Workshop on Identifying Benchmarks and Assessing status of Conservation Units under Strategy 1 of the Wild Salmon Policy.
Challenges and Opportunities in Implementation
Summary Notes. June 17-18, 2010

The aims of the Wild Salmon Policy (WSP) Strategy 1 Implementation Team (coordinated by Neil Schubert) are to develop a consistent methodology for identifying benchmarks and assessing status of Conservation Units (CUs), generate tools to guide staff through technical analyses, and implement assessments in pilot areas, followed by other high-priority CUs. Holt et al. (2009) developed benchmarks for assessing status, but the technical details about how those benchmarks and assessments will be implemented have yet to be determined. A workshop was held at the Pacific Biological Station on June 17-18, 2010 to serve as a 'reality check' by identifying and addressing challenges in applying those benchmarks. Specifically, the goals for the workshop were to:

(1) Present preliminary guidelines for processing data on spawner abundances prior to estimating benchmarks in response to data deficiencies.
(2) Demonstrate a software tool for identifying benchmarks on one dimension of status, spawner abundances, and identify future extensions and applications.
(3) Investigate revisions on benchmarks on fishing mortality that are consistent with benchmarks on spawner abundances.
(4) Explore impacts of non-stationarity in model parameters on benchmarks, and identify possible assessment responses. Should benchmarks be adjusted to account for current or forecasts in productivity? If so, how, and how often?
(5) Develop a work plan for identifying methods for combining information across metrics/dimensions of status.

The workshop was held at PBS and was attended by 9 DFO Area Staff, 6 DFO Core Science Staff, 3 DFO Resource Management Staff, 3 biologists from, or with expertise with First Nations, and one student from Simon Fraser University (see Appendix for participant list, Agenda, and Terms of Reference). Additional DFO staff and independent experts were invited, but declined.

Significant progress on goals (1), (2), and (4) was made. Further discussion is required to come to consensus on the utility of metrics of fishing mortality (goal 3). Work on combining information across metrics/dimensions of

status (goal 5) is still in the early stages of development and will require more work by Stock Assessment Committee, SAC, and Core DFO Science.

(1) Guidelines for handling data deficiencies on spawner abundances

Carrie Holt presented a preliminary set of options for handling data deficiencies 0n spawner abundances based on consultations with stock assessment staff from South Coast. Those data deficiencies focused on three questions: (1) how to select sites/streams for inclusion as indicators for the CU, (2) how to infill missing years of data, and (3) how to aggregate information across sites to develop an overall time-series for the CU. Although these questions were also addressed by the DFO-Ecotrust Partnership Initiative (English et al. 2009), several deficiencies were noted when applying those data to the multi-dimensional assessments required for CUs under the WSP.

The approach presented by Carrie Holt was generally supported by participants, but they recommended that all methods be linked to specific metrics for assessment, and that more detailed criteria on data quality (e.g., types of visual surveys, numbers of visual counts, ease of visual observation for the species or population) and quantity (e.g., duration and the proportion of missing values throughout the time-series, and in the most recent 1-3 generations) be included. Participants also noted that the choice of infilling method should depend on the covariance in time-series among sites, and recommended a simulation modeling approach to assess which methods for infilling are most robust to uncertainties in covariance, as well as the data quantity and quality.

Next steps

Carrie Holt will revise the guidelines according to the suggestions provided and develop a Discussion Paper to be circulated to the group for further comments by Fall 2010. In addition Micheal Folkes and Carrie Holt will develop a simulation model to evaluate methods of interpolation and aggregation under different scenarios of data deficiencies (missing years and sites) and population structure (including covariance among sites within a CU) (to be completed over 2010-2011).

(2) Software to identify benchmarks

Carrie Holt demonstrated a preliminary version of a software tool to estimate benchmarks. Currently the software uses two approaches for estimating benchmarks for CUs with spawner and recruitment data: a standard frequentist approach and a Bayesian approach that incorporates prior information on carrying capacity. Participants were given copies of the software to perform analyses on the example data, as well as their own data.

Participants agreed that the software was useful, but suggested that it be expanded to identify benchmarks on trends in spawner abundances and fishing mortality. Steps on data processing prior to analyses are to be excluded from the software, as staff felt those steps required a level of subjective judgment not possible with the software. They further suggested ideas on software formatting, additional diagnostic plots, incorporating prior information on the productivity parameter in stock-recruitment analyses, and an increased emphasis of the weaknesses of stock-recruit analyses that are derived from time-series data with strong exploitation.

Next steps
Carrie Holt will revise the software according to participants' suggestions by Spring 2011, and will re-distribute an updated version to the group for further comments prior to release.

(3) Benchmarks on fishing mortality
In his presentation, Steve Cox-Rogers described the theoretical relationship between spawner abundances, *S*, and fishing mortality, *F*, and suggested that benchmarks on *S* and *F* should therefore be paired. Currently, the fishing rate required to achieve the lower benchmarks on spawner abundance (*F* that will result in S_{gen}, or F_{gen}) is significantly higher than the lower benchmark on fishing mortality (F_{MSY}). One option is to revise lower benchmarks on fishing mortality from F_{MSY} to F_{gen} to ensure consistenty, but several considerations were raised for benchmarks:

F_{MSY}

- F_{MSY} was originally chosen as a lower benchmark on *F* by Holt et al. (2009) to be consistent with international agreements that state F_{MSY} should be considered a limit reference point, below which *F* should not fall. Although international institutions were largely aimed at marine fisheries, the notion of F_{MSY} as a minimum fishing mortality was used to support the choice of that benchmark for the WSP.
- Using a Monte Carlo simulation model, Holt (2009) demonstrated that CUs managed to F_{MSY} had relatively low probabilities of extirpation and high probabilities of recovery compared with other candidate benchmarks suggested from the literature, such as F_{MED}, the median observed $ln(R/S)$ where *R* is recruits, and F_{CRASH}, the maximum $ln(R/S)$ at low *S*.
- Large uncertainty in the productivity of CUs (and their constituent populations) supports a precautionary lower benchmark on *F* (i.e., a lower benchmark on *F* higher than if productivity was known exactly). For example, allowing a overall fishing mortality at F_{MSY} would likely result in a non-zero probability that the CU (or number of populations

within the CU) will be harvested at rates greater than F_{MSY}. A higher F benchmarks (e.g., F_{gen} or F_{CRASH}) would likely result in a high probability that at least some constituent populations will be harvested at rates greater than sustainable levels ($F>F_{CRASH}$).

- Although the lower benchmark on S could be revised to be consistent with the suggested F lower benchmark, F_{MSY} (i.e., S_{MSY} instead of S_{gen}) that benchmark on S would be higher than deemed reasonable by workshop participants (and higher than current status of most CUs).

F_{gen}

- F_{gen} is consistent with the current lower benchmark on S, S_{gen}, thereby avoiding conflicts when interpreting S and F benchmarks together.
- Because fishing morality is not an intrinsic characteristic of the population, this metric could be considered secondarily to metrics on abundance (current status, trends, and distribution) when information on abundances exists. If F is preserved as a fourth dimension of status and F_{gen} is adopted as the lower benchmark, workshop participants recommended that the distribution of fishing mortality among CUs relative to F_{MSY}, F_{gen}, and F_{CRASH} also be considered (Walters and Martell 2004). Identifying the allowable proportion of CUs within a watershed with F below F_{MSY} , F_{gen}, and F_{CRASH}, will require that the trade-offs between conservation objectives and foregone catch be formalized. Defining those trade-offs will be the responsibility of managers and stakeholders, and was considered to be beyond the role of biological assessments under Strategy 1 of the WSP (but should be included in strategy 4).

In addition, Steve Cox-Rogers emphasized that for many CUs, spawner and recruitment data, and hence estimates of stock-recruitment parameters, are extremely unreliable. In addition, stock-recruitment parameters are often biased when derived from time-series data under high exploitation (positive for productivity parameter and negative for capacity parameter). In response to those uncertainties, the Ricker productivity parameter can be bounded between the mean $ln(R/S)$ at the low end, and likelihood estimates of the Ricker productivity parameter from time-series data at the high end. Those bounds can be used to derive upper and lower scenarios for benchmark estimates.

Several participants suggested including metrics on productivity, such as recruits/spawner, R/S, explicitly as an indicator of status, where R/S = 1 represents a possible lower benchmark below which a CU is not self-sustaining. At least one participant suggested that this benchmark may be not sufficiently precautionary because it assumes that fishing effort would drop to zero at R/S =1 to allow survival rates greater than those needed to sustain the population. Delineating benchmarks on

productivity will be difficult without making assumptions about managers' ability to control fishing mortality.

(4) Non-stationarity in productivity

Sue Grant presented challenges faced when estimating abundance-based benchmarks and productivity is time-varying, for sockeye salmon on the Fraser River. Participants agreed that for stocks where annual estimates of productivity are reasonably reliable and are trending over time, the choice of whether to adjust benchmarks will depend on the cause of those trends. If productivity changes are largely believed to be occurring in freshwater (e.g., due density-dependent processes related to carrying capacity), then benchmarks will not be revised because, for example, increases in benchmark values due to declines in productivity will not be supported under reduced capacity. In addition, observed trends in productivity may be due to delayed density dependence in freshwater (as suggested by Carl Walters at the Pacific Salmon Commission Workshop on the Decline of Fraser River Sockeye Salmon, June 15-17, 2010) possibly warranting revisions to estimates of capacity, though this scenario requires further investigation. In contrast, if productivity changes are largely due to variability in marine survival, then benchmarks can be adjusted in at least three ways: truncating the time series to only the current years for which productivity has remained relatively constant, estimating productivity parameters using time-series analyses (e.g., Kalman filter), and deriving productivity parameters from a combination of expert opinion, information from neighbouring populations, and recent spawner and recruitment data. Those information sources can be combined quantitatively in a Bayesian estimation scheme to estimate revised benchmarks. One caution raised by participants is that abundance-based benchmarks should only raised if capacity is sufficiently large to support increased abundances in order to avoid possible overcrowding in spawning and/or rearing habitat.

Steve Cox-Rogers also suggested that benchmarks on F could be recalculated based on current estimates of productivity, as demonstrated with contour plots that delineate zones of status by productivity (Ricker a parameter, on the X-axis) and exploitation rate (on the Y-axis). Similarly, Bradford et al. (2000) developed a contour plot of lower reference point (LRP) harvest rates for coho salmon along a gradient in marine survival rates (X-axis). That plot (Fig. 6 in Bradford et al. (2000)) shows reductions in LRP harvest rates with reductions in marine survival. In contrast to the suggestions from workshop participants, Bradford et al. (2000) also proposed that the LRP should vary with freshwater conditions, where reduced freshwater capacity is associated with a reduction in LRPs to compensate for the loss.

Several questions emerged from the presentation and discussion: (1) If benchmarks are to be adjusted, how often? (2) How large and certain do the trends in productivity need to be before revisions to the benchmarks are justified? Annual revisions may be justified as they will be expected, to an extent, regardless of any trends in productivity, since estimates of the stock-recruitment model will be updated annually as new data becomes available. However, for many CUs observed changes in productivity may be due to large interannual variability in survival and/or large measurement errors. For those CUs, changes in benchmark estimates that explicitly track the previous year's survival rates may not be warranted.

(5) Stock Assessment Framework
Presentation by Mark Saunders

Mark Saunders provided an overview of progress on the development of a Stock Assessment Framework, defined as the process of developing strategic and operational business plans for the provision of science advice to resource managers. That framework contains monitoring and analysis activities to respond to issues on conservation, production, and explanation. Weaknesses of the current framework include an out-dated structure for SAC, reactive planning, and analyses that are stock-specific instead of synoptic. Possible future steps include expanding the scope of SAC and developing the annual or periodic synoptic assessments for Pacific salmon.

Presentation by Blair

Blair Holtby presented a methodology for synoptically assessing conservation status of CUs for five salmon species. The assessment uses spawner data from NuSEDS and exploitation rates from the DFO-Ecotrust Partnership Initiative (English 2009), and includes metrics on spawner abundances, trends in abundances, distribution, and productivity. Those metrics are combined into several composite indices, and one overall index of conservation status. The methodology provides a means for prioritizing CUs for further investigation based on conservation criteria, but does not provide a conclusive conservation assessment. Several components of the methodology were identified as requiring additional scrutiny: assumptions about age composition, the choice of production model, exploitation rates, and methods for developing composite indices. Further interaction between area staff and Blair will be required to ensure these components are satisfactory. In addition, the assessment methodology could be evaluated using a simulation modelling approach where populations with known characteristics were projected forward in time. When the tool is applied to the simulated data, the resulting observed assessment could be compared with known status under a variety of assumptions about the biological and management systems.

Participants were generally supportive of the methodology, agreed that CSAS review should occur, a simulation study be implemented, and suggested that the recruitment database (adapted from English 2009) be made available assessment staff for review, and then use in their own assessments.

Preliminary survey to elicit expert opinion on combining information across metrics

Elysia Brunet presented a method to elicit expert knowledge on the relative importance of metrics through a best-worst scaling (BWS) survey. Survey results, in the form of metric weight and scale, will demonstrate how experts combine various metrics to provide an overall assessment of CU status, and how those assessments depend on uncertainties in the data and productivity of the CU. Her results will aid in the development of guidelines to generate overall status assessments that could include, for example, a hierarchical arrangement of if-then statements on individual metrics. A short test survey was presented to participants; the final survey will be distributed later this year.

References

English, K.K., Blakley, A., Mochizuki, T., and Robichaud, D. 2009. DFO-Ecotrust Partnership Initiative. Coast-wide Review of BC Salmon Indicator Streams and Estimating Escapement, Catch and Run Size for each Salmon Conservation Unit. Report submitted to DFO 18 June, 2009.

APPENDICES

Participant List (Day1, Day 2)

DFO Area Staff
Steve Cox Rogers (1,2)
Timber Whitehouse (1,2)
Michael Chamberlain (1,2)
Sue Grant (1,2)
David O'Brien (1,2)
Wilf Luedke (1,2)
Dave Peacock (2)
Joel Sawada (1,2)
Pieter Van Will (1,2)

DFO Core Science
Arlene Tompkins (1,2)
Carrie Holt (1,2)
Michael Folkes (1,2)
Blair Holtby (2)
Mark Saunders (2, only partly)

DFO Resource Management
Ann-Marie Huang (1,2)
Jeff Grout (2)
Jamie Scroggie (1,2)
Brent Hargreaves (2) (cross-appointed with Core Science)

First Nations
Mike Staley (2) (FN- Fraser, Consultant)
Katie Beach (Uu-athluk, NTC Fisheries) (2)
Allen Gottesfeld (1,2) (FN- Skeena)

Student
Elysia Brunet (SFU) (1,2)

Agenda

Day 1		Discussion leader
900	Introduction and overview of goals	Carrie Holt
910	Review of some categories of data deficiencies (e.g., missing data, incomplete survey coverage of sites within a CU) and proposed guidelines for addressing them. -Case study from WCVI	Carrie Holt
1010	Discussion	Group
1030	Break	
1045	Examples methods currently used to address data deficiencies by participants from other Areas • **Proposed outcome**: standardized guidelines for processing data on spawner abundances prior to assessment.	Group
1200	Break	
100	Software: overview and hands-on applications to CUs. Identification of bugs	Carrie Holt
230	Break	
245	Discussion of possible extensions and/or other tools to aid in assessments • **Proposed outcome**: tool for identifying benchmark on spawner abundances accessible to assessment staff, and recommendations for future extensions	Group
330	Survey to elicit opinions on ranking information from different metrics of status (e.g., metrics on abundances, trends in abundance, distribution, and fishing mortality).	Elysia Brunet
430	End	

Day 2		Discussion leader
900	Review of Day 1 and Introduction for Day 2	Carrie Holt
910	Investigate inconsistency between lower benchmarks on spawner abundances and fishing mortality, and examples of applications of *F* benchmarks on the central and north coasts	Steve Cox-Rogers (Dave Peacock) & Carrie Holt
940	Discussion on limitations and opportunities for metrics of fishing mortality on CUs in other regions • **Proposed outcome**: revised lower benchmarks on fishing mortality.	Group
1030	Break	

1045	Explore impacts of non-stationarity in model parameters on benchmarks, and identify possible assessment responses Example presented for Fraser River sockeye salmon	Sue Grant & Al Cass
1130	Discussion on standardized approaches to responding to changes in productivity • **Proposed outcome**: guidelines on how benchmarks and assessments should respond to changes in productivity.	Group
1200	Break	
100	Synoptic survey of CUs on conservation status	Blair Holtby
200	Stock Assessment Framework and combining information across metrics/dimensions of status • **Proposed outcome**: work plan for identifying methods for combing information across metrics	Mark Saunders
330	-Review of outcomes from workshop -Identification of remaining challenges -Prioritization for addressing those challenges	Group
430	End (afternoon break at the discretion of the group)	

Terms of Reference

Workshop on Identifying Benchmarks and Assessing status of CUS under Strategy 1 of the Wild Salmon Policy.
Challenges and Opportunities in Implementation

Terms of Reference

Dates: June 17-18, 2010, 9:00-4:30
Location: Pacific Biological Station, Nanaimo, Seminar Room
Audience: (i) biologists and stock assessment staff interested in technical implementation of strategy 1, (ii) biologists, stock assessment staff, and science staff more generally interested identifying challenges and possible solutions for implementation of Strategy 1.

The aim of the WSP Strategy 1 Implementation Team (coordinated by Neil Schubert) is to develop a consistent methodology for identifying benchmarks and assessing status of CUs, generate tools to guide staff through technical analyses, and implement assessments in pilot areas, followed by other high-priority CUs. Holt et al. (2009) developed benchmarks for assessing status, but the technical details about how those benchmarks

and assessments will be implemented have yet to be determined. This workshop will serve as a 'reality check' by addressing the challenges in applying those benchmarks.

The goals for this workshop are to:

(1) Demonstrate a software tool for identifying benchmarks on one dimension of status, spawner abundances.
(2) Present preliminary guidelines for processing data on spawner abundances prior to estimating benchmarks.
(3) Investigate inconsistency between lower benchmarks on spawner abundances and fishing mortality.
(4) Explore impacts of non-stationarity in model parameters on benchmarks, and identify possible assessment responses. Should benchmarks be adjusted to account for current or forecasts in productivity? If so, how and how often?
(5) Develop a work plan for identifying methods for combining information across metrics/dimensions of status.

Day 1 will cover technical implementation details for goals 1 and 2. Day 2 will cover broader topics identified in goals 3, 4, and 5.

In more detail:

(1) **Software tool for identifying benchmarks on spawner abundances**. We will demonstrate a preliminary version of the tool and solicit advice on how that software can be expanded to address other dimensions of status/challenges for assessment (*led by Carrie Holt*).
   - Currently the tool uses two approaches to identifying benchmarks for CUs with spawner and recruitment data: a standard frequentist approach and a Bayesian approach that incorporate prior information on carrying capacity. That software can be expanded to identify benchmarks on trends in spawner abundances, fishing mortality (as identified in Holt et al. 2009), and to incorporate data processing that may be required prior to analyses. Other revisions and extensions will be considered.
   - **Outcome**: tool for identifying benchmark on spawner abundances accessible to assessment staff, and recommendations for future extensions identified.

(2) **Guidelines for processing data on spawner abundances**. We will present preliminary guidelines for processing data on spawner abundances that have been developed for WCVI CUs (*led by Carrie Holt*).
   - Guidelines pertain to inclusion/exclusion of systems within a CU, dealing with years with missing data, aggregating information across systems within a CU.
   - The methods applied will depend on the species, and metrics of interest. For example, some metrics will require higher quality data than others, and some types of data may be appropriate for some species and not others.
   - We will investigate application of those guidelines, or revised versions, to other areas.
   - **Outcome**: guidelines for processing data on spawner abundances prior to assessment.

(3) **Explore revisions to benchmarks on fishing mortality**. Current lower benchmarks on F (F_{MSY}) are inconsistent with lower benchmarks on spawner abundances (S_{gen}) (*led by Steve Cox-Rogers and Dave Peacock*).
- Alternative benchmarks, such as F_{gen}, the fishing mortality that will result in S_{gen}, will be considered.
- Explore use of benchmarks on fishing mortality for CUs managed based on exploitation rate where CU-specific abundances are not available. Examples from the North Coast will be presented
- **Outcome**: revised lower benchmarks on fishing mortality.

(4) **Explore impacts of non-stationarity in model parameters on benchmarks**, and identify possible assessment responses (*Discussion leader Al Cass and Sue Grant*).
- Should benchmarks be adjusted to account for current or forecasts in productivity? (or current or forecasts of capacity).
- If so, how and how often? Will this result in a 'sliding goal post' where expectations are adjusted downwards with deteriorating conditions?
- **Outcome**: guidelines on how benchmarks and assessments should respond to changes in productivity.

(5) **Develop a work plan for identifying methods for combining metrics** within classes of indicators (e.g., combining information from different metrics on rates of change), and among classes of indicators (e.g., combining information from abundances, fishing mortality, rates of change, and distribution) (*lead by Mark Saunders with group discussion*).
- A synoptic survey of conservation status, developed by Blair Holtby, used one approach for combining information on COSEWIC trends, abundances, and distribution in a synoptic survey. Others could also be considered.
- **Outcome**: work plan for identifying methods for combing information across metrics

Several other items have been flagged for discussion, including, developing a systematic process for revising CUs, identifying a level of precaution appropriate for benchmarks that include uncertainty, and developing a consistent methodology for estimating variance in S_{MAX}, a parameter often used as a prior in Bayesian stock-recruitment analyses, or as a benchmark in itself. These topics may be discussed briefly here, but will likely require another workshop with priority on those items.

We ask participants to RSVP for Day 1 (technical discussions about software and guidelines for data processing), and Day 2 (more general discussion about implementation).