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**Canadian Science Advisory Secretariat (CSAS)**

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**Pacific Region**

# Proceedings of the Pacific regional peer review on Lingcod Assessment (*Ophiodon elongatus*) for the Strait of Georgia (Area 4B), British Columbia in 2014

**December 10-11, 2014**
**Nanaimo, BC**

**Kate Rutherford Chairperson and Editor**

Fisheries and Oceans Canada
Science Branch
3190 Hammond Bay Road
Nanaimo, BC V9T 6N7

December 2015

Canada

**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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## SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO), Canadian Science Advisory Secretariat (CSAS) Regional Peer Review meeting of December 10-11, 2014 at the Pacific Biological Station in Nanaimo, B.C. One working paper focusing on a stock assessment of Lingcod in the Strait of Georgia, British Columbia was presented for peer review

In-person and web-based participation included Fisheries and Oceans Canada (DFO) staff from the Science and Fisheries and Aquatic Management Sectors; and external participants from First Nations organizations, the commercial and recreational fishing sectors, environmental non-governmental organizations, and academia.

The conclusions and advice resulting from this review will be provided in the form of a Research Document and a Science Advisory Report providing advice from Science to managers and other clients. These documents will be publicly available on the DFO's CSAS website.

## Compte rendu de l'examen par les pairs de la Région du Pacifique sur l'Évaluation de la morue-linge (*Ophiodon elongatus*) du détroit de Georgia (zone 4B), Colombie-Britannique en 2014


### SOMMAIRE

Le présent compte rendu résume les discussions et les principales conclusions de la réunion régionale d'examen par des pairs de Pêches et Océans Canada (MPO) et du Secrétariat canadien de consultation scientifique (SCCS) qui a eu lieu du 10 au 11 décembre 2014 à la Station biologique du Pacifique de Nanaimo, en Colombie-Britannique. Un document de travail sur l'évaluation du stock de morues-lingues dans le détroit de Géorgie, Colombie-Britannique a été déposé aux fins d'examen par les pairs.

Au nombre des participants en personne ou par conférence Web, il y avait des employés des secteurs des Sciences et de la Gestion des pêches et de l'aquaculture de Pêches et Océans Canada (MPO), et des participants externes provenant d'organisations des Premières Nations, des secteurs de la pêche commerciale et récréative, des organismes non gouvernementaux environnementaux et des universités.

Les conclusions et avis découlant de cet examen seront présentés sous la forme d'un document de recherche et d'un avis scientifique offrant des conseils du Secteur des sciences aux gestionnaires et à d'autres clients. Ces documents seront accessibles au public sur le site Web du SCCS du MPO.

## INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS), Regional Peer Review (RPR) meeting was held on December 10-11, 2014 at the Pacific Biological Station in Nanaimo to review the stock assessment of Lingcod in the Strait of Georgia, British Columbia.

The Terms of Reference (TOR) for the science review (Appendix A) were developed in response to a request for advice from the Fisheries Management Branch of DFO. 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 and academia.

The following working paper (WP) was prepared and made available to meeting participants prior to the meeting (abstract provided in Appendix E):

> Stock assessment for Lingcod (*Ophiodon elongatus*) for the Strait of Georgia, British Columbia in 2014, by Kendra Holt, Jacquelynne King and Brian Krishka. (CSAP WP2014-15/GF10).

The meeting Chair, Kate Rutherford, welcomed participants, reviewed the role of CSAS in the provision of peer-reviewed advice, and gave a general overview of the CSAS process. The Chair discussed the role of participants, the purpose of the various RPR publications (Science Advisory Report, Proceedings and Research Document), and the definition and process around achieving consensus decisions and advice. 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 Terms of Reference, Agenda and working papers.

The Chair reviewed the Agenda (Appendix C) and the Terms of Reference for the meeting, highlighting the objectives and identifying the Rapporteur for the review. The Chair then 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, and in-person attendees were reminded to address comments and questions so they could be heard by those online

Members were reminded that everyone at the meeting had equal standing as participants and that they were expected to contribute to the review process if they had information or questions relevant to the paper being discussed. In total, 24 people participated in the RPR (Appendix D). Lynne Yamanaka was identified as the Rapporteur for the meeting.

Participants were informed that Jennifer Stahl and Kray van Kirk (both from the Alaska Department of Fish and Game) had been asked before the meeting to provide detailed written reviews of the working paper to assist everyone attending the peer-review meeting. Participants were provided with copies of the written reviews.

The conclusions and advice resulting from this review will be provided in the form of a Research Document and a Science Advisory Report providing advice from Science to managers and other clients. These documents will be publicly available on the DFO's Canadian Science Advisory Secretariat (CSAS) website.

## REVIEW

| | |
|---|---|
| Working Paper: | Stock assessment for Lingcod (*Ophiodon elongatus*) for the Strait of Georgia, British Columbia in 2014. CSAP WP2014-15/GF10. |
| Authors: | Kendra Holt, Jacquelynne King and Brian Krishka |
| Reviewers: | Jennifer Stahl, Alaska Department of Fish and Game |
| | Kray van Kirk, Alaska Department of Fish and Game |
| Chairperson: | Kate Rutherford (Groundfish, MEAD, PBS, DFO) |
| Rapporteur: | Lynne Yamanaka (Groundfish, MEAD, PBS, DFO) |
| Presenter: | Kendra Holt (Groundfish, MEAD, PBS, DFO) |
| Meeting: | Dec. 10-11, 2014, Seminar Room, Pacific Biological Station, Nanaimo BC |

## PRESENTATION OF WORKING PAPER

Unless otherwise specified, text in non-italic font reflects questions and comments from the participants. Italicised text reflects the responses and comments by the authors. The Lingcod meeting participants (Appendix D) are collectively called "participants" herein.

The lead author provided the presentation of the working paper, the Abstract for which appears in Appendix E. Information on stock structure and biology, the fishery and management histories, the 2005 Lingcod Framework and the details of the current assessment were provided. The author described the treatment of both commercial and recreational historic catches and calculations of catch per unit effort (CPUE) in the fisheries.

During the presentation a participant pointed out that qualified CPUE for commercial catch data is problematic because you may not see declines in CPUE, and hence abundance, if you are only including catches that meet a certain cut-off.

*The authors agreed that the qualified CPUE should be revisited in the future.*

There were also several questions of clarification from the participants. The authors were asked if both retained and released fish included for the calculation of recreational.

*The authors responded that retained and released were included.*

It was also asked why the recreational CPUE in the noSE scenario shown in Figure 7 was so different from other catch scenarios and whether there was a plot of the various historical catch trajectories provided.

*The author responded that the information was in Table 5 and the information demonstrates that the SE quadrant accounted for over half of the catch in some years.*

A participant pointed out that the model was started at unfished biomass $B_0$ in 1927 but there were already high catches at that time with the history of the fishery going back to the 1860s.

*Because there is no age data, the model did not support starting at an unfished equilibrium in 1927. The authors agreed that this was a limitation of the assessment, and agreed that a recommendation should be made to reconstruct lingcod catch from aggregated "cod" catch records prior to 1927.*

A reviewer praised the authors on the excellent job and asked a question about the age data – given that there are no age data in the model, where did the age data used to calculate the input selectivity-at-age, length/weight-at-age, maturity-at-age, etc. come from?

*The authors responded that ages were not used in the model but limited amounts of age data were available to estimate length-at-age and maturity-at-age relationships. For the 1979 to 1983 period there were fin-ray ages that provided an age frequency distribution from the commercial samples. These samples were used to estimate length-at-age and maturity-at-age relationships, as well as to approximate reasonable age-based commercial selectivity curves. They also used some recreational fishery length data to inform assumptions about length-based selectivity for commercial fisheries. Different selectivity curves were used for each fishery – age structure will affect the age of recruitment.*

A participant asked if it was possible to provide plots of the process error deviations.

*The authors responded that they were available in Figure F.26.*

*The author also pointed out that there was a strong decline in recreational CPUE over the last 3 years, but that the model ignores this because the recruitment process error is constrained to be quite tight in all scenarios. One hundred percent of the scenarios showed that the stock had a 100% probability of being larger in 2014 than in 2006; however, in the last 3 years CPUE is declining, so this strong probability of increase may be due to process error constraint. The model is unable to predict a decline in recruitment in recent years. As a result, the 100% probability of increase since 2006 may be overly optimistic.*

A participant suggested that this limitation should be made clear in the final research document.

*The authors agreed.*

A participant asked whether the recreational data was standardized to time period because of the changes in monitoring over time.

*The authors responded that only CPUE data from the summer months was used to calculate a recreational CPUE index for all years.*

A participant suggested that the authors' interpretation of the way in which assumed density-dependent catchability relationships between CPUE and abundance affect estimated biomass trajectories (which the authors discuss in the working paper and mention during the presentation) needs more thought. Hyperstability in this relationship will mean that CPUE will remain high even when the underlying biomass is declining. The participant suggested that the inclusion of hyperstability (or the opposite effect, hyperdepletion) in some of the Lingcod scenarios will affect estimates of population scale.

*The authors agreed that there needed to be more thought on the interpretation of the CPUE data, and agreed to correct or remove their original interpretation from the working paper.*

## WRITTEN REVIEWS

Unless otherwise specified, text in non-italic font reflects the questions and comments from the reviewer. Italicised text reflects the responses and comments by the authors. The Lingcod meeting participants (Appendix D) are collectively called "participants" herein.

### KRAY VAN KIRK

The review was presented by phone, accompanied by summary slides.

The reviewer began by questioning whether the age structure was based on selectivity and age composition (distribution) curves as the selectivity curves have an effect on the model outcomes.

*The authors stated that this should be investigated further in the future. Selectivity curves were not fit to age data; rather, a few years of available age distributions were likely examined by the*

*authors of the 2005 assessment to approximate a reasonable selectivity assumption. These 2005 assumptions were carried forward to the current assessment. The authors acknowledged that the selectivity curves were assumed known without error, and agreed that this would have an impact on model outcomes.*

The reviewer asked about sample sizes and whether a delay-difference model might have been more appropriate. He was uncomfortable with the level of assumed precision.

*The authors stated that there were between 5000-6000 fin-ray ages from the commercial fishery between 1979 and 1982 that were used as a basis for assumptions about selectivity.*

The reviewer was fine with this.

A participant at the meeting suggested that the assessment model could have actually been fit to these 5000 samples.

The authors agreed that this was a good idea for future consideration.

The reviewer said he would expect to see a significant decrease in the older age classes and if you didn't see it then there is something to worry about in the code.

*The authors agreed to create plots for the second day of the meeting that would show changes in model predictions of age structure over time.*

The reviewer pointed out that Lingcod are sexually dimorphic but the model used a single value for natural mortality (M) for males and females.

*The authors replied that the model would have required reconfiguration and this was not done due to time constraints but agreed that it was a good suggestion.*

The reviewer asked if there were constraints on fishing mortality (F). And, if F was not constrained why didn't the model cope with the outlying high recreational fishery data point?

*The authors replied that the range for F was quite broad, 0-20, but that the model restricts the standard deviation on catch in a given year via a user-specified standard deviation on predicted catch variability. This restriction on catch explains why the model did not attempt to fit to the outlying high recreational catch value during the 1980's.*

The reviewer pointed out that the GLMs that were considered for standardizing recreational CPUE indices were unable to account for the variability on the CPUE and questioned whether they looked for normality.

*The authors replied that the GLM models they considered did not require an assumption of normality because they used non-normal distributions to model the response variable of CPUE; specifically, a log-normal distribution, a binary binomial distribution, and a compound Poisson-Gamma model.*

The reviewer replied that transformation to a normal distribution comes prior to the GLM. He referred to Terry Quinn's book (p. 30) (Quinn and Deriso 1999) for a box-cox transformation of CPUE to normalize it before conducting the GLM.

An industry participant pointed out that with qualified commercial CPUE, you are not seeing the low CPUE values and that makes it appear hyperstable and also makes the stock look bigger than it is.

*The authors agreed that the use of qualified CPUE is not good and would recommended running the GLM on the commercial CPUE dataset.*

The reviewer agreed with the working paper's suggestion for the development of a fishery-independent survey for an index of abundance and for the collection of biological data, including age structures.

In closing, the reviewer asked whether the authors could provide any insight to the presented model scenarios.

*The authors replied that they were unable to pick one out in the working paper but they were not a fan of removing the SE area (noSE scenario) because there is no biological basis for this. It also precludes a fishery in that area because there is no advice provided for the area and no data being collected.*

The reviewer concluded by complimenting the authors on their great job with the bridging analysis

## JENNIFER STAHL

The reviewer was unable to attend and the chair presented summary slides of her comments.

Abundance Indices

1. The reviewer stated that we are looking at a data poor stock and the recent abundance indices are based on the recreational fishery. There is an issue that the recreational fishery data combines both target and non-target trips for lingcod. Is it possible to look at only targeted lingcod trips?

*The authors replied that, based on previous analysis done by Vivian Haist (1995), targeted trips were hyperstable. Furthermore, there were data limitations prior to 2007 that make it difficult to properly tease apart targeted and non-targeted Lingcod catch. Overall there is very little data so wanted to use it all.*

2. The reviewer agreed with the need for a fishery-independent survey on this stock, taking the patchy distribution of lingcod into account in the survey design.

Catch/CPUE Information

1. The reviewer asked for clarification on what recreational gear was used, just hook and line or other types? There would likely be different CPUE for different gear types.
2. It was also asked whether there were any subsistence fisheries currently or in the past? These may have an impact on abundance.
3. The reviewer agreed with the authors that they should include discard mortality in the future and that they should include estimates for the numbers of discards.

*The author replied that recreational gear only includes hook and line gear. Some catch is also taken by spear-fishing gear with scuba equipment, but no catch. There are no data for First Nations catch. The authors agreed with the point on including discard mortality in the future, which was included as a research recommendation in the working paper.*

4. The reviewer suggested that the authors may want to consider different criteria for determining if a commercial trip targeted lingcod instead of a minimum weight landed. They could explore using trips where lingcod catch is greater than 50% of the catch.

Biological Parameters

1. The reviewer suggested that the authors may want to consider some tagging studies to confirm that the Strait of Georgia stock is not mixing with the outside population. Information was provided on a tagging study conducted in Southesast Alaska which showed that some fish travelled considerable distances.

2. In addition, studies to obtain updated reproductive parameters such as fecundity and maturity at age and/or length could be performed. The authors might consider investigating if any skipped spawning occurs with this population or if lingcod spawn every year. Skipped spawning has been observed in Atka Mackerel, which are also a Hexagrammidae species.

*The author agreed that life history relationships may not be static, and noted that they have included a recommendation in the working paper that life history relationships be re-evaluated for the next assessment using biological samples currently being collected from the recreational fishery. Re-visiting these relationships will require aging of fin-rays that have been collected, but not aged.*

3. Authors may consider adding some flexibility in the model for maturity in the future instead of using fixed parameters. Maturity-at-age or maturity-at-length may be dynamic and change with water temperature or fish condition, which could be related to food availability and tied to stock density.
4. In addition, weight-at-length parameters were set the same for males and females. However, male and female weight-at length differs for lingcod and the reviewer suggested having different parameters by sex.

*The authors responded that recent analyses for outside Lingcod stocks in BC showed minor differences between female and male weight-at-length relationships (King et al. 2012; figure to support this statement from King et al. 2012 presented to sub-committee by authors). The authors therefore suggested that using separate male and female curves would have much of an effect on assessment outcomes. The authors note however that one of their research recommendations was to update life history relationships for Strait of Georgia Lingcod before the next assessment, so separate male and female relationships will be used for future assessments based on these analyses.*

*For this assessment, the authors chose to use the same weight-at-length relationship for males and females because this was the approach taken in 2005.*

The first reviewer pointed out that the authors could consider using maturity data for the outside area (3CD).

5. Why did the authors use knife-edge maturity for males? Has this been observed in the Strait of Georgia or was the maturity data limited? In Silberberg et al. 2001 and Richards et al. 1990, they don't have this knife-edge maturity.

Selectivity

1. The model used the same selectivity-at-age for males and females for the commercial fishery and the recreational fishery prior to 1991; even though, lingcod have differences in length-at-age relationships by sex. Authors indicate the program they are using may not allow selectivity by age and sex. Instead, authors could model selectivity with length instead of age as they do for the recreational fishery after 1991. This might be beneficial if fishery selectivity is more of a function of length than age.

*The authors stated that they wanted to use the same criteria as the previous model. However, they did try a run with a length-based commercial selectivity: logistic (mean 650mm) in response to this review comment prior to the meeting, and it did not make much of a difference on results. The authors presented slides of model outputs with age- vs. length-based selectivity to support this conclusion.*

2. The authors used the same selectivity-at-age for trawl and hook and line fisheries. I would expect that the selectivity would be different for these different gear types. Also is

longline gear included with hook and line fisheries? Longline gear and other hook and line fisheries may have different selectivity as well, dependent on the size of the hooks. An explanation is needed why the selectivity is combined for these different commercial fisheries.

*The authors replied that they do not have the information to separate these various line gear types out for the early years. However, they also noted that age distributions were similar from the more recent data that they have for trawl and handline, so it seems plausible that selectivity for these two gear types are similar. The authors showed age frequency distributions from both trawl and handline gear previously published in Cass et al. 1990 to support this statement.*

## GENERAL DISCUSSION

At the conclusion of the reviews the chair opened the floor to general discussion.

**Terms of reference**

There was considerable discussion on what the terms of reference were requesting, i.e., stock status and an update on whether this model could provide harvest advice in the future. A participant pointed out that in 2005, the amount of rockfish that would be caught if the lingcod TAC was set at 26,000 pieces would be unsustainable. This is why the model output was not used to set a TAC for Lingcod.

A participant summarized that the authors were asked to reassess the previous model and explore all the assumptions of the model and their effects with the 12 scenarios. The results of this present analysis showed that the "best" model was not necessarily the one previously chosen. It is not necessary to be tied to this model but it does provide the foundation for moving forward with a model-based assessment.

**Current TAC**

Another participant asked if the current TAC of 5-7,000 pieces of lingcod was allowing the stock to increase.

*The author responded that based on modelling recreational catch, the stock is increasing.*

**Other discussion points**

The reviewer asked if acceptance of this paper and using this model in the future for an assessment was linked.

*The author responded that the two are not necessarily linked.*

A CSAP participant pointed out that future use of the model would be part of the discussion and that there may be suggestions for of changes to the model for its future use.

Another participant pointed out that a discussion of the Precautionary Approach (PA) $B_0$ reference points are difficult in this type of model. The model is initiated in 1927 when the catches are already substantial.

A participant asked whether information from the internet survey of recreational catch (iRec) was used.

*The author stated that they did not use the iRec survey data and that a PBS seminar given last year that compared preliminary catch estimates from iRec and creel interviews indicated that the two data streams do not match well for Lingcod catch.*

The participant also pointed out that the term “overfished” should not be used because seal predation and other sources of mortality, other than fishing, have also had an effect on the stock.

*The author noted that the 2005 assessment document used the term “overfished” but agreed that the term could be removed from the current working paper if the subcommittee felt it was not appropriate.*

**Day 2**

At the start of day two the author presented the age distributions predicted by the model (based on MPD fits) for a subset of modelled years (the start year in 1927, a mid-year in 1988 when the stock was heavily depleted, and the final year 2014).

*The authors pointed out that while there were some shifts in the age distribution among years, changes over time were relatively small compared to those expected from age-structured models that are fit to age data. It is believed that this pattern is due to the tight process error constraint in the model; as noted yesterday, the estimated recruitment process error deviations are very small.*

A participant liked the idea of an age-structured model but here with the ages, there is not much of a change. It is essentially a surplus production model.

*An author agreed, but noted that they prefer the age-structured modelling approach used here to a surplus production model because it allows modelers to be explicit about selectivity assumptions, as well as maturity schedules.*

General discussion continued:

**Pinniped predation**

A participant questioned that with the large increase in pinnipeds, did the authors look at the effect of this predation on the lingcod stock?

*The authors noted that this has always been a question and not an unimportant question. The previous assessment used some scenarios in which they treated pinnipeds as a ‘fishery’ that contributed to overall mortality, but that could not account for the declines in lingcod.*

Another participant noted that the model is fitting to very little data and that you are not likely to get a better fit if you add predation but you can assume M is affected before and after the increase in pinnipeds.

*The authors suggested that a comment could be included in the SAR that ecosystem changes in the Strait of Georgia, including increased pinniped predation, could affect the ability of the stock to rebuild, and cite papers on recent studies describing changes in the Strait of Georgia ecosystem.*

**Non-reported mortality**

A participant asked if there was consideration for non-reported mortality in the commercial or recreational fisheries.

*The authors confirm that fishery mortality did not include discard mortality or non-reporting. This is an area where mortality could be included, but would require a lot of work to investigate each fishery, some of which do not exist anymore. Furthermore, frequent management changes to Lingcod fisheries in the Strait of Georgia over time means that a consistent rate could not be applied to a single gear type for all years.*

*When asked specifically about bycatch in the salmon troll fishery, the authors noted that reported bycatch from this fishery was reviewed by an author a couple years ago and was found to be low; approximately 30 fish a year.*

**Removal of noSE scenario**

There was considerable discussion on removing the three noSE scenarios that excluded the entire southeast quadrant (Minor areas 28 & 29) from the Strait of Georgia stock altogether.

One participant suggested taking out the three noSE scenarios all together. Another participant agreed, stating that the other outcomes all seem reasonable and if you remove the noSE scenario, and average the rest there would be very little difference as the reference points are very similar. It was suggested that the authors leave the noSE scenario in the bridging analysis and not as one of the outcomes.

It was pointed out that the noSE scenario was taken out for the whole catch time series, not just between 1927-1932, and is an unreasonable treatment of the data but is a carryover from the previous model.

At the conclusion of the discussions it was decided by the participants to leave the three noSE scenarios in the research document with an explanation of why they were not recommended as a basis for characterizing stock status in 2014. As the SAR is only intended to characterize the final advice, it was decided that the three noSE scenarios would be left out of the SAR and statements of stock status would be based on the remaining nine scenarios. The reasons for excluding the three noSE scenarios from advice is that there is no biological rationale for this delineation and no harvest advice for these areas when they are excluded.

**Catch History**

A participant pointed out that $B_0$ starting in 1927, when the catches were already large, is a problem. Work is required to reconstruct commercial catch and discards back to the 1860s and the recreational fishery can be moved back to a beginning point in the early 1940s rather than in 1962.

The sub-committee agreed that reconstructing catch data from these historical time periods should be a priority for future assessments.

**Model Averaging**

It was asked whether model averaging was needed among the nine accepted scenarios or whether the authors should simply present all scenarios as is because there is no harvest advice being provided, just a stock status update. Recruitment variations and ecosystem productivity are not handled in the model and the model deals with large catches by inflating $B_0$.

A participant pointed out that the advantage of model averaging would be to simplify the determination of stock status if all the scenarios are equally plausible. Managers and stakeholders preferred to see all the plausible scenarios as well as a model average. They felt that if all nine scenarios have equal weight the model average should be put forward along with the uncertainty around all the scenarios.

It was concluded that after removal of the noSE scenarios the remaining nine scenarios were all equally probable/plausible and that they would all be presented along with the model average.

In the research document discussion of stock status the noSE scenario will not be used and the authors will provide justification for its exclusion.

### Acceptance of the working paper

The participants then discussed whether working with this model would be the best option for providing harvest advice in the future and including closed-loop simulations to evaluate management strategies. Due to data limitations, the participants supported the author's recommendation that use of this model should continue to use a scenario-based approach in the future as was done here, and that future scenarios should explore more fully the biological data and selectivity. It was suggested that this model could be used for giving advice right now or in the near future, and in the long term, there could be other methods employed.

If this modelling approach is continued to be used, it would depend on continued interview sampling from the creel survey program. There was a note made that the reporting of recreational catch data in BC is shifting away from only relying on creel interviews and overflights; there is now an iREC program that asks fishers to submit their catches electronically subsequent to fishing trips. Although some creel interviews are also being conducted in conjunction with iREC it is uncertain whether the coverage of the creel survey program will be affected. The iREC program will be reviewed through CSAS.

One participant noted that in New Zealand, regular fishers have phone apps whereby they can report on a weekly basis. Recall estimates are best collected soon after the fishing event.

The group supported the approach for testing management strategies.

One participant suggested that we may have more confidence in the model's ability to assess current biomass trajectories rather than stock status. It may be possible to manage the fishery on an F-based approach, with Fmsy: Umsy. It was pointed out however, that Fmsy predicted from the model would be too high if the predation by pinnipeds has increased since the mid-60's.

### Reference points

It was asked whether there is a need to present both sets of reference points, i.e., 2005 and PA. Implicit in all these reference points is that the productivity has remained unchanged. Given marine mammal predation and climate regime shifts as reasons of below average periods, we may not be able to get back to $B_0$. The decision was made to keep both sets of reference points in the document.

## CONCLUSIONS

## CONSENSUS ON PAPER ACCEPTABILITY

The working paper was accepted. Required revisions are outlined in the following sections.

## CONSENSUS ON LINGCOD ASSESSMENT

- Given the relatively data-poor nature of this stock, the scenario-based approach taken allows the representation of data and biological uncertainties. Future assessments that seek to provide harvest advice should continue to consider a model-averaging approach that incorporates large structural uncertainties into harvest advice. At this time, no harvest advice was requested.

## INSTRUCTIONS TO AUTHORS

- Include explicit mention that 1927 is already a highly fished state; must draw reference to the assumption of equilibrium, unfished state for the start of the model and therefore $B_0$ is likely underestimated.

- Mention that recreational fishing should maybe start in the 1940's (can cite Yelloweye and Quillback Rockfish assessments which used this as a start year).
- Include the caveat that the model does not cope well with the decline in the last four years of recreational CPUE, so it might be optimistic in the last 4 years. Recreational CPUE drops in recent years, but model doesn't; model can't estimate these yet which may affect the validity of conclusions about recovery since 2006.
- Include discussion of ecosystem changes, including potential marine mammal predation and changes in Strait of Georgia productivity.
- Justify why noSE scenario was considered as a scenario, but not used in final stock status advice.
- Include model averaging in the research document; provide a definition, methods and results.
- Remove incorrect discussion on impacts of hyperstability and relationships on recovery rates from Discussion.
- Add to Discussion: the model is not really estimating any recruitment variation, so high catches in the early years need to increase $B_0$ because cannot chalk it up to a few years of high recruitment
- Add to Discussion: implicit in reference points is assumption that productivity is constant. If this isn't the case, what to use?
- Remove the word "overfished"; replace with "short-term recovery target".

## RECOMMENDATIONS

- Continue work to reconstruct / estimate catch prior to 1927.
- Support the need for continuation of the Strait of Georgia creel survey interviews as the estimates are required for CPUE.

## ACKNOWLEDGEMENTS

The Chair thanks the reviewers, Kray van Kirk and Jennifer Stahl, for their thorough reviews, as well as all the participants for their involvement, and Lynne Yamanaka for taking on the task of rapporteur. The assistance of the CSAP office in providing support for the meeting is greatly appreciated.

## REFERENCES


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## APPENDIX A: TERMS OF REFERENCE

### Lingcod Assessment (Ophiodon elongatus) for the Strait of Georgia (Area 4B), British Columbia in 2014

### Regional Peer Review – Pacific Region

**December 10-11, 2014**
**Nanaimo, British Columbia**

Chair: Kate Rutherford

### Context

Lingcod (*Ophiodon elongatus*) are an important component of First Nations, commercial, and recreational groundfish fisheries off British Columbia, Canada. Commercial fishing for Lingcod in British Columbia dates back to the 1860's (Cass et al. 1990), with catch data available from 1927.

Lingcod populations in British Columbia are assessed and managed as five separate units based on DFO Statistical Areas. These units include one inside stock in the Strait of Georgia (Area 4B) and four outside stocks: southwest Vancouver Island (Area 3C), northwest Vancouver Island (Area 3D), Queen Charlotte Sound (Areas 5A and 5B) and Hecate Strait and the west coast of Haida Gwaii (Areas 5C, 5D and 5E). This assessment provides advice for the inside assessment area only (Area 4B). Stock status advice was provided for outside Lingcod stocks in 2011.

Area 4B Lingcod were last assessed in 2005, at which time both the stock assessment and the development of management advice was overseen by a stakeholder committee and approved by CSAP. A set of biomass-based reference points for Area 4B lingcod were developed as part of the assessment. Spawning biomass in 2005 was estimated to be at 16% of unfished spawning biomass (DFO 2005), which led to the stock being characterized as "overfished". Fishing opportunities for Area 4B Lingcod have been limited in recent years. Currently the directed commercial fishery for lingcod is closed within Area 4B and only a minimal recreational fishery is permitted.

The Department continues to implement the *Sustainable Fisheries Framework* (SFF), which is a toolbox of existing and new policies for DFO and other interests to sustainably manage Canadian fisheries in order to conserve fish stocks and support prosperous fisheries. At this time, Fisheries Resource Management Branch has requested that stock status for Area 4B Lingcod be assessed relative to reference points that are consistent with the *Fishery Decision-making Framework Incorporating the Precautionary Approach* (PA), which is a policy nested within the *Sustainable Fisheries Framework* (SFF). This advice will allow GMU to evaluate whether the current management regime has been successful at increasing abundance for Area 4B Lingcod. Updated harvest advice for Area 4B Lingcod has not been requested at this time.

### Objectives

Guided by the DFO Sustainable Fisheries Framework, particularly the *Fishery Decision-making Framework Incorporating the Precautionary Approach*, meeting participants will review the following working paper to provide the basis for discussion and advice on the specific objectives outlined below.

*Holt, K.R., J. King, and B. Krishka. Stock Assessment for Strait of Georgia Lingcod in 2014. CSAP Working Paper 2014-15/GF08*

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

- Determine whether a model-based assessment of Area 4B lingcod is possible at this time, and evaluate whether available data and analyses are sufficient to support implementation of the PA Framework.
    - If a model-based assessment is possible, present recent biomass trajectories with uncertainty and characterize stock status in terms of the DFO PA framework.
    - If a model-based assessment is not possible, provide a rationale for this decision, summarize available data, and identify information gaps.
- Make recommendations for data collection and analytical work to improve the ability of Science to make Area 4B Lingcod harvest recommendations in the future.

## Expected Publications

- CSAS Science Advisory Report
- CSAS Research Document
- CSAS Proceedings

## Participation

- DFO (Science, Fisheries Management, Oceans, FPP)
- Aboriginal communities
- Province of British Columbia
- External reviewers
- Industry
- Non-governmental organizations and other scientists and stakeholders.

## References

Cass, A.J., R.J. Beamish, and G.A. McFarlane. 1990. Lingcod (*Ophiodon elongatus*). Can Spec. Publ. Fish. Aquat. Sci. 109: 40p.

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DFO, 2009. Sustainable Fisheries Framework.

DFO. 2009. Fishery Decision-making Framework Incorporating the Precautionary Approach.

## APPENDIX B: WORKING PAPER REVIEWS

### REVIEW – KRAY VAN KIRK

The authors are to be commended for a thorough assessment under difficult conditions of high uncertainty and data scarcity. The report is well-organized and presents an enormous amount of information in a clear and coherent manner. The use of multiple scenarios to examine a range of potential stock status estimates relative to uncertainty in both data and assessment assumptions was a good choice. The stated assessment goal was to "update stock status advice for the Lingcod stock in the Strait of Georgia" as per the Request for Science Information regarding changes in stock status since the implementation of the current management regime in 2006. Sections 5.4 and 6.1 state that for all of the 12 scenarios examined, Georgia Strait lingcod stocks are in recovery from historically low levels as well as a 100% probability over all scenarios that spawning biomass has increased since 2006.

I have only a few minor comments.

COMMENTS

1. Are the authors comfortable in making stronger conclusions regarding the District 1 catch scenarios examined? The magnitude of recovery (and therefore overall stock status) is dependent upon the conditions examined. Section 6.2 appears to dismiss the relevancy of the noSE scenario, stating "There is no biological basis for the assumption that recruitment in minor Statistical Areas 28 and 29 is separated from the rest of the Strait of Georgia". Are there similar criticisms of the onlySEpre1947 and the noSEpre1947 scenarios? Is there a recommended set of conditions? Do the authors feel that the results justify removal of some scenarios for future stock assessments and the addition of new scenarios with more relevant conditions to better incorporate and model uncertainty?
2. CPUE is a critical element of this assessment, as no fishery-independent survey yet exists. Figures F1 – F12 suggest that model fitting to CPUE calculations were good, despite the high uncertainty. Although the GLM analyses were reported as being unsuccessful at capturing data variability, was the assumption of normality examined? A Box-Cox transformation of the CPUE data might reveal an underlying normal distribution. Noisy CPUE data are a common problem, and transformations can be useful to increase the signal-to-noise ratio.
3. Section 1.3 states that the stock assessment uses "a catch-at-age population dynamics model to fit the data input. No age composition data were input to the model, although cohorts were tracked by the structural dynamics of the model." (p. 4 bottom, p. 5 top). Given that no fishery independent survey exists, from where did the age data used to calculate the input selectivity-at-age, length/weight-at-age, maturity-at-age, etc. come? These were apparently carried over from Logan et al. (2005) – are they from biological data gathered from creel surveys? If so, is the assumption that individuals taken in the recreational fishery are representative of the population as a whole valid? The impact of fishery removals and the calculations dependent upon them ($F_{MSY}$, etc.) are pivotally dependent on the selectivity-at-age curve- were these parameters estimated within the Logan et al. (2005) stock assessment in Fish++?
4. For future work, I agree that development of a fishery-independent abundance index is of primary importance. It seems unlikely that the data currently available would allow a stock assessment model to identify with sufficient precision stock conditions necessary for the re-opening of a commercial fishery.

## REVIEW – JENNIFER STAHL

1. *Is the purpose of the working paper clearly stated?*

Yes the purpose is stated in the introduction. However, paragraph 2, first sentence says the "the purpose of this stock assessment is to update stock status advice." However, the next paragraph it says the paper will not provide "harvest advice". I would just remove the word "advice" from the first sentence of paragraph 2, so it is clear from the start that the authors are updating only stock status.

2. *Are the data and methods adequate to support the conclusions?*

I think the biggest problem with the methods and the data is pointed out by the authors. This is a data poor stock and the recent abundance indices are based on the recreational fishery; however, the recreational fishery data combines both target and non-target trips for lingcod. I think if only lingcod targeted trips were included, I would feel more comfortable in the conclusions drawn from the data. It is hard to say if the trends in spawning biomass are true based on this limited data with such a big caveat. Recreational CPUE could be affected by how much time is spent targeting lingcod, which may vary annually dependent on how good fishing is for salmon or halibut and what the bag limits are for those species. If they are spending more time targeting other species, then it may seem like CPUE is down for lingcod when in reality they may be spending less time in preferred lingcod habitat. Also if the bag limit is low for lingcod, then they move off of lingcod habitat after they reach their limit but continue fishing, which could reduce the CPUE for lingcod.

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

I think the data and methods are explained in sufficient detail. However, would be nice to clarify what recreational gear was used to capture lingcod. Was it always, hook and line gear or were some other gears used such as scuba or free diving? There would likely be different CPUE for these different gear types. Also were there any subsistence fisheries present currently or in the past? If there was then these fisheries could affect abundance, so good to indicate whether they existed or not.

1. *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?*

Advice was not presented in this document to managers.

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

As mentioned by the authors, a fishery-independent survey is really needed for this stock considering the catch-at-age model in recent years is solely based on the recreational fishery. I suggest that the authors consider the patchy distribution of lingcod in their survey design.

Authors may want to consider some tagging studies to confirm that lingcod are staying within the Strait of Georgia and not intermixing with the outside population. Please see notes on lingcod movements under the "other thoughts/suggestions" section.

Also studies to obtain updated reproductive parameters such as fecundity and maturity at age and/or length could be performed. The authors might consider investigating if any skipped spawning occurs with this population or if lingcod spawn every year. Skipped spawning has been observed in Atka Mackerel, which are also a Hexagrammidae.

Authors may consider adding some flexibility in the model for maturity in the future instead of using fixed parameters. Maturity-at-age or maturity-at-length may be dynamic and change with water temperature or fish condition, which could be related to food availability and tied to stock density.

***Other thoughts/suggestions***

The authors should consider rewording the following statements about lingcod movements:

“they tend to stay close to the reef or rocky area to which they first recruited.”

“Lingcod are considered a non-migratory species because they do not move long distances.”

ADF&G conducted a long term tagging study across Southeast Alaska that suggested that a small proportion of lingcod traveled long distances. For example, three lingcod moved from Southeast, Alaska to the Queen Charlotte Islands and one from Southeast Alaska all the way to Prince William Sound (Stahl et al. 2014). Other tagging studies, including acoustic studies, indicate that lingcod do have strong site fidelity but they perform movements on several temporal/spatial scales: daily movements within their home range, frequent excursions outside home ranges, and long distance migrations. So it is possible that the lingcod within the Strait of Georgia may make excursions outside the area from time to time and mix with other populations.

Weight-at-length parameters were set the same for males and females. However, male and female weight-at age differs for lingcod, so I would suggest having different parameters by sex.

The model used the same selectivity-at-age for males and females for the commercial fishery and the recreational fishery prior to 1991; even though, lingcod have differences in length-at-age relationships by sex. Authors indicate the program they are using may not allow selectivity by age and sex. Instead, authors could model selectivity with length instead of age as they do for the recreational fishery after 1991. This might be beneficial if fishery selectivity is more of a function of length than age.

The authors used the same selectivity-at-age for trawl and hook and line fisheries. I would expect that the selectivity would be different for these different gear types. Also is longline gear included with hook and line fisheries? Longline gear and other hook and line fisheries may have different selectivity as well, dependent on the size of the hooks. An explanation is needed why the selectivity is combined for these different commercial fisheries.

Why did the authors use knife-edge maturity for males? Has this been observed in the Strait of Georgia or was the maturity data limited? In Silberberg et al. 2001 and Richards et al. 1990, they don’t have this knife-edge maturity.

Agree with the authors that they should include discard mortality in the future and that they should include estimates for the numbers of discards.

The authors may want to consider different criteria for determining if a commercial trip targeted lingcod instead of a minimum weight landed. They could explore using trips where lingcod catch is greater than 50% of the catch. It is possible that the CPUE is being biased by the current criteria.

***Minor Edits***

Authors should clarify in the abstract that the range is from “Baja California” and not just “California” which sounds like the state and not Mexico.

I don’t think “Lingcod” is not normally capitalized.

Use “led” not “lead” when referring to past tense.

“Shumagin” not “Shumanagin” Islands for lingcod range in introduction.

Is a “piece” equivalent to a fish? If so, then why not just say fish? If not, maybe can explain what a “piece” is equivalent to.

In Table 2, I would add the word “minimum” for the size limits. At the ADF&G we also use maximum size limits with lingcod for sport fishing.

It should be clarified that the authors are using a two-sex model because lingcod are sexually dimorphic.

## APPENDIX C: AGENDA

Canadian Science Advisory Secretariat
Centre for Science Advice Pacific

**Regional Peer Review Meeting (RPR)**

**Stock Assessment for Lingcod (*Ophiodon elongatus*) in the Strait of Georgia, British Columbia in 2014**

**December 10-11, 2014**

Pacific Biological Station
Nanaimo, BC

Chair: Kate Rutherford

**DAY 1 Wednesday, December 10**

| Time | Subject | Presenter |
|---|---|---|
| 1300 | Introductions<br>Review Agenda & Housekeeping<br>CSAS Overview and Procedures | Chair |
| 1315 | Review Terms of Reference | Chair |
| 1330 | Presentation of Working Paper | Author |
| 1430 | Questions & Points of Clarification | RPR Participants |
| 1445 | ***Break*** | |
| 1500 | Overview of Written Reviews | Chair, Reviewers & Authors |
| 1600 | Identification of Key Issues for Group Discussion | RPR Participants |
| 1645 | Develop Plan for Day 2 Discussions | Chair |
| 1700 | ***Adjourn for the Day*** | |

**Day 2 Thursday, December 11**

| Time | Subject | Presenter |
|---|---|---|
| 0900 | Introductions<br>Review Agenda & Housekeeping<br>Review Status of Day 1<br>Distribute draft Science Advisory Report (SAR) | Chair |
| 0915 | Discussion & Resolution of Technical Issues | RPR Participants |
| 1030 | ***Break*** | |
| 1045 | Discussion & Resolution of Results & Conclusions | RPR Participants |
| 1145 | Develop Consensus on Paper Acceptability & Agreed-upon Revisions | RPR Participants |
| 1200 | ***Lunch Break*** | |
| 1300 | <u>Science Advisory Report (SAR)</u><br>Develop consensus on the following for inclusion:<br>• Results & Conclusions<br>• Sources of Uncertainty<br>• Additional advice to Management (*as warranted*) | RPR Participants |
| 1430 | ***Break*** | |
| 1450 | <u>Science Advisory Report (SAR)</u><br>• Continued | RPR Participants |
| 1600 | Next Steps – Chair to outline:<br>• SAR review/approval process and timelines<br>• Timelines for other documents<br>• Other follow-up or commitments required | RPR Participants |
| 1645 | Concluding Remarks<br>• Other business arising from the review | Chair & RPR Participants |
| 1700 | ***Adjourn meeting*** | |

## APPENDIX D: PARTICIPANTS

| Last Name | First Name | Affiliation |
|---|---|---|
| Acheson | Schon | DFO Science, Groundfish Section |
| Ackerman | Barry | DFO Fisheries Managment Groundfish Management |
| Adams | Devona | DFO Fisheries Managment Recreational Coordinator |
| Edwards | Andrew | DFO Science, Groundfish Section |
| Forrest | Robyn | DFO Science, Groundfish Section |
| Govender | Rhona | Canadian Parks and Wilderness Society |
| Grandin | Chris | DFO Science, Groundfish Section |
| Haigh | Rowan | DFO Science, Groundfish Section |
| Harling | Wayne | Sport Fishing Advisory Board (SFAB) |
| Nottingham | Melissa | DFO Science, Groundfish Section |
| Williams | Daniel | DFO Science, Groundfish Section |
| Holt | Kendra | DFO Science, Groundfish Section |
| King | Jackie | DFO Science, Groundfish Section |
| Tadey | Rob | DFO Fisheries Managment Groundfish Management |
| Krishka | Brian | DFO Science, Groundfish Section |
| Lecomte | Jean-Baptiste | NSERC Visiting Fellowship |
| Yamanaka | Lynne | DFO Science, Groundfish Section |
| MacDougall | Lesley | DFO Science, CSAP |
| Rutherford | Kate | DFO Science, Groundfish Section |
| Starr | Paul | Canadian Groundfish Conservation Society & External Expert |
| Turris | Bruce | Canadian  Groundfish Conservation Society |
| Workman | Greg | DFO Science, Groundfish Section |
| Van Kirk | Kray | Alaska Department of Fish and Game |
| Wyeth | Malcolm | DFO Science, Groundfish Section |

## APPENDIX E: ABSTRACT OF WORKING PAPER

Lingcod are unique to the west coast of North America, with a range extending from California to Alaska. This stock assessment updates stock status advice for the inside Lingcod stock in the Strait of Georgia, British Columbia, which is defined as Minor Statistical Areas 13-19, 28, and 29 within Major Statistical Area 4B. Large estimated declines in Lingcod abundance within the Strait of Georgia between 1927 and 1990 lead to closure of the commercial fishery in 1990, followed by a closure to Lingcod retention by the recreational fishery in 2002. Strait of Georgia

Lingcod were last assessed in 2005, at which time both the stock assessment and the development of management advice were overseen by a Lingcod Management Framework Committee that included stakeholder representatives. That assessment showed increased Lingcod abundance in recent years, which lead to the opening of limited recreational fishing opportunities in minor Statistical Areas 13-19 starting in 2006.

The current 2014 assessment updates the 2005 assessment framework with new data and characterizes stock status based on a range of hypotheses about uncertainties in Lingcod data and biology. Harvest advice for Strait of Georgia has not been requested at this time. Instead, this assessment focuses on characterizing how stock status has changed since the current management regime was introduced in 2006, as well as how current spawning biomass compares to biomass-based reference points. A two-sex statistical catch-at-age model in a

Bayesian estimation framework was used to assess Strait of Georgia Lingcod abundance. The model was fit to catch data and two indices of abundance based on fishery catch-per-unit effort (CPUE). Twelve stock assessment scenarios were used to characterize a range of stock status estimates in 2014. These scenarios differ in (i) their treatment of historic catch data, (ii) assumptions about density-dependent mortality and density-dependent catchability relationships, and (iii) the natural mortality rate $M$. For each scenario, two sets of reference points were used to characterize stock status: the reference points developed by the 2005

Lingcod Management Framework Committee and provisional reference points identified by the more recent DFO Decision-making Framework Incorporating the Precautionary Approach (DFO PA Framework). Reference points for the 2005 Lingcod Management Framework are specified relative to unfished spawning biomass, $B_0$, (Target = $0.40B_0$, Overfished reference = $0.25B_0$,

Limit = $0.10B_0$), while those of the DFO PA framework are set relative to the level of spawning biomass associated with maximum sustainable yield, $B_{MSY}$ (upper stock reference = $0.80B_{MSY}$, limit reference point = $0.40B_{MSY}$).

In all scenarios, spawning biomass in 2014 was predicted with 100% certainty to be greater than spawning biomass at the start of the current management regime in 2006. The estimated magnitude of recovery however, was dependent on both the treatment of historical catch from the DBS District 1 (1927-1946) and the assumption made about density-dependent catchability.

When the 2005 Lingcod Management Framework reference points were used to classify stock status, 1 of the 12 scenarios predicted that spawning biomass in 2014 ($B_{2014}$) was most likely above the target biomass level of $0.40B_0$, 4 scenarios predicted $B_{2014}$ was most likely above the overfishing limit of $0.25B_0$ but below the target of $0.40B_0$, and 7 scenarios predicted that $B_{2014}$ was most likely above the limit reference point of $0.10\ B_0$ but below the overfished reference point of $0.25B_0$. When the DFO PA Framework reference points were used to classify stock status, 1 of the 12 scenarios produced a high probability that $B_{2014}$ was in the healthy zone (i.e., $B_{2014} > 0.8\ B_{MSY}$), 8 scenarios predicted that $B_{2014}$ was most likely in the cautious zone (between $0.4\ B_{MSY}$ and $0.8\ B_{MSY}$), and 3 scenarios predicted that $B_{2014}$ was most likely in the critical zone.