MONTEREY BAY AQUARIUM®

Seafood WATCH

Pink Salmon, Sockeye Salmon

Oncorhynchus gorbuscha, Oncorhynchus nerka

Lummi Island and San Juan Island, Washington State

Reefnet

January 3, 2013
Sam Wilding, Seafood Watch
Recommendation Update March 24, 2015
Sam Wilding, Seafood Watch Senior Fisheries Scientist

Disclaimer

Seafood Watch® strives to ensure all our Seafood Reports and the recommendations contained therein are accurate and reflect the most up-to-date evidence available at time of publication. All our reports are peer-reviewed for accuracy and completeness by external scientists with expertise in ecology, fisheries science or aquaculture. Scientific review, however, does not constitute an endorsement of the Seafood Watch program or its recommendations on the part of the reviewing scientists. Seafood Watch is solely responsible for the conclusions reached in this report. We always welcome additional or updated data that can be used for the next revision. Seafood Watch and Seafood Reports are made possible through a grant from the David and Lucile Packard Foundation.

Final Seafood Recommendation

This report provides recommendations for pink salmon and sockeye salmon caught in the Washington reefnet fishery. The reefnet fishery is restricted to a small area of Puget Sound in Washington and takes place around Lummi Island and another small area in the San Juan Islands. Early Summer-run Fraser River sockeye salmon and Fraser River pink salmon are **Best Choice**. Late-run Fraser River sockeye and Summer-run Frasier River sockeye are a **Good Alternative**.

Stock	Fishery	Impacts on the Stock Rank Score	Impacts on other Species Lowest scoring species Rank*, Subscore, Score	Manage-ment Rank Score	Habitat and Ecosystem Rank Score	Overall Recommendation Score
Early Summer-run Fraser River Sockeye	Washington Reefnet	Green 3.83	Puget Sound Salmon Yellow, 2.64,2.64	Green 3.87	Green 3.87	**BEST CHOICE** **3.51**
Fraser River Pink Salmon	Washington Reefnet	Green 4.47	Fraser River Coho Salmon, Late-run Fraser River Sockeye Yellow, 2.24,2.24	Green 3.87	Green 3.87	**BEST CHOICE** **3.5**
Late-run Fraser River Sockeye	Washington Reefnet	Red 1.92	Fraser River Coho Salmon Yellow, 2.24,2.24	Green 3.87	Green 3.87	**GOOD ALTERNATIVE** **2.83**
Summer-run Fraser River Sockeye	Washington Reefnet	Green 3.83	Late-run Fraser River Sockeye Red, 1.92,1.92	Green 3.87	Green 3.87	**GOOD ALTERNATIVE** **3.24**

Scoring note – scores range from zero to five where zero indicates very poor performance and five indicates the fishing operations have no significant impact.

Table of Contents

Executive Summary

The reefnet fishery, in the waters around Lummi Island and San Juan Island, Washington, encounters five species of Pacific salmonid. For the purposes of this report, recommendations are provided for pink salmon and sockeye salmon. The other salmon species, namely Chinook, chum and coho, are considered as bycatch species for the purposes of this report, although it is acknowledged that these species are often retained (when management permits).

Pink salmon are the most abundant species of Pacific salmon in the Fraser River. They exhibit a two-year lifecycle, which results in highly variable abundances; however, there has been a general trend of increasing abundance, peaking at over 20 million fish in recent years. Fishing effort on Fraser River pink salmon is restrained to protect co-migrating stocks of other Pacific salmonids and is considered a very low conservation concern. The Fraser River sockeye population has been divided into a number of conservation units which describe genetically and geographically distinct stocks. These conservation units have been grouped into four run-timing groups for the purpose of management, and it is this level that is considered in this report. The different conservation units (CUs) and thus run-timing groups, have different levels of conservation concern, ranging from very high for Cultus Lake (Late run) CU to low for the summer-run. The impact of the reefnet fishery on Fraser River pink salmon, and the early summer run and summer run sockeye has been ranked green by Seafood Watch, while the impact on the late run sockeye group has been ranked red due to concerns over the endangered Cultus Lake CU.

The reefnet fishing method is highly selective and bycatch of non-salmonids is minimal, if it exists at all. All non-target species are returned alive, with post-release mortality rates of 0.45%. The Chinook, chum and coho salmon which are encountered by the reefnet fishery (in addition to the pink and sockeye which are the subject of this report) are considered in Criterion 2 of the report. The Criterion 2 score is driven by different species throughout the year, dependent on which species are co-migrating with the target management group. Fraser River Chinook abundance is a high conservation concern, however, the impact of the reefnet fishery is a very low conservation concern, as no wild Chinook can be retained and there is a limit on the number of hatchery reared Chinook which can be retained. There is an unknown proportion of hatchery reared fish in the Fraser River chum salmon population; exploitation by the reefnet fishery is a low concern as overall abundance has been fluctuating around the escapement goal, while the reefnet fishery forms only a small proportion of overall fishing mortality. The Interior Fraser River coho population is listed as endangered by Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and is the limiting factor the Seafood Watch score for bycatch in the late-run sockeye fishery. Exploitation on the Fraser River coho by the reefnet fishery is a very low concern as only hatchery origin fish may be retained. Late-run sockeye are caught during fisheries targeting summer-run salmon, and due to conservation concerns related to the Cultus Lake CU, the impact is ranked red for this fishery. The Early-summer sockeye fishery is limited by the impact of the fishery on Puget Sound salmon populations. It is unclear which populations are specifically impacted, however management

measures prevent endangered and threatened populations from being retained, so a yellow rank is provided for this fishery. The pink salmon fishery is known to interact with Fraser River sockeye populations, including the late-run management group, however sockeye are typically required to be returned alive when endangered or threatened populations are present, therefore a yellow rank is given for bycatch impacts.

Management of the reefnet fishery is part of a complex bilateral management system formed between the US and Canada through the Pacific Salmon Treaty. The fishery takes place in the waters of Washington State; however, the fish being targeted are headed for the Fraser River in British Columbia, Canada. Conservation goals for these stocks are set by the Department of Fisheries and Oceans, and through the Pacific Salmon Treaty (PST) the fisheries are managed bilaterally in order to meet these conservation goals, which includes the seasonal opening of fisheries and the setting of total allowable catch (TACs). Management of these salmon fisheries is considered to be moderately to highly effective, and stocks are protected from overharvesting through restrictions on fishing activities taking place throughout the season in response to real-time data collected and reviewed on a twice-weekly basis. There are concerns over a number of stocks caught in Washington State waters, including within the reefnet fishery, however, on the whole, management restricts fishery impacts on these stocks as much as is practicable. Indeed, in many cases a fishing mortality of zero would not allow the recovery of the stocks of concern because factors such as marine and/or freshwater survival are dictating salmon abundance at the present time.

There is no contact with the seabed from the reefnet gear, and the capture method allows the fishery to be highly selective, returning all non-target species alive with a very low post-release mortality rate (0.45%). No mitigation measures are required for this fishery as the capture method is benign with respect to impacts on the benthic habitat. Ecosystem effects are being considered by the management bodies responsible for the Fraser River salmon fisheries, however, ecosystem based management for salmonid fisheries is particularly complex and there is no information available regarding the importance of salmon within the ecosystem.

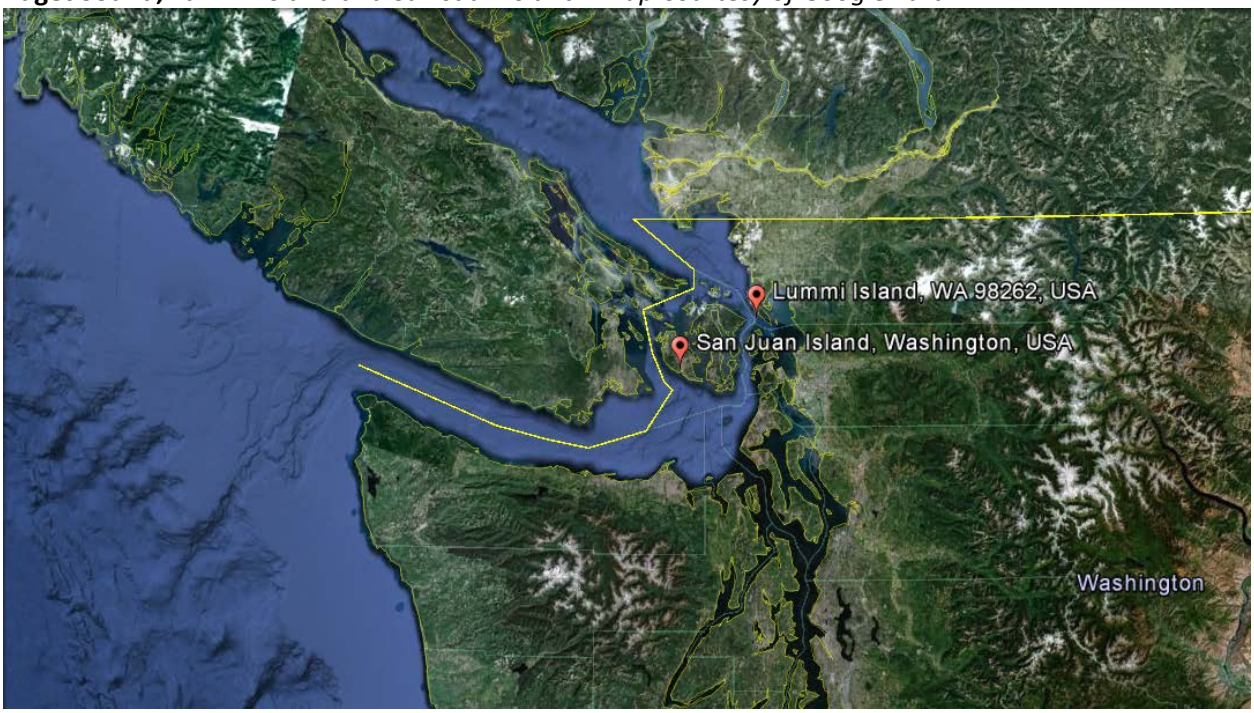
Introduction

Scope of the analysis and ensuing recommendation

This report provides recommendations for pink salmon and sockeye salmon caught in the Washington reefnet fishery. The Washington reefnet salmon fishery encounters a number of Pacific salmon species (from the genus *Oncorhynchus*), and although recommendations are provided for only pink salmon and sockeye salmon, the management of all species in the context of the reefnet fishery has been considered in compiling this report. It can be seen from table 1 that the landings of other species, for example Chinook, are often very low due to the selective nature of the fishery (allowing non-target species to be returned unharmed), and management measures preventing fish from being landed when abundances of returning salmon are below benchmark thresholds.

The reefnet fishery in Washington takes place in two locations, one around Lummi Island which is restricted to a small area of Puget Sound, approximately 0.25 square miles (Riley Starks, Lummi Island Wild, pers. comm.); and another small area in the San Juan Islands (figure 1). The fishery targets salmon migrating through Puget Sound on the way to the Fraser River, although it is likely that there is a small catch of Puget Sound salmon populations.

Figure 1: A map of the Northwest coast of the United States at the Canadian-US border showing Puget Sound, Lummi Island and San Juan Island. *Map Courtesy of Google Earth*



The reefnet fisheries in the Pacific Northwest are historic fisheries which have been conducted for centuries by Native American tribes (though current activities are part of the non-treaty commercial salmon fisheries). The reefnet fishing method has changed little over the centuries,

although modern materials have been used to improve the efficiency of the fishery (Lummi Island Wild). The reefnet method involves setting a net between two vessels which are static in the water. Artificial reefs (lead lines, wings and streamers, see figure 10) are used to guide migrating salmon over the static net that is raised when the salmon have crossed over the headline. This method of fishing is reliant on the movement of salmon following traditional migration routes rather than chasing down the fish, and as such, is considered a very low impact fishery (Lummi Island Wild, Washington Department of Fish and Wildlife (WDFW) website).

Species Overview

i. *Overview of the species and management bodies.*

The pink salmon, *Oncorhynchus gorbuscha*, is the most abundant species of Pacific salmon with some 2200 unique stocks in British Columbia (Henderson & Graham 1998). It is different from all other species of Pacific salmon in that it has a fixed two-year lifecycle (other species will mature over a range of time periods), resulting in two distinct genetic lineages. In the Fraser River, only the odd-numbered year cycle returns in fishable numbers, resulting in large fluctuations in overall landing figures for both the reefnet and British Columbia fisheries. Pink salmon traditionally spawn in the lower reaches of rivers, particularly in larger systems such as the Fraser River, and upon hatching, migrate quickly to the sea (Henderson & Graham 1998). They stay inshore for 2-3 months or so, and then move offshore to grow for 12-18 months before returning to freshwater to spawn (Heard 1991). The homing instincts of pink salmon are not as exact as other species and salmon have been found to return to streams over 600km from their natal stream (although it is worth noting that these were hatchery origin fish) (Heard 1991).

The sockeye salmon is the second most abundant species in British Columbia, Canada (the producing area for the majority of the reefnet fishery) and the Fraser River stocks contribute approximately 50% of the BC population (Henderson & Graham, 1998). The Fraser River population has a distinct age distribution, with 95% of salmon returning at four years of age (other sockeye populations exhibit returns of 3-, 4-, and 5-year old fish, each contributing more than 20% of returns)(Burgner 1991). It also has a distinct return cycle, with one main dominant year (2010-cycle), followed by a sub-dominant year (2011-cycle), and two years of low production (2012 and 2013-cycles) (Henderson & Graham, 1998; Pacific Salmon Commission (PSC), 2012a). Typically sockeye salmon spawn in streams close to lakes and, in some cases, in the lakes themselves. The newly hatched fry move to lakes where they grow for 1 to 2 years before undergoing smoltification and migrating to the ocean to feed and mature for another 1 to 3 years (Burgner 1991; http://www.pwlf.org/sockeyesalmon.htm).

While the Pacific salmon have a wide-ranging ocean distribution, most of the harvest occurs as they return to coastal regions en route to their natal river systems to spawn. This behavior coupled with allocation of catches results in separate regulations for specific regions. The reefnet fishery takes place in Management Area 7 of the Puget Sound commercial salmon fishing management region, and primarily targets salmon returning to the Fraser River system in British Columbia, Canada. As an interception fishery, the conservation and continued productivity of the stocks are the concern of both Canada and the United States, therefore the management falls under the influence of the Pacific Salmon Treaty 1985 (PST) between Canada and the United States. Under the PST, the Fraser River Panel (FRP) was established to manage the Fraser River pink and sockeye salmon fisheries, with assistance from the Canadian Department for Oceans and Fisheries (DFO), National Ocean and Atmospheric Administration (NOAA), WDFW, Canadian First Nations and US tribal organizations. Coho and chum salmon encountered by the reefnet fishery are managed through the Southern Panel and their management is also considered as part of this report in the context of the reefnet fishery as a whole.

ii. *Production statistics. Importance to the US/North American market.*
Pacific salmon, as a group, are one of the most economically and socially important species caught in the waters around the US, with combined commercial landings (across states and species) of 357303.9 metric tons in 2010, representing over 9% of all US landings that year (FIGIS 2012). Salmon has consistently been one of the top three species consumed in the US over the last decade (although this will include a substantial amount of farmed salmon)(Aboutseafood.com).

In contrast to the large volumes landed into the US overall, the Washington reefnet fishery lands relatively small volumes of salmon each year. Table 1 shows the number of fish landed over the last decade. The importance of pink salmon to the Washington fishery in odd-numbered years is evident from table 1.

Table 1: Landings of 5 Pacific salmonid species caught by reefnet in Puget Sound, WA State. Landing figures are from fish ticket data submitted to Washington Dept. of Fish and Wildlife, and show numbers of fish landed as part of commercial and test fisheries.

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Chinook	2	0	0	0	0	0	0	2	4	11
Chum	22109	39492	50823	41218	26851	6493	5742	28737	12622	7462
Pink	0	45815	1	14103	0	49749	0	143385	1	224079
Coho	84	295	1121	629	77	287	15	535	573	472
Sockeye	14630	9776	17181	14498	47847	6266	9998	1602	39958	6027
Combined	36825	95378	69126	70448	74775	62795	15755	174261	53158	238051

The vast majority of salmon caught in the reefnet fishery is sold within the U.S., predominantly in Washington State and Oregon, through both retail and foodservice businesses (Lummi Island Wild).

iii. Common and market names.

Pink salmon is also referred to as humpback salmon, saumon rose, and salmon rosado. Sockeye salmon is also referred to as kokanee, red salmon, saumon nerka, and saumon rouge.

iv. Primary product forms.

Lummi Island reefnet caught pink and sockeye salmon are sold:

- Whole
- Headed and Gutted (fresh)
- Fillets (frozen)
- Fillet portions (frozen)
- Eggs/roe
- Smoked

Analysis

Scoring guide

- All scores result in a zero to five final score for the criterion and the overall final rank. A zero score indicates poor performance, while a score of five indicates high performance.
- The full Seafood Watch Fisheries Criteria that the following scores relate to are available on our website at www.seafoodwatch.org.

Criterion 1: Stock for which you want a recommendation

Guiding principles

- The stock is healthy and abundant. Abundance, size, sex, age and genetic structure should be maintained at levels that do not impair the long-term productivity of the stock or fulfillment of its role in the ecosystem and food web.
- Fishing mortality does not threaten populations or impede the ecological role of any marine life. Fishing mortality should be appropriate given current abundance and inherent vulnerability to fishing while accounting for scientific uncertainty, management uncertainty, and non-fishery impacts such as habitat degradation.

Stock	**Fishery**	**Inherent Resilience** Rank	**Stock Status** Rank (Score)	**Fishing Mortality** Rank (Score)	**Criterion 1** Rank Score
Early Summer-run Fraser River Sockeye	Washington Reefnet	High	Low (4)	Low (3.67)	Green 3.83
Fraser River Pink Salmon	Washington Reefnet	Medium	Low (4)	Very Low (5)	Green 4.47
Late-run Fraser River Sockeye	Washington Reefnet	High	Very High (1)	Low (3.67)	Red 1.92
Summer-run Fraser River Sockeye	Washington Reefnet	High	Low (4)	Low (3.67)	Green 3.83

Justification of Ranking

Pink Salmon

Factor 1.1 Inherent Vulnerability: Medium
Key relevant information:
FishBase vulnerability score is 37 (Froese & Pauly 2012).

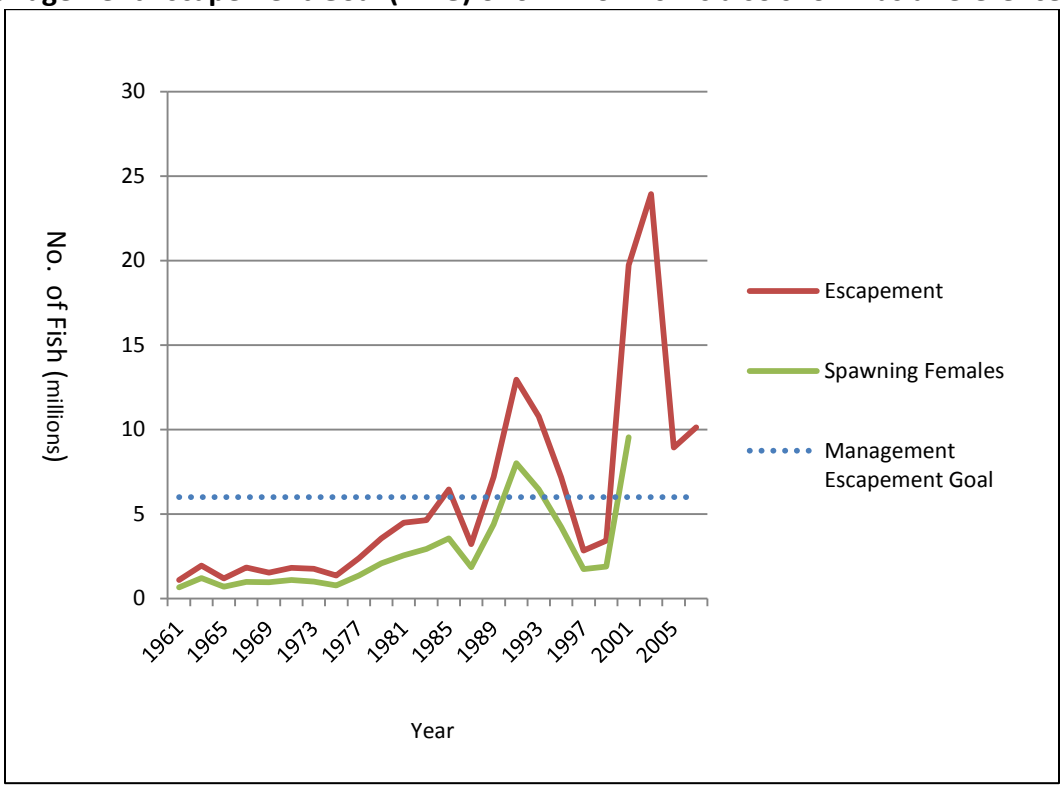
Factor 1.2 Stock status: Low concern
Key relevant information:
Formal target and limit biomass reference points are not been established for pink salmon within the Fraser River system due to their relative healthy status in comparison with other salmon stocks (Intertek Moody Marine 2011a). In the absence of biomass reference points, the Management Escapement Goal (MEG) is used as a proxy. The MEG has been met or exceeded for 8 out of the last 11 spawning years. However, due to the age of the most recent published stock review, there is a level of uncertainty over the current situation.

Detailed rationale (optional):
Pink Salmon are the most abundant species of Pacific salmon in the Fraser River system (Henderson & Graham 1998) with returns exceeding 20 million fish per annum in the last decade. Due to the 2-year lifespan of pink salmon, the Fraser River only experiences commercially viable returns on odd-numbered years. Figure 2 shows the number of adult pink salmon achieving escapement to the Fraser River system from 1961 to 2007, alongside the number of females reaching the spawning habitats up to 2001 (when data collection ceased). While there is much variability in both adult escapement and female spawners, there are general increases in both abundance indicators. Figure 2 illustrates the MEG, set at 6 million fish, which is used as the benchmark target for pink salmon in the Fraser River system (Intertek Moody Marine 2011a). The MEG has been achieved for 8 out of the last 11 odd-numbered spawning years, reflecting the increase in abundance and escapement[1].

While the benchmark target, the MEG, has been exceeded in recent years and that the general trend is one of increasing abundance, there is a high level of variability from year to year, and the most recent stock assessment published is for the 2007 fishery. Therefore, Seafood Watch is cautious over the current situation. These reasons have prevented the Fraser River pink salmon population from gaining the highest score available.

[1] It is worth noting that in 1999, one of the years in which the MEG was not achieved, total returns of Fraser River pink salmon were 3.6 million, therefore, in the absence of any fishing effort it would have been impossible to meet the target (PSC 2001).

Figure 2: Escapement of pink salmon to the Fraser River system from 1961 to 2007, and the number of female spawners reaching the spawning grounds (data collection ceased in 2001). The Management Escapement Goal (MEG) of 6 million fish is also shown as a reference point.



Factor 1.3 Fishing mortality: Very Low Concern

Key relevant information:

There is no target or reference point for fishing mortality in the Fraser River pink salmon fisheries (they are managed to achieve the MEG), and therefore $F_{current}$:F_{MSY} cannot be determined. This is typical of salmonid fisheries as returns can be highly variable from year to year, and therefore it is more appropriate to manage the fisheries through allowable catches to achieve escapement or spawning goals than through a pre-determined ratio. While the ratio of $F_{CURRENT}$:F_{MSY} cannot be determined, the MEG is regularly exceeded.

Detailed rationale (optional):

Overall fishing mortality on Fraser River pink salmon population has decreased in recent years with an average exploitation rate of 8% from 1999 to 2007, compared to an average of 61% from 1959 and 1997 (PSC 2012a). There are several reasons for this decrease, not least is the increased management of vulnerable co-migrating stocks leading to a restriction of effort on pink salmon. Market price for pink salmon has been low over the last decade contributing to low exploitation (Lapointe, pers. comm., 2012), although prices improved in 2009 and 2011, which may lead to increased targeting of pink salmon.

Salmon stocks are subject to widely fluctuating abundances on an annual basis, and it is therefore inappropriate in many cases to manage according to a target fishing mortality. Often, as is the case with Fraser River stocks, escapement or spawning targets are established and, each year, the allowable catches are set to achieve these targets based on pre-season abundance estimates and adapted using in-season monitoring. The Fraser River pink salmon population has achieved the MEG in 8 of the last 11 years and the increasing abundance indicators would suggest that there is evidence of the reduced exploitation rates. Combined with environmental factors leading to improved marine survival, having a positive effect on the pink salmon populations. Notwithstanding this increase in abundance, the exploitation rate of the Washington reefnet fishery is a small fraction of the overall fishing effort.

Sockeye Salmon

The Fraser River system drains from a watershed of 217,000 km^2 (~84,000 sq. miles) (Morrison et al. 2002), with 40 major tributaries (Wikipedia). As a result, there are a number of distinct stocks which require management as part of the Fraser River sockeye salmon fishery. In order to manage the fishery effectively, the DFO has identified genetically and geographically distinct groups defined as CUs. These CUs are managed within 4 run-timing groups (which existed prior to the formation of CUs as groups of stocks) depending on when they migrate in order to ensure that fishing effort for each group is at a suitable level. These management groups are:

- Early Stuart[2]
- Early Summer
- Summer
- Late

The most recent stock assessments available for Fraser River sockeye are up to 2008 (PSC2012b) which is the data that will be used for the purpose of this report. Although there are references in the literature to high returns in 2010, official stock reviews have not been released and cannot be assessed–indications are that returns reached over 30 million fish, mostly within the late run management group (Adicks pers. comm.2012). The individual management groups have been considered and ranked separately for the purpose of Criterion 1 of this Seafood Watch report, which follows a brief overview of studies that are relevant to all stocks.

Within the timing groups that have been identified for management purposes, there exist a number of individual stocks (at a tributary level). Seven of these eighteen individual stocks have been identified as endangered by the IUCN (the stocks identified for the IUCN assessment differ slightly from the stocks identified by the DFO for the purposes of management) (Rand et al. 2012) and are listed in table 2 with their management groups and their status under the

[2] Harvest of Early Stuart has been prohibited for a number of years due to the low abundance of this management group. Fisheries for Fraser River salmon are only opened once the migration of Early Stuart fish has passed, therefore there is minimal chance that they are caught. As there is no harvest of this management group they have not been included within the scope of this report.

different IUCN criteria. The IUCN criteria used to assess salmon populations are A–declining abundance over a 3 generation time period; B–geographic range and changes to this; D–absolute abundance in terms of population size (for more information see http://intranet.iucn.org/webfiles/doc/SSC/RedList/RedListGuidelines.pdf).

Table 2: Fraser River Sockeye stock status in accordance with IUCN Red List criteria A, B, and D. . EN=Endangered, VU=Vulnerable, LC=Least Concern.

Population[a]	Management Group	% change in population[b]	A Status	B Status	D Status	Overall Status
Early Stuart	Early Stuart	-77	EN	VU	LC	EN
Gate	Early Summer	-67	EN	EN	LC	EN
Nahatlatch	Early Summer	-62	EN	EN	LC	EN
Bowron	Early Summer	-69	EN	EN	LC	EN
Chilko	Summer	-38	VU	EN	LC	EN
Stuart Summer	Summer	-78	EN	VU	LC	EN
Cultus Lake	Late	-66	EN	EN	LC	EN

[a] Shown are the seven endangered stocks, an additional eleven stocks are listed as Least Concern.
[b] Change in population over 3 generations (12 years).

When compiling this report, the IUCN listings were carefully considered, however, upon further investigation some of the listings had been discounted. While the IUCN Red List is considered a good indicator of stock status in many cases, there are limitations with the metrics that are used to establish the status of stocks. This is particularly true in the case of salmon where stocks can be very specific to small areas and are subject to natural fluctuations. Some of these natural fluctuations are understood to be connected to long-term climatic changes such as the Pacific Decadal Oscillation (PDO) (Hollowed et al. 2001, Mantua et al. 1997); such fluctuations take place over much longer timescales than can be captured by the IUCN Red List metrics, particularly for short-lived species such as salmon. Indeed, for some stocks the IUCN metrics suggest large reductions in abundance over the last 12 years; however, when considering a longer time frame, the abundances encountered in the last decade are similar to the long-term average (Porszt et al. 2012).

A study by Grant et al. (2011) reviewed a number of different models and indicators for assessing the status of the different CUs. The different models and indicators each provided different benchmarks and classed the status of each CU accordingly. The study categorized the status of each stock as red, amber or green according to the relevant benchmarks: green status was given to CUs when the indicator was above the upper benchmark, red status was given to CUs when the indicator was below the lower benchmark, and amber status was applied to CUs where the indicator fell between the upper and lower benchmarks (it should be noted that this system does not necessarily correlate to the Seafood Watch ranking system) Depending on which model was applied, any given stock could be considered to be in green, amber or red

status. Grant et al. (2011) concluded that the different CUs had unique circumstances and historic trends, which dictated that some models would be more appropriate than others for each individual CU; however, in general, the Larkin model would be most suitable as it accounted for the cyclic nature of Fraser River sockeye stocks. The Grant et al. (2011) study will be discussed for each management group with respect to the relevant CUs.

Early Summer-run Fraser River Sockeye Salmon

Factor 1.1 Inherent Vulnerability: Low

Key relevant information:

FishBase vulnerability score is 32 (Froese & Pauly 2012).

Factor 1.2 Stock status: Low concern

Key relevant information:

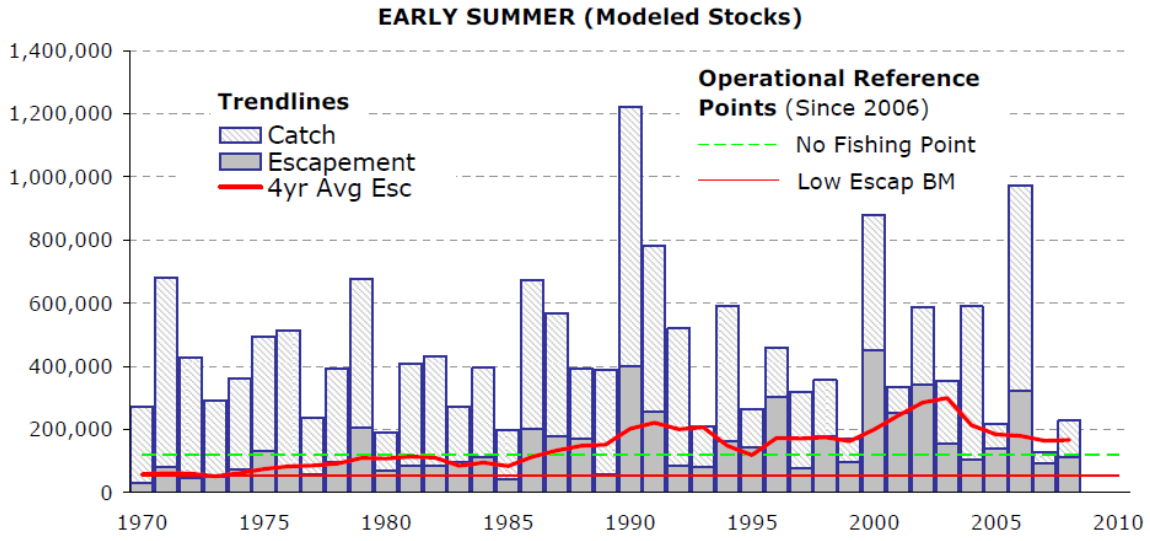
The Early Summer-run management group abundance is above the low escapement benchmark but recent declines are a cause for concern considering that the most recent data is 4 years old (figure 4). There is also concern that the benchmarks may not be sufficiently precautionary to ensure long-term sustainability (Holt 2010).

Detailed rationale (optional):

The Early Summer-run takes place from early July to mid-August (expected), and can therefore overlap with the Early Stuart, Summer, and Late runs. The 4-year average escapement of Early Summer fish has been above the LEBM since 1975, and has been above the 'No Fishing Point' (NFP) since the late 1980s (figure 4). Grant et al. (2011) found that the majority of CUs within the Early Summer management group exhibited a healthy stock level (green); however they also exhibited declines in recent years, which is verified by the overall decline in escapement seen in figure 4. There are also worrying signs with regards to production as many of the Early Summer CUs have shown decreasing productivity over the last decade, resulting in red status when compared to benchmarks on productivity-based population models (Grant et al. 2011).

There are concerns that the benchmarks set for salmon stocks under the Canadian Wild Salmon Policy (WSP) may not be sufficiently precautionary to ensure the long-term sustainability of salmon populations. A number of environmental and anthropogenic factors are believed to affect the productivity of salmon and there is concern that reduced productivity or catastrophic mortality events are not being considered by models used to set benchmarks; resulting in uncertainty in the benchmarks (Holt 2010).

Figure 4: Catch, escapement and operational baselines for Early Summer run Fraser River sockeye salmon. Data is shown from 1970 through 2008, with operational baselines developed in 2006. Chart from Intertek Moody Marine (2010).



Factor 1.3 Fishing mortality: Low concern

Key relevant information:

Total fishing mortality on Early Summer sockeye is considered to be at or around a sustainable level, as the 4-year average escapement remains above the low escapement benchmark and NFP. A decline in the average escapement requires a more precautionary assessment.

Detailed rationale (optional):

A breakdown of fishing mortalities on each management group for the reefnet fishery is not readily available, so the overall fishing mortality for Fraser River sockeye is used as a proxy.

Between 2003 and 2008 the total exploitation rate on Fraser River sockeye averaged 38% (PSC 2007, 2008, 2009, 2011a, 2012a, 2012b) and followed a pattern of reducing exploitation rates since the early 1990s following the introduction of a rebuilding strategy by Canada and restrictions placed upon this population due to conservation concerns over co-migrating stocks. Under the 1999 renewal of fishery arrangements under the PST, the US share of the sockeye TAC was reduced from 22.5% in 1999 to 16.5% in 2001 where it remains (PST 2009). The US sockeye salmon TAC is split between Tribal (67%) and All Citizen (33%) fisheries. The Lummi Island reefnet fishery uses approximately 5% of the All Citizen quota (Lapointe, PSC, pers. comm.2012). Maximum exploitation rate on the sockeye population is limited to 60%, therefore the estimated exploitation rate from the reefnet fishery is 0.16% *(60% maximum F x 16.5% US share x 33% All-Citizen share x 5% reefnet catch*).

Summer-run Fraser River Sockeye Salmon

Factor 1.1 Inherent Vulnerability: Low

Key relevant information:

FishBase vulnerability score is 32 (Froese & Pauly 2012).

Factor 1.2 Stock status: Low Concern

Key relevant information:

The 4-year average escapement is above the LEBM, but a decline in abundance over the last decade threatens to push abundances below the benchmark. There are also concerns that the benchmarks may not be sufficiently precautionary to ensure long-term sustainability (Holt 2010).

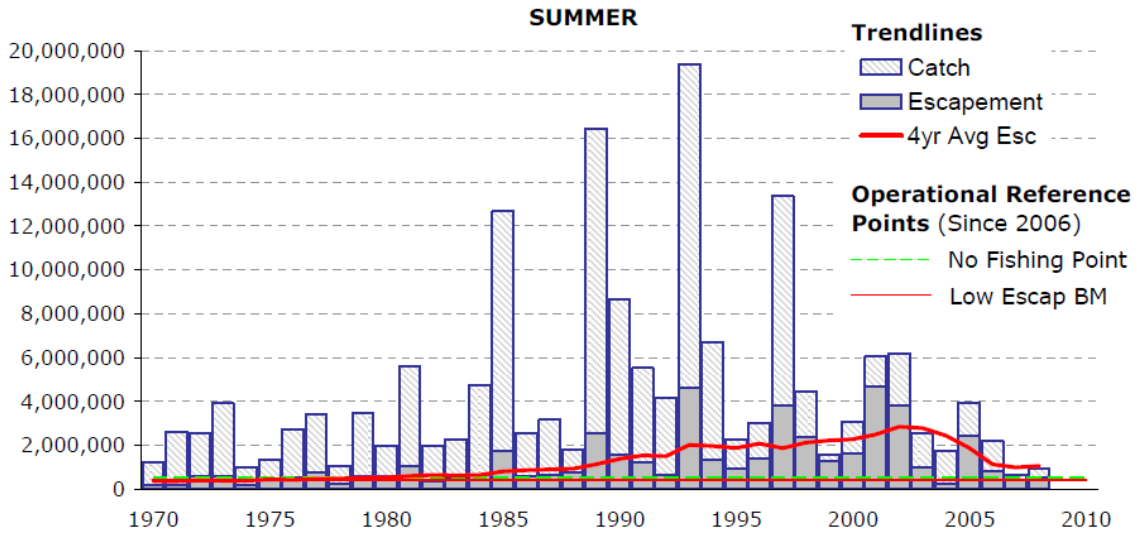
Detailed rationale (optional):

The Summer-run is the largest of the run-timing groups with escapements regularly exceeding 1 million fish and is usually expected between mid-July and late August, therefore overlapping with the Early Summer and Late-runs. The Summer-run has been above the LEBM since the late 1970's and above the NFP since 1981 (figure 5). The 4-year average escapement has declined to around 1 million in recent years, having peaked at around 2.8 million in 2002.

While average escapement is above the LEBM for Summer-run sockeye, there is indication of a decline over the past decade following a prolonged period of population growth. The overall decrease is mirrored by the individual CUs within the Summer-run management group, which show a similar pattern to the Early Summer-run CUs. Grant et al. (2011) have shown that while current abundances are higher than the long-term averages, abundance models based on productivity show abundances below theoretical benchmarks, combined with steep declines in abundance, albeit from historically high levels.

There are concerns that the benchmarks set for salmon stocks under the Canadian WSP may not be sufficiently precautionary to ensure the long-term sustainability of salmon populations. A number of environmental and anthropogenic factors are believed to affect the productivity of salmon and there is concern that reduced productivity or catastrophic mortality events are not being considered by models used to set benchmarks, resulting in uncertainty in those benchmarks (Holt 2010).

Figure 5: Catch, escapement and operational reference points for Summer-run Fraser River sockeye salmon. Data is for the period of 1970 through 2008, with operational benchmarks established in 2006. From Intertek Moody Marine (2010).



Factor 1.3 Fishing mortality: Low Concern

Key relevant information:

Total fishing mortality on Summer-run sockeye is at or around a sustainable level, as the 4-year average escapement remains above the low escapement benchmark and NFP. The age of the latest stock assessment and a decline in the average escapement result in a precautionary assessment.

Detailed rationale (optional):

A breakdown of fishing mortalities on each management group for the reefnet fishery is not readily available, so the overall fishing mortality for Fraser River sockeye is used as a proxy.

Between 2003 and 2008 the total exploitation rate on Fraser River sockeye averaged 38% (PSC 2007, 2008, 2009, 2011a, 2012a, 2012b) and followed a pattern of reducing exploitation rates since the early 1990s, following the introduction of a rebuilding strategy by Canada and restrictions placed upon this population due to conservation concerns over co-migrating stocks. Under the 1999 renewal of fishery arrangements under the PST, the US share of the sockeye TAC was reduced from 22.5% in 1999 to 16.5% in 2001 where it remains (PST 2009). The US sockeye salmon TAC is split between Tribal (67%) and All Citizen (33%) fisheries. The Lummi Island reefnet fishery uses approximately 5% of the All Citizen quota (Lapointe, PSC, pers. comm. 2012). Maximum exploitation rate on the sockeye population is limited to 60%, therefore the estimated exploitation rate from the reefnet fishery is 0.16% *(60% maximum F x 16.5% US share x 33% All Citizen share x 5% reefnet catch*).

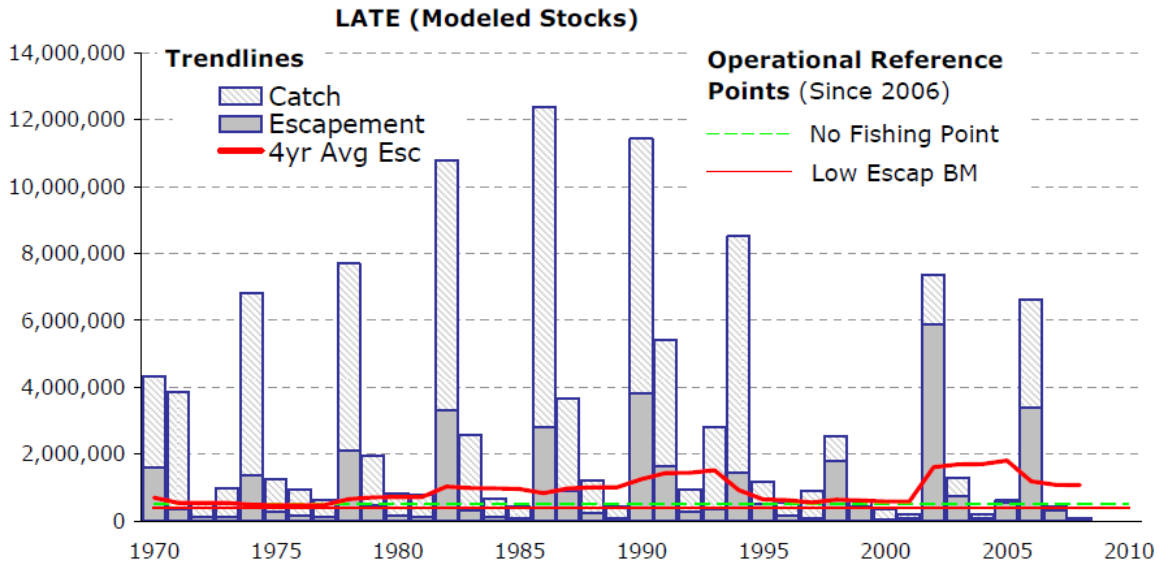
Late-run Fraser River Sockeye Salmon

Factor 1.1 Inherent Vulnerability: Low
Key relevant information:
FishBase vulnerability score is 32 (Froese & Pauly 2012).

Factor 1.2 Stock status: Very High concern
Key relevant information:
The Cultus Lake sockeye CU, which forms part of this management group is listed as endangered by COSEWIC.

Detailed rationale (optional):
The Late-run has a very distinct 4-year cyclic pattern, with dominant years producing escapements of over 3 million fish (1982, 1990, 2002, 2006), while off-cycle years produce few fish, resulting in an average escapement that has fluctuated around 1 million fish since the 1980s. The Late-run migrates through Puget Sound between late July and early September, therefore overlapping with the Summer-run and potentially with the Early Summer-run. The 4-year average has rarely fallen below the LEBM, however, off-cycle years (2007 and 2008 cycles) rarely exceed the LEBM or the NFP (figure 6).

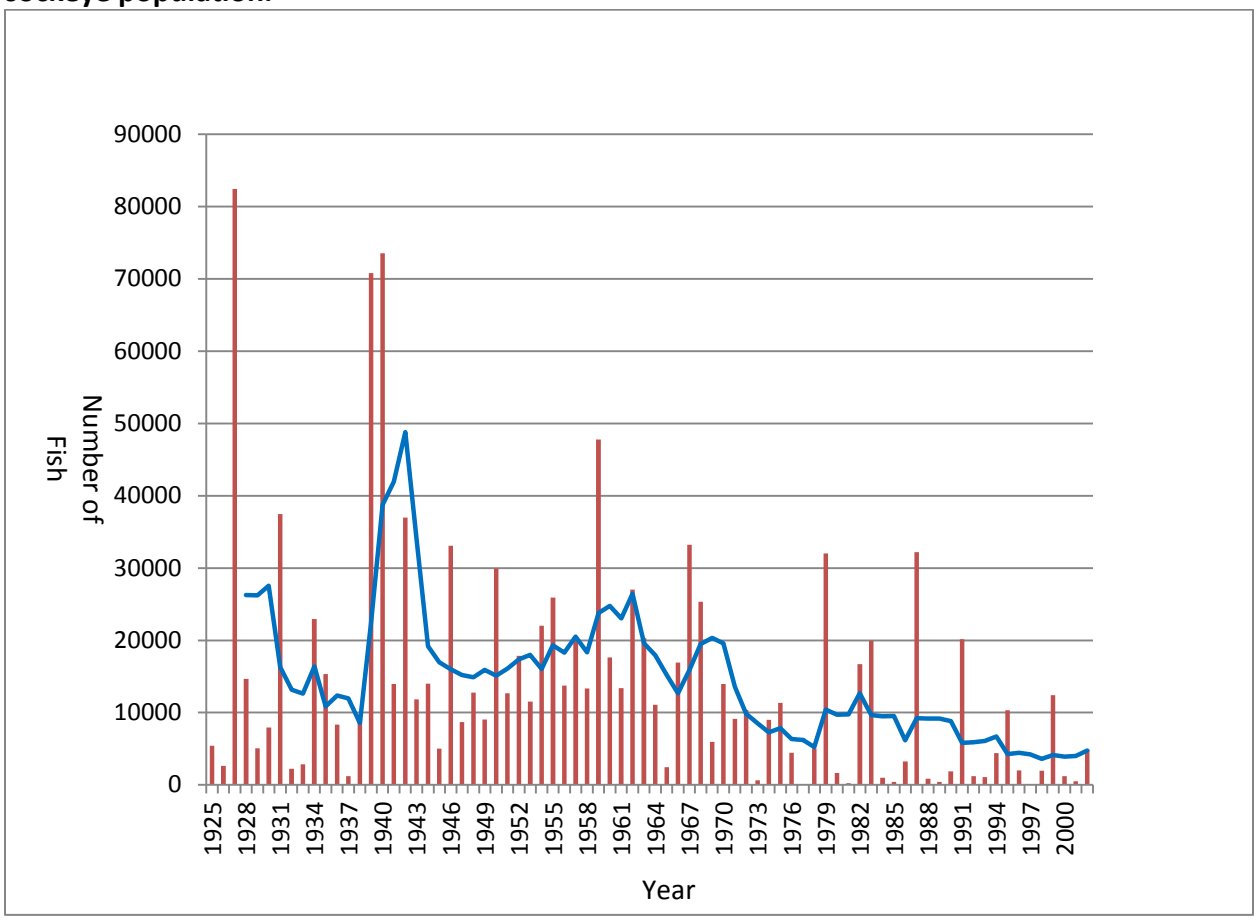
Figure 6: Catch, escapement and operational benchmarks for Late-run Fraser River sockeye salmon. Data is shown for 1970 through 2008, with operational benchmarks established in 2006. Chart from Intertek Moody Marine (2010).



The Late-run management group includes the Cultus Lake CU which is considered Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The Cultus Lake CU has been in decline since the 1960s (figure 7) and is an example of a sockeye stock declining over a longer time period, outside of the effects of the PDO (in contrast to other stocks listed as

endangered under the IUCN criteria). In order to recover the Cultus Lake CU a recovery plan has been put in place (Cultus Sockeye Recovery Team, 2005). As part of the recovery plan, artificially produced salmon have been used to enhance the wild stock. As a result, the majority of sockeye returns (85%) on the weak cycle years are of hatchery origin. Initially stock enhancement activities appear to have reduced the number of natural sockeye in Cultus Lake, however, 2008 and 2009 returns suggest that fry released in 2004 and 2005 have boosted abundance (Bradford et al. 2011).

Figure 7: Escapement of Cultus Lake sockeye from 1925 to 2002. A 4-year average is also shown (solid blue line) to account for the 4-year production cycle evident in the Fraser River sockeye population.



In contrast to the Cultus Lake CU, other Late-run CUs have shown abundances greater than the long-term average (Grant et al. 2011); however the endangered status of the Cultus Lake CU drives the score for this management group (particularly when considered alongside the management of the Late-run management group as discussed under factor 3.1).

Factor 1.3 Fishing mortality: Low Concern

Key relevant information:

The fishing mortality for the reefnet fishery on the endangered Cultus Lake CU cannot be established using the available data. There are data available on landings of sockeye salmon, and when considering total landings in relation to overall run-size the impact is considered to be of low concern.

Detailed rationale (optional):

There are no data available on the numbers of Cultus Lake sockeye taken in the reefnet fishery making it difficult to determine the impact of the fishery on the endangered stock and its associated management unit. The Cultus Lake population makes up a very small proportion of the overall late run management unit, however there is still a risk of interaction with the reefnet gear whilst fishing takes place during the migration period; therefore the impact cannot be considered negligible. Between 2005 and 2011, the reefnet fishery was responsible for approximately 9.5% of U.S. landings of Fraser River sockeye (based on FRP data) (Pacific Salmon Commission 2012a,b,c). If we assume that this percentage is reflected across the management units then the impact of the reefnet fishery on the late-run management unit cannot be considered negligible. There is a significant level of uncertainty with this assumption as fishery openings will dictate that impacts are not uniform against all management units; however this represents a conservative best estimate. Based on the numbers of sockeye taken by the reefnet fishery and a very conservative assumption that all of these fish are from the late-run management group, the average exploitation rate (2005-2011) from the reefnet fishery is approximately 6.3% (Pacific Salmon Commission 2012a,b,c). Seafood Watch considers this sufficiently small to consider the impact a low conservation concern.

Criterion 2: Impacts on other retained and bycatch stocks

Guiding principles

- The fishery minimizes bycatch. Seafood Watch® defines bycatch as all fisheries-related mortality or injury other than the retained catch. Examples include discards, endangered or threatened species catch, pre-catch mortality and ghost fishing. All discards, including those released alive, are considered bycatch unless there is valid scientific evidence of high post-release survival and there is no documented evidence of negative impacts at the population level.
- Fishing mortality does not threaten populations or impede the ecological role of any marine life. Fishing mortality should be appropriate given each impacted species' abundance and productivity, accounting for scientific uncertainty, management uncertainty and non-fishery impacts such as habitat degradation.

Early Summer-run Sockeye Fishery

Stock	**Inherent Resilience** Rank	**Stock Status** Rank (Score)	**Fishing Mortality** Rank (Score)	**Subscore**	**Score** (subscore* discard modifier)	**Rank** (based on subscore)
Puget Sound Salmon	Medium	Moderate (3)	Moderate (2.33)	2.64	2.64	Yellow
Fraser River Chinook Salmon	Low	High (2)	Very Low (5)	3.16	3.16	Yellow
Early Summer-run Fraser River Sockeye	High	Low (4)	Low (3.67)	3.83	3.83	Green
Summer-run Fraser River Sockeye	High	Low (4)	Low (3.67)	3.83	3.83	Green
Fraser River Pink Salmon	Medium	Low (4)	Very Low (5)	4.47	4.47	Green

Summer-run Sockeye Fishery

Stock	**Inherent Resilience** Rank	**Stock Status** Rank (Score)	**Fishing Mortality** Rank (Score)	**Subscore**	**Score** (subscore* discard modifier)	**Rank** (based on subscore)
Late-run Fraser River Sockeye	High	Very High (1)	Low (3.67)	1.92	1.92	Red
Puget Sound Salmon	Medium	Moderate (3)	Moderate (2.33)	2.64	2.64	Yellow
Fraser River Chinook Salmon	Low	High (2)	Very Low (5)	3.16	3.16	Yellow
Early Summer-run Fraser River Sockeye	High	Low (4)	Low (3.67)	3.83	3.83	Green
Summer-run Fraser River Sockeye	High	Low (4)	Low (3.67)	3.83	3.83	Green
Fraser River Pink Salmon	Medium	Low (4)	Very Low (5)	4.47	4.47	Green

Late-run Sockeye Fishery

Stock	**Inherent Resilience** Rank	**Stock Status** Rank (Score)	**Fishing Mortality** Rank (Score)	**Subscore**	**Score** (subscore* discard modifier)	**Rank** (based on subscore)
Late-run Fraser River Sockeye	High	Very High (1)	Low (3.67)	1.92	1.92	Red
Fraser River Coho Salmon	Medium	Very High (1)	Very Low (5)	2.24	2.24	Yellow
Puget Sound Salmon	Medium	Moderate (3)	Moderate (2.33)	2.64	2.64	Yellow
Fraser River Chinook Salmon	Low	High (2)	Very Low (5)	3.16	3.16	Yellow
Fraser River Chum Salmon	Medium	Moderate (3)	Very Low (5)	3.87	3.87	Green
Summer-run Fraser River Sockeye	High	Low (4)	Low (3.67)	3.83	3.83	Green
Early Summer-run Fraser River Sockeye	High	Low (4)	Low (3.67)	3.83	3.83	Green
Fraser River Pink Salmon	Medium	Low (4)	Very Low (5)	4.47	4.47	Green

Pink Salmon Fishery

Stock	Inherent Resilience Rank	Stock Status Rank (Score)	Fishing Mortality Rank (Score)	Subscore	Score (subscore* discard modifier)	Rank (based on subscore)
Fraser River Coho Salmon	Medium	Very High (1)	Very Low (5)	2.24	2.24	Yellow
Late-run Fraser River Sockeye	High	Very High (1)	Very Low (5)	2.24	2.24	Yellow
Puget Sound Salmon	Medium	Moderate (3)	Moderate (2.33)	2.64	2.64	Yellow
Fraser River Chinook Salmon	Low	High (2)	Very Low (5)	3.16	3.16	Yellow
Fraser River Chum Salmon	Medium	Moderate (3)	Very Low (5)	3.87	3.87	Green
Fraser River Pink	Medium	Low (4)	Very Low (5)	4.47	4.47	Green
Early Summer-run Fraser River Sockeye	High	Low (4)	Very Low (5)	4.47	4.47	Green
Summer-run Fraser River Sockeye	High	Low (4)	Very Low (5)	4.47	4.47	Green

Justification of Ranking

Late-run Fraser River Sockeye Salmon

Factor 2.1 Inherent Vulnerability: Low
Key relevant information:
See Factor 1.1

Factor 2.2 Stock status: Very High concern
Key relevant information:
See Factor 1.2 for Late-run Fraser River Sockeye Salmon

Factor 2.3 Fishing Mortality:
Pink salmon fishery - Very Low Concern
Summer-run sockeye fishery – Low Concern
Key Relevant Information:
When targeting pink salmon the reefnet fishery may encounter Fraser River sockeye salmon, however management measures require the live release of these fish resulting in a very low conservation concern. The impact of sockeye targeted fisheries on the late-run Fraser River sockeye and associated Cultus Lake cannot be determined from the current data and is considered a low concern as described in factor 1.3.

Detailed Rationale (optional):
The reefnet fishery is known to catch Fraser River sockeye salmon, including late-run fish which contains the endangered Cultus Lake CU, when targeting pink salmon returning to the Fraser

River. The management systems in place typically requires all sockeye salmon to be returned (non-retention) when endangered or low abundance stocks are in the area as identified in the PSC regulatory announcements (PSC website); since 2006 the fishery has been allowed to retain pink and sockeye together for 6 days (2011). Due to the highly selective nature of the reefnet fishery, the live release of sockeye salmon during pink salmon fisheries, and the low post-release mortality rate (0.45%) (NRC 1995), Seafood Watch considers the impact on sockeye salmon from the reefnet fishery targeting pink salmon to be a Very Low conservation concern.

Fraser River Coho Salmon

Factor 2.1 Inherent Vulnerability: Medium
Key relevant information:
Coho salmon have a vulnerability score of 53 on FishBase (Froese & Pauly 2012).

Factor 2.2 Stock status: Very High Concern
Key relevant information:
The Interior Fraser coho management unit (MU), one of two coho MUs in the Fraser River watershed, is listed as endangered by the COSEWIC.

Detailed rationale (optional):
The Fraser River Coho is managed through two management groups, Interior Fraser Coho (IFC) and Lower Fraser Coho (LFC). The IFC was listed as endangered by COSEWIC in 2002 following a decline in abundance of ~60% over a timescale of 3 generations (in line with IUCN criteria) (DFO, 2006). Since the designation by COSEWIC, there has been a gradual improvement in the health of the IFC management unit and its individual CUs. Abundance has increased above the initial spawning target of 20,000-25,000 wild spawners (DFO, 2006). There is concern, however, that at current levels of fishing exploitation and marine survival, it is unlikely that the stocks will reach target benchmarks (which vary dependent on the model used). Marine survival is a critical factor, and if fishing mortality were reduced to 0% there would be little impact on the recovery potential of IFC if current low survival rates persist (DFO 2006).

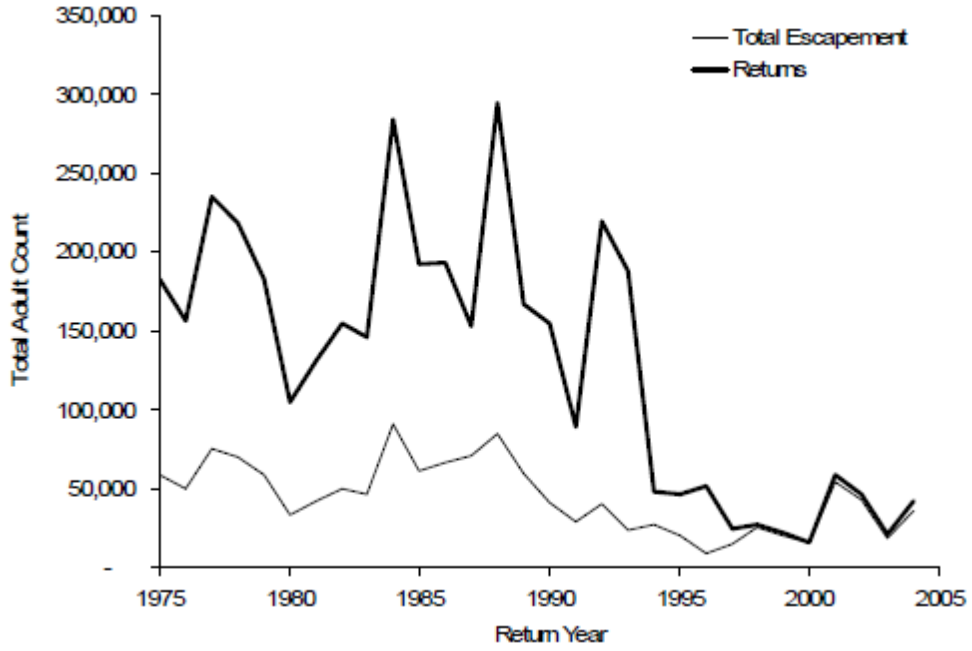
The most recent stock assessment for Fraser River coho is for the 2004 return year and shows that the returns (calculated as escapement plus catch) and escapement of IFC has increased in recent years, although it is still below historic highs (figure 8). The Fraser River coho stocks are supplemented by artificially produced fish, and although there is some management separation of wild and supplemented fish (for example, escapement targets as described by DFO 2006); there is a lack of separation within the stock assessments. When combined with the age of the most recent stock assessment, with nearly a 3 generation gap since the last assessment, it is very difficult to establish an accurate determination of the current Fraser River coho stock health. The COSEWIC listing of Interior Fraser coho therefore dominates the decision making process.

Factor 2.3 Fishing mortality: Very Low Concern
Key relevant information:

The reefnet fishery can only retain hatchery origin fish, with wild fish being returned alive (with a 0.45% mortality rate, NRC 1995).

Detailed rationale (optional):
Only hatchery origin fish may be retained, which are differentiated from wild fish by clipped adipose fins and/or coded wire tags (CWT). Overall, exploitation rates (for all US and Canadian fisheries) on Interior Fraser River coho have been between 4% and 9% since 1998 (DFO 2006) as management measures have been implemented to try to reduce fishing mortality on this endangered MU. While there is no definitive data available to assess the contribution of the reefnet fishery to the overall fishing mortality, it is highly likely that the fishery is only a minor contributor. The high selectivity of the reefnet gear allows all wild coho to be returned as directed by management measures.

Figure 8: Return and escapement of Interior Fraser River coho salmon from 1975 to 2004. From DFO (2006).



Puget Sound Salmon

There is a possibility that Puget Sound salmon populations are encountered and landed during the reefnet fisheries targeting Fraser River sockeye and pink salmon. There is no data available to identify these populations; therefore, they have been scored as though they were unknown stocks.

Factor 2.1 Inherent Vulnerability: Medium
Key relevant information:

Inherent vulnerability of unknown finfish species is considered to be medium according to the Seafood Watch Criteria Document (Seafood Watch 2012).

Factor 2.2 Stock status: Moderate Concern

Key relevant information:

The stock status of Puget Sound salmon is unknown as the individual stocks cannot be identified.

Detailed rationale (optional):

It should be noted that there are some endangered and threatened populations of salmon in Puget Sound that may be encountered by the reefnet fishery, namely Puget Sound Chinook and summer-run Hood Canal chum salmon. These populations have not been scored as part of this criterion as there are regulations in place which ensure that only hatchery reared Chinook may be retained and that all chum must be released prior to 30th September (WDFW 2011). Due to the low post-release mortality of reefnet caught fish, Seafood Watch does not believe that the reefnet fishery has any impact on these populations.

Factor 2.3 Fishing mortality: Moderate Concern

Key relevant information:

The impact of the reefnet fishery on the Puget Sound salmon populations is unknown because the populations themselves cannot be identified.

Chinook Salmon

Factor 2.1 Inherent Vulnerability: High Concern

Key relevant information:

FishBase vulnerability score is 68 (Froese & Pauly 2012).

Factor 2.2 Stock status: High Concern

Key relevant information:

The Fraser River Chinook population is exhibiting decreasing escapement in some aggregates, with a lack of benchmarks for the majority of stocks. The influence of artificially produced fish is unknown. Chinook also has a high vulnerability to fishing pressure.

Detailed rationale (optional):

The Fraser River watershed contains the largest Chinook population in Canada (CTC 2012) with individual stocks which are grouped into the following aggregates for management purposes:

- Fraser Spring run Age 1.3
- Fraser Spring run Age 1.2
- Fraser Summer-run Age 1.3
- Fraser Summer-run Age 0.3
- Fraser Late

The Fraser Spring run Age 1.3 aggregate has shown a general decrease over the last decade to an escapement of 18,061 in 2010 (PSC, 2012c) having peaked at around 50,000 in 1994. The Fraser Spring run Age 1.2 aggregate escapement has fluctuated around 5,000 individuals in recent years, with 6,576 individuals in 2010 (PSC, 2012c); escapement for this aggregate peaked in the mid-1990s and early 2000s and has since decreased, although current levels are similar to those in the 1970s and 1980s. The Fraser Summer-run Age 1.3 has also experienced decreasing escapement to levels similar to the 1970s and 1980s, at between 10–20,000 individuals. There are no approved benchmarks for these stock aggregates, although work is underway to develop thresholds to aid management of these stocks.

The Fraser Summer-run Age 0.3 aggregate has seen increasing escapements over the last 15 years from between 20–30,000 individuals to a record high of 157,274 in 2010 (PSC, 2012c). As with the aggregates above, there are no Chinook Technical Committee (CTC) recognized benchmarks for this aggregate. The Fraser Late aggregate includes the Harrison Lake stock, which is one of the most abundant Chinook stocks in the Fraser watershed. Total aggregate escapements in 2010 were in the region of 190,000 individuals, of which 103,515 were from the Harrison Lake stock. A benchmark range has been established for the Harrison Lake stock at 75,100 to 98,500 fish. The benchmark range was exceeded in 2010, which has happened on nine occasions since 1984. Escapement of Fraser Late and Harrison Lake sockeye fluctuates widely without trend (PSC, 2012c). It should be noted that the vast majority of Chinook from the Fraser River watershed are contained within the Summer-run Age 0.3 and the Late aggregates.

The Fraser River Chinook population is supplemented by artificially produced fish, specifically introduced into the Chilliwack River using Harrison-origin fish. Stock assessments do not differentiate between wild and artificially produced fish and as such the state of wild stocks is unknown.

Factor 2.3 Fishing mortality: Very Low Concern
Key relevant information:
The reefnet landings of Chinook are low as indicated in table 1 (decadal high of 11 fish in 2011), and only artificially produced Chinook can be retained (wild fish are returned alive) (WDFW 2011) so there is minimal impact on the wild population.

Chum Salmon

Factor 2.1 Inherent Vulnerability: Medium
Key relevant information:
Chum salmon has a vulnerability score of 49 on FishBase (Froese & Pauly 2012).

Factor 2.2 Stock status: Moderate Concern
Key relevant information:

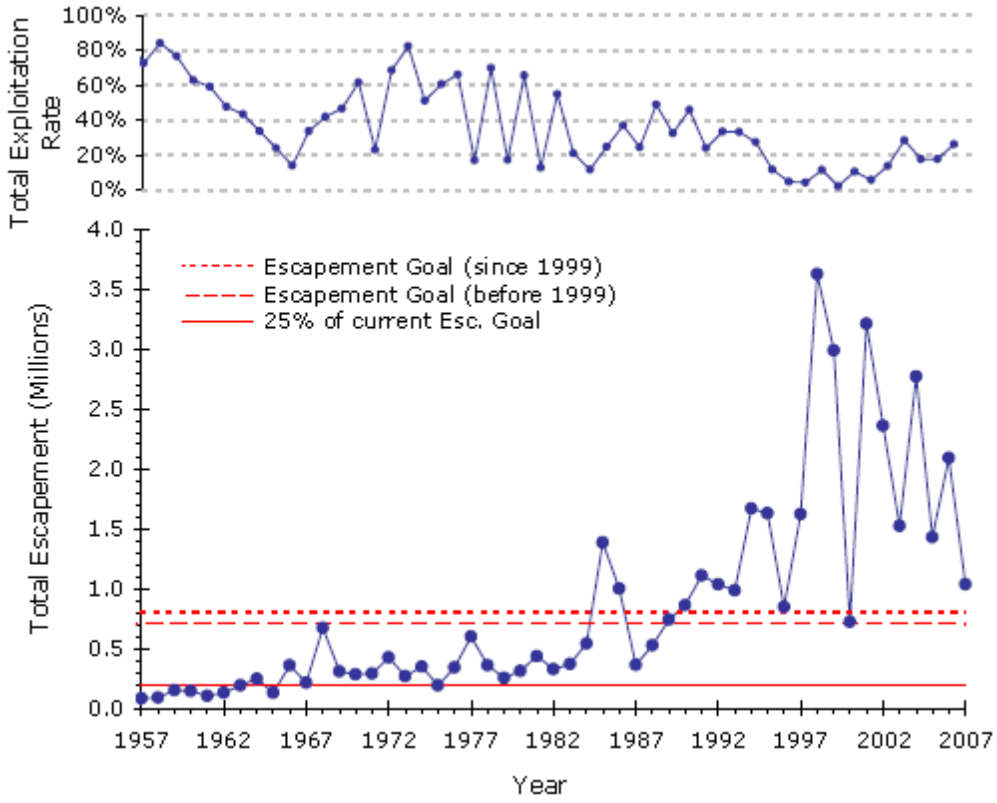
The Fraser River chum salmon population is supplemented with artificially produced fish and, due to a lack of specific management, the health of the wild population cannot be accurately determined.

Detailed rationale (optional):
The Fraser River chum salmon population has increased over recent years (see figure 9, Intertek Moody Marine 2013) from a historical average of 600,000 from 1953 to 2000, to an average of 2 million between 2001 and 2007 (Grant & Pestal 2009), although in 2009 escapement dropped below the benchmark (800,000) for the first time since the year 2000 to a level of 619,686 (PSC 2011b). These figures include both wild chum populations and artificially produced fish, with no separation of numbers allowing an assessment of the wild population. Although it is not possible to accurately determine that the wild population is healthy, the recent average is still much higher than the historical average and the escapement benchmark of 800,000 fish.

Factor 2.3 Fishing mortality: Low Concern
Key relevant information:
Overall abundance is fluctuating around the escapement goal (PSC 2011b), suggesting that current cumulative fishing mortality is at or above a sustainable level. While the reefnet fishery contributes only a small volume to overall fishing mortality, as chum are targeted, to some degree, the fishery is considered a contributor to overall mortality.

Detailed rationale (optional):
The US catch of Fraser River system chum salmon is restricted to a maximum of 130,000 fish in areas 7 and 7A (the areas in which reefnet fisheries take place). In 2009, the overall return of chum to the Fraser System was an estimated 1.175 million fish, reaching the upper threshold allowing the maximum number of fish to be taken by the US. Reefnet catch of chum salmon in 2009 was 2,859 (PSC 2011b), representing a fishing mortality of 0.24% for the reefnet fishery. Such a small level of fishing effort is unlikely to have a negative impact on the stock, however, as abundance is fluctuating around the escapement goal, cumulative fishing mortality is likely to impact the population in some way.

Figure 9: Trends in escapement and exploitation rate of Fraser River Chum salmon from 1957-2007. From Intertek Moody Marine 2013.



Factor 2.4 Overall discard rate

Key relevant information:

The discard rate for the reefnet fishery is considered low and scored accordingly. While non-target species may be caught at any given time, the fish are returned alive; and a study by Natural Resources Consultants (NRC) (1995) has shown that average salmonid mortality rate was 0.45%.

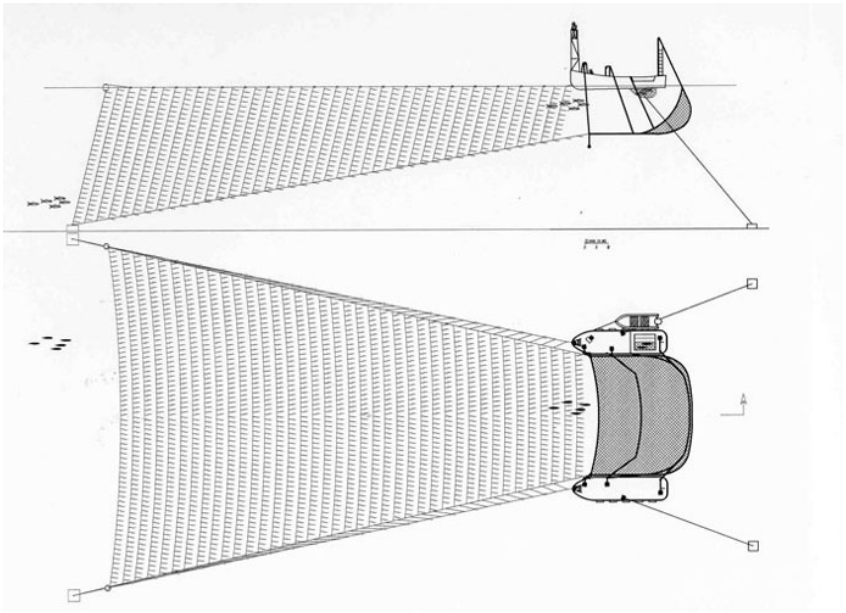
Detailed rationale (optional):

The reefnet fishing method is a highly selective fishing method in that all fish are landed live with minimal damage and can be returned to the water alive. Figure 10 illustrates the reefnet fishing technique, and demonstrates the static nature of the fishing gear. The reefnet fishing method is successful due to the migratory nature of salmon. In the reefnet fishery, vessels

work in pairs and are moored to the bottom, fishing statically. From the vessels, two artificial reefs (consisting of vertical lines with artificial seaweed connected to them to create barriers – see figure 10) are extended which are used to corral the migrating salmon towards a net suspended between them. A lookout is positioned at the top of a tower on one of the vessels, and when the migrating salmon are seen to be above the liftnet, it is raised, capturing the fish in a net enclosure. Fish are then removed from the enclosure and those which can be retained are held in a holding net beneath the vessel, while non-target species are returned unharmed.

A study has shown that the mortality rate of fish returned to the sea from the reefnet fishery is 0.45% (1 coho salmon mortality was observed from 214 coho and a total of 224 finfish caught and returned), illustrating that this ancient method of fishing has a very low impact on non-target stocks and species (NRC 1995).

Figure 10: Diagram of the reefnet fishing gear used to catch salmon off the coast of Lummi Island, Washington. Courtesy of Lummi Island Wild Co-operative.



Criterion 3: Management effectiveness

Guiding principle

- The fishery is managed to sustain the long-term productivity of all impacted species. Management should be appropriate for the inherent vulnerability of affected marine life and should incorporate data sufficient to assess the affected species and manage fishing mortality to ensure little risk of depletion. Measures should be implemented and

enforced to ensure that fishery mortality does not threaten the long-term productivity or ecological role of any species in the future.

Fishery	Management: Retained Species Rank (Score)	Management: Non-retained species Rank (Score)	Criterion 3 Rank Score
Washington Reefnet	Moderate (3)	Excellent (5)	Green 3.87

Fishery	Critical?	Mgmt strategy and implement.	Recovery of stocks of concern	Scientific research and monitoring	Scientific advice	Enforce.	Track record	Stakeholder inclusion
Washington Reefnet	No	Moderately Effective	Moderately Effective	Highly Effective	Moderately Effective	Highly Effective	Moderately Effective	Highly Effective

Fishery	All Species Retained?	Critical?	Mgmt strategy and implement.	Scientific research and monitoring	Scientific advice	Enforce.
Washington Reefnet	No	No	Highly Effective	Highly Effective	Highly Effective	Highly Effective

Synthesis

Management of the reefnet fishery is part of a complex bilateral management system formed between the US and Canada through the PST (2009). The fishery harvests in the waters of Washington State; however, the fish being targeted are headed for the Fraser River in British Columbia, Canada. Conservation goals for these stocks are set by the DFO, and the fisheries are managed bilaterally, through the PST in order to meet these conservation goals, which include the seasonal opening of fisheries and the setting of TACs. Stocks are protected from overharvesting–using real-time data collected and reviewed on a twice-weekly basis–through restrictions on fishing activities throughout the season. There are concerns over a number of stocks caught in Washington State waters, including stocks within the reefnet fishery; however, on the whole, management restricts fishery impacts on these stocks as much as is practicable. Indeed, in many cases a fishing mortality of zero would not allow the recovery of the stocks of concern because factors such as marine and/or freshwater survival are dictating salmon abundance at the present time.

Justification of Ranking

Factor 3.1 Management of fishing impacts on retained species: Moderate Concern

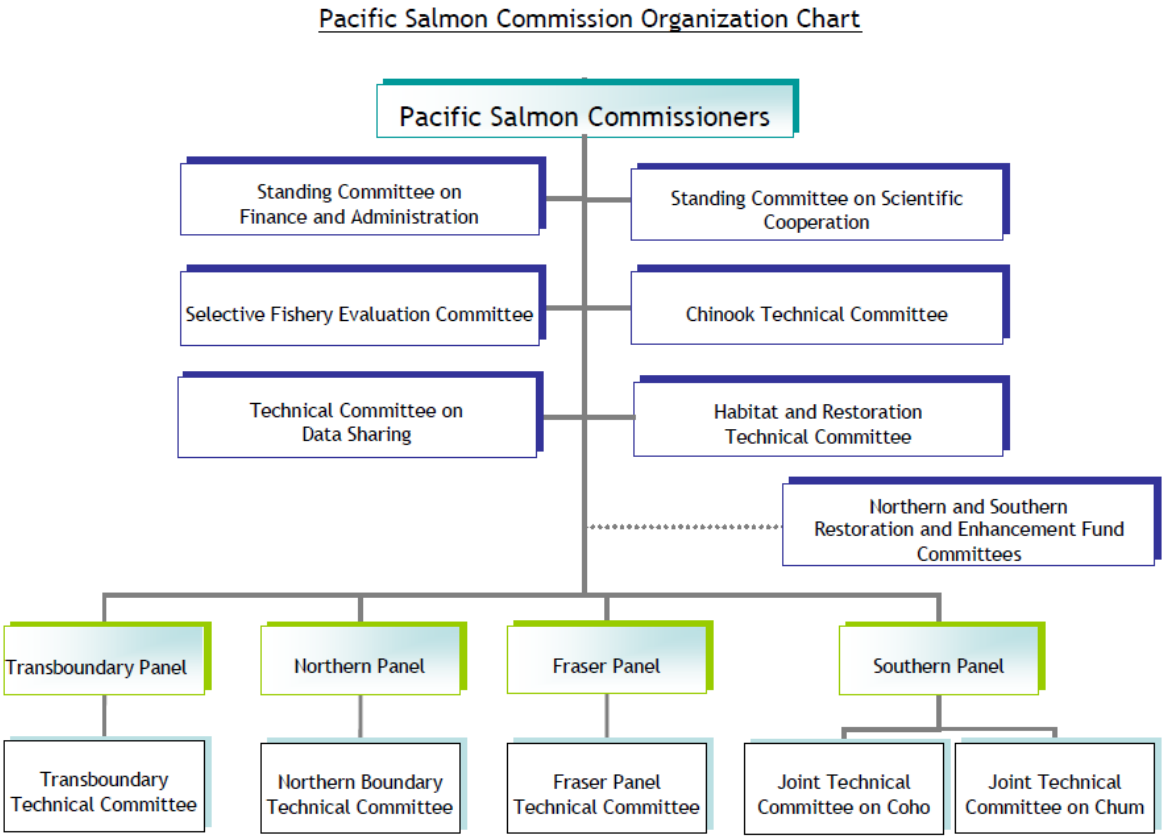
Key relevant information:
Management of the retained species is deemed to be moderate. The fishery is managed through a complex bilateral system, which aims to protect low abundance stocks while allowing exploitation of healthy stocks. There are significant challenges with the management of Fraser River salmon fisheries, however, the scale of the reefnet fisheries and the selectivity of the fishing gear suggest that many of the wider management concerns, such as capture and mortality of co-migrating stocks of species of concern, are reduced for this fishery.

Detailed rationale:
The management system in which the reefnet fishery operates is complex with a number of different layers of management and it is important to understand the overarching system in order to effectively understand the management in the context of the reefnet fishery.

The reefnet fishery is an interception fishery operating in Washington State waters targeting fish migrating towards the Fraser River watershed in British Columbia, Canada. Salmon stocks, which are targeted by both US and Canadian fishers, are managed through the PST (2009) in order to ensure that harvest levels are set appropriately and that depleted or at risk stocks can recover. The Pacific Salmon Commission (PSC) and its various panels, formed by the Canadian and United States governments to implement the PST, provide regulatory advice and recommendations to the two countries. The PSC oversees management for all salmon that originate in one country but are caught in another through interception fisheries, such as Fraser River salmon caught in the reefnet fisheries of Washington. The PSC has two major roles to fulfill: to conserve Pacific salmon in order to achieve optimum production, and to allocate the catch between the US and Canada to ensure that each party is able to reap the benefit of their investment (through conservation) into the management of the fishery. Effectively, the PSC is a forum which enables each country to resolve the complex issues involved with the management of salmon fisheries.

In order to ensure that the mandate of the PSC is fulfilled, the following protocol is used. Each country will provide the commission with technical data on their fishing activities, pre-season abundance estimations and stock enhancement activities. This information is then analyzed by the relevant technical committee (figure 11), which will report to the appropriate panel. The panel will then provide the commissioners with proposed fishery plans and recommendations. Once the plans and recommendations have been agreed by the PSC, they are sent to the Canadian and US governments for regulatory implementation (http://www.psc.org/).

Figure 11: Organizational chart of the Pacific Salmon Commission. From the PSC website



Management of the reefnet fishery is the responsibility of WDFW, with recommendations concerning TACs and seasonal openings being made by the Fraser River Panel (for pink and sockeye salmon fisheries). The Southern Panel reviews annual management plans (for Chinook, chum and coho salmon fisheries) for consistency with the terms of the relevant annexes of the PST.

The PST places the greater burden of conservation of the salmon stock and its management on the country of origin for any particular stock. The Fraser River fish being caught by the reefnet fishery are therefore the responsibility of Canada and, ultimately, the DFO. The FRP ensures that all fisheries targeting Fraser River sockeye and pink salmon are conducted in a way that will enable conservation goals to be met. The FRP reviews fisheries proposed by the US and Canada within the panel area and determines TACs based on pre-season abundance estimates and conservation goals. US fisheries are managed such that the US TACs set by the FRP are not exceeded. Where abundance estimates are low, such that it is likely that conservation goals can only be met through a moratorium on all commercial, and/or tribal, and/or recreational

fishing, fisheries will remain closed (fisheries remain closed by default unless expected abundances exceed escapement targets).

Management Strategy and Implementation: **Moderately Effective**
The Fraser River Panel (FRP) manages the pink and sockeye salmon fisheries, with respect to season openings and allocation of allowable catch, in the panel area in accordance with the following hierarchy of objectives (PSC 2012a):
1: Achieve spawning escapement targets for Fraser River pink and sockeye salmon that are set by Canada.
2: Achieve targets for international sharing of the TAC as defined by the Pacific Salmon Treaty or by agreement among the Parties.
3: Achieve domestic catch allocation goals within each country.

When working to meet these objectives, the FRP is also required to consider the conservation concerns of other stocks and species of salmonids (PST 2009). The management system is extremely fluid and capable of reacting to real-time data collected in-season through test fisheries, escapement counts etc. As a result, pre-season estimates can be adjusted in-season and fishing effort altered accordingly. For example, in 2007 the returns of sockeye were much lower than anticipated, resulting in closure of the majority of fisheries. While pink salmon returns were also lower than expected, they were of sufficient abundance to allow fishing to proceed; however, due to concerns over co-migrating sockeye stocks, fishing activities were limited (PSC 2012a). The reefnet fishery, due to the high selectivity of the gear, was able to proceed with a pink-targeted fishery with any sockeye being returned alive when directed.

The ability to react quickly to changes given the abundance of different management groups and to restrict species retained in the reefnet fishery with minimal impact on non-target species demonstrates a successful and precautionary management strategy. There are some concerns arising from the failure to meet escapement targets, however, these are generally due to poor returns or high en route mortality rather than to fishing intensity, i.e. even with minimal fishing mortality (through test fisheries only) escapement targets cannot be met (PSC 2012a). There are concerns over separating out stocks of concern within the same species, for example: Cultus Lake sockeye from other Late run stocks illustrates that there is still room for improvement in the management of Fraser River fisheries.

WDFW has a suite of management measures which are used to ensure the sustainable exploitation of salmon in Puget Sound, including the reefnet fishery. Commercial fishing can only take place with a license, a cap on which was introduced in 1974.Since then, no new licenses have been issued, only renewals (WDFW 2011). In order to ensure that non-target species can be returned unharmed (by all non-treaty fishing gears), non-treaty fishers working in areas 7 and 7A are required to take a course of safe fish release (Fish Friendly Certificate) (WDFW 2011). Recovery pens are also required to be used by gillnet fishermen to ensure that any fish returned to the water have recovered following the stresses of the capture process. The latter example takes place as a matter of course in reefnet fisheries as the fish are held in

net pens beneath the vessel. The target and non-target fish can be separated easily due to behavioral differences in response to being contained within the net, with non-retained fish being returned while retained fish are bled and placed on ice. WDFW also has restrictions on the sale and transport of salmon caught in Puget Sound to ensure traceability and accurate recording of catch data, and has gear specifications which must be met by reefnet fishermen.

Recovery of stocks of concern: **Moderately Effective**
There are a number of stocks of concern that could potentially be affected by the reefnet fishery, as all five species of Pacific salmon are encountered by the fishery to some degree (although it is evident from table 1 that Chinook landings are negligible). Four- and five-year old stream-type Chinook in the Fraser River were considered to be from stocks of concern for the 2011 season (DFO 2011). In order to protect these stocks, the reefnet fishery is not permitted to retain wild Chinook at any time of the year, and it is only able to retain Chinook of hatchery origin (marked by removal of the adipose fin) prior to October 1st (WDFW 2011, Adicks pers. comm. 2012). The vulnerable Chinook stocks are very minimally affected by the reefnet fishery.

The Interior and Lower Fraser River coho MUs are also considered stocks of concern and are likely to be encountered by the reefnet fishery while targeting pink salmon and/or late-run sockeye. The management requirements for fisheries targeting southern British Columbia, Washington and Oregon coho are laid out in Chapter 5 of the appendix to annex IV of the PST (2009). Maximum allowable exploitation rates on Fraser River coho are set at 10% for US fisheries when abundance is considered to be low (PST 2009), although a reduction can be requested by Canada in order to meet conservation targets. In 1998, the DFO established a goal of zero fishing mortality (from Canadian fisheries) on the Thompson River coho (a stock of the Interior Fraser MU), which has remained a target to present day. Exploitation rates on Interior and Lower Fraser coho remain low following the decreases initiated in 1997. There are still concerns over the recovery of Fraser River coho stocks, however, these are believed to be outside of fisheries management, for example, poor marine survival. It is believed that even with a zero fishing mortality across the whole population, some concerns over long-term productivity would remain (IFC Recovery Team 2006). Regulations prohibit the reefnet fishery from landing wild Fraser River coho, with only hatchery marked coho being retained. With the low post-release mortality associated with the reefnet fishery (NRC 1995), such management measures are able to protect species/stocks of concern.

The Cultus Lake sockeye CU is considered as endangered by COSEWIC. As described previously, the FRP management system is effective at avoiding species or management units of concern by restricting fishing activities, for example, the closure of fisheries until Early Stuart sockeye escapement goals have been reached or the run has passed. There are concerns, however, with management of stocks of concern where they co-migrate with more abundant stocks of the same species, for example, Cultus Lake sockeye stocks migrating with Harrison Lake sockeye within the Late-run management group. Different stocks of the same species that migrate within the same management group are likely to be encountered at the same time; however, they can only be distinguished genetically. As a result, there is a possibility that, even in low

impact, selective fisheries where fish can be returned alive, stocks of concern may be harvested alongside more abundant stocks (English et al. 2011).

While in theory, the management plans used by FRP to manage the sockeye fisheries should protect stocks of concern, according to the primary objective of attaining escapement goals for each stock, there is evidence to suggest that, in some cases, escapement goals are not met due to fishing activities being permitted in order to harvest more abundant, co-migrating stocks. In 2010, the return of sockeye was much higher than previous years, providing managers the opportunity to open the fisheries. As fisheries targeted the more abundant stocks, Cultus Lake stocks were also caught, increasing the fishing mortality on this stock above target levels (20%–30%) (Intertek Moody Marine 2011b). The DFO clearly state in their Fishery Management Plan that the Cultus Lake CU is managed as part of the Late-run management group in such a way that exploitation is increased to allow harvesting of more abundant CUs (DFO 2011). There appears to be clear conflict within DFO policy documents, between the need to recover the Cultus Lake CU and the need to satisfy social and economic needs by allowing increased harvesting of the Late-run management group.

Concerns for the Late-run management group, as a whole, have been raised in recent years due to a change in migration timing and a related increase in pre-spawning and en route mortality (DFO 2011). The early migration has led to increased difficulties with management of stocks of concern. Firstly, there is an increased en route mortality associated with this early migration. Prior to 1996, when the early migration started, en route mortality rarely exceeded 20%; however, by 2001 this had increased to 90%–96% for many stocks (Cooke et al. 2004). In order to meet spawning escapement targets, much higher numbers of returning salmon are required when considering this increased mortality. The early migration also creates an increased overlap with other run-timing groups, creating complications for the protection of stocks of concern and exploitation of abundant stocks.

Concerns over the Cultus Lake CU are acknowledged within the scope of this report, alongside the positive management measures that are in place and successfully protect other species/stocks of concern from being negatively impacted by the reefnet fishery. Overall, the management system is considered to be moderately successful at recovering species/stocks of concern.

Scientific Research and Monitoring: **Highly Effective**

There is a significant effort on the part of the PSC, FRP, the DFO and WDFW to collect data to guide the management of the Fraser River pink and sockeye fisheries. Annually, pre-season recommendations are formulated using information on abundance, timing and migration route forecasts, international and domestic catch allocation goals, management needs for stocks/species of concern, and historic patterns in migration and fisheries dynamics (PSC 2012a&b). Data are continually gathered through test fisheries (which includes the reefnet fishery), fish counters and direct observation throughout the season in order to estimate real-time salmon abundance for different species and management groups, and catch records are collected to ensure catches are within TACs. This data enables fishery managers to make real-

time adjustments to escapement targets and exploitation rates according to the abundance of salmon at any given time (PSC 2012a&b). The models used to develop abundance and escapement estimates, both pre- and in-season, are considered to be state-of-the-art with respect to the management of salmon fisheries (English et al. 2011). While there are some areas where data is not gathered extensively, for example pink salmon spawning escapement, estimations are made using indicator stocks, and these are for management groups that are considered abundant and therefore of least conservation concern (PSC 2012a). With finite resources, only so much can be achieved, and by ensuring data collection is concentrated on stocks of greatest concern, the chance of successful management is increased. Several academic institutions also study a variety of aspects around salmon populations and fisheries in the Pacific Northwest, including research into the early migration of late-run sockeye and the impacts (or potential impacts) of climate change (Morrison et al. 2002, Rand et al. 2006, Adkison et al. 2007, Cooke et al 2012, Hinch et al. 2012).

Scientific Advice: **Moderately Effective**

Scientific advice on stock abundance forecasts, anticipated escapements, and other fishery related information is provided to the FRP by Canada, the US, and PSC staff. Pre-season and in-season information provided to the FRP include escapement targets, abundance forecasts, run-size estimates, run-timings, migration forecasts and diversion rates, which enable the FRP to apply management measures. As conservation of stocks to ensure a long-term sustainable fishery is the primary objective of salmon management under the PST, the forecasts and escapement targets provided by Canada will generally form the basis of the management plans put forward by the panel for adoption, consistent with the terms of Chapter 4 of the treaty. PSC staff can make recommendations for further additions to escapement targets, which will be adopted by the FRP unless both national sections disagree with the recommendations. Such decisions are rare and have happened on only a handful of occasions since 2002 (during which time several hundred management decisions were made) (Lapointe, pers. comm.2012). It is therefore determined that the FRP follow the scientific advice provided to them in the majority of occasions. Evidence of continued exploitation of endangered and threatened stocks prevents the highest score from being achieved.

Enforcement: **Highly Effective**

The Washington Department of Fish and Wildlife enforces non-treaty Fraser River salmon fisheries through patrols, often through cooperation with the NOAA, which look to ensure that fisheries regulations are being adhered to (Adicks pers. comms. 2012). This includes the handling of bycatch, gear restrictions, and the retention of different species. Enforcement officers also visit fish buyers and merchants to ensure compliance with fish reporting regulations. There is an observer program which looks to assess bycatch of non-target species. Due to the small scale, high selectivity of the reefnet fishery, and the high survival rate of returned fish (NRC 1995), observer coverage is concentrated on gillnet and purse seine fisheries. There is little (if any) evidence of illegal, unreported, and unregulated fishing (IUU) within the reefnet sector (Adicks, pers. comm. 2012; Lapointe, pers. comm. 2012).

Track Record: **Moderately Effective**

With the exception of the Cultus Lake CU, the remaining sockeye CUs and the pink salmon population have been protected from over exploitation by fishing activities within the reefnet fishery. The sockeye returns, in the last decade in particular, have been low relative to historical returns and escapement targets, and management measures have protected the low abundance stocks by keeping fisheries closed when the particular stocks are moving through an area. The selectivity of the reefnet fishery allows this fishery to be opened to target other species when abundances are low, helping to ensure that escapement targets are met. Where abundances have not improved significantly, it is likely due to poor marine or freshwater survival, rather than over exploitation (Bradford et al. 2011). The DFO is investigating causes of poor marine and freshwater survival, and how to regenerate critical habitats and aid recovery of stocks. Continued exploitation of the endangered Cultus Lake stock prevents management from receiving the highest score for track record.

Stakeholder inclusion: **Highly Effective**
There is a high level of stakeholder involvement during the pre-season planning and the in-season management for the salmon fisheries in Washington State and those fisheries targeting Fraser River stocks in both Canada and the US. The FRP includes representatives from a wide range of stakeholder groups, including commercial fishermen (using a variety of different gear types), state management (e.g WDFW), national management (e.g. NMFS, DFO), processors and treaty/aboriginal fishers (PSC 2012b, WDFW 2012). The FRP meets twice a week during the summer in order to discuss potential changes to fishing regulations required to effectively manage the fisheries. The stakeholder involvement is, therefore, considered to be highly effective.

Factor 3.2 Management of fishing impacts on bycatch species: Very Low Concern

Key relevant information:
The Lummi Island reefnet fishery has minimal bycatch due to the highly selective fishing method. Any non-target species which are caught are returned alive with a post-release mortality rate of 0.45% (NRC 1995). The management system in place allows the real-time update of which species can or cannot be retained within the multi-species salmon fishery, and with such a low mortality rate, the impact on non-target species is minimal.

Detailed rationale:
Management Strategy and Implementation: **Highly Effective**
As mentioned under Criterion 3.1 (above), the management of salmon likely to be encountered by the reefnet fishery is highly adaptive, using in-season test fisheries to determine abundance estimates for the different salmon stocks. The use of real-time data allow managers to specify which species can be targeted by which gears on any given day. The FRP meets twice a week to examine data and determine which fisheries can be opened. The high selectivity of the reefnet fishery enables the fishery to be opened for abundant species when co-migrating runs of less abundant species prevent other fisheries from being opened. For example, in 2007, Fraser River sockeye abundance was below targets and could not be retained, however, pink salmon returns

were sufficient enough to allow retention, and selective fisheries such as the reefnet fishery were opened to allow harvest of pink salmon with the release of all sockeye.

There are some populations/stocks of salmon encountered by the reefnet fishery that are considered as stocks of concern, for example Interior Fraser River coho and Fraser River Chinook. In order to prevent over exploitation of these populations, the reefnet fishery is restricted to allow only the retention of hatchery origin fish for these species during the migration of the stocks of concern. Hatchery origin fish are identified by clipped adipose fins and/or coded wire tags (CWT). Effective management coupled with the high selectivity and low post-capture mortality rates of the reefnet gear allow minimal impact on stocks of concern.

Scientific Research and Monitoring: **Highly Effective**
See 3.1

Scientific Advice: **Highly Effective**
Management of the reefnet fishery prevents the removal of non-target species until escapement targets have been met. In cases where abundances have been reduced over longer time periods, for example interior Fraser River coho and Fraser River Chinook, only marked hatchery origin fish are permitted to be retained; wild fish are returned with minimal post-release mortality (NRC 1995).

Enforcement: **Highly Effective**
See 3.1

Criterion 4: Impacts on the habitat and ecosystem

Guiding principles

- The fishery is conducted such that impacts on the seafloor are minimized and the ecological and functional roles of seafloor habitats are maintained.
- Fishing activities should not seriously reduce ecosystem services provided by any fished species or result in harmful changes such as trophic cascades, phase shifts or reduction of genetic diversity.

Fishery	**Gear type and substrate** Rank (Score)	**Mitigation of gear impacts** Rank (Score)	**EBFM** Rank (Score)	**Criterion 4** Rank (Score)
Washington Reefnet	None (5)	N/A	Moderate Concern (3)	Green (3.87)

Justification

Factor 4.1 Impact of the fishing gear on the substrate

Key relevant information:
The reefnet does not come into contact with the seabed and therefore impact on the substrate is considered negligible (see diagram in figure 10).

Detailed rationale:
The reefnet vessels are seasonally anchored to permanent moorings placed on the seabed. While there may be a minimal initial impact to the seabed when these moorings are laid, the activity of fishing does not add to this impact and Seafood Watch therefore considers the fishery to have negligible impact on the seabed.

Factor 4.2 Modifying factor: Mitigation of fishing gear impacts

Key relevant information:
N/A

Detailed rationale:
N/A

Factor 4.3 Ecosystem and Food Web Considerations: Moderate Concern

Key relevant information:
Salmon are the only keystone species that are caught or affected directly by the reefnet fishery. There are some management measures in place which take account of ecosystem effects, however there are knowledge gaps which need to be filled in order for management to be effective at an ecosystem level.

Detailed rationale (optional):
Salmon are now considered to be a keystone species (or family), particularly in the Pacific Northwest where their annual migrations upstream transfer nutrients from the marine environment to the freshwater environment, and their death following spawning allows the transfer of nutrients to the terrestrial environments (through predation and scavenging by terrestrial animals) (Willson & Halupka 1995; Willson et al. 1998, Cederholm et al. 1999, Helfield & Naiman 2006, Scheuerell et al. 2007).

The need to manage salmon fisheries through ecosystem based management systems is becoming clear. The current management system takes ecosystem effects into account through conservation and recovery programs (Cultus Sockeye Recovery Team 2005, DFO 2011), which include the protection of critical freshwater habitats, and recognition of the importance of salmon to nutrient transfer. In this context, management is scored as moderate, as there continues to be a lack of knowledge and understanding of the role of salmon within the ecosystem, and it is therefore likely that current management is insufficient from an ecosystem perspective, and there are continued concerns over the decline of some CUs which will have an impact on the ecosystems at a local level.

Overall Recommendation

The overall recommendation for the fishery is as follows:

- **Best Choice** = Final score ≥ 3.2 **and** scores for Criteria 1, 3 and 4 are all ≥ 2.2 **and** Criterion 2 *subscore* ≥ 2.2

- **Some Concerns** = Final score ≥ 2.2 **and** Criterion 3 ≥ 2.2 **and** **(**Final score ≤ 3.2 **or** scores for Criteria 1 &4 ≤ 2.2 **or** Criterion 2 *subscore* ≤ 2.2)

- **Red**= Final score < 2.2 **or** score for Criterion 3 < 2.2 **or** any one criterion has a critical score **or** two or more of the following are < 2.2: Criterion 1 score, Criterion 2 *subscore*, Criterion 4 score

Stock	Fishery	Impacts on the Stock Rank Score	Impacts on other Species Lowest scoring species Rank*, Subscore, Score	Manage-ment Rank Score	Habitat and Ecosystem Rank Score	Overall Recommendation Score
Early Summer-run Fraser River Sockeye	Washington Reefnet	Green 3.83	Puget Sound Salmon Yellow, 2.64,2.64	Green 3.87	Green 3.87	**BEST CHOICE** **3.51**
Fraser River Pink Salmon	Washington Reefnet	Green 4.47	Fraser River Coho Salmon, Late-run Fraser River Sockeye Yellow, 2.24,2.24	Green 3.87	Green 3.87	**BEST CHOICE** **3.5**
Late-run Fraser River Sockeye	Washington Reefnet	Red 1.53	Fraser River Coho Salmon Yellow, 2.24,2.24	Green 3.87	Green 3.87	**GOOD ALTERNATIVE** **2.68**
Summer-run Fraser River Sockeye	Washington Reefnet	Green 3.83	Late-run Fraser River Sockeye Red, 1.53,1.53	Green 3.87	Green 3.87	**GOOD ALTERNATIVE** **3.06**

Acknowledgements

Scientific review does not constitute an endorsement of the Seafood Watch® program, or its seafood recommendations, on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

Seafood Watch® would like to thank three anonymous reviewers for graciously reviewing this report for scientific accuracy.

References

Aboutseafood.com - http://www.aboutseafood.com/about/about-seafood/top-10-consumed-seafoods

Adkison, M.D., Peterman, R.M., Lapointe, M.F., Gillis, D.M., & Korman, J. 2007. Alternative models of climatic effects on sockeye salmon, *Oncorhynchus nerka*, productivity in Bristol Bay, Alaska, and the Fraser River, British Columbia. *Fisheries Oceanography*. **5:**3-4. pp 137-152.

Bradford, M.J., Hume, J.M.B., Withler, R.E., Lofthouse, D., Barnetson, S., Grant, S., Folkes, M., Schubert, N., & Huang, A-M., 2011. Status of Cultus Lake sockeye salmon. *DFO Can. Sci. Advis. Sec. Res. Doc.* 2010/123. Vi + 44p.

Burgner, R.L., 1991. Life History of Sockeye Salmon. *In* Pacific Salmon Life Histories. Ed Groot, C., & Margolis, L. pp 1-118.

Cederholm, C.J., Kunze, M.D., Murota, T., & Sibatani, A., 1999. Pacific Salmon Carcasses: Essential Contributions of Nutrients and Energy for Aquatic and Terrestrial Ecosystems. *Fisheries*. **24:**10 pp 6-15.

Cooke, S.J., Hinch, S.H., Farrell, A.P., Lapointe, M.F., Jones, R.M.J., Macdonald, J.S., Patterson, D.A., Healey, M.C., & Van Der Kraak, G., 2004. Abnormal Migration Timing and High en route Mortality of Sockeye Salmon in the Fraser River, British Columbia. *Fisheries*. **29:**2 pp 22-33.

Cooke, S.J., Hinch, S.G., Donaldson, M.R., Clark, T.D., Eliason, E.J., Crossin, G.T., Raby, G.D., Jeffries, K.M., Lapointe, M., Miller, K., Patterson, D.A., & Farrell, A.P. 2012. Conservation physiology in practice: how physiological knowledge has improved our ability to sustainably manage Pacific salmon during up-river migration. *Philosophical transactions of the Royal British Society B: Biological Sciences*. **367**. pp 1757-1769

Cultus Sockeye Recovery Team, 2005. National conservation strategy for sockeye salmon (*Oncorhynchus nerka*), Cultus Lake population, in British Columbia. Recovery of Nationally Endangered Wildlife (RENEW). Ottoawa, Ontario, 49pp.

Department of Fisheries and Oceans, 2006. Recovery potential assessment for interior Fraser coho salmon (*Oncorhynchus kisutch*). Canadian Science Advisory Secretariat Science Advisory Report 2005/061.

Department of Fisheries and Oceans, 2011. Integrated Fisheries Management Plan: Salmon Southern B.C. June 1, 2011 to May 31, 2012. 268p

English, K.K., Edgell, T.C., Bocking, R.C., Link, M., & Raborn, S., 2011. Fraser River sockeye fisheries and fisheries management and a comparison with Bristol Bay sockeye fisheries. LGL Ltd. Cohen Commission Tech. Rept. 7: 190pp & appendices. Vancouver, B.C.

FIGIS - http://www.fao.org/fishery/statistics/global-capture-production/query/en

Froese, R., & Pauly, D., Editors. 2012. Fishbase. World Wide Web publication. www.fishbase.org

Google.com - https://maps.google.com/maps?hl=en

Grant, S., & Pestal, G., 2009. Certification Unit Profile: Fraser River Chum Panel. *Can. Man. Rep. Fish. Aquat. Sci.* 2874: vii + 40p.

Grant, S.C.H., MacDonald, B.L., Cone, T.E., Holt, C.A., Cass, A., Porszt, E.J., Hume, J.M.B., & Pon, L.B., 2011. Evaluation of Uncertainty in Fraser Sockeye (*Oncorhynchus nerka*) Wild Salmon Policy Status using Abundance and Trends in Abundance Metrics. *Canadian Science Advisory Secretariat Research Document* 2011/087: viii + 183p.

Heard, W.R., 1991. Life History of Pink Salmon (*Oncorhynchus gorbuscha*). *In* Pacific Salmon Life Histories. Ed. Groot, C., & Margolis, L., 1991. pp 119-230.

Helfield, J.M., & Naiman, R.J., 2006. Keystone Interactions: Salmon and Bear in Riparian Forests of Alaska. *Ecosystems*. **9** pp 167-180.

Henderson, M. A. & Graham, C. C., 1998. History and current status of Pacific salmon in British Columbia. North Pacific Anadromous Fish Commission Bulletin. 1: 13-22.

Hinch, S.G., Cooke, S.J., Farrell, A.P., Miller, K.M., Lapointe, M., & Patterson, D.A. 2012. Dead fish swimming: A review of research on the early migration and high premature mortality in adult Fraser River sockeye salmon *Oncorhynchus nerka*. *Journal of Fish Biology*. **81**:2. pp 576-599.

Hollowed, A. B., Hare, S. R., & Wooster, W. S., 2001. Pacific Basin climate variability and patterns of Northeast Pacific marine fish production. *Progress in Oceanography*. **49**. pp 257-282.

Holt, C.A., 2010. Will depleted populations of Pacific salmon recover under persistent reductions in survival and catastrophic mortality events? *ICES Journal of Marine Science.* **67** pp 2018-2026.
Intertek Moody Marine, 2010. The British Columbia Commercial Sockeye Salmon Fisheries. MSC Public Certification Report: Volume 1. iii + 204p.

Intertek Moody Marine, 2011a. British Columbia Pink Salmon (*Onchorhynchus gorbuscha*) Seine, Troll and Gillnet Fishery: British Columbia Coastal and Adjacent Canadian Pacific EEZ Waters. MSC Public Certification Report.

Intertek Moody Marine, 2011b. Surveillance Report British Columbia commercial sockeye salmon fisheries.

Intertek Moody Marine, 2013. British Columbia Chum Salmon (*Oncorhynchus keta*) Fisheries – British Columbia Coastal Waters and Adjacent Canadian Pacific EEZ Waters. MSC Public Certification Report.

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

Lummi Island Wild - http://www.lummiislandwild.com/about-reefnetting.cfm

Mantua, N. J., Hare, S. R., Zhang, Y., Wallace, J. M., & Francis, R. C., 1997. A Pacific interdecadal oscillation with impacts on salmon production. *Bulletin of the American Meteorological Society*. **78:**6. pp 1069-1079.

Morrison, J., Quick, M. C., & Foreman, M. G. G., 2002. Climate change in the Fraser River watershed: flow and temperature projections. *Journal of Hydrology*. **263.** pp 230-244.

Natural Resources Consultants, 1995. Bycatch mortality in the fall Chum Salmon Reefnet fishery in Washington State. November, 1995. pp 5.

Pacific Salmon Commission, 2001. Report of the Fraser River Panel to the Pacific Salmon Commission on the 1999 Fraser River Sockeye and Pink Salmon Fishing Season. March 2001.

Pacific Salmon Commission, 2007. Report of the Fraser River Panel to the Pacific Salmon Commission on the 2003 Fraser River Sockeye and Pink Salmon Fishing Season. December 2007.

Pacific Salmon Commission, 2008. Report of the Fraser River Panel to the Pacific Salmon Commission on the 2004 Fraser River Sockeye Salmon Fishing Season. May 2008.

Pacific Salmon Commission, 2009. Report of the Fraser River Panel to the Pacific Salmon Commission on the 2005 Fraser River Sockeye and Pink Salmon Fishing Season. October 2009.

Pacific Salmon Commission, 2011a. Report of the Fraser River Panel to the Pacific Salmon Commission on the 2006 Fraser River Sockeye Salmon Fishing Season. March 2011.

Pacific Salmon Commission, 2011b. Joint Chum Technical Committee 2009 Post Season Summary Report. TCCHUM (11) – 1: v + 43p.

Pacific Salmon Commission, 2012a. Report of the Fraser River Panel to the Pacific Salmon Commission on the 2007 Fraser River Sockeye and Pink Salmon Fishing Season. March 2012.

Pacific Salmon Commission, 2012b. Report of the Fraser River Panel to the Pacific Salmon Commission on the 2008 Fraser River Sockeye Salmon Fishing Season. May 2012.

Pacfic Salmon Commission, 2012c. Joint Chinook Technical Committee Report: 2011 Annual Report of Catches and Escapements. TCCHINOOK (12) – 1: viii + 135p.

Pacific Salmon Treaty, 2009. Treaty Between the Government of Canada and the Government of the United States of America Concerning Pacific Salmon. Updated January 27, 2009.

Porszt, E.J., Peterman, R.M., Dulvy, N.K., Cooper, A.B., & Irvine, J.R. 2012. Reliability of Indicators of Decline in Abundance. *Conservation Biology*. **26:**5 pp 894-904.

Rand, P.S., Hinch, S.G., Morrison, J., Foreman, M.G.G., MacNutt, M.J., Macdonald, J.S., Healey, M.C., Farrell, A.P., & Higgs, D.A. 2006. Effects of River Discharge, Temperature, and Future Climates on Energetics and Mortality of Adult Migrating Fraser River Sockeye Salmon. *Transactions of the American Fisheries Society*. **135.** pp 655-667.

Rand, P. S., Goslin, M., Gross, M. R., Irvine, J. R., Augerot, X., McHugh, P. A., & Bugaev, V. F., 2012. Global assessment of extinction risk to populations of sockeye salmon *Oncorhynchus nerka*. PLoS ONE. **7:**4 e34065.

Scheuerell, M.D., Moore, J.W., Schindler, D.E., & Harvey, C.J., 2007. Varying effects of anadromous sockeye salmon on the trophic ecology of two species of resident salmonids in southwest Alaska. *Freshwater Biology*. **52** pp. 1944-1956.

WDFW, 2011. Puget Sound Commercial Salmon Regulations. Washington Department of Fish and Wildlife, Olympia, Washington.

WDFW website - http://wdfw.wa.gov/fishing/commercial/salmon/reef_nets.html

Willson, M.F., Gende, S.M., & Marston, B.H., 1998. Fishes and the Forest: Expanding the perspectives on fish-wildlife interactions. *Bioscience*. **48:**6 pp. 455-462.

Willson, M.F., & Halupka, K.C., 1995. Anadromous Fish as Keystone Species in Vertebrate Communities. *Conservation Biology*. **9:**3 pp. 489-497.

Appendix A: Glossary

Conservation Unit–A group of wild salmon sufficiently isolated from other groups that, if extirpated, is very unlikely to recolonize naturally within an acceptable timeframe.

Interception Fishery–A fishery taking in place in one country that targets fish originating from the waters of another country (PST 2009).

Population–A group of salmon that is relatively isolated from other group of salmon. In the context of this report, population generally refers to a group of salmon at the watershed level, i.e. Fraser River.

Stock–An individual breeding group of fish for which management targets or benchmarks have been set. In the context of this report a stock is often at the level of the tributary or spawning lake.

Appendix B: Review Schedule

The report and subsequent recommendations were updated in February 2015 based on information brought to the attention of Seafood Watch. Fishery regulation announcements from the Pacific Salmon Commission's Fraser River Panel provide evidence to show that typically there is non-retention of sockeye salmon during pink salmon reefnet fishery. As a result the impact on endangered Cultus Lake sockeye and the associated Late-run Fraser River sockeye salmon is reduced. The result of these amendments is an improvement in the overall recommendation for reefnet-caught pink salmon from a 'Good Alternative' to a 'Best Choice'.

Fishery reviews are published annually by the Fraser River Panel following a delay of 3-4 years, for example the review of the 2008 fishery was released in 2012. Due to the high annual variability and the need to average salmon abundances across a generation, for example 4 years in sockeye salmon, the typical timescale for updating Seafood Watch reports (every 3 years) should prove sufficient unless a study is published that greatly changes the outlook of fisheries for Fraser River salmon.

About Seafood Watch®

Monterey Bay Aquarium's Seafood Watch® program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the United States marketplace. Seafood Watch® defines sustainable seafood as originating from sources, whether wild-caught or farmed, which can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. Seafood Watch® makes its science-based recommendations available to the public in the form of regional pocket guides that can be downloaded from www.seafoodwatch.org. The program's goals are to raise awareness of important ocean conservation issues and empower seafood consumers and businesses to make choices for healthy oceans.

Each sustainability recommendation on the regional pocket guides is supported by a Seafood Report. Each report synthesizes and analyzes the most current ecological, fisheries and ecosystem science on a species, then evaluates this information against the program's conservation ethic to arrive at a recommendation of "Best Choices," "Good Alternatives" or "Avoid." The detailed evaluation methodology is available upon request. In producing the Seafood Reports, Seafood Watch® seeks out research published in academic, peer-reviewed journals whenever possible. Other sources of information include government technical publications, fishery management plans and supporting documents, and other scientific reviews of ecological sustainability. Seafood Watch® Research Analysts also communicate regularly with ecologists, fisheries and aquaculture scientists, and members of industry and conservation organizations when evaluating fisheries and aquaculture practices. Capture fisheries and aquaculture practices are highly dynamic; as the scientific information on each species changes, Seafood Watch®'s sustainability recommendations and the underlying Seafood Reports will be updated to reflect these changes.

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Seafood Reports in any way they find useful. For more information about Seafood Watch® and Seafood Reports, please contact the Seafood Watch® program at Monterey Bay Aquarium by calling 1-877-229-9990.

Disclaimer

Seafood Watch® strives to have all Seafood Reports reviewed for accuracy and completeness by external scientists with expertise in ecology, fisheries science and aquaculture. Scientific review, however, does not constitute an endorsement of the Seafood Watch® program or its recommendations on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

Seafood Watch® and Seafood Reports are made possible through a grant from the David and Lucile Packard Foundation.

Guiding Principles

Seafood Watch™ defines sustainable seafood as originating from sources, whether fished3 or farmed, that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

The following **guiding principles** illustrate the qualities that capture fisheries must possess to be considered sustainable by the Seafood Watch program:

- *Stocks are healthy and abundant.*
- *Fishing mortality does not threaten populations or impede the ecological role of any marine life.*
- *The fishery minimizes bycatch.*
- *The fishery is managed to sustain long-term productivity of all impacted species.*
- *The fishery is conducted such that impacts on the seafloor are minimized and the ecological and functional roles of seafloor habitats are maintained.*
- *Fishing activities should not seriously reduce ecosystem services provided by any fished species or result in harmful changes such as trophic cascades, phase shifts, or reduction of genetic diversity.*

Based on these guiding principles, Seafood Watch has developed a set of four sustainability **criteria** to evaluate capture fisheries for the purpose of developing a seafood recommendation for consumers and businesses. These criteria are:

1. Impacts on the species/stock for which you want a recommendation
2. Impacts on other species
3. Effectiveness of management
4. Habitat and ecosystem impacts

Each criterion includes:

- Factors to evaluate and rank
- Evaluation guidelines to synthesize these factors and to produce a numerical score
- A resulting numerical score and **rank** for that criterion

Once a score and rank has been assigned to each criterion, an overall seafood recommendation is developed on additional evaluation guidelines. Criteria ranks and the overall recommendation are color-coded to correspond to the categories on the Seafood Watch pocket guide:

3 "Fish" is used throughout this document to refer to finfish, shellfish and other invertebrates.

Best Choices/Green: Are well managed and caught or farmed in environmentally friendly ways.

Good Alternatives/Yellow: Buy, but be aware there are concerns with how they're caught or farmed.

Avoid/Red: Take a pass on these. These items are overfished or caught or farmed in ways that harm other marine life or the environment.