Joint U.S.-Canada Scientific Review Group Report

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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 (here after referred to as "the Treaty"), the Scientific Review Group (SRG) met in Vancouver, British Columbia, 24 to 27 February 2015 to review the draft stock assessment document prepared by the Canada/US Joint Technical Committee (JTC), and research on the acoustic survey methodology and biomass estimation methods conducted by both nations in 2014. 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 24, 2015. John Holmes (meeting chair) welcomed attendees and after a round of introductions reviewed the agenda and SRG Terms of Reference and then assigned reporting duties. He noted that there was a short time between the end of the meeting and the March 1 reporting deadline and indicated that he expected the SRG report would be mostly completed and approved by the end of the meeting on February 27. In addition to SRG members, there were 24 participants at the meeting representing the AP, JMC, JTC, Survey Team, and stakeholders (Attachment 1).

Dr. François Gerlotto (Center for Independent Experts) was introduced and it was noted that he was participating as an "officially invited member" of the SRG. His participation is in response to a 2014 recommendation that the advice of an external expert with expertise in acoustic survey design and estimation would benefit SRG discussions and inform the review of the acoustic survey. Dr. Gerlotto provided recommendations for improvements to the acoustic survey methodology and research priorities, data collection and treatment, and the impact of uncertainty in acoustics estimates on stock dynamics and management quantities used by the JMC.

Conclusions

The following points summarize the main findings of the SRG with respect to the 2015 stock assessment and acoustic survey research.

1. The 2015 base assessment model has the same structure as the 2014 model, with the addition of new catch and age composition data for 2014 and minor refinements to catch estimates for earlier years in the time series. The SRG appreciates the decision made by the JTC to keep

the model structure consistent with that used in 2014. Updating model structure on an annual basis can lead to high variability in perceptions of stock status, and should only be undertaken in the future when supported by compelling new information.

2. The SRG notes that uncertainty measures in the base model account only for the structure and processes included in the model. Thus, uncertainty in current stock status and projections is likely underestimated.

3. The SRG notes that the 2013 survey biomass estimate (age 2+) in the base model includes biomass extrapolated outside the surveyed area as approximately 32% of its total, much greater than the 12% of extrapolated biomass for the 2012 survey estimate. Sensitivity analyses conducted by the survey team showed that the 2013 survey biomass estimate was highly sensitive to the area of extrapolation.

4. The decision tables presented for the base model give the expected effects of various catch levels on stock biomass and fishing intensity. However, the SRG cautions that while the patterns of change in these decision tables are likely correct, the base model presented to the SRG used the survey index in which biomass is extrapolated, particularly in 2012 and 2013. Therefore, the SRG requested the inclusion of additional analysis results in the decision tables in the stock assessment report in which the extrapolated biomass in the 2012 and 2013 surveys was removed. These were the only years in the survey biomass index time series that could be readily reanalyzed during the SRG meeting. The SRG believes that the two analyses likely bracket the range of uncertainty due to extrapolation.

5. The SRG discussed two major concerns regarding survey resources. The first concern is about the trade-off between conducting annual surveys versus conducting surveys every two years. The latter allows more time for research into developing an age-1 index and improving the survey process. An annual survey would be ideal, but given the limited survey resources available, conducting a survey every two years combined with an age-1 index derived from the survey may provide a good balance of benefits to the assessment process. In addition, the SRG recognizes that maintaining flexibility to conduct additional surveys on a priority basis is important when fishery or other indicators show that an unexpected event is occurring.

6. In this regard, the SRG reiterates the following about age-1 index development from its 2012, 2013 and 2014 reports: "*Because the current acoustic survey biomass estimate does not include fish below age 2, a large recruitment (when it occurs) cannot be confirmed for several years, especially if surveys are conducted only every-other year. A reliable index of age-1 hake abundance would always be a valuable data input to the stock assessments, and especially when high recruitment events occur.*" The SRG places a high priority on completing the development of an age-1 index because it provides an early indication of recruitment before the fish are vulnerable to the fishery. Such information would be particularly useful if survey frequency is every second year.

7. The second area of concern to the SRG is the possibility that conflicting objectives in the combined Sardine/Hake survey might compromise the acoustic time series used in the annual Hake stock assessment. The biomass index from the acoustic survey is the sole source of fishery-independent data in the Hake stock assessment and the only information that provides relative estimates of stock biomass. The SRG concludes that clear priorities need to be set for the combined survey which emphasize the importance of the survey biomass index to the Pacific Hake/Whiting assessment required under the Treaty.

8. The median female spawning biomass estimated by the base model at the beginning of 2015 is 1.66 million metric tonnes (Mmt), with a 95% credibility interval of 0.750 to 3.55 Mmt. The 2015 median biomass estimate declined slightly (2.3%) from 2014 after five years of increases beginning in 2009. This decline is due to fishery removals and natural mortality of the 2008 and 2010 cohorts, which are fully mature and not exhibiting the rapid growth rates of juvenile fish. The 2010 and 2008 year classes continue to be influential to stock dynamics, with age-4 and age-6 fish comprising more than 70% of the 2014 catch. In the absence of fishing, the median biomass is expected to be relatively stable from 2015 to 2017, with a 39% probability of decreasing from 2015 to 2016 and a 51% probability of decreasing from 2016 to 2017.

9. For the alternative model, in which extrapolated biomass is removed from the 2012 and 2013 acoustics survey index values, median female spawning biomass at the beginning of 2015 is 1.33 Mmt, with a 95% credibility interval of 0.567 to 3.16 Mmt. The 2015 median biomass estimate declined slightly (2.6%) from 2014 after 5 years of increases beginning in 2009. In the absence of fishing, the median biomass is expected to be relatively stable from 2015 to 2017, with a 33% probability of decreasing from 2015 to 2016 and a 48% probability of decreasing from 2016 to 2017. However, with catches greater than 180,000 mt the probability of decline is greater in this scenario compared to the base model because 2008 and 2010 recruitment is estimated to be lower than in the base model.

10. The 2015 estimate of median stock biomass is well above the $B_{40\%}$ and $B_{10\%}$ biomass thresholds, and fishing intensity is well below the $F_{40\%}$ target, in both the base and alternative models. The SRG concludes that the coastal Pacific Hake/Whiting stock is not overfished and that overfishing is not occurring in either scenario.

11. The base model forecasts that catches of 730,000 mt in 2015 and 650,000 mt in 2016 could be achievable when fishing at the $F_{40\%}$ target fishing intensity, with an equal probability of being above or below the target fishing intensity. In contrast, the alternative model with unextrapolated 2012 and 2013 survey index values forecasts that catches of 580,000 mt in 2015 and 520,000 mt in 2016 may be achievable when fishing at the same target. The SRG notes that preliminary management strategy evaluation (MSE) work on alternative harvest control rules (HCRs) discussed at the 2014 SRG meeting showed that performance of the default $F_{40\%}$ HCR, judged on a combination of conservation and harvest metrics, was poorer than similar HCRs with upper limits of 375,000 mt or 500,000 mt on annual harvest.

12. The JTC did not offer any new MSE results in 2015, but used 2014 to develop design principles for the MSE operating model and to gather input from the JMC, SRG, and AP on the scope of this model. Progress was made in identifying high level aspirational objectives in the Treaty that can be translated into operational objectives and performance metrics and then incorporated into the design of the MSE operating model. Other activities conducted during 2014 included writing a book chapter describing previous MSE simulations (see 11 above) and the completion of programming to evaluate the potential benefits of having an acoustic survey index of age-1 biomass. We commend the JTC for their efforts and we recommend continued MSE development.

13. The SRG concludes that developing a spatially explicit MSE operating model is necessary to examine issues involving fishing by the US and Canada with spatial dimensions, such as the

availability of fish in each country. The list of operational objectives and performance metrics developed by the JTC is a useful starting point for the task.

Overview of the Acoustic Survey

The acoustic survey was not conducted in 2014, rather it was a research year. The SRG reviewed survey methodology and protocols, survey history from 1977 to the present and the adult Pacific Hake time series used to index biomass in the stock assessment. It was noted that the initiation of the combined Sardine-Hake survey in 2012 brought several changes including a broader focus on both Hake and coastal pelagic species, an increase in the area surveyed, lengthened transects, and reduced night-time environmental sampling owing to the need to survey for Sardine at night. The breaking of the environmental data time series was considered an important loss by the survey team as these data are considered valuable for describing Hake habitat in the survey domain.

The Survey Team addressed many of the survey and acoustic research recommendations from 2014 and the SRG was pleased with their progress. Much of the research that was completed focused on survey design, data analysis for survey biomass estimation (kriging), and acoustic issues (target strength, calibration). Sensitivity analyses on the kriging procedure demonstrated that biomass estimates are highly sensitive to extrapolation outside of the survey area. When extrapolation was included, biomass estimates were also sensitive to other kriging parameters, including the search radius. When extrapolation was excluded, biomass estimates were relatively insensitive to the other kriging parameters.

In-situ target strength measurements at depth, trawl camera work, and the development of an age-1 acoustic index are promising ongoing lines of research. A robust age-1 acoustic index would be particularly important both to increase the number of cohorts with information available to the assessment (and the amount of time available for management to respond to incoming cohorts, be they large or small), and to provide a second index point in the life-cycle of Hake for future work evaluating drivers of recruitment. Work is ongoing to address how well the acoustic survey can index age-1 Hake abundance. Trawl cameras have proven useful for acoustic signal interpretation, particularly when the signals are thought to be from mixed species assemblages. The day-time in-situ target strength study is addressing a potentially important bias in the acoustic survey estimate of biomass: Hake are surveyed during the day when they occupy depths of approximately 150-300 m but the target strength estimate is based on fish dispersed closer to the surface at night.

The Hake research program planned by the Survey Team for 2014 was not fully completed, owing to ship-related issues that reduced the number of days at sea and ship time allocations supporting Sardine programs at the expense of Hake-related activities. The SRG is concerned about future occurrences impacting the ability of the Survey Team to achieve its research objectives and respond to SRG requests in support of better Hake science and management.

Fisheries acoustics presents potential errors at each step in the process, which have been identified (e.g., Simmonds and MacLennan 2005) and evaluated with respect to direction and magnitude. When correctly performed, an acoustic biomass estimate is usually reported with a CV between 10% and 40%, depending on survey conditions. The much smaller CV reported by the Hake acoustic survey reflects only uncertainty in the kriging component of the analysis. Therefore, there is a need to identify processes contributing to uncertainty in the survey and biomass index calculation, in order to develop a better estimate of variance in the biomass index

value. A second step would be to design specific experiments to evaluate the magnitude of each source of uncertainty in the Hake survey when no value exists in the literature.

SRG Survey and Acoustic Research Recommendations

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

- *Survey* – The SRG discussed the issue of kriging and extrapolating beyond the survey area when estimating survey biomass and concludes that extrapolation beyond the survey area should be removed for all years included in the survey index. While most discussion focused on the 2013 biomass index value, the SRG recommends that the Survey Team format all the survey data to permit the removal of extrapolation from all biomass estimates since 1995. This action should be a high priority for the 2016 assessment.
- The SRG conclusion to remove extrapolation from the survey biomass index is the expected default approach for the base assessment in 2016. Nonetheless, there may be components of particular surveys for which the JTC and/or Survey Team believe that extrapolation is defensible. The SRG will gladly review the evidence supporting the need for extrapolation at future SRG meetings, as well as scientific work on questions such as the effects of extrapolation on survey bias and optimal methods that prevent excessive extrapolation.
- The SRG recommends that additional effort be devoted to trawling on age-1 Hake during the 2015 survey and going forward, in support of developing an age-1 index.
- *Offshore Hake Distribution* – Survey transects extend to 35 nmi offshore or the 1,500 m depth, whichever is further. If Hake are observed acoustically at the offshore end of a transect, then the transect is extended until Hake are no longer observed for 1 nmi. The SRG notes that the 1 nmi stopping rule is based on logistical rather than scientific considerations. The SRG encourages the Survey Team to continue to explore the possibility that Hake may be found further offshore using information such as commercial catches, pilot studies of distribution and information from other surveys..
- The SRG noted the following in 2014: "*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 recommends that research on the effect of survey direction and duration be conducted, especially if collaboration on the combined Sardine/Hake survey is expected to continue in the future and survey duration increases. The primary concern for the SRG is whether survey duration and direction affects the meaning of the results provided by the acoustic survey as Hake may be migrating during a survey of extended duration.

- *Hake biology and ecology* – the survey team has collected substantial amounts of acoustic and oceanographic data during historical surveys. These data could be used to describe Hake habitat, but a research plan needs to be developed to better define and then accomplish this task. The SRG recommends that the survey team develop an inventory of oceanographic data relevant to the Hake survey and develop a research plan to define Hake habitat using these data as well as the biomass distributions. The SRG also notes that the multi-frequency acoustic data collected by the survey can be used to identify trophic groups (e.g., plankton, fish) and encourages exploration of this data source by the Survey Team. Such research has the potential to benefit the assessment through better understanding of population dynamics (behaviour, migration, recruitment, ecology) and development of better modelling tools for use when substantial Hake biomass is thought to exist outside the survey area.

Overview of the 2015 Stock Assessment

The assessment presented in 2015 by the JTC was based on the same model and data structure as in 2014, with very few changes. This is a Bayesian, statistical catch-age model whose main data inputs are (i) landings data from the fishery, (ii) age composition of fishery landings, (iii) a biomass index (ages 2+) derived from an acoustic survey, and (iv) age composition of the stock sampled by trawling during the acoustic survey. As in 2014, fishery selectivities at ages below 6 were allowed to vary from 1991 onwards, although such variation was strongly penalized. Notably, the model estimates the natural mortality rate (although an informative prior is used), among other parameters.

The major change for 2015 was extending the fishery data series by one year. No new biomass index (acoustic survey) was available, so the index series ended in 2013. The SRG noted that the extrapolation used in computing the survey biomass index for 2013 has been retained in the base model; that extrapolation increased the 2013 index by about 32%, and thus it will influence assessment results.

A slightly newer version of the Stock Synthesis software was used; a sensitivity analysis to this update showed no effect on model outputs. Other sensitivity analyses included the form of natural mortality-at-age, time-invariant weight-at-age, the inclusion of autocorrelation in recruitment deviations, and the omission of extrapolation in the 2012 and 2013 biomass index values.

SRG Assessment Recommendations

The following recommendations are listed from highest to lowest priority.

- Given the information and analyses presented to the SRG at this meeting, the 2016 base assessment model should be fitted to a survey biomass index series (starting in 1995) with no extrapolation. Sensitivity runs can be conducted to assess the effect of extrapolation in the survey index on the assessment, if extrapolation is supported by compelling evidence.
- *Age-1 index* – The SRG recommends that the next assessment include a sensitivity run incorporating the age-1 acoustic index (which begins in 1995) shown in Figure 8 of the draft 2015 assessment document. Results of this run could be used to facilitate an MSE evaluation of the value of developing a formal age-1 index (see below).

- The SRG recommends that future stock assessments include sensitivity analyses that help communicate more of the key structural uncertainties in the current assessment modelling framework. Two key sensitivities in previous Hake assessments are the prior distributions on natural mortality and recruitment variation. The JTC should define a list of additional uncertainties to be examined regularly.
- High uncertainty about species/stock composition of the developing Hake fishery in Mexico and of Hake found south of Point Conception in the southern California Bight does not support the inclusion of these fish in the assessment at this time. The SRG encourages ongoing monitoring and collaborative research on stock structure to resolve stock status. Anecdotal reports that Mexican catches of Hake have increased substantially in recent years are a concern, especially should these catches come from the same offshore stock of Hake covered by this assessment.
- The SRG supports continued collection of ovaries across the range of Hake and analysis of maturity schedules using histological techniques. Analyses conducted in 2014 show that maturity-at-length differs between northern and southern areas of the stock (based on a break-point at Point Conception, 34°N). The SRG notes that the maturity-at-length curve for the northern region is similar to the relationship used in the current stock assessment (based on Dorn and Saunders 1997). Since most of the catch and estimated survey biomass occurs above 34°N, further work on defining the apparent difference between northern and southern regions is expected to have low relevance to the stock assessment. However, further investigation into the source of this difference, including the possibility of a separate southern stock or sub-species, is of interest for increasing our understanding of Hake species.

SRG Recommendations for Management Strategy Evaluation

The JTC focused its 2014 MSE effort on developing design principles for the operating model. No new MSE results were produced in 2014. It was noted that the JTC requires input from the JMC, SRG, and AP on design features and questions to be addressed by an MSE process to guide programming work on the operating model. The SRG offers the following suggestions to guide the JTC's work with MSE during 2015. The recommendations for MSE are separated from other research recommendations (above) in order to have a cohesive set of suggestions for this effort and are organized in rough order of priority.

- The JTC should complete its evaluation of the benefits of having an age-1 acoustic survey index in the assessment model.
- The SRG notes that previous MSE results indicated poor performance of the default $F_{40\%}$ 40-10 HCR relative to alternative HCRs with regard to both conservation and yield metrics. The SRG recommends that the JTC present those results and any additional work along those lines for review at the next SRG meeting. The findings may have significant implications for management processes.
- The SRG encourages the JTC to continue to engage the JMC, SRG and AP members in discussions and development of MSE operational objectives and report its progress towards the specification of a spatially explicit operating model at the next SRG meeting.

- The SRG recommends that the JTC include structural mismatches in future MSE experiments, to evaluate model uncertainties that are inherent but currently not included in stock assessment estimates of uncertainty.

SRG Recommendations for Process

The SRG discussed the timelines for conducting a stock assessment and reviewing its findings for the JMC and offers the following recommendation from that discussion:

- The schedule for delivery of various outputs is constrained on one end by the availability of data and on the other by intra-governmental processes, such as the need to open fishing seasons by a required date. Nevertheless, SRG members need adequate time to review documents so that they can complete the SRG's required tasks in the time allotted. The SRG recommends that the primary actors involved in collecting the data (Survey Team), conducting the stock assessment (JTC), and reviewing the assessment (SRG) conduct a review of the data and product flows in the process with the objective of finding efficiencies in this timeline. It is important that the timeline meets the needs of all participants with respect to having sufficient time to complete their tasks and meet the March 1 reporting deadline.
- The SRG would like to invite a presentation on the Mexican Hake fishery off the west coast of Baja California (including research and management) to assess the potential for future collaboration.

Literature Cited

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Attachment 1

List of Participants

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