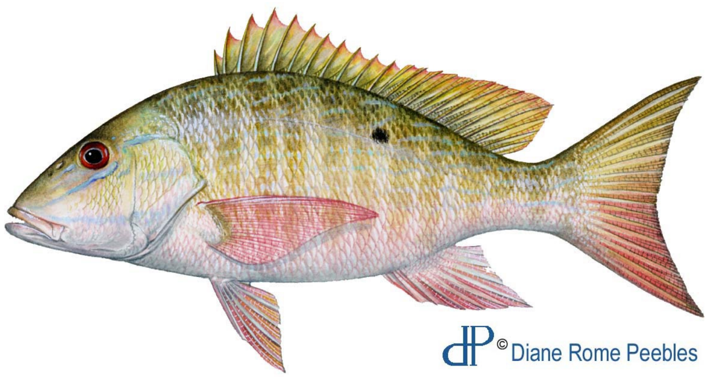
Stock Assessment of Mutton Snapper (*Lutjanus analis*) of the U.S. South Atlantic and Gulf of Mexico through 2013.

SEDAR Update Assessment



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1. Executive Summary

Mutton Snapper in the Southeast United States is considered a single stock that is centered in south Florida.

The von Bertalanffy growth equation was updated with an additional 5,880 lengths and ages, and the new parameters were used to update the Lorenzen, age-specific, natural mortality rates. The revised von Bertalanffy growth equation was also used to develop a stochastic age-length key.

Recreational and commercial landings and discards have been updated through 2013. There are two components to the recreational fishery: headboats and other recreational anglers and the commercial fishery has two primary gears: hook-and-line and longlines. The length samples for the miscellaneous gears such as traps, trawls, etc. were originally combined into an 'Other' gear but we thought that many of the lengths likely came from hook-and-line gear and therefore, we combined the miscellaneous gears with hook-and-line.

To provide guidance to the model, we used seven indices, four were linked to the four fleet sectors, one was a FWC fishery independent index from 183-m haul seine sets that was applied to Age-1, another was the NMFS-University of Miami Reef Visual Census which was applied to ages 1-7, and the final index was the NMFS Riley's Hump index of larger fish which was applied to ages 5-15.

Because this is an update assessment, we used the same statistical catch at age model as was used in SEDAR 15A from the NMFS Assessment Toolbox, ASAP. ASAP's current version is 3.017 and this version allows using single or double logistic selectivity patterns as well as selectivity by age. The SEDAR 15A reviewers noted that selectivity functions were missing in the earlier version,.

Observation uncertainty was evaluated with multiple Markov Chain Monte Carlo simulations using the parameter variance-covariance matrix from the ASAP maximum likelihood solution. Process error was examined with 81 sensitivity runs with different steepness values, average natural mortality rates of 0.08 per year and 0.17 per year as well as the preferred 0.11 per year, a range of fixed steepness and initial steepness values, fishery specific age-length keys, direct aging, and a run without age compositions.

Fishing mortality rates were higher until the 16-inch minimum size was implemented in 1994 and then the rates decreased. The current fishing mortality rate on fully selected ages expressed as the geometric mean of the rates from 2011, 2012, and 2013 was 0.12 per year and the Maximum Fishing Mortality Threshold (MFMT) was 0.18 per year which was defined as the fishing mortality rate associated with a spawning potential ratio of 30% (GMFMC 2011 and SAFMC 2011) such that

Mutton Snapper was not undergoing overfishing. The spawning biomass in 2013 was 2387 mt and the biomass at MFMT was 2,109 mt such that Mutton Snapper were not overfished.

The Overfishing Limit (OFL) was defined as the yield associated the MFMT and the value from the base run was 413,900 mt (912,500 lb) and the Acceptable Biological Catch (ABC) was the yield at a fishing mortality rate associated with a spawning potential ratio of 40% and the value from the base run was 396,400 mt (874,000 lb). The Annual Catch Limit was set to the same value as the ABC.

2. Data Review and Update

2.1 Data Review

This update assessment incorporates data from a variety of sources.

Life History

- Stock identification
- Age and growth from otoliths.
- Maturity
- Morphometrics
- Length – weight conversions
- Length – length conversions.

Landings, discards, and length measurements

- NMFS Accumulated Landings System, Florida Trip Tickets (Commercial landings). 1981 - 2013. Hook-and-line, longline, and gears that incidentally catch Mutton Snapper such as traps or trawls.
- NMFS Coastal Fisheries Logbook Program (Commercial discards). 1992-2013.
- NMFS Southeast Region Headboat Survey (landings, lengths). 1992-2013.
- NMFS Southeast Region Headboat Survey (discards). 2004-2013.
- Florida At-sea headboat sampling (GulfFIN and ACCSP) (discards, lengths). 2005-2013.
- NMFS MRFSS/MRIP (landings, lengths). 1981–2003 MRFSS and 2004-2013 MRIP.
- NMFS MRFSS/MRIP (discards). 1981-2013. Fish released alive (Type B2).
- NMFS Southeast Fisheries Science Center Trip Interview Program (lengths). 1984-2013.
- Florida/NMFS Cooperative Statistics Biological Sampling Program (lengths). 1986-1991.

Indices

- NMFS Commercial Fisheries Logbook Program (Commercial hook-and-line). 1990-2012. Ages 2-9. Selectivity linked to fishery.
- NMFS Commercial Fisheries Logbook Program (Commercial longline). 1990-2012. Ages 4-20. Selectivity linked to fishery.
- NMFS Southeast Region Headboat Survey. 1995-2013. Ages 2-8. Selectivity linked to fishery.
- NMFS MRFSS/MRIP. 1986-2012. Ages 2-8. Selectivity linked to fishery.
- FWC FIM (Fishery independent) haul seine sets. 1998-2013. Age 1.
- NMFS-UM Reef Visual Census. 1998-2012. Ages 1-7.

- NMFS Riley's Hump. 2002-2009, 2011. Ages 5-15.

Additional information for the update included stock identification, age-specific natural mortality determined from the von Bertalanffy growth curve and the maximum observed age (40 years), and the age-specific sex ratio from those fish that were aged and had sex recorded. The spawning season was offset from the beginning of the year by four months to the beginning of May.

2.2 Data Update

Life History

We continue to follow the recommendation from the data workshop (Faunce *et al*. 2007) to consider Mutton Snapper in the Southeastern United States as a single stock. A recent study of the genetics of specimens from the Florida Keys, Puerto Rico, and the U.S. Virgin Islands (Carson et al. 2011) supports the single stock hypothesis.

The pattern of length and age was modeled with a von Bertalanffy growth curve (von Bertalanffy 1938). We used a similar fitting procedure as before (SAS, PROC MODEL; Walter Ingram, NMFS Pascagoula Laboratory, personal communication) but with an additional 5,880 aged fish. Because of size limits biasing the fishery dependent distribution of lengths, fish collected from the fisheries two years old or less were omitted from fitting the von Bertalanffy growth curve. The von Bertalanffy growth curve used in SEDAR 15A (2008) was $L_t = 874(1 - e^{(-0.164(t+1.32))}$ (*n* = 7,172 fish, r^2=0.839) where L_t is the average length at age, *t,* while the growth curve used in this update assessment was $L_t = 861(1 - e^{(-0.165(t+1.23))}$ (*n* = 13,052 fish, r^2=0.803, Fig. 2.2.1, Table 2.2.1). It should be noted that we actually assign fish to year classes which means that fish are only considered age-0 until the following January when they become age-1 fish. In addition to assigning ages to lengths, the von Bertalanffy growth curve formed the basis of age-specific natural mortality that followed a Lorenzen curve (1996, 2005). With a maximum observed age of 40 years, we scaled the age-specific natural mortality to an average of 0.11 per year (Hoenig 1983, Hewitt and Hoenig 2005) for ages three (the age when fish were fully selected by fleets and gear overall in SEDAR 15A) and greater (Table 2.2.1). Late in the development of this update, Then, *et al.* (2015) examined the relationship between t_{max} and natural mortality (this is the third paper in the Hoenig natural mortality series) and concluded that when t_{max} was available, the best estimate of natural mortality came from the equation: $M = 0.899\ t_{max}^{-0.916}$. For a t_{max} of 40 years, the new average natural mortality rate would be 0.17 per year and we ran a sensitivity run using that estimate.

Composite age-length keys across years by fishery were developed by 25 mm length increments to assign ages to the observed total lengths and we also used the von Bertalanffy growth curve, natural mortality, and a linear regression of the coefficient of variation of length-at-age on age to develop a stochastic age-length key. The stochastic age-length key covered ages 0 – 40 years TL and a range of lengths from 100 – 975 mm TL (the largest fish aged thus far). Coefficients of variations (CV) of the observed lengths by age decreased with age (Fig. 2.2.1.b) and a linear regression of CV on age was incorporated into the von Bertalanffy growth curve fitting using PROC MODEL in SAS, Version 9.3 to estimate the standard deviation of length on age (Fig. 2.2.1.c). Fish older than 30 years were assigned a CV of 0.05 because of their very low numbers.

For the first length bin in the stochastic age-length key, the probabilities of fish of age a being in a given length bin b, assuming length at age is normally distributed (Goodyear 1997; Salthaug 2003; Bertignac and de Pontual 2007), were the cumulative probabilities between -∞ and L_b :

$$p(a|L_b) = S_a \cdot \left(\frac{1}{\sigma_a\sqrt{2\pi}}\right) \cdot \int_{-\infty}^{L_b} e^{-\left[\frac{(L_b-\bar{L}_a)^2}{2\sigma_a^2}\right]} \cdot dL \qquad (2.2.1)$$

For the subsequent length bins to the next to last length bin, the probabilities at age were:

$$p(a|L_b) = S_a \cdot \left(\frac{1}{\sigma_a\sqrt{2\pi}}\right) \cdot \left[\int_{-\infty}^{L_b} e^{-\left[\frac{(L_b-\bar{L}_a)^2}{2\sigma_a^2}\right]} - \int_{-\infty}^{L_{b-1}} e^{-\left[\frac{(L_{b-1}-\bar{L}_a)^2}{2\sigma_a^2}\right]}\right] \cdot dL \qquad (2.2.2)$$

For the last length bin, the probablilities-at-age were:

$$p(a|L_b) = S_a \cdot \left(\frac{1}{\sigma_a\sqrt{2\pi}}\right) \cdot \left[1 - \int_{-\infty}^{L_{b-1}} e^{-\left[\frac{(L_{b-1}-\bar{L}_a)^2}{2\sigma_a^2}\right]} \cdot\right] dL \qquad (2.2.3)$$

The stochastic age-length-key probabilities for an age in a given length bin, normalized across the age-at-length bins for ages 0 to the maximum age A, were:

$$ALK_{stochastic}(a|L_b) = p(a|L_b) \;/\; \sum_0^A p(a|L_b) \;. \qquad (2.2.4)$$

We chose the stochastic age-length approach for the base run because of the paucity of ages prior to 1994 other than fish sampled from the headboat fishery (less than 50 per year) and there were very few, if any, ages for the lengths of fish that were released (discarded). Additional sensitivity runs with direct aging and without age compositions were run to provide a context for the aging approaches. However in the next benchmark assessment, we would prefer to use a model that internally assigns the ages to the model (this was also a recommendation by the SEDAR 15A Review Panel).

The SEDAR 15A reviewers commented that maturity estimated from only 39 fish was marginal but, since that assessment, field samplers have collected additional gonad samples and we were able to update the maturity-at-length using a total of 221 fish instead of the original 39 fish. We used the same staging criteria as before (Table 2.2.2, Lowerre-Barbieri, *et al*. 2009; Brown-Peterson *et al.* 2011) and, as before, restricted the specimens to females caught in the Florida Keys during the initial months of the spawning season (April-June) and eliminated fish in the regenerating phase because of the difficulty in confidently assigning fish in this phase to the correct stage (Lowerre-Barbieri, *et al*. 2009). While some of the fish lacked ages, there were ages and reproductive stage information for 192 fish for updating the maturity-at-age relationship.

We also examined sex ratio in Mutton Snapper. There were 4,502 aged fish that had sex reported and the slope of age in the logistic regression did not significantly differ from zero (P = 0.39, df = 4,500) indicating that the probability of fish being female at any age was 50%. Therefore, we treated spawning stock biomass (SSB) in this update as female SSB rather than total SSB as was used previously in SEDAR 15A.

Landings and discards

Specifics on the treatment of data can be found in the SEDAR 15A assessment and data workshop reports. Landings were originally updated through 2012; however, after the various delays with the assessment, we updated the Mutton Snapper landings data through 2013. The MRFSS/MRIP charterboat effort estimates were adjusted to the For-Hire Survey effort estimates (Matter 2012, Diaz and Phares 2004) and the MRFSS catch estimates for the years prior to 2004 were calibrated to the MRIP levels according the *Ad Hoc* working group recommendations (MRFSS/MRIP 2012) with the refinement that the adjustments were made by coast and mode of fishing (Table 2.2.3). After Nelson, *et al.* (2014) brought the issues with the headboat index of abundance for red snapper to light and after receiving further clarification from Dr. Erik Williams at NMFS's Beaufort Laboratory, we included headboat landings data from 1992 and applied the average landings from 1992-1994 with a CV of 0.50 to the earlier years, 1981-1991, to account for some level of removals (Table 2.2.3). The commercial fishery uses two primary gears: hook-and-line and longlines but Mutton Snapper were also caught infrequently in other gears such as traps and trawls. In the previous assessment, we combined the catches from the miscellaneous gears into an 'Other gears' category but while reviewing the data for this update, we found that many of the fish in that category were actually caught with hook-and-line; and, after adjusting for these fish, there were only a few fish remaining in the 'Other gears' category; therefore, for this update, we combined the other gears with hook-and-line (Table 2.2.3). For the period with the 16-inch minimum size, 1995-2013, landings from the two recreational accounted an average of 71% of the total landings.

In addition to landings, many fish are discarded, i.e., released alive or dead. MRFSS/MRIP has estimated the number of fish that were released alive (Type B2) and dead (some Type B1 fish –this category may also include landed fish which were not available for measurement) since the program started in 1979. There were very few reported dead discards in the Type B1 fish over the 33 years of data available from this survey, and anglers in this survey have reported nearly all fish released were alive at the time of release. We used the lengths from the at-sea headboat sampling (see Headboat Survey section) to assign lengths to the released fish and we used the ratio of the number of fish released dead to alive from the same sampling to divide the fish in MRFSS/MRIP's

Type B2, (fish that were released alive) into those fish that were released in poor condition or dead and included these fish in the landings. The remainder of the released fish were considered subject to the assumed shallow water 15% release mortality rate subsequently (Table 2.2.4). Headboat captains began to report their discards in 2004 and at-sea headboat sampling began in 2005. We typified discards with the at-sea sampling data instead of using the captains' reports because the at-sea data also included the length of the fish and the condition of fish at the time of release. Fish whose release condition was bad, dead, or preyed upon (an average of 14.0% on the Atlantic coast and 6.6% on the Gulf coast, the difference may reflect the typical depths at which the vessels fish in those areas; Fig. 2.2.2) were included in the landings and the rest of the released fish were considered subject to the assumed 15% shallow water release mortality rate (Table 2.2.4).

Commercial discard data began to be collected in logbooks in 2002. However, the weighted average discard rate, expressed in total hook-hours, (6.686×10^{-6} discards per hook-hour; Kevin McCarthy, NMFS Southeast Fishery Science Center, personal communication) was used to extend the discard estimates back to the beginning of the logbook data, 1993 (Table 2.2.5). In turn, we used a linear regression of discards on landings to extend discards back to 1981 and, since the intercept was not significant, the regression was recalculated without an intercept such that Discards = Landings * 0.173 ($F = 25.2$, $df = 1, 10$, $P < 0.01$). Early logbook discard data found that approximately 22% of the commercial fish discarded were dead at the time of discarding and these fish were added to the landings while the remainder of the released fish (78%) were believed to experience the shallow water 15% release mortality rate. The commercial hook-and-line discards were estimated in numbers and converted to metric tons using lengths of released fish from the at-sea sampling previously described (Table 2.2.4). There are no estimated discards for the longline fishery because there are no discards of Mutton Snapper in their logbook data and that is reasonable given that longlines are restricted to deeper waters.

Dockside samplers interview fishers in the different fisheries, examine the fisher's landed fish to confirm the fish identifications, measure fish, and, in some cases, collect otoliths for aging the catch. Commercial length data were obtained from the National Marine Fisheries Service's Trip Interview Program (TIP), recreational lengths were available from the Headboat Survey's data base and the MRFSS/MRIP website: http://www.st.nmfs.noaa.gov/recreational-fisheries/index. Otoliths were collected from fish caught by the four fisheries (Table 2.2.6). The table also shows clearly that there were very few otoliths collected before the early 1990s and this paucity of ages and the obvious lack of ages of released fish are why the age-lengths keys by fishery were aggregated across years and why the stochastic age-length key was developed.

The fisheries' catches-at-length used the observed length frequencies from the fleets that were weighted by their respective landings and expressed in numbers of fish prior to assigning ages. Linking ages to the resulting length frequencies involved a hierarchical procedure. The first step linked by fishery, year, region, and season (spawning: April – August and non-spawning: September – March). For fish lengths that were not matched at the initial step, the second attempt combined the seasons; the process continued by combining the regions by coast (Atlantic – Florida Keys and Gulf). The penultimate step was to combine by year, and finally by fishery. The numbers of fish by age in the directed fisheries is listed in Table 2.2.7. The lengths of undersized fish were difficult to match. Discard lengths came from the at-sea sampling and, in the absence of other data, the lengths were applied to the other fisheries by year for 2005-2013 and the average of those years applied to the earlier years (Table 2.2.8). The selectivity of the commercial gears were modeled with flat-topped logistic curves while the selectivity of the recreational fisheries used a dome-shaped selectivity reflecting their operation in shallower water..

Indices were updated and there were some minor modifications in a few cases. The NMFS Southeast Fisheries Center developed commercial indices with logbook data through 2012; the headboat index only included data from 1995 through 2013 because of the difficulties in the early headboat data identified in SEDAR 41 (see the discussion above) and the raising of the minimum size limit to 16 inches in March 1994, the MRFSS/MRIP index was updated through 2012 because the sampling protocols changed in March 2013. The four fishery dependent indices used the selectivities of their respective fisheries.

The update included three fishery independent indices. In SEDAR 15A, a FIM Age-1+ index was defined as comprising those fish from the 183-m seine hauls in samples from Indian River and Loxahatchee River estuaries that were larger than 80mm SL. We re-examined the lengths of specimens in relation to size-at-age estimated using the stochastic age-length-key, and the majority (over 89%) of specimens collected by the 183-m seines in these estuary systems would be estimated to be age-0. Because this index is more appropriate as an estimate of the abundance late-age-0 fish, we “pushed” the index value for the sampled year to the following January 1 and configured the model to use these observed values as an index of age-1 fish expected on January 1. Following Dr. Steve Smith’s recommendation for the NMFS-UM Reef Visual Census, we only used the estimates since 1998 for the consistent treatment of samples taken in strata within Sanctuary Protected Areas. The RVC estimated abundances by length class and year (Fig. 2.2.3.a) and these lengths were assigned ages (Fig. 2.2.3.b) using either the stochastic age-length key or the combined recreational fisheries’ age-length key. Instead of estimating selectivity by age for the RVC, we used a dome-shaped, double logistic curve, for ages one to seven years. The NMFS Riley’s Hump index was updated through its last year, 2011, and applied to ages 5-15 based on limited length estimates. Because of the few lengths, we did not fit selectivity to this index. The seven indices and their CV values are included in Table 2.2.9 and shown in Fig. 2.2.4. The overlaid indices had a general increase after 1994.

Indices that were in SEDAR 15A assessment but not included in the update included the FWC Visual Survey which was absorbed into the NMFS-UM Reef Visual Census (RVC) in 2008. The SEAMAP video survey index was dropped because so few Mutton Snapper were observed in that survey that the index had relatively high uncertainty (CV range 0.32-3.08) with a corresponding poor fit [see Fig. 2.2.3.3 of SEDAR 15A (2008)]. The other two omitted indices were the two headboat indices which were replaced by the headboat index described above.

3. Stock Assessment Methods

3.1 Overview

SEDAR 15A evaluated the status of Mutton Snapper with a suite of analytical models [non-equilibrium surplus production (ASPIC), surplus production (modified DeLury), untuned VPA, stochastic stock reduction (SRA), and statistical catch-at-age (ASAP, generic SCAM)]. The assessment workshop panel recommended using the Legault and Restrepo's peer-reviewed statistical catch-at-age model, Age-Structured Assessment Program (ASAP, version 1A, 1998) as the primary model for the assessment, and to use the other models for supporting analyses. For this update assessment, we used the updated version of ASAP [ASAP3, version 3.0.17; available from the NOAA Fisheries Toolbox (http://nft.nefsc.noaa.gov/)]. Like the earlier version 1A, ASAP3 is a forward-projecting, statistical catch-at-age model written in ADModel Builder (Fournier, et al. 2012) that uses the Toolbox's graphical interface to facilitate data entry and presentation of model results. The model allows for age- and year-specific values for natural mortality rates and in this version, multiple weights by age and year such as average spawning weights, catch weights by fleet if available, and average stock weight at the beginning of the year. Further, it accommodates multiple fleets with one or more selectivity blocks within the fleets, incomplete age-composition to accommodate fisheries that are not sampled every year, and indices of abundance in either numbers or biomass that are offset by month. Discards can be linked to their fishery as can fishery dependent indices and they are related to the specific fishery by the applicable selectivity block for the fleet. Fishery independent indices are linked to the total population and are applied to specific ages with selectivity curves or by age-specific values. The original version of ASAP only allowed for selectivity by specific ages while the recent versions of ASAP have selectivity options for single logistic or double logistic curves (2- or 4-parameters, respectively) which generally reduces the number of parameters in the model compared with age-specific parameters.

ASAP estimates population numbers, fishing mortality rates, stock-recruit parameters, and management benchmarks such as maximum sustainable yield (MSY), the fishing mortality rate at MSY, the spawning biomass at MSY, and the fishing mortality rates corresponding to spawning potential ratios (e.g., 30%, 40%, or 45%). Precisions of parameters can be evaluated by their standard deviations from the variance-covariance matrix or through Markov Chain Monte Carlo

(MCMC) simulations. The recommendation from the SEDAR15A review panel to model the selectivity of ages in the catch of fleets with logistic or double logistic curves was incorporated into this update.

The ASAP model used for this update can only address a single stock but this model limitation does not present a problem for Mutton Snapper because as noted in the life history section (Section 2.2), the stock in U.S. southeastern waters is considered to be comprised of a single unit.

3.2 Data Sources

Mutton snapper landings from the NMFS Southeast Region Head Boat Survey (HBS), Marine Recreational Information Program (MRIP; http://www.st.nmfs.noaa.gov/recreational-fisheries/index) and its predecessor the Marine Recreational Fisheries Statistics Survey (MRFSS), and NMFS's Accumulated Landings System (http://www.st.nmfs.noaa.gov/commercial-fisheries/index) were tallied annually by fleet into the Atlantic region (southeast Florida (Miami-Dade County) to North Carolina) and the Gulf Region (primarily the Florida Keys, but also included data through the northern Gulf of Mexico) for 1981 through 2013. Commercial indices of abundance were generated from the NMFS Coastal Fisheries Logbook Program (CFLP, Kevin McCarthy personal communication), while we generated the indices for HBS and MRFSS/MRIP. Length information was retrieved from the NMFS Trip Interview Program (TIP), HBS, and MRFSS/MRIP, and age information was obtained from Florida Fish and Wildlife Research Institute's Age and Growth Laboratory and from NMFS's Panama City Laboratory from specimens collected by biologists from TIP, HBS, North Carolina Department of Marine Fisheries (NCDMF), FWRI, and other sampling programs. Estimates of the abundance of Mutton Snapper by length class were obtained for Southeast Florida (FIM Age-1 index) and the Florida Keys [NMFS-UM Reef Visual Census (RVC)] for 1998-2012 (J. Ault and S. Smith, University of Miami, personal communication**).**

Some of the life history data used in SEDAR 15A were unchanged in this update like the estimate of natural mortality (Hoenig 1983, Hewitt and Hoenig 2005) based on the maximum observed age (t_{max}=40 years) and adjustment of natural mortality for age-specific estimates for all ages, and a four-month offset to May (for the April-October spawning season) for the estimated spawning date based on field observations of spawning in the Florida Keys (Barbieri and Colvocoresses 2003), and other normal tuning adjustments.

As in the base model for SEDAR 15A, age-length keys by fishery were developed as well as a stochastic age-length key (ALK) was constructed from the von Bertalanffy growth curve, the CV of length-at-age, and the age-specific natural mortality. These ALKs were used to assign ages to the fleet catch-at-length and fleet discards-at-length. The length composition for discarded fish came from at-sea sampling with observers on-board headboat vessels (2005-2013) and extended to the commercial hook-and-line fleet and the MRFSS/MRIP recreation fleet. The age composition by fleet was expressed as the proportion by age and year.

3.3 Model Configuration and Equations

The basic equations for ASAP are similar to the equations used in other statistical catch-at-age models (NOAA Fisheries Toolbox 2012). Recruitment was estimated with a Beverton-Holt stock-recruit relationship with annual deviations (Beverton and Holt 1957). Fishing mortality by fleet in the absence of discards, was considered to be the product of selectivity for age and the annual fishing mortality for fully recruited fish ($Fmult_{f,,y}$, selectivity = 1.0, Doubleday 1976). The annual fishing mortality deviations were multiplicative meaning that the fishing mortality multiplier for a given year depended upon the prior year's fishing mortality multiplier, i.e. $Fmult_{f,y} = Fmult_{f,y-1} * Fmult\_dev_{f,y}$. The equation for the fishing mortality for fleet, f, at age, *a*, in year, *y*, was:

$$F_{f,a,y} = Sel_{f,a} Fmult_{f,y} \tag{3.3.1}$$

where $Sel_{f,a}$ was the selectivity for age, *a*, in that fleet. In the previous assessment, we applied different selectivity patterns when the size limits changed but SEDAR 15A reviewers questioned whether that was appropriate for this benthic reef species since fishers were fishing the hard bottom and not specifically targeting Mutton Snapper. Therefore, we used a single selectivity pattern per fleet and captured the effects of the minimum size changes on the population with the proportion of fish released. Another difference from the earlier assessment is that this version of ASAP allows fitting the flat topped selectivity in the commercial fleets with logistic curves (Quinn and Deriso 1999, Eq. 3.3.2) instead of by individual ages. Dome-shaped selectivity curves (double logistics curves, Eq. 3.3.3) were applied to the recreational fishery because these fisheries tend to fish in shallower depths closer to the coast instead of fishing out to the continental shelf edge where older fish are more likely to be encountered.

$$Sel_{f,a} = \left[\frac{1}{1+e^{-(a-\alpha)/\beta}}\right]\frac{1}{x} \tag{3.3.2}$$

$$Sel_{f,a} = \left[\frac{1}{1+e^{-(a-\alpha1)/\beta1}}\right]\left[1-\frac{1}{1+e^{-(a-\alpha2)/\beta2}}\right]\frac{1}{x} \tag{3.3.3}$$

The term, $\frac{1}{x}$, in Equations 3.3.2 and 3.3.3 normalizes the selectivity values ensuring that at least one age is fully selected ($Sel_{f,a}$ = 1.0). Because $Fmult_{f,y}$ estimates total catch, it is a capture rate and not a mortality rate because some of the discarded fish survive. With discards being linked to the kept fish, the equation for the fishing mortality of the directed fishery at age, *a*, in year, *y*, for fleet, *f*, $F_{f,a,y}$, became:

$$F_{f,a,y} = Sel_{f,a} Fmult_{f,y} (1 - prop\_rel_{f,a,y}) \quad (3.3.4)$$

where $prop\_rel_{f,a,y}$ was the proportion of fish that were discarded by each age and year and the corresponding discard mortality, $F\_disc_{f,a,y}$, was:

$$F\_disc_{f,a,y} = Sel_{f,a} * Fmult_{f,y} * prop\_rel_{f,a,y} * rel\_mort \quad (3.3.5)$$

where *rel_mort* was the release mortality on the discarded fish. The observations from on-board sampling of headboats (see Section 2.2 *Landings and discards*) indicated that a portion of the fish that were released alive died almost immediately after release probably due to hook placement and/or removal, rough handling, barotrauma, predation by birds, sharks, or dolphins. We applied the length frequencies and the observed immediate release mortality rates by length from the at-sea sampling and applied these to the recreational fleets and the commercial hook and line fleet. The discards (live or dead) were used to estimate numbers at age released via the age-length keys for each fleet. There were no estimated discards of Mutton Snapper for the commercial longline fleet. The numbers of fish released alive by age in each fleet were adjusted by year and coast for these deaths and these immediate deaths were added to the directed fishery harvests and were accounted for through equation 3.3.4.

The number of Mutton Snapper at age and year, $N_{a,y}$, was solved forward from recruitment in each year using the total fishing mortality by age and year, $F\_tot_{f.a.y}$ ($F\_tot_{f,a,y} = F_{f,a,y} + F\_disc_{f,a,y}$), and the natural mortality rate, $M_{a,y}$, using Equation 3.3.6.

$$N_{a+1,y+1} = N_{a,y} e^{(-F\_tot_{f,a,y} - M_{a,y})} \quad (3.3.6)$$

The predicted catch-at-age, $\hat{C}_{a,y}$, was calculated from the Baranov catch equation (Murphy 1965, Ricker 1975):

$$\hat{C}_{a,y} = N_{a,y} \frac{F\_tot_{f,a,y}}{(F\_tot_{f,a,y} + M_{a,y})} (1 - e^{[-F\_tot_{f,a,y} - M_{a,y}]}) . \quad (3.3.7)$$

Predicted index values were calculated from the estimated number of Mutton Snapper of the appropriate ages from the appropriate selectivity pattern and the index's catchability coefficient, q_j. For an aged index, I_j, the number of Mutton Snapper at age was summed across the fractions of the applicable ages of the index and multiplied by the catchability, q_j, or

$$\hat{I}_{y,j} = q_j \sum_a Sel_{j,a} N_{a,y} \tag{3.3.8}$$

Recruitment was predicted with a Beverton-Holt stock-recruit equation with annual deviations. The formulation of the Beverton-Holt equation used in ASAP for the recruitment in year, *y* (R_y), from the spawning biomass in year, *y-1* (SSB_{y-1}), was:

$$R_y = \frac{\alpha SSB_{y-1}}{\beta + SSB_{y-1}} + \mathrm{Re}\,c\_dev_y \tag{3.3.9}$$

and

$$\alpha = \frac{4hR_0}{5h-1} \tag{3.3.10}$$

and

$$\beta = \frac{S_0(1-h)}{(5h-1)} \tag{3.3.11}$$

where *h* was the steepness (Francis 1992), S_0 was the virgin spawning biomass and R_0 was the recruitment associated with S_0. Steepness is the ratio of the predicted recruitment at a spawning biomass level of 20% of the spawning biomass with no fishing to the recruitment with no fishing and provides a simple, measure of productivity and is a direct way of comparing stock-recruit curves. A value of *h*=0.75 was chosen as the starting value for the base run which may be appropriate for species like Mutton Snapper based on its life history (Rose et al. 2001, Murphy 1968). We explored the effects of steepness with sensitivity runs over a range of initial values of 0.40 through 0.99 by 0.05. We also made sensitivity runs with fixed steepness values over the same range.

3.4 Parameters Estimated

The base assessment model's configuration estimated 214 parameters. The estimated parameters included selectivity parameters by fleet (12), initial fishing mortality estimates for 1981 by fleet (4), annual fishing mortality deviations by fleet (128), recruitment deviations (33), estimates of the deviations in the number of fish by age in 1981 (24), catchability coefficients for each index (7), selectivity parameters for the NMFS-UM Reef Visual Census (4), the unexploited spawning biomass (1), and steepness (1).

3.5 Benchmark / Reference Point Methods

In the SAFMC Snapper Grouper FMP Amendment 11 (1999) and the Gulf of Mexico Fishery Management Council's Generic Annual Catch Limits/Accountability Measures Amendment (2011), the councils adopted $F_{30\%}$ as a proxy for F_{MSY} or the Maximum Fishing Mortality Threshold (MFMT) and the corresponding yield at $F_{30\%}$ as a proxy for Overfishing Limit, they also adopted yield at F40% as a proxy for the Acceptable Biological Catch (ABC, Snapper Grouper FMP, SAMFC 1998). The SEDAR 15A AW panel did not recommend changing any of the management criteria for mutton snapper.

3.6 Uncertainty and Measures of Precision

Uncertainty evaluated in ASAP is the uncertainty stemming from the input data also known as observation error. In addition to the estimated parameters and their standard deviations, ASAP can also run Markov Chain Monte Carlo (MCMC) simulations. Thirty chains of at least 3.5 million simulations each without any thinning were examined for serial autocorrelation and evidence of non-convergence using the 'boa' package in R (Smith 2007). Burn-in rates appeared minimal after the first 1,000 iterations, and the initial 20,000 iterations were discarded from each of the chains. After thinning rates to reduce serial autocorrelations below 0.1 (Gelman et al. 2014) were estimated, multiple chains (8) of 4.801 million iterations each were run to yield 502 samples from each chain to examine the distributions of selected parameters. The Gelman-Rubin statistic was generated to examine the parameters in the multiple chains for evidence of non-convergence, and all were acceptable for further analyses. These parameters included the geometric mean of the fishing mortality rates on age-3 fish for 2011, 2012, and 2013 (F geo), the equilibrium fishing mortality rate producing a spawning potential ratio of 30% (F30%) and the equilibrium fishing mortality rate producing a spawning potential ratio of 40%,, the spawning biomass In 2013, the yield at F30%, the yield at F40%, estimated recruits and spawning biomass by year, the estimated unfished spawning biomass (S_0), and steepness. Another set of five MCMC chains of the run with ageing from the fishery age-length keys was run with two million simulations for comparison.

The density plots indicate observation error but, because ASAP does not capture the underlying uncertainty in the model configuration, process error was explored with alternative sensitivity runs. The sensitivity runs explored a range of starting values for steepness as well as fixing steepness at different levels, the influence of the different indices, using the MRFSS/MRIP index as a population index instead of as a fishery index because it is based on total catch and is less sensitive to regulatory changes, higher and lower natural mortality rates, higher and lower release mortality rates, eliminating the age compositions, changing the ages included in the MRFSS/MRIP index, running the model with only the fishery dependent indices, and running it with only the fishery independent indices.

4. Stock Assessment Results

4.1 Measures of Overall Model Fit

Table 4.1 list the components of the objective function and their contributions to the fitting process. The ASAP model is fit to four types of data: landings, discards, indices, and age compositions. For landings, the base model fit the longline fishery the closest (standardized residual = 0.0127, Fig. 4.1.1.c, d), the commercial hook-and-line fishery next (standardized residual = 0.2290, Fig. 4.1.1.a, b), headboat next (standardized residual = 0.7562, Fig. 4.1.1.e, f) and MRFSS/MRIP last (standardized residual = 0.8311, Fig. 4.1.1.g, h). For discards, there were no discards for the commercial longline fishery; therefore, the base model fit the headboat fishery the closest (standardized residual = 0.2249, Fig. 4.1.2.c, d), the commercial hook-and-line fishery and MRFSS/MRIP were fit almost equally well (standardized residuals = 0.9691 and 0.9762, Fig. 4.1.2.a, b and 4.1.2. e. f). As is frequently the case, the model fit the indices less well. The NMFS-UM Reef Visual Census had the closest fit (standardized residual = 0.3775, Fig. 4.1.3.a, b), the commercial hook-and-line index was next (standardized residual = 1.0176, Fig. 4.1.3.c, d), followed by the commercial longline index (standardized residual = 1.0652, Fig. 4.1.3.e, f), followed by the fishery independent monitoring survey for recruits (standardized residual = 1.5221, Fig. 4.1.3.g, h), the next index was the MRFSS/MRIP index (standardized residual = 1.7334, Fig. 4.1.3.i, j), followed by the Riley's Hump index on spawning fish (standardized residual = 1.8085, Fig. 4.1.3.k ,l), the poorest fit was to the headboat index (standardized residual = 2.1292, Fig. 4.1.3.m, n). The plots of age compositions for landings are shown in Fig. 4.1.4, discards (Fig. 4.1.5), and indices (Fig. 4.1.6).

4.2 Parameter Estimates

Table 4.2 lists the 214 estimates and their standard deviations.

4.3 Stock Abundance and Recruitment

Table 4.3 lists the estimated numbers of fish by age at the beginning of the each year from 1981 to 2013. The numbers of fish declined until 1998, rose to their highest value at the beginning of 2008, dropped again, and then rose in 2013 (Fig. 4.3a); however over the 33 years, the numbers have been variable but without significant trend (t-test for slope = 0, t = -0.68, df = 31, P = 0.50).

Recruitment the following January (the first column in Table 4.3) has been volatile (Fig. 4.3b) showing 5x variability, but also without significant trend (t-test for slope = 0, t = -1.65, df = 31, P = 0.11). The highest recruitment of the 33 year period was in 2008 and the lowest was in 2011. The recruitment retrospective pattern was minimal (Fig. 4.3.c).

The volatility of recruitment reflects a fluctuating environment. For example, the FIM Age-1, NMFS-UM RVC, and MRFSS/MRIP indices (Fig. 4.1.3 g, i, k), all with large proportions of younger age classes comprising them, trended downward beginning in 2008 and reached their lowest points since 1999 during the 2010-2012 period. It is worth noting that there were several sub-freezing temperatures in South Florida in January of 2008 and 2010 resulting in noticeable mortality of fish from Cape Sable to northeast Florida Bay in the Everglades National Park in January of 2008 and 2010, and Biscayne National Park and nearshore waters of the Florida Keys National Marine Sanctuary in 2010 (Peter Freeza, Audobon Society of Florida, personal communication). Mortality of younger age classes during those cold periods may have be responsible for the trends seen in these indices since age-0 mutton snapper in estuarine seagrass habitats would have been vulnerable to cold kills and were, in fact, observed dead during the January 2010 event along with several other estuarine-dependent species.

4.4 Total and Spawning Stock Biomass

Table 4.4 lists the total biomass at the beginning of the year, spawning biomass at the beginning of May, and the exploitable biomass at the beginning of the year based on overall selectivity. The total biomass of Mutton Snapper declined to a low in 1994 and then has been increasing ever since (Table 4.4, Fig. 4.4). Spawning biomass shows a similar pattern with a low in 1994 and then higher levels afterwards. Exploitable biomass consists of those fish that can be harvested legally and has accounted for about 60% of the total biomass (1981-2013 average 58%). The exploitable biomass has varied little over the years but also reached a low in the early 1990s and then has increased. The decline in exploitable biomass in 2012 as 2013 but not in spawning biomass may reflect the low recruitment in 2010 and 2011. The spawning biomass retrospective pattern was minimal with a slight tendency to increase as more years were added to the analysis (Fig. 4.4.c).

4.5 Selectivity

As expected, selectivity varies by fishery and age. Young fish are more vulnerable to the recreational fisheries and older fish are more vulnerable to the commercial fisheries (Fig. 4.5a). To summarize selectivity across fisheries, one can compute an overall selectivity by age based on age-specific total fishing mortality rates and the numbers of fish by age; in this case, the line labeled 'N-weighted' uses the years 1995-2013 (Fig. 4.5b). For projections, ASAP calculates the overall selectivity just using the total fishing mortality rates from 2013 (the line labeled '2013'in Fig 4.5b). With either method, the overall selectivity is dome-shaped indicating that the older Mutton Snapper are less vulnerable to fishing or, in other words, the recreational fisheries account for more of the harvest.

4.6 Fishing Mortality, Landings, and Discards

The total fishing mortality rates for age-3 fish has been variable, peaking in 1984 at 0.40 per year, and then the rate declined reaching a low of 0.08 per year in 2001 and then increased again to 0.27 per year in 2008 (Table 4.6.1, Fig. 4.6.1a). The larger error bars in the early years reflects the lack of age samples from the fleets. The fishing mortality rate in 2013 was 0.18 per year. Recreational fisheries account for most of the mortality on Mutton Snapper (Headboat in 2013 was 0.02 per year and MRFSS/MRIP was 0.15 per year) while the commercial fisheries accounted for about 0.01

per year (Fig. 4.6.1b). As a reasonableness check, we calculated a total mortality of 0.24 per year using landings-weighted ages (3-40 years) from 2011 – 2013 with a Chapman-Robson catch curve (Chapman and Robson 1960, Murphy 1997). With an average natural mortality for ages 3-40 years of 0.11 per year, the fishing mortality from the catch curve was 0.13 per year. The geometric mean fishing mortality from ASAP for the same years was 0.12 per years. While there are different assumptions involved with the two methods, the similarity is encouraging. The retrospective pattern in fishing mortality rates was minimal (Fig. 4.6.1.d). The fishing mortality rates for discards shows that few fish older than four years are released alive (Table 4.6.2).

The run using the fishery age-length keys had slightly higher fishing mortality rates in the early years but overlaid the rates from the stochastic aging from 1994 and later (Fig. 4.6.2a). The sensitivity run with direct aging had higher values but the pattern was similar to runs with either of the age-length-keys until 1995 but then afterwards, the fishing mortality rates from direct aging did not reflect either the rates from the fishery age-length keys or the stochastic key. The sensitivity run with an average natural mortality rate of 0.08 per year (which would correspond to a maximum age of 56 years) used a separate stochastic age-length key and had higher fishing mortality rates than did the base run (Fig. 4.6.2b). Conversely, the sensitivity run with an average natural mortality of 0.17 per year (based on observed maximum age of 40 years using the newly revised formula of Then et al., 2015) had lower fishing mortality rates than did the base run. Total fishing mortality rates on age-3 fish from this update were similar to those from SEDAR 15A (Fig. 4.6.3).

Landings of Mutton Snapper have varied from 829 mt (1.828 million lb) in 1983 to 203 mt (0.448 million lb) in 2011 and were 386 mt (0.852 million lb) in 2013. MRFSS/MRIP landings averaged 209 (0.461 million lb) mt during 1995-2013, headboat landings averaged 36 mt (0.080 million lb), commercial hook-and-line landings averaged 66 mt (0.146 million lb), and commercial longline landings averaged 39 mt (0.086 million lb) during the same period (Table 2.2.3). Discards (live releases) of MRFSS/MRIP averaged 17 mt (37,500 lb) during 1995-2013, headboat discards (live releases) averaged 0.99 mt (2,200 lb), and commercial hook-and-line discards averaged 0.41 mt (910 lb). There were no discards reported in the longline logbooks. Discards (live releases) of Mutton Snapper were 2.5 mt or less per year from headboats and MRFSS/MRIP discards (live releases) were 27 mt or less per year except in 2008 which had 53 metric tons of discards (Table 2.2.5).

4.7 Spawner-Recruit Parameters

In the base run Beverton-Holt spawner-recruit relationship, steepness was estimated at 0.81 (SD = 0.10) with an initial starting value for steepness of 0.75 (Fig. 4.7.1a) and the unfished spawning biomass was estimated at 8,166 mt (Fig. 4.7.1b; log mean = 9.01, SD = 0.131) and the unfished recruitment was estimated at 711,000 fish. However, one cannot put too much stock in these estimates because there is no obvious pattern between spawning and subsequent recruitment (Fig.

4.7.2a). The intra-annual spawning biomass variability was similar across the time series (Fig. 4.7.2b) and recruitment variability resembled that of fishing mortality, i.e., quite variable in the early years and tighter afterwards until 2013 (Fig. 4.7.2c). There was little contrast in the mean spawning biomass values (1,497 to 2,454 mt) while recruitment numbers have varied from 216,000 to 1,102,000 fish (Fig. 4.7.2a). High recruitment variability with low spawning biomass variability is consistent for a species with a steepness of 0.8 and maturing at relatively young age (2.9 years; Rose et al. 2001, Murphy 1968).

To explore the stock-recruit relationship, we ran two sets of sensitivity runs. The first set used starting steepness values of 0.40 through 0.99 to determine the dependence of the estimated steepness value on the value of steepness used to start the analysis. The resulting estimated steepness values ranged from 0.59 to 1.00 and increased as the initial steepness values were increased (Fig. 4.7.3a) although the objective function values were similar (2681.75-2689.07). There was very little variability in the estimated fishing mortality rates for fully selected ages, spawning biomass, or recruitment (Fig. 4.7.4). Sensitivity runs with fixed steepness values over the same range of steepness values (0.40 – 0.99) also had little contrast in their objective function values (2683.74 – 2706.77) but achieved similar fishing mortality rates (Fig. 4.7.3b). Steepness did not make much of a difference in the model results because the annual recruitment deviations tended to compensate for differences in steepness; in other words, there was not enough information in the data to uniquely identify a steepness value. Lee et al. (2012) noted that good contrast in spawning biomass is needed for a reliable estimation of steepness. We checked to see if the lack of contrast in the spawning biomass was due to using the stochastic age-length keys but the same lack of contrast occurred in the direct aging run (Table 4.8.2).

4.8 Benchmark / Reference Points

As noted in Section 3.5, the status of the stock is evaluated by comparison to benchmarks. For Mutton Snapper, the Council's chose $F_{30\%}$ as a proxy for the fishing mortality rate producing maximum sustainable yield/Overfishing Limit and the equilibrium spawning biomass associated with $F_{30\%}$ as the biomass measure ($SSB_{F30\%}$). Because of the uncertainty in the estimate of fishing mortality in the terminal year, typically the geometric mean of the most recent three years is used to indicate the current fishing mortality rate ($F_{current}$) and that value was 0.12 per year in the base model. With an estimate of $F_{30\%}$ (MFMT) of 0.18 per year; the F-ratio was 0.66 indicating that Mutton Snapper was not undergoing overfishing. The estimated spawning biomass in 2013 was 2,354 mt and the equilibrium spawning biomass at $F_{30\%}$ was 2,109 mt for a biomass ratio of 1.13 indicating that for the base run, Mutton Snapper was not overfished. The Minimum Spawning Stock Threshold, MSST = (1-M)*$SSB_{F30\%}$, was 1,877 mt and had a MSST biomass ratio of 1.27. For age-4 being fully selected instead age-3, the numbers were MFMT = 0.20 per year and $F_{current}$ was 0.12 per year for an F-ratio of 0.62. The biomass and yield numbers are the same as with age-3 being fully selected. A phase plot of the F-ratio on the biomass ratio from the MCMC simulations is in Fig. 4.8.1. None of the F-ratios from the MCMC outcomes were greater than 1.0 and only 6.2% of the SSB-ratios were less than MSST and 24.3% were less than the SSB at $F_{30\%SPR}$. Plots of static and transitional spawning potential ratios by year indicate that SPR has been increasing since the middle 1990s which coincides with the increase in minimum size to 16" TL for retention in 1994 (see F.A.C. chapter 68-14 in Florida FWC 2015) in state waters of Florida and in federal waters of the South Atlantic region (SAFMC 1994, Amendment 7 to the Snapper Grouper Fishery Management Plan). In 1999, regulations for federal waters for many reef fish were made compatible with Florida regulations (GMFMC Reef Fish Amendment 16B, 1999), but the impact on biomass trends of these regulations was less apparent on Mutton Snapper biomass. A listing of the Sustainable Fisheries Act values for the base run is in Table 4.8.1.

In addition to the base run (the first run listed in Table 4.8.2), additional sensitivity runs were made to investigate some of the process error. The runs that used the stochastic age-length keys and the natural mortality averaging 0.11 or 0.17 per year tended to meet both of the management criteria. The exceptions were those runs with low fixed steepness values of 0.40 and 0.45 or the lower natural mortality averaging 0.08 per year. The low steepness runs (Table 4.8.2, runs 2, 3, 42, and 43) failed because the productivity was so low that the spawning biomass at $F_{30\%}$ was negative. The lower natural mortality rate runs (Table 4.8.2, runs 40 and 73) using 0.08 per year (assuming a maximum age of 56 years) resulted in a $F_{30\%}$ slightly less than $F_{current}$ (i.e., overfishing) and $SSB_{30\%}$ greater than SSB_{2013} (i.e., overfished). The sensitivity runs that used direct aging gave a different picture of the stock (Table 4.8.2, runs 74-81). For example, using the run that corresponds to the base run except that the age compositions came from direct aging, the management goal of $F_{30\%}$ was 0.26 per year and the $F_{current}$ was 0.29 per year such that the F-ratio was 1.12 indicating that Mutton Snapper was undergoing overfishing and the spawning biomass in 2013 for was 1,144 mt and the equilibrium spawning biomass at the corresponding $F_{30\%}$ was 1,939 mt for a biomass ratio of 0.59. However, direct aging was not recommended in SEDAR 15A because of the paucity of ages. This situation is improving, especially after 2002, but sampling specimens for age determinations in the earlier years was very sparse.

Comparisons to previous assessment

There were two changes to the landings data: 1) the MRFSS recreational landings from 1981 to 2003 were standardized and adjusted to the estimates from the Marine Recreational Information Program MRIP and 2) the 'Other gears' category was combined with commercial hook-and-line. The assessment program was updated to accommodate logistic and double logistic selectivity patterns instead of having to estimate selectivity for each age separately. The CVs of the landings and indices were used to determine the emphasis of the data instead of instead of assigning arbitrary weightings (lambda values). In a similar vein, the sample sizes for the multinomial fits were down-weighted using the square root of the number of otoliths instead of arbitrarily capping the actual number at 200. Spawning biomass in this assessment was female biomass rather than total (both sexes) as in SEDAR 15A. Finally, we used 0.75 as the starting steepness value but allowed the program to solve for steepness. Even with the changes, the results of this update were similar to those from the earlier assessment -- the base run had $F_{current}$ less than $F_{30\%}$ and SSB_{2013} was greater than $SSB_{F30\%}$. Sensitivity runs that individually omitted an index had the same result as well as runs that only used fishery independent indices and the runs that only used the fishery dependent indices. However as before, sensitivity runs using direct aging had biomass ratios around 0.6 indicating that population was overfished.

4.9 Projections

We ran ASAP's projections using the base run and similar projections using both the lower natural mortality averaging 0.08 per year and the higher natural mortality averaging 0.17 per year. The projections for 2014 and 2015 were run at the current fishing mortality rates and then 20 years with the alternative rates. The fishing mortality options were a) F=0, b) the Councils' MSY proxy fishing rate of F = F30% SPR or the Maximum Fishing Mortality Threshold, c) the Councils' OY proxy fishing rate of F40% or the Acceptable Biological Catch, and d) using the current total harvest fishing mortality or the geometric mean fishing mortality rate of the three most recent years' (2011, 2012, and 2013). The current total harvest fishing mortality rate, 0.12 per year, was less than either F30%SPR or F40%SPR and hence the projected yields were lower at current fishing mortality levels than at either of the limits and, correspondingly, the spawning biomass was higher (Table 4.9, Fig. 4.9).

5. Discussion

The landings, indices, lengths, and ages received much more scrutiny in this update than in SEDAR 15A. In addition, we now have many more fish upon which to base the maturity, more ages by region and gear, more experience with ASAP, MCMC, and the overall assessment process; the consequence of which is that this update should be a solid product. As with SEDAR 15A, most of the runs with reasonable assumptions met the councils' management objectives. The runs that did not meet the objectives used either the low average natural mortality (M=0.08 per year) or direct aging.

As this analysis was an update, we did not think that we should change assessment models and so we have stayed with ASAP. In the next benchmark assessment, we recommend that rather than estimating numbers at age externally to the model and using selectivity based on age it would be preferable to use selectivity based on length, assigning the ages internally in the model for maximum consistency.

6. Acknowledgements

It is important to note the contributions of the university, state and federal field biologists that carry out the many research and monitoring activities on fish populations and fisheries in the southeast region. Their many hours spent at recreational access points and marinas to interview anglers, at seafood houses to interview commercial fishers, on fishing vessels for At-Sea sampling, on fishery-independent sampling cruises, and on underwater surveys result in a rich, diverse array of data on fish populations and specimens for age, growth, and maturity that form the basis of population assessments. For these reasons, we thank the biologists (some still working, some of whom have retired, and some no longer living but not forgotten) gathering the TIP, HBS, and MRIP/MRFSS interviews, the At-Sea observations on headboats, charterboats, and commercial vessels, those taking part in the underwater dives, the SEAMAP and FIM programs, and those involved with cooperative research programs. Of equal importance is the much appreciated cooperation of fishermen, vessel operators, and seafood dealers that allow our samplers access to information about fishing practices, on-the-water observations, and specimens. We thank the fishermen who submit the logbooks and fill out surveys, the dealers that send in the trip tickets and allow us to sample their catches, the charter boat and head boat captains that provide us with better information on vessel and angler trips than we had in the past and for allowing us on their vessels at times to observe fishing activities, and anglers that patiently answer our questions about their recreational catches and releases. Once the specimens are brought back to the lab, often a different set of biologists and technicians perform the tasks of data entry and quality assurance, processing of samples for maturity and/or age determinations, mercury assays, incorporation into data bases, and a host of other chores that are not flashy but are so very important for interpreting and making sense of field data.

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Table 2.2.1. Estimated total length at age, weight at age, maturity, and natural mortality rates at age.

					Natural mortality	
Age (yr)	TL(mm)	Avg Wt (kg)	Maturity	Sex ratio	Ave 0.11 per year	Ave 0.08 per year
1	266	0.235	0.00	0.50	0.27	0.20
2	357	0.579	0.07	0.50	0.22	0.16
3	434	1.055	0.42	0.50	0.18	0.13
4	499	1.623	0.50	0.50	0.16	0.12
5	554	2.242	0.50	0.50	0.15	0.11
6	601	2.878	0.50	0.50	0.14	0.10
7	641	3.504	0.50	0.50	0.13	0.09
8	674	4.102	0.50	0.50	0.12	0.09
9	703	4.659	0.50	0.50	0.12	0.09
10	727	5.170	0.50	0.50	0.12	0.08
11	747	5.632	0.50	0.50	0.11	0.08
12	765	6.045	0.50	0.50	0.11	0.08
13	780	6.410	0.50	0.50	0.11	0.08
14	792	6.731	0.50	0.50	0.11	0.08
15	803	7.011	0.50	0.50	0.11	0.08
16	812	7.255	0.50	0.50	0.10	0.08
17	819	7.466	0.50	0.50	0.10	0.08
18	826	7.648	0.50	0.50	0.10	0.07
19	831	7.805	0.50	0.50	0.10	0.07
20	836	7.940	0.50	0.50	0.10	0.07
21	840	8.055	0.50	0.50	0.10	0.07
22	843	8.153	0.50	0.50	0.10	0.07
23	846	8.238	0.50	0.50	0.10	0.07
24	848	8.309	0.50	0.50	0.10	0.07
25	850	8.371	0.50	0.50	0.10	0.07
26	852	8.423	0.50	0.50	0.10	0.07
27	853	8.467	0.50	0.50	0.10	0.07
28	855	8.505	0.50	0.50	0.10	0.07
29	856	8.537	0.50	0.50	0.10	0.07
30	856	8.564	0.50	0.50	0.10	0.07
31	857	8.587	0.50	0.50	0.10	0.07
32	858	8.607	0.50	0.50	0.10	0.07
33	858	8.623	0.50	0.50	0.10	0.07
34	859	8.638	0.50	0.50	0.10	0.07
35	859	8.650	0.50	0.50	0.10	0.07
36	860	8.660	0.50	0.50	0.10	0.07
37	860	8.668	0.50	0.50	0.10	0.07
38	860	8.676	0.50	0.50	0.10	0.07
39	860	8.682	0.50	0.50	0.10	0.07
40	860	8.687	0.50	0.50	0.10	0.07

Table 2.2.2. Reproductive stages based on Lowerre-Barbieri *et al.* (2009) and Brown-Peterson *et al.* (2011).

Reproductive state		Phase	Histological indicators	Significance
Immature	Non-spawning	Immature	Only oogonia and primary growth oocytes, including chromatin nucleolar and perinucleolar oocytes. Usually no atresia.	Virgin that has not yet recruited to the spawning population.
Mature	Non-spawning	Developing	Cortical alveolar and early vitellogenic oocytes (Vtg1). No evidence of POFs. Some atresia may be present.	Environmental signals have triggered development, but fish are not yet developed enough to spawn.
Mature / **Spawning population**	Spawning-capable	Spawning-capable	Late vitellogenic oocytes (Vtg2 & 3). May be atresia.	Fish developed enough to spawn.
		Subphase Spawning	Oocyte maturation, hydration or POFs.	Fish with indicators of spawning activity.
		Imminent	Early OM (GVM with little yolk coalescence)	Will spawn in 14 h.
		Active	1. Advanced GVM 2. GVBD 3.Hydrated or undergoing ovulation 4. Newly-collapsed POFs	Spawning +/- 2 h.
		Recent	POFs (12-36 h old)	Spawned within 2 d.
Mature	Non-spawning	Regressing	A high percentage of yolked oocytes undergoing atresia (alpha and beta).	Cessation of spawning.
	Non-spawning	Regenerating	Only primary growth oocytes present, including chromatin nucleolar and perinucleolar. Muscle bundles, enlarged blood vessels, thick and/ or convoluted ovarian wall, and gamma or delta atresia may be present.	Sexually mature, reproductively inactive. Most common outside of the spawning season.

Table 2.2.3. Landings without discards in metric tons and effort, either trips or angler-hours, by fishery. The Headboat Survey recommended omitting the 1981-1991 landings and effort.

	Comm HL		Comm LL		HB		MRFSS	
Year	(Trips)	(mt)	(Trips)	(mt)	Directed angler-days	(mt)	(Trips)	(mt)
1981	5,533	104.118	876	45.353	--	--	225,550	489.661
1982	6,622	114.303	980	51.660	--	--	112,446	493.547
1983	5,697	95.441	1,003	57.544	--	--	184,900	578.017
1984	4,821	86.672	777	41.329	--	--	141,263	608.752
1985	6,683	103.551	1,061	53.138	--	--	76,035	56.667
1986	6,499	133.010	1,062	53.160	--	--	177,986	292.919
1987	7,811	167.649	1,453	82.593	--	--	241,179	491.053
1988	6,870	156.348	1,057	51.661	--	--	227,288	393.679
1989	7,756	173.812	1,132	76.566	--	--	210,306	291.504
1990	7,105	143.411	989	60.731	--	--	191,183	199.577
1991	7,155	150.686	867	66.063	--	--	403,301	370.999
1992	8,299	148.826	589	33.484	96,513	56.800	424,077	549.665
1993	8,567	167.339	412	34.062	98,268	68.582	406,356	325.191
1994	7,465	138.193	295	22.596	94,610	81.005	343,656	176.705
1995	6,216	107.718	316	20.717	60,682	44.921	244,542	255.689
1996	5,485	108.321	327	23.013	49,498	48.129	245,325	197.612
1997	5,444	104.926	260	26.575	29,949	31.325	249,510	129.599
1998	4,838	124.480	319	36.016	34,324	26.624	254,802	147.014
1999	3,333	79.916	342	33.603	32,595	21.995	141,693	190.001
2000	3,153	58.703	296	33.368	31,371	27.735	204,999	131.969
2001	3,864	62.895	331	41.795	38,686	32.764	176,274	94.787
2002	4,284	68.310	243	35.948	48,933	23.445	302,801	210.688
2003	4,122	69.270	260	50.441	36,987	26.079	350,139	265.624
2004	3,620	67.378	380	89.366	39,832	22.301	305,104	176.038
2005	3,035	51.394	360	54.680	47,423	39.458	446,406	159.937
2006	2,445	41.389	432	88.073	41,694	39.076	470,538	279.239
2007	2,404	40.805	285	58.609	49,568	43.778	685,325	397.968
2008	2,340	38.002	215	33.535	47,052	31.160	715,126	422.652
2009	2,540	41.652	95	14.705	54,466	46.997	416,325	186.316
2010	2,292	42.092	115	16.326	34,062	36.100	385,660	175.504
2011	2,190	46.522	173	24.839	33,143	39.303	202,548	92.010
2012	2,082	51.196	109	24.144	40,130	52.910	260,986	194.656
2013	1,995	42.591	134	38.939	38,401	34.712		269.297

Table 2.2.4. Estimated discards in metric tons by fishery. The breakdown into dead discards and live discards came from the at-sea sampling program.

	Commercial hook-and-line		Commercial longline		Headboat		MRFSS/MRIP	
Year	Dead (mt)	Live (mt)	Dead (mt)	Live (mt)	Dead (mt)	Live (mt)	Dead (mt)	Live (mt)
1981	0.516	0.301	0.000	0.000	--	--	0.019	0.041
1982	0.573	0.361	0.000	0.000	--	--	0.091	0.147
1983	0.451	0.308	0.000	0.000	--	--	0.653	0.604
1984	0.416	0.204	0.000	0.000	--	--	4.709	9.736
1985	0.373	0.214	0.000	0.000	--	--	1.489	1.429
1986	0.537	0.322	0.000	0.000	--	--	0.921	1.114
1987	0.733	0.361	0.000	0.000	--	--	5.572	6.376
1988	0.944	0.495	0.000	0.000	--	--	2.994	5.831
1989	2.271	0.881	0.000	0.000	--	--	0.624	0.702
1990	1.500	0.663	0.000	0.000	--	--	0.767	1.517
1991	1.330	0.758	0.000	0.000	--	--	7.334	14.842
1992	1.462	0.654	0.000	0.000	0.718	0.759	5.857	9.595
1993	1.207	0.204	0.000	0.000	0.857	0.877	7.664	13.409
1994	1.142	0.246	0.000	0.000	0.866	0.911	4.585	7.102
1995	1.903	0.514	0.000	0.000	1.293	1.301	7.660	11.697
1996	1.851	0.504	0.000	0.000	0.789	0.828	8.307	13.174
1997	1.579	0.540	0.000	0.000	0.811	0.835	14.569	24.273
1998	2.169	0.452	0.000	0.000	0.621	0.654	17.005	26.841
1999	0.991	0.465	0.000	0.000	0.602	0.602	5.682	7.195
2000	1.006	0.442	0.000	0.000	0.713	0.756	7.508	7.961
2001	1.236	0.398	0.000	0.000	0.878	0.918	4.921	5.127
2002	1.268	1.057	0.000	0.000	0.668	0.689	8.987	8.815
2003	1.155	0.284	0.000	0.000	0.647	0.693	7.599	9.496
2004	0.724	0.472	0.000	0.000	0.629	0.652	8.271	8.568
2005	0.670	0.296	0.000	0.000	0.814	0.705	15.815	19.728
2006	0.441	0.109	0.000	0.000	1.255	0.632	17.429	18.098
2007	0.506	0.736	0.000	0.000	1.725	1.887	22.003	26.202
2008	0.487	0.423	0.000	0.000	2.129	1.410	51.890	52.616
2009	0.656	0.276	0.000	0.000	1.821	1.466	14.234	15.668
2010	0.570	0.275	0.000	0.000	2.081	2.501	4.866	4.774
2011	0.673	0.123	0.000	0.000	0.000	0.267	1.792	2.045
2012	0.617	0.145	0.000	0.000	0.149	0.984	10.070	10.733
2013	0.568	0.336	0.000	0.000	0.616	0.931	17.313	23.476

Table 2.2.5. Estimated number of Mutton Snapper discarded by the commercial hook-and-line fishery calculated from logbook discard reports. Discards prior to 2002 were extrapolated from the 2002-2012 average ratio of discards to total hook-hours.

Year	Logbook total hook-hours	Standardized discard rate	Calculated discards	Number of discard trips	Variance (discard rate)	Standard deviation (discard rate)	CV discard rate
1993	1,794,356	0.003535543	6,344		0.000006716	0.002591531	0.732993829
1994	2,164,723	0.003535543	7,653		0.000006716	0.002591531	0.732993829
1995	2,084,284	0.003535543	7,369		0.000006716	0.002591531	0.732993829
1996	2,042,291	0.003535543	7,221		0.000006716	0.002591531	0.732993829
1997	2,189,607	0.003535543	7,741		0.000006716	0.002591531	0.732993829
1998	1,834,254	0.003535543	6,485		0.000006716	0.002591531	0.732993829
1999	1,887,083	0.003535543	6,672		0.000006716	0.002591531	0.732993829
2000	1,792,220	0.003535543	6,336		0.000006716	0.002591531	0.732993829
2001	1,612,785	0.003535543	5,702		0.000006716	0.002591531	0.732993829
2002	1,699,945	0.008915341	15,156	1,069	0.000030556	0.005527748	0.620026532
2003	1,502,184	0.002706648	4,066	1,634	0.000003847	0.001961377	0.724651657
2004	1,345,216	0.005035333	6,774	1,074	0.000009696	0.00311384	0.618398034
2005	1,324,662	0.003204933	4,245	1,038	0.000003683	0.001919114	0.598800117
2006	1,425,045	0.001093640	1,558	809	0.000000902	0.000949737	0.868417976
2007	1,417,695	0.007441484	10,550	1,399	0.000019425	0.00440738	0.59227167
2008	1,325,314	0.004571475	6,059	2,227	0.000006328	0.002515552	0.55027131
2009	1,853,940	0.002131313	3,951	1,255	0.000002895	0.00170147	0.798320097
2010	1,568,148	0.002518992	3,950	1,671	0.000002468	0.001570987	0.623657079
2011	1,407,101	0.001251453	1,761	1,808	0.000000859	0.000926823	0.74059713
2012	1,517,747	0.001371381	2,081	1,788	0.000000800	0.000894427	0.65220935
	Weighted mean discard rate 2002-2011	0.003535543		**Weighted mean variance 02-12**	0.000006716	**Overall CV 02-12**	0.732993829

Table 2.2.6. The number of Mutton Snapper age samples by fishery and year.

Year	Comm HL	Comm LL	Headboat	MRFSS/MRIP	Total
1981	0	0	150	0	150
1982	0	0	169	0	169
1983	0	0	4	0	4
1984	0	0	20	0	20
1985	0	0	76	0	76
1986	0	0	33	0	33
1987	0	0	14	0	14
1988	0	0	33	0	33
1989	0	0	2	0	2
1990	0	0	6	0	6
1991	0	0	11	0	11
1992	51	1	10	0	62
1993	38	11	52	0	101
1994	63	5	49	0	117
1995	36	2	127	0	165
1996	152	0	24	0	176
1997	208	24	19	0	251
1998	209	3	0	0	212
1999	232	5	0	0	237
2000	224	9	3	0	236
2001	259	59	13	5	336
2002	334	101	2	118	555
2003	261	146	146	238	791
2004	169	150	135	129	583
2005	199	147	242	264	852
2006	137	401	237	87	862
2007	179	233	599	21	1032
2008	374	208	742	52	1376
2009	280	135	998	97	1510
2010	526	359	946	97	1928
2011	543	231	497	200	1471
2012	319	258	521	72	1170
Totals	4793	2488	5880	1380	14541

Table 2.2.7. Numbers at age of Mutton Snapper, landings + estimated dead discards, by fishery with an average natural mortality of 0.11 per year. Fishery: **Commercial hook-and-line**

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+	Total
1981	3,866	5,730	3,277	2,901	3,484	4,114	4,397	4,284	3,894	3,375	2,840	2,350	1,929	1,580	1,296	1,067	882	733	612	513	432	365	310	263	1,475	55,971
1982	5,138	8,380	4,635	3,955	4,763	5,361	5,332	4,865	4,210	3,529	2,906	2,372	1,932	1,576	1,291	1,063	881	734	615	518	438	373	318	272	1,600	67,059
1983	4,488	7,461	4,100	3,473	4,185	4,664	4,564	4,099	3,501	2,908	2,379	1,935	1,572	1,281	1,049	864	716	597	501	422	358	305	260	223	1,332	57,238
1984	1,339	40	2	155	1,151	2,939	4,484	5,066	4,784	4,070	3,266	2,540	1,945	1,480	1,124	855	652	498	381	291	222	169	128	96	254	37,931
1985	1,406	42	3	209	1,403	2,855	3,584	3,722	3,560	3,249	2,875	2,492	2,132	1,812	1,536	1,301	1,104	940	802	686	589	506	436	376	2,203	39,823
1986	2,311	2,729	4,711	3,662	2,501	3,045	3,974	4,431	4,372	4,008	3,522	3,024	2,567	2,168	1,830	1,548	1,314	1,119	958	823	710	615	535	466	3,021	59,966
1987	2,372	73	373	910	1,241	3,179	5,798	7,358	7,553	6,888	5,884	4,854	3,934	3,164	2,541	2,043	1,648	1,335	1,085	885	725	595	489	402	1,837	67,167
1988	7,589	12,178	5,627	5,012	6,535	7,186	6,997	6,452	5,735	4,940	4,155	3,440	2,824	2,310	1,891	1,551	1,277	1,055	875	728	608	509	427	358	1,811	92,067
1989	24,443	46,263	21,776	11,349	8,481	7,480	6,626	5,814	5,058	4,341	3,673	3,073	2,553	2,115	1,752	1,454	1,210	1,011	847	712	600	507	429	363	1,871	163,798
1990	10,395	34,515	18,995	9,040	7,083	6,910	6,253	5,221	4,201	3,350	2,684	2,172	1,777	1,469	1,227	1,034	879	753	649	563	491	431	379	336	2,397	123,204
1991	15,568	30,540	19,055	17,108	14,108	10,510	7,464	5,313	3,901	2,969	2,328	1,865	1,519	1,252	1,042	875	740	630	540	465	403	350	306	268	1,773	140,891
1992	9,470	16,612	21,427	16,210	11,592	8,940	7,234	5,897	4,759	3,796	3,008	2,379	1,886	1,502	1,204	973	791	648	534	443	370	310	260	220	1,200	121,662
1993	3,705	7,869	7,563	8,026	9,078	9,734	9,523	8,485	7,062	5,641	4,415	3,428	2,664	2,079	1,635	1,296	1,036	835	678	554	456	377	314	262	1,403	98,117
1994	5,097	4,717	7,890	7,967	8,439	9,056	8,528	7,222	5,761	4,468	3,430	2,632	2,030	1,578	1,238	981	784	632	513	420	346	286	238	198	1,016	85,468
1995	649	16,881	13,175	7,344	5,109	4,627	4,565	4,290	3,776	3,173	2,595	2,094	1,682	1,352	1,091	885	722	593	490	407	340	285	240	202	1,102	77,668
1996	8,700	4,501	8,911	9,300	8,174	6,867	5,562	4,412	3,476	2,740	2,170	1,731	1,395	1,137	937	780	655	554	471	402	345	296	254	218	1,267	75,255
1997	943	4,109	5,307	5,345	6,046	6,677	6,392	5,491	4,436	3,475	2,689	2,075	1,607	1,254	986	782	626	505	410	336	276	229	190	158	813	61,156
1998	508	2,378	3,997	4,637	6,161	7,683	7,914	7,036	5,735	4,469	3,414	2,595	1,979	1,520	1,179	924	731	584	471	383	313	258	214	179	970	66,232
1999	554	5,073	5,953	5,353	4,891	4,609	4,201	3,632	3,012	2,433	1,939	1,537	1,219	971	778	628	510	417	343	284	237	198	166	140	752	49,832
2000	532	4,308	4,453	3,667	3,498	3,428	3,120	2,652	2,161	1,724	1,364	1,080	859	687	555	452	371	307	256	214	181	154	131	112	675	36,941
2001	459	3,353	6,138	5,767	4,895	4,206	3,548	2,896	2,299	1,796	1,393	1,081	842	661	523	418	337	273	224	184	153	127	107	90	493	42,262
2002	947	6,236	8,388	7,171	5,799	4,863	3,910	2,986	2,224	1,654	1,244	953	744	591	478	392	326	274	233	199	172	149	131	115	799	50,978
2003	256	4,055	5,236	4,332	4,426	4,318	3,759	3,040	2,376	1,840	1,431	1,126	898	727	596	495	416	353	302	260	226	197	173	152	1,060	42,052
2004	412	1,571	1,579	1,741	2,406	2,993	3,179	2,999	2,628	2,209	1,817	1,481	1,205	982	804	663	549	458	385	325	276	235	201	173	1,045	32,317
2005	257	1,409	2,590	3,167	3,339	3,349	3,059	2,564	2,039	1,581	1,217	939	731	575	457	368	299	246	204	171	144	122	104	89	560	29,580
2006	97	2,435	3,646	2,827	2,549	2,397	2,102	1,731	1,381	1,092	865	691	558	455	376	313	263	223	190	164	141	123	107	94	622	25,443
2007	635	1,984	2,835	4,147	4,706	4,176	3,182	2,249	1,550	1,069	749	534	390	290	220	170	133	106	85	69	57	47	39	33	173	29,626
2008	404	2,318	2,537	2,372	2,517	2,561	2,322	1,926	1,523	1,181	910	703	547	428	339	270	218	177	145	119	98	82	68	57	289	24,110
2009	294	6,830	9,151	5,999	3,842	2,772	2,101	1,593	1,200	902	681	519	400	312	247	198	160	131	108	90	76	64	54	47	290	38,060
2010	244	2,093	3,783	3,449	3,042	2,596	2,112	1,701	1,378	1,119	910	740	603	493	404	333	276	230	193	162	137	116	99	84	467	26,767
2011	115	3,698	7,427	5,364	3,780	2,958	2,369	1,889	1,496	1,179	927	729	576	458	366	295	240	196	161	133	111	93	78	65	347	35,051
2012	127	1,652	4,185	3,818	3,372	3,426	3,293	2,845	2,275	1,742	1,307	974	728	547	415	317	245	191	149	118	94	75	60	48	209	32,211
2013	573	1,916	2,686	4,112	4,169	3,495	2,764	2,134	1,623	1,225	923	698	531	407	315	246	194	154	124	100	81	66	54	44	206	28,838

Table 2.2.7 continued. Numbers at age of Mutton Snapper, landings + estimated dead discards, by fishery for an average natural mortality of 0.11 per year. Fishery**: Commercial longline**

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+	Total
1981	0	36	189	458	842	1,147	1,380	1,516	1,528	1,439	1,291	1,123	960	812	684	576	486	411	348	296	253	216	185	159	916	17,251
1982	0	44	217	474	898	1,255	1,536	1,704	1,729	1,634	1,470	1,282	1,097	930	784	661	558	472	401	341	291	249	214	183	1,065	19,491
1983	0	51	250	533	1,017	1,431	1,758	1,954	1,985	1,878	1,690	1,474	1,262	1,070	903	762	643	544	462	393	336	287	246	212	1,230	22,374
1984	0	0	12	110	390	772	1,081	1,254	1,296	1,245	1,139	1,010	880	758	650	556	476	409	352	303	262	227	198	172	1,064	14,616
1985	0	0	15	88	145	256	524	873	1,154	1,298	1,317	1,254	1,148	1,027	907	795	694	605	528	461	402	352	308	270	1,700	16,121
1986	0	629	2,483	1,226	1,414	2,247	2,585	2,489	2,193	1,841	1,506	1,217	979	788	637	518	424	349	289	241	202	170	144	122	735	25,429
1987	0	201	1,003	2,322	4,578	6,032	6,104	5,283	4,194	3,185	2,372	1,757	1,304	974	733	557	427	329	256	200	157	124	98	78	298	42,566
1988	0	0	15	185	386	616	1,008	1,403	1,630	1,667	1,573	1,413	1,233	1,059	902	765	648	550	468	398	340	291	249	214	1,227	18,239
1989	0	0	4	94	348	861	1,706	2,505	2,920	2,937	2,700	2,354	1,990	1,654	1,363	1,119	917	752	617	507	416	342	280	229	937	27,553
1990	0	172	977	2,596	3,904	4,196	3,755	3,033	2,331	1,762	1,335	1,024	797	631	508	415	343	287	243	207	179	155	135	118	805	29,909
1991	0	130	347	1,578	2,915	3,493	3,388	2,981	2,509	2,065	1,683	1,367	1,111	906	743	614	510	426	358	303	257	220	188	162	974	29,227
1992	0	12	311	1,142	2,152	2,727	2,640	2,179	1,652	1,206	869	628	458	339	255	195	151	119	94	76	62	51	43	36	211	17,608
1993	0	33	393	962	1,453	1,749	1,824	1,697	1,459	1,198	960	762	605	483	388	314	257	211	176	147	124	105	89	77	476	15,942
1994	0	9	159	489	843	1,052	1,080	991	858	723	603	501	418	349	294	249	212	182	157	136	118	103	91	80	548	10,243
1995	0	76	473	712	915	974	908	795	676	567	473	394	328	274	230	194	164	140	120	103	89	78	68	59	392	9,205
1996	0	4	124	398	573	625	618	591	556	515	468	419	371	326	286	250	219	192	169	149	131	116	103	91	639	7,933
1997	0	30	183	473	729	872	905	868	795	708	620	538	464	400	345	298	259	225	197	173	152	134	119	105	750	10,339
1998	0	63	867	1,469	1,404	1,287	1,196	1,106	1,008	902	797	696	605	524	454	393	342	298	260	228	201	178	157	140	991	15,566
1999	0	49	518	1,096	1,342	1,348	1,243	1,100	955	823	706	606	520	447	386	334	290	253	222	195	172	153	136	121	883	13,898
2000	0	37	386	911	1,236	1,326	1,261	1,127	979	840	718	612	522	447	383	330	285	248	216	189	166	147	130	115	816	13,426
2001	0	20	352	756	1,089	1,344	1,425	1,364	1,237	1,090	947	817	704	607	524	454	395	345	302	266	235	208	185	165	1,200	16,032
2002	0	39	405	935	1,319	1,445	1,377	1,225	1,060	910	782	674	583	506	441	386	339	299	264	234	208	186	166	149	1,111	15,043
2003	0	102	589	1,208	1,467	1,474	1,397	1,303	1,206	1,107	1,006	907	813	726	647	577	514	458	409	365	327	293	263	236	1,774	19,169
2004	0	171	1,626	3,201	3,851	3,796	3,377	2,882	2,445	2,086	1,792	1,549	1,344	1,170	1,022	895	787	694	614	545	485	433	388	348	2,592	38,093
2005	0	81	1,185	2,918	3,457	3,168	2,669	2,182	1,765	1,427	1,159	949	784	653	549	465	397	341	295	257	224	197	174	154	1,096	26,545
2006	0	106	1,235	2,821	3,808	3,921	3,586	3,122	2,664	2,255	1,904	1,610	1,366	1,164	996	857	742	645	563	494	435	385	342	304	2,198	37,523
2007	0	7	386	1,460	2,408	2,838	2,781	2,463	2,076	1,712	1,403	1,151	949	786	657	552	468	399	342	295	256	223	195	172	1,167	25,147
2008	0	291	993	1,206	1,220	1,266	1,286	1,228	1,107	959	811	679	566	472	395	332	281	239	204	175	151	131	114	100	658	14,864
2009	8	344	796	813	863	845	753	636	522	423	341	276	224	183	151	126	106	89	76	65	56	49	42	37	252	8,075
2010	0	114	614	864	857	776	693	609	525	445	374	314	263	222	188	160	137	118	103	89	78	69	61	54	388	8,115
2011	0	151	936	1,717	1,759	1,517	1,234	981	778	620	500	407	335	278	233	197	168	144	124	108	94	82	72	64	449	12,945
2012	0	85	566	1,019	1,150	1,092	987	871	752	639	537	449	375	314	264	223	189	162	139	120	104	90	79	69	468	10,744
2013	1	156	607	1,423	2,088	2,228	2,021	1,701	1,388	1,120	904	732	597	491	407	340	286	243	207	178	154	134	117	102	687	18,312

Table 2.2.7 continued. Numbers at age of Mutton Snapper, landings + estimated dead discards, by fishery for an average natural mortality of 0.11 per year. Fishery: **Headboats**

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+	Total
1981	3,473	8,953	9,699	5,350	2,945	1,838	1,235	856	603	430	311	229	171	130	100	78	62	49	40	32	27	22	18	15	77	36,743
1982	3,195	6,759	10,986	6,337	3,167	1,857	1,242	871	617	440	315	229	168	125	94	72	55	43	34	27	21	17	14	11	49	36,743
1983	3,442	4,208	9,384	7,995	4,713	2,580	1,473	900	581	390	270	192	139	103	78	59	46	36	29	23	18	15	12	10	47	36,743
1984	3,362	4,643	8,319	7,433	4,930	2,957	1,758	1,071	674	438	294	204	145	106	79	60	47	37	30	24	20	16	14	12	72	36,743
1985	3,274	6,888	9,654	6,336	3,641	2,214	1,422	945	643	446	316	228	167	125	94	72	56	44	35	28	22	18	14	12	50	36,743
1986	3,703	5,840	8,597	6,476	3,908	2,368	1,531	1,048	744	542	402	304	233	182	144	116	94	78	65	54	46	39	33	28	169	36,743
1987	4,395	9,576	7,518	5,045	3,243	2,047	1,322	886	617	444	328	248	191	150	119	96	79	65	54	45	38	33	28	24	148	36,743
1988	4,130	8,785	8,522	5,121	2,935	1,882	1,331	975	718	531	395	297	225	173	135	106	85	68	55	45	37	31	26	21	112	36,743
1989	3,775	9,942	9,697	5,386	2,688	1,449	903	627	460	348	268	209	165	132	107	87	72	60	51	43	37	32	27	24	154	36,743
1990	4,951	10,663	8,429	4,907	2,819	1,634	989	634	429	301	217	160	121	93	72	57	45	37	30	25	20	17	14	12	68	36,743
1991	4,061	7,207	9,788	6,001	3,041	1,662	1,053	748	568	446	357	288	235	193	160	134	112	95	81	69	60	52	45	39	248	36,743
1992	3,777	9,855	6,691	4,016	2,395	1,539	1,098	821	621	472	362	280	219	173	139	113	92	77	64	54	46	39	34	29	190	33,196
1993	4,159	9,241	8,730	5,213	3,006	1,937	1,393	1,045	788	595	450	343	265	207	163	130	105	86	71	59	49	42	35	30	184	38,327
1994	3,439	5,435	10,071	6,507	3,419	2,113	1,579	1,259	1,001	784	610	474	370	291	231	185	150	122	101	84	70	59	50	42	262	38,707
1995	620	5,466	7,294	4,138	2,203	1,393	980	711	518	378	277	204	152	114	87	67	52	40	32	25	20	16	12	10	33	24,840
1996	362	1,928	2,863	2,019	1,194	840	707	644	590	529	465	402	344	293	250	214	183	158	136	118	103	90	78	69	459	15,038
1997	548	3,694	4,346	2,337	1,300	845	599	441	331	252	196	154	124	100	83	69	58	49	42	36	32	28	24	21	154	15,863
1998	421	2,544	3,014	1,764	1,073	800	629	486	369	279	211	160	123	96	76	60	48	39	32	26	22	18	15	13	67	12,387
1999	343	2,509	2,907	1,910	1,202	770	505	341	238	170	124	93	71	55	44	35	28	23	19	16	14	12	10	9	55	11,503
2000	396	3,635	3,756	2,058	1,197	824	617	465	347	257	190	142	107	82	63	50	40	32	26	21	18	15	13	11	70	14,431
2001	428	3,408	5,278	3,069	1,553	979	714	529	384	277	200	146	108	81	62	48	38	30	24	20	16	14	12	10	61	17,486
2002	325	2,430	3,661	2,537	1,503	912	576	369	240	158	106	73	51	36	27	20	15	12	9	7	6	5	4	3	15	13,098
2003	317	2,087	3,528	2,569	1,512	906	588	402	282	202	146	108	81	62	48	38	31	25	21	17	14	12	11	9	60	13,076
2004	321	2,432	3,453	2,347	1,384	817	501	322	217	150	107	78	58	44	33	26	20	16	13	11	9	7	6	5	22	12,397
2005	284	5,613	8,370	4,720	2,244	1,106	616	392	273	200	150	114	88	68	54	43	34	28	22	18	15	12	10	9	45	24,527
2006	389	5,004	6,596	3,483	1,701	928	572	395	297	236	194	162	136	116	99	86	74	65	57	50	45	40	35	32	245	21,036
2007	1,133	6,498	8,943	5,114	2,499	1,329	786	507	347	247	180	133	100	76	59	46	36	28	23	18	15	12	9	8	28	28,174
2008	870	6,538	7,185	3,594	1,659	883	535	348	235	163	116	84	62	46	35	27	21	17	13	11	9	7	6	5	19	22,488
2009	653	7,669	9,894	5,639	2,925	1,580	890	524	323	208	140	98	70	52	40	31	25	20	16	14	12	10	8	7	50	30,899
2010	914	5,864	8,036	4,718	2,358	1,241	698	412	252	159	103	69	47	33	23	17	12	9	7	5	4	3	2	2	5	24,993
2011	2	1,992	5,393	4,104	2,488	1,523	960	619	409	277	192	137	100	75	57	45	35	29	23	19	16	14	12	10	64	18,595
2012	281	1,450	4,405	4,372	3,039	1,935	1,255	852	604	443	334	258	204	164	133	110	92	78	67	58	50	44	38	34	252	20,553
2013	338	3,237	4,304	2,548	1,569	1,047	731	533	401	308	240	188	149	120	97	79	65	54	45	38	32	27	23	20	115	16,306

Table 2.2.7 continued. Numbers at age of Mutton Snapper, landings + estimated dead discards, by fishery for an average natural mortality of 0.11 per year. Fishery**: MRFSS/MRIP Recreational**

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+	Total
1981	918	38	15	6	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	980
1982	2,546	53	15	14	11	11	10	8	7	6	4	3	3	2	2	1	1	1	1	1	1	0	0	0	2	2,703
1983	14,254	244	90	144	117	68	37	20	12	7	4	3	2	1	1	1	0	0	0	0	0	0	0	0	0	15,006
1984	185,022	6,911	1,919	962	725	551	415	309	231	174	133	104	83	67	54	45	38	32	27	23	20	18	15	13	91	197,983
1985	26,603	420	92	342	353	226	134	84	56	39	28	21	15	11	8	6	5	4	3	2	2	1	1	1	2	28,459
1986	22,803	517	277	229	147	88	54	36	25	19	15	12	10	8	7	6	5	4	3	3	2	2	2	1	8	24,284
1987	127,336	3,459	1,546	907	540	371	284	235	198	166	137	111	90	72	58	47	38	31	26	21	17	14	12	10	46	135,772
1988	107,130	4,687	960	601	473	384	335	281	220	164	119	85	61	43	31	22	16	12	9	6	4	3	2	2	3	115,656
1989	14,750	477	219	139	94	67	46	30	19	12	7	4	3	2	1	1	1	0	0	0	0	0	0	0	0	15,870
1990	30,391	701	837	572	212	67	22	8	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	32,817
1991	236,072	7,728	2,001	1,338	995	850	757	683	608	528	448	373	308	253	207	170	140	115	95	79	66	55	46	38	180	254,133
1992	155,114	4,905	1,646	818	578	519	514	500	457	395	330	269	217	175	141	114	92	75	61	50	42	34	28	24	118	167,214
1993	253,152	9,192	2,951	1,722	1,279	981	712	493	340	240	176	134	106	85	70	58	49	42	36	31	27	24	21	19	131	272,072
1994	143,274	5,491	2,074	835	479	385	313	239	177	130	97	73	55	43	34	27	21	17	14	12	10	8	7	6	27	153,846
1995	43,231	55,882	12,274	2,687	1,025	550	350	246	184	141	110	87	70	56	46	37	31	25	21	18	15	13	11	9	50	117,169
1996	46,777	59,054	12,925	2,936	1,281	866	632	450	316	224	162	120	91	70	55	44	36	29	24	20	17	14	12	11	63	126,230
1997	93,626	113,869	25,190	5,161	2,086	1,387	969	649	427	285	197	141	105	81	65	53	45	38	33	29	25	22	20	18	136	244,659
1998	96,177	123,390	27,467	5,646	2,094	1,306	985	764	591	455	351	273	214	169	135	108	88	72	60	49	41	35	29	25	138	260,661
1999	22,092	35,252	7,257	1,342	518	338	256	199	155	121	95	75	60	48	39	32	27	22	19	16	13	11	10	8	50	68,056
2000	21,673	43,450	9,247	1,716	579	320	214	150	108	79	58	44	33	26	20	16	13	10	9	7	6	5	4	4	21	77,813
2001	13,692	28,565	6,092	1,102	353	183	116	80	58	43	33	25	20	16	12	10	8	7	6	5	4	3	3	2	14	50,451
2002	22,919	51,584	11,056	1,968	575	254	140	89	61	44	32	24	18	14	11	8	7	5	4	4	3	2	2	2	9	88,836
2003	29,181	47,849	10,319	2,017	724	419	294	218	165	126	97	75	59	47	38	31	25	21	17	15	12	10	9	8	45	91,819
2004	23,368	48,644	10,483	1,938	560	257	159	110	79	58	43	32	24	19	15	12	9	8	6	5	4	4	3	3	15	85,857
2005	62,359	103,004	22,638	4,274	1,495	945	686	487	335	227	153	104	71	49	35	24	17	13	9	7	5	4	3	2	6	196,953
2006	50,391	104,347	22,342	4,124	1,277	592	340	216	143	97	66	45	31	22	16	11	8	6	4	3	2	2	1	1	2	184,092
2007	80,176	138,155	30,642	6,092	1,809	832	539	403	312	243	190	150	120	96	78	64	53	45	38	32	27	23	20	18	114	260,271
2008	147,320	315,099	65,981	10,495	2,564	1,072	638	438	315	231	171	129	98	75	59	46	37	30	24	20	16	14	11	9	48	544,941
2009	45,358	87,803	18,992	3,243	866	451	330	252	188	139	102	75	56	42	32	25	19	15	12	9	7	6	5	4	15	158,045
2010	12,640	28,467	6,111	1,078	301	131	72	42	25	16	10	6	4	3	2	1	1	1	0	0	0	0	0	0	0	48,912
2011	6,010	10,838	2,395	510	176	87	52	35	24	17	13	9	7	5	4	3	3	2	2	1	1	1	1	1	4	20,204
2012	28,838	57,092	12,126	2,537	981	555	360	244	168	117	83	60	44	33	25	19	15	12	9	7	6	5	4	3	14	103,356
2013	75,473	113,901	24,260	4,398	1,454	912	745	635	530	432	345	273	216	171	136	109	88	72	59	48	40	33	28	23	124	224,505

Table 2.2.8. Numbers at age of Mutton Snapper, discards from 15% release mortality rate, by fishery for an average natural mortality of 0.11 per year. Fishery: **Commercial hook-and-line**

Year	1	2	3	4	5	6	7	8	9	10	11	12+	Total
1981	3,951	6,633	3,359	372	0	0	0	0	0	0	0	0	14,314
1982	4,733	7,946	4,025	445	0	0	0	0	0	0	0	0	17,150
1983	4,040	6,783	3,435	380	0	0	0	0	0	0	0	0	14,638
1984	2,677	4,495	2,277	252	0	0	0	0	0	0	0	0	9,701
1985	2,811	4,719	2,390	265	0	0	0	0	0	0	0	0	10,185
1986	4,233	7,106	3,599	398	0	0	0	0	0	0	0	0	15,336
1987	4,741	7,959	4,031	446	0	0	0	0	0	0	0	0	17,178
1988	6,499	10,910	5,526	612	0	0	0	0	0	0	0	0	23,546
1989	11,562	19,410	9,831	1,088	0	0	0	0	0	0	0	0	41,891
1990	8,697	14,600	7,394	818	0	0	0	0	0	0	0	0	31,509
1991	9,945	16,696	8,456	936	0	0	0	0	0	0	0	0	36,032
1992	8,588	14,417	7,302	808	0	0	0	0	0	0	0	0	31,115
1993	2,682	4,502	2,280	252	0	0	0	0	0	0	0	0	9,716
1994	3,235	5,431	2,751	304	0	0	0	0	0	0	0	0	11,721
1995	517	3,660	4,936	2,068	310	25	0	0	0	0	0	0	11,517
1996	506	3,587	4,837	2,027	304	24	0	0	0	0	0	0	11,285
1997	543	3,845	5,186	2,173	326	26	0	0	0	0	0	0	12,099
1998	455	3,221	4,344	1,820	273	22	0	0	0	0	0	0	10,135
1999	468	3,314	4,469	1,873	281	22	0	0	0	0	0	0	10,427
2000	444	3,148	4,245	1,779	267	21	0	0	0	0	0	0	9,903
2001	400	2,832	3,820	1,600	240	19	0	0	0	0	0	0	8,912
2002	1,063	7,528	10,153	4,254	638	51	0	0	0	0	0	0	23,686
2003	285	2,020	2,724	1,141	171	14	0	0	0	0	0	0	6,354
2004	475	3,365	4,538	1,901	285	23	0	0	0	0	0	0	10,586
2005	298	2,109	2,844	1,192	179	14	0	0	0	0	0	0	6,635
2006	109	774	1,044	437	66	5	0	0	0	0	0	0	2,436
2007	740	5,240	7,067	2,961	444	35	0	0	0	0	0	0	16,488
2008	425	3,010	4,059	1,701	255	20	0	0	0	0	0	0	9,469
2009	277	1,963	2,647	1,109	166	13	0	0	0	0	0	0	6,175
2010	277	1,962	2,646	1,109	166	13	0	0	0	0	0	0	6,174
2011	123	875	1,180	494	74	6	0	0	0	0	0	0	2,752
2012	146	1,034	1,394	584	88	7	0	0	0	0	0	0	3,253
2013	338	2,392	3,226	1,352	203	16	0	0	0	0	0	0	7,526

Table 2.2.8 continued. Numbers at age of Mutton Snapper, discards from 15% release mortality rate, by fishery for an average natural mortality of 0.11 per year. **Fishery: Headboats**

Year	1	2	3	4	5	6	7	8	9	10	11	12+	Total
1981	20,697	593	100	43	19	9	5	3	2	1	1	2	21,474
1982	20,694	575	111	52	21	9	5	3	2	1	1	1	21,474
1983	20,695	549	93	65	35	17	9	5	3	2	1	2	21,474
1984	20,696	554	82	57	36	21	12	6	4	2	1	3	21,474
1985	20,696	578	98	48	23	12	7	4	2	2	1	3	21,474
1986	20,700	570	89	50	25	13	8	5	3	2	2	6	21,473
1987	20,707	609	76	34	19	11	6	4	2	2	1	4	21,474
1988	20,704	600	86	36	17	10	7	4	3	2	1	3	21,474
1989	20,701	610	97	37	14	6	3	2	1	1	1	2	21,474
1990	20,711	612	79	32	17	10	5	3	2	1	1	1	21,474
1991	20,701	581	102	45	19	9	5	3	2	1	1	3	21,474
1992	18,769	566	70	30	15	8	5	3	2	1	1	2	19,472
1993	21,475	612	86	37	18	11	7	5	4	3	2	8	22,268
1994	21,856	591	100	55	26	14	9	7	5	4	3	11	22,679
1995	4,430	8,101	1,669	239	45	13	6	3	2	1	1	2	14,513
1996	2,828	4,860	990	138	25	8	5	5	5	5	4	25	8,898
1997	2,915	5,159	1,063	151	28	8	3	2	1	1	1	3	9,334
1998	2,342	4,013	828	119	23	7	3	2	1	1	1	2	7,342
1999	2,031	3,756	771	110	22	7	3	1	1	1	0	1	6,704
2000	2,753	4,681	967	137	24	6	2	1	0	0	0	0	8,573
2001	3,279	5,670	1,176	171	32	9	3	2	1	0	0	1	10,344
2002	2,416	4,253	876	128	26	8	4	2	1	1	0	1	7,716
2003	2,525	4,220	874	129	26	8	3	2	1	1	1	2	7,792
2004	2,301	4,022	831	122	24	7	3	1	1	1	0	1	7,314
2005	1,773	4,469	944	159	39	12	4	2	1	1	0	1	7,405
2006	1,748	3,972	883	123	20	5	1	1	0	0	0	0	6,755
2007	8,094	12,465	1,919	240	44	13	5	3	2	1	1	1	22,787
2008	4,445	8,860	1,864	266	45	11	4	2	1	1	1	1	15,501
2009	3,121	9,702	2,123	284	46	11	4	2	1	1	0	1	15,295
2010	7,781	14,671	3,549	626	119	29	9	3	2	1	0	1	26,791
2011	1,783	1,332	332	51	10	3	1	1	0	0	0	0	3,514
2012	8,692	4,400	877	142	39	16	8	4	2	1	1	3	14,186
2013	3,335	5,805	1,164	157	28	8	4	2	2	1	1	3	10,510

Table 2.2.8 continued. Numbers at age of Mutton Snapper, discards from 15% release mortality rate, by fishery for an average natural mortality of 0.11 per year. Fishery**: MRFSS/MRIP Recreational**

Year	1	2	3	4	5	6	7	8	9	10	11	12+	Total
1981	918	38	15	6	2	1	0	0	0	0	0	0	980
1982	2,546	53	15	14	11	11	10	8	7	6	4	18	2,703
1983	14,254	244	90	144	117	68	37	20	12	7	4	8	15,006
1984	185,022	6,911	1,919	962	725	551	415	309	231	174	133	631	197,983
1985	26,603	420	92	342	353	226	134	84	56	39	28	81	28,459
1986	22,803	517	277	229	147	88	54	36	25	19	15	73	24,284
1987	127,336	3,459	1,546	907	540	371	284	235	198	166	137	593	135,772
1988	107,130	4,687	960	601	473	384	335	281	220	164	119	301	115,656
1989	14,750	477	219	139	94	67	46	30	19	12	7	13	15,870
1990	30,391	701	837	572	212	67	22	8	4	2	1	2	32,817
1991	236,072	7,728	2,001	1,338	995	850	757	683	608	528	448	2,125	254,133
1992	155,114	4,905	1,646	818	578	519	514	500	457	395	330	1,440	167,214
1993	253,152	9,192	2,951	1,722	1,279	981	712	493	340	240	176	834	272,072
1994	143,274	5,491	2,074	835	479	385	313	239	177	130	97	352	153,846
1995	43,231	55,882	12,274	2,687	1,025	550	350	246	184	141	110	488	117,169
1996	46,777	59,054	12,925	2,936	1,281	866	632	450	316	224	162	606	126,230
1997	93,626	113,869	25,190	5,161	2,086	1,387	969	649	427	285	197	811	244,659
1998	96,177	123,390	27,467	5,646	2,094	1,306	985	764	591	455	351	1,435	260,661
1999	22,092	35,252	7,257	1,342	518	338	256	199	155	121	95	430	68,056
2000	21,673	43,450	9,247	1,716	579	320	214	150	108	79	58	218	77,813
2001	13,692	28,565	6,092	1,102	353	183	116	80	58	43	33	136	50,451
2002	22,919	51,584	11,056	1,968	575	254	140	89	61	44	32	114	88,836
2003	29,181	47,849	10,319	2,017	724	419	294	218	165	126	97	412	91,819
2004	23,368	48,644	10,483	1,938	560	257	159	110	79	58	43	158	85,857
2005	62,359	103,004	22,638	4,274	1,495	945	686	487	335	227	153	349	196,953
2006	50,391	104,347	22,342	4,124	1,277	592	340	216	143	97	66	155	184,092
2007	80,176	138,155	30,642	6,092	1,809	832	539	403	312	243	190	879	260,271
2008	147,320	315,099	65,981	10,495	2,564	1,072	638	438	315	231	171	617	544,941
2009	45,358	87,803	18,992	3,243	866	451	330	252	188	139	102	321	158,045
2010	12,640	28,467	6,111	1,078	301	131	72	42	25	16	10	19	48,912
2011	6,010	10,838	2,395	510	176	87	52	35	24	17	13	46	20,204
2012	28,838	57,092	12,126	2,537	981	555	360	244	168	117	83	255	103,356
2013	75,473	113,901	24,260	4,398	1,454	912	745	635	530	432	345	1,421	224,505

Table 2.2.9. Fishery dependent indices (Indices 1-4), fishery independent indices (Indices 5-7), coefficients of variation, and ages used for tuning.

Index	NMFS Logbook hook-and-line		NMFS Logbook Longline		Headboat		MRFSS/MRIP	
Ages	2 - 9		4 - 24		2 - 8		2 - 8	
Year	Index	CV	Index	CV	Index	CV	Index	CV
1981								
1982								
1983								
1984								
1985								
1986							0.93	0.161
1987							0.95	0.173
1988							0.88	0.156
1989							0.76	0.175
1990	0.59	0.356	0.10	0.902			0.63	0.199
1991	1.30	0.316	0.57	0.520			1.05	0.164
1992	0.70	0.194	0.50	0.613			0.98	0.109
1993	0.99	0.174	0.35	0.433			1.09	0.118
1994	0.72	0.173	0.51	0.414			0.84	0.129
1995	0.71	0.171	0.50	0.398	1.20	0.022	0.96	0.143
1996	0.85	0.171	0.38	0.379	0.99	0.030	0.73	0.161
1997	0.74	0.171	0.58	0.369	0.87	0.038	0.92	0.122
1998	0.78	0.175	0.68	0.361	1.01	0.033	1.02	0.109
1999	0.85	0.179	0.70	0.398	0.73	0.042	0.69	0.103
2000	0.71	0.179	1.13	0.387	0.87	0.042	0.93	0.086
2001	0.93	0.177	0.96	0.368	1.09	0.042	1.06	0.083
2002	1.07	0.173	1.32	0.388	1.22	0.045	1.15	0.065
2003	1.14	0.176	1.34	0.369	1.29	0.048	0.97	0.077
2004	1.08	0.174	2.24	0.354	0.80	0.048	0.91	0.080
2005	0.99	0.177	1.28	0.352	0.87	0.040	1.29	0.076
2006	1.14	0.183	1.90	0.346	0.71	0.049	1.14	0.079
2007	1.11	0.184	1.07	0.363	1.03	0.037	1.35	0.068
2008	1.18	0.190	0.81	0.374	1.07	0.025	1.63	0.064
2009	1.23	0.193	1.22	0.419	1.43	0.021	1.40	0.081
2010	1.51	0.198	1.56	0.401	1.30	0.021	1.15	0.081
2011	1.28	0.196	1.35	0.380	1.00	0.026	0.84	0.104
2012	1.43	0.194	1.96	0.414	0.80	0.026	0.75	0.093
2013					0.73	0.025		

Table 2.2.9 continued. Fishery dependent indices (Indices 1-4), fishery independent indices (Indices 5-7), coefficients of variation, and ages used for tuning.

Index	FWC FIM Age 1		NMFS UM Reef Visual Census		Riley's Hump Visual Survey	
Ages	1 - 1		1 - 7		5 - 15	
Year	Index	CV	Index	CV	Index	CV
1981						
1982						
1983						
1984						
1985						
1986						
1987						
1988						
1989						
1990						
1991						
1992						
1993						
1994						
1995						
1996						
1997						
1998	0.49	0.318	0.20	2.309		
1999	0.46	0.391	0.41	3.203		
2000	0.94	0.334	0.90	2.222		
2001	0.73	0.367	0.83	2.067		
2002	0.68	0.315	1.19	2.102	0.46	0.191
2003	1.17	0.246	1.04	1.801	0.71	0.306
2004	0.74	0.316	1.50	1.946	1.35	0.224
2005	0.75	0.265	1.19	1.579	1.34	0.204
2006	0.72	0.292	0.91	1.859	1.40	0.223
2007	1.11	0.256	1.82	1.896	1.18	0.160
2008	2.26	0.221	1.36	1.299	0.58	0.185
2009	2.16	0.240	1.00	1.332	1.12	0.168
2010	1.02	0.263	0.71	1.574		
2011	0.39	0.357	0.78	1.774	0.87	0.248
2012	0.55	0.329	1.17	1.567		
2013	1.13	0.271				

Table 4.1. Objective function component totals for ASAP base run. Legend: nobs -- the number of observations, MSE -- the mean square error, and the objective function which is the basis of the log-likelihood.

Component	nobs	MSE	Objective Function
Catch_Fleet_Total	132	0.584522	-235.659
Discard_Fleet_Total	132	0.708972	-264.008
Commercial hook-and-line index	23	1.01838	-26.397
Commercial longline index	23	1.06912	-8.310
Headboat index	19	2.13462	-21.343
MRFSS/MRIP index	27	1.75529	-18.855
FIM age-1	16	1.52866	-1.192
NMFS UM Reef Visual Census	15	0.377701	3.954
Riley's Hump index	9	1.80966	0.510
Catch_Total age composition	3300		2439.810
Discard_Total age composition	2475		618.703
Index age composition	105		146.390
Commercial hook-and-line selectivity	2		0.513
Commercial longline selectivity	2		2.440
Headboat selectivity	4		2.044
MRFSS/MRIP selectivity	4		2.909
NMFS UM Reef Visual Census selectivity	4		-2.127
Numbers-at-age 1981	24	0.484322	44.714
Recruitment deviations	33	0.669765	-10.978
Steepness	1	0.59163	-1.796
Unfished spawning biomass	1	2.05468	1.361
Objective function total			2672.682

Table 4.2. Parameter estimates and their precisions (standard errors) from ASAP base run.

Parameter number	Parameter	Estimate	Standard error
1	Sel_Comm HL Age 50	2.0922	0.4140
2	Sel_Comm HL slope	1.2133	0.3782
3	Sel_Comm LL Age 50	5.3281	0.4771
4	Sel_Comm LL slope	1.0217	0.1810
5	Sel_Headboat Age 50 (ascending)	1.0292	0.0181
6	Sel_Headboat slope (ascending)	0.0674	0.0319
7	Sel_Headboat Age 50 (descending)	2.6062	0.8413
8	Sel_Headboat slope (descending)	3.6643	0.3510
9	Sel_MRFSS/MRIP Age 50 (ascending)	1.0047	0.0081
10	Sel_MRFSS/MRIP slope (ascending)	0.0382	0.0181
11	Sel_MRFSS/MRIP Age 50 (descending)	1.9987	0.6308
12	Sel_MRFSS/MRIP slope (descending)	3.3886	0.2687
13	log F Comm hook-and-line 1981	-3.6647	0.2500
14	log F Comm longline 1981	-4.2389	0.2825
15	Log F Headboat 1981	-3.1088	0.1638
16	Log F MRFSS/MRIP 1981	-1.9084	0.1705
17	log_F_devs Comm HL 1982	0.1088	0.2676
18	log_F_devs Comm HL 1983	-0.1330	0.2671
19	log_F_devs Comm HL 1984	-0.1827	0.2671
20	log_F_devs Comm HL 1985	0.2007	0.2679
21	log_F_devs Comm HL 1986	0.3333	0.2121
22	log_F_devs Comm HL 1987	0.2757	0.1402
23	log_F_devs Comm HL 1988	0.0018	0.1407
24	log_F_devs Comm HL 1989	0.1698	0.1405
25	log_F_devs Comm HL 1990	-0.1924	0.1395
26	log_F_devs Comm HL 1991	0.0590	0.1396
27	log_F_devs Comm HL 1992	0.0214	0.1396
28	log_F_devs Comm HL 1993	0.1249	0.1398
29	log_F_devs Comm HL 1994	-0.1862	0.1392
30	log_F_devs Comm HL 1995	-0.2509	0.1394
31	log_F_devs Comm HL 1996	-0.0226	0.1402
32	log_F_devs Comm HL 1997	-0.0661	0.1402
33	log_F_devs Comm HL 1998	0.1449	0.1402
34	log_F_devs Comm HL 1999	-0.4487	0.1396
35	log_F_devs Comm HL 2000	-0.3393	0.1394
36	log_F_devs Comm HL 2001	0.0082	0.1393
37	log_F_devs Comm HL 2002	0.0746	0.1391
38	log_F_devs Comm HL 2003	-0.0713	0.1392
39	log_F_devs Comm HL 2004	-0.0145	0.1395

Table 4.2 continued. Parameter estimates and their precisions (standard errors) from ASAP base run.

Parameter number	Parameter	Estimate	Standard error
40	log_F_devs Comm HL 2005	-0.2951	0.1390
41	log_F_devs Comm HL 2006	-0.2464	0.1393
42	log_F_devs Comm HL 2007	0.0819	0.1394
43	log_F_devs Comm HL 2008	-0.0975	0.1388
44	log_F_devs Comm HL 2009	0.0325	0.1393
45	log_F_devs Comm HL 2010	-0.0356	0.1397
46	log_F_devs Comm HL 2011	0.0322	0.1399
47	log_F_devs Comm HL 2012	0.0723	0.1400
48	log_F_devs Comm HL 2013	-0.1411	0.1398
49	log_F_devs Comm LL 1982	0.1312	0.2814
50	log_F_devs Comm LL 1983	0.1511	0.2797
51	log_F_devs Comm LL 1984	-0.3290	0.2794
52	log_F_devs Comm LL 1985	0.2477	0.2802
53	log_F_devs Comm LL 1986	0.0358	0.2030
54	log_F_devs Comm LL 1987	0.4798	0.0728
55	log_F_devs Comm LL 1988	-0.3803	0.0727
56	log_F_devs Comm LL 1989	0.4269	0.0731
57	log_F_devs Comm LL 1990	-0.2312	0.0727
58	log_F_devs Comm LL 1991	0.1289	0.0727
59	log_F_devs Comm LL 1992	-0.6071	0.0727
60	log_F_devs Comm LL 1993	0.0823	0.0729
61	log_F_devs Comm LL 1994	-0.3328	0.0725
62	log_F_devs Comm LL 1995	-0.2257	0.0723
63	log_F_devs Comm LL 1996	0.0093	0.0722
64	log_F_devs Comm LL 1997	0.1871	0.0719
65	log_F_devs Comm LL 1998	0.2600	0.0717
66	log_F_devs Comm LL 1999	-0.1504	0.0714
67	log_F_devs Comm LL 2000	-0.0707	0.0714
68	log_F_devs Comm LL 2001	0.2101	0.0712
69	log_F_devs Comm LL 2002	-0.1438	0.0710
70	log_F_devs Comm LL 2003	0.2797	0.0710
71	log_F_devs Comm LL 2004	0.5370	0.0712
72	log_F_devs Comm LL 2005	-0.5235	0.0708
73	log_F_devs Comm LL 2006	0.4491	0.0711
74	log_F_devs Comm LL 2007	-0.4017	0.0711
75	log_F_devs Comm LL 2008	-0.5490	0.0712
76	log_F_devs Comm LL 2009	-0.7609	0.0710
77	log_F_devs Comm LL 2010	0.0801	0.0710

Table 4.2 continued. Parameter estimates and their precisions (standard errors) from ASAP base run.

Parameter number	Parameter	Estimate	Standard error
78	log_F_devs Comm LL 2011	0.2993	0.0714
79	log_F_devs Comm LL 2012	-0.1312	0.0713
80	log_F_devs Comm LL 2013	0.4895	0.0712
81	log_F_devs Headboat 1982	-0.1621	0.2095
82	log_F_devs Headboat 1983	0.1567	0.2027
83	log_F_devs Headboat 1984	0.2334	0.2081
84	log_F_devs Headboat 1985	-0.1507	0.2258
85	log_F_devs Headboat 1986	0.0413	0.2034
86	log_F_devs Headboat 1987	0.0312	0.2163
87	log_F_devs Headboat 1988	-0.0643	0.2155
88	log_F_devs Headboat 1989	0.2360	0.2107
89	log_F_devs Headboat 1990	-0.2792	0.2177
90	log_F_devs Headboat 1991	-0.1686	0.1972
91	log_F_devs Headboat 1992	0.0480	0.1760
92	log_F_devs Headboat 1993	0.1772	0.1669
93	log_F_devs Headboat 1994	-0.1740	0.1534
94	log_F_devs Headboat 1995	-0.5824	0.1331
95	log_F_devs Headboat 1996	-0.2781	0.1245
96	log_F_devs Headboat 1997	0.1589	0.1268
97	log_F_devs Headboat 1998	-0.2812	0.1275
98	log_F_devs Headboat 1999	0.0564	0.1272
99	log_F_devs Headboat 2000	0.0100	0.1253
100	log_F_devs Headboat 2001	-0.0190	0.1253
101	log_F_devs Headboat 2002	-0.2729	0.1257
102	log_F_devs Headboat 2003	0.1541	0.1262
103	log_F_devs Headboat 2004	0.0563	0.1785
104	log_F_devs Headboat 2005	0.3482	0.1895
105	log_F_devs Headboat 2006	-0.1802	0.1670
106	log_F_devs Headboat 2007	0.4670	0.1577
107	log_F_devs Headboat 2008	-0.3673	0.1076
108	log_F_devs Headboat 2009	0.0724	0.0715
109	log_F_devs Headboat 2010	0.4579	0.0732
110	log_F_devs Headboat 2011	-0.7769	0.1124
111	log_F_devs Headboat 2012	0.8276	0.1210
112	log_F_devs Headboat 2013	-0.3948	0.1328
113	log_F_devs MRFSS/MRIP 1982	0.5176	0.2514
114	log_F_devs MRFSS/MRIP 1983	-0.2004	0.4114
115	log_F_devs MRFSS/MRIP 1984	0.7189	0.4085

Table 4.2 continued. Parameter estimates and their precisions (standard errors) from ASAP base run.

Parameter number	Parameter	Estimate	Standard error
116	log_F_devs MRFSS/MRIP 1985	-2.2564	0.3336
117	log_F_devs MRFSS/MRIP 1986	1.2858	0.3228
118	log_F_devs MRFSS/MRIP 1987	0.7370	0.2590
119	log_F_devs MRFSS/MRIP 1988	-0.1967	0.2915
120	log_F_devs MRFSS/MRIP 1989	-0.6051	0.2827
121	log_F_devs MRFSS/MRIP 1990	-0.0797	0.2345
122	log_F_devs MRFSS/MRIP 1991	0.7749	0.2095
123	log_F_devs MRFSS/MRIP 1992	0.2542	0.1805
124	log_F_devs MRFSS/MRIP 1993	-0.2745	0.1376
125	log_F_devs MRFSS/MRIP 1994	-0.6464	0.1194
126	log_F_devs MRFSS/MRIP 1995	0.3329	0.1545
127	log_F_devs MRFSS/MRIP 1996	-0.1312	0.1728
128	log_F_devs MRFSS/MRIP 1997	0.0651	0.1692
129	log_F_devs MRFSS/MRIP 1998	0.1275	0.1581
130	log_F_devs MRFSS/MRIP 1999	-0.3703	0.1527
131	log_F_devs MRFSS/MRIP 2000	-0.2704	0.1512
132	log_F_devs MRFSS/MRIP 2001	-0.4566	0.1382
133	log_F_devs MRFSS/MRIP 2002	0.6948	0.1252
134	log_F_devs MRFSS/MRIP 2003	0.2010	0.1167
135	log_F_devs MRFSS/MRIP 2004	-0.1480	0.1460
136	log_F_devs MRFSS/MRIP 2005	0.1592	0.1476
137	log_F_devs MRFSS/MRIP 2006	0.3077	0.1288
138	log_F_devs MRFSS/MRIP 2007	0.1772	0.1195
139	log_F_devs MRFSS/MRIP 2008	0.3946	0.1238
140	log_F_devs MRFSS/MRIP 2009	-1.0598	0.1216
141	log_F_devs MRFSS/MRIP 2010	-0.3120	0.1263
142	log_F_devs MRFSS/MRIP 2011	-0.6274	0.1712
143	log_F_devs MRFSS/MRIP 2012	1.0772	0.1942
144	log_F_devs MRFSS/MRIP 2013	0.4762	0.1747
145	log_recruit_devs 1981	0.2219	0.1573
146	log_recruit_devs 1982	0.4233	0.1912
147	log_recruit_devs 1983	0.0031	0.2158
148	log_recruit_devs 1984	-0.1120	0.2057
149	log_recruit_devs 1985	0.1439	0.1777
150	log_recruit_devs 1986	0.0251	0.1800
151	log_recruit_devs 1987	0.1656	0.1757
152	log_recruit_devs 1988	0.2128	0.1629

Table 4.2 continued. Parameter estimates and their precisions (standard errors) from ASAP base run.

Parameter number	Parameter	Estimate	Standard error
153	log_recruit_devs 1989	-0.1272	0.1812
154	log_recruit_devs 1990	0.3540	0.1536
155	log_recruit_devs 1991	0.4417	0.1359
156	log_recruit_devs 1992	0.3150	0.1254
157	log_recruit_devs 1993	0.2673	0.1197
158	log_recruit_devs 1994	0.4255	0.0820
159	log_recruit_devs 1995	-0.3617	0.1003
160	log_recruit_devs 1996	-0.2584	0.0962
161	log_recruit_devs 1997	-0.0086	0.0761
162	log_recruit_devs 1998	-0.6496	0.1031
163	log_recruit_devs 1999	-0.0336	0.0763
164	log_recruit_devs 2000	0.1858	0.0691
165	log_recruit_devs 2001	0.1077	0.0716
166	log_recruit_devs 2002	-0.1379	0.0764
167	log_recruit_devs 2003	-0.3333	0.0775
168	log_recruit_devs 2004	-0.1278	0.0723
169	log_recruit_devs 2005	-0.2108	0.0791
170	log_recruit_devs 2006	0.3049	0.0595
171	log_recruit_devs 2007	0.3674	0.0542
172	log_recruit_devs 2008	0.5951	0.0468
173	log_recruit_devs 2009	-0.0174	0.0596
174	log_recruit_devs 2010	-0.7703	0.0917
175	log_recruit_devs 2011	-1.0394	0.1159
176	log_recruit_devs 2012	-0.5459	0.0909
177	log_recruit_devs 2013	0.1739	0.2360
178	log_N_1981_age_2_devs	0.0203	0.1927
179	log_N_1981_age_3_devs	0.0171	0.2111
180	log_N_1981_age_4_devs	0.2045	0.2339
181	log_N_1981_age_5_devs	0.3600	0.2525
182	log_N_1981_age_6_devs	0.4143	0.2679
183	log_N_1981_age_7_devs	0.3660	0.2809
184	log_N_1981_age_8_devs	0.2819	0.2922
185	log_N_1981_age_9_devs	0.2253	0.3031
186	log_N_1981_age_10_devs	0.1990	0.3119
187	log_N_1981_age_11_devs	0.2136	0.3198
188	log_N_1981_age_12_devs	0.2778	0.3278
189	log_N_1981_age_13_devs	0.3591	0.3339

Table 4.2 continued. Parameter estimates and their precisions (standard errors) from ASAP base run.

Parameter number	Parameter	Estimate	Standard error
190	log_N_1981_age_14_devs	0.4541	0.3396
191	log_N_1981_age_15_devs	0.5544	0.3450
192	log_N_1981_age_16_devs	0.6532	0.3503
193	log_N_1981_age_17_devs	0.7563	0.3555
194	log_N_1981_age_18_devs	0.8505	0.3606
195	log_N_1981_age_19_devs	0.9351	0.3658
196	log_N_1981_age_20_devs	1.0089	0.3711
197	log_N_1981_age_21_devs	1.0727	0.3764
198	log_N_1981_age_22_devs	1.1265	0.3817
199	log_N_1981_age_23_devs	1.1713	0.3872
200	log_N_1981_age_24_devs	1.2074	0.3927
201	log_N_1981_age_25_devs	3.3369	0.4500
202	log_catchability Comm HL index	-7.6842	0.1811
203	log_catchability Comm LL index	-7.8531	0.2233
204	log_catchability Headboat index	-6.8611	0.0847
205	log_catchability MRFSS/MRIP index	-6.7706	0.0846
206	log_catchability FIM index	-6.3653	0.1023
207	log_catchability NMFS-UM RVC index	-7.2028	0.3339
208	log_catchability Riley's Hump index	-6.5103	0.1732
209	index_sel_RVC Age 50 (ascending)	1.0645	0.2081
210	index_sel_RVC slope (ascending)	0.3559	0.1544
211	index_sel_RVC Age 50 (descending)	5.7608	0.9492
212	index_sel_RVC slope (descending)	0.9856	0.4010
213	log_Unexploited spawning biomass	9.0097	0.1307
214	Steepness	0.8144	0.1014

Table 4.3. Numbers of fish by age and year estimated from the ASAP base run.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+	Total
1981	765	504	361	231	161	119	90	70	56	45	37	31	25	21	18	15	13	11	10	8	7	6	5	5	34	2,650
1982	935	534	330	251	167	120	91	71	56	46	37	31	26	22	18	15	13	11	10	8	7	6	6	5	33	2,851
1983	614	621	318	211	170	118	87	69	55	45	37	30	26	22	18	15	13	11	10	8	7	6	5	5	33	2,556
1984	545	427	386	211	147	122	88	67	54	44	36	30	25	21	18	15	13	11	10	8	7	6	5	5	33	2,339
1985	701	370	218	216	126	94	83	63	50	42	35	30	25	21	18	15	13	11	10	9	7	6	6	5	33	2,206
1986	615	527	272	167	168	100	75	67	52	42	35	30	25	21	18	15	13	11	10	9	7	6	6	5	32	2,329
1987	710	443	340	186	118	123	75	58	53	41	34	29	25	21	18	15	13	11	10	8	7	6	5	5	32	2,387
1988	740	499	245	199	116	77	84	53	43	40	32	27	23	20	17	15	13	11	9	8	7	6	5	5	31	2,323
1989	518	528	288	152	130	79	55	61	40	33	32	26	22	19	16	14	12	11	9	8	7	6	5	4	30	2,103
1990	830	380	335	193	105	92	57	41	47	31	26	25	21	17	15	13	12	10	9	8	7	6	5	4	28	2,318
1991	904	602	250	232	138	77	69	44	32	37	25	21	21	17	14	13	11	10	8	7	6	6	5	4	28	2,581
1992	793	648	351	153	151	93	54	50	33	24	29	20	17	17	14	12	10	9	8	7	6	5	5	4	27	2,540
1993	750	558	341	200	93	97	63	38	37	25	19	23	16	14	14	11	10	9	8	7	6	5	5	4	26	2,377
1994	870	535	320	208	128	63	68	46	29	28	19	15	19	13	11	11	9	8	7	6	6	5	4	4	25	2,459
1995	396	639	352	221	149	94	47	52	36	23	23	16	13	15	11	9	10	8	7	6	6	5	4	4	25	2,171
1996	444	288	457	247	157	108	71	36	42	29	19	19	13	11	13	9	8	8	7	6	5	5	4	4	24	2,034
1997	578	326	213	334	180	117	83	56	29	34	24	16	16	11	9	11	8	7	7	6	5	5	4	4	24	2,106
1998	306	426	242	160	248	134	89	65	45	24	28	20	13	14	10	8	9	7	6	6	5	4	4	4	24	1,900
1999	568	225	314	177	116	183	102	69	52	36	19	23	17	11	11	8	6	8	6	5	5	4	4	3	24	1,996
2000	710	416	167	233	132	88	143	81	56	42	30	16	19	14	9	10	7	6	7	5	4	5	4	3	24	2,231
2001	659	529	313	126	179	103	70	116	67	47	36	25	14	17	12	8	9	6	5	6	4	4	4	3	24	2,386
2002	521	495	404	242	99	143	83	58	97	57	40	31	22	12	14	11	7	7	5	4	5	4	3	3	24	2,393
2003	435	386	365	298	182	76	112	67	48	81	47	34	26	19	10	12	9	6	7	5	4	5	3	3	24	2,263
2004	538	321	281	262	218	137	59	89	54	39	67	40	29	22	16	9	11	8	5	6	4	3	4	3	24	2,249
2005	496	398	236	205	195	166	106	47	72	44	32	56	34	24	19	14	8	9	7	5	5	4	3	4	23	2,209
2006	831	368	289	171	151	148	129	85	38	60	37	27	48	29	21	16	12	7	8	6	4	4	3	2	23	2,519
2007	885	607	260	201	120	110	111	100	68	31	49	31	23	40	24	18	14	10	6	7	5	4	4	3	22	2,752
2008	1,107	640	424	173	136	85	81	84	78	54	25	41	26	20	35	21	15	12	9	5	6	5	3	3	22	3,112
2009	600	773	419	270	111	91	59	59	64	62	44	21	34	22	17	30	18	14	11	8	4	5	4	3	22	2,766
2010	284	446	568	310	204	86	72	48	49	54	52	38	18	30	19	15	26	16	12	10	7	4	5	4	22	2,399
2011	220	211	328	423	236	159	69	59	40	41	46	45	33	16	26	17	13	23	14	11	9	6	4	4	23	2,077
2012	364	166	162	256	338	192	131	58	50	34	36	40	40	29	14	23	15	12	21	13	10	8	6	3	25	2,043
2013	749	269	124	118	188	255	149	105	47	42	29	30	35	34	25	12	20	13	10	18	11	8	7	5	25	2,330

Table 4.4. The estimated total biomass at the beginning of the year, spawning biomass, and exploitable biomass in metric tons by year from the base run**.**

Year	Total biomass January 1	Spawning biomass	Exploitable biomass
1981	4,775	2,124	2,833
1982	4,867	2,120	2,731
1983	4,723	2,078	2,728
1984	4,609	2,028	2,270
1985	4,232	1,915	3,347
1986	4,393	1,940	2,686
1987	4,359	1,884	2,568
1988	4,057	1,744	2,318
1989	3,853	1,672	2,718
1990	3,792	1,652	2,644
1991	3,890	1,622	2,512
1992	3,808	1,569	2,265
1993	3,606	1,509	2,318
1994	3,541	1,501	2,493
1995	3,619	1,574	2,583
1996	3,676	1,678	2,703
1997	3,777	1,712	2,891
1998	3,826	1,735	2,915
1999	3,839	1,763	2,728
2000	3,972	1,786	2,763
2001	4,203	1,883	3,236
2002	4,468	2,022	3,124
2003	4,585	2,105	3,150
2004	4,619	2,124	3,413
2005	4,631	2,125	2,855
2006	4,749	2,127	2,968
2007	4,800	2,090	2,722
2008	4,914	2,093	2,803
2009	4,838	2,141	2,906
2010	5,013	2,337	3,141
2011	5,090	2,457	3,431
2012	5,225	2,484	3,035
2013	5,207	2,387	2,779

Table 4.6.1. Fishing mortality per year by age from the base run for the commercial hook-and-line fishery.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981	0.003	0.012	0.017	0.021	0.023	0.025	0.025	0.025	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
1982	0.003	0.013	0.019	0.024	0.026	0.027	0.028	0.028	0.028	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029
1983	0.003	0.012	0.017	0.021	0.023	0.024	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
1984	0.001	0.002	0.005	0.017	0.019	0.020	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
1985	0.002	0.003	0.007	0.021	0.023	0.024	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
1986	0.002	0.016	0.024	0.029	0.033	0.034	0.035	0.035	0.035	0.035	0.035	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
1987	0.003	0.005	0.031	0.039	0.043	0.045	0.046	0.046	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047
1988	0.005	0.022	0.032	0.039	0.043	0.045	0.046	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047
1989	0.009	0.026	0.038	0.046	0.051	0.053	0.055	0.055	0.055	0.055	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056
1990	0.005	0.022	0.031	0.038	0.042	0.044	0.045	0.045	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
1991	0.007	0.023	0.033	0.040	0.045	0.047	0.048	0.048	0.048	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049
1992	0.005	0.023	0.034	0.041	0.046	0.048	0.049	0.049	0.049	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
1993	0.007	0.027	0.038	0.047	0.052	0.054	0.055	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056
1994	0.006	0.022	0.032	0.039	0.043	0.045	0.046	0.046	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047
1995	0.003	0.014	0.024	0.030	0.033	0.035	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
1996	0.009	0.010	0.023	0.029	0.033	0.034	0.035	0.035	0.035	0.035	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
1997	0.003	0.008	0.020	0.027	0.030	0.032	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
1998	0.003	0.008	0.023	0.031	0.035	0.037	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.038
1999	0.002	0.007	0.015	0.020	0.022	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
2000	0.001	0.005	0.011	0.014	0.016	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
2001	0.001	0.005	0.011	0.014	0.016	0.017	0.017	0.017	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
2002	0.001	0.004	0.011	0.015	0.017	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
2003	0.001	0.006	0.011	0.015	0.016	0.017	0.017	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
2004	0.001	0.003	0.009	0.014	0.016	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
2005	0.001	0.003	0.008	0.011	0.012	0.012	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
2006	0.001	0.004	0.007	0.008	0.009	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
2007	0.001	0.002	0.006	0.009	0.010	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
2008	0.001	0.002	0.006	0.008	0.009	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
2009	0.001	0.004	0.007	0.008	0.009	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
2010	0.001	0.003	0.006	0.008	0.009	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
2011	0.001	0.004	0.007	0.008	0.009	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
2012	0.001	0.003	0.007	0.009	0.010	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
2013	0.001	0.002	0.006	0.008	0.009	0.009	0.009	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010

Table 4.6.1.continued. Fishing mortality per year by age from the base run for the commercial longline fishery.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981	0.000	0.001	0.001	0.003	0.006	0.010	0.012	0.013	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
1982	0.000	0.001	0.002	0.004	0.007	0.011	0.014	0.015	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
1983	0.000	0.001	0.002	0.004	0.008	0.013	0.016	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
1984	0.000	0.001	0.001	0.003	0.006	0.009	0.012	0.013	0.013	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
1985	0.000	0.001	0.002	0.004	0.007	0.012	0.015	0.016	0.017	0.017	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
1986	0.000	0.001	0.002	0.004	0.008	0.012	0.015	0.017	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
1987	0.000	0.001	0.003	0.006	0.012	0.019	0.025	0.028	0.029	0.029	0.029	0.029	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
1988	0.000	0.001	0.002	0.004	0.008	0.013	0.017	0.019	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
1989	0.000	0.001	0.003	0.007	0.013	0.020	0.026	0.029	0.030	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
1990	0.000	0.001	0.002	0.005	0.010	0.016	0.021	0.023	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
1991	0.000	0.001	0.003	0.006	0.012	0.018	0.023	0.026	0.027	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
1992	0.000	0.001	0.001	0.003	0.006	0.010	0.013	0.014	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
1993	0.000	0.001	0.002	0.004	0.007	0.011	0.014	0.015	0.016	0.016	0.016	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
1994	0.000	0.000	0.001	0.003	0.005	0.008	0.010	0.011	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
1995	0.000	0.000	0.001	0.002	0.004	0.006	0.008	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
1996	0.000	0.000	0.001	0.002	0.004	0.006	0.008	0.009	0.009	0.009	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
1997	0.000	0.000	0.001	0.002	0.005	0.008	0.010	0.011	0.011	0.011	0.011	0.011	0.011	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
1998	0.000	0.001	0.001	0.003	0.006	0.010	0.012	0.014	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
1999	0.000	0.000	0.001	0.003	0.005	0.008	0.011	0.012	0.012	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
2000	0.000	0.000	0.001	0.003	0.005	0.008	0.010	0.011	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
2001	0.000	0.001	0.001	0.003	0.006	0.010	0.012	0.014	0.014	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
2002	0.000	0.000	0.001	0.003	0.005	0.008	0.011	0.012	0.012	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
2003	0.000	0.001	0.002	0.004	0.007	0.011	0.014	0.016	0.016	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
2004	0.000	0.001	0.003	0.006	0.012	0.019	0.024	0.027	0.028	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029
2005	0.000	0.001	0.002	0.004	0.007	0.011	0.014	0.016	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
2006	0.000	0.001	0.002	0.006	0.011	0.018	0.022	0.025	0.026	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027
2007	0.000	0.001	0.002	0.004	0.008	0.012	0.015	0.017	0.017	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
2008	0.000	0.000	0.001	0.002	0.004	0.007	0.009	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
2009	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
2010	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
2011	0.000	0.000	0.001	0.002	0.003	0.005	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
2012	0.000	0.000	0.001	0.001	0.003	0.004	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
2013	0.000	0.000	0.001	0.002	0.004	0.007	0.008	0.009	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010

Table 4.6.1 continued. Fishing mortality per year by age from the base run for the headboat fishery.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981	0.003	0.042	0.039	0.033	0.028	0.023	0.019	0.015	0.012	0.010	0.008	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
1982	0.002	0.035	0.033	0.028	0.024	0.020	0.016	0.013	0.010	0.008	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
1983	0.003	0.040	0.038	0.033	0.028	0.023	0.019	0.015	0.012	0.010	0.008	0.006	0.005	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
1984	0.003	0.051	0.049	0.042	0.035	0.029	0.024	0.019	0.015	0.012	0.009	0.007	0.006	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000
1985	0.003	0.045	0.042	0.036	0.030	0.025	0.021	0.017	0.013	0.010	0.008	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
1986	0.003	0.046	0.044	0.037	0.032	0.026	0.021	0.017	0.014	0.011	0.009	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
1987	0.004	0.049	0.045	0.039	0.033	0.027	0.022	0.018	0.014	0.011	0.009	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
1988	0.004	0.046	0.042	0.036	0.031	0.025	0.021	0.017	0.013	0.011	0.008	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
1989	0.004	0.058	0.053	0.046	0.039	0.032	0.026	0.021	0.017	0.013	0.010	0.008	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000
1990	0.004	0.044	0.040	0.035	0.029	0.024	0.020	0.016	0.013	0.010	0.008	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
1991	0.003	0.037	0.034	0.029	0.025	0.021	0.017	0.014	0.011	0.009	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
1992	0.003	0.039	0.036	0.031	0.026	0.022	0.018	0.014	0.011	0.009	0.007	0.005	0.004	0.003	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
1993	0.004	0.046	0.043	0.037	0.031	0.026	0.021	0.017	0.013	0.011	0.008	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
1994	0.002	0.038	0.036	0.031	0.026	0.022	0.018	0.014	0.011	0.009	0.007	0.005	0.004	0.003	0.003	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
1995	0.001	0.010	0.017	0.016	0.014	0.012	0.010	0.008	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.001	0.005	0.012	0.012	0.011	0.009	0.007	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.001	0.009	0.015	0.015	0.013	0.011	0.009	0.007	0.006	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.001	0.006	0.011	0.011	0.010	0.008	0.007	0.005	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.001	0.007	0.011	0.012	0.010	0.009	0.007	0.006	0.004	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.001	0.007	0.012	0.012	0.010	0.009	0.007	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.001	0.006	0.012	0.012	0.010	0.008	0.007	0.006	0.004	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.001	0.005	0.009	0.009	0.008	0.006	0.005	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.001	0.005	0.010	0.010	0.009	0.008	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.001	0.006	0.011	0.011	0.010	0.008	0.006	0.005	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.001	0.012	0.017	0.016	0.013	0.011	0.009	0.007	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.001	0.010	0.014	0.013	0.011	0.009	0.008	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.002	0.010	0.021	0.021	0.018	0.015	0.012	0.010	0.008	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.001	0.009	0.014	0.014	0.012	0.010	0.008	0.007	0.005	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2009	0.002	0.010	0.016	0.015	0.013	0.011	0.009	0.007	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.002	0.010	0.021	0.023	0.020	0.017	0.014	0.012	0.009	0.007	0.006	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.010	0.013	0.012	0.010	0.008	0.007	0.005	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.009	0.026	0.026	0.022	0.019	0.015	0.012	0.010	0.008	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
2013	0.001	0.009	0.017	0.017	0.015	0.013	0.010	0.008	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 4.6.1 continued. Fishing mortality per year by age from the base run for MRFSS/MRIP recreational fishery.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981	0.079	0.148	0.127	0.106	0.087	0.070	0.055	0.043	0.033	0.026	0.019	0.015	0.011	0.008	0.006	0.005	0.004	0.003	0.002	0.001	0.001	0.001	0.001	0.000	0.000
1982	0.130	0.248	0.212	0.177	0.145	0.117	0.093	0.072	0.056	0.043	0.033	0.025	0.019	0.014	0.010	0.008	0.006	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001
1983	0.080	0.201	0.173	0.144	0.118	0.095	0.076	0.059	0.046	0.035	0.027	0.020	0.015	0.011	0.009	0.006	0.005	0.004	0.003	0.002	0.001	0.001	0.001	0.001	0.000
1984	0.089	0.393	0.345	0.290	0.237	0.191	0.151	0.118	0.091	0.069	0.053	0.040	0.030	0.023	0.017	0.013	0.009	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001
1985	0.004	0.034	0.035	0.029	0.024	0.019	0.015	0.012	0.009	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
1986	0.043	0.154	0.133	0.111	0.091	0.074	0.058	0.046	0.035	0.027	0.021	0.016	0.012	0.009	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.000	0.000
1987	0.053	0.309	0.275	0.230	0.188	0.151	0.120	0.093	0.072	0.055	0.042	0.032	0.024	0.018	0.013	0.010	0.008	0.006	0.004	0.003	0.002	0.002	0.001	0.001	0.001
1988	0.038	0.256	0.225	0.189	0.154	0.124	0.098	0.076	0.059	0.045	0.034	0.026	0.020	0.015	0.011	0.008	0.006	0.005	0.003	0.003	0.002	0.001	0.001	0.001	0.001
1989	0.013	0.147	0.126	0.105	0.086	0.069	0.055	0.043	0.033	0.025	0.019	0.015	0.011	0.008	0.006	0.005	0.003	0.003	0.002	0.001	0.001	0.001	0.001	0.000	0.000
1990	0.032	0.131	0.115	0.096	0.079	0.064	0.051	0.040	0.031	0.024	0.018	0.014	0.010	0.008	0.006	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000
1991	0.031	0.250	0.235	0.194	0.159	0.128	0.101	0.078	0.060	0.045	0.034	0.026	0.020	0.015	0.011	0.008	0.006	0.005	0.003	0.003	0.002	0.001	0.001	0.001	0.001
1992	0.045	0.354	0.311	0.260	0.213	0.171	0.136	0.106	0.082	0.063	0.048	0.036	0.027	0.020	0.015	0.011	0.009	0.006	0.005	0.004	0.003	0.002	0.001	0.001	0.001
1993	0.036	0.255	0.230	0.193	0.157	0.125	0.098	0.076	0.059	0.045	0.034	0.026	0.019	0.015	0.011	0.008	0.006	0.005	0.003	0.003	0.002	0.001	0.001	0.001	0.001
1994	0.016	0.134	0.120	0.101	0.083	0.067	0.053	0.041	0.032	0.024	0.018	0.014	0.010	0.008	0.006	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000
1995	0.029	0.066	0.126	0.134	0.114	0.093	0.074	0.058	0.045	0.035	0.026	0.020	0.015	0.011	0.009	0.006	0.005	0.004	0.003	0.002	0.001	0.001	0.001	0.001	0.000
1996	0.014	0.041	0.086	0.108	0.096	0.078	0.062	0.049	0.038	0.029	0.022	0.017	0.013	0.010	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000
1997	0.014	0.034	0.053	0.085	0.089	0.075	0.060	0.047	0.036	0.028	0.021	0.016	0.012	0.009	0.007	0.005	0.004	0.003	0.002	0.001	0.001	0.001	0.001	0.000	0.000
1998	0.017	0.041	0.081	0.105	0.098	0.081	0.065	0.051	0.039	0.030	0.023	0.017	0.013	0.009	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.000	0.000
1999	0.029	0.044	0.083	0.098	0.085	0.069	0.055	0.043	0.033	0.025	0.019	0.015	0.011	0.008	0.006	0.005	0.003	0.003	0.002	0.001	0.001	0.001	0.001	0.000	0.000
2000	0.013	0.037	0.071	0.074	0.064	0.052	0.041	0.032	0.025	0.019	0.015	0.011	0.008	0.006	0.005	0.003	0.003	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000
2001	0.007	0.028	0.049	0.049	0.041	0.033	0.026	0.020	0.016	0.012	0.009	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
2002	0.015	0.059	0.100	0.098	0.084	0.068	0.054	0.043	0.033	0.025	0.019	0.015	0.011	0.008	0.006	0.005	0.003	0.003	0.002	0.001	0.001	0.001	0.001	0.000	0.000
2003	0.016	0.069	0.120	0.120	0.102	0.083	0.065	0.051	0.039	0.030	0.023	0.017	0.013	0.010	0.007	0.006	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000
2004	0.016	0.062	0.106	0.104	0.088	0.071	0.056	0.044	0.034	0.026	0.020	0.015	0.011	0.008	0.006	0.005	0.004	0.003	0.002	0.001	0.001	0.001	0.001	0.000	0.000
2005	0.012	0.065	0.110	0.110	0.092	0.068	0.049	0.035	0.025	0.019	0.014	0.011	0.008	0.006	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000
2006	0.023	0.086	0.151	0.159	0.138	0.113	0.090	0.070	0.054	0.042	0.032	0.024	0.018	0.014	0.010	0.008	0.006	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001
2007	0.028	0.092	0.183	0.189	0.161	0.131	0.104	0.081	0.063	0.048	0.037	0.028	0.021	0.016	0.012	0.009	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001
2008	0.057	0.144	0.226	0.251	0.228	0.190	0.153	0.120	0.093	0.071	0.054	0.041	0.031	0.023	0.017	0.013	0.010	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001
2009	0.012	0.057	0.094	0.095	0.082	0.066	0.052	0.041	0.031	0.024	0.018	0.014	0.010	0.008	0.006	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000
2010	0.014	0.064	0.085	0.077	0.065	0.053	0.042	0.033	0.025	0.019	0.015	0.011	0.008	0.006	0.005	0.004	0.003	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000
2011	0.007	0.025	0.046	0.042	0.035	0.028	0.022	0.017	0.013	0.010	0.008	0.006	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
2012	0.015	0.033	0.091	0.110	0.096	0.079	0.063	0.049	0.038	0.029	0.022	0.017	0.013	0.010	0.007	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000
2013	0.025	0.075	0.136	0.161	0.146	0.120	0.095	0.074	0.057	0.043	0.033	0.025	0.019	0.014	0.011	0.008	0.006	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001

Table 4.6.2. Fishing mortality per year by age from the base run for the commercial hook-and-line fishery discards (released alive).

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1982	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1983	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1984	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1985	0.001	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1986	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1987	0.002	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1989	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1990	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 4.6.2 continued. Fishing mortality per year by age from the base run for the headboat fishery discards (released alive).

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1982	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1983	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1984	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1985	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1986	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1987	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1989	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1990	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.001	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.001	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.001	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.002	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.001	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2009	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.002	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2011	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2012	0.002	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2013	0.001	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 4.6.2 continued. Fishing mortality per year by age from the base run for the MRFSS/MRIP recreational fishery discards (released alive).

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1981	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1982	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1983	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1984	0.020	0.004	0.002	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1985	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1986	0.006	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1987	0.019	0.003	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.016	0.002	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1989	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1990	0.006	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.019	0.007	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.024	0.004	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.018	0.005	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.010	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.013	0.022	0.008	0.003	0.002	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.013	0.022	0.011	0.004	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.014	0.025	0.018	0.009	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.016	0.028	0.017	0.009	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.008	0.017	0.008	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.008	0.012	0.005	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.005	0.007	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.010	0.014	0.004	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.013	0.017	0.006	0.002	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.010	0.015	0.005	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.013	0.018	0.007	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.017	0.025	0.010	0.003	0.002	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.020	0.032	0.011	0.004	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.028	0.046	0.024	0.011	0.005	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2009	0.011	0.015	0.006	0.003	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.007	0.008	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2011	0.004	0.005	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2012	0.012	0.022	0.009	0.003	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2013	0.020	0.032	0.017	0.007	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 4.8.1. Sustainable Fisheries Act parameters for Mutton Snapper from the ASAP base run. Both councils have adopted $F_{30\%}$ as their proxy for F_{MSY}. $F_{current}$ is the geometric mean of fishing mortality rates on age-3 from 2011-2013. Note that the yields are the directed landings and do not include discards.

Parameter	Value	English equivalents
Overfishing Limit = Maximum Sustainable Yield (OFL, $Yield_{F30\%}$)	413,900 (kg)	912,500 (lb)
Spawning biomass at OFL ($SSB_{OFL,}$ $SSB_{F30\%}$)	2,108,800 (kg)	4,649,200 (lb)
Maximum Fishing Mortality Threshold (MFMT, $F_{30\%}$)	0.18	Per year
Minimum Spawning Stock Threshold (MSST, (1-0.11)*SSB_{OFL}	1,877,000 (kg)	4,137,700 (lb)
Acceptable Biological Catch (ABC, $Yield_{F40\%}$)	396,400 (kg)	874,000 (lb)
$F_{current}/F_{30\%}$	0.65	--
SSB_{2013}/SSB_{OFL}	1.13	--

Table 4.8.2. Results of ASAP runs showing the composite fishing mortality rate on fully selected ages ($F_{current}$, geometric mean 2011-2013), the fishing mortality rate associated with a spawning potential ratio of 30%($F_{30\%}$), spawning biomass in 2013 (SSB_{2013}), the spawning biomass associated with $F_{30\%}$ ($SSB_{F30\%}$), and $F_{40\%}$. The shaded runs indicate neither overfishing nor the stock being overfished.

Run	Aging methods	Configuration	Steepness	$F_{current}$ per year	$F_{30\%}$ per year	SSB_{2013} (mt)	$SSB_{F30\%}$ (mt)	F-Ratio $F_{current}/F_{30\%}$	Biomass-Ratio $SSB_{2013}/SSB_{F30\%}$	$F_{40\%}$ Per year
1	Stochastic ALK	h=Free, Initial value=0.75	0.81	0.12	0.18	2,354	2,094	0.66	1.12	0.13
2		Fixed h=0.40	0.40	0.09	0.20	4,172	--	0.44	--	0.15
3		Fixed h=0.45	0.45	0.10	0.19	3,272	--	0.53	--	0.14
4		Fixed h=0.50	0.50	0.11	0.18	2,715	1,433	0.60	1.90	0.14
5		Fixed h=0.55	0.55	0.12	0.18	2,423	2,007	0.65	1.21	0.13
6		Fixed h=0.60	0.60	0.12	0.18	2,308	2,135	0.67	1.08	0.13
7		Fixed h=0.65	0.65	0.12	0.18	2,286	2,141	0.68	1.07	0.13
8		Fixed h=0.70	0.70	0.12	0.18	2,304	2,128	0.67	1.08	0.13
9		Fixed h=0.75	0.75	0.12	0.18	2,338	2,117	0.66	1.10	0.13
10		Fixed h=0.80	0.80	0.12	0.18	2,376	2,110	0.66	1.13	0.13
11		Fixed h=0.85	0.85	0.12	0.18	2,413	2,107	0.65	1.15	0.13
12		Fixed h=0.90	0.90	0.12	0.18	2,448	2,105	0.64	1.16	0.13
13		Fixed h=0.95	0.95	0.11	0.18	2,479	2,105	0.64	1.18	0.13
14		Fixed h=0.99	0.99	0.11	0.18	2,507	2,105	0.63	1.19	0.13
15		Initial h=0.40	0.59	0.12	0.18	2,326	2,122	0.67	1.10	0.13
16		Initial h=0.45	0.61	0.12	0.18	2,298	2,141	0.67	1.07	0.13
17		Initial h=0.50	0.64	0.12	0.18	2,287	2,144	0.68	1.07	0.13
18		Initial h=0.55	0.66	0.12	0.18	2,289	2,138	0.68	1.07	0.13
19		Initial h=0.60	0.70	0.12	0.18	2,303	2,129	0.67	1.08	0.13
20		Initial h=0.65	0.73	0.12	0.18	2,326	2,120	0.67	1.10	0.13
21		Initial h=0.70	0.77	0.12	0.18	2,355	2,113	0.66	1.11	0.13
22		Initial h=0.75	0.81	0.12	0.18	2,387	2,109	0.65	1.13	0.13
23		Initial h=0.80	0.86	0.12	0.18	2,419	2,106	0.65	1.15	0.13
24		Initial h=0.85	0.90	0.12	0.18	2,451	2,105	0.64	1.16	0.13
25		Initial h=0.90	0.95	0.11	0.18	2,480	2,105	0.64	1.18	0.13
26		Initial h=0.95	1.00	0.11	0.18	2,506	2,105	0.63	1.19	0.13
27		Initial h=0.99	1.00	0.11	0.18	2,507	2,105	0.63	1.19	0.13

Table 4.8.2 continued. Results of ASAP sensitivity runs showing the composite fishing mortality rate on fully selected ages ($F_{current}$, geometric mean 2011-2013), the fishing mortality rate associated with a spawning potential ratio of 30% ($F_{30\%}$), spawning biomass in 2013 (SSB_{2013}), the spawning biomass associated with $F_{30\%}$ ($SSB_{F30\%}$), and $F_{40\%}$. The shaded runs indicate neither overfishing nor the stock being overfished.

Run	Aging methods	Configuration	Steepness	$F_{current}$ Per year	$F_{30\%}$ Per year	SSB_{2013} (mt)	$SSB_{F30\%}$ (mt)	F-Ratio $F_{current}/F_{30\%}$	Biomass-Ratio $SSB_{2013}/SSB_{F30\%}$	$F_{40\%}$ Per year
28	Stochastic ALK	Omit HL index	0.81	0.12	0.18	2,337	2,088	0.67	1.12	0.13
29		Omit LL index	0.77	0.13	0.17	2,021	1,988	0.74	1.02	0.13
30		Omit HB index	0.82	0.10	0.17	2,638	2,309	0.55	1.14	0.13
31		Omit MRFSS/MRIP	0.80	0.13	0.17	1,944	2,031	0.76	0.96	0.13
32		Omit FIM index	0.81	0.12	0.17	2,275	2,104	0.67	1.08	0.13
33		Omit RVC index	0.81	0.12	0.18	2,359	2,094	0.66	1.13	0.13
34		Omit Riley's Hump index	0.81	0.12	0.18	2,280	2,079	0.68	1.10	0.13
35		Fish. ind. indices	0.80	0.09	0.16	2,286	2,295	0.56	1.00	0.11
36		Fish. dep. indices	0.80	0.12	0.17	2,206	2,088	0.69	1.06	0.13
37		20% rel. mort.	0.82	0.15	0.19	2,078	2,275	0.76	0.91	0.15
38		5% rel. mort.	0.70	0.07	0.10	1,608	1,268	0.74	1.27	0.07
39		MRFSS as pop index	0.81	0.11	0.18	2,427	2,106	0.64	1.15	0.13
40		M = 0.08 per year	0.85	0.16	0.15	1,870	3,143	1.02	0.59	0.12
41		M = 0.17 per year	0.96	0.09	0.20	2,223	1,359	0.42	1.64	0.15
42	Fishery ALK	h=Free, Initial value=0.75	0.92	0.19	0.21	2,912	2,379	0.90	1.22	0.16
43		Fixed h=0.40	0.40	0.08	0.23	5,629	--	0.35	--	0.17
44		Fixed h=0.45	0.45	0.10	0.22	4,228	--	0.44	--	0.16
45		Fixed h=0.50	0.50	0.11	0.21	3,372	1,957	0.52	1.90	0.16
46		Fixed h=0.55	0.55	0.12	0.21	2,907	2,683	0.58	1.21	0.15
47		Fixed h=0.60	0.60	0.12	0.20	2,719	2,743	0.60	1.08	0.15
48		Fixed h=0.65	0.65	0.12	0.20	2,687	2,648	0.61	1.07	0.15
49		Fixed h=0.70	0.70	0.12	0.21	2,717	2,560	0.60	1.08	0.15
50		Fixed h=0.75	0.75	0.12	0.21	2,766	2,497	0.59	1.10	0.15
51		Fixed h=0.80	0.80	0.13	0.21	2,755	2,453	0.60	1.13	0.16

Table 4.8.2 continued. Results of ASAP sensitivity runs showing the composite fishing mortality rate on fully selected ages

($F_{current}$, geometric mean 2011-2013), the fishing mortality rate associated with a spawning potential ratio of 30% ($F_{30\%}$), spawning biomass in 2013 (SSB_{2013}), the spawning biomass associated with $F_{30\%}$ ($SSB_{F30\%}$), and $F_{40\%}$. The shaded runs indicate neither overfishing nor the stock being overfished.

Run	Aging methods	Configuration	Steepness	$F_{current}$ Per year	$F_{30\%}$ Per year	SSB_{2013} (mt)	$SSB_{F30\%}$ (mt)	F-Ratio $F_{current}/F_{30\%}$	Biomass-Ratio $SSB_{2013}/SSB_{F30\%}$	$F_{40\%}$ Per year
52	Fishery ALK	Fixed h=0.85	0.85	0.12	0.21	2,803	2,417	0.59	1.15	0.16
53		Fixed h=0.90	0.90	0.12	0.21	2,898	2,390	0.57	1.16	0.16
54		Fixed h=0.95	0.95	0.12	0.21	2,928	2,366	0.57	1.18	0.16
55		Fixed h=0.99	0.99	0.12	0.21	2,947	2,350	0.57	1.19	0.16
56		Initial h=0.40	0.65	0.12	0.20	2,687	2,652	0.61	1.01	0.15
57		Initial h=0.45	0.68	0.12	0.21	2,700	2,595	0.60	1.04	0.15
58		Initial h=0.50	0.71	0.12	0.21	2,728	2,543	0.60	1.07	0.15
59		Initial h=0.55	0.75	0.12	0.21	2,766	2,497	0.59	1.11	0.15
60		Initial h=0.60	0.79	0.12	0.21	2,806	2,459	0.59	1.14	0.15
61		Initial h=0.65	0.83	0.12	0.21	2,846	2,428	0.58	1.17	0.15
62		Initial h=0.70	0.88	0.12	0.21	2,882	2,402	0.58	1.20	0.16
63		Initial h=0.75	0.92	0.12	0.21	2,912	2,379	0.57	1.22	0.16
64		Initial h=0.80	0.97	0.12	0.21	2,937	2,359	0.57	1.24	0.16
65		Initial h=0.85	1.00	0.12	0.21	2,952	2,346	0.57	1.26	0.16
66		Initial h=0.90	1.00	0.12	0.21	2,952	2,346	0.57	1.26	0.16
67		Initial h=0.95	1.00	0.12	0.21	2,952	2,346	0.57	1.26	0.16
68		Initial h=0.99	1.00	0.12	0.21	2,952	2,346	0.57	1.26	0.16
69		Fish. ind. indices	0.88	0.07	0.19	4,069	2,881	0.35	1.41	0.14
70		Fish. dep. indices	0.91	0.12	0.20	2,622	2,347	0.61	1.12	0.15
71		20% rel. mort.	0.92	0.19	0.21	2,920	2,406	0.92	1.21	0.16
72		5% rel. mort.	0.92	0.12	0.21	2,903	2,327	0.56	1.25	0.15
73		MRFSS as pop index	0.92	0.11	0.21	3,072	2,421	0.54	1.27	0.16
74	Direct	h=Free, Initial value=0.75	0.83	0.29	0.26	1,144	1,939	1.12	0.59	0.19
75		h=0.40	0.66	0.28	0.26	1,193	2,464	1.09	0.48	0.19
76		h=0.50	0.70	0.29	0.26	1,163	2,283	1.11	0.51	0.19
77		h=0.60	0.75	0.29	0.26	1,148	2,125	1.12	0.54	0.19

Table 4.8.2 continued. Results of ASAP sensitivity runs showing the composite fishing mortality rate on fully selected ages ($F_{current}$, geometric mean 2011-2013), the fishing mortality rate associated with a spawning potential ratio of 30% ($F_{30\%}$),

spawning biomass in 2013 (SSB_{2013}), the spawning biomass associated with $F_{30\%}$ ($SSB_{F30\%}$), and $F_{40\%}$. The shaded runs indicate neither overfishing nor the stock being overfished.

Run	Aging methods	Configuration	Steepness	$F_{current}$ Per year	$F_{30\%}$ Per year	SSB_{2013} (mt)	$SSB_{F30\%}$ (mt)	F-Ratio $F_{current}/F_{30\%}$	Biomass-Ratio $SSB_{2013}/SSB_{F30\%}$	$F_{40\%}$ Per year
78	Direct	h=0.70	0.80	0.29	0.26	1,143	1,994	1.12	0.57	0.19
79		h=0.80	0.86	0.29	0.26	1,147	1,890	1.12	0.61	0.19
80		h=0.90	0.93	0.29	0.26	1,158	1,810	1.11	0.64	0.19
81		h=1.00	1.00	0.29	0.26	1,171	1,759	1.10	0.67	0.19
82	None	No age comps	1.00	0.08	0.27	6,419	3,548	0.30	1.81	0.20

Table 4.9. Projected spawning biomass, directed harvest, and discards from ASAP base run (average natural mortality = 0.11 per year) for F30% (OFL), F40% (ABC), and Fcurrent. The projections start in 2014 with the first two years using the current fishing mortality rates.

	Average natural mortality 0.11 per year (Base run)								
	Spawning biomass (mt)			Directed Harvest (mt)			Discard (mt)		
Year	OFL	ABC	Fcurrent	OFL	ABC	Fcurrent	OFL	ABC	Fcurrent
2011	2,457	2,457	2,457	207	207	207	8	8	8
2012	2,484	2,484	2,484	334	334	334	25	25	25
2013	2,387	2,387	2,387	404	404	404	46	46	46
2014	2,296	2,296	2,296	414	414	414	27	27	27
2015	2,290	2,290	2,290	406	406	406	28	28	28
2016	2,282	2,300	2,308	415	313	261	28	21	18
2017	2,270	2,343	2,380	418	326	276	28	22	18
2018	2,259	2,386	2,453	419	337	290	28	22	19
2019	2,247	2,428	2,524	420	346	302	28	22	19
2020	2,237	2,467	2,593	421	354	312	28	22	19
2021	2,227	2,504	2,659	421	360	320	28	22	19
2022	2,217	2,539	2,721	421	365	326	28	22	19
2023	2,208	2,572	2,781	421	369	332	28	23	20
2024	2,201	2,604	2,838	421	372	336	28	23	20
2025	2,194	2,633	2,891	421	374	340	28	23	20
2026	2,187	2,660	2,940	420	377	343	28	23	20
2027	2,180	2,685	2,986	420	379	346	28	23	20
2028	2,174	2,708	3,028	419	380	349	28	23	20
2029	2,168	2,729	3,068	419	382	351	28	23	20
2030	2,164	2,749	3,105	419	383	353	28	23	20
2031	2,159	2,768	3,140	418	384	354	28	23	20
2032	2,155	2,786	3,172	418	385	356	28	23	20
2033	2,151	2,801	3,201	418	386	357	28	23	20
2034	2,147	2,815	3,228	417	387	359	28	23	20
2035	2,143	2,828	3,253	417	388	360	28	23	20

Table 4.9 continued. Projected spawning biomass, directed harvest, and discards from ASAP base run (average natural mortality = 0.11 per year) for F30% (OFL), F40% (ABC), and Fcurrent. . The projections start in 2014 with the first two years using the current fishing mortality rates.

	Average natural mortality 0.08 per year								
	Spawning biomass (mt)			Directed Harvest (mt)			Discard (mt)		
Year	OFL	ABC	Fcurrent	OFL	ABC	Fcurrent	OFL	ABC	Fcurrent
2011	1,923	1,923	1,923	207	207	207	8	8	8
2012	1,962	1,962	1,962	334	334	334	25	25	25
2013	1,888	1,888	1,888	404	404	404	46	46	46
2014	1,813	1,813	1,813	414	414	414	27	27	27
2015	1,805	1,805	1,805	404	404	404	28	28	28
2016	1,821	1,832	1,823	277	210	264	19	14	18
2017	1,885	1,935	1,894	295	230	282	20	15	19
2018	1,951	2,043	1,969	312	249	300	20	16	19
2019	2,015	2,152	2,041	326	267	315	21	16	20
2020	2,077	2,260	2,111	338	282	328	21	17	20
2021	2,136	2,366	2,179	348	295	339	21	17	20
2022	2,192	2,470	2,244	357	306	348	21	17	21
2023	2,247	2,571	2,307	364	315	356	22	17	21
2024	2,300	2,669	2,367	370	323	362	22	18	21
2025	2,350	2,765	2,426	375	330	368	22	18	21
2026	2,398	2,856	2,481	379	336	373	22	18	21
2027	2,444	2,944	2,534	383	342	377	22	18	21
2028	2,487	3,028	2,584	387	347	381	22	18	21
2029	2,528	3,107	2,632	390	351	384	22	18	22
2030	2,567	3,183	2,677	393	355	387	22	18	22
2031	2,604	3,256	2,720	396	359	390	22	19	22
2032	2,638	3,325	2,760	398	362	393	23	19	22
2033	2,671	3,389	2,798	400	366	395	23	19	22
2034	2,701	3,450	2,833	402	368	398	23	19	22
2035	2,729	3,507	2,867	404	371	400	23	19	22

Table 4.9 continued. Projected spawning biomass, directed harvest, and discards from ASAP base run (average natural mortality = 0.11 per year) for F30% (OFL), F40% (ABC), and Fcurrent. . The projections start in 2014 with the first two years using the current fishing mortality rates.

	Average natural mortality 0.17 per year								
	Spawning biomass (mt)			Directed Harvest (mt)			Discards (mt)		
Year	OFL	ABC	Fcurrent	OFL	ABC	Fcurrent	OFL	ABC	Fcurrent
2011	2,408	2,408	2,408	207	207	207	8	8	8
2012	2,380	2,380	2,380	334	334	334	25	25	25
2013	2,223	2,223	2,223	404	404	404	46	46	46
2014	2,100	2,100	2,100	414	414	414	27	27	27
2015	2,098	2,098	2,098	409	409	409	28	28	28
2016	2,085	2,077	2,113	624	461	249	42	31	17
2017	2,071	2,039	2,182	593	458	261	40	30	17
2018	2,059	2,006	2,250	565	453	272	39	30	17
2019	2,050	1,977	2,314	544	450	280	39	30	17
2020	2,042	1,953	2,372	529	447	288	39	30	17
2021	2,035	1,933	2,423	517	445	293	39	30	17
2022	2,030	1,916	2,469	509	443	298	39	30	18
2023	2,025	1,903	2,510	503	442	301	38	30	18
2024	2,022	1,891	2,545	498	441	304	38	30	18
2025	2,019	1,881	2,576	494	440	306	38	30	18
2026	2,016	1,873	2,602	491	440	308	38	30	18
2027	2,014	1,865	2,625	489	439	309	38	30	18
2028	2,012	1,859	2,644	487	439	310	38	30	18
2029	2,010	1,854	2,661	485	438	311	38	30	18
2030	2,009	1,850	2,676	484	438	312	38	30	18
2031	2,008	1,847	2,688	483	438	313	38	30	18
2032	2,007	1,844	2,699	482	437	313	38	30	18
2033	2,006	1,842	2,708	482	437	313	38	30	18
2034	2,006	1,839	2,716	481	437	314	38	30	18
2035	2,005	1,838	2,722	481	437	314	38	30	18

9. Figures

Figure	Description
2.2.1	Observed and predicted total length of Mutton Snapper from ages derived from otoliths collected from fishery dependent and fishery independent samples (n = 13,052 fish).
2.2.2	Depths fished by the recreational fisheries releasing Mutton Snapper alive.
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4.1.2	Fits of the ASAP model to the natural logarithms of discards by fishery.
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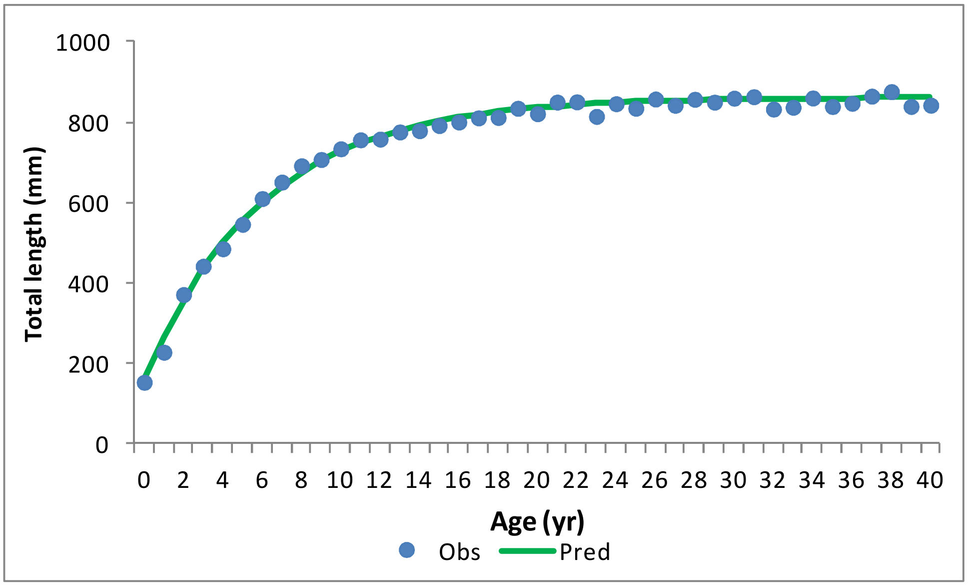
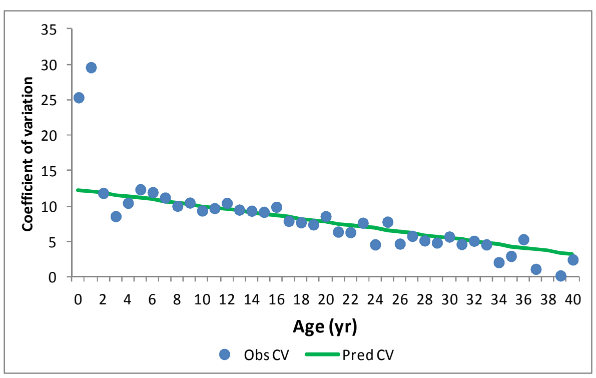
4.7.1	The distribution and normal approximation of steepness (a) and the distribution and log-normal approximation of the unfished spawning biomass in metric tons (b).
4.7.2	Annual recruitment, in thousands of fish, on spawning biomass in metric tons the year before and the predicted stock-recruit curve.
4.7.3	Sensitivity runs for a range of initial (0.40-0.99) and estimated steepness values (a), fishing mortality rates (b), spawning biomass (mt, c), and recruitment (d).
4.7.4	Sensitivity runs for a range of fixed steepness values (0.40-0.99) on fishing mortality rates (a), spawning biomass (mt, b), and recruitment (c).

Figure	Description
4.8.1	Phase plot of ratios of current fishing mortality (geometric mean of F_{2011}, F_{2012}, and F_{2013}) to $F_{30\%}$ on the spawning biomass in 2013 to spawning biomass at $F_{30\%}$ with the base run point estimate shown with a red circle (a) and the distributions of the F- (b) and the biomass-ratios (c).
4.8.2	Yield-per-recruit, spawning potential ratio, and the SPR = 30% limit from the base run (a), static and transitional spawning potential ratios by year from the base run (b), and total directed landings compared to yields at $F_{30\%SPR}$ and $F_{40\%SPR}$ (c).
4.8.3	Ratios of current fishing mortality (geometric mean of F_{2011}, F_{2012}, and F_{2013}) to $F_{30\%}$ and the spawning biomass in 2013 to spawning biomass at $F_{30\%}$ for the sensitivity runs.
4.9.1	Projected spawning biomass with the SSB_{MSY} proxy (a), direct harvest (b) from the ASAP base run under four fishing mortality rates: $F=F_{current}$, F = 0, $F= F_{30\%}$, and $F=F_{40\%}$.
4.9.2	Projected spawning biomass with the SSB_{MSY} proxy (a), direct harvest (b) from the ASAP run with M = 0.08 under four fishing mortality rates: $F=F_{current}$, F = 0, $F= F_{30\%}$, and $F=F_{40\%}$.
4.9.3	Projected spawning biomass with the SSB_{MSY} proxy (a), direct harvest (b) from the ASAP run with M = 0.17 under four fishing mortality rates: $F=F_{current}$, F = 0, $F= F_{30\%}$, and $F=F_{40\%}$.

a.



b. **c.**



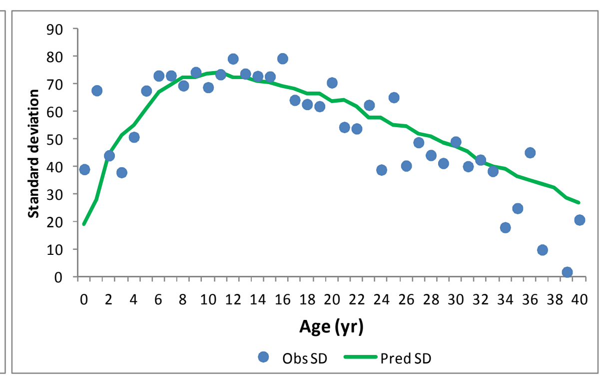
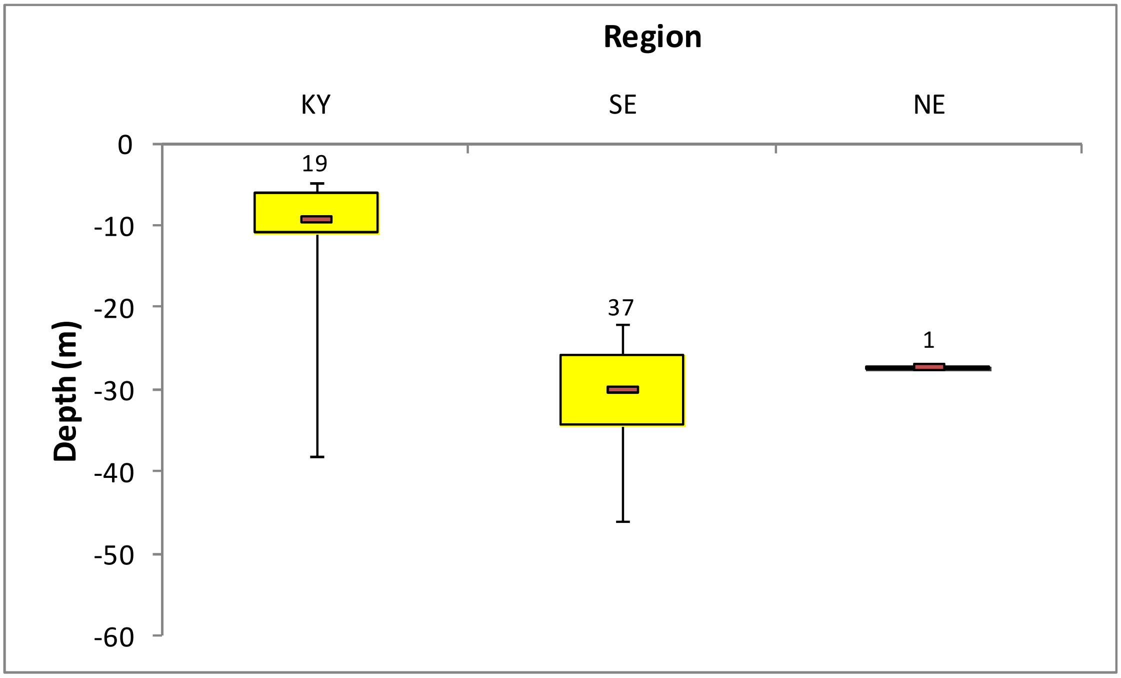


Figure 2.2.1. Observed and predicted total length of Mutton Snapper from ages derived from otoliths collected from fishery dependent and fishery independent samples (n = 13,052 fish). The observed decreasing coefficient of variations of length by age (b) was fitted to estimate the predicted standard deviations by age (c).

a.



b.

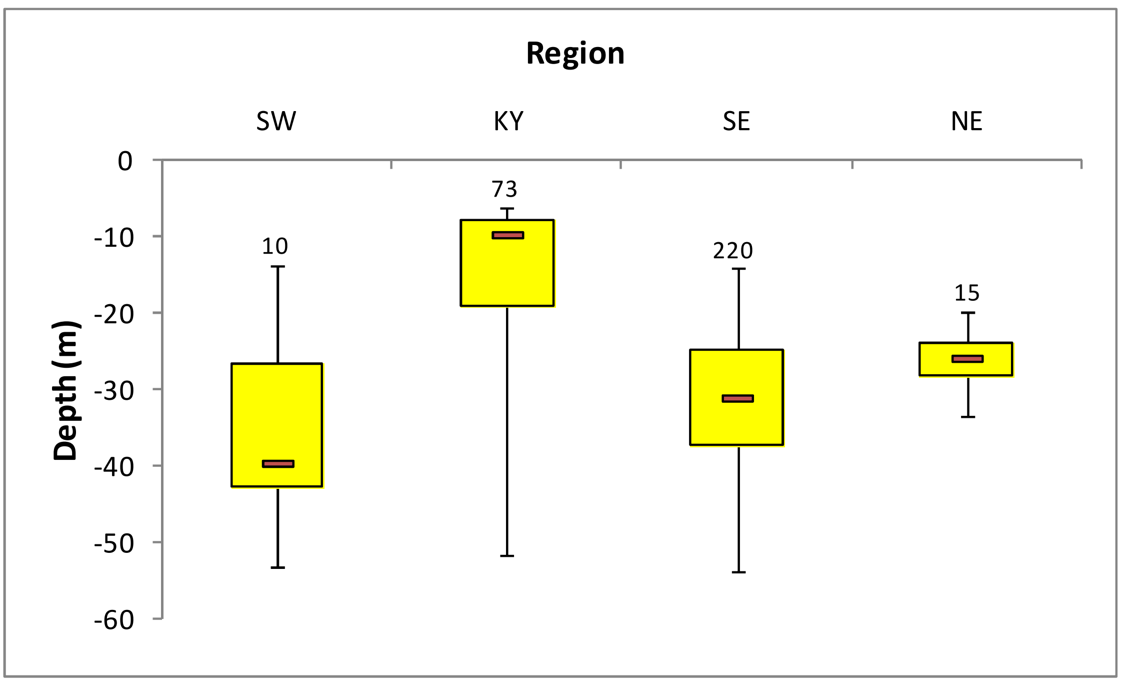
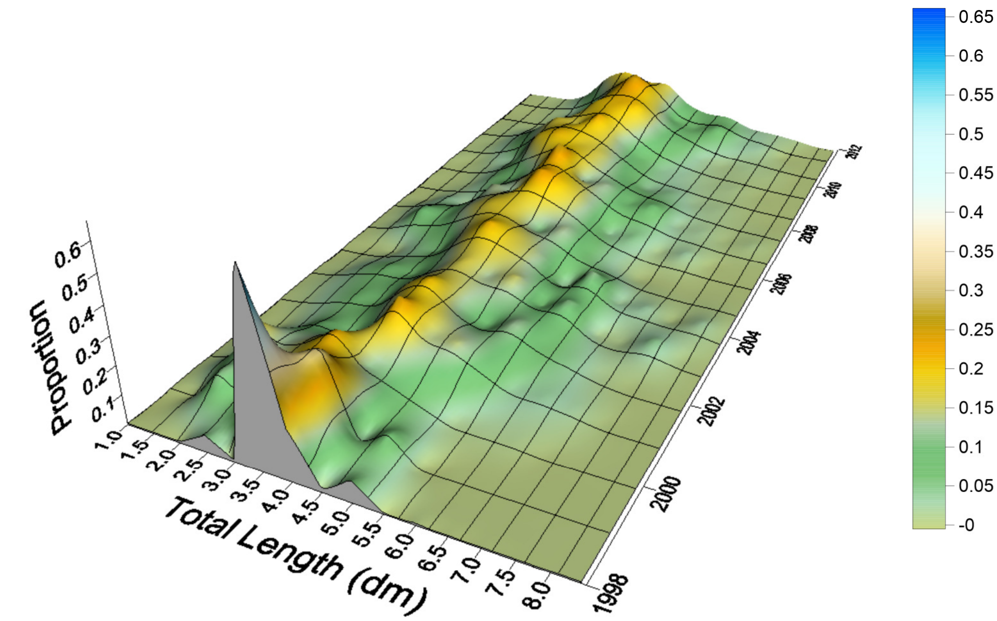


Figure. 2.2.2. Depths fished by the recreational fisheries releasing Mutton snapper alive, charterboats (a) and headboats (b).

a.



b.

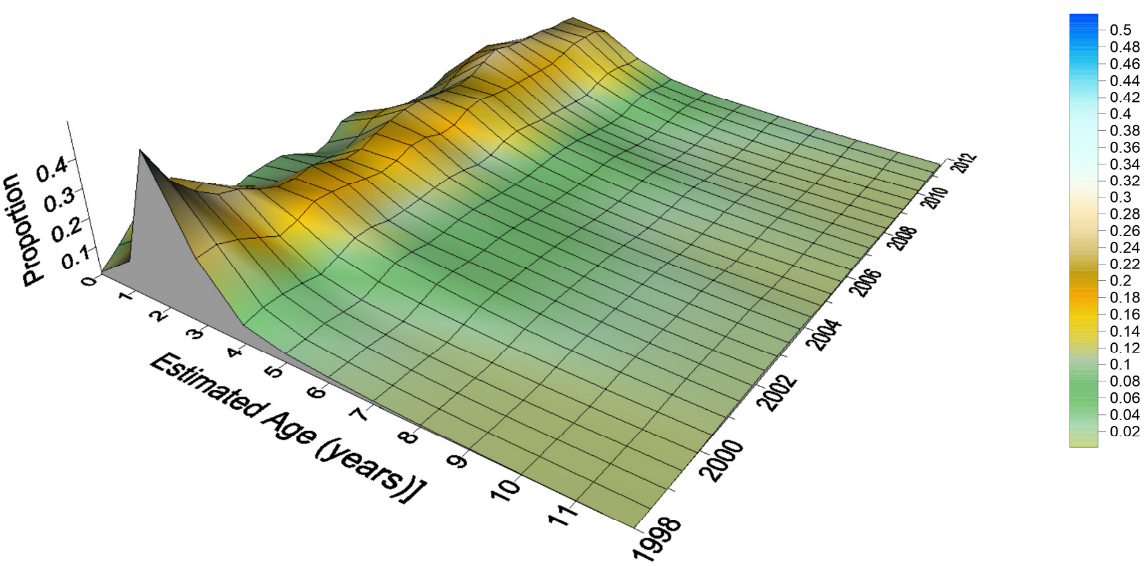


Figure 2.2.3. Surface plot of the NMFS-UM Reef Census Survey index by length (1dm=10cm) and year (a) and by age and year (b).

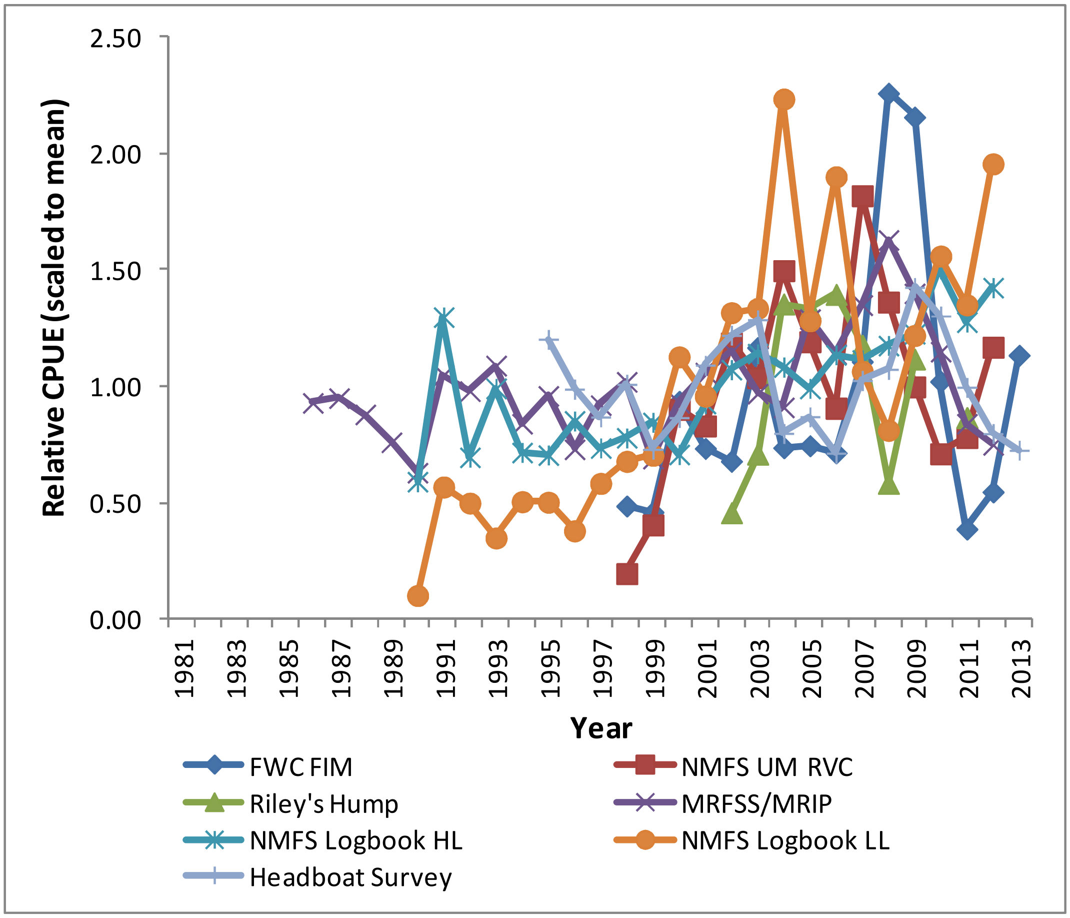
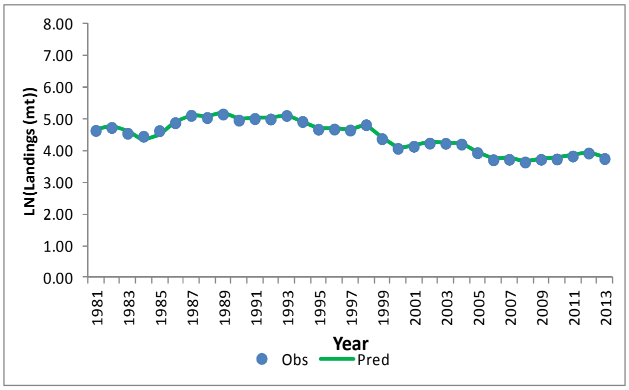


Figure 2.2.4. Relative CPUE indices scaled to their means.

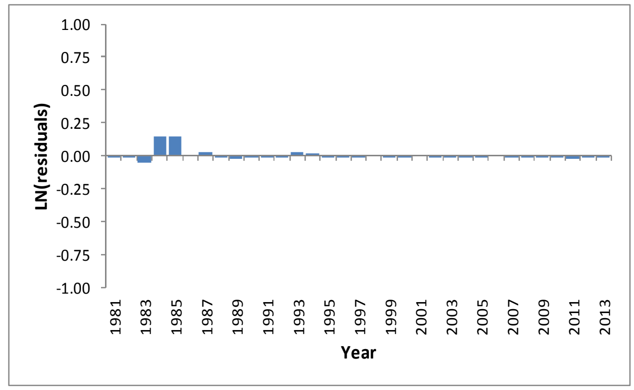
Landings

a. Commercial hook-and-line

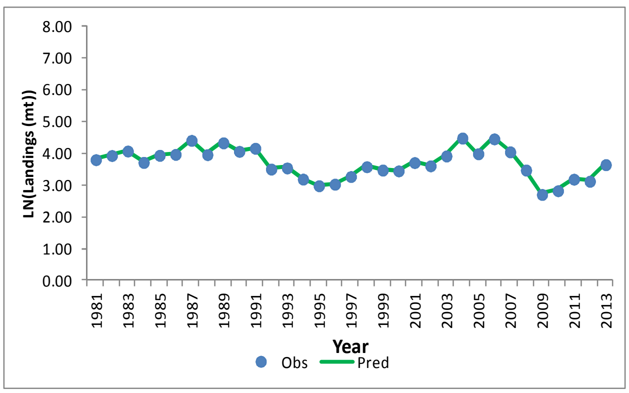


Residuals

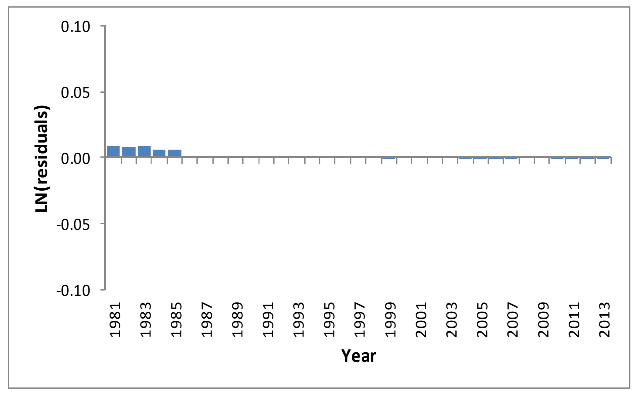
b. Commercial hook-and-line



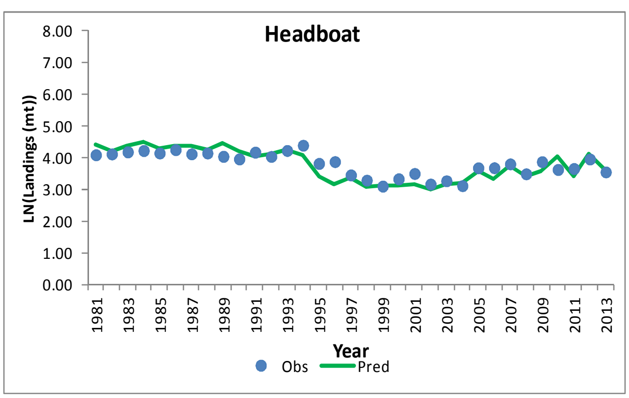
c. Commercial longline



c. Commercial longline



e. Headboat



f. Headboat

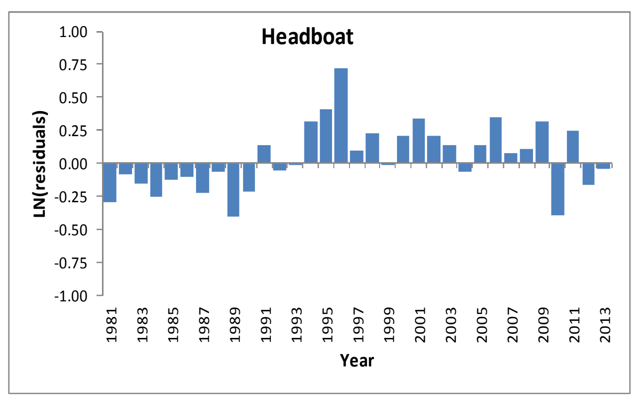
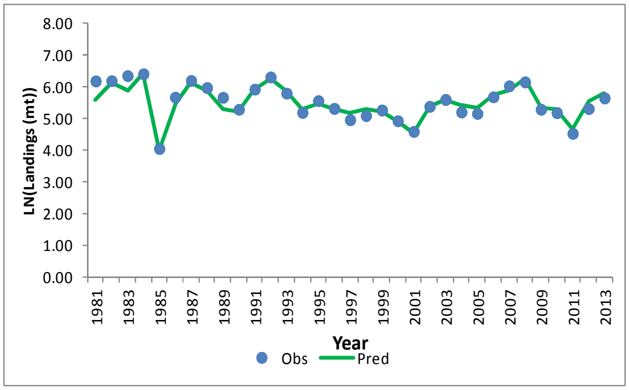


Figure 4.1.1. Fits of the ASAP model to the natural logarithms of annual landings by fishery. The dots are the observed values and the lines are the predicted values. Also included are plots of the natural logarithms of the residuals by fishery and year.

Landings

g. MRFSS/MRIP recreational



Residuals

h. MRFSS/MRIP recreational

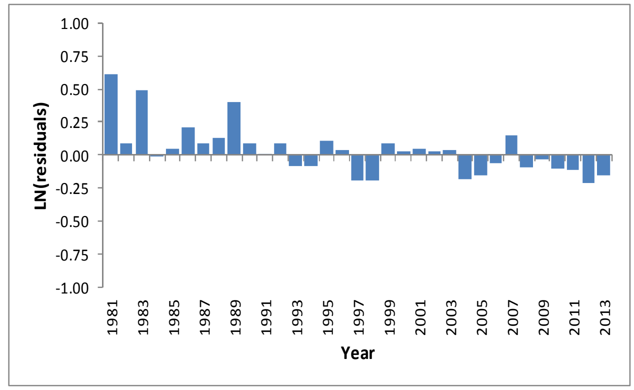


Figure 4.1.1 continued. Fits of the ASAP model to the natural logarithms of annual landings by fishery. The dots are the observed values and the lines are the predicted values. Also included are plots of the natural logarithms of the residuals by fishery and year.

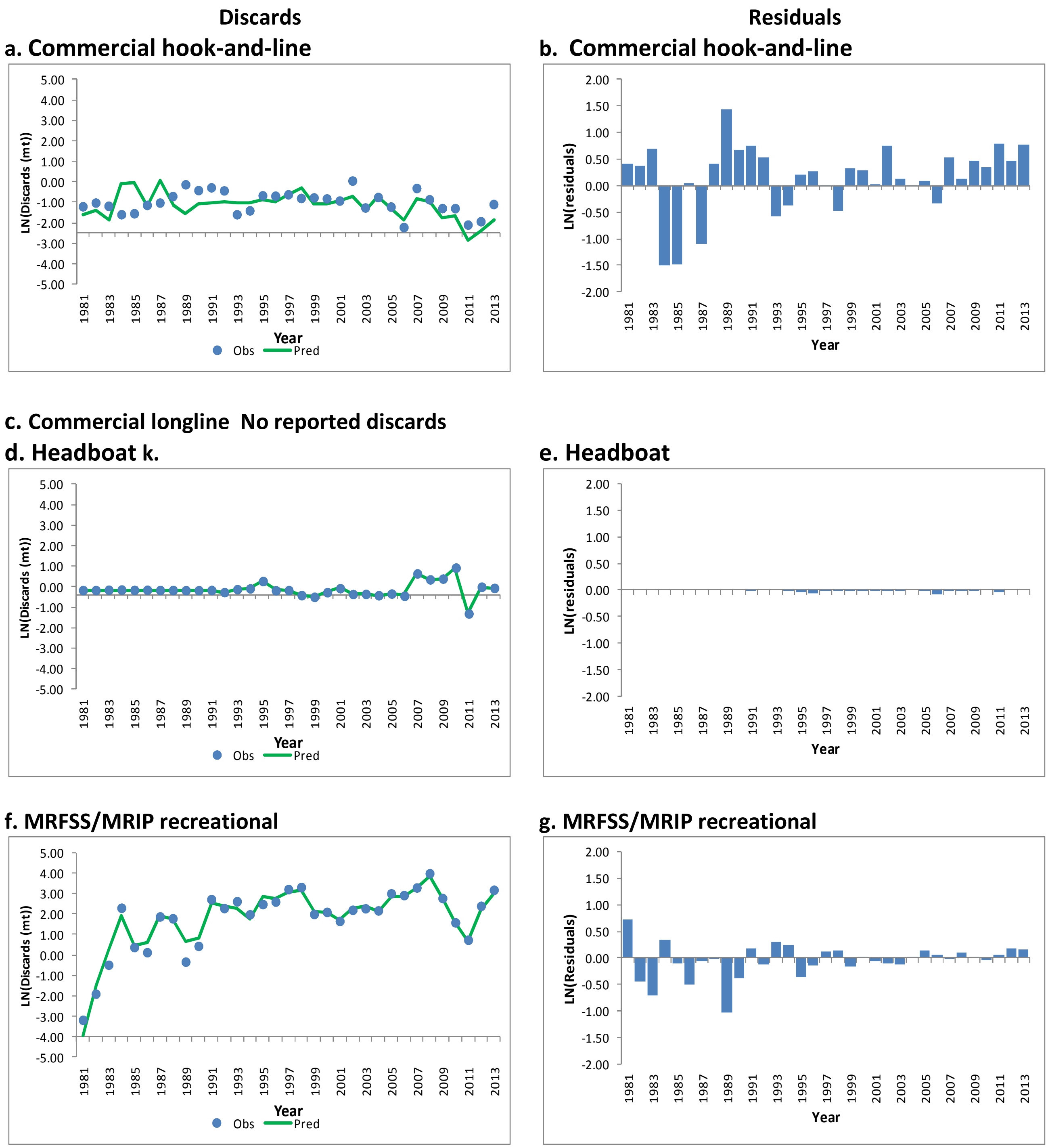
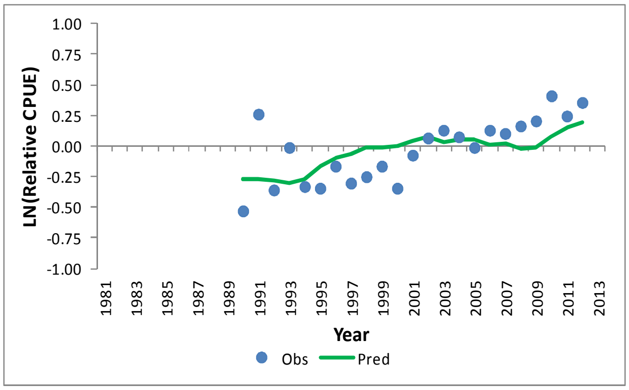


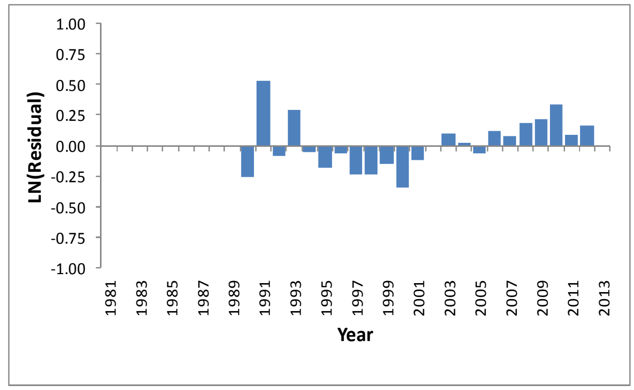
Figure 4.1.2. Fits of the ASAP model to the natural logarithms of discards by fishery. The dots are the observed values and the lines are the predicted values. Also included are plots of the natural logarithms of the residuals by fishery and year.

Index **Residuals**

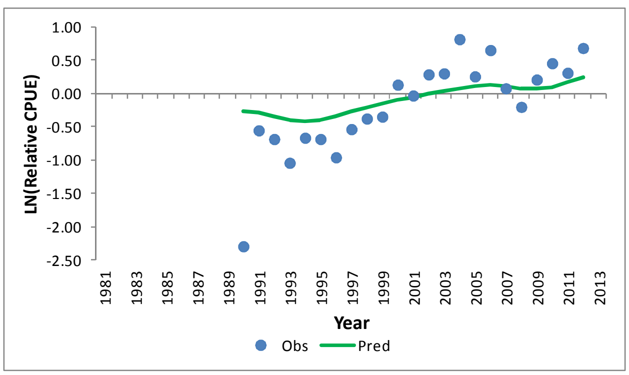
a. Logbook -- Commercial hook-and-line



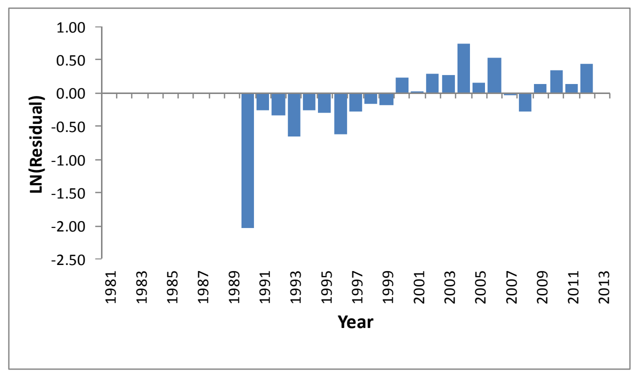
b. Logbook -- Commercial hook-and-line



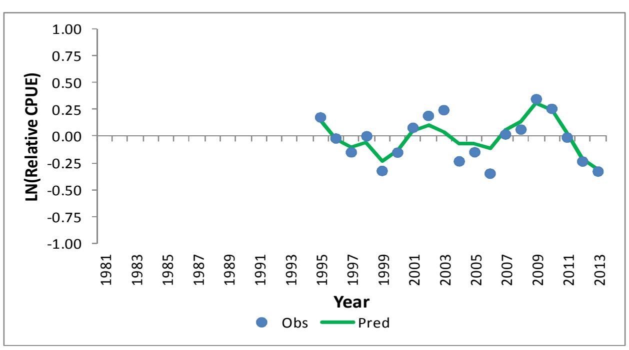
c. Logbook -- Commercial longline



d. Logbook --Commercial longline



e. Headboat



f. Headboat

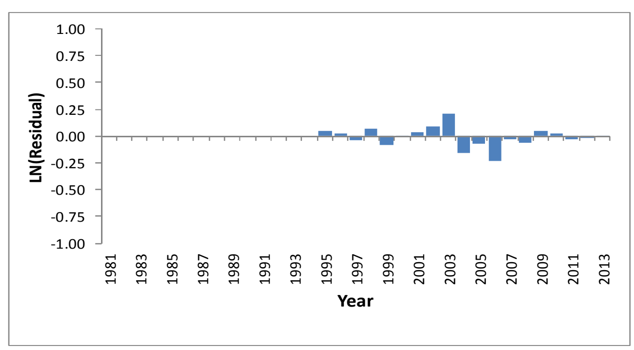
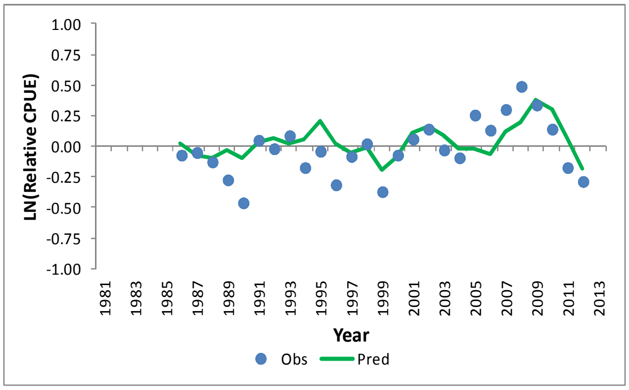


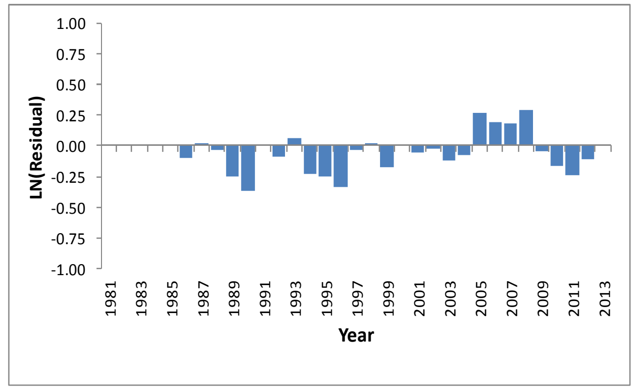
Figure 4.1.3. Fits of the ASAP model to the natural logarithms of indices. The points are the observed values and the lines are the predicted values. Also included are plots of the natural logarithms of the residuals by indices.

Index **Residuals**

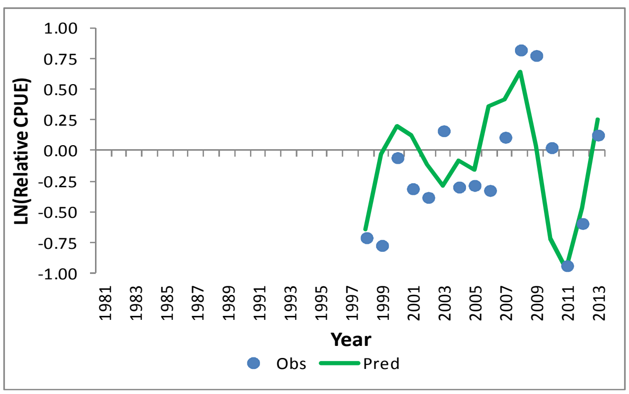
g. MRFSS/MRIP recreational



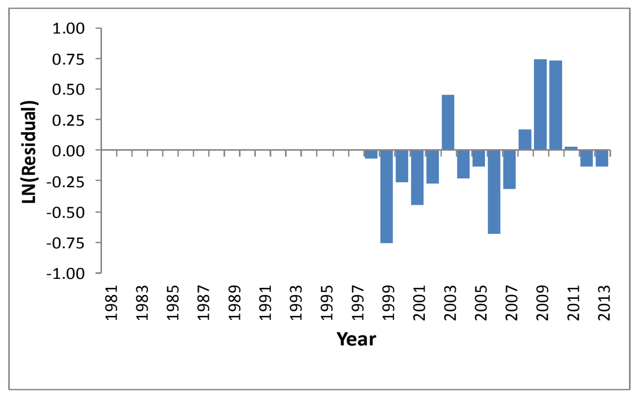
h. MRFSS/MRIP recreational



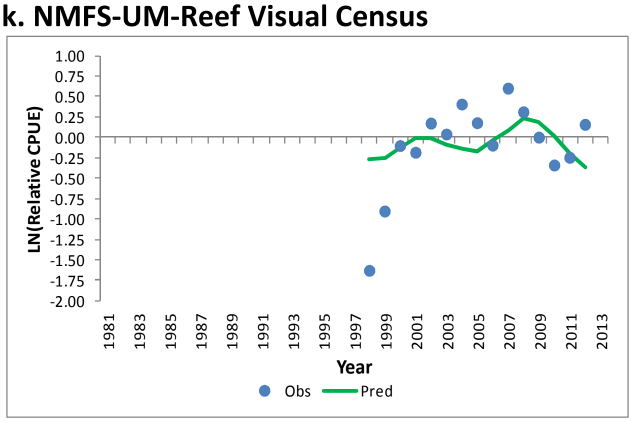
i. FWC FIM Haul seine (age-1)



j. FWC FIM Haul seine (age-1)



k. NMFS-UM-Reef Visual Census



l. NMFS-UM-Reef Visual Census

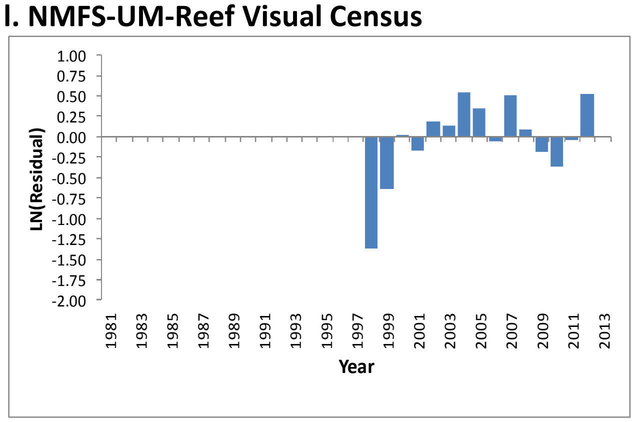
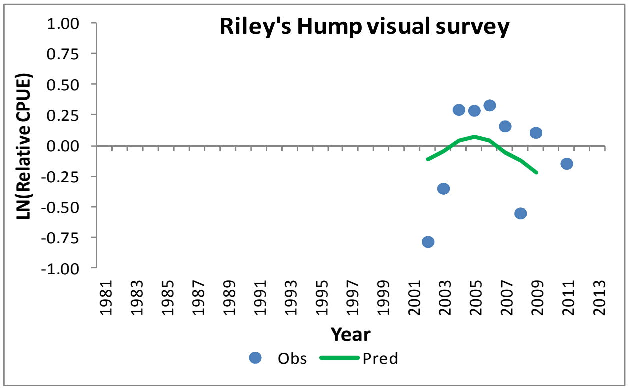


Figure 4.1.3 continued. Fits of the ASAP model to the natural logarithms of indices. The points are the observed values and the lines are the predicted values. Also included are plots of the natural logarithms of the residuals by indices.

Index **Residuals**

m. NMFS Riley's Hump Visual Survey



n. NMFS Riley's Hump Visual Survey

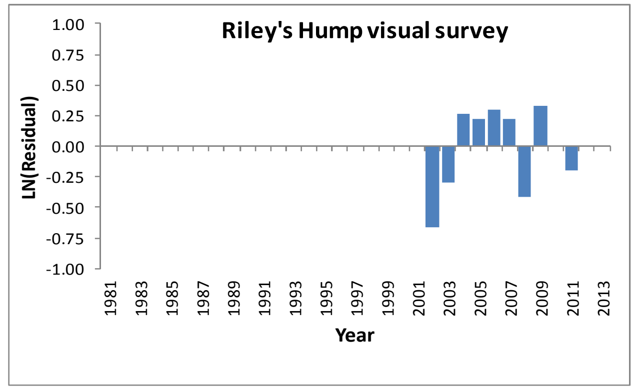


Figure 4.1.3 continued. . Fits of the ASAP model to the natural logarithms of indices. The points are the observed values and the lines are the predicted values. Also included are plots of the natural logarithms of the residuals by indices.

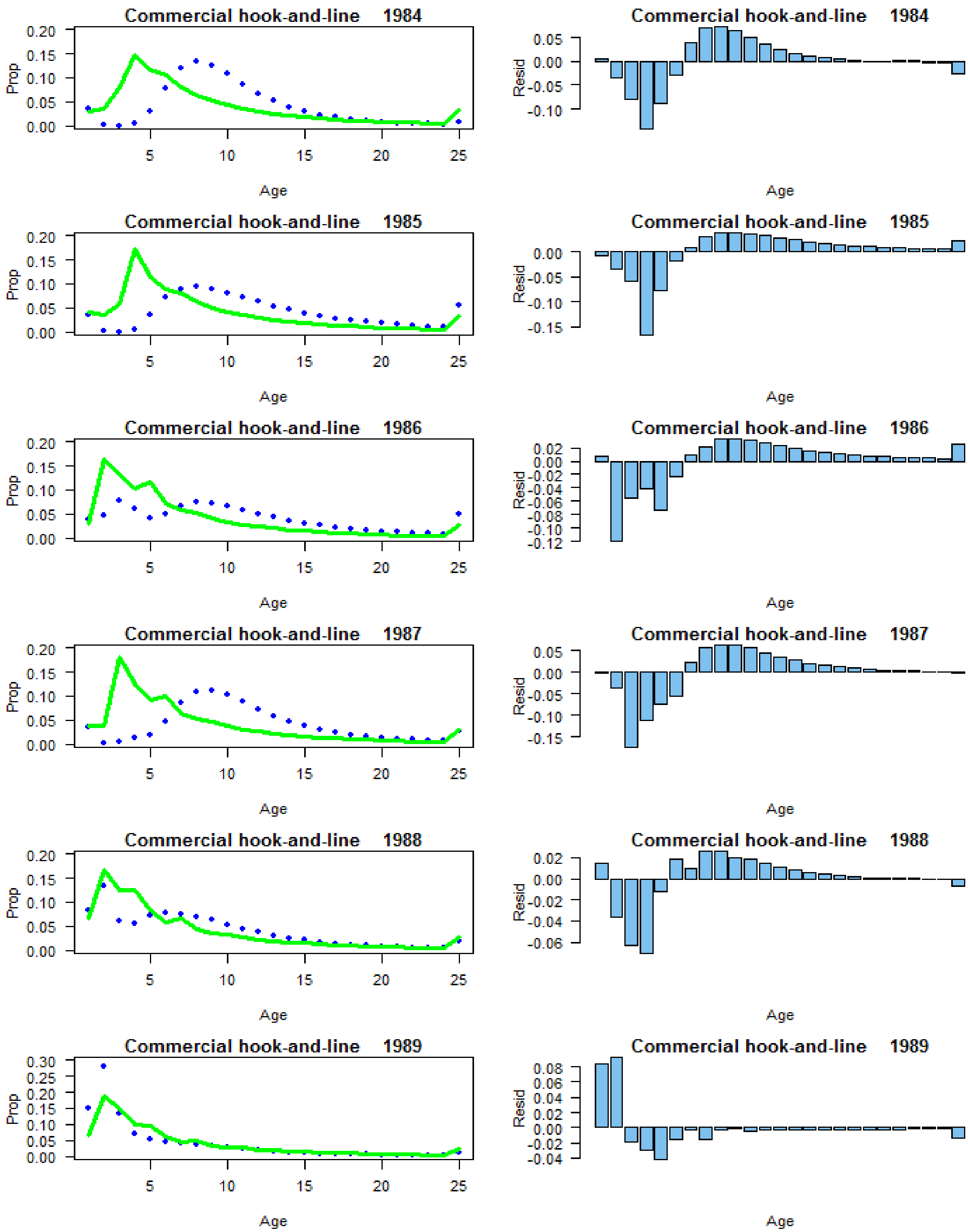


Figure 4.1.4. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

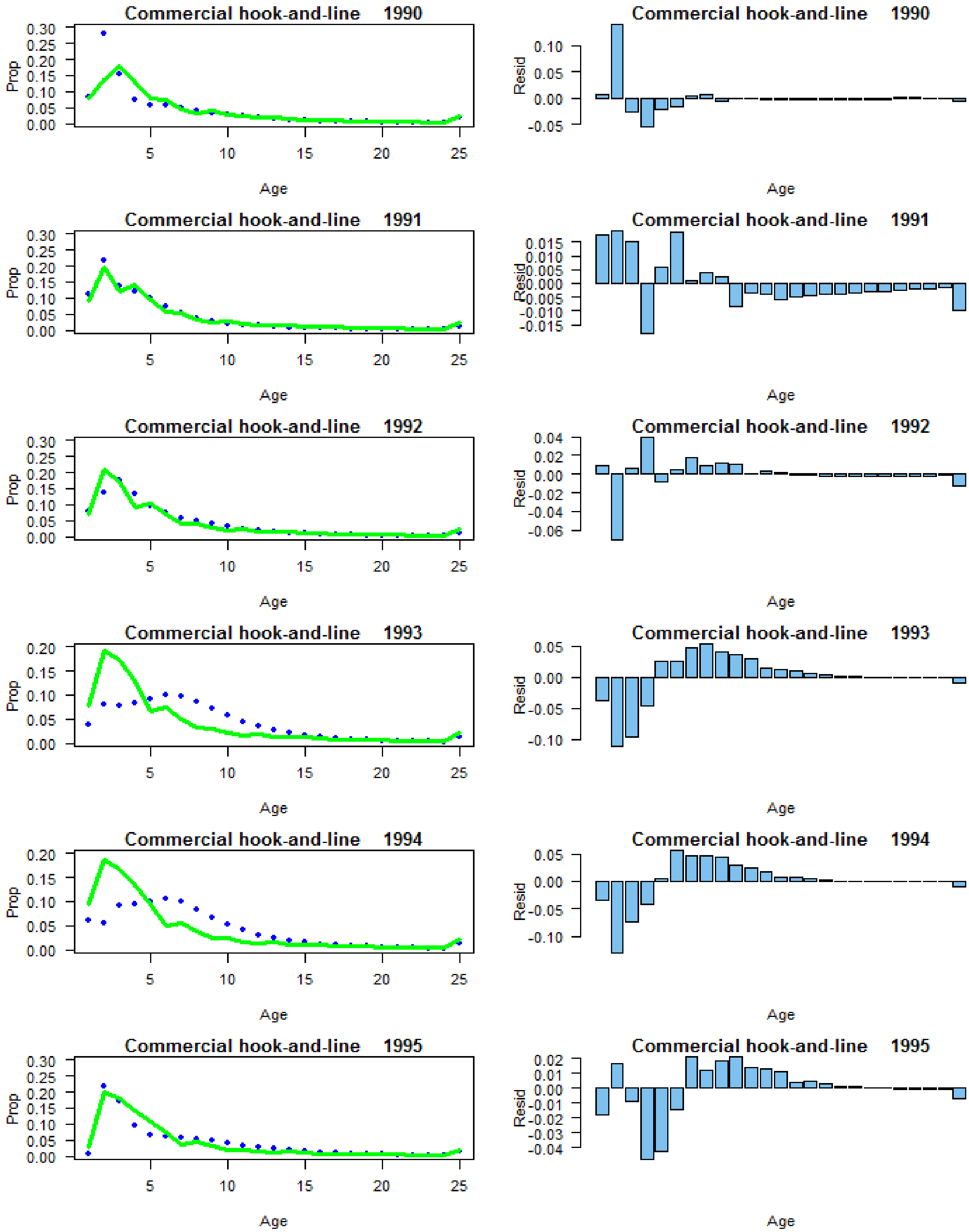


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

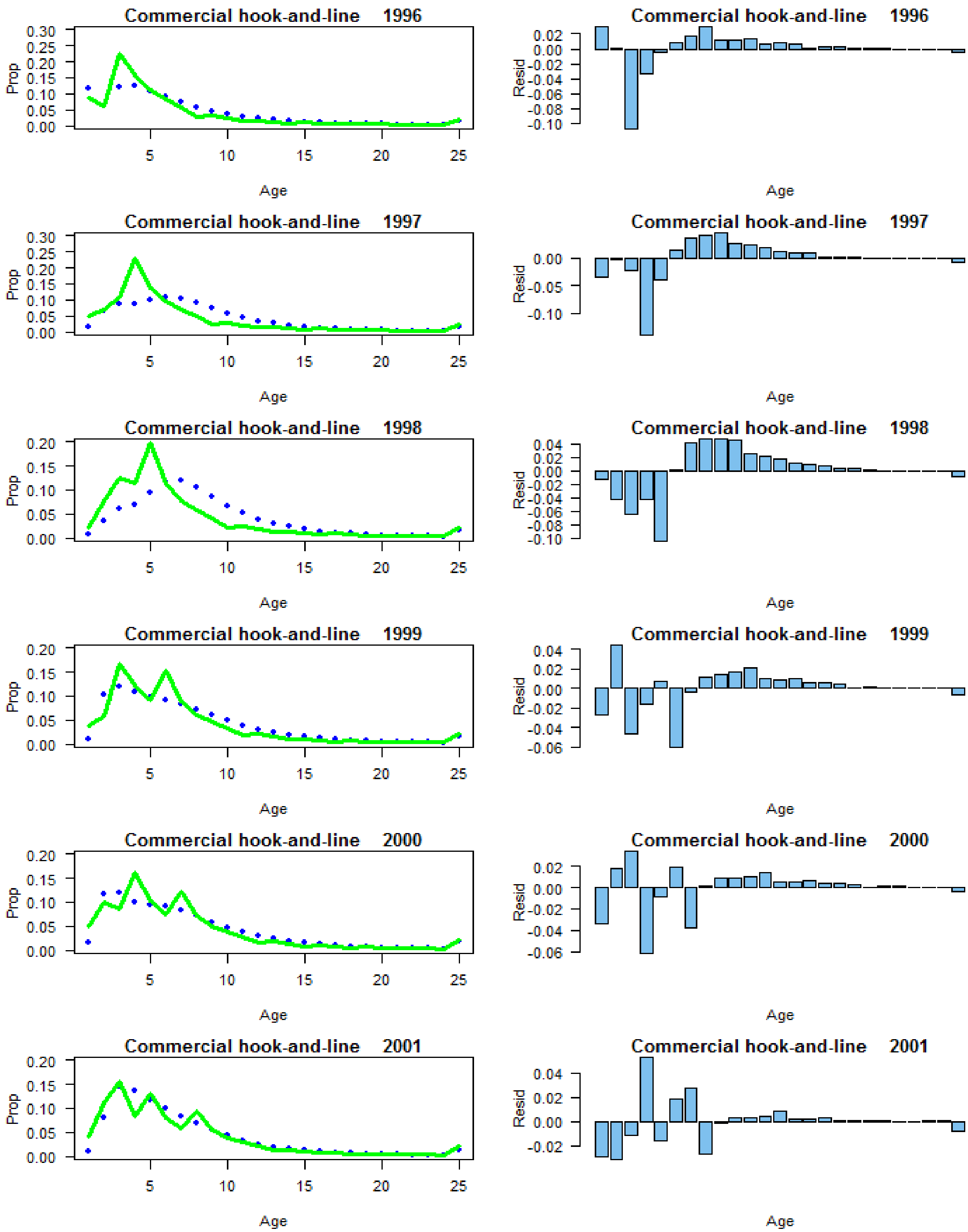


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

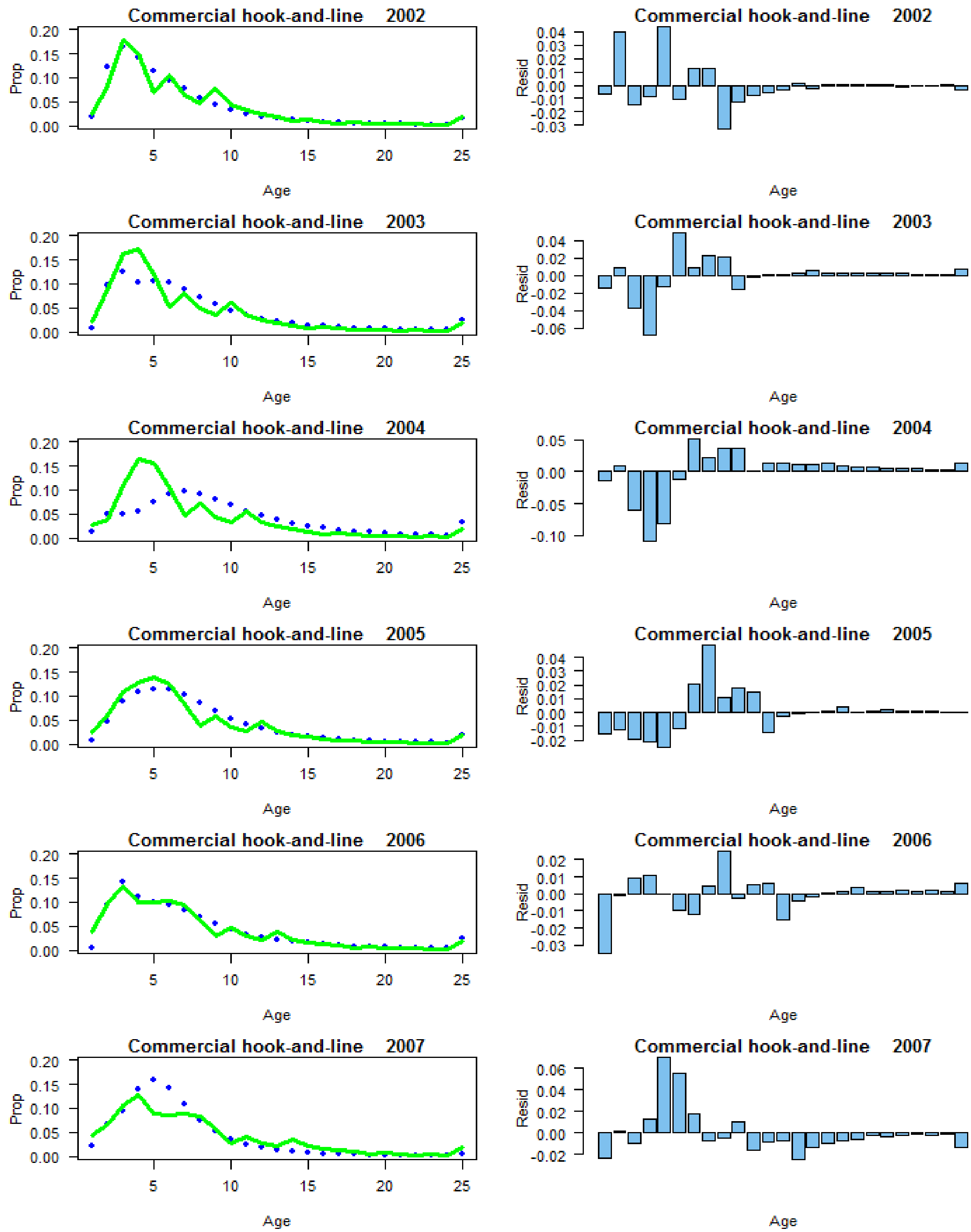


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

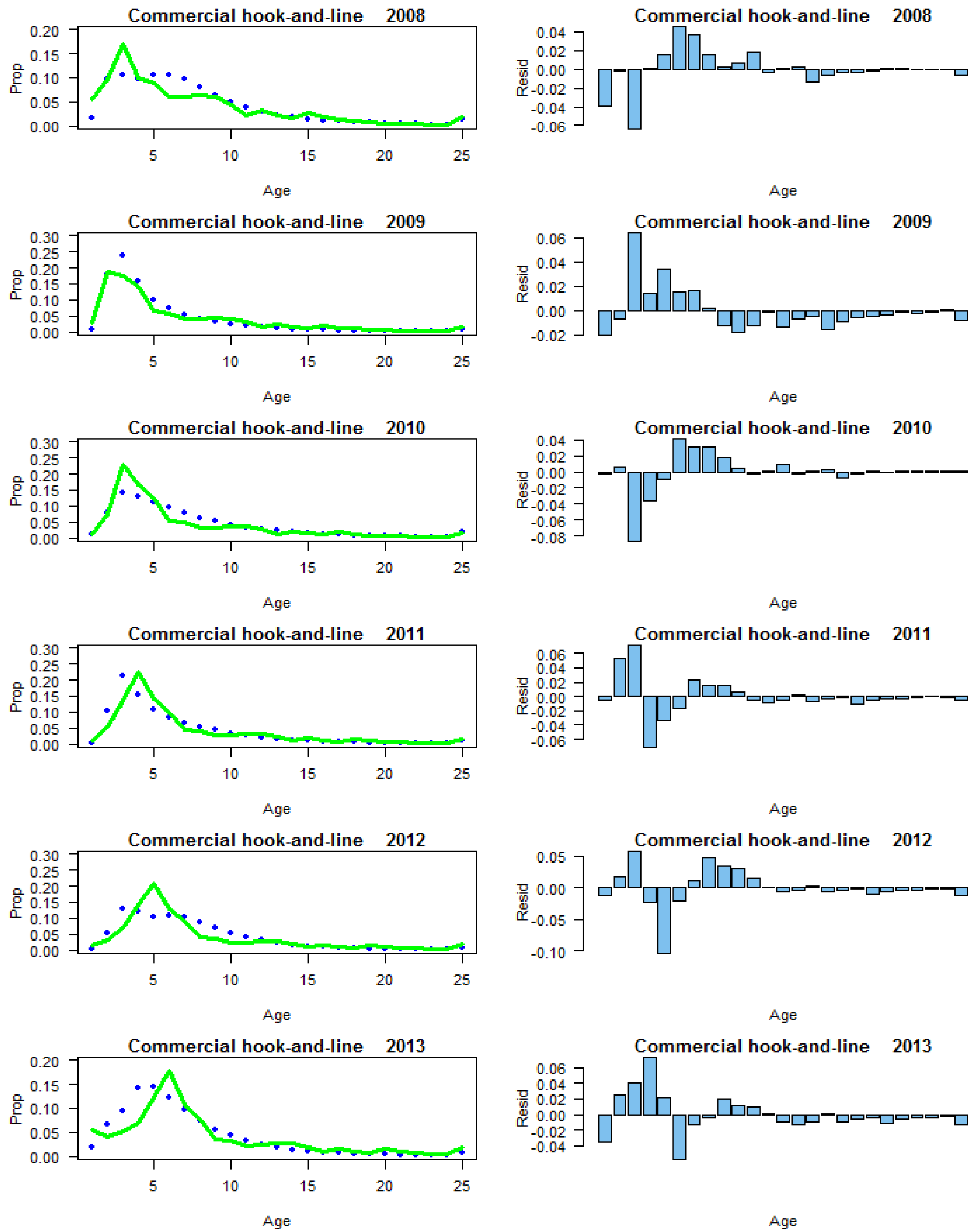


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

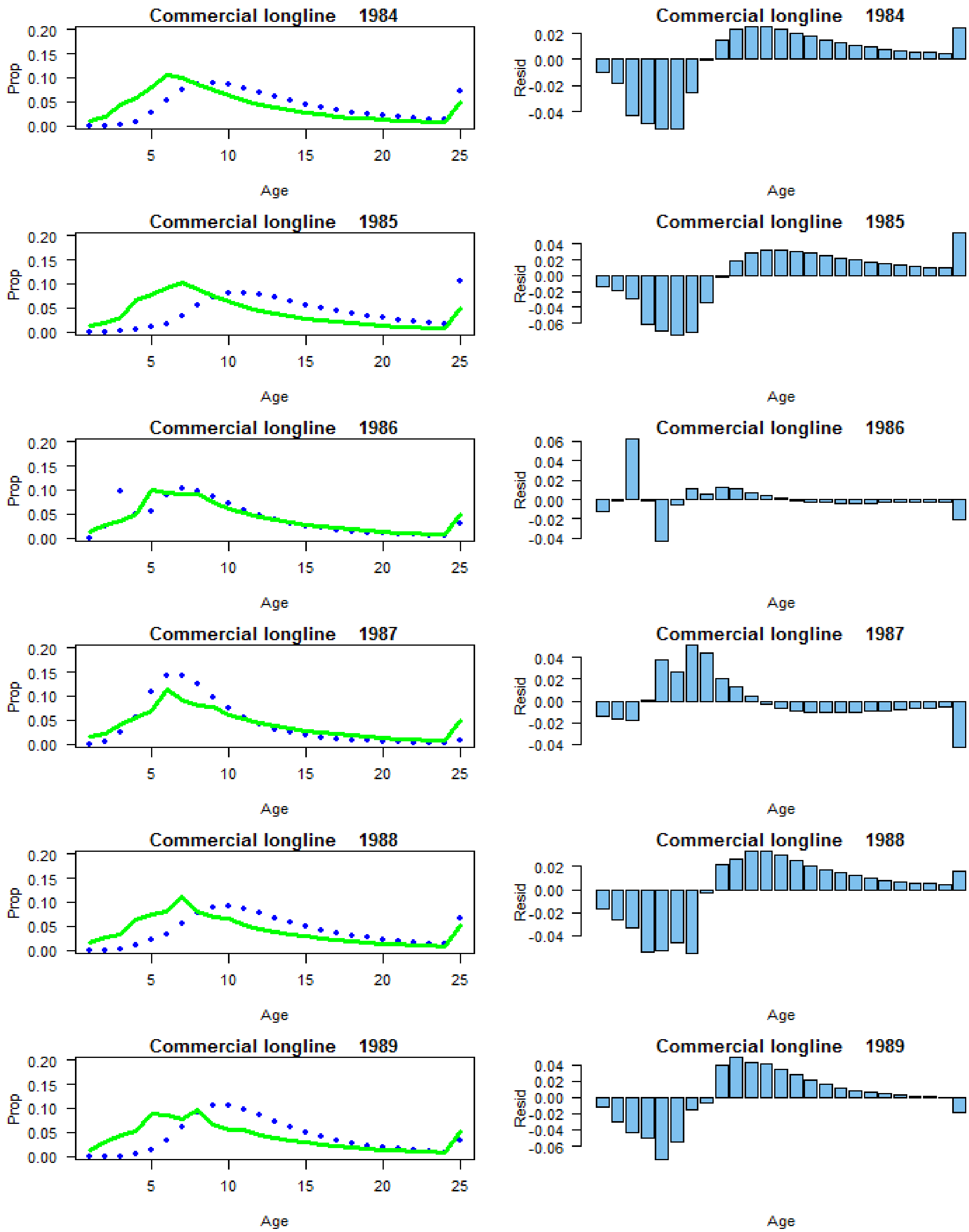


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

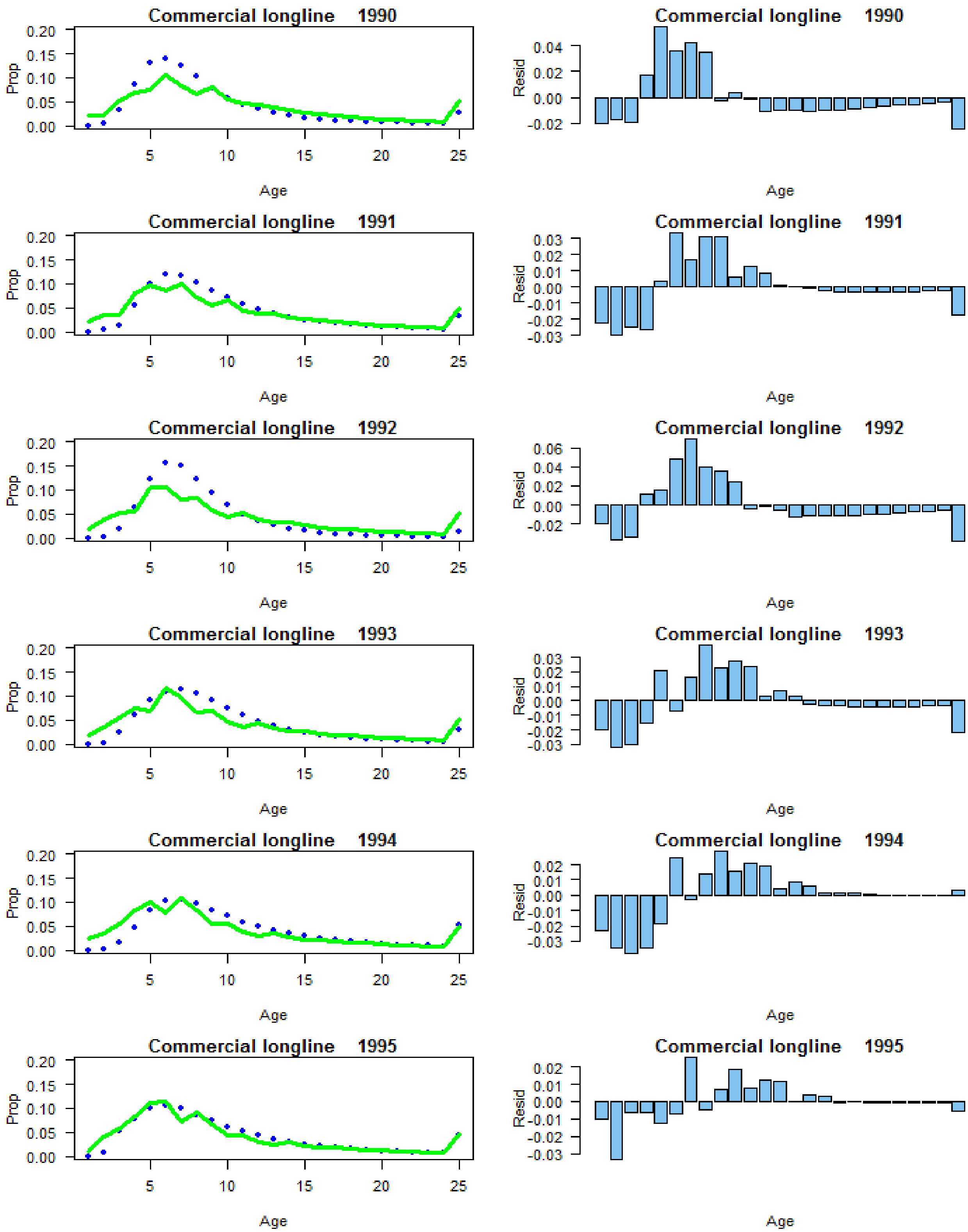


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

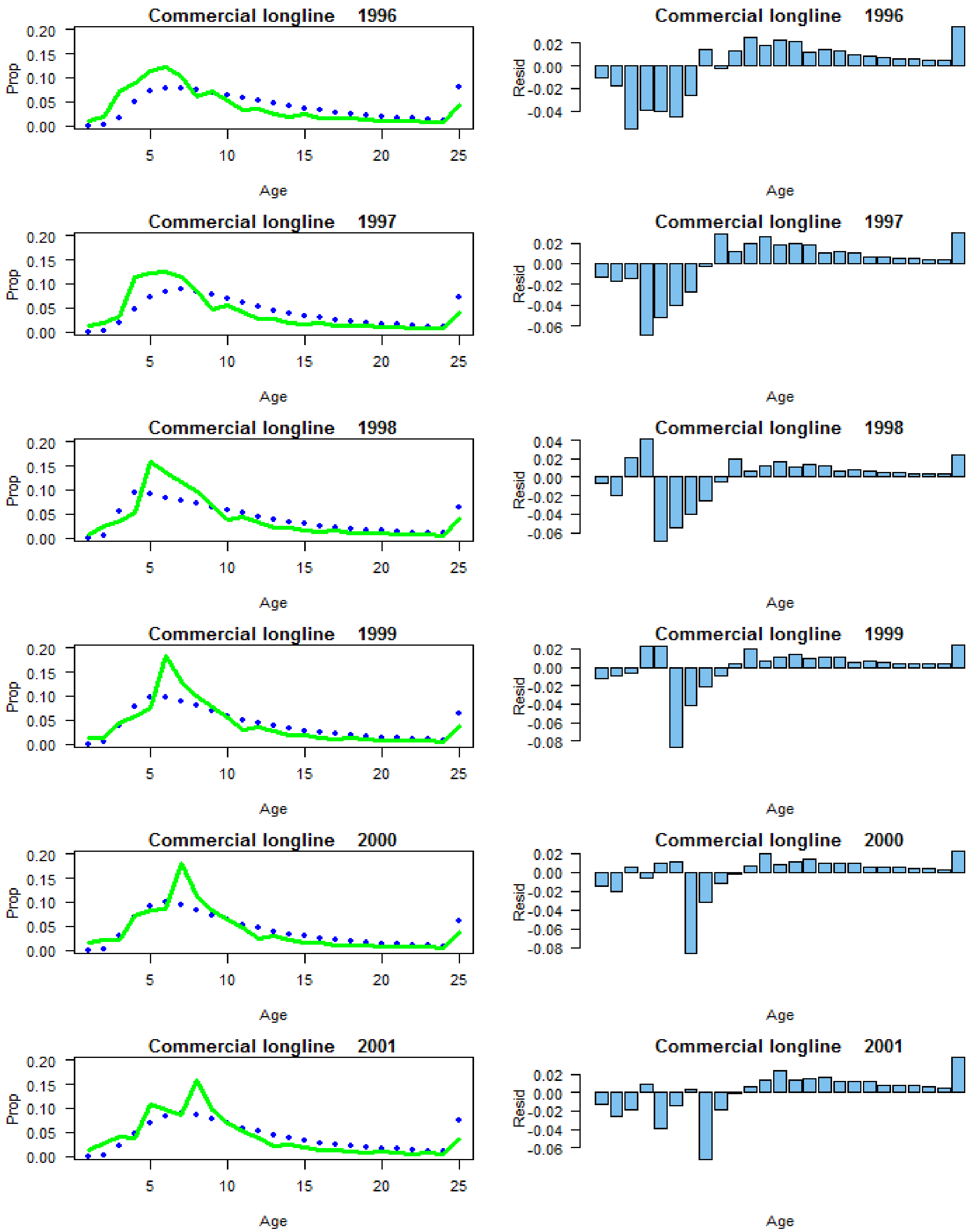


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

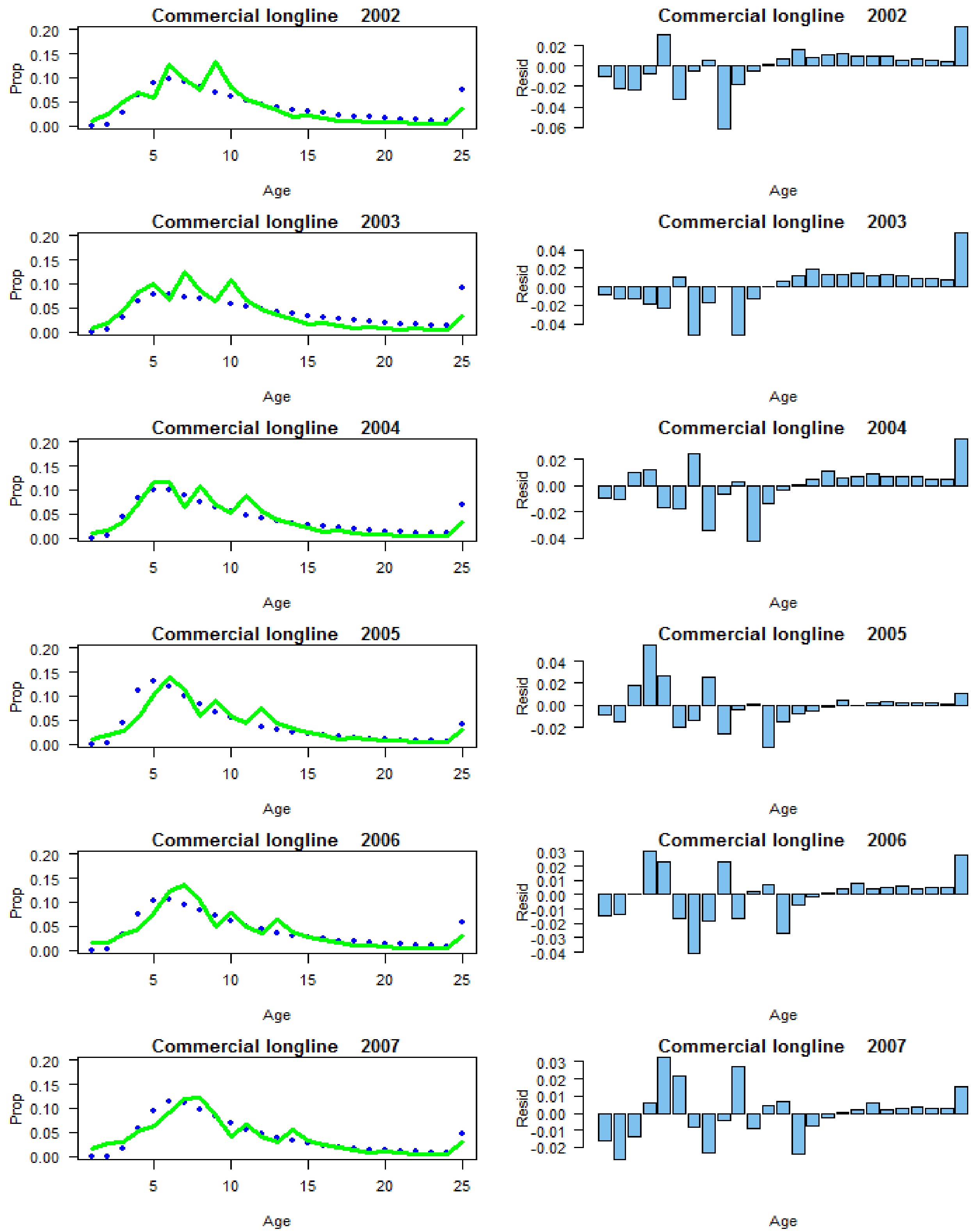


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

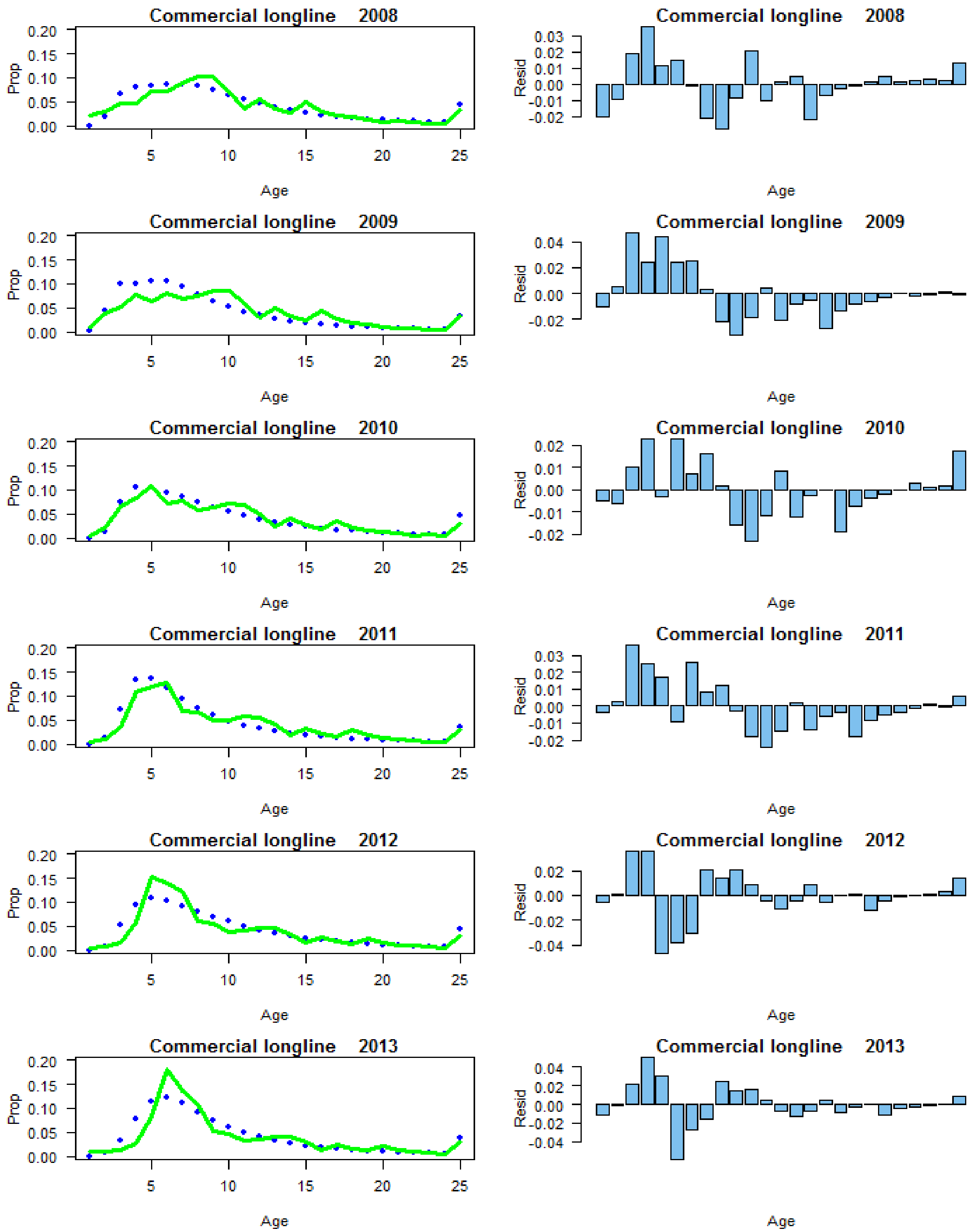


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

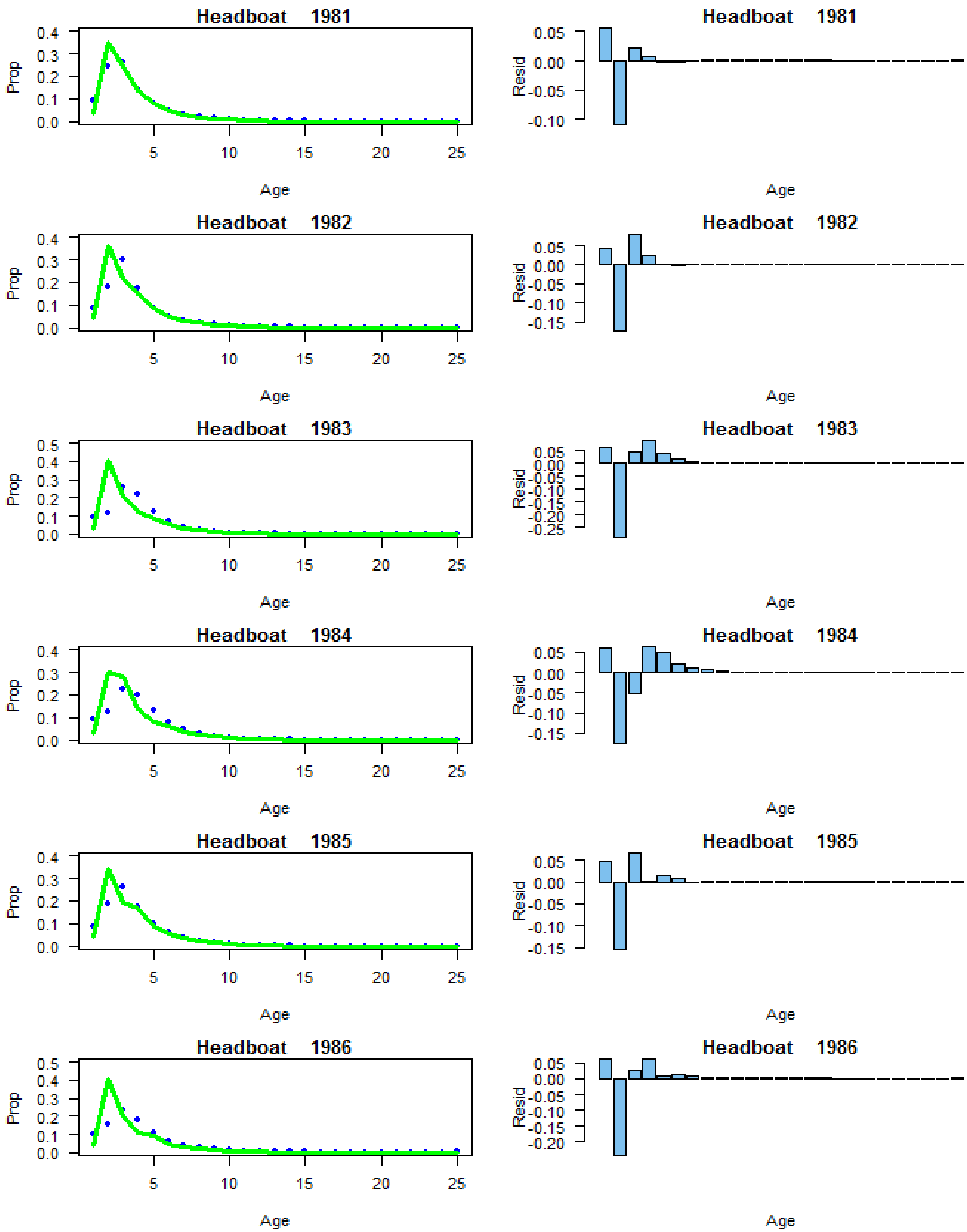


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

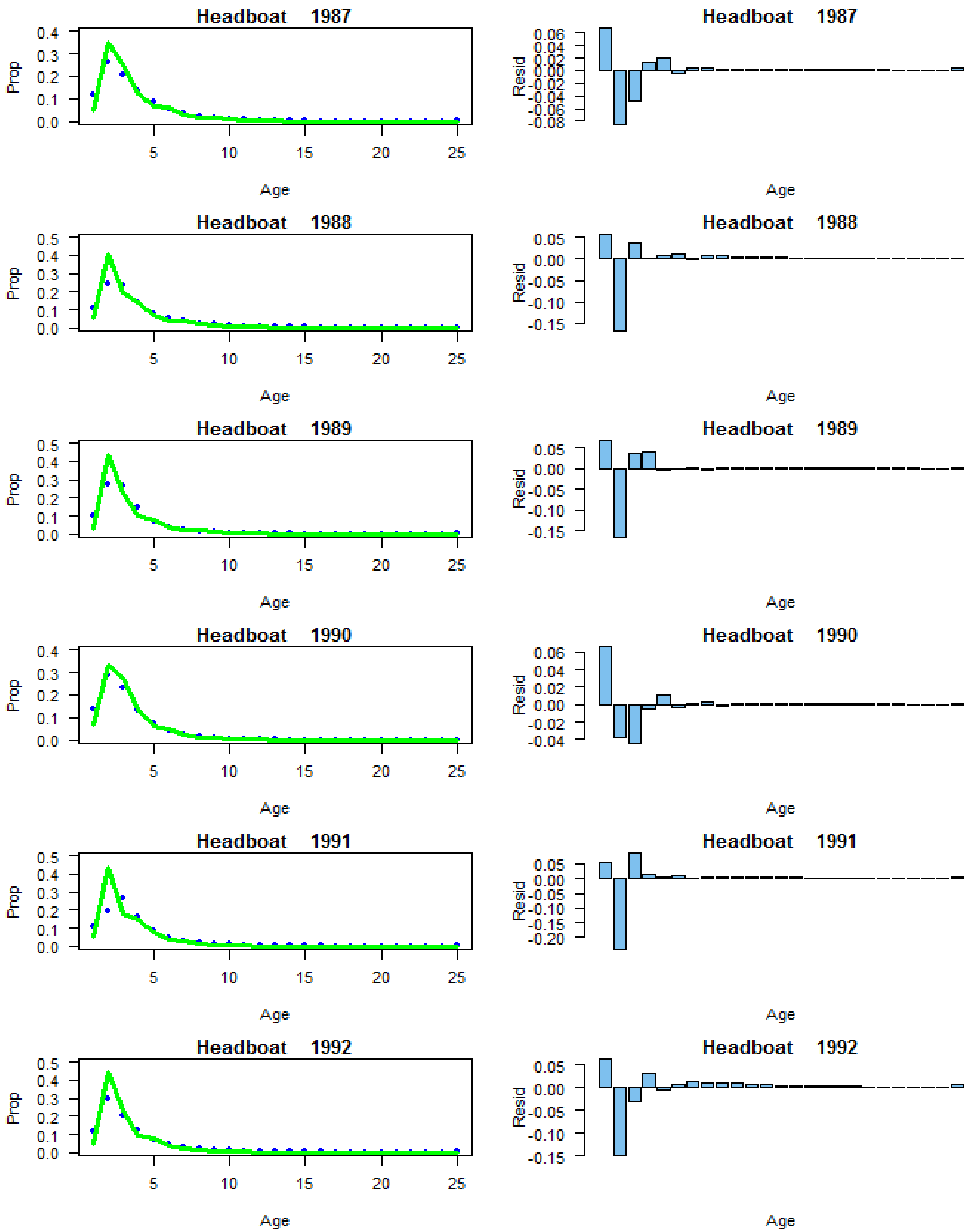


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

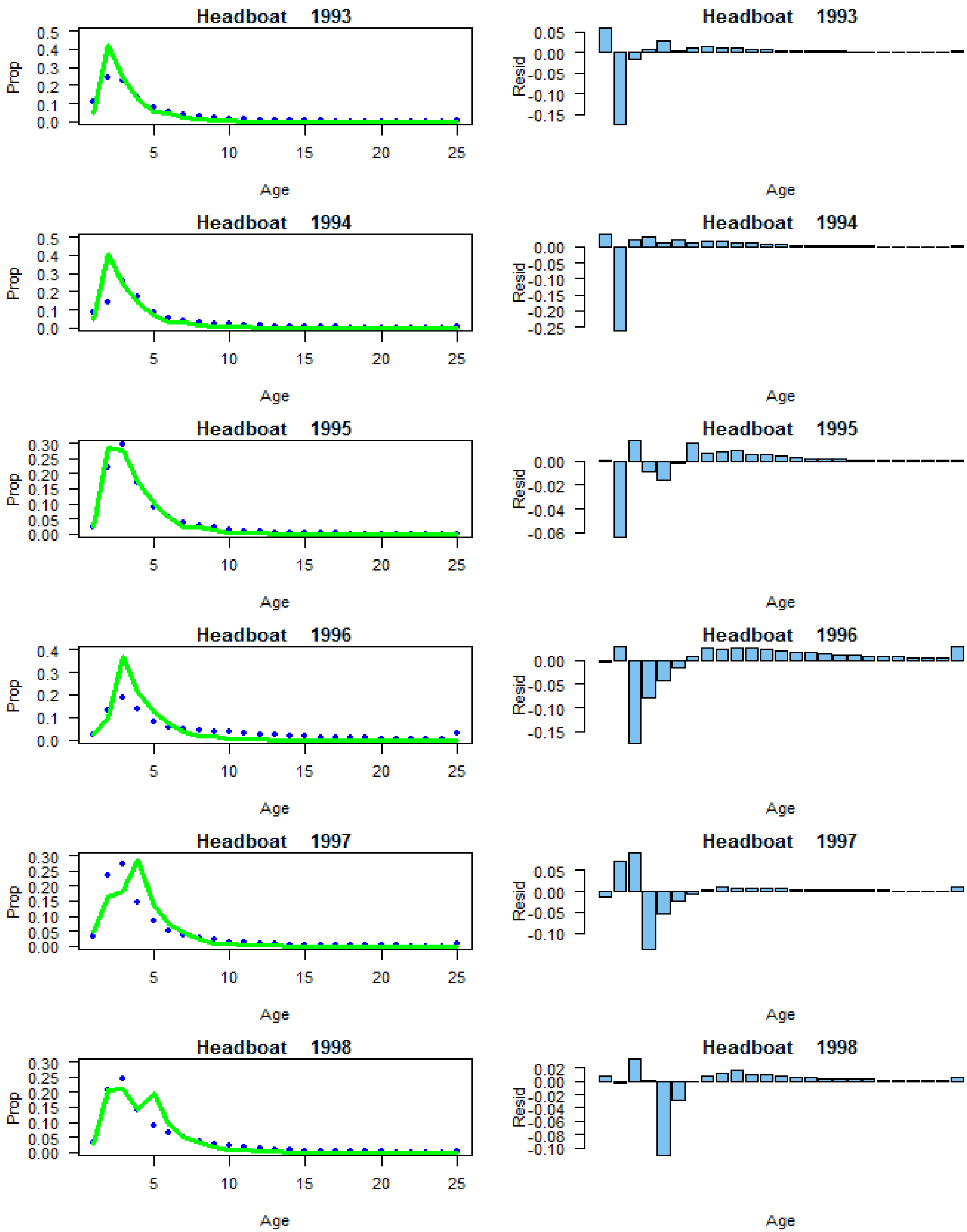


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

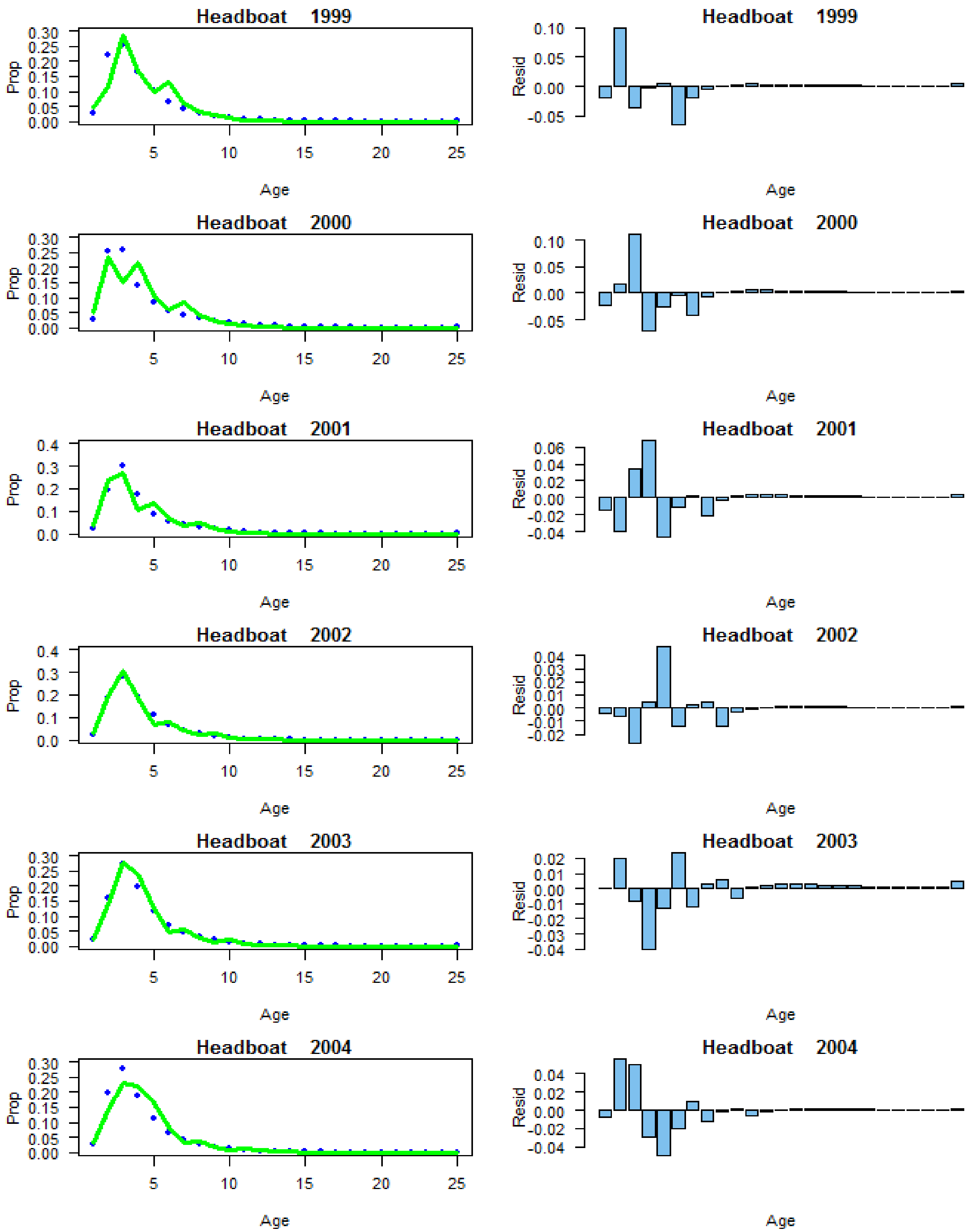


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

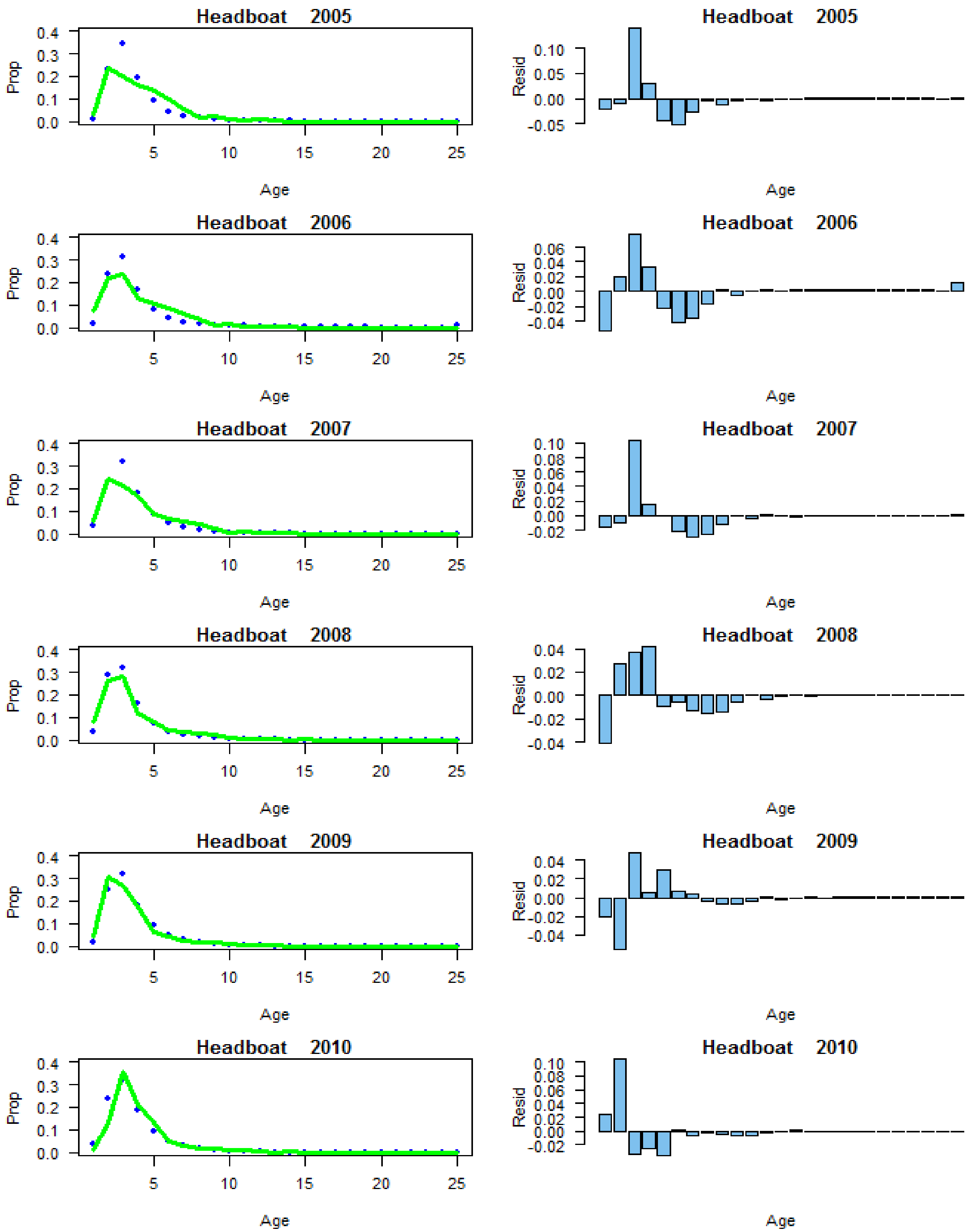


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

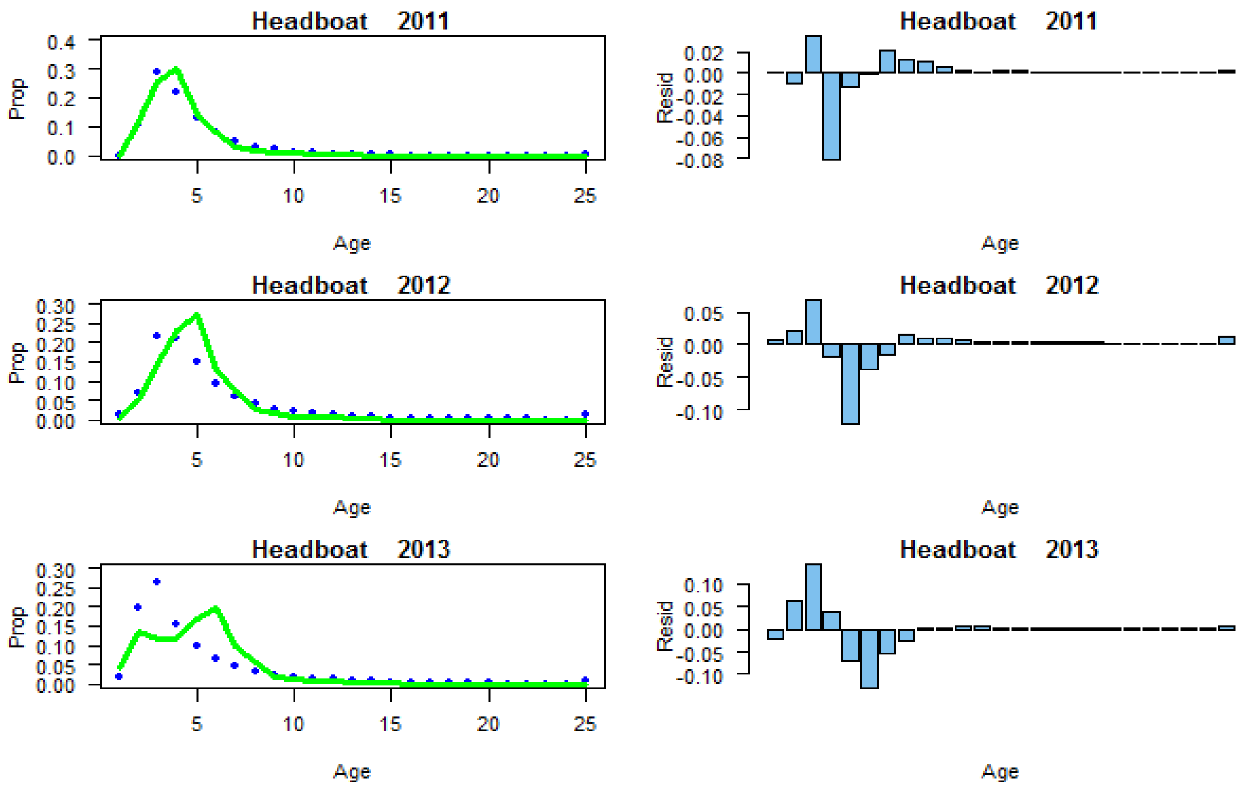


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

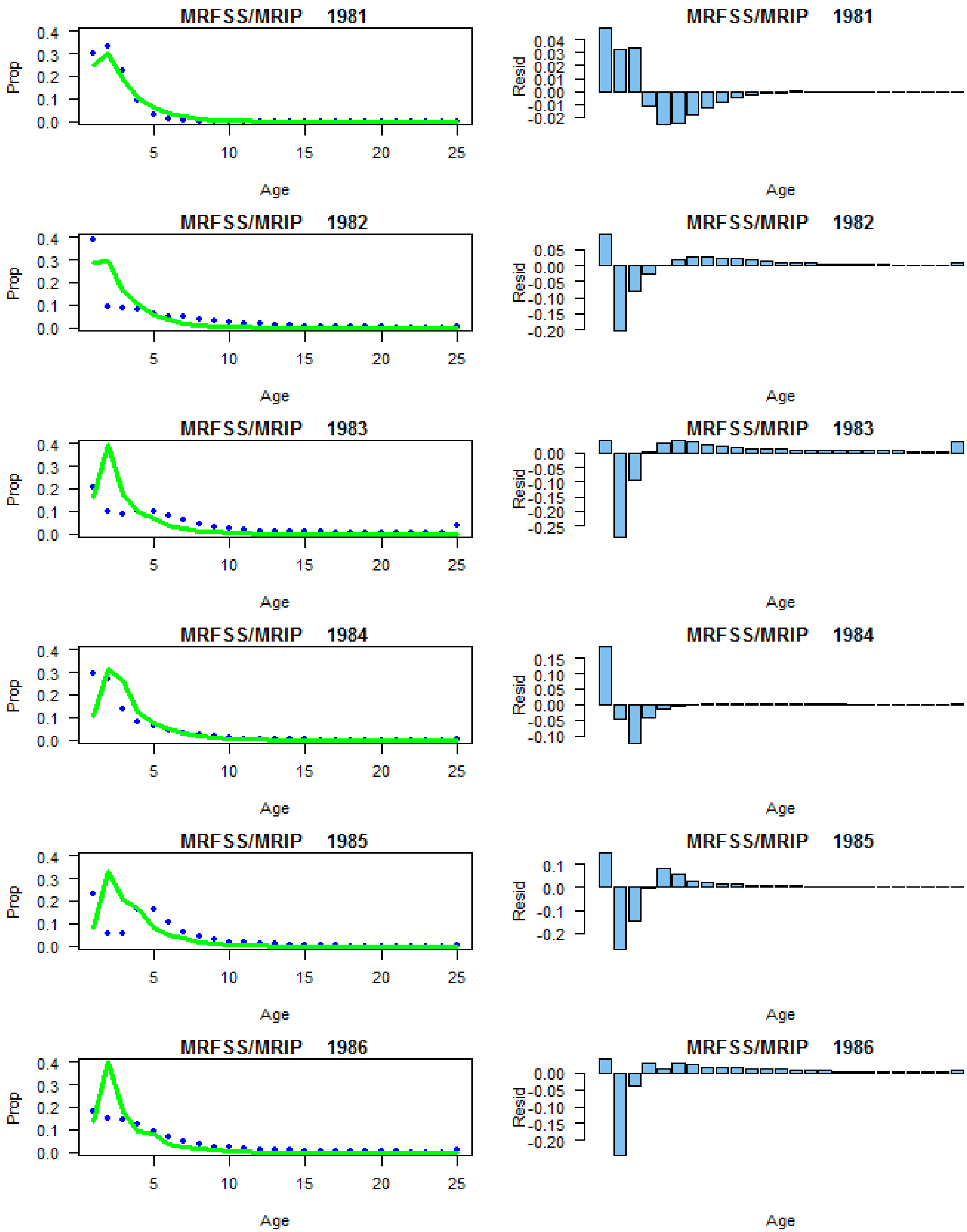


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

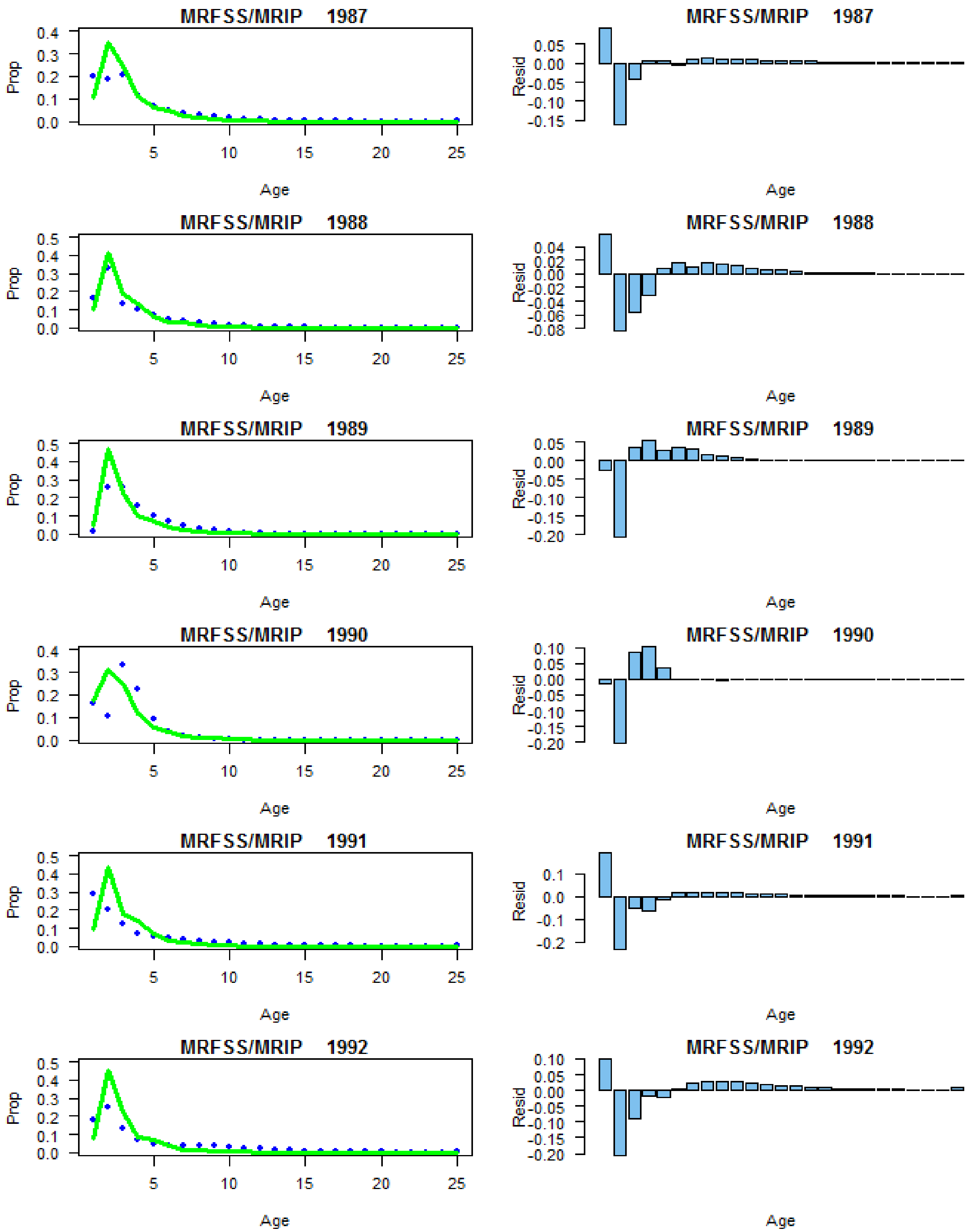


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

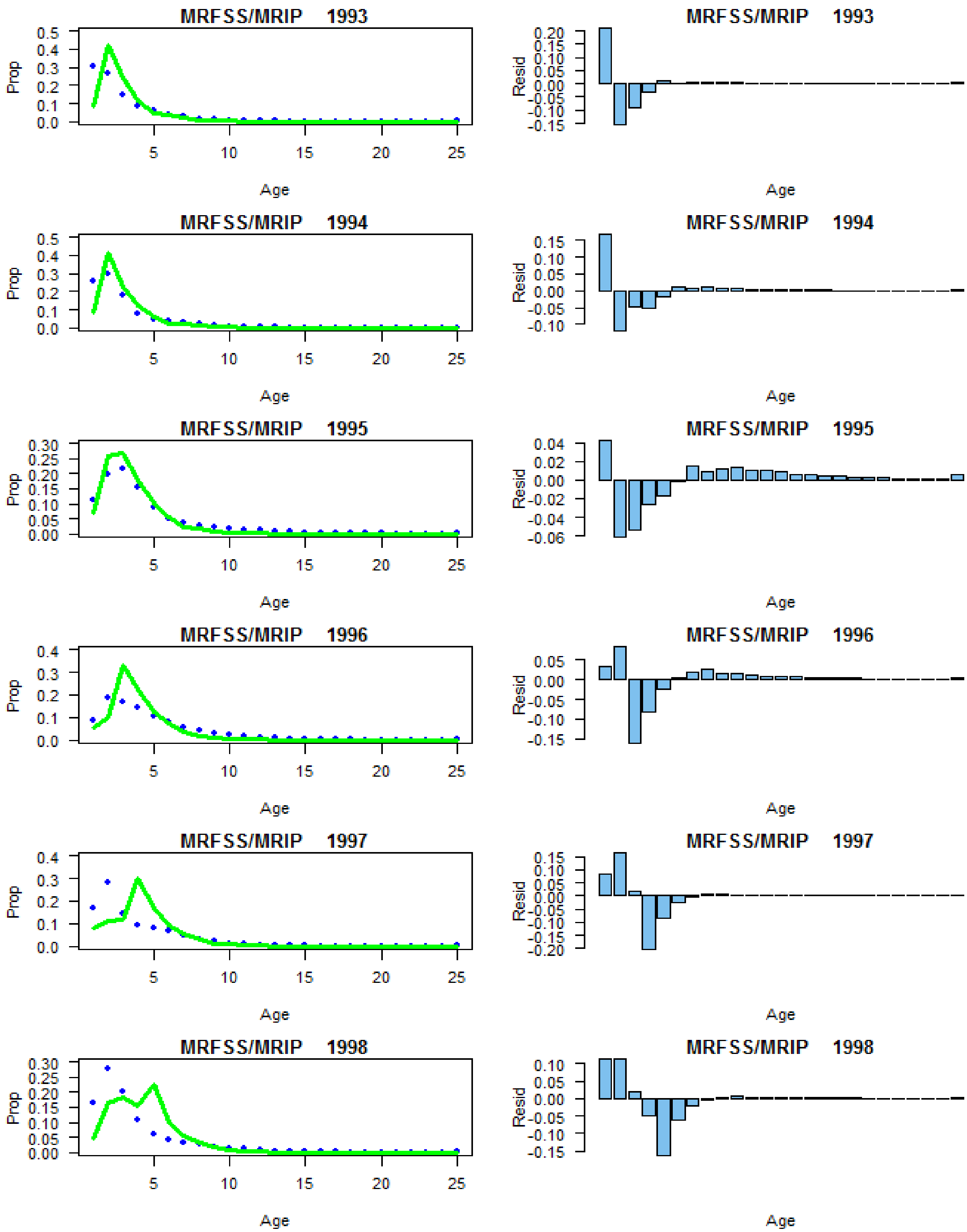


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

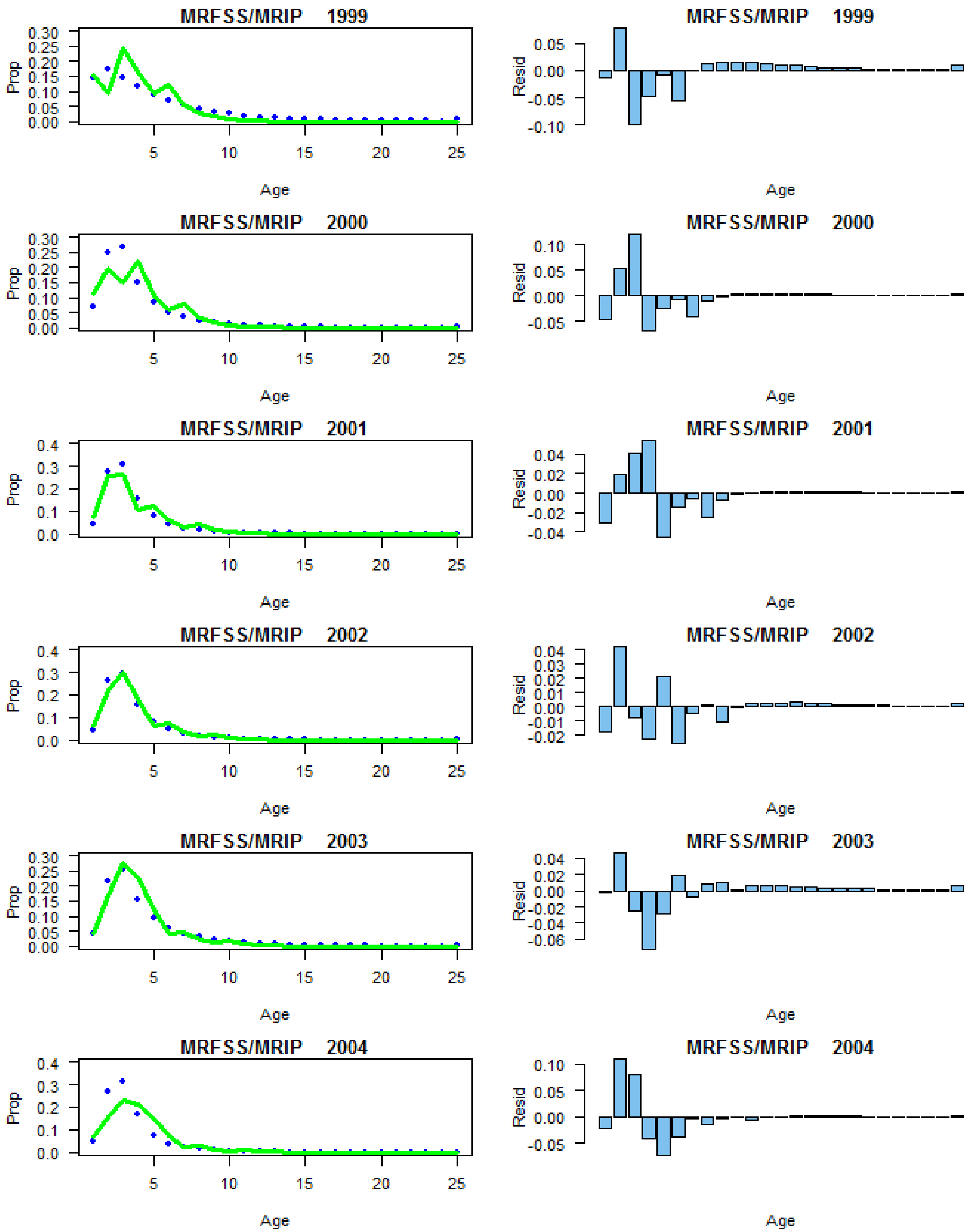


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

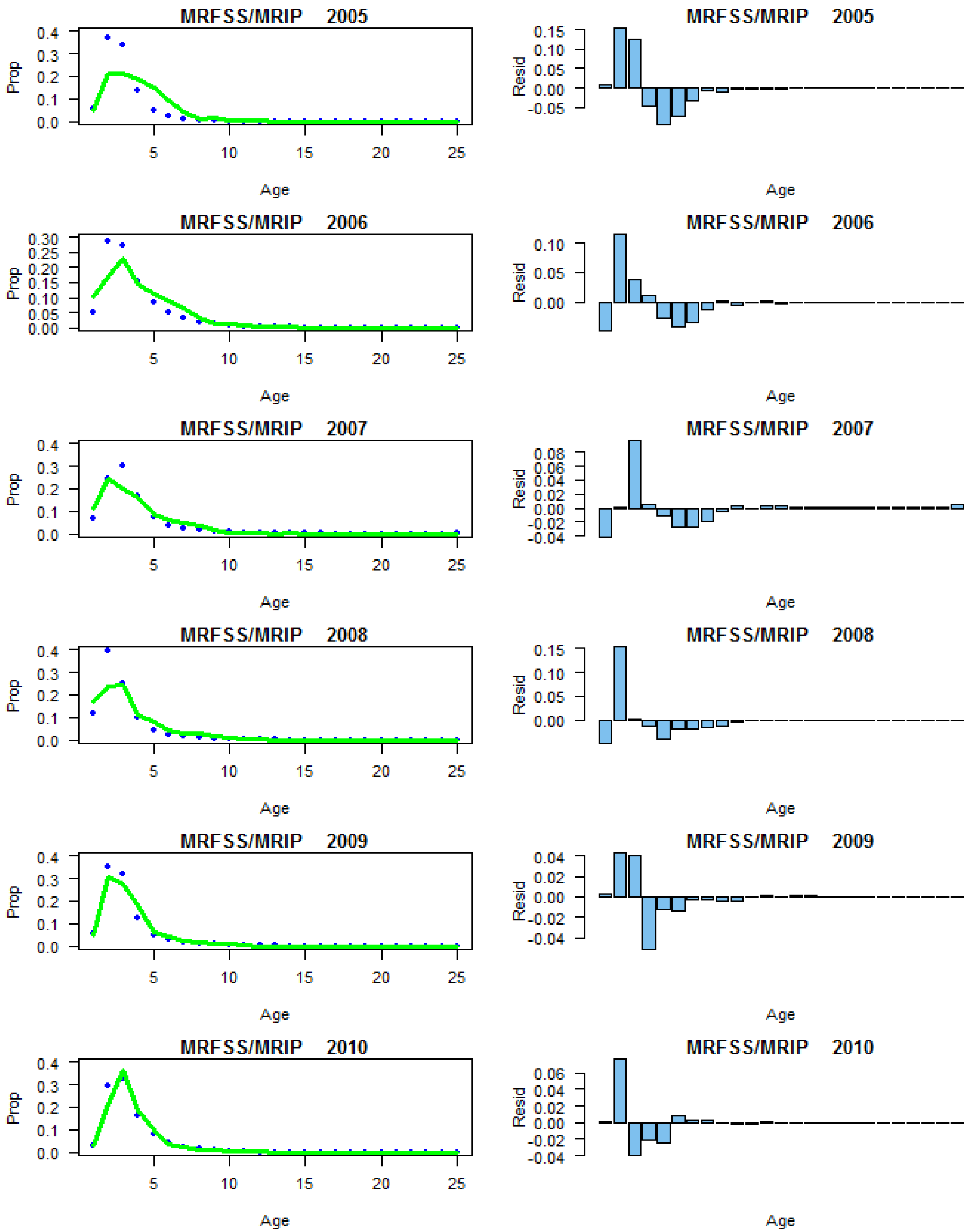


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

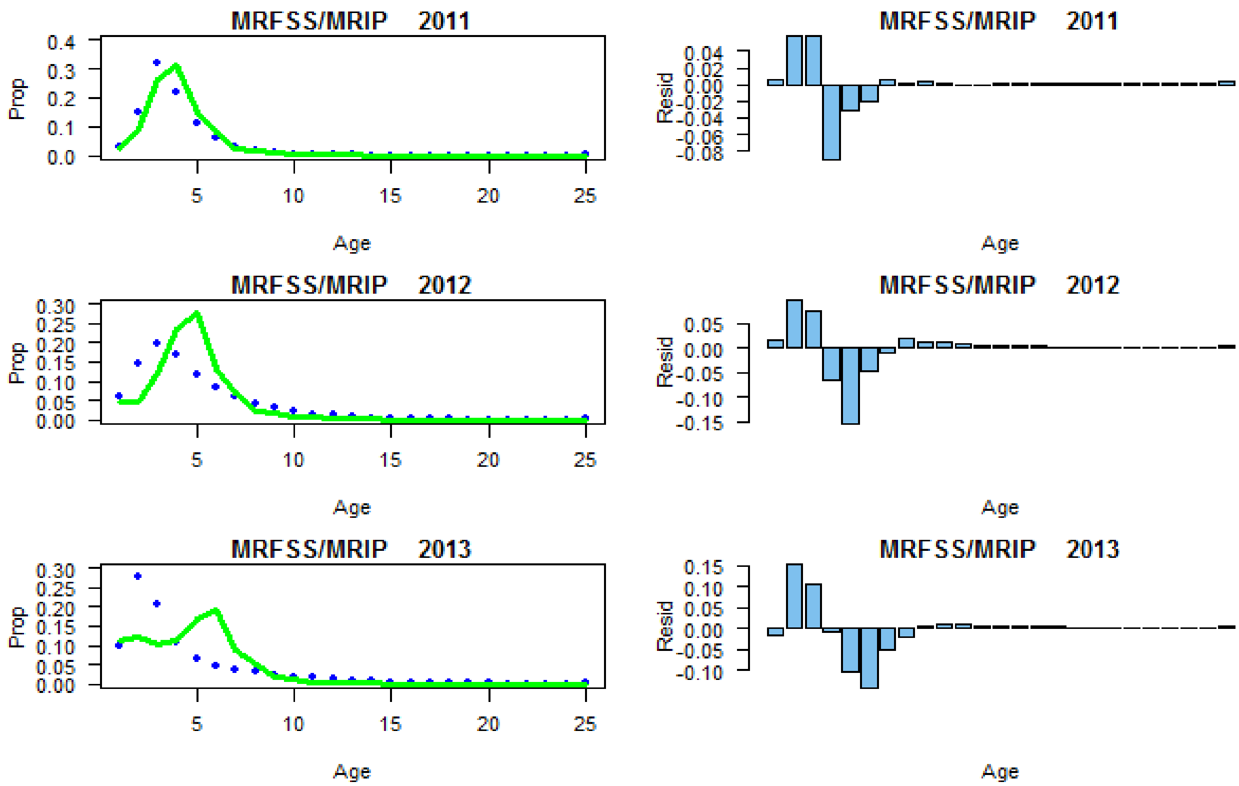


Figure 4.1.4 continued. Fits of the ASAP model to the age composition by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

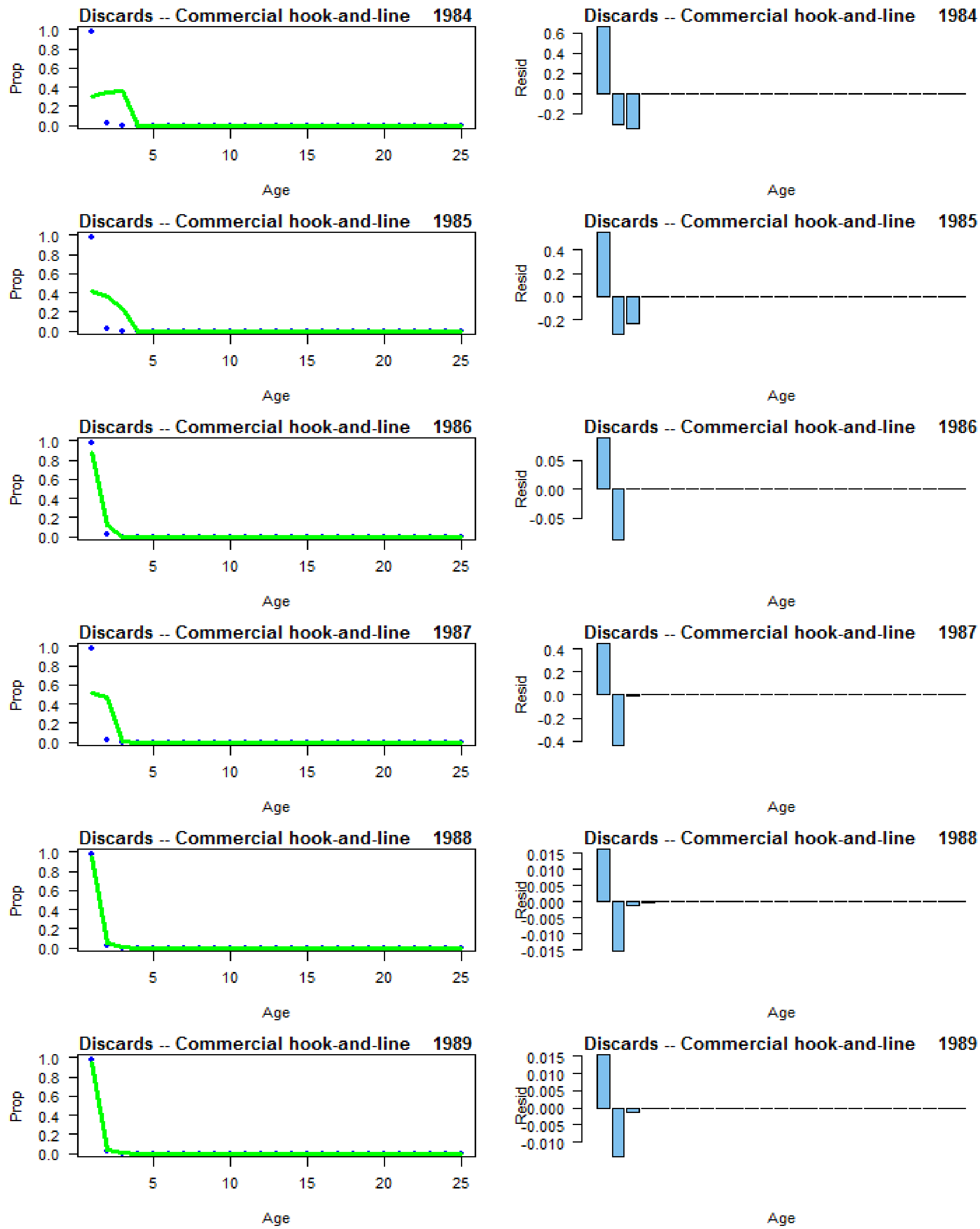


Figure 4.1.5. Fits of the ASAP model to the age composition of discards by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

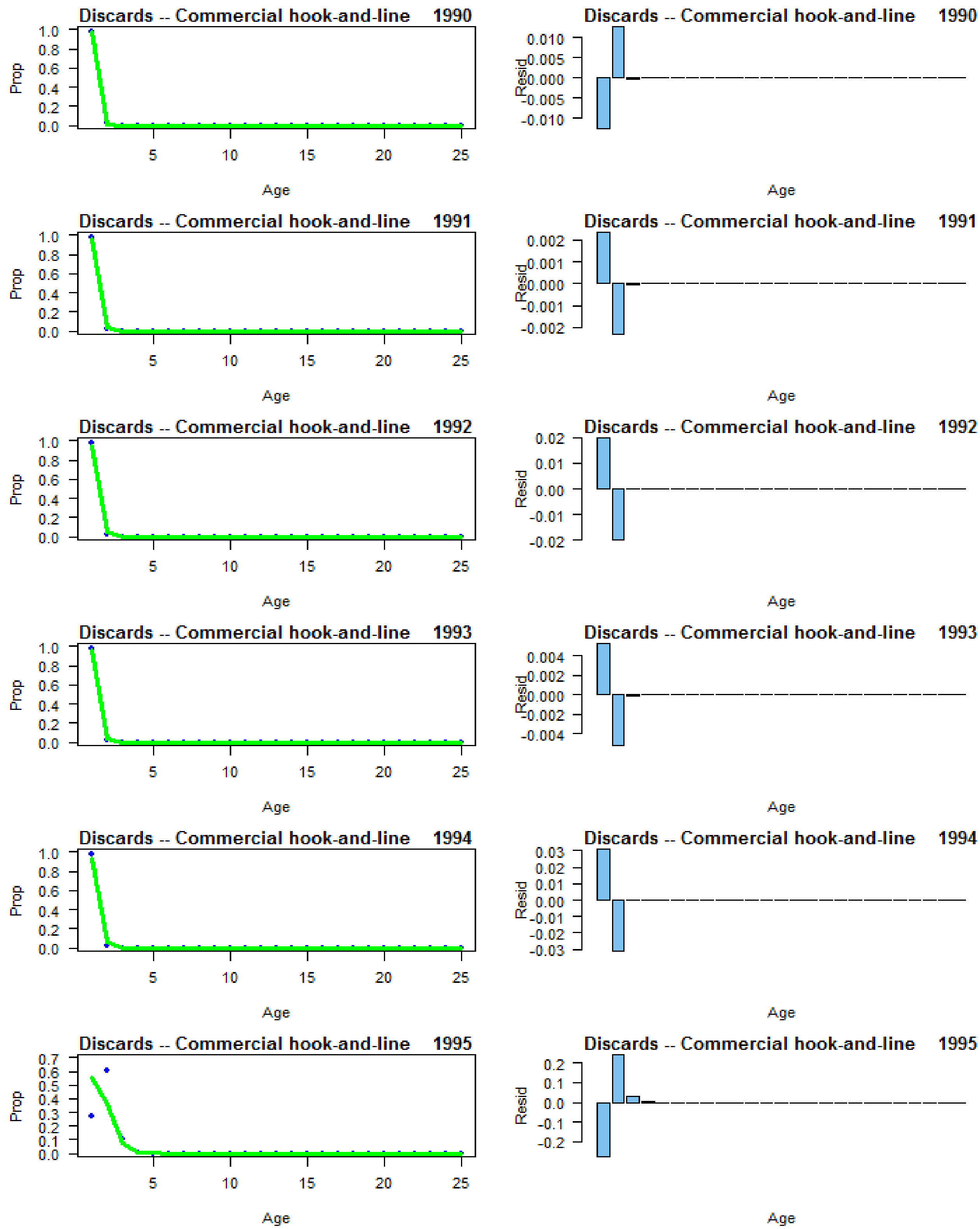


Figure 4.1.5 continued. Fits of the ASAP model to the age composition of discards by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

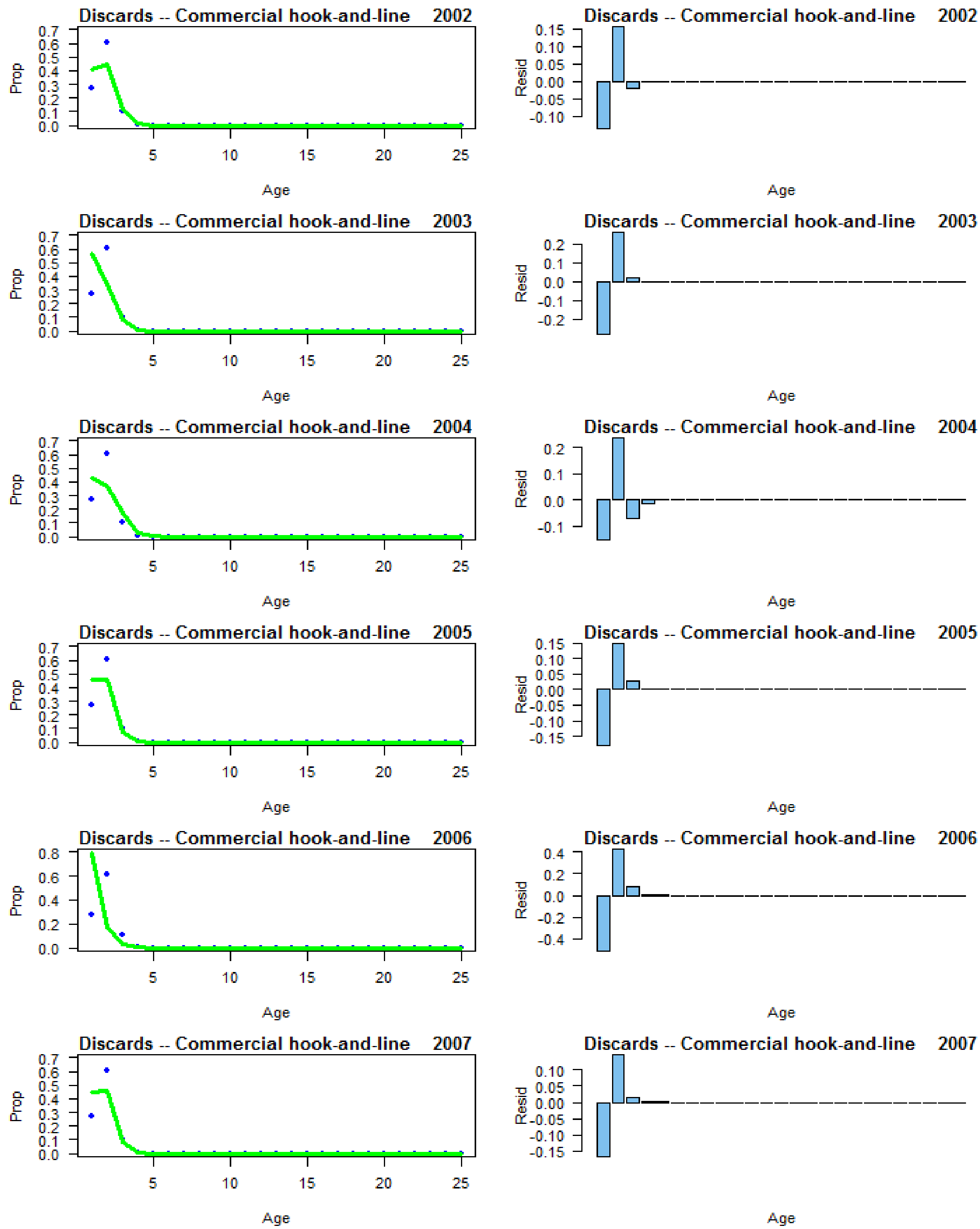


Figure 4.1.5 continued. Fits of the ASAP model to the age composition of discards by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

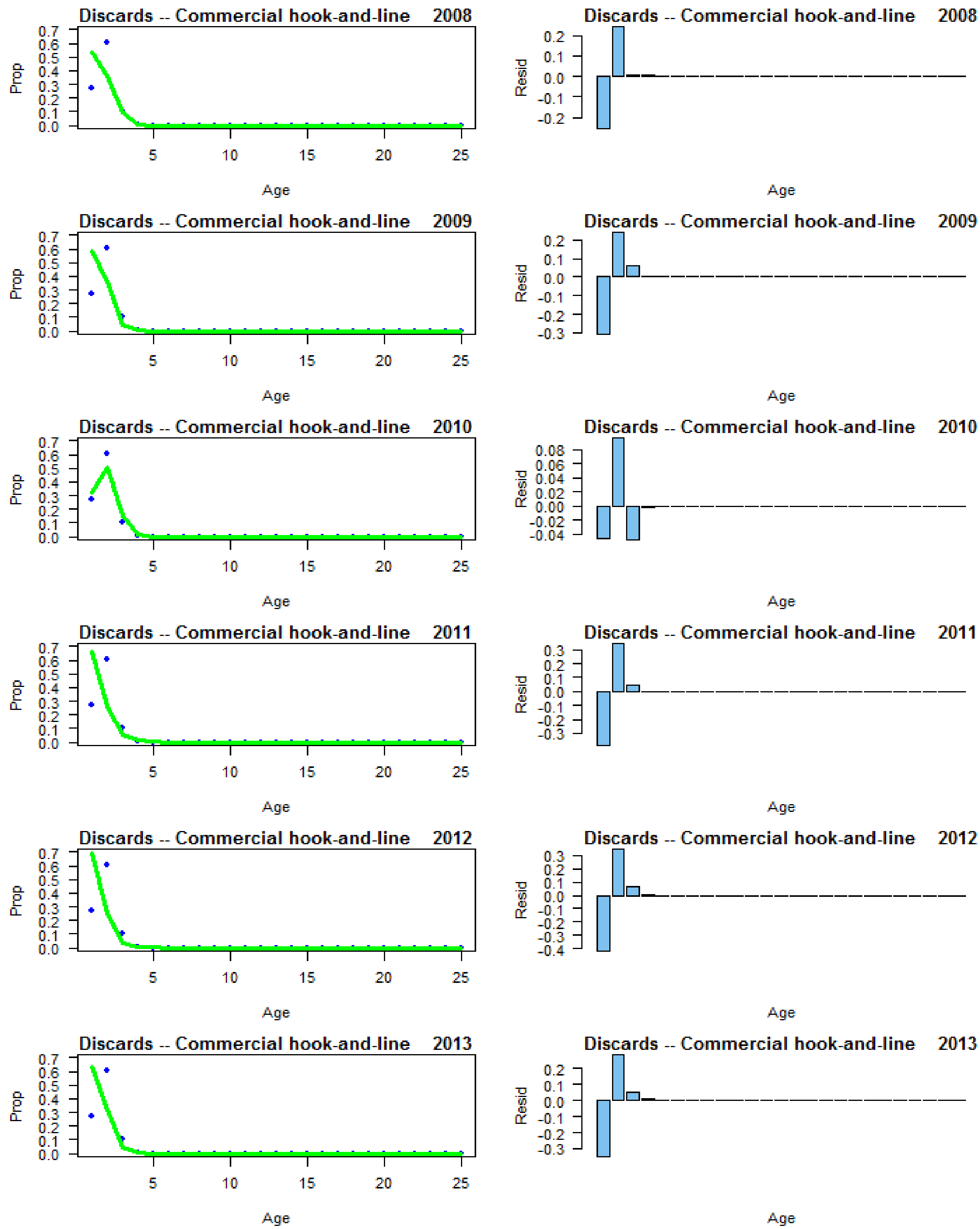


Figure 4.1.5 continued. Fits of the ASAP model to the age composition of discards by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

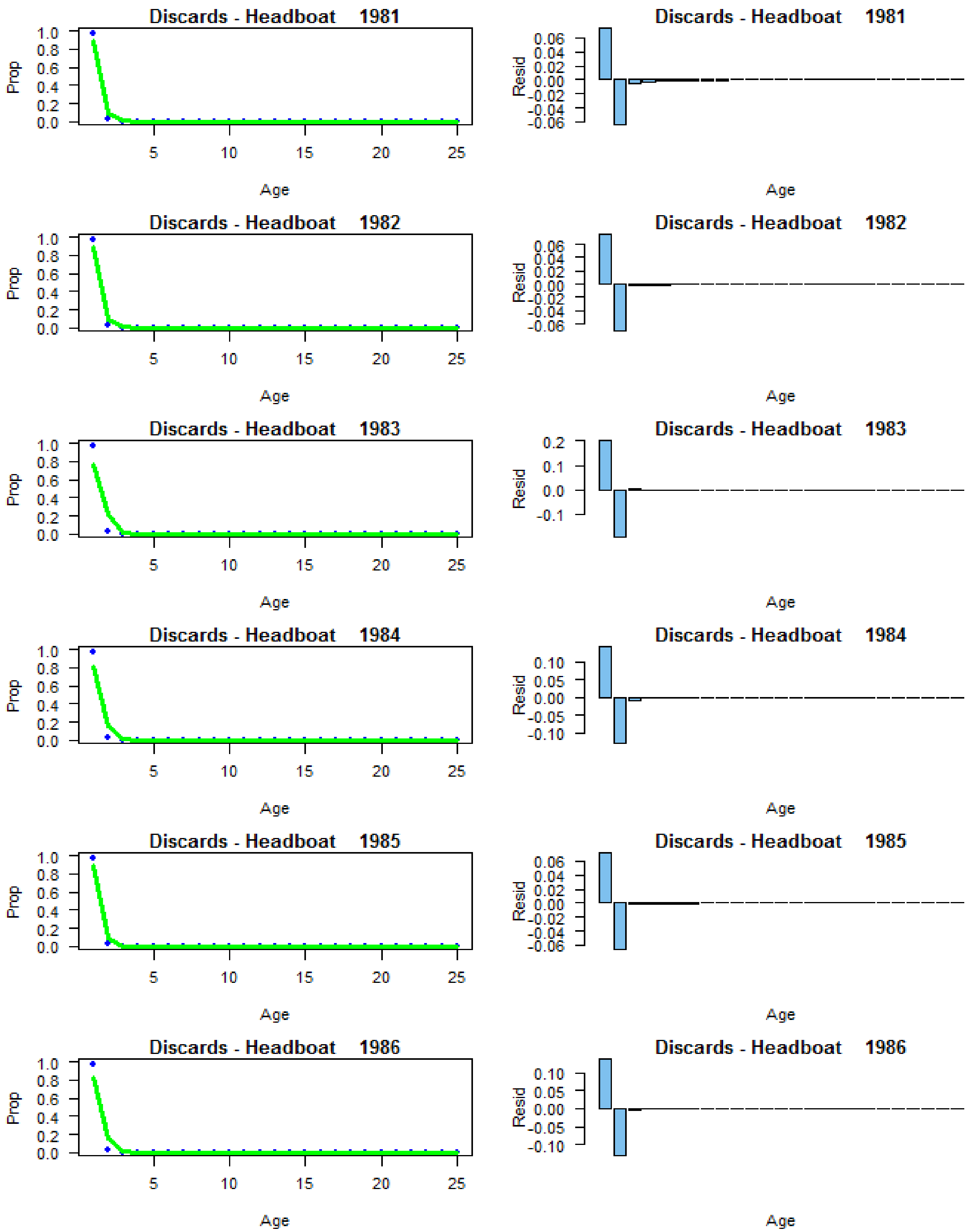


Figure 4.1.5 continued. Fits of the ASAP model to the age composition of discards by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

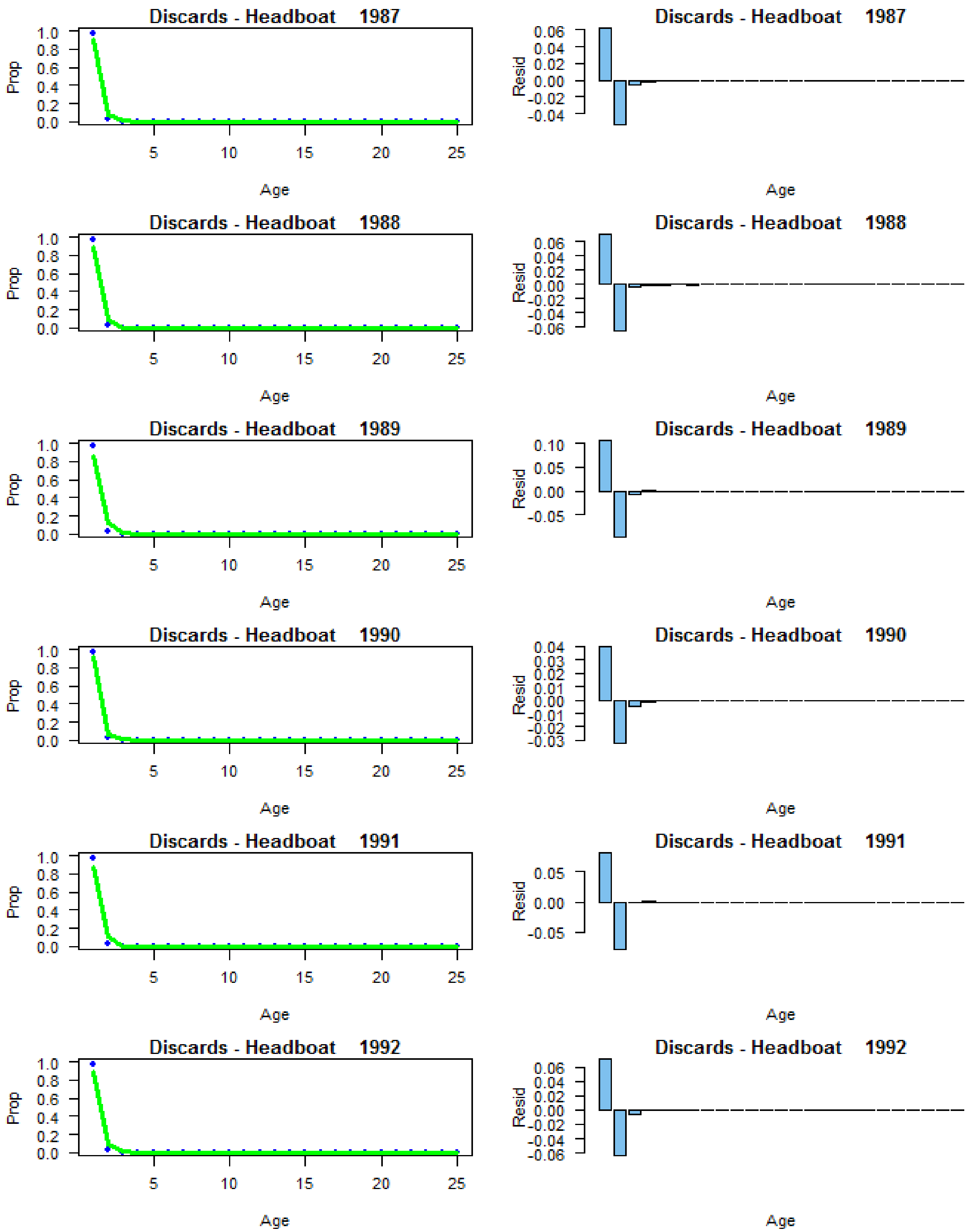


Figure 4.1.5 continued. Fits of the ASAP model to the age composition of discards by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

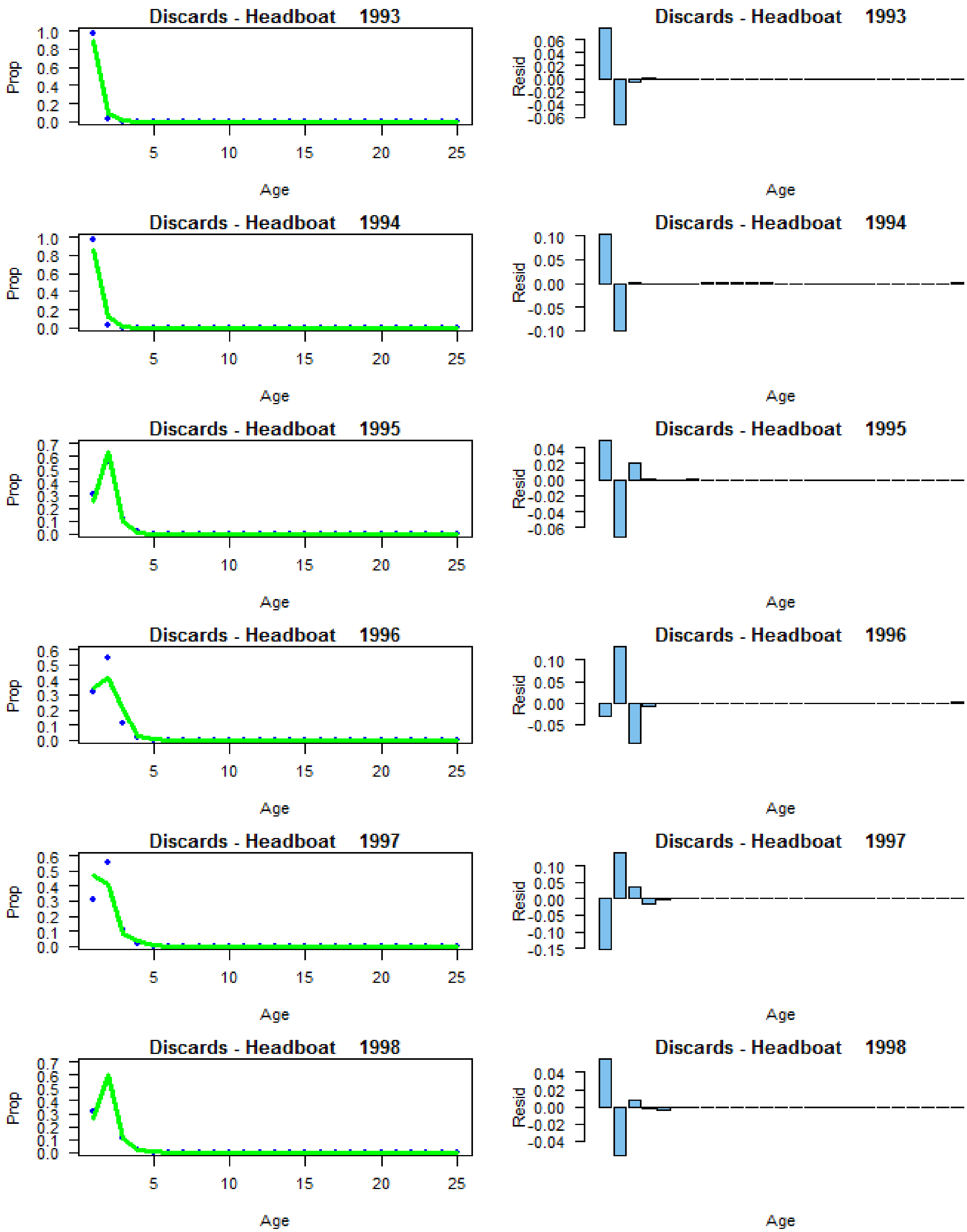


Figure 4.1.5 continued. Fits of the ASAP model to the age composition of discards by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

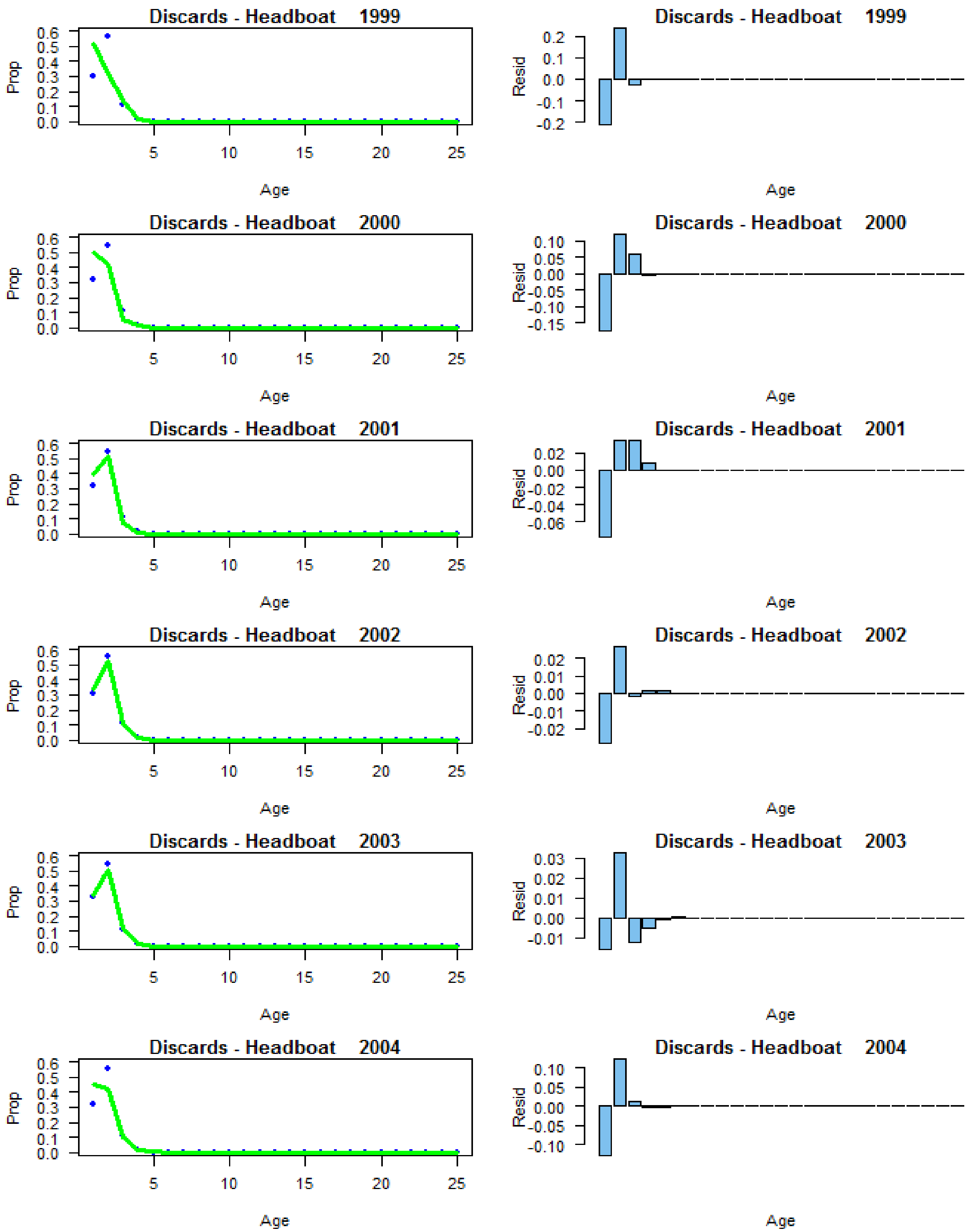


Figure 4.1.5 continued. Fits of the ASAP model to the age composition of discards by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

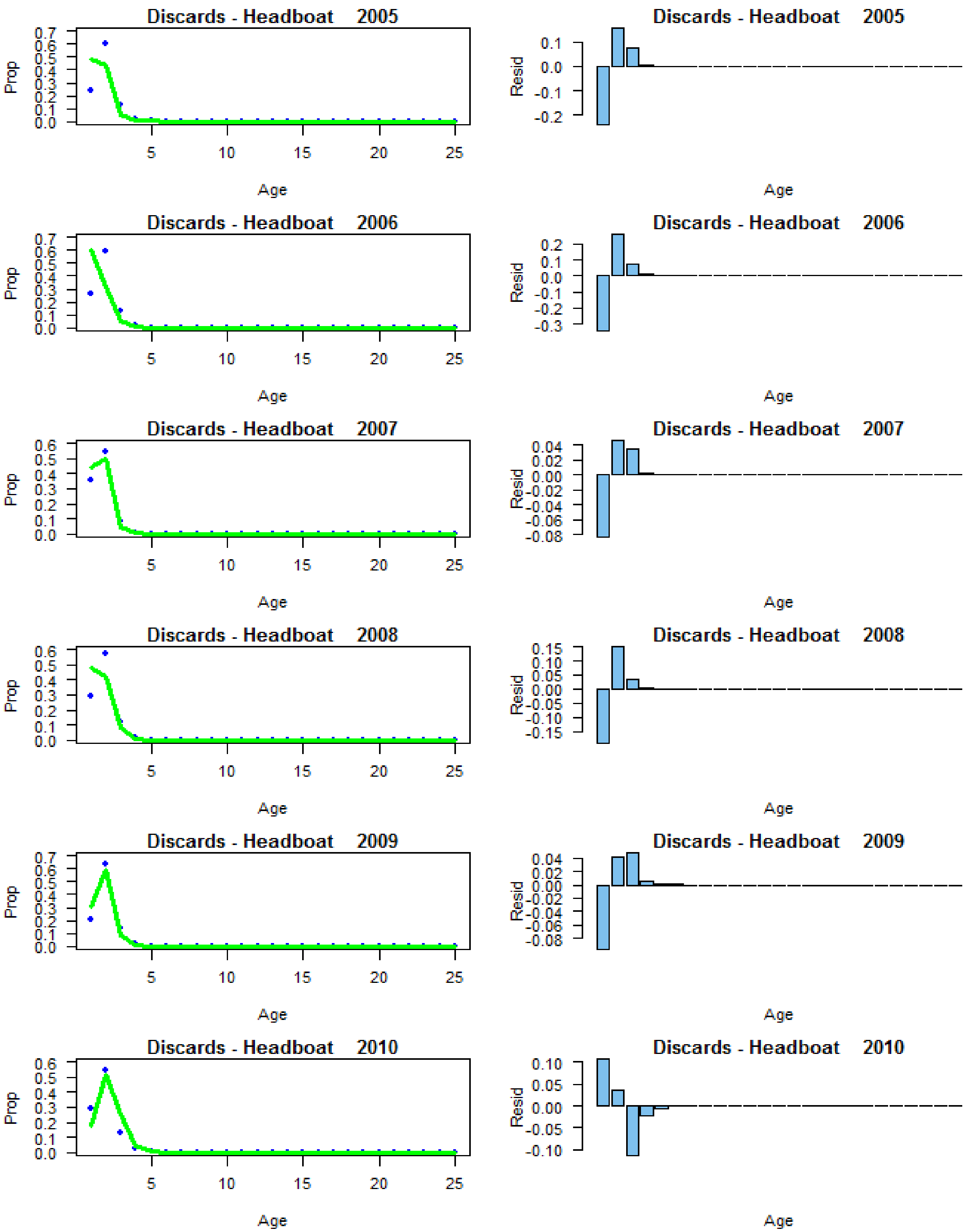


Figure 4.1.5 continued. Fits of the ASAP model to the age composition of discards by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

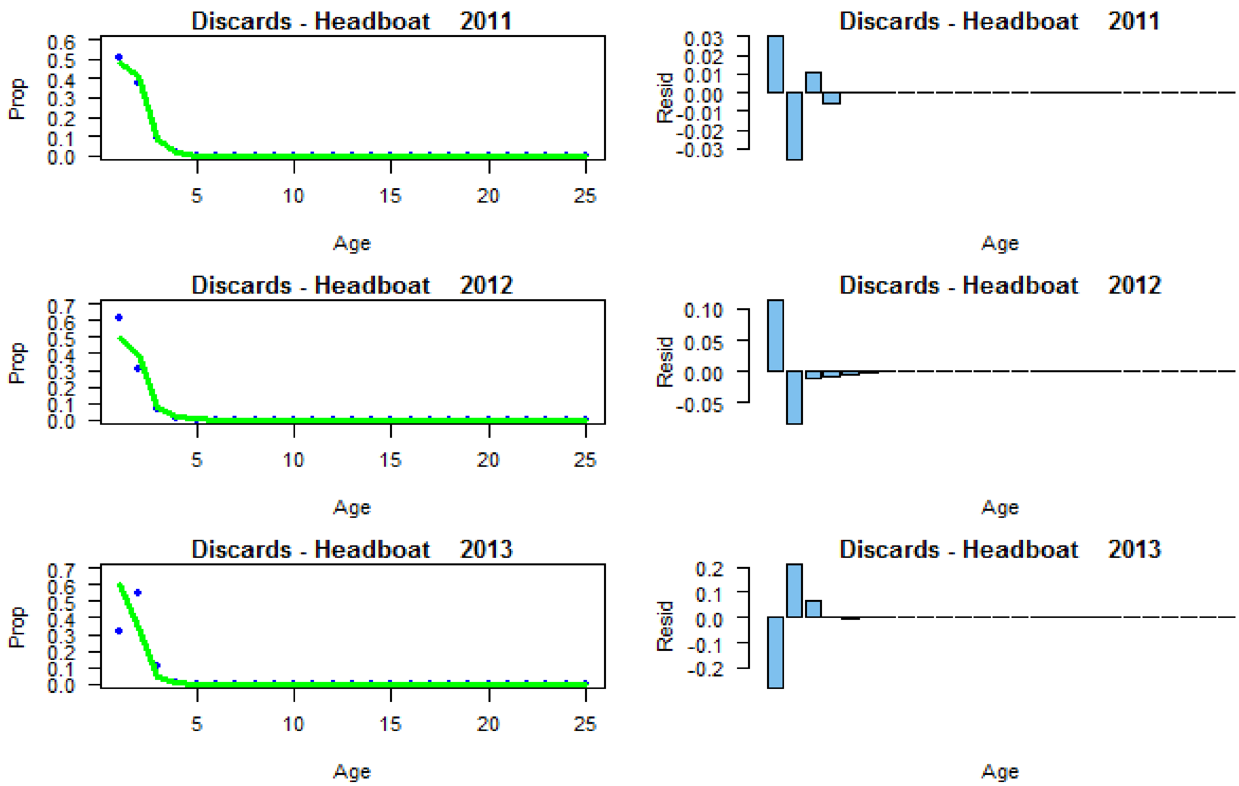


Figure 4.1.5 continued. Fits of the ASAP model to the age composition of discards by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

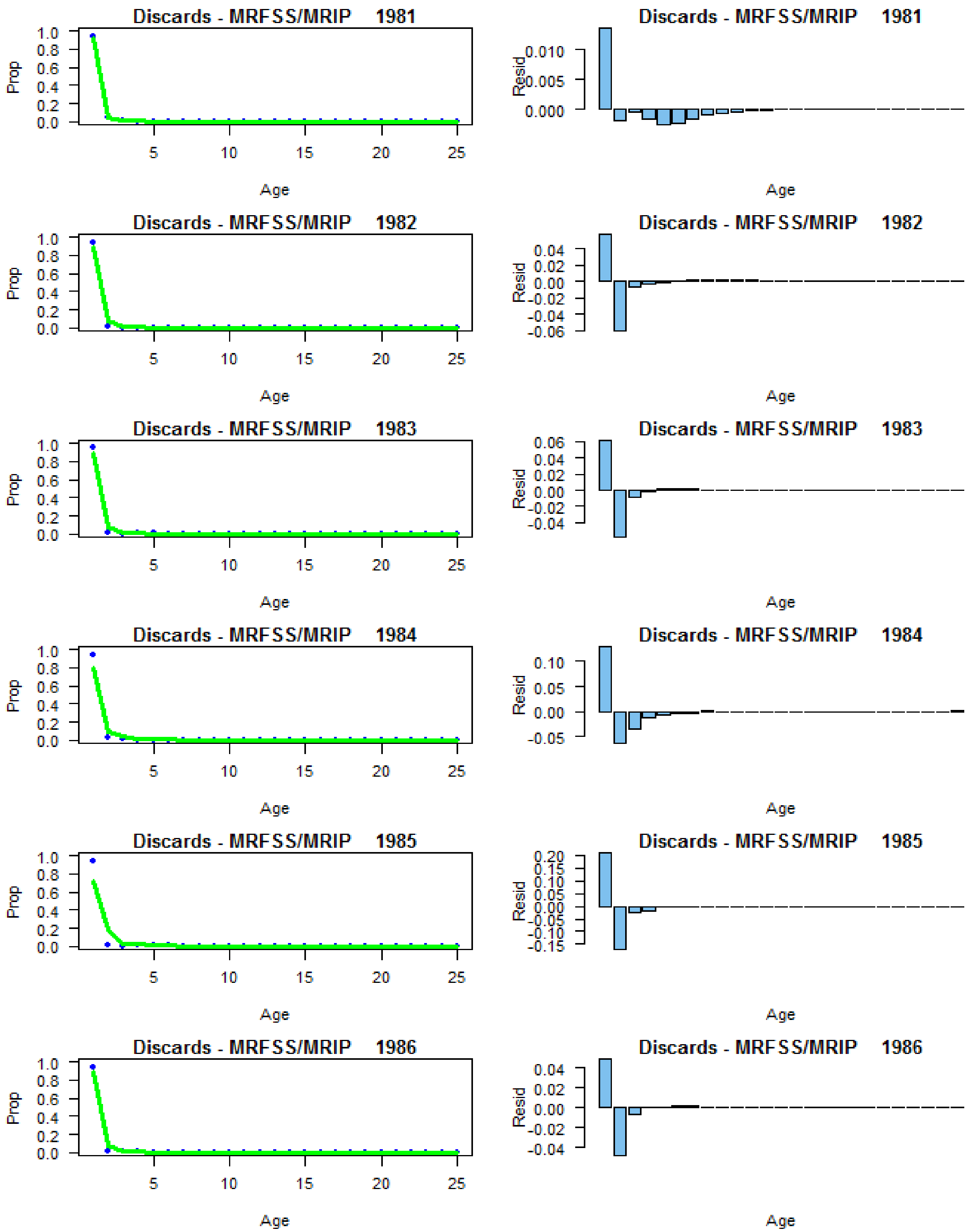


Figure 4.1.5 continued. Fits of the ASAP model to the age composition of discards by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

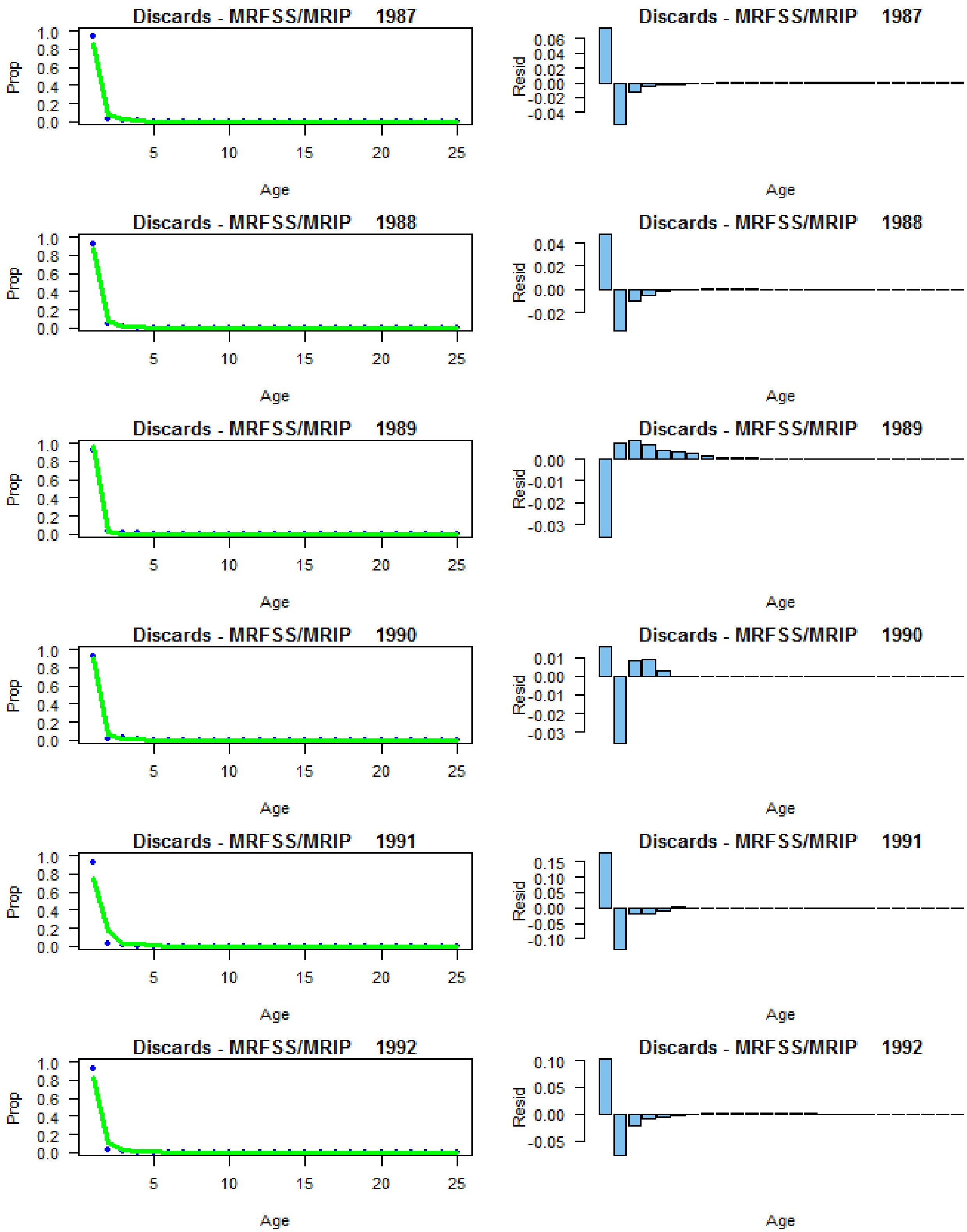


Figure 4.1.5 continued. Fits of the ASAP model to the age composition of discards by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

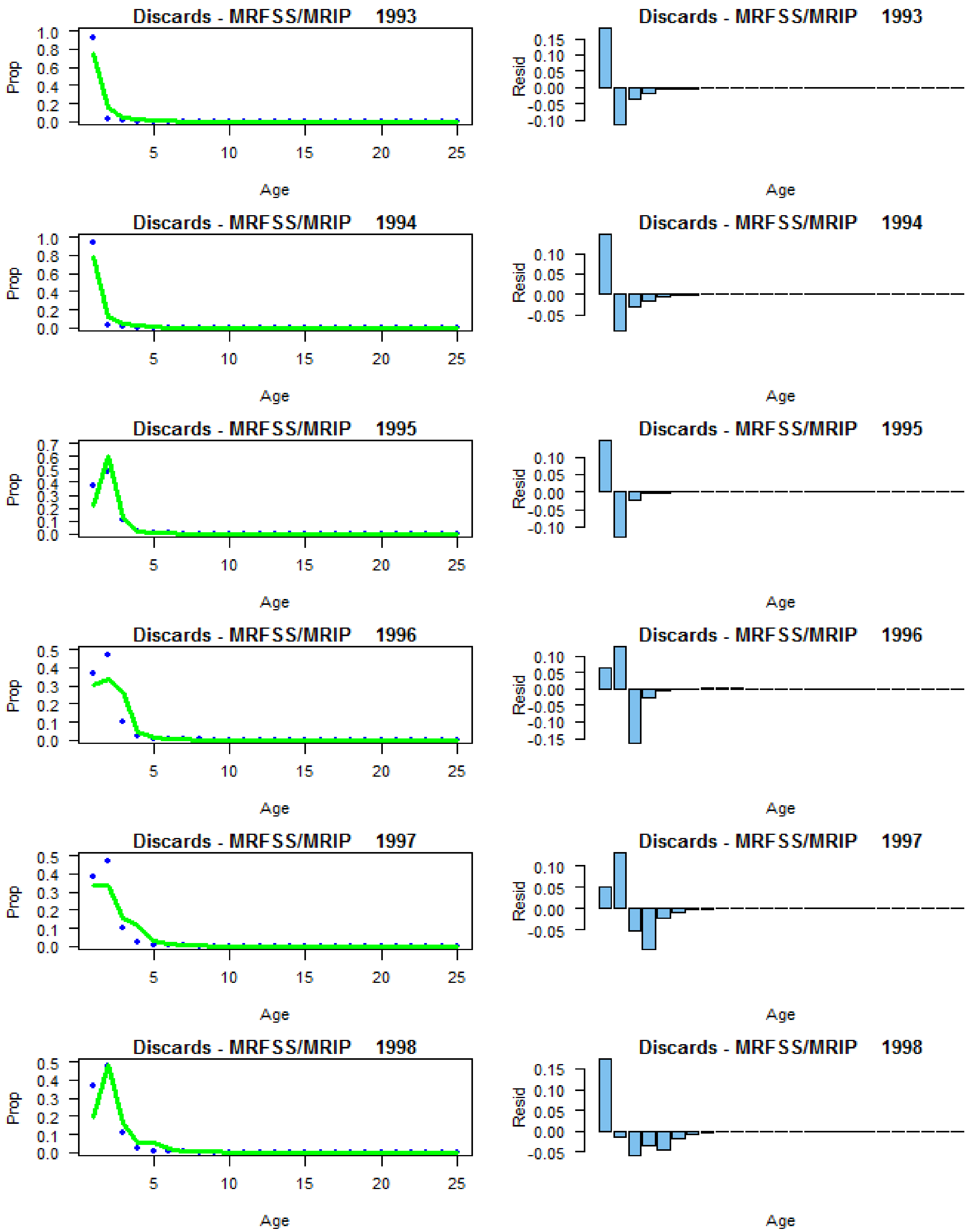


Figure 4.1.5 continued. Fits of the ASAP model to the age composition of discards by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

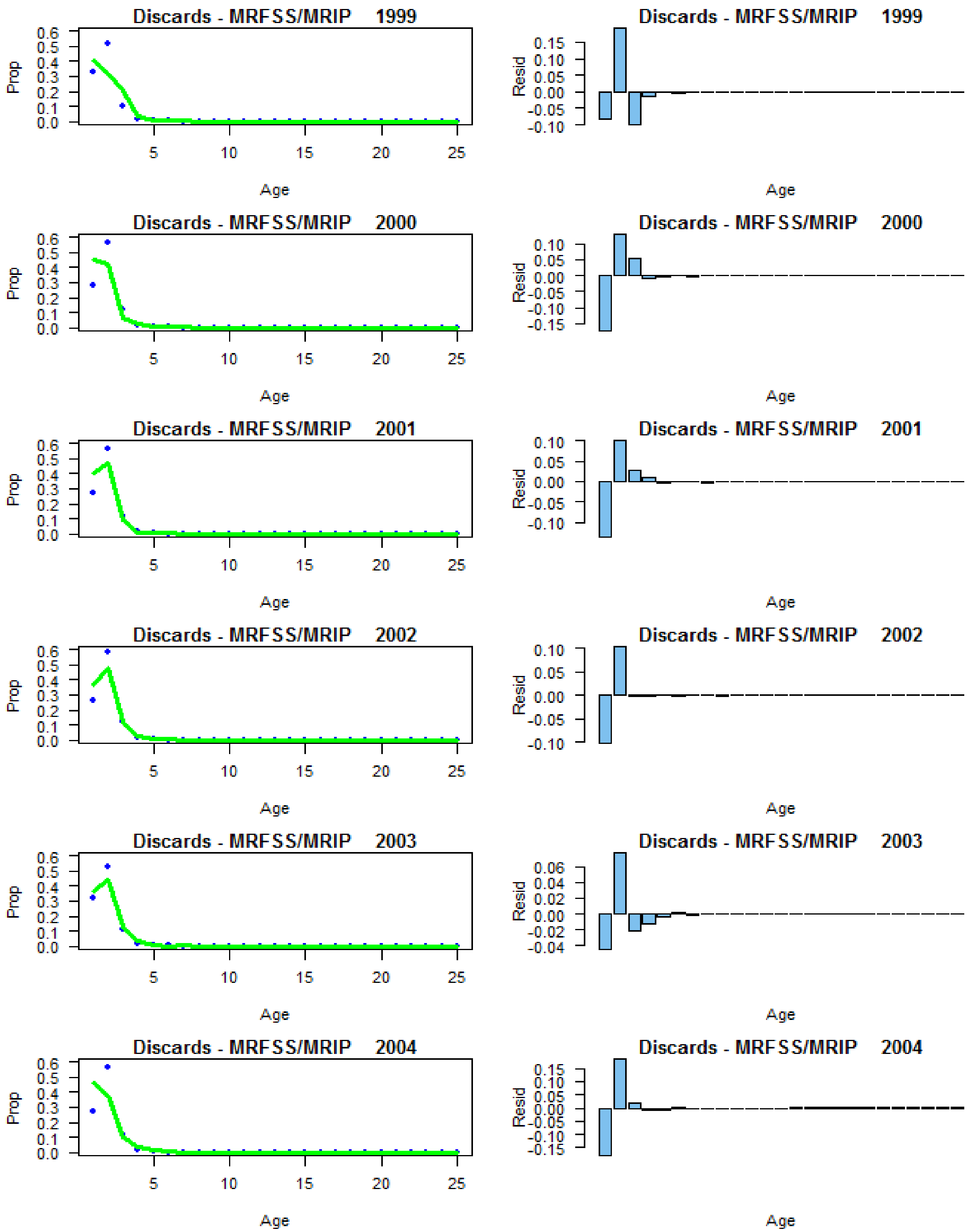


Figure 4.1.5 continued. Fits of the ASAP model to the age composition of discards by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

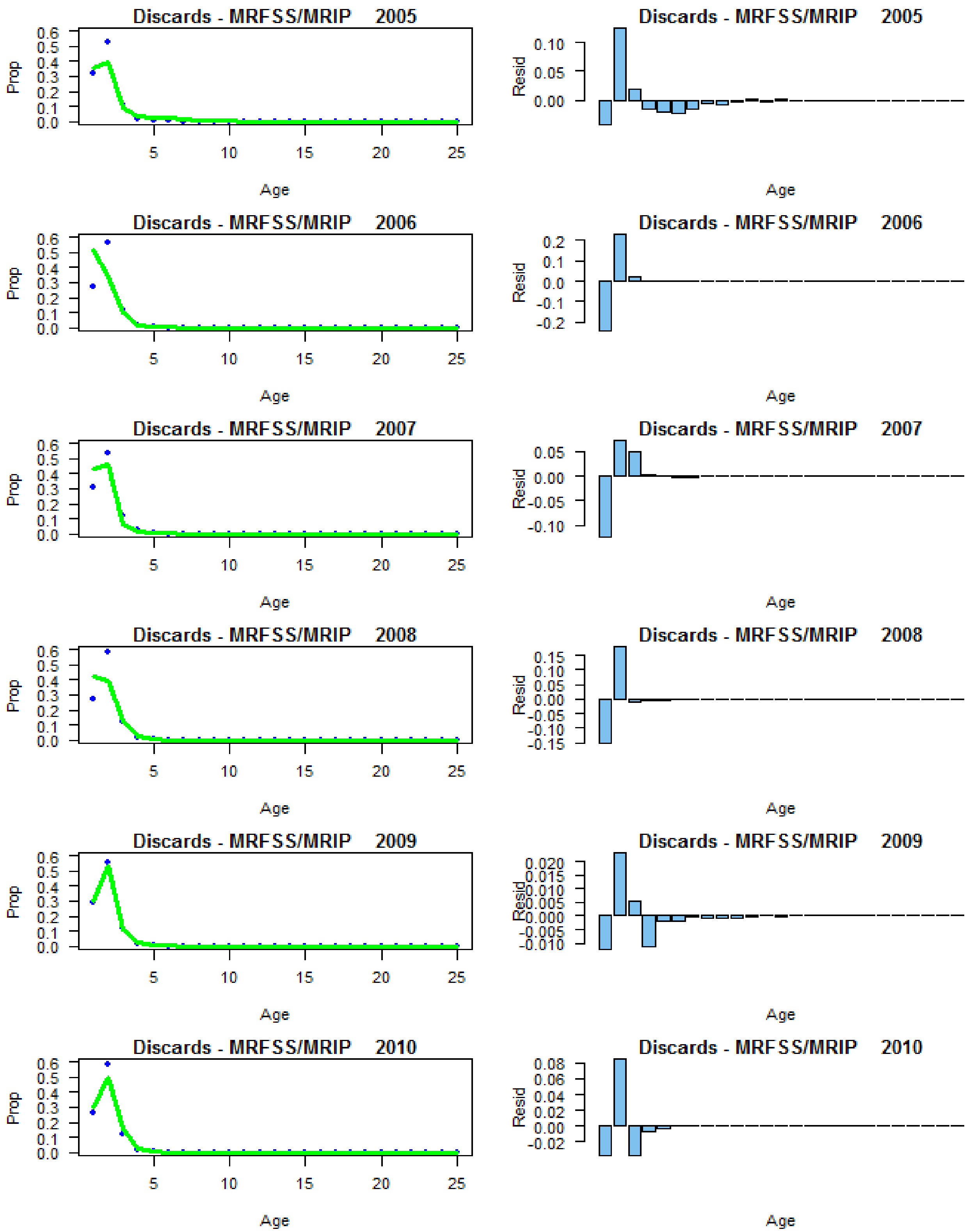


Figure 4.1.5 continued. Fits of the ASAP model to the age composition of discards by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

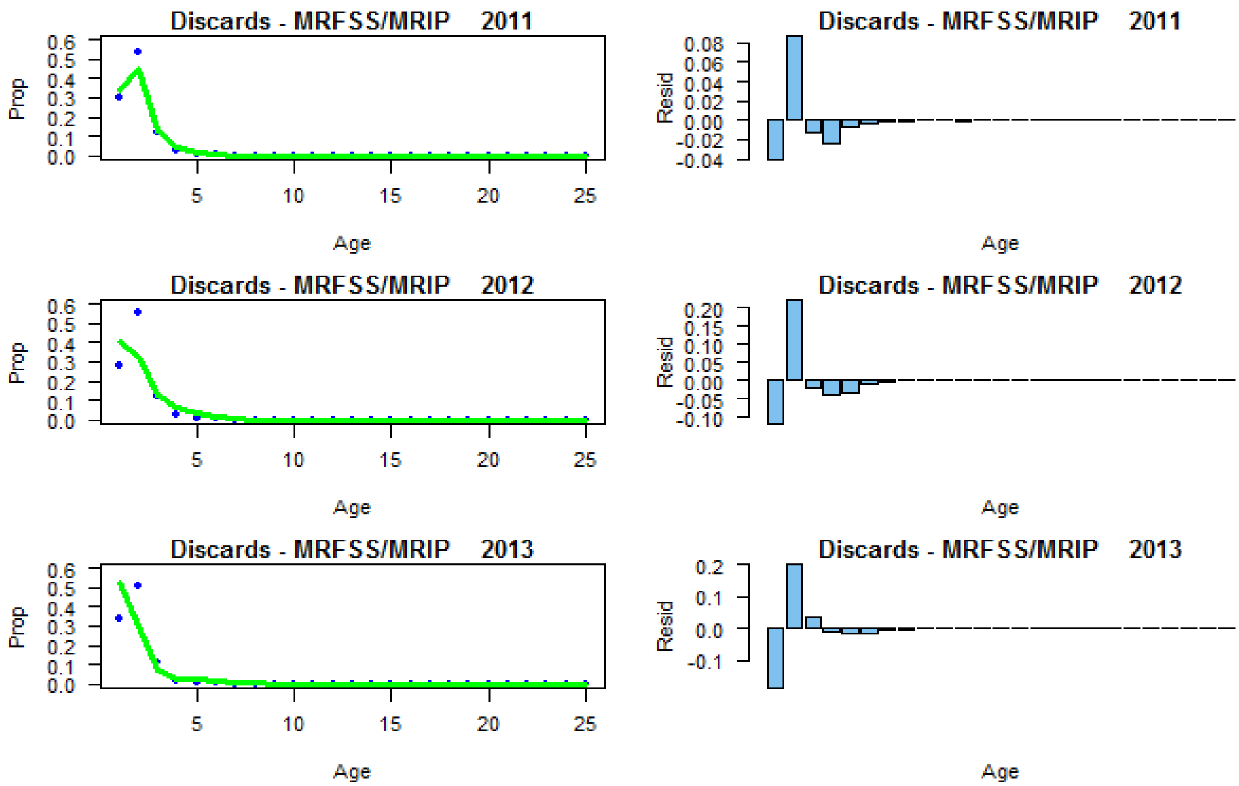


Figure 4.1.5 continued. Fits of the ASAP model to the age composition of discards by fishery and year. The points are the observed proportions and the lines are the predicted values from the model.

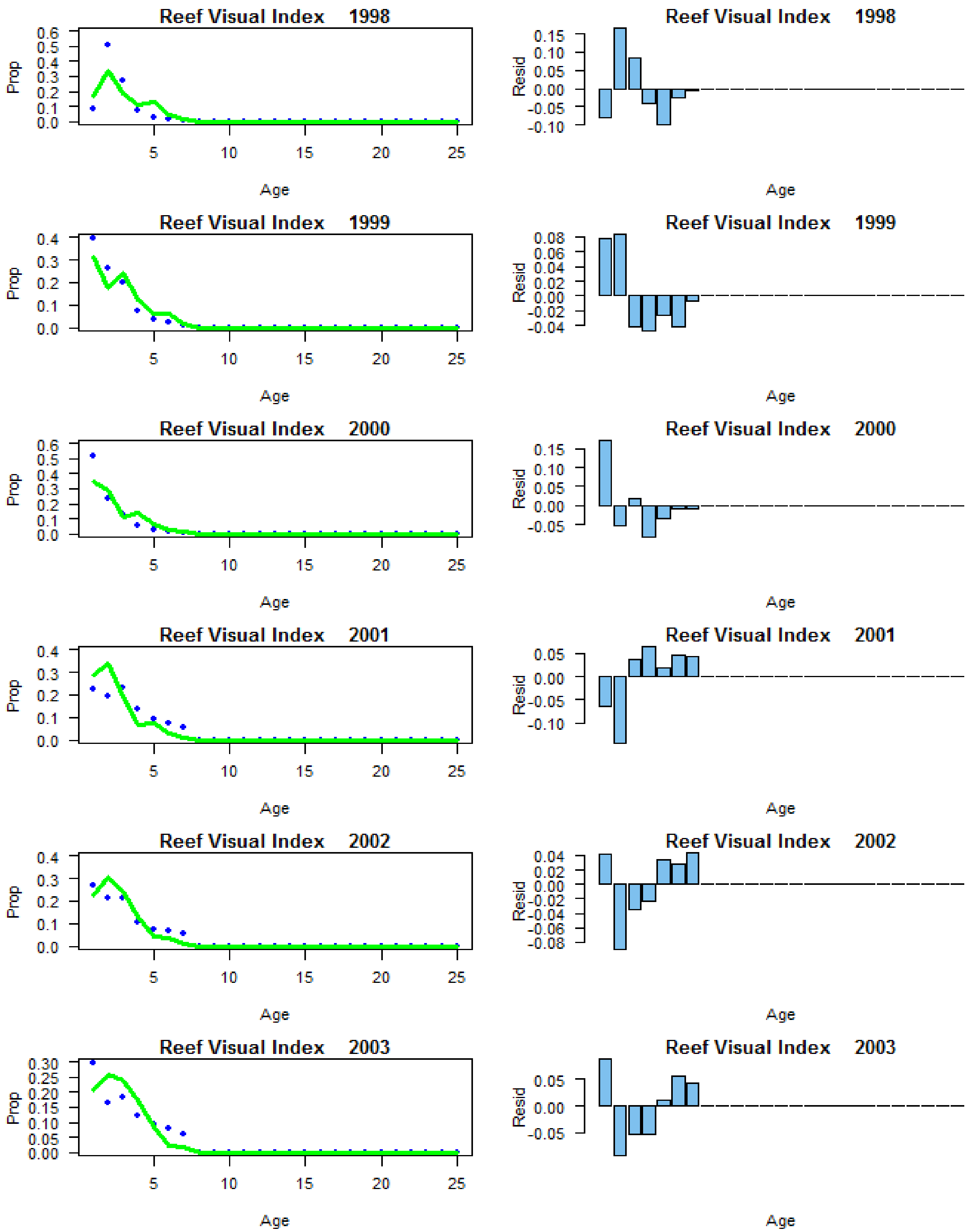


Figure 4.1.6. Fits of the ASAP model to the NMFS-UM Reef Visual Census age composition by year. The points are the observed proportions and the lines are the predicted values from the model.

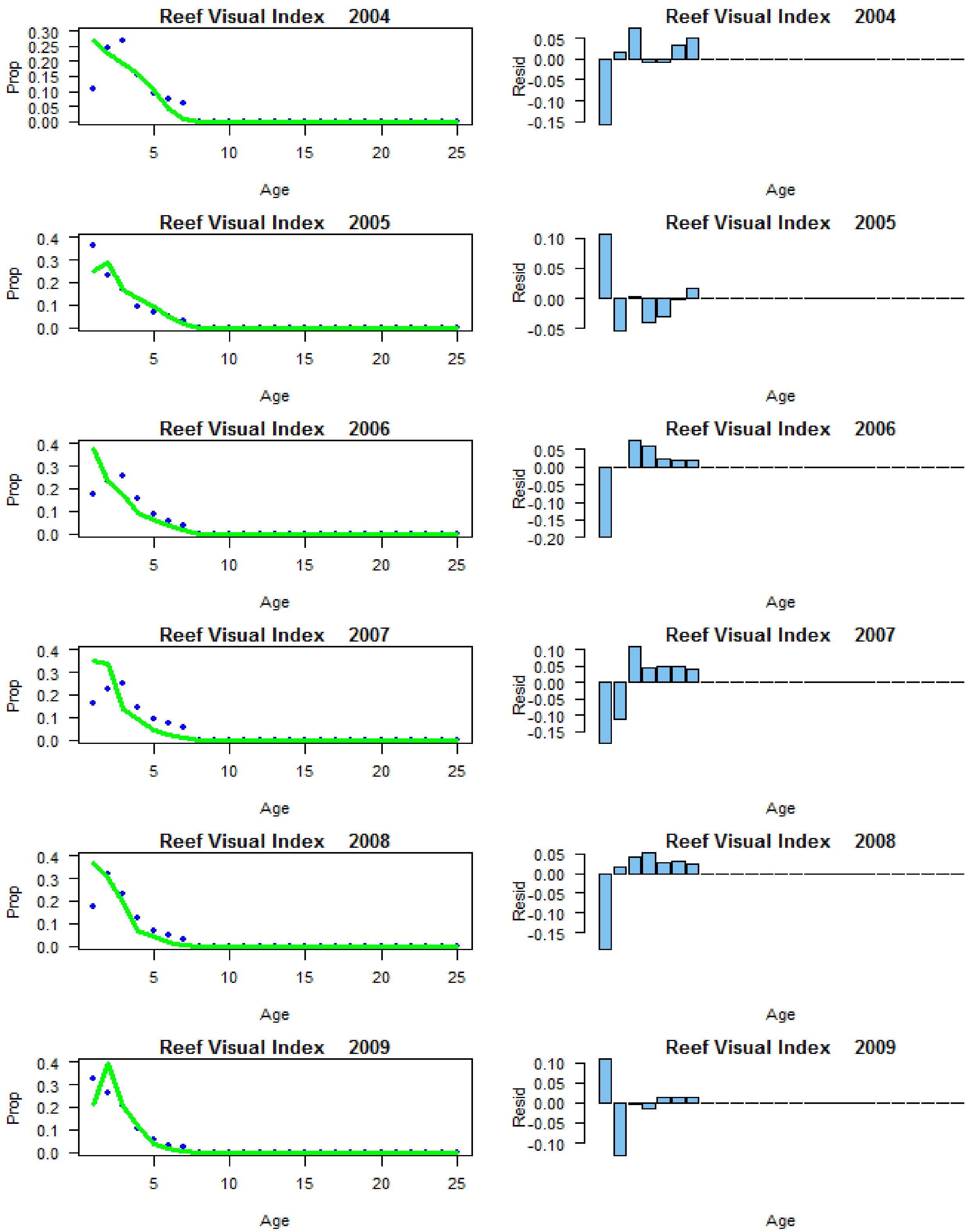


Figure 4.1.6 continued. Fits of the ASAP model to the NMFS-UM Reef Visual Census age composition by year.

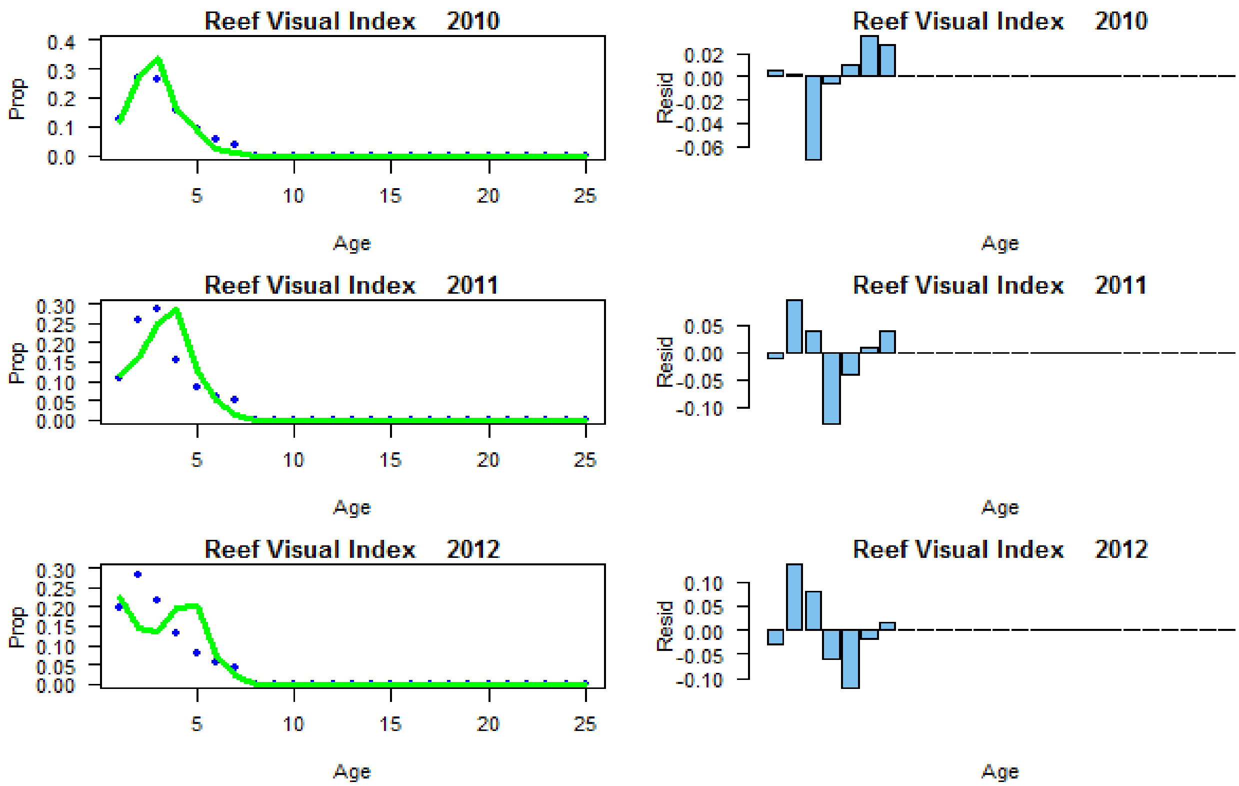
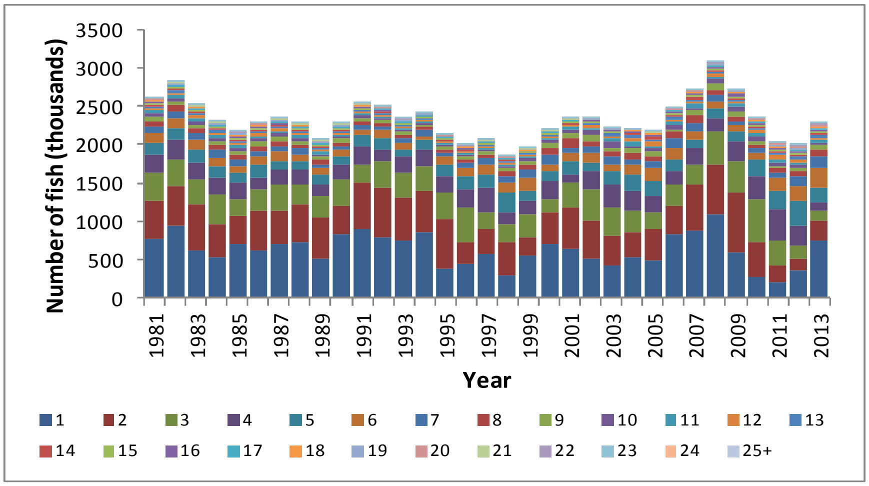
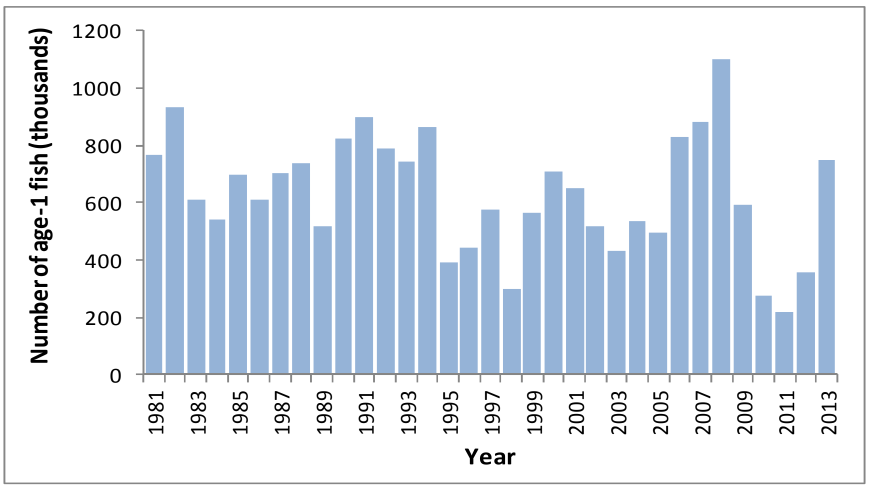


Figure 4.1.6 continued. Fits of the ASAP model to the NMFS-UM Reef Visual Census age composition by year.

a.



b.



c.

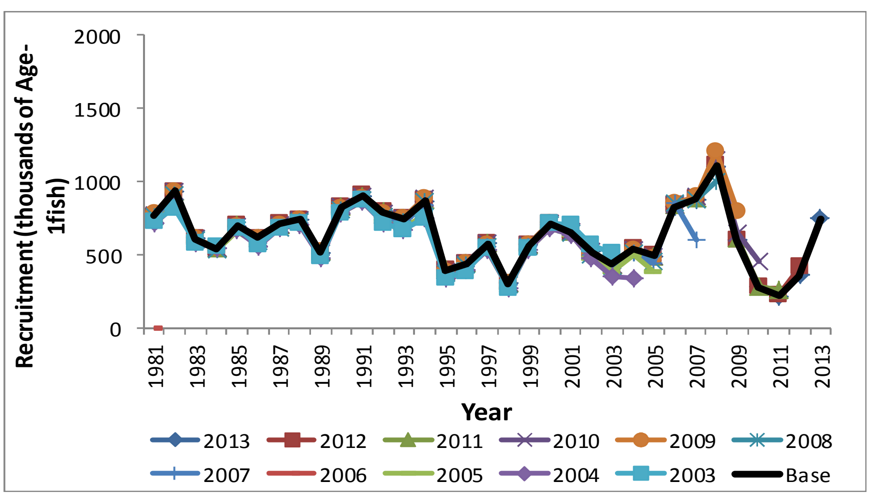
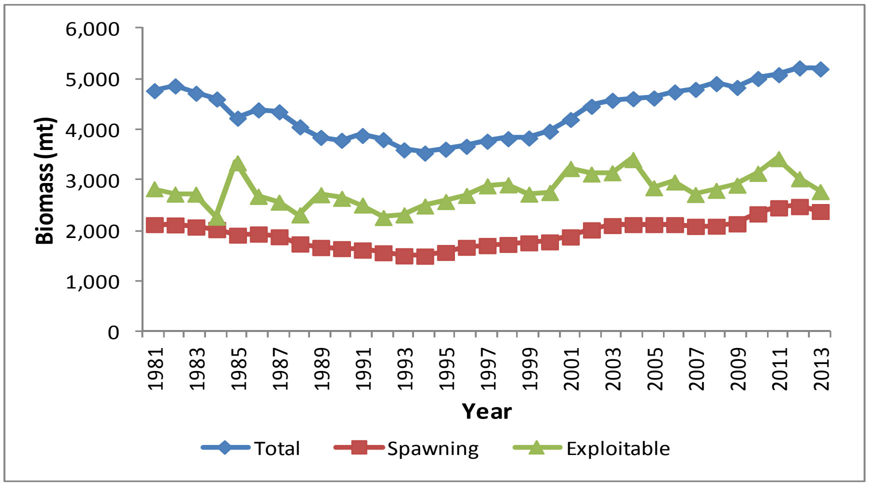
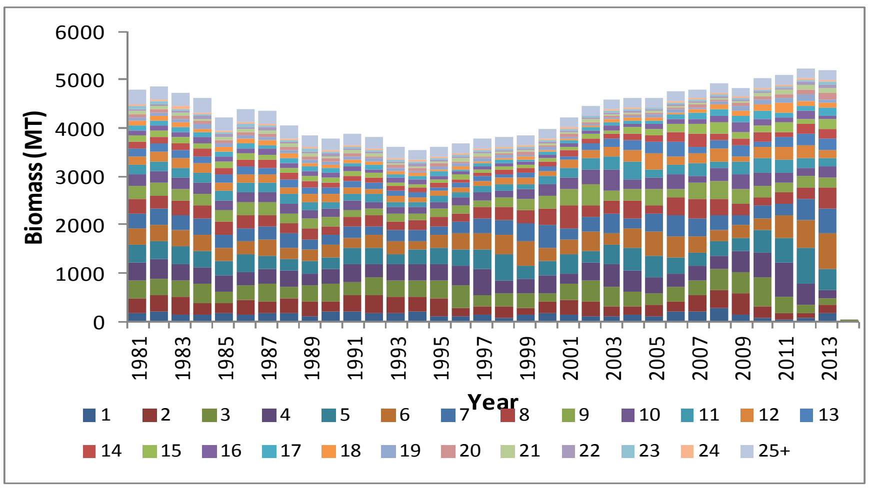


Figure 4.3. Number of fish by year and age from the base run (a), recruitment by year (b), and retrospective recruitment pattern (c).

a.



b.



c.

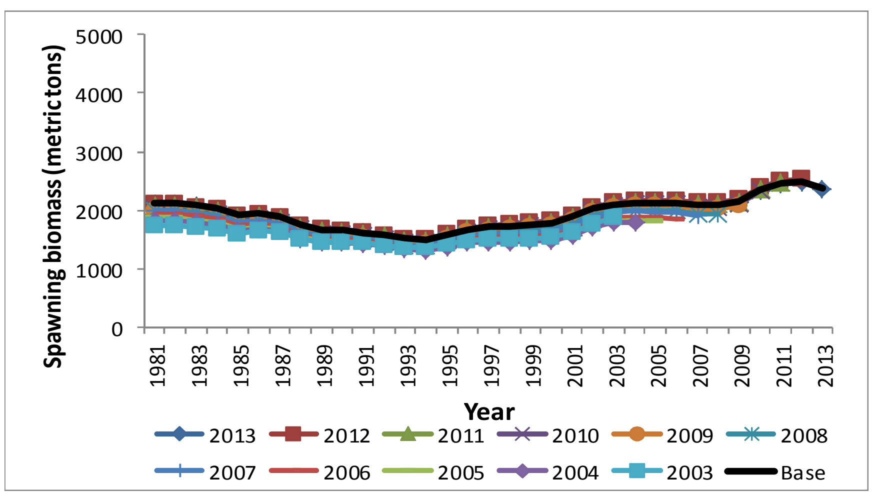
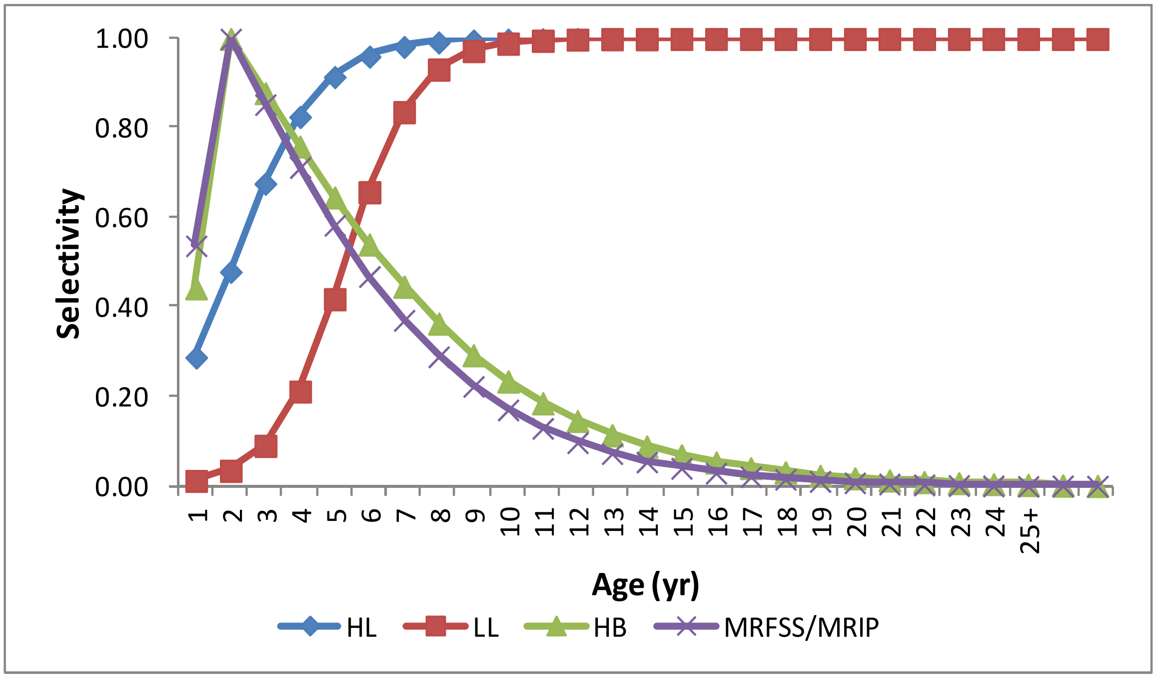


Figure 4.4. The trajectories of total biomass, spawning biomass, and exploitable biomass in metric tons (a), total biomass by year and age (b), and spawning biomass retrospective pattern (c).

a.



b.

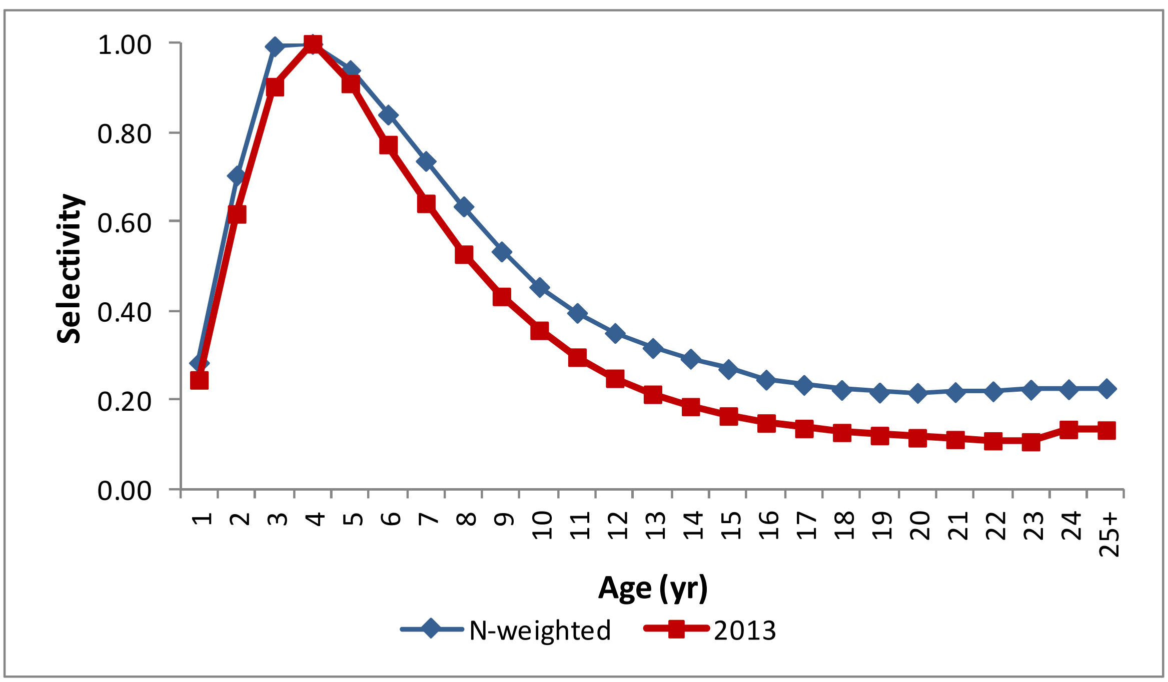


Figure 4.5. Selectivity patterns from ASAP by fishery (a) and the overall selectivity N-weighted across fisheries and using just the 2013 results (b).

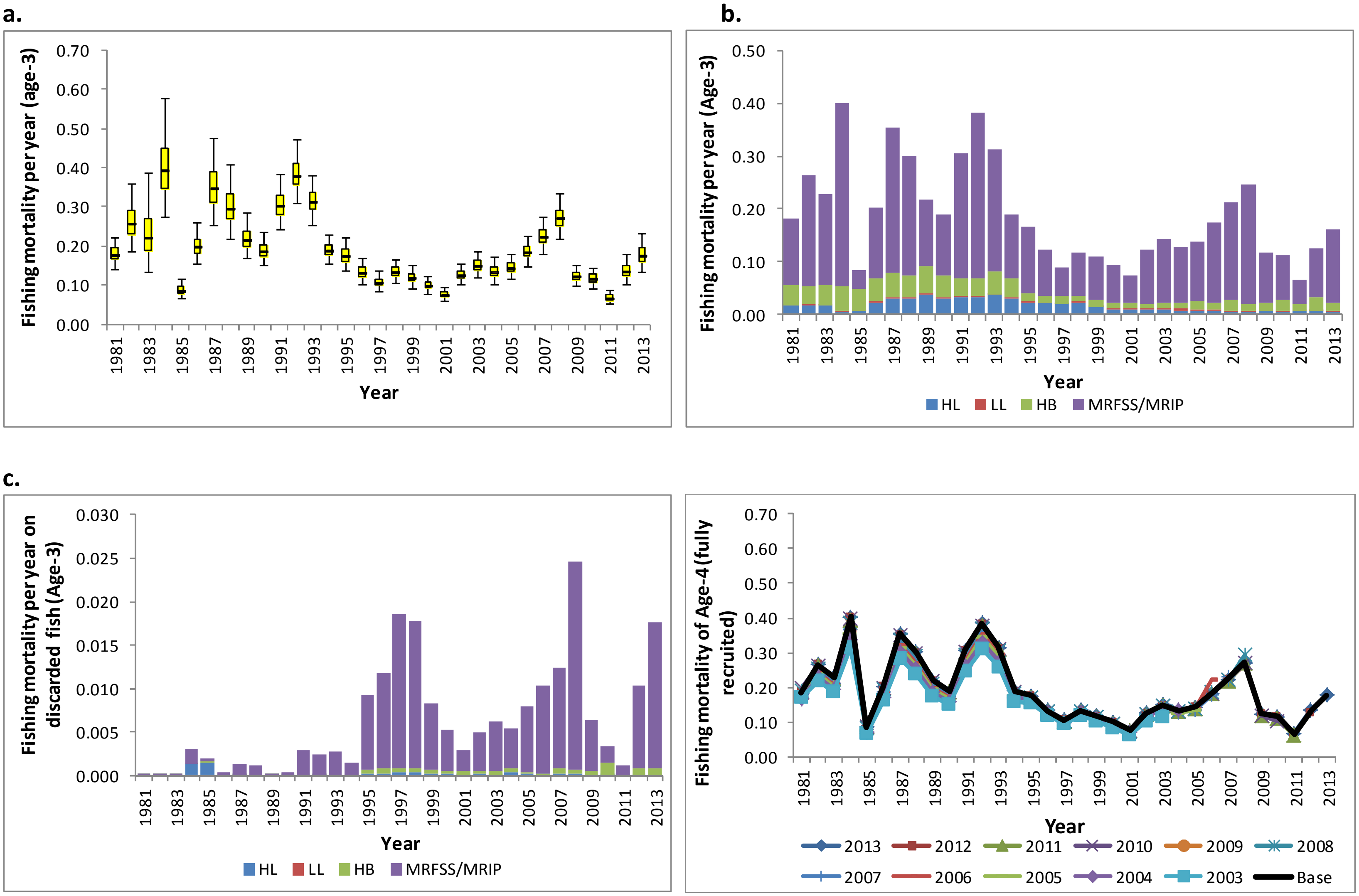
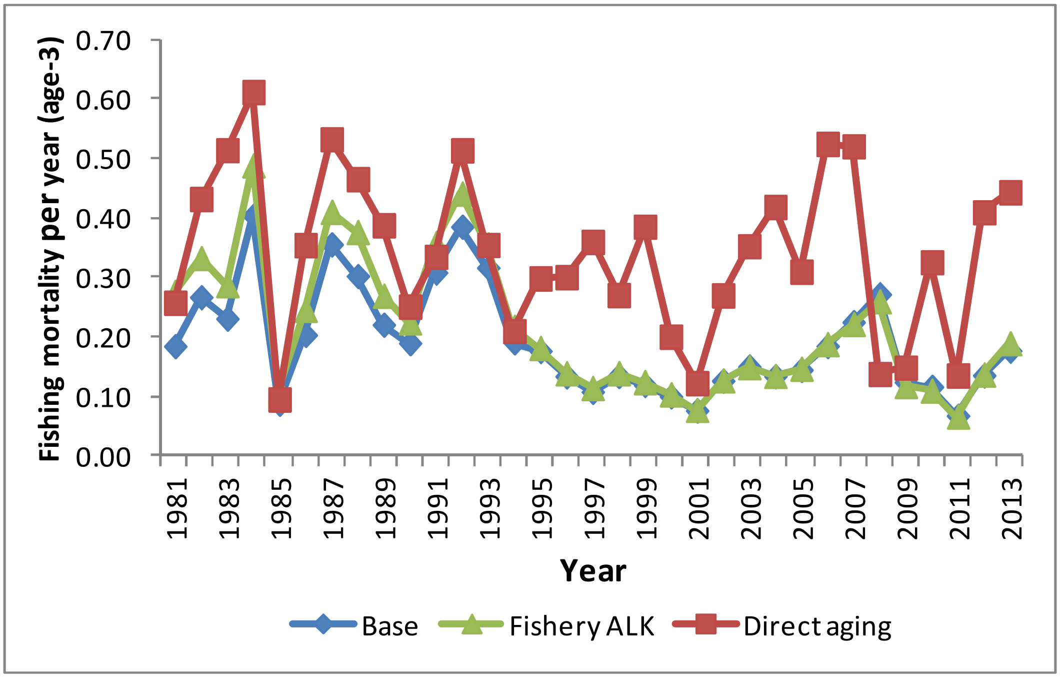


Figure 4.6.1. Comparison of total fishing mortality rates on age-3 fish by year, including discards, from the ASAP base run across fisheries (a), direct fishing mortality rates by fishery (b), discards by fishery (c), and retrospective pattern (d).

a.



b.

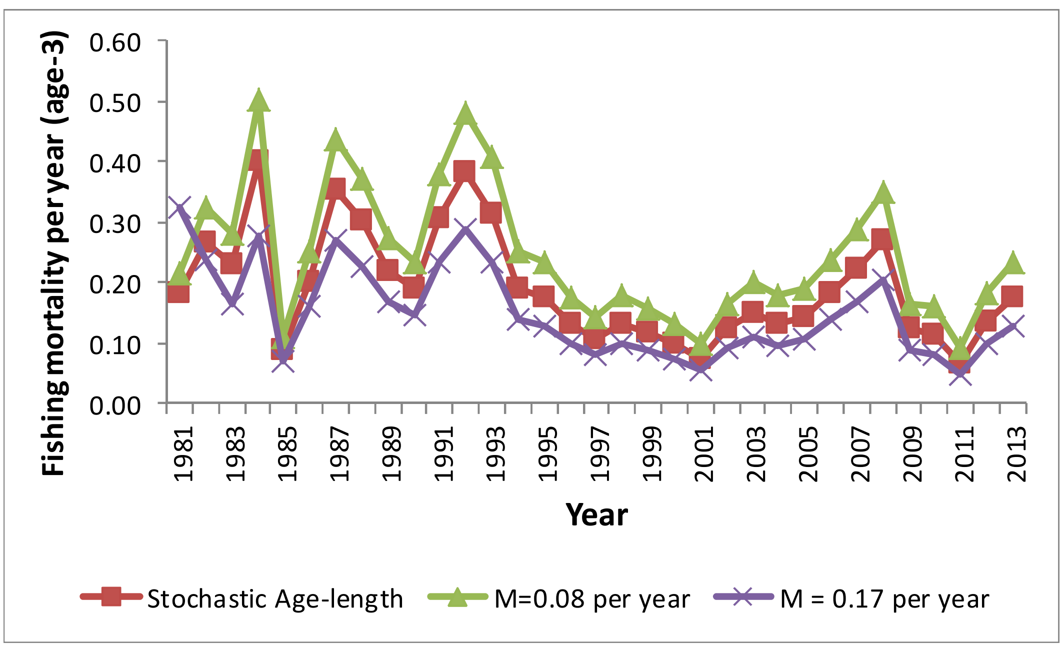


Figure 4.6.2. Comparison of total fishing mortality rates on age-3 fish by year by aging methods, including discards, from the ASAP base run across fisheries (a) and a comparison of the total fishing mortality estimates on age-3 fish using stochastic aging and average natural mortality rates of M = 0.08 per year, M = 0.11 per year (base run), and M = 0.17 per year.

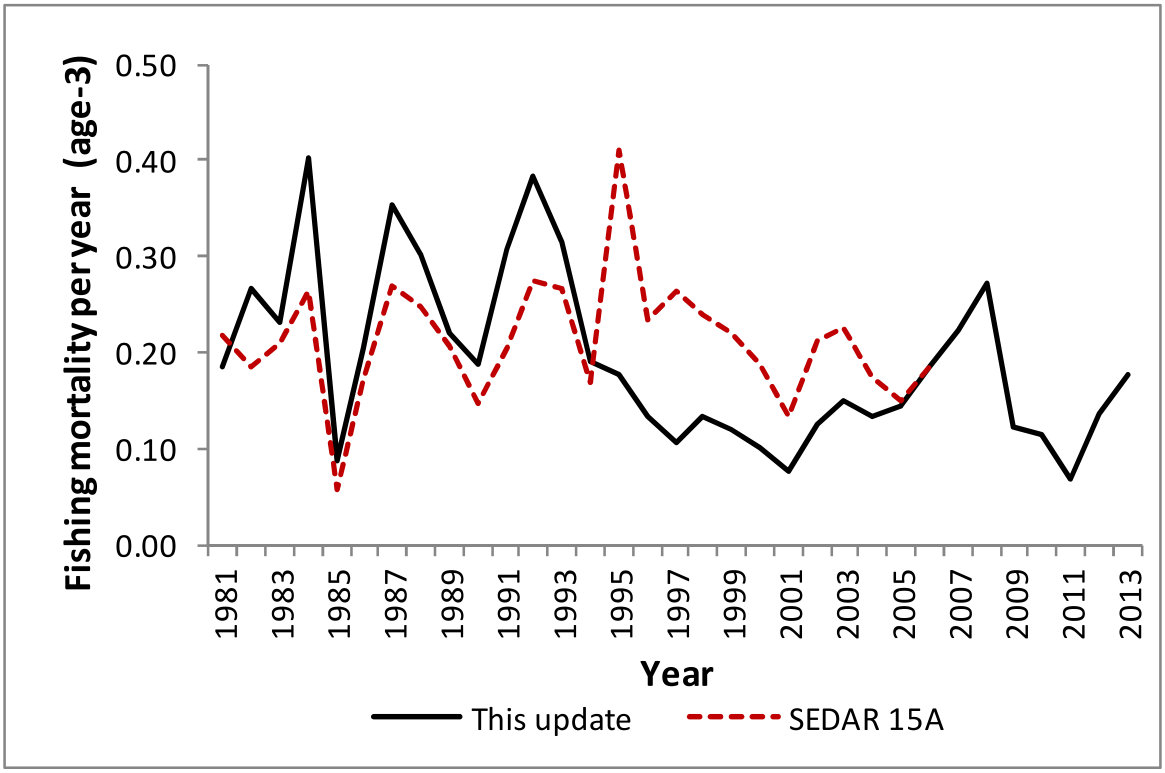
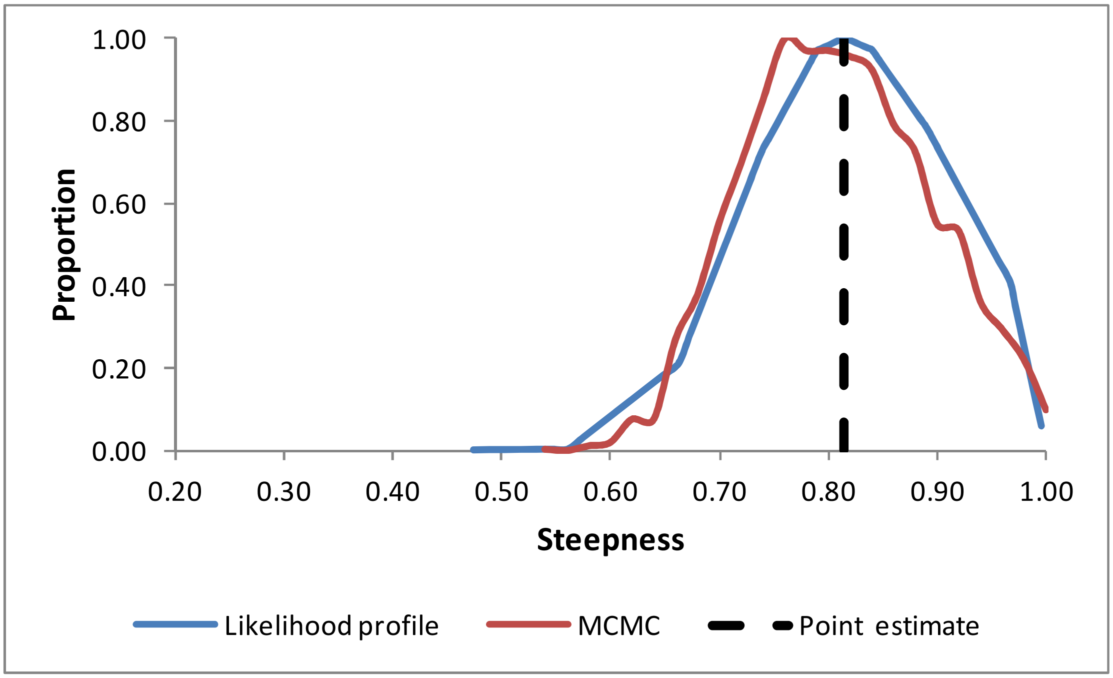


Figure 4.6.3. A comparison of total fishing mortality rates from this update and those from SEDAR 15A.

a.



b.

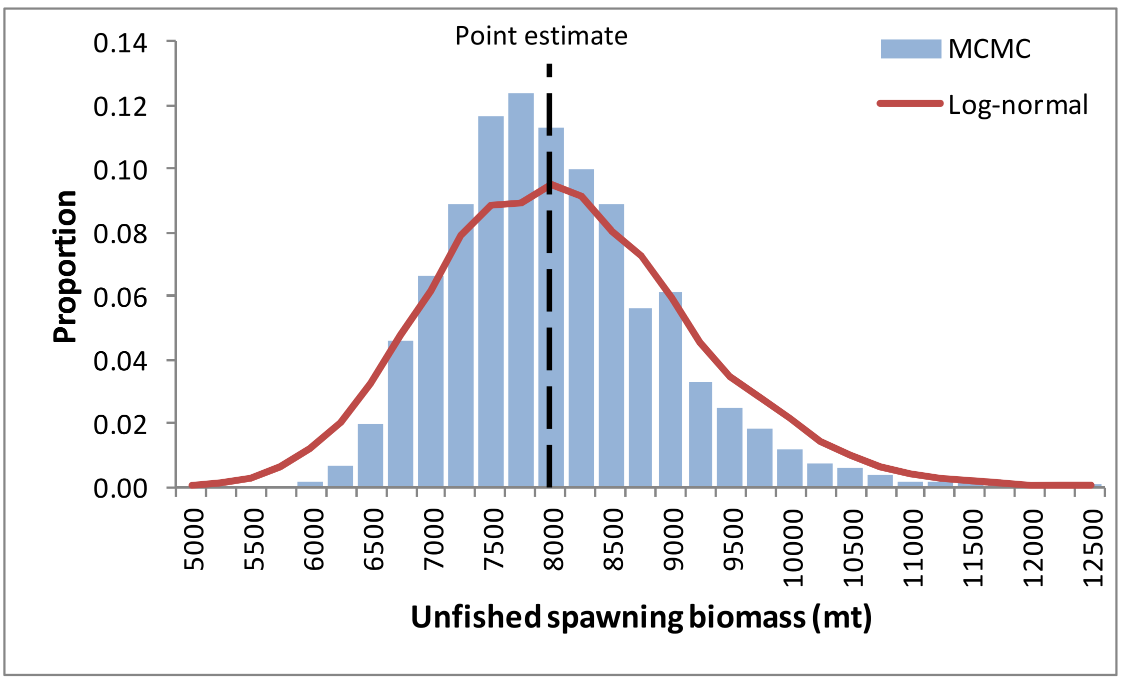
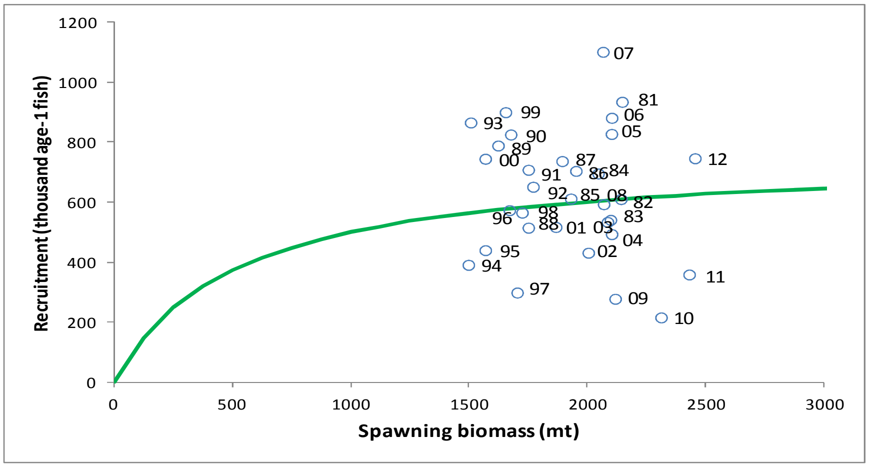
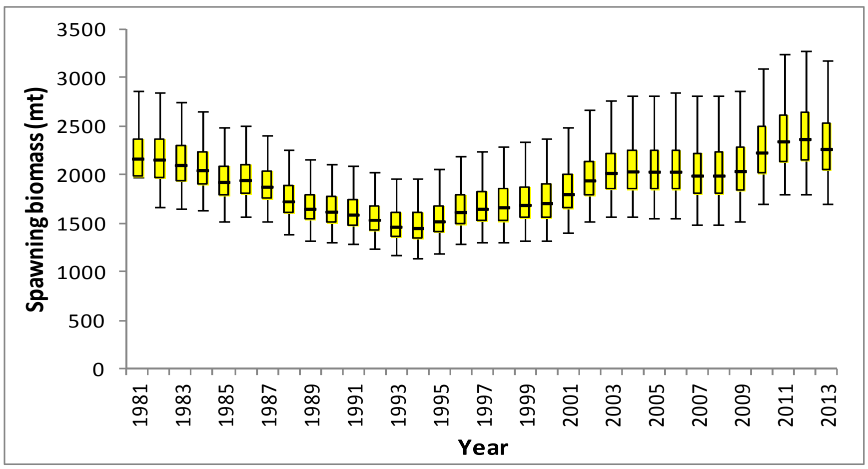


Figure 4.7.1. The distribution and normal approximation of steepness (a) and the distribution and log-normal approximation of the unfished spawning biomass in metric tons (b).

a.



b.



c.

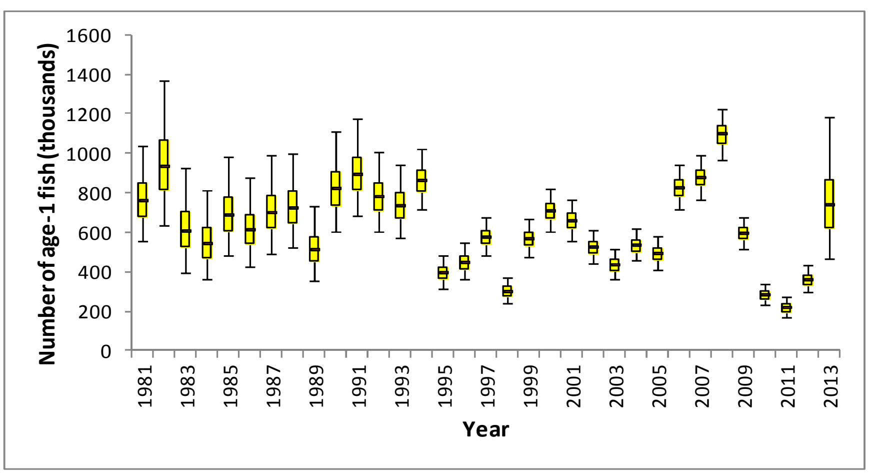


Figure 4.7.2. Annual recruitment, in thousands of fish, on spawning biomass in metric tons the year before and the predicted stock-recruit curve (a), the distribution of annual spawning biomass (a) and the recruitment, number of age-1 fish (b) estimated by Markov Chain Monte Carlo simulations. The vertical lines are the 95% confidence limits, the boxes are the inter-quartile ranges, and the horizontal lines are the medians from 8 MCMC chains.

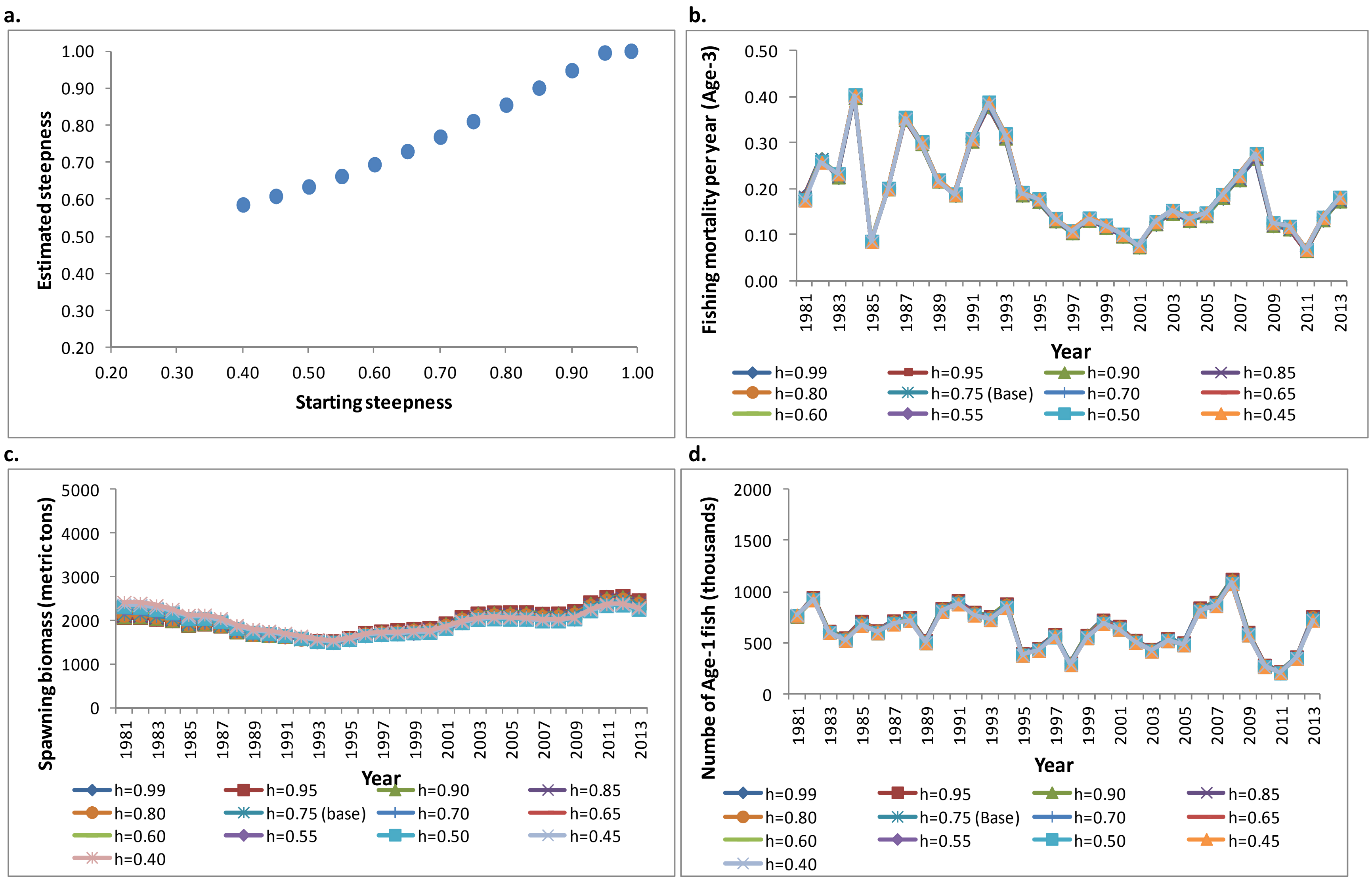
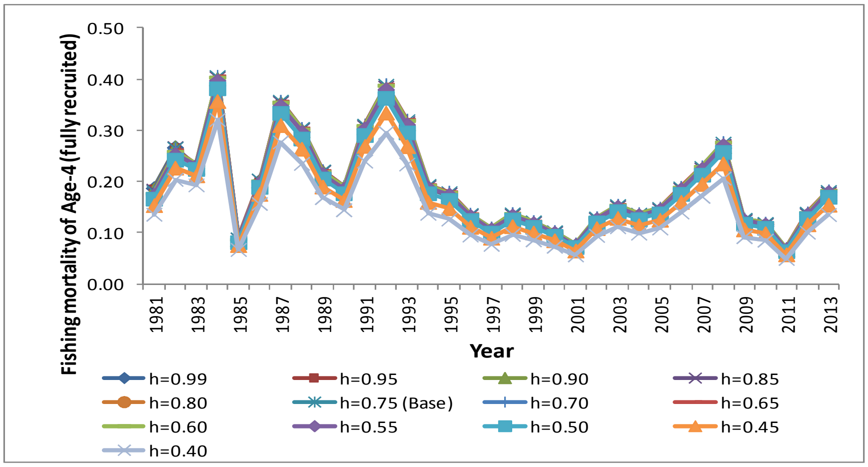
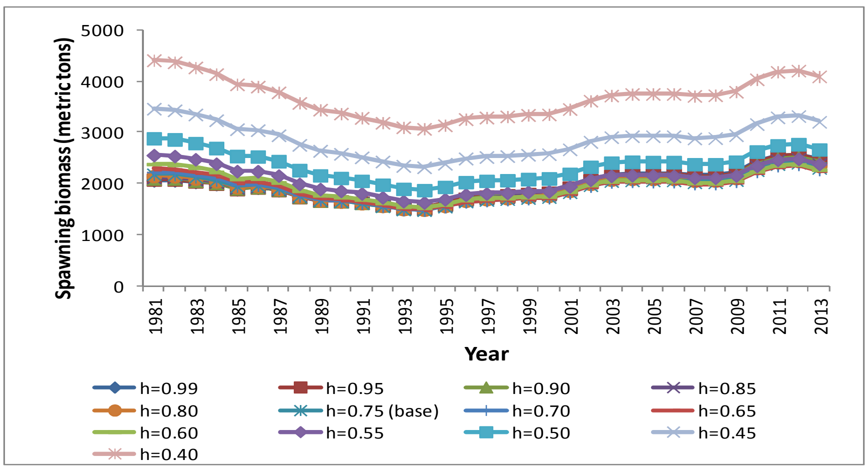


Figure 4.7.3. Sensitivity runs for a range of initial (0.40-0.99) and estimated steepness values (a), fishing mortality rates (b), spawning biomass (mt, c), and recruitment (d).

a.



b.



c.

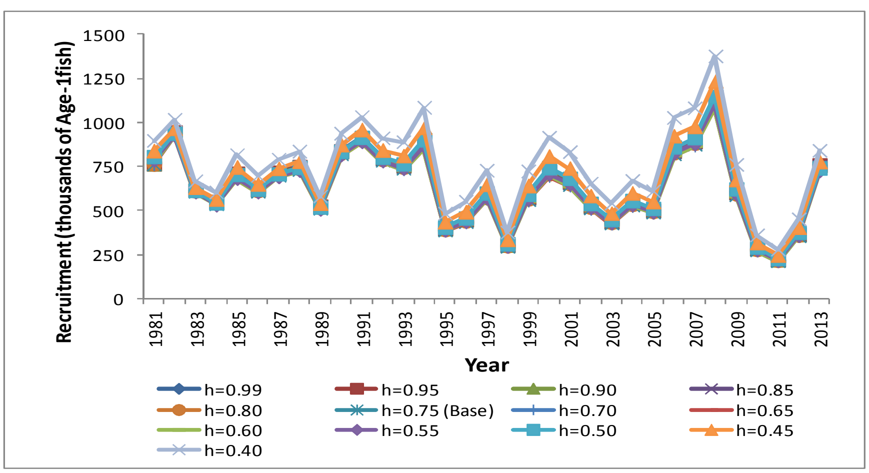
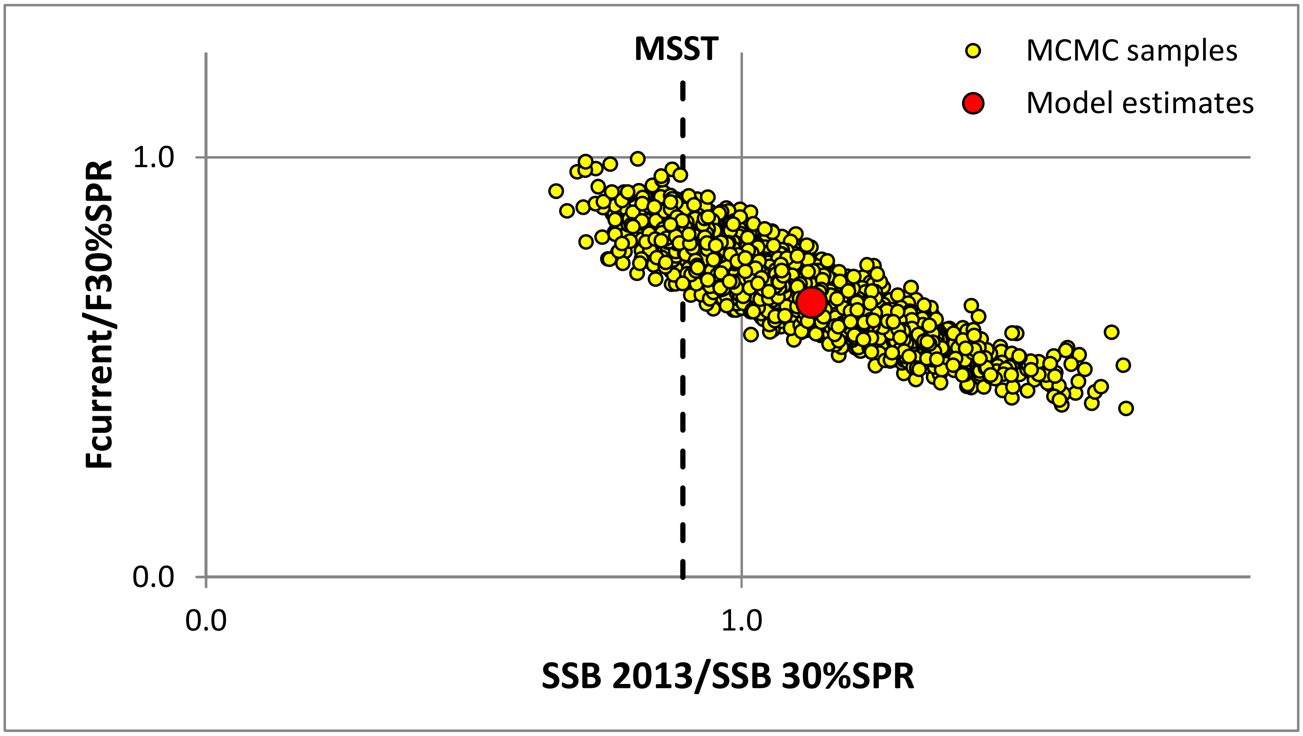
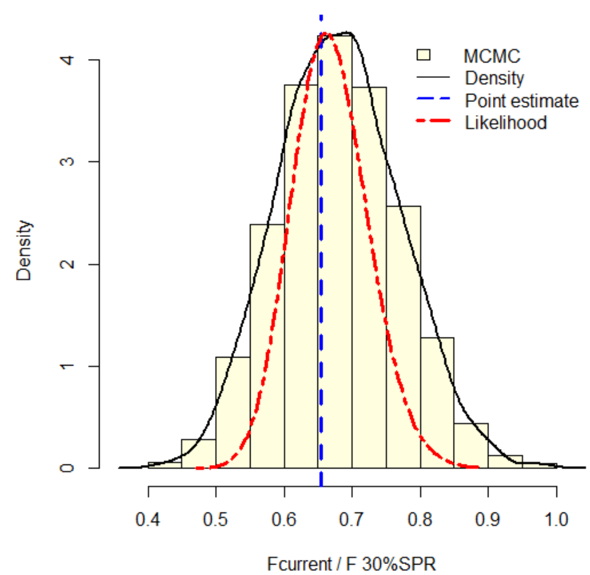


Figure 4.7.4. Sensitivity runs for a range of fixed steepness values (0.40-0.99) on fishing mortality rates (a), spawning biomass (mt, b), and recruitment (c).

a.



b. c.



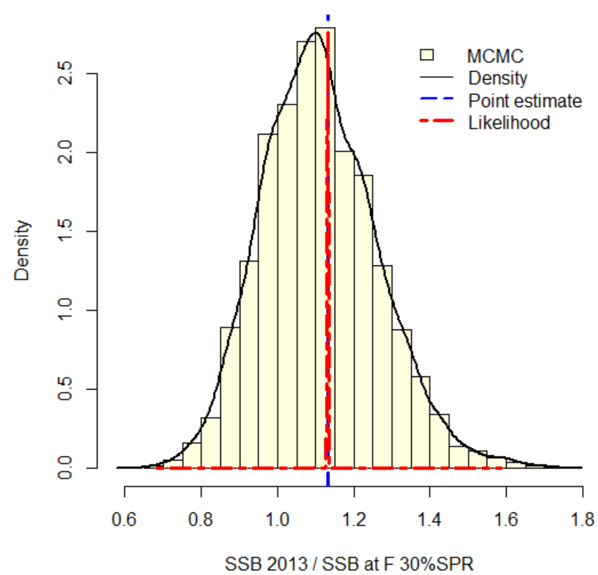
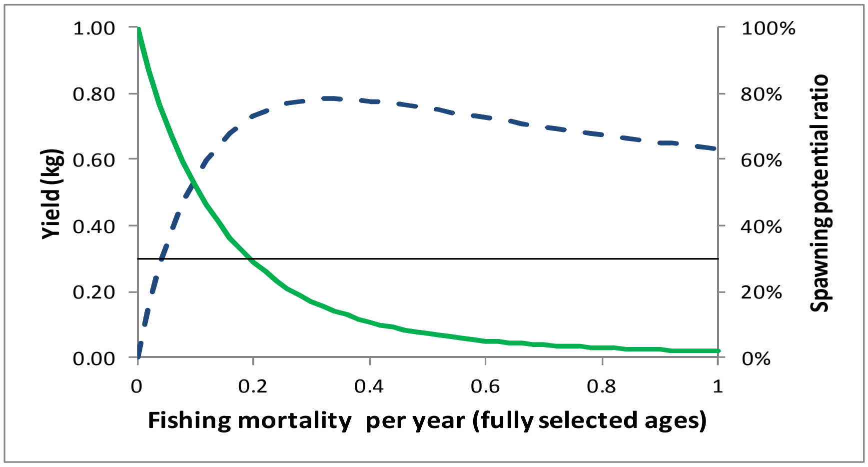
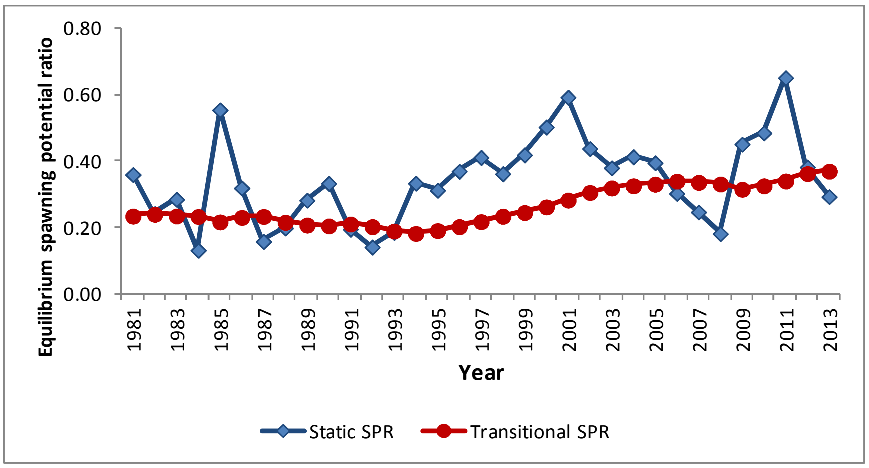


Figure 4.8.1. Phase plot of ratios of current fishing mortality (geometric mean of F_{2011}, F_{2012}, and F_{2013}) to $F_{30\%}$ on the spawning biomass in 2013 to spawning biomass at $F_{30\%}$ with the base run point estimate shown with a red circle (a) and the distributions of the F- (b) and the biomass-ratios (c). .
a.



b.



c.

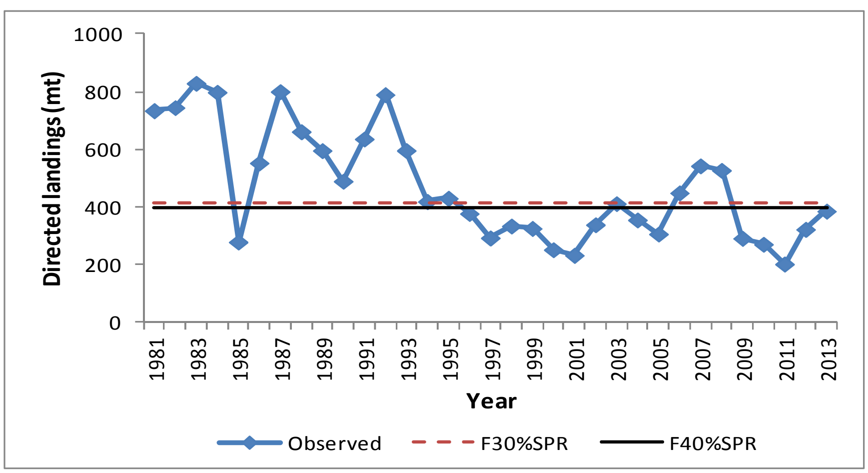


Figure 4.8.2. Yield-per-recruit, spawning potential ratio, and the SPR = 30% limit from the base run (a),. static and transitional spawning potential ratios by year from the base run (b), and total directed landings compared to yields at $F_{30\%SPR}$ and $F_{40\%SPR}$ (c).

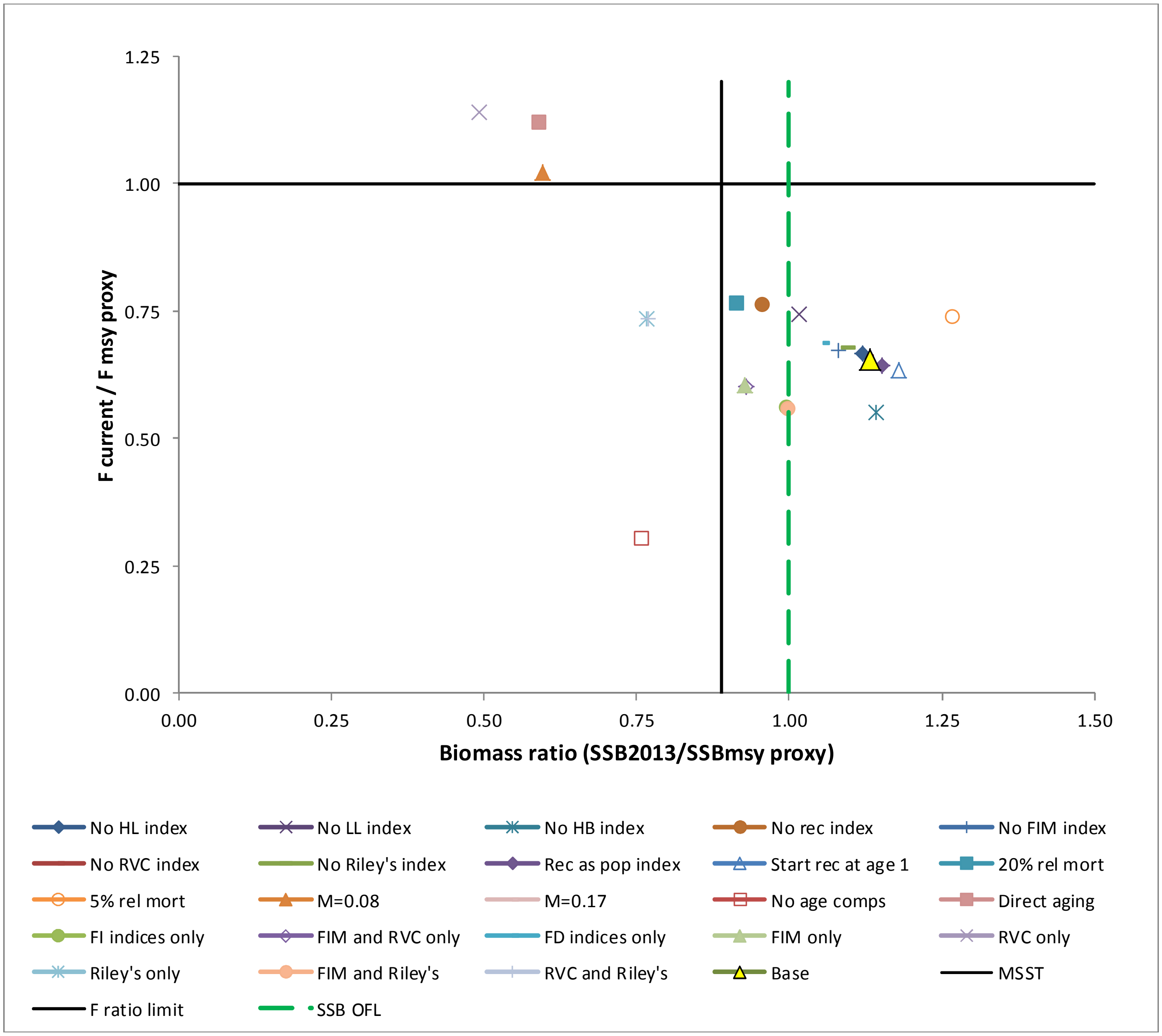
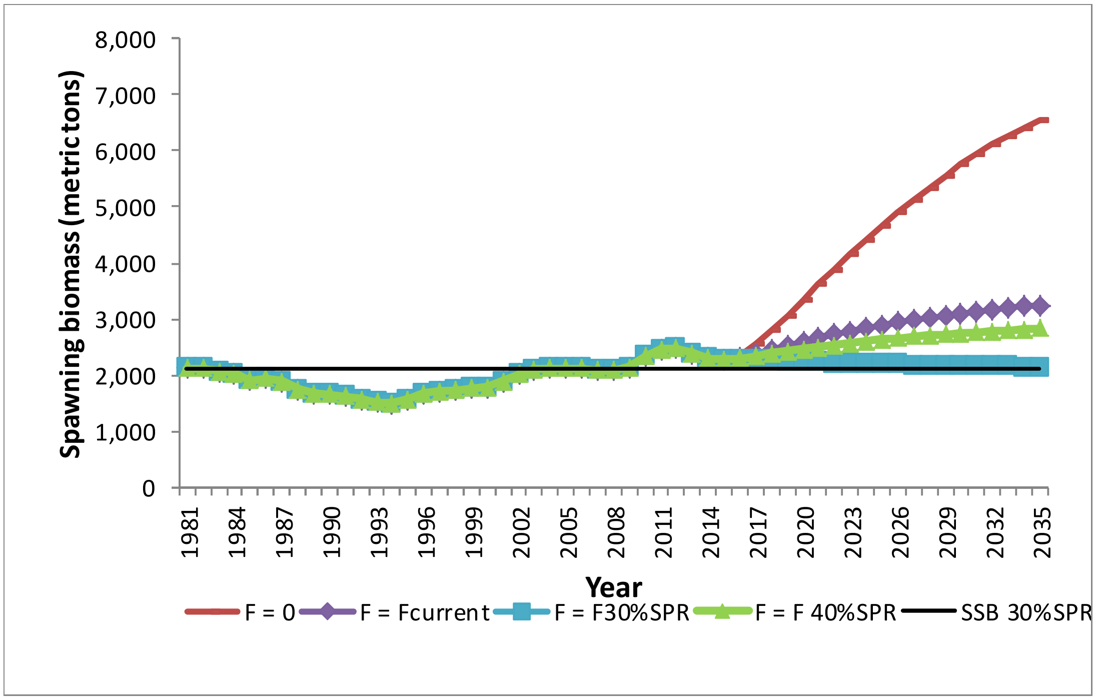


Figure 4.8.3. Ratios of current fishing mortality (geometric mean of F_{2011}, F_{2012}, and F_{2013}) to $F_{30\%}$ and the spawning biomass in 2013 to spawning biomass at $F_{30\%}$ for the sensitivity runs. The yellow triangle marks the point estimates of the base run.

a.



b.

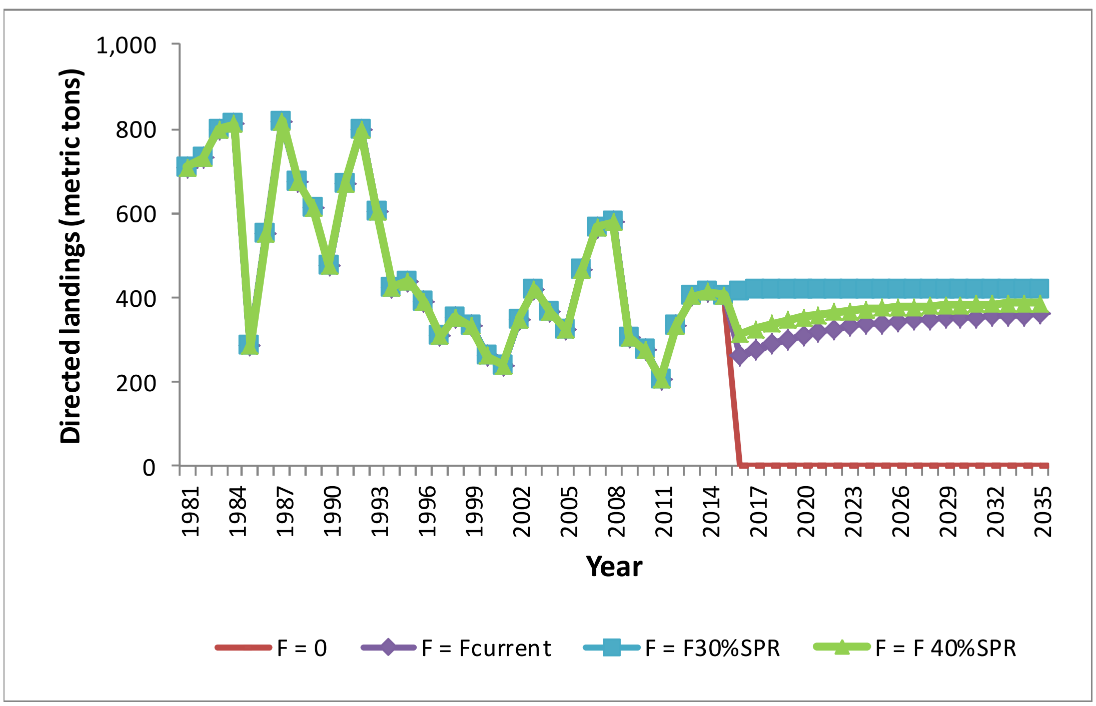
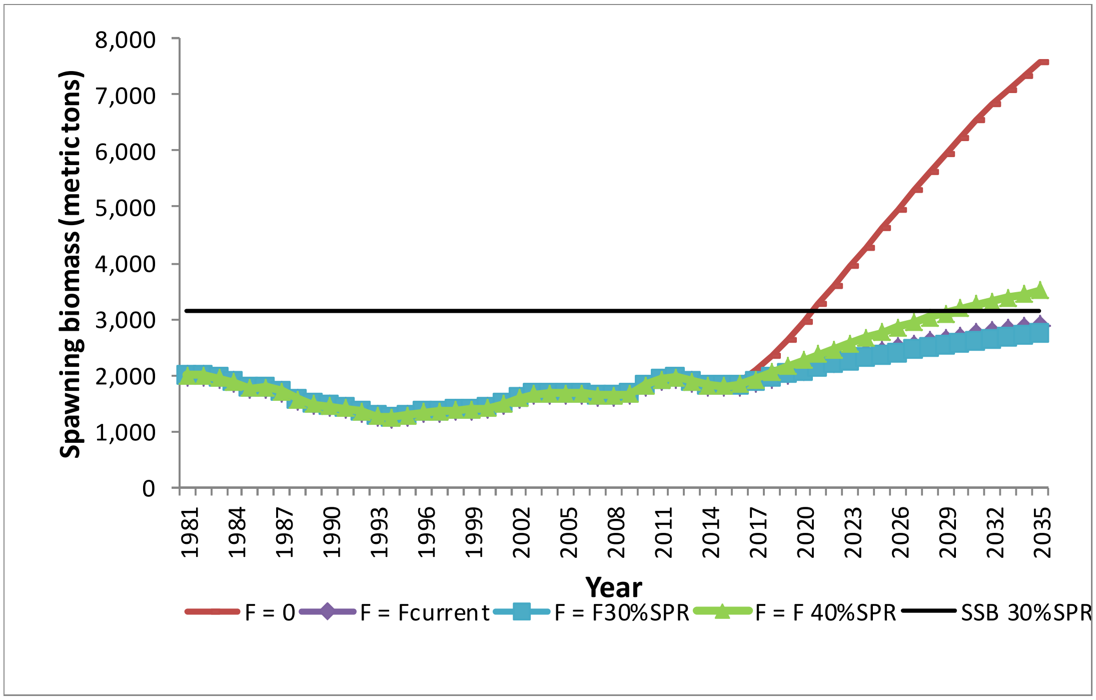


Figure 4.9.1. Projected spawning biomass with the SSB_{MSY} proxy (a), direct harvest (b) from the ASAP base run under four fishing mortality rates: F = 0, $F=F_{current}$, $F= F_{30\%}$, and $F=F_{40\%}$.

a.



b.

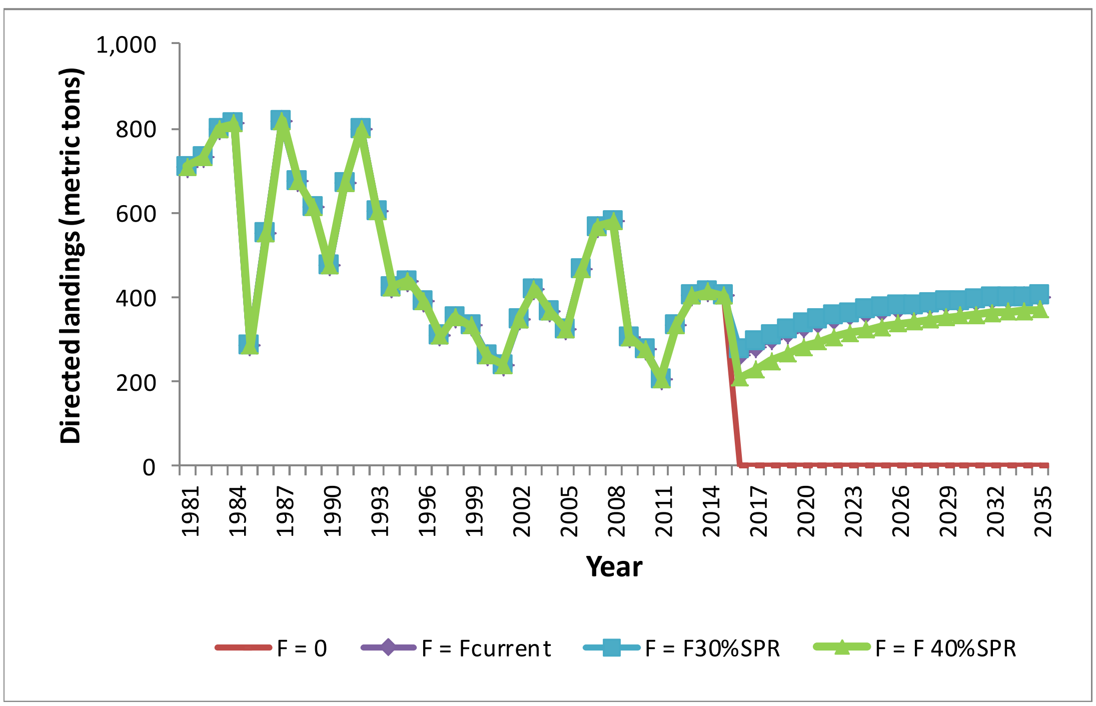
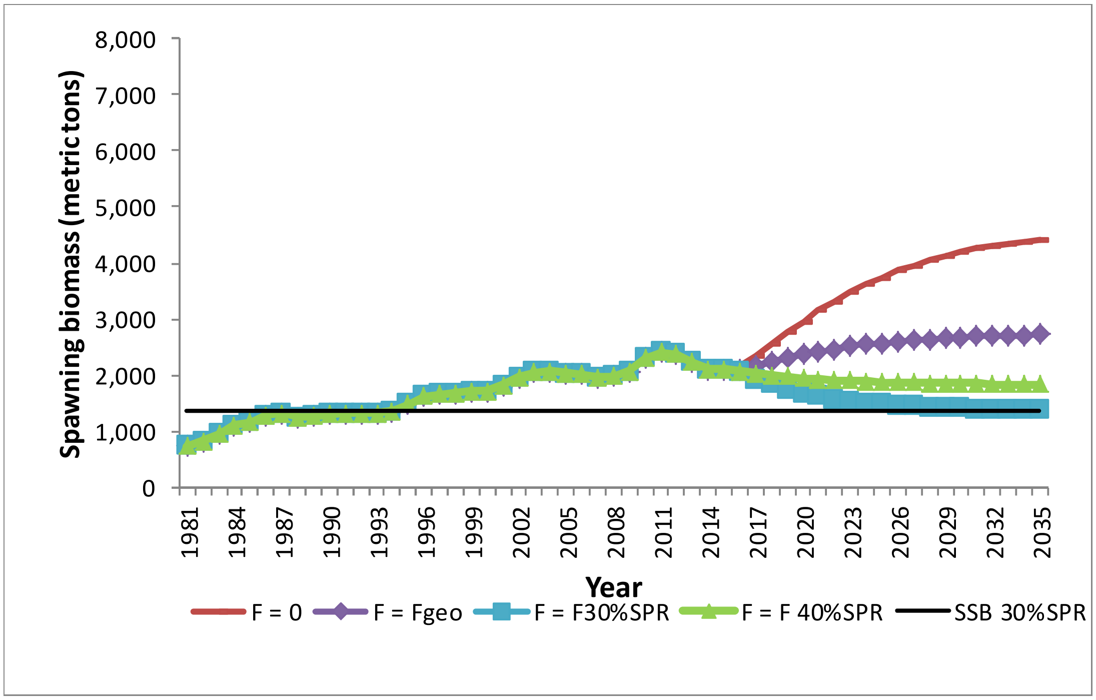


Figure 4.9.2. Projected spawning biomass with the SSB_{MSY} proxy (a), direct harvest (b) from the ASAP run with M = 0.08 per year under four fishing mortality rates: F = 0, $F=F_{current}$, $F= F_{30\%}$, and $F=F_{40\%}$.

a.



b.

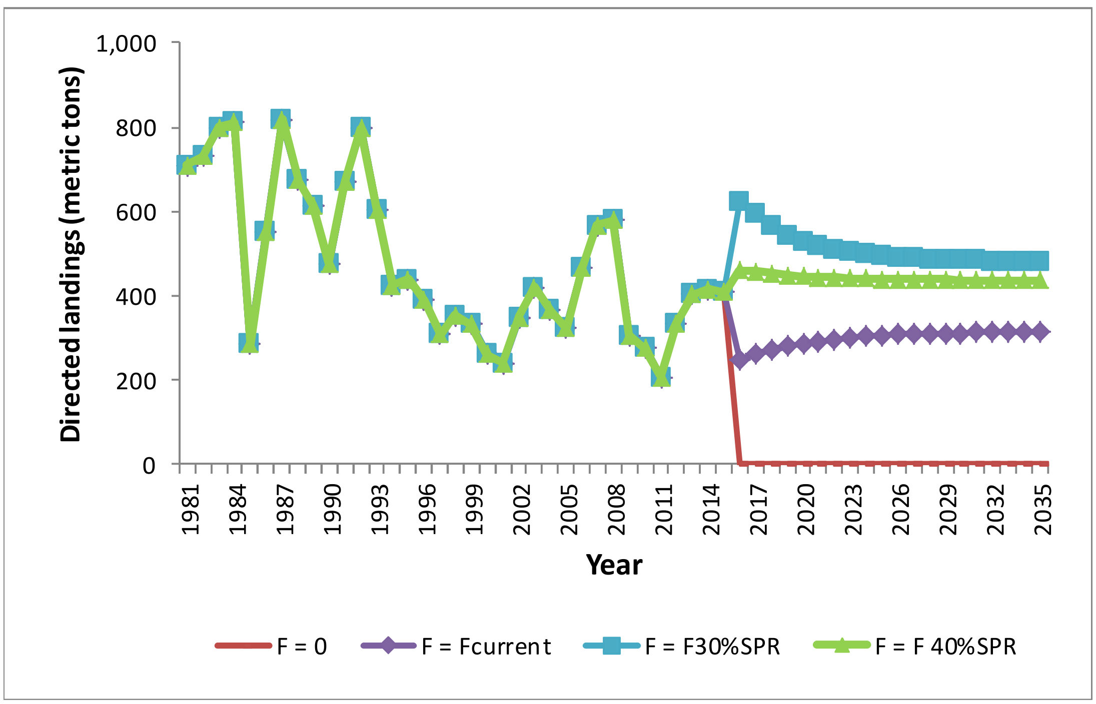


Figure 4.9.3. Projected spawning biomass with the SSB_{MSY} proxy (a), direct harvest (b) from the ASAP run with M = 0.17 per year under four fishing mortality rates: F = 0, $F=F_{current}$, $F= F_{30\%}$, and $F=F_{40\%}$.

Appendix A. Abbreviations and Symbols

Symbol	Meaning
ABC	Acceptable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
ADMB	ADModelBuilder; mathematical routines used with C++ for building computer models
ALK	Age-length key; typically uses proportions of measurements by length, fishery, year, and other groupings to estimate age-at-length. Some pooling of data is typically used to fill gaps in the observed data.
$ALK_{stochastic}$	Stochastic age-length key; uses average length-at-age and standard deviations of lengths-at-age from samples (otoliths), a growth curve, natural mortality rate or age-specific rates, and proportions of fish at a given length in catches or surveys to estimate age-at-length.
ASAP	"Age-Structured Assessment Program", a type of statistical catch-at-age model
ASMFC	Atlantic States Marine Fisheries Commission
ASPIC	"A Stock Production Model Incorporating Covariates", a non-equilibrium surplus production model
B_{year}	Total biomass of stock, conventionally on January 1 of a given year
C++	A system consisting of a compiler and linker using the C++ language to build software
CFLP	NMFS SEFSC Coastal Fisheries Log Book Program
cm	Centimeters. 1 inch=2.54 cm.
CPUE	Catch per unit effort, typically derived from surveys or log book data and used for indices of abundance
CV	Coefficient of variation; a statistical measure of variability, the ratio of the standard deviation to the mean of a sample and may be expressed as a percentage.
DeLury	A type of surplus production model, which may be modified to incorporate indices, fishing effort, and other factors
dm	Decimeters. 1 dm=10 cm.
F_{year}	Instantaneous rate of fishing mortality for a year
$F_{at\ 35\%SPR}$	The fishing mortality rate at a spawning potential ratio of 35%. An example of the use of a proxy for $F_{MSY.}$
F_{MSY}	Fishing mortality rate at which MSY can be attained.
FDM	Fishery Dependent Monitoring Program, FWRI
FIM	Fishery Independent Monitoring Program, FWRI
FL	Fork length, measured from the tip of the snout to the middle of the tail for fish with "forked" tails
FWRI	Fish and Wildlife Research Institute, part of the Florida Fish and Wildlife Conservation Commission
GLM	Generalized linear model
GMFMC	Gulf of Mexico Fishery Management Council
GSMFC	Gulf States Marine Fisheries Commission
HBS	NMFS Beaufort Laboratory Southeast Region Head Boat Survey
kg	Kilograms; equivalent to 2.204623

Appendix A (continued). Abbreviations and Symbols

Symbol	Meaning
lb	Pounds; equivalent to 0.453592 kg
M	Instantaneous rate of natural (non-fishing) mortality
MCMC	Markov Chain Monte Carlo, used in simulations for examining uncertainty in estimates
MFMT	Maximum Fishing Mortality Rate Threshold
mm	millimeters; 1 inch = 25.4 mm
MRFSS	Marine Recreational Fishery Statistics Survey
MRIP	Marine Recreational Information Program
MSST	Minimum Stock-Size Threshold; a limit reference point used in U.S. fishery management. MSST is equal to the spawning biomass at (1-M)·SSB_{MSY}.
MSY	Maximum Sustainable Yield (per year)
mt	Metric tons; equivalent to 1,000 kg or 2,204.623 pounds
N_{year}	Number of fish in the population, conventionally on January 1 of a given year.
NCDMF	North Carolina Division of Marine Fisheries
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OY	Optimum Yield; SFA specifies that OY ≤ MSY
PSE	Proportional standard error; a measure of variability of samples, and calculated like a CV
R_{year}	Recruitment for a given year
RVC	NMFS/UM Reef Visual Census
SAFMC	South Atlantic Fishery Management Council
SCAM	statistical catch-at-age model
SDNR	Standard deviation of normalized residuals
SEDAR	SouthEast Data, Assessment, and Review process
SEFSC	NMFS Southeast Fisheries Science Center, Miami, Florida
SFA	Sustainable Fisheries Act; the Magnuson-Stevens Fishery Management and Conservation Act, as amended
SPR	Spawning potential ratio; the ratio of the SSB in a year to the theoretical SSB before any fishing had ever occurred on a stock
SSB_{year}	Spawning stock biomass; biomass of mature females in a given year
SSB_{MSY}	Spawning stock biomass achieved at MSY
SSRA	stochastic stock reduction analysis
std or s	Sample standard deviation; the square root of variance
s^2	Sample variance; a statistical quantity describing variability of samples
TIP	NMFS SEFSC Trip Interview Program
TL	Total length, measured from the tip of the snout to the maximum length of the tail with the tail compressed
UM	University of Miami
VPA	Virtual population analysis
yr	Year

Appendix B. Fishery Management Regulations affecting Mutton Snapper Harvests in the Southeast Region.

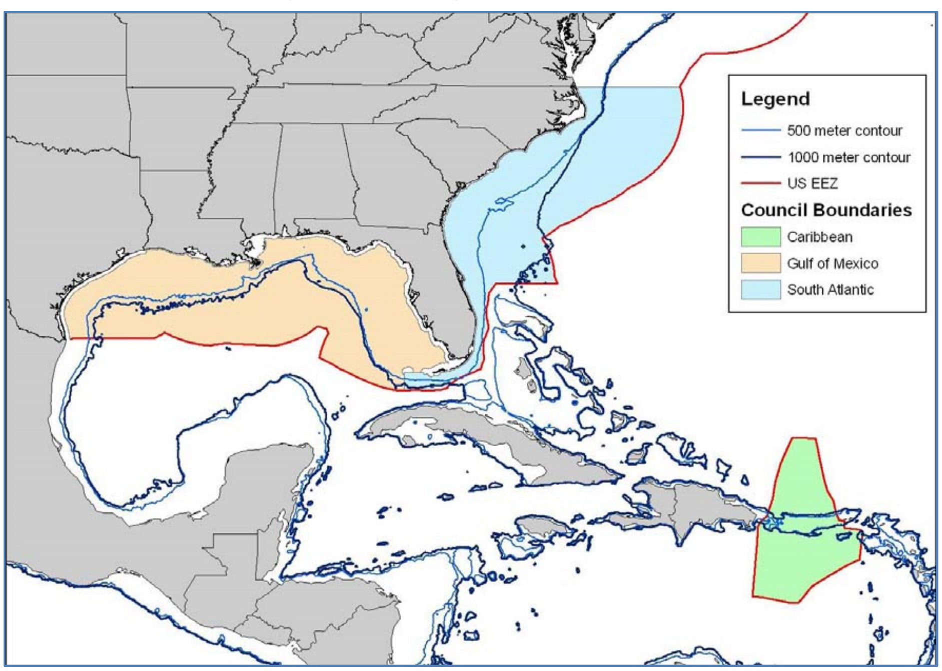
1 *MANAGEMENT OVERVIEW*

1.1 Fishery Management Plans and Amendments

The Florida Fish and Wildlife Conservation Commission (FWC) is responsible for managing fish and wildlife resources for the people of the State of Florida. There are multiple federal and state agencies which also management fish and wildlife resources with overlapping responsibilities and jurisdictions, and the FWC works cooperatively with the regional fishery management councils (South Atlantic Fishery Management Council and Gulf of Mexico Fishery Management Council) and the National Marine Fisheries Service to effectively manage saltwater fisheries in Florida. The FWC Fish and Wildlife Institute is responsible for providing information and research on fish and wildlife resources in the state, including assessments of the status of fish populations such as mutton snapper.

The following summary describes only those management actions in the southeastern U.S. in the jurisdictions of the South Atlantic Fishery Management Council (SAFMC), the Gulf of Mexico Fishery Management Council (GMFMC), and the Florida Fish and Wildlife Conservation Commission (FWC) that were likely to affect mutton snapper fisheries and harvest.

Southeast Region including Council and EEZ Boundaries



Original SAFMC FMP

The Fishery Management Plan (FMP), Regulatory Impact Review, and Final Environmental Impact Statement for the Snapper-Grouper Fishery of the South Atlantic Region, approved in 1983 and implemented in August of 1983, establishes a management regime of the fishery for snappers, groupers, and related demersal species of the continental shelf of the southeastern United States in the fishery conservation zone (FCZ) under the area of authority of the South Atlantic Fishery Management Council (SAFMC) and the territorial seas of the states, extending from the North Carolina/Virginia border through the Atlantic side of the Florida Keys to 83° W longitude. In the case of the sea basses, the management regime applies only to south of Cape Hatteras, North Carolina. Regulations apply only to federal waters.

SAFMC FMP Amendments affecting Mutton Snapper

Description of Action	FMP/Amendment	Effective Date
4" trawl mesh, 12" (305mm) TL minimum size limit	Snapper Grouper FMP	08/31/1983
Trawls to harvest fish prohibited south of Cape Hatteras, NC to north of Cape Canaveral, FL.	Amendment 1 (1988)	01/12/1989
Fish traps prohibited, entanglement nets & longlines within 50 fathoms prohibited, aggregate bag limit of 10 snappers (including mutton snapper, and excluding lane, vermilion, and yelloweye snappers).	Amendment 4 (1991)	01/01/1992
Oculina Experimental Closed Area	Amendment 6 (1993)	06/27/1994
Established 16" TL minimum size for mutton snapper	Amendment 7 (1994)	01/23/1995
Limited entry program: transferable permits and 225-lb non-transferable permits	Amendment 8 (1997)	12/1998
MSY proxy for mutton snapper is 30% static SPR; OY proxy is 40% static SPR. MSST = (1-M) · B_{MSY}. MFMT=F_{MSY}.	Amendment 11B (1998)	12/02/1999
Establish eight deepwater Type II marine protected areas to protect a portion of the population and habitat of long-lived deepwater snapper grouper species	Amendment 15 (2007)	02/12/2009
Required use by commercial and recreational fishermen of dehooking devices for releasing reef fish	Amendment 16 (2009)	07/29/2009
Use of non-stainless steel circle hooks in the snapper -grouper fishery not required south of 28°N	Amendment 17A (2010)	03/02/2011
Established acceptable biological catch (ABC) control rules, ABCs, annual catch limits (ACLs), and accountability measures (AMs) for species not undergoing overfishing. Removes some species from South Atlantic Fishery Management Unit (FMU) and designates others as ecosystem species. Specifies allocations between commercial and recreational sectors for species not undergoing overfishing. Limits the total mortality for federally managed species in the South Atlantic to the ACLs.	Amendment 25 (2011; Comprehensive ACL Amendment)	04/06/2012

Original GMFMC FMP

The Fishery Management Plan (FMP) for the reef fish fishery of the Gulf of Mexico was implemented on November 8, 1984. This plan is for the management of reef fish resources under the authority of the Gulf of Mexico Fishery Management Council. The plan considers reef fish resources throughout its range from Florida through Texas. The areas which will be regulated by the federal government under this plan is confined to the waters of the fishery conservation zone (FCZ). The estimated area of the FCZ is 6.82 x 10^5 km^2 (263,525 square miles) and of that 12.4% of it is estimated as part of the continental shelf that is encompassed within the FCZ. Mutton snapper is one of the many species included in the fishery management unit. The four objectives of the FMP were: (1) to rebuild the declining reef fish stocks wherever they occur within the fishery; (2) establish a fishery reporting system for monitoring the reef fish fishery; (3) conserve reef fish habitats and increase reef fish habitats in appropriate areas and to provide protection for juveniles while protecting existing new habitats; (4) to minimize conflicts between user groups of the resource and conflicts for space.

Measures in the original FMP that would have affected the harvest of Mutton Snapper are maximum sustainable yield (MSY and optimum yield (OY) estimates for all grouper and snapper species in aggregate, permits and gear specifications for fish traps along with a limit on the number of fish traps allowed per vessel, establishment of a stressed area within which the use of fish traps, roller trawls, and powerheads for the taking of reef fish was prohibited, and a prohibition on the use of poison or explosives for taking reef fish.

GMFMC FMP Amendments affecting harvest of Mutton Snapper

Description of Action	FMP/Amendment	Effective Date
MSY and OY estimates for all groupers and snappers in aggregate, permits and gear specifications for fish traps and limits on the number of fish traps allowed per vessel, establishment of a stressed area within which the use of fish traps, roller trawls, and powerheads for reef fish harvest was prohibited, explosives and poisons for taking reef fish prohibited.	Reef Fish FMP	[Submitted 8/1981] 11/08/1984
The stressed area was expanded, and a longline/buoy gear boundary was established. The number of fish traps allowed per vessel was reduced from 200 to 100. Reef fish permits were required for commercial reef fish vessels. Commercial harvest of reef fish using trawls or entangling nets was prohibited. Reporting requirements established for commercial and for-hire recreational vessels, 12” TL minimum size limit for mutton snapper adopted, 10 fish aggregate recreational bag limit for snappers (including mutton snapper) implemented, prohibited use of entangling gear for direct harvest, reef fish vessel permit established with an income qualification. MSY and OY were set to 20% SSBR (spawning stock biomass per	Amendment 1 (1990)	[Submitted 8/1989] 02/21/1990

Description of Action	FMP/Amendment	Effective Date
recruit) and overfishing was defined as the fishing mortality that exceeds 20% transitional SPR.		
Moratorium on new reef fish permits which was extended at various times and was in effect through 2005.	Amendment 4	05/1992
Among other actions, this amendment closed Riley's Hump to all fishing during May and June to protect Mutton Snapper aggregations. All harvest of Mutton Snapper during May and June reduced to the 10-fish aggregate bag limit for snappers with specified bag limits.	Amendment 5	1994
Established a 10-year phase-out of fish traps.	Amendment 14	03-04/1997
Prohibited harvest of reef fish from traps other than permitted reef fish traps, stone crab traps, or spiny lobster traps.	Amendment 15	01/1998
Implemented regulations compatible with Florida rules on mutton snapper size limits of 16" TL and size limits of several other reef fish, including other snappers (cubera, mahogany, schoolmaster), scamp, triggerfish, and hogfish.	Amendment 16B	11/1999
Prohibited retention of reef fish exhibiting "trap rash" on vessels with a reef fish permit that is fishing spiny lobster or stone crab traps except for vessels possessing a valid fish trap endorsement.	Amendment 16A	01/2000
Generic amendment addressing the establishment of the Tortugas Marine Reserves – establishes two marine reserves and prohibits fishing for any species and anchoring by fishing vessels inside the two marine reserves.	Amendment 19	08/19/2002
Commercial and recreational fishermen fishing for reef fish required to use non-stainless steel circle hooks when using natural baits, and to use dehooking and venting tools for releasing reef fish.	Amendment 27	02/2008
Established regulations for ACTs, ACLs, and other Sustainable Fishery Act requirements such as setting the minimum stock size threshold (MSST), maximum fishing mortality rate (MFMT), and other associated parameters for reef fish species for which these have not been defined.	Generic Sustainable Fisheries Act Amendment	12/2011

Original FWC regulations

Florida's management of reef fish fisheries, prior to the establishment of the Marine Fisheries Commission (MFC) in 1983, began with the implementation of size limits in 1979 (Florida Statutes in chapter 370.11) for several groupers (red, Nassau, gag, black, and goliath). In July of 1985, the Florida MFC implemented rules in the Florida Administrative Code (F.A.C.) to establish minimum 12" TL size limits for red, mutton, and yellowtail snapper. Later rules sought to achieve a higher level of conformance between state and federal (Council) regulations to reduce potential conflicts between state and federal management. After the merger of the Florida Department of Environmental Protection and the Florida Game and Freshwater Fish Commission by the Florida Legislature on July 1, 1999, the management functions of the MFC became part of the Florida Fish and Wildlife Conservation Commission (FWC).

While much of the fishery for Mutton Snapper occurs in federal waters, juveniles of this species utilize estuarine and nearshore habitats, particularly seagrass, during their first year after hatching.

FWC regulations affecting Mutton Snapper

Description of Action	Rule chapter	Effective Date
Established 12" TL minimum size for mutton snapper from state waters.	F.A.C. Chap. 68-14	07/1985
Established a 10 fish aggregate bag limit for snappers (included mutton snapper, excluded lane, vermilion, and yelloweye [= silk] snappers). Stab nets (anchored, bottom gill nets) for the harvest of reef fish prohibited.	F.A.C. Chap. 68-14	12/1986
Required the appropriate federal permit to exceed the recreational bag limit in state waters.	F.A.C. Chap. 68-14	12/1992
Temporarily allowed fishermen to land reef fish in the Florida Keys if they possessed either South Atlantic snapper grouper permits or Gulf reef fish permits, with subsequent extensions of these provisions in July 1995 and January 1996.	F.A.C. Chap. 68-14	10/1993
Established 16" TL minimum size for mutton snapper from state waters.	F.A.C. Chap. 68-14	03/1994
Rule changes for mutton snapper, red porgy, and amberjack to be compatible with federal regulations on commercial trips.	F.A.C. Chap. 68-14	01/2003
Prohibited commercial fishermen from harvesting or possessing the recreational bag limit of reef fish species on commercial trips.	F.A.C. Chap. 68-14	07/2007
Required commercial and recreational anglers fishing for any Gulf reef fish species to use circle hooks, de-hooking devices, and venting tools.	F.A.C. Chap. 68-14	06/2008