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Proceedings of the Pacific Scientific Advice Review Committee (PSARC) meeting for the assessment of scientific information for a recovery potential assessment for bocaccio rockfish and basking shark and for the identification of potential critical habitat for stickleback pairs in British Columbia

Compte rendu de la réunion du Comité d'examen des évaluations scientifiques du Pacifique (CEESP) sur l'analyse de l'information scientifique à l'appui de l'évaluation du potentiel de rétablissement du bocaccio et du pèlerin ainsi que de la désignation de l'habitat essentiel de paires d'espèces d'épinoches en Colombie-Britannique

October 22-24, 2008

22-24 octobre 2008

Pacific Biological Station
Nanaimo, BC

Station de biologie du Pacifique
Nanaimo, CB

Al Cass

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October 2009

Octobre 2009

Canada

Foreword

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

Avant-propos

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

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SUMMARY

Participants from Fisheries and Oceans Canada (DFO) Science, Habitat Management and Fisheries and Aquatic Management sectors, the fishing industry, academia, the ENGO community, the Province of British Columbia and the general public including invited biological consultants attended a PSARC review on October 22-24 2008 to assess and develop advice for the following working papers:

- Stock assessment for bocaccio (*Sebastes paucispinis*) in British Columbia waters.
- Assessment of information used to develop a Recovery Potential Assessment for basking shark *Cetorhinus maximus* (Pacific population) in Canada.
- Identification of critical habitat for sympatric stickleback species pairs and the Misty Lake parapatric stickleback species pair (*Gasterosteus spp.*).

Comments received on the three working papers are presented in these Proceedings. All three research documents were accepted subject to a number of revisions. Taking these comments into account, CSAS Research Documents and CSAS Science Advisory Reports will follow for all three subjects.

SOMMAIRE

Des représentants des secteurs des Sciences, de Gestion de l'habitat du poisson et de Gestion des pêches et de l'aquaculture de Pêches et Océans Canada (MPO) ainsi que des participants externes de l'industrie de la pêche, des organisations non gouvernementales de l'environnement (ONGE), du gouvernement de la Colombie-Britannique et du public, y compris des experts biologistes invités, ont assisté à un examen tenu par le CEESP, du 22 au 24 octobre 2008, afin d'évaluer les documents de travail suivants et de formuler un avis connexe.

- Évaluation du stock de bocaccios (*Sebastes paucispinis*) dans les eaux de la Colombie-Britannique.
- Évaluation de l'information à l'appui de l'évaluation du potentiel de rétablissement du pèlerin (*Cetorhinus maximus*), population du Pacifique, au Canada.
- Désignation de l'habitat essentiel de paires d'espèces d'épinoches sympatriques et de la paire d'espèces d'épinoches parapatriques du lac Misty (*Gasterosteus* spp.).

Les commentaires formulés à propos de ces trois documents de travail sont exposés dans le présent compte rendu. Les trois documents ont été acceptés sous réserve qu'un certain nombre de révisions soient apportées. Un document de recherche et un avis scientifique du SCCS tenant compte de ces commentaires seront publiés pour chaque sujet.

INTRODUCTION

A peer review of a stock assessment and scientific information in support of a Recovery Potential Assessment (RPA) took place for bocaccio rockfish and basking shark. Bocaccio rockfish were designated as threatened by the *Committee on the Status of Endangered Wildlife in Canada* (COSEWIC) in November 2002. Basking shark were designated as endangered by COSEWIC in April 2007. In addition, a review of potential critical habitat for sympatric (benthic – limnetic) and parapatric (stream – lake) stickleback pairs was also conducted as part of DFO's mandate to review the biological basis for identifying critical habitat in recovery plans. Several stickleback pair populations in BC are designated as endangered by COSEWIC. A PSARC review of information in support of a Misty Lake stickleback pair RPA was conducted in April 2008. The review of potential critical habitat will be used to complete the RPA. The agenda is provided in Appendix 1.

Working papers were prepared prior to the meeting and distributed to meeting participants. Formal reviews were presented at the meeting. Based on the reviews and discussion by meeting participants, conclusions and advice were formulated in support of public consultation, SARA listing decision making and recovery planning. The 17 steps in the RPA framework were used as guidelines for the peer review of bocaccio rockfish and basking shark. The DFO framework for quantifying habitat quantity and quality were used to guide the peer-review of the stickleback working paper. These frameworks are posted on the CSAS website:
http://www.dfo-mpo.gc.ca/csas/Csas/status/2007/SAR-AS2007_039_e.pdf
http://www.dfo-mpo.gc.ca/csas/Csas/status/2007/SAR-AS2007_038_E.pdf.

The meeting was attended by participants from DFO Science, Fisheries and Aquaculture Management, Habitat Management and Policy sectors. External participants included invited participants from the Province of British Columbia, academia, the ENGO community and industry. A list of participants for each day of the meeting is in Appendix 2.

DETAILED COMMENTS FROM THE REVIEWS

Opening Comments

The Chair, Al Cass, welcomed the large turn-out of participants. He explained the format of the 3 day session – a full day of discussion each, as required, on bocaccio, basking shark and stickleback pairs. He noted that the list of participants attending each day's session was expected to change to reflect differing interests of participants but that all are welcome to attend all three sessions. Brief introductions of participants took place. The Chair explained that there would be three main types of products coming from these meetings – a Research Document on each of the three subjects, a Proceedings Document covering the three days of meetings, and a Science Advisory Report on each of the three topics.

The Chair went on to explain that this is a Science meeting convened to provide advice to Fisheries Management, Policy, Habitat and others such as Recovery Teams needing such advice to develop recovery processes for species that are listed under the Species at Risk Act (SARA) or that might become listed. Everyone attending has full participatory rights. To begin, the authors of the working papers will be afforded sufficient time to make a presentation of their findings and recommendations. Questions may be posed by participants during or after this presentation. Then invited reviews will be presented. Finally a general discussion will be invited. The ultimate purpose is to develop conclusions and advice for the three SARA related topics.

Stock assessment for bocaccio in British Columbia waters
R. D. Stanley, M. McAllister, P. Starr and N. Olsen

working paper accepted with revisions

A summary of the working paper is found in Appendix 3.

The background behind the need for the assessment on bocaccio stems from its designation as a threatened species by COSEWIC, and hence the need to provide advice to the Minister on listing recommendations under SARA. Anticipating the likelihood of such a decision, it was felt wise to provide scientific advice in the form of background for a Recovery Potential Assessment (RPA), a precursor to the development of a recovery strategy and action plan. The authors prepared the report as a stock assessment but in preparing the report, they endeavored to include and address every element of an RPA framework (17 requirements) so that a follow up meeting to specifically generate an RPA wouldn't be needed.

When a species is listed under SARA, it is afforded protection from further harm but there can be exceptions allowed provided that the harm incurred is unavoidable and that it does not interfere with recovery or survival of the species. The question for a non-target species like bocaccio then becomes, what level of incidental harvest is consistent with survival or recovery of the species? Currently, with no directed fishery, the commercial harvest is on the order of 152 tonnes per year. This excludes catches from unknown recreational and First Nations catches. The current catch quota is for bycatch in all commercial fisheries sectors. Recreational and aboriginal fisheries are treated as negligible for the purpose of modeling, though in fact there is no data to support this assumption.

Bocaccio is a data poor species. The paper describes in detail the limitations of each data set. For example, when Canadian and foreign trawl fisheries are believed to have been taking the greatest numbers of bocaccio in the 1960s, this can only be extrapolated, since the various species of rockfish were not separated out in the statistics reported at the time. While halibut longline and salmon troll fisheries are presumed to now account for the majority of bycatch, the accuracy and precision of the catch estimates are not known. Various research surveys also have inherent error factors that need to be taken into consideration.

With only 24 samples for aging starting in 2001, an age-structured model was not considered feasible due to the paucity of data. Instead a modified version of a Bayesian Surplus Production Model (SPM) was developed. The advantage of an SPM model is that it is conceptually simple and computationally efficient. But its usefulness for future predictions of stock size could be biased by many of the underlying assumptions. Such models require the development of Bayesian priors for parameters that cannot be determined based on hard data.

One of the more novel approaches used in applying this model technique involved employing expert local knowledge in the form of advice of 12 skippers with years of experience in the fishery to develop the prior for catchability q and from that to extrapolate the overall size of the current biomass. Simply put, q is the fraction of biomass in the water column between the trawl doors that on average will end up on deck. The 12 skippers interviewed were asked to offer their best estimates on this question, starting with how many fish are in the water column, how many are in front of the path of the doors, and how many of those actually get caught. He noted that fishermen were not keen on doing such an analysis for bocaccio. It would have been a great deal easier for other species, such as ocean perch, yellowtail etc. Similarly they asked the same series of questions to gauge catchability in shrimp nets. As a rule of thumb, groundfish trawls net yields 4-9 times higher than the shrimp trawl.

Not all areas are surveyable (they are not trawlable) so it is necessary to also estimate biomass in those areas not fished and query if the concentration may he higher or lower in those areas. In the model the authors had to estimate a range of possibilities of the relative density in untrawlable versus trawlable areas.

The method used to compile information from the fishermen into the model was explained. The results from the 12 skippers were so variable that they could not be simply averaged. To ground-truth the expert advice, the responses from the 12 skippers (their ratios of catchability) were compared to annual DFO shrimp trawl and groundfish survey results. In the end, the authors deemed it necessary to screen out 6 of the 12 inputs because of their uncertainty.

In an effort to verify the priors chosen, 31 sensitivity tests were performed. For example 8 sensitivity tests were carried out on catch assumptions alone, as well as 8 on the effect of eliminating certain data sets (e.g. what if the trawl survey data is taken out?).

The principal output of the model is summarized in a table of fisheries management constant quota options from 0 to 300 tonnes. The reference case projections for median stock biomass with TACs from 0 to 300 tonnes show that at a TAC of 200 or less a population increase will occur with a probability of 0.5 or greater. However the authors are quick to point out that there is a great deal of uncertainty in the model.

General Discussion

Three reviewers were invited to critique the draft working paper.

The first reviewer commended the authors on the novel approach they had adopted to contend with so little hard data and agreed that in such circumstances Bayesian priors are vital to an analysis. But there needs to be a careful review as to whether priors are chosen correctly. The reviewer commented that for the most part, this appeared to be the case for such parameters as carrying capacity, maximum rate of increase, steepness, instantaneous rate of natural mortality and growth rate. Age at maturity suffers from the small sample under 6 years. The reviewer also expressed concerns over the relative expertise of the twelve skippers who were queried for their input. It appeared from the report that some of them might have had limited experience with shrimp trawls and this might have biased the results. One of the authors responded that there were a number of skippers for whom these arguments are not applicable. But the reviewer argued in favour of retaining all 12 inputs rather than excluding some of those results. Retaining all 12 sources of input based on groundfish trawls would make this analysis more robust. Afterwards it would be feasible to extrapolate to shrimp trawl catchability. The authors welcomed these suggestions on how to improve this form of input. It was suggested that future work could involve using weighting factors to reflect the level of expertise of the captains.

The reviewer made a similar argument in favour of carrying out a sensitivity analysis to be sure that the catchability coefficient *q* is not being artificially impacted by priors. Because *q* is based on expert opinion, it must be treated appropriately since it has a large impact on imputed catch from salmon trollers.

The reviewer also expressed reservations concerning the decision table. There must be better than a 50% probability of achieving the goal, otherwise it is essentially a flip of the coin whether it will occur or not. It is recommended to use the reference case for the population growth parameter *r* rather than looking at the probability of low *r* and high *r*. An author responded that the reference case is more credible, but it is best to frame it with the other low and high priors.

The reviewer summed up by saying that the analysis is a huge achievement based on the minimal data available. Innovative methods like soliciting expert opinion is a big step forward.

The second reviewer agreed that the analysis is thorough and explored many potential modeling methods and data sources. Overall it is suitable for management advice. A comment was made that, in terms of some data sources, some surveys may be getting at different demographic components. The lack of data on age-length makes this impossible to determine.

The second reviewer stated a preference for an age structure model rather that the Surplus Production Model (SPM) using in the analysis despite the paucity of data. The reviewer noted that in the end, however, that may not have changed the results. If the stock recovers as anticipated, this implies a need for a reduction in fishery effort, as TAC will be achieved more easily and rapidly with the same level of effort and continued fishing activity will lead to the TAC being exceeded. The authors responded that the use of a SPM means that they do not have to make future modifications to the model, as would be needed in an age structure model, in response to progressive recovery.

The reviewer expressed the view that it would be good to know how much the final results were affected by each of the seven data series used. The authors noted that the 31 sensitivity analyses do this by taking out one data source at a time.

The third reviewer commended the authors on their extensive assessment effort. The presentation clarified much of what was in the report – for example, the fact that the reference case is not necessarily the recommended case did not emerge in the text. The authors agreed to add clarity in that regard to revisions of the working paper.

Another point in need of clarification in the text is why the limits of 40% B_{msy} and 20% of carrying capacity, K, were chosen and how do these limits relate to SARA? It was explained that this is DFO's provisional precautionary approach policy and the authors agreed it would be better explained in revisions of the text.

The reviewer went on to observe that the model doesn't fit the data particularly well, prompting the question: how much do informative priors affect other informative priors in terms of bias? The 31 sensitivity analyses are all single assumption tests. There needs to be some way to deal with the cumulative effect of multiple factors. The authors agreed that this is something that could be done. The first reviewer interjected that this argues even more for putting additional effort into assessing and improving the old data sets.

A participant from the fishing sector asked where the juveniles are; he commented that he personally caught 1000 lbs of bocaccio this year and all were adults. Having trawled for 40 years, he expressed concern for whether all the management changes that have occurred over the years are extrapolated into the model or if they are perhaps ignored, leading to mistaken results. He noted, for example, that bocaccio are not caught in all salmon fisheries, only in the Chinook fishery. In regard to extrapolating what the densities are in untrawled areas, he noted that troll and longline fisheries both take place in the untrawlable areas, so that should give good information on the abundance in those areas. One of the authors responded that this suggests one could do an experimental troll fishery in those areas to improve the knowledge of abundance relative to bottom type. But information seems to indicate that there is no overlap between longline and trawl fishery areas. Juveniles have not showed up in the catch as long as data is available, so it should not necessarily be treated as an issue of concern. He agreed that effort in the 1940s would not be the same as effort today due to different regulatory control measures. They compensated for this by using various hypothetical catch rates. Another question would be, was the average weight of 4 kg seen today the same back in the 1940s?

There was discussion concerning calibrating 40 year old Pacific Ocean perch surveys with the ones done now to determine the percentage of bocaccio among all rockfish over time. There could be ways to do this, but this wasn't done as part of the current analysis. This would at least show whether the percentage was three or four times higher in the past.

One participant suggested a method of bias removal by feeding posteriors back into the model. But the first reviewer argued this is not a proper technique because it involves using the same data over again.

The Chair summarized that there had been a good discussion on the methodology and assessment. He had heard no overtone of flaws in the application of the Surplus Production Model. He enquired if the authors were comfortable with doing the revisions that reviewers had suggested. They responded that they would be able to do model runs on sensitivity without any data to see the effect this would have on the priors. But it would not be feasible to revisit the priors themselves. The first reviewer suggested it would be better to run the model with informative priors without the data and the authors agreed this was a fair request.

The Chair then asked how well the information presented meshes with the information needs of an RPA. It was pointed out that the authors dealt with this in their closing section that included all three phases of the protocol. One participant stated that the section needs to be expanded. For example, the view was expressed that the argument against the value in establishing an MPA as part of an RPA should be further clarified, and that "residence" (as the term applies under SARA) is not an issue, or that habitat is not limiting. The authors agreed to look at the section in question to see if any additional wording would be beneficial when preparing the RPA. It was noted that in the case of MPAs, they are intended for coastal, more sessile species, not broad-ranging species like bocaccio.

Habitat staff at the canary rockfish RPA meeting in June 2008 wanted more thorough treatment given to the issue of habitat use and this has been taken into account in the working paper on bocaccio.

One of the authors made the point that, if the recovery strategy leads to rigorous controls on commercial catch, then the issue of overlap with the minor fisheries (e.g. recreational, aboriginal) becomes an issue. This analysis does not anticipate or deal with the scenario of a rapid increase or decrease in biomass and, if that should occur, a new analysis would be needed.

It was added that, if the decision is made to reduce commercial take below present levels, the impacts must be assessed on not only the commercial fishery but also on recreational and aboriginal fisheries, since pressure will be there to limit those proportionately as well. Otherwise, these fisheries would take a larger portion of the overall catch and it may no longer be negligible at some point. Another participant expressed fears that, as commercial take is controlled and reduced, the recreational and First Nations fisheries may actually keep growing and defeating the efforts of the recovery plan.

The second reviewer made a suggestion that Tables G10 and G12 in the working paper be moved forward from the appendix into the main part of the document, as they are too important to be relegated to an appendix and potentially missed. The authors agreed with this suggestion.

Conclusions and Advice

- The working paper was accepted with revisions. Participants agreed that the paper satisfied the RPA framework (17 requirements) and that there should be no need for a follow up meeting.

- Participants agreed that the scenarios explored in the assessment were reasonable and accepted the results of the Bayesian Surplus Production model. Participants supported the estimates provided for the species of the median abundance in Canada of 17% of B_{msy} (10-90% range = 6-53%).

- The model predicts that at the current catch rate of approximately 150 t, there is a modest likelihood of an increase over 20 years, but not to the level of 40% B_{msy}. The model predicts a 61% probability over 40 years of achieving this goal. There are major uncertainties underlying these predictions and participants agreed that there are too many uncertainties to extend projections beyond 40 years.

- Participants concluded that the establishment of an MPA to assist recovery is not appropriate, as has been proposed for other rockfish species because bocaccio is too mobile and broad-ranging. Participants concluded that harvest control is really the only reasonable mean to affect human impact and promote recovery.

- Participants agreed with the list of recommendations for future research presented in the working paper and reproduced as follows:

- Continue work on improving estimates of historical catch but this process would be more efficient, more consistent, and more effective if done for many or all of the key species at the same time.

- Explore the potential to work with US biologists for a coastwide assessment of bocaccio, especially as the time series of abundance indices and ageing data expands.

- Develop software and an empirical basis to carry out management strategy evaluation (MSE) of alternative feedback control fisheries management regimes for bocaccio alone or combinations of rockfish species.

- Examine the feasibility of a trolling experiment to estimate the ratio of the densities of bocaccio or other species in trawlable and untrawlable areas in each of the six major survey areas on the BC coast.

- Evaluate the possibility of obtaining additional prior information of the survey net catchability coefficient by studying the relationship between stock size estimates and groundfish survey area swept estimates in the US bocaccio assessments.

- Evaluate the feasibility of a stock structure study of bocaccio in BC and US waters using samples of chemical microconstituents in bocaccio body parts. The presence of much older fish in recent samples from BC and Washington State in comparison with California samples, in spite of significant fishing morality for many decades implies the possibility of gradual migration to BC waters as US fish become older. Microconstituent analysis might reveal the source of larvae and juveniles that recruit to BC fisheries.

- Evaluate the feasibility of acoustic studies of bocaccio or other rockfish behaviour in response to trawl gear.

Assessment of information used to develop a Recovery Potential Assessment for basking shark (Pacific population) in Canada
Gordon (Sandy) McFarlane, Jacquelynne King, Karen Leask and Line Bang Christensen

working paper accepted with revisions

The Chair, Al Cass, opened the meeting by explaining that the sole purpose of this session is to review scientific advice in support of a Recovery Potential Assessment (RPA) for basking shark. He went on to outline the order of the agenda, beginning with a presentation of the working paper by one of the authors, followed by the presentation of the two reviews that have been received, a general discussion and concluding with advice formulation.

A summary of the working paper is found in Appendix 3.

The author emphasized the point that all known or inferred life history parameters lead to the conclusion that recovery of the species is a long-term prospect. If successful, recovery could take approximately 200 years before a return to their unexploited states. If they have complete protection, it will still take hundreds of years for the population to recover to 1000 breeding pairs. Recovery to 30% of the original biomass could happen within 45 years, if complete protection is afforded. The fishing mortality that the population can sustain without suffering further decline from the 2007 population ranges from 10 to 17 individuals annually coastwide including Canadian and US waters. The author further commented that there has been no evidence of recovery of the population at all since it has been under protective management measures.

The author provided an overview of the assessment relative to the three phases in the DFO RPA guidelines.

Phase 1 Current Status

In 2007, the basking shark population off Canada was designated as endangered by COSEWIC. Historically it was abundant in certain bays and sounds of BC in summer and in selected bays (notably Monterey Bay) of southern California in winter. The few sightings in recent years are reported in certain restricted areas (e.g. Clayoquot Sound in 1992). There were still large numbers in Monterey Bay and a few other southern locations in the early 1990s but for unknown reasons these large numbers were not reflected in sightings in BC. Since then there have been fewer sightings in northern and southern portions of the former range. In response to a question, the author noted that the species has generally not been seen off Oregon and northern California during migration, perhaps because they are swimming at depth while migrating, or it may simply be that no one was looking for them in these remote areas.

To determine historic trends, all formal and informal sources were examined. Between 1900-1970 the species was seen regularly in select areas off BC (Barkley Sound, Clayoquot Sound, Rivers Inlet) but now is rarely seen. Also, between1920-1970 the species was actively killed under a government-sponsored program, and was also commercially harvested and taken in a sport fishery. Between 1000 and 2600 are estimated to have been killed between 1945-1970.

Current abundance is unknown, but it is very rare off Canada's Pacific coast. Many surveys have taken place but only 6 authenticated encounters have been recorded since 1996. A total of 97 sightings were reported in Clayoquot Sound in 1992, representing at least 27 individuals. Since 1994 there were not reports in Clayoquot Sound.

The population is assumed to be a single stock off the west coast of North America. Much of what is known about the species comes from US information from directed surveys in the past, general surveys for porpoise and leatherback turtle in recent years, and some tagging in Monterey Bay in the 1990s when there were still large numbers seen (~150 fish). Authenticated aerial observations show that there were at least 2000 individuals in 1948 based on their sighting in Monterey Bay. But since 1994 only 1-3 sightings per year have been reported in porpoise and leatherback turtle surveys south of Monterey Bay.

Potential critical habitat cannot be defined for this species because too little is known about the reasons for the large aggregations observed in the past. It is only possible to define historical occurrence. Aggregation is known to be associated with high zooplankton concentrations, and this and other possible "thermal issues" may presage vulnerability to climate change. In the US, critical habitat is considered to be all areas of historical abundance. As for other broad ranging marine species, there is no "Residence" as defined in SARA.

Recovery goals were developed at a workshop in December, 2007. The short term goal is to promote recovery from the endangered to the threatened status. The interim goal is to seek sustained positive growth. The long term goal is to restore the species' reproducing population sufficiently that it can be de-listed.

To assess the recovery potential, a production model was used to determine the number of years required to obtain these objectives under 4 mortality scenarios: F=0, F=0.05M, F=0.5M and F=M. Two case histories were used which were considered to represent the minimum and maximum historical mortalities in both the US and Canada and which are estimated to have represented unfished populations of 3500 or 5500 respectively in 1920. Based on the analysis, current population off the west coast of North America would be 420 fish in Case 1 and 606 in Case 2 in 2007.

Phase II – Scope for Human-Induced Mortality (Threats)

Human-induced mortality is a significant factor due to late age of maturity, low fecundity, long gestation period and long periods between gestations, low productivity, sex segregated populations, use of habitat that supports commercial fisheries, lack of fear of vessels, and the current small population size. Interaction with fishing gear is the major threat today while historically it was the eradication program and targeted fisheries. Harassment historically was an issue, but if the species begins to recover, this should be easy to prevent through education programs. Collisions with vessels have been a problem and could continue to be.

No identification of habitat important for survival or recovery has been made. The species is compromised by anything that affects zooplankton (e.g. climate change, shoreline development, etc.). Fish farms and log booms could be a small problem. The existing krill fishery is not considered an issue due to timing and location of this fishery.

An analysis of scope for total allowable harm indicates that no more than 2 or 3 sharks can be killed per year in both Canada and the US if fishing mortality is not to exceed 0.05 of natural mortality (F=0.05M) – a conservative but realistic target if recovery is to take place. The population could become extinct within 50 years at F=0.5M and F=M. Recovery times to near historical abundance are very lengthy even under the most optimistic projections. For example, a 390-400 year recovery period at F=0.05M and somewhat shorter for F=0 (which is not considered a realistic scenario).

It is estimated it will take at least 100-150 years to show even minor recovery at low fishing mortality. Under any circumstances, it will take many decades to a couple of centuries to rebuild the population to a healthy condition.

The fishing mortality rate that the population can sustain without suffering further decline from the 2007 population size is 0.015 or 22% of the natural mortality rate (6 to 10 sharks per year).

Phase III - Scenarios to promote recovery.

Reducing both involuntary and voluntary fishing gear encounters is the primary goal. Protection agreements with the US are essential due to the migratory patterns of the species. Improved reporting of sightings is also an objective to gauge progress in recover. In the future, if recovery is evident, educating the public regarding avoidance or harassment and collisions will be important.

Coastal development needs to be managed to reduce impact. Work with the US and other nations to protect habitat will be required. Possible conflict with the krill fishery could be monitored. In terms of mediating threats to individual fish, codes of conduct to avoid harassment could be instituted as in the UK (e.g. similar to those for whales). Contamination is not considered a significant issue, but opportunities to test this hypothesis should be pursued when mortalities do occur.

The population structure may be more complicated than is presently known. However, they may also respond to climate change by shifting distribution to more favourable locations. They may be able to adapt to perturbation, but only on a scale of centuries.

Improvements are needed in public education, such as advising against fishing gear deployment while sharks are observed in the area. Better enumeration through anecdotal reporting mechanisms. Aerial surveys etc. are worth considering. Deterrent devices for fishing gear could be investigated. In conclusion, evidence indicates that numbers have declined by at least 90% in only 2 or 3 generations. The prognosis even with no human impacts is uncertain. It is unreasonable to expect rescue from extant populations given the very low abundance over the entire eastern Pacific Ocean and the unlikely prospect for rescue from transoceanic populations. According to the model, at least 400 years will be needed to recover to 1000 breeding pairs and 85-90 years to achieve 30% of the original biomass. Model results also indicate that extinction will occur within 50 years if human-induce mortality approaches half of natural mortality.

General Discussion

The Chair indicted that two peer reviews of the draft working paper had been received but that only one of the authors was present to discuss the review.

The reviewer in attendance began by concluding that this was an excellent report on scientific information used to support a RPA. There was only one concern that might affect the conclusions. He stated that the report made good use of historical data and the latest information. All steps in the RPA guidelines were addressed adequately. The recovery targets seem reasonable and there are good options presented for achieving them. The inventory of measures and alternative activities was particularly strong. Scenario development in Phase III was limited, but so little is known about the species that this is understandable. The range of activities impacting the species included all the significant ones. More detail could be provided in the text on derivation of natural and human-induced mortality and how they related to the number of sharks actually killed historically. He suggested including the information provided in the author's presentation.

The reviewer further noted that the document uses the word "should" in regard to actions to be taken when it would be more appropriate to use less prescriptive wording. It is not the role of Science to determine these measures. Also the term "mitigate" should be used rather than "mediate" in terms of threats. It would be useful to have a summary discussion of the production model before rather than relegated entirely in an appendix. In one case it is suggested that the model generated values for the rate of decline and recovery when in fact these are assumptions fixed in the model (i.e. 90% decline and certain r population growth rate values).

The review was convinced that the population must have declined historically by at least 90%. The record of the kill history is credible and conservative. The rate of potential population increase has to be incredibly low. He questioned to what extent the model is capable of providing a better estimate of population growth rate *r* compared to those extracted from the literature. How much "updating" (realizing this is not a Bayesian modeling approach) is taking place and how would it be changed by having a larger range of *r* values? He expressed concern that the range of values could be too narrow. The reviewer further noted that this takes on particular importance because a parallel analysis on the east coast conducted last year in which the authors had limited information on the level of decline. In the east coast analysis they had aerial survey evidence of current population numbers between 8000-11,000 in 2007 and they used much more optimistic r values. The reviewer recalled that their conclusion was that the population trend is increasing, though it seems, on the surface, to be implausible. Their estimates of r = 0.032 and 0.04 compare to 0.013 and 0.023 in this study, which makes a difference in terms of recovery potential. Which estimates are more credible? If the *r* values used here were applied on the east coast it would change the finding that recovery is occurring there. The reviewer emphasized that it is important to sort out the difference between the Atlantic and Pacific projections. The author agreed to look into this issue in revising the final research document[1].

The author stated that he was comfortable dealing with all the editorial comments and noted that this latter point in particular will require some additional work.

The reviewer noted that the 90% reduction figure is reasonable, but it could be as high as 99%, which would significantly impact the recovery potential. The author expressed the view that it would not really be a useful exercise to go back and use higher rates of decline in the model because the recovery periods with 90% decline rates are already so lengthy that it is almost immaterial if they are too "optimistic". There is enough information here for decision-makers to develop a reasonable strategy. The reviewer pressed the point and noted that it is not clear how the 90% figure was derived and whether it is considered solidly defensible. The author responded that it came from the COSEWIC report and was used without questioning it. Based on the number of 2000 individuals in 1948 and a number of 200 in the early 1990s, it certainly demonstrates around a 90% decline. Whether it is really 90% or 95%, the recovery strategy will not change. The reviewer continued to emphasize the desirability of providing a better defense of this rate in the text and, if it should seem to the authors to be adequate, perhaps a run of the model with different values would be in order.

Another participant expressed the view that the RPA process is intended to provide sound advice to those who must make decisions. It is important to be able to provide them with some level of confidence that a 90% population reduction is a good estimate. The author agreed to rework the wording in such a way that it would clarify the confidence that exists in using this number as opposed to a higher or lower number. The reviewer once again recommended that if there is every reason to believe that 99% is as valid as 90%, the research document should provide recovery potential estimates based on the more conservative number. The author stated that this would be covered adequately by changes in the text but recommended that this could be included as a matter for future study. He again stated that the end result is academic – recovery to an unexploited state will still take centuries.

The second reviewer was not in attendance. But his comments indicated satisfaction that the working paper addressed all issues raised in an earlier workshop on this subject in September, 2008, and his review was favourable. He supported the paper and made no suggestions for changes.

A participant noted that gear types that could possibly catch basking sharks are mentioned only in passing. Are there recommendations on prevention of mortality in basking shark that

[1] Following the PSARC meeting, further assessment of the reason for the difference in the *r* values used in the east and west coast assessments for Canadian population revealed that *r* values of between 0.032 and 0.04 are the correct values. Revisions to the working paper have since applied those estimates.

could be included? The author observed that this normally left to the group that develops the RPA. The gill net and seine fisheries are the most obvious hazard. In the recent incidents of mortality, trawls have been responsible. There could also be other accidental captures that have gone unreported.

Conclusions and Advice

- Participants concluded that the working paper is accepted with revisions identified during the review.

- The author agreed to follow the advice of the reviewer and provide rationale for the assumed historical 90% population decline rate based on the COSEWIC Status Report. If a 90% decline cannot be supported any more than a higher value then a subsequent analysis should be done at a higher level for comparison. The author indicated that he and the other authors will look at the defensibility of the 90% value and may do model runs at a higher level if this seems to be dictated by their assessment.

- The difference in the population growth rate *r* between the Pacific and Atlantic needs further evaluation given the potential impact on recovery scenarios.

- Research to identify potential critical habitat would be beneficial. Participants concluded that this would be a major research initiative and that it would be almost impossible with the limited number of sightings at present.

- Participants agreed that the format of the paper followed the DFO guidelines for conducting a recovery potential assessment and therefore it would be easily formatted into a Science Advisory Report that references the Research Document.

Identification of potential critical habitat for sympatric stickleback species pairs and the Misty Lake parapatric stickleback species pair
Todd Hatfield

working paper accepted with revisions

The Chair, Al Cass, opened this session by noting the significant difference in the topic of this session versus the topics on the two first days of the meeting. In the previous sessions, scientific data in support of RPAs for marine fish species were considered. In this session science advice is being reviewed in support of the designation of critical habitat for a number of endangered species pairs of freshwater sticklebacks. The author of the working paper will make a formal presentation of the paper and then two invited reviewers will make their presentations, to which the author can respond. Then an open discussion will be held to bring up relevant points from other participants. The goal is to arrive at a set of conclusions and advice on the biological rationale for identifying critical habitat for these species pairs under SARA.

Recently a protocol has been developed on identifying important habitat – geo-referenced potential critical habitat. The recovery team reviewed a working paper in April on scientific information in support of an RPA for the Misty Lake stickleback pair. That working paper was accepted with suitable revisions. Subsequent to that meeting it was agreed that a more in depth review of habitat considerations was appropriate.

Products from this session will include a research document published in the DFO CSAS series if the paper is accepted by meeting participants, with revisions as necessary. The unpublished RPA reviewed in April 2008 will be revised based on the results of this review to complete the Misty Lake stickleback RPA.

A summary of the working paper is found in Appendix 3.

The author, in his opening remarks, commented that the report contains recommendations for identification of critical habitat for a number of sympatric species pairs and one parapatric pair (in Misty Lake). The paper used a framework for determination of critical habitat previously developed by the author and others in 2006[2]. There are three basic steps: 1) establish a recovery target; 2) determine the relationship between habitat and population size; and, 3) based on this, assess how much of the occupied habitat is required to not jeopardize survival or recovery of the species pair.

The author reported that the population numbers used in this study were partially based upon direct study (i.e. mark-recapture surveys) and, where such surveys had not been carried out, estimates were inferred indirectly from comparison with populations where mark-recapture surveys had taken place. The Paxton Lake sympatric pair has been the subject of one limited mark-recapture study and this was used as a tool for estimation of populations in other lakes where such surveys had never taken place. The Misty Lake parapatric pair population was estimated indirectly.

The identification of critical habitat for a species pair, especially sympatric pairs (e.g. Paxton Lake) cannot be treated in the same manner as single species – ecological interaction between the species pair leading to potential hybridization and the breakdown of genetic separation must be considered.

The author pointed out that the ecological communities in these lakes are very simple with limited numbers of other fish species. Accidental or deliberate introduction of other species of fish or invertebrates can results in the loss of genetic separation between the pairs. Water quality, light transmission and nutrients may all play a role in preservation of these species pairs. Water clarity (as affected by suspended solids and tannins etc.) is particularly important to permit distinct species-specific colour variations to be observed during spawning and thus avoid hybridization.

The mark recapture study on Paxton Lake found fewer breeding benthic adults than anticipated. It had been previously assumed that the population abundance would be higher, but the survey found it was actually substantially lower. In Table 2 of the working paper, for example, it was found that there were only 3300 benthic reproductive males. This was much lower than anticipated and probably represents experimental error, such as trap avoidance. Estimates in other lakes based simply upon their relative size compared to Paxton Lake were also on the order of 3000 breeding males and these estimates are considered low by those

[2] Rosenfeld, J. S. and T. Hatfield. 2006. Information needs for assessing critical habitat of freshwater fish. Canadian Journal of Fisheries and Aquatic Science 62:683–698.

who know the systems well, but it is unclear how much higher the populations really are. Estimates of the limnetic populations are considered more reliable.

Section 8 of the working paper establishes the logic for setting the amount of habitat needed to meet abundance targets. Table 10 shows the proportion of the total habitat required to achieve different population targets using a variety of analytical methodologies. A Minimum Viable Population (MVP) target of 10,000 individuals requires all of the lake habitat to meet this target in all lakes examined except in Priest Lake where the proportion is slightly less (0.883). The same was more or less true for an MVP target of 7000 individuals, but with a slightly lower requirement in Priest Lake (0.618) and also Little Quarry Lake (0.920). To meet targets based on population models would require lesser proportions of the total habitat available, but it must be kept in mind that none of these estimates take into account the risk of hybridization. This dictates a more conservative approach in terms of setting habitat targets.

General Discussion

At this point in the proceedings the two invited peer reviewers were asked to present a summary of their observations on the working paper. The first reviewer, having seen the review prepared by the second reviewer, noted that, between the two reviews, all significant issues that ought to be raised had been covered. The author was commended for having made a real effort to capture all the information that is available on the subject, as limited as it may be. Dealing with such little information, it was wise to use multiple approaches to estimate both population numbers and habitat requirements, as the author had done.

The first concern dealt with the inherent biases in the Paxton Lake tag-recapture survey. It is acknowledged in the report and is transparent in Table 2 that these experimental flaws lead to significant underestimates of the number of limnetic females and non-reproductive males. These errors are compounded by being passed on to the other lakes for which population estimates are based on the Paxton Lake survey. There are ways to reduce this bias and the reviewer suggested a number of options. But these inherent sources of error must also be fully recognised in the text, since they cannot be totally corrected.

Another concern was that, even though bathymetric data is available for several of the lakes, the study only used the data for Paxton Lake and extrapolated to the others. The analysis would have been more robust and credible if the data for the three lakes for which bathymetric data exists was all used. The author explained that this approach was an artefact related to funding logistics. Had more funding been available, it would have allowed more time for such analyses, rather than assume these systems were morphologically similar.

In preparing recovery targets based on population modelling, the reviewer noted that the estimates derived are recognised to be underestimates. However, she noted that in some publications these estimates are an order of magnitude larger. That is a significance difference and needs to be explained. The second reviewer clarified that these other estimates were based on the best information available and a number of caveats applied including a very small mark-recapture sample size. The author added that those who know these systems well agree these estimates are low, based on their experience. But while it is easy to capture these fish in large numbers, seemingly indicating large population size, caution is warranted, and it is better overall to use the lower estimates. The reviewer therefore suggested strengthening the discussion of these sources of uncertainty in estimates and the effect of this uncertainty on habitat requirement estimates.

The reviewer noted that she had attempted to replicate the modelling described in the study and had some success with the first model (geometric population model). She expressed the opinion, however, that it really contributes little to this paper. These models do not deal with the most difficult and important questions surrounding the effects of various types of habitat disturbance, including the probability of introductions, which is reasonably high. An attempt should be made to inject probability of environmental stochasticity into the model. The author expressed the view that it is not easy nor necessary to employ a model to cover these types of concerns; they can be dealt with more easily in the text. The reviewer mentioned that there are researchers currently working on probability of invasions and it would be a useful addition to this model, since the high probability of an invasion could have a catastrophic effect on a species pair, as already observed elsewhere.

More difficulty was experienced in replicating the age structured Population Viability Analysis (PVA) model. Additional details in the paper on how this model was constructed would help others who wished to replicate the analysis and verify its findings, or apply the technique to other similar situations. The assumption evidently underlying the age structured model – that all survival and fecundity rates are the same for older age classes – implies that it would be feasible to combine all these and simplify the model.

Table 10 in the working paper contrasts three different methods for determining the amount of habitat required to achieve a range of recovery targets. One method assesses "quasi-extinction targets (QET) but because they take the species closer to the brink, they turn out to be much less conservative for habitat requirements. Obviously it is unwise to even consider a strategy that would bring the species to a level right above extinction – a very low extinction probability threshold is needed. The reviewer stated that it would be best to exclude both QET columns from the table for this reason.

Another participant argued for retaining these estimates in the first two columns in order that they could be used to emphasise the more realistic critical habitat targets found by the other two methods used. It would be useful to emphasise that it is precarious and risky to model habitat requirements at such levels.

Given the uncertainties that underlie all of these methods of estimating critical habitat, and the fact that the most realistic of the estimates calls for protection of 80% of the total habitat, but cannot specify which 80% should be protected, the reviewer agreed that it is reasonable to recommend, as the author has done, that there is a high probability of hybridization and loss of a species pair if less than 100% of the habitat is protected.

On a matter of clarification, the reviewer noted that it was not clear from the text if the two inflow and outflow stream populations in the Misty Lake system were actually one species – a map of Misty Lake would be helpful in visualising the relationship between the two parapatric species and their habitat utilisation.

It was also thought that it would be useful to elaborate on mechanisms through which the proposed riparian buffer strips could be managed to protect the lake and stream habitat given that a riparian buffer is included in the description of habitat in the working paper.

The second reviewer also noted that the working paper was well researched and executed. She also found it easy to follow and to review. It represents a comprehensive review of the existing knowledge on the subject. One particularly strong point was exploring several different approaches to estimating population size in the absence of direct population studies on all lakes.

The reviewer found no major concerns on the execution or contents, but had quite a few suggestions on issues arising from the presentation in the text. Three areas that might merit specific attention were mentioned: First, a schedule of further studies is mentioned but is absent from the text; this would be a valuable addition. Although a number of suggestions for further study are mentioned in the text, they are not summarised or enumerated in the conclusions. It would be good to consolidate these suggestions in one place. A number of other ideas for further research came up in reading the report. For example, the text suggests an attempt should be made to keep macrophytes within the temporal range that they have normally occupied, but the report goes on to state that it is not known what that temporal range is. Natural fluctuations in submerged and emergent vegetation ranges need to be known. Also the accuracy of the population abundance studies is critical. Both of these are areas where future study would be useful.

Second, there are some issues surrounding the concern over species pair collapse. This is not only related to population numbers for sympatric species pairs, though for parapatric species that may be the major controlling variable. For sympatric species pairs, a matter of equal concern is the risk of hybridization and factors that may lead to this. The hard lessons learned from the Enos Lake experience must be used to improve on what is done to prevent a repetition elsewhere. In this regard, the reviewer’s detailed comments allude to three points in Section 4 and 5 of the working paper that could be given more detail to build on the role of habitat in controlling the level of hybridization. One example cited related to the question of increased risk of hybridization due to the tendency of the species pair to use similar juvenile rearing habitat, as discussed on page 4 and 5 of the working paper. The likelihood of this scenario playing out can be inferred from what is known from the Enos Lake experience. Intuitively, the reduction in macrophytes should lead to a disappearance of benthic juveniles at the expense of hybrids and limnetics, but in fact the reverse was seen. This suggests that juvenile rearing habitat use is perhaps a less important issue than intuitively expected. The reviewer noted that this subject requires further discussion in the text.

The third and final major point raised by the reviewer had to do with the data used to estimate population abundance in Section 6. There were four data sources drawn upon in deriving these estimates: mark-recapture studies, effective population size based upon genetic studies, extrapolation from bathymetry and known carrying capacity, and the areal coverage of macrophytes. Several sources of error are inherent in each methodology and some of these are mentioned in the text, but some are overlooked or not fully explored. The Paxton Lake mark-recapture study was the starting point for so many extrapolations to other lake systems that it is very important to ensure that the level of confidence that can be placed in the results is clearly understood. Although the main sources of error are mentioned, these need to be emphasised more. Although sampling took place in four summer months, in reality the sample recapture results were only satisfactory to allow using the results from a single month. This greatly weakens the value and the credibility of the results. There is also the question of the accuracy of the physical features data. In addition, for the limnetic species, the time of year may have been a contributing factor in catchability by the methods used. Die off of males at that time of year is typical. The phenomenon of captured fish becoming “trap shy” and therefore not showing up in the subsequent recapture could lead to an overestimate of the population size. Factors like these that violate the assumptions underlying the population model need to be fully explained if they cannot be corrected. The reviewer suggested a study to improve mark-recapture design for these species would be a useful contribution of the schedule of future studies. Perhaps the simplest solution in the short term would be to carry out multiple mark - recapture studies across the season. Another participant suggested that employing two techniques for capture and recapture (e.g. traps and seines) could eliminate the “trap shy” phenomenon as a source of bias.

The reviewer went on to suggest that a comparison of the confidence intervals (CI) associated with the genetic-based estimate of population abundance used for Misty Lake, and the mark recapture studies used for the benthic/limnetic species pairs, would be beneficial in the text. The CIs for both methods are very similar and, though both methods have limitations, comparing the two would increase the confidence of the reader in the validity of these results.

On the subject of the value of mark - recapture studies as a direct or indirect tool of population estimation, it was noted that there was a significant lack of data available by which to derive an estimate of the populations in the Misty Lake system. There is no mark - recapture data from this lake and a limited study in the inlet/outlet streams. But as was done for Paxton Lake and the other lakes containing sympatric species, it would be possible to borrow information from a similar lake in which a mark - recapture study had taken place (e.g. Drizzle Lake). Drizzle Lake is a bigger lake, but in other ways the two are similar enough to make comparisons and estimates for Misty Lake valid. There is considerable discordance between population estimates based on genetic and mark - recapture techniques in Misty Lake that was not seen in Paxton Lake. This needs to be recognised in the text in order to emphasise the need to improve current estimates. The reviewer suggested that this could be a useful addition to the schedule of future studies. The best available data is simply not good enough for a genetic population estimation in Misty Lake.

One technical issue that could have significant bearing on the population estimates based on bathymetry in Paxton Lake is overlooked. It is noted in the literature that there was a significant drawdown in Paxton Lake in 1970 at the same time that the provincial bathymetry information was recorded. This leads to the apparent discord between that data and the information provided by the TRIM system and would have direct bearing on the population and habitat area estimates, depending upon which source of information was used. It isn’t clear in the text which data source was used for Table 3 in the working paper and this should be clarified. The author explained that most of the data used, with the exception of that shown in italics, is hard data and not extrapolated.

Section 6.2 of the working paper dealt with current available habitat. The reviewer confirmed that macrophyte distribution in Paxton Lake is around 80% and in Priest Lake it is just over half of the area. She emphasised that this is important and supports the need for protection of the whole lake due to the extensive nature of this habitat and its importance for benthic species. But she also added that macrophyte beds are not the only habitat that needs to be quantified and protected. Rocky shorelines are also extensively used by these species. Benthic and limnetic species have different preferences of habitat for nesting (macrophytes versus open areas) but do also share habitat to some extent. Several species of macrophytes are supporting habitat, but not much research has been done on this. For example, there is no data on the relative importance of one macrophyte species versus another. Anecdotally the author noted an apparent preference for macrophyte species that do not reach the surface, so that the sticklebacks can hover over the plants for feeding and quickly dart into them for cover from predation.

The reviewer's final comment was that Paxton Lake has been used for research for a few decades now. It is a relatively untouched system and should be treated as a special resource for meeting the scientific needs pertaining to protection of sympatric species.

The remaining comments in the review are mostly seeking clarification on the text. In regard to the conclusions in Section 8, the reviewer agrees with the arguments for designating entire lakes as critical habitat based on biological considerations, for example, on the Enos Lake experience and the need to avoid hybridization in order to avert collapse of species pairs. This demands that a more precautionary approach be adopted. Misty Lake is different in regard to this concern, as there is little risk of hybridization due to strong habitat separation between the parapatric species pair. It should be stressed that further research is needed to improve the knowledge of how to conserve species pairs and improve the estimates of population size.

One participant commented that the working paper draws the important distinction between the scientific step in identifying critical habitat and the subsequent legal step, which takes other factors into account. It describes the properties of habitat that are important, but with a bit too much emphasis on quantity over quality. He further commented that the implicit trade-offs with economic consequences, whereby protecting a whole lake perhaps is no more costly than protecting a part of it, is not a science-based determination and such judgments should be reserved for later recovery action planning processes. The question was posed, what would be the consequences, in terms of setting critical habitat, of discovering that the population was in fact much larger than the models predicted? What would have to take place for critical habitat to be declared as less than the whole lake? The participant noted that the new DFO protocol for quantifying habitat use and quality dictates developing curves of habitat availability versus population and thus viability. This was not done in this case. Another participant argued that there is not sufficient hard data to generate a curve such as this and hence the more precautionary approach was adopted. Habitat disturbance on any part of the lake could result in increased risk of hybridization anywhere in the lake. The spatial scale is so small and utilization is so high that developing curves like that would not work. The participant rebutted that one should still be prepared to answer these questions so that, in cases in which the scale is much larger, the results from these studies could be extrapolated and contrasted.

Another participant remarked that it is not known what the impact of logging has been historically on these systems, but it is possible to say that the species pair populations have survived whatever the impacts were. This is a mark of their resilience even in the absence of protection of the whole lake habitat.

Another point made was that SARA instructs on the use of precaution in absence of full scientific knowledge, and this would be the case where the effect of past forest harvesting is not known. It cannot be assumed that if the species pair survived one such forestry incident that they would survive another. Concern was also expressed that almost nothing is known about cumulative impacts – when logging was occurring it may have not been compounded by other human impacting activities that exist presently. The author commented that the fact the species pairs survived through earlier logging might, indeed, simply have been fortuitous.

The view was expressed that it is not clear from the paper what happens when less than the whole lake is protected. The commentator expressed concern that the conclusion of the paper in this regard is not scientifically defensible; referring to Table 10 that summarizes an assessment that reports a need to protect <100% of the habitat. One participant stated that a credible argument for protecting the whole lake is based on the knowledge derived from recent experience (e.g. Enos Lake) in that anything that leads to more hybridization will affect the whole lake and the viability of the species pair.

The question was still posed again whether the leap from protection 80% versus 100%, was scientifically defensible. The author wondered on the other hand what scientific logic lies behind the need to pose the question what if the lakes were bigger (scaling up from the current results), since that is not the case in any of the examples where these species pairs are known to exist. The second reviewer commented that the question of what would happen if the lake was bigger may not be the right question to be asking; a more important consideration would be, what if there was more than one population of each species? That could make a considerable difference in robustness and resistance to extinction or species pair collapse due to hybridization. But that too is a hypothetical example that does not exist for any of these lakes or species pairs. The question also would change if the issue dealt with a single population of a non-pair species that was present in large numbers in one lake only. The whole issue would be different in such a case.

The participant who had initially raised the concern over the ability to provide scientifically defensible support for defining whole lakes as critical habitat wished to have recorded the reasoning behind this objection to the working paper as written. In his opinion and forgetting entirely for the moment the difference between the legal and scientific definitions of the term “critical habitat”, that term, as generally used in science, is very precise. In purely scientific terms the critical habitat of a species, or in this instance a species pair, must be more narrowly defined as the habitat which is critical to its survival. In this case, that may well be the portion of the lake where one species in the pair is able to spawn without risk of encountering and potentially hybridizing with the other species. As such, this would be a much smaller proportion of the lake than even the estimates in Table 10 would indicate, let alone the unsupported extrapolation of those numbers to 100% of the lake area plus buffer strips. There may be room in the conclusions of the study to offer well supported scientific advice for increasing the area in need of protection to a larger area, possibly even to the entire lake and buffer strips, but the definition of “critical habitat” in the strict scientific meaning of that term should be reserved for discussions of the area that truly is “critical” and not simply “important” for the purpose of observing an extra measure of precaution.

In contrast to these stated concerns, the second reviewer stressed the need to extend the modelling to build in a probabilistic assessment of factors in the environment that could add to the risk of hybridization and hence the break-down of the genetic separation that maintained these species pairs as distinct. There are in fact methods for factoring in such probabilities (e.g. in particular the probability of introduction of species that would disturb the precarious ecological balance in these simple ecosystems). If, as the previous participant had suggested, the scientific arguments for critical habitat are lessened when considering simply the strict definition of that term in its normal scientific context, factoring in these additional probabilities of disturbance that have bearing on species survival would increase the arguments for placing larger bounds on critical habitat for sympatric species pairs at least.

Finally, a participant cautioned that some further defensible arguments are needed for the inclusion of the riparian buffer strips around the lakes and streams in question. While the arguments for provision of buffer strips in general are obvious and perhaps need little in the way of further clarification in the text, a more thorough review of scientific literature is need to support the recommended size of these protective buffer strips particularly around lakes.

Conclusions and Advice

- The paper was accepted with revisions to include more clarity on a number of issues raised by the reviewers and participants. The author agreed to address recommendations and advice from the review in revisions to the working paper.

- The text needs to provide greater clarity on the definition of the term "critical habitat" as used in the paper. The language in the draft working paper in the Preamble should exclude reference to the interpretation of the legal definition of critical habitat, given that this is a scientific exercise.

- Revisions should strengthen the discussion of the importance of the riparian buffer strip and cite other studies that identify the need to include specific buffer widths for lake environments.

- Revisions should attempt to apply the decision tree in the DFO protocol guidelines for the choice of analytical methods in the assessment of habitat use and habitat quality (DFO 2007).

- Revisions should include a new table (Table 10 in the working paper) showing the proportion of current benthic habitat deemed critical under different assumptions. Revisions to the table should exclude the first 2 columns that show habitat requirements to meet "quasi-extinction" values using 500 mature benthic sticklebacks. Revisions to the table should also list the confidence intervals. That would indicate the uncertainty in the estimates and the degree that the effective population size N_e includes 100% of the available habitat.

- The point estimates of the proportion of the available habitat deemed critical is about 80% for sympatric pair species (working paper Table 10). Participants concluded that the best advice for ensuring sustainability of sympatric pairs is to extend protection to 100% of the habitat. Adding confidence intervals to a new Table 10 is likely to strengthen the basis for this advice.

APPENDIX 1 Meeting Agenda

AGENDA
PSARC RECOVERY POTENTIAL ASSESSMENT MEETING
October 22-24, 2008
Pacific Biological Station
Nanaimo, BC

Wednesday, October 22

9:00	Introductions and Opening Remarks.
9:30-12:00	RPA for Bocaccio Rockfish
12:00-1:00	Lunch
1:00-4:00	RPA for Bocaccio Rockfish

Thursday, October 23

9:00-12:00	RPA for Basking Shark
12:00-1:00	Lunch
1:00-4:00	RPA for Basking Shark

Friday, October 24

9:00-12:00	Potential Critical Habitat for Sympatric and Parapatric Stickleback pair populations
12:00-1:00	Lunch
1:00-4:00	Potential Critical Habitat for Sympatric and Parapatric Stickleback pair populations

APPENDIX 2: Meeting Participants

Name	Email	Attendance		
		22/10/2008	23/10/2008	24/10/2008
Acheson, Schon	schon.acheson@dfo-mpo.gc.ca	Y	Y	
Ackerman, Barry	barry.ackerman@dfo-mpo.gc.ca	Y		
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APPENDIX 3: Working Paper Summaries

Stock assessment for bocaccio (Sebastes paucispinis) in British Columbia waters
R. D. Stanley, M. McAllister, P. Starr and N. Olsen

This document provides a stock assessment for bocaccio in BC waters. Results of the work are intended to serve as advice over the short term to managers and stakeholders on stock status, and likely impacts of different fixed harvest options. As such, it also provides the scientific advice required to develop a Recovery Strategy should this be deemed necessary for this population.

Due to the absence of time series of age-structured data and information on fishery vulnerability at size or age for any of the fisheries capturing BC bocaccio, a surplus production stock assessment methodology, which does not require age information, was applied. The Bayesian Schaefer surplus production model (BSP) was fitted to one fishery dependent and six fishery independent stock biomass trend indices. The model was started in 1935 when it was assumed to be at an unfished equilibrium to the present using a time series of historical catches, some of which were imputed from limited data. . The bycatch of bocaccio in the salmon troll and halibut longline fisheries was estimated from the effort time series for these fisheries from 1935 and independent estimates of catch in some years. Informative Bayesian priors were used when estimating the survey proportionality constants, based in part on interviews with experienced fishermen. . The reference run estimates of current stock size are in the order of 3000-5000 tons, with the stock estimated to lie between 10-15% of unfished stock size. The impacts on current stock status of alternative model assumptions to those made in the reference case were explored over an additional 31 runs. Long term biomass projections were made for the reference case and a selection of the sensitivity runs over 5, 20 and 40 year scenarios under varying fixed harvest assumptions to predict stock abundance relative to the DFO draft policy target references points of 0.4*B_{MSY} and 0.8* B_{MSY}. These projections are shown as harvest tables for the reference set of assumptions as well as two additional scenarios which assume either a lower or higher estimate of productivity (*r*). While the Bayesian approach used in this assessment provides a formal mechanism to include uncertainty in model output (including predictions), managers and stakeholders are advised that not all sources of uncertainty have been addressed and that it is likely that the true uncertainty is even greater than that presented here.

Assessment of information used to develop a Recovery Potential Assessment for basking shark Cetorhinus maximus (Pacific population) in Canada
Gordon (Sandy) McFarlane, Jacquelynne King, Karen Leask and Line Bang Christensen

Basking sharks (Canadian Pacific population) are now suggested for listing as Endangered under the Species at Risk Act. We assessed recovery potential for basking sharks in Canadian Pacific waters by considering current status, potential sources of human-induced mortality, and various strategies to mitigate harm and promote recovery. We used a simulation model to evaluate scenarios that span the range of plausible human activities that cause mortality. Basking sharks in Canadian Pacific waters are considered to be part of a North American Pacific coast population which migrates into Canadian waters in spring and summer and winters off California. We therefore assess scenarios for the whole Pacific coast.

Best estimates of current abundance range from 426 to 659 individuals. It is estimated that the decline from pre-exploited numbers exceeds 90%. It is believed that the bycatch of basking sharks in commercial fisheries limits current abundance. Other threats to the population (collisions with marine traffic, coastal development, ecotourism, etc) were identified, and mitigation proposals examined.

Specified recovery objectives that could be assessed through simulation modelling include a) rebuild to 1000 breeding pairs; b) attain 30, 40, 50, and 99% of carrying capacity (assumed equal to pre-exploitation numbers), and c) attain 30, 40, 50,and 99% of initial biomass (assumed to be biomass prior to exploitation). Recovery potential was estimated as the number of years required to attain the recovery objectives under four levels of human-induced mortality and evaluated using two plausible catch histories.

Production model projections suggest that if a breeding population currently exists in the northeast Pacific Ocean, and no further human-induced mortality and changes to existing habitat occurs, that approximately 400 years are needed before population numbers will return to their unexploited states (Appendix C). If these animals are afforded complete protection, it will still take hundreds of years for the population to recover to 1000 breeding pairs. Recovery to 30% of the original biomass could happen within 85 – 90 years, if complete protection is afforded. The fishing mortality that the population can sustain without suffering further decline from the 2007 population ranges from 6 to 10 individuals annually coast wide .

Basking shark is a long lived species with a low rate of increase (i.e., Generation time of 22-33 years). The uncertainties in the projections of this report increases with time. To make progress in rehabilitating the basking shark population, will require government agencies to promote research and management activities for decades

Working paper summary: Identification of critical habitat for sympatric stickleback species pairs and the Misty Lake parapatric stickleback species pair
Todd Hatfield

In this paper recommendations are provided for defining critical habitat for stickleback species pairs in British Columbia. Recommendations are made for the proportion of existing habitat that can be considered critical, but no effort has yet gone into delineating specific areas in the wild. Critical habitat recommendations were developed using the framework suggested in Rosenfeld and Hatfield (2006). Population targets are explored and supported using multiple approaches, including simple population viability analyses, rules of thumb, and genetic considerations. Simple population viability analyses indicate that stickleback are resilient to environmental stochasticity even when populations are at low abundance. Two quasi-extinction thresholds, based on environmental and genetic considerations were applied. Population models could be improved considerably with additional information on stickleback vital rates, but population-specific data are unlikely to be available soon. Habitat required to meet proposed population targets varied from 5% to 100% of existing habitat depending on the modeling approach. Most defensible approaches indicate that a considerable portion of existing habitat is critical. Practical and logistic considerations suggest that in each case the entire lake plus a riparian buffer should be considered when designating critical habitat.

Recommended critical habitat for benthic-limnetic pairs includes the entire lake for each pair and a riparian buffer of 15 to 30 m width surrounding the wetted perimeter of each species pair lake and all ephemeral and perennial streams flowing into the lakes.

Recommended critical habitat for the Misty Lake pair includes the entire lake, the wetted area of the entire inlet stream, and the wetted area of the outlet stream as far downstream as the lower limit of currently occupied habitat (presently estimated at 2.3 km downstream of the lake). Also included as critical for the Misty Pair is a riparian buffer of 15 to 30 m width on the lake and both inlet and outlet streams, plus any perennial or ephemeral tributaries.

APPENDIX 4: Terms of Reference

Regional Advisory Meeting

Pacific Scientific Advice Review Committee (PSARC)
22-24, October 2008
Nanaimo, BC

Chairperson: Al Cass

Background

A peer review of scientific information in support of a Recovery Potential Analysis (RPA) is planned for bocaccio rockfish and basking shark. Bocaccio rockfish were designated as threatened by the *Committee on the Status of Endangered Wildlife in Canada* (COSEWIC) in November 2002. Basking shark were designated as endangered by COSEWIC in April 2007. In addition, a review of potential critical habitat for sympatric (benthic – limnetic) and parapatric (stream – lake) stickleback pairs will also be conducted as part of DFO's mandate to review the biological basis for identifying critical habitat in recovery plans. Several stickleback pair populations are designated as endangered by COSEWIC in BC. A PSARC review of information in support of a Misty Lake stickleback pair RPA was conducted in April 2008. The review of potential critical habitat will be used to complete the RPA.

The purposes of the *Species at Risk Act* (SARA) are to protect wild species at risk and their habitats in Canada, and to promote their recovery. SARA prohibits killing, harming, harassing capturing or taking individuals of a species listed under the Act as threatened, endangered or extirpated. The SARA also prohibits damaging or destroying their residence or any part of their critical habitat. Furthermore, the SARA provides for the preparation of a recovery strategy for species listed as threatened, endangered or extirpated. The provisions of these recovery strategies must ensure that any possible threat to a given species and its habitat does not jeopardize its survival and recovery.

Section 73 (2) of the SARA provides the competent minister with the authority to permit normally prohibited activities affecting a listed species, its critical habitat, or its residence, even though they are not part of a previously approved recovery plan. Such activities can only be approved if: 1) there are scientific research relating to the conservation of the species and conducted by qualified persons; 2) they will benefit the species and are required to enhance its chance of survival in the wild; or, 3) affecting the species is incidental to the carrying out of these activities.

The decision to permit allowable harm and the development of a recovery strategy must take into consideration the species' current situation and its recovery potential. The recovery potential considers the impacts of human activities on the species and on its ability to recover, as well as the alternatives and measures to reduce these impacts to a level which will not jeopardize the survival and recovery of the species.

Therefore, a species RPA process was developed by DFO Science to provide the information and scientific advice required to meet the various requirements of the SARA, such as the authorization to carry out activities that would otherwise violate the SARA as well as the development of recovery strategies. In the case of a species that has not yet been added to Appendix 1 of the SARA, the scientific information also serves as advice to the DFO Minister regarding the listing of the species under SARA. Consequently, the information is used when analyzing the socio-economic impacts of listing the species and during subsequent consultations.

Objectives

The objectives are to assess the scientific information in support of a Recovery Potential Assessment (RPA) for bocaccio rockfish and basking shark. In addition, a review of potential critical habitat for sympatric (benthic – limnetic) and parapatric (Misty Lake stream – lake) stickleback pair populations will also be conducted. Working papers will be prepared prior to the meeting and distributed to meeting participants. Formal reviews will be presented at the meeting. Based on the reviews and discussion by meeting participants, conclusions/advice will be formulated in support of public consultation, SARA listing decision making and recovery planning. The 17 steps in the RPA framework will be used as guidelines for the peer review of bocaccio rockfish and basking shark. The DFO framework for quantifying habitat quality will be used to guide the peer-review of the stickleback working paper. These frameworks are posted on the CSAS website:
http://www.dfo-mpo.gc.ca/csas/Csas/status/2007/SAR-AS2007_039_e.pdf
http://www.dfo-mpo.gc.ca/csas/Csas/status/2007/SAR-AS2007_038_E.pdf.

Products

The meeting will generate a proceedings report summarizing the deliberations of the participants. This will be published in the Canadian Science Advisory Secretariat (CSAS) Proceedings Series. There will be CSAS Research Documents produced in relation to the working paper(s) presented. Three CSAS Science Advisory Reports will also be completed.

Participants

Participants (approx. 25) will include internal DFO representatives and invites from the Province, academia, First Nations, NGO's and industry.