

## **SALMON AQUACULTURE IN BRITISH COLUMBIA**

### **SUMMARY REPORT OF THE SALMON AQUACULTURE REVIEW**

In July 1995, the Minister of Environment, Lands and Parks and the Minister of Agriculture, Fisheries and Food asked the Environmental Assessment Office to conduct a review of the adequacy of current methods and processes used by the two ministries in regulating and managing salmon aquaculture operations in British Columbia. This is a summary of the Environmental Assessment Office's final report and 49 recommendations to the Ministers.

#### **A. Salmon Farming in British Columbia**

In salmon aquaculture (commonly known as salmon farming), salmon are raised in captivity from the egg stage until they are ready to be shipped to market. The process begins with the collection and fertilization of eggs from mature female salmon. The fertilized eggs are kept in incubation trays at company hatcheries. After approximately a month, the eggs are transferred to freshwater rearing tanks, where they are raised for several months to the smolt stage. The smolts are then transported from the hatchery to saltwater farms in coastal waters, where they are raised to market size.

Each farm typically consists of a series of open mesh net-cages suspended from anchored metal cage frames. Sea-water passes freely through the cages, which average 15 metres square at the surface and are up to 10 metres deep. To a passing boater, the most visible aspect of a salmon farm is the walkways that separate the net-cages and provide access to shore.

Salmon farming is most productive in cool waters that are well flushed by tidal activity and protected from ocean storms. The waters of the Broughton Archipelago, on the northeast coast of Vancouver Island, and of several large sounds on the west coast are particularly well suited for aquaculture, and the large majority of salmon farms in B.C. today are located in these areas. In addition, other coastal areas such as the Queen Charlotte Islands hold potential for future development.

The industry was first introduced to the B.C. coast in the early 1970s. During these early years, two Pacific salmon species (chinook and coho) were farmed almost exclusively; later, for economic reasons, the industry switched predominantly to Atlantic salmon, a European and eastern Canadian species with a faster growth rate and greater tolerance for higher stocking densities. By 1988 there were 101 salmon-farming companies operating in B.C. Over the next four years, approximately one-quarter of these failed as a result of a drop in salmon prices, financial instability, or environmentally unsuitable farming sites. This period was followed by consolidation of ownership of many of the smaller farms, and the 79 active farms that remain today are operated by 16 salmon-farming companies. The industry currently accounts for over 2,200 person years of direct and indirect employment annually. These jobs have contributed to the economic well-being of a number of coastal communities and for those individuals involved, these jobs are extremely important.

Worldwide, salmon-farming operations now provide about one-third of the total annual salmon harvest. In 1995, the harvest of farmed fish accounted for approximately 37 per cent of salmon production in B.C.. Globally, the province's salmon aquaculture industry plays a relatively

insignificant role. The 25 thousand tonnes produced by B.C.'s farms in 1995 represented about 4 per cent of world farmed salmon production. Norway, Chile and the United Kingdom together account for 80 per cent. The rapid growth of the B.C. salmon-farming industry in the 1980s was accompanied by increasing public concerns about the impact of the industry on the marine environment and on other coastal users. The absence of a coordinated regulatory system and of legislative arrangements to deal with an increasingly significant industry provided a further cause of concern. In 1986, the provincial government placed a moratorium on the approval of new farms and undertook a public inquiry (the Gillespie inquiry) regarding the industry. The moratorium was lifted soon after the report from the inquiry was received. In addition to implementing most of the recommendations of the Gillespie inquiry, the government set up the Coastal Resource Interest Studies program to identify and attempt to address causes of local conflict. The Gillespie inquiry also led to the establishment of a Ministers' Aquaculture Industry Advisory Committee, a stakeholders' group with a mandate to advise the Minister of Agriculture, Fisheries and Food on the orderly development of the industry. In 1988, responding to several complaints about the industry, the B.C. Ombudsman's office prepared a special report on the administration of coastal resources. This report focused on administrative fairness and emphasized the need for integrated coastal zone planning, a coordinated regulatory framework, and the use of consensual dispute resolution techniques to deal with conflict fairly and effectively. Although governmental responses to the Gillespie and Ombudsman recommendations led to improvements in the regulation and administration of the industry, public concern about issues such as potential effects of interactions between wild salmon and escaped farm salmon remained strong.

All three formal levels of government—federal, provincial and municipal—currently have a role in regulating the industry. The role of First Nations in resource planning and management is evolving. In 1988, the federal and B.C. governments agreed on the division of responsibilities that exists between them today. The federal government, under the leadership of the Department of Fisheries and Oceans, maintains regulatory authority for the health of fish in aquaculture facilities, food and public health safety, conservation and protection of wild fish stocks and habitat, and protection of navigable waters. The provincial government has authority for overall development and management of the industry, including: location, size and development of farm sites, reporting requirements, and standards for design, construction and layout.

The provincial government's lead agency in dealing with the federal government on aquaculture issues is the Ministry of Agriculture, Fisheries and Food. As the agency that licenses aquaculture operations, the ministry controls most operational aspects of salmon aquaculture. The Ministry of Environment, Lands and Parks regulates siting and waste discharge permits. Applications for tenure (six-month investigative permits, 10-year licences or 30-year leases) on aquatic Crown land are assessed and approved or rejected by the ministry following field inspections and referral to other provincial and federal agencies, local governments, First Nations and interested non-governmental groups. Once a salmon farm tenure is approved, an operator must obtain an aquaculture licence, renewable annually, from the Ministry of Agriculture, Fisheries and Food. This licence contains requirements for compliance with an approved Aquaculture Development

Plan, prevention and reporting of escapes, appropriate attention to the biological needs of the farmed fish, predation and disease prevention, and compliance with laws and orders of all relevant governmental authorities. In addition to the Ministry of Agriculture, Fisheries and Food and the Ministry of Environment, Lands and Parks, the Land Use Coordination Office plays a role at the provincial level, as the agency that coordinates coastal resource inventories and Crown land planning processes. At the local level, regional districts and municipalities administer zoning bylaws and permits prepared in conjunction with Official Community Plans and Rural Land Use Bylaws. As well, First Nations in Clayoquot Sound and northern Vancouver Island have agreements with the province that provide for consultation in decisions regarding aquaculture.

## **B. The Salmon Aquaculture Review**

In April 1995, the B.C. government placed a moratorium on the issuance of new farm tenures and announced an Action Plan for Provincial Salmon Aquaculture, which identifies the need for a definitive review of environmental issues and of provincial salmon aquaculture policies. The government assigned responsibility for the review to the Environmental Assessment Office. While the Environmental Assessment Office is not independent of government, it is not attached to any ministry and has no stake in the development or implementation of salmon aquaculture policies.

The Environmental Assessment Office was established under the *Environmental Assessment Act* in 1994 to conduct environmental impact assessments of major projects. Section 40 of the Act authorizes the Environmental Assessment Office to assess the effectiveness of other Acts and Regulations in B.C. in preventing or reducing adverse environmental effects. Recommendations made under this authority must be consistent with the *Environmental Assessment Act's* expressed purpose of promoting sustainability by protecting the environment and fostering a sound economy and social well-being.

The terms of reference for the Salmon Aquaculture Review, developed through broad public consultation, called for examination of five issues that have been central in the controversy about the salmon farming industry:

- **impacts of escaped farm salmon on wild stocks,**
- disease in wild and farmed fish,
- environmental impacts of waste discharged from farms,
- impacts of farms on coastal mammals and other species, and
- siting of salmon farms.

The terms of reference also provided that the review should include socioeconomic considerations in its assessment of the industry. During the review, the Ministers of Environment, Lands and Parks and Agriculture, Fisheries and Food confirmed that the review should include an assessment of alternative technologies.

The Environmental Assessment Office established a Technical Advisory Team of experts to prepare comprehensive discussion papers and make recommendations on each of the five key issues. In addition, a Review Committee comprising voluntary representatives of a wide variety of interests was set up to provide information, advice and comment to the Technical Advisory Team. The Review Committee held eight working sessions in several coastal communities in 1996 and 1997, providing the public with an opportunity to comment and present written submissions for consideration by the Technical Advisory Team. First Nations representatives, in addition to being part of the review committee and meeting independently with the Technical Advisory Team as a caucus, submitted papers on aboriginal perspectives on salmon aquaculture. The Broughton Archipelago, off the northeast coast of Vancouver Island, was chosen as a study area to document and demonstrate the issues. Field trips and public open houses in the area produced technical and observational information that was in turn provided to the Technical Advisory Team.

Once the Technical Advisory Team papers were completed, the Environmental Assessment Office evaluated the economic, social and administrative implications of their recommendations and prepared its final report for submission to the Minister of Environment, Land and Parks and the Minister of Agriculture, Fisheries and Food.

## **C. General Conclusions**

The Technical Advisory Team concluded that salmon farming in B.C., as presently practiced and at current production levels, presents a low overall risk to the environment. However, this general finding is tempered by certain reservations. First, continuing concern about localized impacts on benthic (seabed) organisms, shellfish populations and marine mammals suggests the need for additional measures to protect them. Second, significant gaps in the scientific knowledge on which the Technical Advisory Team's conclusions are based point to the need for monitoring and research in areas such as the potential impacts of interactions of escaped farmed salmon with wild populations, identification and control of disease and disease pathogens, potential for disease transfer and impacts from antibiotic residues, and effects of waste discharges on water quality and seabed life.

Science rarely has the ability to reach definitive conclusions on the risk or potential severity of the consequences of human interactions with complex ecosystems. In the face of this uncertainty, government still needs to make land and resource management decisions. Direction is provided by the precautionary principle which advocates the consideration and anticipation of the potential negative impacts of an activity before it is approved. Similarly, the concept of preventative management allows government to manage to prevent certain specific effects even though not all potential outcomes can be predicted. Where the risk of environmental impacts from an economically important activity is low but the consequences of damage may be significant, the public interest may best be served by dealing with risk by being precautionary and invoking a series of measures, including: preventative management, adaptive management, and performance-based standards. In the case of salmon farming, this means reducing risk by setting high standards for farm operations based on the best available knowledge, and rigorously enforcing the implementation of those standards. And it means being prepared to alter management practices over time to take account of increased understanding of risk and different means of reducing it. This means that industry will be required to adapt to evolving management schemes.

The salmon farming industry has had a difficult beginning in B.C. It began in a regulatory vacuum, with little legislative or policy guidance and with no clear identification of regulatory responsibilities. Competition with other existing uses led to conflict and distrust from the outset, and insufficient consideration was given to potential impacts on environmental values. Farm practices have generally improved over the years, but in the absence of clear standards, consistent performance, strict enforcement of regulatory requirements and meaningful public participation in siting decisions, suspicion remains high and strong criticism continues. The concerns of those who find fault with government's management of the industry are legitimate and deserve to be addressed. The following sections highlight key points in the recommendations contained in the final report of the Salmon Aquaculture Review. The recommendations are reproduced in their entirety following this summary.

#### **D. Siting and Environmental Issues**

##### **1. Salmon Farm Siting**

The qualities that make a site suitable for salmon farming—good marine water quality, accessible shoreline, access to supplies of fresh water, safe moorage and proximity to population centres—are similarly attractive for other activities. The relatively recent appearance of salmon farms in areas of the coast where several other activities already exist or where other new activities (marine tourism) are growing have frequently led to conflict with other users. In addition to competition over surface uses, concerns continue to exist about localized ecological impacts of farming activity on marine species, including shellfish, benthic organisms, marine birds and mammals, and fish.

Much of the distrust about the siting of salmon farms that exists today stems from the 1980s, when the industry was growing rapidly and regulatory systems had had little chance to develop. The siting policies and procedures used by the Ministries of Environment, Lands and Parks and Agriculture, Fisheries and Food have improved since then, as have some of the farm practices that contributed to local conflict. Concerns remain with respect to the effectiveness of licensing arrangements and problems exist with the current location of some sites that were approved under former policies.

Despite current ministry policy requiring applications for farms within one kilometre of Indian reserves to be referred to First Nations, some applications were approved before the adoption of the policy, without such consultation. Of particular concern to First Nations is the fact that farm waste has been shown to affect life on the sea bed beyond the aquaculture tenure boundary. A complete understanding of the effects on shellfish resources, especially at a distance of 125 metres (the current minimum siting distance set by policy) are unknown. While there has been an improvement in procedures for considering and protecting key tourism and recreational values from visual and amenity disturbance, the requirements are vague and inconsistently applied. There is no policy requirement to identify and avoid prawn fishing areas, but known trap fishery sites are currently being avoided through siting. Likewise, efforts are made to avoid sensitive fish and wildlife habitat, but there are no comprehensive studies of overlap between salmon farms and sensitive habitats, and criteria for their protection need to be made more explicit. Navigation routes, archaeological sites and commercial and sports fishing areas are rarely affected by farm locations.

To identify potential impacts and conflicts in siting, the Ministry of Environment, Lands and Parks routinely refers applications to other agencies and interests. The effectiveness of the referral system is hampered by several factors: if comments are not returned in a timely manner, decisions may be made in the absence of full information; there is no obligation on the part of the Ministry of Environment, Lands and Parks to act on comments they receive; and there is no guidance for making tenuring decisions when conflicting advice is received. Even though the decision-makers have broad discretion, there are few effective avenues for consultations in advance of decisions. Recent initiatives to complement the referral process with face-to-face interagency communication, through the Vancouver Island Fish Farm Review Committee, have encouraged greater coordination and consensus, as well as enabling applications to be considered in groups. The committee approach to tenure review should be formalized, with provincial agency disagreements being referred to Interagency Management Committees for resolution. (Recommendation 1)

Another shortcoming of site-by-site referrals is that they restrict attention to a single site rather than considering the cumulative impact of multiple developments on a variety of values in a region or sub-region. Integrated coastal management plans, based on consensus among stakeholders and a thorough assessment of all biological resources, provide a fair and efficient mechanism for designating specific geographic areas suitable for different types and intensities of activities, including salmon farming. They should be prepared at both the sub-regional level (e.g., Central Coast) and the local level (e.g., Clayoquot Sound). As such plans may take considerable time to prepare, techniques should be developed on an interim basis to assess and allocate salmon farms in groups located within defined geographical areas and to provide for input of all those with an interest in such site allocations. (Recommendations 2 and 3)

To prevent or reduce negative impacts and conflicts, siting criteria should be established to define minimum distances for separation of farm sites from other uses and resource values, with greater than the minimum requirement being provided where detailed site-specific assessments show this to be necessary. (Recommendation 4) Where integrated coastal use plans provide clear direction, sites should be located in accordance with the plan. Thorough inventories and mapping, though expensive, generate cost savings by facilitating precise and expeditious decisions that avoid the risk of conflict by their increased credibility. They are essential both for integrated coastal planning and for the assessment of salmon farm site applications. Government should continue to improve its inventories and mapping base, drawing on federal and provincial data, local and traditional knowledge, and private industry maps. Aquaculture suitability maps should continue to be developed from this information. In addition, to facilitate informed decisions, government should require applicants to provide detailed assessments of specified site characteristics, using resource inventories and mapping, site surveys and studies, and local consultation. (Recommendations 5 and 6)

Despite a keen public interest in the aquaculture industry, current opportunities for involvement in decision-making regarding salmon farming are sporadic and limited. Public input is essential not only to encourage well-

informed decisions and reduce conflict, but as a matter of fairness. In addition to other avenues, government should establish local advisory working committees, comprising a balanced cross section of interests and using existing committees where appropriate, to provide advice on siting and management of farms. (Recommendation 7)

Where existing sites are poorly located and are causing significant problems, remediation plans should be developed, with measures to revise production levels, amend husbandry practices, incorporate different technology, or relocate farms to a different location. (Recommendation 8)

The early stages of the salmon-farming process take place in freshwater facilities, including land-based hatcheries and juvenile-rearing lake net-cages. Two Vancouver Island lakes (Lois and Georgie) currently have active aquaculture operations. Certain environmental impacts of salmon farming can be more significant in fresh water than in the ocean. There is an increased likelihood of escaped salmon competing with native fish populations and establishing colonies. In addition, low production or oligotrophic lakes are particularly susceptible to eutrophication resulting from absorption of waste nutrients. To reduce these risks, the government should prepare effective and consistent guidelines for approval of lake aquaculture facilities, and should develop and enforce water quality standards for dissolved waste discharges. (Recommendations 9 and 10)

## **2. Escaped Farm Salmon**

Factors contributing to the escape of farmed salmon include deficient farm operations, damage to nets by storms or predation, accidents such as inadvertent release during transport, and vandalism. The Aquaculture Regulation requires licence holders to take reasonable precautions to prevent escapes and to report those that do occur. During 1994-95, B.C. salmon farms reported over 60,000 escaped fish (primarily Atlantic salmon), and total escapes may be double that number when unreported "leakage" is taken into account. In recent years the number of escapes has been gradually declining as a result of improved siting, farm design, farm practices and the introduction of acoustic deterrence of predators.

Given the importance of the wild fishery to the economic, social and cultural fabric of B.C., several strong and heartfelt concerns exist about the potential impact of escaped farmed salmon on wild stocks and the possibility of Atlantic salmon establishing in B.C. through reproduction. Deliberate attempts to introduce this species into B.C. in the past have failed. The Technical Advisory Team concluded that colonization by Atlantics is improbable but not impossible; if colonization were to occur, it would likely be possible to target and eradicate stocks that had become established. The Technical Advisory Team also found the potential for interbreeding between escaped Atlantic salmon and wild salmon to be extremely low and found little threat to wild stocks through predation or competition for food by Atlantic salmon. The introduction of an exotic species to the wild is a significant matter, as there are many past examples of damage caused by species presumed to be harmless. However, the risk of escaped Atlantic salmon causing lasting harm appears to be so low that there is no demonstrable basis at this time for discontinuing their culture in B.C.

The risk of genetic alteration due to interbreeding between farmed and wild Pacific salmon is potentially high if escape numbers increase, though B.C. already has a long history of intentional mixing of salmon with different genetic backgrounds through salmon enhancement programs. In addition to reducing the risk through escape prevention, care should be taken not to locate farms near streams that provide habitat for native stocks. Transgenic salmon (salmon that has been altered by introducing new genetic material into its genetic composition) might out-compete wild populations for food; farming of transgenics does not currently take place and should be prohibited. (Recommendation 11)

Current measures for the prevention, monitoring and reporting of escapes are ineffective and must be improved. Provincial agencies and industry should cooperate to develop information on the best available technology and husbandry practices for preventing escapes, and prevention measures should be included as enforceable elements of aquaculture management plans, with escapes over a designated threshold number triggering review and remedial measures. To facilitate monitoring of escapes and of farmed salmon inventories, farmers should be

required to maintain a computerized tracking system, with penalties for mis-reporting. Government monitoring of streams and of commercial and sport catches for escaped salmon should continue. (Recommendations 12 and 13)

In addition to reducing the risk of escape, more effective measures should be taken to reduce the potential impact of escapes that do occur. Salmon farmers should be required to develop plans for the recovery of escaped salmon, and research should be conducted regarding the development of stocks that pose a minimal genetic risk to wild salmon, including all-female or non-productive Atlantic salmon. (Recommendation 14)

### 3. Fish Health

Three primary concerns regarding fish health issues have to do with the risk of importation to B.C. of non-indigenous pathogens and parasites, transfer of disease between farmed and wild fish, and the use of drugs and pesticides on salmon farms. Significant gaps exist in scientific understanding of disease in wild and cultured fish. Current information indicates no evidence of exotic pathogens or parasites having been introduced to B.C., and the Technical Advisory Team found the probability of exotic disease outbreaks to be low. The susceptibility of farmed salmon to disease may be increased by the stress of being raised in captivity; however, it is not known whether there is a greater incidence of disease in farmed than in wild fish. Many farmed fish are vaccinated against disease. Primarily as a result of difficulties in monitoring disease and identifying the source of pathogens, there is no evidence to prove or disprove whether transfer of pathogens and parasites from farmed to wild stocks increases the rate of disease. Because of such information gaps, it is essential that government adopt a more proactive approach to disease prevention, with more rigorous research and monitoring.

A variety of federal and provincial government agencies (including the Ministry of Environment, Lands and Parks, the Ministry of Agriculture, Fisheries and Food, the Department of Fisheries and Oceans and Health Canada) are involved in the prevention and control of disease in farmed and wild fish. The importation of eggs and transportation of live fish are regulated under the provincial Freshwater Fish Regulation and the federal *Fishery General Regulations* and *Fish Health Protection Regulations*. Provincial legislation for animal disease control does not currently apply to fish disease.

Lack of coordination, good communication, clear objectives, and cooperation among the many agencies involved in the management of fish health create serious inconsistencies and redundancies. To overcome these inefficiencies, an interagency Fish Health Working Committee should be established with a mandate to develop management policies regarding surveillance, field investigations, inspections, assessments and reporting. The committee should address interagency disagreements through consensus-based decision-making.

(Recommendation 15)

The current approach to disease management is reactive rather than proactive. Little is known of the incidence of disease and disease-causing organisms in B.C. waters and of the ecological role of disease in regulating or affecting both wild and farmed populations. Current evidence suggests that all existing diseases on fish farms are indigenous rather than exotic, and that diseases are not transferred from farmed to wild fish, but more precise information is needed on the diseases that exist and on causal relationships in order to determine what diseases should be identified and reported by farmers. For these reasons, a comprehensive surveillance program is essential, in order to define all diseases that should be reportable. The program should be carried out by government under legislation (Animal Disease Control Act) with the participation of First Nations, industry, community fishers and wild fishery organizations. (Recommendation 16)



Currently, salmon farmers are required to take reasonable precautions to control disease. Government should set enforceable standards to establish disease prevention and management protocols, minimum health record requirements, outbreak management protocols, drug use standards and disease reporting requirements.

(Recommendation 17)

Development of effective vaccines, improved husbandry practices and a low level of drug use suggest that disease is not a significant problem to farmers. However, a lack of willingness on the part of industry and management agencies to share information has created a high level of public distrust. To counter this, a comprehensive fish health database should be developed containing fish disease and drug use information and should be accessible to the interagency Fish Health Working Committee. Information about diseases, pathogens and parasites should be made more readily available, provided that the proprietary interests of individual salmon farmers are protected and annual reports summarizing the results of the surveillance program and drug use in the industry, should be made available to the public. (Recommendation 18)

To further reduce the likelihood of disease transmission, government should, for salmonids, continue to prohibit the importation of live fish, unfertilized eggs and milt. The Technical Advisory Team found the likelihood of a serious disease outbreak resulting from importation of an exotic pathogen in fertilized eggs to be low but not zero, and the consequences of such an event could be significant. Importation of surface-disinfected fertilized eggs should be permitted only in limited numbers for broodstock development. Surface disinfectants, while generally effective, cannot remove all surface pathogens or pathogens within the egg, therefore multiple sampling of newly hatched fry is essential to ensure the fish are disease-free. Requirements for sampling and reporting of diseases in fish being transferred within the province should be strengthened. (Recommendations 19 and 20)

Both the federal and provincial governments, through a variety of statutes and agencies, regulate pesticide and drug use and the monitoring of aquaculture products, destined for human consumption. There is little risk of human consumers of salmon being affected by diseases in fish. Those pathogens that do affect humans, such as botulism, are usually the result of poor handling and preparation of fish. Drugs added to feed may be a cause of concern, but levels of use are low (about 2.1 per cent of feed used in 1995 was medicated). To guard more completely against the risk of drug contamination of salmon sold to consumers, government monitoring of fish products at processing facilities should be improved. In view of local concerns among First Nations about the risk of contamination of non-farm fish and shellfish that consume waste feed, flag indicators should be used at farms to alert the public when drugs are being used. As the use of antibiotics poses the risk of drug-resistant strains of bacteria developing, drugs should only be used under a veterinarian's prescription, with regular evaluation for changing patterns in bacteria. (Recommendations 21 and 22)

Certain issues, for example risks of those drugs approved for use in human food production, and the consequences of their use, fall under health agencies' jurisdiction. Health agencies should determine a course of action to deal with these issues, recognizing that although there are concerns, no extreme health effects have been identified.

(Recommendation 23)

#### 4. Waste Discharges

Uneaten fish feed and fish faeces make up the bulk of farm waste discharges, with lesser amounts of effluent from workers, and garbage. Antifoulants may leach components into the water column. Solid wastes settle in the water column and on sediments below net-cages and are generally localized within 30 metres of the edge of the net-cage, their amount and degree of movement depending on the action of currents, efficiency of feeding regimes and other factors. Of particular concern, especially to First Nations, is the absorption of antibiotic residues from feed and faeces by marine life such as shellfish. One of the more persistent antibiotics, oxytetracycline, loses its effectiveness in the water column within 30 days, but overall information regarding the impact of antibiotics on marine biota is poor. Where waste accumulates to the point that it can no longer be absorbed by sediments and biota, biological degradation can lead to the production of toxic hydrogen sulphide and methane gases, and biota may be smothered by wastes.

Under the *Waste Management Act* and the *Aquaculture Waste Control Regulation*, farms that exceed minimum amounts in the use of feed (greater than 630 T per year) and discharge of domestic sewage, require permits that provide direction regarding good management practices. This approach has not consistently prevented impacts on the benthos (sea-bed life). More effective measures are needed to measure environmental impacts and to establish standards designed to limit sediment impact. Accordingly, the government should develop a regulation that encourages performance-based management, with clear and consistent standards, a requirement for farms to prepare enforceable waste management plans, and annual fees based on the type and amount of contaminants discharged by each farm calculated through feed use. Farmers should be required to carefully monitor the effects of wastes, making appropriate husbandry adjustments as necessary, and the Ministry of Environment, Lands and Parks should routinely assess monitoring data and be prepared to take immediate action to ensure compliance when standards are not met. A range of allowable limits may be required to account for variations in sediment characteristics, and initial testing and research will be required for the development and upgrading of standards. Until the new regulation takes effect, the existing regulatory regime should be applied and all tenure holders should be advised of the pending regulation which could affect their operations. Where existing farm sites are found to have a high adverse benthic impact, the Ministry of Environment, Lands and Parks should cooperate with farm operators to develop and immediately implement plans to improve benthic conditions or to relocate farms as a remedial measure. (Recommendations 24 to 30)

To address concerns about the impact of farm waste on nearby shellfish beds, provincial and federal agencies should cooperatively develop a program that provides a detailed assessment of that impact, especially with regard to antibiotic residues and suspended solids. The siting standards recommended by this report, especially with regard to distance from shellfish resources, should be reviewed once these assessments are completed and should be adjusted if necessary. (Recommendation 31)

The federal/provincial policy prohibiting polyculture should be reviewed due to the suggestion that shellfish grown near or on salmon farms can reduce particles in the water column. (Recommendation 32)

## **5. Interactions with Coastal Mammals and Other Species**

Predation by seals, sea lions and river otters can cause considerable economic harm to salmon farmers through fish mortalities, wounds that lower market value, and stress that may cause fish to reduce feeding and increase their vulnerability to disease. Tearing of net-cages by predators can result in salmon escapes. In addition to losses caused by marine mammals, farms may face less significant losses to the predatory actions of mink and birds. An estimated 1.5 per cent of total industry production (in excess of 200,000 fish) was lost through predator-induced mortalities and escapes in 1989.

Methods used by salmon farmers to deter predator attacks include predator netting and other physical barriers, shooting, scaring devices (including gunfire, dogs and scarecrows), trapping, night watches, and acoustic deterrent devices (underwater sound-generating devices). Aquaculture licences require farmers to prevent predation, using reasonable and lawful means, and appropriate permits and authorizations are required for the trapping and killing of animals and the use of acoustic deterrent devices.

In the past eight years, over 3,800 harbour seals and California and Steller sea-lions have been reported killed by salmon farmers, and the total number killed may be significantly higher. This suggests that predator prevention efforts are generally ineffective, in part because some farmers are reluctant to invest in expensive predator netting. While overall populations of harbour seals and California sea lions appear not to have been adversely affected, there is strong public opposition to the killing of marine mammals, and shooting at current levels presents a public safety concern, especially at night.

Consequently, there should be tighter controls on shooting and greater efforts at predator prevention, with enforceable predator control plans written into aquaculture licences and government assistance in identifying the best available anti-predation net systems, other technologies and appropriate husbandry practices. Killing of predators should only be permitted if they are inside the nets and are actively attacking fish or about to do so. Farms with ongoing problems with persistent predators should contact government conservation or fisheries officers, who may at their discretion trap and kill predators and recommend improvements in a farm's predation prevention plan. (Recommendations 34 and 35)

Acoustic deterrent devices appear to lose effectiveness over time as seals and sea lions become accustomed to or deafened by them or are strongly motivated by hunger or previous predation success. In addition to causing hearing damage, acoustic deterrent devices may interfere with animal communication signals. Harbour porpoises are known to avoid traditional habitat where acoustic deterrent devices occur. As acoustic deterrent devices are generally ineffective and can pose a significant ecological hazard, they should be phased out over a two-year period and replaced with effective predator control programs. This will require cooperation from DFO. (Recommendation 36)

Several farms have been authorized by DFO to use night-lighting of net-cages to produce faster growth in salmon and to prevent certain maturation problems. The Salmon Aquaculture Review heard concerns that wild species such as herring are attracted by lights and are eaten by farmed fish, that the increased proximity of wild fish encourages the transfer of disease from farmed fish, and that bright lights at fish farms interfere with the aesthetic enjoyment of nearby residents and recreational users. One study has shown that fish in net-cages do not consume significant amounts of wild fish attracted by lighting. However, the paucity of research into this interaction combined with conflicting observational information suggests that further scientific study is needed. Accordingly, no new authorizations of night-lighting should be issued, pending the results of further research.

(Recommendation 37)

### **E. First Nations Issues**

The coastal areas best suited to salmon aquaculture overlap with the traditional territories of several of the Kwakiutl and Nuu-chah-nulth First Nations. Their legal interest in these territories is currently the subject of treaty negotiations although certain Kwakiutl First Nations are party to the Douglas Treaties. The rights of aboriginal peoples in their traditional territories, together with their traditional close relationship with the

resources of the sea, create strong concerns about activities that might affect the economy, culture and traditions of First Nations.

First Nations have received very few, if any, benefits from salmon aquaculture as it is currently practiced, yet they have experienced a greater impact than any other group. Their involvement in decisions regarding salmon aquaculture during the last two decades has been minimal. For these reasons and technical concerns, First Nations have strongly opposed salmon farming in their traditional territories.

Recent court rulings on aboriginal rights (primarily *Delgamuukw v. B.C.*) have established the provincial government's obligation to ensure that a proposed activity will not unjustifiably infringe aboriginal rights before approving the activity. To make that determination and to resolve any apparent conflict, adequate information (technical data and traditional knowledge) and appropriate consultation are needed prior to approval of aquaculture tenures. Where tenures are being considered for renewal or amendment, the vested rights and interests of tenure holders must also be considered.

With respect to the existing tenures, the government needs to conduct a review of existing tenures to determine which ones require consultation to ensure compliance with the current Crown Lands Activities Policy for avoiding infringement of aboriginal rights before a decision on renewal or relocation is made. For new tenures, affected First Nations should be invited to join government agencies on the Fish Farm Review Committees, which should have a primary role in reviewing tenure applications. These committees could provide an efficient mechanism for sharing information about proponent applications and First Nations concerns. In addition, government should consult directly with First Nations on tenure applications to ensure compliance with the Crown Lands Activities Policy and follow processes already established through interim measures agreements where these exist, including the Kwakiutl Territorial Fisheries Commission (for the Broughton Archipelago) and the Central Region Board (for Clayoquot Sound). (Recommendation 38)

In addition to their participation in tenure review processes, First Nations should be more directly involved in the management and operation of the salmon farming industry. Traditional knowledge about ocean resources has often been overlooked in the past, and could be a valuable asset in research, policy development, and monitoring and auditing industry operations. With this knowledge and their residence in the area where salmon farming is conducted, First Nations communities are well placed to provide support and technical services to farms in addition to working with government and industry to improve management practices. The government should

develop training programs and encourage employment of aboriginal people in the industry. In addition, First Nations should be involved in environmental monitoring and auditing, research on the impact of farms on seafood resources such as shellfish, and the development of pilot programs for closed containment technologies.

(Recommendation 39)

## **F. Addressing Risk and Uncertainty**

While understanding of the risks inherent in salmon farming has increased significantly in recent years, it is incomplete. The Technical Advisory Team conducted a comprehensive review of existing scientific literature, research and observational information. It recorded the current state of knowledge, but gaps in that knowledge remain. Consequently, the Salmon Aquaculture Review has not provided unequivocal answers to all questions and concerns raised during the review.

Based on current knowledge, the Technical Advisory Team found a low overall risk in the key areas of concern but some local impacts. Different interests in the public debate over the future of salmon farming react to such a finding in very different ways. Proponents of the industry argue that approval of industry expansion should naturally follow. Some opponents argue that, without proof that there is no risk to the marine environment, net-cage farming should be prohibited completely and replaced with closed-containment systems.

Scientific studies rarely eliminate uncertainty. However, by defining the boundaries of uncertainty, such studies can delineate information gaps and provide a focus for ongoing research. It is the role of government to act on that information and make decisions, to the best of its ability, that protect environmental values while enabling economic progress. This means acknowledging uncertainty where it exists and dealing with it in a precautionary manner. This is accomplished by first anticipating potential negative impacts, and invoking preventative measures to avoid specific effects. It also involves ongoing adaptive management, in which knowledge gaps are identified, research and monitoring needs are defined and implemented, and management and regulation are adjusted as necessary to take account of new information and minimize risk to the degree possible. The Environmental Assessment Office concludes that an adaptive management approach should be taken to the sustainable development of the salmon aquaculture industry.

Within the limits of its resources, government should place a priority on research on each of the four key issues where uncertainty exists: escaped farm salmon, fish health, waste discharges, and interactions of salmon farms with aquatic mammals and other species. Priority research is also needed to assess the effects of salmon farming, particularly when antibiotics are used, on human health. Industry, as a beneficiary of the results of research on each of these issues, should share in the effort and cost. To complement solutions through research, the government should monitor the adequacy of current management techniques through continuous collection and analysis of standardized data. The information gained through research and monitoring on each issue should be applied through the ongoing refinement of standards. (Recommendations 40 and 41)

Even though the risk of significant environmental impacts has been determined to be low, the possibility nevertheless exists for the occurrence of a catastrophic event such as damage to wild salmon stocks through disease transfer or the importation of pathogens. Some participants in the Salmon Aquaculture Review argue that the industry should be required to post a sizable financial bond to provide the funds needed to remedy ecological damage and compensate for economic loss. The Environmental Assessment Office has recommended a range of measures to prevent risk and to ensure information to manage critical issues as a means of preventing a significant event. Should one occur, existing measures should be relied upon to recover the costs of such an event (*Environmental Management Act; Animal Disease Control Act*) and strengthened if necessary. The industry reclamation bond should be reviewed for adequacy. It is currently set at \$25,000.

## **G. Alternate Salmon Farming Technologies**

The grow-out phase of salmon aquaculture in B.C. is conducted entirely with floating net-cages in the sheltered waters of Georgia Strait and the protected sounds and inlets of the west coast of Vancouver Island. This system has the advantage of being easy to operate, requiring relatively low capital investment, and allowing for

incremental change in production capacity with little alteration of a facility. Other technologies, already in use in other countries or currently being developed, have varying potential to reduce environmental impacts of salmon farming, increase the efficiency of culture methods, and allow for expansion into areas where conflicts with other activities may be lessened. These alternative technologies include exposed offshore open marine systems, closed circulating marine systems, and land-based saltwater systems.

***Exposed offshore open marine systems.*** Offshore systems, located anywhere from a few hundred metres to a few hundred kilometres from shore, are exposed to larger waves and potentially higher currents than inshore sites. While the environmental conditions are more harsh, production benefits may be increased as a result of consistently higher water quality and more active tidal flushing.

Developments of offshore finfish aquaculture operations include both surface and submersible cages, which in some cases are mounted on the seabed and operated from the surface. Offshore cage designs are technically feasible and are operating successfully throughout the world. While the cost of switching to such a system and of adopting new culturing methods may be considerable, there would be economic advantages to the industry in increased productivity and expansion opportunities. Some coastal communities, however, may experience an economic disadvantage through the loss of processing and income from services if better product distribution services afforded by larger centres become more accessible.

Environmental impacts such as benthic smothering, enhanced nutrient loadings and predator interactions would generally be lessened, as would be conflicts with other coastal resource users and interest groups. Other potential environmental impacts associated with deep-water siting require assessment. The risk of large-scale escapes through structural failure or collision with a vessel might increase, but could be manageable with proper engineering and safety precautions. Because the locations of offshore systems would in many cases occur outside of the area within authority of British Columbia, many aspects of siting decisions and industry management would likely fall within the mandate of federal agencies.

In order to determine whether to support a shift to offshore systems, the provincial and federal governments should clarify their jurisdictional and management responsibilities and assess the social, economic and environmental impacts of offshore systems. (Recommendation 42)

***Closed, circulating marine systems.*** The two main design types that have been conceived for this technology are closed-wall cages and floating raceways. The closed-wall cages resemble the net-cages currently in use, with the exception that an impermeable membrane replaces the net and water is pumped into the cage.

While closed, circulating marine systems are becoming technically feasible, components such as systems for collection of solid waste require further development. Commercial feasibility remains to be demonstrated. Some environmental impacts, such as escapes, predator interactions and contamination by waste, can be lessened considerably through this technology, though the high volume of water required may have an effect on plankton and on larvae and juveniles of other species. Conflicts with other coastal users would continue to exist and might increase if the technology allows siting in more sheltered locations.

The Ministries of Agriculture, Fisheries and Food and Environment, Lands and Parks should establish a task force, comprised of industry, First Nations and all levels of government, to select sites for the establishment of pilot projects for closed systems. These projects, in a variety of habitat types and locations, should be used to encourage further development of the technology needed to establish economically viable farms with minimal environmental impacts. The salmon farming industry should participate in the cost of developing this technology and other research through funds generated by the establishment of a research and development fund.

(Recommendations 43 and 44)

***Land-based saltwater systems.*** In the most basic form, these consist of deep water ocean or saltwater aquifer intakes, pumps and pipelines, saltwater ponds, effluent structures and site buildings. Other components that may be added as the sophistication of the technology increases include oxygenation, effluent clarification, treatment of

sludge, removal of nitrogenous waste, ozone or ultraviolet disinfection, temperature modification and recirculation.

While a land-based system with recirculation technology would minimize many current concerns about environmental impacts of salmon farming, there are also significant disadvantages. Technologies exist but capital and operating costs would both be extremely high, given those existing technologies. Geographical requirements—a large flat location near sea level, with a deep ocean water source close by—suggest limited availability of suitable land in B.C. as well as a high potential for conflict with adjacent property owners. Land-based saltwater systems are not currently a viable alternative to other salmon aquaculture technologies for commercial grow-out given the need for foreshore land and high, uneconomic cost of production.

## **H. Dispute Avoidance**

Implementation of the recommendations in this report should significantly contribute to avoiding disputes as a means of reducing the level of the conflict that has plagued government in managing the salmon farming industry during the past decade. Nevertheless, disputes may be expected to occur from time to time with regard to both regulatory decisions and operational practices and performance. Mechanisms are needed to deal with such disputes in an efficient, fair and effective manner.

Siting decisions are critical decisions both because of their impact on local communities and the environment and because they represent a long-term commitment ranging from 10 to 30 years. It is therefore essential that they be based on processes that are seen to be fair and effective. An improved information base and better siting criteria will assist in making better decisions. Strengthened processes for public and First Nations participation, with assurance that public concerns will be heard and considered, are recommended. Interagency coordination and cooperation need to be improved to ensure efficient sharing of information and resolution of differences.

Integrated coastal zone planning is an essential initiative to tie these components together, by providing for a consensus-oriented decision-making process that brings together all affected public and government interests and places aquaculture in a broader planning context.

Disputes about specific siting and permitting decisions can be avoided or addressed through several steps.

Licensing agencies should establish procedures and mechanisms, including a Ministry of Agriculture, Fisheries and Food website, to effectively inform the public about the status of tenure and permit applications, and provide an appropriate period for public review and comment. Farm proponents should be required to hold open houses and to meet with local advisory working committees to explain and receive comment on their proposals. The government should take steps to ensure that affected parties are made aware of their right to register a formal objection to a site application with the Ministry of Environment, Lands and Parks. Members of the public will be participants on the local advisory working committee. (Recommendation 42)

Several participants in the Salmon Aquaculture Review expressed frustration that there is no effective means of influencing or registering complaints about poor performance by farms. Three avenues for complaint currently exist. First, complaints to the appropriate licensing agency may lead to an investigation and enforcement or cancellation of a licence where an operator has failed to comply with its terms or conditions. Second, persons who are concerned about a farm impact such as noise, light or odour can contact regional Ministry of Agriculture, Fisheries and Food staff, who will attempt to develop solutions through discussions with the complainant and farmer. And third, since April 1997, individuals can file a complaint with the Farm Practices Board, an independent body established under the recently adopted *Farm Practices (Right to Farm) Act*. If informal resolution is not successful, the Board may hold a formal hearing to determine whether a practice being complained of is “normal farm practice”; if not, the board may order the practice stopped or modified. Each of these dispute resolution mechanisms has the potential to be effective and should be encouraged.

## **I. Policy Context and Advice**

Provincial staff responsible for developing and implementing salmon aquaculture policies and procedures have been hampered by the absence of government-wide direction on environmental, economic and social objectives.

The draft provincial land use goals and the guiding principles contained in the Provincial Land Use Charter and Sustainable Environment Charter have not been applied specifically to aquaculture. This lack of direction has contributed to disagreements among the various agencies involved in the administration of the industry and has encouraged inconsistency among agency-specific policies. With the participation of all key groups and agencies, the government should take steps to develop strategic policy objectives to guide the development of legislation, regulations, programs, policies, guidelines and coastal zone planning processes. (Recommendation 46)

Generally, the development of the industry has outpaced government in planning and managing it. Laws, regulations, policies and guidelines, while continuing to improve, have fallen short of the expectations of groups such as First Nations, local government, commercial fishing, recreation and tourism interests. The Minister's Aquaculture Industry Advisory Council effectively involved several of these interests in providing advice on policy development until 1993, when it disbanded. The government should create a similar body, including representation from all key interests, to provide advice on the development of policy, monitor its implementation, recommend research priorities, and provide a forum for dialogue and information exchange. (Recommendation 47)



## **J. Implementation of the Recommendations**

### **1. Environmental, Economic and Social Implications**

Implementation of the recommendations of the Salmon Aquaculture Review will reduce both uncertainty about and risks of negative ecological impacts from salmon farming, as described in the foregoing discussion of siting and environmental issues. Preventative and adaptive management and performance-based standards are crucial in achieving this goal. The agencies involved in the regulation of the industry should be prepared to adjust policies and practices periodically as knowledge gained through research and monitoring continues to evolve. Farm operators are currently subject to very few objective and measurable (and thus easily enforceable) performance standards. The proposed shift to a regulatory system that emphasizes clear and objective standards will contribute to the prevention or reduction of undesirable environmental impacts.

The real and potential economic benefits of minimizing these risks will include: increased stability and sustainability for the salmon-farming industry, reduced costs in conflict management, reduced risk to commercially valuable wild fish and shellfish populations, and benefits to the outdoor recreation and tourism industries. The economic cost of implementing the recommendations, if adopted, will affect the aquaculture industry, the provincial and federal governments, as well as First Nations and local governments.

The administrative and regulatory costs to the provincial government of implementing the recommendations over the next three years are expected to amount to approximately \$2 million to \$4 million. The cost impact will fall primarily in three areas: fish health surveillance, data management and auditing; development and enforcement of performance standards required of farm operators; and research initiatives.

Costs to the federal government will be related directly to existing responsibilities for the stewardship of wild salmon stocks and other marine species. These costs would include involvement in the establishment of an interagency working committee on fish health; diagnostic and disease identification work; improved inventories and classifications of anadromous fish streams; and participation in coastal zone planning.

Costs to the industry would be associated with new process requirements for siting, escape prevention and mitigation, waste control and predator prevention. Implementation of the recommendations will alter the availability of sites. While some areas may become less available, others are likely to be opened up through coastal zone planning. Moreover, as farming technology improves, deeper, more exposed waters may become suitable for farming, and closed containment systems may increase near-shore opportunities. The primary cost to the industry with regard to a review of tenures is likely to result from the need to relocate or fallow existing farms that have undesirable impacts on benthic biota and nearby shellfish beds. Where these impacts result from inappropriate siting decisions in the past, it may be reasonable to expect that government would contribute to the costs of relocating farms, which may be expected to average about \$50,000 per farm affected.

While it is in the industry's own economic interest to reduce the risk of escapes, disease and predator attack, implementation of the recommendations will result in certain new costs to industry. Escape prevention and mitigation costs will include the expense of developing and implementing escape prevention plans, of standardized inventory control systems, and of escape recovery plans and equipment. The recommendation that farms be subject to enforceable fish health standards is unlikely to create significant new costs to the industry beyond those already experienced in the vigilant efforts that currently exist to ensure healthy farmed populations. The recommendation for increased emphasis on physical barriers to predators rather than acoustic deterrent devices and shooting will result in increased costs for the installation and maintenance of new net systems, which are currently not in use on about one-third of B.C.'s farms. While the cost for such systems is high—about \$250,000—savings may result from reduced financial losses due to escape, mortality, injury and stress in farmed stocks.

The marine tourism industry is one of the fastest-growing sectors of the economy and rivals the employment contribution of salmon-farming in areas such as Clayoquot Sound. Pristine environments are important attributes for activities such as kayaking and whale-watching, and growth in the coastwide number of salmon farms could

result in forgone opportunities for marine tourism operators. However, they may benefit from the implementation of recommendations regarding the phasing out of acoustic deterrent devices, limiting of night-lighting, improved control of waste discharges, separation of sites from key recreation/tourism sites, and preparation of coastal zone management plans.

Implementation of the recommendations may be expected to confer a variety of social benefits on coastal communities. Provisions to address concerns about environmental impacts and to increase public participation in siting decisions should lead to a reduction in conflict, and industry stability should have a positive effect on local employment. First Nations should benefit through increased involvement in decision-making processes, reduced risk to marine resources such as shellfish, and a range of new employment opportunities. Conflicts between salmon farms and marine recreation activities should be reduced by distance restrictions on siting, identification of sensitive areas through improved inventories and mapping, and minimization of visual impacts through design guidelines in an aquaculture code of practices. Finally, development of coastal zone management plans, based on comprehensive and reliable information and on consensual agreement among stakeholders, provides a promising opportunity to balance competing community interests and produce stability and sustainability for a broad range of ocean-based activities.

## **2. Implementation**

The capacity of provincial and federal agencies to implement change quickly in the reform of salmon aquaculture management is constrained by structural reorganization and budget limitations. For that reason it is important to establish priorities in the implementation of the Salmon Aquaculture Review's broad range of recommendations. Immediate emphasis should be placed on promoting effective public participation in decision-making and information-sharing among all parties with an interest in salmon aquaculture issues. First Nations, community groups, environmental organizations and recreation/tourism interests have all expressed deep distrust of the industry and the agencies that regulate it. Meaningful public involvement is necessary not only to address concerns about perceived industry secrecy and government failure to respond to public concerns, but also to ensure that decisions are informed by important local knowledge and technical information. Local advisory working committees should be initially established to provide advice in areas where new sites may be allocated or existing licences are due to be replaced.

The recommended salmon aquaculture advisory group on policy development should be set up with the initial tasks of providing advice on implementing management improvements and a code of salmon aquaculture practices. The code should take the form of a single reference document that identifies all standards and guidelines for the development and operation of salmon farms. Developed cooperatively by government, industry and other key interests, the code would be a primary source for salmon farmers in developing farm management plans and describing specific measures to be used to prevent or mitigate escape, maintain and monitor fish health, contain waste, and deter predators.

Before a performance standard for waste discharges can be established, considerable work needs to be done. Information about the impact of waste from current farms on water quality and benthic life is limited, and that which does exist has not been fully utilized. Intensive monitoring of several key sediment and water quality parameters at salmon farms should be conducted, and the results should be correlated to biodiversity impacts beneath salmon farms, with consideration also given to economic implications for the industry.

A comprehensive code of salmon aquaculture practice that establishes best operational practices and describe application processes as well as methods to address complaints and resolve disputes is a critical component of the proposed management framework. (Recommendation 48)

Legislative, regulatory and policy changes are outlined and should be made to implement the recommendations. Operational policies are needed to implement many of the changes. Processes for the review of tenure applications, salmon aquaculture licence applications and waste management plans are recommended and policy guidelines should be issued to endorse and adopt these. A corporate enforcement and compliance policy should be documented by the managing agencies to provide greater certainty and fairness to the industry and public. (Recommendation 49)

While the Salmon Aquaculture Review has determined that the overall risk to the environment from salmon farming is low, caution needs to be exercised about lifting the moratorium on new tenures before a new management system is fully in place. The government may wish to consider developing selective regional or sub-regional coastal strategies for the issuance of new tenures, where government is confident that issues can be managed. Strategies would have to take into account the need for sites for relocation of farms due to poor siting conditions and First Nations issues (demonstrated through consultation and information assessment). In areas of scarce resource availability, once an area is reserved for relocation, government should consider identifying suitable sites, in consultation with local interests, and allocating them through a competitive proposal call. This approach would allow tight controls pending the implementation of management system reforms and coastal management planning processes.

Immediate direction should be provided to the Central Coast and Queen Charlottes land and resource management process to address salmon aquaculture issues. Comprehensive aquaculture licences could be issued for new farms that impose many of the new operational requirements on a farm by farm basis until regulations are developed. Other priorities in the implementation of the recommendations should include pilot projects to test alternative farming technologies (closed-containment), and research to address significant gaps in information about potential results of interactions between farmed and wild salmon and localized effects of salmon farming.

### **3. Summary of Recommendations**

The following is the full text of the 49 recommendations made by the Environmental Assessment Office in the final report of the Salmon Aquaculture Review.