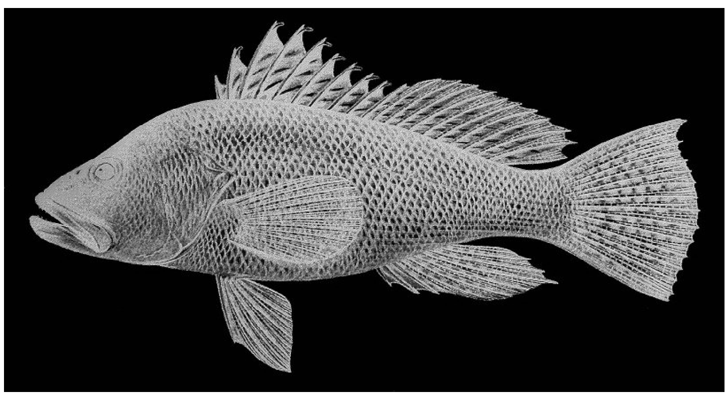
Report of Stock Assessment:

Black Sea Bass

SEDAR Update Process #1



Assessment Workshop of March 15–17, 2005

Beaufort, North Carolina

Report issued: April 22, 2005

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Revision History

April 22, 2005 Original release.

April 26, 2005 Reissued to correct Tables 23, 27–32; Figures 27, 30–35; and corresponding text references to benchmarks. Added PDF bookmarks.

June 5, 2006 Reissued to conceal confidential information. Georgia and Florida commercial landings reported in tables 7 and 8 were combined for reporting purposes.

Executive Summary

A SEDAR stock assessment workshop (AW)[1] was convened at the NOAA Center for Coastal Fisheries and Habitat Research, Beaufort, North Carolina, on Tuesday, March 15, 2005. The workshop's objectives were to conduct an update assessment of the black sea bass (*Centropristis striata*) stock off the southeastern U.S. and to conduct stock projections based on possible management scenarios (terms of reference, Appendix A). Participants in the SEDAR-02 benchmark assessment of black sea bass (Appendix B) and in this update assessment (Appendix C) included state, federal, and university scientists, as well as SAMFC AP members and various observers. The AW worked at Beaufort until March 17 and continued its work by email through April 22. All decisions regarding stock assessment methods and acceptable data were made by consensus.

Available data on the species included abundance indices, recorded landings, and samples of annual size compositions from indices and landings. Five abundance indices were developed by the preceding data workshop: one from the NMFS headboat survey and four from the SC MARMAP fishery-independent monitoring program. Landings data were available from all recreational and commercial fisheries.

A statistical model of catch at age was formulated as the primary assessment model. In addition, an age-aggregated production model was used to investigate results under a different set of model assumptions. The AW developed base runs of both models, analogous to those of the benchmark assessment. The base run of the catch-at-age model was the basis for estimation of benchmarks and stock status.

The 2004 spawning stock biomass is estimated at about 27% of $\mathrm{SSB}_{\mathrm{MSY}}$. By the Council's usual definition of MSST as $(1-M)\mathrm{SSB}_{\mathrm{MSY}}$, the stock is estimated at about 39% of MSST. The 2003 fishing mortality rate is estimated at about $6.15F_{\mathrm{MSY}}$, where F_{MSY} is the MFMT. These results indicate that the stock is overfished and that it is undergoing overfishing.

Projections were used to evaluate the potential of the stock to be rebuilt. Projections with $F = 0$ indicated that the stock could rebuild within 10 years, and thus, the rebuilding duration was set to 10 years in subsequent analyses. Three management scenarios designed to rebuild the stock were evaluated: (1) maximum constant F that allows rebuilding, (2) maximum constant landings rate that allows rebuilding, and (3) $F = F_{\mathrm{MSY}}$ for the first three years followed by maximum constant landings rate that allows rebuilding with $F \leq F_{\mathrm{MSY}}$ in each year. Under scenario 1, projected landings are initially lower than current levels, but exceed current landings within a few years. Under scenario 2, a small reduction in current landings allows rebuilding; however, the reduction is not sufficient to end overfishing during the first several years of projection. Under scenario 3, projected landings in the first three years are lower than current levels and projected landings in subsequent years are slightly higher. Of the three scenarios, total projected yield is largest under scenario 1.

[1] Abbreviations and acronyms used in this report are defined in Appendix D on page 101.

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1 Introduction

At the December, 2004 SAFMC[2] meeting in Atlantic Beach, NC, the Council requested an update assessment of black sea bass, to be available by the end of April, 2005. This is to be accomplished through a SEDAR update process, although the procedures for SEDAR updates are still being developed.

A SEDAR Assessment Workshop (AW) was convened at the NOAA Center for Coastal Fisheries and Habitat Research, Beaufort, North Carolina, by the South Atlantic Fishery Management Council (the Council) and the NMFS Southeast Fisheries Science Center (the Center) under the SEDAR process. The AW met for three days, from March 15 through March 17, 2005. Participation in the workshop (Appendix C) included representatives of the Council and its Scientific and Statistical Committee; representatives of the fishing industry; and scientists from the states of Florida, Georgia, North Carolina, and South Carolina; from state and federal (NMFS) agencies; and from academic institutions, including Brian Murphy, who chaired the AW.

The AW's major objectives were to conduct an update to the SEDAR-02 benchmark assessment of black sea bass, *Centropristis striata*, off the southeastern US, and to conduct corresponding stock projections. In support of those tasks, the AW received data and recommendations resulting from a scoping workshop (SW) that was convened on December 15, 2004. The SW was charged with recommending any model or data changes to be made in this assessment, which was otherwise to be based on the benchmark assessment of black sea bass conducted during SEDAR-02.

As an update report, this document is less detailed than full SEDAR assessment reports. Material not covered in detail here is given in more detail in the benchmark assessment report (SEDAR 2003).

2 Scoping Workshop

The Scoping Workshop (SW) met by conference call on December 15, 2004. Its purpose was to discuss and specify any changes in data processing and modeling approach from the preceding SEDAR benchmark assessment of black sea bass. This section summarizes major conclusions of the SW.

Participants concluded that the update assessment should be conducted with best available science and be reviewed in an appropriate manner, maintaining independence of reviewers and reviewees. As this is the first SEDAR update assessment, the experience of conducting and reviewing it will be helpful in developing general procedures for such updates.

After some discussion of process, determination of the appropriate review process was deferred to the SEDAR Steering Committee. Participants then proceeded to discuss data and modeling issues, the stated goals of the Scoping Workshop conference call. A follow-up conference call was held on January 31, 2005, to discuss any questions about data provided since the original conference call.

The following sections (§2.1–§2.6) summarize conclusions of the SW.

2.1 Data availability and additions

Workshop participants agreed that it would be impossible to obtain and prepare all 2004 data in time for the update. Problems and uncertainties associated with expanding data from partial-year

[2] Abbreviations and symbols are defined in Appendix D on page 101.

to whole-year were discussed and found substantial. Thus, participants concluded that the assessment would use data through 2003.

2.2 Abundance indices

In the benchmark assessment of black sea bass, an abundance index was computed from headboat catch and effort data, using only data on full-day trips. The update will include half-day trips also, as they typically catch black sea bass.

The SW considered adopting results of a recent MARMAP trap-comparison study, which would allow tying together several short indices of abundance into one long index. Although the SW thought that desirable in helping to detect population trends, the SW declined to accept the new index without further analysis.

2.3 Landings

Landings data from the Beaufort headboat survey, the NMFS general canvass, and the NMFS MRFSS program will be used through 2003. In a departure from the benchmark assessment of black sea bass, the coefficient of variation (CV) assumed for commercial landings will vary over time, as in SEDAR-04 assessments. This recognizes the increasing precision of those data in more recent years.

2.4 Life history

The natural mortality rate will be set at $M = 0.3/\mathrm{yr}$, as in the benchmark assessment. The SW agreed that sex ratio and maturity schedules should be smoothed using a logistic function, as done in SEDAR-04. A proposal to combine the three time periods of maturity data into a single maturity schedule was not accepted.

2.5 Modeling

2.5.1 Exploitation rates

Exploitation rates (based on age 1^+ fish) will be reported in addition to the usual fishing mortality rates on fully selected fish. It was noted that the SAFMC uses the exploitation-rate estimates in making decisions and that it would improve the assessment.

2.5.2 Discards

The probability of death for discarded fish will be set at 0.15, as in the benchmark assessment. However, the benchmark assessment assumed commercial discards to be zero, which is clearly an underestimate. To account better for commercial discards, the approach to modeling discard selectivity will be changed slightly. Participants decided to estimate discards in the 1999 and later years using the difference in selectivity between the 1983–1998 and 1999–present time periods. A sensitivity run will use the complement of selectivity, which will most likely overestimate discards, and thus will be labelled as an extreme example.

2.5.3 MSY-related benchmarks

Benchmarks required by SFA will be computed using effort-weighted recent selectivity and will be estimated by simulation. The simulation method of estimation was proposed as most consistent with simulations used in rebuilding projections. Resulting benchmark estimates will be screened using existing methods to ensure that the estimates from simulation are sensible.

2.5.4 Sensitivity runs

The benchmark assessment used a 3×3 grid of natural mortality and steepness values surrounding the base run as the basis for sensitivity runs. This grid will be retained, but the weighted averaging of model results (used as one set of estimates in the benchmark assessment but not recommended by the SEDAR Review Workshop) will be discontinued. Some other sensitivity runs (female SSB with steepness estimated, female SSB with steepness fixed, MRFSS index included, alternative weighting scheme with growth estimated) will be dropped.

2.5.5 Projections

If the stock is estimated to be overfished, recovery projections will be run. Previously, seven different recovery scenarios were examined, but some of them may no longer be necessary. Reducing the number of scenarios would reduce the number of computations and the amount of reporting needed.

The allowable time for rebuilding will be recomputed, based on the generation time and the ability of the stock to recover at $F = 0$, starting in 2007. The rebuilding time may differ from 18 years, the time frame used in previous analyses.

2.6 Report

The report will be brief, and it will be written with references to the benchmark assessment report wherever possible, but it will include a complete description of changes from the benchmark assessment. It will also include new tables and graphs of data and estimates from the update.

3 Background information

3.1 Regulatory history

This stock is managed by the South Atlantic Fishery Management Council (SAFMC 1988; 1991; 1998; 2000). For a summary of regulatory history, see Table 1 on page 29.

3.2 Assessment history

Two assessments of black sea bass were conducted prior to the SEDAR process, both based on tuned VPA. The first (Vaughan et al. 1995) included data through 1990 and estimated that overfishing was occurring during the 1980s. The second (Vaughan 1996) included data through 1995 and estimated that overfishing was occurring to an even greater extent during the early 1990s.

The preceding SEDAR benchmark assessment was conducted in 2002–03, as part of the second SEDAR cycle.

4 Life History

4.1 Management unit

The black sea bass, *Centropristis striata*, is a protogynous serranid that occurs along the U.S. Atlantic coast from Cape Cod, Massachusetts, to Cape Canaveral, Florida, and in the Gulf of Mexico. Two populations, separated by Cape Hatteras, North Carolina, have been reported to occur along the Atlantic coast, although strong genetic similarities have been noted (Robert W. Chapman, pers. comm.). Black sea bass in the Gulf of Mexico are considered a separate subspecies.

Black sea bass north of Cape Hatteras are managed as a stock by the Mid-Atlantic Fishery Management Council; black sea bass south of Cape Hatteras to Florida are managed as a second stock by the SAFMC. This assessment, conducted for the SAFMC, concerns the stock unit south of Cape Hatteras, including waters off North Carolina (NC), South Carolina (SC), Georgia (GA), and the east coast of Florida (FL).

Black sea bass occur in depths of 2 to 120 m, but most adults are found in 20 to 60 m. Although black sea bass north of Cape Hatteras are migratory, tagging studies indicate movements of black sea bass south of Cape Hatteras are limited and less well-defined (Ansley and Davis 1981; Collins et al. 1996).

4.2 Mortality rates

This assessment used a natural mortality rate of $M = 0.3$/yr, as recommended and adopted by the SEDAR-02 data and assessment workshops. In addition, the SEDAR-02 data and assessment workshops recommended and adopted a release mortality fraction of 0.15.

4.3 Length conversions

Conversions among TL, FL, and SL, and between weight and TL, are given in Table 2. As in the SEDAR-02 black sea bass assessment, the relationship between length and weight was estimated using bioprofile data from the headboat fishery. These data were from the years 1975–2003.

4.4 Weight–length relationship

The power model of weight and length ($W = \omega_1 L^{\omega_2}$) was linearized as

$$\ln(W) = \omega_1 + \omega_2 \ln(L) + \epsilon,$$

where W is weight in kg, L is total length in mm, ϵ is a random variable distributed normally with mean 0 and variance σ^2, and ω_1 and ω_2 are estimated parameters (Table 2). The linearized relationship was fit by ordinary least squares. In estimating W at length, the estimate was corrected for transformation bias using $\exp(\frac{\sigma^2}{2})$.

4.5 Growth models

In the SEDAR-02 assessment, the von Bertalanffy growth equation was taken directly from McGovern et al. (2002), who expressed length (SL in mm) as a function of age a in years, based on a sample of 3,494 fish captured during 1987–1998 using blackfish or chevron traps:

$$\text{SL} = 398.1(1 - \exp[-0.164(a + 1.295)]). \quad (1)$$

For this update, J. McGovern re-estimated the von Bertalanffy growth equation from the same data, expressed as TL in mm (Figure 1):

$$\text{TL} = 544.5(1 - \exp[-0.16(a + 1.16)]). \quad (2)$$

The CV of size at age was estimated for each age, 1–7. (The sample sizes were very small, $N < 5$ for ages 8 and 9). The CV for age 0 was set to that for age 1, and the CV for ages 8–11 was set to the mean CV for ages 6 and 7. Lengths and CVs at age are summarized in Table 3.

4.6 Reproductive biology

Black sea bass are protogynous hermaphrodites (i.e., change sex from female to male). Individuals undergoing this transition have been observed throughout the year; however, the percentage of those in transitional is much lower during the spawning season and highest when spent and resting individuals are collected. According to McGovern et al. (2002, p. 1156): "Most black sea bass undergoing transition were 160–259 mm SL (94%) and ages 2–4 (92%)." Males occur in all size and age groups, but are most frequent at sizes greater than 250 mm TL and ages of 4 and older. Black sea bass can live for at least 10 years.

Black sea bass spawn from January through July along the southeastern U.S. coast. Occasionally, spawning is also observed in fall (October and November). The greatest percentage of females in spawning condition occurs during March through May. Females are believed to produce new eggs throughout the spawning season (indeterminate spawning). Eggs are pelagic, as are early-stage larvae, which have been found in inlets, bays, and offshore waters. Larvae become demersal at approximately 13 mm TL. Juveniles have been recorded from bays, estuaries, inlets, and near-shore waters.

To estimate proportion of females at age, a logistic curve was fit to MARMAP data on sex ratio at age (the same data used in the benchmark assessment). Age-specific estimates are summarized in Table 4.

To estimate maturity of females at age, logistic curves were fit to the same MARMAP data used in the benchmark assessment, separated into three time periods (1978–1983, 1984–1989, and 1990–2003). Age-specific estimates of the proportion of females mature are summarized in Table 4.

Male maturity at age is the same as that used in the SEDAR-02 assessment (0% for age 1, 100% for ages 1 and older).

5 Commercial fisheries

5.1 Overview

Black sea bass is a valuable species in commercial fisheries. The most common commercial gear has been traps (pots), with some fish taken by handline or by trawling. However, trawling for black sea bass has been banned since January 1989 (SAFMC 1988) (Table 1).

5.2 Commercial landings

Commercial landings were updated to include 2002 and 2003, using the same corrections developed in the SEDAR-02 data workshop. These corrections excluded landings believed to originate from north of Cape Hatteras, NC, as indicated by NC trip-ticket data. Excluded from analysis were all NC trawl landings and 8% of NC trap landings.

The black sea bass commercial fishery peaked in 1974 at 615 mt (1.36 million lb) and again in 1981 at 543 mt (1.20 million lb) and since then has fluctuated between 250 and 450 mt (0.6 to 1.0 million lb) (Figure 2). Commercial landings are summarized by gear in Tables 5 and 6, and by state in Tables 7 and 8.

During the assessment time period (1978–2003), commercial trap landings peaked in 1981 at 454 mt (1.01 million lb), but have generally averaged around 214 mt (0.47 million lb) with little trend over the last 20 years. Commercial handline landings have averaged about 94 mt (0.21 million lb) with little trend, while the commercial “other” category (includes trawl and miscellaneous gears) has averaged only 6.6 mt (0.01 million lb), also with little trend.

Previous SEDAR workshops have concluded that uncertainty in the quality of landings data should be acknowledged quantitatively in the assessment. As noted in SEDAR-04, confidence in commercial landings data has increased substantially since the 1960s.

Increasing recognition of the importance of fishery data resulted in greater efforts through the 1970s and mid-1980s to collect landings data. In 1984, the state of Florida implemented a trip-ticket program. From 1984 to 1994, all U.S. South Atlantic states improved commercial landings data collection. In 1994, the North Carolina trip-ticket program was implemented. As of 2003, Georgia and South Carolina also implemented trip-ticket programs. The coefficients of variation (CV) of landings data in this update assessment reflect these progressive improvements in landings data. CVs for commercial landings were set at 30% for 1973–1984 data, 5% for 1994–2003 data, and were linearly interpolated for intervening data (Table 5).

5.3 Age and length composition

Length compositions were updated for commercial gears (trap, handline, and other) for 2002–2003, using the same methodology as in the SEDAR-02 assessment. Sample size by gear, including those from recreational and fishery-independent sources, is summarized in Table 9. Commercial length compositions are summarized by gear for 1978-2003 in Table 10 through Table 12 and in Figure 3.

No age-composition data were used in this assessment. Such data were available to the benchmark Assessment Workshop (SEDAR-02), but were characterized by that workshop as unreliable, and were not used in the benchmark assessment.

6 Recreational fisheries—description and data

6.1 Overview of components

The general recreational fishery is sampled by MRFSS. The headboat fishery is sampled separately, and for that reason is distinguished here from the general recreational fishery. These two recreational sectors are referred to here as "MRFSS" and "Headboat." Both recreational fisheries use hook-and-line gear almost exclusively. Recreational landings are shown in Figure 2 and are summarized by fishery in Tables 5 and 6, and by state in Tables 7 and 8.

During the early 1980s, before commercial data were available by species, the MRFSS and headboat sectors each contributed about 37% to the black sea bass total landings. In recent years, the commercial and recreational landings are approximately equal.

6.2 General recreational (MRFSS)

The general recreational fishery is defined here to include all recreational fishing from shore, private boats, and charter boats (for-hire vessels that usually accommodate six or fewer anglers as a group).

6.2.1 Landings

The recreational fishery shows high and quite variable landings in the 1980s, peaking in 1984 at 1,014 mt (2.2 million lb), with declining landings through the 1990s (averaging 291 mt, or 0.64 million lb since 1990).

Data on landings (in weight) were taken from the MRFSS database, updated for 2002–2003. Landings are estimated as MRFSS category A (landed and available for sampling) plus B1 (landed and unavailable for sampling) plus 15% of B2 (released), as in the benchmark assessment (SEDAR-02). To characterize the CV of landings, the reported MRFSS proportional standard errors (PSE) were used, in contrast to the use of a constant value of 5% in SEDAR-02.

6.2.2 Length composition

Data on length composition of general recreational landings were updated for 2002–2003 using the same methodology as in the benchmark assessment (Table 13 and Figure 4).

6.3 Headboat fishery

6.3.1 Overview

The headboat fishery comprises larger, for-hire vessels that generally charge a fee per angler.

6.3.2 Landings

Landings during the assessment period were initially high, peaking in 1982 at 318 mt (0.70 million lb). Landings then declined and since 1990 have averaged 81 mt (0.18 million lb).

While preparing data for this assessment, concern was raised over the mixing of sea basses (principally black and bank sea basses) in the headboat logbook database. In the years 1978–1980, there was no separation, but during 1981–1987 these species were increasingly separated in the data base. To correct for this mixture, the proportion of black sea bass to total sea bass was calculated for 1988–1990 (0.9536) and applied to total (black + bank) sea bass landings for 1978–1987.

Headboat landings, 2002–2003, were updated for this assessment. In the SEDAR-02 black sea bass assessment, a CV of 5% was assumed for all years (1978-2001). For this update assessment, headboat landings retained the assumed CV of 5% for 1988–2003, but doubled this CV to 10% for 1978–1987 to reflect the correction described above.

6.3.3 Length composition

Data on length composition of headboat landings were updated for 2002–2003 (Table 14 and Figure 4) using the same methodology as in the SEDAR-02 benchmark black sea bass assessment.

6.3.4 Abundance index

An abundance index was developed using data on CPUE from the headboat sector. Because the headboat trip data (logbooks) for 1973 were extremely sparse (10 trips in July and August, and one corresponding measured fish in the bioprofile data), this year was not used in developing the index. To address the mixing of black and bank sea basses in this context, the same correction described in §6.3.2 was applied when computing the abundance index, 1974–1987.

Only catches in weight (not number of fish) were available on catch records for 1974–1991. To avoid converting catches in weight to catches in numbers, the abundance index is based on weight directly.

A lognormal GLM (general linear model) approach was used, and was based on positive trips only, as in the benchmark assessment. Factors used in the GLM were year, month, area fished, and trip type (half- or full-day). The resulting abundance index Figure 5, Table 15) describes years 1974–2003 and is expressed in weight per unit effort (lb of fish per angler-trip).

7 Fishery-independent survey data—MARMAP

Fishery-independent data used in this assessment were provided by the MARMAP program. The program is funded by NMFS and conducted by SCDNR.

7.1 Methods, gears, and coverage

Four indices of abundance from MARMAP were used in the SEDAR-02 black sea bass assessment: hook & line (1981–1987), blackfish trap (1981–1987), Florida snapper trap (1981-1987), and chevron trap (1990–2001). For this assessment, the chevron trap index was updated through 2003; the other three indices were unchanged (all, Figure 5 and Table 15). The index from hook & line gear is in units of number fish per collection-hour, and the indices from trap gears are in units of number fish per trap-hour.

7.2 Length composition

Length compositions of MARMAP chevron-trap samples were updated through 2003. Length compositions from other MARMAP gears (1981–1987) were left unchanged in this update assessment. Length compositions from MARMAP gears are shown in Figure 6 and are summarized in Tables 16 through 19.

8 Stock assessment methods

8.1 Model 1: catch-at-age model

The primary model in this assessment (as in the preceding benchmark assessment) was a forward-projecting, statistical catch-at-age model (Quinn and Deriso 1999). The model was implemented in the AD Model Builder software (Otter Research 2000) on a microcomputer (code in Appendix E on page 102). The model is detailed in Table 20. Its major characteristics can be summarized as follows:

Natural morality rate The natural mortality rate was assumed constant over age and time.

Stock dynamics The standard Baranov catch equation was applied. This assumes exponential decay in population size due to fishing and natural mortality processes. The oldest age class allowed for the accumulation of fish (i.e., a plus group).

Growth A von Bertalanffy growth model, constant over time, was used, with parameters as described in §4.5.

Recruitment A Beverton–Holt recruitment model was estimated internally. Estimated annual recruitment was loosely conditioned on that model.

Biological reference points (benchmarks) In SEDAR-02 assessment of black sea bass, the quantities F_{MSY}, SSB_{MSY}, and MSY were estimated by the method of Shepherd (1982). In that method, the point of maximum yield is identified from the recruitment curve and parameters describing growth, natural mortality, fecundity, maturity, and selectivity. While that method is widely used, it has the disadvantage that the estimated F_{MSY} may not always lead to SSB_{MSY} in recovery simulations.

In this update assessment, F_{MSY}, SSB_{MSY}, and MSY were estimated by age-structured simulation, rather than by the Shepherd (1982) method. The new method has the advantage that calculations closely mimic those used for recovery projections. Estimates from the two methods are expected to be similar, but not identical.

As its starting point, the new method uses the equilibrium population size and age distribution corresponding to F_{MSY} as estimated by the method of Shepherd (1982). From that population state, $k = 1000$ simulated populations are projected forward for $t_{\text{sim}} = 200$ yr under a trial value of F and constant selectivity values (described below). In the simulated populations, recruitment is treated as a stochastic process with multiplicative lognormal variation around the estimated stock-recruit curve, as in the assessment model. Multiplicative recruitment deviations are drawn from a lognormal distribution truncated to two standard deviations, with mean equal to one and variance as estimated by the assessment model. This variance is derived from the recruitment residuals estimated for 1978–2000, years not heavily constrained to the stock-recruit curve. After some time, the simulated populations reach a moving equilibrium in age structure, yield, and population size.

Once the moving equilibrium has been reached, estimates of SFA benchmarks are made from properties of the k simulated populations. The sustainable yield for each of the k populations is computed as the median yield during the final t_{eq} = 100 yr of the simulation. The average sustainable yield ASY for that trial F is then computed as the median of the k sustainable yields. The estimate of F_{MSY} is the trial value of F giving the highest ASY, and the estimate of MSY is that ASY. The SSB at F_{MSY} is computed as the median of medians (the same procedure used in computing ASY), providing the estimate of SSB_{MSY}.

In either method, selectivity at age must be specified, because MSY is conditional on selectivity pattern. The selectivity pattern used here was the effort-weighted selectivities at age estimated for the last three years (2001–2003), a period of unchanged regulations.

Fishing Five fisheries were modeled individually: commercial handline, commercial trap, commercial other, recreational headboat, and general recreational (sampled by MRFSS). Separate fishing mortality rates were estimated for each fishery.

Selectivity functions Rather than estimating independent selectivity values for each age, selectivity curves were fit parametrically. This approach reduces the number of estimated parameters and imposes structure on the estimates. Selectivity was modeled using a doubleŰlogistic function (dome-shaped) for MARMAP trap gears, and a logistic function for all other gears.

The selectivity parameters were estimated internally by the assessment model. Selectivity parameters of the major fisheries (commercial trap, commercial handline, recreational headboat, and general recreational) were estimated separately for three different periods of regulations: 1978–1982, no size limit; 1983–1998, 8 inch size limit; and 1999–2003, 10 inch size limit (Table 1). Selectivities of recreational headboat and general recreational were assumed equal. Commercial "other" (the smallest sector) and the MARMAP gears were each assumed to have constant selectivity over time.

Discards Discarded fish are routinely estimated in the MRFSS and are accounted for in the estimate of total landings. However, no discard information from other fisheries was made available by the Data Workshop (DW). Discards from commercial handline, commercial trap, and headboat fisheries were approximated from discard-selectivity curves estimated across different regulation periods. In the period prior to regulations, discards were assumed to be zero. In subsequent periods, the discard selectivity curve was estimated as the greater of zero or the difference between current selectivity and that in the period immediately prior. This approach is likely an underestimate of discards, because it assumes that no discards occurred prior to size regulations, and that discards only result from changes in the size limit. Any regulation, such as trap escape vents, that reduce size-based discards are not specifically modeled.

Discard mortality rates were then estimated by assuming release mortality rates of 0.15, as specified by the DW. The product of release mortality, the estimate of fishing mortality rate, and the estimated discard selectivity curve provided age-specific instantaneous discard mortality rates

(Quinn and Deriso 1999).

Abundance indices The model was fit to the five indices of abundance described above: four fishery-independent indices (hook-and-line, 1981–1987; blackfish trap, 1981–1987; FL snapper trap, 1981–1987; chevron trap, 1990–2003) and one fishery-dependent index (headboat, 1974–2003). The assessment model estimated a catchability coefficient for each index.

Initialization The assessment period starts in 1978 when landings data are available on all fisheries. However, the assessment model starts in 1967. This initialization period (1967–1977) was used to define the age structure at the start of the assessment period, and its duration was set to the maximum age modeled (11 years). Recruitment during the initialization period was constrained to follow the stock–recruit curve, because the data provided little information to estimate recruitment. The initial age structure in 1967 was set to the stable age structure, given the estimated total mortality rate of that year.

Some preliminary model runs depicted a stock that was severely depressed (biomass < 5% virgin biomass) as far back as 1967. Despite substantial landings in the early 1960's, the AW did not believe the stock to be severely depressed in 1967. Thus, to initialize the assessment model, total biomass in 1967 relative to unexploited biomass (B_{1967}/B_0) was treated as a fixed quantity, rather than estimated. By use of a constraint, the AW fixed initial relative biomass at $B_{1967}/B_0 = 0.75$, as estimated by the age–aggregated production model (§8.2).

Fitting criterion The fitting criterion was a likelihood approach in which observed landings were fit almost exactly, and the observed length compositions and abundance indices were fit to the degree that they are compatible. Landings data and abundance index data were fit using a lognormal likelihood, the value of which is inversely related to the coefficient of variation (CV; Table 15, Table 5). Composition data were fit using a multinomial likelihood.

The total likelihood also included penalty terms to discourage large variability in recruitment during the last three assessment years, large variability in fully selected F during the last five assessment years, and fully selected F greater than 5.0 in any year. Relative statistical weighting of each likelihood component was chosen by the AW after examining many candidate model runs. The criteria for choice were a balance of reasonable fit to all available data and a good degree of biological realism in estimated population trajectory. The chosen weighting scheme helped define the base run of the assessment model.

8.1.1 Quality control

The assessment model was repeatedly tested on simulated data prior to the AW. It accurately estimated model parameters, indicating that the model has been implemented correctly and can provide an accurate assessment. In addition, computer programs used for benchmark estimation and projections were reviewed and tested by several stock assessment biologists. Computer files of data input were reviewed for accuracy by participants in the AW.

8.1.2 Measures of precision

The simulation procedure used to estimate benchmarks allows consistency with recovery projections. In addition, the procedure can provide measures of precision of most benchmark quantities. However, the procedure as implemented does not provide measures of precision of F_{MSY}.

Precision of estimated benchmarks (other than F_{MSY}) is represented by the 20th and 80th percentiles of the 1000 simulations used in the benchmark estimation procedure. Likewise, precision of projections is represented by the 20th and 80th percentiles of the 1000 simulated projections (§11). These measures of precision reflect uncertainty due to stochasticity in recruitment, but not uncertainty in the data or model structure. Hence, the actual uncertainty of estimated quantities is likely larger than that depicted by percentiles from the simulations.

8.1.3 Sensitivity analyses

As in the SEDAR-02 assessment, the update assessment applies a 3×3 grid of natural mortality and steepness values surrounding the base run as the basis for sensitivity runs. The base run used $M = 0.3$; sensitivity runs used $M = 0.2$ or $M = 0.4$. The base run estimated steepness (h), a key parameter of the stock-recruit curve; sensitivity runs fixed steepness at $h = 0.4$ or $h = 0.8$. In addition, one sensitivity run assumed discard selectivity to be the complement of fishery selectivity, which most likely overestimates discards. This run is labelled, "extreme discards."

8.2 Model 2: production model

Though the SW considered production model runs unnecessary, the AW concluded that such runs would be useful.

The age-aggregated production model used was the Graham–Schaefer logistic surplus-production model (Schaefer 1954, 1957; Prager 1994). This is a continuous time formulation, conditioned on catch, that does not assume equilibrium conditions. By conditioning on catch, the landings data are assumed more precise than the abundance indices. The model fits more than one abundance index by assuming they are correlated measures of stock abundance and that differences between indices can be considered sampling error. Abundance indices fit by the production model were in units of weight per effort (Figure 7).

One form of the production model was fit: the Schaefer (1954; 1957) model, which assumes $B_{MSY} = 0.5K$, where K is the carrying capacity of the stock (virgin stock size, equivalent to B_0 in the age-structured model). The Schaefer form is often used as a default because of its theoretical simplicity and because it is considered a central case among possible shapes of production model. To fit the production models, version 5.08 of the ASPIC software of Prager (1995) was used.

For use in the production model, the time series of total landings was extended to include years prior to the assessment period, 1950–1977. Extended commercial landings were obtained via the Internet from Fisheries Statistics of the NOAA Fisheries Service (`http://www.st.nmfs.gov/st1/commercial`). Recreational landings during this pre-assessment period were found to have been considerable. The 1960, 1965, and 1970 Saltwater Angling Surveys (Clark 1962; Deuel and Clark 1968; Deuel 1973) indicated recreational landings of 295 mt, 770 mt, and 5600 mt, respectively, by anglers from the South Atlantic Region (Cape Hatteras to Florida). These estimates are higher than the documented commercial landings in those years.

To evaluate effects on the assessment of landings from the pre-assessment period, three applications of ASPIC were made using the extended landings for 1950–1977. Because 1950–1977 recreational landings data were not available, each application of ASPIC assumed a different level of recreational landings relative to commercial landings during the pre-assessment period (Table 21,

Figure 8). These assumptions were that recreational landings were equal to commercial landings ($R = C$), two times commercial landings ($R = 2C$), or three times commercial landings ($R = 3C$). These levels were used because, during the assessment period, the ratio of recreational landings to commercial landings ranged from one to three. The AW recommended that the middle assumption ($R = 2C$) be considered the base run.

9 Assessment results

9.1 Results of catch-at-age model

9.1.1 Model fit

In general, the model fits the available data well. Fits to length compositions from fisheries are close in most years (Figure 9 through Figure 13). Fits to length compositions from MARMAP are adequate, though not as close as those from fisheries, indicating that the MARMAP length compositions are somewhat incompatible with other data (Figure 14; Figure 15).

Of the data sources used in this assessment, observed landings are believed to have the least sampling error. Consequently, the model was configured to fit observed commercial and recreational landings closely, and that was achieved (Figure 16, Figure 17).

Fits to indices of abundance were reasonable. MARMAP indices based on blackfish trap and chevron trap samples were fit well, but those from the FL snapper trap and hook & line were fit less well due to high annual variability in the data (Figure 18). The headboat index, a time series with a pronounced trend, was fit quite well by the model (Figure 19).

9.1.2 Selectivity

Commercial gears Estimated selectivities of commercial gears are presented in Table 22 and in Figures 20–22. Commercial handline shows full selectivity by age four, with little change in selectivity across periods of regulation, other than a decrease in selectivity of age-three fish in the third period. Selectivity of commercial trap shows a gradual slope in the earliest period, knife-edge thereafter, with a shift toward larger fish between period two and period three. Commercial other was approximately knife-edge and fully selected by age four.

Recreational gears For each period of regulation, a single recreational selectivity was applied to headboat and MRFSS. From the earliest to most recent period, the recreational selectivity shifts toward older, larger fish (Table 22, Figure 23).

9.1.3 Mortality rates

The estimated time series of fishing mortality rate (F) shows an increasing trend between the early 1980s and recent years (Figure 24, Table 23). Over the assessment period, F is estimated to have increased from about 0.5/yr to 2.5/yr.

The estimated time series of exploitation rate (E) depends on the ages used in computation (Figure 24). For ages that are fully selected (ages 4^+) or almost fully selected (ages 3^+), the pattern of E is close to that of F. However, if younger fish are included (ages 2^+), the pattern of E shows a different trend, decreasing since the mid-1990s. Exploitation of ages 1^+ shows little trend across time, fluctuating around a mean of about 0.23 and decreasing slightly since the mid-1990s (Table 23).

9.1.4 Abundance and biomass at age

The catch-at-age model provides estimates of abundance in numbers at age (Table 24) and in biomass at age (Tables 25 and 26). Numbers and biomass of younger ages display a general decrease until the early 1990s and are relatively stable since. Abundance of older ages depicts a decrease throughout the time series, with marked truncation of the age structure in recent years.

9.1.5 Total biomass and spawning stock

Total biomass (B) and spawning-stock biomass (SSB) show similar patterns: relatively stable until the mid-1980s, declines between the mid-1980s and mid-1990s, and slight increases since then (Figure 25). By 1995, B had declined to about 45% of its 1978 value, and SSB had declined to about 48% of its 1978 value.

9.1.6 Stock and recruitment

The estimated stock–recruitment relationship shows the usual scatter about a fitted Beverton–Holt recruitment curve (Figure 28). Virgin SSB is estimated to be about $SSB_0 = 17,739$ mt (39.11 million lb) and SSB_{MSY} is estimated to be about $SSB_{MSY} = 6812$ mt (15.017 million lb). Virgin recruitment is estimated to be about $R_0 = 1.523 \times 10^7$ fish and recruitment at MSY is estimated to be about $R_{MSY} = 1.209 \times 10^7$ fish. These estimates, in conjunction with Figure 26, imply that during the assessment period, stock and recruitment have been low relative to their potentials.

The estimated time series of recruitment declines during the 1980s (Figure 29). This decline precedes the decline in estimated SSB. Estimated recruitment events in 1994–1996 are stronger than in surrounding years, contributing toward the slight increase in SSB during the late 1990s until present.

9.1.7 Per recruit analyses

Static spawning potential ratio (SPR) shows little trend over time (Table 23, Figure 26). Static SPR of each year is computed as spawners per recruit given that year's fishery-specific Fs and selectivities, divided by spawners per recruit that would be obtained in an unexploited stock. In this form, SPR ranges between zero and unity and represents SPR that would be achieved under an equilibrium age structure at the current F (hence the designation static). Estimated SPR reached its lowest value in 1995, and has increased since, but in general it fluctuates near a mean value of about 0.25.

Yield per recruit and SSB per recruit were computed as functions of F (Figure 27). These computations applied the average ratios of F among the five fisheries from the last three years (2001–2003), along with the most recent selectivity patterns. The yield-per-recruit curve is nearly flat over the range of Fs estimated to have occurred during the assessment period. The SSB-per-recruit curve approaches an asymptote of about 25%, which is due to the fish reaching maturity before becoming susceptible to harvest. This asymptote helps explain why an increase of F over the last decade does not necessarily translate into a decrease of SSB.

Overlaid on these curves are values of F_{max}, $F_{30\%}$, $F_{40\%}$, and F_{MSY}. The value of $F_{max} = 2.055$/yr was computed as the F that maximizes yield per recruit; the values of $F_{30\%}\% = 1.44$/yr and $F_{40\%}\% = 0.61$/yr were computed as those Fs corresponding to 30% and 40% SSB per recruit, respectively; and the value of $F_{MSY} = 0.429$/yr was computed by simulation as described in §8.1. Mace (1994) recommended $F_{40\%}$ as a proxy benchmark when F_{MSY} cannot be estimated; however, later studies have found that $F_{40\%}$ is too high across many life-history strategies (Williams and Shertzer 2003) and can lead to undesirably low levels of biomass and recruitment (Clark 2002). Figure 27 suggests that a value near $F_{46\%}$ corresponds to F_{MSY} in this stock, but of course, a proxy is unnecessary here because F_{MSY} is estimated directly.

9.1.8 Miscellaneous

The model specification in ADMB language is given in Appendix E on page 102. Raw model output, including all parameter estimates for the base run, is given in Appendix F on page 127.

9.2 Results of production model

Fits to the age-aggregated production model, under assumptions $R = C$, $R = 2C$, or $R = 3C$, are shown in Appendix G on page 129. Though the model structure is quite different from that of the catch-at-age model, the qualitative results in terms of estimated stock status are the same, as described below.

10 Biological reference points

10.1 Estimation methods

As described in §8.1, biological reference points were estimated by simulation. This approach is consistent with simulations used for projections. Values estimated by simulation were compared to those estimated by standard analytical methods, and the values were quite similar. The reference points estimated were F_{MSY}, E_{MSY}, MSY, and SSB_{MSY}. Based on F_{MSY}, three values of F at optimum yield (OY) were considered: $F_{\text{OY}} = 65\% F_{\text{MSY}}$, $F_{\text{OY}} = 75\% F_{\text{MSY}}$, and $F_{\text{OY}} = 85\% F_{\text{MSY}}$. For each, the corresponding OY was computed using the same simulation procedure.

10.2 Results

Estimates of biological reference points are summarized in Table 27. Time series of estimated SSB, F, and $E(1^+)$ relative to corresponding MSY benchmarks are shown in Figure 30. The trajectory of $\text{SSB}/\text{SSB}_{\text{MSY}}$ is near 0.5 during the early assessment period, consistent with the substantial fishery of black sea bass in the 1960s and 1970s. This trajectory declines during the late 1980s and early 1990s, and it remains between 0.2 and 0.3 since. The trajectory of F/F_{MSY} is highly variable but consistently above one, indicating that overfishing has occurred throughout the assessment period. This trajectory shows an increasing trend over the last two decades. Like F/F_{MSY}, the trajectory of E/E_{MSY} of ages 1^+ is consistently above unity.

Results of the catch-at-age model are compared to those of the base-run production model in Figure 31. For consistency with the production model, Figure 31 displays relative biomass from the catch-at-age model in terms of total biomass, rather than spawning stock biomass. Both models depict $F > F_{\text{MSY}}$ and $B < B_{\text{MSY}}$ throughout the assessment period.

10.3 Status indicators

10.3.1 Definitions

The maximum fishing mortality threshold (MFMT) was taken to be F_{MSY}, and the minimum stock size threshold (MSST) was taken to be $(1 - M)\text{SSB}_{\text{MSY}}$ (Restrepo et al. 1998). Overfishing is defined by $F >$ MFMT and overfished by SSB $<$ MSST. Current status of the fishery is estimated to be that of the latest assessment year, and current status of the stock is estimated to be that at the beginning of 2004.

10.3.2 Status of stock and fishery

At the beginning of 2004, the status of the stock is estimated as $\mathrm{SSB}_{2004}/\mathrm{SSB}_{\mathrm{MSY}} = 0.273$ and $\mathrm{SSB}_{2004}/\mathrm{MSST} = 0.390$. The status of the fishery is estimated to be $F_{2003}/F_{\mathrm{MSY}} = 6.151$ and $E_{2003}/E_{\mathrm{MSY}} = 1.617$ (Table 27). Thus the stock is estimated to be overfished and to be undergoing overfishing.

10.3.3 Sensitivity analyses

Sensitivity analyses (described in §2.5.4) included nine model runs in addition to the base run. All ten of the model runs estimate that the stock is undergoing overfishing, and nine estimate that the stock is overfished (Table 28). Though quantitative results may differ among model runs, the qualitative results appear to be robust: the stock is overfished and is undergoing overfishing.

11 Projections (rebuilding analyses)

11.1 Projection methods

Because the stock was estimated to be below MSST, recovery projections were made. The structure of the projection model was the same as that of the assessment model, and parameter estimates were those from the assessment's base run. Time-varying parameters, such as the female maturity schedule and fishery selectivity curves, were the most recent values used during the assessment period.

11.1.1 Initialization

The recovery period starts in 2007. Because the assessment period ended in 2003, projections required a three-year initialization period (2004–2006). The initial abundance at age in 2004, other than age 0s, was taken to be the 2003 estimate of abundance at age, discounted by natural and fishing mortalities. The initial abundance of age 0s was computed using a stochastic recruitment model (described below) and based on the 2003 estimate of SSB. The fishing mortality rates in the initialization period were estimated to be those that maintain current landings. Current landings were defined as the arithmetic mean of observed landings in the last three assessment years, 2001–2003.

To incorporate fishery-specific selectivities, the projected total F was distributed among fisheries in proportion to current effort. Current effort by fishery was estimated as the geometric mean of the estimated fishery-specific Fs during 2001–2003.

11.1.2 Stochasticity

Projections used a bootstrap procedure to generate stochasticity in the stock–recruit relationship. The Beverton–Holt model fit by the assessment was used to compute expected annual recruitment values ($\bar{R}_y$). Variability was added to the expected values by choosing multiplicative deviations at random from a lognormal distribution,

$$R_y = \bar{R}_y \exp(\gamma_y). \quad (3)$$

Here γ_y was drawn from a normal distribution with mean 0 and standard deviation 0.28, the value estimated by the assessment for years without heavy constraint on the stock-recruit curve (1978–2000). The distribution was truncated at two standard deviations, which includes 95% of all possible values, but excludes extreme recruitment events from the tails of the distribution.

The bootstrap procedure generated 1000 replicate projections, each with a different stream of stochastic recruitments. Annual estimates of SSB, F, recruitment, and landings were represented by median values computed across bootstrap replicates. The stock was considered to be rebuilt when the projected median SSB reached SSB_{MSY} = 6811.641 mt (15.017 million lb).

11.1.3 Projections with $F = 0$

The time frame for rebuilding was based on projections with fishing mortality equal to zero. Those projections estimated that the stock can be rebuilt within 10 years (Table 29, Figure 32). Thus, in accordance with the National Standards, the time frame for rebuilding was set at 10 years. In projected management scenarios, the criterion for rebuilding is that SSB has reached SSB_{MSY} = 6811.641 mt (15.017 million lb) by the start of year 2017.

11.2 Management scenarios considered

Projections considered three management scenarios designed to rebuild the stock:

- **Scenario 1:** Maximum constant fishing mortality rate that allows rebuilding
- **Scenario 2:** Maximum constant landings rate that allows rebuilding
- **Scenario 3:** $F = F_{MSY}$ in the first three years, followed by maximum constant landings that allow rebuilding, under the constraint $F_y \leq F_{MSY}$ for all y (i. e., in every year)

11.3 Projection results

Under scenario 1, projections estimate that the stock can rebuild if F remains constant at no greater than $F = 0.29$/yr, which is about 68% of F_{MSY} (Table 30, Figure 33). Landings drop initially to about 27% of the current level, but rebound quickly as the stock recovers.

Under scenario 2, projections estimate that the stock can rebuild if landings remain constant at no greater than 526 mt (1.16 million lb) (Table 31, Figure 34), a modest reduction from the current level. However, to sustain 526 mt of landings, the annual fishing mortality rate exceeds F_{MSY} in four of the ten rebuilding years.

Under scenario 3, fishing at $F = F_{MSY}$ leads to landings that increase during the first three years (2007–2009), from about 38% to 88% of the current level (Table 32, Figure 35). Starting in 2010, landings must remain constant at no greater than 607 mt (1.34 million lb). Larger constant landings may still allow the stock to recover by 2017, but would lead to a violation of the constraint $F_y \leq F_{MSY}$.

A comparison of management scenarios reveals that landings under scenario 1 are initially below those of scenario 2 and scenario 3, but rebound quickly to surpass them within a few years. By 2016, cumulative landings of scenario 1 are estimated to be about 533 mt (1.17 million lb) higher than those of scenario 2, and about 391 mt (0.86 million lb) higher than those of scenario 3.

11.4 Comments on projections

As usual, projections should be interpreted in light of the model assumptions and key aspects of the data. Some major considerations are—

- Initial abundance at age of the projections are based on estimates from the assessment. If those estimates are inaccurate, rebuilding will likely be affected.
- Fisheries are assumed to continue fishing at their estimated current proportions of total effort, using their estimated current selectivity patterns. New management regulations that alter those proportions or selectivities would likely affect rebuilding.
- In constant-landings scenarios, it is necessary to reduce the fishing mortality rate F

continually as the population increases. This implies decreasing the annual fishing effort throughout the recovery period.

- The projections assume no increase in the proportion of catch that is discarded. As recovery generally begins with the smallest size classes, management action may be needed to meet that assumption.

- The projections assume that the estimated stock–recruit relationship applies in the future and that past residuals represent future uncertainty in recruitment. The assessment results suggest that the stock may be characterized by periods of unusually high or low recruitment, possibly due in part to environmental conditions. If so, rebuilding may be affected.

12 Recommendations for future research and assessment

12.1 Progress on previous recommendations

The AW considered existing recommendations for research and data management and discussed what progress had been made on these recommendations since the SEDAR-02 assessment workshop. Future efforts to address these recommendations were also identified.

The numbered items below are taken verbatim from the benchmark assessment document:

1. Representative age sampling is needed (proportional); also commercial age sampling. *Response:* The MARMAP program will ensure that all sampled black sea bass are aged, which will provide age-composition data on MARMAP samples.

2. Increases in fishery independent sampling. *Response:* The MARMAP program is continuing to increase sampling at the northern and southern extremes of its range, and has already extended its range considerably. For example, sampling stations suggested by commercial fishermen have been added to the sampling plan.

3. Development of logbook indices is recommended. *Response:* In response to this and similar recommendations, the Population Dynamics Team at Beaufort has developed logbook indices for other species; those indices have been used or considered in recent SEDAR assessments. The technology should be applicable to future assessments of black sea bass.

4. Information about fecundity is needed (batch fecundity and frequency at age and/or size). *Response:* MARMAP is currently conducting a fecundity study, which should be complete by the next assessment of black sea bass. In the meantime, spawning biomass has been used as a widely accepted proxy for population fecundity.

5. Further consideration of implications of change in sex for fishery management. *Response:* These issues have been considered. Presently, the assessment uses total mature biomass, rather than mature biomass of females only. The AW recommends considerable additional research, which will require added resources to conduct. Funding for a relevant study is being pursued by investigators at Virginia Tech.

6. Further development of analytical models to incorporate historical catch information. *Response:* The methodological development has been done, but under the rules of a SEDAR update assessment, catch data were not extended back in time longer than the

preceding benchmark assessment. The AW concluded that historical data (1950–1972) can and should be used in the next benchmark assessment.

7. *(Unnumbered in original document.)* Future research should be conducted to further develop age-structured models that could account for historic landings. Specifically, methods that allow scaling of uncertainty in landings records over time are needed. We need to include more historical records which are more uncertain than current records, this may be done by changing CVs over time as opposed to constant CV for a data series. *Response:* The first part of this recommendation is addressed in the preceding item. The second part was addressed in this update by incorporating CVs that vary over time in accordance with our knowledge of data precision, a process used in SEDAR-04 and approved at the Scoping Workshop.

12.2 New recommendations

New recommendations for research, data collection, and assessment procedure were then put forth. To improve future assessments of black sea bass, the AW further recommends the following research, not necessarily in order of importance:

1. Development and implementation of more extensive methods to estimate bycatch and discards are required, preferably by age and size class. This should improve future assessments and help managers better understand the effects of possible management measures.

2. As representative age-composition data become available, they should be incorporated into the assessment.

3. Tagging and genetic studies should be used to gain information on population structure. At present, tagging studies by Gary Shepherd and others have been taking place. Bert Ely (University of South Carolina) is conducting a genetics study that could provide useful information.

4. A study is recommended to examine whether a recruitment index could be derived from such sources as the BridgeNet sampling program at Beaufort, the SEAMAP program, or other monitoring programs (e. g., state or inter-jurisdictional projects).

5. A study is recommended to determine whether the MARMAP gear-standardization study currently being conducted can be used to effectively combine trap indices in future assessments. This standardization would provide an additional relatively long index of abundance. The possibility was considered by the SW and deferred because only one year of the three-year study had been completed.

6. A study of ghost pots (unrecovered traps) is recommended. Of interest are estimating occurrence, configuration, and possible effects of such gear, both on the fish stock through unreported mortality and on the habitat through mechanical damage. The potential for removing traps is also of interest.

7. The AW recommends that the next benchmark assessment of black sea bass be conducted in five years.

8. The AW recommends that the headboat program commence collecting depth and more detailed location information (e.g., GPS or VMS coordinates) with catch records.

9. To date, SEDAR assessments have computed MSY-related benchmarks based on existing selectivity patterns. However, MSY varies with selectivity. The AW recommends that in future assessments, possible changes in selectivity be modeled, to estimate whether better yield per recruit, and thus increased sustainable yield, could be attained.

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13 Tables

Table 1. Black sea bass regulatory history[a]

Date	Amendment	Details
31 Aug 1983	[FMP]	8" TL minimum size limit and 4" trawl mesh size
12 Jan 1989	1	Prohibit trawls.
1 Jan 1992	4	Prohibit fish traps, entanglement nets, and longline gear within 50 fathoms; black sea bass pot gear and identification requirements.
Dec 1998	8	Limited entry program; transferable permits and 225-pound non-transferable permits.
24 Feb 1999	9	10" TL minimum size limit and 20 fish recreational bag limit; escape panel in traps.

[a] This table is provided for convenience. It should not be considered definitive.

Table 2. Black sea bass length–length and length–weight relationships

Equation	Source	Units	n	R^2
TL = FL	SEDAR-02 DW (for TIP)	—	—	—
TL = 1.35SL − 10.83	McGovern et al. (2002)	TL and SL in mm	34,382	0.98
$W = \exp(-16.952 + 2.794 \ln(\mathrm{TL}))$	Headboat (1975–2003)	TL in mm; W in kg	107,895	0.90

Note: assessment uses TL in mm.

Table 3. Black Seabass: Length at age (mid-year)

Age	Length (mm)	Length (in)	CV of length (mm)
0	127.0	5.0	0.088
1	188.7	7.4	0.088
2	241.3	9.5	0.147
3	286.2	11.3	0.155
4	324.4	12.8	0.137
5	356.9	14.1	0.122
6	384.6	15.1	0.107
7	408.3	16.1	0.104
8	428.4	16.9	0.106
9	445.6	17.5	0.106
10	460.2	18.1	0.106
11	472.7	18.6	0.106

Table 4. Maturity and sex ratio of black sea bass.

	Proportion of females mature			Proportion
Age	1978–1983	1984–1989	1990–2003	male
0	0.000	0.000	0.000	0.000
1	0.473	0.986	0.854	0.101
2	0.905	0.992	0.980	0.237
3	0.990	0.995	0.998	0.462
4	0.999	0.997	1.000	0.703
5	1.000	0.998	1.000	0.868
6	1.000	0.999	1.000	0.948
7	1.000	0.999	1.000	0.980
8	1.000	1.000	1.000	0.993
9	1.000	1.000	1.000	0.997
10	1.000	1.000	1.000	0.999
11	1.000	1.000	1.000	1.000

Note: All males are assumed mature.

Table 5. Landings of black sea bass (mt) by gear, as used in assessment.

	Commercial (mt)			Recreational (mt)		Total	Coefficients of variation				
Year	Handln	Trap	Other	Hdbt	MRFSS	ldgs	Handln	Trap	Other	Hdbt	MRFSS
1973	29.3	369.6	15.5	–	–	–	0.30	0.30	0.30	–	–
1974	41.8	554.3	18.6	–	–	–	0.30	0.30	0.30	–	–
1975	46.8	338.6	10.5	–	–	–	0.30	0.30	0.30	–	–
1976	34.6	152.8	11.5	–	–	–	0.30	0.30	0.30	–	–
1977	29.9	117.1	12.4	–	–	–	0.30	0.30	0.30	–	–
1978	48.3	54.3	12.6	237.5	584.7	937.4	0.30	0.30	0.30	0.1	0.17
1979	65.7	294.2	9.3	259.1	584.7	1213.0	0.30	0.30	0.30	0.1	0.17
1980	50.0	387.9	11.0	280.2	584.7	1313.9	0.30	0.30	0.30	0.1	0.17
1981	74.1	454.4	14.5	307.7	362.1	1212.8	0.30	0.30	0.30	0.1	0.22
1982	71.9	344.6	12.0	318.1	795.2	1541.8	0.30	0.30	0.30	0.1	0.16
1983	74.8	210.9	3.9	313.2	432.2	1035.0	0.30	0.30	0.30	0.1	0.19
1984	96.9	176.6	4.3	301.1	1014.5	1593.4	0.30	0.30	0.30	0.1	0.12
1985	79.7	171.8	7.2	257.8	632.5	1149.1	0.275	0.275	0.275	0.1	0.14
1986	82.3	220.1	4.0	246.5	256.3	809.3	0.250	0.250	0.250	0.1	0.14
1987	69.3	176.5	16.2	287.3	492.7	1042.1	0.225	0.225	0.225	0.1	0.12
1988	116.8	223.7	15.1	288.1	721.9	1365.7	0.200	0.200	0.200	0.05	0.28
1989	124.2	226.1	9.2	216.8	554.9	1131.1	0.175	0.175	0.175	0.05	0.14
1990	128.1	298.7	15.2	172.2	256.5	870.7	0.150	0.150	0.150	0.05	0.12
1991	139.1	267.9	4.9	129.8	409.4	951.2	0.125	0.125	0.125	0.05	0.16
1992	116.5	235.9	7.1	97.9	324.8	782.2	0.100	0.100	0.100	0.05	0.12
1993	95.8	218.2	18.5	64.9	282.5	679.9	0.075	0.075	0.075	0.05	0.16
1994	115.9	225.6	5.6	60.1	350.2	757.3	0.05	0.05	0.05	0.05	0.15
1995	76.2	182.8	4.3	57.9	326.5	647.8	0.05	0.05	0.05	0.05	0.16
1996	78.6	224.2	5.0	66.5	342.8	717.1	0.05	0.05	0.05	0.05	0.17
1997	112.8	242.7	2.7	67.0	288.8	714.0	0.05	0.05	0.05	0.05	0.15
1998	124.4	193.5	2.1	64.6	219.0	603.5	0.05	0.05	0.05	0.05	0.18
1999	110.9	222.8	2.0	88.5	206.6	630.8	0.05	0.05	0.05	0.05	0.26
2000	53.7	188.1	1.3	65.6	214.7	523.4	0.05	0.05	0.05	0.05	0.27
2001	52.1	215.7	2.3	78.0	370.5	718.6	0.05	0.05	0.05	0.05	0.18
2002	49.7	175.1	1.7	55.9	214.9	497.3	0.05	0.05	0.05	0.05	0.22
2003	49.0	189.8	2.7	60.8	264.6	566.9	0.05	0.05	0.05	0.05	0.19

Table 6. Landings of black sea bass (klb) by gear.

	Commercial (klbs)			Recreational (klbs)		Total
Year	Handln	Trap	Other	Hdbt	MRFSS	ldgs
1973	64.59	814.83	34.21	–	–	–
1974	92.21	1221.98	41.02	–	–	–
1975	103.23	746.52	23.10	–	–	–
1976	76.34	336.96	25.41	–	–	–
1977	66.01	258.20	27.29	–	–	–
1978	106.54	119.67	27.76	523.53	1289.03	2066.53
1979	144.81	648.54	20.50	571.23	1289.03	2674.11
1980	110.31	855.12	24.28	617.79	1289.03	2896.52
1981	163.26	1001.76	32.02	678.37	798.32	2673.72
1982	158.43	759.79	26.55	701.36	1753.01	3399.14
1983	164.93	464.90	8.65	690.38	952.85	2281.70
1984	213.72	389.32	9.49	663.76	2236.53	3512.81
1985	175.81	378.69	15.90	568.36	1394.47	2533.23
1986	181.51	485.14	8.89	543.49	565.08	1784.11
1987	152.85	389.20	35.66	633.32	1086.27	2297.31
1988	257.57	493.24	33.33	635.22	1591.49	3010.86
1989	273.80	498.44	20.23	478.03	1223.23	2493.73
1990	282.43	658.44	33.61	379.57	565.43	1919.48
1991	306.64	590.67	10.82	286.24	902.66	2097.02
1992	256.82	519.97	15.60	215.87	716.15	1724.41
1993	211.14	481.04	40.89	143.02	622.90	1499.00
1994	255.50	497.31	12.38	132.44	771.97	1669.60
1995	168.03	403.08	9.41	127.62	719.89	1428.04
1996	173.25	494.34	11.06	146.54	755.68	1580.87
1997	248.61	535.10	6.01	147.74	636.61	1574.07
1998	274.20	426.49	4.62	142.50	482.76	1330.56
1999	244.59	491.09	4.41	195.12	455.39	1390.61
2000	118.39	414.66	2.82	144.59	473.42	1153.88
2001	114.93	475.57	5.08	172.02	816.73	1584.33
2002	109.57	386.03	3.75	123.27	473.77	1096.38
2003	108.03	418.43	5.95	134.11	583.34	1249.86

Table 7. Landings of black sea bass (mt) by state

	Commercial			Recreational (headboat)				Recreational (MRFSS)			
Year	NC	SC	GA/FL	NC	SC	GA/NFL	SEFL	NC	SC	GA	FL
1974	495.88	60.92	57.91	—	—	—	—	—	—	—	—
1975	278.07	66.48	51.37	—	—	—	—	—	—	—	—
1976	116.41	40.59	42.00	—	—	—	—	—	—	—	—
1977	116.63	7.53	35.28	—	—	—	—	—	—	—	—
1978	51.59	25.23	38.38	46.69	119.00	82.88	0.46	204.20	123.70	30.80	226.00
1979	237.86	100.01	31.29	49.59	155.31	61.20	5.62	204.20	123.70	30.80	226.00
1980	322.74	96.86	29.33	37.35	194.80	59.78	1.94	204.20	123.70	30.80	226.00
1981	230.57	283.22	29.17	58.10	188.10	74.51	1.91	202.24	114.23	4.93	40.72
1982	161.35	232.12	35.07	55.83	171.89	105.65	0.74	74.69	92.81	139.84	487.82
1983	158.72	105.78	25.11	44.96	162.44	120.44	0.52	225.73	58.73	3.34	144.40
1984	169.01	77.53	31.29	43.16	155.36	111.21	4.72	239.29	135.34	10.62	629.23
1985	171.40	64.81	22.51	41.50	153.53	72.11	8.48	204.96	172.03	17.23	238.30
1986	179.67	107.22	19.53	32.24	142.56	76.78	3.75	35.00	111.92	25.89	83.51
1987	138.30	101.97	21.79	23.62	165.06	97.49	7.08	200.16	107.37	40.26	144.95
1988	223.53	107.94	24.21	22.59	159.09	100.29	6.16	511.88	82.67	7.45	119.89
1989	230.41	107.07	21.97	13.71	109.66	80.48	12.98	144.13	238.18	27.55	144.99
1990	251.62	156.27	34.13	20.78	73.56	75.09	2.74	125.36	35.60	20.78	74.74
1991	243.59	146.25	22.09	15.00	75.25	38.41	1.18	63.63	222.84	7.80	115.17
1992	238.84	108.36	12.22	10.73	61.64	24.56	0.99	105.55	99.42	37.33	82.54
1993	239.13	82.51	10.87	12.59	41.21	10.20	0.94	77.34	108.72	43.51	52.96
1994	228.75	107.57	10.77	10.65	40.12	8.72	0.73	63.51	145.16	51.42	90.08
1995	174.33	78.98	10.01	10.47	32.25	14.13	1.05	70.27	161.81	53.57	40.89
1996	239.97	60.30	7.56	20.78	34.47	11.21	0.04	64.48	53.96	78.39	145.94
1997	277.11	75.28	5.82	15.39	39.74	11.47	0.41	74.51	80.39	66.45	67.42
1998	256.46	55.34	8.12	21.01	35.91	7.08	0.97	93.35	59.84	17.45	48.34
1999	247.97	83.76	3.97	29.32	42.05	16.99	0.13	38.41	78.01	4.02	86.13
2000	204.34	37.38	1.35	28.99	27.42	9.85	1.31	83.08	39.02	27.19	65.45
2001	224.25	43.84	2.07	25.30	41.66	9.26	2.49	114.70	79.40	63.16	113.21
2002	194.02	27.40	5.08	19.91	26.93	8.04	1.04	63.25	58.01	11.69	81.99
2003	216.11	19.53	5.86	19.40	29.44	10.56	1.43	89.03	39.58	61.14	74.90

Table 8. Landings of black sea bass (klb) by state

	Commercial			Recreational (headboat)				Recreational (MRFSS)			
Year	NC	SC	GA/FL	NC	SC	GA/NFL	SEFL	NC	SC	GA	FL
1974	1093.23	134.31	127.68	—	—	—	—	—	—	—	—
1975	613.05	146.55	113.25	—	—	—	—	—	—	—	—
1976	256.64	89.48	92.58	—	—	—	—	—	—	—	—
1977	257.13	16.59	77.78	—	—	—	—	—	—	—	—
1978	113.74	55.62	84.61	102.94	262.36	182.71	1.01	450.18	272.71	67.90	498.24
1979	524.40	220.47	68.98	109.33	342.41	134.91	12.38	450.18	272.71	67.90	498.24
1980	711.53	213.53	64.65	82.34	429.46	131.79	4.27	450.18	272.71	67.90	498.24
1981	508.33	624.39	64.32	128.09	414.70	164.26	4.21	445.86	251.83	10.87	89.76
1982	355.72	511.75	77.31	123.08	378.95	232.92	1.63	164.66	204.62	308.29	1075.46
1983	349.91	233.20	55.37	99.12	358.13	265.52	1.15	497.64	129.49	7.37	318.36
1984	372.60	170.93	69.00	95.15	342.52	245.17	10.40	527.54	298.38	23.42	1387.21
1985	377.88	142.89	49.63	91.50	338.47	158.98	18.71	451.87	379.25	38.00	525.37
1986	396.11	236.39	43.05	71.08	314.29	169.27	8.27	77.15	246.75	57.08	184.10
1987	304.89	224.80	48.03	52.07	363.90	214.94	15.61	441.27	236.70	88.75	319.56
1988	492.81	237.97	53.37	49.81	350.73	221.11	13.58	1128.50	182.26	16.43	264.32
1989	507.98	236.06	48.44	30.22	241.76	177.44	28.61	317.76	525.09	60.74	319.66
1990	554.72	344.53	75.23	45.81	162.16	165.55	6.05	276.37	78.49	45.80	164.77
1991	537.03	322.42	48.69	33.07	165.90	84.67	2.59	140.28	491.28	17.20	253.90
1992	526.55	238.90	26.94	23.66	135.89	54.15	2.17	232.70	219.19	82.30	181.97
1993	527.19	181.91	23.96	27.75	90.86	22.50	2.07	170.52	239.69	95.93	116.77
1994	504.32	237.15	23.74	23.47	88.45	19.22	1.60	140.01	320.02	113.36	198.59
1995	384.33	174.11	22.08	23.08	71.09	31.15	2.31	154.92	356.73	118.11	90.15
1996	529.05	132.94	16.67	45.82	76.00	24.71	0.09	142.15	118.97	172.83	321.74
1997	610.93	165.97	12.82	33.92	87.61	25.30	0.91	164.26	177.22	146.51	148.63
1998	565.40	122.00	17.90	46.32	79.16	15.61	2.14	205.80	131.93	38.46	106.57
1999	546.68	184.66	8.75	64.63	92.71	37.46	0.28	84.68	171.99	8.85	189.88
2000	450.49	82.40	2.98	63.91	60.44	21.71	2.88	183.17	86.02	59.95	144.28
2001	494.38	96.65	4.56	55.78	91.84	20.41	5.50	252.87	175.05	139.24	249.58
2002	427.75	60.41	11.20	43.90	59.37	17.72	2.29	139.44	127.88	25.78	180.76
2003	476.44	43.05	12.92	42.76	64.91	23.29	3.14	196.28	87.25	134.78	165.13

Table 9. Sample sizes of available length-composition data.

	MARMAP				Commercial			Recreational	
Year	Hook & line	Blackfish trap	FL snapper trap	Chevron trap	All trap	Hook & line	Trawl & other	Headboat	MRFSS
1978	–	–	–	–	–	–	–	2357	–
1979	–	–	–	–	–	–	–	1655	361
1980	–	–	–	–	–	–	–	2420	158
1981	439	1772	1088	–	–	–	–	3035	194
1982	728	1671	2423	–	–	–	–	3686	417
1983	950	3384	1378	–	–	–	–	5734	173
1984	694	2860	1760	–	870	1453	29	6091	285
1985	680	2972	1798	–	654	1124	14	5860	488
1986	411	1719	1444	–	41	1393	968	6551	380
1987	394	1494	932	–	761	1274	34	6443	668
1988	–	–	–	–	1260	981	304	4256	595
1989	–	–	–	–	369	706	15	3836	651
1990	–	–	–	6771	770	1256	201	6200	417
1991	–	–	–	4105	1172	1684	157	5381	223
1992	–	–	–	4667	1482	1450	26	5186	612
1993	–	–	–	4544	395	1144	783	3941	349
1994	–	–	–	4772	1019	997	680	4215	323
1995	–	–	–	4518	218	600	338	3325	314
1996	–	–	–	3698	213	713	376	3212	315
1997	–	–	–	4324	935	1009	261	3678	306
1998	–	–	–	4324	428	1638	54	4365	357
1999	–	–	–	4779	868	1749	2	4114	419
2000	–	–	–	4589	448	1083	173	3419	367
2001	–	–	–	4215	587	1880	417	2983	568
2002	–	–	–	2798	4265	1578	4	1958	267
2003	–	–	–	1808	7781	1014	8	2366	744

Table 10. Length compositions in 10 mm bins—Commercial hook and line

Year	*N*	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290
1984	1453	0	0	0	0	0	0	0	0	1	3	6	10	29	39	51	67	89	66	77	95
1985	1124	0	0	0	0	0	0	0	0	0	2	1	6	18	21	46	43	65	73	73	63
1986	1393	0	0	0	0	0	0	0	0	1	3	6	18	25	45	48	70	65	65	82	86
1987	1274	0	0	0	0	0	0	0	0	1	2	9	13	26	41	52	67	66	86	92	79
1988	981	0	0	0	0	0	0	0	0	0	3	10	14	27	31	47	79	63	63	98	57
1989	706	0	0	0	0	0	0	0	0	1	2	4	9	18	31	41	31	40	41	37	45
1990	1256	0	0	0	0	0	0	0	0	0	0	4	18	34	49	63	74	80	89	108	101
1991	1684	0	0	0	0	0	0	0	0	0	0	6	23	61	94	101	104	118	113	110	103
1992	1450	0	0	0	0	0	0	0	0	0	0	3	12	41	53	77	109	111	105	91	79
1993	1144	0	0	0	0	0	0	0	0	0	0	0	1	9	23	36	49	73	71	81	78
1994	997	0	0	0	0	0	0	0	0	0	0	4	10	18	31	21	35	50	52	40	45
1995	600	0	0	0	0	0	0	0	0	0	0	0	1	1	8	13	18	16	28	27	37
1996	713	0	0	0	0	0	0	0	0	0	1	1	3	6	15	26	29	29	27	35	40
1997	1009	0	0	0	0	0	0	0	0	0	0	0	0	5	18	27	48	57	61	70	68
1998	1638	0	0	0	0	0	0	0	0	0	0	2	3	10	16	30	53	92	104	123	115
1999	1749	0	0	0	0	0	0	0	0	0	0	0	1	4	20	33	66	104	123	117	138
2000	1083	0	0	0	0	0	0	0	0	0	0	0	0	2	1	4	26	64	72	85	88
2001	1880	0	0	0	0	0	0	0	0	0	0	2	0	4	1	11	39	89	95	117	108
2002	1578	0	0	0	0	0	0	0	0	0	0	0	2	11	13	12	38	38	59	65	76
2003	1014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	18	20	42	50	49

Year	300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500
1984	100	115	101	74	76	65	71	53	61	42	35	39	27	21	14	3	10	4	4	1	4
1985	65	71	59	50	49	48	61	43	39	55	35	32	29	26	16	12	13	5	3	0	2
1986	79	81	87	75	76	60	64	56	53	51	49	41	30	22	13	13	10	8	5	2	4
1987	69	85	79	59	67	53	44	47	45	30	33	39	24	23	18	6	7	4	4	3	1
1988	48	62	57	49	37	37	32	38	28	25	15	18	12	10	9	4	4	3	0	1	0
1989	50	41	40	38	23	34	33	27	29	19	17	14	9	9	11	5	2	2	0	1	2
1990	92	88	76	76	51	51	30	33	23	19	22	21	18	10	5	9	5	3	1	0	3
1991	79	81	90	79	77	64	66	60	46	34	43	34	22	17	13	18	8	7	4	2	7
1992	108	81	63	70	58	55	60	39	46	43	27	34	24	14	18	11	3	8	5	1	1
1993	70	80	63	65	79	60	44	56	30	38	33	26	19	17	7	11	7	5	3	5	5
1994	53	63	61	72	70	68	51	33	42	38	36	26	16	17	12	14	5	5	2	0	7
1995	41	31	32	34	36	20	30	35	24	38	20	23	12	21	15	3	14	5	3	5	9
1996	42	40	51	44	39	43	47	29	34	34	22	19	19	16	8	5	4	2	1	1	1
1997	77	60	63	61	62	56	59	63	37	26	19	15	20	10	7	8	5	2	2	1	2
1998	109	114	121	93	93	77	86	67	69	67	49	51	33	22	18	6	9	0	1	2	3
1999	136	114	111	111	100	99	81	66	81	52	51	38	34	17	11	12	7	12	5	1	4
2000	81	71	72	81	56	57	44	58	32	35	38	37	29	19	12	9	5	2	2	1	0
2001	105	136	128	132	113	104	119	99	86	66	77	39	64	47	38	19	22	5	12	2	1
2002	80	107	83	88	98	90	94	104	87	73	89	73	51	53	29	19	8	12	5	6	15
2003	81	54	70	48	92	51	44	38	69	42	63	25	48	27	38	10	12	13	2	3	0

Table 11. Length compositions in 10 mm bins—Commercial trap

Year	*N*	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290
1984	870	0	0	0	0	0	0	0	1	1	4	8	27	47	60	76	67	71	65	65	48
1985	654	0	0	0	0	0	0	0	0	0	1	3	15	31	33	56	36	59	69	65	62
1986	41	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	1	2	6	2	1
1987	761	0	0	0	0	0	0	0	0	1	4	12	23	20	45	40	51	47	42	58	43
1988	1260	0	0	0	0	0	0	0	0	0	5	7	28	60	110	97	85	77	81	51	54
1989	369	0	0	0	0	0	0	0	13	1	0	4	22	44	22	23	33	35	25	20	24
1990	770	0	0	0	0	0	0	0	0	0	0	3	21	47	84	70	83	83	55	54	41
1991	1172	0	0	0	0	0	0	0	0	0	3	5	35	55	76	91	89	78	77	84	67
1992	1482	0	0	0	0	0	0	0	0	0	0	16	56	83	148	127	118	107	105	79	67
1993	395	0	0	0	0	0	0	0	0	0	1	1	9	22	34	26	25	34	27	29	25
1994	1019	0	0	0	0	0	0	0	0	0	0	4	21	54	69	86	82	79	73	62	61
1995	218	0	0	0	0	0	0	0	0	0	0	0	2	5	6	14	15	18	17	17	16
1996	213	0	0	0	0	0	0	0	0	0	1	11	10	19	20	12	20	11	14	15	14
1997	935	0	0	0	0	0	0	0	0	0	1	3	19	32	56	52	85	85	98	81	60
1998	428	0	0	0	0	0	0	0	0	0	0	2	14	27	39	42	46	37	33	24	25
1999	868	0	0	0	0	0	0	0	0	0	0	1	2	18	29	62	93	89	72	70	53
2000	448	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	16	30	64	58
2001	587	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	10	40	73	88	76
2002	4265	0	0	0	0	0	0	0	0	0	0	0	5	7	11	80	310	337	857	545	597
2003	7781	0	0	0	0	0	0	0	1	0	0	0	0	1	8	157	593	616	1069	703	811

Year	300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500
1984	48	47	39	41	22	28	27	15	14	5	12	11	9	5	3	1	1	1	1	0	0
1985	37	31	37	25	10	15	10	16	12	12	9	4	3	0	2	0	0	0	0	1	0
1986	3	1	3	0	2	2	3	0	3	0	1	1	3	0	0	1	0	0	0	0	0
1987	53	33	34	47	30	26	29	23	21	19	11	12	8	7	2	6	7	4	3	0	0
1988	53	86	75	79	75	53	46	41	32	20	13	9	6	7	5	2	0	1	1	0	1
1989	14	20	15	14	11	7	5	4	2	2	0	3	4	0	2	0	0	0	0	0	0
1990	47	26	26	22	23	11	15	8	12	13	8	5	5	2	4	2	0	0	0	0	0
1991	60	80	55	56	43	42	21	27	24	19	16	17	16	12	8	6	3	3	4	0	0
1992	68	81	70	61	45	40	38	37	34	23	18	16	15	12	6	5	1	1	2	1	2
1993	20	23	19	13	7	14	10	13	9	9	9	2	4	4	5	0	0	0	0	0	1
1994	55	45	33	36	43	36	36	29	25	21	26	12	4	9	7	5	5	0	0	0	1
1995	9	17	14	9	8	6	9	3	7	6	5	2	5	3	4	1	0	0	0	0	0
1996	13	9	7	2	8	10	6	5	1	2	1	1	0	0	1	0	0	0	0	0	0
1997	61	52	32	45	38	25	27	22	20	13	15	3	6	1	1	1	1	0	0	0	0
1998	24	18	15	17	12	10	12	7	6	7	2	5	2	1	1	0	0	0	0	0	0
1999	58	40	41	39	37	28	39	21	19	14	17	11	3	4	2	2	3	0	0	0	1
2000	43	31	32	33	26	22	22	17	14	10	8	9	3	2	0	1	0	0	0	0	0
2001	56	41	39	22	24	25	17	21	14	12	9	9	3	5	0	1	0	0	0	0	0
2002	297	379	163	132	129	66	79	40	65	66	25	22	16	17	6	3	3	2	1	2	3
2003	418	811	408	359	376	205	266	127	279	240	77	96	38	54	16	36	7	5	3	1	0

Table 12. Length compositions in 10 mm bins—Commercial "other"

Year	*N*	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290
1984	29	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	6	5	3	1	1
1985	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
1986	968	0	0	0	0	0	0	0	0	1	1	10	35	89	101	75	59	77	67	78	49
1987	34	0	0	0	0	0	0	0	0	3	1	2	3	3	0	0	2	0	1	1	0
1988	304	0	0	0	0	0	0	1	1	0	1	2	8	10	16	18	21	20	15	15	15
1989	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
1990	201	0	0	0	0	0	0	0	0	0	0	1	1	6	8	11	16	26	11	15	14
1991	157	0	0	0	0	0	0	0	0	0	0	2	1	2	8	14	18	14	4	12	6
1992	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	2	0	2	1
1993	783	0	0	0	0	0	0	0	0	0	0	2	6	16	46	48	45	69	70	67	56
1994	680	0	0	0	0	0	0	0	0	0	0	2	2	14	12	27	45	46	41	51	49
1995	338	0	0	0	0	0	0	0	0	0	0	0	5	5	17	16	17	15	23	22	18
1996	376	0	0	0	0	0	0	0	0	0	2	0	11	20	24	33	32	28	26	26	18
1997	261	0	0	0	0	0	0	0	0	0	0	0	1	7	17	28	17	16	25	14	18
1998	54	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	3	5	5	4	7
1999	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	173	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	15	26	17	18	10
2001	417	0	0	0	0	0	0	0	0	0	0	0	1	2	8	35	49	50	32	23	16
2002	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0
2003	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0

Year	300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500
1984	0	1	1	0	0	0	3	1	0	0	1	0	0	0	3	0	0	0	1	0	0
1985	0	0	0	2	1	0	0	1	1	2	0	1	0	1	1	1	0	0	1	0	0
1986	53	46	54	40	27	30	22	14	7	10	8	5	2	3	2	2	1	0	0	0	0
1987	0	1	2	1	2	0	1	3	1	1	0	3	0	0	0	3	0	0	0	0	0
1988	17	10	13	12	10	14	8	18	6	12	6	4	9	5	5	4	5	1	0	1	1
1989	2	2	1	1	0	1	0	0	0	1	0	0	0	2	0	1	1	0	0	0	0
1990	17	12	4	10	6	5	7	9	4	1	2	4	5	2	1	2	1	0	0	0	0
1991	8	6	8	2	5	7	4	4	4	2	5	5	3	4	2	1	1	4	1	0	0
1992	1	3	2	1	2	0	0	1	2	1	0	0	2	0	0	0	0	0	0	0	0
1993	55	46	42	44	22	32	19	15	16	15	11	9	10	9	5	4	2	0	1	1	0
1994	58	43	46	41	44	24	26	20	18	19	11	16	12	4	5	0	2	0	1	1	0
1995	20	14	22	7	21	26	13	12	11	15	10	7	9	6	4	1	2	0	0	0	0
1996	26	22	14	11	15	11	12	14	5	7	5	4	2	3	2	2	0	0	1	0	0
1997	15	20	6	19	14	19	11	8	3	3	0	0	0	0	0	0	0	0	0	0	0
1998	3	4	2	3	2	2	1	4	1	3	1	0	1	0	0	0	0	0	0	0	0
1999	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	9	11	8	5	5	3	6	7	5	11	3	5	2	1	0	0	0	0	0	0	0
2001	27	28	14	29	14	14	21	12	7	9	7	8	4	3	2	0	0	1	1	0	0
2002	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	1	0	0	0	0	0	1	2	0	0	1	0	0	0	0	0	0	1	0	0	0

Table 13. Length compositions in 10 mm bins—MRFSS

Year	*N*	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290
1979	361	0	0	0	0	0	2	11	8	32	16	41	16	29	9	16	16	16	19	24	12
1980	158	0	0	1	1	2	3	7	4	9	13	17	13	8	6	13	8	12	10	6	0
1981	194	0	0	0	0	3	10	11	29	31	26	10	16	5	26	3	10	2	2	1	1
1982	417	2	0	1	3	2	5	2	3	7	7	10	14	9	13	41	54	31	16	38	12
1983	173	0	0	0	1	3	1	10	13	9	14	8	2	6	6	17	12	16	9	10	6
1984	285	0	0	0	0	3	2	2	2	9	4	4	7	3	5	5	16	19	18	21	64
1985	488	0	2	6	6	6	22	8	27	63	20	21	7	39	21	29	19	28	16	17	25
1986	380	0	0	0	1	6	1	3	5	34	14	21	15	62	16	21	22	16	4	25	39
1987	668	0	0	0	0	1	1	1	4	12	31	47	48	62	96	40	29	47	18	40	47
1988	595	0	0	0	0	2	1	0	5	6	5	13	23	33	18	28	63	60	23	10	9
1989	651	0	0	0	0	4	1	7	4	12	19	22	28	31	30	32	44	22	49	64	36
1990	417	0	0	0	0	1	1	1	10	2	18	26	27	21	18	52	45	40	17	25	13
1991	223	0	0	0	0	0	0	0	0	1	2	8	6	6	10	4	10	6	18	28	78
1992	612	0	0	0	0	0	2	4	0	4	7	22	34	26	82	64	27	33	34	36	63
1993	349	0	0	0	0	0	0	3	1	3	5	11	16	18	12	11	29	24	26	17	12
1994	323	0	0	0	3	1	0	2	2	2	2	3	24	22	18	9	11	17	61	11	6
1995	314	0	0	0	1	0	1	0	1	0	3	16	14	6	17	18	13	12	10	10	18
1996	315	0	0	0	0	0	0	0	1	0	1	7	5	14	23	16	20	11	15	9	7
1997	306	0	0	0	0	0	2	0	1	0	2	3	26	7	20	22	15	38	19	28	11
1998	357	0	0	0	0	0	0	2	2	2	7	12	10	3	15	29	10	23	12	41	52
1999	419	0	0	0	0	0	0	0	1	2	4	4	9	3	7	13	25	29	32	31	29
2000	367	0	0	0	0	0	0	0	1	1	0	4	8	4	18	12	23	69	33	25	31
2001	568	0	0	0	0	0	0	0	2	2	0	4	3	0	5	10	16	38	53	75	38
2002	267	0	0	0	0	0	0	0	0	0	0	0	1	0	2	10	5	17	43	26	27
2003	744	0	0	0	0	0	0	0	0	0	0	0	6	13	6	23	32	64	66	80	70

Year	300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500
1979	19	19	11	10	9	2	3	1	5	2	1	1	0	1	2	1	1	0	2	1	3
1980	5	6	0	3	2	0	2	2	1	1	1	1	0	0	0	0	0	0	0	0	1
1981	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
1982	23	25	26	13	9	15	15	7	4	0	0	1	8	1	0	0	0	0	0	0	2
1983	6	8	6	5	0	2	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0
1984	24	15	8	11	4	8	10	8	6	0	0	3	3	3	0	0	0	0	0	0	0
1985	20	22	10	14	8	2	11	2	0	4	0	2	2	2	5	0	0	0	0	0	0
1986	13	2	31	11	5	2	5	1	3	1	1	0	0	0	0	0	0	0	0	0	0
1987	17	16	15	5	21	4	5	14	4	7	19	9	0	8	0	1	0	0	0	0	0
1988	10	6	6	34	7	95	5	4	36	0	62	1	1	30	0	0	1	0	0	1	1
1989	21	26	25	30	19	10	24	9	12	7	4	13	2	21	5	0	5	1	0	0	8
1990	15	15	11	6	7	9	6	2	1	1	1	0	0	3	1	2	1	0	1	1	18
1991	17	1	1	2	5	2	6	0	2	1	4	4	1	0	0	0	0	0	0	0	0
1992	34	44	20	8	11	11	9	16	8	2	2	1	3	2	1	0	2	0	0	1	1
1993	17	39	26	10	10	13	11	0	4	1	4	9	3	2	2	0	0	0	0	0	9
1994	22	11	13	9	34	14	3	1	0	7	3	2	6	2	2	0	0	0	0	0	0
1995	7	8	32	10	1	5	39	7	40	3	1	12	2	2	1	1	0	1	0	1	0
1996	29	36	3	10	4	6	29	3	2	9	15	3	25	5	4	0	0	0	1	0	1
1997	25	17	13	15	12	9	12	0	1	1	2	0	1	3	0	1	0	0	0	0	0
1998	18	24	6	9	7	35	6	2	9	4	4	2	3	2	3	0	0	0	0	2	2
1999	13	40	17	12	14	18	23	16	14	17	5	2	13	6	6	6	3	0	0	0	6
2000	44	21	27	12	14	11	2	1	3	0	1	0	0	0	1	0	0	0	0	0	0
2001	27	30	46	38	61	19	24	27	25	12	1	6	0	3	2	0	0	0	0	0	0
2002	37	13	23	21	7	9	10	6	4	3	1	0	0	0	1	0	0	0	0	0	0
2003	45	56	54	46	44	38	34	11	9	23	10	3	1	8	1	2	0	0	0	0	0

Table 14. Length compositions in 10 mm bins—Headboat

Year	*N*	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290
1978	2357	0	0	0	0	1	15	27	32	66	108	104	142	132	134	145	135	141	131	113	104
1979	1655	0	0	0	0	2	5	8	13	34	61	73	103	98	155	112	119	118	99	88	85
1980	2420	0	0	0	1	3	15	19	48	87	151	195	191	166	167	173	187	151	136	124	93
1981	3035	0	1	4	6	3	16	40	52	91	130	178	231	229	243	225	245	190	180	133	136
1982	3686	0	2	1	2	4	6	22	64	134	232	302	264	270	284	269	262	251	234	170	155
1983	5734	0	0	0	0	4	13	40	85	152	301	400	414	378	458	475	436	435	341	298	266
1984	6091	0	0	0	0	2	3	13	23	59	138	260	441	540	510	519	499	424	382	379	327
1985	5860	0	0	2	2	1	4	25	59	118	220	470	540	536	484	456	444	415	375	324	278
1986	6551	0	1	1	0	2	12	24	60	140	306	526	653	595	574	598	531	472	420	323	290
1987	6443	0	0	3	1	1	5	11	29	109	317	473	542	589	619	604	567	440	417	309	284
1988	4256	0	0	0	0	0	0	9	13	73	169	270	303	415	372	388	365	277	280	252	234
1989	3836	0	0	0	0	0	0	6	7	66	193	282	317	282	373	305	283	294	208	228	211
1990	6200	0	0	0	0	0	1	1	16	62	156	210	444	514	757	549	647	474	416	353	316
1991	5381	0	0	0	0	0	0	4	5	19	73	188	390	576	631	603	544	446	393	315	266
1992	5186	0	0	0	0	0	0	0	8	12	90	143	334	552	657	601	580	431	356	282	232
1993	3941	0	0	0	0	0	0	0	0	4	23	66	173	285	393	388	395	358	341	287	205
1994	4215	0	0	0	0	0	0	0	1	5	11	84	172	286	477	383	406	342	365	290	212
1995	3325	0	0	0	0	0	0	0	3	1	22	85	179	309	286	331	270	255	207	237	174
1996	3212	0	0	0	0	0	0	0	1	1	11	47	171	241	387	361	305	329	195	205	182
1997	3678	0	0	0	0	0	0	0	0	0	9	41	125	296	331	344	321	342	268	265	280
1998	4365	0	0	0	0	0	0	0	0	1	24	51	142	336	371	306	354	385	336	328	337
1999	4114	0	0	0	0	0	0	0	0	0	0	1	9	32	50	139	321	569	564	513	347
2000	3419	0	0	0	0	0	0	0	0	0	0	0	0	3	15	43	218	413	610	490	333
2001	2983	0	0	0	0	0	0	0	0	2	2	1	1	4	19	118	278	491	610	385	259
2002	1958	0	0	0	0	0	0	0	0	0	0	3	1	4	20	85	173	280	309	265	180
2003	2366	0	0	0	0	0	0	0	0	0	0	0	0	1	4	27	138	342	418	298	300

Year	300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500
1978	100	100	90	81	67	64	58	51	43	33	33	24	22	14	11	9	8	6	3	4	4
1979	75	55	44	57	35	38	43	30	26	16	14	7	5	5	14	8	4	3	1	1	1
1980	87	55	69	58	39	28	46	22	23	15	18	12	5	9	7	8	1	7	1	0	3
1981	122	96	107	60	49	57	36	28	25	27	21	11	13	10	11	10	2	4	2	3	11
1982	117	126	78	74	71	91	34	23	25	25	24	23	18	16	4	1	4	0	1	0	6
1983	218	168	181	119	111	75	79	55	45	27	45	23	21	18	13	9	13	11	1	1	4
1984	272	224	198	167	134	111	93	93	50	56	42	31	30	24	22	7	4	2	3	3	9
1985	232	170	150	134	100	74	59	41	42	23	20	19	9	12	7	5	4	3	1	0	3
1986	231	182	132	81	88	77	49	38	33	23	20	13	16	11	9	2	5	5	1	2	6
1987	231	171	137	129	100	71	54	60	45	31	35	19	11	10	7	3	6	0	1	0	5
1988	170	132	102	100	72	45	43	38	31	30	14	20	9	6	8	3	0	2	4	1	5
1989	137	126	135	93	90	52	45	29	14	18	9	9	12	3	3	2	2	0	5	0	0
1990	247	228	210	122	106	94	60	42	52	29	19	22	14	12	11	11	3	0	2	0	1
1991	218	188	140	92	67	64	35	25	24	18	17	7	8	2	7	5	5	0	2	2	2
1992	241	136	132	62	78	56	46	36	18	23	22	17	8	5	9	6	5	2	2	0	1
1993	187	137	139	89	90	72	63	48	42	22	26	23	28	13	15	12	4	3	3	2	6
1994	216	201	134	157	104	63	63	54	43	43	33	20	13	9	12	3	6	4	1	1	1
1995	155	135	99	96	69	74	58	64	46	39	34	32	16	13	11	9	8	2	3	1	3
1996	104	120	101	88	65	59	40	39	27	23	30	9	19	13	12	6	5	6	4	1	6
1997	181	169	138	125	76	64	67	51	38	25	32	24	18	15	9	10	4	6	2	1	1
1998	232	167	182	135	132	122	93	67	41	40	55	31	15	15	19	15	16	5	4	5	3
1999	278	228	192	177	116	96	97	50	75	46	60	38	47	21	18	14	3	8	1	6	0
2000	263	234	158	71	128	72	58	88	39	38	31	15	32	11	25	12	7	6	2	0	2
2001	221	142	94	80	49	54	32	30	22	19	17	6	22	6	7	5	1	2	0	2	1
2002	136	114	87	67	67	48	20	29	18	10	16	6	10	4	2	0	0	3	0	0	3
2003	202	142	104	83	69	78	39	28	15	12	17	10	12	8	10	4	3	0	2	0	0

Table 15. Abundance indices and CVs. MARMAP hook & line (HL) in units of no. fish per collection-hour; MARMAP traps (SNT, BLT, CVT) in units of no. fish per trap-hour; and Headboat in units of lbs fish per angler-trip.

	MARMAP indices [a]				Headboat	MARMAP CVs				Headboat
Year	HL	SNT	BLT	CVT	index	HL	SNT	BLT	CVT	index CV
1974	–	–	–	–	7.24	–	–	–	–	0.059
1975	–	–	–	–	9.85	–	–	–	–	0.046
1976	–	–	–	–	6.60	–	–	–	–	0.039
1977	–	–	–	–	7.48	–	–	–	–	0.036
1978	–	–	–	–	9.02	–	–	–	–	0.036
1979	–	–	–	–	7.50	–	–	–	–	0.035
1980	–	–	–	–	8.00	–	–	–	–	0.034
1981	9.89	10.76	8.92	–	8.04	0.161	0.111	0.070	–	0.033
1982	15.47	22.98	7.84	–	8.18	0.252	0.156	0.082	–	0.033
1983	11.25	11.91	7.70	–	8.25	0.230	0.172	0.056	–	0.033
1984	12.72	8.35	6.08	–	7.44	0.279	0.113	0.060	–	0.029
1985	8.77	13.89	8.60	–	7.41	0.150	0.132	0.058	–	0.031
1986	7.18	8.08	6.66	–	7.47	0.175	0.131	0.080	–	0.031
1987	5.69	4.63	6.64	–	7.68	0.251	0.233	0.081	–	0.032
1988	–	–	–	–	6.62	–	–	–	–	0.031
1989	–	–	–	–	4.42	–	–	–	–	0.031
1990	–	–	–	11.44	4.57	–	–	–	0.074	0.035
1991	–	–	–	9.28	3.48	–	–	–	0.088	0.029
1992	–	–	–	9.03	3.41	–	–	–	0.090	0.030
1993	–	–	–	4.82	2.60	–	–	–	0.084	0.033
1994	–	–	–	6.95	2.28	–	–	–	0.084	0.033
1995	–	–	–	7.64	1.64	–	–	–	0.081	0.033
1996	–	–	–	6.24	1.81	–	–	–	0.102	0.034
1997	–	–	–	6.09	2.32	–	–	–	0.098	0.040
1998	–	–	–	8.06	2.39	–	–	–	0.094	0.031
1999	–	–	–	12.05	2.82	–	–	–	0.121	0.029
2000	–	–	–	9.99	2.10	–	–	–	0.119	0.032
2001	–	–	–	9.62	1.90	–	–	–	0.142	0.032
2002	–	–	–	7.76	1.66	–	–	–	0.161	0.033
2003	–	–	–	4.88	1.64	–	–	–	0.156	0.032

[a] HL: hook and line; SNT: snapper trap; BLT: blackfish trap; CVT: chevron trap.

Table 16. Length compositions in 10 mm bins—MARMAP hook and line

Year	*N*	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290
1981	439	0	0	0	0	1	1	3	12	13	31	42	45	44	40	41	35	21	23	11	14
1982	728	0	0	0	0	0	2	2	9	10	34	59	86	74	61	51	38	44	35	33	27
1983	950	0	0	0	0	1	4	17	20	34	59	72	95	106	94	76	57	48	42	30	26
1984	694	0	0	0	0	1	0	0	6	11	28	62	58	73	59	56	68	42	34	32	28
1985	680	0	0	1	1	2	2	4	8	21	40	61	63	65	66	56	39	30	25	30	25
1986	411	0	0	0	0	1	2	3	6	17	30	37	38	38	21	31	24	23	27	17	19
1987	394	0	0	0	0	0	0	2	9	18	31	54	42	30	42	25	17	15	17	19	12

Year	300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500
1981	8	12	4	9	4	5	5	5	0	2	3	3	1	1	0	0	0	0	0	0	0
1982	25	25	20	14	13	7	13	6	8	8	5	2	3	4	5	2	1	0	1	0	1
1983	29	22	19	16	20	9	12	10	3	3	3	4	4	3	3	2	3	0	1	1	2
1984	23	26	11	22	11	12	7	6	4	3	1	6	1	1	1	1	0	0	0	0	0
1985	36	13	16	15	6	14	10	7	4	4	4	2	2	4	0	2	0	1	0	1	0
1986	12	8	12	12	2	6	2	7	1	3	2	2	1	1	4	0	1	0	0	1	0
1987	17	11	10	4	4	1	3	2	6	1	0	1	0	0	1	0	0	0	0	0	0

Table 17. Length compositions in 10 mm bins—MARMAP Florida snapper trap

Year	*N*	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290
1981	1088	0	0	0	0	0	2	10	8	21	56	124	154	125	89	70	64	57	48	40	42
1982	2423	0	0	0	1	6	9	18	59	115	207	372	362	361	224	166	106	68	61	53	38
1983	1378	0	0	0	0	0	0	10	46	81	122	220	198	166	103	76	61	56	44	42	22
1984	1760	0	0	1	2	11	23	60	110	157	196	222	167	156	124	104	91	62	56	39	29
1985	1798	0	0	0	2	8	11	18	44	149	191	249	249	179	116	101	70	62	56	36	38
1986	1444	0	0	0	0	1	9	28	53	139	177	208	181	128	104	75	56	49	33	42	23
1987	932	0	0	0	0	0	1	18	69	96	93	118	124	114	68	48	43	25	19	21	22

Year	300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500
1981	26	19	21	26	12	13	11	13	7	6	7	7	3	1	2	3	1	0	0	0	0
1982	36	32	21	15	14	18	14	7	6	9	6	6	5	2	1	0	0	1	3	1	0
1983	27	16	17	11	5	8	7	6	8	7	0	3	4	2	3	2	2	1	2	0	0
1984	30	22	25	22	7	10	12	4	6	3	1	1	2	4	1	0	0	0	0	0	0
1985	26	21	25	32	32	12	15	10	9	7	4	8	3	4	7	1	3	0	0	0	0
1986	22	22	17	10	14	14	12	9	4	3	2	1	2	2	3	1	0	0	0	0	0
1987	12	8	11	6	5	6	1	0	0	4	0	0	0	0	0	0	0	0	0	0	0

Table 18. Length compositions in 10 mm bins—MARMAP blackfish trap

Year	*N*	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290
1981	1772	0	0	0	0	0	0	3	1	4	18	81	181	248	227	178	134	130	104	82	65
1982	1671	0	0	0	1	2	0	2	8	20	61	104	191	215	208	150	148	118	82	62	54
1983	3384	0	0	0	0	1	2	15	47	79	81	175	315	499	470	407	243	217	176	112	94
1984	2860	0	0	0	1	1	2	8	12	25	45	146	198	312	362	371	294	218	156	148	104
1985	2972	0	0	0	0	1	4	0	4	21	40	116	189	305	362	332	285	212	178	155	106
1986	1719	0	0	0	0	0	0	6	6	23	49	100	145	179	200	165	132	133	121	92	65
1987	1494	0	0	0	0	0	2	2	5	10	27	75	122	223	221	164	137	120	71	65	59

Year	300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500
1981	74	43	44	48	35	21	12	14	7	7	3	5	1	0	0	0	1	0	1	0	0
1982	42	40	38	24	27	15	17	14	8	5	5	3	2	2	1	1	0	1	0	0	0
1983	82	54	47	42	30	32	37	23	14	15	11	17	9	10	7	8	10	0	2	0	1
1984	115	89	75	47	35	22	12	10	13	10	8	5	6	3	2	4	1	0	0	0	0
1985	101	109	89	68	73	50	44	21	29	13	17	13	9	7	9	3	3	2	1	1	0
1986	67	46	41	28	24	16	21	12	6	12	8	3	3	5	5	2	2	1	0	1	0
1987	41	42	22	22	16	17	6	9	7	6	3	0	0	0	0	0	0	0	0	0	0

Table 19. Length compositions in 10 mm bins—MARMAP chevron trap

Year	*N*	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290
1990	6771	0	0	0	0	2	12	58	179	350	714	970	955	811	588	403	309	202	217	149	150
1991	4105	0	0	0	0	3	2	29	111	268	552	636	581	408	375	277	169	104	123	102	89
1992	4667	0	0	0	0	0	4	38	96	241	474	572	569	521	439	365	277	177	205	104	116
1993	4544	0	0	0	0	6	17	78	224	471	471	424	499	468	428	332	214	214	178	121	102
1994	4772	0	0	0	0	4	20	91	241	475	523	556	547	444	341	274	201	181	171	127	149
1995	4518	1	0	1	0	9	79	243	475	606	551	450	426	343	252	231	138	138	124	104	83
1996	3698	0	0	0	0	2	4	24	46	164	312	400	428	441	405	339	227	182	153	112	103
1997	4324	0	0	0	1	2	9	37	135	327	471	392	412	395	408	344	344	220	148	119	117
1998	4324	0	0	0	1	0	10	81	248	358	407	506	496	423	334	316	258	190	143	112	92
1999	4779	0	0	0	0	0	2	26	96	224	439	675	641	584	432	342	293	192	144	139	114
2000	4589	1	0	0	0	1	2	14	80	173	308	505	631	607	459	369	266	221	190	166	140
2001	4215	0	0	0	0	0	2	27	115	257	328	318	389	444	528	412	377	250	175	169	96
2002	2798	0	0	0	0	0	5	16	56	127	220	362	368	338	273	207	189	143	125	97	82
2003	1808	0	0	0	0	0	0	0	10	45	91	164	180	234	228	167	171	127	85	61	56

Year	300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500
1990	151	121	93	80	78	45	35	27	21	17	9	10	6	2	1	1	2	1	2	0	0
1991	71	52	36	30	26	23	14	10	3	6	1	1	1	1	0	0	0	1	0	0	0
1992	129	58	49	49	48	42	21	19	10	6	12	9	5	4	2	4	1	0	1	0	0
1993	83	69	37	30	20	20	15	4	0	3	6	1	3	1	1	2	1	0	0	0	1
1994	115	82	55	43	51	21	13	9	11	9	5	6	2	1	2	0	2	0	0	0	0
1995	74	65	34	31	22	18	7	3	3	2	1	0	2	0	0	0	0	1	0	0	1
1996	77	73	71	36	20	20	18	8	6	8	5	6	5	0	1	0	1	1	0	0	0
1997	91	65	63	57	52	33	30	21	11	7	6	4	2	0	1	0	0	0	0	0	0
1998	69	63	60	32	28	23	20	18	12	10	4	1	2	3	2	1	1	0	0	0	0
1999	98	102	74	49	34	31	20	10	4	7	0	3	1	2	1	0	0	0	0	0	0
2000	111	81	81	49	43	25	27	15	5	10	3	2	1	1	2	0	0	0	0	0	0
2001	85	55	51	47	40	13	13	5	7	6	2	2	2	0	0	0	0	0	0	0	0
2002	51	40	28	27	16	10	6	4	5	0	2	0	0	1	0	0	0	0	0	0	0
2003	56	32	19	36	18	16	4	5	2	0	0	0	1	0	0	0	0	0	0	0	0

Table 20. General descriptions and definitions. Hat notation ($\hat{*}$) indicates parameters estimated by the assessment model, and breve notation ($\breve{*}$) indicates estimated quantities whose fit to data forms the objective function.

Quantity	Symbol	Description or definition
General Definitions		
Index of years	y	$y = \{1978 \dots 2003\}$
Index of ages	a	$a = \{0 \dots A\}$, where $A = 11^+$
Index of regulation periods	r	$r = \{1 \dots 3\}$ where 1 = 1978 – 1982 (no size limit), 2 = 1983 – 1998 (8 inch size limit), and 3 = 1999 – 2003 (10 inch size limit)
Length bin (mm)	l'	$l' = \{100, 110, \dots, 500\}$, with bin size of 10 mm.
Index of fisheries	f	$f = \{1 \dots 5\}$ where 1=commercial handline, 2=commercial trap, 3=commercial other, 4=recreational headboat, 5=recreational MRFSS
Index of CPUE	u	$u = \{1 \dots 5\}$ where 1 = MARMAP hook & line, 2 = MARMAP FL trap, 3 = MARMAP blackfish trap, 4 = MARMAP chevron trap, 5 = headboat
Input Data		
Mean length at age	l_a	$l_a = L_\infty(1 - \exp[-K(a + 0.5 - t_0)])$ where K, L_∞, and t_0 are fixed parameters. Mean length is that at the midpoint of the year (accounted for by the term 0.5).
Age–length conversion	$\psi_{a,l'}$	$\psi_{a,l'} = \frac{1}{\sqrt{2\pi}(c_a l_a)} \frac{\exp\left[-(l'-l_a)^2\right]}{\left(2(c_a l_a)^2\right)}$, the Gaussian density function, where c_a is a fixed coefficient of variation in length at age. The matrix $\psi_{a,l'}$ is re-scaled to sum to unity across ages.
Individual weight at age	w_a	Computed from length at age at the midpoint of the year by $w_a = \exp[\omega_1 + \omega_2 \cdot \log(l_a)]$ where ω_1 and ω_2 are fixed parameters
Proportion male at age	ρ_a	Determined by logistic function estimated from MARMAP samples.
Proportion female at age	$1 - \rho_a$	Complement of above
Proportion mature at age: males	m'_a	All males age 1^+ considered mature. Constant across years.

Table 20. (continued)

Quantity	Symbol	Description or definition
Proportion mature at age: females	$m_{a,y}$	Determined by logistic functions estimated from MARMAP samples over three different time periods.
Observed abundance indices	$U_{u,y}$	$u = 1$, MARMAP hook & line, $y = \{1981 \ldots 1987\}$ $u = 2$, MARMAP FL trap, $y = \{1981 \ldots 1987\}$ $u = 3$, MARMAP blackfish trap, $y = \{1981 \ldots 1987\}$ $u = 4$, MARMAP chevron trap, $y = \{1990 \ldots 2003\}$ $u = 5$, headboat, $y = \{1974 \ldots 2003\}$
CVs of abundance indices (CPUE)	$c_{u,y}$	$u = \{1 \ldots 5\}$ as above. For MARMAP, annual values estimated directly from data; for headboat, from bootstrap of lognormal GLM
Observed length compositions	$p_{(f,u),l',y}$	Proportional contribution of length l' in year y to fishery f or index u.
Length comp. sample sizes	$n_{(f,u),y}$	Number of length samples collected in year y from fishery f or index u.
Observed fishery landings	$L_{f,y}$	Reported weight of landings in year y from fishery f
CVs of landings	$c_{L_f,y}$	Annual values based on understanding of historical accuracy of data or, in the case of MRFSS, estimated
Natural mortality rate	M	Fixed by Data Workshop, based on natural history.
Discard mortality	H	Fixed by Data Workshop.
Population Model		
Fishery selectivity	$s_{f,a,r}$	$s_{f,a,r} = \frac{1}{1+\exp[-\hat{\eta}_{f,r}(a-\hat{\alpha}_{f,r})]}$ where $\hat{\eta}_{f,r}$ and $\hat{\alpha}_{f,r}$ are fishery-specific parameters estimated for each regulation period. Commercial other is an exception, assumed to be constant across periods. Selectivity of MRFSS and headboat assumed equal.
Discard selectivity	$s'_{f,a,r}$	$s'_{f,a,r} = \begin{cases} 0 & : \text{for } f = 1,2,4; r = 1 \\ \max\left[0, \left(s_{f,a,r} - s_{f,a,r-1}\right)\right] & : \text{for } f = 1,2,4; r = 2,3 \end{cases}$
Index selectivity	$s''_{u,a}$	$s''_{u,a} = \begin{cases} \frac{1}{1+\exp[-\hat{\eta}_u(a-\hat{\alpha}_u)]} & : \text{for } u = 1 \\ \left(\frac{1}{\max s''_{u,a}}\right)\left(\frac{1}{1+\exp[-\hat{\eta}_{1,u}(a-\hat{\alpha}_{1,u})]}\right) \left(1 - \frac{1}{1+\exp[-\hat{\eta}_{2,u}(a-[\hat{\alpha}_{1,u}+\hat{\alpha}_{2,u}])]}\right) & : \text{for } u = 2 \ldots 4 \\ s_{4,a} & : \text{for } u = 5 \end{cases}$

Table 20. (continued)

Quantity	Symbol	Description or definition
Fishing mortality rate	$F_{f,a,y}$	$F_{f,a,y} = s_{f,a,y}\hat{F}_{f,y}$ where $\hat{F}_{f,y}$ is an estimated fully selected fishing mortality rate and $s_{f,a,y} = s_{f,a,r}$ for y in the years represented by r.
Total fishing mortality rate	F_y	$F_y = \sum_f \hat{F}_{f,y}$
Discard mortality rate	$D_{f,a,y}$	$D_{f,a,y} = Hs'_{f,a,y}\hat{F}_{f,y} \; : f = 1,2,4$ where $s'_{f,a,y} = s'_{f,a,r}$ for y in the years represented by r.
Total mortality rate	$Z_{a,y}$	$Z_{a,y} = M + \sum_{f=1}^{5} F_{f,a,y} + \sum_{f=1,2,4} D_{f,a,y}$
Abundance at age	$N_{a,y}$	$N_{0,1967} = \hat{\gamma}\hat{R}_0$ $N_{a+1,1967} = N_{a,1967}\exp(-Z_{a,1967})$ $N_{A,1967} = N_{A-1,1967}\frac{\exp(-Z_{A-1,1967})}{1-\exp(-Z_{A,1967})}$ $N_{0,y} = \frac{0.8\hat{R}_0\hat{h}S_y}{0.2\phi_0\hat{R}_0(1-\hat{h})+(\hat{h}-0.2)S_y} + \hat{R}_y$ $N_{a+1,y+1} = N_{a,y}\exp(-Z_{a,y})$ $N_{A,y} = N_{A-1,y-1}\frac{\exp(-Z_{A-1,y-1})}{1-\exp(-Z_{A,y-1})}$ where $\hat{\gamma}$ is an estimated parameter that scales the initial conditions, $\hat{R}_0$ (virgin recruitment) and $\hat{h}$ (steepness) are estimated parameters of the stock-recruit curve, and $\hat{R}_y$ is estimated annual recruitment deviation. Quantities ϕ_0 and S_y are described immediately below.
Virgin mature biomass per recruit	ϕ_0	$\phi_0 = \sum_a N'_a w_a[\rho_a m'_a + (1-\rho_a)m_{a,1967}]$ where $N'_0 = 1$; $\quad N'_{a+1} = N'_a\exp(-M)$; $\quad N'_A = N'_{A-1}\frac{\exp(-M)}{1-\exp(-M)}$
Mature biomass	S_y	$S_y = \sum_a N_{a,y}w_a[\rho_a m'_a + (1-\rho_a)m_{a,y}]$ Also referred to as SSB
Population biomass	B_y	$B_y = \sum_a N_{a,y}w_a$
Catch at age	$C_{f,a,y}$	$C_{f,a,y} = \frac{F_{f,a,y}}{Z_{a,y}}N_{a,y}[1-\exp(-Z_{a,y})]$
Predicted landings	$\check{L}_{f,y}$	$\check{L}_{f,y} = \sum_a C_{f,a,y}w_a$
Predicted length compositions	$\check{p}_{(f,u),l',y}$	$\check{p}_{(f,u),l',y} = \frac{C_{(f,u),l',y}}{\sum_{l'} C_{(f,u),l',y}}$
Predicted CPUE	$\check{U}_{u,y}$	$\check{U}_{u,y} = \hat{q}_u\sum_a N_{a,y}s''_{u,a}$ where $\hat{q}_u$ is the estimated catchability coefficient of index u

Table 20. (continued)

Quantity	Symbol	Description or definition
Negative Log-Likelihood		
Multinomial length compositions	Λ_1	$\Lambda_1 = -\lambda_1 n_{(f,u),y} \sum_{l'} (p_{(f,u),l',y} + x) \log(\check{p}_{(f,u),l',y} + x) - (p_{(f,u),l',y} + x) \log(p_{(f,u),l',y} + x)$ where $\lambda_1 = 1$ is a preset weight and x is fixed at an arbitrary value of 0.001
Lognormal landings	Λ_2	$\Lambda_2 = \lambda_2 \sum_{y} \frac{[\log(L_{f,y}+x) - \log(\check{L}_{f,y}+x)]^2}{2c^2_{L_{f,y}}}$ where $\lambda_2 = 500$ is a preset weight and x is fixed at an arbitrary value of 0.001
Lognormal CPUE	Λ_3	$\Lambda_3 = \lambda_3 \sum_{y} \frac{[\log(U_{u,y}+x) - \log(\check{U}_{u,y}+x)]^2}{2c^2_{u,y}}$ where $\lambda_3 = 10$ is a preset weight and x is fixed at an arbitrary value of 0.001
Constraint on recruitment	Λ_4	$\Lambda_4 = \lambda_4 \sum_{y} R^2_y$ where $\lambda_4 = 1$ is a preset weight
Additional constraint on recruitment	Λ_5	$\Lambda_5 = \lambda_5 [\sum_{y=1968}^{1977} R^2_y + \sum_{y=2001}^{2003} R^2_y]$ where $\lambda_5 = 1000$ is a preset weight
Constraint on $\frac{B_{1967}}{B_0}$	Λ_6	$\Lambda_6 = \lambda_6 (\frac{B_{1967}}{B_0} - \chi)^2$ where $\lambda_6 = 1,000,000$ is a preset weight and $\chi = 0.75$ is fixed as described in the text
Constraint on $F_{y=1999...2003}$ variability	Λ_7	$\Lambda_7 = \lambda_7 \sum_{y=2000}^{2003} (F_y - F_{y-1})^2$ where $\lambda_7 = 50$ is a preset weight
Constraint on F_y	Λ_8	$\Lambda_8 = \lambda_8 \sum_{y} I_y (F_y - 5.0)^2$ where $\lambda_8 = 1000$ is a preset weight and $I_y = \begin{cases} 1 & : \text{if } F_y > 5.0 \\ 0 & : \text{otherwise} \end{cases}$

Table 21. Extended landings (mt) used in production model

Year	Commercial landings [a]	Total landings assuming R:C = 1:1	R:C = 2:1	R:C = 2:1
1950	144.9	289.8	434.7	579.6
1951	102.6	205.2	307.8	410.4
1952	79.3	158.6	237.9	317.2
1953	55.6	111.2	166.8	222.4
1954	33.2	66.4	99.6	132.8
1955	20.5	41.0	61.5	82.0
1956	34.9	69.8	104.7	139.6
1957	34.2	68.4	102.6	136.8
1958	33.9	67.8	101.7	135.6
1959	46.5	93.0	139.5	186.0
1960	66.6	133.2	199.8	266.4
1961	310.9	621.8	932.7	1243.6
1962	726.3	1452.6	2178.9	2905.2
1963	246.2	492.4	738.6	984.8
1964	261.5	523.0	784.5	1046.0
1965	270.0	540.0	810.0	1080.0
1966	377.0	754.0	1131.0	1508.0
1967	681.7	1363.4	2045.1	2726.8
1968	386.2	772.4	1158.6	1544.8
1969	621.8	1243.6	1865.4	2487.2
1970	725.8	1451.6	2177.4	2903.2
1971	518.3	1036.6	1554.9	2073.2
1972	576.0	1152.0	1728.0	2304.0
1973	436.4	872.8	1309.2	1745.6
1974	659.9	1319.8	1979.7	2639.6
1975	421.3	842.6	1263.9	1685.2
1976	210.1	420.2	630.3	840.4
1977	167.1	334.2	501.3	668.4

[a] Commercial landings include NC and states south; exclude NC trawl.

Table 22. Black sea bass: Estimated selectivities of fisheries. Lengths are mean values from the estimated von Bertalanffy curve. Gears are denoted as Com.H = commercial handline; Com.T = commercial trap; Com.O = commercial other; and Rec = recreational. Periods of regulations are denoted as 1 = period 1978–1982; 2 = period 1983–1998; and 3 = period 1999–2003.

Age	Length(mm)	Length(in)	Com.H 1	Com.H 2	Com.H 3	Com.T 1	Com.T 2	Com.T 3	Com.O	Rec 1	Rec 2	Rec 3
0	127.0	5.0	0.000	0.000	0.000	0.057	0.000	0.000	0.000	0.000	0.000	0.000
1	188.7	7.4	0.000	0.000	0.000	0.093	0.002	0.000	0.000	0.147	0.001	0.000
2	241.3	9.5	0.005	0.001	0.000	0.149	0.521	0.000	0.038	0.992	0.805	0.001
3	286.2	11.3	0.431	0.431	0.007	0.231	0.999	0.731	0.829	1.000	1.000	0.965
4	324.4	12.8	0.991	0.998	0.992	0.339	1.000	1.000	0.998	1.000	1.000	1.000
5	356.9	14.1	1.000	1.000	1.000	0.468	1.000	1.000	1.000	1.000	1.000	1.000
6	384.6	15.1	1.000	1.000	1.000	0.601	1.000	1.000	1.000	1.000	1.000	1.000
7	408.3	16.1	1.000	1.000	1.000	0.720	1.000	1.000	1.000	1.000	1.000	1.000
8	428.4	16.9	1.000	1.000	1.000	0.815	1.000	1.000	1.000	1.000	1.000	1.000
9	445.6	17.5	1.000	1.000	1.000	0.883	1.000	1.000	1.000	1.000	1.000	1.000
10	460.2	18.1	1.000	1.000	1.000	0.928	1.000	1.000	1.000	1.000	1.000	1.000
11	472.7	18.6	1.000	1.000	1.000	0.957	1.000	1.000	1.000	1.000	1.000	1.000

Table 23. Black sea bass: Estimated time series and status indicators. Exploitation rate (E) is of ages 1+, F is the fully selected fishing mortality rate, and SPR is static spawning potential ratio. SSB is in mt.

Year	E	E/E_{MSY}	F	F/F_{MSY}	SSB	SSB/SSB_{MSY}	SPR
1978	0.182	1.81	0.453	1.05	3557	0.522	0.322
1979	0.218	2.18	0.797	1.86	3629	0.533	0.264
1980	0.223	2.22	1.000	2.33	3595	0.528	0.235
1981	0.223	2.22	1.071	2.50	3568	0.524	0.249
1982	0.260	2.59	1.159	2.70	3738	0.549	0.203
1983	0.189	1.89	0.590	1.37	3481	0.511	0.290
1984	0.258	2.58	0.958	2.23	4151	0.609	0.241
1985	0.222	2.21	0.784	1.83	3631	0.533	0.270
1986	0.152	1.52	0.531	1.24	3589	0.527	0.340
1987	0.208	2.07	0.570	1.33	3724	0.547	0.318
1988	0.301	3.00	0.966	2.25	3460	0.508	0.244
1989	0.261	2.60	1.149	2.68	2773	0.407	0.231
1990	0.243	2.43	1.183	2.76	2321	0.341	0.239
1991	0.267	2.66	1.413	3.29	2264	0.332	0.220
1992	0.281	2.81	1.267	2.95	1944	0.285	0.234
1993	0.260	2.60	1.153	2.69	1705	0.250	0.240
1994	0.318	3.17	1.683	3.92	1543	0.226	0.205
1995	0.215	2.15	2.096	4.88	1591	0.234	0.189
1996	0.274	2.73	2.143	4.99	1757	0.258	0.206
1997	0.233	2.32	1.588	3.70	1880	0.276	0.222
1998	0.215	2.14	1.122	2.61	1865	0.274	0.263
1999	0.179	1.79	2.396	5.58	1895	0.278	0.276
2000	0.155	1.55	1.643	3.83	1824	0.268	0.288
2001	0.222	2.21	2.578	6.00	1814	0.266	0.257
2002	0.150	1.50	2.391	5.57	1683	0.247	0.276
2003	0.162	1.62	2.641	6.15	1800	0.264	0.258
2004	–	–	–	–	1858	0.273	–

Table 24. Black sea bass: Estimated aboundance (numbers) at age

Year	0	1	2	3	4	5	6	7	8	9	10	11
1978	10522600	6831010	5506280	2812580	1209810	651957	268240	114552	47032	17696	6285	8826
1979	14868100	7764340	4785890	2892790	1431290	596668	318576	129875	55007	22437	8403	7144
1980	11665300	10781100	5267360	2344800	1332980	613628	243571	123684	48197	19696	7830	5308
1981	16551700	8377890	7159430	2423150	1001080	521482	223665	82554	39266	14528	5720	3699
1982	10126100	11796900	5578130	3575080	1091650	399091	190292	74539	25356	11305	3993	2491
1983	12499000	7273070	7691140	2264030	1325300	363994	123976	54982	20178	6518	2800	1558
1984	10552000	9249540	5358220	3934970	977988	544329	149467	50908	22577	8286	2677	1790
1985	10804900	7809770	6813200	2072290	1194120	277982	154676	42472	14466	6416	2354	1269
1986	7508180	7996000	5753610	3053760	749010	404048	94032	52322	14367	4893	2170	1226
1987	7357640	5555400	5892310	3157060	1416550	326495	176078	40978	22801	6261	2132	1480
1988	8882310	5446010	4095710	3025630	1381460	593723	136818	73786	17172	9555	2624	1514
1989	7306930	6571630	4008240	1626650	921627	389671	167415	38579	20806	4842	2694	1167
1990	8057600	5402470	4829010	1508230	434058	216488	91482	39304	9057	4885	1137	906
1991	5067850	5950930	3964520	2099770	425026	98588	49125	20759	8919	2055	1108	464
1992	5100770	3743210	4369840	1510300	492937	76764	17786	8862	3745	1609	371	284
1993	4851310	3768190	2751620	1844580	406186	102961	16016	3711	1849	781	336	137
1994	9863940	3583960	2771730	1197230	527273	95101	24085	3747	868	433	183	110
1995	6581610	7279250	2629800	934009	223835	72705	13096	3317	516	120	60	40
1996	8149480	4853550	5329740	723985	124426	20421	6622	1193	302	47	11	9
1997	5431190	6013300	3560890	1922820	115531	10844	1775	576	104	26	4	2
1998	5366830	4009420	4416400	1437290	430531	17521	1642	269	87	16	4	1
1999	5720080	3966710	2952760	2215380	472113	103962	4225	396	65	21	4	1
2000	4394370	4237510	2925510	2023300	498939	32119	7017	285	27	4	1	0
2001	6578780	3255410	3128770	2035590	519873	71735	4602	1005	41	4	1	0
2002	5590490	4873640	2399370	2110440	238402	29360	4035	259	57	2	0	0
2003	6099440	4141520	3598230	1658530	459731	16295	1991	274	18	4	0	0
2004	6406360	4518540	3053150	2418930	207048	24407	861	105	14	1	0	0

Table 25. Black sea bass: Estimated biomass at age (mt)

Year	0	1	2	3	4	5	6	7	8	9	10	11
1978	345.189	677.739	1085.810	892.728	544.958	383.620	194.545	98.143	46.098	19.357	7.524	11.384
1979	487.741	770.339	943.751	918.189	644.726	351.088	231.052	111.272	53.914	24.542	10.059	9.215
1980	382.673	1069.640	1038.700	744.253	600.443	361.068	176.654	105.967	47.240	21.544	9.374	6.846
1981	542.972	831.212	1411.800	769.122	450.938	306.848	162.217	70.729	38.486	15.891	6.848	4.771
1982	332.182	1170.430	1099.980	1134.750	491.733	234.831	138.013	63.862	24.853	12.366	4.780	3.214
1983	410.025	721.597	1516.650	718.615	596.983	214.179	89.916	47.106	19.777	7.130	3.352	2.010
1984	346.154	917.693	1056.610	1248.980	440.535	320.291	108.404	43.616	22.129	9.063	3.204	2.309
1985	354.450	774.846	1343.530	657.758	537.893	163.569	112.181	36.389	14.179	7.018	2.819	1.637
1986	246.302	793.323	1134.580	969.279	337.392	237.748	68.198	44.827	14.082	5.353	2.598	1.581
1987	241.364	551.179	1161.930	1002.070	638.084	192.114	127.704	35.108	22.348	6.848	2.553	1.909
1988	291.380	540.326	807.651	960.352	622.280	349.355	99.230	63.217	16.831	10.451	3.141	1.953
1989	239.700	652.005	790.403	516.307	415.147	229.288	121.421	33.053	20.393	5.296	3.225	1.505
1990	264.326	536.006	952.256	478.721	195.521	127.385	66.349	33.674	8.877	5.343	1.361	1.169
1991	166.248	590.422	781.783	666.479	191.453	58.011	35.628	17.785	8.741	2.248	1.327	0.598
1992	167.328	371.383	861.709	479.378	222.043	45.169	12.899	7.593	3.671	1.760	0.444	0.366
1993	159.145	373.861	542.604	585.481	182.966	60.584	11.616	3.179	1.812	0.855	0.402	0.176
1994	323.582	355.582	546.570	380.008	237.510	55.959	17.468	3.210	0.851	0.473	0.219	0.142
1995	215.907	722.211	518.582	296.460	100.827	42.781	9.498	2.842	0.506	0.131	0.071	0.052
1996	267.340	481.545	1051.000	229.797	56.048	12.016	4.803	1.022	0.296	0.051	0.013	0.012
1997	178.167	596.609	702.189	610.315	52.041	6.381	1.287	0.493	0.102	0.029	0.005	0.002
1998	176.056	397.794	870.890	456.204	193.933	10.310	1.191	0.230	0.085	0.017	0.005	0.001
1999	187.644	393.557	582.268	703.173	212.663	61.173	3.064	0.339	0.064	0.023	0.005	0.002
2000	144.155	420.424	576.894	642.208	224.747	18.899	5.089	0.244	0.026	0.005	0.002	0.000
2001	215.814	322.986	616.976	646.107	234.177	42.210	3.338	0.861	0.040	0.004	0.001	0.000
2002	183.393	483.538	473.143	669.864	107.388	17.276	2.927	0.222	0.055	0.003	0.000	0.000
2003	200.089	410.900	709.553	526.426	207.086	9.588	1.444	0.234	0.017	0.004	0.000	0.000
2004	210.158	448.307	602.066	767.784	93.265	14.361	0.624	0.090	0.014	0.001	0.000	0.000

Table 26. Black sea bass: Estimated biomass at age (klb)

Year	0	1	2	3	4	5	6	7	8	9	10	11
1978	761.012	1494.159	2393.802	1968.129	1201.427	845.737	428.898	216.369	101.628	42.674	16.587	25.099
1979	1075.285	1698.307	2080.615	2024.261	1421.378	774.017	509.383	245.313	118.861	54.106	22.176	20.317
1980	843.650	2358.153	2289.942	1640.797	1323.750	796.019	389.455	233.617	104.146	47.495	20.666	15.094
1981	1197.049	1832.509	3112.487	1695.624	994.148	676.484	357.627	155.931	84.848	35.034	15.097	10.519
1982	732.336	2580.357	2425.041	2501.696	1084.086	517.714	304.267	140.792	54.791	27.261	10.539	7.085
1983	903.951	1590.849	3343.641	1584.275	1316.122	472.184	198.230	103.852	43.601	15.719	7.391	4.430
1984	763.139	2023.167	2329.427	2753.530	971.214	706.121	238.990	96.157	48.786	19.981	7.064	5.089
1985	781.429	1708.243	2961.977	1450.108	1185.851	360.608	247.317	80.223	31.259	15.471	6.214	3.609
1986	543.003	1748.978	2501.321	2136.895	743.822	524.145	150.351	98.826	31.045	11.800	5.727	3.486
1987	532.117	1215.142	2561.618	2209.187	1406.735	423.539	281.539	77.400	49.269	15.098	5.628	4.208
1988	642.383	1191.215	1780.566	2117.214	1371.893	770.196	218.764	139.369	37.105	23.041	6.924	4.305
1989	528.448	1437.425	1742.541	1138.262	915.243	505.494	267.688	72.870	44.958	11.676	7.111	3.318
1990	582.739	1181.691	2099.365	1055.399	431.050	280.836	146.274	74.238	19.571	11.779	3.000	2.578
1991	366.514	1301.658	1723.537	1469.335	422.082	127.892	78.547	39.210	19.272	4.956	2.925	1.318
1992	368.895	818.760	1899.743	1056.848	489.521	99.580	28.439	16.739	8.092	3.880	0.979	0.806
1993	350.855	824.223	1196.237	1290.765	403.371	133.564	25.609	7.009	3.996	1.884	0.886	0.388
1994	713.376	783.924	1204.981	837.774	523.620	123.368	38.510	7.077	1.876	1.043	0.482	0.314
1995	475.994	1592.203	1143.278	653.583	222.286	94.315	20.940	6.265	1.115	0.288	0.157	0.115
1996	589.384	1061.625	2317.059	506.616	123.564	26.491	10.588	2.253	0.653	0.113	0.029	0.026
1997	392.791	1315.298	1548.062	1345.514	114.730	14.068	2.838	1.087	0.224	0.063	0.011	0.005
1998	388.137	876.986	1919.984	1005.758	427.549	22.729	2.625	0.508	0.188	0.038	0.010	0.003
1999	413.684	867.645	1283.681	1550.231	468.842	134.863	6.756	0.748	0.140	0.051	0.010	0.003
2000	317.807	926.876	1271.834	1415.827	495.482	41.666	11.219	0.539	0.058	0.011	0.004	0.001
2001	475.789	712.062	1360.199	1424.422	516.272	93.056	7.359	1.899	0.088	0.009	0.002	0.001
2002	404.312	1066.019	1043.102	1476.798	236.750	38.086	6.452	0.489	0.122	0.006	0.001	0.000
2003	441.121	905.880	1564.297	1160.571	456.547	21.138	3.184	0.517	0.038	0.009	0.000	0.000
2004	463.319	988.348	1327.329	1692.674	205.614	31.661	1.377	0.199	0.031	0.002	0.001	0.000

Table 27. Black sea bass: Estimated status indicators and benchmarks from catch-at-age model. Estimates are median values from stochastic simulations. Precision is represented by 20th and 80th percentiles. Exploitation rates E are of ages 1+. Estimates of optimal yield OY_1, OY_2, *and* OY_3 *correspond to the yields under* $F = 65\% F_{MSY}$, $F = 75\% F_{MSY}$, *and* $F = 85\% F_{MSY}$, *respectively. Rate estimates* (F_{MSY}, E_{MSY}) *are in units of per year; status indicators are dimensionless; and biomass estimates are in units of mt or klb, as indicated. Symbols, abbreviations, and acronyms are listed in Appendix D on page 101.*

Quantity	Estimate (mt)	Precision	Estimate (klb)
F_{MSY}	0.429	–	–
E_{MSY}	0.100	(0.099, 0.101)	–
SSB_{MSY}	6812	(6588, 7014)	15017
MSST	4768	(4612, 4910)	10512
MSY	1260	(1220, 1299)	2777
OY_1	1220	(1186, 1257)	2691
OY_2	1244	(1206, 1282)	2743
OY_3	1255	(1218, 1295)	2767
F_{2003}/F_{MSY}	6.151	–	–
E_{2003}/E_{MSY}	1.617	(1.602, 1.631)	–
SSB_{2004}/SSB_{MSY}	0.273	(0.265, 0.282)	–
$SSB_{2004}/MSST$	0.390	(0.378, 0.403)	–

Table 28. Black sea bass: Status indicators from sensitivity runs of catch-at-age model. Sensitivity runs were conducted over a 3×3 *grid of natural mortality (*$M = 0.2, 0.3,$ *or* 0.4*) and steepness (*$h = 0.4, 0.8,$ *or estimated, as indicated by "est"). Base run in* ***bold.*** *Run labelled "Extreme discards" assumes discard selectivity to be the complement of fishery selectivity, which most likely overestimates discards. Exploitation rates are of ages 1+. Symbols, abbreviations, and acronyms are listed in Appendix D on page 101.*

Run	$F_{2003}/F_{\mathrm{MSY}}$	$E_{2003}/E_{\mathrm{MSY}}$	$\mathrm{SSB}_{2004}/\mathrm{SSB}_{\mathrm{MSY}}$	$\mathrm{SSB}_{2004}/\mathrm{MSST}$
M=0.2, h=0.4	11.847	4.291	0.016	0.023
M=0.2, h=est	6.512	1.798	0.259	0.370
M=0.2, h=0.8	6.267	1.758	0.269	0.385
M=0.3, h=0.4	7.144	3.330	0.063	0.090
M=0.3, h=est	**6.151**	**1.617**	**0.273**	**0.390**
M=0.3, h=0.8	3.146	1.150	0.544	0.778
M=0.4, h=0.4	4.479	2.159	0.206	0.295
M=0.4, h=est	3.901	1.800	0.289	0.413
M=0.4, h=0.8	1.283	0.821	0.834	1.191
Extreme discards	5.985	1.921	0.184	0.263

Table 29. Black sea bass: Projection results under scenario with F=0. Values are medians of 1000 bootstrap replicates.

Year	SSB(mt)	Recruits(1000s)	F(/yr)	Landings(mt)	Landings(klb)	Cum. landings(klb)
2004	1858	6550	2.31	594	1310	1310
2005	1922	6523	2.30	594	1310	2620
2006	2034	6690	2.08	594	1310	3930
2007	2157	6879	0.00	0	0	3930
2008	3080	7025	0.00	0	0	3930
2009	4002	8700	0.00	0	0	3930
2010	4974	9838	0.00	0	0	3930
2011	5987	10,941	0.00	0	0	3930
2012	7059	11,569	0.00	0	0	3930
2013	8158	11,908	0.00	0	0	3930
2014	9215	12,928	0.00	0	0	3930
2015	10,283	13,247	0.00	0	0	3930
2016	11,280	13,736	0.00	0	0	3930
2017	12,182	14,214	–	–	–	–

Table 30. Black sea bass: Projection results under management scenario 1 (maximum constant F). Values are medians of 1000 bootstrap replicates. See §11 for details.

Year	SSB(mt)	Recruits(1000s)	F(/yr)	Landings(mt)	Landings(klb)	Cum. landings(klb)
2004	1858	6550	2.31	594	1310	1310
2005	1922	6523	2.30	594	1310	2620
2006	2034	6690	2.08	594	1310	3930
2007	2157	6879	0.29	158	349	4280
2008	2875	7025	0.29	305	673	4952
2009	3444	8366	0.29	418	921	5873
2010	3948	9135	0.29	503	1108	6981
2011	4456	9911	0.29	562	1240	8221
2012	4916	10,273	0.29	631	1390	9612
2013	5397	10,503	0.29	704	1552	11,163
2014	5841	11,326	0.29	774	1705	12,869
2015	6233	11,567	0.29	840	1851	14,720
2016	6607	11,853	0.29	899	1981	16,701
2017	6880	12,233	–	–	–	–

Table 31. Black sea bass: Projection results under management scenario 2 (maximum constant landings). Values are medians of 1000 bootstrap replicates. See §11 for details.

Year	SSB(mt)	Recruits(1000s)	F(/yr)	Landings(mt)	Landings(klb)	Cum. landings(klb)
2004	1858	6550	2.31	594	1310	1310
2005	1922	6523	2.30	594	1310	2620
2006	2034	6690	2.08	594	1310	3930
2007	2157	6879	1.34	526	1160	5090
2008	2409	7025	0.92	526	1160	6250
2009	2699	7575	0.69	526	1160	7409
2010	3046	7975	0.52	526	1160	8569
2011	3440	8601	0.42	526	1160	9729
2012	3892	9161	0.34	526	1160	10,888
2013	4431	9425	0.28	526	1160	12,048
2014	4976	10,279	0.23	526	1160	13,207
2015	5562	10,725	0.20	526	1160	14,367
2016	6218	11,181	0.17	526	1160	15,527
2017	6816	11,732	–	–	–	–

Table 32. Black sea bass: Projection results under management scenario 3 ($F = F_{MSY}$ in first three years, then maximize constant landings). Values are medians of 1000 bootstrap replicates. See §11 for details.

Year	SSB(mt)	Recruits(1000s)	F(/yr)	Landings(mt)	Landings(klb)	Cum. landings(klb)
2004	1858	6550	2.31	594	1310	1310
2005	1922	6523	2.30	594	1310	2620
2006	2034	6690	2.08	594	1310	3930
2007	2157	6879	0.43	224	493	4424
2008	2788	7025	0.43	404	890	5313
2009	3243	8239	0.43	525	1158	6471
2010	3624	8864	0.43	607	1338	7809
2011	4001	9511	0.39	607	1338	9147
2012	4427	9825	0.34	607	1338	10,485
2013	4910	10,071	0.28	607	1338	11,824
2014	5455	10,811	0.24	607	1338	13,162
2015	5992	11,220	0.21	607	1338	14,500
2016	6588	11,665	0.18	607	1338	15,838
2017	7158	12,196	–	–	–	–

14 Figures

Figure 1. Von Bertalanffy growth of black sea bass.

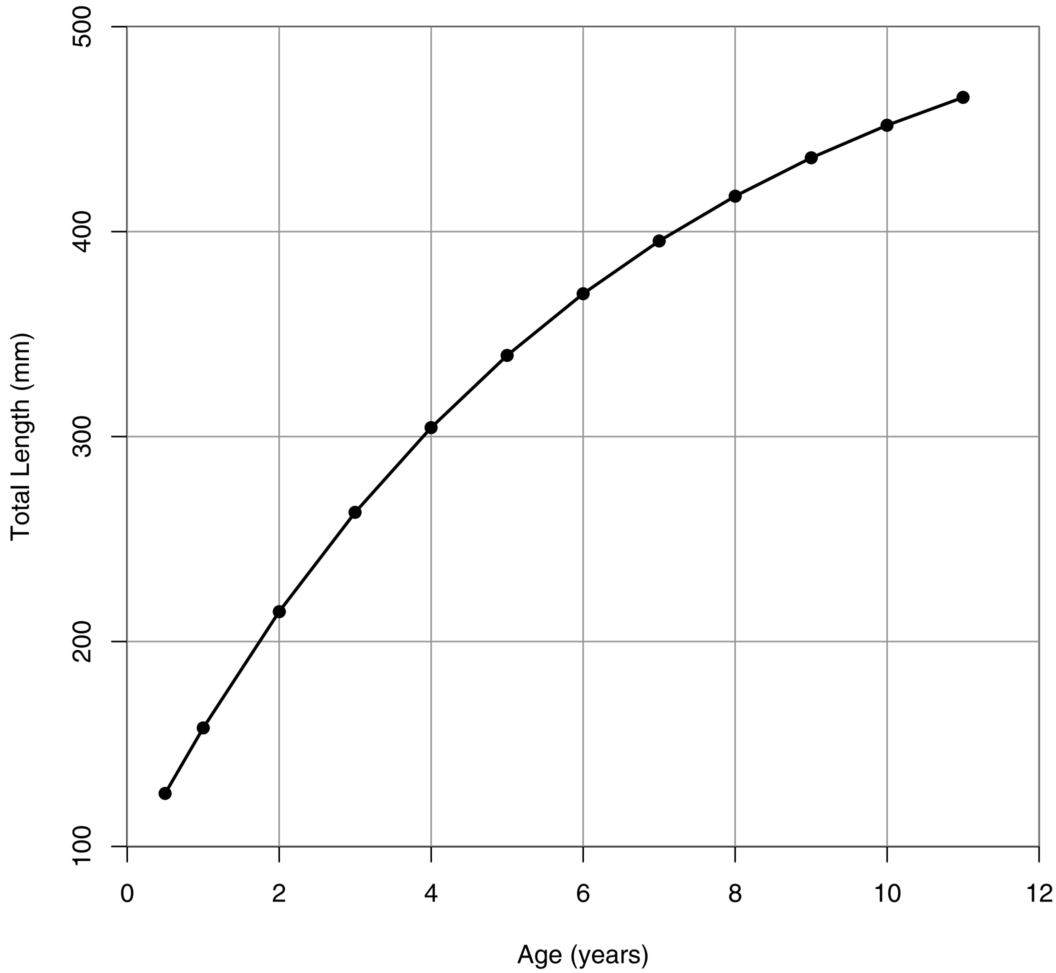


Figure 2. Landings of black sea bass by fishery and in total.

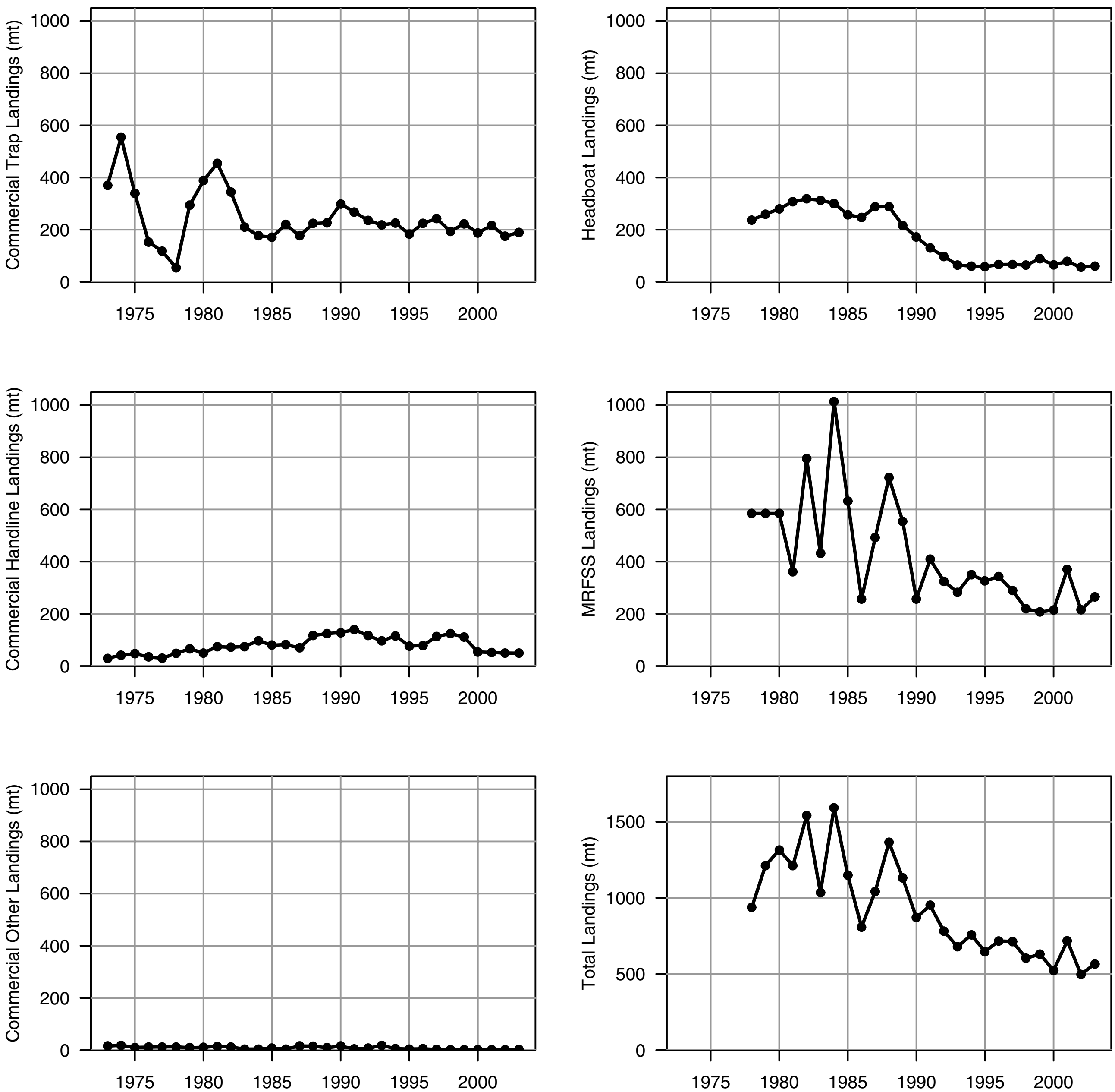
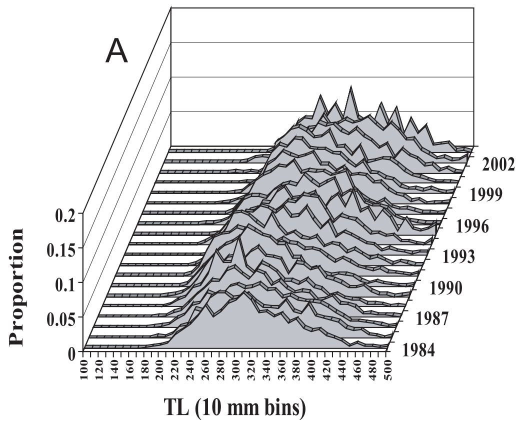
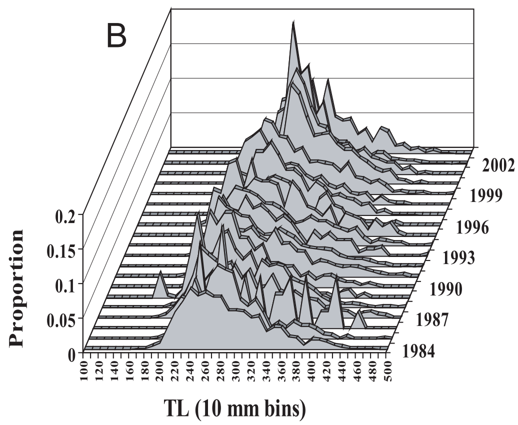


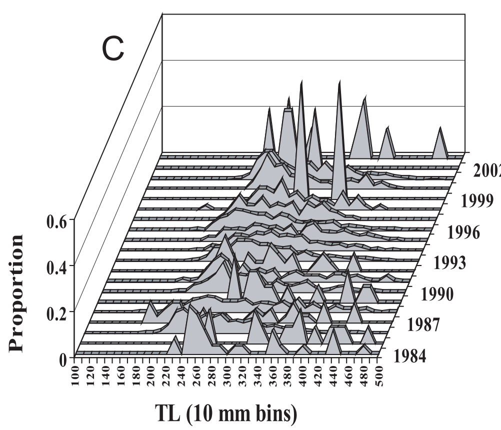
Figure 3. Length compositions of black sea bass from commercial fisheries. A) Handline; B) Trap; and C) Other



Year	N
1984	1453
1985	1124
1986	1393
1987	1274
1988	981
1989	706
1990	1256
1991	1684
1992	1450
1993	1144
1994	997
1995	600
1996	713
1997	1009
1998	1638
1999	1749
2000	1083
2001	1880
2002	**1578**
2003	**1014**

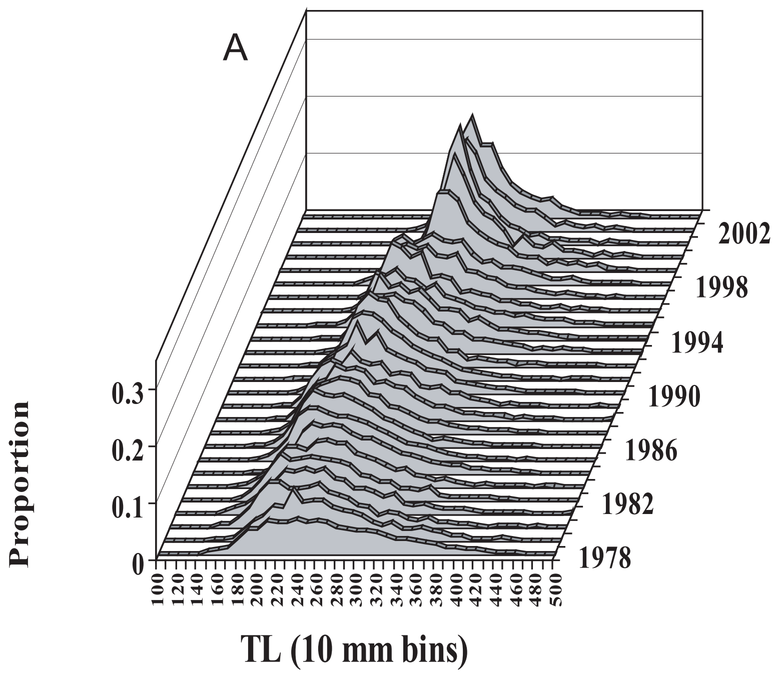


Year	N
1984	870
1985	654
1986	41
1987	761
1988	1260
1989	369
1990	770
1991	1172
1992	1482
1993	395
1994	1019
1995	218
1996	213
1997	935
1998	428
1999	868
2000	448
2001	587
2002	**4265**
2003	**7781**

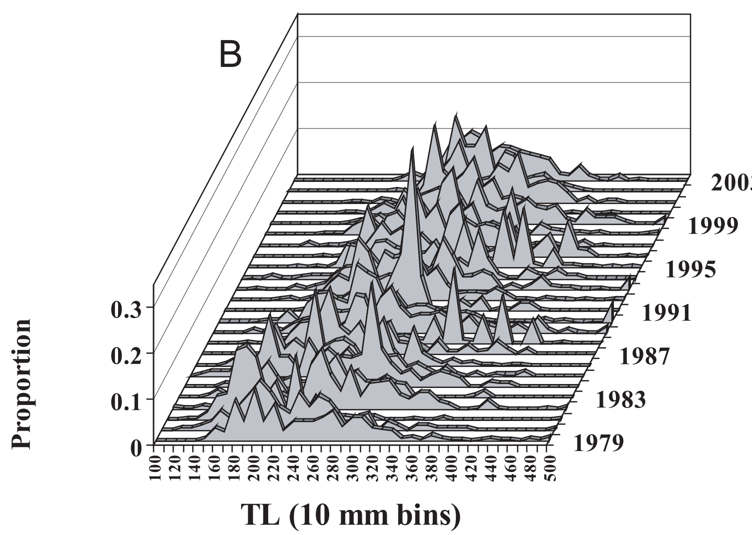


Year	N
1984	29
1985	14
1986	968
1987	34
1988	304
1989	15
1990	201
1991	157
1992	26
1993	783
1994	680
1995	338
1996	376
1997	261
1998	54
1999	2
2000	173
2001	417
2002	**4**
2003	**8**

Figure 4. Length compositions of black sea bass from recreational fisheries. A) Headboat and B) MRFSS



Year	N
1978	2357
1979	1655
1980	2420
1981	3035
1982	3686
1983	5734
1984	6091
1985	5860
1986	6551
1987	6443
1988	4256
1989	3836
1990	6200
1991	5381
1992	5186
1993	3941
1994	4215
1995	3325
1996	3212
1997	3678
1998	4365
1999	4114
2000	3419
2001	2983
2002	**1958**
2003	**2366**



Year	N
1979	361
1980	158
1981	194
1982	417
1983	173
1984	285
1985	488
1986	380
1987	668
1988	595
1989	651
1990	417
1991	223
1992	612
1993	349
1994	323
1995	314
1996	315
1997	306
1998	357
1999	419
2000	367
2001	568
2002	**267**
2003	**744**

Figure 5. Black sea bass: Indices of abundance used in catch-at-age model. MARMAP hook & line in units of no. fish per collection-hour; MARMAP traps in units of no. fish per trap-hour; and Headboat in units of lbs fish per angler-trip.

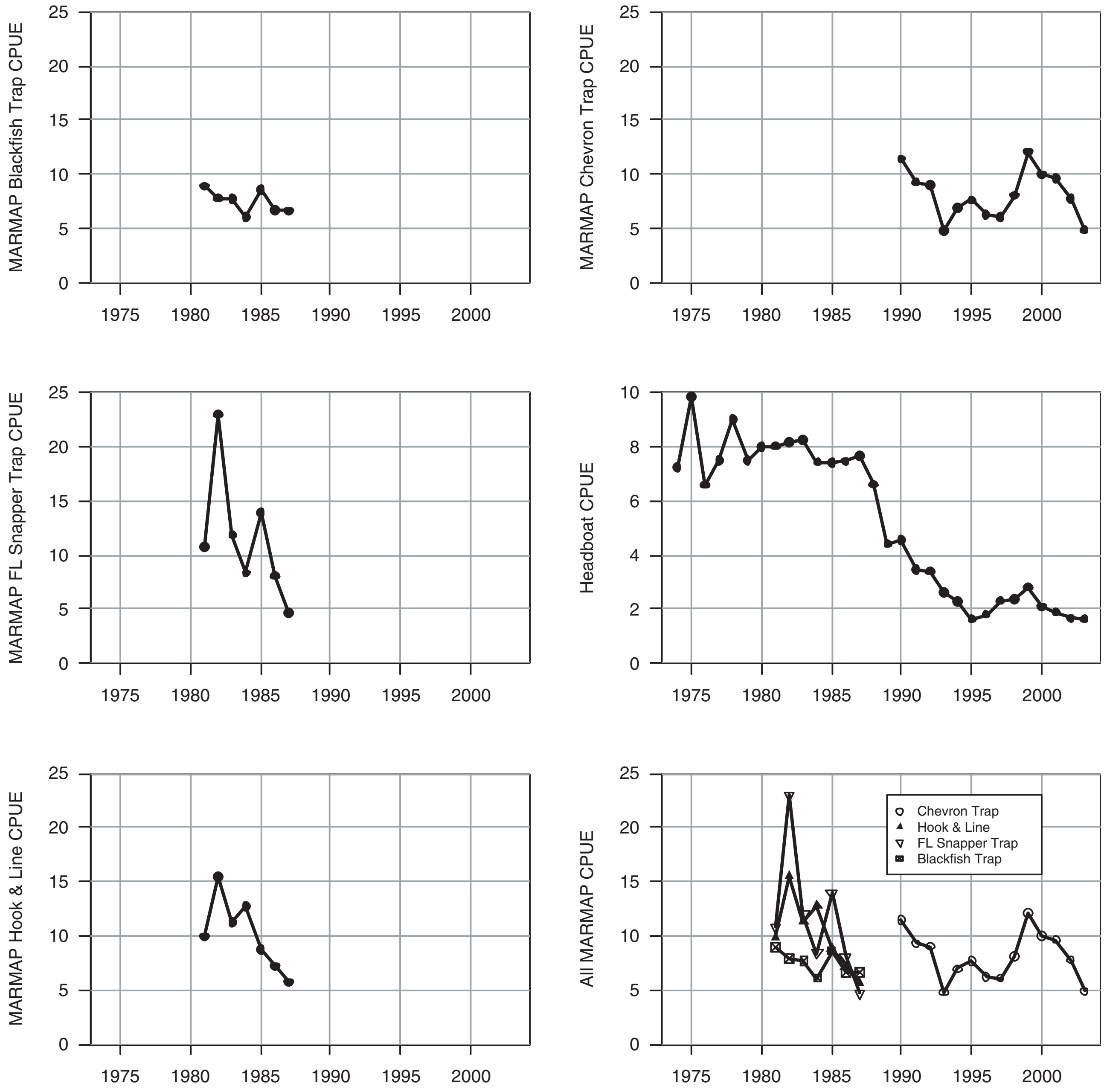


Figure 6. Length compositions of black sea bass from MARMAP. A) Hook & line; B) FL snapper trap; C) Blackfish trap; and D) Chevron trap

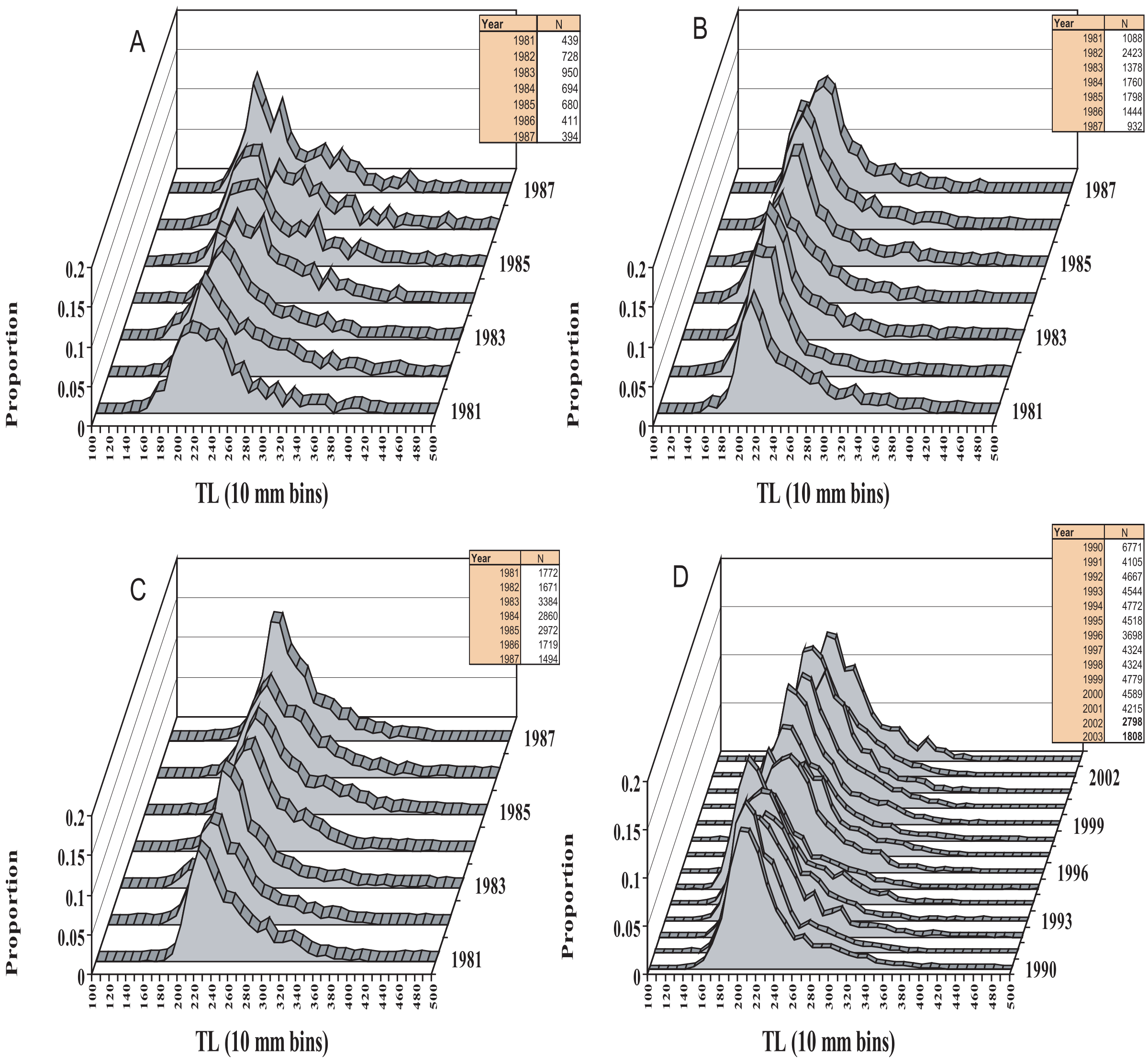


Figure 7. Black sea bass: Indices of abundance used in production model. MARMAP hook & line in units of kg fish per collection-hour; MARMAP traps in units of kg fish per trap-hour; and Headboat in units of kg fish per angler-trip.

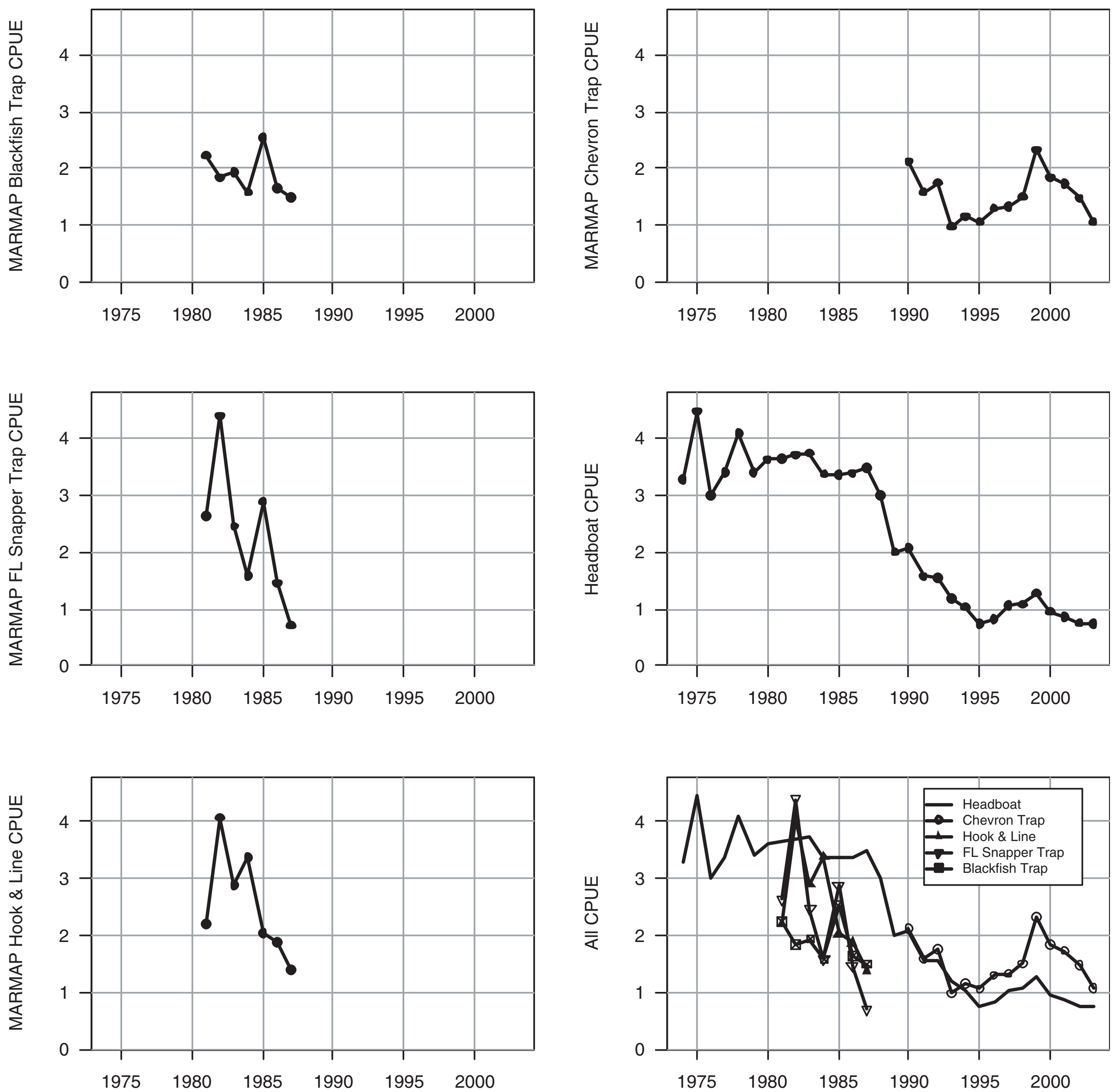


Figure 8. Landings of black sea bass used in the production model. A) Total commercial landings. B) Total landings (commercial + recreational), in which pre-1978 recreational landings were assumed to be one (lower dashed line), two (solid line, open circles), or three (upper dashed line) times the commercial landings. In both panels, landings after the solid vertical line were also used in the age-structured assessment model.

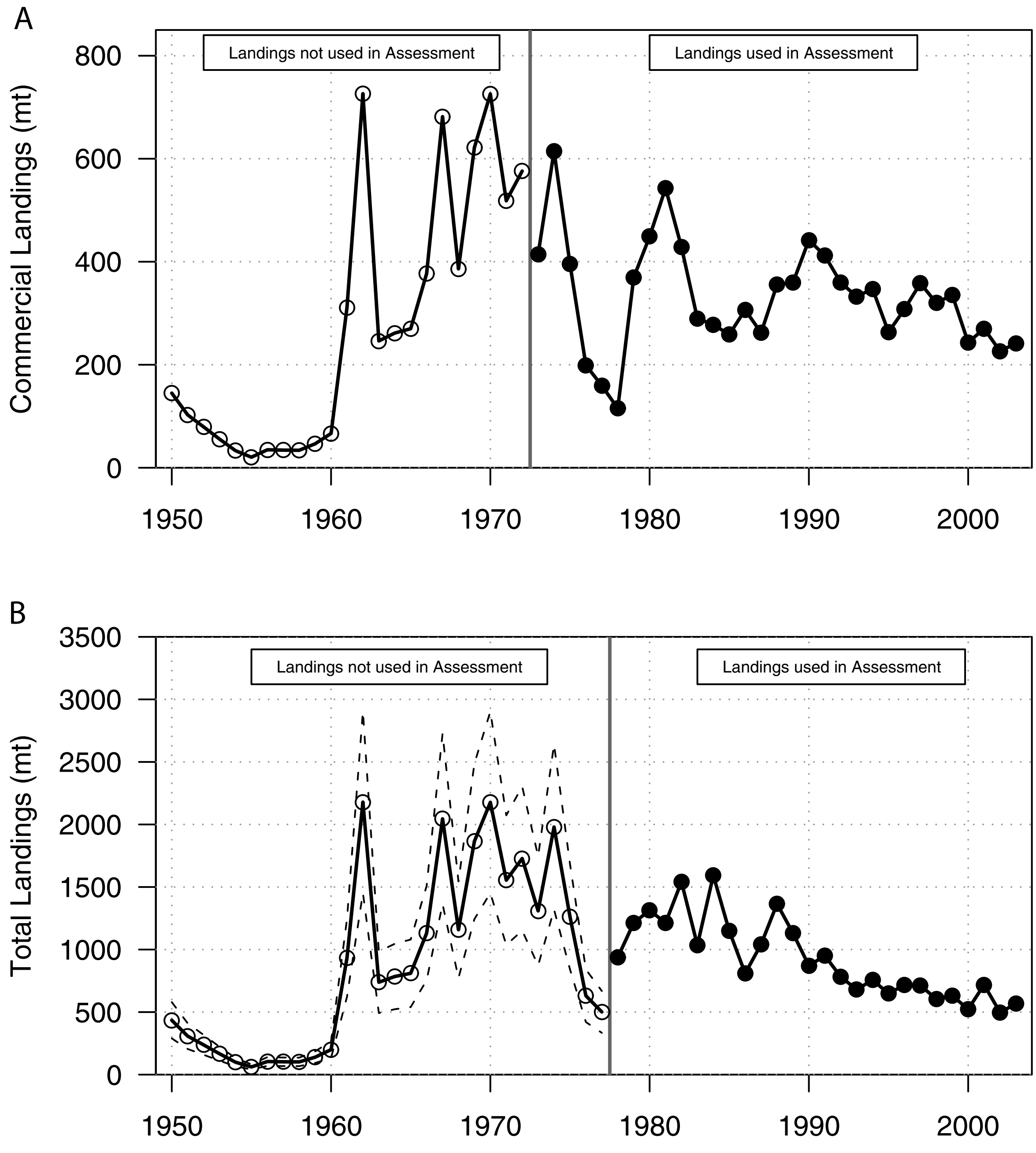


Figure 9. Black sea bass: Estimated (line) and observed (circles) annual length compositions from commercial handline.

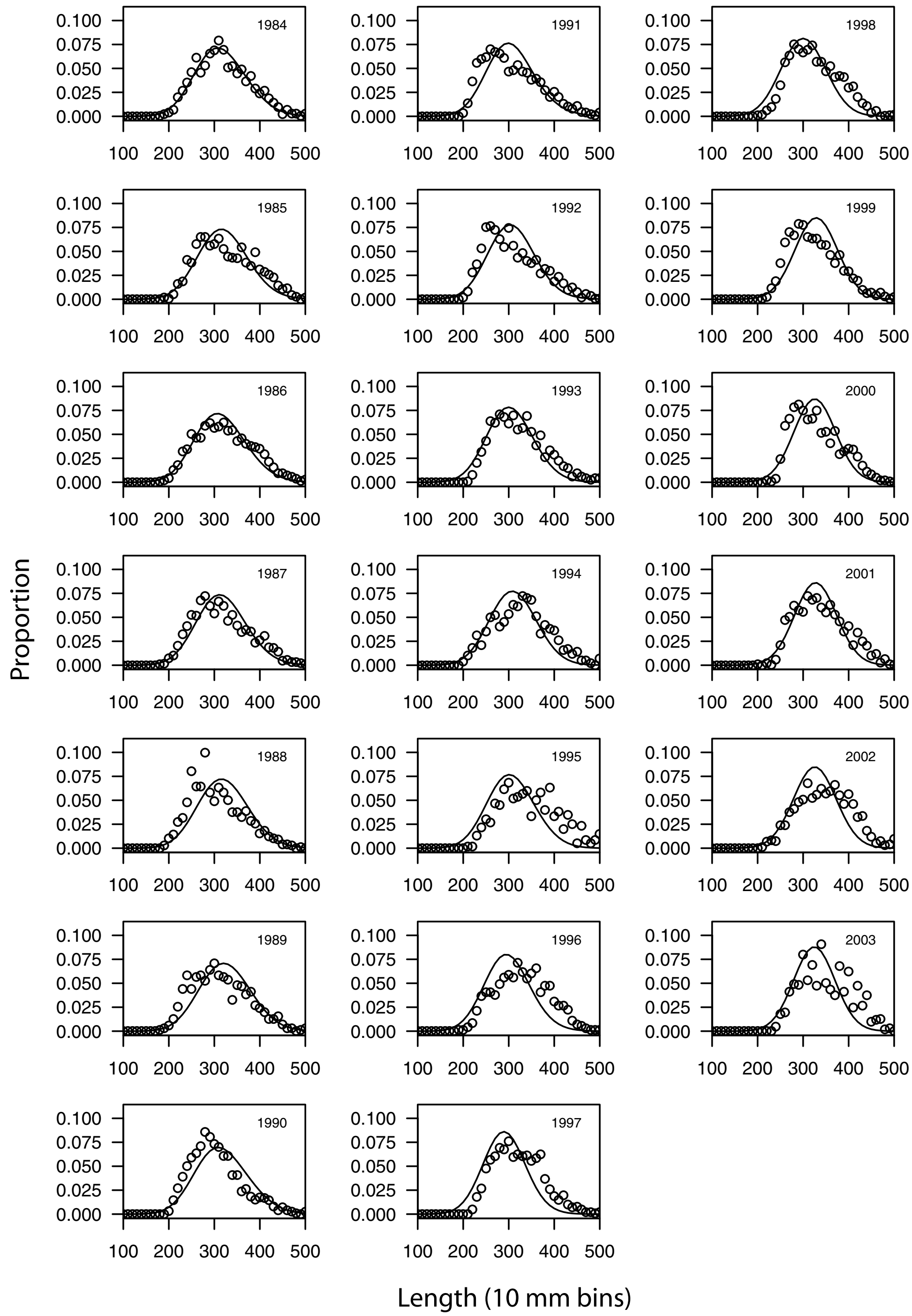


Figure 10. Black sea bass: Estimated (line) and observed (circles) annual length compositions from commercial traps.

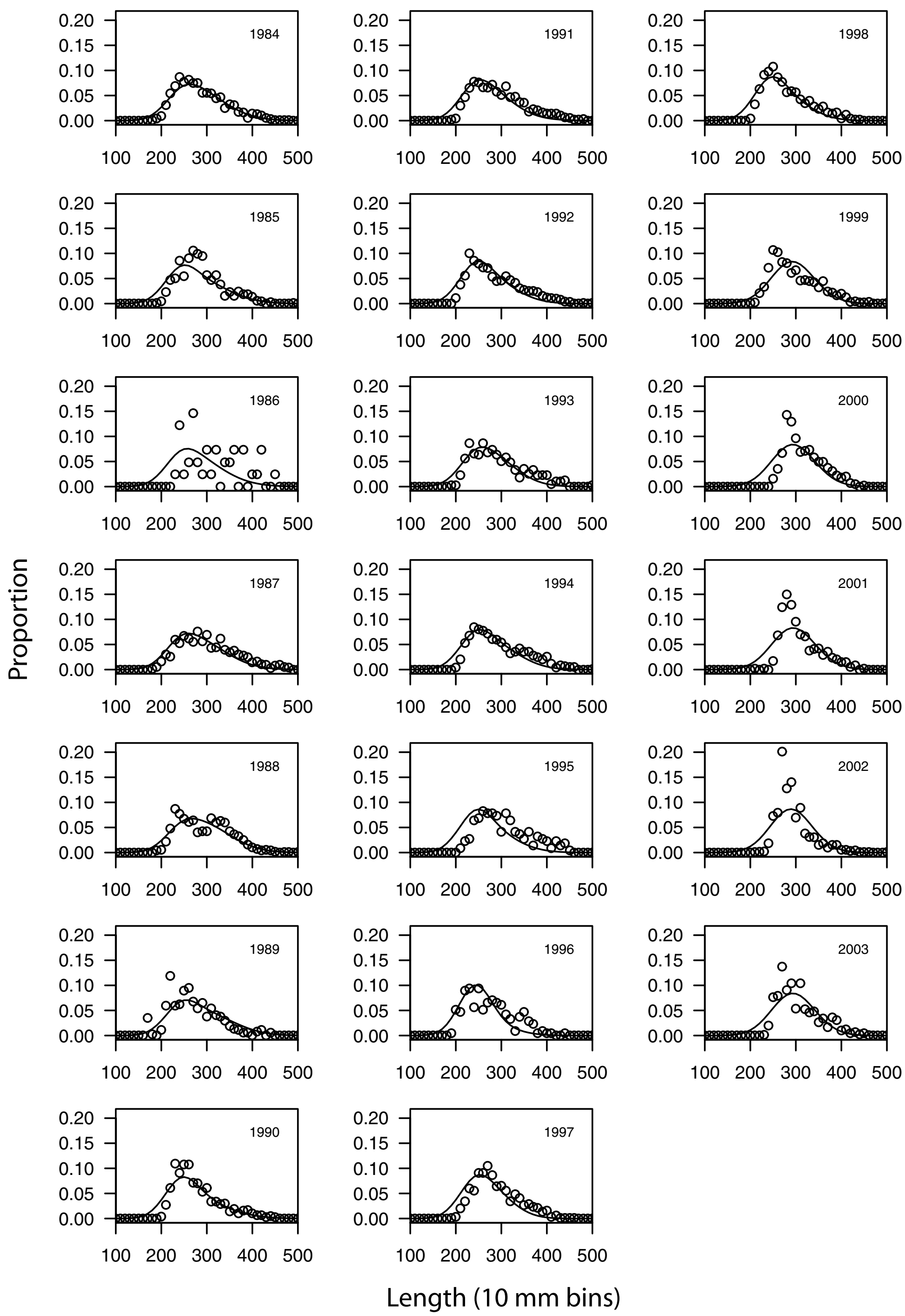


Figure 11. Black sea bass: Estimated (line) and observed (circles) annual length compositions from commercial other. Note difference of scales in 1999, 2002, and 2003.

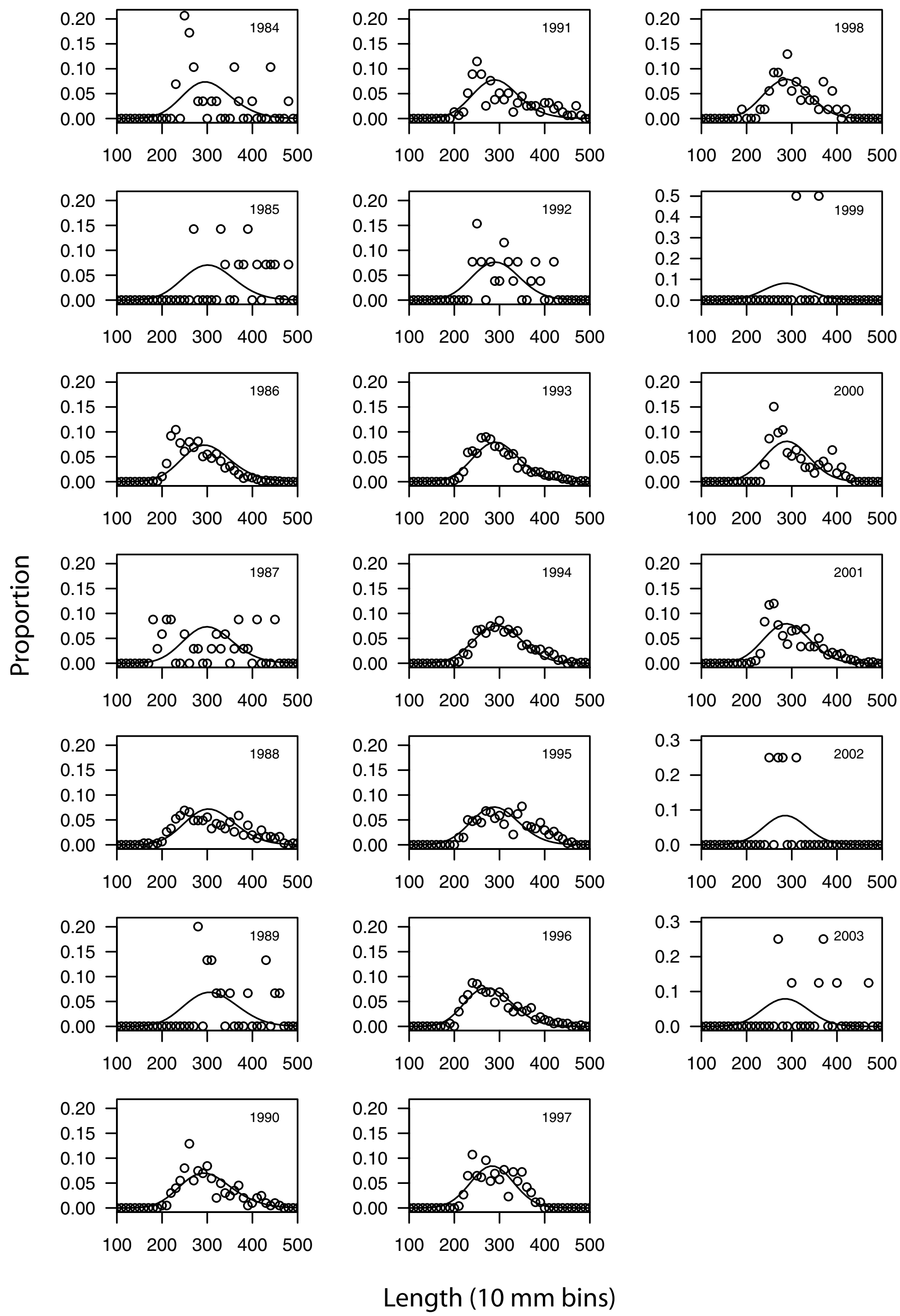


Figure 12. Black sea bass: Estimated (line) and observed (circles) annual length compositions from the recreational fishery component sampled by the headboat program.

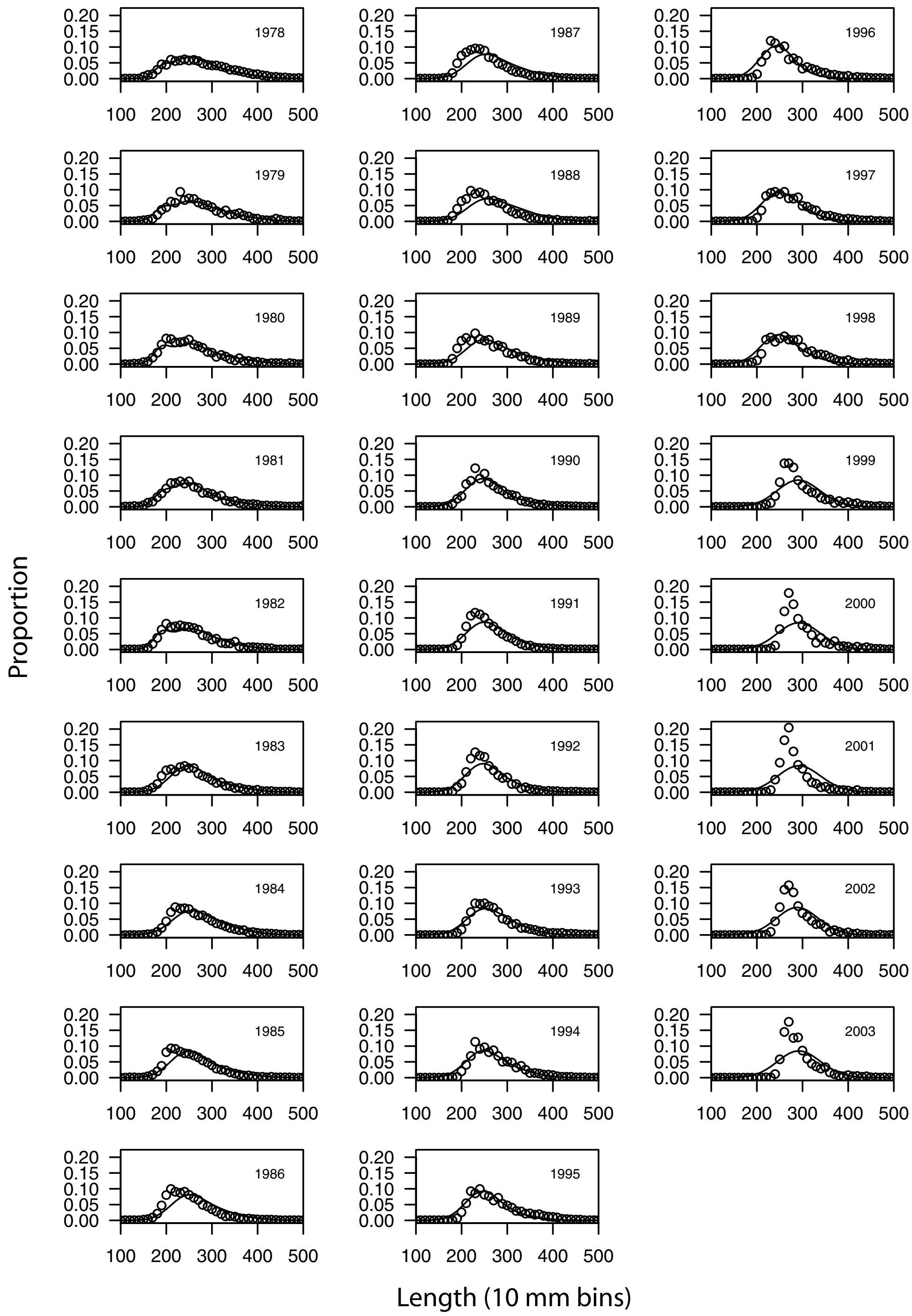


Figure 13. Black sea bass: Estimated (line) and observed (circles) annual length compositions from the recreational fishery as sampled by MRFSS. Note difference of scales in 1984 and 1991.

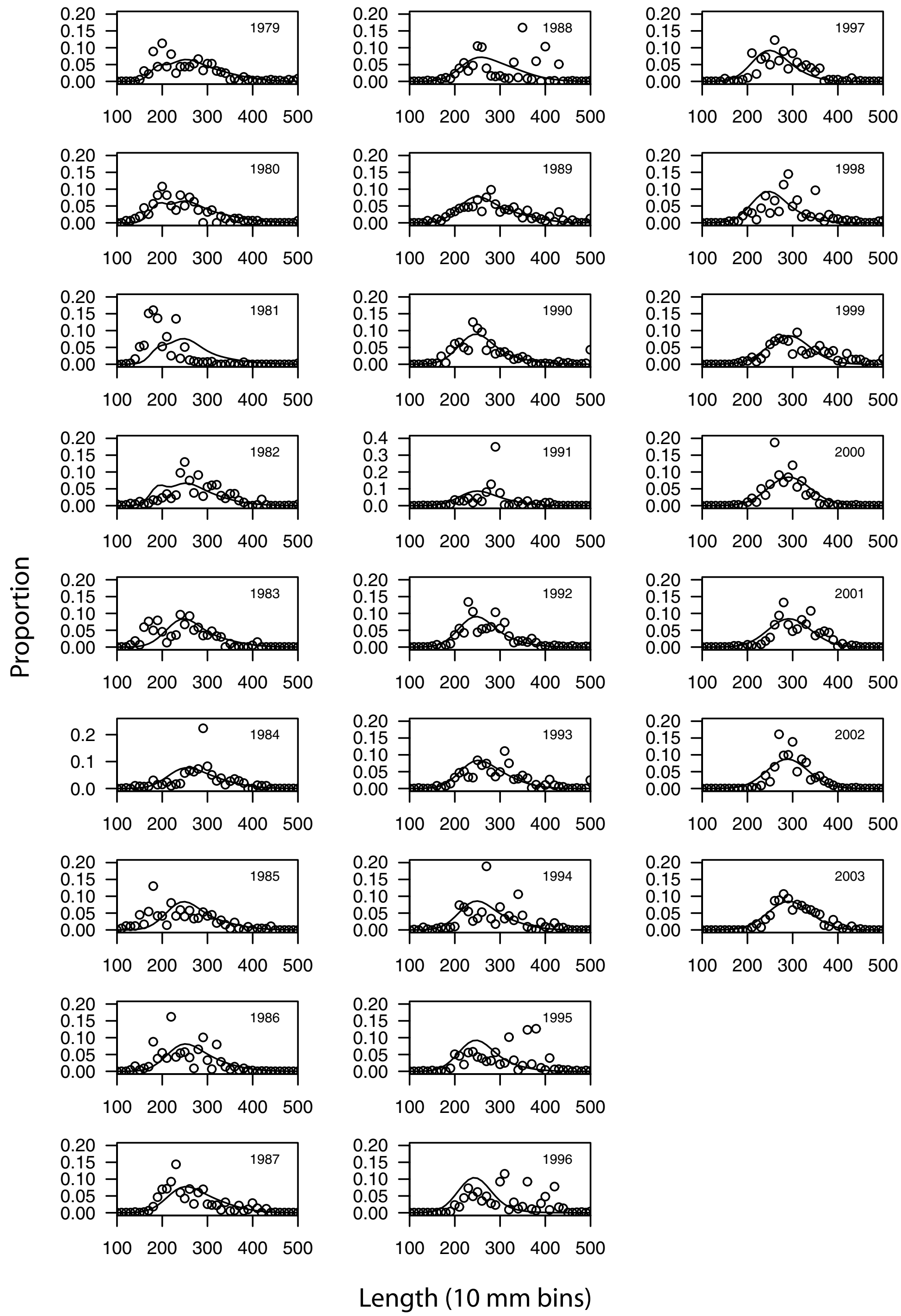


Figure 14. Black sea bass: Estimated (line) and observed (circles) annual length compositions from MARMAP gears, A) Blackfish trap and B) FL snapper trap.

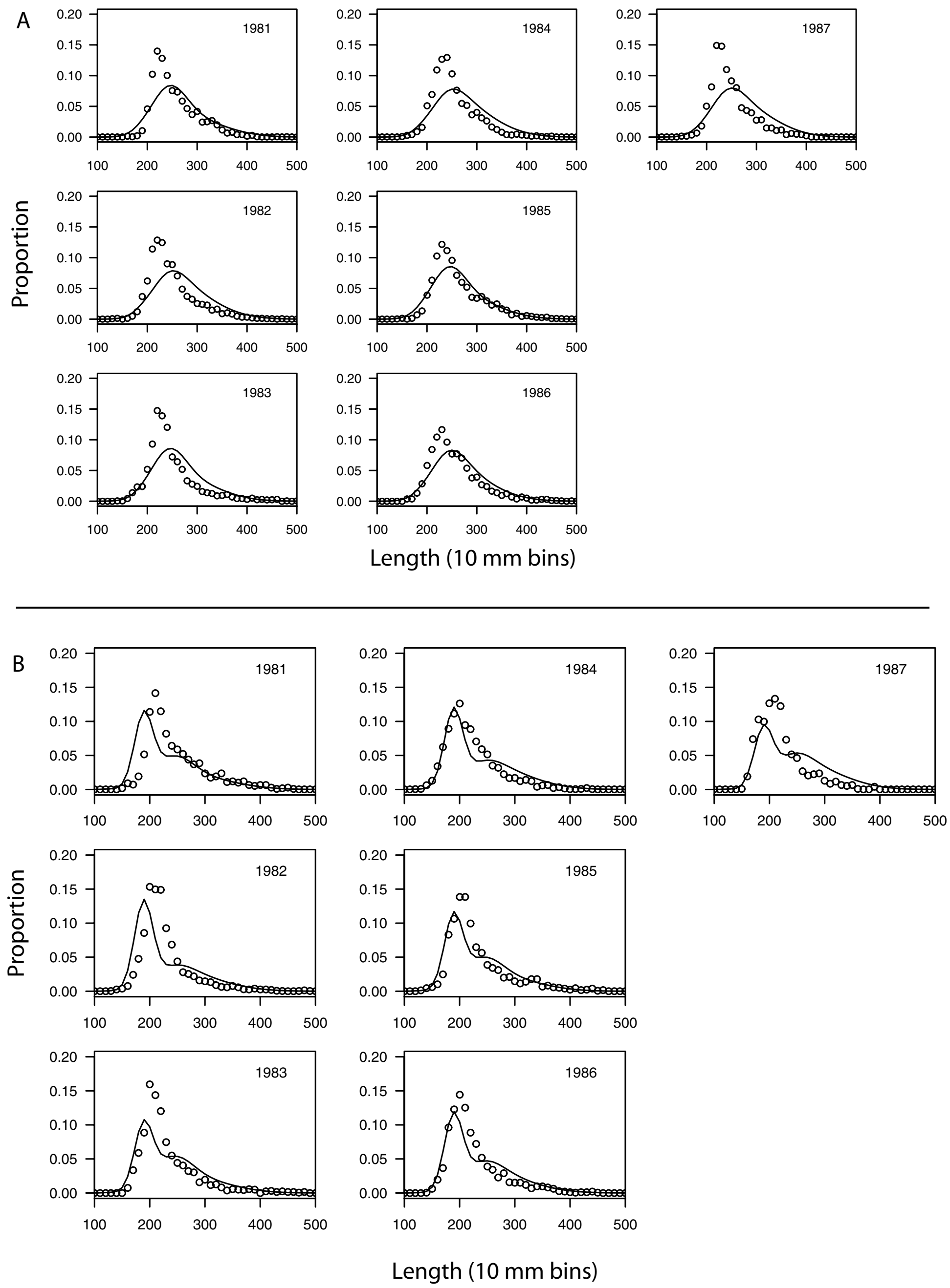


Figure 15. Black sea bass: Estimated (line) and observed (circles) annual length compositions from MARMAP gears, A) Hook & line and B) Chevron trap.

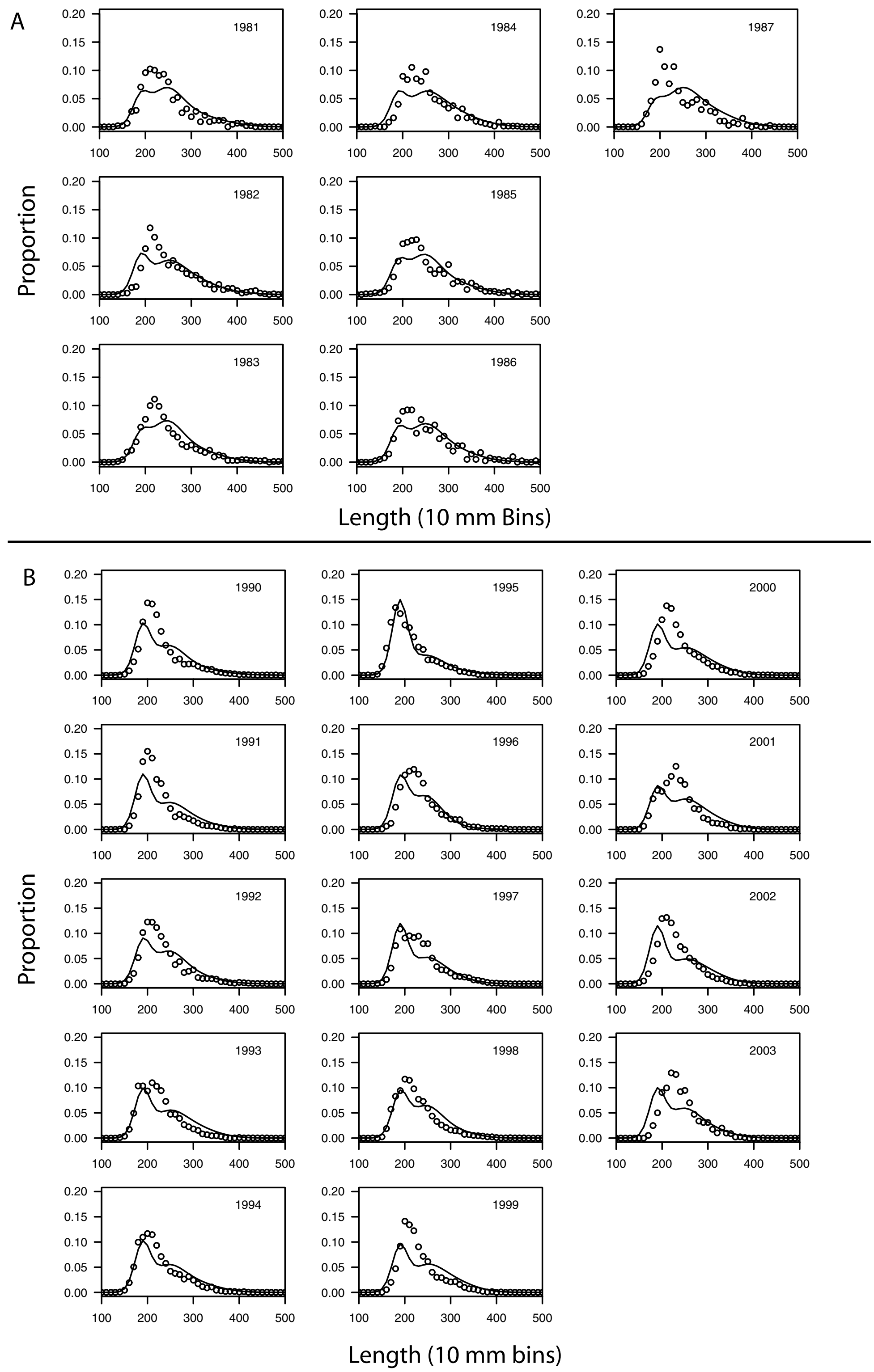


Figure 16. Commercial landings of black sea bass from the assessment model, estimated (line) and observed (filled circles). A) Handline; B) Trap; and C) Other. Note differences of scale.

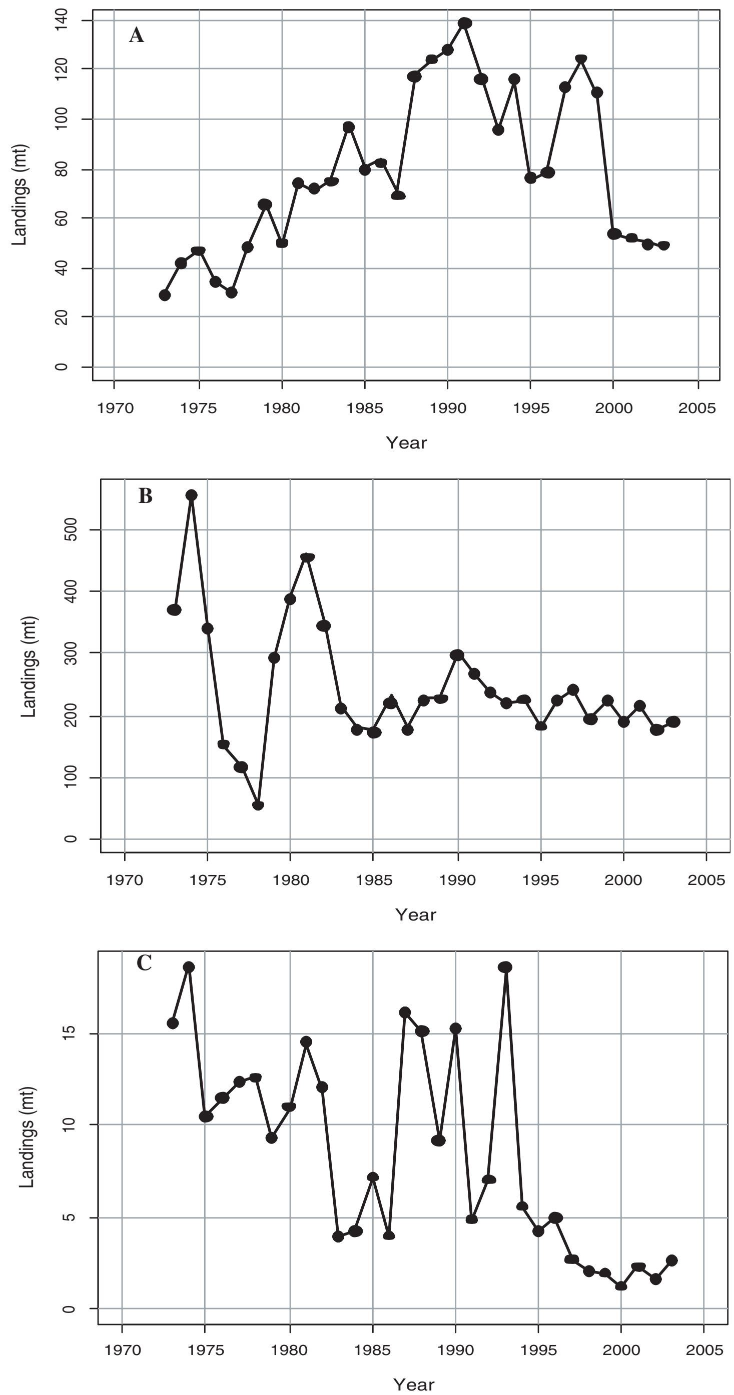


Figure 17. Recreational landings of black sea bass from the assessment model, estimated (line) and observed (filled circles). A) Headboat and B) MRFSS. Note differences of scale.

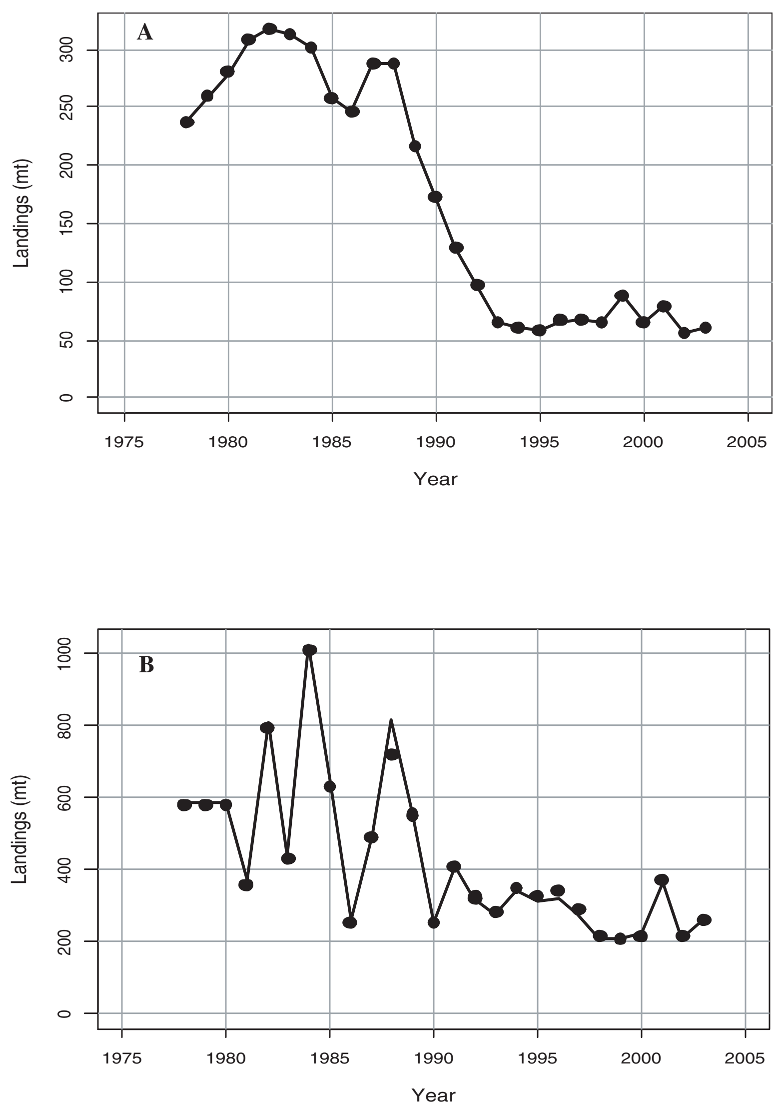


Figure 18. Black sea bass index of abundance from MARMAP data, estimated (line) and observed (filled circles). A) Blackfish trap; B) Hook & line; C) FL snapper trap; and D) Chevron trap.

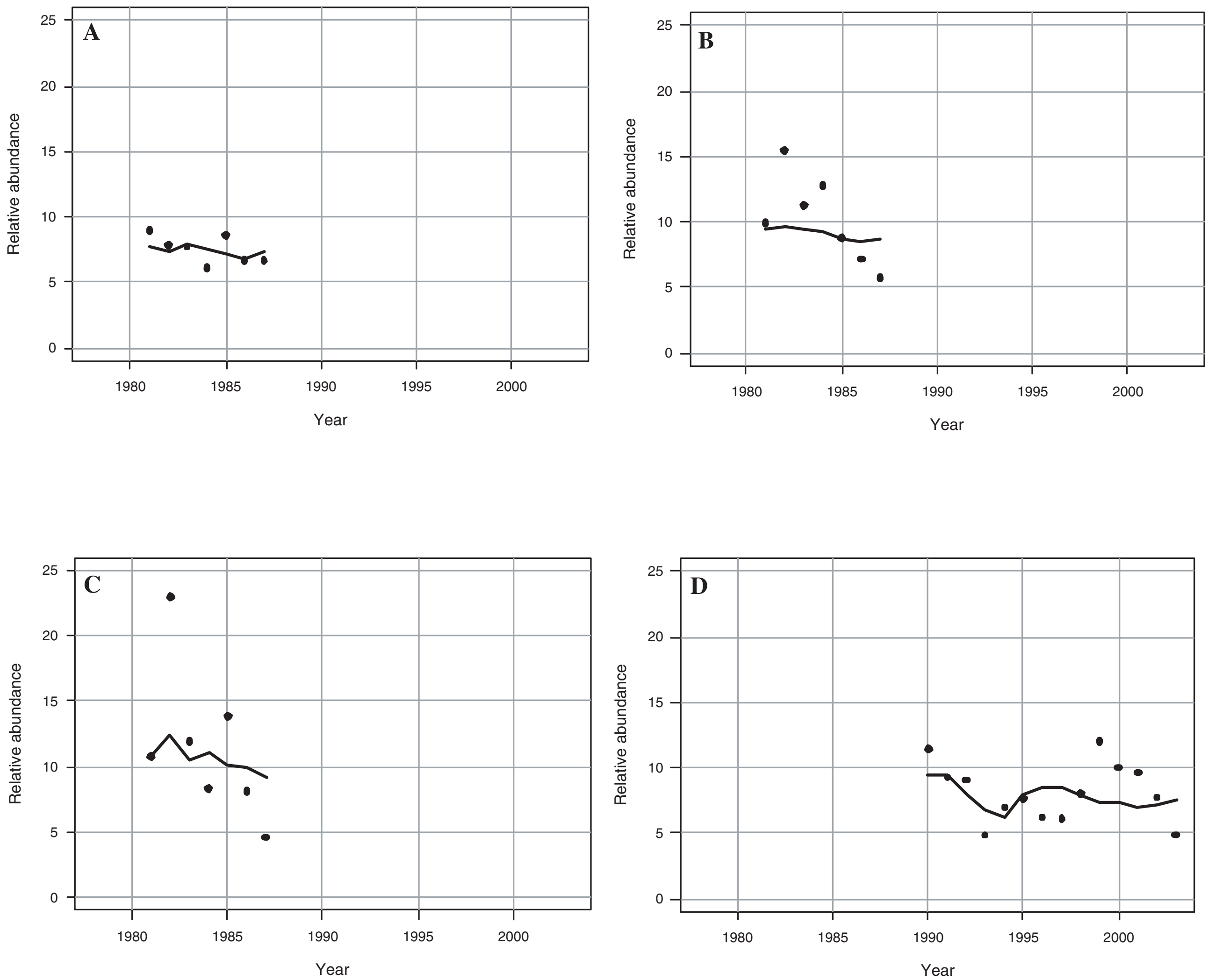


Figure 19. Black sea bass index of abundance from headboat data, estimated (line) and observed (filled circles).

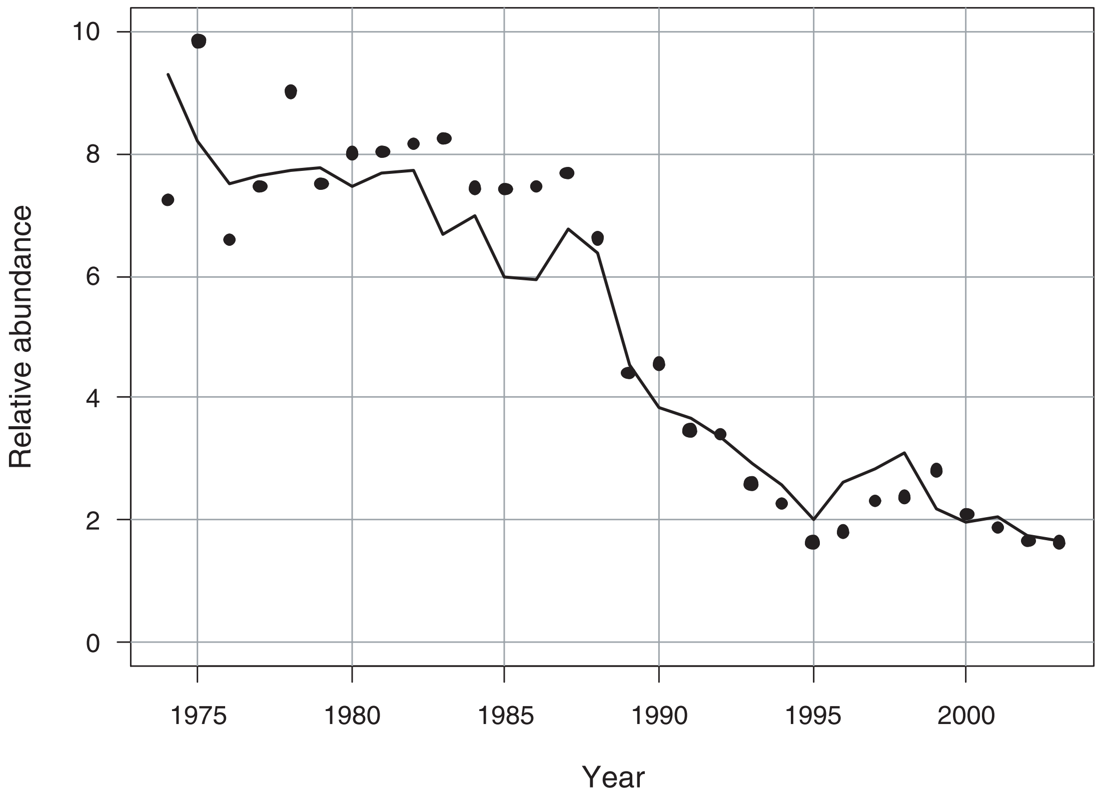


Figure 20. Black sea bass: Estimated selectivities of commercial handline. A) Period 1 (1978–1982); B) Period 2 (1983–1998); and C) Period 3 (1999–2003).

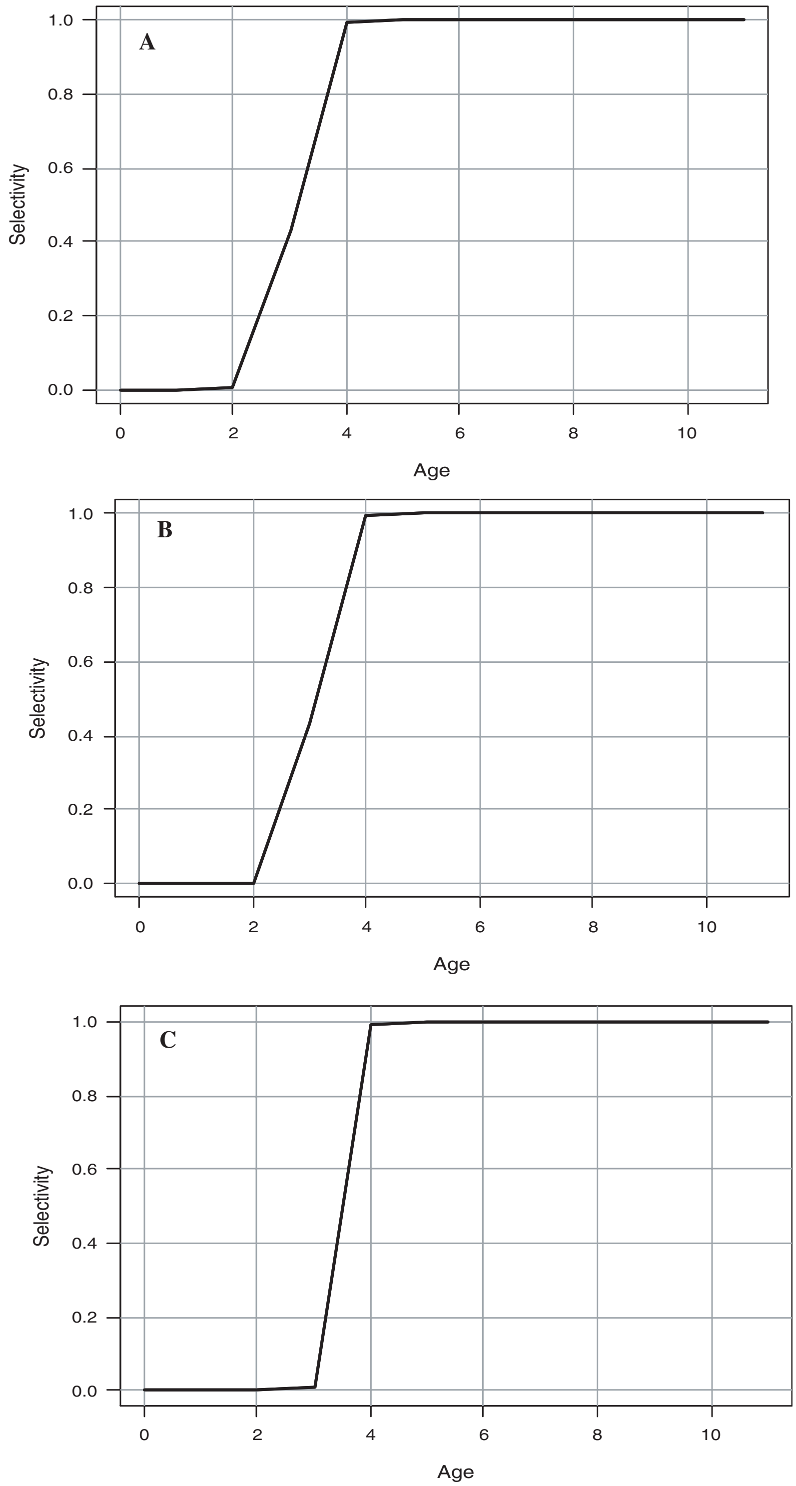


Figure 21. Black sea bass: Estimated selectivities of commercial trap. A) Period 1 (1978–1982); B) Period 2 (1983–1998); and C) Period 3 (1999–2003).

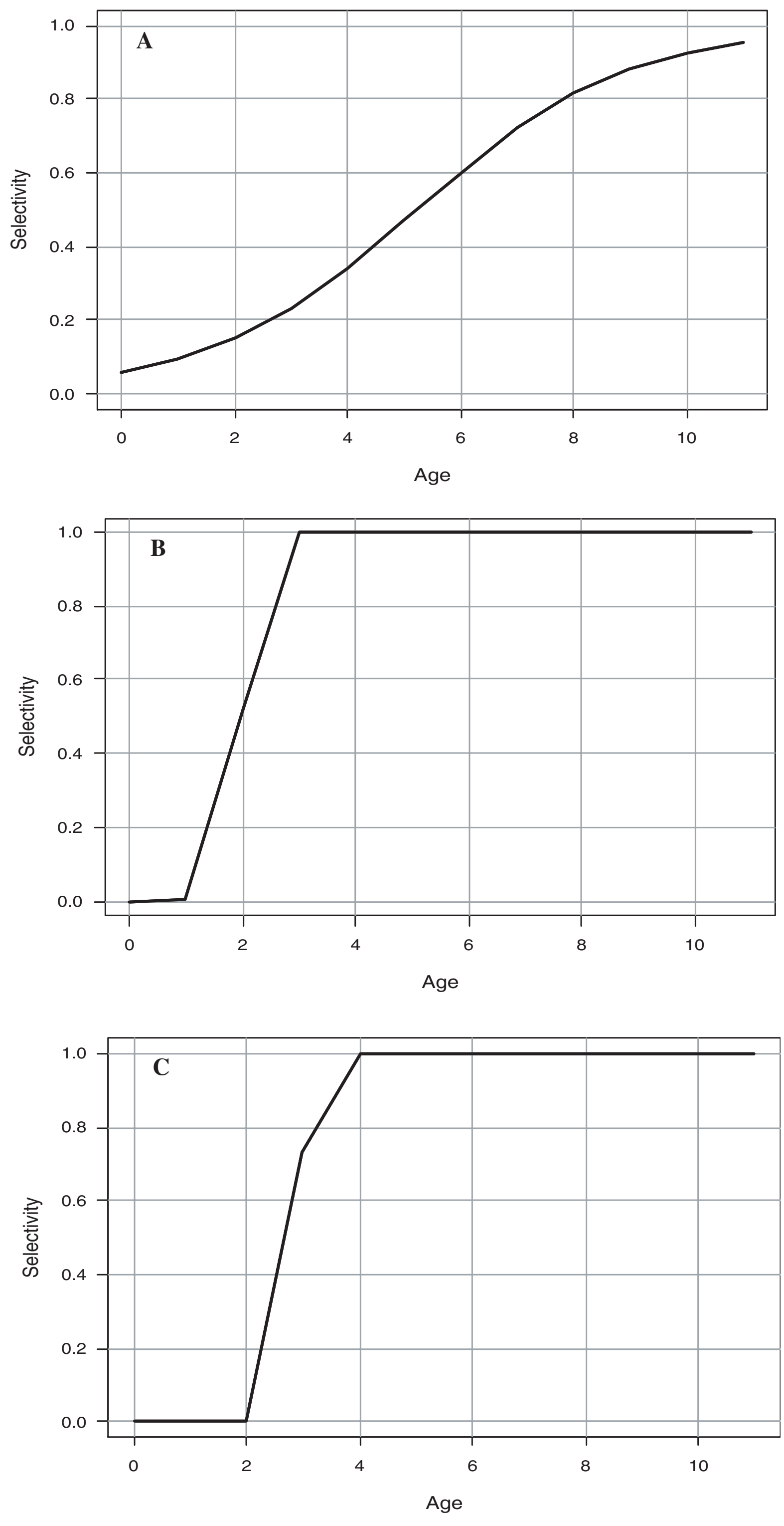


Figure 22. Black sea bass: Estimated selectivity of commercial other, assumed constant across periods of regulation.

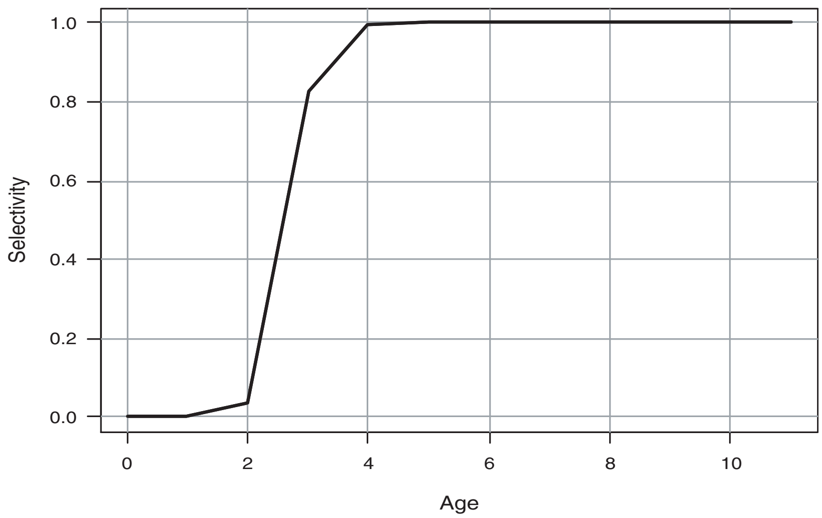


Figure 23. Black sea bass: Estimated selectivities of recreational (headboat and MRFSS) fisheries. A) Period 1 (1978–1982); B) Period 2 (1983–1998); and C) Period 3 (1999–2003).

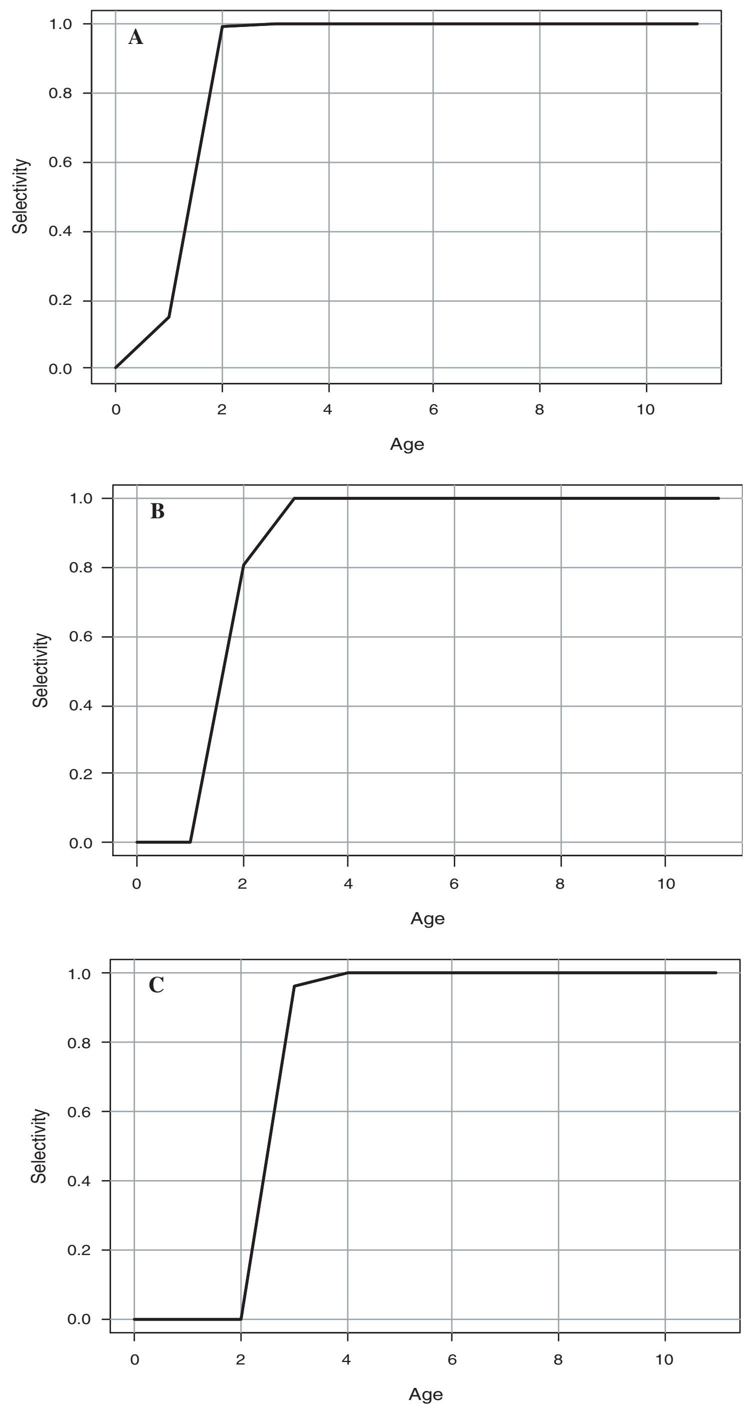
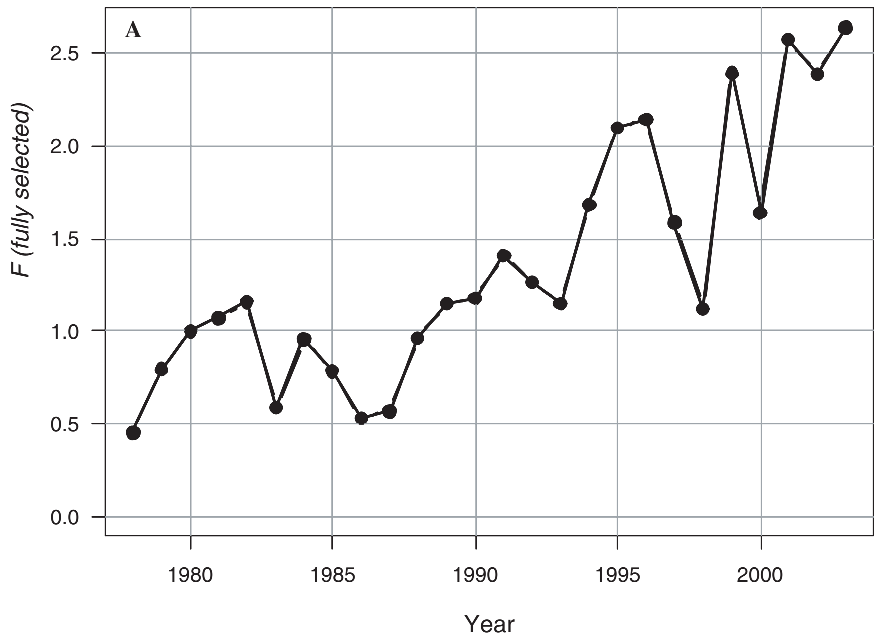


Figure 24. Estimated fishing mortality rates of black sea bass. A) Fully selected fishing mortality rate and B) Exploitation rate of fish age 1+, 2+, 3+, and 4+.



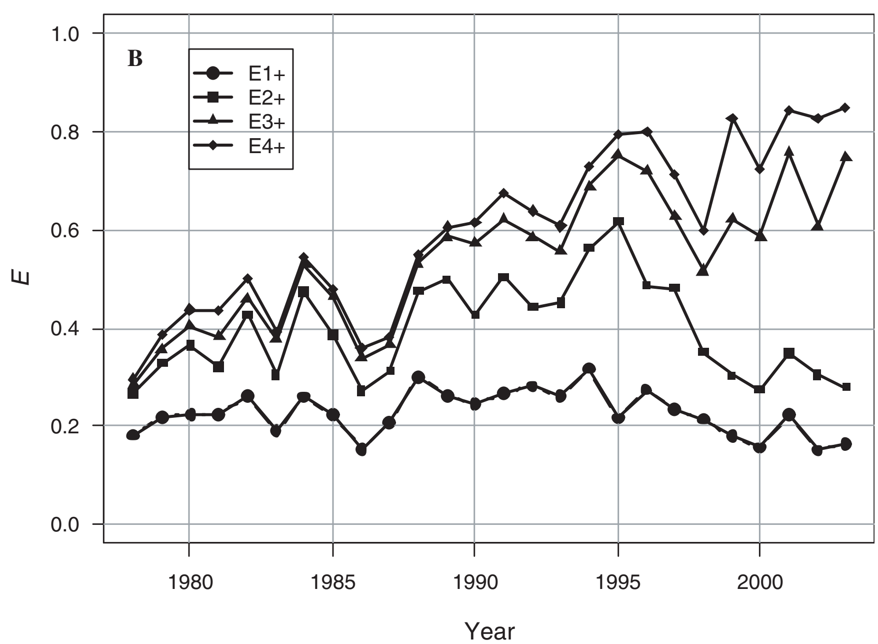


Figure 25. Estimated biomass of black sea bass. A) Total biomass (mt) and B) Spawning stock biomass (male mature biomass + female mature biomass, mt).

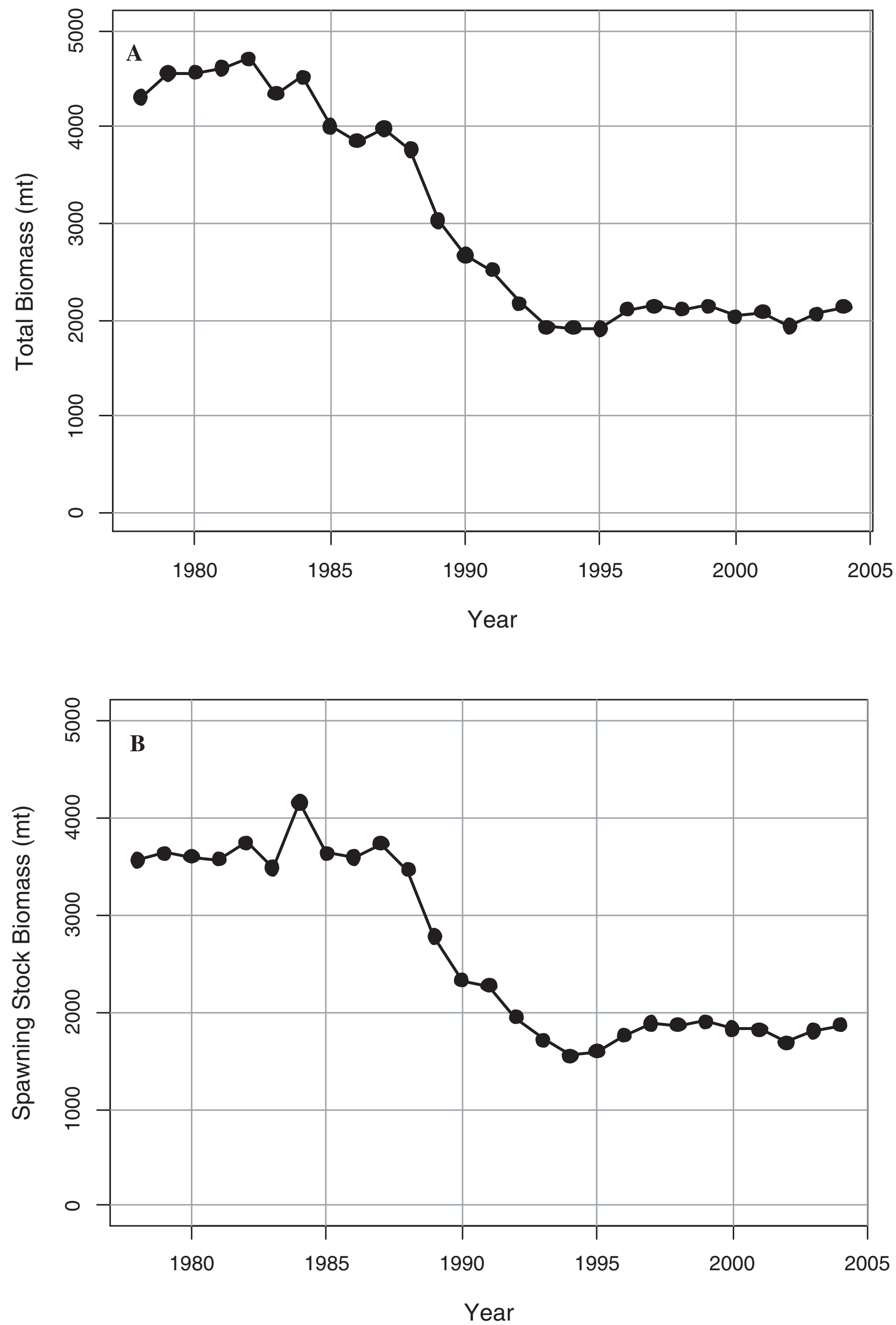


Figure 26. Black sea bass: Estimated time series of static spawning potential ratio (SPR).

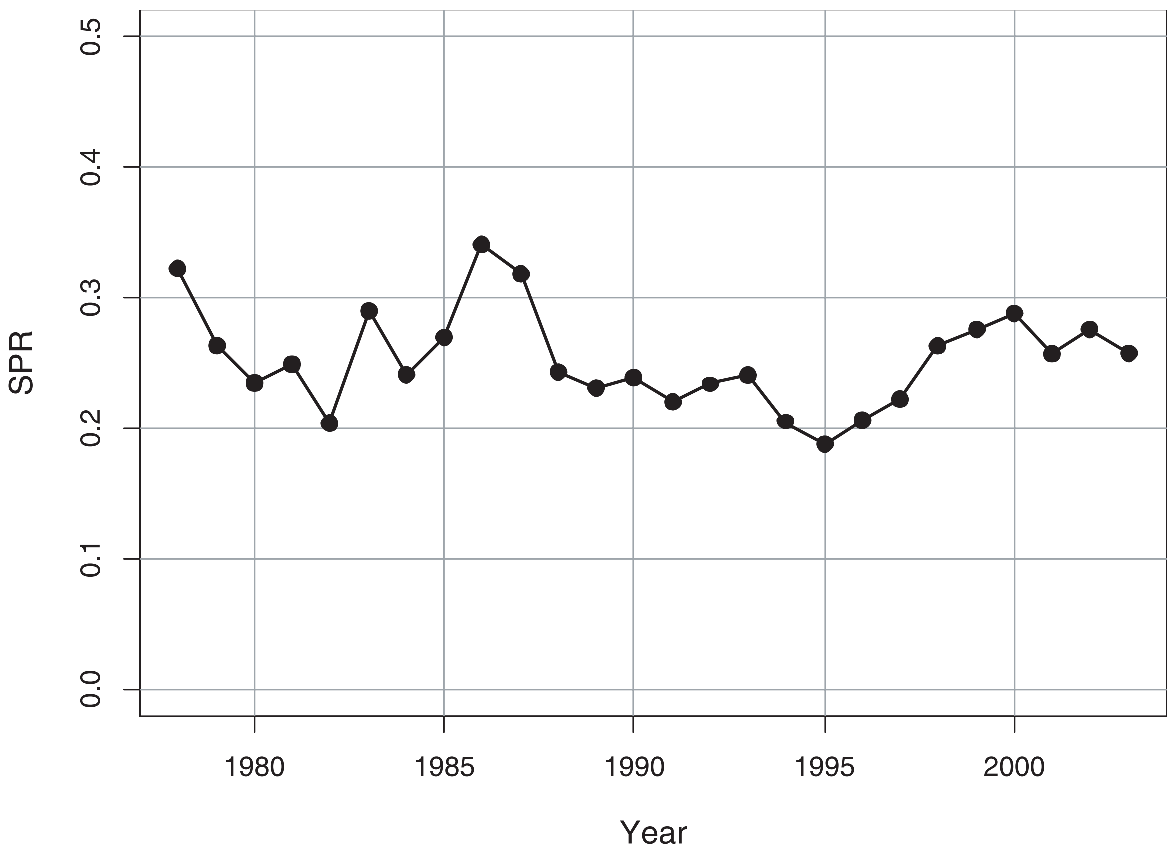
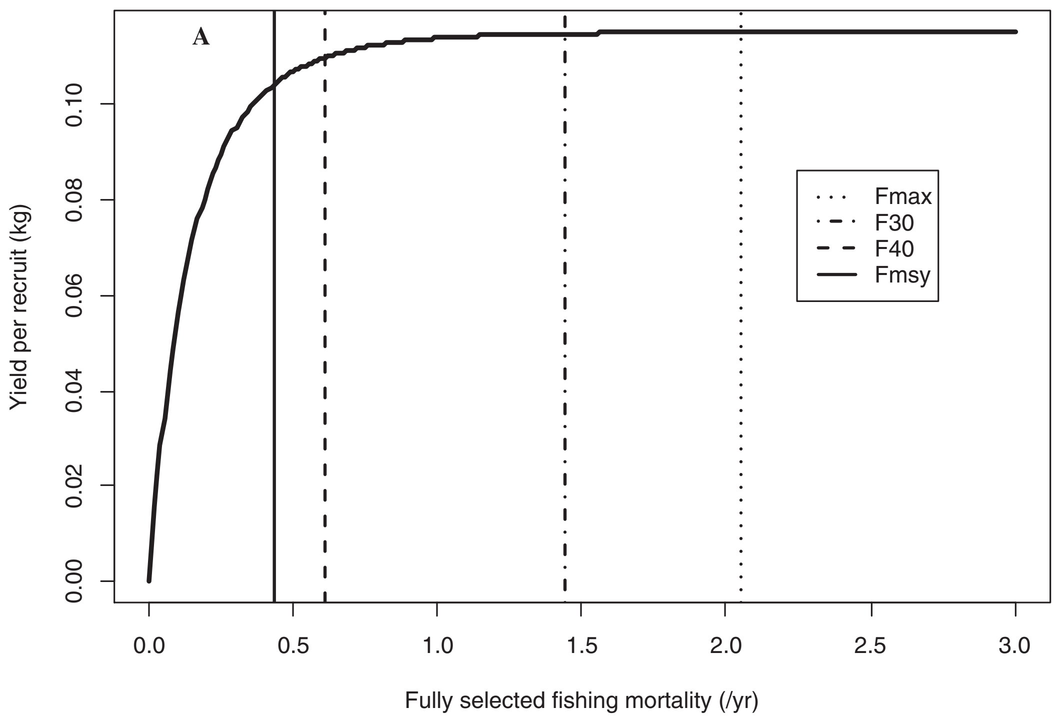


Figure 27. Black sea bass: Estimated A) yield and B) SSB *per recruit as functions of fishing mortality. Vertical lines represent F_{max}, $F_{30\%}$, $F_{40\%}$, and F_{MSY}.*



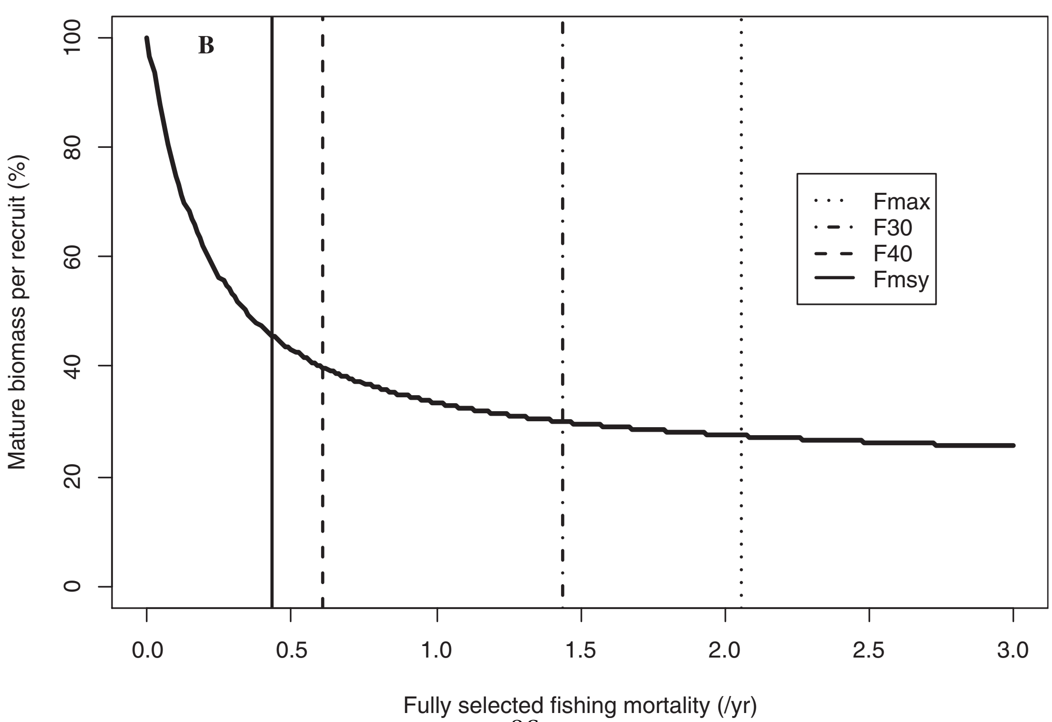


Figure 28. Estimated stock–recruitment relationship of black sea bass. Curve is average relationship; circles are estimated recruitment values from assessment period.

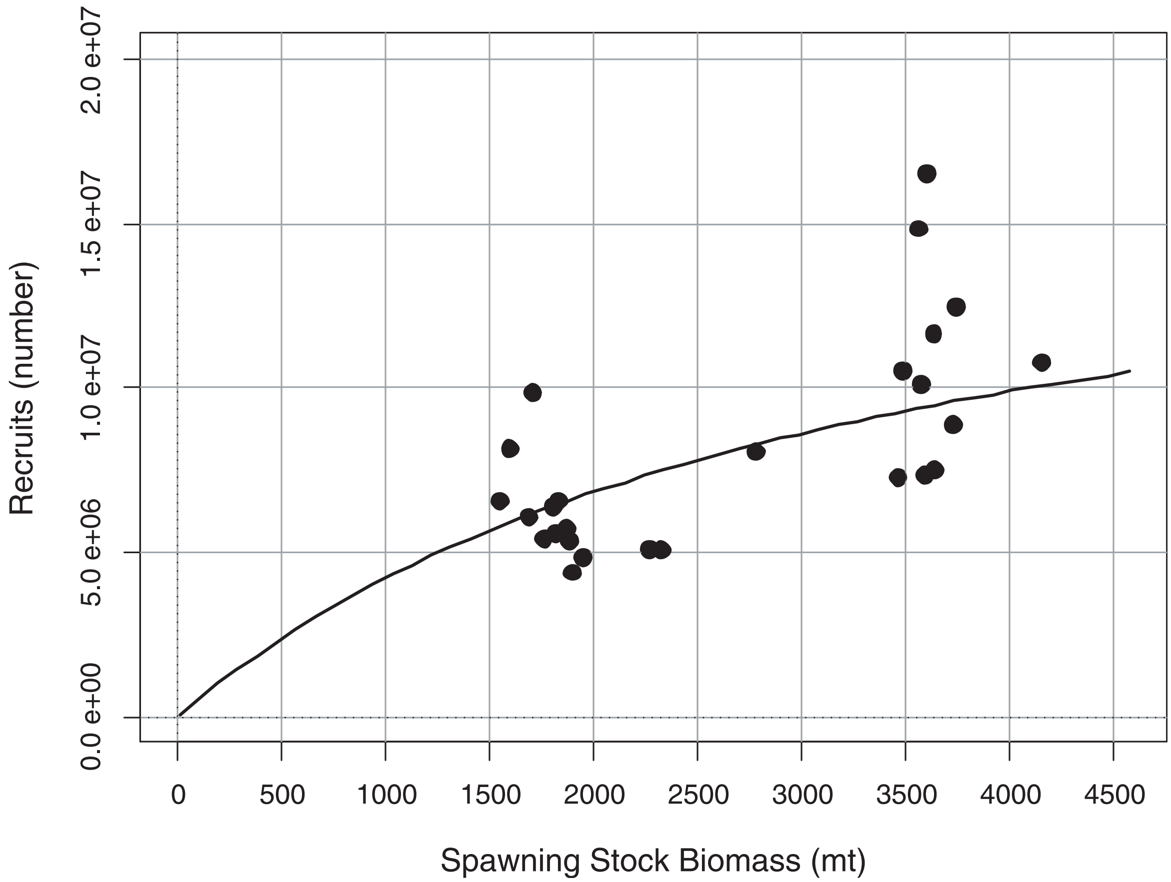


Figure 29. Estimated time series of recruitment of black sea bass.

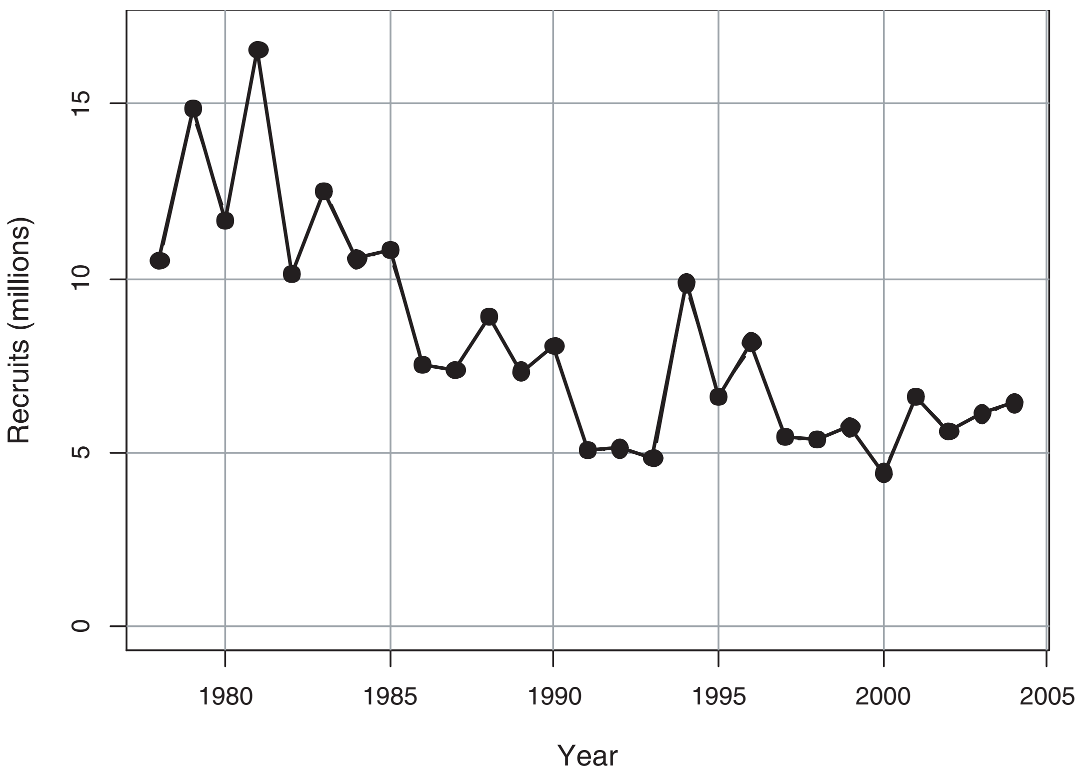


Figure 30. Black sea bass: Estimated time series, relative to MSY *benchmarks, of* SSB*, fully selected F, and exploitation (E) of age 1+ fish.*

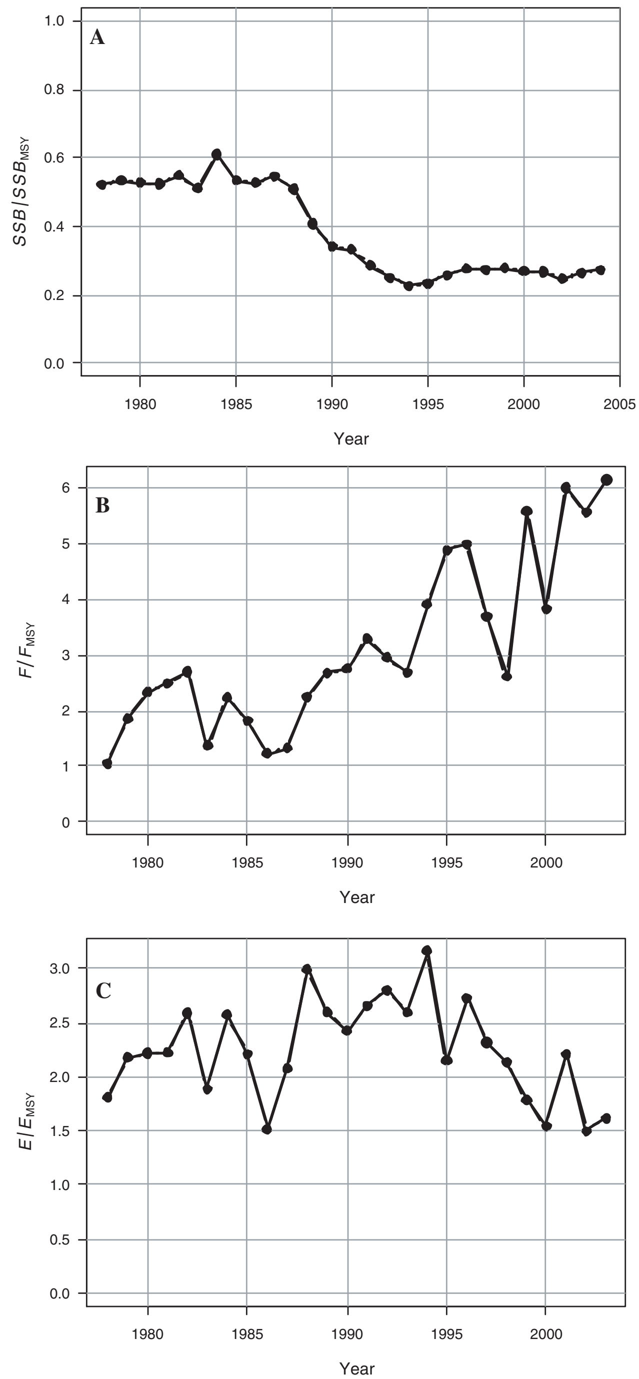


Figure 31. Black sea bass: Comparison of results from catch-at-age model (solid circles) and production model (open circles). A) F relative to F_{MSY} and B) B relative to B_{MSY} .

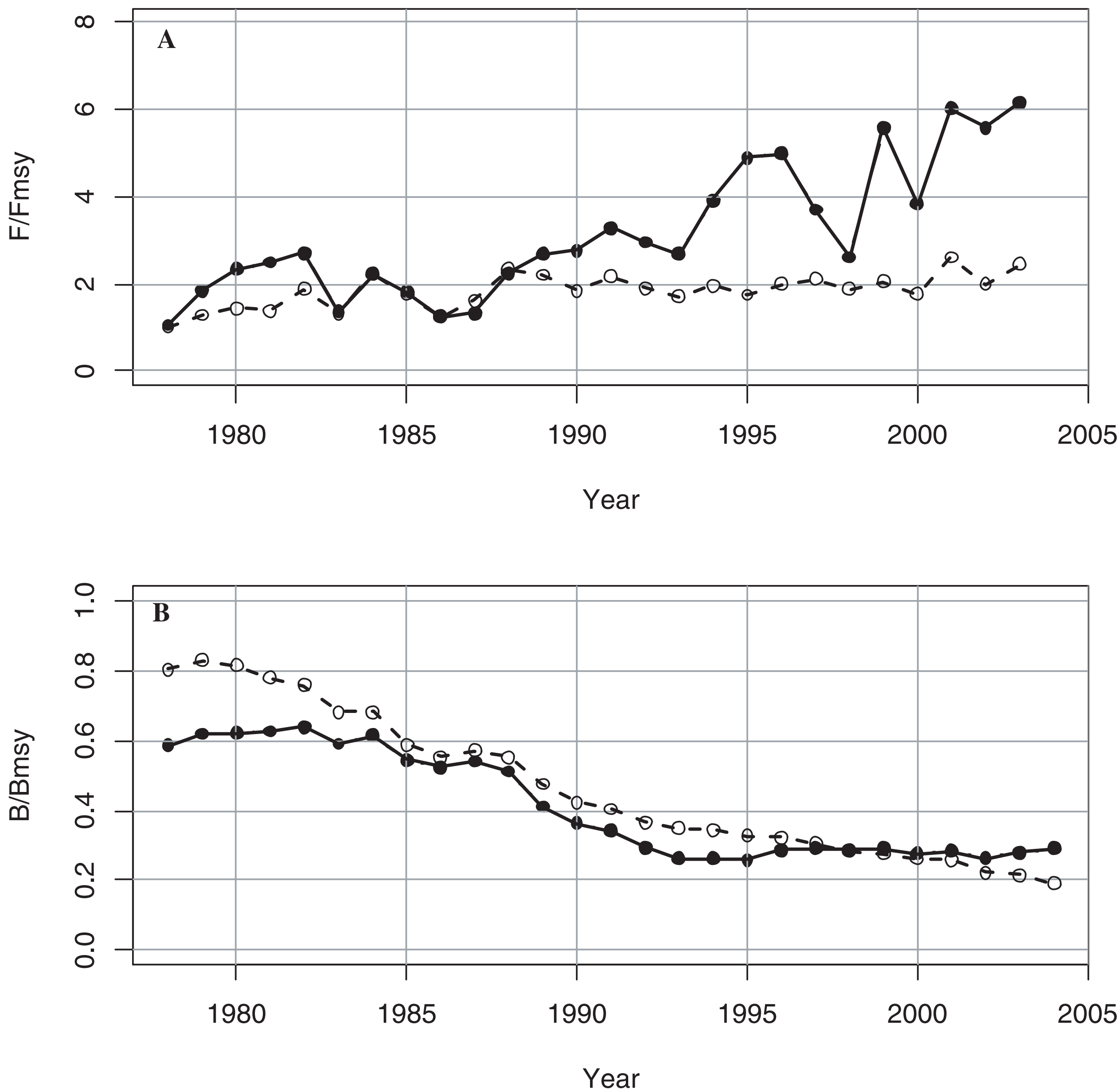


Figure 32. Projections with $F = 0$. Based on 1000 bootstrap replicates, the solid lines with circles represent median values, and the dashed lines represent 20th and 80th percentiles. A) SSB, horizontal line is SSB_{MSY}; B) Recruits, horizontal line is R_{MSY}; C) Fishing mortality rate, horizontal line is F_{MSY}; and D) Landings, horizontal line is MSY.

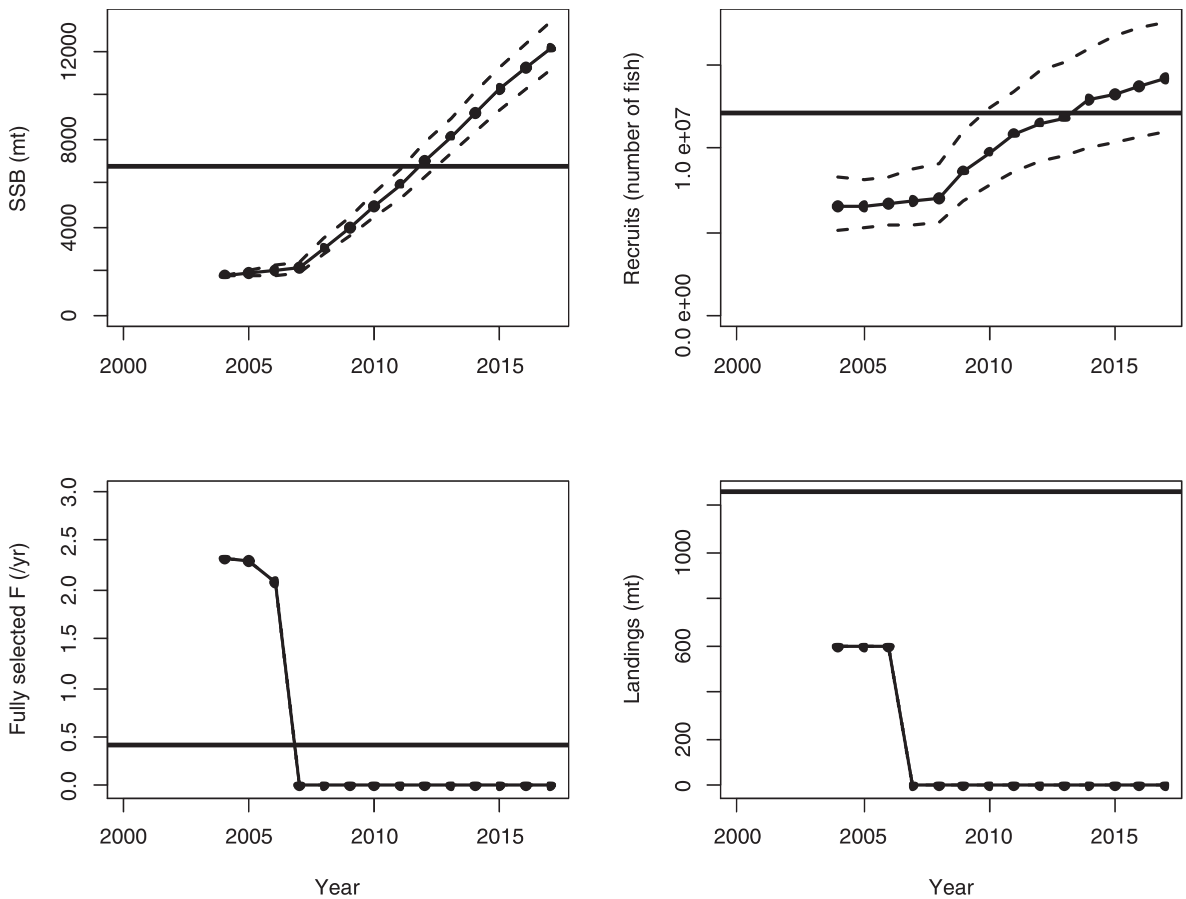


Figure 33. Projections under management scenario 1. Based on 1000 bootstrap replicates, the solid lines with circles represent median values, and the dashed lines represent 20th and 80th percentiles. A) SSB, *horizontal line is* SSB_{MSY}*; B) Recruits, horizontal line is* R_{MSY}*; C) Fishing mortality rate, horizontal line is* F_{MSY}*; and D) Landings, horizontal line is* MSY.

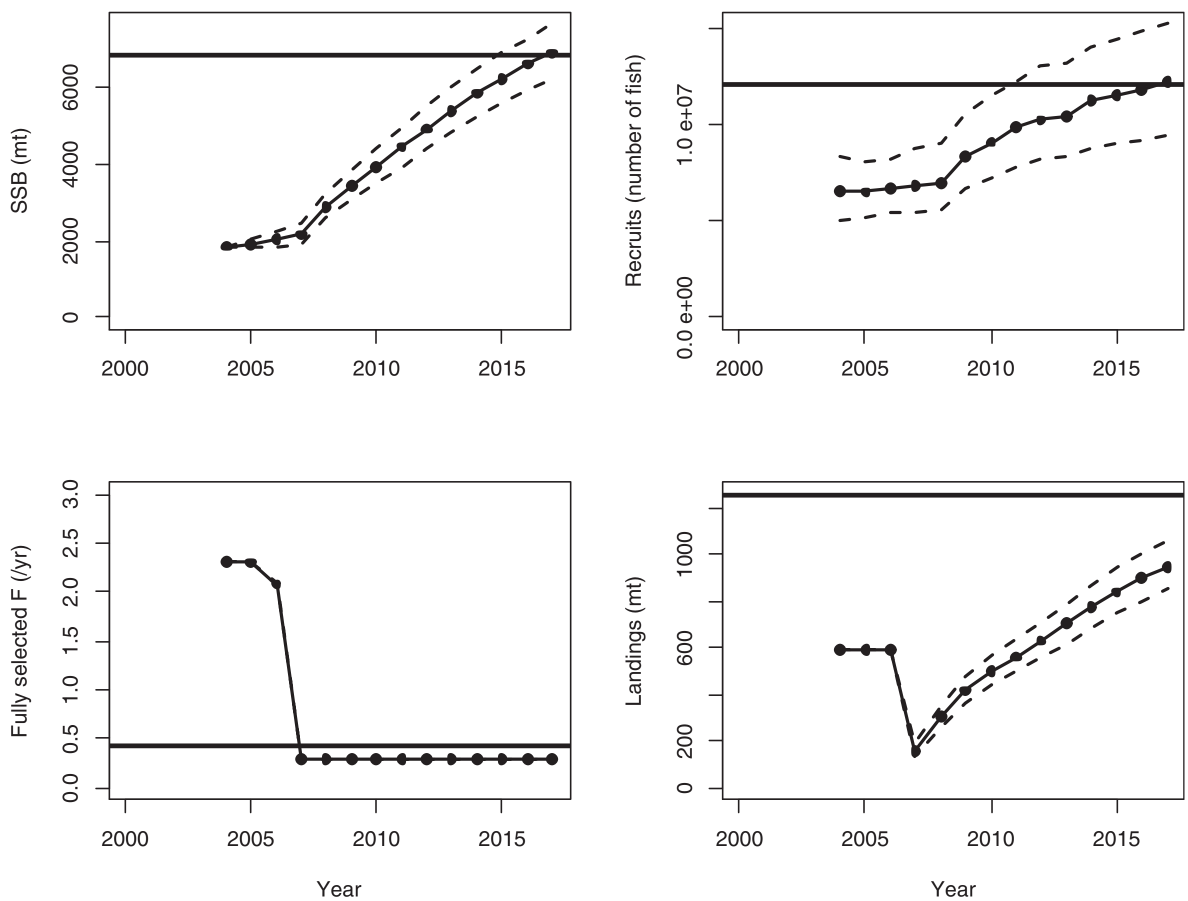


Figure 34. Projections under management scenario 2. Based on 1000 bootstrap replicates, the solid lines with circles represent median values, and the dashed lines represent 20th and 80th percentiles. A) SSB, *horizontal line is* SSB_{MSY}*; B) Recruits, horizontal line is* R_{MSY}*; C) Fishing mortality rate, horizontal line is* F_{MSY}*; and D) Landings, horizontal line is* MSY.

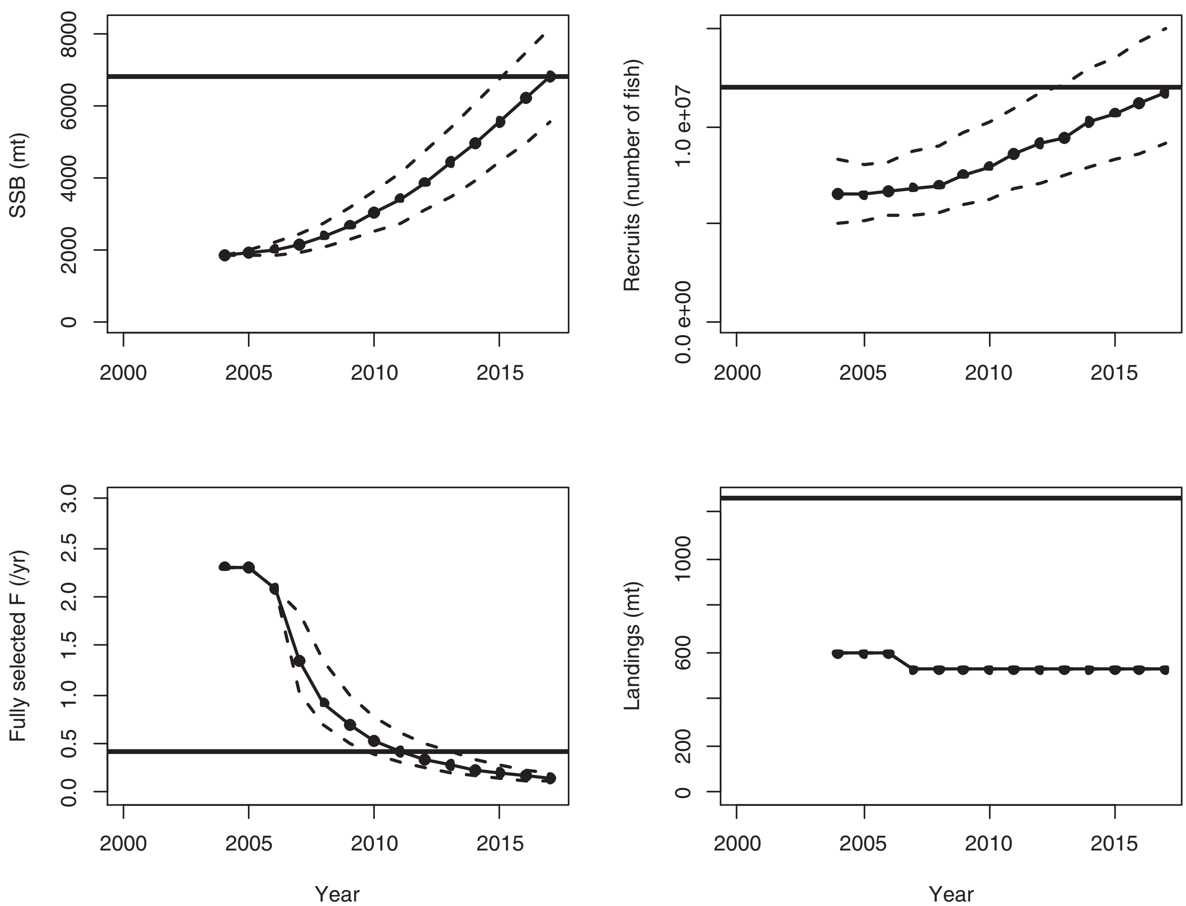
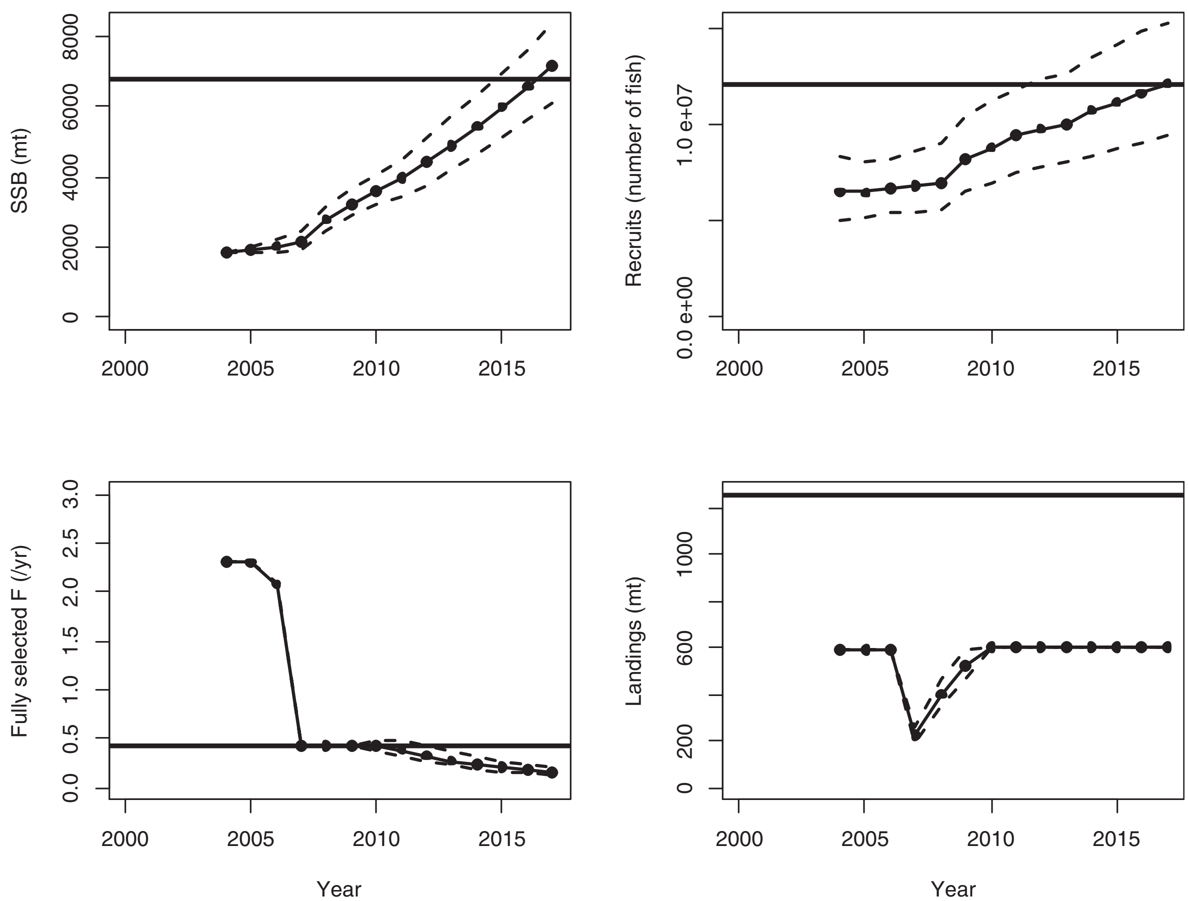


Figure 35. Projections under management scenario 3. Based on 1000 bootstrap replicates, the solid lines with circles represent median values, and the dashed lines represent 20th and 80th percentiles. A) SSB, *horizontal line is* SSB_{MSY}*; B) Recruits, horizontal line is* R_{MSY}*; C) Fishing mortality rate, horizontal line is* F_{MSY}*; and D) Landings, horizontal line is* MSY.



Appendix A Terms of reference for the SEDAR black sea bass update assessment workshop

1. Update the SEDAR-02 assessment of South Atlantic black sea bass with data through 2003.

2. Document any changes or corrections made to input datasets, all additional data added for the update, and any modifications applied to the additional data.

3. Document any changes in assessment methodology incorporated in the update as well as changes made to correct the errors identified in the SEDAR-02 benchmark assessment.

4. Incorporate the model changes accepted for SEDAR-04: annual CV's for catch datasets, trend in catchability for the headboat index.

5. Estimate and provide complete tables of stock parameters, including but not necessarily limited to the following:

   - Population abundance at age
   - Population biomass
   - Spawning stock biomass
   - Fishery selectivity at age and size
   - Fishing mortality at age
   - Yield
   - Stock–recruitment relationship

6. Update measures of uncertainty and provide representative measures of precision for stock parameter estimates.

7. Update estimates of stock status and SFA parameters and provide declarations of stock status relative to SFA criteria. The following quantities are to be provided as required for Amendment 13B to the snapper-grouper FMP:

   1. MSY (pounds, to the pound)
   2. MFMT = F_{MSY}
   3. F_{OY} and OY based on:
      65% of F_{MSY}, 75% of F_{MSY}, and 85% of F_{MSY}; (pounds to the pound)
   4. MSST, based on $(1-M)SSB_{MSY}$, (pounds to the pound). (Preferred is 75%.)
   5. Bcurrent/MSST and Fcurrent/MFMT
   6. Tmin and generation time

8. Evaluate future stock status using the following criteria:

   1) Provide a baseline rebuilding time (Tmin) based on $F = 0$. If this exceeds 10 years, provide the estimated maximum rebuilding time based on Tmin + 1 generation time.
   2) Estimate average landings in 5 year blocks under exploitation rates of
      i) $F = F_{MSY}$
      ii) $F = F_{OY}$
      iii) F = Frebuild (maximum F that will rebuild in allotted time).
      iv) F = currentaverage, (last 3 years estimated).
   3) Determine the maximum constant landings that will allow the stock to rebuild in the allotted time and estimate associated annual fishing mortality rates.

      Caveats:

      – Any management changes should be assumed to take effect 1/1/2007

- Exploitation during the period between the terminal year of the assessment and 1/1/2007 should be assumed equal to the average of the last 3 years estimated in the assessment.
- There are three alternative F_{OY} values under consideration in amendment 13B. Under item 2.ii above, the first priority is to analyze F_{OY} at 75% of F_{MSY} followed by F_{OY} at 85% of F_{MSY}. If time allows, F_{OY} at 65% of F_{MSY} should also be analyzed.

9. Recommend sampling intensity in terms of the number of sampling events and the quantity of individual lengths measured and age structures taken by gear, quarter, state, market category, fishery, and area in order to complete the ACCSP sampling design matrix.

10. Review the research recommendations from the previous assessment, note any which have been completed, and make any necessary additions or clarifications.

11. Develop a stock assessment workshop report to fully document the input data, methods, and results of the stock assessment update.

    It is not required that this report be as detailed as the standard benchmark assessment report. For example, it will not require a separate Data Workshop report segment and may rely on citation of the previous benchmark report for specific details.

    The report should include tables of all input data in the assessment report, including landings statistics by state, gear, year, and fishery; biological sampling intensity; biological characteristics of the catch (e.g., length and age compositions); survey CPUE values, and all life history characteristics. Data may be summarized in the report and provided in their entirety in spreadsheet format (i.e., items such as length compositions, size data, and maturity may be presented in figures with data provided separately).

    Nonetheless, the report shall include complete tabulation of input data and stock assessment results as noted above.

    The report should include additional information as needed to comply with suggestions provided by recent review panels. These include:

    1. Provide complete input and model specification details and a summary of sampling intensity to correct shortcomings noted in the CIE review report for SEDAR-02;
    2. As requested by the Review Panel for SEDAR-04, provide complete tabulation of model equations, parameter definitions, and parameter values;
    3. As requested by the Review Panel for SEDAR-04, clearly differentiate between fixed parameters, estimated parameters, derived quantities, and observations.

    The report shall be provided to the SAFMC no later than 5 p.m. on April 22, 2005.

NOTE: Council requests that biomass values be reported in pounds.

Appendix B Workshop attendees of SEDAR-02

Dagger (†) denotes attendance at Data Workshop only; asterisk (*) denotes attendance at Assessment Workshop only; others attended both workshops.

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Appendix C Workshop attendees of update assessment

Dagger (†) denotes attendance at Scoping Workshop only; asterisk (*) denotes attendance at Assessment Workshop only; others attended both workshops.

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Appendix D Abbreviations and symbols

Table 33. Acronyms, abbreviations, and mathematical symbols used in this report

Symbol	Meaning
AW	Assessment Workshop (here, for black sea bass)
ASY	Average Sustainable Yield
B	Total biomass of stock, conventionally on January 1r
CPUE	Catch per unit effort; used after adjustment as an index of abundance
CV	Coefficient of variation
DW	Data Workshop (here, for black sea bass)
E	Exploitation rate; fraction of the biomass taken by fishing per year
E_{MSY}	Exploitation rate at which MSY can be attained
F	Instantaneous rate of fishing mortality
F_{MSY}	Fishing mortality rate at which MSY can be attained
FL	State of Florida
GA	State of Georgia
K	Average size of stock when not exploited by man; carrying capacity
kg	Kilogram(s); 1 kg is about 2.2 lb.
klb	Thousand pounds; thousands of pounds
lb	Pound(s); 1 lb is about 0.454 kg
m	Meter(s); 1 m is about 3.28 feet.
M	Instantaneous rate of natural (non-fishing) mortality
MARMAP	Marine Resources Monitoring, Assessment, and Prediction Program, a fishery-independent data collection program of SCDNR
MFMT	Maximum fishing-mortality threshold; a limit reference point used in U.S. fishery management; often based on F_{MSY}
mm	Millimeter(s); 1 inch = 25.4 mm
MRFSS	Marine Recreational Fisheries Statistics Survey, a data-collection program of NMFS
MSST	Minimum stock-size threshold; a limit reference point used in U.S. fishery management. The SAFMC has defined MSST for black sea bass as $(1 - M)\text{SSB}_{\text{MSY}} = 0.7\text{SSB}_{\text{MSY}}$.
MSY	Maximum sustainable yield (per year)
mt	Metric ton(s). One mt is 1000 kg, or about 2205 lb.
N	Number of fish in a stock, conventionally on January 1
NC	State of North Carolina
NMFS	National Marine Fisheries Service, same as “NOAA Fisheries Service”
NOAA	National Oceanic and Atmospheric Administration; parent agency of NMFS
OY	Optimum yield; SFA specifies that OY ≤ MSY.
PSE	Proportional standard error
R	Recruitment
SAFMC	South Atlantic Fishery Management Council (also, Council)
SC	State of South Carolina
SCDNR	Department of Natural Resources of SC
SEDAR	SouthEast Data Assessment and Review process
SFA	Sustainable Fisheries Act; the Magnuson–Stevens Act, as amended
SL	Standard length (of a fish)
SPR	Spawning potential ratio
SSB	Spawning stock biomass; mature biomass of males and females
SSB_{MSY}	Level of SSB at which MSY can be attained
SW	Scoping workshop; first of 3 workshops in SEDAR updates
TIP	Trip Interview Program, a fishery-dependent biodata collection program of NMFS
TL	Total length (of a fish), as opposed to FL (fork length) or SL (standard length)
VPA	Virtual population analysis, an age-structured assessment model characterized by computations backward in time; may use abundance indices to influence the estimates
yr	Year(s)

Appendix E AD Model Builder implementation of catch-at-age assessment model

```
//##--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>
//##  SEDAR-02 - Update
//##
//##  Black Sea Bass
//##
//##  Kyle Shertzer and Doug Vaughan, NMFS, Beaufort Lab
//##  (Kyle.Shertzer@noaa.gov, Doug.Vaughan@noaa.gov)
//##  April 2005
//##
//##--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>
//##--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>


DATA_SECTION
//Create ascii file for output
//!!CLASS ofstream report1("bsbresults.rep",ios::out);  //create file for output

// Starting and ending year of the model (year data starts)
init_int styr; init_int endyr;

//3 periods: 1978-82 no restrictions, 1983-98 8inch TL, 1999-01 10inch TL
init_int endyr_period1; init_int endyr_period2;

//Total number of ages
init_int nages;

// Vector of ages for age bins
init_ivector agebins(1,nages);

//starting year for recruitment estimation (not being read in) and number assessment years
int styrR; number nyrs;
//this section MUST BE INDENTED!!!
 LOCAL_CALCS
   styrR=styr-(nages-1);
   nyrs=endyr-styr+1.;
 END_CALCS

//discard mortality constants
init_number set_Dmort_commHAL; init_number set_Dmort_commTRP;
init_number set_Dmort_HB;

//Total number of iterations for spr calcs
init_int n_iter_spr;

//Total number of length bins for each matrix
init_int nlenbins;

// Vector of lengths for length bins (midpoint)
init_ivector lenbins(1,nlenbins);

// Von Bert parameters (from McGovern et al.)
init_number set_Linf; init_number set_K; init_number set_t0;

//length(mm)-weight(kg) relationship: W=exp{-wgtpar_a+wgtpar_b*log(L)}
init_number wgtpar_a; init_number wgtpar_b;

//CV of length at age
init_vector set_len_cv(1,nages);

//Sex ratio and maturity
init_vector prop_m(1,nages);                    //Proportion male
by age init_vector maturity_m_obs(1,nages);            //total
maturity of males init_matrix maturity_f_obs(styr,endyr,1,nages);
//total maturity of females


//###MARMAP FL snapper trap index################################
//CPUE
init_int styr_mmFST_cpue; init_int endyr_mmFST_cpue; init_vector
obs_mmFST_cpue(styr_mmFST_cpue,endyr_mmFST_cpue);   //Observed
CPUE init_vector mmFST_cpue_cv(styr_mmFST_cpue,endyr_mmFST_cpue);
//CV of cpue
```

```
//Length Compositions
init_int styr_mmFST_lenc; init_int endyr_mmFST_lenc; init_matrix
obs_mmFST_freq(styr_mmFST_lenc,endyr_mmFST_lenc,1,nlenbins);
 vector nsamp_mmFST_lenc(styr_mmFST_lenc,endyr_mmFST_lenc);
 matrix obs_mmFST_lenc(styr_mmFST_lenc,endyr_mmFST_lenc,1,nlenbins);


//##############MARMAP Chevron trap index##############################
//CPUE
init_int styr_mmCVT_cpue; init_int endyr_mmCVT_cpue; init_vector
obs_mmCVT_cpue(styr_mmCVT_cpue,endyr_mmCVT_cpue);   //Observed
CPUE init_vector mmCVT_cpue_cv(styr_mmCVT_cpue,endyr_mmCVT_cpue);
//cv of cpue
//Length Compositions
init_int styr_mmCVT_lenc; init_int endyr_mmCVT_lenc; init_matrix
obs_mmCVT_freq(styr_mmCVT_lenc,endyr_mmCVT_lenc,1,nlenbins);
 vector nsamp_mmCVT_lenc(styr_mmCVT_lenc,endyr_mmCVT_lenc);
 matrix obs_mmCVT_lenc(styr_mmCVT_lenc,endyr_mmCVT_lenc,1,nlenbins);

//##############MARMAP black fish trap index###############################
//CPUE
init_int styr_mmBFT_cpue; init_int endyr_mmBFT_cpue; init_vector
obs_mmBFT_cpue(styr_mmBFT_cpue,endyr_mmBFT_cpue);   //Observed
CPUE init_vector mmBFT_cpue_cv(styr_mmBFT_cpue,endyr_mmBFT_cpue);
//CV of cpue
//Length Compositions
init_int styr_mmBFT_lenc; init_int endyr_mmBFT_lenc; init_matrix
obs_mmBFT_freq(styr_mmBFT_lenc,endyr_mmBFT_lenc,1,nlenbins);
 vector nsamp_mmBFT_lenc(styr_mmBFT_lenc,endyr_mmBFT_lenc);
 matrix obs_mmBFT_lenc(styr_mmBFT_lenc,endyr_mmBFT_lenc,1,nlenbins);

//##############MARMAP hook and line index###############################
//CPUE
init_int styr_mmHAL_cpue; init_int endyr_mmHAL_cpue; init_vector
obs_mmHAL_cpue(styr_mmHAL_cpue,endyr_mmHAL_cpue);   //Observed
CPUE init_vector mmHAL_cpue_cv(styr_mmHAL_cpue,endyr_mmHAL_cpue);
//CV of cpue
//Length Compositions
init_int styr_mmHAL_lenc; init_int endyr_mmHAL_lenc; init_matrix
obs_mmHAL_freq(styr_mmHAL_lenc,endyr_mmHAL_lenc,1,nlenbins);
 vector nsamp_mmHAL_lenc(styr_mmHAL_lenc,endyr_mmHAL_lenc);
 matrix obs_mmHAL_lenc(styr_mmHAL_lenc,endyr_mmHAL_lenc,1,nlenbins);

//##################Commercial Hook and Line fishery landings########################
// Landings (mt)
init_int styr_commHAL_L; init_int endyr_commHAL_L; init_vector
obs_commHAL_L(styr_commHAL_L,endyr_commHAL_L); //vector of
observed landings by year init_vector
commHAL_L_cv(styr_commHAL_L,endyr_commHAL_L);    //vector of CV of
landings by year
// Length Compositions
init_int styr_commHAL_lenc; init_int endyr_commHAL_lenc;
init_matrix
obs_commHAL_freq(styr_commHAL_lenc,endyr_commHAL_lenc,1,nlenbins);
 vector nsamp_commHAL_lenc(styr_commHAL_lenc,endyr_commHAL_lenc);
 matrix obs_commHAL_lenc(styr_commHAL_lenc,endyr_commHAL_lenc,1,nlenbins);

//#############################Commercial Trap fishery landings#######################
// Landings (mt)
init_int styr_commTRP_L; init_int endyr_commTRP_L; init_vector
obs_commTRP_L(styr_commTRP_L,endyr_commTRP_L); init_vector
commTRP_L_cv(styr_commTRP_L,endyr_commTRP_L);    //vector of CV of
landings by year
// Length Compositions
init_int styr_commTRP_lenc; init_int endyr_commTRP_lenc;
init_matrix
obs_commTRP_freq(styr_commTRP_lenc,endyr_commTRP_lenc,1,nlenbins);
 vector nsamp_commTRP_lenc(styr_commTRP_lenc,endyr_commTRP_lenc);
 matrix obs_commTRP_lenc(styr_commTRP_lenc,endyr_commTRP_lenc,1,nlenbins);

//##############################Commercial Trawl+Other fishery landings###############
// Landings (mt)
init_int styr_commTWL_L; init_int endyr_commTWL_L; init_vector
obs_commTWL_L(styr_commTWL_L,endyr_commTWL_L); init_vector
commTWL_L_cv(styr_commTWL_L,endyr_commTWL_L);    //vector of CV of
landings by year
// Length Compositions
init_int styr_commTWL_lenc; init_int endyr_commTWL_lenc;
```

```
init_matrix
obs_commTWL_freq(styr_commTWL_lenc,endyr_commTWL_lenc,1,nlenbins);
 vector nsamp_commTWL_lenc(styr_commTWL_lenc,endyr_commTWL_lenc);
 matrix obs_commTWL_lenc(styr_commTWL_lenc,endyr_commTWL_lenc,1,nlenbins);

//################################Headboat landings########################################
//CPUE
init_int styr_HB_cpue; init_int endyr_HB_cpue; init_vector
obs_HB_cpue(styr_HB_cpue,endyr_HB_cpue);//Observed CPUE
init_vector HB_cpue_cv(styr_HB_cpue,endyr_HB_cpue); //CV of cpue
// Landings (weight,mt)
init_int styr_HB_L; init_int endyr_HB_L; init_vector
obs_HB_L(styr_HB_L,endyr_HB_L); init_vector
HB_L_cv(styr_HB_L,endyr_HB_L); !!cout << "HB_L_cv=" << HB_L_cv <<
endl;
// Length Compositions
init_int styr_HB_lenc; init_int endyr_HB_lenc; init_matrix
obs_HB_freq(styr_HB_lenc,endyr_HB_lenc,1,nlenbins);
 vector nsamp_HB_lenc(styr_HB_lenc,endyr_HB_lenc);
 matrix obs_HB_lenc(styr_HB_lenc,endyr_HB_lenc,1,nlenbins);

//###########################MRFSS landings (collapsed across modes) ################################
// Landings (weight,mt)
init_int styr_MRFSS_L; init_int endyr_MRFSS_L; init_vector
obs_MRFSS_L(styr_MRFSS_L,endyr_MRFSS_L); init_vector
MRFSS_L_cv(styr_MRFSS_L,endyr_MRFSS_L);
// Length Compositions
init_int styr_MRFSS_lenc; init_int endyr_MRFSS_lenc; init_matrix
obs_MRFSS_freq(styr_MRFSS_lenc,endyr_MRFSS_lenc,1,nlenbins);
 vector nsamp_MRFSS_lenc(styr_MRFSS_lenc,endyr_MRFSS_lenc);
 matrix obs_MRFSS_lenc(styr_MRFSS_lenc,endyr_MRFSS_lenc,1,nlenbins);

//////////////////////////////////
//--weights for likelihood components-----------------------------------------------------------------------
init_number set_w_L; init_number set_w_lc; init_number set_w_I_mm;
init_number set_w_I_hb; init_number set_w_R; init_number
set_w_R_plus; init_number set_w_F; init_number set_w_B1dB0;
// weight on B1/B0 init_number set_w_fullF_extra;   //penalty for
any fullF>5 !!cout << "set_w_fullF_extra=" << set_w_fullF_extra <<
endl;

//Initial guesses or fixed values
init_number set_steep; init_number set_M;

//--index catchability--------------------------------------------------------------------------------------
init_number set_logq_mmFST;  //catchability coefficient (log) for
the MARMAP snapper trap index init_number set_logq_mmCVT;
//catchability coefficient (log) for the MARMAP chevron trap index
init_number set_logq_mmBFT;  //catchability coefficient (log) for
the MARMAP blackfish trap index init_number set_logq_mmHAL;
//catchability coefficient (log) for the MARMAP hook-and-line
index init_number set_logq_HB;     //catchability coefficient
(log) for the headboat index

//--F's--------------------------------
init_number set_log_avg_F_HB; init_number set_log_avg_F_MRFSS;
init_number set_log_avg_F_commHAL; init_number
set_log_avg_F_commTRP; init_number set_log_avg_F_commTWL;

//Set some more initial guesses of estimated parameters
init_number set_log_R0; init_number set_S1dS0; init_number
set_R1_mult; init_number set_B1dB0;

!!cout << "set_S1dS0=" << set_S1dS0 << endl;

init_number set_selpar_L50_mmFST; init_number
set_selpar_L502_mmFST; init_number set_selpar_slope_mmFST;
init_number set_selpar_slope2_mmFST;

init_number set_selpar_L50_mmCVT; init_number
set_selpar_L502_mmCVT; init_number set_selpar_slope_mmCVT;
init_number set_selpar_slope2_mmCVT;

init_number set_selpar_L50_mmBFT; init_number
set_selpar_L502_mmBFT; init_number set_selpar_slope_mmBFT;
init_number set_selpar_slope2_mmBFT;

init_number set_selpar_L50_mmHAL; init_number
```

```
set_selpar_slope_mmHAL;

init_number set_selpar_L50_HB1; init_number set_selpar_slope_HB1;
init_number set_selpar_L50_HB2; init_number set_selpar_slope_HB2;
init_number set_selpar_L50_HB3; init_number set_selpar_slope_HB3;

init_number set_selpar_L50_commHAL1; init_number
set_selpar_slope_commHAL1; init_number set_selpar_L50_commHAL2;
init_number set_selpar_slope_commHAL2; init_number
set_selpar_L50_commHAL3; init_number set_selpar_slope_commHAL3;

init_number set_selpar_L50_commTRP1; init_number
set_selpar_slope_commTRP1; init_number set_selpar_L50_commTRP2;
init_number set_selpar_slope_commTRP2; init_number
set_selpar_L50_commTRP3; init_number set_selpar_slope_commTRP3;

init_number set_selpar_L50_commTWL; init_number
set_selpar_slope_commTWL;

!!cout << "set_selpar_slope_commTWL=" << set_selpar_slope_commTWL
<< endl;
// #######Indices for year(iyear), age(iage),length(ilen) ##############
int iyear; int iage; int ilen;


//##--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>
//##--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>
PARAMETER_SECTION
//--------------Growth---------------------------------------------------------------------------
  number Linf;
  number K;
  number t0;
  vector wgt(1,nages);
  vector meanlen(1,nages);                          //mean length at age
  number sqrt2pi;
  matrix lenprob(1,nages,1,nlenbins);               //distn of size at age (age-length key)
  vector len_cv(1,nages);                           //cv of length at age
  matrix pred_mmFST_lenc(styr_mmFST_lenc,endyr_mmFST_lenc,1,nlenbins);
  matrix pred_mmCVT_lenc(styr_mmCVT_lenc,endyr_mmCVT_lenc,1,nlenbins);
  matrix pred_mmBFT_lenc(styr_mmBFT_lenc,endyr_mmBFT_lenc,1,nlenbins);
  matrix pred_mmHAL_lenc(styr_mmHAL_lenc,endyr_mmHAL_lenc,1,nlenbins);
  matrix pred_commHAL_lenc(styr_commHAL_lenc,endyr_commHAL_lenc,1,nlenbins);
  matrix pred_commTRP_lenc(styr_commTRP_lenc,endyr_commTRP_lenc,1,nlenbins);
  matrix pred_commTWL_lenc(styr_commTWL_lenc,endyr_commTWL_lenc,1,nlenbins);
  matrix pred_HB_lenc(styr_HB_lenc,endyr_HB_lenc,1,nlenbins);
  matrix pred_MRFSS_lenc(styr_MRFSS_lenc,endyr_MRFSS_lenc,1,nlenbins);

//-----Population--------------------------------------------------------------------------------
  matrix N(styrR,endyr+1,1,nages);          //Population numbers by year and age
  matrix B(styrR,endyr+1,1,nages);          //Population biomass by year and age
  vector totB(styrR,endyr+1);               //Total biomass by year
  number R1;                                //Recruits in styrR

  //init_bounded_number log_R1(5,20,1);        //log(Recruits) in styrR
  sdreport_vector SSB(styrR,endyr+1);       //Spawning biomass by year
  sdreport_vector rec(styrR,endyr+1);       //Recruits by year
  vector prop_f(1,nages);                   //Proportion female by age
  matrix maturity_f(styrR,endyr,1,nages);
  matrix maturity_m(styrR,endyr,1,nages);  //time-invariant, but left with flexibility to change that
  matrix reprod(styrR,endyr,1,nages);

//---Stock-Recruit Function (Beverton-Holt, steepness parameterization)----------
  init_bounded_number log_R0(10,30,1);       //log(virgin Recruitment)
  sdreport_number R0;
  init_bounded_number steep(0.3,0.9,1);     //steepness
  //number steep;  //uncomment to fix steepness, comment line directly above
  init_bounded_dev_vector log_dev_N_rec(styrR+1,endyr,-3,3,2); //log recruitment deviations
  number var_rec_dev;                       //variance of log recruitment deviations.
                                            //Estimated from yrs with unconstrainted S-R(1978-2000)
  sdreport_number steep_sd;                 //steepness for stdev report
  number S0;                                //equal to spr_F0*R0 = virgin SSB
  number B0;                                //equal to bpr_F0*R0 = virgin B
  number S1;                                //initial SSB
  number S1dS0;                             //S1967/S0
  number B1dB0;                             //B1dB0 computed and used in constraint
  init_bounded_number R1_mult(0.1,3.0);     //R1967=R1_mult*R0
  sdreport_number S1S0;                     //SSB(styr) / virgin SSB
  sdreport_number popstatus;                //SSB(endyr) / virgin SSB
```

```
//---Selectivity-------------------------------------------------------------------------

  //Marmap FL trap: double logistic
  vector sel_mmFST(1,nages);
  init_bounded_number selpar_slope_mmFST(0.1,10.0);
  init_bounded_number selpar_L50_mmFST(0.0,6.);
  init_bounded_number selpar_slope2_mmFST(0.,10.,3);
  init_bounded_number selpar_L502_mmFST(0.1,12.,3);
  //Marmap Chevron trap: double logistic
  vector sel_mmCVT(1,nages);
  init_bounded_number selpar_slope_mmCVT(0.1,10.0);
  init_bounded_number selpar_L50_mmCVT(0.0,6.);
  init_bounded_number selpar_slope2_mmCVT(0.,10.,3);
  init_bounded_number selpar_L502_mmCVT(0.1,12.,3);
  //Marmap blackfish trap: double logistic
  vector sel_mmBFT(1,nages);
  init_bounded_number selpar_slope_mmBFT(0.1,10.0);
  init_bounded_number selpar_L50_mmBFT(0.0,6.);
  init_bounded_number selpar_slope2_mmBFT(0.,10.,3);
  init_bounded_number selpar_L502_mmBFT(0.1,12.,3);
  //Marmap hook and line: logistic
  vector sel_mmHAL(1,nages);
  init_bounded_number selpar_slope_mmHAL(0.1,10.0);
  init_bounded_number selpar_L50_mmHAL(0.0,6);
  //Headboat: logistic, parameters allowed to vary with period defined by size restrictions
  matrix sel_HB(styrR,endyr,1,nages);
  init_bounded_number selpar_slope_HB1(0.1,10.0);     //period 1
  init_bounded_number selpar_L50_HB1(0.0,6.);
  init_bounded_number selpar_slope_HB2(0.1,10.0);     //period 2
  init_bounded_number selpar_L50_HB2(0.0,6.);
  init_bounded_number selpar_slope_HB3(0.1,10.0);     //period 3
  init_bounded_number selpar_L50_HB3(0.0,6.);
  //MRFSS: same as HB selectivity (AW)
  matrix sel_MRFSS(styrR,endyr,1,nages);
  //Commercial hook and line
  matrix sel_commHAL(styrR,endyr,1,nages);
  init_bounded_number selpar_slope_commHAL1(.1,10.0); //period 1
  init_bounded_number selpar_L50_commHAL1(0.0,6);
  init_bounded_number selpar_slope_commHAL2(.1,10.0); //period 2
  init_bounded_number selpar_L50_commHAL2(0.0,6);
  init_bounded_number selpar_slope_commHAL3(.1,10.0); //period 3
  init_bounded_number selpar_L50_commHAL3(0.0,6);
  //Commercial trap: AW recommended against double logistic
  matrix sel_commTRP(styrR,endyr,1,nages);
  init_bounded_number selpar_slope_commTRP1(.1,10.0); //period 1
  init_bounded_number selpar_L50_commTRP1(0,6);
  init_bounded_number selpar_slope_commTRP2(.1,10.0); //period 2
  init_bounded_number selpar_L50_commTRP2(0,6);
  init_bounded_number selpar_slope_commTRP3(.1,10.0); //period 3
  init_bounded_number selpar_L50_commTRP3(0,6);
  //Commercial other: not enough data to estimate time variability or double logistic
  vector sel_commTWL(1,nages);
  init_bounded_number selpar_slope_commTWL(1,10.0);  //period 1
  init_bounded_number selpar_L50_commTWL(0,6);


//-------CPUE Predictions--------------------------------
  vector pred_mmFST_cpue(styr_mmFST_cpue,endyr_mmFST_cpue);
  matrix N_mmFST(styr_mmFST_cpue,endyr_mmFST_cpue,1,nages); //mmFST numbers

  vector pred_mmCVT_cpue(styr_mmCVT_cpue,endyr_mmCVT_cpue);
  matrix N_mmCVT(styr_mmCVT_cpue,endyr_mmCVT_cpue,1,nages); //mmCVT numbers

  vector pred_mmBFT_cpue(styr_mmBFT_cpue,endyr_mmBFT_cpue);
  matrix N_mmBFT(styr_mmBFT_cpue,endyr_mmBFT_cpue,1,nages); //mmBFT numbers

  vector pred_mmHAL_cpue(styr_mmHAL_cpue,endyr_mmHAL_cpue);
  matrix N_mmHAL(styr_mmHAL_cpue,endyr_mmHAL_cpue,1,nages); //mmHAL numbers

  vector pred_HB_cpue(styr_HB_cpue,endyr_HB_cpue);

//---Catchability (CPUE q's)----------------------------------------------------------
  init_bounded_number log_q_mmFST(-16,0,1);
  init_bounded_number log_q_mmCVT(-16,0,1);
  init_bounded_number log_q_mmBFT(-16,0,1);
  init_bounded_number log_q_mmHAL(-16,0,1);
  init_bounded_number log_q_HB(-16,0,1);
```

```
//---Catch (numbers), Landings (mt)-----------------------------------------------
  matrix C_HB(styrR,endyr,1,nages);                      //catch (numbers) at age
  matrix L_HB(styrR,endyr,1,nages);                      //landings (mt) at age
  vector pred_HB_L(styr_HB_L,endyr_HB_L);                //yearly landings summed over ages

  matrix C_MRFSS(styrR,endyr,1,nages);                   //catch (numbers) at age
  matrix L_MRFSS(styrR,endyr,1,nages);                   //landings (mt) at age
  vector pred_MRFSS_L(styr_MRFSS_L,endyr_MRFSS_L);       //yearly landings summed over ages

  matrix C_commHAL(styrR,endyr,1,nages);                  //catch (numbers) at age
  matrix L_commHAL(styrR,endyr,1,nages);                  //landings (mt) at age
  vector pred_commHAL_L(styr_commHAL_L,endyr_commHAL_L); //yearly landings summed over ages

  matrix C_commTRP(styrR,endyr,1,nages);                  //catch (numbers) at age
  matrix L_commTRP(styrR,endyr,1,nages);                  //landings (mt) at age
  vector pred_commTRP_L(styr_commTRP_L,endyr_commTRP_L); //yearly landings summed over ages

  matrix C_commTWL(styrR,endyr,1,nages);                  //catch (numbers) at age
  matrix L_commTWL(styrR,endyr,1,nages);                  //landings (mt) at age
  vector pred_commTWL_L(styr_commTWL_L,endyr_commTWL_L); //yearly landings summed over ages

  matrix C_total(styrR,endyr,1,nages);
  matrix L_total(styrR,endyr,1,nages);
  vector L_total_yr(styrR,endyr);                         //total landings by yr summed over ages

//---MSY calcs---------------------------------------------------------------------

  number F_commHAL_prop;  //proportion of F_full attributable to hal, last three yrs
  number F_commTRP_prop;  //proportion of F_full attributable to trp, last three yrs
  number F_commTWL_prop;  //proportion of F_full attributable to twl, last three yrs
  number F_HB_prop;       //proportion of F_full attributable to headboat, last three yrs
  number F_MRFSS_prop;    //proportion of F_full attributable to MRFSS, last three yrs
  number F_temp_sum;      //sum of geom mean full Fs in last yrs, used to compute F_fishery_prop

  matrix N_msy(1,3,1,nages);
  matrix Z_msy(1,3,1,nages);
  matrix F_age_msy(1,3,1,nages);
  vector C_age_msy(1,nages);
  vector SSB_msy(1,3);
  vector F_msy(1,3);
  vector L_msy(1,3);
  vector spr_msy(1,3);
  vector R_eq(1,3);

  number df;
  number dmsy;
  number dmsy_bc;
  number ddmsy;

  number SSB_msy_out;           //SSB at msy
  number F_msy_out;             //F at msy
  number msy_out;               //max sustainable yield
  number B_msy_out;             //total biomass at MSY
  number E_msy_out;             //exploitation rate (age 1+) at MSY
  number R_msy_out;             //equilibrium recruitment at F=Fmsy

  number SSB_msy_out_bc;           //bias-corrected SSB at msy
  number F_msy_out_bc;             //bias-corrected F at msy
  number msy_out_bc;               //bias-corrected max sustainable yield
  number B_msy_out_bc;             //bias-corrected total biomass at MSY
  number E_msy_out_bc;             //bias-corrected exploitation rate (age 1+) at MSY
  number R_msy_out_bc;             //bias-corrected equilibrium recruitment at F=Fmsy

  sdreport_vector FdF_msy(styrR,endyr);
  sdreport_vector EdE_msy(styrR,endyr);
  sdreport_vector SdSSB_msy(styrR,endyr+1);
  sdreport_number SdSSB_msy_end;
  sdreport_number FdF_msy_end;
  sdreport_number EdE_msy_end;

//--------Mortality----------------------------------------------------------------
  number M;
  matrix F(styrR,endyr,1,nages);
  vector fullF(styrR,endyr);                    //Fishing mortality rate by year
  vector E(styrR,endyr);                        //Exploitation (1+) rate by year
  sdreport_vector fullF_sd(styrR,endyr);
  sdreport_vector E_sd(styrR,endyr);
```

```
  matrix Z(styrR,endyr,1,nages);

  init_bounded_number log_avg_F_HB(-10,2,1);
  init_bounded_dev_vector log_F_dev_HB(styr_HB_L,endyr_HB_L,-10,5,2);
  matrix F_HB(styrR,endyr,1,nages);
  vector F_HB_out(styrR,endyr_HB_L);        //used for intermediate calculations in fcn get_mortality
  number log_F_init_HB;

  init_bounded_number log_avg_F_MRFSS(-10,2,1);
  init_bounded_dev_vector log_F_dev_MRFSS(styr_MRFSS_L,endyr_MRFSS_L,-10,5,2);
  matrix F_MRFSS(styrR,endyr,1,nages);
  vector F_MRFSS_out(styrR,endyr_MRFSS_L); //used for intermediate calculations in fcn get_mortality
  number log_F_init_MRFSS;

  init_bounded_number log_avg_F_commHAL(-10,2,1);
  init_bounded_dev_vector log_F_dev_commHAL(styr_commHAL_L,endyr_commHAL_L,-10,5,2);
  matrix F_commHAL(styrR,endyr,1,nages);
  vector F_commHAL_out(styrR,endyr_commHAL_L); //used for intermediate calculations in fcn get_mortality
  number log_F_init_commHAL;

  init_bounded_number log_avg_F_commTRP(-10,2,1);
  init_bounded_dev_vector log_F_dev_commTRP(styr_commTRP_L,endyr_commTRP_L,-10,5,2);
  matrix F_commTRP(styrR,endyr,1,nages);
  vector F_commTRP_out(styrR,endyr_commTRP_L); //used for intermediate calculations in fcn get_mortality
  number log_F_init_commTRP;

  init_bounded_number log_avg_F_commTWL(-10,2,1);
  init_bounded_dev_vector log_F_dev_commTWL(styr_commTWL_L,endyr_commTWL_L,-10,5,2);
  matrix F_commTWL(styrR,endyr,1,nages);
  vector F_commTWL_out(styrR,endyr_commTWL_L); //used for intermediate calculations in fcn get_mortality
  number log_F_init_commTWL;

//--Discard mortality stuff------------------------------------------------------------------------------
  matrix sel_discard_commHAL(styrR,endyr,1,nages);
  matrix F_discard_commHAL(styrR,endyr,1,nages);
  matrix sel_discard_commTRP(styrR,endyr,1,nages);
  matrix F_discard_commTRP(styrR,endyr,1,nages);
  matrix sel_discard_HB(styrR,endyr,1,nages);
  matrix F_discard_HB(styrR,endyr,1,nages);

  number Dmort_commHAL;
  number Dmort_commTRP;
  number Dmort_HB;

//---Per-recruit stuff----------------------------------------------------------------------------------
  vector N_age_spr(1,nages);         //numbers at age for SPR calculations
  vector C_age_spr(1,nages);         //catch at age for SPR calculations
  vector Z_age_spr(1,nages);         //total mortality at age for SPR calculations
  vector spr_static(styrR,endyr);    //vector of static SPR values by year
  vector F_spr(1,n_iter_spr);        //values of full F to be used in per-recruit and equilibrium calculations
  vector spr_spr(1,n_iter_spr);      //reporductive capacity-per-recruit values corresponding to F values in F_spr
  vector L_spr(1,n_iter_spr);        //landings(mt)-per-recruit values corresponding to F values in F_spr
  vector R_spr_eq(1,n_iter_spr);     //equilibrium recruitment values corresponding to F values in F_spr
  vector L_spr_eq(1,n_iter_spr);     //equilibrium landings(mt) values corresponding to F values in F_spr
  vector SSB_spr_eq(1,n_iter_spr);   //equilibrium reproductive capacity values corresponding to F values in F_spr
  vector B_spr_eq(1,n_iter_spr);     //equilibrium biomass values corresponding to F values in F_spr
  vector E_spr(1,n_iter_spr);        //exploitation rate values corresponding to F values in F_spr

  vector N_spr_F0(1,nages);          //Used to compute spr at F=0
  vector spr_F0(styrR,endyr);        //Spawning biomass per recruit at F=0
  vector bpr_F0(styrR,endyr);        //Biomass per recruit at F=0

//-------Objective function components-------------------------------------------------------------------------
  number w_L;
  number w_lc;
  number w_I_mm;
  number w_I_hb;
  number w_R;
  number w_R_plus;
  number w_F;
  number w_B1dB0;
  number w_fullF_extra;

  number f_mmFST_cpue;
  number f_mmCVT_cpue;
  number f_mmBFT_cpue;
  number f_mmHAL_cpue;
  number f_HB_cpue;
```

```
  number f_HB_L;
  number f_MRFSS_L;
  number f_commHAL_L;
  number f_commTRP_L;
  number f_commTWL_L;
  number f_mmFST_lenc;
  number f_mmCVT_lenc;
  number f_mmBFT_lenc;
  number f_mmHAL_lenc;
  number f_commHAL_lenc;
  number f_commTRP_lenc;
  number f_commTWL_lenc;
  number f_HB_lenc;
  number f_MRFSS_lenc;
  number f_N_dev;           //weight on recruitment deviations to fit S-R curve
  number f_N_dev_early;     //extra weight against deviations before styr
  number f_N_dev_last3;     //extra constraint on last 3 years of recruitment variability
  number f_Fend_constraint; //penalty for F deviation in last 5 years
  number f_B1dB0_constraint;//penalty to fix B(1967)/K
  number f_fullF_constraint;//penalty for fullF>5

  objective_function_value fval;


//--Dummy arrays for output convenience  --------------------------
  vector xdum(styrR,endyr);
  vector xdum2(styrR,endyr+1);
//--Other dummy variables ----
  number sel_diff_dum;
  number zero_dum;

//------Projection variables ------------------------------
//%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
//%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
//##--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>
//##--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>
INITIALIZATION_SECTION


//##--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>
//##--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>
GLOBALS_SECTION
  #include "admodel.h"          // Include AD class definitions
  #include "mhp-s-funcs.cpp"    // Include S-compatible output functions (needs preceding)

//##--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>
RUNTIME_SECTION
 maximum_function_evaluations 2000, 3000, 20000;
 convergence_criteria 1e-8, 1e-8, 1e-8;
//##--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>
//##--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>
//##--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>
PRELIMINARY_CALCS_SECTION

// Set values of fixed parameters or set initial guess of estimated parameters
  Dmort_commHAL=set_Dmort_commHAL;
  Dmort_commTRP=set_Dmort_commTRP;
  Dmort_HB=set_Dmort_HB;

  Linf= set_Linf;
  K=set_K;
  t0=set_t0;

  M=set_M;
  steep=set_steep;
  log_dev_N_rec=0.0;

  log_q_mmFST=set_logq_mmFST;
  log_q_mmCVT=set_logq_mmCVT;
  log_q_mmBFT=set_logq_mmBFT;
  log_q_mmHAL=set_logq_mmHAL;
  log_q_HB=set_logq_HB;

  w_L=set_w_L;
  w_lc=set_w_lc;
  w_I_mm=set_w_I_mm;
  w_I_hb=set_w_I_hb;
  w_R=set_w_R;
```

```
  w_R_plus=set_w_R_plus;
  w_F=set_w_F;
  w_B1dB0=set_w_B1dB0;
  w_fullF_extra=set_w_fullF_extra;

  log_avg_F_HB=set_log_avg_F_HB;
  log_avg_F_MRFSS=set_log_avg_F_MRFSS;
  log_avg_F_commHAL=set_log_avg_F_commHAL;
  log_avg_F_commTRP=set_log_avg_F_commTRP;
  log_avg_F_commTWL=set_log_avg_F_commTWL;

  len_cv=set_len_cv;
  log_R0=set_log_R0;
  S1dS0=set_S1dS0;
  R1_mult=set_R1_mult;
  B1dB0=set_B1dB0;

  selpar_L50_mmFST=set_selpar_L50_mmFST;
  selpar_L502_mmFST=set_selpar_L502_mmFST;
  selpar_slope_mmFST=set_selpar_slope_mmFST;
  selpar_slope2_mmFST=set_selpar_slope2_mmFST;

  selpar_L50_mmCVT=set_selpar_L50_mmCVT;
  selpar_L502_mmCVT=set_selpar_L502_mmCVT;
  selpar_slope_mmCVT=set_selpar_slope_mmCVT;
  selpar_slope2_mmCVT=set_selpar_slope2_mmCVT;

  selpar_L50_mmBFT=set_selpar_L50_mmBFT;
  selpar_L502_mmBFT=set_selpar_L502_mmBFT;
  selpar_slope_mmBFT=set_selpar_slope_mmBFT;
  selpar_slope2_mmBFT=set_selpar_slope2_mmBFT;

  selpar_L50_mmHAL=set_selpar_L50_mmHAL;
  selpar_slope_mmHAL=set_selpar_slope_mmHAL;

  selpar_L50_HB1=set_selpar_L50_HB1;
  selpar_slope_HB1=set_selpar_slope_HB1;
  selpar_L50_HB2=set_selpar_L50_HB2;
  selpar_slope_HB2=set_selpar_slope_HB2;
  selpar_L50_HB3=set_selpar_L50_HB3;
  selpar_slope_HB3=set_selpar_slope_HB3;

  selpar_L50_commHAL1=set_selpar_L50_commHAL1;
  selpar_slope_commHAL1=set_selpar_slope_commHAL1;
  selpar_L50_commHAL2=set_selpar_L50_commHAL2;
  selpar_slope_commHAL2=set_selpar_slope_commHAL2;
  selpar_L50_commHAL3=set_selpar_L50_commHAL3;
  selpar_slope_commHAL3=set_selpar_slope_commHAL3;

  selpar_L50_commTRP1=set_selpar_L50_commTRP1;
  selpar_slope_commTRP1=set_selpar_slope_commTRP1;
  selpar_L50_commTRP2=set_selpar_L50_commTRP2;
  selpar_slope_commTRP2=set_selpar_slope_commTRP2;
  selpar_L50_commTRP3=set_selpar_L50_commTRP3;
  selpar_slope_commTRP3=set_selpar_slope_commTRP3;

  selpar_L50_commTWL=set_selpar_L50_commTWL;
  selpar_slope_commTWL=set_selpar_slope_commTWL;

 sqrt2pi=sqrt(2.*3.14159265);
 df=0.0000001; //difference for msy derivative approximations
 zero_dum=0.0;
 prop_f=1.0-prop_m;

 SSB_msy_out=0.0;

//fill in maturity matrix for calculations for styrR to styr
    for(iyear=styrR; iyear<=styr-1; iyear++)
        {
         maturity_f(iyear)=maturity_f_obs(styr);
         maturity_m(iyear)=maturity_m_obs;
        }
    for (iyear=styr;iyear<=endyr;iyear++)
        {
         maturity_f(iyear)=maturity_f_obs(iyear);
         maturity_m(iyear)=maturity_m_obs;
        }
```

```
//##From length frequencies, calculate yearly sample sizes and proportional compositions for each fishery
 nsamp_mmFST_lenc=rowsum(obs_mmFST_freq);
 for (iyear=styr_mmFST_lenc;iyear<=endyr_mmFST_lenc;iyear++)
     {
      obs_mmFST_lenc(iyear)=obs_mmFST_freq(iyear)/nsamp_mmFST_lenc(iyear);
     }
 nsamp_mmCVT_lenc=rowsum(obs_mmCVT_freq);
 for (iyear=styr_mmCVT_lenc;iyear<=endyr_mmCVT_lenc;iyear++)
     {
      obs_mmCVT_lenc(iyear)=obs_mmCVT_freq(iyear)/nsamp_mmCVT_lenc(iyear);
     }
 nsamp_mmBFT_lenc=rowsum(obs_mmBFT_freq);
 for (iyear=styr_mmBFT_lenc;iyear<=endyr_mmBFT_lenc;iyear++)
     {
      obs_mmBFT_lenc(iyear)=obs_mmBFT_freq(iyear)/nsamp_mmBFT_lenc(iyear);
     }
 nsamp_mmHAL_lenc=rowsum(obs_mmHAL_freq);
 for (iyear=styr_mmHAL_lenc;iyear<=endyr_mmHAL_lenc;iyear++)
     {
      obs_mmHAL_lenc(iyear)=obs_mmHAL_freq(iyear)/nsamp_mmHAL_lenc(iyear);
     }
 nsamp_commHAL_lenc=rowsum(obs_commHAL_freq);
 for (iyear=styr_commHAL_lenc;iyear<=endyr_commHAL_lenc;iyear++)
     {
      obs_commHAL_lenc(iyear)=obs_commHAL_freq(iyear)/nsamp_commHAL_lenc(iyear);
     }
 nsamp_commTRP_lenc=rowsum(obs_commTRP_freq);
 for (iyear=styr_commTRP_lenc;iyear<=endyr_commTRP_lenc;iyear++)
     {
      obs_commTRP_lenc(iyear)=obs_commTRP_freq(iyear)/nsamp_commTRP_lenc(iyear);
     }
 nsamp_commTWL_lenc=rowsum(obs_commTWL_freq);
 for (iyear=styr_commTWL_lenc;iyear<=endyr_commTWL_lenc;iyear++)
     {
      obs_commTWL_lenc(iyear)=obs_commTWL_freq(iyear)/nsamp_commTWL_lenc(iyear);
     }
 nsamp_HB_lenc=rowsum(obs_HB_freq);
 for (iyear=styr_HB_lenc;iyear<=endyr_HB_lenc;iyear++)
     {
      obs_HB_lenc(iyear)=obs_HB_freq(iyear)/nsamp_HB_lenc(iyear);
     }
 nsamp_MRFSS_lenc=rowsum(obs_MRFSS_freq);
 for (iyear=styr_MRFSS_lenc;iyear<=endyr_MRFSS_lenc;iyear++)
     {
      obs_MRFSS_lenc(iyear)=obs_MRFSS_freq(iyear)/nsamp_MRFSS_lenc(iyear);
     }

//fill in F's and Catch matrices with zero's
  F_HB.initialize();
  C_HB.initialize();
  F_MRFSS.initialize();
  C_MRFSS.initialize();
  F_commHAL.initialize();
  C_commHAL.initialize();
  F_commTRP.initialize();
  C_commTRP.initialize();
  F_commTWL.initialize();
  C_commTWL.initialize();
  F_discard_commHAL.initialize();
  F_discard_commTRP.initialize();
  F_discard_HB.initialize();

//##--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>
//##--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>
TOP_OF_MAIN_SECTION
  arrmblsize=20000000;
  gradient_structure::set_MAX_NVAR_OFFSET(1600);
  gradient_structure::set_GRADSTACK_BUFFER_SIZE(2000000);
  gradient_structure::set_CMPDIF_BUFFER_SIZE(2000000);
  gradient_structure::set_NUM_DEPENDENT_VARIABLES(500);

//>--><>--><>--><>--><>
//##--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>
PROCEDURE_SECTION
 R0=mfexp(log_R0);
```

```
 //cout<<"start"<<endl;
 get_length_and_weight_at_age();
 get_reprod();
 //cout << "got length and weight transitions" << endl;
 get_length_at_age_dist();
 //cout<< "got predicted length at age distribution"<<endl;
 get_spr_F0();
 //cout << "got F0 spr" << endl;
 get_selectivity();
 //cout << "got selectivity" << endl;
 get_mortality();
 //cout << "got mortalities" << endl;
 get_numbers_at_age();
 //cout << "got numbers at age" << endl;
 get_catch_at_age();
 //cout << "got catch at age" << endl;
 get_landings();
 //cout << "got landings" << endl;
 get_length_comps();
 //cout<< "got length comps"<< endl;

 evaluate_objective_function();
 //cout << "objective function calculations complete" << endl;



FUNCTION get_length_and_weight_at_age
  //compute mean length and weight at age
  for (iage=1;iage<=nages;iage++)
  {
    meanlen(iage)=Linf*(1.0-mfexp(-K*((agebins(iage)+0.5)-t0)));
    wgt(iage)=mfexp(wgtpar_a + wgtpar_b*log(meanlen(iage)))*0.001; //.001 converts from kg to mt
  }

FUNCTION get_reprod
  for (iyear=styrR;iyear<=endyr;iyear++)
  {
   //product of stuff going into reproductive capacity calcs
   reprod(iyear)=elem_prod((elem_prod(prop_f,maturity_f(iyear))+elem_prod(prop_m,maturity_m(iyear))),wgt);
  }

FUNCTION get_length_at_age_dist
  //compute matrix of length at age, based on the normal distribution
  for (iage=1;iage<=nages;iage++)
  {
    for (ilen=1;ilen<=nlenbins;ilen++)
    {
      lenprob(iage,ilen)=(mfexp(-(square(lenbins(ilen)-meanlen(iage))/
      (2.*square(len_cv(iage)*meanlen(iage)))))/(sqrt2pi*len_cv(iage)*meanlen(iage)));
    }
    lenprob(iage)/=sum(lenprob(iage)); //standardize to account for truncated normal (i.e., no sizes<0)
  }

FUNCTION get_spr_F0
  N_spr_F0(1)=1.0;
  for (iage=2; iage<=nages; iage++)
  {
    N_spr_F0(iage)=N_spr_F0(iage-1)*mfexp(-1.0*M);
  }
  N_spr_F0(nages)=N_spr_F0(nages-1)*mfexp(-1.0*M)/(1.0-mfexp(-1.0*M)); //plus group

  for(iyear=styrR; iyear<=endyr; iyear++)
  {
    //spr_F0(iyear)=sum(elem_prod( elem_prod(elem_prod(N_spr_F0,prop_f),maturity_f(iyear))+
    //elem_prod(elem_prod(N_spr_F0,prop_m),maturity_m(iyear)) ,wgt));
    spr_F0(iyear)=sum(elem_prod(N_spr_F0,reprod(iyear)));
    bpr_F0(iyear)=sum(elem_prod(N_spr_F0,wgt));
  }


FUNCTION get_selectivity

//---selectivities constant across the 3 periods (marmap and commTWL)
  for (iage=1; iage<=nages; iage++)
  {
   //---double logistic-----------------------------------------------
   sel_mmFST(iage)=(1./(1.+mfexp(-1.*selpar_slope_mmFST*(double(agebins(iage))-selpar_L50_mmFST))))*
```

```
    (1-(1./(1.+mfexp(-1.*selpar_slope2_mmFST*(double(agebins(iage))-(selpar_L50_mmFST+selpar_L502_mmFST))))));
   sel_mmCVT(iage)=(1./(1.+mfexp(-1.*selpar_slope_mmCVT*(double(agebins(iage))-selpar_L50_mmCVT))))*
    (1-(1./(1.+mfexp(-1.*selpar_slope2_mmCVT*(double(agebins(iage))-(selpar_L50_mmCVT+selpar_L502_mmCVT))))));
   sel_mmBFT(iage)=(1./(1.+mfexp(-1.*selpar_slope_mmBFT*(double(agebins(iage))-selpar_L50_mmBFT))))*
    (1-(1./(1.+mfexp(-1.*selpar_slope2_mmBFT*(double(agebins(iage))-(selpar_L50_mmBFT+selpar_L502_mmBFT))))));
   //---logistic-------------------------------------------------------
   sel_mmHAL(iage)=1./(1.+mfexp(-1.*selpar_slope_mmHAL*(double(agebins(iage))-selpar_L50_mmHAL)));
   sel_commTWL(iage)=1./(1.+mfexp(-1.*selpar_slope_commTWL*(double(agebins(iage))-selpar_L50_commTWL)));
  }
  sel_mmFST=sel_mmFST/max(sel_mmFST);
  sel_mmCVT=sel_mmCVT/max(sel_mmCVT);
  sel_mmBFT=sel_mmBFT/max(sel_mmBFT);

//---time-varying selectivities
  for (iyear=styrR; iyear<=endyr_period1; iyear++)
  {
     for (iage=1; iage<=nages; iage++)
     {
       sel_HB(iyear,iage)=1./(1.+mfexp(-1.*selpar_slope_HB1*(double(agebins(iage))-selpar_L50_HB1))); //logistic
       sel_MRFSS(iyear,iage)=1./(1.+mfexp(-1.*selpar_slope_HB1*(double(agebins(iage))-selpar_L50_HB1))); //logistic
       sel_commHAL(iyear,iage)=1./(1.+mfexp(-1.*selpar_slope_commHAL1*
        (double(agebins(iage))-selpar_L50_commHAL1))); //logistic
       sel_commTRP(iyear,iage)=1./(1.+mfexp(-1.*selpar_slope_commTRP1*
        (double(agebins(iage))-selpar_L50_commTRP1))); //logistic

     }


     sel_discard_commHAL(iyear)=0.0; //assume no discards prior to regulations
     sel_discard_commTRP(iyear)=0.0;
     sel_discard_HB(iyear)=0.0;
  }
  for (iyear=endyr_period1+1; iyear<=endyr_period2; iyear++)
  {
     for (iage=1; iage<=nages; iage++)
     {
       sel_HB(iyear,iage)=1./
        (1.+mfexp(-1.*selpar_slope_HB2*(double(agebins(iage))-selpar_L50_HB2))); //logistic
       sel_MRFSS(iyear,iage)=1./
        (1.+mfexp(-1.*selpar_slope_HB2*(double(agebins(iage))-selpar_L50_HB2))); //logistic
       sel_commHAL(iyear,iage)=1./
        (1.+mfexp(-1.*selpar_slope_commHAL2*(double(agebins(iage))-selpar_L50_commHAL2))); //logistic
       sel_commTRP(iyear,iage)=1./
        (1.+mfexp(-1.*selpar_slope_commTRP2*(double(agebins(iage))-selpar_L50_commTRP2))); //logistic

       sel_diff_dum=sel_HB(styr,iage)-sel_HB(iyear,iage);
       sel_discard_HB(iyear,iage)=max(zero_dum,sel_diff_dum);
       sel_diff_dum=sel_commHAL(styr,iage)-sel_commHAL(iyear,iage);
       sel_discard_commHAL(iyear,iage)=max(zero_dum,sel_diff_dum);
       sel_diff_dum=sel_commTRP(styr,iage)-sel_commTRP(iyear,iage);
       sel_discard_commTRP(iyear,iage)=max(zero_dum,sel_diff_dum);
     }

  }
  for (iyear=endyr_period2+1; iyear<=endyr; iyear++)
  {
     for (iage=1; iage<=nages; iage++)
     {
       sel_HB(iyear,iage)=1./
        (1.+mfexp(-1.*selpar_slope_HB3*(double(agebins(iage))-selpar_L50_HB3))); //logistic
       sel_MRFSS(iyear,iage)=1./
        (1.+mfexp(-1.*selpar_slope_HB3*(double(agebins(iage))-selpar_L50_HB3))); //logistic
       sel_commHAL(iyear,iage)=1./
        (1.+mfexp(-1.*selpar_slope_commHAL3*(double(agebins(iage))-selpar_L50_commHAL3))); //logistic
       sel_commTRP(iyear,iage)=1./
        (1.+mfexp(-1.*selpar_slope_commTRP3*(double(agebins(iage))-selpar_L50_commTRP3))); //logistic

       sel_diff_dum=sel_HB(styr,iage)-sel_HB(iyear,iage);
       sel_discard_HB(iyear,iage)=max(zero_dum,sel_diff_dum);
       sel_diff_dum=sel_commHAL(endyr_period2,iage)-sel_commHAL(iyear,iage);
       sel_discard_commHAL(iyear,iage)=max(zero_dum,sel_diff_dum);
       sel_diff_dum=sel_commTRP(endyr_period2,iage)-sel_commTRP(iyear,iage);
       sel_discard_commTRP(iyear,iage)=max(zero_dum,sel_diff_dum);
     }


  }
```

```
FUNCTION get_mortality
  fullF=0.0;
  log_F_init_HB=sum(log_F_dev_HB(styr_HB_L,endyr_period1))/
    (endyr_period1-styr_HB_L+1);
  log_F_init_MRFSS=sum(log_F_dev_MRFSS(styr_MRFSS_L,endyr_period1))/
    (endyr_period1-styr_MRFSS_L+1);
  log_F_init_commHAL=sum(log_F_dev_commHAL(styr_commHAL_L,endyr_period1))/
    (endyr_period1-styr_commHAL_L+1);
  log_F_init_commTRP=sum(log_F_dev_commTRP(styr_commTRP_L,endyr_period1))/
    (endyr_period1-styr_commTRP_L+1);
  log_F_init_commTWL=sum(log_F_dev_commTWL(styr_commTWL_L,endyr_period1))/
    (endyr_period1-styr_commTWL_L+1);

  for (iyear=styrR; iyear<=endyr; iyear++)
  {
    if(iyear<styr_HB_L)
    {
      F_HB_out(iyear)=mfexp(log_avg_F_HB+log_F_init_HB);
    }
    else
    {
      F_HB_out(iyear)=mfexp(log_avg_F_HB+log_F_dev_HB(iyear));
    }
    F_HB(iyear)=sel_HB(iyear)*F_HB_out(iyear);
    F_discard_HB(iyear)=sel_discard_HB(iyear)*Dmort_HB*F_HB_out(iyear);
    fullF(iyear)+=F_HB_out(iyear);

    if(iyear<styr_MRFSS_L)
    {
      F_MRFSS_out(iyear)=mfexp(log_avg_F_MRFSS+log_F_init_MRFSS);
    }
    else
    {
      F_MRFSS_out(iyear)=mfexp(log_avg_F_MRFSS+log_F_dev_MRFSS(iyear));
    }
    F_MRFSS(iyear)=sel_MRFSS(iyear)*F_MRFSS_out(iyear);
    fullF(iyear)+=F_MRFSS_out(iyear);

    if(iyear<styr_commHAL_L)
    {
      F_commHAL_out(iyear)=mfexp(log_avg_F_commHAL+log_F_init_commHAL);
    }
    else
    {
      F_commHAL_out(iyear)=mfexp(log_avg_F_commHAL+log_F_dev_commHAL(iyear));
    }
    F_commHAL(iyear)=sel_commHAL(iyear)*F_commHAL_out(iyear);
    F_discard_commHAL(iyear)=sel_discard_commHAL(iyear)*Dmort_commHAL*F_commHAL_out(iyear);
    fullF(iyear)+=F_commHAL_out(iyear);

    if(iyear<styr_commTRP_L)
    {
      F_commTRP_out(iyear)=mfexp(log_avg_F_commTRP+log_F_init_commTRP);
    }
    else
    {
      F_commTRP_out(iyear)=mfexp(log_avg_F_commTRP+log_F_dev_commTRP(iyear));
    }
    F_commTRP(iyear)=sel_commTRP(iyear)*F_commTRP_out(iyear);
    F_discard_commTRP(iyear)=sel_discard_commTRP(iyear)*Dmort_commTRP*F_commTRP_out(iyear);
    fullF(iyear)+=F_commTRP_out(iyear);

    if(iyear<styr_commTWL_L)
    {
      F_commTWL_out(iyear)=mfexp(log_avg_F_commTWL+log_F_init_commTWL);
    }
    else
    {
      F_commTWL_out(iyear)=mfexp(log_avg_F_commTWL+log_F_dev_commTWL(iyear));
    }
    F_commTWL(iyear)=sel_commTWL*F_commTWL_out(iyear);
    fullF(iyear)+=F_commTWL_out(iyear);


    F(iyear)=F_HB(iyear);
    F(iyear)+=F_MRFSS(iyear);
    F(iyear)+=F_commHAL(iyear);
    F(iyear)+=F_commTRP(iyear);
```

```
    F(iyear)+=F_commTWL(iyear);
    F(iyear)+=F_discard_HB(iyear);
    F(iyear)+=F_discard_commHAL(iyear);
    F(iyear)+=F_discard_commTRP(iyear);

    Z(iyear)=F(iyear)+M;
  }

FUNCTION get_numbers_at_age
//Initial age
  S0=spr_F0(styrR)*R0;
  B0=bpr_F0(styrR)*R0;
  S1=S0*S1dS0;
  R1=R1_mult*mfexp(log(((0.8*R0*steep*S1)/(0.2*R0*spr_F0(styrR)*(1.0-steep)+(steep-0.2)*S1))+0.00001));
  N(styrR,1)=R1;
  for (iage=2; iage<=nages; iage++)
  {
    N(styrR,iage)=N(styrR,iage-1)*mfexp(-1.*Z(styrR,iage-1));
  }
  //plus group calculation
  N(styrR,nages)=N(styrR,nages-1)*mfexp(-1.*Z(styrR,nages-1))/(1.-mfexp(-1.*Z(styrR,nages)));
  SSB(styrR)=sum(elem_prod(N(styrR),reprod(styrR)));
  B(styrR)=elem_prod(N(styrR),wgt);
  totB(styrR)=sum(B(styrR));
  var_rec_dev=norm2(log_dev_N_rec(styr,(endyr-3))-sum(log_dev_N_rec(styr,(endyr-3)))/(nyrs-3))/(nyrs-4.);
        //sample variance yrs 1978-2000

//Rest of years ages
  for (iyear=styrR; iyear<endyr; iyear++)
  {
    //add 0.00001 to avoid log(zero)
    N(iyear+1,1)=mfexp(log(((0.8*R0*steep*SSB(iyear))/(0.2*R0*spr_F0(iyear)*
        (1.0-steep)+(steep-0.2)*SSB(iyear)))+0.00001)+log_dev_N_rec(iyear+1));
    N(iyear+1)(2,nages)=++elem_prod(N(iyear)(1,nages-1),(mfexp(-1.*Z(iyear)(1,nages-1))));
    N(iyear+1,nages)+=N(iyear,nages)*mfexp(-1.*Z(iyear,nages));//plus group
    //SSB(iyear+1)=sum(elem_prod( elem_prod(elem_prod(N(iyear+1),prop_f),
    //maturity_f(iyear+1))+ elem_prod(elem_prod(N(iyear+1),prop_m),maturity_m(iyear+1)) ,wgt));
    SSB(iyear+1)=sum(elem_prod(N(iyear+1),reprod(iyear+1)));
    B(iyear+1)=elem_prod(N(iyear+1),wgt);
    totB(iyear+1)=sum(B(iyear+1));
  }

    //last year (projection) has no recruitment variability
    N(endyr+1,1)=mfexp(log(((0.8*R0*steep*SSB(endyr))/(0.2*R0*spr_F0(endyr)*
        (1.0-steep)+(steep-0.2)*SSB(endyr)))+0.00001));
    N(endyr+1)(2,nages)=++elem_prod(N(endyr)(1,nages-1),(mfexp(-1.*Z(endyr)(1,nages-1))));
    N(endyr+1,nages)+=N(endyr,nages)*mfexp(-1.*Z(endyr,nages));//plus group
    //SSB(endyr+1)=sum(elem_prod( elem_prod(elem_prod(N(endyr+1),prop_f),
    //maturity_f(endyr))+ elem_prod(elem_prod(N(endyr+1),prop_m),maturity_m(endyr)) ,wgt));
    SSB(endyr+1)=sum(elem_prod(N(endyr+1),reprod(endyr)));
    B(endyr+1)=elem_prod(N(endyr+1),wgt);
    totB(endyr+1)=sum(B(endyr+1));

//Recruitment time series
  rec=column(N,1);

//Benchmark parameters
  S1S0=SSB(styr)/S0;
  popstatus=SSB(endyr+1)/S0;

FUNCTION get_catch_at_age //Baranov catch eqn
  for (iyear=styrR; iyear<=endyr; iyear++)
  {
    for (iage=1; iage<=nages; iage++)
    {
      C_HB(iyear,iage)=N(iyear,iage)*F_HB(iyear,iage)*
        (1.-mfexp(-1.*Z(iyear,iage)))/Z(iyear,iage);
      C_MRFSS(iyear,iage)=N(iyear,iage)*F_MRFSS(iyear,iage)*
        (1.-mfexp(-1.*Z(iyear,iage)))/Z(iyear,iage);
      C_commHAL(iyear,iage)=N(iyear,iage)*F_commHAL(iyear,iage)*
        (1.-mfexp(-1.*Z(iyear,iage)))/Z(iyear,iage);
      C_commTRP(iyear,iage)=N(iyear,iage)*F_commTRP(iyear,iage)*
        (1.-mfexp(-1.*Z(iyear,iage)))/Z(iyear,iage);
      C_commTWL(iyear,iage)=N(iyear,iage)*F_commTWL(iyear,iage)*
        (1.-mfexp(-1.*Z(iyear,iage)))/Z(iyear,iage);
    }
  }
```

```
FUNCTION get_landings
//---Predicted CPUEs------------------------
 //MARMAP cpue
  for (iyear=styr_mmFST_cpue; iyear<=endyr_mmFST_cpue; iyear++)
  {
      N_mmFST(iyear)=elem_prod(N(iyear),sel_mmFST);
      pred_mmFST_cpue(iyear)=mfexp(log_q_mmFST)*sum(N_mmFST(iyear));
  }
  for (iyear=styr_mmCVT_cpue; iyear<=endyr_mmCVT_cpue; iyear++)
  {
      N_mmCVT(iyear)=elem_prod(N(iyear),sel_mmCVT);
      pred_mmCVT_cpue(iyear)=mfexp(log_q_mmCVT)*sum(N_mmCVT(iyear));
  }
  for (iyear=styr_mmBFT_cpue; iyear<=endyr_mmBFT_cpue; iyear++)
  {
      N_mmBFT(iyear)=elem_prod(N(iyear),sel_mmBFT);
      pred_mmBFT_cpue(iyear)=mfexp(log_q_mmBFT)*sum(N_mmBFT(iyear));
  }
  for (iyear=styr_mmHAL_cpue; iyear<=endyr_mmHAL_cpue; iyear++)
  {
      N_mmHAL(iyear)=elem_prod(N(iyear),sel_mmHAL);
      pred_mmHAL_cpue(iyear)=mfexp(log_q_mmHAL)*sum(N_mmHAL(iyear));
  }
 //Headboat cpue
  for (iyear=styr_HB_cpue; iyear<=endyr_HB_cpue; iyear++)
  {
      pred_HB_cpue(iyear)=mfexp(log_q_HB)*sum(elem_prod(wgt,elem_prod(N(iyear),sel_HB(iyear))));
  }


//---Predicted landings------------------------
  for (iyear=styrR; iyear<=endyr; iyear++)
  {
    L_HB(iyear)=elem_prod(C_HB(iyear),wgt);
    L_MRFSS(iyear)=elem_prod(C_MRFSS(iyear),wgt);
    L_commHAL(iyear)=elem_prod(C_commHAL(iyear),wgt);
    L_commTRP(iyear)=elem_prod(C_commTRP(iyear),wgt);
    L_commTWL(iyear)=elem_prod(C_commTWL(iyear),wgt);
  }

  for (iyear=styr_HB_L; iyear<=endyr_HB_L; iyear++)
    {
     pred_HB_L(iyear)=sum(L_HB(iyear));
    }
  for (iyear=styr_MRFSS_L; iyear<=endyr_MRFSS_L; iyear++)
    {
     pred_MRFSS_L(iyear)=sum(L_MRFSS(iyear));
    }
  for (iyear=styr_commHAL_L; iyear<=endyr_commHAL_L; iyear++)
    {
     pred_commHAL_L(iyear)=sum(L_commHAL(iyear));
    }
  for (iyear=styr_commTRP_L; iyear<=endyr_commTRP_L; iyear++)
    {
     pred_commTRP_L(iyear)=sum(L_commTRP(iyear));
    }
  for (iyear=styr_commTWL_L; iyear<=endyr_commTWL_L; iyear++)
    {
     pred_commTWL_L(iyear)=sum(L_commTWL(iyear));
    }


FUNCTION get_length_comps
 //MARMAP
  for (iyear=styr_mmFST_lenc;iyear<=endyr_mmFST_lenc;iyear++)
  {
    pred_mmFST_lenc(iyear)=(N_mmFST(iyear)*lenprob)/sum(N_mmFST(iyear));
  }
  for (iyear=styr_mmCVT_lenc;iyear<=endyr_mmCVT_lenc;iyear++)
  {
    pred_mmCVT_lenc(iyear)=(N_mmCVT(iyear)*lenprob)/sum(N_mmCVT(iyear));
  }
  for (iyear=styr_mmBFT_lenc;iyear<=endyr_mmBFT_lenc;iyear++)
  {
    pred_mmBFT_lenc(iyear)=(N_mmBFT(iyear)*lenprob)/sum(N_mmBFT(iyear));
  }
  for (iyear=styr_mmHAL_lenc;iyear<=endyr_mmHAL_lenc;iyear++)
  {
```

```
    pred_mmHAL_lenc(iyear)=(N_mmHAL(iyear)*lenprob)/sum(N_mmHAL(iyear));
  }
 //Commercial
  for (iyear=styr_commHAL_lenc;iyear<=endyr_commHAL_lenc;iyear++)
  {
    pred_commHAL_lenc(iyear)=(C_commHAL(iyear)*lenprob)/sum(C_commHAL(iyear));
  }
  for (iyear=styr_commTRP_lenc;iyear<=endyr_commTRP_lenc;iyear++)
  {
    pred_commTRP_lenc(iyear)=(C_commTRP(iyear)*lenprob)/sum(C_commTRP(iyear));
  }
  for (iyear=styr_commTWL_lenc;iyear<=endyr_commTWL_lenc;iyear++)
  {
    pred_commTWL_lenc(iyear)=(C_commTWL(iyear)*lenprob)/sum(C_commTWL(iyear));
  }
 //Headboat
  for (iyear=styr_HB_lenc;iyear<=endyr_HB_lenc;iyear++)
  {
    pred_HB_lenc(iyear)=(C_HB(iyear)*lenprob)/sum(C_HB(iyear));
  }
 //MRFSS
  for (iyear=styr_MRFSS_lenc;iyear<=endyr_MRFSS_lenc;iyear++)
  {
    pred_MRFSS_lenc(iyear)=(C_MRFSS(iyear)*lenprob)/sum(C_MRFSS(iyear));
  }




//---------------------------------------------------------------------------------------------------
FUNCTION get_msy

  F_temp_sum=0.0;
  F_temp_sum+=mfexp((3.0*log_avg_F_commHAL+sum(log_F_dev_commHAL(endyr-2,endyr)))/3);
  F_temp_sum+=mfexp((3.0*log_avg_F_commTRP+sum(log_F_dev_commTRP(endyr-2,endyr)))/3);
  F_temp_sum+=mfexp((3.0*log_avg_F_commTWL+sum(log_F_dev_commTWL(endyr-2,endyr)))/3);
  F_temp_sum+=mfexp((3.0*log_avg_F_HB+sum(log_F_dev_HB(endyr-2,endyr)))/3);
  F_temp_sum+=mfexp((3.0*log_avg_F_MRFSS+sum(log_F_dev_MRFSS(endyr-2,endyr)))/3);

  F_commHAL_prop=mfexp((3.0*log_avg_F_commHAL+sum(log_F_dev_commHAL(endyr-2,endyr)))/3)/F_temp_sum;
  F_commTRP_prop=mfexp((3.0*log_avg_F_commTRP+sum(log_F_dev_commTRP(endyr-2,endyr)))/3)/F_temp_sum;
  F_commTWL_prop=mfexp((3.0*log_avg_F_commTWL+sum(log_F_dev_commTWL(endyr-2,endyr)))/3)/F_temp_sum;
  F_HB_prop=mfexp((3.0*log_avg_F_HB+sum(log_F_dev_HB(endyr-2,endyr)))/3)/F_temp_sum;
  F_MRFSS_prop=mfexp((3.0*log_avg_F_MRFSS+sum(log_F_dev_MRFSS(endyr-2,endyr)))/3)/F_temp_sum;

  F_msy(1)=0.2; //starting value for Fmsy calc
  //use Newton's method to get Fmsy, MSY, and Smsy
  for (int i=1; i<=10; i++){
    F_msy(2)=F_msy(1)-df;
    F_msy(3)=F_msy(1)+df;
    L_msy=0.0;

    F_age_msy(1)=F_msy(1)*F_commHAL_prop*sel_commHAL(endyr)+
        F_msy(1)*F_commTRP_prop*sel_commTRP(endyr)+F_msy(1)*F_commTWL_prop*sel_commTWL;
    F_age_msy(1)+=F_msy(1)*F_HB_prop*sel_HB(endyr)+F_msy(1)*F_MRFSS_prop*sel_MRFSS(endyr);
    F_age_msy(2)=F_msy(2)*F_commHAL_prop*sel_commHAL(endyr)+F_msy(2)*
        F_commTRP_prop*sel_commTRP(endyr)+F_msy(2)*F_commTWL_prop*sel_commTWL;
    F_age_msy(2)+=F_msy(2)*F_HB_prop*sel_HB(endyr)+F_msy(2)*F_MRFSS_prop*sel_MRFSS(endyr);
    F_age_msy(3)=F_msy(3)*F_commHAL_prop*sel_commHAL(endyr)+
        F_msy(3)*F_commTRP_prop*sel_commTRP(endyr)+F_msy(3)*F_commTWL_prop*sel_commTWL;
    F_age_msy(3)+=F_msy(3)*F_HB_prop*sel_HB(endyr)+F_msy(3)*F_MRFSS_prop*sel_MRFSS(endyr);

    Z_msy(1)=M+F_age_msy(1)+F_msy(1)*F_commHAL_prop*Dmort_commHAL*sel_discard_commHAL(endyr)+
        F_msy(1)*F_commTRP_prop*Dmort_commTRP*sel_discard_commTRP(endyr)+
        F_msy(1)*F_HB_prop*Dmort_HB*sel_discard_HB(endyr);
    Z_msy(2)=M+F_age_msy(2)+F_msy(2)*F_commHAL_prop*Dmort_commHAL*sel_discard_commHAL(endyr)+
        F_msy(2)*F_commTRP_prop*Dmort_commTRP*sel_discard_commTRP(endyr)+
        F_msy(2)*F_HB_prop*Dmort_HB*sel_discard_HB(endyr);
    Z_msy(3)=M+F_age_msy(3)+F_msy(3)*F_commHAL_prop*Dmort_commHAL*sel_discard_commHAL(endyr)+
        F_msy(3)*F_commTRP_prop*Dmort_commTRP*sel_discard_commTRP(endyr)+
        F_msy(3)*F_HB_prop*Dmort_HB*sel_discard_HB(endyr);


    //Initial age
    N_msy(1,1)=1.0;
    N_msy(2,1)=1.0;
    N_msy(3,1)=1.0;
```

```
    for (iage=2; iage<=nages; iage++)
    {
      N_msy(1,iage)=N_msy(1,iage-1)*mfexp(-1.0*Z_msy(1,iage-1));
      N_msy(2,iage)=N_msy(2,iage-1)*mfexp(-1.0*Z_msy(2,iage-1));
      N_msy(3,iage)=N_msy(3,iage-1)*mfexp(-1.0*Z_msy(3,iage-1));
    }
    //last age is pooled
    N_msy(1,nages)=N_msy(1,nages-1)*mfexp(-1.*Z_msy(1,nages-1))/(1.-mfexp(-1.0*Z_msy(1,nages)));
    N_msy(2,nages)=N_msy(2,nages-1)*mfexp(-1.*Z_msy(2,nages-1))/(1.-mfexp(-1.0*Z_msy(2,nages)));
    N_msy(3,nages)=N_msy(3,nages-1)*mfexp(-1.*Z_msy(3,nages-1))/(1.-mfexp(-1.0*Z_msy(3,nages)));
    spr_msy(1)=sum(elem_prod( elem_prod(elem_prod(N_msy(1),prop_f),maturity_f(endyr))+
        elem_prod(elem_prod(N_msy(1),prop_m),maturity_m(endyr)) ,wgt));
    spr_msy(2)=sum(elem_prod( elem_prod(elem_prod(N_msy(2),prop_f),maturity_f(endyr))+
        elem_prod(elem_prod(N_msy(2),prop_m),maturity_m(endyr)) ,wgt));
    spr_msy(3)=sum(elem_prod( elem_prod(elem_prod(N_msy(3),prop_f),maturity_f(endyr))+
        elem_prod(elem_prod(N_msy(3),prop_m),maturity_m(endyr)) ,wgt));
    R_eq(1)=(R0/((5.0*steep-1)*spr_msy(1)))*(4.0*steep*spr_msy(1)-spr_F0(endyr)*(1-steep));
    R_eq(2)=(R0/((5.0*steep-1)*spr_msy(2)))*(4.0*steep*spr_msy(2)-spr_F0(endyr)*(1-steep));
    R_eq(3)=(R0/((5.0*steep-1)*spr_msy(3)))*(4.0*steep*spr_msy(3)-spr_F0(endyr)*(1-steep));

    //Initial age
    N_msy(1)=R_eq(1);
    N_msy(2)=R_eq(2);
    N_msy(3)=R_eq(3);
    for (iage=2; iage<=nages; iage++)
    {
      N_msy(1,iage)=N_msy(1,iage-1)*mfexp(-1.*Z_msy(1,iage-1));
      N_msy(2,iage)=N_msy(2,iage-1)*mfexp(-1.*Z_msy(2,iage-1));
      N_msy(3,iage)=N_msy(3,iage-1)*mfexp(-1.*Z_msy(3,iage-1));
    }
    //last age is pooled
    N_msy(1,nages)=N_msy(1,nages-1)*mfexp(-1.0*Z_msy(1,nages-1))/(1.-mfexp(-1.0*Z_msy(1,nages)));
    N_msy(2,nages)=N_msy(2,nages-1)*mfexp(-1.0*Z_msy(2,nages-1))/(1.-mfexp(-1.0*Z_msy(2,nages)));
    N_msy(3,nages)=N_msy(3,nages-1)*mfexp(-1.0*Z_msy(3,nages-1))/(1.-mfexp(-1.0*Z_msy(3,nages)));
    SSB_msy(1)=sum(elem_prod( elem_prod(elem_prod(N_msy(1),prop_f),maturity_f(endyr))+
        elem_prod(elem_prod(N_msy(1),prop_m),maturity_m(endyr)) ,wgt));
    SSB_msy(2)=sum(elem_prod( elem_prod(elem_prod(N_msy(2),prop_f),maturity_f(endyr))+
        elem_prod(elem_prod(N_msy(2),prop_m),maturity_m(endyr)) ,wgt));
    SSB_msy(3)=sum(elem_prod( elem_prod(elem_prod(N_msy(3),prop_f),maturity_f(endyr))+
        elem_prod(elem_prod(N_msy(3),prop_m),maturity_m(endyr)) ,wgt));
    for(iage=1; iage<=nages; iage++){
      L_msy(1)+=N_msy(1,iage)*(F_age_msy(1,iage)/Z_msy(1,iage))*(1.-mfexp(-1.0*Z_msy(1,iage)))*wgt(iage);
      L_msy(2)+=N_msy(2,iage)*(F_age_msy(2,iage)/Z_msy(2,iage))*(1.-mfexp(-1.0*Z_msy(2,iage)))*wgt(iage);
      L_msy(3)+=N_msy(3,iage)*(F_age_msy(3,iage)/Z_msy(3,iage))*(1.-mfexp(-1.0*Z_msy(3,iage)))*wgt(iage);
    }
    dmsy=(L_msy(3)-L_msy(2))/(2.0*df);
    ddmsy=(L_msy(3)-2.0*L_msy(1)+L_msy(2))/square(df);
    if(square(ddmsy)<=1e-12){
      F_msy(1)=F_msy(1);
    }
    if(square(ddmsy)>1e-12){
      F_msy(1)-=(dmsy/ddmsy);
    }
    if(F_msy(1)<=df){
      F_msy(1)=df;
    }
  }

  for(iage=1; iage<=nages; iage++){
    C_age_msy(iage)=N_msy(1,iage)*(F_age_msy(1,iage)/Z_msy(1,iage))*(1.-mfexp(-1.0*Z_msy(1,iage)));
  }

  cout << "MSY convergence dy = " << dmsy << endl;
  msy_out=L_msy(1);
  F_msy_out=F_msy(1);
  R_msy_out=R_eq(1);
  SSB_msy_out=SSB_msy(1);
  B_msy_out=sum(elem_prod(N_msy(1),wgt));
  E_msy_out=sum(C_age_msy(2,nages))/sum(N_msy(1)(2,nages));


FUNCTION get_msy_BiasCorrected

  F_msy(1)=0.1; //starting value for Fmsy calc
  //use Newton's method to get Fmsy, MSY, and Smsy
  for (int i=1; i<=10; i++){
    F_msy(2)=F_msy(1)-df;
    F_msy(3)=F_msy(1)+df;
```

```
L_msy=0.0;

F_age_msy(1)=F_msy(1)*F_commHAL_prop*sel_commHAL(endyr)+F_msy(1)*F_commTRP_prop*sel_commTRP(endyr)+
    F_msy(1)*F_commTWL_prop*sel_commTWL;
F_age_msy(1)+=F_msy(1)*F_HB_prop*sel_HB(endyr)+F_msy(1)*F_MRFSS_prop*sel_MRFSS(endyr);

F_age_msy(2)=F_msy(2)*F_commHAL_prop*sel_commHAL(endyr)+
    F_msy(2)*F_commTRP_prop*sel_commTRP(endyr)+F_msy(2)*F_commTWL_prop*sel_commTWL;
F_age_msy(2)+=F_msy(2)*F_HB_prop*sel_HB(endyr)+F_msy(2)*F_MRFSS_prop*sel_MRFSS(endyr);

F_age_msy(3)=F_msy(3)*F_commHAL_prop*sel_commHAL(endyr)+
    F_msy(3)*F_commTRP_prop*sel_commTRP(endyr)+F_msy(3)*F_commTWL_prop*sel_commTWL;
F_age_msy(3)+=F_msy(3)*F_HB_prop*sel_HB(endyr)+F_msy(3)*F_MRFSS_prop*sel_MRFSS(endyr);

Z_msy(1)=M+F_age_msy(1)+F_msy(1)*F_commHAL_prop*Dmort_commHAL*sel_discard_commHAL(endyr)+
    F_msy(1)*F_commTRP_prop*Dmort_commTRP*sel_discard_commTRP(endyr)+
    F_msy(1)*F_HB_prop*Dmort_HB*sel_discard_HB(endyr);
Z_msy(2)=M+F_age_msy(2)+F_msy(2)*F_commHAL_prop*Dmort_commHAL*sel_discard_commHAL(endyr)+
    F_msy(2)*F_commTRP_prop*Dmort_commTRP*sel_discard_commTRP(endyr)+
    F_msy(2)*F_HB_prop*Dmort_HB*sel_discard_HB(endyr);
Z_msy(3)=M+F_age_msy(3)+F_msy(3)*F_commHAL_prop*Dmort_commHAL*sel_discard_commHAL(endyr)+
    F_msy(3)*F_commTRP_prop*Dmort_commTRP*sel_discard_commTRP(endyr)+
    F_msy(3)*F_HB_prop*Dmort_HB*sel_discard_HB(endyr);


//Initial age
N_msy(1,1)=1.0;
N_msy(2,1)=1.0;
N_msy(3,1)=1.0;
for (iage=2; iage<=nages; iage++)
{
  N_msy(1,iage)=N_msy(1,iage-1)*mfexp(-1.0*Z_msy(1,iage-1));
  N_msy(2,iage)=N_msy(2,iage-1)*mfexp(-1.0*Z_msy(2,iage-1));
  N_msy(3,iage)=N_msy(3,iage-1)*mfexp(-1.0*Z_msy(3,iage-1));
}
//last age is pooled
N_msy(1,nages)=N_msy(1,nages-1)*mfexp(-1.*Z_msy(1,nages-1))/(1.-mfexp(-1.0*Z_msy(1,nages)));
N_msy(2,nages)=N_msy(2,nages-1)*mfexp(-1.*Z_msy(2,nages-1))/(1.-mfexp(-1.0*Z_msy(2,nages)));
N_msy(3,nages)=N_msy(3,nages-1)*mfexp(-1.*Z_msy(3,nages-1))/(1.-mfexp(-1.0*Z_msy(3,nages)));
spr_msy(1)=sum(elem_prod( elem_prod(elem_prod(N_msy(1),prop_f),maturity_f(endyr))+
    elem_prod(elem_prod(N_msy(1),prop_m),maturity_m(endyr)) ,wgt));
spr_msy(2)=sum(elem_prod( elem_prod(elem_prod(N_msy(2),prop_f),maturity_f(endyr))+
    elem_prod(elem_prod(N_msy(2),prop_m),maturity_m(endyr)) ,wgt));
spr_msy(3)=sum(elem_prod( elem_prod(elem_prod(N_msy(3),prop_f),maturity_f(endyr))+
    elem_prod(elem_prod(N_msy(3),prop_m),maturity_m(endyr)) ,wgt));
R_eq(1)=exp(var_rec_dev/2.0)*(R0/((5.0*steep-1)*spr_msy(1)))*(4.0*steep*spr_msy(1)-spr_F0(endyr)*(1-steep));
R_eq(2)=exp(var_rec_dev/2.0)*(R0/((5.0*steep-1)*spr_msy(2)))*(4.0*steep*spr_msy(2)-spr_F0(endyr)*(1-steep));
R_eq(3)=exp(var_rec_dev/2.0)*(R0/((5.0*steep-1)*spr_msy(3)))*(4.0*steep*spr_msy(3)-spr_F0(endyr)*(1-steep));

//Initial age
N_msy(1)=R_eq(1);
N_msy(2)=R_eq(2);
N_msy(3)=R_eq(3);
for (iage=2; iage<=nages; iage++)
{
  N_msy(1,iage)=N_msy(1,iage-1)*mfexp(-1.*Z_msy(1,iage-1));
  N_msy(2,iage)=N_msy(2,iage-1)*mfexp(-1.*Z_msy(2,iage-1));
  N_msy(3,iage)=N_msy(3,iage-1)*mfexp(-1.*Z_msy(3,iage-1));
}
//last age is pooled
N_msy(1,nages)=N_msy(1,nages-1)*mfexp(-1.0*Z_msy(1,nages-1))/(1.-mfexp(-1.0*Z_msy(1,nages)));
N_msy(2,nages)=N_msy(2,nages-1)*mfexp(-1.0*Z_msy(2,nages-1))/(1.-mfexp(-1.0*Z_msy(2,nages)));
N_msy(3,nages)=N_msy(3,nages-1)*mfexp(-1.0*Z_msy(3,nages-1))/(1.-mfexp(-1.0*Z_msy(3,nages)));
SSB_msy(1)=sum(elem_prod( elem_prod(elem_prod(N_msy(1),prop_f),maturity_f(endyr))+
    elem_prod(elem_prod(N_msy(1),prop_m),maturity_m(endyr)) ,wgt));
SSB_msy(2)=sum(elem_prod( elem_prod(elem_prod(N_msy(2),prop_f),maturity_f(endyr))+
    elem_prod(elem_prod(N_msy(2),prop_m),maturity_m(endyr)) ,wgt));
SSB_msy(3)=sum(elem_prod( elem_prod(elem_prod(N_msy(3),prop_f),maturity_f(endyr))+
    elem_prod(elem_prod(N_msy(3),prop_m),maturity_m(endyr)) ,wgt));
for(iage=1; iage<=nages; iage++){
  L_msy(1)+=N_msy(1,iage)*(F_age_msy(1,iage)/Z_msy(1,iage))*(1.-mfexp(-1.0*Z_msy(1,iage)))*wgt(iage);
  L_msy(2)+=N_msy(2,iage)*(F_age_msy(2,iage)/Z_msy(2,iage))*(1.-mfexp(-1.0*Z_msy(2,iage)))*wgt(iage);
  L_msy(3)+=N_msy(3,iage)*(F_age_msy(3,iage)/Z_msy(3,iage))*(1.-mfexp(-1.0*Z_msy(3,iage)))*wgt(iage);
}
dmsy_bc=(L_msy(3)-L_msy(2))/(2.0*df);
ddmsy=(L_msy(3)-2.0*L_msy(1)+L_msy(2))/square(df);
if(square(ddmsy)<=1e-12){
  F_msy(1)=F_msy(1);
```

```
    }
    if(square(ddmsy)>1e-12){
      F_msy(1)-=(dmsy_bc/ddmsy);
    }
    if(F_msy(1)<=df){
      F_msy(1)=df;
    }
  }

  for(iage=1; iage<=nages; iage++){
    C_age_msy(iage)=N_msy(1,iage)*(F_age_msy(1,iage)/Z_msy(1,iage))*(1.-mfexp(-1.0*Z_msy(1,iage)));
  }

  cout << "Bias-corrected MSY convergence dy = " << dmsy_bc << endl;
  msy_out_bc=L_msy(1);
  F_msy_out_bc=F_msy(1);
  R_msy_out_bc=R_eq(1);
  SSB_msy_out_bc=SSB_msy(1);
  B_msy_out_bc=sum(elem_prod(N_msy(1),wgt));
  E_msy_out_bc=sum(C_age_msy(2,nages))/sum(N_msy(1)(2,nages));

//----------------------------------------------------------------------------------------------------
FUNCTION get_miscellaneous_stuff
  //compute total catch-at-age and landings
  C_total=C_HB+C_MRFSS+C_commHAL+C_commTRP+C_commTWL;
  L_total=L_HB+L_MRFSS+L_commHAL+L_commTRP+L_commTWL;
  //compute exploitation rate of age 1+
  for(iyear=styrR; iyear<=endyr; iyear++)
  {
    E(iyear)=sum(C_total(iyear)(2,nages))/sum(N(iyear)(2,nages));
    L_total_yr(iyear)=sum(L_total(iyear));
  }

  steep_sd=steep;
  fullF_sd=fullF;
  E_sd=E;

  if(E_msy_out>0)
    {
      EdE_msy=E/E_msy_out;
      EdE_msy_end=EdE_msy(endyr);
    }
  if(F_msy_out>0)
    {
      FdF_msy=fullF/F_msy_out;
      FdF_msy_end=FdF_msy(endyr);
    }
  if(SSB_msy_out>0)
    {
      SdSSB_msy=SSB/SSB_msy_out;
      SdSSB_msy_end=SdSSB_msy(endyr+1);
    }


//----------------------------------------------------------------------------------------------------
FUNCTION get_per_recruit_stuff
  //static per-recruit stuff
  for(iyear=styrR; iyear<=endyr; iyear++)
  {
    N_age_spr(1)=1.0;
    for(iage=2; iage<=nages; iage++)
    {
      N_age_spr(iage)=N_age_spr(iage-1)*mfexp(-1.*Z(iyear,iage-1));
    }
    N_age_spr(nages)=N_age_spr(nages-1)*mfexp(-1.*Z(iyear,nages-1))/(1-mfexp(-1.*Z(iyear,nages)));
    spr_static(iyear)=sum(elem_prod(N_age_spr,reprod(iyear)))/spr_F0(iyear);
  }

  //fill in Fs for per-recruit stuff
  F_spr.fill_seqadd(0,.01);
  //compute SSB/R and YPR as functions of F
  for(int ff=1; ff<=n_iter_spr; ff++)
  {
    //uses fishery-weighted F's, same as in MSY calculations
    Z_age_spr=0.;
    Z_age_spr=M+F_spr(ff)*F_commHAL_prop*sel_commHAL(endyr)+F_spr(ff)*F_commTRP_prop*sel_commTRP(endyr)+
        F_spr(ff)*F_commTWL_prop*sel_commTWL;
    Z_age_spr+=F_spr(ff)*F_HB_prop*sel_HB(endyr)+F_spr(ff)*F_MRFSS_prop*sel_MRFSS(endyr);
```

```
    Z_age_spr+=F_spr(ff)*F_commHAL_prop*Dmort_commHAL*sel_discard_commHAL(endyr)+
        F_spr(ff)*F_commTRP_prop*Dmort_commTRP*sel_discard_commTRP(endyr)+
        F_spr(ff)*F_HB_prop*Dmort_HB*sel_discard_HB(endyr);
    N_age_spr(1)=1.0;
    for (iage=2; iage<=nages; iage++)
    {
      N_age_spr(iage)=N_age_spr(iage-1)*mfexp(-1.*Z_age_spr(iage-1));
    }
    N_age_spr(nages)=N_age_spr(nages-1)*mfexp(-1.*Z_age_spr(nages-1))/(1-mfexp(-1.*Z_age_spr(nages)));
    spr_spr(ff)=sum(elem_prod(N_age_spr,reprod(endyr)));
    L_spr(ff)=0.0;
    for (iage=1; iage<=nages; iage++)
    {
      C_age_spr(iage)=N_age_spr(iage)*((Z_age_spr(iage)-M)/Z_age_spr(iage))*(1.-mfexp(-1.*Z_age_spr(iage)));
      L_spr(ff)+=C_age_spr(iage)*wgt(iage);
    }
    E_spr(ff)=sum(C_age_spr(2,nages))/sum(N_age_spr(2,nages));

    //Compute equilibrium values of R, SSB and Yield at each F

    R_spr_eq(ff)=(R0/((5.0*steep-1.0)*spr_spr(ff)))*(4.0*steep*spr_spr(ff)-spr_F0(endyr)*(1.0-steep));
    N_age_spr*=R_spr_eq(ff);
    SSB_spr_eq(ff)=sum(elem_prod(N_age_spr,reprod(endyr)));
    B_spr_eq(ff)=sum(elem_prod(N_age_spr,wgt));
    L_spr_eq(ff)=sum(elem_prod(C_age_spr*R_spr_eq(ff),wgt));
  }


//-------------------------------------------------------------------------------------------------------------

FUNCTION evaluate_objective_function
  fval=0.0;

  f_mmFST_cpue=0.0;
  for (iyear=styr_mmFST_cpue; iyear<=endyr_mmFST_cpue; iyear++)
  {
    f_mmFST_cpue+=square(log(pred_mmFST_cpue(iyear)+0.001)-
        log(obs_mmFST_cpue(iyear)+0.001))/(2.0*square(mmFST_cpue_cv(iyear)));
  }
  fval+=w_I_mm*f_mmFST_cpue;

  f_mmCVT_cpue=0.0;
  for (iyear=styr_mmCVT_cpue; iyear<=endyr_mmCVT_cpue; iyear++)
  {
    f_mmCVT_cpue+=square(log(pred_mmCVT_cpue(iyear)+0.001)-
        log(obs_mmCVT_cpue(iyear)+0.001))/(2.0*square(mmCVT_cpue_cv(iyear)));
  }
  fval+=w_I_mm*f_mmCVT_cpue;

  f_mmBFT_cpue=0.0;
  for (iyear=styr_mmBFT_cpue; iyear<=endyr_mmBFT_cpue; iyear++)
  {
    f_mmBFT_cpue+=square(log(pred_mmBFT_cpue(iyear)+0.001)-
        log(obs_mmBFT_cpue(iyear)+0.001))/(2.0*square(mmBFT_cpue_cv(iyear)));
   }
  fval+=w_I_mm*f_mmBFT_cpue;

  f_mmHAL_cpue=0.0;
  for (iyear=styr_mmHAL_cpue; iyear<=endyr_mmHAL_cpue; iyear++)
  {
    f_mmHAL_cpue+=square(log(pred_mmHAL_cpue(iyear)+0.001)-
        log(obs_mmHAL_cpue(iyear)+0.001))/(2.0*square(mmHAL_cpue_cv(iyear)));
  }
  fval+=w_I_mm*f_mmHAL_cpue;

  f_HB_cpue=0.0;
  for (iyear=styr_HB_cpue; iyear<=endyr_HB_cpue; iyear++)
  {
    f_HB_cpue+=square(log(pred_HB_cpue(iyear)+0.001)-
        log(obs_HB_cpue(iyear)+0.001))/(2.0*square(HB_cpue_cv(iyear)));
  }
  fval+=w_I_hb*f_HB_cpue;

  f_HB_L=0.0;
  for (iyear=styr_HB_L; iyear<=endyr_HB_L; iyear++)
  {
    f_HB_L+=square(log(pred_HB_L(iyear)+0.001)-
        log(obs_HB_L(iyear)+0.001))/(2.0*square(HB_L_cv(iyear)));
```

```
}
fval+=w_L*f_HB_L;

f_MRFSS_L=0.0;
for (iyear=styr_MRFSS_L; iyear<=endyr_MRFSS_L; iyear++)
{
  f_MRFSS_L+=square(log(pred_MRFSS_L(iyear)+0.001)-
      log(obs_MRFSS_L(iyear)+0.001))/(2.0*square(MRFSS_L_cv(iyear)));
}
fval+=w_L*f_MRFSS_L;

f_commHAL_L=0.0;
for (iyear=styr_commHAL_L; iyear<=endyr_commHAL_L; iyear++)
{
  f_commHAL_L+=square(log(pred_commHAL_L(iyear)+0.001)-
      log(obs_commHAL_L(iyear)+0.001))/(2.0*square(commHAL_L_cv(iyear)));
}
fval+=w_L*f_commHAL_L;

f_commTRP_L=0.0;
for (iyear=styr_commTRP_L; iyear<=endyr_commTRP_L; iyear++)
{
  f_commTRP_L+=square(log(pred_commTRP_L(iyear)+0.001)-
      log(obs_commTRP_L(iyear)+0.001))/(2.0*square(commTRP_L_cv(iyear)));
}
fval+=w_L*f_commTRP_L;

f_commTWL_L=0.0;
for (iyear=styr_commTWL_L; iyear<=endyr_commTWL_L; iyear++)
{
  f_commTWL_L+=square(log(pred_commTWL_L(iyear)+0.001)-
      log(obs_commTWL_L(iyear)+0.001))/(2.0*square(commTWL_L_cv(iyear)));
}
fval+=w_L*f_commTWL_L;

f_mmFST_lenc=0.0;
for (iyear=styr_mmFST_lenc; iyear<=endyr_mmFST_lenc; iyear++)
{
  f_mmFST_lenc-=nsamp_mmFST_lenc(iyear)*
      sum(elem_prod((obs_mmFST_lenc(iyear)+.001),log(pred_mmFST_lenc(iyear)+.001)));
}
fval+=w_lc*f_mmFST_lenc;

f_mmCVT_lenc=0.0;
for (iyear=styr_mmCVT_lenc; iyear<=endyr_mmCVT_lenc; iyear++)
{
  f_mmCVT_lenc-=nsamp_mmCVT_lenc(iyear)*
      sum(elem_prod((obs_mmCVT_lenc(iyear)+.001),log(pred_mmCVT_lenc(iyear)+.001)));
}
fval+=w_lc*f_mmCVT_lenc;

f_mmBFT_lenc=0.0;
for (iyear=styr_mmBFT_lenc; iyear<=endyr_mmBFT_lenc; iyear++)
{
  f_mmBFT_lenc-=nsamp_mmBFT_lenc(iyear)*
      sum(elem_prod((obs_mmBFT_lenc(iyear)+.001),log(pred_mmBFT_lenc(iyear)+.001)));
}
fval+=w_lc*f_mmBFT_lenc;

f_mmHAL_lenc=0.0;
for (iyear=styr_mmHAL_lenc; iyear<=endyr_mmHAL_lenc; iyear++)
{
  f_mmHAL_lenc-=nsamp_mmHAL_lenc(iyear)*
      sum(elem_prod((obs_mmHAL_lenc(iyear)+.001),log(pred_mmHAL_lenc(iyear)+.001)));
}
fval+=w_lc*f_mmHAL_lenc;

f_commHAL_lenc=0.0;
for (iyear=styr_commHAL_lenc; iyear<=endyr_commHAL_lenc; iyear++)
{
  f_commHAL_lenc-=nsamp_commHAL_lenc(iyear)*
      sum(elem_prod((obs_commHAL_lenc(iyear)+.001),log(pred_commHAL_lenc(iyear)+.001)));
}
fval+=w_lc*f_commHAL_lenc;

f_commTRP_lenc=0.0;
for (iyear=styr_commTRP_lenc; iyear<=endyr_commTRP_lenc; iyear++)
{
```

```
    f_commTRP_lenc-=nsamp_commTRP_lenc(iyear)*
        sum(elem_prod((obs_commTRP_lenc(iyear)+.001),log(pred_commTRP_lenc(iyear)+.001)));
  }
  fval+=w_lc*f_commTRP_lenc;

  f_commTWL_lenc=0.0;
  for (iyear=styr_commTWL_lenc; iyear<=endyr_commTWL_lenc; iyear++)
  {
    f_commTWL_lenc-=nsamp_commTWL_lenc(iyear)*
        sum(elem_prod((obs_commTWL_lenc(iyear)+.001),log(pred_commTWL_lenc(iyear)+.001)));
  }
  fval+=w_lc*f_commTWL_lenc;

  f_HB_lenc=0.0;
  for (iyear=styr_HB_lenc; iyear<=endyr_HB_lenc; iyear++)
  {
    f_HB_lenc-=nsamp_HB_lenc(iyear)*
        sum(elem_prod((obs_HB_lenc(iyear)+.001),log(pred_HB_lenc(iyear)+.001)));
  }
  fval+=w_lc*f_HB_lenc;

  f_MRFSS_lenc=0.0;
  for (iyear=styr_MRFSS_lenc; iyear<=endyr_MRFSS_lenc; iyear++)
  {
    f_MRFSS_lenc-=nsamp_MRFSS_lenc(iyear)*
        sum(elem_prod((obs_MRFSS_lenc(iyear)+.001),log(pred_MRFSS_lenc(iyear)+.001)));
  }
  fval+=w_lc*f_MRFSS_lenc;

  f_N_dev=0.0;
  f_N_dev=norm2(log_dev_N_rec);
  fval+=w_R*f_N_dev;

  f_N_dev_early=0.0;
  f_N_dev_early=norm2(log_dev_N_rec(styrR+1,styr-1));
  fval+=w_R_plus*f_N_dev_early;

  f_N_dev_last3=0.0;
    f_N_dev_last3=norm2(log_dev_N_rec(endyr-2,endyr));
  fval+=w_R_plus*f_N_dev_last3;

  f_B1dB0_constraint=0.0;
    f_B1dB0_constraint=square(totB(styrR)/B0-B1dB0);
  fval+=w_B1dB0*f_B1dB0_constraint;

  f_Fend_constraint=0.0;
  f_Fend_constraint=norm2(first_difference(fullF(endyr-5,endyr)));
  fval+=w_F*f_Fend_constraint;

  f_fullF_constraint=0.0;
  for (iyear=styrR; iyear<=endyr; iyear++)
    {
     if (fullF(iyear)>5.0)
     {
     f_fullF_constraint+=square(fullF(iyear)-5.0);
     }
    }
  fval+=w_fullF_extra*f_fullF_constraint;



REPORT_SECTION

  get_msy();
  get_msy_BiasCorrected();
  get_miscellaneous_stuff();
  get_per_recruit_stuff();

  cout << "Fmsy=" << F_msy_out<< "   SSBmsy=" << SSB_msy_out <<endl;
  cout << "BC Fmsy=" << F_msy_out_bc<< "   BC SSBmsy=" << SSB_msy_out_bc <<endl;
  cout << "var_rec_resid (78-00)="<<var_rec_dev<<endl;



    report << "TotalLikelihood " << fval << endl;
    report << "f_mmFST_cpue "<<w_I_mm*f_mmFST_cpue<<"    weight= "<<w_I_mm<<endl;
    report << "f_mmCVT_cpue "<<w_I_mm*f_mmCVT_cpue<<"    weight= "<<w_I_mm<<endl;
```

```
  report << "f_mmBFT_cpue "<< w_I_mm*f_mmBFT_cpue<<"    weight= "<<w_I_mm<<endl;
  report << "f_mmHAL_cpue "<< w_I_mm*f_mmHAL_cpue<<"    weight= "<<w_I_mm<<endl;
  report << "f_HB_cpue "<< w_I_hb*f_HB_cpue<<"    weight= "<<w_I_hb<<endl;
  report << "f_HB_L "<< w_L*f_HB_L<<"    weight= "<<w_L<<endl;
  report << "f_MRFSS_L "<< w_L*f_MRFSS_L<<"    weight= "<<w_L<<endl;
  report << "f_commHAL_L "<< w_L*f_commHAL_L<<"    weight= "<<w_L<<endl;
  report << "f_commTRP_L "<< w_L*f_commTRP_L<<"    weight= "<<w_L<<endl;
  report << "f_commTWL_L "<< w_L*f_commTWL_L<<"    weight= "<<w_L<<endl;
  report << "f_mmFST_lenc "<< w_lc*f_mmFST_lenc<<"    weight= "<<w_lc<<endl;
  report << "f_mmCVT_lenc "<< w_lc*f_mmCVT_lenc<<"    weight= "<<w_lc<<endl;
  report << "f_mmBFT_lenc "<< w_lc*f_mmBFT_lenc<<"    weight= "<<w_lc<<endl;
  report << "f_mmHAL_lenc "<< w_lc*f_mmHAL_lenc<<"    weight= "<<w_lc<<endl;
  report << "f_commHAL_lenc "<< w_lc*f_commHAL_lenc<<"    weight= "<<w_lc<<endl;
  report << "f_commTRP_lenc "<< w_lc*f_commTRP_lenc<<"    weight= "<<w_lc<<endl;
  report << "f_commTWL_lenc "<< w_lc*f_commTWL_lenc<<"    weight= "<<w_lc<<endl;
  report << "f_HB_lenc "<< w_lc*f_HB_lenc<<"    weight= "<<w_lc<<endl;
  report << "f_MRFSS_lenc "<< w_lc*f_MRFSS_lenc<<"    weight= "<<w_lc<<endl;
  report << "f_N_dev "<< w_R*f_N_dev<<"    weight= "<<w_R<<endl;
  report << "f_N_dev_early "<< w_R_plus*f_N_dev_early<<"    weight= "<<w_R_plus<<endl;
  report << "f_N_dev_last3 "<< w_R_plus*f_N_dev_last3<<"    weight= "<<w_R_plus<<endl;
  report << "f_Fend_constraint "<< w_F*f_Fend_constraint<<"    weight= "<<w_F<<endl;
  report << "f_B1dB0_constraint "<< w_B1dB0*f_B1dB0_constraint<<"    weight= "<<w_B1dB0<<endl;
  report << "f_fullF_constraint "<< w_fullF_extra*f_fullF_constraint<<"    weight= "<<w_fullF_extra<<endl;
  report<<" "<<endl;

report << "MSY stuff" << endl;
report << "N-R_convergence " << dmsy << endl;
report << "Fmsy " << F_msy_out << endl;
report << "Emsy(1+) " << E_msy_out << endl;
report << "SSBmsy " << SSB_msy_out << endl;
report << "Rmsy " << R_msy_out << endl;
report << "Bmsy " << B_msy_out << endl;
report << "MSY " << msy_out << endl;
report << "F/Fmsy " << fullF/F_msy_out << endl;
report << "E/Emsy " << E/E_msy_out << endl;
report << "SSB/SSBmsy " << SSB/SSB_msy_out << endl;
report << "B/Bmsy " << totB/B_msy_out << endl;
report << "Yield/MSY " << L_total_yr/msy_out <<endl;
report << "F(2003)/Fmsy " << fullF(endyr)/F_msy_out << endl;
report << "E(2003)/Emsy " << E(endyr)/E_msy_out << endl;
report << "SSB(2004)/SSBmsy " << SSB(endyr+1)/SSB_msy_out << endl;
report << "Predicted Landings(2003)/MSY " << L_total_yr(endyr)/msy_out <<endl;
report  << " "<<endl;

report << "Bias-corrected (BC) MSY stuff" << endl;
report << "N-R_convergence " << dmsy_bc << endl;
report << "BC Fmsy " << F_msy_out_bc << endl;
report << "BC Emsy(1+) " << E_msy_out_bc << endl;
report << "BC SSBmsy " << SSB_msy_out_bc << endl;
report << "BC Rmsy " << R_msy_out_bc << endl;
report << "BC Bmsy " << B_msy_out_bc << endl;
report << "BC MSY " << msy_out_bc << endl;
report << "BC F/Fmsy " << fullF/F_msy_out_bc << endl;
report << "BC E/Emsy " << E/E_msy_out_bc << endl;
report << "BC SSB/SSBmsy " << SSB/SSB_msy_out_bc << endl;
report << "BC B/Bmsy " << totB/B_msy_out_bc << endl;
report << "BC Yield/MSY " << L_total_yr/msy_out_bc <<endl;
report << "BC F(2003)/Fmsy " << fullF(endyr)/F_msy_out_bc << endl;
report << "BC E(2003)/Emsy " << E(endyr)/E_msy_out_bc << endl;
report << "BC SSB(2004)/SSBmsy " << SSB(endyr+1)/SSB_msy_out_bc << endl;
report << "BC Predicted Landings(2003)/MSY " << L_total_yr(endyr)/msy_out_bc <<endl;
report  << " "<<endl;

report << "Mortality and growth" << endl;
report << "M "<<M<<endl;
report << "Linf="<<Linf << "   K=" <<K<<"   t0="<< t0<<endl;
report << "mean length " << meanlen << endl;
  report << "cv length " << len_cv << endl;
report << "wgt " << wgt << endl;

report<<" "<<endl;

report << "Stock-Recruit " << endl;
report << "R0= " << R0 << endl;
report << "Steepness= " << steep << endl;
report << "spr_F0= " << spr_F0 << endl;
report << "Recruits(R) " << rec << endl;
report << "VirginSSB " << S0 << endl;
```

```
 report << "SSB(1978)/VirginSSB " << S1S0 << endl;
 report << "SSB(2004)/VirginSSB " << popstatus << endl;
 report << "SSB " << SSB << endl;
 report << "Biomass " << totB << endl;
 report << "log recruit deviations (1978-2003)   " << log_dev_N_rec(1978,2003) <<endl;
 report << "variance of log rec dev (1978-2000)  "<<var_rec_dev<<endl;
 report<<" "<<endl;

report << "Exploitation rate(1+) (1967-2003)" << endl;
report << E << endl;
report << "Fully-selected F (1967-2003)" << endl;
report << fullF << endl;
report << "Headboat F" << endl;
report << F_HB_out << endl;
report << "MRFSS F" << endl;
report << F_MRFSS_out << endl;
report << "commHAL F" << endl;
report << F_commHAL_out << endl;
report << "commTRP F" << endl;
report << F_commTRP_out << endl;
report << "commTWL F" << endl;
report << F_commTWL_out << endl;
 report<<" "<<endl;
report << "Headboat selectivity" << endl;
report << sel_HB << endl;
report << "Headboat DISCARD selectivity" << endl;
report << sel_discard_HB << endl;
report << "MRFSS selectivity" << endl;
report << sel_MRFSS << endl;
report << "commHAL selectivity" << endl;
report << sel_commHAL << endl;
report << "commHAL DISCARD selectivity" << endl;
report << sel_discard_commHAL << endl;
report << "commTRP selectivity" << endl;
report << sel_commTRP << endl;
report << "commTRP DISCARD selectivity" << endl;
report << sel_discard_commTRP << endl;
report << "commTWL selectivity" << endl;
report << sel_commTWL << endl;
report << "mmFST selectivity" << endl;
report << sel_mmFST << endl;
report << "mmCVT selectivity" << endl;
report << sel_mmCVT << endl;
report << "mmBFT selectivity" << endl;
report << sel_mmBFT << endl;
report << "mmHAL selectivity" << endl;
report << sel_mmHAL << endl;

report << "log_q_mmFST="<<log_q_mmFST<< "  log_q_mmCVT="<<log_q_mmCVT<<
   "  log_q_mmBFT="<<log_q_mmBFT<< "  log_q_mmHAL="<<log_q_mmHAL<< "  log_q_HB="<<log_q_HB<< " ";
report << "Obs  mmFST U"<<obs_mmFST_cpue << endl;
report << "pred mmFST U"<<pred_mmFST_cpue << endl;
report << "Obs  mmCVT U"<<obs_mmCVT_cpue << endl;
report << "pred mmCVT U"<<pred_mmCVT_cpue << endl;
report << "Obs  mmBFT U"<<obs_mmBFT_cpue << endl;
report << "pred mmBFT U"<<pred_mmBFT_cpue << endl;
report << "Obs  mmHAL U"<<obs_mmHAL_cpue << endl;
report << "pred mmHAL U"<<pred_mmHAL_cpue << endl;
report << "Obs  HB U"<<obs_HB_cpue << endl;
report << "pred HB U"<<pred_HB_cpue << endl;

report << "Obs  HB landings"<<obs_HB_L << endl;
report << "pred HB landings"<<pred_HB_L << endl;
report << "Obs  MRFSS landings"<<obs_MRFSS_L << endl;
report << "pred MRFSS landings"<<pred_MRFSS_L << endl;
report << "Obs  commHAL landings"<<obs_commHAL_L << endl;
report << "pred commHAL landings"<<pred_commHAL_L << endl;
report << "Obs  commTRP landings"<<obs_commTRP_L << endl;
report << "pred commTRP landings"<<pred_commTRP_L << endl;
report << "Obs  commTWL landings"<<obs_commTWL_L << endl;
report << "pred commTWL landings"<<pred_commTWL_L << endl;

report<<" "<<endl;
report << "Total catches (number) by year and age"<<endl;
   for(iyear=styrR; iyear<=endyr; iyear++)
   {
   report <<iyear<<"  "<<  C_total(iyear)<<endl;
   }
```

```
report<<" "<<endl;
report << "Total landings (mt) by year and age"<<endl;
   for(iyear=styrR; iyear<=endyr; iyear++)
   {
   report <<iyear<<"  "<<L_total(iyear)<<endl;
   }
report<<" "<<endl;
report << "Headboat catches by year and age"<<endl;
report <<C_HB<<endl;
report << "MRFSS catches by year and age"<<endl;
report <<C_MRFSS<<endl;
report << "CommHAL catches by year and age"<<endl;
report <<C_commHAL<<endl;
report << "CommTRP catches by year and age"<<endl;
report <<C_commTRP<<endl;
report << "CommTWL catches by year and age"<<endl;
report <<C_commTWL<<endl;

report << "Observed mmFST length distn"<<endl;
report<<obs_mmFST_lenc<<endl;
report << "Predicted mmFST length distn"<<endl;
report<<pred_mmFST_lenc<<endl;
report << "Observed mmCVT length distn"<<endl;
report<<obs_mmCVT_lenc<<endl;
report << "Predicted mmCVT length distn"<<endl;
report<<pred_mmCVT_lenc<<endl;
report << "Observed mmBFT length distn"<<endl;
report<<obs_mmBFT_lenc<<endl;
report << "Predicted mmBFT length distn"<<endl;
report<<pred_mmBFT_lenc<<endl;
report << "Observed mmHAL length distn"<<endl;
report<<obs_mmHAL_lenc<<endl;
report << "Predicted mmHAL length distn"<<endl;
report<<pred_mmHAL_lenc<<endl;
report << "Observed commHAL length distn"<<endl;
report<<obs_commHAL_lenc<<endl;
report << "Predicted commHAL length distn"<<endl;
report<<pred_commHAL_lenc<<endl;
report << "Observed commTRP length distn"<<endl;
report<<obs_commTRP_lenc<<endl;
report << "Predicted commTRP length distn"<<endl;
report<<pred_commTRP_lenc<<endl;
report << "Observed commTWL length distn"<<endl;
report<<obs_commTWL_lenc<<endl;
report << "Predicted commTWL length distn"<<endl;
report<<pred_commTWL_lenc<<endl;
report << "Observed HB length distn"<<endl;
report<<obs_HB_lenc<<endl;
report << "Predicted HB length distn"<<endl;
report<<pred_HB_lenc<<endl;
report << "Observed MRFSS length distn"<<endl;
report<<obs_MRFSS_lenc<<endl;
report << "Predicted MRFSS length distn"<<endl;
report<<pred_MRFSS_lenc<<endl;

report << "Numbers at age by year" << endl;
report << N << endl;


 report << " " <<endl;
 report << "F_spr  "<<"E_spr  "<<"SPR  "<<"YPR  "<<"R_eq(number) "<<"SSB_eq(mt) "<<"Yield_eq(mt)  "<<endl;
 for(int ff=1; ff<=n_iter_spr; ff++)
 {
  report <<F_spr(ff)<<" "<< E_spr(ff)<<" "<<spr_spr(ff)<<" "<<L_spr(ff)<<" "<<
   R_spr_eq(ff)<<" "<<SSB_spr_eq(ff)<<" "<<L_spr_eq(ff)<<endl;
 }


#include "bsb-s-report8.cxx"   // ADMB code to write the S-compatible report
```

Appendix F Parameter estimate file from catch-at-age assessment model

```
# Number of parameters = 228  Objective function value = 826906.  Maximum gradient component = 508947.
# log_R0:
16.5388
# steep:
0.623554
# log_dev_N_rec:
 -0.00337878 -0.00600149 -0.00587484 -0.0100838 -0.00187461 0.0969857 -0.0339135 0.0850935 0.104942
-0.0175484 0.101098 0.447054 0.195017 0.549311 0.0614778 0.250459 0.114335 0.0734249 -0.229496 -0.244169
-0.0733243 -0.233459 -0.0221310 -0.390315 -0.369290 -0.326861 0.466557 0.128863 0.321689 -0.149627
-0.204749 -0.135888 -0.409746 0.0180963 -0.141276 -0.00539593
# R1_mult:
2.41767
# selpar_slope_mmFST:
10.0000
# selpar_L50_mmFST:
0.612982
# selpar_slope2_mmFST:
0.792392
# selpar_L502_mmFST:
7.77096
# selpar_slope_mmCVT:
9.99929
# selpar_L50_mmCVT:
0.923094
# selpar_slope2_mmCVT:
0.383552
# selpar_L502_mmCVT:
7.31109
# selpar_slope_mmBFT:
10.0000
# selpar_L50_mmBFT:
1.43264
# selpar_slope2_mmBFT:
0.616982
# selpar_L502_mmBFT:
7.56709
# selpar_slope_mmHAL:
7.64478
# selpar_L50_mmHAL:
1.12433
# selpar_slope_HB1:
6.62724
# selpar_L50_HB1:
1.26507
# selpar_slope_HB2:
8.98285
# selpar_L50_HB2:
1.84237
# selpar_slope_HB3:
9.99995
# selpar_L50_HB3:
2.66806
# selpar_slope_commHAL1:
4.95709
# selpar_L50_commHAL1:
3.05625
# selpar_slope_commHAL2:
6.29778
# selpar_L50_commHAL2:
3.04428
# selpar_slope_commHAL3:
```

```
9.79413
# selpar_L50_commHAL3:
3.50653
# selpar_slope_commTRP1:
0.537203
# selpar_L50_commTRP1:
5.24017
# selpar_slope_commTRP2:
6.49728
# selpar_L50_commTRP2:
1.98733
# selpar_slope_commTRP3:
9.98058
# selpar_L50_commTRP3:
2.89967
# selpar_slope_commTWL:
4.79969
# selpar_L50_commTWL:
2.67059
# log_q_mmFST:
-14.4060
# log_q_mmCVT:
-13.9438
# log_q_mmBFT:
-14.2085
# log_q_mmHAL:
-14.1973
# log_q_HB:
-6.07949
# log_avg_F_HB:
-1.99874
# log_F_dev_HB:
 -0.340793 -0.209519 -0.0576859 -0.0168004 0.0850821 0.134394 0.198779 0.119424 -0.0122833 0.0356267
0.253870 0.346502 0.216773 0.0522936 -0.196344 -0.476605 -0.291413 0.00891789 -0.310063 -0.375738
-0.631017 0.366755 0.0699955 0.498650 0.0831625 0.448036
# log_avg_F_MRFSS:
-0.961900
# log_F_dev_MRFSS:
 -0.469426 -0.426665 -0.349937 -0.866763 -0.0163570 -0.564658 0.390434 0.00833002 -0.996277 -0.446627
0.257443 0.254301 -0.416771 0.164981 -0.0354452 -0.0616295 0.413539 0.657722 0.235399 0.0166811
-0.495069 0.193086 0.277060 1.00228 0.392469 0.881899
# log_avg_F_commHAL:
-1.75796
# log_F_dev_commHAL:
 -2.29587 -1.74295 -1.46068 -1.73951 -1.90238 -1.46058 -1.16462 -1.29040 -0.739697 -0.760743 -0.677128
-0.413042 -0.416199 -0.465513 -0.873815 -0.272671 0.245650 0.764114 0.978284 0.936405 0.674501 1.12394
1.34144 1.81176 1.37766 1.14259 1.87302 1.02030 1.17306 1.83820 1.37488
# log_avg_F_commTRP:
-1.15737
# log_F_dev_commTRP:
 0.0693945 0.652267 0.338914 -0.428312 -0.711442 -1.51414 0.183593 0.554511 0.775671 0.550949 -0.909175
-1.04543 -0.928007 -0.782842 -1.14250 -0.723661 -0.307575 0.138733 0.107295 0.0461647 0.0419314
0.368893 0.537743 0.400167 0.274711 -0.147954 0.662976 0.488203 0.869029 0.628430 0.951456
# log_avg_F_commTWL:
-4.65618
# log_F_dev_commTWL:
 -0.209481 0.150636 -0.274147 -0.165939 -0.0858384 -0.123985 -0.430925 -0.102706 0.282497 0.0461307
-0.979597 -0.953087 -0.184466 -0.934159 0.283259 0.329120 0.330387 1.20551 0.108202 0.639701 1.51226
0.665923 0.929002 1.31670 -0.0758632 -0.501587 -0.693820 -1.13962 -0.312444 -0.659992 0.0283374
```

Appendix G   ASPIC (Production Model) Output

G.1   Run with R:C = 1:1

```
 Black Seabass -- SEDAR, March 2005 -- Four indices & extended catch                                         Page 1
                                                                                   Tuesday, 15 Mar 2005 at 20:50:37
ASPIC -- A Surplus-Production Model Including Covariates (Ver. 5.07)
                                                                                                   FIT program mode
Author:     Michael H. Prager; NOAA Center for Coastal Fisheries and Habitat Research           LOGISTIC model mode
            101 Pivers Island Road; Beaufort, North Carolina  28516  USA                           YLD conditioning
            Mike.Prager@noaa.gov                                                                   SSE optimization

Reference:  Prager, M. H. 1994. A suite of extensions to a nonequilibrium          ASPIC User's Manual is available
            surplus-production model.  Fishery Bulletin 92: 374-389.                        gratis from the author.

CONTROL PARAMETERS USED (FROM INPUT FILE)                                                   Input file: bsb001.inp
------------------------------------------------------------------------------------------------------------------
Operation of ASPIC:  Fit logistic (Schaefer) model by direct optimization.
Number of years analyzed:                         54         Number of bootstrap trials:                         0
Number of data series:                             4         Lower bound on MSY:                         2.000E+02
Objective function:                    Least squares         Upper bound on MSY:                         2.000E+05
Relative conv. criterion (simplex):        1.000E-08         Lower bound on K:                           1.000E+03
Relative conv. criterion (restart):        4.000E-08         Upper bound on K:                           1.500E+06
Relative conv. criterion (effort):         1.000E-04         Random number seed:                           1951385
Maximum F allowed in fitting:                  4.000         Monte Carlo search mode, trials:        1      100000
Identical convergences required in fitting:        6


PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS)                                           error code   0
------------------------------------------------------------------------------------------------------------------
Normal convergence

WARNING: Negative correlations detected between some indices.  A fundamental assumption of ASPIC is that all indices
         represent the abundance of the stock.  That assumption appears to be violated.
Number of restarts required for convergence:    275


CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)
------------------------------------------------------------------------------------------------------------------
                                       |
 1  HB Index (WPUE), Yield ext @ Rec...|   1.000
                                       |      30
                                       |
 2  MARMAP Chevron Trap                |   0.570   1.000
                                       |      14      14
                                       |
 3  MARMAP Blackfish Trap              |   0.099   0.000   1.000
                                       |       7       0       7
                                       |
 4  MARMAP Hook & Line Index           |   0.440   0.000  -0.059   1.000
                                       |       7       0       7       7
                                       --------------------------------------------------
                                               1       2       3       4


GOODNESS-OF-FIT AND WEIGHTING (NON-BOOTSTRAPPED ANALYSIS)
------------------------------------------------------------------------------------------------------------------
                                                 Weighted            Weighted      Current      Inv. var.   R-squared
Loss component number and title                       SSE       N         MSE       weight         weight     in CPUE

Loss(-1)  SSE in yield                          0.000E+00
Loss(0)   Penalty for B1 > K                    9.970E-05       1         N/A    1.000E+00           N/A
Loss(1)   HB Index (WPUE), Yield ext @ Rec = Com  1.568E+00    30   5.599E-02    1.000E+00     1.202E+00      0.804
Loss(2)   MARMAP Chevron Trap                   1.237E+00      14   1.031E-01    1.000E+00     6.529E-01     -0.291
Loss(3)   MARMAP Blackfish Trap                 2.736E-01       7   5.472E-02    1.000E+00     1.230E+00     -0.302
Loss(4)   MARMAP Hook & Line Index              5.639E-01       7   1.128E-01    1.000E+00     5.969E-01      0.240
.............................................................................................
TOTAL OBJECTIVE FUNCTION, MSE, RMSE:       3.64229083E+00           7.142E-02    2.672E-01

NOTE: B1-ratio penalty term contributing to loss. Sensitivity analysis advised.
Estimated contrast index (ideal = 1.0):            0.8720           C* = (Bmax-Bmin)/K
Estimated nearness index (ideal = 1.0):            1.0000           N* = 1 - |min(B-Bmsy)|/K
```

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	User/pgm guess	2nd guess	Estimated	User guess
B1/K	Starting relative biomass (in 1950)	1.010E+00	5.000E-01	7.144E-01	1	1
MSY	Maximum sustainable yield	1.010E+03	1.000E+03	6.375E+02	1	1
K	Maximum population size	6.955E+03	1.000E+04	3.825E+03	1	1
phi	Shape of production curve (Bmsy/K)	0.5000	0.5000	----	0	1
---------	Catchability Coefficients by Data Series ---------------					
q(1)	HB Index (WPUE), Yield ext @ Rec = Com	8.974E-04	1.450E-04	1.378E-02	1	1
q(2)	MARMAP Chevron Trap	1.110E-03	1.210E-04	1.150E-02	1	1
q(3)	MARMAP Blackfish Trap	5.980E-04	8.500E-04	8.075E-02	1	1
q(4)	MARMAP Hook & Line Index	7.708E-04	1.500E-04	1.425E-02	1	1

MANAGEMENT and DERIVED PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Logistic formula	General formula
MSY	Maximum sustainable yield	1.010E+03	----	----
Bmsy	Stock biomass giving MSY	3.477E+03	K/2	K*n**(1/(1-n))
Fmsy	Fishing mortality rate at MSY	2.903E-01	MSY/Bmsy	MSY/Bmsy
n	Exponent in production function	2.0000	----	----
g	Fletcher's gamma	4.000E+00	----	[n**(n/(n-1))]/[n-1]
B./Bmsy	Ratio: B(2004)/Bmsy	2.761E-01	----	----
F./Fmsy	Ratio: F(2003)/Fmsy	1.963E+00	----	----
Fmsy/F.	Ratio: Fmsy/F(2003)	5.095E-01	----	----
Y.(Fmsy)	Approx. yield available at Fmsy in 2004	2.787E+02	MSY*B./Bmsy	MSY*B./Bmsy
	...as proportion of MSY	2.761E-01	----	----
Ye.	Equilibrium yield available in 2004	4.805E+02	4*MSY*(B/K-(B/K)**2)	g*MSY*(B/K-(B/K)**n)
	...as proportion of MSY	4.760E-01	----	----
---------	Fishing effort rate at MSY in units of each CE or CC series ---------			
fmsy(1)	HB Index (WPUE), Yield ext @ Rec = Com	3.235E+02	Fmsy/q(1)	Fmsy/q(1)

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1950	0.042	7.024E+03	6.886E+03	2.898E+02	2.898E+02	3.888E+01	1.450E-01	2.020E+00
2	1951	0.030	6.774E+03	6.730E+03	2.052E+02	2.052E+02	1.261E+02	1.050E-01	1.948E+00
3	1952	0.024	6.694E+03	6.689E+03	1.586E+02	1.586E+02	1.484E+02	8.167E-02	1.925E+00
4	1953	0.017	6.684E+03	6.701E+03	1.112E+02	1.112E+02	1.419E+02	5.716E-02	1.922E+00
5	1954	0.010	6.715E+03	6.744E+03	6.640E+01	6.640E+01	1.188E+02	3.392E-02	1.931E+00
6	1955	0.006	6.767E+03	6.795E+03	4.100E+01	4.100E+01	9.079E+01	2.078E-02	1.946E+00
7	1956	0.010	6.817E+03	6.821E+03	6.980E+01	6.980E+01	7.628E+01	3.525E-02	1.960E+00
8	1957	0.010	6.824E+03	6.826E+03	6.840E+01	6.840E+01	7.318E+01	3.451E-02	1.962E+00
9	1958	0.010	6.828E+03	6.830E+03	6.780E+01	6.780E+01	7.099E+01	3.419E-02	1.964E+00
10	1959	0.014	6.832E+03	6.822E+03	9.300E+01	9.300E+01	7.553E+01	4.696E-02	1.965E+00
11	1960	0.020	6.814E+03	6.792E+03	1.332E+02	1.332E+02	9.235E+01	6.755E-02	1.960E+00
12	1961	0.095	6.773E+03	6.552E+03	6.218E+02	6.218E+02	2.193E+02	3.269E-01	1.948E+00
13	1962	0.248	6.371E+03	5.860E+03	1.453E+03	1.453E+03	5.298E+02	8.538E-01	1.832E+00
14	1963	0.089	5.448E+03	5.535E+03	4.924E+02	4.924E+02	6.557E+02	3.064E-01	1.567E+00
15	1964	0.092	5.611E+03	5.659E+03	5.230E+02	5.230E+02	6.121E+02	3.183E-01	1.614E+00
16	1965	0.094	5.700E+03	5.726E+03	5.400E+02	5.400E+02	5.874E+02	3.248E-01	1.639E+00
17	1966	0.133	5.748E+03	5.669E+03	7.540E+02	7.540E+02	6.084E+02	4.581E-01	1.653E+00
18	1967	0.259	5.602E+03	5.262E+03	1.363E+03	1.363E+03	7.409E+02	8.925E-01	1.611E+00
19	1968	0.154	4.980E+03	5.003E+03	7.724E+02	7.724E+02	8.153E+02	5.318E-01	1.432E+00
20	1969	0.258	5.023E+03	4.815E+03	1.244E+03	1.244E+03	8.591E+02	8.896E-01	1.444E+00
21	1970	0.333	4.638E+03	4.363E+03	1.452E+03	1.452E+03	9.423E+02	1.146E+00	1.334E+00
22	1971	0.253	4.129E+03	4.097E+03	1.037E+03	1.037E+03	9.774E+02	8.714E-01	1.187E+00
23	1972	0.289	4.070E+03	3.983E+03	1.152E+03	1.152E+03	9.881E+02	9.964E-01	1.170E+00
24	1973	0.220	3.906E+03	3.967E+03	8.728E+02	8.728E+02	9.894E+02	7.579E-01	1.123E+00
25	1974	0.343	4.022E+03	3.850E+03	1.320E+03	1.320E+03	9.972E+02	1.181E+00	1.157E+00
26	1975	0.223	3.700E+03	3.783E+03	8.426E+02	8.426E+02	1.002E+03	7.672E-01	1.064E+00
27	1976	0.101	3.859E+03	4.143E+03	4.202E+02	4.202E+02	9.704E+02	3.493E-01	1.110E+00
28	1977	0.071	4.409E+03	4.696E+03	3.342E+02	3.342E+02	8.834E+02	2.451E-01	1.268E+00
29	1978	0.191	4.958E+03	4.905E+03	9.374E+02	9.374E+02	8.392E+02	6.582E-01	1.426E+00
30	1979	0.259	4.860E+03	4.684E+03	1.213E+03	1.213E+03	8.871E+02	8.919E-01	1.398E+00
31	1980	0.303	4.534E+03	4.337E+03	1.314E+03	1.314E+03	9.469E+02	1.044E+00	1.304E+00
32	1981	0.300	4.167E+03	4.044E+03	1.213E+03	1.213E+03	9.823E+02	1.033E+00	1.198E+00
33	1982	0.423	3.937E+03	3.648E+03	1.542E+03	1.542E+03	1.005E+03	1.456E+00	1.132E+00
34	1983	0.306	3.400E+03	3.386E+03	1.035E+03	1.035E+03	1.009E+03	1.053E+00	9.777E-01
35	1984	0.522	3.374E+03	3.050E+03	1.593E+03	1.593E+03	9.919E+02	1.799E+00	9.702E-01
36	1985	0.430	2.772E+03	2.670E+03	1.149E+03	1.149E+03	9.549E+02	1.482E+00	7.972E-01
37	1986	0.305	2.578E+03	2.652E+03	8.093E+02	8.093E+02	9.525E+02	1.051E+00	7.414E-01
38	1987	0.389	2.721E+03	2.676E+03	1.042E+03	1.042E+03	9.559E+02	1.341E+00	7.825E-01
39	1988	0.571	2.635E+03	2.392E+03	1.366E+03	1.366E+03	9.098E+02	1.966E+00	7.578E-01
40	1989	0.559	2.179E+03	2.022E+03	1.131E+03	1.131E+03	8.320E+02	1.927E+00	6.267E-01
41	1990	0.474	1.880E+03	1.836E+03	8.707E+02	8.707E+02	7.845E+02	1.634E+00	5.407E-01
42	1991	0.565	1.794E+03	1.684E+03	9.512E+02	9.512E+02	7.407E+02	1.946E+00	5.159E-01
43	1992	0.508	1.583E+03	1.539E+03	7.822E+02	7.822E+02	6.958E+02	1.751E+00	4.553E-01
44	1993	0.454	1.497E+03	1.498E+03	6.799E+02	6.799E+02	6.825E+02	1.563E+00	4.305E-01
45	1994	0.521	1.499E+03	1.453E+03	7.573E+02	7.573E+02	6.674E+02	1.795E+00	4.312E-01
46	1995	0.459	1.410E+03	1.413E+03	6.478E+02	6.478E+02	6.536E+02	1.580E+00	4.054E-01
47	1996	0.521	1.415E+03	1.376E+03	7.171E+02	7.171E+02	6.409E+02	1.795E+00	4.070E-01
48	1997	0.556	1.339E+03	1.284E+03	7.140E+02	7.140E+02	6.080E+02	1.915E+00	3.851E-01
49	1998	0.493	1.233E+03	1.224E+03	6.035E+02	6.035E+02	5.857E+02	1.698E+00	3.546E-01
50	1999	0.533	1.215E+03	1.185E+03	6.308E+02	6.308E+02	5.706E+02	1.834E+00	3.495E-01
51	2000	0.444	1.155E+03	1.178E+03	5.234E+02	5.234E+02	5.680E+02	1.531E+00	3.322E-01
52	2001	0.649	1.200E+03	1.107E+03	7.186E+02	7.186E+02	5.401E+02	2.237E+00	3.450E-01
53	2002	0.484	1.021E+03	1.027E+03	4.974E+02	4.974E+02	5.081E+02	1.669E+00	2.937E-01
54	2003	0.570	1.032E+03	9.951E+02	5.670E+02	5.670E+02	4.951E+02	1.963E+00	2.968E-01
55	2004		9.601E+02						2.761E-01

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) HB Index (WPUE), Yield ext @ Rec = Com

Data type CC: CPUE-catch series Series weight: 1.000

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale
1	1950	*	6.179E+00	0.0421	2.898E+02	2.898E+02	0.00000
2	1951	*	6.039E+00	0.0305	2.052E+02	2.052E+02	0.00000
3	1952	*	6.002E+00	0.0237	1.586E+02	1.586E+02	0.00000
4	1953	*	6.013E+00	0.0166	1.112E+02	1.112E+02	0.00000
5	1954	*	6.051E+00	0.0098	6.640E+01	6.640E+01	0.00000
6	1955	*	6.097E+00	0.0060	4.100E+01	4.100E+01	0.00000
7	1956	*	6.121E+00	0.0102	6.980E+01	6.980E+01	0.00000
8	1957	*	6.126E+00	0.0100	6.840E+01	6.840E+01	0.00000
9	1958	*	6.129E+00	0.0099	6.780E+01	6.780E+01	0.00000
10	1959	*	6.122E+00	0.0136	9.300E+01	9.300E+01	0.00000
11	1960	*	6.095E+00	0.0196	1.332E+02	1.332E+02	0.00000
12	1961	*	5.879E+00	0.0949	6.218E+02	6.218E+02	0.00000
13	1962	*	5.258E+00	0.2479	1.453E+03	1.453E+03	0.00000
14	1963	*	4.967E+00	0.0890	4.924E+02	4.924E+02	0.00000
15	1964	*	5.078E+00	0.0924	5.230E+02	5.230E+02	0.00000
16	1965	*	5.138E+00	0.0943	5.400E+02	5.400E+02	0.00000
17	1966	*	5.087E+00	0.1330	7.540E+02	7.540E+02	0.00000
18	1967	*	4.722E+00	0.2591	1.363E+03	1.363E+03	0.00000
19	1968	*	4.489E+00	0.1544	7.724E+02	7.724E+02	0.00000
20	1969	*	4.321E+00	0.2583	1.244E+03	1.244E+03	0.00000
21	1970	*	3.915E+00	0.3327	1.452E+03	1.452E+03	0.00000
22	1971	*	3.677E+00	0.2530	1.037E+03	1.037E+03	0.00000
23	1972	*	3.574E+00	0.2893	1.152E+03	1.152E+03	0.00000
24	1973	*	3.560E+00	0.2200	8.728E+02	8.728E+02	0.00000
25	1974	3.284E+00	3.455E+00	0.3428	1.320E+03	1.320E+03	0.05073
26	1975	4.469E+00	3.395E+00	0.2227	8.426E+02	8.426E+02	-0.27501
27	1976	2.992E+00	3.718E+00	0.1014	4.202E+02	4.202E+02	0.21729
28	1977	3.393E+00	4.214E+00	0.0712	3.342E+02	3.342E+02	0.21669
29	1978	4.093E+00	4.402E+00	0.1911	9.374E+02	9.374E+02	0.07277
30	1979	3.401E+00	4.204E+00	0.2589	1.213E+03	1.213E+03	0.21188
31	1980	3.630E+00	3.892E+00	0.3030	1.314E+03	1.314E+03	0.06962
32	1981	3.646E+00	3.629E+00	0.2999	1.213E+03	1.213E+03	-0.00464
33	1982	3.709E+00	3.274E+00	0.4226	1.542E+03	1.542E+03	-0.12486
34	1983	3.740E+00	3.039E+00	0.3057	1.035E+03	1.035E+03	-0.20768
35	1984	3.373E+00	2.737E+00	0.5223	1.593E+03	1.593E+03	-0.20881
36	1985	3.363E+00	2.396E+00	0.4303	1.149E+03	1.149E+03	-0.33892
37	1986	3.386E+00	2.379E+00	0.3052	8.093E+02	8.093E+02	-0.35279
38	1987	3.484E+00	2.402E+00	0.3894	1.042E+03	1.042E+03	-0.37206
39	1988	3.005E+00	2.147E+00	0.5709	1.366E+03	1.366E+03	-0.33632
40	1989	2.003E+00	1.814E+00	0.5595	1.131E+03	1.131E+03	-0.09898
41	1990	2.071E+00	1.647E+00	0.4744	8.707E+02	8.707E+02	-0.22899
42	1991	1.576E+00	1.511E+00	0.5649	9.512E+02	9.512E+02	-0.04205
43	1992	1.545E+00	1.381E+00	0.5083	7.822E+02	7.822E+02	-0.11232
44	1993	1.178E+00	1.344E+00	0.4538	6.799E+02	6.799E+02	0.13215
45	1994	1.035E+00	1.304E+00	0.5211	7.573E+02	7.573E+02	0.23104
46	1995	7.430E-01	1.268E+00	0.4586	6.478E+02	6.478E+02	0.53414
47	1996	8.220E-01	1.235E+00	0.5211	7.171E+02	7.171E+02	0.40703
48	1997	1.053E+00	1.153E+00	0.5559	7.140E+02	7.140E+02	0.09042
49	1998	1.082E+00	1.098E+00	0.4930	6.035E+02	6.035E+02	0.01508
50	1999	1.277E+00	1.063E+00	0.5325	6.308E+02	6.308E+02	-0.18348
51	2000	9.530E-01	1.057E+00	0.4444	5.234E+02	5.234E+02	0.10338
52	2001	8.600E-01	9.931E-01	0.6493	7.186E+02	7.186E+02	0.14392
53	2002	7.510E-01	9.213E-01	0.4845	4.974E+02	4.974E+02	0.20439
54	2003	7.440E-01	8.930E-01	0.5698	5.670E+02	5.670E+02	0.18250

* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1950     0.0000                                             |
1951     0.0000                                             |
1952     0.0000                                             |
1953     0.0000                                             |
1954     0.0000                                             |
1955     0.0000                                             |
1956     0.0000                                             |
1957     0.0000                                             |
1958     0.0000                                             |
1959     0.0000                                             |
1960     0.0000                                             |
1961     0.0000                                             |
1962     0.0000                                             |
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0507                                             |==
1975    -0.2750                                  ===========|
1976     0.2173                                             |=========
1977     0.2167                                             |=========
1978     0.0728                                             |===
1979     0.2119                                             |========
1980     0.0696                                             |===
1981    -0.0046                                             |
1982    -0.1249                                        =====|
1983    -0.2077                                     ========|
1984    -0.2088                                     ========|
1985    -0.3389                               ==============|
1986    -0.3528                               ==============|
1987    -0.3721                              ===============|
1988    -0.3363                                =============|
1989    -0.0990                                         ====|
1990    -0.2290                                    =========|
1991    -0.0421                                           ==|
1992    -0.1123                                         ====|
1993     0.1321                                             |=====
1994     0.2310                                             |=========
1995     0.5341                                             |=====================
1996     0.4070                                             |================
1997     0.0904                                             |====
1998     0.0151                                             |=
1999    -0.1835                                      =======|
2000     0.1034                                             |====
2001     0.1439                                             |======
2002     0.2044                                             |========
2003     0.1825                                             |=======
                   ------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED) MARMAP Chevron Trap

Data type I1: Abundance index (annual average) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index
1	1950	0.000E+00	0.000E+00	--	*	7.643E+00	0.00000
2	1951	0.000E+00	0.000E+00	--	*	7.469E+00	0.00000
3	1952	0.000E+00	0.000E+00	--	*	7.424E+00	0.00000
4	1953	0.000E+00	0.000E+00	--	*	7.437E+00	0.00000
5	1954	0.000E+00	0.000E+00	--	*	7.484E+00	0.00000
6	1955	0.000E+00	0.000E+00	--	*	7.541E+00	0.00000
7	1956	0.000E+00	0.000E+00	--	*	7.570E+00	0.00000
8	1957	0.000E+00	0.000E+00	--	*	7.576E+00	0.00000
9	1958	0.000E+00	0.000E+00	--	*	7.580E+00	0.00000
10	1959	0.000E+00	0.000E+00	--	*	7.571E+00	0.00000
11	1960	0.000E+00	0.000E+00	--	*	7.538E+00	0.00000
12	1961	0.000E+00	0.000E+00	--	*	7.271E+00	0.00000
13	1962	0.000E+00	0.000E+00	--	*	6.504E+00	0.00000
14	1963	0.000E+00	0.000E+00	--	*	6.143E+00	0.00000
15	1964	0.000E+00	0.000E+00	--	*	6.281E+00	0.00000
16	1965	0.000E+00	0.000E+00	--	*	6.355E+00	0.00000
17	1966	0.000E+00	0.000E+00	--	*	6.292E+00	0.00000
18	1967	0.000E+00	0.000E+00	--	*	5.840E+00	0.00000
19	1968	0.000E+00	0.000E+00	--	*	5.552E+00	0.00000
20	1969	0.000E+00	0.000E+00	--	*	5.344E+00	0.00000
21	1970	0.000E+00	0.000E+00	--	*	4.842E+00	0.00000
22	1971	0.000E+00	0.000E+00	--	*	4.547E+00	0.00000
23	1972	0.000E+00	0.000E+00	--	*	4.420E+00	0.00000
24	1973	0.000E+00	0.000E+00	--	*	4.403E+00	0.00000
25	1974	0.000E+00	0.000E+00	--	*	4.273E+00	0.00000
26	1975	0.000E+00	0.000E+00	--	*	4.198E+00	0.00000
27	1976	0.000E+00	0.000E+00	--	*	4.599E+00	0.00000
28	1977	0.000E+00	0.000E+00	--	*	5.212E+00	0.00000
29	1978	0.000E+00	0.000E+00	--	*	5.444E+00	0.00000
30	1979	0.000E+00	0.000E+00	--	*	5.199E+00	0.00000
31	1980	0.000E+00	0.000E+00	--	*	4.813E+00	0.00000
32	1981	0.000E+00	0.000E+00	--	*	4.488E+00	0.00000
33	1982	0.000E+00	0.000E+00	--	*	4.049E+00	0.00000
34	1983	0.000E+00	0.000E+00	--	*	3.758E+00	0.00000
35	1984	0.000E+00	0.000E+00	--	*	3.386E+00	0.00000
36	1985	0.000E+00	0.000E+00	--	*	2.964E+00	0.00000
37	1986	0.000E+00	0.000E+00	--	*	2.943E+00	0.00000
38	1987	0.000E+00	0.000E+00	--	*	2.970E+00	0.00000
39	1988	0.000E+00	0.000E+00	--	*	2.655E+00	0.00000
40	1989	0.000E+00	0.000E+00	--	*	2.244E+00	0.00000
41	1990	1.000E+00	1.000E+00	--	2.126E+00	2.037E+00	0.04268
42	1991	1.000E+00	1.000E+00	--	1.585E+00	1.869E+00	-0.16477
43	1992	1.000E+00	1.000E+00	--	1.753E+00	1.708E+00	0.02610
44	1993	1.000E+00	1.000E+00	--	9.830E-01	1.663E+00	-0.52563
45	1994	1.000E+00	1.000E+00	--	1.153E+00	1.613E+00	-0.33559
46	1995	1.000E+00	1.000E+00	--	1.062E+00	1.568E+00	-0.38945
47	1996	1.000E+00	1.000E+00	--	1.302E+00	1.527E+00	-0.15963
48	1997	1.000E+00	1.000E+00	--	1.328E+00	1.426E+00	-0.07091
49	1998	1.000E+00	1.000E+00	--	1.506E+00	1.359E+00	0.10305
50	1999	1.000E+00	1.000E+00	--	2.321E+00	1.315E+00	0.56845
51	2000	1.000E+00	1.000E+00	--	1.842E+00	1.307E+00	0.34310
52	2001	1.000E+00	1.000E+00	--	1.727E+00	1.228E+00	0.34077
53	2002	1.000E+00	1.000E+00	--	1.477E+00	1.139E+00	0.25945
54	2003	1.000E+00	1.000E+00	--	1.063E+00	1.104E+00	-0.03821

* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1950     0.0000                                             |
1951     0.0000                                             |
1952     0.0000                                             |
1953     0.0000                                             |
1954     0.0000                                             |
1955     0.0000                                             |
1956     0.0000                                             |
1957     0.0000                                             |
1958     0.0000                                             |
1959     0.0000                                             |
1960     0.0000                                             |
1961     0.0000                                             |
1962     0.0000                                             |
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981     0.0000                                             |
1982     0.0000                                             |
1983     0.0000                                             |
1984     0.0000                                             |
1985     0.0000                                             |
1986     0.0000                                             |
1987     0.0000                                             |
1988     0.0000                                             |
1989     0.0000                                             |
1990     0.0427                                             |==
1991    -0.1648                                      =======|
1992     0.0261                                             |=
1993    -0.5256                        =====================|
1994    -0.3356                                =============|
1995    -0.3894                             ================|
1996    -0.1596                                       ======|
1997    -0.0709                                          ===|
1998     0.1030                                             |====
1999     0.5685                                             |=======================
2000     0.3431                                             |==============
2001     0.3408                                             |==============
2002     0.2594                                             |==========
2003    -0.0382                                           ==|
                   ------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 3 (NON-BOOTSTRAPPED) MARMAP Blackfish Trap

Data type I1: Abundance index (annual average) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index
1	1950	0.000E+00	0.000E+00	--	*	4.118E+00	0.00000
2	1951	0.000E+00	0.000E+00	--	*	4.024E+00	0.00000
3	1952	0.000E+00	0.000E+00	--	*	4.000E+00	0.00000
4	1953	0.000E+00	0.000E+00	--	*	4.007E+00	0.00000
5	1954	0.000E+00	0.000E+00	--	*	4.032E+00	0.00000
6	1955	0.000E+00	0.000E+00	--	*	4.063E+00	0.00000
7	1956	0.000E+00	0.000E+00	--	*	4.079E+00	0.00000
8	1957	0.000E+00	0.000E+00	--	*	4.082E+00	0.00000
9	1958	0.000E+00	0.000E+00	--	*	4.084E+00	0.00000
10	1959	0.000E+00	0.000E+00	--	*	4.079E+00	0.00000
11	1960	0.000E+00	0.000E+00	--	*	4.061E+00	0.00000
12	1961	0.000E+00	0.000E+00	--	*	3.918E+00	0.00000
13	1962	0.000E+00	0.000E+00	--	*	3.504E+00	0.00000
14	1963	0.000E+00	0.000E+00	--	*	3.310E+00	0.00000
15	1964	0.000E+00	0.000E+00	--	*	3.384E+00	0.00000
16	1965	0.000E+00	0.000E+00	--	*	3.424E+00	0.00000
17	1966	0.000E+00	0.000E+00	--	*	3.390E+00	0.00000
18	1967	0.000E+00	0.000E+00	--	*	3.147E+00	0.00000
19	1968	0.000E+00	0.000E+00	--	*	2.991E+00	0.00000
20	1969	0.000E+00	0.000E+00	--	*	2.879E+00	0.00000
21	1970	0.000E+00	0.000E+00	--	*	2.609E+00	0.00000
22	1971	0.000E+00	0.000E+00	--	*	2.450E+00	0.00000
23	1972	0.000E+00	0.000E+00	--	*	2.381E+00	0.00000
24	1973	0.000E+00	0.000E+00	--	*	2.372E+00	0.00000
25	1974	0.000E+00	0.000E+00	--	*	2.302E+00	0.00000
26	1975	0.000E+00	0.000E+00	--	*	2.262E+00	0.00000
27	1976	0.000E+00	0.000E+00	--	*	2.478E+00	0.00000
28	1977	0.000E+00	0.000E+00	--	*	2.808E+00	0.00000
29	1978	0.000E+00	0.000E+00	--	*	2.933E+00	0.00000
30	1979	0.000E+00	0.000E+00	--	*	2.801E+00	0.00000
31	1980	0.000E+00	0.000E+00	--	*	2.593E+00	0.00000
32	1981	1.000E+00	1.000E+00	--	2.235E+00	2.418E+00	-0.07882
33	1982	1.000E+00	1.000E+00	--	1.846E+00	2.181E+00	-0.16696
34	1983	1.000E+00	1.000E+00	--	1.940E+00	2.025E+00	-0.04279
35	1984	1.000E+00	1.000E+00	--	1.586E+00	1.824E+00	-0.13985
36	1985	1.000E+00	1.000E+00	--	2.531E+00	1.597E+00	0.46063
37	1986	1.000E+00	1.000E+00	--	1.644E+00	1.586E+00	0.03620
38	1987	1.000E+00	1.000E+00	--	1.495E+00	1.600E+00	-0.06807
39	1988	0.000E+00	0.000E+00	--	*	1.431E+00	0.00000
40	1989	0.000E+00	0.000E+00	--	*	1.209E+00	0.00000
41	1990	0.000E+00	0.000E+00	--	*	1.098E+00	0.00000
42	1991	0.000E+00	0.000E+00	--	*	1.007E+00	0.00000
43	1992	0.000E+00	0.000E+00	--	*	9.201E-01	0.00000
44	1993	0.000E+00	0.000E+00	--	*	8.959E-01	0.00000
45	1994	0.000E+00	0.000E+00	--	*	8.689E-01	0.00000
46	1995	0.000E+00	0.000E+00	--	*	8.446E-01	0.00000
47	1996	0.000E+00	0.000E+00	--	*	8.229E-01	0.00000
48	1997	0.000E+00	0.000E+00	--	*	7.681E-01	0.00000
49	1998	0.000E+00	0.000E+00	--	*	7.320E-01	0.00000
50	1999	0.000E+00	0.000E+00	--	*	7.083E-01	0.00000
51	2000	0.000E+00	0.000E+00	--	*	7.042E-01	0.00000
52	2001	0.000E+00	0.000E+00	--	*	6.618E-01	0.00000
53	2002	0.000E+00	0.000E+00	--	*	6.139E-01	0.00000
54	2003	0.000E+00	0.000E+00	--	*	5.950E-01	0.00000

* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 3
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1950     0.0000                                             |
1951     0.0000                                             |
1952     0.0000                                             |
1953     0.0000                                             |
1954     0.0000                                             |
1955     0.0000                                             |
1956     0.0000                                             |
1957     0.0000                                             |
1958     0.0000                                             |
1959     0.0000                                             |
1960     0.0000                                             |
1961     0.0000                                             |
1962     0.0000                                             |
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981    -0.0788                                          ===|
1982    -0.1670                                      =======|
1983    -0.0428                                           ==|
1984    -0.1398                                       ======|
1985     0.4606                                             |==================
1986     0.0362                                             |=
1987    -0.0681                                          ===|
1988     0.0000                                             |
1989     0.0000                                             |
1990     0.0000                                             |
1991     0.0000                                             |
1992     0.0000                                             |
1993     0.0000                                             |
1994     0.0000                                             |
1995     0.0000                                             |
1996     0.0000                                             |
1997     0.0000                                             |
1998     0.0000                                             |
1999     0.0000                                             |
2000     0.0000                                             |
2001     0.0000                                             |
2002     0.0000                                             |
2003     0.0000                                             |
                   ------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 4 (NON-BOOTSTRAPPED) MARMAP Hook & Line Index

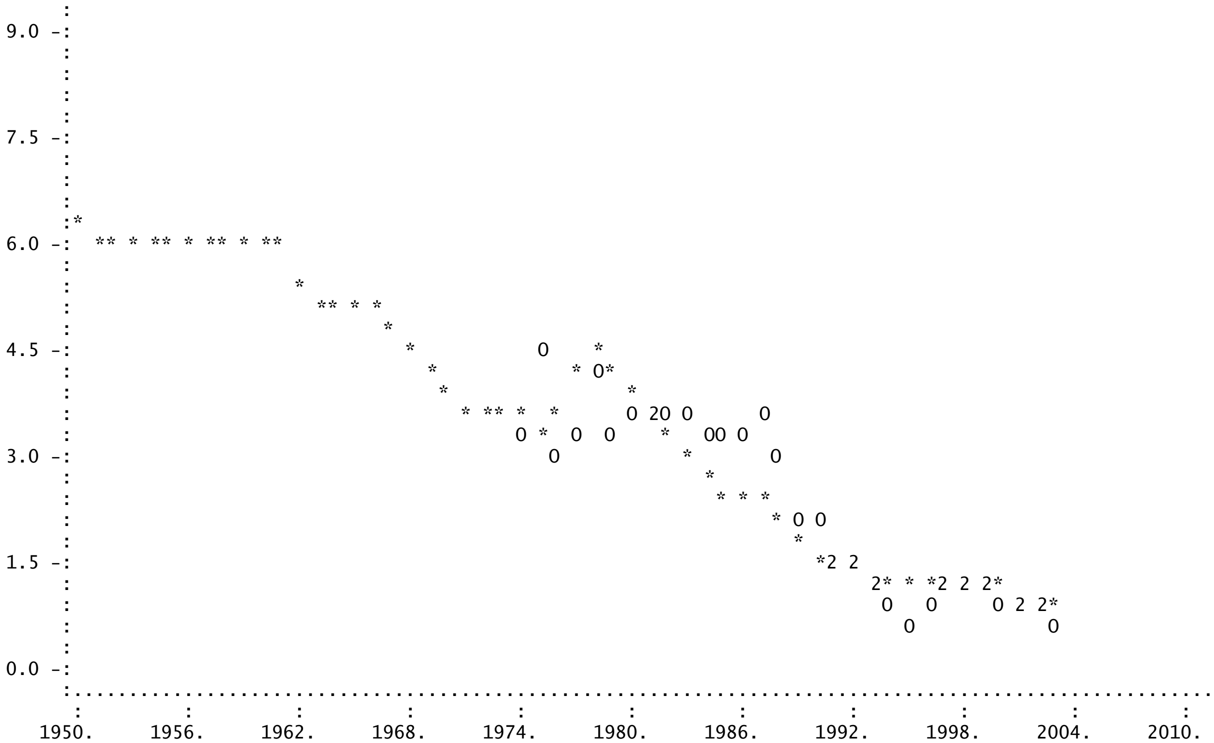
Data type I1: Abundance index (annual average) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index
1	1950	0.000E+00	0.000E+00	--	*	5.308E+00	0.00000
2	1951	0.000E+00	0.000E+00	--	*	5.187E+00	0.00000
3	1952	0.000E+00	0.000E+00	--	*	5.156E+00	0.00000
4	1953	0.000E+00	0.000E+00	--	*	5.165E+00	0.00000
5	1954	0.000E+00	0.000E+00	--	*	5.198E+00	0.00000
6	1955	0.000E+00	0.000E+00	--	*	5.237E+00	0.00000
7	1956	0.000E+00	0.000E+00	--	*	5.257E+00	0.00000
8	1957	0.000E+00	0.000E+00	--	*	5.262E+00	0.00000
9	1958	0.000E+00	0.000E+00	--	*	5.265E+00	0.00000
10	1959	0.000E+00	0.000E+00	--	*	5.258E+00	0.00000
11	1960	0.000E+00	0.000E+00	--	*	5.235E+00	0.00000
12	1961	0.000E+00	0.000E+00	--	*	5.050E+00	0.00000
13	1962	0.000E+00	0.000E+00	--	*	4.517E+00	0.00000
14	1963	0.000E+00	0.000E+00	--	*	4.267E+00	0.00000
15	1964	0.000E+00	0.000E+00	--	*	4.362E+00	0.00000
16	1965	0.000E+00	0.000E+00	--	*	4.413E+00	0.00000
17	1966	0.000E+00	0.000E+00	--	*	4.369E+00	0.00000
18	1967	0.000E+00	0.000E+00	--	*	4.056E+00	0.00000
19	1968	0.000E+00	0.000E+00	--	*	3.856E+00	0.00000
20	1969	0.000E+00	0.000E+00	--	*	3.711E+00	0.00000
21	1970	0.000E+00	0.000E+00	--	*	3.363E+00	0.00000
22	1971	0.000E+00	0.000E+00	--	*	3.158E+00	0.00000
23	1972	0.000E+00	0.000E+00	--	*	3.070E+00	0.00000
24	1973	0.000E+00	0.000E+00	--	*	3.058E+00	0.00000
25	1974	0.000E+00	0.000E+00	--	*	2.968E+00	0.00000
26	1975	0.000E+00	0.000E+00	--	*	2.916E+00	0.00000
27	1976	0.000E+00	0.000E+00	--	*	3.194E+00	0.00000
28	1977	0.000E+00	0.000E+00	--	*	3.620E+00	0.00000
29	1978	0.000E+00	0.000E+00	--	*	3.781E+00	0.00000
30	1979	0.000E+00	0.000E+00	--	*	3.611E+00	0.00000
31	1980	0.000E+00	0.000E+00	--	*	3.343E+00	0.00000
32	1981	1.000E+00	1.000E+00	--	2.210E+00	3.117E+00	-0.34394
33	1982	1.000E+00	1.000E+00	--	4.077E+00	2.812E+00	0.37151
34	1983	1.000E+00	1.000E+00	--	2.894E+00	2.610E+00	0.10329
35	1984	1.000E+00	1.000E+00	--	3.382E+00	2.351E+00	0.36353
36	1985	1.000E+00	1.000E+00	--	2.035E+00	2.058E+00	-0.01136
37	1986	1.000E+00	1.000E+00	--	1.873E+00	2.044E+00	-0.08726
38	1987	1.000E+00	1.000E+00	--	1.388E+00	2.063E+00	-0.39621
39	1988	0.000E+00	0.000E+00	--	*	1.844E+00	0.00000
40	1989	0.000E+00	0.000E+00	--	*	1.558E+00	0.00000
41	1990	0.000E+00	0.000E+00	--	*	1.415E+00	0.00000
42	1991	0.000E+00	0.000E+00	--	*	1.298E+00	0.00000
43	1992	0.000E+00	0.000E+00	--	*	1.186E+00	0.00000
44	1993	0.000E+00	0.000E+00	--	*	1.155E+00	0.00000
45	1994	0.000E+00	0.000E+00	--	*	1.120E+00	0.00000
46	1995	0.000E+00	0.000E+00	--	*	1.089E+00	0.00000
47	1996	0.000E+00	0.000E+00	--	*	1.061E+00	0.00000
48	1997	0.000E+00	0.000E+00	--	*	9.901E-01	0.00000
49	1998	0.000E+00	0.000E+00	--	*	9.435E-01	0.00000
50	1999	0.000E+00	0.000E+00	--	*	9.130E-01	0.00000
51	2000	0.000E+00	0.000E+00	--	*	9.077E-01	0.00000
52	2001	0.000E+00	0.000E+00	--	*	8.530E-01	0.00000
53	2002	0.000E+00	0.000E+00	--	*	7.914E-01	0.00000
54	2003	0.000E+00	0.000E+00	--	*	7.670E-01	0.00000

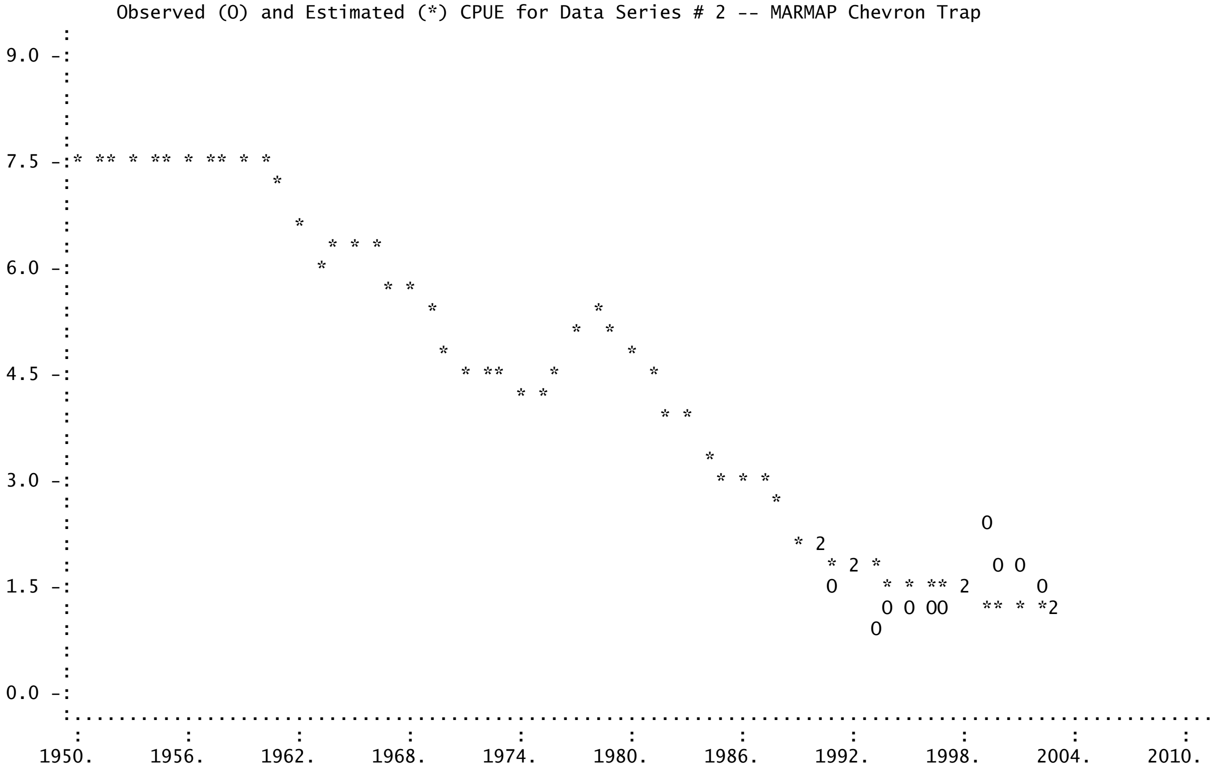
* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 4
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1950     0.0000                                             |
1951     0.0000                                             |
1952     0.0000                                             |
1953     0.0000                                             |
1954     0.0000                                             |
1955     0.0000                                             |
1956     0.0000                                             |
1957     0.0000                                             |
1958     0.0000                                             |
1959     0.0000                                             |
1960     0.0000                                             |
1961     0.0000                                             |
1962     0.0000                                             |
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981    -0.3439                               ==============|
1982     0.3715                                             |===============
1983     0.1033                                             |====
1984     0.3635                                             |===============
1985    -0.0114                                             |
1986    -0.0873                                          ===|
1987    -0.3962                             ================|
1988     0.0000                                             |
1989     0.0000                                             |
1990     0.0000                                             |
1991     0.0000                                             |
1992     0.0000                                             |
1993     0.0000                                             |
1994     0.0000                                             |
1995     0.0000                                             |
1996     0.0000                                             |
1997     0.0000                                             |
1998     0.0000                                             |
1999     0.0000                                             |
2000     0.0000                                             |
2001     0.0000                                             |
2002     0.0000                                             |
2003     0.0000                                             |
                   ------------------------------------------------------------------------------------
```

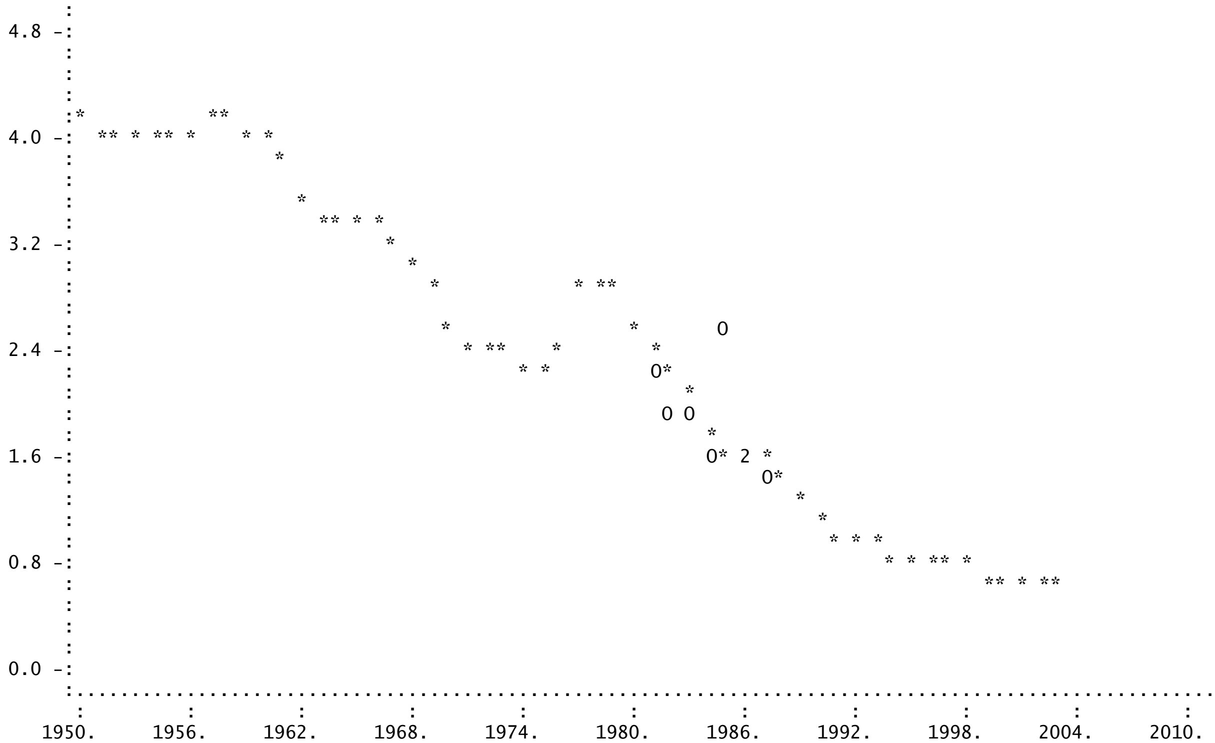
Observed (O) and Estimated (*) CPUE for Data Series # 1 -- HB Index (WPUE), Yield ext @ Rec = Com



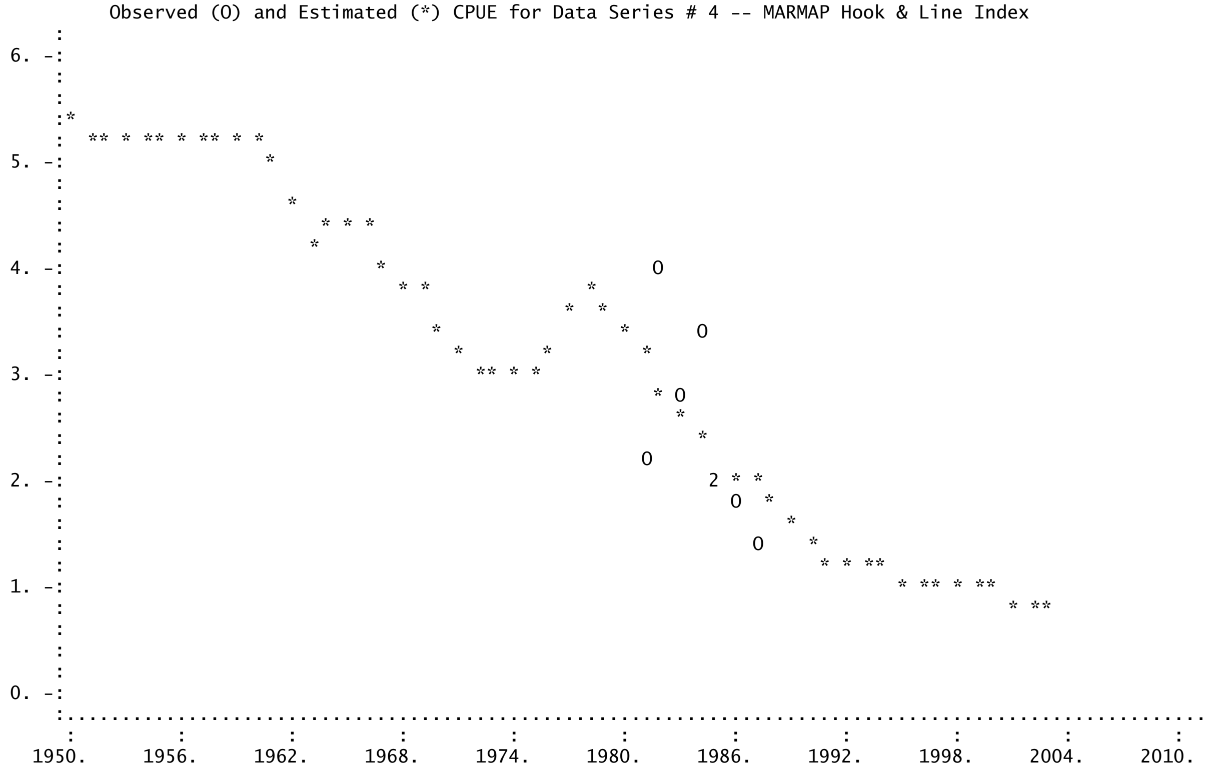
Observed (O) and Estimated (*) CPUE for Data Series # 2 -- MARMAP Chevron Trap



Observed (O) and Estimated (*) CPUE for Data Series # 3 -- MARMAP Blackfish Trap



Observed (O) and Estimated (*) CPUE for Data Series # 4 -- MARMAP Hook & Line Index



```
                                  Time Plot of Estimated F/Fmsy and B/Bmsy (dashed line = 1.0)
      :
2.4 -:
      :
      :                                                                                     F
      :
      :
2.0 -:B         B BB B                                               F                        F
      :  BB B BB        BB                                              F  F         F
      :                    B                                                              F
      :                                                         F            F  F   F
      :                           B                                                     F      F
1.6 -:                      BB B  B                                       F    F  F
      :                                                          F                        F
      :                              B B              B     F
      :                                 B              B             F
      :                                             B    B
1.2 -:                                   B B  F           B
      :                                 F    B B  B         B
      :                                          B       F F  F    F
      :- -- - -- - -- - -- - -- - -- - -- - -- - 2- - -- - -- - -- 2 2- - -- - -- - -- - -- - -- - -- - -- - -- -
      :                    F       F   F  F            F
0.8 -:                                          F               B   B
      :                                      F                      B  B
      :                                               F                  B
      :                              F                                     B
      :                           F                                         B B
0.4 -:                                                                        BB B BB
      :                  F   FF F                 F                                    B BB B BB
      :                                              F                                            B
      :F
      :  FF F         F F
0.0 -:       FF F FF
      :.......................................................................................................
       :         :         :         :         :         :         :         :         :         :         :
     1950.     1956.     1962.     1968.     1974.     1980.     1986.     1992.     1998.     2004.     2010.
```

Elapsed time: 0 hours, 0 minutes, 22 seconds.

G.2 Run with R:C = 2:1

```
 Black Seabass -- SEDAR, March 2005 -- Four indices & extended catch                                          Page 1
                                                                                      Tuesday, 15 Mar 2005 at 21:01:37
ASPIC -- A Surplus-Production Model Including Covariates (Ver. 5.07)
                                                                                                     FIT program mode
Author:    Michael H. Prager; NOAA Center for Coastal Fisheries and Habitat Research               LOGISTIC model mode
           101 Pivers Island Road; Beaufort, North Carolina  28516  USA                              YLD conditioning
           Mike.Prager@noaa.gov                                                                      SSE optimization

Reference:  Prager, M. H. 1994. A suite of extensions to a nonequilibrium            ASPIC User's Manual is available
           surplus-production model.  Fishery Bulletin 92: 374-389.                          gratis from the author.

CONTROL PARAMETERS USED (FROM INPUT FILE)                                                     Input file: bsb002.inp
-----------------------------------------------------------------------------------------------------------------------
Operation of ASPIC:  Fit logistic (Schaefer) model by direct optimization.
Number of years analyzed:                      54            Number of bootstrap trials:                           0
Number of data series:                          4            Lower bound on MSY:                           2.000E+02
Objective function:                 Least squares            Upper bound on MSY:                           2.000E+05
Relative conv. criterion (simplex):     1.000E-08            Lower bound on K:                             1.000E+03
Relative conv. criterion (restart):     4.000E-08            Upper bound on K:                             1.500E+06
Relative conv. criterion (effort):      1.000E-04            Random number seed:                             1951385
Maximum F allowed in fitting:               4.000            Monte Carlo search mode, trials:        1         40000
Identical convergences required in fitting:     6


PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS)                                                   error code   0
-----------------------------------------------------------------------------------------------------------------------
Normal convergence

WARNING: Negative correlations detected between some indices.  A fundamental assumption of ASPIC is that all indices
        represent the abundance of the stock.  That assumption appears to be violated.
Number of restarts required for convergence:     67


CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)
-----------------------------------------------------------------------------------------------------------------------
                                       |
 1  HB Index (WPUE), Yield ext @ Rec...|   1.000
                                       |      30
                                       |
 2  MARMAP Chevron Trap                |   0.570   1.000
                                       |      14      14
                                       |
 3  MARMAP Blackfish Trap              |   0.099   0.000   1.000
                                       |       7       0       7
                                       |
 4  MARMAP Hook & Line Index           |   0.440   0.000  -0.059   1.000
                                       |       7       0       7       7
                                       --------------------------------------------------
                                               1       2       3       4


GOODNESS-OF-FIT AND WEIGHTING (NON-BOOTSTRAPPED ANALYSIS)
-----------------------------------------------------------------------------------------------------------------------
                                                   Weighted                Weighted      Current     Inv. var.    R-squared
Loss component number and title                         SSE        N           MSE        weight        weight      in CPUE

Loss(-1)  SSE in yield                            0.000E+00
Loss(0)   Penalty for B1 > K                      0.000E+00        1           N/A     1.000E+00          N/A
Loss(1)   HB Index (WPUE), Yield ext @ Rec = 2xCo 1.849E+00       30     6.602E-02     1.000E+00     1.108E+00        0.806
Loss(2)   MARMAP Chevron Trap                     1.382E+00       14     1.151E-01     1.000E+00     6.354E-01       -0.423
Loss(3)   MARMAP Blackfish Trap                   2.249E-01        7     4.498E-02     1.000E+00     1.627E+00       -0.077
Loss(4)   MARMAP Hook & Line Index                5.724E-01        7     1.145E-01     1.000E+00     6.391E-01        0.243
.............................................................................................
TOTAL OBJECTIVE FUNCTION, MSE, RMSE:         4.02755265E+00           7.897E-02     2.810E-01
Estimated contrast index (ideal = 1.0):              0.8239           C* = (Bmax-Bmin)/K
Estimated nearness index (ideal = 1.0):              1.0000           N* = 1 - |min(B-Bmsy)|/K
```

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	User/pgm guess	2nd guess	Estimated	User guess
B1/K	Starting relative biomass (in 1950)	3.674E-01	8.000E-01	7.144E-01	1	1
MSY	Maximum sustainable yield	1.142E+03	1.000E+03	7.674E+02	1	1
K	Maximum population size	1.288E+04	1.000E+04	4.604E+03	1	1
phi	Shape of production curve (Bmsy/K)	0.5000	0.5000	----	0	1
---------	Catchability Coefficients by Data Series ---------------					
q(1)	HB Index (WPUE), Yield ext @ Rec = 2xCo	6.730E-04	1.450E-05	1.378E-03	1	1
q(2)	MARMAP Chevron Trap	7.661E-04	1.210E-05	1.150E-03	1	1
q(3)	MARMAP Blackfish Trap	4.544E-04	8.500E-05	8.075E-03	1	1
q(4)	MARMAP Hook & Line Index	5.857E-04	1.500E-05	1.425E-03	1	1

MANAGEMENT and DERIVED PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Logistic formula	General formula
MSY	Maximum sustainable yield	1.142E+03	----	----
Bmsy	Stock biomass giving MSY	6.441E+03	K/2	K*n**(1/(1-n))
Fmsy	Fishing mortality rate at MSY	1.772E-01	MSY/Bmsy	MSY/Bmsy
n	Exponent in production function	2.0000	----	----
g	Fletcher’s gamma	4.000E+00	----	[n**(n/(n-1))]/[n-1]
B./Bmsy	Ratio: B(2004)/Bmsy	1.918E-01	----	----
F./Fmsy	Ratio: F(2003)/Fmsy	2.445E+00	----	----
Fmsy/F.	Ratio: Fmsy/F(2003)	4.090E-01	----	----
Y.(Fmsy)	Approx. yield available at Fmsy in 2004	2.189E+02	MSY*B./Bmsy	MSY*B./Bmsy
	...as proportion of MSY	1.918E-01	----	----
Ye.	Equilibrium yield available in 2004	3.958E+02	4*MSY*(B/K-(B/K)**2)	g*MSY*(B/K-(B/K)**n)
	...as proportion of MSY	3.467E-01	----	----
---------	Fishing effort rate at MSY in units of each CE or CC series ---------			
fmsy(1)	HB Index (WPUE), Yield ext @ Rec = 2xCo	2.634E+02	Fmsy/q(1)	Fmsy/q(1)

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1950	0.086	4.733E+03	5.060E+03	4.347E+02	4.347E+02	1.088E+03	4.847E-01	7.348E-01
2	1951	0.053	5.386E+03	5.798E+03	3.078E+02	3.078E+02	1.129E+03	2.995E-01	8.362E-01
3	1952	0.036	6.207E+03	6.661E+03	2.379E+02	2.379E+02	1.138E+03	2.015E-01	9.637E-01
4	1953	0.022	7.107E+03	7.582E+03	1.668E+02	1.668E+02	1.104E+03	1.241E-01	1.103E+00
5	1954	0.012	8.044E+03	8.515E+03	9.960E+01	9.960E+01	1.021E+03	6.600E-02	1.249E+00
6	1955	0.007	8.966E+03	9.397E+03	6.150E+01	6.150E+01	8.995E+02	3.693E-02	1.392E+00
7	1956	0.010	9.804E+03	1.014E+04	1.047E+02	1.047E+02	7.630E+02	5.823E-02	1.522E+00
8	1957	0.010	1.046E+04	1.074E+04	1.026E+02	1.026E+02	6.327E+02	5.391E-02	1.624E+00
9	1958	0.009	1.099E+04	1.121E+04	1.017E+02	1.017E+02	5.156E+02	5.119E-02	1.707E+00
10	1959	0.012	1.141E+04	1.155E+04	1.395E+02	1.395E+02	4.218E+02	6.812E-02	1.771E+00
11	1960	0.017	1.169E+04	1.177E+04	1.998E+02	1.998E+02	3.592E+02	9.576E-02	1.815E+00
12	1961	0.081	1.185E+04	1.157E+04	9.327E+02	9.327E+02	4.158E+02	4.547E-01	1.840E+00
13	1962	0.207	1.133E+04	1.053E+04	2.179E+03	2.179E+03	6.771E+02	1.168E+00	1.759E+00
14	1963	0.075	9.829E+03	9.871E+03	7.386E+02	7.386E+02	8.178E+02	4.222E-01	1.526E+00
15	1964	0.079	9.908E+03	9.921E+03	7.845E+02	7.845E+02	8.083E+02	4.461E-01	1.538E+00
16	1965	0.082	9.932E+03	9.930E+03	8.100E+02	8.100E+02	8.064E+02	4.602E-01	1.542E+00
17	1966	0.116	9.929E+03	9.774E+03	1.131E+03	1.131E+03	8.357E+02	6.529E-01	1.542E+00
18	1967	0.226	9.633E+03	9.053E+03	2.045E+03	2.045E+03	9.511E+02	1.275E+00	1.496E+00
19	1968	0.137	8.539E+03	8.471E+03	1.159E+03	1.159E+03	1.028E+03	7.716E-01	1.326E+00
20	1969	0.233	8.409E+03	7.992E+03	1.865E+03	1.865E+03	1.074E+03	1.317E+00	1.306E+00
21	1970	0.308	7.617E+03	7.063E+03	2.177E+03	2.177E+03	1.128E+03	1.739E+00	1.183E+00
22	1971	0.245	6.568E+03	6.353E+03	1.555E+03	1.555E+03	1.141E+03	1.381E+00	1.020E+00
23	1972	0.296	6.154E+03	5.843E+03	1.728E+03	1.728E+03	1.131E+03	1.669E+00	9.556E-01
24	1973	0.240	5.557E+03	5.457E+03	1.309E+03	1.309E+03	1.115E+03	1.354E+00	8.628E-01
25	1974	0.405	5.363E+03	4.886E+03	1.980E+03	1.980E+03	1.073E+03	2.286E+00	8.327E-01
26	1975	0.292	4.456E+03	4.330E+03	1.264E+03	1.264E+03	1.019E+03	1.647E+00	6.919E-01
27	1976	0.143	4.211E+03	4.411E+03	6.303E+02	6.303E+02	1.028E+03	8.061E-01	6.539E-01
28	1977	0.102	4.609E+03	4.897E+03	5.013E+02	5.013E+02	1.075E+03	5.776E-01	7.156E-01
29	1978	0.178	5.183E+03	5.268E+03	9.374E+02	9.374E+02	1.104E+03	1.004E+00	8.047E-01
30	1979	0.229	5.349E+03	5.294E+03	1.213E+03	1.213E+03	1.105E+03	1.293E+00	8.305E-01
31	1980	0.256	5.242E+03	5.128E+03	1.314E+03	1.314E+03	1.094E+03	1.445E+00	8.138E-01
32	1981	0.245	5.022E+03	4.954E+03	1.213E+03	1.213E+03	1.081E+03	1.381E+00	7.797E-01
33	1982	0.333	4.890E+03	4.635E+03	1.542E+03	1.542E+03	1.051E+03	1.877E+00	7.592E-01
34	1983	0.236	4.399E+03	4.395E+03	1.035E+03	1.035E+03	1.026E+03	1.329E+00	6.830E-01
35	1984	0.391	4.391E+03	4.074E+03	1.593E+03	1.593E+03	9.866E+02	2.207E+00	6.817E-01
36	1985	0.313	3.784E+03	3.671E+03	1.149E+03	1.149E+03	9.304E+02	1.766E+00	5.875E-01
37	1986	0.223	3.565E+03	3.623E+03	8.093E+02	8.093E+02	9.230E+02	1.260E+00	5.535E-01
38	1987	0.288	3.679E+03	3.618E+03	1.042E+03	1.042E+03	9.222E+02	1.625E+00	5.712E-01
39	1988	0.414	3.559E+03	3.301E+03	1.366E+03	1.366E+03	8.697E+02	2.334E+00	5.526E-01
40	1989	0.392	3.063E+03	2.889E+03	1.131E+03	1.131E+03	7.942E+02	2.209E+00	4.756E-01
41	1990	0.327	2.726E+03	2.664E+03	8.707E+02	8.707E+02	7.490E+02	1.844E+00	4.232E-01
42	1991	0.384	2.604E+03	2.480E+03	9.512E+02	9.512E+02	7.098E+02	2.164E+00	4.043E-01
43	1992	0.339	2.363E+03	2.306E+03	7.822E+02	7.822E+02	6.711E+02	1.914E+00	3.669E-01
44	1993	0.304	2.252E+03	2.240E+03	6.799E+02	6.799E+02	6.559E+02	1.713E+00	3.496E-01
45	1994	0.349	2.228E+03	2.167E+03	7.573E+02	7.573E+02	6.390E+02	1.971E+00	3.459E-01
46	1995	0.309	2.109E+03	2.097E+03	6.478E+02	6.478E+02	6.222E+02	1.743E+00	3.275E-01
47	1996	0.354	2.084E+03	2.027E+03	7.171E+02	7.171E+02	6.054E+02	1.996E+00	3.236E-01
48	1997	0.376	1.972E+03	1.901E+03	7.140E+02	7.140E+02	5.744E+02	2.119E+00	3.062E-01
49	1998	0.334	1.833E+03	1.806E+03	6.035E+02	6.035E+02	5.504E+02	1.886E+00	2.845E-01
50	1999	0.365	1.779E+03	1.728E+03	6.308E+02	6.308E+02	5.305E+02	2.059E+00	2.763E-01
51	2000	0.312	1.679E+03	1.676E+03	5.234E+02	5.234E+02	5.168E+02	1.762E+00	2.607E-01
52	2001	0.463	1.672E+03	1.551E+03	7.186E+02	7.186E+02	4.835E+02	2.614E+00	2.597E-01
53	2002	0.352	1.437E+03	1.411E+03	4.974E+02	4.974E+02	4.454E+02	1.989E+00	2.232E-01
54	2003	0.433	1.385E+03	1.308E+03	5.670E+02	5.670E+02	4.166E+02	2.445E+00	2.151E-01
55	2004		1.235E+03						1.918E-01

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) HB Index (WPUE), Yield ext @ Rec = 2xCom

Data type CC: CPUE-catch series Series weight: 1.000

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale
1	1950	*	3.405E+00	0.0859	4.347E+02	4.347E+02	0.00000
2	1951	*	3.902E+00	0.0531	3.078E+02	3.078E+02	0.00000
3	1952	*	4.483E+00	0.0357	2.379E+02	2.379E+02	0.00000
4	1953	*	5.103E+00	0.0220	1.668E+02	1.668E+02	0.00000
5	1954	*	5.731E+00	0.0117	9.960E+01	9.960E+01	0.00000
6	1955	*	6.324E+00	0.0065	6.150E+01	6.150E+01	0.00000
7	1956	*	6.828E+00	0.0103	1.047E+02	1.047E+02	0.00000
8	1957	*	7.227E+00	0.0096	1.026E+02	1.026E+02	0.00000
9	1958	*	7.544E+00	0.0091	1.017E+02	1.017E+02	0.00000
10	1959	*	7.776E+00	0.0121	1.395E+02	1.395E+02	0.00000
11	1960	*	7.923E+00	0.0170	1.998E+02	1.998E+02	0.00000
12	1961	*	7.790E+00	0.0806	9.327E+02	9.327E+02	0.00000
13	1962	*	7.084E+00	0.2070	2.179E+03	2.179E+03	0.00000
14	1963	*	6.643E+00	0.0748	7.386E+02	7.386E+02	0.00000
15	1964	*	6.677E+00	0.0791	7.845E+02	7.845E+02	0.00000
16	1965	*	6.683E+00	0.0816	8.100E+02	8.100E+02	0.00000
17	1966	*	6.578E+00	0.1157	1.131E+03	1.131E+03	0.00000
18	1967	*	6.093E+00	0.2259	2.045E+03	2.045E+03	0.00000
19	1968	*	5.701E+00	0.1368	1.159E+03	1.159E+03	0.00000
20	1969	*	5.379E+00	0.2334	1.865E+03	1.865E+03	0.00000
21	1970	*	4.754E+00	0.3083	2.177E+03	2.177E+03	0.00000
22	1971	*	4.276E+00	0.2447	1.555E+03	1.555E+03	0.00000
23	1972	*	3.932E+00	0.2957	1.728E+03	1.728E+03	0.00000
24	1973	*	3.673E+00	0.2399	1.309E+03	1.309E+03	0.00000
25	1974	3.284E+00	3.288E+00	0.4052	1.980E+03	1.980E+03	0.00128
26	1975	4.469E+00	2.914E+00	0.2919	1.264E+03	1.264E+03	-0.42748
27	1976	2.992E+00	2.969E+00	0.1429	6.303E+02	6.303E+02	-0.00774
28	1977	3.393E+00	3.296E+00	0.1024	5.013E+02	5.013E+02	-0.02909
29	1978	4.093E+00	3.545E+00	0.1780	9.374E+02	9.374E+02	-0.14366
30	1979	3.401E+00	3.563E+00	0.2291	1.213E+03	1.213E+03	0.04651
31	1980	3.630E+00	3.452E+00	0.2562	1.314E+03	1.314E+03	-0.05042
32	1981	3.646E+00	3.334E+00	0.2448	1.213E+03	1.213E+03	-0.08943
33	1982	3.709E+00	3.119E+00	0.3326	1.542E+03	1.542E+03	-0.17311
34	1983	3.740E+00	2.958E+00	0.2355	1.035E+03	1.035E+03	-0.23464
35	1984	3.373E+00	2.742E+00	0.3911	1.593E+03	1.593E+03	-0.20716
36	1985	3.363E+00	2.471E+00	0.3130	1.149E+03	1.149E+03	-0.30821
37	1986	3.386E+00	2.438E+00	0.2234	8.093E+02	8.093E+02	-0.32844
38	1987	3.484E+00	2.435E+00	0.2881	1.042E+03	1.042E+03	-0.35836
39	1988	3.005E+00	2.222E+00	0.4137	1.366E+03	1.366E+03	-0.30204
40	1989	2.003E+00	1.944E+00	0.3915	1.131E+03	1.131E+03	-0.02973
41	1990	2.071E+00	1.793E+00	0.3268	8.707E+02	8.707E+02	-0.14420
42	1991	1.576E+00	1.669E+00	0.3835	9.512E+02	9.512E+02	0.05747
43	1992	1.545E+00	1.552E+00	0.3392	7.822E+02	7.822E+02	0.00462
44	1993	1.178E+00	1.507E+00	0.3036	6.799E+02	6.799E+02	0.24651
45	1994	1.035E+00	1.459E+00	0.3494	7.573E+02	7.573E+02	0.34318
46	1995	7.430E-01	1.411E+00	0.3090	6.478E+02	6.478E+02	0.64136
47	1996	8.220E-01	1.364E+00	0.3538	7.171E+02	7.171E+02	0.50660
48	1997	1.053E+00	1.279E+00	0.3756	7.140E+02	7.140E+02	0.19474
49	1998	1.082E+00	1.215E+00	0.3342	6.035E+02	6.035E+02	0.11614
50	1999	1.277E+00	1.163E+00	0.3650	6.308E+02	6.308E+02	-0.09327
51	2000	9.530E-01	1.128E+00	0.3123	5.234E+02	5.234E+02	0.16844
52	2001	8.600E-01	1.044E+00	0.4633	7.186E+02	7.186E+02	0.19383
53	2002	7.510E-01	9.497E-01	0.3525	4.974E+02	4.974E+02	0.23473
54	2003	7.440E-01	8.805E-01	0.4334	5.670E+02	5.670E+02	0.16848

* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    -------------------------------------------------------------------------------------
1950      0.0000                                            |
1951      0.0000                                            |
1952      0.0000                                            |
1953      0.0000                                            |
1954      0.0000                                            |
1955      0.0000                                            |
1956      0.0000                                            |
1957      0.0000                                            |
1958      0.0000                                            |
1959      0.0000                                            |
1960      0.0000                                            |
1961      0.0000                                            |
1962      0.0000                                            |
1963      0.0000                                            |
1964      0.0000                                            |
1965      0.0000                                            |
1966      0.0000                                            |
1967      0.0000                                            |
1968      0.0000                                            |
1969      0.0000                                            |
1970      0.0000                                            |
1971      0.0000                                            |
1972      0.0000                                            |
1973      0.0000                                            |
1974      0.0013                                            |
1975     -0.4275                           =================|
1976     -0.0077                                            |
1977     -0.0291                                           =|
1978     -0.1437                                      ======|
1979      0.0465                                            |==
1980     -0.0504                                          ==|
1981     -0.0894                                        ====|
1982     -0.1731                                     =======|
1983     -0.2346                                   =========|
1984     -0.2072                                    ========|
1985     -0.3082                                ============|
1986     -0.3284                               =============|
1987     -0.3584                              ==============|
1988     -0.3020                                ============|
1989     -0.0297                                           =|
1990     -0.1442                                      ======|
1991      0.0575                                            |==
1992      0.0046                                            |
1993      0.2465                                            |==========
1994      0.3432                                            |==============
1995      0.6414                                            |==========================
1996      0.5066                                            |====================
1997      0.1947                                            |========
1998      0.1161                                            |=====
1999     -0.0933                                        ====|
2000      0.1684                                            |=======
2001      0.1938                                            |========
2002      0.2347                                            |=========
2003      0.1685                                            |=======
                   -------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED) MARMAP Chevron Trap

Data type I1: Abundance index (annual average) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index
1	1950	0.000E+00	0.000E+00	--	*	3.876E+00	0.00000
2	1951	0.000E+00	0.000E+00	--	*	4.441E+00	0.00000
3	1952	0.000E+00	0.000E+00	--	*	5.102E+00	0.00000
4	1953	0.000E+00	0.000E+00	--	*	5.808E+00	0.00000
5	1954	0.000E+00	0.000E+00	--	*	6.523E+00	0.00000
6	1955	0.000E+00	0.000E+00	--	*	7.198E+00	0.00000
7	1956	0.000E+00	0.000E+00	--	*	7.771E+00	0.00000
8	1957	0.000E+00	0.000E+00	--	*	8.226E+00	0.00000
9	1958	0.000E+00	0.000E+00	--	*	8.586E+00	0.00000
10	1959	0.000E+00	0.000E+00	--	*	8.851E+00	0.00000
11	1960	0.000E+00	0.000E+00	--	*	9.018E+00	0.00000
12	1961	0.000E+00	0.000E+00	--	*	8.866E+00	0.00000
13	1962	0.000E+00	0.000E+00	--	*	8.064E+00	0.00000
14	1963	0.000E+00	0.000E+00	--	*	7.561E+00	0.00000
15	1964	0.000E+00	0.000E+00	--	*	7.600E+00	0.00000
16	1965	0.000E+00	0.000E+00	--	*	7.607E+00	0.00000
17	1966	0.000E+00	0.000E+00	--	*	7.487E+00	0.00000
18	1967	0.000E+00	0.000E+00	--	*	6.935E+00	0.00000
19	1968	0.000E+00	0.000E+00	--	*	6.490E+00	0.00000
20	1969	0.000E+00	0.000E+00	--	*	6.122E+00	0.00000
21	1970	0.000E+00	0.000E+00	--	*	5.411E+00	0.00000
22	1971	0.000E+00	0.000E+00	--	*	4.867E+00	0.00000
23	1972	0.000E+00	0.000E+00	--	*	4.476E+00	0.00000
24	1973	0.000E+00	0.000E+00	--	*	4.180E+00	0.00000
25	1974	0.000E+00	0.000E+00	--	*	3.743E+00	0.00000
26	1975	0.000E+00	0.000E+00	--	*	3.317E+00	0.00000
27	1976	0.000E+00	0.000E+00	--	*	3.379E+00	0.00000
28	1977	0.000E+00	0.000E+00	--	*	3.751E+00	0.00000
29	1978	0.000E+00	0.000E+00	--	*	4.035E+00	0.00000
30	1979	0.000E+00	0.000E+00	--	*	4.055E+00	0.00000
31	1980	0.000E+00	0.000E+00	--	*	3.929E+00	0.00000
32	1981	0.000E+00	0.000E+00	--	*	3.795E+00	0.00000
33	1982	0.000E+00	0.000E+00	--	*	3.551E+00	0.00000
34	1983	0.000E+00	0.000E+00	--	*	3.367E+00	0.00000
35	1984	0.000E+00	0.000E+00	--	*	3.121E+00	0.00000
36	1985	0.000E+00	0.000E+00	--	*	2.813E+00	0.00000
37	1986	0.000E+00	0.000E+00	--	*	2.775E+00	0.00000
38	1987	0.000E+00	0.000E+00	--	*	2.771E+00	0.00000
39	1988	0.000E+00	0.000E+00	--	*	2.529E+00	0.00000
40	1989	0.000E+00	0.000E+00	--	*	2.213E+00	0.00000
41	1990	1.000E+00	1.000E+00	--	2.126E+00	2.041E+00	0.04095
42	1991	1.000E+00	1.000E+00	--	1.585E+00	1.900E+00	-0.18124
43	1992	1.000E+00	1.000E+00	--	1.753E+00	1.767E+00	-0.00778
44	1993	1.000E+00	1.000E+00	--	9.830E-01	1.716E+00	-0.55694
45	1994	1.000E+00	1.000E+00	--	1.153E+00	1.660E+00	-0.36468
46	1995	1.000E+00	1.000E+00	--	1.062E+00	1.606E+00	-0.41361
47	1996	1.000E+00	1.000E+00	--	1.302E+00	1.553E+00	-0.17615
48	1997	1.000E+00	1.000E+00	--	1.328E+00	1.456E+00	-0.09217
49	1998	1.000E+00	1.000E+00	--	1.506E+00	1.383E+00	0.08504
50	1999	1.000E+00	1.000E+00	--	2.321E+00	1.324E+00	0.56129
51	2000	1.000E+00	1.000E+00	--	1.842E+00	1.284E+00	0.36109
52	2001	1.000E+00	1.000E+00	--	1.727E+00	1.188E+00	0.37392
53	2002	1.000E+00	1.000E+00	--	1.477E+00	1.081E+00	0.31217
54	2003	1.000E+00	1.000E+00	--	1.063E+00	1.002E+00	0.05886

* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1950     0.0000                                             |
1951     0.0000                                             |
1952     0.0000                                             |
1953     0.0000                                             |
1954     0.0000                                             |
1955     0.0000                                             |
1956     0.0000                                             |
1957     0.0000                                             |
1958     0.0000                                             |
1959     0.0000                                             |
1960     0.0000                                             |
1961     0.0000                                             |
1962     0.0000                                             |
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981     0.0000                                             |
1982     0.0000                                             |
1983     0.0000                                             |
1984     0.0000                                             |
1985     0.0000                                             |
1986     0.0000                                             |
1987     0.0000                                             |
1988     0.0000                                             |
1989     0.0000                                             |
1990     0.0409                                             |==
1991    -0.1812                                      =======|
1992    -0.0078                                             |
1993    -0.5569                       ======================|
1994    -0.3647                              ===============|
1995    -0.4136                            =================|
1996    -0.1761                                      =======|
1997    -0.0922                                         ====|
1998     0.0850                                             |===
1999     0.5613                                             |======================
2000     0.3611                                             |==============
2001     0.3739                                             |===============
2002     0.3122                                             |============
2003     0.0589                                             |==
                   ------------------------------------------------------------------------------------
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RESULTS FOR DATA SERIES # 3 (NON-BOOTSTRAPPED) MARMAP Blackfish Trap

Data type I1: Abundance index (annual average) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index
1	1950	0.000E+00	0.000E+00	--	*	2.299E+00	0.00000
2	1951	0.000E+00	0.000E+00	--	*	2.634E+00	0.00000
3	1952	0.000E+00	0.000E+00	--	*	3.026E+00	0.00000
4	1953	0.000E+00	0.000E+00	--	*	3.445E+00	0.00000
5	1954	0.000E+00	0.000E+00	--	*	3.869E+00	0.00000
6	1955	0.000E+00	0.000E+00	--	*	4.270E+00	0.00000
7	1956	0.000E+00	0.000E+00	--	*	4.609E+00	0.00000
8	1957	0.000E+00	0.000E+00	--	*	4.879E+00	0.00000
9	1958	0.000E+00	0.000E+00	--	*	5.093E+00	0.00000
10	1959	0.000E+00	0.000E+00	--	*	5.250E+00	0.00000
11	1960	0.000E+00	0.000E+00	--	*	5.349E+00	0.00000
12	1961	0.000E+00	0.000E+00	--	*	5.259E+00	0.00000
13	1962	0.000E+00	0.000E+00	--	*	4.783E+00	0.00000
14	1963	0.000E+00	0.000E+00	--	*	4.485E+00	0.00000
15	1964	0.000E+00	0.000E+00	--	*	4.508E+00	0.00000
16	1965	0.000E+00	0.000E+00	--	*	4.512E+00	0.00000
17	1966	0.000E+00	0.000E+00	--	*	4.441E+00	0.00000
18	1967	0.000E+00	0.000E+00	--	*	4.113E+00	0.00000
19	1968	0.000E+00	0.000E+00	--	*	3.849E+00	0.00000
20	1969	0.000E+00	0.000E+00	--	*	3.631E+00	0.00000
21	1970	0.000E+00	0.000E+00	--	*	3.209E+00	0.00000
22	1971	0.000E+00	0.000E+00	--	*	2.887E+00	0.00000
23	1972	0.000E+00	0.000E+00	--	*	2.655E+00	0.00000
24	1973	0.000E+00	0.000E+00	--	*	2.480E+00	0.00000
25	1974	0.000E+00	0.000E+00	--	*	2.220E+00	0.00000
26	1975	0.000E+00	0.000E+00	--	*	1.968E+00	0.00000
27	1976	0.000E+00	0.000E+00	--	*	2.004E+00	0.00000
28	1977	0.000E+00	0.000E+00	--	*	2.225E+00	0.00000
29	1978	0.000E+00	0.000E+00	--	*	2.393E+00	0.00000
30	1979	0.000E+00	0.000E+00	--	*	2.405E+00	0.00000
31	1980	0.000E+00	0.000E+00	--	*	2.330E+00	0.00000
32	1981	1.000E+00	1.000E+00	--	2.235E+00	2.251E+00	-0.00708
33	1982	1.000E+00	1.000E+00	--	1.846E+00	2.106E+00	-0.13175
34	1983	1.000E+00	1.000E+00	--	1.940E+00	1.997E+00	-0.02887
35	1984	1.000E+00	1.000E+00	--	1.586E+00	1.851E+00	-0.15455
36	1985	1.000E+00	1.000E+00	--	2.531E+00	1.668E+00	0.41687
37	1986	1.000E+00	1.000E+00	--	1.644E+00	1.646E+00	-0.00120
38	1987	1.000E+00	1.000E+00	--	1.495E+00	1.644E+00	-0.09481
39	1988	0.000E+00	0.000E+00	--	*	1.500E+00	0.00000
40	1989	0.000E+00	0.000E+00	--	*	1.313E+00	0.00000
41	1990	0.000E+00	0.000E+00	--	*	1.210E+00	0.00000
42	1991	0.000E+00	0.000E+00	--	*	1.127E+00	0.00000
43	1992	0.000E+00	0.000E+00	--	*	1.048E+00	0.00000
44	1993	0.000E+00	0.000E+00	--	*	1.018E+00	0.00000
45	1994	0.000E+00	0.000E+00	--	*	9.848E-01	0.00000
46	1995	0.000E+00	0.000E+00	--	*	9.526E-01	0.00000
47	1996	0.000E+00	0.000E+00	--	*	9.210E-01	0.00000
48	1997	0.000E+00	0.000E+00	--	*	8.637E-01	0.00000
49	1998	0.000E+00	0.000E+00	--	*	8.204E-01	0.00000
50	1999	0.000E+00	0.000E+00	--	*	7.853E-01	0.00000
51	2000	0.000E+00	0.000E+00	--	*	7.614E-01	0.00000
52	2001	0.000E+00	0.000E+00	--	*	7.048E-01	0.00000
53	2002	0.000E+00	0.000E+00	--	*	6.411E-01	0.00000
54	2003	0.000E+00	0.000E+00	--	*	5.945E-01	0.00000

* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 3
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1950     0.0000                                             |
1951     0.0000                                             |
1952     0.0000                                             |
1953     0.0000                                             |
1954     0.0000                                             |
1955     0.0000                                             |
1956     0.0000                                             |
1957     0.0000                                             |
1958     0.0000                                             |
1959     0.0000                                             |
1960     0.0000                                             |
1961     0.0000                                             |
1962     0.0000                                             |
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981    -0.0071                                             |
1982    -0.1317                                        =====|
1983    -0.0289                                            =|
1984    -0.1546                                       ======|
1985     0.4169                                             |=================
1986    -0.0012                                             |
1987    -0.0948                                         ====|
1988     0.0000                                             |
1989     0.0000                                             |
1990     0.0000                                             |
1991     0.0000                                             |
1992     0.0000                                             |
1993     0.0000                                             |
1994     0.0000                                             |
1995     0.0000                                             |
1996     0.0000                                             |
1997     0.0000                                             |
1998     0.0000                                             |
1999     0.0000                                             |
2000     0.0000                                             |
2001     0.0000                                             |
2002     0.0000                                             |
2003     0.0000                                             |
                   ------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 4 (NON-BOOTSTRAPPED) MARMAP Hook & Line Index

Data type I1: Abundance index (annual average) Series weight: 1.000

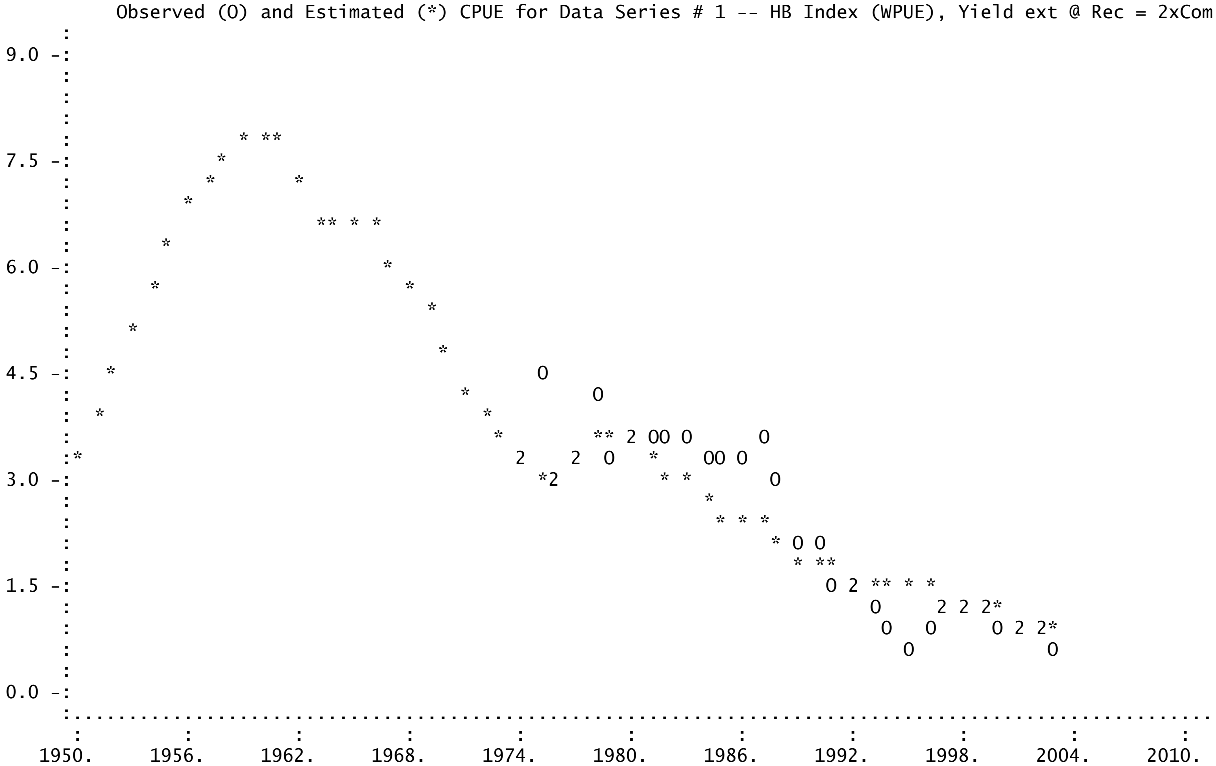
Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index
1	1950	0.000E+00	0.000E+00	--	*	2.964E+00	0.00000
2	1951	0.000E+00	0.000E+00	--	*	3.396E+00	0.00000
3	1952	0.000E+00	0.000E+00	--	*	3.901E+00	0.00000
4	1953	0.000E+00	0.000E+00	--	*	4.441E+00	0.00000
5	1954	0.000E+00	0.000E+00	--	*	4.987E+00	0.00000
6	1955	0.000E+00	0.000E+00	--	*	5.504E+00	0.00000
7	1956	0.000E+00	0.000E+00	--	*	5.942E+00	0.00000
8	1957	0.000E+00	0.000E+00	--	*	6.290E+00	0.00000
9	1958	0.000E+00	0.000E+00	--	*	6.565E+00	0.00000
10	1959	0.000E+00	0.000E+00	--	*	6.768E+00	0.00000
11	1960	0.000E+00	0.000E+00	--	*	6.895E+00	0.00000
12	1961	0.000E+00	0.000E+00	--	*	6.779E+00	0.00000
13	1962	0.000E+00	0.000E+00	--	*	6.166E+00	0.00000
14	1963	0.000E+00	0.000E+00	--	*	5.781E+00	0.00000
15	1964	0.000E+00	0.000E+00	--	*	5.811E+00	0.00000
16	1965	0.000E+00	0.000E+00	--	*	5.817E+00	0.00000
17	1966	0.000E+00	0.000E+00	--	*	5.725E+00	0.00000
18	1967	0.000E+00	0.000E+00	--	*	5.302E+00	0.00000
19	1968	0.000E+00	0.000E+00	--	*	4.962E+00	0.00000
20	1969	0.000E+00	0.000E+00	--	*	4.681E+00	0.00000
21	1970	0.000E+00	0.000E+00	--	*	4.137E+00	0.00000
22	1971	0.000E+00	0.000E+00	--	*	3.721E+00	0.00000
23	1972	0.000E+00	0.000E+00	--	*	3.422E+00	0.00000
24	1973	0.000E+00	0.000E+00	--	*	3.196E+00	0.00000
25	1974	0.000E+00	0.000E+00	--	*	2.862E+00	0.00000
26	1975	0.000E+00	0.000E+00	--	*	2.536E+00	0.00000
27	1976	0.000E+00	0.000E+00	--	*	2.584E+00	0.00000
28	1977	0.000E+00	0.000E+00	--	*	2.868E+00	0.00000
29	1978	0.000E+00	0.000E+00	--	*	3.085E+00	0.00000
30	1979	0.000E+00	0.000E+00	--	*	3.101E+00	0.00000
31	1980	0.000E+00	0.000E+00	--	*	3.004E+00	0.00000
32	1981	1.000E+00	1.000E+00	--	2.210E+00	2.902E+00	-0.27229
33	1982	1.000E+00	1.000E+00	--	4.077E+00	2.715E+00	0.40664
34	1983	1.000E+00	1.000E+00	--	2.894E+00	2.574E+00	0.11712
35	1984	1.000E+00	1.000E+00	--	3.382E+00	2.386E+00	0.34875
36	1985	1.000E+00	1.000E+00	--	2.035E+00	2.150E+00	-0.05520
37	1986	1.000E+00	1.000E+00	--	1.873E+00	2.122E+00	-0.12474
38	1987	1.000E+00	1.000E+00	--	1.388E+00	2.119E+00	-0.42303
39	1988	0.000E+00	0.000E+00	--	*	1.933E+00	0.00000
40	1989	0.000E+00	0.000E+00	--	*	1.692E+00	0.00000
41	1990	0.000E+00	0.000E+00	--	*	1.560E+00	0.00000
42	1991	0.000E+00	0.000E+00	--	*	1.453E+00	0.00000
43	1992	0.000E+00	0.000E+00	--	*	1.351E+00	0.00000
44	1993	0.000E+00	0.000E+00	--	*	1.312E+00	0.00000
45	1994	0.000E+00	0.000E+00	--	*	1.270E+00	0.00000
46	1995	0.000E+00	0.000E+00	--	*	1.228E+00	0.00000
47	1996	0.000E+00	0.000E+00	--	*	1.187E+00	0.00000
48	1997	0.000E+00	0.000E+00	--	*	1.113E+00	0.00000
49	1998	0.000E+00	0.000E+00	--	*	1.058E+00	0.00000
50	1999	0.000E+00	0.000E+00	--	*	1.012E+00	0.00000
51	2000	0.000E+00	0.000E+00	--	*	9.815E-01	0.00000
52	2001	0.000E+00	0.000E+00	--	*	9.085E-01	0.00000
53	2002	0.000E+00	0.000E+00	--	*	8.265E-01	0.00000
54	2003	0.000E+00	0.000E+00	--	*	7.663E-01	0.00000

* Asterisk indicates missing value(s).

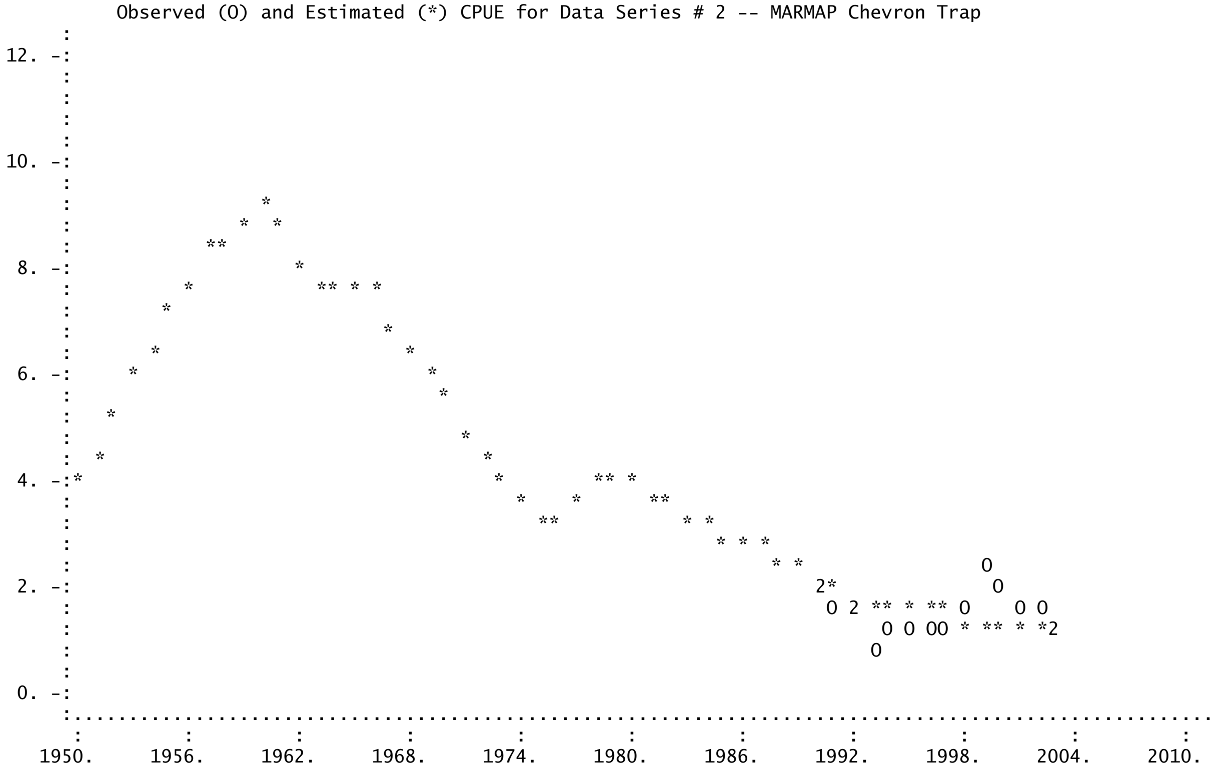
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 4

```
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1950     0.0000                                             |
1951     0.0000                                             |
1952     0.0000                                             |
1953     0.0000                                             |
1954     0.0000                                             |
1955     0.0000                                             |
1956     0.0000                                             |
1957     0.0000                                             |
1958     0.0000                                             |
1959     0.0000                                             |
1960     0.0000                                             |
1961     0.0000                                             |
1962     0.0000                                             |
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981    -0.2723                                  ===========|
1982     0.4066                                             |================
1983     0.1171                                             |=====
1984     0.3487                                             |==============
1985    -0.0552                                           ==|
1986    -0.1247                                        =====|
1987    -0.4230                            =================|
1988     0.0000                                             |
1989     0.0000                                             |
1990     0.0000                                             |
1991     0.0000                                             |
1992     0.0000                                             |
1993     0.0000                                             |
1994     0.0000                                             |
1995     0.0000                                             |
1996     0.0000                                             |
1997     0.0000                                             |
1998     0.0000                                             |
1999     0.0000                                             |
2000     0.0000                                             |
2001     0.0000                                             |
2002     0.0000                                             |
2003     0.0000                                             |
                   ------------------------------------------------------------------------------------
```

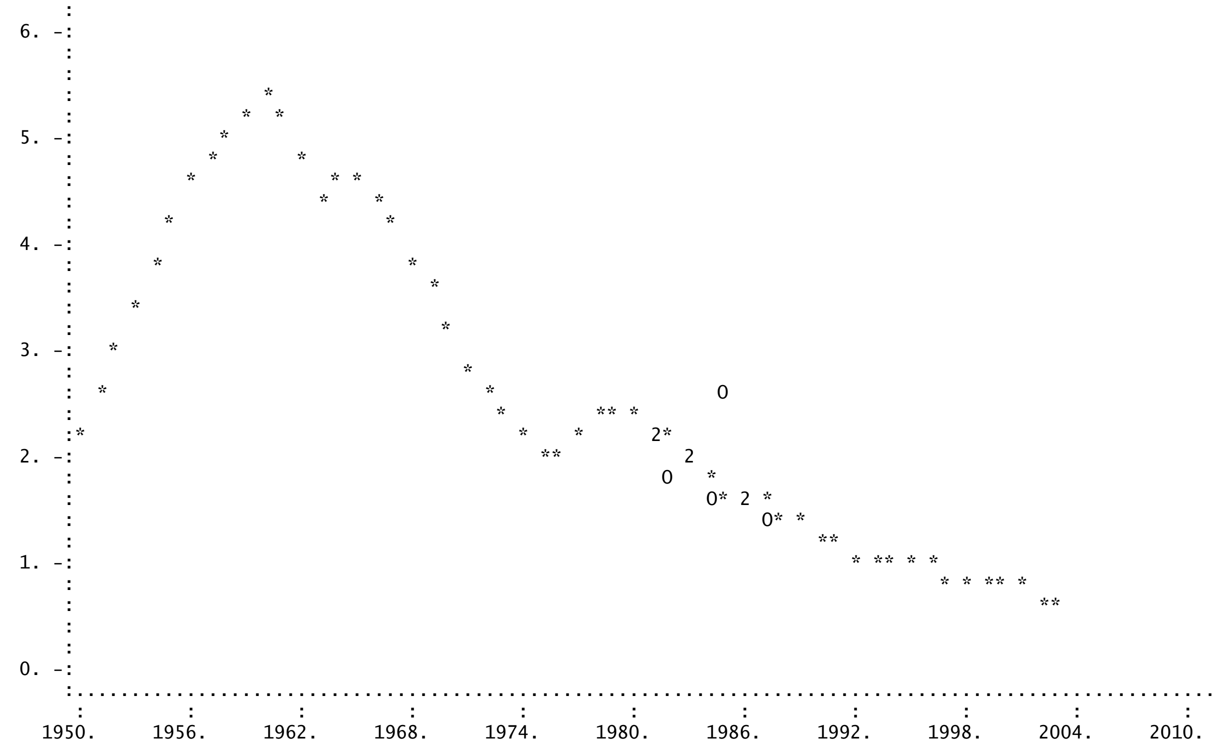
Observed (O) and Estimated (*) CPUE for Data Series # 1 -- HB Index (WPUE), Yield ext @ Rec = 2xCom



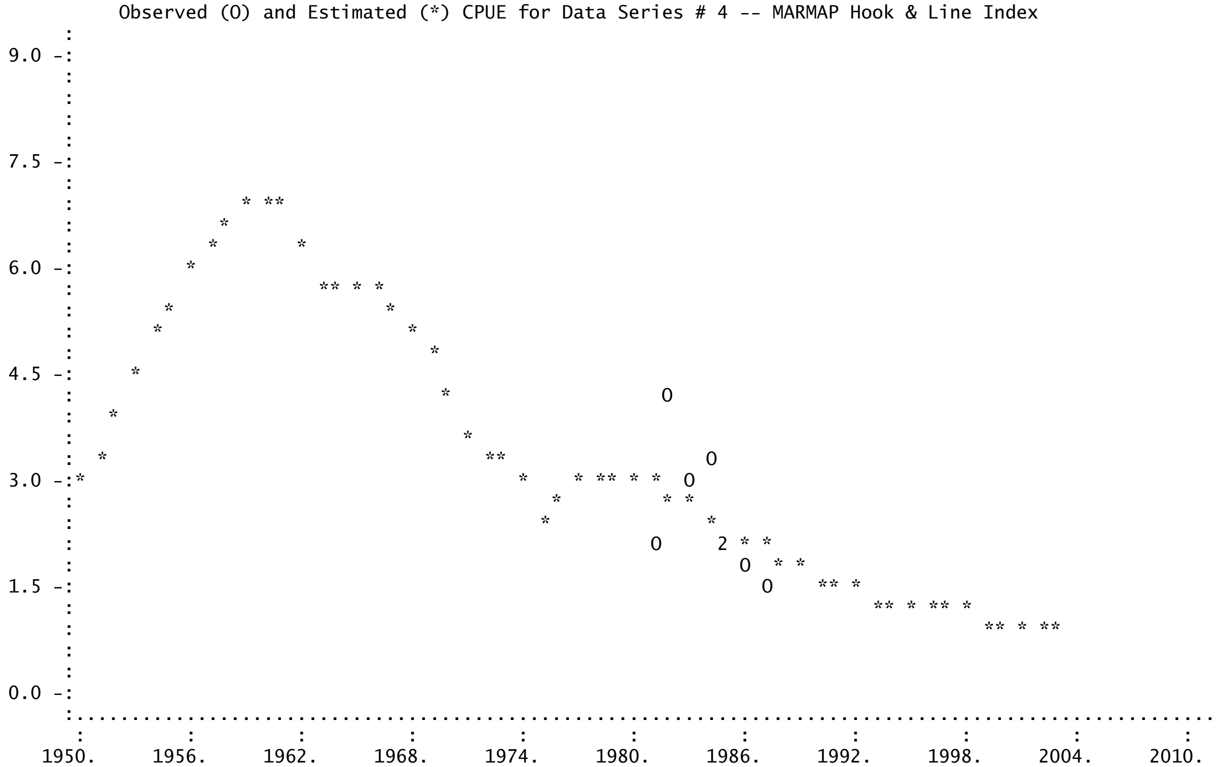
Observed (O) and Estimated (*) CPUE for Data Series # 2 -- MARMAP Chevron Trap



Observed (O) and Estimated (*) CPUE for Data Series # 3 -- MARMAP Blackfish Trap



Observed (O) and Estimated (*) CPUE for Data Series # 4 -- MARMAP Hook & Line Index



```
                              Time Plot of Estimated F/Fmsy and B/Bmsy (dashed line = 1.0)
       :
  3.0 -:
       :
       :
       :
       :                                                                                     F
  2.5 -:
       :                                                                                        F
       :                                        F                      F
       :                                                         F       F  F
       :                                                                              F   F
  2.0 -:                                                                         F   F         F
       :                                                     F                F         F
       :               B BB B                                     F        F              F
       :             B                   F   F                                  F  F
       :            B                             F                   F
  1.5 -:          B           BB B BB
       :        B                          F  F           F F
       :                            F B 2               F      F    F
       :       B            F            B
       :     B
  1.0 -:- -2 - -- - -- - -- - -- - -- - -- 2 2- - -- - 2- - -- - -- - -- - -- - -- - -- - -- - -- - -- - -- -
       :                                      B
       :  B                           F         B  F   BB B BB
       :B                          F              BB B         B B
       :                                             F            B B BB
  0.5 -:F                 F      F                                       B
       :                      FF                                           BB B
       :  F                                                                     BB B BB B BB B
       :   F                                                                                   BB B
       :     F F  F FF F F
  0.0 -:        F
       :........................................................................................................
        :         :         :         :         :         :         :         :         :         :         :
     1950.     1956.     1962.     1968.     1974.     1980.     1986.     1992.     1998.     2004.     2010.
```

Elapsed time: 0 hours, 0 minutes, 10 seconds.

G.3 Run with R:C = 3:1

```
 Black Seabass -- SEDAR, March 2005 -- Four indices & extended catch                                    Page 1
                                                                               Tuesday, 15 Mar 2005 at 21:21:56
ASPIC -- A Surplus-Production Model Including Covariates (Ver. 5.07)
                                                                                               FIT program mode
Author:    Michael H. Prager; NOAA Center for Coastal Fisheries and Habitat Research         LOGISTIC model mode
           101 Pivers Island Road; Beaufort, North Carolina  28516  USA                        YLD conditioning
           Mike.Prager@noaa.gov                                                                SSE optimization

Reference: Prager, M. H. 1994. A suite of extensions to a nonequilibrium             ASPIC User's Manual is available
           surplus-production model.  Fishery Bulletin 92: 374-389.                         gratis from the author.

CONTROL PARAMETERS USED (FROM INPUT FILE)                                                      Input file: bsb003.inp
-----------------------------------------------------------------------------------------------------------------------
Operation of ASPIC:  Fit logistic (Schaefer) model by direct optimization.
Number of years analyzed:                         54            Number of bootstrap trials:                           0
Number of data series:                             4            Lower bound on MSY:                           1.000E+02
Objective function:                    Least squares            Upper bound on MSY:                           5.000E+04
Relative conv. criterion (simplex):        1.000E-08            Lower bound on K:                             1.000E+03
Relative conv. criterion (restart):        4.000E-08            Upper bound on K:                             5.000E+05
Relative conv. criterion (effort):         1.000E-04            Random number seed:                             1952385
Maximum F allowed in fitting:                  4.000            Monte Carlo search mode, trials:        1        500000
Identical convergences required in fitting:        6


PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS)                                                     error code   0
-----------------------------------------------------------------------------------------------------------------------
Normal convergence

WARNING: Negative correlations detected between some indices.  A fundamental assumption of ASPIC is that all indices
         represent the abundance of the stock.  That assumption appears to be violated.
Number of restarts required for convergence:      70


CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)
-----------------------------------------------------------------------------------------------------------------------
                                       |
 1  HB Index (WPUE), Yield ext @ Rec...|   1.000
                                       |      30
                                       |
 2  MARMAP Chevron Trap                |   0.570   1.000
                                       |      14      14
                                       |
 3  MARMAP Blackfish Trap              |   0.099   0.000   1.000
                                       |       7       0       7
                                       |
 4  MARMAP Hook & Line Index           |   0.440   0.000  -0.059   1.000
                                       |       7       0       7       7
                                       --------------------------------------------------
                                               1       2       3       4


GOODNESS-OF-FIT AND WEIGHTING (NON-BOOTSTRAPPED ANALYSIS)
-----------------------------------------------------------------------------------------------------------------------
                                                    Weighted             Weighted      Current      Inv. var.    R-squared
Loss component number and title                          SSE        N         MSE       weight         weight      in CPUE

Loss(-1)  SSE in yield                             0.000E+00
Loss(0)   Penalty for B1 > K                       0.000E+00        1         N/A    1.000E+00            N/A
Loss(1)   HB Index (WPUE), Yield ext @ Rec = 3xCo  1.959E+00       30   6.995E-02    1.000E+00      1.075E+00        0.793
Loss(2)   MARMAP Chevron Trap                      1.480E+00       14   1.234E-01    1.000E+00      6.098E-01       -0.515
Loss(3)   MARMAP Blackfish Trap                    2.084E-01        7   4.167E-02    1.000E+00      1.805E+00       -0.006
Loss(4)   MARMAP Hook & Line Index                 5.766E-01        7   1.153E-01    1.000E+00      6.522E-01        0.238
.............................................................................................
TOTAL OBJECTIVE FUNCTION, MSE, RMSE:          4.22383594E+00            8.282E-02    2.878E-01
Estimated contrast index (ideal = 1.0):               0.8669            C* = (Bmax-Bmin)/K
Estimated nearness index (ideal = 1.0):               1.0000            N* = 1 - |min(B-Bmsy)|/K
```

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	User/pgm guess	2nd guess	Estimated	User guess
B1/K	Starting relative biomass (in 1950)	8.170E-01	4.000E-01	7.144E-01	1	1
MSY	Maximum sustainable yield	1.254E+03	1.400E+03	8.972E+02	1	1
K	Maximum population size	2.106E+04	1.200E+04	5.383E+03	1	1
phi	Shape of production curve (Bmsy/K)	0.5000	0.5000	----	0	1
---------	Catchability Coefficients by Data Series ---------------					
q(1)	HB Index (WPUE), Yield ext @ Rec = 3xCo	5.073E-04	5.450E-04	5.178E-02	1	1
q(2)	MARMAP Chevron Trap	5.733E-04	5.210E-04	4.950E-02	1	1
q(3)	MARMAP Blackfish Trap	3.517E-04	2.500E-04	2.375E-02	1	1
q(4)	MARMAP Hook & Line Index	4.533E-04	5.500E-04	5.225E-02	1	1

MANAGEMENT and DERIVED PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Logistic formula	General formula
MSY	Maximum sustainable yield	1.254E+03	----	----
Bmsy	Stock biomass giving MSY	1.053E+04	K/2	K*n**(1/(1-n))
Fmsy	Fishing mortality rate at MSY	1.191E-01	MSY/Bmsy	MSY/Bmsy
n	Exponent in production function	2.0000	----	----
g	Fletcher's gamma	4.000E+00	----	[n**(n/(n-1))]/[n-1]
B./Bmsy	Ratio: B(2004)/Bmsy	1.521E-01	----	----
F./Fmsy	Ratio: F(2003)/Fmsy	2.805E+00	----	----
Fmsy/F.	Ratio: Fmsy/F(2003)	3.565E-01	----	----
Y.(Fmsy)	Approx. yield available at Fmsy in 2004	1.908E+02	MSY*B./Bmsy	MSY*B./Bmsy
	...as proportion of MSY	1.521E-01	----	----
Ye.	Equilibrium yield available in 2004	3.525E+02	4*MSY*(B/K-(B/K)**2)	g*MSY*(B/K-(B/K)**n)
	...as proportion of MSY	2.811E-01	----	----
---------	Fishing effort rate at MSY in units of each CE or CC series ---------			
fmsy(1)	HB Index (WPUE), Yield ext @ Rec = 3xCo	2.348E+02	Fmsy/q(1)	Fmsy/q(1)

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1950	0.034	1.721E+04	1.729E+04	5.796E+02	5.796E+02	7.378E+02	2.815E-01	1.634E+00
2	1951	0.023	1.737E+04	1.752E+04	4.104E+02	4.104E+02	7.024E+02	1.967E-01	1.649E+00
3	1952	0.018	1.766E+04	1.783E+04	3.172E+02	3.172E+02	6.517E+02	1.494E-01	1.677E+00
4	1953	0.012	1.799E+04	1.818E+04	2.224E+02	2.224E+02	5.920E+02	1.027E-01	1.708E+00
5	1954	0.007	1.836E+04	1.856E+04	1.328E+02	1.328E+02	5.244E+02	6.006E-02	1.744E+00
6	1955	0.004	1.875E+04	1.895E+04	8.200E+01	8.200E+01	4.535E+02	3.634E-02	1.781E+00
7	1956	0.007	1.913E+04	1.926E+04	1.396E+02	1.396E+02	3.933E+02	6.087E-02	1.816E+00
8	1957	0.007	1.938E+04	1.949E+04	1.368E+02	1.368E+02	3.471E+02	5.894E-02	1.840E+00
9	1958	0.007	1.959E+04	1.968E+04	1.356E+02	1.356E+02	3.080E+02	5.786E-02	1.860E+00
10	1959	0.009	1.976E+04	1.981E+04	1.860E+02	1.860E+02	2.805E+02	7.883E-02	1.876E+00
11	1960	0.013	1.986E+04	1.986E+04	2.664E+02	2.664E+02	2.705E+02	1.126E-01	1.885E+00
12	1961	0.064	1.986E+04	1.940E+04	1.244E+03	1.244E+03	3.639E+02	5.382E-01	1.886E+00
13	1962	0.163	1.898E+04	1.779E+04	2.905E+03	2.905E+03	6.532E+02	1.371E+00	1.802E+00
14	1963	0.059	1.673E+04	1.665E+04	9.848E+02	9.848E+02	8.310E+02	4.966E-01	1.588E+00
15	1964	0.063	1.658E+04	1.648E+04	1.046E+03	1.046E+03	8.546E+02	5.330E-01	1.574E+00
16	1965	0.066	1.638E+04	1.628E+04	1.080E+03	1.080E+03	8.805E+02	5.570E-01	1.556E+00
17	1966	0.095	1.618E+04	1.589E+04	1.508E+03	1.508E+03	9.299E+02	7.971E-01	1.537E+00
18	1967	0.185	1.561E+04	1.473E+04	2.727E+03	2.727E+03	1.052E+03	1.554E+00	1.482E+00
19	1968	0.113	1.393E+04	1.372E+04	1.545E+03	1.545E+03	1.139E+03	9.452E-01	1.323E+00
20	1969	0.194	1.353E+04	1.285E+04	2.487E+03	2.487E+03	1.192E+03	1.625E+00	1.284E+00
21	1970	0.255	1.223E+04	1.136E+04	2.903E+03	2.903E+03	1.244E+03	2.145E+00	1.161E+00
22	1971	0.204	1.057E+04	1.015E+04	2.073E+03	2.073E+03	1.252E+03	1.715E+00	1.004E+00
23	1972	0.251	9.750E+03	9.195E+03	2.304E+03	2.304E+03	1.233E+03	2.104E+00	9.258E-01
24	1973	0.208	8.679E+03	8.401E+03	1.746E+03	1.746E+03	1.203E+03	1.745E+00	8.241E-01
25	1974	0.359	8.136E+03	7.349E+03	2.640E+03	2.640E+03	1.138E+03	3.016E+00	7.726E-01
26	1975	0.267	6.634E+03	6.309E+03	1.685E+03	1.685E+03	1.052E+03	2.243E+00	6.299E-01
27	1976	0.138	6.002E+03	6.098E+03	8.404E+02	8.404E+02	1.032E+03	1.157E+00	5.699E-01
28	1977	0.105	6.193E+03	6.389E+03	6.684E+02	6.684E+02	1.060E+03	8.784E-01	5.880E-01
29	1978	0.141	6.585E+03	6.659E+03	9.374E+02	9.374E+02	1.085E+03	1.182E+00	6.252E-01
30	1979	0.182	6.732E+03	6.667E+03	1.213E+03	1.213E+03	1.085E+03	1.528E+00	6.392E-01
31	1980	0.203	6.604E+03	6.480E+03	1.314E+03	1.314E+03	1.069E+03	1.703E+00	6.271E-01
32	1981	0.193	6.359E+03	6.276E+03	1.213E+03	1.213E+03	1.050E+03	1.622E+00	6.038E-01
33	1982	0.260	6.196E+03	5.925E+03	1.542E+03	1.542E+03	1.014E+03	2.185E+00	5.883E-01
34	1983	0.183	5.668E+03	5.642E+03	1.035E+03	1.035E+03	9.840E+02	1.540E+00	5.382E-01
35	1984	0.302	5.617E+03	5.282E+03	1.593E+03	1.593E+03	9.422E+02	2.533E+00	5.334E-01
36	1985	0.238	4.966E+03	4.832E+03	1.149E+03	1.149E+03	8.869E+02	1.997E+00	4.715E-01
37	1986	0.171	4.704E+03	4.737E+03	8.093E+02	8.093E+02	8.745E+02	1.435E+00	4.466E-01
38	1987	0.223	4.769E+03	4.680E+03	1.042E+03	1.042E+03	8.671E+02	1.870E+00	4.528E-01
39	1988	0.317	4.594E+03	4.311E+03	1.366E+03	1.366E+03	8.165E+02	2.660E+00	4.362E-01
40	1989	0.294	4.045E+03	3.849E+03	1.131E+03	1.131E+03	7.492E+02	2.467E+00	3.841E-01
41	1990	0.243	3.663E+03	3.580E+03	8.707E+02	8.707E+02	7.078E+02	2.042E+00	3.478E-01
42	1991	0.283	3.500E+03	3.358E+03	9.512E+02	9.512E+02	6.722E+02	2.379E+00	3.323E-01
43	1992	0.249	3.221E+03	3.148E+03	7.822E+02	7.822E+02	6.377E+02	2.087E+00	3.058E-01
44	1993	0.223	3.076E+03	3.047E+03	6.799E+02	6.799E+02	6.207E+02	1.874E+00	2.921E-01
45	1994	0.258	3.017E+03	2.939E+03	7.573E+02	7.573E+02	6.023E+02	2.164E+00	2.865E-01
46	1995	0.229	2.862E+03	2.830E+03	6.478E+02	6.478E+02	5.835E+02	1.922E+00	2.718E-01
47	1996	0.264	2.798E+03	2.720E+03	7.171E+02	7.171E+02	5.643E+02	2.213E+00	2.657E-01
48	1997	0.280	2.645E+03	2.554E+03	7.140E+02	7.140E+02	5.345E+02	2.348E+00	2.511E-01
49	1998	0.250	2.466E+03	2.418E+03	6.035E+02	6.035E+02	5.099E+02	2.095E+00	2.341E-01
50	1999	0.274	2.372E+03	2.299E+03	6.308E+02	6.308E+02	4.879E+02	2.303E+00	2.252E-01
51	2000	0.238	2.229E+03	2.202E+03	5.234E+02	5.234E+02	4.696E+02	1.996E+00	2.116E-01
52	2001	0.354	2.175E+03	2.031E+03	7.186E+02	7.186E+02	4.370E+02	2.971E+00	2.065E-01
53	2002	0.270	1.894E+03	1.845E+03	4.974E+02	4.974E+02	4.009E+02	2.264E+00	1.798E-01
54	2003	0.334	1.797E+03	1.697E+03	5.670E+02	5.670E+02	3.717E+02	2.805E+00	1.706E-01
55	2004		1.602E+03						1.521E-01

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) HB Index (WPUE), Yield ext @ Rec = 3xCom

Data type CC: CPUE-catch series Series weight: 1.000

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale
1	1950	*	8.771E+00	0.0335	5.796E+02	5.796E+02	0.00000
2	1951	*	8.886E+00	0.0234	4.104E+02	4.104E+02	0.00000
3	1952	*	9.046E+00	0.0178	3.172E+02	3.172E+02	0.00000
4	1953	*	9.225E+00	0.0122	2.224E+02	2.224E+02	0.00000
5	1954	*	9.418E+00	0.0072	1.328E+02	1.328E+02	0.00000
6	1955	*	9.611E+00	0.0043	8.200E+01	8.200E+01	0.00000
7	1956	*	9.769E+00	0.0072	1.396E+02	1.396E+02	0.00000
8	1957	*	9.887E+00	0.0070	1.368E+02	1.368E+02	0.00000
9	1958	*	9.983E+00	0.0069	1.356E+02	1.356E+02	0.00000
10	1959	*	1.005E+01	0.0094	1.860E+02	1.860E+02	0.00000
11	1960	*	1.007E+01	0.0134	2.664E+02	2.664E+02	0.00000
12	1961	*	9.843E+00	0.0641	1.244E+03	1.244E+03	0.00000
13	1962	*	9.027E+00	0.1633	2.905E+03	2.905E+03	0.00000
14	1963	*	8.446E+00	0.0591	9.848E+02	9.848E+02	0.00000
15	1964	*	8.359E+00	0.0635	1.046E+03	1.046E+03	0.00000
16	1965	*	8.259E+00	0.0663	1.080E+03	1.080E+03	0.00000
17	1966	*	8.059E+00	0.0949	1.508E+03	1.508E+03	0.00000
18	1967	*	7.473E+00	0.1851	2.727E+03	2.727E+03	0.00000
19	1968	*	6.962E+00	0.1126	1.545E+03	1.545E+03	0.00000
20	1969	*	6.520E+00	0.1935	2.487E+03	2.487E+03	0.00000
21	1970	*	5.765E+00	0.2555	2.903E+03	2.903E+03	0.00000
22	1971	*	5.148E+00	0.2043	2.073E+03	2.073E+03	0.00000
23	1972	*	4.665E+00	0.2506	2.304E+03	2.304E+03	0.00000
24	1973	*	4.262E+00	0.2078	1.746E+03	1.746E+03	0.00000
25	1974	3.284E+00	3.728E+00	0.3592	2.640E+03	2.640E+03	0.12691
26	1975	4.469E+00	3.201E+00	0.2671	1.685E+03	1.685E+03	-0.33384
27	1976	2.992E+00	3.093E+00	0.1378	8.404E+02	8.404E+02	0.03335
28	1977	3.393E+00	3.241E+00	0.1046	6.684E+02	6.684E+02	-0.04574
29	1978	4.093E+00	3.378E+00	0.1408	9.374E+02	9.374E+02	-0.19194
30	1979	3.401E+00	3.382E+00	0.1819	1.213E+03	1.213E+03	-0.00550
31	1980	3.630E+00	3.287E+00	0.2028	1.314E+03	1.314E+03	-0.09922
32	1981	3.646E+00	3.184E+00	0.1932	1.213E+03	1.213E+03	-0.13550
33	1982	3.709E+00	3.006E+00	0.2602	1.542E+03	1.542E+03	-0.21020
34	1983	3.740E+00	2.862E+00	0.1834	1.035E+03	1.035E+03	-0.26744
35	1984	3.373E+00	2.679E+00	0.3017	1.593E+03	1.593E+03	-0.23021
36	1985	3.363E+00	2.452E+00	0.2378	1.149E+03	1.149E+03	-0.31612
37	1986	3.386E+00	2.403E+00	0.1709	8.093E+02	8.093E+02	-0.34298
38	1987	3.484E+00	2.374E+00	0.2227	1.042E+03	1.042E+03	-0.38349
39	1988	3.005E+00	2.187E+00	0.3168	1.366E+03	1.366E+03	-0.31769
40	1989	2.003E+00	1.953E+00	0.2939	1.131E+03	1.131E+03	-0.02542
41	1990	2.071E+00	1.816E+00	0.2432	8.707E+02	8.707E+02	-0.13126
42	1991	1.576E+00	1.703E+00	0.2833	9.512E+02	9.512E+02	0.07768
43	1992	1.545E+00	1.597E+00	0.2485	7.822E+02	7.822E+02	0.03298
44	1993	1.178E+00	1.546E+00	0.2232	6.799E+02	6.799E+02	0.27153
45	1994	1.035E+00	1.491E+00	0.2577	7.573E+02	7.573E+02	0.36486
46	1995	7.430E-01	1.436E+00	0.2289	6.478E+02	6.478E+02	0.65859
47	1996	8.220E-01	1.380E+00	0.2636	7.171E+02	7.171E+02	0.51811
48	1997	1.053E+00	1.296E+00	0.2796	7.140E+02	7.140E+02	0.20727
49	1998	1.082E+00	1.227E+00	0.2496	6.035E+02	6.035E+02	0.12555
50	1999	1.277E+00	1.166E+00	0.2743	6.308E+02	6.308E+02	-0.09052
51	2000	9.530E-01	1.117E+00	0.2377	5.234E+02	5.234E+02	0.15880
52	2001	8.600E-01	1.030E+00	0.3539	7.186E+02	7.186E+02	0.18051
53	2002	7.510E-01	9.358E-01	0.2696	4.974E+02	4.974E+02	0.22005
54	2003	7.440E-01	8.610E-01	0.3341	5.670E+02	5.670E+02	0.14607

* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1950     0.0000                                             |
1951     0.0000                                             |
1952     0.0000                                             |
1953     0.0000                                             |
1954     0.0000                                             |
1955     0.0000                                             |
1956     0.0000                                             |
1957     0.0000                                             |
1958     0.0000                                             |
1959     0.0000                                             |
1960     0.0000                                             |
1961     0.0000                                             |
1962     0.0000                                             |
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.1269                                             |=====
1975    -0.3338                                =============|
1976     0.0334                                             |=
1977    -0.0457                                           ==|
1978    -0.1919                                     ========|
1979    -0.0055                                             |
1980    -0.0992                                         ====|
1981    -0.1355                                        =====|
1982    -0.2102                                     ========|
1983    -0.2674                                  ===========|
1984    -0.2302                                    =========|
1985    -0.3161                                =============|
1986    -0.3430                               ==============|
1987    -0.3835                              ===============|
1988    -0.3177                                =============|
1989    -0.0254                                            =|
1990    -0.1313                                        =====|
1991     0.0777                                             |===
1992     0.0330                                             |=
1993     0.2715                                             |===========
1994     0.3649                                             |===============
1995     0.6586                                             |==========================
1996     0.5181                                             |=====================
1997     0.2073                                             |========
1998     0.1256                                             |=====
1999    -0.0905                                         ====|
2000     0.1588                                             |======
2001     0.1805                                             |=======
2002     0.2200                                             |=========
2003     0.1461                                             |======
                   ------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED) MARMAP Chevron Trap

Data type I1: Abundance index (annual average) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index
1	1950	0.000E+00	0.000E+00	--	*	9.912E+00	0.00000
2	1951	0.000E+00	0.000E+00	--	*	1.004E+01	0.00000
3	1952	0.000E+00	0.000E+00	--	*	1.022E+01	0.00000
4	1953	0.000E+00	0.000E+00	--	*	1.042E+01	0.00000
5	1954	0.000E+00	0.000E+00	--	*	1.064E+01	0.00000
6	1955	0.000E+00	0.000E+00	--	*	1.086E+01	0.00000
7	1956	0.000E+00	0.000E+00	--	*	1.104E+01	0.00000
8	1957	0.000E+00	0.000E+00	--	*	1.117E+01	0.00000
9	1958	0.000E+00	0.000E+00	--	*	1.128E+01	0.00000
10	1959	0.000E+00	0.000E+00	--	*	1.136E+01	0.00000
11	1960	0.000E+00	0.000E+00	--	*	1.138E+01	0.00000
12	1961	0.000E+00	0.000E+00	--	*	1.112E+01	0.00000
13	1962	0.000E+00	0.000E+00	--	*	1.020E+01	0.00000
14	1963	0.000E+00	0.000E+00	--	*	9.545E+00	0.00000
15	1964	0.000E+00	0.000E+00	--	*	9.445E+00	0.00000
16	1965	0.000E+00	0.000E+00	--	*	9.333E+00	0.00000
17	1966	0.000E+00	0.000E+00	--	*	9.106E+00	0.00000
18	1967	0.000E+00	0.000E+00	--	*	8.444E+00	0.00000
19	1968	0.000E+00	0.000E+00	--	*	7.867E+00	0.00000
20	1969	0.000E+00	0.000E+00	--	*	7.368E+00	0.00000
21	1970	0.000E+00	0.000E+00	--	*	6.514E+00	0.00000
22	1971	0.000E+00	0.000E+00	--	*	5.817E+00	0.00000
23	1972	0.000E+00	0.000E+00	--	*	5.271E+00	0.00000
24	1973	0.000E+00	0.000E+00	--	*	4.816E+00	0.00000
25	1974	0.000E+00	0.000E+00	--	*	4.213E+00	0.00000
26	1975	0.000E+00	0.000E+00	--	*	3.617E+00	0.00000
27	1976	0.000E+00	0.000E+00	--	*	3.496E+00	0.00000
28	1977	0.000E+00	0.000E+00	--	*	3.663E+00	0.00000
29	1978	0.000E+00	0.000E+00	--	*	3.817E+00	0.00000
30	1979	0.000E+00	0.000E+00	--	*	3.822E+00	0.00000
31	1980	0.000E+00	0.000E+00	--	*	3.715E+00	0.00000
32	1981	0.000E+00	0.000E+00	--	*	3.598E+00	0.00000
33	1982	0.000E+00	0.000E+00	--	*	3.397E+00	0.00000
34	1983	0.000E+00	0.000E+00	--	*	3.235E+00	0.00000
35	1984	0.000E+00	0.000E+00	--	*	3.028E+00	0.00000
36	1985	0.000E+00	0.000E+00	--	*	2.770E+00	0.00000
37	1986	0.000E+00	0.000E+00	--	*	2.715E+00	0.00000
38	1987	0.000E+00	0.000E+00	--	*	2.683E+00	0.00000
39	1988	0.000E+00	0.000E+00	--	*	2.472E+00	0.00000
40	1989	0.000E+00	0.000E+00	--	*	2.207E+00	0.00000
41	1990	1.000E+00	1.000E+00	--	2.126E+00	2.052E+00	0.03523
42	1991	1.000E+00	1.000E+00	--	1.585E+00	1.925E+00	-0.19423
43	1992	1.000E+00	1.000E+00	--	1.753E+00	1.804E+00	-0.02892
44	1993	1.000E+00	1.000E+00	--	9.830E-01	1.746E+00	-0.57474
45	1994	1.000E+00	1.000E+00	--	1.153E+00	1.685E+00	-0.37914
46	1995	1.000E+00	1.000E+00	--	1.062E+00	1.622E+00	-0.42362
47	1996	1.000E+00	1.000E+00	--	1.302E+00	1.559E+00	-0.18044
48	1997	1.000E+00	1.000E+00	--	1.328E+00	1.464E+00	-0.09749
49	1998	1.000E+00	1.000E+00	--	1.506E+00	1.386E+00	0.08285
50	1999	1.000E+00	1.000E+00	--	2.321E+00	1.318E+00	0.56576
51	2000	1.000E+00	1.000E+00	--	1.842E+00	1.262E+00	0.37795
52	2001	1.000E+00	1.000E+00	--	1.727E+00	1.164E+00	0.39445
53	2002	1.000E+00	1.000E+00	--	1.477E+00	1.058E+00	0.33407
54	2003	1.000E+00	1.000E+00	--	1.063E+00	9.730E-01	0.08850

* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    -------------------------------------------------------------------------------------
1950      0.0000                                            |
1951      0.0000                                            |
1952      0.0000                                            |
1953      0.0000                                            |
1954      0.0000                                            |
1955      0.0000                                            |
1956      0.0000                                            |
1957      0.0000                                            |
1958      0.0000                                            |
1959      0.0000                                            |
1960      0.0000                                            |
1961      0.0000                                            |
1962      0.0000                                            |
1963      0.0000                                            |
1964      0.0000                                            |
1965      0.0000                                            |
1966      0.0000                                            |
1967      0.0000                                            |
1968      0.0000                                            |
1969      0.0000                                            |
1970      0.0000                                            |
1971      0.0000                                            |
1972      0.0000                                            |
1973      0.0000                                            |
1974      0.0000                                            |
1975      0.0000                                            |
1976      0.0000                                            |
1977      0.0000                                            |
1978      0.0000                                            |
1979      0.0000                                            |
1980      0.0000                                            |
1981      0.0000                                            |
1982      0.0000                                            |
1983      0.0000                                            |
1984      0.0000                                            |
1985      0.0000                                            |
1986      0.0000                                            |
1987      0.0000                                            |
1988      0.0000                                            |
1989      0.0000                                            |
1990      0.0352                                            |=
1991     -0.1942                                    ========|
1992     -0.0289                                           =|
1993     -0.5747                     =======================|
1994     -0.3791                             ===============|
1995     -0.4236                           =================|
1996     -0.1804                                     =======|
1997     -0.0975                                        ====|
1998      0.0828                                            |===
1999      0.5658                                            |=======================
2000      0.3779                                            |===============
2001      0.3945                                            |================
2002      0.3341                                            |=============
2003      0.0885                                            |====
                   -------------------------------------------------------------------------------------
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RESULTS FOR DATA SERIES # 3 (NON-BOOTSTRAPPED) MARMAP Blackfish Trap

Data type I1: Abundance index (annual average) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index
1	1950	0.000E+00	0.000E+00	--	*	6.080E+00	0.00000
2	1951	0.000E+00	0.000E+00	--	*	6.160E+00	0.00000
3	1952	0.000E+00	0.000E+00	--	*	6.271E+00	0.00000
4	1953	0.000E+00	0.000E+00	--	*	6.395E+00	0.00000
5	1954	0.000E+00	0.000E+00	--	*	6.529E+00	0.00000
6	1955	0.000E+00	0.000E+00	--	*	6.663E+00	0.00000
7	1956	0.000E+00	0.000E+00	--	*	6.772E+00	0.00000
8	1957	0.000E+00	0.000E+00	--	*	6.853E+00	0.00000
9	1958	0.000E+00	0.000E+00	--	*	6.920E+00	0.00000
10	1959	0.000E+00	0.000E+00	--	*	6.967E+00	0.00000
11	1960	0.000E+00	0.000E+00	--	*	6.984E+00	0.00000
12	1961	0.000E+00	0.000E+00	--	*	6.823E+00	0.00000
13	1962	0.000E+00	0.000E+00	--	*	6.257E+00	0.00000
14	1963	0.000E+00	0.000E+00	--	*	5.855E+00	0.00000
15	1964	0.000E+00	0.000E+00	--	*	5.794E+00	0.00000
16	1965	0.000E+00	0.000E+00	--	*	5.725E+00	0.00000
17	1966	0.000E+00	0.000E+00	--	*	5.586E+00	0.00000
18	1967	0.000E+00	0.000E+00	--	*	5.180E+00	0.00000
19	1968	0.000E+00	0.000E+00	--	*	4.826E+00	0.00000
20	1969	0.000E+00	0.000E+00	--	*	4.520E+00	0.00000
21	1970	0.000E+00	0.000E+00	--	*	3.996E+00	0.00000
22	1971	0.000E+00	0.000E+00	--	*	3.569E+00	0.00000
23	1972	0.000E+00	0.000E+00	--	*	3.234E+00	0.00000
24	1973	0.000E+00	0.000E+00	--	*	2.954E+00	0.00000
25	1974	0.000E+00	0.000E+00	--	*	2.585E+00	0.00000
26	1975	0.000E+00	0.000E+00	--	*	2.219E+00	0.00000
27	1976	0.000E+00	0.000E+00	--	*	2.144E+00	0.00000
28	1977	0.000E+00	0.000E+00	--	*	2.247E+00	0.00000
29	1978	0.000E+00	0.000E+00	--	*	2.342E+00	0.00000
30	1979	0.000E+00	0.000E+00	--	*	2.345E+00	0.00000
31	1980	0.000E+00	0.000E+00	--	*	2.279E+00	0.00000
32	1981	1.000E+00	1.000E+00	--	2.235E+00	2.207E+00	0.01254
33	1982	1.000E+00	1.000E+00	--	1.846E+00	2.084E+00	-0.12112
34	1983	1.000E+00	1.000E+00	--	1.940E+00	1.984E+00	-0.02253
35	1984	1.000E+00	1.000E+00	--	1.586E+00	1.857E+00	-0.15795
36	1985	1.000E+00	1.000E+00	--	2.531E+00	1.699E+00	0.39833
37	1986	1.000E+00	1.000E+00	--	1.644E+00	1.666E+00	-0.01311
38	1987	1.000E+00	1.000E+00	--	1.495E+00	1.646E+00	-0.09613
39	1988	0.000E+00	0.000E+00	--	*	1.516E+00	0.00000
40	1989	0.000E+00	0.000E+00	--	*	1.354E+00	0.00000
41	1990	0.000E+00	0.000E+00	--	*	1.259E+00	0.00000
42	1991	0.000E+00	0.000E+00	--	*	1.181E+00	0.00000
43	1992	0.000E+00	0.000E+00	--	*	1.107E+00	0.00000
44	1993	0.000E+00	0.000E+00	--	*	1.071E+00	0.00000
45	1994	0.000E+00	0.000E+00	--	*	1.033E+00	0.00000
46	1995	0.000E+00	0.000E+00	--	*	9.951E-01	0.00000
47	1996	0.000E+00	0.000E+00	--	*	9.566E-01	0.00000
48	1997	0.000E+00	0.000E+00	--	*	8.981E-01	0.00000
49	1998	0.000E+00	0.000E+00	--	*	8.504E-01	0.00000
50	1999	0.000E+00	0.000E+00	--	*	8.086E-01	0.00000
51	2000	0.000E+00	0.000E+00	--	*	7.743E-01	0.00000
52	2001	0.000E+00	0.000E+00	--	*	7.141E-01	0.00000
53	2002	0.000E+00	0.000E+00	--	*	6.487E-01	0.00000
54	2003	0.000E+00	0.000E+00	--	*	5.969E-01	0.00000

* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 3
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1950     0.0000                                             |
1951     0.0000                                             |
1952     0.0000                                             |
1953     0.0000                                             |
1954     0.0000                                             |
1955     0.0000                                             |
1956     0.0000                                             |
1957     0.0000                                             |
1958     0.0000                                             |
1959     0.0000                                             |
1960     0.0000                                             |
1961     0.0000                                             |
1962     0.0000                                             |
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981     0.0125                                             |=
1982    -0.1211                                        =====|
1983    -0.0225                                            =|
1984    -0.1579                                       ======|
1985     0.3983                                             |================
1986    -0.0131                                            =|
1987    -0.0961                                         ====|
1988     0.0000                                             |
1989     0.0000                                             |
1990     0.0000                                             |
1991     0.0000                                             |
1992     0.0000                                             |
1993     0.0000                                             |
1994     0.0000                                             |
1995     0.0000                                             |
1996     0.0000                                             |
1997     0.0000                                             |
1998     0.0000                                             |
1999     0.0000                                             |
2000     0.0000                                             |
2001     0.0000                                             |
2002     0.0000                                             |
2003     0.0000                                             |
                   ------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 4 (NON-BOOTSTRAPPED) MARMAP Hook & Line Index

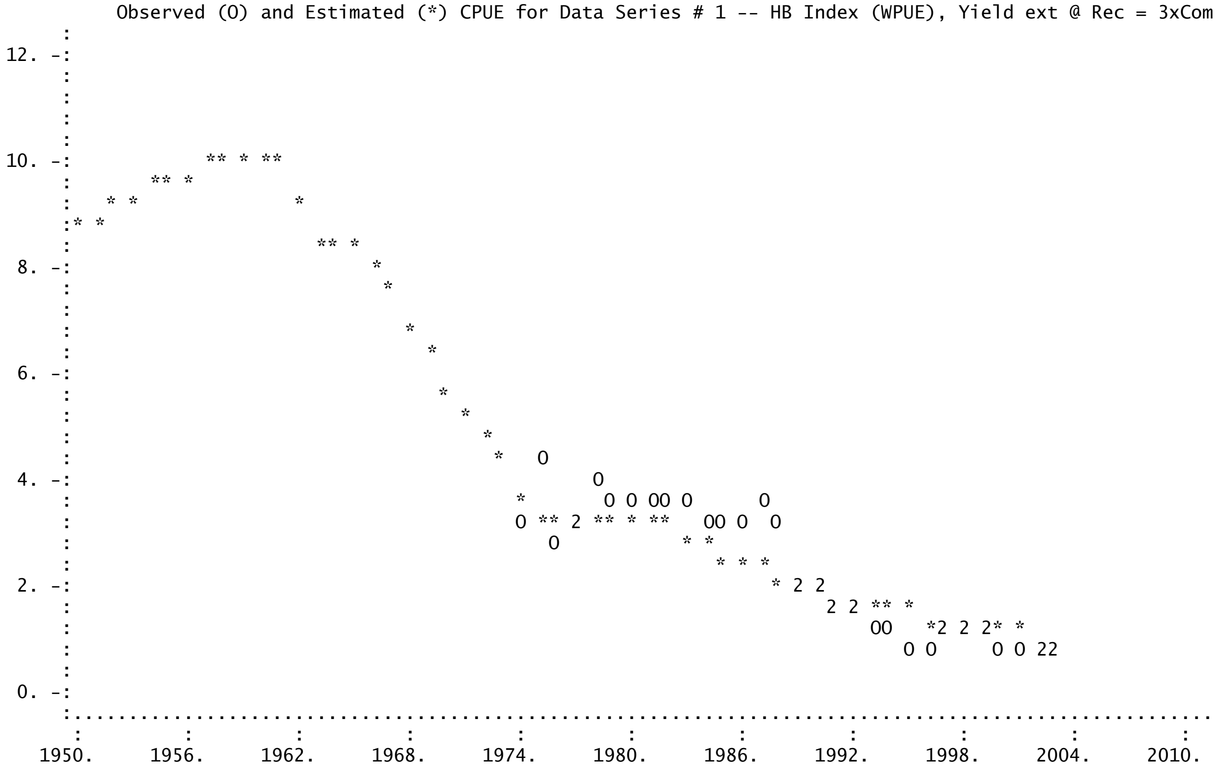
Data type I1: Abundance index (annual average) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index
1	1950	0.000E+00	0.000E+00	--	*	7.837E+00	0.00000
2	1951	0.000E+00	0.000E+00	--	*	7.940E+00	0.00000
3	1952	0.000E+00	0.000E+00	--	*	8.082E+00	0.00000
4	1953	0.000E+00	0.000E+00	--	*	8.242E+00	0.00000
5	1954	0.000E+00	0.000E+00	--	*	8.415E+00	0.00000
6	1955	0.000E+00	0.000E+00	--	*	8.588E+00	0.00000
7	1956	0.000E+00	0.000E+00	--	*	8.729E+00	0.00000
8	1957	0.000E+00	0.000E+00	--	*	8.834E+00	0.00000
9	1958	0.000E+00	0.000E+00	--	*	8.920E+00	0.00000
10	1959	0.000E+00	0.000E+00	--	*	8.980E+00	0.00000
11	1960	0.000E+00	0.000E+00	--	*	9.002E+00	0.00000
12	1961	0.000E+00	0.000E+00	--	*	8.794E+00	0.00000
13	1962	0.000E+00	0.000E+00	--	*	8.065E+00	0.00000
14	1963	0.000E+00	0.000E+00	--	*	7.547E+00	0.00000
15	1964	0.000E+00	0.000E+00	--	*	7.468E+00	0.00000
16	1965	0.000E+00	0.000E+00	--	*	7.380E+00	0.00000
17	1966	0.000E+00	0.000E+00	--	*	7.200E+00	0.00000
18	1967	0.000E+00	0.000E+00	--	*	6.677E+00	0.00000
19	1968	0.000E+00	0.000E+00	--	*	6.220E+00	0.00000
20	1969	0.000E+00	0.000E+00	--	*	5.825E+00	0.00000
21	1970	0.000E+00	0.000E+00	--	*	5.151E+00	0.00000
22	1971	0.000E+00	0.000E+00	--	*	4.600E+00	0.00000
23	1972	0.000E+00	0.000E+00	--	*	4.168E+00	0.00000
24	1973	0.000E+00	0.000E+00	--	*	3.808E+00	0.00000
25	1974	0.000E+00	0.000E+00	--	*	3.331E+00	0.00000
26	1975	0.000E+00	0.000E+00	--	*	2.860E+00	0.00000
27	1976	0.000E+00	0.000E+00	--	*	2.764E+00	0.00000
28	1977	0.000E+00	0.000E+00	--	*	2.896E+00	0.00000
29	1978	0.000E+00	0.000E+00	--	*	3.018E+00	0.00000
30	1979	0.000E+00	0.000E+00	--	*	3.022E+00	0.00000
31	1980	0.000E+00	0.000E+00	--	*	2.937E+00	0.00000
32	1981	1.000E+00	1.000E+00	--	2.210E+00	2.845E+00	-0.25252
33	1982	1.000E+00	1.000E+00	--	4.077E+00	2.686E+00	0.41741
34	1983	1.000E+00	1.000E+00	--	2.894E+00	2.558E+00	0.12360
35	1984	1.000E+00	1.000E+00	--	3.382E+00	2.394E+00	0.34549
36	1985	1.000E+00	1.000E+00	--	2.035E+00	2.190E+00	-0.07361
37	1986	1.000E+00	1.000E+00	--	1.873E+00	2.147E+00	-0.13652
38	1987	1.000E+00	1.000E+00	--	1.388E+00	2.121E+00	-0.42421
39	1988	0.000E+00	0.000E+00	--	*	1.954E+00	0.00000
40	1989	0.000E+00	0.000E+00	--	*	1.745E+00	0.00000
41	1990	0.000E+00	0.000E+00	--	*	1.623E+00	0.00000
42	1991	0.000E+00	0.000E+00	--	*	1.522E+00	0.00000
43	1992	0.000E+00	0.000E+00	--	*	1.427E+00	0.00000
44	1993	0.000E+00	0.000E+00	--	*	1.381E+00	0.00000
45	1994	0.000E+00	0.000E+00	--	*	1.332E+00	0.00000
46	1995	0.000E+00	0.000E+00	--	*	1.283E+00	0.00000
47	1996	0.000E+00	0.000E+00	--	*	1.233E+00	0.00000
48	1997	0.000E+00	0.000E+00	--	*	1.158E+00	0.00000
49	1998	0.000E+00	0.000E+00	--	*	1.096E+00	0.00000
50	1999	0.000E+00	0.000E+00	--	*	1.042E+00	0.00000
51	2000	0.000E+00	0.000E+00	--	*	9.981E-01	0.00000
52	2001	0.000E+00	0.000E+00	--	*	9.204E-01	0.00000
53	2002	0.000E+00	0.000E+00	--	*	8.362E-01	0.00000
54	2003	0.000E+00	0.000E+00	--	*	7.693E-01	0.00000

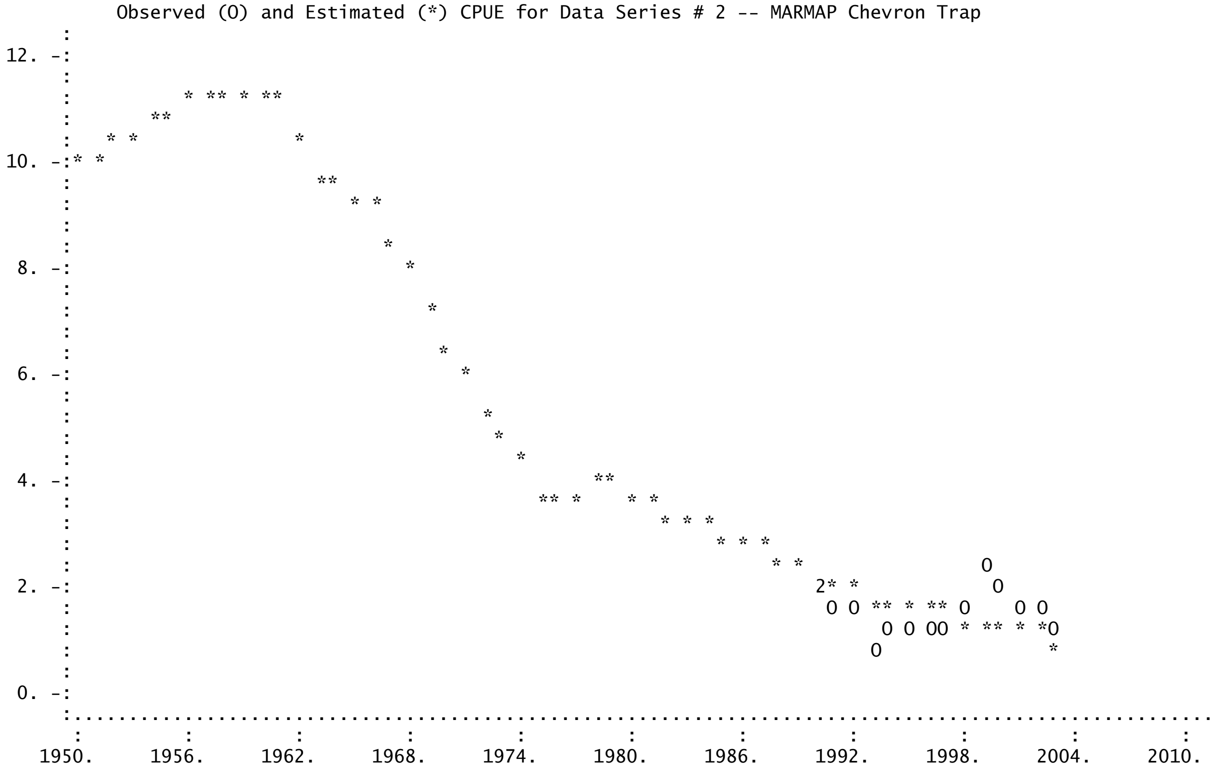
* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 4
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    -------------------------------------------------------------------------------------
1950     0.0000                                             |
1951     0.0000                                             |
1952     0.0000                                             |
1953     0.0000                                             |
1954     0.0000                                             |
1955     0.0000                                             |
1956     0.0000                                             |
1957     0.0000                                             |
1958     0.0000                                             |
1959     0.0000                                             |
1960     0.0000                                             |
1961     0.0000                                             |
1962     0.0000                                             |
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981    -0.2525                                   ==========|
1982     0.4174                                             |=================
1983     0.1236                                             |=====
1984     0.3455                                             |==============
1985    -0.0736                                          ===|
1986    -0.1365                                        =====|
1987    -0.4242                            =================|
1988     0.0000                                             |
1989     0.0000                                             |
1990     0.0000                                             |
1991     0.0000                                             |
1992     0.0000                                             |
1993     0.0000                                             |
1994     0.0000                                             |
1995     0.0000                                             |
1996     0.0000                                             |
1997     0.0000                                             |
1998     0.0000                                             |
1999     0.0000                                             |
2000     0.0000                                             |
2001     0.0000                                             |
2002     0.0000                                             |
2003     0.0000                                             |
                   -------------------------------------------------------------------------------------
```

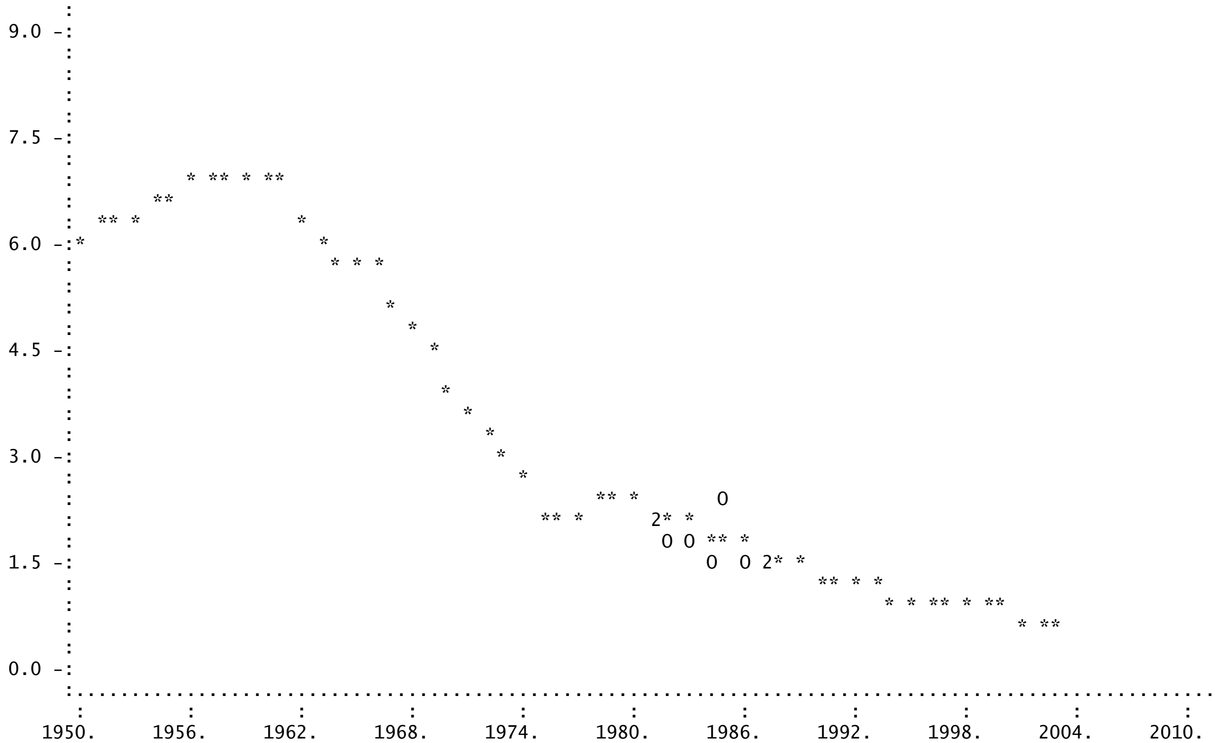
Observed (O) and Estimated (*) CPUE for Data Series # 1 -- HB Index (WPUE), Yield ext @ Rec = 3xCom



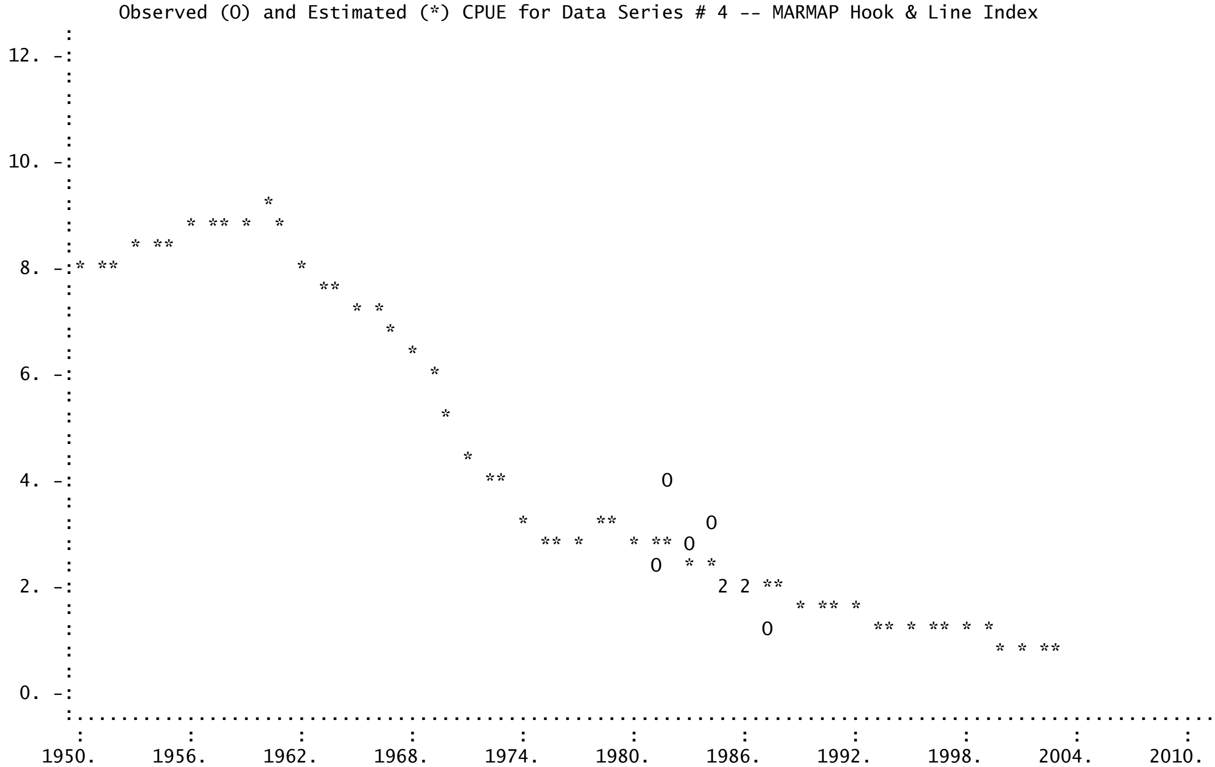
Observed (O) and Estimated (*) CPUE for Data Series # 2 -- MARMAP Chevron Trap



Observed (O) and Estimated (*) CPUE for Data Series # 3 -- MARMAP Blackfish Trap



Observed (O) and Estimated (*) CPUE for Data Series # 4 -- MARMAP Hook & Line Index



```
 Black Seabass -- SEDAR, March 2005 -- Four indices & extended catch                                         Page 14

                                  Time Plot of Estimated F/Fmsy and B/Bmsy (dashed line = 1.0)
     :
3.6 -:
     :
     :
     :
     :
3.0 -:                                        F                                            F
     :
     :                                                                                        F
     :                                                               F
     :                                                         F       F
2.4 -:                                                                    F         F
     :                                          F                                       F    F
     :                                 F   F               F                   F   F
     :                                                          F        F  F         F  F
     :             B B BB                                           F         F  F
1.8 -:       BB B B       B                 F
     :B BB B                          F  F              F F
     :                      BB B BF                   F      F
     :                            B                               F
     :                    F         B B
1.2 -:                                 B         F   F
     :
     :- -- - -- - -- - -- - -- - -- 2 -- 2 2- - -- - -- - -- - -- - -- - -- - -- - -- - -- - -- - -- - -- - -- - -- -
     :                           F          B      F
     :                                        B
0.6 -:                         F                BB B BB B BB
     :                  F   FF                               B BB B BB
     :                                                                 B BB B
     :F F                                                                     BB B BB B BB B
     :   F F F  F    F F                                                                     BB B
0.0 -:        F   FF
     :........................................................................................................
      :         :         :         :         :         :         :         :         :         :         :
   1950.     1956.     1962.     1968.     1974.     1980.     1986.     1992.     1998.     2004.     2010.

Elapsed time: 0 hours, 0 minutes, 44 seconds.
```