Pacific Mackerel

DRAFT STAR Panel Meeting Report

NOAA / Southwest Fisheries Science Center
La Jolla, California
May 4-8, 2009

STAR Panel Members:
André Punt (Chair), Scientific and Statistical Committee (SSC), Univ. of Washington
Owen Hamel, SSC, NMFS, Northwest Fisheries Science Center
Gary Melvin, Center for Independent Experts (CIE),
Alec MacCall, External Reviewer, Southwest Fisheries Science Center (SWFSC)
Ken Burnham, External Reviewer, Colorado State University

Pacific Fishery Management Council (Council) Representatives:
Greg Krutzikowsky, Coastal Pelagic Species Management Team (CPSMT)
Mike Okoniewski, Coastal Pelagic Species Advisory Subpanel (CPSAS)
Mike Burner, Council Staff

Pacific Mackerel Stock Assessment Team:
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Kevin Hill, NMFS, SWFSC
Jenny McDaniel, NMFS, SWFSC
Nancy Lo, NMFS, SWFSC

1) Overview

The Pacific mackerel Stock Assessment Review (STAR) Panel (henceforth, referred to as Panel) met at the Southwest Fisheries Science Center (La Jolla, CA) from May 4-8, 2009 to review a draft assessment by the Stock Assessment Team (STAT) for Pacific mackerel. Introductions were made (see list of attendees, Appendix 1), and Mike Burner (Council Staff) reviewed the Terms of Reference for coastal pelagic species (CPS) assessments with respect to how the Panel would be conducted. Draft assessment documents, model input and output files, and extensive background material (previous assessments, previous Panel reports, Science and Statistical Committee (SSC) statements, etc.) were provided to the Panel in advance of the meeting on a file-transfer protocol (FTP) site, which served as a timely and convenient means to distribute the material 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.

Paul Crone, with assistance from Nancy Lo, led the presentation on the draft assessment.

The previous assessments (2007, 2008) were conducted using the Age-structured Assessment Program (ASAP) model and included catch combined from the commercial and recreational fisheries, age data from the commercial fishery, and three indices of relative abundance: commercial passenger fishing vessel (CPFV), spotter, and California Cooperative Oceanic Fisheries Investigations (CalCOFI). However, the ASAP model was not capable of including length-composition data and thus, it was not possible to independently estimate the selectivity pattern for the recreational fishery (and hence that for the CPFV index). In addition, the version of the ASAP model on which past assessments have been based assumed that the weight-at-age for the catch is the same as that for the population, which implies that any stock recruitment relationship may be biased. Further, selectivity parameterization in the ASAP model could not be adequately evaluated, given limitations addressing fishery (e.g., time blocks specific to a single fishery only), index (e.g., must be linked to a fishery or fixed accordingly), and selectivity-at-age estimation (e.g., strictly by age, with no capability of examining underlying functional forms, such as normal- and logistic-related distributions). Finally, the ASAP model does not allow alternative assumptions to be explored regarding 'beginning year' dynamics associated with the fish/fishery, i.e., formulation of population abundance in the first year of the model time period cannot be perturbed to evaluate equilibrium vs. non-equilibrium initial conditions or related issues surrounding initial age composition, recruitment, and fishing mortality.

There have been attempts to change the modelling platform from ASAP to Stock Synthesis (SS) over the past few years. While this was not successful in the past, it was again the goal for this assessment. The objectives of the STAT in developing the draft assessment were to:

(1) build the ASAP "management model," i.e., update the current ASAP model using new data;
(2) construct an SS alternative base-model that mirrors ASAP;

(3) develop a suite of alternative SS models that is an improvement to the SS base-model; and
(4) choose a preferred SS model from the suite of alternative models.

The STAT achieved these four objectives. The Panel agreed that the SS baseline model was adequately equivalent to the ASAP model. The suite of alternative SS models included changing to a quarterly time step, adding length frequency data for the recreational fleet, estimating selectivity patterns for the commercial and recreational fleets, and removing or revising the spotter and/or the CalCOFI indices. The STAT preferred model in the draft assessment (S1_qa25) did not include the spotter and CalCOFI indices, and allowed for estimation of commercial selectivity in three time blocks and recreational selectivity for a single time block. Selectivity for the CPFV index, which is based on the recreational fishery, was set equal to that recreational fleet.

There was considerable discussion during the meeting regarding the relative usefulness of the indices, as well as a number of modelling issues. These are detailed in Section 2 of this report. In particular, the details of the CalCOFI data collection and analysis were discussed in some detail. While several ways of improving the treatment of CalCOFI data were suggested, the lack of information from Mexico, the preponderance of zeroes in the data, and the conflict in relative scale with the CPFV index led to the conclusion that a CalCOFI index should not be included in the base-model, or in alternative models in its current form. A blocked (super year) version of the CalCOFI index was developed during the meeting for consideration. However this index, while more consistent with the final base-model, was not included in this model. Further, at this time, the general consensus from both the Panel and STAT was to also remove the spotter survey index from future SS models, given documented concerns regarding spatial sampling biases over time and subsequently, its abbreviated status in the current model (i.e., time series ends in 2002).

The final base model ("AA") returned to an annual time step, had an increased input σ_R of 1.0, doubled the weight on the recreational length compositions compared to that in model S1_qa25 and continued to exclude both the CalCOFI and spotter indices. An alternative model ("AB") was also produced, but was not fully developed. This model reflected a recent change in selectivity using an additional selectivity time block for both the recreational and commercial fisheries starting in 2000 and by splitting the CPFV index in 2000. This alternative model improves the fit by about 40 log likelihood points, is more consistent with the low commercial fishery catches in recent years, and removes the conflict with the CalCOFI index even though the fit to that index was not included in the likelihood. The biomass at the end of the time period for this alternative model is lower than for the final base-model (Fig. 1), and, although there are plausible reasons why a change in selectivity and/or catchability might have occurred around 2000, it is not clear that the magnitude of the change is accurately reflected in this model.

The Panel reiterates the recommendations from previous CPS Panels that standard data processing procedures be developed for CPS species, similar to those developed for groundfish species, and that a 'data document' be developed that provides, in considerable detail, how the basic data sources (e.g., catches, CPFV indices, etc.) are constructed. Much of this information has been published in the past, but a single (and

'living') document describing the basic data will assist assessment authors and future review panels.

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.

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

The STAT presented the equivalent of an update assessment by applying the ASAP model on which the last assessment was based using updated data, and also a generally equivalent SS model S1_aa. The Panel agreed that the SS model was adequately equivalent to the ASAP model. The STAT then changed the time step of the model from annual (model S1_aa) to seasonal or quarter (model S1_qa), and showed a suite of alternative models working forward from S1_qa. The STAT preferred base-model, S1_qa25, did not include the spotter or CalCOFI indices. The Panel moved forward in evaluating S1_qa25 and requesting sensitivities to this model.

A: The Panel requested information about potential area block effects in the CPFV fishery and index. Area blocks are not currently used in the analysis of these data. In particular, it would be useful to see the distribution of effort and catch by block, and a list of potential explanatory variables.

Rationale: Area block effects may be important in determining catch rate and therefore should be considered. Moreover, there may have been changes in fishing practices in recent years given the considerable changes in management arrangements over this period.

Response: The distribution of fishing effort has not changed in a substantial manner across years. However overall effort has decreased (Appendix 2).

B: The Panel requested a new treatment of the CalCOFI data: (a) construct time blocks of six years duration (weighted average P_h values) starting with the first year in which a new net was used (1978) and use only data from off of California (not Mexico), and (b) construct a separate series of 6-year blocks using all data (including data from Mexico) for the years prior to 1978. Within each 6-year block, weight the annual mean egg counts by the number of tows each year. Use the root mean squared error (RMSE) to determine a constant standard deviation (SD) in log space (= constant coefficient of variation [CV] in real space).

Rationale: This is a way to deal with zeroes in the data, to smooth year to year variability, while still allowing data to be used to inform different periods.

Response: New indices were produced as requested.

The STAT presented the results of two sensitivities that had been discussed but were not formal requests:

(i) The Panel was concerned about possible bias in the CPFV data since 2004. However, removing the CPFV index data prior to 2006 from the assessment leads to a catastrophic and unsupported decrease in biomass. Removing only the 2007 and 2008 CPFV indices aggravates the potential bias. The Panel agreed that removing the CPFV index data from 2004 was not sensible.

(ii) The Panel was interested in seeing the impact of adding an extra block for commercial selectivity from 2000 onwards. In this configuration, selectivity for age 0 increases and for age 6 decreases. This line of inquiry was continued with request "E" below.

C: Start the model later than 1962 (once the stock begins to increase).
Rationale: There isn't much information to inform the beginning of the current model.
Response: The Panel assigned this task low priority and, while models with alternative start-years were explored, the Panel ultimately decided to retain the STAT choice of 1962 for the start year of the model.

D: Force commercial selectivity to be asymptotic in the final time block.
Rationale: To see if there is a substantial change in likelihood; the current decrease in selectivity with age occurs at an age to which few animals would survive, given the assumed value for natural mortality, and so this decline may be based on few data and have little impact.
Response: Forcing asymptotic for the commercial fishery resulted in changes to the biomass trajectory (a lower peak in the mid-1980s). Also, the objective function increased from 3390.7 to 3412.66 with three fewer estimated parameters. The biggest impact of the change appears to be on recreational selectivity, with much lower selection for the younger ages. Forcing asymptotic selectivity for the commercial fishery did not impact the fits qualitatively, although the likelihood values suggested that the model fits the age-composition data better, the recreational length compositions worse, and the survey index somewhat better.

E: Add an additional selectivity time block from 2000 onwards for both the recreational and the commercial fisheries.
Rationale: To better reflect current fisheries.
Response: Under this model configuration, the biomass collapses in recent years and there are marked changes in selectivity for the recreational fishery. Allowing for a change in selection in 2000 led to a reduction in the objective function from 3390.7 to 3345.9 with an additional 12 estimable parameters. The model fitted the survey index and the age- and length-compositions better, but fitted the size-at-age data worse. The Panel noted that this model configuration assumed that catchability remained constant for the recreational fleet and therefore considered a follow-up analysis in which separate catchability parameters were estimated pre- and post 2000 (see "O" below).

F: Use and estimate double normal length-based selectivity for the recreational fishery.
Rationale: To better fit the length data: fish are growing quickly at a young age, and the smallest mackerel (<10 cm) appear not to be selected, but the model with age-based selectivity predicts that such animals should be caught in the recreational fishery.
Response: The fit to the recreational length-frequency data was better in that no small fish were estimated to be caught. However, this modification did not change the overall biomass trajectory and the objective function was larger than when selectivity was assumed to be age-based (3404.3 vs. 3390.7). The STAT stated it would prefer to assume that selectivity is age-based. The eventual change back to annual time steps for the final

base model resolved the mismatch of season-independent age-based selectivity and rapid growth within the first year.

G: Remove the largest (> 55 cm) and smallest (<10 cm) animals from the recreational length compositions by setting these to zero.
Rationale: Large fish in the length compositions may be misidentifications of other species as Pacific mackerel fish may be misidentified as Pacific mackerel, and small fish are rare and not representative.
Response: This was not completed during the Wednesday round of requests. A revised request is given at "Q" below.

H: Use annual time step instead of a quarterly time step.
Rationale: This may improve the fit to the age- and length-composition data because age-based selectivity that does not account for growth within the year.
Response: The STAT ran an annual model based on the specifications of model S1_qa25, but did not estimate the selectivity parameters. See "H2" below for a model configuration which did implement the specifications requested by the Panel.

I: Ignore ageing error.
Rationale: The model cannot fit large catches of a single year-class due to smoothing across year-classes. Ageing error appears to be too high at least for 0- and 1-year-olds (in some years).
Response: Ignoring ageing error led to lower estimated biomass during the 1980s and at the end of the modelled period. However, while the fits to the age-compositions were improved, those to the survey index and size-at-age data were poorer. The Panel agreed to retain the current ageing error matrix and recommended that better quantifying ageing error remain a research priority.

J: Remove the size-at-age data from 1974 through 1980.
Rationale: The model does not fit the size-at-age data well during these years. Ignoring these data allows the impact of this misfit to be explored.
Response: Ignoring the size-at-age data resulted in an increase to the estimates of the biomass during the 1980s and at the end of the time series. There appears to be a conflict between the size-at-age and the length-composition data. The model behaved generally as expected, and without a large impact on current biomass when these data were omitted. The STAT and Panel agreed that this is not a major source of sensitivity.

K: Divide the CV on the last CPFV index data point by 100 to force the model to get closer to this data point.
Rationale: This will force the model to get closer to the last CPFV data point and reveal what in the data is causing the model to not fit this point.
Response: This sensitivity behaved as expected; the trajectory of predicted CPFV catch per unit of effort (CPUE) was forced through the last point in the CPFV series. One of the selectivity parameters hit a bound.

L: Add in the new (time-blocked) CalCOFI indices (from Request B).
Rationale: To see if these data can be fit adequately and if they inform the model.

Response: This had little impact on the results. The model shows a plausible fit to the five data points in the second blocked CalCOFI time series. The first blocked CalCOFI time series contains only two points in the period considered by the model, and is therefore not informative.

M: Model with new CalCOFI indices in and CPFV index out.
Rationale: To see if the revised CalCOFI index provides enough information to drive the model, and what is the result.
Response: This run did not converge.

H2: Repeat request "H" as intended (i.e. a model exactly like S1_qa25 except with annual time steps).
Rationale: This is what the Panel asked for in "H" above.
Response: There are trade-offs between the seasonal and annual models. The STAT stated that it preferred to use the annual model for the current assessment, and planned to explore quarterly models again in the future. The SS model may need to be revised to better address quarterly time-steps. **This model configuration became the working base-model.**

N: Make commercial selectivity time block from 1978-present asymptotic (based on the working base-model).
Rationale: As for request "D".
Response: The estimated biomass during the 1980s and recently is again lower.

O: Add an additional selectivity time block from 2000 onwards for both the recreational and commercial fisheries. Split the CPFV index into two series (still mirroring recreational selectivity).
Rationale: This is a potential alternative model which may more accurately reflect the reality of recent fishery selectivities.
Response: The hessian matrix did not invert. See request "U" below.

P: As for request "O", except that the post-1980 blocked CalCOFI index is included in the objective function.
Rationale: As for "O", except also to determine if the model can fit the CalCOFI index and if its inclusion has an effect on biomass estimation.
Response: The biomass estimates were substantially larger historically than for the working base-model, but similar to those from the working base-model at present. The selection patterns for the recreational and commercial fisheries during the recent period appear similar to those during the 1970s The model appeared able to fit the blocked CalCOFI index, although the very low point at the end of the time series gets very high weight due to the assumption of a constant CV (constant SD in log space).

Q: Drop all fish larger than 55 cm from the length-frequency data for the recreational fishery.
Rationale: Large fish may be misidentified, data may be anomalous.
Response: The results were qualitatively identical to those for the working base-model. The STAT and Panel agreed not to delete these data.

R: Conduct a series of model runs based on the working base-model to determine the relationship between the input and output values for σ_R. Consider input σ_R values of 0.7, 0.9, 1.1, and 1.3. Also, try once (using linear interpolation) to match the input and output σ_R values.
Rationale: The output σ_R is about 1.1 for the working base-model (input σ_R = 0.7). Try to find where the input and output σ_R values match by increasing the input σ_R.
Response: The output σ_R continues to be larger than the input σ_R, even when the input σ_R exceeds 2.0. See also request "S".

S: Show detailed results for the working base-model when σ_R is set to 1.0.
Rationale: Similar to one iteration for an original input σ_R of 0.7 with one significant digit.
Response: Small changes overall, the output σ_R is closer to the input value than before. **The STAT and Panel agreed to make this model the working base-model.**

T: Using the working base-model (see "S"), reduce λ for the age-composition data to 0.25 and increase λ for the length-composition data to 2.0.
Rationale: Reducing the emphasis on the commercial age-composition data and increasing that on the recreational length-composition data allows the input and effective sample sizes to match better.
Response: The entire biomass time-series was lower. The fit to the CPFV index was better, the output σ_R was 0.994, and the effective and input samples sizes for the recreational and commercial composition data matched better. However, one of the selectivity parameters hit a bound. The Panel and the STAT discussed whether this model reflected better performance and whether it should (following resolution of the bound problem) form the base-model. See request "V" below.

U: Repeat request "O", but with the working base-model.
Rationale: To carry forward the alternative model.
Response: Age-0 animals are now fully-selected by the commercial fishery in the last time-block. The fits to the CPFV series are good while those to the age- and length-composition are similar to those for the working base-model. The objective function is lower (1309.4 vs. 1347.2) with 10-15 additional parameters. The Panel noted that run "P" led to higher biomasses, but dropping the last CalCOFI data point led to results more similar to run "U". This suggests that the very low data point at the end of CalCOFI series is very influential because of the assumption of a constant SD in log space for all data points. The Panel concluded that there is very little information in the new time-blocked CalCOFI index (except that caused by the way the variances had been specified).

V: Repeat request "T" "fixing" the selectivity bound problem.
Rationale: This is the tentative base-model and the Panel wanted to check that the bound had no qualitative impact on the model outputs.
Response: There was a "crash penalty" in the early 1960s (see request "W").

W: As for request "V", but starting the model in 1969.
Rationale: To keep reweighting in and hopefully eliminate the crash penalty.
Response: This model continued to hit bounds, suggesting that starting the model later did not resolve the crash penalty problem.

AA: Using model "S", increase the weight on the recreational length-frequency data by a factor of 2, but do not down-weight the age-composition data (start the model in 1962).
Rationale: Apply reweighting where possible, see if model behaves.
Response: This model configuration fit all of the data sources adequately and the match between the effective and input sample sizes was improved compared to the working base-model. **The STAT and Panel agreed that this model configuration would be the final base-model.**

AB: Repeat "O" for the final base-model (AA) – i.e. add an additional selectivity time block from 2000 onwards for both the recreational and commercial fisheries, and split the CPFV index into two series (still mirroring recreational selectivity).
Rationale: This is the major sensitivity identified, so the Panel wished to see it relative to the final base-model.
Response: This alternative model is more consistent with the relative difficulty in catching Pacific Mackerel in recent years. The biomass at the end of the time period is lower than for the final base model. While there are reasons to believe a change in selectivity may have occurred sometime in the vicinity of 2000, this run does not represent a full exploration of the possibilities regarding this change. Adding in any time block where all selectivities and catchabilities change will necessarily lead to overfitting of data and some loss of signal. None-the-less, this model configuration represents an important sensitivity to the base model

The key features of the final base-model are:

- Annual time-step.
- σ_R set to 1.
- The weight on the recreational length-frequency data set to the actual number of fish measured divided by 12.5 (25 divided by 2 - twice the weighting used in model configurations in general).
- Fitted only to the CPFV index.

The Panel recommended that the assessment document that will be presented to the Council in June should focus on the final base-model (additional sensitivity tests should, of course, be conducted and documented). The alternative model (AB) should be included in the report, noting that it represents an alternative plausible view of the situation, but that there is no direct evidence (except model fit) to support splitting the recreational data in 2000. The comparison between the ASAP model and the corresponding SS model (S1_aa) should be included in an Appendix.

3) Technical Merits and/or Deficiencies of the Assessment
The SS model is an improvement over the ASAP model, given its capability of including a broad range of data sources and its underlying flexibility addressing critical areas of model development, including overall estimation methods, virgin state dynamics,

biology, selectivity, catchability, and projections. The Panel supports the STATs base model ("AA") as the basis for management advice with the caution that there is a plausible alternative model indicating a severe decline in the resource.

4) Areas of Disagreement

There were no major areas of disagreement between the STAT and the Panel. There was disagreement within the Panel whether the assumption that 12.5 equals 25 divided by 2 was properly documented.

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.

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. Previous Panels recommended that efforts be made to obtain biological sampling data from the Mexican component 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. Obtaining data from the Mexican fishery might help remove this important source of uncertainty.
2) 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 based on fishery-dependent data, the use of CPFV index in the assessment as an index of stock abundance is predicated on the assumption that catchability and selectivity have not changed over time, or that the changes have been adequately included in the model configuration.
3) The outcomes from models AA and AB differ markedly for the recent years. It is unlikely that either model AA or AB captures the temporal pattern of selectivity and catchability for the CPFV fleet perfectly.

6) Research Recommendations

A. Collect biological data on mackerel caught in Pacific NW.
B. Improve collaboration with fishery researchers from Mexico and Canada. 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 related biological data from the Mexican fisheries for inclusion in stock assessments.
C. The data on catches come from several sources. The catch history from 1926-27 to present should be documented in a single report.
D. Reconsider the suite of indices and make recommendations for future assessments.
E. Review and analyse the raw data on which the CPFV index is based and consider area blocks as a factor in generalized linear models (GLMs).
F. Bolster the current monitoring program for CPFV fleet to improve data collection.
G. Look at correlation of Pacific mackerel catch in CPFV with other CPS species to explore the possibility of changes in targeting practices within the CPFV fleet across years. Perhaps apply the MacCall and Stephens subsetting approach.

H. Increase support of current port sampling and laboratory analysis programs for CPS. In particular, there is need to reanalyse biological parameters such as maturity-at-age, ageing error, sex ratio, sex-specific parameters, and natural mortality rates (*M*), including the possibility of larger *M* on 0- and 1-year-old Pacific mackerel.
I. Ageing error should be revisited. There are currently very few otoliths that have been read multiple times so additional readings need to be made. 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 and other validation methods.
J. Conduct a study to update the information used to determine maturity-at-length (and maturity-at-age).
K. Do more research/assessment on related/competing species including anchovy and jack mackerel.
L. Future SS assessments should consider fitting to the length-composition and the conditional age-at-length information. This may require estimating time-varying growth curves and may require multiple time-steps within each year.
M. Future assessments should consider sex-structured models.

The developers of SS should be requested to modify the seasonal model so that age-based selectivity more correctly handles within-year changes in age. In addition, the output viewer appeared to contain some glitches when applied to output from a seasonal model. The viewer made the work of the Panel much easier and its development (and refinement) should continue. One suggestion is that it should be made easier to specify output of only a subset of the possible plots.

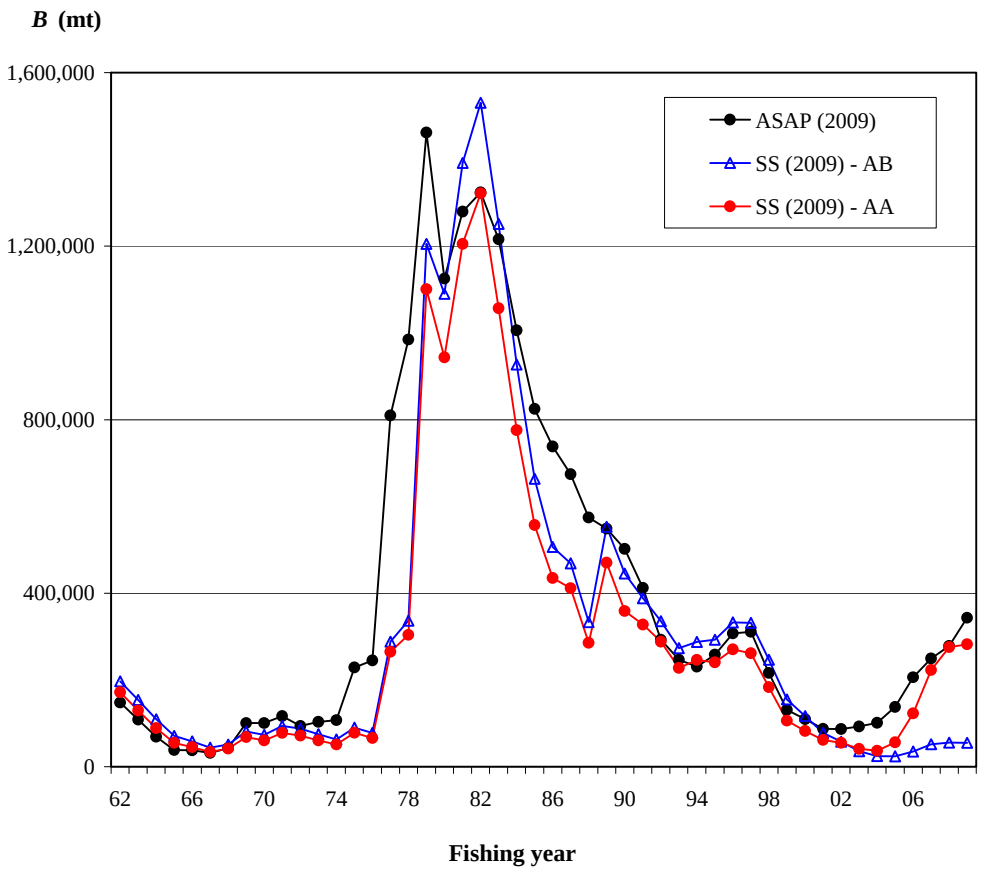

Figure 1. Time-trajectory of 1+ biomass from the ASAP model, the final base-model (AA), and the alternative model (AB).

Appendix 1

STAR Panel Members:
André Punt (Chair), Scientific and Statistical Committee (SSC), Univ. of Washington,
Owen Hamel, SSC, NMFS, Northwest Fisheries Science Center
Gary Melvin, Center for Independent Experts (CIE),
Alec MacCall, External Reviewer, Southwest Fisheries Science Center (SWFSC)
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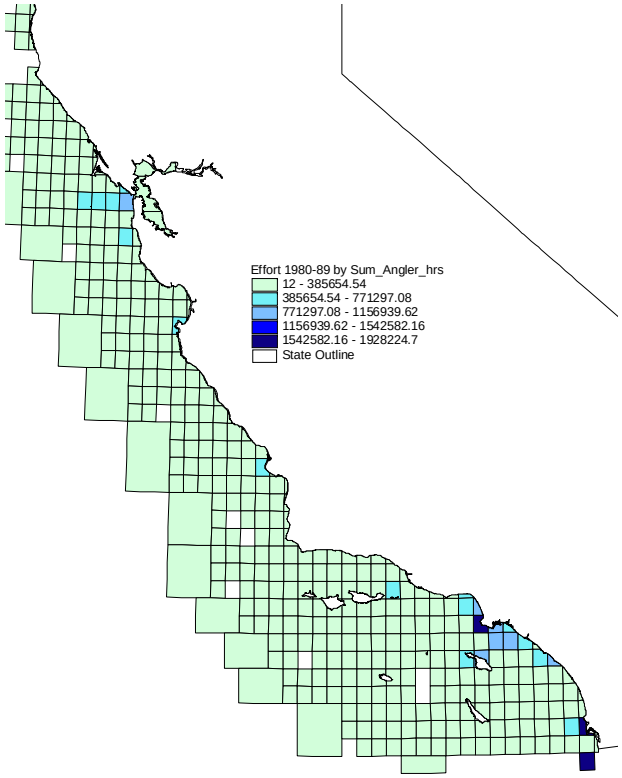
Nancy Lo, NMFS, SWFSC

Others in Attendance
Alexandre Aires-da-Silva, Inter-American Tropical Tuna Commission (IATTC)
Briana Brady, California Department of Fish and Game (CDFG), CPSMT
Tom Barnes, CDFG, SSC
Ray Conser, SWFSC, SSC
Doyle Hanan, Hanan and Associates
Sam Herrick, SWFSC, CPSMT
Rodger Hewitt, SWFSC
Ryan Kapp, Astoria Fisherman
Josh Lindsay, NMFS, Southwest Regional Office
Mark Maunder, IATTC
Sam McClatchie, SWFSC
Jonathan Phinney, SWFSC
Kevin Piner, SWFSC
Dianne Pleschner-Steele, California Wetfish Producers Association, CPSAS
Rosa Runcie, SWFSC
John Rutter, SWFSC
Bob Seidel, Astoria Holdings Inc.
Sarah Shoffler, SWFSC
Dale Sweetnam, CDFG, CPSMT
Akinori Takasuka, SWFSC
Russ Vetter, SWFSC
Ed Weber, SWFSC

Appendix 2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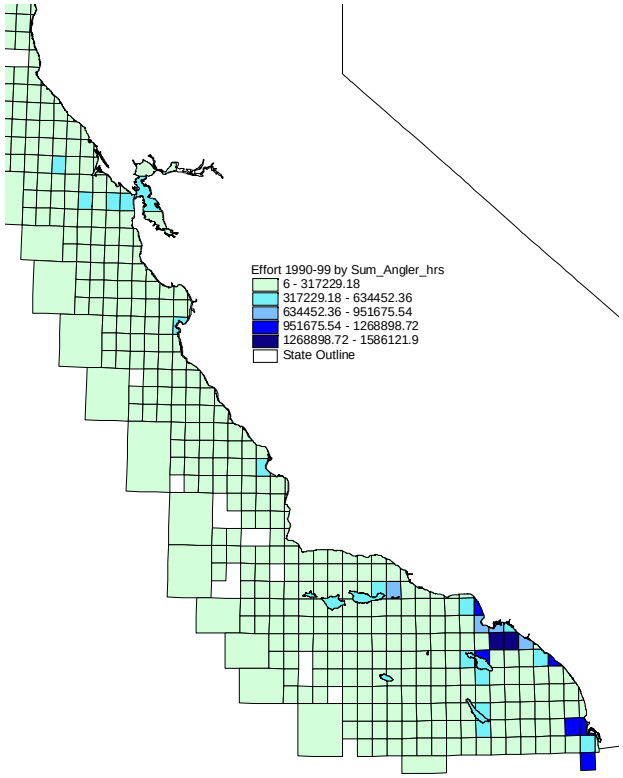
State Outline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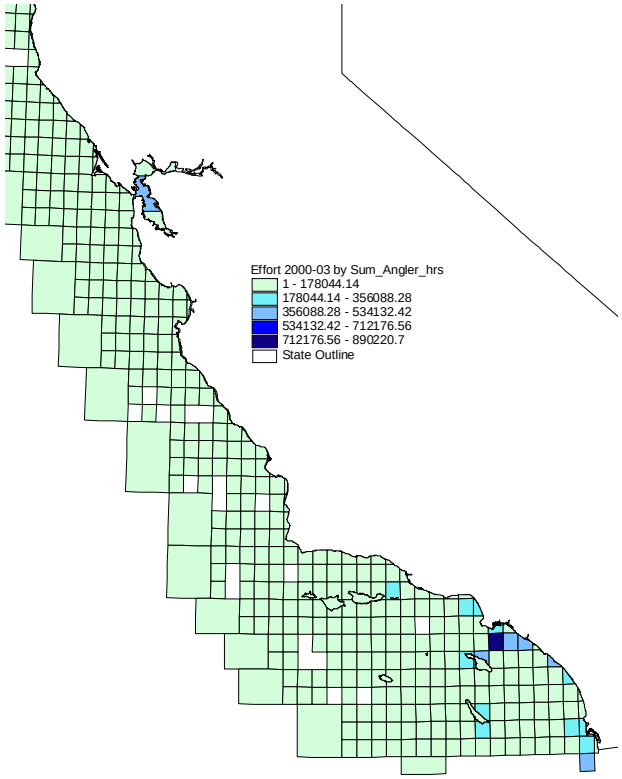
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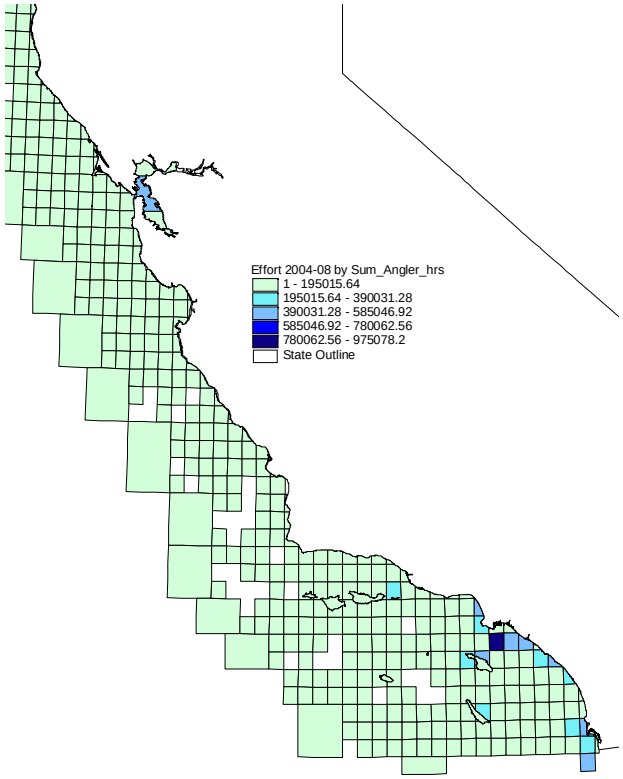
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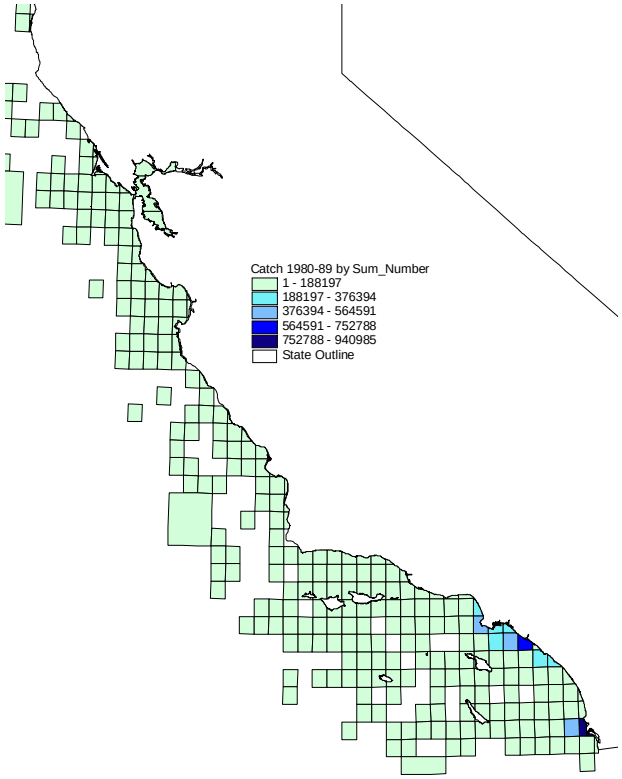
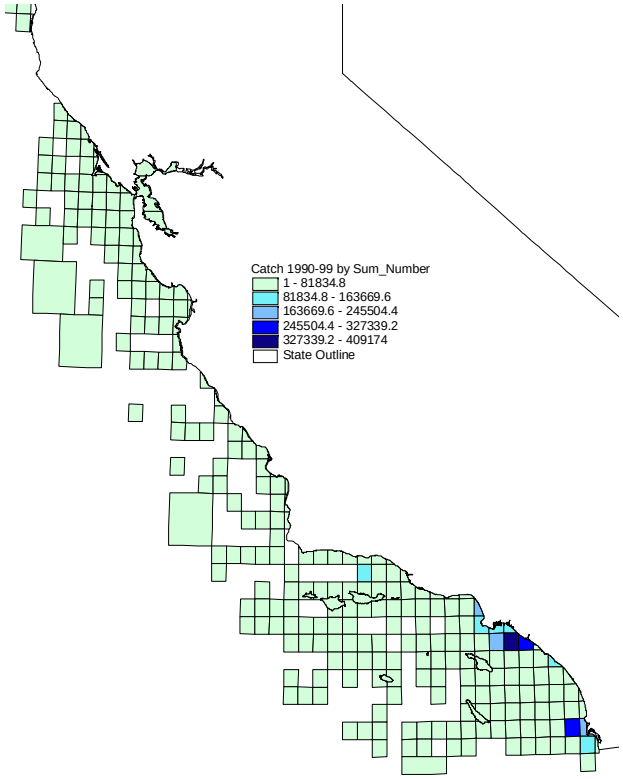
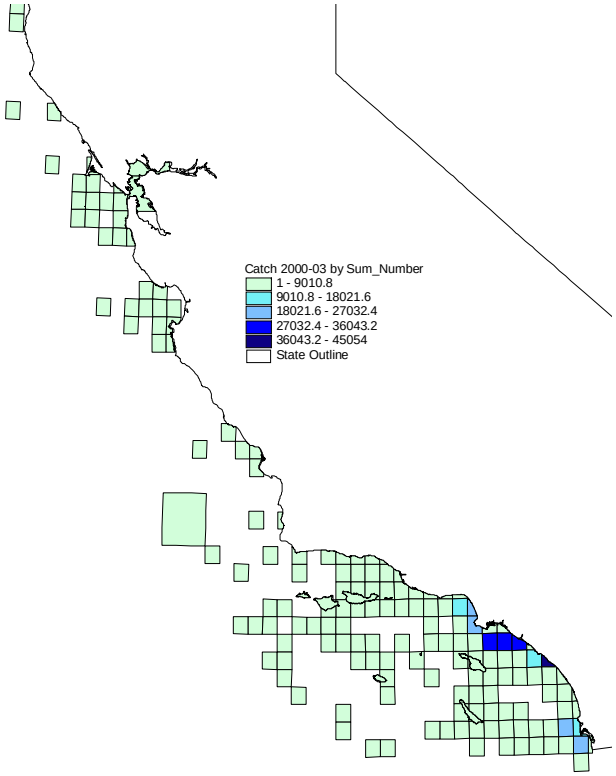
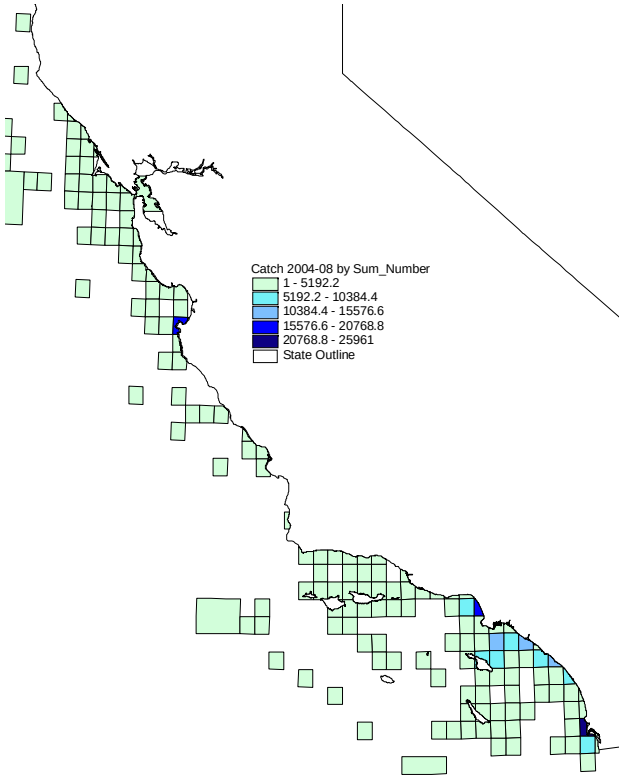
State Outline


Catch 1980-89 by Sum_Number
1 - 188197
188197 - 376394
376394 - 564591
564591 - 752788
752788 - 940985
State Outline


Catch 1990-99 by Sum_Number
1 - 81834.8
81834.8 - 163669.6
163669.6 - 245504.4
245504.4 - 327339.2
327339.2 - 409174
State Outline


Catch 2000-03 by Sum_Number
1 - 9010.8
9010.8 - 18021.6
18021.6 - 27032.4
27032.4 - 36043.2
36043.2 - 45054
State Outline


Catch 2004-08 by Sum_Number
1 - 5192.2
5192.2 - 10384.4
10384.4 - 15576.6
15576.6 - 20768.8
20768.8 - 25961
State Outline