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Proceedings of the PSARC Pelagic Subcommittee Meeting, September 4-6, 2002

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Pelagic Subcommittee Chair

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

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PACIFIC SCIENTIFIC ADVICE REVIEW COMMITTEE (PSARC)
PELAGIC SUBCOMMITTEE MEETING

SUMMARY

The Pacific Scientific Advice Review Committee (PSARC) Pelagic Subcommittee met September 4-6, 2002 at the Pacific Biological Station, Nanaimo, B.C. to review scientific information relating to B.C. herring biology and the status of B.C. herring stocks.

Working Paper P2002-01: An evaluation of a recruitment forecasting procedure for Strait of Georgia herring

The Subcommittee concluded that summer offshore trawl estimates of proportion of age-2 herring can be used to estimate the proportion of age-3 herring available in the Strait of Georgia the following spring. The Subcommittee recommended that a retrospective analysis on recruitment forecasting be provided using the estimated Strait of Georgia proportion of age-3 herring from offshore trawl estimates of proportion of age-2 herring in the previous summer and applying it to the age-structured model estimates of pre-spawning biomass. The paper was accepted on condition that retrospective analyses be reviewed by the Subcommittee at the November, 2002 meeting in order to assess the applicability of forecasting recruitment. Until a retrospective analysis of forecasted recruitment is provided, any estimates of recruitment should not be incorporated into the stock assessment.

Working Paper P2002-02: Metapopulation dynamics of British Columbia herring during cool and warm climate regimes

Though still a work in progress, the implications for potential dispersal among stocks could have stock assessment implications and future research should attempt to include metapopulation concepts and applications in the age-structured model. Specifically, the dispersal variability across areas might account for some observed differences between the age-structured and escapement models' estimates of spawner biomass. The Subcommittee accepted this paper with minor revisions and recommended that the dispersal mechanisms identified in the paper be incorporated in the age-structured model analyses.

Working Paper P2002-03: Analyses of juvenile herring surveys for recruitment prediction in the Strait of Georgia

Estimates of the numbers of age-3 recruits in 2002, determined from the age-structure analysis in the annual assessment document (Working Paper P2002-05) were not available and could not be included in this paper at the time of submission. Subsequently, the inclusion of 2002 estimate of the number of age-3 recruits from the stock assessment model was an extreme outlier in the relationship between juvenile abundance and recruitment to the fishery. Its addition to regression undermines the statistical significance of the relationship predicting recruitment from juvenile herring surveys. Irrespective of the 2002 data outlier, the Subcommittee concluded that some analytical issues need to be addressed before the utility of the

survey can be adequately assessed. Since there is no immediate requirement for a decision or management recommendation from this paper, the Subcommittee requested that additional analyses be undertaken. If revisions are not possible by the November meeting, the Subcommittee would reconvene in early 2003 to reconsider this paper.

Working Paper P2002-05: Stock assessment for B.C. herring in 2002 and forecasts of the potential catch in 2003

The five major herring stocks in B.C. are managed by a fixed harvest rate policy in conjunction with a fishing threshold or cutoff level. Cutoff levels are set at 25 percent of the estimated unfished average biomass. Cutoff levels have been established through stock-recruitment curves or bootstrapping of the observed recruitment time series. Biomass forecasts are provided for three classifications of recruitment assumption: poor, average and good. Poor, average, and good recruitment levels in the age-structured model are calculated as the mean of the lowest 33%, the mid 33%, and the highest 33% of the estimate of historic age-2+ fish abundance. The Subcommittee reviews spawn survey information, perceptions of skippers and managers, age-structured model information, biological data and other auxiliary information to select the appropriate recruitment assumption. When information is incomplete or status of the stock is unknown, the default recruitment assumption is average. Yield recommendations are set at 20 percent of forecast annual biomass unless the forecast is close to or below cutoff levels. Assessments of major stocks in 2002 were conducted using an age-structured model only, while previous years' assessments have also presented estimates of forecast biomass from the escapement model. The paper was accepted with revisions and the Subcommittee accepted yield recommendations outlined in Appendices 4-8.

For the five major stock assessment regions in B.C., the forecast biomass for 2003 is 224,160 tonnes. This represents an increase of 21% over the 2002 abundance level. This increase reflects increased abundance in the south coast stocks particularly the Strait of Georgia. However, abundance in the Queen Charlotte Islands is below the cutoff level and is severely depressed. Application of the harvest policy results in a potential coastwide harvest of 43,390 tonnes for 2003.

Queen Charlotte Islands – The pre-fishery biomass forecast for 2003 is 7,200 tonnes (95% C.I.: 5,800 – 10,400 tonnes) assuming average recruitment. The forecast of returning biomass is below the cutoff level of 10,700 tonnes. No harvest (0 tonnes) is recommended for this stock.

Prince Rupert District – The pre-fishery biomass forecast for 2003 is 31,660 tonnes (95% C.I.: 27,000 – 38,300 tonnes) assuming average recruitment. The forecast of returning biomass is above the cutoff level of 12,100 tonnes. Application of the 20 percent harvest rate to the forecast results in a potential harvest of 6,330 tonnes.

Central Coast - The pre-fishery biomass forecast for 2003 is 25,260 tonnes (95% C.I.: 18,100 – 27,000 tonnes) assuming average recruitment. The forecast of returning biomass is above the cutoff level of 17,600 tonnes. Application of the 20 percent harvest rate to the forecast results in a potential harvest of 5,050 tonnes.

Strait of Georgia - The pre-fishery biomass forecast for 2003 is 130,010 tonnes (95% C.I.: 106,060 – 150,100 tonnes) assuming good recruitment. The forecast of returning biomass is well above the cutoff level of 21,200 tonnes. Application of the 20 percent harvest rate to the forecast results in a potential harvest of 26,000 tonnes.

West Coast Vancouver Island - The pre-fishery biomass forecast for 2003 is 30,030 tonnes (95% C.I.: 29,700 – 45,200 tonnes) assuming poor recruitment. The forecast of returning biomass is above the cutoff level of 18,800 tonnes. Application of the 20 percent harvest rate to the forecast results in a potential harvest of 6,010 tonnes.

Minor stocks – Typically, potential harvest for minor stocks are identified as 10% of observed spawn biomass. The Subcommittee identified a potential harvest of 85 tonnes for Area 27. Based on an estimated spawning biomass of 130 tonnes for 2W, the Subcommittee could not recommend any harvest for this minor stock for 2002.

SOMMAIRE

Le Sous-comité des poissons pélagiques du Comité d'examen des évaluations scientifiques du Pacifique (CEESP) s'est réuni du 4 au 6 septembre 2002 à la station biologique du Pacifique, à Nanaimo (C.-B.) pour examiner l'information scientifique sur la biologie et sur l'état des stocks de hareng de la C.-B.

Document de travail P2002-01 : Évaluation d'un processus de prévision du recrutement appliqué au hareng du détroit de Georgia

Le Sous-comité a conclu que la proportion de harengs d'âge 2 estimée à partir de relevés estivaux effectués au chalut dans les eaux hauturières pouvait servir à estimer celle de harengs d'âge 3 dans le détroit de Georgia le printemps suivant. Il a recommandé une analyse rétrospective des prévisions du recrutement dans laquelle la proportion estimée de harengs d'âge 3 dans le détroit de Georgia établie à partir des estimations de la proportion de harengs d'âge 2 l'été précédent sera appliquée aux biomasses de harengs avant la fraie estimées par le modèle de structure par âge. Le document a été accepté à la condition que le Sous-comité examine les analyses rétrospectives à sa réunion du 22 novembre 2002 afin d'établir si ce processus peut permettre de prévoir le recrutement. En attendant l'analyse rétrospective des prévisions du recrutement, aucune estimation du recrutement ne devrait être incorporée dans l'évaluation des stocks.

Document de travail P2002-02 : Dynamique de la métapopulation de hareng de la Colombie-Britannique pendant les régimes de climat frais ou chaud

Bien que l'étude soit encore en cours, les mouvements possibles de poissons entre les stocks pourraient avoir une incidence sur l'évaluation des stocks, et les recherches futures devraient appliquer le concept de métapopulation au modèle de structure par âge. Plus précisément, la variabilité des déplacements entre les régions pourrait expliquer certaines différences constatées entre les biomasses des géniteurs estimées par les modèles de structure par âge et d'échappée. Le Sous-comité a accepté ce document avec des révisions mineures et a recommandé que les mécanismes de déplacement déterminés dans le document soient incorporés dans les analyses avec le modèle par structure d'âge.

Document de travail P2002-03 : Analyses des relevés de harengs juvéniles pour prévoir le recrutement dans le détroit de Georgia

Les estimations du nombre de recrues d'âge 3 en 2002, déterminées par l'analyse de la structure par âge dans le document sur l'évaluation annuelle (document de travail P2002-05) n'étaient pas disponibles et ne pouvaient être incluses dans le présent document au moment où il a été soumis. Par la suite, le nombre de recrues d'âge 3 en 2002 estimé par le modèle d'évaluation des stocks constituait une valeur aberrante par rapport à la plage de points illustrant la relation entre l'abondance des juvéniles et le recrutement à la pêche. Son ajout dans la régression mine la signification statistique de la relation permettant de prévoir le recrutement à partir des relevés de harengs juvéniles. Abstraction faite du cas particulier des données de 2002, le Sous-comité a conclu qu'il fallait régler certaines questions d'analyse avant de pouvoir évaluer adéquatement l'utilité du relevé. Comme aucune décision ni recommandation de gestion ne doivent découler immédiatement de ce document, le Sous-comité a demandé que d'autres analyses soient faites. Si des révisions ne pouvaient pas être apportées d'ici à la réunion de novembre, le Sous-comité se réunirait de nouveau au début de 2003 pour réexaminer le document.

Document de travail P2002-05 : Évaluation des stocks de hareng de la C.-B. en 2002 et prévisions des prises potentielles en 2003

La pêche des cinq principaux stocks de hareng en C.-B. est régie par un taux d'exploitation fixe, assorti d'un seuil ou d'une limite de pêche. Les limites ont été établies à 25 p. 100 de la biomasse moyenne non exploitée estimée à partir des courbes stock-recrutement ou par la méthode bootstrap appliquée aux séries chronologiques observées du recrutement. Des prévisions de la biomasse sont fournies pour trois classes de recrutement hypothétique : faible, moyen et bon. Les niveaux de recrutement faible, moyen et bon dans le modèle de structure par âge correspondent respectivement à la moyenne du tiers (33 %) plus faible, du tiers moyen (33 %) et du tiers le plus élevé (33 %) de l'estimation de l'abondance historique des poissons d'âge 2+. Le Sous-comité examine l'information tirée des

relevés des géniteurs, les perceptions des capitaines et des gestionnaires, l'information tirée du modèle de structure par âge, les données biologiques et l'information secondaire pour choisir la bonne hypothèse quant au recrutement. Lorsque l'information est incomplète ou que l'état des stocks est inconnu, on suppose par défaut que le recrutement est moyen. Les recommandations pour le rendement sont fixées à 20 p. 100 de la biomasse annuelle prévue, à moins que la prévision soit proche de la limite ou y soit inférieure. Les principaux stocks en 2002 ont été estimés uniquement par le modèle de structure par âge, alors que les biomasses prévues l'ont aussi été par le modèle d'échappée dans les évaluations de l'an dernier. Le document a été accepté avec des révisions, et le Sous-comité a accepté les recommandations sur le rendement exposées dans les annexes 4-8.

Pour les cinq principales régions d'évaluation des stocks en C.-B., la biomasse prévue pour 2002 est de 224 160 tonnes, soit une hausse de 21 % par rapport au niveau d'abondance de 200l. Cette augmentation reflète la plus grande abondance des stocks du sud de la côte, en particulier du détroit de Georgia. Cependant, l'abondance, qui est très à la baisse dans les îles de la Reine-Charlotte est inférieure à la limite. L'application du taux d'exploitation résulte en une récolte potentielle à la grandeur de la côte de 43 390 tonnes pour 2003.

Îles de la Reine-Charlotte – La prévision de la biomasse avant la pêche pour 2003 est de 7 200 tonnes (I.C. de 95 % : 5 800 – 10 400 tonnes), en supposant un recrutement moyen. La prévision de la biomasse des harengs qui sont de retour est inférieure à la limite de 10 700 tonnes. Aucune pêche (0 tonne) de ce stock n'est recommandée.

District de Prince Rupert – La prévision de la biomasse avant la pêche pour 2003 est de 31 660 tonnes (I.C. de 95 % : 27 000 – 38 300 tonnes), en supposant un recrutement moyen. La prévision de la biomasse des harengs qui sont de retour est supérieure à la limite de 12 100 tonnes. L'application du taux d'exploitation de 20 p. 100 à la prévision résulte en des prises potentielles de 6 330 tonnes.

Centre de la côte - La prévision de la biomasse avant la pêche pour 2003 est de 25 260 tonnes (I.C. de 95 % : 18 100 – 27 000 tonnes), en supposant un recrutement moyen. La prévision de la biomasse des harengs qui sont de retour est supérieure à la limite de 17 600 tonnes. L'application du taux d'exploitation de 20 p. 100 à la prévision résulte en une récolte potentielle de 5 050 tonnes.

Détroit de Georgia - La prévision de la biomasse avant la pêche pour 2003 est de 130 010 tonnes (I.C. de 95 % : 106 060 – 150 100 tonnes), en supposant un bon recrutement. La prévision de la biomasse des harengs qui sont de retour est de beaucoup supérieure à la limite de 21 200 tonnes. L'application du taux d'exploitation de 20 p. 100 à la prévision résulte en une récolte potentielle de 26 000 tonnes.

Côte Ouest de l'île de Vancouver - La prévision de la biomasse avant la pêche pour 2003 est de 30 030 tonnes (I.C. de 95 % : 29 700 – 45 200 tonnes), en supposant un

faible recrutement. La prévision de la biomasse des harengs qui sont de retour est inférieure à la limite de 18 800 tonnes. L'application du taux d'exploitation de 20 p. 100 à la prévision résulte en une récolte potentielle de 6 010 tonnes.

Stocks mineurs – Typiquement, la récolte potentielle pour les stocks mineurs correspond à 10 % de la biomasse des géniteurs observée. Le Sous-comité a établi une récolte potentielle de 85 tonnes pour la zone 27. Étant donné la biomasse des géniteurs estimée à 130 tonnes dans 2W, le Sous-Comité ne pouvait pas recommander l'exploitation de ce stock mineur en 2002.

INTRODUCTION

The PSARC Pelagic Subcommittee met September 4-6, at the Pacific Biological Station in Nanaimo, British Columbia. External participants from First Nations, fishing industry and environmental groups attended the meeting. The Subcommittee Chair, J. King, 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.

The Subcommittee reviewed four Working Papers. Summaries of the Working Papers are in Appendix 1. The meeting agenda appears as Appendix 2. A list of meeting participants, observers and reviewers is included as Appendix 3. Criteria for assessment of stock status in 2002 and yield recommendations for 2003 for the five major herring assessment areas are included as Appendices 4 –8. The following acronyms are used throughout the document:

ASM	Age-structured model
CC	Central Coast
CI	Confidence Interval
CPUE	Catch Per Unit Effort
FSC	Food, Social, Ceremonial
PR	Prince Rupert District
QCI	Queen Charlotte Islands
SB*	Unfished Equilibrium Biomass
SB	Spawner Biomass
SG	Strait of Georgia
WCVI	West Coast Vancouver Island

DETAILED COMMENTS FROM THE REVIEWS

For many of these papers, the Subcommittee discussed the implications that the scientific research held for management advice. Even though Requests for Advice had been submitted by management for the scientific papers, the questions outlined in the requests did not provide adequate direction on which the Subcommittee could

formulate management recommendations. The Subcommittee noted that the questions that Reviewers are asked to answer while reviewing Working Papers, were more applicable for PSARC Subcommittees that deal with forecasting procedures only and do not necessarily encompass the interests of all PSARC Subcommittees. The Subcommittee agreed that a more coordinated approach between management and science would alleviate the difficulty in providing explicit management recommendations and might reduce the number of papers required for PSARC Subcommittee meetings.

P2002-01: An evaluation of a recruitment forecasting procedure for Strait of Georgia herring

R. Tanasichuk **Accepted subject to revisions (to be presented in November 2002)**

Rapporteur: Doug Hay

The Reviewers raised a number of vital comments that must be addressed in a revision, in particular inclusion of adequate discussion of herring biology, herring fisheries and the herring stock assessment is required in order for this document to be comprehensible to all readers. In addition, it was noted that the paper does not provide explicit management recommendations, and the paper should outline how the research conclusions can be used in the management process.

The Subcommittee discussion noted that the paper really did two things, in separate processes. The first was an estimation of the proportion of age-3 fish in the Strait of Georgia in the spring from offshore west coast Vancouver Island trawl samples from the previous summer. This estimate was derived directly from field sampling and stands alone as a separate and distinct activity. The second component of the paper was the description of estimated proportion of age-3 fish to estimate (forecast) Strait of Georgia recruitment. These estimates of recruitment require information from the age-structured model output, specifically the estimate of spawning biomass for post-recruit fishes for the Strait of Georgia. The procedures for incorporating the proportion of age-3 fish estimates into an estimate of recruitment received considerable Subcommittee discussion, which was mainly based on clarification of methodology and estimates of error. The Subcommittee felt that explicit coverage is required in the revised paper outlining assumptions of error and its estimation.

It was noted that the age-structured model itself may contain inherent errors and that inter-annual changes in the output of the age-structured model could confound attempts to do retrospective analyses. It was suggested by the Reviewers and some Subcommittee members that the addition of simulation techniques to estimate error may be a better method of estimating uncertainty and assessing the ability of this method to forecast recruitment. Other members felt that the process would not add any value to the analyses.

There were comments that the paper contained no mechanisms to evaluate the success of the prediction of recruitment. The author noted that this was problematic, because the procedure for forecasting recruitment inherits the error in the age-structured model when estimated proportions of age-3 fish are applied to the forecasted biomass of returning adult (age-4 and older) fish provided by the model. The Subcommittee agreed that the forecast of recruitment should be expressed in terms of poor, average and good as defined in the herring stock assessment. These forecast recruitment classifications should be compared to observed recruitment in a retrospective analysis.

A Reviewer indicated that the offshore trawl samples collected in the summer are obtained without sample design and the weighting procedures (i.e. use of catch per unit effort) are not appropriate. It was clarified that some trawls are made on herring schools while others are opportunistic catches of herring while targeting other species. The Reviewer suggested that since the sampling design is a mixed bag of dedicated and opportunistic samples and is therefore not repeatable, there is no way that estimates of error can be replicated. The author clarified that in one year the survey was replicated and similar results were obtained. Although there was considerable discussion about the lack of an apparent sampling design, the Subcommittee was sympathetic that some of the offshore trawl samples were taken opportunistically, as time and conditions on the vessels permitted.

Conclusions

The Subcommittee concluded that the summer offshore trawl estimates of proportion of age-2 herring can be used to estimate the proportion of age-3 herring available in the Strait of Georgia the following spring. However, until a retrospective analysis of forecast recruitment is provided, any estimates of recruitment should not be incorporated into the stock assessment. Estimates of recruitment should be monitored for the next few years to assess forecasting performance for a sufficient time period. The Subcommittee accepted this paper with major revisions, specifically the addition of retrospective analysis on recruitment forecasting.

Recommendations

The Subcommittee recommended a retrospective analysis on recruitment forecasting be provided using the estimated Strait of Georgia proportion of age-3 herring from offshore trawl estimates of proportion of age-2 herring in the previous summer and applying it to the age-structured model estimates of pre-spawning biomass. These revisions will be reviewed by the Subcommittee at the November, 2002 meeting.

P2002-02: Metapopulation dynamics of British Columbia herring during cool and warm climate regimes

D.M. Ware and J. Schweigert **Accepted subject to revisions**

Rapporteur: Tom Therriault

Reviewers comments were positive and they did not have major concerns about the data or analyses. The Reviewers raised some interesting theoretical questions that the authors agreed to give some consideration in the revised paper. Specifically, discussion on the theoretical mechanisms for dispersal (i.e. density and climate impacts on density); discussion regarding when dispersal may occur (e.g. during migration to offshore feeding areas, between feeding areas, or migration back to spawning grounds); and discussion on the affinity of stocks to each other (i.e. the evidence of metapopulation structure).

It was suggested that the difference in dispersal rates during warm and cold climate regimes might be an artifact of differences between reduction (cold regime) vs. roe fisheries (warm regime) and associated tagging and biological data. Reduction fisheries occurred in summer while roe fisheries occur in spring. The authors responded that the data were filtered using tagging data from the spawning season. Admittedly, the reduction period data are less certain but should not be dismissed.

While not providing direct stock assessment advice, this work is progressing along a risk-assessment front and should next investigate sensitivity of stocks to dispersal. This could clarify uncertainty about stock-recruitment relationships for herring. Clearly, B.C. herring stocks are not discrete, independent entities but are related. The dispersal relationships presented in the paper have potential to improve the age-structured model forecast.

Conclusions

Understanding herring in terms of a metapopulation is an improvement over the discrete stock hypothesis. Though still a work in progress, this could have stock assessment implications and future research should aim at including this in the age-structured model. This dispersal variability might account for some observed differences between the age-structured and escapement models' estimates of spawner biomass. The Subcommittee accepted this paper with minor revisions as indicated by the Reviewers.

Recommendations

The Subcommittee recommended that the dispersal mechanisms identified here be incorporated in the age-structured model analyses.

P2002-03: Analyses of juvenile herring surveys for recruitment prediction in the Strait of Georgia

D.E. Hay, J. Schweigert, M. Thompson and C.W. Haegele **Deferred for further analyses**

Rapporteur: Chuck Fort

While unavailable at the time of submission, data on the number of age-3 recruits in 2002 estimated by the age-structured model were presented to the Subcommittee. The 2002 data point was an extreme outlier and its addition to regression undermines the statistical significance of the resulting relationship predicting recruitment. The Subcommittee noted that the 2002 model estimate of age-3 recruits may not be well determined. Irrespective of the 2002 data outlier, the Reviewers had highlighted some problems in the analysis of the available data and provided several recommendations of other analytical techniques that should be investigated before acceptance of the paper. Discussion on analytical techniques covered the use and effect of transformed and untransformed data, pooling data, and analysis of variance (ANOVA).

The Subcommittee discussed the utility and validity of continuing the survey given the cost and the fact that the survey is not presently providing a means of predicting recruitment. The Subcommittee felt that it was still uncertain if the survey was useful or not, but the fact that only the 2002 data point didn't fit is quite meaningful. While a point estimate for recruitment is preferable, a reasonable goal for the survey may be a prediction of recruitment corresponding to the poor, average and good classifications currently used. The senior author noted that many factors can affect the survival of a cohort between the time when these surveys are conducted (when they are 6 months of age) and the time of recruitment, 30 months later. For this reason, the accuracy of forecasts from these surveys may be limited and at best might only be useful to only predict 'poor' and 'not poor' recruitment.

Conclusions

The Subcommittee concluded that some analytical issues need to be addressed before the utility of the survey can be assessed. Since there is no immediate requirement for a decision or management recommendation from this paper, the Subcommittee requested that additional analyses as suggested by Reviewers be undertaken. Given other commitments, revisions may not be possible by the November meeting. If not, the Subcommittee would reconvene in early 2003 to reconsider this paper.

Recommendations

The Subcommittee recommended deferral of this paper until early 2003 so that additional analyses, as outlined by the Reviewers, can be undertaken.

P2002-05: Stock assessment for British Columbia herring in 2002 and forecasts of the potential catch in 2003

J. Schweigert **Accepted subject to revisions**

Rapporteur: Dennis Chalmers

The escapement model was not included in this year's assessment document and discussion began with whether or not it was required for consideration. It was brought to the attention of the Subcommittee that last year's PSARC Subcommittee report requested that both models (age-structured and escapement models) should be included. There was concern that the age-structured model estimates of abundance exceeded the spawn index estimates in some areas. Many of the Subcommittee members recollected from last year's discussions (contrary to the report) that it had been agreed that only the age-structured model would be used for the analysis this year. It was noted that the two models are not independent, because the age-structured model uses output from the escapement model as a index of spawner biomass. All of the critical data that the escapement model estimates (i.e. spawn index and biomass) are within tables in the body of the stock assessment document. A Subcommittee member mentioned that assessing both models for each region allows the Subcommittee to see if there is a major discrepancy between models. For example, this year the age-structured model is more optimistic than the spawning index (escapement model).

There was some discussion on the weighting of the spawn data in the age-structured model during different time periods. It was recommended that different weighting schemes for different time periods should be investigated before the next review to see the effect on biomass estimates.

Subcommittee members provided data and information for each assessment area on the completeness of catch reporting, spawn survey coverage, skippers' and managers' perception of stock status and incorporated it with information from the model. These criteria, along with yield recommendations, are presented here as Appendices 4-8. The Subcommittee noted that the estimated biomass for 2003 for the Queen Charlotte Island stock is well below the cutoff level for that area.

The Subcommittee discussed the stock status of two minor stocks (Areas 27 and 2 West). Charter skippers and managers felt that the stocks in Area 27 had improved and approximately 850 tonnes of spawn were observed in 2002. Biological sample and spawn survey information suggested that a continuance of the 10% harvest rule for minor stock areas was appropriate. In 2 West there was very good sample coverage in 2002. Charter skippers thought that the stock doubled from 2001 and approximately 5000 tonnes of herring were sounded. However, the only spawn observed and measured was in Kano Inlet and it was a small spawn. A charter boat was present and looking for spawn. From Reynolds Sound to Port Louis there were

age1+ and age2+ fish that appeared to be mature. Subcommittee members noted that 2 West is an area of intermittent spawns. There is large uncertainty regarding stock status in 2 West. Applying the 10% harvest rule to 2 West would result in an available harvest 13 tonnes. Given that the observed spawn was small, a no-harvest strategy is recommended. The Subcommittee noted that there are insufficient criteria for setting cutoff levels for minor stock areas.

Conclusions

The paper was accepted with revisions and the Subcommittee accepted yield recommendations outlined in Appendices 4-8.

Recommendations

1. The Subcommittee recommended that use of different weighting schemes applied to different time periods of the historical spawn data should be explored before the 2003 PSARC review.
2. The Subcommittee recommended the maximum potential yields for each assessment area as outlined in Appendices 4-8.
3. A potential yield of 85 tonnes (based on the 10% harvest rule for the minor stock areas) is recommended for Area 27.
4. No harvest is recommended for minor stock Area 2 West. The Subcommittee recommended that special consideration be given to ensuring adequate biological sampling and spawn assessment in 2003 is carried out in Area 2 West.

APPENDIX 1: Working Paper Summaries

P2002-01: An evaluation of a recruitment forecasting procedure for Strait of Georgia herring

R. Tanasichuk

This report describes an evaluation of an extension of the recruitment forecasting procedure which has been used since 1987 to forecast recruitment (number of age 3 spawners) for the West Coast Vancouver Island (WCVI) stock of Pacific herring (*Clupea pallasi*) (Ware and Tanasichuk 1987). The extension is to forecast recruitment for Strait of Georgia herring. The forecasting procedure is based on the age composition of samples of herring trawled along the southwest coast of Vancouver Island during summer fisheries oceanography surveys.

Results of geometric mean regression analyses showed that proportion of age 3 fish observed in the prefishery biomass of Strait of Georgia herring can be predicted from the proportion of age 3 fish in the samples trawled the previous summer. Residual analysis showed no time trend in the residuals, nor any effect of sampling time or the magnitude of the forecast. A retrospective analysis of the forecasts over 1994 – 2002 showed that observed proportions at age 3 were within the 95% confidence interval of the forecast for 6 of 8 years. On average, the forecasted proportion of age 3 fish was 0.02 ± 0.084 (mean $\pm$ 2 SE) less than observed proportion.

P2002-02: Metapopulation dynamics of British Columbia herring during cool and warm climate regimes

D.M. Ware and J. Schweigert

In a previous paper the authors documented the dispersal and production dynamics of the five major B.C. herring stocks during the 1977-98 “warm” climate period (Ware and Schweigert 2001), and applied the results to develop a structured metapopulation model (SMP). In this paper, the authors analyze the production dynamics of the five major B.C. herring stocks during the 1951-76 “cool” climate regime and incorporate them into the SMP model to estimate dispersal rates during this period. The authors also compare and contrast the dispersal rates and population dynamics of the major B.C. herring stocks during the most recent warm and cool climate regimes.

Dispersal rates from the five major populations during the cool base period ranged from 2% to 26% per year, and are significantly lower than the dispersal rates (range =15% to 36%) during the warm base period. In two of the three populations with a reasonable contrast in spawner biomass, the cool period straying rates appeared to be density-dependent, with higher dispersal occurring at higher spawner biomass. The authors found the same response during the 1977-98 warm regime.

A common *isolation by distance* relationship adequately describes the dispersal pattern in the major populations during both the cool and warm base periods. The isolation by distance model indicates that most herring stray to nearby populations. However, a few individuals stray to the most distant ones. Consequently, all of the major populations are genetically linked by dispersal, and the dispersal rates are high enough to ensure that there is unlikely to be any genetic differentiation between them. However, there could be some differentiation in several minor populations that are more geographically, or reproductively isolated from the major stocks. During the 1951-76 period, the harvest rates were high so the spawner biomass was significantly lower than it was during the 1977-98 warm period. In response to these lower stock sizes, the authors estimate that only about 7 kt/yr of adult herring strayed between the major populations, compared with about 25 kt/yr during the warm regime.

Dispersal is important because it tends to stabilize the spatial distribution of spawners in the metapopulation, and increases the persistence time of the less productive populations in two ways: 1) the density-dependent straying response increases the fidelity rate when a population is declining, and (2) declining populations will tend to receive more migrants from other populations than they export. Dispersal is also important because it recolonizes new and vacant spawning habitat. This enables the metapopulation to adapt to habitat changes, and to alter its spatial distribution in response to low frequency trends in climate, and other factors.

Dispersal adjusted estimates of the average natural mortality rate (M) of each population during the cool base period ranged from –0.16 to –0.52. There is a 92% probability that these rates are *lower* than the estimated warm period natural mortality rates, which ranged from –0.33 to –0.61. Average recruitment was significantly higher in the WCVI and QCI populations during the cool period. It was also higher in the other populations, but the interannual variability was so large that much longer time series are required to determine if the apparent difference in these populations is real. Population growth rates (G) were also slightly higher during the cool period, but not significantly higher than the warm period rates. The stock-recruit (S-R) relationships during the cool period for the WCVI, GS, CC and QCI populations were dome-shaped, while the PRD S-R relationship fit a hockey stick model. Curiously, the authors found that the underlying forms of the S-R relationships were completely reversed during the warm base period. This is important because the shape of the stock-recruit relationship has a large effect on the estimated unfished equilibrium biomass (SB^*). Currently, the largest uncertainty in SB^* occurs in the northern populations, particularly for the PRD stock.

A dispersal sensitivity index, derived from the metapopulation model implies that the Georgia Strait and PRD populations tend to be major exporters of adult herring to other populations, while the Central Coast and QCI populations tend to be major importers. There was remarkably good agreement between the dispersal index times series and the spawner biomass difference time series in the WCVI population. This implies that a large part of the difference in spawner biomass estimated by the

escapement and age-structured models (ASModels) in this population may be caused by dispersal. There was also moderate agreement between the dispersal index times series and the SB difference time series in the PRD population. However, there was no agreement in the QCI and CC populations. This suggests that either the escapement SB time series and/or the ASModel SB time series in these populations may contain large measurement and process errors, or that the straying estimates for these stocks are incorrect. Future research should attempt to resolve this question.

P2002-03: Analyses of juvenile herring surveys for recruitment prediction in the Strait of Georgia

D.E. Hay, J. Schweigert, M. Thompson and C.W. Haegele

The authors estimated annual variation in the relative abundance of juvenile herring from purse seine surveys conducted from 1991 to 2001 in the Strait of Georgia. The objective was to evaluate the predictive capability for estimating the relative size of the recruiting year class before it enters the fishery at age 3. In some years, a substantial part of the fished population (20-50%) consists of herring that recruit in the same year. Therefore, such predictive capability would be useful as ancillary information for determining total allowable catches (TAC's) for the fishery. Purse seine surveys were made throughout the Strait of Georgia in September and October. Sets were made at ten fixed transects, each with about five fixed sampling stations that varied in depth and distance from shore. Juvenile herring in their first year of life (about 6 months of age) were the most common species captured, followed by age 1+ herring. Juvenile herring abundance changed significantly among years, but there also were significant inter-annual differences in abundance among different regions of the Strait of Georgia. For each year of the survey, the authors compared the numbers and weight of age 0+ juvenile herring catches with the number of age 3 recruits, of the same cohort, estimated independently 3 years later, from age-structure analyses used for the annual assessments. In general, the relationship is positive and significant, although there is considerable annual variation in the data. Even so, surveys of age 0+ herring may provide sufficient data to support an empirical prediction of recruitment into several approximate categories: poor, average and good. Such a prediction could be made nearly two years prior to the recruitment. The authors comment on the potential of this approach for future use by management.

P2002-05: Stock assessment for British Columbia herring in 2002 and forecasts of the potential catch in 2003

J. Schweigert

Herring stock abundance in British Columbia waters was assessed for 2002 and forecasts were made for 2003 using an age structured assessment model for the major stock assessment regions and an escapement model for the minor stocks in

Areas 2W and 27. These models have been applied to assess herring abundance since 1984. As in the 2001 assessment, changes to the analytical model were introduced to account for temporal change in the spawn index. A fixed spawn conversion or catchability factor was applied for the dive survey era beginning in 1988 and a free fitted parameter was estimated for the earlier surface survey period. All available biological data on total harvest, spawn deposition, and age and size composition of the spawning runs were used to determine current abundance levels. No significant problems were evident in the extent and comprehensiveness of the data collections. All data were included in and summarized from an Access database which differ slightly from earlier procedures. Impacts on estimated run size was shown to be minor. Coastwide, the estimated pre-fishery stock biomass for all assessment regions in 2002 was 233,000 tonnes based on the age-structured model which represents a 21% increase over the 2002 abundance level. This increase reflects increased abundance in the south coast stocks particularly the Strait of Georgia. However, abundance in the Queen Charlotte Islands is depressed and fisheries should be closed for conservation considerations.

The estimated harvestable surplus in 2003 (20% of the 2002 forecast herring run) based on forecast abundance to the five assessment regions is 41,530 tonnes for the B.C. coast assuming average recruitment to all areas. However, since consensus on stock levels for each assessment region may change as a result of PSARC review of these data, forecast run sizes, and harvestable surpluses, are subject to change.

APPENDIX 2: PSARC Pelagic Subcommittee Meeting Agenda September 4-6, 2002

PSARC Pelagic Subcommittee Meeting
September 4-6, 2002
Nanaimo, B.C.

Wednesday, September 4

8:30 Introductions and Opening Remarks.

9:00-11:00 Analyses of juvenile surveys for recruitment predictions in the Strait of Georgia (D. Hay et al.).

11:00-12:00 An evaluation of a recruitment forecasting procedure for Strait of Georgia herring (R. Tanasichuk).

12:00 *Lunch*

1:00-2:00 Tanasichuk continued.

2:00-4:00 Metapopulation dynamics of British Columbia herring during cool and warm climate regimes (D. Ware & J. Schweigert).

Thursday, September 5

9:00-12:00 Stock assessment for B.C. herring in 2002 and forecasts of the potential catch in 2003 (J. Schweigert).

12:00 *Lunch*

1:00-4:00 Schweigert continued.

Friday, September 6

9:00-12:00 Formulation of recommendations.
Finalize report. Plan upcoming meeting.

APPENDIX 3: List of Attendees & Reviewers

Subcommittee Chair: Jackie King
PSARC Chair: Al Cass

DFO Participants	**Wed.**	**Thurs.**	**Fri.**	
* Subcommittee Members				
Anderson, Don	✓	✓	✓	
Chalmers, Dennis*	✓	✓	✓	
Daniel, Kristen	✓	✓		
Flostrand, Linnea	✓	✓	✓	
Fort, Chuck*	✓	✓	✓	
Fu, Caihong	✓	✓	✓	
Groves, Steven	✓	✓	✓	
Hamer, Lorena*	✓	✓	✓	
Hay, Doug*	✓	✓	✓	
Hrabok, Christa	✓	✓	✓	
McCarter, Bruce*	✓	✓	✓	
McFarlane, Sandy*		✓		
Midgley, Peter*	✓	✓	✓	
Potyrala, Mark*		✓	✓	
Saunders, Mark	✓			
Schweigert, Jake*	✓	✓	✓	
Tanasichuk, Ron*	✓	✓	✓	
Thomas, Greg*		✓	✓	
Thompson, Matthew	✓	✓	✓	
Trager, Diana*	✓	✓	✓	
Therriault, Tom	✓	✓	✓	
External Participants:				**Affiliation**
Chow, Sharon	✓			Sierra Club
Hall, Don	✓	✓		Nuu Chah Nulth Tribal Council
Johansen, Gina	✓	✓	✓	Spawn on Kelp Operators Assoc.
Jones, Russ	✓	✓	✓	Haida Fisheries Program
Safarik, Ed	✓	✓		Herring Cons. and Res. Soc.
Sewid, Alvin	✓	✓	✓	Kwakiutl Territory Fisheries Comm.
Speck, Fred	✓			Kwakiutl Territory Fisheries Comm.
Webb, Lloyd	✓	✓	✓	Fishing Vessel Owners Assoc.
Ware, Daniel	✓	✓	✓	Herring Cons. and Res. Soc.
Observers:				
Hill, Cecil	✓	✓	✓	Spawn on Kelp Operators Assoc.
Holkestad, Ross	✓	✓	✓	Fishing Vessel Owners Assoc.
Osborne, Josie	✓	✓	✓	Nuu Chah Nulth Tribal Council
Taylor, April	✓			

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.

Mike Bradford	Fisheries and Oceans Simon Fraser University
Gayle Brown	Fisheries and Oceans
Martin Dorn	NOAA
Caihong Fu	Fisheries and Oceans
Rowan Haigh	Fisheries and Oceans
Blair Holtby	Fisheries and Oceans
Skip McKinnell	North Pacific Marine Science Org.
Ian Perry	Fisheries and Oceans

Appendix 4. Criteria for assessment of stock status in 2002 and yield recommendation for 2003: Queen Charlotte Islands

Criteria	Status
1. Data Quality	
a) All catch reported	a) No FSC. Poor estimates only.
b) All spawn surveyed	b) Yes. Some minor areas were milt only, no eggs.
c) Good sample coverage	c) Yes.
2. Stock status and trends	
a) Age-structured model	a) Significant decrease from 2001, below cutoff.
b) Spawn indices	b) Length, width and layers decreased dramatically to near historic lows.
3. Perceptions of Stock Status	
a) Charter skippers comments	a) Stocks poor, below abundance of previous years.
b) Management staff	b) Stocks poor, below abundance of previous years, lots of small (age 1+) fish that were mature.
4. Recruitment	
a) Age-structured model	a) 1998 and 1999 poor.
5. Retrospective Analysis	
a) Consistency	a) Slight tendency to over forecast.
6. Forecast Abundance	
a) Profile Likelihood	a) 95% C.I.: 5 800 – 10 400 tonnes
b) Recruitment Assumption • Poor • **Average** • Good	b) Abundance / Harvest 5 290 t / 0 t **7 200 t / 0 t** 15 370 t / 3 070 t
7. Additional Information	None
8. Cutoff:	10 700 tonnes
9. Yield Recommendation	Maximum potential yield of 0.00 tonnes

Appendix 5. Criteria for assessment of stock status in 2002 and yield recommendation for 2003: Prince Rupert District

Criteria	Status
1. Data Quality	
a) All catch reported	a) No FSC reporting.
b) All spawn surveyed	b) Yes.
c) Good sample coverage	c) Yes.
2. Stock status and trends	
a) Age-structured model	a) Increase since 1997, slight decrease in 2002.
b) Spawn indices	b) Length decreased significantly, width increased, layers decreased slightly. Spawning biomass based on spawning index is lower than age-structured model estimate.
3. Perceptions of Stock Status	
a) Charter skippers comments	a) Big Bay slightly higher; Kitkatla lots of movement and mixing so difficult to assess but down slightly.
b) Management staff	b) Comparable to previous years. Very concerned with 46% drop in spawn index.
4. Recruitment	
a) Age-structured model	a) 1997 average; 1998 good; 1999 average.
5. Retrospective Analysis	
a) Consistency	a) Slight tendency to over forecast.
6. Forecast Abundance	
a) Profile Likelihood	a) 95% C.I.: 27 000 – 38 300 tonnes
b) Recruitment Assumption • Poor • **Average** • Good	b) Abundance / Harvest 28 940 t / 5 790 t **31 660 t / 6 330 t** 40 580 t / 8 120 t
7. Additional Information	
a) Size-at-age	a) Stable.
8. Cutoff:	12 100 tonnes.
9. Yield Recommendation	Maximum potential yield of 6 330 tonnes.

Appendix 6. Criteria for assessment of stock status in 2002 and yield recommendation for 2003: Central Coast

Criteria	Status
1. Data Quality	
a) All catch reported	a) FSC improvement in reporting but still incomplete.
b) All spawn surveyed	b) No. There may have been some missed late spawn. E. Higgins incomplete.
c) Good sample coverage	c) Yes.
2. Stock status and trends	
a) Age-structured model	a) Decrease since 1998.
b) Spawn indices	b) Length increased, width decreased significantly, layers unchanged.
3. Perceptions of Stock Status	
a) Charter skippers comments	a) Stock strength overall slightly down. Spiller Inlet considerably low. Kitasu, Marvin Island and E. Higgins look good.
b) Management staff	b) Overall no increase; build up of stocks in fringe areas. Spiller Inlet is down.
4. Recruitment	
a) Age-structured model	a) 1997 average; 1998 poor; 1999 average.
5. Retrospective Analysis	
a) Consistency	a) Consistent.
6. Forecast Abundance	
a) Profile Likelihood	a) 95% C.I.: 18 100 – 27 000 tonnes
b) Recruitment Assumption • Poor • **Average** • Good	b) Abundance / Harvest 22 930 t / 4 590 t **25 260 t / 5 050 t** 31 990 t / 6 400 t
7. Additional Information	None.
8. Cutoff:	17 600 tonnes.
9. Yield Recommendation	Maximum potential yield of 5 050 tonnes.

Appendix 7. Criteria for assessment of stock status in 2002 and yield recommendation for 2003: Strait of Georgia

Criteria	Status
1. Data Quality	
a) All catch reported	a) Yes.
b) All spawn surveyed	b) No. Hatched or hatching spawn in Areas 17 and 19.
c) Good sample coverage	c) Yes. At time of assessment no ages for food fishery.
2. Stock status and trends	
a) Age-structured model	a) Increasing.
b) Spawn indices	b) Length decreased slightly; width unchanged; layers decreased slightly.
3. Perceptions of Stock Status	
a) Charter skippers comments	a) Continuing strong.
b) Management staff	b) Continuing strong; major change in spawning patterns.
4. Recruitment	
a) Age-structured model	a) 1997 – 1999 good.
5. Retrospective Analysis	
a) Consistency	a) Reasonably consistent.
6. Forecast Abundance	
a) Profile Likelihood	a) 95% C.I.: 106 600 – 150 100 tonnes
b) Recruitment Assumption • Poor • Average • **Good**	b) Abundance / Harvest 102 440 t / 20 490 t 115 670 t / 23 130 t **130 010 t / 26 000 t**
7. Additional Information	Difficulty in obtaining pre-fishery samples due to marine mammals and fish behavior (avoidance).
8. Cutoff:	21 200 tonnes
9. Yield Recommendation	Maximum potential yield of 26 000 tonnes.

Appendix 8. Criteria for assessment of stock status in 2002 and yield recommendation for 2003: West Coast of Vancouver Island

Criteria	Status
1. Data Quality	
a) All catch reported	a) FSC incomplete.
b) All spawn surveyed	b) Yes.
c) Good sample coverage	c) Yes.
2. Stock status and trends	
a) Age-structured model	a) Increasing slightly since 2000.
b) Spawn indices	b) Length and width increased; layers unchanged.
3. Perceptions of Stock Status	
a) Charter skippers comments	a) Barkley Sound improved; Area 24 poor; Esperanza good; Kyoquot Sound had good spawning.
b) Management staff	b) Barkley Sound improved with usual spawn locations, but timing unusual; Area 24 poor. Esperanza good, some of the spawning moved in Kyoquot; Nootka Sound had fish but no spawn.
4. Recruitment	
a) Age-structured model	a) 1997 poor; 1998 average; 1999 good.
b) Offshore trawl survey	b) Forecast poor for 2002.
5. Retrospective Analysis	
a) Consistency	a) Tendency to over forecast
6. Forecast Abundance	
a) Profile Likelihood	a) 95% C.I.: 29,700 – 45, 200 tonnes
b) Recruitment Assumption • **Poor** • Average • Good	b) Abundance / Harvest **30 030 t / 6 010 t** 35 110 t / 7 020 t 50 350 t / 10 070 t
7. Additional Information	None.
8. Cutoff:	18 800 tonnes
9. Yield Recommendation	Maximum potential yield of 6 010 tonnes.