PROGRESS TOWARDS ENVIRONMENTAL SUSTAINABILITY IN BRITISH COLUMBIA'S SEAFOOD SECTOR

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Prepared for:

BC SEAFOOD ALLIANCE

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1.0 INTRODUCTION

Over the past decade numerous changes have occurred in the way that the fisheries and aquaculture industries are conducted and managed in British Columbia. The following trends are noteworthy:

- shift from competitive "Derby Fisheries" to Individual Quota management,
- increased data resulting from fisheries and environmental monitoring programs, catch and compliance reporting,
- increased co-management and industry participation in fisheries and aquaculture management and planning,
- increased awareness of individual responsibility for resource stewardship,
- selective fishing initiatives aimed to reduce the catch of non-target species and stocks,
- increased government and industry regulatory regime including Codes of Practice and compliance reporting,
- recognition of the need to address uncertainty in the management regime.

Many of the measures have been undertaken at considerable effort and cost to the BC seafood industry and have contributed to the development of more environmentally sustainable practices. In many cases adoption of these measures has resulted in both an improved management regime and economic benefits to the industry.

The BC Seafood Alliance, an umbrella organisation of 14 associations representing participants in the BC seafood industry, has organised the BC Seafood Summit, held in Vancouver on May 29th, 2001. The objective of the Seafood Summit is to review the state of the seafood industry and plan for its future based on principles of environmental sustainability, international competitiveness and economic viability. The BC Seafood Alliance engaged Archipelago Marine Research Ltd. to prepare a background report on progress towards environmental sustainability in the fisheries and aquaculture sectors for the British Columbia for this summit.

Our approach was to report on progress towards environmental sustainability based on three principles:

1. Sustainable Harvest of Target Species and Stocks,
2. Limiting Impacts of the Fishery on Non-Target Species, Habitats and Ecosystems,
3. An Effective Management/Regulatory System.

The background for selection of these principles is provided in subsequent sections of the report. The focus of this report is the commercial fisheries and aquaculture sectors. Recreational and First Nation fisheries are not addressed. In addition, third party influences on fisheries and aquaculture sustainability, such as fish/forestry interactions and effluent discharge impacts, are not considered. The 1990's time period was chosen as the focus for this analysis as sustainability principles were brought to global prominence in the first half of the past decade (Section 2) and management regimes and tools to implement sustainable practices have generally been implemented in the past 10 years.

Information for the assessment was obtained through interviews with industry, federal (Fisheries and Oceans Canada) and provincial (BC Ministry of Agriculture, Food and Fisheries) agencies

(see contact list, Appendix 1) as well as review of fishing management plans and additional referenced material.

The intent of this report is to:
1. provide a general framework for the assessment of environmental sustainability,
2. assess recent trends in management practices in the context of that framework, and
3. report on areas of substantive progress and identify areas where further progress in warranted.

It is hoped that this report will aid the BC Seafood Summit to recognise the substantive progress that the industry has made towards environmental sustainability over the last decade as well as identify key areas where further progress is warranted. We also hope that this assessment framework can be used to identify strategic initiatives to address continued progress towards environmental sustainability in the British Columbia seafood sector.

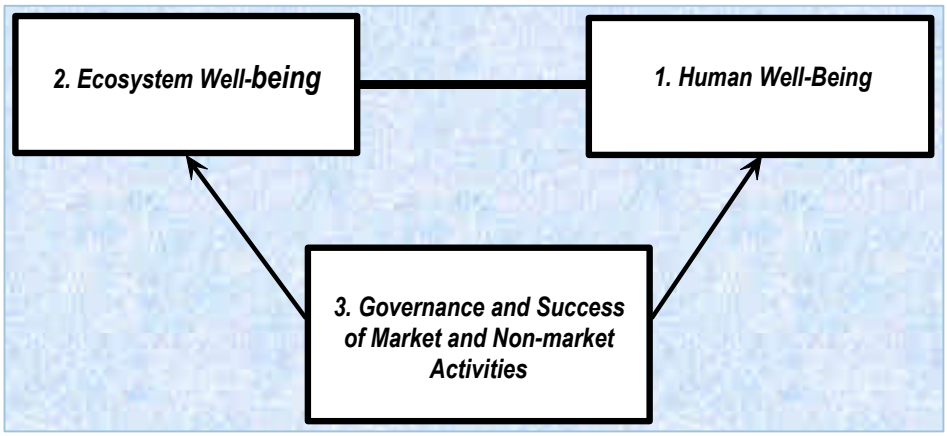
2.0 WHAT IS SUSTAINABLE FISHING AND AQUACULTURE?

2.1 THE CONCEPT OF SUSTAINABLE DEVELOPMENT

The idea of sustainable development evolved from realisation that earlier measures of economic growth and well-being did not consider a broad enough base on which to evaluate costs and benefits, and also tended to focus on short term results, not longer term objectives. Sustainable development was championed by the World Conference of Environment and Development in 1987 and, most simply stated, is "development that meets the needs of the present generation without compromising the needs of future generations" (WCED 1987).

Since 1987 a considerable amount of international, national and community effort has been dedicated to putting the concepts of sustainability and sustainable development into practice, particularly in the resource (energy, mineral, forestry, agriculture and fishing) sectors. Sustainable development recognises the fundamental interdependence of human well-being and ecosystem well-being, as well as the essential role of governance (management and regulation) in ensuring that this relationship is maintained in a healthy manner (Figure 1). An ecosystem-based view of sustainable development focuses on maintaining the stability and resilience of the ecosystem, while recognising the interdependence of human economies with their environment. Within this context there is a need for scientific understanding of ecosystem function and ecosystem change, and there is a need for human economies to be responsive and adaptive to ecosystems. (FAO 1999).

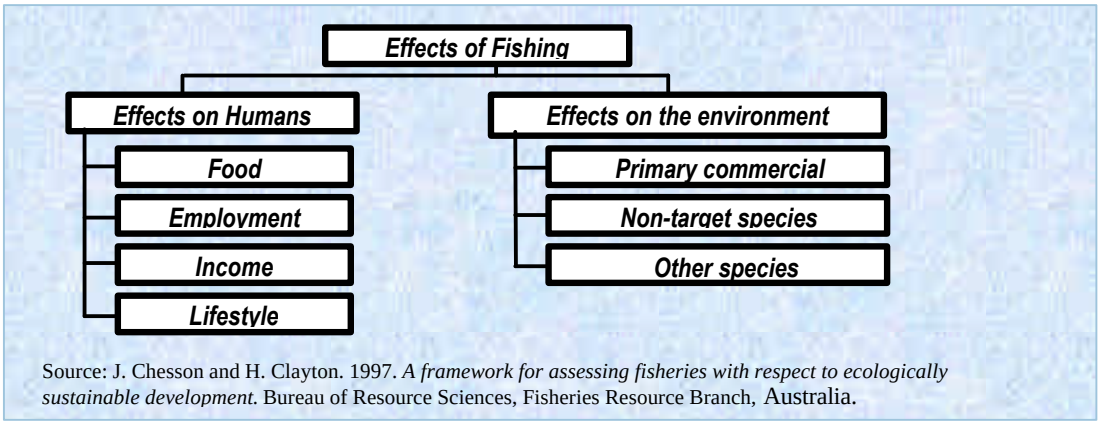
Figure 1. The results triangle for implementing sustainable development



2.2 RESPONSIBLE FISHING AND SUSTAINABLE FISHERIES

Elements of a sustainable development framework for fisheries are outlined in Figure 2. The framework for aquaculture is similar. Elements of environmental sustainability (the focus of this report) are outlined on the right hand side of Figure 2; namely the effects of fishing and aquaculture practices on target species, non-target species and associated habitats and ecosystem processes.

Figure 2. Framework for sustainable fisheries



Source: J. Chesson and H. Clayton. 1997. *A framework for assessing fisheries with respect to ecologically sustainable development.* Bureau of Resource Sciences, Fisheries Resource Branch, Australia.

Over the last decade there have been a series of initiatives to define criteria and assess sustainable fishing and aquaculture practices. At a global level the Food and Agricultural Organisation (FAO) has led this process, producing a code of conduct for responsible fishing (FAO 1995), technical guidelines for responsible fishing (FAO 1996, 1999) and responsible aquaculture (1997). Canada has responded to international initiatives by producing a Code of Conduct for Responsible Fishing (DFO 1998) which has been ratified by a large number of fishing industry associations in British Columbia. In addition to international and national government initiatives, industry and non-profit partnerships have begun a process of using market forces and consumer purchasing power to support sustainable fishing practices through a certification process (Marine Stewardship Council 1998). These documents define and address criteria for assessing sustainable fishing and aquaculture practices. For fish harvesting, there are three common principles:

1. **Sustainable harvest of target species and stocks**
   "Sustainability is understood to mean the harvesting of a stock in such a way and at such a rate that is does not threaten the health of the stock or inhibit its recovery, thereby maintaining its potential to meet the needs of present and future generations of fish harvester's" (Canadian Code of Conduct for Responsible Fishing Operations, DFO 1998).

2. **Limiting impacts of the fishery on non-target species, habitats and ecosystems**
   "To the extent practical, fish harvester's will minimise unintended bycatch and reduce waste and adverse impacts to ecosystems and habitats" (Canadian Code of Conduct for Responsible Fishing Operations, DFO 1998).

   "*Fishing operations should allow for the maintenance of the structure, productivity, function and diversity of the ecosystem (including habitat and ecologically related species) on which the fishery depends*" (Marine Stewardship Council, 1998).

3. **An effective fisheries management system**
   " *Conservation and management decisions for fisheries should be based on the best scientific information available, also taking into account traditional knowledge of the resources and their habitat. States should assign priority to research and data collection in order to*

improve scientific and technical knowledge of their fisheries including interactions with the ecosystem. States should encourage bilateral and multilateral co-operation in research as appropriate" (FAO 1995).

"*The fishery is subject to an effective management system that respects local, national and international laws and standards and incorporates institutional and operational frameworks that require use of resources to be responsible and sustainable*" (Marine Stewardship Council, 1998).

The first two principles address the ecosystem well-being component of sustainable development (Figure 1 and the right hand side of Figure 2). An effective management system, emphasising scientific principles, credible and reliable data gathering systems, co-management principles and transparency, monitoring and surveillance, as well as adherence to national and international law, is essential to ensure that the objectives of the first two principles are met. The third principle also addresses the need for effective governance within a sustainable development framework (Figure 1).

2.3 SUSTAINABLE AQUACULTURE PRACTICES

States should promote responsible development and management of aquaculture, including an advance evaluation of the effects of aquaculture development on genetic diversity and ecosystem integrity, based on the best available scientific information (FAO 1995).

States should establish effective procedures specific to aquaculture to undertake appropriate environmental assessment and monitoring with the aim of minimising adverse ecological changes and related economic and social consequences resulting from water extraction, land use, discharge of effluents, use of drugs and chemicals, and other aquaculture activities (FAO 1995*).*

Environmental sustainability criteria and issues for aquaculture are similar to harvest fisheries, but differ in emphasis. Sustainability of the target (cultured) species is essentially an economic rather than environmental issue, however interactions between cultured species and aquatic ecosystems (including wild stocks of cultured species) are an environmental concern for many cultured species. Reliance on wild stocks for broodstock or juvenile stages of cultured species increases this concern. The interaction between aquaculture practices and the environment (wild species, habitats and ecosystem components) as well as the regulatory and management regimes used to address these issues (e.g. Principles 2 and 3 outlined above) are the key elements of environmentally sustainable aquaculture practices.

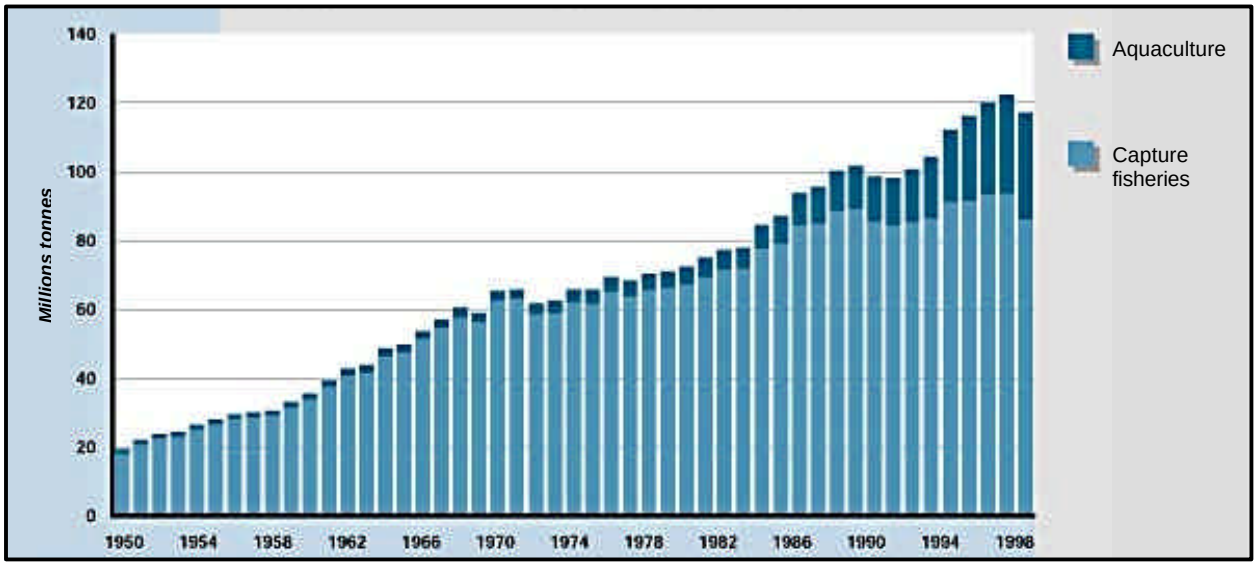
3.0 WHY ARE SUSTAINABLE FISHERIES AND AQUACULTURE PRACTICES IMPORTANT?

3.1 THE GLOBAL CONTEXT

Figure 3 summarises global growth in capture fisheries and aquaculture production from 1950 to 1999 (FAO 2000). About 90% of production is from marine waters. The figure shows a relatively rapid growth in capture fisheries production from 1950 to 1970. During the 1970's and 1980's growth in production declined to about 2% annually and there has been essentially no production growth since 1988. Globally about 25% of wild fish stocks are considered overexploited, 50% fully exploited and 25% either underexploited or lacking sufficient data for assessment (FAO 2000). There is little potential to significantly increase production from wild fisheries, yet current global production generates over 10kg of fish per person per year., and over 20% of the world population depend on fisheries production to fulfil animal protein requirements. Sustainable fishing practices are needed to ensure continuity of this protein source.

Figure 3 also summarises the growth in aquaculture production over the same time period. In contrast to capture fisheries, most (about 60%) of aquaculture production is from freshwater areas. In contrast to capture fisheries, the rate of growth of aquaculture production is increasing, from 5% per year in the 1950's and 60's to 10% per year in the 1990's. Currently 25% of world fisheries production is from aquaculture sources. 10-15% of marine fisheries production is from aquaculture sources. Aquaculture is one of the fastest growing food production systems in the world, and aquaculture provides an important means of maintaining and enhancing global fish production (FAO 1997). On the other hand the rapid expansion of the aquaculture sector is associated with environmental issues including disease control, exotic introductions, genetic interactions, conflicting land uses, habitat loss, species introductions and pollution. This underscores the requirement for the implementation of sustainable practices.

Figure 3. World capture fisheries and aquaculture production



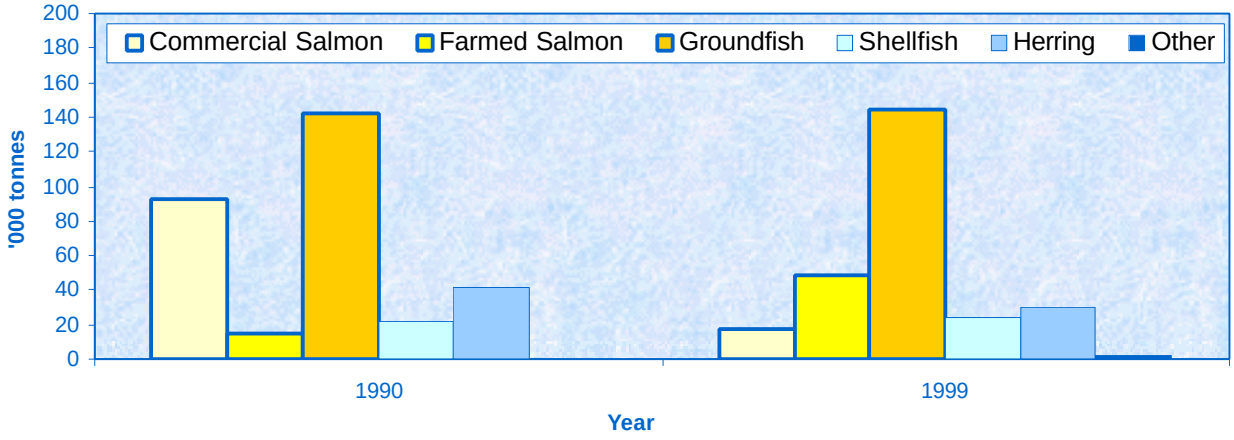
Note: Aquaculture quantities prior to 1984 are estimates
(Source: FAO, 2000)

3.2 THE BRITISH COLUMBIA CONTEXT

Total landings from wild fisheries in British Columbia have declined by about 25% (300,000 tonnes to 220,000 tonnes) between 1990 to 1999. Most (over 90%) of this decline can be attributed to the dramatic reduction in landings of wild salmon. Most other sectors have remained relatively stable (Figure 4). With changes in the climatic regime, and effective recovery plans, there is considerable scope for increased salmon landings over the next ten years. However the decline in salmon fisheries has also led to increased participation in alternative fisheries such as shrimp, crab and prawn meaning that most fisheries (in keeping with the global pattern) are now fully subscribed with limited potential for dramatic increases in landed volume. Sustainable fishing practices are thus necessary to ensure the continuity of BC's wild fisheries.

Annual farmed salmon production in British Columbia has increased from 15,400 tonnes in 1990 to 49,000 tonnes in 1999 (Figure 4), an annual growth rate of approximately 10% per year. The rate of growth of shellfish (oyster, clam and scallop) production over the past decade is considerably slower, with current production at about 6,000 tonnes, but the potential for growth of this sector is recognised (Coopers & Lybrand 1998). Currently aquaculture accounts for about 20% of British Columbia's seafood production by volume (Figure 4), and approximately 30% of the wholesale value of seafood products (BC Fisheries). The aquaculture sector is an important component of BC's seafood production with potential for continued growth. Both the federal and provincial governments recognise aquaculture as an important, viable component of the seafood sector, while recognising a commitment to ecologically and environmentally sound aquaculture development (DFO 1995).

Figure 4. British Columbia seafood landings 1990 and 1999



(Source: BC Fisheries Statistics)

4.0 PRINCIPLE 1 - SUSTAINABLE HARVEST OF TARGET SPECIES AND STOCKS

> *"Sustainability is understood to mean the harvesting of a stock in such a way and at such a rate that is does not threaten the health of the stock or inhibit its recovery, thereby maintaining its potential to meet the needs of present and future generations of fish harvester's"* (DFO 1998).

Appendix 2 provides a listing of regulation, management, and industry initiatives undertaken over the past decade (1990-2000) in British Columbia's seafood sector which addresses this sustainability principle. Illustrative examples and key challenges for the future are provided in subsequent sections.

4.1 INFORMED STOCK ASSESSMENT

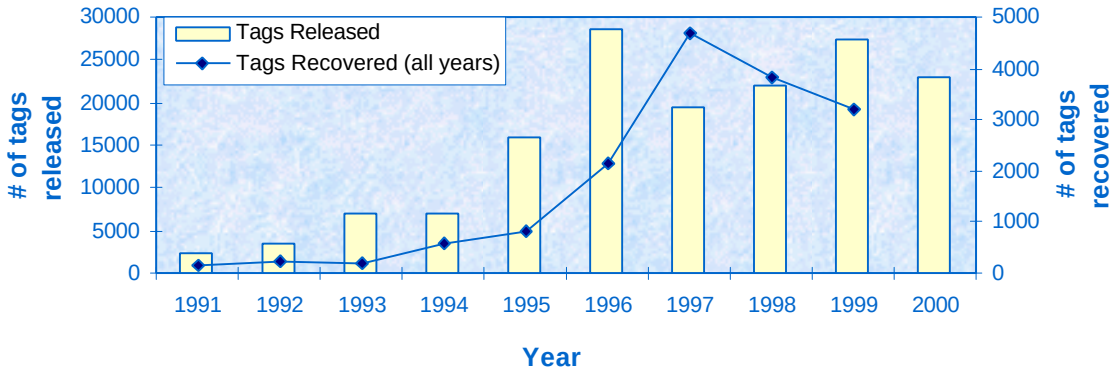
4.1.1 Improving Models, Data and Effort

The primary management tool of many, but not all, fisheries are harvest quotas, a limit to the number of fish which can be harvested on an annual basis. Determination of sustainable harvest levels requires an understanding of the size of the fish stock and the factors which control changes in stock size (biomass, recruitment, fishing mortality, natural mortality). In Canada, stock assessment is traditionally the role of fishery scientists working in the Science Branch of the Department of Fisheries and Oceans. Informed stock assessment requires development of assessment models defining the population dynamics determining stock size, and collection of biological and fisheries data to support the assessment model. Over the past decade co-management initiatives have resulted in the acquisition of much larger and more reliable data sets for stock assessment models. Examples include:

Improving estimates of exploitation rate and biomass - Sablefish tagging

While sablefish tagging has occurred since the late 1970's, tagging surveys for the purpose of determining annual exploitation rates (what proportion of the population is being harvested) have been conducted annually since the early 1990's. This program and the subsequent stock assessment are collaborative efforts between the Department. of Fisheries and Oceans and the Canadian Sablefish Association. Over the last decade there has been a tenfold increase in tagging effort and a corresponding increase in tag recovery (Figure 5). This successful tagging effort has resulted in a more confident estimate of the sablefish exploitation rate and stock size (DFO 1999)

Figure 5. Sablefish tagging and tag recovery 1991 - 2000

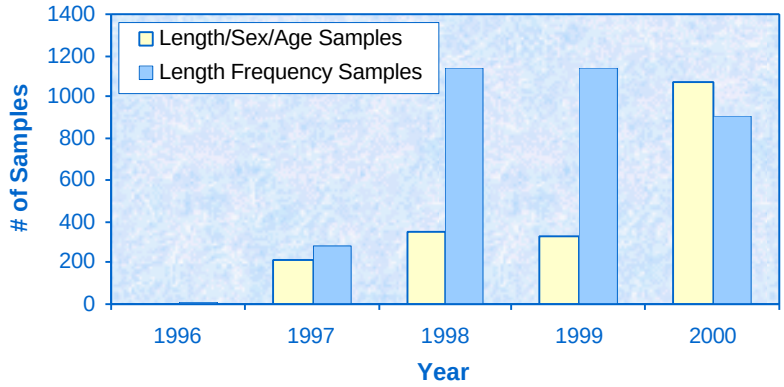


(Source: Canadian Sablefish Association, Department of Fisheries and Oceans)

Improving our knowledge of fish population parameters - Biological sampling of groundfish catch

Most stock assessment models require biological data collected from the commercial catch. This includes age composition, age/length relationships, sex and maturity indices and stomach contents. The collection of adequate, representative datasets requires considerable sampling effort. Prior to the initiation of full observer coverage of the BC groundfish trawl fleet in 1996, the number of biological samples collected from this fishery were, at most, a few hundred annually. Currently the at sea observer program collects 1,500 to 2,000 biological samples annually (Figure 6), adding substantially to the stock assessment data set. In addition, since 1996, observer programs have provided catch composition estimates for all Option A (outside the Strait of Georgia) trawl fishing activity, which provides a more complete and reliable measure of fishing mortality for stock assessment models then was previously possible (see Section 5.1).

Figure 6. At sea observer sampling of groundfish trawl catch 1996 - 2000



(Source: Archipelago Marine Research Ltd.)

Improved stock estimates - British Columbia's dive fisheries

Most dive fisheries in British Columbia (geoduck clams, red and green sea urchins and sea cucumbers) conduct annual biomass surveys. For geoduck and red sea urchins these surveys have been ongoing since 1994. Survey methods are developed in collaboration with the Dept. of Fisheries and Oceans and co-ordinated by qualified biologists. In addition, both the Underwater Harvester's Association (geoduck harvesters) and the Pacific Urchin Harvester's Association maintain a number of areas where collaborative research is undertaken to monitor recruitment, growth, and mortality in fished and unfished plots (See Inset Box on sea cucumber management, Section 8.0, and Appendix 2).

4.1.2 Key Considerations

Co-management efforts over the past decade have resulted in increased biological data collection, dedication of research areas, increased effort towards stock assessment modelling and additional financial resources to the stock assessment process. In addition important co-management partnerships have been made through sectorial committees, advisory committees and industry associations (see Section 7.1). These groups now address many issues related to stock assessment and information requirements.

Despite the progress made over the past decade towards more informed stock assessment and more industry involvement in stock assessment processes, challenges remain.

1. **The increasing diversity and complexity of stock assessment requirements**
   The increased emphasis on weak stock management in the salmon and groundfish fisheries, the increased diversity of species landed in the groundfish trawl fishery, the need to develop approaches for species assemblage (ecosystem-based) management rather than single species management, as well as accounting for environmental and assessment uncertainty requires new approaches to stock assessment and more sophisticated data.

2. **Limited allocation of resources to stock assessment**
   Many of the industry and management representatives consulted during this project expresses concern as to the limited allocation financial and personnel resources to stock assessment. For example the Groundfish Stock Assessment Group at the Pacific Biological Station is responsible for the assessing about 60 stocks of groundfish. Current resources permit the assessment of 8 to 10 stocks annually. While all stocks do not necessarily have to be subject to annual assessment, the current level of assessment is less than desirable. Co-management initiatives and industry funded stock assessment research has helped to mitigate the impact of limited resources but do not address, nor necessarily should address, the full requirements of the assessment process.

3. **Lack of adequate catch and biological data in certain fisheries**
   Despite considerable progress in catch monitoring and reporting (Section 4.2.2) over the past decade, important catch and biological data is lacking or inadequate for a number of fisheries or gear types. There is a recognised lack of catch (as opposed to landings) composition data for longline fisheries (halibut, sablefish and rockfish - see Section 5.3). Approximately 50% of the shrimp trawl catch is from offshore areas with no allocated Total Allowable Catch due to the lack of stock assessment data. Catch (as opposed to landings) reporting in the salmon fishery was only instituted in 1998, and the first set of coastwide salmon catch data is being collected this year (2001). This data is important in managing the catch of non-target species and stocks (see Section 5.0), but is also required to more accurately estimate fishing mortality for these stocks.

4. **Developing appropriate assessment methods for adaptive, precautionary management**
   Accounting for environmental factors such as climate change and decadal regime shifts, as well as developing decision making processes for adaptive, precautionary management represents a considerable challenge. Although the principles of precautionary, adaptive management are recognised in fishing management plans, there is no consensus or blueprint on how to appropriately manage using these principles (Fisheries 2000).

5. **Redefining roles and responsibilities in an evolving co-management model**
   There is clear consensus among industry, communities and governments that co-management and consultative processes are of benefit to both the fishing community and the resource. The changing roles and responsibilities should be clearly defined and acceptable to all parties. It is important that the principles of transparency and credibility are maintained within the co-management model.

British Columbia's Herring Fishery
Conservative and Adaptive Management

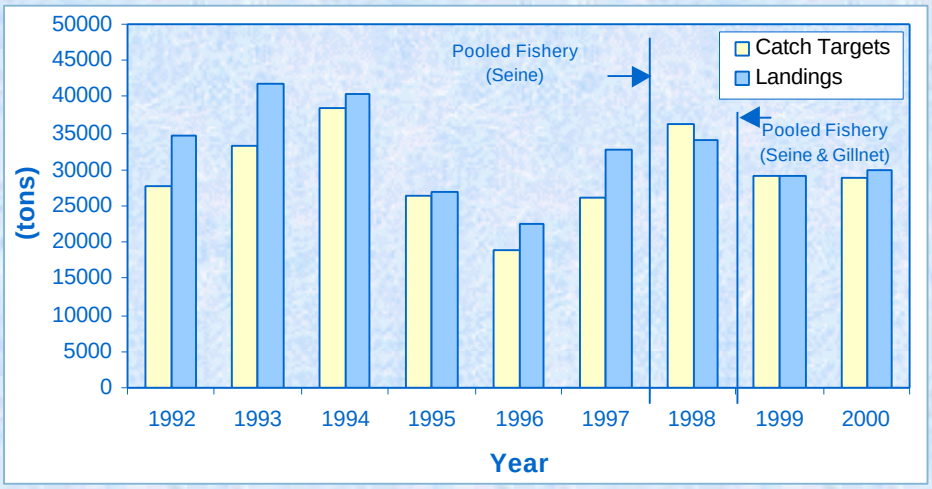
Stock Assessment Relies on:

- Biological sampling to assess year class strength.
- Hydroacoustic surveys of spawning stocks.
- Diver surveys of spawning area from which spawner biomass is estimated.
- Stock identification to understand the interactions between major and minor spawning stocks.

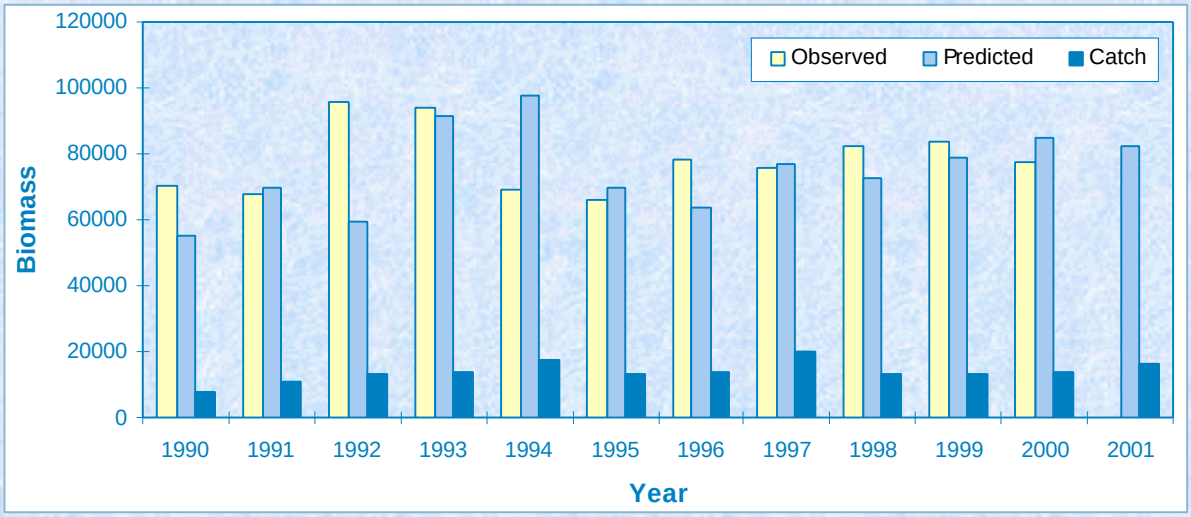
Management involves:

- 20% exploitation rate – far below pre 1970's level (see figure).
- Fishery cutoff thresholds – no fishery if estimated stock is less than 25% of historic average for an area.
- Area management – based on 5 major stocks.
- No fishing of minor stocks.
- Pooled fishing strategy to control catch (see figure).
- Full accounting of all fish harvested.
- Co-management.

Herring roe fishery: Coastwide catch targets vs. landings 1992 - 2000



Strait of Georgia: Roe fishing predicted and observed spawning stock



This management model has been adopted for Alaska and Washington to California herring fisheries

(Source: Pacific Biological Station, Department of Fisheries and Oceans.)

4.2 LIMITING THE CATCH OF TARGET SPECIES

4.2.1 Conservative Quotas and Fishing Thresholds

In British Columbia, a number of fisheries are managed under a quota regime which is more conservative than other jurisdictions. Annual fishing quotas for geoduck are based on 1% of the biomass estimate; red sea urchin quotas are based on 2% of the biomass quotas. Conservative quotas are necessary for these fisheries as geoducks are long lived (20-30 years, with some individuals aged at over 100 years old) and urchins cannot be reliably aged but are also thought to be long lived. In Washington State geoduck harvest quotas are based on 2.7% of the biomass estimate and red urchins based on 4.5% of the biomass estimate.

In British Columbia the harvest policy for Pacific herring has been based on a fixed harvest rate of 20% of forecast biomass for each assessment region since 1983 (see Herring Management Inset Box). Annual exploitation rates during the 1960's reduction fishery (which collapsed in 1966) were well over 50% annually. In 1985 this harvest policy was augmented to include a fishing threshold, set at 25% of the unfished biomass. Commercial harvests in an assessment area are not permitted if forecasted abundance does not exceed the threshold level. Since 1990 there have been fishery closures in the Queen Charlotte Islands and, most recently, the west coast of Vancouver Island because forecasted abundance has not met fishing thresholds; an example of precautionary, adaptive management practices.

4.2.2 Verifiable Quota Management

Although many fisheries in British Columbia have been subject to catch quotas (Total Allowable Catch or TAC) for several decades, managing the fishery within these quotas was often unsuccessful and, at times, impossible despite licence limitations and time, area and gear restrictions. In most cases the fishing fleet was capable of catching more then the allowable catch within prescribed opening times, and there were no mechanisms to report catch in a manner which could close fisheries before total allowable catch quotas were exceeded. Most of these "derby fisheries" were predicated on catching as many fish as possible in the shortest amount of time. Some herring seine openings were less than one half hour, time to make just one set, yet area quotas were often exceeded by 10-30%.

Since 1989, eight commercial fisheries (geoduck, red and green urchins, sea cucumbers, halibut, sablefish, groundfish trawl, and roe herring) have adopted some form of individual quota (IQ) management (see Appendix 3 for dates of implementation). The herring roe on kelp fishery has been an individual quota fishery since its inception. Under IQ management systems the TAC is allocated to fishing vessels and each vessel (or licence holder) is responsible for fishing within their allocated quota level. The eight BC fisheries under IQ management employ third party monitoring of all landings and use timely data reporting systems for quota management. The shift from competitive, derby fisheries to IQ management has provided an effective, verifiable means of managing catch within quotas determined by the stock assessment process, resulting in major progress in meeting the sustainability principle of limiting the catch of target species (see Inset Box on Individual Quota Management).

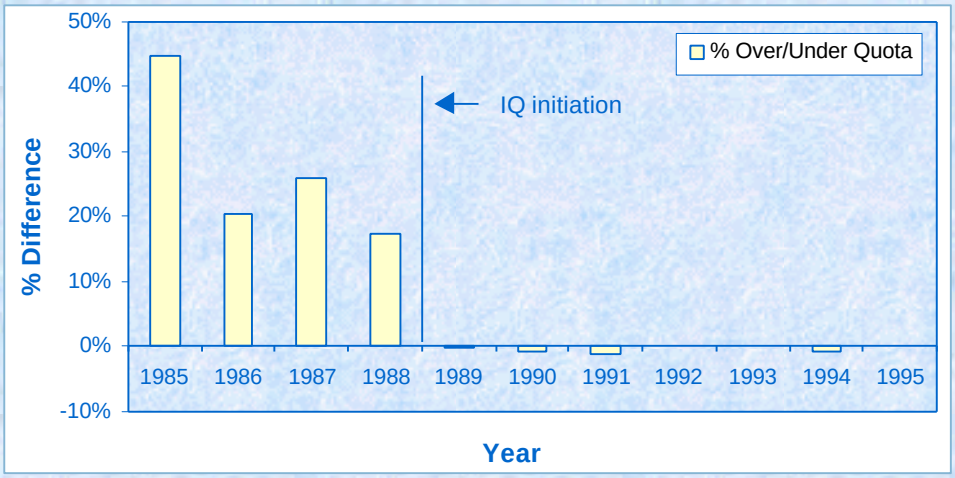
It is important to note that IQ management may not be an appropriate tool for managing all fisheries. It is difficult to determine pre-season catch targets in the salmon fishery, and fishing hails, logbook systems and timely catch reporting systems are evolving to better manage target

catch levels. Pooled fishing effort, as undertaken in the BC herring fishery, may be a way of addressing better catch management in certain salmon seine fisheries. Some fisheries (prawn, crab) are not managed by TACs (Section 4.2.3) and, for these fisheries, IQs may be of value for economic management (meeting market demand), but not necessarily sustainable harvest of target species.

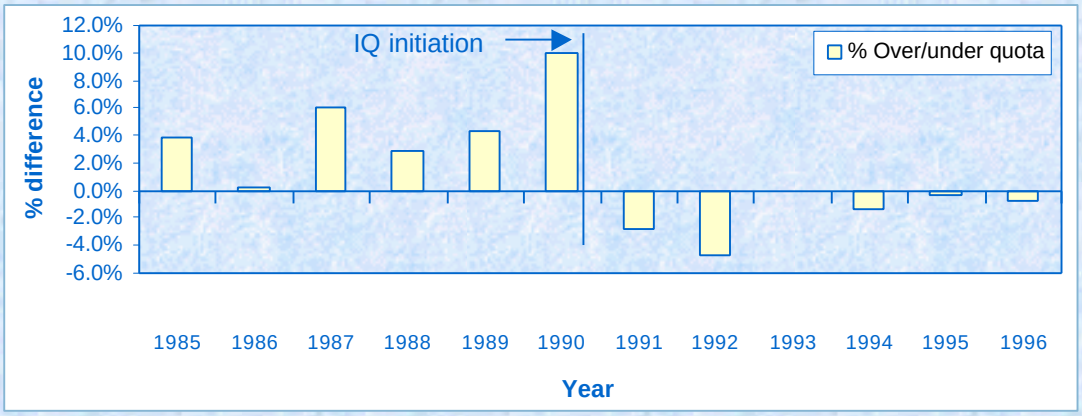
Improved Management of Target Catch Using Individual Quotas

- Portions of the total allowable catch (TAC) is allocated to fishing vessels, licence holders, and/or fishing communities as Individual Quotas (IQ).
- The IQ holder is responsible for managing catch within quota limits.
- The system eliminates the race for fish and has rapidly brought over fishing quota under control (see figures).
- The quota holder does not benefit from exceeding quota limits and may be penalised.
- IQ management requires third party verification and monitoring of landings.
- On-grounds monitoring may also be required to manage quotas (e.g. groundfish trawl fishery).
- Data systems have been built to manage and report quota on a daily basis.

BC geoduck fishery: Coastwide landings vs. TAC 1985 - 1995



BC halibut fishery landings vs. TAC 1985 - 1996



4.2.3 Limiting Fishing Effort

Most fisheries use gear or fishing area restrictions to manage the catch of target and non-target species. (e.g. mesh size, seasonal openings, area closures). Some fisheries in British Columbia (notably prawn and Dungeness crab trap fisheries) are managed primarily by input controls (measures which restrict harvest throughout the fishing period) rather than catch quotas, in part due to the difficulties of assessing stock status. Dungeness crab fisheries have historically been managed by a minimum size limit and non-retention of female crabs. These mechanisms are intended to conserve reproductive potential, ensuring that mature females are able to spawn and that fishing does not impact future recruitment. Prawn fisheries are managed by seasonal closures triggered by monitoring a target spawner index, designed to protect egg bearing females until the end of the larval hatching period. Both fisheries are highly selective and use mesh size restrictions or escape ports to permit the release of undersize crabs or prawns on the seabed.

During the 1990's both the crab and prawn fisheries experienced large increases in the price paid to harvesters, and, despite licence limitations, there was a corresponding increase in fishing effort. For example crab trap fishing days on the south coast doubled between 1991 and 1998 (DFO 2000), and prawn trap fishing effort increased in a similar manner from 1985 to 1995 (Morrison *et al*. 1998). Despite the use of input controls to conserve the reproductive potential of spawning females, the increased fishing effort and corresponding landings has been a key management concern since the mid-1990s. Significant co-management efforts have been mounted to reduce and stabilise fishing effort. The prawn fishery was limited to 300 traps per licence in 1995 with stacked (two licences per vessel) licences restricted to 500 traps. This has resulted in a reduction of 8,000 traps, or about 10% of the fishing effort. On recommendation of industry, the threshold for spawner index closures has been increased in certain fishing areas and, in 2000, trap hauling has been restricted to single hauls in a 24 hour period.

Similar crab trap limitations were introduced in 2000. In both the crab and prawn fisheries trap limits and trap haul restrictions are monitored by third party on-grounds monitoring. In 2000, the Area A (north coast) crab harvesters co-developed an innovative on-board electronic monitoring system. Each Area A crab vessel carries a computer system (including video) capable of monitoring position, set and haul back activities as well as trap inventories (using an electronic chip marker). This system provides comprehensive monitoring of trap limitation compliance as well as documentation of all fishing activity. This system is now being considered in several Pacific Ocean fisheries as a cost effective means of monitoring catch and compliance with area and gear restrictions.

4.2.4 Key Considerations

Effective implementation of measures to limit the catch of target species requires appropriate tools for ensuring effective monitoring, compliance and enforcement. These tools include:

- On grounds monitoring, fisheries hail and logbooks programs, electronic vessel monitoring to address catch and effort,
- Dockside monitoring programs to address landings,
- Individual Vessel Quotas to address quota management,
- Hail out systems to monitor fishing activity and forecast expected catch,
- Centralised database and data reporting systems (including Internet access) which provide timely information to both harvesters and fishery managers.

Both the Dept. of Fisheries and Oceans and the fishing industry have undertaken substantive changes over the past decade to address shortcomings in managing catch and fishing effort. Industry has undertaken the funding of most of these initiatives (dockside monitoring, log book programs, much of the at sea observer effort). Prior to the initiation of individual quotas for geoduck in 1989, there were limited ways of managing the catch of target species (fishing hails, limited on grounds monitoring, sales slip records) which were either inadequate in scope, not verifiable or not timely enough to permit corrective action. In 2001 essentially all fisheries in British Columbia employed one or more of the above tools to manage target catches and fishing effort (see Appendix 3).

These tools are extremely effective in managing target catches of many BC fisheries, however they have not been fully or effectively applied in certain fisheries, in particular:

1. **Salmon fisheries**
   There is an inherent difficulty in addressing harvest targets for stocks as opposed to species. The limited ability to address harvest targets in advance of in-season test fisheries impacts the ability to use tools such as individual quotas to manage harvest targets. In addition, the catch hail program in the salmon fishery is very recent (1998 on the south coast, 2000 on the north coast) and, despite limited on board observers and surveillance effort, lacks the third party verification component of dockside monitoring programs.

2. **Rockfish longline fisheries**
   Area and species aggregate quotas are still, at times, exceeded despite a dockside monitoring program and fishing activity hail program.

3. **Shrimp fisheries**
   Total Allowable Catches in some fishing areas are exceeded, but the greater problem is the lack of stock assessment data to develop biologically based fishing quotas Section 4.1.2).

5.0 PRINCIPLE 2A - LIMITING IMPACTS OF FISHERIES ON NON-TARGET SPECIES

> *"To the extent practical, fish harvester's will minimise unintended bycatch and reduce waste and adverse impacts to ecosystems and habitats"* (Canadian Code of Conduct for Responsible Fishing Operations, DFO 1998).

This section addresses the first component of this principle, reducing impacts on non-target species. Appendix 2 provides a list of initiatives undertaken over the past decade (1990-2000) which addresses this sustainability principle. Illustrative examples and key challenges for the future are provided below.

During the 1990's the catch of non-target species, often referred to as bycatch[1], emerged as a major issue in the management of global fisheries throughout the world. Estimates of global fisheries discard levels range from approximately 10% of total landings (Saila 1983) to 40% of total landings (Alverson *et al.* 1994), although it is extremely difficult to estimate discard levels as most fisheries report only fish brought to the dock (landings data) as opposed to what is caught (catch data). Some fisheries are highly selective and the catch of non-target species is minimal. In British Columbia the dive fisheries (geoduck, sea urchin and sea cucumber) are inherently selective as divers harvest selected individuals of each species. Horse clams are occasionally taken in the geoduck fishery but total harvest is less than 1% of geoduck harvest levels, which is within specific catch ceilings specified by the Management Plan. Trap fisheries (prawn, crab and sablefish) are quite selective, with high survival of most non-targeted catch (other crab species, octopus).

Other fisheries are less selective. Globally, concerns have focused on trawl and longline fisheries. In British Columbia catch of non-target species is of concern in the groundfish and shrimp trawl fisheries, the halibut, sablefish, rockfish (ZN) longline fisheries as well as the Schedule II fishery, which primarily targets lingcod and dogfish. In addition, managing the salmon fishery to conserve weak stocks of a single species (e.g. upper Skeena and Thompson River coho) presents a particularly challenging management problem as non-target catch must be controlled on a stock as well as a species level during mixed stock fisheries (see below).

5.1 MOVING FROM LANDINGS TO CATCH DATA

Managing non-target catch requires the collection of catch data, ideally on a gear, time and area basis, in order to understand the scope and extent of the problem and to develop strategic plans to reduce non-target catch if required. Prior to 1990 almost all fishing data was derived from landings information (sales slips), there was very little information on catch and catch composition.

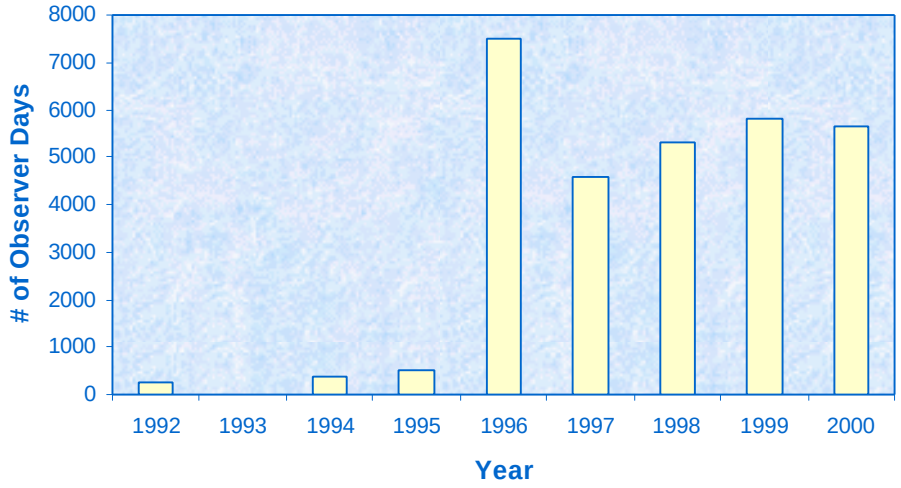
Since 1995 considerable progress has been made to collect information on catch composition from all of the British Columbia fisheries identified above as having potential issues with non-target catch. In 1996 concern about catch and discard levels in BC's groundfish trawl fishery led

[1] In this report the term non-target catch and bycatch are used interchangeably. Bycatch is defined as fish harvested in the fishery that are not kept but rather discarded (live or dead) for market or regulatory reasons. Bycatch may also include birds, mammals and invertebrates

to the implementation of 100% at-sea observer coverage for the Option A trawl fleet (Figure 7), which has generated a comprehensive and verifiable dataset on trawl catch and discards (see Inset Box). This observer program is one of the most comprehensive small vessel catch and quota management programs in the world and is highly regarded by fisheries managers in the United States, Australia and New Zealand.

Since 1999, catch sampling programs in the shrimp trawl, halibut, sablefish and rockfish (ZN) longline fisheries have collected catch data on board fishing vessels, although the level of coverage is generally considered less than adequate to properly address the catch data requirement. In 1998 a catch hail system was introduced for the south coast salmon fisheries; this program has been expanded to the north coast for 2001. The catch hail program is coupled with a limited on-grounds observer program which has been in place with the salmon fleet since 1998, with the most intense coverage in areas with the greatest concerns with respect to non-target catch (e.g. Skeena River fisheries). A primary objective of all these programs is the collection of catch composition information, directed at defining and managing non-target catch (see Inset Box).

Figure 7. At sea observer effort on the groundfish trawl fishery



Note: Since 1996, here has been 100% observer coverage of the Option A (outside St. of Georgia) groundfish trawl fleet.

5.2 ADDRESSING ADMINISTRATIVE BARRIERS

The move to more restrictive licensing in the 1970's and 1980's (e.g. halibut, sablefish and ZN rockfish licences) created situations where licence holders were required to discard non-permitted catch. For example, halibut licence holders discarded rockfish caught above their allowable limits, ZN rockfish licence holders discarded halibut, and these removals (discards) were not accounted for due to the lack of catch data in these fisheries. This is a particular concern for species such as rockfish, which have a high rate of mortality if, caught and discarded. In recent years there has been some movement to more integrated fishing plans, with the specific objective of reducing rockfish discards. Since 2000, rockfish bycatch holdings have been transferable between halibut licence holders. A combination fishing option has also been available, since 2000, to dual licence holders (ZN rockfish and halibut) which allows them to

combine the fishing privileges of both licences. In this manner rockfish and halibut catch can be managed to specific individual quotas and the discarding of bycatch reduced. A similar combination fishing proposal has been made for fishermen holding both ZN rockfish and sablefish licences. Since 1997, groundfish trawl licence holders have been permitted to transfer quota between licence holders which minimises discarding of marketable quota species (but not non-quota or unmarketable species, see Groundfish Trawl Inset Box).

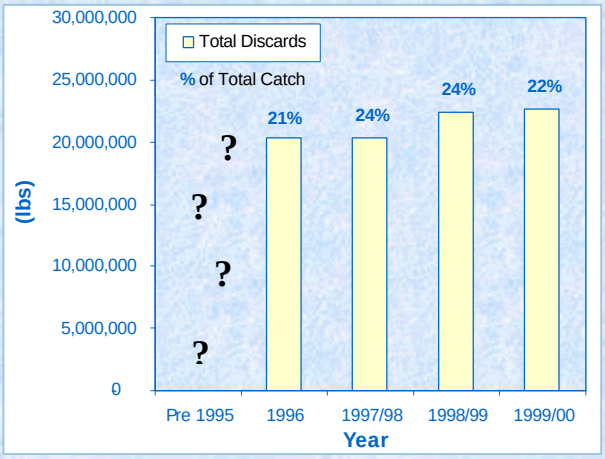
These initiatives represent movement towards more integrated management of fisheries which catch many of the same species. However, significant administrative (regulatory) barriers still exist which restrict the retention of marketable species for specific licence holders. The end result is discarding (and non-accounting) of marketable fish, a practice which, for species with high discard mortalities (e.g. rockfish), does not meet the sustainability principle of reducing impacts to non-target species (See Sections 5.3 and 8.0).

BC Groundfish Trawl Fishery

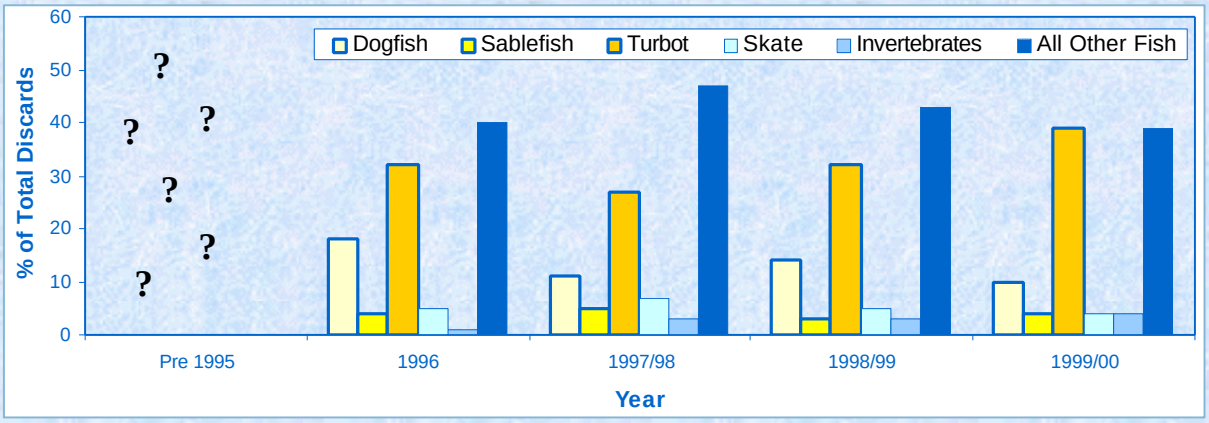
DEVELOPING INFORMATION AND TOOLS TO ADDRESS DISCARDS

- Prior to 1996 there was no comprehensive data on catch and discard in the groundfish trawl fishery.
- Concern over quota management and level of discards led to implementation of 100% on board observer coverage in 1996.
- Since 1996 catch and discard data has been collected for the entire fleet, which defines the scope and trends for the fishery (upper and middle graph).
- Discard data is now accounted for in the stock assessment process which was not possible prior to 1996.
- The catch and discard information can be used to define strategic ways of reducing discards , such as increased retention and utilisation of skate (lower graph).
- Industry is now using this information to develop ways of reducing discards and better utilisation of catch..

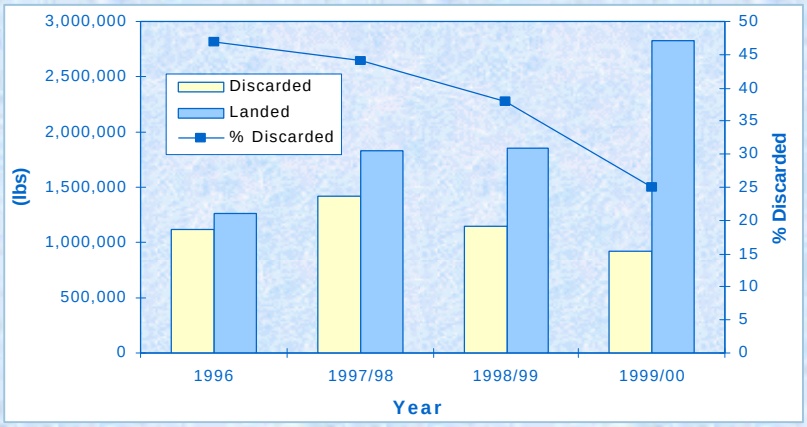
Groundfish trawl discards 1996 - 2000



Groundfish trawl discard composition 1996 - 2000



Groundfish trawl: Retention and discard of skates 1996 - 2000



5.3 SELECTIVE FISHING

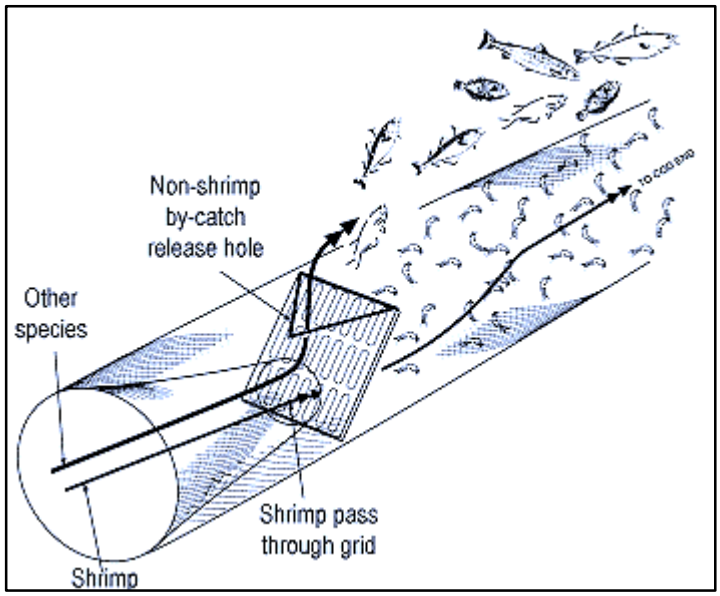
Selective fishing is defined as the ability to avoid non-target fish, invertebrates, seabirds and marine mammals and, if encountered, to release them alive and unharmed (DFO 2001). Selective fishing is essentially a toolbox of fishing strategies (time and area closures, improved handling procedures, as well as gear, setting and hauling modifications) designed to reduce the catch of non-target species. The importance of catch composition data for designing selective fishing strategies is obvious – to develop an effective selective fishing strategy you need to know where the fish are and when they are there. Secondly catch data is essential to monitor the effectiveness of selective fishing programs. Selective fishing approaches are a key component of Canada's Responsible Fishing Strategy (DFO 1998) and a policy for selective fishing in Canada's Pacific Fisheries has recently been released (DFO 2001), which proposes to develop selective fishing standards and implementation plans for all recreational and commercial fisheries by January 2003.

The first priority of a selective fishing plan is to avoid catching non-target species. Time and area closures are used to ensure that fishing gear will not catch both target and non-target species. For example "red zoned" no fishing areas are a key component of the coho recovery program. In 2000, eight areas of the BC coast were designated as rockfish protection areas, with no commercial longline fisheries permitted. Area closures have been implemented in the shrimp trawl fishery to reduce the catch of eulachon, a species with conservation concerns for many stocks particularly on the Central Coast. Several areas of Hecate Strait are closed to groundfish trawling in the winter and early spring to avoid harvesting Pacific cod and Pacific ocean perch during the spawning season.

5.3.1 Cleaner Shrimp Fisheries

On the US east coast and the Gulf of Mexico the catch of non-target species in the shrimp trawl fishery can be two to four times the catch of shrimp (Graham 1996). In response to these concerns, in 1997, an observer and fishing log book program was initiated to collect catch data from the BC shrimp trawl fishery. Although bycatch levels are generally lower in British Columbia than those reported for tropical or sub tropical waters, there is considerable variation in the level of non-targeted catch between fishing areas and gear types (Olsen *et al.* 2000). Shrimp beam trawls have generally higher catches of non-target species, particularly commercial flatfish, dogfish and skates, than otter trawl gear. However, otter trawls have higher catches of eulachon, a species of conservation concern. In conjunction with catch monitoring initiatives, the shrimp trawl fishery has developed a proactive approach to addressing non-target catch. A number of selectivity experiments, most notably the use of bycatch reduction devices (exclusion grates or excluder nets, Figure 8) have been initiated. These devices permit the escape of larger fish before they enter the cod end. In 2000, upon the recommendation of the shrimp trawl industry, exclusion devices become a condition of licence for shrimp trawls. In 2001, again upon recommendations from industry, the use of an additional rigid square mesh panel is a condition of licence for otter trawl gear. This mesh reduces the catch of eulachon, which often pass through exclusion grids. On-going catch monitoring will be required to assess the effectiveness of these devices at a commercial level.

Figure 8. Using exclusion grids to reduce bycatch in shrimp trawl



(Source: Department of Fisheries and Oceans)

5.3.2 Selective Salmon Fisheries

In 1998, in response to conservation concerns with respect to coho stocks, particularly the upper Skeena and Thompson River stocks, DFO announced a coho recovery program for the west coast. In the words of then Fisheries Minister David Anderson the coho recovery plan will "have profound implications for the way we conduct the salmon fishery". The focus of the coho recovery plan is selective fisheries – avoid catching non-target species and stocks and reducing mortality when these stocks are caught unintentionally. Protection of the critical Skeena and Thompson coho stocks was provided primarily by designating no salmon fishing (red) zones in areas where these stocks were prevalent. In other areas (yellow zones), fishing was permitted but selective measures were implemented to reduce the risk of coho mortalities (barbless hooks, mandatory brailing from seine sets, reduced "soak" times for gillnets and use of revival tanks for any coho caught). In addition, 5% of the coastwide salmon Total Allowable Catch was allocated to experimental selective fishing projects. Several of these initiatives are outlined below.

Avoiding Coho by using selective trolling gear

Experimental fisheries have demonstrated that use of larger plugs greatly reduces the catch of coho in targeted chinook troll fisheries when compared to control gear (flashers and hooks). Table 1 outlines the results for an experimental fishery in Area G, at the northern end of Vancouver Island.

Table 1. Catch of Chinook and Coho in Area G Selective Troll Gear Fisheries Experiment
(catch expressed per fishing hour)

GEAR TYPE	CHINOOK	COHO
7" Plugs	3.24	0.20
Control	6.97	4.50

(Source: Area G Selective Fisheries Study, 2000)

Avoiding Coho by timing fishing activity

Early results from selective gillnet fishing experiments indicate that less coho are caught during daylight fishing as compared to dawn and night fishing (Table 2). Although less sockeye are also taken in daytime fishing, the difference is less dramatic than coho, making it possible to use manipulation of fishing times as a tool to reduce coho catch.

Table 2. Catch of Sockeye and Coho in Area D Selective Gillnet Fisheries Experiment
(catch expressed per fishing hour)

FISHING PERIOD	# OF SOCKEYE	# OF COHO	SOCKEYE/ COHO
Dawn	17.7	1.3	13.6
Daylight	22.9	0.5	45.8
Night	32.8	1.5	21.9

(Source: Area D Salmon Gillnet Association, 2000)

Reducing Coho mortalities in troll and seine fisheries.

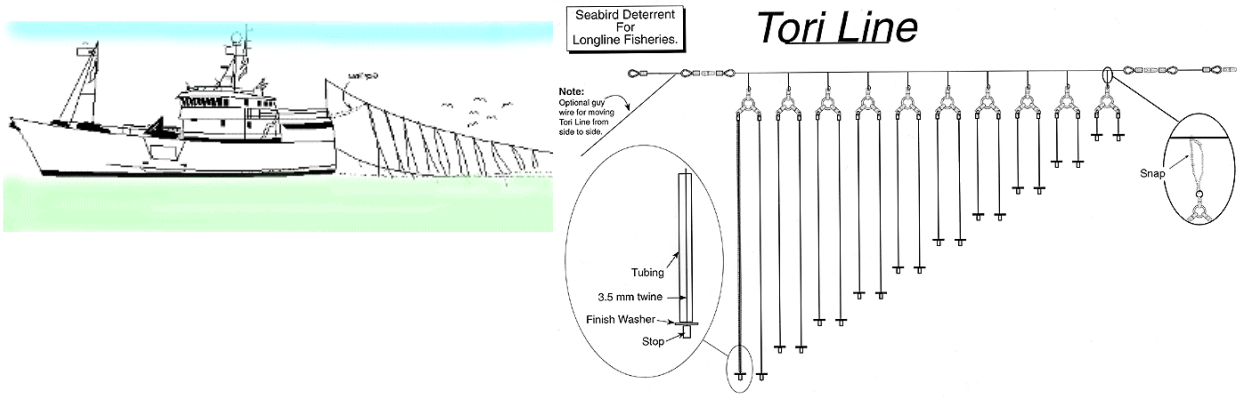
Monitoring the recovery of coho caught in commercial seine fisheries indicates that careful handling of catch, brailing (dipnetting), sorting, and use of revival tanks can reduce short term mortality of coho from 25% to 5% (DFO 2001). Similarly, in the troll fishery, use of barbless hooks, careful handling and revival tanks appears to reduce short term mortality from the standard 25% to approximately 10% (DFO 20001).

Under the recent policy for selective fishing (DFO 2001), selective fishing methods will remain the new way for salmon fisheries long after the coho recovery program. Much of the current focus of the salmon selective fisheries program is education; the transfer of the results and tools of experimental fisheries to the commercial fleet through workshops and demonstration.

5.3.3 Avoiding Seabirds

The incidental catch of seabirds, particularly several threatened species of albatross, on longline fishing gear is a sustainable fisheries issue throughout the world. During long line fishing seabirds are attracted to baited hooks as the fishing gear is being set. There are several simple avoidance devices (bird lines, tori lines) which make it harder for birds to seize baited hooks. A tori line (Figure 9) consists of a line with streamers attached, mounted on a sternpole and towed behind the boat directly over the baited longline. Properly designed tori lines can reduce seabird bycatch by up to 80% (CCAMLR, 1996). In 2000 the Pacific Halibut Management Association recommended that all members use seabird avoidance devices while longline fishing. Use of seabird avoidance devices will likely become a mandatory licence condition for the BC Halibut fishery in 2002.

Figure 9. Using Tori Lines to reduce bird bycatch



(Source: Seabird Bycatch Project, Seattle, Washington)

5.4 KEY CONSIDERATIONS

The development of catch data collection programs and selective fishing technologies over the past decade provides the basic tools for developing approaches to managing non-target catch. This represents substantive progress since 1990, when bycatch could not be systematically addressed due to the lack of information. However development of these tools is very recent. For example, 2001 will be the first year in which catch (in addition to landings) data is available for all gear types and areas in the BC commercial salmon fishery. Selective fishing initiatives in salmon fishery and shrimp trawl fishery are less than five years old. The effectiveness of individual quota to address overfishing of target catches is clearly demonstrable (Section 4.2.2), however, in many cases, it is too early to fully assess the effectiveness of selective fishing measures at reducing the catch of non-target species.

There are a number of key issues which require continued attention in order to more effectively address the principle of reducing impacts on non-targeted species and stocks:

1. **Continued lack of comprehensive, verifiable catch data for certain fisheries**
   It is generally acknowledged that catch data for BC's longline fisheries (halibut, sablefish, ZN rockfish and Schedule II fisheries) is inadequate. Partial at-sea observer coverage has not generated adequate catch data, although there are recent initiatives to increase observer coverage in the halibut longline fisheries. More comprehensive catch data from these fisheries is essential to provide full accounting of all longline fishing mortalities, particularly rockfish where lack of catch data is identified as a specific management issue. Catch information from recently implemented salmon catch hail system, which relies on daily hails from the fishing grounds, is not currently verifiable except by a very limited on-board observer program or DFO surveillance. Consideration should be given to developing adequate data quality controls for the salmon catch hail program such that the accuracy of the information can be assessed.

2. **The requirement to manage salmon catch on a stock rather than species basis**
   Selectively separating different stocks of the same species is difficult, expensive and, in certain cases, impossible (DFO 2001). For salmon a number of techniques, including DNA analysis, are used but are difficult to conduct on the fishing grounds during selective fishing operations. The requirement to manage salmon fisheries on a stock rather than species basis will be a continuing challenge to the development of selective salmon fisheries.

3. **Defining strategies and monitoring effectiveness**
   As well as having information and technological tools, effective management of non-target catch requires definition of target objectives, methods to meet objectives and monitoring progress. Currently management plans tend to define non-target catch issues but lack a strategic plan to address the issues. This will be addressed further in Section 8.0

4. **Continued regulatory barriers**
   Despite some movement towards reducing regulatory barriers resulting in the discard of marketable fish (Section 5.2), there is still considerable progress to the made in this area. Schedule II licence holders targeting lingcod are required to discard rockfish. Longline licence holders must discard any rockfish above regulated bycatch allocations. While this might be an appropriate strategy for a species with a high survival rate if caught (e.g. dogfish), it is less appropriate for species with high mortality such as rockfish. A fundamental objective of sustainable fishing practices should be that gear and species allocation management should not result in increased fishing mortality of sensitive species. This will require movement to more integrated fishing plans for sectors such as groundfish (see Section 8.0).

6.0 PRINCIPLE 2B - LIMITING IMPACTS ON HABITATS AND ECOSYSTEMS

> *"To the extent practical, fish harvester's will minimise unintended bycatch and reduce waste and adverse impacts to ecosystems and habitats"* (Canadian Code of Conduct for Responsible Fishing Operations, DFO 1998).

This section addresses the second component of this principle, reducing impacts on habitats and species, (also see Appendix 2). Sustainable aquaculture practices (Section 6.2) are considered under this heading as the interaction between aquaculture practices and associated habitats and ecosystems is a key environmental sustainability issue. Illustrative examples and key challenges for the future are provided below.

6.1 EFFECTS OF MOBILE FISHING GEAR (LONGLINE AND TRAWL)

In some areas of the world fishing activity (particularly trawling) is extensive in area and intensive in effort. In the southern North Sea, one of the most intensely fished areas of the world, it has been estimated that the entire area is subject to trawling 1-2 times per year (Lindebroom and de Groot 1998). Off British Columbia, the shelf and slope area (to 1700m depths) subject to trawling is much lower (about 12% between 1996 and 1998, Schute *et al*. 1999). The intensity of trawl activity within this area is extremely variable. It is generally acknowledged that trawling on soft substrate bottoms (mud, sand, fine gravel) has short term (months to several years) effects on some aspects of physical structure and benthic community composition (Schwinghamer *et al*. 1998, Engel and Kvitek 1998). However, the long term effects relative to natural variation are not well understood (Kaiser 1998). The Department of Fisheries and Oceans has recently initiated a National Workgroup to further examine the benthic impacts of mobile fishing gear.

Given the low intensity of trawl activity in British Columbia and the uncertainly with regard to impacts on soft bottom habitats, it is more appropriate to focus attention on impacts of mobile fishing gear on valued, sensitive habitats, particularly structure forming features such as hard corals and sponge reefs. Hard corals (tree corals) grow on hard substrates at depths below 200m. These corals are slow growing and can be 2 -3m in size. Silica (glass) sponge reefs up to 18m high are found in Hecate Strait and Queen Charlotte Sound and are considered unique to the western Canadian shelf (DFO 2000). These sponge reefs have existed in these areas for an estimated 9,000 years. Both coral and sponge communities form complex habitat structures. The location and extent of these areas is not well documented. Fishing data can be used to more fully document the occurrence and location of these features and fishing plans developed to minimise impacts to documented areas.

The 2001 shrimp trawl management plan makes specific mention of glass sponge reefs and provides locations to licence holders, requesting that trawlers avoid these areas. The 2001 groundfish trawl management plan and rockfish (ZN), sablefish or halibut management plans do not refer to the known locations of these reefs, nor are there specific fishing closures in effect to protect known areas. Under sustainable fishing plans, known areas of valued, sensitive habitats should be protected from the impacts of mobile fishing gear.

6.2 SUSTAINABLE AQUACULTURE PRACTICES

The Food and Agricultural Organisation's principles for responsible aquaculture development (examples are provided in Section 1.3) focus on four main themes:

1. Impacts to and interactions with ecosystems particularly species and habitats,
2. Interactions with other resources (land, water, fisheries),
3. The need for precautionary and adaptive management,
4. Effective administrative (regulatory and management) frameworks.

Most of the following information pertains to the salmon farming industry, where environmental issues are most prominent. The concluding section (6.2.2 Key Considerations) is also applicable to the shellfish aquaculture sector.

6.2.1 Salmon Aquaculture

In 1995, concerns about the environmental impacts of salmon farming, focusing on issues related the above four themes, led to a moratorium on new salmon farm licences and an environmental review of the salmon aquaculture industry by the BC Environmental Assessment Office (the Salmon Aquaculture Review or SAR). The environmental review focused on five environmental issues; (1) farm siting, (2) escaped fish and interactions with wild stocks, (3) fish health and interactions with wild stocks, (4) impacts of waste discharges and (5) impacts on coastal mammals, including predator control. The SAR was an extensive environmental review of the salmon farming industry and provided a summary of the "best available scientific information" as suggested by FAO's principles for responsible aquaculture (FAO 1997).

The SAR report was released in 1997 and contained 49 recommendations related to the five environmental issues as well as requirements for effective regulation and management of the aquaculture industry. The British Columbia government did not formally accept these recommendations until late 1999, which led to considerable uncertainly as to the future direction of the industry and delayed the implementation of improved environmental management practices. However, over the past 3-4 years, both industry and government have made substantive progress towards building the management and regulatory infrastructure to address many of the recommendations of the environmental assessment review. The British Columbia Salmon Farmer's Association (BCSFA) has developed a Code of Practice for salmon farming. A Salmon Aquaculture Implementation Advisory Committee (SAIAC), with representation from federal, provincial, municipal and First Nations governments as well as industry and environmental groups, has been formed to review and advise the provincial government on the implementation of the Salmon Aquaculture Policy Framework.

A brief summary of recent policy and regulatory initiatives is provided below (also see Appendix 2):

Farm siting

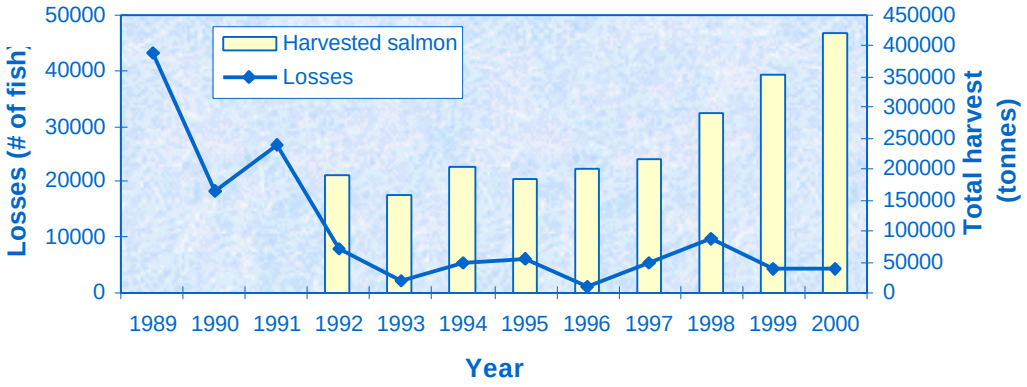
In 2000 the British Columbia government released new siting criteria for fish farms and initiated a Fish Farm Review Committee, with federal and provincial agency representation, to advise on re-siting of fish farm tenures and the siting of new finfish operations. Both these initiatives were recommended by the SAR report. This committee has adopted a phased approach to the relocation of existing tenures, based on environmental and conflicting resource use priorities.

Escape prevention

The SAR report concluded that the risk of establishment of Atlantic salmon in British Columbia streams is "improbable but not impossible." The SAR also concluded that genetic interaction between escaped Pacific salmon and wild stocks is possible but "BC has a long history of intentional mixing of salmon genetics though the salmon enhancement programs". Recommendations of the SAR focused on improved escape prevention, reducing potential interactions with salmon streams through improved siting criteria and continuing the prohibition of transgenic (genetically modified) fish in aquaculture operations. In 2000, escape prevention standards focusing on netpen and anchor system design and maintenance as well as escape response and reporting were added to the aquaculture regulation section of the BC Fisheries Act. These regulations are considered to be the most comprehensive in the world (BC Fisheries 2001). In 2001, the salmon farming industry produced and submitted escape prevention plans for all farm sites (BC Fisheries 2001).

Over the past decade, farm losses (escapes) have decreased, particularly in relation to farm production (Figure 10). Escape prevention plans should continue this trend but it is unrealistic to expect regulations and engineering to achieve zero escapes. Episodic escapes events resulting from storms or equipment failure should be expected and planned for. Recapture plans are a required component of the escape response plans. In addition, the Atlantic Salmon Watch program, on-going for over 12 years, has focused on monitoring streams for escaped and juvenile Atlantic salmon as well as escape response.

Figure 10. BC salmon farms: Reported losses vs. production 1989 - 2000



Environmental impacts of waste discharges

On fish farms, organic waste discharges result primarily from uneaten feed and fish faeces. This material can lie on the bottom, smothering benthic organisms and impacting sediment composition and sediment chemistry. The degree, extent and duration of these impacts are variable between sites and depend on depth, currents and the presence of benthic resources. The SAR report made a number of recommendations with respect to managing wastes discharges, all leading to the development of performance based standards. Prior to 1999 farms were regulated by prescriptive standards which arbitrarily limited fish production based on feed requirements. Performance based standards will require farms to comply with impact thresholds to sediment, sediment chemistry and/or benthic infaunal community, regardless of farm size and feed requirements.

In late 1999 an interim benthic monitoring program was initiated at all farm sites. In addition a more intensive research sampling program was carried out at six farm and reference sites. The objective of these programs was the collection of baseline environmental data leading to the establishment of performance based standards.

Fish health and disease control

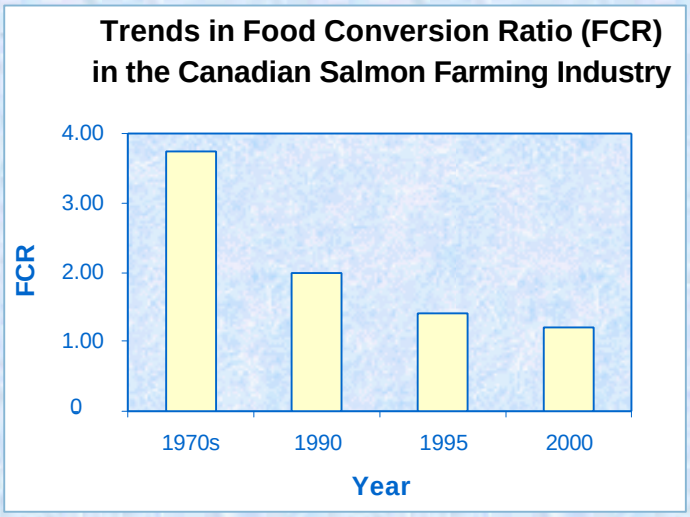
The Salmon Aquaculture Review recommended that systems and standards for disease surveillance, control and reporting be strengthened. To this end a fish health code of practice is under development and a comprehensive fish health database is currently being piloted. This database will include information from DFO Salmon Enhancement facilities, provincial fish culture facilities as well as farm sites. These initiatives will provide an accessible, comprehensive information source on fish health and disease which should benefit both farmed and wild stocks. In addition improved husbandry practices (separation of year classes to different grow out sites, more extensive use of fallowing, increased attention to personnel and equipment moving between sites) has been adopted by the industry and incorporated into the BCSFA Code of Practice.

Interactions with predators

As with selective fishing initiatives, avoidance is the first priority for controlling predators at farm sites. This is emphasised in the BCSFA Code of Practice. A predator avoidance plan, emphasising equipment design and practices to avoid equipment damage and fish escapes, is a required element of provincially mandated escape response plans. The BCSFA Code of Practice specifically prohibits killing of birds and outlines procedures for the use of firearms for predator control, the primary control being the requirement for permitting and reporting to the Dept. of Fisheries and Oceans. Acoustic deterrent devices, which use underwater sound to deter marine mammals, are generally no longer used at BC farm sites, but are not specifically prohibited. These devices may have negative impacts on the behaviour of marine mammals and the SAR contains a specific recommendation to phase out the use of acoustic deterrents.

BC SALMON FARMS - GROWING MORE WITH LESS

- Since 1995 farmed fish production has doubled, at a time when the total number of farm sites was capped at 121.
- Improved feeds, selective breeding, reduced mortality, and improved feeding technologies have led to 3-4 times more fish being produced per kg of feed than 25 years ago.
- Better farm sites and use of performance based standards will contribute to increased efficiency and production levels.



6.1.3 Key Considerations

The Salmon Aquaculture Review provided a science-based evaluation and prioritisation of environmental issues related to salmon aquaculture. Industry has responded in a positive manner to these recommendations. The report also highlights the lack of regulatory infrastructure to manage the industry. Since 1999, the regulatory infrastructure and environmental management framework has been developed (Codes of Practice, monitoring, reporting and compliance requirements), primarily through provincial and industry initiatives. Reporting systems as well as tools and technology have been developed to address many of the recommendations of the SAR report. In many cases these initiatives are so recent that it is not yet possible to assess their effect on reducing potential impacts to habitats and ecosystems.

Key challenges include:

1. **The development measurable performance based standards**
   Performance standards are an example of the development of realistic, measurable objectives for assessing progress towards environmental sustainability. The development of performance based standards to manage fish farm wastes potentially represents significant process in this direction, however these objectives have yet to be developed or implemented. With the development of information systems to monitor fish health and escapement reporting, similar performance based standards should be considered for managing fish health and disease, escapement and predator control.

2. **Continued development of consultative processes**
   The requirement to consider interactions with other resources and stakeholders requires consultative processes and co-operative management initiatives. The formation of the Salmon Aquaculture Implementation Advisory Committee and the Shellfish Development Committee shows commitment to this consultative process. In addition the aquaculture industry has involved a number of First Nation partners during the first phase of the farm site relocation process. It is important that these processes remain effective in the next phases of aquaculture development.

3. **Need for a transparent, harmonised regulatory regime**
   Over the past two years the aquaculture industry, particular salmon farming, has been subject to a rapidly evolving regulatory regime. These changes have built the regulatory framework for sustainable aquaculture practices and are generally supported and, at times, initiated by industry. The regulatory regime should be (1) visionary in that objectives are clearly stated and understood (2) harmonised with minimal need to duplicate information for different agencies, (3) transparent and verifiable, in that monitoring data is available to direct future management initiatives and that credibility is established using verification procedures.

4 **The development and implementation of precautionary and adaptive management.**
   As in wild fisheries management the principles of precautionary and adaptive management are recognised in aquaculture policy but there is considerable uncertainty as to how to implement these principles. Two examples from the BC aquaculture sector are considered:

Culture of new species requires a precautionary approach.
The code of conduct for responsible aquaculture development calls for advance evaluation of the effects of aquaculture development on genetic diversity and ecosystem integrity, based on best available scientific information (FAO 1995). This was the mandate of the BC Salmon Aquaculture Review in 1995, albeit somewhat after the establishment of salmon aquaculture in British Columbia. To meet recognised criteria for responsible aquaculture, similar environmental assessment processes should take place *prior to* the implementation of commercial culture of new aquaculture species in British Columbia (e.g. sablefish and halibut).

Potential for establishment of Atlantic salmon in BC rivers requires an adaptive management approach.
The SAR concluded that the potential for Atlantic salmon to establish in BC streams was "improbable but not impossible", based on previous deliberate attempts to establish this species in BC streams. Since 1997, spawning and juvenile rearing of Atlantic salmon has been documented in three BC streams (Carnation, Amor de Cosmos and Tsitikia). The numbers of observed juveniles observed are small and it is too early to conclude that Atlantic salmon have "established" in these systems. However, these observations should trigger a re-assessment of original assumptions regarding the potential for this species to establish in BC rivers and thresholds for specific management initiatives should be developed if continued information indicates an increase in the juvenile population in BC streams.

7.0 PRINCIPLE 3 - ENSURING EFFECTIVE MANAGEMENT AND REGULATION

> "*The fishery is subject to an effective management system that respects local, national and international laws and standards and incorporates institutional and operational frameworks that require use of resources to be responsible and sustainable*" (Marine Stewardship Council, 1998).

Many aspects of this topic have been addressed in previous sections of this report (informed stock assessment, verifiable quota management, landings and catch data systems, monitoring and compliance initiatives). However two aspects of effective management with profound impacts on environmental sustainability, require further emphasis. These are (1) the role of effective co-management models and individual responsibility and (2) the importance of international agreements.

7.1 THE ROLE OF EFFECTIVE CO-MANAGEMENT AND INDIVIDUAL RESPONSIBILITY

Elsewhere in this report the importance of co-management and industry associations in the development and implementation of sustainable initiatives has been emphasised. During the interview phase of this project many industry members commented that the most important factor in achieving change within the seafood industry was the growing sense of individual responsibility, sometimes termed stewardship. During the 1990's cohesive industry associations developed and undertook specific responsibilities under co-management models. For example, the development of individual quota management led to responsible management of quota allocations, rather than racing for fish. In any management system, responsibility generates leadership and a more opened attitude to change. While this trend is difficult to measure quantitatively, it may ultimately prove to be one of the most significant factors in continued progress towards environmental sustainability.

7.2 THE IMPORTANCE OF INTERNATIONAL AGREEMENTS

On the Pacific coast migratory stocks of halibut, salmon and hake move through Canadian and American waters at various times of the year. Effective, sustainable management of these migratory stocks requires a high level of international cooperation and agreement.

A sustained international agreement for Pacific halibut

The International Pacific Halibut Commission (IPHC) was established by Convention between the United States and Canada in 1923. This Convention and subsequent renewals and amendments has provided sustained international management of North Pacific halibut stocks for over 75 years. It is considered a model international fisheries agreement and has played a recognised and vital role in the sustainability of the halibut fishery.

Stalemated renewal of the Pacific Salmon Treaty

The renewal of the Pacific Salmon Treaty, which expired in 1992, was stalemated for eight years (1992-1999) over allocation issues. During this period both nations fished without full regard for each other's harvest levels, and it is acknowledged that many stocks, particularly sensitive chinook and coho stocks, were adversely impacted. In 1999 the Pacific Salmon Treaty was renewed, with long term (10-12 years) fishing arrangements for boundary fisheries and transboundary stocks, using a management framework which is considered more sensitive to

conservation requirements than previous approaches. The continuity of the Pacific Salmon Treaty is vital to achieving sustainable salmon fisheries.

Continued lack of international agreement on Pacific hake allocations

While Canada and the United States carry out joint stock assessments for Pacific hake and make yield recommendations to their respective governments, there is no international agreement which binds each nation to a specified allocation of the recommended yield. For over ten years Canada and the United States have disagreed on the each nation's allocation, with Canada claiming 30% and the United States claiming 80%. Effectively this means that 110% of the recommended yield is allocated for harvest each year, a practice which clearly does not meet the sustainability principles outlined in this report.

8.0 MOVING FORWARD

Over the past decade BC's Seafood industry has made substantial progress towards environmental sustainability as measured against the three principles outlined in this report. Progress has been achieved by the establishment of management tools such as individual quotas, which rapidly brought Total Allowable Catch overfishing under control in many fisheries. New and innovative fisheries data systems and selective fishing tools are evolving at a rapid pace. Progress has also been achieved in less tangible but equally important ways such as cohesive industry associations and a growing sense of resource stewardship. These changes (as well as market forces) have, at times, led industry to institute sustainability initiatives ahead of regulations (selectivity devices in the shrimp fishery, bird avoidance devices in the halibut fishery). Moving forward requires addressing many of the key considerations and issues brought up in previous sections of this report. In particular we wish to emphasise the following:

1. **The need to develop sustainability targets**
   Moving further towards sustainable practices requires setting realistic, measurable targets in the context of the three sustainability principles outlined in this report. There is a need to develop indicators for these targets and monitor and report on progress towards objectives. DFO's recent selective fishing policy paper (DFO 2001) puts forth the objective of setting selective fishing standards by January, 2003. A more comprehensive strategy should identify sustainable management issues for specific fisheries, gear types or integrated fisheries (see below) and develop targeted objectives and a monitoring plan. For example, what are the targets for bycatch reduction in the shrimp fishery over the next five years? How will this be achieved and what indicators will be used to monitor progress towards these objectives?

2. **Moving further towards integrated fisheries management**
   Licensing and quota allocation requirements which lead to discarding marketable fish, particularly species like rockfish which suffer high mortalities if caught and released, underscores the need to move towards more integrated fisheries management and full accounting of catch. As outlined in Section 5.4, a fundamental objective of sustainable fishing practices should be that gear and species allocation management should not result in increased fishing mortality of sensitive species. This will require movement to more integrated fishing plans for sectors such as groundfish.

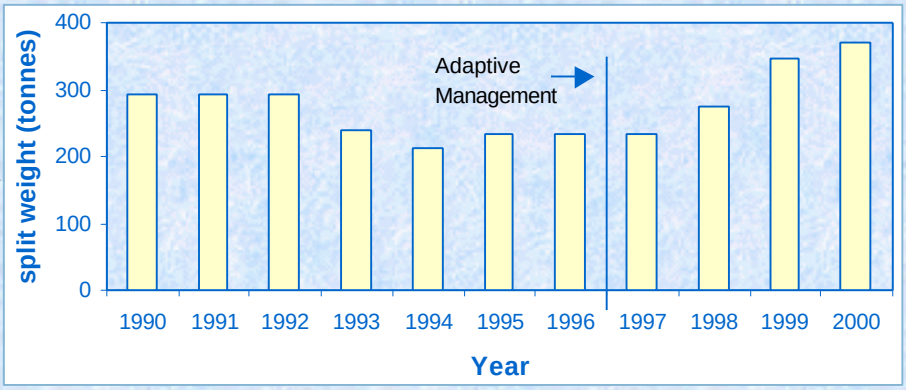
3. **Developing appropriate approaches to precautionary, adaptive management**,
   This recommendation is a recurring theme throughout this report. Precautionary management requires consideration of uncertainty which may be due to lack of stock assessment data, lack of information on ecosystem interactions (the predation of urchins and geoducks by the growing population of sea otters on the west coast of Vancouver Island is a good example), climate change, or decadal cycling of oceanographic conditions. Adaptive management treats management as an experiment, and management prescriptions change as a result of new information. Defining acceptable levels of uncertainty and decision thresholds under adaptive management will be key to the success of these approaches. This is particularly important in the aquaculture sector, where adaptive management approaches are required to react to potential ecosystem interactions (e.g. disease transfer, genetic interactions and exotic introductions). An example of a precautionary, adaptive approach by one of the smaller BC

fisheries, sea cucumbers, is provided in the inset box. In this fishery uncertainty about stock size did not lead to closure of the fishery, but to reduced quota and fishing areas coupled with an active program to acquire more survey data. As a result of this adaptive approach fishing quotas are now 60% higher than mid 1990 levels and are based on better estimates of the stock size for sea cucumbers on the BC coast.

BC SEA CUCUMBER FISHERY

An Approach to Adaptive Management

- Little was known of the biology and abundance of sea cucumbers in British Columbia.
- Initial stock assessments used a conservative abundance estimate of 2.5 cucumbers/m of shoreline.
- In 1997, harvesting was restricted to 25% of the BC coast, with 25% set aside for experimental harvest and 50% unharvested.
- Co-management surveys have demonstrated that actual sea cucumber density is 3-4 times higher than original estimates.
- As a result of better survey data, harvest quotas have increased by about 60% over 1997 levels.



Consistency of quality and supply is a key market demand in the seafood industry. Many aspects of environmentally sustainable fishing and aquaculture practices can help meet this market demand. The evolution of individual quota management has led to a more consistent, year round supply of quality seafood to the market place. However, maintaining sustainable harvests of target species, the first principle of sustainable fishing practices, will at times require adaptive approaches and fluctuating target catches. This is particularly true for species like salmon, which appear are sensitive to climatic cycles, and species with highly variable recruitment rates. The BC Seafood industry will have to incorporate adaptive change into harvest and marketing practices. The newly developed data and monitoring systems, selective fishing tools and increased level of resource stewardship positions the seafood industry to adapt and continue progress toward the elusive goal of environmental sustainability.

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APPENDIX 1

LIST OF CONTACT PERSONS

Appendix 1. List of contact persons

Sector	Name	Affiliation
Salmon	Murray Chatwin	Ocean Fisheries Ltd.
	Don Lawseth	Department of Fisheries and Oceans - Selective Fishing
	Les Rombough	Area D Salmon Gillnet Association
	Bob Rezansoff	Pacific Salmon Harvester's Society
	Mike Griswold	Pacific Salmon Harvester's Society
Herring	Edward Safarik	Ocean Fisheries Ltd.
	Gina Johansen	Spawn on Kelp Operators Association
	Greg Thomas	Department of Fisheries and Oceans
	Jake Schweigert	Department of Fisheries and Oceans
Groundfish	Chris Sporer	Pacific Halibut Management Association
	Bruce Turris	GF Research and Conservation Society/ Canadian Sablefish Assoc.
	Brian Mose	Groundfish Trawl License Holder
	Henry Heggelund	Halibut License Holder
	Bob Fraumeni	Sablefish License Holder
	John Koolman	ZN longline License Holder
	Jeff Fargo	Department of Fisheries and Oceans
	Rick Stanley	Department of Fisheries and Oceans
	Sandy MacFarlane	Department of Fisheries and Oceans
Dive Fisheries	Jamie Austin	Underwater Harvester's Association
	Mike Featherstone	Pacific Urchin Harvester's Association
	Michelle James	Underwater Harvester's Association
	Claudia Hand	Department of Fisheries and Oceans
Crab and Prawn	Brian van Dorp	Pacific Prawn Association
	Sam Bowes	Crab License Holder
Shrimp Trawl	Lorne Clayton	Pacific Coast Shrimpers Co-op
	Bruce Evans	Shrimp Trawl Sectoral Committee Member
	Mark Decarte	Pacific Coast Shrimpers Co-op
	Guy Whyte	Shrimp Trawl Sectoral Committee Member
Aquaculture	Anita Peterson	BC Salmon Farmer's Association
	Anne McMullin	BC Salmon Farmer's Association
	Ruth Salmon	BC Shellfish Grower's Association
	Joe Truscott	BC Ministry of Agriculture, Food & Fisheries

APPENDIX 2

SUMMARY OF MANAGEMENT INITIATIVES MEETING ENVIRONMENTAL SUSTAINABILITY PRINCIPLES

Appendix 2. Summary of management initiatives meeting environmental sustainability principles

Species	Gear Type	Management Initiative	Year Implemented	Sustainability Principle *	Comments
Salmon	All Types	Emphasis on managing for and recovery of weak stocks	on-going increased emphasis in 1998	P1, P2	Steelhead, Upper Skeena coho, Thompson coho, early Stuart sockeye are recent examples
		Pacific Salmon Treaty	1999	P1, P2, P3	Agreement on long term fishing arrangements based on abundance-based management as opposed to catch ceilings
		Area Licencing, Single gear Licencing	1996	P1	Spreads fleet fishing effort over broader area, reduces number of licences fishing
		Daily Hail Requirements, Offload Validation, On-Board Monitoring	1998	P1, P2, P3	Measures to ensure that catch does not exceed target levels monitoring catch of non-target species
	Selective Fishing	Experimental Pilot Projects in Selective Fishing	1998	P2	5% of Commercial TAC allocated to Experimental Projects
		Selective Fishing Measures	1998	P2	Emphasis on avoiding catch of non-target species- Time and area closures, modified fishing gear design, daytime only fishing in selected areas, terminal fisheries. Release and increased survival non-target species - mandatory brailing, revival tanks, use of barbless hooks, reduced set times, fish traps and weirs
Herring	All Types	Conservative Quotas, Fishing Cutoff (Escapement) Thresholds Fishing only on 5 major stocks	1985	P1	Fishing quotas are set at 20% of forecasted spawning stock. No fishing if forecasted spawner biomass for a specific area is less than 25% of unfished average biomass
		Minor stocks are not fished	pre-1990	P2	Ensures protection of minor stocks and conserves genetic diversity
		Industry funded Research and Development	1995	P1, P3	Herring Conservation and Research Society coordinates spawn surveys and hydroacoustic surveys as well as funded tagging and genetic studies
	Seine	Pooled fishing Effort (Licence quotas, reduced fishing effort, on-grounds hails, dockside validation)	1998	P1, P3	Measures to ensure and verify that the total allocated catch (TAC) is not exceeded.
	Gillnet	Pooled fishing Effort (Licence quotas, reduced fishing effort, on-grounds hails, dockside validation)	1999	P1, P3	Measures to ensure and verify that the total allocated catch (TAC) is not exceeded.
	Spawn on Kelp	Individual Quota Allocation	pre-1990	P1	100T allocation to closed ponds, 35T allocation to open ponds
		On Grounds Monitoring and Dockside Validation	1996	P1, P3	Monitor input of herring and kelp to ponds, monitor product harvest and release of ponded herring and surplus eggs, verify product production and licence quotas

* Sustainability Principles
P1 = sustainable harvest of target species
P2 = limiting impacts on non-target species, habitats and ecosystems

Appendix 2. Summary of management initiatives meeting environmental sustainability principles

Species	Gear Type	Management Initiative	Year Implemented	Sustainability Principle *	Comments
Groundfish	Trawl	Individual Quotas, Quota Transferability	1997	P1	Provides verifiable quota management system and ability to meet but not exceed quotas while minimizing catch of non-target species
		100% dockside monitoring	1994	P1, P3	Provides verifiable quota management system and ability to meet but not exceed quotas.
		Area and Species or Species aggregate Management	1996	P1	Reduction of fishing effort and intensity in specific areas
		100% onboard observer coverage	1996	P1, P2, P3	Provides verifiable catch composition and bycatch data necessary to manage quota allocations and meet bycatch targets for halibut and sablefish. Provides opportunity for increased biological sampling effort.
		Bycatch quotas for Halibut, sablefish	1996	P2	Limits catch of non-target species, reduced discarding
		Increased co-management efforts	1996	P1, P3	Includes increased biological sampling effort, stock assessment modeling for specific groundfish species (thornyheads)
		Experimental Trawl Gear Modifications (larger mesh, square mesh, escape panels)	1992 to 1995	P2	Increased mesh size from 4.5 to 6 inches, reduction in catch of juvenile Pacific cod, rock sole, English sole.
Rockfish (ZN)	Hook and Line	100% dockside monitoring	1995 for ZN, 1996 for Sched. 11	P1, P3	Provides verifiable quota management system and ability to meet but not exceed quotas.
		Targeted 10% onboard observer coverage	1999	P1, P2, P3	Attempt to address lack of catch composition data in the ZN fishery, acknowledged that sampling effort is inadequate.
		Area and Trip limits	1995	P1, P2	Quota is managed by species aggregates and fishing areas., reducing fishing effort and intensity in specific areas
		Rockfish Protection areas	2000	P2	Implemented toprotect spawning, nursery areas and/or permit recovery of rockfish populations in 8 designated areas.
Halibut	Hook and Line	Individual Quotas, 100% dockside Monitoring, Tagging Landed Halibut	1991	P1, P3	Provides verifiable quota management system and ability to meet but not exceed quotas.
		Targeted 10% onboard observing	1999	P1, P2, P3	Attempt to address lack of catch composition data in the ZN fishery, acknowledged that sampling effort is inadequate.
		Yelloweye Rockfish allocations	1999	P2	Limits to the catch of non-target rockfish species reduces discarding
		Rockfish Protection Areas	2000	P2	Implemented to protect spawning, nursery areas and/or permit recovery of rockfish populations in 8 designated areas.
		Recommended Bird Avoidance Measures	2000	P2	Use of bird aviodance devices (eg. Tori lines) to reduce catch of birds on longlines
Sablefish		Individual Quotas and dockside monitoring	1990	P1, P3	Provides verifiable quota management system and ability to meet but not exceed quotas.
		Increased Co-management efforts, including enhanced tagging program	1990	P1, P3	Tagging program is an important component of the stock assessment program (estimate of exploitation rate)
		Juvenile Escapement Rings in Traps	1999	P2	Permits escapement of undersized sablefish from traps

* Sustainability Principles
P1 = sustainable harvest of target species
P2 = limiting impacts on non-target species, habitats and ecosystems
P3 = effective management

Appendix 2. Summary of management initiatives meeting environmental sustainability principles

Species	Gear Type	Management Initiative	Year Implemented	Sustainability Principle *	Comments
Shrimp	Trawl	Area quotas, mandatory logbook and hail program	1997	P1	Not all fishing areas are subject to quotas
		Industry funded stock assessment surveys and selectivity research	1997	P1, P2	
		Mandatory use of fish exclusion devices	2000	P2	Effective at reducing bycatch of larger fish
		Use of Rigid Square top mesh	2001	P2	Reduction of bycatch of smaller fish inc. eulachon
		Timed Closures to permit spawning	1997	P1	Fishing is closed during egg bearing period
Prawn	Trap	Area fisheries and trap limits coupled with on grounds monitoring program	1995	P1, P3	Provides verifiable monitoring of fishing effort.
		Single daily haul provision	2000	P1	Permits bottom sorting and release of undersize prawns
		Minimum Mesh Size Restrictions	1988	P1, P2	Permits bottom sorting and release of undersize prawns
		Management by Spawner Index, with on ground monitoring and hail in program	1994	P1, P3	Permits escapement of a target proportion of adult females to meet spawning requirements.
		Increase in Spawner Index thresholds for specific areas (Saanich Inlet, Howe Sound)	1998	P1	Permits growth in stock before first capture.
		Increases in minimum size from 30 to 33mm			Permits higher escapement in specific areas.
		Seasonal closures and extension of subsequent year's opening date	on-going	P1	Season closures protect egg bearing females until larval hatching is completed. Fisheries opening dates have moved from March 31st to May 01 in recent years to help ensure

* Sustainability Principles
P1 = sustainable harvest of target species
P2 = limiting impacts on non-target species, habitats and ecosystems
P3 = effective management

Appendix 2. Summary of management initiatives meeting environmental sustainability principles

Species	Gear Type	Management Initiative	Year Implemented	Sustainability Principle *	Comments
Crab	Trap	Area Licencing and limited entry	1990-91	P1	
		Area fisheries and trap limits with on grounds monitoring or electronic monitoring	2000	P1, P3	Provides verifiable monitoring of fishing effort.
		Mandatory release of undersize crab (<165mm for Dungeness) and female crab, soft shell closures	pre-1990	P1	Imput controls. Soft-shell crabs are susceptible to handling mortality
		Mandatory escape ports		P1	Escape hole of 100-110mm which limits catch of undersize crabs
		Mandatory Rot Cords		P1, P2	Reduce "ghost fishing" of lost gear
		Industry funded research and surveys	1998?	P1, P2, P3	Soft-shell monitoring and surveys
Geoduck	Diver	Area and licence quotas coupled with on-grounds and dockside Monitoring	1989	P1, P3	Provides verifiable quota management system and ability to meet but not exceed quotas
		No product grading	pre-1990	P1, P3	A single price is negotiated with buyers, and product is not graded. This removes the incentive for hygrading, which can be a significant discard
		Conservative Management - harvest quotas set at 1% of biomass estimate	pre -1990	P1	Washington and Alaska set harvest quotas at 2.0 to 2.5% of biomass estimate
		Industry Funded Stock Assessment Surveys and Research Areas	1994	P1, P3	Diver surveys of geoduck abundance and density in commercial beds. Population parameters (recruitment, mortality, growth) monitored at three research plot areas (Marina Island, Gabriola Pass and Richie Bay).
		Industry Funded Enhancement Efforts	1997	P1, P3	The UHA maintains an active hatchery and outplanting program, with the objective of outplanting 2 million seed per year. Enhancement is coupled with concurrent research programs on stock genetics and disease.
		Restrictions on harvest areas (e.g. no harvesting at elevations above -3.0m, bed harvest closures during herring spawning season)	pre 1990	P2	Protects most eelgrass habitat from harvest impacts, and herring eggs from sedimentation impacts
Red Sea Unchin	Diver	Area and licence quotas coupled with on grounds and dockside monitoring	1997-98	P1, P3	Provides verifiable quota management system and ability to meet but not exceed quotas
		Conservative Management - harvest quotas set at 2% of biomass		P1	
		Industry Funded Research and assessment surveys	1994	P1, P3	Biomass surveys of commercial beds. Biomass, recruitment and growth monitoring in closed research areas (Clayoquot Sound, Johnstone Strait, Queen Charlotte Islands and Central coast)
		Industry Funded Enhancement Efforts		P1, P3	Hatchery program, no outplanting to commercial beds
Sea Cucumber	Diver	Area and licence quotas coupled with on grounds and dockside monitoring	1995	P1, P3	Provides verifiable quota management system and ability to meet but not exceed quotas
		Conservative Management - harvest quotas set at 4.2% of biomass estimate		P1, P3	Applied to commercial harvest areas only, under the adaptive management plan coastwide exploitation rate is considerably lower
		An adaptive management plan which restricts fishing areas	1997	P1, P3	Due to lack of information on stock status and population parameters, commercial fishing is restricted to 25% of total coastline in a non-contiguous (patchy) fashion). 25% reserved for research and 50% unharvested
		Industry Funded stock assessment surveys	1998?	P1, P3	Conducted in both commercial harvest and research areas

* Sustainability Principles
P1 = sustainable harvest of target species
P2 = limiting impacts on non-target species, habitats and ecosystems
P3 = effective management

Appendix 2. Summary of management initiatives meeting environmental sustainability principles

Species	Environmental Issue	Management Initiative	Year Implemented	Sustainability Principle *	Comment
Salmon Aquaculture	Farm Siting	New Tenure Siting Criteria and Requirements for Baseline Assessments	2000	P2	Addresses SAR Recommendations 4 and 5
		Establishment of Fish Farm Review Committee to advise on aquaculture siting	2000	P3	Addresses SAR Recommendation 1
	Escaped Fish	Escapement Prevention and Response Plans and BCSFA Code of Practice	2000	P2, P3	Addresses SAR Recommendations 12 and 13, focusing on preventing escapement (equipment design and maintenance and inception) and reducing ecological risks resulting from escapes
		Atlantic Salmon Watch	pre 1990	P2	Focus on escape response, documentation and stream surveys.
		Escape Amendments to the BC Aquaculture Regulations	2000	P2, P3	performance based monitoring standards are to be developed from the results of the interim monitoring program, as per SAR recommendation 24.
	Fish Health	BCSFA Code of Practice	2000	P2, P3	Outlines practices to promote fish health and practices for use of therapeutants
		Fish Health Management Reporting and Database	2001	P2, P3	Addresses SAR Recommendations 16 and 18, need for accessible, trusted data source on fish health and disease
	Waste Discharges	Interim Environmental Monitoring Program	2000	P2, P3	Collection of site specific data on benthic sediments which will form the basis of performance based standards (SAR recommendations 25, 26)
		Intensive Monitoring Research	2000	P2	A more intensive benthic sampling program undertaken at six farm sites in British Columbia
		Development and Implementation of Performance based waste management	Under Development	P2, P3	Performance based monitoring standards are to be developed from the results of the interim monitoring program, as per SAR recommendation 24.
	Predator Control	Part 9 BCSFA Code of Practice	2000	P2	Addresses priority for use of deterrents and criteria for firearm use and control.
		Predator Avoidance Plan	1999		Requirement of the BC Commercial Aquaculture Management Plan

* Sustainability Principles
P1 = sustainable harvest of target species
P2 = limiting impacts on non-target species, habitats and ecosystems
P3 = effective management