APPENDIX 2

2006 PACIFIC MACKEREL STOCK ASSESSMENT, JUNE 2006 SCIENTIFIC AND STATISTICAL COMMITTEE STATEMENT, AND 2004 STOCK ASSESSMENT REVIEW PANEL REPORT

The 2006 Pacific mackerel stock assessment and harvest guideline for 2006-2007 fishery management will be reviewed at the June 2006 Council meeting and can be found at the Council web page at the address below.

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PACIFIC MACKEREL (*Scomber japonicus*) STOCK ASSESSMENT FOR U.S. MANAGEMENT IN THE 2006-07 FISHING YEAR

by

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Pacific Fishery Management Council
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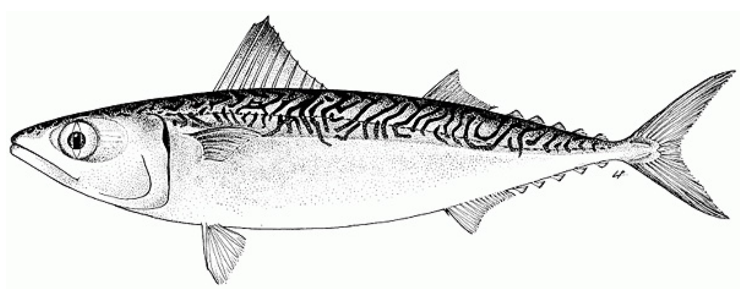
May 24, 2006



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PREFACE

A Pacific mackerel stock assessment is conducted annually in support of the Pacific Fishery Management Council (PFMC) process, which ultimately establishes a harvest guideline (HG or quota) for the fishery that operates off the U.S. Pacific coast. The HG for mackerel applies to a fishing/management season that spans from July 1st and ends on June 30th of the subsequent year (i.e., a 'fishing year' basis). The primary purpose of the assessment is to provide an estimate of current abundance (in biomass), which is used in a harvest control rule for calculation of annual-based quotas. For details regarding this species' harvest control rule, see Amendment 8 of the Coastal Pelagic Species (CPS) Fishery Management Plan (FMP), section 4.0 (PFMC 1998).

The last assessment and quota-setting process was completed in June 2005—setting a 2005-06 'fishing year' (July 1, 2005 – June 30, 2006) quota of 17,419 mt. The 2006-07 stock assessment presented here is an 'update' based on the ASAP model presented to the PFMC in 2005 (see Hill and Crone 2005). In this context, this updated assessment includes an additional year of data associated with sample information used in the overall assessment (e.g., from ongoing fishery-dependent and fishery-independent sampling programs), with similar model parameterizations as the analysis conducted in 2005. Also, sensitivity analysis related to the ASAP (2006) baseline model was conducted based on recommendations from previous reviews within the Science and Statistical Committee (SSC) and Coastal Pelagic Species Management Team (CPSMT) forums. In this context, an 'updated' stock assessment is presented here that follows PFMC protocols for 'off year' (i.e., years in which no Stock Assessment Review, STAR, takes place) population assessments of coastal pelagic species. Readers interested in further details regarding the sample data and model parameterizations used in this assessment should consult Hill and Crone (2005). The next formal STAR for Pacific mackerel is scheduled for 2007. Finally, electronic versions of model programs, input data, and displays (table and figures) can be obtained from the authors directly.

Stock distribution

There are possibly three spawning stocks of Pacific mackerel (*Scomber japonicus*) along the Pacific coasts of the U.S. and Mexico: one in the Gulf of California; one in the vicinity of Cabo San Lucas; and one extending along the Pacific coast north of Punta Abreojos, Baja California. The latter "northeastern Pacific Ocean" stock is harvested by fishers in the U.S. and Baja California, Mexico, and is considered in this assessment.

In terms of the U.S.-related management of this species through the PFMC, the northeastern Pacific Ocean population assessed here is considered an independent stock, with no area- or sector-specific allocations. The PFMC's harvest control rule does, however, prorate the seasonal HG by a 70% portion assumed to reside in U.S. waters, see PFMC (1998) and Management below.

Data

<u>Landings</u>

Pacific mackerel landings from both commercial and recreational fisheries in California and commercial landings in Baja California represent the catch time series (1929-06) used in the assessment, with estimates from all three fishing sectors pooled and treated as a single fishery within the model. Landings were aggregated on a fishing year (see Preface above) basis (Figure 1). For purposes of providing a HG for the 2006 fishing year (July 1, 2006-June 30, 2007), we assumed landings for April-June 2006 and July 2006-June 2007 would be similar to analogous periods in the previous 2005 fishing year; namely, April-June 2005 and then subsequently, July 2005-June 2006.

Additionally, biological data are collected through a California Department of Fish and Game (CDFG) port (commercial) sampling program. The CDFG has collected biological data on Pacific mackerel landed in the San Pedro (southern California) fishery since 1929. Biological data include the following specimen-based information: weight (whole in g), length (fork in mm), sex, maturity, and otoliths for age determination. Further, to some degree, port sampling data have been collected by researchers from Ensenda, Mexico (Instituto Nacional de la Pesca, INP) since 1989, but this information has not been made available to U.S.-based research teams. Thus, particular stock parameter assumptions (e.g., catch-at-age and weight-at-age distributions) used in the assessment model necessarily are based on using (assuming) sample data applicable to the California commercial fishery. We feel that a lack of Baja California port sampling data is not a serious problem for years when catches from the Mexico fleet are relatively low; however, recently, landings from both fisheries are assumed to be roughly equivalent, which potentially could introduce substantial bias inherent in unrepresentative sampling efforts (see Research and data needs below). The CDFG sample sizes relative to total landings are presented Hill and Crone (2005).

Biological parameters

Catch-at-age

Various sources were used to reconstruct a catch-at-age time series for Pacific mackerel (Hill and Crone 2005). For the most part, age determinations involved ageing research based on otoliths. Seven age classes represent the overall population, beginning with age-0 fish and ending with a 'plus group' for age 6 and older (Figure 2)

Weight-at-age

Year-specific weight-at-age distributions (i.e., a matrix) from fishery samples were developed for inclusion in the assessment model. This matrix was used to calculate population biomass ($\geq$ age-1 fish, *B*) and spawning stock biomass (*SSB*) from estimated population abundance (by age in numbers of fish, *N*) generated from the model efforts. While it is possible that the weight estimates associated with the population-at-large differ from those derived through commercial fishery samples, no such fishery-independent data exist to further explore this uncertainty and thus, we assumed growth was similar for both the population and the fisheries that exploit it.

Maturity-at-age

Maturity schedules were not year-specific, but rather assumed consistent from year-to-year (1929-06): age 0=0%; age 1=7%; age 2=25%; age 3=47%; age 4=73%; ages $\geq$5=100%.

Natural mortality-at-age

Natural mortality estimates were assumed constant across all ages (0-$\geq$6) and years (1929-05), M=0.5 yr^{-1}.

Survey indices of abundance

Fishery-independent survey data used in the ASAP model include (Figure 3): (1) an index ('proportion positive') of spawning abundance based on ichthyoplankton data collected through the ongoing CalCOFI survey; (2) a standardized, catch-per-unit-effort (CPUE) index from California-based commercial passenger fishing vessel (CPFV) logbooks; and (3) a standardized, index of total abundance from aerial 'spotter' plane survey data. The selectivity distributions associated with these three indices are presented in Figure 4 (bottom display). Ultimately, the three survey abundance indices for Pacific mackerel vary in quality both spatially and temporally; however, following recommendations from the previous STAR (conducted in 2004), no single index is proposed to be superior with respect to comprehensiveness or sampling design. Strengths and weaknesses of each survey program are presented in Hill and Crone (2005).

Assessment model

The stock assessment model for Pacific mackerel was developed using a forward-simulation, maximum likelihood-based Age-structured Assessment Program (ASAP). The ASAP model is based on the 'Automatic Differentiation Model Builder' (ADMB) software environment, which is essentially a C++ library of automatic differentiation code for nonlinear statistical optimization. Hill and Crone (2005) and Legault and Restrepo (1998) provide additional details concerning the ASAP modeling platform.

The final (baseline) ASAP model was based on fishery-dependent data from a single fishery, i.e., combined landings from California's commercial and recreational fisheries, and the fishery off Baja California, Mexico (see above). Fishery-independent data used in the model consisted of three relative abundance time series (survey indices) described above. In general, parameterization of the ASAP (2006) baseline model was similar to the final configuration accepted in the previous assessment conducted in 2005. That is, this year's modeling efforts included sensitivity analysis that resulted in a relatively robust baseline model that generally mimicked the model scenario developed in 2005. Sensitivity analysis addressed both time-varying effective sample sizes (1929-60 and 1961-05) and selectivity (1929-65 and 1966-05) associated with the fishery (catch-at-age) data included in the model (Table 1B). Additionally, preliminary sensitivity analysis involved further examining error assumptions associated with recruitment estimation (recruitment 'deviations' from the stock-recruitment relationship), as well as steepness associated with the stock-recruitment relationship. Finally, given the limited scope of this updated assessment, further details (diagnostics, related parameterizations, and results say) regarding the ASAP (2006) baseline model will be made available at the upcoming meeting in May 2006.

Results

Overview

As stated previously, sensitivity analysis resulted in a robust ASAP (2006) baseline model. Results are presented under several broad categories, including likelihood component estimates (Table 1A), as well as other pertinent model-related estimates (e.g., fishery selectivity, fits to survey indices, and stock-recruitment relationship for Figures 4-6, respectively) and finally, management-related estimated time series (e.g., fishing mortality, biomass, spawning stock biomass, and recruitment for Figures 7-10, respectively). Model scenarios associated with sensitivity analysis (conducted resulted in generally similar findings as the baseline model; critical statistics from these model runs are presented in Table 1B.

Fishery selectivity

In general, an asymptotic fishery (catch-at-age distribution) selectivity ogive was estimated within the ASAP (2006) baseline model, with full selection at age 5 and slightly lower selectivity for the plus group (≥age-6 fish), see Figure 4 (top display).

Fits to survey indices

Fits to survey indices are presented in Figure 5. For all of the indices, recent data points were fit relatively well, with some poorly fit years earlier in the time series depending on the index of interest. For example, the abbreviated (i.e., ends in 2000) spotter index of abundance was poorly fit in the middle of the time series in the baseline configuration, as well as other scenarios in the overall sensitivity analysis.

Stock-recruitment relationship

The estimated Beverton-Holt (B-H) stock-recruitment relationship for the ASAP (2006) baseline model is presented in Figure 6. As indicated in last year's assessment findings, the baseline model configuration in 2006 resulted in a relatively low estimated steepness (0.36), i.e., minor compensatory processes acting on the spawning stock at low absolute levels of abundance.

Fishing mortality-at-age

Estimated fishing mortality (*F*)-at-age time series for the ASAP (2006) baseline model are presented in Figure 7.

Biomass

The estimated time series of population biomass (≥age-1 fish, *B*) for the ASAP (2006) baseline model is presented in Figure 8. Estimated *B* for the 2006 fishing year (July 2006-June 2007) was 112,700 mt. As stated previously, the overall *B* time series from this year's baseline model generally mimicked that estimated in 2005.

Spawning stock biomass

The estimated time series of spawning stock biomass (*SSB*) for the ASAP (2006) baseline model is presented in Figure 9.

Recruitment

In general, estimated recruitment (age-0 fish, *R*) was loosely constrained to a B-H stock-recruitment relationship (see above) in the ASAP (2006) baseline model (Figure 10). That is, given that these models are typically highly parameterized, convergence problems and/or unrealistic estimated recruitment precluded strictly unconstrained estimation of this stock parameter; however, the compensatory productivity of the population at low adult stock sizes (i.e., the 'steepness' parameter) was freely estimated.

Management

A federal FMP for CPS, including Pacific mackerel, was implemented by the PFMC in January 2000 (PFMC 1998), see Preface above. The FMP's harvest policy for Pacific mackerel, originally implemented by the State of California, is based on MacCall et al. (1985) simulation analysis, with the addition of a proration to nominally account for the portion of the stock assumed to inhabit U.S.-based waters. In Amendment 8 to the CPS FMP (PFMC 1998), the recommended maximum sustainable yield (MSY) harvest control rule for Pacific mackerel was:

$$HARVEST_{06} = (BIOMASS_{06} - CUTOFF) \bullet FRACTION \bullet DISTRIBUTION,$$

where $HARVEST_{06}$ is the U.S. HG_{06} for the 2006 fishing year (July 2006-June 2007), CUTOFF (18,200 mt) is the lowest level of estimated biomass (*B*) at which harvest is allowed, FRACTION (0.3) is the fraction of *B* above the CUTOFF that can be harvested by fisheries, and DISTRIBUTION (0.7) is the average fraction of total *B* in U.S. waters. $BIOMASS_{06}$ (112,700 mt) is the estimated B_{06} as of July 1, 2006. Based on this harvest control rule, the HG_{06} is 19,845 mt, which reflects a quota that pertains to the 2006 fishing year (July 2006-June 2007):

B_{06} (mt)	Cutoff (mt)	Fraction	Distribution	HG_{06} (mt)
112,700	18,200	0.3	0.7	**19,845**

Finally, it is important to note that over the last several fishing years, the U.S.-based commercial fishery has not realized the recommended HGs (Figure 11, top display). However, uncertainty (to some degree) still exists concerning the magnitude of fisheries in Mexico that harvest Pacific mackerel and thus, caution is recommended when interpreting catch vs. HG statistics (see Landings above and Research and data needs below). In this context, total landings (including U.S. commercial, U.S. recreational, and Mexico commercial fisheries) vs. 'hypothetical,' population-wide HGs (i.e., ignoring the 'U.S. Distribution' parameter in the harvest control) are presented in Figure 11 (bottom display).

Research and data needs

Since the late 1920s, California's Pacific mackerel fishery has been sampled by CDFG for purposes of collecting biological (size/age) data that largely serve as the foundation for catch-at-age modeling efforts. However, as previous assessments have noted, biological data from the Mexico-based fishery are generally lacking and further, coalescing catch statistics from this fishery is also somewhat problematic. Thus, NOAA Fisheries (Southwest Fisheries Science Center) continues to emphasize collaborative data exchange with Mexico (INP, Ensenada) researchers to ensure assessment-related results accurately reflect this trans-boundary fish population. Finally, although the ASAP model is a sound modeling platform for analyzing fishery-related data, it is not possible to evaluate some parameterization (including diagnostics) issues inherent in fishery assessments and thus, efforts have begun to develop a length-based, age-structured population analysis for this stock using the Stock Synthesis 2 (SS2) modeling platform (Methot 2005a, 2005b). It is expected that alternative, SS2 model configurations for Pacific mackerel will be presented at the next formal STAR scheduled in 2007.

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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. Pacific Fishery Management Council June 2005 Briefing Book, Agenda Item F.1.b, Attachment 1. 167 p.

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Methot, R. D. 2005a. Technical description of the Stock Synthesis II assessment program: Version 1.17 (March 2005). NOAA Fisheries, Northwest Fisheries Science Center, 2725 Montlake Blvd. East , Seattle, WA 98112. 54 p.

Methot, R. D. 2005b. User manual for the assessment program Stock Synthesis 2 (SS2): Version 1.19 (April 27, 2005). NOAA Fisheries, Northwest Fisheries Science Center, 2725 Montlake Blvd. East , Seattle, WA 98112. 47 p.

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Table 1. Estimated likelihood components for the ASAP (2006) baseline model, display (A): *n*=number of observations in that component; λ=weight given that component, *RSS*=residual sum of squared deviations; and *L*=likelihood value. Sensitivity analysis associated with ASAP (2006) baseline model, display (B): scenario=parameterization revision; SSB_0=estimated virgin SSB (mt); SSB_{06}=estimated 2006 SSB (mt); steepness=estimated steepness from stock-recruitment relationship; and L_{total}=total likelihood value.

(A)

Component	*n*	λ	*RSS*	*L*	% of Total
Catch (weight) - fishery	78	101	0.0196	1.98	0.2%
Catch-at-age (proportions) - fishery	546	na	na	395.92	33.8%
Fits - Survey indices					
Spotter	37	1	81.92	452.63	
CPFV	63	1	16.78	58.74	
CalCOFI	45	1	27.04	129.28	
All	145	3	125.78	640.89	54.8%
Recruitment (deviations)	78	1	20.08	20.08	1.7%
Stock-recruit fit	78	1	20.08	110.95	9.5%
F penalty	546	0.001	0.5017	0.0005	<1%
Number of estimated parameters (Total)	181	na	na	na	
Objective function (Total)	na	na	na	1,169.81	100%

(B)

Scenario[1]	SSB_0	SSB_{06}	Steepness	L_{total}
(1) Baseline model	212,783	32,171	0.36	1,169.81
(2) Time-varying selectivtiy - Fishery	236,515	34,873	0.35	1,076.78
(3) Time-varying effective sample sizes - Fishery	272,185	39,119	0.34	1,219.23

[1]Scenario denotes: (1) final, ASAP (2006) baseline model configuration; (2) model configuration with fishery-related selectivity parameterization based on two time periods (1929-65 and 1966-05); and (3) model configuration with fishery-related effective sample sizes (catch-at-age) based on two time periods (1929-60 and 1961-05).

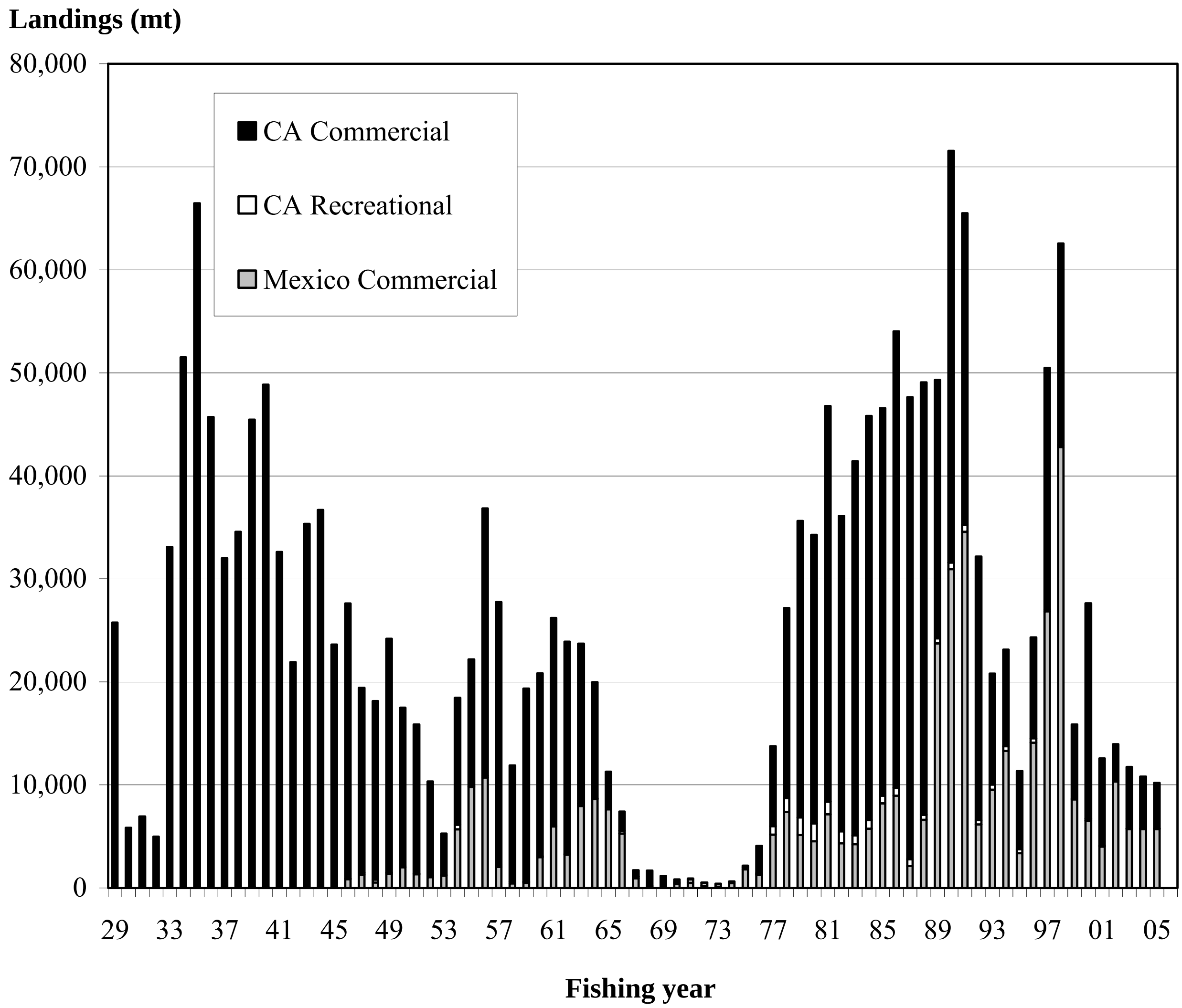


Figure 1. Commercial and recreational landings (mt) of Pacific mackerel in California (CA) and Baja California (MX), for 1929-05. Data from 1929-76 are based on a May-April 'fishing year,' and data from 1977-05 are based on a July-June 'fishing year.'

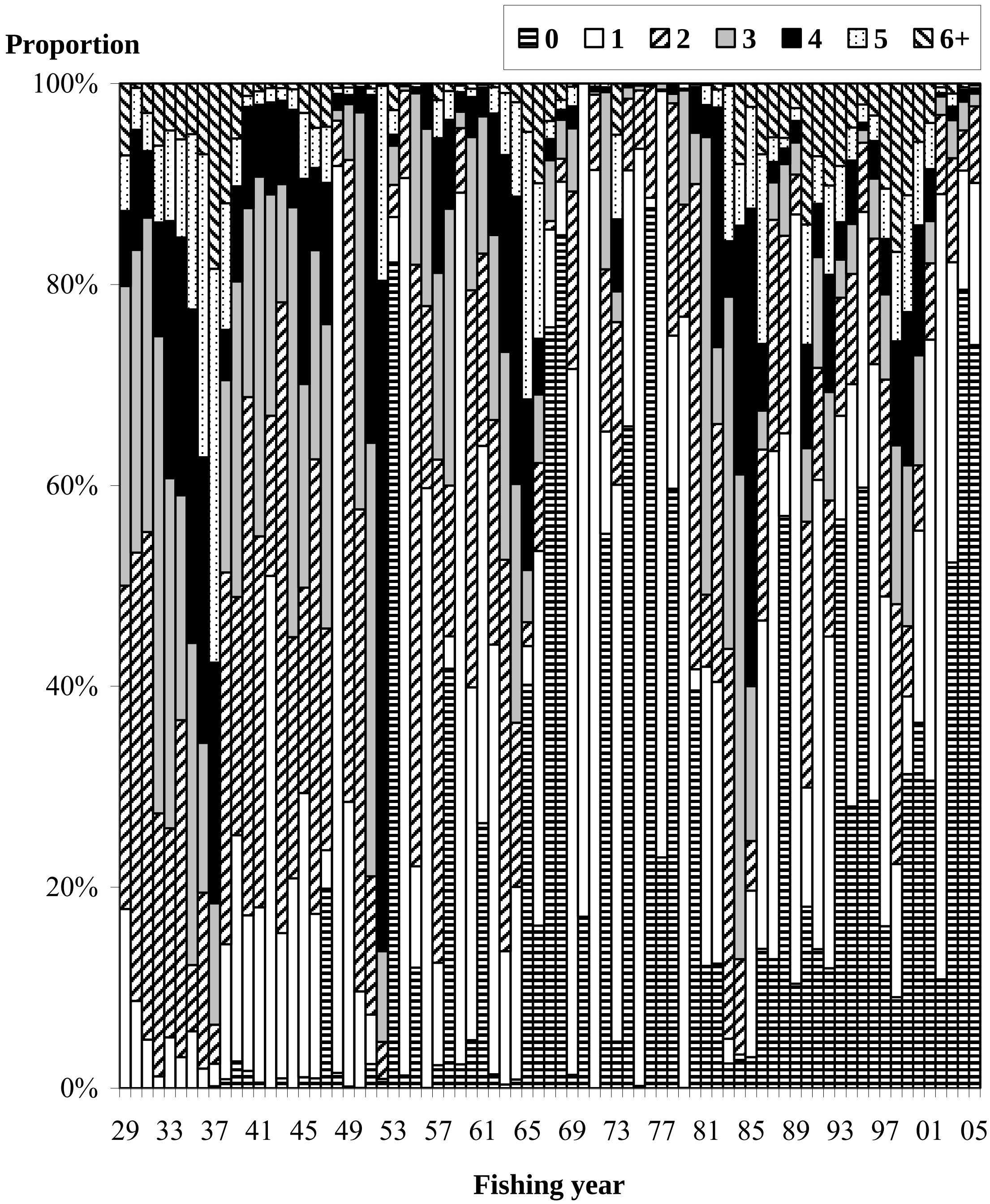


Figure 2. Pacific mackerel catch-at-age (in proportion) estimates used in the ASAP (2006) baseline model (1929-05).

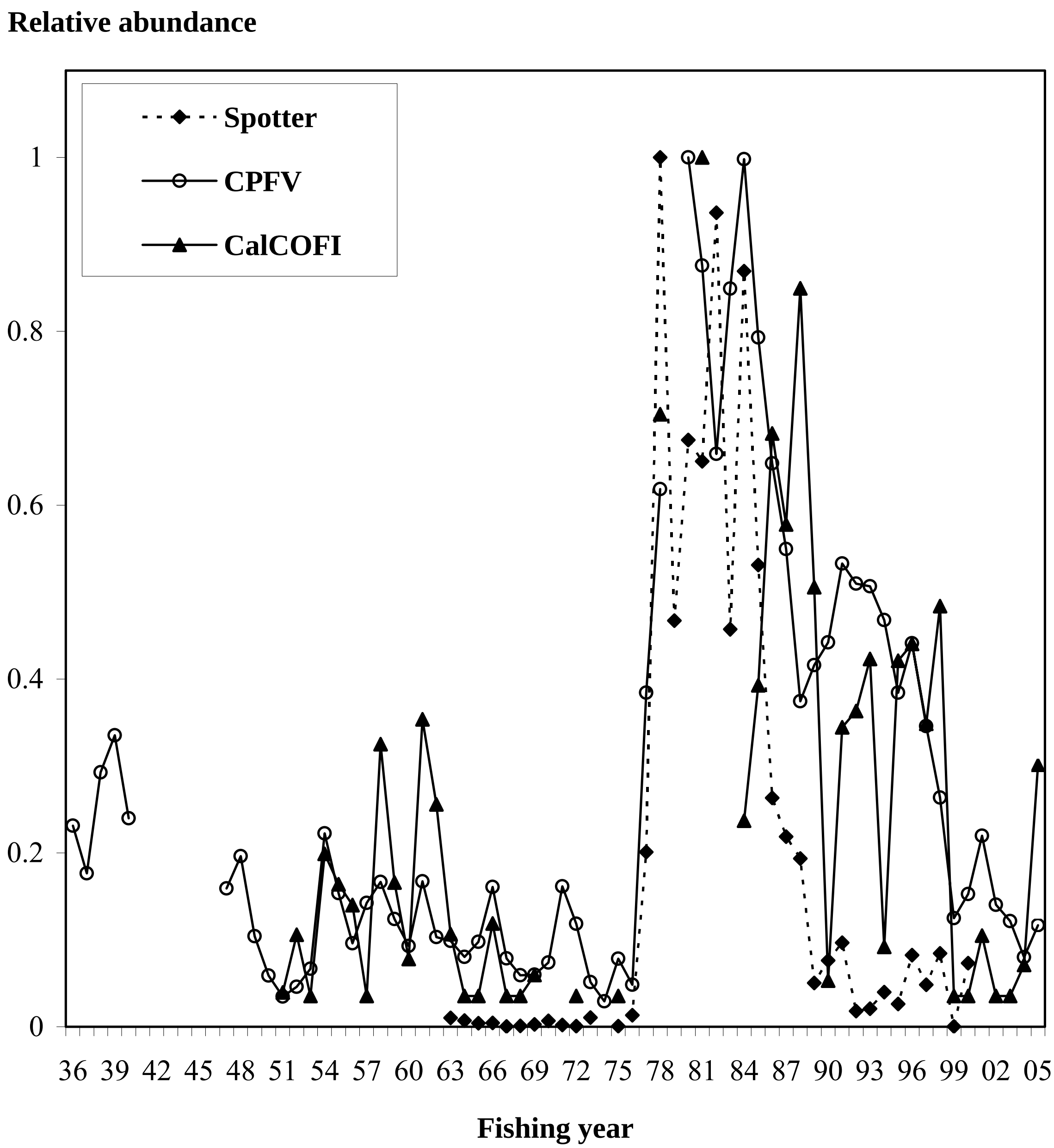


Figure 3. Indices of abundance time series for Pacific mackerel used in the ASAP (2006) baseline model. Indices are rescaled (normalized) to a maximum of 1.

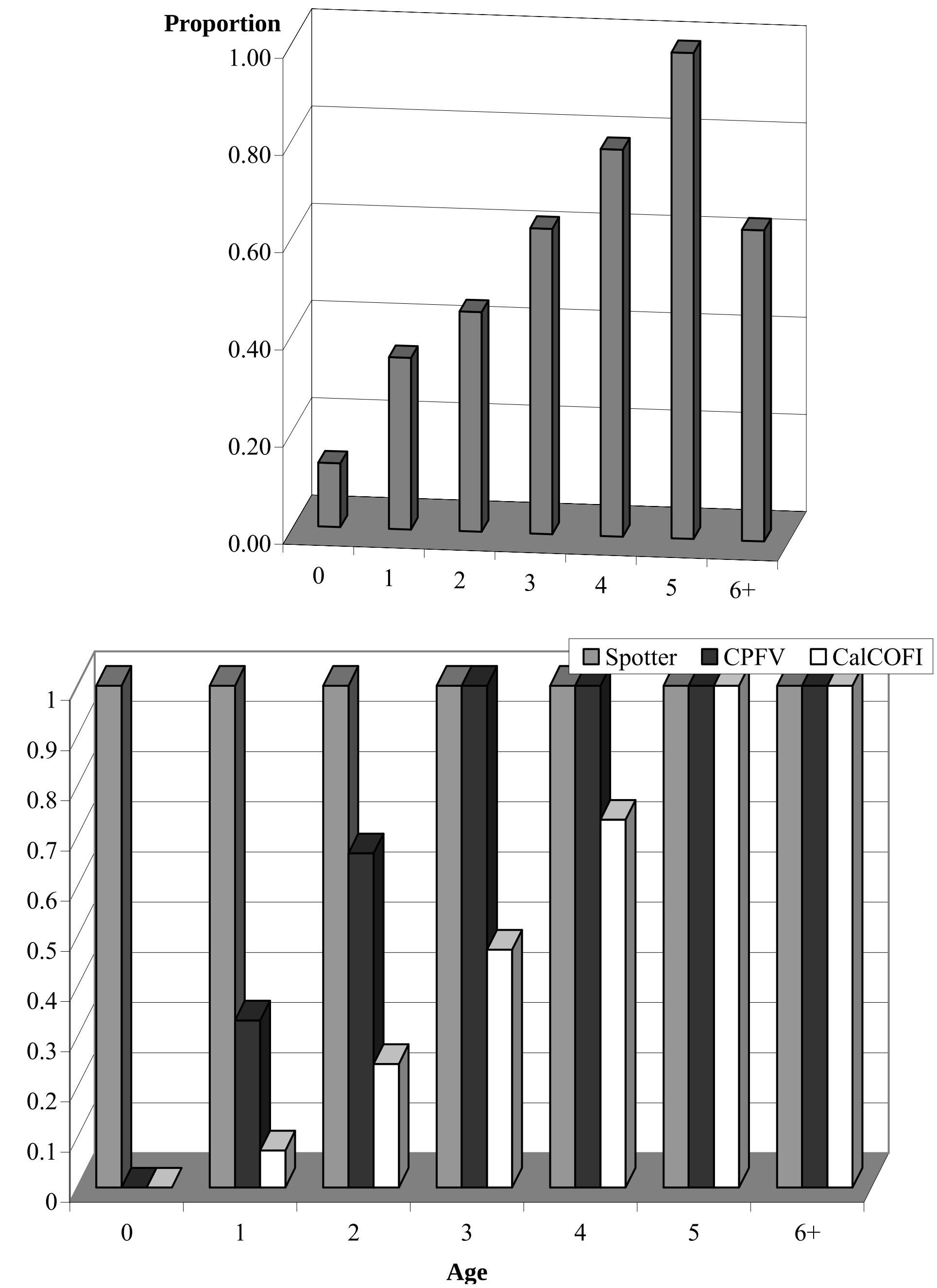


Figure 4. Estimated selectivity schedule for fishery (catch-at-age) data (top display) and assumed selectivity ogives for survey-related indices of abundance (Spotter, CPFV, and CalCOFI) from the ASAP (2006) baseline model. Note that CPFV ogive represents (1990-05), with ogive for 1929-89 parameterized with slightly different probabilities for ages 1 and 2.

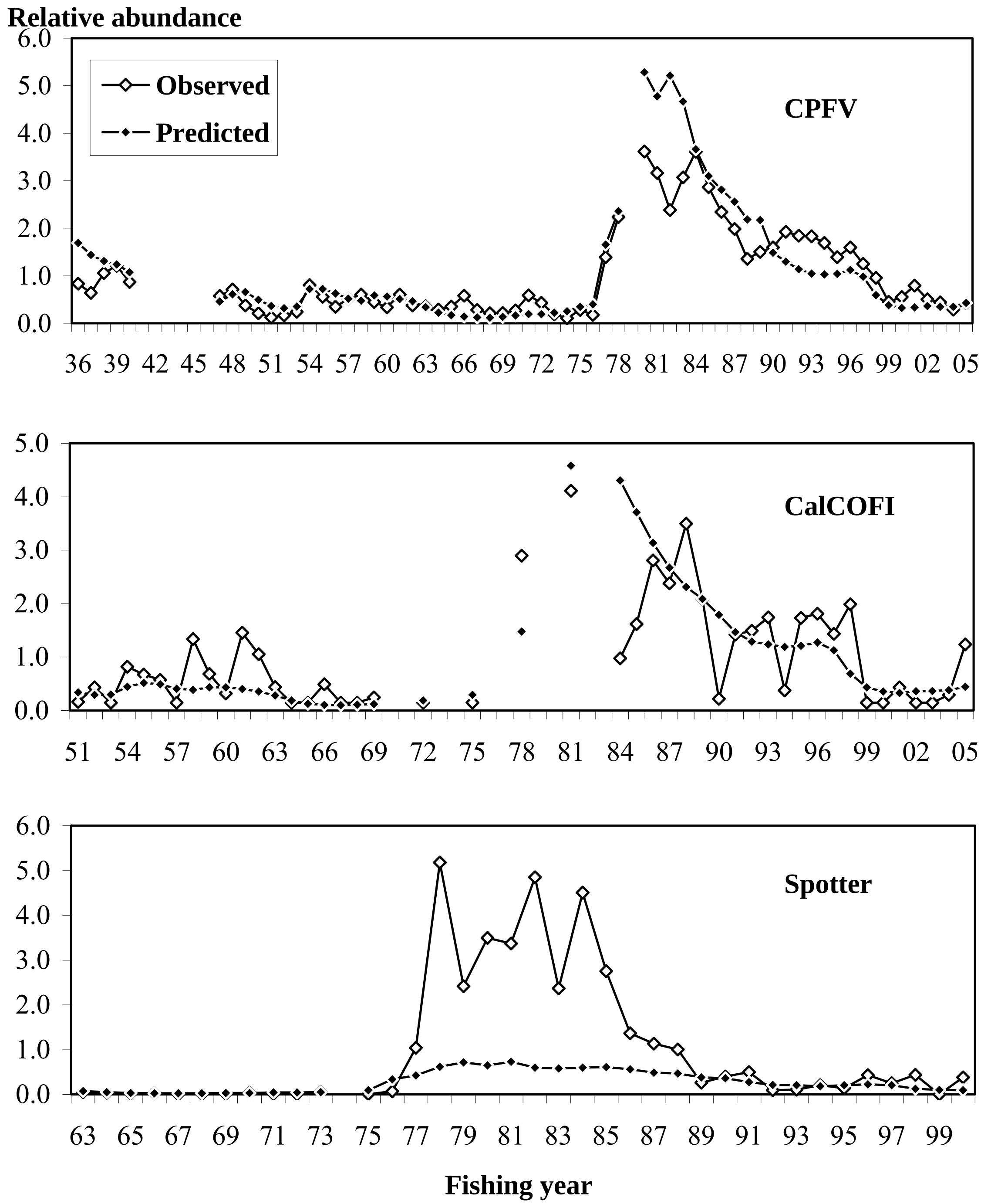


Figure 5. Observed and predicted estimates from survey index fits generated from the ASAP (2006) baseline model: CPFV (top display); CalCOFI (middle); and Spotter (bottom).

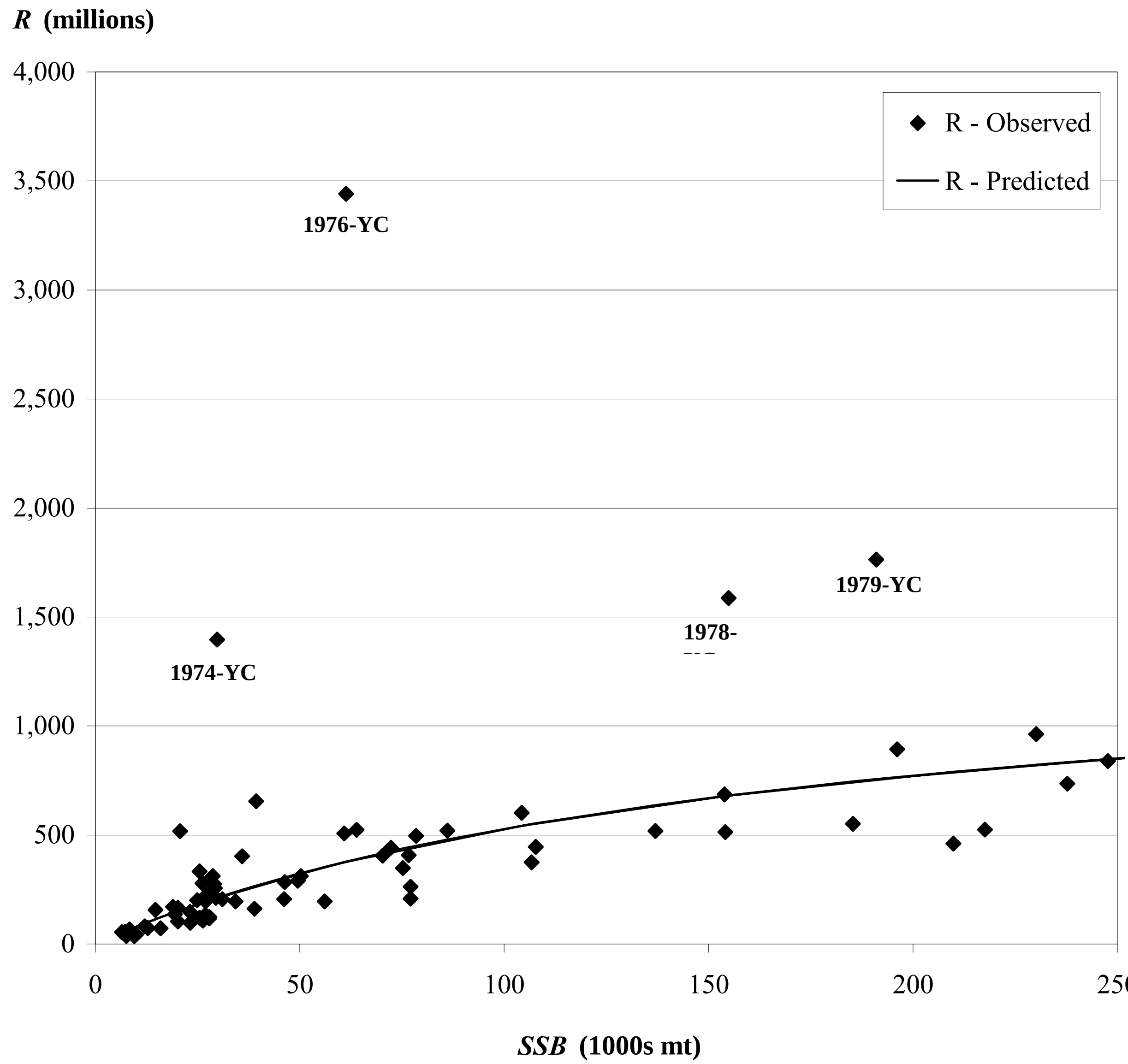


Figure 6. Beverton-Holt stock (SSB in 1000s mt)-recruitment (R in millions of fish) relationship for Pacific mackerel estimated in the ASAP (2006) baseline model (1929-05). Recruitment are presented as (year+1) values. Strong year classes are highlighted. Steepness=0.36

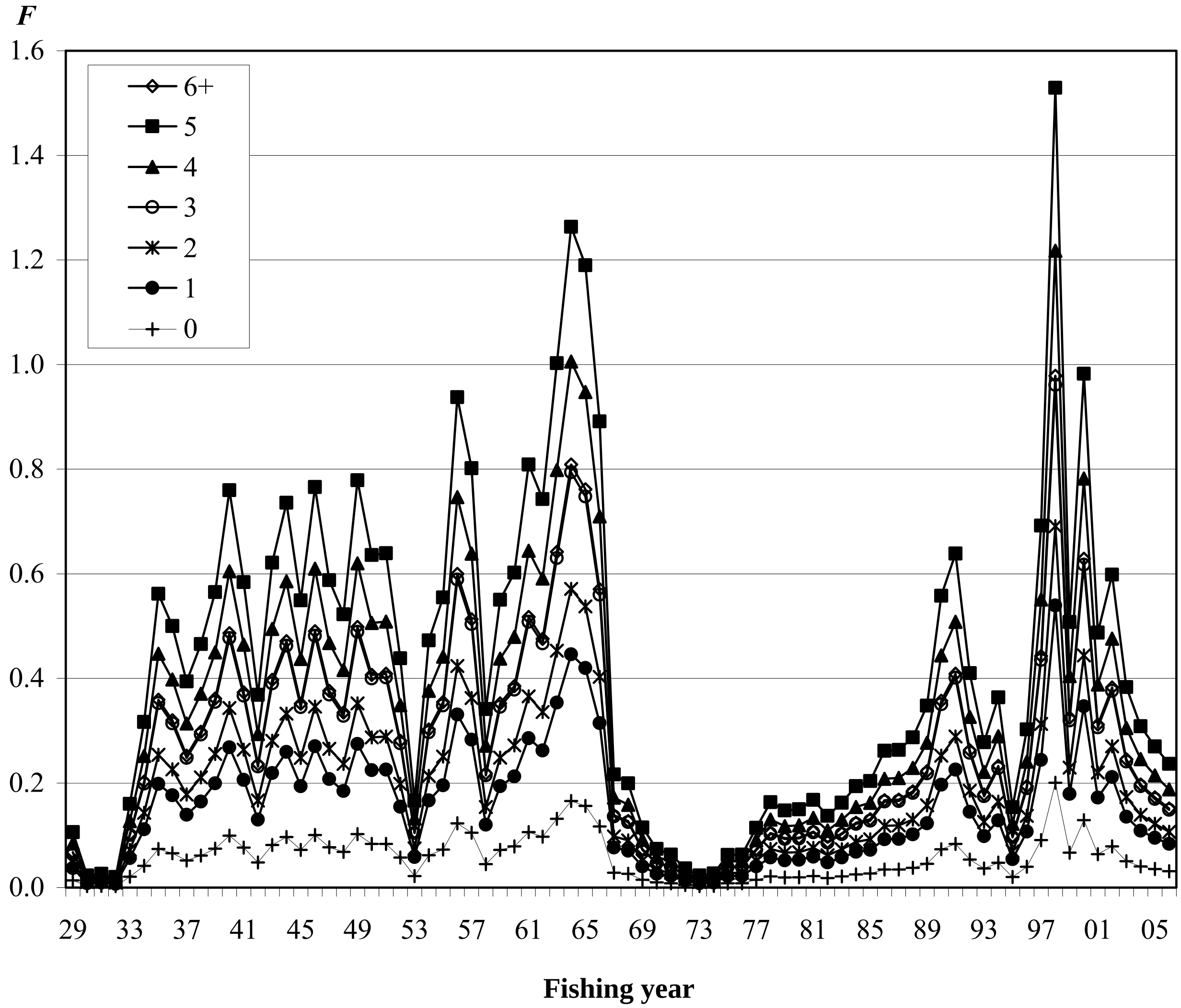


Figure 7. Estimated instantaneous fishing mortality (total) F-at-age for Pacific mackerel generated from the ASAP (2006) baseline model.

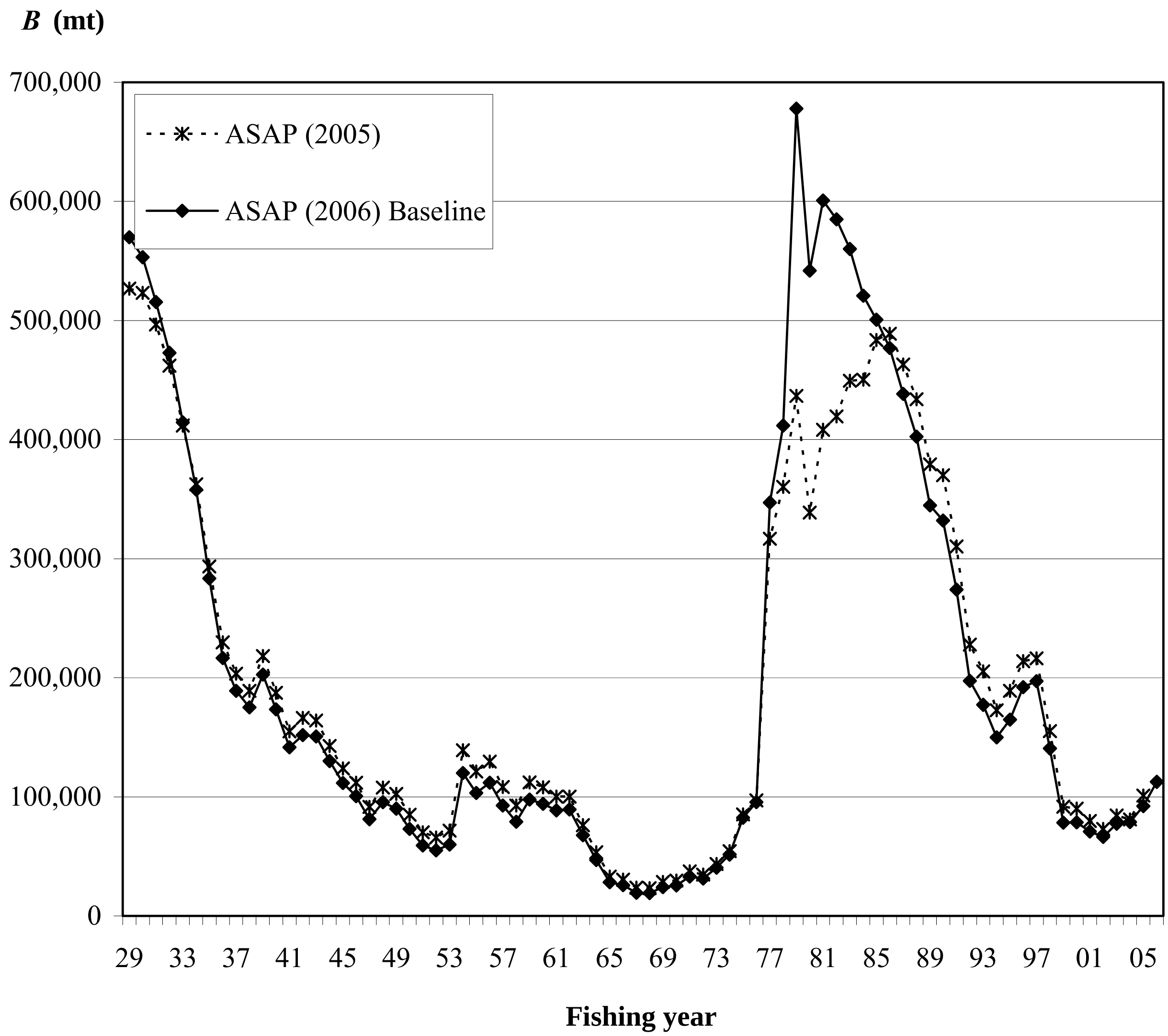


Figure 8. Estimated biomass (>age-1 fish, B in mt) of Pacific mackerel generated from the ASAP (2006) baseline model (1929-06). Estimated B for ASAP (2005) baseline model is also presented.

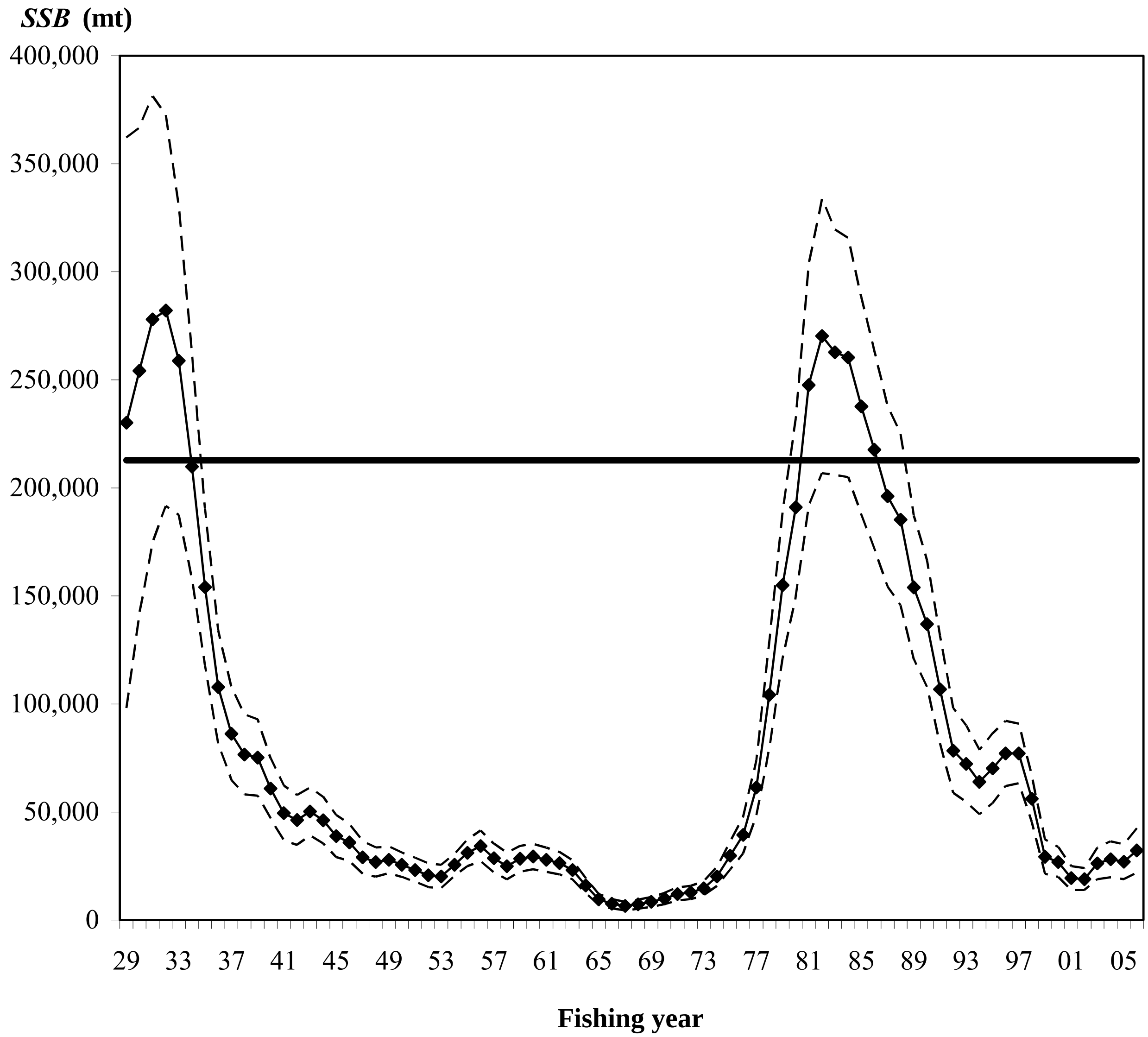


Figure 9. Estimated spawning stock biomass (SSB in mt) of Pacific mackerel generated from the ASAP (2006) baseline model (1929-06). The 95% CI associated with this time series is also presented. Estimated 'virgin' SSB from stock-recruitment relationship is presented as solid horizontal line (see Figure 6).

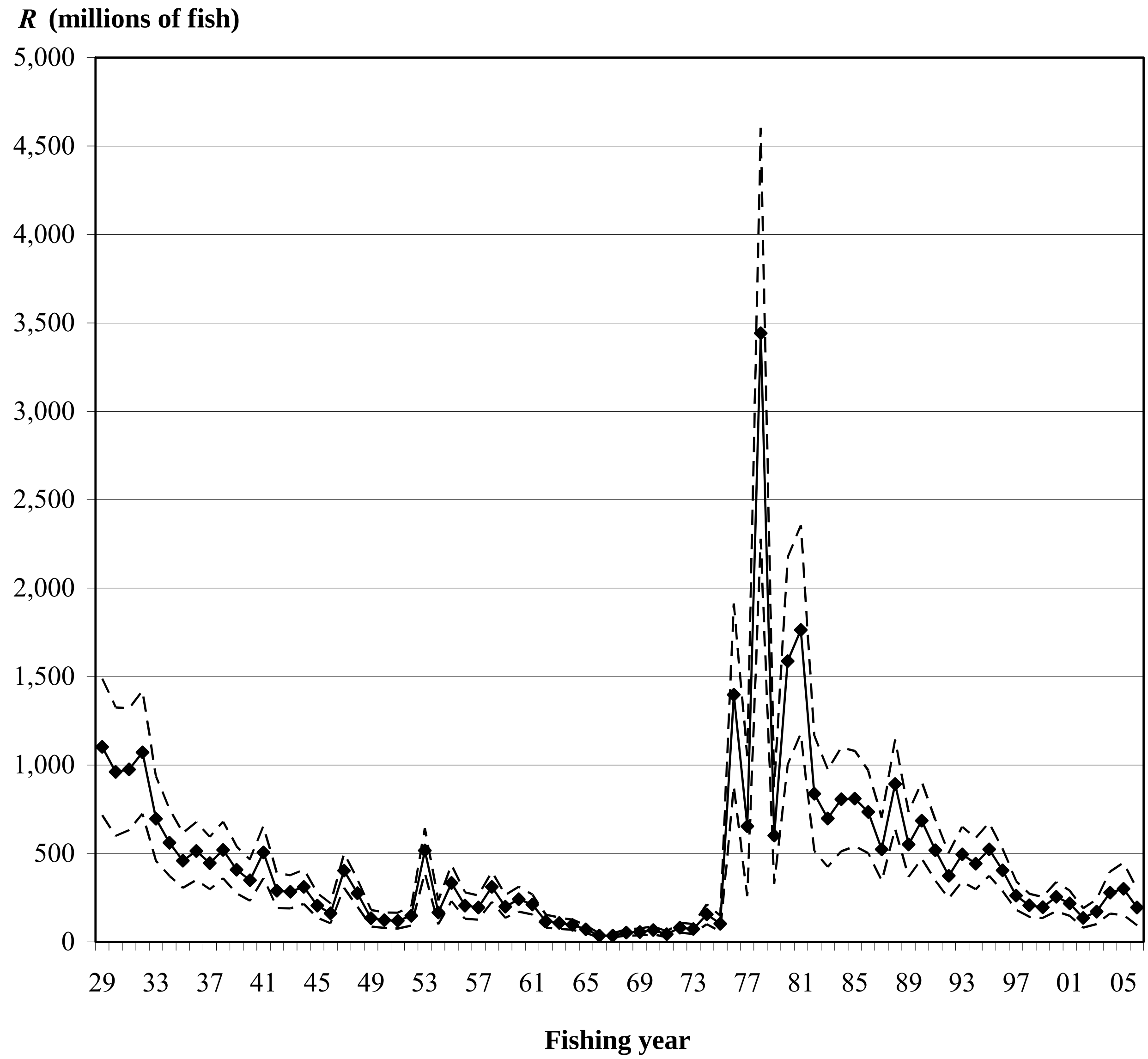


Figure 10. Estimated recruitment (age-0 fish in millions, R) of Pacific mackerel generated from the ASAP (2006) baseline model (1929-06). The 95% CI associated with this time series is also presented.

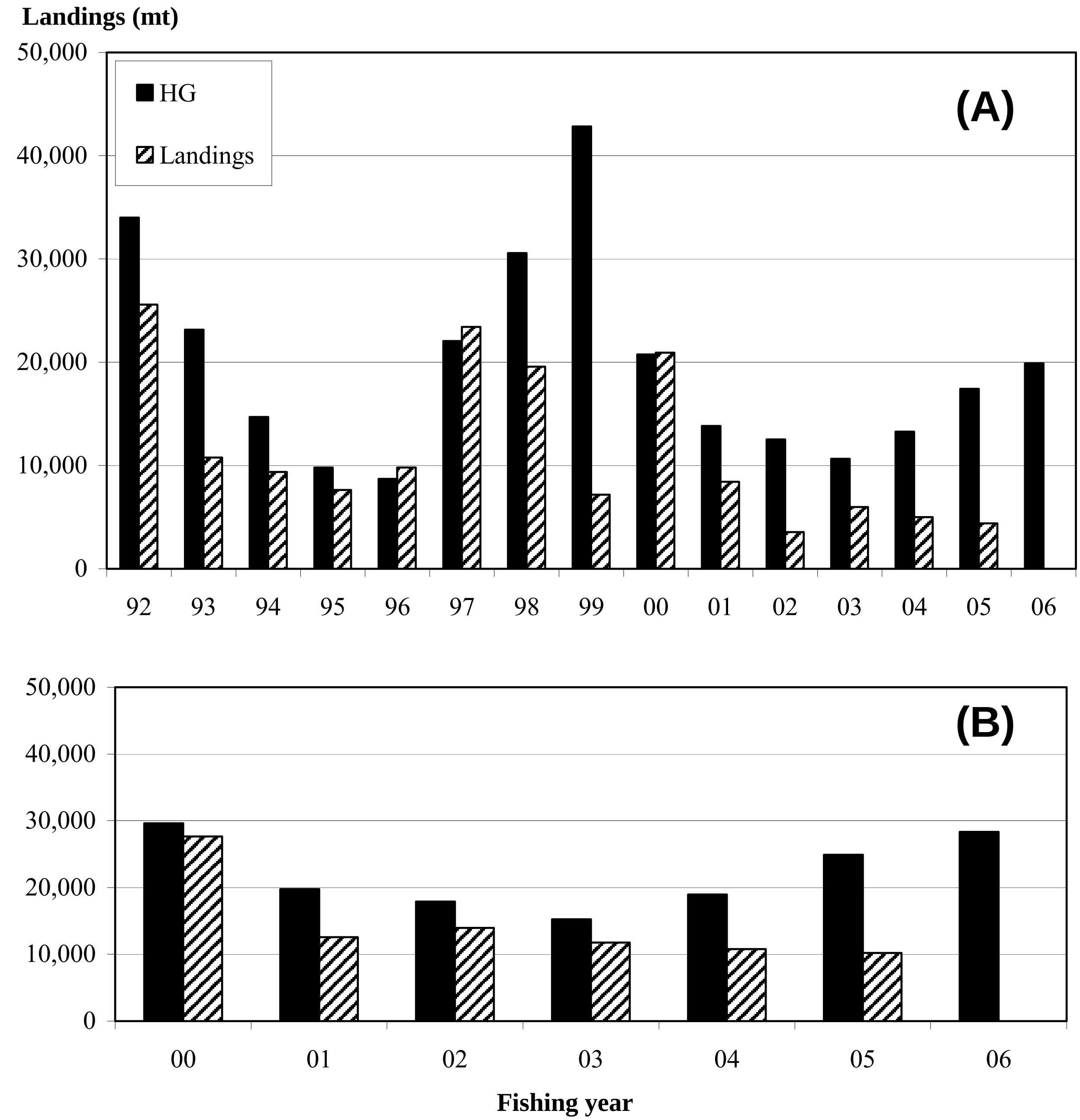


Figure 11. Commercial landings (California directed fishery in mt) and quotas (HGs in mt) for Pacific mackerel (1992-06), display (A). Total landings (mt) and hypothetical quotas for Pacific mackerel (2000-06) based on no U.S. Distribution parameter in harvest control rule, display (B). Incidental landings from Pacific Northwest fisheries are not included, but typically range 100 to 300 mt per year.

Agenda Item C.1.b
Supplemental SSC Report
June 2006

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON PACIFIC MACKEREL HARVEST GUIDELINE FOR 2006-2007 SEASON

A Pacific Fishery Management Council-sponsored review of the Pacific Mackerel Assessment took place on May 16, 2006, at the Southwest Fisheries Science Center in La Jolla. Reviewers at the La Jolla meeting included Tom Barnes and David Sampson of the Scientific and Statistical Committee (SSC), and several members of the Coastal Pelagic Species (CPS) Management Team. Paul Crone, a member of the Stock Assessment Team (STAT), presented the data and modeling results. The reviewers and the STAT selected a Base Model that was an update of the previous assessment.

The current stock assessment model configuration for Pacific mackerel was developed in 2004, and was first used for management during the 2005-2006 fishing season. The assessment for 2006 was conducted as an update, in that the STAT adhered to the previously reviewed model configuration in deriving the Base Model results. A full Stock Assessment Review (STAR) Panel reviewed and accepted the modeling approach in 2004, and subsequently the SSC reviewed and accepted the 2005 assessment. In the 2006 assessment the principle change was the inclusion of new fishery and survey data from 2005, as well as correcting a previous error in the treatment of four "missing" years in the California Cooperative Oceanic Fisheries Investigations (CalCOFI) survey index. The STAT and the reviewers agreed on the Base Model results that estimated the 2006 biomass to be 112,700 mt. The SSC concurs that the Base Model results are the best available science and provide a suitable basis for Council management decisions.

Recommendations for the Next Assessment

Several technical issues were identified that would benefit from further exploration as part of the next full assessment, including investigation of time-varying selection to account for an absence of young fish during the early part of the time series, and examination of historical CalCOFI data, which cover a wider geographic range, to explore possible north-south shifts in distribution. These issues will be brought to the attention of the next assessment team.

Under the current Council process a single STAR panel reviews the stock assessments for Pacific mackerel and Pacific sardine, even though the fishing seasons for the two species are offset by six months. For 2007 the SSC recommends that the Council convene separate STAR panels, one during the fall for sardine and another during spring for mackerel. Each panel should consist of three reviewers with at least one being external to the Council and region. The SSC will work with the Southwest Center to facilitate the STAR Panels.

Prior to the next round of CPS stock assessments, the Terms of Reference for CPS assessments should be reviewed and revised, especially with regard to update assessments. The extant Terms of Reference do not specify what constitutes an update or the information that should be documented in an update report.

Management Issues

Several issues have been identified concerning the Pacific Mackerel Harvest Control Rule. how this could be accomplished in the near term. The reviewers at the May meeting noted that the Harvest Control Rule is for age-1+ fish, but in some years a significant portion of the landings are age-0 fish. The basis of the harvest guidelines should be consistent with the age composition of the catch. Also, results from the current mackerel assessment indicate that spawning stock biomass is only about 15% of the unexploited level and that the level of steepness in the spawner-recruit curve is very low.

Specific Issues to be Addressed by the Next Assessment

- *The CalCOFI time series includes several years where no Pacific mackerel larvae were collected in the samples, and for those years the zero value was replaced by the lowest observed positive value. This causes a distortion of the dynamic range in the CalCOFI index compared to the other survey indices. It is recommended that the treatment of zeros be re-examined.*
- *The lack of age zero fish in the early part of the time series is inconsistent with the assumption of constant fishery selection. The STAT investigated time-blocking for the selectivity and got improved fit and more consistent effective sample sizes, and this change should be considered for adoption.*
- *The CalCOFI index is based only on data from the southern California Bight. It would be informative to explore coastwide CalCOFI data to clarify possible shifts in the geographic distribution. Also, it may be possible to develop a southern larval index that is more closely associated with the center of geographic distribution of the stock, based on historical CalCOFI and more recent IMMECOCAL data.*
- *The maturity schedule was developed many years ago, and it should be re-examined, preferably with new data. The curve seems unusually flat. Runs should be conducted to evaluate the sensitivity of the model to the assumed maturity-at-age relationship.*
- *There should be a formal evaluation of the sensitivity of the model to the "sigma" (error) values assumed for the three tuning indices.*
- *There seems to be a mis-match between the observed recruitment dynamics (boom-bust) and the underlying spawner recruit model (uncorrelated recruitment deviations).*
- *The revised Terms of Reference should specify detailed lists of results to be included in the assessment document.*

PFMC
06/13/06

Pacific Mackerel

STAR Panel Meeting Report

NOAA / Southwest Fisheries Science Center
La Jolla, California
June 21 – 24, 2004

STAR Panel
Tom Barnes, California Department of Fish and Game (Chair)
Andre Punt, University of Washington (SSC Representative)
Rodolfo Serra, IFOP, Valparaiso, Chile
John Wheeler, Department of Fisheries and Oceans, Canada (CIE, Rapporteur)

PFMC
Brian Culver, Washington Department of Fish and Wildlife, CPSMT
Diane Pleschner-Steele, CPSAS

STAT
Kevin Hill, NOAA / Southwest Fisheries Science Center
Paul Crone, NOAA / Southwest Fisheries Science Center

1) Overview

On June 21st to 24th, 2004, a STAR Panel (hereafter the Panel) met in La Jolla, CA for the first formal PFMC-sponsored stock assessment review of Pacific mackerel. The STAR Panel terms of reference were adhered to, in that the Panel worked with the STAT to ensure that the assessment was reviewed as needed and that meeting discussions were documented. However, it was noted that a recent SSC report on Pacific mackerel (June 2004, Supplemental SSC Report F.2.b.) recommended a separate future STAR panel to deal with issues of yield and harvest formula for CPS species. Therefore, summaries of stock status and harvest guidelines were not reviewed by this STAR panel as the focus of the meeting was to review assessment methodologies and not results.

The STAR Panel members received copies of all documentation approximately one week prior to the meeting, which provided sufficient time for review. The meeting commenced on June 21st with introductions (see list of attendees) followed by a brief overview by the Chair (Tom Barnes). Kevin Hill, with assistance from Paul Crone, led the presentation on assessment methodology. Nancy Lo gave a presentation on the aerial spotter program, an abundance index in the assessment.

The CPS fishery in California takes market squid, sardine and mackerel. The fishery has progressed from one focused primarily on mackerel in the early 1980’s, to one that focuses substantially on sardine and squid, although the fishery still relies on all three species.

The most recent mackerel assessment, intended for PFMC management decisions for the period July 1, 2004 to June 30, 2005, used a modified virtual population analysis model (ADEPT) to estimate Pacific mackerel biomass. During the meeting, the Panel briefly reviewed the method and results from the ADEPT model. However, most discussion focused on a forward-projection age structured assessment program (ASAP) model which the STAT proposed for future assessments of Pacific mackerel. The ASAP model is intended as an alternative statistical model to evaluate more fully the relationship between the species’ population dynamics and associated fishery operations than is possible using ADEPT.

For illustrative purposes and to provide a basis for discussion, the STAT presented two ASAP models. The baseline model attempted to mimic the ADEPT formulation for the 2004 assessment. It included the four indices used in ADEPT and fixed selectivity over the entire period (1929-2003). The alternative approach eliminated one index, combined two other indices, and separated selectivity into two time periods.

In examining the results of the illustrative ASAP models, it was noted that results from both the baseline and alternative approach are very similar. Population numbers and biomass increased through the late 1970's and early 1980's similar to the ADEPT model, but peaked at much lower levels.

The Panel and the STAT agreed that ASAP should form the basis for the 2005 assessment. For continuity purposes, future assessments should include an ADEPT analysis as a sensitivity test.

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

a. There were questions regarding the length of the time series to be included in the ASAP model, given uncertainties regarding earlier landings data. **Request:** the Panel requested that a sensitivity analysis be conducted to compare starting the model in the 1920's versus starting it when the stock rebounded in 1978. **Response:** the STAT provided numerous runs during the meeting comparing model outputs based on the entire time series and a truncated time series commencing in 1978.
b. There were concerns regarding biological sample sizes on which the catch at age data for some years is based, in particular during the 1970's when the fishery was closed. There were also concerns regarding the temporal and spatial variability of sampling. **Request:** the Panel requested that sample sizes by year be provided. **Response:** these were provided during the meeting and it was decided that it was not necessary to conduct a sensitivity analysis since there are several sources of uncertainty associated with the catch at age data other than sampling error, such as potential seasonal sampling bias. However, given the small sample sizes during the 1970's, it was suggested that this may be a further reason to begin the ASAP model subsequent to this period.
c. Weight at age data exhibited considerable variability over time, in particular during the mid 1970's when landings were low and sampling was reduced. It was suggested that this is another reason to start the ASAP model subsequent to this period. No requests or recommendations were made.
d. There were questions regarding the comparability of the new aerial spotter index and the historical fishery-based spotter index. No requests or recommendations were made.
e. In examining abundance indices, it was difficult for the Panel to compare one index with another. **Request:** the Panel requested that the abundance indices be plotted against each other (X-Y plots) to examine the degree of agreement between them. **Response:** three plots were provided during the meeting: 1) aerial spotter index vs. CalCOFI index, 2) aerial spotter index vs. CPFV index, and 3) CalCOFI index vs. CPFV index. These plots (see Figure 1) suggest that the relationship between the aerial spotter index and the CalCOFI and CPFV indices is not linear.
f. There were questions regarding the use of the northern CPFV index in ADEPT because its trend is contradictory with that of the southern CPFV index. The Panel and STAT agreed that a single combined index be used in the ASAP model.
g. There was a discussion regarding the use of the triennial and impingement indices. The Panel and STAT agreed that these indices be eliminated from the ASAP model.
h. In discussing the CalCOFI and aerial spotter indices, it was noted that there are zero values in the indices. However, the ASAP model replaces zero values by 0.0001 after the indices are rescaled to 1. **Request:** the Panel requested that a sensitivity analysis be conducted to examine the impact of adding a small value to the zero values in the ASAP input file. **Response:** the STAT provided numerous runs that illustrated that the ASAP model was highly sensitive to the addition of small values to the zeros. It was suggested, that in the long term, a negative binomial error structure be incorporated in the model to

allow for zero values. However, after much discussion, it was concluded that, in the short term, zero values in an index be replaced with the smallest observed value in that index.

i. After an extensive discussion, several other issues were identified that required further evaluation and review. **Request:** the Panel requested that the following ASAP sensitivity analyses be conducted: 1) three indices (CalCOFI, CFPV, and aerial spotter) vs. two indices (CalCOFI and CFPV), and 2) the full time series vs. a truncated time series commencing in 1978. **Response:** the STAT presented each of the above sensitivity analyses. The exclusion of the spotter index did not change the model fit substantially. It was concluded that all three abundance indices be included in the model, that the full time series be used, that zero values in indices be replaced with the minimum estimate from the index, and that the same coefficients of variation be assigned to all data points.

j. The baseline model of ASAP did not mimic the catch in 1998. **Request:** the Panel requested that the STAT conduct analyses in which the weight assigned to the catch data was increased (lambda values of 100, 300, and 1000) and provide a table with predicted 1998 catch, and 1+ biomass in 2003. A bubble plot was also requested to examine residual patterns. **Response:** the STAT provided this information (Table 1 and Figure 2).

3) Technical Merits and/or Deficiencies of the Assessment

The lack of catch at age and weight at age data from the Mexican (Ensenada) fishery is a major source of uncertainty, especially in recent years when Mexican landings have been as large as or larger than Californian landings.

Pacific mackerel range from the Gulf of California to southeastern Alaska and are harvested from Ensenada to British Columbia. However, the abundance indices used in the assessment are all derived from the Southern California Bight, a relatively small area compared to the distributional range. It was also noted that even within this area, there may be a spatial bias as most abundance indices are derived from the northern part of the spawning range, which is thought to range from central Baja California to the Southern California Bight.

The Panel could not fully review the age composition data due to a lack of information on how they were developed. There is considerable inter-annual variation in the proportion of catch in different age classes and this results in systematic patterns in the residuals about the fit to the catch-at-age data. The ASAP model is based on the assumption that all of the discrepancy between the observed and model – predicted age proportions is due to observation error. There are, however, alternative explanations: ageing error (both systematic and random), non-random sampling of the landings, the impact of seasonal variation in the fishery, and random changes in availability. The Panel strongly recommends examination of the basis for the age composition data and the possible benefits of allowing for time dependent selectivity. The Panel noted that variance in age composition data could be partitioned into component parts to estimate observation error and process error. The fishery was not conducted year-round in all years, which may have introduced a source of variability in the annual catch-at-age data. A sensitivity analysis could be conducted by down-weighting years with only a partial year of fishing.

4) Areas of Disagreement

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

5) Unresolved Problems and Major Uncertainties

Problems unresolved at the end of the meeting form the basis for the research recommendations in Section 6.

6) Research Recommendations

The following recommendations are not given in priority order.

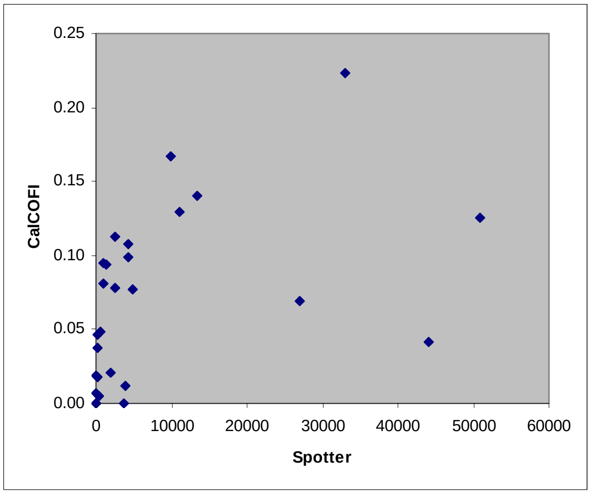
a. There was a discussion regarding the overall lack of fishery independent survey data, in particular outside of the Southern California Bight. **Recommendation:** the Panel recommended a concerted approach to develop a coastwide synoptic survey, ideally on an annual basis, to estimate an index of mackerel biomass.
b. There was a discussion regarding the survey design of the new aerial spotter index. **Recommendation:** the Panel recommended that the survey design incorporate rigorous protocols. Attempts should be made to estimate school surface area. The Panel also recommended that an aerial spotter survey be initiated in the Pacific Northwest in conjunction with industry.
c. The Panel endorsed and encouraged overall greater collaboration with industry in the collection and analysis process for coastal pelagic species, including Pacific mackerel.
d. There is a lack of biological sampling data available from Mexico for inclusion in the assessment. The lack of Mexican catch-at-age data is more critical in recent years when the Mexican catch has been as large as or larger than that of California. **Recommendation:** the Panel recommended that fishery and survey (IMECOCAL) data be acquired from Mexico and incorporated into future assessments.
e. **Recommendation:** the Panel recommended that spawning biomass be defined in terms of the numbers at the end of the year.
f. There were questions regarding the length of the time series to be included in the ASAP model, given uncertainties regarding earlier landings data. Although it was decided to use the entire time series, it was considered that the use of a truncated time series be evaluated further. **Recommendation:** the Panel recommended that consideration be given to using the ASAP model for 1978 to the present.
g. There were questions regarding the use of fishery-based weights at age to estimate population parameters as they are derived from only part of the population. **Recommendation:** the Panel recommended that this be examined and that a Von Bertalanffy curve be used if it includes samples from throughout the stock range.
h. **Recommendation:** the Panel recommended that all indices be plotted with confidence intervals in future assessments.
i. **Recommendation:** the Panel recommended that the STAT evaluate year – area

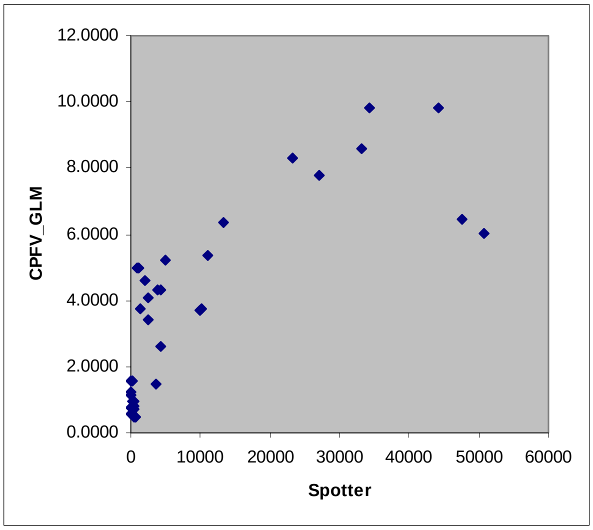
interactions in the GLM used to standardize the catch – effort data.

j. There was a discussion regarding selectivity patterns for the CPFV index which were estimated outside of the ASAP model. **Recommendation:** the Panel recommended that selectivity within the model be estimated by treating CPFV as a separate fishery using available biological data.
k. There were questions regarding how the catch-at-age (in number) is developed. **Recommendation:** the Panel recommended that this requirement should be included in the STAR terms of reference.
l. There was a question whether the CPFV index includes estimates of discards. It was noted that discard rates were only available in logbooks since 1994. **Recommendation:** the Panel recommended that the magnitude of discards be examined for the next assessment.
m. There was a brief discussion on the catch at age matrix, whether it should be extended beyond age 5+. It was noted that this may be more feasible if a truncated time series is used in the ASAP model. **Recommendation:** the Panel recommended that these issues be examined for the next assessment.
n. The Panel strongly recommends examination of the basis for the age composition data and the possible benefits of allowing for time-dependent selectivity.
o. The spotter index was not fit well. **Recommendation:** the trade-offs for leaving this index in or out of the assessment are complex and not readily apparent, and this decision should be left to the STAT as work progresses on the next assessment.
p. There were questions regarding how an assumed birth date of July 1st is accounted for in a model with a calendar year basis. **Recommendation:** the Panel recommended that, if practicable, the model year commence on July 1st to match the assumed birth date.
q. Noting the lack of a linear relationship between the aerial spotter index and the remaining indices, there was a discussion whether the aerial spotter index should be included in the ASAP model even though it is the only "recruitment index" available. This index assumes full selectivity across all ages. **Recommendation:** the Panel requested that selectivity within the model be estimated by creating a 'fleet' with no catch and no sampling. It was considered that this may not work but would at least provide selectivity estimates that could then be examined.
r. Observed vs. predicted catch proportions were presented, derived from the baseline ASAP model. Problems were identified with data through the 1970's, as residual patterns were not random. **Recommendation:** the Panel requested that this or a similar plot be used as a standard diagnostic in the assessment report.
s. The specific details of the method used to develop catch-at-age data were not provided. **Recommendation**: the Panel requested that the STAT document how catch-at-age was estimated.
t. An error was made in summing catch-at-age data for annual estimates, due to misapplication of the July 1st birth date that is used in assigning ages. **Recommendation:** a correction needs to be made to account for the July 1 birth date that is used in assigning ages, when aggregating catch-at-age data over calendar year time periods.
u. Certain modifications are required to the ASAP model:
    - make allowance for fleet-specific weights-at-age (specifically the fishery weights-at-age for the fishery in the Pacific northwest);
    - define spawning biomass in terms of the numbers at the end of the year;

- explicitly include a zero age-class;
- include a log-normal bias-correction factor in the component of the objective function related to deviations about the stock-recruitment relationship; and
- quantify parameter uncertainty using the MCMC algorithm.

Figure 1. X-Y Plots of indices used in Mackerel assessment.





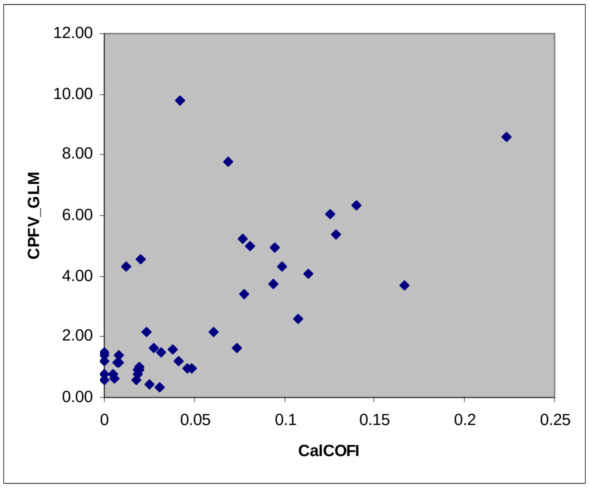


Figure 2. Bubble plots of residuals

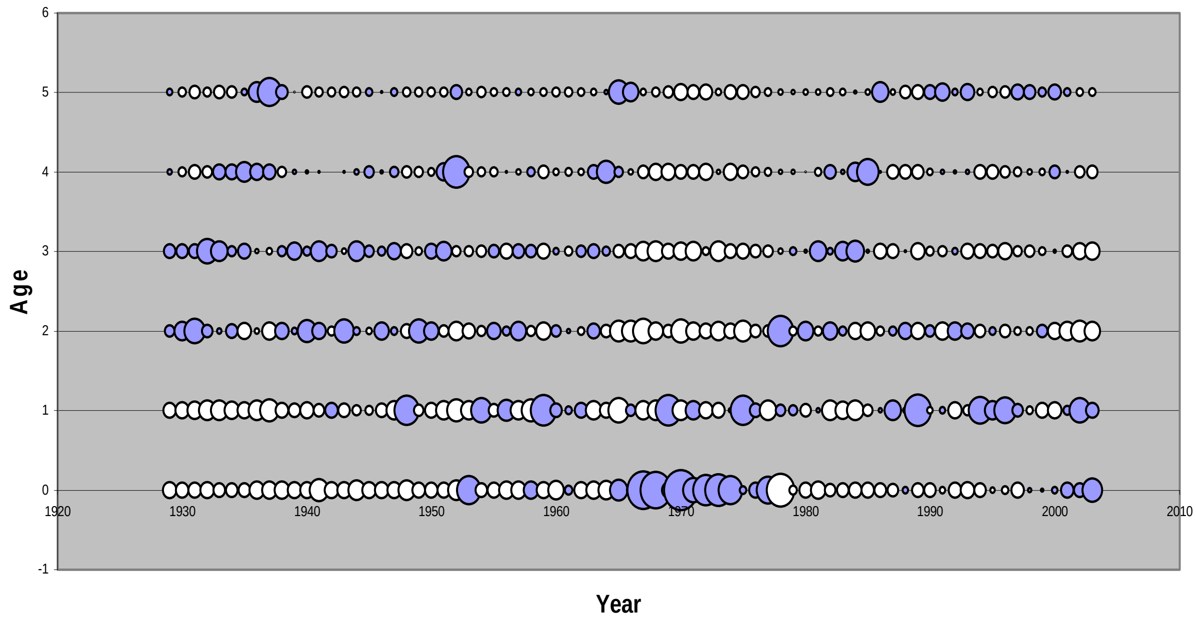


Table 1. New baseline results with increasing lambda catch.

G_2h Summary			
		1998 catch	
Lambda Catch	obj_fun	(obs-pred)	Biomass (Age 1+, Jan 2003)
100	1194.93	-8059.1	85,183
300	1197.07	-2673.2	87,138
1000	1197.84	-798.5	87,912