PACIFIC FISHERIES RESOURCE CONSERVATION COUNCIL
Conseil pour la conservation des ressources halieutiques du pacifique

RESPONSIBLE FISHING IN CANADA'S PACIFIC REGION SALMON FISHERIES

FEBRUARY 2009

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INTRODUCTION

BACKGROUND

The Pacific Fisheries Resource Conservation Council (PFRCC or 'the Council') provides independent advice on conservation and environmental sustainability of Pacific salmon stocks and their freshwater and ocean habitats. Created by the federal Minister of Fisheries and Oceans on 18 September 1998, the Council's role is to advise the federal Minister of Fisheries and Oceans, the BC Minister of Fisheries and the public.

The Council assists in encouraging the free exchange of information among governments, First Nations, stakeholders and the general public, communicating primarily through the release of reports, advisories, backgrounders, events and public meetings. In 2004, the PFRCC commissioned the report *The Evolution of Commercial Salmon Fishing in BC* (Nelson and Turris 2004). The report described changes in the management and operation of the province's commercial salmon fishery over the past six decades and concludes that although significant progress has been made, conservation requirements will continue to rise given the need to protect weak stocks, the requirements of the US-Canada Salmon Treaty, legislation recently passed to protect endangered species and greater public scrutiny of the fishery. In 2006, the PFRCC commissioned the report *The Evolution of the Recreational Fishery in BC* (Kristianson and Strongitharm 2006). This report explains how the recreational and sports salmon fishery evolved in BC and how it has undergone significant growth in the last century. The report suggests that the long-term sustainability of both salmon and sports fishery are inextricably linked and effective conservation is an imperative.

This report builds on these two earlier reports and specifically addresses the issue of responsible fishing in Canada's Pacific Region with a focus on the BC salmon fishery. We examine what responsible fishing means, what is driving the move towards more responsible salmon fishing, what is inhibiting it, and what can be done to further support responsible fishing. We identify options, recommendations and opportunities for improvement and/or expanded implementation of responsible and selective fishing in these fisheries. Recent and current harvesting issues and challenges are examined for responsible fishing solutions through four case studies. Throughout this document the reader will find key conclusions or recommendations contained within text boxes.

RECENT HISTORY OF RESPONSIBLE FISHING IN THE BC SALMON FISHERY

At least since 1990, DFO and BC salmon harvesters have been pursuing ways to reduce release mortalities of the by-catch of non-target species in the BC salmon fishery. The history of this move toward increasing selectivity is described in this report. Over the same period, coast-wide salmon abundance, primarily for sockeye, coho and chum has declined and some stocks or populations are now critically endangered (e.g., Cultus sockeye, Sakinaw sockeye, Interior Fraser coho) (English *et al.* 2008). Despite these population-specific concerns, the total commercial catch of salmon has remained relatively constant at around 10 million pieces since 2001 but down considerably from an average of around 20 million pieces prior to 1998 (Figure 1 and Figure 2). At least since 1953, pink, sockeye and chum salmon have always dominated the commercial catch and there has been a significant reduction in the catch of chinook and coho since 1996 to where these two species now represent a small fraction of the total commercial catch. Over the same period (1953–2003), the recreational fishery catch of salmon in BC increased dramatically from an average of 300,000 pieces (1953–1970) to 830,000 pieces (1971–1997) and then back to 380,000 (1998–2003) (Figure 3). The recreational catch of salmon has always been dominated by chinook and coho, with pink salmon also being targeted at

times. Sockeye has only been a species of interest to the recreational sector since the mid 1980s. First Nation catches of salmon have also increased dramatically since 1953 with sockeye dominating the catch (Figure 4). However, reporting inconsistencies in these data for some time periods urge caution in interpreting these data (Irvine *et al.* 2004). After sockeye, pink and chum salmon dominate the coast wide harvest in First Nation fisheries.

Overall, chinook and coho catches in BC have experienced the greatest decline and reached all time lows in the late 1990s but have been increasing steadily since then. Extreme conservation concerns for several of these stocks have resulted in an even greater urgency to find effective means to maximize the number of fish returning to threatened river systems while continuing to harvest more abundant target species and stocks. This has included; 1) moving fisheries away from mixed-stock areas or times, 2) requiring various mandatory selective fishing methods in mixed-stock fisheries with non-retention of by-catch, and 3) developing new science information systems (e.g., DNA analyses for stock discrimination) to improve decision-making regarding fishery management measures and improve selective fishing techniques.

FIGURE 1. Total commercial catch of salmon, by species, in BC, 1953–2003.
(Irvine et al. 2004)

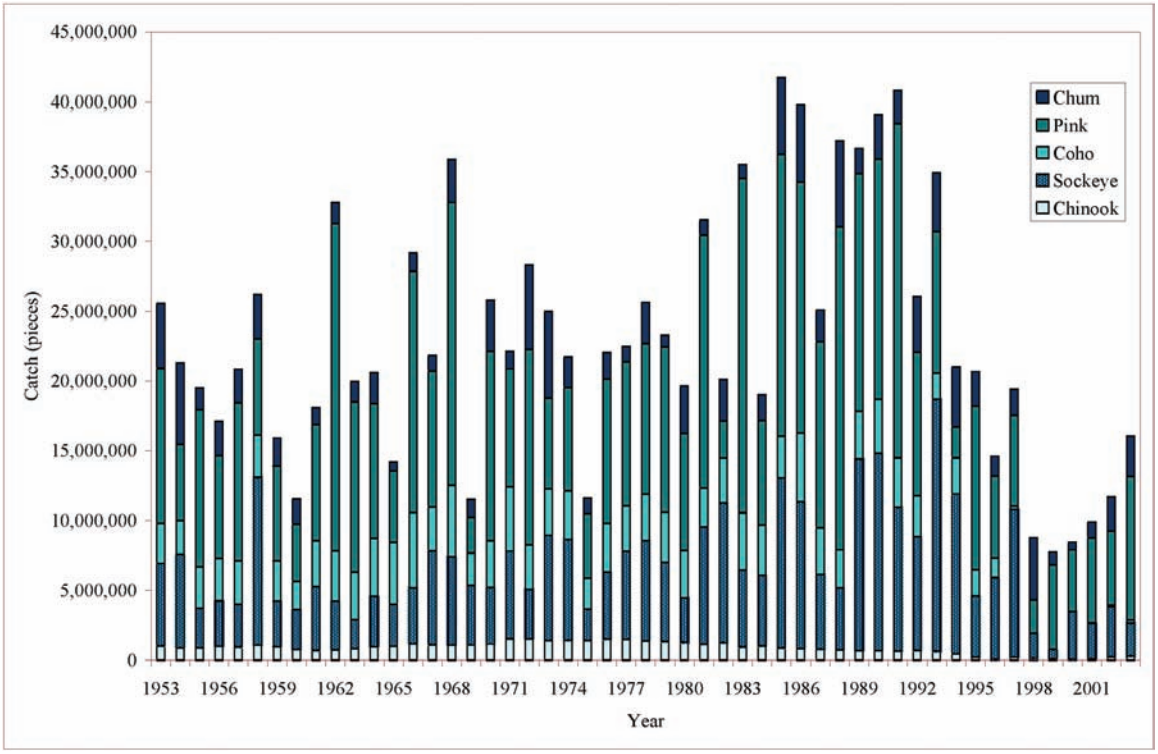

FIGURE 2. Total commercial catch of salmon in BC, 2001–2008.
(DFO Licencing Branch)

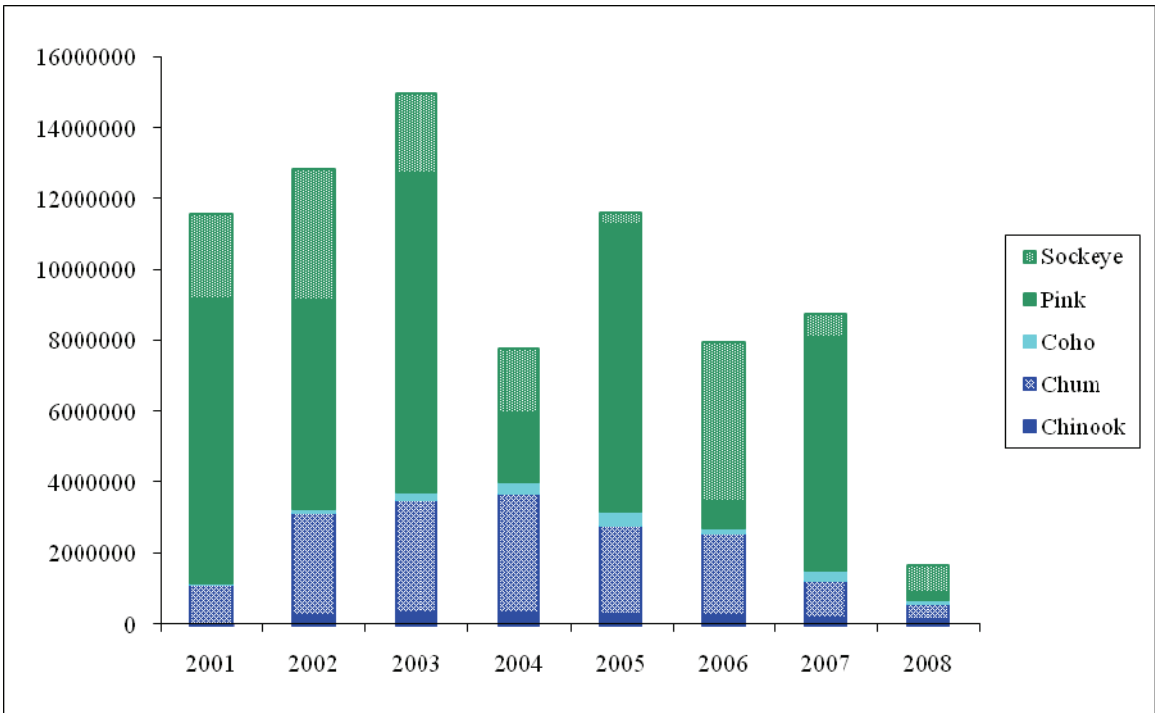

FIGURE 3. Total recreational catch of salmon, by species, in BC, 1953–2003.
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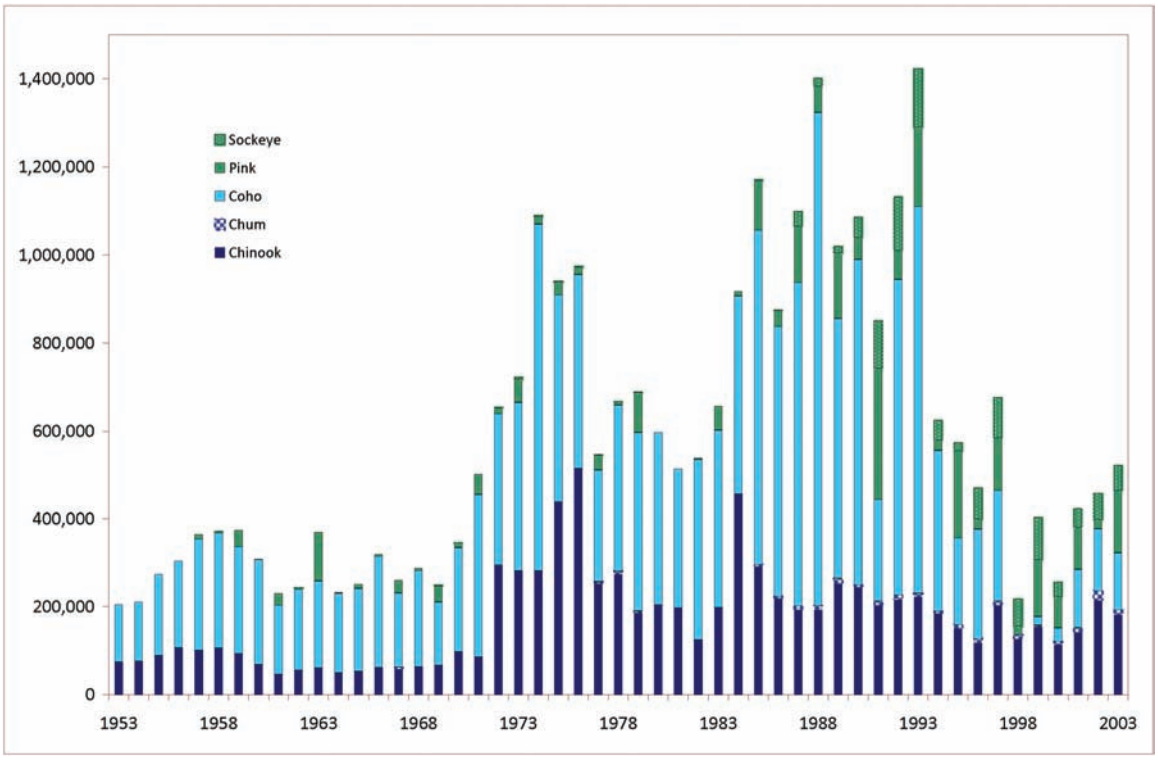
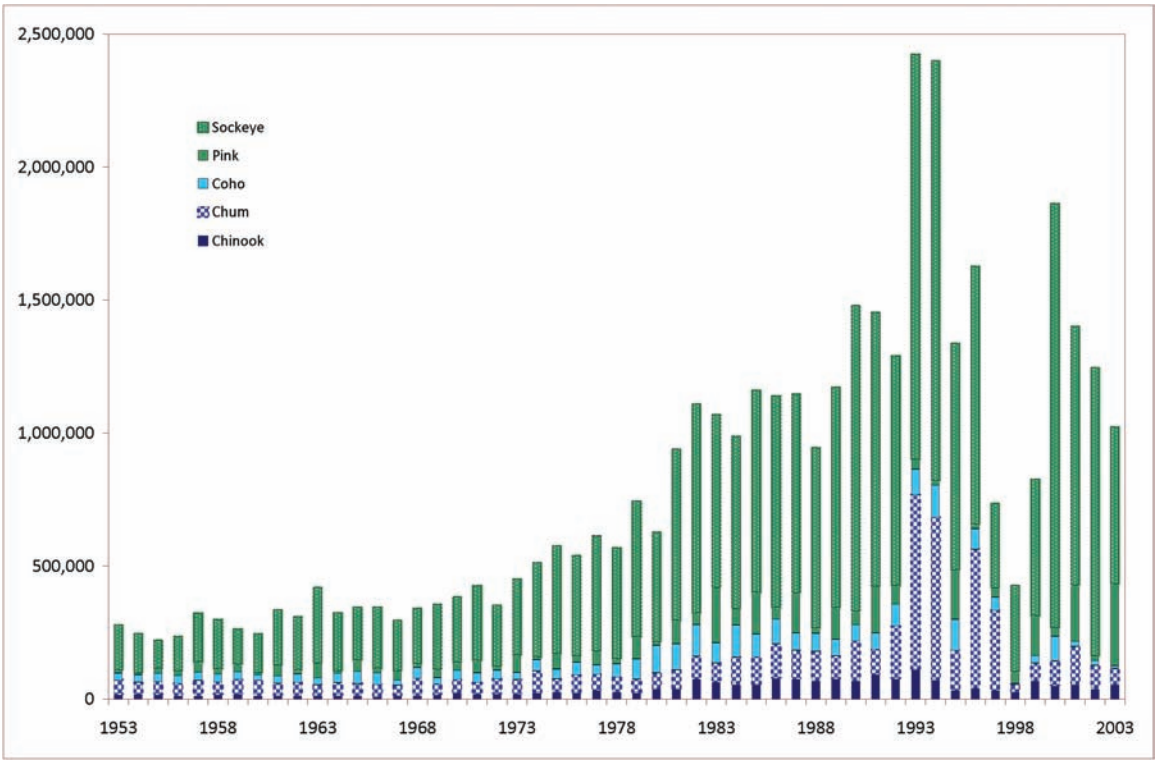
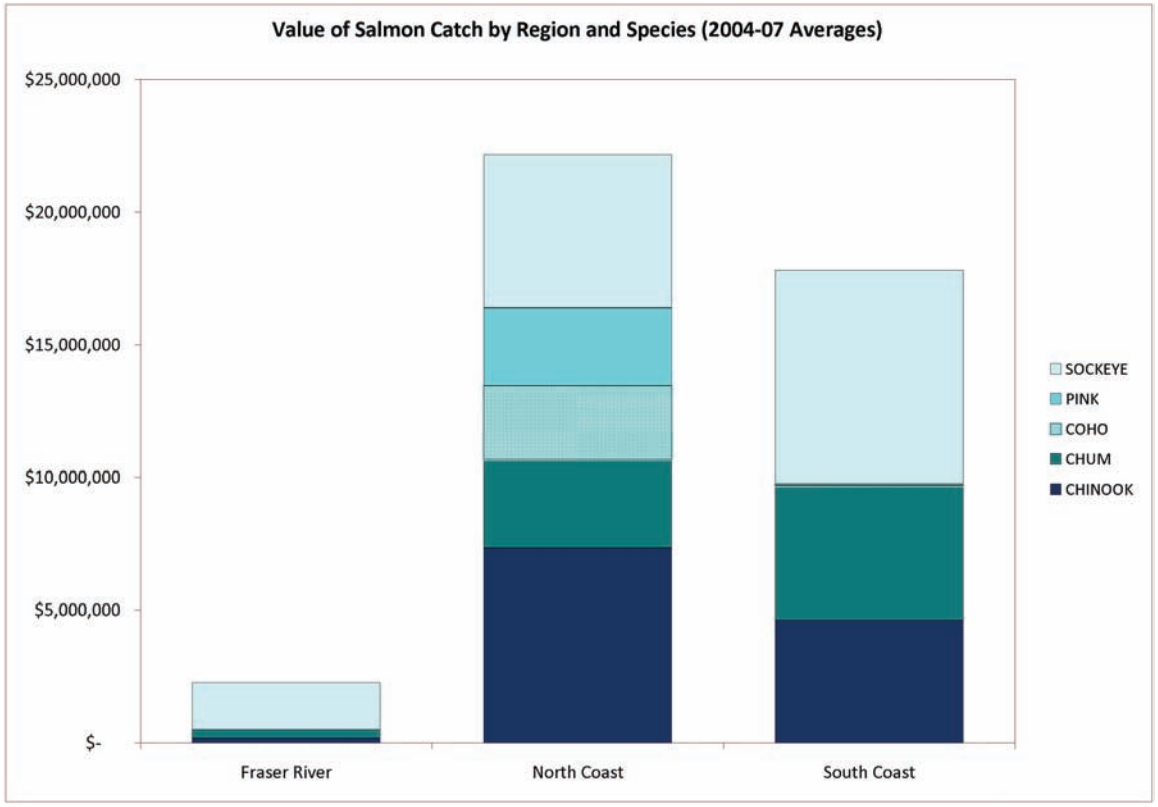


FIGURE 4. Total First Nation catch of salmon, by species, in BC, 1953–2003.
(Irvine et al. 2004)



From 2004 to 2007, most of the value in the commercial sector has been in the north coast of BC (Stat Areas 1–9) and south coast areas (11–28) with considerably less in the Fraser River approaches (Area 29) (Figure 5). Sockeye and chinook contribute most of the value to the commercial salmon industry, followed by chum salmon.

FIGURE 5. Value of the salmon fishery by region and species, 2004–2007.
(Source: DFO Catch Statistics website)



The use of selective fishing techniques is a key aspect of responsible fishing. In 1998, Fisheries and Oceans Canada launched a four-year program to assist First Nations and commercial harvesters and recreational anglers in developing increasingly selective fishing gear and practices. At the same time, the department released the report titled *Selective Fishing in Canada's Pacific Fisheries—A New Direction* in 1999, followed by *A Policy for Selective Fishing in Canada's Pacific Region* in 2001. These policies were subsequently followed by the Wild Salmon Policy, an Allocation Policy, and Canada's Pacific Fishery Reform initiative. Underpinning these initiatives is Canada's 1992 ratification of the Convention on Biological Diversity and signatory status of the United Nations FAO Code of Conduct for Responsible Fishing.

KEY ELEMENTS OF RESPONSIBLE FISHERIES

Sissenwine and Mace (2001) examined the governance of responsible fishing in a presentation to the Reykjavik Conference on Responsible Fisheries in the Marine Ecosystem. Within an ecosystem approach to fishing they defined "responsible fishing" as sustainable production of human benefits, which are distributed "fairly," without causing unacceptable changes in ecosystems. The responsibility is shared among all those involved in the fishery not just the fish harvesters:

> *"An ecosystem approach for responsible fisheries requires self-governance by the scientific community, the fishing industry, and the public (including politicians), as well as responsible fisheries management."*

They define the key elements of responsible fishing as:

- Goals and constraints that characterize the desired state of fisheries and undesirable ecosystem changes;
- Conservation measures that are precautionary, take account of species interactions, and are adaptive;
- Allocation of rights to provide incentives for conservation;
- Decision-making that is participatory and transparent;
- Ecosystem protection for habitat and species of special concern; and
- Management support, including scientific information, enforcement, and performance evaluation.

These key elements are addressed for BC salmon fisheries in a wide variety of policies and programs that are described later on in this paper. In general, Canada has strived to put in place management measures that address each of these elements, some more successfully than others.

Sissenwine and Mace (2001) further state:

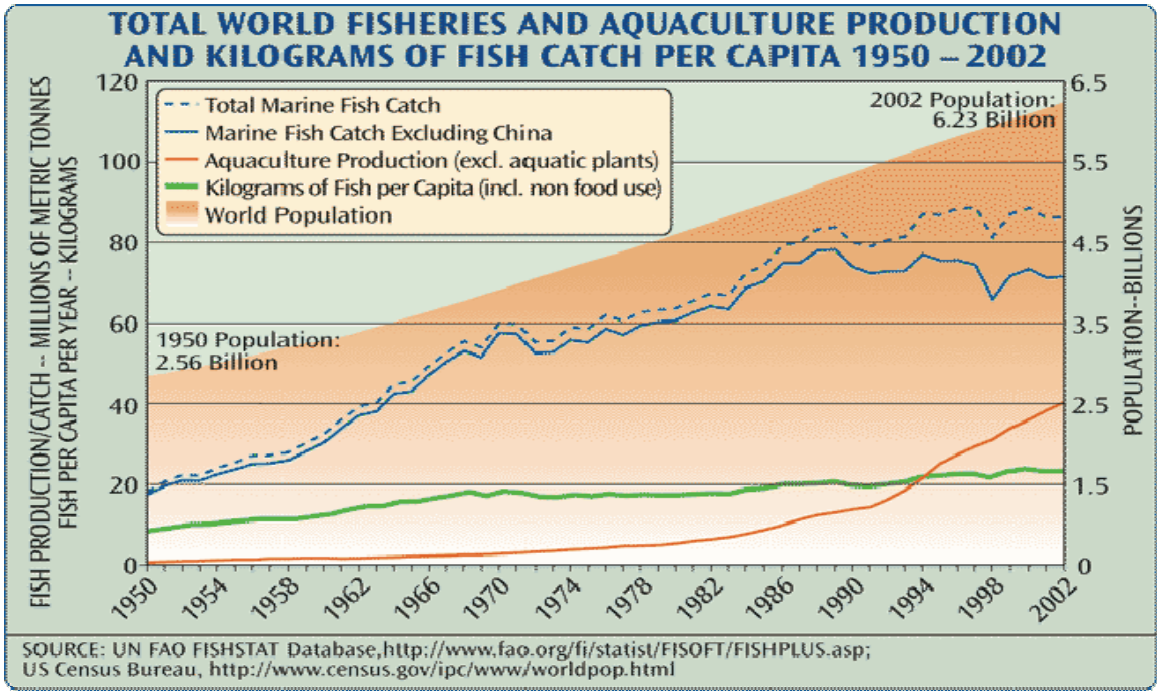
> *"For an ecosystem approach for responsible fisheries, the fishing industry should govern itself to accept responsibility for providing fisheries information, embrace collaborative research, participate in the fishery management process and live with the outcome, comply with regulations, avoid waste, and develop training to instill a responsible fishing ethic. The public (including environmentalists) should also participate in the fisheries management process and live with the outcome. Politicians should produce legislation that is clear in intent and achievable within realistic funding levels. No one should make or condone "end runs" that undermine fishery management decisions. All stakeholders should be respectful of other stakeholders."*

Few would argue with this statement. The question becomes what are the incentives to promote responsible fishing and what are or should be the consequences of not fishing responsibly; whether you are a fisher, a manager, or the public.

DRIVERS FOR RESPONSIBLE FISHING IN CANADA'S PACIFIC REGION

The world's fisheries and aquaculture production experienced great change in the early 1990s. Marine catch reached a plateau and started to decrease in some areas, aquaculture became the growth sector and the operational practice of moving 100 km from an over-fished to an un-fished area to remain profitable did not results in anticipated gains (Figure 6).

FIGURE 6. World fisheries and aquaculture production from 1950–2002.



The need for new approaches became clear. In response, the United Nations (UN) and the Food and Agriculture Organization (FAO) developed the UN FAO Code of Conduct for Responsible Fishing which was ratified in 1995. In the same year the FAO Code was followed by the UN Convention on the Law of the Sea (UNCLOS) and further defined in the "Agreement on Straddling Fish Stocks and Highly Migratory Species" which came into force in 2001. These international drivers of responsible fishing were based on new regulations and monitoring of those regulations. In 1998, a different approach was taken by the non-government Marine Stewardship Council (MSC) in motivating fisheries to become more responsible through financial incentives. A fishery that fulfilled criteria set by the MSC was labelled to be sustainable in its management and practices and resulted in higher value of the products from certified fisheries. Canada took a leading role in the development of the UN FAO Code of Conduct for Responsible Fishing and the later Canadian Code of Conduct for Responsible Fishing Operations (1998)[1] was therefore consistent with the international code and led to the development of additional Canada-wide responsible fishing policy papers. It also triggered the Selective (Salmon) Fisheries Program initiated in 1998 by Fisheries and Oceans Canada. The timely "coho crisis" in 1997 reinforced the need for the introduction of responsible fishing measures into the BC salmon fisheries and a time of experimental development of new measures of selectivity started.

[1] http://www.dfo-mpo.gc.ca/communic/fish_man/code/cccrfo-cccppr_e.htm

INTERNATIONAL AGREEMENTS AND POLICIES AFFECTING RESPONSIBLE FISHING

UN FAO CODE OF CONDUCT FOR RESPONSIBLE FISHING

In 1995, more than 17O members of the Food and Agriculture Organization of the United Nations (FAO) adopted the Code of Conduct for Responsible Fisheries. The Code stresses that those countries and all those involved in fisheries and aquaculture should work together to conserve and manage fish resources and their habitats. All people involved in fisheries should strive to maintain or restore fish stocks to levels capable of producing reasonable amounts of catch both now and into the future. In March of 1999, the Ministers responsible for fishing in their respective countries made a declaration that can be found in its entirety on the internet[2]. The main articles of the document advise signatory States of the agreement to manage their fisheries based on the following general principles (with comments relating to the BC salmon fishery in *italics* in column 3 of Table 1):

- A precautionary approach to fisheries management needs to be taken;
- Sound fisheries data need to be collected and made publicly available;
- Fisheries management decisions need to be based on the best scientific data available;
- Ensure that stocks remain economically viable;
- Safe harbours for fishing vessels and adequate servicing facilities for vessels, vendors and buyers need to be provided;
- Ensure that an administrative framework is in place to manage fish stocks on the regional and the international level;
- Encourage the development of a sustainable aquaculture industry;
- Integrate fisheries management into coastal area management; and
- Conduct ongoing fisheries research.

Table 1 shows examples of articles specific to responsible fishing in the FAO Code of Conduct for Responsible Fishing and comments by the authors that relate the article's content to the BC salmon fishery.

[2] http://www.fao.org/DOCREP/005/v9878e/v9878e00.htm

TABLE 1. Examples of articles specific to responsible fishing in the FAO Code of Conduct for Responsible Fishing and comments by the authors that relate the article's content to the BC salmon fishery.

UN FAO Code Article #:	Example Summaries of Responsible Fishing Specific Policy	Comments in Relation to BC Salmon Fishery
7.2.2.a	Reduce excess fishing capacity	*The size of the salmon fleet has been reduced but is still too large to create sufficient profit per licence*
8.5.1	Develop selectivity to minimize waste, discards, catch of non-target fish and non-fish species and impacts on associated or dependent species	*Species selectivity has become a licence requirement but stock selectivity is still coarse, discards are not always monitored*
7.2.2.b	Create economic conditions under which fishing industries operate that promote responsible fisheries	*Salmon gillnet fisheries are still fast and competitive with lower product value than could be obtained if fisheries were slowed to promote responsible fisheries. Some pilots have been underway in recent years (e.g., Area F troll)*
8.5.2.	The range of selective fishing gear, methods and strategies available to the industry should be part of policy design	*Many selectivity measures have become part of policy but are not reliably enforced*
8.5.4	The need for international cooperation to develop fishing gear selectivity, fishing methods and strategies, dissemination of research results and technology transfer	*Pacific Salmon Treaty has been signed, measures of selectivity have not been coordinated between the US and Canada*

UNITED NATIONS CONVENTION ON THE LAW OF THE SEA (UNCLOS): AGREEMENT ON STRADDLING FISH STOCKS AND HIGHLY MIGRATORY SPECIES

The 1982 United Nations Convention on the Law of the Sea[3] (UNCLOS) is the defining document of international oceans law. It has been in force since 16 November 1994 and was ratified by Canada on 06 November 2003. The Agreement (from here on referred to as "the UNCLOS Agreement") based on the "Conference on Straddling Fish Stocks and Highly Migratory Species" in 1995 replaced earlier and insufficient provisions on responsible fisheries and their selectivity in UNCLOS and came into force on 11 December 2001[4].

In concert with the UN FAO Code for Responsible Fishing, the UNCLOS agreement puts the following general policies into effect:

- It promotes good order in the oceans through the effective management and conservation of high seas resources by establishing, among other things, detailed minimum international standards for the conservation and management of straddling fish stocks and highly migratory fish stocks;
- Ensures that measures taken for the conservation and management of those stocks in areas under national jurisdiction and in the adjacent high seas are compatible and coherent; and
- Ensures that there are effective mechanisms for compliance and enforcement of those measures on the high seas, recognizing the special requirements of developing States in relation to conservation and management as well as the development and participation in fisheries for the two types of stocks mentioned above.

[3] http://www.un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm

[4] http://daccessdds.un.org/doc/UNDOC/GEN/N95/274/67/PDF/N9527467.pdf?OpenElement

The UNCLOS Agreement requires signatory states to manage their fisheries properly, aim for selectivity, coordinate their fisheries management efforts, gather reliable and publicly available fisheries data and conserve and sustain fish, their habitat and their fisheries.

Table 2 shows examples of articles specific to responsible fishing in the UNCLOS Agreement and comments by the authors that relate the article's content to the BC salmon fishery.

TABLE 2. Examples of articles specific to responsible fishing in the UNCLOS Agreement and comments by the authors that relate the article's content to the BC salmon fishery.

UNCLOS Agreement Article #:	Example Summaries of Responsible Fishing Specific Policy	Comments in Relation to BC Salmon Fishery
Preamble	Problems of over-capitalization, excessive fleet size, insufficiently selective gear, and lack of sufficient cooperation between States	*See comments to UN FAO Code of Responsible Fishing*
Article 6.2	Fisheries management applies the precautionary approach when information is uncertain, unreliable or inadequate	*The precautionary approach is applied through management for Maximum Sustainable Yield (MSY), buffers beyond MSY as suggested by the Canada Privy Council should be implemented*[5]
Article 5.f	States ensure the development and use of selective, environmentally safe and cost-effective fishing gear and techniques	*The Selective Salmon Fishing Program was initiated, responsible fishing measures became licence requirements, mixed-stock fishery are still problematic*
Article 5.i	Fisheries management takes into account the interests of artisan and subsistence fish harvesters	*Food, Social and Ceremonial(FSC) fisheries in BC are second in line only to conservation, FSC allocations are not always provided*
Article 6.3.d	Fisheries management develops data collection and research programs to assess the impact of fishing on non-target species	*Data collection on non-target species is not sufficient in the BC salmon fisheries, discard data are not collected*
Annex 2 Article 5	Develop limit reference points or target reference points for stocks and ensure that conservation and management action is triggered by them	*Limit reference points have been set in many BC salmon fisheries and are used as decision points for management action*

[5] Canada Privy Council Office (2003), A Framework for the Application of Precaution in Science-based Decision-Making about Risk.

MARINE STEWARDSHIP COUNCIL CERTIFICATION

The Marine Stewardship Council (MSC) is a non-profit organization dedicated to the long-term protection or "sustainability" of marine fisheries and related habitats[6]. The MSC standards for sustainable fisheries management were developed through an 18-month process (May *et al.* 2003) and the final MSC standard was issued in 1998. The MSC is now a fully independent organization that is governed by an independent Board of Directors advised by a panel of scientific, economic, and fishery experts.

The current MSC mission statement reads: "To safeguard the world's seafood supply by promoting the best environmental choice". To achieve this goal, fisheries are scored based on the following three principles:

Principle 1. A fishery must be conducted in a manner that does not lead to over-fishing or depletion of the exploited populations and, for those populations that are depleted, the fishery must be conducted in a manner that demonstrably leads to their recovery;

Principle 2. Fishing operations should allow for the maintenance of the structure, productivity, function and diversity of the ecosystem (including habitat and associated dependent and ecologically related species) on which the fishery depends;

Principle 3. 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 the resource to be responsible and sustainable.

The scoring of the fishery occurs through performance indicator ratings between 0–100 through a consensus process where the entire assessment team agrees to the assigned score. Scoring guideposts labelled as '100' indicate the best performance achievable for an indicator. An indicator score below 60 indicates a major deficiency in the fishery that needs corrective action. A fishery fails the assessment process if the weighted average scores for any of the three MSC Principles falls below 80, or if any individual performance indicator is assigned a score of less than 60. In either case, before certification can be awarded, the applicant must show that the factors causing the problems have been corrected. Once certified, fisheries will be awarded the opportunity to utilize an MSC promoted eco-label to gain economic advantages in the marketplace. MSC certification therefore adds value to the harvested fish and is becoming the entrance requirement for the import of seafood into many international markets. MSC certification is explicitly bound to by-catch reduction, decrease in by-catch mortality and fisheries management that facilitates these indicators of responsible fishing. As of September 2007 there were 857 MSC-labelled seafood products sold in 34 countries worldwide.

The BC Salmon Marketing Council initiated the MSC Certification process for BC's commercial salmon fishery in 2001 after Alaska was awarded MSC certification for all of its commercial salmon fisheries. Given the complexity of the fisheries, stocks, management system, social and political issues in BC, the BCSMC and DFO decided to proceed with the certification process in phases, starting with the four major BC sockeye fisheries (Nass, Skeena, Barkley Sound and Fraser). The first task in the BC sockeye process was to review existing MSC certification criteria and define a set of certification criteria for BC salmon fisheries that would be acceptable to MSC, regional fisheries scientists, environmental groups and First Nations. The BC criteria were intended to address perceived deficiencies in the Alaska salmon certification process. Table 3 provides examples of the criteria that have been used in the evaluation of the BC sockeye fisheries that are specifically relevant to the issue of responsible fishing. In August 2007, the MSC certification report for the four major

[6] http://www.msc.org/assets/docs/fishery_certification/Flow%20chart%20of%20Fishery%20Assessment%20Process.doc

BC sockeye fisheries was released for public review. Comments on this report were filed prior to the 30 November 2007 deadline and the sockeye report is currently in the final peer review phase of the MSC process. In September 2007, the BC salmon processing industry initiated the MSC process for BC's pink and chum salmon fisheries. DFO is currently preparing its initial submissions against each of the evaluation criteria for all BC pink and chum salmon fisheries (Christina Burridge, pers. comm.).

TABLE 3. Examples of articles specific to responsible fishing in the Marine Stewardship Certification Guidelines and comments by the authors that relate the article's content to the BC salmon fishery.

MSC Certification Indicator Examples for the Fraser Sockeye Fishery	MSC Certification 80–100 Scoring Guidepost Examples for the Fraser Sockeye Fishery	Example of Concerns Identified for the Fraser Sockeye Fishery
Indicator 1.1.2.1: Estimates exist of the removals for each stock unit.	Catch estimates are available for non-target stocks where the catch of the non-target stock represents a significant portion of the harvest of that stock	*For fisheries targeting Fraser sockeye, catch estimates for several depleted non-target stocks are not adequate (e.g., Sakinaw sockeye, Fraser white sturgeon)*
Indicator 2.3.1: Management strategies include provision for restrictions to the fishery to enable recovery of non-target stocks to levels above established Limit Reference Points (LRP).	The management system has a reasonable (>60%) probability of achieving long-term recovery of depleted non-target stocks	*Limit Reference Points (LRP) or their equivalent need to be defined for Fraser sockeye salmon stocks, recovery plans must be developed and implemented for stocks that are below LRP*
Indicator 3.1.8: The management system provides for socioeconomic incentives for sustainable fishing.	The management system has formal procedure for providing social and economic incentives to stakeholders in the fishery to develop and utilize sustainable fishing practices, particularly the development of selective fishing gear and practices that lead to improved conservation	*DFO's Policy for Selective Fishing in Canada's Pacific Fisheries suggests a clear commitment but its incentives for implementation of this policy have been lacking*

PACIFIC SALMON TREATY

In 1985, Canada and the United States signed the Pacific Salmon Treaty. After years of dispute over the conservation and harvest components of the treaty, the two countries finally signed the Pacific Salmon Agreement in 1999 which resulted in modification of the Pacific Salmon Treaty. The new agreement established abundance-based fishing regimes for the salmon fisheries under its jurisdiction. There are no less than 60 references to conservation in the treaty affirming the commitment by each country to preserve wild salmon. This language within the Pacific Salmon Treaty should promote responsible fishing by each country. Table 4 shows examples of articles specific to responsible fishing in the Pacific Salmon Treaty and comments by the authors that relate the article's content to the BC salmon fishery.

TABLE 4. Examples of articles specific to responsible fishing in the Pacific Salmon Treaty and comments by the authors that relate the article's content to the BC salmon fishery.

Pacific Salmon Treaty Article #	Example Summaries of Responsible Fishing Specific Policy	Comments in Relation to BC Salmon Fishery
Article III.1a	With respect to stocks subject to this Treaty, each party shall conduct its fisheries and its salmon enhancement programs so as to: (a) prevent overfishing and provide for optimum production	*Prevention of overfishing in the salmon fishery requires adherence to responsible fishing practices including selective fishing*
Article VIII.2 (see also Annex IV of the PST)	Annex IV of the PST states a desire to maximize the harvest of Tahltan/Tuya sockeye salmon in their existing fisheries while considering the conservation needs of wild salmon runs	*The most often cited measure for ensuring conservation of wild salmon stocks is the control of fisheries using harvest rates although each country is able to implement their own management actions provided they are effective in achieving conservation goals*
Article IX	In fulfilling their functions, the Panels and Commission shall take into account the conservation of steelhead	*As steelhead are taken as by-catch in many fisheries, selective fishing is a necessary measure for conservation goals (e.g., Skeena)*
Chapter 5—Coho Salmon	The Parties are encouraged to pursue selective fishery practices where critical stock problems are identified within the constraints on allowable impacts on key management units or critical stocks, provided that such selective fisheries do not compromise capabilities to meet conservation objectives for natural stocks, complete stock assessments, or evaluate fishery impacts	*Direct reference to the use of selective fishing practices in response to the coho crisis of the late 1990's*

CONCLUSIONS: INTERNATIONAL DRIVERS FOR RESPONSIBLE FISHING

International drivers for responsible fishing are requiring signatories to manage their fisheries:

- To enforce by-catch reduction and release and to promote selective fishing practices (UN FAO Code, UNCLOS, MSC Certification);
- To reduce excessive fleet size and overcapitalization (UN FAO Code, UNCLOS);
- To reliably assess the condition of all stocks or conservation units large and small, enhanced and wild, targeted and non-targeted (UNCLOS, Pacific Salmon Treaty, MSC Certification);
- To focus their management on adding value and thus creating conditions for long-term economic sustainability of their fisheries (UNFAO Code, MSC Certification);
- To promote international cooperation in fisheries management (UNFAO Code, Pacific Salmon Treaty);
- To protect sustenance fisheries (UNCLOS, MSC Certification);
- To set limit reference points or minimum sustainable escapement numbers for all stocks or conservation units (UN FAO Code);
- To collect catch data and assess the impact of fishing on non-target species; and
- To protect non-target stocks in salmon fisheries (Pacific Salmon Treaty).

While Canada is a signatory in the mentioned international agreements and is attempting to earn MSC certification, many of the international policies are not yet part of the management of the BC salmon fishery. For example, limit reference points and stock assessment for many conservation units are currently lacking, the fleet is too large, overcapitalized and not economically sustainable, not all First Nation fisheries are adequately protected and selective fishing practices are encouraged but not fully enforced. Fishery and catch monitoring programs are weak and data is lacking in many fisheries.

CANADIAN LAW AND POLICIES AFFECTING RESPONSIBLE FISHING

The following section describes Canadian legislation, policies and programs that promote responsible fishing in Canadian fisheries.

THE FISHERIES ACT AND BILL C32

Canada's Fisheries Act is the main legislation governing the protection of fish and fish habitat and management of domestic fisheries. While the Act itself says little about responsible fishing (other than through licensing requirements), the Fishery (General) Regulations, [S.O.R./93-53] require fish harvesters to return incidentally caught live fish to the waters in which they were caught with the least possible harm. The penalty for not doing so is set at $50.00.

General licence conditions for each of the salmon fisheries can be found at http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/MPLANS/conditions.htm. Mandatory selective fishing measures such as revival tanks, barbless hooks, gillnet characteristics and use, and species retention restrictions are documented for each licence type.

In December of 2006, Canada proposed a modernized fisheries act in the form of Bill C45. After a series of consultations with stakeholders, the legislation was re-drafted and re-introduced to the legislature as Bill C32. The proposed new legislation has a number of key application principles describing how fisheries are to be managed by the Minister of Fisheries and Oceans:

- Affirmation that the fisheries are a common property resource and the intent of Parliament to manage the fisheries as such for the benefit of Canadians;
- Affirmation that the Minister must take into account conservation in licensing and allocation decisions and then all other important considerations;
- Affirmation that the Minister must seek to apply an ecosystem approach;
- Affirmation that the Minister must seek to apply a precautionary approach; and
- Affirmation that the Minister must seek to manage consistent with aboriginal and treaty rights.

While the current Fisheries Act is enabling legislation for the Governor in Council to manage Canadian fisheries, it did not have the specific language of application principles that the new legislation does. Fines of $50 for not releasing incidental by-catch with the least harm possible amount cannot serve as a deterrent but are considered a cost of doing business. Moreover, they are rarely enforced. In combination with positive compliance incentives that are discussed at different points in this report, fines have to be higher and enforced to have any effect. If passed, Bill C32 will clarify the responsibilities of the Minister with respect to conservation and protection of BC salmon and support, more clearly in law, responsible fishing.

SPECIES AT RISK ACT

The *Species at Risk Act* (SARA) was proclaimed in June 2003. The Act, in part, fulfils a Canadian commitment under the United Nations Convention on Biological Diversity[7] to preserve biological diversity and to coordinate an approach between the federal and provincial/territorial governments to protect specie at risk[8]. Under SARA, DFO is responsible for protecting aquatic species at risk and their habitat. This responsibility includes the legal requirements to implement prohibitions, develop recovery and action plans, and protect critical habitat. As of December 2007, in addition to those for numerous non-salmon species, DFO has developed recovery strategies for Cultus Lake sockeye, Sakinaw Lake sockeye, and Interior Fraser coho. None of these stocks were ultimately listed under SARA despite being recommended for listing by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The federal government's decision not to provide legal protection through SARA was based on concern for potential socio-economic impacts of large-scale fishery closures to protect small populations of salmon. The government also stated at the time that adequate protection of theses populations was available through the Fisheries Act.

> *The Species at Risk Act is considered less flexible legislation than the Fisheries Act and legal listing under SARA could compel DFO into complete closure of large mixed-stock fisheries to protect weaker conservation units or populations. Even the threat of SARA listing can result in changes to the management system. Unfortunately it appears necessary to drive a population to near extinction before drastic management changes to protect it are implemented.*

ABORIGINAL AND DOMESTIC TREATY RIGHTS

The Constitution of Canada and numerous court decisions have affirmed that Canada's First Nations have ancestral and treaty rights. One of these rights is commonly interpreted as a priority to fish for domestic purposes (often termed Food, Social and Ceremonial (FSC) purposes born out of the 1990 Sparrow Decision and therefore entrenched in law) subject only to conservation. Fisheries managers are therefore required to manage fisheries to provided sufficient fish to First Nations to meet their FSC needs prior to meeting commercial and recreational sector allocations. First Nation FSC fisheries for salmon occur throughout the coastal migration range of returning salmon and are generally targeted on specific stocks or species but all species caught are generally taken for use. As such, and inherent to First Nation culture, discards of unwanted by-catch in these fisheries is a rare event except where regulations prohibit retention (e.g., Fraser River white sturgeon). The majority of the FSC catch of salmon in BC occurs in terminal areas but there can still be incidences of harvests of stocks for which there is a conservation concern (e.g., harvests of Cultus Lake sockeye in First Nation fisheries in the lower Fraser). In this regard, First Nations in BC have a strong history of curtailing their fisheries to meet conservation needs when required. First Nation fisheries occurring in ocean areas of BC suffer from similar issues as commercial fisheries on mixed-stocks when threatened stocks occur. However, given the relatively small proportion of the total Canadian catch of salmon that these First Nation FSC fisheries comprise, this is not as pressing an issue as for the commercial sector.

There is currently only one First Nation Treaty Settlement in BC. The Nisga'a Final Agreement provides for specific allocations of each salmon species as a function of the Total Return to Canada (TRTC). The Nisga'a Final Agreement salmon provisions have enabled improved fisheries management for salmon and since it's coming into effect in 2000, conservation objectives have been met.

[7] http://www.cbd.int/doc/legal/cbd-un-en.pdf

[8] http://www.sararegistry.gc.ca/approach/strategy/default_e.cfm#2

Two other treaties are currently before the Canadian Parliament having been ratified by the Provincial Legislature. These are with the Maanulth and Tsawwassen First Nations. These treaties also provide for specific allocations of salmon to each of the First Nations, subject to conservation, public health and safety. Unlike the Nisga'a Final Agreement, these agreements provide the First Nation with either a fixed quantity of salmon or a proportion of the Canadian Total Allowable Catch.

Fisheries under Aboriginal and Treaty rights to salmon have first priority after conservation. They are often carried out in terminal fishing areas and therefore offer and opportunity to fish on a stock-selective basis and showcase responsible fishing. Based on the fiduciary responsibility of the federal government to ensure that sufficient salmon are provided not only for conservation but also for First Nation domestic fisheries, is another indirect important driver for sustainable fishing in all fishing sectors.

A NEW DIRECTION FOR CANADA'S PACIFIC SALMON FISHERIES

In 1998 a discussion paper entitled *A New Direction for Canada's Pacific Salmon Fisheries* was distributed by DFO to stakeholders to describe broad policy issues associated with a new approach to the management and conservation of Pacific salmon fisheries. The paper put forward 12 principles that cover the full range of activities involved in the management of the resource. The principles fall into three categories—conservation, sustainable use and improved decision making. Six key messages relate directly to responsible fishing[9]:

- Conservation of the stocks would take precedence in managing the resource;
- A precautionary fisheries management approach would be applied;
- An ecological approach would guide fisheries and oceans management in the future;
- Any trade-offs between current harvest benefits and long term stock well-being would be resolved in favour of the long term;
- Selective fishing methods would be used to harvest salmon; and
- The commercial fishery should diversify into other species, and reduce dependence on the salmon resource.

An additional two messages relate to fishing opportunities:

- First Nations requirements for food, social, and ceremonial purposes would continue to have first priority after conservation requirements; and
- Recreational fisheries would be provided with more reliable and stable fishing opportunities.

The "New Direction" discussion paper clearly directs all salmon fisheries towards responsible fisheries management and practices, explicitly mentioning the importance of the First Nations and Recreational Fisheries, two sectors that traditionally have high species selectivity and low discard mortalities.

[9] http://www-comm.pac.dfo-mpo.gc.ca/pages/release/bckgrnd/1998/bg981014a_e.htm

ALLOCATION POLICY FOR PACIFIC SALMON

In December 1998, DFO released a discussion paper entitled *An Allocation Framework for Pacific Salmon*[10]. This paper proposed a series of seven principles to guide decisions around the allocation of harvestable surpluses in the salmon fishery. Based on the discussion following the framework's publication an Allocation Policy was developed. This policy represented a significant step towards providing certainty and fairness by establishing clear priorities for allocation between fishery sectors and within the commercial fishery between gear types. The policy is expected to guide salmon allocation decisions into the foreseeable future.

A fundamental aspect of the Allocation Policy is that resource allocations would be shifted to sectors employing selective fishing methods while adhering to the following principles:

- Following conservation, priority of harvest is affirmed for First Nation's food, social and ceremonial requirements and fishing rights that may be defined in treaties;
- After First Nations priorities, a priority to the recreational sector for chinook and coho salmon is given and provides for more predictable recreational fishing opportunities for sockeye, pink and chum salmon;
- The commercial sector allocation of the total allowable catch of the combined recreational and commercial harvest of sockeye, pink and chum will still be 95% or higher, after the priority described above for the recreational sector; commercial harvest of chinook and coho will occur when abundance permits;
- Selective fishing will be encouraged by setting aside a portion of the total available catch for commercial licence holders to test more selective harvesting gear and technology; and
- Target allocations for the commercial sector will be set on a coast-wide basis by gear and may be subject to adjustments over time to account for conservation requirements, and possible changes resulting from the voluntary salmon licence retirement program.

The Allocation Policy affirms that First Nations FSC fisheries have highest priority for all species while sockeye, chum and pink salmon will be next allocated to the Commercial fishing sector and coho and chinook next allocated to the recreational sector. In combination with the DFO Policy for Selective Fishing (see below), the Allocation Policy further promotes responsible fishing since non-target species will need to be released by commercial or recreational sectors to adhere to the policy over time.

[10]http://www-comm.pac.dfo-mpo.gc.ca/publications/allocation/st9810e.htm

DFO POLICY FOR SELECTIVE FISHING IN CANADA'S PACIFIC FISHERIES

The objective of the DFO Policy for Selective Fishing in Canada's Pacific Fisheries[11] (2001) is to ensure that selective fishing technology and practices are adopted where appropriate in all fisheries in the Pacific Region, and that there are continuing improvements in harvesting gear and related practices. Selective fishing is identified as a requisite element of conservation-based fisheries as noted in the responsible fishing drivers described above. In meeting conservation objectives, fishing opportunities and resource allocations will be shaped by the ability of all harvesters—First Nations, commercial and recreational anglers—to fish selectively. The five principles of the Selective Fishing Policy are:

Principle 1.

- Conservation of Pacific fisheries stocks is the primary objective and will take precedence in managing the resource:
    - Adoption of a precautionary approach to all fisheries,
    - The long-term productivity will not be compromised for short-term harvest benefits, and
    - First Nations and other stakeholders will together be responsible and accountable for sustainable fisheries.

Principle 2.

- All Pacific recreational and commercial fisheries will adhere to selective fishing standards within set timelines. Examples of standards are:
    - Certification of licence holders in responsible and selective fishing standards,
    - Classification of fisheries according to risk; higher risk fisheries would require more stringent selective fishing standards and techniques, and
    - Fishery or vessel by-catch limits that may trigger closure of a fishery when the overall by-catch limit is reached or the exit of a vessel from a fishery when a particular vessel surpasses its by-catch limit.

Principle 3.

- In fisheries where selective harvesting standards are not met within prescribed timelines, and by-catches prevent achievement of conservation objectives, fishing opportunities will be curtailed. Steps in resolving the inability to meet standards will be:
    - Modify existing gear and practices,
    - Re-allocate within a fishing sector, and
    - Re-allocate between sectors.

[11] http://www-comm.pac.dfo-mpo.gc.ca/publications/selectivep_e.pdf

Principle 4.

- Four fundamental strategies in fishing selectively to minimize mortalities and maximize chances for survival of non-target fish, invertebrates, seabirds and marine mammals will be adopted through increased knowledge of fishing gear and practices. The strategies in order of preference are:
    - Avoidance of non-target species and stocks through time and area restrictions,
    - Avoidance through gear design,
    - Release alive and unharmed before being brought aboard or ashore, through gear design, and
    - Release alive and unharmed from the deck of the vessel or landing site (e.g., shore or fishing pier).

Principle 5.

- First Nations and the recreational and commercial fishing sectors will be responsible for continuous learning and skills development and transfer of responsible and selective harvesting practices

DFO's Selective Fishing Policy also allocates a portion of the total available commercial catch to existing commercial licence holders to test alternative, more selective harvesting gear. It also advises that, over time, commercial allocations will favour those who can demonstrate their ability to fish selectively. With regards to Principle 1: Point 2 a detailed manual was developed to calculate the "Measurement of Fishing Gear Selectivity[12] (1995)".

> *The Policy for Selective Fishing in Canada's Pacific Fisheries if fully implemented would guide all of the Pacific Fisheries towards selectivity. Implementation would consistently re-allocate catch from the less to the more selective sectors thereby providing incentive to fish more selectively. The measurement manual for selectivity should be widely used but needs financial support to allow for the necessary research.*

[12]http://www-comm.pac.dfo-mpo.gc.ca/publications/methodology/default_e.htm

WILD SALMON POLICY

The Wild Salmon Policy was completed by DFO in 2005 and is currently in the process of being implemented by the Department. The goal of the Wild Salmon Policy is "to restore and maintain healthy and diverse salmon populations and their habitats for the benefit and enjoyment of the people of Canada in perpetuity." The policy describes how DFO will meet its responsibilities for the conservation of wild Pacific salmon guided by the following four principles:

- Conservation of wild Pacific salmon and their habitats is the highest priority in resource management decision-making;
- Resource management processes and decisions will honour Canada's obligations to First Nations;
- Resource management decisions will consider biological, social, and economic consequences, reflect best science including Aboriginal Traditional Knowledge (ATK), and maintain the potential for future generations to meet their needs and aspirations; and
- Resource management decisions will be made in an open, transparent and inclusive manner.

There are three specific objectives of the policy:

- Safeguard the genetic diversity of wild Pacific salmon;
- Maintain habitat and ecosystem integrity; and
- Manage fisheries for sustainable benefits.

The WSP states that it will adhere to the use of precaution and be consistent with the Privy Council Office[13] framework and FAO[14]. The goals of the WSP are to be met through a series of strategies designed to assess and monitor the status of wild salmon and their habitats. A key outcome of the WSP will be strategic plans that:

- Specify long-term biological targets for conservation units (CU) and groups of CUs that ensure conservation and sustainable use;
- Identify recommended resource management actions to protect or restore Pacific salmon, their habitats, and ecosystems in order to achieve these targets; and
- Establish timeframes and priorities for actions.

The Wild Salmon Policy, if fully implemented can provide significant incentive to fish responsibly for Pacific Salmon. However, the Federal Government has clearly stated that it must be implemented within the current fiscal situation for DFO. Its success will ultimately depend on adherence to its principles by all members of the salmon community.

[13] Canada Privy Council Office (2003), *A Framework for the Application of Precaution in Science-based Decision-Making about Risk*

[14] FAO (1995), *Precautionary Approach to Fisheries; Part 1: Guidelines on the precautionary approach to capture fisheries and species introductions*

RESOURCE MANAGEMENT SUSTAINABLE DEVELOPMENT STRATEGY

The DFO has recently developed a strategy for sustainable resource development. Of particular relevance to the management of the Pacific salmon fishery are two documents that are intended to guide fishery managers in employing the precautionary approach[15]. These are more explicitly described in *A Harvest Strategy Compliant with the Precautionary Approach* (Canadian Science Advisory Secretariat Science Advisory Report 2006/023) and a fisheries checklist for managers. The strategy is consistent with the Wild Salmon Policy and requires the determination of Limit Reference Points (LRP) and Stock Status Zones (SSZ).

The stock status zones are created by defining the LRP at the Critical: Cautious zone boundary and an Upper Stock Reference Point (USR) at the Cautious: Healthy zone boundary and the Removal Reference or maximum removal rate for each of the three zones. Achievement of sustainable management for specific stock groupings should necessitate responsible fishing.

INTEGRATED FISHERIES MANAGEMENT PLANNING

Through Integrated Fisheries Management Plans (IFMPs) DFO and other stakeholders lay out the guidelines for annual fishing plans and management of Pacific salmon and other fish species for all licence areas on Canada's Pacific Coast. The stakeholders are organized in the Integrated Harvest Planning Committee (IHPC) and for salmon the committee is typically comprised of First Nations, recreational and commercial interests (as represented by the Sport Fishing Advisory Board and the Commercial Salmon Advisory Board) and the Marine Conservation Caucus (representing a coalition of environmental organizations). The general objective of the IFMP process is to ensure that stocks are returning at sustainable levels. When returns decline below sustainable levels, management actions are taken which may include reducing the impact of fisheries on specific stocks, strategic enhancement and habitat restoration. All IFMP-based fishing plans are rooted in, and therefore implement, the international and national policy framework described above under the "Canadian and International Law and Policies Affecting Responsible Fishing".

IFMPs contain area- and species-specific information along with the factors that influence the decision making process for harvest. The plans incorporate the results of pre- and in-season consultation to establish opening times, areas, and harvest levels which are subject to change as the predictability of the return improves.

Specifically with regards to responsible fishing objectives for stocks of concern are listed, allocation percentages for all species and sectors are given, and species and sector specific selective fishing measures are described and justified in detail.

As a primary conservation and protection objective, compliance with Federal acts and regulations is listed along with statements regarding the commitment to prosecute violators with particular attention given to the enforcement of the mandatory selective fishing measures such as revival tanks, brailing, catch reporting requirements, short sets, barbless hooks (recreational and troll) and non-retention of prohibited species.

> *Measures of responsible fishing outlined in national and international policies are implemented on the fishing grounds by Integrated Fisheries Management Plans. These plans describe management measures and selective fishing requirements to ensure that conservation goals are met. They provide the necessary level of detail required to support penalties for non-compliance.*

[15] Available from website at http://www.dfo-mpo.gc.ca/communic/fish_man/consultations/RMSDF-CDDGR/index_e.htm

GROUNDFISH INTEGRATION

The management of the groundfish fishery on Canada's Pacific Coast tries to balance the harvest of more than 50 individual species and seven distinct harvester groups to conserve each species while allowing access to the fish for all harvesters. In contrast to the harvest of salmon species where mixed stock fisheries are a concern, groundfish fisheries constantly encounter mixed species scenarios. Therefore unwanted by-catch is easier to identify by the trained eye. Groundfish harvest is dependent on the species regulated through a combination of Individual Vessel Quotas and Individual Quotas independent of vessels. Since 2003, DFO has focused on working with the commercial groundfish harvesters and others to address management and sustainability issues in the commercial groundfish fisheries. Following significant work through the Commercial Groundfish Industry Advisory Committee (CGIAC) and the Commercial Industry Caucus (CIC), a three year pilot integration program was introduced in the commercial groundfish fisheries in 2006. The reforms focused on 100% at-sea monitoring and 100% dockside monitoring, individual vessel accountability for all catch, both retained and released, individual vessel quotas and reallocation of these quotas between vessels and fisheries to cover by-catch of non-directed species[16]. Five guiding principles were identified for the commercial groundfish sector:

- All rockfish catch must be accounted for;
- Rockfish catches will be managed according to established rockfish management areas;
- Fish harvesters will be individually accountable for their catch;
- New monitoring standards will be established and implemented to meet the above three objectives; and
- Species and stocks of concern will be closely examined and actions such as reduction of Total Allowable Catch and other catch limits will be considered and implemented to be consistent with the precautionary approach for management.

The Groundfish Integration Program is designed as follows:

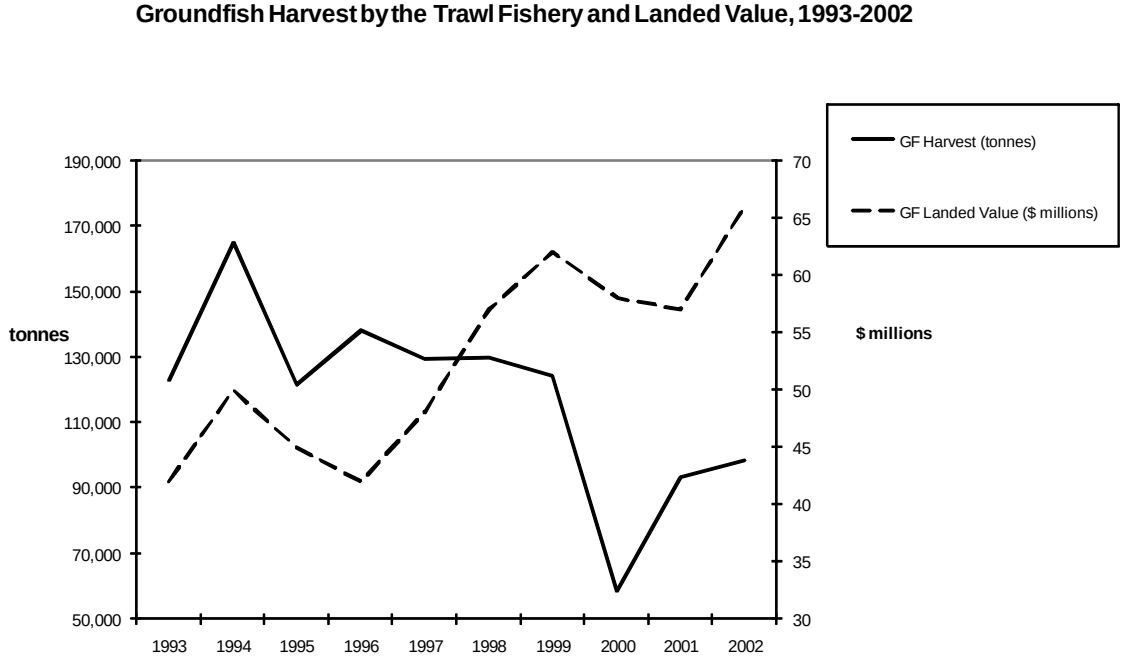
- For the species that are most frequently encountered in an area, specific Total Allowable Catch is set for all sectors as a species- and area-specific quota;
- The area-species quotas are then split between the different sectors and individual quotas for each species and area are attached to harvesters or vessels. Quotas can be bought or traded within or among sectors for the duration of the pilot program or three years; after that only within sector quota trades or sale will be permitted;
- The quota for all species and areas that is linked to each vessel is the cap for the fishing effort. Once the cap is reached the vessel has to cease its fishing activities in the area or buy more quota;
- A commercial area specific harvest allocation is also set for non-quota species and split by harvest sectors;
- Species not covered by quota or Total Allowable Catch regulations also have to be retained and their catch is limited by trip limits or they have to be recorded and discarded at sea; and
- All fishing operations are covered by 100% monitoring through cameras or observers and each vessel is accountable for its compliance with limits and rules.

[16] http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/MPLANS/plans08/08_GroundfishIFMP.pdf

While the total landed weight of the BC groundfish fishery has decreased between 1998 and 2002, the value of its landings has increased (Figure 7). Both of these developments have often been described as positive outcomes of responsible fishing (Hillborn *et al.* 2005).

> *The Groundfish Integration Program is a tool of motivation to selectively harvest the target quota species while avoiding all others. Discarding of fish is minimal and accounted for since most species can be sold legally. Once quota is reached, fishing operations have to be halted. Thus, the fishery has been slowed down and allows harvesters to concentrate on quality rather than quantity and implement measures of responsible fishing.*

FIGURE 7. The development of groundfish harvest and its landed value during Individual Transferable Quota (ITQ) or Individual Vessel Quota (IVQ) introduction, 1993–2003.
(From: Presentation on Groundfish Integration Bruce Turris 2007)



PACIFIC FISHERIES REFORM

On 14 April 2005, the Minister of Fisheries and Oceans announced a new management reform initiative, called Pacific Fisheries Reform. This initiative is intended to address a number of continuing problems in the sustainable management of fisheries resources, such as poor economic performance, particularly in the commercial salmon fishery as identified in the report *Treaties and Transitions: Towards a Sustainable Fishery on Canada's Pacific Coast* (McRae and Pearse 2004). Pacific Fisheries Reform is also intended to address the aspirations of First Nations for increased economic access to fisheries resources as described in the Jones *et al*. (2004) report named *Our Place at the Table*. The five key elements of Pacific Fisheries Reform are:

- Resource conservation through a precautionary approach;
- Certainty and stability by establishing clear rules for harvesting and associated monitoring and by better defining the shares of the available catch for each participant or group of participants in the fisheries;
- First Nation's place in the fishery through interim arrangements (pre-treaty) that provide increased access to economic fisheries;
- Shared management responsibility and accountability including shared funding of management costs; and
- Realizing social and economic potential and self-reliance of fisheries.

Background documents supporting Pacific Fisheries Reform[17] generally recognize that among all fisheries in BC, the need for reform is greatest in the BC salmon fishery. Conservation concerns are large and the fishery is economically troubled. It is also recognized that conservation concerns will inevitably reduce the available harvests in mixed stock fisheries unless means can be found to harvest the stronger and more abundant components of the runs selectively.

The following principles underlay Pacific Fishery Reform:

- Conservation is paramount (e.g., consistency with the Wild Salmon Policy);
- Consistent legal framework;
    - Pacific fisheries resources are a common property resource managed by the Minister of Fisheries and Oceans,
    - Fisheries must be conducted under an integrated management plan authorized by the Minister; and;
    - All commercial participants fish under the same priority of access and similar rules.
- Aboriginal and treaty rights of First Nations;
    - First Nations access to food, social and ceremonial fisheries will be respected, and
    - First Nations interests in increased economic access will be addressed in a manner consistent with Canada's treaty process.
- Fair transfer of fishing opportunity;
    - Transfer of economic fishing opportunity to First Nations will be accomplished through voluntary licence retirement from willing sellers, and within existing programs, to mitigate impacts on established fish harvesters.

[17] A Discussion Paper on the Implementation of Pacific Fisheries Reform, DFO, September 2005

- Stable resource access and allocation; certainty will be provided for allocations between harvest sectors (First Nations, recreational and commercial);
    - Allocation policy as it pertains to chinook and coho salmon will be maintained,
    - Certainty of harvest shares will be provided to commercial participants, and
    - Commercial harvesters will enjoy a similar level of certainty regarding fisheries access.
- Responsibility and accountability;
    - First Nations and stakeholders will assume a greater role in operational decision making and program delivery through effective co-management processes.
- Management regimes for commercial fisheries;
    - Fleets will be enabled to self-adjust,
    - Resource management practices will be designed to optimize economic performance while meeting conservation objectives,
    - Fleets will have the capacity to assume a larger share of the cost of management of their fishery,
    - Catch monitoring and independent validation will be implemented, and
    - Measures will be adopted to provide confidence that adequate compliance is achieved.
- Transition and adjustment;
    - Existing government programs will be coordinated to best meet the needs of those impacted by change.

Many of the principles described under Pacific Fishery Reform are consistent with those stated in Bill C32, the Wild Salmon Policy, and the Allocation Policy. The Pacific Fisheries Reform is therefore directly in line with other policies of responsible fishing.

PACIFIC INTEGRATED COMMERCIAL FISHING INITIATIVE

The Pacific Integrated Commercial Fishing Initiative is a federal program tasked with addressing Pacific Fisheries Reform. The five year program is designed to support the long term viability of BC commercial fisheries while sustaining fisheries resources. It is focused on the following four key elements[18]:

- Improved Pacific Co-Management approaches to establish more effective mechanisms for increasing the collaboration of resource users in commercial fisheries decision-making;
- First Nation Participation in Integrated Commercial Fisheries BC-wide through voluntary commercial licence retirement;
- First Nations Capacity Building to support the development of First Nations commercial fisheries businesses; and
- Fisheries Accountability Measures to support enhanced fisheries monitoring, catch reporting, greater enforcement and enable the development of a traceability system.

[18] http://www-comm.pac.dfo-mpo.gc.ca/pages/consultations/Consultation2007/Presentations/Adobe Final Presentations/PICFI overview – fall dialogue%20FINAL.pdf

The promotion of First Nation participation in fisheries must be done in a way that ensures viable fisheries. It is envisioned that some of this increased participation will come in the form of enhanced terminal fisheries which would reduce harvests in mixed-stock ocean fisheries. A pilot program has been underway in the Skeena River to provide commercial fishing opportunities to First Nations. The location of these fisheries reduces the harvest of non-target stocks and species from levels that would occur in the ocean gillnet fisheries. Nevertheless, the commercial fisheries in the Skeena River are still harvesting a mixture of stocks. To maintain at least species selectivity, selective fishing techniques such as beach seining are well enforced licence requirements. Stock selectivity is tried to be addressed through openings times and area closures.

HARVESTER LED INITIATIVES

Canadian Code of Conduct for Responsible Fishing Operations: In 1994, the Canadian commercial fishing industry moved to create the "Canadian Code of Conduct for Responsible Fishing Operations"[19] that built on the "United Nations Convention on the Law of the Sea (UNCLOS): Agreement on Straddling Fish Stocks and Highly Migratory Species" described earlier in this document. The commercial sector code was designed to meet the unique needs of Canadian commercial fish harvesters, and be built by the industry for the industry. It provides operational standards and practical directions to aid in attaining responsible and sustainable harvesting operations for all commercial fishing operations in Canadian waters. The code encompasses 10 Conservative Principles, the foundations for conservation, and 36 Operational Guidelines, the ways to achieve conservation.

The now defunct Canadian Responsible Fisheries Board, made up of commercial harvesters, was responsible for overseeing ratification of the Code by commercial fishing organizations in Canada. Board members were chosen by Canadian commercial fish harvesters and represented the Atlantic and Pacific coasts, the Arctic and freshwater fisheries, and Aboriginal commercial fish harvesters.

In the Pacific Region, the following organizations ratified the code in December of 1999: Deep Sea Trawlers Association of BC, Area D Gillnet Association, Area E Gillnetters Association, Fishing Vessel Owners' Association of BC, Pacific Gillnet Association, Pacific Trollers Association, Northern Trollers Association, BC Beam Trawlers Association, Underwater Harvesters Association, Pacific Urchin Harvesters Association, Pacific Halibut Management Association of BC, Gulf Trollers Association, and Krill Trawlers Association.

[19] http://www.dfo-mpo.gc.ca/communic/fish_man/code/cccrfo-cccppr_e.htm

TABLE 5. Examples of articles specific to responsible fishing in the Canadian Code of Responsible Fishing and comments by the authors that relate the article's content to the BC salmon fishery.

Canadian Code of Responsible Fishing Article #:	Example Summaries of Responsible Fishing Specific Policy	Comments in Relation to BC Salmon Fishery
Principle 6	To the extent practical, fish harvesters will minimize unintended by-catch and reduce waste and adverse impacts on the freshwater and marine ecosystems and habitats to ensure healthy stocks	*Selective fishing measures have been made licence requirements and are generally adhered to; when economic conditions undermine motivation, exemptions are made (Skeena 2006); positive compliance motivators are needed*
Guideline: 2.1	Develop protocols (including, when practical and appropriate, the use of selective fishing gears and practices) regarding the catch of non-targeted resources which jeopardize the health of the stocks	*See comments to Principle 6*
Guideline 2.4	Conduct, in consultation with relevant sectors, research to assess fishing gears, and promote and utilize new fishing gears and practices which are consistent with sustainable fishing practices	*Several new selective fishing gears and practices have been utilized; none are voluntarily used and reluctance to utilization of new gears and practices is still common; …there is no conclusive evidence to suggest that harvesters have altered their behaviour to handle fish with care…" (Quote taken from Final Report on Pacific Salmon Selective Fishing Program[20])*
Guideline 6.2	Promote the development of education and training programs designed to enhance the skills of responsible fishing in specific fisheries	*Necessary step based on a good idea; to the knowledge of the authors no training programs were carried out on a larger scale*

EXAMPLES OF COMMERCIAL HARVESTER CONSULTATION BOARDS AND THEIR ROLE IN RESPONSIBLE FISHING

Salmon Advisory Board and Area Harvest Committees: The Commercial Salmon Advisory Board (CSAB) consists of two representatives from the regional Area Harvest Committees, as well as two representatives each from the Native Brotherhood of BC, the processing sector and the United Harvesters and Allied Workers' Union. The Area Harvest Committees are the CSAB's representatives on all of the regional fisheries management tables. It is the CSAB's mandate to[21]:

- Provide advice on policy matters related to the commercial salmon fishery;
- Develop commercial salmon harvest plans that consolidate and co-ordinate the interests of the various areas and gear types, according to the objectives and criteria developed by the Integrated Salmon Harvest Planning Committee;
- Provide recommendations to resolve conflicting issues within the commercial sector allocation, harvesting priorities and responses to SARA concerns (as they pertain to impacts on salmon fisheries); and
- Serve as the consultative body on issues that affect commercial salmon fisheries.

[20] http://www.dfo-mpo.gc.ca/communic/cread/evaluations/04-05/salmon_e.htm

[21] http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/consultations/salmon/CSAB/CSAB_TOR.pdf

Some of the CSAB's guiding principles explicitly refer to measures of responsible fishing. They are:

- Develop measures and mechanisms for timely and accurate data collection or monitoring as required by the Department;
- Provide advice on principles and guidelines for the commercial harvesting component for any new or emerging stock assessment programs;
- Provide advice on improved selective fishing practices; and
- Develop or acquire scientific expertise necessary to adequately represent the commercial sector in dealing with issues like endangered species, reduced harvest rates on particular stocks, departmental spawning ground initiatives, etc.

As part of the Area Harvest Committee's responsibilities with regards to responsible fishing it is stated that: "It is the particular responsibility of the Area Harvest Committees that sit on the regional CSAB to:

- Develop recommendations to the CSAB for appropriate co-ordination of monitoring and data collection programs; and
- Identify problems encountered regarding the management or enforcement of the fishery[19]".

The CSAB and the Area Harvest Committees have an important role in the monitoring of data collection and identification of monitoring or fisheries management and enforcement, all essential parts of responsible fisheries.

Sports Fishing Advisory Board: The Sport Fishing Advisory Board works year-round on a watershed by watershed basis to formulate fishing plans and address conservation objectives which continually integrate measures of selective fishing. The Sport Fishing Advisory Board (SFAB) consists of seven members of its regional North and South coast SFAB sub-committees that participate in regional harvest committees. Moreover, the Sport Fishing Advisory Committee forms sub-committees dedicated to specific tasks such as, catch monitoring, data collection, and the evaluation of DNA and Coded Wire Tag data to determine the origin of fish caught in the recreational fisheries. SFAB board members typically represent primary organizations (angling) and secondary organizations (business/industry) and appoint representatives to the Pacific Salmon Commission[22]. The Sports Fishing Advisory Board's Code of Conduct summarizes general advice on responsible fishing, such as:

- Handle all fish with care;
- Limit your catch to ensure fish for the future;
- Use the proper tackle and methods for the species being targeted;
- Promote the sport by teaching children and new participants how to fish;
- Become informed about your fishery and participate in its management;
- Report all illegal fishing activities to the proper authorities; and
- Learn the fishing and boating laws and abide by them.

[22] http://www.pac.dfo-mpo.gc.ca/recfish/KeyPoints/fishingresponsibly_e.htm

The Sports Fishing Advisory Board also recommends other gear specific tools of responsible fishing such as, the use of large lures or artificial baits to reduce the incidental catch of undersize fish and the proper way to release fish with the least harm. In the WCVI Recreational Fishery case study a future initiative towards responsible fishing is described in more detail.

> *The Sports Fishing Advisory Board takes a year-round active role in regional fisheries management as part of harvest committees and a BC-wide role as part of the Pacific Salmon Commission. With regards to responsible fishing, it promotes advice on proper fish handling and adherence to fishing regulations. In the future the SFAB plans to take a more active role in fisheries management as well as training in and marketing of responsible fishing attributes.*

TOOLS OF SELECTIVITY IN BC'S SALMON FISHERY

INTRODUCTION

Selective fishing measures are paramount to ensuring responsible fishing in terms of by-catch reduction. The following section outlines selective fishing initiatives that have been carried out on an experimental scale over the last twenty years in different statistical areas of the BC salmon fishery to reduce mortality of non-target species. Some of these measures have been implemented as licence requirements for commercial salmon fisheries, most notably in the Area C gillnet fishery. In addition, less explored or international tools of fisheries selectivity are described. These are presented as new avenues to explore for the BC salmon fishery since the possibilities with regards to timing, location and small modifications to established fishing gear are currently limited. Many of the technologies described in the following paragraphs were developed under funding provided by the Selective (Salmon) Fisheries Program initiated in 1998 by Fisheries and Oceans Canada, Pacific Region, in response to the "coho crisis". The program was concluded in 2002 as a key element of the Pacific Fisheries Adjustment and Restructuring Fund. A total of 122 projects ranging from small modifications to established fishing methods to completely innovative methods were funded to evaluate their by-catch avoidance, by-catch reduction, reduction of gear mortality and economic feasibility. Representatives of all stakeholders in the salmon resource, namely First Nations, commercial harvesters, recreational harvesters and the scientific fisheries community participated and much was achieved. Project summaries can be found mainly in three documents (Edwin Blewett & Associates 1999, Brookhouse Consultants Inc. 2000 and DFO Selective Salmon Fisheries Program, Final Report[23]). All project numbers mentioned in the following paragraphs refer to projects in the Selective Salmon Fisheries Program. The results of a few projects were published in separate reports to DFO or in peer-reviewed publications and are cited as such.

SPECIES AND STOCK SELECTIVITY

Most fishing gear adjustments described in the following paragraphs aim to increase species selectivity to favour the catch of desired species while hindering the catch of unwanted by-catch species. Stock selectivity within the same species poses a problem that is harder to address. For example, sockeye salmon in the Skeena River, regardless of their natal stream, enter the commercial fishing areas in their approach to the Skeena River, concurrently. In years when large numbers of enhanced sockeye salmon return to the Skeena River, harvesters anticipate being able to catch large numbers of fish. However, abundant Fulton River enhanced sockeye are caught in the same mixed-stock net fishery as Kitwanga River sockeye which are returning in very low numbers (Figure 21). Stock selectivity can sometimes be addressed by timing commercial openings to avoid the low abundance stocks and still harvest the abundant ones. In the case of some stocks, such as less abundant Skeena River sockeye stocks, avoidance by timing is not as easy. Full stock selectivity is only possible when fish are harvested close to their natal stream where the economic value of the fish is lower. Consequently, in approach waters, exploitation rates on the abundant stocks would have to be curtailed to levels which less abundant stocks may be able to withstand (see Walters *et al.* 2008). Both timing of fisheries and exploitation rate ceilings have been used in management of Skeena River salmon. Selective fishing measures of the future should look at methods that will enable fisheries managers to separate selected fish stocks from others within the same species at suitable fishing locations (see: "Artificial Imprinting and Non-Physical Barriers" later in this document).

[23] http://www.pac.dfo-mpo.gc.ca/ops/fm/selective/reports/SFFinalReport_e.pdf

MEASURES AND TOOLS TO ACHIEVE SELECTIVITY

ALTERNATIVE FISHING GEAR

Fishwheels and Motorized Paddle Traps: Fish wheels are generally comprised of two to four baskets attached to an axle that floats in the river on two pontoons (Figure 8). Very large fishwheels with numerous baskets were built into fixed shoreline structures and fished on the lower Columbia River from 1886 to 1927, when they were prohibited[24]. As the water flows downstream, the current puts the fishwheel into motion, scooping fish from the river as they swim upstream into the baskets. As the basket moves up into a vertical position, the fish drop down a short distance onto a slide which carries them into a holding pen of river water or a harvest box in the case of the fishwheels used for harvesting on the Columbia and Yukon rivers. Fishwheels have been used successfully for many years to catch salmon alive for stock assessment programs as well as for harvest on many Alaskan rivers (e.g., Copper, Chilkat, and lower Yukon), Transboundary Rivers (e.g., Yukon and Taku) and several rivers in BC (Nass, Skeena and Fraser).

FIGURE 8. Fish wheel, with baskets elevated out of the water.
(Courtesy of Nisga'a Fisheries Program)

[24] http://www.nwcouncil.org/history/CommercialFishing.asp

Edwin Blewett & Associates (1999) provides a brief overview description of some of the BC experiences with fishwheels in the 1990s. The most recently extensive and consistent use of fishwheels in BC has been by the Nisga'a First Nation on the Nass River from 1992-present (Link and English 1996, Link *et al.* 1996). On the Nass River, there are numerous locations in canyons which are ideal for a successful fishwheel operation and the Nisga'a have incorporated fish wheels extensively into their in season stock assessment programs used to monitor the return of all salmon species, steelhead and lamprey to the Nass River (Alexander *et al.* Draft). A combination of the right water depth (3–5 m), the naturally turbid Nass River water, a canyon to congregate fish into a small area, the positioning of wheels along canyon walls and strong but regular flows make the Nisga'a fishwheels very efficient. On average a single Nisga'a fishwheel catches 2.4% of the total return of sockeye to the Nass River (Alexander *et al.* Draft).

High catch efficiencies have also been achieved by fishwheels operated in the Copper River[25], Babine River and Fraser River canyon. Continued testing of fishwheels on the lower Fraser River is planned for 2008 when shoreline and offshore fish guidance systems will be deployed in an attempt to concentrate the migrating salmon into a location where multiple fishwheels of varying size will be operated.

Power assisted fish wheels, also called "paddle traps" connected to leads of small mesh seine net that guide fish into the trap were tested in Canoe Pass, an approach area to the Fraser River in 1999 and 2000 (Pearson 1999 and 2001). Paddle traps caught all five species of Pacific Salmon and Steelhead in low numbers and showed no gear related mortalities (Pearson 2001). Power assisted fish wheels were also tested on the Nass River in 1998 and on the lower Fraser River in 2000 and 2007 with limited success. In the approach waters to the Skeena, a power assisted fishwheel was tested and apparently harvested fish that were led into the wheel by "non-physical barriers" of an unknown nature (Tuff Marine Products Ltd., Koe McAlister, in Skeena Watershed Committee 1995). The use of non-physical barriers, (e.g., sound, light or electricity), to lead fish into a desired fishing location has not been tested in conjunction with in-river fishwheel operations but low frequency or infrasound has shown promise as a reliable non-physical barrier for Atlantic salmon in a Norwegian River (Knudsen *et al.* 1994).

Fish Traps (Trap Net): Pile traps (Figure 9) and floating trap nets (Figure 10) have been used extensively in Japan, Alaska, southern BC and the Pacific Northwest to catch large numbers of migration salmon in marine waters. In the early 1900s there were an estimated 163 traps operated in Washington State (Roos 1991) and over 400 floating traps and 276 pile traps used to harvest salmon in southern and central Alaska. The very large pile traps built on the sand and mud sea bed near the mouth of the Fraser River and in the San Juan Islands (e.g., the 1905 Cannery Point trap near the southeast tip of Point Roberts, Roos 1991) were so efficient that their use was banned because these industrial traps effectively privatized a substantial portion of the salmon harvest. Aside from a few First Nations locations (e.g., Annette Island), traps were banned from Alaskan waters in 1959 (Ward 1993). Floating trap nets, similar to those used at Annette Island through the 1990s, have been used successfully in Japan to catch Pacific salmon but there are no examples of successful deployments of these types of floating traps in BC.

[25] http://a257.g.akamaitech.net/7/257/2422/14mar20010800/edocket.access.gpo.gov/2003/03-13994.htm

FIGURE 9. A pile-driven fish trap used in Alaska before 1959, the net-clad arm reaching out into the migration pass of salmon (called "Jigger") guides fish into a holding cage where fish can be selectively removed.
(Colt 2000[26])

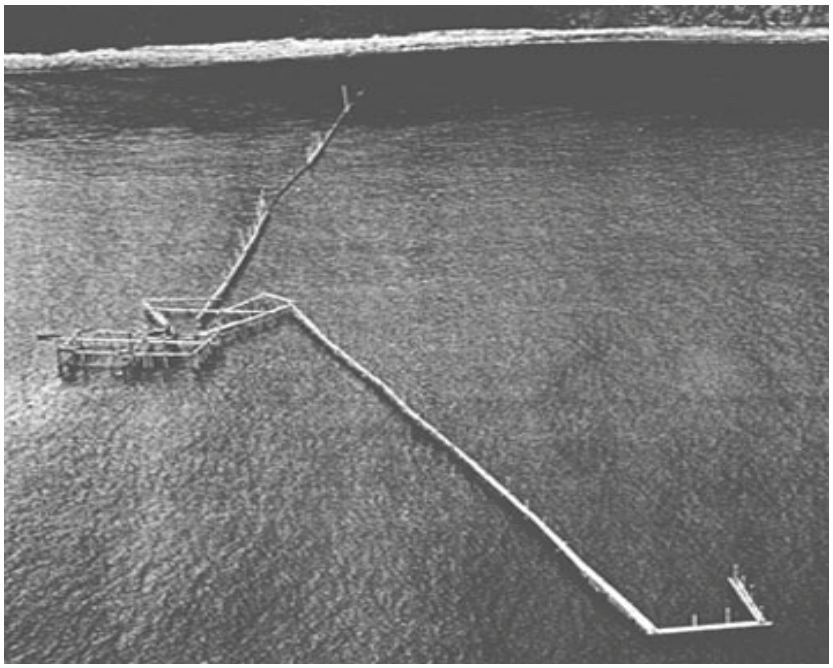
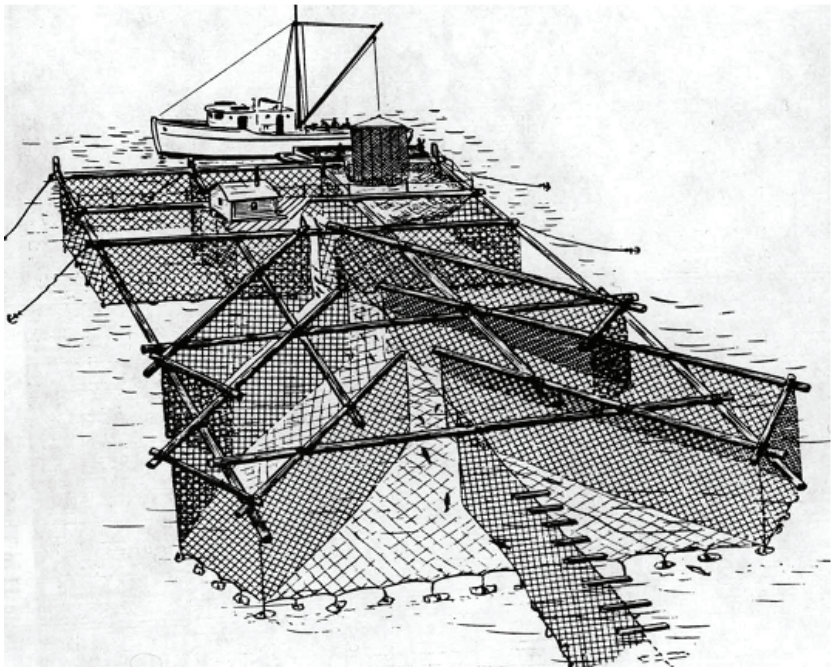


FIGURE 10. Floating fish trap used in Alaska prior 1959, set in migration pass fish are lead into a holding cage for selective removal.
(Colt 2000[25])



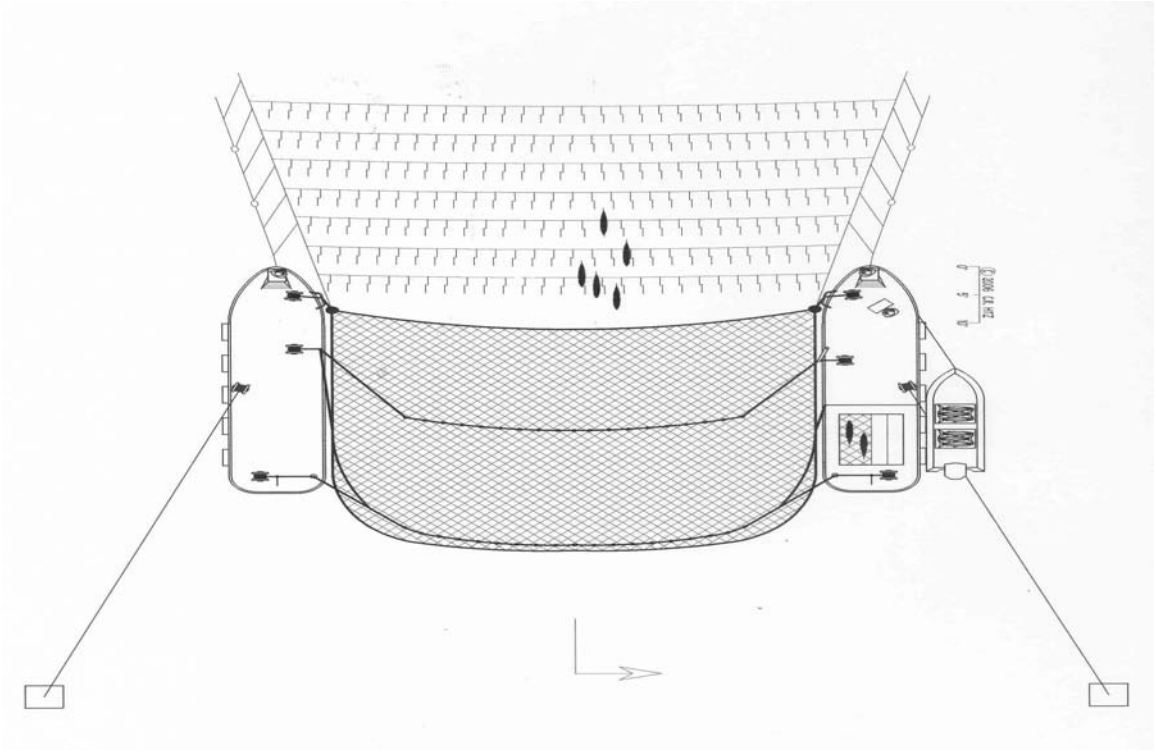
[26] http://www.iser.uaa.alaska.edu/iser/people/colt/fishtrap.pps#278,1,Salmon Fish Traps in Alaska: Some Historical Perspectives

Two types of modified floating traps that were kept open by two boats were tested as part of the Selective Salmon Fisheries Program (1998–2002). The T'sou-ke trap net deployed in the lower Fraser River in 1999 caught 900 fish (mostly pink salmon) in 33 days and released all fish unharmed (Brookhouse Consultants Inc., 2000, Selective Fisheries Program Project Number: TNFR22). The absence of by-catch mortality makes this type of trap completely selective. However, its low catch rate in the Fraser needs to be addressed if traps are planned to be used as a harvesting rather than a sampling tool.

The Hawkshaw Floating Fish Trap deployed in the commercial fisheries in Statistical Areas 3 and 4 in 1999 (Brookhouse Consultants Inc., 2000, Selective Fisheries Program Project Number: TNNC09) showed more promise as a selective tool for commercial salmon fishing. It harvested 2941 pink salmon, representing a catch of pink salmon that was higher than the catch of 1067 fish in the control gillnet sample. A small sub sample (15 fish) of the trapped pink salmon was successfully kept alive in high flow tanks for 36 days to assess long-term mortality. Live landed pink salmon have fetched up to seven times higher per pound values (from $0.15 to $1.00, Fred Hawkshaw, pers. comm.) than dead landed pinks. Thus live fish landing to serve a high quality market can be seen as a profitable opportunity to catch all Pacific salmon species.

Reef Nets: A reef net, similar to a trap net, also guides fish along lead nets into a capture bag. But different from trap nets, reef nets are actively set into the path of migrating salmon on a flooding tide (Figure 11).

FIGURE 11. Reef net bird's eye view showing that two boats are needed to properly suspend and operate the net.
(Drawing by C.R. Hitz [27])

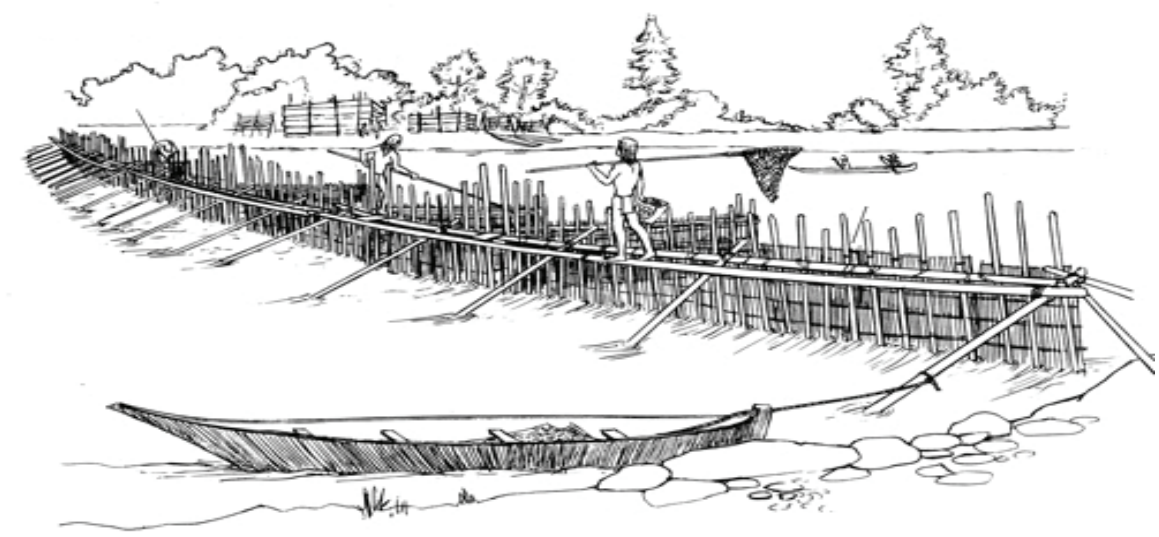


[27] http://www.lummiislandwild.com

The reef net is secured in place with heavy anchors while the lead nets are suspended from floats. The net guides the salmon into a capture bag or bunt end that must be quickly raised to catch fish. The capture nets, currently permitted for use in Washington State, have strict design limitations on the types of leads and size of net that can be used to capture salmon. The leads can not be made of mesh (i.e., they could only guide, not trap salmon). In addition, the capture nets are restricted to a 50 ft^2 flat net made of 3 inch mesh to prevent gilling. The harvesting method is like a large dip net operation and the progress of the salmon is observed as they are guided towards the capture net. When fish enter the capture net they are captured by rapid retrieval of the net using power winches. Harvesters have roughly 10 seconds to bring the net to the surface before the net is detected by the fish and they escape. This requires a clear vision of the salmons' movement and clear ocean conditions. Currently, there are 11 reef net fishing operations in Washington State. Daily catch data from two of these operations are used in the Pacific Salmon Commission's in-season assessment of the abundance of sockeye and pink salmon returning to the Fraser River. Reef nets have traditionally been used by First Nations with great success. Much of the traditional knowledge about trap locations, timing and operation crucial to their successful deployment has been lost as elders have passed away. As part of the Selective (Salmon) Fisheries Program reef nets were used with variable degree of success in catching or retaining fish in Kitimat Arm and Nitinat Lake (RNNC01 and RNSC01).

Fishing Weirs: Weirs were the selective fishing tool used by many First Nations in traditional terminal fisheries. A weir is a structure constructed to span a river (Figure 12). Migrating salmon approaching the weir from downstream are channeled through a gate and into a holding box or pen. The morphology and flow of smaller salmon bearing streams or shallow lake outlets with slow currents are conducive to weir construction. On a larger scale, the Babine counting fence is annually used to harvest up to 400,000 sockeye salmon selectively (English *et al.* 2004).

FIGURE 12. Traditional fish weir.
(Drawing from: Stewart 1994[28])



[28] http://www.sfu.museum/time/en/panoramas/beach/weirs-and-fish-traps/

Beach Seines: Seine nets are manually operated from a near-shore or on-shore position commonly using a boat if larger numbers of fish are desired or deeper water is fished. Beach seining in a suitable location can be very successful in catching large numbers of fish and releasing by-catch with low mortality rates. Projects in the lower Fraser River (J.O. Thomas 1998, BSSC03) have proven effective for targeting chum salmon while coho and steelhead are released without direct mortalities and in good condition. In the Skeena River, beach seining is used on a large scale as a tool to selectively fish salmon as part of the Allocation Transfer Program that allows First Nations to harvest commercial ocean allocations freed through commercial licence retirements or buy-backs.

Artificial Imprinting and Non-physical Barriers: As part of the 1994 Skeena Green Plan, funding was provided to support basic research of imprinting mechanisms in sockeye fry (Plate 2001). In this artificial imprinting study, juvenile fish were exposed to an odorant stimulus in a laboratory setting. The odorant stimulus was memorized by the juvenile salmon and recognized as their natal stream odour when they matured (Plate 2001). These results gave hope for the development of a stock selective fishing tool for the lower Skeena River. Sockeye imprinted as juveniles to a particular odour were hoped to be lured into suitable fishing locations laced by their home stream smell. Funding for the testing of the laboratory results in a field study was never provided but could be pursued in the future. The application of artificial imprinting as a selective fishing measure may be more relevant as First Nations gain increased access to economic fisheries in terminal areas. If the recognition of an artificial imprinting odorant could be used to separate enhanced sockeye salmon from co-migrating wild stocks, as in the Skeena River case study reviewed in this report, economic First Nation in-river fishing opportunities could selectively target imprinted spawning-channel enhanced sockeye salmon.

Non-physical barriers, such as low frequency or infrasound (1–10Hz), have also been successful in forcing fish away from obstacles or into desired migration paths (Knudsen *et al.* 1994, Bullen and Carlson 2003). These could conceivably also be used to guide fish into fishwheels, fish traps or congregate them for beach seining or other selective harvesting methods especially in terminal fishing locations.

> *Fishwheels, traps connected to leads, beach seining, weirs and reef nets inflict little harm on the salmon that they are catching. Their efficiency is highly dependent on location and operator experience and should be further investigated to become accepted modes of commercial and First Nation salmon harvests. In the future, the application of artificial imprinting and non-physical barriers may also enhance stock selective harvesting in terminal areas.*

SELECTIVITY TOOLS FOR ALL FISHERIES

Location and Timing: The two most important tools of fisheries management are spatial and temporal closures. Monitoring of these measures is easy and protection of unwanted by-catch is usually successful. The smaller the scale of the closures the more detailed knowledge is necessary to allow small or short openings in between closed areas. For example, studies in the approach to the Skeena River in 1998 (GNMNC01) demonstrated that particular corridors produce significantly more coho by-catch than others and could therefore be avoided if coho are in need of protection, while other corridors could remain open for fishing. Small area or time closures are good selective fishing tools in areas where variability in fish migratory routes and timing is minimal and enforcement is adequate. Moving fisheries from large mixed-stock ocean fisheries to in-river terminal areas would certainly reduce by-catch and mortality of non-target species and stocks, but would also reduce economic value.

Fish Handling: Fish handling is an important selectivity and mortality reducing tool that could be paid more attention. The Pacific Fishery Regulations (Department of Justice Canada 1993), as well as licence conditions require that all live fish caught incidentally be released with the least possible harm. As part of the Selective (Salmon) Fisheries Program instructional videos demonstrating best handling practices were produced and widely circulated. While a good initial step, the suggestion of mandatory fish handling courses (Edwin Blewett & Associates 1999) for all fishing sectors seems a worthwhile idea for industry pursue. Fish handling practices cannot be fully enforced unless complete observer coverage is assured or cameras are installed on every vessel. Other motivators should be investigated to encourage good handling practices. The switch from high volume to high quality could be such a motivator that would automatically translate good handling practices into higher profit.

Revival Tanks: Revival tanks of two different design choices are currently mandatory in all BC commercial salmon fisheries as stipulated in licence conditions. Revival tanks improve the condition of most salmon that are held in them (Buchanan *et al.* 2002, Hargreaves & Tovey 2001). It was demonstrated that improved revival tank design (from simple blue box to Jake Fraser or JF Revival tank, see Buchanan *et al.* 2002 and Farrell *et al.* 2001) with higher flow aimed at the gills are more successful in reviving coho salmon (overall mortality >10). The combination of "Jake Fraser" revival tanks, short soak times (see below) and best handling practices can achieve a six times reduction in by-catch mortality from 60% to 10% even in a commercial fishery (Buchanan *et al.* 2002). Additional experiments that would compare survival of released fish to the spawning grounds are required. Commercial harvesters view revival boxes at times of low fish abundance as an impediment to their economic survival as documented in the 2006 Skeena sockeye salmon fishery (publicized communications between DFO and commercial fishing sector documented in a string of e-mails accessed through the freedom of information act).

> *Complete temporal or spatial closures of fishing opportunities are the most often used and effective tools of selectivity but can also reduce economic value. Excellent fish handling practices and the proper use of revival tanks are very important tools of responsible fishing and all harvesters should be trained in their use. Their use may enable harvester access to selective fishing opportunities without complete closure. However, the use of revival tanks as a licence requirement must be enforced or other motivation for their diligent use must be found.*

PURSE SEINE

Selectivity Grids, Brailing with Sock Brailers or Pump Transfer Systems and Wet Sorting: Escape grids are slightly oval plastic panels with a slit size that allows fish below a desired size to escape. They can be mounted into the bunt or the end of the purse seines close to the float line and allow small fish to escape without handling (Seine selectivity grid studies in 1998, 1999, SNGSC05). Selectivity grids allow 95% of small fish to escape while no reduction in the catch of desired species and sizes is observed once the correct slit width is determined. The collapse of the bunt end of a seine net compresses fish into a small area and can increase fish stress and mortality. When a motorized skiff is used to keep the net bag open fish stress and mortality can be reduced (Budden 1999). Once fish are to be loaded onto a boat, fish stress and mortality rates can also be reduced through the use of sock brailers (round dip nets connected to a polyvinyl sock with the release end connected to a sorting table) that minimize air exposure and compression of salmon. They have proven to be successful in decreasing scale loss in sockeye salmon and therefore improve fish value and could, in the longer term, lower fungus growth and mortality (Budden 1999). A significant reduction in chemical stress indicators and lowered mortality rates (after 24 hours) was observed in the brailed versus ramped (all fish are brought on board fish in the compressed into the purse seine) (Farrell and Pike 2001 draft). As a result of wet sorting (sorting on trays that maintain a water environment for the fish to reduce air

exposure and related stress), fish quality of retained and released fish was observed to be higher (Budden 1999). The most sensitive brailing method, the use of sock side brailers, which transfer fish without air exposure into a water filled tank, should be considered as a licence requirement for the Pacific seine fleet. However, wet brailers are heavy and hard to operate in rough weather when they have a tendency to swing, which will pose a problem for smaller vessels. Pump transfer systems, although very expensive ($200,000/boat), could replace brailing entirely and they are commonly used in the extraction of fish from aquaculture net pens. They showed great promise in removing fish from purse seines with little mortalities (>1%) and minimal scale loss for the Sechelt First Nation in a 1999 experiment.

Escape grids, motorized skiffs to keep the net bag open, and sock side-purse brailers or fish transfer pumps in combination with wet or underwater sorting make seine nets more selective, reduce by-catch mortality and increase fish value. These tools of responsible fishing for the seine sector should be considered as licence requirements where unwanted by-catch is a problem.

GILL OR TANGLE NETS

Short Soak Times: The shorter the soak time of a gillnet, the higher the survival of coho by-catch in the commercial salmon gillnet fishery on Canada's Pacific Coast (Buchanan *et al.* 2002, Hargreaves & Tovey, 2001). In combination with excellent handling practices or "kissing the fish" as it is called in the industry, and revival boxes, short soak times can reduce mortality of coho by-catch to less than 10% (Hansen and O'Connor 2000, Buchanan *et al.* 2002). Prior to 1998 soak times were unregulated and commonly longer than one hour and at times as long as 12–24 h. From 1998 onwards, soak times in fisheries with by-catch concerns such as the Skeena were reduced to 30 minutes under selective fishing measures. To further reduce mortalities, harvesters were asked to cut the meshes that entangle a caught non-target fish to aid in a quick release with less harm.

Weed lines: Weed lines suspend the gillnet mesh below the surface by a specified distance to permit species such as steelhead, which migrate predominantly near the surface, to pass over the net unharmed (Ruggerone *et al.* 1990). Weed lines of a length between 1.2–1.5 m have been proven to reduce steelhead by-catch by 70% while keeping the harvest rate on sockeye or chum salmon high (Lewynsky, Western Renewable Resources, 1992). The selective ability of weed lines may be compromised by heavy boat traffic that can cause fish to migrate deeper. Research is needed to investigate the behaviour of steelhead in intensive vessel fisheries. Weed lines are now mandatory when fishing in Area 4 under selective fishing regulations (Pacific Region Integrated Fisheries Management Plan, Salmon Northern B.C. 2007).

Tooth-Tangle Nets and Short Soak Times: A tooth-tangle net catches salmon by entangling teeth or other projections around the mouth or the operculum instead of entangling fish behind the operculum or gill plate. Although this type of net is slightly less efficient than traditionally gilling net it does not suffocate fish or cut their gills. Tooth-tangle nets therefore promote the capture of live fish or fish that are in better condition to survive when released. In the approach waters to the Fraser River, tooth-tangle nets were used successfully to catch chum salmon with coho by-catch mortalities of less than 4% (Petrunia 1999, GNGFR02). In the Skeena approach area, the same nets were successful in catching pink and sockeye salmon at rates (>10%) lower then experienced with conventional gillnets (<40%)(J.O. Thomas and Associates Ltd. 2002). In both instances, drop-off mortality from tooth-tangle nets was not assessed but due to the short soak times used in combination with tooth-tangle nets, drop-off is expected to be lower than for conventional gillnets due to the less injuring nature of tooth tangle nets when compared with conventional gill nets. The loss in quantity experienced when fishing tooth-tangle nets would be more than equalized by a gain in fish quality. Live landed pink salmon can often be sold for a seven times higher price ($0.15 to $1.00/pound) to a live buyer (Fred Hawkshaw pers. comm.). Tooth-

tangle nets are commonly made from stretchy 3 or 4 strand Alaska Twist netting material, hung at a loose hanging ration and set in an S-shape to facilitate optimal entangling. Short soak times of tooth-tangle nets suspended below weedlines are a very low mortality fishing tool. Short soak times would not require a significant increase in effort considering that, under selective fishing regulations for example in the approach to the Skeena, set or soak times are anyhow limited to 40 minutes. The Skeena Independent Science Review panel specifically recommended the use and further research into tooth-tangle nets in fisheries targeting Skeena River salmon (Walters *et al.* 2008).

Larger Mesh Size versus Smaller Mesh Size and Their Effects: Commonly, a minimum mesh size is a licence requirement for the gillnet sector. The mesh size is chosen to allow smaller unwanted fish to pass the net unharmed. However, most gillnet fisheries on the BC Coast are not fishing in areas of mixed age groups but rather target one or two age classes of mature fish. By limiting mesh to a value that is aiming at the larger fish in a population, smaller fish of the same species have a higher chance to reproduce (Ricker 1981, Law 2000). But over time, the weight at maturity for the whole population decreases. The value per fish also decreases over time and more fish are required to be caught to remain profitable. Mesh size restrictions should be revisited to allow the harvest of small and large, or less fit or fitter fish, out of the same population while not selecting for only larger fish.

Day versus Night Fishing: Salmon species such as coho or chinook are visually-based active predators and should therefore have the acuteness of vision and alertness to avoid nets during daylight hours. In contrast, salmon species such as chum or sockeye are more passively foraging on planktonic organisms from the water column and therefore are likely to be less alert to visual obstacles or nets. Therefore, the ratio of targeted chum or sockeye to unwanted by-catch coho should be higher at daylight and lower in darkness. Studies in the commercial fisheries have not conclusively corroborated these assumptions (Edwin Blewett & Associates 1999, GNMNC01). However, many commercial fisheries are now restricted to daylight hours to also facilitate better fishery monitoring.

> *Mandatory and enforced operation of revival tanks, the use of tooth-tangle nets (during daylight hours) suspended from weed lines in combination with short soak times should be considered as licence requirements for all mixed-stock gillnet fisheries where unwanted by-catch is a problem. The encouragement of live landing fish to processors or quality grading for different prices in the processing plant (see: "The Role of the Processing Industry" in this text) may enhance the ability of the gillnet sector to survive economically by adding value to each fish.*

TROLL

Barbless and Single Hooks: Troll fish harvesters are required by regulation to use single barbless hooks because they cause less damage to hooked fish than traditional barbed hooks when fish are being released (Cox-Rogers *et al.* 1999).

Selective Gear: The colour of lures or hooks delivers limited selectivity and by-catch reduction. While the colour red, for example, attracts species such as sockeye, pink and chum salmon, it does not necessarily reduce the amount of coho by-catch (TRGSC12). In other experiments it was shown that the use of large plugs (a herring or fish mimicking lure that rotates through the water) will catch larger fish in comparison to small plugs. With the reduction in catch of small fish came a reduction in overall catch. Therefore, large plugs will be a selective fishing tool in areas where large fish such as chinook are targeted while smaller fish such as coho are not.

Release and Transfer Techniques: Waterline release into a net cage in comparison to release of fish into revival tanks appeared to reduce mortality rate (TRGSC12) of coho by-catch in the troll fishery. The revival cage attached to the side of the boat also forced coho salmon into muscle activity that aided in the quick reduction of chemical stress and muscle fatigue indicators (Farrell *et al.* 2001a). However, only fish that were lethargic were placed into the revival tank while lively fish were released directly into the ocean and their mortality was not assessed. Dip netting in comparison to direct handling of the fish to transfer them from the hook to revival tanks should further reduce mortalities if knotless dip netting is used. More work is needed to quantify the by-catch mortality reduction related to this measure.

Restriction to large plugs when fishing for chinook salmon, barbless hooks on all gear and the quick transfer of by-catch into waterline cages improves the selectivity and by-catch survival in the troll fishery and should be considered as licence requirements for troll fisheries where unwanted by-catch is a problem.

RECREATIONAL

Barbless Single Hooks, Faster Fishing Methods, and Retention Limits: Cox-Rogers *et al.* (1999) reviewed the literature on hooking mortality of salmon in recreational fisheries and concluded that hooking mortalities are likely higher than the 10% currently assumed for fisheries models. Cox-Rogers *et al.* (1999) also concluded that the use of specific fishing methods and single barbless hooks can reduce this mortality. Fishing methods that offered the lure or bait in a slower way had higher mortality rates than methods that presented lures quicker. A combination of slow presentation and natural bait seemed to produce the highest mortality rates. Mortality was directly related to hooking location in the fish's mouth. Whereas deeper hooking location in the esophagus region increased mortality and shallower, gum or teeth area hooking location reduced mortality.

While a barbless hook regulation has been adopted for the entire BC coast, treble hooks are still legal and the speed of lure or bait presentation is unregulated. In recreational fisheries mainly the effort, and to a lesser extent the catch, determine economic viability. Catch limits could therefore be stricter than the current four coho and two chinook (or four salmon combined) daily limits adopted in the tidal Skeena region. Alternatively, retention of all fish that can legally be kept could be made mandatory, thus reducing mortality of fish that are released in the hopes of landing a 'better one'.

Single barbless hooks, faster presentation of artificial lures, advice to retain all fish that are bleeding or hooked deep in the throat (within legal limits) and lower retention limits could be used as tools of responsibility in recreational fisheries. Requiring that every fish caught within legal limits must be kept could also reduce release mortality.

COMPLIANCE MONITORING

Electronic monitoring with cameras that observe on deck landing activities, trap number readers and hydraulic sensors to record trap setting frequency and location were introduced in the 2000 Area A Dungeness crab fishery. This monitoring system was asked for by the industry to overcome financial losses caused by the cutting of lines in oversetting areas, resulting loss of expensive gear on a large scale and the stealing of crab out of the set traps. The financial losses based on illegal practices in this otherwise very profitable fishery were a strong incentive to install an expensive monitoring system (Archipelago Marine Research Limited 2008).

The per boat income for smaller vessels in the salmon fleet is substantially lower than in the Dungeness crab fleet and the costs for camera installation, maintenance and data evaluation would be proportionally more expensive, perhaps to the point of making the fishery uneconomical (subsidies could help to alleviate this situation). Salmon purse seiners, on the other hand, have generally higher profit margins per boat and could potentially carry electronic monitoring costs. All sectors may be able to offset the cost of electronic monitoring systems through increased fishing opportunity.

The question remains what needs to be monitored in the salmon fleet to achieve a higher selectivity and reduced fish mortality. Compliance concerns in the BC salmon fishery are mainly related to insensitive fish handling practices, long soak times, lack of commitment to the use of revival tanks, illegal retention of by-catch and laundering of FSC fish into the commercial fisheries. A greater presence of Fishery Officers on the fishing grounds in combination with clearly defined and enforced fines may provide all of the compliance monitoring needed in the BC salmon fishery. An example of a practical fine could be the prompt exclusion of non-compliant harvesters from openings. As another practical fine, reduction of quota in an ITQ system, followed by ITQ suspension would be an effective tool that would benefit the fish if enforced (both suggestions from long-time commercial harvesters and also suggested in Bill C32).

COMPLIANCE MOTIVATORS AND LOCAL WATERSHED COMMITTEES

Multi-stakeholder tables that make harvest decisions based on conservation concerns, sustainability and socio-economic considerations create ownership and transparency. They also lead to higher compliance with regulations and a willingness to fish under selective fishing regimes. As a recent example, a Fisheries Decision Committee was recommended for the Skeena Watershed by the Skeena Independent Science Panel in 2008 (Walters *et al.* 2008, p.12). As an example of the past the Skeena Watershed Committee (1993–1997) was formed to protect weaker stocks while achieving sustainable fisheries (all information regarding Skeena Watershed Committee from Wood 2002). Funding for the initiative was provided under the Skeena-Kitimat Sustainable Fisheries Program or "Skeena Green Plan". Initiatives under the Skeena Green Plan were proposed and approved by a consensus-based process within the Skeena Watershed Committee. The Skeena Watershed Committee was comprised of five equal partners representing the interests of aboriginal people, commercial fishing groups, recreational fishing groups, DFO, and the Province of BC. Special emphasis was given to evaluating more selective harvesting techniques and new opportunities for terminal harvest and therefore helped spawn the Selective Fishing Policy even before the coho crisis was evident. It was explicitly recognized that if selective harvest rates were applied in the tidal fishery, less of the fishing effort would need to be shifted to lower quality terminal fisheries.

Under this multi-stakeholder management regime the commercial gillnet, seine net and troll as well as the recreational fisheries experimented with the use of alternative and more selective fishing methods described in detail above. Initially the Skeena Watershed Committee process was hailed as a great success because of renewed co-operation among stakeholders and significant progress on many issues of mutual concern. However, in the fall of 1996, the commercial fishing sector withdrew from the Skeena Watershed Committee after becoming frustrated that the "up-river" stakeholders were gaining too much influence over commercial fishing opportunities in tidal waters. The remaining partners expressed strong support for continuing the Skeena Watershed Committee process. However, most research and monitoring activities were discontinued after 1997 with the termination of Skeena Green Plan funding. The Skeena Independent Science Review Panel emphasized the importance of the resurrection of a governance model that allows all user groups to participate in decision making to achieve a more responsible fishing regime (Walters *et al.*, 2008).

NEW FISHERIES MODELS

All or most of the aforementioned methods to increase selectivity and reduce by-catch mortality require increased fishing and monitoring effort. In fast-paced competitive fisheries, catch and related profit will decrease when selectivity and reduced mortality are desired. This is not an incentive for harvesters to be more selective and reduce mortality of by-catch. Different models of fisheries management have been suggested to slow down salmon fisheries to allow them to become more responsible while maintaining profitability.

Individual Transferable Quotas Held by Individuals or Co-operatives: Individual Transferable Quotas or ITQs have been proposed as a potential way to make fisheries more responsible while maintaining profitability to the quota owners. In the ITQ system, quotas are commonly given to long-term participants in a fishery according to their average share of the Total Allowable Catch (TAC). The quota is then generally fished in a non-competitive style avoiding the race for the fish and thereby slowing the fishery down.

Advantages of this fishery management scheme are opportunities for higher catch selectivity combined with higher fish value, less competition and better safety on vessels as well as a longer season that can avoid flooding of the market following openings. This also prolongs the processing season and increases the number of days that processors operate. Seasons may not necessarily become prolonged under an ITQ system if stocks of concern enter a fishing area requiring the fishery be stopped. In this scenario harvesters may still rush to catch their fish without due consideration to fish quality.

Potential disadvantages of ITQs are the danger of consolidation or even monopolization of the right to fish in the hands of a few if quotas are owned by individuals and fully transferable. Often companies that buy quota are laterally diversified, meaning that they also have access to processing and marketing capacity and can therefore take hold of the industry from catch to the consumer. From an economic point of view, ITQs are an efficient system, but from the point of small independent fisher they can appear to be a potential step into dependency and fixed pricing. The monopolization disadvantages can be counteracted by quota limitations per person or organization and quota ownership tied to regions (e.g., cooperatives). A flexible approach, searching for local buy-in and different options, is recommended for the introduction of novel fisheries management regimes by licence regulating agencies (Hillborn *et al.* 2005).

The initial allocation of quota based on previous share in catch is often followed by the need to buy quota in the next generation at prohibitively high prices, or lease and lose independence (Copes 2004). Again this disadvantage could be offset with quotas given to fishing cooperatives or to community based fisheries boards that are responsible for the distribution of the quota and have a say in the management of the local fishery. A current and successful example is the salmon fishery of the Chignik Area in Alaska (Knapp and Hill 2003). Individual Transferable Quotas (ITQs) in the Chignik area are held by a fishing co-operative (from now on called CO-OP) of purse seiners. The fishing CO-OP consists of equal shares for all co-operative members and changing personnel to fish the allowed quota (Hillborn *et al.* 2005). It has resulted in a reduced number of vessels and an increase in the quality and price of the landed fish. In this model the total allowable catch (TAC) was set for the whole CO-OP by adding up the former catch percentage of its participants and dividing it into equal income shares from the fishery. In this model, 30% of the harvesters were paid to catch the TAC allocation while 70% stayed home and all CO-OP members received a 1.3% share of the fish sales profit (Knapp and Hill 2003). Generally, high producers in the Chignik area salmon fishery were less likely to join the cooperative than low producers. Therefore the regulating agency decided to allocate 30.7% of the harvest to 23% of the non-CO-OP harvesters in a competitive-style fishery (Knapp and Hill 2003). The reported effects were two-fold; CO-OP participants were mostly satisfied and felt that their situation improved while non-participants felt the opposite way.

Other positive factors of the ITQ / CO-OP fishery model are reduced capitalization, better fish quality, and overall slower fishery that promote the conditions for more responsible fishing and a higher predictability of income and catch. The system also forces improved communication, planning and decision making between harvesters in the CO-OP and all-sector planning meetings improve overall information exchange.

In BC, a pooled-seine fishery operated in the Strait of Juan de Fuca in 2001-2002[29] where DFO set a ceiling on the number of vessels that could participate in the opening. Area A seine harvesters agreed on who would fish and how the profits would be disbursed. As another example, in the ongoing "Johnston Strait Chum Seine Demonstration Fishery" [30] individual catch targets were assigned to boats by DFO and could be harvested over a given period of time. In both examples, the harvesters invested part of their profit into the monitoring of the fisheries.

The examples shown above are meant to represent a starting point for DFO and commercial fishing sectors to examine the creative development of location specific responsible fishing schemes.

Compliance monitoring of responsible fishing measures in large-scale and mixed stock fisheries is difficult, expensive and therefore lacking. Incentive based fisheries, such as the pooled fisheries examples given in the previous chapter, can help finance the simple monitoring of these fisheries out of their fishing profits. Alternatively electronic monitoring (potentially subsidized) of all commercial salmon fishing sectors would change harvester attitudes and lead to MSC certification, higher fish value and overall more responsible fishing methods. Species quotas given to co-operatives or regional multi-stakeholder groups rather than individuals or corporations can slow fisheries down, add value to fish and make them more responsible. The development of new, incentive based responsible fishing regimes and fishing techniques needs to be promoted and financed.

[29] http://www.sfos.uaf.edu/salmontools/edu/workshops/2002/options/BCControlledFisheries.pdf
[30] http://www.psc.org/pubs/21stAnnualReport.pdf (page 57)

CASE STUDIES

INTRODUCTION

In selecting the case studies to be included in this report, the following selection criteria were used:

- Detailed data have to be readily accessible;
- Examples had to cover all commercial and recreational sectors, namely gillnet, seine, troll and recreational;
- In the combined examples different approaches to similar problems could be demonstrated; and
- The outcome of the implemented measures of responsible fishing had to be well documented.

First Nation fisheries are touched on briefly in the context of economic opportunities but not food, social, and ceremonial fisheries which are, for the most part, full retention fisheries. For all licence areas and their location with regards to statistical management areas see Table 6 and Figure 13. Based on these selection criteria the following case studies were chosen:

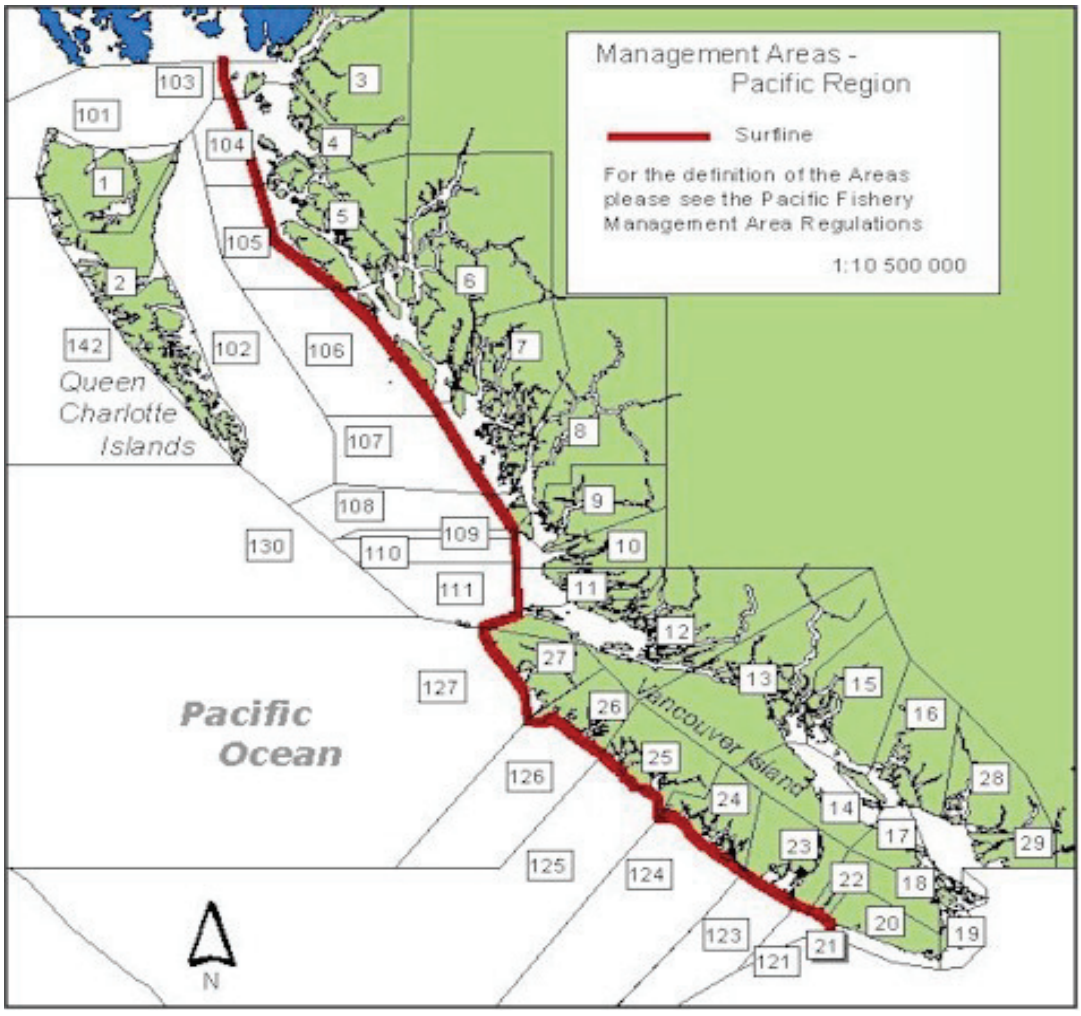
- **The Area C (Skeena Approach) Gillnet and Seine Fisheries:** This is a mixed-stock and multi-species gillnet and seine fishery dominated by the harvest of two enhanced sockeye stocks that poses potential over exploitation problems for co-migrating coho, chum and steelhead and for 20 co-migrating sockeye stocks. Fisheries management and operations have undergone significant and well documented changes over the last 20 years but more changes are needed. The Skeena Independent Science Review panel has just completed its report on this fishery (Walters *et al.* 2008).
- **The Area F (Southern Limit North of Vancouver Island to Alaskan Border, Coastal and Outside Waters) and Troll Fishery:** This is a mixed-stock troll fishery focusing on the catch of chinook salmon that has currently been offered the opportunity to switch to an Individual Transferable Quota or ITQ system. The fishery is curtailed by the presence of West Coast Vancouver Island chinook salmon, a stock aggregate of special concern as well as Skeena River chinook stocks of concern.
- **The West Coast of Vancouver Island Recreational Fishery:** This is a mixed-stock recreational fishery that has experienced large increases in fishing effort over the last 20 years and is now divided into an offshore fishery for non-local and inshore fishery for local stocks. After First Nations, priority allocations for chinook in most areas and coho and sockeye in terminal fisheries are given to the recreational sector. Stocks of concern in this fishery are West Coast Vancouver Island chinook stocks, Lower Georgia Strait and early Fraser chinook stocks, as well as Thompson River coho and other smaller coho stocks.
- **The Area 26 (Fraser River Estuary) Fishery:** This is a mixed-stock and multi-species commercial gillnet and seine fishery in the approach waters to the Fraser River as well as an in-river First Nations fishery utilizing selective and non-selective fishing methods. The fishery is complex and curtailed through concerns for several of its many sockeye stocks or aggregates (i.e., early Stuart, Cultus Lake and Sakinaw sockeye), for early-run chinook salmon and for later running interior coho and steelhead, to name just a few. Sturgeon by-catch is also a concern.

While the names of the fish stocks of concern change for different areas and sectors, the main predicament faced in all case studies is similar. How can a mixed-stock fishery for abundant species or stocks be managed without jeopardizing the weak species or stocks?

TABLE 6. Licence areas and accompanying statistical areas on Canada's Pacific Coast.

Licence Area	Statistical Areas
Salmon Area A Seine	Areas 1 to 10, Subarea 101-7
Salmon Area B Seine	Areas 11 to 29 and 121
Salmon Area C Gillnet	Areas 11 to 15 and 23 to 27
Salmon Area D Gillnet	Areas 11 to 15 and 23 to 27
Salmon Area E Gillnet	Areas 16 to 22, 28, 29 and 121
Salmon Area F Troll	Areas 1 to 10, 101 to 110, 130 and 142
Salmon Area G Troll	Areas 11, 20 to 27, 111, 121, 123 to 127 and Subarea 12-5 to 12-16
Salmon Area H Troll	Areas 12 to 19, 28 and 29

FIGURE 13. DFO Statistical Management Areas for the Pacific region.

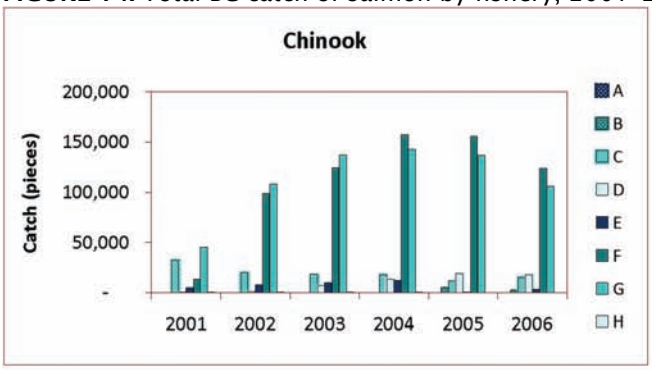


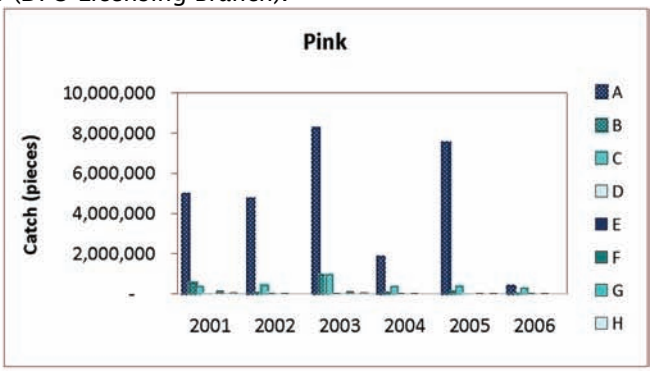
TOTAL CATCH OF SALMON BY FISHERY ON THE BC COAST

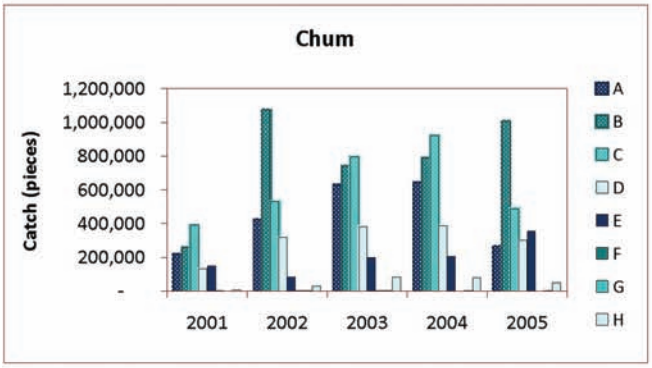
The case studies need to be conceptually framed by an overview of the contribution to the harvest of salmon by all fishing gear sectors as shown in Figure 14. Between 2001 and 2006 chinook and coho were mainly caught by the Troll sector in licence areas F and G for chinook and Area F for coho (Figure 14, top and bottom panels on the left). This reflects the move of coho from the inside waters of Georgia and Johnston straits to the outside waters of the West Coast of Vancouver Island and the more northerly waters of BC's Central and North Coast over the last 20 years. In addition, approximately 30% of chinook salmon and 15% of all coho salmon are harvested through the recreational sector. The Area H troll fishery (Georgia and Johnston straits) is now focusing on sockeye and chum salmon (Figure 14, middle panels on the right and left). The majority of pink salmon are harvested in the Area A (Northern Waters, approach to Nass, Skeena and Dean Rivers and Queen Charlotte Islands) seine fishery. Chum and sockeye are encountered in all seine and gillnet fisheries on the BC coast with the highest portion caught in the Area C gillnet (Northern Waters, approach to Nass, Skeena and Dean Rivers and Queen Charlotte Islands) and Area B Seine (Georgia, Johnston and Juan de Fuca Straits) fisheries. These data reveal that measures to responsibly harvest the following species will have the most impact if they are fully implemented in the following gear sectors:

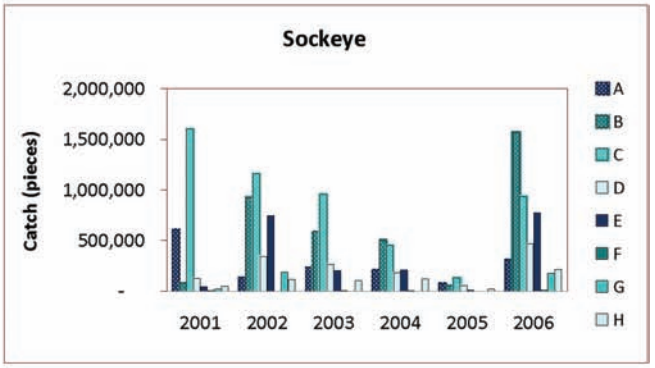
- Chinook—Troll and Recreational
- Coho—Recreational and Troll
- Sockeye—Gillnet and Seine
- Chum—Seine and Gillnet
- Pink—Seine

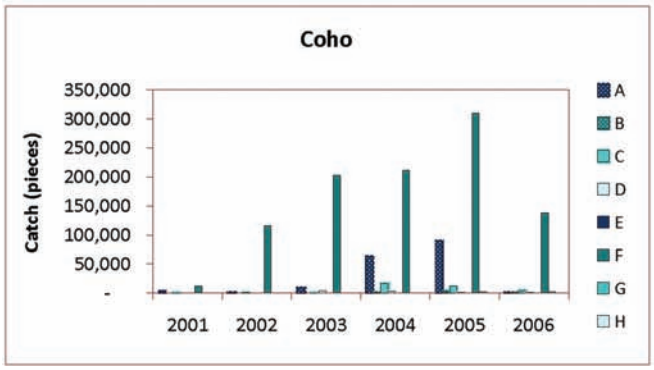
FIGURE 14. Total BC catch of salmon by fishery, 2001–2006 (DFO Licensing Branch).

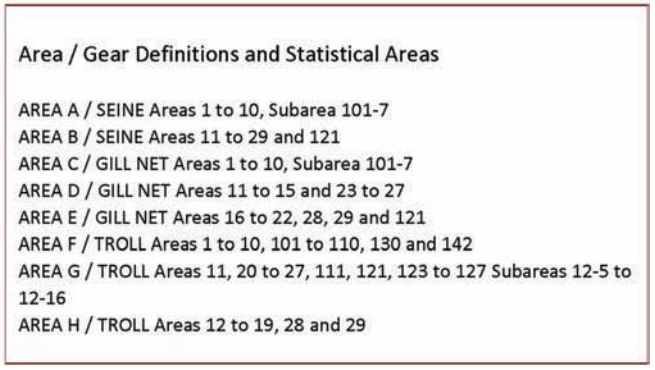












SKEENA RIVER CASE STUDY

HISTORY, LOCATION AND FISH STOCKS

The commercial salmon fishery targeting Skeena sockeye salmon began with the first cannery operations in the 1870s. Prior to this period, harvests were by First Nations and primarily at terminal locations within the river. From the conception of the commercial fishery, sockeye salmon were harvested predominantly by gillnets in the Skeena River until the 1930s when powered vessels moved out to ocean fishing areas (Wood 2002). In the 1950s a seine fleet moved into the area and grew rapidly. At the peak of the fishery 350 seine vessels and over 1000 gillnet vessels were licensed to fish commercially for salmon in Statistical Areas 1-10 (Area C) (Figure 15). In 2007, 168 seine vessels and 658 gillnet vessels were licensed to fish in the Area C gillnet fishery.

At the present time, the Area C gillnet fishery mainly harvests sockeye and pink salmon and to a lesser degree chum and chinook salmon in the inshore areas ranging from the Alaska border in the north, to Cape Caution in the south on the mainland side. On the Queen Charlotte Island side (Area 1 and 2), the Area C gillnet fishery is restricted to the inshore waters only, targeting terminal chum stocks. The access to the Area C gillnet and the gillnet fisheries in all other licensing areas is limited to the initial licence recipients but can be transferred by sale.

FIGURE 15. Area C gillnet licence area map.

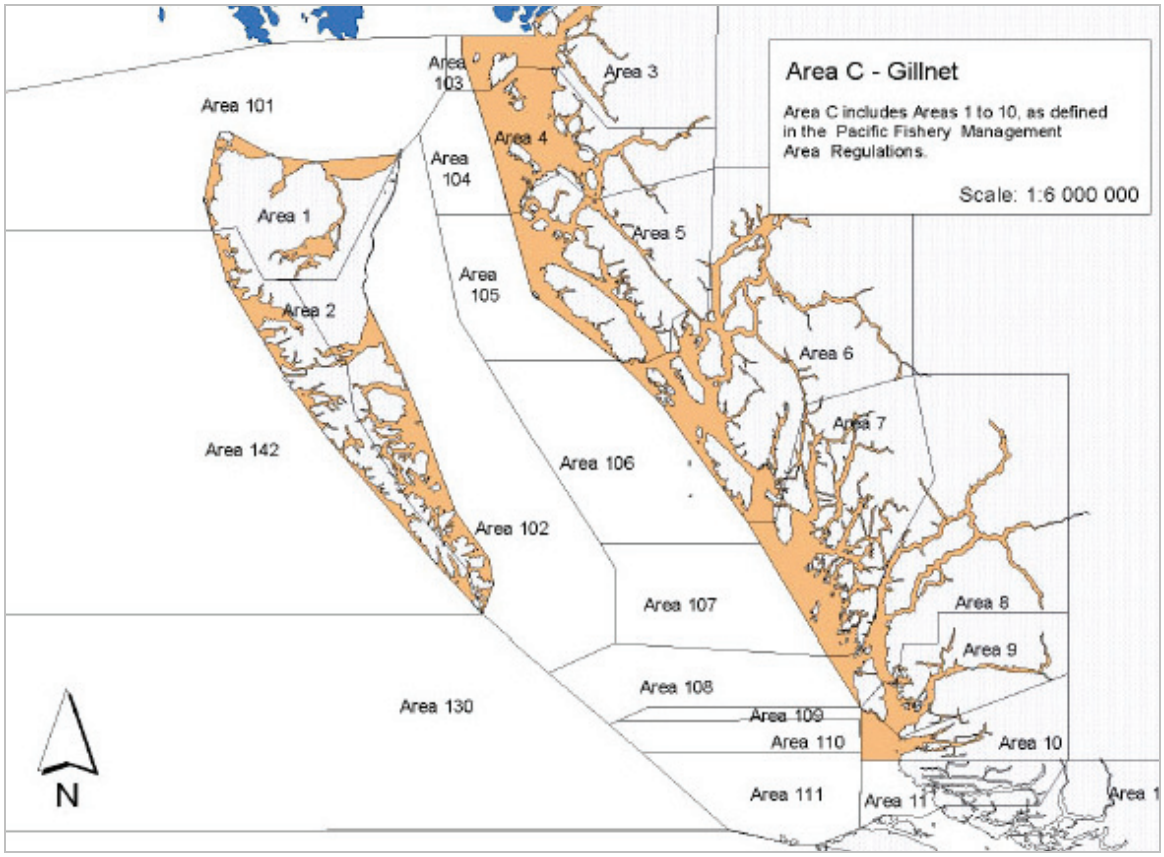
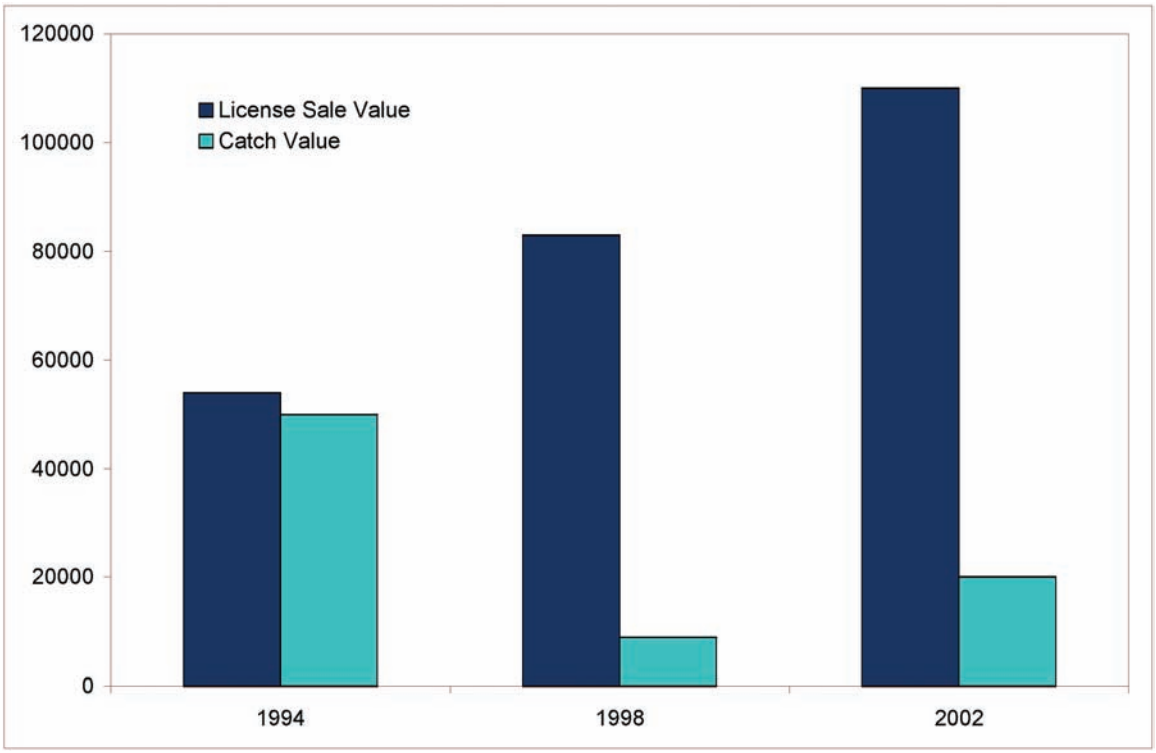


FIGURE 16. Change in average purchase price or sale value of a licence in the BC gillnet fleet and the average catch value per licence.
(Data from DFO Catch Statistics in Ecotrust 2004)



The total value of each licence is composed of actual licence fees and its sales value for the purpose of ownership change. While the total licence value in the BC gillnet has doubled from $54,000 in 1994 to $110,000 in 2004, the value of the fish caught (catch value) under each licence has lost more than 60% of its value (From $50,000 to $10,000–$20,000 (Figure 16)). This development makes the sale of a gillnet licence under a government buy-back program appear to be an attractive alternative to fishing it. Consequently, the number of harvesters that operate under an Area C gillnet licence has decreased.

This case study is focused on the Area C gillnet harvest of salmon migrating through statistical Areas 3, 4 and 5 towards the Skeena River. The following reasons explain this rationale:

- Skeena bound sockeye comprise the majority of the weight and value of catch in the Area C gillnet fishery;
- The selective fishing measures and challenges that apply to Skeena bound sockeye salmon also apply to sockeye migrating towards the Nass River and potentially other watersheds in Area C; and
- The net fisheries conducted in Area 3, 4 and 5 are the primary Canadian fisheries that catch adult salmon returning to the Skeena River.

However, it should be noted that significant numbers of Skeena River salmon are also taken by US fishers in Southeast Alaska. On average, 12% (range 3–20% for 1982–2006) of the Skeena sockeye run is harvested in Alaskan fisheries (Alexander *et al*. Draft) and Alaskan exploitation rates on Skeena chinook and coho are very high at 44% and 54%, respectively.

SPECIES OR STOCKS OF CONCERN AND SELECTIVE FISHING MEASURES

Fisheries targeting Skeena stocks have major mixed-stock and multi-species fishery challenges. Abundant stocks of pink salmon and enhanced Babine Lake sockeye co-migrate with wild sockeye, steelhead, coho, chum and chinook stocks. The Tyee test fishery located near the mouth of the Skeena River provides a good indication of the overlap in run-timing of these species (Figure 17). In recent years, the commercial fishing season in Area 4 began in early-mid June with one to three short gillnet chinook openings. These fisheries are followed by gillnet fisheries in early July that target Skeena sockeye stocks. Purse seine fisheries are generally not permitted before mid-July. In most years since 1995, harvesting pressure has been concentrated in July (80–90% of the sockeye catch) in order to limit harvest rates on Upper Skeena summer-run steelhead and coho stocks that are more abundant in August and September. While DFO manages the enhanced stocks sustainably, many smaller stocks have decreased in numbers (Walters *et al*. 2008) and at least one sockeye stock declined to 211 spawners in 2007 (Kitwanga River).

On one hand, the low prices for pink salmon in recent years have helped to keep the catch of the co-migrating chum salmon at relatively low levels. On the other hand, sockeye fisheries that extend into August in years of high abundance can still result in significant by-catch of the depleted Skeena chum stocks. Chinook by-catch in the sockeye and pink salmon fisheries has not been a major issue in recent years, with strong chinook returns to most spawning areas and little timing overlap. Bear River chinook, the single population within the Upper Skeena Chinook Conservation Unit under the Wild Salmon Policy, are the one exception, showing relatively low returns from 2002–2006 (Figure 18).

FIGURE 17. Average escapement timing through the mouth of the Skeena River for Skeena salmon and steelhead stocks based on the 1998-2000 Tyee test fishery data
(Source data: DFO, Prince Rupert).

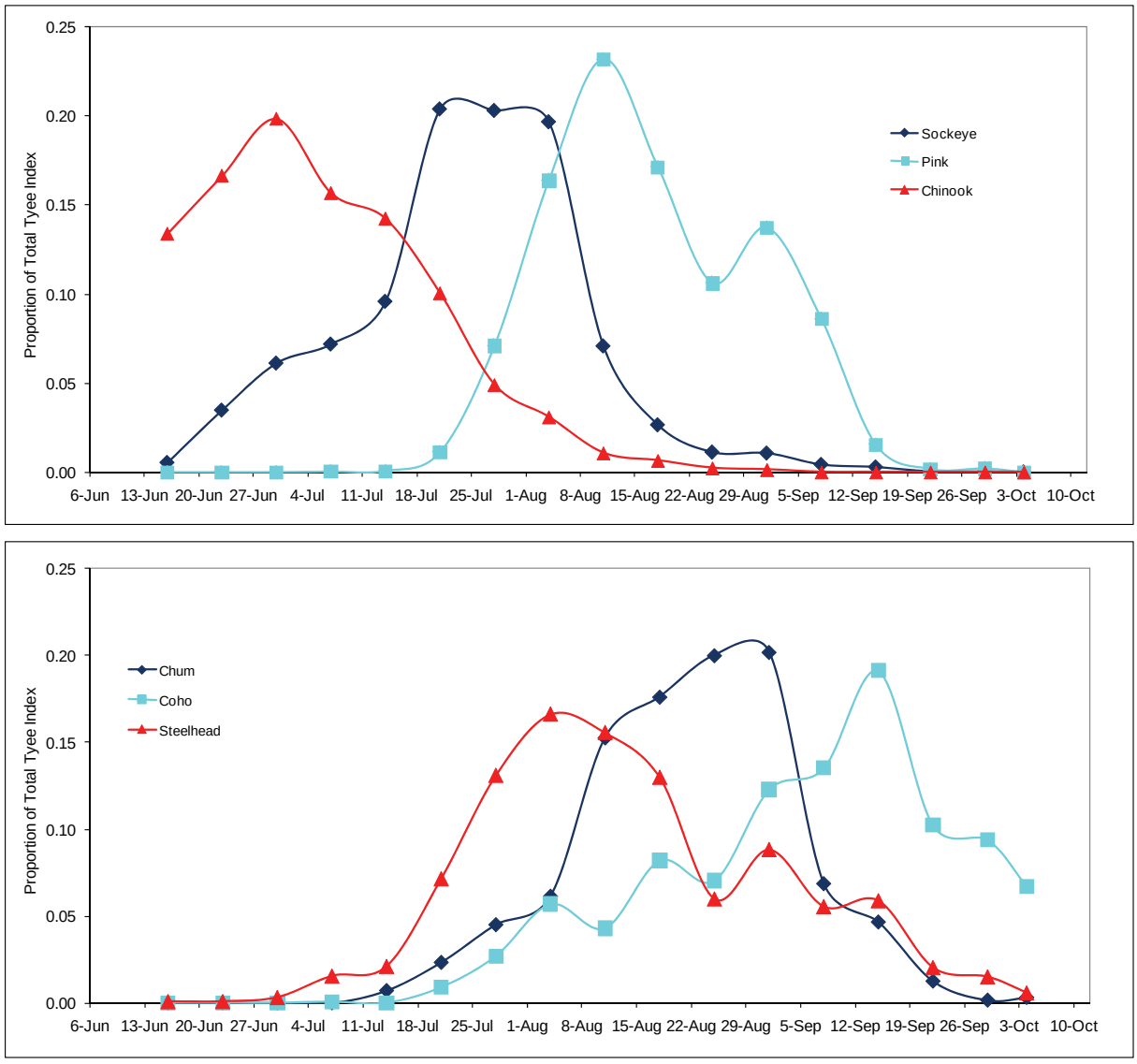
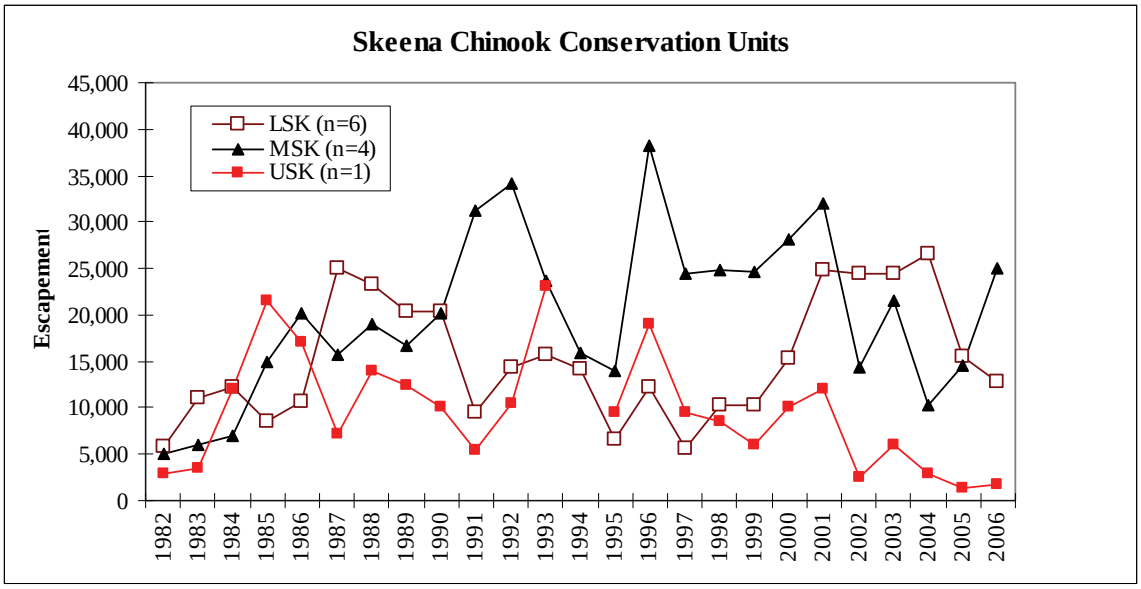


FIGURE 18. Escapement trends for the indicator streams representing three of the major Conservation Units for Skeena chinook.
Bear River is the sole indicator stream for the USK Conservation Unit.(LSK = Lower Skeena, MSK = Middle Skeena, USK = Upper Skeena)



Sockeye Salmon & Their Enhancement

Mixed-stock harvest of wild and enhanced salmon stocks greatly complicates the conservation of salmon diversity and the exploitation of sensitive conservation units. While this poses a problem in most BC Salmon fisheries, it is particular evident in the fisheries for sockeye salmon in the Skeena River (Wood 2002, Walters *et al.* 2008). The aggregate of Skeena sockeye salmon is composed of least 70 distinct spawning populations, utilizing 27 lakes (Smith and Lucop 1966) that vary widely in productivity and size. In contrast to the high number of genetically distinct conservation units, 81–97% of all Skeena sockeye return to the enhanced (Pinkut and Fulton spawning channels) and naturally productive Babine lake system (Figure 19).

The Babine system is the largest natural lake wholly located in BC (500 km^2) and augmented by the production from Fulton River and Pinkut Creek spawning channels, supports one of the largest sockeye salmon populations in Canada. Fulton and Pinkut spawning channels first released sockeye in 1962 and 1964, respectively. Fulton and Pinkut spawning channels can contribute up to 260 M fry to Babine Lake. This high fry and later smolt output sustained exploitation rates of 50–80% throughout the 1970s and 1980s (Figure 20).

The management of these enhanced stocks is based on the harvest of the highest number of fish that can be harvested while sustainably maintaining stocks to replace themselves, also called the maximum sustainable yield or MSY. The maintenance of MSY for enhanced stocks has been achieved in the Skeena, as can be clearly seen in the relatively stable total sockeye escapement for the Skeena over the last twenty years (Figure 20). However, decreasing spawner numbers for many non-Babine sockeye stocks indicate that the Skeena's wild sockeye stocks are being negatively impacted by high exploitation rates. Recently, the Skeena Panel Review on Fisheries Management (Walters *et al.* 2008) concluded:

"If the Wild Salmon Policy commitment to maintain diversity through the protection of Conservation Units is interpreted as meaning that overharvesting will not be permitted for any Skeena salmon conservation unit, then DFO needs to make structural changes in the harvesting system for the Skeena" and continue to suggest as one of the changes: "…ocean harvest must be reduced by roughly 50%."

Kitwanga River sockeye salmon are an example of a stock or conservation unit that has declined to 211 spawners in 2007 (Figure 21) because its migration timing is unfortunately overlapping with the enhanced returns of Babine sockeye (Rabnett 2005). The situation is worsened by an invasive noxious aquatic weed (*Elodea canadensis*) that colonizes sockeye beach spawning locations and beaver dams that change landscapes of and flows in former sockeye spawning streams (Rabnett 2005).

FIGURE 19. Escapement of Skeena River sockeye between 1985–2006, showing the dominant influence of Babine Lake in Skeena River sockeye production.
(Data from DFO Prince Rupert)

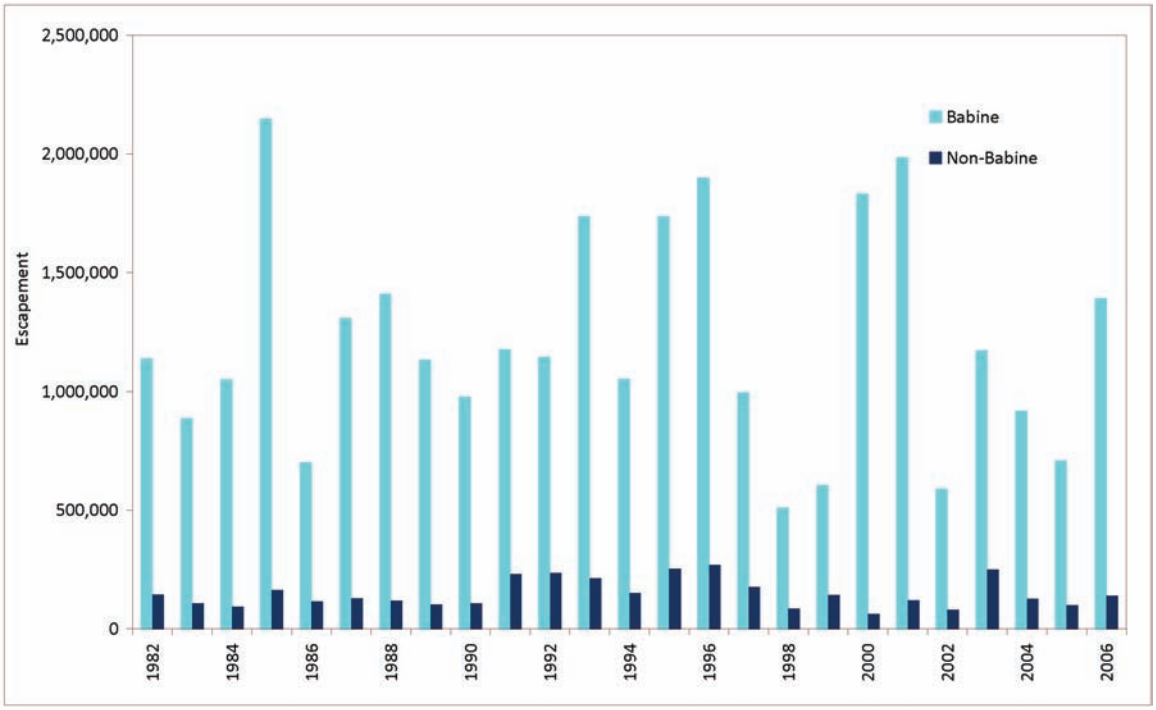


FIGURE 20. Escapement, total catch and exploitation rate of Skeena River Sockeye salmon, 1905–2001. *(From Wood 2002) Black line refers to exploitation rate.*

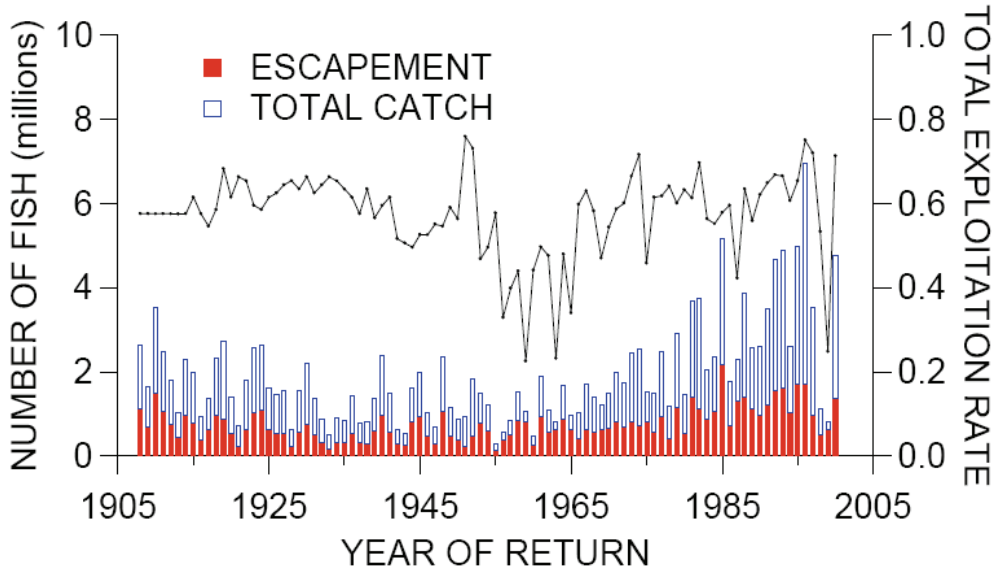
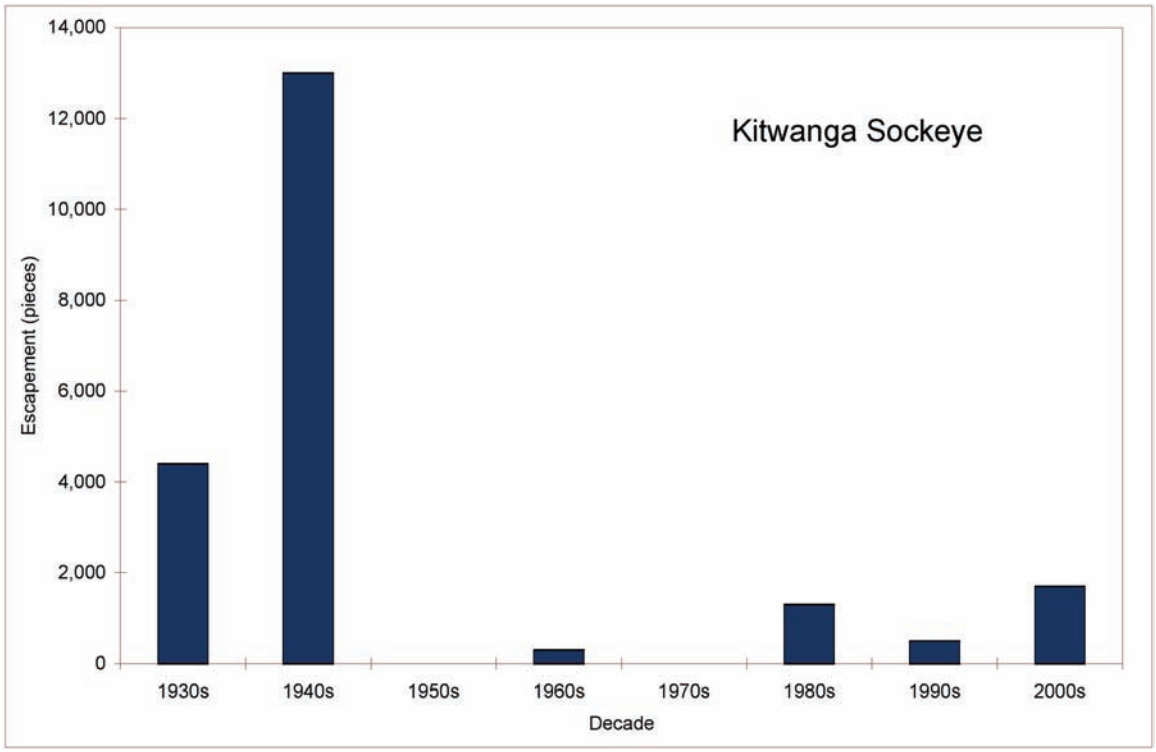


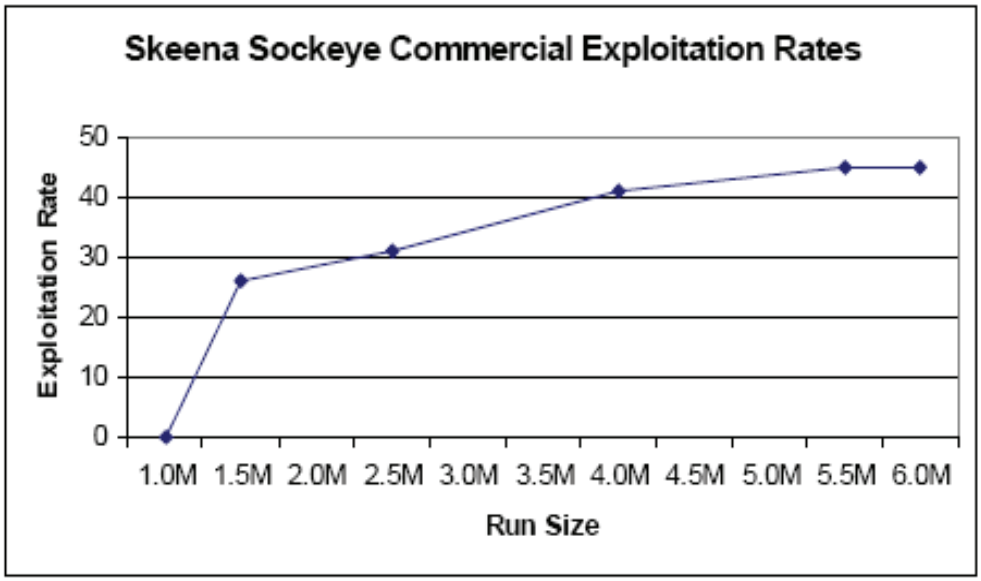
FIGURE 21. Average decadal sockeye escapement into Skeena tributary Kitwanga River, 1930s–2000s. *(Data from DFO Prince Rupert Office). Data for some decades are not complete and the decadal average may therefore be dominated by returns in less than ten years.*



At present, Canadian fisheries that harvest Skeena sockeye are managed by gradually increasing the maximum exploitation rate limit as the return run size increases (Figure 22)[31]. In general, the timing of openings is adjusted to capture the Babine sockeye runs at their peak presence in harvesting locations and limit harvesting pressure in August to protect coho and steelhead stocks.

The sliding scale of the commercial exploitation rate is based on the assumption that in years of abundant return of spawning channel enhanced sockeye, wild sockeye stocks should have been exposed to equally good ocean conditions and thus be abundant. Following this rationale, higher exploitation rates should be compensated by higher abundance. While this assumption is true for the majority of sockeye salmon returning to the Skeena systems (Figure 19), small stocks such as Kitwanga sockeye still suffer (Figure 21).

FIGURE 22. Sliding and total return size dependent scale for commercial exploitation rates of Skeena River sockeye[4].



Recently, the Skeena Independent Science Review Panel (Walters *et al*. 2008) suggested that the closure of the Fulton River and Pinkut Creek spawning channels should be considered to implement the Wild Salmon Policy and protect all Skeena sockeye conservation units. The production of adult offspring per spawner in spawning channels is generally higher than experienced under natural conditions. Therefore, sustainable exploitation rates for enhanced stocks are generally higher than for wild stocks. The decrease of smolt output from the spawning channels would also increase initial marine survival of wild smolts (Walters *et al.* 2008) and may compensate for economic losses inferred. Since 1994, the spawning channels have also been plagued by disease outbreaks that severely reduced their production, while the expectation to harvest large numbers of sockeye remained. It can be considered a risk-prone strategy to base high production of sockeye from a watershed on one uncertain source. A less risk-prone strategy would be to rely on the somewhat lower production from many sources.

[31] (Integrated Fisheries Management Plan North Coast Salmon 2007)

Pink Salmon

A mixed-stock and multi-species pink retention fishery has been allowed for the Skeena approach region in years of high pink abundance. This fishery is conducted in the statistical areas closest to the Skeena River following the completion of the regular sockeye fishery and has the following requirements to increase its selectivity[32]:

- Small mesh nets of approximately 121 mm (4 ¾") maximum mesh size;
- Short sets and revival boxes;
- The fleet is expected to be small and may fish as a pool (or pools depending on vessel numbers) in close proximity of each other;
- The fishery will be monitored for handling techniques, observed fish condition at release and short set compliance;
- The vessel operators will be required to pay for a shared observer provided by a service provider;
- Pools should be limited to a maximum of 4 to 6 vessels to provide adequate observer coverage; and
- The fishery may be administered under an experimental licence and may close on short notice based on the compliance and observed success of the selective harvest requirements.

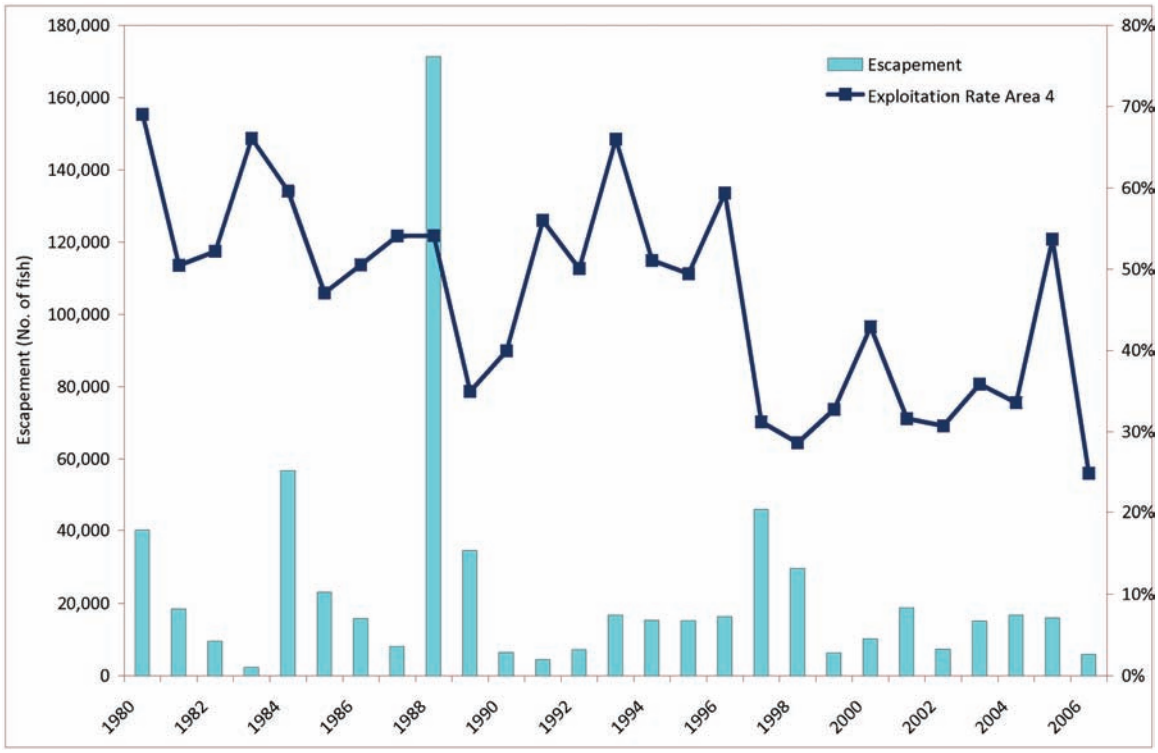
The Skeena pink fishery and its attached licence requirements is an example of a modern application of conventional methods of fishing selectivity. Nets are selective and set for short periods of time in specific locations and monitoring of compliance of all rules is paid for on a pool basis by the resource users. Still, compliance to selectivity measures is rarely enforced and monitoring and collection of by-catch data are lacking.

Chum and Coho Salmon

The extensive temporal overlap in the migration timing of sockeye and pink salmon with Skeena chum and coho salmon, as well as steelhead, is a key reason to recommend the implementation and enforcement of selective fishing techniques for all Skeena fisheries (Figure 17). Between 1980 and 2006, the numbers of chum salmon returning to the Skeena River has been very low even though the Area 4 exploitation for chum has been reduced (Figure 23).

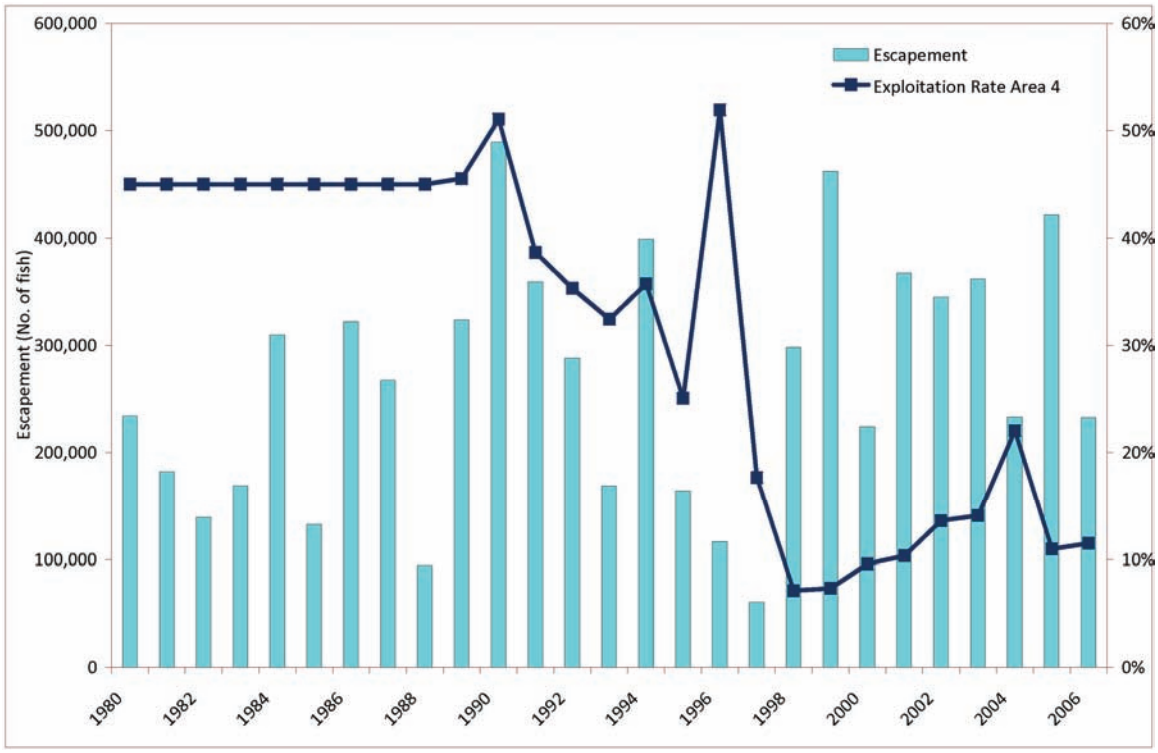
[32] Integrated Fisheries Management Plan Salmon North Coast, 2007

FIGURE 23. Chum escapement and exploitation rate in Area 4 (Skeena approach), 1980–2006.



For coho salmon the situation was similar to chum before drastic measures were taken during the "coho crisis" to reduce the Canadian exploitation rates from the 40–50% range in the 1989–1996 period to 10–27% from 1998–2006 (Figure 24). The sudden collapse of the upper Skeena coho aggregate (and the Interior Fraser coho) caught the attention of fisheries management and the public during the "coho crisis" in 1997. Reasons for the collapse were easy to point out: targeted over-fishing in the commercial and recreational sector, by-catch mortality, and low ocean survival.

FIGURE 24. Coho escapement and exploitation rate in Area 4 (Skeena approach), 1980–2006.



The success in rebuilding Skeena coho stocks from the low levels of 1997–98 is a good example of the successful combination of several measures of fisheries management. The "coho crisis" provided an opportunity to test alternative selective fishing techniques. These techniques include:

- The testing and later requirement for weedlines (1997);
- The mandatory operation of revival boxes (1997);
- Mandatory coho, chum and steelhead release and a request to release chinook alive (1998);
- Daylight only fisheries (1998);
- Half length nets and 20 minute soak times (net completely set to beginning of retrieve)(2001);
- Slight net modifications combined with recommendations for sensitive fish handling;
- To avoid bird by-catch every fifth cork must be red; and
- In addition the seine fleet is required to brail all fish and wet sort if possible.

Although these measures have not been consistently required or enforced, there have been periods when they have contributed to a reduction in coho and steelhead by-catch mortality in seine and gillnet fisheries. It should be noted, however, that the method that reduced the coho and steelhead by-catch exploitation rate the most was avoidance of interception as demonstrated in the following examples:

- Area zone management (Red Zones= Coho present means complete closure, 1998);
- The complete closure of recreational retention of coho (1998);
- First Nations Communal Licence closures (1998);
- The gradual shift to earlier gillnet openings; and
- The complete closure of all fishing as experienced in 1998.

The above combination of closures and timing changes enabled fisheries managers to reduce the exploitation rate of coho in Canadian fisheries to less than 15% in 2001 and since.

Steelhead

Skeena steelhead by-catch and related mortalities in the Area 4 mixed-stock and multi-species gillnet and seine fisheries resulted in the foundation of several organizations that are striving to protect the wild steelhead stocks and the world renowned recreational fishery targeting them. As for coho salmon, the timing of steelhead migration through the Area 4 harvest locations overlaps with the migration timing of the enhanced Fulton and Pinkut spawning channel sockeye and the Skeena Pink salmon aggregate (Figure 17).

To respond to this mixed-species fishery problem, the interception of Skeena steelhead in the Sockeye fisheries is currently managed to an average annual harvest rate of 37% for early timed steelhead, and 24% for the complete steelhead aggregate. The Skeena steelhead by-catch mortality model is based on a relative index of steelhead abundance calculated from catches in the Tyee Test Fishery. This method of steelhead harvest rate determination represents two problems:

- Commercial by-catch and mortality as well as recreational release mortality data are missing; and
- Escapement data are notably lacking for most Skeena steelhead stocks.

Therefore, it is impossible to realistically assess the health or exploitation rate of most steelhead conservation units in the Skeena watershed. Since steelhead are under provincial jurisdiction, it is incumbent for provincial agencies to ensure better steelhead stock assessment and to become part of all decisions in Skeena salmon fisheries management. Moreover, studies are needed to verify assumed steelhead by-catch rates and mortalities to improve fisheries management. A combination of improved steelhead stock assessment and fisheries management can lead to the sustainable harvest of steelhead.

Over the last 20 years various selective fishing methods have been used to reduce fishing related mortality of Skeena steelhead. They are listed in detail above in the Skeena coho example but their successful application is dependent on compliance. Low compliance can skew harvest rate model outputs resulting in errors in the estimate of steelhead by-catch related mortality.

Based on the little data available, the total Skeena steelhead aggregate (as determined from the Tyee Test fishery) has not been overexploited to the point that the recruitment from one generation of fish can not sustain the next generation of fish (Walters *et al.* 2008).

FISHERY MANAGEMENT MEASURES: MOVING FISHERIES INTO THE SKEENA RIVER

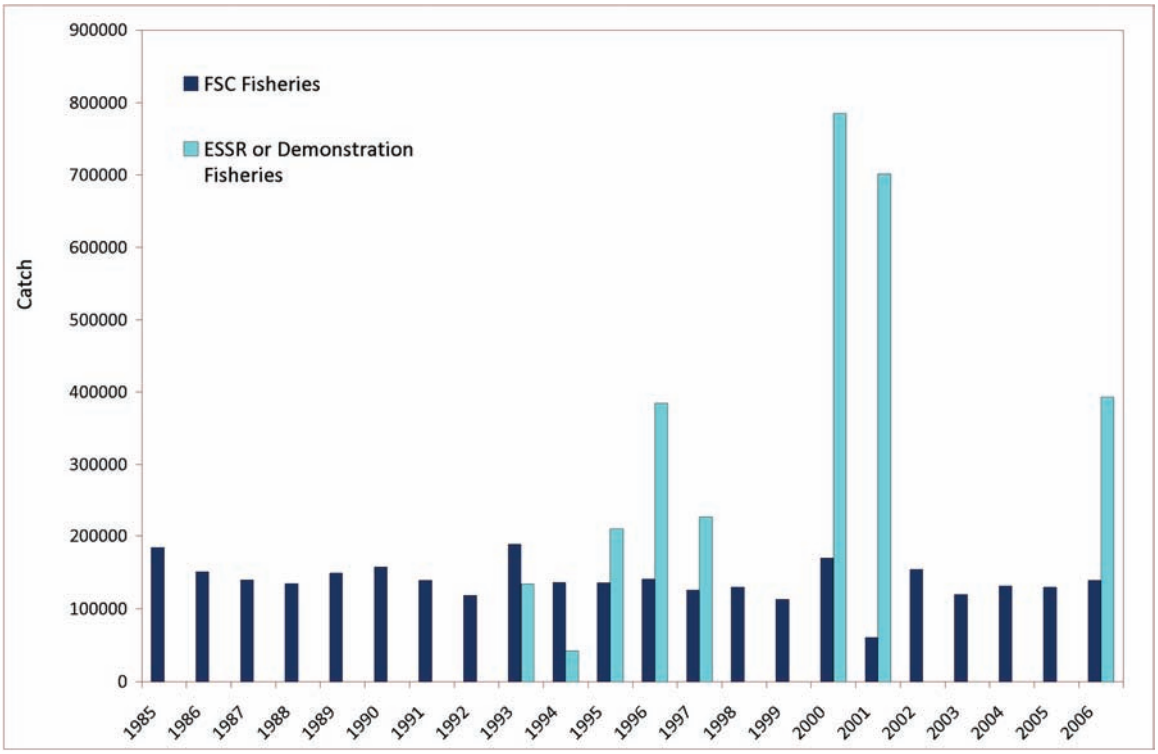
In-river First Nation fisheries are currently divided into two types of harvest: 1) the harvest for FSC use of salmon; and 2) harvests for commercial purposes. In-river FSC fisheries have not changed considerably over the last 20 years and sockeye harvests remain close to an annual allocation of 150,000. The commercial in-river fishing opportunities were first introduced as Excess Salmon to Spawning Requirement (ESSR) fisheries, which occur when salmon stocks return to a system after passing through the various fisheries at a level in excess of their spawning requirements[33]. In 2006, the Skeena Watershed ESSR fisheries were carried out in three locations on the Babine River, thus avoiding non-Babine stocks but still encountering a mixture of enhanced and non-enhanced Babine stocks. In addition, an ESSR fishery took place in Babine Lake at Fulton River for a truly terminal and stock-specific fishery.

In 2006, a Demonstration Fishery was initiated in the Skeena watershed to test the feasibility of transferring commercial harvest opportunities and allocations from marine fisheries to in-river fisheries. Commercial harvests by First Nations in ESSR and Demonstration fisheries have been substantial in some years (Figure 25). All ESSR and Demonstration fisheries are species-specific and must use DFO approved selective fishing techniques such as, beach seines, tangle nets, fishwheels, and fish weirs to harvest the target species and release all by-catch species with the least harm possible. ESSR and Demonstration fisheries are conducted separately from FSC fisheries. Future First Nations Treaty Settlements will likely transfer more of the retired or bought back fishing capacity of the non-First Nations commercial fleet to terminal locations in the river. As a result, the harvest of sockeye salmon in the Skeena Watershed would become more species selective, since by-catch can be easily released unharmed when the aforementioned fishing techniques are used. The in-river fisheries in the lower Skeena will still target mixed sockeye stocks and new ways to improve stock selectivity are still needed.

One disadvantage of the more terminal in-river fisheries is the reduced marketability and therefore reduced price of the salmon caught. While fish are migrating up the river they metabolize their fat reserves and their muscle tissue losses some of the red coloration (Ando 1986) that is the trademark of high quality salmon demanded by the markets. However, this loss in marketability can potentially be overcome by also selling salmon eggs or roe. Roe increases in value at terminal fishing locations since it is the recipient of the red coloration or carotenoids drained from the muscle tissue (Ando 1986). Additionally, value to the fish can be added by smoking or canning and a marketing campaign that could take advantage of MSC certification.

[33] http://www-comm.pac.dfo-mpo.gc.ca/pages/release/p-releas/2001/nr049_e.htm

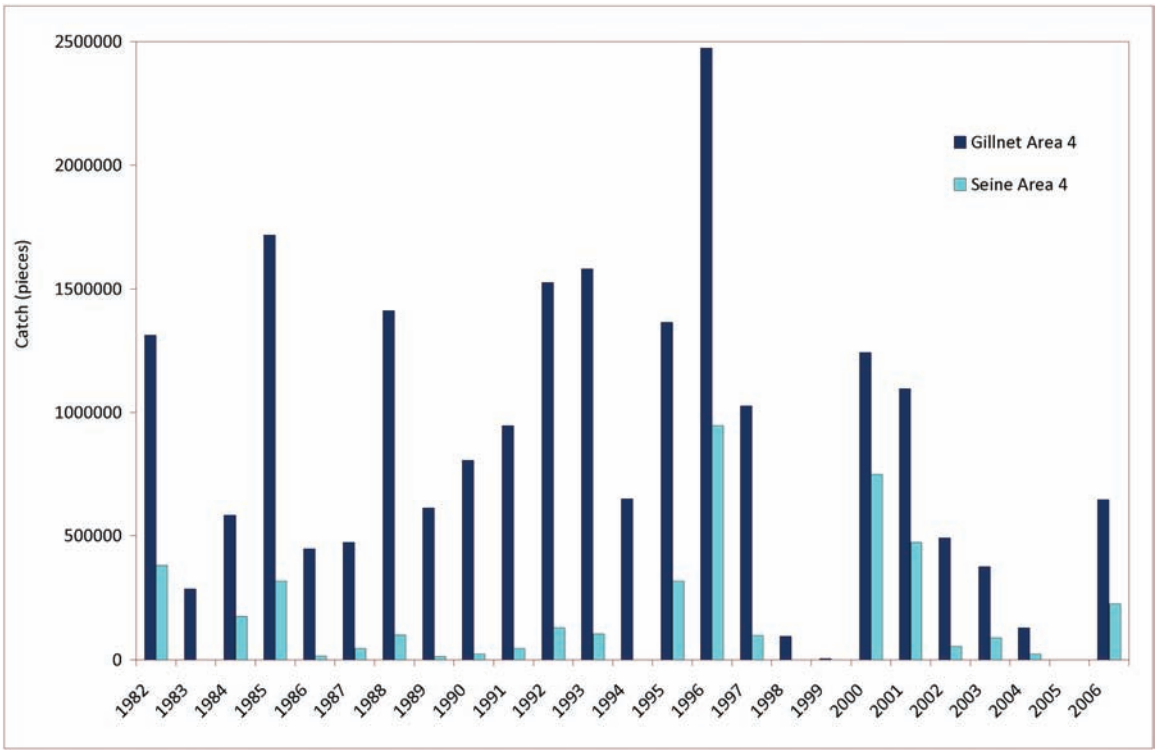
FIGURE 25. Sockeye harvest in annual First Nations FSC fisheries compared to the occasional large harvests in selective ESSR and demonstration fisheries conducted in the middle Skeena and Babine River, 1985–2006.



FISHERY MANAGEMENT MEASURES: COMMERCIAL FLEET SECTOR CHANGES

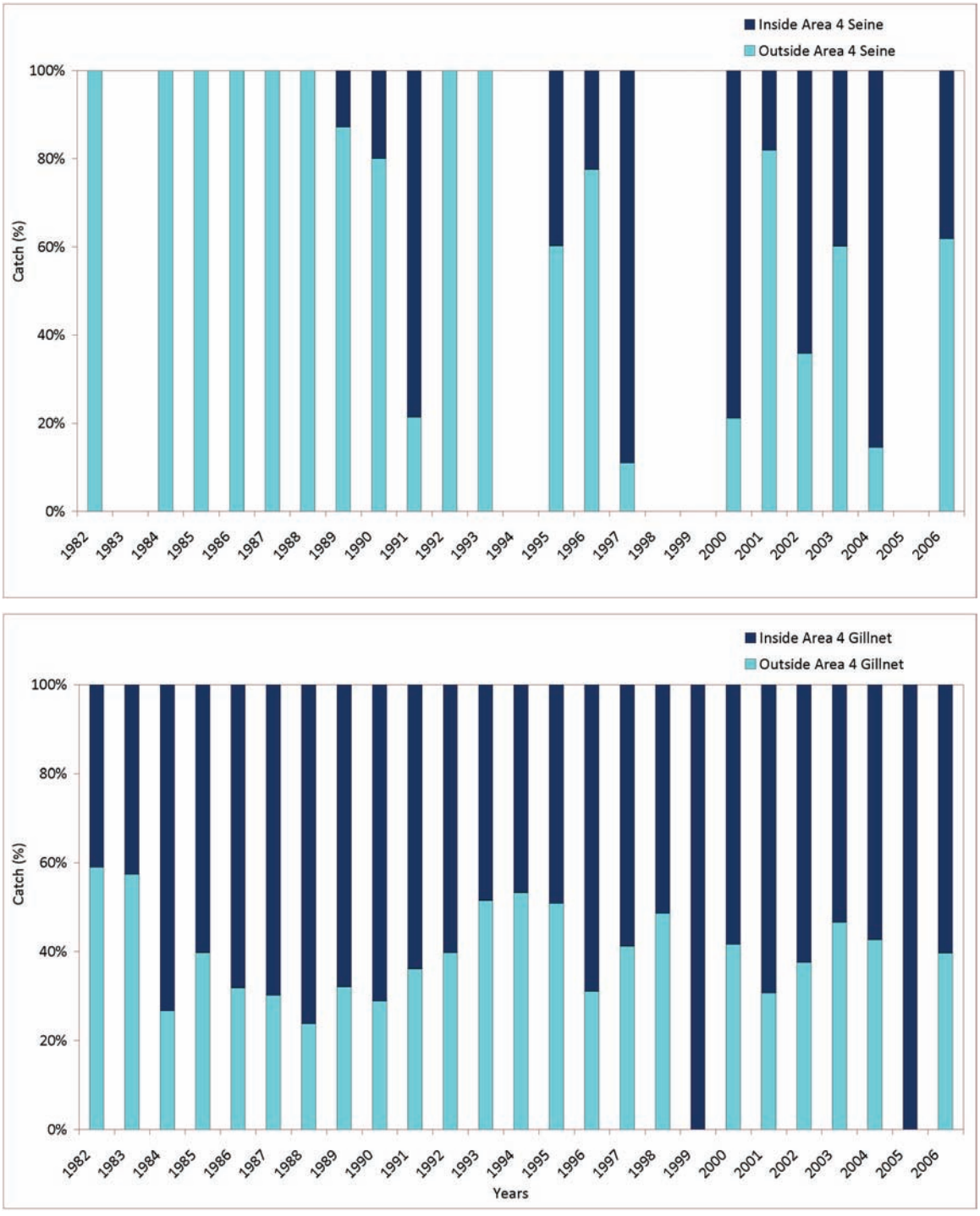
The harvest of Skeena salmon has also changed through a higher number of licence retirements through government buy-backs in the gillnet fleet when compared with the seine fleet. Consequently, the Area 4 catch of the gillnet fleet decreased while the catch of the seine fleet stayed relatively stable (Figure 26).

FIGURE 26. Area 4 (Skeena approach) gillnet and seine sockeye net catch from 1982–2006.



As an active measure of responsible fishing taken by DFO, the seine fleet's effort was re-directed from the outside areas to the inside or Skeena-near areas within Statistical Area 4. At the same time, the gillnet fleet's efforts are still evenly distributed between the inside and the outside waters of the Skeena approach (Figure 27). The movement of the seine fleet is aimed to reduce overall by-catch of non-Skeena stocks and to switch to seine fishing in general. Commercial fishing with seine nets is perceived to create less by-catch mortality than gillnet fishing. By consolidation of the seine fishery into a smaller and more terminal area and the timing of seine openings to follow gillnet openings, the later portion of the Area 4 fishery is easier to monitor and has, in combination with mandatory brailing and wet sorting, become more species selective.

FIGURE 27. Relative catch of sockeye by distance from Skeena River for Area 4 (Skeena approach), seine (upper chart) and gillnet (lower chart) fleets.
"Inside Area 4" refers to the areas closest to the commercial fishing boundary in the tidal portion of the Skeena River, while "Outside Area 4" refers to the fishing areas furthest away from the same commercial fishing boundary.



SKEENA CASE STUDY SUMMARY: CHALLENGES, SOLUTIONS AND FUTURE IMPROVEMENTS

- **Responsible Fishing Challenges:** All fisheries in the Skeena approach waters are targeting mixed-stocks and mixed-species. The effect of subtle changes to the allowed gear types, such as weed lines, short soak times, reduced net size, brailing, wet sorting and day-time fishing can not be properly assessed unless stock assessment for all stocks or conservation units and all species is ensured. The high production of sockeye smolts from spawning channels has created high expectations of their catch as adults. The continued high production from spawning channels may hinder attempts to protect small conservation units and therefore the implementation of the Wild Salmon Policy, which explicitly states the protection of all conservation units of all species as its outcome.
- **Responsible Fishing Solutions:** River-approach gillnet and seine fisheries have been curtailed through many measures of selective fishing to protect wild sockeye, coho, steelhead, and chum stocks. Temporal and spatial closures have protected wild stocks and reduced the opportunity to fish. Mixed-stock in-river fisheries can be more species selective when proven methods of selective fishing, such as tangle nets, beach seining, fish wheels, fish traps and weirs are used. In terminal in-river fisheries salmon can be harvested more selectively but with lower economic value.
- **Future Improvements:** Increase stock assessment of good indicators for all non-target salmon and steelhead stocks; develop techniques that can separate stocks at locations of high economic value; reduce output from the Babine Lake spawning channels and manage to achieve sustainable yield for all salmon and steelhead conservation units.

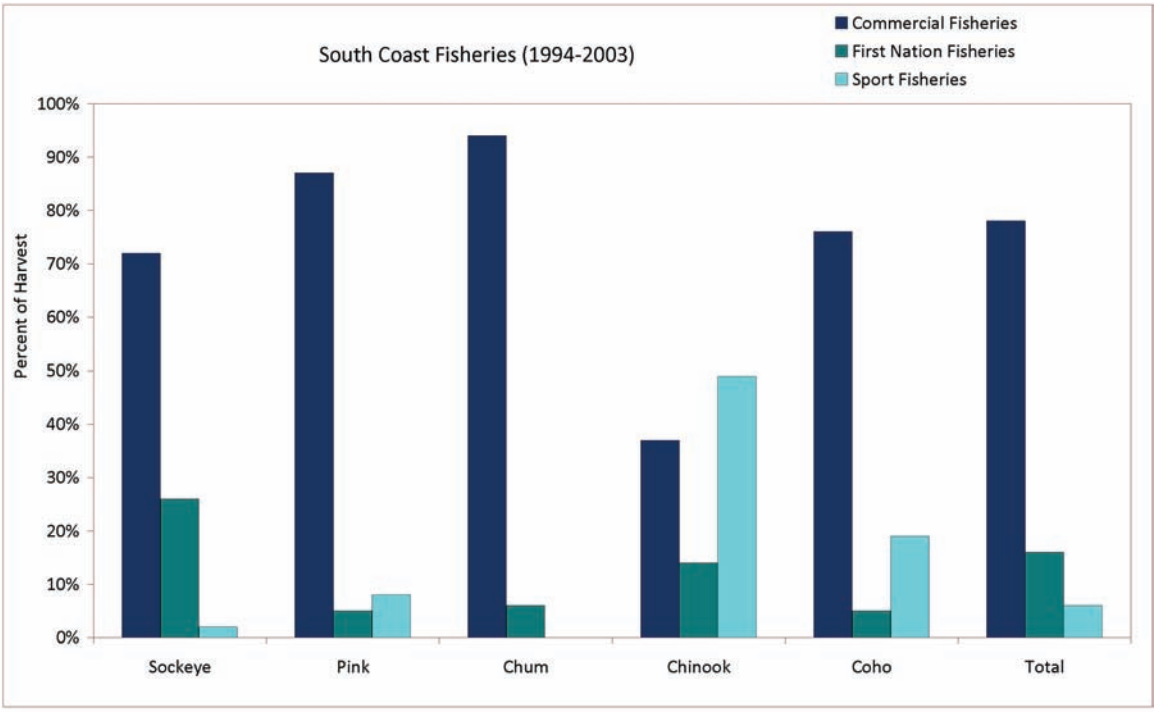
FRASER CASE STUDY

HISTORY, LOCATION AND FISH STOCKS

In southern BC, commercial fisheries typically account for the vast majority of the harvest of all salmon species including Fraser River stocks, except chinook which are taken mostly in recreational fisheries. Until recently, the vast majority of the harvests of Fraser salmon occurred in marine waters. Sockeye, pink and chum salmon were harvested primarily in the commercial purse seine and gillnet fisheries in Juan de Fuca Strait, Johnstone Strait and off the mouth of the Fraser River. Most of the harvest of Fraser chinook and coho was taken in commercial troll fisheries off the Northern BC coast and West Coast of Vancouver Island or in the recreational fisheries in the Strait of Georgia.

Over the 10 year period between 1994 and 2003, the catch distribution was 78% commercial, 16% First Nations FSC and 6% recreational for all species combined (Figure 28).

FIGURE 28. Salmon harvest proportions for the three major fishing sectors (commercial, First Nations FSC and recreational) in southern BC fisheries by species, 1994–2003.



The primary gear types used by commercial fisheries over the past 60 years have been gillnet, troll and purse seine. Historically, seine and gillnet fisheries have accounted for 84–97% of the commercial harvest of sockeye, pink and chum while troll fisheries accounted for 80–90% of the commercial harvest of chinook and coho (Figure 29). Conservations concerns related to Interior Fraser coho resulted in major restrictions to south coast troll fisheries thus substantially reducing the number of Fraser chinook and coho harvested in commercial fisheries. Very low prices for pink and chum salmon coupled with smaller returns in recent years and conservation concerns for late-run sockeye, coho and steelhead have further reduced fisheries in September to October for Fraser River pink and chum salmon to 10% of the catches observed in the 1980s. Early in the fishing season, conservation concerns for early-run chinook and Early Stuart sockeye have resulted in reduced opportunities for all fisheries. It has become clear in recent years that all fishing sectors must continue to expand their selective fishing capabilities in order to retain the opportunity to harvest the more abundant species and stocks from the Fraser River.

On a landed value basis, sockeye and chinook salmon have been the most important species in recent years, with chinook values exceeding the sockeye values in 2005 and 2007 due to poor sockeye returns to the Fraser River (Figure 30). In these years of sockeye low abundance, First Nation FSC fisheries accounted for more than 90% of the Canadian harvest of Fraser River sockeye salmon.

Historically, First Nations, commercial and recreational fisheries have targeted specific species based on the timing and relative abundance of the salmon runs. The first fisheries in each year target the spring-run chinook stocks that begin to enter the Fraser River in February and continue through early July (Figure 31). These are followed by the major fisheries targeting Fraser sockeye (Figure 32). In even numbered years, most of the salmon caught in July and August fisheries are sockeye and summer-run chinook stocks.

FIGURE 29. Salmon harvest proportions for the three major commercial gear types (gillnet, purse seine and troll) in southern BC fisheries by species, 1994–2003.

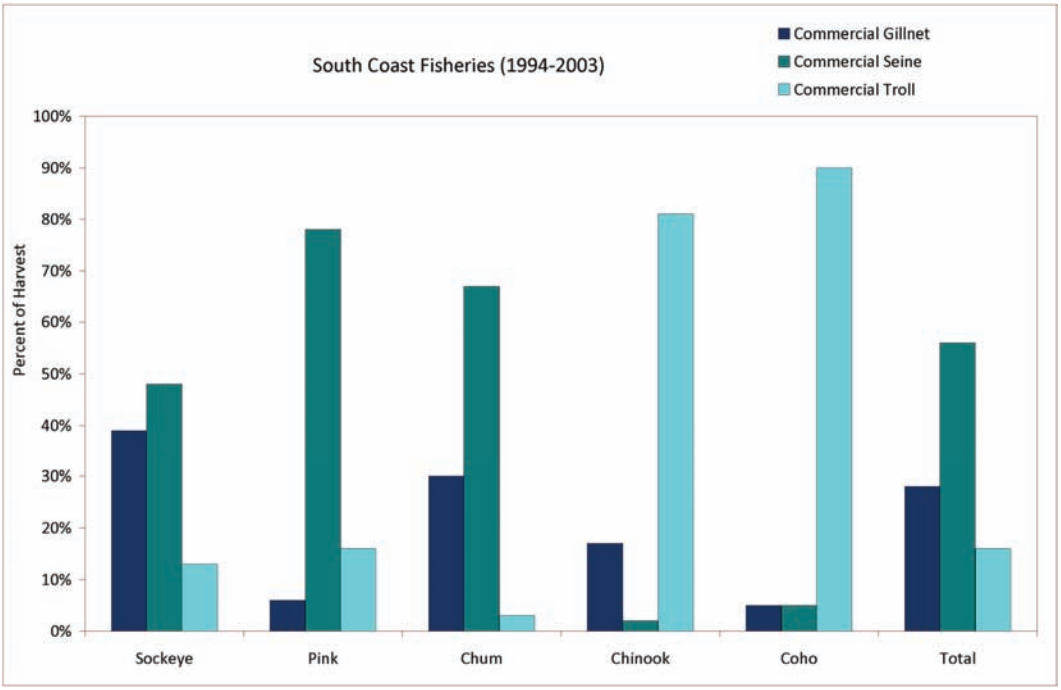


FIGURE 30. Landed value of each salmon species harvested in south coast commercial fisheries, 2004–07.

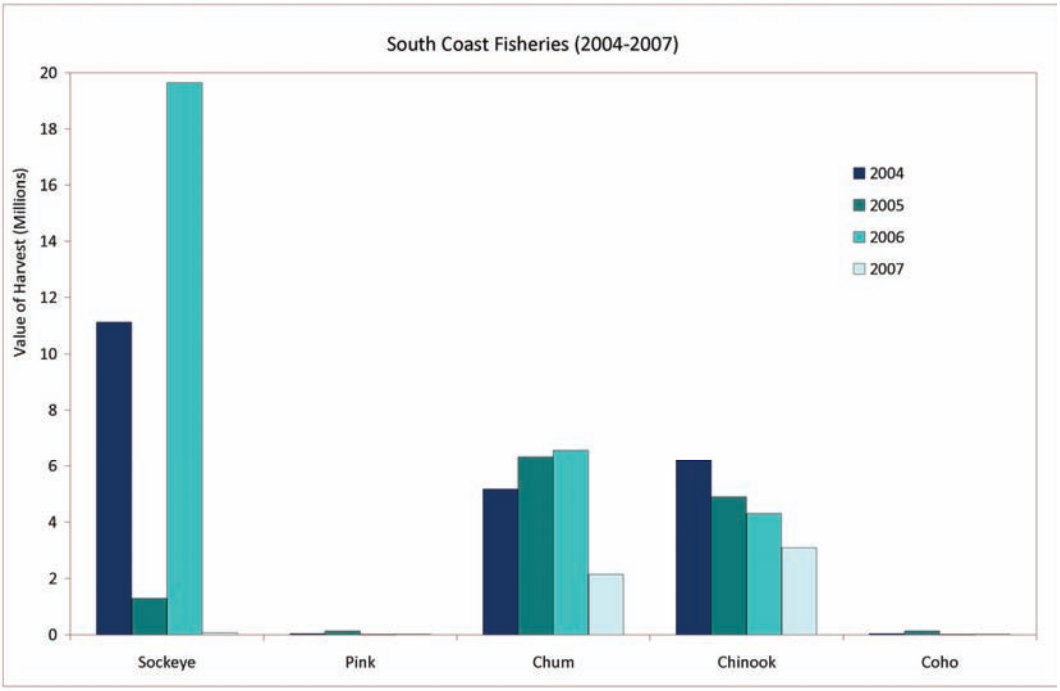


FIGURE 31. Run-timing and abundance estimates for the five major stock groups for Fraser chinook salmon in 2006.
(English et al. 2007)

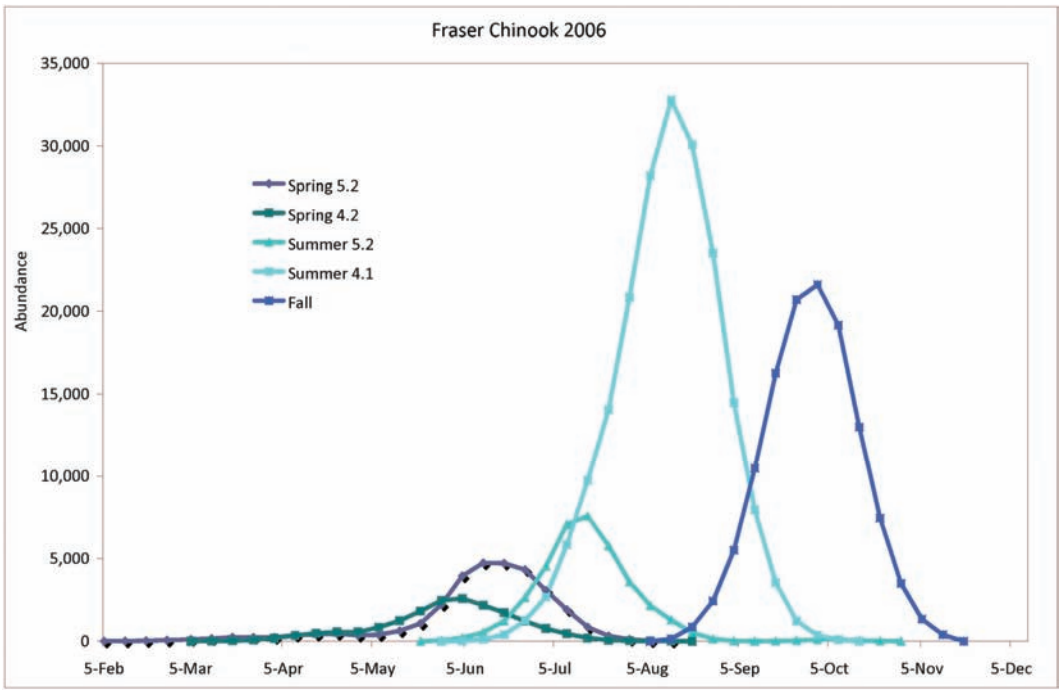
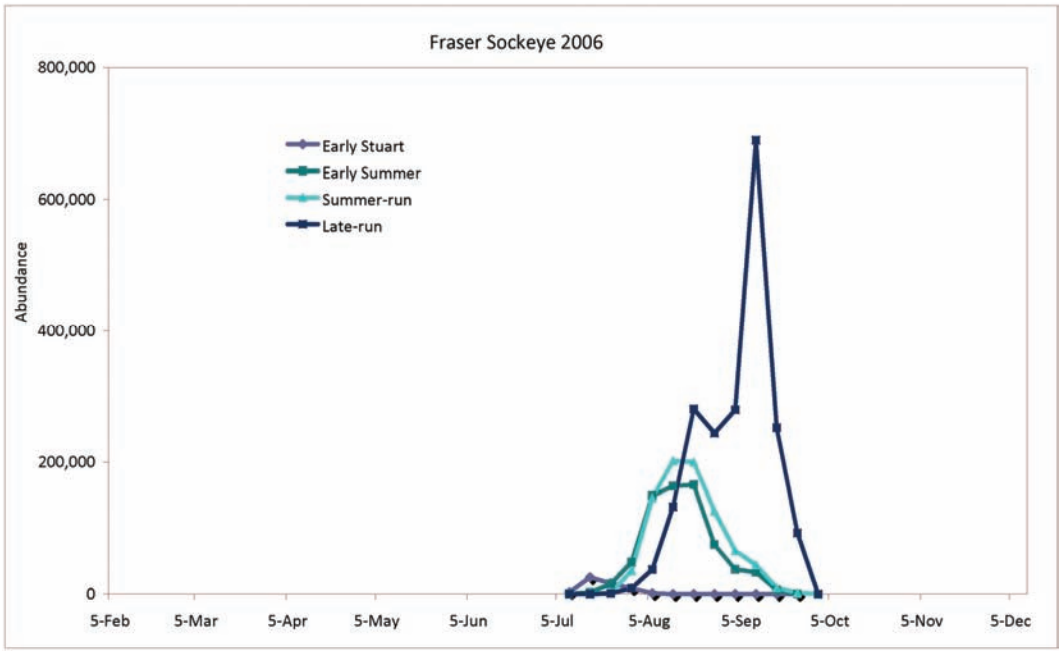


FIGURE 32. Run-timing and abundance estimates for the four major run-timing groups for Fraser sockeye salmon in 2006.
(Abundance expressed in number of fish; Source data: Pacific Salmon Commission)

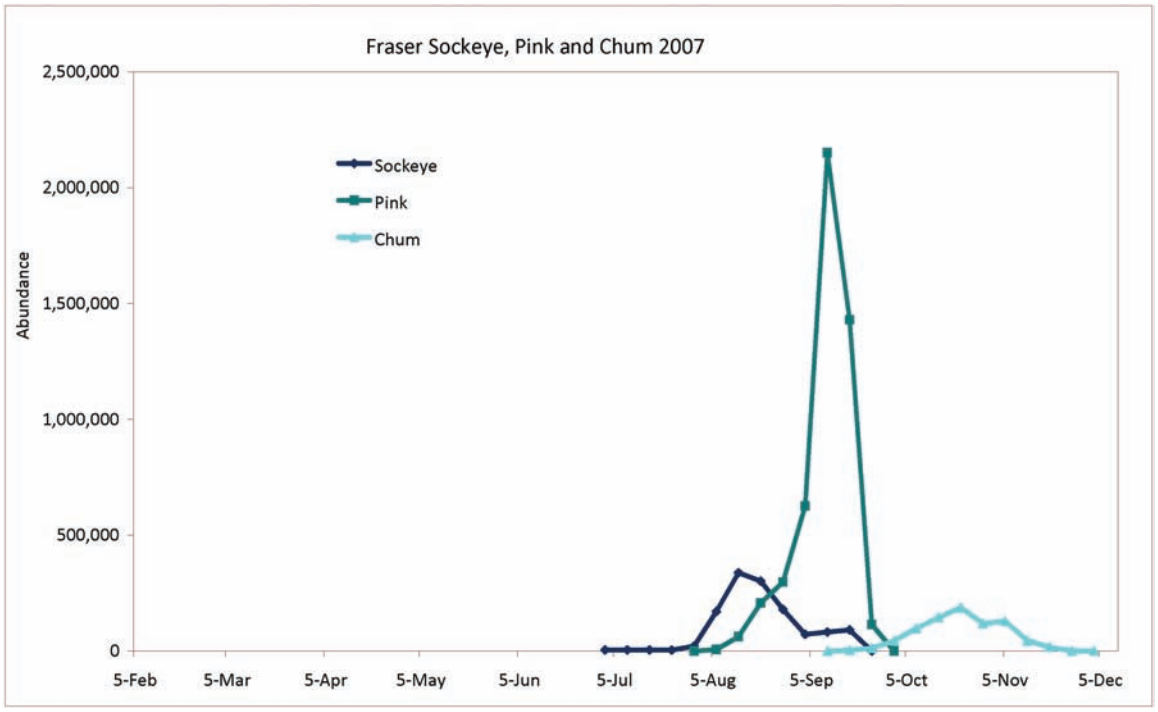


In odd numbered years, pink salmon are the most abundant species in late August through the end of September (Figure 33) but in-river fisheries for pink salmon have been limited to live capture gear in recent years due to the significant overlap in run timing with depleted Cultus sockeye, interior Fraser coho and Fraser steelhead stocks.

Closures and selective fishing restrictions for lower Fraser fisheries from September through mid October have resulted in very low harvest rates for fall-run chinook stocks returning to the Harrison and Chilliwack rivers. Chum fisheries typically begin in mid October and run into early November with additional restrictions on time or gear depending on the strength of Thompson River steelhead that have very similar migration timing to Fraser chum (Figure 33).

All of the above run-timing groups are still represented by one or more Fraser stocks but concerns over declining abundance of specific stock-timing groups (e.g., early-run chinook and sockeye, some late-run sockeye stocks, Interior Fraser coho and steelhead) have resulted in major restrictions on fishing time, locations and gear.

FIGURE 33. Run-timing and abundance estimates Fraser sockeye, pink and chum salmon past Mission in 2007.
(Sockeye and pink estimates from PSC, chum estimates from Albion Test Fishery)



SPECIES OR STOCKS OF CONCERN

Sockeye

Cultus Lake sockeye are one of the populations contributing to the late-run Fraser sockeye aggregate. A recent stock status report reviewed by PSARC detailed a serious decline on all four cycle lines in the past 20 or more years for Cultus sockeye (DFO, Report by the External Steering Committee 2003). Returns since the mid-1980s have been under 10,000 but in 1997, only 88 adults were estimated to have arrived on the spawning grounds prompting an 'endangered' status through an emergency listing by COSEWIC on 24 October 2002. Abundance was higher in 2002, with an estimated escapement for Cultus sockeye of 4882 fish but the population has suffered subsequent poor returns and is still a major conservation concern.

Numerous factors have been identified that have affected Cultus Lake sockeye, including historic over-harvesting (although there have been no targeted fisheries on these stocks in recent years), poor marine survival, habitat concerns, and predation. They have also been impacted severely in recent years by high prespawning mortality (DFO, Report by the External Steering Committee 2003).

The Early Stuart sockeye run, commonly referred to as the Early Stuart Run, consists of more than 40 stocks which spawn exclusively in the Stuart River Watershed. The total return of the Early Stuart sockeye aggregate was well below cycle average of 182,000 fish for the last four years. The 50% probability forecast for the 2008 season is 35,000 sockeye or 19% of the cycle average (DFO IFMP, Southern BC 2008). The Early Stuart sockeye aggregate is therefore still a major concern for conservation.

Chinook

Several stocks of Fraser early-run chinook return earlier and have lower productivity than the others (i.e., Birkenhead, Upper Chilcotin, Westroad, Cottonwood, Coldwater, Spius, and Louis). These early-timed stocks are more vulnerable to potential over-exploitation for a variety of reasons: 1) they migrate through the Fraser River canyon relatively slowly (except Birkenhead), exposing them to fisheries over a longer period, 2) they return to their natal streams during the spring months but do not spawn until late summer or fall, again subjecting them to increased mortality, 3) they have lower productivity than other chinook stocks, and 4) pre-season forecasts for these early-run stocks are not available due to the lack of data for reconstructing adult run size (Pestal 2006).

Major in-river harvesters of early-run chinook are First Nations' FSC fisheries, which are managed in nine distinct units based on area and fishing gear. For each unit, the pre-season guidelines specify a range of weekly openings, which are reviewed and adjusted throughout the season (Pestal 2006).

The recreational fishery also intercepts early-run Fraser chinook and for these fisheries, the pre-season guidelines cover two distinct units: 1) Fraser River, and 2) Parts of Southern WCVI, Lower Georgia Strait, and Juan de Fuca Strait. For these fisheries, the pre-season guidelines specify a flexible range for the beginning of each year's opening, and a set of potential local measures like spot closures or catch & release (Pestal 2006).

Commercial troll fisheries have some incidental harvests of Spring-run Fraser chinook, but are managed based on total abundance of chinook. For these fisheries, the pre-season guidelines specify localized conservation measures (e.g., sub-area closures, ribbon boundaries) during critical times to protect Spring-run chinook when necessary (Pestal 2006).

Interior Fraser Coho

Measures to protect Interior Fraser River coho were first implemented in 1998. Since then, the conservation objective has been clarified to limit the exploitation rate to 3% or less. As a result of these measures, improved escapements totaling 57,700 were observed for Interior Fraser coho in 2007 (DFO IFMP, Southern BC 2008), up from less than 10,000 fish in the 1996–1997 period (Folkes & Irvine, 2005). However, ongoing concerns over water supply will continue to limit recovery of coho stocks and further the requirement for actions to limit exploitation (DFO IFMP, Southern BC 2008).

Steelhead

The protection of interior Fraser or more precisely the Thompson and Chilcotin rivers steelhead stocks has become the focus of fisheries management measures in all Fraser River approach fisheries. Summer-run steelhead returning to the Thompson River and its tributaries support a major freshwater sport fishery. To reduce steelhead by-catch, time, area and gear restrictions on commercial fisheries targeting other salmon species have been implemented. In 2006 a subcommittee of the Pacific Scientific Advice Review Committee concluded: *"…unless rectified, current empirical data deficiencies for steelhead will frustrate any future analysis… of steelhead exploitation in the Fraser*" (Hyatt 2006). Target escapements to the Thompson and Chilcotin River steelhead groups have been set at 1250 fish and there are ongoing discussions between DFO and the Province to develop a management framework for Interior Fraser Steelhead. It is expected that this management framework could include the following items (DFO IFMP, Southern BC 2008):

- Shift the timing of the commercial fishery window to protect the Deadman River steelhead while avoiding the peak timing of steelhead escapement;
- Improve steelhead catch monitoring in fisheries that occur on the stocks prior to the Fraser River and the development of "stop light" criteria that would govern opening fisheries in future years based on abundance indicators; and
- Set escapement targets for steelhead stocks.

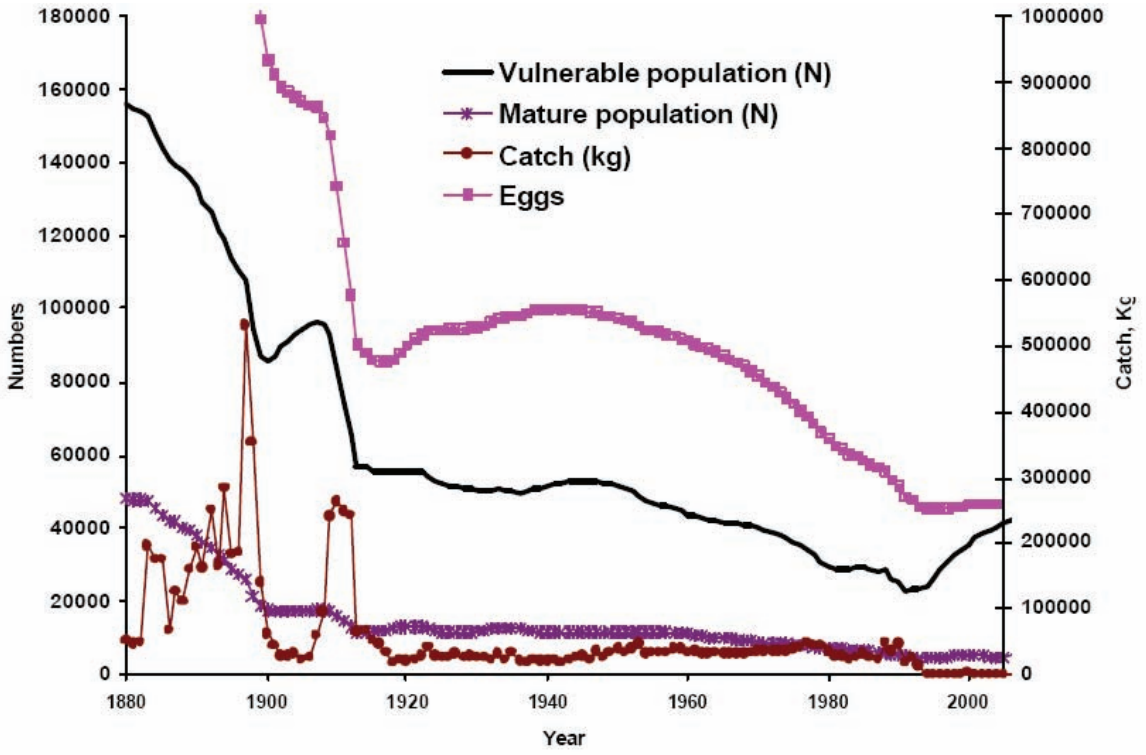
Fishing plans will be developed that meet the objective for Interior Fraser River steelhead to protect 80% of the run through restrictions on all commercial fisheries from early September to mid-late October in the Fraser main stem from the mouth to Mission.

Sturgeon

A large resident stock of white sturgeon in the lower Fraser River was exploited over a very short period at the turn of the 20th century driving this fishery into commercial extinction (Figure 34). However, it was not until 1990 that white sturgeon was listed as a "species of special concern" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and in 1994 the harvest of all sturgeon in BC was curtailed by law. Four populations of white sturgeon have been identified and classified as endangered in the Fraser River of whom only the middle and lower population units have not been listed under the Species at Risk Act (SARA). Through a large tagging study in the lower Fraser River it was estimated that about 18% of the sturgeon population is killed each year by natural mortality, unreported angling mortality, mortality from commercial or First Nation gillnets, or poaching (Nelson *et al.* 2004).

Among the different fishing techniques, set gillnets proved to be causing post-release mortalities of 46.9% in comparison to low post-release mortalities from the angling (2.6%) and drift gillnet (0%) fisheries (Robichaud *et al.* 2006) based on the very long 11 hour average set-times of the gillnets. The Fraser River white sturgeon remains a species of special concern in all fisheries and has to be released with the least possible harm.

FIGURE 34. Stock reduction analysis (SRA) model estimates of historical white sturgeon stock sizes needed to have withstood historical catches and give recent abundance consistent with mark-recapture data. *(From: Walters et al, 2005)*



SELECTIVE FISHING MEASURES SPECIFIC TO THE FRASER

A wide variety of fish capture techniques have been used over hundreds of years by local First Nations and later by the commercial fishing sectors to harvest adult salmon on their return migration to the Fraser River. Examples of traditional First Nations marine techniques have included traps, reef nets, hook and line techniques. These were later replaced by gillnets and purse seines in the commercial fisheries. In freshwater, the concentration of migrating salmon close to shore, in shallow waters and clear water streams have made it possible for First Nations to use an even wider variety of selective or live capture harvesting techniques, including: gaffs, spears, hooks, dip nets, beach seines, baskets, weirs, traps and fishwheels. In recent times gillnets and tangle nets were added. Some of these techniques are effective live capture methods while others are less suitable for conducting species-specific "selective" fisheries.

Over the past 20 years in the Fraser approach fisheries, numerous tests of live capture "selective fishing" techniques have been conducted to minimize the mortalities for non-target species. The techniques that are most promising include: purse seines in marine waters; tooth-tangle nets and beach seines in the lower Fraser; fishwheels and dip nets in the Fraser canyons; and weirs and traps in tributaries. The following sections give examples of selective fishing techniques that have been demonstrated to be effective for Fraser salmon fisheries.

Reef Nets: The reef nets currently used by US fishers to catch Fraser sockeye (Figure 11) and pink salmon are modifications of the original reef nets fished by First Nations for hundreds of years prior to initiation of commercial salmon canning industry in the 1860's. A picture, as well as a more detailed description of a reef net operation can be found under "Measures and Tools to Achieve Selectivity". Reef nets were adapted for commercial fishing after the use of pile traps and floating net traps was banded in Alaska in 1959. The Washington State reef net currently has a zero by-catch mortality rating and all non-target species are released directly from the net with minimal handling. Fish caught using these reef nets are held alive in pens and often sold to customers directly out of these pens or taken to nearby shore selling stations in small numbers for sale directly to the public at prices 3–5 times those paid by processors for purse seine and gillnet caught fish (Jack Giard, Washington Reef Net Owners Association, pers. comm.).

Purse Seines: Purse seine techniques have the capability of being species selective, with relatively low by-catch mortality for most non-target species. However, this selectivity and low by-catch mortality requires that careful brailing is conducted and seine crews are trained in fish handling and revival techniques. Short-term holding studies have shown that mortality rates for steelhead and coho can be as low as 4% and 6% respectively after 48 hours (JO Thomas and Associates 1997, Blewett and Taylor 1999). Higher mortality rates (23–45%) have been observed for coho and chinook caught in commercial purse seine fisheries under "normal fishing conditions". Purse seine techniques were successfully used to capture Fraser bound adult sockeye for large scale radio-telemetry studies conducted in 2002, 2003 and 2006. These studies demonstrated that short-term mortalities were very low (<1%) for properly handled fish and survival of tagged fish migrating from Johnston Strait and Juan de Fuca Strait to detection sites in the lower Fraser River was 73–75%, after removals in marine fisheries were accounted for (English *et al.* 2005). The long-term survival rates for fish released directly without the additional stress of tagging and biological sampling would likely be higher.

Tangle Nets: Tooth-tangle nets have been used on the Lower Fraser River to target chum and permit the live release of coho and steelhead. In a 1996 test using 3.5 inch mesh tooth-tangle nets allowed for live release of 88% of the coho, 98% of the chinook and 100% of the steelhead caught on the lower Fraser River (JO Thomas & Associates 1997). In every instance, fishers have noted that a second person is required on board to ensure the proper handling of non-target species (JO Thomas & Associates 1997). Tooth-tangle nets have also been demonstrated to be an effective gear for the live capture of salmon for tagging studies. In the Nass River in 1992, tangle nets were used to capture adult chinook for a radio-telemetry study and 84% of the tagged fish, not removed by fisheries, were subsequently tracked to spawning areas (Koski *et al.* 2006). Similarly, tooth-tangle nets were used in 2005 to capture adult summer-run sockeye in the lower Fraser River and losses related to capture and tagging were estimated to be 10% of the 303 radio-tagged summer-run sockeye (Robichaud and English 2006).

Beach Seines: Beach seines have been demonstrated to be an effective technique for selective harvesting of chum and pink salmon on the lower Fraser (Blewett and Taylor 1999). Survival of non-target species released from these beach seine fisheries has not been quantitatively assessed but observers have noted that scale loss is generally very low and the fish appear to be in good condition. As with other fishing gears, the key to minimizing mortalities is training the fishing crews in proper handling techniques and the rapid release of any non-target species.

Fishwheels: Fishwheels have been tested and operated along the Fraser River by several First Nations: Lheidi'T'enneh, Siska, Yale, Shuswap, Sto'lo, Skway, Sumas and Matsqui. The best sites for deploying fishwheels occur in the Fraser canyon, where operations are facilitated by steep valley walls that provide water depths of 10–20 ft adjacent to the shoreline, turbid water and offshore velocity barriers concentrate the upstream migrating salmon along the river bank. There are numerous locations between Hope and the

confluence of the Chilcotin that are ideal for fishwheel operations. Fishwheels have also been operated successfully by the Yale First Nation (1998–2000) and Siska First Nations (2000–2007) at several of the potential canyon sites and the Lheidi'T'enneh First Nation (1997–98) on the Fraser River near Prince George.

Rigorous testing of alternative fishwheel configurations, sites, fish guidance and power assist systems was initiated in the Mission area in 2007 in an attempt to develop a live capture tagging and sampling platform to improve the annual assessment of returns to the lower Fraser River for all salmon species and potentially steelhead (Robichaud *et al.* 2008).

Dip Nets: Dip nets are one of the most selective fishing methods and this technique has been used successfully by First Nations to harvest salmon along the Fraser River mainstem above Hope and in several major tributaries. Dip nets usually capture fish one at a time such that non-target species can be quickly released with little or no handling. Consequently, survival rates for fish release from dip net fisheries are believed to be close to 100%. Like fishwheels and most other live capture gear used in rivers, the effectiveness of dip nets is highly site specific. Examples of excellent dip nets sites include: Bridge River Rapids and several sites along the lower Thompson River.

FISHERY MANAGEMENT MEASURES

The main tools that fishery managers have used to reduce by-catch of non target stocks in Fraser River fisheries has been area and time restrictions to reduce harvest rates on weak stocks. The combination of concerns for both early and late-run sockeye stocks (1995–present), low prices for pink and chum salmon (1990–present) and increased allocations for in-river First Nation fisheries (1993–present) have resulted in major restrictions to commercial fishing opportunities in marine waters. Concerns for Interior Fraser coho stocks (1998–present) resulted in further restriction of all marine and freshwater fisheries that could encounter these stocks.

In 2007, the target exploitation rate for Cultus Lake sockeye was set at 20%, up from 15% set in 2002 (DFO IFMP, Southern BC 2008). However, it should be noted that there is high uncertainty in the pre-season forecasts of the total return of Cultus sockeye. For Early Stuart sockeye, the allowable mortality rate has been, for example, set at zero in 2008 when a return of 35,000 sockeye, well below the run size reference point of 108,000 fish, was expected (DFO IFMP, Southern BC 2008).

The objective for Interior Fraser River coho (including Thompson River coho) is to limit the Canadian fishery exploitation rate to 3% (not including terminal harvest on systems experiencing strong escapements of enhanced fish). During May through September, when Interior Fraser coho are encountered in southern BC waters, management actions range from non-retention to time and area closures (DFO IFMP, Southern BC 2008).

Recent (2005–present) declines in a few small chinook stocks that return to the Fraser between March and early June (2005–present) are likely to result in further reduced fishing opportunities in the spring for both sport and First Nation FSC fisheries. Early timing Fraser chinook stock components are classified as stocks of concern, as escapements have dropped to less than 100 fish for four of the seven populations (Spius, Coldwater, upper Chilcotin, Louis, Chilako, Cottonwood, and Birkenhead chinook stocks) (DFO IFMP, Southern BC 2008).

Every Canadian fishery that harvests Fraser salmon stocks has experienced some level of restriction in fishing time, gear or location to reduce their impact on non-target species of stocks. Most harvesters realized that the viability of their fisheries in the short-term, and probably the long-term, will depend on their ability to move to fishing techniques that minimize the mortality rates for non-target species. The challenge is to design and implement a plan that will facilitate this transition.

SUMMARY, FRASER FISHERIES: CHALLENGES, SOLUTIONS AND FUTURE IMPROVEMENTS

- **Fraser Fisheries Challenges:** Conservation measures for Interior Fraser River coho, Thompson River steelhead, Early chinook stocks, Cultus and Early Stuart sockeye, and sturgeon will continue to constrain Fraser River salmon fisheries for the foreseeable future. The requirement for rigorous and robust stock assessment programs continues to be paramount.
- **Fraser River Fisheries Solutions:** Continued implementation and expansion of known selective fishing measures and exploration of new measures are required if increased fishing opportunities on strong stocks are to be realized.
- **Fraser River Fisheries Future Recommendations:** Continue to implement selective fishing methods (e.g., beach seines, fishwheels, terminal weirs) to enable harvests of strong stocks and integrate these initiatives with rigorous stock assessment programs to provide information necessary to evaluate success.

AREA F TROLL

HISTORY, LOCATION AND FISH STOCKS

The Area F troll fishery (Figure 35) has been a competitive fishery as have all other troll fisheries in BC focusing primarily on chinook and coho salmon and harvesting a wide range of chinook and coho stocks originating from streams in Washington State, Oregon, and Southern BC (Winther and Beacham 2006). A total fleet quota for chinook and coho is set each year, guided by the Pacific Salmon Treaty. The vast majority of the catch is taken in Statistical Areas 1 and 2.

Since 2000, the landed value of the Area F troll fishery has been steadily increasing (Table 7). This improvement can be attributed to increased fishing opportunities in recent years (DFO 2006). From 1952 to 1982, opening times for the fishery varied but typically commenced 15 April and ended 30 September until the Pacific Salmon Treaty was established in 1985 (Winther and Beacham 2006). Over time, the start and duration of the fishing season has been significantly curtailed and in the late 1980s the fishery did not commence until late June or early July (Figure 36 and Figure 37). In 1999, the fishery on chinook was restricted to the first two weeks of August. In 2000, the fishery did not commence until 1 September. Commencing in 2001, the fishery started expanding again into the spring and early summer period. The timing of the Area F troll fishery for coho and sockeye has experienced very little change over the same time period although after 1997, the fishery was limited due to conservation concerns for Upper Skeena and Thompson coho (Figure 38 and Figure 39). There has been no change in the timing of the troll fishery for pink salmon (Figure 40).

FIGURE 35. Area F troll fishery management area.

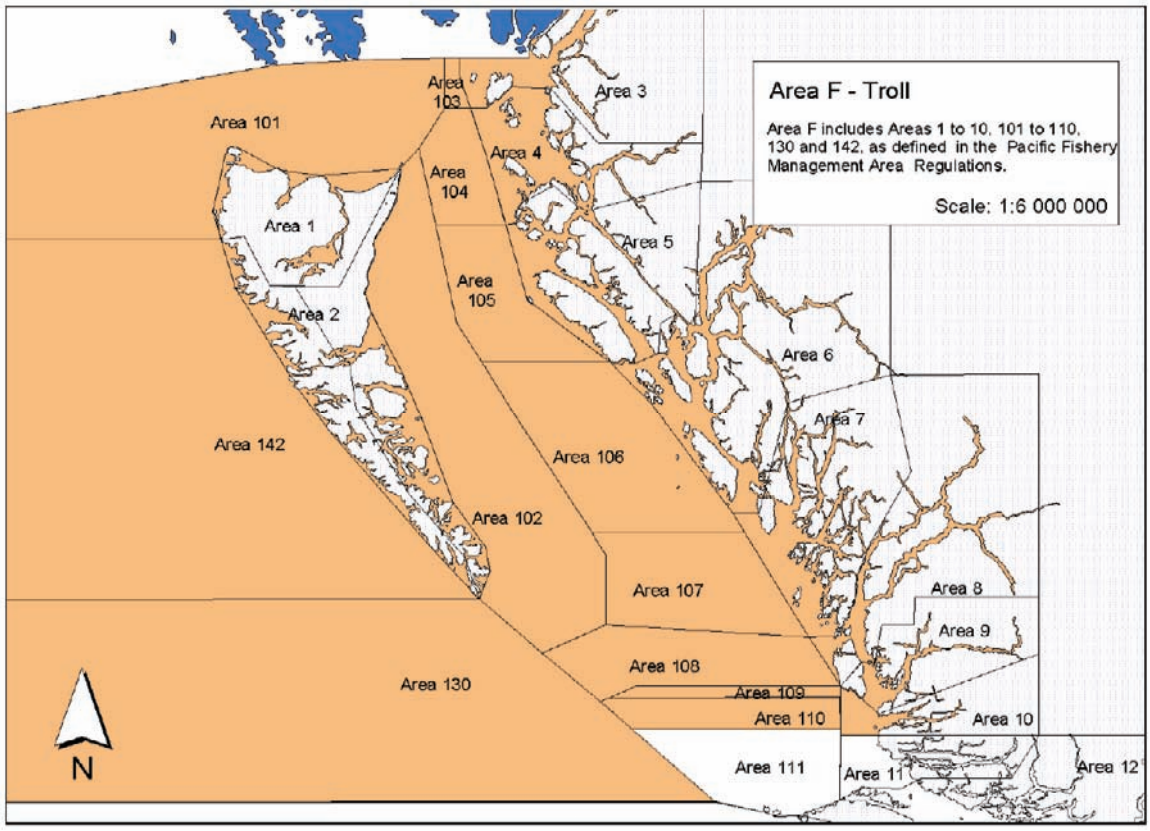


TABLE 7. Area F troll fishery total landed value (Sporer 2006).

Year	Total Landed Value (2005 $)	Landed Value per Licensed Vessel (2005 $)	Landed Value per Active Vessel (2005 $)
2000	983,280	6,690	18,210
2001	1,264,600	8,850	15,810
2002	5,055,640	33,700	50,060
2003	6,753,460	43,600	53,600
2004	11,055,080	69,100	80,700

FIGURE 36. Start and end weeks for the Area F troll fishery since 1952.
(Source of data: DFO North Coast)

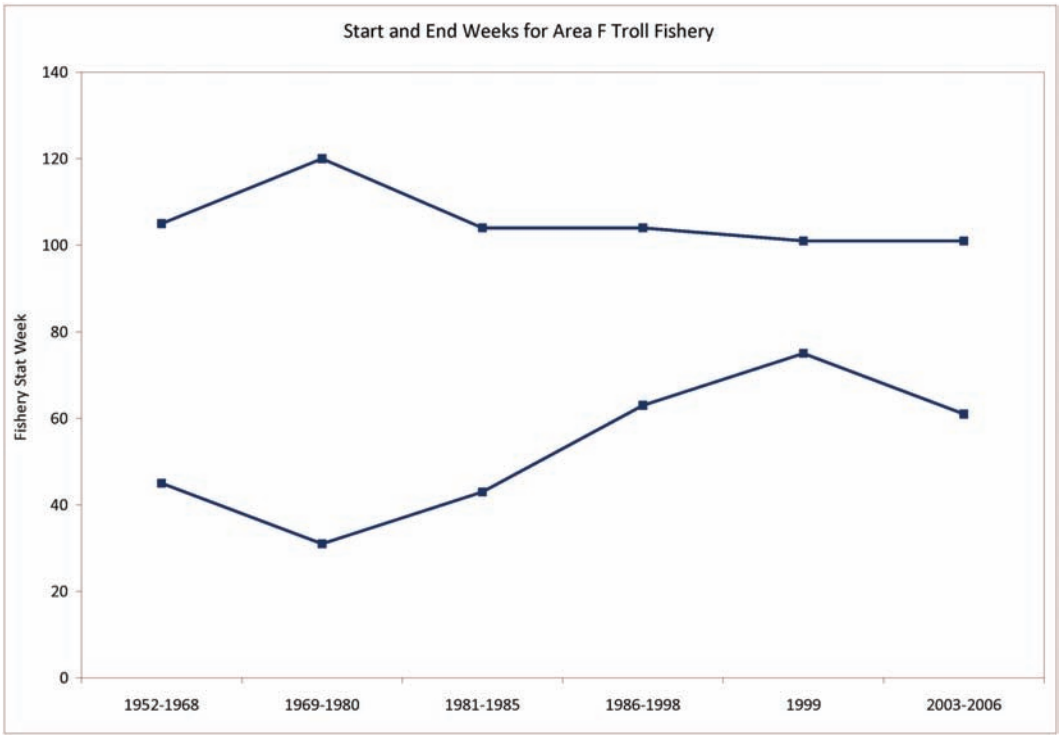


FIGURE 37. Cumulative catch of chinook salmon in the Area F troll fishery since 1952, based on sales slip information.
(Source of data: DFO North Coast). Data not available by week for 2000–2002.

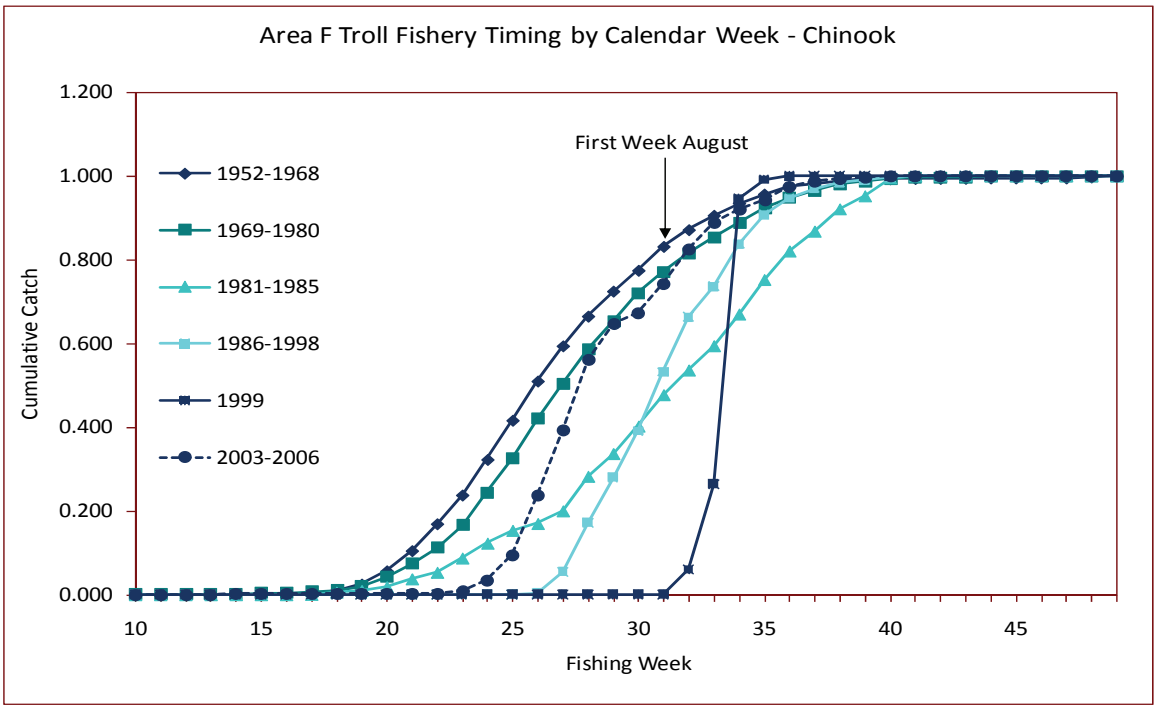


FIGURE 38. Cumulative catch of coho salmon in the Area F troll fishery since 1952, based on sales slip information.
(Source: DFO North Coast). Data not available by week for 1998–2002.

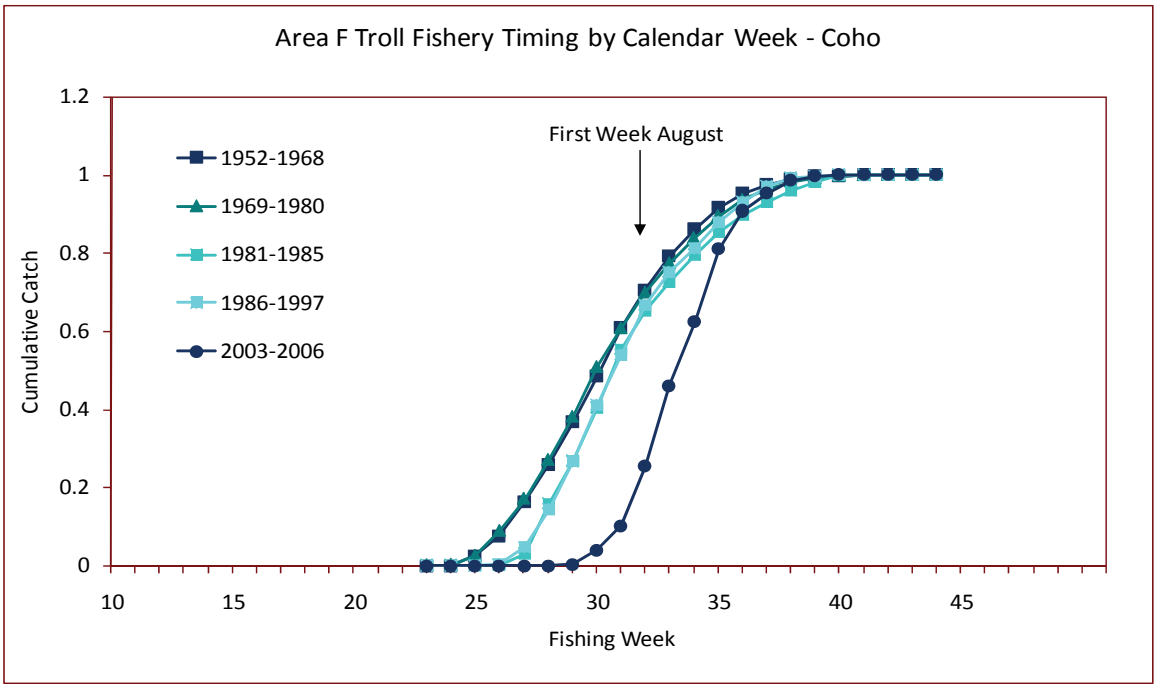


FIGURE 39. Cumulative catch of sockeye salmon in the Area F troll fishery since 1952, based on sales slip information.
(Source: DFO North Coast). Data not available by week for 1998–2002.

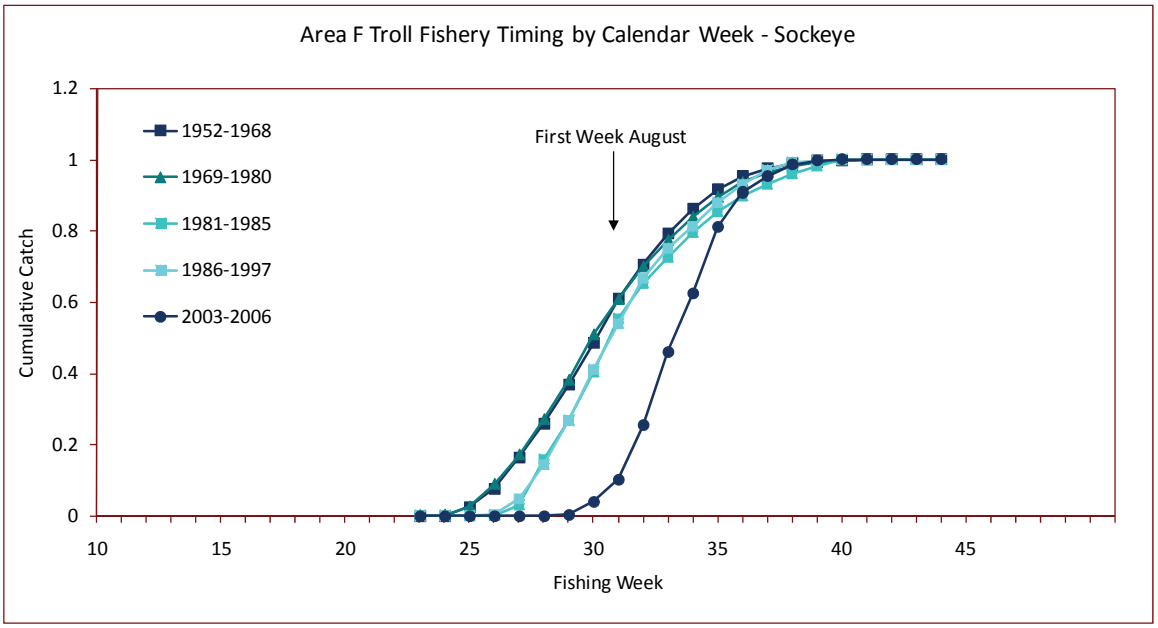
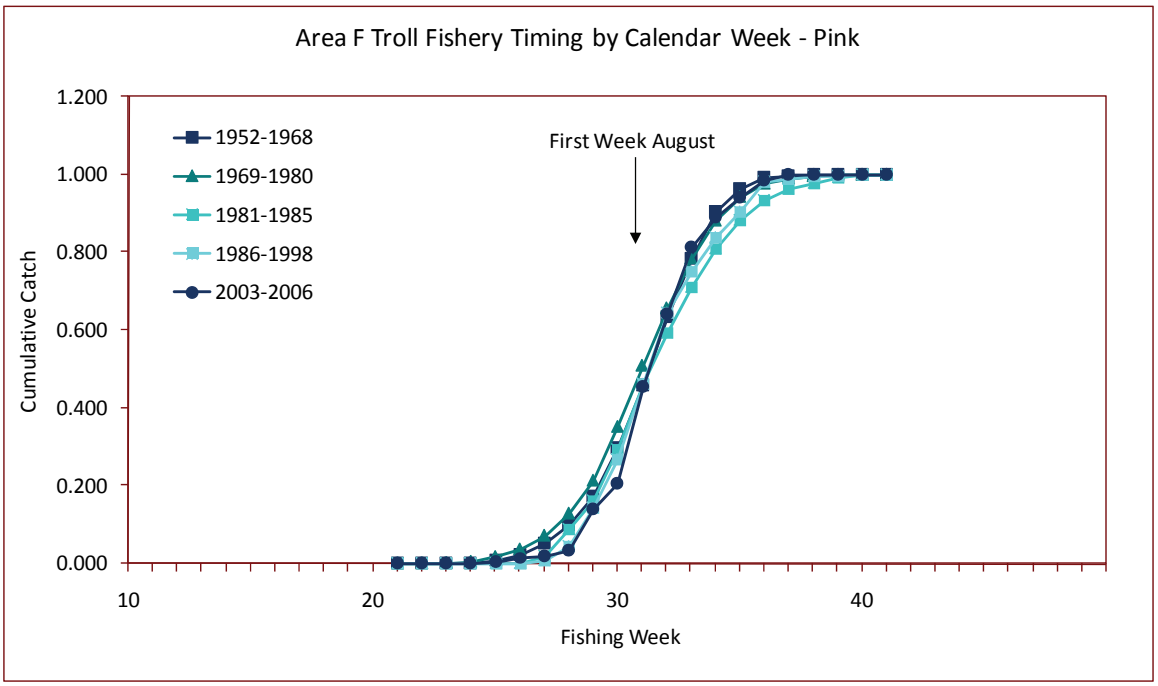


FIGURE 40. Cumulative catch of pink salmon in the Area F troll fishery since 1952, based on sales slip information.
(Source: DFO North Coast). Data not available by week for 1999–2002.



SPECIES OR STOCKS OF CONCERN

A large number of stocks and species contribute to the catch in the Area F troll fishery. Under the general licence conditions, Area F licence holders are permitted to retain sockeye, pink and chum salmon although fisheries targeting Fraser sockeye were eliminated after 1995. Sockeye and chum retention is typically subject to area closures. For example, in 2006 there was non-retention of chum salmon while in 2007; non-retention was in place for chum salmon except in Area 101[34]. Troll vessels may also retain Lingcod while fishing for salmon under Schedule II licence conditions. All rockfish (*Sebastes* sp.), except Yelloweye, Quillback, China, Tiger and Copper, to a maximum of 20 fish per day, may be retained as by-catch. Yelloweye, Quillback, China, Tiger and Copper rockfish may not be retained due to conservation concerns. These species measures are subject to variation under the *Pacific Fishery Regulations, 1993* and fishery notices.

By regulation, Area F trollers are required to release all chinook below 67 cm in length to protect juvenile chinook. This regulation has been in place for a number of years. The ability of the Area F troll fleet to harvest its chinook allocation is greatly affected by conservation concerns for West Coast Vancouver Island (WCVI) chinook stocks as agreed to in the Pacific Salmon Treaty. Spawning populations for WCVI chinook range from less than 100 to more than 100,000 in rivers with major hatcheries. These populations are an important fishery resource to local First Nation peoples, and coastal fisheries from Vancouver Island north through SE Alaska. Robertson Creek Hatchery on the Stamp River system has become one of Canada's major producers of chinook salmon, with large contributions to ocean troll and sport fisheries, and stimulating the development of substantial terminal sport, native, and commercial fisheries (DFO 2006).

The Area F chinook fishery is currently managed to a numerical ceiling of WCVI chinook mortalities set pre-season. The ceiling is based on the exploitation rate and pre-season forecasts of anticipated WCVI chinook returns (Winther and Beacham 2006). The number of WCVI chinook mortalities permitted in the northern troll fishery in a given year is then calculated.

As outlined in the 2005/2006 Salmon Northern BC Integrated Fisheries Management Plan, the objective for WCVI chinook is to manage Pacific fisheries (not including enhanced terminal areas) to an exploitation rate of 10%. Northern BC troll fishery exploitation rates on WCVI—Robertson Creek chinook stocks have averaged 2.9% since conservation actions were first taken for this stock in 1995, compared to 9.2% prior to 1995 (DFO 2006).

Currently there are no conservation concerns for coho in the Area F troll fishery (Joel Sawada, pers. comm.). In the late 1990s, the fishery was cut back significantly to protect Upper Skeena River and Thompson River coho stocks (Winther and Beacham 2006). Interior Fraser coho, a stock currently identified as a conservation concern, are not presently harvested in appreciable numbers in the Area F troll (Joel Sawada, DFO, pers. comm.).

Management of this mixed-stock fishery traditionally relied heavily on the Coded Wire Tag Recovery Program (CWT) and harvesters returned the heads of coded-wire tagged salmon that identified their stream of origin. Under general licence conditions for the Area F troll fishery, harvesters are still required to retain and offload all heads removed from all chinook and coho[35]. Compliance with this measure is considered to be generally good and the sampling requirement of 20% of the catch of marked fish is most often reached (Ivan Winther, DFO, pers. comm.).

[34] Salmon Licence Area F North Coast Troll 2006 and 2007 IFMP summaries provided by Dave Rekdal, DFO.

[35] Conditions of 2007/2008 salmon Area F licence / licence period: 1April 2007 to 31 March 2008 (troll – north coast)

Since 2002, DFO has also used DNA analysis to ascertain stock composition of chinook catches and monitor the Area F harvest of WCVI chinook. DNA samples are obtained from both regular commercial landings and test fishing vessels prior to, within, and after each fishery. If DNA analysis indicates that the abundance of WCVI chinook (as a percentage of the catch) is greater than the percentage guideline, DFO will delay the opening or close the fishery if fishing operations are already underway. In some years, the prevalence of WCVI chinook has caused the northern troll chinook fishery to close before the Area F fleet has attained its chinook allocation.

To meet conservation objectives, the Area F troll fishery is controlled primarily by regulating fishing areas and times to meet conservation objectives. DFO and the industry plan fishery openings at different times of the year in an effort to avoid WCVI chinook and extend the harvest. However, the majority of the harvest takes place between 1 June and 30 September.

SELECTIVE FISHING MEASURES

Under licence conditions, Area F troll vessels must use barbless hooks and be equipped with a revival tank to temporarily hold and revive injured or stressed fish which the vessel is prohibited from retaining:

> *"Salmon and steelhead that are lethargic or appear dead shall be placed in the revival tank until revived to a vigorous condition or for at least one hour and then must be released back into the water from which they were caught in the manner that causes the least harm. The revival tank must be operating while the vessel is engaged in fishing. For the purpose of this condition, "fishing" is defined as having hooks in the water. The tank must be full of oxygenated seawater that is the same temperature as the seawater from which it is drawn prior to placing fish in the tank. When the revival tank is holding fish during fishing or after fishing is completed, the revival tank must remain filled with seawater and there must be a constant exchange of oxygenated seawater throughout the tank.[27]."*

Measures to protect seabirds are also in place when fishing for groundfish (except when fishing for tuna or smelt) but there are not specific requirements when fishing for salmon. These groundfish measures include:

- Use of a streamer line (a line with brightly coloured ribbons spaced 5 m apart or towed buoy when setting long lines; and
- Release any caught birds with the least possible harm.

A one nautical mile ribbon boundary is currently in place around Langara Island to protect local salmon stocks during the summer fishery. In addition, all vessels must maintain a daily catch log.

AREA F DEMONSTRATION FISHERY (2005-2007)

From 2005 to 2007, the Area F troll has been managed as a demonstration fishery to assess Individual Transferable Quota (ITQ) management. Licence holders were given a choice of participating in the demonstration ITQ fishery or the competitive fishery. Each individual licence in Area F was assigned 1,000 pieces of chinook. In the competitive fishery, vessels would compete for a total catch based on the number of licences that opted to fish in this manner multiplied by 1,000 pieces. In the demonstration fishery, each licensed vessel that chose this option would receive 1,000 chinook as its ITQ.

In 2005, all but seven of the 168 trollers in Area F opted to participate in the demonstration fishery of which 130 actively fished. The demonstration fishery fished from 3 June to 30 September while the small competitive fishery operated from mid June to mid July and achieved their total quota. DFO collected DNA

samples from both the fishery and a test fishery to ensure that sufficient samples were collected. The 2005 fishery was managed to within the overall quotas established and under the WCVI chinook harvest ceiling.

In 2006, all but 6 of 246 eligible trollers selected the demonstration fishery (DFO 2007). The demonstration fishery operated from 7 June to 30 September while the competitive fishery operated from 7 June to 4 July.

Some comments on the ITQ demonstration fishery (DFO 2007) were:

- Safety was higher due to the ability of harvesters to choose their fishing days;
- Higher product quality; and
- Concerns regarding high grading were unfounded.

FISHERY MANAGEMENT MEASURES

Prior to 2002, the Area F troll fishery was managed through large scale quota reductions and area closures (Winther and Beacham 2006). Since 2002, microsatellite DNA has been used to inform stock-specific management actions. As mentioned previously, the Area F troll fishery is currently managed to a WCVI chinook harvest ceiling based on returns to key indicator stocks. Stock-specific management allows for PST negotiated allocations to be approached while reducing exploitation of WCVI chinook (Winther and Beacham 2006).

The WCVI index represents the sum of escapements for six rivers (Marble, Tahsis, Burman, Artlish, Kaouk, and Tahsish) selected as an 'index' of escapement for wild WCVI stocks in aggregate (Pacific Salmon Commission Chinook Technical Committee 2008). These stocks were chosen based on historical consistency of data quality and having a CWT component. None of these stocks have biological escapement goals that have been accepted by the PST Chinook Technical Committee (CTC). Additional review of the indices for WCVI chinook is planned by the CTC to determine whether they adequately represent impacts on the WCVI wild aggregate.

Between 1995 and 2001, the average reduction in the Area F troll catch of chinook salmon has been approximately 70% of the pre-season Total Allowable Catch (TAC) (Winther and Beacham 2006). Since 2002, with DNA analysis, only 13% of the TAC has not been caught with most of this occurring in 2002 (Winther and Beacham 2006). Over this same period, the total mortality in the Area F troll fishery of Robertson Creek Hatchery chinook has been only 2.3% (Winther and Beacham 2006).

One concern identified by Winther and Beacham (2006) is the inherent weakness in the pre-season forecast of WCVI chinook using Robertson Creek Hatchery chinook as the main driver. Uncertainty in the pre-season forecast of these stocks is transferred into uncertainty in the total mortality on these stocks.

FISHERY MONITORING, COMPLIANCE AND OTHER CONSIDERATIONS

Although at-sea monitoring is required when fishing for all groundfish species except tuna and smelt, at-sea monitoring is not a specific licence requirement when fishing for salmon. At-sea monitoring for groundfish must be by means of either a designated groundfish at-sea observer carried on board the vessel or the use of a functioning Electronic Monitoring (EM) system on board the vessel. However, at-sea monitoring of all fishing activity under this licence is not required when less than 500 pounds (227 kg) of Lingcod are caught and retained while fishing for salmon by troll gear. This would be the case, anyways, for fisheries targeting salmon.

During the demonstration fishery, dock-side monitoring was in place which provided more timely and accurate catch data than the usual hail and sales slip program (DFO 2006). This applied to both the demonstration and competitive fishery. This way the ITQ system provides more accurate data obtained through less monitoring and is therefore cost efficient from the monitoring point of view.

As considerations for future management of the Area F troll fisheries, the following concerns voiced by harvesters and fisheries managers should be addressed:

- The demonstration quota fishery in Area F is attracting effort (number of licences fishing) away from other areas while the quota for the area remains stable resulting in quota per vessel going down in Area F;
- Continue to monitor the potential for high grading or the release of smaller fish to wait for bigger fish under the ITQ; and
- The risk of having the Area F troll fisheries closed if the WCVI component climbs above 6% resulted in a complete shutdown of the fisheries in the past and may lead harvesters to "front-end load" their catch and again create a competitive like fishery with pressure on earlier migrating stocks. This should be closely monitored.

SUMMARY, AREA F TROLL FISHERY: CHALLENGES, SOLUTIONS AND FUTURE IMPROVEMENTS

- **Area F Troll Fishery, Challenges:** The immediate challenge for the Area F troll fishery is achieving the total allowable catch while not exceeding the exploitation rate ceiling for West Coast Vancouver Island chinook stocks. Assuming the ITQ fishery remains in place, spreading the fishing effort over the entire season will continue to be challenging with the fishery managed to the WCVI chinook exploitation rate ceiling. In the future, other chinook or coho conservation concerns may arise in this fishery, but the ability to detect these concerns is hampered by inadequate stock assessment data for, particularly, north coast chinook and coho stocks.
- **Area F Troll Fishery, Solutions:** Ensure a rigorous and timely stock composition program (DNA sampling of catch) remains in place with a suitable feedback loop to fishery managers so that weekly (or monthly) allowable catch amounts can be determined. Continue to monitor compliance with selective fishing measures and potential high grading.
- **Area F Troll Fishery, Future Recommendations:** Stock assessment coverage of north coast chinook and coho stocks needs to improve so that all conservation concerns can be identified in a timely manner. This is also necessary to fully implement the Wild Salmon Policy. Regardless of whether the ITQ fishery continues or not, put in place measures to slow the fishery down and spread the effort over the season so that the likelihood of exceeding the WCVI ceiling is minimized.

WEST COAST VANCOUVER ISLAND (WCVI) RECREATION

HISTORY, LOCATION AND FISH STOCKS

Chinook and coho salmon are the main species of interest in the West Coast Vancouver Island (WCVI) Sport Fishery (Figure 41). In addition, a terminal fishery for sockeye salmon in Alberni Inlet has been a growing recreational fishing opportunity, especially for smaller boats that cannot access the more weather-exposed outside areas. The recreational fishing sector's use of the West Coast of Vancouver Island is divided into: 1) the private recreational users that mainly use the automobile accessible areas, 2) the guided recreational users that fish both inshore and offshore waters adjacent to boat ramps and marinas, and 3) the lodge-based users that fish more remote areas accessible only by shuttle boat or water plane (GS Gislason 2004). There are also a few lodge-based operations based in more accessible communities (e.g., Ucluelet). The long-term combined WCVI recreational fishery contributes less than 5% to the combined commercial and recreational harvest of pink, chum and sockeye salmon and about 30% to the harvest of chinook and lately 15% to the harvest of coho salmon (Fisheries and Oceans

Canada, Recreational Catch Data, DFO South Coast). Under the Allocation Policy for Pacific Salmon,[36] the recreational sector has been given priority access to chinook and coho (after First Nation FSC), while the commercial sector can harvest these species when additional abundances allow. For pink, chum and sockeye the scenario is reversed and the commercial sector has been allocated 95% of the total harvest while the recreational sector can harvest the remaining 5%. The recreational fishing sector is generally believed to have by-catch mortalities of less than 15% (Cox-Rogers *et al.* 1999) and high value of each fish caught when compared to the commercial net and troll sectors (Kristianson and Stongitharm 2006). The economic sustainability and contribution made to the overall economy of BC by the recreational sector is based on a relatively small number of fish caught (ARA Consulting Group 1996).

Terminal fisheries on enhanced stocks are one way fisheries can be designed to maximize opportunity while exercising conservation of wild stocks. One such example is the Area 23 (Alberni Canal and Barkley Sound) recreational fishery. A key management objective of this fishery is to target the recreational fishery on abundant, enhanced stocks and away from less abundant wild stocks. Chinook, coho and sockeye salmon stocks encountered in Area 23 are enhanced by hatchery programs and lake fertilization as well some habitat restoration and side channel developments. The three main species encountered in this fishery and their catch fluctuations over the years are shown in Figure 42. Catches for all three species are variable and dependent on the production from enhancement measures that buffer the effects of ocean survival variability to a certain extent. Terminal fisheries in Area 3 become more stock selective on enhanced stocks the closer they are to the Stamp/Somass river enhanced system and can result in opportunities for large recreational catches of sockeye, coho and chinook in a responsible fishery close to the river mouth.

Recreational harvesters have, aided by devices such as depth finders, downriggers and readily available and detailed information on fishing locations and techniques, learned to fish more efficiently when pursuing their favoured prey, chinook salmon. This is particularly true for the recreational fisheries of Area 23. An example of a new fishing method that has increased the catch efficiency for chinook salmon, while reducing catch of other species, is the pink hootchie. This lure demonstrates how a small change in the colour and speed of an offering to salmon can make a fishery more species-selective and efficient and therefore more responsible.

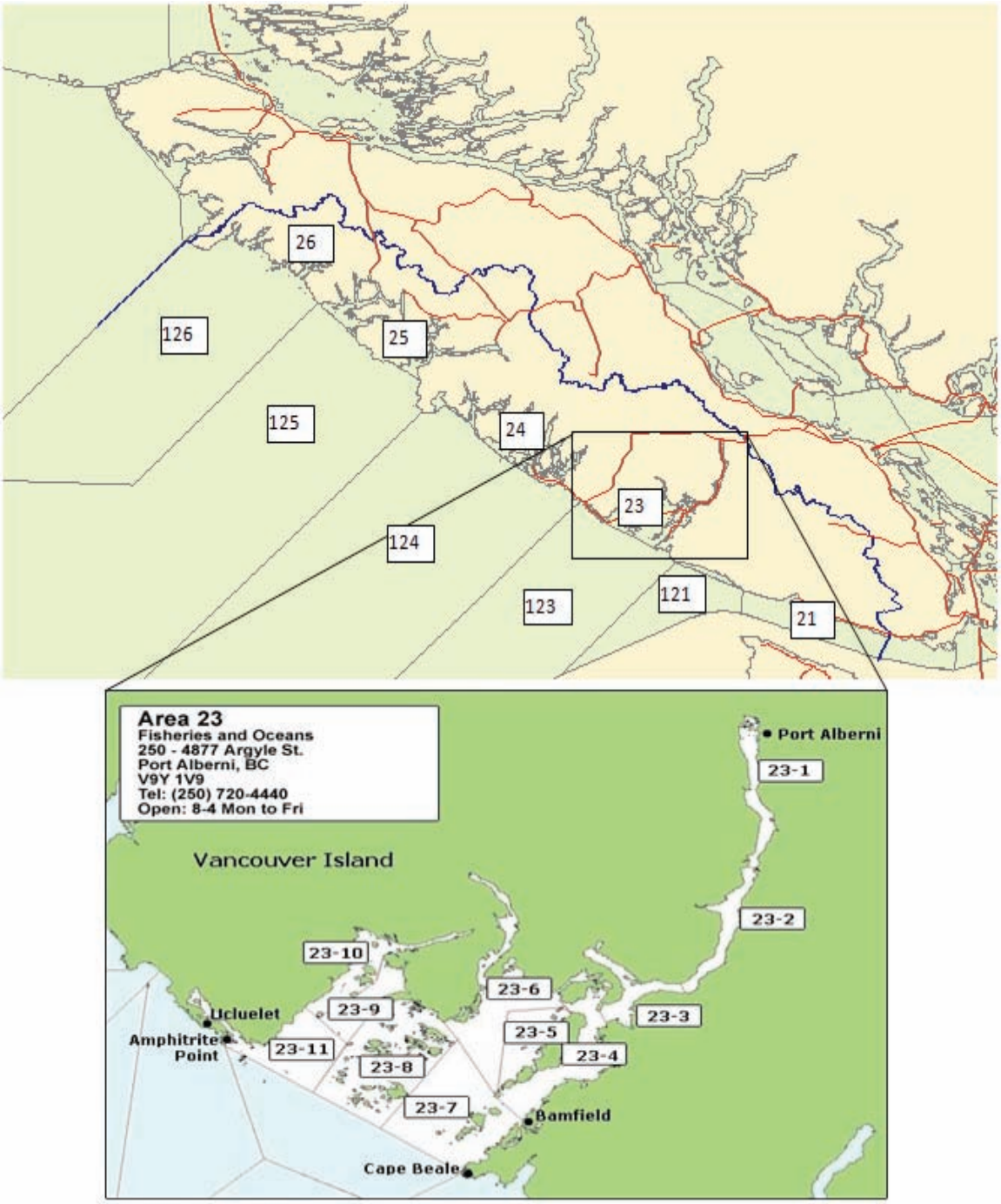
As a result, the catchability of chinook in this area has increased between 1990 and 2007 (Figure 43, upper panel) while the effort in the Area 23 recreational fishery for chinook salmon has decreased (Figure 43, lower panel). The combination of higher chinook catch efficiency and less fishing effort has left the recreational chinook catch at a relatively stable average level of 40,000 fish per year for the last decade.

There have also been other changes in the Area 23 recreational fishery. The recreational WCVI fishing sector halibut catch in Area 23 and Area 123 has increased between 1984 and 2006 (Figure 44). This increase can be attributed to the introduction of Global Positioning Systems (GPS), depth sounders, bigger and faster boats and increased knowledge (Marilyn Murphy, pers. comm.). Halibut fishing in Areas 23 and 123 is not currently hampered by by-catch of stocks or species with conservation concerns. The increase in halibut fishing can be viewed as a positive move to diversify the fishery and reduce pressure on chinook resulting in a more responsible fishery. However, while the hooking mortality of halibut is very low since they do not suffer from adverse gas expansion effects or barotrauma (Albin and Karpov 1998), rockfish are affected by barotrauma and release mortality can be high. Rockfish are therefore a group of fish species that deserves special consideration in the WCVI recreational fishery. There are currently 14 rockfish conservation areas (RCAs) on the west coast of Vancouver Island where fishing for rockfish is closed.[37]

[36] http://www-comm.pac.dfo-mpo.gc.ca/publications/allocation/st9810e.htm

[37] http://www.pac.dfo-mpo.gc.ca/recfish/Restricted_Areas/RCAs/Areas/WC_e.htm

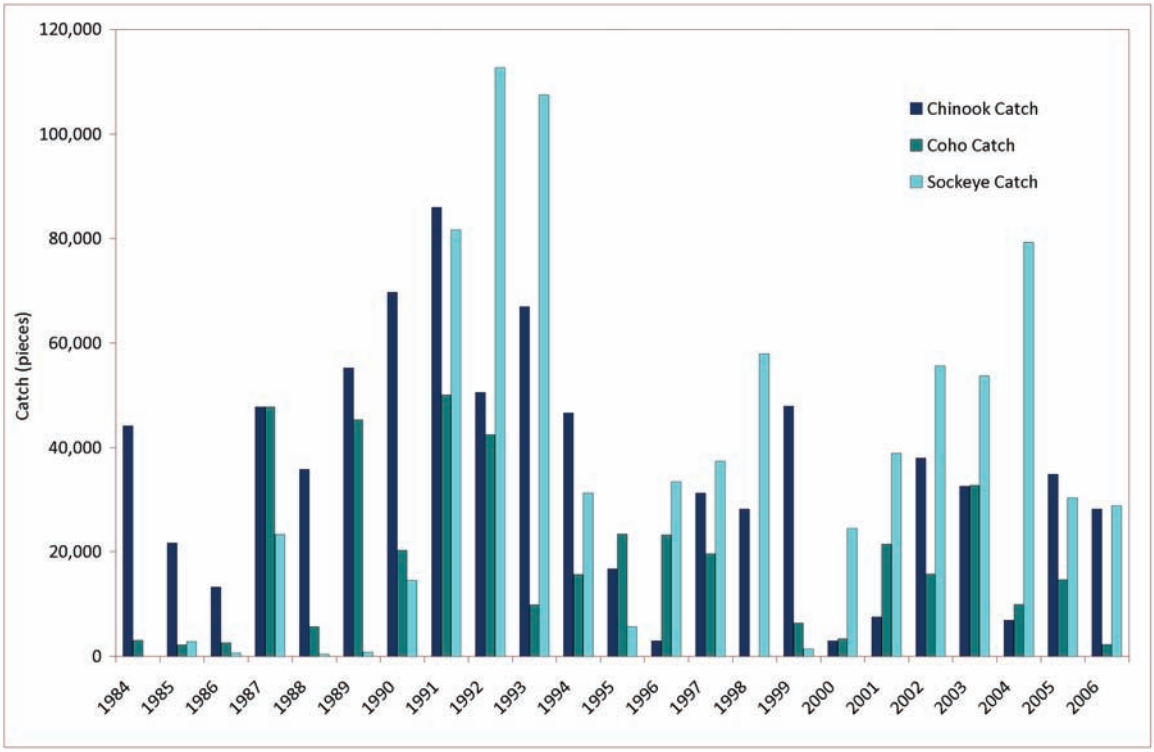
FIGURE 41. DFO West Coast Vancouver Island Fisheries Management Areas in overview[38] and detail of Area 23[39], the area with the longest standing record of catch estimates for the recreational sector.



[38] http://www.pac.dfo-mpo.gc.ca/ops/fm/Areas/area_23_e.htm

[39] http://www.shim.bc.ca/tofino/main.cfm?sector=all&name=WCVI%20Information%20System&lat=49.5&Lon=-126.0&scale=2100000

FIGURE 42. Recreational fishery catch for Statistical Management Area 23 as an example for the main species caught, 1984–2006.
(Data source: DFO Pacific Region Regional Data Unit[40])



[40] http://www-sci.pac.dfo-mpo.gc.ca/sa/Recreational/WCVI%20Summaries_e.htm

FIGURE 43. Increase in chinook catchability (top panel) and decrease in effort (bottom panel) by the recreational sector in Barkley sound (left), 1990–2007 (years of recreational chinook closures were left out).
(Data Source: DFO South Coast)

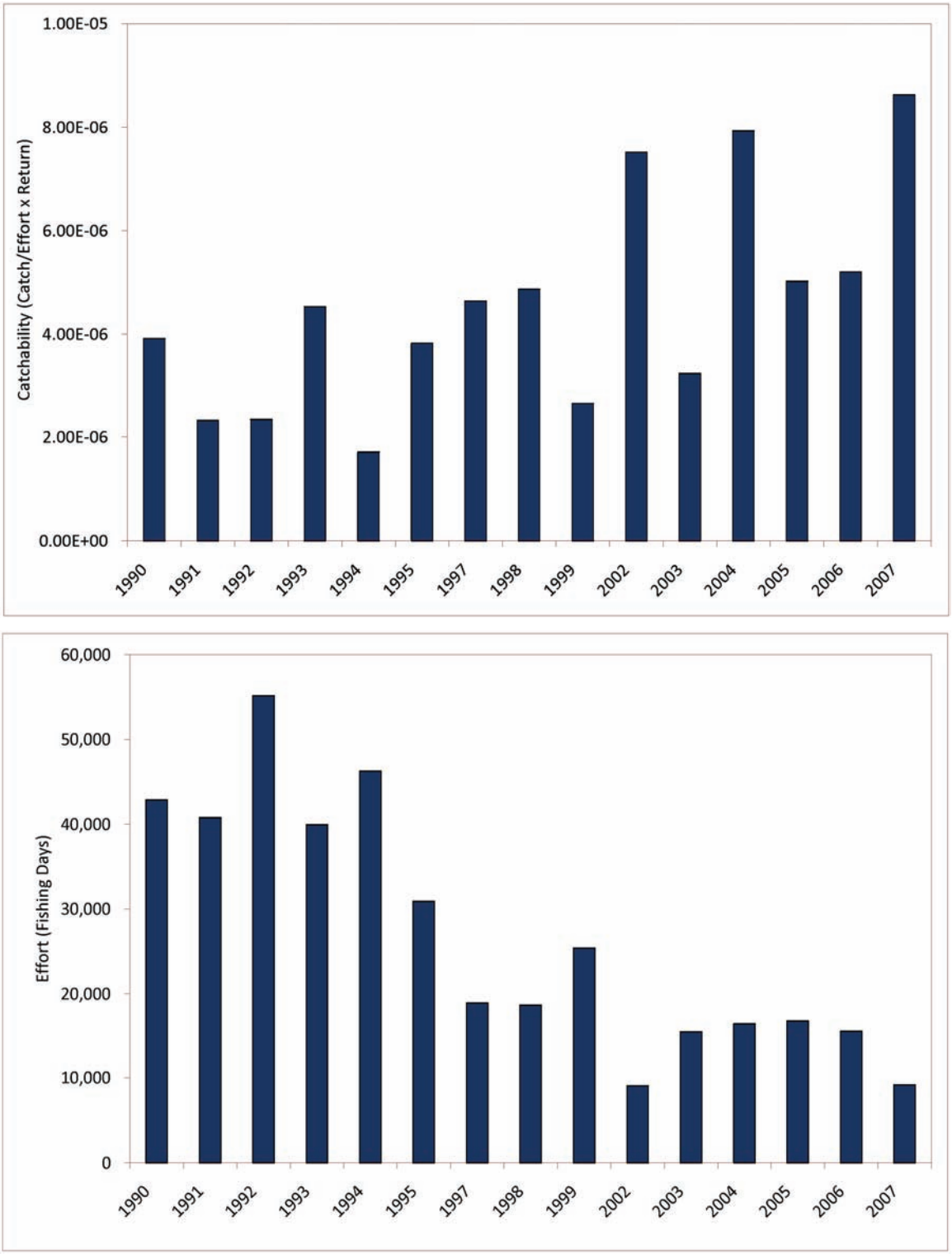
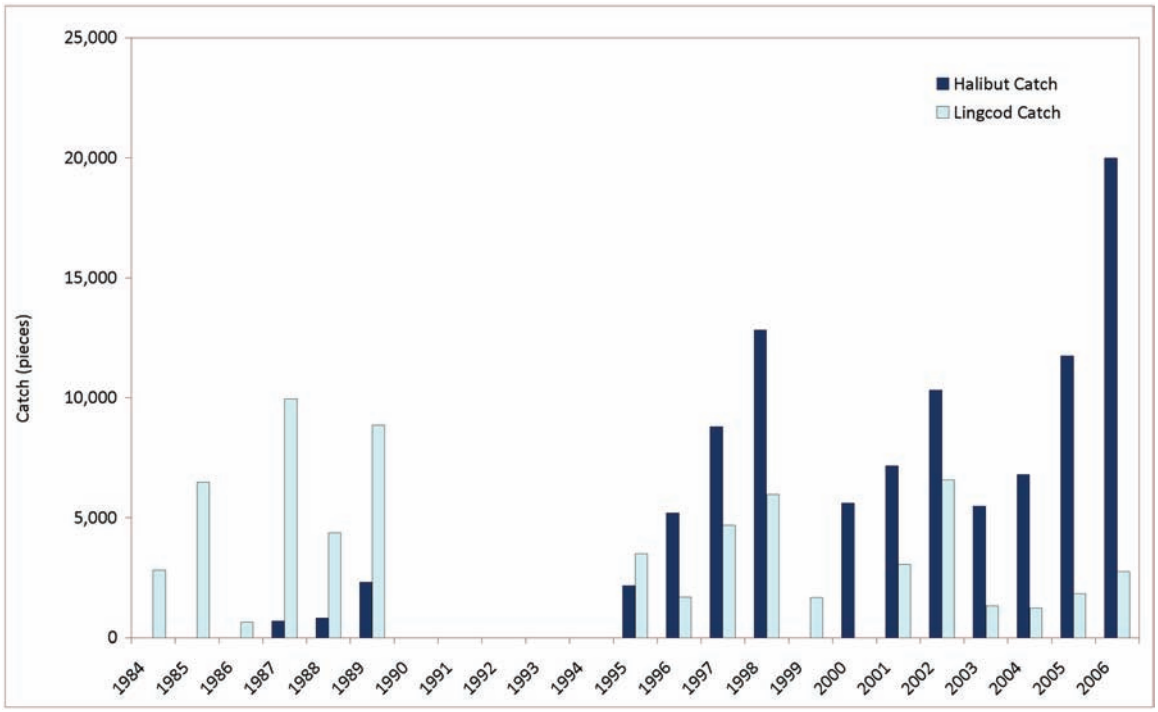


FIGURE 44. Halibut and lingcod catches in the recreational fishery in Statistical Area 23 as an example of overall trends in the WCVI recreational fishery, 1984–2006.
(Data source: DFO Pacific Region Regional Data Unit)



SPECIES OR STOCKS OF CONCERN IN THE WCVI RECREATIONAL FISHERY

The WCVI recreational fishery can be divided into three categories:

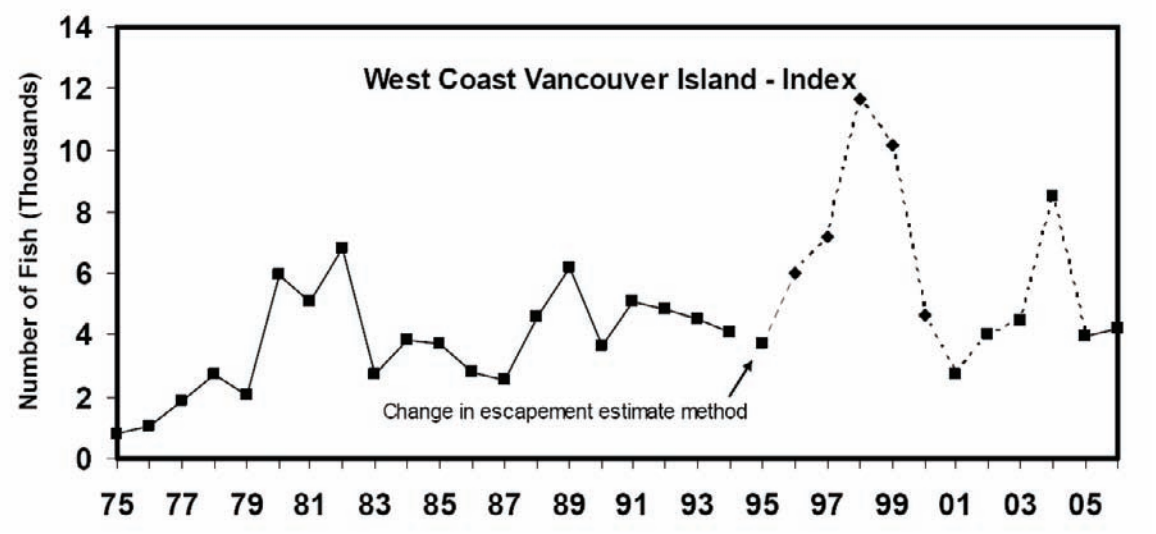
1. The fishery inshore of a conservation corridor extending 1 nautical mile offshore from the surfline where mostly local chinook and coho are encountered;
2. The fishery outside of the conservation corridor extending 1 nautical mile offshore from the surfline where mostly non-local chinook and coho are encountered; and
3. Localized and terminal fishing opportunities for enhanced chinook, coho or sockeye salmon stocks are offered on a short notice basis, once total return numbers can be reliably assessed. These fisheries are typically aiming for a single stock and are managed by allowing the harvest of fish that are surplus to the sustainability requirements of the respective enhanced system and First Nations needs.

Chinook

Historic spawning escapement records for chinook exist for more than 100 WCVI rivers and streams, with 60 of those having records of at least 100 chinook. Of these 60 systems, 20 have been supplemented through enhancement activities, while 40 support completely wild populations. Chinook escapement to the entire aggregate of WCVI rivers 180,000 fish in 1992 with 140,000 attributable to the enhanced Somass/Stamp system. Many of the larger populations are enhanced through small volunteer projects or federally-funded major hatcheries located on the Stamp, Nitinat and Conuma rivers (data from DFO South Coast[41]).

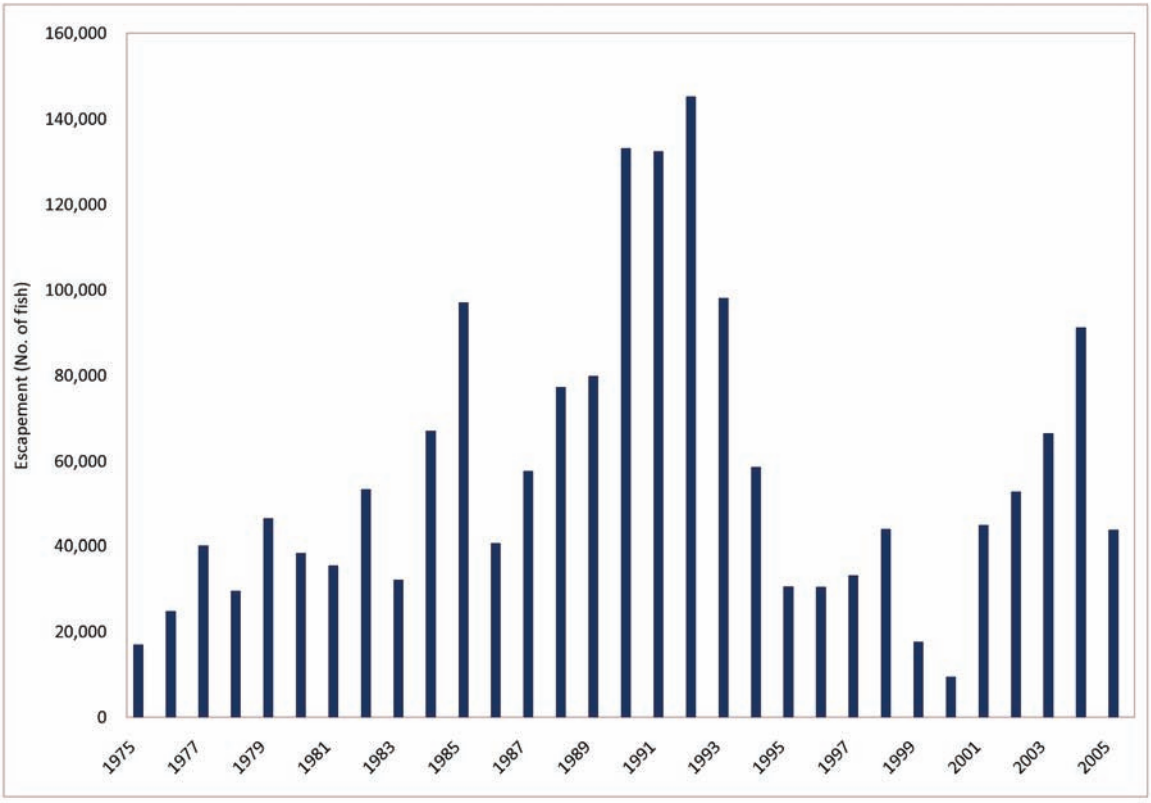
Conservation of WCVI chinook stocks in ocean fisheries is accomplished by using the Somass/Stamp (also called the Robertson Creek Hatchery stock) as an enhanced chinook indicator (Canadian Stock Assessment Secretariat 2006). Six other streams (Marble, Tahsis, Burman, Artlish, Kaouk, and Tahsish) are used as an indicator of the total abundance of WCVI wild chinook stocks (Pacific Salmon Commission Joint Chinook Technical Committee 2008). Between 1995 and 2006 the escapement of chinook to the wild indicator streams has numbered between 3,000 and 12,000 fish (Figure 45) while the escapement to the Somass/Stamp River system as numbered between 9,000 and 90,000 (Figure 46).

FIGURE 45. Escapement index for wild West Coast Vancouver Island chinook stocks composed of escapements to Marble, Tahsis, Burman, Artlish, Kaouk, and Tahsish watersheds, 1975–2005. *(Pacific Salmon Commission Chinook Technical Committee 2008)*



[41] http://www-comm.pac.dfo-mpo.gc.ca/publications/speciesbook/Salmon/Chinook.wcvi.html

FIGURE 46. Escapement of chinook to the Somass River, 1975–2005.
(DFO South Coast data)



No escapement goal for the wild chinook indicator streams has been agreed upon by the Pacific Salmon Commission Chinook Technical Committee as of yet. The average survival rate for WCVI chinook, from release to age two, has been 5–6%. The survival rate for the cohort from the 1995 brood dropped to 0.3% due to heavy predation by mackerel, a fish species that follows warmer water from the south flowing to the north during El Niño[42] years. Stocks currently under conservation concern for the inshore fishery are wild chinook originating from WCVI systems. Stocks that are of special concern in the offshore fishery are the Lower Strait of Georgia (in particular the Cowichan River chinook) and Early Fraser River chinook (Pacific Salmon Commission Joint Chinook Technical Committee 2008). Conservation concerns for chinook stocks in Washington, Oregon and California also curtail fishing opportunities for WCVI recreational fisheries in the offshore area. In May of 2008, Canada and the US agreed to a 30% reduction in the total allowable catch of WCVI chinook as part of the Pacific Salmon Treaty to protect US-bound chinook.

[42] El Niño is an irregularly occurring climate phenomenon that weakens north-easterly trade winds and thus releases warm surface water to flow towards the Chilean coast and disrupt upwelling of nutrient rich deepwater. On the BC Coast, it regularly increases water temperatures, lowers productivity and thus facilitates the immigration of predators that are usually found further south.

Coho

There are as many as 700 distinct WCVI populations of coho salmon. The majority of the streams have escapements averaging fewer than 85 fish. Only the Somass and San Juan rivers typically support more than 5,000 spawners. The total escapement of wild WCVI coho has been estimated at between 70,000 and 270,000 [43].

Assessments of WCVI coho populations are based on information from a set of indicator stocks. Returns to Carnation Creek in Alberni Inlet, Robertson Creek Hatchery and counts at the Stamp Falls fishway are used to estimate total escapement. The estimate of WCVI coho exploitation rates are mainly based on coded-wire tag recoveries in the commercial and recreational fisheries and were estimated to be 65–70% between 1963 and 1998. Starting in 1995, annual fry and adult salmon surveys have been conducted on 30 to 40 WCVI streams in order to monitor abundances in non-indicator systems. A marked decline in marine survival over this period culminated in very low survival of coho that returned to spawn in 1994.[44]

In 1998 no directed commercial fisheries were allowed to protect depressed Interior Fraser River coho stocks and the recreational fisheries were subjected to new geographical restrictions. Middle North Thompson coho salmon stocks had declined due to excessive exploitation rates (Figure 47) habitat alteration, disruption and destruction from various human activities (logging, agriculture, hatchery influences, urban/rural developments, mining), and lower marine survival (Interior Fraser coho Recovery Team FCRT 2006, English at al. 2008). The middle North Thompson coho stocks were classified as highly impacted and have been COSEWIC (Committee on the Status of Endangered Wildlife in Canada) listed since 2002, but not listed under the Species at Risk Act (SARA). The COSEWIC designation prompted the need for immediate recovery goals to be established by the Interior Fraser coho North Thompson River coho salmon (Interior Fraser coho Recovery Team. 2006, English *et al.* 2008). Total returns of Upper-Middle Thompson coho have dropped from foremost more than 50,000 fish to fewer than 500 in 2006 (Figure 47).

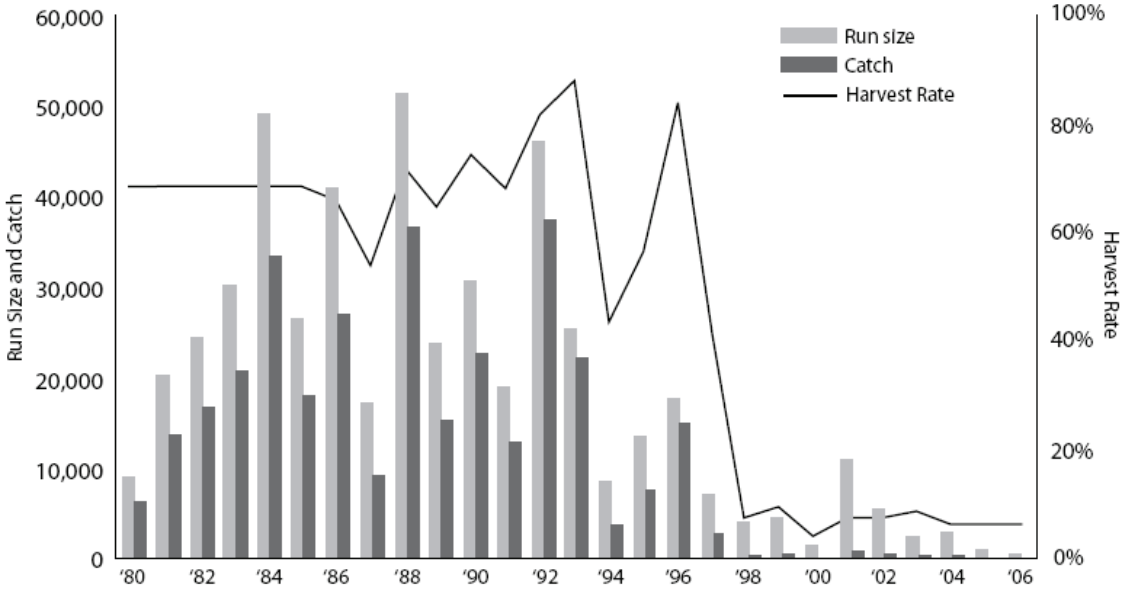
To protect Interior Fraser River coho, Pacific Region waters were divided into yellow and red zones. Only in the yellow zones, where past coded-wire tag recoveries indicated endangered stocks were not prevalent, were commercial and recreational fishing for other species allowed. These fisheries were required to release any live coho that were caught during operations. No fishing was allowed in red zones, areas in which Interior Fraser River coho were known to be prevalent. These measures were later relaxed when a wild coho non-retention policy came into effect to allow for the capture of adipose fin clipped enhanced coho.

A similar story emerges for Cowichan River coho salmon. Overharvesting at exploitation levels between 60% and 80% in the past, habitat degradation causing severe sedimentation, and changing marine conditions have all contributed to decline in Cowichan coho abundance (Cowichan Recovery Plan. 2005, English *et al.*, 2008). In addition, water shortage at base flows has affected coho and chinook salmon in the past and will likely impact the stock more in the future when the change in climate conditions will restrict flow even more (Nelitz *et al.*, 2007). Both the Cowichan and the Upper-Middle Thompson coho stocks have been determined to frequent the WCVI recreational fishing areas and their protection has been directly responsible for no-fishing and no-retention policies.

[43] http://www-comm.pac.dfo-mpo.gc.ca/publications/speciesbook/Salmon/coho.wcvi.html

[44] http://www-comm.pac.dfo-mpo.gc.ca/publications/speciesbook/Salmon/coho.wcvi.html

FIGURE 47. Trends in annual escapement estimates for Middle North Thompson coho salmon, 1980–2006.
(From: English et al. 2008)



Sockeye

More than 20 distinctive stocks of sockeye can be found on WCVI. However, the majority of sockeye taken in the WCVI recreational and commercial fisheries return to Great Central, Sproat and Henderson lakes and are harvested in Alberni Canal. The returns to these systems have, in response to lake fertilization programs, increased from an average of 100,000 fish before 1972 to an average of more than 400,000 fish between 1972 and 1998[45]. Barkley Sound sockeye are currently managed to meet a target of no less than 200,000 adult spawners.

Recently, production and catches of Barkley Sound sockeye have declined dramatically due to lower marine productivity. Marine conditions are especially unfavourable for juvenile sockeye survival when coastal ocean temperatures are high, salinities are low, and migratory predators such as Pacific hake and mackerel frequent the WCVI in higher numbers as occurs in El Niño years. Prior to the 1992–94 El Niño event, Barkley Sound sockeye returns peaked at almost 2 million fish in 1991 followed by a 10-fold decline to only 200,000 returning fish in 1995.

Recent forecasts of total returns of sockeye are based on models that account for annual variations in marine survival, as well as the abundance of juvenile sockeye migrating seaward from various nursery lakes. Marine survival predictions are based on direct observations of strong associations between coastal ocean climate indicators (salinity and temperature during ocean entry by juveniles) and return rates. Pre-season forecasts generated annually since 1988 have been applied with excellent success by fisheries managers to anticipate when to plan for either strict stock conservation or progressive harvest measures for WCVI sockeye.

[45] http://www-comm.pac.dfo-mpo.gc.ca/publications/speciesbook/Salmon/sockeye.wcvi.html

Fishery Changes

The WCVI recreational fishery has experienced a large influx of recreational harvesters that used to fish in the Strait of Georgia but moved to the west coast of Vancouver Island (Figure 48) when a change in local climates changed the behaviour of coho salmon to stage on the WCVI instead of the Strait of Georgia (Beamich *et al.* 1999). This is reflected in the contrary trends in the two areas shown in Figure 48. While the chinook catch in the Strait of Georgia decreased from 500,000 fish to a 10,000 fish (1975–2006) the chinook catch on the WCVI increased from initially very low numbers to values between 50,000 and 100,000 fish annually. At the same time, the chinook catch of the commercial troll fisheries decreased for both areas, due to area closures (Figure 49).

FIGURE 48. Recreational catch of chinook salmon in Georgia Strait and WVCI areas, 1975–2006.
(Data Source: Pacific Salmon Commission Joint Chinook Technical Committee 2008)

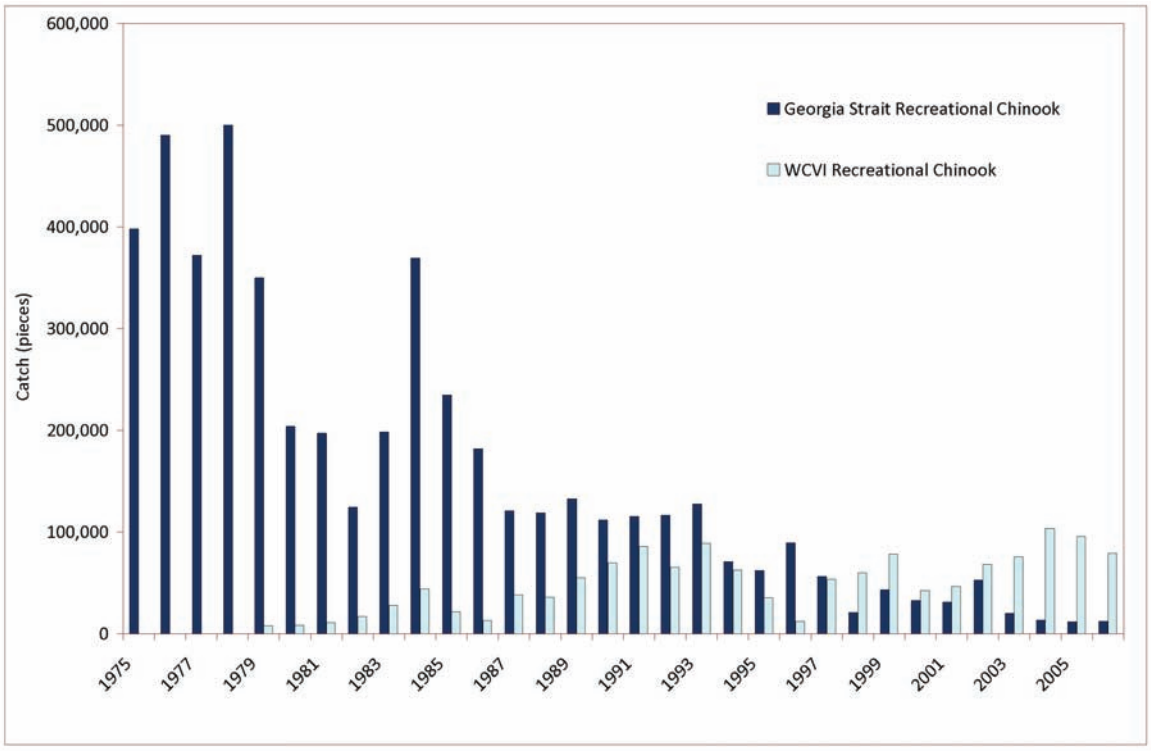
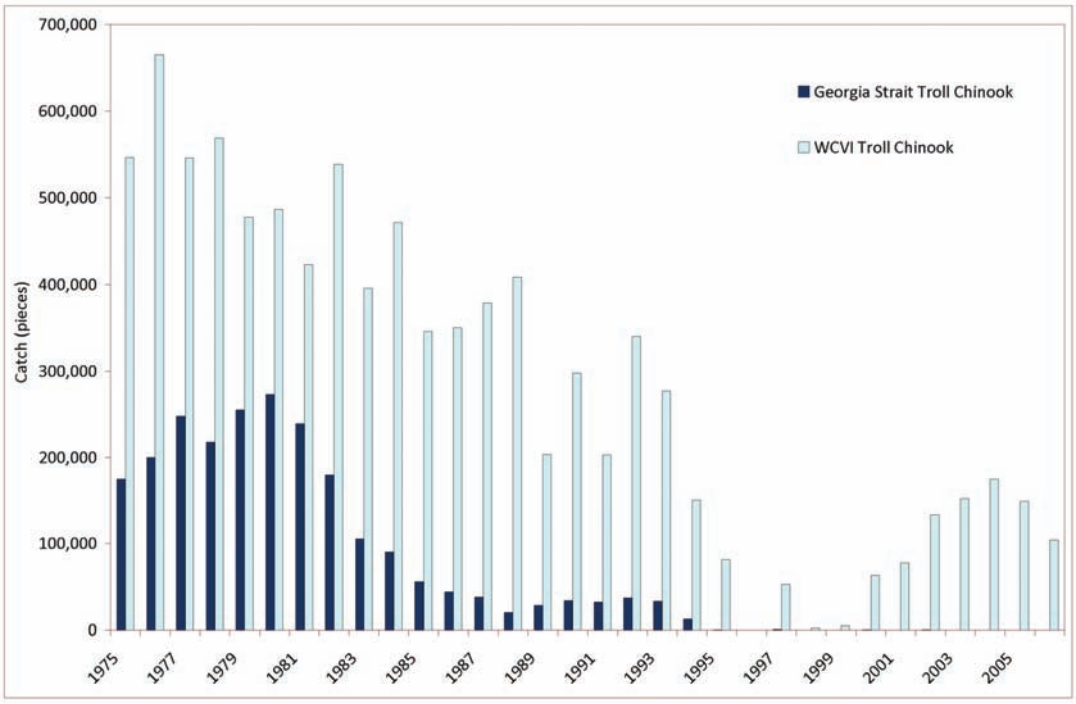


FIGURE 49. Troll sector catch of chinook salmon in Georgia Strait and WCVI areas, 1975–2006.
(Data Source: Pacific Salmon Commission Joint Chinook Technical Committee 2008)



MANAGEMENT ACTIONS TOWARDS RESPONSIBLE FISHING

Aggregate Abundance Based Management: Forecasts of aggregate abundances for chinook and coho are made through Aggregate Abundance Based Management (AABM) models designed and administered by the United Sates and Canada under the Pacific Salmon Treaty. In the AABM regime, harvest rates are variable from year to year and respond to pre-season and in-season indicators of abundance of indicator stocks. The returns to indicator stocks are either identified by the percentage of coded-wire-tagged and fin-clipped fish or by the monitoring of the unique DNA fingerprint of a random subsample of the catch in a fishery. DNA samples are analyzed inseason[46] to identify the stock composition of catches for the larger stocks. Subsamples are typically too small to identify the contribution of smaller stocks to catches. AABM management enables fishery managers to implement area and time restrictions to protect stocks of concern for which adequate stock assessment data exists (e.g., Somass/Stamp chinook).

Migration Corridors and Daily Limits: Through the establishment of no-fishing (red zones) or non-retention (yellow zones) areas, protection corridors for chinook and coho salmon stocks of concern were created. In the yellow zones, or non-retention areas, the harvest of other species or adipose fin clipped (enhanced) stocks of the same species is generally allowed (Integrated Fisheries Management Plan Salmon Southern BC 2007). Since 1999, the recreational fishery "management corridor", extending one nautical mile offshore from the surfline, has been in place along the West Coast of Vancouver Island. It lowers the exploitation rate on adult female chinook that are migrating along the shoreline back to their local natal streams. Depending on the area, either after 15 July or 1 August, a daily limit of two chinook, of which only one can be greater than 77 cm is in place.

[46] http://www.dfo-mpo.gc.ca/media/backgrou/1999/hq-ac29-104_e.htm

The length at age distribution of WCVI origin chinook indicates that about 98% of all age 3 chinook shorter than 77 cm at maturity are males and that the majority of age 4 fish greater than 77 cm are spawning females. The "over and under" 77 cm size limit regulation inside the corridor provides the opportunity for recreational fishers to catch at least one large chinook, yet provides additional protection to females that are returning back to their spawning grounds.

Gear Restrictions: All recreational fisheries on the WCVI are restricted to the use of barbless hooks. An additional ban of treble hooks and the introduction of circle hooks, that have been proven to hook less fish in the deep throat or soft tissue area, and therefore lead to reduced mortalities, are encouraged and may be implemented through policy changes in the future.

INDUSTRY DRIVEN MEASURES PROPOSED TOWARDS RESPONSIBLE FISHING

The Sport Fishing Institute of BC is in the initial stages of designing a responsible fishing branding system for participating commercial fishing guides operations. Components of a responsible fishing strategy could include (since the program is in its preliminary stages, components may change; all information based on personal communication with Marilyn Murphy and Owen Bird, Sport Fishing Institute of BC):

- A training program for responsible fishing that would cover subjects such as fish species knowledge, sensitive fish handling, boat safety, maintenance and operation as well as communications and the conduct with clients, colleagues and other users of the outdoors;
- The submission of catch data in logbooks to facilitate good fisheries management. In the future paper logbooks may be replaced by electronic log books that will be coupled to GPS units and allow operators to record the position of the fish caught in addition to number, size and species; and
- Catch and biological data are lacking and the WCVI recreational sector is suggesting taking over the sampling of coded-wire tags and tissue for DNA analysis. Under the DFO Allocation Policy, the recreational sector has priority access to chinook and coho salmon over the other commercial fishing sectors following conservation concerns and First Nations needs.

This responsible fishing initiative can be seen as an effort parallel to the Marine Stewardship Council Certification of other commercial fishing sectors and is aimed at making the B.C. recreational fishing sector a leader in responsible fishing practices.

SUMMARY, WCVI RECREATIONAL FISHERY: CHALLENGES, SOLUTIONS AND FUTURE IMPROVEMENTS

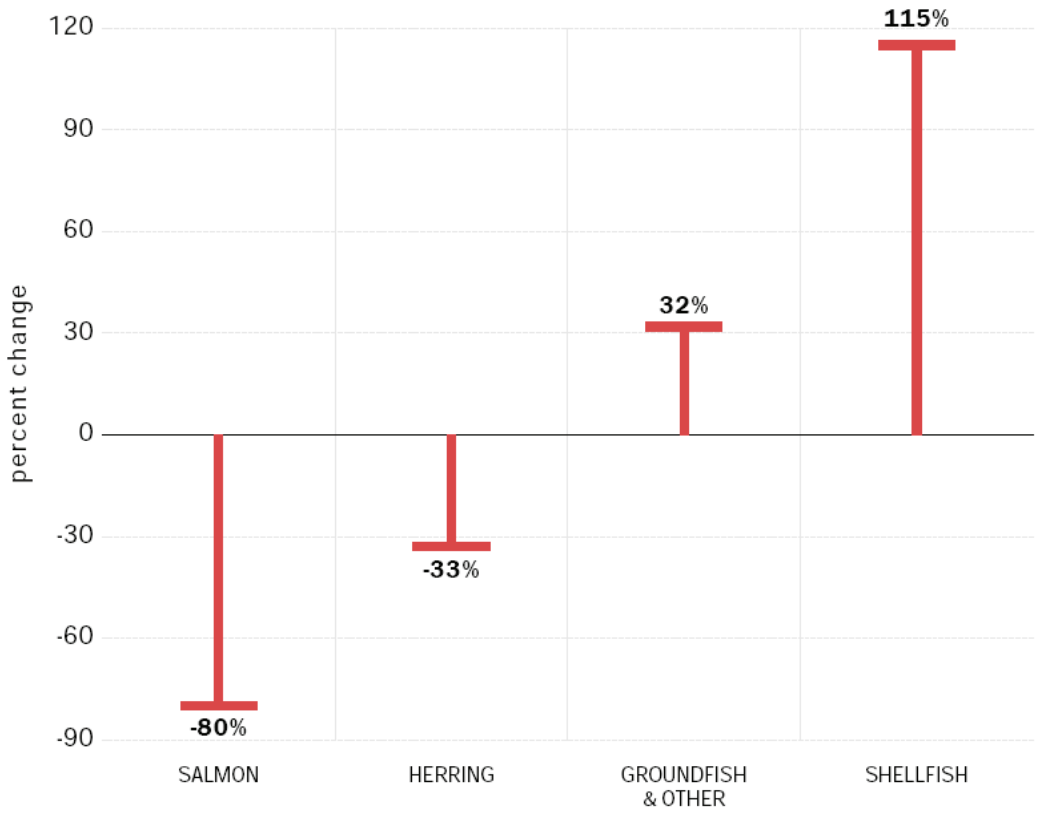
- **WCVI Recreational Fishery, Challenges:** The WCVI recreational fishery is managed to protect chinook (e.g., early Fraser, wild WVCI, Cowichan River, US origin) and coho stocks (e.g., Thompson River) of concern.
- **WCVI Recreational Fishery, Solutions:** Small retention limits for all chinook salmon (daily limit of 2) and even smaller retention limits for female chinook spawners belonging to wild stocks (1 fish > 77cm in migration corridor) are the main measures of responsible fishing. The retention of coho is generally not allowed, unless they are originating from an enhancement facility (clipped adipose fin) or encountered in terminal areas with little or no mixed-stock concerns. Stocks or species other than salmon encountered in this fishery are generally not at a level of concern.
- **WCVI Recreational Fishery, Future Recommendations:** Despite this positive assessment of the WCVI recreational fishery, the implementation of the following measures of responsible fishing would lead to its improvement in terms of responsible fishing. The use of barbless circle hooks should be considered where by-catch of unwanted species is high and should include the monitoring and investigation of release mortalities. The recreational sector, led by the Sport Fishing Institute of BC, is also proposing to create a training and certification process for guides and to collect DNA samples and Coded Wire Tags of chinook and coho salmon for DFO.

FACTORS THAT ARE INFLUENCING RESPONSIBLE FISHING IN BC'S SALMON FISHERY

COMPETITIVE STYLE FISHERIES AND THEIR ECONOMIC VIABILITY

Competitive style fisheries put a premium on volume over quality through their relatively rapid execution. The flooding of the world markets with farmed salmon (Pierce 2006) have decreased the value of salmon landed on Canada's Pacific Coast by 80% between 1993 and 2003 (Figure 50). Over the same period, the value of salmon landed per gillnet licence in BC decreased from $50,000 to under $20,000 (Ecotrust 2004). Less fish and a lower price per landed fish, have led to an economically unsustainable state. Hillborn *et al.* (2005) list several examples for attributes of responsible fisheries and economical sustainability as well as biological top the list of attributes. Economic sustainability in BC salmon fisheries is important for all potential measures of responsible fishing to be successfully implemented. Competitive style fisheries do not foster economic sustainability or responsibility in fishing techniques and create difficulties for management or monitoring. While economically sustainable fisheries should evolve out of necessity, over time, the process is greatly delayed by government subsidies that maintain the status quo.

FIGURE 50. The change in value of landings from 1993–2003 in the salmon, herring, groundfish and shellfish fisheries.
(From McRea and Pearse 2004)



RESISTANCE TO CHANGE

In 2005, the Department of Fisheries and Oceans published a final evaluation report on the Pacific Salmon Selective Fishing Program[47]. As one of the conclusions of the program the following was stated:

> *"The monitoring and enforcement components did not change the habits of all harvesters, pre-existing cultural disposition, and the complexity of survival in the commercial harvesting industry. A number of constraints exist within the Program's environment such as: harvesters long living fishing habits".*

Pre-existing cultural disposition of harvesters in all sectors remains a hindrance in the progress towards a responsible salmon fishery. The future survival of all commercial salmon fishing sectors on the BC coast is tied to adherence to responsible fishing techniques already implemented and openness to future measures. In light of lower ocean survival of salmon, International and domestic policy, laws respecting fishing rights (i.e., First Nations), and an increasing demand of Canadian and international consumers for responsibly harvested fish, the BC Salmon fisheries must change out of necessity.

The implementation of responsible fishing techniques such as short soak times in the gillnet fishery, single fish sorting in the seine industry, or the use of revival tanks in the troll sector require a willingness to change at a time while BC's commercial salmon fleet is rapidly ageing (according to harvesters interviewed in this study). To ameliorate concerns over the ability of the ageing fleet to implement potentially more physically demanding fishing techniques, boats should be operated by a minimum two-person crew, as recommended by harvesters to ensure proper handling of non-target species (J.O. Thomas & Associates 1997). The introduction of younger crew into the fleet and focus on low volume and high quality fishing techniques may help to reduce fatigue of an ageing fleet. Of note is that a selected few of the oldest harvesters are also the most progressive in their practices and their knowledge should be employed to introduce younger crew to responsible fishing.

INCENTIVES TO CHANGE

There are a number of ways to motivate changes to human behaviour and organizations. For the BC salmon fishery the four that stand out are: 1) compliance monitoring (i.e., enforcement), 2) market-based incentives, 3) access to salmon tied to behaviour, and 4) flexibility in regulations. Compliance is discussed below and market based incentives were discussed above.

DFO's Selective Fishing Policy enables DFO to reward fishers who fish responsibility with increased allocations. The policy if fully implemented would re-allocate catch from the less to the more selective sectors, thereby providing incentive to fish more responsibly. However, industry leaders have indicated that they feel that commercial fleets have not been rewarded for fishing responsibly and that they would be further encouraged to do so if DFO would fine-tune or liberate some of the restrictions. For example, allowing the seine fleet to ramp (heave fish onto the deck inside the net bag) in areas where by-catch is not an issue or in areas where jellyfish create a fishing environment where nothing caught will survive in any case would be welcome by industry. The relaxation of selective fishing measures in these special cases would provide increased incentive for seiners to brail in areas and at times when survival of by-catch is likely to be high. Flexibility would be required of the commercial fishing fleets to respond to short notice regulation changes and in exchange DFO would exhibit flexibility in the application of rules when they are restrictive for no reason. This flexibility on the part of DFO and industry requires on-the-ground monitoring of all fisheries and therefore increased funding.

[47] http://www.dfo-mpo.gc.ca/communic/cread/evaluations/04-05/salmon_e.htm

THE PROCESSING INDUSTRY'S ROLE

Currently, the majority of the salmon processing industry is not rewarding the catch of better quality fish, especially sockeye and pink, with a higher price paid to the harvester. In a competitive style fishery with quality detached from the fishery, any extra time spent on each fish translates into less profit to a harvester. Currently, the salmon species caught in the highest volume (sockeye and pink) are mainly processed into canned fish (data from BC Salmon Marketing Council[48]). Between 1988 and 2001, the percentage of wild salmon that was canned increased from 32% to 50% (data from BC Salmon Marketing Council). New products could add value to each individual fish through, for example, smoking or the presentation of individual prepared or unprepared filets. While the processing of these value added products has increased from 7% to 15% between 1988 and 2001 (data from BC Salmon Marketing Council), more could be done.

Over the same period of time the percentage of farmed salmon processed in BC increased from less than 1% to over 74% (data from BC Salmon Marketing Council). Consequently the processing industry invests more into processing of farmed than wild salmon. This trend has continued between 2001and 2006 (Fraser River Sockeye Salmon Benchmark Study published by Agriculture and Agri-Food Canada)[49]. In addition, harvesters that catch high quality fish using responsible methods (e.g., tooth-tangle nets) should be rewarded for high quality. New high quality niche markets will need to be found if higher prices are to be paid to harvesters. However, if quality and price grading become common practice, more harvesters would become motivated to deliver fewer but higher quality fish and the processing industry could become a driver of responsible fishing practices.

In addition to the suggested changes for the seafood processing sector, governmental subsidies could be used to market Wild Canadian Salmon once the harvest practices are limited to those that produce a higher quality product. A lot can be learned from the fish farming industry that increased the value of its products significantly since 2002 (Pierce 2006). Legislation, Policy Implementation Gaps and Compliance

Legislation and policies to fish responsibly for salmon on the BC coast are already in place and fully support progress toward increased responsible fishing. However, enforcement of legislation and policies is essential to the achievement of responsible fishing. Low compliance rates with fishing regulations lead directly to higher by-catch mortalities and indirectly to inaccuracies in fisheries models that lead to an underestimation of the real catch, effort and by-catch. The DFO Policy for Selective Fishing in Canada's Pacific Fisheries [50] (2001) is very explicit in its recommendations towards re-allocation of catch to more responsible fishing techniques within and in between fishing sectors and the threat of restricting fishing opportunity if measures of responsible fishing are not adhered to. The slow pace of implementation of measures of responsible fishing and non-compliance to responsible fishing rules undermines the movement towards a more responsible BC salmon fishery as a whole and indirectly stalls the addition of value through product incentives such as MSC certification. Affordable electronic monitoring of the gillnet fisheries, or federal and provincial subsidies to install electronic monitoring equipment is one example of a measure that could help the industry to better comply with regulations.

[48] http://www.bcsalmon.ca/

[49] http://atn-riae.agr.ca/canada/4228_e.htm#_Toc140651804

[50] http://www-comm.pac.dfo-mpo.gc.ca/publications/selectivep_e.pdf

REDUCING OR AVOIDING MIXED-STOCK FISHERIES

The continuance of mixed-stock fisheries will continue to make it challenging for both government and industry to create a truly responsible salmon fishery. However, the complete elimination of large, mixed-stock fisheries is both economically and politically challenging. Nevertheless, steps are currently being taken to reduce the impact of these fisheries on weak salmon stocks. Most notably are: 1) First Nation treaty negotiations along with in-river demonstration fisheries, and 2) the recent report of the Skeena Independent Science Review Panel. Increased access to economic fisheries for First Nations through Fisheries Reform and ultimately through treaty settlements represent perhaps the best opportunity to shift catch away from mixed-stock fisheries to terminal areas. However, in the larger river systems such as the Fraser, Skeena, and Nass, mainstem river fisheries also may have mixed-stock concerns and these may or may not be easier to address through selective fishing measures than the larger, ocean mixed-stock fisheries. The Skeena Independent Science Review panel noted with similar caution that movement of fisheries targeting Skeena salmon into the river may help alleviate some of the conservation concerns for non-target species and stocks (Walters *et al.* 2008).

IMPLEMENTATION OF SELECTIVE FISHING PRACTICES

Selective fishing practices feasible for introduction into all commercial fishing sectors have been well researched and documented as described earlier in this document. Some of them have become licence requirements but many have not. For example, tooth-tangle nets, sock brailers, and wet sorting are all proven to reduce catch mortality but they have not been made licence requirements. These and other techniques can be employed with little or no reduction in catch while landed fish quality and price can be improved. Any limitations to the further introduction of selective fishing measures are not apparent with the exception of a lack of funding for ongoing research into selective fishing practices. Research should be continued and funded for promising practices whose effectiveness in reducing mortality and by-catch or overall catch remains uncertain. Two examples are motor-driven fish wheels and ocean fish traps. In all fisheries a portion of the Total Allowable Catch could be allocated to the evaluation of new fishing techniques as was the case during the Selective Salmon Fisheries Program from 1998 to 2002.

STOCK ASSESSMENT INFORMATION FOR SPECIES AND STOCKS WITH REDUCTIONS IN FUNDING

Assessment of non-target salmon species and stocks is essential to measure the success of fisheries management actions aimed at reducing by-catch. Micro-Satellite DNA analysis is currently used to determine stock composition of salmon in several fisheries and has become an important tool for fisheries management to augment scale analysis and coded-wire tag recovery. The near real-time and decreased cost of analysis of large numbers of DNA samples will assist in managing mixed-stock fisheries to adhere to exploitation rate ceilings for stocks of concern (e.g., WCVI chinook ceiling for Area F troll). Recently, the analysis of single nucleotide polymorphisms (SNPs) to use as a genetic identification marker for salmon populations has been introduced as a cheaper, faster, more precise and more repeatable method for stock identification.

However, despite the increasing need for improved stock assessment techniques, funding for salmon management in the Pacific Region continues to decline. According to Page 28 of the "Report on Plans and Priorities for Fisheries and Oceans Canada 2006-2007 Estimates[51]", the funding for the Science Sector of DFO (responsible for assessment activities) has been or will be cut from $152.9Million Can in 2006-2007 to

[51] http://www.tbs-sct.gc.ca/rpp/0607/fo-po/fo-po_e.pdf

$138.3Million Can in 2008-2009. This 10% reduction in the funding to DFO's Science Sector fisheries will further reduce fisheries manager's abilities to properly assess salmon stocks, especially for non-target species. In addition, a 25% cut from $379.5 Million Can in 2006-2007 to $282 Million Can in 2008-2009 for DFO's fisheries management sector will further deteriorate DFO's ability to properly manage both target and non-target salmon stocks. To achieve a more responsible salmon fishery in BC, an increase in stock assessment effort especially of non-target species is needed to allow for inseason management as well as post-season calibration of fisheries models. The importance of non-target species stock assessment was also recently emphasized by the Skeena Independent Science Review Panel (Walters *et al.* 2008, p.14).

CLIMATE CHANGE: A CONFOUNDING FACTOR

Nelitz *et al.* (2007), in a report to the Pacific Fisheries Resource Conservation Council described the effects of climate change for BC salmon stocks as follows:

> *"In BC, a variety of measurable changes in air temperatures, precipitation, snow pack, streamflows, and water temperatures are expected. For instance, in the Okanagan, predictions suggest noticeable increases in winter air temperatures (from 1.5 to 4.0 ºC) and precipitation (5-20%) by the 2050s, as well as decreases in summer precipitation (by 20%). By the 2050s in the Georgia Basin, climate models predict general warming (1.5-2.0 ºC), a reduction in snowpack (by 50%), and a possible increase in December runoff (by 60%). On the coast, these predictions mean little change in the total amount of water flowing through our watersheds, though increases in the number and size of floods are likely. For Pacific salmon, the effect of such changes in freshwater flows and temperatures are fundamentally linked to their survival. Warming of Fraser River water temperatures can delay sockeye salmon migration and reduce enroute survival. Low water flows in the late summer can block access to spawning grounds. Winter flooding can wash eggs out of the gravels."*

These statements by Nelitz *et al*. represent a good summary of potential climate change effects on salmon in BC. For fisheries management, climate change represents an additional factor of uncertainty in pre-season estimates of return for all stocks. A more precautionary approach including a reduction in exploitation rates to below the level of maximum sustainable yield for all BC salmon stocks may be an initial step to counter some of the uncertainty imposed by climate change effects, recognizing that climate change will not have the same effect on all of BC's salmon stocks. Currently, unproductive (or oligotrophic) watersheds of lakes in higher elevation locations may become more productive, while sockeye salmon traveling through the lower Fraser River, for example, may not survive high water temperatures (as is already evident).

EDUCATION AND AWARENESS

With the exception of initiatives being considered by the Sports Fishing Institute of BC, there are few, if any formal programs focused on educating fishers about responsible fishing. Education is also part of the mandate of the Canadian Council of Professional Fish Harvesters, though this organization has been met with more controversy in the Pacific Region than elsewhere in the Maritimes (Don Lawseth, pers. comm.). The salmon Integrated Fisheries Management Plans, Fishery Notices, and Licence regulations all provide a list of current requirements for selective fishing, but these are far from a comprehensive approach to implementing responsible fishing. Government and each fishing sector should develop programs that would educate fishers on 'Best Management Practices' for responsible fishing. These could include current and potential selective fishing measures, best fish handling practices, benefits of spreading effort out over space and time, importance of stock assessment information, etc. In due course, such program could become mandatory or be associated with product incentives as recommended by the Sports Fishing Institute.

CONCLUSIONS AND RECOMMENDATIONS

There is an increasing recognition of the need to make salmon fisheries in the Pacific Region of Canada more responsible. The main issue is the need to reduce by-catch of non-target species and stocks, particularly those with conservation concerns. In our review, we were unable to find any serious inhibitors to responsible salmon fishing in Canadian legislation or policies, nor in selective fishing technologies. The primary inhibitors are poor economic conditions in the commercial salmon fisheries, particularly for sockeye, pink and chum, and low motivation for change within certain sectors of the fishery. Fisheries management capability to manage in a way that reduces by-catch and ensure compliance is also an inhibitor to responsible fishing, primarily due to: 1) a lack of funding, and 2) limitations of current assessment techniques. There is also a lack of education and awareness of what constitutes responsible salmon fishery among some participants in the salmon industry.

The following recommendations are provided as measures that should be pursued by governments and industry to further responsible fishing in the Pacific Region salmon fisheries. They are discussed under four main headings: 1) economic state of the fishery, 2) conservation measures, 3) motivating change, 4) education, 5) stock assessment, and 6) Joint decision-making.

Economic State

1. Continue the demonstration ITQ fisheries (e.g., Area F troll) and pilot pool fisheries. Monitor for undesirable effects such as high grading or intense fishing to beat reaching exploitation ceilings such as the West Coast Vancouver Island chinook catch ceiling for the Area F troll fishery.

2. Address all issues required to achieve and maintain MSC certification as soon as possible so harvesters can receive the maximum benefits from their selective harvesting and responsible fishing investments.

3. Create incentives for local processors to add value to salmon products such that full advantage can be taken of terminal and stock-selective fishing opportunities.

Conservation Measures

4. Assess the implications for negative interactions between enhanced stocks and stocks of concern. Where there are negative interactions, take action to align government enhancement initiatives with responsible fishing (examples are: interaction between enhanced Weaver Creek sockeye with weak Cultus sockeye in the Fraser or enhanced Fulton-Pinkut sockeye with weak Kitwanga sockeye in the Skeena).

5. Continue to pilot the transfer of allowable catch to more terminal areas, including into rivers of distinct stock origin to reduce the magnitude of mixed-stock fisheries and unwanted by-catch.

6. Increase funding for research into additional selective fishing methods and formalize the process by which these measures would be put into effect in fisheries in a timely manner through the development of action plans for each fishery. Continued research into non-physical sound barriers, fishwheels and traps, beach seining, and imprinting technology should be encouraged.

7. Fully implement and enforce the use of proven selective fishing methods, on a case-by-case basis, for mixed-stock/species fisheries. Under special conditions (i.e., time periods and locations where it can be clearly demonstrated that the catch of non-target species is very small and/or these species can support this level of harvest) non-selective harvesting techniques should be permitted and all catch retained to enable cost-efficient fisheries. In all other fisheries where by-catch is a concern, precaution should be followed, and non-selective fishing techniques should be phased out.

8. Subject to 6 above, commercial gillnet fisheries should be required to have a crew of two operators and use the short net, short-set, 3–3.5 inch mesh tangle net fishing technique and have fully functional revival tanks to aid in the recovery and live release of non-target species where there are weak stock concerns. The use of fixed-nets and long set times for in-river gillnet fisheries should be phased out. Fishery openings may need to be extended to provide sufficient time for fishers to harvest the available salmon using shorter soak times.

9. Subject to 6 above, commercial seine fisheries should be required to include escape grids and use sock brailers that do not expose fish to air. The use of wet sorting techniques and a powered tender to avoid net collapse should also be required.

10. Subject to 6 above, treble hooks should be eliminated and replaced with circle single hooks in the troll and recreational fisheries where by-catch reduction of species of concern can be improved by using these methods.

11. Subject to 6 above, First Nation FSC fisheries that use gillnets should be required to use the short net, short-set, 3–3.5 inch mesh tangle net fishing technique and where commercial size vessels are used these vessels should also have fully functional revival tanks to aid in the recovery and live release of non-target species. The use of fixed-nets and long set times for in-river gillnet fisheries should be phased out. Fishery openings may need to be extended to provide sufficient time for fishers to harvest the available salmon using shorter soak times.

Motivating Change

12. Until such time as industry is self-regulating, compliance monitoring by DFO should be increased to ensure compliance with the new requirements for all gear types, including the use of electronic log books coupled to GPS units and or better monitoring cameras the standard in all fisheries. Self-regulation should be encouraged through the use of short-term, and where necessary, long-term closures for non-compliance with a selective fishing regulation. Prohibition of access to a fishery for individuals that do not comply may be more effective than fines.

13. Market incentives as described above, should be used to reward fishers for fishing responsibly.

14. Increase access to salmon should be explicitly used as an incentive for fishing responsibly by rewarding those fisheries fishing responsibly with increased access.

15. Selective fishing measures should be relaxed for those fisheries where implementation is unwarranted (e.g., where jellyfish encounters comprise release survival of by-catch species).

16. The commercial salmon sector should accelerate it's exploration of incentive-based fishing regimes.

17. Conclude agreements (both treaty and non-treaty) with First Nations to provide clear definition of harvest shares and support improvements to catch monitoring programs and selective fishing measures.

Training and Education

18. Everyone engaged in harvesting salmon should be trained in proper fish handling techniques and be required to implement these techniques. This could be promoted with a mandatory course as a licence requirement. Participants must recognize that improvements towards more responsible fishing operations are possible and needed in all fisheries that capture salmon or steelhead to ensure the survival of commercial salmon fishing. Education in this regard is essential.

Stock Assessment

19. Stock assessment programs should be increased to monitor the escapement of key non-target salmon species and stocks. Knowledge about the aggregate or stock specific escapement non-target species or stocks is critically important for both fishery management and implementation of the Wild Salmon Policy.

20. New and existing selective fisheries (commercial, First Nations and recreational) should be integrated into the annual stock assessment system for salmon returning to all major watersheds. These marine and lower river fisheries could provide platforms for tagging and sampling specific salmon species while middle and upper river fisheries and monitoring locations could provide mark-rate samples for every marked species.

21. Maintain or increase the current DNA catch sampling in all fisheries and explore the application of new cheaper and more reliable DNA analysis tools, such as the identification and monitoring of Single Nucleotide Polymorphisms or SNPs for all harvested salmon stocks.

22. Where feasible, involve the harvesters in the collection of coded-wire tags and tissue sampling for DNA analysis and determination of stock composition in mixed-stock fisheries.

Joint Decision-Making

23. Establishment of multi-stakeholder decision-making organizations in key watersheds. Decision making panels should include the commercial sector, the recreational sector, environmental organizations, First Nations, DFO and the Province to cooperate in fisheries management and promote responsible fishing with a unified voice. These organizations can also be used as vehicles to build ownership of the resource salmon and aid in self regulation, compliance monitoring and understanding of fisheries management. Existing examples are the Aquatic Management Board for the west coast of Vancouver Island and the soon to be resurrected Skeena Watershed Committee (Walters *et al*. 2008).

LITERATURE CITED

Albin, B. and K.A. Karpov (1998). Mortality of lingcod, *Ophiodon elongatus,* related to capture by hook and line. Marine Fisheries Reviews, vol.60 (3): 29–34

Alexander, R.F., R.J. Bussanich, and M.O. Jessop (2008, draft). The 2007 fishwheel project on the Nass River, BC.

Ando, S. (1986). Carotenoid Decomposition in chum salmon, *Oncorhynchus keta*. Agricultural and Biological Chemistry, 50 (9): 2209–2215.

ARA Consulting Group Incorporated (1996). The economic value of salmon: chinook and coho in British Columbia: Discussion document prepared for: Canada Department of Fisheries

Archipelago Marine Research Limited (2008). http://www.archipelago.ca/highlight.aspx?ID=CF3EA83A-DB53-4F69-B787-3F7AEF432C2B

Beamish, R.J., G.A. McFarlane, and R.E. Thomson (1999). Recent declines in the recreational catch of coho salmon (*Oncorhynchus kisutch*) in the Strait of Georgia are related to climate. Canadian Journal of Fisheries and Aquatic Sciences, 56: 506–515.

Blewett, E. and T. Taylor. (1999). Selective fisheries review and evaluation. Prepared by Edwin Blewett & Associates Inc. and Timothy Taylor Consulting Services Inc. for Fisheries and Oceans, Canada. 106 p.

Brookhouse Consultants Ltd. (2000). Fishing salmon selectively in British Columbia. Report of third selective fisheries multi-stakeholder workshop. November 22–24, 1999, Richmond, B.C. For Fisheries and Oceans Canada.

Buchanan, S., A.P. Farrell, J. Fraser, P. Gallaugher, R. Joy, and R. Routledge (2002). Reducing gillnet mortality of incidentally caught coho salmon. North American Journal of Fisheries Management, 22: 1270–1275.

Budden, G. (1999). Seine brailer and wet sorting study. Submitted to: Selective Fisheries Program, Fisheries and Oceans Canada.

Bullen, C.R. and T.J. Carlson (2003). Non-physical barrier systems: their development and potential applications to marine ranching. Reviews in Fish Biology and Fisheries, 13: 201–212.

Canadian Science Advisory Secretariat Science Advisory Report 2006/023 (2006). A harvest strategy compliant with the precautionary approach. Report for: Department of Fisheries and Oceans Canada. On the Internet: http://www.dfo-mpo.gc.ca/csas/Csas/status/2006/SAR-AS2006_023_E.pdf

Canadian Stock Assessment Secretariat (2006). Review of 2005 WCVI chinook salmon returns and forecast abundance for Stamp River/Robertson Creek Hatchery indicator stock in 2006. Canadian Stock Assessment Secretariat Science Advisory Report 2006/036.

Colt, S. (2000). Salmon fish traps in Alaska: An economic history perspective. ISER Working Paper 2000.2, Version 1.1. On the Internet: http://www.alaskool.org/projects/traditionalife/fishtrap/FISHTRAP.htm

Copes, Parzival (2004). Socioeconomics of individual transferable quotas and community-based fishery management. Agricultural and Resource Economics Review, Oct 2004.

Cowichan Recovery Plan (2005). Prepared for the Cowichan Tribes Treaty Department. Prepared by LGL Limited, 9768 Second Street, Sidney, BC, V8L 3Y8.

Cox-Rogers, S., T. Gjernes, and E. Fast (1999). A review of hooking mortality rates of marine recreational coho and chinook salmon fisheries in British Columbia. Canadian Science Advisory Secretariat, Research Document 99/127.

Department of Justice Canada. (1993). Fisheries Act, Pacific Fishery Regulations, 1993 (SOR/93-54). On the Internet: http://laws.justice.gc.ca/en/F-14/SOR-93-54/index.html

DFO Canada (1998). Canadian Code of Conduct for Responsible Fishing Operations, Consensus Code 1998. On the Internet: http://www.dfo-mpo.gc.ca/communic/fish_man/code/cccrfo-cccppr_e.htm

DFO, Report by the External Steering Committee (2003). Review of the 2002 Fraser River Sockeye Fishery. On the Internet: http://www-comm.pac.dfo-mpo.gc.ca/pages/consultations/fisheriesmgmt/Report_e.pdf

DFO (2006). Review of 2005 WCVI chinook salmon returns and forecast abundance for Stamp River / Robertson Creek Hatchery indicator stock in 2006. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2006/036.

DFO (2007). 2006 Salmon licence Area F troll demonstration individual transferable chinook quota (ITQ) fishery review.

DFO IFMP, Integrated Fisheries Management Plan, Salmon Southern BC, Draft (2008).

Ecotrust Canada (2004). Catch-22: Conservation, communities and the privatization of the BC fisheries.

Edwin Blewett & Associates (1999). Selective fisheries: Review & evaluation. For: Department of Fisheries and Oceans, Canada, Pacific Region.

English, K.E., W.J. Gazey, D. Peacock, and G. Oliver (2004). Assessment of the Canadian and Alaskan sockeye stocks harvested in the northern boundary fisheries using run reconstruction techniques, 1982–2001. Pacific Salmon Commission Technical Report No.13.

English, K.K., R.E. Bailey, and D. Robichaud (2007). Assessment of chinook returns to the Fraser River watershed using run reconstruction techniques, 1982–04. Canadian Science Advisory Secretariat, Research Document 2007/020. 76 p.

English, K., G.J. Glova, and A.C. Blakley (2008). An upstream battle: Declines in 10 Pacific salmon stocks and solutions for their survival. Report Prepared for David Suzuki Foundation.

Farrell, A.P. and D.D. Pike (2001 draft). Physiological evaluation of various brailing and sorting box methods for seine captured coho salmon.

Farrell, A.P., P.E. Gallaugher, and R. Routledge (2001). Rapid recovery of exhausted adult coho salmon after commercial capture by troll fishing. Canadian Journal of Fisheries and Aquatic Sciences, 58: 2319–2324

Farrell, A.P., P.E. Gallaugher, J. Fraser, D Pike, P. Bowering, A.K.M. Hadwin, W. Parkhouse, and R. Routledge (2001). Successful recovery of the physiological status of coho salmon on board a commercial gillnet vessel by means of a newly designed revival box. Canadian Journal of Fisheries and Aquatic Sciences, 58: 1932–1946.

Fisheries and Oceans Canada (1998). An allocation framework for pacific salmon 1999–2005. http://www-comm.pac.dfo-mpo.gc.ca/publications/allocation/AllocMain.PDF

Folkes, M. and J. Irvine (2005). Recovery potential assessment of interior Fraser coho salmon (*Oncorhynchus kisutch*). Canadian Science Advisory Secretariat, Science Advisory Report 2005/061.

GSGislason and Associates (2004). British Columbia seafood sector and tidal water recreational fishing: A strengths, weaknesses, opportunities, and threats assessment. Prepared for: BC Ministry of Agriculture, Food and Fisheries Victoria, BC

Hansen, K. and G. O'Connor (2000). Upper Skeena coho modified revival box demonstration fishery, Interim Report for Community Fisheries Development Centre.

Hargreaves, N.B. and C. Tovey (2001). Mortality rates of coho salmon caught by commercial salmon gillnets and the effectiveness of revival tanks and reduced soak time for decreasing coho mortality rates. Canadian Science Advisory Secretariat, Research Document 2001/154.

Hillborn, R., J.M. Orensanz, and A.M. Parma (2005). Institutions, incentives and the future of fisheries. Philosophical Transactions of the Royal Society B, 360: 47–57.

Hyatt, K. (2006). Canadian Science Advisory Secretariat Proceedings Series 2006/027, Proceedings of the PSARC Salmon Subcommittee Meeting, October 18, 2006, Pacific Biological Station, Nanaimo, BC

Interior Fraser coho Recovery Team (2006). Conservation strategy for coho salmon (*Oncorhynchus kisutch*), Interior Fraser River populations. Fisheries and Oceans Canada. 132p.

Integrated Fisheries Management Plan, Salmon, Northern BC, June 1, 2007–May 31, 2008 (2007).

Integrated Fisheries Management Plan, Salmon Southern B.C., June 1, 2007 to May 31, 2008 (2007).

Irvine, J.R., L. Bijsterveld, L. Biagini, and M. Poon (2004). An update on catch trends for Pacific salmon in British Columbia Canada. (NPAFC Doc. No. 802). Dept. of Fisheries and Oceans, Science Branch & Corporate Services Branch - Pacific Region, Vancouver, B.C. Canada. V6C 3S4

J.O Thomas and Associates Ltd. (1998). 1997 Fraser selective salmon fisheries, Final report. Prepared for: The Ministry of Environment, Land and Parks, Kamloops BC.

J.O Thomas and Associates Ltd. (2002). Tooth tangle net study 2001. Prepared for: Fred Hawkshaw and Fisheries and Oceans Canada.

Jones, R., M. Shepert, and N.J. Sterritt (2004). Our place at the table. First Nations in the BC fishery. Report to the First Nation Panel on Fisheries.

Knapp, G. and L. Hill (2003). Effects of the Chignik salmon cooperative: What the permit holders say. Understanding Alaska, Institute of Social and Economic Research, University Alaska Anchorage, UA Research Summary No.1.

Kristianson, G. and D. Stongitharm. (2006). The evolution of recreational salmon fisheries in British Columbia. Report to the Pacific Fisheries Resource Conservation Council, Suite 290, 858 Beatty Street, Vancouver, BC V6B 1C1.

Knudsen, F.R., P.S. Enger, and O. Sand (1994). Avoidance responses to low frequency sounds in downstream migrating Atlantic salmon smolt, *Salmo salar* L. Journal of Fish Biology vol.45, issue 2: 227–233.

Law, R. 2000. Fishing, selection, and phenotypic evolution. ICES Journal of Marine Sciences, 57 (3): 659–668.

Lewynsky, V.A. Western Renewable Resources (1992). Experimental assessment of weedline modified gillnets in statistical Area 4 (Skeena River), 1991. Prepared for: Department of Fisheries and Oceans, 202–417 2nd Avenue West, Prince Rupert, B.C., V8J 1G8.

Link, M.R. and K.K. English (1996). The 1993 fishwheel project on the Nass River and an evaluation of fishwheels as an in-season management and stock assessment tool for the Nass River. Can. Tech. Rep. Fish Aquat. Sci. 2130: 103 p.

Link, M.R., K.K. English, and R.C. Bocking (1996). The 1992 fishwheel project on the Nass River and an evaluation of fishwheels as an in-season management and stock assessment tool for the Nass River. Can. Manuscr. Rep. Fish Aquat. Sci. 2372: 82 p.

May, B., D. Leadbitter, M. Sutton, and M. Weber (2003). The Marine Stewardship Council. In: Eco-labeling in fisheries: What is it all about? B. Phillips, T. Ward, and C. Chaffee (eds.), Blackwell Publishing: 14–33.

McRae, D.M. and P.H. Pearse (2004). Treaties and transitions: Towards a sustainable fishery on Canada's Pacific Coast. For: Federal-Provincial / Post Treaty Fisheries Joint Task Force.

Nelitz, M., C.A.D. Alexander, and K. Wieckowski (2007). Helping Pacific salmon survive the impact of climate change on freshwater habitats: Case studies: Perspectives from the Okanagan, Quesnel, Nicola, Cowichan, Nass, and Englishman River watersheds. Report prepared for Pacific Fisheries Resource Conservation Council, Suite 290, 858 Beatty Street, Vancouver, BC V6B 1C1.

Nelson, S. and B. Turris (2004). The Evolution of Commercial Salmon Fisheries in British Columbia. Vancouver, BC: Prepared for the Pacific Fisheries Resource Conservation Council.

Nelson, T.C., W.J. Gazey, K.K. English, and M.L. Rosenau (2004). Status of white sturgeon in the Lower Fraser River, Report on the findings of the Lower Fraser River White Sturgeon Monitoring and Assessment Program, 1999–2004. Report prepared by: LGL Limited, Environmental Research Associates. Report prepared for: Fraser River Sturgeon Society, Vancouver, BC.

Pacific Region Integrated Fisheries Management Plan, Salmon Northern B.C. (2007).

Pacific Salmon Commission Chinook Technical Committee (2008). 2007 Annual report of catches and escapements, exploitation rate analysis and model calibration. Pacific Salmon Commission Report TCCHINOOK (08)-1.

Pacific Salmon Commission (2008). Recommendations for application of Genetic Stock Identification (GSI) methods to management of ocean salmon fisheries: Special report of the Genetic Stock Identification Steering Committee and the Pacific Salmon Commission's Committee on Scientific Cooperation. Pacific Salmon Commission Technical Report No. 23: 35 p.

Pacific Salmon Commission Chinook Technical Committee (2006). Final Report on the October 19, 2005 Assignment Re: Conduct of Canadian AABM Fisheries. http://www.psc.org/pubs/TCCHINOOK06-1wm.pdf

Pacific Salmon Commission Chinook Technical Committee (2008). 2007 Annual report of catches and escapements, exploitation rate analysis and model calibration. Report: TCCHINOOK (08)-1.

Pearson, R. (1999). Canoe Pass selective paddle trap. Report submitted to Department of Fisheries and Oceans Canada.

Pearson, R. (2001). Canoe Pass selective paddle trap. Report submitted to Department of Fisheries and Oceans Canada.

Pestal, G. (2006). Simple decision making guidelines for managing spring-run Fraser chinook, Short handout. Report prepared by: Spring-Run Fraser Chinook Working Group. Report prepared for: Department of Fisheries and Oceans Canada.

Pierce, J.J. (2006). Farmed salmon outpacing wild salmon in Japanese and other major markets. Quick Frozen Foods International, 10, 2006. http://www.allbusiness.com/wholesale-trade/merchant-wholesalers-nondurable/3911823-1.html

Plate, E. (2001). Olfactory imprinting in sockeye salmon (*Oncorhynchus nerka*). Ph. D. dissertation, University of Victoria, Victoria, B.C. 160 p.

Petrunia, W.M. (1999). Final Report, Refinement of mesh and twine size for a small mesh tooth tangle net. Submitted to: Selective Fisheries Program, Fisheries and Oceans Canada.

Rabnett, K. (2005). Kitwanga sockeye recovery plan backgrounder. For: Skeena Fisheries Commission can be found on the internet at: http://www.skeenafisheries.ca/publication_Kitwanga%20sockeye%20Recovery%20Backgrounder.pdf

Ricker, W.E. (1981). Changes in the average size and age of Pacific salmon. Canadian Journal of Fisheries and Aquatic Science 38: 1636–1656.

Robichaud, D., K.K. English, R.C. Bocking, and T.C. Nelson (2006). Direct and delayed mortality of white sturgeon caught in three gear-types in the lower Fraser River. Report prepared by: LGL Limited environmental research associates, Sidney, Victoria BC. Prepared for: Tsawwassen First Nation Fisheries, 131N Tsawwassen Drive, Delta, BC, V4M 4G2.

Robichaud, D., K.K. English, and J.J. Smith (2008). Feasibility of fishwheel use for escapement estimation and tracking results from salmon radio-tagged on the lower Fraser River in 2007. Prepared by LGL Limited for Pacific Salmon Commission, Vancouver, BC. 127 p.

Roos, J.F. (1991). Restoring Fraser River salmon. In the series of publications of The Pacific Salmon Commission, Vancouver, Canada: 438 pp.

Rugerone, G.T., T.P. Quinn, I.A. McGregor, and T.D. Wilkinson (1990). Horizontal and vertical movements of adult steelhead trout, *Oncorhynchus mykiss*, in the Dean and Fisher channels, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences, 47: 1963–1969.

Sissenwine, M.P. and Mace P.M. (2003) Governance for responsible fisheries: an ecosystem approach. In: Sinclair M., Valdimarsson G. (eds) Responsible fisheries in the marine ecosystem. FAO, Rome, & CABI Publishing, Wallingford, UK: 363–390.

Skeena coho modified revival box demonstration gillnet fishery data (2000).

Skeena Watershed Committee (1995). Enhancement & habitat restoration workshop. Selective harvesting workshop. Workshop Proceedings. Conley D.C. (ed.).

Smith, H.D. and J. Lucop (1966). Catalogue of salmon spawning grounds and tabulation of escapements in the Skeena River and Department of Fisheries Statistical Area 4. Fisheries Research Board of Canada Manuscript Report Series (Biol.), Nanaimo, 882:1–7.

Sporer, C. (2006). 2005 Licence Area F ITQ demonstration fishery: A review. Report prepared for Fisheries and Oceans Canada by Christopher Sporer Consultants Ltd.

Walters, C.J., J.A.Lichatowich, R.M.Peterman, and J.D.Reynolds (2008). Report of the Skeena independent Science Review Panel. Submitted to the Department of Fisheries and Oceans and the British Columbia Ministry of the Environment: 144 pp.

Walters, C., J. Korman, and S. McAdam (2005). An assessment of white sturgeon stock status and trends in the Lower Fraser River. Canadian Science Advisory Secretariat, Research Document 2005/066.

Ward, B.R. (1993). Selective harvest in salmonid trap-net fisheries of the past, present and future. First Nations' Amer. Fish. Soc. Workshop, Richmond Inn, B.C., Jan. 16–18, 1993.

Winther, I. and T.D. Beacham (2006). The application of chinook salmon stock composition data to management of the Queen Charlotte Islands troll fishery, 2002 to 2005. Canadian Technical Report of Fisheries and Aquatic Sciences 2665.

Wood, C.C. (2002). Managing biodiversity in Pacific salmon: The evolution of the Skeena River sockeye salmon fishery in British Columbia. Washington, DC: Global Environment Facility.

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