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Compte rendu de la réunion du souscomité des poissons pélagiques du CEESP tenue les 17 et 18 novembre 2003.

November 17-18, 2003
Nanaimo, B.C.

T. Therriault
Pelagic Subcommittee Chair

Fisheries and Oceans Canada
Pacific Scientific Advice Review Committee
Pacific Biological Station
Nanaimo, British Columbia V9T 6N7

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Canada

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PACIFIC SCIENTIFIC ADVICE REVIEW COMMITTEE (PSARC)

SUMMARY

The Pacific Scientific Advice Review Committee (PSARC) Pelagic Subcommittee met November 17-18, 2003 at the Pacific Biological Station, Nanaimo, British Columbia to review scientific information relating to British Columbia (BC) herring biology, distribution and assessment.

Working Paper P2003-04: Herring metapopulation dynamics: Spawn disappearance and recolonization events

The Subcommittee accepted this paper subject to revisions and recommended management should continue using the current stock units.

This working paper examined existing spawn data to identify disappearance and recolonization events. Results showed that 55% of herring sections experienced at least one disappearance event between 1943 and 2002. Given sufficient time, most locations where spawn disappeared were eventually recolonized (spawning returned) with the time required for recolonization related to the amount of spawning habitat available, section size, degree of habitat isolation and other factors. Oceanic regime appears to affect the rate of disappearance and recolonization with increased disappearance rates during the "warm" regime resulting in fewer sections containing spawn. Thirty-four sections did not experience any disappearance events and these sections contain 85% of the total BC herring spawning habitat. Thus, preservation of these habitats should be a priority. The very low site fidelity at small spatial scales (i.e., section) makes management at this scale impossible. It is appropriate that herring management be continued at the population (stock) level.

Working Paper P2003-05: An evaluation of alternative catch-age models for risk assessment of Pacific herring stocks

The Subcommittee accepted this paper subject to revisions. There was considerable discussion on how to recommend a single model for risk analysis and decided three models should be evaluated further. Also, the Subcommittee recommended an additional performance measure (the ability to forecast spawner biomass) be considered in future analyses. Furthermore, the Subcommittee cautions that if herring biology is not adequately accounted for in any "new" model, resulting analysis/risk assessment will not be accurate.

This working paper is the first in a series required to develop a formal, risk assessment analysis framework for the BC herring fishery. The existing herring age-structure model is not readily transferable to the Bayesian framework required for risk analyses so alternative models were developed and evaluated. Four new age-structured models (NASM) and two existing age-structured models (EASM) were evaluated under five different scenarios (four presented in the working paper plus an

additional one suggested by the Subcommittee) developed to represent plausible variation in natural mortality (*M*) and spawn conversion (*q*) through simulated data sets. All models were evaluated on their ability to estimate *q* and *M* from simulated data. Two NASM models were eliminated from further consideration because they failed to accurately estimate known parameters. Models were evaluated with respect to their ability to predict spawner biomass (SB), catch, the number of recruits to the population, the number of recruits to the fishery (age-3 herring), and the ability to estimate age-compositions. Although different models might be chosen based on different performance measures, the model recommended by the authors (NASM-3) estimates annual variation in natural mortality rates (*M*) and fixes the spawn conversion factor (*q*) at 1.0. The potential limitation to this model is its tendency to overestimate the proportion of recruits. The evaluation of different selectivity functions might improve model performance by reducing the bias in the estimate of recruits. The two preferred new models and the two existing models also were evaluated against available fishery data for the five major BC herring stocks.

SOMMAIRE

Le Sous-comité des poissons pélagiques du Comité d'examen des évaluations scientifiques du Pacifique (CEESP) s'est réuni les 17 et 18 novembre 2003 à la Station biologique du Pacifique, située à Nanaimo (C.-B.), pour examiner l'information scientifique sur la biologie, la distribution et l'évaluation du hareng de la Colombie-Britannique.

Document de travail P2003-04 : Dynamique de la métapopulation de harengs – Absence et reprise de la fraie

Le Sous-comité accepte ce document sous réserve de révisions et recommande aux gestionnaires de continuer à utiliser les unités de stock actuelles.

Sont examinées dans ce document de travail les données existantes sur la fraie afin de cerner les périodes sans reproduction et les périodes de reprise de celle-ci. Les résultats montrent qu'il y a eu au moins une période sans fraie dans 55 % des secteurs de hareng entre 1943 et 2002. Avec le temps, la fraie a repris dans la plupart des secteurs où elle avait cessé. La durée de la période de rétablissement dépend de la quantité d'habitats disponibles pour la fraie, de la taille des secteurs, de l'isolement des habitats et d'autres facteurs. Le régime océanique semble influer sur la fraie : la proportion de secteurs où celle-ci est absente est plus élevée au cours des régimes « chauds ». La fraie a été constante dans 34 secteurs, et ceux-ci comprennent 85 % des habitats de fraie du hareng en C.-B. La préservation de ces habitats devrait donc constituer une priorité. La très faible fidélité du hareng aux secteurs fait en sorte que la gestion à cette échelle est impossible. La gestion du hareng doit continuer d'être axée sur les populations (stocks).

Document de travail P2003-05 : Évaluation d'autres modèles de prises par âge pour l'évaluation des risques auxquels font face les stocks de hareng du Pacifique

Le Sous-comité accepte ce document sous réserve de révisions. La façon de recommander un seul modèle d'analyse des risques fait l'objet d'une longue discussion, et il est convenu que trois modèles devraient être évalués de manière plus approfondie. Le Sous-comité recommande l'utilisation d'une mesure de performance supplémentaire (la capacité de prévision de la biomasse des géniteurs) dans le cadre des analyses ultérieures. De plus, le Sous-comité signale que si le ou les nouveaux modèles ne tiennent pas compte adéquatement de la biologie du hareng, l'analyse ou l'évaluation des risques subséquente sera inexacte.

Ce document est le premier d'une série qui est nécessaire à l'élaboration d'un cadre officiel d'analyse des risques pour la pêche du hareng en C.-B. Comme le modèle existant de la structure d'âge du hareng n'est pas facilement applicable au cadre bayesien nécessaire aux analyses des risques, d'autres modèles ont été élaborés et évalués. Quatre nouveaux modèles fondés sur la structure d'âge et deux modèles existants ont été évalués selon cinq scénarios différents (quatre sont présentés dans le document de travail et un autre a été suggéré par le Sous-comité) élaborés de manière à ce qu'ils soient représentatifs de la variation possible de la mortalité naturelle (*M*) et de la conversion du frai (*q*). Tous les modèles ont été évalués sur le plan de leur capacité à estimer *q* et *M* à partir de données simulées. Deux des nouveaux modèles ont été abandonnés puisqu'ils n'ont pas permis d'estimer avec exactitude des paramètres connus. La capacité de prévision de la biomasse des géniteurs, des prises et du nombre de recrues dans la population et dans la pêche (hareng de 3 ans) ainsi que la capacité d'estimation de la composition en âge ont également été évaluées. Bien que différents modèles peuvent être choisis en fonction de différentes mesures de performance, le modèle recommandé par les auteurs (le nouveau modèle n^{o} 3) permet d'estimer les variations annuelles des taux de mortalité naturelle (*M*) et d'établir le facteur de conversion du frai (*q*) à 1,0. Le facteur limitant de ce modèle est sa tendance à surestimer la proportion de recrues. L'évaluation de différentes fonctions de sélectivité pourrait améliorer la performance du modèle en réduisant le biais lié à l'estimation du nombre de recrues. Les deux nouveaux modèles préférés et les deux modèles existants ont également été évalués en fonction de données de pêche disponibles pour les cinq principaux stocks de hareng de la C.-B.

INTRODUCTION

The PSARC Pelagic Subcommittee met November 17-18, 2003 at the Pacific Biological Station in Nanaimo, British Columbia. External participants from industry and First Nations attended. The Subcommittee Chair, T. Therriault, opened the meeting by welcoming the participants. During the introductory remarks the objectives of the meeting were reviewed, and the Subcommittee accepted the meeting agenda following discussion of agenda items. The Subcommittee had subsequent discussion on the role of PSARC and the process for getting working papers/additional items added to the PSARC agenda. The Chair presented recommendations and discussion items from the September 19, 2003 meeting of Resource Management Executive Committee (RMEC) at which recommendations from the last Pelagic Subcommittee meeting were presented. RMEC's concern on assuming average recruitment in the absence of information/data on recruitment strength was discussed. The Subcommittee has agreed to provide RMEC with a rationale for this approach to be prepared for the next PSARC Pelagic Subcommittee meeting (tentatively scheduled for February 2004) and provided to RMEC in the subsequent advisory document.

The Subcommittee reviewed two working papers and three updates. Working paper summaries are in Appendix 1. The meeting agenda appears as Appendix 2. A list of meeting participants and reviewers is included as Appendix 3.

DETAILED COMMENTS

P2003-04: Herring metapopulation dynamics: Spawn disappearance and recolonization events

D. Ware and C. Tovey (**Accepted subject to revisions**)

Subcommittee Discussion

This working paper investigated herring spawning time series data to identify disappearance events and recolonization events. Correlations between the number of disappearance events and other variables were explored but no causes for disappearance events were given. This was troubling to some Subcommittee members who felt that any study that did not include fishery removals was incomplete since fishing activities could result in local depletion (with no observable spawn in some sections). The authors maintained that their intent was not to provide possible causes or mechanisms in this paper but to identify disappearance and recolonization events at the section level. The single reviewer complemented the author on the analysis but questioned how the Working Paper was linked to metapopulation theory. The Subcommittee encouraged future studies to explore probable causes for local spawn disappearance and it should be noted that Herring Conservation and Research

Society (HCRS) funded projects are underway to address some of these issues. There was debate as to whether "local spawning aggregations" are representative of sub-population structure. The authors maintained this was a valid approach but some Subcommittee members were not convinced and felt local, special interest groups could misconstrue the interpretation of results presented by the authors. It is important to note that the authors and the Subcommittee agree that herring sections do not reflect distinct populations. Concerns were raised about the amount of time herring spend on spawning grounds (approx. 2% of their life) and whether spawning aggregations reflect population sub-structure (metapopulation) or reflect the outcome of random and/or deterministic processes.

There was discussion to clarify variables used in the principal component analysis (spawner biomass estimates) and details will be added to the paper during revisions. The Subcommittee thought that it was valuable to include historic disappearance rates determined for each stock assessment area and for northern and southern management areas separately. It was noted that figures in the Working Paper showed section boundaries that were not consistent with some current herring section boundaries and some locations reported to have had consistent spawn were not correct. The authors agreed to revise the paper accordingly. Also, there was concern that the number of herring sections identified (105) were not up-to-date (101) but the authors indicated that the ones retained for analyses (76) were consistent with currently accepted sections and further changes were not required. The Subcommittee discussed the potential impacts of the record abundance of herring in the Strait of Georgia and the possibility that spawning patterns for this stock might be different from other stocks. The authors concluded that with increased spawning biomass, herring were spawning in more locations, but not necessarily in more sections. The Subcommittee raised concerns about possible biases from locations where continuous spawn overlaps multiple sections. The Subcommittee discussed how the sections were first defined based on herring spawning patterns but noted this was done following the fishery collapse at a time when stock abundance was low. Some Subcommittee members felt that some of the current herring sections may no longer have a biological basis and questioned their suitability for the present study. However, both the Subcommittee and authors recognize the creation of new spatial scales for analyses would be extremely labor intensive and beyond the scope of revisions.

Subcommittee Conclusions

The Subcommittee agreed to accept the paper with revisions, but the decision was not unanimous. Revisions are to include: 1) re-analysis of the data at the major stock assessment level; 2) comparisons between northern stock assessment areas (QCI, PRD, and CC) and southern ones (SOG and WCVI); 3) consideration of the possible effects of size of suitable habitat on disappearance and recolonization events as differences in section size could have biased some results; and 4) a table providing the locations of the 34 herring sections that did not experience disappearance events.

Subcommittee Recommendations

1) BC herring are believed to represent a metapopulation. Given the structure of the metapopulation, and the high fidelity rates of the major stocks, it is appropriate that management of the resource be maintained using the current geographic groups.
2) A total of 34 herring sections has not experienced a disappearance event and account for 85% of herring spawning habitat. Preservation of these locations should be a priority.

P2003-05: An evaluation of alternative catch-age models for risk assessment of Pacific herring stocks

C. Fu, J. Schweigert, and C. Wood (**Accepted with revisions**)

Subcommittee Discussion

Subcommittee discussion focussed on deliberations about which of the six alternative age-structured models should be recommended for the risk analysis and the next step in the science-based review of herring stock assessment. One reviewer questioned why it was necessary to eliminate any models at this stage. The Subcommittee felt that the four scenarios that were evaluated were reasonable but asked the authors to consider a scenario allowing *q*, the spawn conversion factor, to vary around some low mean value for a time and then to vary around a higher mean value. This scenario is similar to those developed to simulate the change from surface-based to diver spawn surveys, but the scenarios investigated in the working paper did not consider variability around *q*. There was extensive Subcommittee discussion regarding how to decide which model(s) to recommend for the risk analysis. Some found the selection of the most appropriate model(s) difficult because the performance measures in the Working Paper were hard for them to interpret. As noted by both reviewers, the Subcommittee had difficulty understanding the results because insufficient tabular summaries were provided. The reviewers and Subcommittee recommended that tables be developed which summarize results of the simulation scenarios, model performance rankings and the main findings regarding the reconstruction of the fishery data. The Subcommittee and reviewers were concerned that there was no retrospective analysis of the forecasts using the different models. The authors indicated that retrospective analysis would be part of the risk analysis work to be done for the next PSARC paper.

Subcommittee Conclusions

The Subcommittee acknowledges the time and effort that has gone into the development and evaluation of the new age-structured models presented in this working paper. The Subcommittee accepts the paper with revisions. These revisions include: 1) an additional scenario with multiple *q*'s (spawn conversion factors); 2) inclusion of summary tables with actual units for simulation scenarios and model performance evaluation that will facilitate comparisons among models. Furthermore, inclusion of results with actual units of measurement would be useful for some Subcommittee members (e.g., tons of fish).

As a first step in the development of an Objective-Based Fishery Management (OBFM) framework, it was perceived that a modified age-structured model was required to facilitate the risk assessment for Pacific herring and to assess alternative assumptions about population dynamics and harvest rules. The current herring age-structured model cannot be easily incorporated into the preferred Bayesian, risk analysis framework. The Subcommittee felt strongly that extensive and methodical analysis of any "new" model is required before adopting it for either stock assessment forecasting or risk analysis. This is imperative because if the biology contained in the model is not correct (e.g., herring productivity), resulting analyses will not be accurate (e.g., impacts of harvesting).

The Subcommittee accepts the authors' conclusion that the NASM-3 [New Age-Structured model] is probably the best model to proceed with for the risk analysis given the scenarios explored and models evaluated in this paper. However, the Subcommittee feels that the existing model (EASM-2) also should be included in future analyses while others felt NASM-4 also should be retained until evaluated further.

The Subcommittee recognizes there are several performance measures that could be evaluated but feel that the ones used by the authors are acceptable for the current work on model evaluation. However, the Subcommittee recommends that additional performance measures be considered for the risk assessment analyses (see below). Also, the authors' note that the NASM-3 tends to overestimate the proportion of age-3 herring in the catch-at-age and a more appropriate selectivity function needs to be explored. It was unclear to the Subcommittee when this would be done, by whom, and what the implications for risk assessment analyses are.

The Subcommittee recognizes there are potential discrepancies in the data and the way in which existing data can be summarized for model development and evaluation and cautions that these are considered in the risk analysis. For example, there was Subcommittee discussion about using only the most recent data in future models.

Models tended to have difficulty predicting spawner biomass for years prior to the roe fishery, especially for QCI, but preformed better during the roe fishery period in the stock reconstructions. The Subcommittee debated the validity of continuing to use data from the reduction fishery period given the increased variability and uncertainty associated with this data but did not reach a conclusion.

Subcommittee Recommendations

1) The Subcommittee recommended that an additional scenario be considered that allows for multiple levels of *q* (spawn conversion factor) to vary around different levels and might capture actual herring data better (e.g., differences between spawn surveys over time).
2) The Subcommittee recommended that the spawning biomass predicted one year in advance (SB_{t+1}) should be considered as an additional performance measure for any model used in risk assessment analyses (the next paper in this series).
3) The Subcommittee recommended NASM-3, NASM-4, and EASM-2 each be evaluated in the risk assessment analysis.

Update Genetic DNA Analysis

T. Beacham

This ongoing project uses 15 microsatellite loci to evaluate potential differences among BC herring populations. The genetic results are consistent with past and present tagging data that show there is sufficient mixing among putative populations to preclude much differentiation. However, populations identified as potentially different in this update included Skidegate Inlet and Masset Inlet (QCI), summer spawning Metlakatla (PRD), and Portage Inlet/Esquimalt Harbour (SOG) (the most genetically distinct). Additional sampling is required to determine if genetic signals are consistent over time. Results to date also indicate a number of small inlet populations appear genetically different from populations in adjacent major stock assessment areas. Again, additional sampling is required.

Sardine Update

J. Schweigert

The allowable harvest of sardine in BC is a function of the US stock assessment for this species. The Canadian harvest from this stock is based on assuming a 10% migration rate into BC waters and adopting the US harvest rate based on current water temperatures; a 15% harvest rate. With a US forecast of 1.09 million mt, the potential BC harvest for 2004 would be 16,359 mt (<2% of total stock biomass), and

would have negligible impacts on the overall stock. Preliminary landings to date in 2003 are approximately 1,000 mt.

Coded Wire Tag Update

L. Flostrand and J. Schweigert

The update presented a summary of recent releases and recoveries of CWT in BC since 1999. The number of tags released and recovered in 2003 also was presented. Tagging efforts were focused on three stock assessment areas (SOG, CC, and PRD) with 326,732 tags released. Almost 25% of the BC roe herring harvest was searched for CWTs resulting in 1,148 recoveries. Most recoveries were in-season or 1-year-at-large. Straying among stocks was observed with the greatest number of strays observed between SOG releases and WCVI recoveries and between PRD and CC. Although presented as an update at this meeting, it was noted that no working paper has been presented to the Subcommittee at this time and one would be welcomed given the five years invested in this project.

APPENDIX 1: Working Paper Summary

P2003-04 Herring metapopulation dynamics: Spawn disappearance and recolonization events

D. Ware and C. Tovey

This is the fourth in a series of papers outlining the evidence that British Columbia herring are spatially structured and interact like a metapopulation. The purpose of this paper is to analyze the spawn time series for indications of "disappearance" and "recolonization" events. Some local communities in British Columbia believe that each bay where herring spawn contains a genetically discrete stock. Accordingly, if one of these "stocks" fails to return to spawn the implication is that some unique genetic diversity has probably been lost. The metapopulation concept provides an ecological basis for explaining that small, herring spawning aggregations can disappear for a time due to natural causes. And that vacant habitat will eventually be recolonized, when suitable conditions return. We analyzed the spawn time series (from 1943 to 2002) in 76 spatial "sections" where herring spawn in BC. We identified 82 spawn disappearance events, and found that 55% of the sections experienced one or more disappearance events in the last 60 years. We found that smaller sections experience more disappearance events, and that most vacant habitats are eventually recolonized. On average, stray spawners from other areas recolonized vacant sections in 11 years. Some sections were recolonized in less than five years; while at the other extreme, one section has not been recolonized for 35 years. Only 53 % of the recolonization attempts were successful. The high degree of straying between nearby sections explains why herring spawning aggregations at the "section" spatial scale have a low coherence. We found that 18 sections currently contain no spawn. These vacant sections have a smaller amount of spawn habitat, and a higher probability of disappearance events than sections containing spawn. The near unity balance between the spawn disappearance and recolonization rates changed when the last "cool" climate regime ended in 1977. During the warm regime that followed the disappearance rate tended to be higher than the recolonization rate, so the number of sections occupied by spawners declined in the 1980s and 1990s. There were no spawn disappearance events in 34 sections. These important sections contain about 85% of the total herring spawn habitat in BC, and therefore should be protected from shoreline development, pollution and other sources of habitat degradation. Loss of these habitats will almost certainly have a negative impact on the dynamics and resilience of the herring metapopulation.

P2003-05: An evaluation of alternative catch-age models for risk assessment of Pacific herring stocks

C. Fu, J. Schweigert, and C. Wood

Recent declines in two of the five major Pacific herring stocks in British Columbia have raised concerns about the assessment and management of the herring stocks. The Department of Fisheries and Oceans is committed to a science-based review of the stock assessment and fishery management framework for the herring stocks. As a first step in this review process, we have developed a new age-structured model (NASM) in a Bayesian context. The purpose of this paper is to compare its performance with that of the existing age-structured model (EASM) using simulation-estimation experiments and through reconstructing the dynamics of the five major herring stocks.

The simulation-estimation experiments indicate that if the underlying spawn index conversion factor (q) changes from one constant value to another and the time of change is known, model selection is difficult; however, if the underlying q changes randomly, the new model NASM-3 that estimates annual variations in natural loss (M) but fixes q performs the best. When the underlying M shifts its mean drastically from one period of time to another (i.e., regime shift), NASM-3 and NASM-4, which account for annual variations in M perform significantly better. However, if M changes only randomly around a constant level, the advantage of estimating annual variations in M becomes less obvious. Overall, NASM-3 seems very promising based on the simulation results.

In applying the four models (NASM-3, NASM-4, EASM-1, and EASM-2) to the five herring stocks, the differences in parameter estimates were as expected from the simulation results for three of the five stocks (QCI, GS and WCVI), for which we are reasonably confident in identifying the most plausible reconstructions. The promising model NASM-3 tends to overestimate the proportion at age 3 in all the five stocks suggesting more appropriate selective functions be used. If this model is to be used for future stock assessment and risk assessment, a further investigation into different selectivity functions is warranted.

APPENDIX 2: PSARC Pelagic Subcommittee Meeting Agenda November 17-18, 2003

AGENDA
PSARC PELAGICS SUBCOMMITTEE MEETING
November 17-18, 2003
Seminar Room - Pacific Biological Station
Nanaimo, BC

Monday, November 17

8:30	Introductions and Opening Remarks.
9:00-12:00	An evaluation of alternative catch-age models for risk assessment of Pacific herring stocks (C. Fu, J. Schweigert, and C. Wood)
12:00	Lunch
1:00-2:00	Fu et al. continued if required.
2:00-4:00	Herring metapopulation dynamics: Spawn disappearance and recolonization events (D. Ware and C. Tovey).

Tuesday, November 18

9:00-10:00	Update Genetic DNA Analysis (T. Beacham)
10:00-11:00	Sardine Update (J. Schweigert)
11:00-12:00	Coded-wire tag Update (L. Flostrand and J. Schweigert)
12:00	Lunch
1:00-4:00	Formulation of Subcommittee Conclusions and Recommendations

APPENDIX 3: List of Attendees & Reviewers

Subcommittee Chair: Tom Therriault
PSARC Chair: Al Cass

DFO Participants	
* Subcommittee Members	
Cass, Al	
Chalmers, Dennis*	
Flostrand, Linnea	
Fu, Caihong	
Hamer, Lorena*	
Hay, Doug*	
Henderson, Sharlene	
Hrabok, Christa	
Kristen, Daniel	
Mijacika, Lisa	
McCarter, Bruce*	
Midgley, Peter*	
Rusch, Bryan*	
Schweigert, Jake*	
Tanasichuk, Ron* Trager, Diana*	
External Participants:	**Affiliation**
Hall, Don	Nuu-Chah-Nulth Tribal Council
Ware, Dan	Consultant
Webb, Lloyd	Fishing Vessel Owners Assoc.

Reviewers for the PSARC papers presented at this meeting are listed below, in alphabetical order. Their assistance is invaluable in making the PSARC process work.

Brown, E	University of Alaska Fairbanks
Cox, S	Simon Fraser University
Martell, S.	University of Maryland