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Proceedings of the Pacific Scientific Advice Review Committee (PSARC) Salmon Subcommittee meeting

Compte rendu de la réunion du sous-comité du saumon du Comité d'examen des évaluations scientifiques du Pacifique (CEESP)

June 13-14, 2007

Du 13 au 14 juin 2007

Kim Hyatt

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Fisheries and Oceans Canada
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July 2008

Juillet 2008

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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings include research recommendations, uncertainties, and the rationale for decisions made by the meeting. Proceedings also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

Avant-propos

Le présent compte rendu a pour but de documenter les principales activités et discussions qui ont eu lieu au cours de la réunion. Il contient des recommandations sur les recherches à effectuer, traite des incertitudes et expose les motifs ayant mené à la prise de décisions pendant la réunion. En outre, il fait état de données, d'analyses ou d'interprétations passées en revue et rejetées pour des raisons scientifiques, en donnant la raison du rejet. Bien que les interprétations et les opinions contenus dans le présent rapport puissent être inexacts ou propres à induire en erreur, ils sont quand même reproduits aussi fidèlement que possible afin de refléter les échanges tenus au cours de la réunion. Ainsi, aucune partie de ce rapport ne doit être considéré en tant que reflet des conclusions de la réunion, à moins d'indication précise en ce sens. De plus, un examen ultérieur de la question pourrait entraîner des changements aux conclusions, notamment si l'information supplémentaire pertinente, non disponible au moment de la réunion, est fournie par la suite. Finalement, dans les rares cas où des opinions divergentes sont exprimées officiellement, celles-ci sont également consignées dans les annexes du compte rendu.

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PACIFIC SCIENTIFIC ADVICE REVIEW COMMITTEE (PSARC)

SUMMARY

The Pacific Scientific Advice Review Committee (PSARC) met June 13-14, 2007 at the Coast Bastion Inn in Nanaimo, B.C. Two working papers were reviewed.

Working Paper: Conservation Units for Pacific Salmon under the Wild Salmon Policy

There was a general consensus that results from applying the methodology should be "reasonably" repeatable if applied by others independent of the authors. To facilitate such future use, a flow chart identifying each of the methodological steps in sequence along with a concise text rationale for each should be included in the revised paper.

There is a lot of new terminology introduced or developed in the current paper so assembly of a glossary of terms and acronyms was suggested to improve readability. Further, several variants of conservation terminology (CU, DU, ESU, etc.) used in the document should be clarified as to their similarities and differences.

Given data limitations regarding the use of phenotypic information (*i.e.,* principally salmon run timing information) and genetic information serving as a basis for Conservation Unit (CU) identification, the authors were requested to add 1 or more paragraphs indicating which additional types of information or traits (e.g., life history, genetics) might be usefully assembled and applied to future analyses using the general methodology developed here. Once identified and assembled, this new information should be applied in analyses and future reports that build on the foundation of CU delineation developed here.

Key recommendations from the paper should be brought together in a short set of summary recommendations regarding the utility of information to applied resource managers.

A list of CUs was deliberately not included by the authors. As the method has been accepted by the Salmon Subcommittee, subject to the successful completion of revisions, a list of the CUs should be added to the final version (i.e., the list arrived at after systematically applying the general method).

Meeting participants acknowledged the importance of Aboriginal Traditional Environmental Knowledge (ATEK) to further define wild salmon CUs and that the current paper lacked appropriate information sources or informants to satisfy this requirement. Accordingly, the Subcommittee noted that a portion of future Wild Salmon Policy consultation effort with First Nations groups should be expended to this end.

Given completion of key revisions, further independent application and testing of the CU methodology and its outcomes is possible and desirable.

Working Paper: Comparison of the Fishery and Conservation Performance of Fixed- and Abundance-Based Exploitation Regimes for Coho Salmon in Southern British Columbia

The papers were accepted by the Salmon PSARC Subcommittee pending changes to the model inputs and structure and additional simulations recommended by the reviewers and the Subcommittee. There was general agreement about the following:

- In the papers, the authors present a valid methodology for examining reference points for coho Conservations Units (CUs).

- Once reference points are established for coho CUs and these can be used as inputs to the model, the modeling framework will provide a means for assessment of CU status.

- The methodology can also be used to explore alternative management strategies (e.g., abundance-based vs. fixed or stepped harvest rates) and recommend specific strategies with respect to the Pacific Salmon Treaty.

- Additional simulations are required to test the sensitivity of the model results, especially concerning the long term measures of conservation status, to particular inputs and stream structure before more specific management advice is warranted.

- When the model can be modified to represent specific CUs with CU-specific data, specific management recommendations will be possible.

- Subcommittee discussion resulted in the strong recommendation that management targets for coho should not be based on recruitment forecasts. In addition, management targets should not be based on a projected total allowable catch that is not adjusted by in-season information.

SOMMAIRE

Les membres du Comité d'examen des évaluations scientifiques du Pacifique (CEESP) se sont réunis les 13-14 juin 2007, au Coast Bastion Inn, à Nanaimo, en Colombie-Britannique. Ils ont examiné deux documents de travail.

Document de travail : Unités de conservation du saumon du Pacifique en vertu de la Politique du Canada pour la conservation du saumon sauvage du Pacifique (*Conservation Units for Pacific Salmon under the Wild Salmon Policy*)

Les participants s'entendent tous pour dire que les résultats obtenus devraient être « raisonnablement » reproductibles lorsque la méthode appliquée est utilisée par des personnes indépendantes des auteurs. Pour faciliter une telle utilisation future, il faudrait inclure au document révisé un organigramme sur lequel les étapes méthodologiques sont énumérées dans l'ordre, chacune étant assorties d'une justification textuelle concise.

Une multitude de nouveaux termes sont présentés ou précisés dans ce document. On propose donc, d'une part, d'établir un glossaire de termes et d'acronymes qui pourra faciliter la compréhension du document et, d'autre part, d'expliquer les similitudes et les différences entre plusieurs variantes des termes de conservation employés (unité de conservation [Conservation Unit – CU], unités désignables [Designatable Unit – UD], unité évolutionnaire significative [Evolutionarily Significant Unit – ESU], etc.).

En raison des limites liées à l'utilisation de l'information phénotypique (surtout en ce qui a trait à la migration anadrome des saumons) et de l'information génétique en tant qu'éléments de base pour l'identification des unités de conservation (CU), les participants demandent aux auteurs d'ajouter un ou plusieurs paragraphes indiquant quels types de renseignements ou de caractéristiques supplémentaires (p. ex. cycle biologique, génétique) pourraient être regroupés et appliqués à de futures analyses en utilisant la méthodologie générale décrite dans ce document. Une fois relevée et réunie, cette nouvelle information devrait être appliquée aux analyses et aux futurs rapports prenant appui sur la méthode de délimitation des unités de conservation décrite dans ce document.

Les participants recommandent que l'on regroupe les principales recommandations formulées dans ce document dans un bref ensemble de recommandations sommaires sur l'utilité de l'information destinée aux gestionnaires de la ressource.

Lea auteurs ont délibérément omis d'inclure une liste des unités de conservation. Comme le sous-comité du saumon a accepté la méthode, sous réserve d'un processus de révision mené à bien, on devrait inclure une liste des unités de conservation à la version finale (c.-à-d. une liste dressée suivant l'application systématique de la méthode générale).

Les participants reconnaissent le rôle important que peuvent jouer les connaissances écologiques autochtones dans la définition des unités de conservation du saumon sauvage et ils estiment que ce document ne contient pas suffisamment de sources d'information et d'informateurs pour satisfaire à cette exigence. Le sous-comité souligne donc qu'une partie de l'effort de consultation future sur la Politique du Canada pour la conservation du saumon sauvage du Pacifique devra être menée auprès de groupes des Premières nations.

Une fois que les principales modifications auront été apportées, il sera possible et souhaitable de faire une application et un essai indépendants de la méthodologie des unités de conservation et de ses résultats.

Document de travail : Comparaison du rendement des pêches et des activités de conservation pour des régimes d'exploitation fixes et fondés sur l'abondance du saumon coho présent dans le sud de la Colombie-Britannique (*Comparison of the Fishery and Conservation Performance of Fixed- and Abundance-Based Exploitation Regimes for Coho Salmon in Southern British Columbia*)

Le document a été accepté par le sous-comité du Saumon du CEESP sous réserve de l'apport de changements à la structure et aux données de sortie du modèle et l'ajout de simulations supplémentaires, comme le recommandent les évaluateurs et membres du sous-comité. Les points suivants font l'unanimité.

- Dans le document, les auteurs présentent une méthodologie valide pour l'examen des points de référence applicables aux unités de conservation du saumon coho.

- Une fois que des points de référence auront été établis pour les unités de conservation du saumon coho et que ceux-ci pourront être employés comme données d'entrée du modèle, le cadre de modélisation pourra être utilisé pour évaluer la situation des unités de conservation.

- La méthodologie peut également être utilisée pour explorer des stratégies de gestion de rechange (p. ex. taux d'exploitation fondés sur l'abondance vs taux d'exploitation fixes ou graduels) et pour recommander des stratégies particulières en regard du Traité sur le saumon du Pacifique.

- Des simulations supplémentaires sont nécessaires pour éprouver la sensibilité des résultats du modèle obtenus avec des données d'entrée et des structures hydrographiques particulières, notamment en ce qui a trait aux mesures de conservation à long terme, avant que l'on puisse formuler des avis de gestion plus précis.

- Lorsque nous pourrons modifier le modèle afin qu'il puisse représenter des unités de conservation particulières avec des données qui leur sont propres, il sera possible de formuler des recommandations de gestion précises.

- À la suite de discussions, les membres du sous-comité recommandent fortement que les cibles de gestion du saumon coho ne soient pas basées sur des prévisions concernant le recrutement. Ces cibles ne devraient pas être basées non plus sur un total autorisé des captures projeté qui n'a pas été corrigé en fonction de données de la saison en cours.

INTRODUCTION

The Pacific Scientific Advice Review Committee (PSARC) met on June 13-14 at the Coast Bastion Inn in Nanaimo, B.C. to review two Working Papers. The meeting Chair, K. Hyatt welcomed the participants and a round of introductions was completed. There was good representation from industry, universities, First Nations, NGOs and the province. During the introductory remarks, the objectives of the meeting were reviewed and the participants accepted the meeting agenda.

The meeting participants reviewed two Working Papers which are summarized in Appendix 1. The meeting agenda appears as Appendix 2. A list of meeting participants and reviewers is included as Appendix 3

DETAILED COMMENTS FROM THE REVIEW

Working Paper: Conservation Units for Pacific Salmon under the Wild Salmon Policy

L.B. Holtby and K.A. Ciruna

* Paper accepted subject to revisions.

Rapporteur: C. Parken

Meeting Discussion

Summary

Conservation Units (CU) under Canada's Policy for the Conservation of Wild Pacific Salmon are defined as "a group of wild salmon sufficiently isolated from other groups that, if extirpated is very unlikely to recolonize naturally within an acceptable timeframe, such as a human lifetime or a specified number of salmon generations." Fisheries and Oceans Canada's (DFO) Wild Salmon Policy (WSP) specifies a requirement to develop a science-based methodology that may be used to identify individual CUs making up the wild salmon complex in Canada's Pacific region. The primary purpose of this working paper is to describe the method that was developed to identify the "Conservation Units" for the five species of Pacific salmon in British Columbia.

The approach of Waples et al.[1] was modified to characterize diversity in Pacific salmon along three major axes: ecology, life history and molecular genetics, and then to compartmentalize that diversity into CUs. The first major step in the methodology involved the use of ecological and environmental attributes for

[1] Waples, R.S., Gustafson, R.G., Weitkamp, L.A., Myers, J.M., Johnson, O.W., Busby, P.J., Hard, J.J., Bryant, G.J., Waknitz, F.W., Nelly, K., Teel, D., Grant, W.S., Winans, G.A., Phelps, S., Marshall, A., and Baker, B.M. 2001. Characterizing diversity in salmon from the Pacific Northwest. J. Fish. Biol. **59**: 1-41.

classifications as these categories contained useful information for all spawning locations. The ecotypologies used include a characterization of the near-shore marine environment in addition to one for fresh water. The second stage of the description involves the use of life history, molecular genetics and further ecological characterizations to group and partition the first stage units into the final Conservation Units. The result is the identification of CUs along with their associated geographic locations of origin in freshwater. The author's analysis suggests a high degree of concordance between ecotypic, biological (life history) and genetic characterizations of intraspecific diversity, in agreement with earlier analyses of Waples et al. Molecular genetics were essential to the identification of CUs in areas of high genetic diversity but once identified, ecotypology appeared capable of mapping the genetic diversity. Similarly, there were instances where life histories differed and where ecological descriptors mapped that diversity. The high levels of concordance between the three axes strongly suggest that the CUs describe real and presumably adaptive diversity. Use of the classification methodology as presented in the paper suggests that Pacific salmon are very diverse comprising more than 440 CUs in Canada's Pacific region (i.e., pink-43, chum-28, coho-45, chinook-50 and sockeye salmon-280).

Reviewers of this Working Paper noted that it provides a timely and important conservation methodology for recognizing and maintaining diversity at the sub-species level within the Pacific salmon complex in Canada. Both reviewers commended the authors for compiling such a paper given the scope of the subject material, the geographic scale involved and the general quality of the work as presented. The paper presents an essential framework to formulate appropriate conservation units for wild salmon. The methodology appears to be sufficiently integrative that it should generate meaningful, biologically-based units on which to focus DFO's future management to meet both biological conservation and fisheries sustainability objectives.

The methodology as initially applied identifies the minimum level of diversity in the face of limitations of current life history, ecological and genetics information. Inclusion of additional information in future analyses will facilitate identification of a higher proportion of the full range of wild salmon biodiversity. However, the methodology generally provides a basis to move forward and account for biodiversity, while recognizing a need for future refinement and inclusion of new information (e.g., life history phenotypes or ecological variates such as productvity) to refine and improve delineation of CUs. The approach described may work well for some species or just in some areas for a specific species, but additional developments are needed to capture the expression of biodiversity that is evident among some outliers or groups of outliers within geographic areas identified as joint adaptive zones for CUs. In most circumstances the approach outlined appears suitable, yet in others additional refinements or developments, such as an objective interpretation of the genetic data, are still needed. Overall this is a substantial piece of useful work that will facilitate identification of an initial

defensible list of CUs to manage for biodiversity. It is significant progress that provides a foundation for future development and refinement.

General Discussion

Significant concerns raised by the reviewers and discussed by Subcommittee participants were as follows:

General Editorial Concerns:

Reviewers and Salmon Subcommittee participants noted that, given the size and complexity of this work, there were several revisions that would contribute to clarifying and strengthening various parts of the working paper as follows:

1. The complexity, length and lack of clarity in many parts of the text (*e.g., distinction between terms such as mutually interchangeable versus exchangeable; ecotypic approach versus ecological approach*) suggest the need for a careful edit and the addition of more explanatory figures and tables to supplement existing text descriptions (*e.g., link Figures 17 and 18 and other similar figures with a visual representation of major defined populations groups on a map of BC, so its readily apparent where these groups exist relative to adaptive zones*).

2. Some participants expressed concerns that the paper was too "cryptically" written to understand exactly what had been done and why (*with respect to the CU identification methodology*) so a careful edit for greater readability appears warranted.

3. Eliminate exotic terminology, where possible (*e.g.*, ecotypic vs ecological, genodeme, topodeme GFE_ID, CU, ESU, DU etc.), and add a glossary to help readers more effectively access ideas in the text where new terminology is unavoidable.

4. Subcommittee members suggested that maps illustrating the locations and distributions of CUs, genetic information, spawning times, etc. would be helpful for communicating how the method was applied. However, these could not be developed within the time frames to prepare the report and it was uncertain if they could be developed within the time frames for revisions to be completed. It was communicated that these were valuable and that the OHEB was contributing to the mapping of this and other WSP information.

Content Issues:

1. One reviewer queried whether the current work would be extended to include steelhead, rainbow and cutthroat trout given the objective of the working

paper to identify conservation units for all species of Pacific salmon. Some participants indicated that B.C. Ministry of Environment staff have applied these methods and developed a list of CUs and inquired about where to send their list to help DFO reconcile its management (e.g. fishery, habitat, etc.) with conservation, now that it has been hi-lighted at a policy level.

2. Adaptive Zones: Reviewers identified the definition and use of joint adaptive zones consisting of freshwater and marine habitats occupied by CUs as useful but were unclear where information on marine distributions had been obtained and whether such information was sufficiently rich to identify the majority of CUs. More information is required on how marine adaptive zones were defined for individual populations and qualifiers for populations where information is uncertain. If conservation units are defined principally on the basis of FAZ the potential for classification bias should be acknowledged.

3. One reviewer noted that strong correlations between genetic and life history data at one scale (e.g. regional) does not ensure similar relationships exist at finer (i.e., local) scales when defining Conservation Units. However, the authors expressed the view that these types of associations seemed to exist at all scales down to tens of km. A second reviewer suggested that the relative weightings implicitly attached to genetics, life history and ecological attributes should be made more explicit with some discussion about whether the values of the various attributes are readily interchangeable.

4. Interpretation of Genetic Classification Levels: The level of genetic classification employed as part of the methodology varied among species and decision rules regarding the level to use were not clear. A biologically significant level had not been determined to assist with consistent application of the method. In general a bifurcation rule was followed, but not always. Often an attempt was made to interpret genetic distances, and separation was attempted for distant spawning locations, but the approach was somewhat subjective and influenced by the set of systems in the genetic analysis. This raised concerns that application of the method by different people could produce differences in identified CUs. Subjectivity could be reduced by describing the genetic groups more objectively (e.g. the report did not present the dendogram for Chinook or unrooted tree diagrams to clarify bifurcation terminology).

5. Genetic diversity was not surveyed among spawning locations following a statistically based study design aimed to develop information to represent the genetic diversity of salmon among ecotypes, life history, or other possible strata. Thus genetic diversity might be underestimated, especially if adaptive gradients exist within FAZ that were not correlated with spawn timing. Further, the multivariate cluster analysis approaches applied to estimate the genetic classification levels are sensitive to the degree to which CUs sampled among rivers for genetic data are representative in addition to the

sample sizes for each sampling location (e.g. small sample sizes could make a sampling location appear distinctive if all were collected from the same family). For example, the coverage of the locations sampled for coho appeared much more limited than for other species, and the classification levels may differ somewhat after more of the genetic variation has been surveyed. This circumstance does not preclude reapplication of the method after more locations have been surveyed for a species.

6. Ecotypology-Life History: Reviewers and Salmon Subcommittee participants were concerned that the ecotypic approach utilized in the paper relied principally on run-timing as a life history attribute and suggested other traits (e.g., size-at-maturity, smolt age, body morphology etc.) be considered in the methodology to ensure that diversity identified within the salmon complex reflects a variety of life-history data axes. The author(s) agreed but noted that data such as these were available for only a relatively small subset of salmon populations.

7. Figure 1 in the working paper and associated text were insufficiently detailed to allow reviewers to identify each of the stepwise elements employed to identify specific CUs. Application of the methodology involved different combinations of data sets for different species due to data availability differences. However, there was some concern expressed that use of different attributes and less than fully transparent decision rules may result, upon closer inspection, in the creation of several species-specific methodologies rather than the application of an overarching general methodology for identifying CUs among species. In addition, a general concern emerged about whether the methodology could be employed independently by others to arrive at the same CU endpoints. For example, it's not clear from Table 4 how the authors chose between genetic classification level 3 versus level 4 and the possible influence of such decisions on the number of CUs subsequently identified. There was a general consensus that results from applying the methodology should be very repeatable if applied by others independent of the originating authors. A sequence diagram or flow chart identifying each of the methodological steps along with a text rationale for each would appear to be highly desirable.

8. Aboriginal Traditional Environmental Knowledge (ATEK): Some Subcommittee members expressed concerns that ATEK of wild salmon should be considered as a routine source of information for use with the general methodology, while others expressed views that western scientific knowledge should be the primary and perhaps sole basis for CU identification. Further discussion suggested that ATEK could serve as a significant source of information for defining conservation units (e.g., ATEK from an initial WSP consultation was used to help differentiate salmon CUs associated with the Hecate Lowlands versus fjord areas).

Subcommittee Recommendations:

1. There was a general consensus that results from applying the methodology should be "reasonably" repeatable if applied by others independent of the authors. To facilitate such future use, a flow chart identifying each of the methodological steps in sequence along with a concise text rationale for each should be included in the revised paper.

2. There is a lot of new terminology introduced or developed in the current paper so assembly of a glossary of terms and acronyms was suggested to improve readability. Further, several variants of conservation terminology (CU, DU, ESU, etc.) used in the document should be clarified as to their similarities and differences.

3. Given data limitations regarding the use of phenotypic information (*i.e.,* principally salmon run timing information) and genetic information serving as a basis for CU identification, the authors were requested to add 1 or more paragraphs indicating which additional types of information or traits (e.g., life history, genetics) might be usefully assembled and applied to future analyses using the general methodology developed here. Once identified and assembled, this new information should be applied in analyses and future reports that build on the foundation of CU delineation developed here.

4. Key recommendations from the paper should be brought together in a short set of summary recommendations regarding the utility of information to applied resource managers.

5. A list of CUs was deliberately not included by the authors. As the method has been accepted by the Salmon Subcommittee, subject to the successful completion of revisions, a list of the CUs should be added to the final version (i.e., the list arrived at after systematically applying the general method).

6. Meeting participants acknowledged the importance of ATEK to further define wild salmon CUs and that the current paper lacked appropriate information sources or informants to satisfy this requirement. Accordingly, the Subcommittee noted that a portion of future WSP consultation effort with First Nations groups should be expended to this end.

7. Given completion of key revisions, further independent application and testing of the CU methodology and its outcomes is possible and desirable.

Working Paper: Comparison of the Fishery and Conservation Performance of Fixed- and Abundance-Based Exploitation Regimes for Coho Salmon in Southern British Columbia

J. Korman and A. Tompkins

*accepted subject to minor revision

Rapporteur: G. Brown

Meeting Discussion

Recommendations from the Reviewers to the Authors

The two reviewers concluded that the modeling framework developed in the first paper offers a valid and promising methodology for developing reference points for conservations units for Coho in British Columbia. Both reviewers, however, recommended a number of modifications to the parameter values used as input to the model and to the model structure as well. The authors accepted all of the reviewers' recommendations including additional grammatical corrections to the text.

Conclusions and Recommendations

The specific concerns raised by the reviewers about the model input values and structure were also similar points of concerne raised during the discussion period by PSARC Subcommittee members. These concerns are summarized in the next section.

Recommendations from the Salmon PSARC Subcommittee to the Authors

Discussion by the Subcommittee members along with the reviewers focused on a number of related issues. These were the specific parameters used as input to the model, certain features of the model structure and certain features of the output. Specific points about these issues follow below:

1) Inputs to the model

a) Data from the Minter Creek population should be excluded and data available from other B.C. populations should be included for derivation of the stock productivity parameters and survival rate values.

b) Survival rates of 1-3% (to be informed by examination of available recent 10-year averages) should be included in the simulations to represent more recent

and current reality. Although much higher survival rates were observed in the past, these have not been observed in recent times (with the exception of recent increases in Puget Sound Coho survival rates) and there is little expectation of substantial improvements for southern BC populations in the near future.

c) Substitute the extirpation/extinction criteria that were used in the model simulations for others such as the 23,000 spawners recommended for the Thompson aggregate in the Thompson River Coho Recovery Potential Plan.

2) Structure of the model

a) Most discussion focused on the 'habitat' structure, i.e., the number and length of streams, used as the fundamental model structure. There was concern that the structure used by the authors (100 streams of 12 km each) while based on a reasonable total length of accessible stream in the Thompson aggregate, was not representative of either the Georgia Basin West (GBW) aggregate or the Thompson River aggregate. The main concern was that the stream structure had a strong but unknown influence on the simulation results. The recommendation was made to use a stream structure of 24 streams x 50 km each for the GBW aggregate and a structure of even fewer streams (5, 11 or 20 as in the Wood and Bradford COSEWIC Recovery Potential Plan) for the Thompson aggregate. Equal stream length was recommended but the suggestion was made to allow for annual variation in the amount of accessible stream length per stream. This latter modification would represent changes in stream-specific accessibility due to considerable variation in annual flow.

b) The authors were asked to consider using a different approach for drawing model input parameters for simulations. The current selection method may be influencing and in particular, decreasing the range of output generated by the model.

c) The strong recommendation was made that the production forecasts in the model should be based on marine survival rates rather than recruitment.

d) Forecast error should be implemented as a function related to abundance rather than as random noise.

e) Management implementation error should also be implemented such that it increases and decreases with abundance.

f) Two items that were suggested for implementation, if time permitted, were the inclusion of a depensation factor at low abundances and allowance for straying of spawners among streams. The latter is thought to be more prevalent at high abundances.

3) Conservation metrics output from the model

a) Concern was raised that either the model structure, or the specific conservation metrics used as outputs, were too insensitive to variation in the model parameters. The authors were requested to consider inclusion of additional conservation metrics such as decline in area and rates of decline (as defined by the COSEWIC IUCN Red List Criteria).

4) Additional simulations

a) Explore the sensitivity of the model to changes in stream structure and to extirpation criteria.

b) Explore the consequences of a TAC-based constant harvest rate management strategy to show how it performs relative to the effort-based approach. For these simulations, the implementation of forecast error and management error should be made more realistic (i.e., not random noise).

5) Other items

a) The authors will integrate some discussion of the stock or population concept as it applies to coho salmon. There was general agreement that in the context of the papers, the word 'stream' should be substituted for 'population'.

b) A table will be included that lists all the input parameters and their values as shown in the meeting presentation.

c) A paragraph will be included that discusses the assumptions used in the model and the logic for them. For example, stationarity of the stock-recruit relationships is assumed although this is unlikely to reflect reality. Nevertheless, the authors adopted the assumption due to the lack of quantitative data.

d) A summary section will be included that specifically addresses the four stated requests from Fishery Management.

Recommendations from the Salmon PSARC Subcommittee to Fishery Management

The papers were accepted by the Salmon PSARC Subcommittee pending changes to the model inputs and structure and additional simulations recommended by the reviewers and the Subcommittee. There was general agreement about the following:

1) In the papers, the authors present a valid methodology for examining reference points for coho Conservations Units (CUs).

2) Once reference points are established for coho CUs and these can be used as inputs to the model, the modeling framework will provide a means for assessment of CU status.

3) The methodology can also be used to explore alternative management strategies (e.g., abundance-based vs. fixed or stepped harvest rates) and recommend specific strategies with respect to the Pacific Salmon Treaty.

4) Additional simulations are required to test the sensitivity of the model results, especially concerning the long term measures of conservation status, to particular inputs and stream structure before more specific management advice is warranted.

5) When the model can be modified to represent specific CUs with CU-specific data, specific management recommendations will be possible.

6) Subcommittee discussion resulted in the strong recommendation that management targets for coho should not be based on recruitment forecasts. In addition, management targets should not be based on a projected total allowable catch that is not adjusted by in-season information.

APPENDIX 1. Working Paper Summaries

Conservation Units for Pacific Salmon under the Wild Salmon Policy
L.B. Holtby and K.A. Ciruna

The initial steps in protecting biological diversity and also the primary roles of scientific research, are to identify the diversity and then take inventory of the units of diversity that require conservation[2]. Consequently, the first of six strategies in the *Wild Salmon Policy*[3] concerns the identification of the units and determining their conservation status. The primary purpose of this document is to describe the method that was developed to identify the "Conservation Units" for the five species of Pacific salmon in British Columbia. The description of units in most of the Yukon[4] and Northwest Territories will proceed using this method once the ecotypology of those areas is completed.

The approach of Waples et al.[5] was modified to characterize diversity in Pacific salmon along three major axes: ecology, life history and molecular genetics, and then to compartmentalize that diversity into Conservation Units. The three descriptive axes are used to map local adaptation, which is actually what is to be conserved, in a variety of ways. The maps are then examined and combined to locate and describe the Conservation Units. The first stage in the description of the Conservation Units is based solely on ecology. The ecotypologies used include a characterization of the near-shore marine environment in addition to one for fresh water. The second stage of the description involves the use of life history, molecular genetics and further ecological characterizations to group and partition the first stage units into the final Conservation Units. The result is Conservation Units that are described through the joint application of all three axes.

There is a high degree of concordance between ecotypic, biological (life history) and genetic characterizations of intraspecific diversity, confirming the principal conclusions of Waples et al.[4] Molecular genetics was essential in areas of high genetic diversity but once identified, ecotypology appeared capable of mapping the genetic diversity. Similarly, there were instances where life histories differed and where ecological descriptors mapped that diversity. The high levels of

[2] see Wood, C.C. 2001. Managing Biodiversity in Pacific Salmon: The Evolution of the Skeena River Sockeye Salmon Fishery in British Columbia. Blue Millennium: Managing Global Fisheries for Biodiversity, Victoria, British Columbia, Canada, p. 34p. Proceedings of the Blue Millennium International Workshop, June 25-27, 2001, Victoria, BC, Canada. Papers available at http://www.worldfish.org/bluem-reports.htm

[3] DFO. 2005. Canada's policy for conservation of wild Pacific salmon. Fisheries and Oceans Canada, 401 Burrard Street, Vancouver, BC V6C 3S4. p. 49+v.

[4] Several of the ecotypic zones straddle the Yukon-British Columbia border and are described in this document.

[5] Waples, R.S., Gustafson, R.G., Weitkamp, L.A., Myers, J.M., Johnson, O.W., Busby, P.J., Hard, J.J., Bryant, G.J., Waknitz, F.W., Nelly, K., Teel, D., Grant, W.S., Winans, G.A., Phelps, S., Marshall, A., and Baker, B.M. 2001. Characterizing diversity in salmon from the Pacific Northwest. J. Fish. Biol. **59**: 1-41.

concordance between the three axes strongly suggest that the Conservation Units describe real and presumably adaptive diversity.

In addition to the pragmatic advantages of a method that uses all available information to describe intraspecific diversity, an ecotypic approach has benefits stemming from characterizations of salmon habitat in its broadest sense. Importantly, the method supports the intent of the WSP to use CUs for the conservation of both pattern and process[6].

One general conclusion from this exercise is that Pacific salmon in Canada are very diverse. This diversity is reflected in the estimated numbers of CUs by species shown in the following table:

species	number of CUs
pink-odd	19
pink-even	13§
chum	37†
coho	43
chinook	62†
sockeye-river	24
sockeye-lake	214

§ An additional CU may be allowed for the Fraser River and its tributaries if the persistence of the even-year race in the Fraser River is confirmed.
† Additional CUs will be described in the Yukon River. Although additional CUs are possible in the Mackenzie River, they would be outside of the geographic purview of the Wild Salmon Policy.

Comparison of the Fishery and Conservation Performance of Fixed- and Abundance-Based Exploitation Regimes for Coho Salmon in Southern British Columbia
J. Korman and A. Tompkins

We compared alternate fixed- and abundance-based harvest rate policies for coho salmon in Southern British Columbia using a simulation model. The model consisted of a two-stage (spawner-smolt, smolt-adult recruit) population dynamics component and a management component that simulated error in recruitment forecasts and harvest implementation, and was parameterized based on an analysis of existing data. The model simulated the dynamics of multiple populations of differing productivity and capacity within a management unit. Performance under different harvest regimes was evaluated based on simulated yield, inter annual variability in yield, as well as conservation status of individual populations. We simulated fixed harvest rate policies ranging from 0.1 to 0.8 and

[6] Pattern is the diversity that currently exists. Process refers to the evolutionary processes that create and maintain diversity. (see Moritz, C. 2002. Strategies to protect biological diversity and the evolutionary processes that sustain it. Systematic Biology **51**: 238 - 254.)

abundance-based policies with a range of escapement floors, escapement ceilings, and harvest rates.

At the historical marine survival rate of 7%, catch was maximized at a fixed exploitation rate of 0.4. There was a near linear increase in the conservation failure rate as exploitation rates rose from 0.3 to 0.6. Rates greater than 0.4 resulted in a rapid increase in the fraction of stocks that were extirpated. Both yield and conservation statistics suggest there is little sense in harvesting coho at rates of greater than 0.4 unless marine survival increases beyond the historical average. The extent to which exploitation rate should be reduced to improve the status of weak stocks is hard to determine because the biological significance of reducing the conservation failure rate is highly uncertain.

Abundance-based harvest regimes had much better performance than fixed exploitation rate regimes, but only in cases when they were compared to fixed exploitation rates that exceeded the rate where catch is maximized. Abundance-based harvest regimes performed poorly compared to fixed exploitation regimes when harvest rates at the escapement ceilings exceeded the optimal rate of 0.4. This occurred because the abundance-based harvest rate was determined from the recruitment of the aggregate stock. It was possible to overexploit weak populations and maintain an aggregate recruitment that was still large enough to justify relatively high harvest rates. There was little conservation or yield benefits associated with abundance-based policies compared to fixed exploitation strategies when the latter regime was based on a rate that optimized yield for the aggregate stock. Considering the increased costs of implementing abundance-based strategies and the increased variability in yield, a fixed exploitation strategy is recommended. Reductions in harvest implementation error through better inseason management will likely lead to improvements in both conservation status of weak populations and fisheries yields.

APPENDIX 2: PSARC Meeting Agenda, June 13-14, 2007

PACIFIC SCIENTIFIC ADVICE REVIEW COMMITTEE
SALMON SUBCOMMITTEE MEETING

June 13-14, 2007
Coast Bastion Inn, Nanaimo, B.C.
Agenda

WEDNESDAY– JUNE 13	
Introduction and procedures	9:00 – 9:15
Conservation Units for Pacific salmon under the Wild Salmon Policy Holtby, LB; Ciruna, K	9:15 – 10:00
Lunch Break	12:00 – 1:00
Conservation Units for Pacific Salmon under the Wild Salmon Policy cont'd	1:00 – 4:00
Adjournment	4:00
THURSDAY – JUNE 14	
Comparison of the Fishery and Conservation Performance of Fixed and Abundance-Based Exploitation Regimes for Coho Salmon in Southern British Columbia Korman, J. and A. Tompkins	9:00-12:00
Lunch Break	12:00 – 1:00
Comparison of the Fishery and Conservation Performance of Fixed and Abundance-Based Exploitation Regimes for Coho Salmon in Southern British Columbia cont'd	1:00-4:00
Adjournment	4:00

APPENDIX 3. List of Attendees

Subcommittee Chair: Kim Hyatt

External Participants	
Name	**Affiliation**
Blackbourn, David	Consultant
Cox, Sean	Simon Fraser University
English, Karl	LGL Limited
Ennis, Gordon	PFRCC
Gable, Jim	Pacific Salmon Commission
Harvey, Brian	Consultant
Howard, Sara	Nature Conservancy of Canada
Innes, Keith	Kitkatla Council
Korman, Josh	Ecometric Research Inc.
Kristianson, Gerry	Sport Fish Advisory Board
LeBlond, Paul	PFRCC
Milne, Saul	Fraser Basin Council
Orr, Craig	Watershed Watch Salmon Society
Parkinson, Erik	Ministry of Environment
Staley, Mike	Fraser River Watershed Committee
Tautz, Art	Ministry of Environment
Temple, Nicola	Raincoast Conservation Society
Walsh, Michelle	Secwepemc Fisheries Commission
Walters, Carl	University of British Columbia
Wilson, Ken	Fraser River Aboriginal Fisheries Resource Conservation Council
Wright, Howie	Okanagan Nation Alliance
DFO Participants	
Bailey, Richard	
Bradford, Mike	
Brown, Gayle	
Candy, John	
Cass, Al	
Cross, Carol	
Curtis, Janelle	
Dobson, Diana	
Folkes, Michael	
Grout, Jeff	
Hargreaves, Brent	
Holtby, Blair	
Huang, Ann-Marie	
Hyatt, Kim	
Irvine, Jim	

Jantz, Les	
Lauzier, Ray	
Luedke, Wilf	
McNicol, Rick	
O'Brien, David	
Parken, Chuck	
Riddell, Brian	
Saunders, Mark	
Sawada, Joel	
Schubert, Neil	
Scroggie, Jamie	
Shaw, Bill	
Sturhahn, Neil	
Sullivan, Melanie	
Tadey, Joe	
Ryall, Paul	
Tompkins, Arlene	
Wood, Chris	

The reviewers for the PSARC paper presented at this meeting are listed below. Their assistance is invaluable in making the PSARC process work.

Bradford, Mike	DFO, Pacific Region
Busack, Craig	Washington Department of Fish and Wildlife
Fraser, Dylan	Dalhousie University
Staley, Mike	Fraser River Watershed Committee
Stephenson, Rob	DFO, Maritimes Region