Agenda Item F.4.a
Attachment 3
March 2006

Report

of the

Joint Canadian and U.S. Pacific Hake/Whiting Stock Assessment Review Panel

conducted on
February 6-9, 2006

Northwest Fisheries Science Center
2725 Montlake Blvd. East, Seattle Washington

Overview

On February 6th - 9th a joint Canada-US Pacific Hake/Whiting STAR Panel met in Seattle, Washington to review the stock assessment by Helser et al. (2006). The Panel operated according to the Terms of Reference for STAR Panels (SSC 2004), but as in 2005, the Panel attempted to adhere to the spirit of the Treaty on Pacific Hake/Whiting. As was the case in 2004 and 2005, both a Panel member and Advisor from Canada participated in the review (see List of Attendees). The revised stock assessment and the STAR Panel review will be forwarded to the Pacific Fishery Management Council, council advisory groups, and to Canadian DFO managers and the PSARC Groundfish Sub-committee.

The STAT Team was represented at the meeting by Thomas Helser, Guy Fleischer, Ian Stewart, and Steve Martell. Public comment was entertained during the meeting. The STAR Panel members received a draft of the assessment over two weeks prior to the meeting, which was sufficient time to adequately review the assessment. The meeting commenced on February 6th, 2006 with introductions followed by a review of the 2005 acoustic survey by Guy Fleischer. After the acoustic survey presentation, Tom Helser began a detailed description of the stock assessment. He noted that the new assessment was conducted in Stock Synthesis II version 1.21 (SS2) (Methot 2005), and explained how this modeling environment afforded improvements over the previous ADMB Pacific hake model. A presentation of the input data and modeling results from the 2006 assessment followed. Steve Martell gave a presentation on time varying and cohort based growth of Pacific hake. He explained why time varying k was used in the SS2 modeling. On the second day of the meeting, Tom Helser concluded his presentation of the assessment results. Panel discussion continued until the meeting was adjourned on February 9th. The Panel recognized and appreciated the contributions of the STAT team.

The Panel recommended acceptance of two equally plausible models to represent the uncertainty in the relative depletion level and productivity of the stock, one in which q was fixed at 1 and the other in which q was estimated with an informative prior (mean of 1 and a standard deviation equivalent to 0.1).

The STAT Team conducted a retrospective that sequentially removed the most recent years data back to 2000 in the q=1 model. The most prominent divergence from the general trend was the downward trend of the model that used data only to the year 2000, which failed to capture the upturn in stock biomass associated with the 1999 year class. This analysis revealed no obvious model pathologies.

The STAT Team proposed and is intending to construct a post-STAR Panel review Bayesian model run that would be integrated over the range of q implied by the prior distribution. The STAR Panel acknowledges the value of this approach, but due to the time constraints associated with producing these results, the STAR panel did not have the opportunity to review this work.

The Panel concurred that the assessment is suitable for use by the Council and Council advisory bodies for ABC and OY projections.

The STAR Panel commends the STAT team for the quality of the document provided for review and their cooperation in performing additional analyses requested during the meeting (see list of new analyses requested by the STAR Panel, below).

Summary of stock assessment and Panel discussion

The assessment highlights focused on the migration of the 2005 hake assessment model (programmed in ADMB, Helser et al. 2005) into SS2 (Version 1.21). The overarching objective focused on bringing the model to the data (in other words, keeping the data in it's most pure, elemental form), explicitly estimating growth dynamics, and achieving parsimony in terms of model complexity. For example, selectivity was previously modeled as a random walk process (to characterize removals as best as possible), and previous review panels thought this may have led to over-parameterization.

. The dynamic growth model has reduced the need for this approach. The STAT Team recognized that future directions for research and modeling include incorporating migration into the model, evaluating the increased use of covariates, modeling different sectors of the hake fishery in the U.S. and Canada independently, and further evaluating cohort-specific growth.

There was some discussion regarding interesting occurrences in both age and length composition data and in growth rates. For example, Canadian length composition data suggest a strong 1994 year class (observed as age 1 fish in 1995, age 2 fish in 1996, with apparently rapid growth rates), not observed in any other data. The possibility has been discussed that these fish may have been spawned in the north and never migrated south. Similarly, there is a lack of fit in 2001 and 2002 that may be due to a limited migration of the main stock and changes in the spatial distribution of fishing effort.

Other issues related to the acoustic survey were discussed, such as the varying spatial coverage (both latitudinal and across depth), and the use or removal of the 1986 data point, without which, the survey is essentially flat. The relative flatness of the acoustic time series is difficult to reconcile with the age and length composition data. In general, the fit to the age composition data dominate the objective function. The possibility of disregarding the pre-1992 data altogether has also been discussed, as acoustic technology has changed substantially since this period, and raw data for early years are difficult to reconstruct and reanalyze.

List of New Analyses Requested by the STAR Panel

The following list describes each request made of the STAT team, followed by the reason for the request and outcomes of the analysis:

1) Use the biomass at age and the survey selectivity curve to assess what proportion of the spawning biomass is less vulnerable with respect to the acoustic survey. Rationale: there are concerns regarding the inability of the survey to “see” the entire biomass.

Response: The STAT Team presented a graph of both the absolute and relative proportions of SSB that is not observed by the survey due to estimated selectivity. The fraction of this biomass was on the order of 15% throughout the early part of the time series, increased to as much as 30% during the mid- and late 1990s when the 1980 and the 1984 cohorts moved into older age classes. Over recent years, the fraction of biomass not seen by the survey has fallen to 5 to 10%, as the population is composed primarily of younger fish. This suggests that the current SSB is reflecting fish that are being seen in the survey. The Panel suggested that a figure such as the one produced by the STAT Team should be included in the final assessment document.

2) Run the model using asymptotic selectivity for the acoustic survey, both with age of full selectivity free and with a prior on the ascending slope of the selectivity curve that would approximate full selectivity at age 5. Rationale is same as above.

Response: The STAT Team reported that there was a degradation of fit to the age composition data by assuming asymptotic selectivity to the acoustic survey. Although the trend in depletion is comparable with the STAT base model (depletion is slightly greater, such that the 2006 biomass is below $B_{25\%}$), there is a generally downward scaling of the total stock biomass over time. The SSB time series with the age of full selectivity moved forward to age 5, there was little change relative to the base model result.

3) Explore the results when pre-1992 acoustic survey data points (both biomass and age/size comps) are removed from the model. Rationale: The higher CVs used in the early acoustic survey data lead the Panel to question what impact those data are having in the model. Similarly, the observation that full selectivity is not reached until age 9, whereas 9 year old fish rarely comprise a major fraction of the catch at age, lead to questions regarding the true shape of the acoustic survey selectivity curve.

Response: The resulting model shows a shift in the selectivity of acoustic survey towards older age classes, the relative size of the 1999 year class is increased, and the 2006 SSB is estimated to be at approximately target levels (B_{40}): very little else changes in the model.

4) Down-weight the input sample sizes to the 2001-2002 Canadian age-composition data (as well as conditional length at age) to assess what the impact is to the model. Rationale: This will allow the STAT and STAR to evaluate what the consequences of these patterns may be to the model (particularly the strength of the 1999 year class).

Response: The input sample sizes were set to 1 for these years, and the selectivity block for 2001-2002 was merged with that for 2003-2005. The bottom line was that there is very little overall change, the model comes up with the same expected values for those years, but they are no longer contributing to the objective function.

5) Following up on request #2 to use asymptotic selectivity for acoustic survey, repeat this run, but (1) allow q to be estimated in one of the asymptotic selectivity runs, (2) allow M to be estimated with a uninformative prior, if feasible.

Response: The resulting objective function was degraded from the base model (dome-shaped selectivity), the estimated value for M was 0.33, and the ending biomass is approximately $B_{25\%}$. Essentially, the model predicts fewer older fish, and forces fishery selectivity curves into unusual configurations. In this run, the STAT Team used a very uninformative prior on M, with a standard deviation of 0.8. When estimated, q fell to unrealistically low values, indicating some sort of informative prior was necessary to fit it.

6. With respect to the catchability coefficient (q), run the model with an informative prior on q (mean of 1 and a standard deviation of 0.1), both with the entire acoustic biomass time series as well as without the pre-1992 data. Rationale: Fixing q at 1 underestimates the true uncertainty in the model.

Response: The STAT Team noted that q in the model is estimated in log space, so the prior had a mean of 0 with a standard deviation of 0.112, which provides an equivalent probability density to the request. The result of the first run gave an estimated q of 0.69, consistent with the general tendency of this model to estimate a lower q. The greatest change was in global scaling upward in total biomass, a slightly greater upswing relative to the 1999 year class, and slightly lower depletion level (close to 0.4) in 2006. The question was raised as to whether there would be significant changes to the confidence intervals in the forecasts, the STAT Team opined that any resulting changes would be modest. The catch forecasts from this model were on the order of 1 million tons (942,000) in 2006, dropping to 587,000 in 2007; nearly double those of the base model.

With the pre-1992 data excluded, q ends up at about 0.76 rather than 0.69, the trend is similar throughout the beginning of the time series, but towards the end of the time series the size of the 1999 year class is substantially increased (to the second-largest in the time series, after 1980), and depletion is less (on the order of 0.5). This implies that q was lower in the early survey years. In general, the STAT Team thinks that by leaving the entire time series in the model, being forthcoming about the additional uncertainty in the early part of the time series, the model may provide a more appropriate reflection of the survey index over time. The overall improvement in fit was extremely small, suggesting that there is little information in the data to inform an estimate of q.

7. Run the model with a steepness value (h) of 0.75. Rationale: There is some resistance to the idea that recruitment is entirely independent of SSB. In a meta-analysis of steepness values for thirteen assessed Merluciid stocks, Dorn (1999) had earlier estimated a posterior mode of approximately 0.6, with a wide posterior distribution that was indicative of a great deal of uncertainty. The STAR Panel suggests that a reasonable expectation for steepness might be 0.75, based on theoretical considerations as well as Myers et al. 2002.

The resulting biomass and relative depletion trends were nearly identical to the base model, as the observed recruitments have been driven by age data. However the forecasts are considerably less optimistic as there is an element of density dependence in future mean recruitment. Catch projections for 2006 were nearly identical, but projections for future catches declined somewhat more rapidly than the base model. The objective function reflected an extremely small change in overall fit. There was general agreement expressed by both the STAT and the STAR Panel that the lower steepness value may represent a more realistic expectation for h.

8. Provide the relative contributions to changes in likelihood in the model runs in request # 2 (asymptotic versus dome-shaped selectivity, and a freely estimated M). Rationale: the Panel was interested in what factors actually contributed to the relative changes in likelihood.

Response: Where there were changes in likelihood components, the greatest changes were observed in fits to age composition data, which comprised the largest part of the overall likelihood. By forcing asymptotic selectivity, there was a slight improvement in fit to the Canadian age composition data, but degradation in fit to the U.S. fishery and acoustic survey data. Perhaps the Canadian fishery should be modeled with asymptotic selectivity in future assessments.

9. Evaluate the relative proportion of older hake in the triennial versus the acoustic survey over time. Rationale: There are questions lingering regarding where the older fish (i.e. those not seen in the acoustic survey) might be. If feasible, explore doing this with the Canadian catch-at-age data as well.

Response: A cursory attempt was made using acoustic and bottom trawl survey age composition data to evaluate whether there was empirical evidence for dome-shaped selectivity. The analysis conducted by the STAT team during the meeting provided preliminary evidence in support of dome-shaped selectivity. However, a more through analysis is needed to adequately address this issue.

10. Provide graphs of the time series from beginning of the modeled time period to 2009 that includes catch, spawning biomass, depletion, and exploitation rate (relative to vulnerable biomass). Present the time series to 2005 and the forecasts with a different set of symbols. Do these for the STAT base model with steepness set at 0.75.

Response: The STAT Team provided a graphic of the proportion of the ABC that the OY would represent in the forecasts (presented as Figure 1, below), such that in 2006 the OY would be close to 90% of the ABC, and in 2009 the OY would be roughly 55% of the ABC. The forecasts were then shown plotted with the historical trajectories, which showed that the SSB would decline to the lowest level of the time series by 2009. Depletion would fall below 25% in 2007 and drop to ~20% in 2008. The OY in 2006 would be well above any historical catch, and the exploitation rate would be significantly greater than any historical rate. Both catch and exploitation rate would drop from 2007 to 2009, while SSB and depletion would remain relatively constant.

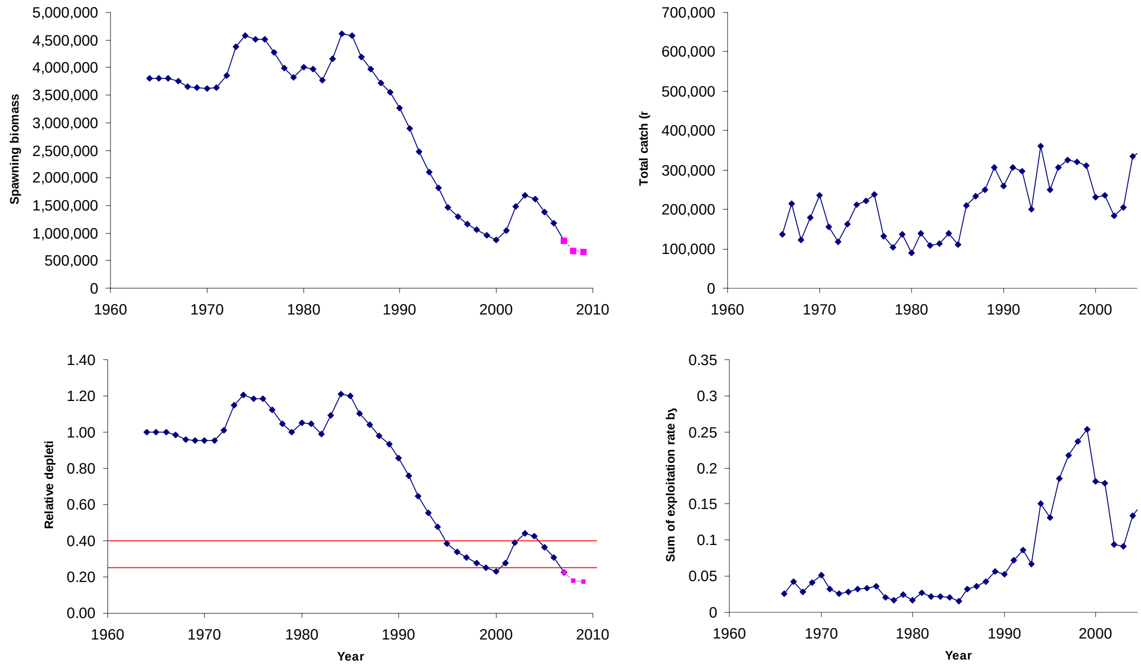

Figure 1: Graphs of the time series from beginning of the modeled time period to 2009 that includes catch, spawning biomass, depletion, and exploitation rate (relative to vulnerable biomass).

11) The STAR Panel requests that the base model be run with steepness fixed at 0.75 and acoustic survey catchability (q) estimated with a mean of 1 and a standard deviation of 0.1 in the equivalent log domain. Rationale: The STAR Panel would like to evaluate the STAT base model with steepness fixed at 0.75, with q estimated.

Response: The absolute scale of spawning biomass shows a relatively modest difference in total spawning biomass, with the q estimated scenario scaling the biomass upwards by nearly 1 million tons in the early part of the time series. From the perspective of relative depletion, trends are nearly identical until the year 2001, where there is a greater difference in the relative strength of the 1999 year class, such that depletion is greater (~0.31) with the q=1 scenario than the q estimated scenario (~0.37).

12) The STAR would like to see projections of the base model with a range of catches (0 to 400,000 tons in 100,000 ton increments) to evaluate the relative impact of harvest on the biomass trajectory. Rationale: Given that the strict application of the 40:10 harvest rule in this run will result in stock biomass falling below the 25% depletion level,

the STAR Panel would like to explore the relative impact of fishing on future stock biomass.

Response: With catch set at 0 in 2006 onward, the biomass continues to decline, albeit modestly, until 2009 when it increases slightly (Results shown as Figure 2a). Only this scenario, and that in which the catch equals 100,000 mt show the biomass remaining above $B_{25\%}$ through 2009. The scenarios in which the annual catch was fixed at 200,000 to 400,000 mt show increasing declines through 2009 (the former only modestly, the latter substantially). It was agreed that this graph was informative, and the STAT and STAR agreed that this result should be included in the final assessment document. There was agreement that it would be beneficial to produce this graph, and the accompanying tables of SSB and depletion, for any of the alternative states of nature included in the decision table.

13) The STAR Panel would like to see the same graphic as in request #12 with the q estimated scenario (as in request #11). Rationale: Same as request # 12.

Response: Provided as Figure 2b (below). In this scenario, only catch streams of 400,000 tons or greater drive the stock below the $B_{25\%}$ threshold (and this only in later years).

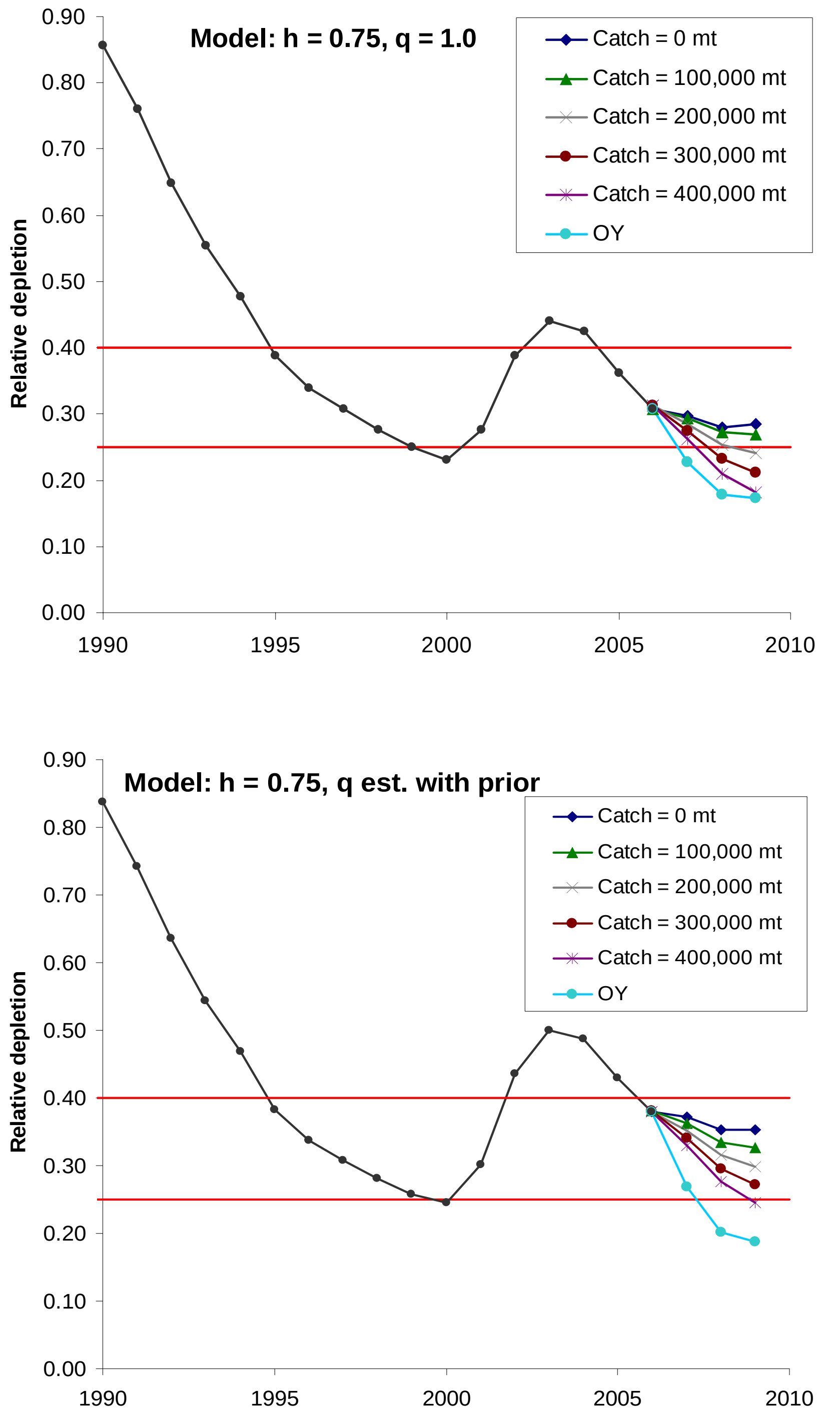

Figure 2a and 2b. Projections of the two base models (q fixed at 1, top; q estimated with an informative prior, bottom) with a range of catches (0 to 400,000 tons in 100,000 ton increments) to evaluate the relative impact of harvest on the biomass trajectory.

14) The STAR Panel would like to see a draft decision table, based on the two scenarios presented as preliminary base and alternative models in request # 11 (the STAT base model with steepness fixed at 0.75 and acoustic survey catchability (q) estimated with an informative prior with mean of 1 and a standard deviation of 0.1 in the equivalent log domain). Rationale: The STAR Panel considers these two models to be the two most important alternative states of nature for the final document. The decision table will include the following management actions: OY from model 1, OY from model 2, and 200,000 and 400,000 mt total coast-wide catch for 2006-2008.

The STAT Team produced a decision table as requested (Table 1, below). In all of the resulting scenarios, the biomass trended downward over time, in nearly all of the scenarios the stock was projected to be depleted (below $B_{25\%}$) by 2009. Assuming the more optimistic state of nature (q estimated), when the true state of nature was q=1 resulted in substantial depletion by 2009, although this scenario was associated with what might be considered an unrealistic catch in 2006 (880,000 mt).

In the scenario in which both the assumed and the true state of nature was q=1, depletion was 0.31 in 2006, 0.23 in 2007, and 0.14 in 2008. In the scenario in which both the assumed and the true state of nature was the q as estimated, depletion was 0.38 in 2006, 0.27 in 2007, and 0.20 in 2008.

Table 1: Decision Table for the 2006 Pacific hake assessment

			State of nature	
Relative probability			**50%**	**50%**
Model			**1**	**2**
Details			h = 0.75, q = 1.0	h = 0.75, q est. with prior
Management action				
	Catch (mt)	Year	Relative depletion	Relative depletion
OY Model 1	593,746	2006	0.308	0.380
	358,416	2007	0.227	0.310
	213,223	2008	0.178	0.263
	183,620	2009	0.172	0.254
OY Model 2	883,490	2006	0.308	0.380
	522,511	2007	0.202	0.268
	302,298	2008	0.144	0.202
	240,702	2009	0.136	0.188
Catch = 200,000 mt	200,000	2006	0.308	0.380
(coastwide)	200,000	2007	0.282	0.351
	200,000	2008	0.250	0.315
	200,000	2009	0.239	0.299
Catch = 400,000 mt	400,000	2006	0.308	0.380
(coastwide)	400,000	2007	0.258	0.330
	400,000	2008	0.207	0.276
	400,000	2009	0.178	0.245

Technical merits and deficiencies

There was considerable discussion of the merits of using time varying growth and cohort-based fits of the growth curves, as SS2 can allow any of the growth parameters to vary over time. The STAT Team experimented with fitting three different growth models using survey data (assuming constant size selectivity), noting that fish of a given age were almost 40% smaller (in mass) in the mid-1980s relative to recent years. Time varying growth in the base model was implemented using differences in both L_{max} and K in pre- and post- 1980 blocks. The STAR Panel requested that supporting documentation of the time-varying growth analysis be included in the final stock assessment document.

Areas of Major Uncertainty

All model runs provided by the STAT Team showed similar results with respect to depletion trends. With respect to absolute abundance, the run with asymptotic acoustic selectivity provides a substantially lower SSB estimate over time (with greater depletion and exploitation rates), and the runs with lower (estimated) q has a higher scaled total biomass. The model with steepness fixed at 0.75 diverges very little from the base, with the greatest differences arising in longer term forecasts. With the exception of the poorer fits in the asymptotic acoustic selectivity run, the most striking observation was the wide range of estimated optimum yields, with very little changes in the total likelihood value. The biomass trend is robust, what is observed is a scaling issue of the total biomass over time. Most of the harvest rates estimated in these models indicate that these rates would be among the highest ever observed for all model formulations.

The acoustic survey q continues to be a major source of uncertainty in the stock assessment. Future work is needed to help resolve the *q* issue (see Research Recommendations). Past STAR Panels bounded uncertainty with q=0.6 and q=1.0. This Panel decided to represent uncertainty over the states of nature by the model with q fixed at 1, and the model with q estimated (but a prior placed on 1, with a standard deviation equivalent to 0.1). Although the approach differed from past panels, the end result with respect to the two scenarios was consistent, reflecting the model's tendency to estimate lower q values and scale the total biomass and trend accordingly. The Panel and STAT team concluded that sufficient information was not available at the meeting to determine *q* more precisely.

The Southwest Fisheries Science Center Santa Cruz Lab juvenile survey was used to provide a recruitment index for Pacific hake from 1986 to 2005, and the index was used to inform the 2004 and 2005 recruitment levels for projections. The results of a similar survey conducted jointly by the Northwest Fisheries Science Center (NWFSC) and the Pacific Whiting Conservation Cooperative (PWCC), which covers a larger geographic area, were presented to the STAR Panel but were not used in this assessment. It was noted that the two surveys had conflicting results in 2003, but were in agreement that the 2004 year class was likely above average. Due to the high CV's associated with the index, the model essentially disregards the index in the presence of informative age or length information. Specifically the presence of large number of age-2 fish in the 2005 survey has led the model to estimate close to average recruitment in 2003, which is the lowest data point in the survey index. Plans are underway to have a workshop related to application of the juvenile indices, which should focus on addressing many of the issues related to the use of these data.

For Pacific hake, with its particularly high recruitment variability, it would be advisable to utilize projections with time horizons shorter than 10 years. A reasonable projection time frame would be 3-4 years. In this assessment, 2009 (a four year projection) was the last year in which biomass projections were not substantially affected by the model assumption of recruitment based on the spawner recruit curve.

Areas of Disagreement

There were no substantial areas of disagreement between the STAT team and the STAR Panel.

Research Recommendations

The Panel considered the topic of research recommendations in two parts: 1) review of the status of old recommendations (made by the 2005 STAR Panel) and 2) development of new recommendations. The Panel prioritized each of the old recommendations as "S" (short term; to be addressed in the 2007 assessment), "M" (medium term; to be addressed by the 2008 assessment), and "L" (long term; to be addressed by the 2009 assessment and beyond).

Review of Old Recommendations

1. Continue to compare spatial distributions of hake across all years and between bottom trawl and acoustic surveys to estimate changes in catchability/availability across years. The two primary issues are related to the changing spatial distribution of the survey as well as the environmental factors that may be responsible for changes in the spatial distribution of hake. This issue is also important with respect to the acoustic survey selectivity curve, and with respect to the potential inclusion of environmental covariates in selectivity. **(M-in progress).**

2. Initiate analysis of the acoustic survey data to determine variance estimates for application in the assessment model. The analysis would provide a first cut to define the appropriate CV for the weighting of the acoustic data **(M to L-in progress)**

3. Continue to analyze proportions at age for the acoustic survey, as well as with the bottom trawl survey and commercial fisheries, to further evaluate the evidence for dome-shaped selectivity. Evaluate the changes in growth on selectivity. **(S- in progress)**

4. Continue to evaluate the current target strength for possible biases, and explore

alternative methods for estimating target strength. **(S- in progress)**

5. Develop an informed prior for the acoustic *q*. This could be done either with empirical experiments (particularly in off-years for the survey) or in a workshop format with technical experts. There is also the potential to explore putting the target strength estimation in the model directly. This prior should be used in the model when estimating the q parameter. **(M)**

6. Investigate covariates that may influence fishery selectivity **(L)**

7. Hold a workshop (currently in early planning stages) that focuses on evaluating the methodology and utility of the two ongoing juvenile surveys. Issues to be considered include investigating how the surveys are conducted and how the resulting indices are brought into assessment models. **(S)**

8. As a diagnostic exercise, conduct a VPA (Virtual Population Analysis) of the existing data. **(M).**

9. Address the inconsistencies in age reading, attempt to standardize the criteria and methods between the two labs, preferably thorough the Committee of Age Reading Experts (CARE). **(S)**

New Recommendations

10 Review the acoustic data to assess whether there are spatial trends in the acoustic survey indices that are not being captured by the model. The analysis should include investigation of the migration (expansion/contraction) of the stock in relation to variation in environmental factors. This would account for potential lack of availability of older animals and how it affects the selectivity function. **(M)**

11. Consider localized depletion experiments to estimate trawl and acoustic survey catchability coefficients (q's) and selectivity. Begin this process with consideration of experimental procedures and design, including smaller-scale trial experiments **(M)**

12. Evaluate harvest strategies and stock-size thresholds, through simulation studies or other means, that may better account for the variability and dynamics of the hake resource. This should include management strategies based on trend data, rather than absolute abundance estimates, similar to the current approach for managing Pacific cod in Canada. **(L)**

13. Consider the carrying capacity of the California Current to Pacific hake from an ecosystem perspective. For example, use existing information on the relative abundance and productivity of hake prey, from available data and/or ecosystem models (Ecopath, Atlantis), to consider plausible bounds on the total hake biomass in the California Current **(L)**

14. Investigate aspects of the life history characteristics for Pacific hake and their possible effects on the interrelationship of growth rates and maturity at age. This should include additional data collection of maturity states and fecundity, as current information is limited **(L)**

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Marion Larkin GAP Advisor
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