CEFAS
The Centre for Environment, Fisheries & Aquaculture Science

Review of 2005 STAR Panel for Pacific hake (whiting)

for

University of Miami Independent System for Peer Review

February 2005

CEFAS Contract C2455

COMMERCIAL IN CONFIDENCE

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Executive Summary

The STAR panel reviewed the 2004 assessment of Pacific hake (whiting). The review was held February 1st to 3rd 2005 at the Northwest Fisheries Science Center in Seattle, Washington. The draft assessment was presented to the Panel and other attendees, and the issues evaluated through open discussion. A conclusion was then drawn on whether to accept the assessment as a basis for management of the fishery. Recommendations from the previous STAR report were reviewed to determine the extent to which they had been addressed, and new recommendations were made.

The 2004 assessment represented an "expedited stock assessment update". The assessment model and data sources were as agreed by the previous STAR panel, and the 'new' information represented an additional year of catch age structure and landings information. Therefore detailed review and "altering of the model…[was] resisted". The model was checked for comparability with that used for the 2003 assessment, and comments and requests were restricted to examination of the projection process. Recommendations that would have resulted in alternative model runs during a full review were instead either examined as sensitivity analyses during the panel, or indicated as areas for future research work.

Overall, the modelling approach, despite uncertainties listed in this document, was adequate for the current stock assessment. The CIE reviewer's views on uncertainties in the modelling approach and recommendations for future work were fully incorporated in the STAR panel report.

The acoustic survey represents a major area of uncertainty, as its ability to survey the entire biomass available is unknown. This reflects the uncertainty over the value of survey *q*. Recommendations are:

- Develop a prior for acoustic survey *q*, through expert consultation. Consider whether improvements to the survey in more recent years mean it more closely surveys absolute biomass, and hence whether a differential *q* value could be applied to the two different time-series (requiring accompanying estimates of CV).
- As further years of survey information are obtained, consider excluding earlier (less certain) years of survey data before fitting the model.
- Present CVs with annual acoustic survey results, so that uncertainties can be visualized.

The model is complex, requiring the estimation of a high (and increasing) number of variables. Recommendations for the model are:

- Re-formulate the model into a format that requires the estimation of considerably fewer parameters.
- Examine the performance of simpler assessment approaches (e.g. VPA), which might validate the results of the current approach (or in the worst case contradict the current trends!).
- Analyse available biological information to examine the variability in M (potentially at age), and both weight-at-age and maturity-at-age (between years and cohorts), in an attempt to improve biological realism.

- First, however, the potential benefits of incorporating increased biological realism within the model (including the sex-specific model suggested by the 2004 STAR panel) should be assessed using simulation evaluation. This would identify which parameters are the most influential, and hence where modelling effort should be focussed, or whether the effort investigating improved modelling of biological inputs are actually worthwhile.
- Perform a sensitivity analysis to examine the effect of increasing CVs on the earlier multinomial age compositions in line with those applied to the surveys. This requires the estimation of a CV for the multinomial ages.

The projection format was discussed in detail (being outside the limitations dictated by the 'expedited stock assessment update' format). Concerns focused on the length of the projection, given the variability in Pacific hake recruitment, and inconsistencies between parameter settings within the projection. Recommendations are:

- A 4-5 year projection is more appropriate than the 10-year projection currently mandated. Available information on recent recruitment from the surveys provides some indication of likely abundance levels of the key exploited age groups out to this time.
- Analyse the patterns in weight-at-age to better model future patterns (e.g. examining for evidence of density-dependence in cohorts) as described under the assessment recommendations above. See also comments regarding simulation evaluation.

Recommendations on reference points focussed on B_0, while the overall management procedure was also considered:

- Perform a retrospective analysis to examine non-stationarity in the value of B_0.
- Use management procedure simulation/evaluation to examine whether the current harvest policy is robust to the biology of Pacific hake, or whether alternative approaches are more robust to the uncertainties in biology and the assessment.

Background

This report reviews the 2004 assessment of the Pacific hake (*Merluccius productus*, also called Pacific whiting) resource off the Pacific coast of Canada and the U.S., at the request of the Center for Independent Experts (see Appendix 2). The author was provided with draft stock assessment reports and relevant files and documents (see bibliography), and participated in the Stock Assessment Review (STAR) panel meeting. External, independent review of the Pacific hake (whiting) stock assessment work is an essential part of the STAR panel process and a requirement in the U.S./Canada agreement regarding the offshore hake/whiting resources (a trans-boundary resource), although this agreement has not yet been ratified.

Prior to 1997, separate Canadian and U.S. assessments were submitted to each nation's assessment review process. In the past, this has resulted in differing yield options being submitted to managers. Multiple interpretations of stock status made it difficult to coordinate overall management policy for this trans-boundary stock. To address this problem, the working group agreed in 1997 to present scientific advice in a single assessment, and that agreement was officially formalized in 2003. This aims to satisfy management responsibilities of both the U.S. Pacific Fisheries Management Council (PFMC) and the Canadian Pacific Stock Assessment Review Committee (PSARC).

Description of review activities

The review was undertaken by Dr Graham Pilling at the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) (Lowestoft, UK) and during the STAR panel review held in Seattle, Washington, at the Northwest Fisheries Science Center. The STAR panel was convened during the period February 1st to 3rd 2005. The panel membership is listed in Appendix 3.

The documentation (see bibliography) was reviewed at CEFAS. Dr Pilling actively participated in the STAR panel meeting in Seattle and assisted with the development of the STAR panel meeting report. The separate report to CIE was completed on return to CEFAS.

Observers, including members of the fishing industry, attended the STAR panel meeting. The draft assessment was presented to the panel and other attendees, and the issues were evaluated through open discussion. A conclusion was then drawn on whether to accept the assessment as a basis for management of the fisheries. Recommendations from the previous STAR panel report were reviewed to determine the extent to which they had been addressed.

Summary of findings

The coastal population of Pacific hake (*Merluccius productus*, also called Pacific whiting) is assessed using an age-structured assessment model coded within AD Model Builder. The U.S. and Canadian fisheries were treated as distinct fisheries. The primary indicator of stock abundance is the acoustic survey, and a midwater trawl juvenile survey provides an indicator of recruitment. New data included in the reviewed assessment were limited to catch-at-age through 2004 and recruitment indices from the Santa Cruz juvenile survey in 2004. The US/Canadian acoustic survey, which is the primary index of hake abundance, was last conducted in summer 2003, but another is planned for summer 2005. As in the 2003 assessment (undertaken in 2004), uncertainty in model results is represented by a range of biomass. The lower biomass end of the range is based upon the conventional assumption that the acoustic survey catchability coefficient, q=1.0, while the higher end of the range represents the q=0.6 assumption.

The assessment presented at the STAR panel meeting represented an 'update' assessment. Under the guidelines of the STAR panel, this meant that the terms of reference for the "expedited stock assessment update" were followed (Appendix F of the "Groundfish stock assessment and review process for 2005-2006" document). This process is "less rigorous" than usual. Detailed review and "altering of the model…[was] resisted". As a result, the model and data sources were checked for comparability with that presented at the 2004 STAR panel, and comments and requests were restricted to examination of the projection process and recommendations which would have resulted in alternative model runs were recommended as future research work (see below).

The CIE reviewer's views on uncertainties in the modelling approach and recommendations for future work were fully incorporated in the STAR panel report. The strengths, weaknesses and uncertainties inherent in the approach are described below within relevant sections. Numbered recommendations (in bold) refer to the conclusions and recommendations section of this report.

Acoustic and trawl surveys

The value of q (for the joint US-Canadian acoustic survey) used in the model remained a source of considerable uncertainty; assessment results are highly sensitive to the value selected. The value q=1.0 means that the abundance estimate from the survey exactly equals the population abundance in the area, q<1.0 means that there are more fish in the water than the abundance indicated by the acoustic survey (e.g. they are present in the acoustic 'dead zone' near the sea bed and therefore not assessed). Two assessments were presented using values of q=1.0 and q=0.6, bracketing the likely ranges of this parameter (as indicated by the 2004 STAR panel). However, when the model freely estimates q, the value is much less than 0.6, which seems unrealistic. The value of q used within the assessment was not open to change under the 'expedited stock assessment update' guidelines for the STAR panel, although no real insight into alternatives values was gained during the meeting. Inclusion of a prior for q seems sensible, but this would have to be fairly informative, being highly skewed towards 1.0 to counteract the model's desire to fit a low q (a uniform prior for q would likely result in a posterior highly skewed towards the lower

boundary). A panel of acoustic experts are needed to develop this prior. **See recommendation 1.** The production of an assessment using q=0.8 was also suggested during the meeting to inform managers. The results of this run were not included within the assessment report.

The consistency of the acoustic signal provided by Pacific hake was considered during the meeting. Uncertainty results from changes in signal strength from different sizes of fish and the individual orientation of fish to the beam, for example. This means that the estimated regression line used to model the functional acoustic response with changing fish length may not be consistent. GAM analyses are already underway to look at this issue. As noted, fish inside the 'dead zone' of the acoustic survey, representing the 1 m or so near the seabed where the acoustic survey does not pick up signals, will not be assessed by the survey. Total abundance will then be under-represented, and hence q is unlikely to equal 1. Further examination of the bottom-trawl survey data and alternative techniques is already being considered to reduce this uncertainty.

The geographic range of the acoustic surveys performed from 1990 is greater than that of the earlier surveys. Expansion factors were therefore developed to make the earlier surveys comparable with those in later years. The use of expansion factors introduces some uncertainty in the abundance estimates. To compensate, CVs set on the earlier surveys are greater than those in later years. **See recommendation 2**.

The survey path is interpolated for a 5 nautical mile band either side of the actual cruise path. The raw survey data could be examined to investigate spatial trends that are not captured by the model, and to develop variance estimates. Bootstrapping of the survey estimates has already indicated a CV of 0.37 (likely to represent mainly process error).

Inconsistencies were noted between the recruitment estimates from the 2003 Santa Cruz trawl survey and the PWCC survey of that year; the Santa Cruz survey indicated a relatively low recruitment level, whereas the PWCC recruitment estimate was above average. Sensitivity runs were performed during the meeting to examine the effect of removing the 2003 and 2004 points from the Santa Cruz survey data. Note, however, that CVs were not presented for the estimates from either survey; given the high uncertainty on each point, it is possible that the two survey estimates were in actual fact consistent. **See recommendation 3**. The PWCC survey cannot yet be used as a primary trawl data source, owing to its short time-series. However, its greater geographic coverage will make it a valuable source of information in future.

Assessment

The current age-structured model uses standard population dynamics equations. The Canadian and U.S. fisheries are modelled as distinct year-round fisheries. Fishing selectivity patterns are year-specific (constrained by a random walk) to allow for changes in fish distribution and fleet composition. The acoustic time-series is modelled using a single selectivity pattern that applies to both the biomass indices and estimated proportions at age. The estimation procedure is through maximum likelihood approaches, with Bayesian methods applied to estimate parameter uncertainty, and the model is fitted to the data using AD Model Builder software.

The current assessment scientists have inherited the modelling approach. This methodology requires the estimation of a considerable number of parameters (327 this year, and the number of parameters to be estimated increases by around 5 with each additional year of data). **See recommendations 4 and 5**.

An assumption within the model is that the population in 1966 is at unexploited equilibrium (i.e. represents B_0). The model was changed slightly this year because the initial population starting condition in 1966 was not actually equal to B_0. The starting F value previously set for 1966 (F=0.01) was not low enough to mimic zero fishing when large numbers of individuals were involved. The model was run for the current review with starting F set at a lower level (F=0.0001) so that biomass in 1966 was equal to B_0. This resulted in a greater stock abundance across time (stock status against B_0 was approximately 8% greater). While a minimal effect, this could be significant if the stock was reduced close to the critical level (25% of B_0).

The biological parameters used within the model are held constant between years:

- The value used for M does not appear to be unreasonable (if a constant M must be used) because it lies within the range of values for this parameter calculated for other hake species and has been estimated within the model (under the assumption of an asymptotic selectivity ogive). M is fixed across ages, although where an asymptotic selectivity ogive was selected and M estimated at age, M at older ages increased to mimic the lack of older fish found in the survey. The Martell *et al*. paper demonstrated the potential interactions between selectivity and natural mortality. Natural mortality might also vary between cohorts and years owing to density-dependence and increased cannibalism in stronger year classes (for example).
- Maturity-at-age is held constant between years, although this too may vary. Indeed, maturity is likely to be related to size, rather than age, and density-dependent growth is therefore a potential factor.
- Weight-at-age data are highly variable. As this species shows very strong recruitment pulses, there is the potential for significant cohort and year effects (cannibalism, density-dependence, etc.).

See recommendations 6 and 7.

A major forcing issue within the model is the difficulty in fitting to years of high biomass indicated by the catch-age data when the abundance data from the acoustic surveys do not indicate a high biomass. This pulls the model in different directions. **See recommendation 8.**

Projections

The projection format was discussed in detail (being outside the limitations dictated by the ‘expedited stock assessment update’ guidelines).

Stock status is projected forward 10 years, as specified by the SSC. However, in stocks such as Pacific hake, which show highly variable recruitment, stock status later in the 10-year period will be highly uncertain. **See recommendation 9**.

Based on the current 10-year projection format, two other comments can be made:

- Pacific hake show considerable year-to-year variation in weight-at-age (as seen in the landings data). The use of a 3-year average of weight-at-age within 10-year projections appears inappropriate. The rationale is that a 3-year average most closely represents current conditions, but given the variability seen between years, it is difficult to assume a recent average will hold over 10 years.
- There is an inconsistency between the averaging period used for weight-at-age (3 years) and recruitment (total time-series average) within the projections. Use of a longer averaging period for weight-at-age (e.g. 10 years) was shown during the meeting to cause a 10% change in the estimate of SSB.

See recommendation 10.

Reference points and management

B_0, the reference point used to monitor stock status, is estimated within the model. However, there is evidence for non-stationarity in this parameter between years as additional data is added to the time series. In theory, the value of B_0 should stabilize over time as additional information is added. However, no retrospective analysis on the value of B_0 has been presented. **See recommendation 11**.

The efficacy of the current management procedure (F40%/F45%) has not been tested under the highly variable recruitment pattern shown by Pacific hake. **See recommendation 12.**

Conclusions and recommendations

As the 2004 assessment presented at the STAR panel meeting represented an 'update', the model was checked for comparability with the previous year, and comments and requests were restricted to examination of the projection process. Recommendations that would have resulted in alternative model runs during a full review were instead either examined using sensitivity analyses during the meeting, or indicated as areas for future research work.

Overall, the modelling approach, despite the uncertainties, is adequate for the current stock assessment. A number of recommendations are made in the section above, and are summarized here.

Acoustic and trawl surveys

The acoustic survey represents a major area of uncertainty; its ability to survey the entire biomass available is unknown. This reflects the uncertainty over the value of survey *q*. Recommendations are:

Recommendation 1: Develop a prior for acoustic survey *q*, through expert consultation. Consider whether improvements to the survey in more recent years (e.g. increased geographic range) mean that it may more closely survey absolute stock biomass, and hence whether a differential *q* value could be applied to the two time periods (requiring accompanying estimates of CV).

Recommendation 2: As further years of survey information are obtained, consider excluding earlier (less certain) years of survey data before attempting to fit the model.

Recommendation 3: Present CVs with annual acoustic survey results, so that uncertainties can be visualized.

Assessment

The model is complex, requiring the estimation of a high (and increasing) number of variables with each year of additional data. Recommendations for the model are:

Recommendation 4: Re-formulate the model into a format that requires the estimation of considerably fewer parameters. (See also the presentation by Martell and Taylor made during the panel meeting).

Recommendation 5: Examine the performance of simpler assessment approaches (e.g. VPA), which might validate the results of the current approach (or in the worst case contradict the current trends!).

Recommendation 6: Analyse available biological information to examine the variability in M (potentially at age), and both weight-at-age and maturity-at-age (between years and cohorts), in an attempt to improve biological realism.

Recommendation 7: First, however, the potential benefits of incorporating increased biological realism within the model (including the sex-specific model suggested by the 2004 STAR panel) should be assessed using simulation evaluation. This would identify which parameters are the most influential, and hence where modelling effort should be focused, or whether the effort investigating improved modelling of biological inputs is actually worthwhile.

Recommendation 8: Perform a sensitivity analysis to examine the effect of increasing CVs on the samples sizes of the multinomial age compositions in earlier survey years. This would be consistent with the higher CVs used for the biomass estimates in those years, applied to account for the expansion factor. This recommendation requires the estimation of CVs for the multinomial ages.

Projection

The projection format was discussed in detail (being outside the limitations dictated by the ‘expedited stock assessment update’ format). Concerns focused on the length of the projection, given the variability in Pacific hake recruitment, and inconsistencies between parameter settings within the projection. Recommendations are:

Recommendation 9: A 4-5 year projection is more appropriate than the 10-year projection currently mandated. Available information on recent recruitment from the surveys provides some indication of likely abundance levels of the key exploited age groups out to this time.

Recommendation 10: Analyse patterns in weight-at-age to model future patterns better (e.g. examining for evidence for density-dependence in cohorts), as described within the assessment recommendations above. See also recommendation 7 regarding simulation evaluation.

Reference points and management

Recommendations on reference points focussed on B_0, while the overall management procedure was also considered:

Recommendation 11: Perform a retrospective analysis to examine non-stationarity in the value of B_0.

Recommendation 12: Use management procedure simulation/evaluation to examine whether the current harvest policy is robust to the biology of Pacific hake, or whether alternative approaches are more robust to uncertainties in hake biology and the assessment.

Appendix 1. Bibliography

Documents received prior to the meeting

Steven Martell, Nathan Taylor, Thomas Helser, and Guy Fleischer (2005). Estimating selectivity and natural mortality in the statistical catch-at-age model for Pacific hake *Merluccius productus*.

Thomas E. Helser, Guy W. Fleischer, Steve Martell, Nathan Taylor (2005). Stock Assessment of Pacific Hake (Whiting) in U.S. and Canadian Waters in 2004.

Groundfish stock assessment and review process for 2005-2006.

Thomas E. Helser, Richard D. Methot, and Guy W. Fleischer (2004). Stock Assessment of Pacific Hake (Whiting) in U.S. and Canadian Waters in 2003.

STAR Panel Report on the Stock Assessment of Pacific Hake (Whiting) in U.S. and Canadian Waters in 2003.

Thomas E. Helser, Martin W. Dorn, Mark W. Saunders, Christopher D. Wilson, Michael A. Guttormsen, Kenneth Cooke, and Mark E. Wilkins (2002). Stock Assessment of Pacific Whiting in U.S. and Canadian Waters in 2001.

Thomas E. Helser (2002). A rebuilding analysis of the West Coast Pacific Whiting (Hake) stock.

Report of the Joint Canada - USA Review Panel on the Stock Assessment of the Coastal Pacific Hake/Whiting Stock Off the West Coast of North America.

Pacific Whiting assessment update for 2000.

Documents received at the meeting

Thomas E. Helser, Guy W. Fleischer, Steve Martell, Nathan Taylor (2005). Stock Assessment of Pacific Hake (Whiting) in U.S. and Canadian Waters in 2004. Revised version.

Agreement between the Government of Canada and the Government of the United States of America on Pacific Hake/Whiting

Jake Schweigert (2005). Review of Helser et al. (2005) “Stock assessment of Pacific Hake (Whiting) in U.S. and Canadian waters in 2004.

Appendix 2. Statement of work

Consulting Agreement between the University of Miami and Dr. Graham Pilling

January 14, 2005

General

External, independent review of the Pacific hake (Whiting) stock assessment work is an essential part of the STAR panel process and a requirement in the U.S./Canada agreement regarding the offshore hake/whiting resources, although this agreement has not yet been ratified. The stock assessment will provide the basis for the management of the Pacific hake (Whiting) resource off the Pacific coast of Canada and the U.S.

The consultants will participate in the Stock Assessment and Review (STAR) Panel of the Pacific Fishery Management Council (PFMC) for the review of the stock assessment of Pacific hake (Whiting) in U.S. and Canadian waters. The consultants should have expertise in fish population dynamics with emphasis on age-structured statistical catch at age modeling and experience with AD Model Builder. Documents to be provided to the consultants prior to the STAR Panel meeting include:

- Current draft Pacific hake stock assessment report;
- Most recent previous Pacific hake stock assessment;
- An electronic copy of the data, the parameters, and the model used for the assessments (if requested by the reviewers).

Specific

The consultant's duties shall not exceed a maximum total of 14 days: several days prior to the meeting for document review; the three-day meeting; and several days following the meeting to complete the written report. The report is to be based on the consultant's findings, and no consensus report shall be accepted.

The consultant's tasks consist of the following:

1) Become familiar with the draft Pacific hake stock assessment and background materials.
2) Actively participate in the STAR Panel to be held in Seattle, Washington from February 1-3, 2005.
3) Comment on the primary sources of uncertainty in the assessment.
4) Comment on the strengths and weaknesses of current approaches.
5) Recommend alternative model configurations or formulations as appropriate during the STAR Panel.
6) Complete a final report after the completion of the STAR Panel meeting.
7) No later than February 21, 2005, submit a written report consisting of the findings, analysis, and conclusions (see Annex I for further details), addressed to the "University of Miami Independent System for Peer Review," and sent to Dr. David Die, via e-mail to ddie@rsmas.miami.edu, and to Mr. Manoj Shivlani, via e-mail to mshivlani@rsmas.miami.edu.

ANNEX 1: Contents of Panelist Report

1. The report shall be prefaced with an executive summary of findings and/or recommendations.

2. The main body of the report shall consist of a background, description of review activities, summary of findings (including answers to the questions in this statement of work), and conclusions/recommendations.

3. The report shall also include as separate appendices the bibliography of all materials provided by the Center for Independent Experts and a copy of the statement of work.

Appendix 3. STAR panel attendees

Name	Affiliation	Role
Tom Jagielo	SSC, WDFW	Panel chair
Jake Schweigert	DFO	Panel participant
Kevin Piner	SWFSC	Panel participant
Graham Pilling	CEFAS	CIE Reviewer
Jeff Fargo	DFO	Advisor
Rod Moore	GAP	Advisor
Jim Hastie	GMT	Advisor
Tom Helser	NWFSC	Lead author
Guy Fleischer	NWFSC	Co-author
Steve Martell	UBC	Co-author
Nathan Taylor	UBC	Co-author
Brad Pettinger	Oregon trawl commission	Attendee
Jim Colbert	Oregon State university	Attendee
Vera Agostini	University of Washington	Attendee
Ian Stewart	University of Washington	Attendee
Vidar Wespestad	Pacific Whiting Conservation Cooperative	Attendee
Rick Dunn	Hake consortium of BC	Attendee
Steve Joner	Makah tribe	Attendee
Mike Buston	Leader fishing	Attendee
Stacey Miller	NWFSC, stock assessment coordinator	Attendee
Elizabeth Clarke	NWFSC	Attendee
Dan Waldeck	Pacific whiting Conservation Cooperative	Attendee
Bruce Turris	CGRCS	Attendee
Joe Bersch	SAS	Attendee
Bill Clinghan	Ocean gold	Attendee
Barry Ackerman	DFO	Attendee
Carrie Nordeen	NMFS/NWR	Attendee
Mark Saelens	ODFW/GMT	Attendee

The Centre for Environment, Fisheries & Aquaculture Science
Lowestoft Laboratory, Pakefield Road,
Lowestoft, Suffolk NR33 0HT UK
Tel: +44 (0) 1502 562244
Fax: +44 (0) 1502 513865
www.cefas.co.uk