REPORT CARDS FOR THREE BC RECREATIONAL FISHERIES

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Watershed Watch Salmon Society
Watching out for BC's Wild Salmon

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1. Purpose of the Report Card Series

This report card, like the two preceding it[1], is meant to "grade" the management of fisheries in British Columbia. Our goal is to provide government, First Nations, the BC fishing industry and the general public with conservationist-oriented assessments of why and how the sustainability[2] of salmon fisheries might be improved.

The three case studies in this report card have been evaluated and graded based on the same assessment criteria used in our previous report cards, with the same questions guiding our approach and conclusions:

- Do current fishing practices place the species or populations at risk of depletion, collapse or extirpation?
- Does fishing impede the rate of recovery of depleted populations?
- To what extent does fishing impact non-targeted species and other ecosystem components?
- Is there sufficient biological knowledge about the targeted species to warrant a fishery?
- Is there adequate, up-to-date stock status information?
- Does the federal Department of Fisheries and Oceans (DFO) have a handle on how much of each species is being caught in the fishery?
- Is the fishery being managed in a precautionary way with the best available management and stock assessment methods?
- Do fisheries management plans consider ecosystem effects?

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[1] The previous report cards are the "Strait of Georgia Roe Herring Fishery Report Card" (2003) and the "Nass River Salmon Fishery Report Card" (2006), both published by the Sierra Club of Canada's BC Chapter.

[2] For the purpose of the report cards, sustainability is defined as the persistence of a stock to be used by both humans and other parts of the ecosystem. We are not looking at other sustainability issues, such as the consumption of fossil fuels to undertake a fishery or socio-economic factors.

Grading Criteria

The table below summarizes the grading criteria we have adopted for the report card series. Detailed explanations are provided in Appendix 1.

Topic	Grading Criteria
Knowledge of Species Life History	The degree to which relevant life history information required for sustainable fisheries is known.
Stock Assessment and Sustainable Quota Determination	The degree to which Fisheries and Oceans Canada is able to estimate stock size and consequently allocate sustainable quotas.
Management System	The degree to which the management system is able to control and account for catches of targeted and incidentally caught species in a timely way.
Ecosystem Considerations	The degree to which ecosystem-based approaches are incorporated into management decisions.
Precautionary Measures and Long Term Sustainability	The degree to which risk-averse, precautionary approaches are incorporated into management decisions to ensure sustainability.
Biodiversity Conservation	The degree to which the fishery operates without causing irreversible harm to non-target stocks.

Appendix 1. Grading Criteria: Table from Levy Nass Report Card, page ii, (http://www.sierraclub.ca/national/postings/scc-nass-salmon-report-card.pdf)

The information in this document is based on the best available to us, but may contain inaccuracies. We also acknowledge that such evaluations can in no way remain static over time; future information, actions and conditions may affect the report card "grade" assigned to any particular fishery.

2. Report Cards for Three BC Recreational Fisheries

Criterion	Langara Island Chinook and coho	Fraser River sockeye (non-tidal)	Skeena River steelhead
1. Knowledge of species life history	B	A-	C
2. Stock assessment and sustainable quota determination	C-	B-	C-
3. Management system	C	C	C+
4. Ecosystem considerations	C	B	B+
5. Precautionary measures and long-term sustainability	C	C	B
6. Biodiversity conservation	C	B	C
Overall Grade	C	B-	C+

Main Findings

- For all four species evaluated, there is a very limited understanding of productivity and factors affecting marine survival. This gap results in inaccurate forecasts of run-size, which can lead to overfishing of depleted stocks or missed fishing opportunities.
- Because recreational fisheries generally harvest a small number of fish compared to other fisheries, there are relatively small effects on overall abundance and likely no ecosystem impacts. The main concern is small and depleted stocks, which could potentially be affected by intensive recreational fisheries that harvest many fish within a short time period or particular region.
- Monitoring efforts are insufficient, so precautionary management is crucial to protect stocks.

Langara Island (Haida Gwaii) Chinook and coho

- There is a good program to estimate catch and effort in recreational fisheries. This includes creel surveys carried out by First Nations and logbooks completed by fishing lodges.
- Abundance of Chinook and coho is estimated from troll fisheries but better in-season assessment of marine survival and abundance is necessary to protect small stocks.

Fraser River sockeye (non-tidal)

- Excellent in-season assessment of run-timing groups but monitoring of individual stocks, especially less abundant runs, is limited.
- The decision making process for fisheries openings is unclear and certain fishing regulations are difficult to monitor and enforce.

Skeena River steelhead

- Steelhead angling in the Skeena watershed is catch-and-release (C&R) only, which minimizes population impacts.
- Limited understanding of life history and biology, insufficient stock assessment and catch monitoring, and ineffective inter-sectoral fisheries management put steelhead stocks at risk. A number of management changes and research projects addressing these issues are underway.

3. Introduction: Where We've Been

The idea that recreational fishing should be scrutinized at all is a modern one. Sports fishing in BC waters was completely unregulated until 1951, when the first "bag limit" was imposed; between 1956 and 1976, DFO estimates of catch and effort in the sports fishery were based on subjective assessments by fishery officers and small-scale creel surveys. As recently as 1981, fishing licences were not required and no catch statistics were collected in the province.

For more than a century the Chinook, coho and steelhead of the greater Georgia Basin were the primary focus of sports fishermen in BC, peaking in the decades immediately following the Second World War. The lower Fraser River and its many tributaries attracted generations of sports fishermen targeting Chinook, coho and steelhead. The steelheading streams of legend on the east coast of Vancouver Island, draining into the Strait of Georgia, also absorbed seasonal migrations of anglers. Towns like Campbell River and Chilliwack built their respective tourism industries on the expectation that trophy fish were a short boat ride away.

Technological advancements that saw cars, outboard motors and floatplanes become ubiquitous, as well as refinements in fishing rods, line and tackle, ultimately made recreational fishing more accessible to more and more British Columbians.

But by the early 1990s, the declines of steelhead and coho – followed shortly after by Chinook – across the greater Georgia Basin forced dramatic changes in how and where sports fishing occurred in BC. The holds of Vancouver Island-bound weekend ferries no longer brimmed with boat trailers and camper hitches en-route to the Little and Big Qualicum, the Nanaimo, or the Englishman. Gone too were the annual seasonal migrations for steelhead, to the Thompson on Thanksgiving weekend, or summer steelheading forays to the Coquihalla, Silver Hope and many other island and mainland rivers and streams.

With the declines has come a gradual shift in sports fishing effort in British Columbia: ever farther north, beyond Rivers Inlet to Prince Rupert, Haida Gwaii[3], and outward to the western fringes of Vancouver Island. With few exceptions (e.g., steelheading on the Chilliwack/Vedder), the epicentres of BC salmon and steelheading angling effort have shifted in a very short time.

These geographical shifts of fishing effort have also prompted increased reliance on targeting mixed salmon stocks, and greater fishing effort expended towards halibut and in some locations, rockfish as well.

To their credit, Canada's federal government no longer considers the impact of BC sports fishing to be negligible. Although the overall recreational share of the total salmon catch is estimated to

[3] The Queen Charlotte Islands were officially renamed "Haida Gwaii" as part of a reconciliation agreement between the province of BC and the Haida Nation announced in December 2009.

be about 3%, recreational fishers catch larger total proportions of Chinook (35%) and coho (30%). Steelhead have always been targeted primarily by recreational anglers.

The three case studies contained in this report card thus not only focus on Chinook, coho and steelhead, but on relatively new epicentres of fishing effort for these species: steelhead on the Skeena River, coho and Chinook salmon at Langara Island/Haida Gwaii, and sockeye salmon in the non-tidal waters of the lower Fraser River.

These three fisheries occur at very different geographical locations in the province, and each features participants that are widely varied too: the upscale fishing lodges based on Langara Island and northern Graham Island on Haida Gwaii cater primarily to high-end Canadian and foreign clientele; the Skeena and its tributaries attract a mixture of local, BC and visiting foreign anglers; and the sockeye fishery on the Fraser is dominated by local resident anglers.

4. Report Card for the Langara Island Coho and Chinook Recreational Fishery

4.1 Introduction and Background

Situated at the first point of landfall for salmon migrating through the North Pacific, Langara Island is among the best Chinook and coho marine angling hotspots in the province.

From the northwestern tip of Haida Gwaii, an angler can intercept salmon bound for west coast natal streams from northern BC all the way to southern Oregon. In mid-June of 2009 for example, many of the Chinook encountered by Langara anglers originated from the south Thompson (Fraser River), Upper Columbia, and north and central Oregon; a week later, fish from north and south Oregon and the West Coast of Vancouver Island were encountered.

Chinook and coho salmon are the principal quarry of sports fisheries based at Langara Island and Haida Gwaii. Both of these species are closely related within the genus *Oncorhynchus* whereas sockeye, chum and pink salmon form the second sub-grouping of Pacific salmon found in BC. Chinook and coho are the most sought-after for sport fishing, likely because of their aggressive feedings habits, athleticism and relatively large size. Because of their economic and cultural value, both of these species, especially populations from the Fraser and Columbia basins, have been studied extensively and many aspects of their biology are well understood.

Chinook salmon *(Oncorhynchus tshawytscha)* are the largest in size and least abundant of the five species of Pacific salmon in BC (not including steelhead). Compared to other species of Pacific salmon, Chinook have diverse life histories. Adults may return to spawn in streams any month of the year and based on the timing of spawning migration are often referred to as spring-, summer-, fall- or winter-runs. Variation also exists in the timing of seaward migration by juveniles. 'Stream-type' populations rear in freshwater for one year or more whereas 'ocean-type' populations migrate into saltwater shortly after emergence as fry. Age at maturity varies substantially. Individuals can become sexually mature and return to spawn between two and eight years of age but four- and five-year olds are the most common spawners in BC. Chinook that become sexually mature at two or three years of age are typically male and are often called "mini-jacks" or "jacks," respectively.

Coho salmon (*Oncorhynchus kisutch)* are the second least abundant of the Pacific salmon in BC, after Chinook salmon. On average, their body size is smaller than Chinook and chum salmon but larger than sockeye and pink salmon. The majority of coho return to spawn at three years of age. Juveniles typically spend one to two years rearing in natal streams before migrating to the ocean, although some may go to sea in the spring as fry. Most individuals spend one full year at sea; however, some males spend only one summer at sea and return at two years, and some males and females spend two years at sea and return at four years old.

Despite the abundance of both Chinook and coho in the waters surrounding Haida Gwaii, big sports fishing lodges and charter operators are only recent arrivals to these islands. In 1985 there were no fishing lodges at all on Haida Gwaii; by 1990 there were eight in the Langara-Naden Harbour area alone. Today there are at least 23 major lodges[4], including six concentrated in a tiny area between the southern shores of Langara Island and the mainland of Graham Island.

The major lodges include traditional land-based lodges and newer "floating" lodges – often lavishly refitted ships and pleasure craft. The latter can be harboured during the winter out of the harsh elements, do not require property or a foreshore lease, and if need be, can follow the fish to new areas of abundance.

Bob Wright's Oak Bay Marine Group (OBMG) is a dominant owner and operator of BC fishing lodges, and a prime example of a business that has followed salmon ever northward since its inception in 1962. OBMG established a lodge at Rivers Inlet on the central BC coast in 1985, and three years later launched the *MV Charlotte Princess* on southern Langara Island – a luxury yacht converted into "one of the world's most desirable sports fishing resorts." In 1993, the *MV Salmon Seeker*, a former ice breaker, was established at Kano Inlet on the west coast of Graham Island.

While the growth of new lodges has remained static since 2001, the sports fishing industry continues to grow in two ways: lodges and charters often target fish from May to September, whereas in the past, such businesses fished during July and August only; and, some lodges continue to expand in size and infrastructure at their current sites.

In terms of commercial fisheries, there have been no gillnet or seine fisheries in DFO's statistical Area 1 – a geographical area that includes the coastal waters from Rose Spit eastward to Langara Island – since the early 1990s. Troll fisheries for Chinook and coho coexist uneasily with the sports fishery, focusing their efforts between Langara Island and down the west coast of Graham Island, and between Naden harbour around Rose spit and down the east coast, respectively.

Langara Island, as stated above, is home to an unusually high concentration of big fishing lodges, and is thus the focus of this evaluation; however, the discussion that follows also relates more generally to the directed Chinook and coho sports fisheries based on the entire Haida Gwaii archipelago.

[4] This number does not include the unknown number of smaller charter operators and independents who operate out of Masset, Sandspit, Queen Charlotte City, and other locations.

4.2 Status and Report Card Evaluation

Langara Island Coho and Chinook Recreational Fishery Overall Grade: C

Criterion	Grade	Comments/Summary
1. Knowledge of species life history	B	Most aspects of life history and biology are well understood. Very limited understanding of marine survival and factors affecting mortality in the ocean.
2. Stock assessment and sustainable quota determination	C-	Data from troll fishery combined with recreational fisheries monitoring provides reasonable estimates of abundance. Better in-season assessment and monitoring of individual populations are needed to improve management. Methods of recreational fishery monitoring have not been validated.
3. Management system	C	Good system for estimating recreational catch and effort. Stock composition of catch is assessed by genetic analyses or coded wire tags (CWT). Improved in-season assessment of marine survival or abundance is needed to inform in-season management decisions.
4. Ecosystem considerations	C	Management has acknowledged the importance of ecosystem values but has yet to incorporate ecosystem considerations into salmon management.
5. Precautionary measures and long-term sustainability	C	Recreational fisheries closures in past years reflect a precautionary approach. However, reliance on preseason forecasts and post-season stock composition may put small stocks at risk. Wild Salmon Policy (WSP) benchmarks are consistent with a precautionary approach but are not yet implemented.
6. Biodiversity conservation	C	Stocks of conservation concern are not caught in large numbers. Ongoing and improved monitoring of stock composition and abundance may be necessary to reduce risk of biodiversity loss.

4.3 Criterion 1 - Knowledge of Species Biology and Life History

GRADE = B

Assessment of life history and biology knowledge required for sustainable fisheries management (1 = nothing known, 2= poorly understood, 3 = limited understanding, 4 = sound understanding, 5 = excellent understanding).

Biology and Life History Topic	Knowledge Base
Distribution and Migration	4
Genetic and spatial structure of populations	4
Longevity	5
Age of maturity	4
Habitat requirements	3
Spawning requirements	4
Prey source	4
Predation and Mortality	2
Ecosystem role	4
Environmental conditions and recruitment	2
Total	36/50

Chinook salmon ocean distribution and behaviour is difficult to study because of logistic challenges but some information has been gathered using analysis of scale patterns, tagging studies and genetic analysis. In general, stream-type Chinook are more widely distributed in the North Pacific and migrate further offshore whereas ocean-type Chinook do not migrate as far offshore and stay closer to natal watersheds (Healey 1991). As noted above, Chinook caught by sport fisheries based on Haida Gwaii include populations from all over the Pacific coast but fish from West coast of Vancouver Island, South Thompson River (Fraser River), Upper Columbia River, and Oregon dominate the catch (Winther 2008).

Many studies have assessed the genetic and population structure of Chinook salmon in North America. This information has been used to estimate run-timing, population size, and diversity among populations in order to improve management of mixed-stock commercial and recreational fisheries in salt- and fresh-water. DFO's WSP aims to protect salmon biodiversity by identifying and managing distinct conservation units (CUs), which are populations or groups of populations that represent significant biodiversity based on ecotypology, life history, genetics, behavioural traits and ecological characteristics of their habitat (DFO 2005). Sixty-eight CUs of Chinook salmon in BC were identified (DFO 2009a).

Like Chinook and all Pacific salmon, most coho return to spawn in their natal stream but some may stray. There are few studies providing accurate estimates of straying rates but, in general, coho are thought to have high rates of straying compared to other species of Pacific salmon. Estimates of straying by coho have ranged from ~20% to less than 1% (Sandercock 1991). The rate of straying may depend on environmental conditions, availability of spawning habitat, population of origin, and whether fish are wild or from hatcheries (Quinn 2005).

The WSP identified 43 CUs of coho in BC. Coho caught by the recreational fishery based on Haida Gwaii are predominately from the central BC coast and Haida Gwaii. Coho from Alaska, Vancouver Island, the Nass River, the Skeena River and the Fraser River watershed are also caught (Sawada 2005).

4.4 Room for Improvement

There is sufficient information about the biology and life history of Chinook and coho salmon to effectively manage and protect these species. Population structure, genetic variation and timing of migration have been studied for the populations caught in Haida Gwaii. Habitat requirements and factors affecting survival in freshwater are reasonably well understood.

One important gap in understanding of Chinook and coho biology is marine survival and factors that affect mortality in the ocean. Rates of marine survival of Chinook and coho can vary drastically. For instance, coho survival has declined from 10-20% in the 1970s to less than 2% in 2007 (DFO 2009b). Marine survival is known to vary with environmental conditions but these processes are not well understood for Pacific salmon (or most other marine fishes), making it difficult to predict the number of returning adults.

4.5 Criterion 2 – Stock Assessment and Sustainable Quota Determination

GRADE = C-

4.6 Methods of Stock Assessment

Stocks are assessed through pre-season and in-season abundance estimates from the North British Columbia troll fishery and also through monitoring of recreational fishing harvest and effort. The Pacific Salmon Commission (PSC) and DFO use both of these sources to monitor abundance, calculate stock-specific exploitation rates, estimate incidental mortality of released fish, and forecast future returns (PSC 2008).

There are good estimates of recreational fishing harvest and effort in Haida Gwaii including Langara Island. The recreational fishery is monitored by DFO using a combination of logbooks completed by lodge and charter operators, creel surveys conducted by the Haida Fisheries Program, and mail-out surveys. There are some limitations to these estimates. For instance, the logbook program is voluntary and does not include many small independent charter companies. The reliability of creel surveys has often been questioned and a study in the Strait of Georgia found that creel surveys consistently underestimated catch of Chinook and coho salmon (Diewert et al. 2005). Nonetheless, monitoring of recreational fishing is much better in Haida Gwaii compared to many areas of the province and likely provides a reasonable estimate of harvest and catch per unit effort (CPUE), data which are used in stock assessment.

CWT data from indicator stocks are used to assess abundance of stock aggregates for Chinook and coho. DNA analyses are also used to assess stock composition of recreational and commercial catch, and to estimate migration timing of specific populations through the fisheries (e.g., Chinook – Winther 2008; coho – Sawada 2005). DNA analyses are currently highly inaccurate for northern coho; therefore management focuses on aggregate abundances from CWT data. Together, CWT and DNA analyses are used to estimate exploitation rates in the post-season and, if necessary, reduce fishing pressure on stocks of concern by adjusting the timing or locale of fisheries openings in future years.

4.7 Trends in Catch, Effort and Abundance

Data from the Haida Fisheries Program indicate that total catch of Chinook by recreational fisheries in Area 1 (North Haida Gwaii including Langara Island) increased from 1999 to 2004 then decreased from 2004 to 2007 (Figure 2). Catch of coho has remained stable from 2001 to 2007 (Figure 2). Fishing effort has increased steadily since 1996 but may have decreased slightly in 2006 and 2007 (Figure 3). The result is that CPUE in Area 1 has fluctuated but remained fairly consistent since 1999 (Figure 3).

Winther et al. (2008) used the creel survey, logbook data, and earlier estimates of Chinook abundance from fisheries observers and found a similar trend of increasing catch from 1985 through 2004, and decreasing catch since 2004. Models reconstructing historical abundance of Fraser River Chinook based on escapement and in-river fisheries mirror this steady population increase from 1982 to 2004 for all run-timings and age-groupings (English et al. 2007).

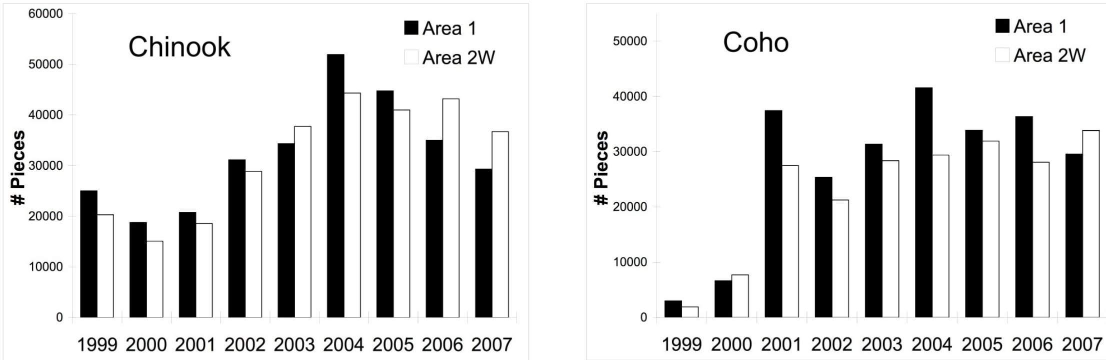

Figure 1. Total recreational fishery catch of coho and Chinook salmon, Haida Gwaii, 1999 to 2007. Area 1 data are from creel surveys and Area 2W data are from logbooks and creel surveys. Figure modified from Haida Fisheries Program (unpublished data).

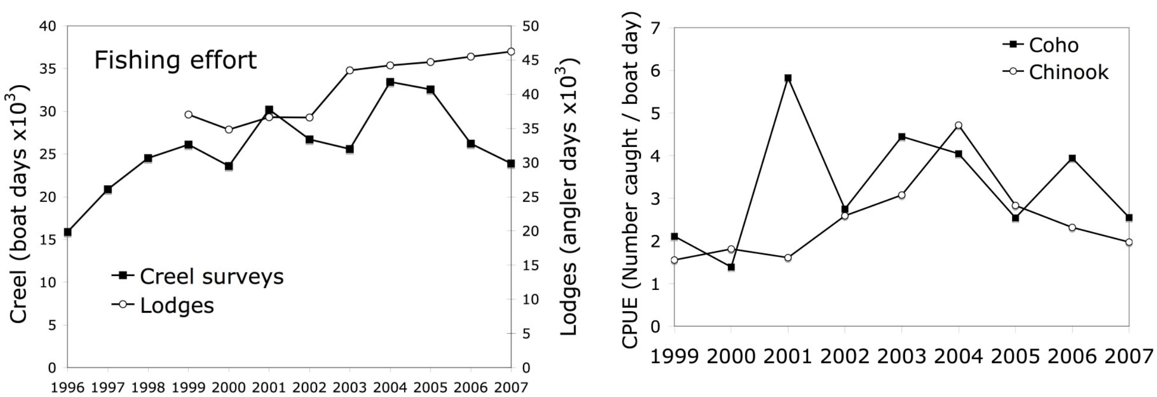

Figure 2. Fishing effort (left panel) and catch per unit effort (CPUE; right panel) in Area 1 of Haida Gwaii as determined by creel surveys and fishing lodge logbooks. Data were obtained from the Haida Fisheries Program. CPUE data are a combination of creel surveys and lodge logbooks.

4.8 Quota Determination

There is no explicit limit on the total harvest of Chinook and coho by the Haida Gwaii recreational fishery (Winther and Beacham 2005). Restrictions to recreational fishing opportunities in Haida Gwaii have included closure of Chinook sport fishing in 1996 to protect threatened stocks from the West Coast of Vancouver Island and restrictions in the late 1990s to protect upper Skeena River coho; however, since the late 1990s there have been few restrictions, other than harvest limits for individual anglers, on recreational fishery harvest. Quotas (total allowable catch) for the Chinook troll fishery are based on pre-season abundance indices minus the forecasted catch by the recreational fishery (Winther and Beacham 2005). These abundances are based on CWT data for stock aggregates (PSC 2008).

4.9 Room For Improvement

Stock assessment of Haida Gwaii Chinook and coho uses a combination of data from the troll fishery and recreational fishery that together are thought to provide reasonable estimates of abundance and exploitation rates. However, Holt et al. (2007) highlighted a number of limitations of current stock assessment and potential quota determination for coho. North coast coho populations are managed as large stock aggregates but there are discrepancies in marine survival between aggregates and individual stocks. These authors suggested that aggregate-based management combined with highly uncertain estimates of marine survival could potentially result in over-fishing or missed harvest opportunities. Holt et al. (2007) suggested a shift towards in-season abundance estimates combined with marine survival predictions to gradually adjust exploitation rates.

Although Langara Island has a relatively extensive fisheries monitoring program, data from creel surveys and mail-out surveys often have serious biases (e.g., changes in reporting frequency or accuracy) and the efficacy of logbooks is unknown. Rates of unreported catch using these methods can be substantial (Ainsworth and Pitcher 2005). Therefore, it may be important to validate these methods by evaluating the accuracy of reporting or comparing data to other estimates of abundance. For instance, Sawada (2005) found relationships between CPUE in Haida Gwaii recreational fisheries and direct estimates of adult returns of Babine River coho. More studies validating catch monitoring efforts and their use in estimating abundance are necessary.

4.10 Criterion 3 – Management System

GRADE = C

4.11 Management and Policies

DFO manages the BC recreational fishery in tidal waters, including setting regulations, licensing and, stock assessment. Canada’s policy for allocating salmon to different user groups (DFO 1999) gives precedence to conservation of depleted populations followed by priority access to salmon by First Nations for food, social, and ceremonial purposes. After conservation and First Nations requirements, recreational fisheries have a priority access to a directed fishery for Chinook and coho salmon whereas commercial fisheries have priority for chum, sockeye and pink salmon.

Management has a good system for monitoring recreational catch and effort (see "Stock Assessment and Sustainable Quota Determination"). In-season catch is estimated using creel surveys whereas post-season estimates use both logbooks and creel surveys (Winther 2007). Greater emphasis on monitoring and managing individual stocks is necessary to avoid over-fishing depleted stocks (Holt et al. 2007). Some efforts have been made to manage at the stock level. For instance, the Chinook Technical Committee of the PSC has estimated historical abundances of individual Chinook populations (PSC 2008). DNA analyses suggest that coho stocks that are of conservation concern, such as those from the North Thompson and upper Skeena Rivers, were not caught in large numbers in the recreational fishery in Haida Gwaii (Sawada 2005). However, all of these analyses have been retrospective, and very little information is available for in-season management of specific stocks or indicators populations.

4.12 Regulations

All anglers must have a BC tidal waters license and require a "Salmon Conservation Stamp" to retain salmon. There are no restrictions on the number of licenses sold or angler days in Haida Gwaii. Harvest limits for Chinook salmon in Area 1 (Northern Haida Gwaii including Langara Island) are two per day, a possession limit of four, an annual limit of 30, and a minimum size of 45 cm. Harvest limits for coho in Area 1 are four per day, a possession limit of eight, no annual limit, and a minimum size of 30 cm. The aggregate daily limit of all salmon species combined is four. There are no restrictions to the number of salmon caught and released.

4.13 Room For Improvement

Because marine survival is variable and hard to predict, better methods for in-season monitoring and forecasting are required (Holt et al. 2007, 2009). Improved in-season assessment would allow management actions, such as restricting harvest in certain zones or times that protect small stocks in years of low marine survival. For example, a recent study used CWT data from an early season troll fishery in Alaska to estimate marine survival of indicator stocks of coho and thus help predict the number of returning adults (Holt et al. 2009). This type of model could be used to inform management decisions in later occurring fisheries, such as those in Haida Gwaii, but has not yet been used by managers.

A shift towards better monitoring of individual populations rather than aggregates would improve management. Stock composition has been assessed by DNA analysis for Chinook caught in the recreational fishery since 2002 but management is largely aggregate-based. DNA stock identification is currently inaccurate for northern coho and this problem is unlikely to be resolved in the near future due to the life history of coho (J. Sawada, DFO, personal communication). Development of a greater number of indicator stocks could improve managers' ability to protect small stocks.

A 2004 report suggested that lack of funding and staffing is limiting management of recreational fisheries in BC (GSGislason & Assoc., 2004). Management of recreational fisheries at that time was comprised of less than 10 person-years (ibid). It is not clear whether a lack of resources are to blame for the slow shift to in-season stock-specific management or other deficiencies, such as insufficient coverage of indicator stocks for coho.

4.14 Criterion 4 – Ecosystem Considerations

GRADE = C

Canada's WSP (WSP; DFO 2005) recognizes that healthy stocks of Pacific salmon are critically important to the functioning of marine, fresh-water and terrestrial ecosystems. One of the policy's three main objectives is to "Maintain habitat and ecosystem integrity." Currently, the degree to which ecosystems are considered is as follows (DFO 2005):

> *"The Department's intent is to progressively consider ecosystem values in salmon management, but it acknowledges a limited ability to do so at the present time."*

Inability to incorporate ecosystem considerations in management stems from the lack of scientific understanding of the interactions between salmon and their ecosystems and limited technical capacity to study these issues. For example, salmon carcasses are an important source of nutrients for freshwater and riparian ecosystems but it is unknown how many salmon need to return to spawning streams to maintain healthy ecosystems. DFO intends to improve ecosystem-based management through two steps. The first is to "Identify indicators to monitor status of freshwater ecosystems." The second is to "Integrate climate and ocean information into annual salmon management processes." Recent progress towards ecosystem based management goals of the WSP include a discussion paper released for review in the fall of 2009 and ongoing fieldwork in spawning tributaries in the Fraser watershed and central coast (DFO 2009c).

To our knowledge, management of the Haida Gwaii and Langara Island recreational fishery in particular does not include any ecosystem considerations, beyond what is planned through the WSP.

4.15 Room For Improvement

Ecosystem impacts of recreational fishing in Haida Gwaii are unknown. Because the fishery harvests a significant number of salmon, there is potential for ecosystem level impacts, especially for freshwater ecosystems that are highly dependent on salmon for nutrients and that have small, vulnerable salmon populations. Management has acknowledged the importance of ecosystem values but has yet to incorporate ecosystem considerations into salmon management. Potential room for improvement concerns the timeliness of implementing ecosystem considerations into management actions. Developing monitoring approaches and gathering data regarding ecosystem effects will be a lengthy process. The effectiveness of ecosystem-based management will depend on how and when results are translated into management.

4.16 Criterion 5 – Precautionary Measures and Long Term Sustainability

GRADE = C

Precautionary management is necessary to ensure sustainability of all stocks, given uncertainties regarding Chinook and coho biology and fisheries. Monitoring of recreational fisheries catch and effort near Langara Island is sufficient to make risk-averse decisions. In past years when stocks of concern were in very low abundance, recreational fishing has been halted or restricted as a precautionary conservation measure (e.g. Chinook in1996; coho in late 1990s).

The main uncertainty in management of Langara Island Chinook and coho is marine survival. Current practices of assessing stock composition occur after the fishing season and are therefore not precautionary in terms of protecting stocks that may have had poor marine survival and are at low levels of abundance. Efforts are being made to move towards in-season assessment and management to address this issue (see Criterion 3 – Room for Improvement).

The WSP proposes to monitor salmon by developing benchmarks that represent biological status of CUs. These benchmarks correspond to a given level of abundance, risk of extirpation and extent of management intervention for conservation. The lower benchmark is described as:

> *"...a level of abundance high enough to ensure there is a substantial buffer between it and any level of abundance that could lead to a CU being considered at risk of extinction by COSEWIC [the Committee on the Status of Endangered Wildlife in Canada]. The buffer will account for uncertainty in data and control of harvest management."*

If a CU is below the lower benchmark, management will initiate immediate actions to protect the fish, increase their abundance, and prevent extirpation. Thus, the WSP's benchmarks as indicators of status are precautionary and promote long-term sustainability. However, Levy (2006) suggested that proposed management responses to stocks below the lower benchmark were vague and could be compromised by non-biological objectives. He recommended an additional benchmark that represents a critically-low abundance that triggers COSEWIC listing as a response threshold to better protect biodiversity.

4.17 Room For Improvement

Inaccurate pre-season forecasts and inadequate in-season management put stocks of concern at risk in years of low abundance due to poor marine survival. Methods to estimate in-season survival and abundance and restrict fisheries accordingly, such as those proposed by Holt et al. (2007, 2009), should be further developed and implemented.

Currently there is no limit on total recreational catch of Chinook and coho. If the recreational fishery continues to expand and stocks continue to decline as they have since 2004, precautionary measures restricting fishing opportunities may be needed to allow smaller stocks to rebuild.

4.18 Criterion 6 – Biodiversity Conservation

GRADE = C

Population structure and genetics of Chinook and coho caught in the Langara Island recreational fishery are well understood. CUs that represent significant diversity have recently been identified (DFO 2009a). Thus, managers have a good understanding of the biodiversity that exists, and have identified the scale at which diversity should be protected.

Stock composition of recreational catch has been assessed in 2004 for coho and every year since 2002 for Chinook. In general, stocks of conservation concern were not caught in large numbers by the recreational fishery. However, this was only assessed for coho in one year.

There is evidence that some stocks of Chinook and coho have been declining since 2004 (e.g., PSC 2008). However, the causes of declining Pacific salmon stocks are complex and likely include numerous factors such as changing ocean conditions, habitat degradation and inter-sectoral fisheries. Therefore, recent declines in Chinook and coho stocks cannot be attributed to recreational fisheries though it is possible they play a role.

4.19 Room For Improvement

Current methods of assessing stock composition of coho salmon catch using CWT and indicator stocks are likely insufficient. Indicator stocks do not exist for some regions, and indicators are not always representative of population trends in individual stocks. Accurate DNA analysis for stock identification of coho caught at Langara Island would improve management and conservation but may not be possible in the near future because of life history characteristics of coho (e.g., straying). In the absence of accurate stock identification, a greater number of indicator stocks and evaluation of the effectiveness of indicators in predicting population abundances is needed. A greater reliance on in-season assessment and management rather than using uncertain pre-season forecasts to make harvest decisions (for the combined recreational and commercial catch) would also reduce risk of depleting small stocks or missing fishing opportunities for conservation purposes.

5. Report Card for the (Non-Tidal) Fraser River Sockeye Salmon Recreational Fishery

5.1 Introduction and Background

Prized for its high oil content and deep-hued red flesh, sockeye salmon (*Oncorhynchus nerka*) have been a vital food and trade commodity to First Nations from Bristol Bay Alaska to the Fraser River for thousands of years. It was also the first Pacific salmon targeted by BC commercial fisheries and canneries established by European settlers in the late 19^{th} century.

Of the province's great sockeye rivers, none is as abundant and economically important as the Fraser, which includes the famous Adams, Quesnel, and Horsefly sockeye runs.

Fraser sockeye return to the Fraser River beginning each June, as part of five separately timed stock groups. First is the Early Stuart run, consisting of more than 40 populations spawning exclusively in the Stuart River system in northern BC. From mid-July to mid-August, Early Summer sockeye return – including populations that spawn predominantly in small streams and lakes found in the Lower Fraser, South and North Thompson, Chilcotin, Nechako and Upper Fraser watersheds. The summer-run is made up of salmon populations distributed across four areas within the Fraser watershed: the Chilcotin, Quesnel, upper Nechako and Stuart River systems. Late-run summer sockeye on the Fraser include fish bound for the Shuswap's Adams River, the Harrison River and Cultus Lake, the latter being home to an endangered sockeye population near Chilliwack.

Sockeye returns to the Fraser River follow a four-year cycle; one in four brood years is numerically dominant, while there is a subdominant and two low-abundance years as well. The dominant runs are not always abundant, however, as 2009 proved (see below).

Until recently, Chinook and coho were the only salmon species permitted to sports fishermen upstream of Mission on the lower Fraser River, a situation that changed in 1991, when DFO opened a new directed sports fishery on sockeye. The new fishery, which has historically been open through the month of August targeting early summer- and summer-run fish (sometimes late-run in years of high abundance, e.g., Adams dominant years) – was established by DFO in large part to compensate for increasing angler restrictions on coho and Chinook salmon.

Established during a time when Fraser sockeye returns were still strong, this sports fishery thrived and grew in short order: in 1995 DFO estimated that less than 10,000 sockeye were caught (estimated harvested + released) on the Fraser by sports fishermen; by the 2002 fishing year, more than 190,000 Fraser sockeye were landed.

From the beginning the sockeye sports fishery was very different from the lower Fraser sports fisheries for Chinook and coho. Not only were sockeye superior-quality eating fish, they were also abundant and easy to catch, three qualities that quickly turned the nascent sockeye fishery into a “meat fishery” – where recreational anglers increasingly saw an opportunity to fill their freezers with the best eating salmon every summer.

Initially, the fishery was concentrated downstream of the Agassiz Rosedale bridge, where anglers used floats, lead weights and tufts of coloured wool on a hook, typically presented to the fish from gravel bars. Sockeye generally cease feeding upon entering the Fraser River, and it was quickly realized that the harvested sockeye were being snagged as they swam up-river in dense formation. The practice came to be known as “flossing” – a density-dependent harvesting method, where a long weighed leader is bounced along the river bottom. The fish are snagged through the mouth – at least theoretically – as they migrate up-river.

Flossing is an effective method of catching fish, particularly when an angler focuses his efforts at any number of pinch points along the lower Fraser River between the Vedder River mouth and Hope, where masses of fish are forced through smaller channels. This includes Landstrom Bar downstream of Hope, perhaps the most productive sports fishing site in the entire province, which has been known to attract upwards of 2000 angler days of effort each day during the peak of the sockeye fishery. From such a vantage point at the height of the Adams or Horsefly River sockeye runs, an angler’s hook can be potentially exposed to 200,000 densely concentrated fish in the course of a fishing day.

Over the years, the geographical area open to sockeye sports fishing has expanded: originally the fishery was allowed only between the Agassiz Rosedale Bridge and Mission, but with growing crowds, the eastern limit was moved to the Alexandra Bridge near Spuzzum. Rolling closures were later introduced that would follow the salmon as they migrated through the Fraser Valley.

As it has became more popular, the sports fishery for sockeye has also created new tensions on the river, as increasing numbers of sports fishermen lined gravel bars at the same times that local First Nations were attempting to net the same fish.

The general productivity of Fraser River sockeye salmon has declined since the mid-1990s, and this has had a significant impact on sports fishing opportunities: in 2007, following a banner year in 2006 that saw total catches approaching 150,000 sockeye, there was no recreational opening.

2008 was not much better: in late July, DFO opened a sports fishery on Fraser River summer-run sockeye, even though fisheries managers based the opening entirely on the strength of the early summer-run size. When it became clear the summer run was collapsing, it took DFO three days to close the fishery, by which time sports fishermen had killed more than 16,000 sockeye.

This past year, amid disastrous returns that saw just over one million of a forecasted 10 million-strong dominant sockeye run return to the Fraser, there were no sports or commercial openings at all. A federal commission of inquiry has since been called to probe the disappearance of the fish – including the “policies and practices of the Department of Fisheries and Oceans” – with a final report due in 2011.

5.2 Status and Report Card Evaluation

(Non-Tidal) Fraser River Sockeye Salmon Recreational Fishery Overall Grade: B-

Criterion	**Grade**	**Comments/Summary**
1. Knowledge of species life history	A-	Life history and biology are well understood. Very limited understanding of factors affecting marine survival and productivity.
2. Stock assessment and sustainable quota determination	B-	Pre-season forecasts are imprecise and inaccurate due to uncertainties about productivity. Excellent in-season assessment of run-timing groups. In-season monitoring of individual stocks, especially less abundant runs, is lacking.
3. Management system	C	Working system of catch and effort monitoring (creel surveys) but needs improvement. Decision-making process and regulation of fisheries openings may need to be clarified and improved. All sectors are consulted in developing management plans.
4. Ecosystem considerations	B	Fishery removes relatively small number of sockeye from the watershed and has negligible ecosystem effects.
5. Precautionary measures and long-term sustainability	C	Fishery is generally precautionary and aims to protect small stocks and maintain long-term angling opportunities. Unclear management plans could potentially allow fisheries openings that put stocks at risk.
6. Biodiversity conservation	B	Recreational angling is managed such that stocks of concern including Cultus and early Stuart sockeye are not affected. Improved in-season monitoring of small stocks would help ensure depleted late-run populations are not overharvested.

5.3 Criterion 1 – Knowledge of Species Biology and Life History

GRADE = A-

Assessment of life history and biology knowledge required for sustainable fisheries management (1 = nothing known, 2= poorly understood, 3 = limited understanding, 4 = sound understanding, 5 = excellent understanding).

Biology and Life History Topic	Knowledge Base
Distribution and Migration	5
Genetic and spatial structure of populations	4
Longevity	5
Age of maturity	5
Habitat requirements	4
Spawning requirements	4
Prey source	4
Predation and Mortality	3
Ecosystem role	3
Environmental conditions and recruitment	2
Total	39/50

Sockeye salmon have less variable life histories compared to the other Pacific salmon. The majority of populations are "lake-type," which rear in a freshwater lake for one to two years before migrating to sea. Most fish return to spawn at four years of age but three-year-old ("jacks") and five-year-old spawners also exist. Sockeye return to spawn in natal lakes or streams with high precision and have low rates of straying. The combination of non-overlapping generations (because the vast majority of spawners are four year olds) and low straying rates result in a high degree of genetic distinctiveness among populations and specific adaptations to natal watersheds. There are over 150 spawning populations of sockeye salmon in the Fraser watershed, which DFO has divided into 37 CUs.

Fraser River sockeye salmon have been studied extensively since the early 1900s. A great deal is known about their life history and biology including migration and run-timing, reproductive biology, genetics and spatial structure of populations. The population dynamics of sockeye salmon have also been the focus of many studies yet are still poorly understood. The number of adults produced per spawner, called the productivity, varies substantially among populations and years. Productivity of Fraser River sockeye has declined significantly in the past 15 years. Productivity depends on the number of offspring produced and survival at several different life stages, all of which can depend on environmental, biological and human factors. How these factors interact and cumulatively affect the number of adults produced is not well understood. As a result, predictions of the abundance of sockeye that will return are highly variable and often inaccurate.

5.4 Room For Improvement

There is a need to better understand how various environmental (e.g., oceanographic conditions) and biological (e.g., prey sources, parasites and disease) factors affect the number of returning adults. Survival during the first year at sea is thought to be particularly important in determining the number of adults and seems to depend on climate and ocean regimes (Beamish et al. 2004), but relatively little is known about this life stage. Large-scale investigations of marine survival of sockeye and other Pacific salmon and links to oceanographic conditions are planned for the near future.

Recent changes in migration behaviour of Fraser sockeye also have an impact on fisheries. Since 1996 late-run sockeye have been foregoing typical holding behaviour in the Strait of Georgia and entering the river four to six weeks earlier than normal when temperatures are much higher than they would typically experience (Cooke et al. 2004). This abnormal behaviour has resulted in high rates of mortality (up to 90%). These high rates of mortality and overlap in timing between abundant summer runs and late-run stocks have resulted in restrictions to fisheries to protect weaker late-run stocks and lost opportunities for fishing abundant summer runs. Despite several years of research on this issue, the cause of abnormally early river entry is not known.

5.5 Criterion 2 – Stock Assessment and Sustainable Quota Determination

GRADE = B-

There is a good system for assessing stocks of Fraser River sockeye both in-season and pre-season. The number of adults returning to a stream, called the spawning escapement, is estimated for all Fraser River sockeye populations using either counting fences, mark-recapture studies, DIDSON (a type of sonar), or visual surveys. For the return of each brood year (four year cycle), the abundance of major stocks in each run-timing group is estimated pre-season and in-season. Pre-season estimates of abundance use escapement data and the historical average marine survival. In-season abundance is estimated using test fishing operations, catches in commercial fisheries, and hydroacoustic estimates at Mission, BC. Because of practical constraints, in-season catch and exploitation rates are generally only calculated for run-timing groups and not individual stocks (DFO 2009d).

Escapement goals are calculated pre-season and adjusted during the season. Escapement goals are modified by a "management adjustment," which accounts for en-route mortalities (which depends on river conditions and migration timing) and error in estimates of run-size. Total allowable catch including all fishing sectors is then calculated based on the escapement goal and predicted return of adults. Fisheries openings for the recreational and other sectors depend on the total allowable catch, but also on river conditions and conservation requirements for co-migrating stocks of concern.

The recreational fishery is allowed to harvest sockeye salmon in the Fraser River only when there is a surplus after escapement goals and First Nations needs are met, and potential impacts of fishing on stocks of conservation concern are not significant (DFO 2009d). In addition, the number of sockeye harvested by the recreational fishery cannot exceed 5% of the combined commercial/recreational catch (DFO 1999, 2009d). Typically, recreational catch has been much lower than the 5% limit, yet in years when commercial harvest has been restricted for conservation reasons, commercial catch has declined while recreational catch has increased and the 5% limit has likely been approached (Kristianson and Strongitharm 2006).

5.6 Room For Improvement

There is an effective system in place for assessing stocks of Fraser sockeye. Limited understanding of marine survival and the influence of climatic and oceanic factors result in imprecise and inaccurate pre-season forecasts of run-size. Fundamental research concerning marine survival is greatly needed and is planned for the near future, but will not likely significantly improve forecasts any time soon. The limitation is partly compensated for by effective in-season monitoring.

Current in-season models for estimating abundance and migration timing focus on run-timing groups instead of individual stocks. It is difficult to estimate abundance and timing of small stocks because few individuals are caught in the test fisheries or available for DNA analyses at the hydroacoustic station. These small sample sizes for less abundant stocks result in inaccurate estimates of run size. In-season management would be improved by greater ability to monitor small stocks but it is unclear how this could be achieved with the current assessment methods.

5.7 Criterion 3 – Management System

GRADE = C

DFO is responsible for stock assessment and regulation of Fraser River sockeye fishing but the province of BC is responsible for licensing of freshwater angling. The Integrated Harvest Planning Committee (IHPC) is the primary source of stakeholder input for salmon fisheries and includes representatives of commercial and recreational fisheries, First Nations and environmental groups. The IHPC helps advise DFO on the Integrated Fisheries Management Plan (IFMP) for salmon, which outlines the decision making process and objectives for salmon allocation and monitoring.

The Sport Fishing Advisory Board (SFAB) is an official advisory group to DFO and main representative for recreational fishing in saltwater and for salmon fishing in freshwater. The SFAB advises DFO on issues including stock assessment, regulations, enforcement, and angling experience (DFO 2008). The recreational sector, through the SFAB, is also expected and has agreed to share the responsibility and financing of catch and effort monitoring (DFO 2001, 2008). Kristianson and Strongitharm (2006) pointed out the challenges of a purely volunteer organization with little funding taking on the responsibility of catch monitoring.

Catch and effort monitoring is accomplished by creel surveys carried out by DFO. Currently, creel survey methods for non-tidal Fraser sockeye combine data from interviews, rod counts, and overflights to estimate total catch and mortality (Tadey and Mahoney 2009). Catches of sockeye salmon and total fishing effort in the Fraser River are available from 1984 to 1990 and 1995 to 2009. However, an intensive creel survey focused on non-tidal Fraser sockeye was not conducted until 2002 (Kristianson and Strongitharm 2006). Harvest of sockeye increased from 1995 to 2006 in all brood years, with catches of over 100,000 in 2006 and 2002 (Figure 5). Total fishing effort (all salmon species) generally increased from 1999 to 2006 and dropped significantly in 2007 to 2009 (Figure 3). Fishing effort directed specifically to sockeye salmon is not calculated because it is difficult to determine what species anglers are targeting (Joe Tadey, DFO, personal communication).

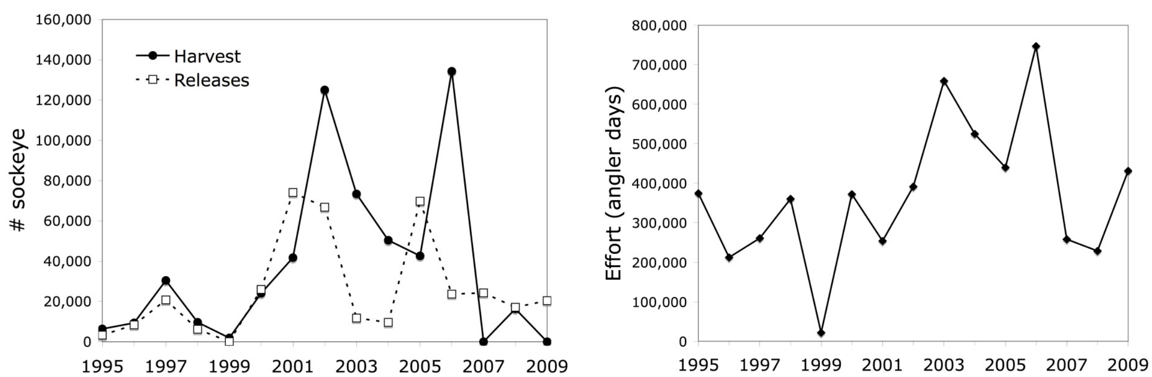

Figure 3. Estimated total number of sockeye harvested and released in the non-tidal Fraser River recreational fishery (left panel) and total annual fishing effort for all salmon species combined (right panel). Catch and effort are estimated using creel surveys, rod counts and overflights. Note that angler effort was estimated for different time periods in different years. (DFO Fraser River Creel Summary)

The non-tidal recreational fishery for Fraser sockeye may be opened or closed in-season depending on abundance of fish and constraints imposed by stocks of conservation concern. Depending on the situation, management options include: 1) a sockeye retention fishery, 2) a non-retention but targeted fishery for sockeye, 3) a targeted fishery for other salmon species where sockeye caught as bycatch must be released, 4) all salmon fishing closed to protect sockeye and/or other species. The fishery occurs upstream of the Vedder River, where endangered Cultus Lake sockeye exit the Fraser River, to avoid catching this stock. Other stocks of conservation concern include late-runs, especially in years when river conditions are unfavourable and when river entry timing is extremely early (timing has been several weeks early since the mid 1990s but varies somewhat from year to year).

The use of catch-and-release (C & R) fishing as a management tool raises questions about the impact of this practice on sockeye. Recreational fisheries for Chinook and coho salmon in saltwater assume C & R mortality rates of 10-15% based on previous studies. Post-release mortality has not previously been assessed for sockeye in freshwater but an ongoing study (2008-2010) seeks to fill this gap. It is not known whether C & R angling has more subtle consequences for salmon, such as effects on reproduction or long term survival.

5.8 Room For Improvement

Improvement is needed in the process of opening and regulating non-tidal Fraser sockeye angling opportunities. Regulations concerning angling openings or closings (location, time, etc.) change quickly and frequently during the fishing season, which can confuse anglers. The decision-making process that leads to non-retention or other opportunities is somewhat vague. For example, it is difficult to determine when recreational fishing for other species will have a "significant" impact on stocks of concern (DFO 2009d). Furthermore, regulations such as open salmon fishing but non-retention and no targeting of sockeye, are difficult or perhaps impossible to monitor and enforce (i.e., it is difficult to enforce the species targeted, as many angling methods are non-selective). Frequent in-season regulation changes are likely necessary to provide fishing opportunities while protecting weak stocks. However, managers may need to be more clear about decisions leading to openings and develop regulations that can be effectively implemented and enforced.

Mangers have acknowledged the need for improved catch and effort monitoring, and that the responsibility should be shared with the recreational sector (DFO 2009d). To date, SFAB has not been involved in monitoring of Fraser sockeye fishing and may currently have limited resources and ability to do so. The role of SFAB (and other stakeholders) in monitoring and conservation should be clearly defined and implemented.

5.9 Criterion 4 – Ecosystem Considerations

GRADE = B

Canada's WSP (WSP; DFO 2005) proposes an ecosystem-based approach but current management does not generally consider ecosystem values (see Criterion 4 of Langara Island case study).

The number of sockeye removed from the Fraser River by recreational fisheries is relatively small. In two of the past three years there has been no recreational harvest of sockeye. In general, the ecosystem effects of recreational harvest are negligible. However, during fisheries openings, angling pressure can be intense and the fishery can remove a large number of sockeye in short time periods (e.g., >46,000 fish during September 1-7, 2005). Therefore, it is important that recreational sockeye openings not impact small stocks, which if depleted could have ecosystem consequences to their spawning streams. Current management plans already make efforts to avoid opening sockeye sport fishing when stocks of concern are at risk.

5.10 Room For Improvement

Improvements to the monitoring of abundance and run-timing of small stocks (as in Criterion 2) would help ensure Fraser sockeye sport fishing is not allowed at times and places when small or depleted stocks are migrating.

5.11 Criterion 5 – Precautionary Measures and Long Term Sustainability

GRADE = C

The WSP's conservation benchmarks can be considered precautionary but have yet to be implemented, as discussed in the Langara Island case study (Criterion 5).

Recent management actions, such as closure of all in-river sport fishing for sockeye (including non-retention) due to low abundance or conservation constraints, have been precautionary. Managers have dealt with declining productivity of some stocks (e.g., early Stuart) by using a greater probability run-size forecast (75% instead of 50% of reaching predicted run-size) as a precautionary measure. However, descriptions of decision-making and conditions under which sport fishing may be allowed are vague and allow some room for interpretation (see DFO 2009d and Criterion #3). Thus, it is possible that such management plans would permit angling opportunities that put stocks at risk, especially given the strong pressure managers are often under to open recreational fisheries.

5.12 Room For Improvement

We recommend clarifying the conditions under which sport fishing is allowed to ensure risk-averse openings in the future and prevent disagreements among sectors. This decision-making process should be consistent with the WSP's benchmarks and resulting management responses.

More information is also needed regarding the effects of C & R on sockeye stocks, and of effectiveness of angling opportunities that target other species when sockeye are at risk (i.e., do anglers comply with not targeting sockeye and is this policy enforceable?). Until data concerning these issues are available, the use of C & R and openings targeting other species, but potentially affecting sockeye, should be viewed with caution.

5.13 Criterion 6 – Biodiversity Conservation

GRADE = B

With over 150 spawning populations and 37 CUs, there is considerable diversity within Fraser River sockeye salmon. The low straying rates and genetic isolation of most sockeye populations result in specialized adaption to natal watersheds. These traits also mean that if a population becomes extinct, recolonization of the watershed is less likely and that important biodiversity will have been lost.

The main sockeye stocks of conservation concern in the Fraser watershed are early Stuart sockeye, Cultus Lake sockeye and other stocks from the late-run group. Early Stuart sockeye have suffered from very small and declining returns in recent years, due in part to high en-route mortality. There have been no recent in-river recreational openings during early Stuart migration and this is unlikely to change. Cultus sockeye were emergency listed as endangered in 2002, and have had very small returns since then. Non-tidal sockeye fisheries occur upstream of the Vedder River, which Cultus sockeye enter to reach spawning ground in Cultus Lake, such that Cultus sockeye are not captured by anglers targeting sockeye.

Late-run sockeye are of concern because early river-entry behaviour occurring since 1995 often results in very high rates of en-route and pre-spawn mortality. The earlier migration timing also means that some declining late-run stocks migrate at the same time as abundant summer-runs, which are often the target of fisheries. The recreational fishery is sometimes opened during times when late-runs are migrating if abundance is high and conservation risks are below an acceptable level (DFO 2009d).

With regard to bycatch, the Fraser River sockeye fishery is thought to be a fairly "clean" fishery, meaning that it does not catch significant numbers of non-target species (Kristianson and Strongitharm 2006). However, little data is available to support this claim, and the main technique used for targeting sockeye (bottom-bouncing or "flossing") is non-selective.

5.14 Room For Improvement

The Fraser River sockeye recreational fishery has no impact on early Stuart or Cultus Lake sockeye – two main stocks of concern. Bycatch of other species is not known but probably not substantial. Improved monitoring of the abundance and run-timing of small stocks in the late-run group would reduce the risk of a short-term but intensive recreational fishery affecting these runs. In years where significant numbers of sockeye are harvested, DNA analyses, which are relatively affordable and well established for Fraser sockeye, could be used to assess the stock composition of catch, instead of relying on downstream hydroacoustic estimates and test fisheries.

6. Report Card for the Skeena River Steelhead Recreational Fishery

6.1 Introduction and Background

A Note on Steelhead Versus Pacific Salmon

Observing steelhead and Chinook salmon in a BC stream in the 1860s, British naturalist John Keast Lord immediately noted the differences:

> "*[Steelhead] may be readily distinguished from the [Chinook] by its rounded blunt-looking nose, shorter and much thicker head, straighter back and more slender figure, the tail not nearly as much forked," he wrote. "This salmon is common in the Fraser, Chilukweyuk [Chilliwack] and Sumass [Sumas] rivers and in every stream along the mainland and island coasts up which salmon ascend."*

Over time, many other differences have been observed. Unlike most salmon, steelhead often survive to reproduce again; in a given stream, anywhere from 10-20% of returns can be repeat spawners. Steelhead also show a greater variation in the time they spend in freshwater (1-5 years) and saltwater (1 to 3 years); adults return in lower numbers than salmon over a wider period of time, spawning in spring as opposed to fall.

Steelhead typically follow three distinct seasonal run timings: summer-run steelhead enter fresh water between May and September; fall-runs arrive between August and November; winter-run steelhead arrive between November and May. The summer- and winter-runs generally occur in coastal systems (e.g., Vancouver Island and lower Fraser River), while fall-runs occur in interior systems like the Thompson River.

6.2 Steelhead Management: A Brief Historical Perspective

Steelhead have been managed by the province of British Columbia since at least the mid-1930s, when the federal government delegated the inland management of steelhead to the province. All other species of Pacific salmon are the responsibility of the federal government.

Over the years, there has been much official confusion over what actually constitutes a steelhead: up to 1940, the province made no distinction between sea-run steelhead and resident populations of rainbow trout; prior to that, there was a formal "trout fishing season," even though steelhead could be caught by anglers on coastal rivers even when the "trout" seasons were closed.

Prior to 1940, there was no limit on the number of trout and steelhead that could be caught by an angler in BC. But that year, a steelhead was formally defined as a trout that weighed more than five pounds (2.2 kg), and a catch limit of 15 trout a day and three steelhead was imposed. Nearly 20 years later, a steelhead was redefined as an anadromous (sea-going) rainbow trout in excess of

18 inches (46 cm); two years later, the minimum length of a steelhead was increased to 20 inches.

In 1988 the American Fisheries Society ended 150 years of documenting steelhead as *Salmo gairdneri;* now known as *Oncorhynchus mykiss,* these sea-run rainbow trout are often considered to be a sixth species of Pacific salmon in BC.

6.3 Steelhead in the Skeena Watershed

Although the Chilliwack-Vedder is currently the single most fished steelhead river system in BC in terms of effort, the Skeena River watershed has emerged as a prime angling destination for both traditional anglers and fly fishermen from BC, Alberta, Europe and the US.

The emergence of the Skeena watershed as a tourist destination for steelhead anglers is a relatively recent phenomena – it is only in the last two decades that guiding businesses catering to Americans and Albertans have thrived in the watershed. Today sports fishing for steelhead is focused primarily on road-accessible Skeena River tributaries in the upper watershed such as the Kispiox and Morice-Bulkley**.**

Skeena steelhead were fished very lightly by local residents through the late 1940s and early 1950s, although a small number of "alien" anglers were already known to fish there by this time. Trophy steelhead ensured more outsiders would come: in 1952, a Prince George angler landed a 36-pound record steelhead on the Kispiox River; about a decade later, a Californian fly fisherman landed a 33-pound Kispiox steelhead, a record that still stands.

By the 1971-72 fishing season, 6700 sports fishermen targeted steelhead in the Skeena system, including 21% who were not residents of BC. Already by this time, fishery managers considered the Skeena steelhead to be a "generally declining resource," affected by the impacts of new settlement and land development, forestry, and a booming commercial salmon fishery.

Steelhead regulations in the Skeena watershed began as early as 1931. Local closures started on the Bulkley and Lakelse in 1945 and continued into the mid-1950s, spreading to the Morice and Babine; between 1956 and 1972, roe bans were imposed at varying times on the Bulkley, Morice Kispiox and Babine. Provincial steelhead stream classification policy implemented in 2007 made all wild BC steelhead strictly catch-and-release, although Skeena steelhead had already been non-retention since the early 1990s.

As the Skeena continued to grow as a steelheading destination, conflicts with commercial salmon fishing interests emerged. Between 1963 and 1974, over 90% of the commercially-intercepted steelhead in BC were taken by various gillnet fisheries, and the Skeena River area accounted for nearly 40% of all steelhead caught by commercial fishermen in BC, followed by the Dean River area at 11%. By 1996, a lucrative commercial fishery was exploiting Skeena-bound runs that exceeded 3.7 million sockeye.

Skeena River commercial and recreational fishing interests clashed in 2006 (not the first time) after an unexpectedly large run of sockeye returned to the Skeena River system. DFO allowed a commercial opening of 11 days, during which time large numbers of steelhead were allegedly taken as bycatch. Similar conflicts in 2007 led to calls for a review of salmon and steelhead management by independent scientists, resulting in the creation of the Skeena Independent Science Review Panel, which worked from January to April 2008.

The Panel's report was published in May 2008, including specific management recommendations for Pacific salmon and steelhead in the Skeena watershed, as well as guidance on how to best implement the federal government's WSP.[5]

[5] Using similar criteria to those applied to salmon, the province has defined two steelhead CUs for the Skeena watershed based on adult run-timing (summer-run and winter-run). This said, steelhead are not included in the Wild Salmon Policy.

6.4 Status and Report Card Evaluation

Skeena River Steelhead Recreational Fishery Overall Grade: C+

Criterion	Grade	Comments/Summary
1. Knowledge of species life history	C	Basic distribution, migration, genetics and life history is known but information concerning the many small populations is lacking.
2. Stock assessment and sustainable quota determination	C-	Long-term monitoring of steelhead abundance does not exist. Better estimates of exploitation rate by commercial fishery and recreational angling effort are needed. Monitoring options have been recommended by the Skeena Panel and some are currently being implemented. Lack of funding and priority has limited monitoring efforts.
3. Management system	C+	Provincial and regional regulations for steelhead fishing (e.g., C&R only, limiting angler effort in select areas) reduce population impacts. Inadequate monitoring of abundance trends and angling pressure limits effectiveness. Management has also been hindered by lack of communication among provincial and federal managers, First Nations and other stakeholders.
4. Ecosystem considerations	B+	Steelhead angling is non-retention so does not remove fish from ecosystem. Depressed stocks of other species (e.g., chum) may be caught but the impact is not likely significant. Ecosystem impacts are unlikely to be significant.
5. Precautionary measures and long-term sustainability	B	Uncertainty in management includes status of steelhead populations, angling effort, and population effects of C&R fishing. Fishing regulations are somewhat risk-averse but improvements are needed to ensure sustainability of small, vulnerable stocks.
6. Biodiversity conservation	C	There is considerable diversity among Skeena steelhead stocks but management acknowledges two CUs. Status of small stocks is unknown and potentially declining. There are many challenges to managing individual populations.

6.5 Criterion 1 – Knowledge of Species Biology and Life History

GRADE = C

Assessment of life history and biology knowledge required for sustainable fisheries management (1 = nothing known, 2= poorly understood, 3 = limited understanding, 4 = sound understanding, 5 = excellent understanding).

Biology and Life History Topic	Knowledge Base
Distribution and Migration	3
Genetic and spatial structure of populations	3
Longevity	3
Age of maturity	3
Habitat requirements	4
Spawning requirements	4
Prey source	4
Predation and Mortality	2
Ecosystem role	4
Environmental conditions and recruitment	2
Total	32/50

The Skeena watershed has a summer-run and a winter-run of steelhead. Summer-runs are much more abundant and populations are distributed throughout the drainage whereas winter-run populations have fewer individuals and are only found in coastal areas downstream of Terrace, BC. Summer-run populations enter the river in July and August (Figure 4) and spend the winter in rivers or lakes whereas winter-run populations return during November through March. Both runs spawn in the spring (April to June). There is some understanding of spawning migration timing in individual populations although data are lacking for most smaller populations (Ward et al. 1992; Beacham et al. 2001). For instance, Susut and Morice are thought to migrate earlier in the year whereas Babine and Bulkley dominate the runs in September. Some work has also been done assessing the genetic structure and diversity among Skeena steelhead populations (Beacham et al. 2000; Heath et al. 2001). Steelhead from tributaries including the Babine, Bulkley, Morice, Kispiox, Toboggan, Susut and Zymoetz Rivers are genetically distinct enough to be differentiated by DNA analyses from fish caught in the marine test fishery.

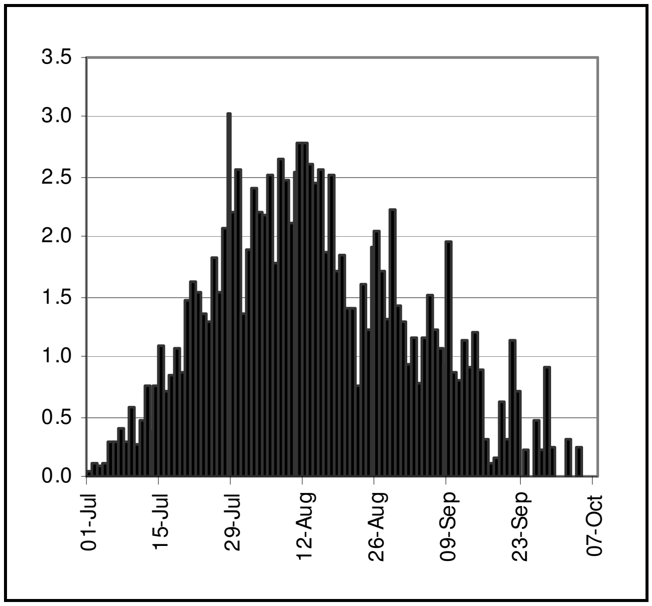

Figure 4. Timing of summer-run steelhead entry into the Skeena River, showing daily indices from the Tyee test fishery, 1990-1999. Figure from Gottesfeld and Rabnett (2008).

Compared to other anadromous salmonids, steelhead have more diverse life histories, spending between one and five years in freshwater and one and three years in the ocean. In the Skeena watershed most populations spend three years in freshwater and two years in the ocean, although there is considerable variation among populations. Steelhead can spawn more than once in their lifetime (iteroparity), as some individuals migrate back to sea after spawning and return in future years. The percentage of individuals that are repeat spawners, generally 10-20% in steelhead, has been estimated in some Skeena populations (e.g., 2% in Babine River, 7% in Kitwanga River, 14% in Kispiox River, 22% in Zymoetz; Gottesfeld et al. 2002).

6.6 Room For Improvement

Though managers possess a basic understanding of timing and life history of Skeena steelhead, information concerning the many small populations is lacking. This knowledge gap can be attributed to lack of funding by the management agencies and logistic difficulties relating to monitoring. Because many of the small populations spawn over large geographic areas in small, remote streams during periods of high discharge, observing the timing and abundance of spawners is difficult (Gottesfeld et al. 2002).

A second important knowledge gap concerns smolt-to-adult recruitment and marine survival. The factors that control marine survival are not well understood and this seriously limits the ability of managers to predict the number of returning adults, even in cases where effective counts of smolts or escapement exist. This knowledge gap is not limited to Skeena steelhead and extends across species of salmon and steelhead in BC.

6.7 Criterion 2 - Stock Assessment and Sustainable Quota Determination

GRADE = C-

6.8 Stock Assessment and Monitoring

There is not an adequate long-term monitoring program for abundance of Skeena River steelhead. Abundance of returning adult steelhead has been estimated by the Tyee test fishery near the mouth of the Skeena since 1956, but the reliability of these data has been questioned (Walters et al. 2008). Limitations of the test fishery include too short of a sampling period and the fact that changing environmental conditions may bias abundance estimates (e.g., fish may mill near the test area at the river mouth more during low discharge years). Data from the Tyee test fishery suggest that steelhead abundance in the Skeena increased modestly from 1956-2003 and has declined since 2004 (Figure 5). Catch and effort monitoring of recreational steelhead angling is not reliable and is therefore not used for assessing abundance (see Criterion 3).

The commercial fishery near the mouth of the Skeena, especially for sockeye salmon, can have a significant impact on the abundance of steelhead available to recreational fisheries. In recent years the in-season management of the commercial fishery has included the use of a computer spreadsheet model that estimates cumulative exploitation rate of steelhead caught as bycatch based on fishing effort, run-timing, and assumptions about encounter rates and post-release survival when using selective fishing techniques (e.g., short sets, revival boxes, etc.); however, the model is based on a number of unvalidated assumptions, produces unrealistically precise estimates, and is therefore not a reliable tool for estimating bycatch of steelhead in commercial fisheries (Walters et al. 2008). Thus, there is no reliable method for in-season assessment of steelhead caught in and passing through the commercial fisheries.

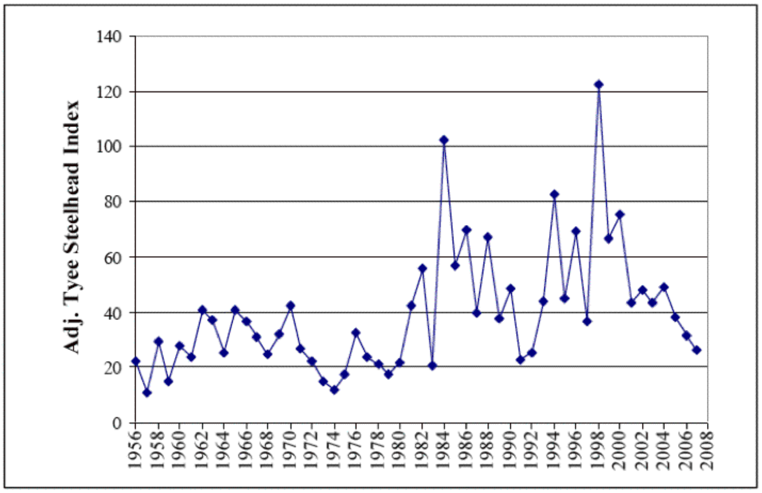

Figure 5. Catch indices of steelhead from the Tyee test fishery, 1956-2007. Indices were adjusted for annual variation in sockeye catchability. Figure from Walters et al. (2008).

Quota determination does not apply directly to recreational fishing for steelhead in the Skeena watershed because the fishery is strictly non-retention. This does not, however, mean that the recreational fishery lacks the potential to negatively impact steelhead populations. Recreational angling effort has increased in the past 20 years in most Skeena watershed rivers (MoE 2007; Figure 6). Only a few studies have examined mortality caused by C & R fishing of steelhead, making it difficult to draw conclusions about potential impacts on populations. Angled winter-run steelhead in the Chilliwack River, BC had low rates of post-release mortality (4% or less) and multiple captures did not affect survival (Nelson et al. 2005). A C & R study of steelhead in the lower Skeena River also found that short-term mortality of released fish was low (~1%). However, an earlier study on the Skeena River found that eight of twenty (40%) steelhead caught by angling were fatally hooked and died shortly after capture (Lough 1979). Rates of mortality in C & R fisheries can vary widely with water temperature, hooking location, angler skill, gear type and the condition of fish (Nelson et al. 2005). More studies assessing mortality and sublethal physiological, behavioural, or reproductive consequences of C & R of Skeena steelhead are needed. Management options to reduce potential impacts of C & R fishing could include limiting angler access in certain rivers and regulations for fishing practices that reduce fishing mortality. Such regulations are already in place or are proposed in many rivers in the Skeena watershed.

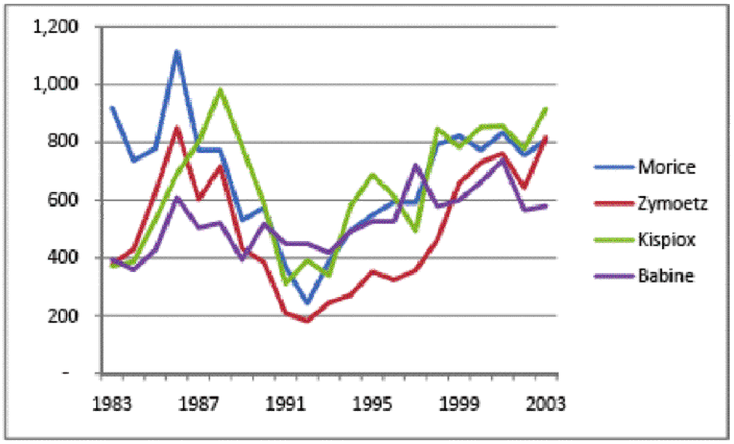

Figure 6. Number of anglers per year fishing selected Skeena River tributaries, 1983-2003.

6.9 Room For Improvement

The Skeena Independent Science Review Panel (Walters et al. 2008) concluded that a long-term monitoring program for steelhead does not exist and is necessary to effectively manage and protect populations. Monitoring options recommended by the report include: (1) a radio-telemetry study to estimate exploitation rates by coastal and in-river commercial fisheries and post-release survival, (2) monitoring of numbers of steelhead released by commercial, First Nations and recreational fisheries, (3) long-term monitoring of steelhead escapement to specific drainages using some combination of an expanded Tyee test fishery, genetic composition analyses, in-river mark-recapture, and direct estimates of escapement (e.g., counting fences) in selected 'indicator' streams. The report also suggests that recreational angling catch and effort be better quantified through methods such as automated photographic monitoring and reports submitted by guides, and that data from recreational fisheries also be used for long-term abundance monitoring and genetic analyses assessing stock-composition.

The BC Ministry of Environment (MoE) has begun a number of projects addressing the issues mentioned above. These include the extension of the test fishery, addition of a DIDSON (a type of sonar) to improve abundance estimates, genetic analyses of steelhead stock composition and population structure, and various telemetry studies to assess steelhead behaviour and evaluate assessment methods.

6.10 Criterion 3 - Management System

GRADE = C+

6.11 Management System

The MoE is primarily responsible for management of steelhead in the Skeena watershed, including regulation of the sport fishery. DFO is responsible for the protection of steelhead habitat and monitoring bycatch of steelhead in commercial salmon fisheries. Many other stakeholder groups including recreational fishing groups, First Nations, businesses and community members have been engaged in the consultation process during recent changes to regulations and management.

The MoE used the criteria of the WSP and identified two CUs for Skeena steelhead: the summer-run and the winter-run. These two CUs are likely composed of many "demographically independent and genetically distinct" populations but it is not possible or practical to manage at the population level (Parkinson et al. 2005 as cited by Walters et al. 2008).

6.12 Catch Monitoring

Estimates of steelhead angling catch and effort exist through the Steelhead Harvest Analysis (SHA; mail-out angler surveys) and creel surveys. However, these data are not reliable because of inconsistencies in reporting over time and other biases (Gottesfeld et al. 2002; Hooton 2008). For this reason, results of SHA and creel surveys are not discussed in detail in the present report.

6.13 Regulation

The Provincial Steelhead Stream Classification Policy and Procedures (SSCPP) was implemented in 2007 and includes a province-wide non-retention regulation for steelhead (the Skeena watershed has been non-retention for steelhead since the early 1990s). The SSCPP also identifies "Classified Waters" in the Skeena Basin, which are streams and time periods that have specific regulations pertaining to steelhead angling such as requirements for additional licenses, gear restrictions, and limited access for guided angling.

The Skeena Quality Waters Strategy Angling Management Plans (SQWSAMP) is a mutli-stakehodler initiative that will recommend river-specific and basin-wide changes to recreational steelhead fishing regulations in the Skeena watershed (Dolan 2009). The SQWSAMP addresses issues concerning quality of angling experience (e.g., crowding, large numbers of non-resident or guided anglers, etc.) and not population status or conservation concerns. Although not aimed at conservation specifically, proposed changes such as limiting non-resident and guided fishing days, a rod-day booking system, increased license costs, and angler education programs clearly have implications for steelhead populations. For example, these changes would likely reduce angling pressure in certain areas and improve estimates of angling effort. The SQWSAMP recommendations are currently under review by the MoE and will be implemented in 2011/2012 at the earliest.

6.14 Room For Improvement

A recent evaluation of the management of the Skeena salmon fisheries in 2008 suggested that important habitat for steelhead and salmon was not adequately being monitored and protected, that commercial fisheries continued to overharvest to the detriment of First Nations and recreational fishing, and that enforcement of regulations and policies were inadequate (SkeenaWild Conservation Trust 2009). Common regulation infringements in the recreational fishery included illegal guiding, the use of barbed hooks and killing non-retention species such as steelhead. Both the Skeena Panel (Walters et al. 2008) and the SkeenaWild Conservation Trust reports criticized the lack of coordination and communication among federal (DFO) and provincial (MoE) managers, First Nations, and interest groups, which has seriously hindered effective management.

Current regulations such as C & R fishing only and other angling restrictions are effective management tools helping protect Skeena steelhead; however, there is clearly room for improvement in the management system. Better communication among management agencies and interest groups is needed. Improved monitoring of steelhead abundance and fishing pressure by commercial and recreational sectors is necessary in order to make sound management decisions. Thus, the effectiveness of the management system in the future will partly depend on which of the monitoring options pertaining to steelhead suggested by the Skeena Panel (Walters et al. 2008) are adopted. The management process should continue to engage recreational fishing groups, businesses, First Nations, and community members. Lack of funding for steelhead biology at the MoE appears to be limiting management activities.

6.15 Criterion 4 - Ecosystem Considerations

GRADE = B+

Much of the recreational steelhead fishery occurs in remote and relatively pristine watersheds, particularly in the upper Skeena. Indeed, the wilderness setting is one of the main factors that make the Skeena a world-class destination for steelhead fishing (Counterpoint Consulting 2008). It is therefore important to consider whether the steelhead fishery may have impacts on other components of the ecosystem.

Steelhead angling in the Skeena watershed is strictly non-retention, and C & R mortality and illegal harvest are not likely large sources of mortality. Therefore, there are not ecosystem consequences related to the removal of steelhead from the ecosystem by the recreational fishery. Although steelhead are targeted using specific gears and techniques, other species can be caught. Other than steelhead, species of conservation concern because of depressed stocks include chum and coho salmon, but it is not known how many of these species are caught by steelhead anglers. Reports submitted yearly to the MoE by fishing guides on the Skeena would reveal the numbers of other species caught but these data have not been analyzed due to lack of funding and priority

(Walters et al. 2008). Because steelhead angling is a targeted fishery and most species of concern that are caught incidentally are likely released, recreational bycatch is unlikely to pose a serious threat to Skeena watershed ecosystems.

Indirect impacts of the steelhead fishery such as the footprint of fishing lodges or access roads are beyond the scope of this report but are worth mentioning and have the potential to have larger ecosystem impacts compared to C & R angling. There are eight fishing lodges on the lower Skeena near Terrace, BC, which target primarily salmon and some steelhead, and 14 lodges on the upper Skeena, which focus primarily on steelhead fishing (Counterpoint Consulting 2008). Indirect ecosystem impacts of the steelhead fishing industry have not been quantified but may need to be assessed in the future, especially if the industry continues to expand.

6.16 Room For Improvement

The recreational steelhead fishery likely does not have substantial impacts on other components of the ecosystem. Currently, other proposed or ongoing industries such as coal bed methane, hydroelectric power and logging pose a much greater threat to Skeena ecosystems than steelhead angling. Nonetheless, studies assessing indirect impacts of the steelhead fishing industry may be needed in the future. Managers should also assess the abundance of species of concern (e.g., chum salmon) that are caught incidentally by steelhead anglers, data that have already been collected in past years but not yet analyzed.

6.17 Criterion 5 - Precautionary Measures and Long Term Sustainability

GRADE = B

Precautionary and risk-averse approaches in the face of scientific uncertainty are essential to sustainable fisheries management. Major sources of uncertainty associated with the management of Skeena steelhead include:

- Status and trends in abundance of individual populations and CUs;
- Causes of marine mortality and changes in future survival related to changing environmental conditions;
- Impacts of climate change (e.g., altered hydrology) and habitat degradation (e.g., oil and gas, mining, coal bed methane) on survival during freshwater stages;
- Effects of C & R angling and release by commercial fisheries on steelhead mortality.

The fact that the population status of many small populations is unknown and reliable long-term monitoring of abundance does not exist suggests that a precautionary approach is particularly important. In terms of regulations and exploitation by the recreational fishery, the management of steelhead in the Skeena can be considered precautionary. Although it is possible that some larger populations of steelhead could sustain a regulated consumptive fishery, and fishing groups have recently proposed reinstating a so-called 'kill' fishery, regulations for the release of all wild steelhead have remained in place. In addition, there have been efforts to reduce angler effort in certain areas although the level of C & R fishing pressure remains quite high on many rivers.

Overall management of Skeena steelhead has not been risk-averse. For instance, the Skeena Panel reported that the MoE has done little to monitor population trends or angling effort, a failure attributed to lack of priority and deficient funding (Walters et al. 2008). Enforcement of regulations has also been inadequate and infringements have likely been fairly common (SkeenaWild Conservation Trust 2009). In light of the relatively high fishing pressure for Skeena steelhead, failure to monitor populations and enforce regulations does not represent precautionary management.

The MoE is currently in the process of revising C & R steelhead fishing regulations in the Skeena watershed (i.e., the SQWSAMP). These changes are being made without reliable information on angling effort or population status. Although the changes are not necessarily inconsistent with a precautionary approach, they suggest that decisions based on economic and political reasons are given priority over science and conservation.

6.18 Room For Improvement

There is a dire need to analyze existing data and gather new information concerning steelhead abundance, angling effort and exploitation rates to reduce uncertainty surrounding management decisions and tradeoffs. Because the Skeena watershed is subject to high levels of recreational fishing, studies are also needed to assess potential population impacts of C & R fishing. Without such data, a precautionary approach could be better adopted by limiting C & R fishing in streams with small, vulnerable or unknown steelhead populations, and better information sharing and collaboration between the management of commercial and recreational fisheries.

6.19 Criterion 6 - Biodiversity Conservation

GRADE = C

Considerable diversity exists among populations of Skeena steelhead. Populations from different tributaries are genetically distinct, have different migration timing, and exhibit different life histories (e.g., age at maturity and time spent in freshwater). Despite these differences, Skeena steelhead are managed as two CUs based on run timing (summer- and winter-run). Therefore, biodiversity at the population level is not being protected. For example, abundances of individual populations are not assessed. Populations can be differentiated by DNA analyses but it is difficult and unreliable to estimate stock composition from the test fishery because of generally low sample sizes. Another challenge is that there is considerable or complete overlap between the run-timing of many populations, making it difficult to manage co-migrating populations in mainstem rivers.

Recreational fishing in the Skeena watershed has different regulations for different tributaries and lakes. These include a fishing ban in some areas, and two levels of "Classified Waters" designation that limit guided fishing effort. Similar stream-specific regulations limiting or banning C & R steelhead fishing in tributaries with very small and vulnerable populations is a potential management option to preserve diversity but it will be difficult to know where to focus these efforts until stock assessments and monitoring are improved.

Aspects of steelhead biology such as life history and straying rates are also important considerations for biodiversity conservation. Steelhead generally home to natal tributaries with high precision and have low rates of straying into other streams to reproduce (Quinn 1993). Evidence supports this notion in Skeena steelhead, as there is little immigration and gene flow among populations (Heath et al. 2002). Such low rates of straying reduce the chance of a depressed or extirpated population being recolonized by fish from another population. However, diverse life histories and the ability to spawn more than once make steelhead less vulnerable to local extinction. Because Skeena steelhead vary in age at maturity there is overlap among generations. If a certain year class fails to produce many spawning adults, older and younger age classes will also reproduce that year, thus buffering the population against extinction. In addition, steelhead populations can be very productive at low spawner abundance such that populations can be rebuilt relatively quickly (Ward 2006).

6.20 Room For Improvement

Better catch monitoring and abundance assessment is needed for the many small populations of steelhead in the Skeena but this will be challenging because many streams are remote and small populations may be spread over large geographic areas. One good option to obtain this information is to engage recreational anglers and guides in monitoring and assessment through logbook or similar programs.

7. Conclusion

Recently, the need for effective regulation and management of recreational fisheries has been recognized but little work has been done to assess the impacts of recreational fisheries on salmon populations. This report provides a basic and overdue assessment of potential impacts of recreational fisheries on salmon stocks and monitoring and management needed to mitigate these.

On a province-wide basis, recreational catch of salmon is relatively small. In comparison, commercial fisheries and environmental conditions have a much greater impact on salmon populations. However, the present evaluation of three specific recreational fisheries highlights the potential for angling to negatively impact populations or contribute to biodiversity loss. The main concern is impacts of angling on small and vulnerable stocks. In many cases, small, depleted stocks co-migrate with more abundant stocks that are targeted by fisheries. Certain recreational salmon fisheries such as the Fraser sockeye fishery can harvest a substantial number of fish in a short time period across a small area, and could thus impact populations with small returns.

The potential for impacts on less abundant salmon runs highlights the need for improved monitoring of recreational fishing and assessment of abundance for small runs. Unfortunately, it is the small stocks that are most at risk for which run-timing and abundance is the most difficult to estimate. If recreational and other sectors wish to continue to take advantage of harvest opportunities for more abundant runs, a greater capability to forecast and monitor smaller stocks may be required.

Monitoring of recreational catch and effort in popular fisheries like Langara Island and the Fraser River sockeye fishery is thought to be reasonably effective; however, in many parts of the province monitoring is non-existent or insufficient. Furthermore, coverage of creel surveys is declining as funding becomes increasingly limited. In the meantime, salmon stocks are generally declining and recreational fisheries are expanding in some areas. Clearly, there is an urgent need to improve monitoring of recreational fisheries in the province.

One recent initiative aiming to improve catch monitoring in BC is the Monitoring and Compliance (M & C) Panel of the Integrated Salmon Dialogue Forum. The panel includes members of government, non-governmental organizations, and all fisheries sectors. Some key priorities of the panel are to develop standards and objectives for M & C, develop practical recommendations for improving M & C in all fisheries, and identify incentives and ways for each sector to share responsibility of M & C. Numerous initiatives evaluating and planning fisheries monitoring are underway and these efforts are expected to facilitate improved monitoring and participation of stakeholders within one to three years. Although not without its limitations, monitoring programs near Langara Island provide another good example of effective co-management. Creel surveys are carried out by First Nations and fishing guides participate in logbook programs and collect biopsies for research and assessment. Other options to improve monitoring in BC include mandatory reporting of all catch by anglers, as is currently required for Chinook salmon, and expansion of logbook programs. Because monitoring efforts such as creel surveys are often imprecise, it is important to evaluate the efficacy of current and new monitoring programs.

An important issue that arose in each of the three fisheries examined was a lack of funding for necessary monitoring and assessment. Through the Wild Salmon Policy, stakeholders have expressed the need to protect the abundance and biodiversity of wild Pacific salmon. Clearly, greater commitments from governments and all sectors are necessary in order to achieve these goals and effectively implement the WSP.

Finally, the lack of effective monitoring and/or insufficient assessment information for many fisheries reinforces the need for a precautionary approach to management. Further evaluations of the impacts of recreational fisheries are necessary to ensure that management practices are precautionary and populations of Pacific salmon are sustainable in the future.

List of Abbreviations

BC	British Columbia
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPUE	Catch per unit effort
C & R	Catch-and-release
CU	Conservation unit
CWT	Coded wire tag
DFO	Federal Department of Fisheries and Oceans Canada
IHPC	Integrated Harvest Planning Committee
IFMP	Integrated Fisheries Management Plan
MoE	British Columbia Ministry of Environment
PSC	Pacific Salmon Commission
SFAB	Sport Fishing Advisory Board
SHA	Steelhead harvest analysis
SQWSAMP	Skeena Quality Waters Strategy Angling Management Plans
SSCPP	Steelhead Stream Classification Policy and Procedures
WSP	Wild Salmon Policy

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Appendix 1: Grading Criteria

Grading Criterion 1: Knowledge of Species Life History

The degree to which relevant life history information required for sustainable fisheries is known.

A Every aspect of the species life history is well understood. There are no outstanding concerns regarding habitat requirements, reproduction, migration or distribution.
B Sound understanding sufficient to make informed and risk adverse management decisions.
C Limited understanding which may place the species or populations at risk to over-harvest.
D Poorly understood life history which compromises the long term sustainability of the fishery and places severe risk to the species and populations.
F Nothing known. No justification for a fishery.

Assessment of life history and biology knowledge required for sustainable fisheries management (1 = nothing known, 2 = poorly understood, 3 = limited understanding, 4 = sound understanding, 5 = excellent understanding).

Biology and Life History Topic	**Knowledge Base**
Distribution and Migration	X
Genetic and spatial structure of populations	X
Longevity	X
Age of maturity	X
Habitat requirements	X
Spawning requirements	X
Prey source	X
Predation and Mortality	X
Ecosystem role	X
Environmental conditions and recruitment	X
	n/50

Grading Criterion 2: Stock Assessment and Sustainable Quota Determination

The degree to which Fisheries and Oceans Canada is able to estimate stock size and consequently allocate sustainable quotas.

A An excellent estimate of current (in-season) stock size based on validated models, fishery-independent methods of measuring abundance, historical information, most advanced system known, solid understanding of all populations and species directly impacted by fishing.

B Excellent estimates of major stocks based on validated models utilizing fisheries-independent indices of abundance. No method of accurately assessing in-season stock size. Some understanding of minor stocks.

C A reasonable estimate of major stocks based on historical assessments and fisheries-dependent indices of abundance.

D Quotas based on outdated stock assessment information with no method of assessing sustainability. The stock assessment is on the primary targeted species with no consideration to minor species landed in the same fishery.

F No stock assessment conducted on the target species or other species directly impacted by the fishery (bycatch). High potential for overexploitation or impact to incidental populations.

Grading Criterion 3: Management System

The degree to which the management system is able to control and account for catches of targeted and incidentally caught species in a timely way.

A There is an excellent management system to account for the quantities being landed, spatial extent of the fishing effort and timely information required for in-season controls where appropriate. Catch levels of incidentally-caught and discarded fish are well understood and documented. No harvest on depleted or rebuilding populations. Minimal illegal fishing.

B There is a working system to account for in-season quantities being landed and the spatial extent of the fishing effort, but improvement is necessary. Good understanding of non-reported or illegal catches. Low levels of catch on rebuilding populations.

C Reasonable estimate of catch and spatial distribution of catch, but not bycatch. Insufficient understanding of the level of illegal or non-reported catches. Evidence that depleted populations are harvested at rates that may prevent maximum rebuilding.

D Poor estimate of catch and poorly understood spatial distribution of fishing. No understanding or controls of bycatch in the fishery. Unknown levels of illegal or non-reported catch.

F No idea of quantities of catches or spatial distribution of fishing. No understanding or controls of bycatch in the fishery.

Grading Criterion 4: Ecosystem Considerations

The degree to which ecosystem-based approaches are incorporated into management decisions.

A Ecosystem-based approaches are central to the management of the fishery. This includes an understanding of impacts to non-target species, spatial reserves where relevant, protection of habitats, and an understanding of trophic interactions.
B Ecosystem-based approaches are acknowledge and are being incorporated into management plans.
C No consideration for ecosystem approaches or impacts to other ecosystem components but fishery very limited in the amount landed and spatial distribution. No disruption of habitat.
D No consideration for ecosystem approaches or impacts to other ecosystem components. Fishing method does not physically impact habitats.
F No consideration for ecosystem approaches or impacts to other ecosystem components. Severe known damage to habitats and non-target species.

Grading Criterion 5: Precautionary Measures and Long-term Sustainability

The degree to which risk-averse, precautionary approaches are incorporated into management decisions to ensure sustainability.

A A well-incorporated and understood system of precautionary measures are utilized by management and accepted by industry. This includes spatial refuges, conservation quotas, and mechanisms to allow for rebuilding.
B Some precautionary measures taken but not to a full extent to allow for conservation or rebuilding of populations.
C A good understanding of biological and fisheries information on how to integrate precautionary measures, but none taken (e.g. spatial reserves, reduced quotas, size limits etc.).
D Gaps in understanding of basic scientific knowledge to sustainably manage a fishery are well-documented, but no risk-averse actions have been taken.
F The fishery is executed despite the absence of basic knowledge required to manage a fishery. No precautions taken, resulting in high mortality rates of targeted or incidentally caught species well above natural mortality. Fishing practices place targeted populations or incidentally caught species at severe risk of depletion.

Principle 15 of the *Rio Declaration* brought the precautionary approach to a global level. It is now considered a fundamental principle in the management of fisheries. In essence the precautionary approach states that "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

Grading Criterion 6: Biodiversity Conservation

The degree to which the fishery operates without causing irreversible harm to non-target stocks.

A The fishery has no adverse impacts on the long-term viability and sustainability of non-target stocks.

B Weaker stocks are declining but actions have been taken and there is evidence of stock recovery.

C Weaker stocks are declining and actions have been taken but their effectiveness is unknown.

D Weaker stocks are declining, but no actions have been taken to arrest the decline.

F The operation of the fishery is resulting in the local extinction of genetically unique stocks.