Report on the 2009 Stock Assessment Review for Pacific Hake

N. G. Hall

Unit 2
2 Wexford Street
Subiaco
Western Australia 6008
Australia
Phone: +61 8 9401 6891
Email: nghall@iinet.net.au

February 2009

Contents

1. Executive Summary

The STAR Panel reviewed the 2009 stock assessment developed by the STAT for Pacific Hake and, after exploring areas of concern, accepted a base model for use in calculating the status of the stock and the decision table of predicted outcomes under alternative catch scenarios, as required by the Pacific Fishery Management Council. The accepted base model, which was developed using the Stock Synthesis III (SS3) software package, differs slightly from that which had been developed by the STAT in that it freely estimates survey catchability and the parameters of time-varying selectivity curves for U.S. and Canadian fisheries, where four-year rather than two-year time blocks are used for recent years. As in previous assessments, model estimates and predictions continue to be imprecise, primarily as a result of the lack of information in the input data relating to the values of acoustic survey catchability and natural mortality. It should be noted that the decision table produced in the assessment does not capture additional uncertainty that is associated with the inadequacy of some aspects of model structure, which is evident in the patterns of residuals in the length-composition data and tension between the length- and conditional age-composition data.

The STAR Panel recommended the use of a decision table to be constructed using the results of a Markov Chain Monte Carlo (MCMC) analysis to be run following the review and before completion of the final assessment document. As a contingency against failure of the MCMC run to converge, however, the Panel recommended the construction of an alternative decision table based on the results of Maximum Likelihood Estimation (MLE) using SS3. An initial row of such a decision table, containing a three-year forecast of the estimated female spawning biomass and depletion under three different states of nature using coast-wide catches estimated under the 40:10 rule for the base model, was prepared as an example. The MLE estimate of female spawning biomass in 2009 was 435,000 mt, while conservative and optimistic estimates were 294,000 and 575,000 mt, respectively. The corresponding estimates of depletion were 32, 22 and 41%, respectively. The values of the 2009, 2010 and 2011 catches calculated using the base model under the 40:10 rule were 253,582, 193,109, and 189,054 mt, respectively.

A priority for research is to obtain a more detailed description of the midwater trawl component of the acoustic survey, with explicit details of the criteria used to determine when and where trawls are made, and their duration, and of the way in which these data are combined with the acoustic data to derive estimates of biomass and length- and age-composition data. Re-analysis of these data are essential as current methods of analysis, such as post-stratification based on the nature of the data rather than depth or geography, appear to have the potential to introduce bias. The addition of sex-structure to the assessment model was also seen as a research priority, as this has the potential of resolving some of the structural inadequacy that is currently evident.

The STAT is to be commended for the quality of the stock assessment and documentation that they submitted to the STAR Panel, and for their very competent and professional responses to the Panel's many requests.

2. Background

2.1. *Overview*

A STAR meeting to review the 2009 stock assessment for Pacific Hake/Whiting was held in Seattle from 3-6 February, 2009. The STAR Panel comprised, as Chairman, Dr David Samson, who represented the Scientific Steering Committee's Groundfish Subcommittee, Drs Jon Vølstad and Norman Hall, who had been appointed by the Center for Independent Experts (CIE), and Dr Tom Carruthers, from the University of British Columbia.

Two weeks prior to the STAR meeting, the stock assessment document and other background documentation had been made available to Panel members. A list of these documents is presented in Appendix 1.

The Statement of Work provided to Dr Norm Hall by the CIE is attached as Appendix 2. This requires that, in addition to satisfying the Pacific Fisheries Management Council's requirements for STAT Panel members under its "Terms of Reference for the Groundfish Stock Assessment and Review Process for 2009-2010", an independent peer review of the assessment and review process is prepared. This report documents the findings of that independent review and is prepared in accordance with the CIE Statement of Work.

2.2. *Terms of Reference*

The terms of reference for the STAR Panel are set out in the Pacific Fishery Management Council's document, "Terms of Reference for the Groundfish Stock Assessment and Review Process for 2009-2010", while the terms of reference for this independent peer review are presented in Annex 2 of Appendix 2.

2.3. *Panel membership*

Details of the Panel that undertook the review of the Pacific Hake stock assessment are presented in Appendix 3. In particular, the STAR Panel members comprised:

- David Sampson, Scientific and Statistical Committee (SSC) Representative, Panel Chair
- Jon Vølstad, Center for Independent Experts (CIE)
- Norman Hall, Center for Independent Experts (CIE)
- Tom Carruthers, University of British Columbia

2.4. *Date and place*

The STAR Panel met to review the stock assessments for Pacific Hake on February 3-6, 2009, at Hotel Deca, Seattle.

2.5. Disclaimer

The information in this report has been provided by way of review only. The author makes no representation, express or implied, as to the accuracy of the information and accepts no liability whatsoever for either its use or any reliance placed on it.

2.6. Acknowledgments

Thanks are expressed to the personnel at the NWFSC for making the review such an interesting and positive experience, and particularly to Drs Ian Stewart and Owen Hamel, who responded so positively and rapidly to the many requests that were made of them. Mr John DeVore is to especially thanked for the great assistance that he provided throughout the entire meeting, tirelessly taking comprehensive notes of the activity and discussions, and thereby allowing reviewers to focus on the stock assessment and models.

3. Description of Reviewer's role in review activities

As required under the CIE's statement of work, I familiarised myself with the assessment documentation and actively participated in the review. Details of the review, which comprised the majority of my activities, are included in Section 4.8. Subsequent to the review, I participated in the on-going email discussion as the STAR Panel's report, under the very able leadership of Dr Samson, was completed.

4. Summary of findings

In this section of the document, I have attempted to present my own assessment of each of the Terms of Reference for the review, to supplement the views expressed in the discussion of the STAR Panel review presented in Section 4.8. Note that the material below is derived from the draft assessment report, other background material provided for the review (Appendix 1), and from the presentations provided by the STAT and the discussions among members of the STAR Panel and STAT and other participants during the review.

4.1. Stock assessment documents

TOR 1. Become familiar with the draft Pacific hake stock assessment and background materials. Along with other members of the Panel, determine if the stock assessment document is sufficiently complete according to the Pacific Fishery Management Council's Terms of Reference for West Coast Groundfish Stock Assessment and STAR Panels (to be included once finalized).

It is appropriate to mention at the outset that the STAT was required to process biological data and collate fisheries data that, for both the U.S. and Canadian fisheries, were collected very late in 2008, to undertake the assessment and to produce an assessment report such that this could be circulated to the STAR Panel two weeks before February 3, 2009. Such a task is daunting, and it is inevitable that the assessment report fails to include aspects of the results of exhaustive exploration that would normally be produced. Those responsible for processing the data and getting these to the STAT in time for the STAR meeting are to be commended for their efforts. In particular, the STAT is to be commended on its achievement in undertaking and reporting the assessment in the brief time that was available. Unfortunately, this meant that the stock assessment document reflects analyses of data that exclude the 2008 Canadian length and age composition data. These data were however included in the final analysis that was presented to the STAR Panel at the review meeting, and will, no doubt, be included in the final assessment document that is prepared by the STAT. In addressing the above item of the terms of reference for CIE reviewers, *i.e.*, TOR 1, the document presented to the STAR Panel is considered and thus the content of this document excludes the results of the more recent analysis that includes the 2008 Canadian length and age composition data.

Overall, Drs Hamel and Stewart have produced an assessment document (Hamel and Stewart, 2009) that, in the main, meets the requirements of the Pacific Fishery Management Council's Terms of Reference. There are minor inadequacies, such as the lack of detail of the management of the Canadian fishery, and the omission of the results of explorations that led to the selection of the particular blocking structure for fishery selectivity, that could be addressed. Details of these are included in the discussion below in which I have examined each of the requirements of the PFMC's Terms of Reference for the assessment document.

In the detailed discussion below, the text presented in italics is extracted from the Pacific Fishery Management Council's Terms of Reference for the Groundfish Stock Assessment and Review Process for 2009-2010, which provides the following outline of items that should be included in stock assessment reports for groundfish managed by the Pacific Fishery Management Council. Interspersed with this italicised text, I provide my assessment of the extent to which the STAT has fulfilled the requirements of the PFMC's specification, together with comments on any concerns that I have relating to the content of the assessment document. Initially, I have considered the content of the assessment document as a whole, and, subsequently, I have examined the extent to which Drs Hamel and Stewart have satisfied the requirements for the Executive Summary.

The outline is a working document meant to provide assessment authors with flexible guidelines about how to organize and communicate their work. All items listed in the outline may not be appropriate or available for each assessment. Also, items flagged with asterisks (*) are optional for draft assessment documents prepared for STAR panel meetings but should be included in the final document. In the interest of clarity and uniformity of presentation, stock assessment authors and reviewers are encouraged (but not required) to use the same organization and section names as in the outline. It is important that time trends of catch, abundance, harvest rates, recruitment and other key quantities be presented in tabular form to facilitate full understanding and follow-up work.

A. Title page and list of preparers – the names and affiliations of the stock assessment team (STAT) either alphabetically or as first and secondary authors

OK

B. Executive Summary (see attached template and example in Appendices C and D).

This section is discussed below.

C. Introduction

1. Scientific name, distribution, the basis for the choice of stock structure, including regional differences in life history or other biological characteristics that should form the basis of management units.

The assessment document provides the scientific and common names of the species, describes its distribution, and the stock structure of the species in waters off the western coasts of the U.S. and Canada. The genetic basis for the stock structure is reported, and the particular stock that is the subject of the stock assessment is identified. A slightly more detailed description of samples used and the analysis that was undertaken by Utter (1971, as cited by Hamel and Stewart, 2009) would have been preferred, and summaries of results of other more recent studies, such as that by Iwamoto *et al*. (2004), reported. From the background material, it is unclear whether the samples used to distinguish the stocks genetically came only from known spawning grounds, or other samples of genetic material were taken from the offshore stock throughout its known range and were found to be similar to those from spawning fish taken off south-central California. The assessment document reports that the coastal stock is distinguished from the inshore populations by larger body size and seasonal migratory behaviour, but cites no reference to support this claim. While the offshore stock may grow to a larger body size, younger fish from this stock must possess a smaller body size, which potentially matches the size of the individuals of other stocks. The question of whether there is potential to misclassify catches from the different stocks has not been addressed adequately, and evidence has not been presented to demonstrate that such misclassification does not occur.

2. A map depicting the scope of the assessment and identifying boundaries for fisheries or data collection strata.

While no map is presented in the document to depict the range of the stock considered in the assessment, the entire coastal stock of Pacific Hake is clearly identified as the subject of the assessment. The typical range of this stock is described as extending from the waters off southern California to Queen Charlotte Sound. Catches from both U.S. and Canadian waters are included in the assessment. Maps are presented in a subsequent section of the document that show the occurrence of acoustic backscattering attributed to Pacific Hake in joint US-Canada surveys from 1995 to 2007. This information is adequate for understanding the scope of the assessment and boundaries for fisheries or data collection strata.

3. Description of fisheries for this species off Canada or Alaska, including references to any recent assessments of those stocks.

The stock assessment covers the fisheries for both the U.S. and Canada, and includes catches of foreign fishing vessels that exploited the stock of Pacific Hake. Adequate details of the history of fishing and of the current fisheries for each nation are presented in the introduction to the stock assessment document. It would be useful to note in this section that catches from the stock by other fisheries are considered to be negligible.

*4. Important features of life history that affect management (*e.g., *migration, sexual dimorphism, bathymetric demography).*

The stock assessment document reports the broad characteristics of the current conceptual understanding of the life history of the stock, and the information available on the timing and location of spawning, subsequent northward and onshore migration by adult fish, and, in summer, formation of midwater aggregations associated with the shelf break. The document reports that northward migration is typically greatest for the older and larger females, but that the distributions of both juveniles and adults vary considerably over years, where it is hypothesised that this may relate to environmental factors such as El Niño events. The document reports that there is limited knowledge of spawning events due to the difficulty of locating major offshore spawning aggregations. The information reported in the introduction is sufficient to recognise that northward migration and distribution of fish differs considerably among years, and that, in association with this migration, there is an age- and size-dependent spatio-temporal distribution of fish that, in combination with the requirement in the U.S. to avoid excessive bycatch, must affect the age and size composition of the catches taken by the different fisheries.

5. Important features of current fishery and relevant history of fishery.

While a description of historical and current fishing is presented in the introduction of the stock assessment document, the spatial and temporal distribution of the foreign fishery in earlier years and the fishing gear used by this fishery could quite conceivably have differed from that of the current fishery. No details of the distributions of fishing in earlier years are provided in the assessment document. It is possible that the distribution of fishing by the U.S. fleet expanded with the development of surimi plants, but no information on the distribution of catches (or landings) is reported in the assessment document. Although the gear used by the current U.S. fleet is described, *i.e.*, "pelagic trawls with a codend mesh that is at least 7.5 cm (3 inches)", no similar description is provided of the gear used in the Canadian fishery. No details are provided of the changes in fishing gear that may have occurred, or of changes in technology that might have improved searching efficiency through the time series. Some slight inconsistencies were detected in the data for recent years reported in Table 1 and the values recorded in the input data for Stock Synthesis III (Appendix A of the stock assessment document).

*6. Summary of management history (*e.g., *changes in mesh sizes, trip limits, or other management actions that may have significantly altered selection, catch rates, or discards).*

Although a description of the management that has been applied to the U.S. sector of the Pacific Hake fishery is provided in the stock assessment document, no similar detailed description of the management of the Canadian sector is reported. For example, no mention is made of the use of individual vessel quotas rather than a TAC in Canada. The description of the management of the U.S. fishery might be improved slightly. For example, it is reported that "regulations also restrict the area and season of fishing to reduce the bycatch of Chinook salmon and several depleted rockfish stocks". It is unclear, however, whether the opening dates and spatial closures that are subsequently reported in the paragraph relate to those regulations. Presentation of a detailed table reporting the timeline of management changes, and the purpose of each regulation, might prove useful. There would be considerable value in defining the precise meaning of ABC and OY, and describing how these are determined (including details of the 40-10 rule). Based on the information presented in the assessment document alone, this is currently vague.

*7. Management performance – a table or tables comparing acceptable biological catches, optimum yields, landings, and catch (*i.e., *landings plus discard) for each area and year*

A table (Table 2 of the assessment document) of annual coast-wide landings, and the associated values of OY and ABC for 1999-2008 was presented.

D. Assessment

1. Data

*a. Landings by year and fishery, historical catch estimates, discards (generally specified as a percentage of total catch in weight and in units of mt), catch-at-age, weight-at-age, abundance indices (typically survey and CPUE data), data used to estimate biological parameters (*e.g., *growth rates, maturity schedules, and natural mortality) with coefficients of variation (CVs) or variances if available. Include complete tables and figures and date of extraction.*

The assessment report provided details of the data that are input to the model. These included details of

- annual catches (landings plus estimated discards) by the U.S. and Canadian fisheries from 1966 to 2008;
- length compositions from the U.S. fishery (1975-2008) and Canadian fishery (1988-2007). Note that, although not available for inclusion in the draft assessment document, the length composition and age-at-length compositions for Canadian catches in 2008 were received by the

STAT just prior to the STAR meeting and were included in the results presented to the STAR Panel during the review;

- age compositions from the U.S. fishery (1973-1974) and Canadian fishery (1977-1987);
- conditional age-at-length compositions from the U.S. fishery (1975-2008) and Canadian fishery (1988-2007). Note that, as described above, Canadian data from 1988-2008 were used in the model results reviewed by the STAR Panel;
- biomass indices, length compositions and conditional age-at-length composition data from the joint US-Canadian acoustic/midwater trawl surveys in 1977, 1980, 1983, 1986, 1989, 1992, 1995, 1998, 2001, 2003, 2005, and 2007;
- ageing error matrices on cross-read otoliths, with an adjustment for the "lumping effect" associated with relatively strong cohorts;
- seasonal length composition data from Santa Barbara for 1963-1970.

Pre-recruit data from the NWFSC-PWCC midwater juvenile hake and rockfish surveys (2001-2008) were also input but, due to inconsistency with other data sets, tuned out by the iterative reweighting approach used by the model. These data were used in one of the STAR Panel's explorations.

The length at age 2 and the "parameters describing the distribution of length at each age were fixed at values estimated directly from the data", however it is not stated which data were used in this analysis or which methods were used to estimate these values. Other growth parameters are estimated by the model.

Parameters of the logistic relationship between the proportion of females that were mature and fish length, derived externally from the model by Dorn and Saunders (1997, as cited by Hamel and Stewart, 2009) using the subjective classifications of the maturity of 782 fish based on visual examination of their ovaries, were input to the model.

The basis for the parameters of the weight-length relationship used in the model is not presented.

An estimate of natural mortality, M = 0.23 year^{-1}, which was derived externally to the model by Dorn *et al*. (1994, as cited by Hamel and Stewart, 2009) using the decline in abundance of a year class in successive acoustic surveys, was used in the assessment as the natural mortality of fish to age 13.

The steepness of the Beverton and Holt stock-recruitment relationship was assumed to have a beta prior, based on the results reported for the family Gadidae by Myers *et al*. (1999).

The relationship between fecundity and length was reported to be the same as in previous assessments, but no details were provided in the stock assessment document of the derivation of this relationship.

Details of the annual catches of the various fishing sectors in both U.S. and Canadian waters were reported in Table 1 of the stock assessment report. It was reported that the values for shore-based landings are from the Pacific Fishery Information Network (PacFIN). No information is presented to explain how the catch data were collected or processed, or to demonstrate that they are accurate. Similarly, no information is presented on the method of data capture by observers and subsequent data processing for the foreign and joint-venture catches for 1981-1990, or the domestic at-sea catches for 1991-2008. How were quantities of catches assessed? Was the catch recorded for every haul? No details are presented of the method by which estimates were obtained of catches from Canadian waters by foreign vessels. More details of the methods used to record the Canadian catches should be presented, *e.g.*, do observers record the catch of every haul, what is the volume/density method, how are mixtures of species in catches handled, etc? Sufficient information should be presented in the assessment document to demonstrate that the catch data are reliable.

Although Table 1 in the assessment document is apparently intended to include discards, no details of these are presented. Although the level of discards is estimated to be less than 1% of landings (page 2 of draft assessment document), and is therefore negligible, there is value in reporting these values such that the decision to exclude explicit calculation of discards within the model is justified.

Under-reporting of historical catches in U.S. waters by foreign fishers is listed in the assessment document as a topic for future research. The document reports that the sensitivity of the assessment to such under-reporting was produced for the 2008 assessment, but no similar analysis was conducted for the 2009 assessment. Such an evaluation would be useful as the 2009 base model differs from that of 2008.

A brief summary of the U.S. observer program would be useful. Are observers on every vessel, and do they monitor every haul? Were the hauls that are sampled for length, weight and age composition data representative of the hauls made by the fishers? Was there a bias towards sampling the catches of foreign or joint-venture fisheries, and, if so, did such bias change through time?

The sampling regime for U.S. and Canadian catches in recent years appears likely to obtain samples that are representative of the hauls or trips that are the primary sampling units for these fisheries. There would be value, however, in demonstrating that the observer and port sampling programs avoided bias through demographic analysis of the proportions of foreign, joint-venture and domestic at-sea hauls sampled, and the distributions of samples relative to trips across the different ports of landing through time.

The design of the acoustic survey appears adequate with transects at 10 nm intervals now covering the range where backscatter intensity indicate that Pacific Hake are present. A table should be included, however, providing for each year details of the depth range covered, the latitudinal extent of the coverage, and comment as to whether the survey in that year covered the full extent of the range occupied by the stock. The criteria for determining the locations of the associated midwater trawls should be specified in the assessment document. The criteria for post-stratification should also be specified. Concerns relating to the quality of the survey data are expressed in Section 4.2.

b. Sample size information for length and age composition data by area, year, gear, market category, etc., including both the number of trips and fish sampled.

Details are presented of the number of hauls from which length and age samples were taken in the at-sea U.S. fishery and the Canadian joint-venture fishery. The numbers of trips from which length samples were taken in the U.S. shore-based and Canadian domestic fisheries are also reported. For these four sets of data, the numbers of length and ages are also reported, together with both the sampled and total weights.

c. All data sources that include the species being assessed, which are used in the assessment, and provide the rationale for data sources that are excluded.

Details of the data used in the model, and their sources, were dealt with above. Other data that were not used in the assessment model are discussed below.

Triennial bottom trawl survey data collected by the Alaska Fisheries Science Center (1977-2001) and, from 2003, by the Northwest Fisheries Science Center were excluded from analysis by the model as they failed to cover adequately the area occupied by Pacific Hake, and had limited effectiveness in catching individuals of the species.

Exclusion of CalCOFI larval hake production index (1951-2006) from the data input to the model was justified on the basis of inadequate coverage of the geographic range of the distribution of eggs and larvae of Pacific Hake. The conclusion that these data were non-representative and should be excluded was endorsed by earlier STAR Panels.

2. History of modeling approaches used for this stock – changes between current and previous assessment models

A summary of the modelling approaches used since the early 1980s was presented in the stock assessment report. The report documents the changes that were made in moving from the 2008 to the 2009 assessment. These included the use of the additional year of catch data for both the U.S. and Canadian fisheries, the additional year of length composition and conditional age at length composition data for the U.S. fishery, further uncertainty in the degree of recruitment variability σ_r, and more flexible time-varying selectivity for the U.S. and Canadian fisheries. The ageing error matrices were enhanced by including additional data and adjusting for the "lumping" effect of strong year classes. The value of the acoustic survey catchability q was fixed at 0.7 in the base model presented to the STAR Panel. Subsequently, following preparation of the draft report, length composition and conditional age at length composition data were obtained for 2008 for Canada and incorporated in the assessment that was presented by the STAT to the STAR Panel.

a. Response to STAR panel recommendations from the most recent previous assessment.

The assessment document reported the STAT's response to each of the STAR Panel's requests, but resources limited the extent to which some of these issues could be addressed. The recommendations relating to the Management Strategy Evaluation (MSE) have been deferred till the U.S.-Canada treaty is finally ratified and the MSE can be addressed by a joint U.S.-Canadian STAT. Progress was made on improving the ageing-error matrix, and work on the acoustic data is underway.

b. Report of consultations with GAP and GMT representatives regarding the use of various data sources in the stock assessment.

No consultation was reported.

3. Model description

Detailed descriptions of the Stock Synthesis 3 model (and its predecessors) have been prepared by Dr Richard Methot, and these descriptions (and the model) continue to be refined. These descriptions were provided to the STAR Panel as background material to accompany the assessment report.

a. Complete description of any new modeling approaches.

The basis of the STAT's decision to use a fixed value for the acoustic catchability q was presented in the assessment document. The sensitivity of the predictions of the values required for management to the value used for this parameter was, however, identified later in the assessment document.

Changes to the form of the functions describing selectivity at age for the acoustic survey and both fisheries, from double logistic to double normal, were justified on the basis of improved stability.

The adjustments made to the ageing error matrix were described, and the basis for the correction for the "lumping" effect for strong year classes presented. A more detailed description of the information presented in Figure 20 is warranted, as this currently is unclear.

Justification was provided from external analysis for the decision to assume time-varying growth, with length at age 12 assumed to differ between 1960-1983 and 1984-2008 and with the growth parameter k varying between the common value assumed for 1960-1979 and 1987-1998 and that for both 1980-1986 and 1999-2008.

The complex blocking structure for the selectivity at age for the U.S. fishery (ascending width for 9 periods – 1966-1980, 1981-1984, 1985-1988, 1989-

1992, 1993-1996, 1997-2000, 2001-2004, 2005-2006, and 2007-2008; peak selectivity for 10 periods – 1966-1980, 1981-1984, 1985-1988, 1989-1992, 1993-1996, 1997-2000, 2001-2002, 2003-2004, 2005-2006, and 2007-2008; and final selectivity for 3 periods – 1966-1983, 1984-2000, and 2001-2008) and the Canadian fishery (ascending width for 5 periods -1966-1984, 1985-1988, 1989-2000, 2001-2004, and 2005-2008; and peak selectivity for 8 periods – 1966-1980, 1981-1984, 1985-1988, 1989-1992, 1993-2000, 2001-2003, 2004-2005, and 2006-2008) was described. The justification for introducing this time-varying selectivity was the need to account for temporal changes in the fishery and shifts in selectivity due to targeting of stronger year classes.

A linear increase in natural mortality for older fish, *i.e.* 14 and 15+, from that of fish at age 13 (and younger) was assumed and both the mortality for 15+ fish and the parameter associated with recruitment variability σ_r were estimated.

The assessment document reports the use of multinomial sample sizes initially estimated as the number of hauls or trips sampled for fishery data and of tows for acoustic survey data. For data other than that associated with acoustic survey catchability, input sample sizes were iteratively reweighted to match the effective sample size estimated by the model.

b. Definitions of fleets and areas.

The fleets described by the model were currently those of the combined at-sea and shore based U.S. fishery and the combined joint-venture and domestic Canadian fishery. Catch, length and age composition, and conditional age at length compositions related to these areas.

*d. Assessment program with last revision date (*i.e., *date executable program file was compiled).*

The latest version of Stock Synthesis (SS v.3.01o) was used for the results presented in the assessment document, but an even later version was used in the results presented to the STAR, which incorporated the Canadian length and age composition data for 2008.

e. List and description of all likelihood components in the model.

Unfortunately, the assessment document has relied on the descriptions of the likelihood components presented in Stock Synthesis documentation. There would be great benefit in explicitly stating the components of the log-likelihood within the assessment document.

f. Constraints on parameters, selectivity assumptions, natural mortality, assumed level of age reader agreement or assumed ageing error (if applicable), and other assumed parameters.

Details of the constants used, the priors assumed for the different parameters, the CVs assumed, and the assumptions relating to the form of selectivity equations are all presented. Presentation of the data files used by the Stock Synthesis model ensures that all assumptions and constraints are explicitly presented.

g. Description of stock-recruitment constraints or components.

The form of the stock-recruitment model is that of the Beverton and Holt model. The steepness is assumed to have a beta prior, with values describing the distribution derived for Gadidae from the meta-analysis by Myers *et al*. (1999). The mean level of recruitment is estimated by the model.

*h. Description of how the first year that is included in the model was selected and how the population state at the time is defined (*e.g., *B0, stable age structure, etc.).*

The model was used to describe data from 1960 to 2008, where it was assumed that the fishery was at an unexploited equilibrium at 1960. This assumption was justified by the fact that, until foreign fleets arrived in the mid-1960s, there had been little exploitation of the stock. Catches for the foreign fleets in U.S. and Canadian waters were first recorded for 1966.

i. Critical assumptions and consequences of assumption failures.

No explicit statement is made that identifies the assumptions that are considered critical. The document does, however, report exploration of the sensitivity of current biomass estimates and estimates of depletion to the value selected for use as the catchability of the acoustic survey q and the value used as the estimate of natural mortality M.

A key assumption made in the model is that there is no spatial structure. This assumption and the resulting model structure requires that the patterns of movement, the varying size-dependent distribution of fish along the coast, and the varying age and length compositions of the catches made by the U.S. and Canadian fisheries must be explained by the time-varying selectivity patterns associated with those fisheries. Lack of detailed information on the distribution and movement of the Pacific Hake makes this assumption essential for modelling, but it is likely to create some tension among data sets.

The document does discuss the implications of the failure to include gender-specific growth. Plans for future research reported in the document include the restructuring of the model to incorporate sex-specific representation of the stock.

4. Model selection and evaluation

a. Evidence of search for balance between model realism and parsimony.

In discussing model selection and evaluation, the authors of the assessment document report that their extensive evaluation (over hundreds of model runs) of time-blocking for fishery selectivity demonstrated the sensitivity of the model to the blocking that was used, but this sensitivity declined as additional complexity was introduced. It might be argued that the very complex time-blocking structure of fishery selectivity flies in the face of parsimony, yet it is clear from the descriptions of the fishery that fishers target strong year classes and adjust their fishing patterns accordingly, and that the distribution of fish varies markedly from year to year and its effect on the fishery must be considered. It is accepted that with the single-area assumption made in the model, variation in the size and age composition of the U.S. and Canadian fisheries must be accommodated by use of a complex, time-varying selectivity for each fishery.

It should be noted that model selection for the Pacific Hake fishery has occurred over an extended period of years, and the models used have evolved through successive assessments. Although summarised briefly in the descriptions of the history of assessments, the earlier versions of assessment models are not considered in the current assessment document in a model comparison framework.

*b. Comparison of key model assumptions, include comparisons based on nested models (*e.g.*, asymptotic vs. domed selectivities, constant vs. time-varying selectivities).*

Details of the results of models comparing asymptotic and domed selectivities, and constant versus time-varying selectivities are not included in the assessment document. The only information that is provided is a brief description of the analyses and the conclusion that was drawn from the exploration. No evidence, *e.g.* comparison of the Akaike Information Criteria for the different models and diagnostic plots, is presented that justifies the decisions that were made.

c. Summary of alternate model configurations that were tried but rejected.

The alternative model configuration that was represented by the model used in the 2008 assessment is described. No explicit and full description of other alternate model configurations and results for these models are presented.

*d. Likelihood profile for the base-run (or proposed base-run model for a draft assessment undergoing review) configuration over one or more key parameters (*e.g.*, M, h, Q) to show consistency among input data sources.*

Although a likelihood profile is presented in the assessment document, this comprises only the total negative log-likelihood, not the components of the log-likelihood relating to the various input data sets. Consequently, tensions among data sets were not demonstrated, although were described in sections of the text.

e. Residual analysis for the base-run configuration (or proposed base-run model in a draft assessment undergoing review) e.g.*, residual plots, time* *series plots of observed and predicted values, or other approaches. Note that model diagnostics are required in draft assessments undergoing review.*

The document contains a plot of the fitted time series of biomasses estimated from the acoustic surveys, their confidence limits, and the values predicted by the model for the original base case brought to the STAR Panel, *i.e.*, before inclusion of the 2008 Canadian size and age composition data. It also includes plots for this base case model of the sample sizes input to the model versus those estimated by the model, and plots of the predicted and observed length and age distributions for each fishery, for the acoustic survey and the earlier Californian data, together with residual plots.

f. Convergence status and convergence criteria for the base-run model (or proposed base-run)

The model was reported to have converged and the convergence criterion for the maximum gradient at convergence, as reported in the input data for Stock Synthesis, was 0.0000001.

g. Randomization run results or other evidence of search for global best estimates.

Results of jittering were not reported in the assessment document.

h. Evaluation of model parameters. Do they make sense? Are they credible?

Model parameters (as shown in plots of growth, selectivity and mortality) and predictions reported from the base case run brought to the STAR Panel (before inclusion of 2008 Canadian length and age composition data) appeared credible.

*i. Are model results consistent with assessments of the same species in Canada and Alaska? Are parameter estimates (*e.g.*, survey catchability) consistent with estimates for related stocks?*

The assessment includes the data for Canada, and thus are consistent with those data.

5. Point-by-point response to the STAR panel recommendations. (Not required in draft assessment undergoing review.)*

Not applicable.

6. Base-run(s) results

*a. Table listing all explicit parameters in the stock assessment model used for base runs, their purpose (*e.g.*, recruitment parameter, selectivity parameter) and whether or not the parameter was actually estimated in the stock assessment model.*

Table 13 of the stock assessment report presents these data.

b. Population numbers at age × year × sex (if sex-specific M, growth, or selectivity) (May be provided as a text file). (Not required in draft assessment undergoing review.)*

Table 17 of the assessment document presents the numbers at age for each year estimated using the base case model brought to the STAR Panel (prior to inclusion of the 2008 Canadian length and age composition data). No breakdown by sex is presented as the current model does not consider the sexes separately.

c. Time-series of total, summary, and spawning biomass, depletion relative to B0, recruitment and fishing mortality or exploitation rate estimates (table and figures).

Tables 15 and 16 of the assessment document report the time series of estimates of total and spawning biomass, summary biomass, *i.e.*, 3+ biomass, depletion, recruitment and exploitation rate derived from the base case model brought to the STAR Panel (prior to inclusion of 2008 Canadian length and age composition data).

d. Selectivity estimates (if not included elsewhere).

Contour plots are used to describe the time-varying selectivities of the U.S. and Canadian fisheries for the base case model brought to the STAR Panel (prior to inclusion of the 2008 Canadian length and age composition data), while a plot of the selectivity curve presents the selectivity of the acoustic survey.

e. Stock-recruitment relationship.

A plot of the stock-recruitment curve determined when fitting the base case model brought to the STAR Panel (prior to inclusion of the 2008 Canadian length and age composition data) is included in the assessment document as Figure 60. The document also reports in the executive summary that the estimate of steepness was 0.89 and that unfished recruitment was 2.43 billion fish. It would be useful to include a table containing details of the estimates and confidence limits for all parameters fitted in the model.

7. Uncertainty and sensitivity analyses. The best approach for describing uncertainty and the range of probable biomass estimates in groundfish assessments may depend on the situation. Important factors to consider include:

*a. Parameter uncertainty (variance estimation conditioned on a given model, estimation framework, data set choice, and weighting scheme), including likelihood profiles of important assessment parameters (*e.g., *natural mortality). This also includes expressing uncertainty in derived outputs of the model and estimating CVs by an appropriate methods (*e.g., *bootstrap, asymptotic methods, Bayesian approaches, such as MCMC).*

Approximate 95% confidence limits of the estimates of spawning biomass of females, depletion, recruitment and the relative spawning potential, (1-SPR)/(1-$SPR_{Target=0.4}$) from the base case model described in the draft assessment document are presented in plots. Incidentally, (1-SPR)/(1-$SPR_{Target=0.4}$) is frequently mis-typed in the assessment document. The sensitivities of estimates of female spawning stock biomass and 2009 ABC to alternative values of acoustic survey catchability are presented. Likelihood profiles for acoustic survey q and the natural mortality rate for the younger fish (to age 13) are also displayed. A decision table derived using MCMC integration of the posterior distribution of estimated spawning biomass for females and for depletion projected for 2009-2011 under different annual catches is presented in the document. The results of the MCMC integration were qualified as being preliminary, as there had been insufficient time to run the analysis over a sufficiently large set of iterations.

*b. Sensitivity to data set choice and weighting schemes (*e.g., *emphasis factors), which may also include a consideration of recent patterns in recruitment.*

No details of the results of such exploration are presented.

c. Sensitivity to assumptions about model structure, i.e., *model specification uncertainty.*

A description of the exploration of alternative time-blocking structures for growth and fishery selectivity is provided in the assessment document, but the results of these explorations are not presented.

d. Retrospective analysis, where the model is fitted to a series of shortened input data sets, with the most recent years of input data being dropped.

Results of retrospective analysis are presented in Figure 66 of the assessment document.

e. Historical analysis (plot of actual estimates from current and previous assessments).

A plot of the time series of female spawning biomass estimated using the 2008 and 2009 models is presented in the stock assessment report.

f. Subjective appraisal of the magnitude and sources of uncertainty.

The assessment document includes discussion of the sources of uncertainty, highlighting the sensitivity of model results to the values of acoustic survey catchability and natural mortality for fish to age 13. Further discussion of the magnitude of uncertainty and the implications of model uncertainty and the results of the retrospective analysis for the management advice that was presented would have been useful.

g. If a range of model runs is used to characterize uncertainty it is important to provide some qualitative or quantitative information about relative probability of each.

Rather than using a range of runs based on alternative parameter estimates, Drs Hamel and Stewart appropriately chose to use MCMC to integrate the data over the full range of uncertainty for the base case model.

h. If possible, ranges depicting uncertainty should include at least three runs: (a) one judged most probable; (b) at least one that depicts the range of uncertainty in the direction of lower current biomass levels; and (c) one that depicts the range of uncertainty in the direction of higher current biomass levels. The entire range of uncertainty should be carried through stock projections and decision table analyses.

Use of the MCMC approach captures the uncertainty of the model predictions more adequately than use of a range of three runs over a limited range of selected parameter estimates.

E. Reference points (biomass and exploitation rate).
1. Unfished spawning stock biomass, summary age biomass, and recruitment.

The assessment document presents estimates of unfished female spawning biomass, total biomass and 3+ biomass in Table h of the Executive Summary (note that two tables are identified as Table h). It also reports the estimate of the expected unfished mean recruitment.

2. Reference points based on B40% (spawning biomass, SPR, exploitation rate, equilibrium yield).

Table h of the Executive Summary of the assessment document presents estimates of the specified reference points.

3. Reference points based on default SPR proxy (spawning biomass, SPR, exploitation rate, equilibrium yield).

Table h of the Executive Summary of the assessment document presents estimates of the specified reference points.

4. Reference points based on MSY (if estimated) (spawning biomass, SPR, exploitation rate, equilibrium yield).

Table h of the Executive Summary of the assessment document presents estimates of the specified reference points.

5. Equilibrium yield curve showing various BMSY proxies (see attached example).

Figure h in the Executive Summary of the assessment document presents the equilibrium yield curve. The various BMSY proxies shown in the example plot are not displayed on the curve.

F. Harvest projections and decision tables (Not required in draft assessment undergoing review.)*

*1. Harvest projections and decision tables (*i.e., *a matrix of states of nature versus management action) should cover the plausible range of uncertainty about current biomass and the full range of candidate fishing mortality targets used for the stock or requested by the GMT. These should at least include calculation of the ABC based on FMSY (or its proxy) and the OY that is implied under the Council's 40:10 harvest policy. Ideally, the alternatives described in the decision table will be drawn from a probability distribution which describes the pattern of uncertainty regarding the status of the stock and the consequences of alternative future management actions. Where alternatives are not formally associated with a probability distribution, the document needs to present sufficient information to guide assignment of approximate probabilities to each alternative. Decision tables should follow the format of the example Executive Summary for canary rockfish (Appendix D of this document) in which the columns represent the states of nature and the rows the management decisions. In most cases, management decisions will represent the sequence of catches obtained by applying the Council 40-10 harvest policy to each state of nature; however other alternatives may be suggested by the GMT as being more relevant to Council decision-making. For example, when recent catches are much less than the OY, there may be more interest in status quo projections.*

Table 19 of the assessment document presents a decision table that explores the possible outcomes of various harvest projections under alternative states of nature represented by the distribution of values of female spawning biomass and estimated depletion determined from the results of an MCMC analysis. Drs Hamel and Stewart note that these values are preliminary, however, as they were based on a limited number of iterations. The table includes the values of ABC and OY for 2009-2011 calculated from the maximum likelihood results based on the 40:10 harvest control rule and the $F_{40\%}$ overfishing limit/target, which are presented in Table 18 of the assessment document.

2. Information presented should include biomass, stock depletion, and yield projections of ABC and OY for ten years into the future, beginning with the first year for which management action could be based upon the assessment.

The decision table presented in the assessment document includes the female spawning biomass and depletion estimates associated with catches from 2009-2011. The decision to restrict the forecast to three rather than ten years is justified given the highly variable recruitment exhibited by this fishery.

G. Regional management considerations.

1. Discuss whether a regional management approach make sense for the species from a biological perspective.

There is no discussion in the stock assessment document of whether a regional management approach is appropriate for the species given its biological characteristics. Determination of ABC and OY is based on available data for the stock, and this is allocated between the U.S. and Canadian fisheries on the basis of an agreement between the two nations.

2. If there are insufficient data to analyze a regional management approach, what are the research and data needs to answer this question?

A recommendation of the 2008 STAR Panel was to explore geographical variations in fish densities and relationships, possibly by including spatial structure in future assessments. No progress has yet been made on this recommendation.

H. Research needs (prioritized).

A list of research and data needs is included on page 12 of the draft assessment document, but it is unclear whether these have been listed in priority order.

*I. Acknowledgments-include STAR panel members and affiliations as well as names and affiliations of persons who contributed data, advice or information but were not part of the assessment team. * (Not required in draft assessment undergoing review.)*

A list of acknowledgments is included in the draft assessment document.

J. Literature cited.

A bibliography is included in the draft assessment document.

K. An appendix with the complete parameter and data in the native code of the stock assessment program. (For a draft assessment undergoing review, these listings can be provided as text files or in spreadsheet format.)

A complete listing of the content of the various control and data files for SS3 is included in an appendix to the draft assessment document.

Executive summary

Stock: species/area, including an evaluation of any potential biological basis for regional management

The Executive Summary identifies the stock that is assessed and notes that, although assessed as a single stock, the U.S. and Canadian fishing fleets are considered separately in the assessment to account for aspects of spatial variability in the distributions of the stock and of the catches of these two fleets.

Catches: trends and current levels-include table for last ten years and graph with long term data

A table of catches for 1999-2008 and plot of catches from 1960-2008 are included in the Executive Summary.

Data and assessment: date of last assessment, type of assessment model, data available, new information, and information lacking

The Executive Summary presents a brief history of earlier assessments, and describes the model that is used in the current assessment, the new data that are used in the new assessment and how the assessment differs from that of 2008.

Unresolved problems and major uncertainties: any special issues that complicate scientific assessment, questions about the best model scenario, etc.

The Executive Summary discusses the uncertainties associated with acoustic survey catchability and selectivity, and the need to obtain a greater understanding of the acoustic survey data through re-analysis.

Reference points: management targets and definition of overfishing, including the harvest rate that brings the stock to equilibrium at B40% (the BMSY proxy) and the equilibrium stock size that results from fishing at the default harvest rate (the FMSY proxy).

A summary of the estimated values of the various reference points is included as Table h of the Executive Summary (noting that two tables are identified as Table h).

Stock biomass: trends and current levels relative to virgin or historic levels, description of uncertainty-include table for last 10 years and graph with long term estimates

The trend in female spawning biomass is discussed, a figure showing the long term trends in this variable is presented, and a table providing details of the estimates in female spawning biomass and depletion, with approximate 95% confidence limits, is included.

Recruitment: trends and current levels relative to virgin or historic levels-include table for last 10 years and graph with long term estimates

A plot of the estimates of recruitment, with approximate asymptotic confidence limits, and a table containing details for the last ten years are included in the Executive Summary.

*Exploitation status: exploitation rates (*i.e.*, total catch divided by exploitable biomass, or the annual SPR harvest rate) – include a table with the last 10 years of data and a graph showing the trend in fishing mortality relative to the target (y-axis) plotted against the trend in biomass relative to the target (x-axis).*

A table of values of the relative spawning potential ratio, (1-SPR)/(1-$SPR_{Target=0.4}$), for the last ten years, with approximate 95% confidence limits, and a plot of this variable over the period covered by the model are presented in the Executive Summary. A plot of this variable against ratio of female spawning biomass to the proxy 40% level of this variable is also presented.

Management performance: catches in comparison to ABC and OY values for the most recent 10 years (when available), overfishing levels, actual catch and discard.

A table of landings versus the coast-wide (U.S. plus Canada) OY and ABC for the past ten years is included in the Executive Summary.

Forecasts: ten-year forecasts of catch, summary biomass, spawning biomass, and depletion. (Not required in draft assessments undergoing review.)*

A three-year forecast of catches, female spawning biomass and depletion is presented. No estimates of summary biomass, *i.e.*, 3+ biomass, are included in this table. The decision by Drs Hamel and Stewart to present a forecast for three rather than ten years is justified by the high level of recruitment variability exhibited by this stock.

Decision table: projected yields (ABC and OY), spawning biomass, and stock depletion levels for each year. (Not required in draft assessments undergoing review.)*

A decision table with three-year projections under a range of alternative catch scenarios is included. This displays the expected results generated using an MCMC analysis, but the authors note that the table is preliminary as only a relatively small number of iterations were able to be run.

Research and data needs: identify information gaps that seriously impede the stock assessment.

A list of research and data needs is presented in the Executive Summary.

Rebuilding Projections: principal results from rebuilding analysis if the stock is overfished. This section should be included in the Final/SAFE version assessment document but is not required for draft assessments undergoing review. See Rebuilding Analysis Terms of Reference for detailed information on rebuilding analysis requirements.*

Not included.

Summary Table: as detailed in the attached example.

Summary tables of trends in exploitation and stock levels and of reference points have been included in the Executive Summary.

4.2. Data collection operations and survey design

TOR 2. Evaluate, data collection operations and survey design and make recommendations for improvement

The current design of the acoustic survey appears adequate with transects at 10 nm intervals covering the depths and range where backscatter intensity indicates that Pacific Hake are present. The design of the associated midwater trawling, however, apparently relies on subjective decisions on where and when to trawl, and, accordingly, is likely to produce samples that are potentially biased. There appears to be no explicit specification of the criteria that should be applied when determining when to trawl, and the criteria that have been used may have changed over time. The post-stratification scheme used when analysing the data is difficult to justify statistically. The data produced by the acoustic survey provide crucial information for the current stock assessment, and need urgent attention to determine whether it is possible to re-analyse past data and obtain reliable estimates of length composition and conditional age-at-length compositions. The design of the acoustic/midwater trawl survey should be critically reviewed to ensure that it is statistically robust and represents the current state-of-the-art for such studies. The potential that the design might produce biased or imprecise estimates of length or age-at-length composition needs to be critically assessed.

The potential exists that greater use will need to be made of spatially-or temporally-disaggregated data in future assessments. Consideration should be given to ensuring that data are recorded at an appropriate level of spatio-temporal resolution.

4.3. Quality of data used in assessment

TOR 3. Comment on quality of data used in the assessment.

Although the consistency of the ages assigned by different readers within different laboratories has been assessed, the current assessment document provides no evidence that the growth zones on the otoliths are formed annually, and that their number may be used to assign accurate ages to the fish from which the otoliths were extracted.

The length and age-at-length composition data collected from the catches of the U.S. and Canadian fisheries appear sound, although it was clear from the STAT's explorations that the data for the different sexes need to be separated. Although catch data that have been collected for the more recent years appear sound, earlier data for the foreign fishery operating in U.S. waters are potentially biased through under-reporting. Estimates of the extent of under-reporting are required to bracket the range of possible values in each year over the earlier period and allow for the uncertainty introduced by this practice.

It appears improbable that the seasonal catches from Santa Barbara from 1963-1970 are representative of the catches from the U.S. fishery in those years. There appears little justification in including these latter data in the set of data used by the model.

Potential exists that the relationship between maturity and length may have changed over time.

4.4. Analytic methodologies

TOR 4. Evaluate and comment on analytic methodologies

Stock Synthesis III (SS3) is considered to be one of the leading stock assessment tools currently available. It provides considerable versatility and can be used to represent a wide range of fishery, survey, and biological data. Despite its versatility however, aspects peculiar to the Pacific Hake fishery, such as the targeting of strong year classes by the U.S. and Canadian fisheries, cannot yet be represented by the model. The versatility of the SS3 model also impedes the development of alternative, simpler models, which can often provide useful insight into the state of a fish stock. As demonstrated by the history of stock assessments reported in the assessment document, the current process of model development is one of incremental improvement, where alternative models are explored and discarded rather than pursued to determine whether markedly different model structures could be developed to provide feasible representations of the data, yet markedly different predictions.

Data dredging appears to have occurred in the development of the blocking structure for fishery selectivities. Statistically, data dredging has the consequence that the precision of model estimates can no longer be properly assessed and that comparisons of the model with other models are no longer sound. It can be argued, however, that there was an a priori basis for a model structure that included time-blocking for fishery selectivities, and that there was therefore a basis for introducing this structure. It is suggested that the STAT might consider whether data dredging has or has not occurred, and if the former is the case, the implications for the stock assessment.

4.5. Assumptions, estimates, and major uncertainties

TOR 5. Evaluate model assumptions, estimates, and major sources of uncertainty. Specifically, recommend improvements including alternative model configurations or formulations as appropriate during the panel meeting and comment on the primary sources of uncertainty in the assessment model.

A common problem to all models of the Pacific Hake fishery is the fact that predictions are likely to be highly uncertain as the data contain insufficient information to obtain precise estimates of survey q or natural mortality. Lack of precision of the forecasts is also introduced through the relatively high level of recruitment variability and the fact that, until the strengths of newly-recruited year classes are reflected adequately in the length and age-at-length composition data for the fisheries, it is difficult to assess with precision the future state of the stock.

The assumptions made by Hamel and Stewart (2009) appear feasible, and thus, if these assumptions are true, the model predictions would be sound. However, the strong residual pattern in the length composition data suggests that some assumptions are inappropriate, which implies that there is likely to be a bias in the predictions made by the model, the magnitude of which cannot yet be assessed. Similarly, the tension among some data sets is reflected by confounding of some parameter estimates, and, as a consequence, increased imprecision of estimates. Again, these tensions suggest some inadequacy of model structure. The proposal by the STAT to introduce sex structure into the model is sound, and may assist in resolving some of the structural inadequacy. However, the life history of the species suggests that the migration of fish along the coast, the changing distribution of the stock, and the targeting by fishers will be factors that may need to be considered in future spatially-structured models.

A concern that emerges from consideration of the current model is that using a time-blocking structure for fishery selectivity, it is possible to explain a paucity of older fish resulting from fishing mortality by an increasingly dome-shaped selection curve. The absence of cryptic older fish is then explained by introduction of increased natural mortality of 14 and 15+ individuals, evidence for which there appeared no basis in the assessment document. The dome-shaped selectivity pattern of the fishery data appears to be connected to the assumption of dome-shaped selectivity for the acoustic survey and Canadian data. While it is possible that older fish elude capture by the midwater trawls employed in the acoustic/midwater trawl surveys, or that the trawls are deployed with respect to backscatter patterns that are related to younger fish, it would be valuable to undertake research to determine the validity of this argument. The appropriateness of an assumption of dome-shaped selectivity for the Canadian fishery also appears questionable. While the data (and NLL) appear to support the assumptions of dome-shaped selectivity for the survey and the fisheries, I would strongly encourage further development of a model that employs asymptotic selectivity curves, as I suspect that such a model is more likely to detect adverse trends in spawning stock and, with further refinement, may provide a fit that is comparable with that of the model employing dome-shaped selectivity curves.

4.6. Quality of science

TOR 6. Insert an explicit statement as to whether this stock assessment represents the best available science.

The current model applies sound stock assessment techniques consistent with assumptions that appear to be valid and is tuned such that, with the current structure and parameter estimates, the fit to the current input data maximizes the likelihood estimate. However, Hamel and Stewart (2009) have advised that the available data could be separated into data for each sex, and the model could use such data and take into account the different growth curves exhibited by those sexes. Thus, while the STAT is to be commended for the quality of the work they have undertaken, there is potential for further model refinement.

4.7. Recommendations for improvement

TOR 7. Recommendations for any further improvements

The quality of the assessment is currently hampered by uncertainty associated with the acoustic/midwater trawl survey, and, in particular, the lack of explicit descriptions of the criteria used to determine the location and duration of the trawls that are undertaken and the method of post-stratification used to determine the length and age-at-length compositions of the data. It is possible that the trawl survey design and methods used to analyse the data could be improved, but without information on the current approaches, it is impossible to assess whether this is the case. Sufficiently detailed technical descriptions should be available, as the survey has been run since 1977.

The current model should be enhanced to include sex-structure, and search for assumptions and model structure that can overcome tensions among data and eliminate the strong patterns evident in the residuals of the length composition data should continue.

Research is needed to test the hypothesis that older and larger fish are likely to elude capture in the trawls undertaken during the acoustic/midwater trawl survey and to assess the extent to which the selectivity curve for the surveys is likely to be dome-shaped.

Research should be undertaken to assess whether individuals of Pacific Hake experience increased natural mortality as they become older.

Some effort should be directed towards developing models with alternative structure that fit and explain the available data. In particular, consideration should be given to refining a model that employs asymptotic selectivity for the acoustic surveys and the Canadian fishery.

A management strategy evaluation should be undertaken to assess whether current data collection, assessment and decision rules are likely to be effective. It would be useful to assess whether use of a model with dome-shaped fishery selectivity is more effective in sustaining the stock than one with asymptotic selectivity.

4.8. Panel review proceedings

TOR 8. Brief description on panel review proceedings highlighting pertinent discussions, issues, effectiveness, and recommendations

The meeting was opened by Dr Elizabeth Clarke (U. S. National Marine Fisheries Service) who provided an update of progress on ratifying the U.S.-Canada treaty on Pacific Whiting. Dr Samson then reviewed the Agenda (Appendix 4), provided a brief explanation of the STAR Panel's terms of reference, and made arrangements for reporting the meeting. Mr John DeVore had kindly offered to take notes of the discussion throughout the entire meeting. Panel members were assigned the task of recording the technical discussions associated with the assessment and with the exploratory runs requested of the STAT by the STAR Panel during the course of the Meeting. Dr Hall was assigned responsibility for reporting Day 1, activities. Dr Vølstad was assigned Day 2, and Dr Carruthers Day 3. The review itself then commenced, with all Panel members probing the material that was presented, identifying areas of concern, and suggesting approaches that might improve the assessment.

Mr John DeVore and Mr Barry Ackerman reviewed the management needs of the U.S. and Canadian fisheries, respectively, while Dr Stewart and Mr Grandin presented descriptions of the 2008 fishing season for the U.S. and Canadian fisheries, respectively. Possibly one of the most important features of these latter reviews was the fact that, for both fisheries, there had been difficulty in taking the allocated catches earlier in the season (because of bycatch issues in the U.S. and patchy distribution and scarcity of fish in Canada) and that a relatively large portion of the catch had been taken late in the year. It became clear from these and subsequent discussions that there was a timing issue in the data collection-stock assessment-decision making process. Biological data from late in the year must be processed and prepared for input to a stock assessment that must be documented and then reviewed in February, such that decisions on allowed catch can be made before the commencement of the U.S. fishery in April. With such a schedule, there is insufficient time to undertake stock assessment with sufficient rigor and to carry out the necessary comprehensive exploration of various diagnostic analyses. Consideration should possibly be given to setting a cut-off date for data to be included in the assessment, such that two to three months are available for this analysis. This may require, however, that a preliminary catch allowance, which is based on the previous year's assessment, is made for the earlier portion of the U.S. fishery.

Following the review of the outcomes of the 2008 fishing season, Dr Stewart described the data that were available for use in the assessment and Dr Chu presented information on the progress that had been made in improving the estimates of biomass and size/age composition data from the acoustic/midwater trawl survey and described further work that was planned in this area. Subsequently, Drs Stewart and Hamel discussed the Stock Synthesis III (SS3) approach used in the 2009 assessment, how this differed from the Stock Synthesis II (SS2) approach used in the 2008 assessment, the basis for the structural changes that had been implemented, and the results obtained.

The first major issues that were identified by the STAR Panel were the design of the acoustic/midwater trawl survey and the methods used to analyse these data (see Section 4.2, above). The data provided by this survey are the only fishery-independent data that are currently used in the assessment, and these data are relatively unbiased with respect to the distribution of the stock and, compared with the fishery-dependent data, the distribution of fishing (the depth range covered by earlier surveys was less than that of later surveys, however, and the surveys did not extend northward to the same extent as later surveys). Accordingly, they are a crucial element of the stock assessment, and the paucity of older fish in earlier surveys is critical in determining whether the selectivity of the trawls used in this survey is dome-shaped rather than asymptotic. Unfortunately, it was not possible to determine the precise nature of the current trawling regime and whether a consistent trawling regime had been applied over time, nor was it possible at this time to assess whether current and proposed re-analysis of the raw data will be successful in deriving more reliable estimates of biomass and/or size and age composition data. In this respect, it is difficult to accept that the present design and analytical methods represent the current state of the art in acoustic/trawl survey design. The need to re-analyse these data, and to improve the reliability of estimates derived from the acoustic/midwater trawl survey is of high priority. Such improvement may require implementation of more statistically-robust sampling designs, recognising that issues related to consistency and comparability of data need to be considered.

The very detailed and exhaustive exploration of the temporal structure of fishery selectivity, involving, according to Hamel and Stewart (2009), "hundreds of model runs", raised concern that data dredging had occurred, whereby an exhaustive search through alternative combinations of time-blocking had produced the final model structure. Such data dredging would result in an excellent description of the data, but predictive ability would be sacrificed and precision of predictions would be uncertain. This concern is discussed above (Section 4.4). A further concern associated with the complex time-blocking structure that had been used to describe fishery selectivity was that, with in excess of 100 parameters, the model might have become over-parameterized. This concern was followed up by the STAR Panel, in requests #1 and #3 for exploratory analyses to be undertaken by the STAT.

Strong residual patterns in the length composition data for both the fisheries and the acoustic/midwater trawl survey suggested the possibility of inadequate model structure and possible tension among data sets. There was also concern that, by fixing survey q to 0.7, it was not possible to assess how the value of this parameter influenced the tradeoffs between the likelihood contributions from the different data sets. The STAR Panel requested an exploratory run (#2) to examine this issue and also investigated the extent to which survey q, the natural mortality of older (15+) fish and final acoustic selectivity were confounded (Request #4).

Concerned that the tension between length composition and age-at-length compositions, and relatively large effective sample sizes for these data might be influencing the need for an overly complex blocking structure for the fisheries selectivity, the length and age data were down-weighted and alternative less complex blocking structures for fisheries selectivity were explored (Request #5). This led to the decision by the STAR Panel and STAT to use a four-year rather than two-year blocking structure for post-2000 data in subsequent sets of exploratory runs requested by the Panel. The STAR Panel also investigated the implications of asymptotic rather than dome-shaped selectivity for the survey, and how this affected the time-blocking of fishery selectivities (Request #6). The possibility that the tension between age-at-length composition and length composition data evident in the likelihood profile produced in response to Request #2 had resulted in a marked change in the state of the stock was investigated (Request #8).

The potential that the starting year of the four-year blocking periods for fisheries selectivity and the extent to which the starting years differed between the U.S. and Canadian fisheries would influence the negative log-likelihood of the fitted model was investigated (Request 9), leading to the decision to start the four-year blocking periods at 1981 (treating earlier data as a single time block) and to synchronize these for the U.S. and Canadian fisheries. A retrospective analysis was undertaken to assess potential bias (Request #10). Rather than fixing survey q and estimating final survey selectivity, the Panel requested exploration of the consequences of fixing the final survey selectivities and estimating survey q to test whether the model would converge (Request #11). Conditional on the runs in Request #11 converging, a further retrospective analysis was requested for each of these runs (Request #12). The STAT also produced a run that demonstrated that convergence was achieved when survey q, the natural mortality of old fish and final survey catchability were estimated.

The STAR Panel had by this stage selected the model to be used as the base case, *i.e.*, a model with survey q and final survey selectivity estimated with a synchronized four-year blocking structure for fishery selectivities starting at 1981. Jittering of this model was requested to confirm convergence (Request #13). Further evaluation of sensitivity of this model was requested, with Request #14 exploring the influence of the pre-recruit trawling survey data and Request #15 examining the influence of the Californian length composition data for the early years of the fishery. The influence of the use of dome-shaped rather than asymptotic selectivity for the acoustic survey and the Canadian fishery was assessed (Request #16) and the trade-off between a greater value of natural mortality and potentially-reduced value of the estimate of natural mortality for old (15+) fish was explored (Requests #17 and 19). A likelihood profile over natural mortality was also calculated (Request #20)

Finally, values of survey q that might represent optimistic and conservative states of female spawning stock biomass that were approximately 50% as likely as the base model were calculated (Request #18) and the first row of a decision table showing the forecasts under alternate states of nature was produced (Request #21).

Details of the results of the exploratory runs produced by the STAT in response to the STAR Panel's requests are presented below. Following consideration of the exploratory analyses, the Panel commenced drafting its report.

Request #1: Provide the inverse Hessian matrix for the STAR base run (with the 2008 Canadian data) to show parameter correlation which might reveal possible model over-parameterization.

The STAT produced a bubble plot (Fig. 1) displaying the correlations among the different pairs of parameters. This clearly showed strong correlations among many parameters, suggesting over-parameterization. However, the STAT also advised that time-blocking of selectivities was implemented in SS3 using an offset from a base parameter, which would result in some of the high correlations evident in the bubble plot.

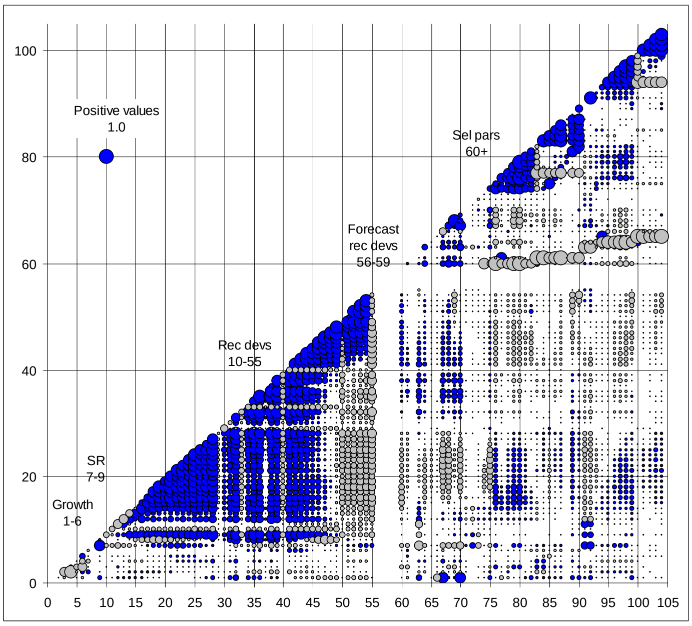


Figure 1. Response to Request #1. Bubble plot of correlations among parameters as derived from the Hessian matrix.

Request #2: Provide a likelihood profile across survey q for all the likelihood components to expose tensions among the data.

The likelihood profile produced by the STAT demonstrated that the value of acoustic survey q = 0.7, used for the base case model brought to the STAR Panel was sub-optimal, and that a better fit would be obtained with a value of q slightly greater than 0.9 (Fig. 2). The profile revealed tension between the age-at-length and length composition data, with length composition data being better represented at low values of survey q, and age-at-length compositions better represented at high values of q, with the critical value of survey q delineating these two regions of the likelihood surface being approximately 0.87.

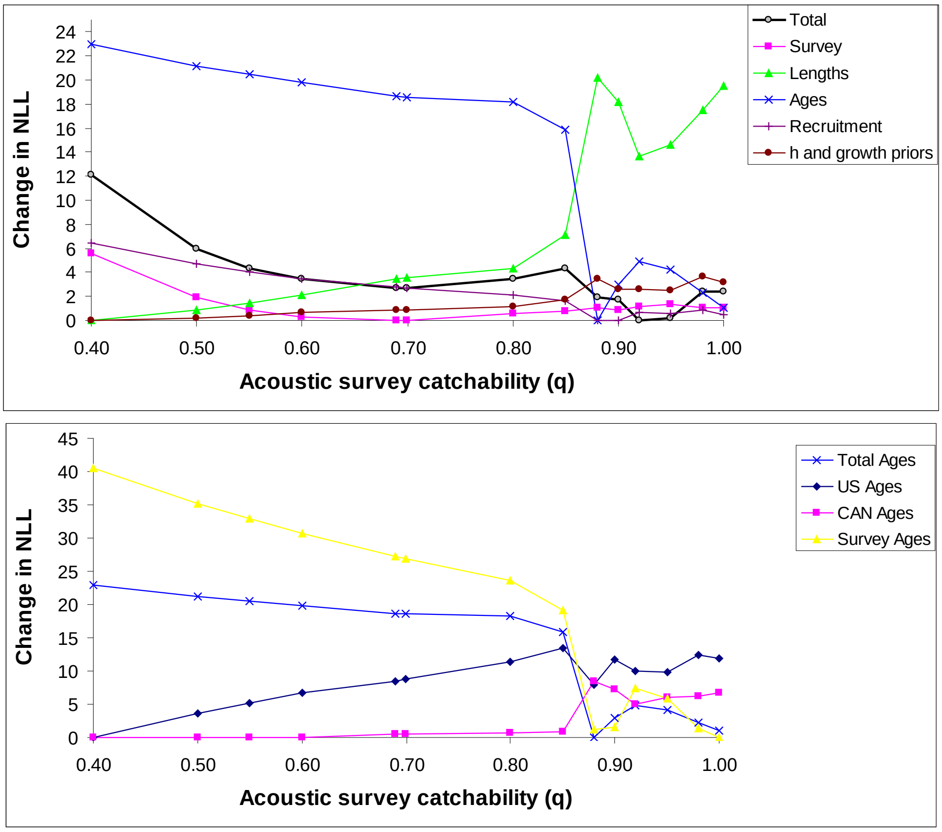


Figure 2. Response to Request #2. Likelihood profiles of each component of the overall likelihood with respect to acoustic survey q.

Request #3: Provide the MCMC result (cross-correlation matrix for "old M", *i.e.*, the natural mortality of fish of age 15+) and the dome-shaped selectivity parameters) for the base model (pre-STAR base although not a fully converged chain). This will provide more information about possible parameter confounding and the shape of the joint posterior function.

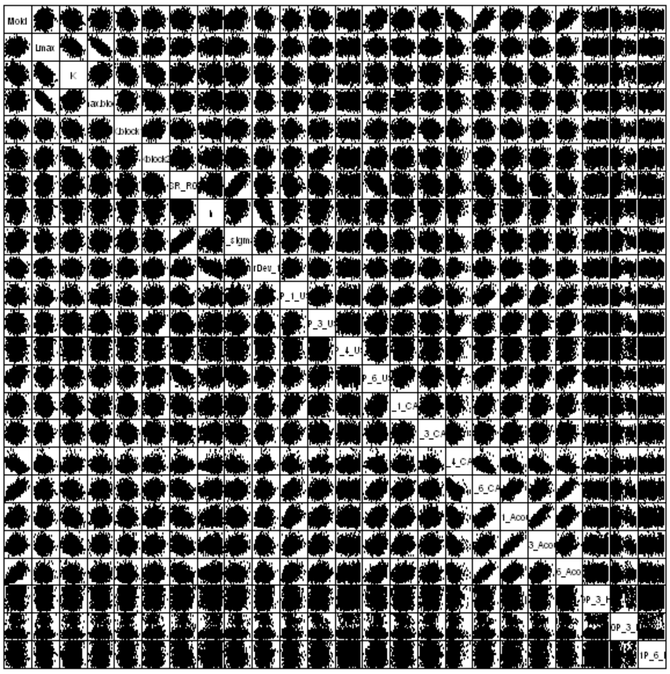


Figure 3a. Response to Request #3. Scattergrams of the basic parameter estimates from a chain of a preliminary MCMC run, including parameters in the burn-in phase of the run.

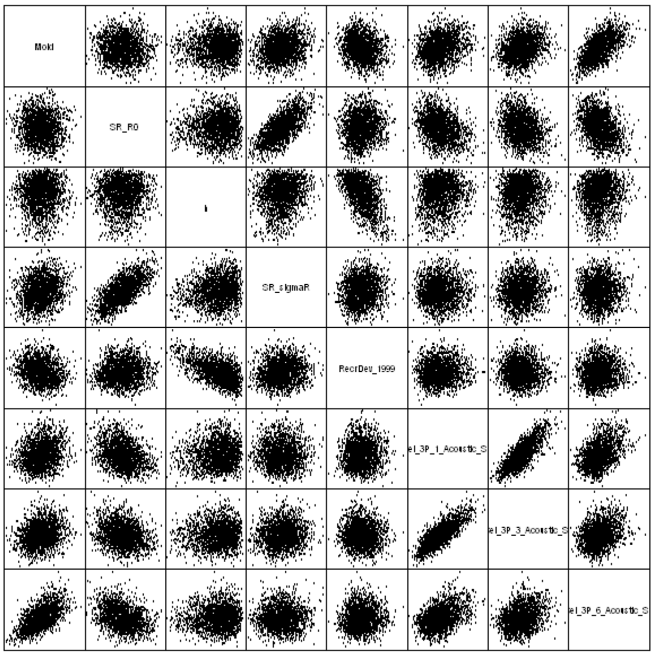


Figure 3b. Response to Request #3. Scattergrams of estimates of the key parameters from a chain of a preliminary MCMC run, including parameters in the burn-in phase of the run.

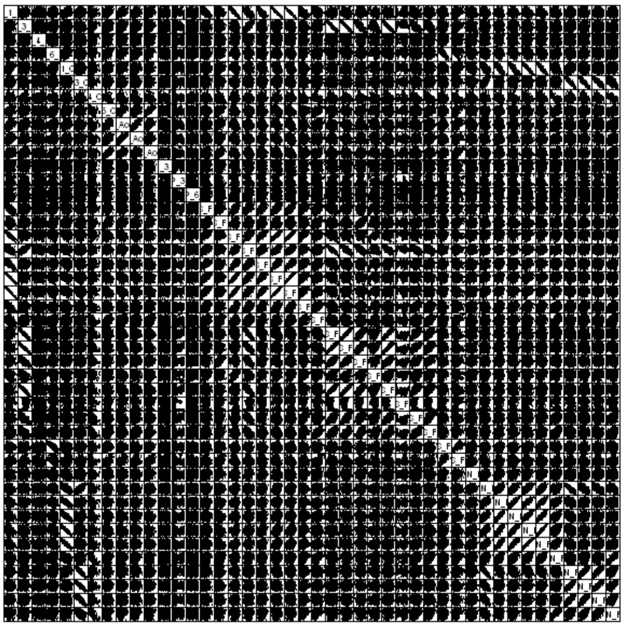


Figure 3c. Response to Request #3. Scattergrams of estimates of all selectivity parameters from a chain of a preliminary MCMC run, including parameters in the burn-in phase of the run.

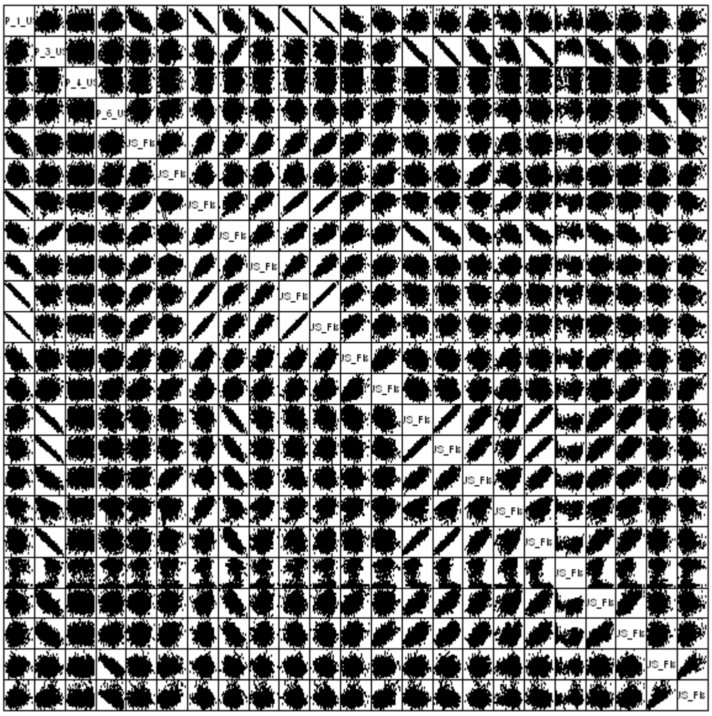


Figure 3d. Response to Request #3. Scattergrams of estimates of U.S. selectivity parameters from a chain of a preliminary MCMC run, including parameters in the burn-in phase of the run.

The results obtained by plotting scattergrams of the pairs of parameter estimates produced over all iterations in the preliminary MCMC analysis (Figs 3a-d) confirmed the findings of Request #1. Clearly, a number of parameters are highly correlated, suggesting that the model is over-parameterized. However, because of the use of offset parameters in Stock Synthesis III, some correlations among selectivity parameters would be expected.

Request #4: Provide likelihood contour plots that represent the posterior correlation around MLE estimates for the following three comparisons: a) survey q vs. old M, b) old M vs. old acoustic survey selection, and c) survey q vs. old selection. This will provide insight to the extent these parameters are confounded.

The surfaces of the likelihood contour plots were relatively flat, suggesting that there would be difficulty in obtaining precise estimates of these three parameters (Fig. 4).

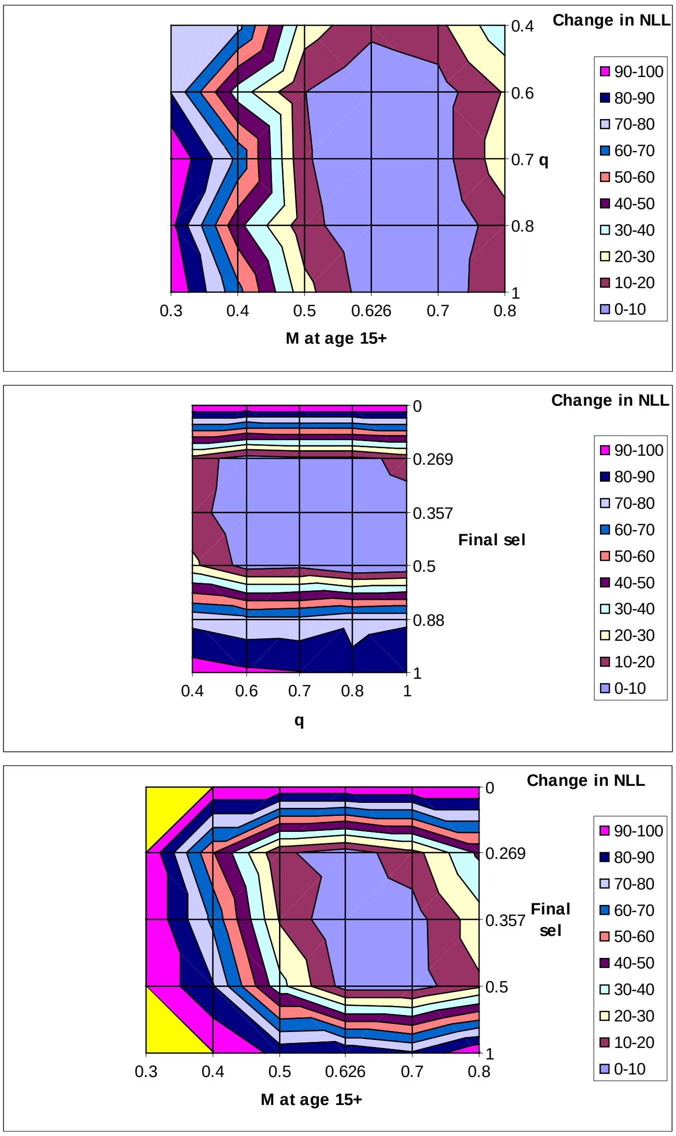


Figure 4. Response to Request #4. Bivariate contour likelihood plots for acoustic survey q, survey selectivity of older fish, and natural mortality of 15+ fish.

Request #5: Change the effective sample sizes with regard to Canadian and U.S. length data and the catch-at-age data. Reduce the effective sample sizes by half relative to the base model and evaluate three different selectivity scenarios ranging towards less complexity from the base model structure to a time invariant structure. Compare the number of parameters and likelihoods for the model components for this weighting change and the base model run. The panel is seeking confirmation that the model result is not driven by weighting. In addition, the panel would like to see residual bubble plots and the estimated selectivities, the time series of female spawning biomass, and the fit to the survey.

The STAT presented model results showing the effects of different time-blocking structures (Fig. 5). They also reported that, with weighting of length-composition data set to a tenth of that of the base case model, the overall negative log-likelihood increased by 166 points with 27 fewer parameters, but that, with four-year blocking and the same weighting, the negative log-likelihood increased by only about 11.4 points with six fewer parameters. The weight applied to the length composition data did not appear to influence the time-blocking structure required by the model. However, both the STAT and the STAR agreed that use of four-year time blocks for fishery selectivity was warranted as this would reduce model complexity slightly without sacrificing quality of fit too greatly.

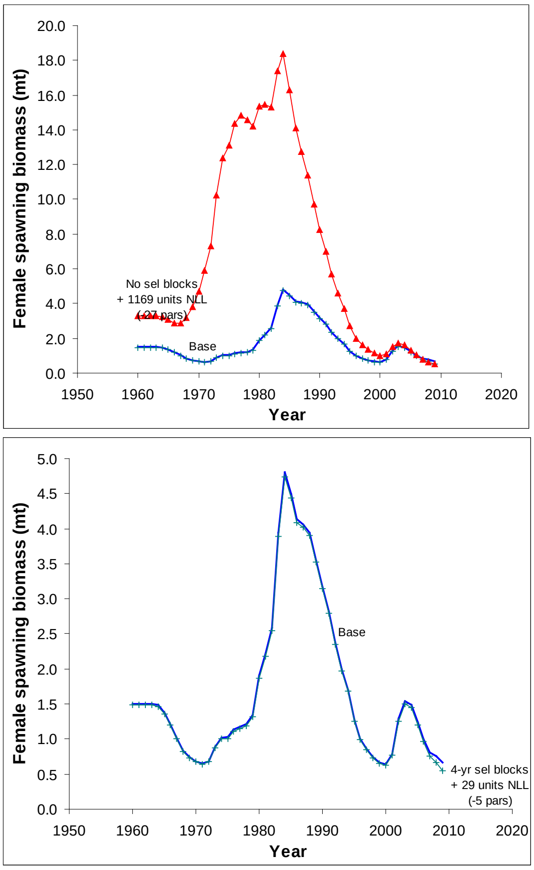


Figure 5. Estimates of female spawning biomass for the base case model, for a model without time-blocking of fishery selectivities, and for a model using four-year blocks for fishery selectivity.

Request #6: The panel would like to assess the consequences of asymptotic selectivity in the survey. The panel recognizes that the selectivity pattern is uncertain; however, a fixed asymptotic acoustic survey selectivity may help to understand how this pattern affects the model results. Additionally this scenario may also reveal how acoustic selectivity is related to the time blocking assumption and the shape of the commercial selectivities estimated in the base model.

The model failed to converge when survey selectivity was constrained to be asymptotic. When time-blocking of fishery selectivity after 2001 was removed, however, the model converged (Fig. 6). The STAT attributed this result to the fact that there was inconsistency between the assumption of asymptotic survey selectivity and the descending width parameters of the fishery selectivity curves that, in the time-blocked case, accounted for the larger catches of the 1999 year class. It was suggested by the STAT that the larger female spawning biomass of the dome-shaped base model than that of the asymptotic model was probably due to the "cryptic" biomass of older fish that is estimated as a consequence of the reduced selectivity of these fish when a dome-shaped selectivity is assumed.

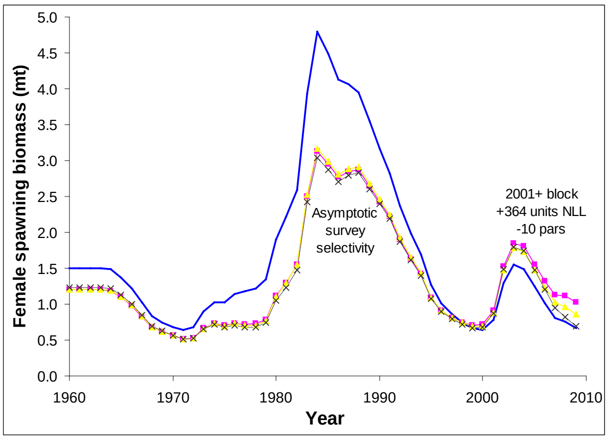


Figure 6. Estimates of female spawning biomass for dome-shaped (solid line) and asymptotic survey selectivity.

Request #7: The panel requested jitter runs to assess whether the model runs are converging appropriately using the fixed q parameter versus a freely estimated q model scenario.

This request was set aside by the STAT because of the time required to respond to other requests. It subsequently became clear that the putative base model presented to the STAR Panel by the STAT was unlikely to be selected as the base model, and that the jittering run would be more appropriately applied to the final model selected by the Panel. The request was subsequently replaced by Request #13.

Request #8: In reference to Request #2, identify components and parameters responsible for abrupt changes in likelihood with changes in the fixed q values. This will allow better understanding of the apparent trade-offs between different data sources and model configurations.

Similar trends in female spawning biomass and in the form of the acoustic survey selectivity were obtained when the model was fitted with different fixed values of survey q ranging from 0.7, the value used in the base model presented to the STAR Panel by the STAT, to 1 (Fig. 7). As survey q was increased, the estimates of female spawning biomass were reduced, and the level of depletion appeared to increase. At the same time, the selectivity curve for the survey shifted, progressively reducing the proportion of younger fish and increasing the proportion of older fish that were considered to be vulnerable to the trawl survey. There appeared, however, to be no marked change in the state of the system when survey q was increased from values below 0.87 to values above 0.87, *i.e.*, the value that appeared to mark the change in appearance of the likelihood surface that was presented in the response to Request #2 (Fig. 2). The Panel concluded that the change in the likelihoods was due to the tension between the age-at-length compositions and length composition data, rather than a marked change in parameters associated with a change in system state.

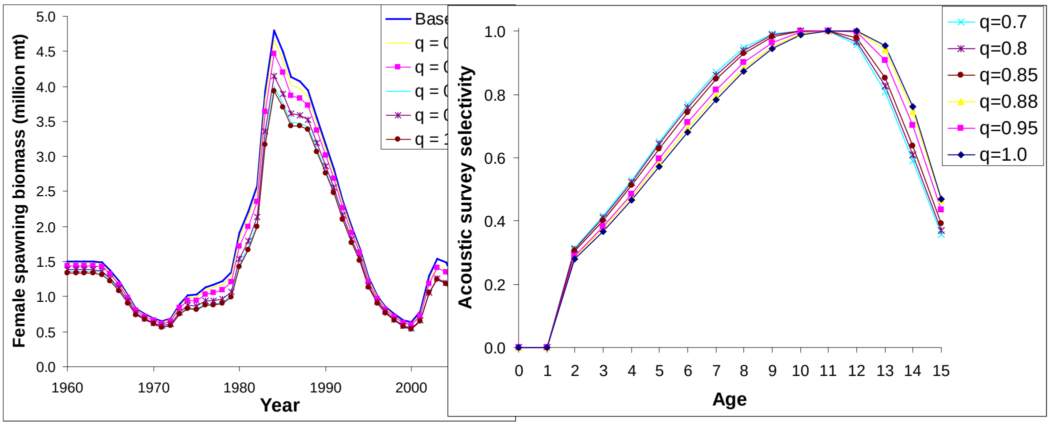


Figure 7. Response to Request #8: Estimates of female spawning biomass and of acoustic survey catchability when the model was fitted using different fixed values of survey q.

Request #9: Start the 4-yr selectivity blocking structures at different years with a) no offset between U.S. and Canadian fisheries and b) a 2-yr offset between these fisheries. Collapse the blocks at the end of the time series using the base model. The current blocking selection is somewhat arbitrary and there is a need to understand how sensitive the model is to the blocking structure.

The fit of the model was sensitive to the starting year of the four-year blocking structure, with the best fit resulting from a 1981 starting point and with synchronized blocking for the U.S. and Canadian fisheries (Fig. 8). The STAT suggested that this structure probably best matched the targeting of strong year classes by the fisheries, noting that SS3 could not represent such targeting and that time-blocking was currently the only tool available to represent this feature of the fishery.

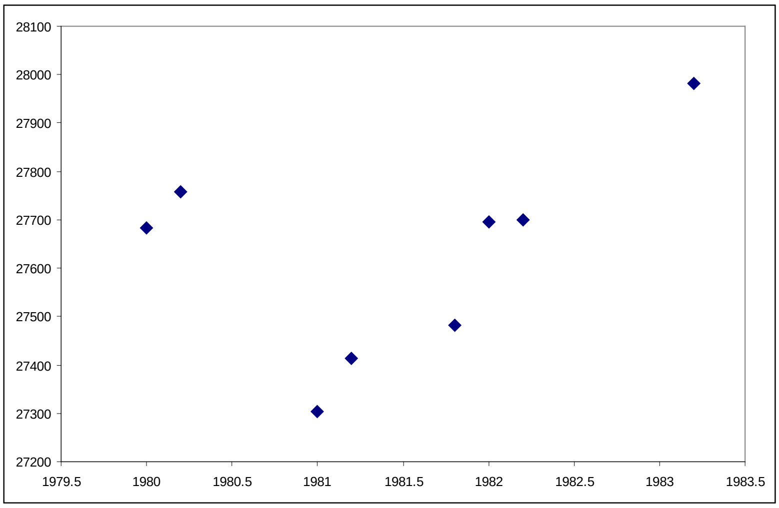


Figure 8. Response to Request #9: Values of negative log-likelihood obtained using four-year blocking for fishery selectivities with different starting years, and with the blocking for the Canadian fishery (a) synchronized with that of the U.S. fishery, and (b) lagged by two years. The value for 1981.8 represents the result when the ending block is collapsed to include eight years.

Request #10: A retrospective analysis of the best model from Request #8 (where q is fixed and final survey selectivity is estimated) featuring runs up to 2000, 2002, 2004, 2006 and 2008 with projections based on observed catches. These runs should undertake projections using the most recent selectivities. This analysis will be used to assess potential bias of model results and projections.

Estimates of female spawning biomass increased slightly when the model was fitted using data to 2007 rather than to 2008, as in the base model presented by the STAT (Fig. 9a). A further, more marked increase was evident when the model was fitted to data to 2005, and an even greater increase when data to 2003 were employed. Part of this increase was probably due to the time-blocking structure of fishery selectivity and collapsing of years for incomplete four-year blocks into the last complete time block. There was, however, a slight reduction in the estimates of female spawning biomass for earlier years when the model was fitted using data only to 2001. In this last case, the signal relating to the strong 1999 year class had been lost from the fishery length and age-at-length composition data and the model predicted a continued decline in female spawning abundance. Fishery selectivity for the different end years became increasingly asymptotic from 2008 through 2005, but then became increasingly dome-shaped for 2003 and 2001 (Fig 9b). No retrospective pattern can be determined from these data as they relate to different years. Similar estimates of recruitment were obtained for earlier years, but estimates for later years, and particularly estimates of the 1999 year class, were strongly influenced by the data that were available (Fig. 9c). The importance of recent fishery length and age composition data in confirming the strength of newly recruiting year classes was demonstrated by this analysis.

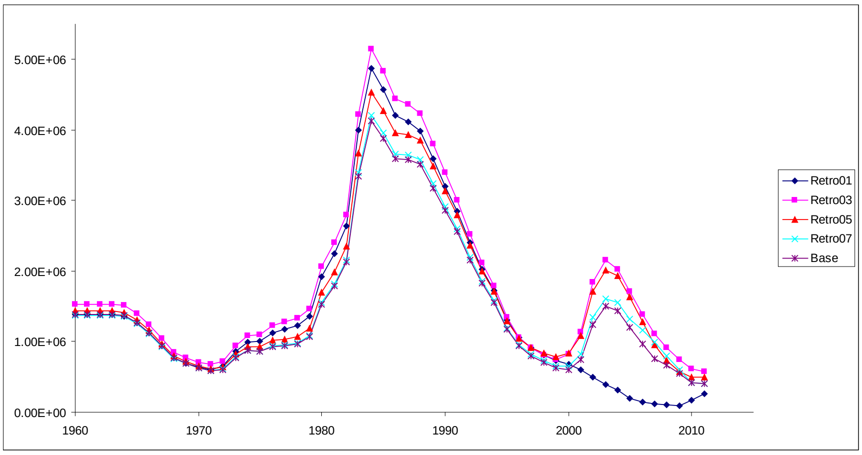


Figure 9a. Response to Request #10. Estimates of female spawning biomass and projections using subsequently-observed catches obtained when survey q was fixed and final survey selectivity was estimated and using data to 2001, 2003, 2005, 2007 and 2008.

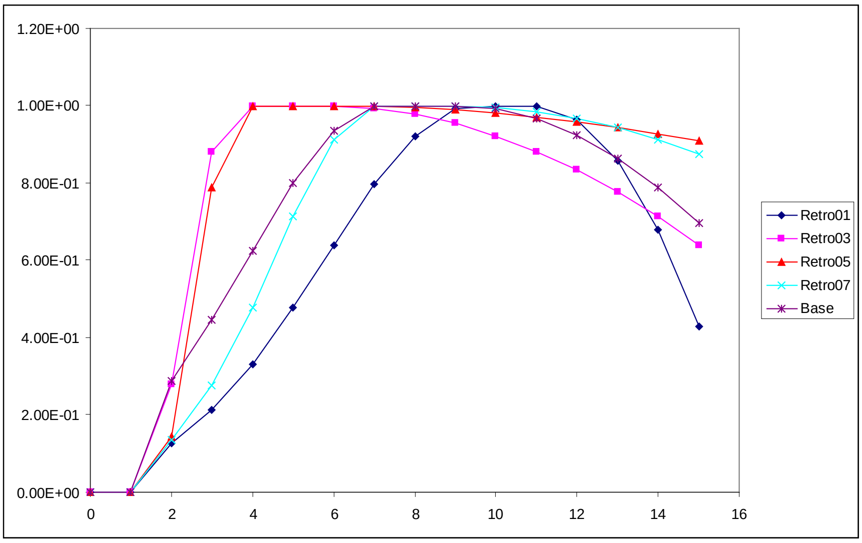


Figure 9b. Response to Request #10. Estimates of U.S. selectivity for the end year obtained when survey q was fixed and final survey selectivity was estimated and using data to 2001, 2003, 2005, 2007 and 2008.

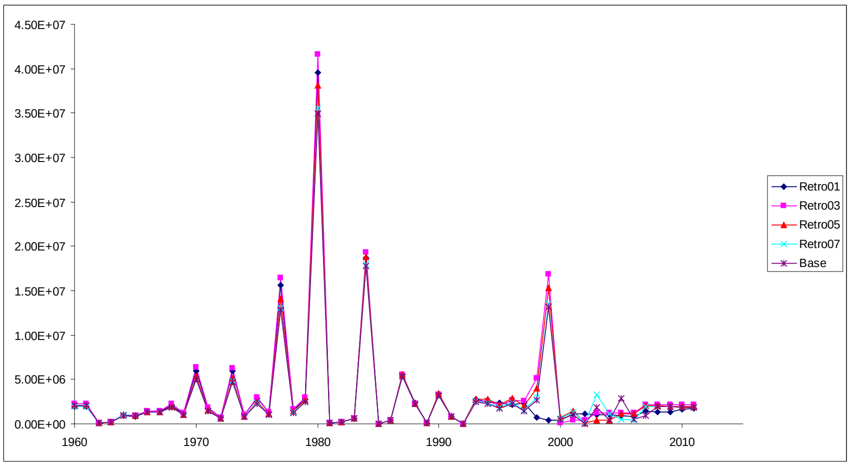


Figure 9c. Response to Request #10. Estimates of recruitment obtained when survey q was fixed and final survey selectivity was estimated and using data to 2001, 2003, 2005, 2007 and 2008.

Request #11: Provide runs where q is freely estimated and final survey selectivities are fixed at 0.9, 0.6, and 0.3 (assuming that q can be reliably estimated given fixed selectivity). These runs will ascertain whether the model can converge given those three fixed selectivities.

Convergence was obtained in all cases, with estimates of survey q increasing from 0.76, through 0.88 to 0.9 as the final survey selectivity was increased from 0.3, through 0.6 to 0.9, respectively (Fig. 10). When both survey q and final survey selectivity were estimated, the estimated value of survey q was 0.85. Estimates of female spawning biomass were reduced as the final value of survey selectivity increased (and estimated values of survey q also increased).

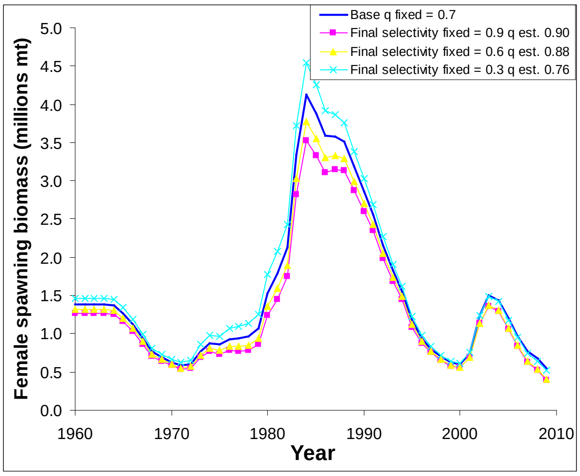


Figure 10. Response to Request #11. Estimates of female spawning biomass obtained when survey q is estimated and final survey selectivity fixed at 0.3, 0.6, and 0.9, compared with the values obtained with the STAT's base model.

Request #12: If there is convergence and plausible results for the Request #11 runs, provide a retrospective analysis as structured in Request #10 with the fixed selectivities under Request #11. This analysis will be used to assess potential bias of model results and projections.

As with the results of Request #10, the estimates of female spawning biomass increased as years were dropped from the analysis, and, ultimately with data only to 2000, information relating to the strong 1999 year class was no longer available to the model (Figs 11a-d). Greater values of final survey selectivity resulted in reduced estimates of female spawning biomass, but the trends using different cut-off years for the data were consistent. After considering these results, and a run for which survey q, old M, and final survey selectivity were estimated, the Panel concluded that the best model configuration would be one in which survey q was estimated.

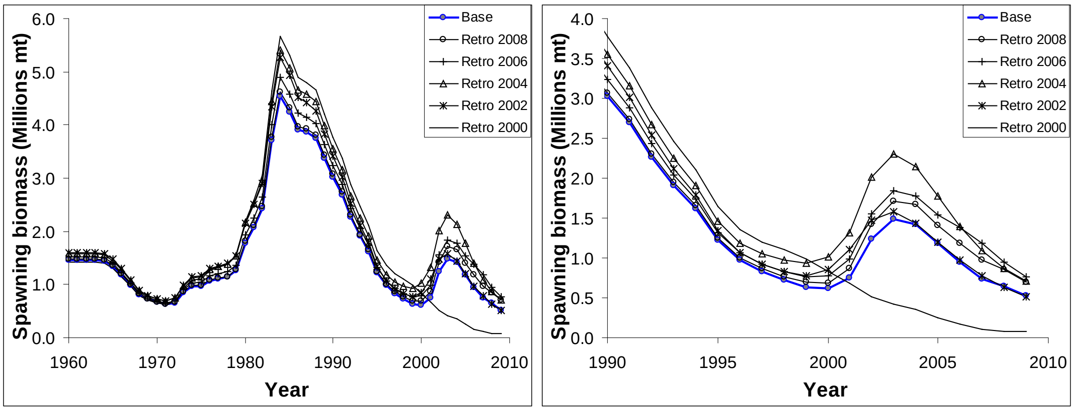


Figure 11a. Response to Request #12: Retrospective analysis using data to 2008, 2006, 2004, 2002 and 2000 for models with survey q estimated and final survey selectivity fixed at 0.3.

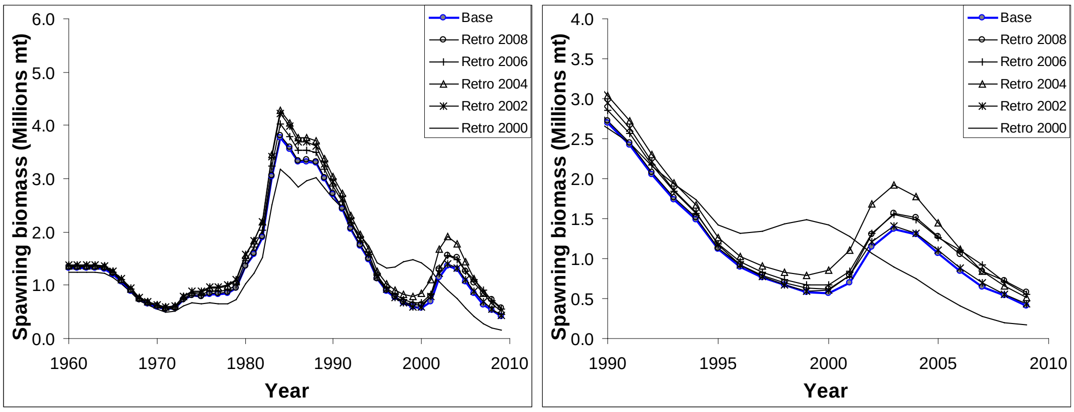


Figure 11b. Response to Request #12: Retrospective analysis using data to 2008, 2006, 2004, 2002 and 2000 for models with survey q estimated and final survey selectivity fixed at 0.6.

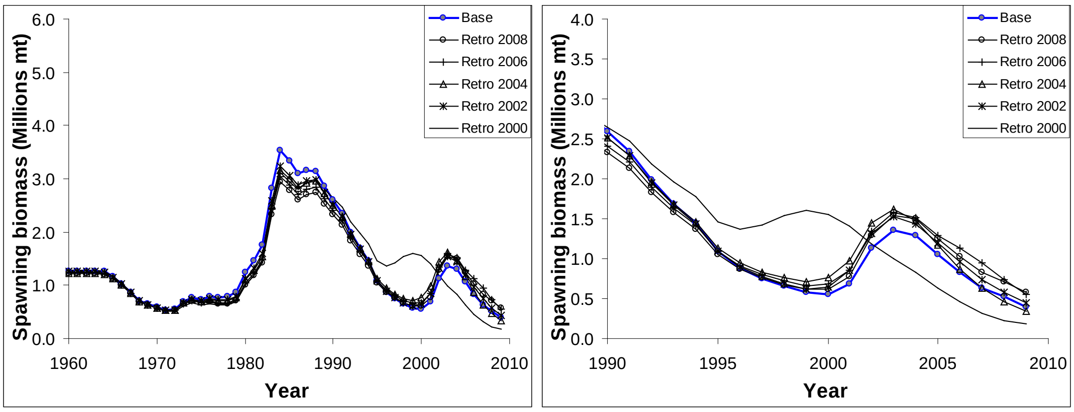
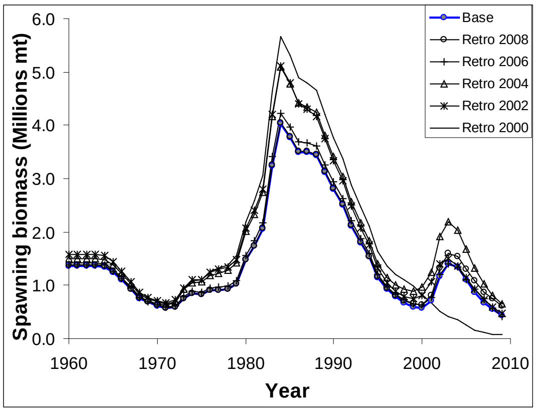


Figure 11c. Response to Request #12: Retrospective analysis using data to 2008, 2006, 2004, 2002 and 2000 for models with survey q estimated and final survey selectivity fixed at 0.9.



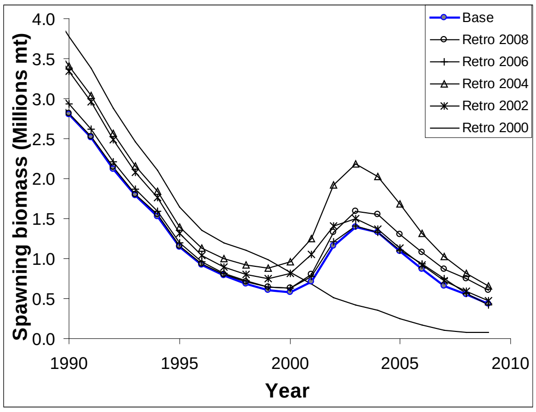


Figure 11d. Response to Request #12: Retrospective analysis using data to 2008, 2006, 2004, 2002 and 2000 for models with survey q, old M and final survey selectivity estimated.

Request #13: Jitter the new preferred base model with q freely estimated, final acoustic survey selectivity estimated, and a simplified blocking structure. This preferred model differs from the pre-STAR base model by allowing q to be freely estimated and simplifying the selectivity blocking structure to be four year blocks. This is the new preferred base model. The jitters will confirm convergence properties for this model configuration.

The STAT ran 200 jitters, with random perturbations of the starting values of all parameters, where the perturbation was normally distributed about the current parameter estimate with a standard deviation equal to 2% of the range between the minimum and maximum bound for the parameter. Of these 200 runs, 27.5% converged. In no case was a lower estimate of negative log-likelihood detected, and all of the converged runs produced approximately the same relative depletion rate and female spawning biomass for 2009. The Panel concluded that a model with the selected structure was likely to converge successfully and to attain a global minimum NLL.

Request #14: Provide sensitivity analyses using the pre-recruit survey index with the current weighting of the fishery comp data and a down-weighting of the fishery comp data. Include a run with a simplified 8-yr selectivity blocking structure and under the down-weighting scenario with the pre-recruit index included. This may reveal a general pattern of model sensitivity to such data that may be informative for recruitments. Tension in the data might be informative.

The estimated level of female spawning stock biomass .for the 1999 year class was reduced in response to the down-weighting and the inclusion of the pre-recruit data. This was possibly a result of tension between the pre-recruit data and the survey and fishery data as the pattern of the pre-recruit data was markedly inconsistent with information regarding recruitment that was present in those other time series of data. The STAR Panel endorsed the decision to exclude these data from the current assessment.

Request #15: Provide a sensitivity analysis of an alternative model where historical California length frequencies are dropped. This will determine the sensitivity of model results to these data.

The exclusion of the historical Californian length-composition data had little effect on the biomass estimates produced by the model.

Request #16: Provide a run with asymptotic selectivities for the acoustic survey and the Canadian fishery. This will provide an alternative view where the age data are not fitted by the selectivity functions becoming more dome-shaped. Forcing asymptotic selectivity for the Canadian fishery and the survey recognizes that the Canadian fishery tends to catch larger fish reducing availability of larger fish in the U.S. fishery.

The imposition of asymptotic selectivity curves for the acoustic survey and the Canadian fishery led to the selectivity curves for the U.S. fishery becoming more asymptotic (Fig. 12a). The uncertainty of the estimates of recruitment for the larger year classes decreased (Fig. 12d). The estimate of survey q increased to 1.4, but values of spawning biomass were of reduced magnitude (Fig. 12e). This scenario provided a poorer fit than that obtained with the base model, with negative log-likelihood increasing by 184 points for three fewer parameters. When M for older fish was fixed and selectivities were not constrained to be asymptotic, the negative log-likelihood was 128 likelihood points from the base case with two parameters additional to those of the previous scenario.

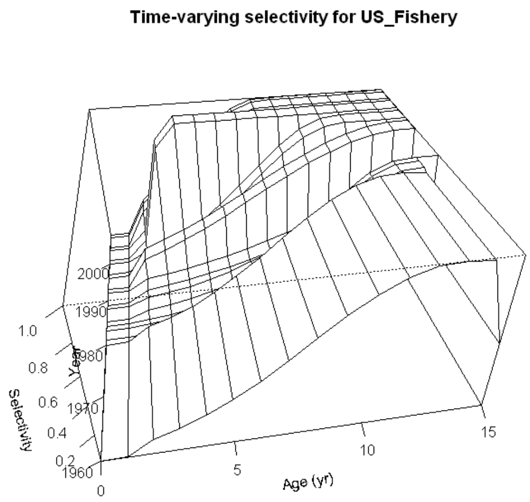


Figure 12a. Response to Request #16. Estimates of time-varying selectivities for the U.S. fishery when natural mortality is constrained to 0.23 throughout life and asymptotic selectivities are assumed for both the acoustic survey and the Canadian fishery.

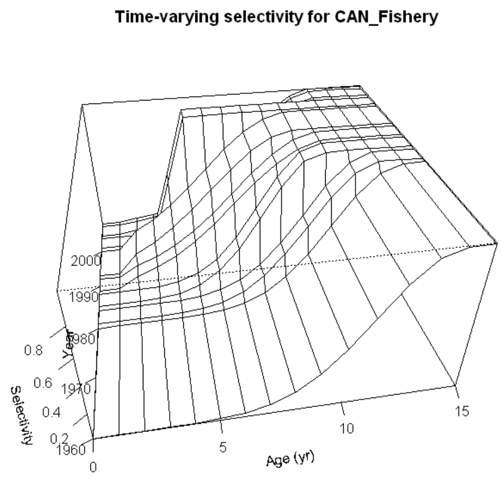


Figure 12b. Response to Request #16. Estimates of time-varying selectivities for the Canadian fishery when natural mortality is constrained to 0.23 throughout life and asymptotic selectivities are assumed for both the acoustic survey and the Canadian fishery.

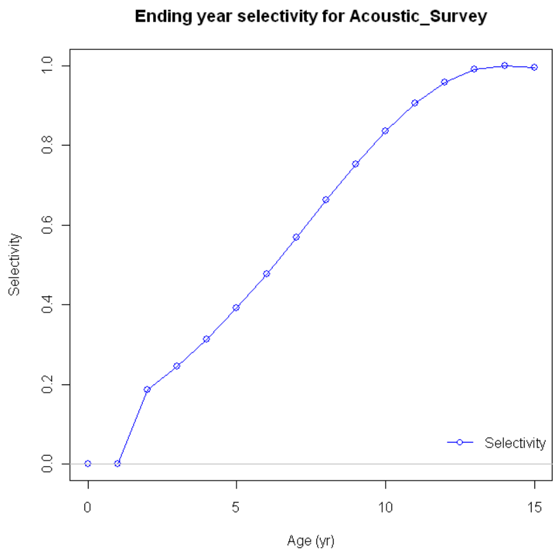


Figure 12c. Response to Request #16. Estimates of selectivities for the acoustic survey when natural mortality is constrained to 0.23 throughout life and asymptotic selectivities are assumed for both the acoustic survey and the Canadian fishery.

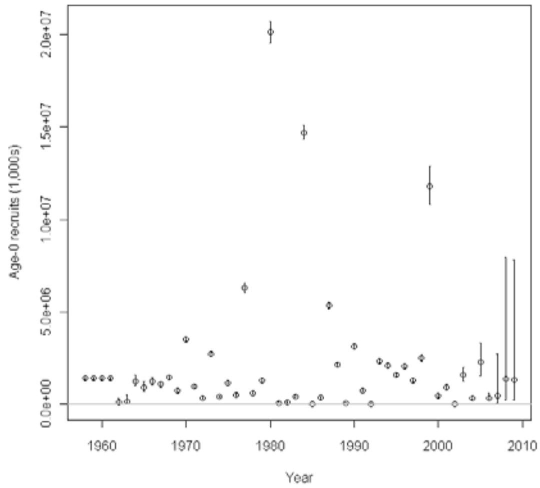


Figure 12d. Response to Request #16. Estimates of recruitment when natural mortality is constrained to 0.23 throughout life and asymptotic selectivities are assumed for both the acoustic survey and the Canadian fishery.

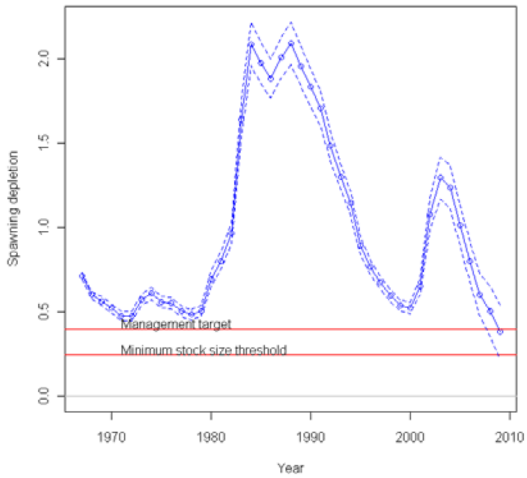


Figure 12e. Response to Request #16. Estimates of recruitment when natural mortality is constrained to 0.23 throughout life and asymptotic selectivities are assumed for both the acoustic survey and the Canadian fishery.

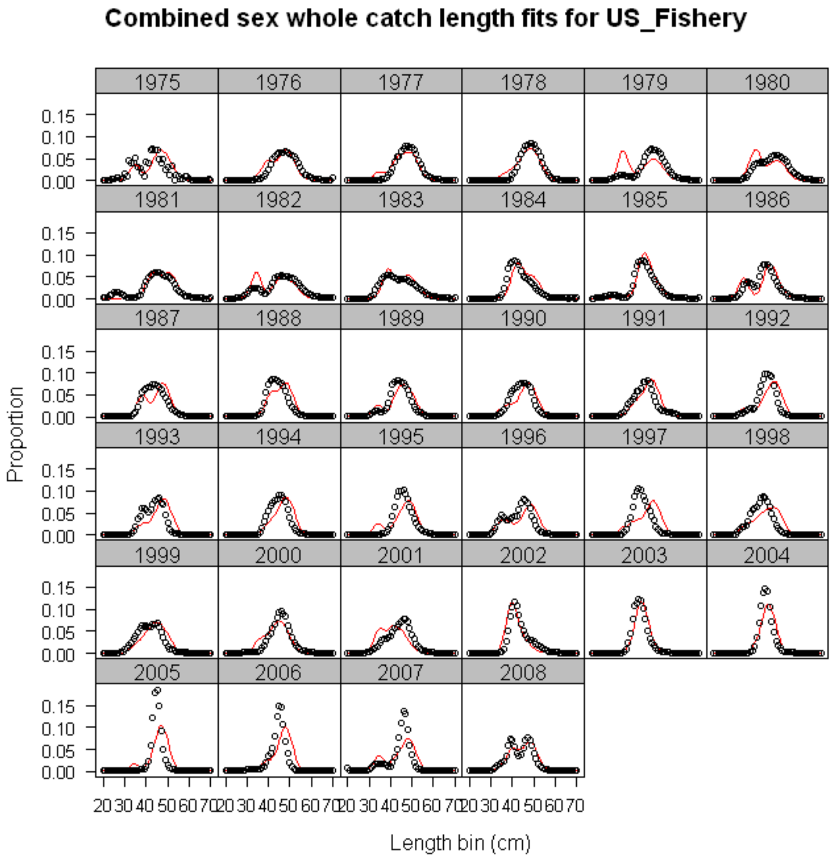


Figure 12f. Response to Request #16. Observed and estimated length compositions for the U.S. fishery when natural mortality is constrained to 0.23 throughout life and asymptotic selectivities are assumed for both the acoustic survey and the Canadian fishery.

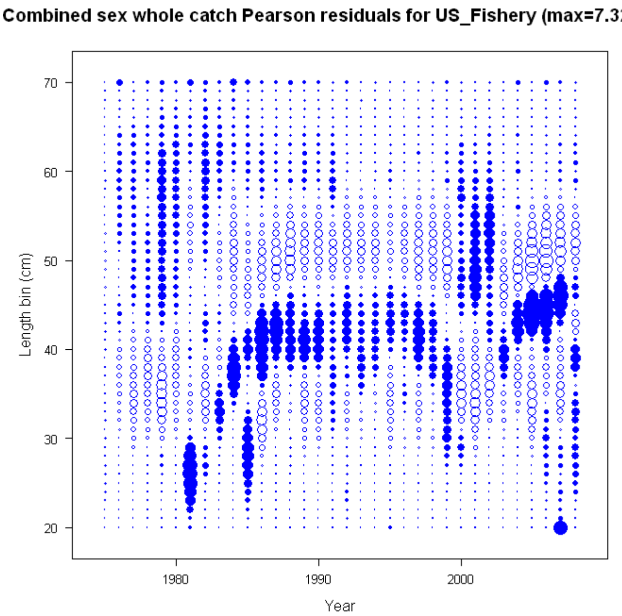


Figure 12g. Response to Request #16. Residuals of observed from estimated length compositions for the U.S. fishery when natural mortality is constrained to 0.23 throughout life and asymptotic selectivities are assumed for both the acoustic survey and the Canadian fishery.

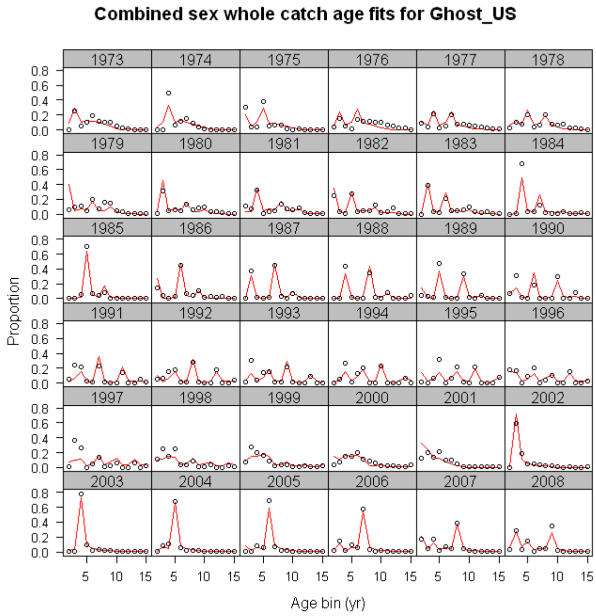


Figure 12h. Response to Request #16. Observed and estimated implied age compositions for the U.S. fishery when natural mortality is constrained to 0.23 throughout life and asymptotic selectivities are assumed for both the acoustic survey and the Canadian fishery.

Request #17: Provide a sensitivity analysis assuming an M of 0.25 with and without the free estimation of M for age 15+. This will explore the necessity of assuming a high M for old fish.

When the value of M throughout life was set to 0.25, a slightly better fit was obtained than that with M = 0.23 (Request #16), resulting in an estimate of log-likelihood 109 points from the base level. The selectivity curves are shifted to the right, with low values of selectivity of 15+ fish, *i.e.*, less than 0.1, for the acoustic survey and both fisheries (Fig. 13). Survey q was estimated to be 0.34, which, in combination with the estimate of q=1.4 obtained in the results for Request #16 when M was set to 0.23, provided further evidence of the confounding that exists between survey q and M. Dr Stewart advised that such confounding had been the reason why they had proposed the use of a fixed value of survey q in the model presented to the STAR Panel. The estimates of female spawning stock biomass obtained with M=0.25 throughout life increase markedly from the estimates of this variable for the unfished stock, a result that the STAT considered implausible. The result obtained when freely estimating the natural mortality of older fish is presented in the results for Request #20. For this latter run, the trajectory of values of female spawning biomass appears far more plausible. The STAT advised that a defensible prior was available for M, and that, although it wasn't used in the MLE run, this could be used in the MCMC run.

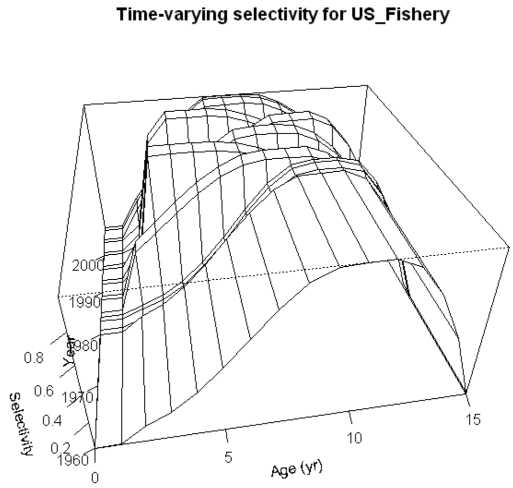


Figure 13a. Response to Request #17. Estimates of time-varying selectivity for the U.S. fishery when natural mortality of fish is constrained to 0.25 throughout life and selectivities are not constrained to be asymptotic.

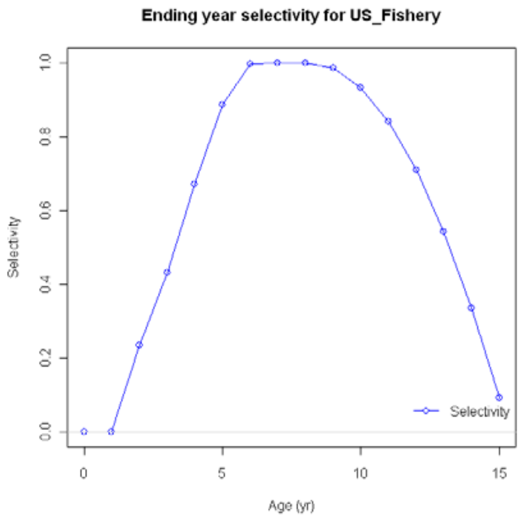


Figure 13b. Response to Request #17. Estimates of the ending year selectivity for the U.S. fishery when natural mortality of fish is constrained to 0.25 throughout life and selectivities are not constrained to be asymptotic.

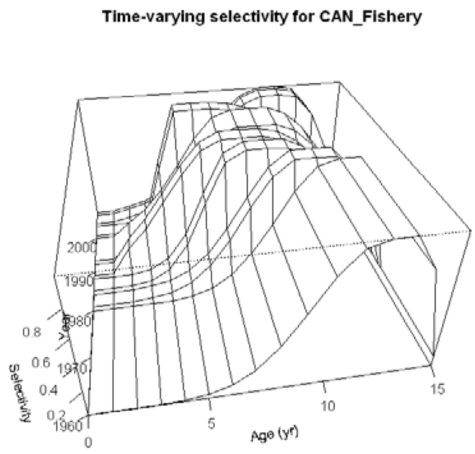


Figure 13c. Response to Request #17. Estimates of time-varying selectivity for the Canadian fishery when natural mortality of fish is constrained to 0.25 throughout life and selectivities are not constrained to be asymptotic.

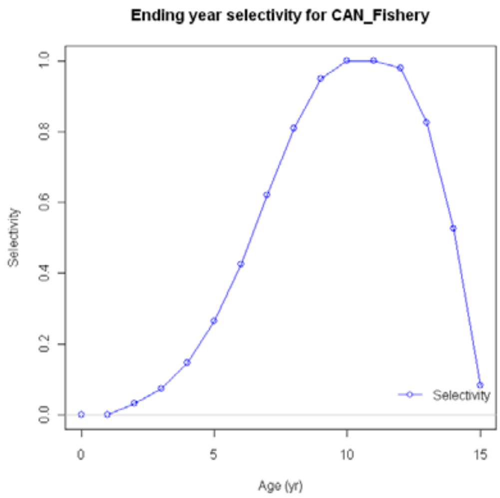


Figure 13d. Response to Request #17. Estimates of the ending-year selectivity curve for the Canadian fishery when natural mortality of fish is constrained to 0.25 throughout life and selectivities are not constrained to be asymptotic.

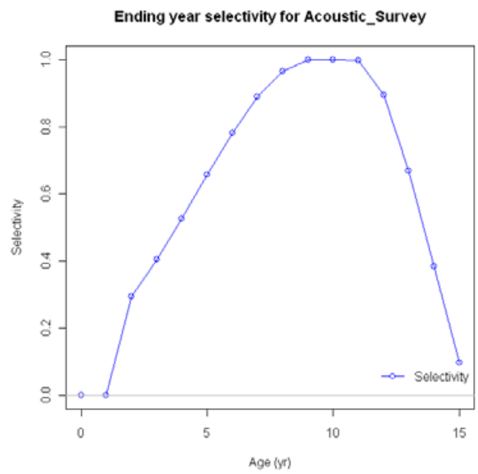


Figure 13e. Response to Request #17. Estimates of selectivity for the acoustic survey when natural mortality of fish is constrained to 0.25 throughout life and selectivities are not constrained to be asymptotic.

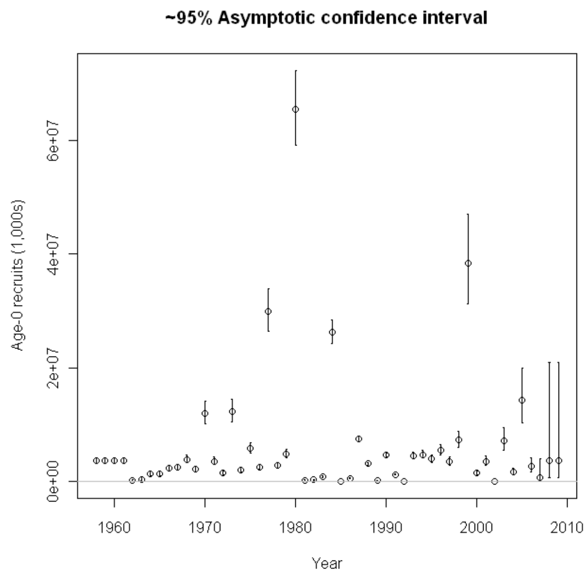


Figure 13f. Response to Request #17. Estimates of recruitment when natural mortality of fish is constrained to 0.25 throughout life and selectivities are not constrained to be asymptotic.

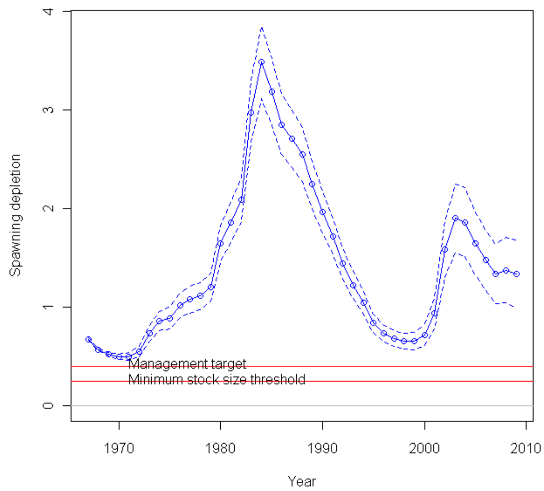


Figure 13g. Response to Request #17. Estimates of female spawning stock biomass when natural mortality of fish is constrained to 0.25 throughout life and selectivities are not constrained to be asymptotic.

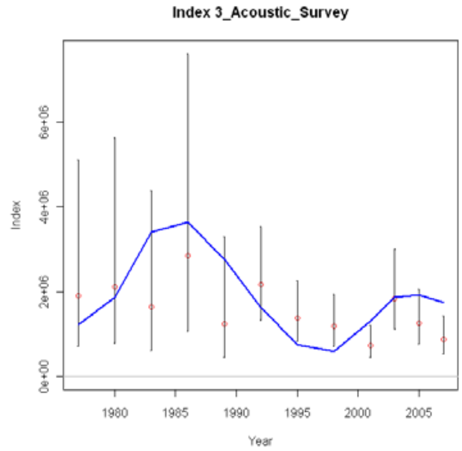


Figure 13h. Response to Request #17. Estimates of survey biomass when natural mortality of fish is constrained to 0.25 throughout life and selectivities are not constrained to be asymptotic.

Request #18: Provide values of q that result in 12.5% and 87.5% of the female spawning biomass probability distribution. This assumes normal distribution of probabilities of the female spawning biomass around the MLE estimate. This may be the basis for an alternative decision table if the MCMC does not converge.

The required values for q were obtained by varying q manually to match the estimates of female spawning biomass to the values of the 12.5th and 87.5th percentiles of the (assumed) normal distribution of values of this parameter estimate around the MLE for the parameter. The resulting values were used to produce the row of the decision table shown in the results for Request #21.

Request #19: Provide a run fixing base M at 0.25 and allowing M for older fish (age 15+) to be freely estimated. This will assess whether a higher M for older fish or a higher estimate of base M is needed to explain the lack of older fish.

The results of this run are included in the results presented for Request #20. They showed a slight increase in female spawning stock biomass and depletion from that estimated using the base model.

Request #20: Profile over base M from 0.21 to 0.25 with the M for older aged fish and q freely estimated using a) dome-shaped and b) asymptotic selectivity in the acoustic survey and the Canadian fishery. This will establish model sensitivity to estimates of base M.

The model failed to converge for M=0.215 using asymptotic selectivity and the value of negative log-likelihood for M=0.21 using dome-shaped selectivity appeared anomalous. The STAT was unable to pursue these issues in the time available and thus, in the plots that follow, the smallest value of M that should be considered is M=0.215. The STAT favoured the use of dome-shaped selectivity, coupled with increased mortality of older fish. Without the latter, a large number of cryptic older fish would accumulate, which seems implausible. The likelihood profile was relatively flat over the range of M from 0.215 to 0.25, indicating that there was little information in the data that would allow precise estimation of this parameter. A poorer fit was obtained using asymptotic selectivity and, for this reason, further consideration of asymptotic selectivity was not pursued by the STAR Panel.

The estimate of survey q decreased as M increased, while those of B_0 and depletion and estimates of female spawning stock biomass and of the recruitment of the larger year classes increased. The estimates of female spawning biomass for recent years were influenced less by the value of M than those till the early 1990s.

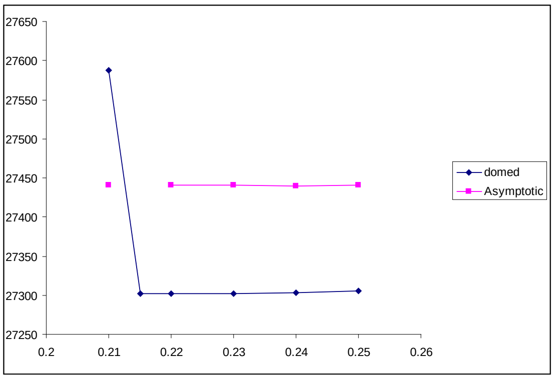


Figure 14a. Response to Request #20. Profiles of values of negative log-likelihood for natural mortality estimates ranging from 0.21 to 0.25, estimating survey q and M for older fish, and employing asymptotic and domed curves for both the survey and Canadian fishery.

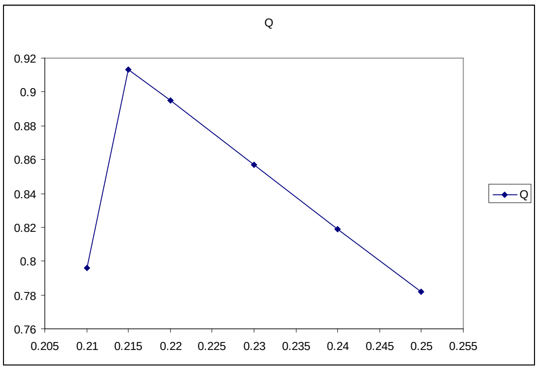


Figure 14b. Response to Request #20. Profiles Estimates of survey q for natural mortality estimates ranging from 0.21 to 0.25, estimating survey q and M for older fish, and employing domed selectivity curves for both the survey and Canadian fishery.

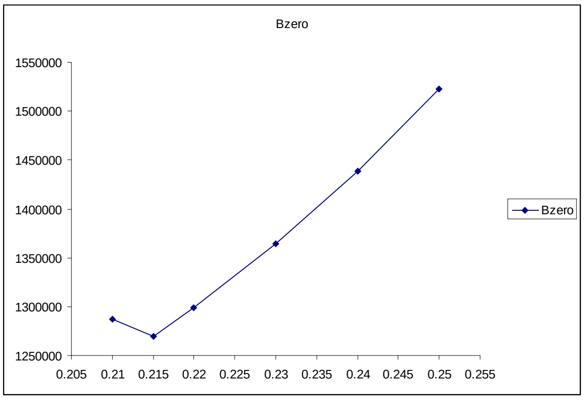


Figure 14c. Response to Request #20. Estimates of B_0 for natural mortality estimates ranging from 0.21 to 0.25, estimating survey q and M for older fish, and employing domed selectivity curves for both the survey and Canadian fishery.

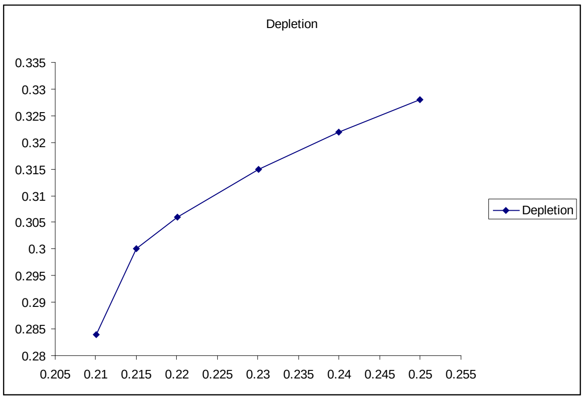


Figure 14d. Response to Request #20. Estimates of depletion for natural mortality estimates ranging from 0.21 to 0.25, estimating survey q and M for older fish, and employing domed selectivity curves for both the survey and Canadian fishery.

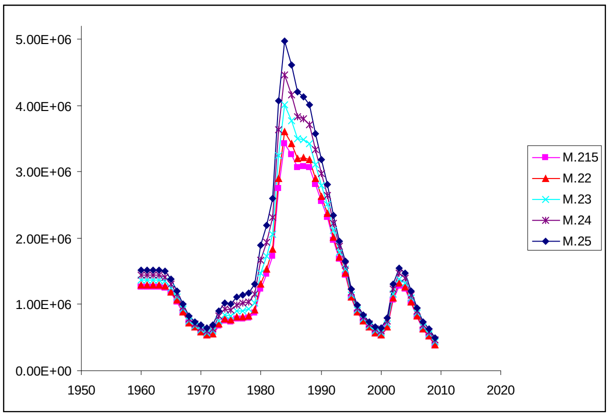


Figure 14e. Response to Request #20. Estimates of female spawning stock biomass for natural mortality estimates ranging from 0.21 to 0.25, estimating survey q and M for older fish, and employing domed selectivity curves for both the survey and Canadian fishery.

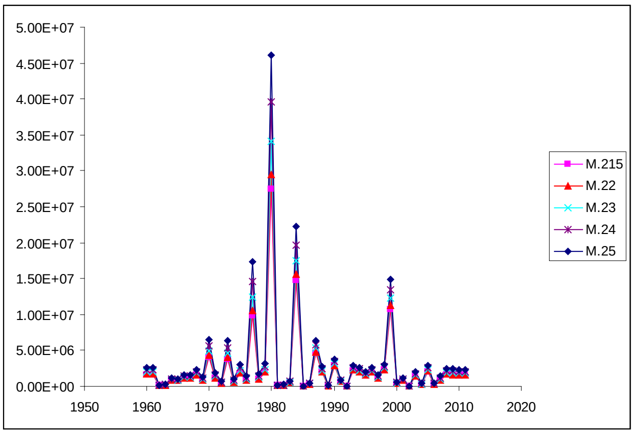


Figure 14f. Response to Request #20. Estimates of recruitment for natural mortality estimates ranging from 0.21 to 0.25, estimating survey q and M for older fish, and employing domed selectivity curves for both the survey and Canadian fishery.

Request #21: Using the results of Request #18, develop one row of a decision table that can be used to exemplify a contingency decision table if the MCMC results do not converge.

Values of OY were calculated for 2009-2011 using the base model selected by the STAR Panel and the $SPR_{40\%}$ fishing mortality target/limit, the 40:10 harvest control rule, and the 73.88% U.S. – 26.12% Canada catch allocation agreement. These catches were then used to construct the first row of a decision table, employing the values of survey q estimated at Request #18 to provide estimates of alternative states of nature with relative probabilities approximately half of that associated with the base model (Table 1). Uncertainty of the value of natural mortality, M, was not currently captured in the decision table, but a defensible prior distribution for this parameter could be used in the MCMC run. The STAR Panel endorsed the use of MCMC to integrate over uncertainty in the base model, as this would provide better estimates of the range of outcomes that were likely. However, in the event that the MCMC run failed to converge, an extended version of the decision table presented in Table 1 could serve to provide estimates based on MLE results based on one axis of uncertainty, *i.e.*, that over survey q. It was noted by the STAR Panel that neither the decision table nor the results of the proposed MCMC run would capture the structural uncertainty of the model. That such uncertainty exists is evident in the pattern of residuals seen in the length composition data.

		State of nature					
		12.5th percentile of female spawning biomass from the base model		Base model		87.5th percentile of female spawning biomass from the base model	
Relative probability		0.25		0.5		0.25	
Management action							
Year	Coast-wide catch (mt)	Female spawning biomass (millions mt)	Estimated depletion (%)	Female spawning biomass (millions mt)	Estimated depletion (%)	Female spawning biomass (millions mt)	Estimated depletion (%)
2009	253,582	0.294	22	0.435	32	0.575	41
2010	193,109	0.230	17	0.357	26	0.484	35
2011	189,054	0.251	19	0.363	27	0.476	34

Table 1. Predictions of female spawning stock biomass and depletion under three model scenarios assuming that catches in 2009-2011 are those calculated using the base model under the 40:10 rule

5. References

Dorn, M. W. and M. W. Saunders. 1997. Status of the coastal Pacific whiting stock in U.S. and Canada in 1997. In Pacific Fishery Management Council, Appendix: Status of the Pacific Coast groundfish fishery through 1997 and recommended acceptable biological catches in 1998: Stock assessment and fishery evaluation. Pacific Fishery Management Council, 2130 SW Fifth Avenue, Suite 224, Portland, OR 97201.

Dorn, M. W., E. P. Nunnallee, C. D. Wilson and M. E. Wilkins. 1994. Status of the coastal Pacific whiting resource in 1993. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/AFSC-47, 101 p.

Hamel, O. S., and Stewart, I. J. 2009. Draft - Stock assessment of Pacific Hake, *Merluccius productus*, (a.k.a. Whiting) in U.S. and Canadian waters in 2009. Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle. Draft dated: 20 January 2009.

Iwamoto, E., Ford, M. J., and Gustafson, R. G. 2004. Genetic population structure of Pacific Hake, *Merluccius productus*, in the Pacific Northwest. Environmental Biology of Fishes, 69: 187-199.

Myers, R. A, Bowen, K. G., and Barrowman, N. J. 1999. Maximum reproductive rate of fish at low population sizes. Can. J. Fish. Aquat. Sci. 56: 2404-2419.

Utter, F. M. 1971. Biochemical polymorphisms in Pacific hake (*Merluccius productus*). Cons. Perm. Int. Explor. Mer Rapp. P.-V. Reun. 161: 87-89.

Appendix 1: Bibliography of all material provided

I. Current Draft Stock Assessments

Hamel, O. S., and Stewart, I. J. 2009. Draft - Stock assessment of Pacific Hake, *Merluccius productus*, (a.k.a. Whiting) in U.S. and Canadian waters in 2009. Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle. Draft dated: 20 January 2009.

II. Background Materials

A. 2007 Review

Helser, T. E., and Martell, S. 2007. Stock Assessment of Pacific Hake (Whiting) in U.S. and Canadian Waters in 2007. Report of the U.S.-Canada Pacific Hake Joint Technical Committee (JTC). Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle. 362 pp.

STAR Panel. 2007. Report of the Joint Canadian and U.S. Pacific Hake/Whiting Stock Assessment Review Panel. Revised 22 March 2007

B. 2008 Review

Helser, T. E., Stewart, I. J., and Hamel, O. S. 2008. Stock Assessment of Pacific Hake, *Merluccius productus*, (a.k.a Whiting) in U.S. and Canadian Waters in 2008. Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle. 128 pp.

Martell, S. 2008. Assessment and Management advice for Pacific hake in U.S. and Canadian waters in 2008. University of British Columbia Fisheries Centre, Vancouver, Canada. 56 pp.

Sinclair, A. F., and Grandin, C. J. 2008. Canadian Fishery Distribution, Index Analysis, and Virtual population Analysis of Pacific Hake, 2008. Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, Canada. 61 pp.

Samson, D., Haddon, M., Cadigan, N., Waldeck, D., and Wallace, J. 2008. Report of the 2008 U.S. / Canada Pacific Hake (Whiting) Stock Assessment Review (STAR) Panel. 33 pp.

C. Acoustic survey details

Fleischer, G. W., Cooke, K. D., Ressler, P. H., Thomas, R. E., de Blois, S. K., Hufnagle, L. C., Kronlund, A. R., Holmes, J. A., and Wilson, C. D. 2005. The 2003 Integrated Acoustic and Trawl Survey of Pacific Hake, *Merluccius productus*, in U.S. and Canadian Waters off the Pacific Coast. NOAA Technical Memorandum NMFS-NWFSC-65. 45 pp.

D. Materials for 2009 Review

- Cover letter to STAR Panel by Ms Stacey Miller, Stock Assessment Coordinator, Northwest Fisheries Science Center.
- Draft agenda for Joint US-Canada Technical Review Panel for the Pacific Hake / Whiting Stock Assessment meeting - 3-6 February 2009.
- List of participants for the Joint US-Canadian Review Panel of the Pacific hake / Whiting Stock Assessment.

- Terms of reference for the groundfish stock assessment and review process for 2009-2010.
- Pacific Whiting Act of 2006
- Agreement between the Government of the United States of America and the Government of Canada on Pacific Hake/Whiting

E. Details of Stock Synthesis Model

Methot, R. D. 2009. User Manual for Stock Synthesis Model. Version 3.02B. Updated January 20, 2009. NOAA Fisheries, Seattle, WA. 117 pp.

Program files:

- SS3t-NewFeatures.zip
- SS3t-Sheets.zip
- SS3t-Simple.zip
- SS_T_Ver302B.zip

Appendix 2: Copy of CIE Statement of Work

External Independent Peer Review by the Center for Independent Experts

Joint US-Canada Technical Review Panel for the Pacific Hake / Whiting Stock Assessment

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract to provide external expertise through the Center for Independent Experts (CIE) to conduct impartial and independent peer reviews of NMFS scientific projects. This Statement of Work (SoW) described herein was established by the NMFS Contracting Officer's Technical Representative (COTR) and CIE based on the peer review requirements submitted by NMFS Project Contact. CIE reviewers are selected by the CIE Coordination Team and Steering Committee to conduct the peer review of NMFS science with project specific Terms of Reference (ToRs). Each CIE reviewer shall produce a CIE independent peer review report with specific format and content requirements (**Annex 1**). This SoW describes the work tasks and deliverables of the CIE reviewers for conducting an independent peer review of the following NMFS project.

Project Description: The Pacific hake (Whiting) stock assessment is a collaborative effort between U.S. and Canadian stock assessments to assess the stock status of the largest fishery along the West Coast of the U.S. and British Columbia. For example, in 2006 the Pacific whiting fishery accounted for 91% of the landed catch and 44% of the associated ex-vessel value in the groundfish fishery. The stock assessment provides the basis for the management of this fishery. The Magnuson Stevens Reauthorization Act (MSRA) of 2006 mandates that the national fishery conservation and management program utilizes, and is based upon, the best scientific information available. In addition, a treaty between the U.S. and Canada, ratified by the U.S. in the MSRA, establishes an annual assessment, review, and management process and is expected to be ratified by the end of 2008. The treaty will likely not be fully implemented by February 2008, therefore, the review of the international stock assessment will fall under the current Pacific Fishery Management Council's Stock Assessment Review (STAR) Panel.

The STAR panel is part of the Pacific Fishery Management Council's process to provide peer review as referenced in the 2006 Reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act, which states that " the Secretary and each Regional Fishery Management Council may establish a peer review process for that Regional Fishery Management Council for scientific information used to advise the Regional Fishery Management Council about the conservation and management of the fishery (see Magnuson-Stevens Act section 302(g)(1)(E)). If a peer review process is established, it should investigate the technical merits of stock assessments and other scientific information used by the Council's Scientific and Statistical Committee (SSC). The peer review process is not a substitute for the SSC and should work in conjunction with the SSC."

The Pacific Fishery Management Council's Terms of Reference for the West Coast Groundfish Stock Assessments and STAR Process for 2009-2010 requires that some reviewers be appointed from the Center for Independent Experts (CIE). The terms of reference document will be included as background material once the document is finalized by the Pacific Fishery Management Council family.

The Terms of Reference (ToRs) for the CIE reviewer's role in the peer review are attached in **Annex 2**. The draft agenda of the panel review meeting is attached in **Annex 3**.

Requirements for CIE Reviewers: Two CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. The CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review described herein. The CIE reviewers shall have the expertise, background, and experience to complete an independent peer review in accordance with the SoW and ToRs herein. The CIE reviewers shall have expertise in fish population dynamics, with experience in the integrated analysis modeling approach, using age-and size-structured models, use of MCMC to develop confidence intervals, and use of Generalized Linear Models in stock assessment models.

Location of Peer Review: The CIE reviewers shall conduct an independent peer review during the panel review meeting in Seattle, Washington during the tentative dates of February 3-6, 2009.

Statement of Tasks: The CIE reviewers shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering committee, the CIE shall provide the CIE reviewer information (name, affiliation, and contact details) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, foreign national security clearance, and information concerning other pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When CIE reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for CIE reviewers who are non-US citizens. For this reason, the CIE reviewers shall provide requested information (e.g., name, contact information, birth date, passport number, travel dates, and country of origin) to the NMFS Project Clearance for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations (available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/sponsor.html).

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send by electronic mail or make available at an FTP site to the CIE reviewers all necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE on where to send documents. The CIE reviewers shall read all documents in preparation for the peer review.

Documents to be provided to the CIE reviewers prior to the STAR Panel meeting include:

- The current draft Pacific hake stock assessment report(s);
- The most recent previous Pacific hake stock assessment and STAR Panel report;
- A copy of the "Pacific Whiting Act of 2006";
- The Pacific Fishery Management Council's Scientific and Statistical Committee's Terms of Reference for Stock Assessments and STAR Panel Reviews;
- Stock Synthesis (SS) Documentation

- Additional supporting documents as available.
- An electronic copy of the data, the parameters, and the model used for the assessments (if requested by reviewer).

Additional background documents may also be provided.

This list of pre-review documents may be updated up to two weeks before the peer review. Any delays in submission of pre-review documents for the CIE peer review will result in delays with the CIE peer review process, including a SoW modification to the schedule of milestones and deliverables. Furthermore, the CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewers in accordance to the SoW scheduled deadlines specified herein.

Panel Review Meeting: The CIE reviewers shall conduct the independent peer review in accordance with the SoW and ToRs. **Modifications to the SoW and ToRs can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** The CIE reviewers shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified in the contract SoW. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

In most circumstances a STAR Panel will include a chair appointed from the SSC's Groundfish Subcommittee and three other experienced stock assessment analysts. The STAR panel chair is responsible for: 1) developing an agenda for the STAR panel meeting, 2) ensuring that STAR panel members and STAT teams follow the Terms of Reference, 3) participating in the review of the assessment, 4) guiding the STAR panel and STAT team to mutually agreeable solutions, and 5) coordinating review of final assessment documents.

The CIE reviewer’s role includes being an active panel participant and participants are strongly encouraged to voice all comments regarding the assessment data, model configurations, and uncertainty during the STAR Panel so the assessment teams can address the comments during the Panel meeting and incorporate changes when appropriate. The assessments are finalized by the end of the Panel meeting and comments made after the fact will not be able to be included in the final assessment document. The CIE reviewers shall also contribute to the final STAR Panel Review Report. Additional details regarding the STAR Panel reviewer’s responsibilities will be included in the Pacific Fishery Management Council’s final Terms of Reference for Groundfish Stock Assessments and STAR Panel meetings.

Contract Deliverables - Independent CIE Peer Review Reports: The CIE reviewers shall complete an independent peer review report in accordance with the SoW. The CIE reviewers shall complete the independent peer review according to required format and content as described in Annex 1. The CIE reviewers shall complete the independent peer review addressing each ToR as described in Annex 2.

Other Tasks – Contribution to Summary Report: The CIE reviewers will assist the Chair of the panel review meeting with contributions to the Summary Report. The CIE reviewers are not required to reach a consensus and may provide dissenting opinions.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review;
2) Participate during the panel review meeting at the Deca Hotel, Seattle, Washington on February 3-6, 2009, and conduct an independent peer review in accordance with the ToRs (Annex 2);
3) No later than February 20, 2009, the CIE reviewers shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator, via email to David Die at ddie@rsmas.miami.edu.
4) The CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in Annex 2;
5) The CIE reviewers shall address changes as required by the CIE review in accordance with the schedule of milestones and deliverables.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

28 December 2008	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
19 January 2009	NMFS Project Contact sends the CIE Reviewers the pre-review documents
3-6 February 2009	Each reviewer participates and conducts an independent peer review during the panel review meeting
20 February 2009	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
5 March 2009	CIE submits CIE independent peer review reports to the COTR
12 March 2009	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: Requests to modify this SoW must be made through the Contracting Officer's Technical Representative (COTR) who submits the modification for approval to the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the CIE within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and Terms of Reference (ToR) of the SoW as long as the role and ability of the CIE reviewers to complete the SoW deliverable in accordance with the ToRs and deliverable schedule are not adversely impacted. The SoW and ToRs cannot be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (the CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards: (1) the CIE report shall have the format and content in accordance with Annex 1, (2) the CIE report shall address each ToR as specified in Annex 2, (3) the CIE report shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon notification of acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the approved CIE reports to the NMFS Project Contact and regional Center Director.

Key Personnel:

William Michaels, Contracting Officer's Technical Representative (COTR)
NMFS Office of Science and Technology
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
William.Michaels@noaa.gov Phone: 301-713-2363 ext 136

Manoj Shivlani, CIE Lead Coordinator
Northern Taiga Ventures, Inc.
10600 SW 131st Court, Miami, FL 33186
shivlanim@bellsouth.net Phone: 305-383-4229

NMFS Project Contact:

Stacey Miller
NWFSC/FRAM Division
2032 SE OSU Drive, Newport OR 97365
Stacey.Miller@noaa.gov Phone: 206-437-5670

Elizabeth Clarke
NWFSC/FRAM Division
2725 Montlake Blvd. E, Seattle WA 98112
Elizabeth.Clarke@noaa.gov Phone: 206-860-5616

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR, and Conclusions and Recommendations in accordance with the ToRs.

   a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including providing a detailed summary of findings, conclusions, and recommendations.

   b. Reviewers should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.

   c. Reviewers should elaborate on any points raised in the Summary Report that they feel might require further clarification.

   d. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

   e. The CIE independent report shall be a stand-alone document for others to understand the proceedings and findings of the meeting, regardless of whether or not they read the summary report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.

3. The reviewer report shall include as separate appendices as follows:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work
   Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Annex 2: Terms of Reference for the Peer Review

Joint US-Canada Technical Review Panel for the Pacific Hake / Whiting Stock Assessment

1. *Become familiar with the draft Pacific hake stock assessment and background materials. Along with other members of the Panel,* determine if the stock assessment document is sufficiently complete according to the Pacific Fishery Management Council's Terms of Reference for West Coast Groundfish Stock Assessment and STAR Panels (to be included once finalized).
2. *Evaluate, data collection operations and survey design and make recommendations for improvement*
3. *Comment on quality of data used in the assessment.*
4. *Evaluate and comment on analytic methodologies*
5. *Evaluate model assumptions, estimates, and major sources of uncertainty. Specifically, recommend improvements including alternative model configurations or formulations as appropriate during the panel meeting and comment on the primary sources of uncertainty in the assessment model.*
6. *Insert an explicit statement as to whether this stock assessment represents the best available science.*
7. *Recommendations for any further improvements*
8. *Brief description on panel review proceedings highlighting pertinent discussions, issues, effectiveness, and recommendations*

Note – CIE reviewers typically address scientific subjects, hence ToRs usually do not involve CIE reviewers with regulatory and management issues unless this expertise is specifically requested in the SoW.

Appendix 3: Panel membership

Participants for the Joint US-Canadian Review Panel
of the Pacific hake / Whiting Stock Assessment

February 3-6, 2009,
Hotel Deca
4507 Brooklyn Avenue N.E.
Seattle, WA 98105

Panel Reviewers

David Sampson, Oregon State University and Scientific and Statistical Committee (SSC) Representative, Panel Chair
Norman Hall, Center for Independent Experts (CIE)
Jon Helge Vølstad, Center for Independent Experts (CIE)
Tom Carruthers, University of British Columbia, Canada

Panel Advisors

Dan Waldeck, Groundfish Advisory Panel (GAP) Representative
John Wallace, Groundfish Management Team (GMT) Representative
Greg Workman, Department of Fisheries and Oceans (DFO), Canada
Jeff Fargo, Department of Fisheries and Oceans (DFO), Canada
Chris Grandin, Department of Fisheries and Oceans (DFO), Canada
John DeVore, PFMC Representative

Stock Assessment (STAT) Team

Owen Hamel, Northwest Fisheries Science Center, National Marine Fisheries Service
Ian Stewart, Northwest Fisheries Science Center, National Marine Fisheries Service

Appendix 4 Agenda

Joint US-Canada Technical Review Panel for the Pacific Hake / Whiting Stock Assessment
February 3-6 2009,
Hotel Deca
4507 Brooklyn Avenue NE
Seattle, WA 98105

Tuesday, February 3, 2008

9:00 a.m.	Welcome and Introductions (Elizabeth Clarke, NMFS).
9:15 a.m.	Review the Agenda and Discussion of Meeting Format (David Sampson, Panel Chair, SSC rep.). - Review U.S. Management Needs (John DeVore, PFMC) - Review Canadian Management Needs (Barry Ackerman, DFO) - Review Terms of Reference for Assessment and Review Panel - Discuss Process to Incorporate 2008 Canadian Lengths/Ages - Assignment of reporting duties - Discuss and agree to format for the final assessment document.
10:00 a.m.	Overview of 2008 Whiting Fisheries - U.S. Fishery (Ian Stewart, NMFS) - Canadian Fishery (Chris Grandin, DFO)
10:15 a.m.	STAT Presentations of Pacific hake / Whiting Stock Assessment. - Review of input data for the assessment (Ian Stewart, NMFS).
12:00 p.m.	Lunch (On Your Own)
1:00 p.m.	STAT Presentations of Pacific hake / Whiting (continued). - Plans and progress for improving Pacific hake biomass estimate (Dezhang Chu, NMFS) - Stock Synthesis Modeling (Owen Hamel and Ian Stewart, NMFS).
3:00 p.m.	Q&A session with the STAT & Panel discussion.
4:30 p.m.	Panel develops first list of model runs / analyses for the STAT team(s).
5:30 p.m.	Adjourn for day.

Wednesday, February 4, 2009

9:00 a.m. STAT Presentation(s) of first set of requested model runs/analyses.

12:00 p.m. Lunch (On Your Own).

1:00 p.m. Panel discussion.

- Panel develops second list of model runs / analyses for the STAT team(s).
- Panel begins drafting report.

5:30 p.m. Adjourn for day.

Thursday, February 5, 2009

9:00 a.m. STAT presentation(s) of second set of requested model runs/analyses.

12:00 p.m. Lunch (On Your Own).

1:00 p.m. Panel discussion.

- Identification of base model and elements for the decision table.
- Panel develops third list of model runs for decision table and begins drafting STAR report.

5:30 p.m. Adjourn for day.

Friday, February 6, 2009

9:00 a.m. STAT presentation(s) of third set of requested model runs/analyses.

10:00 a.m. Panel discussion.

- Discuss MCMC runs for base case model and decision table
- Panel agree to process for completing final STAR report by Council Briefing Book deadline (2/18 for mailed BB).
- Panel finishes report.

12:00 p.m. Review Panel Adjourn.