Review of the 2007 Pacific Mackerel (*Scomber japonicus*) assessment.

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Executive Summary

The STAR panel for the Pacific mackerel assessment was held at the La Jolla South West Fisheries Science Center over Tuesday May 1st to Thursday May 3rd, 2007, with a short extension into Friday May 4th, 2007. The review process was successful in identifying a base case assessment for the Pacific mackerel along with sensitivity model runs used to characterize the uncertainty inherent in the assessment. The attempt to implement the assessment in the new stock assessment platform of Stock Synthesis 2 had to be abandoned because of technical difficulties, which could not be solved in the time available. The agreed base case assessment continued to use the Age-Structured Assessment Program (ASAP). An important change with the new assessment was the use of a much larger value for the recruitment variability, which allowed an improved fit to the rapid changes in available biomass that are evident in the observations from the fishery. The final STAR panel report is appended.

The STAR process provides a vigorous review of the assumptions and validity of the assessment model and its outcomes provided in the assessment. However, when dealing with only a single species, allowing about 2.5 days risks placing the STAT under a great deal of stress to conduct all the analyses that might prove necessary, as was the case with Pacific mackerel. It is recommended that such meetings be at least 3.5 days long, or that two species be reviewed over five days, to provide more time for exploratory analyses and explanations.

The provision of all material prior to the review on an FTP site proved useful and workable.

Background

Statement and History of the Problem

The Pacific mackerel (*Scomber japonicus* – the chub or blue mackerel) has a distribution off the west coast of North America extending from south-eastern Alaska south to Banderas Bay (Puerto Vallarta), Mexico, including the Gulf of California. Within U.S. waters, the Pacific Fishery Management Council (PFMC) establishes a harvest guideline (HG or quota) for Pacific mackerel on the basis of an annual stock assessment. The Harvest Guideline is completed by May ready for the subsequent fishing season extending from the following July 1st to the end of the following June 30th. The assessment aims to provide an estimate of current abundance (as biomass of fish aged 1 and older), which when put into the standard harvest control rule leads to a particular annual HG.

The control rule for Pacific mackerel is currently:

HARVEST = (BIOMASS-CUTOFF) x FRACTION x DISTRIBUTION,

where HARVEST is the U.S. Harvest Guideline, CUTOFF (18,200 metric tonnes) is the lowest level of estimated biomass at which harvest is allowed, FRACTION (30%) is the fraction of biomass above CUTOFF that may be taken by fisheries, and DISTRIBUTION (70%) is the average fraction of total BIOMASS assumed in U.S. waters. The CUTOFF and FRACTION values have been determined from earlier work (not seen in this review). The BIOMASS is that of fish aged 1 and older.

The stock assessment process appears to make a distinction between full assessments and updated assessments. Full assessments involve the use of a new model or significant revisions of the structure or components of the assessment, Updated assessments can be as simple as incrementing the data series used in the model fitting process, although some revision of biological parameters and input data can also occur. The distinction between a full assessment and an updated assessment is not clear but does not appear to be important. The last updated assessment was completed in May 2006. This was an update on an assessment drafted for a previous STAR panel (Hill & Crone, 2005). The previous STAR Panel Report for Pacific mackerel (PFMC 2004) included recommendations for improving the input data and model configuration. Many of these recommendations have been included in the 2007 assessment (Dorval *et al*., 2007) and it is this latest assessment that was the subject of the STAR panel held at La Jolla in May 2007. Apart from additional years of data and new indices of relative abundance (using the CalCOFI and aerial spotter survey data), the most important innovation is the proposed use of Stock Synthesis II (SS2) as an alternative modelling platform within which to conduct the assessment (Methot, 2005, 2007). This was proposed as an alternative to the ASAP (Age-Structured Assessment Program used in the previous assessment.

The history of the fishery is one of remarkable variation in yield and apparent availability. There were large catches through the 1930s to 1960s, but these were followed by rapidly declining catches until there was a moratorium declared in 1970 with the fishery reopening under a quota system in 1977. Catches increased again in the 1980s and except for a short increase in 1998 and 1999 have declined to low levels again. Since 2001 the U.S. commercial fleet has only taken a fraction of the recommended Harvest Guidelines. In discussions with representatives from the fishing industry this has been attributed to a number of factors. These

include higher fuel costs that were not matched by comparable increases in price for product, combined with the limited availability of fish close to port. This latter factor is important because as a result of increased fuel prices, the area of the fishery has contracted closer to shore. This may also have influenced the age composition in recent years by increasing the proportion of 0+ and 1+ fish in the catches. This contraction in area has been exacerbated by spotter plane effort being redirected to higher value fisheries such as tuna. The increased proportion of 0+ fish in recent years has implications for the selectivity of the fishery and suggests the estimates of 1+ and older biomass may be conservative (for reasons of the reduction in area fished not presenting a representative sample of stock availability).

The specific objectives for the CIE reviewer within the STAR process were:

1) Become familiar with the Pacific mackerel stock assessments; proposed methodological improvements; and background materials.
2) Participate in the STAR Panel meeting in La Jolla, California during 1-3 May 2007.
3) Comment on the strengths and weaknesses of current approaches and proposed improvements.
4) Recommend alternative methods and/or modifications of proposed methods, as appropriate during the STAR Panel meeting.

In addition, to assisting with the generation of the STAR panel report, this CIE report also contains brief commentary on the STAR panel process.

Review Activities

The review was conducted at the South West Fisheries Science Center in La Jolla, San Diego over the three days: Tuesday 1st May to Thursday 3rd May 2007; with a three hour extension on the morning of Friday 4th May from 0700 – 1000 to allow the Stock Assessment Team (STAT) to complete some requested tasks. The review process began with the chair (Tom Jagielo) leading formal introductions and providing a description of the review process. This was followed by a series of presentations by various contributors to the Pacific mackerel assessment with consequent questions and discussions. The presenters were Emmanis Dorval, Kevin Hill, and Nancy Lo. The presentations led to questions, clarifications, and recommendations for alternative model runs which were executed and the results returned to the Panel and STAT for further discussion and development of ideas. The intention of the meeting was to settle on an assessment platform, generate a base case assessment, and characterize the uncertainty inherent in the assessment by suggesting model runs that considered the sensitivity of the assessment to different assumptions and input data.

Four presentations were given:

1. Pacific mackerel stock assessment 2007: Life history, fisheries, and available data.
2. Pacific Mackerel Stock Assessment For U.S. Management In The 2007-08 Fishing Season
3. Daily Larval Production of Pacific mackerel (*Scomber japonicus*) off California in 1951-2006.
4. Relative Abundance of Pacific mackerel from Fish Spotter Pilot surveys in 1963-2005

Attendees at the Meeting:

STAR Panel Members in Attendance
Mr. Tom Jagielo (Chair), SSC - Washington Department of Fish and Wildlife
Dr. André Punt, SSC - University of Washington
Dr. Malcolm Haddon, CIE - University of Tasmania
Mr. Dale Sweetnam, CPSMT - California Department of Fish and Game
Ms. Diane Pleschner-Steele, CPSAS - California Wetfish Producers Association

STAT Members in Attendance
Dr. Emmanis Dorval, NMFS, Southwest Fisheries Science Center (SWFSC)
Dr Kevin Hill, NOAA / SWFSC
Dr. Nancy Lo, NMFS, SWFSC
Ms. Jennifer McDaniel, NMFS, SWFSC

Others in Attendance on some or all days.
Mr. Mike Burner, Pacific Fishery Management Council
Dr. Ray Conser, NMFS, SWFSC
Dr. Paul Crone, NMFS, SWFSC
Dr. Sam Herrick, NMFS, SWFSC
Mr. Jason Larese, NMFS, SWFSC
Dr. Mark Maunder, Inter-American Tropical Tuna Commission (IATTC)
Dr. Kevin Piner, NMFS, SWFSC
Mr. Alexandre Silva, IATTC

The Terms of Reference for the Stock Assessment review included:

1. reviewing draft stock assessment documents and any other pertinent information (e.g.; previous assessments and STAR Panel reports, if available);

2. working with STAT Teams to ensure assessments are reviewed as needed;

3. documenting meeting discussions;

4. reviewing summaries of stock status (prepared by STAT Teams) for inclusion in the Stock Assessment and Fishery Evaluation (SAFE) document; and,

5. recommending alternative methods and/or modifications of proposed methods, as appropriate during the STAR Panel meeting.

By way of clarification, the terms of reference for the STAR panel members included the following paragraph:

> The STAR Panel's terms of reference concern technical aspects of stock assessment work. The STAR Panel should strive for a risk neutral approach in its reports and deliberations. Confidence intervals of indices and model outputs, as well as other measures of uncertainty that could affect management decisions, should be provided in completed stock assessments and the reports prepared by STAR Panels. The STAR Panel should identify scenarios that are unlikely or have a flawed technical basis.

The review process was conducted in a positive and friendly atmosphere with great interest and enthusiasm being expressed by the stock assessment team at the South West Fisheries Science Center in La Jolla for any discussion relating to their work. The comparisons of the two assessment platforms (SS2 and ASAP) complicated the review process and led to numerous alternative trial runs, so it is fortunate that the researchers in La Jolla are so enthusiastic and committed. Their openness to critical discussion does them and their organization credit.

I would like to thank the assessment team at the SWFSC for making the review such an interesting and positive experience.

DISCLAIMER

Summary of Findings

Structure of Document

Included as Appendix 4 is the final STAR panel report, which contains the details of the technical questions and responses that were obtained during the review process. It would be inappropriate to alter the structure of this consensus report. Only a summary or the main points from the Pacific mackerel review will be reiterated here. However, in addition, it was deemed appropriate to comment on the structure and process of the STAR panel process.

The Pacific Mackerel Review

After the presentations from the STAT, the STAR panel began the review by asking for a demonstration that the SS2 implementation of the assessment could generate outcomes equivalent to those produced by the ASAP assessment model; this was in order to demonstrate a sufficient degree of continuity between the two assessment platforms. To do this, both models were set up to reflect similar data inputs and assumptions especially with respect to selectivity and weight-at-age. In fact, under those conditions it was possible to obtain similar estimates of 1+ biomass and recruitment from both models. This opened up the possibility of exploring the use of the expanded options of the SS2 implementation. The STAR panel deliberations were mostly of a technical nature and delved into exploring how best to model the manner in which weight-at-age and selectivity changed through time. Finally, annual estimates of weight-at-age (wherever there was sufficient data) and three periods exhibiting different selectivity patterns were chosen as representing the dynamics of the fishery most appropriately. The three selectivity patterns reflected the period prior to the moratorium, the seven years of the moratorium, and the period since the moratorium. This matched the size- and age-distributions of the catch and appeared a sensible solution.

Unfortunately, after a number of sensitivity runs had been conducted the SS2 model outputs were found to contain occasional years in which the predicted harvest rate ran up against the harvest rate limit (0.9 – implying that the fishery was taking 90% of available exploitable biomass). This implied that the SS2 implementation was not imputing sufficient initial biomass and subsequent production to account for all the catches. Manipulations of the harvest rate limit (to 0.95), increasing the penalty term on high harvest rates, and changing the selectivity patterns (to estimates by age) removed some of the problem years but not all. This problem was exactly the kind of flawed technical basis that the STAR panel were asked to consider in its terms of reference. Eventually, it was decided that it would take too long to solve this problem with the SS2 implementation and the assessment strategy was forced to revert to the ASAP model. Retaining the ASAP model approach has three disadvantages. The first is that it can only account for a single fleet (so that the recreational catches could not be independently modelled); the second is that the ASAP model uses the same weight-at-age for the catch as for the population, which implies that any stock recruitment relationship may be biased. Finally, in order to estimate selectivity for any particular relative abundance index, the ASAP model requires that index to be associated with a particular fishery. This means there are difficulties estimating the selectivity for the larval abundance and spotter plane indices. Nevertheless, there were no diagnostic problems with the outputs from the ASAP assessment (*e.g.* harvest rates were generally less than 0.7 for all years) so it was deemed possible to produce a workable assessment using this platform. The expectation is that the STAT at the

SWFSC in La Jolla will continue to work with SS2 and attempt to resolve the issues identified in this review ready for the next annual assessment.

Some of the difficulties encountered stemmed from the fact the SS2 is currently undergoing further development (Methot, 2007) and there were options and parameters now available whose functions were not immediately obvious or known to anyone present. It was an obvious gamble attempting to implement a full assessment model using such a new version of SS2 in such a short time. Had it succeeded it would have definitely been worth the effort but now it will need to wait for the next assessment. For other assessments and reviews it would be worth noting which diagnostics to consider when using SS2. Certainly, the occurrence of parameter estimates butting up against threshold limits should be considered early on as a clear signal that something in the setup is out of balance.

The use of wireless technology for provision of the shared disk space gave a few problems during the review. If such problems are likely to be experienced then it may be preferable to resort to older but sometime more reliable cable based equipment. Having said that, it should also be said that the materials provided to the review panel before the review was excellent and access to presentations and documentation during the review was good. The use of the FTP site for distributing files was very effective. The only issue during the review was that accessing the shared server was occasionally a problem.

The STAR Panel Process

The two and a half days originally designated for the STAR panel process stemmed from the fact that previously two species would be reviewed in five days. However, such reviews do not proceed in a linear fashion. When reviewing two species there would have been efficiencies of time that lead to more time being available for sensitivity runs and extra analyses should they be required. In the instance of the Pacific mackerel review this lack of available time was further exacerbated by the attempts to introduce a new assessment platform (SS2). The STAR process appears to be an excellent strategy for ensuring rigorous review of stock assessments. The problem with the SS2 model was only detected because the review team was examining the model output files in detail. However, such examinations are necessary and, if there are non-obvious problems with the assessment, this is where they will be detected. During this review there were problems that required a lot of extra-session work and the 2.5 days proved to be too short a period. The STAT team performed very well indeed but the workload in such a short time was undoubtedly excessive and potentially stressful. It is recommended that either more time (at least another day) be allowed for such single species reviews or two species are dealt with over five days, as before, in order that sufficient time for required work is available without having to over-extend the STAT members.

The STAR panel process permits a remarkably thorough critical examination of a stock assessment. By presenting all details of the assessment and running through the model output files it is possible to be clear about all aspects of the assessment. Few if any formal publications receive such a detailed review. The timelines and deadlines for the production of stock assessments are clearly very tight, so a rigorous review process is necessary to catch errors which, given more time, could be avoided by the STAT. The process as a whole is well designed as an adaptation to the expectation of producing detailed stock assessments in too short a time. The process must be very stressful to the STAT members, who should not feel they are being criticized. Rather, the review process should be seen as a form of backstop that is required because of the short but rigid timelines in place for the production of the

assessments. There would not appear to be any way of increasing the time available for the production of the assessments so the running of these STAR panels becomes a necessity that needs to continue.

The STAR panel review is frequently focused on highly technical aspects of the assessment. The Industry members present at the meeting in La Jolla appeared interested in all aspect do the review but nevertheless, whether they would appreciate the organization of a specific day for their input during these reviews is a possibility that could be explored. It is undoubtedly the case that the presence and contribution of the Industry members was invaluable but more effective use of their time might be possible.

Conclusions/Recommendations

As the STAR panel report states, the 2007 stock assessment for Pacific mackerel should be based on the ASAP platform. It was deemed best to include all three time series of indices of relative abundance. The model was age-structured rather than length-based.

Efforts to implement the assessment in the SS2 platform should continue as this is more flexible and permits more realistic assessment modelling.

The STAR panel process was successful, but only after the review was extended slightly by adding three hours from 0700 to 1000 on Friday May 4th. This was necessary because the work requests were numerous and overloaded the STAT. It is recommended that more time be made available to single species STAR panel meetings or that two species be reviewed in five days to permit my degrees of freedom in terms of time available for requested analyses and clarifications.

Appendix I: Background material and bibliography

Crone, P.R., Hill, K.T. and J.D. McDaniel (2007) *Pacific Mackerel (*Scomber japonicus*) Stock Assessment for U.S. Management in the 2006-2007 Fishing Season. Executive Summary.* NOAA Fisheries. Southwest Fisheries Science Center. Pp 1-22.

Dorval, E., Hill, K.T., Lo, N.C.H., and J.D. McDaniel (2007) *Pacific Mackerel (*Scomber japonicus*) Stock Assessment for U.S. Management in the 2007-08 Fishing Season.* Draft document for STAR Review. NOAA Fisheries Service, Southwest Fisheries Science Center. Pp 1- 96

Hewitt, R.P. (1988) Historical review of the oceanographic approach to fishery research. *CalCOFI Report* **29**: 27-41

Hill, K.T. and P.R. Crone (2005) *Assessment of the Pacific Mackerel (*Scomber japonicus*) Stock for U.S. Management in the 2005-2006 Season.* NOAA Fisheries, Southwest Fisheries Science Center. Pp 1- 167

Legault, C.M. and V.R. Restrepo (1998) A flexible forward age-structured assessment program. *ICCAT Working Document SCRS/98/58: 1-15*

Lo, N.C.H. (2007) Spotter data analysis for the Pacific mackerel in 1963-2005 using Delta GAM. *Appendix I* of *Pacific Mackerel (*Scomber japonicus*) Stock Assessment for U.S. Management in the 2007-08 Fishing Season.* NOAA Fisheries Service, Southwest Fisheries Science Center. Pp 97-110

Lo, N.C.H., Huang, Y. and E. Doval (2007) Daily larval production of Pacific mackerel (*Scomber japonicus*) off California from 1951 to 2006. *Appendix II* of *Pacific Mackerel (*Scomber japonicus*) Stock Assessment for U.S. Management in the 2007-08 Fishing Season.* NOAA Fisheries Service, Southwest Fisheries Science Center. Pp 111 – 122.

Methot, R. (2005) *Technical Description of the Stock Synthesis II Assessment Program. Version 1.17.* NOAA Fisheries, Seattle. Pp 1-54.

Methot, R. (2007) *User manual for the Integrated Analysis Program Stock Synthesis 2 (SS2) Model Version 2.00c.*NOAA Fisheries Service, Seattle. Pp 1-84.

Pacific Fishery Management Council (PFMC). (2004) *Pacific mackerel STAR panel meeting report.* Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR 97220. 10 p.

Appendix 2: Acronyms and Abbreviations

APE – Average Percentage Error
ASAP – Age-structured Assessment Program
CalCOFI – Californian Cooperative Oceanic Fisheries Investigations
CPFV – Charter – Fishing Vessel
CPSAS – Coastal Pelagic Species Advisory Subpanel
CV – Coefficient of Variation
GAM – Generalized Additive Model
GLM – Generalized Linear Model
IATTC – Inter-American Tropical Tuna Commission
PFMC – Pacific Fishery Management Committee
SAFE – Stock Assessment and Fishery Evaluation report
SS2 – Stock Synthesis 2
SSC – Science and Statistical Committee
STAR – Stock Assessment Review
STAT – Stock Assessment Team
SWFSC – South West Fisheries Science Center

Appendix 3: Consulting Agreement between the University of Miami and Dr. Malcolm Haddon

STATEMENT OF WORK

Stock Assessment Review Panel for Pacific Mackerel

April 16, 2007

General

The consultant will serve as a member of a Stock Assessment Review (STAR) Panel of the Pacific Fishery Management Council (PFMC) during 1-3 May 2007 in La Jolla, California. This review will focus on a new stock assessment of Pacific mackerel. Under the PFMC's Coastal Pelagic Species Fishery Management Plan (CPS FMP), the assessment provides the basis for setting annual harvest levels of Pacific mackerel off the west coast of the United States.

The consultant should have hands-on experience in conducting fish stock assessments. Expertise with age-structured modeling is particularly important. Experience with coastal pelagic species assessment is desirable.

The consultant's duties shall not exceed a maximum total of 12 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 will be provided with the following:

1. Recent stock assessment reports for Pacific mackerel, including the last full stock assessment (2004) and the assessment updates carried out in 2005 and 2006.
2. Additional background material including the PFMC's Terms of Reference for CPS STAR Panels; report of the last CPS STAR Panel (2004); and documents describing the models used in both the past and current stock assessments.
3. Draft report on the new stock assessment – including additional sources of data and methodology improvements – which, after review and modification, will provide the basis for management during the fishing year beginning on 1 July 2007.
4. An electronic copy of the data and the models used for the new assessment (if requested by reviewer).

Specific

5) Become familiar with the Pacific mackerel stock assessments; proposed methodological improvements; and background materials.

6) Participate in the STAR Panel meeting in La Jolla, California during 1-3 May 2007.

7) Comment on the strengths and weaknesses of current approaches and proposed improvements.

8) Recommend alternative methods and/or modifications of proposed methods, as appropriate during the STAR Panel meeting.

9) No later than May 17, 2007, submit a written report[1] consisting of the findings, analysis, and conclusions, addressed to the "University of Miami Independent System for Peer Review," and sent to Dr. David Die, via email to ddie@rsmas.miami.edu, and to Mr. Manoj Shivlani, via email to mshivlani@rsmas.miami.edu. See Annex I for additional details on the requirements for the report.

Submission and Acceptance of CIE Reports

The CIE shall provide the consultant's final report for review for compliance with this Statement of Work and approval by NOAA Fisheries to the COTR, Dr. Stephen K. Brown (Stephen.K.Brown@noaa.gov), no later than May 31, 2007. The COTR shall notify the CIE via e-mail regarding acceptance of the consultant's report. Following the COTR's approval, the CIE shall provide a pdf format version of the approved report to the COTR.

[1] The written report will undergo an internal CIE review before it is considered final.

ANNEX I: REPORT GENERATION AND PROCEDURAL ITEMS

1. The report should be prefaced with an executive summary of comments and/or recommendations.

2. The main body of the report should consist of a background, description of review activities, summary of comments, and conclusions/recommendations.

3. The report should also include as separate appendices the bibliography of materials provided by the Center for Independent Experts, including any additional literature cited, and a copy of the Statement of Work.

Please refer to the following website for additional information on report generation: http://www.rsmas.miami.edu/groups/cimas/Report_Standard_Format.html

Appendix 4: Pacific mackerel STAR Panel final report

Pacific Mackerel

STAR Panel Meeting Report

NOAA / Southwest Fisheries Science Center
La Jolla, California
May 1-4, 2007

STAR Panel
Tom Jagielo, Washington Department of Fish of Wildlife (Chair)
André Punt, University of Washington (SSC representative)
Malcolm Haddon, University of Tasmania (CIE)

PFMC
Diane Pleschner-Steele (CPSAS)
Dale Sweetnam, SWFSC (CPSMT)

STAT
Emmanis Dorval, NOAA / SWFSC
Kevin Hill, NOAA / SWFSC
Nancy Lo, NOAA / SWFSC
Jennifer McDaniel, NOAA / SWFSC

1) Overview

The Pacific Mackerel STAR Panel (Panel) met at the Southwest Fisheries Science Center, La Jolla, CA Laboratory from May 1-4, 2007 to review a draft assessment by the Stock Assessment Team (STAT) for Pacific Mackerel. The Panel was originally scheduled to conclude on May 3rd, however, additional time was needed and the Panel also met on the morning of May 4th. Introductions were made (see list of attendees, Appendix 1), and the Panel chair (Tom Jagielo) reviewed the Terms of Reference for CPS assessments with respect to how the STAR Panel would be conducted. Draft assessment documents, model input and output files, and extensive background material (previous assessments, previous STAR Panel reports, SSC statements, etc.) were provided to the Panel in advance of the meeting on an FTP site, which served as a timely and convenient means to distribute the material for review. The Panel chair thanked the STAT for providing the draft assessment approximately one week prior to the meeting, which provided sufficient time for review. A file server was provided at the meeting room to provide common access to all presentation material and the additional model runs that were conducted during the course of the Panel meeting.

Emannis Dorval, with assistance from Kevin Hill, led the presentation on assessment methodology. Nancy Lo gave presentations on candidate indices for the stock abundance based on: 1) an aerial spotter program GAM analysis (Appendix I to the draft assessment report), and 2) CalCOFI larval production data (Appendix II to the draft assessment report).

The previous mackerel assessment, used for PFMC management decisions for the period July 1, 2005 to June 30, 2006, used a forward-projection age-structured assessment program (ASAP) model to estimate Pacific mackerel biomass. During the meeting, the Panel reviewed an updated ASAP model, and an alternative model in SS2 provided by the STAT. Initial discussion focused on resolving differences between outputs coming from the two models.

To demonstrate continuity from the previous assessment, the STAT presented revised models in which the ASAP formulation mimicked a comparable SS2 model as closely as possible (see also Section 2 below). The discussion focused on how best to model time changing weight-at-age using SS2, after it was noted that similar estimates of 1+ biomass and recruitment could be obtained from SS2 and ASAP if these two assessment packages were based on the same set of specifications.

Despite the relatively close agreement of many of the outputs from the ASAP and SS2 model runs, detailed scrutiny of the diagnostics and outputs from the SS2 modelling runs revealed that the SS2 model invariably ran up against the harvest rate limit (0.9 and 0.95) in a number of years. Attempts to mitigate this problem were unsuccessful. This was considered to be a critical factor which prevented acceptance of the SS2 implementation. The Panel and the STAT agreed that an updated version of the ASAP model should form the basis for the 2007 assessment.

The Panel commended the STAT for their excellent presentations, well-written and complete documentation, and their willingness to respond to the Panel's requests for additional analyses.

2) Discussion and Requests Made to the STAT during the Meeting

1. The selectivity pattern for the CPFV index is based on fitting the length-frequency data for all recreational modes. The length-frequency data for the CPFV fleet should be compared with the length-frequency data from the other recreational modes to test the assumption that the selectivity pattern for the CPFV fleet is the same as that for the remaining recreational fleets. **Response**. Ultimately, the model chosen as the basecase was framed as an age-structured model obviating the need for this comparison.
2. The CalCOFI indices are based on four methods for estimating the mortality rate and the initial number of larvae (methods "1" – "4"). Methods "3" and "4" are used in cases in which it was impossible to estimate the values for these parameters using weighted non-linear regression. A sensitivity test should be conducted in which the index values based on methods "3 and "4" (which should be the least reliable) are omitted. **Response**: Given the time spent on trying to get the SS2 model to operate successfully, insufficient time remained to attempt this sensitivity analysis.
3. The CalCOFI indices are based on data for the "core" area off southern California, but mackerel spawn from Baja through to northern California. The larval densities for Mexico and the "core" area should be plotted for the years for which data on larval abundance are available for both areas. **Response**. Larval density of mackerel off Mexico is substantially higher than off the "core" area (Fig. 1a). The results of a regression of average larval densities on those for the "core" area (Fig. 1b) indicate that the CALCOFI indices for the "core" area may be able to detect years when larval abundance is high, but the relationship between the larval density for the "core" area and for the region including both Mexico and the "core" area is weak (r^2~0.1) when the two highest larval densities are ignored.
4. The design of the survey used to extend the spotter plane index covers different areas and with different design than the historical (opportunistic) surveys. In addition, estimating the tonnage per block and the proportion positives using models that include a smoothing spline on year leads to temporal correlation among the year-factors. This is inconsistent with the assumptions related to how indices of abundance are included in ASAP and SS2 assessments. Repeat the construction of the spotter plane index using a GLM model in which the survey data (2004 and 2005, years with survey data) and the data for 2003 (low number of trips) are ignored, and in which the smoothing splines on year in the models for the proportion positive and tonnes per block are replaced by a year factor. **Response**. The revised spotter plane index exhibited substantially more inter-annual variability, and the coefficients of variation for the indices were higher. The STAT replaced the original GAM index with the GLM index.
5. Examine the implications of moving from an assessment based on ASAP to one based on SS2. As a first step in this process, apply ASAP and SS2 based on model configurations that are as similar as possible so that the impact of a change in platform can be examined. This can be achieved using the following specifications for ASAP and SS2:

   ASAP configuration:
   - Set the weight-at-age in the fishery to the weight-at-age in the population.
   - Rescale the catch-at-age data so that the product of catch-at-age and weight-at-age (now based on that for the population) equals the total catch for each year.

   SS2 configuration:
   - Omit length-based selectivity – assume that selectivity is independent of length.

- Assume age-based selectivity – estimate a selectivity parameter for each age (selectivity option 14).
- Use the catch-at-age data included in the ASAP model (no length data).
- Set weight-at-age to that used in ASAP (not time-varying).
- Have one selectivity pattern only (not time-varying).
- Set selectivity for the spotter and CPFV indices to those used in ASAP.
- Set the recreational catch to 0.0001 for all years.

Response. The STAT conducted the requested analysis, setting the CVs for the ASAP run to the "tuned" values based on the SS2 analyses and setting $\sigma_R = 0.8$. The results from ASAP and SS2 were very similar for the years 1967-2004 but differed slightly for the first years of the assessment period and substantially for the years 2005 onward. The differences between the results for SS2 and ASAP after 2004 were due to the use of the forecast option in SS2, which led to recruitments substantially in excess of those expected under the deterministic stock-recruitment relationship. The Panel agreed that SS2 and ASAP lead to adequately similar results when using the same data, but the SS2 forecast file needs to be corrected for the projections beyond 2004.

6. The recreational catches are included as weights and not numbers in the SS2 assessment. The catches-in-weight are calculated from the catches-in-number under the assumption that each fish weighs 1lb on average. However, SS2 is capable of using catch data entered as catch-in-numbers. Conduct a sensitivity test in which the recreational catches are included in the assessment in the form of catch-in-numbers rather than of catch-in-weight. **Response**. The request became irrelevant once the updated ASAP model was chosen as the assessment platform.
7. The SS2 run presented to the Panel had five time blocks for length-at-age and weight-at-length. Provide the basis for the time-blocking of the growth curves by plotting the annual length-weight relationships for each block. **Response**. The STAT provided the Panel with plots of length versus weight for each year from 1962. There are between-year differences in the length-weight relationship, but it was not possible to identify a preferred time block structure.
8. Run SS2 with pre-specified year-specific growth curves and year-specific length-weight regressions. The CV of length-at-age should be based on the averages over time and the age-specific selectivity pattern for the commercial fishery should be set to three double-normal functions (one for each selectivity epoch). **Response**. The STAT provided the Panel with several runs in which the CV of length-at-age was set to 0.166 for age 0 animals and 0.05 for age 11 animals (the maximum across years), in which $\sigma_R = 0.8$ (selected by comparing the RMSE for the recruitment residuals and the pre-specified value for σ_R), and in which the CVs assigned to the indices were tuned. The peak abundance is highly sensitive to the value assumed for σ_R. All of the analyses provided to the Panel led to exploitation rates in the 1950s, 1960s, and/or 1990s that exceeded the value permissible value (0.9 and 0.95). After many additional analyses, the Panel and STAT agreed that it would not be possible to base an assessment of Pacific mackerel on SS2 and all additional analyses were based on ASAP.
9. There are concerns with all three potential indices of abundance as they may be in conflict to some extent. Repeat the assessment in which the model is fitted to each index independently. **Response**. The STAT provided results for the ASAP analyses. The different time series are in conflict in some years. For example, the CalCOFI index exhibits an increase in the years 1996 and 1997 whereas the other indices either do not exhibit an increase or show a decline. The stock size exhibits an upturn in the last three or

four years of the assessment period. This disappears when the CPFV time series is omitted and only the CalCOFI time series is used (Figure 3).

10. The three indices should be plotted together to provide a visual comparison of where the indices may be in conflict or where each contributes information to the model fit. **Response.** The STAT team produced a graph with an adequate interpretation.
11. Sensitivity runs were requested to examine the impact of varying the natural mortality rate between 0.35 and 0.7yr^{-1}. **Response.** The STAT produced graphs of initial and 1+ biomass which exhibited the expected behaviour; some instability in the model fitting was detected with M between 0.55 and 0.6yr^{-1}. In addition, a table of the likelihood components for the range of M values was produced to aid in the identification of which factors are most influenced by M (Figure 4).

The commercial fleet has failed to take a large proportion of the recommended Harvest Guidelines since 2001. Higher fuel costs that were not matched by comparable increases in price for product were presented as part of the explanation in conjunction with the limited availability of fish close to port. As a result of the increased fuel prices, the area of the fishery has contracted closer to shore, which may have influenced the age composition in recent years by increasing the proportion of 0+ and 1+ fish in the catches. This contraction in area has been exacerbated by spotter plane effort being redirected to higher value fisheries such as tuna.

The results from the 2007 runs based on ASAP are most similar to those from the ADEPT model conducted for assessments prior to 2006 in terms of biomass trends since 1975 (Figure 2). However, there are major differences in biomass trajectories for the years prior to 1950. The results for the 2006 and 2007 ASAP runs differ markedly in terms of biomass in the peak years, in the years prior to 1950 and in recent years. Part of the explanation for this difference is that σ_R has been increased which leads to higher biomass than in the past and because selectivity is estimated for three, rather than one epoch. The increase in biomass in the last three years is a consequence of fitting to the CPFV index; runs without this index lead to markedly less optimistic values.

3) Technical Merits and/or Deficiencies of the Assessment

It was decided to base the 2007 assessment on an ASAP model that includes three selectivity epochs and a higher value for σ_R. Unlike SS2, this model did not lead to diagnostics that were clearly problematical. However, the ASAP is not capable of including more than one fleet so the recreational catches could not be independently modelled. In addition, the ASAP model uses the same weight-at-age for the catch as for the population, which implies that any stock recruitment relationship may be biased. In order to estimate selectivity for a relative abundance index, ASAP requires that the index be associated with a particular fishery. This means there are difficulties estimating the selectivity for the larval abundance and spotter plane indices.

The Panel accepts that the ASAP E1-base model can be used as the basis for management advice and advices that the runs based on all indices included and M=0.35 and M=0.70 be used in order to bracket uncertainty.

4) Areas of Disagreement

There were no major areas of agreement between the STAT and Panel.

5) Unresolved Problems and Major Uncertainties

Problems unresolved at the end of the meeting form the basis for some of the research recommendations in Section 6. The background to three of the main issues are given here.

1) While the best estimates of the landings off Mexico are included in the assessment, there is a continuing lack of size- and age-composition data from these catches. The 2004 STAR Panel recommended that efforts be made to obtain biological sampling data and especially catch-at-age data from the Mexican fraction of the fishery. The SWFSC began the process of acquiring this information by organizing a US-Mexico workshop in 2007 and obtaining commitments for data provision in time for future assessments. The size and age composition data from the San Pedro fishery are presently assumed to be representative of the whole stock. In addition, two of the indices of relative abundance used in the assessment (the CalCOFI larval survey and the CPFV recreational data) only relate to the Southern Californian Bight. The spawning area is known to extend south to the tip of Baja California. Obtaining data from the Mexican fishery, including the Mexican larval surveys (IMECOCAL) might help remove this important source of uncertainty.
2) There is currently no true fishery-independent index of relative abundance for the whole stock and there are concerns with the three indices used in the present assessment.
    a. The CalCOFI larval surveys are often relatively poor at finding Pacific mackerel larvae. Whether these surveys and the estimates of larval production at hatching constitute representative estimates of the spawning stock size of mackerel is uncertain, especially because the area surveyed is only a fraction of the total spawning region. Obtaining access to the Mexican larval survey data (IMECOCAL) may help solve this problem. In addition, the occurrence of larvae can be limited to one or two size classes in years of relatively low abundance, which compromises the estimation of the larval production at hatching for those years.
    b. The aerial spotter index, up until 2002, provides an opportunistic method for estimating relative abundance. The structure of the index includes an estimate of area based on the number of 10’ x 10’ blocks surveyed, but this number varies from year to year, and includes coastal blocks which are not strictly 10’ x 10’. This acts as a source of uncertainty among years. A further problem with the spotter plane index of abundance is that the design of the sampling changed after 2002. Specifically, a fishery-independent aerial survey was begun in 2004 using a grid search pattern with the added freedom to search for more fish if a school of fish is found. However, the adherence of the pilots to the sampling grid has yet to become stable. The very different sampling strategy used prior to 2003 means that it is questionable whether this new time series can be combined in a meaningful way with the earlier one.
    c. The CPFV index is based on the logbook data from the CPFV fleet for California (although limited data do exist for Mexico). Given that it is fishery-dependent data, its use in the assessment as an index of stock abundance is predicated on the assumption that catchability has not changed over time. While this is a concern for all indices of abundance based on fishery-dependent data, the fact that mackerel is not a target species for the CPFV fleet suggests that this assumption may be acceptable in this case.
3) Ageing error rates (see Table 1) indicate substantial imprecision and /or bias, particularly for the younger age-classes (0 and 1), which currently constitute a large

fraction of the catch. The impact of this error rate will only become apparent once an ageing error matrix is included in the assessment.

6) Research Recommendations

A. One of the major uncertainties associated with the assessment is that no account is taken of ageing error. SS2 can include an age-reading error matrix. The data from age-reading studies should be used to construct an age-reading error matrix for inclusion in future (SS2) assessments. However, there are currently very few otoliths that have been read multiple times so additional readings need to be made. In the longer-term, an age validation study should be conducted for Pacific mackerel. Such a study should compare age readings based on whole and sectioned otoliths and consider a marginal increment analysis.

B. The next assessment should continue to examine the possibility of using SS2 as the assessment platform. The analyses presented to the Panel suggested that ASAP and SS2 lead to similar outcomes when configured in a similar manner. However, SS2 deals better with indices that are not tied directly to a fishery, can include age-reading error, and allows weight-at-age in the catch to differ from weight-at-age in the population. In principle, it should be easier to represent uncertainty using the MCMC algorithm for assessments based on SS2.

C. The construction of the spotter plane index is based on the assumption that blocks are random within region (the data for each region is a "visit" by a spotter plane to a block in that region). The distribution of density-per-block should be plotted or a random effects model fitted in which block is nested within region to evaluate this assumption (e.g. examine whether certain blocks are consistently better or worse than the average).

D. The data on catches come from several sources. The catch history from 1926-27 to 2006-07 should be documented in a single report.

E. Conduct a study to update the information used to determine maturity-at-length (and maturity-at-age).

F. A large fraction of the catch is taken off Mexico. In particular, catches of mackerel have been as large as those off California in recent years. Efforts should continue to be made to obtain length, age and biological data from the Mexican fisheries for inclusion in stock assessments. Survey data (IMECOCAL program) should be obtained and analyses conducted to determine whether these data could be combined with the CalCOFI data to construct a coastwide index of larval abundance.

G. The SS2 assessment is based on fitting to age-composition data for the commercial fishery. Future SS2 assessments should consider fitting to the length composition and the conditional age-at-length information. This will require estimating time-varying growth curves and may require multiple time-steps within each year.

H. The CalCOFI data should be reviewed further to examine the extent to which CalCOFI indices for the "core" area can be used to provide information on the abundance of the coastwide stock.

I. There are uncertainties regarding the early biological and fishery data. The Panel reiterates the recommendation of the 2004 STAR Panel that consideration should be given to initiating the assessment model in a more recent year (e.g. 1978).

J. The concern of the 2004 STAR Panel that fishery-based weights are used to estimate population parameters has still not been addressed. Future assessments should attempt to estimate a population growth curve in order, for example, to estimate the time-trajectories of 1+ and spawning biomass.

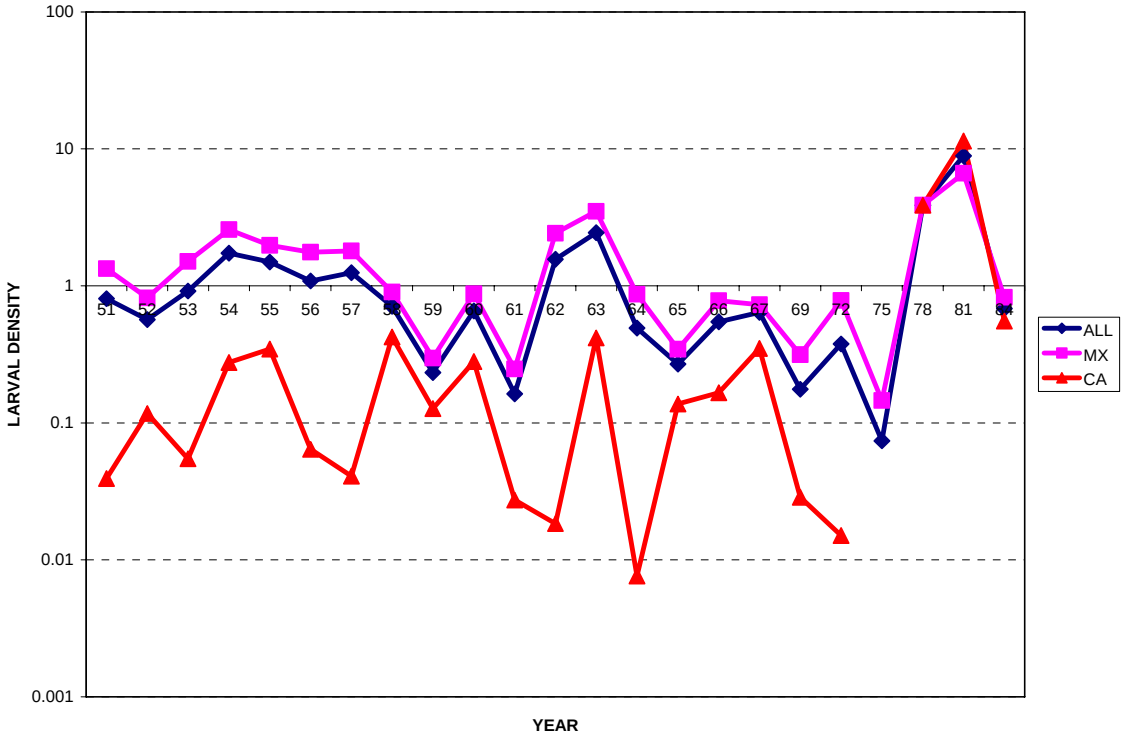

Figure 1a. Coastwide larval densities (diamonds), larval densities off Mexico (squares), and larval densities for the "core" area (results based on CalCOFI surveys that covered Mexico and the "core" area (1951-1984)).

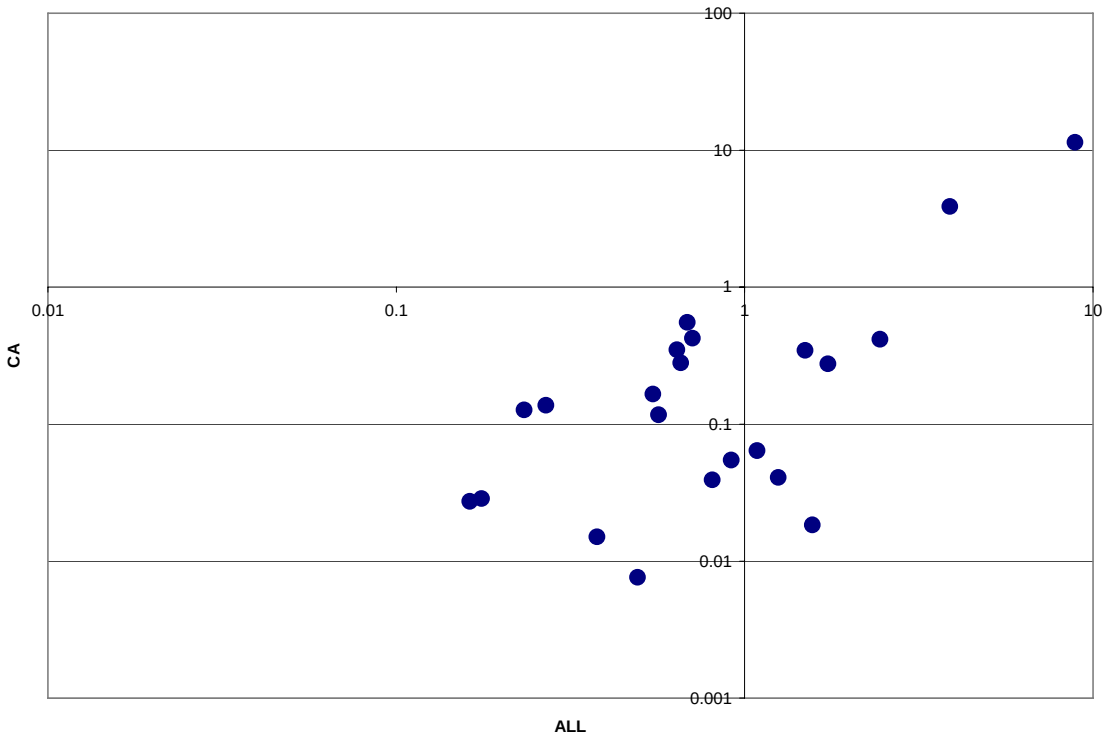

Figure 1b. Average larval densities (Mexico and the "core" area) versus larval densities for the "core" area based on CalCOFI surveys that covered Mexico and the "core" area (1951-1984).

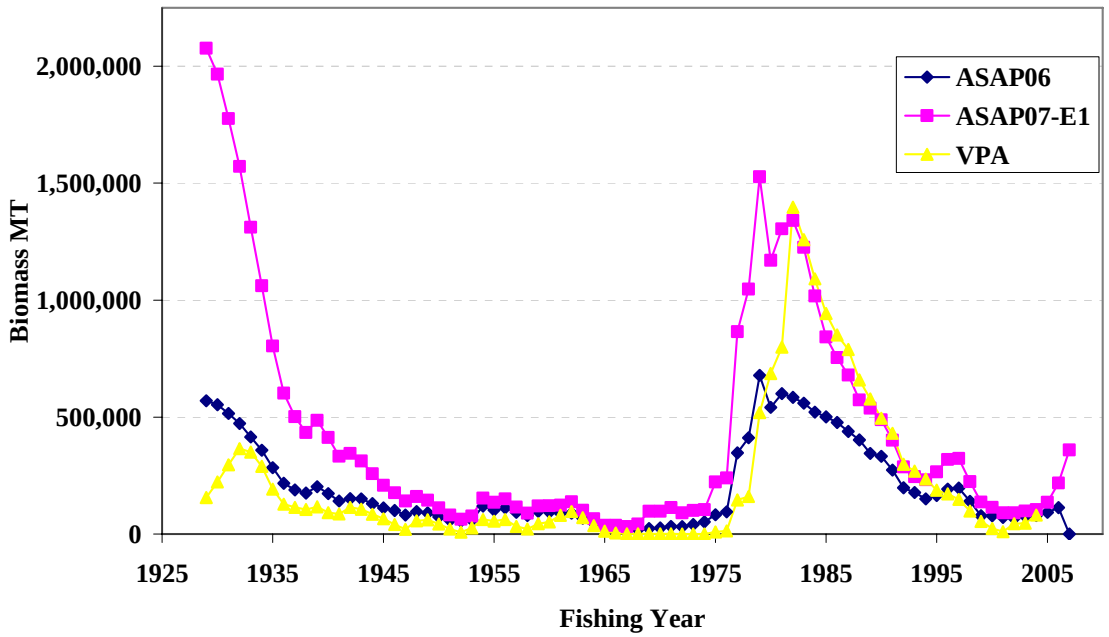

Figure 2. Estimated biomass (age 1+ fish, B in mt) of Pacific mackerel generated from the VPA (2006 assessment), and the ASAP-BaseCase model for the 2007 assessment.

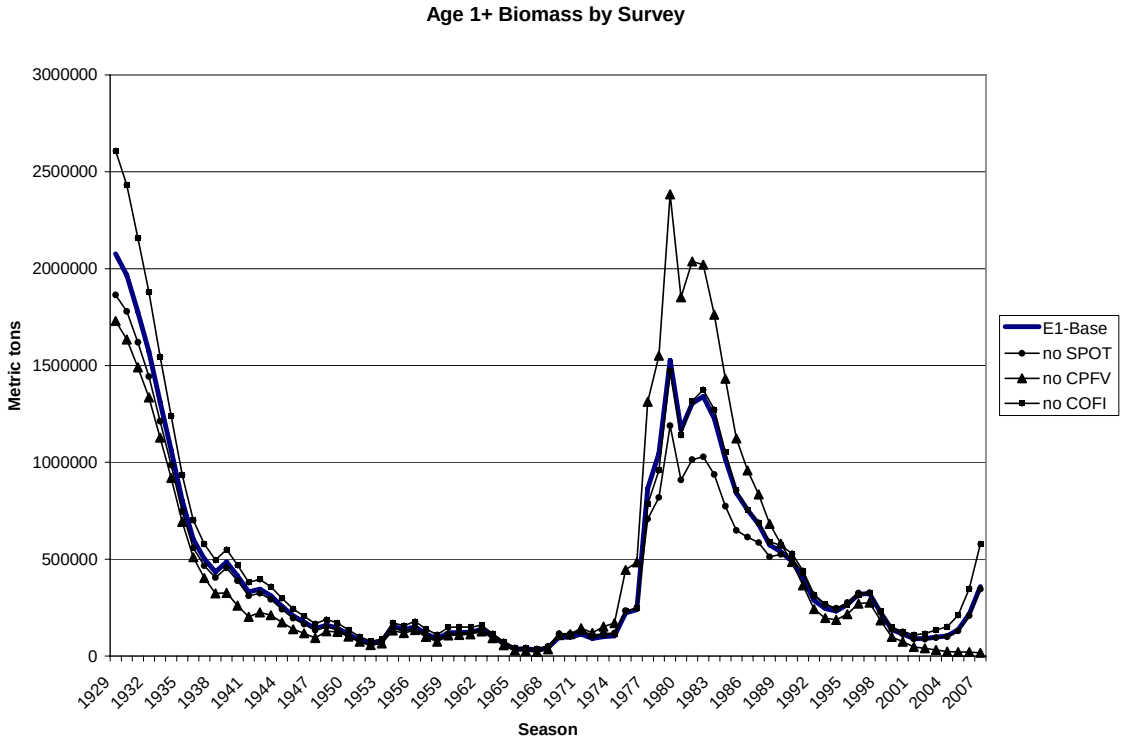

Figure 3. Sensitivity of Base-Case ASAP Model to Indices of Abundance.

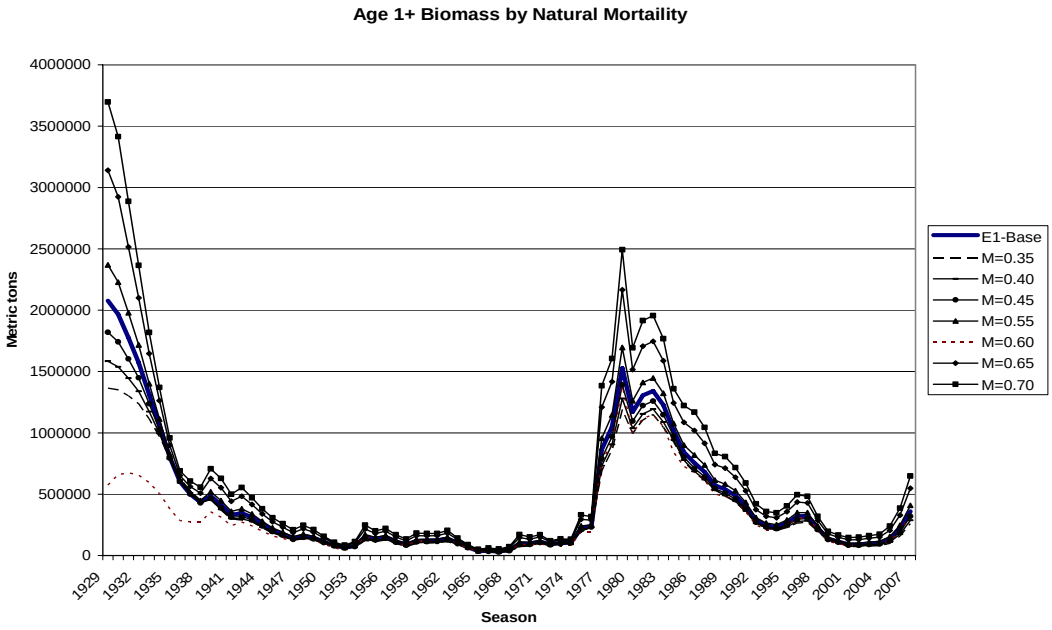

Figure 4. Sensitivity of Base-Case ASAP Model to Natural Mortality.

Table 1
Measures of age-reading error

	Age							
	0	1	2	3	4	5	6	7+
APE	0.298	0.276	0.158	0.150	0.139	0.112	0.111	0.096
CV	0.888	0.758	0.447	0.423	0.408	0.338	0.343	0.286

Appendix 1

STAR Panel Members in Attendance
Mr. Tom Jagielo (Chair), SSC - Washington Department of Fish and Wildlife
Dr. André Punt, SSC - University of Washington
Dr. Malcolm Haddon, CIE - University of Tasmania
Mr. Dale Sweetnam, CPSMT - California Department of Fish and Game
Ms. Diane Pleschner-Steele, CPSAS - California Wetfish Producers Association

STAT Members in Attendance
Dr. Emmanis Dorval, NMFS, Southwest Fisheries Science Center (SWFSC)
Dr Kevin Hill, NMFS, SWFSC
Dr. Nancy Lo, NMFS, SWFSC
Ms. Jennifer McDaniel, NMFS, SWFSC

Others in Attendance
Mr. Mike Burner, Pacific Fishery Management Council
Dr. Ray Conser, NMFS, SWFSC
Dr. Paul Crone, NMFS, SWFSC
Dr. Sam Herrick, NMFS, SWFSC
Mr. Jason Larese, NMFS, SWFSC
Dr. Mark Maunder, Inter-American Tropical Tuna Commission (IATTC)
Dr. Kevin Piner, NMFS, SWFSC
Mr. Alexandre Silva, IATTC