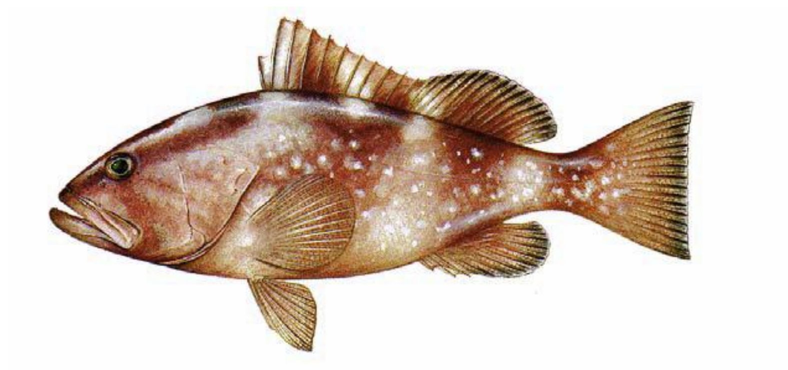
Stock Assessment of Red Grouper in the Gulf of Mexico

-- SEDAR Update Assessment --



Report of Assessment Workshop
Miami, Florida
March 30-April 2, 2009

August 3, 2009

1 Introduction

A SEDAR Assessment Workshop (AW) was convened during March 30-April 2, 2009 at the NMFS Southeast Fisheries Science Center, Miami, Florida, by the Gulf of Mexico Fishery Management Council and the NMFS Southeast Fisheries Science Center under the SEDAR process. The objective of the AW's was to update the benchmark assessments of gag (*Mycteroperca microlepis*) and red grouper (*Epinephelus morio*) within US waters of the Gulf of Mexico (benchmark assessments conducted in 2006 as SEDAR 10 and SEDAR 12, respectively). This report presents results of the 2009 red grouper update assessment. Results of the 2009 gag update assessment are presented in a separate report.

1.1 Terms of Reference

Terms of Reference as approved by the Reef Fish SSC, Standing SSC, and the Gulf of Mexico Fishery Management Council for the Gulf of Mexico Red Grouper Assessment Update:

1. Evaluate any relevant data and parameters to be included into the stock assessment model. This evaluation should be conducted in a workshop setting with all relevant scientific input.
2. Evaluate the relative reliability of fishery dependent and independent data sources and adjust model input appropriately.
3. Update the approved SEDAR 12 red grouper model base configuration, forward projection catch-age model using ASAP with data through 2008. This configuration includes time-varying catchability, adjusted natural mortality scaling, incorporation of the NMFS longline survey, and reduced influence by the derived discard age composition.
4. Document any changes or corrections made to input datasets and tabulate complete updated input datasets. Provide tables of commercial and recreational landings and discard in pounds gutted weight. Clarify units of measurement in all tables.
5. Estimate and provide complete updated tables of stock parameters.
6. Update measures of uncertainty and provide representative measures of precision for stock parameter estimates.
7. Update estimates of stock status and SFA parameters; provide declarations of stock status relative to current SFA criteria.
8. Specify OFL, and may recommend a range of ABC for review by the SSC in compliance with ACL guidelines.
9. Evaluate future stock status for 2009-2014 according to the specifications in Table 2.
10. Review the research recommendations from the previous assessment, note any which have been completed, and make any necessary additions or clarifications.

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

1.2 Update Assessment Workshop Participants

Assessment Panel

Luiz Barbieri, Chair .... GMFMC SSC
Harry Blanchet .... GMFMC SSC
Bill Lindberg........ GMFMC SSC
Russell Nelson .... GMFMC Reef Fish AP

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Appointed Observers

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Observers

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1.3 List of Update Workshop Working Papers & Documents

Document #	Title	Authors
Documents Prepared for the Data Workshop		
SEDAR-UPDATE-01	Index Updates for Gulf of Mexico Gag and Red Grouper Sampled during NMFS Bottom Longline and Reef Fish Video Surveys through 2008	Ingram, Walter
SEDAR-UPDATE-02	An update on standardized and nominal catch rates and distribution of red grouper, *Epinephelus morio*, collected during NOAA Fisheries Bottom Longline Surveys from the U.S. Gulf of Mexico (2000-2008).	Walter Ingram, Linda Lombardi-Carlson, and John Walter
SEDAR-UPDATE-03	Brief summary of the NMFS PC Lab St. Andrew Bay fishery-independent survey of juvenile red grouper in the St. Andrew Bay, Florida	Walter Ingram
SEDAR-UPDATE-04	Summary of fishery-independent surveys of juvenile gag grouper in the Gulf of Mexico	Walter Ingram and Luke McEachron
SEDAR-UPDATE-05	Summary of the fishery-independent NMFS PC Lab trap-camera survey of gag and red grouper in the northeast Gulf of Mexico	Walter Ingram
SEDAR-UPDATE-06	Summary of gag and red grouper age data from the northeastern Gulf of Mexico for SEDAR (10/12) update: 2006-2008	Linda Lombardi, Gary Fitzhugh, Chris Palmer, Beverly Barnett, Laura Goetz, and Carrie Fioramonti
SEDAR-UPDATE-07	Annual Indices and Trends of Abundance for Gag (*Mycteroperca microlepis*) on the Shallow Continental Shelf in the Northeastern Gulf of Mexico	William J. Lindberg, Mary C. Christman, Doug M. Marcinek and Thomas F. Bohrmann
SEDAR-UPDATE-08	Bottom longline fishery bycatch of red grouper from observer data: update	Loraine Hale
SEDAR-UPDATE-09	Recreational Survey Data for Gag in the Gulf of Mexico	Vivian M. Matter
SEDAR-UPDATE-10	Recreational Survey Data for Red Grouper in the Gulf of Mexico	Vivian M. Matter

2 Background Information

2.1 Regulatory history

Effective Date	Regulations
February 21, 1990	- Minimum size of 20 inches TL - 5 grouper recreational bag limit; - 9.2 MP, WW, shallow-water quota.
November 8, 1990	Closure of commercial shallow water grouper in EEZ until December 31, 1990; catch met the commercial allocation
November 12, 1991	One time increase in shallow-water quota from 9.2 to 9.9 MP, WW. Until December 31, 1991.
June 22, 1992	Commercial shallow-water grouper quota increased from 8.2 to 9.8 MP WW
January 1, 1994	- Established a 15.1 MP ABC, - Maintained the 20 inch TL commercial size limit.
June 19, 2000	- Increased the commercial size limit for gag from 20 to 24 inches TL, - Increased recreational size limit for gag from 20 to 22 inches TL, - Prohibited commercial harvest and sale of gag, black, and red grouper each year from February 15 to March 15, and - Established two marine reserves (Steamboat Lumps and Madison-Swanson) closed year-round to fishing for all species under the Council's jurisdiction. - A longline and buoy gear boundary at approximately the 50-fathom depth contour west of Cape San Blas, Florida, and the 20-fathom contour east of Cape San Blas, Florida was established. Vessels fishing with longlines and buoy lines were prohibited from fishing inshore of the 20- and 50-fathom contours.
November 24, 2000	Determination that the red grouper fishery is overfished and GOMFMC is notified
August 19, 2002	Established Tortugas marine reserves and provide enhanced protections in the vicinity of the Dry Tortugas.
June 3, 2004	Steamboat Lumps and Madison-Swanson marine reserves were continued for an additional six years.
July 15, 2004	- Red grouper quota of 6.56 MP, GW, - Commercial quota 5.31 MP, GW, and

	- Recreational allocation 1.25 MP, GW.
November 15, 2004	Closure of the commercial shallow-water grouper in the EEZ until January 1, 2005 due to the red grouper quota being met.
February 17, 2005	Commercial trip limits implemented (shallow water or red grouper); - 10,000-pound limit to start, - 7,500-pound limit when 50 percent of the quota is reached, - 5,500-pound limit when 75 percent of the quota is reached.
June 9, 2005	Shallow water and deep water grouper trip limit reduced to 7500 lbs until December 31, 2005.
August 4, 2005	Shallow water grouper trip limit reduced to 5500 lbs until December 31, 2005.
August 9, 2005	- Aggregate bag limit reduced from 5 to 3 fish per person per day, - Closed season for all recreational grouper harvest for November-December 2005. - Red grouper recreational bag limit reduced from 2 to 1 fish per person per day.
October 10, 2005	Closure of shallow water grouper until January 1, 2006 due to the red grouper quota being met.
October 31, 2005	- Aggregate bag limit for recreational grouper increased from 3 to 5 fish per person per day, - Closure modified to only include red grouper closure for November-December 2005.
January 1, 2006	Establishes a 6000 lb commercial trip limit for shallow and deep water grouper in EEZ
January 24, 2006	Groupers combined excluding goliath and nassau equals 5 per person per day but not exceeding 1 speckled hind, 1 warsaw per vessel or 1 red grouper per day

July 17, 2006	Recreational bag limit 1 red grouper per person per day, zero for headboat/charter captains and crew
September 8, 2006	- VMS required; - Sea turtle & sawfish release gear and protocols; - No gulf reef fish other than sand or dwarf perch can be used as bait; - When commercial quantities of reef fish are on board, no bag limit may be possessed; - When commercial quantities of reef fish in excess of bag/possession limits then may not possess reef fish that do not comply with the com min size limit;
December 18, 2006	Seasonal recreational closure for gag, red grouper, black grouper February 15 - March 15 every year
June 1, 2008	Gulf reef fish fishery must use non-stainless steel circle hooks when using natural baits to fish, and use de-hooking devices and venting tools.

3 Life History

3.1 Management Unit

The red grouper fishery has been managed in the US as separate Gulf and Atlantic stock units with the boundary being U.S. Highway 1 in the Florida Keys. For the purposes of this stock assessment update the management unit for Gulf of Mexico red grouper extends from the United States–Mexico border in the west through the northern Gulf of Mexico waters and west of the Dry Tortugas and the Florida Keys (waters within the Gulf of Mexico Fishery Management Council boundaries).

3.2 Natural mortality

Additional age information based on 4,209 red grouper otoliths collected during 2006-2008 support the conclusion that the maximum age of red grouper in the Gulf of Mexico is 29 years. Therefore, the update AW Panel recommended the use of the natural mortality estimate (M) developed for Gulf of Mexico red grouper during the SEDAR 12 Data Workshop (M=0.14).

An age-varying M approach was developed during the red grouper SEDAR assessment workshop (SEDAR12, following Lorenzen 1996). This approach inversely relates the natural mortality-at-age to the mean weight-at-age by a power function, $M = 3*W^{-0.288}$, incorporating a scaling parameter. Lorenzen (1996) provided point estimates and 90% confidence intervals of the power and scaling parameters for oceanic fishes, which are used for initial parameterization. In SEDAR 12, it was concluded that the Lorenzen approach is more biologically plausible than a fixed M for all ages. The Lorenzen estimate was re-scaled to the oldest observed age (29 years) so that the cumulative natural mortality through this age was equivalent to that of constant M (M=0.14) for all ages from the Hoenig (1983) method based upon maximum age.

3.3 Meristic Conversions

Updated meristic relationships were calculated for red grouper caught in the Gulf of Mexico for length types (total and fork) and body weights (whole and gutted), (Table 3.1). Coefficients of determination were high for linear (length) and nonlinear (weight) regressions ($r^2 > 0.95$). However, though these meristic relationships were updated, equations presented in SEDAR 12 were used for continuity purposes.

3.4 Age and growth

The existing red grouper age dataset (1991-2005, n = 15,953) was amended with an additional 4,209 red grouper otoliths. The length distributions of the otolith sampled red grouper continued to be skewed to the right reflecting effect of the size-limit (20 in, 508 mm). However, an increase in fishery independent sampling (2006-2008) resulted in a larger percentage of fish lengths below the size limit. Mean lengths were significantly different among years (single factor ANOVA, $F = 45.47$, $df = 17$, $p < 0.0001$, $r^2 = 0.04$) and the overall mean length was 605 ± 108 mm. The recent age distributions of red grouper were still dominated by the 1999 year class (age 7 in 2006, age 8 in 2007, and age 9 in 2008). The overall average age was 7.48 ± 2.94 yr and the mean ages were significantly different among years (single factor ANOVA, $F = 24.82$, $df = 17$, $p < 0.0001$, $r^2 = 0.02$). Red grouper caught in the fishery and by fishery independent surveys represented a large range of ages (0 – 29 yrs).

Red grouper fractional ages and observed total lengths from the entire time series (1991-2008) were fit to a size-modified von Bertalanffy growth model to obtain population growth parameters. One of the assumptions of the size-modified growth model is that there is a constant deviance in size-at-age; however, there was some deviance in length among ages. The model predicted the following parameters: $L_\infty = 884$ mm, $k = 0.13$, $t_o = -1.01$. While increased fishery independent sampling of age 0-2 red grouper resulted in better model fits to observed data; fishery dependent data, particularly for age 3 and older still reflected the effect of size truncation due to minimum size limits. Though an updated model was presented, the same growth model used in SEDAR 12: $L_\infty = 854$ mm, $k = 0.16$, $t_o = -0.19$ was used based upon the AWP request.

Please refer to SEDAR documents SEDAR-UPDATE-06 (Lombardi-Carlson et al. 2009) for a more detailed description of red grouper age and growth information used in the assessment update.

3.5 Reproductive biology

No new information on the reproductive biology of red grouper in the eastern Gulf of Mexico was available to the AW update Panel and working group. Therefore, red grouper reproductive parameters used in the last benchmark assessment (SEDAR 12, 2006) were used for the 2009 gag assessment update. Red grouper is a protogynous sequential hermaphrodite, maturing first as females (50% mature females at 3 years old) and then becoming males (50% mature males at 11 years old).

Maturity and fecundity series were developed according to the recommendations of the SEDAR 12 DW and AW panels. A proxy for fecundity was developed such that fecundity is equal to Proportion Mature * Proportion Female * Gonad Weight so that estimates of spawning stock abundance are in units of mature female gonad weight (g).

A summary of the reproductive biology of red grouper in the Gulf of Mexico can be found in Fitzhugh et al. 2006, SEDAR12-DW-04.

4 Commercial fisheries

4.1 Commercial landings

The base assessment includes commercial landings data for the period 1986-2008. The commercial fishery is divided into three fleets:

1. Commercial Longline, 1986-2008
2. Commercial Handline (which includes electric, hydraulic or bandit gear), 1986-2008
3. Commercial Trap, 1986-2006 (discontinued in 2006)

4.1.1 Calculations of 2008 landings for Red Grouper (July-December):

Data from the ALS database and verified landings from quota monitoring were compared and the higher (especially Oct.-Dec.) and verified landings data from the quota monitoring (03/25/09) were used. Using this approach the estimate for 2008 was revised up by ~150,000 lbs (of 4.7 mp).

4.2 Commercial discards

Total discards were reported (or estimated) in numbers (Table 4.1).

4.2.1 Discard calculation – handline trips

- Self reported discard logbook data (20% subsample of vessels)
- Used the same methods as in the previous assessment
- Stephens & MacCall method to identify trips within the fishery

- Defined four regions in eastern Gulf of Mexico
- Region specific discard rates determined for trips in the fishery and for all other trips
- Discard rates applied to total effort for each stratum (region * in or out of fishery)

4.2.2 Discard calculation – longline trips

- Appears to be underreporting of discards by longline vessels
- Followed 2006 method to estimate longline discards by applying handline discards:landings ratio to longline landings
- Used 2006 region specific discards:landings ratios

4.2.3 Observer data

- Began sampling vertical line (handline & bandit rig) in mid 2006
  - Reduced funding in 2008 = less sampling
- Sampling is random within gear/region/quarter strata
  - East and west Gulf of Mexico
  - Exception to non-random sampling of longline vessels in 2008
- On longline trips all catch is recorded, but may not be measured
- On vertical line trips, reels are randomly sampled with all hooks on the reel sampled, but not necessarily measured
- Size composition of catch – including discards

4.2.4. Converting size composition to ages

In the SEDAR 12 assessment discard age composition was derived from the length composition of the landed fish using the probabilistic model of Goodyear (1997) that creates a distribution of discarded from from the recorded lengths of the landed fish. This methods proceeds by recreating and age distribution from the landed size samples and then re-converting this distribution of ages to lengths and assuming that any fish estimated to be under the size limit is released. In contrast, for this update, the discard sizes provide an empirical measure of the size, and- to the extent that age can be inferred from size- the age composition of the discards. Empirically-based age composition is preferable in that it reflects the actual fishery dynamics.

The observed length compositions for the discarded fish (Figure 4.1) were converted to ages using the same Goodyear (2007) probabilistic model and assuming a selectivity pattern for each fleet equal to the average ASAP-estimated selectivity pattern for the years 1986-1990 before size limits were in place. The estimated age composition for the handline (Figure 4.2) and longline (Figure 4.3) indicates that the discard ages were shifted about 1 year older than the previous model-derived estimates. As no observer discard lengths were available prior to 2006, the arithmetic average discard age composition was used for years 1986-2005.

5 Recreational fisheries

5.1 Overview of components

Estimates of recreational retained catch (A+B1) and discards (B2) were available for the Gulf of Mexico from MRFSS since 1981 and from the Headboat survey since 1986. Texas Parks and Wildlife Division (TPWD) provided estimates of recreational landings in Texas, but not discards. For modeling purposes, the recreational fisheries were classified into two sectors: Headboat (1986-2007) and other recreational (MRFSS; 1981-2008). Ratios of discards to retained catch for the Headboat fishery are based on the ratios of discards from the MRFSS estimates. The size composition of the A+B1 retained catch was determined from size samples collected by MRFSS and other sources (SEDAR-10 DW report). Very limited size data have been collected on discarded fish from recreational fisheries.

5.2 Catch estimates

5.2.1 MRFSS

Tables 5.1 and 5.2 show the MRFSS catch estimates by mode and by state for the Gulf of Mexico. The Florida Keys (Monroe county) is included in the estimates for West Florida. The missing estimate for 1981, wave 1 was substituted using the average of wave1/waves 2-6 for 1982-1984 by state, mode, and area. This is consistent with SEDAR 12.

In the tables, estimated A+B1 is the catch that was killed and B2 is the catch that was released alive. In the intercepts, Type A is the catch that was seen and identified by the interviewer. Type B is the catch that was not seen by the interviewer but was reported by the angler. Type B1 is the type B catch reported dead (released dead, used as bait, eaten, etc.) and type B2 is the type B catch reported as released alive.

Tabulated estimates use the new charterboat method (FHS) for 1998-2008. The charterboat estimates for 1986-1997 and charter+headboat estimates for 1981-1985 are calibrated to the new method using the conversion factors estimated in Diaz and Phares.

5.2.2 Headboat Survey

Table 5.3 shows the Headboat Survey catch estimates (Estimated catch includes only kept fish) by year and area group. Headboat areas for Florida Keys (areas 12 and 17) are not included in this dataset. This is consistent with SEDAR 12. Headboat estimates for 2008 were not available as of the date of this document. 2008 estimates were substituted using a two year average (2006-2007) though a Gulf-wide estimate was made for 2008.

Headboat Survey Gulf area codes for reference in reviewing the tables:

18=Dry Tortugas (Gulf vessels)
21=SW FL - full day trips (Naples to Crystal River)

22=Fl. Middle Grounds trips
23=NW FL and AL (Carrabelle to Pensacola, including Panama City and Destin)
24=LA
25=NE TX (Sabine Pass-Freeport)
26=Port Aransas, TX
27=Port Isabel, TX

5.2.3 Adjustments to estimates

Estimation of the number of fish released in the Headboat Survey.

Table 5.4 shows the estimated number of discards for the headboat mode using the MRFSS private mode ratios of B2/(A+B1). This is consistent with SEDAR 12. These ratios were applied to the HBS number of fish landed, since there is no estimate of fish released dead in the Headboat Survey. The MRFSS includes fish released dead in the B1 catch, and while the fish released dead cannot be separated from other kinds of B1 catch in the estimates, this quantity is small in the sample data relative to the total B1 samples.

In 2004 the Headboat Survey logbook trip reports started collecting information on fish released alive and returned dead but estimates of the total fish released were not generated. However, the sample data (trip reports) for 2004-2007 can be used to re-examine which mode of estimates for B2 / (A+B1) from the MRFSS to use to estimate the releases in the Headboat Survey.

Examination of the 2004-2007 headboat release data by vessel indicate that some vessels may not have been reporting released fish (or at least not on some trips). Since it was not clear which trips were reporting zero released fish and which were simply not reporting, only trips with some release data for any species were selected. Of those trips reporting releases, trips with red grouper (kept or released) were further selected. Of these, the quality of data may have varied. For instance, the reports for certain vessels often contained identical entries for the number of fish released as the number of fish kept, a prominent difference from other vessels.

Table 5.5 shows the ratios for fish released alive to total catch (kept + released dead + released alive) calculated using Headboat Survey 2004-2007 trip reports. The ratios are calculated as released_hbt = live/ (num+dead+live), where live = fish released alive, num = fish kept, and dead = fish released dead.

State-run headboat observer programs were implemented in Alabama in 2004 and in Florida in 2005. During randomly sampled trips, catches and releases of all species are observed. Table 5.6 shows the B2/(A+B1+B2) ratios from the headboat observer programs conducted by Florida and Alabama.

Tables 5.7 and 5.8 show the ratios of B2/(A+B1+B2) calculated using the MRFSS private and charter boat mode estimates respectively. The ratios are calculated as released mrfss = B2 / (A+B1+B2).

Figure 5.1 depicts the discard ratios for red grouper from all sources for 2004-2007. Figure 4.1. depicts the size composition of measured discarded fish from headboats observers.

5.2.4 Discard age composition from observed lengths

Discard age composition was obtained by probabilistically converting the observed lengths to ages by the same method as the commercial handline and longline fisheries. These estimated ages indicated that the age composition of discards were approximately one year older than the model-based discard age composition used in SEDAR 12 (Figure 5.2). Age composition estimates were available for years 2005-2007 and for 2008 and all years prior to 2005 the arithmetic average of the 2005-2007 age composition was used.

6 Indices of abundance

Both fishery-dependent and fishery-independent indices of abundance were included in the assessment developed for the 2009 red grouper assessment update.

6.1 Fishery-independent indices

6.1.1 NMFS SEAMAP video survey

The relative fishery independent indices from SEAMAP Video Surveys used in SEDAR 12 were also extended for this update to include data through 2008 (SEDAR-UPDATE-01). No modifications were recommended for these indices. Detailed description of the standardization methods and estimation were provided in the SEDAR12-DW report CPUE section.

6.1.2 NMFS longline survey

The workshop reviewed the fishery-independent longline survey conducted by the NMFS Pascagoula Lab (SEDAR-UPDATE-02). The longline survey was originally conceived as a shark longline survey, but in 2000 the original J-hooks were replaced with 15-O Mustad circle hooks. That change significantly increased the efficiency of the gear with respect to snappers and groupers, without changing the efficiency with respect to shark. Prior to that change in gear, few reef fish were taken in the survey, though the bait remained unchanged (cut Atlantic mackerel). Due to this gear change, the 8 most recent years were examined for possible use as a fishery-independent index of abundance for red grouper. However, the available information provided significant challenges in developing an index of abundance. Two issues most crucial to the panel were the varying geographic distribution of samples between years and the low numbers of samples taken overall in some years. For some years of the survey, only the northernmost stations were sampled, while during other years the entire Gulf peninsula of Florida had good coverage. The species does not seem to be distributed evenly down the peninsula, with lower CPUEs occurring in stations north of 28-29 degrees N latitude, and near the Keys. Therefore, when these regions dominated the samples taken in a year, the numbers of stations with positive occurrences of red grouper was low, leading to low confidence (and high CV) for these years. For some years, the regional distribution was relatively uniform, but the overall number of stations was low. Again, this led to low confidence (and high CV) in these circumstances. The workgroup considers this index to have significant potential to characterize the standing stock and age composition of red grouper. However, until the problems of adequate sample numbers and spatial coverage are analyzed completely, and methods applied to resolve these challenges, the workgroup does not recommend inclusion of this index.

6.1.3 NMFS St. Andrews Bay survey

The workshop also considered an Age-0 survey for St. Andrews Bay (1998-2008) by the NMFS Panama City Lab (SEDAR-UPDATE-03). However, because of low occurrences of red grouper and limited geographic coverage, this Age-0 fishery-independent index was not included in the updated assessment model.

6.2 Fishery-dependent indices

6.1.1 All fishery-dependent indices of abundance that were used in the SEDAR 12 red grouper stock assessment (MRFSS 1981-2004, Headboat 1986-2004, Handline 1990-2004, and Longline 1990-2004) were extended for this update to include data for each index through 2008. The original 2006 and updated 2009 commercial handline, longline, MRFSS and headboat standardized indices of abundance are shown in Figures 6.1.1-1-6.1.1-4. No modifications were recommended for these indices. Detailed description of the standardization methods and estimation were provided in the SEDAR12-DW report CPUE section.

7 Stock assessment methods

7.1. Model structure

7.1.1. Model summary

The ASAP model (Legault and Restrepo 1998) was applied to Gulf of Mexico red grouper in SEDAR 12 (SEDAR 12, 2006, Cass-Calay and Brown, 2007). The basic model structure is a forward-computing statistical catch-at-age model developed using AD Model Builder software (Otter Research 2000). A complete description of the model configuration are given in the SEDAR 12 Addendum 1 (SEDAR 12, 2006). The AWP agreed that ASAP should be also used for the update with some slight modifications:

1. Allow for a fleet-specific penalty on the curvature of selectivity at age.

2. For some fleets, utilization of directly estimated discards at age obtained from age-converted discard length observations
3. Creation of a 'red tide' model with an additional natural mortality term for 2005.
4. Reduction in the maximum ages for which selectivity is estimated.

7.1.2. Data inputs

Data inputs were almost exactly the same as the SEDAR 12 model with landings and indices updated with three additional years of data to span the time period 1986-2008. The main difference in data inputs lies in the incorporation of observed discard lengths for the recreational and commercial longline and handline fleets. The incorporation of these age-converted lengths provided an empirical estimate of discard age composition and proportion released at age. Details of these calculations and derivations are provided in sections 4 and 5.

The basic model structure has ages 1-20+ and four fleets:

1. Commercial Longline
2. Commercial Handline (which includes electric, hydraulic or bandit gear)
3. Commercial Trap (discontinued in 2006)
4. Recreational (includes charter, headboat and private)

and six indices of abundance:

1. Commercial Longline	(fishery-dependent: 1990-2008)
2. Commercial Handline	(fishery-dependent: 1990-2008)
3. MRFSS recreational	(fishery-dependent: 1986-2008)
4. Headboat (size limit 18")	(fishery-dependent: 1986-1990)
5. Headboat (size limit 20")	(fishery-dependent: 1991-2008)
6. SEAMAP Video survey	(fisheries-independent: 1993-1997, 2002, 2004, 2005-2008)

Natural mortality is modeled using the same the age-varying Lorenzen (1996) function developed during the SEDAR12 review workshop (Table 7.1, Figure 7.1). Growth and length/weight at age conversions were performed with a von Bertalanffy growth equation where L_∞ =854 mm; K = 0.16; t_0 = -0.19 yr, $\alpha = 7.00e^{-8}$ and $\beta = 2.76$ (Table 7.1, Figure 7.1). An offset of 135 days was used to calculate weight-at-age as the weight at the peak of the spawning season (May 15). Although weight-at-age was calculated in millimeters and kilograms, it was converted to pounds gutted weight (Table 7.1).

Maturity and fecundity were input using the vectors established during SEDAR 12 (proportion mature * proportion Female * gonad weight (Table 7.2, Figure 7.1). No new data were presented. Therefore, estimates of spawning stock abundance are in units of mature female gonad weight (g). Peak spawning was assumed to occur on May 15 (i.e., an offset of 135 days was used to calculate number-at-age at time of spawning).

Landings in weight (gutted lbs) are summarized in Table 7.3. The landings of the commercial fisheries are reported in weight; therefore, no conversions were necessary. Recreational landings are reported in numbers (MRFSS A+B1 + HB) and converted to landed weight-at-age using the modeled proportion at age and the weight at age matrix (Table 7.4).

Total discards were reported (or estimated) in numbers (far right column in Tables 7.5-7.8). Technically, the version of ASAP used here requires annual estimates of dead discards to be input in units of weight. Therefore the discard numbers at age had to be multiplied by the weight at age matrix used for the landed catch before being input into the model. Discards in weight were obtained using the derived proportion-at-age multiplied by the weight-at-age matrices and the discard mortality rate (Tables 7.5-7.8). Since ASAP uses the same weight-at-age matrix to predict the weight of the discards, fitting the discards in weight is effectively equivalent to fitting the discards in numbers. However, the reader should keep in mind that the output from ASAP is not intended to reflect the true weight of discarded red grouper (because discarded animals are likely to be smaller at a given age than landed animals).

The age composition of the dead discards for the trap fishery and the proportion discarded (alive and dead) at age for the recreational and trap fisheries were modeled using the Goodyear (1997) approach as described in SEDAR12-AW-06. However, direct observations of discard length were available for the recreational, longline and handline fleets for several recent years. For the recreational fishery, lengths measured by observers on headboats from 2005-2007 were available. For the longline and handline fishery observer data from 2006-2008 were available. These discards at length were converted to discards at age with the Goodyear (1997) method. Note that the AWP decided to apply the headboat observer data for the entire recreational fishery as no observed discard lengths were available for the rest of the recreational fishery. In addition it was decided to apply the arithmetic average discard age composition from the years with data (2005-2007 for rec; 2006-2008 for Comm HL and Comm LL) to the remaining years that reported discards. To obtain dead discards at age in number for commercial longline, handline and recreational fisheries (Tables 7.5,7.6,7.8) the year-specific or average discard age compositions were multiplied by the total number of discards and then multiplied by the fishery-specific assumed discard mortality rate (0.45 for Comm LL, 0.1 for recreational and handline). To obtain total weight of discards the discard in numbers was multiplied by the weight at age matrix and summed over all ages. For the Trap fishery, the modeled discard at age was used for these same calculations (Table 7.7).

Direct observations of the age of landed red grouper were available from otolith analysis (SEDAR12-DW-03). Observations (by year and age) were stratified by region (North and South of 28°N), gear (LL, HL, Electric Reel, Trap) and mode (Headboat, Charterboat, Private). The age compositions corresponding to the four fleets (Commercial LL, Commercial HL + Electric Reel, Commercial Trap and Recreational) were constructed by weighting the age compositions corresponding to each strata by the corresponding landings fractions (Table 7.9). The effective sample sizes (i.e., strata sample sizes weighted by the corresponding proportion of the total catch, Table 7.9) were used to weight the direct observed catch-at-age (by year and fleet) in the ASAP model. A maximum value of 200 was used to prevent excessive weighting of this data.

ASAP also requires input of the proportion discarded at age. For the commercial longline and handline fishery this discard proportion comes from a ratio of discarded to kept fish at age:

$$\frac{D_a * fracdisc}{(fracdisc * D_a + C_a)}$$

Where D_a is the discard relative age composition of the discards obtained from age-converted observed lengths, $fracdisc$ is overall fraction discarded obtained from the ratio of discards to kept fish in number (Section 4.1.1 and 4.1.2) and C_a is the relative age composition of the landed (kept) fish, obtained from direct otolith observations. However low numbers of observed fish at older ages biased these calculations, resulting in high and anomalous estimates of proportion released. To fix this problem we fit a lognormal regression of the proportion discarded for ages 8-20+ to provide a more stable estimate of proportion released (Tables 7.10-7.11). For 2006-2008 the actual proportion was used for ages 1-10 and then for ages 11-20 it was replaced by the regression predictions at age. For all other years the geometric mean at age of 2006-2008 was used for ages 1-8 and the lognormal prediction at age was used for ages 11-20 (Tables 7.10-7.11, Figures 7.3-7.4).

The above procedure could not be applied to the recreational and trap fisheries because the observed age composition data were too sparse, therefore the method used by SEDAR 12 was retained; i.e., the proportions discarded at age were obtained by dividing the Goodyear model estimates of discards at age by the sum of the Goodyear estimates of landings and discards (Tables 7.12-13).

The same six indices of abundance used n SEDAR 12 were retained: SEAMAP Video, Commercial Longline, Commercial Handline, Headboat 18”, Headboat 20” and MRFSS (Table 7.15, Figure 7.4). The indices were updated with new years of data using the same standardization models as used in the 2006 assessment. For the central model no changes catchability (q) were implemented, however sensitivity runs assuming a 2% annual increase and 2% decrease in q were performed. To achieve an increase or decrease in q, the fisheries dependent indices were incremented or decremented by dividing the annual index values by a q-scalar equal to 1.0 in the initial year, and decreasing 2% or increasing 2% annually.

The decision by the AWP to make the constant q model the central model was based upon analyses presented during the 2008 SEDAR workshop on catchability (Thorson et al, *in review*; SEDAR 2009). It appears possible that density-dependent decreases in q may have offset technological increases in q, such that the overall trend in q over time may not have increased. Because of this, the AWP decided to use the constant q model as the central model and to use increases and decreases in q as sensitivity runs. It should be noted that further investigation of the nature of changes in q over time and in methods of estimating changes in q should be explored in the next benchmark assessment.

7.1.3. Population dynamics

The basic population dynamics are entirely the same as for SEDAR12. For reference purposes the same text has been provided here. In the population dynamics model of ASAP fleet specific catch and fishing mortality is accommodated. For the following description, let:

a = age	1…A
y = year	1…Y
g = fleet	1…G
u = index	1…U

Age-specific selectivity coefficients were estimated subject to the following penalties used to constrain the amount of curvature allowed in the fleet-specific selectivity patterns by age:

$$\rho_{selA} = \lambda_{\rho 1} \sum_{y} \sum_{g} \sum_{a(g_{start})}^{a(g_{end})-2} \left(S_{a,y,g} - 2S_{a+1,y,g} + S_{a+2,y,g} \right)^2 \qquad \text{(Eq. 1)}$$

and over time:

$$\rho_{selY} = \lambda_{\rho 2} \sum_{a} \sum_{g} \sum_{Y=1}^{Y-2} \left(S_{a,y,g} - 2S_{a,y+1,g} + S_{a,y+2,g} \right)^2 \qquad \text{(Eq. 2)}$$

where the weighting of the penalty λ_{p1} was 400 (CV = 0.05). The base model did not allow annual deviations for fleet-specific selectivity. Therefore, selectivity was estimated over the entire time period (1986-2008). However, it is important to note that although time-invariant selectivity functions were estimated, the discard fractions are estimated directly, and do vary annually. Therefore, although management actions (such as increasing the minimum size limit) will not modify the selectivity vector, they may cause changes the proportion of the catch discarded.

An additional penalty is used in early phases of the estimation procedure to keep the average fishing mortality rate close to the natural mortality rate. This penalty ensures that the population abundance estimates do not get exceedingly large during the early phases of minimization.

Directed fishing mortality ($dirF$) is calculated as follows:

$$dirF_{a,y,g} = S_{a,y,g} * Fmult_{y,g} * (1.0 - PropRel_{a,y,g}) \qquad \text{(Eq. 3)}$$

where $S_{a,y,g}$ is the selectivity by age, year and fleet; $Fmult_{y,g}$ is the annual fleet-specific fishing mortality multiplier, and $PropRel_{a,y,g}$ is the proportion of fish released by age, year and fleet.

Discard fishing mortality (*discF*) is calculated as follows:

$$discF_{a,y,g} = S_{a,y,g} * Fmult_{y,g} * PropRel_{a,y,g} * RelMort_g \qquad \text{(Eq. 4)}$$

where $S_{a,y,g}$ is the selectivity by age, year and fleet; $Fmult_{y,g}$ is the annual fleet-specific fishing mortality multiplier, $PropRel_{a,y,g}$ is the proportion of fish released by age, year and fleet and $RelMort_g$ is the fleet-specific release mortality rate.

Total fishing mortality at age and year is the sum of the fleet-specific directed and discard fishing mortality rates.

$$Ftot_{a,y} = \sum_g dirF_{a,y,g} + discF_{a,y,g} \qquad \text{(Eq. 5)}$$

Total mortality is the sum of the total fishing mortality and the natural mortality (*M*).

$$Z_{a,y} = Ftot_{a,y} + M_{a,y} \qquad \text{(Eq. 6)}$$

Catch-at-age, by year and fleet, is calculated as:

$$C_{a,y,g} = \frac{N_{a,y} * dirF_{a,y,g} * \left(1 - e^{-Z_{a,y}}\right)}{Z_{a,y}} \qquad \text{(Eq. 7)}$$

where *N* is the population abundance at the start of the year. Discards-at-age, by year and fleet, are calculated in a similar fashion.

$$D_{a,y,g} = \frac{N_{a,y} * discF_{a,y,g} * \left(1 - e^{-Z_{a,y}}\right)}{Z_{a,y}} \qquad \text{(Eq. 8)}$$

The landings and discards (in weight) by age, year and fleet are calculated

$$Y_{a,y,g} = C_{a,y,g} * W_{a,y} \quad or \quad discY_{a,y,g} = D_{a,y,g} * W_{a,y} \qquad \text{(Eq. 9)}$$

where $W_{a,y}$ is the weight of a fish of age a in year y.

The proportion of catch-at-age (or discards-at-age) within a year by a fleet is:

$$P_{CAA1_{a,y,g}} = \frac{C_{a,y,g}}{\sum_a C_{a,y,g}} \qquad \text{for the modeled catch – at – age}$$

(Eq. 10)

$$P_{CAA2_{a,y,g}} = \frac{C_{a,y,g}}{\sum_a C_{a,y,g}} \qquad \text{for the direct observed catch – at – age}$$

$$or \quad P_{DAA_{a,y,g}} = \frac{D_{a,y,g}}{\sum_a D_{a,y,g}} \qquad \text{for the modeled discards – at – age}$$

Note: There are two catch-at-age matrices, the modeled CAA estimated using the Goodyear approach (CAA1), and the directly observed otolith observations (CAA2).

The recruitment in the first year is estimated as deviations from the predicted virgin recruitment

$$N_{1,y} = \overline{N_o} e^{\nu_y}$$

(Eq. 11)

where $\nu_y \sim N(0,\sigma_{Ny}^2)$. For the base case, deviations from the average value were assigned a CV equal to 0.5.

The population age structure in year 1 is estimated as deviations from equilibrium at unfished (virgin) condition.

$$N_{a,1} = N_{1,1} e^{-\sum_{i=1}^{a-1} M_{i,1}} e^{\psi_a} \qquad for \quad a < A$$

(Eq. 12)

$$N_{a,1} = \frac{N_{1,1} e^{-\sum_{i=1}^{a-1} M_{i,1}}}{1 - e^{-M_{A,1}}} e^{\psi_a} \qquad for \quad a = A$$

where $\psi_a \sim N(0,\sigma_{Na}^2)$. The remaining population abundance at age and year is then computed using the recursion:

$$N_{a,y} = N_{a-1,y-1} e^{-Z_{a-1,y-1}} \qquad for\ a < A$$

$$N_{a,y} = N_{a-1,y-1} e^{-Z_{a-1,y-1}} + N_{a,y-1} e^{-Z_{a,y-1}} \qquad for\ a = A$$

(Eq. 13)

where Z is the total mortality (Eq. 6).

Predicted indices of abundance ($\hat{I}$) are a measure of the population scaled by catchability coefficients (q) and selectivity at age (S)

$$\hat{I}_{u,y} = q_{u,y} \sum_{a(u_{start})}^{a(u_{end})} S_{u,a,y} N^*_{a,y} \qquad \text{(Eq. 14)}$$

Where $a(u_{start})$ and $a(u_{end})$ are the starting and ending ages for the index, and N^* is the population abundance, which can be expressed either in weight or numbers. The abundance index selectivity at age can be linked to that of a fleet, or input directly. If the latter is chosen, the age range can be smaller than that of the fleet and the annual selectivity values are rescaled to equal 1.0 for a specified age (a_{ref}) such that the catchability coefficient (q) is linked to this age.

$$S_{u,a,y} = \frac{S_{a,y,g}}{Sa_{ref}, y, g} \qquad \text{(Eq. 15)}$$

The settings used for the indices listed below. Selectivities for all indices except the SEAMAP video were linked to that of the corresponding fleet. For the SEAMAP Video Survey, a fixed selectivity vector based on the age composition was input (Relative selectivity at age 1 = 0; age 2 = 0; age 3 = 0.5; ages 4 to 20+ = 1.0).

INDEX	START AGE	END AGE	a_{ref}	Selectivity linked to fleet?
SEAMAP Video	3	20	4	FIXED
COM LL	4	20	4	COM LL
COM HL	4	20	4	COM HL
HB 1986-1990	4	20	4	REC
HB 1990-2005	4	20	4	REC
MRFSS	1	20	4	REC

7.1.3. Parameter Estimation

ASAP requires initial guesses for certain parameters ($S_{g,a}$, $F_{g,1}$, $Q_{u,1}$, steepness, virgin stock size) which are estimated in early estimation phases. These initial guesses scale the parameters to biologically reasonable values, and facilitate the evaluation of parameters estimated in subsequent phases (F deviations, recruitment deviations, selectivity deviations etc.). As noted in below in 7.1.4.2. Input specification changes, the initial starting vector for selectivity in the phase file was changed to be the ASAP 2006 model estimated average for 1986-1990. All parameters are re-estimated in the final phase. Initial guesses are summarized in Table 7.16.

A total of 180 parameters were estimated during the ASAP base run, including:

1) 23 Recruitment deviations (1986-2008)

2) 19 Population abundance in Year 1 (Ages -1)
3) 92 Fishing mortality rate multipliers (23 Years * 4 Fleets)
4) 38 Selectivity-at-age
5) 6 Catchabilities (6 indices)
6) 2 Stock Recruitment parameters (Virgin reproductive potential, steepness)

The likelihood function to be minimized includes the following components (excluding constants). Variables with a hat ($\wedge$) are estimated by the model and variables without a hat are input as observations. The weighting (λ) assigned to each component of the likelihood function are essentially equivalent to the inverse of the variance assumed to be associated with that component ($\lambda = 1/\sigma^2$) where $\sigma^2 = \ln(CV^2 + 1)$.

Total catch in weight by fleet (lognormally distributed)

$$L_{Total\ Catch} = \lambda_1 \left[\ln\left(\sum_a Y_{a,y,g} \right) - \ln\left(\sum_a \hat{Y}_{a,y,g} \right) \right]^2 \qquad \text{(Eq. 19)}$$

where λ_1 is a weighting component assumed to equal 100.5 (CV = 0.1).

Total discards in weight by fleet (lognormally distributed)

$$L_{TotalDiscards} = \lambda_2 \left[\ln\left(\sum_a discY_{a,y,g} \right) - \ln\left(\sum_a disc\hat{Y}_{a,y,g} \right) \right]^2 \qquad \text{(Eq. 20)}$$

where λ_2 is a weighting component assumed to equal 11.6 (CV = 0.3).

Two matrices of catch-at-age and one discard-at-age matrix are included in the red grouper ASAP model runs, the modeled catch-at-age (CAA1) and discards-at-age matrices (DAA) were estimated using the Goodyear approach (SEDAR12-AW-06). The second catch-at-age matrix (CAA2) is the direct otolith observations. A separate likelihood component was included for each. These were assumed to be multinomially distributed and were calculated:

$$L_{CAA_1} = -\sum_y \sum_g \lambda_{3,y,g} \sum_a P_{a,y,g} \left[\ln\left(\hat{P}_{CAA1\,a,y,g} \right) - \ln\left| P_{CAA1a,y,g} \right| \right] \qquad \text{(Eq. 21)}$$

$$L_{CAA2} = -\sum_y \sum_g \lambda_{4,y,g} \sum_a P_{a,y,g} \left[\ln\left(\hat{P}_{CAA2\,a,y,g} \right) - \ln\left| P_{CAA2a,y,g} \right| \right] \qquad \text{(Eq. 22)}$$

$$L_{DAA} = -\sum_{y}\sum_{g}\lambda_{5,y,g}\sum_{a}P_{a,y,g}\left[\ln\left(\hat{P}_{DAA\,a,y,g}\right) - \ln\left(P_{DAA\,a,y,g}\right)\right] \quad \text{(Eq. 23)}$$

The weighting components (λ_3, λ_4 and λ_5) are year and fleet specific. Setting λ=0 will assign a weight of zero to a given year/fleet combination. When this occurs, only total catch (or discards) in weight will be incorporated into the objective function for that fleet and year. The derived catch-at-age (CAA1) was not used because direct observations of age composition were available. Therefore, λ_3 was set equal to 0 for all years and fleets. The weighting components, λ_4, for the direct observations of age composition (CAA2; from otolith analysis) were set to the effective sample sizes (Table 3.2 10; *Note: maximum effective sample size was capped at 200 to avoid excessive weighting*).

The likelihood component for the indices of abundance (lognormally distributed) was calculated:

$$L_{Indices} = \sum_{g}\lambda_{6,g}\sum_{y}\left[\ln\left(I_{y,g}\right) - \ln\left(\hat{I}_{y,g}\right)\right]^2 / 2\sigma^2_{y,g} + \ln\left(\sigma_{y,g}\right) \quad \text{(Eq. 24)}$$

where λ_6 is a weighting component assumed equal to 25 (CV = 0.2) for all indices. The sigmas (σ) in equation 23 can be set equal to 1.0, or input. For the ASAP base run, the indices were equally weighted, and all CVs were assumed to equal 0.2.

Weighting factors for the time-varying parameters are also included in the likelihood by setting λ equal to the inverse of the assumed variance for each component:

$$L_{sel} = \sum_{g}\lambda_{7,g}\sum_{a}\sum_{y}\varepsilon^2_{a,y,g} \quad (selectivity) \quad \text{(Eq. 25)}$$

$$L_{q} = \sum_{u}\lambda_{8,u}\sum_{y}\omega^2_{u,y} \quad (catchability) \quad \text{(Eq. 26)}$$

$$L_{Fmult} = \sum_{g}\lambda_{9,g}\sum_{y}\eta^2_{y,g} \quad (F\ multipliers) \quad \text{(Eq. 27)}$$

$$L_{R} = \lambda_{10}\sum_{y}\nu^2_{y} \quad (recruitment) \quad \text{(Eq. 28)}$$

$$L_{N_1} = \lambda_{11}\sum_{y}\psi^2_{y} \quad (N\ year\ 1) \quad \text{(Eq. 29)}$$

where

Selectivity Deviations:	λ_7 = N/A;	None estimated
Catchability Deviations:	λ_8 = N/A;	None estimated
F_{Mult} Deviations (by Fleet):		
Commercial LL:	λ_9 = 11;	CV $\cong$ 0.29
Commercial HL	λ_9 = 11;	CV $\cong$ 0.29
Commercial Trap	λ_9 = 11;	CV $\cong$ 0.29
Recreational	λ_9 = 11;	CV $\cong$ 0.29

Recruitment Deviations λ_{10} = 4.48 CV $\cong$ 0.50
N_{Year1} Deviations λ_{11} = 4.48 CV $\cong$ 0.50

In addition, there is a weighting factor for fitting a Beverton and Holt type stock-recruitment relationship

$$L_{SR} = \lambda_{12} \sum_{y} \left[\ln\left(N_{1,y} \right) - \ln\left(\frac{\alpha SS_{y-1}}{\beta + SS_{y-1}} \right) \right]^2 \quad \text{(Eq. 30)}$$

where *SS* is the spawning stock reproductive potential, α and β are parameters to be estimated, and λ_{12} is the inverse of variance assigned to virgin stock size. For the base case, λ_{12} = 0. This setting causes the virgin stock size to be estimated as a free parameter. Note: ASAP estimates alpha and beta, but uses the re-parameterized inputs virgin reproductive potential (or biomass) and steepness.

The function to be minimized is the sum of the likelihoods and penalties.

$$L = L_{TotalCatch} + L_{TotalDiscards} + L_{CAA1} + L_{CAA2} + L_{DAA} + L_{Indices} + L_{Sel} + L_{Q} + L_{FMult} + L_{R} + L_{NYear1} + L_{SR} + \rho_{SelA} + \rho_{SelY} \quad \text{(Eq. 31)}$$

The component weightings recommended by the SEDAR12 review workshop are mostly unchanged except as noted in 7.1.4.2. Input specification changes, are summarized in Table 7.17.

7.1.4. Changes to the ASAP model for 2009 update

7.1.4.1 Coding changes

7.1.4.1.1. Constraint on the curvature of selectivity at age made fleet-specific.

With the incorporation of observed discard lengths (section 5.3.3) it was evident that red grouper under the age of two were rarely caught by the recreational fishery, but many fish age three and older were common; hence there must be a steep increase in selectivity from age 1 to 3. To allow for this steep increase in selectivity for the recreational fleet from age 1 to 3, it was necessary to make the penalty term (lambda) on the curvature of selectivity at age fleet-specific, rather than applied to all fleets equally. A lambda value of 11.6 (cv=0.3) was used for the recreational fleet, while the previous lambda of 400 (cv=0.05) were retained for all other fleets. This involved the creation of a new ASAP executable (available from the SEFSC).

7.1.4.1.2. Red tide mortality model.

Given the systematic decline in all indices between the years 2005-2006 there was a general concern the extensive red tide that occurred during 2005 on the West Florida Shelf may have substantially affected the red grouper population. The assessment panel desired a model that could test this 'red tide hypothesis' by allowing and estimating an additional source of mortality during 2005. To accommodate this request within the current ASAP framework, we modified the original base code to estimate an extra mortality term for 2005 where total mortality ($Z_{a,2005}$) is estimated as below:

$$Z_{a,2005} = F_{a,2005} + M_{a,2005} + M_{rt} \qquad (1)$$

Where $M_{a,2005}$ is natural mortality at age in 2005, input as the Lorenzen-scaled M vector and M_{rt} is an extra mortality term. This also involved the creation of a new ASAP executable (asap2009redtide.tpl, available from the SEFSC). Without information on the age-specific effects of red tide and with observations of large groupers floating dead on the surface during a red tide event (Mark Grace, NMFS, *pers. comm.*) we assumed M_{rt} to be constant with age. Although the red tide event was most intense in August and September, the annual computations in ASAP required the episodic mortality event to be modeled as though it operated over the entire year (but see below).

To adjust for the year-long implementation of the red tide mortality in the model when it may actually have been a shorter-duration episode, it was possible to modify the timing of when each index was assumed to index the populations. ASAP fits predicted fleet (u) specific indices of abundance (I_u) as a measure of the population abundance (N*) at a specific time of the year, scaled by the fleet catchability coefficient (q_u) and fleet selectivity at age ($S_{u,a}$)

$$\hat{I}_{u,y} = q_{u,} \sum_{a(u_{start})}^{a(u_{end})} S_{u,a} \, N^{*}_{a,y}$$

Although it was not possible to change the time in which the mortality event was assumed to occur, it was possible to change the time of year that each index was assumed to reference the population abundance. For instance, the central model and all models conducted for SEDAR 12 assumed that each index reflected the average abundance over the course of the year.

Notwithstanding the occurrence of several severe hurricanes, the year 2005 was rather odd in that, while it was a year of severe red tide, it was also the highest recorded CPUE for the headboat, longline, handline and video indices. These high catch rates (and high estimated landings) prompted the closure of the commercial shallow water grouper fishery on October 10. In addition, the recreational fishery was also closed for November and December. These closures meant that no CPUE data from the time period after the red tide event was used in the construction of the HL, LL and HB indices. In contrast, the MRFSS index, because it includes discards, does include catch rate observations from after this event. Further, since the video index is obtained during the summer, it, too would have likely have indexed the population prior to the mortality event. Thus, it is likely that, many of the indices would not have reflected a depleted population, with the exception of MRFSS for which a decline begins in 2005 (Figure 7.4).

Given the extremely high catch rates for the HB, HL, LL and video indices, coupled with the fact that for the HL and LL indices, historically 60-70% of the catch rate data is obtained prior to August, the index month was shifted to 0.1, or the beginning of the year. Changing the timing of the HB, HL, LL and video indices for the entire modeled time series was an approximation necessary to reference population abundance prior to timing of the red tide event. For the MRFSS index, the timing remained the average year timing because it appeared the MRFSS index started to decline in 2005, likely feeling the effects of the red tide in that year. While it would be preferable and recommended for a benchmark assessment to be able to change or estimate the timing of the actual episodic mortality event, this was beyond the scope of this update assessment.

INDEX	START AGE	END AGE	Selectivity	Index Month
NMFS VIDEO	3	20	Fixed starting at age 3	0.1
COM LL	4	20	Linked to fleet	0.1
COM HL	4	20	Linked to fleet	0.1
HB 18”	4	20	Linked to fleet	0.1
HB 20”	4	20	Linked to fleet	0.1
MRFSS	1	20	Linked to fleet	Average year (-1)

7.1.4.2. Input specification changes

Several changes to the input specifications were made for the updated models:

1) Consistent with changing the initial recreational selectivity in sections 4.1.3 and 5.1.3, the initial starting vector for selectivity in the phase file was also changed to be the ASAP 2006 model estimated average for 1986-1990.
2) The maximum ages over which selectivity was estimated were reduced from 15, 15, 12, and 10 to 10, 10, 10 and 8 respectively for the commercial longline, handline, trap and recreational fisheries (Table 7.7). This was done because sensitivity analyses showed that age the composition data were too sparse to support precise estimation of unique selectivity parameters for fish older than age 10.
3) The weights on the discards at age for Commercial LL, HL and REC, derived from the observed discard lengths were increased from an effective sample size of 1 to an effective sample size of 11.6 (Table 7.8). In SEDAR 12 the discards at age were entirely model-based and it was decided to give these a very low weight (effective sample size=1). Weights were increased for the years where observer data exists (2006-2008 or 2005-2007 for recreational) and also for the years for which the average observer discards at age were applied (all other years).

7.1.1. Measures of precision and uncertainty

Precision in the estimated parameters can be assessed from the standard deviation derived by taking the inverse of the Hessian matrix at the maximum likelihood estimate. Each component of the objective function is reported to the output file along with the corresponding number of observations, weight assigned to that component, and the residual sum of squared deviations (when appropriate). In this update, the ASAP model was not bootstrapped so that true bootstrapped estimates of uncertainty could not be obtained with the PRO-2BOX projection software. PRO-2BOX projections were bootstrapped but uncertainty was only carried forward in the estimated recruitment values.

7.1.3. Sensitivity analyses/Alternative models

Eleven sensitivity runs were conducted, numbered sequentially assuming that the 'central model' is run 1:

2) Red tide model described in 7.1.2.1.2.
3) Assume 2% increase in catchability (decrement fisheries dependent indices).
4) Assume 2% decrease in catchability (increment fisheries dependent indices).
5) Increase natural mortality-at-age vector by 10% (multiply vector by 1.1).
6) Decrease natural mortality-at-age vector by 10% (multiply vector by 0.9).
7) Red tide model all indices linked to average year abundance
8) Red tide model with a 2% increase in catchability (decrement fisheries dependent indices)
9) Red tide model with a 2% decrease in catchability (decrement fisheries dependent indices)
10) Red tide model with increase natural mortality-at-age vector by 10%
11) Red tide model with decrease natural mortality-at-age vector by 10%

These runs span several hypotheses regarding increasing or decreasing catchability over time and a range of natural mortality. The red tide model is described in (7.1.2.1.2. Red tide mortality model). Run 7 was conducted to examine the red tide model with all indices referencing average year abundance similar to the central model. Note that the base model for SEDAR12 assumed a 2% increase in catchability for the fishery-dependent indices.

8 Assessment results

8.1 Results of central model

8.1.1. Model fit

The objective function value, likelihood components and residual sums of squares are tabulated in Table 8.1.1.

Model fits to the catch series were good, as would be expected given the high weighting on this component (λ = 100.5; CV=0.1; Table 8.1.2 and Figure 8.1.1). Residuals seldom exceeded 10% of the total annual catch.

The predicted discard series were estimated with a greater assumed variance (λ = 11.6; CV=0.3), thereby allowing a greater departure from observed values. Therefore, the fits were less precise, but acceptable. Residuals were generally 10-30% of the annual discards in weight, with the exception of the trap fleet for which residuals often exceeded 100% of the annual discards (Table 8.1.3 and Figure 8.1.2). Given that the trap fleet discards were generally less than 1% of all discards it is unlikely that this would have much effect upon the results.

The predicted index values were assigned moderate variance (λ = 25; CV=0.2). The six indices were equally weighted, and the yearly estimates of each index were also assigned an equal weighting (CV = 0.2). The fits and residuals to the indices of abundance are summarized in Table 8.1.4 and Figures 8.1.3 and 8.1.4.

Similar to fits from SEDAR 12, for the years 1998-2005, the predicted index values were lower than the observed values for the COM HL, LL and HB 20" minimum size limit (1990-2005) indices. The MRFSS index deviated from the predicted values primarily during the early years of the time series (1988-1992) and in 2004.

A dominant feature of all indices is a buildup beginning around 2002 to quite high values in 2005 (except for MRFSS which has the second highest value overall in 2004) and then a steep decline of approximately 50% between 2005 and 2006. CPUE fits generally do not match this increase or the very high 2005 values, with very high residuals for 2005 and for several years prior (Figure 8.1.4). Similarly, the fitted CPUEs fail to match the observed declines between 2005 and 2006.

Fits to the landings-at-age and discard at age were generally acceptable (Figures 8.1.5-8.1.12) and show the influence of strong year classes, particularly fish born in 1999 and 1996. Poor fits to the landings- or discards-at age were generally caused by low effective sample sizes, particularly for the trap and recreational fisheries (See Tables 7.9. A-D).

Discards at age for the HL, LL and REC fleets were obtained from age-converted observed lengths, rather than solely from model-based estimates as in SEDAR 12. Observed discards at age were available for three years (2006-2008 for HL and LL; 2005-2007 for REC) and averaged discard age compositions were used back in time. Though employing and average age composition back in time would not capture changes in year class strength, it does more closely reflect the observation that older ages of fish were discarded then the previous model-based estimates from SEDAR 12. Consequently, it was appropriate to give these discards a higher weighting (CV = 0.3) to reflect the slightly greater confidence in the empirical nature of this age composition. The resulting observed and fitted age composition indicate that the modal age for discards is shifted approximately 1-2 years older than previously assumed in SEDAR 12.

8.1.2. Selectivity

A single selectivity-at-age vector was estimated for each fleet. Each vector applies to the total catch (landed and released animals). The selectivity vectors are summarized in Figure 8.1.13 and Table 8.1.5. As mentioned previously, the selectivities of fish older than about age ten were, in general, rather poorly determined due to low numbers of fish in older age classes for most fleets. Thus it was necessary to restrict the age range over which age-specific selectivity coefficients were estimated to avoid the undesirable situation where small changes in model configuration resulted in large shifts in the right tail of the selectivity vectors from dome-shaped or asymptotic, or vice versa.

The estimated selectivity vector for the recreational fishery is dome-shaped, with a peak at age 4, rather than ages 1 and 2 as estimated in SEDAR 12. This shift reflects the influence of using actual observations of the length composition of discards from the headboat fishery, which were unavailable at the time of SEDAR 12, but now indicate that very few age 1 and 2 fish are caught. The AWP felt that these data constitute the best representation of the size of recreational discards available at the present time.

The selectivity vector for the commercial longline is no longer estimated to be dome-shaped. This change in the estimated longline selectivity pattern from weakly dome-shaped (SEDAR 12) to asymptotic appeared reasonable to the AWP as it is unlikely that the longline gear itself would exclude older animals (it is capable of capturing even the largest red groupers) and there does not appear to be a strong ontogenetic shift of older red grouper to waters deeper than those fished by the red grouper longline fishery (if there were, one might expect to see more red grouper among the catch of the deepwater longline fishery for tilefish and yellowedge grouper).

The estimated handline selectivity pattern is dome-shaped with selectivities on older fish being somewhere between those of the recreational and longline fleets (generally unchanged from that estimated during SEDAR 12). This pattern is not surprising as the commercial handline fishery fishes in shallower water on average than the longline fishery, but deeper on average than the recreational fishery. The handline fishery is also more of a multispecies fishery than the longline fishery and may select for fewer older red grouper although it is not obvious how this might occur. In future assessments it would be desirable to incorporate age-composition data from a source with an assumed known selectivity pattern such as a research survey, which would help to verify the fishery-dependent selectivity vectors.

8.1.3. Fishing mortality

Estimated fleet-specific total fishing mortality rates (landings + discards) are summarized in Figures 8.1.14 and 8.1.15 and Table 8.1.6. The commercial longline fleet has historically exerted the highest directed fishing mortality rates with the recreational, handline and trap fleets approximately equal but much lower. The trap fishery was closed after 2006. Similarly, the commercial longline fishery has the highest estimated discard mortality with the recreational fleet second.

Overall, annual estimates of apical F (landings + discards) indicate that fishing mortality has generally declined from values ~0.25 during the late 1980s and early 1990s to values ~0.2 during the early 2000s (Figure 8.1.16, Table 8.1.7). In the most recent three years since the 2006 assessment, apical F has appeared to decline even further to values ~0.14.

8.1.4. Fishing mortality rate at age

Total fishing mortality-at-age (landings + discards) is summarized in Table 8.1.8. These estimates indicate relatively minimal F on animals younger than 2 and highest F values on ages 6 and above. During the 18” size limit (1986-1990) maximal F occurred on animals aged 4-6 and ages 6-10 after the 20” minimum size limit (1990-2005).

8.1.5. Abundance and biomass at age

Abundance in number also increased fairly steadily since the beginning of the time series (Figure 8.1.17, Figure 8.1.18A, Tables 8.1.9-11). At the beginning of the time series, fish older than 10 years comprised a much larger proportion of the stock. During the early 1990s older fish declined in abundance, likely as a result of the higher fishing mortalities during this time period. As overall fishing mortality has declined and with the strong 1996 and 1999 recruitments (seen as age 1 fish in 1997 and 2000, Figure 8.1.17) estimated numerical abundance, and, as these fish have grown, stock biomass have increased. According to these results, the stock is comprised mostly of individuals less than 10 years old though the age composition appears to be showing signs of expansion as large year classes mature. Estimated recruitment (age 1 abundance) has deviated without obvious trend throughout the time series (Figure 8.1.18B) and is similar to recruitment estimated for the 2006 assessment for most contiguous years.

8.1.6 Total biomass and spawning stock

Total biomass and spawning stock reproductive potential (SS) in grams of mature female gonad weight as a proxy for spawning stock biomass, has generally increased since 1986 (Figure 8.1.18A and Table 8.1.11). The SS trajectory is similar to that estimated for the 2006 Base assessment, though the rate of increase is not as steep (Figure 8.1.19).

8.1.7 Stock and recruitment

A Beverton-Holt stock recruitment relationship was assumed and estimated by two parameters; steepness and virgin reproductive potential (Figure 8.1.20). Steepness was estimated using a triangular prior in the same manner as for SEDAR 2006 (as recommended by the 2002 Reef Fish Stock Assessment Panel) with a maximum probability at 0.7, and zero probability of steepness < 0.3 or >0.9.

Estimated steepness was 0.84 (SD = 0.05) (Table 8.1.12). The virgin spawning stock size was estimated as a free parameter (no prior was used). The estimated value was 1.663E+09 (grams mature female gonad). The estimated steepness and virgin spawning stock size correspond to Beverton-Holt stock recruitment parameters: α =10,691,500 and β =83,148,000.

8.2. Results of Red tide model
8.2.1 Model fit

The objective function value, relative negative log-likelihood components and residual sums of squares are tabulated for the red tide model in Table 8.2.1. While the overall and individual likelihood components are not strictly equivalent to an AIC or other model comparison metrics, for models with the same number of parameters, data inputs and weighting factors, they do provide a measure of goodness of fit. The red tide model has one additional parameter (the extra mortality in 2005) so it would be expected to have a lower objective function value if it allowed the model to provide a better fit to the data. The likelihood components for both the indices (82.719) and overall (2961.33) for the red tide model were lower than for the central model indicating a substantially better fit. The estimated episodic M from the red tide model (for 2005) was equal to 0.317 = ln(-1.148) which is more than double the assumed overall natural mortality rate of 0.14 (Table 8.2.12).

The improved fit of the red tide model can be observed in the fits to the indices (Figure 8.2.3, Table 8.2.4) and smaller residuals (Figure 8.2.4). The red tide fits both the increasing abundance trend up until 2005 and then the abrupt decrease afterwards far better than the central model, though, even so, the predicted values never reach the very high observed index values for 2005.

Fits to the landings, discards, catch and discards at age show no particular differences between the two models (Tables 8.2.2 -3 and Figures 8.2.1-2, Figures 8.2.5-12).

8.1.2 Selectivity

The selectivity vectors were estimated to be almost exactly the same as for the central model (Figure 8.2.13, Table 8.2.4).

8.1.3 Fishing mortality

Estimated fleet-specific total fishing mortality rates (landings + discards) are summarized in Figures 8.2.14 and 8.2.15 and Table 8.2.6. The trends were largely the same except that the red tide model did not show as strong of a decline in directed and discard F for the longline or the recreational fleets between the years 2004 to 2007.

Annual estimates of apical F (landings + discards) for the red tide model also show a similar pattern but with less of a decline in apical F in the most recent four years (Figure 8.2.16, Table

8.2.7). Estimated total fishing mortality-at-age (landings + discards) is summarized in Table 8.2.8 and also shows a similar pattern as the central model.

8.2.5 Abundance and biomass at age

Abundance and biomass at age show similar patterns to the central model (Figure 8.2.17, Tables 8.2.9-11).

8.2.6 Total biomass and spawning stock

Total biomass, number and spawning stock reproductive potential (Figures 8.2.18 and 8.2.19A) indicate substantial divergence between the two models for the years leading up to 2005 and immediately afterward. Biomass in the central model never reaches as high as the red tide model in the years leading up to 2005, nor does it exhibit as sharp of a decline.

8.2.7 Stock and recruitment

Substantive differences in the stock-recruitment relationship were estimated for the two models. Estimated steepness was similar 0.83 (SD = 0.05) but virgin spawning stock size was estimated to be higher for the red tide model (1.83E+09 grams mature female gonad) than for the central model (1.663E+09) . The estimated steepness and virgin spawning stock size for the red tide model correspond to Beverton-Holt stock recruitment parameters: α = 11,767,400 and β =96,391,600 (Figure 8.2.20). Asymptotic recruitment was estimated to be more than one million recruits (~10%) higher for the red tide model than for the central model. Model-estimated recruitments were higher for the red tide model as similar years can be seen as adjacent points with the red tide recruitment systematically higher for all years (Figure 8.2.20).

8.2.8 Summary of differences between the models

Overall the red tide model estimates higher SSB in 2004 and lower SSB after 2005 than the central model. In this manner it is more like the previous assessment which showed increasing biomass up to 2005. Because the central model without red tide cannot explain the rapid increase up to 2004 followed by the sudden decrease in 2005 it has to split the difference and estimate a lower biomass in 2004 (Figure 8.2.18A,B). In contrast, the red tide model allows for the buildup of the stock in years following the high 2000 recruitment and then a rapid decline due to some mortality event during 2005 (Figure 8.2.3 and Figure 8.2.18A,B). While fishing mortality may not have been the primary cause of the decline, it has not diminished as much as might be suggested by the diminished catch because the exploitable biomass was so greatly reduced by the red tide. However the red tide model, because of the higher productivity of the stock recruitment relationship, implies a somewhat greater capacity to recover from stock declines.

8.3. Sensitivity analyses

Diagnostics for the sensitivity analyses are available from the SEFSC, however for brevity we will not show the tabled results in this document. Fits to landings, discards, indices and age compositions were similar, however the models with the 2% increase in q on the fishery dependent indices had the lowest objective function indicative of a slightly better fit. The model results are summarized in section 9.1 and tables 9.1 and 9.2.

9 Biological reference points

9.1 Estimation methods

Management reference points (F_{MSY}, F_{MAX}, $F_{0.1}$, $F_{20\%SPR}$, $F_{30\%SPR}$, $F_{40\%SPR}$, $F_{90\%maxYPR}$ and $F_{75\%Fmax}$) for the central model, the continuity case model run with data up to 2006 and sensitivity runs were obtained with the PRO-2BOX projection software using the ASAP-estimated Beverton-Holt stock recruitment relationship. Details of the calculation of these benchmarks are provided in the PRO-2BOX reference manual (Porch 2002). All benchmarks were calculated based upon a single, averaged over all fleets selectivity vector obtained from the relative vulnerabilities from 2008 and a single overall growth curve and include both discard and directed fishing mortality. Benchmarks for the red tide model and sensitivity runs were also obtained with PRO-2BOX projection software.

9.2. Results

Management benchmarks and associated reference values (Current F, $F_{current}/F_{MSY}$, and SSB/SSB_{MSY}) for the central and red tide models are shown in tables 9.1 and 9.2. For reference purposes results from the 2006 model are shown as well.

9.3. Status indicators

9.3.1 Definitions

The update AWP decided that current status of the fishery would be calculated as the geometric mean of the annual, overall (discard and direct) F for years 2005-2007. To obtain the annual F, direct and discard fishing mortality at age was summed over all fleets and the apical, or maximal, F over all ages was used as a proxy for the overall fishing mortality rate. Note that this designation of current F differs from the decision made in SEDAR 12 where the terminal (2006) year F was used. Current stock status is estimated to be SSB (or in this case, the SSB proxy) in 2008.

The maximum fishing mortality threshold (MFMT) was taken to be F_{MSY}, and the minimum stock size threshold (MSST) is defined by the Council as $(1-M)SSB_{MSY}$ (Restrepo et al. 1998). Overfishing is defined as F > MFMT and overfished as SSB < MSST.

9.3.2 Status of stock and fishery

The results of the central run estimate that, as of 2008, the stock was not overfished or undergoing overfishing (SS_{2008}/MSST=1.28, $F_{current}/F_{MSY}$ = 0.778) and was only slightly below the level that would produce the optimum yield (OY). Management reference points are as follows MFMT = F_{MSY} = 0.186 and MSST = (1-M) * SS_{MSY} = 5.57E+08, where M = 0.14. Maximum sustainable yield is estimated to be 6,962,000 lbs and current F=0.14 (Table 9.1 and 9.3). Time series of F/F_{MSY} and SSB/SSB_{MSY} indicate an overall increasing trend in spawning stock biomass and a parallel but lower trend in absolute values for F/F_{MSY} relative to SEDAR 12 (Figure 8.1.19).

The results from the red tide model were somewhat less optimistic in terms of current stock status. The spawning stock was estimated to be below levels that would produce MSY, but not overfished or undergoing overfishing (SS_{2008}/MSST=1.004, $F_{current}/F_{MSY}$ = 0.863). On the other hand, the red tide model suggested a potentially more productive stock with a larger estimated MSY (7,670,000 lbs). Management reference points are as follows MFMT = F_{MSY} = 0.187 and MSST = (1-M) * SS_{MSY} = 6.12E+08, current F=0.16 (Table 9.2 and 9.3). Time series of SSB/SSB_{MSY} and F/F_{MSY} and indicate a stronger decline in SSB/SSB_{MSY} between 2005 and 2006 and less of a reduction in F/F_{MSY} after 2004 relative to the central model (Figure 8.1.19C,D).

A complete summary of the benchmarks and reference points can be found in Tables 9.1-9.3. Uncertainty values, where available, are summarized in Tables 8.1.12 and 8.2.12.

9.3.3 Outcome of sensitivity analyses

Tables 9.1 and 9.2 document the results of the various sensitivity runs for both central model and the red tide model. Both models show similar and characteristic responses to increases and decreases in q and natural mortality with the current stock biomass status somewhat higher (Figure 9.1A) and the current fishing mortality status very slightly lower (Figure 9.1B) for the central model.

Runs where q decreases and M increases show more favorable stock status, and, vice versa for runs assuming an increase in catchability over time or a lower natural mortality rate. For the central model, only the run with a 2% increase in q indicates that overfishing is occurring ($F_{current}/F_{MSY}$=1.102). All other runs indicate that the stock status is neither overfished nor undergoing overfishing. For the red tide model (Table 9.2) the sensitivity runs assuming the lower M and an increase in q both indicate an overfished condition (SSB/MSST= 0.901 and 0.917, respectively) while the latter run is also estimated to be undergoing overfishing ($F_{current}/F_{MSY}$=1.065).

10. Projections

10.1 Projection methods

Projections for the central model and the red tide model were conducted with the PRO-2BOX (Porch 2002) projection software. Projections were run through 2019, beginning in 2009 with the 2009 landings set to the total commercial and recreational landings target of 7.57 million gutted pounds. Future recruitment was projected using the ASAP-estimated Beverton-Holt stock-recruitment relationship (Figures 8.1.20, 8.2.20.) and the 2008 selectivity vector. To estimate the variance of the projections, 500 bootstraps were conducted from the deterministic ASAP results. These bootstraps only considered variability in the stock recruitment relationship by incorporating a standard deviation of 0.4 (in the lognormal scale) on the lognormal recruitment deviations. Note that these bootstraps did not account for any model error or other sources of process error. Projection control files are available from the SEFSC.

10.2 Projection scenarios

Projections considered four fixed F scenarios:

<u>Central model</u>

Scenario 1: F= $F_{current}$ (0.132) (Note that this is F_{2008}, not the F current used for status determination)
Scenario 2: F=F_{MSY} (0.1864)
Scenario 3: F=90%F_{MSY} (0.1588)
Scenario 4: F=75%F_{MSY} (0.1323)

<u>Red tide model</u>

Scenario 1: F= $F_{current}$ (0.159) (Note that this is F_{2008}, not the F current used for status determination)
Scenario 2: F=F_{MSY} (0.1865)
Scenario 3: F=90%F_{MSY} (0.168)
Scenario 4: F=75%F_{MSY} (0.1399)

10.3. Projection results

Projection results for the central model predicted total biomass, landings, recruitment and benchmarks shown as F/F_{MSY} and SSB/SSB_{MSY} (note that here we have not used MSST), are depicted in Figures 10.1 and 10.3 and Tables 10.1 to 10.6. As MSST< SSB_{MSY}, the biomass ratios are lower than if MSST was used in the denominator. For the central run, all fixed F scenarios indicate that biomass will increase or remain stable and above SSB_{MSY} (Table 10.5) and that F will remain at or below F_{MSY} as expected. Imposition of the 2009 landings target of 7.57 mp results in a single year spike in fishing mortality rate but not above overfishing criteria.

Projections of the red tide model with a 2009 quota of 7.57 mp indicate a single-year increase in F above F_{MSY} (Figures 10.2-10.3 and Tables 10.7-10.12). Nevertheless, all fixed F scenarios indicate an increase in biomass and maintenance of F at or below F_{MSY} as would be expected for the choice of scenarios and the low value of current F (0.162).

The major difference between the two projections is in recruitment levels. The red tide model has approximately 10% greater recruitment potential for the same spawning stock biomass (Figure 10.3) resulting in higher predicted recruitments and a more rapid increase in biomass despite the fact that the spawning stock is in a lower status compared to the central model. The projected recruitment does not vary greatly between the projected F scenarios because spawning stock is currently near MSY levels and the four F-scenarios are designed to keep it near the MSY level or slightly above. Hence, one should get projections of recruitment that are similar to recent levels (Tables 10.4 and 10.10., Figure 10.3).

Based upon the projections a decision table which presents the probability of overfishing ($F>F_{MSY}$) for a suite of fixed harvest quotas spanning the central model estimate of MSY (6.96 mp) was constructed (Table 10.13). Tables were created from 500 bootstrap projections from the proportion of the 500 bootstraps for which $F>F_{MSY}$ in for the years 2009-2019. Note that for 2009, the landings were estimated to be 7.57 mp, which is the reason that many scenarios indicate overfishing in that year only. The probability of overfishing was calculated for the central model, +/- 2% change in q and 1.1 and 0.9*natural mortality and for the red tide model.

10.4. Comments on projections

The red tide model has approximately 10% greater recruitment potential for the same spawning stock biomass (Figure 10.3) resulting in higher predicted recruitments and a rapid increase in biomass despite the fact that the spawning stock is at a lower status compared to the central model. It should be noted that the projections do not capture all of the variability inherent in the stock assessment but only include variability in recruitment. Further, the recruitment variability only substantively affects the population and the benchmarks several years after the recruitment event, because the recruits must be several years old to recruit to the spawning stock or to be observed into the landings and hence to factor into SSB or F calculations. It is likely that model uncertainty and other sources of error would make these projections even more uncertain and variable than they currently appear. Further, given the strong influence of recruitment on future stock status and the high uncertainty in recruitment, future realized stock status will depend strongly upon actual recruitment.

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13 Tables

Table 3.1. Meristic regressions for red grouper from the Gulf of Mexico (1991-2008). Refer to SEDAR-12-DW-03, for details.

Conversion and Units	Equation	n	r^2	Data Ranges
FL (mm) to TL (mm)	TL = 1.05 * FL – 5.95	4954	0.99	TL (mm): 171 – 954 FL (mm): 171 – 910
TL (mm) to W. Wt (kg)	W. Wt = 6 x 10-09 * ($TL^{3.14}$)	3627	0.99	TL (mm): 213 – 954 W. Wt (kg): 0.14 – 16.96
FL (mm) to W. Wt (kg)	W. Wt = 7 x 10-09 * ($FL^{3.14}$)	3101	0.95	FL (mm): 211 – 965 W. Wt (kg): 0.14 – 16.96
TL (mm) to G. Wt (kg)	G. Wt = 7 x 10-08 * ($TL^{2.76}$)	629	0.99	TL (mm): 458 – 980 G. Wt (kg): 0.82 – 15.05
FL (mm) to G. Wt (kg)	G. Wt = 4 x 10-9 * ($FL^{3.24}$)	2844	0.97	FL (mm): 420 – 890 G. Wt (kg): 0.91 – 16.69

Table. 4.1. Estimated discards in number in commercial handline, trap and longline fleets.

year	handline	TRAP	longline
1990	233,263	20,891	432,644
1991	347,371	42,406	811,121
1992	436,300	80,948	403,550
1993	197,971	22,289	540,683
1994	238,279	20,004	412,423
1995	218,443	19,733	514,351
1996	277,560	19,566	638,383
1997	267,806	15,796	715,060
1998	260,986	11,108	597,663
1999	335,615	13,423	676,715
2000	314,057	15,009	567,579
2001	314,818	14,159	628,331
2002	309,319	15,572	588,338
2003	309,429	12,707	605,732
2004	266,639	9,653	631,573
2005	232,954	7,506	576,157
2006	237,974	8,027	541,735
2007	240,722	244	338,735
2008	235,615	0	505,406

Table 5.1. Estimated MRFSS A+B1 (fish killed) and B2 catch (released alive) by mode for red grouper in the Gulf of Mexico. Charterboat and cbt/hbt estimates use the new method or are calibrated to the new method.

	Cbt		Cbt/Hbt		Priv		Shore		Total	
YEAR	ab1	b2	ab1	b2	ab1	b2	ab1	b2	ab1	b2
1981			182,113	27,053	104,360	50,058	15,020	3,855	301,493	80,967
1982			40,128	6,655	259,607	55,502	4,068	0	303,804	62,157
1983			77,192	24,959	540,104	190,529	24,684	0	641,980	215,488
1984			240,646	47,390	1,102,567	394,364	76,924	19,163	1,420,137	460,918
1985			331,973	76,877	432,956	39,262	0	5,121	764,929	121,260
1986	71,462	61,526			670,984	444,261	5,863	5,863	748,309	511,650
1987	55,612	63,738			337,531	403,467	10,105	0	403,249	467,205
1988	44,556	37,005			631,814	817,327	7,601	11,632	683,972	865,964
1989	38,901	91,183			712,589	1,877,785	0	1,794	751,490	1,970,761
1990	45,911	182,336			116,750	1,358,409	13,506	20,881	176,168	1,561,626
1991	14,124	47,116			264,147	2,922,955	9,378	33,429	287,649	3,003,500
1992	36,082	136,388			382,585	2,450,741	24,264	81,896	442,931	2,669,025
1993	30,156	109,133			315,253	1,621,466	16,797	7,567	362,205	1,738,166
1994	25,620	102,739			269,162	1,546,760	3,770	16,405	298,552	1,665,904
1995	54,786	135,386			226,334	1,481,149	1,315	5,099	282,435	1,621,635
1996	20,447	66,209			106,029	994,391	0	14,287	126,476	1,074,887
1997	21,474	102,748			64,735	968,470	1,369	8,894	87,578	1,080,112
1998	21,989	223,670			81,619	1,293,502	901	9,758	104,508	1,526,930
1999	33,278	324,000			144,732	1,756,987	0	6,049	178,011	2,087,036
2000	115,826	526,803			217,853	1,688,318	0	7,793	333,679	2,222,914
2001	58,136	230,251			156,663	1,432,283	0	3,234	214,799	1,665,768
2002	45,538	225,579			202,419	1,723,762			247,957	1,949,341
2003	45,062	293,344			172,294	1,786,673	0	914	217,356	2,080,930
2004	98,488	370,911			397,454	2,761,968	0	3,922	495,942	3,136,801
2005	83,829	250,353			133,635	1,392,100	0	2,372	217,464	1,644,824
2006	38,210	121,880			100,303	752,179			138,513	874,059
2007	26,294	124,738			121,557	922,102	0	3,374	147,851	1,050,213
2008	42,151	364,242			90,383	2,653,583	0	74,202	132,534	3,092,028

Table 5.2. Estimated MRFSS A+B1 (fish killed) and B2 catch (released alive) by state for red grouper in the Gulf of Mexico. Charter and cbt/hbt estimates use the new method or are calibrated to the new method. FLW includes Monroe county.

	LA		MS		AL		FLW		Total	
YEAR	ab1	b2	ab1	b2	ab1	b2	ab1	b2	ab1	b2
1981							301,493	80,967	301,493	80,967
1982							303,804	62,157	303,804	62,157
1983							641,980	215,488	641,980	215,488
1984					352	0	1,419,785	460,918	1,420,137	460,918
1985							764,929	121,260	764,929	121,260
1986							748,309	511,650	748,309	511,650
1987							403,249	467,205	403,249	467,205
1988							683,972	865,964	683,972	865,964
1989							751,490	1,970,761	751,490	1,970,761
1990					0	226	176,168	1,561,400	176,168	1,561,626
1991	735	0					286,914	3,003,500	287,649	3,003,500
1992							442,931	2,669,025	442,931	2,669,025
1993							362,205	1,738,166	362,205	1,738,166
1994							298,552	1,665,904	298,552	1,665,904
1995					167	0	282,268	1,621,635	282,435	1,621,635
1996					1,033	0	125,443	1,074,887	126,476	1,074,887
1997							87,578	1,080,112	87,578	1,080,112
1998							104,508	1,526,930	104,508	1,526,930
1999					37	0	177,974	2,087,036	178,011	2,087,036
2000					33	0	333,646	2,222,914	333,679	2,222,914
2001					37	66	214,762	1,665,702	214,799	1,665,768
2002			595	0	1,673	10,818	245,688	1,938,523	247,957	1,949,341
2003			0	191	4,991	28,661	212,365	2,052,078	217,356	2,080,930
2004			912	0	12,725	9,412	482,306	3,127,389	495,942	3,136,801
2005					5,510	7,706	211,954	1,637,118	217,464	1,644,824
2006					3,778	897	134,736	873,162	138,513	874,059
2007					144	0	147,706	1,050,213	147,851	1,050,213
2008					0	9	132,534	3,092,018	132,534	3,092,028

Table 5.3. Headboat Survey estimated catch by area groups for Gulf of Mexico red grouper. (Estimated catch includes only kept fish.) A Gulf-wide estimate was made for 2008.

year	SW FL-Mid.gr. 18+21+22	NW FL-Texas 23-27	All Gulf areas
1986	31,692	1,221	32,913
1987	24,766	963	25,729
1988	27,298	656	27,954
1989	49,472	305	49,777
1990	14,306	276	14,582
1991	9,260	249	9,509
1992	8,875	174	9,049
1993	7,626	1,176	8,802
1994	8,893	724	9,617
1995	13,775	724	14,499
1996	13,880	1,714	15,594
1997	3,509	1,167	4,676
1998	3,527	855	4,382
1999	6,298	620	6,918
2000	7,965	896	8,861
2001	3,025	2,535	5,560
2002	2,363	2,039	4,402
2003	3,784	3,737	7,521
2004	8,742	5,068	13,810
2005	8,588	5,379	13,967
2006	1,273	3,357	4,630
2007	2,406	1,839	4,245
2008			4,438

Table 5.4. Headboat Survey estimated discards by area groups for Gulf of Mexico red grouper. Discards estimated using MRFSS private mode estimates discard ratios (B2/(A+B1)). Discard estimate for 2008 was applied using a Gulf-wide ratio.

year	SW FL-Mid.gr. 18+21+22	NW FL-Texas 23-27	All Gulf areas
1986	26,591	1,393	27,984
1987	28,404	317	28,721
1988	42,082	31	42,113
1989	162,378	25	162,403
1990	183,532	61	183,593
1991	106,483	563	107,046
1992	53,923	1,057	54,980
1993	49,817	275	50,092
1994	49,225	2,425	51,650
1995	92,242	4,926	97,168
1996	133,283	11,808	145,091
1997	52,980	6,028	59,008
1998	64,116	523	64,639
1999	75,066	2,625	77,691
2000	63,522	4,674	68,196
2001	35,336	7,277	42,613
2002	19,822	21,297	41,119
2003	53,519	32,072	85,591
2004	80,927	14,394	95,321
2005	120,430	26,539	146,969
2006	19,595	18,034	37,629
2007	28,776	7,701	36,477
2008			123,070

Table 5.5. Ratios of fish released alive to total catch (kept + released dead+ released alive) from the Headboat Survey trip report data for red grouper by year and area group. Only trips that reported discards for any species are included.

	NW FL and AL (23)			SW FL- Mid.gr. (18+21+22)		
year	rel_live	kept+dead+live	live/kept+dead+live	rel_live	kept+dead+live	live/kept+dead+live
2004	215	584	0.37	18,249	21,899	0.83
2005	72	243	0.30	10,621	16,685	0.64
2006	298	701	0.43	5,983	6,349	0.94
2007	173	424	0.41	12,388	13,126	0.94

Table 5.6. Ratios of fish released alive (B2) to total catch (A+B1+B2) for red grouper from headboat observer programs in Florida (2005+) and Alabama (2004+).

	FLW panhandle + AL			FLW peninsula		
year	b2	ab1b2	b2/ab1b2	b2	ab1b2	b2/ab1b2
2004	109	130	0.84			
2005	222	326	0.68	1381	1447	0.95
2006	51	94	0.54	1049	1155	0.91
2007	21	52	0.40	1678	1842	0.91

Table 5.7. Ratios of fish released alive (B2) to total catch (A+B1+B2) from MRFSS private mode catch estimates by year and area group for red grouper in the Gulf of Mexico. Post-stratified estimates were used in order to separate FL peninsula from FL panhandle.

	FLW panhandle + AL			FLW peninsula		
year	b2	ab1b2	b2/ab1b2	b2	ab1b2	b2/ab1b2
2004	426,564	576,738	0.74	2,181,543	2,417,199	0.90
2005	250,606	301,399	0.83	1,106,685	1,185,606	0.93
2006	363,354	430,989	0.84	275,518	293,415	0.94
2007	276,847	342,960	0.81	601,306	651,581	0.92

Table 5.8. Ratios of fish released alive (B2) to total catch (A+B1+B2) from MRFSS charter boat mode catch estimates by year and area group for red grouper in the Gulf of Mexico. Post-stratified estimates were used in order to separate FL peninsula from FL panhandle.

	FLW panhandle + AL			FLW peninsula		
year	b2	ab1b2	b2/ab1b2	b2	ab1b2	b2/ab1b2
2004	63,725	111,468	0.57	281,544	325,758	0.86
2005	54,355	107,675	0.50	192,843	222,271	0.87
2006	33,533	56,711	0.59	86,547	100,839	0.86
2007	12,934	28,119	0.46	108,101	117,985	0.92

Table 7.1. Natural mortality, weight at age, length at age used for the 2009 update run. Note that these are identical to the 2006 base run.

age	Natural mortality	gutted weight (lbs) at age	fork length (cm) at age
1	0.494	0.20	105.05
2	0.339	0.75	215.79
3	0.268	1.65	310.15
4	0.228	2.79	390.56
5	0.202	4.09	459.09
6	0.184	5.46	517.48
7	0.171	6.83	567.23
8	0.162	8.16	609.63
9	0.154	9.41	645.76
10	0.148	10.57	676.55
11	0.144	11.62	702.79
12	0.140	12.57	725.15
13	0.137	13.42	744.20
14	0.135	14.17	760.43
15	0.133	14.83	774.27
16	0.131	15.41	786.06
17	0.130	15.91	796.10
18	0.128	16.35	804.66
19	0.127	16.73	811.96
20	0.127	17.82	818.17

Table 7.2. Fecundity proxy, identical to the 2006 base run.

Age	Proportion Mature	Proportion Female	Gonad Weight (g)	Proxy for fecundity
1	0	1	0	0
2	0.143	0.949	2.3	0.31
3	0.75	0.898	11	7.41
4	0.907	0.848	32.6	25.06
5	0.95	0.797	54.3	41.1
6	0.977	0.746	83.4	60.79
7	0.965	0.695	83.4	55.93
8	0.988	0.645	115.5	73.58
9	1	0.594	161.1	95.63
10	1	0.543	181.4	98.49
11	1	0.492	209.2	103
12	1	0.441	238.4	105.25
13	1	0.391	268.8	105.02
14	1	0.34	300.4	102.12
15	1	0.289	333.2	96.33
16	1	0.24	367	88.09
17	1	0.24	402	96.47
18	1	0.24	438	105.11
19	1	0.24	474.9	113.99
20+	1	0.24	512.9	123.1

Table 7.3. Landings in weight (gutted pounds).

YEAR	COM LL	COM HL	COM TRAP	REC
1986	2,482,090	3,116,270	714,626	2,400,300
1987	3,742,400	2,531,260	444,230	1,464,660
1988	2,172,240	2,035,100	535,166	2,475,990
1989	3,048,280	3,740,150	579,480	2,761,300
1990	2,015,800	2,454,250	339,231	1,127,740
1991	2,588,390	2,131,680	374,442	1,775,110
1992	2,408,440	1,452,930	601,907	2,656,870
1993	4,302,810	1,359,830	716,986	2,091,160
1994	2,703,460	1,283,180	916,222	1,808,210
1995	2,466,020	1,222,430	1,057,700	1,862,550
1996	2,992,060	903,136	559,086	893,755
1997	3,136,150	1,005,100	707,225	562,353
1998	2,851,890	798,246	317,165	643,079
1999	3,920,670	1,264,060	779,347	1,152,780
2000	2,981,130	1,805,390	1,048,270	2,107,720
2001	3,524,250	1,652,550	769,937	1,327,800
2002	3,205,740	1,700,290	998,902	1,611,130
2003	3,062,780	1,158,200	716,197	1,275,830
2004	3,545,970	1,427,090	770,342	3,037,020
2005	3,326,160	1,454,300	630,560	1,464,990
2006	3,156,360	1,385,340	602,207	925,923
2007	2,072,720	1,586,390	23,763	959,754
2008	2,753,210	1,968,170	0	860,986

Table 7.4. Calculation of recreational landings in weight (gutted pounds).
A) Multiply number landed (MRFSS AB1 + HB) by derived age composition to estimate number-at-age.

LANDINGS PROPORTION AT AGE FROM GOODYEAR

YEAR	NUMBER LANDED	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11	AGE 12	AGE 13	AGE 14	AGE 15	AGE 16	AGE 17	AGE 18	AGE 19	age 20+
1986	781,221	0.00	0.14	0.29	0.25	0.16	0.08	0.04	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1987	428,975	0.00	0.14	0.28	0.22	0.14	0.08	0.05	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	711,924	0.00	0.11	0.28	0.23	0.15	0.09	0.06	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1989	801,269	0.00	0.06	0.29	0.27	0.17	0.09	0.05	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1990	190,749	0.00	0.03	0.05	0.15	0.20	0.18	0.13	0.09	0.06	0.04	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1991	297,158	-	0.00	0.01	0.14	0.24	0.22	0.15	0.09	0.05	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1992	451,983	0.00	0.00	0.02	0.15	0.24	0.21	0.14	0.09	0.05	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1993	371,008	-	0.00	0.04	0.17	0.24	0.20	0.13	0.08	0.05	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	308,166	-	0.00	0.02	0.15	0.25	0.21	0.14	0.09	0.05	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	296,934	-	0.00	0.02	0.13	0.22	0.21	0.15	0.10	0.06	0.04	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1996	142,071	-	0.00	0.01	0.12	0.22	0.21	0.16	0.10	0.06	0.04	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1997	92,257	-	0.00	0.02	0.13	0.24	0.22	0.15	0.09	0.06	0.04	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1998	108,894	-	0.00	0.03	0.16	0.23	0.20	0.14	0.09	0.06	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1999	184,926	-	0.00	0.03	0.12	0.22	0.21	0.15	0.10	0.06	0.04	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2000	342,541	-	0.00	0.03	0.16	0.22	0.19	0.14	0.09	0.06	0.04	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2001	220,361	-	0.00	0.02	0.15	0.24	0.21	0.14	0.09	0.06	0.04	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2002	252,361	-	0.00	0.01	0.12	0.21	0.21	0.16	0.10	0.07	0.04	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2003	224,878	-	0.00	0.03	0.18	0.25	0.20	0.13	0.08	0.05	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	512,584	-	0.00	0.02	0.16	0.25	0.20	0.14	0.09	0.05	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2005	231,305	-	-	0.01	0.11	0.23	0.22	0.16	0.10	0.06	0.04	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2006	143,143	-	0.00	0.02	0.11	0.20	0.21	0.16	0.11	0.07	0.04	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2007	152,097	-	0.00	0.01	0.12	0.22	0.21	0.16	0.10	0.07	0.04	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2008	136,972	-	0.00	0.02	0.12	0.21	0.21	0.16	0.10	0.07	0.04	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00

B) Multiply number-at-age by weight-at-age to estimate total landings (MRFSS AB1 + HB) in weight.

YEAR	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11	AGE 12	AGE 13	AGE 14	AGE 15	AGE 16	AGE 17	AGE 18	AGE 19	age 20+	TOTAL WT (GUTTED LBS)
1986	81	81205	375345	535839	500236	349909	215733	128306	76795	46985	29512	19049	12603	8518	5874	4099	2896	2060	1472	3777	2400295
1987	3	45471	199797	261112	246426	195853	145108	105454	76287	54858	39159	27801	19676	13889	9804	6935	4918	3483	2476	6147	1464657
1988	5	56253	333259	458441	444034	366586	269511	184770	122584	80391	52689	34754	23112	15505	10502	7166	4933	3417	2392	5683	2475986
1989	2	36465	381852	612168	558902	411096	273773	174572	110059	69675	44576	28920	19019	12656	8529	5794	3979	2763	1924	4579	2761302
1990	1	3739	14928	81226	155828	186023	173411	140845	106342	77315	55130	38992	27488	19359	13661	9662	6843	4856	3463	8623	1127737
1991	-	1	6927	115454	296411	354780	301919	221074	152517	103196	69624	47215	32226	22151	15337	10680	7480	5265	3714	9140	1775111
1992	144	743	17280	187403	442528	516280	443257	330265	230676	156744	105505	71055	48077	32724	22427	15472	10742	7505	5270	12774	2656871
1993	-	1210	23637	177500	371772	407039	333194	240736	166217	113542	77702	53514	37111	25865	18126	12760	9007	6393	4551	11278	2091155
1994	-	29	8696	127793	314903	361486	303190	221922	153119	103112	68892	46096	31004	20989	14314	9832	6795	4742	3313	7982	1808208
1995	-	2	7928	104501	262646	335935	313048	248209	181405	127344	87722	60040	41084	28175	19416	13438	9358	6541	4601	11153	1862546
1996	-	1	3169	47841	126786	164044	151995	119609	86873	60671	41623	28379	19354	13237	9107	6288	4376	3058	2141	5202	893755
1997	-	5	2370	33952	88871	108487	94248	70806	50221	34853	24026	16547	11435	7922	5503	3853	2705	1897	1338	3314	562353
1998	-	16	5299	47319	104124	119845	103962	79225	56799	39535	27129	18546	12684	8688	5992	4145	2880	2011	1422	3456	643079
1999	-	146	7976	60889	163490	210908	194241	152642	111094	77918	53735	36867	25300	17404	12029	8353	5825	4088	2878	7002	1152783
2000	-	47	17036	149546	302207	346109	316559	260152	200837	148861	107458	76424	53915	37883	26610	18708	13177	9320	6608	16266	2107724
2001	-	3	6186	90886	214859	248084	214121	163313	117963	83043	57733	39960	27649	19161	13320	9293	6509	4578	3229	7910	1327799
2002	-	14	5836	82511	219672	286380	268848	215216	159329	113458	79248	54935	37997	26304	18259	12729	8912	6263	4417	10797	1611125
2003	-	4	9483	112074	231303	248892	204085	148196	102286	69358	46889	31824	21743	14938	10338	7197	5029	3548	2493	6147	1275828
2004	-	569	17130	224369	514814	568511	474012	356706	258614	184369	130147	91425	64076	44884	31490	22145	15596	11037	7813	19313	3037020
2005	-	0	2319	68809	216455	281673	252698	192969	137809	95862	66091	45555	31474	21825	15204	10633	7464	5265	3731	9157	1464993
2006	-	4	3606	43768	119554	161439	156312	127474	95003	67551	46889	32239	22119	15193	10472	7243	5045	3532	2476	6004	925923
2007	-	8	3164	49808	135307	176265	164735	130044	94203	65405	44564	30202	20495	13960	9567	6596	4583	3189	2242	5416	959754
2008	-	2	3418	45310	120127	159397	149283	117137	84313	58251	39508	26669	18025	12231	8351	5733	3963	2747	1924	4597	860986

Table 7.5. Calculation of ***commercial longline*** dead discards in weight (gutted pounds).
A) Obtain discard fraction at age from age-converted observed lengths for 2006-2008, multiply the average 2006-2008 by the total discards in number to obtain discards at age. Use the actual numbers of discards at age from the probabilistic aging of the observed lengths for 2006-2008.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20+	TOTAL DISCARDS
2006	0.000	0.017	0.218	0.329	0.221	0.111	0.052	0.025	0.012	0.006	0.003	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	
2007	0.000	0.016	0.197	0.333	0.231	0.116	0.054	0.025	0.012	0.006	0.003	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	Age composition of discards from observed lengths
2008	0.000	0.008	0.140	0.336	0.266	0.135	0.061	0.027	0.013	0.006	0.003	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	
average 2006-2008	0.000	0.014	0.185	0.332	0.239	0.121	0.056	0.026	0.012	0.006	0.003	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	19	5974	79960	143845	103503	52333	24099	11173	5407	2753	1473	824	479	288	178	113	73	48	32	70	432644
1991	36	11200	149909	269681	194047	98113	45180	20947	10137	5162	2761	1544	899	540	334	212	137	90	60	131	811121
1992	18	5572	74583	134172	96542	48813	22478	10422	5043	2568	1374	768	447	269	166	105	68	45	30	65	403550
1993	24	7466	99928	179766	129349	65401	30117	13963	6757	3441	1840	1030	599	360	223	141	91	60	40	88	540683
1994	18	5695	76223	137122	98665	49887	22972	10651	5154	2625	1404	785	457	275	170	108	70	46	30	67	412423
1995	23	7102	95061	171011	123049	62216	28650	13283	6428	3273	1751	979	570	343	212	134	87	57	38	83	514351
1996	29	8815	117984	212249	152722	77219	35559	16486	7978	4063	2173	1216	707	425	263	166	108	71	47	103	638383
1997	32	9874	132155	237743	171066	86494	39830	18466	8936	4551	2434	1362	792	476	295	186	121	79	53	116	715060
1998	27	8253	110459	198711	142981	72293	33291	15435	7469	3804	2034	1138	662	398	246	156	101	66	44	97	597663
1999	30	9344	125069	224994	161892	81855	37694	17476	8457	4307	2303	1289	750	451	279	176	114	75	50	110	676715
2000	25	7837	104899	188708	135784	68654	31615	14658	7093	3612	1932	1081	629	378	234	148	96	63	42	92	567579
2001	28	8676	116126	208907	150317	76003	34999	16227	7853	3999	2139	1196	696	418	259	164	106	70	46	102	628331
2002	26	8124	108735	195610	140750	71165	32771	15194	7353	3744	2002	1120	652	392	242	153	99	65	43	95	588338
2003	27	8364	111950	201393	144911	73269	33740	15643	7570	3855	2062	1153	671	403	250	158	102	67	45	98	605732
2004	28	8721	116726	209985	151093	76395	35179	16310	7893	4019	2150	1203	700	421	260	165	107	70	47	102	631573
2005	26	7956	106484	191560	137836	69692	32093	14879	7200	3667	1961	1097	638	384	237	150	97	64	43	93	576157
2006	71	9292	117900	178148	119684	60361	28300	13399	6608	3418	1851	1046	614	371	231	147	95	63	42	93	541734
2007	1	5516	66749	112656	78216	39421	18326	8603	4213	2168	1170	659	386	233	145	92	60	39	26	57	338736
2008	0	4037	70638	169823	134370	68271	30710	13820	6498	3226	1688	928	531	316	193	121	78	51	34	74	505407

B) Multiply discards in number by assumed discard mortality rate (0.45 for commercial longline) and weight at age vector to obtain dead discard in weight. Note that these weight values are used only to accommodate the input requirements of the ASAP model. They are not intended to represent the actual weight of discards, which will be somewhat lower than indicated in the table below (see discussion in section 7.1.2).

DEAD DISCARDS IN WEIGHT

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20+	total dead discards in weight
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	2	2020	59273	180823	190626	128597	74084	41019	22896	13094	7702	4661	2895	1838	1190	782	523	353	241	562	733181
1991	3	3788	111124	339006	357385	241094	138893	76902	42925	24549	14440	8739	5427	3445	2231	1467	981	661	451	1054	1374567
1992	2	1884	55287	168663	177807	119949	69102	38261	21356	12214	7184	4348	2700	1714	1110	730	488	329	224	525	683877
1993	2	2525	74074	225977	238229	160710	92584	51262	28613	16364	9625	5825	3618	2296	1487	978	654	441	301	703	916270
1994	2	1926	56502	172371	181716	122587	70622	39102	21825	12482	7342	4444	2760	1752	1134	746	499	336	229	536	698914
1995	2	2402	70467	214972	226626	152883	88075	48766	27219	15567	9157	5542	3442	2185	1415	930	622	419	286	669	871645
1996	3	2981	87459	266811	281276	189750	109314	60525	33783	19321	11365	6878	4272	2711	1756	1155	772	520	355	830	1081836
1997	3	3339	97964	298858	315060	212541	122444	67795	37841	21642	12730	7704	4785	3037	1967	1293	865	583	398	929	1211777
1998	2	2791	81880	249792	263335	177647	102341	56664	31628	18089	10640	6439	3999	2538	1644	1081	723	487	332	777	1012831
1999	3	3160	92711	282832	298165	201144	115878	64159	35812	20481	12047	7291	4528	2874	1861	1224	819	552	376	880	1146796
2000	2	2650	77759	237219	250079	168705	97190	53812	30036	17178	10104	6115	3798	2411	1561	1026	687	463	316	738	961849
2001	2	2934	86082	262610	276847	186762	107593	59572	33251	19017	11186	6770	4204	2669	1728	1136	760	512	349	817	1064802
2002	2	2747	80603	245895	259226	174875	100745	55780	31135	17806	10474	6339	3937	2499	1618	1064	712	480	327	765	997029
2003	2	2829	82986	253165	266890	180045	103723	57430	32055	18333	10784	6526	4053	2573	1666	1095	733	494	337	787	1026505
2004	2	2949	86526	263965	278275	187726	108148	59879	33423	19115	11244	6805	4226	2682	1737	1142	764	515	351	821	1070296
2005	2	2690	78934	240804	253859	171254	98659	54626	30490	17438	10257	6208	3855	2447	1585	1042	697	470	320	749	976386
2006	6	3142	87397	223944	220428	148325	87000	49191	27981	16255	9682	5919	3708	2366	1542	1019	680	464	316	746	890111
2007	0	1865	49480	141616	144054	96869	56338	31584	17840	10310	6120	3729	2331	1486	968	638	430	287	196	457	566597
2008	0	1365	52362	213479	247476	167763	94408	50737	27516	15342	8829	5251	3207	2015	1288	839	559	375	256	593	893660

Table 7.6. Calculation of ***commercial handline*** dead discards in weight (gutted pounds).
A) Obtain discard fraction at age from age-converted observed lengths for 2006-2008, multiply the average 2006-2008 by the total discards in number to obtain discards at age. Use the actual numbers of discards at age from the probabilistic aging of the observed lengths for 2006-2008.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20+	
2006	0.000	0.032	0.273	0.329	0.195	0.091	0.041	0.019	0.009	0.005	0.003	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Age composition of discards from observed lengths
2007	0.000	0.008	0.114	0.310	0.272	0.151	0.073	0.035	0.017	0.009	0.005	0.003	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	
2008	0.000	0.028	0.246	0.317	0.213	0.105	0.047	0.021	0.010	0.005	0.003	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
average 2006-2008	0.000	0.023	0.211	0.319	0.227	0.116	0.054	0.025	0.012	0.006	0.003	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	TOTAL DISCARDS
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	24	5353	49238	74363	52854	27039	12526	5809	2804	1423	758	422	245	147	91	57	37	24	16	35	233263
1991	35	7971	73324	110740	78709	40266	18653	8651	4175	2119	1129	629	365	219	135	85	55	36	24	51	347371
1992	44	10012	92096	139090	98859	50574	23428	10865	5244	2661	1417	790	458	275	169	107	69	45	30	65	436300
1993	20	4543	41788	63112	44857	22948	10630	4930	2380	1208	643	358	208	125	77	49	31	20	14	29	197971
1994	24	5468	50297	75962	53990	27620	12795	5934	2864	1453	774	431	250	150	93	59	38	25	16	35	238279
1995	22	5013	46110	69638	49496	25321	11730	5440	2626	1332	710	395	229	138	85	54	34	23	15	32	218443
1996	28	6369	58588	88485	62891	32174	14904	6912	3336	1693	902	502	291	175	108	68	44	29	19	41	277560
1997	27	6146	56529	85375	60681	31043	14380	6669	3219	1634	870	485	281	169	104	66	42	28	18	40	267806
1998	27	5989	55090	83201	59135	30253	14014	6499	3137	1592	848	472	274	164	101	64	41	27	18	39	260986
1999	34	7702	70843	106992	76045	38903	18022	8358	4034	2047	1090	607	352	211	130	82	53	35	23	50	335615
2000	32	7207	66292	100120	71160	36404	16864	7821	3775	1916	1020	568	330	198	122	77	50	32	21	46	314057
2001	32	7224	66453	100362	71333	36493	16905	7840	3784	1920	1023	570	331	198	122	77	50	33	22	47	314818
2002	32	7098	65292	98609	70087	35855	16609	7703	3718	1887	1005	560	325	195	120	76	49	32	21	46	309319
2003	32	7101	65315	98644	70112	35868	16615	7706	3719	1887	1005	560	325	195	120	76	49	32	21	46	309429
2004	27	6119	56283	85003	60416	30908	14318	6640	3205	1626	866	483	280	168	104	66	42	28	18	39	266639
2005	24	5346	49173	74265	52784	27003	12509	5801	2800	1421	757	422	245	147	90	57	37	24	16	34	232954
2006	54	7586	64884	78312	46424	21747	9748	4486	2171	1109	595	334	195	118	73	46	30	20	13	93	238038
2007	18	2043	27500	74694	65387	36324	17537	8329	4079	2090	1120	627	365	219	135	86	55	36	24	57	240725
2008	1	6710	58046	74693	50196	24850	11139	5009	2354	1168	611	335	192	114	70	44	28	18	12	74	235664

B) Multiply discards in number by assumed discard mortality rate (0.45 for commercial longline) and the weight at age vector to obtain dead discard in weight. Note that these weight values are used only to accommodate the input requirements of the ASAP model. They are not intended to represent the actual weight of discards, which will be somewhat lower than indicated in the table below (see discussion in section 7.1.2).

DEAD DISCARDS IN WEIGHT

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20	total dead discards in weight
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	402	8111	20773	21632	14765	8557	4739	2638	1504	881	531	329	208	134	88	59	39	27	62	85480
1991	1	599	12079	30935	32214	21988	12743	7058	3929	2239	1312	791	490	310	200	132	87	59	40	92	127294
1992	1	752	15171	38855	40461	27617	16005	8864	4935	2813	1648	993	615	389	251	165	110	74	50	115	159883
1993	0	341	6884	17630	18359	12531	7262	4022	2239	1276	748	451	279	177	114	75	50	33	23	52	72547
1994	0	411	8285	21220	22097	15083	8741	4841	2695	1536	900	542	336	213	137	90	60	40	27	63	87317
1995	0	377	7596	19453	20258	13827	8013	4438	2471	1408	825	497	308	195	126	83	55	37	25	58	80049
1996	1	479	9651	24718	25740	17569	10182	5639	3139	1789	1048	632	391	248	160	105	70	47	32	73	101712
1997	1	462	9312	23849	24835	16952	9824	5441	3029	1726	1011	609	377	239	154	101	67	45	31	71	98138
1998	1	450	9075	23242	24203	16520	9574	5302	2952	1682	986	594	368	233	150	99	66	44	30	69	95638
1999	1	579	11670	29888	31124	21244	12311	6819	3796	2163	1267	764	473	300	193	127	84	57	38	88	122986
2000	1	542	10920	27968	29124	19879	11521	6381	3552	2025	1186	715	443	280	181	119	79	53	36	83	115086
2001	1	543	10947	28036	29195	19927	11549	6396	3561	2029	1189	716	444	281	181	119	79	53	36	83	115365
2002	1	533	10755	27546	28685	19579	11347	6284	3499	1994	1168	704	436	276	178	117	78	52	35	82	113350
2003	1	534	10759	27556	28695	19586	11351	6287	3500	1995	1168	704	436	276	178	117	78	52	35	82	113391
2004	1	460	9271	23745	24727	16878	9781	5417	3016	1719	1007	607	376	238	154	101	67	45	31	70	97710
2005	0	402	8100	20746	21603	14746	8546	4733	2635	1502	880	530	328	208	134	88	58	39	27	61	85366
2006	1	570	10688	21876	19000	11875	6659	3660	2043	1172	692	420	262	167	108	71	48	33	22	166	79533
2007	0	154	4530	20866	26761	19835	11980	6795	3838	2209	1302	788	490	310	200	133	88	59	40	102	100480
2008	0	504	9562	20865	20544	13570	7610	4086	2215	1234	710	421	258	162	104	68	45	29	20	132	82139

Table 7.7. Calculation of ***commercial trap*** dead discards in weight (gutted pounds).

A) multiply number discarded dead by derived age comp to estimate the number discarded - at-age.

Proportion discarded at age from derived probabilistic age composition

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20	TOTAL DISCARDS
1986	0.000	0.610	0.348	0.036	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
1987	0.000	0.777	0.204	0.017	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
1988	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
1989	0.000	0.787	0.193	0.017	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
1990	0.000	0.145	0.317	0.291	0.151	0.060	0.022	0.008	0.003	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	20891
1991	0.000	0.144	0.372	0.286	0.127	0.046	0.016	0.006	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	42406
1992	0.000	0.151	0.235	0.305	0.176	0.076	0.031	0.013	0.006	0.003	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	80948
1993	0.000	0.003	0.246	0.432	0.209	0.072	0.024	0.008	0.003	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	22289
1994	0.000	0.022	0.218	0.379	0.225	0.096	0.037	0.014	0.006	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	20004
1995	0.000	0.117	0.416	0.269	0.120	0.047	0.018	0.007	0.003	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	19733
1996	0.000	0.648	0.219	0.085	0.031	0.011	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	19566
1997	0.000	0.609	0.231	0.097	0.039	0.015	0.006	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	15796
1998	0.000	0.104	0.241	0.324	0.191	0.083	0.033	0.013	0.006	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	11108
1999	0.000	0.017	0.236	0.362	0.220	0.097	0.039	0.016	0.007	0.003	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	13423
2000	0.000	0.207	0.320	0.248	0.129	0.056	0.023	0.009	0.004	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	15009
2001	0.000	0.163	0.303	0.289	0.146	0.059	0.023	0.009	0.004	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	14159
2002	0.000	0.158	0.246	0.266	0.177	0.087	0.037	0.016	0.007	0.003	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	15572
2003	0.000	0.173	0.337	0.248	0.133	0.062	0.027	0.011	0.005	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	12707
2004	0.000	0.008	0.203	0.348	0.243	0.112	0.047	0.020	0.009	0.004	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	9653
2005	0.000	0.038	0.278	0.352	0.199	0.082	0.031	0.012	0.005	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	7506
2006	0.000	0.011	0.319	0.371	0.185	0.072	0.026	0.010	0.004	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	8027
2007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	244
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

B) multiply number-discarded-at-age by the weight-at-age matrix to derive total dead discards in weight. Note that these weight values are used only to accommodate the input requirements of the ASAP model. They are not intended to represent the actual weight of discards, which will be somewhat lower than indicated in the table below (see discussion in section 7.1.2).

DEAD DISCARDS IN WEIGHT

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20	total dead discards in weight
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	227	1090	1698	1292	688	316	139	63	29	14	7	4	2	1	1	0	0	0	0	5573
1991	0	459	2595	3382	2205	1074	466	197	86	39	19	9	5	3	1	0	1	0	0	0	10542
1992	0	922	3140	6892	5829	3350	1733	883	455	240	130	73	42	25	15	10	6	5	2	3	23755
1993	0	4	902	2690	1911	879	365	153	67	31	15	8	4	2	1	1	0	0	0	0	7033
1994	0	33	718	2117	1841	1044	501	229	105	50	25	13	7	4	2	1	1	1	1	0	6691
1995	0	173	1351	1483	968	510	247	117	56	28	14	8	4	2	1	1	1	0	0	0	4966
1996	0	953	706	466	247	113	50	22	10	5	3	1	1	0	0	0	0	0	0	0	2579
1997	0	723	601	427	251	127	60	29	14	7	4	2	1	1	0	0	0	0	0	0	2248
1998	0	87	441	1006	870	503	251	120	58	29	15	8	4	3	1	1	1	1	0	0	3398
1999	0	17	523	1356	1210	711	359	173	84	42	22	12	6	4	2	1	1	1	0	0	4524
2000	0	233	792	1041	792	459	234	115	56	28	14	8	4	2	2	1	1	0	0	0	3782
2001	0	173	706	1144	845	457	225	109	53	27	14	8	4	3	2	1	1	0	0	0	3772
2002	0	185	631	1159	1130	739	397	198	98	49	25	14	8	4	3	2	1	1	0	1	4642
2003	0	165	705	882	691	429	233	118	59	30	15	8	5	3	2	1	1	0	0	0	3346
2004	0	6	323	940	960	591	312	159	82	43	23	13	7	4	3	2	1	1	0	0	3470
2005	0	22	344	739	611	335	157	71	32	15	8	4	2	1	1	0	0	0	0	0	2342
2006	0	6	421	832	607	315	145	65	30	14	7	4	2	1	1	0	0	0	0	0	2450
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 7.8. Calculation of ***recreational*** dead discards in weight (gutted pounds).
A) Multiply discard age composition from the total number of discards (B2 numbers from MRFSS). Discard age composition comes from age-converted observed discard lengths from Headboats for 2005-2007. The arithmetic mean for 2005-2007 is applied for the years when no observed data existed.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20+	
2005	0.0411	0.1977	0.3251	0.2261	0.1142	0.0513	0.0227	0.0105	0.0051	0.0026	0.0014	0.0008	0.0005	0.0003	0.0002	0.0001	7E-05	5E-05	3E-05	7E-05	
2006	0.0238	0.2085	0.2884	0.2359	0.1322	0.0606	0.0265	0.0119	0.0056	0.0028	0.0015	0.0008	0.0005	0.0003	0.0002	0.0001	7E-05	5E-05	3E-05	7E-05	
2007	0.0541	0.3496	0.2366	0.17	0.0971	0.0467	0.0216	0.0105	0.0055	0.0031	0.0018	0.0011	0.0007	0.0005	0.0003	0.0002	0.0001	1E-04	7E-05	0.0002	
average 2005-2007	0.0397	0.2519	0.2834	0.2107	0.1145	0.0528	0.0236	0.011	0.0054	0.0029	0.0016	0.0009	0.0006	0.0004	0.0002	0.0001	1E-04	7E-05	4E-05	1E-04	
TOTAL DISCARDS																					Number discarded
1986	21402	135954	152924	113699	61793	28508	12755	5918.7	2923.6	1539.9	857.56	500.41	303.31	189.21	121.03	78.744	52.265	35.195	23.894	53.456	539633
1987	19669	124942	140538	104489	56788	26199	11722	5439.3	2686.8	1415.1	788.1	459.87	278.74	173.88	111.23	72.366	48.031	32.345	21.958	49.127	495924
1988	36015	228779	257336	191328	103984	47972	21464	9959.8	4919.7	2591.2	1443.1	842.07	510.4	318.39	203.67	132.51	87.949	59.225	40.208	89.955	908076
1989	84603	537426	604509	449450	244269	112691	50421	23397	11557	6087.1	3389.9	1978.1	1199	747.93	478.44	311.28	206.6	139.13	94.452	211.31	2133166
1990	69217	439686	494569	367710	199844	92196	41251	19142	9455.2	4980.1	2773.4	1618.4	980.93	611.91	391.43	254.66	169.03	113.82	77.274	172.88	1745213
1991	123367	783666	881485	655381	356189	164324	73523	34117	16852	8876.1	4943.2	2884.4	1748.4	1090.6	697.66	453.9	301.26	202.87	137.73	308.13	3110547
1992	108036	686280	771944	573937	311926	143903	64386	29877	14758	7773.1	4328.9	2526	1531.1	955.09	610.96	397.49	263.83	177.66	120.61	269.84	2724003
1993	70924	450531	506768	376780	204774	94470	42268	19614	9688.4	5102.9	2841.8	1658.3	1005.1	627	401.08	260.95	173.2	116.63	79.18	177.15	1788261
1994	68120	432717	486730	361882	196677	90735	40597	18838	9305.3	4901.1	2729.5	1592.7	965.39	602.21	385.22	250.63	166.35	112.02	76.05	170.14	1717552
1995	68169	433032	487085	362145	196820	90801	40627	18852	9312.1	4904.7	2731.5	1593.9	966.09	602.65	385.51	250.81	166.47	112.1	76.105	170.27	1718803
1996	48386	307360	345725	257045	139700	64449	28836	13381	6609.6	3481.3	1938.7	1131.3	685.72	427.75	273.63	178.02	118.16	79.568	54.018	120.85	1219980
1997	45178	286987	322810	240008	130440	60177	26925	12494	6171.5	3250.5	1810.2	1056.3	640.27	399.4	255.49	166.22	110.33	74.294	50.438	112.84	1139118
1998	63123	400979	451030	335339	182251	84080	37619	17457	8622.8	4541.7	2529.3	1475.9	894.58	558.04	356.97	232.25	154.15	103.8	70.472	157.66	1591576
1999	85855	545375	613451	456098	247882	114358	51166	23743	11728	6177.1	3440.1	2007.4	1216.7	758.99	485.52	315.88	209.66	141.18	95.849	214.44	2164719
2000	90867	577218	649268	482728	262355	121034	54154	25129	12413	6537.8	3640.9	2124.6	1287.8	803.31	513.87	334.32	221.9	149.43	101.45	226.96	2291110
2001	67756	430407	484131	359950	195627	90250	40380	18738	9255.6	4875	2714.9	1584.2	960.23	598.99	383.17	249.29	165.46	111.42	75.644	169.23	1708382
2002	78943	501473	564068	419383	227928	105152	47048	21832	10784	5679.9	3163.2	1845.8	1118.8	697.89	446.43	290.45	192.78	129.82	88.133	197.18	1990460
2003	85926	545828	613960	456477	248088	114452	51209	23763	11738	6182.3	3442.9	2009	1217.7	759.62	485.92	316.14	209.83	141.3	95.929	214.62	2166516
2004	128901	818817	921025	684778	372166	171694	76820	35647	17608	9274.3	5164.9	3013.8	1826.8	1139.5	728.95	474.26	314.78	211.97	143.91	321.95	3250072
2005	73570	354103	582209	404974	204528	91792	40725	18775	9149.1	4713.5	2552.6	1445.2	849.55	515.73	321.83	204.89	133.93	87.953	58.969	128.93	1790839
2006	21723	190088	262952	215089	120545	55220	24185	10872	5150	2582	1364	756	437	261	161	101	65	43	29	61	911684
2007	58762	379888	257143	184767	105517	50703	23517	11405	5972	3365	2006	1245	796	519	344	231	157	108	74	172	1086691
2008	127514	810007	911114	677410	368161	169847	75994	35263	17419	9174.5	5109.3	2981.4	1807.1	1127.3	721.11	469.15	311.39	209.69	142.36	318.49	3215101

B) Multiply total discards by discard mortality rate (0.10 for HL) and then multiply by the weight-at-age matrix to derive total dead discards in weight.

DEAD DISCARDS

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20+	total dead discards
1986	2140.2	13595	15292	11370	6179.3	2850.8	1275.5	591.87	292.36	153.99	85.756	50.041	30.331	18.921	12.103	7.8744	5.2265	3.5195	2.3894	5.3456	53963.3
1987	1966.9	12494	14054	10449	5678.8	2619.9	1172.2	543.93	268.68	141.51	78.81	45.987	27.874	17.388	11.123	7.2366	4.8031	3.2345	2.1958	4.9127	49592.4
1988	3601.5	22878	25734	19133	10398	4797.2	2146.4	995.98	491.97	259.12	144.31	84.207	51.04	31.839	20.367	13.251	8.7949	5.9225	4.0208	8.9955	90807.6
1989	8460.3	53743	60451	44945	24427	11269	5042.1	2339.7	1155.7	608.71	338.99	197.81	119.9	74.793	47.844	31.128	20.66	13.913	9.4452	21.131	213316.6
1990	6921.7	43969	49457	36771	19984	9219.6	4125.1	1914.2	945.52	498.01	277.34	161.84	98.093	61.191	39.143	25.466	16.903	11.382	7.7274	17.288	174521.3
1991	12337	78367	88149	65538	35619	16432	7352.3	3411.7	1685.2	887.61	494.32	288.44	174.84	109.06	69.766	45.39	30.126	20.287	13.773	30.813	311054.7
1992	10804	68628	77194	57394	31193	14390	6438.6	2987.7	1475.8	777.31	432.89	252.6	153.11	95.509	61.096	39.749	26.383	17.766	12.061	26.984	272400.3
1993	7092.4	45053	50677	37678	20477	9447	4226.8	1961.4	968.84	510.29	284.18	165.83	100.51	62.7	40.108	26.095	17.32	11.663	7.918	17.715	178826.1
1994	6812	43272	48673	36188	19668	9073.5	4059.7	1883.8	930.53	490.11	272.95	159.27	96.539	60.221	38.522	25.063	16.635	11.202	7.605	17.014	171755.2
1995	6816.9	43303	48708	36215	19682	9080.1	4062.7	1885.2	931.21	490.47	273.15	159.39	96.609	60.265	38.551	25.081	16.647	11.21	7.6105	17.027	171880.3
1996	4838.6	30736	34573	25705	13970	6444.9	2883.6	1338.1	660.96	348.13	193.87	113.13	68.572	42.775	27.363	17.802	11.816	7.9568	5.4018	12.085	121998
1997	4517.8	28699	32281	24001	13044	6017.7	2692.5	1249.4	617.15	325.05	181.02	105.63	64.027	39.94	25.549	16.622	11.033	7.4294	5.0438	11.284	113911.8
1998	6312.3	40098	45103	33534	18225	8408	3761.9	1745.7	862.28	454.17	252.93	147.59	89.458	55.804	35.697	23.225	15.415	10.38	7.0472	15.766	159157.6
1999	8585.5	54538	61345	45610	24788	11436	5116.6	2374.3	1172.8	617.71	344.01	200.74	121.67	75.899	48.552	31.588	20.966	14.118	9.5849	21.444	216471.9
2000	9086.7	57722	64927	48273	26236	12103	5415.4	2512.9	1241.3	653.78	364.09	212.46	128.78	80.331	51.387	33.432	22.19	14.943	10.145	22.696	229111
2001	6775.6	43041	48413	35995	19563	9025	4038	1873.8	925.56	487.5	271.49	158.42	96.023	59.899	38.317	24.929	16.546	11.142	7.5644	16.923	170838.2
2002	7894.3	50147	56407	41938	22793	10515	4704.8	2183.2	1078.4	567.99	316.32	184.58	111.88	69.789	44.643	29.045	19.278	12.982	8.8133	19.718	199046
2003	8592.6	54583	61396	45648	24809	11445	5120.9	2376.3	1173.8	618.23	344.29	200.9	121.77	75.962	48.592	31.614	20.983	14.13	9.5929	21.462	216651.6
2004	12890	81882	92102	68478	37217	17169	7682	3564.7	1760.8	927.43	516.49	301.38	182.68	113.95	72.895	47.426	31.478	21.197	14.391	32.195	325007.2
2005	7357	35410	58221	40497	20453	9179.2	4072.5	1877.5	914.91	471.35	255.26	144.52	84.955	51.573	32.183	20.489	13.393	8.7953	5.8969	12.893	179083.9
2006	2172.3	19009	26295	21509	12055	5522	2418.5	1087.2	515	258.2	136.4	75.6	43.7	26.1	16.1	10.1	6.5	4.3	2.9	6.1	91168.4
2007	5876.2	37989	25714	18477	10552	5070.3	2351.7	1140.5	597.2	336.5	200.6	124.5	79.6	51.9	34.4	23.1	15.7	10.8	7.4	17.2	108669.1
2008	12751	81001	91111	67741	36816	16985	7599.4	3526.3	1741.9	917.45	510.93	298.14	180.71	112.73	72.111	46.915	31.139	20.969	14.236	31.849	321510.1

Table 7.9. Direct observed landings-at-age from Panama City Lab otolith analysis.

A) Commercial Longline

YEAR	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11	AGE 12	AGE 13	AGE 14	AGE 15	AGE 16	AGE 17	AGE 18	AGE 19	AGE 20	EFF SAMPLE SIZE
1986	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1987	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1989	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1991	0.00	0.00	0.07	0.07	0.14	0.34	0.07	0.00	0.10	0.07	0.00	0.10	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	9.62
1992	0.00	0.00	0.00	0.00	0.17	0.22	0.27	0.24	0.00	0.04	0.01	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.48
1993	0.00	0.00	0.02	0.17	0.20	0.26	0.21	0.13	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.29
1994	0.00	0.00	0.00	0.19	0.36	0.19	0.12	0.07	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	123.67
1995	0.00	0.00	0.00	0.03	0.21	0.33	0.28	0.07	0.02	0.03	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	92.78
1996	0.00	0.00	0.00	0.04	0.14	0.38	0.25	0.10	0.07	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.18
1997	0.00	0.00	0.00	0.00	0.29	0.14	0.42	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.60
1998	0.00	0.00	0.04	0.14	0.21	0.14	0.15	0.07	0.11	0.11	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	14.42
1999	0.00	0.00	0.00	0.01	0.15	0.12	0.16	0.30	0.11	0.10	0.00	0.02	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	32.47
2000	0.00	0.00	0.00	0.33	0.14	0.16	0.10	0.07	0.07	0.05	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	104.02
2001	0.00	0.00	0.00	0.05	0.40	0.12	0.16	0.07	0.03	0.05	0.04	0.02	0.03	0.01	0.01	0.01	0.01	0.00	0.00	0.00	296.02
2002	0.00	0.00	0.01	0.04	0.11	0.26	0.14	0.14	0.09	0.06	0.04	0.04	0.02	0.02	0.01	0.01	0.00	0.00	0.01	0.01	122.82
2003	0.00	0.00	0.00	0.08	0.10	0.20	0.28	0.12	0.09	0.04	0.02	0.02	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.01	135.36
2004	0.00	0.00	0.00	0.02	0.38	0.12	0.16	0.13	0.05	0.04	0.03	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	244.56
2005	0.00	0.00	0.00	0.00	0.10	0.63	0.08	0.07	0.05	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	183.89
2006	0.00	0.00	0.00	0.00	0.02	0.15	0.51	0.18	0.05	0.04	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	146.12
2007	0.00	0.00	0.00	0.01	0.26	0.09	0.15	0.30	0.09	0.04	0.02	0.02	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	196.19
2008	0.00	0.00	0.00	0.00	0.07	0.51	0.10	0.10	0.14	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	201.68

B) Commercial Handline

YEAR	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11	AGE 12	AGE 13	AGE 14	AGE 15	AGE 16	AGE 17	AGE 18	AGE 19	AGE 20	EFF SAMPLE SIZE
1986	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1987	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1989	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1991	0.00	0.00	0.07	0.07	0.14	0.34	0.07	0.00	0.10	0.07	0.00	0.10	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	9.62
1992	0.00	0.00	0.00	0.00	0.17	0.22	0.27	0.24	0.00	0.04	0.01	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.48
1993	0.00	0.00	0.02	0.17	0.20	0.26	0.21	0.13	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.29
1994	0.00	0.00	0.00	0.19	0.36	0.19	0.12	0.07	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	123.67
1995	0.00	0.00	0.00	0.03	0.21	0.33	0.28	0.07	0.02	0.03	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	92.78
1996	0.00	0.00	0.00	0.04	0.14	0.38	0.25	0.10	0.07	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.18
1997	0.00	0.00	0.00	0.00	0.29	0.14	0.42	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.60
1998	0.00	0.00	0.04	0.14	0.21	0.14	0.15	0.07	0.11	0.11	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	14.42
1999	0.00	0.00	0.00	0.01	0.15	0.12	0.16	0.30	0.11	0.10	0.00	0.02	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	32.47
2000	0.00	0.00	0.00	0.33	0.14	0.16	0.10	0.07	0.07	0.05	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	104.02
2001	0.00	0.00	0.00	0.05	0.40	0.12	0.16	0.07	0.03	0.05	0.04	0.02	0.03	0.01	0.01	0.01	0.01	0.00	0.00	0.00	296.02
2002	0.00	0.00	0.01	0.04	0.11	0.26	0.14	0.14	0.09	0.06	0.04	0.04	0.02	0.02	0.01	0.01	0.00	0.00	0.01	0.01	122.82
2003	0.00	0.00	0.00	0.08	0.10	0.20	0.28	0.12	0.09	0.04	0.02	0.02	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.01	135.36
2004	0.00	0.00	0.00	0.02	0.38	0.12	0.16	0.13	0.05	0.04	0.03	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	244.56
2005	0.00	0.00	0.00	0.00	0.10	0.63	0.08	0.07	0.05	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	183.89
2006	0.00	0.00	0.00	0.00	0.02	0.15	0.51	0.18	0.05	0.04	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	146.12
2007	0.00	0.00	0.00	0.01	0.26	0.09	0.15	0.30	0.09	0.04	0.02	0.02	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	196.19
2008	0.00	0.00	0.00	0.00	0.07	0.51	0.10	0.10	0.14	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	201.68

C) Commercial Trap

Year	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11	AGE 12	AGE 13	AGE 14	AGE 15	AGE 16	AGE 17	AGE 18	AGE 19	AGE 20	EFF SAMPLE SIZE
1986	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1987	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1989	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.04	0.04	0.23	0.32	0.30	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.97
1994	0.00	0.00	0.00	0.00	0.00	0.03	0.17	0.24	0.31	0.14	0.03	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	10.58
1995	0.00	0.00	0.00	0.00	0.05	0.46	0.10	0.15	0.13	0.03	0.00	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.87
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.13	0.25	0.25	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.43
1997	0.00	0.00	0.00	0.06	0.35	0.29	0.06	0.18	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.43
1998	0.00	0.00	0.03	0.09	0.03	0.15	0.24	0.15	0.21	0.06	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.61
1999	0.00	0.00	0.00	0.03	0.06	0.06	0.03	0.26	0.23	0.10	0.13	0.00	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.00	12.65
2000	0.00	0.00	0.00	0.03	0.03	0.39	0.24	0.11	0.11	0.05	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.59
2001	0.00	0.00	0.00	0.00	0.06	0.13	0.21	0.20	0.05	0.20	0.02	0.07	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	15.51
2002	0.00	0.00	0.00	0.06	0.06	0.19	0.18	0.18	0.08	0.06	0.06	0.05	0.04	0.01	0.01	0.01	0.00	0.00	0.00	0.00	36.54
2003	0.00	0.00	0.00	0.04	0.02	0.11	0.24	0.09	0.10	0.09	0.03	0.15	0.05	0.03	0.03	0.01	0.00	0.00	0.00	0.00	30.85
2004	0.00	0.00	0.00	0.03	0.14	0.06	0.22	0.19	0.03	0.14	0.06	0.00	0.00	0.06	0.00	0.03	0.00	0.06	0.00	0.00	17.71
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.02	0.12	0.57	0.13	0.03	0.05	0.04	0.02	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	68.90
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2008	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

D) Recreational

Year	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11	AGE 12	AGE 13	AGE 14	AGE 15	AGE 16	AGE 17	AGE 18	AGE 19	AGE 20	EFF SAMPLE SIZE
1986	0.00	0.13	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
1987	0.00	0.18	0.37	0.18	0.12	0.43	0.12	0.18	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.72
1988	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1989	0.00	0.31	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1991	0.00	0.00	0.03	0.13	0.43	0.17	0.07	0.10	0.03	0.10	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.08	1.24
1992	0.00	0.00	0.02	0.19	1.34	0.17	0.08	0.38	0.34	0.44	0.42	0.30	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.79
1993	0.00	0.02	0.11	1.44	0.35	0.61	1.47	0.99	0.88	0.17	0.34	0.00	0.09	0.00	0.09	0.00	0.00	0.02	0.00	0.02	6.61
1994	0.00	0.00	0.28	1.20	1.30	1.16	0.87	0.90	0.15	0.32	0.17	0.17	0.17	0.08	0.00	0.00	0.00	0.00	0.00	0.20	6.98
1995	0.00	0.00	0.00	0.89	4.02	4.67	2.90	2.09	1.68	0.47	0.79	0.65	0.23	0.61	0.00	0.10	0.00	0.00	0.00	0.37	19.46
1996	0.00	0.00	0.11	0.00	4.37	9.99	5.42	1.80	1.23	0.58	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.14	23.79
1997	0.00	0.00	0.71	1.05	2.82	5.62	7.61	2.41	0.29	0.05	0.52	0.24	0.24	0.24	0.24	0.24	0.00	0.00	0.00	0.00	22.26
1998	0.00	0.00	0.00	1.96	5.87	5.17	3.58	1.51	0.24	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	18.54
1999	0.00	0.00	0.18	1.14	8.02	3.85	2.05	2.92	1.44	0.61	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.18	20.58
2000	0.00	0.00	0.00	5.25	2.76	3.07	1.38	2.71	2.37	0.68	0.36	0.00	0.68	0.00	0.34	0.00	0.34	0.00	0.00	0.34	20.26
2001	0.00	0.00	0.00	0.97	6.88	2.56	2.11	0.00	0.00	0.26	0.00	0.00	0.26	0.00	0.00	0.00	0.26	0.00	0.00	0.00	13.32
2002	0.00	0.00	0.72	4.87	13.23	23.99	7.12	2.94	1.54	0.20	1.08	0.92	0.76	0.36	0.36	0.00	0.00	0.00	0.00	0.18	58.28
2003	0.00	0.00	2.70	32.03	9.07	7.54	13.47	1.37	1.93	0.97	0.00	2.30	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	71.57
2004	0.00	0.00	0.18	3.86	34.67	6.45	3.97	3.24	1.00	2.74	0.36	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	56.65
2005	0.00	0.00	0.00	0.54	6.92	17.43	1.56	0.59	1.82	0.05	0.43	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	29.39
2006	0.00	0.00	0.03	1.10	1.97	5.95	3.63	1.13	0.53	0.27	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	14.88
2007	0.00	0.69	1.35	2.06	3.24	4.27	3.73	0.72	0.80	0.23	0.17	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.42
2008	0.00	0.00	7.21	5.34	4.00	2.62	1.26	2.94	0.06	0.31	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.43

Table 7.10. Calculation of the proportion discarded (alive and dead) at age for commercial longline. *Fracdisc* is the fraction = total discards/sum(discards +landed) obtained from the estimated numbers of discards (section 4.1.3).

AGE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
Discard age proportion																				
2006	0.000	0.017	0.218	0.329	0.221	0.111	0.052	0.025	0.012	0.006	0.003	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.016	0.197	0.333	0.231	0.116	0.054	0.025	0.012	0.006	0.003	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.008	0.140	0.336	0.266	0.135	0.061	0.027	0.013	0.006	0.003	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Direct aging proportion																				
2006	0.000	0.000	0.000	0.000	0.027	0.155	0.343	0.154	0.101	0.076	0.045	0.027	0.022	0.018	0.011	0.009	0.001	0.002	0.002	0.005
2007	0.000	0.000	0.000	0.002	0.057	0.087	0.185	0.283	0.128	0.063	0.081	0.028	0.024	0.032	0.012	0.005	0.002	0.002	0.006	0.002
2008	0.000	0.000	0.000	0.000	0.014	0.153	0.121	0.255	0.243	0.071	0.049	0.040	0.009	0.016	0.007	0.007	0.007	0.005	0.001	0.002
fraction discarded (equation 1)																				
1.411	1.000	1.000	1.000	1.000	0.921	0.503	0.177	0.185	0.145	0.104	0.096	0.090	0.069	0.050	0.050	0.040	0.201	0.067	0.046	0.050
1.421	1.000	1.000	1.000	0.995	0.851	0.656	0.293	0.113	0.121	0.126	0.057	0.091	0.062	0.030	0.047	0.073	0.093	0.063	0.019	0.089
1.601	1.000	1.000	1.000	1.000	0.969	0.586	0.446	0.146	0.078	0.126	0.099	0.068	0.153	0.058	0.081	0.052	0.034	0.034	0.093	0.092
								-1.69	-1.93	-2.26	-2.34	-2.40	-2.67	-2.99	-2.99	-3.21	-1.60	-2.70	-3.09	-2.99
								-2.18	-2.11	-2.07	-2.86	-2.39	-2.78	-3.51	-3.05	-2.61	-2.37	-2.77	-3.95	-2.42
								-1.92	-2.55	-2.07	-2.31	-2.69	-1.88	-2.85	-2.52	-2.96	-3.38	-3.39	-2.38	-2.39
geometric mean 2006-2008											LN regression									
1986-2005	1.000	1.000	1.000	0.998	0.912	0.578	0.285	0.145	0.111	0.118	0.093	0.086	0.080	0.075	0.069	0.065	0.060	0.056	0.052	0.048
2006	1.000	1.000	1.000	1.000	0.921	0.503	0.177	0.185	0.145	0.104	0.093	0.086	0.080	0.075	0.069	0.065	0.060	0.056	0.052	0.048
2007	1.000	1.000	1.000	0.995	0.851	0.656	0.293	0.113	0.121	0.126	0.093	0.086	0.080	0.075	0.069	0.065	0.060	0.056	0.052	0.048
2008	1.000	1.000	1.000	1.000	0.969	0.586	0.446	0.146	0.078	0.126	0.093	0.086	0.080	0.075	0.069	0.065	0.060	0.056	0.052	0.048

age	ln(prop)	prediction
8	-2.16	0.115
9	-2.24	0.107
10	-2.31	0.099
11	-2.38	0.093
12	-2.45	0.086
13	-2.52	0.080
14	-2.60	0.075
15	-2.67	0.069
16	-2.74	0.065
17	-2.81	0.060
18	-2.88	0.056
19	-2.96	0.052
20	-3.03	0.048

SUMMARY OUTPUT

Regression Statistics

Multiple R	0.5256
R Square	0.2763
Adjusted R Square	0.2567
Standard Error	0.4478
Observations	39

ANOVA

	df	*SS*	*MS*	*F*	*Sig.F*
Regression	1	2.8323	2.8323	14.124	0.0006
Residual	37	7.4194	0.2005		
Total	38	10.252			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-1.587	0.2777	-5.716	2E-06	-2.15	-1.02	-2.15	-1.02
X Variable 1	-0.072	0.0192	-3.758	6E-04	-0.11	-0.03	-0.11	-0.03

equation 1

proportion discarded =

$$\frac{D_a * fracdisc}{(fracdisc * D_a + C_a)}$$

where C_a is the landings at age fraction from direct otolith observation, fracdisc is the overall fraction discarded and D_a is the discard age composition obtained from age-converted observed lengths

Table 7.11.Calculation of the proportion discarded (alive and dead) at age for commercial handline. *Fracdisc* is the fraction = total discards/sum(discards +landed) obtained from the estimated numbers of discards (section 4.2.3).

AGE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
Discard age proportion																				
2006	0.000	0.032	0.273	0.329	0.195	0.091	0.041	0.019	0.009	0.005	0.003	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.008	0.114	0.310	0.272	0.151	0.073	0.035	0.017	0.009	0.005	0.003	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.028	0.246	0.317	0.213	0.105	0.047	0.021	0.010	0.005	0.003	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Direct aging proportion																				
2006	0.000	0.000	0.000	0.000	0.016	0.152	0.508	0.183	0.049	0.041	0.019	0.009	0.007	0.005	0.001	0.005	0.002	0.001	0.000	0.003
2007	0.000	0.000	0.000	0.005	0.262	0.088	0.148	0.297	0.089	0.039	0.023	0.015	0.005	0.004	0.005	0.007	0.005	0.004	0.000	0.003
2008	0.000	0.000	0.000	0.000	0.075	0.508	0.097	0.104	0.144	0.024	0.016	0.009	0.010	0.004	0.003	0.003	0.000	0.001	0.000	0.003
fraction discarded (equation 1)																				
0.560	1.000	1.000	1.000	1.000	0.874	0.252	0.043	0.054	0.094	0.060	0.068	0.080	0.061	0.051	0.236	0.023	0.038	0.078	1.000	0.021
0.838	1.000	1.000	1.000	0.980	0.465	0.589	0.292	0.089	0.138	0.156	0.144	0.123	0.213	0.159	0.082	0.043	0.035	0.030	1.000	0.065
0.586	1.000	1.000	1.000	1.000	0.626	0.109	0.222	0.107	0.039	0.108	0.087	0.084	0.048	0.067	0.051	0.033	1.000	0.039	0.070	0.022
								-2.910	-2.368	-2.810	-2.685	-2.530	-2.794	-2.973	-1.445	-3.771	-3.268	-2.551	0.000	-3.843
								-2.419	-1.983	-1.858	-1.935	-2.092	-1.549	-1.839	-2.499	-3.146	-3.347	-3.502	0.000	-2.741
								-2.233	-3.241	-2.228	-2.438	-2.473	-3.044	-2.698	-2.966	-3.411	0.000	-3.256	-2.660	-3.794
geometric mean 2006-2008											LN regression									
1986-2005	1.000	1.000	1.000	0.993	0.634	0.253	0.141	0.080	0.080	0.100	0.084	0.077	0.071	0.065	0.060	0.055	0.050	0.046	0.042	0.039
2006	1.000	1.000	1.000	1.000	0.874	0.252	0.043	0.054	0.094	0.060	0.084	0.077	0.071	0.065	0.060	0.055	0.050	0.046	0.042	0.039
2007	1.000	1.000	1.000	0.980	0.465	0.589	0.292	0.089	0.138	0.156	0.084	0.077	0.071	0.065	0.060	0.055	0.050	0.046	0.042	0.039
2008	1.000	1.000	1.000	1.000	0.626	0.109	0.222	0.107	0.039	0.108	0.084	0.077	0.071	0.065	0.060	0.055	0.050	0.046	0.042	0.039

age	ln(prop)	prediction
8	-2.215	0.109
9	-2.302	0.100
10	-2.388	0.092
11	-2.475	0.084
12	-2.561	0.077
13	-2.647	0.071
14	-2.734	0.065
15	-2.820	0.060
16	-2.907	0.055
17	-2.993	0.050
18	-3.080	0.046
19	-3.166	0.042
20	-3.253	0.039

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.52
R Square	0.27
Adjusted R Square	0.249
Standard Error	0.535
Observations	36

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	3.604	3.604	12.59	0.001
Residual	34	9.735	0.286		
Total	35	13.34			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-1.52	0.344	-4.43	9E-05	-2.22	-0.82	-2.22	-0.82
X Variable 1	-0.09	0.024	-3.55	0.001	-0.14	-0.04	-0.14	-0.04

equation 1

proportion discarded =

$$\frac{D_a * fracdisc}{(fracdisc * D_a + C_a)}$$

where C_a is the landings at age fraction from direct otolith observation, fracdisc is the overall fraction discarded and D_a is the discard age composition obtained from age-converted observed lengths

Table 7.12. Calculation of the proportion discarded (dead and alive) at age for trap fishery. Divide the discard at age (B) by the sum of the landings at age (A) and discard at age (B) to obtain the discard proportion at age.

A) Landings at age from derived probabilistic aging

Landings TRAP (PLUS GROUP 20), from derived probabilistic aging

YEAR	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20+
1986	0	8281	70951	60736	39705	23849	13581	7555	4208	2380	1375	815	495	308	195	126	83	55	37	80
1987	0	15609	61387	41789	22439	11998	6491	3565	2002	1154	682	413	257	162	105	69	46	31	21	46
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	18252	67347	47839	26410	14916	8721	5128	3023	1797	1082	663	414	263	170	111	74	50	34	76
1990	0	306	3828	6837	9565	8957	6659	4437	2823	1769	1110	705	456	301	203	141	99	71	51	135
1991	0	117	999	6917	12699	12165	8877	5763	3576	2192	1348	839	530	340	221	146	98	66	45	101
1992	0	0	275	5388	12370	13540	11562	8938	6561	4668	3260	2257	1557	1074	743	515	359	251	176	421
1993	0	0	601	14223	28559	25643	17713	11256	6996	4344	2717	1721	1105	719	474	316	213	145	100	226
1994	0	0	134	3551	8874	9969	8100	5685	3739	2396	1525	975	629	411	271	181	122	83	57	129
1995	0	0	834	7304	12342	12196	9719	6986	4768	3172	2088	1374	908	604	405	274	187	128	89	206
1996	0	2	1532	10906	17244	15624	11521	7842	5174	3378	2203	1444	954	636	427	289	198	137	95	221
1997	0	3	1374	10063	17604	17514	13995	10181	7090	4830	3256	2192	1478	1001	682	468	322	224	156	367
1998	0	0	189	3321	7677	8455	6986	5099	3517	2364	1571	1044	696	467	316	215	147	102	70	165
1999	0	0	339	7000	17473	20113	17071	12641	8773	5904	3923	2602	1732	1159	782	531	364	251	174	404
2000	0	5	1566	12574	24378	26591	22502	16742	11658	7856	5220	3460	2300	1539	1037	704	482	332	231	540
2001	19	2	481	8131	17872	19249	15989	11882	8356	5708	3845	2579	1733	1169	793	542	373	258	179	419
2002	0	0	341	6379	18384	24055	21971	16904	11979	8163	5466	3644	2433	1633	1103	750	514	355	247	575
2003	0	45	457	6693	14759	17135	15257	11745	8341	5678	3789	2515	1672	1116	751	509	348	239	166	383
2004	0	0	184	5192	15278	18313	16113	12547	9193	6504	4510	3098	2122	1453	998	689	477	332	233	550
2005	0	0	314	6749	17051	18951	15170	10531	6883	4400	2802	1795	1161	760	503	337	228	155	107	243
2006	0	0	502	8860	18858	19458	15159	10465	6859	4406	2819	1812	1176	771	511	343	232	158	109	249
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

B) Discards at age from derived probabilistic aging

DISCARD + RELEASED TRAP PLUS GROUP 20, from derived probabilistic aging

YEAR	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20+
1986	0	7500	4280	447	61	12	3	1	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	14137	3703	307	35	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	16532	4062	352	41	7	2	1	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	10000	21881	20093	10432	4163	1528	565	220	91	41	19	10	5	3	2	1	1	0	0
1991	0	18920	48824	37523	16698	6095	2113	750	282	114	50	23	11	6	3	1	1	0	0	0
1992	0	13256	20606	26670	15396	6632	2742	1170	523	246	121	63	34	19	11	7	4	3	1	2
1993	0	452	41719	73402	35582	12269	4070	1426	541	222	99	46	23	12	7	4	2	1	1	1
1994	0	1190	11740	20419	12121	5150	1977	755	300	127	57	27	14	7	4	2	1	1	1	0
1995	0	14563	51848	33557	14944	5906	2286	907	377	166	77	38	20	11	6	4	2	1	1	1
1996	0	474776	160581	62520	22604	7764	2730	1018	408	176	81	40	21	11	7	4	2	2	1	0
1997	0	364538	138320	57940	23218	8788	3352	1337	565	254	121	61	32	18	10	6	4	2	2	1
1998	0	5206	12103	16266	9601	4160	1658	666	279	124	59	29	15	8	4	2	2	2	0	0
1999	0	1836	25105	38390	23393	10300	4154	1678	706	312	147	73	38	20	12	7	5	3	2	1
2000	0	48604	75251	58366	30286	13147	5374	2198	930	414	194	96	50	27	16	9	6	3	2	2
2001	0	27289	50750	48476	24436	9917	3900	1580	673	303	144	72	37	21	12	7	4	3	2	1
2002	0	23091	35913	38903	25906	12693	5447	2273	972	435	205	103	53	29	16	10	6	3	2	3
2003	0	23248	45360	33459	17895	8324	3615	1536	664	298	141	70	36	20	11	7	4	3	1	1
2004	0	649	16650	28533	19892	9184	3875	1657	737	344	169	86	46	26	15	9	5	3	2	2
2005	0	4700	33944	43032	24285	9975	3739	1407	556	234	105	50	25	14	8	4	2	2	1	0
2006	0	1482	44370	51651	25717	9999	3682	1384	549	232	105	50	26	14	8	4	2	2	1	0
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

C) Proportion released dead or alive.

PROPORTION RELEASED DEAD OR ALIVE TRAP

YEAR	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20+
1986	0.000	0.475	0.057	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
1987	0.000	0.475	0.057	0.007	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
1988	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	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	0.000	0.475	0.057	0.007	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
1990	0.000	0.970	0.851	0.746	0.522	0.317	0.187	0.113	0.072	0.049	0.036	0.026	0.021	0.016	0.015	0.014	0.010	0.014	0.000	0.000
1991	0.000	0.994	0.980	0.844	0.568	0.334	0.192	0.115	0.073	0.049	0.036	0.027	0.020	0.017	0.013	0.007	0.010	0.000	0.000	0.000
1992	0.000	1.000	0.987	0.832	0.554	0.329	0.192	0.116	0.074	0.050	0.036	0.027	0.021	0.017	0.015	0.013	0.011	0.012	0.006	0.005
1993	0.000	1.000	0.986	0.838	0.555	0.324	0.187	0.112	0.072	0.049	0.035	0.026	0.020	0.016	0.015	0.013	0.009	0.007	0.010	0.004
1994	0.000	1.000	0.989	0.852	0.577	0.341	0.196	0.117	0.074	0.050	0.036	0.027	0.022	0.017	0.015	0.011	0.008	0.012	0.017	0.000
1995	0.000	1.000	0.984	0.821	0.548	0.326	0.190	0.115	0.073	0.050	0.036	0.027	0.022	0.018	0.015	0.014	0.011	0.008	0.011	0.005
1996	0.000	1.000	0.991	0.851	0.567	0.332	0.192	0.115	0.073	0.050	0.035	0.027	0.022	0.017	0.016	0.014	0.010	0.014	0.010	0.000
1997	0.000	1.000	0.990	0.852	0.569	0.334	0.193	0.116	0.074	0.050	0.036	0.027	0.021	0.018	0.014	0.013	0.012	0.009	0.013	0.003
1998	0.000	1.000	0.985	0.830	0.556	0.330	0.192	0.116	0.073	0.050	0.036	0.027	0.021	0.017	0.013	0.009	0.013	0.019	0.000	0.000
1999	0.000	1.000	0.987	0.846	0.572	0.339	0.196	0.117	0.074	0.050	0.036	0.027	0.021	0.017	0.015	0.013	0.014	0.012	0.011	0.002
2000	0.000	1.000	0.980	0.823	0.554	0.331	0.193	0.116	0.074	0.050	0.036	0.027	0.021	0.017	0.015	0.013	0.012	0.009	0.009	0.004
2001	0.000	1.000	0.991	0.856	0.578	0.340	0.196	0.117	0.075	0.050	0.036	0.027	0.021	0.018	0.015	0.013	0.011	0.011	0.011	0.002
2002	0.000	1.000	0.991	0.859	0.585	0.345	0.199	0.119	0.075	0.051	0.036	0.027	0.021	0.017	0.014	0.013	0.012	0.008	0.008	0.005
2003	0.000	0.998	0.990	0.833	0.548	0.327	0.192	0.116	0.074	0.050	0.036	0.027	0.021	0.018	0.014	0.014	0.011	0.012	0.006	0.003
2004	0.000	1.000	0.989	0.846	0.566	0.334	0.194	0.117	0.074	0.050	0.036	0.027	0.021	0.018	0.015	0.013	0.010	0.009	0.009	0.004
2005	0.000	1.000	0.991	0.864	0.588	0.345	0.198	0.118	0.075	0.050	0.036	0.027	0.021	0.018	0.016	0.012	0.009	0.013	0.009	0.000
2006	0.000	1.000	0.989	0.854	0.577	0.339	0.195	0.117	0.074	0.050	0.036	0.027	0.022	0.018	0.015	0.012	0.009	0.013	0.009	0.000
2007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	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 7.13. Calculation of the proportion discarded (dead or alive) at age for the recreational fishery. Divide the discard at age (B) by the sum of the landings at age (A) and discard at age (B) to obtain the discard proportion at age.

A) Landings at age from derived probabilistic aging

LANDINGS REC (PLUS GROUP 20), from derived probabilistic aging

YEAR	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20+
1986	412	108055	227857	191818	122224	64078	31579	15727	8161	4446	2539	1515	939	601	396	266	182	126	88	212
1987	16	60505	121289	93472	60210	35866	21241	12926	8107	5191	3369	2211	1466	980	661	450	309	213	148	345
1988	28	74853	202308	164111	108492	67132	39451	22648	13027	7607	4533	2764	1722	1094	708	465	310	209	143	319
1989	8	48522	231807	219142	136558	75283	40075	21398	11696	6593	3835	2300	1417	893	575	376	250	169	115	257
1990	6	4975	9062	29077	38074	34066	25384	17264	11301	7316	4743	3101	2048	1366	921	627	430	297	207	484
1991	0	1	4205	41330	72423	64970	44195	27098	16208	9765	5990	3755	2401	1563	1034	693	470	322	222	513
1992	737	988	10490	67086	108124	94545	64884	40482	24514	14832	9077	5651	3582	2309	1512	1004	675	459	315	717
1993	0	1610	14349	63541	90836	74540	48773	29508	17664	10744	6685	4256	2765	1825	1222	828	566	391	272	633
1994	0	39	5279	45747	76941	66198	44381	27202	16272	9757	5927	3666	2310	1481	965	638	427	290	198	448
1995	0	3	4813	37409	64173	61519	45824	30424	19278	12050	7547	4775	3061	1988	1309	872	588	400	275	626
1996	0	1	1924	17126	30978	30041	22249	14661	9232	5741	3581	2257	1442	934	614	408	275	187	128	292
1997	0	6	1439	12154	21714	19867	13796	8679	5337	3298	2067	1316	852	559	371	250	170	116	80	186
1998	0	21	3217	16939	25441	21947	15218	9711	6036	3741	2334	1475	945	613	404	269	181	123	85	194
1999	0	194	4842	21797	39946	38623	28433	18710	11806	7373	4623	2932	1885	1228	811	542	366	250	172	393
2000	0	62	10342	53534	73839	63382	46338	31888	21343	14086	9245	6078	4017	2673	1794	1214	828	570	395	913
2001	0	4	3755	32535	52497	45431	31343	20018	12536	7858	4967	3178	2060	1352	898	603	409	280	193	444
2002	0	18	3543	29537	53673	52444	39354	26380	16932	10736	6818	4369	2831	1856	1231	826	560	383	264	606
2003	0	5	5757	40120	56515	45579	29874	18165	10870	6563	4034	2531	1620	1054	697	467	316	217	149	345
2004	0	757	10399	80319	125786	104110	69386	43723	27483	17446	11197	7271	4774	3167	2123	1437	980	675	467	1084
2005	0	0	1408	24632	52887	51582	36990	23653	14645	9071	5686	3623	2345	1540	1025	690	469	322	223	514
2006	0	5	2189	15668	29211	29564	22881	15625	10096	6392	4034	2564	1648	1072	706	470	317	216	148	337
2007	0	11	1921	17830	33060	32279	24114	15940	10011	6189	3834	2402	1527	985	645	428	288	195	134	304
2008	0	3	2075	16220	29351	29190	21852	14358	8960	5512	3399	2121	1343	863	563	372	249	168	115	258

B) Discards at age from derived probabilistic aging

DISCARD + RELEASED REC PLUS GROUP 20, from derived probabilistic aging

YEAR	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20+
1986	256853	229852	48022	4223	548	100	24	7	2	1	1	0	0	0	0	0	0	0	0	0
1987	236049	211235	44132	3881	504	92	22	6	2	1	0	0	0	0	0	0	0	0	0	0
1988	432223	386787	80810	7106	922	169	40	12	4	2	1	0	0	0	0	0	0	0	0	0
1989	1015337	908604	189831	16693	2166	396	94	27	10	4	2	1	1	0	0	0	0	0	0	0
1990	185503	348108	606547	369259	156016	52889	16983	5755	2178	933	451	242	136	79	48	30	19	12	8	17
1991	330628	620444	1081067	658141	278071	94265	30269	10257	3883	1664	805	431	242	141	85	53	34	22	14	31
1992	289541	543342	946724	576355	243516	82551	26508	8982	3400	1457	705	377	212	124	75	46	30	19	13	26
1993	190079	356695	621508	378367	159864	54193	17402	5897	2232	956	463	248	139	81	49	30	19	13	8	18
1994	182563	342591	596933	363406	153543	52051	16714	5664	2144	919	444	238	133	78	47	29	19	12	8	16
1995	182696	342840	597368	363671	153655	52089	16726	5668	2145	919	445	238	134	78	47	29	19	12	8	16
1996	129674	243342	424002	258128	109062	36972	11872	4023	1523	653	316	169	95	55	33	21	13	9	6	12
1997	121080	227214	395899	241019	101833	34521	11085	3756	1422	609	295	158	89	52	31	19	12	8	5	11
1998	169173	317463	553151	336752	142281	48233	15488	5248	1987	851	412	220	124	72	44	27	17	11	7	15
1999	230093	431785	752346	458020	193518	65602	21065	7138	2702	1158	560	300	168	98	59	37	23	15	10	22
2000	243528	456995	796273	484762	204817	69432	22295	7555	2860	1225	593	317	178	104	63	39	25	16	11	22
2001	181588	340761	593746	361466	152723	51773	16625	5633	2132	914	442	237	133	78	47	29	19	12	8	16
2002	211571	397026	691782	421149	177940	60321	19370	6563	2485	1065	515	276	155	90	55	34	22	14	9	18
2003	230284	432143	752971	458400	193679	65657	21083	7144	2704	1159	560	300	168	98	59	37	23	15	10	22
2004	345458	648274	1129559	687663	290545	98494	31627	10717	4057	1738	841	450	253	147	89	55	35	23	15	32
2005	190353	357209	622404	378913	160094	54272	17427	5905	2235	958	463	248	139	81	49	31	19	13	8	18
2006	96905	181849	316855	192898	81501	27629	8872	3006	1138	488	236	126	71	41	25	16	10	6	4	8
2007	115507	216757	377679	229927	97146	32932	10575	3583	1356	581	281	150	84	49	30	19	12	8	5	10

C) Proportion released dead or alive.

PROPORTION RELEASED DEAD OR ALIVE REC

YEAR	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20+
1986	0.998	0.680	0.174	0.022	0.004	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
1987	1.000	0.777	0.267	0.040	0.008	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
1988	1.000	0.838	0.285	0.042	0.008	0.003	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
1989	1.000	0.949	0.450	0.071	0.016	0.005	0.002	0.001	0.001	0.001	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1990	1.000	0.986	0.985	0.927	0.804	0.608	0.401	0.250	0.162	0.113	0.087	0.072	0.062	0.055	0.050	0.046	0.042	0.039	0.037	0.034
1991	1.000	1.000	0.996	0.941	0.793	0.592	0.406	0.275	0.193	0.146	0.118	0.103	0.092	0.083	0.076	0.071	0.067	0.064	0.059	0.057
1992	0.997	0.998	0.989	0.896	0.693	0.466	0.290	0.182	0.122	0.089	0.072	0.063	0.056	0.051	0.047	0.044	0.043	0.040	0.040	0.035
1993	1.000	0.996	0.977	0.856	0.638	0.421	0.263	0.167	0.112	0.082	0.065	0.055	0.048	0.042	0.039	0.035	0.032	0.032	0.029	0.028
1994	1.000	1.000	0.991	0.888	0.666	0.440	0.274	0.172	0.116	0.086	0.070	0.061	0.054	0.050	0.046	0.043	0.043	0.040	0.039	0.034
1995	1.000	1.000	0.992	0.907	0.705	0.458	0.267	0.157	0.100	0.071	0.056	0.047	0.042	0.038	0.035	0.032	0.031	0.029	0.028	0.025
1996	1.000	1.000	0.995	0.938	0.779	0.552	0.348	0.215	0.142	0.102	0.081	0.070	0.062	0.056	0.051	0.049	0.045	0.046	0.045	0.039
1997	1.000	1.000	0.996	0.952	0.824	0.635	0.446	0.302	0.210	0.156	0.125	0.107	0.095	0.085	0.077	0.071	0.066	0.065	0.059	0.056
1998	1.000	1.000	0.994	0.952	0.848	0.687	0.504	0.351	0.248	0.185	0.150	0.130	0.116	0.105	0.098	0.091	0.086	0.082	0.076	0.072
1999	1.000	1.000	0.994	0.955	0.829	0.629	0.426	0.276	0.186	0.136	0.108	0.093	0.082	0.074	0.068	0.064	0.059	0.057	0.055	0.053
2000	1.000	1.000	0.987	0.901	0.735	0.523	0.325	0.192	0.118	0.080	0.060	0.050	0.042	0.037	0.034	0.031	0.029	0.027	0.027	0.024
2001	1.000	1.000	0.994	0.917	0.744	0.533	0.347	0.220	0.145	0.104	0.082	0.069	0.061	0.055	0.050	0.046	0.044	0.041	0.040	0.035
2002	1.000	1.000	0.995	0.934	0.768	0.535	0.330	0.199	0.128	0.090	0.070	0.059	0.052	0.046	0.043	0.040	0.038	0.035	0.033	0.029
2003	1.000	1.000	0.992	0.920	0.774	0.590	0.414	0.282	0.199	0.150	0.122	0.106	0.094	0.085	0.078	0.073	0.068	0.065	0.063	0.060
2004	1.000	0.999	0.991	0.895	0.698	0.486	0.313	0.197	0.129	0.091	0.070	0.058	0.050	0.044	0.040	0.037	0.034	0.033	0.031	0.029
2005	1.000	1.000	0.998	0.939	0.752	0.513	0.320	0.200	0.132	0.096	0.075	0.064	0.056	0.050	0.046	0.043	0.039	0.039	0.035	0.034
2006	1.000	1.000	0.993	0.925	0.736	0.483	0.279	0.161	0.101	0.071	0.055	0.047	0.041	0.037	0.034	0.033	0.031	0.027	0.026	0.023
2007	1.000	1.000	0.995	0.928	0.746	0.505	0.305	0.184	0.119	0.086	0.068	0.059	0.052	0.047	0.044	0.043	0.040	0.039	0.036	0.032

Table 7.14. Proportion of red grouper released (dead or alive).

A) Commercial Longline

PROPORTION RELEASED DEAD OR ALIVE LONGLINE

YEAR	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	1	1	0.9983	0.9124	0.5784	0.2851	0.1451	0.1111	0.1183	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484
1991	0	1	1	0.9983	0.9124	0.5784	0.2851	0.1451	0.1111	0.1183	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484
1992	0	1	1	0.9983	0.9124	0.5784	0.2851	0.1451	0.1111	0.1183	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484
1993	0	1	1	0.9983	0.9124	0.5784	0.2851	0.1451	0.1111	0.1183	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484
1994	0	1	1	0.9983	0.9124	0.5784	0.2851	0.1451	0.1111	0.1183	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484
1995	0	1	1	0.9983	0.9124	0.5784	0.2851	0.1451	0.1111	0.1183	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484
1996	0	1	1	0.9983	0.9124	0.5784	0.2851	0.1451	0.1111	0.1183	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484
1997	0	1	1	0.9983	0.9124	0.5784	0.2851	0.1451	0.1111	0.1183	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484
1998	0	1	1	0.9983	0.9124	0.5784	0.2851	0.1451	0.1111	0.1183	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484
1999	0	1	1	0.9983	0.9124	0.5784	0.2851	0.1451	0.1111	0.1183	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484
2000	0	1	1	0.9983	0.9124	0.5784	0.2851	0.1451	0.1111	0.1183	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484
2001	0	1	1	0.9983	0.9124	0.5784	0.2851	0.1451	0.1111	0.1183	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484
2002	0	1	1	0.9983	0.9124	0.5784	0.2851	0.1451	0.1111	0.1183	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484
2003	0	1	1	0.9983	0.9124	0.5784	0.2851	0.1451	0.1111	0.1183	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484
2004	0	1	1	0.9983	0.9124	0.5784	0.2851	0.1451	0.1111	0.1183	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484
2005	0	1	1	0.9983	0.9124	0.5784	0.2851	0.1451	0.1111	0.1183	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484
2006	0	1	1	1	0.9209	0.5034	0.1769	0.1846	0.145	0.1044	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484
2007	0	1	1	0.9949	0.8513	0.6557	0.2935	0.1132	0.1212	0.1256	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484
2008	0	1	1	1	0.9687	0.5863	0.4462	0.1463	0.078	0.1261	0.0926	0.0861	0.0802	0.0746	0.0694	0.0646	0.0601	0.0559	0.052	0.0484

B) Commercial Handline

PROPORTION RELEASED DEAD OR ALIVE HANDLINE

YEAR	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	1	1	0.9934	0.6338	0.2528	0.141	0.0804	0.0796	0.1004	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387
1991	0	1	1	0.9934	0.6338	0.2528	0.141	0.0804	0.0796	0.1004	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387
1992	0	1	1	0.9934	0.6338	0.2528	0.141	0.0804	0.0796	0.1004	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387
1993	0	1	1	0.9934	0.6338	0.2528	0.141	0.0804	0.0796	0.1004	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387
1994	0	1	1	0.9934	0.6338	0.2528	0.141	0.0804	0.0796	0.1004	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387
1995	0	1	1	0.9934	0.6338	0.2528	0.141	0.0804	0.0796	0.1004	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387
1996	0	1	1	0.9934	0.6338	0.2528	0.141	0.0804	0.0796	0.1004	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387
1997	0	1	1	0.9934	0.6338	0.2528	0.141	0.0804	0.0796	0.1004	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387
1998	0	1	1	0.9934	0.6338	0.2528	0.141	0.0804	0.0796	0.1004	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387
1999	0	1	1	0.9934	0.6338	0.2528	0.141	0.0804	0.0796	0.1004	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387
2000	0	1	1	0.9934	0.6338	0.2528	0.141	0.0804	0.0796	0.1004	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387
2001	0	1	1	0.9934	0.6338	0.2528	0.141	0.0804	0.0796	0.1004	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387
2002	0	1	1	0.9934	0.6338	0.2528	0.141	0.0804	0.0796	0.1004	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387
2003	0	1	1	0.9934	0.6338	0.2528	0.141	0.0804	0.0796	0.1004	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387
2004	0	1	1	0.9934	0.6338	0.2528	0.141	0.0804	0.0796	0.1004	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387
2005	0	1	1	0.9934	0.6338	0.2528	0.141	0.0804	0.0796	0.1004	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387
2006	0	1	1	1	0.8745	0.2524	0.0432	0.0545	0.0937	0.0602	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387
2007	0	1	1	0.9802	0.4651	0.5895	0.2915	0.089	0.1376	0.1561	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387
2008	0	1	1	1	0.626	0.1085	0.2225	0.1072	0.0391	0.1078	0.0842	0.0772	0.0708	0.065	0.0596	0.0546	0.0501	0.046	0.0422	0.0387

C) Commercial Trap

PROPORTION RELEASED DEAD OR ALIVE TRAP

YEAR	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20+
1986	0.998	0.680	0.174	0.022	0.004	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
1987	1.000	0.777	0.267	0.040	0.008	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
1988	1.000	0.838	0.285	0.042	0.008	0.003	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
1989	1.000	0.949	0.450	0.071	0.016	0.005	0.002	0.001	0.001	0.001	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1990	1.000	0.986	0.985	0.927	0.804	0.608	0.401	0.250	0.162	0.113	0.087	0.072	0.062	0.055	0.050	0.046	0.042	0.039	0.037	0.034
1991	1.000	1.000	0.996	0.941	0.793	0.592	0.406	0.275	0.193	0.146	0.118	0.103	0.092	0.083	0.076	0.071	0.067	0.064	0.059	0.057
1992	0.997	0.998	0.989	0.896	0.693	0.466	0.290	0.182	0.122	0.089	0.072	0.063	0.056	0.051	0.047	0.044	0.043	0.040	0.040	0.035
1993	1.000	0.996	0.977	0.856	0.638	0.421	0.263	0.167	0.112	0.082	0.065	0.055	0.048	0.042	0.039	0.035	0.032	0.032	0.029	0.028
1994	1.000	1.000	0.991	0.888	0.666	0.440	0.274	0.172	0.116	0.086	0.070	0.061	0.054	0.050	0.046	0.043	0.043	0.040	0.039	0.034
1995	1.000	1.000	0.992	0.907	0.705	0.458	0.267	0.157	0.100	0.071	0.056	0.047	0.042	0.038	0.035	0.032	0.031	0.029	0.028	0.025
1996	1.000	1.000	0.995	0.938	0.779	0.552	0.348	0.215	0.142	0.102	0.081	0.070	0.062	0.056	0.051	0.049	0.045	0.046	0.045	0.039
1997	1.000	1.000	0.996	0.952	0.824	0.635	0.446	0.302	0.210	0.156	0.125	0.107	0.095	0.085	0.077	0.071	0.066	0.065	0.059	0.056
1998	1.000	1.000	0.994	0.952	0.848	0.687	0.504	0.351	0.248	0.185	0.150	0.130	0.116	0.105	0.098	0.091	0.086	0.082	0.076	0.072
1999	1.000	1.000	0.994	0.955	0.829	0.629	0.426	0.276	0.186	0.136	0.108	0.093	0.082	0.074	0.068	0.064	0.059	0.057	0.055	0.053
2000	1.000	1.000	0.987	0.901	0.735	0.523	0.325	0.192	0.118	0.080	0.060	0.050	0.042	0.037	0.034	0.031	0.029	0.027	0.027	0.024
2001	1.000	1.000	0.994	0.917	0.744	0.533	0.347	0.220	0.145	0.104	0.082	0.069	0.061	0.055	0.050	0.046	0.044	0.041	0.040	0.035
2002	1.000	1.000	0.995	0.934	0.768	0.535	0.330	0.199	0.128	0.090	0.070	0.059	0.052	0.046	0.043	0.040	0.038	0.035	0.033	0.029
2003	1.000	1.000	0.992	0.920	0.774	0.590	0.414	0.282	0.199	0.150	0.122	0.106	0.094	0.085	0.078	0.073	0.068	0.065	0.063	0.060
2004	1.000	0.999	0.991	0.895	0.698	0.486	0.313	0.197	0.129	0.091	0.070	0.058	0.050	0.044	0.040	0.037	0.034	0.033	0.031	0.029
2005	1.000	1.000	0.998	0.939	0.752	0.513	0.320	0.200	0.132	0.096	0.075	0.064	0.056	0.050	0.046	0.043	0.039	0.039	0.035	0.034
2006	1.000	1.000	0.993	0.925	0.736	0.483	0.279	0.161	0.101	0.071	0.055	0.047	0.041	0.037	0.034	0.033	0.031	0.027	0.026	0.023
2007	1.000	1.000	0.995	0.928	0.746	0.505	0.305	0.184	0.119	0.086	0.068	0.059	0.052	0.047	0.044	0.043	0.040	0.039	0.036	0.032

D) Recreational

PROPORTION RELEASED DEAD OR ALIVE RECREATIONAL

YEAR	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20
1986	0.9984	0.6802	0.1741	0.0215	0.0045	0.0016	0.0008	0.0004	0.0002	0.0002	0.0004	0	0	0	0	0	0	0	0	0
1987	0.9999	0.7773	0.2668	0.0399	0.0083	0.0026	0.001	0.0005	0.0002	0.0002	0	0	0	0	0	0	0	0	0	0
1988	0.9999	0.8379	0.2854	0.0415	0.0084	0.0025	0.001	0.0005	0.0003	0.0003	0.0002	0	0	0	0	0	0	0	0	0
1989	1	0.9493	0.4502	0.0708	0.0156	0.0052	0.0023	0.0013	0.0009	0.0006	0.0005	0.0004	0.0007	0	0	0	0	0	0	0
1990	1	0.9859	0.9853	0.927	0.8038	0.6082	0.4009	0.25	0.1616	0.1131	0.0868	0.0724	0.0623	0.0547	0.0495	0.0457	0.0423	0.0388	0.0372	0.0339
1991	1	1	0.9961	0.9409	0.7934	0.592	0.4065	0.2746	0.1933	0.1456	0.1185	0.103	0.0916	0.0827	0.076	0.071	0.0675	0.064	0.0593	0.057
1992	0.9975	0.9982	0.989	0.8957	0.6925	0.4661	0.29	0.1816	0.1218	0.0894	0.0721	0.0625	0.0559	0.051	0.0473	0.0438	0.0426	0.0397	0.0396	0.035
1993	1	0.9955	0.9774	0.8562	0.6377	0.421	0.263	0.1666	0.1122	0.0817	0.0648	0.0551	0.0479	0.0425	0.0386	0.035	0.0325	0.0322	0.0286	0.0276
1994	1	0.9999	0.9912	0.8882	0.6662	0.4402	0.2736	0.1723	0.1164	0.0861	0.0697	0.061	0.0544	0.05	0.0464	0.0435	0.0426	0.0397	0.0388	0.0345
1995	1	1	0.992	0.9067	0.7054	0.4585	0.2674	0.157	0.1001	0.0709	0.0557	0.0475	0.0419	0.0378	0.0347	0.0322	0.0313	0.0291	0.0283	0.0249
1996	1	1	0.9955	0.9378	0.7788	0.5517	0.3479	0.2153	0.1416	0.1021	0.0811	0.0697	0.0618	0.0556	0.051	0.049	0.0451	0.0459	0.0448	0.0395
1997	1	1	0.9964	0.952	0.8242	0.6347	0.4455	0.3021	0.2104	0.1559	0.1249	0.1072	0.0946	0.0851	0.0771	0.0706	0.0659	0.0645	0.0588	0.0558
1998	1	0.9999	0.9942	0.9521	0.8483	0.6873	0.5044	0.3508	0.2477	0.1853	0.15	0.1298	0.116	0.1051	0.0982	0.0912	0.0859	0.0821	0.0761	0.0718
1999	1	0.9996	0.9936	0.9546	0.8289	0.6294	0.4256	0.2762	0.1862	0.1357	0.108	0.0928	0.0818	0.0739	0.0678	0.0639	0.0591	0.0566	0.0549	0.053
2000	1	0.9999	0.9872	0.9005	0.735	0.5228	0.3248	0.1915	0.1182	0.08	0.0603	0.0496	0.0424	0.0375	0.0339	0.0311	0.0293	0.0273	0.0271	0.0235
2001	1	1	0.9937	0.9174	0.7442	0.5326	0.3466	0.2196	0.1454	0.1042	0.0817	0.0694	0.0606	0.0545	0.0497	0.0459	0.0444	0.0411	0.0398	0.0348
2002	1	1	0.9949	0.9345	0.7683	0.5349	0.3298	0.1992	0.128	0.0902	0.0702	0.0594	0.0519	0.0462	0.0428	0.0395	0.0378	0.0353	0.033	0.0288
2003	1	1	0.9924	0.9195	0.7741	0.5902	0.4137	0.2823	0.1992	0.1501	0.1219	0.106	0.094	0.0851	0.078	0.0734	0.0678	0.0647	0.0629	0.0599
2004	1	0.9988	0.9909	0.8954	0.6979	0.4861	0.3131	0.1969	0.1286	0.0906	0.0699	0.0583	0.0503	0.0444	0.0402	0.0369	0.0345	0.033	0.0311	0.0287
2005	1	1	0.9977	0.939	0.7517	0.5127	0.3202	0.1998	0.1324	0.0955	0.0753	0.0641	0.056	0.05	0.0456	0.043	0.0389	0.0388	0.0346	0.0338
2006	1	1	0.9931	0.9249	0.7362	0.4831	0.2794	0.1613	0.1013	0.0709	0.0553	0.0468	0.0413	0.0368	0.0342	0.0329	0.0306	0.027	0.0263	0.0232
2007	1	0.9999	0.9949	0.928	0.7461	0.505	0.3049	0.1835	0.1193	0.0858	0.0683	0.0588	0.0521	0.0474	0.0444	0.0425	0.04	0.0394	0.036	0.0318
2008	1	1	0.9981	0.9767	0.9073	0.7695	0.5888	0.4248	0.3093	0.2378	0.1966	0.1734	0.1569	0.1447	0.1352	0.1288	0.1232	0.1204	0.1154	0.1103

Table 7.15. Indices of abundance. Indices were equally weighted (note that actual CVs were not used but a CV of 0.2 was used for all indices).

Year	Video		Comm LL		Comm HL		HB(18" MSL)		HB(20" MSL)		MRFSS	
	INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV
1986							0.745	0.325			0.593	0.599
1987							1.184	0.319			0.647	0.602
1988							1.043	0.316			0.937	0.478
1989							1.218	0.319			1.370	0.437
1990			0.713	0.151	0.633	0.251	0.810	0.348	0.837	0.516	1.927	0.458
1991			0.705	0.130	0.592	0.229			0.931	0.504	1.257	0.495
1992			0.644	0.148	0.689	0.210			0.787	0.532	1.343	0.422
1993	0.810	0.222	1.017	0.118	0.613	0.187			0.747	0.506	0.796	0.498
1994	0.842	0.196	0.861	0.113	0.818	0.177			0.787	0.515	0.960	0.458
1995	0.557	0.240	0.956	0.112	0.783	0.174			0.910	0.515	0.808	0.513
1996	0.871	0.199	0.846	0.112	0.578	0.179			0.736	0.548	0.616	0.538
1997	0.932	0.161	1.036	0.108	0.560	0.182			0.559	0.556	0.545	0.574
1998			1.064	0.111	0.507	0.184			0.618	0.552	0.775	0.458
1999			0.991	0.116	0.702	0.171			0.627	0.528	0.904	0.420
2000			0.938	0.112	0.875	0.168			0.864	0.521	1.027	0.411
2001			1.329	0.108	1.332	0.165			0.839	0.497	0.867	0.410
2002	1.153	1.153	1.020	0.112	1.356	0.161			0.924	0.495	0.908	0.403
2003			0.960	0.112	1.033	0.160			1.369	0.445	1.083	0.373
2004	1.384	0.116	1.256	0.109	1.632	0.156			2.005	0.421	1.656	0.305
2005	1.472	0.091	1.558	0.109	1.984	0.157			2.293	0.421	1.090	0.360
2006	1.074	0.140	1.195	0.110	1.302	0.160			1.011	0.490	0.465	0.547
2007	0.976	0.180	0.886	0.114	1.422	0.161			1.039	0.482	0.879	0.420
2008	0.931	0.180	1.024	0.114	1.590	0.162			1.118	0.479	1.548	0.330

Table 7.16. Starting values for parameters to initialize estimation procedure.

Parameter		Initial guess	comments		
Log(F-mult in Year 1)		-3			
Log(Q in Year 1)		-16			
Log(Virgin Stock Size)		15			
Steepness		0.8	Triangular prior with bounds at 0.3 and 0.9.		
Selectivity-at-age	COM-LL	COM-HL	COM-TRAP	REC	Comments
Age 1	0.05	0.2	0.2	0.1055	Rec is the ASAP 2006 model estimated average for 1986-1990, all others are the same as used in the ASAP 2006 Base model.
Age 2	0.07	0.26	0.26	0.3411	
Age 3	0.11	0.32	0.32	0.9539	
Age 4	0.17	0.39	0.39	1	
Age 5	0.25	0.48	0.48	0.9173	
Age 6	0.35	0.57	0.57	0.7806	
Age 7	0.45	0.67	0.67	0.6385	
Age 8	0.63	0.78	0.78	0.5251	
Age 9	0.78	0.88	0.88	-	
Age 10	0.9	0.96	0.96	-	The symbol (-) indicates that selectivity-at-age is not estimated for this age. Instead it is fixed at the value estimated for the oldest estimated age (COMLL and COM-HL = 10; COM-TRAP = 10; REC = 8).
Age 11	-	-	-	-	
Age 12	-	-	-	-	
Age 13	-	-	-	-	
Age 14	-	-	-	-	
Age 15	-	-	-	-	
Age 16	-	-	-	-	
Age 17	-	-	-	-	
Age 18	-	-	-	-	
Age 19	-	-	-	-	
Age 20+	-	-	-	-	

Table 7.17. Model component weightings and deviation terms expressed as coefficients of variation. (Note: the model generally requires inputs as λ where $\lambda = 1/[\ln(CV_2 + 1)]$ or, in the case of age composition the weights are effective sample sizes.

Model Component	Change from ASAP 2006 BASE	CV or weighting factor	Description/Comments
Indices of abundance	no, only updated years	0.2	Note that in the Base case, all indices are applied to average year abundance. In the red tide model, only MRFSS index applies to average abundance. All other indices are applied to month 0.1, or beginning year abundance.
Total Landings (weight)	no, only updated years	0.1	
Total Discards (weight)	no, only updated years	0.3	
Derived Catch at age (Goodyear, 1997)	no, only updated years	0	Not used to fit CAA but used for some fleets to obtain discard proportion at age
Direct otolith observed catch at age	no, only updated years	variable	Used effective sample sizes (Table 3.2.10) with a maximum effective sample size of 200 (CV = 0.07). This limit prevents the model from degrading the fits to other model components due to numerous otolith observations.
Derived discards at age	no, but only used for TRAP	1.3	Downweight discards when only model-based, based upon 2006 RW recommendation
Direct length frequency discards at age (converted to ages, Goodyear (1997))	Yes, observer data used for LL, HL and REC	0.3 (where data exists)	Obtained from observed discard lengths. Headboat observer data applied to entire REC fleet. Average of three years of observer coverage applied back in time for unobsered years.
F-Mult Deviations by Fleet	no	0.3	All fleets
N in year 1 deviation	no	0.5	deviation from unfished condition
q deviations	no	0.01	all indices
selectivity deviations	no	0.1	all indices
Recruitment deviations	no	0.5	Log-normal deviation from stock-recruitment relationship. Applied to each year.
Fleet specific Curvature on selectivity at age	Yes, made fleet specific	0.05 (LL, HL, TRAP); 0.3 (REC)	This was done to allow the rec selectivity to change more abruptly between age 1 and 3.
Curvature of selectivity by year	no	NA	NOT USED. Only one selectivity function estimated for each fleet for all years. Selectivity functions apply to the population (catch + discards). Annual discard fractions are estimated independently and will vary with changes in size limit.

8.1.1. Central case likelihood component values and objective function estimates (lower values denote better fits). RSS is the residual sum of squares.

component	RSS	nobs	Lambda	Likelihood	
Catch_Fleet_Comm LL	0.0688	23	100.5	6.9126	
Catch_Fleet_Comm HL	0.0572	23	100.5	5.7480	
Catch_Fleet_Comm Trap	2.4395	23	100.5	245.1690	
Catch_Fleet_REC	0.0653	23	100.5	6.5593	
Catch_Fleet_Total	2.6307	92	100.5	264.3890	
Discard_Fleet_Comm LL	1.0924	23	11.6	12.6713	
Discard_Fleet_Comm HL	1.8448	23	11.6	21.3996	
Discard_Fleet_Comm Trap	12.5672	23	11.6	145.7790	
Discard_Fleet_REC	1.4071	23	11.6	16.3224	
Discard_Fleet_Total	16.9115	92	11.6	196.1730	
Modeled CAA_proportions	N/A	1840	N/A	0.0000	*Not used
Observed CAA2_proportions	N/A	1840	Prop to eff. sample size	1047.1700	
Discard_proportions	N/A	1840	11.6 (where data exists)	206.1600	
Index_Fit_SEAMAP video	0.4131	11	25.5	5.2672	
Index_Fit_Comm LL	0.5716	19	25.5	7.2876	
Index_Fit_Comm HL	1.8631	19	25.5	23.7547	
Index_Fit_HB 18	0.2983	5	25.5	3.8035	
Index_Fit_HB20	1.3113	19	25.5	16.7186	
Index_Fit_MRFSS	2.4256	23	25.5	30.9267	
Index_Fit_Total	6.8830	96	153	87.7583	
Fmult_fleet_Comm LL	1.1475	22	11	12.6224	
Fmult_fleet_Comm HL	0.9147	22	11	10.0614	
Fmult_fleet_Comm Trap	89.5582	22	11	985.1400	
Fmult_fleet_REC	2.1897	22	11	24.0869	
Fmult_fleet_Total	93.8101	88	44	1031.9100	
N_year_1	10.5860	19	4.48	47.4255	
Stock-Recruit_Fit	1.7500	23	4.48	-21.0709	
Recruit_devs	1.7500	23	4.48	7.8402	
SRR_steepness	0.0016	1	1	0.0024	
SRR_virgin_stock	38.8390	1	0	0.0000	
overall obj_fun	=	2973.4			

Table 8.1.2. Fits to the catch series (gutted lbs).

	COM LL			COM HL			COM TRAP			REC		
YEAR	OBS	PRED	RESID	OBS	PRED	RESID	OBS	PRED	RES	OBS	PRED	RESID
1986	2,482,090	2,660,950	-178,860	3,116,270	3,149,930	-33,660	714,626	700,878	13,748	2,400,300	2,368,870	31,430
1987	3,742,400	3,556,120	186,280	2,531,260	2,554,960	-23,700	444,230	472,430	-28,200	1,464,660	1,645,890	-181,230
1988	2,172,240	2,360,900	-188,660	2,035,100	2,177,010	-141,910	535,166	534,746	420	2,475,990	2,461,270	14,720
1989	3,048,280	3,043,400	4,880	3,740,150	3,539,180	200,970	579,480	562,700	16,780	2,761,300	2,839,390	-78,090
1990	2,015,800	2,097,270	-81,470	2,454,250	2,206,640	247,610	339,231	384,317	-45,086	1,127,740	1,129,610	-1,870
1991	2,588,390	2,612,540	-24,150	2,131,680	1,975,770	155,910	374,442	430,551	-56,109	1,775,110	1,699,430	75,680
1992	2,408,440	2,420,790	-12,350	1,452,930	1,505,330	-52,400	601,907	658,616	-56,709	2,656,870	2,506,830	150,040
1993	4,302,810	3,695,390	607,420	1,359,830	1,303,540	56,290	716,986	701,077	15,909	2,091,160	2,087,870	3,290
1994	2,703,460	2,619,790	83,670	1,283,180	1,248,420	34,760	916,222	835,831	80,391	1,808,210	1,811,340	-3,130
1995	2,466,020	2,483,120	-17,100	1,222,430	1,191,860	30,570	1,057,700	887,316	170,384	1,862,550	1,769,970	92,580
1996	2,992,060	2,956,440	35,620	903,136	980,809	-77,673	559,086	528,993	30,093	893,755	929,573	-35,818
1997	3,136,150	3,128,600	7,550	1,005,100	1,029,460	-24,360	707,225	577,576	129,649	562,353	610,545	-48,192
1998	2,851,890	2,896,120	-44,230	798,246	884,552	-86,306	317,165	352,153	-34,988	643,079	681,162	-38,083
1999	3,920,670	3,576,700	343,970	1,264,060	1,282,140	-18,080	779,347	690,820	88,527	1,152,780	1,152,100	680
2000	2,981,130	2,967,620	13,510	1,805,390	1,692,730	112,660	1,048,270	881,587	166,683	2,107,720	1,956,960	150,760
2001	3,524,250	3,279,270	244,980	1,652,550	1,622,750	29,800	769,937	719,360	50,577	1,327,800	1,396,070	-68,270
2002	3,205,740	3,104,430	101,310	1,700,290	1,629,840	70,450	998,902	851,644	147,258	1,611,130	1,561,540	49,590
2003	3,062,780	3,035,650	27,130	1,158,200	1,202,330	-44,130	716,197	658,600	57,597	1,275,830	1,342,610	-66,780
2004	3,545,970	3,368,000	177,970	1,427,090	1,384,010	43,080	770,342	671,417	98,925	3,037,020	2,764,540	272,480
2005	3,326,160	3,295,920	30,240	1,454,300	1,455,280	-980	630,560	544,522	86,038	1,464,990	1,511,550	-46,560
2006	3,156,360	3,227,600	-71,240	1,385,340	1,422,870	-37,530	602,207	394,014	208,193	925,923	987,743	-61,820
2007	2,072,720	2,285,200	-212,480	1,586,390	1,600,000	-13,610	23,763	13,676	10,088	959,754	1,024,510	-64,756
2008	2,753,210	2,822,690	-69,480	1,968,170	1,931,300	36,870	0	3	-3	860,986	892,746	-31,760

Table 8.1.3. Fits to the discard series (gutted lbs).

	COM LL			COM HL			COM TRAP			REC		
YEAR	OBS	PRED	RESID	OBS	PRED	RESID	OBS	PRED	RES	OBS	PRED	RESID
1986	0	0	0	0	0	0	0	0	0	31,693	27,094	4,599
1987	0	0	0	0	0	0	0	0	0	29,125	22,212	6,913
1988	0	0	0	0	0	0	0	0	0	53,333	35,262	18,071
1989	0	0	0	0	0	0	0	0	0	125,285	68,051	57,234
1990	733,181	678,160	55,021	85,480	183,130	-97,650	5,573	3,009	2,564	346,258	358,614	-12,356
1991	1,374,570	1,029,740	344,830	127,294	185,788	-58,494	10,542	4,377	6,165	617,148	580,955	36,193
1992	683,877	1,041,170	-357,293	159,883	133,166	26,717	23,755	7,982	15,773	540,455	585,133	-44,678
1993	916,270	1,582,110	-665,840	72,547	114,177	-41,630	7,033	9,319	-2,286	354,799	416,522	-61,723
1994	698,914	1,110,080	-411,166	87,317	105,541	-18,224	6,691	12,241	-5,550	340,769	368,756	-27,987
1995	871,645	975,284	-103,639	80,049	87,701	-7,652	4,966	12,541	-7,575	341,018	340,733	285
1996	1,081,840	1,031,100	50,740	101,712	63,802	37,910	2,579	7,197	-4,618	242,052	209,665	32,387
1997	1,211,780	975,442	236,338	98,138	64,152	33,986	2,248	7,366	-5,118	226,005	168,911	57,094
1998	1,012,830	890,969	121,861	95,638	59,911	35,727	3,398	4,171	-773	315,774	223,678	92,096
1999	1,146,800	1,154,000	-7,200	122,986	92,247	30,739	4,524	8,060	-3,536	429,490	360,842	68,648
2000	961,849	1,011,680	-49,831	115,086	130,696	-15,610	3,782	10,092	-6,310	454,567	454,680	-113
2001	1,064,800	1,226,330	-161,530	115,365	129,379	-14,014	3,772	8,704	-4,932	338,952	344,007	-5,055
2002	997,029	1,180,230	-183,201	113,350	132,181	-18,831	4,642	10,914	-6,272	394,916	450,451	-55,535
2003	1,026,510	1,224,610	-198,100	113,391	115,254	-1,863	3,346	8,637	-5,291	429,846	439,326	-9,480
2004	1,070,300	1,441,340	-371,040	97,710	115,471	-17,761	3,470	9,189	-5,719	644,829	572,817	72,012
2005	976,386	1,197,430	-221,044	85,366	90,932	-5,566	2,342	7,460	-5,118	355,311	308,164	47,147
2006	890,113	851,242	38,871	79,418	85,137	-5,719	2,450	4,993	-2,543	180,881	177,045	3,836
2007	566,596	619,807	-53,211	100,472	107,263	-6,791	0	0	0	215,603	188,952	26,651
2008	893,659	797,564	96,095	82,053	101,225	-19,172	0	0	0	637,894	339,581	298,313

Table 8.1.4 Fits to the indices of abundance.

	SEAMAP VIDEO			COM_LL			COM_HL			HB18			HB20			MRFSS		
YEAR	OBS	PRED	RESID	OBS	PRED	RESID	OBS	PRED	RESID	OBS	PRED	RESID	OBS	PRED	RESID	OBS	PRED	RESID
1986	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.59	0.71	-0.11
1987	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.65	0.77	-0.12
1988	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.94	0.82	0.12
1989	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.37	0.87	0.50
1990	0.81	0.90	-0.09	0.71	0.80	-0.09	0.63	0.72	-0.08	0.74	0.77	-0.02	0.84	0.76	0.08	1.93	0.91	1.02
1991	0.84	0.89	-0.05	0.71	0.82	-0.12	0.59	0.77	-0.18	1.18	0.89	0.29	0.93	0.91	0.02	1.26	0.96	0.30
1992	0.56	0.85	-0.30	0.64	0.82	-0.18	0.69	0.79	-0.10	1.04	1.14	-0.10	0.79	0.87	-0.08	1.34	0.99	0.36
1993	0.87	0.82	0.06	1.02	0.83	0.18	0.61	0.81	-0.20	1.22	0.97	0.25	0.75	0.92	-0.18	0.80	0.95	-0.16
1994	0.93	0.83	0.10	0.86	0.86	0.01	0.82	0.84	-0.02	0.81	1.20	-0.39	0.79	0.96	-0.17	0.96	0.89	0.07
1995	1.15	1.07	0.09	0.96	0.89	0.07	0.78	0.86	-0.07	-	-	-	0.91	0.92	-0.01	0.81	0.84	-0.03
1996	1.38	1.10	0.29	0.85	0.90	-0.05	0.58	0.85	-0.27	-	-	-	0.74	0.81	-0.07	0.62	0.81	-0.19
1997	1.47	1.06	0.41	1.04	0.91	0.12	0.56	0.84	-0.28	-	-	-	0.56	0.76	-0.21	0.54	0.84	-0.30
1998	1.07	1.06	0.02	1.06	0.95	0.12	0.51	0.86	-0.36	-	-	-	0.62	0.83	-0.21	0.78	0.90	-0.13
1999	0.98	1.05	-0.08	0.99	0.95	0.04	0.70	0.86	-0.16	-	-	-	0.63	0.80	-0.17	0.90	0.95	-0.04
2000	0.93	1.10	-0.16	0.94	0.98	-0.04	0.88	0.91	-0.03	-	-	-	0.86	1.00	-0.14	1.03	0.99	0.04
2001	-	-	-	1.33	0.97	0.36	1.33	0.91	0.43	-	-	-	0.84	0.92	-0.08	0.87	1.10	-0.24
2002	-	-	-	1.02	0.96	0.06	1.36	0.88	0.47	-	-	-	0.92	0.82	0.11	0.91	1.21	-0.30
2003	-	-	-	0.96	1.08	-0.12	1.03	1.05	-0.02	-	-	-	1.37	1.34	0.03	1.08	1.16	-0.07
2004	-	-	-	1.26	1.14	0.11	1.63	1.11	0.52	-	-	-	2.00	1.26	0.74	1.66	1.09	0.56
2005	-	-	-	1.56	1.15	0.40	1.98	1.09	0.89	-	-	-	2.29	1.01	1.29	1.09	1.02	0.07
2006	-	-	-	1.19	1.21	-0.01	1.30	1.12	0.18	-	-	-	1.01	1.04	-0.03	0.46	0.98	-0.52
2007	-	-	-	0.89	1.25	-0.37	1.42	1.13	0.29	-	-	-	1.04	0.98	0.06	0.88	1.01	-0.13
2008	-	-	-	1.02	1.30	-0.28	1.59	1.15	0.44	-	-	-	1.12	0.99	0.13	1.55	1.02	0.53

Table 8.1.5 Selectivity-at-age by fleet. Note: these selectivity vectors apply to the total catch (landed + released).

	COMM LL	COMM HL	TRAP	REC
Age 1	0.000	0.000	0.000	0.106
Age 2	0.235	0.390	0.009	0.432
Age 3	0.375	0.584	0.018	0.918
Age 4	0.567	0.816	0.039	1.000
Age 5	0.760	0.973	0.081	0.977
Age 6	0.878	1.000	0.163	0.665
Age 7	0.945	0.928	0.303	0.397
Age 8	0.988	0.817	0.493	0.316
Age 9	1.000	0.708	0.699	0.165
Age 10	0.979	0.627	0.888	0.149
Age 11	0.952	0.585	1.000	0.142
Age 12	0.952	0.585	1.000	0.142
Age 13	0.952	0.585	1.000	0.142
Age 14	0.952	0.585	1.000	0.142
Age 15	0.952	0.585	1.000	0.142
Age 16	0.952	0.585	1.000	0.142
Age 17	0.952	0.585	1.000	0.142
Age 18	0.952	0.585	1.000	0.142
Age 19	0.952	0.585	1.000	0.142
Age 20	0.952	0.585	1.000	0.142

Table 8.1.6 Fishing mortality (due to landings and discards) by year and fleet.

YEAR	COM LL	COM HL	COM TRAP	REC
1986	0.059	0.085	0.021	0.121
1987	0.085	0.071	0.016	0.079
1988	0.059	0.060	0.021	0.113
1989	0.078	0.098	0.025	0.134
1990	0.116	0.097	0.020	0.060
1991	0.155	0.087	0.026	0.090
1992	0.148	0.062	0.043	0.117
1993	0.224	0.053	0.049	0.093
1994	0.157	0.049	0.060	0.080
1995	0.140	0.044	0.061	0.077
1996	0.155	0.035	0.034	0.041
1997	0.153	0.036	0.034	0.027
1998	0.136	0.031	0.019	0.030
1999	0.167	0.044	0.036	0.051
2000	0.142	0.060	0.045	0.083
2001	0.160	0.056	0.038	0.058
2002	0.148	0.054	0.045	0.065
2003	0.142	0.041	0.035	0.053
2004	0.154	0.042	0.034	0.091
2005	0.137	0.039	0.027	0.051
2006	0.114	0.041	0.018	0.034
2007	0.077	0.040	0.000	0.034
2008	0.097	0.052	0.000	0.033

Table 8.1.7. Annual estimates of total fishing mortality (landings + discards) expressed as Apical F (maximum annual F at any age), F as a fraction of F at maximum sustainable yield (F_{MSY}) and F as a fraction of F at optimal yield (F_{OY}).

YEAR	Apical F	Fmsy	F/Fmsy
1986	0.246	0.186	1.318
1987	0.212	0.186	1.138
1988	0.214	0.186	1.149
1989	0.285	0.186	1.529
1990	0.221	0.186	1.184
1991	0.261	0.186	1.402
1992	0.252	0.186	1.353
1993	0.287	0.186	1.541
1994	0.234	0.186	1.258
1995	0.219	0.186	1.175
1996	0.188	0.186	1.008
1997	0.184	0.186	0.985
1998	0.157	0.186	0.845
1999	0.214	0.186	1.150
2000	0.231	0.186	1.241
2001	0.222	0.186	1.189
2002	0.220	0.186	1.180
2003	0.190	0.186	1.021
2004	0.221	0.186	1.185
2005	0.179	0.186	0.960
2006	0.145	0.186	0.778
2007	0.117	0.186	0.630
2008	0.132	0.186	0.708

Table 8.1.8. Total fishing mortality (due to landings and discards) by age and year. Shaded values is apical F for each year.

YEAR	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11	AGE 12	AGE 13	AGE 14	AGE 15	AGE 16	AGE 17	AGE 18	AGE 19	AGE 20
1986	0.001	0.067	0.165	0.221	0.246	0.220	0.188	0.176	0.154	0.148	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144	0.144
1987	0.001	0.058	0.129	0.183	0.212	0.201	0.183	0.176	0.160	0.155	0.151	0.151	0.151	0.151	0.151	0.151	0.151	0.151	0.151	0.151
1988	0.001	0.049	0.134	0.192	0.214	0.190	0.162	0.153	0.134	0.131	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128
1989	0.001	0.065	0.160	0.250	0.285	0.259	0.225	0.211	0.187	0.180	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175
1990	0.002	0.023	0.040	0.062	0.129	0.196	0.213	0.221	0.199	0.190	0.188	0.189	0.190	0.191	0.191	0.192	0.193	0.193	0.194	0.194
1991	0.003	0.028	0.051	0.079	0.160	0.233	0.251	0.261	0.235	0.227	0.225	0.227	0.228	0.229	0.230	0.231	0.231	0.232	0.233	0.233
1992	0.003	0.027	0.051	0.088	0.174	0.233	0.242	0.252	0.227	0.224	0.225	0.226	0.227	0.228	0.229	0.229	0.230	0.230	0.231	0.231
1993	0.002	0.031	0.056	0.098	0.179	0.243	0.267	0.287	0.273	0.271	0.272	0.274	0.275	0.276	0.277	0.278	0.279	0.279	0.280	0.280
1994	0.002	0.023	0.042	0.073	0.142	0.197	0.215	0.232	0.222	0.224	0.227	0.229	0.230	0.231	0.231	0.232	0.233	0.233	0.233	0.234
1995	0.002	0.022	0.039	0.066	0.128	0.181	0.199	0.216	0.206	0.209	0.213	0.214	0.215	0.216	0.216	0.217	0.218	0.218	0.218	0.219
1996	0.001	0.019	0.034	0.052	0.096	0.145	0.170	0.187	0.182	0.181	0.182	0.183	0.184	0.185	0.185	0.186	0.186	0.187	0.187	0.188
1997	0.001	0.018	0.031	0.047	0.086	0.133	0.160	0.178	0.177	0.177	0.178	0.179	0.180	0.181	0.181	0.182	0.182	0.183	0.183	0.184
1998	0.001	0.017	0.030	0.046	0.080	0.121	0.143	0.157	0.153	0.150	0.150	0.151	0.152	0.152	0.153	0.153	0.154	0.154	0.155	0.155
1999	0.002	0.023	0.041	0.061	0.112	0.169	0.196	0.214	0.206	0.204	0.205	0.206	0.207	0.208	0.209	0.209	0.210	0.210	0.211	0.211
2000	0.002	0.024	0.045	0.075	0.142	0.200	0.217	0.231	0.214	0.213	0.214	0.215	0.216	0.217	0.218	0.218	0.219	0.219	0.220	0.220
2001	0.002	0.023	0.040	0.065	0.125	0.183	0.206	0.222	0.211	0.209	0.209	0.210	0.211	0.212	0.213	0.214	0.214	0.215	0.215	0.216
2002	0.002	0.022	0.040	0.063	0.123	0.182	0.204	0.220	0.208	0.208	0.209	0.210	0.211	0.212	0.213	0.214	0.214	0.215	0.215	0.216
2003	0.002	0.020	0.037	0.059	0.108	0.155	0.175	0.190	0.182	0.181	0.182	0.183	0.184	0.185	0.186	0.186	0.187	0.187	0.188	0.188
2004	0.002	0.024	0.045	0.077	0.145	0.195	0.208	0.221	0.203	0.201	0.201	0.202	0.203	0.204	0.205	0.205	0.206	0.206	0.207	0.207
2005	0.001	0.019	0.033	0.052	0.100	0.148	0.166	0.179	0.170	0.167	0.167	0.168	0.169	0.170	0.170	0.171	0.171	0.171	0.172	0.172
2006	0.001	0.015	0.026	0.040	0.070	0.123	0.145	0.145	0.137	0.137	0.135	0.136	0.136	0.137	0.137	0.138	0.138	0.138	0.139	0.139
2007	0.001	0.012	0.021	0.034	0.079	0.088	0.107	0.117	0.102	0.096	0.095	0.096	0.096	0.097	0.097	0.097	0.098	0.098	0.098	0.098
2008	0.001	0.015	0.027	0.038	0.071	0.118	0.116	0.132	0.124	0.114	0.112	0.113	0.113	0.114	0.115	0.115	0.115	0.116	0.116	0.116

Table 8.1.9. Number-at-age and recruitment (Age 1) by year.

YEAR	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10
1986	6,225,620	7,104,780	3,592,600	1,688,560	1,081,620	623,493	520,299	359,881	325,491	280,876
1987	12,276,000	3,792,720	4,732,800	2,330,310	1,078,000	691,377	416,400	363,160	256,801	239,249
1988	11,401,600	7,482,070	2,549,150	3,181,930	1,544,910	712,642	470,309	292,196	259,219	187,511
1989	8,355,230	6,946,640	5,073,400	1,704,460	2,091,770	1,019,140	490,290	336,928	213,316	194,219
1990	11,282,400	5,089,470	4,637,240	3,307,850	1,057,110	1,285,520	654,578	329,974	232,061	151,726
1991	10,447,800	6,869,880	3,544,590	3,406,850	2,475,160	759,446	879,360	445,581	225,124	162,983
1992	8,880,940	6,356,500	4,758,830	2,576,630	2,506,210	1,724,050	500,602	576,729	291,917	152,474
1993	6,710,980	5,402,030	4,407,310	3,458,370	1,878,390	1,721,630	1,135,680	331,291	381,287	199,373
1994	7,059,770	4,085,180	3,732,260	3,186,210	2,497,530	1,284,140	1,122,800	732,660	211,474	248,634
1995	8,787,360	4,298,550	2,843,210	2,736,400	2,358,540	1,770,260	877,373	763,239	494,171	145,131
1996	7,176,980	5,350,630	2,997,130	2,090,970	2,040,630	1,696,370	1,228,660	605,977	523,366	344,630
1997	13,203,100	4,373,110	3,738,240	2,216,220	1,580,040	1,514,560	1,220,490	873,530	427,716	373,892
1998	7,629,090	8,047,000	3,058,810	2,771,280	1,683,190	1,184,870	1,102,860	876,072	621,854	307,054
1999	7,155,550	4,648,870	5,633,770	2,269,440	2,108,100	1,269,430	873,493	805,384	636,766	457,594
2000	21,132,000	4,357,940	3,236,570	4,136,910	1,700,450	1,540,730	892,246	605,109	552,992	444,262
2001	9,836,850	12,862,800	3,031,550	2,367,540	3,057,300	1,205,940	1,049,850	605,213	408,522	382,557
2002	7,231,160	5,991,320	8,958,140	2,227,700	1,767,320	2,205,860	835,806	720,193	412,558	283,489
2003	11,290,500	4,403,420	4,173,930	6,583,790	1,666,160	1,277,520	1,529,750	574,364	491,761	287,057
2004	7,734,590	6,876,640	3,073,750	3,077,690	4,942,450	1,222,610	910,535	1,082,100	403,959	351,383
2005	9,399,840	4,707,630	4,780,910	2,247,480	2,268,230	3,492,600	836,883	623,308	738,236	282,606
2006	10,501,600	5,726,510	3,291,120	3,538,100	1,699,840	1,676,530	2,505,700	597,133	443,426	534,072
2007	9,058,190	6,400,710	4,019,330	2,453,020	2,705,980	1,295,300	1,232,990	1,826,400	439,596	331,513
2008	9,572,840	5,520,810	4,505,010	3,009,320	1,887,650	2,043,090	986,904	933,258	1,381,810	340,186

YEAR	AGE 11	AGE 12	AGE 13	AGE 14	AGE 15	AGE 16	AGE 17	AGE 18	AGE 19	AGE 20
1986	267,874	232,486	209,850	193,340	173,504	158,629	145,872	133,528	122,322	351,346
1987	208,892	200,869	174,978	158,416	146,303	131,556	120,482	110,948	101,681	361,272
1988	176,710	155,628	150,206	131,238	119,102	110,215	99,274	91,045	83,941	350,830
1989	141,864	134,654	119,029	115,227	100,918	91,769	85,066	76,729	70,453	336,993
1990	139,915	103,125	98,247	87,107	84,527	74,179	67,568	62,721	56,642	301,278
1991	108,149	100,440	74,214	70,847	62,910	61,125	53,699	48,951	45,474	259,650
1992	111,943	74,775	69,598	51,516	49,246	43,776	42,568	37,428	34,131	212,882
1993	105,069	77,452	51,858	48,362	35,851	34,314	30,534	29,715	26,146	172,657
1994	131,028	69,300	51,197	34,341	32,069	23,801	22,800	20,302	19,768	132,335
1995	171,286	90,393	47,922	35,474	23,830	22,282	16,553	15,870	14,144	106,011
1996	101,500	119,909	63,436	33,700	24,987	16,807	15,734	11,698	11,222	85,043
1997	247,814	73,252	86,773	46,007	24,482	18,179	12,242	11,470	8,536	70,290
1998	270,066	179,615	53,236	63,198	33,565	17,886	13,296	8,962	8,403	57,800
1999	227,795	201,326	134,271	39,886	47,434	25,229	13,460	10,016	6,758	49,954
2000	321,643	160,740	142,414	95,172	28,315	33,717	17,953	9,586	7,139	40,447
2001	309,644	224,940	112,684	100,036	66,955	19,947	23,777	12,671	6,770	33,632
2002	267,671	217,532	158,419	79,519	70,706	47,385	14,131	16,859	8,991	28,686
2003	198,559	188,054	153,208	111,799	56,206	50,042	33,574	10,021	11,963	26,756
2004	206,499	143,347	136,112	111,121	81,220	40,887	36,446	24,473	7,311	28,264
2005	247,826	146,253	101,779	96,841	79,188	57,956	29,208	26,057	17,510	25,474
2006	206,133	181,585	107,457	74,948	71,438	58,500	42,865	21,622	19,308	31,872
2007	401,387	155,994	137,830	81,763	57,135	54,544	44,723	32,803	16,562	39,238
2008	259,601	315,993	123,201	109,135	64,871	45,407	43,408	35,632	26,160	44,549

Table 8.1.10. Biomass-at-age by year.

year	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10
1986	1,217,746	5,339,376	5,918,029	4,716,956	4,426,832	3,404,693	3,554,437	2,936,022	3,062,856	2,968,294
1987	2,401,215	2,850,301	7,796,261	6,509,671	4,412,016	3,775,386	2,844,648	2,962,774	2,416,486	2,528,380
1988	2,230,180	5,622,917	4,199,172	8,888,653	6,322,976	3,891,507	3,212,929	2,383,827	2,439,240	1,981,614
1989	1,634,303	5,220,531	8,357,326	4,761,372	8,561,153	5,565,194	3,349,430	2,748,765	2,007,294	2,052,504
1990	2,206,864	3,824,833	7,638,847	9,240,408	4,326,518	7,019,809	4,471,768	2,692,032	2,183,684	1,603,438
1991	2,043,614	5,162,845	5,838,943	9,516,962	10,130,284	4,147,089	6,007,372	3,635,190	2,118,407	1,722,402
1992	1,737,133	4,777,030	7,839,140	7,197,761	10,257,364	9,414,479	3,419,876	4,705,137	2,746,927	1,611,343
1993	1,312,684	4,059,728	7,260,087	9,660,882	7,687,836	9,401,264	7,758,429	2,702,776	3,587,894	2,106,971
1994	1,380,908	3,070,090	6,148,089	8,900,609	10,221,839	7,012,273	7,670,439	5,977,271	1,989,961	2,627,561
1995	1,718,828	3,230,442	4,683,572	7,644,075	9,652,984	9,666,817	5,993,798	6,226,744	4,650,128	1,533,743
1996	1,403,834	4,021,100	4,937,121	5,841,080	8,351,848	9,263,328	8,393,625	4,943,751	4,924,852	3,642,046
1997	2,582,558	3,286,475	6,157,939	6,190,963	6,466,755	8,270,522	8,337,811	7,126,533	4,024,789	3,951,286
1998	1,492,268	6,047,473	5,038,726	7,741,511	6,888,925	6,470,192	7,534,219	7,147,271	5,851,620	3,244,943
1999	1,399,643	3,493,714	9,280,414	6,339,632	8,627,988	6,931,946	5,967,292	6,570,576	5,991,941	4,835,848
2000	4,133,469	3,275,074	5,331,547	11,556,369	6,959,567	8,413,428	6,095,403	4,936,670	5,203,631	4,694,955
2001	1,924,111	9,666,637	4,993,821	6,613,672	12,512,854	6,585,248	7,172,079	4,937,518	3,844,175	4,042,858
2002	1,414,432	4,502,590	14,756,592	6,223,032	7,233,251	12,045,488	5,709,832	5,875,561	3,882,153	2,995,908
2003	2,208,449	3,309,253	6,875,644	18,391,676	6,819,225	6,976,123	10,450,530	4,685,842	4,627,450	3,033,615
2004	1,512,904	5,167,925	5,063,336	8,597,461	20,228,357	6,676,278	6,220,345	8,828,112	3,801,237	3,713,411
2005	1,838,631	3,537,873	7,875,512	6,278,287	9,283,365	19,071,958	5,717,189	5,085,143	6,946,769	2,986,577
2006	2,054,138	4,303,581	5,421,406	9,883,606	6,957,070	9,154,988	17,117,759	4,871,599	4,172,620	5,644,066
2007	1,771,803	4,810,255	6,620,974	6,852,459	11,074,979	7,073,214	8,423,205	14,900,346	4,136,580	3,503,425
2008	1,872,470	4,148,993	7,421,027	8,406,471	7,725,735	11,156,653	6,742,062	7,613,813	13,002,773	3,595,081

year	AGE 11	AGE 12	AGE 13	AGE 14	AGE 15	AGE 16	AGE 17	AGE 18	AGE 19	AGE 20
1986	3,113,602	2,923,250	2,816,562	2,740,092	2,573,536	2,444,572	2,321,444	2,183,396	2,046,479	6,259,583
1987	2,428,032	2,525,702	2,348,518	2,245,135	2,170,071	2,027,360	1,917,381	1,814,177	1,701,150	6,436,425
1988	2,053,968	1,956,847	2,016,033	1,859,957	1,766,607	1,698,482	1,579,871	1,488,725	1,404,352	6,250,390
1989	1,648,940	1,693,123	1,597,582	1,633,043	1,496,888	1,414,218	1,353,765	1,254,643	1,178,699	6,003,870
1990	1,626,286	1,296,681	1,318,645	1,234,521	1,253,759	1,143,137	1,075,299	1,025,585	947,631	5,367,571
1991	1,257,057	1,262,920	996,082	1,004,069	933,126	941,967	854,583	800,434	760,785	4,625,926
1992	1,301,156	940,206	934,128	730,098	730,449	674,609	677,430	611,999	571,016	3,792,707
1993	1,221,257	973,868	696,027	685,398	531,762	528,792	485,923	485,893	437,428	3,076,058
1994	1,522,989	871,367	687,155	486,693	475,673	366,781	362,851	331,962	330,726	2,357,681
1995	1,990,923	1,136,586	643,192	502,749	353,459	343,381	263,427	259,500	236,631	1,888,693
1996	1,179,773	1,507,721	851,426	477,610	370,622	259,002	250,400	191,279	187,754	1,515,125
1997	2,880,437	921,065	1,164,649	652,032	363,139	280,147	194,821	187,559	142,813	1,252,291
1998	3,139,081	2,258,456	714,516	895,673	497,862	275,630	211,596	146,547	140,592	1,029,756
1999	2,647,749	2,531,448	1,802,157	565,283	703,575	388,792	214,198	163,781	113,059	889,986
2000	3,738,580	2,021,125	1,911,450	1,348,810	419,991	519,606	285,704	156,749	119,432	720,606
2001	3,599,111	2,828,367	1,512,421	1,417,750	993,129	307,388	378,392	207,198	113,268	599,193
2002	3,111,243	2,735,220	2,126,266	1,126,975	1,048,762	730,231	224,889	275,673	150,427	511,070
2003	2,307,927	2,364,567	2,056,325	1,584,460	833,692	771,174	534,304	163,863	200,142	476,676
2004	2,400,217	1,802,427	1,826,866	1,574,851	1,204,715	630,094	580,003	400,166	122,308	503,559
2005	2,880,577	1,838,967	1,366,056	1,372,471	1,174,578	893,144	464,827	426,080	292,947	453,840
2006	2,395,963	2,283,227	1,442,265	1,062,197	1,059,623	901,526	682,168	353,556	323,028	567,835
2007	4,665,475	1,961,449	1,849,925	1,158,775	847,469	840,563	711,736	536,386	277,087	699,065
2008	3,017,442	3,973,256	1,653,578	1,546,705	962,218	699,744	690,806	582,632	437,655	793,676

Table 8.1.11. Total number, total biomass**,** Spawning stock (SSB) reproductive potential (mature female gonad weight (g)), SSB as a function of maximum sustainable yield (MSY) and ratio of SSB to SSB_{msy}.

YEAR	Total number	Total biomass (gutted lbs)	SSB in female gonad wt	SSBmsy	SSB/SSBmsy
1986	23,791,971	66,967,759	477,667,000	647,666,000	0.738
1987	27,892,214	64,111,088	461,323,000	647,666,000	0.712
1988	29,549,725	63,248,246	455,644,000	647,666,000	0.704
1989	27,698,095	63,532,642	458,732,000	647,666,000	0.708
1990	29,103,237	61,497,315	454,238,000	647,666,000	0.701
1991	30,102,232	63,760,058	476,845,000	647,666,000	0.736
1992	29,052,742	64,669,990	501,654,000	647,666,000	0.775
1993	26,238,297	64,660,959	512,967,000	647,666,000	0.792
1994	24,697,598	62,792,918	508,612,000	647,666,000	0.785
1995	25,617,998	62,619,671	520,284,000	647,666,000	0.803
1996	24,539,379	62,513,296	512,097,000	647,666,000	0.791
1997	30,119,944	64,434,584	514,862,000	647,666,000	0.795
1998	27,988,107	66,766,855	525,513,000	647,666,000	0.811
1999	26,614,526	69,459,020	556,801,000	647,666,000	0.860
2000	39,456,335	71,842,167	572,553,000	647,666,000	0.884
2001	35,719,179	74,249,190	559,060,000	647,666,000	0.863
2002	31,543,446	76,679,596	591,754,000	647,666,000	0.914
2003	33,118,434	78,670,938	633,051,000	647,666,000	0.977
2004	30,491,386	80,854,573	667,069,000	647,666,000	1.030
2005	30,205,816	79,784,790	674,739,000	647,666,000	1.042
2006	31,329,760	80,652,221	649,526,000	647,666,000	1.003
2007	30,785,009	82,715,170	666,573,000	647,666,000	1.029
2008	31,248,833	86,042,790	712,501,000	647,666,000	1.100

Table 8.1.12. Selected parameter estimates with standard deviation. NOTE: F reference points include landings and discards.

name	value	std
log_Fmult_year1_Comm LL	-2.879	0.0854
log_Fmult_year1_Comm HL	-3.006	0.0879
log_Fmult_year1_Comm trap	-3.851	0.0911
log_Fmult_year1_Rec	-3.121	0.0828
logVirgin reproductive potential	2.123E+01	0.0509
SRR_steepness	0.84	0.0524
MSY	6,961,700	222,600
SS/SSmsy_ratio	1.100	0.0747
Fmsy_ratio	0.708	0.0647
log_q_year1_SEAMAP video	-16.220	0.0713
log_q_year1_comm LL	-18.563	0.0882
log_q_year1_comm HL	-18.138	0.0807
log_q_year1_HB18	-15.317	0.1234
log_q_year1_HB20	-15.773	0.0969
log_q_year1_MRFSS	-16.433	0.0731

8.2.1. Red tide model likelihood component values and objective function estimates (lower values indicated better fits). RSS is the residual sum of squares.

component	RSS	nobs	Lambda	Likelihood	
Catch_Fleet_Comm LL	0.0658	23	100.5	6.614	
Catch_Fleet_Comm HL	0.0559	23	100.5	5.619	
Catch_Fleet_Comm Trap	2.4469	23	100.5	245.910	
Catch_Fleet_REC	0.0608	23	100.5	6.106	
Catch_Fleet_Total	2.6293	92	100.5	264.249	
Discard_Fleet_Comm LL	1.0738	23	11.6	12.456	
Discard_Fleet_Comm HL	1.8924	23	11.6	21.952	
Discard_Fleet_Comm Trap	12.5894	23	11.6	146.037	
Discard_Fleet_REC	1.3029	23	11.6	15.114	
Discard_Fleet_Total	16.8586	92	11.6	195.559	
Modeled CAA_proportions	N/A	1840	N/A	0.000	*Not used
Observed CAA2_proportions	N/A	1840	Prop to eff. sample size	1044.230	
Discard_proportions	N/A	1840	11.6 (where data exists)	206.928	
Index_Fit_SEAMAP video	0.3099	11	25.5	3.951	
Index_Fit_Comm LL	0.3576	19	25.5	4.559	
Index_Fit_Comm HL	1.9753	19	25.5	25.186	
Index_Fit_HB 18	0.2699	5	25.5	3.441	
Index_Fit_HB20	1.1778	19	25.5	15.017	
Index_Fit_MRFSS	2.3973	23	25.5	30.565	
Index_Fit_Total	6.4878	96	153.0	82.719	
Fmult_fleet_Comm LL	1.0893	22	11.0	11.982	
Fmult_fleet_Comm HL	0.9407	22	11.0	10.348	
Fmult_fleet_Comm Trap	89.0186	22	11.0	979.204	
Fmult_fleet_REC	1.9647	22	11.0	21.612	
Fmult_fleet_Total	93.0132	88	44.0	1023.150	
N_year_1	10.9483	19	4.5	49.049	
Stock-Recruit_Fit	1.9057	23	4.5	-19.508	
Recruit_devs	1.9057	23	4.5	8.538	
SRR_steepness	0.0011	1	1.0	0.002	
SRR_virgin_stock	40.0096	1	0.0	0.000	
overall obj_fun	=	2961.33			

Table 8.2.2. Red tide model fits to the catch series (gutted lbs).

	COM LL			COM HL			COM TRAP			REC		
YEAR	OBS	PRED	RESID	OBS	PRED	RESID	OBS	PRED	RES	OBS	PRED	RESID
1986	2,482,090	2,665,140	-183,050	3,116,270	3,155,440	-39,170	714,626	701,301	13,325	2,400,300	2,374,160	26,140
1987	3,742,400	3,565,670	176,730	2,531,260	2,561,320	-30,060	444,230	472,531	-28,301	1,464,660	1,649,660	-185,000
1988	2,172,240	2,364,130	-191,890	2,035,100	2,180,490	-145,390	535,166	534,813	353	2,475,990	2,465,400	10,590
1989	3,048,280	3,049,670	-1,390	3,740,150	3,550,290	189,860	579,480	562,760	16,720	2,761,300	2,847,710	-86,410
1990	2,015,800	2,100,740	-84,940	2,454,250	2,210,750	243,500	339,231	384,329	-45,098	1,127,740	1,128,670	-930
1991	2,588,390	2,615,550	-27,160	2,131,680	1,979,170	152,510	374,442	430,257	-55,815	1,775,110	1,700,340	74,770
1992	2,408,440	2,423,610	-15,170	1,452,930	1,508,130	-55,200	601,907	657,818	-55,911	2,656,870	2,510,710	146,160
1993	4,302,810	3,703,830	598,980	1,359,830	1,306,350	53,480	716,986	700,239	16,747	2,091,160	2,091,630	-470
1994	2,703,460	2,626,380	77,080	1,283,180	1,251,260	31,920	916,222	834,949	81,273	1,808,210	1,814,850	-6,640
1995	2,466,020	2,488,340	-22,320	1,222,430	1,194,200	28,230	1,057,700	886,686	171,014	1,862,550	1,772,250	90,300
1996	2,992,060	2,963,220	28,840	903,136	982,696	-79,560	559,086	528,813	30,273	893,755	930,452	-36,697
1997	3,136,150	3,138,550	-2,400	1,005,100	1,031,850	-26,750	707,225	577,610	129,615	562,353	610,968	-48,615
1998	2,851,890	2,905,600	-53,710	798,246	886,594	-88,348	317,165	352,225	-35,060	643,079	681,316	-38,237
1999	3,920,670	3,591,740	328,930	1,264,060	1,285,110	-21,050	779,347	691,230	88,117	1,152,780	1,152,290	490
2000	2,981,130	2,977,050	4,080	1,805,390	1,696,370	109,020	1,048,270	882,250	166,020	2,107,720	1,956,820	150,900
2001	3,524,250	3,292,960	231,290	1,652,550	1,625,600	26,950	769,937	720,016	49,921	1,327,800	1,394,780	-66,980
2002	3,205,740	3,104,610	101,130	1,700,290	1,628,820	71,470	998,902	851,965	146,937	1,611,130	1,556,430	54,700
2003	3,062,780	3,022,130	40,650	1,158,200	1,200,820	-42,620	716,197	658,729	57,468	1,275,830	1,338,020	-62,190
2004	3,545,970	3,380,870	165,100	1,427,090	1,397,940	29,150	770,342	679,174	91,168	3,037,020	2,781,350	255,670
2005	3,326,160	3,263,580	62,580	1,454,300	1,453,520	780	630,560	545,458	85,102	1,464,990	1,505,560	-40,570
2006	3,156,360	3,152,120	4,240	1,385,340	1,396,480	-11,140	602,207	388,126	214,081	925,923	968,992	-43,069
2007	2,072,720	2,278,050	-205,330	1,586,390	1,593,230	-6,840	23,763	13,655	10,108	959,754	1,018,470	-58,716
2008	2,753,210	2,816,140	-62,930	1,968,170	1,920,220	47,950	0	3	-3	860,986	883,781	-22,795

Table 8.2.3. Red tide model fits to the discard series (gutted lbs).

		COM LL			COM HL			COM TRAP			REC	
YEAR	OBS	PRED	RESID	OBS	PRED	RESID	OBS	PRED	RES	OBS	PRED	RESID
1986	0	0	0	0	0	0	0	0	0	31,693	26,696	4,997
1987	0	0	0	0	0	0	0	0	0	29,125	22,082	7,043
1988	0	0	0	0	0	0	0	0	0	53,333	35,110	18,223
1989	0	0	0	0	0	0	0	0	0	125,285	68,067	57,218
1990	733,181	672,672	60,509	85,480	181,273	-95,793	5,573	3,001	2,572	346,258	361,591	-15,333
1991	1,374,570	1,024,670	349,900	127,294	183,903	-56,609	10,542	4,387	6,155	617,148	584,245	32,903
1992	683,877	1,036,410	-352,533	159,883	131,626	28,257	23,755	8,025	15,730	540,455	586,041	-45,586
1993	916,270	1,573,890	-657,620	72,547	112,701	-40,154	7,033	9,379	-2,346	354,799	416,481	-61,682
1994	698,914	1,102,440	-403,526	87,317	104,180	-16,863	6,691	12,313	-5,622	340,769	368,652	-27,883
1995	871,645	967,308	-95,663	80,049	86,604	-6,555	4,966	12,587	-7,621	341,018	340,673	345
1996	1,081,840	1,022,060	59,780	101,712	62,985	38,727	2,579	7,209	-4,630	242,052	209,488	32,564
1997	1,211,780	966,400	245,380	98,138	63,264	34,874	2,248	7,366	-5,118	226,005	168,837	57,168
1998	1,012,830	881,090	131,740	95,638	59,000	36,638	3,398	4,165	-767	315,774	223,813	91,961
1999	1,146,800	1,141,620	5,180	122,986	90,954	32,033	4,524	8,037	-3,513	429,490	361,718	67,772
2000	961,849	1,000,640	-38,791	115,086	129,092	-14,006	3,782	10,060	-6,278	454,567	457,119	-2,552
2001	1,064,800	1,217,730	-152,930	115,365	128,503	-13,138	3,772	8,682	-4,910	338,952	346,509	-7,557
2002	997,029	1,172,310	-175,281	113,350	131,709	-18,359	4,642	10,898	-6,256	394,916	456,012	-61,096
2003	1,026,510	1,213,450	-186,940	113,391	114,901	-1,510	3,346	8,634	-5,288	429,846	444,634	-14,788
2004	1,070,300	1,442,950	-372,650	97,710	116,618	-18,908	3,470	9,302	-5,832	644,829	583,386	61,443
2005	976,386	1,187,260	-210,874	85,366	91,105	-5,739	2,342	7,502	-5,160	355,311	312,314	42,997
2006	890,113	842,745	47,368	79,418	84,996	-5,578	2,450	4,974	-2,524	180,881	178,947	1,934
2007	566,596	641,332	-74,736	100,472	110,690	-10,218	0	0	0	215,603	197,678	17,925
2008	893,659	850,262	43,397	82,053	108,670	-26,617	0	0	0	637,894	370,220	267,674

Table 8.2.4 Red tide model fits to the indices of abundance.

	SEAMAP VIDEO			COM_LL			COM_HL			HB18			HB20			MRFSS		
YEAR	OBS	PRED	RESID	OBS	PRED	RESID	OBS	PRED	RESID	OBS	PRED	RESID	OBS	PRED	RESID	OBS	PRED	RESID
1986	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.59	0.68	-0.08
1987	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.65	0.74	-0.09
1988	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.94	0.79	0.15
1989	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.37	0.84	0.52
1990	0.81	0.92	-0.11	0.71	0.79	-0.07	0.63	0.71	-0.07	0.74	0.77	-0.02	0.84	0.75	0.09	1.93	0.89	1.04
1991	0.84	0.91	-0.07	0.71	0.82	-0.12	0.59	0.77	-0.18	1.18	0.89	0.30	0.93	0.91	0.02	1.26	0.94	0.32
1992	0.56	0.87	-0.31	0.64	0.83	-0.18	0.69	0.79	-0.10	1.04	1.14	-0.10	0.79	0.87	-0.09	1.34	0.97	0.37
1993	0.87	0.82	0.05	1.02	0.85	0.16	0.61	0.83	-0.22	1.22	1.00	0.22	0.75	0.93	-0.19	0.80	0.94	-0.14
1994	0.93	0.84	0.09	0.86	0.86	0.00	0.82	0.84	-0.02	0.81	1.17	-0.36	0.79	0.95	-0.17	0.96	0.89	0.07
1995	1.15	1.17	-0.02	0.96	0.89	0.06	0.78	0.86	-0.08	-	-	-	0.91	0.92	-0.01	0.81	0.83	-0.02
1996	1.38	1.26	0.12	0.85	0.90	-0.06	0.58	0.85	-0.27	-	-	-	0.74	0.80	-0.07	0.62	0.81	-0.20
1997	1.47	1.24	0.23	1.04	0.92	0.12	0.56	0.85	-0.29	-	-	-	0.56	0.76	-0.20	0.54	0.85	-0.31
1998	1.07	0.90	0.17	1.06	0.95	0.11	0.51	0.87	-0.36	-	-	-	0.62	0.82	-0.21	0.78	0.92	-0.14
1999	0.98	0.89	0.09	0.99	0.98	0.01	0.70	0.89	-0.18	-	-	-	0.63	0.81	-0.19	0.90	0.98	-0.07
2000	0.93	0.96	-0.03	0.94	1.03	-0.09	0.88	0.95	-0.08	-	-	-	0.86	1.04	-0.18	1.03	1.03	-0.01
2001	-	-	-	1.33	1.03	0.30	1.33	0.96	0.37	-	-	-	0.84	0.97	-0.13	0.87	1.18	-0.31
2002	-	-	-	1.02	1.03	-0.01	1.36	0.95	0.41	-	-	-	0.92	0.88	0.05	0.91	1.32	-0.41
2003	-	-	-	0.96	1.17	-0.21	1.03	1.14	-0.11	-	-	-	1.37	1.47	-0.10	1.08	1.30	-0.22
2004	-	-	-	1.26	1.29	-0.03	1.63	1.25	0.38	-	-	-	2.00	1.43	0.58	1.66	1.25	0.40
2005	-	-	-	1.56	1.32	0.24	1.98	1.24	0.74	-	-	-	2.29	1.15	1.14	1.09	1.03	0.06
2006	-	-	-	1.19	1.00	0.19	1.30	0.93	0.37	-	-	-	1.01	0.88	0.13	0.46	0.86	-0.39
2007	-	-	-	0.89	1.02	-0.13	1.42	0.92	0.50	-	-	-	1.04	0.83	0.21	0.88	0.91	-0.03
2008	-	-	-	1.02	1.06	-0.04	1.59	0.95	0.65	-	-	-	1.12	0.84	0.28	1.55	0.96	0.59

Table 8.2.5. Red tide model selectivity-at-age by fleet. Note: these selectivity vectors apply to the total catch (landed + released).

	COMM LL	COMM HL	TRAP	REC
Age 1	0.000	0.101	0.000	0.101
Age 2	0.008	0.419	0.008	0.419
Age 3	0.017	0.906	0.017	0.906
Age 4	0.037	1.000	0.037	1.000
Age 5	0.078	0.966	0.078	0.966
Age 6	0.158	0.667	0.158	0.667
Age 7	0.296	0.405	0.296	0.405
Age 8	0.486	0.321	0.486	0.321
Age 9	0.694	0.165	0.694	0.165
Age 10	0.886	0.149	0.886	0.149
Age 11	1.000	0.142	1.000	0.142
Age 12	1.000	0.142	1.000	0.142
Age 13	1.000	0.142	1.000	0.142
Age 14	1.000	0.142	1.000	0.142
Age 15	1.000	0.142	1.000	0.142
Age 16	1.000	0.142	1.000	0.142
Age 17	1.000	0.142	1.000	0.142
Age 18	1.000	0.142	1.000	0.142
Age 19	1.000	0.142	1.000	0.142
Age 20	1.000	0.142	1.000	0.142

Table 8.2.6. Red tide model fishing mortality (due to landings and discards) by year and fleet.

YEAR	COM LL	COM HL	COM TRAP	REC
1986	0.060	0.084	0.022	0.122
1987	0.087	0.071	0.017	0.079
1988	0.060	0.060	0.021	0.113
1989	0.080	0.098	0.025	0.133
1990	0.118	0.097	0.021	0.060
1991	0.158	0.087	0.027	0.090
1992	0.150	0.062	0.044	0.116
1993	0.227	0.052	0.050	0.092
1994	0.157	0.049	0.061	0.079
1995	0.140	0.043	0.061	0.075
1996	0.153	0.034	0.034	0.040
1997	0.150	0.034	0.033	0.026
1998	0.132	0.029	0.019	0.029
1999	0.162	0.042	0.035	0.049
2000	0.136	0.057	0.044	0.078
2001	0.151	0.052	0.036	0.054
2002	0.137	0.049	0.042	0.059
2003	0.128	0.036	0.032	0.047
2004	0.136	0.037	0.031	0.079
2005	0.136	0.039	0.027	0.050
2006	0.133	0.048	0.021	0.038
2007	0.092	0.048	0.001	0.039
2008	0.117	0.060	0.000	0.039

Table 8.2.7. Red tide model annual estimates of total fishing mortality (landings + discards) expressed as apical F (maximum annual F at any age), F as a fraction of F at maximum sustainable yield (F_{MSY}) and F as a fraction of F at optimal yield (F_{OY}).

YEAR	Apical F	Fmsy	F/Fmsy
1986	0.244	0.186	1.308
1987	0.211	0.186	1.129
1988	0.213	0.186	1.141
1989	0.283	0.186	1.518
1990	0.224	0.186	1.201
1991	0.265	0.186	1.419
1992	0.255	0.186	1.365
1993	0.289	0.186	1.547
1994	0.238	0.186	1.275
1995	0.220	0.186	1.182
1996	0.188	0.186	1.007
1997	0.182	0.186	0.978
1998	0.153	0.186	0.819
1999	0.206	0.186	1.106
2000	0.220	0.186	1.179
2001	0.208	0.186	1.114
2002	0.202	0.186	1.083
2003	0.171	0.186	0.917
2004	0.195	0.186	1.046
2005	0.177	0.186	0.951
2006	0.168	0.186	0.901
2007	0.140	0.186	0.751
2008	0.159	0.186	0.853

Table 8.2.8. Red tide model total fishing mortality (due to landings and discards) by age and year. Shaded values is apical F for each year.

YEAR	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11	AGE 12	AGE 13	AGE 14	AGE 15	AGE 16	AGE 17	AGE 18	AGE 19	AGE 20
1986	0.001	0.065	0.162	0.220	0.244	0.220	0.190	0.179	0.156	0.151	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148
1987	0.001	0.056	0.127	0.182	0.211	0.202	0.185	0.179	0.164	0.159	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155
1988	0.001	0.048	0.132	0.191	0.213	0.191	0.165	0.156	0.137	0.134	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132
1989	0.001	0.063	0.157	0.249	0.283	0.260	0.228	0.215	0.191	0.185	0.181	0.181	0.181	0.181	0.181	0.181	0.181	0.181	0.181	0.181
1990	0.002	0.022	0.039	0.062	0.127	0.195	0.215	0.224	0.203	0.195	0.193	0.194	0.195	0.196	0.197	0.197	0.198	0.199	0.199	0.200
1991	0.002	0.027	0.050	0.078	0.157	0.232	0.252	0.265	0.239	0.232	0.231	0.233	0.234	0.235	0.236	0.237	0.237	0.238	0.239	0.239
1992	0.003	0.026	0.050	0.087	0.170	0.232	0.243	0.255	0.230	0.228	0.230	0.231	0.232	0.233	0.234	0.234	0.235	0.235	0.236	0.237
1993	0.002	0.029	0.054	0.096	0.174	0.240	0.267	0.289	0.276	0.276	0.278	0.279	0.281	0.282	0.282	0.283	0.284	0.285	0.285	0.286
1994	0.002	0.022	0.041	0.071	0.138	0.193	0.213	0.232	0.223	0.226	0.231	0.232	0.233	0.234	0.235	0.235	0.236	0.236	0.236	0.238
1995	0.002	0.020	0.037	0.063	0.123	0.177	0.196	0.214	0.206	0.210	0.214	0.215	0.216	0.217	0.218	0.218	0.219	0.219	0.220	0.220
1996	0.001	0.018	0.032	0.050	0.092	0.141	0.166	0.184	0.180	0.181	0.182	0.183	0.184	0.185	0.185	0.186	0.186	0.187	0.187	0.188
1997	0.001	0.017	0.029	0.045	0.082	0.128	0.156	0.174	0.174	0.175	0.177	0.178	0.179	0.179	0.180	0.181	0.181	0.181	0.182	0.182
1998	0.001	0.016	0.028	0.043	0.076	0.115	0.138	0.153	0.149	0.147	0.148	0.149	0.149	0.150	0.150	0.151	0.151	0.152	0.152	0.153
1999	0.001	0.021	0.038	0.057	0.105	0.159	0.187	0.206	0.199	0.198	0.200	0.201	0.202	0.203	0.203	0.204	0.205	0.205	0.206	0.206
2000	0.002	0.021	0.041	0.069	0.131	0.187	0.205	0.220	0.204	0.204	0.206	0.207	0.208	0.209	0.209	0.210	0.211	0.211	0.211	0.212
2001	0.001	0.020	0.036	0.059	0.114	0.168	0.192	0.208	0.199	0.198	0.199	0.200	0.201	0.202	0.202	0.203	0.204	0.204	0.204	0.205
2002	0.001	0.019	0.035	0.056	0.110	0.164	0.186	0.202	0.192	0.193	0.195	0.196	0.197	0.198	0.198	0.199	0.199	0.200	0.200	0.201
2003	0.001	0.017	0.032	0.051	0.094	0.136	0.156	0.171	0.164	0.164	0.166	0.167	0.167	0.168	0.169	0.169	0.170	0.170	0.171	0.171
2004	0.002	0.020	0.038	0.067	0.125	0.170	0.183	0.195	0.180	0.179	0.180	0.181	0.182	0.183	0.183	0.184	0.184	0.185	0.185	0.186
2005	0.001	0.018	0.031	0.050	0.097	0.144	0.164	0.177	0.169	0.168	0.168	0.169	0.170	0.171	0.171	0.172	0.172	0.172	0.173	0.173
2006	0.001	0.016	0.029	0.046	0.079	0.141	0.167	0.168	0.160	0.161	0.159	0.160	0.161	0.161	0.162	0.162	0.163	0.163	0.164	0.164
2007	0.001	0.014	0.024	0.040	0.092	0.103	0.127	0.140	0.123	0.116	0.116	0.116	0.117	0.117	0.118	0.118	0.118	0.119	0.119	0.119
2008	0.001	0.017	0.031	0.045	0.083	0.139	0.139	0.159	0.150	0.139	0.137	0.138	0.139	0.140	0.140	0.141	0.141	0.142	0.142	0.142

Table 8.2.9. Red tide model number-at-age, recruitment (Age 1) and total abundance (sum) by year.

YEAR	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10
1986	6,271,410	7,059,260	3,570,330	1,675,180	1,069,900	617,998	515,906	357,553	323,127	278,901
1987	12,426,500	3,820,790	4,713,410	2,321,250	1,070,390	685,081	412,569	359,344	254,441	236,862
1988	11,505,900	7,574,010	2,573,300	3,176,010	1,540,880	708,720	465,859	288,913	255,727	185,148
1989	8,473,340	7,010,520	5,144,320	1,724,060	2,089,350	1,017,970	487,280	332,985	210,320	191,048
1990	11,444,700	5,161,720	4,690,330	3,363,460	1,070,740	1,286,610	653,245	326,893	228,386	148,928
1991	10,642,700	6,969,270	3,597,930	3,449,080	2,518,660	770,510	880,605	443,908	222,316	159,806
1992	9,097,880	6,475,870	4,832,950	2,618,750	2,540,070	1,758,550	508,435	576,562	289,869	149,988
1993	6,925,650	5,534,830	4,495,210	3,517,270	1,911,740	1,750,540	1,160,470	336,121	380,285	197,401
1994	7,326,970	4,216,380	3,829,640	3,256,180	2,545,790	1,312,450	1,145,210	748,956	214,276	247,314
1995	9,172,220	4,461,770	2,938,150	2,812,550	2,415,250	1,811,860	899,905	779,603	505,272	146,924
1996	7,563,180	5,585,670	3,114,880	2,164,660	2,102,080	1,744,840	1,263,010	623,138	535,456	352,599
1997	14,077,400	4,608,810	3,907,530	2,307,550	1,639,540	1,566,440	1,261,160	901,230	441,072	383,209
1998	8,271,950	8,580,500	3,228,050	2,902,430	1,756,940	1,234,650	1,146,610	909,525	644,143	317,573
1999	7,914,340	5,041,060	6,015,710	2,399,980	2,213,790	1,331,020	915,324	841,727	664,227	475,808
2000	24,046,700	4,820,780	3,516,690	4,430,880	1,805,420	1,629,480	944,081	639,570	582,688	466,643
2001	11,469,100	14,640,300	3,361,330	2,582,120	3,292,380	1,293,940	1,124,750	647,969	436,757	407,112
2002	8,579,600	6,986,730	10,221,800	2,479,860	1,938,560	2,401,520	909,699	782,515	447,895	306,841
2003	13,953,500	5,225,770	4,881,450	7,547,560	1,867,200	1,419,640	1,694,950	636,289	543,971	316,714
2004	9,659,550	8,500,600	3,658,960	3,617,640	5,708,950	1,389,050	1,030,480	1,221,970	456,398	395,758
2005	11,708,800	5,881,460	5,933,360	2,693,460	2,694,960	4,117,000	975,281	723,311	855,340	326,721
2006	11,237,600	5,194,620	2,997,500	3,202,460	1,486,250	1,455,550	2,158,590	507,923	375,258	450,866
2007	9,535,620	6,848,810	3,640,630	2,227,670	2,436,880	1,122,390	1,052,000	1,538,730	365,282	274,167
2008	10,170,600	5,811,270	4,812,780	2,717,400	1,705,030	1,817,170	842,424	780,614	1,138,110	276,959

AGE 11	AGE 12	AGE 13	AGE 14	AGE 15	AGE 16	AGE 17	AGE 18	AGE 19	AGE 20	
265,837	230,765	208,348	191,996	172,359	157,631	144,988	132,763	121,674	346,016	23,711,942
206,722	198,594	173,031	156,692	144,741	130,197	119,275	109,862	100,719	355,374	27,995,844
174,214	153,299	147,817	129,177	117,261	108,534	97,794	89,715	82,735	344,032	29,719,045
139,587	132,242	116,797	112,959	98,952	90,003	83,447	75,295	69,158	329,517	27,929,149
136,905	100,887	95,933	84,983	82,387	72,315	65,888	61,173	55,264	293,100	29,423,847
105,663	97,765	72,221	68,812	61,050	59,260	52,070	47,478	44,113	251,349	30,514,564
109,208	72,632	67,349	49,838	47,550	42,230	41,024	36,077	32,906	204,907	29,552,644
102,929	75,185	50,121	46,564	34,509	32,965	29,307	28,493	25,074	165,379	26,800,045
129,172	67,522	49,429	33,010	30,709	22,784	21,784	19,379	18,850	126,074	25,361,879
169,997	88,835	46,546	34,142	22,834	21,270	15,796	15,114	13,458	100,684	26,472,179
102,697	118,849	62,260	32,689	24,016	16,083	14,999	11,148	10,674	80,677	25,523,604
253,721	74,117	86,006	45,155	23,748	17,473	11,715	10,935	8,135	66,702	31,691,647
277,318	184,122	53,930	62,718	32,984	17,371	12,796	8,587	8,021	54,944	29,705,163
236,281	207,214	137,963	40,502	47,185	24,851	13,104	9,662	6,491	47,626	28,583,866
336,372	167,569	147,324	98,289	28,900	33,713	17,776	9,381	6,922	38,798	43,767,976
328,092	237,144	118,429	104,332	69,716	20,527	23,971	12,650	6,680	32,583	40,209,882
288,019	232,894	168,765	84,454	74,523	49,863	14,697	17,178	9,072	28,177	36,022,661
218,159	205,284	166,420	120,846	60,573	53,522	35,853	10,577	12,371	26,847	38,997,495
231,734	160,111	151,065	122,731	89,274	44,810	39,642	26,579	7,848	29,120	36,542,268
285,252	167,626	116,122	109,798	89,355	65,087	32,708	28,962	19,433	27,053	36,851,089
173,461	152,033	89,588	62,200	58,916	48,016	35,016	17,612	15,610	25,072	29,744,141
330,779	128,113	112,610	66,512	46,262	43,884	35,808	26,138	13,158	30,418	29,875,860
210,459	255,191	99,145	87,363	51,700	36,016	34,211	27,944	20,416	34,071	30,928,873

Table 8.1.10. Red tide model biomass-at-age by year.

YEAR	AGE 1	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10
1986	1,226,703	5,305,167	5,881,344	4,679,579	4,378,865	3,374,687	3,524,426	2,917,030	3,040,611	2,947,422
1987	2,430,653	2,871,396	7,764,320	6,484,362	4,380,870	3,741,006	2,818,477	2,931,641	2,394,279	2,503,155
1988	2,250,581	5,692,012	4,238,953	8,872,116	6,306,482	3,870,091	3,182,529	2,357,043	2,406,380	1,956,642
1989	1,657,405	5,268,538	8,474,151	4,816,125	8,551,248	5,558,805	3,328,867	2,716,596	1,979,102	2,018,993
1990	2,238,610	3,879,130	7,726,301	9,395,753	4,382,303	7,025,761	4,462,661	2,666,896	2,149,103	1,573,869
1991	2,081,737	5,237,538	5,926,809	9,634,931	10,308,320	4,207,506	6,015,877	3,621,541	2,091,984	1,688,828
1992	1,779,567	4,866,739	7,961,237	7,315,422	10,395,946	9,602,872	3,473,388	4,703,774	2,727,655	1,585,071
1993	1,354,674	4,159,529	7,404,883	9,825,418	7,824,330	9,559,132	7,927,783	2,742,181	3,578,466	2,086,131
1994	1,433,173	3,168,689	6,308,501	9,096,069	10,419,357	7,166,865	7,823,534	6,110,219	2,016,328	2,613,611
1995	1,794,108	3,353,104	4,839,965	7,856,798	9,885,085	9,893,981	6,147,726	6,360,247	4,754,588	1,552,691
1996	1,479,376	4,197,737	5,131,089	6,046,931	8,603,350	9,528,007	8,628,288	5,083,756	5,038,618	3,726,262
1997	2,753,573	3,463,608	6,436,808	6,446,091	6,710,275	8,553,822	8,615,650	7,352,518	4,150,469	4,049,748
1998	1,618,013	6,448,408	5,317,512	8,107,876	7,190,768	6,742,024	7,833,098	7,420,191	6,061,358	3,356,107
1999	1,548,064	3,788,452	9,909,577	6,704,293	9,060,554	7,268,269	6,253,061	6,867,074	6,250,348	5,028,333
2000	4,703,591	3,622,907	5,792,984	12,377,568	7,389,186	8,898,063	6,449,516	5,217,813	5,483,069	4,931,477
2001	2,243,383	11,002,462	5,537,062	7,213,097	13,474,985	7,065,788	7,683,761	5,286,335	4,109,865	4,302,355
2002	1,678,190	5,250,660	16,838,198	6,927,436	7,934,098	13,113,923	6,214,634	6,384,004	4,214,673	3,242,692
2003	2,729,338	3,927,265	8,041,130	21,083,947	7,642,038	7,752,195	11,579,098	5,191,046	5,118,744	3,347,030
2004	1,889,431	6,388,362	6,027,343	10,105,800	23,365,473	7,585,153	7,039,753	9,969,216	4,294,686	4,182,366
2005	2,290,269	4,420,028	9,773,923	7,524,123	11,029,877	22,481,605	6,662,659	5,900,999	8,048,713	3,452,783
2006	2,198,101	3,903,855	4,937,731	8,946,003	6,082,893	7,948,287	14,746,467	4,143,796	3,531,162	4,764,746
2007	1,865,190	5,147,010	5,997,148	6,222,948	9,973,612	6,129,009	7,186,767	12,553,444	3,437,288	2,897,393
2008	1,989,393	4,367,279	7,928,011	7,590,999	6,978,312	9,922,977	5,755,043	6,368,495	10,709,567	2,926,899

AGE 11	AGE 12	AGE 13	AGE 14	AGE 15	AGE 16	AGE 17	AGE 18	AGE 19	AGE 20	total
3,089,925	2,901,610	2,796,403	2,721,044	2,556,553	2,429,192	2,307,376	2,170,887	2,035,638	6,164,624	66,449,086
2,402,809	2,497,096	2,322,385	2,220,702	2,146,903	2,006,417	1,898,172	1,796,419	1,685,055	6,331,346	63,627,463
2,024,956	1,927,562	1,983,968	1,830,748	1,739,300	1,672,577	1,556,323	1,466,990	1,384,170	6,129,277	62,848,700
1,622,473	1,662,794	1,567,625	1,600,900	1,467,721	1,387,006	1,327,989	1,231,192	1,157,027	5,870,678	63,265,235
1,591,299	1,268,540	1,287,587	1,204,416	1,222,025	1,114,426	1,048,553	1,000,283	924,580	5,221,872	61,383,968
1,228,162	1,229,281	969,332	975,231	905,532	913,226	828,658	776,333	738,020	4,478,036	63,856,882
1,269,366	913,268	903,937	706,327	705,294	650,794	652,868	589,910	550,521	3,650,625	65,004,581
1,196,383	945,368	672,717	659,929	511,867	508,011	466,402	465,904	419,500	2,946,394	65,255,003
1,501,416	849,007	663,427	467,832	455,495	351,122	346,676	316,869	315,369	2,246,135	63,669,694
1,975,940	1,116,999	624,731	483,867	338,692	327,776	251,383	247,143	225,154	1,793,787	63,823,765
1,193,687	1,494,392	835,636	463,280	356,223	247,848	238,698	182,286	178,570	1,437,339	64,091,371
2,949,096	931,935	1,154,358	639,948	352,247	269,265	186,432	178,797	136,099	1,188,365	66,519,105
3,223,373	2,315,127	723,842	888,866	489,245	267,700	203,634	140,414	134,194	978,888	69,460,639
2,746,385	2,605,483	1,851,710	574,016	699,888	382,974	208,534	157,997	108,588	848,512	72,862,112
3,909,781	2,106,992	1,977,351	1,392,984	428,669	519,545	282,884	153,394	115,812	691,218	76,444,804
3,813,539	2,981,819	1,589,529	1,478,635	1,034,084	316,326	381,476	206,853	111,765	580,501	80,413,617
3,347,755	2,928,380	2,265,128	1,196,910	1,105,373	768,417	233,892	280,886	151,783	502,002	84,579,033
2,535,746	2,581,215	2,233,654	1,712,678	898,458	824,803	570,569	172,951	206,963	478,305	88,627,170
2,693,533	2,013,216	2,027,562	1,739,393	1,324,175	690,542	630,871	434,604	131,296	518,795	93,051,567
3,315,593	2,107,708	1,558,565	1,556,101	1,325,382	1,003,033	520,517	473,572	325,124	481,969	94,252,544
2,016,204	1,911,644	1,202,424	881,520	873,887	739,960	557,253	287,984	261,156	446,685	70,381,761
3,844,771	1,610,877	1,511,427	942,628	686,184	676,285	569,862	427,395	220,138	541,924	72,441,300
2,446,246	3,208,740	1,330,696	1,238,143	766,849	555,034	544,441	456,934	341,562	607,015	76,032,633

Table 8.2.11. Red tide model total number, total biomas**s,** Spawning stock (SSB) reproductive potential (mature female gonad weight (g)), SSB as a function of maximum sustainable yield (MSY) and ratio of SSB to SSB_{msy}.

YEAR	Total number	Total biomass (gutted lbs)	SSB in female gonad wt	SSBmsy	SSB/SSBmsy
1986	23,711,942	66,449,086	473,719,000	712,657,000	0.665
1987	27,995,844	63,627,463	457,130,000	712,657,000	0.641
1988	29,719,045	62,848,700	451,696,000	712,657,000	0.634
1989	27,929,149	63,265,235	455,866,000	712,657,000	0.640
1990	29,423,847	61,383,968	452,881,000	712,657,000	0.635
1991	30,514,564	63,856,882	477,367,000	712,657,000	0.670
1992	29,552,644	65,004,581	504,143,000	712,657,000	0.707
1993	26,800,045	65,255,003	517,377,000	712,657,000	0.726
1994	25,361,879	63,669,694	515,432,000	712,657,000	0.723
1995	26,472,179	63,823,765	529,859,000	712,657,000	0.743
1996	25,523,604	64,091,371	524,384,000	712,657,000	0.736
1997	31,691,647	66,519,105	530,388,000	712,657,000	0.744
1998	29,705,163	69,460,639	545,012,000	712,657,000	0.765
1999	28,583,866	72,862,112	582,042,000	712,657,000	0.817
2000	43,767,976	76,444,804	605,185,000	712,657,000	0.849
2001	40,209,882	80,413,617	599,313,000	712,657,000	0.841
2002	36,022,661	84,579,033	646,991,000	712,657,000	0.908
2003	38,997,495	88,627,170	708,517,000	712,657,000	0.994
2004	36,542,268	93,051,567	762,376,000	712,657,000	1.070
2005	36,851,089	94,252,544	792,547,000	712,657,000	1.112
2006	29,744,141	70,381,761	561,651,000	712,657,000	0.788
2007	29,875,860	72,441,300	573,210,000	712,657,000	0.804
2008	30,928,873	76,032,633	615,524,000	712,657,000	0.864

Table 8.2.12. Selected parameter estimates with standard deviation. NOTE: F reference points include landings and discards.

name	value	std
log_Fmult_year1	-2.852	0.0857
log_Fmult_year1	-2.971	0.0881
log_Fmult_year1	-3.838	0.0911
Log_Fmult_year1	-3.107	0.0828
LogVirgin reproductive potential	2.133E+01	0.0620
SRR_steepness	0.833	0.0554
MSY	7,670,200	314,050
SSmsy_ratio	0.864	0.0667
Fmsy_ratio	0.853	0.0889
log_q_year1_SEAMAP video	-16.387	0.0711
log_q_year1_comm LL	-18.777	0.0886
log_q_year1_comm HL	-18.350	0.0814
log_q_year1_HB18	-15.516	0.1236
log_q_year1_HB20	-15.966	0.0972
log_q_year1_MRFSS	-16.468	0.0737
log_episodic_M	-1.148	0.2050

Table 9.1. Reference points and benchmarks for the 2009 red grouper central model, continuity model (central run through 2006) and sensitivity runs. Yield benchmarks are in gutted lbs, SSB benchmarks are in mature female gonad weight (grams). Shaded values indicate status benchmarks, with the red indicating SSB_{2008}<MSST or $F_{current}$>F_{msy}.

RUN NUMBER	2006 Base	cont case Note that final year values are 2005 for these runs	Central 1	2% q Increase 3	2% q Decrease 4	M * 1.1 5	M x 0.9 6
ASAP Objective function	1068.11	1589.08	2973.39	2966.56	2988.23	2977.64	3002.23
Fit to indices	67.78	60.88	87.76	91.75	89.23	87.12	88.47
F Current (Geo mean 05-07)	0.17	0.16	0.14	0.19	0.11	0.13	0.16
F2008	0.16	0.13	0.13	0.18	0.10	0.12	0.14
SSB 2008	7.516E+08	8.815E+08	7.125E+08	5.417E+08	9.380E+08	7.742E+08	6.581E+08
MSST	5.085E+08	6.087E+08	5.570E+08	5.043E+08	6.315E+08	5.477E+08	5.772E+08
SSB/MSST	1.48	1.45	1.28	1.07	1.49	1.41	1.14
Fcurrrent/Fmsy	0.80	0.86	0.78	1.02	0.60	0.65	0.93
SSB2008/ SSBmsy	1.27	1.26	1.10	0.92	1.28	1.22	0.98
F2008/Fmsy	0.73	0.71	0.71	0.98	0.53	0.60	0.84
F at MSY	0.22	0.19	0.19	0.18	0.19	0.20	0.17
MSY	7.702E+06	8.095E+06	6.962E+06	6.278E+06	7.845E+06	6.957E+06	7.050E+06
Y/R at MSY	0.85	0.77	0.73	0.74	0.73	0.60	0.90
S/R at MSY	64.81	66.80	68.35	68.73	68.60	54.97	86.09
SPR AT MSY	0.40	0.41	0.42	0.42	0.42	0.43	0.41
SSB AT MSY	5.903E+08	6.989E+08	6.477E+08	5.864E+08	7.343E+08	6.369E+08	6.711E+08
F at max. YPR	0.26	0.22	0.22	0.22	0.22	0.24	0.20
Y/R maximum	0.85	0.78	0.74	0.74	0.74	0.60	0.91
S/R at Fmax	57.73	60.74	62.63	62.81	62.47	50.39	78.84
SPR at Fmax	0.35	0.37	0.38	0.38	0.38	0.40	0.37
SSB at Fmax	5.167E+08	6.274E+08	5.865E+08	5.291E+08	6.597E+08	5.765E+08	6.078E+08
F 0.1	0.14	0.12	0.12	0.12	0.13	0.14	0.11
Y/R at F0.1	0.78	0.72	0.69	0.69	0.69	0.56	0.85
S/R at F0.1	82.32	84.11	84.52	84.70	84.34	67.14	107.30
SPR at F0.1	0.50	0.52	0.52	0.52	0.52	0.53	0.51
SSB at F0.1	7.724E+08	9.032E+08	8.205E+08	7.408E+08	9.259E+08	7.974E+08	8.564E+08
F 0.2 SPR	0.46	0.42	0.42	0.41	0.42	0.44	0.40
Y/R at F20	0.80	0.71	0.66	0.67	0.66	0.55	0.80
S/R at F20	40.55	40.12	40.86	41.03	40.71	34.38	48.79
SSB at F20	3.380E+08	3.841E+08	3.537E+08	3.185E+08	3.947E+08	3.654E+08	3.455E+08
F 0.3 SPR	0.34	0.31	0.32	0.32	0.32	0.37	0.27
Y/R at F30	0.84	0.76	0.71	0.71	0.71	0.57	0.89
S/R at F30	49.21	49.18	49.22	49.19	49.16	38.37	63.95
SSB at F30	4.281E+08	4.910E+08	4.431E+08	3.974E+08	4.976E+08	4.180E+08	4.778E+08
F 0.4 SPR	0.21	0.20	0.20	0.20	0.20	0.23	0.17
Y/R at F40	0.84	0.78	0.74	0.74	0.74	0.60	0.91
S/R at F40	65.66	65.53	65.55	65.54	65.58	51.14	85.36
SSB at F40	5.991E+08	6.839E+08	6.177E+08	5.555E+08	6.975E+08	5.864E+08	6.647E+08
F 0.9 maxY/R	0.13	0.11	0.11	0.11	0.11	0.12	0.10
Y 0.9 maxY/R	7.212E+06	7.551E+06	6.486E+06	5.853E+06	7.310E+06	6.486E+06	6.547E+06
Y/R 0.9 maxY/R	0.77	0.70	0.66	0.67	0.66	0.54	0.82
S/R 0.9 maxY/R	84.98	87.53	88.97	89.17	89.15	70.76	113.80
SSB 0.9 maxY/R	8.001E+08	9.435E+08	8.681E+08	7.840E+08	9.845E+08	8.451E+08	9.128E+08
F 0.75 ofFmax	0.20	0.17	0.16	0.16	0.16	0.18	0.15
Y 0.75 ofFmax	7.688E+06	8.063E+06	6.926E+06	6.247E+06	7.809E+06	6.923E+06	7.010E+06
Y/R at 0.75Fmax	0.84	0.76	0.72	0.73	0.72	0.59	0.89
S/R at 0.75Fmax	68.04	71.59	73.81	73.95	73.68	59.02	93.49
SSB at 0.75Fmax	6.239E+08	7.555E+08	7.060E+08	6.368E+08	7.961E+08	6.903E+08	7.357E+08

Table 9.2. Reference points and benchmarks for the red tide model and sensitivity runs. Yield benchmarks are in gutted lbs, SSB benchmarks are in mature female gonad weight (grams). Shaded values indicate status benchmarks, with the red indicating SSB_{2008}<MSST or $F_{current}$>F_{msy}.

RUN	Red Tide	Red Tide 2% q Increase	Red Tide 2% q Decrease	Red Tide M * 1.1	Red Tide M x 0.9	Red tide, all average time indices
NUMBER	2	2c	2D	2E	2F	2b
ASAP Objective function	2961.33	2958.82	2978.98	2966.98	3173.98	2966.55
Fit to indices	82.72	91.86	83.41	82.54	82.26	86.16
F Current (Geo mean 05-07)	0.16	0.20	0.12	0.15	0.16	0.15
F2008	0.16	0.21	0.11	0.15	0.16	0.15
SSB 2008	6.155E+08	4.897E+08	8.275E+08	6.745E+08	5.916E+08	6.442E+08
MSST	6.129E+08	5.436E+08	7.085E+08	6.011E+08	6.449E+08	6.028E+08
SSB/MSST	1.004	0.901	1.168	1.122	0.917	1.069
Fcurrrent/Fmsy	0.863	1.065	0.670	0.728	0.966	0.829
SSB2008/ SSBmsy	0.864	0.775	1.005	0.965	0.789	0.919
F2008/Fmsy	0.853	1.104	0.625	0.720	0.962	0.802
F at MSY	0.19	0.19	0.18	0.20	0.17	0.19
MSY	7.671E+06	6.821E+06	8.710E+06	7.627E+06	7.840E+06	7.547E+06
Y/R at MSY	0.74	0.74	0.74	0.60	0.90	0.74
S/R at MSY	68.75	68.61	69.68	55.39	86.28	68.61
SPR AT MSY	0.42	0.42	0.43	0.43	0.41	0.42
SSB AT MSY	7.127E+08	6.321E+08	8.238E+08	6.990E+08	7.499E+08	7.009E+08
F at max. YPR	0.22	0.22	0.22	0.24	0.20	0.22
Y/R maximum	0.74	0.74	0.74	0.61	0.91	0.74
S/R at Fmax	62.77	62.90	62.60	50.51	78.83	62.72
SPR at Fmax	0.38	0.39	0.38	0.40	0.37	0.38
SSB at Fmax	6.422E+08	5.727E+08	7.267E+08	6.283E+08	6.771E+08	6.328E+08
F 0.1	0.12	0.12	0.13	0.14	0.11	0.12
Y/R at F0.1	0.69	0.69	0.69	0.57	0.84	0.69
S/R at F0.1	84.84	84.77	84.36	67.36	107.10	84.60
SPR at F0.1	0.52	0.52	0.52	0.53	0.50	0.52
SSB at F0.1	9.020E+08	8.002E+08	1.025E+09	8.724E+08	9.532E+08	8.859E+08
F 0.2 SPR	0.42	0.42	0.42	0.44	0.40	0.42
Y/R at F20	0.67	0.67	0.67	0.56	0.80	0.67
S/R at F20	41.31	41.36	41.12	34.74	48.85	41.18
SSB at F20	3.897E+08	3.486E+08	4.321E+08	3.997E+08	3.845E+08	3.834E+08
F 0.3 SPR	0.32	0.32	0.32	0.37	0.27	0.32
Y/R at F30	0.72	0.72	0.72	0.58	0.88	0.72
S/R at F30	49.16	49.24	49.18	38.42	63.98	49.16
SSB at F30	4.821E+08	4.306E+08	5.426E+08	4.530E+08	5.322E+08	4.758E+08
F 0.4 SPR	0.20	0.20	0.20	0.23	0.17	0.20
Y/R at F40	0.74	0.74	0.74	0.61	0.90	0.74
S/R at F40	65.63	65.58	65.65	51.12	85.31	65.60
SSB at F40	6.759E+08	6.006E+08	7.686E+08	6.371E+08	7.405E+08	6.661E+08
F 0.9 maxY/R	0.11	0.11	0.11	0.12	0.10	0.11
Y 0.9 maxY/R	7.147E+06	6.354E+06	8.166E+06	7.122E+06	7.297E+06	7.038E+06
Y/R 0.9 maxY/R	0.67	0.67	0.67	0.55	0.82	0.67
S/R 0.9 maxY/R	89.27	89.19	89.11	70.94	113.50	89.02
SSB 0.9 maxY/R	9.541E+08	8.462E+08	1.090E+09	9.243E+08	1.016E+09	9.371E+08
F 0.75 ofFmax	0.16	0.16	0.16	0.18	0.15	0.16
Y 0.75 ofFmax	7.635E+06	6.787E+06	8.684E+06	7.596E+06	7.797E+06	7.510E+06
Y/R at 0.75Fmax	0.73	0.73	0.73	0.60	0.89	0.73
S/R at 0.75Fmax	73.84	73.96	73.71	59.06	93.51	73.82
SSB at 0.75Fmax	7.725E+08	6.877E+08	8.792E+08	7.522E+08	8.204E+08	7.612E+08

Table 9.3. Required SFA and MSRA evaluations for Gulf of Mexico red grouper for central and red tide models. *The red tide model was recommended by the SSC. Yield units are million pounds, gutted weight (MSY, OY, OFL, ABC), spawning stock measures (SSB, MSST) are in million grams of mature female gonad weight. Note that the SSC did not accept the 2011-2014 OFL and OY values and asked that they be reevaluated when 2009 landings are available so that ABCs for following years can be determined.

Criteria	Definition	Central	*Red Tide w/ no inc in q
	Mortality Rate Criteria		
$F_{MSY\ or\ proxy}$	Fmsy	0.1864	0.1865
MFMT	Fmsy	0.1864	0.1865
F_{OY}	75% OF F_{MSY}	0.1398	0.1399
$F_{CURRENT}$	Geometric mean 2005-2007	0.145	0.161
$F_{CURRENT}$/MFMT	Geometric mean 2005-2007	0.778	0.863
Base M		0.14	0.14
Biomass Criteria			
SSB_{msy}	Equilibrium SSB @ Fmsy	647.7	615.5
MSST	(1-M)*SSB_{Msy} M=0.14	557.0	612.9
$SSB_{CURRENT}$	SSB_{2008}	712.5	712.7
$SS_{CURRENT}$/MSST	SSB_{2008}	1.28	1.00
Equilibrium MSY	Equilibrium Yield @ F_{MSY}	6.96	7.67
Equilibrium OY	Equilibrium Yield @ F_{OY}	6.81	7.50
OFL	Annual Yield @ FMFMT		
	SEDAR 12 OFL 2009	7.72	7.72
	Update OFL 2010	7.80	6.43
	Update OFL 2011	7.70	6.63
	Update OFL 2012	7.55	6.74
	Update OFL 2013	7.48	6.94
	Update OFL 2014	7.38	7.05
Annual OY (ACT)	Annual Yield @ F_{OY}		
	SEDAR 12 OY 2009	7.57	7.57
	Update OY 2010	5.96	4.91
	Update OY 2011	6.12	5.26
	Update OY 2012	6.21	5.53
	Update OY 2013	6.34	5.86
	Update OY 2014	6.41	6.10
	Annual Yield (2010) @ 65% FMFMT	5.21	4.29
Alternative ACT:	Annual Yield (2010) @ 75% FMFMT	5.96	4.91
	Annual Yield (2010) @ 85% FMFMT	6.71	5.52
Generation Time			
Rebuild Time	(if B_{2008}<MSST)		
Tmin	@ F=0	n/a	n/a
Midpoint	mid of Tmin, Tmax	n/a	n/a
Tmax	if Tmin>10y, Tmin + 1 Gen	n/a	n/a
ABC	Recommended by SSC		
	2010 Yield at F_{OY}	n/a	5.96

Table 10.1. Center model predicted yield (millions of lbs gutted weight) for the four projections (2009-2020) with 80% confidence intervals.

	Fcurrent			Fmsy			90% FMSY			75% FMSY		
Year	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL
2009	7.570	7.570	7.570	7.570	7.570	7.570	7.570	7.570	7.570	7.570	7.570	7.570
2010	5.651	5.651	5.651	7.798	7.798	7.798	7.073	7.073	7.073	5.964	5.964	5.964
2011	5.833	5.834	5.835	7.701	7.702	7.703	7.092	7.093	7.094	6.117	6.118	6.119
2012	5.943	5.952	5.966	7.537	7.549	7.568	7.037	7.048	7.065	6.197	6.206	6.221
2013	5.997	6.112	6.298	7.332	7.487	7.737	6.931	7.073	7.302	6.220	6.341	6.536
2014	5.877	6.247	6.826	6.954	7.438	8.192	6.645	7.094	7.793	6.065	6.454	7.061
2015	5.860	6.341	7.174	6.758	7.369	8.435	6.514	7.084	8.075	6.026	6.527	7.393
2016	5.851	6.510	7.420	6.610	7.427	8.540	6.416	7.187	8.236	6.001	6.682	7.626
2017	5.811	6.642	7.660	6.424	7.429	8.651	6.276	7.239	8.413	5.938	6.799	7.849
2018	5.809	6.733	7.799	6.366	7.445	8.790	6.236	7.293	8.540	5.926	6.877	7.996
2019	5.878	6.801	8.124	6.338	7.459	8.970	6.238	7.298	8.770	5.986	6.935	8.293
2020	5.887	6.892	8.169	6.308	7.455	8.955	6.233	7.343	8.754	5.981	7.018	8.330

Table 10.2. Center model spawning stock (grams mature female gonad * 10^6) for the four projections (2009-2020) with 80%confidence intervals.

	Fcurrent			Fmsy			90% FMSY			75% FMSY		
Year	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL
2009	718.7	718.7	718.7	718.7	718.7	718.7	718.7	718.7	718.7	718.7	718.7	718.7
2010	711.7	712.5	713.7	711.7	712.5	713.7	711.7	712.5	713.7	711.7	712.5	713.7
2011	714.3	727.55	748.5	688.9	702.05	722.9	697.5	710.65	731.5	710.6	723.8	744.7
2012	699.2	736.7	793.8	652.9	689.75	746.2	668.3	705.4	762.1	692.4	729.7	786.7
2013	697	750.95	839.7	633.3	686	772.5	654.3	707.4	794.7	687.4	741.15	829.7
2014	691.1	769.55	874.7	614.8	689.7	791.1	639.8	715.3	817.9	679.5	757.15	861.5
2015	684.7	780.45	894.4	597.1	687.5	797.6	624.9	717.4	829.1	670.9	766.35	879.4
2016	689	793.45	915.1	595.1	689.7	807.3	625.4	722.65	841	674.4	776.95	897.8
2017	695.4	803.5	957.1	591.2	691	830.9	623.6	726.5	871.5	679.5	785.65	937.3
2018	699.4	813.9	974.1	588	694.25	838.3	621.3	732.2	881.6	681.3	794.65	951.5
2019	702.2	821.95	983.9	588.9	695.3	839.8	624.9	734.1	885.6	685	801.25	960.1
2020	714.7	826.9	983.7	598	695.15	833.3	635.2	737.3	879.1	695.3	806	959.3

Table 10.3. Center model fishing mortality for the four projections (2009-2020) with 80% confidence intervals.

	Fcurrent			Fmsy			90% FMSY			75% FMSY		
Year	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL
2009	0.1805	0.1805	0.1805	0.1805	0.1805	0.1805	0.1805	0.1805	0.1805	0.1805	0.1805	0.1805
2010	0.132	0.132	0.132	0.1864	0.1864	0.1864	0.1677	0.1677	0.1677	0.1398	0.1398	0.1398
2011	0.132	0.132	0.132	0.1864	0.1864	0.1864	0.1677	0.1677	0.1677	0.1398	0.1398	0.1398
2012	0.132	0.132	0.132	0.1864	0.1864	0.1864	0.1677	0.1677	0.1677	0.1398	0.1398	0.1398
2013	0.132	0.132	0.132	0.1864	0.1864	0.1864	0.1677	0.1677	0.1677	0.1398	0.1398	0.1398
2014	0.132	0.132	0.132	0.1864	0.1864	0.1864	0.1677	0.1677	0.1677	0.1398	0.1398	0.1398
2015	0.132	0.132	0.132	0.1864	0.1864	0.1864	0.1677	0.1677	0.1677	0.1398	0.1398	0.1398
2016	0.132	0.132	0.132	0.1864	0.1864	0.1864	0.1677	0.1677	0.1677	0.1398	0.1398	0.1398
2017	0.132	0.132	0.132	0.1864	0.1864	0.1864	0.1677	0.1677	0.1677	0.1398	0.1398	0.1398
2018	0.132	0.132	0.132	0.1864	0.1864	0.1864	0.1677	0.1677	0.1677	0.1398	0.1398	0.1398
2019	0.132	0.132	0.132	0.1864	0.1864	0.1864	0.1677	0.1677	0.1677	0.1398	0.1398	0.1398
2020	0.132	0.132	0.132	0.1864	0.1864	0.1864	0.1677	0.1677	0.1677	0.1398	0.1398	0.1398

Table 10.4. Center model recruitment (millions) for the four projections (2009-2020) with 80% confidence intervals.

	Fcurrent			Fmsy			90% FMSY			75% FMSY		
Year	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL
2009	5.494	9.726	16.390	5.494	9.726	16.390	5.494	9.726	16.390	5.494	9.726	16.390
2010	5.771	9.398	15.730	5.771	9.398	15.730	5.771	9.398	15.730	5.771	9.398	15.730
2011	5.868	9.533	14.950	5.868	9.533	14.950	5.868	9.533	14.950	5.868	9.533	14.950
2012	5.643	9.535	16.480	5.621	9.501	16.420	5.629	9.513	16.440	5.640	9.530	16.470
2013	5.727	9.536	15.970	5.683	9.468	15.860	5.699	9.492	15.890	5.721	9.527	15.950
2014	5.744	9.702	16.440	5.696	9.620	16.290	5.712	9.648	16.350	5.737	9.690	16.420
2015	5.878	9.513	15.980	5.802	9.411	15.780	5.831	9.448	15.850	5.868	9.499	15.950
2016	5.994	9.761	16.290	5.918	9.626	16.070	5.945	9.673	16.150	5.983	9.743	16.260
2017	5.433	9.639	15.520	5.365	9.506	15.250	5.393	9.561	15.340	5.422	9.623	15.480
2018	5.791	9.727	16.300	5.705	9.569	16.080	5.735	9.622	16.150	5.779	9.706	16.270
2019	5.658	9.584	16.410	5.583	9.433	16.190	5.609	9.483	16.270	5.647	9.558	16.380
2020	5.849	9.801	15.340	5.751	9.643	15.020	5.785	9.705	15.140	5.835	9.781	15.310

Table 10.5. Center model SS/SS_{MSY} for the four projections (2009-2020).

year	Fcurrent	Fmsy	90% FMSY	75% FMSY
2009	1.110	1.110	1.110	1.110
2010	1.100	1.100	1.100	1.100
2011	1.123	1.084	1.097	1.118
2012	1.137	1.065	1.089	1.127
2013	1.159	1.059	1.092	1.144
2014	1.188	1.065	1.104	1.169
2015	1.205	1.062	1.108	1.183
2016	1.225	1.065	1.116	1.200
2017	1.241	1.067	1.122	1.213
2018	1.257	1.072	1.131	1.227
2019	1.269	1.074	1.133	1.237
2020	1.277	1.073	1.138	1.244

Table 10.6. Center model F/F_{MSY} for the four projections (2009-2020).

year	Fcurrent	Fmsy	90% FMSY	75% FMSY
2009	0.968	0.968	0.968	0.968
2010	0.708	1.000	0.900	0.750
2011	0.708	1.000	0.900	0.750
2012	0.708	1.000	0.900	0.750
2013	0.708	1.000	0.900	0.750
2014	0.708	1.000	0.900	0.750
2015	0.708	1.000	0.900	0.750
2016	0.708	1.000	0.900	0.750
2017	0.708	1.000	0.900	0.750
2018	0.708	1.000	0.900	0.750
2019	0.708	1.000	0.900	0.750
2020	0.708	1.000	0.900	0.750

Table 10.7. Red tide model predicted yield (millions of lbs gutted weight) for the four projections (2009-2020) with 80% confidence intervals.

Year	Fcurrent			Fmsy			90% FMSY			75% FMSY		
	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL
2009	7.570	7.570	7.570	7.570	7.570	7.570	7.570	7.570	7.570	7.570	7.570	7.570
2010	5.542	5.542	5.542	6.425	6.425	6.425	5.827	5.827	5.827	4.913	4.913	4.913
2011	5.842	5.843	5.844	6.626	6.627	6.628	6.100	6.100	6.101	5.259	5.260	5.260
2012	6.047	6.058	6.075	6.725	6.738	6.758	6.274	6.286	6.304	5.519	5.529	5.544
2013	6.211	6.351	6.576	6.787	6.947	7.205	6.408	6.554	6.790	5.740	5.865	6.066
2014	6.146	6.595	7.297	6.610	7.118	7.909	6.307	6.777	7.509	5.746	6.150	6.781
2015	6.192	6.770	7.772	6.579	7.226	8.349	6.330	6.931	7.972	5.837	6.366	7.283
2016	6.243	7.029	8.114	6.565	7.439	8.618	6.366	7.176	8.295	5.922	6.652	7.654
2017	6.231	7.228	8.451	6.497	7.571	8.887	6.328	7.359	8.622	5.963	6.883	8.010
2018	6.287	7.392	8.667	6.523	7.701	9.141	6.378	7.510	8.837	6.036	7.061	8.240
2019	6.398	7.495	9.048	6.580	7.786	9.453	6.472	7.599	9.212	6.172	7.203	8.671
2020	6.450	7.631	9.142	6.627	7.864	9.485	6.526	7.727	9.262	6.238	7.356	8.797

Table 10.8. Red tide model spawning stock (grams mature female gonad * 10^6) for the four projections (2009-2020) with 80%confidence intervals.

	Fcurrent			Fmsy			90% FMSY			75% FMSY		
Year	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL
2009	629.4	629.4	629.4	629.4	629.4	629.4	629.4	629.4	629.4	629.4	629.4	629.4
2010	629.8	630.6	632.0	629.8	630.6	632.0	629.8	630.6	632.0	629.8	630.6	632.0
2011	644.4	658.4	680.6	633.4	647.4	669.5	640.9	654.9	677.0	652.2	666.3	688.5
2012	636.4	676.0	736.5	616.1	655.5	715.6	629.8	669.4	729.7	651.1	690.9	751.6
2013	642.3	699.2	792.7	614.0	670.3	762.6	633.1	689.7	782.8	663.1	720.5	814.8
2014	645.1	726.3	836.7	610.5	690.6	799.1	633.7	714.5	824.4	670.6	753.7	865.1
2015	643.7	744.4	864.7	604.2	701.4	819.3	630.6	730.0	849.7	674.5	776.9	898.0
2016	655.4	761.9	889.3	611.8	713.9	840.3	641.0	746.1	872.5	688.4	798.9	929.1
2017	663.7	776.2	935.4	614.7	722.9	875.5	647.5	758.6	916.2	702.3	817.5	981.5
2018	668.5	789.5	955.4	618.1	733.4	889.8	651.5	771.4	933.8	711.6	834.6	1005.0
2019	679.0	799.6	965.8	624.6	740.0	898.4	660.6	779.3	944.0	720.9	847.5	1020.0
2020	694.9	809.6	968.4	638.1	744.1	895.2	676.2	788.1	942.5	737.5	858.5	1025.0

Table 10.9. Red tide model fishing mortality for the four projections (2009-2020) with 80% confidence intervals.

	Fcurrent			Fmsy			90% FMSY			75% FMSY		
Year	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL
2009	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221
2010	0.159	0.159	0.159	0.187	0.187	0.187	0.168	0.168	0.168	0.140	0.140	0.140
2011	0.159	0.159	0.159	0.187	0.187	0.187	0.168	0.168	0.168	0.140	0.140	0.140
2012	0.159	0.159	0.159	0.187	0.187	0.187	0.168	0.168	0.168	0.140	0.140	0.140
2013	0.159	0.159	0.159	0.187	0.187	0.187	0.168	0.168	0.168	0.140	0.140	0.140
2014	0.159	0.159	0.159	0.187	0.187	0.187	0.168	0.168	0.168	0.140	0.140	0.140
2015	0.159	0.159	0.159	0.187	0.187	0.187	0.168	0.168	0.168	0.140	0.140	0.140
2016	0.159	0.159	0.159	0.187	0.187	0.187	0.168	0.168	0.168	0.140	0.140	0.140
2017	0.159	0.159	0.159	0.187	0.187	0.187	0.168	0.168	0.168	0.140	0.140	0.140
2018	0.159	0.159	0.159	0.187	0.187	0.187	0.168	0.168	0.168	0.140	0.140	0.140
2019	0.159	0.159	0.159	0.187	0.187	0.187	0.168	0.168	0.168	0.140	0.140	0.140
2020	0.159	0.159	0.159	0.187	0.187	0.187	0.168	0.168	0.168	0.140	0.140	0.140

Table 10.10. Red tide model recruitment (millions) for the four projections (2009-2020) with 80% confidence intervals.

	Fcurrent			Fmsy			90% FMSY			75% FMSY		
Year	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL	Low 80% CL	Median	Upp 80% CL
2009	5.838	10.330	17.420	5.838	10.330	17.420	5.838	10.330	17.420	5.838	10.330	17.420
2010	6.145	10.006	16.750	6.145	10.006	16.750	6.145	10.006	16.750	6.145	10.006	16.750
2011	6.255	10.160	15.940	6.255	10.160	15.940	6.255	10.160	15.940	6.255	10.160	15.940
2012	6.029	10.210	17.660	6.015	10.190	17.620	6.025	10.200	17.650	6.039	10.220	17.680
2013	6.120	10.210	17.110	6.093	10.170	17.040	6.111	10.200	17.090	6.139	10.240	17.160
2014	6.184	10.445	17.640	6.155	10.385	17.540	6.175	10.425	17.610	6.204	10.475	17.710
2015	6.301	10.255	17.170	6.249	10.200	17.060	6.284	10.240	17.140	6.336	10.300	17.250
2016	6.462	10.505	17.540	6.414	10.430	17.390	6.447	10.480	17.490	6.494	10.560	17.640
2017	5.864	10.395	16.690	5.811	10.320	16.570	5.844	10.375	16.640	5.906	10.460	16.790
2018	6.258	10.495	17.640	6.208	10.415	17.490	6.242	10.470	17.600	6.292	10.555	17.730
2019	6.133	10.365	17.780	6.090	10.275	17.660	6.119	10.335	17.750	6.163	10.420	17.870
2020	6.325	10.610	16.530	6.261	10.505	16.340	6.305	10.580	16.470	6.364	10.675	16.670

Table 10.11. Red tide model SS/SS_{MSY} and SS/SS_{OY} for the four projections (2009-2020).

year	Fcurrent	Fmsy	90% FMSY	75% FMSY
2009	0.883	0.883	0.883	0.883
2010	0.885	0.885	0.885	0.885
2011	0.924	0.908	0.919	0.935
2012	0.949	0.920	0.939	0.969
2013	0.981	0.940	0.968	1.011
2014	1.019	0.969	1.003	1.058
2015	1.045	0.984	1.024	1.090
2016	1.069	1.002	1.047	1.121
2017	1.089	1.014	1.064	1.147
2018	1.108	1.029	1.082	1.171
2019	1.122	1.038	1.094	1.189
2020	1.136	1.044	1.106	1.205

Table 10.12. Red tide model F/F_{MSY} for the four projections (2009-2020).

year	Fcurrent	Fmsy	90% FMSY	75% FMSY
2009	1.187	1.187	1.187	1.187
2010	0.853	1.000	0.900	0.750
2011	0.853	1.000	0.900	0.750
2012	0.853	1.000	0.900	0.750
2013	0.853	1.000	0.900	0.750
2014	0.853	1.000	0.900	0.750
2015	0.853	1.000	0.900	0.750
2016	0.853	1.000	0.900	0.750
2017	0.853	1.000	0.900	0.750
2018	0.853	1.000	0.900	0.750
2019	0.853	1.000	0.900	0.750
2020	0.853	1.000	0.900	0.750

Table 10.13. Probability of overfishing for Gulf of Mexico red grouper based on fixed landing projection scenarios. 500 bootstraps were run for each projection scenario. Recruitments were randomly resampled for each run. Probability based on the percentage of runs in which F> Fmsy.

Central	Fixed Landing Scenarios									
year	4.46 mp	4.96 mp	5.46 mp	5.96 mp	6.46 mp	6.96 mp	7.46 mp	7.96 mp	0.85 mp	8.96 mp	9.46 mp
2009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
2013	0.00	0.00	0.00	0.00	0.00	0.00	0.13	1.00	1.00	1.00	1.00
2014	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.89	0.98	1.00	1.00
2015	0.00	0.00	0.00	0.00	0.00	0.02	0.49	0.84	0.97	1.00	1.00
2016	0.00	0.00	0.00	0.00	0.00	0.07	0.47	0.83	0.95	0.99	1.00
2017	0.00	0.00	0.00	0.00	0.00	0.12	0.46	0.79	0.94	0.99	1.00
2018	0.00	0.00	0.00	0.00	0.00	0.14	0.47	0.79	0.94	0.99	1.00
2019	0.00	0.00	0.00	0.00	0.01	0.15	0.48	0.79	0.92	0.99	1.00
Increasing q											
year	4.46 mp	4.96 mp	5.46 mp	5.96 mp	6.46 mp	6.96 mp	7.46 mp	7.96 mp	0.85 mp	8.96 mp	9.46 mp
2009	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2010	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2011	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2012	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2013	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2014	0.00	0.00	0.14	0.84	0.98	1.00	1.00	1.00	1.00	1.00	1.00
2015	0.00	0.00	0.13	0.72	0.95	1.00	1.00	1.00	1.00	1.00	1.00
2016	0.00	0.00	0.12	0.63	0.92	0.98	1.00	1.00	1.00	1.00	1.00
2017	0.00	0.00	0.11	0.52	0.88	0.98	1.00	1.00	1.00	1.00	1.00
2018	0.00	0.00	0.11	0.48	0.83	0.98	1.00	1.00	1.00	1.00	1.00
2019	0.00	0.00	0.09	0.44	0.81	0.97	1.00	1.00	1.00	1.00	1.00
Decreasing q											
year	4.46 mp	4.96 mp	5.46 mp	5.96 mp	6.46 mp	6.96 mp	7.46 mp	7.96 mp	0.85 mp	8.96 mp	9.46 mp
2009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2013	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2014	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
2015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.35
2016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.46
2017	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.21	0.50

2018	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.26	0.55
2019	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.29	0.61
Central 1.1*M											
year	4.46 mp	4.96 mp	5.46 mp	5.96 mp	6.46 mp	6.96 mp	7.46 mp	7.96 mp	0.85 mp	8.96 mp	9.46 mp
2009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00
2013	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.92	1.00	1.00
2014	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.82	0.96	1.00
2015	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.43	0.81	0.95	0.99
2016	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.47	0.80	0.94	0.98
2017	0.00	0.00	0.00	0.00	0.00	0.01	0.17	0.49	0.80	0.94	0.99
2018	0.00	0.00	0.00	0.00	0.00	0.02	0.20	0.52	0.80	0.94	0.99
2019	0.00	0.00	0.00	0.00	0.00	0.05	0.22	0.56	0.81	0.93	0.99
Central 0.9*M											
year	4.46 mp	4.96 mp	5.46 mp	5.96 mp	6.46 mp	6.96 mp	7.46 mp	7.96 mp	0.85 mp	8.96 mp	9.46 mp
2009	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2010	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
2011	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
2012	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
2013	0.00	0.00	0.00	0.00	0.00	0.77	1.00	1.00	1.00	1.00	1.00
2014	0.00	0.00	0.00	0.00	0.00	0.57	0.94	1.00	1.00	1.00	1.00
2015	0.00	0.00	0.00	0.00	0.02	0.52	0.88	0.99	1.00	1.00	1.00
2016	0.00	0.00	0.00	0.00	0.06	0.44	0.83	0.96	1.00	1.00	1.00
2017	0.00	0.00	0.00	0.00	0.08	0.42	0.78	0.95	1.00	1.00	1.00
2018	0.00	0.00	0.00	0.00	0.09	0.39	0.75	0.94	1.00	1.00	1.00
2019	0.00	0.00	0.00	0.00	0.08	0.36	0.73	0.90	0.99	1.00	1.00
Red Tide											
year	4.46 mp	4.96 mp	5.46 mp	5.96 mp	6.46 mp	6.96 mp	7.46 mp	7.96 mp	0.85 mp	8.96 mp	9.46 mp
2009	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2010	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2011	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
2012	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
2013	0.00	0.00	0.00	0.00	0.00	0.86	1.00	1.00	1.00	1.00	1.00
2014	0.00	0.00	0.00	0.00	0.01	0.54	0.93	0.99	1.00	1.00	1.00
2015	0.00	0.00	0.00	0.00	0.02	0.44	0.83	0.97	1.00	1.00	1.00
2016	0.00	0.00	0.00	0.00	0.04	0.36	0.74	0.93	0.98	1.00	1.00
2017	0.00	0.00	0.00	0.00	0.04	0.32	0.68	0.90	0.98	1.00	1.00
2018	0.00	0.00	0.00	0.00	0.05	0.27	0.61	0.87	0.97	1.00	1.00
2019	0.00	0.00	0.00	0.00	0.04	0.23	0.59	0.83	0.96	0.99	1.00

14 Figures

Figure 4.1. Size frequency histograms, sample sizes and mean lengths of red grouper obtained from observers on commercial handline, longline and headboat vessels.

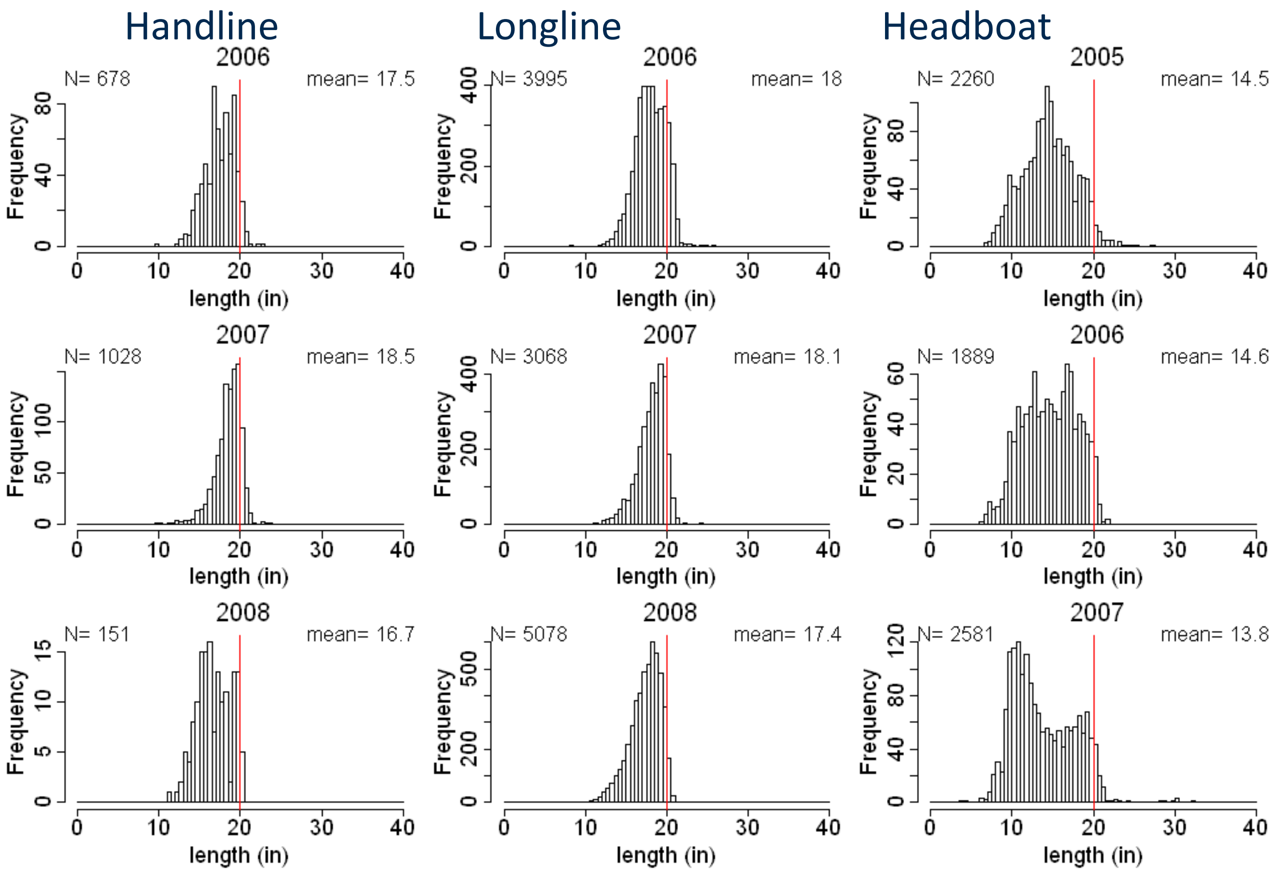


Figure 4.2. A. Previous (SEDAR 12) estimated handline discard age composition derived from landed lengths. B. New discard age composition estimated from observed discard lengths.

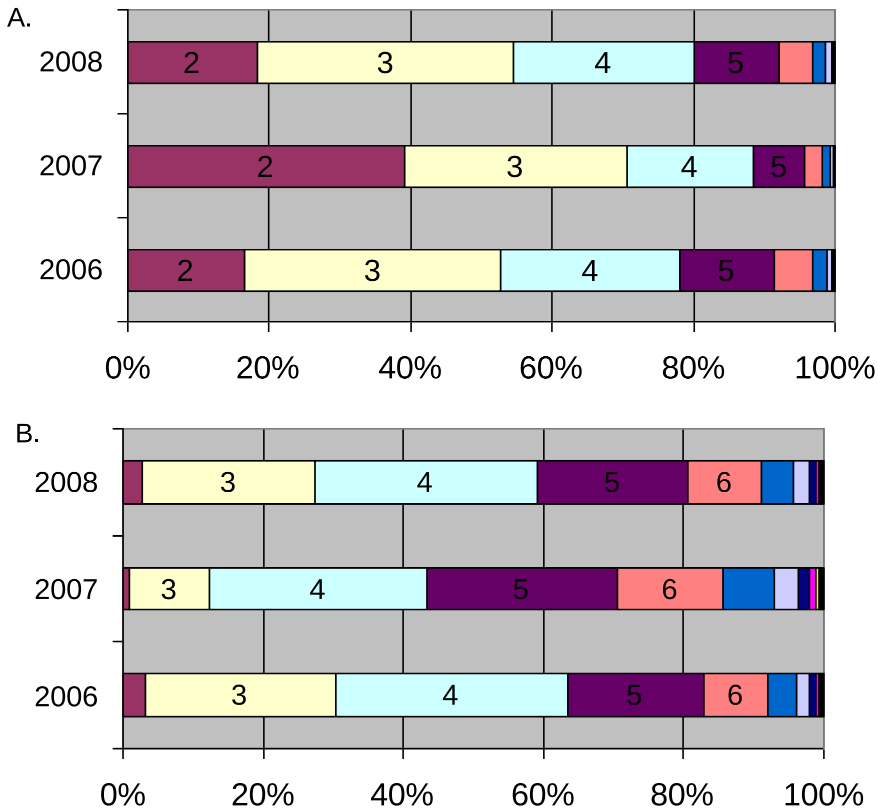


Figure 4.3. A. Previous (SEDAR 12) estimated longline discard age composition derived from landed lengths. B. New discard age composition estimated from observed discard lengths.

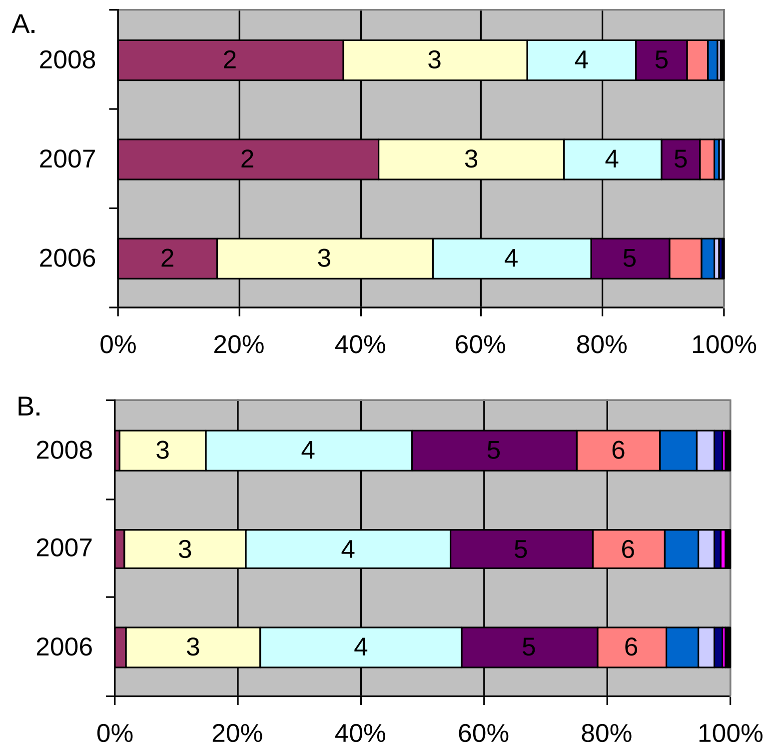


Figure 5.1. Ratios of fish released alive (B2) to total catch (A+B1+B2) for red grouper from all sources for FL peninsula.

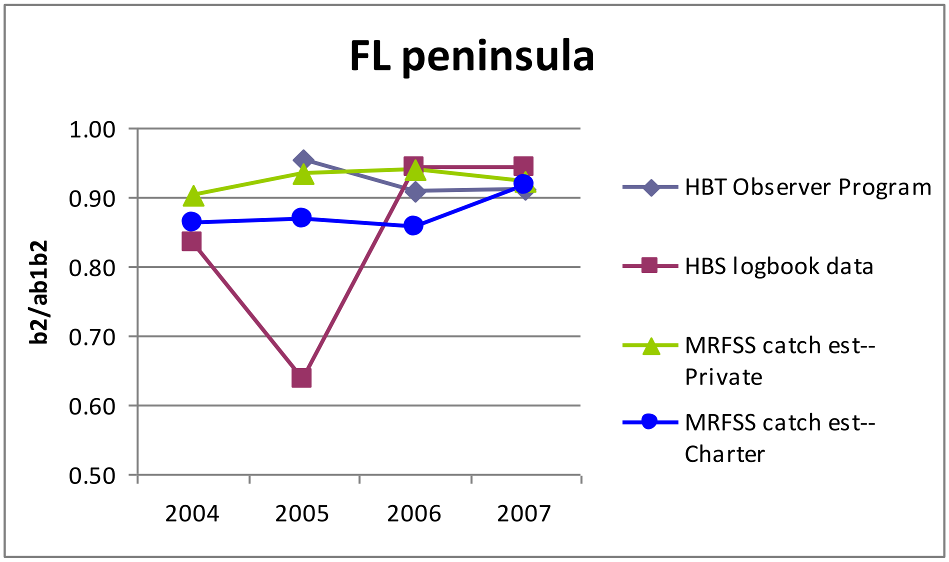


Figure 5.2. A. Previous (SEDAR 12) estimated headboat discard age composition derived from landed lengths. B. New discard age composition estimated from observed discard lengths.

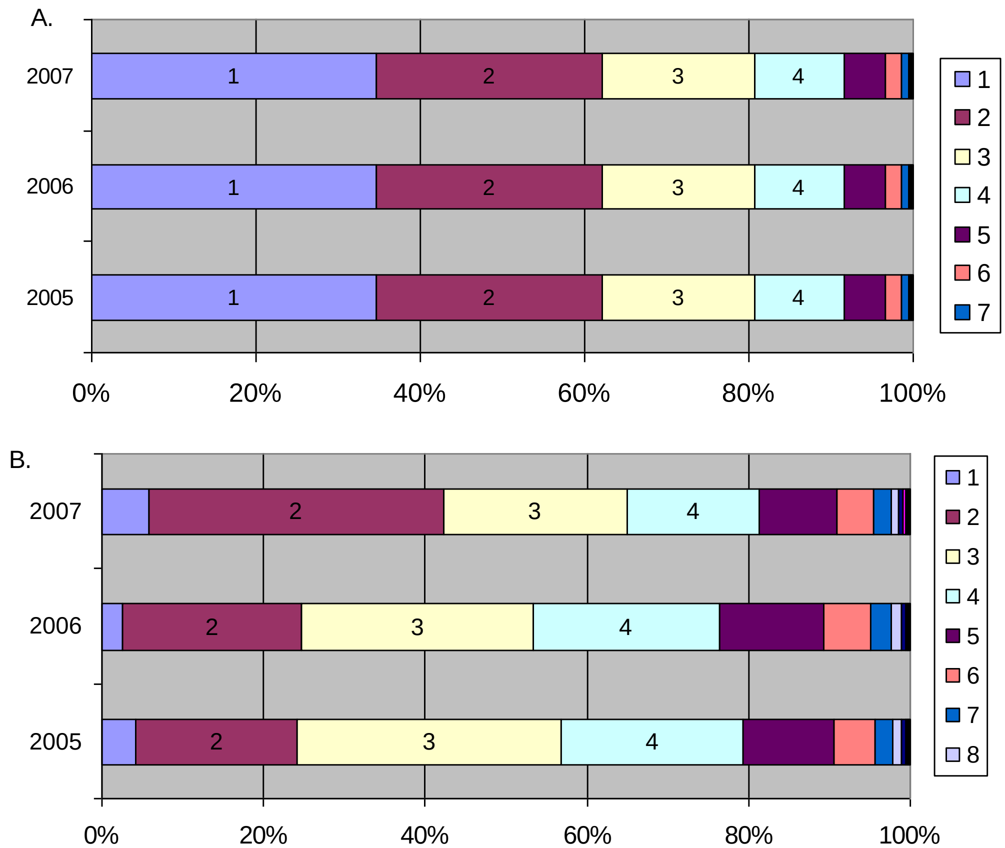


Figure 6.1.1-1. Red grouper 2006 and updated 2009 standardized indices of abundance constructed using commercial vertical line (handline and bandit rig) self-reported logbook data. Indices were scaled to the mean CPUE of the common years.

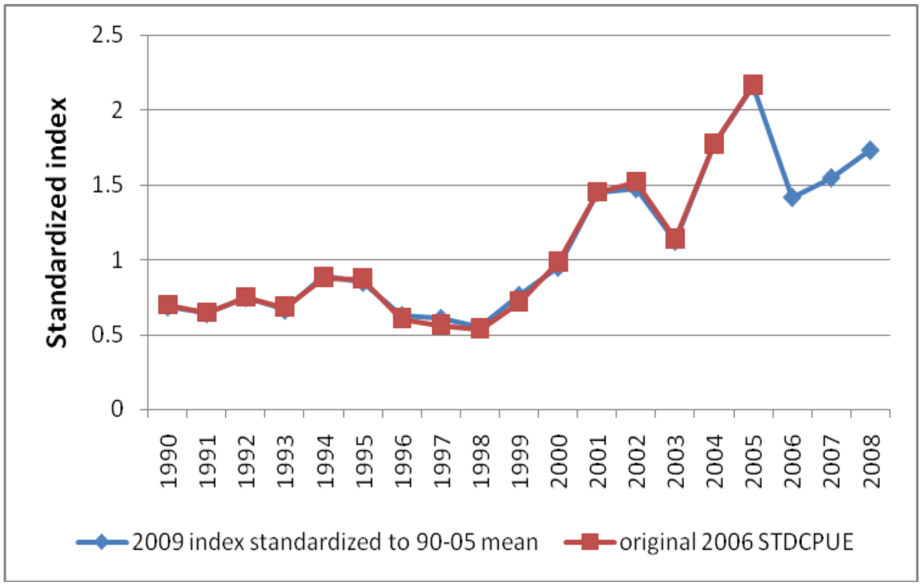


Figure 6.1.1-2. Red grouper 2006 and updated 2009 standardized indices of abundance constructed using commercial longline self-reported logbook data. Indices were scaled to the mean CPUE of the common years.

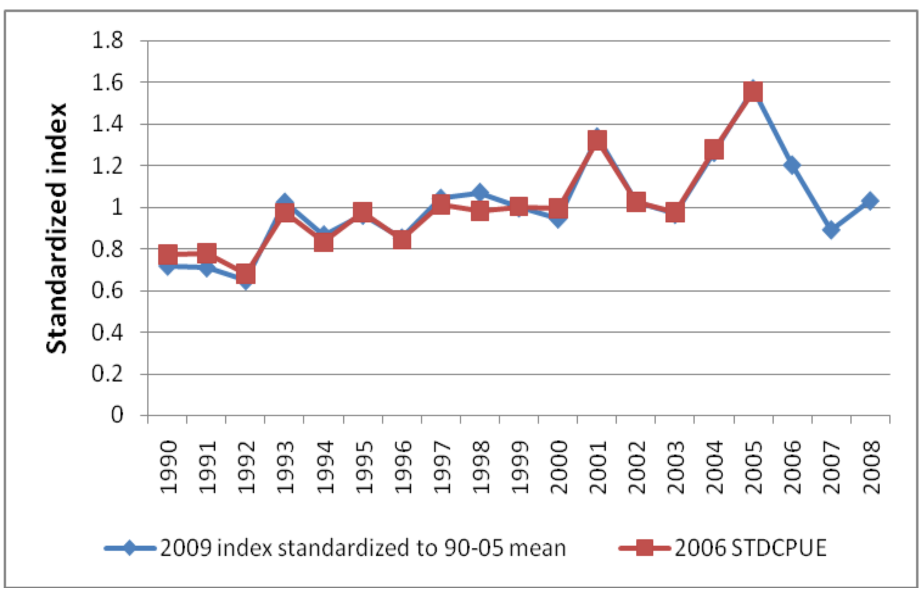


Figure 6.1.1-3. Red grouper 2006 and updated 2009 standardized indices of abundance constructed using MRFSS data. For comparison purposes, both the old and updated indices are scaled with a 2% increasing catchability. Error bars are 95% confidence intervals.

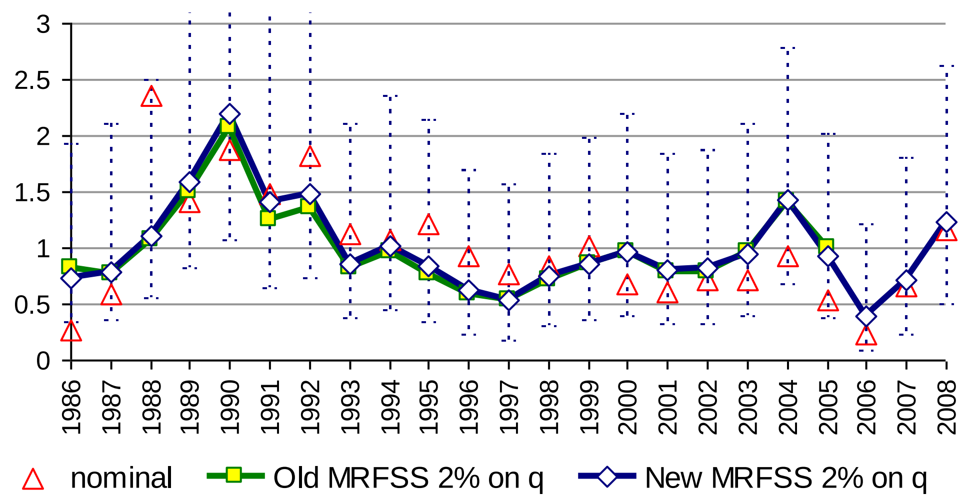


Figure 6.1.1-4. Red grouper 2006 and updated 2009 standardized indices of abundance constructed using headboat data. For comparison purposes, both the old and updated indices are scaled with a 2% increasing catchability. Error bars are 95% confidence intervals.

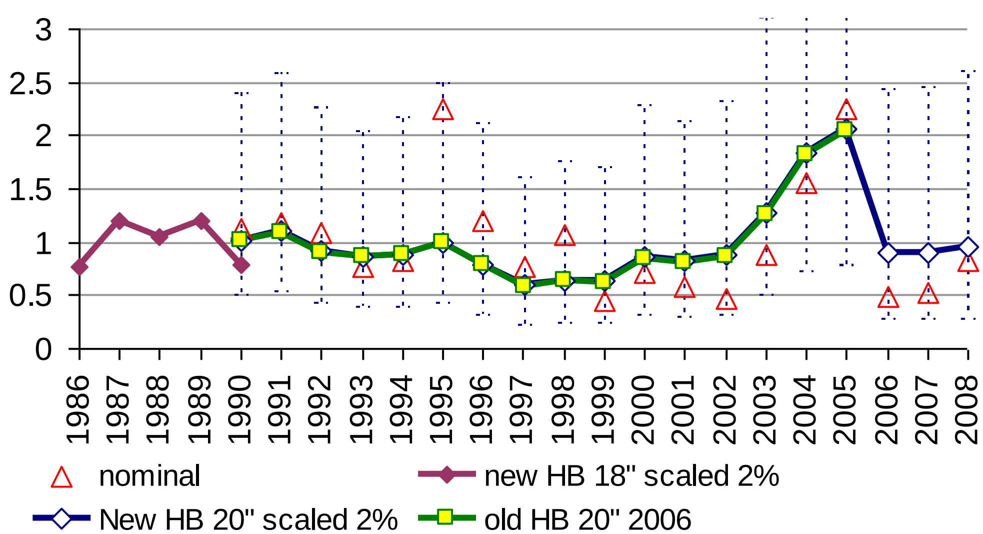


Figure 7.1. A. Von Bertalanffy growth model used for Red Grouper. B. Fecundity at age proxy. C. Gutted weight at age (lbs). D. Natural mortality at age.

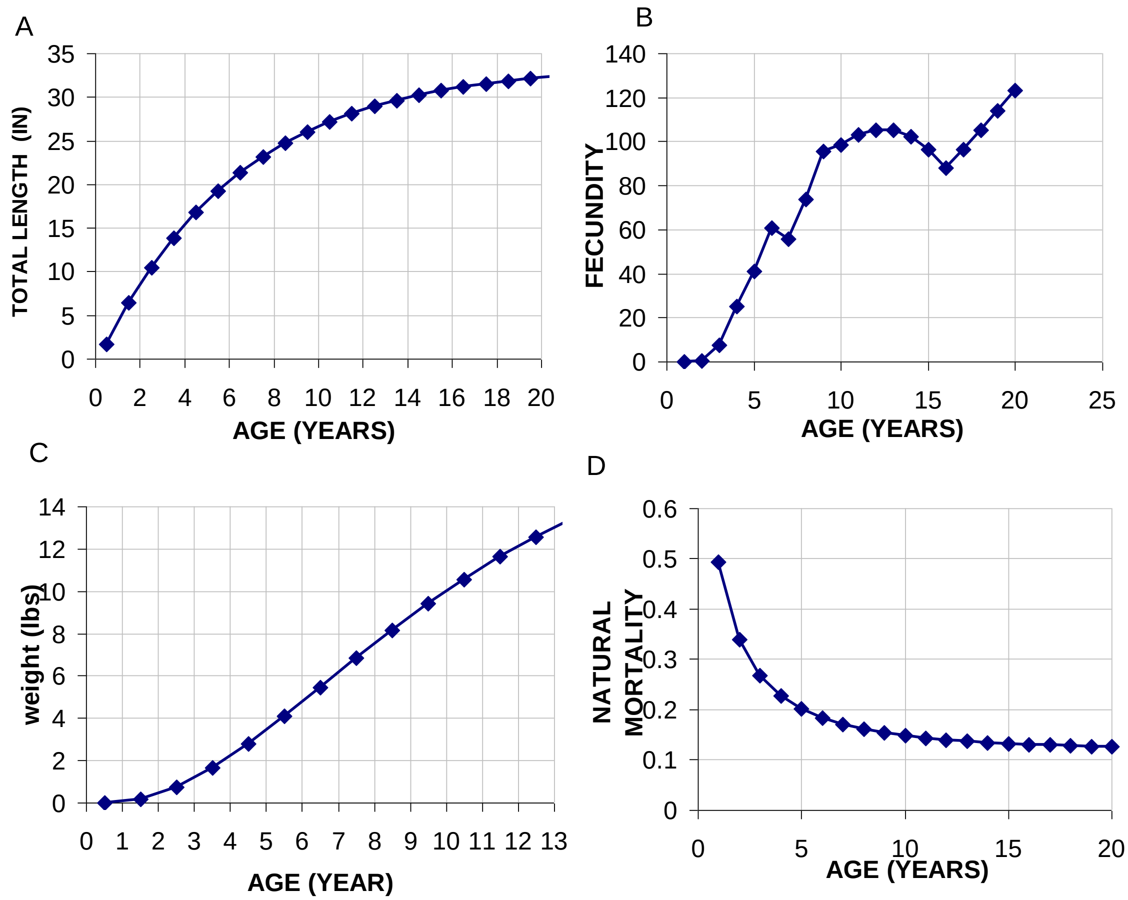


Figure 7.2 Comparison of the model-based SEDAR 12 proportion discard at age versus the empirical estimates the lognormal regression used for the 2009 update for commercial longline.

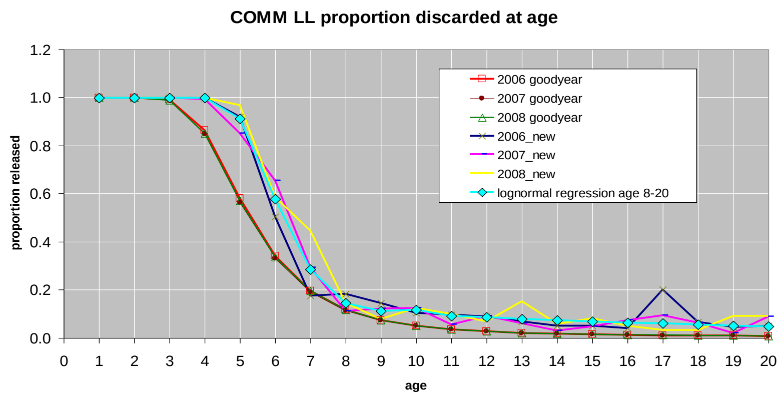


Figure 7.3 Comparison of the model-based SEDAR 12 proportion discard at age versus the empirical estimates the lognormal regression used for the 2009 update for commercial handline.

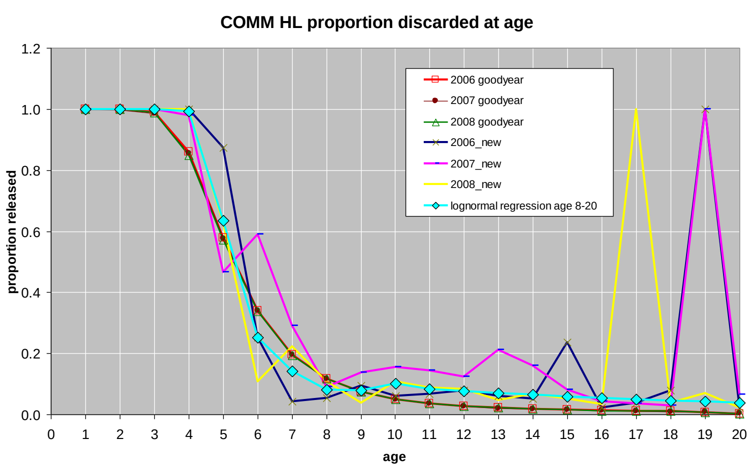


Figure 7.4. Indices of abundance used in the 2009 Gulf of Mexico red grouper assessment.

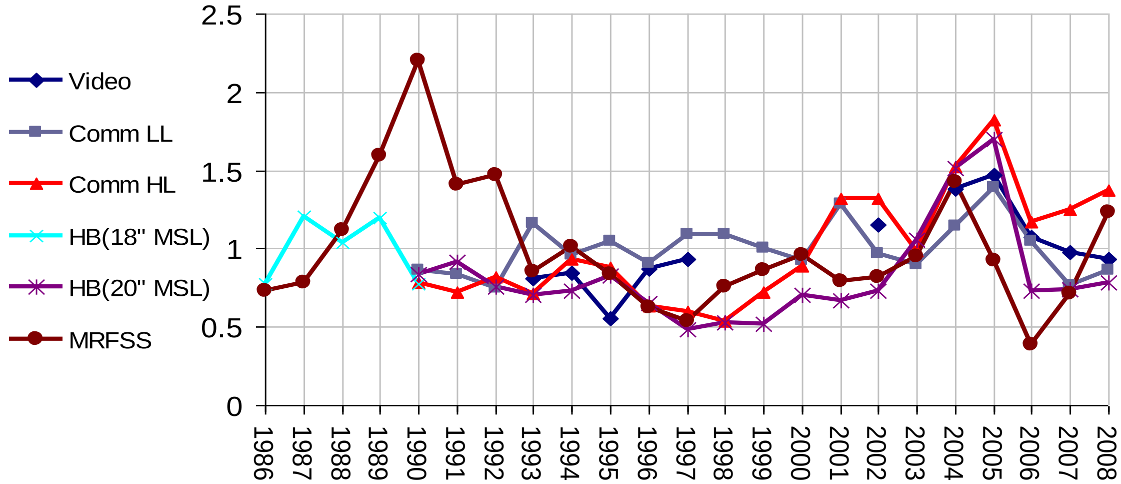


Figure 8.1.1. Central model fits to the catch series (gutted lbs).

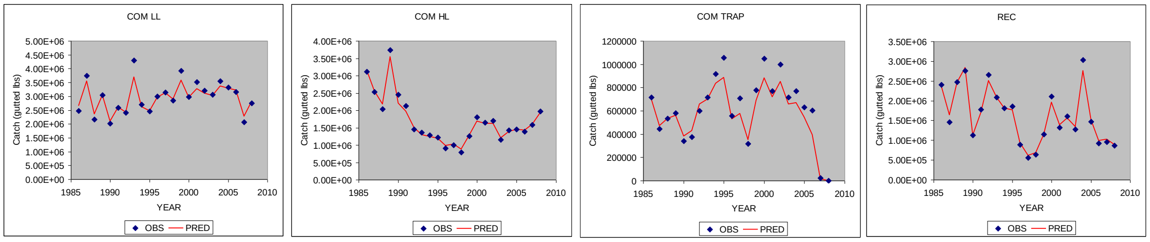


Figure 8.1.2. Central model fits to the discard series (gutted lbs).

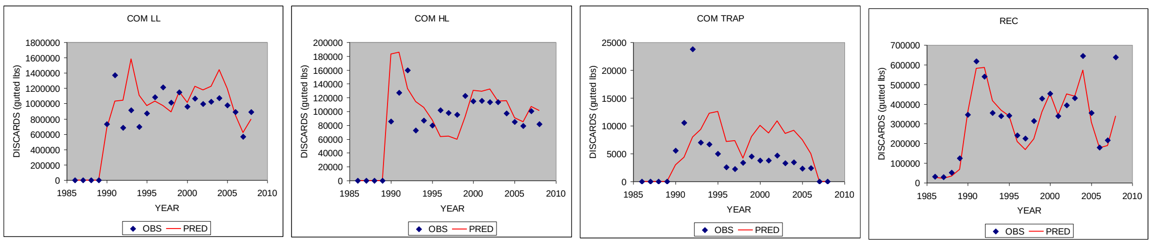


Figure 8.1.3. Central model fits to the indices of abundance.

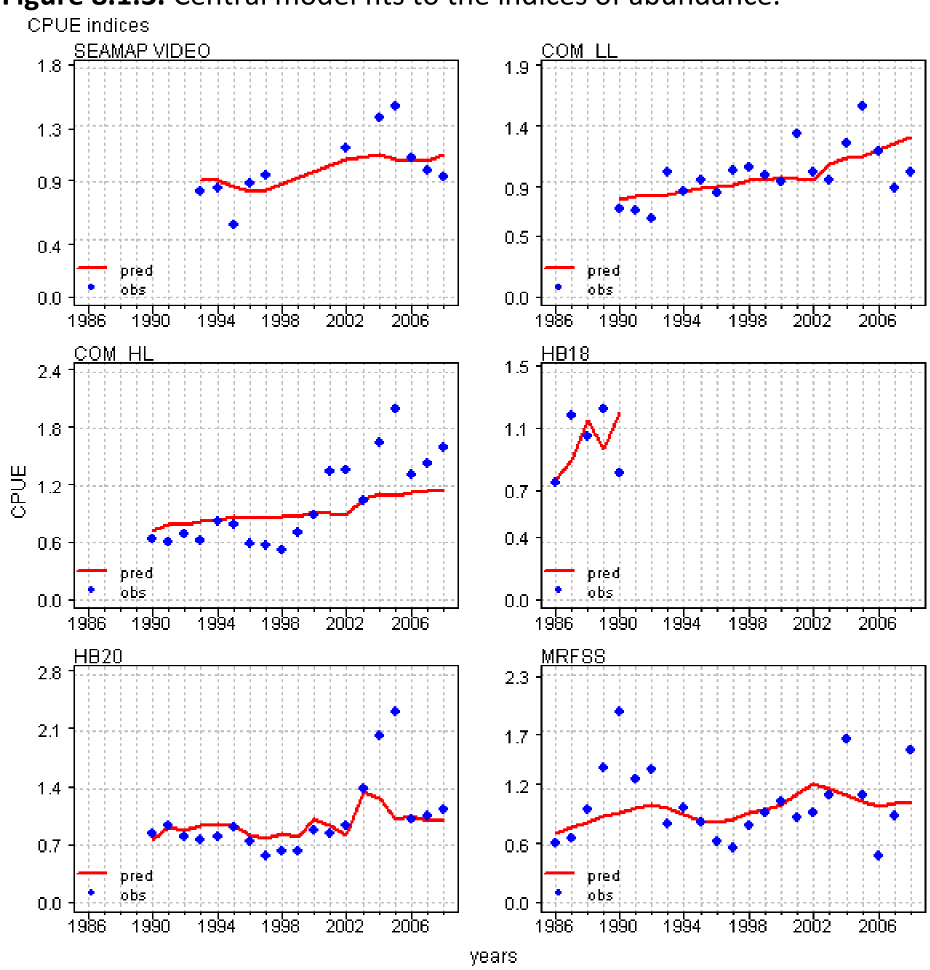


Figure 8.1.4. Central model indices of abundance residuals (observed minus predicted).

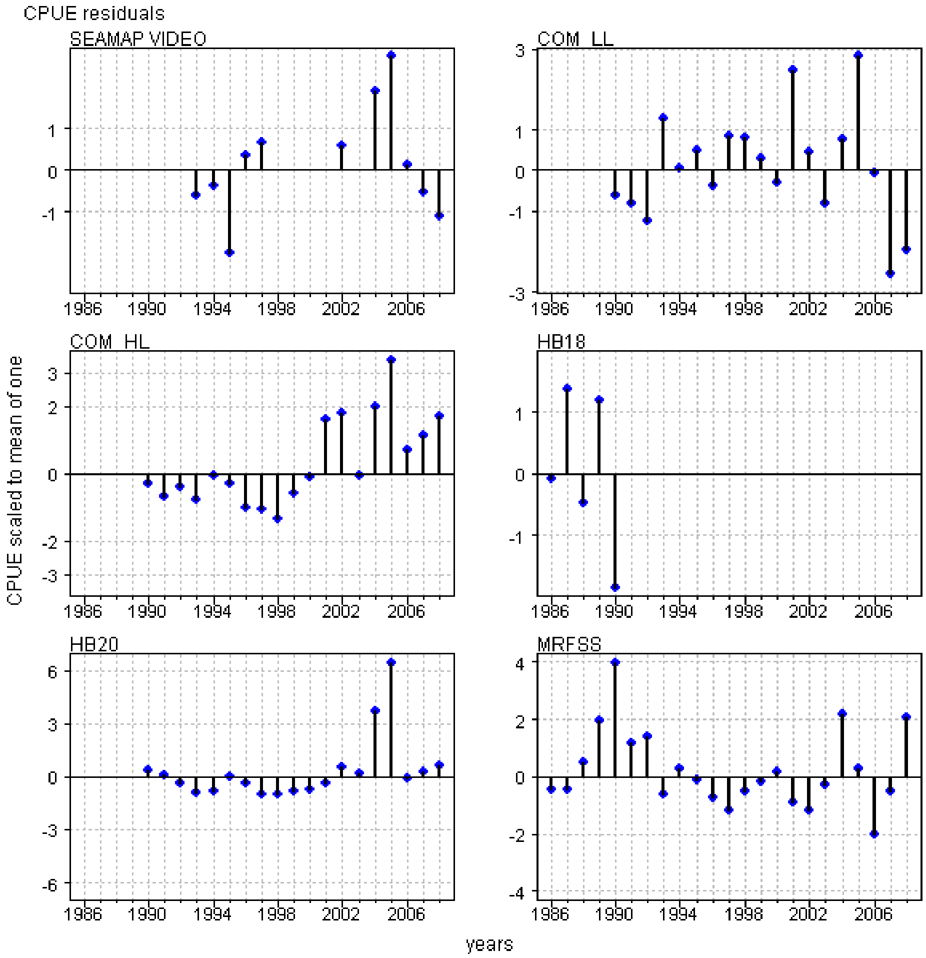


Figure 8.1.5. Fits to the direct observed catch-at-age for the commercial longline fleet. Note: there are no observations before 1991.

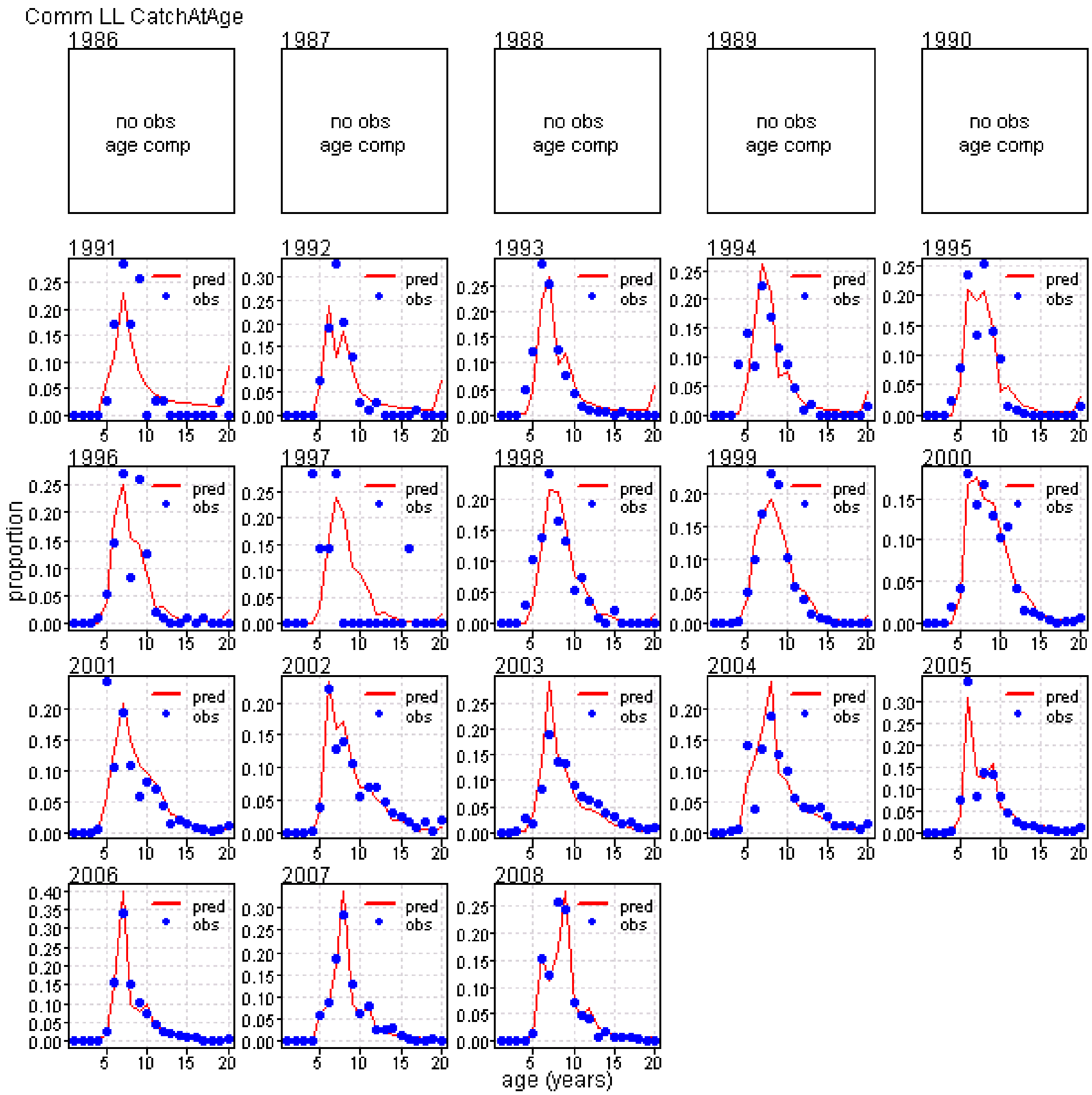


Figure 8.1.6. Fits to the observed discard-at-age for the commercial longline fleet. Note: there are no observations before 1991.

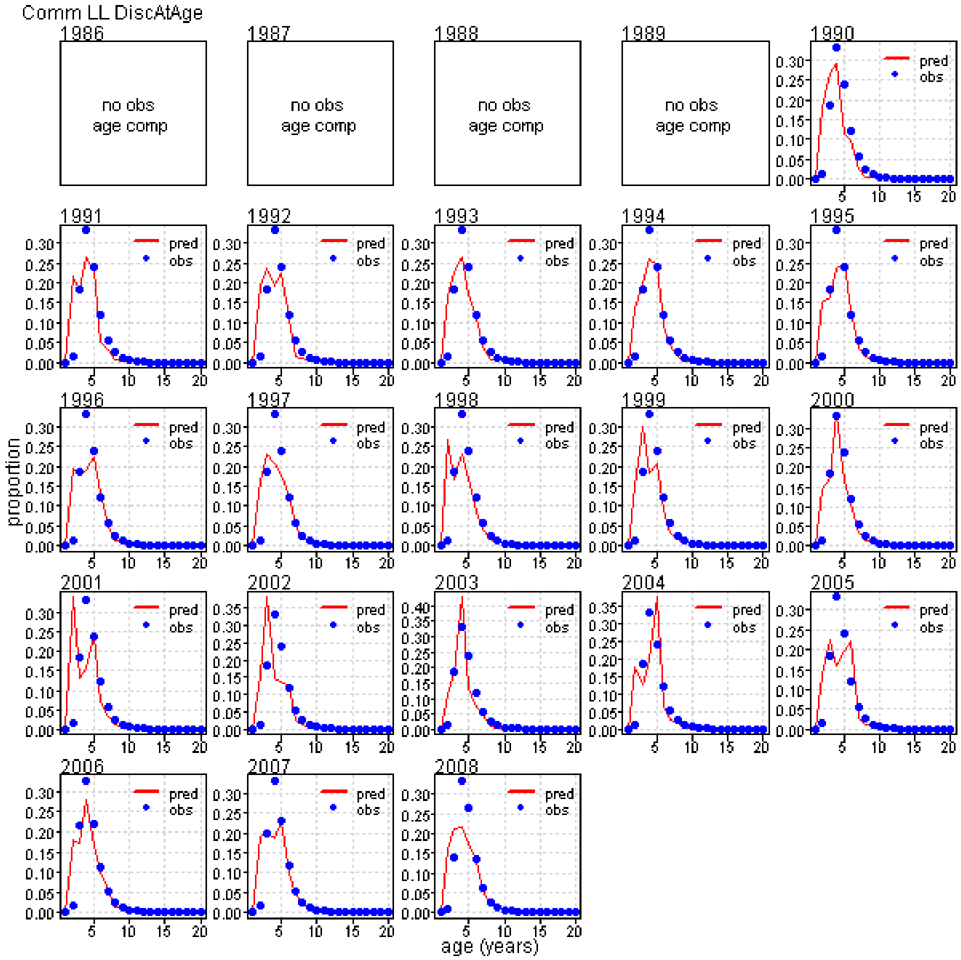


Figure 8.1.7. Fits to the direct observed catch-at-age for the commercial handline fleet. Note: there are no observations before 1991.

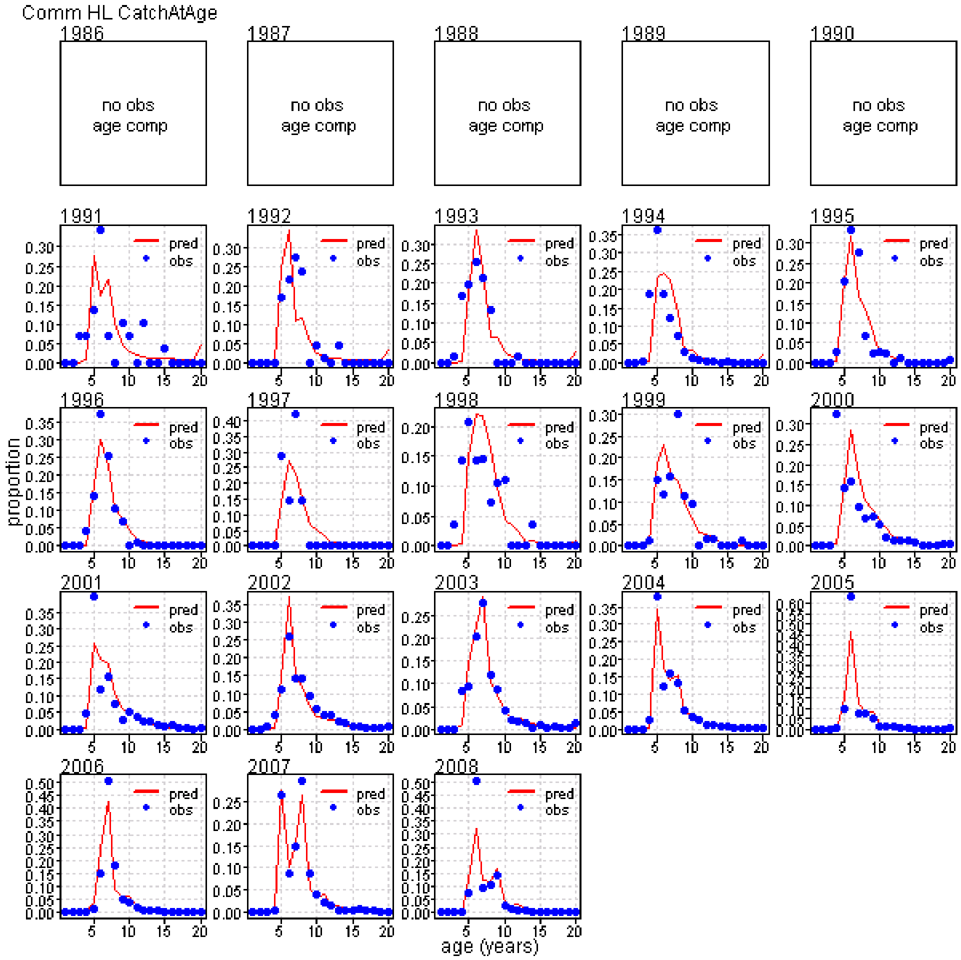


Figure 8.1.8. Fits to the observed discards-at-age for the commercial handline fleet. Note: there are no estimates before 1990.

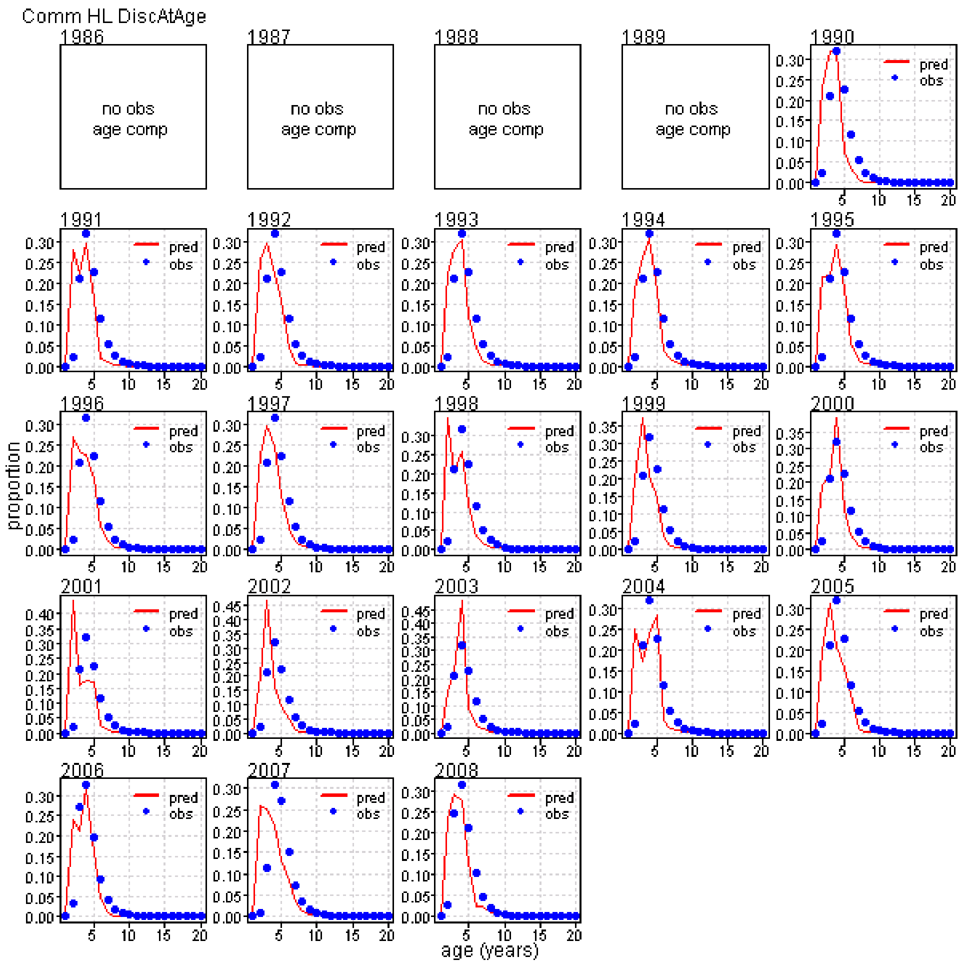


Figure 8.1.9. Fits to the direct observed catch-at-age for the commercial trap fleet. There were no observations in 1988 or 1990.

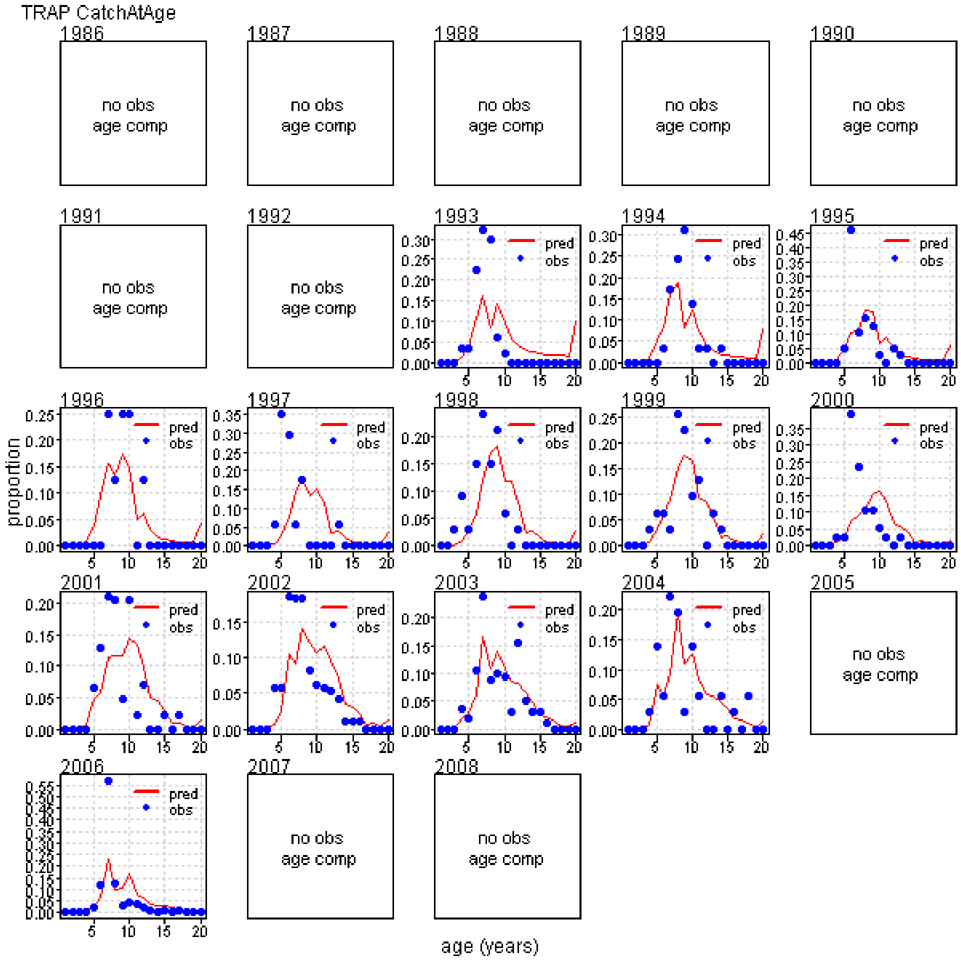


Figure 8.1.10. Fits to the modeled discards-at-age for the commercial trap fleet. Note: there are no estimates before 1993 or after 2006.

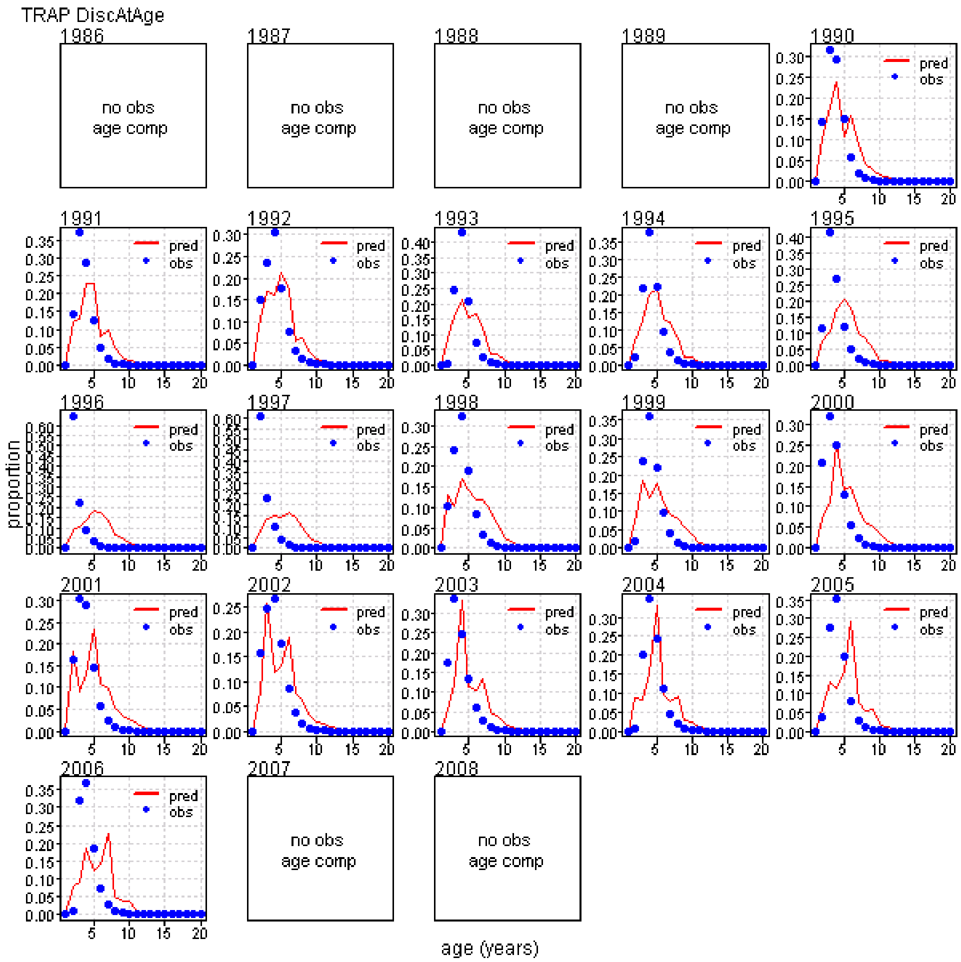


Figure 8.1.11. Fits to the direct observed catch-at-age for the recreational fleet. There were no observations in 1988 or 1990.

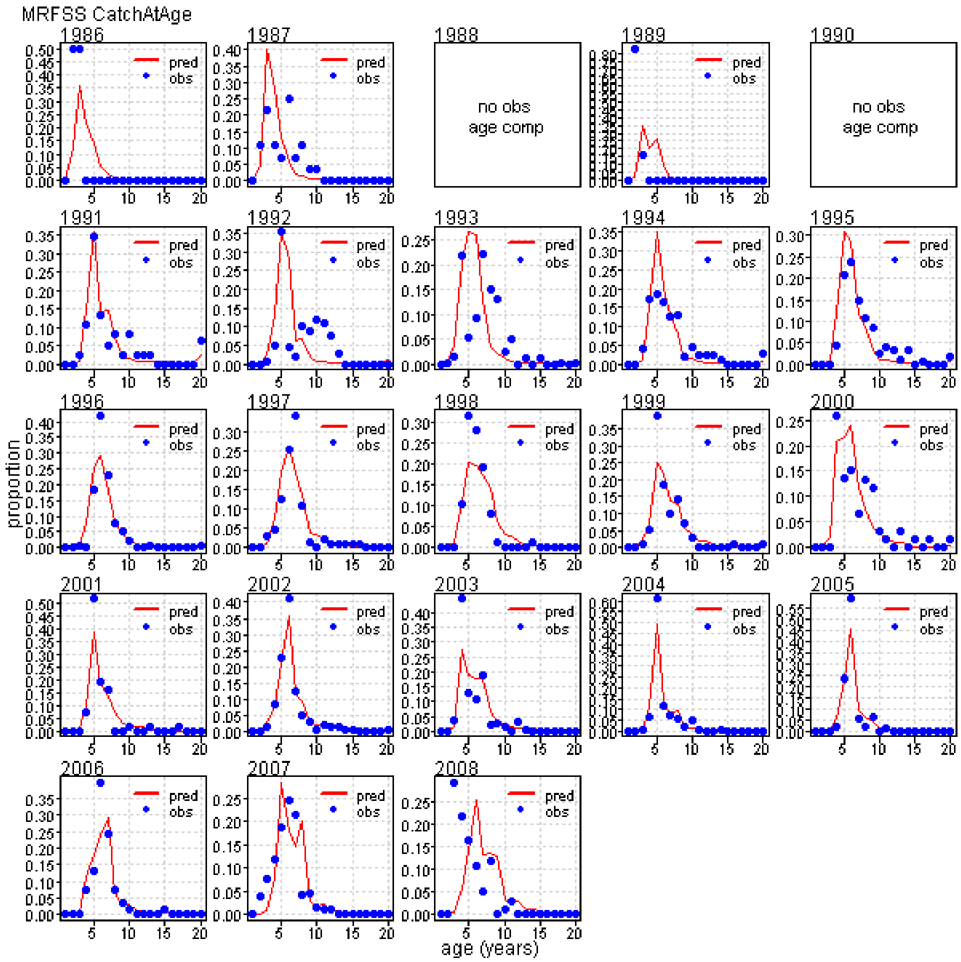


Figure 8.1.12. Fits to the observed discards-at-age for the recreational fleet.

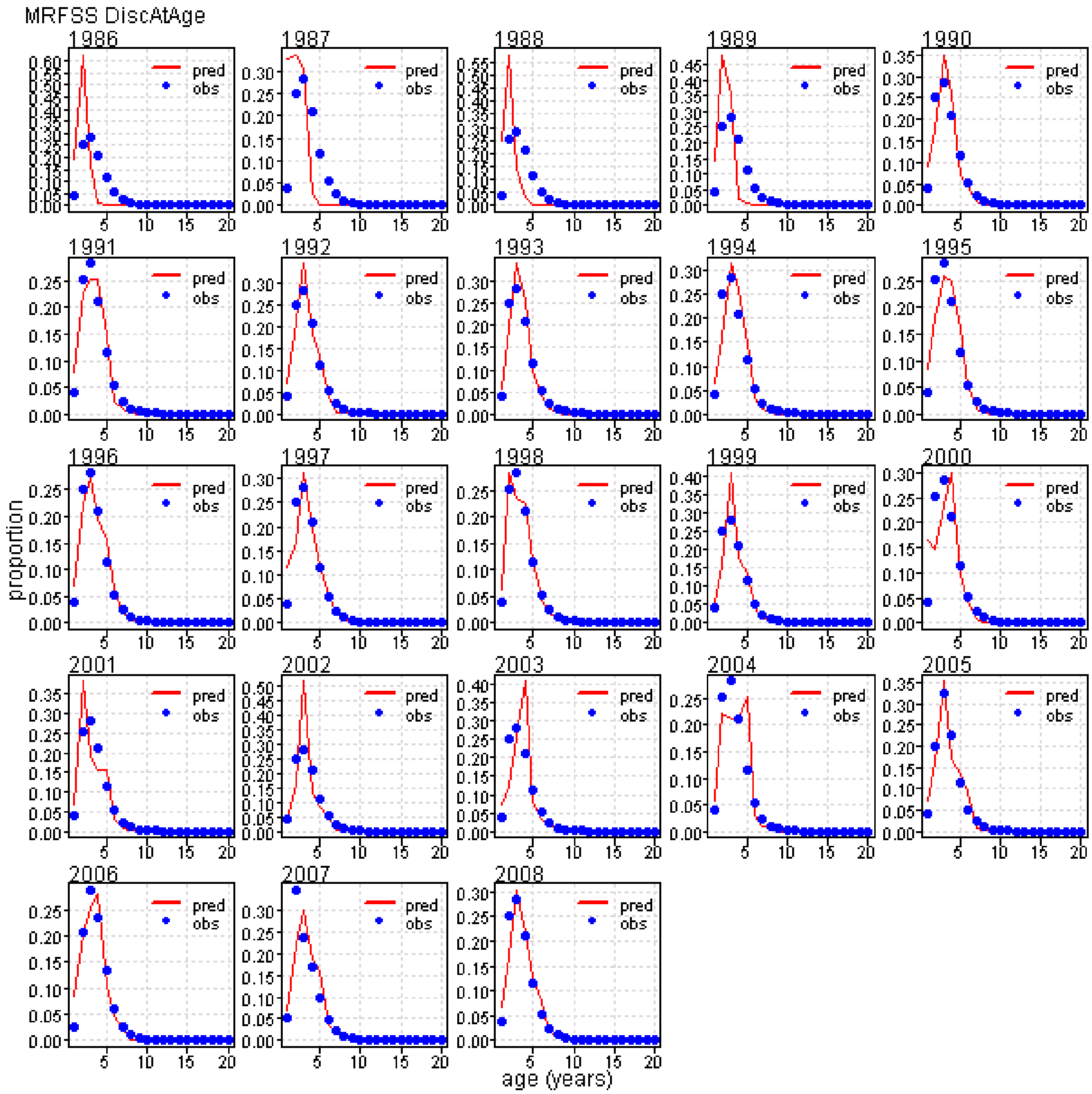


Figure 8.1.13 Selectivity-at-age by fleet. Note: these selectivity vectors apply to the total catch (landed + released).

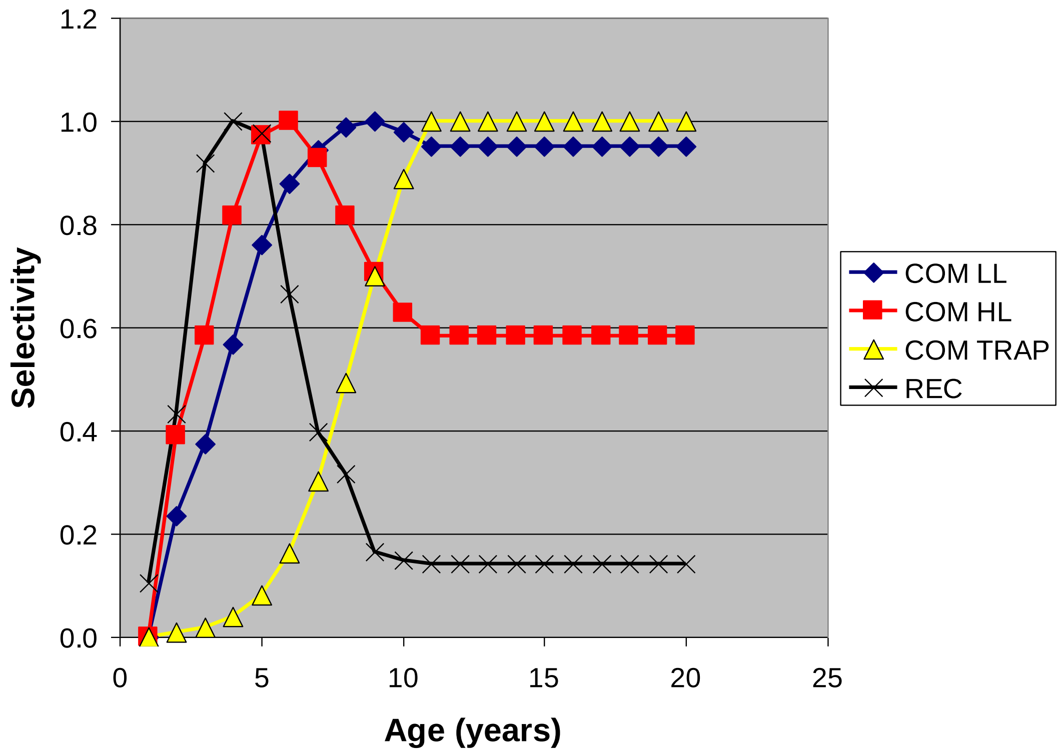


Figure 8.1.14. Directed Fishing mortality (landings + discards) by year and fleet.

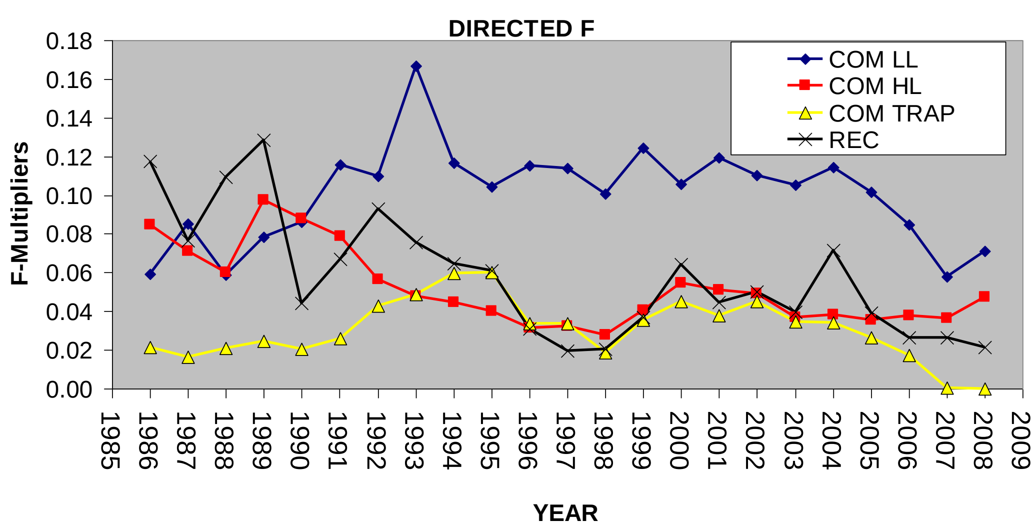


Figure 8.1.15. Discard Fishing mortality (landings + discards) by year and fleet.

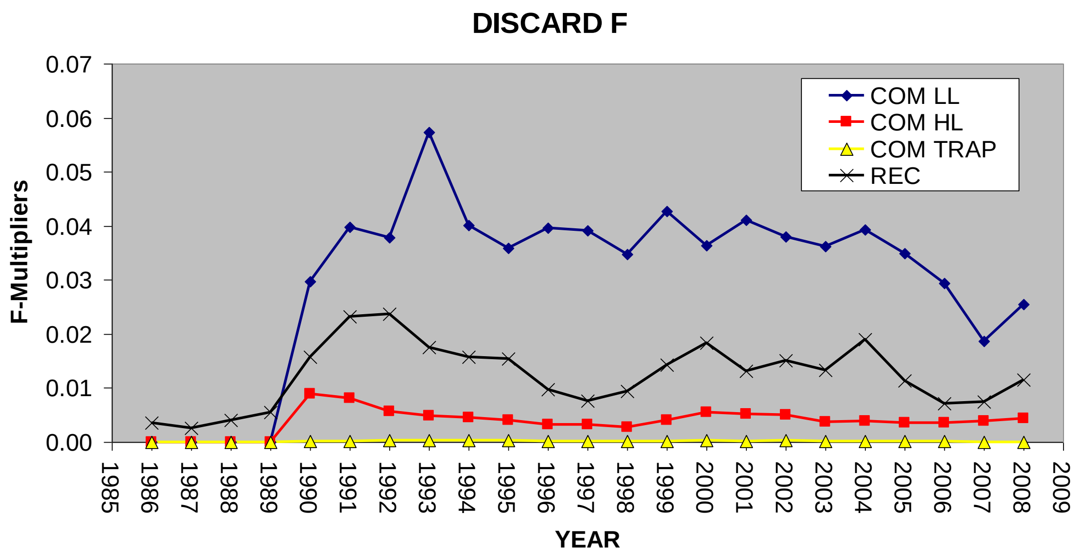


Figure 8.1.16. Apical fishing mortality rate by year.

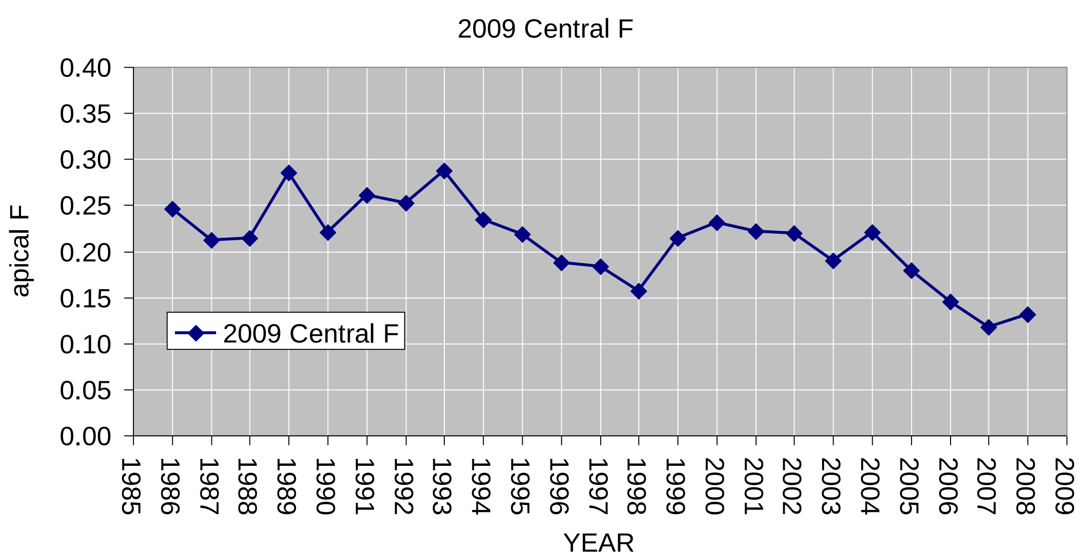


Figure 8.1.17. Number-at-age. The area of the circle is proportional to the number of fish at that age.

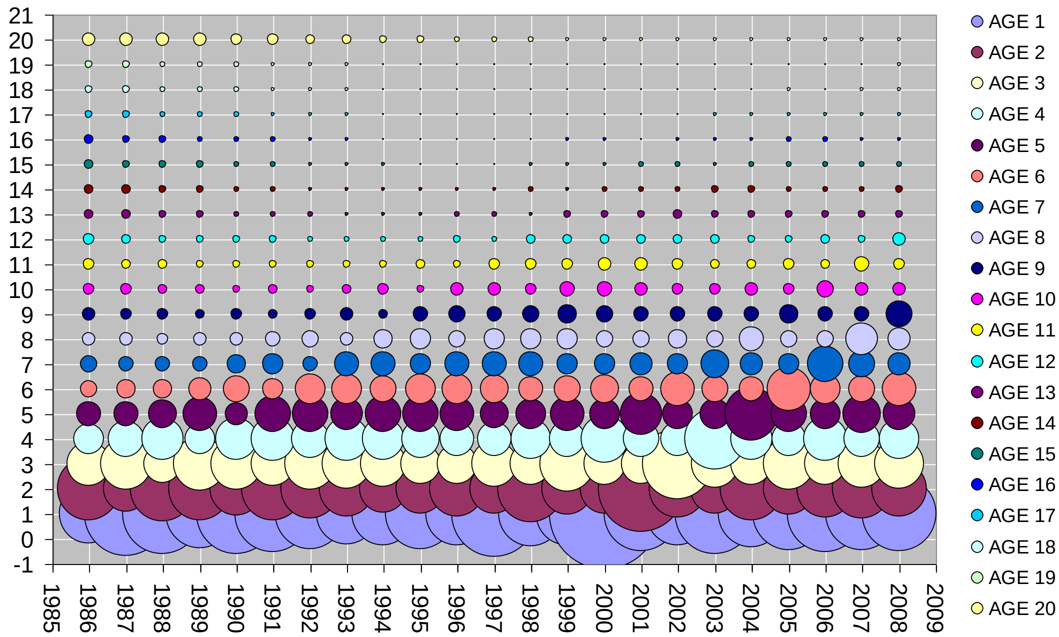
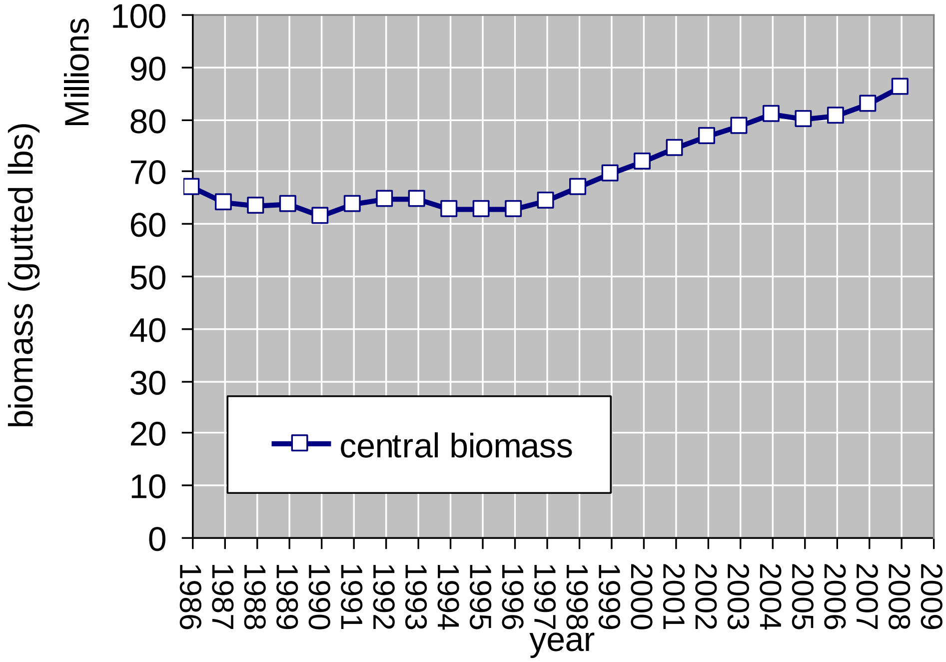


Figure 8.1.18. A. Total biomass for central model. B. Total numbers.



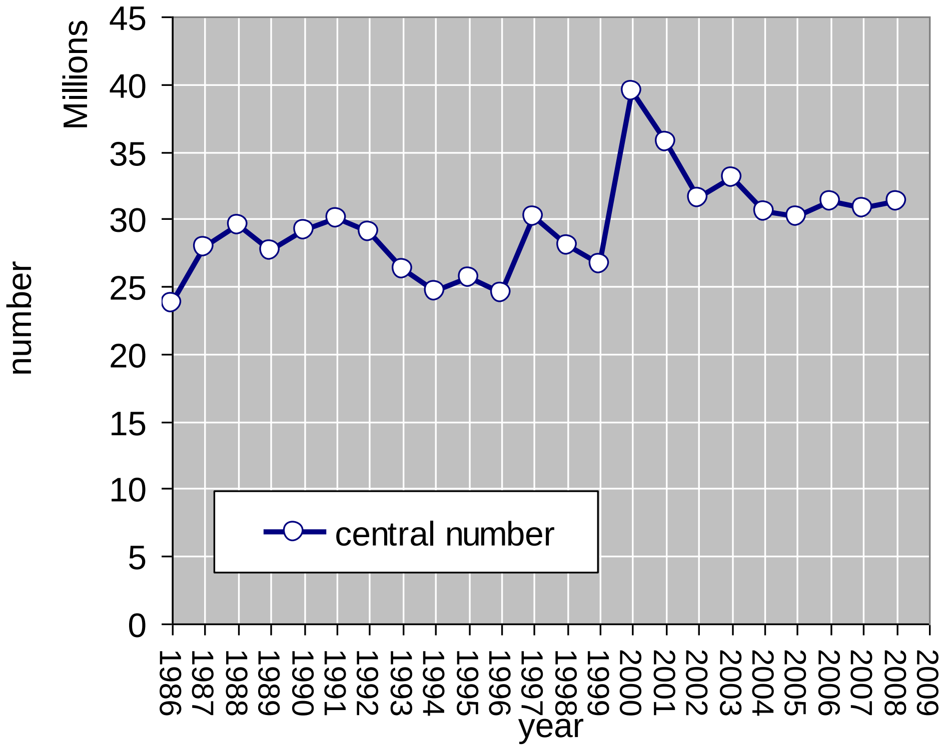


Figure 8.1.19. Central model 2009 and 2006 Base model A) Spawning stock biomass (grams mature female gonad weight), B) Annual estimates of recruitment (Age 1). Large year classes occurred in 1996 and 1999. **C)** SS as a function of SS at maximum sustainable yield (SS_{MSY}) and **D)** F as a fraction of F at maximum sustainable yield (F_{MSY}).

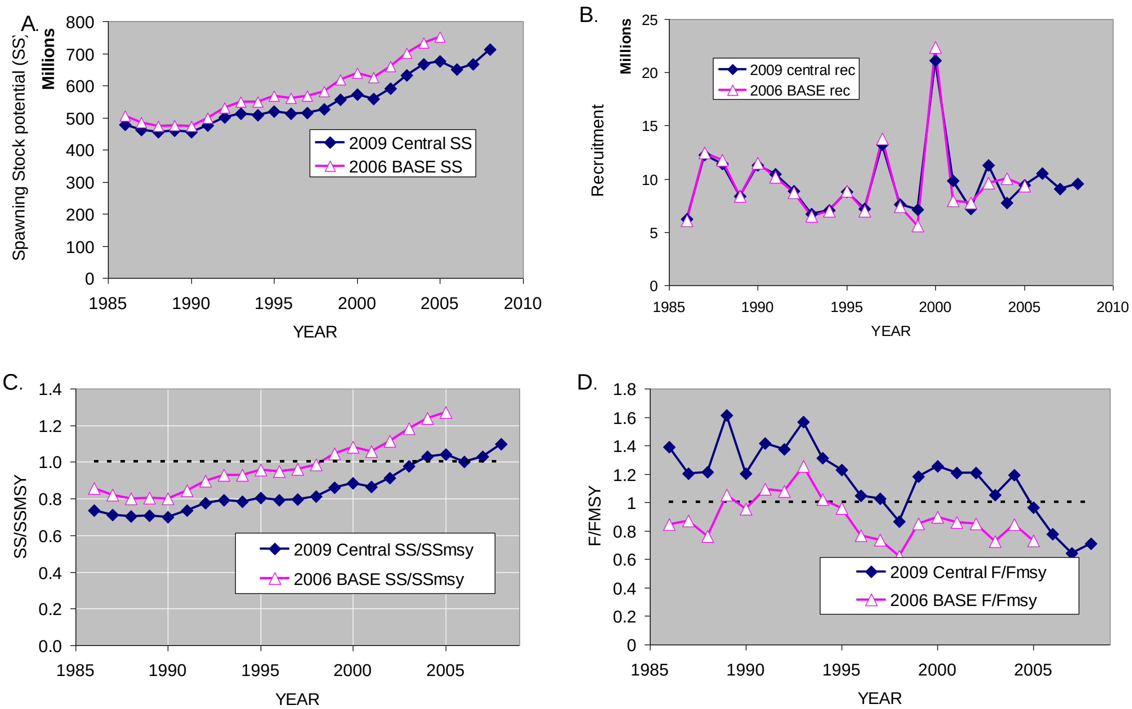


Figure 8.1.20. Beverton and Holt stock recruitment relationship (bias-corrected). The dotted line in the average recruitment (1986-2008). Note that 'recruits' are age 1 fish, i.e. recruits in year 2000 were actually born in 1999.

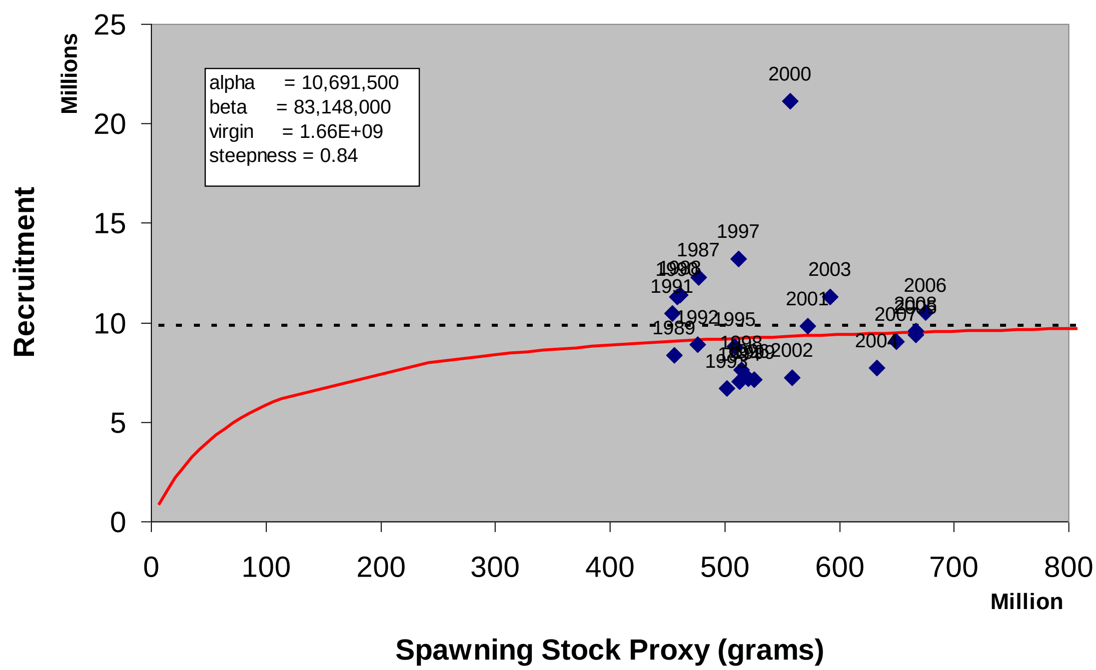


Figure 8.2.1. Red tide model fits to the catch series (gutted lbs).

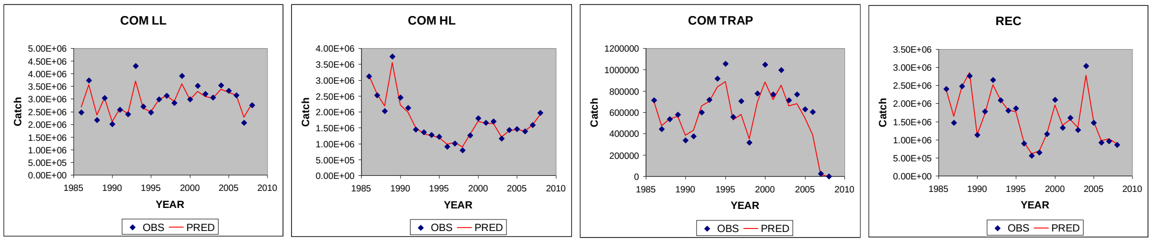


Figure 8.2.2. Red tide model fits to the discard series (gutted lbs).

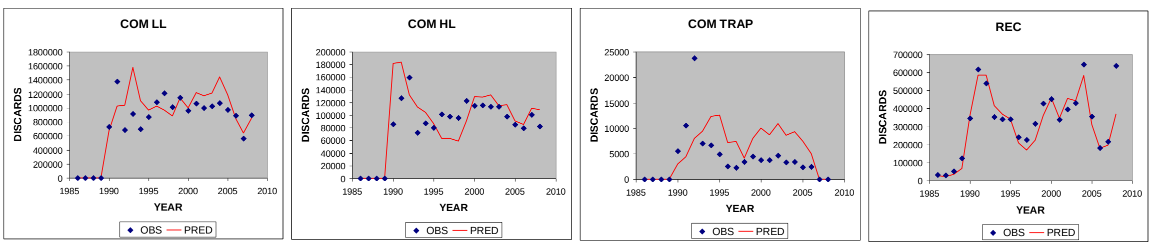


Figure 8.2.3. Red tide model fits to the indices of abundance.

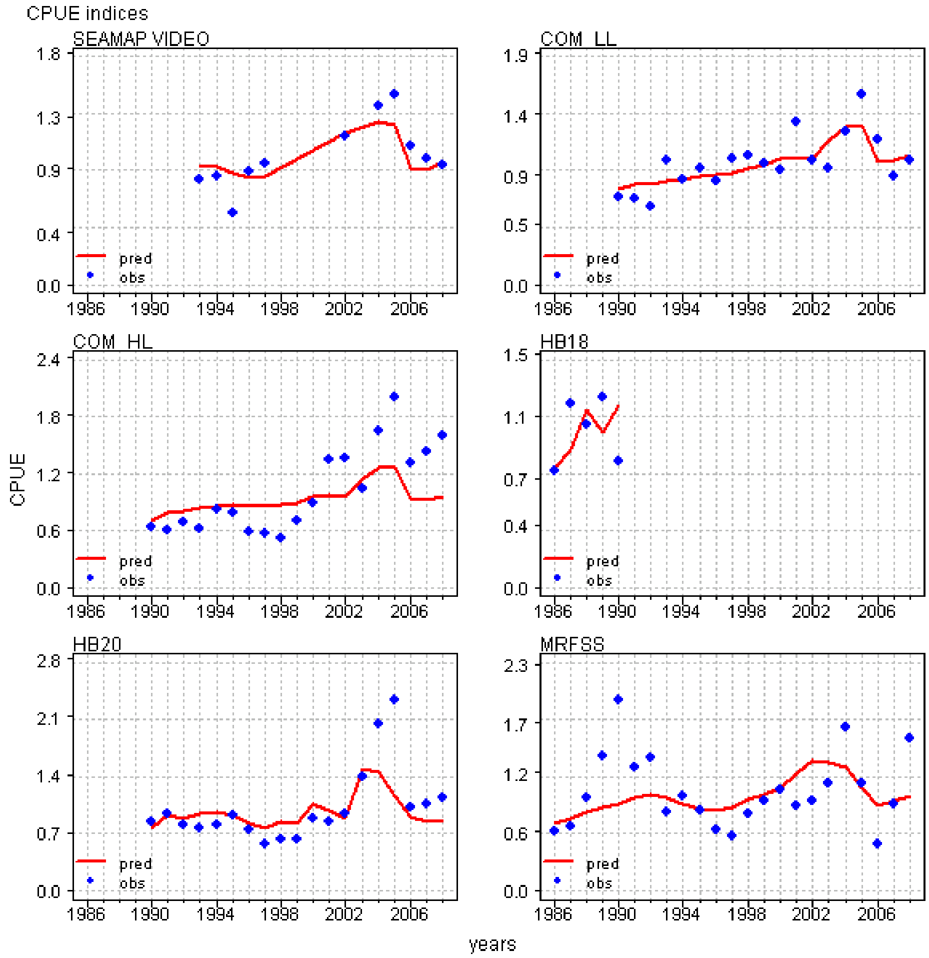


Figure 8.2.4. Red tide model indices of abundance residuals.

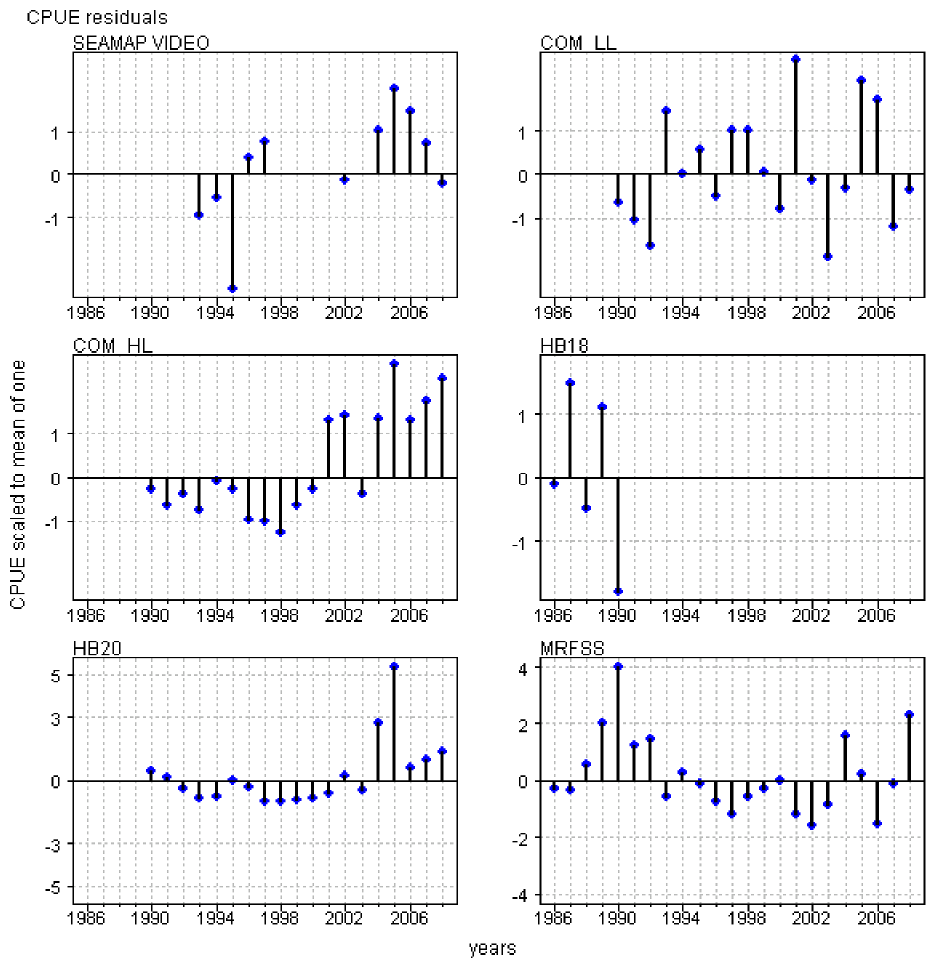


Figure 8.2.5. Red tide fits to the direct observed catch-at-age for the commercial longline fleet. Note: there are no observations before 1991.

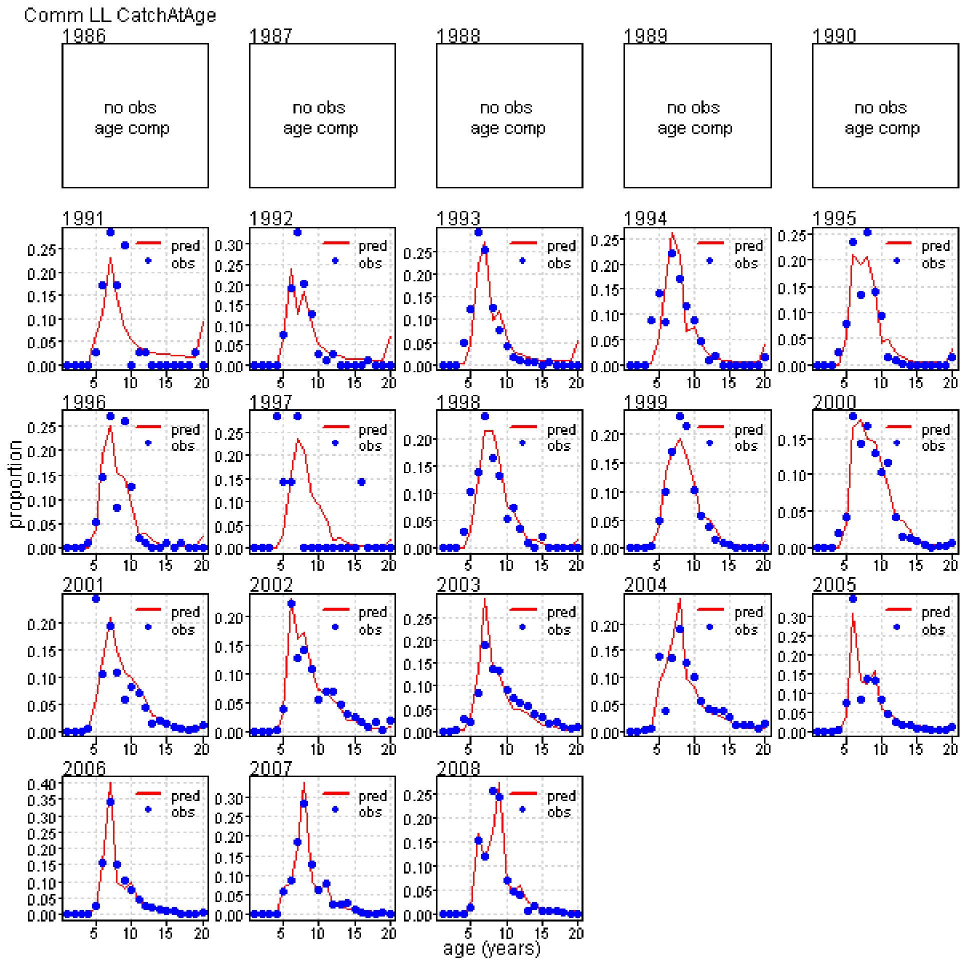


Figure 8.2.6. Red tide model fits to the observed discard-at-age for the commercial longline fleet. Note: there are no observations before 1991.

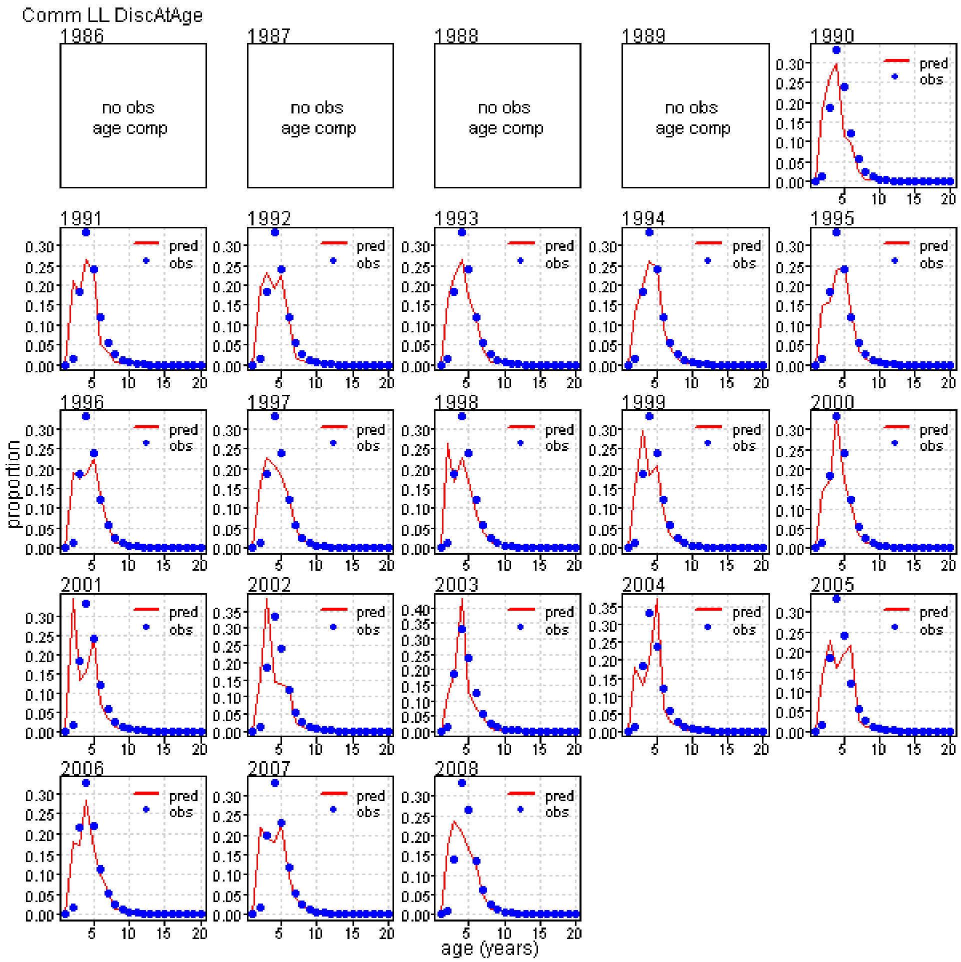


Figure 8.2.7. Fits to the direct observed catch-at-age for the commercial handline fleet. Note: there are no observations before 1991.

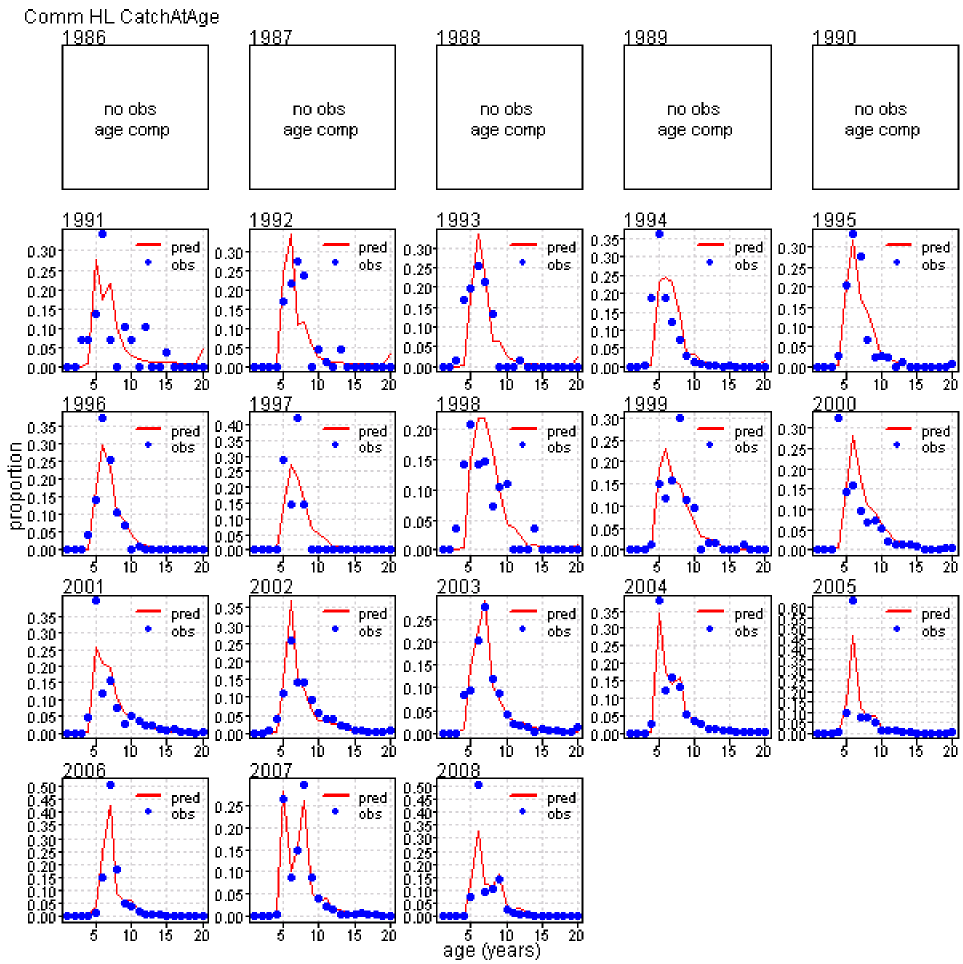


Figure 8.2.8. Fits to the observed discards-at-age for the commercial handline fleet. Note: there are no estimates before 1990.

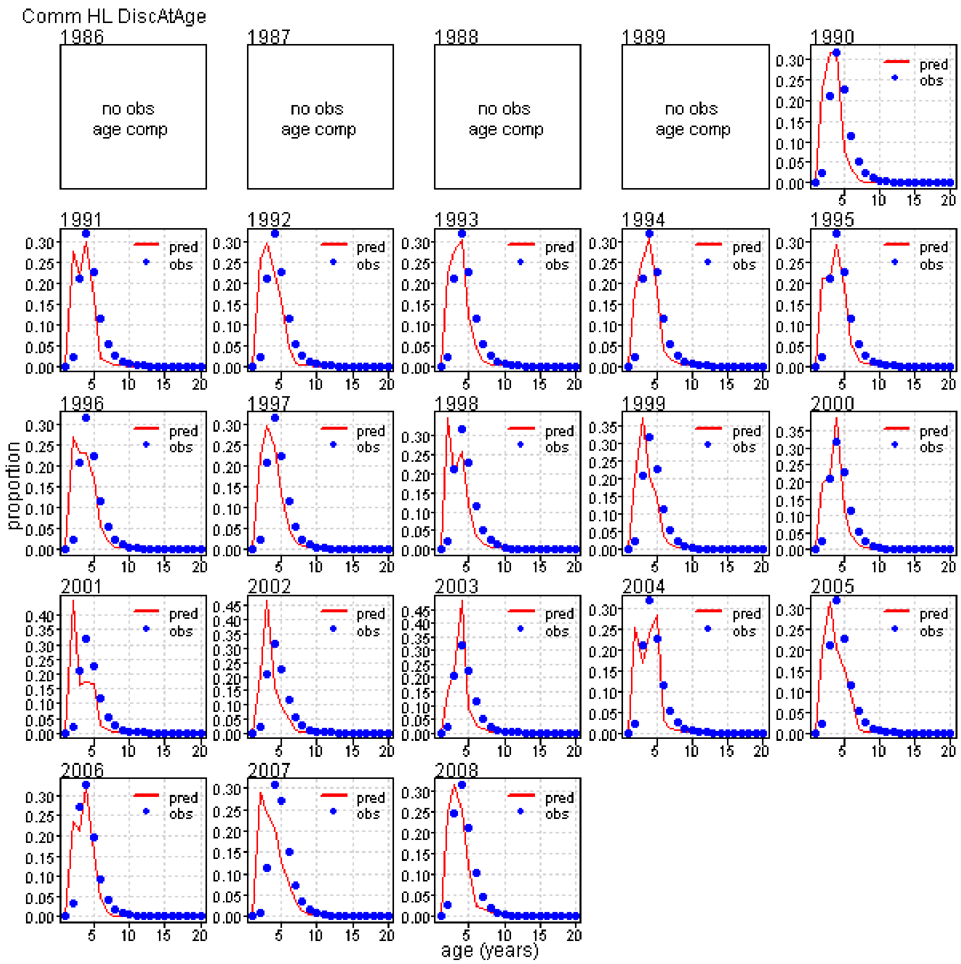


Figure 8.2.9. Fits to the direct observed catch-at-age for the commercial trap fleet. There were no observations in 1988 or 1990.

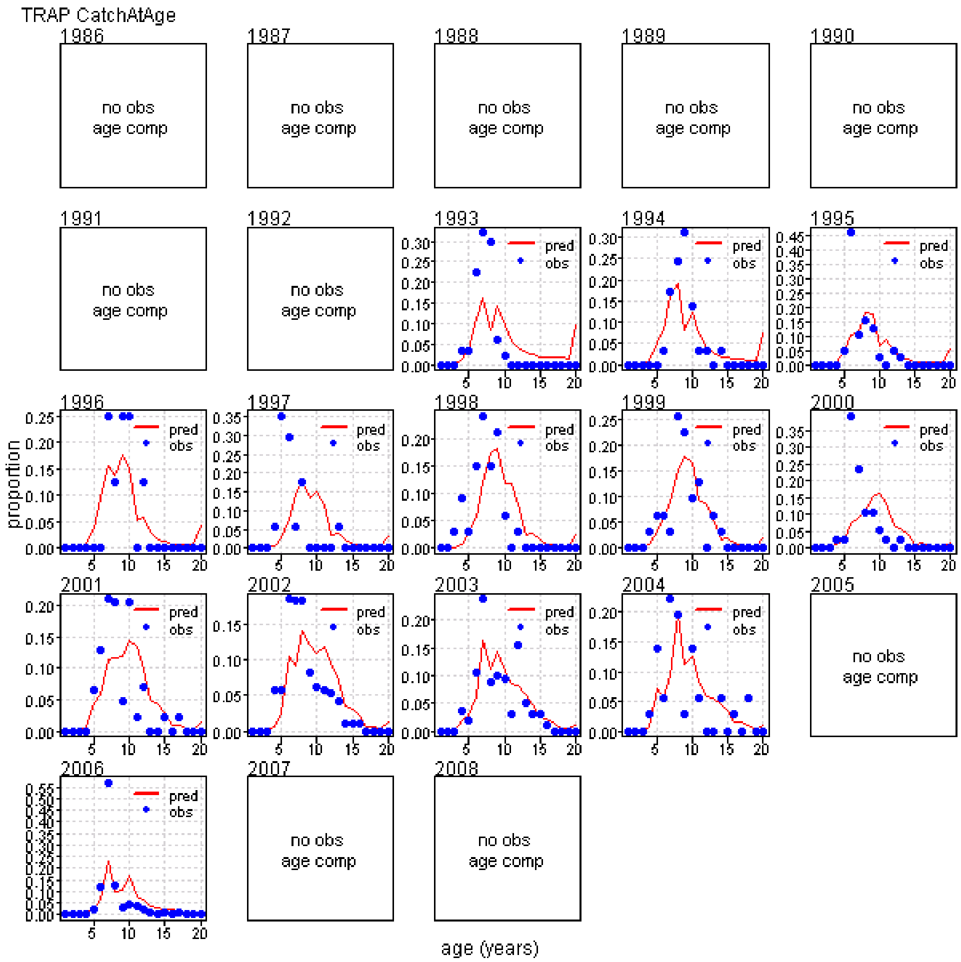


Figure 8.2.10. Red tide model Fits to the modeled discards-at-age for the commercial trap fleet. Note: there are no estimates before 1993 or after 2006.

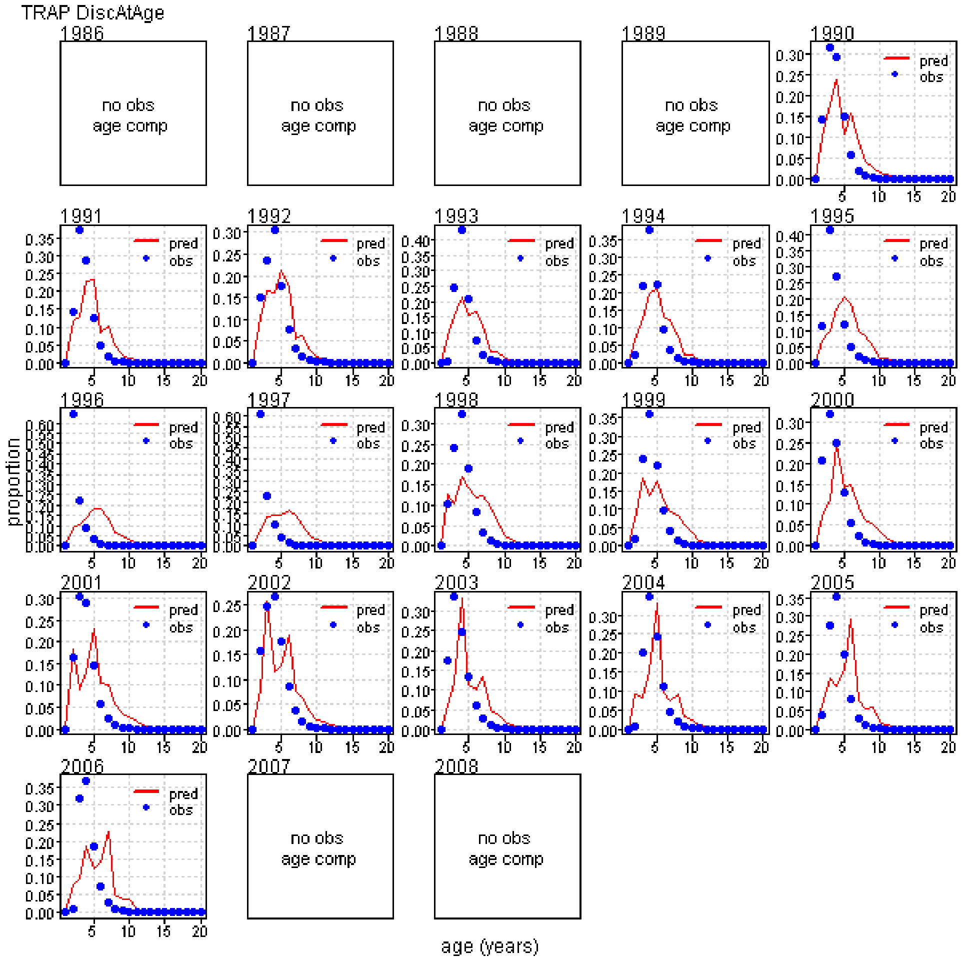


Figure 8.2.11. Red tide model fits to the direct observed catch-at-age for the recreational fleet. There were no observations in 1988 or 1990.

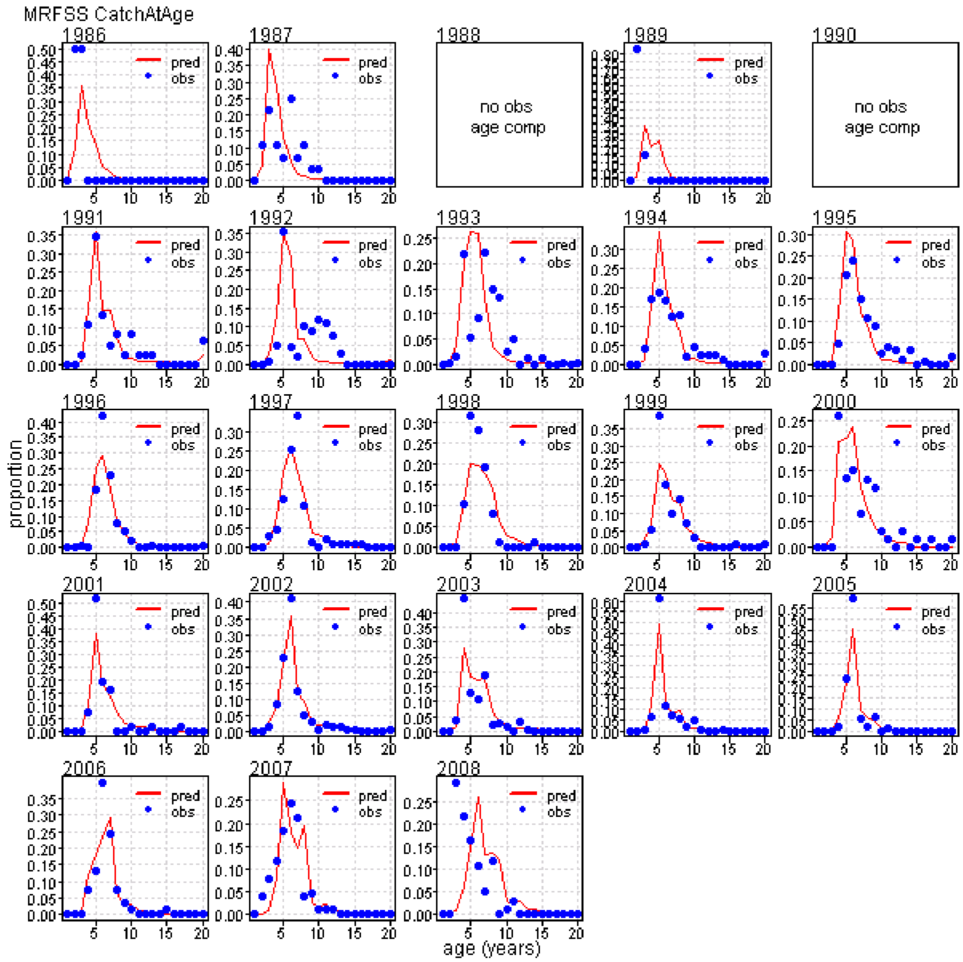


Figure 8.2.12. Red tide model fits to the observed discards-at-age for the recreational fleet.

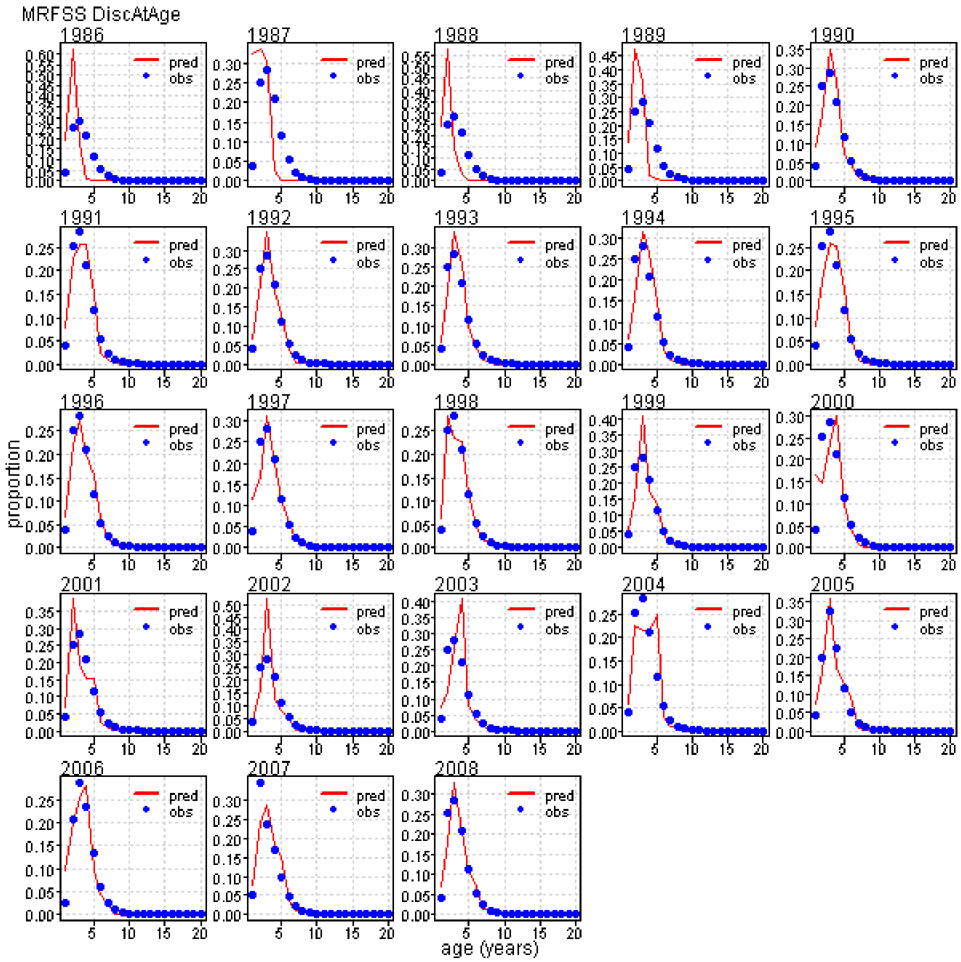


Figure 8.2.13. Selectivity-at-age by fleet. Note: these selectivity vectors apply to the total catch (landed + released).

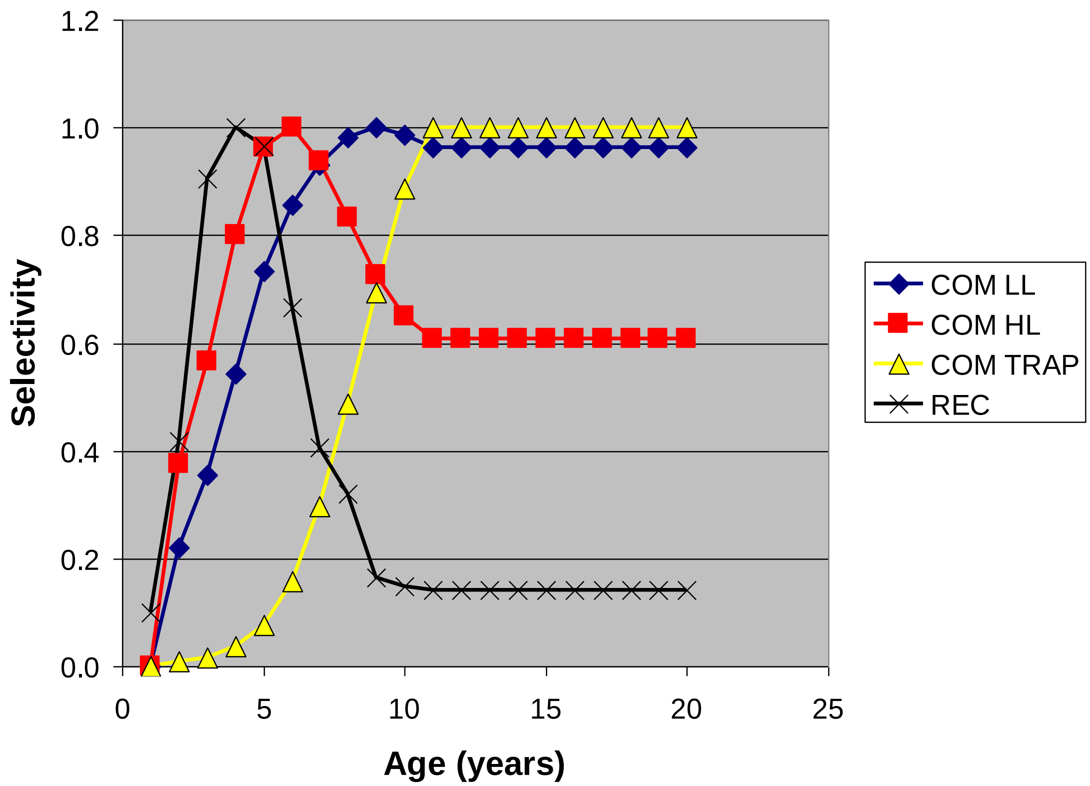


Figure 8.2.14. Directed Fishing mortality (landings + discards) by year and fleet.

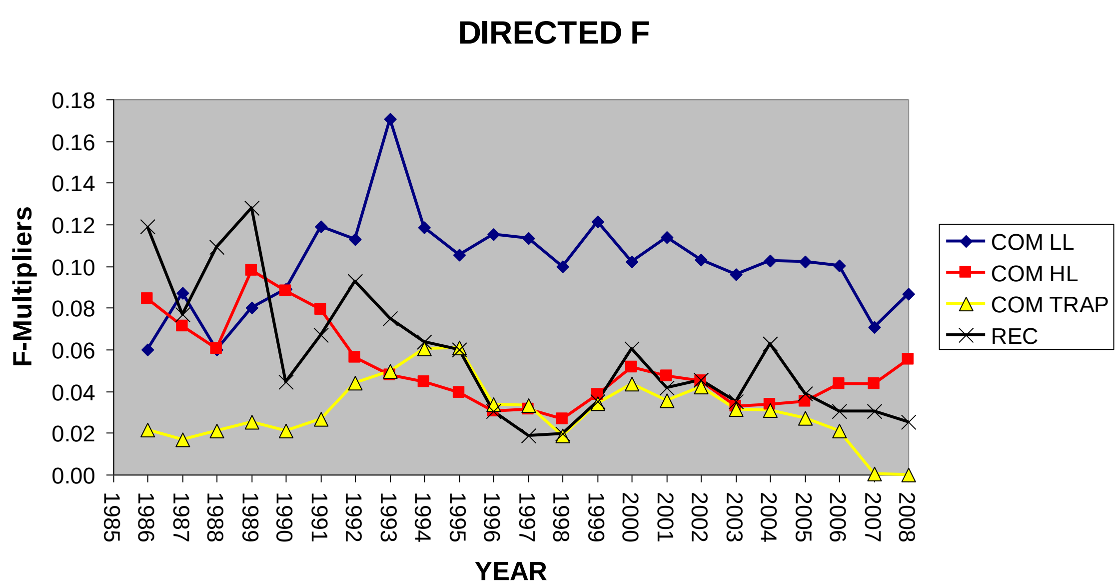


Figure 8.2.15. Discard Fishing mortality (landings + discards) by year and fleet.

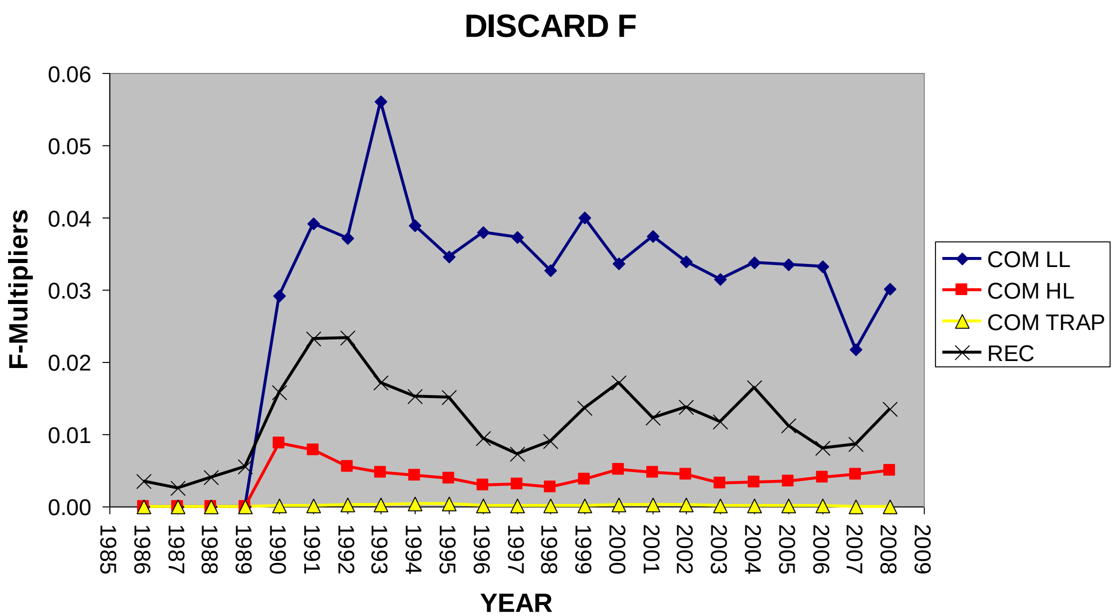


Figure 8.2.16. Apical fishing mortality rate by year for the central model and the red tide model.

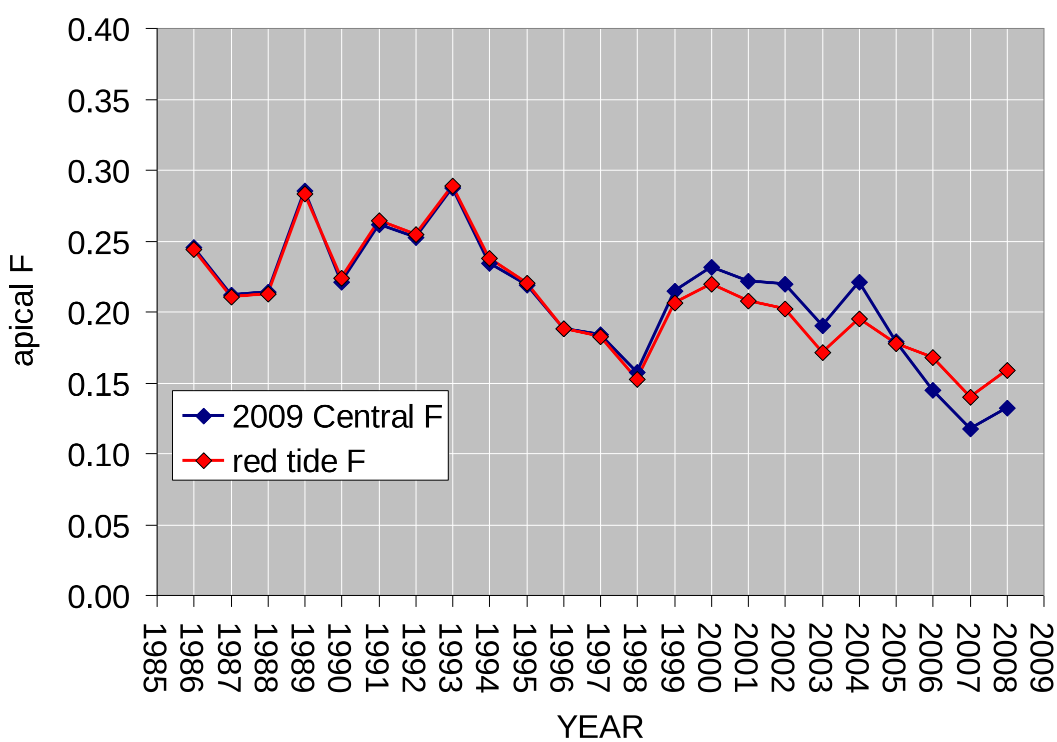


Figure 8.2.17. Number-at-age. The area of the circle is proportional to the number of fish at that age.

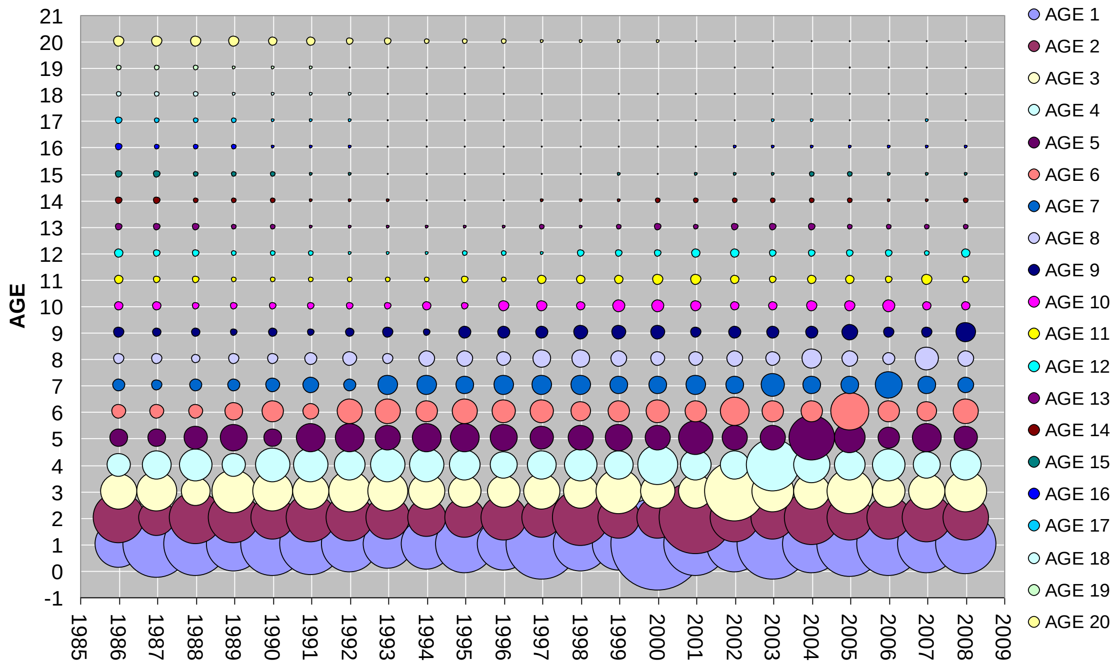
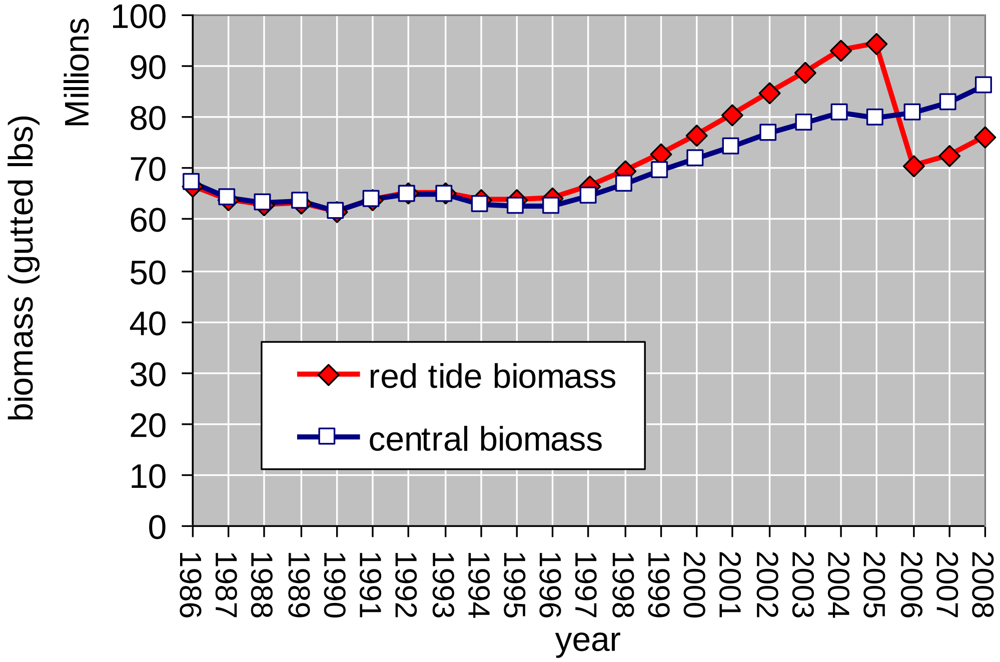


Figure 8.2.18. A. Total biomass for red tide and central model. B. Total numbers for both models.



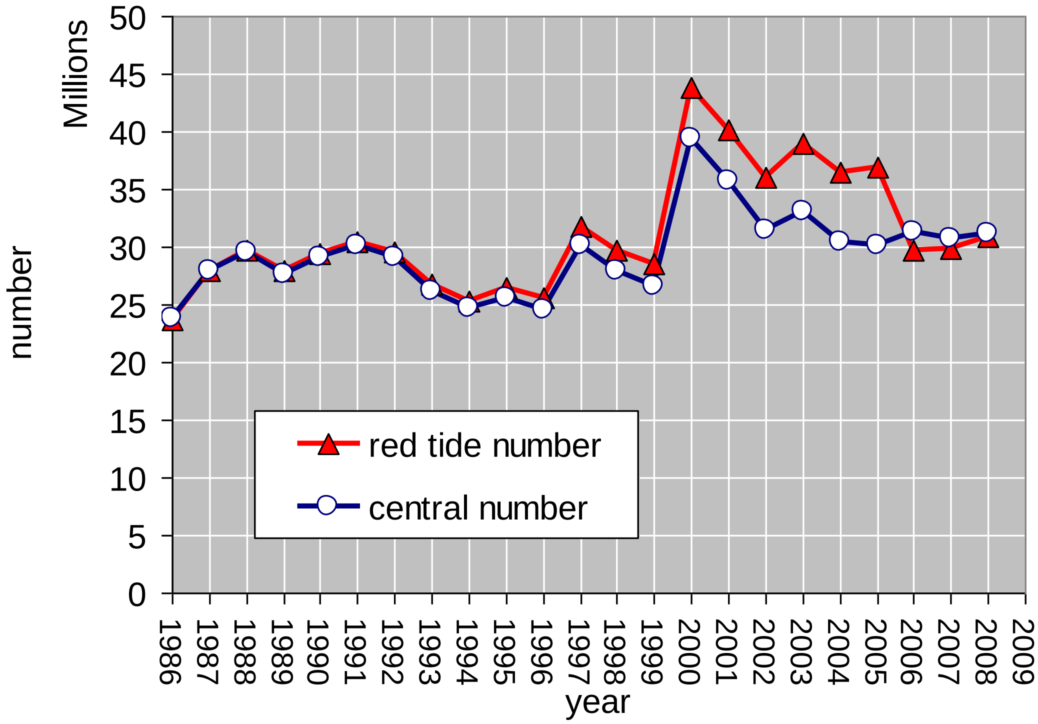


Figure 8.2.19. Red tide model 2009, 2009 Central model and 2006 Base model A) Spawning stock biomass (grams mature female gonad weight), B) Annual estimates of recruitment (Age 1). Large year classes occurred in 1996 and 1999. **C)** SSB as a function of SSB at maximum sustainable yield (SSB_{MSY}) and **D)** F as a fraction of F at maximum sustainable yield (F_{MSY}).

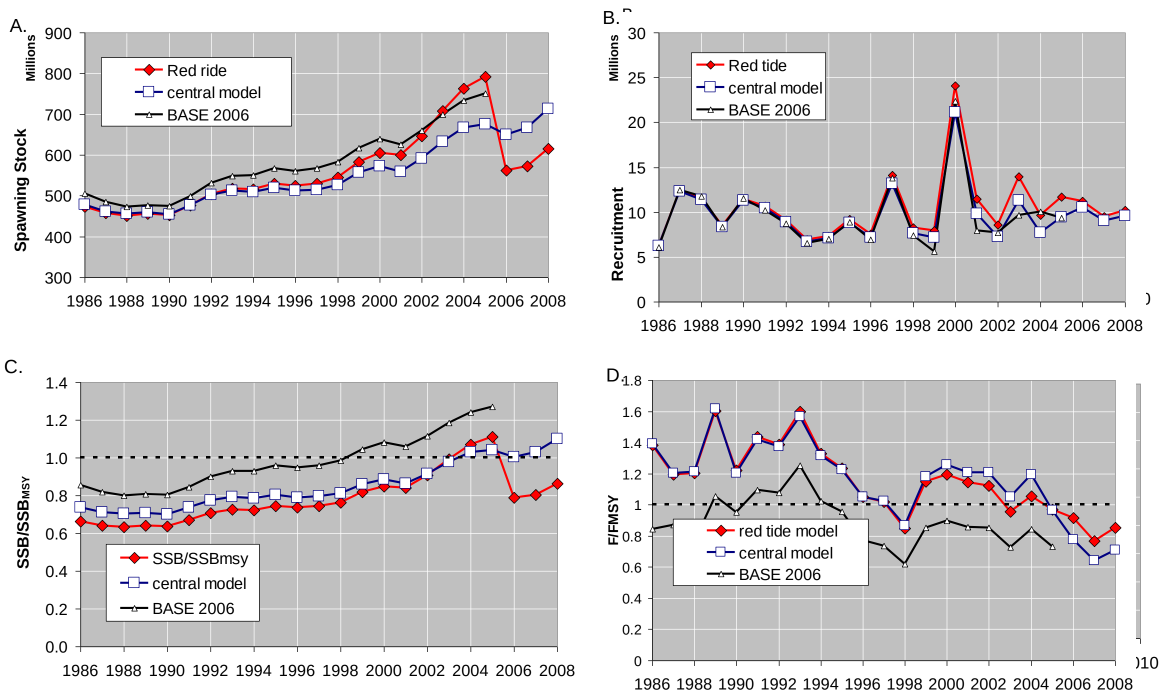


Figure 8.2.20. Red tide model Beverton and Holt stock recruitment relationship (bias-corrected). The dotted line in the average recruitment (1986-2008). Note that 'recruits' are age 1 fish, i.e. recruits in year 2000 were actually born in 1999.

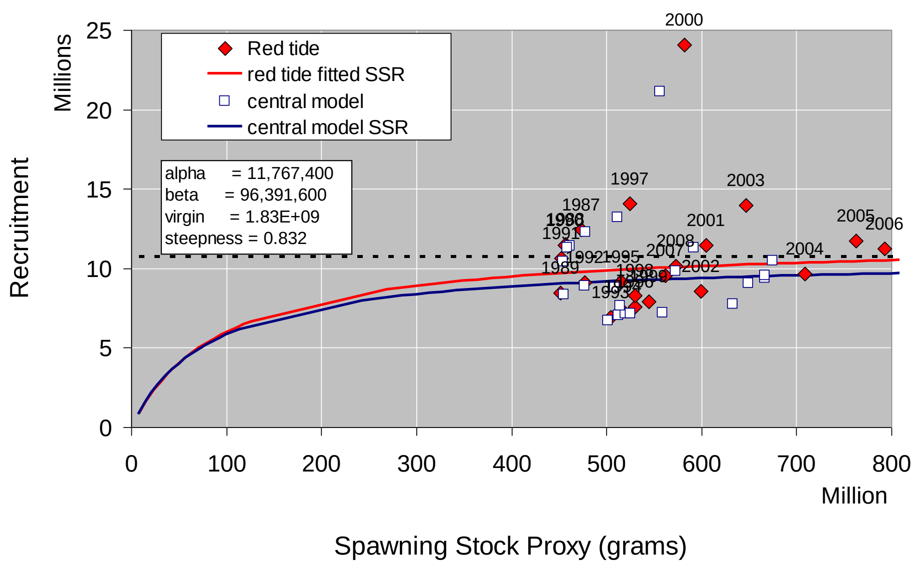
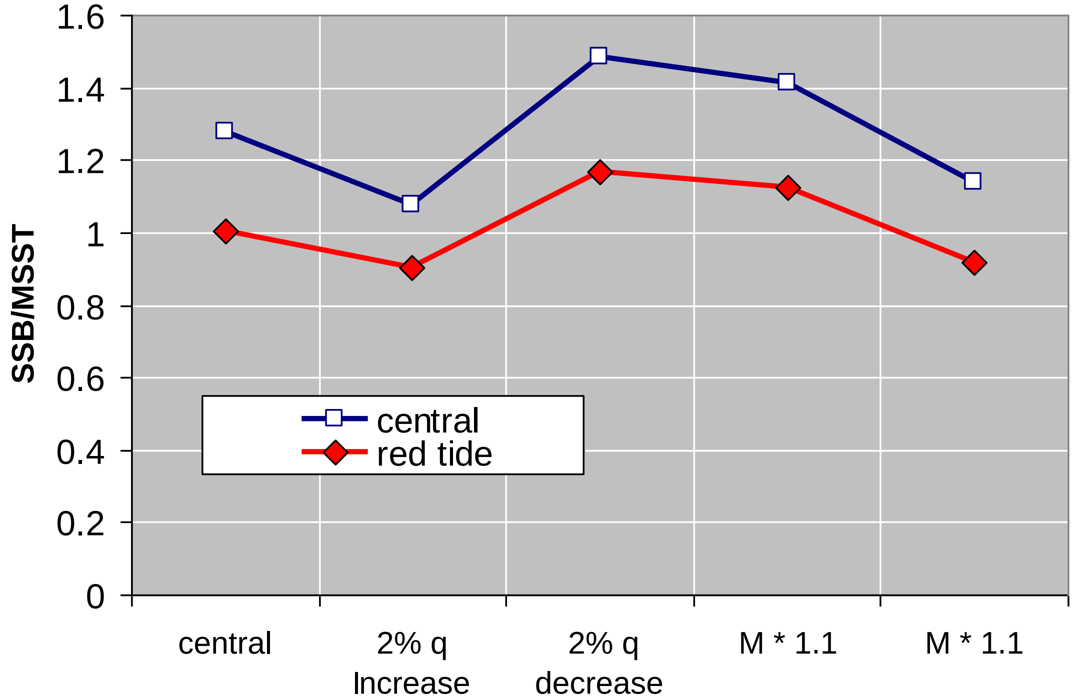


Figure 9.1. Comparison of central model and red tide model benchmarks. A. SSB/MSST B. F/Fmsy



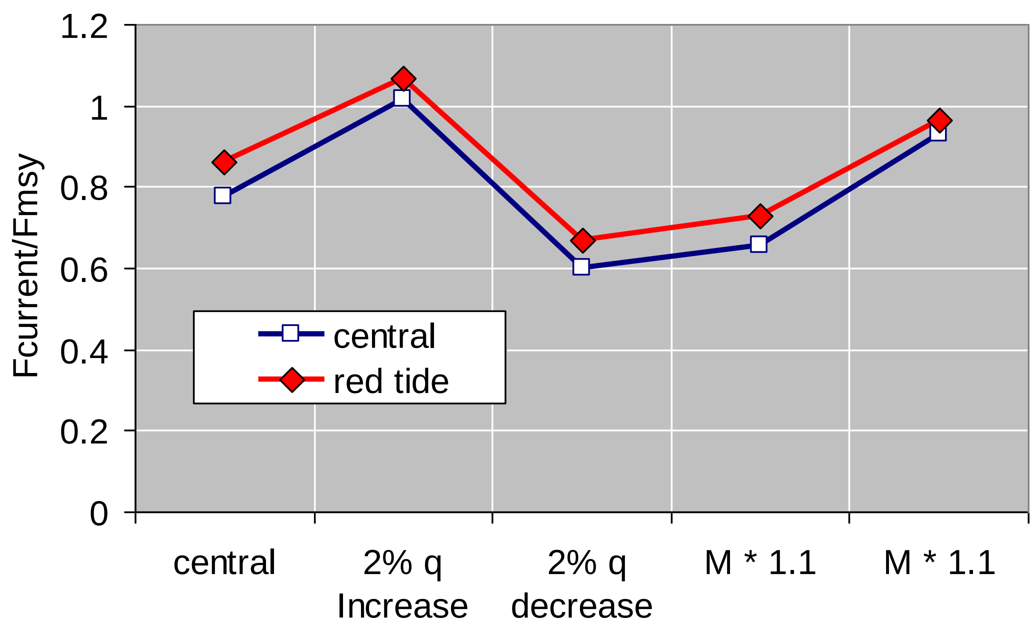


Figure 9.1. Status results control rule plot for the central model and the red tide model and the BASE 2006 model.

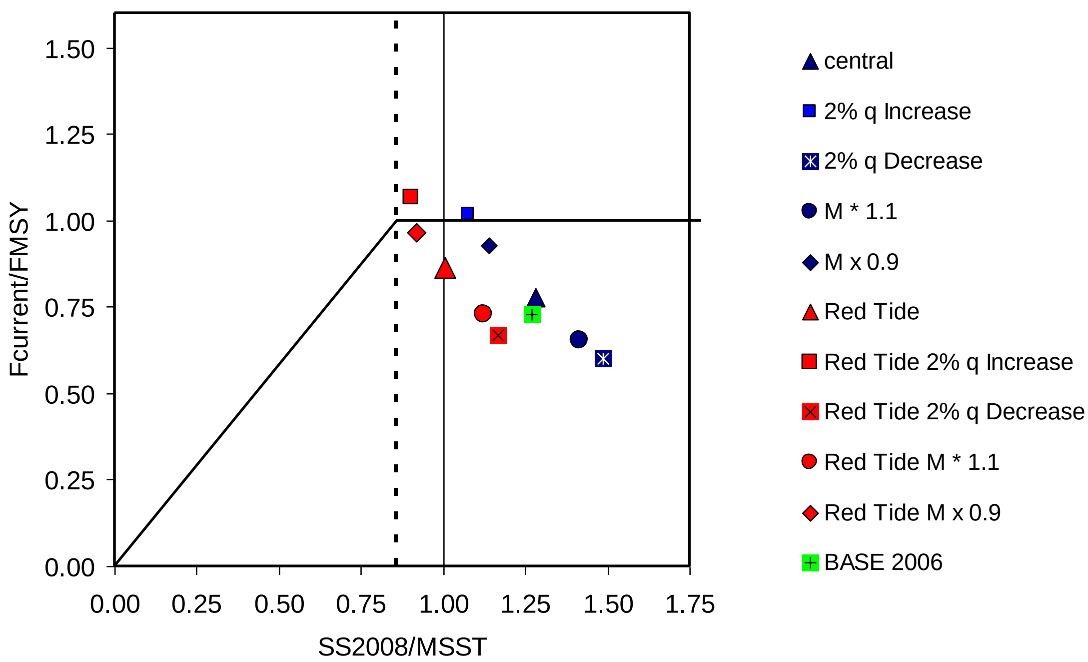


Figure 10.1. Median projected total biomass, landings, F/Fmsy and SSB/SSBmsy estimates from the central run for the four projected F scenarios. Note that SSBmsy in this these plots is not MSST.

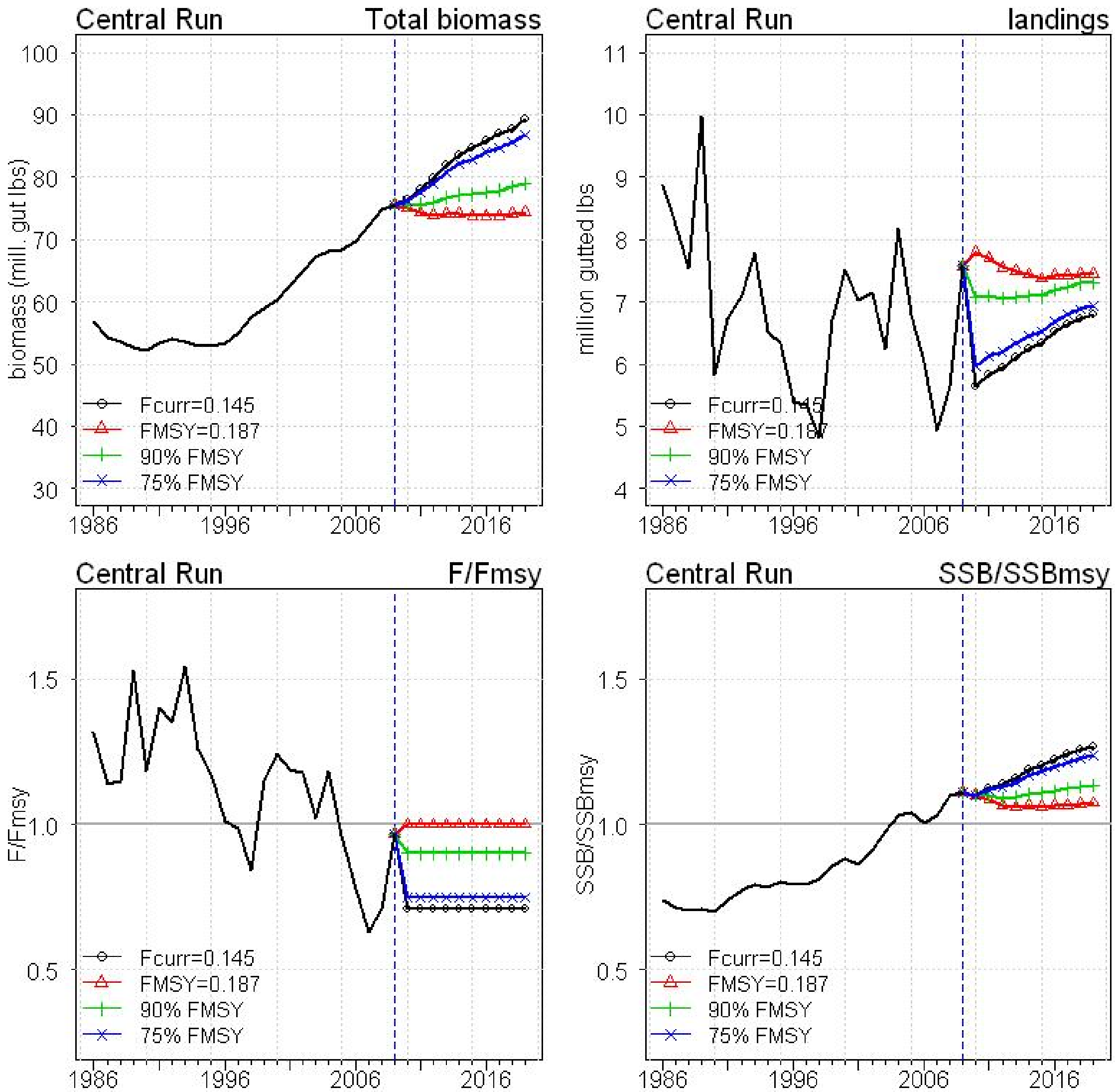


Figure 10.2. Median projected total biomass, landings, F/Fmsy and SSB/SSBmsy estimates from the red tide run for the four projected F scenarios.

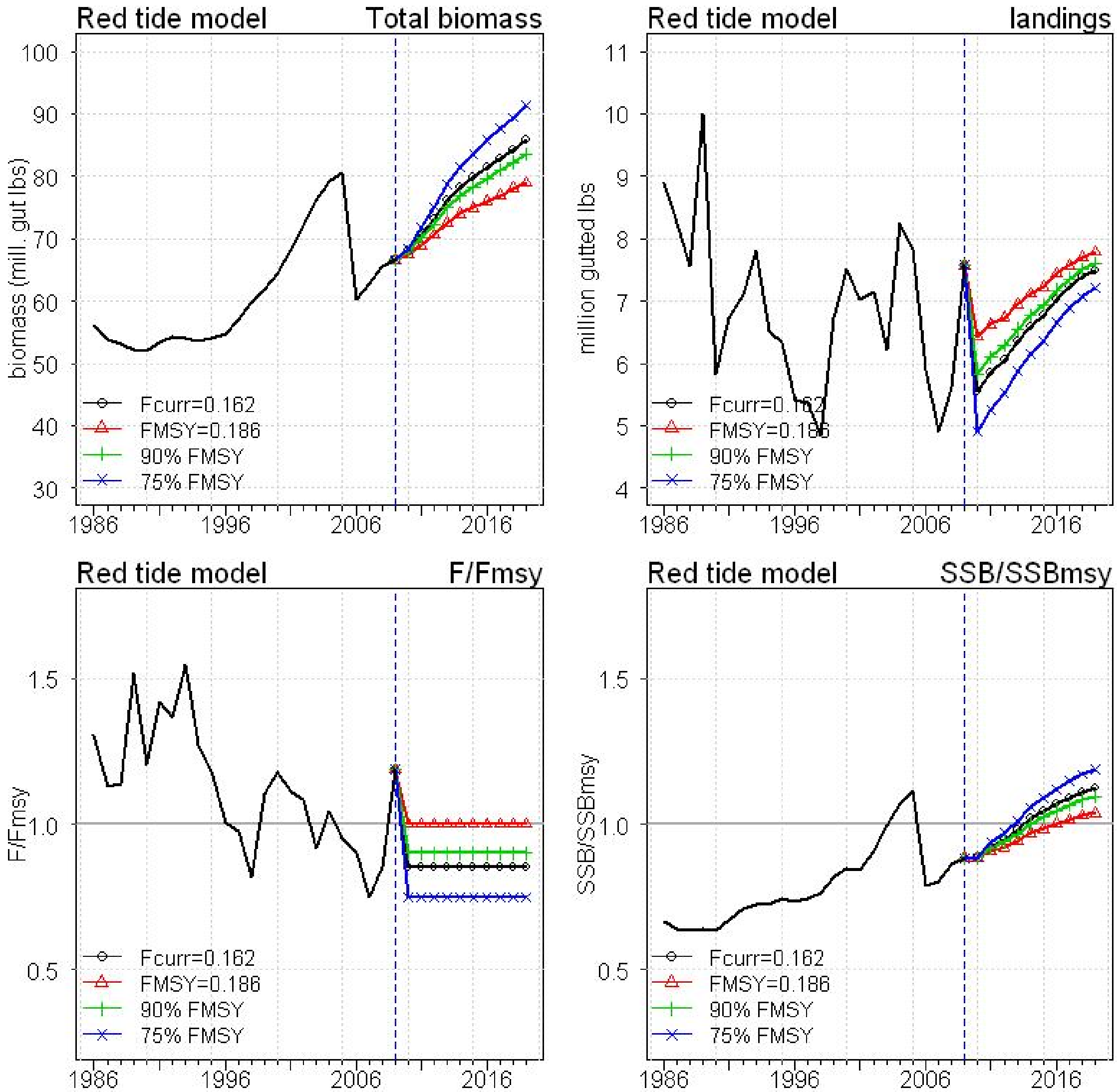


Figure 10.3. Median projected recruitments for central and red tide run for the four projected F scenarios.