Report

of the

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

Silver Cloud Inn – University District
Seattle, Washington

5-9 February 2007

Overview

During 5-9 February 2007, a joint Canada-U.S. Pacific Hake/Whiting Stock Assessment Review (STAR) Panel met in Seattle, Washington, to review the stock assessment by Helser and Martell (2007). The Panel operated under the U.S. Pacific Fishery Management Council's Terms of Reference for STAR Panels (SSC 2006), but as in previous years, the Panel attempted to adhere to the spirit of the Canada-U.S. Treaty on Pacific Hake/Whiting. As was the case in 2004, 2005, and 2006, both a Panel member and Advisor from Canada participated in the review (see *List of Participants*). 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.

Both members of the stock assessment team (STAT) – Drs. Thomas Helser and Steve Martell – attended and actively participated in the meeting. Public comment was entertained throughout the week. A local area network and file server were set up in the meeting room to facilitate sharing the presentations, model results, and various parts of the Panel's draft report. The STAR Panel members received a draft of the assessment two weeks prior to the meeting, which was sufficient time to adequately review the assessment.

The Panel convened at 13:00 on February 5th. Jim Hastie (NWFSC) welcomed the group. Ray Conser (STAR Panel Chair) then opened the meeting with an overview of the review process including the terms of reference, Panel membership, expected products, and a timeline for completion of the Panel's report. Rapporteurs were assigned for each section of the Panel report. Tom Helser then provided a detailed description of the stock assessment including an overview of the acoustic survey work and Steve Martell presented preliminary research on a simplified stock assessment model for hake (Helser and Martell 2007 – Appendix 2). Jim Hastie summarized the results and conclusions of the "Pre-Recruit Survey Workshop" held in September 2006 (Ralston and Hastie 2006). Steve Martell also presented a paper evaluating the utility and cost effectiveness of pre-recruit surveys. Barry Ackerman and Jeff Fargo provided an overview of the Canadian hake fisheries in 2006 and Dan Waldeck and Mark Saelens provided a similar review of the 2006 U.S. fisheries.

Based on discussion of the stock assessment document and related presentations, the Panel requested nine additional model runs to help clarify the base cases and the full range of uncertainty in the stock assessment. This iterative process of making additional model runs and discussing the results continued through the end of the day on February 8th. The Panel spent the morning of February 9th reviewing a first draft of its report. The meeting was adjourned at 12:00 on February 9th. The Panel Chair agreed to produce a second draft of the Panel report and distribute it by email to all Panel participants. The final Panel report was completed on February 16th – the deadline for material to be included in the PFMC's "briefing book" for its March meeting.

The Panel recommended acceptance of two equally plausible SS2 models (conditioned on differing catchability assumptions for the acoustic survey) to reflect stock status and to quantify the uncertainty in the relative depletion level and productivity of the stock[1]. In Model 1, survey q was fixed at 1.0; while in Model 2, survey q was estimated using a highly informative prior (mean of 1.0 and a standard deviation equivalent to 0.1). The estimated 2007 spawning stock biomass (SSB) is either near the mid-point (Model 1) or near the maximum (Model 2) of the precautionary range ($0.25 \cdot SSB_0 – 0.40 \cdot SSB_0$). However, projections indicate that if the annual allowable biological catches (ABC) are taken, the SSB will fall below the overfished threshold ($0.25 \cdot SSB_0$) in either 2008 (Model 1) or 2009 (Model 2). The current fishing mortality (2006) rate is less than the F_{MSY}-proxy ($F_{40\%}$) for both models. Since 1999, managers have set the annual allowed harvest below the ABC. Continuation of this practice could delay a fall below the overfished threshold until 2009 (Model 1) or 2010 (Model 2) – see Table 1.

The Panel concurred that the stock assessment is suitable for use by the Council and Council advisory bodies for ABC and optimal yield (OY) determination, and for stock projections.

The status of the hake stock – as well as the quantification of uncertainty – is not greatly different than that indicated in the last stock assessment (Helser et al. 2006). However, the Panel considered several potentially important sources of uncertainty in the SS2 modelling that if fully explored in the context of the next assessment, may lead to different conclusions. In particular, the Panel found that the currently-configured SS2 model for hake tends to overestimate SSB_0 – the critical level needed for depletion estimation and the determination of an overfished state. When coupled with the observation that SSB has been in decline since 2003 while ABC has increased substantially over the same period (both models), there may be cause for concern if managers elect to take the full ABC.

The STAR Panel commends the STAT for the quality of the document provided for review and their cooperation in performing additional analyses requested during the meeting.

Summary of stock assessment and Panel discussion

The 2007 assessment was conducted using the Stock Synthesis II (SS2) model, Version 1.23E, and was the first hake assessment conducted after the migration to this model, which was accomplished in 2006. U.S. and Canadian fishery data were updated through the end of 2006 and a new coast-wide pre-recruit survey (PWCC/NMFS-SWFSC Santa Cruz survey) was used as an index of recruitment in SS2, following the findings of the pre-recruit survey workshop in September 2006 (Ralston and Hastie 2006). Comparison of the 2006 assessment with the 2007 assessment (with the only difference being the

[1] In the Helser and Martell (2007) stock assessment document, the two models are called “base model” and “alternative model.” Since the models are considered equally likely by the STAT and the STAR Panel, the Panel prefers the nomenclature “Model 1” and “Model 2,” respectively. The latter naming convention is used throughout the STAR Panel report.

updated fishery data) showed that trends in Age-0 recruitment, age 3+ biomass, and depletion in 2007 did not differ substantially from trends estimated in 2006. Use of the new recruitment index did not alter trends in these parameters relative to trends produced using the Santa Cruz index only.

STAT provided a detailed review of the data used in the assessment (fishery, hydroacoustic survey, and biological), the SS2 model structure and assumptions, model results and diagnostic tests, and preliminary assessment of hake stock status and future prognosis. There was some discussion about the sensitivity of a forward projecting model such as SS2 to initial conditions, particularly the value of B_0, the virgin unexploited biomass, which is assumed to be 1966 for hake. There are no records of catches prior to 1967 in U.S. waters and although there may have been harvesting activities in Canadian waters, the records of these landings are not readily available at present. Based on the review of the fishery data, it is clear that both the at-sea and shore-based fisheries in the U.S. and Canada were primarily harvesting fish from the 1999 year-class. The STAT recognized that future directions for research and modelling include incorporating migration into the model, evaluating the use of environmental covariates, modelling 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 features 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 working hypothesis is that these fish may have been spawned in the north and never migrated south. The lack of fit in 2001 and 2002 may be due to a limited migration of the main stock and changes in the spatial distribution of fishing effort. Based on the 2005 acoustic survey length composition data a moderately strong 2003 year-class was moving into the fishery, whereas the fishery data are consistent with a moderately strong 2004 year-class.

Discussion of the SS2 model assumptions and structure focused on the appropriateness of fixing $h = 0.75$ (steepness of the stock-recruit relationship) and the use of dome-shaped fishery and acoustic survey selectivity curves. The steepness (h) parameter is difficult to estimate directly because it is confounded with other parameters estimated at the same time, notably R_0. The original formulation of the Beverton-Holt stock recruitment relationship has better numerical stability and may be a better parameterization to use within the SS2 model.

Discussion of the acoustic survey time series focused on potential biases and differences in trends inferred from the fishery data. The model was run using survey data from all years except 1986, which was omitted because of transducer calibration issues. Given the assumed CVs for the survey, omitting the 1986 data point results in a long-term survey index that is essentially flat (1977-2005). This flatness conflicts with the SS2 trend of sharply declining biomass over the 1988-97 period, which is largely driven by the age-composition data – a less than idea situation for stock assessment.

The possibility of disregarding the pre-1992 data altogether was also discussed, as acoustic technology has changed substantially since this period, and the raw data for early years are difficult to reconstruct and reanalyze. Prior to 1992 acoustic surveys did not go sufficiently far north in Canadian waters to ensure that the entire distribution of hake was covered and the acoustic data from this period are potentially biased as a result of signal saturation when high hake densities were observed. The Simrad EK-500 system, which is more stable in performance and less subject to signal saturation, has been used by both countries beginning with the 1992 survey. The U.S. upgraded to the Simrad EK-60 system for the 2005 survey and Canada will upgrade to this system when its new research vessel is delivered (~2011).

A brief synopsis of a pre-recruit survey workshop held in September 2006 at the SWFSC, Santa Cruz, was provided by Jim Hastie (see also Ralston and Hastie 2006). The focus of this workshop was on integrating the older SWFSC Santa Cruz juvenile rockfish survey with the newer PWCC/NMFS young-of-the-year Pacific whiting/hake survey. The SWFSC survey was initiated in 1983 and the newer PWCC/NMFS survey in 2001. Since 2001 substantial work has gone into standardizing the gear, tow durations, and design of these surveys. Spatial coverage of these surveys has gradually expanded south and north during the 2001-2006 period. Workshop participants suggested that for species found north of Point Conception (including Pacific hake), data from the SWFSC and PWCC/NMFS survey combined during the 2001-2006 period may provide acceptable spatial coverage for a coast-wide index of recruitment abundance and that the methods and catch rate patterns of the SWFSC and PWCC/NMFS surveys are sufficiently similar to permit combining the data to form a single pre-recruit index. However, the spatial coverage of the SWFSC survey during the 1983-2000 period was inadequate for indexing pre-recruit abundance for most species, especially for coast-wide assessment areas. Workshop participants also agreed that substantial density-dependent mortality can occur following the measurement of pre-recruit abundance and if this mortality did occur, then it would result in non-linearities in the relationship between the index and recruitment.

A modelling exercise looking at the impact of juvenile surveys on assessment model performance and management performance was discussed by Steve Martell. Four scenarios (1-Juvenile index used in fitting, forecast based on mean R from previous 5 years; 2-Forecast based on mean S-R relationship; 3-Forecast based solely on juvenile survey; and 4-Forecast based on weighted average of S-R and juvenile surveys) were assessed. Regardless of the scenario chosen, there was little impact on stock assessment performance, but clear impacts on management performance. Improvements in forecasting could potentially enhance fisheries yields or reduce implementation error. Juvenile surveys do little to improve estimates of reference points. This introduces a trade-off: Invest more resources in juvenile surveys or surveys that provide better estimates of B_0 and recruitment compensation (steepness). Based on the results of this exercise and subsequent discussion, more investment in increasing the precision of the juvenile surveys is warranted, but it may be extremely costly to reduce survey CVs so that they are less than the CV in recruitment deviations. Furthermore, this cost may exceed the value of the additional gains.

Steve Martell also introduced a simplified age-structured model designed to provide another view of Pacific hake dynamics and status of the stock (from that provided using SS2). The appeal of the model (described in Appendix 2 of the stock assessment document) lies in its ability to include all available hake data sources; the principal dynamics of the fisheries and the survey; and time-varying biology, (e.g. changes in growth), yet the model appears to run several orders of magnitude more quickly than SS2. This makes extensive sensitivity analysis feasible, provides better insight into the dominant axes of uncertainty, and allows for practical management strategy evaluation. The simplified model was used to explore alternative model structure and assumptions which differed from those used in the Model 1 and Model 2 SS2 runs. For example, in one run of the simplified the parameters q, B_0, h, and M were all estimated and the selectivities for all fisheries and the survey were taken to be flat-topped.

The simplified model runs – carried out before and during the Panel meeting – suggested large uncertainty in the estimate of B_0, and that B_0 may be smaller than that estimated by SS2 Model 1 and Model 2 runs. However, the MSY and ABC posterior densities suggested estimates similar to those from SS2. The Panel recognized that there was value in using this simplified age-structured model to investigate some of the complexities of SS2 behavior. But the Panel also recognized that SS2 has been peer reviewed and used widely for Pacific groundfish assessments in the U.S. while Martell's simplified model is still under development and has yet to have been peer reviewed – although similar models have used in other assessment/management settings. As such, it would be premature to use the simplified model's results as the basis of management recommendations. Nonetheless, there appears to be great promise in this approach.

The Panel and the STAT briefly discussed two sources of data that were not used in the stock assessment modelling, namely (1) NMFS Triennial Bottom Trawl Survey and (2) the CalCOFI Ichthyoplankton Survey. Both have potentially useful information on hake abundance but also have shortcomings and/or limitations that may diminish their utility. The Panel did not have an opinion on pursuing these data sources but for completeness, asked the STAT to briefly describe them in the revised assessment document and provide the rationale for not using them in the assessment.

List of New Analyses Requested by the STAR Panel

The following list describes each request made of the STAT team, the rationale for the request, and outcome of the analysis:

1. The scaling factor, q, should be estimable from the acoustic survey biomass time-series, but this has proven difficult to do in the past, resulting in a previous Panel's request to conduct two model runs (one with q = 1.0 and the other with q estimated with an informative prior) representing alternate states of nature. The 2007 STAR Panel requested that STAT:

a. Estimate q for 1992 to 2005 survey data. Acoustic survey biomass and age composition data from 1977 to 1989 period are ignored since survey spatial coverage was known to be incomplete (not far enough north) during this period and acoustic gear issues also affected measurements prior to the 1992 survey. Both Canada and the U.S. had switched to the Simrad EK-500 echosounder by 1992, which reduced biases associated with gear issues in the earlier surveys.
b. Estimate separate q and selectivities for the 1977-1989 and 1992-2005 surveys.

Response: [1.a.] Using Model 1, the STAT estimated q = 0.15 from the 1992 to 2005 acoustic survey data. However, the standard error of the q estimate was large, i.e., precision was low. Survey selectivity for this time period was still dome-shaped, but less so than the selectivity estimated in SS2 Models 1 and 2. The biomass scaled much higher. These results were not credible.

[1.b.] Using Model 1, the STAT reported that including the early survey data resulted in the model estimating a q of 0.062 (1977-1989) and 0.069 (1992-2005). Selectivities in this run were dome-shaped, but the 1977-1989 data exhibit a more pronounced dome-shape, presumably due to incomplete spatial coverage in Canadian waters. The precision of the selectivity estimates were not available, but the different patterns in 1977-1989 and 1992-2005 seem to provide a more realistic picture to the STAR panel, at least consistent with what is known about the survey history. Discussion of these results led the STAR Panel to Request 8, below.

2. The SS2 Model 1 and 2 dome-shaped selectivity for the Canadian and U.S. fisheries as well as for the acoustic survey needs to be examined more closely. The Panel was concerned that the proportion of the SSB never observed through fishery or survey sampling (cryptic biomass) appeared to be quite large, particularly in recent years. Quantify the contribution of the cryptic biomass in the SS2 Model 1 and Model 1 SSB results; and further explore this issue as follows:
    a. Use asymptotic selectivity for the Canadian fishery (large fish get further north – distributional rationale) and do a sensitivity run with M and h fixed as before.
    b. Use asymptotic selectivity for both fisheries and the acoustic survey and do a sensitivity run with age-specific M of 0.23 yr^{-1} up to age 10, followed by a linear increase to 0.46 yr^{-1} or some model estimated value (preferred option) of M over remaining ages

Response: [2.a.] STAT reported that using an asymptotic selectivity curve for the Canadian fishery degraded the model fit by 500 log likelihood units. The main areas of degradation are in the fits to the Canadian fishery age compositions and acoustic survey age compositions. The degradation in fit of the acoustic survey age compositions was unexpected but related to the fact that most of the older fish are in Canada. This run forced an unusual selectivity pattern for the acoustic survey, which explained the lack of fit. The SS2 model only sees old fish in Canada so it skews the selectivity for this observation. These results are similar to findings of previous STAR panel requests to explore flat-topped selectivities. The bottom line is that the acoustic survey data is affected in a non-intuitive way.

[2.b.] In order to do a sensitivity run with age specific M and asymptotic selectivities, STAT allowed dome-shaped selectivity for the US fishery and allowed M to ramp up, otherwise the model drives biomass to low levels that are inconsistent with observations. Although the preferred option was to estimate the final M, STAT suggests that this did not work because the base level M (0.23 yr^{-1}) was too high. An M of 0.46 yr^{-1} for older ages drove the population down to 2.2%, indicating that the SS2 penalties may not be strong enough to entertain this scenario. The U.S. fishery appears to have dome-shaped selectivity in the early time blocks but later periods tend to be asymptotic, which may reflect the fact that the US fishery is fishing almost exclusively on the 1999 year-class in later years. The plausibility of the mortality schedule used in this run of SS2 is clearly questionable, but it was used because the STAR panel is trying to address alternate explanations for the observed data and the very low selectivities of older fish in the Model 1 and 2 runs. Discussion of this run resulted in a follow-up request from the STAR panel (see 9 below).

3. Do sensitivity run of model with h=1.0. In particular, what is the impact on model projections relative to h=0.75?

   Response: The results of this run were not surprising. A higher value of h allows recruitment variation to increase and results in higher spawning biomass. Slightly higher yields result in the forward projections relative to those from Model 1 (h=0.75, q = 1.0). When h=1.0 and q is estimated with informative prior, SSB is lower than the Model 2 run (h=0.75, q estimated with informative prior), which implies that B_0 is lower. This result appeared to be counter-intuitive.

4. The simplified age-structured model – as reported in the stock assessment document – did not capture growth changes. Capture changes in growth regimes in new series of runs.

   Response: STAT (Steve Martell) provided six scenarios with different assumptions regarding weights on age composition data (effective sample size), catch-age likelihood (multinomial vs. Fournier's robust likelihood), and use of acoustic survey data. These scenarios are described fully in Appendix 2 of the revised stock assessment document. All 6 scenarios result in similar estimates of current SSB (2006). However, major uncertainty was seen in estimates of SSB_0 and in some cases, the respective depletion levels. The simplified model tended to estimate lower M (~ 0.15 yr^{-1}) than the fixed M=0.23 assumption used in the SS2 model runs. Steepness (h) estimates were generally in the neighborhood of h=0.75. Survey q estimates varied but tended to be less than 1.0. The conclusion from this analysis is that the structural assumptions, especially objective function weighting, do have an impact on the bottom line. The Panel used this simplified model as an exploratory tool to help with its understanding of the sensitivities of SS2 to changes to the weighting of age composition data and acoustic surveys. The Panel followed up with an SS2 request (Request 9) to examine objective function weighting in SS2. The results from the simplified model were instrumental in specifying the details of Request 9.

5. Carry out sensitivity analyses that drop the early years of the Santa Cruz pre-recruit survey – consistent with the findings of September 2006 Santa Cruz workshop.

   Response: STAT reported that dropping the Santa Cruz survey data from the 1983-2000 had little impact on model fitting. The 1999 year class remained relatively strong and current SSB remained about the same. SSB_0 did not change, and the fit to the acoustic survey did not change. There were no surprises in these results. The STAR Panel recommends that STAT remove the Santa Cruz recruitment survey data (1983-2000) from Models 1 and 2, consistent with the findings of the juvenile survey workshop (Ralston and Hastie, 2006) and the related results presented to the STAR panel. The early part of this survey had limited spatial coverage and the index of hake recruitment was based on catches at 5 stations in the outer Monterey stratum.

6. STAT team should be clear about why 2007 SSB and projections of catch and depletion rates are similar to 2006 SSB and projections. Are these similarities due to model changes, data changes or both?

   Response: STAT is cognizant of the need to clarify this point in the assessment document that will go forward from the Panel process.

7. The Panel attempted to explore an alternate explanation of the observed data compared to those attempted by previous Panels by trying to determine if the SS2 model can estimate M values that make population dynamics sense, including population sizes consistent with removals. Following from request 2b, the Panel requests that STAT:
   a. Assign asymptotic selectivities to the Canadian and U.S. fisheries and the acoustic survey and allow the model to estimate base M (ages 0 through 10) and where M ultimately ends up for the older age groups.
   b. A default option if 7a is not feasible is to fix the upper M at 0.46 yr^{-1} and allow the model to estimate the initial or base M (ages 0 through 10).

   Response: STAT reported that these requests were difficult to fulfill. Freely estimating an initial M and final M for older age groups [7.a.] resulted in values of 0.1 and 0.26, respectively. However, the model developed pathological behavior near the end of the simulation period, apparently because the 1999 year class was not large enough to support the observed removals. This result was unexpected and there was much discussion of possible explanations. The Panel concluded that freely estimating M when all selectivities are asymptotic cannot easily be accomplished with SS2. Dome-shaped selectivity patterns for all fisheries and the survey remain a source of uncertainty in the model with important management implications – particularly with the concomitant high proportion of cryptic biomass in the population. STAT advised that pursing this line of investigation further was not practical given time constraints and the amount of work necessary to implement the process in SS2.

8. Block acoustic surveys into 1977-1989 and 1992-2005 periods and estimated separate selectivities for each period. The Panel requests that STAT do this for runs in which
    a. q is fixed at 1.0, and
    b. q estimated using informed prior.

   Response: With q fixed at 1.0, blocking the acoustic survey data into 2 periods [8.a.] improves the model fit marginally by about 40 likelihood units. The likelihood for the fit to the acoustic survey data changes little relative to the Model 1. The gain in fit seems to be in the age composition fits, especially the acoustic survey age compositions. The fit to the survey biomass is similar to the Model 1, but it does not dip down between 2003 and 2005 as in Model 1. Blocking the acoustic surveys also seems to have resulted in an increase in 1999 year-class recruitment. Depletion in the final year was 0.405. 2007 spawning biomass is roughly at the B_{40} target. The STAR Panel noted the marginal improvement in statistical fit of the age composition data but was not able to determine what property in these data would account for this improvement. The 1992-2005 selectivity is still dome-shaped, but is shifted to the right of the 1977-1989 selectivity curve. The STAR Panel did not see any real advantage in proceeding with block selectivities of acoustic surveys in SS2 because improvement in model performance was marginal; change for change's sake is not warranted in these circumstances.

9. Objective function weighting. The Panel is concerned that the acoustic survey data are having little or no influence in the model and consequently, the age- and length-compositions are unduly influencing trend and scale. Give more weight to acoustic survey and down-weight age- and length- compositions. Decrease acoustic survey CVs assigned to the early years and reduce age-composition and length- composition effective sample sizes. Note that in Models 1 and 2, the effective age composition sample size was set to 50% of the nominal sample size and that the effective size composition sample size was set to 30% of the nominal sample size. Also note that in Models 1 and 2, the survey CV was set to 0.50 for the early years (1977-89) and 0.25 for the latter survey years (1992-2005).
    a. Conduct runs with age compositions (effective sample size) set to 25% of the nominal sample size for q = 1.0 and q estimated with an informed prior,
    b. Conduct runs with age compositions (effective sample size) set to 15% of the nominal sample size for q = 1.0 and q estimated with an informed prior, and
    c. Conduct runs with age compositions (effective sample size) set to 15% of the nominal sample size and length compositions set to 15% of the nominal sample size for q = 1.0 and q estimated with an informed prior.

   Response: For all runs, the STAT set the acoustic survey CV=0.25 for all years. Results are shown in Figure 1 for Model 1 (q=1) and in Figure 2 for Model 2 (q estimated with an informed prior). Despite significant downweighting of the age- and size-compositions, all of the runs appeared to fit the observed age- or size-compositions quite well. For both Model 1 and Model 2, fits to the acoustic survey data improved as less weight was given to the age- and size-compositions (Figures 1a and 2a); furthermore, estimates of SSB_0 declined as less weight was given to the age- and size-compositions (Figures 1b and 2b). Depletion estimates were not affected as greatly but some down weighted runs showed terminal depletion levels below the $0.25 \cdot SSB_0$ overfished threshold (Figures 1c and 2c).

Although the particular levels of downweighting used in these requests are somewhat arbitrary, the exercise established that the rigidity of the SS2 hake modelling (i.e. M fixed, h fixed, and q essentially fixed) coupled with the large relative weighting given to the age- and size-compositions may be causing lack of fit to the acoustic survey and an upward bias in the Model 1 and Model 2 estimates of SSB_0 as well as concomitant effects in depletion estimates. These results are consistent with dozens of runs made using the simplified model (Request 4, above) that tended to estimate smaller SSB_0 than the Model 1 and 2 SS2 estimates. The STAT suggested that a more objective way to handle downweighting the age- and size-compositions would be to use Fournier's robust likelihood (as done in MULTIFAN-CL). While this was done for the simplified model (Request 4, above), it was not possible to make such modifications to SS2 during the course of the Panel meeting. The Panel recommended that this be done in the next hake stock assessment.

Technical merits and deficiencies

1. The current form of the assessment model (SS2 Ver 1.23E) evolved from a 2005 STAR Panel recommendation to develop a more parsimonious model. The number of parameters has been reduced from more than 300 to the current 80 or so parameters. The current version is a single-sex age/length structured model with standard fish population dynamics. The objective function is maximum likelihood with different weighting schemes for different data sources. Bayesian priors can be used in the parameter estimation. Nonlinear optimization is carried out using the tools in the AD Model Builder package. The Panel generally supports the use of this modelling and estimation procedure but also saw value in the use of a simplified age-structured model to provide better understanding of the sometimes complex behavior of SS2. The Panel recommends the joint use of these complementary models in future assessments.

2. Objective function weighting is a particularly difficult issue in the hake assessment. Appropriate CVs for the acoustic survey are not known. CVs are set somewhat arbitrarily to 25% for the recent period (1992-2005) and 50% for the earlier years (1977-89). The number of available age and size samples is unusually large and the nominal number of samples considerably overestimates the true effective sample sizes. The original sample sizes were reduced somewhat arbitrarily by 50% for age-compositions and 70% for the length-compositions in Models 1 and 2. An exercise carried out at the Panel meeting to reduce further the effective sample sizes showed little effect on model fit but somewhat different conclusions on the value of earlier survey data, the estimates of SSB_0, and on

some depletion estimates. The Panel encourages further work on objective function weighting in conjunction with the next assessment (as outlined in Request 9, above).

3. The estimated selectivity functions for the Canadian fishery, the U.S. fishery, and the acoustic survey are all strongly dome-shaped. While plausible mechanisms were postulated for some degree of domeness, the Panel did not find the unusually small selectivities for older fish (say age 12+) to be entirely credible. Such model structure has management implications in that the cryptic biomass can represent a significant proportion of standing stock of SSB in some years. Since by definition the cryptic biomass can never be sampled or measured directly by either fishery or by the acoustic survey, it is difficult to gauge the reliability of the SSB and other biomass estimates.

4. The Panel suggests that the re-parameterization of the original Beverton-Holt stock-recruitment model to the Mace-Doonan formulation in SS2 (Methot 2005, page 8, equation 1.6) may lead to numerical instabilities. Steepness (h) and S_0 are more highly confounded in the Mace-Doonan formulation than are the α and β parameters in the original Beverton-Holt formulation.

Areas of Major Uncertainty

The Panel identified three major axes of uncertainty in the hake stock assessment. Only the first of these uncertainties can be expressed quantitatively at this time.

a) Acoustic survey catchability continues to be a major source of uncertainty in the stock assessment. This has been a central issue in previous assessments and for the STAR Panels that reviewed them. No new information or data has come to light that helps to resolve the issue. Following the recommendation from the 2006 STAR Panel, the STAT captured this uncertainty quantitatively by developing two models – one with q=1.0 (Model 1) and the other with q estimated with an informative prior (Model 2). The Panel endorses the continuation of this approach. But future research should focus sharply on both the catchability and the selectivity of the acoustic survey. If the SS2 modelling is correct, then the resultant small survey q ($q \approx 0.1$ when freely estimated) and the sharply domed-shaped selectivity curve (missing both young and old fish) may imply that the acoustic survey (as presently conducted) is not an efficient means to develop a reliable fishery-independent index of abundance for hake.

b) Objective function weighting of the fishery-dependent and fishery-independent data is potentially a major source of uncertainty (see discussion under Request 9 and Technical Merits and Deficiencies #2, above). However, at this time there does not appear to be a practical means of quantifying this uncertainty. Without quantification, this uncertainty cannot be captured in decision tables. The next assessment should address this issue quantitatively.

c) The correct shape of the various selectivity curves (dome-shaped or asymptotic) is potentially a major source of uncertainty (see discussion under Technical Merits and Deficiencies #3, above). However, at this time there does not appear to be a practical means to quantify this uncertainty. Without quantification, this uncertainty cannot be captured in decision tables. The next assessment should address this issue quantitatively.

Areas of Disagreement

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

Management, data, or fishery issues raised by Panel advisors

<u>Summary of Management and the Fishery of Pacific Hake in 2006</u>

Canadian Fishery

In 2007, Pacific hake was allocated to domestic and JV operations with 79,826 t caught in domestic operations and 13,735 t caught during the Joint Venture. The JV started Aug. 1 in Queen Charlotte Sound.

- Catch was distributed between Queen Charlotte Sound (27,600 t) and the west coast of Vancouver Island (52,180 t) between the months of May-November.
- The catch peaked in July for Queen Charlotte Sound and in October for the west coast of Vancouver Island.
- Landings from the north were composed of exceptionally large fish with a low parasite load. While landings from the south were dominated by smaller fish.
- The fishery was monitored with observers and electronic monitoring devices.

U.S. Fishery

- The United States allocation was split between the following sectors:
  Tribal (35,000 mt)
  U.S. shoreside (97,469 mt)
  At-sea Catcher/Processor (78,903 mt)
  At-sea Mothership (55,696 mt)
  Bycatch in all other fisheries (2,000 mt)

- Video cameras were used to monitor the shoreside fishery while the at-sea fishery (JV) was monitored by observers.

- The catcher-processor sector of the fishery voluntarily curtailed fishing operations in response to higher than normal widow rockfish bycatch to prevent premature closure of the shoreside fishery. After the shoreside fishery attained it's allocation and closed, both at-sea sectors resumed and the entire catcher-processor and mothership allocations were caught.

- The catch taken in the early part of the fishery showed a high proportion of juveniles while larger fish dominated as the season progressed.

- The shoreside fleet reduced bycatch for Chinook salmon, canary rockfish, darkblotched rockfish and widow rockfish compared to 2005.

- The shoreside fishery nearly reached their full allocation and closed on August 6.

- The shoreside observation program will begin to transition to federal coordination during 2007.

Research Recommendations

The Panel considered the topic of research recommendations in two parts: 1) review of the status of previous research recommendations (made by previous STAR Panels) and 2) development of new recommendations. The Panel prioritized each of the previous recommendations as “S” (short term; to be addressed in the 2008 assessment), “M” (medium term; to be addressed by the 2009 assessment), and “L” (long term; to be addressed by the 2010 assessment and beyond).

<u>2005 STAR Recommendations</u>

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 domeshaped 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. (M- 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. This prior could 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. *Completed.*

8. As a diagnostic exercise, conduct an alternative analysis in parallel with SS2 using a simplified model, e.g. a VPA (Virtual Population Analysis) or as recommended by the 2007 Panel, Martell's age-structure model. (S-in progress).

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). Although this has been a recommendation in the past the ageing lab at PBS has done some comparison with the NMFS-Seattle lab and found no discrepancy. (M)

<u>2006 STAR Panel Recommendations</u>

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) *Acoustic survey workshop topic – see Item 5.*

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 evaluation should include management strategies based on trend data,

rather than absolute abundance estimates, similar to the current approach for managing Pacific cod in Canada. (M)

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)

<u>2007 STAR Panel Recommendations</u>

15. Current modelling assumes a single (U.S./Canada) coastwide stock without explicit parameterization for migration. As research advances on spatially-explicit models, hake might be a good candidate for application of these models (M).

16. Currently the assessment is conducted using a single sex model. Empirical evidence suggests growth differences between sexes and most fisheries and survey data are available by sex. Future assessment should consider modelling both sexes (S).

17. Use Martell's simplified age-structured model in parallel with SS2 for the next stock assessment and for the provision of management advice. Compare management advice from both approaches (S).

18. With regard to Martell's simplified model, add the frequency of the stock going below $0.25 \cdot SSB_0$ as a performance measure. This would make Martell's analysis relevant to both Magnuson-Stevens Act mandates – achieving optimum yield and preventing overfishing (S).

19. Investigate whether the early fishery (foreign fishery) operated differently, e.g., bottom trawl rather than mid-water trawl, which could influence the age of fish caught during that period (L).

20. In the next assessment, capture all three major axes of uncertainty in the management advice (see Areas of Major Uncertainty, above) (S).

21. Investigate whether the SS2 model handles the underlying production curve correctly as a code debugging exercise. Put the model in deterministic mode with fixed M, q, h, and selectivities, seed the model with previously estimated B_0, and run forward to present day. In this mode the model should return an estimate of MSY similar to the true, analytically-calculated MSY (S).

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References

Helser, Thomas E., and Steve Martell. 2007. Stock Assessment of Pacific Hake (Whiting) in U.S. and Canadian Waters in 2007

Methot, Richard. 2006. User Manual for the Assessment Program Stock Synthesis 2 (SS2). Model Version 1.21. January 20, 2006. .NOAA Fisheries Seattle, WA.

Ralston, Stephen, and Jim Hastie. 2006. Pre-recruit survey workshop, September 13-15, 2006, Southwest Fisheries Science Center, Santa Cruz, California. Summary report, 7 p.

Table 1. Decision table showing the consequences of management action given a state of nature. States of nature include the Model 1 (h=0.75, q=1.0) and Model 2 (h=0.75, q prior). The management actions include the optimum yield (OY) from each state of nature and constant coast wide catch scenarios.

			State of Nature	
Relative probability			**0.5**	**0.5**
Model			**h = 0.75, q = 1.0**	**h = 0.75, q prior**
Management action	Total coast-wide Catch (mt)	Year	Relative depletion (2.5%-97.5% interval)	
OY Model h=0.75, q=1.0	573,858	2007	0.321 (0.243-0.397)	0.398 (0.308-0.488)
	378,962	2008	0.245 (0.195-0.295)	0.326 (0.236-0.417)
	234,093	2009	0.193 (0.150-0.236)	0.271 (0.180-0.363)
	193,195	2010	0.184 (0.102-0.266)	0.257 (0.138-0.376)
OY Model h=0.75, q prior	889,555	2007	0.321 (0.243-0.397)	0.398 (0.308-0.488)
	568,864	2008	0.208 (0.126-0.290)	0.293 (0.236-0.350)
	341,109	2009	0.139 (0.052-0.226)	0.222 (0.176-0.268)
	236,775	2010	0.124 (0.008-0.240)	0.203 (0.117-0.289)
Total coast-wide catch = 100,000 mt	100,000	2007	0.321 (0.243-0.397)	0.398 (0.308-0.488)
	100,000	2008	0.305 (0.230-0.379)	0.377 (0.290-0.463)
	100,000	2009	0.279 (0204-0.354)	0.344 (0.259-0.428)
	100,000	2010	0.274 (0.167-0.381)	0.333 (0.218-0.447)
Total coast-wide catch = 200,000 mt	200,000	2007	0.321 (0.243-0.397)	0.398 (0.308-0.488)
	200,000	2008	0.291 (0.216-0.367)	0.365 (0.277-0.452)
	200,000	2009	0.254 (0.177-0.332)	0.323 (0.233-0.409)
	200,000	2010	0.239 (0.131-0.348)	0.303 (0.186-0.419)
Total coast-wide catch = 300,000 mt	300,000	2007	0.321 (0.243-0.397)	0.398 (0.308-0.488)
	300,000	2008	0.278 (0.201-0.355)	0.354 (0.266-0.442)
	300,000	2009	0.230 (0.150-0.309)	0.302 (0.213-0.389)
	300,000	2010	0.205 (0.094-0.316)	0.273 (0.155-0.392)
Total coast-wide catch = 400,000 mt	400,000	2007	0.321 (0.243-0.397)	0.398 (0.308-0.488)
	400,000	2008	0.265 (0.187-0.342)	0.343 (0.253-0.432)
	400,000	2009	0.205 (0.124-0.286)	0.280 (0.190-0.371)
	400,000	2010	0.170 (0.057-0.283)	0.244 (0.123-0.364)

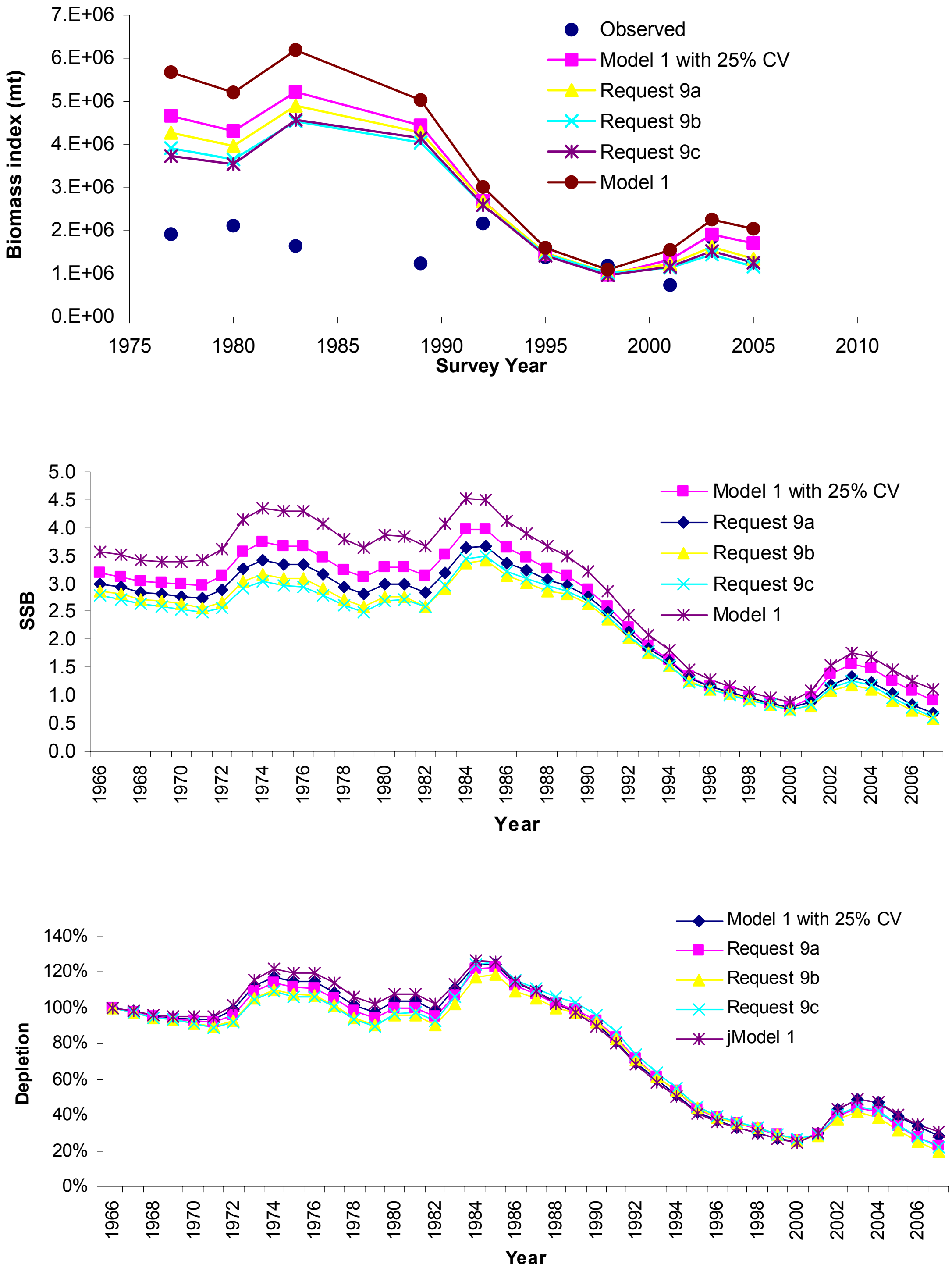

Figure 1. Results from STAR Panel Request 9 for Model 1 (q=1). In the text, the top panel is called Fig. 1a, the middle panel is Fig. 1b, and the lower panel is Fig 1c.

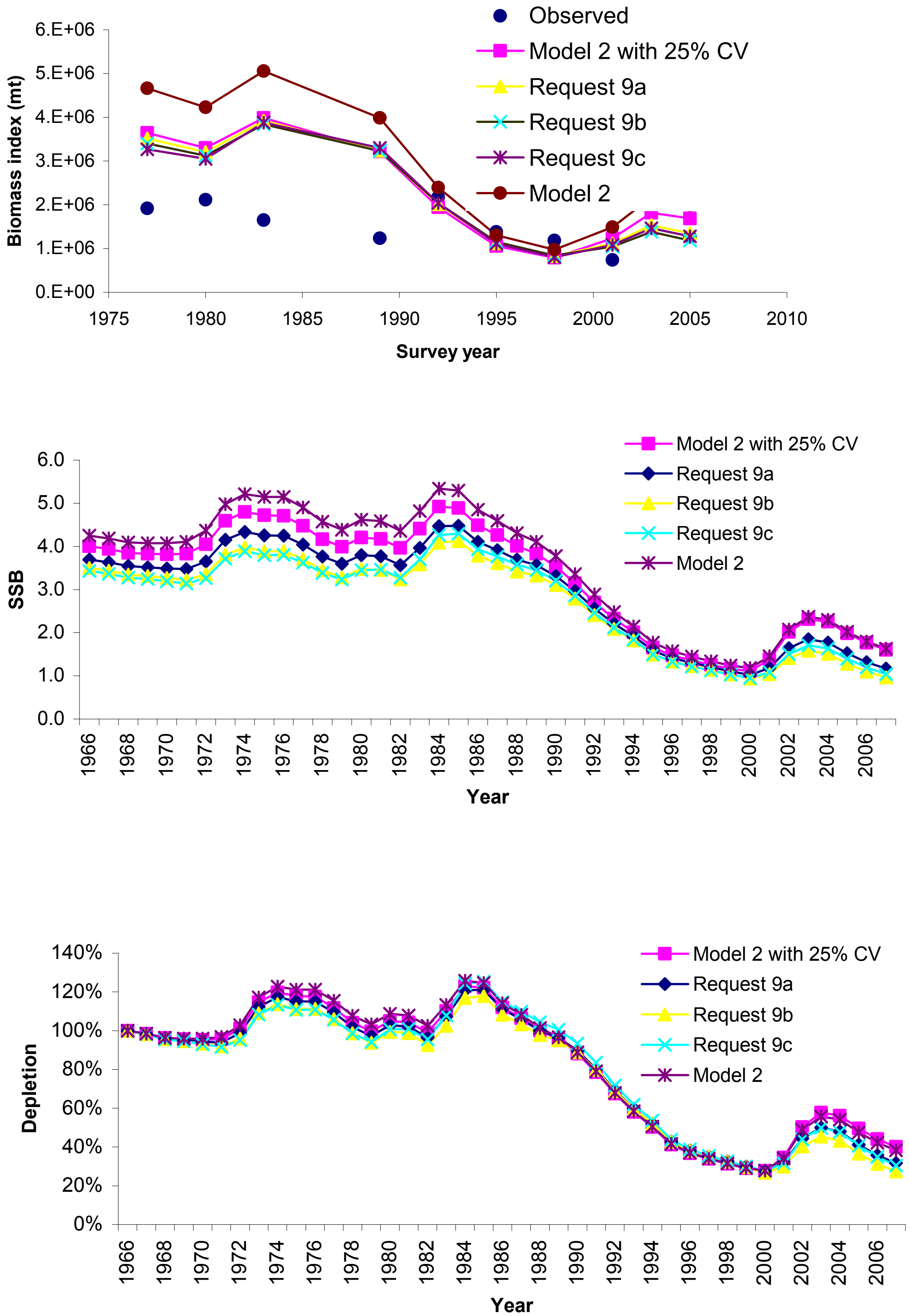

Figure 2. Results from STAR Panel Request 9 for Model 2 (q estimated using informed prior). In the text, the top panel is called Fig. 2a, the middle panel is Fig. 2b, and the lower panel is Fig 2c.