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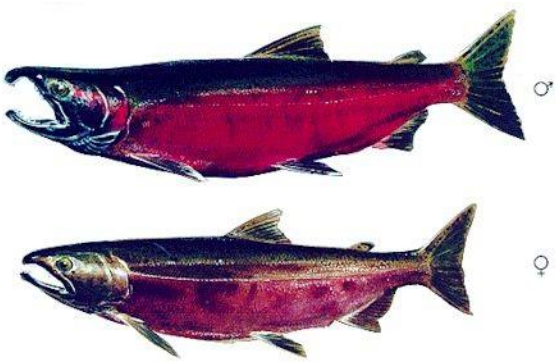
Canadian Science Advisory Secretariat

Pacific Region **Science Advisory Report 2015/nnn - Approved Pre-Publication Version**

WILD SALMON POLICY BIOLOGICAL STATUS ASSESSMENT FOR CONSERVATION UNITS OF INTERIOR FRASER RIVER COHO SALMON *(ONCORHYNCHUS KISUTCH)*



Coho Salmon adult spawning phase. Fisheries and Oceans Canada website.

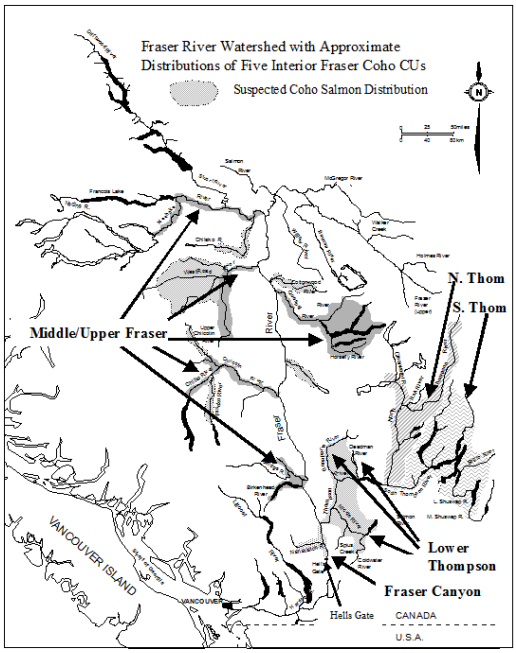


Figure 1 Distribution of five Interior Fraser Coho Salmon Conservation Units reproduced from Irvine (2002).

Context:

Canada's Wild Salmon Policy's (WSP) identifies six strategies for implementation. Strategy 1 is "Standardized monitoring of wild salmon status" and requires biological status assessments for all Pacific Salmon conservation units (CUs). To conduct WSP status assessments, a toolkit comprised of a number of classes of indicators and metrics for status evaluation was completed in 2009. However, since a number of metrics can be used to evaluate biological status, it is possible that each metric can indicate a different status (Red, Amber, or Green). Therefore, status integration, which includes synthesis of CU status information across metrics into one or more status zones, and the provision of expert commentaries on the information used to assess status, is used in the status designation process. This assessment includes the development of abundance-based benchmarks, the review of population dynamics, abundance, trend, distribution, and productivity information for Interior Fraser River Coho Salmon CUs, and the application of WSP status integration conducted in a workshop of scientific experts. This work builds upon a previous application of WSP status integration techniques conducted for Fraser Sockeye and Southern British Columbia Chinook CUs.

This Science Advisory Report is from the November 6-7, 2014 Assessment of Interior Fraser River Coho Salmon Conservation Units' Benchmarks and Status. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

Canada

SUMMARY

- The Wild Salmon Policy (WSP) outlines Fisheries and Oceans Canada's (DFO) strategies for managing Canada's salmon resources. The status assessment (Strategy 1) involves developing benchmarks and determining the biological status of Conservation Units (CUs).
- In order to apply the WSP status assessment strategy to Interior Fraser Coho (IFC) salmon (*Oncorhynchus kisutch*), abundance-based benchmarks were calculated, based on previously published methods, and a comprehensive set of population dynamics, abundance, trend, distribution, and productivity information were reviewed for each of the five CUs.
- A workshop of scientific experts was held to review and integrate the benchmarks and other information and recommend the WSP biological status for each of the 5 IFC CUs. A Delphi method was used to integrate expert opinions and to arrive at concensus-based status determinations. Status recommendations from the workshop were brought forward to this Canadian Science Advisory Secretariat (CSAS) Regional Peer Review process.
- The biological (abundance-based) benchmarks have moderate to high amounts of uncertainty. This uncertainty was considered in the assessment of status.
- The estimates of the upper and lower benchmarks of abundance from the stock-recruitment analyses were imprecise. In many cases, the confidence intervals for upper and lower abundance benchmarks overlap. The sum of median estimates (50% credible interval) of the upper benchmark for the five CUs is 17,147 spawners. The sum of median estimates of the lower benchmark across the five CUs is 8,654 spawners.
- Three CUs were determined to have an integrated status of AMBER (Middle Fraser, Fraser Canyon, South Thompson) and two were determined to have an integrated status of AMBER/GREEN (Lower Thompson, North Thompson).
- The sum of median estimates of the upper benchmark (80% of S_{MSY}) is slightly below the Conservation Strategy for Coho Salmon (*Oncorhynchus kisutch*) Interior Fraser River Populations (IFCRT 2006) recovery objective of 20,000 to 25,000 spawners. That the summed 80% of S_{MSY} is close to Interior Fraser River Recovery Team (IFCRT) recovery objective highlights the risks of managing to S_{MSY}, as there appears to be negative consequences for the MU if abundances fall significantly below S_{MSY}.
- The WSP status metric values varied considerably over short time periods and it is recommended that these parameters be monitored annually, and reassessed when there are signs that productivity, spawner abundance, smolt-adult survival, or smolt production patterns change. The benchmarks and the integrated status should be reassessed if there are significant revisions to exploitation rates, total spawner, or hatchery-origin spawner data.
- This assessment found no evidence that smolt-adult survival has improved or returned to the higher productivity regime. Because the productivity is low, the sustainable harvest that can be expected from the management unit is also low relative to historic levels.
- Further work regarding potential harvest strategies, which include analyses for both high and low productivity regimes, is recommended

INTRODUCTION

The goal of the Wild Salmon Policy (WSP) is to "restore and maintain healthy salmon populations and their habitats for the benefit and enjoyment of the people of Canada in perpetuity" (DFO 2005). In order to achieve this goal, the WSP outlines a number of strategies, including Strategy 1 (Standardized Monitoring of Wild Salmon Status), which is the subject of this Science Advisory Report. To see how Strategy 1 aligns with the other strategies, consult Figure 1 in the Wild Salmon Policy (DFO 2005). Action Steps for Strategy 1 include: (1) identification of Conservation Units (CUs); (2) development of criteria to assess CUs and identification of benchmarks to represent biological status; and, (3) monitoring and assessment of CU status. Work on these action steps has progressed since the WSP was published in 2005, with the following peer-reviewed milestones:

- method for the identification of Pacific salmon CUs (Holtby & Ciruna 2007);
- method for the assessment of Pacific salmon biological status under the WSP (Holt et al. 2009);
- technical background for WSP status assessments (Holt 2009; Porszt 2009; Holt 2010; Holt & Bradford 2011; Porszt et al. 2012); and
- integration techniques for WSP status assessments of salmon CUs (Grant & Pestal 2013).

Four classes of indicators have been recommended to evaluate WSP status of wild Pacific salmon: abundance, trends in abundance, distribution and fishing mortality (Holt et al. 2009). Within each class of indicator, one or more metrics can be used for status assessments and, for each metric, a lower benchmark and upper benchmark delineate, respectively, the Red to Amber and Amber to Green status zones (Table 1). These biological benchmarks are specifically used for status assessments, and are not prescriptive for specific management actions. They are also designed to be more conservative than the criteria established by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), as required by the WSP.

Table 1. The three zones of biological status defined in the WSP (Grant & Pestal 2013).

Status	Definition
Red	"… established at a level of abundance high enough to ensure there is a substantial buffer between it and any level of abundance that could lead to a CU being considered at risk of extinction by COSEWIC"
Amber	"While a CU in the Amber zone should be at low risk of loss, there will be a degree of lost production. Still, this situation may result when CUs share risk factors with other, more productive units"
Green	"identif[ies] whether harvests are greater than the level expected to provide on an average annual basis, the maximum annual catch for a CU, given existing conditions…there would not be a high probability of losing the CU"

Since CU status evaluations can include more than one metric, it is possible that different metrics could each indicate a different WSP status zone from Red (poor status) to Green (healthy status). For example, the WSP recent trends in abundance metric could suggest a CU's status is poor, while conversely, the long-term trend metric could indicate the same CU's status is healthy. In cases where metric information is contradictory, provision of this metric-specific status information alone does not provide complete scientific advice to fisheries

management. Instead, a final step that synthesizes all metric and status-related information into an integrated status for each CU, and provides expert commentary on this information, is necessary as inputs into subsequent implementation of WSP Strategy 4 (Integrated Strategic Planning) to prioritize assessment activities and management actions (Table 2).

Table 2: Guidance in the WSP on assessment actions and management considerations for CUs in each status zones (Grant & Pestal 2013).

Status	Assessment Actions	Management Considerations
Red	"… a detailed analytical assessment will normally be triggered to examine impacts on the CU of fishing, habitat degradation, and other human factors, and evaluate restoration potential", "… detailed stock assessments will identify the reasons for the change in status". "CUs in the Red zone … will be identified as management priorities … the protection and restoration of these CUs will be primary drivers for harvest, habitat, and enhancement planning."	"Biological considerations will be the primary driver for the management of CUs with Red status". "The presence of a CU in the Red zone will initiate immediate consideration of ways to protect the fish, increase their abundance, and reduce the potential risk of loss".
Amber	"… a detailed analytical assessment may be required to input into Strategies 2 & 3…"	"Decisions about the conservation of CUs in the Amber zone will involve broader considerations of biological, social, and economic issues"; "involves a comparison of the benefits from restoring production versus the costs arising from limitations imposed on the use of other CUs to achieve that restoration"; "implies caution in the management of the CU"
Green	" a detailed analytical assessment of its biological status will not usually be needed"	"Social and economic considerations will tend to be the primary drivers for the management of CUs in the green zone, though ecosystem or other non-consumptive values could also be considered".

For Pacific Salmon CUs, WSP biological status integration methods have previously been developed and applied to Sockeye Salmon assessments (Grant & Pestal 2013) and southern BC Chinook Salmon CUs (publication pending). The success of this previous work has allowed for a slightly different approach for this assessment. In this case, a smaller workshop was conducted then a working paper was developed for peer review at a typical CSAS Regional Peer Review (RPR) meeting. This SAR summarizes the results from this recent RPR concerning the WSP status assessment working paper presented at the review meeting. The subject of the WSP status assessment was the genetically distinct Coho Salmon of the interior Fraser River watershed. These Coho are referred to as the Interior Fraser Coho (IFC) Management Unit (MU). The IFC MU is comprised of five Wild Salmon Policy Conservation Units, each of which is made up of 1-3 subpopulations. The WSP provides the guidance and requirements for establishing biologically-based benchmarks to determine the status for IFC CUs. Fisheries and Oceans Canada (DFO) committed to the completion of WSP benchmarks and status assessment of the five IFC CUs during the fall of 2014.

The objectives of the working paper were to:

- Develop WSP biological benchmarks for IFC CUs.
- Determine WSP biological status for each IFC CUs.

- Provide advice on an approach that would trigger a re-assessment of IFC CUs benchmark(s) and status.

ASSESSMENT

Methods

Abundance-Based Benchmarks and Other Biologically-Based Metrics

Overall, much of the data used in the analyses were based on indirect or modeled estimates, rather than on direct observations. The data set held by the DFO Fraser Stock Assessment program is the most up-to-date source for the five IFC CUs and was used for this assessment. Information on data quality and age structure (from 1998 to 2013) was obtained from the same source. Some in-filling of the data time series was required in order to account for missing values.

To assess the abundance of each CU, the geometric average of the last generation of natural spawners was compared to biologically-based upper and lower abundance benchmarks, related to Maximum Sustainable Yield (MSY) derived from stock-recruitment analyses. Upper benchmarks are set as 80% of the spawner abundance at MSY (S_{MSY}), and lower benchmarks are equal to the spawner abundance that results in recovery to S_{MSY} in one generation under equilibrium conditions (S_{gen}), as recommended by Holt et al. (2009).

Exploitation rates (ER) on IFC have been estimated using four different approaches since 1975 (Decker et al. 2014; Table 3). The reliability of IFC ER estimates from 1998 onward is uncertain. The IFC ER series was recently reported by Decker et al. (2014) through return year 2012. Canadian ER for 2010-2013 were provided by DFO South Coast and Fraser area stock assessment staff. None of the IFC ER models has undergone a formal peer review process, such as a Canadian Science Advisory Secretariat (CSAS) regional peer review. However, these are the best estimates currently available, and have been used to make inferences about fishing impacts on IFC in recent CSAP assessments (Table 3; Decker et al, 2014; Decker and Irvine 2013; Irvine et al. 2001; Simpson et al. 2004; Folkes et al. 2005).

An index of wild smolt production was back-calculated for the IFC MU by brood year using the age-specific adult recruitment estimates and the smolt-adult survival. Previous IFC assessments (Folkes et al. 2005; Decker and Irvine 2013) used smolt-adult survival based on Strait of Georgia wild indicator stocks; however, it was found that the IFC MU index explained a higher proportion of the variation in adult recruitment than wild indicator stock data from the Strait of Georgia MU. Thus, the IFC MU series was used because it appears to better represent the variation in recruitment caused by trends in smolt-adult survival.

The temporal trends in abundance, over the short-term (ten years) and long-term (historical record), were assessed using two metrics outlined by Holt et al. (2009). An additional metric, the probability of decline, was used to quantify uncertainties in the short term-trend assessment that may arise due to incomplete sampling of the CU (Holt et al. 2009).

There is currently no standardized approach for evaluating distribution in WSP assessments. Changes in the number of locations used for spawning was assessed to provide ancillary information for consideration in the integrated assessment.

The analysis and assemblage of data utilized for IFC CU status determination was compiled into information packages called “dashboards” for each CU. The dashboards consist of a series of figures and tables that are organized consistently to enable the project team to review the information efficiently, and facilitate comparisons among CUs.

Biological Status

A one-day workshop was held to review key information and determine the WSP biological status for each of the 5 IFC CUs. A Delphi method was used to integrate expert opinions and to arrive at concensus-based status determinations. The workshop participants were divided into several breakout groups for discussion of the CU dashboards. Following the breakout discussion, the participants discussed the results in a plenary session. In general, the breakout groups were not very far apart on the status determinations, and it was a relatively easy process to arrive at integrated consensus-based status determinations for all CUs, through compromise where necessary.

Results

Abundance-Based Benchmarks and Other Biologically-Based Metrics

The abundance-based benchmarks and biologically-based metrics are reported in the research document resulting from this review; a summary of the benchmarks is presented in Table 3. Generally, the estimates of the upper and lower benchmarks from the stock-recruitment analyses were imprecise. This likely resulted from several factors including low contrast in spawner abundance, few observations at a high spawner level, high variability in recruitment over a narrow range of spawners, and frequent recruitment failures regardless of spawner abundance. In many cases, the confidence intervals for upper and lower benchmarks overlap.

The sum of median estimates (50% credible interval) of the upper benchmark (80% of S_{MSY}) for the five CUs is 17,147 spawners. The sum of median estimates of the lower benchmark (S_{gen}) across the five CUs is 8,654, and is similar in magnitude to the lowest abundance observed in the aggregate (in 2006).

Although not an explicit objective of this assessment, a comparison was conducted between the benchmark estimates produced and the short- and long-term recovery objectives for the IFR MU established by the Interior Fraser River Recovery Team (IFCRT 2006) recovery objectives. The IFCRT short-term objective is that the three-year average escapement, in at least half of the sub-populations within each of the five populations, is to exceed 1,000 spawners. This objective will be achieved when the escapement to the MU is at least 20,000 to 25,000 wild spawners.

The sum of median estimates of the upper benchmark (80% of S_{MSY}) is slightly below IFCRT (2006) recovery objectives, based on distribution of 20,000 to 25,000 spawners. Therefore, the upper benchmark not only signifies a level of abundance which could result in a reduced sustainable yield, but also the desirable property of having a reasonable number of spawners widely distributed throughout the larger CUs. That the summed 80% of S_{MSY} is close to IFCRT (2006) recovery objective highlights the risks of managing to S_{MSY}, as there appears to be negative consequences for the MU if abundances fall significantly below S_{MSY}.

If a level of abundance below the lower benchmark (S_{gen}) was sustained, several spawning streams are likely to be unoccupied and few of the 11 subpopulations are likely to meet the IFCRT (2006) recovery objective of 1,000 spawners, averaged over a generation. These observations suggest the lower benchmarks are consistent with the IFCRT analyses, indicating significant increases in risk to the MU if abundances fall below the lower benchmark.

Table 3. Abundance-based benchmarks and credible intervals for each of the IFC Conservation Units (80% S_{MSY} = upper benchmark; S_{gen} = lower benchmark). Note that the status designations did not solely rely on these benchmarks.

				Credible Intervals						
CU	Benchmark	Mean	SD	5%	10%	25%	50%	75%	90%	95%
Middle Fraser	80% S_{MSY}	2,940	1,301	1,030	1,424	2,035	2,785	3,718	4,695	5,317
	S_{gen}	1,650	650	938	1,065	1,290	1,585	1,894	2,198	2,460
Fraser Canyon	80% S_{MSY}	1,582	441	886	1,043	1,288	1,562	1,862	2,154	2,338
	S_{gen}	772	241	451	516	620	741	887	1,059	1,178
Lower Thompson	80% S_{MSY}	3,133	1,119	1,412	1,792	2,380	3,052	3,824	4,604	5,099
	S_{gen}	1,489	587	742	872	1,135	1,405	1,754	2,130	2,477
North Thompson	80% S_{MSY}	5,301	908	3,832	4,154	4,688	5,286	5,901	6,470	6,817
	S_{gen}	2,603	636	1,685	1,866	2,182	2,546	2,980	3,375	3,737
South Thompson	80% S_{MSY}	4,735	2,127	1,629	2,286	3,287	4,462	5,959	7,596	8,664
	S_{gen}	2,511	1,078	1,370	1,600	1,990	2,377	2,837	3,375	3,742

Biological Status

Previous assessments have reported that there are two distinct productivity regimes for the IFC MU; this was most recently reported by Decker et al. (2014). The productivity shifted to a lower regime after brood year 1990, due to a substantial decline in smolt-adult survival. The combination of low intrinsic productivity, low smolt-adult survival, and high variability in the freshwater environment causes these CUs to be susceptible to perturbations, and have low population growth rates. During the last 13 years of the lower productivity regime, CUs have not achieved replacement in four to six years (31%-46% of the time).

The integrated Wild Salmon Policy status evaluations are reported in Table 4. These represent the consensus evaluations that were determined in a plenary session following the breakout group discussions. In some cases, not all groups completed status evaluations for all of the CUs. In no cases did all of the groups initially have identical status evaluations. It was only during the plenary discussion that the consensus evaluations were determined.

Table 4. Summary of integrated WSP status evaluations for Interior Fraser Coho CUs.

Integrated Status	Conservation Unit	Main Considerations
AMBER	Middle Fraser	The main considerations in the integrated status determination were: (1) the patterns of productivity with frequent failures to achieve replacement over the most recent 13 years, (2) the low productivity and low smolt-adult survival over the last two decades, (3) the poorly described and imprecise stock-recruitment function, (4) moderate to high level of uncertainty and variability for the information presented, and (5) the current spawner abundance relative to benchmark estimates and COSEWIC reference points.
AMBER	Fraser Canyon	The main considerations in the integrated status determination were (1) the short-term trend was in the red zone for all but the most recent year and there is a moderate probability that the CU is currently in the red zone, (2) the patterns of productivity with frequent failures to achieve replacement over the most recent 13 years, (3) the low productivity and low smolt-adult survival since 1998, (4) the short time series with no information prior to 1998, (5) the abundance exceeded the COSEWIC reference points, (6) the CU has a small capacity and has low-moderate intrinsic productivity, and (7) this is a single-site CU with spawners in a short section of one river which reduces resilience to perturbations and there is no likelihood of replacement from adjacent tributaries.
AMBER/GREEN	Lower Thompson	The main considerations in the assignment of mixed status were (1) the short-term trend was increasing and there was virtually 0% probability for the red zone, (2) the extent of decline metric showed the recent spawner abundance was above the long-term average and generally above the average level during the period of higher productivity (pre 1991), (3) the last four years exceeded the upper abundance-based benchmark, (4) the patterns of productivity with frequent failures to achieve replacement over the most recent 13 years—with 3 of the last 6 years very near replacement, (5) the low productivity and low smolt-adult survival since 1998, and (6) the steadily increasing trend in smolt production since 1995.
AMBER/GREEN	North Thompson	The main considerations in the integrated status determination of mixed status were (1) the short-term trend was increasing, (2) the extent of decline metric showed the recent two years had increased but it was in the yellow or red zone in the eight previous years, (3) productivity was often below replacement (6 of the last 13 brood years), (4) spawner abundance exceeded the upper confidence limit for the upper benchmark over the last three years, and (5) smolt-adult survival has been low and stable since brood year 2000.
AMBER	South Thompson	The main considerations in the integrated status determination were (1) the patterns of productivity with frequent failures to achieve replacement over the most recent 13 years, (2) the low productivity and low smolt-adult survival over the last two decades, (3) the poorly described and imprecise stock-recruitment function, (4) moderate level of uncertainty and variability with the information presented, and (5) the spawner abundance relative to benchmark estimates.

Sources of Uncertainty

Overall, much of the data used to estimate the abundance benchmarks and status metrics for the IFC CUs were based on indirect or modeled estimates, rather than on real observations. The highest quality data available are the spawner estimates, which come from annual escapement programs. Separation of spawners into natural and hatchery-origin components is more uncertain due to incomplete coded-wire tag (CWT) marking of releases or subsequent incomplete sampling of spawners among sites (i.e. “dispersal”; IFCRT 2006). Survival rates were based on CWT data, which have become increasingly uncertain for many reasons (PSC

2008). Exploitation rate estimates were derived from different models that used catch data, assumptions about stock-specific encounters, and release mortality rates—that are yet to be verified with actual sample data.

The uncertainty in the exploitation rate series arises from the methods, structural assumptions, and observation and process errors. Temporal variation in accuracy is a concern for the estimation of adult recruitment and estimation of the stock-recruitment function, because the methods varied and they likely have different biases. The DFO has identified that the methods used to estimate ER will be reviewed and evaluated (e.g. quantification of uncertainty) in an upcoming CSAS assessment.

Uncertainty in the stock-recruitment analysis resulted from uncertainty in the data and natural variation, and also with the change in productivity. Stock-recruitment-based benchmarks were calculated from recent data only, i.e. from 1998 to present. The analysis was restricted to these years because data were of higher quality and from the low productivity regime currently exhibited by all CUs. Guidance was taken from the WSP, which clearly states that benchmarks that are based on statistics such as S_{MSY} are to be based on "existing environmental conditions".

CONCLUSIONS AND ADVICE

The biological (abundance-based) benchmarks (Table 3) have moderate to high amounts of uncertainty due to variability in spawner-recruitment data, short time series, frequent recruitment failures regardless of spawner abundance, low contrast for spawner abundance, and few observations for high spawner abundances. This uncertainty was considered in the assessment of status.

The WSP biological status (Table 4) was AMBER for the Middle Fraser, Fraser Canyon and South Thompson CUs and it was AMBER/GREEN for the Lower and North Thompson CUs.

The WSP status metric values varied considerably over short time periods. These parameters should be monitored annually. Integrated status should be reassessed when there are signs that productivity, spawner abundance, smolt-adult survival, or smolt production patterns change. The benchmarks should be reviewed, and the integrated status should be reassessed, if there are significant revisions to ER, total spawner, or hatchery-origin spawner data.

This assessment found no evidence for improved smolt-adult survival (brood year 2010 declined) or a return to the higher productivity regime, similar to recent science advice (Decker et al. 2014). The status of the CUs appears to be reasonably good under the current productivity regime. However, because the productivity is low, the sustainable harvest that can be expected from the management unit is also low relative to historic levels.

The results of this assessment suggest that the advice reported in Decker et al. (2014) regarding harvest levels remains valid. However, further work regarding potential harvest strategies, which include analyses for both high and low productivity regimes, is recommended.

Further work on WSP assessment guidelines, utilizing the lessons learned from this and previous WSP integration processes, and from similar processes in other jurisdictions, is recommended. Although it is likely that expert opinion will continue to be a component of these WSP Status assessments, guidelines, where appropriate, would lead to improved repeatability and confidence in the results. In addition, it was acknowledged that for future WSP status assessments that there should be increased consideration of the role of ecosystems and habitat.

An important success factor for this assessment was the collaborative and inclusive approach that was undertaken with Fraser River First Nations. This approach was essential for completing

the project within the required timeframe and producing a robust assessment that incorporates a range of expertise and experience, and is recommended for future WSP status assessments.

OTHER CONSIDERATIONS

It is important to note that the biological status assessment under the WSP is quite different than the status assessment of Coho MU under the Pacific Salmon Treaty (PST). Under the current low productivity regime the PST status would likely be lower than that based on the WSP's framework that considers abundance in the context of the current environmental conditions, which included fishing mortality rates estimated to be less than 13%.

SOURCES OF INFORMATION

This Science Advisory Report is from the November 6-7, 2014 Assessment of Interior Fraser River Coho Salmon Conservation Units' Benchmarks and Status. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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