Joint U.S.-Canada Scientific Review Group Report for 2017

Morris J. Wosk Centre for Dialogue
580 West Hastings Street
Vancouver, BC
February 14-16, 2017

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Introduction

Under the authority of the Agreement Between The Government of The United States of America and The Government of Canada on Pacific Hake/Whiting (hereafter referred to as "the Treaty"), the Scientific Review Group (SRG) met in Vancouver, British Columbia, 14 to 16 February 2017 to review the draft stock assessment document prepared by the Canada/US Joint Technical Committee (JTC), and acoustic survey research conducted by both nations in 2017. The SRG based its terms of reference on the language of the Treaty and on the Pacific Fishery Management Council's Stock Assessment and Review (STAR) terms of reference; the Joint Management Committee (JMC) has now approved these as the formal Terms of Reference for the SRG. The SRG is composed of two US, two Canadian, and two independent members designated by the JMC, based on recommendations from the Advisory Panel (AP). The JMC also appointed two industry advisors to assist the SRG in its deliberations.

The Scientific Review Group provides independent peer review of the Joint Technical Committee's work. The SRG is charged with:

1. Reviewing the stock assessment criteria and methods and survey methodologies used by the Joint Technical Committee;
2. Providing annually, by March 1, unless otherwise specified by the Joint Management Committee, a written technical report of the stock assessment and its scientific advice on annual potential yield; and
3. Performing other duties and functions as directed by the Joint Management Committee.

The SRG meeting convened at 9AM Tuesday, February 14, 2017. John Holmes (meeting chair) welcomed attendees and after a round of introductions reviewed the agenda (Attachment 1) and SRG Terms of Reference and then assigned reporting duties. It was noted that the SRG was expected to submit its report to the JMC by February 22nd. There were 22 participants at the meeting representing the AP, JMC, JTC, Survey Team, and stakeholders (Attachment 2).

Lori Steele and Shannon Mann were introduced as USA and Canada AP representatives, respectively, and it was noted that their appointments as advisors to the SRG as specified in Article II, Section 2 of the Treaty, were not yet official. A motion was proposed, and seconded, that they be appointed on an ad hoc basis to SRG for this meeting. SRG members voted unanimously in favour of this motion.

Conclusions

The following points summarize the main findings of the SRG with respect to the 2017 stock assessment and acoustic survey research.

1. The structure of the 2017 assessment model is similar to the 2016 model, with the addition of catch and age composition data for 2016, an updated weight-at-age matrix, a 1995 survey biomass estimate and minor changes to survey biomass estimates for 1998 and its CV and 2015 (CV only), and improved catch estimates from earlier years. Time-varying fishery selectivity is retained in the 2017 base model but the standard deviation on annual deviations (ϕ, phi), used in penalizing deviations, was increased from 0.03 (used since 2014) to 0.20 for 2017, giving selectivity more flexibility for change.

2. The uncertainty measures in the base model are only applicable for the structure and processes included in the model. Thus, uncertainty in current stock status and projections is likely underestimated. The 2014 cohort (age-2 fish) is estimated to be large and influential in the decision tables, but the absolute size is highly uncertain because it is based on only two years of fishery observations (2015 and 2016) and it has not been observed in the survey yet, except in the provisional age-1 index.

3. The 2010 cohort (age-6 fish) was the numerically dominant cohort in Canadian fishery catches, while the 2014 cohort (age-2 fish) was the numerically dominant cohort in US fishery catches in 2016.

4. An acoustic survey will be conducted in 2017, beginning at Point Conception, CA, (34.5°N) and moving northward. The SRG believes that this is an appropriate starting point for the survey until new information about the starting point is received.

5. The SRG recommends the base model in the 2017 assessment as the best available science information on Pacific Hake. Although the SRG agrees with the use of time-varying selectivity in the assessment, there was substantial debate concerning the way in which time-varying selectivity was parameterized in the 2017 base model. Time-varying selectivity is modeled with yearly deviations applied to the selectivity-at-age parameters and a penalty function is applied to each deviation to constrain the amount that the deviation can stray from zero. A value of $\phi = 0.03$ has been applied to the entire time series in assessment models since 2014 based on an analysis that showed this value permitted the estimation of time-varying selectivity without allowing large year-to-year changes. However, applying $\phi = 0.03$ to the entire time series in the 2017 base model (1991-2016) led to a recruitment estimate for the 2014 year class that was more than twice the largest estimate in the time series. Based on a heuristic approach, $\phi = 0.20$ was applied in the 2017 base model, which permitted more flexibility in fitting the fishery data, especially the large 2014 recruitment event. Although there is some evidence from the age-1 index sensitivity runs that corroborates the large size of the 2014 year class, the uncertainty concerns whether 2014 recruitment is (a) well above average or (b) more than twice the largest observed recruitment in the time series. While the SRG recommends the 2017 base model, it notes that the decision tables based on this model could be considered conservative since they are based on the possibility that 2014 recruitment is well above average. For example, a sensitivity run applying a ϕ value of 0.03 to 1991-2016 selectivity is more optimistic and results in much larger estimated stock biomass owing to the influence of the 2014 year class. We anticipate that the upcoming 2017 summer acoustic survey will help to reduce this uncertainty.

6. The SRG recommends that the JTC investigate more objective approaches to setting the ϕ parameter value for time-varying selectivity in future assessments. As a starting point, we suggest a review of how time-varying selectivity is parameterized in other assessments that have implemented it. The SRG requests a summary of this effort be included in the 2018 assessment.

7. The median estimate of female spawning biomass at the beginning of 2017 is 2.129 million tonnes (Mt), with a 95% credibility interval of 0.763 to 7.445 Mt. The 2017 median biomass estimate increased slightly from 2016 due to above average recruitment in 2014. The 2014 year class is estimated to be among the largest observed and is likely to be important to stock dynamics for many years. In contrast, the influence of the 2010 year class has declined and

will continue to do so because losses of biomass through natural mortality are greater than gains from growth, but it remains the dominant cohort in Canadian catches.

8. The 2017 median estimate of stock biomass in the base model is well above the $B_{40\%}$ and $B_{10\%}$ biomass reference points, and fishing intensity is well below the $F_{40\%}$ reference point. The SRG concludes that the coastal Pacific Hake/Whiting stock is not overfished and that overfishing is not occurring. The uncertainty in the choice of ϕ value does not change this conclusion.
9. The decision tables presented for the base model give the expected effects of various catch levels on stock biomass and fishing intensity (a measure of the relative magnitude of fishing often expressed as a percentage). The base model forecasts that median catches of 969,840 t in 2017 and 843,566 t in 2018 could be achievable when fishing at the $F_{40\%}$ reference point, with an equal probability of being above or below the reference point.
10. The SRG concludes that developing a spatially explicit operating model is an important next step for the development of the MSE process for Pacific Hake, since many of the management and science questions posed by the JMC, AP and SRG have spatial dimensions, such as the availability of fish in each country. Other areas of inquiry for an MSE include evaluating the impact on management system performance of survey frequency (annual, biannual, tri-annual, etc.), time-varying selectivity, juvenile indices, and climate change effects.
11. The SRG appreciates that both the Survey Team and the JTC continue to provide high quality analysis and advice to the SRG and for management of the stock.

Overview of the Winter Research Cruise

The NOAA acoustic survey team conducted a winter research cruise on the NOAA Research Vessel *Bell M. Shimada* in 2016 and 2017. Sampling was aimed at characterizing the distribution of adult hake during the spawning season, understanding between-year variability in distribution, and collecting biological information during the winter. The NOAA survey team provided the SRG with an overview of the 2016 cruise, which took place between January 9 and February 9, 2016 and operated between Newport, OR, and San Diego, CA. Weather during the 2016 sampling period was favourable, resulting in more transects being surveyed than originally planned. The winter 2016 survey was conducted during a period of ocean conditions that were unique in the observational record; more observations will be needed before generalizations about winter biology of hake can be drawn. A summary of the 2017 cruise is not yet available, having ended shortly before the SRG meeting. The SRG recognizes the large amount of work that was directed to the winter cruise over the past two years and appreciates the efforts of the survey team to organize and conduct the survey, as well as provide a synthesis of the outcomes.

A large amount of valuable information was collected in 2016, resulting in several new insights into winter-season hake distribution and catch composition:

- Hake were observed off both California and Oregon (the cruise operated from Newport, OR, southward), with adult hake occurring primarily offshore in deeper waters than they are typically observed during the summer. In comparison, age-1 hake were found further inshore, just off the shelf break.

- Hake aggregations were not as dense as expected based on the spawning aggregations observed for other gadid species nor were they concentrated in the southern area of the cruise.
- Adult hake appeared to undertake daily vertical migrations and were found at deeper depths during the day than at night.
- The proportion of hake classified as actively spawning based on visual inspections of gonads was higher than the proportion observed during the summer; however, not all fish sampled during the winter were at the same stage of spawning. Males were more likely to be in active spawning stages while females were more likely to be in gonadal development stages. These results are based on visual inspections of gonads, which are less reliable than histological analysis methods.
- The sex ratio of samples was consistently biased towards males across the range of latitudes sampled, which is different from summer sex ratios which are typically 50:50. It is unknown where the unobserved portion of the female population was during the winter sampling period.
- Stomach content analyses showed evidence that some fish were eating during the spawning season, which was unexpected.

Winter Research Cruise Recommendations

1. Further analysis of data collected during the 2016 and 2017 winter research cruises should be undertaken to improve understanding of hake distribution and spawning behaviour. At a minimum, these analyses should include:
   i. Comparison of the 2016 and 2017 winter sampling data to characterize variation in the distribution and biological characteristics of hake between the two years and associations with environmental conditions;
   ii. Analysis of histological samples collected during winter sampling to better determine what proportion of fish were spawning and estimate maturity ogives; and
   iii. Additional analysis of stomach content data to estimate the proportion of samples that were feeding in 2016 and 2017. These summaries should explicitly distinguish between everted stomachs (turned inside out) and empty stomachs.
2. In the longer-term, results from these analyses should be used to inform objectives and priorities for future winter sampling of hake aggregations.

Overview of Survey and Acoustic Research

No summer acoustic/trawl survey was conducted in 2016. The acoustic-survey team reported considerable research progress in various areas. Some notable items include the following:

- Reanalysis of 1995 survey information to generate a 1995 survey estimate consistent with the revisions to the survey biomass series conducted for the 2016 assessment. The 1995 survey estimate was included in the survey biomass series for the 2017 assessment.
- Improved documentation of the survey and its analysis. In particular, the SRG appreciated the draft document provided to the meeting titled "Pacific Hake Integrated Acoustic and

Trawl Survey Methods" describing factors that determine survey trawl locations, as was requested by the SRG in its 2016 report.

- Increased sampling of zooplankton and physical oceanography, which ultimately may inform models of hake in its ecosystem and be useful in MSE analyses.
- Continued generation of a provisional age-1 index from survey observations.
- Completion of a winter cruise examining Pacific Hake distribution and biology.
- Completion of three tasks needed for adoption of EK80 echosounders, which are expected to replace the current EK60 models sometime after the 2017 summer survey.
- Collection of x-ray images of 273 individual fish in five groups for use in target-strength modelling studies.
- Paired-trawl studies of marine mammal excluder devices (MMED) to evaluate net performance in terms of stability during the tow and sampling bias with respect to species composition and size with and without the MMED installed in the net. This work was undertaken in anticipation that MMEDs may be mandated for future surveys.

SRG Survey and Acoustic Research Recommendations

Ongoing SRG recommendations for survey and acoustic research are marked (*).

- * Hake biology and ecology – Considerable environmental and biological data have been collected during previous acoustic surveys and should be analyzed to better understand hake recruitment variations. Developing a research plan is an important first step. In addition, efforts to understand environmental drivers of recruitment variation are being undertaken by a postdoc at the Northwest Fisheries Science Center in Seattle.
- * Trawl calibration work should continue to focus efforts on calibration of gear between Canadian and US vessels. AP members have substantial experience in this area so communication and collaboration with AP-nominated representatives is encouraged by the SRG.
- The SRG recommends continuing efforts to determine best techniques for use of MMEDs (if mandated) and other gear to quantify their effects on survey trawls. AP members have substantial expertise in the deployment of MMEDs and there should be ongoing communication and collaboration on this issue.
- The SRG continues to recommend that the survey team analyze commercial catch and fishing effort to better characterize hake distribution with respect to the survey, especially in offshore areas.
- * Survey variance. The SRG noted in 2014 and 2015: "The estimated survey variance is extremely small, based on the smoothed surface produced by kriging instead of the underlying data, and is highly dependent on the size of the cells in the kriged grid. The SRG recommends that further study be given to methods of estimating the variance of the estimated survey biomass so that the estimate meaningfully reflects all sources of variance." The nominal CV reported for the survey accounts for uncertainty in kriging, but is an underestimate of the true variance. The sources of uncertainty in acoustic surveys come from acoustic techniques and instruments, biological sampling, and survey design and analysis.

The SRG recommends that the Survey Team develop a list of potential sources of uncertainty in the Hake survey and begin the process of quantifying the CV of each source to assess its contribution to variance in the biomass index value produced for each survey.

- The SRG previously recommended research into the impact of survey direction on the survey biomass index but there has been confusion concerning the implementation of this recommendation. To clarify, it was the SRG's intention that this recommendation might best be explored through simulation modeling, rather than duplicate surveys, which the SRG agrees would be too costly for this purpose.
- The survey team has worked hard to standardize methods between both countries. The SRG recommends that the survey methods documentation produced for this SRG meeting be expanded to include the Canadian portion of the survey and then be prepared for publication as a DFO or NOAA technical report.
- Operationally, the SRG recommends that the survey team expand in-survey documentation of all trawls by including an operator ID, rationale for the trawl (what was the echo sign that triggered a trawl), species expected in the trawl, confidence in that expectation, and species actually caught. The survey team provided the SRG with a template capturing this information, which the SRG recommends the survey team use in the 2017 survey.
- Age-1 index. The SRG is appreciates the progress on the age-1 index, including plans for publication of this work.

The SRG recommendation for more detailed records on trawls is intended to further several goals: (1) better characterize the uncertainty in interpreting acoustic signals, (2) build a catalogue of objective feedback for the survey team on interpretation successes and failures, (3) promote continuity across personnel changes, and (4) demonstrate the rigor and objectivity of the methods being used. The SRG's wish for better records is intended to support the credibility of the survey.

The SRG appreciates that the hake assessment could not have attained its current high level of quality without the outstanding effort, knowledge, and experience of the acoustic survey team.

Overview of the 2017 Stock Assessment

The 2017 assessment uses the same basic model structure as used in the past three assessments. Annual catches-at-age in the model begin in 1966 and are modelled by a single coast-wide fleet. The model is informed by age-composition observations from the fishery, an age 2+ biomass index from the acoustic survey, and observations of survey age-composition based on trawl samples taken during the survey. Age-specific fishery selectivity coefficients for ages 1 to 6 are estimated for the survey and fishery, with constrained annual variation allowed in fishery selectivity. The model uses a matrix of annual empirical weights-at-age, thereby avoiding the complexity of modeling growth and size-at-age, which is very variable from year to year for this species. A Bayesian approach is used for parameter estimation, with informative priors specified for natural mortality (M) and spawner-recruit steepness (h).

Changes from the 2016 assessment included minor revisions to the catch and the fishery age-composition series, the addition of 2016 data for fishery catch, age-composition and weight-at-age, and the addition of data for 1995 for the survey biomass index and age-composition series, which had not been revised in time for the 2016 assessment. There were also small changes to the 1998 survey biomass index value, its CV, and the associated age-composition data, and to the

CV of the 2015 biomass index, as well as retuning of the model for age-composition weights. The most influential change to the model was in the fixed (i.e., not estimated within the model) parameter that controls the year-to-year variation in the fishery selection parameters. In the 2016 assessment (and going back to the first implementation of time-varying selectivity in the 2014 assessment) this parameter (ϕ) was fixed at $\phi = 0.03$; in the 2017 assessment it was changed to $\phi = 0.20$. This change had the desirable effect of reducing the estimated recruitment for 2014, which would otherwise have been more than twice the size of the largest previously observed cohort, but the undesirable effect of greatly increasing the variability in estimated fishery selection curves for all years in the time series. With these changes, the 2017 assessment estimates that 2014 recruitment is well above average and that spawning biomass at the start of 2017 increased from 2016, but estimates of both quantities are highly uncertain.

The 2017 assessment included the suite of sensitivity analyses that the SRG had requested in 2016 as part of the standard assessment report: inclusion of the age-1 acoustic survey index, changes to the assumed maximum age for changes in selectivity, changes to the standard deviations of the priors for natural mortality and steepness, and changes to the level of annual variation around the recruitment curve (σ_r). The 2017 assessment also included sensitivity runs to illustrate sensitivity to the ageing error assumed for 2014 and the value assumed for ϕ (which controls flexibility in estimating time-varying selectivity). During the assessment review the SRG requested the following additional sensitivity runs:

1) Inclusion of the age-1 acoustic survey index and fixing ϕ at its 2016 value ($\phi = 0.03$);
2) Sensitivity analysis that uses $\phi = 0.03$ for 1991-2008 and $\phi = 0.20$ for 2009-2016;
3) Sensitivity analysis that uses $\phi = 0.03$ for 1991-2015 and $\phi = 0.20$ for 2016;
4) Running the base model with a longer MCMC chain length of 24 million, taking 999 samples, and presenting convergence diagnostics since it appears from the draft assessment document that the burn-in period was not long enough.
5) Preparing a table of exploitation rates by age from age 1 on and year for inclusion in the final assessment document going to the JMC.
6) Preparing a table of cohort catch weight, natural mortality weight, and surviving weight (including growth) by age for inclusion in the assessment report submitted to the JMC.

SRG Assessment Recommendations

Here we provide a number of recommendations for research and development in the coming year, ordered from highest to lowest priority.

- In the current assessment, the change from $\phi = 0.03$ to $\phi = 0.2$ has a large effect on fisheries selectivity in all years, as well as on the estimate of 2017 female spawning biomass. The SRG is concerned about the broad-reaching impact of this change, intended to reduce an anomalously high 2014 recruitment estimate informed solely by fishery catch-at-age data. As discussed above, the SRG recommends continued work on evaluating the impact of flexibility in time-varying selectivity and a more objective way of determining an appropriate value of ϕ (or other parameterizations of time-varying selectivity) for future assessments.

- The next priority for 2018 is processing the archived ovary collections of Pacific Hake, and re-estimating the maturity schedule based on histological techniques. Three issues are of particular interest: addressing the question of different maturity schedules north and south of Point Conception (34.5°N); bringing the stock assessment up to date given that the current assessment is based on information more than 20 years old from Dorn and Saunders (1997); and assessing whether maturity is more dependent upon age or upon weight. If maturity is more dependent on weight, then the assessment model would need revisions to obtain maturity-at-age from the empirical weight-at-age-and-year matrices, resulting in variable proportions of mature fish-at-age in each year.
- The SRG notes that MCMC convergence diagnostics for the 2017 base model pointed towards the need for a longer MCMC chain (24 million rather than 12 million in length) in the 2017 assessment. We recommend that for the 2018 assessment, the JTC investigate running longer MCMC chains, into retaining a higher number of samples than the current 999 samples for greater precision, and look into more efficient methods of obtaining Bayesian posteriors if available (e.g., Monnahan et al. 2016).
- The list of sensitivity tests presented in the 2017 assessment covers the major axes of uncertainty and should be continued in future assessments, including the sensitivity tests for alternative values for σ_r (which sets variability around the theoretical recruitment model) of 1.0 and 2.0. The SRG requests that future assessments, beginning with 2018, include the following key sensitivity tests: natural mortality, stock-recruit steepness (*h*), σ_r, inclusion of the age-1 index, and exploring the degree of flexibility in time-varying selectivity or the ϕ parameter, as well as any others the JTC deems appropriate.
- The SRG supports continued development of an age-1 index from the acoustic survey, and recommends continuing to run sensitivity tests in future assessments fitted to the current provisional age-1 index. This index is most important in years where auxiliary information is needed to assess the likelihood of small or large recruitment events that are influential in projections, but highly uncertain.
- Current biological evidence does not support including Pacific Hake south of Point Conception (34.5°N) in the assessment. The SRG encourages ongoing collection and analysis of genetic material in both Canadian and US waters to resolve stock structure in the California Current.
- The following two recommendations are to fulfil requests for specific information by the AP representatives:
  - A table providing exploitation rates by age and year be added to future assessment documents.
  - A table in future assessment documents reporting on the model estimates of the annual weight of each cohorts that is caught, dies from natural mortality, and lives, by year.

Management Strategy Evaluation

The JMC requested by letter on February 14, 2017, that the SRG provide guidance on appropriate next steps for management strategy evaluation (MSE) modeling efforts, using both information provided at the SRG meeting and a scoping document (Attachment 3) drafted by Dr. Sean Cox. Two areas of particular concern for the JMC are:

1. understanding the costs and benefits of having the JTC take a lead role or having an independent contractor serving that function; and
2. the costs and benefits of a fleet-as-area model vs. a more explicit spatially structured model.

The JMC also requested specific guidance about issues the MSE should address or approaches it should take.

SRG Guidance for Management Strategy Evaluation

The SRG believes that it is important that development of operating models and overall framework for the MSE be compatible with the assessment model and programming techniques used by the JTC. Therefore, we strongly recommend that the JTC have at least an oversight role in the development of operating models and corresponding revisions to the MSE framework. The acoustic survey team also is expected to have a role in data development for this process. The SRG should not have a role in this development process as it is the primary review body under the Agreement and is expecting to review MSE results as they become available. The SRG has no specific guidance regarding the role of a contractor in the MSE process except to note that the level of resources allocated to the task may alter the delivery timeline regardless of who conducts the analysis.

The SRG discussed the relative merits of the fleets-as-area and a more explicit spatially structured model. In order to advance the MSE process, the SRG recommends the development of a spatially structured (or spatially explicit) operating model that can capture seasonal effects and potential climate forcing influences on stock and fishery dynamics. The fleets-as-area approach is viewed as a possible alternative approach to structuring an assessment model, but is not suitable for development of an operating model in the MSE context.

The following guidance is provided for advancing the MSE process:

1. Develop measurable management objectives (conservation, fishery, etc.) and performance indicators to measure their achievement. These objectives are important because they are the basis for evaluating the performance of a management procedure and the robustness of a management procedure across a range of uncertainties.
2. Measureable objectives consist of three components: (1) a target or threshold value (e.g., for abundance, variation in catch), (2) a time horizon for measurement, and (3) an acceptable probability of either achieving a target or avoiding a threshold. The process of developing these objectives is not a scientific exercise, although it can be informed by science. At this stage, nonetheless, the SRG recommends that the JTC develop provisional objectives and performance metrics based on feedback to date. These provisional objectives will provide a range of options for consideration, modification and approval by the JMC and AP.
3. The SRG reiterates its previous recommendation that a spatially explicit operating model is needed for the MSE process, given the types of questions that the JMC has raised. This is consistent with the outline of Option B described by S. Cox (Attachment 3). Since the operating model represents a hypothesis about the state of nature, the SRG notes that multiple operating models may be developed representing different plausible population dynamics, environmental conditions and other drivers of hake abundance and distribution

(also termed ‘states of nature’). A three-year timeline is expected for development of the OM. This timeline could be changed by the level of resources allocated to the task.

4. Documentation of the design and technical implementation of MSE components (operating models, management procedures) is necessary to ensure scientific credibility, continuity and maintainability as personnel involved in the process changes.
5. Some factors to consider in the development of the operating model include seasonality, environmental drivers of hake dynamics, migration behaviour, fleet behaviour, and interactions between areas. Such issues need to be carefully considered in the development phase so as not to limit further development in the future.
6. As the MSE process proceeds, it is important to coordinate the hake survey and other ecological investigations to ensure that priority data are collected to inform the operating model, for example, with information about seasonal occurrence of Pacific Hake.

Other SRG Recommendations

- The SRG suggests that more routine communication be instituted between all bodies (AP, JMC, SRG, JTC, Survey Team) supporting the implementation of the Pacific Hake/Whiting Agreement so that members of the SRG are updated about research and analysis priorities and concerns of the management and stakeholder communities.
- The SRG also requests that the JMC, when it identifies specific areas on which it would like SRG input, submit written requests to the SRG co-chairs preferably two weeks before the SRG meeting to allow time for the SRG agenda to be adjusted appropriately, and for review by SRG members of any background materials.
- The SRG requests that the JMC provide a written opinion on the utility for decision-making of providing more than one decision table as a means of highlighting the impact of major uncertainties that are not captured in the single base case parameterization of the assessment model (e.g., due to different assumptions about an influential fixed parameter .
- The SRG appreciated that both the survey team and the JTC presented explicit responses to previous SRG recommendations. We request that this approach be continued into the foreseeable future.

Literature Cited

Dorn, M. W. and M. Saunders. 1997. Status of the coastal Pacific whiting stock in U.S. and Canada in 1997. In Appendix: Status of the Pacific Coast Groundfish Fishery Through 1997 and Recommended Biological Catches for 1998: Stock Assessment and Fishery Evaluation. Pacific Fishery Management Council. Portland, OR. 84 p.

Monnahan, C.C,, Thorson, J.T,, and Branch, T.A. 2016. Faster estimation of Bayesian models in ecology using Hamiltonian Monte Carlo. Methods in Ecology and Evolution doi: 10.1111/2041-210X.12681

ATTACHMENT 1

Joint US-Canada Scientific Review Group for Pacific Whiting

Room 320
Morris J. Wosk Centre for Dialogue
Simon Fraser University
580 West Hastings Street
Vancouver, B.C., Canada, V6B 1L6
February 14 – 16, 2017

Revised and Adopted MEETING AGENDA

Tuesday, February 14, 2017

09:00 Welcome and Introductions

09:15 Review and Approve Meeting Agenda (Chair)

- Review Terms of Reference for Assessments and Review Meeting
- Meeting report mechanics
- Assignment of reporting duties

09:45 Review 2016 SRG Recommendations

10:00 2016 Winter Survey Results (survey team & JTC)

11:00 Presentation of the 2016 survey-related research (JTC & survey team) – mark ID and trawl attribution of Sa

12:00 *Lunch (on your own)*

13:30 Discussion of winter survey results and survey-related research (SRG, JTC and survey team)

15:00 MSE update (JTC)

- Next Steps & Options as requested by JMC

16:30 Public comment on winter survey, survey research, and MSE

17:00 Adjourn for the day

Wednesday, February 15, 2017

08:00 MSE update and discussion-- continued (SRG and JTC)

09:00 Overview of the 2016 Whiting Fisheries

- Canadian Waters
- U.S. Waters

10:00 Presentation of draft 2017 update assessment (JTC)

12:00 *Lunch (on your own)*

13:00 Discussion of update assessment

15:00 SRG discussion

- Evaluation of base model and primary sources of uncertainty
- Compile a list of catch levels to consider in a decision table
- Develop list of additional requests to the JTC

16:30 Public comment on assessment

17:00 Adjourn for day

<u>Thursday, February 16, 2017</u>

08:00 Presentation and Discussion of response to SRG requests

09:00 SRG discussion continued of research needs for 2017 and longer-term

- Evaluation of base model and primary sources of uncertainty
- Compile a list of catch levels to consider in a decision table
- MSE methodology and approaches
- Research needs for 2017 and longer-term

11:00 Survey design and planning for the Joint Hake/Sardine survey in 2017

- Discuss protocol document distributed this year

12:00 Distribution and review status of notes and draft SRG Report

13:00 Meeting Adjourned

ATTACHMENT 2

List of Participants

Name	Affiliation
Aaron Berger	JTC, NWFSC, NMFS/NOAA
Trevor Branch	SRG, Univ. Washington, USA
Julia Clemons	Survey Team, NWFSC, NMFS, NOAA
Sean Cox	JTC, SFU, Canadian appointee
Andrew Edwards	JTC, PBS, DFO
Chris Grandin	JTC, PBS, DFO
Stephane Gauthier	Survey Team, IOS, DFO
John Holmes	SRG, PBS, DFO
Kendra Holt	SRG, PBS, DFO
Larry Hufnagle	Survey Team, NWFSC, NMFS, NOAA
Mike Hyde	AP, USA appointee
Shannon Mann	AP, Canadian appointee
Michelle McClure	SRG, NWFSC, NMFS/NOAA
Brian Mose	AP, Canadian appointee
Michael Prager	SRG, US independent appointee
David Sampson	SRG, Oregon St. Univ, USA
Lori Steele	AP, USA appointee
Rob Tadey	GMU, FM, DFO
Ian Taylor	JTC, NWFSC, NMFS/NOAA
Rebecca Thomas	Survey Team, NWFSC, NMFS, NOAA
Miako Ushio	NWFSC, NMFS/NOAA
Dan Waldeck	JMC, USA appointee

ATTACHMENT 3

8 February 2017

DRAFT: Scoping options to develop a harvest strategy simulation framework for Pacific Hake

Prepared by: Sean Cox and Ashleen Benson, Landmark Fisheries Research, Ltd

Preamble

This scoping document explores three simulation software options (A1, A2, and B) to improve progress on developing, testing, and implementing a closed-loop simulation framework for evaluating harvest strategies of interest to the Pacific Hake Joint Management Committee (JMC). Note that this scoping document is intended to inform preliminary discussion on the topic and would be need to be revised and agreed prior to any commitments on behalf of the parties involved.

Option A1: Landmark Fisheries Research leads development of fleets-as-areas simulation modelling framework for evaluating Pacific hake harvest strategies using mseR software - $100,000-$150,000

Option A2: Hake JTC leads development of fleets-as-areas simulation modelling framework for evaluating Pacific hake harvest strategies using mseR software

Options A1 and A2 would use existing mseR software to develop a multi-fleet, age-/sex structured operating model capable of simulating the effects of alternative harvest strategies for Pacific hake. The mseR simulation framework has been extensively developed, tested, and applied to actual multi-fleet fisheries since it was first developed in 2009 by S.P. Cox and A.R. Kronlund. Applications to actual fisheries include B.C. Sablefish, Atlantic Cod, Pacific Herring, and Atlantic Halibut. The only difference between A1 and A2 is in who leads the project.

Under Option A1 (see **Table A** for project specifications), Landmark Fisheries Research would lead all aspects of the project, including,

1. - development of model specifications and requirements via consultations with JTC and JMC;
2. - parameterization of operating model scenarios, management procedures, performance criteria, and graphics;
3. - model testing and verification; and implementation to evaluate JTC/JMC questions.
4. - Training JTC members to use the customized mseR software via graphic user interface, R computer code, input files, batch processor, parallel processor, and performance output.

Under Option A2, the JTC would lead most aspects of the project after mseR training provided by Landmark. The project structure would then be:

1. - Training JTC members to use mseR software;

2. - Training JTC members in how to modify mseR operating models, management - procedures, performance criteria, graphics, and output; -
3. - JTC development of model specifications and requirements via consultations with JMC;
4. - JTC parameterization of operating models, management procedures, and performance criteria;
5. - JTC model testing and verification; and implementation to evaluate JTC/JMC questions.

Details of project management and coordination under Option A2 would need further discussion, e.g., whether Landmark would "manage" the project or provide training only.

The main advantage of Option A1 is that progress toward addressing MSE-related topics would essentially be guaranteed over the course of 2017-18 provided that the process is guided by reasonably focused management questions. The JTC and JMC have actually made the most progress on the management questions, so this is probably a "low risk" project. Option A2 also has the advantage of using/adapting existing software, but is probably "medium/high risk" because there is no guarantee that JTC staff will be available to make progress in training and model development. Option A1 also has the advantage of engaging JTC and JMC members in a structured MSE process, which would inevitably lead to insights and improvements in how the fishery is currently managed.

The disadvantages to both Options A1 and A2 are that mseR would need to mimic (i) the actual SS3 stock assessment model for Pacific hake and (ii) the spatial dynamics of age dependent hake migration. For (i), it is possible to use the actual SS3 model (including MCMC algorithm) within mseR; however, in the spirit of "low risk" and fast turnaround, the age-structured assessment model within mseR is actually a good approximation as we recently showed in tests against a complex model for Atlantic cod. Mimicking the spatial dynamics of Pacific hake could also be reasonably achieved via age-specific availability factors of difference age-classes to multiple fleets (e.g., US-offshore, US inshore, Canadian). Options for linking migration and hake distribution to oceanographic factors could be explored as part of Option A1/A2, or left to future development once the NOAA post-doc is settled in working on this topic.

Option B: Landmark Fisheries Research leads development of spatially explicit simulation modelling framework for evaluating Pacific hake harvest strategies in the presence of oceanographic influences on distribution (Phase 1-2: $100,000-$150,000; Phase 3-4: $100,000-$150,000)

Option B develops a spatially explicit closed-loop simulation framework appropriate for Pacific hake (Table B). The end product would be a simulation software package capable of representing spatial and temporal dynamics of Pacific hake given input assumptions about population dynamics, oceanographic influences on spatial distribution, and exploitation by multiple fishing fleets, as well as providing detailed graphics and performance statistics related to Pacific hake management objectives.

Option B is obviously a far more complex modeling task because of the spatial dimension, although our experience developing and using mseR and other spatially explicit simulation packages would help to streamline the process and reduce project risk (i.e., the ability to deliver what was requested on time and on budget). Project lead would be similar to Option A1 although the increased effort and expertise would increase cost.

The complexity of building a spatial model under Option B should not be underestimated, especially where the model needs to be customized to effectively mimic the dynamics of Pacific hake and fisheries. Two immediate challenges are (i) inputs of spatial fishery and survey data and (ii) conditioning a spatial model so that MP evaluations remain plausible and consistent with historical observations for the hake abundance, spatial distributions, and fishery catches. The project phases in this case could be broken down into a "pilot study phase" and "application phase", where the former would allow for more rapid development and testing of the models without the pressure to customize the model for Pacific hake, although the model would be very hake-like at first. The specific management procedures (data, assessment, harvest control rules) and performance criteria would be similar to those under Option A1 and thus not difficult to implement.