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Proceedings of the PSARC Groundfish Subcommittee Meeting

Compte rendu de la réunion du sous-comité du CEESP sur le poisson de fond

January 18-19, 2006
Coast Bastion Hotel
Nanaimo, BC

18 et 19 janvier 2006
Hôtel Coast Bastion
Nanaimo, C.-B,

J. Fargo

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Pacific Biological Station
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PACIFIC SCIENTIFIC ADVICE REVIEW COMMITTEE (PSARC)
GROUNDFISH SUBCOMMITTEE MEETING

SUMMARY

The Groundfish Subcommittee of the Pacific Scientific Advice Review Committee (PSARC) met to review three Working Papers on January 18-19, 2006 at the Coast Bastion Hotel, Nanaimo, British Columbia.

Working Paper G2006-01: A review of redbanded rockfish *Sebastes babcocki* along the Pacific Coast of Canada: biology, distribution, and abundance trends.

- The Subcommittee asked that the authors include a summary of the management history for redbanded rockfish.
- The Subcommittee noted that catch tables should be modified to include reported landings prior to 1996, and these tables should include dockside validated landings from hook and line gear, and in particular landings from the halibut fleet.
- The Subcommittee concluded that the maturity analysis in the paper should focus on May samples.
- The Subcommittee requested that material currently in the Analytical Methods section be moved to an appendix;
- The Subcommittee requested that analyses of length-at-age, maturity-at-age, mortality rates and generation time be repeated using only ages determined using the otolith burnt-section method;
- The Subcommittee requested that the authors include information or references to management tactics applied to the fishery for redbanded rockfish;
- The Subcommittee requested that the International Pacific Halibut Commission (IPHC) setline survey be included as a potential source of stock abundance data for redbanded rockfish and that the list of survey data source be updated to reflect this potential data source;
- The Subcommittee requested that tables of landings data be updated to include dockside validated landings from hook and line gears;
- The Subcommittee requested that a description of the new catch-curve methodology applied to redbanded rockfish be added to the working paper as an appendix.

G2006-02: A proposal for an adaptive increase in arrowtooth flounder (*Atheresthes stomias*) catches

- The Subcommittee requested explicit conservation and economic objectives for the arrowtooth flounder fishery.
- The Subcommittee was concerned that an experimental design for the proposed management experimentation was not provided in the Working Paper.

- The Subcommittee noted that there were alternative harvest strategies presented. These included using the average catch of the last several years (approximately 8,000 t) or the maximum catch prior to 2005 (approximately 10,000 t).
- The Subcommittee was concerned that the lack of a stopping rule for the management experiment could lead to over harvest of the arrowtooth flounder resource.
- The Subcommittee recommended conducting simulations based on data currently available to examine the consequences of different harvest rules.

G2006-03: Rock sole (*Lepidopsetta spp*) in British Columbia, Canada: Stock assessment for 2005 and advice to managers for 2006/2007

- The Subcommittee noted that given the current abundance is estimated to be relatively low for the 5AB stock, emphasis should be put on stock growth;
- The Subcommittee could not resolve whether the "fixed M" or "estimated M" model results better reflected stock dynamics of rock sole for region 5CD and concluded that the document should retain the results for both models;
- The Subcommittee concluded that the decision tables based on the standardized commercial CPUE index be accepted as the advice for rock sole in regions 5AB and 5CD.
- The Subcommittee asked the authors to alter the decision tables to reflect the landings of males and females combined, not just females. The authors agreed to insert 2 additional columns: catch of both sexes, and landings of both sexes.
- The Subcommittee requested that the Appendix Table captions include the name of the stock;
- The Subcommittee requested that while the results of the arithmetic CPUE index would remain in Appendix F of the Working Paper as described, any decision tables pertaining to the arithmetic index would be removed from Appendices F and G and the main text;
- The Subcommittee requested that the terminology for B_{min} be revised to note that the stock has not yet demonstrated a capacity to recover from this reference level.

SOMMAIRE

Le Sous-comité du poisson de fond du Comité d'examen des évaluations scientifiques du Pacifique (CEESP) s'est réuni les 18 et 19 janvier 2006, à l'hôtel Coast Bastion, à Nanaimo (Colombie-Britannique), afin d'étudier trois documents de travail.

Document de travail G2006-01 : Examen du sébaste à bandes rouges, *Sebastes babcocki,* le long de la côte du Pacifique du Canada : biologie, répartition et tendances de l'abondance.

- Le Sous-comité demande aux auteurs d'inclure un résumé des antécédents de gestion du sébaste à bandes rouges.
- Le Sous-comité fait remarquer que les tableaux sur les prises devraient être modifiés de manière à y inclure les débarquements déclarés avant 1996; de plus, ces tableaux devraient indiquer les débarquements des ligneurs, validés à quai, tels que ceux de la flottille de pêche du flétan.
- Le sous-comité conclut que l'analyse de maturité présentée dans le document devrait porter sur les échantillons de mai.
- Le Sous-comité demande que l'information qui figure actuellement dans la section des méthodes d'analyse soit déplacée dans une annexe.
- Le Sous-comité demande que les analyses de la longueur selon l'âge, de la maturité selon l'âge, des taux de mortalité et de la durée de génération soient reprises en utilisant uniquement les âges déterminés à l'aide de la méthode de coupe et brûlage des otolithes.
- Le Sous-comité demande aux auteurs d'inclure de l'information ou des documents de référence relativement aux méthodes de gestion appliquées à la pêche du sébaste à bandes rouges.
- Le Sous-comité demande que le relevé à ligne fixe de la Commission internationale du flétan du Pacifique soit inclus comme source possible de données sur l'abondance du stock de sébaste à bandes rouges et que la liste des sources de données du relevé soit mise à jour en tenant compte de cette source de données possible.
- Le Sous-comité demande que les tableaux des données sur les débarquements soient mis à jour afin d'y inclure les débarquements des ligneurs validés à quai.
- Le Sous-comité demande d'ajouter en annexe une description de la nouvelle méthode de la courbe des prises appliquée au sébaste à bandes rouges.

G2006-02 : Proposition d'augmentation adaptée des prises de plie à grande bouche (*Atheresthes stomias*)

- Le Sous-comité demande que soient fixés des objectifs économiques et des objectifs de conservation explicites pour la pêche de la plie à grande bouche.
- Le Sous-comité est préoccupé par l'absence, dans le document de travail, de la méthodologie expérimentale pour les expériences de gestion proposées.
- Le Sous-comité note que d'autres stratégies de pêche ont effectivement été présentées, notamment l'utilisation de la moyenne des prises des dernières années (environ 8 000 t) ou du maximum des prises avant 2005 (environ 10 000 t).
- Le Sous-comité craint que l'absence d'une règle d'arrêt à l'expérience de gestion n'entraîne une surexploitation des ressources de plie à grande bouche.
- Le Sous-comité recommande de faire des simulations basées sur les données existantes afin d'étudier les conséquences des différentes règles de pêche.

G2006-03 : Fausse limande (*Lepidopsetta spp*) en Colombie-Britannique, Canada : Évaluation des stocks pour 2005 et conseils aux gestionnaires pour 2006-2007

- Le Sous-comité fait remarquer qu'en raison de l'estimation relativement faible de l'abondance actuelle du stock de 5AB, l'accent devrait être mis sur la croissance du stock.
- Le Sous-comité n'a pu déterminer lesquels des résultats du modèle à paramètre « *M* fixe » ou « *M* estimé » correspondent mieux à la dynamique de la fausse limande de la région 5CD et conclut que le document devrait conserver les résultats des deux modèles.
- Le Sous-comité conclut que les tables décisionnelles basées sur l'indice normalisé des CPUE commerciales devraient être acceptées comme conseils sur la fausse limande des régions 5AB et 5CD.
- Le Sous-comité demande aux auteurs de modifier les tables de décision de manière à tenir combe des débarquements de mâles et de femelles combinés, et non pas seulement de femelles. Les auteurs acceptent d'insérer deux colonnes additionnelles : les prises des deux sexes et les débarquements des deux sexes.
- Le Sous-comité demande que les titres de colonne des tableaux de l'annexe incluent le nom du stock.
- Le Sous-comité demande que, tout en conservant les résultats de l'indice arithmétique des CPUE en annexe F du document de travail tel que décrit, toutes les tables de décision relatives à l'indice arithmétique soient retirées des annexes F et G et du texte principal.

- Le Sous-comité demande de revoir la terminologie de B_{min} afin de noter que le stock n'a pas encore fait preuve de la capacité de se rétablir par rapport à ce niveau de référence.

INTRODUCTION

The PSARC Groundfish Subcommittee met January 18-19, 2006 at the Coast Bastion Inn in Nanaimo, British Columbia. External participants from industry, academia, First Nations and conservation groups attended the meeting. The Subcommittee Chair, J. Fargo, 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 three 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

G2006-01: A review of redbanded rockfish *Sebastes babcocki* along the Pacific Coast of Canada: biology, distribution, and abundance trends

R. Haigh and P.J. Starr

Paper accepted subject to revisions

This paper reviews the current data on the biology, distribution, and abundance trends for redbanded rockfish *Sebastes babcocki*. The Subcommittee noted that the authors had chosen not to provide harvest advice; rather they provided a species summary document similar to those submitted to the National Advisory Process (NAP) for reviewing pre-COSEWIC data and status assessments. One reviewer felt that the objectives of the paper were not clear. This reviewer noted that the authors had highlighted the data limitations for redbanded rockfish but was critical that some conclusions did not reflect the uncertainty of the analyses based on these limited data.

Since the current version of the document follows a NAP format, one reviewer was not convinced the Analytical Methods section needs to be in the main text. None of the methods appear new (i.e., the von Bertalanffy parameterization) and perhaps most of the methodology has been stated in previous documents, not to mention the citations. He suggested that this section be converted to an appendix. The authors agreed to the proposed change.

One reviewer noted that the 1967 and 1969 ageing data were based on surface readings and stated that these data would bias the length-at-age analysis. He recommended analyses of maturity-at-age, mortality rates, and generation time should be re-done after omitting these data. The authors agreed to re-do the analysis using ages based only on the otolith burnt-section method.

The reviewer also noted that most attempts to assess maturity-at-age for rockfishes acknowledged that field macroscopic observations cannot reliably distinguish between Stage 1 and 2 (immature and maturing) at all times of the year. One strategy to circumvent this problem is to restrict the data set to those 4-6 months of mid, to late, maturation and parturition. He suggested that the authors repeat the maturity-at-age analysis, after restricting the data to specific months of the year when Stage 2's can be assumed to be immature.

Methods of age determination and their effects on the growth and maturity-at-age analyses were discussed by the Subcommittee. The Subcommittee noted the absence of age readings for young redbanded rockfish and suggested that this absence may have produced the unrealistic estimates of t_0 for the von Bertalanffy growth analysis. It was also noted that recent otolith samples from smaller fish (<20 cm), should be read in the future.

A new catch-curve analysis technique was used to estimate total mortality rates. The Subcommittee noted that the new methodology was not described in the Working Paper. The authors noted that a manuscript had been submitted for primary publication but was not available for this meeting. The authors agreed to include an appendix in the Working Paper that described the new catch-curve methodology.

One reviewer disagreed with the assumption that annual harvests of 400-500 t over the last one to two decades were sustainable. He felt that it was plausible to argue that the current fishing mortality may be much greater than natural mortality. The authors agreed to remove any reference to sustainability. Another reviewer recommended that Section 3 of the Working Paper should be revised or removed if the authors cannot derive a means of estimating fishing mortality more appropriate to recent fishery history.

The reviewer also suggested that if the authors wished to point out there were no quotas, they should summarize whatever trip limits were in place. In the reviewer's opinion, the omission of information would incorrectly imply that there were no controls on the fishery. The authors agreed to include references to management actions.

One reviewer suggested that the unknown catchability should be emphasized in the estimates of biomass. One consequence of not making this point clear could lead to the incorrect conclusion that the biomass in Queen Charlotte Sound in 2003, 2004, and 2005 was approximately 1,119 t, 662 t and 1,386 t, respectively. He also suggested that the results and an assessment of the potential usefulness of that survey should also be included in the report. He added that the area surveyed may have special value in that it was very close to a key trawl location for redbanded rockfish at the head of Goose Island Gully.

Similarly, he suggested that fishery-independent catch rate data from the IPHC setline survey should be evaluated as a potential index of relative abundance. However, it was pointed out that the set-line survey extends back to the early 1990s and rockfish catch data were noted, though complete hook by hook species identification was not done every year. Previous inspection of these data indicated that the IPHC survey may provide an effective source of stock assessment data for redbanded rockfish. He also recommended that the bullets referring to surveys be updated to include reference to the additional surveys mentioned in the review. The authors agreed to include this survey in their review of survey data applicable to redbanded rockfish.

The Subcommittee asked that the authors make it clear that the NMFS triennial survey was terminated for Canadian waters in 2001 but is ongoing in U.S. waters. The Subcommittee noted that the IPHC setline surveys in 1993 to 1996, 2003, and 2004 included complete hook by hook enumeration of species and species composition for selected hooks on each string in other years. These fishery-independent survey data may be useful for developing an index of stock abundance for redbanded rockfish.

Both reviewers felt that the analysis of commercial CPUE data could provide a misleading perspective on long-term stock abundance trends. They pointed out that the behaviour of fishermen, management actions, and fish behaviour can all lead to hyperstability of CPUE data. The reviewers were critical of the lack of consideration of these sources of bias and suggested that the data should be explored in greater detail given some areas showed declines in fishery CPUE.

One reviewer suggested that it was inappropriate to summarize commercial catch rates without providing evidence that catch rate data track stock abundance. For example, it is possible that catch rates since 1996 exhibit hyperstability given redbanded rockfish catches were constrained by trip limits on other rockfish. The other reviewer suggested the detection of trends in stock indices might be enhanced by applying a narrower depth restriction in the analysis of both the survey data as well as the analysis of commercial CPUE (i.e., rather than using the 1st and 99th quantiles, use the 25th and 75th quantiles).

One of the reviewers concluded that the data and methods described were not adequate to support all of the conclusions. In general more justification is required for the choice of the models and more information should be provided to enable the reader to evaluate model adequacy. Referring to the bullets in Section 6 of the Working Paper, the reviewer agreed with the authors concerning the widespread distribution of the species. However, he felt that Point 2 did not explicitly state that the natural mortality rate was inferred from other rockfish species and an estimate specific to redbanded rockfish does not exist. He also felt that more details should be provided on data used in the catch curve analysis. These data apparently represented only 3 years from an unspecified geographic distribution and consequently it was suggested the results should be treated with a high degree of uncertainty.

The reviewer felt that the comparison of light to heavily fished sites required more analysis and explanation. He suggested that age histograms and descriptive statistics such as those provided in Fig 2 and Table 1 of Kronlund and Yamanaka 2001 would be more useful than cumulative proportions at age. The authors noted that the histograms were already in the document.

One reviewer felt that the observation that the Triangle Island region displayed an older age distribution compared to other areas and should be explored in greater detail since this area is considered to be lightly exploited. He suggested if the model places the greatest weight on the older age classes, then a site with an older age distribution should show a difference. It was pointed out that the second Vancouver Island site was identified as Top Knot in other working papers while the same area appears as Brooks in this paper. Also, the data presented for Top Knot in the Working Paper have a depth range of 165-260 m which is inconsistent with that described by Kronlund and Yamanaka (2001) where the depth was restricted to 35-100 m. The authors noted that the older age classes are still apparent in all regions and the data were qualified by the authors to occur in similar depth ranges to remove possible effects of migration to depth as fish age.

One reviewer commented that the authors had not demonstrated whether the treatments in their fishing experiment would be strong enough to produce the measurable differences. He also questioned why there was no correspondence in the recruitment anomalies among the four areas, or at least between the nearby sites. He added that the variability in the National Marine Fisheries Service (NMFS) Triennial survey might be reduced by focusing on a narrower depth range.

There was some confusion concerning Section 2.3.1 of the Working Paper. One reviewer pointed out that it was written as if the authors had used an area-weighted estimate. He pointed out if any pooled estimate is "weighted" in some manner this section reduces to: "The mean weight of weighed specimens in GFBio is 1.384 kg". The authors declined this suggestion stating that the table gives information on mean weights for the PFMC areas.

Subcommittee Conclusions

The Subcommittee asked that the authors include a summary of the management measures applicable to fishing redbanded rockfish. Although there is no TAC assigned to this species, other measures such as trip limits in the trawl fishery and implementation of recommendations from the Halvorson Report have affected fishery performance.

The Subcommittee noted that catch tables should be modified to include reported landings prior to 1996, and these tables should include dockside validated landings from hook and line gear, and in particular landings from the halibut fleet.

The Subcommittee concluded that the maturity analysis in the paper should focus on May samples.

Subcommittee Recommendations

1. The Subcommittee requested that material currently in the Analytical Methods section be moved to an appendix;
2. The Subcommittee requested that analyses of length-at-age, maturity-at-age, mortality rates and generation time be repeated using only ages determined using the otolith burnt-section method;
3. The Subcommittee requested that the authors include information or references to management tactics applied to the fishery for redbanded rockfish;
4. The Subcommittee requested that the IPHC setline survey be included as a potential source of stock abundance data for redbanded rockfish and that the list of survey data source be updated to reflect this potential data source;
5. The Subcommittee requested that tables of landings data be updated to include dockside validated landings from hook and line gears;
6. The Subcommittee requested that a description of the new catch-curve methodology applied to redbanded rockfish be added to the Working Paper as an appendix.

G2006-02: A proposal for an adaptive increase in arrowtooth flounder (*Atheresthes stomias*) catches

P.J. Starr and J. Fargo

Paper not accepted

Overall, both reviewers felt the document was well written and the analyses were sound. However, their views diverged on design, the proposed level of harvest increase, and the recommendations of the Working Paper.

The first reviewer explained that adaptive management was designed to identify and address key uncertainties about resource dynamics, and to iteratively use feedback information from the system being managed to reduce uncertainty. The consequences of management actions are determined by measurable quantities which can be compared against defined objectives to determine whether the management actions were successful.

The second reviewer pointed out that adaptive management strategies treat management as an adaptive learning process, where management activities themselves are viewed as the primary tools for "experimentation". He also mentioned that this involves a considerable commitment to planning and monitoring of strategy implementation. He noted that worldwide there are very few examples of successful implementations of adaptive management.

The first reviewer felt that the authors had done a good job of explaining the advantages and disadvantages of the various data available for arrowtooth flounder, the analytical methods, and the tools currently available for monitoring fishery performance and stock status. For example, fishery-independent surveys (NMFS Triennial, WCVI shrimp trawl, Hecate Strait assemblage surveys) have a relatively short history and typically are multi-species surveys so the sampling design is not optimized for arrowtooth flounder.

This reviewer commented that the author's use of CPUE abundance indices from a variety of research surveys and GLM models were adequate to investigate relative trends in abundance for this species. The reviewer agreed with the author's view that the survey indices and results of GLM analyses of fishery-dependent data were reasonably consistent. These indices show increasing trends over time in the late 1990s and early 2000s. He supported the analysis and resulting recommendations for a limited term experimental increase in arrowtooth flounder catches. He also stated that if this increase was implemented, then updating the analyses in 2006 is a critical step in monitoring performance.

The second reviewer outlined his concerns about the proposed management experiment and stated that there was inadequate justification of the recommended catch of 20,000 t. He stated that it would have been helpful if the authors included a discussion of the significance of the binomial analysis and the combined binomial/lognormal analysis. He posed the following questions:

1. Is the binomial or combined index a “better” indicator of population abundance than the lognormal?
2. Under what conditions would either index be considered an alternative to the lognormal index?
3. What is the implicit weighting assigned to the lognormal and binomial indices respectively in equation 15, and is it possible to use alternative explicit weightings?
4. Is the binomial index in equation 15 the canonical representation of the main effect of year, or the binomial parameter for year?

The reviewer suggested that consideration of these questions would help resolve the difficulty of being presented with a number of abundance indices without an indication of which might be preferred.

GLM methods

The second reviewer stated that the GLM model selection process, while having a sound theoretical basis also had some potential flaws. He pointed out that several of the main effects in the model were actually nested within other factors and could not be considered independent. For example, locality is nested within major area and locality and longitude are partially nested. He suggested that there was little statistical advantage to including all three in a single analysis.

The authors pointed out that the analysis was not truly nested because each explanatory variable was offered to the model and the variable with the greatest explanatory power would be selected. Additional “nested” variables were rarely selected after the first variable was selected because they offered no additional reduction in the model deviance.

The reviewer pointed out that for arrowtooth flounder practical experience with the fishery indicated that there are interactions among month, depth and several factors included in the GLM models. The significant seasonal migration of arrowtooth flounder from shallow waters in summer to deeper waters in winter is not captured in the analysis due to the lack of interaction terms. These migrations also span localities, major areas and even the traditional stock area boundaries (e.g., 5AB/5CD, 5CD/5E). The reviewer found it difficult to accept a stock index derived from a GLM model that lacks these potentially significant interaction terms.

Experimental design

The first reviewer commented that the purpose of the paper was clearly stated in the Working Paper. However, he noted the authors did not provide an estimate of biomass for arrowtooth flounder which might provide support for their catch recommendation. He also suggested rethinking Recommendation 3 in the Working Paper so that it is consistent with the analyses He pointed out that knowledge of the generation time for arrowtooth flounder was also necessary for ensuring an appropriate time horizon for experimentation.

The second reviewer asserted that the proposal in the paper lacked a conceptual description, statement of alternative hypotheses, an experimental design with treatments and controls, an indication of safeguards to prevent serious overfishing, and a mechanism to reduce exploitation once the proposed fishing-down period was over.

The first reviewer commented that the rationale for the 20,000 t experimental catch had both practical (e.g., this is the level that can be achieved by the fishery) and policy (e.g., conservation concerns and by-catch) aspects. However, there was consideration of conservation objectives for arrowtooth flounder stocks and whether there was a means of determining when the biomass would be driven down to an unsustainable level. The authors argued that removals had to be large enough to introduce a depletion signal into the stock indices and that 20,000 t was judged to be adequate for this purpose. They also stated in the paper that the short-term (2 year) nature of the increase, combined with interim progress evaluations, provided a sufficient safeguard against outcomes detrimental to arrowtooth flounder stocks.

The first reviewer also suggested that two points in the paper should be explicitly stated. First, the distribution of effort for turbot among vessels has shifted to turbot “hotspots” in 2005 but the significance of this change is not clear. Second, an indicator of declining abundance associated with annual catches of 20,000 t might be a shift in fishing effort away from arrowtooth flounder "hotspots". While the latter change should be detectable in the catch and effort data available from the observer program, the paper did not identify a stopping rule for the proposed harvest.

Alternatives

The second reviewer pointed out that that there are over 20 groundfish species under TAC regulation on the BC coast and none of these were established using an adaptive management strategy. He suggested that the Working Paper should have explored the methods and approaches used to set these TACs as alternatives. Although the paper presented alternative models (e.g., binomial, lognormal, combined), members of the Subcommittee expected more supporting rationale for the proposed harvest of 20,000 t. The authors agreed that more discussion of the alternative models was needed to establish that the proposed action was the best choice among the possible alternatives.

The first reviewer suggested that the most practical course would be to implement the authors' recommendations and follow them until termination in 2007/08. He discounted the idea of doing research in this area for two reasons. First, analyses presented in the paper were based on the assumption that there is a relationship between the putative stock indices and actual abundance of arrowtooth flounder. He pointed out that this relationship had not been demonstrated and that there was no estimate of the absolute size of arrowtooth flounder stocks. Second, the catchability of arrowtooth flounder is unknown and it is possible that the apparent increases in various indices and surveys could be related to a change in the catchability of arrowtooth flounder rather than an increase in abundance.

The second reviewer proposed a number of alternatives to the approach used by the authors. One alternative is to use biomass estimates from bottom trawl surveys and a target harvest rate. There are a number of bottom trawl surveys that apply to groundfish habitat in areas 3CD and 5AB/5CD. These surveys include the Hecate Strait survey (2005), the Queen Charlotte Sound survey (2003-2005), and west coast Vancouver Island survey (2004). Given an assumed catchability of 1.0, the reviewer calculated a biomass of 35,400 t using the sum of the survey biomass estimates from the 2005 Hecate Strait survey, the median value of the Queen Charlotte Sound surveys, and the west coast Vancouver Island survey. He felt that this could represent a conservative estimate of arrowtooth flounder biomass and pointed out that catchability in surveys may exceed 1.0 due to the herding effect of the sweep lines to the doors. One Subcommittee member did not agree with this assumption, stating that values of $q<1$ had been used for flatfish survey work in other cases. Reviewer 2 then estimated an exploitation rate of 0.58 for a 20,000 t removal from a biomass if 35,000 t, considerably higher than the natural mortality rate (M=0.2). He also acknowledged that there may be information on arrowtooth flounder trawl survey catchability in NMFS assessments that may be more realistic. The authors stated that the surveys cited by the reviewer were designed to measure relative abundance, not absolute abundance.

The second reviewer thought it would have been useful if the authors had provided the stratum areas used in the stratified mean calculations for each survey. He also suggested another alternative approach would be to adopt the average catch in recent years as the recommended TAC. This suggestion was predicated on the basis that the indices indicate little change in arrowtooth flounder abundance over the past decade or so, and it thus appears that the average catch of about 8,800 t may be sustainable. Another alternative choice of a TAC is to use the maximum catch in recent years of about 10,000 t. There was Subcommittee support for both of these alternatives.

Power analysis

The second reviewer suggested that the paper should include a power analysis to determine the level of change in arrowtooth flounder abundance detectable with existing monitoring tools. He noted that one possible outcome in two years is no change in the various abundance indices. The authors pointed out that based on previous analyses a 50% change in biomass may be needed to detect a change in harvest impacts over a short time period (2-3 years) with survey coefficients of variation of about 20%.

The second reviewer recommended rejection of the working paper. The first reviewer did not specify acceptance or rejection but did support "… *the analysis and resulting recommendations for a limited term experimental increase in turbot catches*".

Subcommittee Conclusions

The paper was not accepted by the Subcommittee however, there was consensus on the following conclusions:

- There were no defined conservation and economic objectives for the arrowtooth flounder fishery.
- An experimental design for the proposed management experimentation was not provided by the Working Paper. The Subcommittee remarked that there was no demonstration that the existing fishery data was suitable for monitoring changes in arrowtooth flounder abundance.
- The Working Paper advocated a harvest of 20,000 t over 3 years and did not give due consideration to the alternative harvests. These options include, for example, the average catch of the last several years (approximately 8,000 t) and the maximum catch prior to 2005 (approximately 10,000 t).
- The Subcommittee was concerned that the lack of a stopping rule for the management experiment could lead to over harvest of the arrowtooth flounder resource.
- The Subcommittee recommended that it would be valuable to conduct simulations based on data currently available to examine the consequences of different harvest rules. These analyses would help determine whether the data were adequate for assessing whether fishery objectives were being attained.

G2006-03: Rock sole (*Lepidopsetta spp*) in British Columbia, Canada: Stock assessment for 2005 and advice to managers for 2006/2007

P.J. Starr, A.R. Kronlund, G. Workman, N. Olsen and J. Fargo

Paper accepted subject to revision

The first reviewer stated that although the paper represented a substantial amount of work on all aspects of the rock sole populations and fishery, he did not think the paper was ready for publication. He felt that there were some weak assumptions about the data, and a lack of evaluation and interpretation of results.

In contrast, the overall assessment of the second reviewer was that the material was clearly presented. However, he found it difficult to find firm conclusions. He felt that there should have been greater discussion on the pros and cons of the various model "cases." He also questioned whether there were compelling reasons to consider the nominal (arithmetic) CPUE series in any of the analyses. The second reviewer concluded that the assessments appeared to provide the needed information on catch recommendations so that management decisions can be made. He felt that it also reflected the uncertainty in the data. The reviewer complimented the authors on the section on future research requirements. The reviewer suggested that the treatment of selectivity (during known changes in the fishery) could be improved but appreciating the complexity (given interaction with CPUE series) the approach taken by the authors' seemed like a reasonable compromise.

The Subcommittee focused on the appropriateness of the arithmetic and standardized commercial CPUE indices. Both the reviewers and the Subcommittee favoured using the standardized CPUE series. There was some discussion about removing the effects of depth, DFO locality, and month that change over time for the standardized CPUE because trends in stock abundance may be masked by changes in fishing patterns.

One reviewer was concerned that the use of arithmetic and standardized CPUE made the assessment of limited use to a manager. He felt that it should not be the manager's responsibility to determine which CPUE index was superior. If the only issue were a ranking of various TAC options, then one might decipher which option ranks the highest for both CPUE series but this was not possible for this assessment. The reviewer provided the following example. Suppose that a manager chooses to find the TAC that provides at least 80% chance of meeting all "selected" performance measures. Inspection of Table 2 in the Working Paper for the region 5AB analysis would provide the TAC results summarized in the following table for standardized (Std) and arithmetic (Arith) CPUE series:

CPUE series	$P\left(U_{2006} < \bar{U}_{1966-2005}\right)$	$P\begin{pmatrix} B_{2007} > \\ \min[B_{1966} : B_{2005}] \end{pmatrix}$	$P\left(B_{2007} > \bar{B}_{1977-1985}\right)$	$P\left(B_{2007} > B_{2006}\right)$
Std	250	1000	0	350
Arith	450	750	0	350

Obviously, only a TAC = 0 will meet the manager's requirement regardless of CPUE series. The implication is that a manager faces the task of weighting the performance criteria and the CPUE series. The reviewer suggested that the assessment process should include the choice of standardized CPUE over the arithmetic mean series. In support of this view, the Subcommittee noted the authors' recommendation that harvest decisions should be based on the model results based on the "Standardized" CPUE trend. The Subcommittee suggested, and authors agreed, that while the results of the arithmetic index would remain in Appendix F as described, any decision tables pertaining to the arithmetic index would be removed from Appendices F and G and the main text.

The following comments pertain to the use of the delay-difference model for the region 5AB stock assessment. One reviewer said that the authors should provide a more objective evaluation of the delay-difference model for Area 5AB that accounts for the degree of sampling bias in biomass and natural mortality rate estimates. Estimates of *M* were almost double those used in U.S. assessments for northern rock sole and higher than most other estimates provided in Appendix A which could have been used as informative priors in the Bayesian analysis. He commented that *M* should be treated as a free parameter without any informative prior for the population in region 5AB. He also felt that current estimates of M are almost biased high. The reviewer recommended a more objective evaluation of the fit of the model to the mean weight data. He noted that most statistical tests would show a substantial lack of fit based on the residuals in Figures F-6 and F-7 and suggested that the mean weight data were not that useful. The reviewer suggested that the delay-difference model chosen for 5AB be replaced by a simple surplus production model. The second reviewer also questioned use of the delay-difference model for the region 5AB stock given the poor fit to the observations on mean weight. The authors suggested, and the Subcommittee agreed that there was enough information in the weight at age data to assist the model.

The other reviewer concluded that the assessment model approach used by the authors was a good one and the level of model complexity seemed appropriate as detailed in appendices F and G of the Working Paper. However, he noted that there was some circularity in the treatment of the variance terms for both of these models. In particular, the model was iteratively re-fit to find appropriate weights for different objective function components. This is technically a rigorous thing to do but may tend to give too much credence to the model specification. This approach essentially implies that unexplained variance is basically in the data, and in the process of data collection, rather than in the dynamics of the model.

The extent to which this has happened for the rock sole models is uncertain but worth thinking about. In particular, the area-swept indices in Appendix G of the Working Paper were iterated so as to become virtually meaningless with respect to model fitting. This may be a realistic treatment of the data, but may also reflect unanticipated model convergence issues. For example, if robust likelihoods are used "too early" in the estimation phase, the MPD and covariance estimates may reflect results that effectively ignore real patterns in the data. Some baseline results using input variances and comparing those with final values derived from weighting system would be useful to review. He posed the following questions: (1) for the CPUE indices that are used, are effective minimum variances used?, and (2) can the re-weighted variances end up being smaller than the original input variances?

One reviewer suggested that future use of delay-difference models should append forecasts corresponding to the expected time-span between assessments. The authors noted while long-term forecasting could be attempted, the uncertainty of the forecasts would be more extreme than those for the age-structured model because of the lack of age-structured data in the delay-difference model. The projections would be based only on the recruitment function which would lead to extreme uncertainty in the predictions of future biomass.

The reviewer also suggested that too much time was devoted to the CPUE analysis and not enough to evaluating mean weight at age. In his opinion the paper should have included an evaluation of whether the mean weight data are adequate for fitting the region 5AB assessment model. In particular the paper used "…*mean fish weight data derived from samples of commercial landings*…". There was a very strong assumption here that fish in the commercial samples are representative of fish in the vulnerable female population. The reviewer doubted that this was true on average, or over time. He pointed out that the authors acknowledged this stating that "…*it was not possible to fit the average weight data adequately with M [natural mortality rate] fixed*". The reviewer suggested that this was equivalent to admitting that the mean weight data should not have been used in fitting. He criticized the treatment of *M* as a free parameter in an assessment model that included mean weight, and suggested that modeling choice only served to mask errant assumptions and biases behind uncertainty in *M*.

The authors agreed that the delay-difference model makes the strong assumption of knife-edged recruitment, with all fish in the population vulnerable to the fishery after that age. However, the authors noted that a similar model fitted to the 5CD data performed well when compared to the more complex age-structured model.

A reviewer commented that the tactic of adding parameters to overcome inconsistencies between the model and data for region 5AB was quite different from the approach taken in 5CD. For example, two selectivity functions were evaluated in the age-structured assessment for region 5CD. A simple preliminary evaluation of the data was completed and it was concluded that the data were, in fact, inadequate for the purpose. The simpler model and its consequences were adopted rather than adding model complexity, as was the practice for region 5AB.

One reviewer commented that posterior distributions for *M* for the region 5AB analysis (Figs F-10 and F-11) were very different from the assumed uniform (0.1-1.0) priors. He suggested that the posteriors for *M* merely reflected the average of the observed weights and the growth parameters and that the posteriors biased high due to (1) the way growth parameters were estimated (both the data themselves and the estimation procedure) and (2) fitting the model to mean weight of commercial samples.

The authors noted that changes between the prior and the posterior in a Bayesian model is an indication that the model data are having an influence on the values taken by the parameter in question. The opposite situation, when the model data have little effect on the prior, is much more of a problem because it indicates that the model has very little information for the parameter in question.

One reviewer pointed out that there was a difference between the data that the authors said they used for growth parameters on page F-2 and what was actually estimated from the data. The growth parameters used for 5AB were said to have come from port samples which according to Appendix A (Fig. A-1) were Linf = 525, k = 0.203, t0 = -0.769. However, the assessment specification followed Table A-3, which had Linf = 507, k = 0.243, t0 = 0.1998. The reviewer felt that these two parameter sets implied about a 25% difference in the implied *M* and questioned which ones were actually used in the 5AB result.

The authors noted that the growth parameters used in the delay-difference model are specified in the tables contained in Section 1.0 of Appendix E and are based on all the available 5AB data: research, port samples and observer data. The authors considered that the port sample data did not include sufficient small fish to provide an adequate sample of smaller sized fish.

The other reviewer suggested that the calculation of mean weight-at-age for 5CD should include a bias correction for the variance in length-at-age, which appears to be large based on Figs A-1 and A-2. He provided a formula based on a Taylor series expansion about the mean length:

$$\overline{W}_a = b_0 \overline{L}_a^{b_1} + \frac{s_a^2}{2} b_0 b_1 (b_1 - 1) \overline{L}_a^{b-2}$$

where (b_0,b_1) are the length-weight conversion parameters, *a* indexes age, s_a^2 is the variance in length-at-age *a*, and the bar symbols indicate the means for length and weight. Alternatively, the original formula (Eq 5 in Appendix G) could be applied to the individual lengths in the data set and then taking the mean, which would be unbiased. The authors agreed that the bias-correction factor could have been used when converting from length to weight observations, but expected the difference would have a very small impact in the current assessment relative to other uncertainties and that the model tended to be self-correcting because a constant age-weight relationship was used over the entire period.

The Subcommittee and reviewers agreed that the appendix dedicated to describing the fishery independent data (Appendix D) was useful. For the obvious cases, like shrimp surveys, the authors stated that the data are unlikely to be useful for indexing rock sole. The authors also evaluated the Hecate Strait survey and conclude that it is reasonable to use as a relative index of female rock sole biomass (since the region 5CD model is females only).

One reviewer suggested that the region 5CD analysis of expected values of performance measures should also be presented for region 5AB. He further suggested that stock projections should be performed for at least the time interval between assessments for this stock, which is about 5 years and that the one year projections for region 5AB make the decision tables very difficult to interpret and use. The authors agreed to make the decision tables based on the delay-difference model results for 5AB similar to those for the 5CD catch-age model by adding tables of the expected change in the future biomass relative to the reference biomass. The authors agreed that an informative prior on *M* might alter the outcome of the model and scale the model outputs differently. However, they noted that they had allowed *M* to be both estimated and fixed *M*=0.2, a value consistent with previous practice for rock sole. There was no additional information on which to base a more informative prior.

One reviewer argued that the rationale provided for comparing performance measures expressed as <u>ratios</u> instead of <u>absolute</u> quantities was spurious and stated that these two forms are not directly comparable. He suggested that ratios of current biomass to the unfished state (commonly known as depletion ratios) are just as stable as the ones described in this Working Paper. More importantly, they do not suffer from the shifting baseline syndrome because depletion ratios generally improve with the accumulation of more data and were equally as dependent upon the data. He pointed out that the $F_{40\%}$ rule with 40-10 adjustment used by the U.S. agencies involves estimation of current biomass relative to unfished biomass. Under this policy many of their stocks and fisheries have shown marked improvement. He also felt that the arguments used to justify "pragmatic" fishery performance measures seemed weak. In particular, the measure related to minimum biomass seemed to invite a ratchet effect toward lower and lower biomass levels.

The authors disagreed with this reviewer, arguing that ratios based on B0 were no more stable than selected periods within the stock reconstruction history.

Moreover, estimates of B0 were often sensitive to model assumptions that were independent of the data, such as the form of the stock recruitment function, the assumed value of M or stock recruitment "steepness" parameter. On the other hand, fixed periods in the stock reconstruction history tended to behave similarly across a range of assumption choices because they are usually strongly affected by the available data, depending on the period selected.

He also identified what he felt were problems with the decision tables. First, the numbers in Table 2 were based on 1-year projections which made them overly sensitive to TAC choices. For example, why did a 100 t difference in TAC cause a probability to change from almost a certainty (i.e., $\mathrm{P}\left(B_{2007} > B_{2006}\right)$ = 98%) to extremely unlikely (i.e., $\mathrm{P}\left(B_{2007} > B_{2006}\right)$ = 4%). The reviewer suggested that a longer projection horizon be adopted for region 5AB, such as the 5-year projection used for region 5CD.

The authors noted that the 5AB depletion model was not currently programmed to make projections over a longer period. The authors also felt that the one-year projections were on more solid ground because they were based on data for the current partial year (1 April 2005 to 30 September 2005) which meant that the projections were not entirely reliant on the model estimates of recruitment.

The authors used a specific set of biomass reference points to enable managers to make decisions about this fishery. The minimum biomass performance measure was indicated by $P(B_{2007} > \min[B_{1966}:B_{2005}])$. There was some confusion over the terminology and justification of the reference points used. The Subcommittee considered the perspective of one reviewer who felt that the minimum on the right hand side of the inequality ($B_{\min}$) was something to avoid, and was labeled "pragmatic" because it was not as model-dependent as other reference points like unfished biomass (B_0) or B_{MSY}. It might also be pragmatic because it was the lowest point from which the stock has recovered. He also noted that it was highly likely that at some point in the future the stock would be below the original $B_{\min}$, which would, in turn, result in a new, lower $B_{\min}$. The new $B_{\min}$ would then serve as the reference point to be avoided. He was concerned about this 'shifting baseline' where the reference level is continually lowered when trying to maintain the stock above $B_{\min}$. He recommended using reference points based on unfished biomass to avoid this effect.

The Subcommittee disagreed with the reviewer's comment that the limit reference point should be defined from B_0 given the large uncertainty in the estimation of B_0. The Subcommittee also noted that $B_{\min}$, the limit reference point proposed as a candidate for $B_{recovery}$, was drawn from a recent period and that the stock has not yet demonstrated the capacity to recover from this point and requested that this be emphasized in the document.

Subcommittee Conclusions

The Subcommittee accepted the Working Paper with revisions.

The Subcommittee arrived at the following conclusions:

- The Subcommittee noted that given the current abundance is estimated to be at a relatively low level for the 5AB stock, emphasis should be put on stock growth;
- The Subcommittee could not resolve whether the "fixed *M*" or "estimated *M*" model results better reflected stock dynamics of rock sole for region 5CD and concluded that the document should retain the results for both models;
- The Subcommittee concluded that the decision tables based on the standardized commercial CPUE index be accepted as the advice for rock sole in regions 5AB and 5CD.

Subcommittee Recommendations

The Subcommittee accepted all the general research recommendations in the document, subject to consideration of other research priorities and limits in funding. In particular, the Subcommittee requested the following revisions to the document:

1. The Subcommittee asked the authors to alter the decision tables to reflect the landings of males and females combined, not just females. The authors agreed to insert 2 additional columns: catch of both sexes, and landings of both sexes. Thus, each decision table will have 3 "left-hand" columns: catch of females, catch of both sexes, and landings of both sexes;
2. The Subcommittee requested that the Appendix Table captions include the name of the stock;
3. The Subcommittee requested that while the results of the arithmetic CPUE index would remain in Appendix F as described, any decision tables pertaining to the arithmetic index would be removed from Appendices F and G and the main text;
4. The Subcommittee requested that the terminology for B_{min} be revised to note that the stock has not yet demonstrated a capacity to recover from this reference level. The intent here is to avoid accepting B_{min} as $B_{recovery}$.

APPENDIX 1. Working Paper Summary

Working Paper G2006-01: A review of redbanded rockfish *Sebastes babcocki* along the Pacific Coast of Canada: biology, distribution, and abundance trends

R. Haigh and P.J. Starr

This paper reviews the current data on the biology, distribution, and abundance trends for redbanded rockfish *Sebastes babcocki*. This species has a mean weight of 1.384 kg/fish. Allometric growth shows no difference between the sexes; however, mature females achieve a larger size than males of equal age. With an estimated age-of-50%-maturity at 11.5 years, and an assumed natural mortality rate of 0.035, generation time is roughly 40 years. Model estimates of total mortality rate for the years 1997/98 range from 0.04 to 0.07, with no variation among areas of purported light and heavy exploitation. According to commercial trawl records, redbanded rockfish prefer depths between 132 m and 421 m. Using this preference, a bathymetric analysis estimates the potential extent of occurrence at 47,877 km^2 and the area of occupancy at 27,432 km^2. However, based on trawl observations alone, the area of occupancy could easily equal 33,200 km^2. Within its habitat, the two dominant concurrent species are Pacific ocean perch *Sebastes alutus* and arrowtooth flounder *Atheresthes stomias*. Total removals of redbanded rockfish from BC coastal waters by the commercial fleet from 1996 to Sep 2005 equal approximately 3 million fish. Survey indices of abundance are currently not useful for assessing redbanded rockfish population trends. The Hecate Strait assemblage and WCVI shrimp surveys are too shallow; the US triennial survey too uncertain, and the QCS synoptic survey too short. The commercial trawl CPUE indices show a slightly increasing trend in management area 3CD and slightly declining trends in areas 5AB and 5CD. The commercial longline CPUE indices show very strong trends, but these probably reflect fluctuations in catch activity rather than changes in fish population density.

Working Paper G2006-02: A proposal for an adaptive increase in arrowtooth flounder (*Atheresthes stomias*) catches

P.J. Starr and J. Fargo

Arrowtooth flounder catches in 2005 increased dramatically compared to previous years as a result of improved markets for this species which in turn led to increased species targeting, some of which has been performed by specialist vessels which were introduced into the fishery in late spring 2005. Management initially responded to this increase by allowing arrowtooth flounder catches to remain uncapped and to request a PSARC paper designing an “adaptive management” experimental increase to determine an appropriate catch level which would lead to a better estimate of the sustainable yield for arrowtooth flounder. Later, as catches continued to increase, a cap of 20,000 t, including discard mortalities, was placed on arrowtooth flounder for the 2005/06 fishing year. This paper contains the requested design for this experiment, and provides a review of existing monitoring methods, an analysis of the by-catch of associated species and a spatial analysis of the recent fishery. This paper also reviews the tools available to monitor the adaptive increase in catches, which include five research surveys, an analysis of CPUE data, and spatial and biological sampling information which result from the 100 percent coverage of the fishery by an independent observer program.

Arrowtooth flounder total mortalities (landings plus discards) exceeded 15,000 t in the six month period from April–September 2005, a total which is at least 50% higher than the corresponding mortalities in any previous complete fishing year. The increased level of landings was taken without a corresponding increase in the level of arrowtooth flounder discards and without an appreciable increase in total effort (measured as either number of tows or total hours fished) in all three areas examined (3CD, 5AB and 5CD). The fishery in 2005/06 appears to have contracted to a relatively small number of arrowtooth flounder "hot spots" compared to the extent of the fishery in earlier years and is being prosecuted by a range of vessels in the fleet. The biological composition of the catch is smaller than average in 3CD and 5AB, but not outside the range of sizes seen in previous years. The total by-catch of the main associated groundfish species is unchanged in the northern areas (5AB and 5CD) but appears to be elevated in area 3CD (west coast of Vancouver Island).

This paper was not able to provide a quantitative recommendation as to the required size and timing of an increase to achieve the objective of better knowledge of the sustainable yield for B.C. arrowtooth flounder, mainly because the answer to this question requires an estimate of the current stock size which is a key component of the experimental increase. Instead this paper adopted a pragmatic approach by recommending that the existing cap on the arrowtooth flounder fishery of 20,000 t be continued for two more years to allow each key survey to obtain one data point following the increase in catches. This paper also recommends improved biological sampling for arrowtooth flounder and a repeat of the analyses contained in this paper next year to provide an opportunity for an interim evaluation of the experimental increase.

Working Paper G2006-03: Rock sole (*Lepidopsetta spp*) in British Columbia, Canada: Stock assessment for 2005 and advice to managers for 2006/2007

P.J. Starr, A.R. Kronlund, G. Workman, N.Olsen, and J. Fargo

Rock sole (*Lepidopsetta spp*) stock status in British Columbia for 2005 was updated and advice to managers provided for management regions 5AB and 5CD for the 2006/2007 fishing year. Data for rock sole in B.C. were reviewed and their potential for supporting quantitative stock assessment was evaluated.

Biological information for rock sole was presented and information on the occurrence and prevalence of northern rock sole in B.C. was assessed.

The rock sole stock in region 5AB (Queen Charlotte Sound) was assessed using a females-only delay-difference model tuned to biomass indices derived from fishery catch per unit effort (CPUE) data and to mean fish weight data derived from samples of commercial landings. The main uncertainty investigated in the region 5AB modeling was the difference in stock status associated with a standardized or nominal arithmetic biomass index series generated from the analysis of fishery CPUE data. Rock sole in region 5CD (Hecate Strait) was assessed using a females-only age-structured age model tuned to commercial trawl fishery catch rates and two fishery-independent surveys. The interpretation of rock sole status in Hecate Strait was also dependent on whether a standardized or nominal arithmetic fishery catch rate abundance index was modeled.

Both stock assessments used a Bayesian approach to portray model uncertainty. In each case the model and the posterior probability density were used to conduct stock projections over a range of constant annual catch levels. The projections indicate the expected outcomes that arise from adopting a fixed annual catch over the projection period. Performance measures were calculated for each projection to assist the selection of short-term catches.

APPENDIX 2. PSARC Groundfish Subcommittee Meeting Agenda

AGENDA
PSARC Groundfish Subcommittee Meeting
January 18-19, 2006
Coast Bastion Inn
Colville Room

Wednesday, January 18	
Introduction and procedures	09:00 – 09:15
Redbanded Rockfish Assessment	09:15 – 12:00
Lunch Break	*12:00 – 13:00*
A short term harvest strategy for Arrowtooth Flounder	13:00 – 16:00
Thursday, January 19	
Rock Sole Assessment	09:00-12:00
Lunch Break	*12:00 – 13:00*
Rock Sole Assessment (cont'd)	13:00 – 16:00

APPENDIX 3. List of Attendees

External Participants	
Name	**Affiliation**
Chalmers, Dennis	MAFF
Mann, Shannon	CGRCS
Mose, Brian	CGRCS
Starr, Paul	CGRCS
Turris, Bruce	CGRCS
DFO Participants	
Acheson, Schon	
Ackerman, Barry	
Anderson, Kris	
Cass, Al (PSARC Chair)	
Fargo, Jeff (Meeting Chair)	
Haigh, Rowan	
Krishka, Brian	
Kronlund, Rob	
McFarlane, Sandy	
Olsen, Norm	
Rutherford, Kate	
Schnute, Jon	
Sinclair, Alan	
Stanley, Rick	
Trager, Diana	
Workman, Greg	

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.

Cox, S.P.	Simon Fraser University
Ianelli, J.	Alaska Fish. Science Center
Sinclair, A.	Fisheries and Oceans Canada
Stanley, R.	Fisheries and Oceans Canada