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Regional Science Advisory Process on the Pacific Review of Yelloweye Rockfish (*Sebastes ruberrimus*)

Processus de consultation scientifique régional du Pacifique pour l'examen du sébaste aux yeux jaunes (*Sebastes ruberrimus*)

September 22, 2010
Nanaimo, British Columbia

Le 22 septembre 2010
Nanaimo, Colombie-Britannique

Chairperson
Greg Workman

Président de la réunion
Greg Workman

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Science Branch / Secteur des Science
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September 2011 / **Septembre 2011**

Foreword

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

Avant-propos

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

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SUMMARY

A regional advisory process meeting was held September 22, 2010 in Nanaimo (BC) to conduct a science peer review of the status of the inside population of yelloweye rockfish (*Sebastes ruberrimus*) in British Columbia, Canada. The science review was conducted in response to a request from DFO Fisheries and Aquaculture Management (FAM) for advice regarding the current stock status of the inside population of yelloweye rockfish, primarily located in Groundfish Major Area 4B which encompasses protected waters to the east of Vancouver Island. Advice was requested on recommended limit reference point (LRP), upper stock reference point (USR) and target reference point (TRP), and the supporting rationale for their application to management of the inside yelloweye rockfish population. An assessment of the status of the inside population of yelloweye rockfish relative to recommended reference points was requested, as was an evaluation of the impacts of varying harvest levels on future population trends.

Population dynamics were modeled using two variants of a Bayesian surplus production model. The first model explicitly incorporated changes in predation of yelloweye rockfish by pinnipeds (PBSP), while the second formulation was a standard Bayesian surplus production (BSP) model without pinniped predation. Working paper results suggested that pinniped predation is a plausible cause of the decrease of this yelloweye rockfish population over the last few decades and constrains population rebuilding. Review of the working paper identified (*i*) problems in the definition and application of MSY-based reference points, and (*ii*) large uncertainties in pinniped diet and population index assumptions. Consequently, conclusions regarding the applicability of management advice were deferred pending re-assessment of data inputs, additional model sensitivity tests, and development of the MSY-based reference points in the presence of removals due to pinniped predation. The revised working paper will be re-examined via a regional advisory process in 2011.

SOMMAIRE

Le 22 septembre 2010, on a tenu une réunion du processus de consultation scientifique régionale à Nanaimo (C.-B.) afin d'effectuer un examen scientifique par des pairs de l'état de la population de sébastes aux yeux jaunes (*Sebastes ruberrimus*) des eaux intérieures de la Colombie-Britannique, au Canada. Cet examen scientifique faisait suite à la demande de Gestion des pêches et de l'aquaculture du MPO concernant la formulation d'un avis sur l'état actuel de la population de sébastes aux yeux jaunes des eaux intérieures, laquelle se trouve principalement dans la zone principale du poisson de fond 4B, qui comprend les eaux protégées de l'est de l'île de Vancouver. On a demandé un avis sur un point de référence limite (PRL), un point de référence supérieur (PRS) et un point de référence cible (PRC) ainsi qu'une justification de leur application à la gestion de la population de sébastes aux yeux jaunes des eaux intérieures. On a demandé un avis sur l'état de la population de sébastes aux yeux jaunes des eaux intérieures en fonction des points de référence recommandés ainsi qu'une évaluation des impacts qu'auraient différents niveaux de prélèvement sur les tendances démographiques futures.

On a modélisé la dynamique de la population en utilisant deux variantes d'un modèle bayésien de la production excédentaire. Le premier modèle intègre explicitement les changements dans la prédation des sébastes aux yeux jaunes par les pinnipèdes, tandis que la deuxième formulation est un modèle bayésien standard de la production excédentaire, lequel ne tient pas compte de la prédation par les pinnipèdes. Les résultats tirés du document de travail laissent sous-entendre que la prédation par les pinnipèdes est une cause plausible de la diminution de la population de sébastes aux yeux jaunes survenue au cours des dernières décennies et limite la reconstitution de la population. L'examen du document de travail a permis de relever : *i*) des problèmes dans la définition et dans l'application des points de référence fondés sur le RMS; *ii*) d'importantes incertitudes entourant le régime alimentaire des pinnipèdes et les hypothèses sur l'indice de la population. En conséquence, les conclusions concernant l'applicabilité de l'avis sur la gestion ont été mises en veilleuse pendant que l'on procède à la réévaluation des données d'entrée, à d'autres tests de sensibilité du modèle et à l'élaboration de points de référence fondés sur le RMS en tenant compte des prélèvements attribuables à la prédation par les pinnipèdes. Le document de travail révisé sera réexaminé dans le cadre d'un processus de consultation scientifique régional en 2011.

INTRODUCTION

A Pacific Regional Science Advisory process peer review of a stock assessment for the inside population of yelloweye rockfish (*Sebastes ruberrimus*) in British Columbia was conducted in Nanaimo (BC) on September 22, 2010. The terms of reference for the science review were developed by the CSAP office, Pacific region (Appendix 1) in response to a request from Fisheries Management (FAM). Notifications of the science review and conditions for participation were sent to identified industry associations, non-governmental organizations, and First Nations organizations with an interest in the inside population of yelloweye rockfish in British Columbia (Appendix 2).

A working paper was prepared and made available for review by meeting participants on September 9, 2010:

Stock assessment for the inside population of yelloweye rockfish (*Sebastes ruberrimus*) in British Columbia, Canada for 2010. K.L. Yamanaka, M.K. McAllister, M.-P. Etienne, S. Obradovich, and R. Haigh. CSAP Working Paper 2010/P06.

The meeting began at 9:00 AM, Wednesday, September 22, 2010. Chair G. Workman welcomed participants, explained room arrangements and reviewed the agenda (Appendix 4) for the meeting. The chair asked meeting participants to introduce themselves (Appendix 3). The chair then reviewed the rules of exchange for the meeting, reminding participants that the meeting was a science review although all participants were encouraged to voice their comments and questions. Rapporteur duties were assigned to A.R. Kronlund and N. Taylor (Science, Pacific Region).

The proceedings presented in this series focus on the main points discussed in the presentations and deliberations stemming from the activities of the science advisory regional Committee. The regional review is a process opened to all participants who are able to provide a critical outlook on the status of the assessed resources. In this regard, participants from outside the DFO are invited to take part in the Committee's activities. Proceedings also focus on recommendations made by the meeting participants.

CONTEXT

In 2006 the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) requested and received from DFO a report summarizing the biology, life history, catch history and trends in yelloweye rockfish abundance (Yamanaka et al. 2006). In November 2008, COSEWIC reviewed this report and designated the both the inside and outside populations of yelloweye rockfish as *Species of Special Concern* (http://www.cosewic.gc.ca/). Yelloweye rockfish were last assessed by DFO Science in 2001.

Fisheries and Aquaculture Management requested an assessment of the status of yelloweye rockfish in support of continued implementation of the Rockfish Conservation Strategy and to address the Special Concern designation. The request for advice identified the requirement for recommendations on a Limit Reference Point (LRP), an Upper Stock Reference (USR) point, Target Reference Point (TRP) and Removal Reference rate for the inside population of yelloweye rockfish. The status of this yelloweye rockfish population relative to the proposed reference points should be assessed. Advice is to include an evaluation of the consequences of alternative removal levels for both targeted and non-targeted fisheries.

WORKING PAPER SUMMARY

The working paper was presented by three of the authors: K.L. Yamanaka, M. McAllister, and R. Haigh. The working paper described a stock assessment of yelloweye rockfish for inside waters in British Columbia that include Queen Charlotte Strait, Johnstone Strait and the Strait of Georgia. Population dynamics were modeled using two variants of a Bayesian surplus production model. The first model explicitly incorporated changes in predation of yelloweye rockfish by pinnipeds (PBSP), while the second formulation was a standard Bayesian surplus production (BSP) model without pinniped predation. Pinniped species included in the analyses were harbour seals (*Phoca vitulina*), Steller sea lions (*Eumetopias jubatus*), and California sea lions (*Zalophus californianus*). All models were fitted to (*i*) four standardized commercial catch per unit effort (CPUE) series that covered four different periods in the history of the fishery; and (*ii*) eight fishery independent longline survey indices that varied in spatial coverage within the assessment area. All survey indices were derived from longline surveys of rockfishes with the exception of a directed dogfish (*Squalus ancanthias*) survey that intercepts yelloweye rockfish. A suite of sensitivity tests was conducted to evaluate the effects of uncertainty in key model parameters, the magnitude of the commercial catch and the influence of different indices. Results from each sensitivity test were compared with a reference case model that included pinniped predation and was fit to all twelve indices.

Sensitivity tests were divided into six categories that included specific hypotheses based on alternative choices of parameter values:

a) Value assumed for the prior mean of the intrinsic rate of population growth, r (two alternatives to reference case value);
b) Value assumed for B_{1918}/K_0, where B_{1918} is the exploitable biomass in 1918 and K_0 represents the unfished, unpredated population size (five alternatives to reference case value);
c) Uncertainty in catch estimates (two alternatives to reference case value);
d) Influence of stock trend data (three alternatives to reference case value);
e) Consumption rate of predators (five alternatives to reference case value);
f) Uncertainty in maximum fraction of rockfish in diet (two alternatives to reference case value); and
g) Effect of pinniped predation assumed constant, i.e., a conventional BSP with no extra predation term.

Results of sensitivity tests were discussed in terms of predictions for various performance measures including: B_{1918}, B_{2009}, Replacement Yield in 2009 ($RepY_{2009}$), B_{2009} / B_{init}, F_{2009} / F_{MSY}, Predation$_{2009}$, Catch$_{2009}$/$RepY_{2009}$, relative to the reference case model values. All scenarios using the pinniped predation BSP model (a-f) resulted in similar predictions in terms of F_x / F_{MSY} and Catch$_{2009}$/ $RepY_{2009}$, except for hypothesis (e) when pinniped consumptions was set to 10 percent of the reference case value. Performance measures obtained under category (g) of a standard BSP model with no pinniped predation were markedly different from results obtained under any hypothesis that included pinniped predation.

Within each of the above six sensitivity categories where models were fit to the same data (a-c, e, f) a Bayesian sampling-importance-resampling algorithm was used to estimate the relative posterior probability of each model and the reference case given the data. For category (e) with pinniped consumption set to 10% of the reference case, the estimated posterior probability was low (0.03) when compared to the other pinniped consumption scenarios and the reference case model (0.54). This result was used to assign a probability of < 0.1 to the "no pinniped predation" hypotheses under category (g) in comparison to the reference model which was assigned a probability > 0.9. No further sensitivity analyses or projections were therefore done with models that omitted pinniped predation.

Projections were conducted for 5, 10 and 40 year horizons under four alternative TAC and three alternative fixed fishing mortality policies using the reference model. Two scenarios for pinniped abundance were considered: (1) pinnipeds remain at 2009 level, and (2) pinnipeds are reduced to 1/3 of 2009 level. Performance measures computed from the projections included median B_{Final} / $0.5B_{1918}$; $P(B > 0.4B_{1918})$ in any year of the projection; and $P(B_{Final} > B_{2009})$. For the pinniped abundance case (1) the yelloweye rockfish population was predicted to decline towards zero, with zero probability of recovery under all fishing scenarios including TAC = 0. Similar results were obtained for pinniped abundance case (2), although the declines were less severe under the alternative fishing scenarios and the probability of recovery was greater than 0, especially for the longer time horizons.

Projections were repeated for the minimum and maximum parameter values within each sensitivity test category a-c, e, and f. Results from the projections were compared relative to the reference case in terms of median $B_{Final}/0.5B_{1918}$ only. Finally, projections were done that compared predicted median $B_{Final}/0.5B_{1918}$ from the reference case to predicted median $B_{Final}/0.5B_{1918}$ from the conventional BSP model under category (g). In general, the alternative hypotheses provided results similar to the reference model with the exception of two hypotheses. First, the median predicted $B_{Final}/0.5B_{1918}$ was about an order of magnitude greater relative to the reference case for the hypothesis where pinniped consumption of yelloweye rockfish is 10 percent. Second, for test category (g) where a BSP model without a pinniped predation was assumed the median predicted $B_{Final}/0.5B_{1918}$ was always greater than results for the reference case. For 20 and 40-year time horizons, yelloweye rockfish was predicted to recover significantly under combined low TAC and low F policies, whereas there was little or no recovery for the reference case.

DISCUSSION OF REVIEWS

The Committee considered reviews by I. Stewart (NOAA Fisheries), N. Taylor, and R. Forrest following the presentation of the working paper. A summary of the major issues identified by each reviewer is included below.

Reviewer 1 concluded that the use of a Bayesian surplus production model is reasonable given the limited scope of the available data but raised several technical issues related primarily to prior probability distributions. The reviewer noted that the posterior distributions for parameters and output quantities within each model run are reasonably narrow relative to the uncertainty among sensitivity analyses. He attributed this result to the use of a simple population dynamics and the small number of estimated parameters. However, the reviewer pointed out that there appears to be considerably more uncertainty in the current status and future projections for yelloweye rockfish in inside B.C. waters than is represented among these sensitivity analyses. For example, he noted that the fixed parameter describing the proportion of yelloweye within the rockfish occurring in pinniped diets (0.36) represents a very high proportion of rockfishes. Alternative values for this parameter could scale the results to the same degree as any parameter or data choices in the suite of sensitivity tests. The reviewer noted that no evidence was presented to support the contention that pinnipeds specifically eat yelloweye rockfish. On this basis the reviewer concluded the data are inadequate to support the conclusions of the reference case, although it does provide a plausible hypothesis to explain the failure of the yelloweye stock to recover under recently reduced fishery harvests.

Reviewer 1 concluded that the data sources used in the assessment were relatively poorly informative of trend but were consistent in showing a decline in the population and failure to recover in the last decade during a period of greatly reduced fishery removals. He acknowledged the novel application of pinniped predation dynamics to yelloweye rockfish assessment but noted (*i*) the calculation of total consumption was dependent on a sequence of calculations that relied on fixed parameters, (*ii*) there are no direct observations, data or expert opinion to support the fixed proportion of yelloweye rockfish in the rockfish component of pinniped diets, (*iii*) the use of rockfish species proportions obtained from jig and long-line surveys as a surrogate for pinniped consumption patterns is a tenuous assumption. Therefore, the reviewer judged the data inadequate to support adoption of the pinniped predation model as the reference case. He offered competing explanations for the relatively flat recent population trend following the TAC reductions: (*i*) below average recruitment during the 1990s and the continued decline in the adjacent and perhaps demographically linked Puget Sound population, and (*ii*) concurrent lack of recovery in coastal U.S. yelloweye stocks in the last decade under reduced fishing mortality which was considered plausible given estimated somatic growth rates and population productivity of yelloweye rockfish.

The reviewer suggested that understanding of the relationships among reference points and stable states in the reference case model would be assisted by a phase plot indicating the equilibrium yelloweye rockfish and pinniped populations. The plot could also indicate the stock size at which the yelloweye rockfish population becomes unstable as it enters the “predator pit”. The reviewer also questioned whether it was reasonable to expect the yelloweye rockfish population would be abundant in 1918 compared to the expected long-term equilibrium state in the presence of pinniped populations near current levels. He suggested this could be an artifact of model “burn-in” rather than an accurate representation of the unfished state.

When considering the appropriateness of the predator-prey functional form, Reviewer 1 commented that the estimation of trends in aggregate rockfish abundance, and especially the prey species that comprise the bulk of the pinniped diets such as herring, squid and salmon, is essential for this analysis. The relative abundance of competing predators, such as lingcod, might also be important determinants of yelloweye rockfish mortality. The current predator-prey dynamics imply that both yelloweye rockfish and pinnipeds are the most important component for the other.

Reviewer 1 stated that the use of a recent meta-analysis (Forrest et al. 2010) to derive an informative prior on the rate of population increase, *r*, does not fully represent the information available for a 2010 stock assessment. As many as four more recent stock assessments for each species considered in the original analysis by Dorn (2002) are available and it appears that none of the data sets for west coast stocks were updated for the current working paper. Furthermore, the reviewer commented that the priors developed from this meta-analysis were analyzed as if they were generated in the absence of predation. Like the other reviewers, he questioned why the priors derived from meta-analyses and life-history relationships are relevant unless predation was modeled in the underlying studies, which was not the case. The results appear to be heavily influenced by the informative prior on B_{1918}/K, as the posterior distribution is bounded by the upper tail (see Figure 13 of the working paper). This prior is arbitrary, and it is not clear to the reviewer why it is so strongly informative rather than being appropriately diffuse or even non-informative. Table 13 shows this to be one of the most sensitive assumptions in terms of current depletion.

The reviewer commented on model fit by noting all non-zero process errors shown in Figure 12 of the working paper (panel c) are positive. He suggested this could be considered a poor residual diagnostic which indicates that the deterministic stock declines are less plausible given the data. Nevertheless these results are what is used for the projections. He further questioned whether model results are sensitive to the standard deviation parameter describing the deviations in surplus production (σ_p), as the use of a fixed value is not clearly justified in the working paper.

The Bayesian surplus production model and the methods used to derive data sources were considered to be well documented in this assessment. However, the reviewer suggested that improved explanations should be provided for (*i*) the method of determining the proportions of prey in scat samples, (*ii*) the determination of target species in logbook records to allow potential biases to be assessed in the choice of records to omit from the analysis, and (*iii*) the proportion of logbook records excluded. Reviewer 1 also noted that development of an age-structured model is not obviously precluded by the available sample sizes and suggested that such a model should be constructed in order to evaluate what additional information might be gained by making use of all available sources of data, e.g., length and age frequency distributions. The sentiment to evaluate an age-structured model was also expressed by the other reviewers.

Reviewer 1 supported the organization of the decision table to contain several alternative management actions and summarize the results among alternative states of nature. He cautioned that managers are not encouraged to select a state of nature, but to select a management action and then evaluate plausible outcomes across alternative states of nature. He suggested it would provide a helpful comparison case for managers if results for sensitivity runs without explicit pinniped predation were updated to reflect the 2006-2009 catch per unit effort (CPUE) data.

Reviewer 2 noted the relatively novel decision to include pinniped predation into yelloweye rockfish assessments and the resultant exposure of (*i*) several key assessment uncertainties and (*ii*) failings in the development of operational target reference points. The reviewer suggested that more consideration be given to the choice of functional response type used in the model and encouraged the authors to provide more explanation to justify their choice with appropriate citation of supporting literature. The reviewer argued that the form of the predator functional response curve is a key determinant of predicted population dynamics and is therefore also a key factor in the determination of policy analyses. He criticized the omission of any discussion of the form of the functional response as a key model uncertainty and provided a synopsis of alternative response predator-prey functional forms and their possible implications.

Reviewer 2 concluded that the author's contention that age-structured data are insufficient to provide a reliable fully age-structured assessment model is both false and is inconsistent with the objectives of the analysis. His view is that the justification for building an age-structured model is to examine key sensitivities such as changes in targeting behaviour by the fishing fleet or predators that might have arisen with changes in targeting on yelloweye rockfish due to abundance trends or interactions with other species, or due to changes in fishing technology. He noted that the authors had identified prey size preference as a key hypothesis to examine, but had made no attempt to consider time varying selectivity of the fisheries.

Reviewer 2 suggested that the introduction of predator-prey interactions renders meaningless both prior and posteriors values for leading production model parameters (*r, K*), as well as the definition of simple reference points such as maximum sustained yield (MSY) and fishing mortality at MSY, F_{MSY}. He noted previous work that considered the absence of meaningful operational definitions of fisheries reference points in an ecosystem context and asked for a discussion of how MSY is defined with multiple sources of removals with different selectivity functions operating. The reviewer stated that if yelloweye rockfish population dynamics are strongly determined by pinniped densities, then both leading and derived parameters will depend also on equilibrium pinniped conditions. He questioned the construction of prior probability distributions in the presence of predator-prey interactions, citing complications due to the assumed distribution of natural mortality in development of the prior for *r* that occur in the presence of pinniped-induced mortality. He questioned the assumption of stationarity, noting that capacity and productivity depend on the risk ratio of predators to food supply, during a period when pinniped populations had undergone significant changes in abundance. The reviewer concluded that this assessment helped to expose the difficulties of defining operational fisheries reference points in an ecosystem context such as that posed by the consideration of pinniped predation on yelloweye rockfish.

Reviewer 2 suggested more work was required to describe the development of commercial CPUE indices. In particular he requested clarification on whether records were filtered to remove zeros, whether any data imputation occurred for areas no longer fished, and whether movement of fleets (or pinnipeds) among areas within the assessment region. The latter phenomenon can cause bias in linear model treatments of spatially resolved data. Finally the reviewer asked for specific details on the form of the growth modeling to allow review and discussion of possible bias in priors and the estimates of growth parameters.

Reviewer 3 also acknowledged the authors' efforts to bring forward consideration of the difficult implications of pinniped predation for fisheries management. For example, the analyses raise the questions of how to manage a population that may be undergoing unsustainable rates of predation, and what the meaning of MSY would be for such a population. However, the reviewer suggested that a major shortcoming of the paper was the lack of discussion of the applicability of fisheries reference points in the presence of changing mortality due to predation, pointing out that major problems can arise in interpreting quantities such as MSY and B_{MSY}. If predation is being modeled as a process outside the intrinsic rate of growth, *r*, then the carrying capacity *K* becomes a theoretical parameter (K_0 in the assessment) representing the carrying capacity *in the absence of fishing and predation*. Unless predators were introduced into the system after the reference year, which they were not, K_0 can be assumed to have never existed. Furthermore, MSY, calculated as $rK_0/4$, and B_{MSY}, calculated as $K_0/2$, are also in reference to the state without fishing or predation. Therefore reference points that depend on MSY and B_{MSY} cannot be expressed without reference to the level of pinniped predation. Keeping in mind that MSY and B_{MSY} are long-term, equilibrium concepts, B_{MSY} in the absence of pinniped predation is a different quantity to B_{MSY} at the current level of pinniped predation.

Reviewer 3 noted that the working paper does not specifically relate the computed fishery reference points to those suggested by DFO policy outlined by the Sustainable Fisheries Framework (DFO 2009). For example, if values for the LRP and USR respectively are $0.4B_{MSY}$ and $0.8B_{MSY}$.then in conventional surplus production models B_{MSY} occurs at $0.5B_0$. If B_{1918} can be assumed to represent the unfished population, this implies that the LRP would occur at $0.2B_{1918}$ and USR would occur at $0.4B_{1918}$. Therefore, the values for B_{2009}/B_{1918} given in Table 13 of the working paper imply that the yelloweye population is in the Critical Zone for all scenarios.

Reviewer 3 pointed to two major sources of structural uncertainty that were not explored in the assessment: (*i*) the form of the functional response describing the consumption rate of predators per prey as a function of prey density; and (*ii*) the structure of the population dynamics model, e.g., surplus production versus age-structured. A Type I (capped linear) functional response was adopted in the analysis, which excluded consideration of mechanisms that would permit depensatory predation rates at low prey density; prey switching by the predator as the relative abundance of prey types vary, spatial refuges, or foraging arena theory (e.g., a Type III functional response). The Type III response can include search time and handling time. Although the authors cite the lack of information on handling time as a reason for not exploring the Type III functional form, they acknowledged that it could permit persistence of yelloweye rockfish at high levels of predator abundance. The reviewer suggested that sensitivity of results to the functional response type should be included in future work, and strongly encouraged the authors to include discussion of the large body of predator-prey theory that examines complex interactions between predators and fisheries that may include multiple stable states. In particular, the reviewer provided references to a number of papers that specifically consider interactions among marine mammals, their prey, and fisheries. The reviewer reported that the main conclusions of these papers suggest that (*i*) the complex interactions among mammal predators, fish and fisheries are often mitigated by other components of the ecosystem; and (*ii*) the definition of maximum sustainable yield changes when predators are explicitly taken into account.

The reviewer's main concern related to the lack of discussion of the most appropriate management actions, stating that in its current form the assessment is unable to provide direct management advice and therefore does not directly meet the objectives for the assessment. The reviewer suggested this issue should be the focus of subsequent work given the major uncertainties in predator-prey dynamics among pinnipeds and yelloweye rockfish are unlikely to be resolved in the near future.

Reviewer 3 noted that the authors make mention of the possibility that larger rockfish could avoid predation by pinnipeds. The reviewer stated that selectivity by predators or a fishery is a key determinant of maximum sustainable yield, and selectivity effects cannot be explored without an age-structured model. The reviewer concluded there is sufficient information about life-history parameters and the age structure of the population to construct an age-structured model, even if application is limited to generating plausible scenarios for selectivity and changes in selectivity over time. Temporal dynamics implied by the late maturity of this species could also be explored with an age-structured model. In addition, the key reference point F_{MSY} will be strongly influenced by size-selective predation and fishery effects, and by other factors such as the ratio between age at first harvest and age at maturity. The opinion of the reviewer was that this work should be extended to examine the effects of size-selective predation on model predictions and management advice.

The authors responded to the criticism of relatively precise prior distributions noted by Reviewer 1 by explaining that the high precision was required to enable successful model fitting. However, the effects of those assumptions were examined using the sensitivity tests. Reviewer 1 questioned whether the posterior probabilities could be reliably interpreted in the face of strong influence from the priors.

GENERAL DISCUSSION

The Chair reviewed the requirements of the working paper identified in the terms of reference (Appendix 1), asked that discussion be framed around the questions raised by the reviews, and opened general discussion to the Committee.

General discussion was centred on the themes of (*i*) reliability of the catch reconstruction, (*ii*) reliability of CPUE indices, (*iii*) reliability of the pinniped consumption and abundance estimates, (i*v*) interpretation of fishery CPUE indices, and (*v*) selection of the preferred model hypothesis.

Catch Reconstruction

Discussion of the quality of the catch reconstruction for the assessment area was framed around the widely known problems of species composition, misreporting of area of capture, and accuracy of reported landings prior to 2006. Industry participants questioned the accuracy of catch (landings) reported for the early period of the reconstruction to 1951. One participant noted that Yamanaka et al. (2006) had excluded these data and objected to their use in the current working paper. Both DFO and industry participants noted that rockfishes were landed under the “red rockfish” designation up to the 1960s and 1970s and consequently species discrimination is poor for this period. An industry participant thought the overall estimate of the yelloweye rockfish biomass series seemed high for the Strait of Georgia, and noted that many of the fish landed in Vancouver prior to the 1980s was actually caught on the west coast of Vancouver Island. However, it was also pointed out that no reliable data on the level of at sea releases is available prior to 2006; consequently these unknown removals are not reflected in the annual landings data. Furthermore, the rate of at-sea release varied over time with the accumulation of various management measures such as the introduction of trip limits in 1981. Another participant noted that the landings data in the 2006 paper had included some catches 4-5 times higher than those presented in the current paper for the post-1951 period.

The authors briefly described their work to resolve yelloweye rockfish catches up to 1951 using Dominion Bureau Statistics. A management participant suggested that the report on the catch reconstruction methodology be tabled at CSAP to resolve the discussion in anticipation of future analyses. A participant from the BC Provincial government related his experience when developing landings series for lingcod (*Ophiodon elongatus*). It was determined that lingcod from District 1 had been double counted in the Dominion Bureau Statistics. The accounting error was resolved in the transition from the Dominion data system to the sales slip system in 1951. The decision taken for the lingcod analysis was to exclude District 1 catch data up to 1951. His view upon recent inspection of the rockfish series in the Dominion Bureau Statistics was that the same problem may exist for “red rockfish”.

The authors responded that uncertainties around the level of historical catch are unlikely to be resolved. That uncertainty motivated the sensitivity tests provided in the working paper which include cases where historical catches are 50% lower or higher than the reported values. They additionally pointed out that the causes of shortcomings in the pre-1951 data are not consistent among years and cannot be easily addressed by simple data manipulations, even in sensitivity tests. However, the authors predicted that a sensitivity test where District 1 catches were removed from the analysis would result in outcomes very similar to the results for the existing sensitivity test where catches were reduced by 50%. Industry participants suggested that the level of landings back to 1918, or even the choice of 1918 as a starting year for the analyses, could have a significant impact on the calculation of limit reference points and rebuilding targets.

The authors suggested it is possible to implement additional sensitivity tests that use the BSP model without predation to evaluate how catch uncertainties affect results, and they predicted that (*i*) the results of such tests would be similar to those cases with relatively low rates of pinniped predation, and (*ii*) that the BSP model could be more sensitive to misspecification of landings data than models that included pinniped predation.

Fishery CPUE Indices

Industry participants questioned the use of fishery CPUE indices, pointing out that yelloweye rockfish had, over time, become a species to be avoided and therefore fishery-dependent indices could not be considered proportional to abundance. Representatives of the hook and line Zn-licensed fleet stated that yelloweye rockfish are no longer a desirable species for the Strait of Georgia because they cannot be marketed live, and that this statement is particularly true beginning in 2006. Industry participants were generally skeptical of the accuracy of the estimates of yelloweye rockfish catches from 1997-2005 based on expansion of logbook records. The authors responded that for hypotheses that include pinniped predation, results were relatively insensitive to the assumed level of the catch series, i.e., 50% lower or higher.

Pinniped Consumption and Abundance Estimates

Discussion of the pinniped data was related to two main themes, namely the credibility of pinniped consumption estimates as raised by the reviewers, and the appropriateness of the Stellar sea lion abundance index. A Science participant clarified that the Alaska Stellar sea lion foraging data pertains to juvenile animals rather than adults and is derived from summer activity only. The authors clarified that estimates of the proportion of rockfish in a Stellar sea lion diet was obtained via personal communication with A. Trites but that reported subsequent research had located papers that show evidence of yelloweye rockfish in pinniped diets. Based on this literature the authors suggested it was reasonable to assume up to 11 percent of the diet may be rockfish and some component of that must be yelloweye rockfish. Sensitivity tests set the percentage of yelloweye rockfish between 0.12 and 1.2 percent; the low values yielded model results similar to the BSP case with no predation component. They referred to Table 13 in the working paper, citing results for the hypothesis where yelloweye rockfish comprise 0.3 percent of the diet as an example. However, the authors argued that the posterior probabilities suggest that consumption rates at the lower end of the tested range are not as plausible as higher values. They concluded that even if the diet composition and Stellar sea lion numbers were reduced to a third of the reported values the model predicted that pinnipeds were on the threshold of having a fairly substantial impact.

A Science participant clarified that he is aware of only one record of yelloweye rockfish being observed in samples from Stellar sea lions in samples collected from outside of the assessment area. The utility of the Stellar sea lion abundance index was questioned by the same Science participant. He stated that the abundance index used in the assessment is inappropriate for the assessment area because (*i*) data outside the assessment area are included in the index and (*ii*) there are few Stellar sea lions in the Strait of Georgia and Johnstone Strait in summer months. Industry participants, however, reported their presence in late July when fishing Johnstone Strait. The Science participant also reported that the “inside waters” definition used for the derivation of abundance estimates and that used to determine diet components were significantly different. He suggested that rockfish comprise perhaps 0.5% of the Stellar sea lion diet within the assessment area.

Other participants questioned the assumption of time-invariant diet components as the relative abundance of prey species such as Pacific herring (*Clupea harengus pallasi*) and salmonids, had certainly changed over the assessment period. There was additional discussion related to the use of longline survey species composition as a surrogate for the proportion of rockfishes in diet, i.e., different surveys would lead to different estimates. One participant supported the view of a reviewer who had suggested that the availability of yelloweye rockfish to survey gear would be much different (lower) than their availability to pinnipeds. The participant suggested that much smaller estimates of the proportion of yelloweye rockfish could be obtained from other survey sources. He argued that the assessment should be revised to reflect a more traditional single species assessment with an alternative hypothesis that explored predation effects. A Science participant suggested that the ROV surveys might provide a reasonable basis estimating the proportion of yelloweye rockfish to total rockfish available for predation.

A Science participant held the view that pinnipeds would be focusing on juvenile yelloweye rockfish, suggesting that age-based selectivity is important. An industry participant suggested that mortality of rockfishes due to pinniped predation could be higher than represented in diet data because of fish killed but not consumed, e.g., during interaction with fishing gear.

The authors provided clarification that the fraction of yelloweye rockfish predated upon varies linearly with prey abundance to a maximum, e.g., saturation occurs so that pinniped predation is bounded.

Reference Points

The reviewers had identified that reference points that depend on MSY and B_{MSY} cannot be expressed without reference to the level of pinniped predation; B_{MSY} in the absence of pinniped predation is a different quantity to B_{MSY} at the current level of pinniped predation. The Committee requested that information describing the development and interpretation of reference points presented at the meeting should be included in the paper. A reviewer noted that the working paper cites the Terms of Reference requirement for limit, upper stock and target reference points but these quantities are not mentioned subsequently in the document. Instead, performance benchmarks such as median($B_{\mathrm{final}}/0.5B_{\mathrm{init}}$), P($B > 0.4B_{\mathrm{init}}$), and P($B_{\mathrm{final}} > B_{2009}$) are used without supporting rationale for compliance with DFO (2009).

An industry participant suggested that it was premature to discount the potential impact of the 75% reduction in TAC that occurred in 2002, citing the lag in recruitment response to a reduced F attributable to the estimated age of maturity for yelloweye rockfish. The authors agreed that the BSP model could not anticipate the lag due to late maturity of this species but noted that even with no fishing during the projection period for PBSP model hypotheses, the population declined over time.

CONCLUSIONS AND RECOMMENDATIONS

The Chair opened discussion on whether the working paper had met the requirements of the Terms of Reference. Each requirement was reviewed and the associated Committee discussion is provided below.

Review of the working paper identified problems in the definition and application of MSY-based reference points, and large uncertainties in pinniped diet and population index assumptions. Reviewers agreed that major structural assumptions, such as the choice of a Bayesian surplus production model in favor of an age-structured model, or the choice of the function form of the predator-prey relationship merited reconsideration. These choices are likely to have impacts of management advice at least as large as those factors evaluated in sensitivity tests provided in the working paper. Consequently, conclusions regarding the applicability of management advice arising from this working paper were deferred pending (*i*) re-assessment of data inputs primarily related to pinniped consumption and population abundance, (*ii*) the completion of additional model sensitivity tests for the BSP model without predation, and (*iii*) development and interpretation of MSY-based reference points in the presence of removals due to pinniped predation. The revised working paper will be re-examined via a regional advisory process in 2011.

The Committee conclusions with respect to the working paper can be summarized as follows:

1. Regardless of model formulation, the status of the inside yelloweye rockfish population is well below the minimum reference point for all hypotheses (e.g. the population is less than $0.2B_{\text{init}}$ for all outcomes);
2. Management implications between hypotheses that include predation and a traditional BSP model are very different, i.e., the yelloweye rockfish population is projected to recover only in the absence of pinniped predation. Projections for all hypotheses with pinniped predation suggest the yelloweye rockfish population will go to extinction or at best will not rebuild in 40 years even when the fishing mortality is trivial. Paradoxically, fishing mortality is a large determinant of future population status for BSP cases without predation and implies management actions related to the fishery will yield positive results;
3. A large main uncertainty in the PBSP model is the percentage of yelloweye rockfish in pinniped diets, outweighing even the uncertainty attributable to fishery removals. Yet there are no direct observations that yelloweye rockfish are specifically identified in the diet of pinnipeds. Despite this uncertainty, only one hypothesis explored the effects of ignoring pinniped predation and was assigned a low plausibility weighting. The Committee adopted the position that uncertainty related to the reliability of data and assumptions used to derive the proportion of yelloweye rockfish in pinniped diets makes inferences about the impact of the predator-prey relationship tenuous and weakens the hypothesis that pinniped abundance is the dominant driver of yelloweye rockfish abundance;
4. The reference points provided in the working paper differ from guidelines provided by DFO (2009) policy without supporting rationale to demonstrate compliance with the Precautionary Approach. Furthermore the development and interpretation of MSY, and MSY-based reference points in the presence of predation is not explained in the working paper;
5. The effect of the prior for B_{init}/K_0 prior is very strong yet it is set assuming a high predation scenario at 0.10. This parameter was fixed for all sensitivity analyses and should be considered a key uncertainty;
6. All catch sensitivity tests should be repeated using the BSP model without a predation component;

7. The Stellar sea lion and California sea lion abundance indices utilizes data outside of the assessment area that must be revised;
8. There is a need for much expanded development of management objectives in anticipation of a potential requirement for trade-off decisions between yelloweye rockfish and pinnipeds. This work, though outside the scope of the working paper, is required for future development of management advice for the inside population of yelloweye rockfish.

The Chair closed the meeting at 4:30PM, September 22, 2010.

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APPENDIX 1: TERMS OF REFERENCE

Terms of Reference

Centre for Science Advice Pacific (CSAP)
Groundfish Standing Committee

Pacific Regional Advisory Meeting

September 22, 2010
Seminar Room, Pacific Biological Station
Nanaimo, BC

Chairperson: Greg Workman

Background

Declines in inshore rockfish catch indices, particularly within the Strait of Georgia were first reported early on in the commercial fishery. Inshore rockfish assessments throughout the 1990's identified numerous symptoms of stock decline yet data sources were insufficient to set sustainable Total Allowable Catches (TACs). Recommendations to manage rockfish across all fishery sectors and institute spatial management measures to protect a portion of the inshore rockfish population led to the development and implementation of the Rockfish Conservation Strategy (RCS) in 1999. Fisheries and Oceans Canada (DFO) initiated action on the RCS in consultation with industry, First Nations, as well as the general public. The RCS articulated 4 key objectives: account for all inshore rockfish catch; decrease fishing mortality; establish rockfish protection areas; and improve stock monitoring and assessment.

In 2006 the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) requested and received from DFO a report summarizing the biology, life history, catch history and trends in yelloweye rockfish abundance. In November 2008, COSEWIC reviewed this report and designated the species (both the inside and the outside populations) as *Species of Special Concern.* Yelloweye rockfish were last assessed by DFO Science in 2001.

In support of continued implementation of the Rockfish Conservation Strategy and management of those fisheries where targeted and non-targeted catch of yelloweye rockfish occurs, DFO Pacific Fisheries and Aquaculture Management Branch have asked Science Branch for an assessment of resource status.

Objectives

One working paper will be reviewed at this science advisory review process:

"Stock assessment for the inside population of yelloweye rockfish (Sebastes ruberrimus) in British Columbia, Canada"

Guided by the DFO Sustainable Fisheries Framework, particularly the Fishery decision-making framework incorporating the Precautionary Approach the following objectives for this assessment have been established:

- Recommend a Limit Reference Point (LRP), an Upper Stock Reference (USR), Target Reference Point (TRP) and Removal Reference for the inside population of yelloweye rockfish;
- Assess the status of the inside stock of yelloweye rockfish relative to the recommended limit reference points;
- Provide rationale for the recommended LRP, USR and TRP candidates if they differ from the PA default reference points;

- Evaluate the consequences of varying harvest levels on future population trends.

Products

- CSAS Proceedings document summarizing the subcommittee discussions of the review.
- CSAS Research Document based on the working paper presented.
- CSAS Science Advisory Report, summarizing key conclusions and science advice.

Participants

Participants (approx. 25) will include authors, reviewers, internal DFO representatives and invitees from academia, First Nations, NGO's and the commercial and recreational fishing industry.

APPENDIX 2: ATTENDEES

Last Name	First Name	Affiliation
DFO PARTICIPANTS		
Acheson	Schon	Science, Groundfish Section
Anderson	Kris	Science, Groundfish Section
Edwards	Andrew	Science, Groundfish Section
Flemming	Rob	Science, Groundfish Section
Forrest	Robyn	Science, Groundfish Section
Haigh	Rowan	Science, Groundfish Section
Holt	Kendra	Science, Groundfish Section
Joyce	Marilyn	Science, CSAP
Keizer	Adam	FAM, Groundfish Management
Kronlund	Allen	Science, Groundfish Section
Mawani	Tamee	FAM, Groundfish Management
MacConnachie	Sean	Science, Conservation Biology
Ou	Wan Li	FAM, Groundfish Management
Olesiuk	Peter	Science, Conservation Biology
Schweigert	Jake	Science, Conservation Biology
Stanley	Rick	Science, Groundfish Section
Tadey	Rob	FAM, Groundfish Management
Taylor	Nathan	Science, Groundfish Section
Workman	Greg	Science, Groundfish Section
Yamanaka	Lynne	Science, Groundfish Section
EXTERNAL PARTICIPANTS		
Argue	Sandy	Province of British Columbia
Boyes	Dave	Commercial Industry Caucus, Halibut
Haggarty	Dana	Parks Canada
Harling	Wayne	Sport Fish Advisory Board
Koolman	John	Commercial Industry Caucus, Rockfish Outside
Kristiansen	Gerry	Sport Fish Advisory Board
MacAllister	Murdoch	University of British Columba
Mose	Brian	Commercial Industry Caucus, Trawl
Renwick	Mike	BC Dogfish Hook & Line Industry Association
Sporer	Chris	Pacific Halibut Management Association
Stewart	Ian	National Marine Fisheries Service
Turris	Bruce	Canadian Groundfish Research and Conservation Society
Wallace	Scott	David Suzuki Foundation

APPENDIX 3: AGENDA

Agenda

Centre for Science Advice Pacific (CSAP)
Groundfish Standing Committee
Regional Advisory Meeting

September 22, 2010
Seminar room, Pacific Biological Station, Nanaimo, BC
Chairperson: Greg Workman

Convene – Review Agenda Introductions Review terms of reference	09:00
Presentation: Stock assessment for the inside population of yelloweye rockfish (*Sebastes ruberrimus*) in British Columbia, Canada. K.L. Yamanaka, M.K. McAllister, M.-P. Etienne, S. Obradovich, and R. Haigh.	09:15
Coffee	10:15
Reviews: • Ian Stewart, NOAA Fisheries • Nathan Taylor, Groundfish Section, PBS • Robyn Forrest, Groundfish Section, PBS Committee discussion	10:30
Lunch	12:00
Committee discussion Address review questions • Is the purpose of the working paper (Advice) clearly stated? • Are the data and methods adequate to support the conclusions? • Are the data and methods explained in sufficient detail to properly evaluate the conclusions? • Are the recommendations provided in a form useful to a fisheries manager? • Does the advice reflect the uncertainty in the data, analysis or process? • Can you suggest additional areas of research that are needed to improve our assessment abilities?	12:45
Coffee	14:30
Acceptance of working paper Formulate recommendations • to FAM • to Authors Discussion of next steps – formulation of SAR	14:45 16:30