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Proceedings of the Pacific regional peer review on Stock assessment for Pacific Ocean Perch in Areas 3CD and 5DE (British Columbia); and A Simultaneous Stock Assessment of Five Rockfishes in British Columbia Waters: Splitnose, Greenstriped, Redstripe, Harlequin and Sharpchin Rockfish

November 6-9, 2012
Nanaimo, BC

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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may 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.

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TABLE OF CONTENTS

SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada, Canadian Science Advisory Secretariat (CSAS) Regional Advisory Process meeting, held from November 6-9, 2012 at the Pacific Biological Station in Nanaimo, British Columbia. Presented for peer review were two working papers focusing on stock assessments for Pacific Ocean Perch (*Sebastes alutus*) in management areas 3CD and 5DE, and one working paper presenting a simultaneous assessment of five data-limited rockfish (*Sebastes sp.*) species.

In-person and web-based participation included Fisheries and Oceans Canada staff from the Science Sector and Fisheries and Aquatic Management Sector, plus external participants from the commercial and recreational fishing sectors, provincial government, academia and the United States National Oceanographic and Atmospheric Administration. The meeting was originally planned for four days, but the reviews were completed in three days.

Two stock assessments were reviewed for Pacific Ocean Perch (POP), a commercially important species of rockfish in British Columbia. The status of POP and harvest advice were provided for the stocks within Pacific Marine Fisheries Commission (PMFC) major areas 3C and 3D (3CD) off the west coast of Vancouver Island, and major areas 5D and 5E (5DE) off the north and west coasts of Haida Gwaii. The two working papers were accepted subject to revision.

The working paper concerning the simultaneous assessment of five data-limited rockfish species was then reviewed. The modelling approach taken was unable to produce reliable results that could be used to provide advice for the five stocks. For example, estimates of maximum sustainable yield varied greatly between sensitivity cases. It was agreed that further model fitting would be unlikely to resolve the uncertainties (given the available data). Consequently it was recommended that the working paper should be revised and published as a Research Document to record the approach taken. A Science Advisory Report would not be written, given that advice to managers could not be provided based on the assessment.

The conclusions and advice resulting from this review will be provided in the form of one Science Advisory Report (for the two POP assessments combined). The advice requested by the Groundfish Management Unit, Fisheries Management Branch is used to inform the selection of harvest levels for fishery planning.

The Science Advisory Report and three Research Documents will be made publicly available on the Canadian Science Advosry Secretariat (CSAS) Science Advisory Schedule.

Compte rendu de l'examen par les pairs de la région du Pacifique sur l' Évaluation des stocks de sébaste à longue mâchoire dans les zones 3CD et 5DE (Colombie-Britannique); et Évaluation simultanée des stocks de cinq sébastes des eaux de la Colombie-Britannique : bec-de-lièvre, à bandes vertes, à raie rouge, arlequin et à menton pointu

SOMMAIRE

Le présent compte rendu résume les discussions pertinentes et les principales conclusions qui ont découlé d'une réunion du processus de consultation régionale du Secrétariat canadien de consultation scientifique (SCCS) de Pêches et Océans Canada tenue du 6 au 8 novembre 2012 à la Station biologique du Pacifique à Nanaimo, en Colombie-Britannique. Deux documents de travail axés sur l'évaluation des stocks du sébaste à longue mâchoire (*Sebastes alutus*) dans les zones de gestion 3CD et 5DE et un document de travail offrant une évaluation simultanée de cinq espèces de sébastes (*Sebastes spp.*) pour lesquelles les données sont limitées ont été présentés aux fins d'examen par les pairs.

Au nombre des participants qui ont assisté à la réunion en personne ou par conférence Web, on comptait des représentants des secteurs des Sciences et de la Gestion des pêches et de l'aquaculture de Pêches et Océans Canada ainsi que des secteurs de la pêche commerciale et récréative, du gouvernement de la province, des universités et de la National Oceanographic and Atmospheric Administration des États-Unis. La réunion devait au départ durer quatre jours, mais les examens ont été réalisés en trois jours.

Deux évaluations des stocks ont été passées en revue pour le sébaste à longue mâchoire, une espèce de sébaste importante sur le plan commercial pour la Colombie-Britannique. Le statut du sébaste à longue mâchoire et des avis sur la pêche pour les stocks des zones principales 3C et 3D (3CD), au large de la côte ouest de l'île de Vancouver, ainsi que des zones principales 5D et 5E (5DE), au large des côtes nord et ouest d'Haida Gwaii, de la Commission des pêches maritimes du Pacifique (CPMP). Les deux documents de travail ont été adoptés sous réserve de modification.

Le document de travail portant sur l'évaluation simultanée de cinq espèces de sébaste pour lesquelles les données sont limitées a ensuite été examiné. L'approche de modélisation adoptée n'a pas permis de produire des résultats fiables pouvant être utilisés pour formuler des conseils au sujet des cinq stocks. Par exemple, les estimations de la production maximale soutenable variaient grandement entre les analyses de sensibilité. Il a été convenu qu'il était peu probable que d'autres ajustements du modèle résolvent les incertitudes (en raison des données disponibles). Par conséquent, il a été recommandé que le document de travail soit révisé et publié en tant que document de recherche afin de consigner l'approche adoptée. Un avis scientifique ne sera pas rédigé, puisque les conseils destinés aux gestionnaires n'ont pas pu être offerts en fonction de l'évaluation.

Les conclusions et avis découlant de cet examen seront présentés sous la forme d'un avis scientifique (pour les deux évaluations sur le sébaste à longue mâchoire combinées). L'avis demandé par l'Unité de gestion des poissons de fond, Direction de la gestion des pêches servira à déterminer les niveaux de prises de façon éclairée pour la planification des pêches.

L'avis scientifique et trois documents de recherche à l'appui seront rendus publics dans le calendrier des avis scientifiques du SCCS.

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INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS), Regional Advisory Process (RAP) meeting was held from November 6-8, 2012 at the Pacific Biological Station in Nanaimo, British Columbia, to review three working papers and to formulate advice to groundfish managers. Working paper topics included stock assessments for two stocks of Pacific Ocean Perch (*Sebastes alutus*) and a simultaneous stock assessment for five data-limited rockfishes (*Sebastes* sp.).

The Terms of Reference (TOR) for the science review (Appendix A) were developed in response to requests for advice from the DFO Groundfish Management Unit, Pacific Region. Notifications of the science review and conditions for participation were sent to representatives with relevant expertise from First Nations, commercial and recreational fishing sectors, environmental non-governmental organizations, academia, and provincial and United States government.

The following working papers (WPs) were prepared and made available to meeting participants prior to the meeting:

1. "Pacific Ocean Perch (*Sebastes alutus*) stock assessment for the west coast of Vancouver Island, British Columbia" by A.M. Edwards, R. Haigh and P.J. Starr. (CSAP WP 2012-P02a).
2. "Pacific Ocean Perch (*Sebastes alutus*) stock assessment for the north and west coasts of Haida Gwaii, British Columbia" by A.M. Edwards, R. Haigh and P.J. Starr. (CSAP WP 2012-P02b).
3. "A Simultaneous Stock Assessment of Five Rockfishes in British Columbia Waters: Splitnose Rockfish, Greenstriped Rockfish, Redstripe Rockfish, Harlequin Rockfish, Sharpchin Rockfish" by N. Taylor and R. Stanley. (CSAP WP 2012-P54).

Duties of the Chair were shared by Rob Kronlund (WP #1, #2) and Andrew Edwards (WP #3). The Chair welcomed participants (Appendix B), reviewed the role of CSAS in the provision of peer-reviewed advice, and provided a general overview of the CSAS process. The role of participants was discussed, as was the purpose of the various RAP publications (Science Advisory Report, Proceedings and Research Document). The definition and process around achieving consensus decisions and advice was reviewed. Everyone was invited to participate fully in the discussion and to contribute knowledge to the process, with the goal of delivering scientifically defensible conclusions and advice. It was confirmed with participants that all had received copies of the TOR and working papers.

The Chair reviewed the Agenda (Appendix C) and the TOR for the meeting, highlighting the objectives pertaining to each WP. The Chair reviewed the ground rules and process for exchange, reminding participants that the meeting was a science review and not a consultation. The room was equipped with microphones to allow remote participation by web-based attendees. In total, thirty people participated in the RAP over the course of the three day meeting. Lisa Lacko (WP #1, #2) and Kate Rutherford (WP #3) acted as the rapporteurs. Abstracts of the working papers are provided in Appendix D.

Participants were informed that Pete Hulson and Jaclyn Cleary had been asked before the meeting to provide written reviews for the POP working papers to assist everyone attending the peer-review meeting. Similarly, Vladlena Gertseva and Zane Zhang provided written reviews of the five-rockfish species working paper. Participants were provided with copies of the written reviews (given in Appendix E).

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report to Fisheries and Aquaculture management to inform fishery planning for the POP stocks. A Science Advisory Report will not be produced for the five-rockfish species working paper since fishery planning advice was not possible (as discussed below). One Science Advisory Report and three supporting Research Documents will be made publicly available on the CSAS Science Advisory Schedule

REVIEW OF WORKING PAPER #1

Working Paper:	Pacific Ocean Perch (*Sebastes alutus*) stock assessment for the west coast of Vancouver Island, WP2012-P02a
Rapporteur:	L. Lacko
Presenter(s):	A.M. Edwards, P.J. Starr, R. Haigh

PRESENTATION OF WORKING PAPER

A sex-specific age-structured assessment model was fitted to observations of fishery independent population indices, fishery independent age compositions, commercial fishery catch and commercial fishery age compositions. The model was implemented using a Bayesian framework that applied the Markov Chain Monte Carlo procedure to quantify uncertainty of estimated parameters. A very similar model was used for WP #2, differing in the input data but having the same model structure and employing similar assumptions. Therefore, the discussion of issues common to both working papers is only presented here, rather than being repeated under the section titled Review of WP #2.

The Authors presented an overview of key model inputs, in particular describing details of catch reconstruction and the selection of survey observations for use as relative abundance indices. Most difficulties encountered in reconstructing historical catches for POP were related to foreign fleets recording rockfish catches as perches (Russia) or POP (Japan, during the 1960s and 1970s prior to the declaration of the 200 mile Economic Exclusion Zone) when more than one species may have been caught. In addition, foreign catch off the west coast of Vancouver Island was reported for the “Vancouver” area (PMFC 3BCD) that includes waters off northern Washington. There was no obvious way to determine the percentage catch in BC waters so the assessment used 100% of the rockfish catch reported by foreign vessels.

In addition, the foreign fleet catch was assigned to management areas that differ from those in use today, which meant that there was no objective way to apportion historical catches to the stock areas used for the assessment. For example, Japanese and Russian catches recorded as being taken from the “Vancouver” area were assumed to be taken from Canadian waters even though this area extended down into US waters off the coast of Washington.

The Authors noted that the selectivity ogive indicated that some POP were vulnerable before the age of 50% maturity, but that model estimates of trends in female spawning biomass and total vulnerable biomass (the latter includes both sexes and makes no assumptions about maturity) were similar, indicating that the maturity assumption did not greatly affect the assessment conclusions. The stock reconstruction was characterized by a decline in vulnerable biomass as a result of large catches in the late 1960s and early 1970s, along with a period of below average recruitment during the 1970s. Exploitation rates first peaked in the mid-1960s due to the harvest by foreign fleets, and then peaked again in the early 1990s. Exploitation rates have remained low since the mid-1990s, with the median exploitation rate for 2012 estimated as 0.035.

The spawning biomass (mature females only) at the beginning of 2013 was estimated to be 0.41 (0.19-0.68) of unfished spawning biomass, denoting median and 5th and 95th quantiles of the Bayesian posterior distribution. It was estimated to be 1.53 (0.55-3.32) of B_{MSY}, where B_{MSY} is the equilibrium spawning biomass that would support the maximum sustainable yield (MSY).

The primary reference points used to characterize stock status were a limit reference point of $0.4B_{MSY}$ and an upper stock reference point of $0.8B_{MSY}$. The female spawning biomass at the start of 2013 had a probability of 0.87 of being in the Healthy zone (i.e. of being $>0.8B_{MSY}$). Projections were presented of future female spawning stock abundance subject to a range of fixed annual catches over a 10-year forecast period. The projections, based on draws from the Bayes posterior distribution, were used to derive decision tables that listed the future probabilities of exceeding the limit and upper stock reference points based on a range of constant catch scenarios. Decision tables were also provided with respect to B_{MSY}, and two additional reference points based on the unfished equilibrium female spawning stock biomass, $0.2B_0$ and $0.4B_0$.

Model results were described as being relatively unaffected by (a) removal of the 1967-1970 G.B. Reed survey data, and (b) adjusting historical catches by increases of 20% (1987-1990), 40% (1991-92), and 60% (1993-95) to account for potential misreporting of those catches.

WRITTEN REVIEWS

The Committee considered reviews by Peter Hulson (Research Fish Biologist, Auke Bay Laboratories, Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA, USA) and Jaclyn Cleary (Research Biologist, Conservation Biology Section, Pacific Biological Station, DFO). Each reviewer provided comments on both the area 3CD and area 5DE stock assessments; therefore comments common to both assessments occur here and are not repeated under the discussion of WP #2. A summary of the major issues identified by each reviewer is included below, and the full reviews appear in Appendix E.

Reviewer #1

The Reviewer concluded that assessments for both stocks were very comprehensive and based upon sound and widely accepted stock assessment methods. The reviewer concluded that the assessment models fit the available data reasonably well and used the most current information available to provide advice to fishery managers. The Reviewer advised that caution should be taken to ensure that catch did not exceed maximum sustainable yield (MSY), in view of the uncertainty in reference points and stock size, and noted that the recent catches were reported to be below the MSY estimate of 1,048 t (median of the marginal Bayes posterior; t is metric tonnes) for this stock, although the total allowable catch (TAC) of 530 t had been exceeded in five years since 2003. The Reviewer noted that the estimated vulnerable biomass appeared to be increasing for area 3CD although the recent synoptic trawl survey index series did not indicate a clear increasing trend in relative biomass. Main review points focused on estimation of the maturity schedule, the requirement for a sex-specific model, length-composition data, and ageing errors. These were presented as possible avenues that may be considered for future improvements.

The Reviewer described analyses underway for Alaskan rockfish stocks that compared estimates of the maturity schedule based on macroscopic versus histological methods, noting in particular the possible confusion of classifying maturing fish as immature when using macroscopic methods. Experience for Alaskan rockfishes had indicated that the use of histological data could result in changes to the estimated age of 50% maturity by as much as 3-5 years. The reviewer suggested that consideration might be given to fitting the maturity schedule within the assessment model to incorporate uncertainty and thus giving more weight to maturity observations at younger ages. The reason for this approach was that estimates of management parameters used in Alaska, such as $F_{40\%}$, were determined to be inversely proportional to the age of 50% maturity and highly sensitive to the estimated value.

The Reviewer raised the issue of whether sex-specific differences in growth were biologically significant in the context of this stock assessment, particularly in view of ageing errors. The Reviewer suggested that a combined sex model be tried to determine if a more parsimonious model improved performance with respect to model fit, the characterization of uncertainty, and management advice. He suggested that the requirement for a sex-specific model could be tested through a simulation study that compared small differences in growth between the sexes, comparable to those estimated for POP. As an additional concern, the Reviewer noted the small sample sizes (number of fish aged) for annual ageing data for the POP stocks (average of ~172 fish for males and ~224 fish for females for the 3CD survey age compositions, an average of ~189 fish for males and ~251 fish for females for the 5DE fishery age compositions, and ~172 fish for males and ~167 fish for females for the 5DE survey age compositions). Alaskan rockfish assessments use much larger sample sizes for ages, and their analysts are of the opinion that samples sizes of 1000 to 1,500 ages per annum could be considered adequate. Even with the small sample sizes, however, the sex-specific age compositions were very similar, as were the sex-specific estimates for survey and fishery selectivity and natural mortality. The Reviewer suggested that the small sample sizes in the age composition datasets could be driving the small differences in sex-specific parameters, and wondered if these differences would persist if larger sample sizes could be attained.

The Reviewer noted that, because of the lack of early age composition data, the early recruitment estimates were effectively constant, as was the case for estimated recruitment in recent years where fish have not yet been fully selected and have been observed relatively few times. Due to concerns that the estimated stock-recruitment parameters might be misleading, the Reviewer suggested including length composition data in the model, particularly prior to 1980, to supplement recruitment estimation. This change should affect estimates of stock-recruitment parameters and thereby the estimates of key management parameters. Alternatively, the stock-recruitment parameters could be estimated using only the range of data supported by age composition observations. The Reviewer further commented that inclusion of sex-specific length composition data could possibly justify a sex-specific model, rather than a simpler combined sex assessment model.

The Reviewer pointed to a recent ageing error analyses for Sablefish (*Anoplopoma fimbria*) which showed that ignoring ageing error resulted in severe underestimates of recruitment variability and consequently compromised the robustness of assessment results. Although known-age POP are not available, the inclusions of multiple age readings using ad hoc methods worked surprisingly well for sablefish, and for the Alaskan POP, the inclusion of an ageing precision component based on percentage agreement to the model produced a 96% difference in the resulting Acceptable Biological Catch. The Reviewer advocated consideration of including at least some measure of ageing error into the assessment models for POP in area 3CD and 5DE (as well as area 5ABC when next assessed).

Reviewer #2

The Reviewer concluded that the presentation of data, methods, modelling approach and results were thorough and benefited from interactions with the Technical Working Group. This Reviewer also focused on whether there was sufficient support for a sex-specific model, citing the small sample sizes for ageing. In particular, the Reviewer asked for clarification on the overlap of survey series and the role of the iterative re-weighting algorithm in weighting the indices. The Reviewer raised two issues with respect to the provision of management advice. First, it was suggested that some advice be provided by the Authors on the required frequency of stock assessment for POP, particularly given the low estimated exploitation rate. Second, the

Reviewer suggested a table comparing B_{MSY} and B_0 based reference points be provided to assist managers in interpretation and application of these quantities. For example, the Reviewer noted that the estimate of $0.1B_0$ is approximately $0.4B_{MSY}$, and $0.2B_0$ was approximately the same as $0.8B_{MSY}$, so that the values of ($0.4B_{MSY}$, $0.8B_{MSY}$) and ($0.2B_0$, $0.4B_0$) were not equivalent.

GENERAL DISCUSSION

The Chair reviewed the requirements of the working paper identified in the TOR (Appendix A), asked that discussion be framed around the questions raised by the reviews, and opened general discussion to the Committee. General discussion was centered on the themes of:

a) estimation of the maturity schedule,
b) sex-specific modelling,
c) inclusion of length composition data,
d) ageing errors, and
e) interpretation and application of reference points.

The Authors suggested that the similarity of the biomass trajectories of the female spawning stock biomass and vulnerable biomass time series meant that problems introduced through mis-classifying maturity stage were probably not significant in this stock assessment. This conclusion was based on the observation that the vulnerable biomass, which was not based on the maturity schedule, provided similar conclusions to those made from the spawning biomass with respect to stock status. A Reviewer clarified that a 4-5 year difference in the age of 50% maturity due to the use of histological determination of maturity can have a large effect on key management parameters such as B_{MSY} and u_{MSY} and thereby management advice. The number of immature fish at 12-15 years of age (Table D.2 of the working paper) was noted, and it was suggested that these fish should be assumed to be mature. A Science participant also pointed out that there is no evidence to date in the literature of skip-spawning for POP.

In response to the suggestion that a combined-sex model be attempted, the Authors thought that essentially the same stock reconstruction and advice would result, given the similarities in the age frequency data. A Reviewer re-iterated concerns over the low sample size for age data in both the areas 3CD and 5DE assessments and commented that a sample size of 1200-1500 ages is used for a combined-sex model for POP in Alaska. The Authors pointed out that the number of trips or sets was the primary determinant of sample size in these models, rather than the number of specimens, because of the correlation among specimens caught in the same trip or set (e.g., skipper behaviour and at-sea observer effects on sample selection).

The Authors acknowledged the suggestion that length composition data could be included but suggested that experience in other modelling situations has shown that there was usually little information in the length data with respect to recruitment for slow-growing old fish, where a large proportion of the specimens were near the maximum length. The Authors noted that their investigations of ageing error for Yellowmouth Rockfish (a sensitivity test where 20% of age observations were assigned to adjacent age classes) had little effect on the outcome of the stock assessment. A Science participant commented that ageing data based on landed samples could be biased because small, unmarketable POP would be discarded at-sea, although he acknowledged that this would be more of problem with other rockfish species. An Author suggested that it might be possible to develop separate selectivity functions for observer-based and port samples and treat these components as separate fisheries in the model, or more simply just use at-sea ageing samples at the cost of losing the shore-based age data.

The relatively large estimate of the 1999 year class was noted for area 3CD; this result contrasted with results for the area 5DE assessment which was dominated by a large 1976 year class and did not show a strong 1999 year class. The Authors responded that there was evidence in the commercial age data for 2010 and 2011 for a strong 1999 year class for both the males and females. Similarly, the 2008 and 2010 WCVI surveys also showed a strong 1999 year class. A Reviewer reported that 1999 and 2000 are above-average year classes in the Gulf of Alaska and Aleutians.

An Author suggested that the issue of catch reconstruction for groundfish species be formally addressed by a specific project. A Science participant noted that work was already progressing on this issue.

An Industry participant reported to the Committee that trawl selectivity had been changing over the last 14 months as nine vessels (four bottom trawl) changed the type of trawl doors used for commercial fishing. This change has resulted in an increase in door spread (from 195-210 m to 310-400 m) and less contact with the bottom. Since the net would be fishing higher in the water column relative to the bottom, the participant suggested that the average size of POP in the commercial catch would be larger in comparison to those captured with the previous type of trawl doors commonly used.

The frequency of stock assessments for POP was discussed by the Committee. An Author recommended that the assessment(s) be updated in 5 years. The Committee agreed that about five years would be an appropriate frequency based on competing requirements for assessments for other groundfish species, the availability of two additional survey index observations, and the increasing reliance on the assumption of average recruitment towards the end of the 10-year forecast period.

The Committee discussed content that would be appropriate for the Ecosystem Considerations section of the Science Advisory Report, noting that WP #1 and WP #2 provided summaries of species caught concurrently with POP and provided an estimate of habitat area for POP. The Committee noted that a comprehensive review of species caught concurrently in various depth ranges may be worthy of consideration as a separate project outside a stock assessment focussed on a specific species. However, it was suggested that recent work on restricting the area contacted by bottom trawl gear be noted in the SAR (i.e., freezing of the trawl footprint). An Industry participant suggested there would be little shifting in fishing directed to POP due to the introduction of the fixed trawl footprint.

The Committee discussed the role of reference points based on B_{MSY} versus those based on B_0 (Table 1). The use of ($0.4B_{MSY}$, $0.8B_{MSY}$) as limit and upper stock reference points was considered by the Committee to be consistent with the DFO Fishery Decision-Making Framework Incorporating the Precautionary Approach ('DMF'; DFO 2009). This working paper, and the WP for area 5DE POP also presented reference points of $0.2B_0$ and $0.4B_0$. These choices were based on practice in New Zealand (Ministry of Fisheries 2008) where $0.2B_0$ is considered to be a *soft limit* that, when breached, triggers management actions intended to encourage stock growth to a higher biomass level, but not curtail fishing as intended by $0.4B_{MSY}$. In the case of area 3CD POP, the stock level at $0.4B_{MSY}$ is ~$0.1B_0$, which is similar to the *hard limit* of $0.1B_0$ applied in New Zealand. The use of $0.4B_0$ was presented because this value has been proposed as a proxy management target for low productivity stocks in some jurisdictions (e.g., United States, New Zealand). This reference point has a similar function to B_{MSY} in the DMF. However, the Committee agreed that the reference points ($0.2B_0$, $0.4B_0$) were not equivalent in stock depletion level to ($0.4B_{MSY}$, $0.8B_{MSY}$) and should not be substituted as equivalent reference points to demarcate the stock status zones.

Table 1. Summary of biological reference points used for POP for areas 3CD and 5DE. Quantities are classed as being a target reference point (TRP), limit reference point (LRP), upper stock reference point (USR), operational reference point (ORP), or reference removal rate (RR). Operational reference points are intended to trigger some management action, such as a reduction in removal rate. All estimated values are medians of 1,000 draws from the Bayes posterior distribution of the base case catch-at-age model fit for the corresponding stock area (see working papers for summaries of the marginal posterior distribution of each parameter). All biomass quantities in expressed as tonnes.

Quantity	Definition	Function	Area 3CD	Area 5DE
B_{MSY}	Spawning biomass at MSY	Minimum TRP	5,809	7,304
$0.4B_{MSY}$	40% of B_{MSY}	LRP	2,324	2,921
$0.8B_{MSY}$	80% of B_{MSY}	USR	4,647	5,843
u_{MSY}	Exploitation rate at MSY	Limit RR	0.091	0.109
D_{MSY}	Depletion at MSY	Minimum TRP	0.272	0.231
$0.4D_{MSY}$	Depletion at $0.4B_{MSY}$	LRP	0.109	0.092
MSY	Maximum Sustainable Yield	Catch LRP	1,048	1,488
B_0	Unfished spawning biomass	-	21,442	31,242
$0.2B_0$	20% of B_0	ORP	4,288	6,248
$0.4B_0$	40% of B_0	(Minimum) TRP	8,577	12,497
B_{2013}	Current spawning biomass	Stock growth reference point	8,745	11,286

The Committee noted that the DMF supports the use of F_{MSY} as a limit instantaneous fishing mortality rate, and concluded that the exploitation rate at maximum sustainable yield, u_{MSY}, could similarly be viewed as a limit exploitation rate. Thus, it was suggested by the Committee that the Authors include suitable figures and/or tables that summarized the probability of exceeding u_{MSY} over the same forecast period and range of catch levels used for the stock status-based reference points. The Committee also discussed the usefulness of including a stock-growth performance statistic relating future female spawning biomass in each of the 10 forecast years to that at the start of 2013. While it was suggested that such information be included, the Committee noted that this was not due to concerns that rebuilding of area 3CD POP was required. Instead this performance statistic could be routinely provided for groundfish stock assessments.

CONCLUSIONS

The Chair opened discussion on whether the working paper had met the requirements of the Terms of Reference. The TOR focused on the requirements to:

1) recommend reference points consistent with the DFO Fishery Decision-Making Framework Incorporating the Precautionary Approach (DMF, DFO 2009),
2) characterize stock status with respect to the reference points, and

3) provide harvest advice in the form of decision tables illustrating the consequences of a range of fixed annual catches.

Each requirement was reviewed and any associated Committee discussion is provided below.

Reference Points

Recommend reference points consistent with the DFO Precautionary Approach. Include the biological considerations and rationale used to make such a determination.

The Committee supported the adoption of limit and upper stock reference points of $0.4B_{MSY}$ and $0.8B_{MSY}$, respectively. The rationale for these choices is that they are provided as provisional reference points in the DMF. The Committee also noted that the exploitation rate at maximum sustainable yield, u_{MSY}, can be considered a limit exploitation rate consistent with the use of F_{MSY} as a limit instantaneous fishing mortality rate as supported by the DMF. Therefore, the Committee suggested that there is utility in the provision of decision tables that show the probability of exceeding u_{MSY} over the same 10-year time horizon and range of catches that were evaluated for the B_{MSY}-based stock status reference points.

The Committee concluded that the reference points based on unfished female spawning biomass, $0.2B_0$ and $0.4B_0$, were appropriate to include in the working paper for consideration by fishery managers. However, the Committee suggested that some context be added to the POP working papers to support their use and to point out where management decisions might differ depending on whether B_0-based or B_{MSY}-based reference points are applied.

Stock Status

Assess the current status of the Pacific Ocean Perch area 3CD stock relative to the recommended reference points.

The Committee concluded that the sex-specific catch-at-age analysis of area 3CD POP provided an acceptable characterization of stock status and reflected uncertainty adequately by adopting a Bayesian formulation. The female spawning biomass of POP at the start of 2013 in management area 3CD was estimated to be 0.41 (0.19-0.68) of the unfished biomass (denoting the median and 5th and 95th quantiles of the marginal Bayes posterior distribution), and estimated to be lying in the Healthy zone with probability $P(B_{2013}>0.8B_{MSY})=0.87$. The exploitation rate of area 3CD POP in 2012 was estimated to be $u_{2012}=0.035$ (0.018-0.077), with the median about 40% of the median of u_{MSY} (0.091). The probability of u_{2012} being less than u_{MSY} was $P(u_{2012}<u_{MSY})=0.89$. Recent average catches were about 547 t, compared to the MSY catch of 1,048 t (700-1,509 t).

Harvest Advice

Evaluate the consequences of varying constant catches on future population status, providing decision tables and figures of projected biomass.

Decision tables were provided that showed the probability of female spawning biomass, B_t, exceeding $0.4B_{MSY}$, $0.8B_{MSY}$ and B_{MSY} in each year of a ten-year projection from beginning of year 2013 to 2023 for fixed annual catch levels ranging from 0 to 2,000 t. Similarly, decision tables showed the probability of exceeding $0.2B_0$ and $0.4B_0$, respectively, over the same 10-year time horizon and range of fixed annual catches.

The Committee recommended that the stock be re-assessed in about five years to take advantage of two additional multi-species synoptic survey data points, and to update the forecasts which increasingly rely on an assumption of average recruitment toward the end of the 10-year forecast period.

Ecosystem Considerations

The working paper reported the species caught concurrently with Pacific Ocean Perch and the depth range over which commercial bottom trawl activities occurred within the assessment area. The interception of species of conservation concern (e.g., Boccacio, the Rougheye Rockfish-Blackspotted Rockfish species complex) was reported.

RECOMMENDATIONS AND ADVICE

The Committee concluded that the working paper had met the requirements of the TOR and accepted the working paper subject to revisions. The Committee recommended that decision tables provided for the base case catch-at-age model fit be used as advice to fishery managers.

The Committee requested that the Authors add decision tables corresponding to

(a) the probability of exceeding uMSY, or P(ut>uMSY), for 2013 to 2023, and

(b) the probability of future beginning of year female spawning biomass exceeding beginning of year female spawning biomass in 2013, or P(Bt>B2013), for 2013 to 2023.

The Committee noted, however, that the order of application of the decision tables depends on

(a) the precedence of objectives related to conservation, stock growth, and yield, and

(b) the current status of the stock.

For example, when the spawning biomass is estimated to be near or in excess of a target reference point, the requirement to select harvests that encourage stock growth will be reduced. In fact, when the spawning stock biomass is substantially in excess of B_{MSY} it may be difficult to achieve stock growth unless yields are substantially reduced, which would currently be unnecessary for reasons of POP stock conservation.

The Committee noted that reviews had focused on uncertainty introduced by

(a) sample sizes for ageing data and

(b) ageing errors which are not accounted for in the catch-at-age model.

The Committee recommended that consideration be given to evaluation of ageing errors for the next round of POP assessments, potentially involving the inclusion of an ageing precision matrix in the catch-at-age model similar to the practice used in Alaskan POP stock assessments.

The Committee concluded that the general knowledge of POP dynamics and the comprehensive stock assessments now completed for stocks in management areas 3CD, 5DE, and 5ABC are sufficient to support the development of an operating model, candidate management procedures and robustness testing using closed-loop feedback simulation. The Committee recommended that Management Strategy Evaluation methodology be considered for the next assessment of 3CD POP, concurrently with analyses of the other POP stocks.

The Committee recommended that, in cases where the stock assessment areas differ from the management areas, the algorithm for area apportionment be included in the working paper for review.

REVIEW OF WORKING PAPER #2

Working Paper: Pacific Ocean Perch (*Sebastes alutus*) stock assessment for the north and west coasts of Haida Gwaii, British Columbia, WP2012-P02b

Rapporteur: L. Lacko

Presenters: A.M. Edwards and P.J. Starr

PRESENTATION OF WORKING PAPER

A sex-specific age-structured assessment model was fitted to observations of fishery independent population indices, fishery independent age compositions, commercial fishery catch, and commercial fishery age compositions. The model was implemented using a Bayesian framework that applied the Markov Chain Monte Carlo procedure to quantify uncertainty of estimated parameters. This model is similar to that described for Working Paper #1, therefore review issues common to both WPs appear under Review of Working Paper #1 and are not repeated here. This section focuses in the review and conclusions specific to the area 5DE POP stock assessment.

The Authors presented an overview of key model inputs, in particular describing details of catch reconstruction and the selection of survey observations for use as relative abundance indices. Projections of future spawning stock abundance subject to a range of fixed annual catches over a 10-year forecast period were presented and used to derive decision tables that listed the probability of exceeding reference points.

Estimated exploitation rates for area 5DE POP peaked in the late-1960s due to large catches by foreign fleets, and peaked again at higher values in the mid-1980s, coincident with an overfishing experiment operating in the Langara Spit region of area 5E. The exploitation rate for 2012 was estimated to be 0.053 (0.023-0.119, denoting median and 5th and 95th quantiles of the Bayesian posterior distribution). For management area 5DE, female spawning biomass at the beginning of 2013 was estimated to be 0.37 (0.16-0.67) of the unfished spawning biomass. The female spawning stock abundance was estimated to be 1.61 (0.57-3.57) of B_{MSY}. In contrast to the 3CD stock of POP, an exceptionally strong recruitment of age-1 fish in 1977 was estimated for the stock in area 5DE.

The Authors noted that the definition of area 5DE does not exactly match the management units currently defined for assigning total allowable catches (TACs), and some apportionment of the selected TAC will be required.

The primary reference points used to characterize stock status were a limit reference point of $0.4B_{MSY}$ and an upper stock reference point of $0.8B_{MSY}$. The female spawning biomass at the beginning of 2013 has a probability of 0.88 of being in the Healthy zone for the area 5DE stock. Projections of future female spawning stock abundance subject to a range of fixed annual catches over a 10-year forecast period were presented by the Authors. The forecasts, based on 1,000 draws from the Bayes posterior distribution, were used to derive decision tables that listed the future probability of exceeding the limit and upper stock reference points. Decision tables were also provided with respect to B_{MSY}, and two reference points based on the unfished equilibrium female spawning stock biomass, $0.2B_0$ and $0.4B_0$.

Sensitivity analyses were reported that

(a) excluded the 1997 F/V Ocean Selector survey from the WCHG synoptic survey series, and

(b) adjusting historical catches through selective decreases to adjust for vessels reporting catch from a quota area to the unrestricted experimental area: 1984 (−19%), 1985 (−18%), 1986 (−27%), 1987 (−10%), 1988 (−11%), and 1989 (−15%).

The result of the first sensitivity test indicated a less productive stock with lower values for unfished recruitment, R_0, B_0, MSY, and B_{MSY}, but still with a high probability (0.73) of female spawning stock biomass being in the Healthy zone. The second sensitivity test resulted in an assessment almost identical to the base case.

PRESENTATION AND DISCUSSION OF WRITTEN REVIEWS

Most of the issues noted by the Reviewers for WP #1 are applicable to WP #2 and are not repeated here. With respect to the area 5DE stock assessment, one Reviewer noted that the estimated vulnerable biomass appeared to be slightly decreasing for area 5DE, largely due to a low observation for 2010 in the survey relative biomass index from the synoptic trawl survey. However, the Reviewer warned that:

(a) the decrease in the assessment model estimates of vulnerable biomass is not as large as the decrease observed in the survey biomass index, and

(b) that the projections of spawning biomass for area 5DE resulted in an increasing trend with a constant annual catch of 1,000 t.

The latter result seemed contrary to the recent decreasing trends in both the model estimated vulnerable biomass and the survey biomass index that were observed when catches were, on average, smaller than 1,000 t. He suggested this result may indicate potential problems with the spawner-recruit relationship.

GENERAL DISCUSSION

Significant issues of discussion applicable to the area 5DE stock assessment considered by the Committee are addressed under the discussion for area 3CD stock assessment (WP #1). With respect to the suggestion by a Reviewer that there may be potential problems with the spawner-recruit relationship, an Author noted that the projections reflected the reconstructed recruitments which were based on recent age composition data. The drop in survey biomass recorded for 2010 was proportionately large for such a long-lived population and could have been the result of process error. The Author also noted that a constant catch of 1,000 t/year would be about two thirds of the MSY of nearly 1,500 t.

CONCLUSIONS

The Chair opened discussion on whether the working paper had met the requirements of the Terms of Reference. The TOR focused on the requirement to:

1) recommend reference points consistent with the DFO Fishery Decision-Making Framework Incorporating the Precautionary Approach (DMF),

2) characterize stock status with respect to the reference points, and

3) provide harvest advice in the form of decision tables illustrating the consequences of a range of fixed annual catches. Each requirement was reviewed and any associated Committee discussion is provided below.

Reference Points

Recommend reference points consistent with the DFO Precautionary Approach. Include the biological considerations and rationale used to make such a determination.

The Committee supported the adoption of limit and upper stock reference points of $0.4B_{MSY}$ and $0.8B_{MSY}$, respectively. The rationale for these choices is that they are provisional reference points in the DMF. The Committee also noted that the exploitation rate at maximum sustainable yield, u_{MSY}, can be considered a limit exploitation rate consistent with the use of F_{MSY} as a limit instantaneous fishing mortality rate supported by the DMF. Therefore, the Committee suggested that there is utility in the provision of decision tables that show the probability of exceeding u_{MSY} over the same 10-year time horizon and range of catches that were evaluated for the B_{MSY}-based stock status reference points.

The Committee concluded that the reference points based on unfished female spawning biomass, $0.2B_0$ and $0.4B_0$, were appropriate to include in the working paper for consideration by fishery managers. However, the Committee suggested that some context be added to the POP working papers to support their use and to point out where management decisions might differ depending on whether B_0-based or B_{MSY}-based reference points are applied.

Stock Status

Assess the current status of the Pacific Ocean Perch 5DE stock relative to the recommended reference points.

The Committee concluded that the sex-specific catch-at-age analysis of area 5DE POP provided an acceptable characterization of stock status and reflected uncertainty adequately by adopting a Bayesian formulation. The female spawning biomass of POP in management area 5DE was estimated to be 0.37 (0.16-0.67) of the unfished biomass. The spawning biomass at the start of 2013 was characterized as lying in the Healthy zone with probability $P(B_{2013}>0.8B_{MSY})=0.88$. The exploitation rate of area 5DE POP in 2012 was estimated to be $u_{2012}=0.053$ (0.023-0.119), with a median about 50% of the median of u_{MSY} (0.109). The probability of u_{2012} being less than u_{MSY} was $P(u_{2012}<u_{MSY})=0.84$. Recent average catches were about 937 t, compared to the MSY catch of 1,488 t (998-2,258 t).

Harvest Advice

Evaluate the consequences of varying constant catches on future population status, providing decision tables and figures of projected biomass.

Decision tables were provided that showed the probability of female spawning biomass, B_t, exceeding $0.4B_{MSY}$, $0.8B_{MSY}$ and B_{MSY} in each year of a ten-year projection from beginning of year 2013 to 2023 for fixed annual catch levels ranging from 0 to 2,000 t. Similarly, decision tables showed the probability of exceeding $0.2B_0$ and $0.4B_0$, respectively, over the same 10-year time horizon and range of fixed annual catches.

The Committee recommended that the stock be re-assessed in about five years to take advantage of three additional multi-species synoptic survey data points, and to update the forecasts which increasingly rely on an assumption of average recruitment toward the end of the 10-year forecast period.

Ecosystem Considerations

The working paper reported the species caught concurrently with Pacific Ocean Perch and the depth range over which commercial bottom trawl activities occurred within the assessment area. The interception of species of conservation concern (e.g., Bocaccio, the Rougheye Rockfish-Blackspotted Rockfish species complex) was reported.

RECOMMENDATIONS AND ADVICE

The Committee concluded that the working paper had met the requirements of the Terms of Reference and accepted the working paper subject to revisions. The Committee recommended that decision tables provided for the base case catch-at-age model fit be used as advice to fishery managers. The Committee suggested that requests for revisions and recommendations for area 3CD POP are also applicable to the stock assessment for area 5DE POP.

REVIEW OF WORKING PAPER #3

Working Paper:	A Simultaneous Stock Assessment of Five Rockfishes in British Columbia Waters: Splitnose Rockfish, Greenstriped Rockfish, Redstripe Rockfish, Harlequin Rockfish, Sharpchin Rockfish
Rapporteur:	K. Rutherford
Presenter(s):	N.G. Taylor and R.D. Stanley

PRESENTATION OF WORKING PAPER

The lead author gave a presentation of the working paper (see Appendix D for Abstract). He explained some of the methods (including choices regarding age composition, selection of surveys and sensitivity cases) and results for looking at such data-poor stocks. For the sensitivity cases it was noted that labels on graphs are wrong (in that 2010 should be 2011), but the results are correct. He emphasized that a wide range of Maximum Sustainable Yield (MSY) values resulted from the sensitivity cases, and consequently the resulting decision tables are meaningless.

With respect to the five species:

Splitnose Rockfish – the only survey series to show a historical decline is the Triennial Survey. Otherwise, the Goose Island Gully survey and all recent Groundfish Synoptic surveys show positive trends. There was a very broad range of values for reference points with MSY estimates ranging from 43-524 t.

Greenstriped Rockfish – survey trajectories are mainly upward, but if catches are impacting the stock then there should be a reflection of this in the indices. Very broad range of values for reference points with MSY estimates ranging from 1,870-7,553 t.

Redstripe Rockfish – this was most poorly behaved of the assessments. The survey indices were noisy, with a mix of increasing, flat and decreasing trends. To produce reasonable estimates of MSY, the Goose Island Gully survey was removed as it was the most problematic. The biomass reconstructions were flat. Very different reference points were again calculated depending on the sensitivity case, with MSY estimates ranging from 1,226-10,870 t.

Harlequin Rockfish – It was not possible to fit an assessment model for this stock. There are no observations more than 10 years old. Current survey trajectories indicate an upward trend.

Sharpchin Rockfish – again, there are ambiguous survey results. So the model predicts a flat or slightly increasing trend in biomass. The stock appeared practically unfished, but sensitivity cases still had a wide range of reference points, with MSY estimates ranging from 431-20,000 t.

The general conclusions was that, given the uninformative data, all model predictions are very sensitive to priors and structural assumptions but recent catches have not caused synoptic survey indices to decline.

The Authors concluded that there is no such thing as a minimalist stock assessment. In general the stocks do not appear to be in decline based on the mean survey biomass estimates. But, it is not possible to recommend reference points, and more model fitting will not resolve the ambiguity in the data. The authors suggest that the only reasonable way to proceed is to test an assortment of management procedures (i.e. data choices, assessment models, and control rules) in simulation before using them to provide management advice.

Questions of clarification included why was the 2004 US Triennial survey not used (because it did not go into Canadian waters), and what are the units for weights (metric tonnes).

PRESENTATION AND DISCUSSION OF WRITTEN REVIEWS

The Committee considered written reviews by Vladlena Gertseva (Northwest Fisheries Science Center, National Marine Fisheries Service, NOAA, USA) and Zane Zhang (Shellfish Section, Pacific Biological Station, DFO). A summary of the major issues identified in the meeting by each reviewer is included below, and the full reviews appear in Appendix E.

Vladlena Gertseva

The reviewer recommended several other methods available to deal with data-poor and data-moderate stocks. She highlighted the following specific points (with author responses):

- some survey trends are conflicting (with other surveys). Did the authors look at area differences concerning where the surveys were conducted, as some surveys may be more representative of stock dynamics? Response: the surveys in question (such as US Triennial and Goose Island Gully survey) don't overlap.
- input data. Regarding the use of Ketchen's "intermediate" estimates in Haigh and Yamanaka, did the authors look at alternative foreign catch scenarios? Response: we tried to do this in case 2 for Redstripe Rockfish, but the other species were not used by Ketchen. Haigh and Yamanaka's document reconstructs based on ratios of species to Pacific Ocean Perch, so the catch data does reflect the influence of foreign removals.
- survey series. There was no description of the methods used to estimate survey indices of abundance (response: we will add this to the paper). Also, did you look into other methods such as general linear models (which may provide more understanding)? Response: did not consider other such methods.
- age composition data. Did you use the break and burn method (response: yes), and what about ageing error? Response: we did not examine matrices of ageing error; the plus group for the model is age 30 so data only need to be accurate to that point – ageing is good to that point. Sensitivity in the model was related to the removal of age information all together.
- regarding the use of age data for growth parameters, it would be useful to examine the bias. Response: this would be useful to pursue but in terms of ageing budget may not be affordable.
- there are alternative minimalist approaches, such as simple Stock Synthesis. Response: were not aware of that approach, which may be an encouraging approach worth pursuing in future, but there will still be issues to resolve.
- regarding parameters (e.g. natural mortality) and values such as maximum ages, you could compare your data with other sources. Response: would be worth checking.
- regarding assumptions on selectivity, is this hardwired into the model and could you look at length data? Response: it is age-based selectivity, and length data adds a whole other realm of complication due to individual asymptotic sizes/growth type groups etc. Age composition data were thought to provide more information.

Zane Zhang

The reviewer likes this type of assessment, conducted in the Bayesian sense (giving more information on the usefulness of the data). However, he found the age-structured model to be too complicated relative to the amount of information available from the data, and recommended the authors look at even simpler models (such as the surplus production model). A hierarchical modelling approach might be more useful, still combining the species into one model, borrowing the strongest aspects from some species to help the assessment of the others. In this approach, one could perhaps assume that the intrinsic population growth rate is the same across species. He appreciated the authors' honest scientific attitude regarding their explicit statements of the model outputs not being reliable.

The author agreed that the model is over-parameterized, and the reason for the age-structure approach is to reach back in history. But it was not very useful in this case, and he indeed anticipated a parsimony problem at the outset.

Further points highlighted by the review (with author responses):

- a surplus production model should address most of the manager's needs. Wonder whether you could achieve more objective outputs if give very little (prior) belief into the model. Response: agree. Though the only reasonable way to see if a surplus production model produces better results is to use in a management strategy evaluation context. He didn't think that any further model fitting would help.

A participant then asked that if the ageing data were dropped, how many parameters would be left to be estimated? Response: MSY and U_{MSY}, and the process errors. One would need to do simulations to see if one modelling approach performs better than others in terms of management performance (bearing in mind that the age data themselves are not always consistent).

- regarding objectives, what were the reasons for doing simultaneous models (across five species)? Response: to increase efficiency, though it probably did not work. Doing five at once, the extraction data from databases and assembling the data is indeed more efficient, but this is nothing to do with the stock assessment approach.
- the priors for U_{MSY} have a very strong influence on the posteriors. So it would help to see the distribution of U_{MSY} and MSY, not just point estimates.
- the conflicting abundance indices for the same years, but for different areas, causes some problems. Is it possible to add a parameter to reflect variations in spatial distributions of population in different areas? Instead of assuming an abundance across the whole study area, one could apply proportions by area using a probability distribution with a different percentage to each area in different years. This could better reflect abundance in an area. Response: would need some matrix relating to areas, but this is not an easy way to model. In a surplus production model one can estimate 'gravity'. We began assuming coastwide stocks so each survey is assumed to be telling us something about the coastwide stock. There were not enough data (or time) to estimate how to parse it out between areas. A participant noted that there is already a strong assumption of coastwide stocks, so wildly different indices may indicate there is not one stock. This may have a biological basis.
- the model results in terms of biomass and recruitment are unrealistically stable. These generally haven't changed even though catches have varied. The catches are relatively small compared to biomass so have no impact. It would be useful to add some discussion about the model's estimate of apparently constant biomasses over time.

- the depletion ratio shows some variation but the biomass looks constant. Response: there is so much uncertainty in the estimates that you can't see the medians changing (due to the scale of the graph).
- Eq. 2.2.12a on catchability is wrong. Response: there is a documentation error and it should be the average. Same for 2.2.19b, which also needs to be fixed. The equations are okay in the code.
- regarding sensitivity cases, what is the merit for excluding age data in an age-structured model? Response: because the age composition data has its own inconsistencies, caused by observation errors (e.g, not able to follow year classes, such as lots of three-year-olds in one year, then lots of eight-year-olds the next year).
- a consistent problem of the model is the outrageous estimates for MSY. There is no indication that the catch is impacting the biomass.
- one could list model parameters and number of data points in a table. Response: this can be done and can say it is over parameterized. A participant asked what would count as a 'data point'? Response: indeed, the observations are themselves correlated, so it's not easy to say.
- issues with the equations (see written review). Response: will correct them.

GENERAL DISCUSSION

General discussion covered the following areas:

- the models want to make the stocks big because they are not being constrained by the prior on U_{MSY}.
- the lead author said the resulting assessment is not credible. He suggested rejecting the stock assessment approach and trying an alternative data-based approach for management. Others agreed that the authors cannot 'data fit their way out of this' – the range of uncertainties are not going to be overcome by, for example, changing the priors. The value of the work accomplished is that there may be enough data at some point to better parameterize such models.
- how do managers set the catch limits for species like these? Management answered that depending on assessment results, they manage these species (except Redstripe Rockfish which has a quota) as part of an aggregate with trip limits. If there was strong advice, they would take steps to set caps on the catch.

Given the problems with the results, it was agreed that there was not too much point in further going over the methods in detail.

A discussion took place regarding the objectives in the Terms of Reference, with the final conclusions given below in Conclusions (based on text drafted by the Chair and then edited with participants at 11am on Thursday 8th November).

- the Chair asked if there was consensus that we cannot provide any advice. A participant said that we cannot characterize stock status, but thought there was a notion that current catches were not causing declines in survey trends. It was pointed out that in the past COSEWIC has simply analysed survey trends to make conclusions. A participant pointed out that given coastwide management units, we cannot say that levels of catch are not causing small scale depletions (these could arise, especially given no consistent signal between surveys).

- a participant asked whether it was felt that managers would be putting the species at risk by opening the fishery at current levels of catch? A participant thought that nothing looked pathologically bad – there was little information for Harlequin but the trend was upwards, and the others were flat. A similar approach was taken four or five years ago with Redbanded and Yellowmouth Rockfishes, but it's not a satisfying result. Another participant noted that you can look at the trends if the stock assessment doesn't work but need to do some simulations first. A problem with a trend approach is that the time series may be too short. Further discussion considered the merits of looking at survey trends, but since no statistical analysis had been conducted in this respect, it was deemed unsuitable to provide advice to managers based on 'eyeballing' the survey trends.
- a participant summarised that a key requirement for the desired approach required calculating reference points, but it is clear that the approach taken could not do this, therefore abandon the stock assessment approach but record the results so that it isn't done again.
- one author suggested that, given there are lots of other species like these data-poor ones, it would be useful to develop some survey-based rules to manage rockfish. A participant suggested that an obvious next step is to do a proof of concept with one of these species, developing a methodology that can be applied to other species, though the author suggested trying for other rockfish species rather than one of these five.

It was agreed that no advice to management could be given regarding these five stocks, and hence a Science Advisory Report would not be written. It was recommended that the Working Paper be suitably revised and published as a Research Document so that the methods used and the approach taken are properly documented. However, caution was given about publishing the unreliable biomass estimates (as they could be taken out of context, especially if not read in conjunction with these Proceedings). Therefore, the authors were advised to make much stronger the wording in the abstract that currently calls the results 'not credible', and to add words of caution regarding the resulting numbers throughout the Research Document. Also, there are statements in the Working Paper indicating that there are no problems with the survey trends, so these should also be taken out.

The meeting was adjourned for the day and it was agreed to reconvene at 11am on Thursday 8th November, so the Chair could draft the text below (regarding the Terms of Reference) and participants could edit to reach consensus.

CONCLUSIONS

The authors themselves concluded in the working paper that "Unfortunately, not much can be done to make the assessments of the five rockfish stocks reliable from a statistical perspective." It was noted that the model wants to make the stocks very large; for example, the estimates of maximum sustainable yield (MSY) for Redstripe Rockfish varied ten-fold between sensitivity tests, with the highest estimates being unrealistically high. While a number of alternative approaches were suggested, the consensus was that there were not enough data to warrant further analyses of this type. One suggested approach was to look at survey trends, but even this would require some management strategy evaluation work. It was suggested that such an approach might be considered in conjunction with future assessments of these species.

The Terms of Reference (Appendix A) for the meeting stated that the Working Paper would be used to provide advice on the six points given below (the resulting advice is given in italics):

1) Examine a "minimalist" approach to stock assessment analyses, even if sufficient data are available for more complex assessments.
Several methods were explored, and one type of "minimalist" approach was taken, but

failed to produce reliable results that could be used to provide advice for these stocks. It was noted that further model fitting is unlikely to resolve uncertainties and produce credible results.

2) Examine whether current survey and sampling procedures are adequate for providing advice for such species.
This question cannot be answered in this case (or any others) because determining if the data are adequate depends on objectives and how the data are used. In order to answer it, a management procedure evaluation is needed to devise a procedure that meets stated objectives.

3) Recommend reference points consistent with the DFO Precautionary Approach. Include the biological considerations and rationale used to make such a determination.
The provisional Precautionary Approach reference points could not be reliably estimated, and so these or others could not be recommended.

4) Assess the current status of the five stocks relative to the recommended reference points.
Cannot be done, given the model results.

5) Evaluate the consequences of varying constant catches on future population status, providing decision tables and figures of projected biomass.
Cannot be done, given the model results.

6) Provide recommendations on approaches for streamlining the production of assessments.
Several components of the work could be useful for producing future assessments, for example, the algorithm for choosing suitable surveys.

Participants concluded that since harvest advice could not be provided based on the assessment, a Science Advisory Report would not be written.

It was recommended that the Working Paper should be revised to be published as a Research Document. The methods would then be documented for the future even though the approach taken did not work for these stocks. Revisions would include:

1) Address the necessary concerns of the two reviewers (without doing any more computational work, or testing other modelling approaches).

2) Ensure that in the abstract and throughout the document (wherever numerical results are presented for quantities such as MSY) that it is very clearly stated that the results are not useable for assessing stock status.

3) Correct the model notation to make it understandable and reproducible, and text should be added to describe the various parts of the model.

4) Edits to the text are needed to improve clarity, and the document will need to be re-formatted to conform to the CSAS requirements.

RECOMMENDATIONS AND ADVICE

The outputs of the stock assessment could not be used to estimate stock status reliably, and consequently no Science Advisory Report will be produced. The Working Paper should be revised as noted above to be published as a Research Document.

ACKNOWLEDGEMENTS

The Chairs thank the efforts of reviewers P. Hulson (Working Papers #1-2), J.S. Cleary (Working Papers #1-2), Z. Zhang (Working Paper #3), and V. Gertseva (Working Paper #3). Thanks also to rapportuers L. Lacko (Working Papers #1, 2) and K. Rutherford (Working

Paper #3). The assistance of N. Dedeluk in providing support for meeting logistics is greatly appreciated.

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APPENDIX A: TERMS OF REFERENCE

Stock assessment for Pacific Ocean Perch in Areas 3CD and 5DE (British Columbia); and A Simultaneous Stock Assessment of Five Rockfishes in British Columbia Waters: Splitnose, Greenstriped, Redstripe, Harlequin and Sharpchin Rockfish

Regional Peer Review – Pacific Region

November 6-9, 2012
Nanaimo, BC

Chairpersons: Andrew Edwards and Rob Kronlund

Stock assessment for Pacific Ocean Perch in Areas 3CD and 5DE (British Columbia)

(November 6 at 9:00am to November 7 at 12:00pm)

Context

Of the current annual Total Allowable Catch of rockfish on the west coast of Canada, Pacific Ocean Perch is the species that has the largest single-species quota. It accounts for 25% of the total weight of rockfish landed by bottom trawl gear. A detailed stock assessment has never been done for stocks 3CD and 5DE. Harvest advice is required to determine if current harvest levels are sustainable and compliant with the *Fishery Decision-making Framework Incorporating the Precautionary Approach* (DFO 2009).

Objectives

Guided by the Fisheries and Oceans Canada (DFO) Sustainable Fisheries Framework, particularly the *Fishery Decision-making Framework Incorporating the Precautionary Approach* (DFO 2009), meeting participants will review the working papers:

Stock assessment for Pacific Ocean Perch (*Sebastes alutus*) for Area 3CD in British Columbia. Edwards, A.,Starr, P. and Haigh, R. CSAP Working Paper 2012/P02a

Stock assessment for Pacific Ocean Perch (*Sebastes alutus*) for Area 5DE in British Columbia. Edwards, A.,Starr, P. and Haigh, R. CSAP Working Paper 2012/P02b

The working papers will be used to provide advice with respect to the following objectives:

- Recommend reference points consistent with the DFO Precautionary Approach. Include the biological considerations and rationale used to make such a determination.
- Assess the current status of the Pacific Ocean Perch 3CD and 5DE stocks relative to the recommended reference points.
- Evaluate the consequences of varying constant catches on future population status, providing decision tables and figures of projected biomass.

A Simultaneous Stock Assessment of Five Rockfishes in British Columbia Waters: Splitnose, Greenstriped, Redstripe, Harlequin and Sharpchin Rockfish

(November 7 at 1:00 pm to November 9 at 12:00 pm)

Context

Currently, Splitnose, Greenstriped, Redstripe, Harlequin and Sharpchin Rockfish are captured incidentally in British Columbia waters. Redstripe Rockfish has previously been assessed as part of a larger rockfish complex, but the other four stocks have not previously been assessed.

The Fisheries Management Branch of Fisheries and Oceans Canada has requested advice on the status of the coastwide stocks of these five rockfishes. Advice will be given in terms of reference points based on both B_{MSY} (the biomass at the maximum sustainable yield) and on depletion (biomass relative to unfished equilibrium biomass).

Objectives

Guided by the DFO Sustainable Fisheries Framework, particularly the *Fishery Decision-making Framework Incorporating the Precautionary Approach* (DFO 2009), meeting participants will review the working paper:

A Simultaneous Stock Assessment of Five Rockfishes in British Columbia Waters: Splitnose, Greenstriped, Redstripe, Harlequin and Sharpchin. Taylor, N., Stanley, R. Starr, P., Rutherford, K., and Haigh, R. CSAP Working Paper 2011/P01

The working paper will be used to provide advice with respect to the following objectives:

- Examine a "minimalist" approach to stock assessment analyses, even if sufficient data are available for more complex assessments.
- Examine whether current survey and sampling procedures are adequate for providing advice for such species.
- Recommend reference points consistent with the DFO Precautionary Approach. Include the biological considerations and rationale used to make such a determination.
- Assess the current status of the five stocks relative to the recommended reference points.
- Evaluate the consequences of varying constant catches on future population status, providing decision tables and figures of projected biomass.
- Provide recommendations on approaches for streamlining the production of assessments.

Expected Publications

- CSAS Science Advisory Reports (2)
- CSAS Research Documents (2)
- CSAS Proceedings (1)

Participation

- DFO Science
- DFO Oceans
- DFO Habitat
- DFO Fisheries Management
- Aboriginal Communities
- Province of BC
- External Reviewers
- Industry
- Non-governmental Organizations
- Other Stakeholders.

References

DFO. 2009. A fishery decision-making framework incorporating the Precautionary Approach.

APPENDIX B: PARTICIPANTS

Last Name	First Name	Affiliation
DFO		
Acheson	Schon	Science, Groundfish Section
Ackerman	Barry	FAM, Groundfish Mgmt.
Caron	Chantelle	FAM, Groundfish Mgmt.
Cleary	Jaclyn	Science, Conserv. Biol.
Edwards	Andrew	Science, Groundfish Section
Flemming	Rob	Science, Groundfish Section
Forrest	Robyn	Science, Groundfish Section
Haigh	Rowan	Science, Groundfish Section
Hargreaves	Marilyn	Science, CSAP
King	Jackie	Science, Groundfish Section
Kronlund	Allen (Rob)	Science, Groundfish Section
Neate	Holly	Science, Groundfish Section
Rutherford	Kate	Science, Groundfish Section
Stanley	Rick	Science, Groundfish Section
Taylor	Nathan	Science, Groundfish Section
Workman	Greg	Science, Groundfish Section
Wyeth	Malcolm	Science, Groundfish Section
Yamanaka	Lynne	Science, Groundfish Section
External		
Chalmers	Dennis	Province of British Columbia
Gertseva	Vladlena	NOAA
Harling	Wayne	Sport Fish Advisory Board
Hulson	Pete	NOAA (AFSC)
Mose	Brian	Comm. Industry Caucus, Trawl
Pawlowicz	Rich	University of British Columbia
Starr	Paul	Can. Groundfish Res. Cons. Soc.
Turris	Bruce	Can. Groundfish Res. Cons. Soc.

APPENDIX C: AGENDA

Regional Peer Review Meeting (RPR)

Stock assessment for Pacific Ocean Perch in Areas 3CD and 5DE (British Columbia)

November 6-9, 2012

Pacific Biological Station
Nanaimo, British Columbia

Chair: Rob Kronlund

DAY 1 - Tuesday 6 November

Time	**Subject**	**Presenter**
0900	Introductions Review agenda & housekeeping CSAS overview & procedures	Chair
0915	Review Terms of Reference	Chair & participants
0930	Presentation of working papers including results for Vancouver Island assessment	Authors
1030	**Break**	
1045	Presentation of results for Haida Gwaii assessment	Authors
1115	First review & author's responses	Pete Hulson, Auke Bay Laboratories, Alaska Fisheries Science Center, NOAA, USA (via Webinar)
1200	**Lunch Break**	
1245	First review & author's responses	Jaclyn Cleary, Conservation Biology Section, PBS
1330	Confirmation of key issues for discussion Discussion focusing on Vancouver Island assessment	Participants
1430	**Break**	
1445	Discussion focusing on Haida Gwaii assessment	Participants
1630	**Adjourn**	

DAY 2 - Wednesday 7 November

Time	**Subject**	**Presenter**
0900	Introductions Review agenda & housekeeping CSAS overview & procedures (if necessary)	Chair
0920	Discussion regarding any remaining issues. 1. Are the data and methods adequate to support the conclusions? 2. Does the advice reflect the uncertainty in the data, analysis or process? 3. Does the paper meet the objectives in the Terms of Reference?	Authors
1030	**Break**	
1050	Decision on acceptability of working paper. Consensus regarding: • Key Findings & Conclusions • Uncertainties • Ecosystem Considerations • Advice for Management Recommendations for Future Work	Participants
1110	Summary of conclusions and advice: what to include in the Science Advisory Report	Participants
1200	**Lunch Break**	

A Simultaneous Stock Assessment of Five Rockfishes in British Columbia Waters: Splitnose, Greenstriped, Redstripe, Harlequin and Sharpchin Rockfish

November 6-9, 2012

Pacific Biological Station
Nanaimo, British Columbia

Chair: Andrew Edwards

DAY 2 - Wednesday 7 November 1:00pm

Time	Subject	Presenter
1300	Introductions Review agenda & housekeeping CSAS overview & procedures	Chair
	Review Terms of Reference	Chair & participants
1330	Presentation of working paper	Authors
1430	***Break***	
1445	First review & authors' responses	Vladlena Gertseva, Northwest Fisheries Science Center, NOAA, USA (via Webinar).
1530	Second review & authors' responses (continued tomorrow)	Zane Zhang, Shellfish Section, PBS
1615	Summary of the afternoon and issues for tomorrow.	Participants
1630	***Adjourn***	

DAY 3 - Thursday 8th November

Time	Subject	Presenter
0900	Introductions Review agenda & housekeeping CSAS overview & procedures	Chair
0920	Confirmation of key issues for discussion. Continuation of authors' responses to reviewers. Discussion of working paper, focussing on methods and general approach.	Participants
1045	***Break***	
1100	Continuation of discussion on methods and general approach.	Participants
1200	***Lunch Break***	

Time	Subject	Presenter
1245	Discussion of data and results for each species: • Redstripe • Splitnose • Greenstriped	Chair
1415	***Break***	
1430	Continuation of discussion for: • Harlequin • Sharpchin	Participants
1530	Discussion regarding any remaining issues. 1. Are the data and methods adequate to support the conclusions? 2. Does the advice reflect the uncertainty in the data, analysis or process? 3. Does the paper meet the objectives in the Terms of Reference?	Participants
1630	***Adjourn***	

DAY 4 - Friday 9th November

Time	Subject	Presenter
0900	Introductions Review agenda & housekeeping CSAS overview & procedures (if necessary)	Chair
0920	Decision on acceptability of working paper. Consensus regarding: • Key Findings & Conclusions • Uncertainties • Ecosystem Considerations • Advice for Management • Recommendations for Future Work	Participants
1030	***Break***	
1050	Summary of conclusions and advice – what to include in the Science Advisory Report.	Participants
1200	***Lunch Break***	

APPENDIX D: ABSTRACTS OF THE WORKING PAPERS

Pacific Ocean Perch (*Sebastes alutus*) stock assessment for the west coast of Vancouver Island, British Columbia by A.M. Edwards, R. Haigh and P.J. Starr. (CSAP WP 2012-P02a)

Pacific Ocean Perch (*Sebastes alutus*, POP) is a commercially important species of rockfish that inhabits the marine canyons along the coast of British Columbia. The status of POP off the west coast of Vancouver Island, British Columbia, is assessed here under the assumption that it is a single stock harvested entirely in Pacific Marine Fisheries Commission (PMFC) major areas 3C and 3D. This is the first time that a population model has been used to assess this stock. We used an annual two-sex catch-at-age model tuned to: three fishery-independent trawl survey series, annual estimates of commercial catch since 1940, and age composition data from the commercial fishery (15 years of data) and from one of the survey series (four years of data). The model starts from an assumed unfished equilibrium state in 1940, and the survey data cover the period 1967 to 2012 (although not all years are represented). The model was implemented in a Bayesian framework (using the Markov Chain Monte Carlo procedure) to quantify uncertainty of estimated quantities.

Estimated exploitation rates were calculated as the ratio of total catch to the vulnerable biomass in the middle of each year. Rates peaked in the mid-1960s due to large catches by foreign fleets, and peaked again (though not as high) in the early 1990s. Exploitation rates have remained low since the mid-1990s, with the exploitation rate for 2012 estimated as 0.035 (0.018-0.077), denoting median and 5th and 95th quantiles of the Bayesian posterior distribution.

The spawning biomass (mature females only) at the beginning of 2013 was estimated to be 0.41 (0.19-0.68) of unfished spawning biomass. It was estimated to be 1.53 (0.55-3.32) of B_{MSY}, where B_{MSY} is the equilibrium spawning biomass that would support the maximum sustainable yield (MSY).

Advice to managers was presented as a set of decision tables that provided probabilities of exceeding limit and upper stock reference points for ten-year projections across a range of constant catch scenarios. The primary reference points used were a limit reference point of $0.4B_{\text{MSY}}$ and an upper stock reference point of $0.8B_{\text{MSY}}$. Decision tables were also presented with respect to alternative reference points based on the unfished equilibrium biomass (B_0). The estimated spawning biomass at the beginning of 2013 had a 0.99 probability of being above the limit reference point of $0.4B_{\text{MSY}}$, and a 0.87 probability of being above the upper stock reference point of $0.8B_{\text{MSY}}$. The estimated median MSY (tonnes) was 1,048 (700-1,509), compared to the recent average catch (from 2007-2011) of 547 t. The probability that the exploitation rate in 2012 was below that associated with MSY is 0.89.

Ten-year projections, for constant catches of 600 t, indicated no change from the probabilities of the spawning biomass being above the reference points at the end of the projection period, and indicated a probable increase in the median spawning biomass.

Pacific Ocean Perch (*Sebastes alutus*) stock assessment for the north and west coasts of Haida Gwaii, British Columbia (CSAP WP 2012-P02b)

Pacific Ocean Perch (*Sebastes alutus*, POP) is a commercially important species of rockfish that inhabits the marine canyons along the coast of British Columbia. The status of POP off the north and west coasts of Haida Gwaii, British Columbia, is assessed here under the assumption of a single stock harvested entirely in Pacific Marine Fisheries Commission (PMFC) major areas 5D and 5E. This is the first time that a population model has been used to assess this stock. We used an annual two-sex catch-at-age model tuned to: one fishery-independent trawl survey series, annual estimates of commercial catch since 1940, and age composition data from the commercial fishery (29 years of data) and from the survey series (five years of data). The model starts from an assumed unfished equilibrium state in 1940, and the survey data cover five years from 1997 to 2010. The model was implemented in a Bayesian framework (using the Markov Chain Monte Carlo procedure) to quantify uncertainty of estimated quantities.

Estimated exploitation rates were calculated as the ratio of total catch to the vulnerable biomass in the middle of each year. Rates peaked in the late-1960s due to large catches by foreign fleets, and peaked again at higher values in the mid-1980s, coincident with an overfishing experiment operating in the Langara Spit region of area 5E. The exploitation rate for 2012 is estimated to be 0.053 (0.023-0.119), denoting median and 5th and 95th quantiles of the Bayesian posterior distribution.

The spawning biomass (mature females only) at the beginning of 2013 was estimated to be 0.37 (0.16-0.67) of unfished spawning biomass. It was estimated to be 1.61 (0.57-3.57) of B_{MSY}, where B_{MSY} was the equilibrium spawning biomass that would support the maximum sustainable yield (MSY). There was estimated to have been an exceptionally strong recruitment of age-1 fish in 1977.

Advice to managers was presented as a set of decision tables that provided probabilities of exceeding limit and upper stock reference points for ten-year projections across a range of constant catch scenarios. The primary reference points used were a limit reference point of $0.4B_{\mathrm{MSY}}$ and an upper stock reference point of $0.8B_{\mathrm{MSY}}$, which are the Fisheries and Oceans Canada Precautionary Approach provisional reference points. Decision tables were also presented with respect to alternative reference points based on the unfished equilibrium biomass (B_0). The estimated spawning biomass at the beginning of 2013 had a 0.98 probability of being above the limit reference point of $0.4B_{\mathrm{MSY}}$, and a 0.88 probability of being above the upper stock reference point of $0.8B_{\mathrm{MSY}}$. The estimated median MSY (tonnes) was 1,488 (998-2,258), compared to the recent mean catch (from 2007-2011) of 937 t. The probability that the exploitation rate in 2012 was below that associated with MSY is 0.84. Ten-year projections, for constant catches of 1,000 t (slightly above the recent mean catch), indicated no change in the probabilities of the spawning biomass being above the reference points at the end of the projection period.

A Simultaneous Stock Assessment of Five Rockfishes in British Columbia Waters: Splitnose Rockfish, Greenstriped Rockfish, Redstripe Rockfish, Harlequin Rockfish, Sharpchin Rockfish (CSAP WP 2011-P01)

This is an assessment of five minor rockfish stocks captured in BC waters. The majority of catches for these stocks occur in trawl fisheries. None of these stocks have had a stock-specific assessment in BC waters and only Redstripe Rockfish has been assessed as part of a complex in 1996 and 1999. Until this assessment, Fisheries and Oceans Canada had no regional estimates of growth or maturity for any of these species; for Harlequin Rockfish, this the first published report of growth and maturity parameters.

We had the following objectives:

1) Examine a minimalist approach to stock assessment analyses, even if sufficient data are available for more complex assessments;
2) Determine if current harvest rates are placing populations at risk over the short-term (5 years) and, if possible, provide managers with harvest advice;
3) Provide a first attempt to streamline production of advice for minor species;
4) Examine whether current survey and sampling procedures are adequate for providing advice for such species;
5) Recommend reference points consistent with the DFO Precautionary Approach. Include the biological considerations and rationale used to make such a determination;
6) Assess the current status of the five stocks relative to the recommended reference points;
7) Evaluate the consequences of varying constant catches on future population status, providing decision tables and figures of projected biomass.

This document contains five assessments that use a single approach. For each stock, we first determine growth and maturity parameters. Secondly, we describe and compare the available survey and age-composition data that can be used for stock assessment. Using a series of priors on the leading parameters, selectivity and natural mortality, we fit an age-structured model to all available survey time-series. We use only survey series that qualify according to a formalized set of criteria and use all available survey age-composition data from the qualified surveys. We do a range of sensitivity cases testing the effects of different priors on the leading U_{MSY} prior and the exclusion of age-composition data for two alternative reconstructed catch series.

We use a statistical-catch-at-age model that is parameterized using the management-oriented approach and project the stocks under a series of constant-catch policies that range from 25 to 175% of current levels. We present future stock status relative to the Precautionary Approach (B_{MSY}-based) and a set of depletion-based (stock size relative to unfished B_0) reference points.

Unfortunately, not much can be done to make the assessments of the five rockfish stocks reliable from a statistical perspective. In all cases, the models were sensitive to prior assumptions of the leading parameter and particularly sensitive to the inclusion or exclusion of age-composition data. We recommend focussing attention on how to design effective harvest control rules for data-poor, incidentally captured species that occur in a larger multi-species fishery.

APPENDIX E: WRITTEN REVIEWS

Review #1

Date: November 3, 2012

Reviewer: Peter Hulson, Ph.D., Research Fish Biologist, Auke Bay Laboratories, Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA

Working Papers: Edwards, A.E., R. Haigh, and P.J. Starr. Pacific ocean perch (*Sebastes alutus*) stock assessment for the west coast of Vancouver Island, British Columbia. Working Paper 2012/P02a and Edwards, A.E., R. Haigh, and P.J. Starr. Pacific ocean perch (*Sebastes alutus*) stock assessment for north and west coasts of Haida Gwaii, British Columbia. Working Paper 2012/P02b

The content presented in this review do not necessarily represent the views or official position of the Department of Commerce, the National Oceanic and Atmospheric Administration, or the National Marine Fisheries Service.

General comments

Overall, the Pacific ocean perch (POP) assessments for stocks off the west coast of Vancouver Island (referred to as '3CD' from here forward) and the north and west coasts of Haida Gwaii (referred to as '5DE' from here forward) of British Columbia presented in these documents are very comprehensive and are based upon sound and widely accepted stock assessment methods. The assessment models being reviewed are sex-specific age-structured assessment models fit to observations of fishery independent population indices, fishery independent age compositions, commercial fishery catch, and commercial fishery age compositions. The assessment models fit the available data reasonably well and use the most current information available to provide advice to fishery managers. Both the 3CD and 5DE POP stocks are in the 'healthy' zone relative to the DFO Precautionary Approach provisional reference points of $0.4B_{\text{MSY}}$ and $0.8B_{\text{MSY}}$. It should be noted that for both POP stocks in areas 3CD and 5DE, caution should be taken to ensure that catch does not exceed MSY, as it has been generally accepted by fisheries scientists that managing directly for MSY can be dangerous, given the uncertainty in reference points and stock size.

The estimated vulnerable biomass appears to be increasing for area 3CD, although, the recent survey index (from the synoptic trawl survey) do not exhibit a clear increasing trend in relative biomass. Since 2003, recent fishery catches also appear to be below the estimated MSY of 700 t for area 3CD (with the exception of 2008), however, the Total Allowable Catch (TAC) has been exceeded in 5 years since 2003 (including last year, 2011). For area 3CD, based on the recent trend of increasing estimated vulnerable biomass, and resulting increases in estimated spawning biomass from projections with a constant catch of 600 t, a recent combined TAC for areas 3C and 3D of 530 t could potentially be increased, although, caution should be taken in the magnitude of the TAC increase as the increasing trend in modeled vulnerable biomass is not completely supported by the observed survey biomass index.

The estimated vulnerable biomass appears to be slightly decreasing for area 5DE, which is supported by a decreasing trend in the recent survey relative biomass index (from the synoptic trawl survey). However, it should be noted that the decrease in the assessment model estimates of vulnerable biomass is not as large as the decrease observed in the survey biomass index. Catches have exceeded the estimated MSY of 998 t for area 5DE in 4 years since 2003, including the last two years (2010 and 2011, albeit, by only 1 t in 2010), but it isn't possible to compare recent catches to TAC for this area based on the data provided in Table B.1 (as the TACs for areas 5C and 5D are combined). It is somewhat puzzling that the projections of spawning biomass for area 5DE result in an increasing trend with a catch of 1,000 t upon comparison with the recent decreasing trends in both the model estimated vulnerable biomass and the survey biomass index that are related to catches that are, on average, smaller than 1,000 t. Such a projection that is counter to the recent trends in assessment model estimates and observed survey biomass indices may indicate potential problems with the spawner-recruit relationship. It is not recommended that the TAC be increased for area 5DE; rather, consideration should be made to decrease TAC to level that is lower than the estimated MSY, as the average catch since 2003 is only 4% smaller than the estimated MSY and may be exceeding the productivity of POP in area 5DE.

The remainder of my review is more focused on possible avenues the assessment authors may want to consider for future improvements to the model input data as well as model formulations than on specific details of each of the assessment models. The topics on which I've focused in this review include use of maturity information for female POP, the construct of sex-specific modeling, inclusion of available length composition data, inclusion of ageing error, and estimating the terminal year's catch. I also include references to studies cited in the review that the authors may want to investigate for future improvement to the stock assessment models for POP.

Maturity

There are two primary methods to determine maturity, macroscopically (which is used to infer maturity in these assessments) and microscopically (by evaluating histological slides). Evaluation of histological slides microscopically can be more informative primarily because the stage of oocytes and the presence of post ovulatory follicles or atresia (resorbtion of oocytes or remnant eggs) can be determined, which can be difficult to determine with only macroscopic evaluation. Thus, microscopic evaluation may be necessary for determining maturity correctly. However, the utility of either method depends on the species and also the time of year. For instance, during some times of year, histology was not needed for POP (Hannah et al. 2009). Although, POP exhibit an adolescent stage where maturity can be aborted (Hannah and Parker 2007), which makes characterizing maturity difficult. Also, there can be confusion between maturing fish and spent or resting fish, especially without histology (Hannah et al. 2009), and in a maturity study performed on POP in the Gulf of Alaska (GOA) it was found that some maturing fish (i.e., classified as immature fish) may have actually been mature (Lunsford 1999).

In these assessments macroscopic evaluation of maturity was only used from January to June, concurrent with a drop in the proportion of spent fish, thus, the timing of determining maturity macroscopically does have support. However, the number of 'older' fish within the immature stages 1 and 2 (say, greater than age-15 where the double normal model indicates maturity of essentially 100%) seems unusually large, ranging from 17-25% of the total number of fish evaluated (as determined from table D7 in the QCS assessment). The authors of these assessments may consider a study that evaluates maturity microscopically that would ground-truth the macroscopic methods that are used and to determine if some of these fish that were categorized as immature might actually be mature (i.e., Lunsford 1999). Albeit, in the assessment model the authors consider maturity to be 100% at these ages (i.e., greater than age-15), so, in terms of assessment model results this type of study would not have a large influence (if any), but it may be informative to the authors to evaluate the differences between the microscopic and macroscopic determination of maturity.

Recently, in the rockfish assessments performed by the Alaska Fisheries Science Center (AFSC) we have had to re-evaluate the use of maturity in our assessment models. Last year (2011) we did this for northern and dusky rockfish maturity in the GOA (Hulson et al. 2011, Lunsford et al. 2011), this year (2012) maturity is being re-evaluated for northern rockfish in the Bering Sea and Aleutian Islands (BSAI; Spencer and Ianelli in review), and next year (2013) we will be re-evaluating for the GOA POP and rougheye/blackspotted rockfish assessment models.

What we have found in this re-evaluation is that the age at 50% maturity (a parameter estimated by the logistic function) can be very different depending on whether macroscopic or microscopic evaluations were performed (the earlier studies were macroscopic and the recent studies were microscopic). There are two goals that we are trying to achieve with this re-evaluation:

1) attempt to estimate the average maturity (as we do not have evidence to deem either method unsuitable, whether macroscopic or microscopic), and
2) try to incorporate the uncertainty in maturity within the assessment model results.

For (1) we fit maturity models (in this case we used the logistic model rather than the double normal) to both datasets to try and estimate the mean maturity. We ultimately decided to use the binomial likelihood (after also exploring the methods used in these assessments), which inherently weights each observation by the sample size. Similar to the problem encountered in these assessments, the logistic model did not fit the observations at the younger ages very well (i.e., consistently over-estimated maturity at younger ages). To overcome this difficulty, rather than use the observed proportions at the younger ages (as is done in these assessments) we gave larger weight to the observations at younger ages so that the logistic model fit these observations more accurately. Overall, the reason behind increasing the weight at younger ages, rather than use the observations, was to achieve our second goal: to incorporate the uncertainty in maturity within the assessment model. What we ended up doing was estimating the logistic maturity parameters within the assessment model and adding the binomial likelihood for the fit to the female maturity data to the joint likelihood function so that uncertainty in maturity was propagated through the assessment model to the management quantities of interest. Whether estimating maturity independently (i.e., outside the assessment model), or, estimating maturity dependently (i.e., concurrently with the other parameters within the assessment model), we obtained equivalent results; the main difference was the assumptions surrounding the uncertainty in maturity.

The reason behind the fairly extensive focus on maturity in this review is due to the sensitivity of assessment model results, in terms of management quantities, to the assumptions surrounding maturity. For instance, in Lunsford et al. (1999) a sensitivity analysis was performed to evaluate the relationship between the age at 50% mortality and $F_{40\%}$ (the fishing rate which reduces the spawners-per-recruit to 40% of its unfished level). What was found was an inverse relationship between the age at 50% mortality and $F_{40\%}$, as the age at 50% maturity increased $F_{40\%}$ decreased fairly substantially. Thus, getting maturity correct should be a concern in all assessments. A related issue to this is the determination of the portion of the female population that will produce offspring in the current year, and, the related issue of whether maturity is potentially time-dependent. It seems that there is a fairly extensive dataset for maturity of POP used in these assessments for which time-dependent maturity could be investigated. An additional concern is whether or not there is evidence of skip-spawning, which is difficult to discern from the data provided (i.e., is the proportion of mature female POP producing offspring at older ages actually 100% in any given year?). However, these are more over-arching issues that we've been grappling with and would be very interested if the data used in these assessments could elucidate these questions.

Sex-Specific Modeling

All of the assessment models reviewed herein for POP are sex-specific assessments. The support of this construction is given by significant differences found in the growth (both weight and length-at-age) between male and female POP. Significant differences are also found between sexes in the GOA and BSAI; however, these significant differences are possibly due to large sample sizes (creating hypersignificant results). Another complicating issue is the potential for ageing error (discussed further below) and how it relates to the growth parameters. The main question to be answered is whether or not these differences in growth are biologically significant in the context of stock assessment.

A possible way to evaluate whether a sex-specific model would be biologically significant in the context of stock assessment would be through comparison of age and length compositions. Upon inspection of the sex-specific age compositions for both assessments reviewed here (the same is also true for QCS) the age compositions for males and females are very similar. If indeed the ratio between males and females in the population is 50%, then one would expect the age compositions to be similar. With similar age compositions, one could then inspect the length composition to find if there are differences between sexes. That is, are the observed length compositions representative or indicative of the differences in growth of the different sexes? One would assume so based on the growth differences between sexes; however, there are usually many more samples available from surveys/fisheries for length composition than for age-length pairs used for growth modeling. If the length compositions are not appreciably different then a sex-specific model may not be warranted, conversely, if there are differences then there is further support for sex-specific models. Additional further analyses could be conducted by including the sex-specific length composition in the assessment model to find if improvements are made over a combined sex model (addition of length composition into the stock assessment models is discussed further below).

A secondary consideration, potentially just as important as the previous question to be evaluated, is whether there are sufficient sample sizes in the sex-specific age compositions to support sex-specific modeling. Based on the figures and sample sizes for age compositions provided in Appendix E of both stock assessments the sex-specific sample sizes are fairly small (average of ~172 for males and ~224 for females for the 3CD survey age compositions, an average of ~189 for males and ~251 for females for the 5DE fishery age compositions, and ~172 for males and ~167 for females for the 5DE survey age compositions). Even with the small sample sizes, however, the sex-specific age compositions are very similar (as mentioned previously). In terms of sex-specific model estimates, the sex-specific estimates for survey and fishery selectivities are very similar, as are the sex-specific natural mortality estimates. Indeed, for the 3CD assessment the sex-specific natural mortalities were not significantly different. Further, it is a concern as to whether the small sample sizes in the age composition datasets are driving the differences in natural mortality and if these differences would emerge with larger sample sizes.

It is recommended that in the future the authors consider an alternative model scenario that is a combined sex assessment model. It would be informative to compare between a more parsimonious combined sex model and the current sex-specific model, including investigation of the fits to observed data as well as the resulting uncertainty in model results. Such an alternative model would help to answer the question: does a sex-specific assessment model out-perform a more parsimonious combined sex model? One way to test this would be to simulate data with small growth differences between sexes and see if it produces substantive differences in management advice given differing sample sizes available. Currently, rockfish assessment models for the GOA and BSAI performed by AFSC are not sex-specific, in part due to the impression that the small differences in growth are far less important than the greater uncertainty of the survey abundance indices or available life history information. We also think that our sample sizes are not substantial enough for most our stocks for sex-specific modeling.

Inclusion of available length composition data

In the current stock assessment models for POP in 3CD and 5DE there are no length compositions that are fit to supplement lack of age composition data. In the GOA and AI rockfish assessments we currently use length composition data, when available, to supplement lack of age composition data. For the GOA POP in particular, this is especially true for the early years of the model (i.e., during the foreign fleet fishery; Hanselman et al. 2011a). In 3CD the earliest age composition data available is in 1980 and for 5DE the earliest age composition data available is 1987. The lack of age composition in the early years of the assessment model's time series is apparent upon inspection of the estimated recruitment time series. For both assessment models early recruitment estimates are essentially constant, as is the case for recent year's estimated recruitment. The more recent year's recruitment appears to exhibit this trend due to lack of age composition observations for fish less than around age-5.

If available, the authors should consider including available length composition data, especially in the early time series (i.e., prior to 1980) to supplement recruitment estimation. Doing so would also affect the stock-recruitment relationship, which would then propagate uncertainty into the estimated management quantities. An alternative to estimating a spawner-recruit relationship for the entire modeled time series, if length data is not available to supplement recruitment estimation, would be to only use recruitment estimates that are supported by age composition data. That is, instead of using the entire estimated recruitment time series in the Beverton-Holt model use the time periods in which variable recruitment is estimated (around 1960 – 2005 for 3CD and 1950 – 2005 for 5DE). Currently, the estimated spawner-recruit relationship may be misleading when applied to recruitment estimates that are not supported by observed age or length composition datasets, which is related to the estimation of steepness and subsequent management quantities.

Including length data into an age-structured assessment is straight-forward and can be done through the use of an age-length conversion matrix, in which the variability around the estimated growth curves can be taken into account within the assessment model (e.g., Hanselman et al. 2011a). Further, inclusion of sex-specific length composition data, as discussed previously, could justify using a sex-specific model rather than a simpler combined sex assessment model.

Inclusion of ageing error

In the assessments the authors state (in Section 8) "We did not explore ageing error…. with the conclusion that a full investigation of ageing error would require an independent dedicated analysis, which is beyond the capacity of the current assessment." Also, in Section 12 the authors propose to "Research how best to incorporate the uncertainty of ageing error into Canadian rockfish assessment models – the Sclerochronology Laboratory at the Pacific Biological Station currently records uncertainty for each aged otolith." From these statements, it seems that the authors are looking for a known-age type study so that ageing error can be incorporated into the assessment models. Currently, the only stock assessment within the suite of assessments conducted by AFSC that incorporates ageing error from known-age studies is sablefish (Hanselman et al. 2011b). All of the rockfish assessments conducted by AFSC incorporate ageing error based on percent agreements among otolith readers. The reason for the difficulties for known-age studies on rockfish is because rockfish are physoclistic and subject to barotrauma. Thus, it is unlikely that a mark-recapture type of study to validate ages through a known-age study will be able to be performed on rockfish (however, a successful mark-recapture study for rockfish would be invaluable to stock assessment).

While percent agreement doesn't account for the variability between the reader age and the true age (bias), it does provide some quantification of measurement error in the reading of otoliths. That is, using percent agreement can be considered as a minimum estimate of ageing error. Hanselman et al. (2012) using known age sablefish showed that ignoring ageing error severely underestimates variability in recruitment, and thus, the robustness of assessment results. An interesting finding was that ad hoc methods routinely used to estimate ageing error by using reader error work surprisingly well. Further, for a long-lived species like rockfish, the percent agreement has been found to degrade with increasing age of POP. For instance, percent agreement among readers for GOA POP resulted in coefficients of variation ranging from ~2%

for age-2 up to ~10% for age-30. In terms of stock assessment results, the relative difference is 96% in resulting Acceptable Biological Catch (ABC) from the most recent full assessment (2011) for GOA POP when ageing error based on percent agreement is used to model the age composition data compared to when the ages are assumed known without error within the age composition data. With such variability in management quantities resulting from a similar assessment to the ones presented in these reports, the authors should consider including at least some measure of ageing error into the assessment models for POP in 3CD and 5DE (as well as QCS). As the authors state, uncertainty in each otolith is recorded, thus, the data is available to evaluate ageing error based on percent agreement.

Estimating terminal year catch

In these assessments for the terminal year (in this case 2012) the authors use the previous year's catch (2011) as model input. This is because the catch for the terminal year is incomplete (in this case up to September). For GOA rockfish assessments we estimate the terminal year catch by using the ratio of catch up to the month in which the catch data is pulled to the total year's catch for the most recent three years in which the catch records are complete. This ratio can then be applied to the terminal year's catch to estimate the total catch that could possibly be taken. A reason for this is the potential for the terminal year's catch being larger than the previous year's catch, in which case the catch would be underestimated. Conversely, if the current year's catch will be smaller than the previous year, catch could be overestimated. The author's may consider a method similar to this to more accurately estimate the terminal year's catch, which would then influence the subsequent projections. A more accurate projection will allow for more stability in harvest recommendations.

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Lunsford, C.R. 1999. Distribution patterns and reproductive aspects of Pacific ocean perch (*Sebastes alutus*) in the Gulf of Alaska. Masters Thesis, University of Alaska Fairbanks.

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Review #2

Reviewer: Jaclyn Cleary, Pacific Biological Station, DFO, Nanaimo, BC

Working Papers: Pacific Ocean Perch (*Sebastes alutus*) stock assessment for the west coast of Vancouver Island, British Columbia, and Pacific Ocean Perch (*Sebastes alutus*) stock assessment for the north and west coasts of Haida Gwaii, British Columbia

Overall

Presentation of data, methods, modeling approach and results is thorough and well thought out, clearly benefitting from inputs/ interactions with the Technical Working Group. Presentation of stocks as two papers, 3CD and 5DE, improves clarity and is warranted.

The following questions/ comments fall into three categories:

1) data use, methods, modeling approach,

2) provision of management advice, and

3) minor comments. Given overlap in application of methods, the comments herein refer to content of the 3CD WP (WP 2012/P02a), unless specified as 5DE (WP 2012/P02b).

Comments on data use, methods, modelling approach:

1) Age composition data

- Appendix E (pg 69) details the two-step stratified weighting scheme applied to the biological data (generating weight-age frequencies). Appendix F (pg 86) then described calculation of a weighting factor necessary to account for unequal sample sizes (each year) between data sources.
    - o Clarify differences between iterative reweighting from Yellowmouth, vs. this paper;
    - o Re: Yellowmouth assessment (Edwards et al, 2012a), paper states "This procedure did not perform well…" (pg 86) however then on the following page, states that in Edwards et al (2012a) the reweighting after the first r=1 had little effect, thus "for the current assessment we used just one reweighting". It is unclear why r=1 reweighting is justified based on Edwards et al 2012a, if the conclusions from that paper state "procedure did not perform well".
    - o Do these reweighting schemes have implications for the type of likelihood function used for fitting the age composition data?

2) Survey data

- Main text describes three survey indices, and history of each survey is detailed in Appendix C. Model-fitting includes estimation of three survey catachability parameters: q_g, g=1,2,3 with q–values are reported in Table G.2 (pg 117).
    - o Are the three relative abundance indices given equal weight in the assessment? [Suggest to add this to F.2 Model assumptions (pg 74). Were considerations given to weighting survey indices? Or are they all thought to be equally representative? Justification/ discussion along these lines would be helpful.

Comments on provision of management advice:

1) Clarify advice to FM on catch threshold/ projections

- There appears to be a maximum catch threshold ~800-1,000 tonnes (Fig 9, pg 25) where biomass switches from increasing Bt over the projection period to declining Bt. Also evidenced in projection tables (pg 27-29).
    - This information is useful in longer term planning for this fishery – it would be useful to highlight this to FM.
    - Link these results to numeric estimates of MSY and the PA policy, and specifically the target of F < Fmsy. e.g., discuss in context of Fig 8.

2) Biological reference points

    - Clarify in the text that 0.4 and 0.8 Bmsy are used here as provisional reference points. Population modeling or other has not been carried out to determine the suitability of the 0.4Bmsy as a limit reference point. Given the status of current stock biomass, relative to these reference points (Fig 7, pg 23), and the low exploitation rates, I don't see this as a concern for the advice provided herein, however it is important not to assume a one-size-fits-all approach with the provisional reference points.
    - RSIA requests information on whether alternative reference points should be considered – I think the presentation of Bo values (0.2, 0.4Bo, and depletion estimates) is useful and can be linked to Table.

3) Recommendations on future work

    - Given this is the first detailed stock assessment, can the authors recommend assessment frequency for next update; can the authors comment on the necessity of this level of assessment (SCA model vs. others) given low exploitation rates, stock biology, etc. for the next assessment.

Minor comments:

- Suggest including plots of weight- (or length-) age (e.g., in Appendix D).
- Suggest referring to table of priors (Table F.4, pg 81) in the main body of Section 7.
- Age-composition bubble plots (Fig G.2, G.3) – use diagonal lines to show tracking of large cohorts and include year-class – it's difficult to read years of the x-axis.
- Recruitment vs. numbers at age, main text (pg 8 and Fig 5, pg 21) – suggest using numbers age-1, unless you are discussing recruitment to fishery, spawning biomass, etc. Also, Fig 5 – units for y-axis. Also, discussing range in recruitment relative to other groundfish species, or other POP stocks would be useful to the non-groundfish audience.

Review #3

Date: November 2, 2012

Reviewer: Dr. Vladlena Gertseva, United States Department of Commerce, National Oceanic & Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center

Working Paper: Taylor, N and Stanley, R. A Simultaneous Stock Assessment of Five Rockfishes in British Columbia Waters: Splitnose Rockfish, Greenstriped Rockfish, Redstripe Rockfish, Harlequin Rockfish, Sharpchin Rockfish**.** CSAP Working Paper 2012/P54

I reviewed a Simultaneous Stock Assessment of Five Rockfishes in British Columbia Waters: Splitnose Rockfish, Greenstriped Rockfish, Redstripe Rockfish, Harlequin Rockfish, Sharpchin Rockfish. My comments are provided below. In this document I first answer questions provided to me as the general guidelines for reviewers, and then I offer my comments on the data and methods used.

Responses to General Guidelines for Reviewers

Is the purpose of the working paper clearly stated?

Yes, the purpose of the paper is to assess five data-poor to data-moderate rockfish species, following a minimalist approach in assessment techniques.

Are the data and methods adequate to support the conclusions?

Assessments for all five species produce significant uncertainty in their results, which in some cases prevents providing harvest advice. The method used requires strong assumptions, which are difficult to justify with the limited amount of data available. It would be beneficial to evaluate these five stocks with other data-poor and data-moderate methods; I mentioned some of these methods in my comments below.

Are the data and methods explained in sufficient detail to properly evaluate the conclusions?

Not fully. It would be useful to see more discussion of the data treatment outside the model. Specifically, the document lacks description of how indices of survey abundance were estimated, whether (and how) quality of age data was evaluated, and how the life history parameters estimated within the assessment compare with those made for the same species elsewhere (U.S. West Coast and Alaska).

If the document presents advice to decision-makers, are the recommendations provided in a useable form, and does the advice reflect the uncertainty in the data, analysis or process?

Given the limited amount of data and restrictions of the minimalist approach, the results were not always informative enough to provide harvest advice in terms of status relative to the reference points.

The authors however, provide a general conclusion that helps the reader interpret assessment results; the authors discuss the utility of these results in the fishery management arena and outline potential solutions for the future.

Can you suggest additional areas of research that are needed to improve our assessment abilities?

The assessment would benefit from thorough sensitivity analyses, which would help bring to light the effect of model assumptions and fixed parameters on model results. Exploring the use of other data-limited, data-moderate approaches (some listed in comments below) would also be useful.

Comments of data and methods used for the assessment

Input data

The input data used in the assessments include catch time series, survey indices of abundance and age composition data.

Catch data: The catch time series goes back to 1918, as estimated by Haigh and Yamanaka (2011). These time series include estimates of both landings and discards. They also include removals by the foreign fleets in the mid-1960s, at the time of the POP fishery. The catch time series (until 1996, when the 100% of catch started to be observed) is quite uncertain. The assessments include sensitivity analysis to evaluate effect of the alternative catch histories on model output, but this sensitivity analysis is limited to model runs with alternative catch between mid-1980s and mid-1990s.

It would be helpful to more fully explore the effect of alternative catch histories on model results, and to include sensitivity runs to alternative assumptions about foreign removals as well. Foreign removals represented a substantial (if not major) portion of the catch for some species, especially those that co-occur with POP. Haigh and Yamanaka (2011) use “intermediate estimates” of foreign removals (as opposed to “minimal” and “maximum”), as calculated by Ketchen. Running the model with all three foreign removals scenarios would benefit the understanding of effects of catch history on the estimated dynamics and current status of species assessed.

Survey series: Several fishery-independent surveys were used in the assessment. However, there is no description of the methods used to estimate survey indices of abundance. The assessment also uses the U.S. triennial survey, however the time series of this survey was truncated at 2001, and the last year of the assessment (2004) was not included. That year, NWFSC (and not AFSC) conducted the survey, but the same survey methods were followed. U.S. groundfish assessments routinely use this survey data through 2004.

Age composition samples: Limited age data were available for assessment. Long-lived rockfish are difficult to age, with significant uncertainty associated with age estimates, particularly for older fish. No ageing error matrix (with a measure of bias and imprecision associated with the age estimates) was included in the assessment. It is not clear whether the quality of age data was evaluated outside the model or not.

Length composition data: No length composition data were used in the assessment, aside from estimating length at age parameters outside the model. Length data can provide important information on shape of the selectivity curve and selectivity parameters.

Analysis of Biological Data

Growth and maturity parameters: The authors refer to Love et al (2002) throughout the assessment as well as to assessments conducted elsewhere (U.S. West Coast, Alaska) for the five rockfish species assessed. I would have liked to see the comparison of life history parameters used in this assessment with parameters reported elsewhere. If substantial differences are noted, the sensitivity analysis (to explore effect of these parameters on model output) would be beneficial.

Natural mortality: Natural mortality was estimated using the Hoenig method, which uses maximum age as a predictor of natural mortality. A limited amount of age data were available for assessment, which could affect the understanding of the maximum age of species assessed. For example, the splitnose rockfish assessment reports 75 years as a maximum age, while on the U.S. West Coast, maximum age of splitnose rockfish was reported to be 103 years. It would be very useful to estimate natural mortality using other methods that exist as well (and not only Hoenig's) and compare the estimates. Sensitivity analysis should be also conducted to evaluate effect of alternative mortality estimates on model output.

Sensitivity analysis

Only a few sensitivity runs were conducted and those were limited to exploring the effect uncertainty in catch in the mid1980s on model results. A limited amount of data were used to estimate life history parameters (fixed in the model), and a number of strong assumptions were made. Thorough sensitivity analyses of those parameters and assumptions would promote understanding of the dynamics and current status of the stocks assessed. See my comments above for specific sensitivity runs suggested.

Modeling method

The assessments of five rockfish are based on MARS, a multispecies age-structured rockfish assessment model. The authors follow a minimalist approach, as these five species do not have a lot of data available for the assessment.

The MARS was developed to deal with data limited (data moderate) situations. The authors evaluated available methods to deal with data-limited simulation, including depletion-based and surplus production methods.

The results of MARS were found to be very sensitive to the assumptions, and data are often limited to describe stock past dynamics and reliably estimate stock status. The results are associated with significant uncertainty.

There are several other (than depletion-based and surplus production) methods which currently exist to deal with data-poor and data-moderate stocks. These methods might provide an additional venue to explore for these five rockfish species. Recently, a Stock Synthesis (SS) based method for data-poor stocks, SSS (simple Stock Synthesis) was developed (Cope 2012). This method is based on catch time series and basic life history parameters. Also recently, data-moderate SS and DB-SRA based methods were developed (XDB-SRA and exSSS) that allow utilizing abundance indices, in addition to catch time and basic life history parameters. Both methods were adopted by the Pacific Fishery Management Council to assess data-moderate species on the U.S. West Coast. Given the data used for the five rockfish species (and given the limited amount, and unknown quality of age data used), exSSS and XDB-SRA could be good assessment techniques to explore for these species.

Model assumptions

The model relies upon a number of strong assumptions. I would like to see a discussion, justifying the validity of these assumptions in relation to each species assessed; for example, explaining how appropriate it is to assume asymptotic selectivity for the shelf survey, when species distribution extends to the slope area, and species exhibit ontogenetic movements when older (larger) individuals move into deeper waters.

References

Cope, J.M. 2012. Implementing a statistical catch-at-age model (Stock Synthesis) as a tool for deriving overfishing limits in data-limited situations. *Fisheries Research*. In press.

Review #4

Reviewer: Zane Zhang

Working Paper: A Simultaneous Stock Assessment of Five Rockfishes in British Columbia Waters: Splitnose Rockfish Greenstriped rockfish Redstripe Rockfish Harlequin Rockfish Sharpchin Rockfish

Authors: Nathan Taylor and Richard Stanley

The authors used a catch-at-age model to conduct stock assessment of five rockfish populations simultaneously. They presented an effective way of designing harvest control rules, from which I learned quite a bit. However, the outputs of this assessment work are not credible, as the authors themselves have also explicitly stated. The data do not provide sufficient amount information to the models, which are sensitive to priors (beliefs), especially to the prior for the leading parameter, Umsy. In this review, I address my concerns from a technical point of views.

1) The authors claimed that they used a minimalist approach to conduct the stock assessment. However, this age-structured model still appears to be too complicated relative to the amount of information available from the data. Priors for Umsy have to be very informative (small standard deviation) in order to produce stable posteriors. I would recommend the authors to consider to use even simpler models, such as the surplus production model (SPM), to see if posteriors may be estimated more objectively without having to use informative priors. The authors have presented the reasons for rejecting the use of the SPM (p. 29). However, I believe that the SPM would still fulfill almost all the requirement for the management, as the outputs from the SPM includes estimates of MSY, Bmsy, Umsy, Bo, Bcurrent, and Ecurrent. The five rockfish stocks could still be simultaneously modelled possibly using a hierarchical structure, assuming the intrinsic population growth rate (r) to be exchangeable among the five rockfish stocks.

2) The authors gave two reasons for the simultaneous modelling of all the five stocks. The 1st one is to increase the efficiency of the assessment process, and the 2nd one is to allow stocks with less data to borrow information from stocks with more data (Robin Hood approach). However, this Robin Hood approach was eventually not used. Would a hierarchical model be more appropriate, by assuming, for instance, Umsys for the five different stocks are exchangeable and come from a normal distribution. With a hierarchical structure, posterior distributions could be formulated by borrowing strength from likelihood contributions from the other stocks.

3) The authors may consider to plot the posterior distributions of MSY and Umsy together with the corresponding priors to show more clearly the amount of influence of the priors on the posteriors. In the current paper, readers could only judge the influences by comparing the prior means with the MPD (maximum posterior density) estimates.

4) Conflicting abundance indices for the same years but in different areas are used in the assessment. These conflicting abundance indices cause some problems to the assessment. A high abundance index in one area may indicate high fish abundance for that area but not necessarily for the entire studied region, if a higher proportion of the fish happens to be distributed in that area for the survey year. To mitigate the problem of using conflicting abundance indices, is it possible to add a parameter to reflect variations in the spatial distribution of the population in different years?

5) The model outputs in terms of biomass and recruitment seem to be unrealistically stable (Fig. 3.10 for instance). Estimates of biomass and recruitment do not appear to have changed over the past years in most cases, although commercial catches varied considerably over the period. This seems to say that the amount of catch, at least within

the observed range, has no impact on the biomass. The authors need to discuss about the causes and implications for such a high stability in estimated biomass and recruitment.

6) Why the depletion (B/Bo) shows some variations over the years (Fig. 3.10 for instance), whereas the biomass looks constant over this same period?

7) Eq 2.1.12a states that the catchability coefficient q varies with time for each survey series, and the expected value of q is positively correlated with the survey abundance index. If the survey methodology for each survey series is relatively fixed, should q remain unchanged for each series in the modelling exercise?

8) Eqs 2.1.12a and 2.1.12b seem to indicate that expected abundance index equals the observed abundance index without errors, whereas Eq 2.1.12c shows there is an error involved.

9) Eq. 2.1.19b uses η_{iat} which is defined as residuals in Eq. 2.1.18b. Why are the "sum of squared" residuals not used for likelihood calculation?

10) Six scenarios are employed to study the impact of data uncertainties and different Umsy settings on the models. In two of the six scenarios, age data are excluded. What is the rational of not using age data in an age-structured model? Could the authors indicate which model outputs have more merits, including the age information or excluding the information? As the model outputs are rather sensitive to the exclusion of age-composition data, understanding the relative merits may help in selecting management measures.

11) The prior mean for log MSY was set at 14.05 for Sharpchin Rockfish. What is the measuring unit for this prior mean, kg or mt? The MPD estimate of MSY is about 15000 mt, while exp(14.05) = 1264263.

12) Why are the catches between 1960 and 2010 chosen to be used for formulating the mean of the normal prior for MSY.

13) New Zealand's limit reference point is Bt ≤ Bmsy / 2 or Bt ≤ 10%Bo. One of the proposed critical zones in this paper is Bt/Bmsy ≤ 0.4. According to New Zealand's standard, should this be Bt/Bmsy ≤ 0.5?

14) In Figure 11.3 (for instance), residuals are calculated as predicted – observed. Why not presented in the usual form: observed – predicted.

15) The authors may consider to list the number of model parameters vs the number of data points available for each rockfish population in the paper. Is the number of model parameters too large relative to the number of data points?

16) Despite the difficulties associated with this assessment, the study demonstrated that the rockfish stocks would generally remain in the healthy zones under a number of studied scenarios, provided the current catch levels are maintained. The authors should highlight this point in the Discussion, as the findings are perhaps of use for the management of these rockfish populations.

17) What does this '*' mean in Eq. 2.1.1b?

18) Clear Eq. 2.1.12d.

19) In Eq. 2.1.18a, should X have been x in this equation?

20) In Eqs. 2.1.19a and 2.1.19b, should the two taus be exchanged, as tau1 is for survey indices, and tau2 for proportions at age?

21) Why catchability q is listed in the data section in Table 2.1?

22) Delete "we following" in the 2nd para. on p. 33.

23) Change Redstripe to be “deflated” to Redstripe to be “inflated” on p. 41.