SEDAR

SouthEast Data, Assessment, and Review

SEDAR 24
Stock Assessment Report

South Atlantic Red Snapper

October 2010

SEDAR
4055 Faber Place Drive, Suite 201
North Charleston, Sc 29405

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1 SEDAR Process Description

SouthEast Data, Assessment, and Review (SEDAR) is a cooperative Fishery Management Council process initiated in 2002 to improve the quality and reliability of fishery stock assessments in the South Atlantic, Gulf of Mexico, and US Caribbean. The improved stock assessments from the SEDAR process provide higher quality information to address fishery management issues. SEDAR emphasizes constituent and stakeholder participation in assessment development, transparency in the assessment process, and a rigorous and independent scientific review of completed stock assessments.

SEDAR is managed by the Caribbean, Gulf of Mexico, and South Atlantic Regional Fishery Management Councils in coordination with NOAA Fisheries and the Atlantic and Gulf States Marine Fisheries Commissions. Oversight is provided by a Steering Committee composed of NOAA Fisheries representatives: Southeast Fisheries Science Center Director and the Southeast Regional Administrator; Regional Council representatives: Executive Directors and Chairs of the South Atlantic, Gulf of Mexico, and Caribbean Fishery Management Councils; and Interstate Commission representatives: Executive Directors of the Atlantic States and Gulf States Marine Fisheries Commissions.

SEDAR is organized around three workshops. First is the Data Workshop, during which fisheries, monitoring, and life history data are reviewed and compiled. Second is the Assessment process, which is conducted via webinars, during which assessment models are developed and population parameters are estimated using the information provided from the Data Workshop. Third and final is the Review Workshop, during which independent experts review the input data, assessment methods, and assessment products. The completed assessment, including the reports of all 3 workshops and all supporting documentation, is then forwarded to the Council SSC for certification as 'appropriate for management' and development of specific management recommendations.

SEDAR workshops are public meetings organized by SEDAR staff and the lead Council. Workshop participants are drawn from state and federal agencies, non-government organizations, Council members, Council advisors, and the fishing industry with a goal of including a broad range of disciplines and perspectives. All participants are expected to contribute to the process by preparing working papers, contributing, providing assessment analyses, and completing the workshop report.

SEDAR Review Workshop Panels consist of a chair, three reviewers appointed by the Center for Independent Experts (CIE), and one or more SSC representatives appointed by each council having jurisdiction over the stocks assessed. The Review Workshop Chair is appointed by the council having jurisdiction over the stocks assessed and is a member of that council's SSC. Participating councils may appoint representatives of their SSC, Advisory, and other panels as observers.

2 Management Overview

Table 2.1. General Management Information

Species	Red Snapper (*Lutjanus campechanus*)
Management Unit	Southeastern US
Management Unit Definition	All waters within South Atlantic Fishery Management Council Boundaries
Management Entity	South Atlantic Fishery Management Council
Management Contacts SERO / Council	Jack McGovern/Myra Brouwer
Current stock exploitation status	Overfishing
Current stock biomass status	Overfished

Table 2.2. Specific Management Criteria

SEDAR 15 (2008) updated stock status information for red snapper. From Table 4.1 in SEDAR 15 (2008) Red Snapper projections V, dated March 19, 2009.

Quantity	Units	$F_{40\%}$ Proxy	$F_{30\%}$ Proxy	Status
F_{MSY}	y−1	0.104	0.148	–
SSB_{MSY}	1000 lb	17,863	13,283	–
D_{MSY}	1000 fish	39	54	–
Recruits at F_{MSY}	1000 fish	693	686	–
Y at 65% F_{MSY}	1000 lb	1984	2257	–
Y at 75% F_{MSY}	1000 lb	2104	2338	–
Y at 85% F_{MSY} Y	1000 lb	2199	2391	–
Y at F_{MSY}	1000 lb	2304	2431	–
MSST	1000 lb	16,470	12,247	–
F_{2006}/ F_{MSY}	–	7.67	5.39	Overfishing
SSB_{2006}/SSB_{MSY}	–	0.02	0.03	–
SSB_{2006}/MSST	–	0.03	0.04	Overfished

Source: Table 4.1 in Red Snapper Projections, V dated March 19, 2009.

Stock Rebuilding Information

Prior to 2006, red snapper was listed as overfished. As such, Amendment 4 (regulations effective January 1992) implemented a rebuilding plan ≤ 15 years beginning in 1991. Red snapper's overfished status was changed to unknown from overfished in 2006 because the previous pre-SFA determination of overfished for this stock was based on SPR, which is inadequate to determine the overfished status because it is not biomass-based and therefore does not meet criteria specified in the SFA. Based on the results from SEDAR 15 (2008) red snapper is currently listed as overfished and a new rebuilding plan is being developed in Amendment 17A to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region.

Table 2.3. Stock projection information.

(This provides the basic information necessary to bridge the gap between the terminal year of the assessment and the year in which any changes may take place or specific alternative exploitation rates should be evaluated)

Requested Information	Value
First Year of Management	2011
Projection Criteria during interim years should be based on (e.g., exploitation or harvest)	Fixed Exploitation; Modified Exploitation; Fixed Harvest*
Projection criteria values for interim years should be determined from (e.g., terminal year, avg of X years)	Average of previous 3 years

*Fixed Exploitation would be $F=F_{MSY}$ (or $F<F_{MSY}$) that would rebuild overfished stock to B_{MSY} in the allowable timeframe. Modified Exploitation would be allow for adjustment in $F<=F_{MSY}$, which would allow for the largest landings that would rebuild the stock to B_{MSY} in the allowable timeframe. Fixed harvest would be maximum fixed harvest with $F<=F_{MSY}$ that would allow the stock to rebuild to B_{MSY} in the allowable timeframe.

Table 2.4. Quota Calculation Details

If the stock is managed by quota, please provide the following information

Quota Detail	Value
Current Quota Value	N/A
Next Scheduled Quota Change	N/A
Annual or averaged quota?	N/A
If averaged, number of years to average	N/A
Other?	N/A

Table 2.5. Regulatory and FMP History

Description of Action	FMP/Amendment	Effective Date
4” Trawl mesh size and 12” TL minimum size limit	Snapper Grouper FMP	8/31/1983
Prohibit trawls	Snapper Grouper Amend 1	1/12/1989
Required permit to fish for, land or sell snapper grouper species	Snapper Grouper Amend 3	1/31/1991
Prohibited gear: fish traps except bsb traps north of Cape Canaveral, FL; entanglement nets; longline gear inside 50 fathoms; bottom longlines to harvest wreckfish; powerheads and bangsticks in designated SMZs off S. Carolina. Established 20” TL minimum size and a 10 snapper/person/day bag limit, excluding vermilion snapper, and allowing no more than 2 red snappers.	Snapper Grouper Amend 4	1/1/1992
Oculina Experimental Closed Area.	Snapper Grouper Amend 6	6/27/1994
Limited entry program; transferable permits and 225 lb non-transferable permits.	Snapper Grouper Amend 8	12/14/1998
Vessels with longline gear aboard may only possess snowy grouper, warsaw grouper, yellowedge grouper, misty grouper, golden tilefish, blueline tilefish, and sand tilefish.	Snapper Grouper Amend 9	2/24/1999
Approved definitions for overfished and overfishing. MSST = [(1-M) or 0.5 whichever is greater]*B_{MSY}. MFMT = F_{MSY}	Snapper Grouper Amend 11	12/2/1999
Extended for an indefinite period the regulation prohibiting fishing for and possessing snapper grouper species within the *Oculina* Experimental Closed Area.	Snapper Grouper Amend 13A	4/26/2004
Prohibit harvest and possession of red snapper from January 4, 2010 to June 2, 2010. Can be extended for 186 days.	Red Snapper Interim Rule	12/4/2009

Table 2.6. Annual Regulatory Summary [1]

	Commercial Fishery Regulations				Recreational Fishery Regulations				
Effective Date	Size Limit	Trip Limit	Season	Catch Limit	Size Limit	Possession Limit	Season	Catch Target	Both/ Other
8/31/1983	12" TL				12" TL				
1/1/1992	20" TL				20" TL				
1/1/1992						10 snapper/person/day bag limit, excluding vermilion snapper, and allowing no more than 2 red snappers			
1/2/2010	Commercial and recreational harvest and possession prohibited from 1/4/10 to 6/2/10, and can be extended for 186 days.								

References

Manooch, C.S., III, J.C. Potts, D.S. Vaughan, and M.L. Burton. 1998. Population assessment of the red snapper from the southeastern United States. Fisheries Research. 38:19-32.

SEDAR 15. 2008. Stock Assessment Report 1 (revised March, 2009). South Atlantic Red Snapper. Available from the SEDAR website: www.sefsc.noaa.gov/sedar/.

3 Assessment History & Review

In the early 1990s, a series of reports were prepared by the SAFMC Plan Development Team (in 1990) and by the NOAA-Beaufort Reef Fish Team (in 1991 and 1992), intended for prioritizing stocks for assessment. Those reports described “snapshot” analyses conducted on several snapper-grouper species, including red snapper. The analyses included the estimation of SPR (spawning potential ratio) based on a single year of data.

The first formal assessment of red snapper in the U.S. Atlantic was conducted by Manooch et al. (1998; abstract below). In that assessment, two age-structured models were used: an un-calibrated separable VPA and FADAPT. The results from FADAPT were downplayed because the model was calibrated to an abundance index derived from MARMAP chevron trap data, which had very low sample sizes. Manooch et al. (1998) concluded that “the status is less than desirable, but does appear to be responsive to recent management actions.” They found that the fishing mortality rate (F) should be reduced by 33% to 68%, depending on the natural mortality rate and desired SPR. Prior to publication, a report of that assessment was submitted to the SAFMC. After publication, the results were revisited by Potts and Brennan (2001) in a trends report, also prepared for the SAFMC. Potts and Brennan (2001) repeated the findings of Manooch et al. (1998), but suggested a broader range of reduction in F, from 30% to 80%.

This stock of red snapper was first assessed through the SEDAR process in 2007 (SEDAR review held Jan. 28 − Feb. 1, 2008). That assessment applied a statistical catch-age model using data through 2006 (SEDAR 15, 2008). Because the spawner-recruit parameter of steepness was not estimable (hit its upper bound), the SEDAR review panel recommended using proxies for MSY-related benchmarks based on 40%SPR. Relative to those benchmarks, the assessment found that since the 1960s, overfishing had been occurring and the stock had been overfished. In the terminal year, the assessment estimated F2006/F40%=7.7 and SSB2006/SSBF40%=0.03. Although quantitative results varied, these qualitative results of overfishing a depleted stock were consistent across all catch-age model configurations examined during and after the assessment process (~40 sensitivity runs), as well as with an alternative model formulation (surplus-production model). SEDAR24−AW−012.

References

Manooch, C.S., III, J.C. Potts, D.S. Vaughan, and M.L. Burton. 1998. Population assessment of the red snapper from the southeastern United States. Fisheries Research 38:19−32.

Potts, J.C. and K. Brennan. 2001. Trends in catch data and estimated static SPR values for fifteen species of reef fish landed along the southeastern United States. Report prepared for SAFMC.

SEDAR 15. 2008. Stock assessment report (SAR 1) South Atlantic red snapper. (Revised March, 2009) Available at http://www.sefsc.noaa.gov/sedar/

Abstract from Manooch et al. (1998): Changes in the age structure and population size of red snapper, *Lutjanus campechanus*, from North Carolina through the Florida Keys were examined using records of landings and size frequencies of fish from commercial, recreational, and headboat fisheries from 1986 to 1995. Population size in numbers at age was estimated for each year by applying separable virtual population analysis (SVPA) to the landings in numbers at age. SVPA was used to estimate annual, age-specific fishing mortality (*F*) for four levels of natural mortality (*M*=0.15, 0.20, 0.25, and 0.30). Although landings of red snapper for the three fisheries have declined, minimum fish size regulations have also resulted in an increase in the mean size of red snapper landed. Age at entry and age at full recruitment were age-1 for 1986-1991, compared with age-2 and age-6, respectively, for 1992-1995. Levels of mortality from fishing (*F*) ranged from 0.31 to 0.69 for the entire period. Spawning potential ratio (SPR) increased from 0.09 to 0.24 (M=0.25) from 1986 to 1995. The SPR level could be improved with a decrease in *F*, or an increase in age at entry to the fisheries. The latter could be enhanced now if fishermen, particularly recreational fishermen, comply with minimum size regulations.

4 Regional Maps

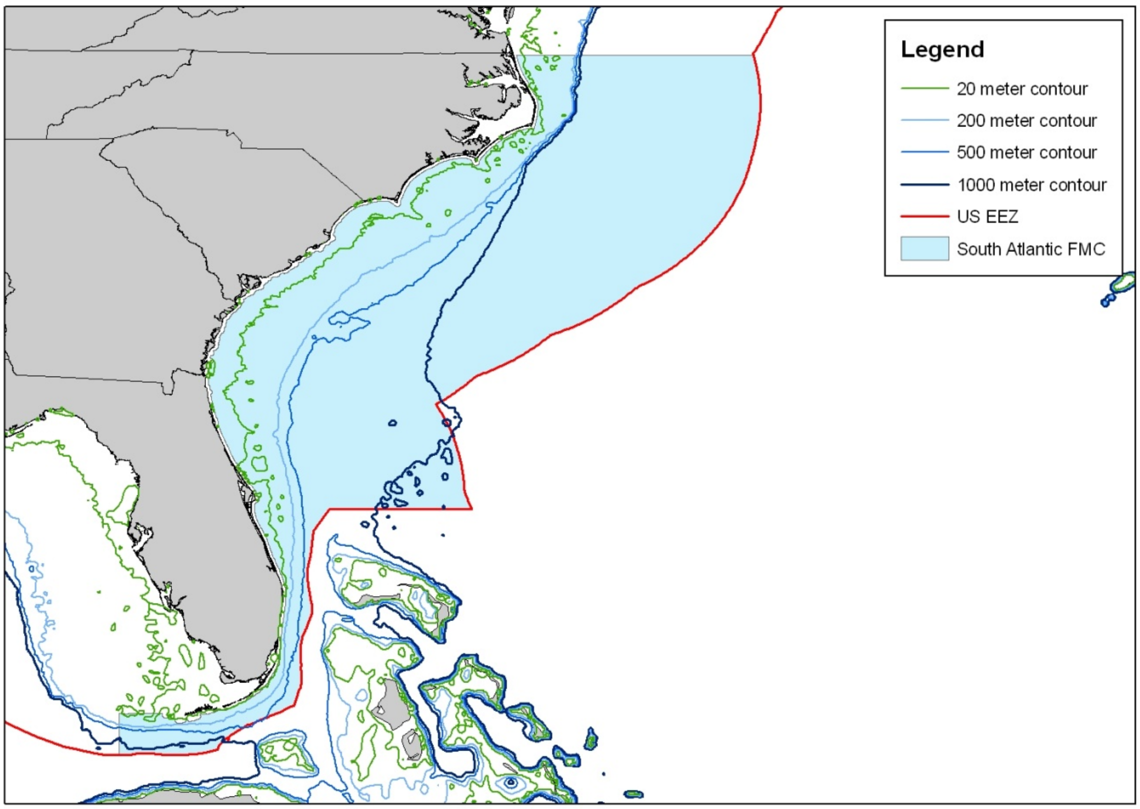


Figure 4.1. South Atlantic Fishery Management Council and EEZ boundaries.

5 Assessment Summary Report

The Summary Report provides a broad but concise view of the salient aspects of the 2010 red snapper stock assessment (SEDAR 24). It recapitulates: (a) the information available to and prepared by the Data Workshop (DW); (b) the application of those data, development and execution of one or more assessment models, and identification of the most reliable model configuration as the base run by the Assessment Workshop (AW); and (c) the findings and advice determined during the Review Workshop.

Stock Status and Determination Criteria

Point estimates from the base model indicate that the U.S. southeast stock of red snapper (*Lutjanus campechanus)* is currently overfished and is experiencing overfishing.

Estimated time series of stock status (SSB/MSST) shows decline until the late 1980s, and then some increase since the mid-1990s (Figure 5.8a). The increase in stock status appears to have been initiated by the 1992 management regulations, and then perhaps reinforced by strong recruitment events. Base-run estimates of spawning biomass have remained below MSST throughout most of the time series. Current stock status was estimated in the base run to be $SSB_{2009}/MSST = 0.09$. Uncertainty from the MCB analysis suggests that the estimate of overfished status (i.e., SSB < MSST) is robust. Age structure estimated by the base run shows fewer older fish than the (equilibrium) age structure expected at MSY. However, in the terminal year (2009), ages 3 and 4 approach the MSY age structure as a result of recent strong year classes.

The estimated time series of F/F_{MSY} suggests that overfishing has been occurring throughout most of the assessment period (Figure 5.8a). Current fishery status in the terminal year, with current F represented by the geometric mean from 2007–2009, is estimated by the base run to be $F_{2007\text{–}2009}/F_{\mathrm{MSY}} = 4.12$. This estimate indicates current overfishing and appears robust across MCB trials. It might, however, be subject to some retrospective error.

Table 5.1. Summary of stock status determination criteria. Estimates of yield do not include discards. Rate estimates (F) are in units of y^{-1}; status indicators are dimensionless; and biomass estimates are in units of metric tons or pounds, as indicated. Spawning stock biomass (SSB) is measured by total gonad weight of mature females.

Criteria	Recommended Values from SEDAR 24	
	Definition	Value
M (Instantaneous natural mortality; per year)	Average of Lorenzen M (if used)	0.08
F_{2009} (per year)	Apical Fishing mortality in 2009	0.9076
$F_{current}$ (per year)	Geometric mean of the fishing mortality rates in 2007 - 2009	0.73*
F_{MSY} (per year)	F_{MSY}	0.178
B_{MSY} (metric tons)	Biomass at MSY	13632
SSB_{2009} (metric tons)	Spawning stock biomass in 2009	13
SSB_{MSY} (metric tons)	SSB_{MSY}	156
MSST (metric tons)	(1-M)*SSB_{MSY}	144
MFMT (per year)	F_{MSY}	0.178
MSY (1000 pounds)	Yield at MSY	1842
OY (1000 pounds)	Yield at F_{OY}	OY (65% F_{MSY})= 1712 OY (75% F_{MSY})= 1780 OY (85% F_{MSY})= 1821
F_{OY} (per year)	F_{OY} = 65%,75%, 85% F_{MSY}	65% F_{MSY}= 0.115 75% F_{MSY}= 0.133 85% F_{MSY}= 0.151
Biomass Status	SSB_{2009}/MSST	0.09
Exploitation Status	$F_{current}/F_{MSY}$	4.12

*$F_{current}$ was adjusted down for the projections to reflect the moratorium

Species Distribution

Red snapper are found in the Gulf of Mexico and eastern coast of the North, Central, and northern South America. They extend northward to Massachusetts in North America although they are rare north of the Carolinas.

Stock Identification and Management Unit

No new evidence is available that suggests the Atlantic and Gulf should be managed as a single stock, and no new evidence of regional separation within the Atlantic is available. The Life History group recommended that the Atlantic be recognized as a single stock. The Gulf of Mexico is currently divided into eastern and western gulf components, but the sub-stocks are managed as a single unit (SEDAR7).

Stock Life History

- Tagging studies do not provide any new evidence that suggests movement between Gulf of Mexico and Atlantic stocks, other than one fish tagged off Pensacola, FL, and recaptured off St. Augustine, FL (Burns et al. 2008). Fishermen have suggested that seasonal migration of fish occurs among regions of the South Atlantic. Telemetry studies are recommended to investigate movement of fish along the Atlantic coast.
- The DW recommended using the observed maximum age of 54 years. Although there were few fish over the age of 20, two fish were harvested from the South Atlantic over 50 years old and the maximum age observed in the Gulf of Mexico was 57.
- The DW recommended using the scaled age-specific Lorenzen natural mortality estimate for age 1+ since this is a commonly used method to estimate natural mortality.
- Based on the results of growth model comparisons between sexes, the life history workgroup recommended that a sex pooled growth model be used in the assessment model.
- Based on the plots of fishery specific growth models for Atlantic red snapper, the life history workgroup recommended developing a fishery pooled growth curve for Atlantic red snapper.
- Red snapper do not change sex during their lifetime (gonochorism).

Assessment Methods

Four different models were discussed for red snapper during the Assessment Workshop (AW): the Beaufort statistical catch-age model (BAM), virtual population analysis (VPA), stochastic stock reduction analysis (SSRA) and surplus-production models (ASPIC). The BAM was selected at the AW to be the primary assessment model. This report focuses on the BAM, as well as surplus-production models. In addition, catch curve analysis was used to examine mortality (SEDAR-24-AW07). An SSRA application received preliminary examination by the AW panel, but was not completed in time for this report.

The primary model in this assessment was the Beaufort statistical catch-age model (BAM). The model was implemented with the AD Model Builder software (ADMB Foundation 2009), and its structure and equations are detailed in SEDAR-24-RW-01. In essence, a statistical catch-age model simulates a population forward in time while including fishing processes (Quinn and Deriso 1999; Shertzer et al. 2008*a*). Quantities to be estimated are systematically varied until characteristics of the simulated populations match available data on the real population. Statistical catch-age models share many attributes with ADAPT-style tuned and untuned VPAs.

Assessment Data

The catch-age model included data from four fleets that caught southeastern U.S. red snapper: commercial lines (primarily handlines), commercial dive, recreational for-hire (headboats and charterboats), and recreational private boats. The model was fit to data on annual landings (in units of 1000 lb whole weight for commercial fleets, 1000 fish for recreational fleets), annual discard mortalities (in units of 1000 fish for commercial lines and recreational fleets), annual length compositions of landings, annual age compositions of landings, annual length compositions of discards, three fishery dependent indices of abundance (commercial lines, headboat, and headboat discards). Not all of the above data sources were available for all fleets in all years. Data used in the model are tabulated in the DW report and in the assessment report (Section III, part 2; also Figure 5.1 and 5.5 of the summary report).

Release Mortality

A special workgroup was convened to discuss release (discard) mortality for red snapper. Discards were assumed to have fleet-specific mortality probabilities, as suggested by the DW (commercial lines, 0.48; for-hire, 0.41; private, 0.39). Annual discard mortalities, as fit by the model, were computed by multiplying total discards (tabulated in the DW report) by the fleet-specific release mortality probability. For for-hire and private fleets, discard time series were assumed to begin in 1983, with the start of the 12-inch size limit; for the commercial lines fleet, discards were modeled starting in 1992 with the 20-inch size limit. Discards from the commercial dive fleet were assumed negligible and not modeled. Discard mortalities by sector are Figure 5.2 of this summary report.

Landings Trends

See Figure 5.1 panels *a-d* for detail on landings trends. Commercial line landings peaked in the later 1960s with a general decline until 2009. Commercial dive landings peaked in 2002 and were low compared to other sectors. Private recreational landings peaked in the late 1980s, with a generally declining but variable pattern after that time. For-hire landings (headboats + charterboats) peaked in the late 1960s. The historic recreational (1955-1980 private and for-hire fleets) landings were estimated using ratios to the commercial lines landings, as recommended by a special working group that was convened to advise the DW panel.

Fishing Mortality Trends

The estimated fishing mortality rates (F) increased through the 1970s, and since then have been quite variable. Recreational fleets dominate the total F (Table 5.4, Figure 5.3).

Stock Abundance and Biomass Trends

In general, estimated abundance at age shows a truncation of the older ages. Total estimated abundance at the end of the assessment period shows sharp increase, reaching levels not seen since the late 1970s, albeit with a quite different age structure. This increase appears to be driven by recent recruitment. Annual number of recruits is shown in Table 5.6 and Figure 5.6 below. Notably strong year classes (age-1 fish) were predicted to have occurred in 2006 and 2007.

Estimated biomass at age follows a similar pattern as abundance at age. Total biomass and spawning biomass show similar trends - general decline until the mid-1990s, and general increase since then but with a downturn at the end of the time series.

Projections

Projection scenario 1, in which $F = 0$, predicted the chance of rebuilding to reach at least 50% in the year 2025 (Figure 5.9). If used to define the rebuilding time frame, this result plus one generation time (22 years) would suggest that rebuilding should occur in 2047 (or by the start of 2048). The projection with F at F_{current} predicted the stock to remain at low levels. It suggests further that the F_{current} is not sustainable without consistently higher than expected recruitment, as has occurred near the end of the assessment period. Projections with F at 65%, 75%, 85%, or 100% of F_{MSY} predicted increased biomass and landings. The continued moratorium projection also predicted increased biomass, but suggested that the moratorium alone is insufficient for stock recovery. The F_{rebuild} projections did allow stock recovery (by design) in the year 2047.

Scientific Uncertainty

Although qualitative results were robust, uncertainties remain, as in all assessments. Several sources of uncertainty are discussed below

This assessment lacked a reliable fishery independent index of abundance. Thus, the fishery dependent indices were the primary source of information on relative abundance. In general, fishery independent indices are preferable. Nonetheless, steps were taken to make the available fishery dependent indices as reliable as possible (using trip selection and standardization methods to develop the indices, and using time-varying catchability to fit them). In addition, the headboat index was developed from a multispecies fishery, which would tend to minimize effects of targeting that could otherwise occur with fleets focused primarily on the species of interest. A new fishery independent sampling program was initiated in the summer of 2010, and this new data source is expected to be available for the next benchmark assessment.

Compared to other fishes, the South Atlantic and Gulf of Mexico stocks of red snapper demonstrate rapid body growth and early maturity relative to their potential longevity (Charnov 1993; Beverton 1992). This could indicate that life-history characteristics, such as growth and maturity schedules, have adapted over time in response to exploitation. Resource managers might wish to consider possible evolutionary effects of fishing (Dunlop et al. 2009).

A source of uncertainty not modeled here is the aggregation of headboats and charterboats into the for-hire fleet, which was recommended by the DW. It was recognized by the AW that charterboats generally fish in deeper water than headboats. Depth of the entire for-hire fleet was accounted for when estimating discard mortality rates, by aggregating the depth distributions of the two components (headboats and charterboats) weighted by their respective landings. However, if selectivities differ between headboats and charterboats, the estimated selectivity of the for-hire fleet should be considered to represent the "average." Charterboat landings were generally higher than those of headboats, so if depths fished by charterboats resulted in selectivity that is less dome-shaped than the pattern used here, results of this assessment would likely be overly optimistic.

Among the many decisions deliberated over by the AW panel was choice of the starting year of the model. The panel thought that it was important to include the 1960s, when landings appeared to have peaked, and to examine sensitivity to those landings through sensitivity and uncertainty analyses. Ignoring this early time frame could have ignored potential stock productivity (Rosenberg et al. 2005). However, the historical period (pre-1976) did not include CPUE or composition data, and thus the model had little or no information to estimate variability of year-class strength in the 1950s and 1960s. Thus, the estimates of historic recruitment should not be considered reliable. Instead, the historic period was viewed by the AW panel as an initialization era leading up to the assessment period of 1976–2009, used to estimate age structure at the onset of CPUE and composition data. Those early recruitment deviations were excluded from the likelihood component of the spawner-recruit curve. Sensitivity runs starting in 1976 or 1986 provided results similar to those of the base run starting in 1955.

Perhaps the greatest uncertainty in this assessment was the spawner-recruit relationship. Steepness could not be estimated reliably (tended toward its upper bound), and $R0$, although estimated, relied on predicted recruitment events that occurred at low stock sizes. Potential stock productivity at high stock sizes remains to be observed. It is possible that this assessment under-predicted potential productivity by underestimating $R0$, or perhaps over-predicted productivity at high stock sizes, if increased spawners were to have an increasing deleterious effect on recruitment (although mechanisms underlying Ricker dynamics are not known to occur for this stock). Either way, the long-term potential for MSY is, for now, uncertain. Still, the stock dynamics and productivity in recent years might be more relevant to current environmental or ecological conditions, and therefore the results from this assessment would represent our best estimate for the near future.

Because steepness could not be estimated reliably in this assessment, its value was fixed at the mode of its prior distribution. Thus MSY-based management quantities are conditional on that value of steepness. An alternative approach would be to choose a proxy for F_{MSY}, most likely $F_{X\%}$ (such as $F_{30\%}$ or $F_{40\%}$). However, such proxies do not provide biomass-based benchmarks. If managers wish to gauge stock status, further assumptions about equilibrium recruitment levels would be necessary. Furthermore, choice of X% implies an underlying steepness, as described by Brooks et al. (2009). Thus, choosing a proxy equates to choosing steepness. Given the two alternative approaches, it seems preferable to focus on steepness, as its value is less arbitrary, coming from a prior distribution estimated through meta-analysis.

The assessment predicted relatively high abundance in recent years. This prediction is consistent with reports from fishermen of increased abundance. However, this increase appears to be the result of unusually strong year classes (age-1) in 2006 and 2007. The observed age structure of landings remains more truncated than would be expected from a healthy population of a fish with maximum age that exceeds 50 years.

Significant Assessment Modifications

The review panel accepted the base run as developed by the assessment panel but requested several additional sensitivity runs. The review panel suggested that two of the additional runs be reported alongside sensitivity runs devised by the assessment workshop panel. Section VI of the Stock Assessment Report details updates to tables and figures made by the review panel.

Sources of Information

The contents of this summary report were taken from the data, assessment, and review reports.

Tables

Table 5.2. Life-history characteristics at age of the population, including average body size and weight (mid-year), gonad weight, and proportion females mature.

Age	Total length (mm)	Total length (in)	CV length	Whole weight (kg)	Whole weight (lb)	Gonad weight (kg)	Female maturity
1	277.2	10.9	0.18	0.30	0.66	0.00	0.22
2	410.5	16.2	0.12	1.02	2.25	0.01	0.55
3	515.4	20.3	0.10	2.07	4.57	0.02	0.84
4	597.9	23.5	0.08	3.29	7.26	0.04	0.96
5	662.8	26.1	0.08	4.54	10.01	0.07	0.99
6	713.8	28.1	0.07	5.72	12.61	0.11	1.00
7	754.0	29.7	0.07	6.79	14.96	0.15	1.00
8	785.6	30.9	0.06	7.71	17.01	0.19	1.00
9	810.4	31.9	0.06	8.50	18.74	0.22	1.00
10	829.9	32.7	0.06	9.16	20.19	0.25	1.00
11	845.3	33.3	0.06	9.70	21.38	0.28	1.00
12	857.4	33.8	0.06	10.14	22.35	0.30	1.00
13	866.9	34.1	0.06	10.49	23.13	0.32	1.00
14	874.4	34.4	0.06	10.78	23.76	0.34	1.00
15	880.3	34.7	0.06	11.00	24.26	0.35	1.00
16	884.9	34.8	0.06	11.19	24.66	0.36	1.00
17	888.6	35.0	0.06	11.33	24.98	0.37	1.00
18	891.4	35.1	0.06	11.44	25.23	0.37	1.00
19	893.7	35.2	0.06	11.53	25.43	0.38	1.00
20	895.5	35.3	0.06	11.61	25.59	0.38	1.00

Table 5.3a. Landings and discards, as fitted by the BAM (i.e., model input). The private recreational landings reported here include modifications recommended by the assessment panel and include; smoothing the private landings (1981-2009), smoothing the private and for hire landings (1955-1980), and adjusting the 1981-1985 for hire landings estimated charter landings.

	Recreational				Commercial		
	Landings		Discards		Landings		Discards
	Numbers (1000's)				Whole Pounds (1000's)		
Year	ForHire	Private	ForHire	Private	Lines	diving	Lines
1955	68.301	13.763			497.800		
1956	74.807	18.067			484.300		
1957	81.321	22.657			868.900		
1958	84.472	26.582			617.300		
1959	85.598	30.115			662.700		
1960	85.480	33.277			677.100		
1961	83.527	35.672			799.800		
1962	79.441	37.195			662.577		
1963	76.530	39.544			504.840		
1964	78.771	44.904			559.491		
1965	86.525	53.626			656.795		
1966	96.861	64.051			740.057		
1967	104.809	72.901			963.706		
1968	104.716	76.108			1069.332		
1969	95.537	72.701			700.493		
1970	82.889	66.731			640.918		
1971	71.743	62.080			543.433		
1972	65.493	61.735			468.602		
1973	65.872	67.536			387.344		
1974	71.612	78.477			632.507		
1975	77.286	89.063			745.363		
1976	78.829	94.852			619.011		
1977	75.868	95.145			649.273		
1978	68.640	89.822			589.918		
1979	58.535	80.445			409.939		
1980	47.760	69.978			380.596		
1981	69.519	121.730			371.379		
1982	37.726	52.932			306.128		
1983	59.229	43.885	42.281	8.679	310.268		
1984	60.094	161.385	121.668	22.845	248.195	1.317	
1985	97.119	178.659	27.775	63.501	240.971	2.547	
1986	98.995	78.195	0.158	8.679	215.743	0.508	
1987	40.286	51.281	0.158	106.560	187.211	0.030	
1988	62.664	98.608	0.158	48.373	164.123	0.013	
1989	44.461	107.354	0.158	20.038	258.478	0.006	
1990	26.656	11.091	0.158	8.679	215.047	1.859	
1991	30.623	31.351	0.697	35.853	134.032	5.898	
1992	45.611	38.345	17.936	19.492	89.062	9.614	14.233
1993	14.948	10.864	33.397	48.989	189.994	5.611	14.926
1994	22.589	13.567	7.359	62.577	179.615	13.116	20.638
1995	22.423	2.386	24.366	37.932	166.772	10.037	19.437
1996	8.681	11.419	5.053	17.628	130.650	6.153	24.867
1997	62.935	3.545	19.038	8.679	101.232	7.531	27.458
1998	18.112	7.585	8.856	22.970	80.009	8.063	21.106
1999	49.363	22.660	47.594	132.663	80.506	9.974	19.387
2000	19.508	57.664	32.530	223.334	92.109	10.376	18.975
2001	21.879	40.185	32.845	179.264	175.233	18.238	19.014
2002	30.115	33.865	25.886	105.891	163.092	22.097	42.356
2003	23.899	16.111	21.700	139.401	118.803	17.454	13.973
2004	24.796	25.390	37.465	163.953	149.791	19.647	5.170
2005	23.113	21.172	49.435	79.725	118.015	9.344	4.999
2006	17.293	14.541	23.194	115.593	80.291	4.163	7.425
2007	17.326	31.324	118.249	339.128	104.737	7.514	14.759
2008	41.780	84.502	59.846	352.213	240.735	6.304	15.512
2009	50.210	92.814	35.131	183.886	341.241	8.011	20.402

Table 5.3b. Landings and dead discards in 1000 pounds whole weight, as estimated by the BAM (i.e., model output).

	Landings (1000 lb)					Discards (1000 lb)			
Year	Commercial Lines	Commercial Dive	For Hire	Private	Total Landings	Commercial Lines	For Hire	Private	Total
1955	497.92	0	703.84	188.24	1390				
1956	484.42	0	824.35	248.89	1557.66				
1957	869.31	0	952.27	317.92	2139.5				
1958	617.52	0	1032.46	395.25	2045.22				
1959	662.96	0	1073.06	465.85	2201.87				
1960	677.39	0	1082.99	526.99	2287.38				
1961	800.22	0	1058.43	570.93	2429.59				
1962	662.89	0	1001.28	596.96	2261.12				
1963	505.03	0	957.22	633.77	2096.01				
1964	559.74	0	976.81	717.28	2253.84				
1965	657.16	0	1063.03	853.59	2573.78				
1966	740.55	0	1177.49	1016.48	2934.52				
1967	964.6	0	1256.95	1153.34	3374.89				
1968	1070.51	0	1231.92	1197.62	3500.05				
1969	701.03	0	1095.58	1131.97	2928.58				
1970	641.4	0	923.86	1021.66	2586.93				
1971	543.81	0	777.41	930.71	2251.93				
1972	468.9	0	693.13	906.15	2068.18				
1973	387.56	0	684.07	974.66	2046.29				
1974	633.14	0	706.54	1118.46	2458.14				
1975	746.32	0	706.34	1247.28	2699.93				
1976	619.61	0	573.93	1252.47	2446				
1977	649.73	0	571.33	1154.81	2375.86				
1978	590.31	0	564.67	987.29	2142.26				
1979	410.17	0	502.53	957.76	1870.46				
1980	380.83	0	389.89	872.7	1643.42				
1981	371.67	0	548.41	1534.75	2454.84				
1982	306.45	0	268.07	627.82	1202.34				
1983	310.67	0	381.76	466.58	1159.02	0	9.13	1.78	10.92
1984	248.37	1.32	260.55	1360.31	1870.56	0	28.8	5.15	33.95
1985	241.02	2.55	430.42	1171.53	1845.52	0	7.08	15.39	22.46
1986	215.76	0.51	592.84	537.97	1347.08	0	0.04	2.01	2.04
1987	187.17	0.03	226.51	420.71	834.43	0	0.03	21.29	21.33
1988	163.97	0.01	284.61	770.69	1219.28	0	0.04	11.78	11.82
1989	258.29	0.01	235.14	710.72	1204.15	0	0.04	4.24	4.28
1990	214.96	1.86	122.02	80.1	418.93	0	0.04	1.96	1.99
1991	133.98	5.9	128.81	202.68	471.37	0	0.16	7.91	8.07

1992	89.03	9.61	363.59	313	775.24	16.99	13.42	13.88	44.29
1993	189.81	5.61	102.03	74.86	372.31	20.26	28.34	39.53	88.12
1994	179.57	13.12	161.33	97.5	451.52	28.43	6.11	49.31	83.85
1995	166.7	10.04	177.09	18.98	372.8	26.67	23	34.05	83.72
1996	130.61	6.15	74.12	97.78	308.66	35.55	3.49	11.56	50.6
1997	101.24	7.53	637.11	36.67	782.55	28.43	11.81	5.12	45.37
1998	80.02	8.06	151.57	64.99	304.64	25.95	6.71	16.56	49.22
1999	80.52	9.97	362.88	168.86	622.24	24.69	31.43	83.17	139.3
2000	92.13	10.38	146.29	441.08	689.87	22.52	24.02	156.32	202.87
2001	175.32	18.24	151.48	280.75	625.78	25.81	29.15	150.8	205.76
2002	163.11	22.1	219.31	247.6	652.12	61	23.25	90.28	174.53
2003	118.79	17.45	202	136.94	475.19	18.51	15.79	96.22	130.53
2004	149.73	19.65	236.07	244.04	649.48	6.58	30.99	128.66	166.23
2005	117.99	9.34	224.78	206.96	559.07	7.12	44.7	68.56	120.38
2006	80.29	4.16	183.87	156.5	424.82	7.34	9.14	43.31	59.8
2007	104.72	7.51	187.91	366.92	667.06	15.24	85.09	231.43	331.76
2008	240.48	6.3	301.94	616.19	1164.92	21.44	55.76	310.78	387.97
2009	340.89	8.01	382.32	708.17	1439.4	30.33	34.88	173.44	238.65

Table 5.4. Estimated instantaneous fishing mortality rate (per year) at age, including discard mortality.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1955	0.02	0.03	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1956	0.02	0.04	0.05	0.04	0.04	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1957	0.03	0.05	0.06	0.06	0.05	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
1958	0.03	0.05	0.07	0.06	0.06	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
1959	0.04	0.06	0.07	0.07	0.06	0.05	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
1960	0.04	0.06	0.08	0.08	0.07	0.06	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
1961	0.04	0.07	0.09	0.09	0.08	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
1962	0.04	0.07	0.09	0.09	0.08	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
1963	0.04	0.06	0.09	0.09	0.08	0.06	0.05	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
1964	0.05	0.07	0.11	0.10	0.09	0.07	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
1965	0.05	0.08	0.13	0.12	0.11	0.09	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
1966	0.06	0.10	0.16	0.15	0.13	0.10	0.08	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
1967	0.07	0.12	0.19	0.18	0.16	0.13	0.10	0.08	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
1968	0.08	0.14	0.21	0.20	0.18	0.15	0.11	0.09	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
1969	0.08	0.13	0.21	0.20	0.18	0.14	0.10	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
1970	0.07	0.12	0.20	0.19	0.17	0.13	0.10	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
1971	0.07	0.11	0.19	0.18	0.16	0.13	0.10	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
1972	0.06	0.11	0.19	0.18	0.16	0.13	0.10	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
1973	0.07	0.11	0.21	0.20	0.18	0.14	0.10	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
1974	0.08	0.14	0.27	0.25	0.23	0.18	0.13	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
1975	0.09	0.17	0.33	0.31	0.28	0.22	0.17	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
1976	0.08	0.16	0.34	0.32	0.29	0.23	0.17	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
1977	0.09	0.18	0.36	0.34	0.31	0.24	0.18	0.16	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
1978	0.09	0.18	0.35	0.33	0.30	0.24	0.18	0.15	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
1979	0.10	0.18	0.36	0.34	0.30	0.24	0.18	0.15	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
1980	0.09	0.17	0.37	0.35	0.31	0.24	0.18	0.15	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
1981	0.16	0.31	0.73	0.69	0.61	0.48	0.35	0.29	0.26	0.26	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1982	0.09	0.20	0.42	0.39	0.35	0.28	0.21	0.18	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
1983	0.08	0.32	0.44	0.42	0.38	0.30	0.23	0.19	0.18	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
1984	0.10	0.40	0.93	0.88	0.78	0.60	0.44	0.36	0.33	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
1985	0.11	0.44	0.87	0.83	0.73	0.57	0.42	0.34	0.32	0.31	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
1986	0.10	0.43	0.65	0.62	0.55	0.43	0.33	0.27	0.25	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
1987	0.13	0.45	0.48	0.46	0.41	0.33	0.25	0.21	0.20	0.20	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
1988	0.10	0.43	0.94	0.88	0.79	0.61	0.45	0.37	0.34	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
1989	0.12	0.55	1.06	1.01	0.91	0.72	0.55	0.47	0.44	0.43	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
1990	0.06	0.31	0.40	0.39	0.36	0.31	0.27	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
1991	0.08	0.33	0.49	0.47	0.42	0.34	0.27	0.23	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
1992	0.03	0.11	1.10	0.99	0.88	0.69	0.50	0.41	0.38	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
1993	0.06	0.18	0.42	0.33	0.31	0.27	0.23	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
1994	0.06	0.20	0.46	0.34	0.31	0.26	0.22	0.20	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
1995	0.08	0.26	0.42	0.26	0.24	0.21	0.17	0.16	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1996	0.05	0.19	0.41	0.21	0.19	0.16	0.14	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
1997	0.04	0.19	1.04	0.79	0.70	0.55	0.41	0.33	0.31	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
1998	0.02	0.09	0.39	0.30	0.27	0.22	0.17	0.15	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
1999	0.08	0.25	0.64	0.49	0.44	0.34	0.25	0.21	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
2000	0.09	0.25	0.67	0.53	0.47	0.37	0.27	0.23	0.21	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
2001	0.09	0.24	0.43	0.32	0.28	0.23	0.19	0.16	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
2002	0.09	0.28	0.45	0.28	0.24	0.20	0.16	0.13	0.13	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
2003	0.13	0.36	0.39	0.21	0.18	0.15	0.11	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
2004	0.17	0.46	0.50	0.31	0.26	0.21	0.16	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
2005	0.20	0.53	0.52	0.29	0.25	0.20	0.15	0.13	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
2006	0.07	0.21	0.38	0.26	0.22	0.18	0.13	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
2007	0.11	0.31	0.64	0.49	0.43	0.33	0.24	0.20	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
2008	0.14	0.39	0.67	0.49	0.43	0.35	0.27	0.22	0.21	0.21	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
2009	0.22	0.59	0.91	0.63	0.55	0.44	0.35	0.30	0.28	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27

Table 5.5a. Estimated total abundance at age (1000 fish) at start of year.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
1955	637.4	468.2	388.1	334.1	293.5	260.9	234.7	211.6	192.9	175.9	160.4	146.3	134.8	124.1	114.4	105.4	97.1	89.4	82.4	963.4	5215
1956	367.7	462.6	382.5	327.8	288.4	256.9	232.1	210.0	191.8	175.0	159.7	145.6	134.2	123.6	113.9	104.9	96.6	89.0	82.0	959.1	4903
1957	360.7	265.8	376.0	320.9	281.2	251.0	227.6	207.1	190.0	173.7	158.6	144.7	133.3	122.8	113.1	104.2	96.0	88.4	81.5	952.9	4649
1958	353.9	259.5	213.7	311.0	271.5	241.7	219.9	201.1	185.7	170.6	156.1	142.5	131.3	121.0	111.5	102.7	94.6	87.2	80.3	939.1	4395
1959	347.1	253.6	208.1	175.9	262.0	232.5	211.3	194.3	180.5	166.9	153.4	140.4	129.5	119.3	110.0	101.3	93.3	86.0	79.2	926.2	4171
1960	340.3	247.9	202.3	169.7	146.9	222.6	202.1	185.9	173.7	161.6	149.6	137.6	127.1	117.3	108.1	99.6	91.7	84.5	77.8	910.4	3956
1961	333.2	242.4	196.8	163.6	140.7	124.0	192.5	177.0	165.6	155.1	144.4	133.7	124.2	114.8	105.9	97.6	89.9	82.8	76.3	892.3	3753
1962	326.2	236.9	191.5	157.9	134.6	117.9	106.5	167.8	157.0	147.2	138.0	128.6	120.2	111.7	103.2	95.2	87.7	80.8	74.5	870.9	3554
1963	319.2	231.9	187.3	153.5	129.8	112.7	101.3	92.9	148.9	139.7	131.1	122.9	115.7	108.2	100.5	92.9	85.7	78.9	72.7	850.6	3376
1964	312.0	226.9	183.5	149.9	125.9	108.5	96.8	88.4	82.5	132.7	124.6	116.9	110.7	104.2	97.4	90.5	83.7	77.2	71.1	831.8	3215
1965	304.5	221.0	178.4	145.1	121.6	104.3	92.5	84.0	78.1	73.2	117.7	110.6	104.8	99.3	93.4	87.4	81.2	75.0	69.2	809.6	3051
1966	296.8	214.2	171.6	138.1	115.4	98.9	87.6	79.3	73.5	68.6	64.4	103.6	98.3	93.2	88.3	83.1	77.7	72.2	66.7	781.3	2873
1967	288.8	206.7	163.5	129.0	106.8	91.5	81.5	74.0	68.6	63.9	59.7	56.1	91.1	86.5	82.0	77.7	73.1	68.3	63.5	746.0	2678
1968	280.6	199.1	154.6	118.8	96.6	82.3	73.6	67.6	63.0	58.7	54.8	51.2	48.6	79.0	74.9	71.1	67.3	63.3	59.2	701.4	2465
1969	272.5	192.2	146.8	109.6	86.9	72.9	65.0	60.2	56.8	53.3	49.8	46.5	43.9	41.6	67.7	64.2	60.9	57.7	54.3	651.7	2254
1970	263.5	187.0	142.8	104.6	80.6	65.9	58.0	53.6	51.0	48.4	45.5	42.5	40.1	37.9	35.9	58.4	55.4	52.5	49.8	609.3	2083
1971	252.9	181.8	139.9	102.6	77.5	61.5	52.7	47.9	45.5	43.6	41.4	39.0	36.8	34.7	32.8	31.1	50.5	47.9	45.5	570.1	1935
1972	240.2	175.5	137.2	101.5	76.7	59.7	49.5	43.8	40.8	39.0	37.4	35.6	33.8	32.0	30.1	28.5	27.0	43.9	41.6	534.5	1808
1973	228.9	167.1	132.9	99.5	75.9	59.0	48.0	41.2	37.3	35.1	33.5	32.2	30.9	29.4	27.8	26.2	24.7	23.4	38.1	500.7	1692
1974	261.7	158.6	125.8	94.5	73.0	57.5	47.0	39.6	34.9	31.9	30.0	28.7	27.8	26.8	25.4	24.0	22.6	21.4	20.3	466.1	1618
1975	281.2	179.4	116.0	84.7	65.9	52.8	44.0	37.5	32.7	29.0	26.6	25.0	24.2	23.5	22.6	21.4	20.2	19.1	18.0	410.0	1534
1976	479.8	190.8	127.8	73.6	55.8	45.2	38.7	34.0	30.1	26.5	23.6	21.6	20.6	19.9	19.3	18.6	17.6	16.6	15.7	351.9	1628
1977	195.7	327.8	136.8	80.0	47.9	37.9	32.9	29.8	27.2	24.4	21.5	19.2	17.7	16.9	16.3	15.8	15.2	14.5	13.6	301.4	1392
1978	155.5	132.8	231.5	83.8	50.9	31.9	27.1	25.0	23.6	21.8	19.5	17.2	15.5	14.4	13.7	13.2	12.8	12.3	11.7	255.4	1170
1979	159.9	104.9	93.2	143.5	54.0	34.3	23.0	20.7	19.8	18.9	17.5	15.7	14.0	12.6	11.7	11.1	10.8	10.4	10.0	217.1	1003
1980	188.0	107.7	73.8	57.1	91.5	36.0	24.6	17.6	16.5	15.9	15.2	14.1	12.8	11.4	10.3	9.5	9.1	8.8	8.5	185.1	913
1981	150.7	127.7	76.3	45.0	36.2	60.8	25.8	18.7	13.9	13.2	12.8	12.2	11.5	10.4	9.3	8.4	7.7	7.4	7.1	157.3	812
1982	160.2	95.6	79.2	32.4	20.3	17.8	34.5	16.6	13.0	9.9	9.4	9.2	8.9	8.3	7.5	6.7	6.1	5.6	5.3	119.2	666

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
1983	637.2	108.0	66.3	45.9	19.6	12.9	12.3	25.6	12.9	10.2	7.8	7.4	7.3	7.1	6.6	6.0	5.4	4.8	4.5	99.0	1107
1984	647.9	436.9	66.5	37.5	27.1	12.2	8.8	9.0	19.5	9.9	7.9	6.0	5.8	5.7	5.5	5.2	4.7	4.2	3.8	81.2	1405
1985	126.9	435.5	246.7	23.1	14.0	11.3	6.1	5.2	5.8	13.0	6.7	5.3	4.1	4.0	3.9	3.8	3.5	3.2	2.9	57.8	983
1986	82.5	84.6	236.8	90.5	9.1	6.1	5.8	3.7	3.4	3.9	8.8	4.5	3.7	2.8	2.7	2.7	2.6	2.4	2.2	41.8	600
1987	509.5	55.3	46.4	108.5	43.8	4.7	3.6	3.8	2.6	2.4	2.8	6.4	3.3	2.7	2.1	2.0	2.0	1.9	1.8	32.2	838
1988	76.7	332.6	29.9	25.1	61.4	26.2	3.1	2.6	2.9	2.0	1.8	2.1	4.9	2.6	2.1	1.6	1.5	1.5	1.5	26.1	608
1989	176.8	51.5	182.3	10.3	9.3	25.3	13.0	1.8	1.6	1.9	1.3	1.2	1.4	3.3	1.7	1.4	1.1	1.0	1.0	18.5	506
1990	178.6	116.4	25.1	55.3	3.4	3.4	11.2	6.8	1.1	1.0	1.1	0.8	0.8	0.9	2.0	1.1	0.8	0.7	0.6	11.9	423
1991	261.9	125.0	72.3	14.7	33.5	2.1	2.3	7.9	4.9	0.8	0.7	0.8	0.6	0.6	0.7	1.5	0.8	0.6	0.5	9.3	541
1992	225.8	179.7	75.8	39.0	8.3	19.9	1.4	1.6	5.8	3.7	0.6	0.5	0.6	0.4	0.4	0.5	1.1	0.6	0.5	7.4	574
1993	161.3	162.7	135.4	22.1	13.0	3.1	9.2	0.8	1.0	3.6	2.3	0.4	0.3	0.4	0.3	0.3	0.3	0.7	0.4	5.1	523
1994	153.3	112.9	115.1	78.5	14.2	8.7	2.2	6.6	0.6	0.7	2.7	1.8	0.3	0.3	0.3	0.2	0.2	0.2	0.6	4.1	503
1995	36.1	106.7	78.0	63.9	50.2	9.5	6.1	1.6	5.0	0.4	0.6	2.1	1.4	0.2	0.2	0.2	0.2	0.2	0.2	3.6	366
1996	153.4	24.6	69.8	45.0	44.0	35.8	7.0	4.7	1.3	4.0	0.3	0.4	1.7	1.1	0.2	0.2	0.2	0.1	0.1	3.1	397
1997	256.5	108.6	17.3	40.7	32.6	32.9	27.8	5.6	3.8	1.0	3.3	0.3	0.4	1.4	0.9	0.1	0.1	0.2	0.1	2.7	536
1998	236.5	183.3	75.6	5.3	16.5	14.6	17.4	16.9	3.7	2.6	0.7	2.3	0.2	0.3	1.0	0.6	0.1	0.1	0.1	1.9	580
1999	511.2	171.3	140.9	44.8	3.5	11.4	10.7	13.4	13.5	3.0	2.1	0.6	1.8	0.2	0.2	0.8	0.5	0.1	0.1	1.7	932
2000	450.9	348.4	113.1	65.3	24.5	2.1	7.4	7.6	10.0	10.3	2.3	1.6	0.4	1.4	0.1	0.2	0.6	0.4	0.1	1.3	1048
2001	199.8	306.3	230.1	50.7	34.4	13.9	1.3	5.1	5.6	7.5	7.8	1.7	1.2	0.3	1.1	0.1	0.1	0.5	0.3	1.1	869
2002	164.9	136.0	203.8	131.2	33.0	23.4	10.0	1.0	4.0	4.4	6.0	6.2	1.4	1.0	0.3	0.9	0.1	0.1	0.4	1.1	729
2003	248.1	111.4	86.6	113.6	89.3	23.5	17.6	7.8	0.8	3.3	3.6	4.9	5.1	1.1	0.8	0.2	0.7	0.1	0.1	1.2	720
2004	120.2	161.7	65.9	51.7	82.8	67.6	18.6	14.3	6.6	0.7	2.8	3.1	4.2	4.3	1.0	0.7	0.2	0.6	0.1	1.1	608
2005	66.3	74.8	85.9	35.0	34.2	57.6	50.0	14.4	11.5	5.3	0.6	2.3	2.5	3.4	3.6	0.8	0.6	0.2	0.5	1.0	450
2006	793.6	40.2	37.3	44.8	23.4	24.1	43.2	39.3	11.7	9.5	4.4	0.5	1.9	2.1	2.8	3.0	0.7	0.5	0.1	1.2	1084
2007	582.3	546.9	27.5	22.4	31.0	16.9	18.5	34.5	32.5	9.8	7.9	3.7	0.4	1.6	1.8	2.4	2.5	0.6	0.4	1.1	1345
2008	163.0	385.0	338.2	12.7	12.3	18.4	11.1	13.2	26.1	25.0	7.5	6.1	2.9	0.3	1.2	1.4	1.9	2.0	0.4	1.2	1030
2009	78.2	104.6	221.0	152.3	7.0	7.2	11.9	7.8	9.8	19.6	18.8	5.7	4.6	2.2	0.2	0.9	1.1	1.4	1.5	1.3	657
2010	196.2	46.7	48.9	78.3	72.9	3.6	4.2	7.7	5.4	6.8	13.8	13.2	4.0	3.3	1.6	0.2	0.7	0.8	1.0	1.9	511

Table 5.5b. Estimated biomass at age (1000 lb) at start of year.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
1955	420	1051	1772	2424	2937	3290	3511	3598	3614	3550	3429	3269	3117	2949	2775	2598	2424	2256	2095	24650	75729
1956	243	1039	1746	2379	2886	3240	3472	3571	3594	3533	3413	3254	3103	2936	2762	2587	2414	2246	2085	24540	75043
1957	238	597	1717	2328	2814	3166	3405	3521	3560	3507	3390	3233	3083	2917	2744	2570	2398	2232	2072	24383	73874
1958	234	583	976	2257	2717	3048	3290	3421	3480	3444	3337	3185	3038	2875	2704	2533	2363	2199	2042	24029	71752
1959	229	570	950	1276	2622	2932	3161	3304	3382	3369	3280	3138	2995	2835	2667	2498	2331	2169	2014	23699	69420
1960	224	557	924	1231	1470	2808	3023	3161	3255	3263	3198	3074	2941	2786	2622	2455	2291	2132	1980	23295	66686
1961	220	544	899	1187	1408	1564	2880	3010	3103	3131	3088	2988	2872	2727	2569	2406	2245	2090	1940	22832	63702
1962	215	532	874	1146	1347	1487	1594	2853	2942	2972	2950	2873	2780	2653	2504	2348	2191	2039	1894	22283	60477
1963	211	521	855	1113	1299	1422	1515	1580	2791	2820	2803	2747	2676	2570	2437	2290	2140	1992	1850	21766	57395
1964	206	510	838	1088	1260	1369	1449	1503	1547	2678	2663	2613	2561	2476	2364	2232	2090	1947	1809	21284	54482
1965	201	496	815	1053	1217	1315	1384	1428	1464	1477	2516	2471	2425	2359	2267	2155	2027	1893	1760	20715	51435
1966	196	481	784	1002	1154	1247	1310	1349	1378	1386	1376	2315	2273	2215	2142	2049	1940	1821	1696	19993	48105
1967	191	464	747	936	1069	1155	1219	1259	1286	1290	1277	1253	2108	2054	1989	1915	1825	1724	1614	19089	44463
1968	185	447	706	862	967	1038	1101	1149	1181	1186	1171	1145	1123	1876	1818	1752	1681	1598	1506	17946	40435
1969	180	431	670	795	870	919	973	1024	1065	1076	1064	1038	1015	989	1641	1583	1521	1455	1380	16676	36364
1970	174	420	652	759	807	831	867	911	956	977	973	950	927	900	871	1440	1384	1326	1266	15590	32980
1971	167	408	639	744	776	776	788	814	852	879	885	871	851	824	795	766	1262	1209	1156	14587	30049
1972	159	394	627	737	768	753	741	744	765	787	800	796	782	759	731	702	674	1107	1058	13678	27560
1973	151	375	607	722	759	745	719	700	700	708	717	719	716	698	674	645	618	592	969	12810	25342
1974	173	356	574	686	731	725	703	674	654	644	641	641	644	636	617	592	566	540	516	11925	23236
1975	185	403	530	614	659	666	658	638	613	586	568	559	560	558	547	529	506	482	459	10491	20809
1976	316	428	584	534	558	570	580	579	565	535	505	484	476	473	468	458	440	420	399	9005	18375
1977	129	736	624	580	479	478	493	507	510	492	459	428	410	401	396	390	380	365	347	7711	16314
1978	103	298	1057	608	510	402	406	426	442	439	417	385	359	342	332	326	320	311	298	6535	14316
1979	105	236	426	1042	540	432	344	352	372	381	374	351	324	300	284	274	268	263	255	5554	12476
1980	124	242	337	415	915	454	369	299	308	322	325	315	296	271	250	235	226	221	216	4737	10877
1981	99	287	348	327	362	767	386	319	261	266	274	274	265	247	225	206	193	186	181	4026	9498
1982	106	215	361	235	203	224	517	283	244	200	202	205	205	197	183	166	151	142	136	3049	7222

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
1983	420	243	303	333	196	163	184	434	241	206	166	166	169	168	160	148	134	122	114	2534	6601
1984	427	981	304	272	271	153	131	152	365	201	169	135	135	136	134	128	118	106	96	2077	6490
1985	84	978	1126	168	140	142	91	88	109	262	143	119	95	94	95	93	88	81	73	1479	5545
1986	55	190	1081	657	91	77	87	62	63	79	188	101	85	67	66	66	65	61	56	1069	4266
1987	336	124	212	787	438	60	54	65	48	49	60	143	77	64	50	49	49	48	45	824	3583
1988	51	747	137	182	615	331	47	43	54	40	40	48	113	61	50	39	38	38	37	668	3377
1989	117	116	832	75	93	319	194	31	31	38	28	27	33	78	42	34	27	26	26	474	2639
1990	118	261	115	401	34	43	168	116	20	20	24	17	17	21	49	26	21	17	16	305	1808
1991	173	281	330	107	336	27	34	134	93	15	15	19	13	13	16	37	19	16	12	238	1926
1992	149	403	346	283	83	251	21	27	108	74	12	12	15	10	10	12	28	15	12	189	2060
1993	106	365	618	160	131	39	137	13	18	73	50	8	8	10	7	7	8	18	10	130	1916
1994	101	253	526	569	142	110	33	113	11	15	58	39	6	6	8	5	5	6	14	106	2126
1995	24	240	356	464	502	119	92	27	94	9	12	47	32	5	5	6	4	4	5	93	2138
1996	101	55	319	326	440	451	105	80	24	81	7	10	39	26	4	4	5	3	3	79	2162
1997	169	244	79	295	326	415	416	96	72	21	70	6	9	33	22	4	3	4	3	68	2355
1998	156	412	345	39	165	184	260	288	70	53	15	50	4	6	23	15	2	2	3	49	2143
1999	337	385	643	325	35	143	161	228	253	60	45	13	43	4	5	19	13	2	2	42	2758
2000	297	782	516	474	245	26	111	129	188	208	49	36	10	34	3	4	15	10	2	34	3173
2001	132	688	1050	368	344	175	20	87	105	152	166	39	28	8	26	2	3	12	8	27	3439
2002	109	305	930	952	331	295	150	17	75	90	127	138	32	23	7	21	2	2	10	28	3644
2003	164	250	396	824	893	296	263	133	15	66	77	109	117	27	20	6	18	2	2	31	3709
2004	79	363	301	375	828	853	278	244	123	14	59	68	96	103	24	17	5	15	1	28	3874
2005	44	168	392	254	342	726	748	245	216	108	12	50	58	81	86	20	14	4	13	25	3605
2006	523	90	170	325	234	304	646	668	220	191	94	10	43	50	69	73	17	12	3	31	3772
2007	384	1228	126	162	310	213	276	587	609	197	169	82	9	38	43	59	62	14	10	29	4608
2008	108	864	1544	92	123	232	166	225	489	504	161	136	66	7	30	34	47	49	11	31	4919
2009	52	235	1009	1105	70	91	178	132	183	395	401	127	107	52	6	23	26	36	38	32	4297
2010	129	105	223	568	730	46	64	131	100	138	294	296	94	79	38	4	17	19	26	50	3148

Table 5.6. Spawning stock biomass (female gonad weight, mt) and recruitment (1000s of age-one fish).

Year	SSB	Recruits (1000 fish)
1955	452.75	637.38
1956	448.13	367.65
1957	441.81	360.67
1958	433	353.87
1959	421.94	347.09
1960	408.15	340.27
1961	391.82	333.23
1962	374.36	326.21
1963	357.01	319.21
1964	338.88	311.96
1965	318.82	304.46
1966	296.53	296.76
1967	271.67	288.81
1968	245.38	280.56
1969	221.35	272.52
1970	200.54	263.45
1971	182.43	252.87
1972	166.49	240.23
1973	151.76	228.93
1974	136.08	261.71
1975	118.98	281.23
1976	102.92	479.75
1977	88.76	195.67
1978	76.87	155.53
1979	66.92	159.85
1980	58.18	187.97
1981	46.82	150.71
1982	37.98	160.2
1983	32.13	637.2
1984	24.99	647.89
1985	18.96	126.93
1986	15.35	82.45
1987	13.15	509.49
1988	10.43	76.67
1989	7.41	176.82
1990	5.93	178.6
1991	5.54	261.9
1992	4.65	225.84

1993	4.53	161.26
1994	5.18	153.34
1995	5.97	36.1
1996	6.87	153.35
1997	6.39	256.49
1998	6.19	236.47
1999	6.62	511.16
2000	6.91	450.85
2001	7.92	199.79
2002	9.54	164.9
2003	11.34	248.12
2004	12.66	120.23
2005	13.33	66.28
2006	13.83	793.57
2007	13.81	582.3
2008	13.62	162.97
2009	12.43	78.2

Figures

Figure 5.1a. Landings by fishery sector. Observed (open circles) and estimated (line, solid circles) commercial lines landings (1000 lb whole weight).

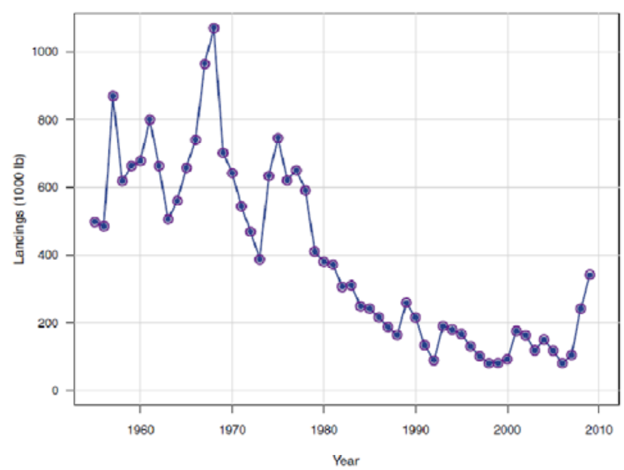


Figure 5.1b. Landings by fishery sector. Observed (open circles) and estimated (line, solid circles) commercial dive (1000 lb whole weight).

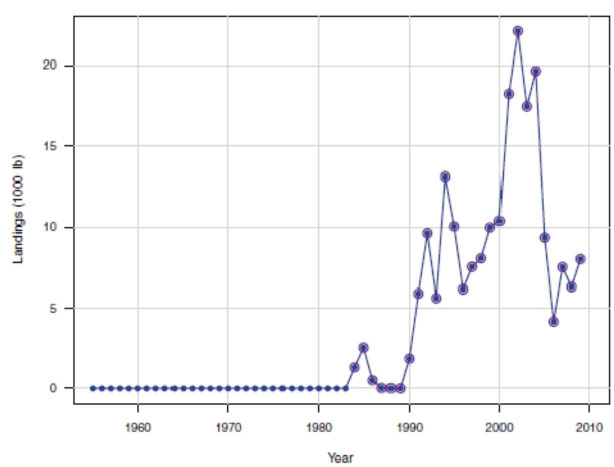


Figure 5.1c. Landings by fishery sector. Observed (open circles) and estimated (line, solid circles) for-hire landings (1000 fish).

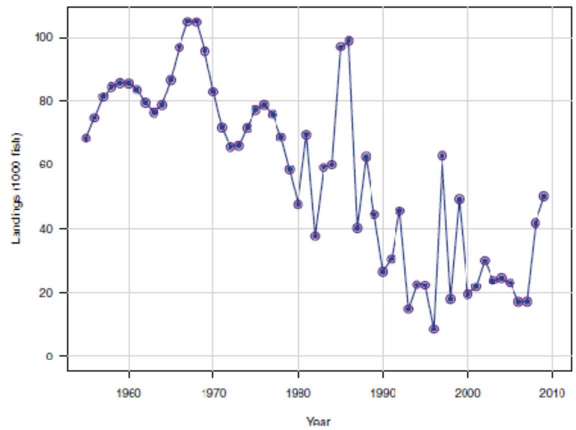


Figure 5.1d. Landings by fishery sector. Observed (open circles) and estimated (line, solid circles) private recreational landings (1000 fish).

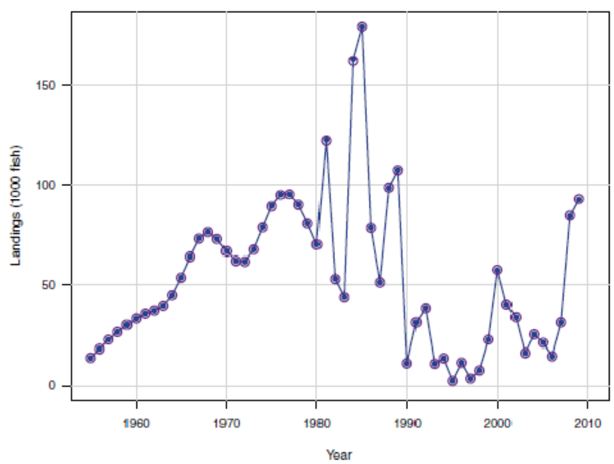


Figure 5.2a. Discards by fishery sector. Observed (open circles) and estimated (line, solid circles) commercial lines discard mortalities (1000 dead fish).

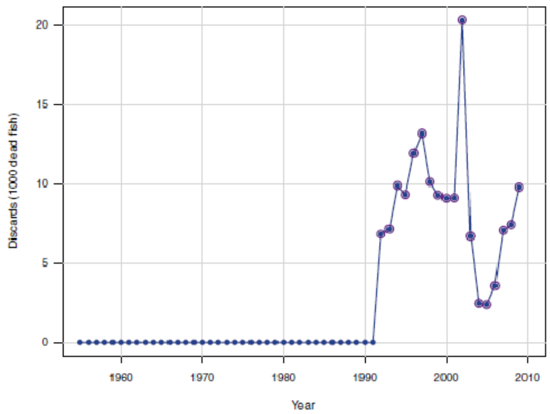


Figure 5.2b. Discards by fishery sector. Observed (open circles) and estimated (line, solid circles) for-hire discard mortalities (1000 dead fish).

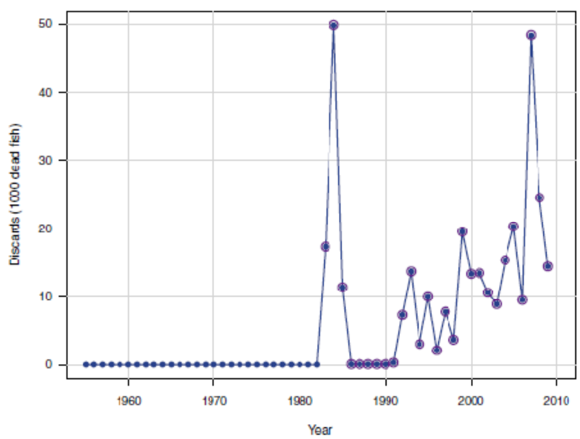


Figure 5.2c. Discards by fishery sector. Observed (open circles) and estimated (line, solid circles) private recreational discard mortalities (1000 dead fish).

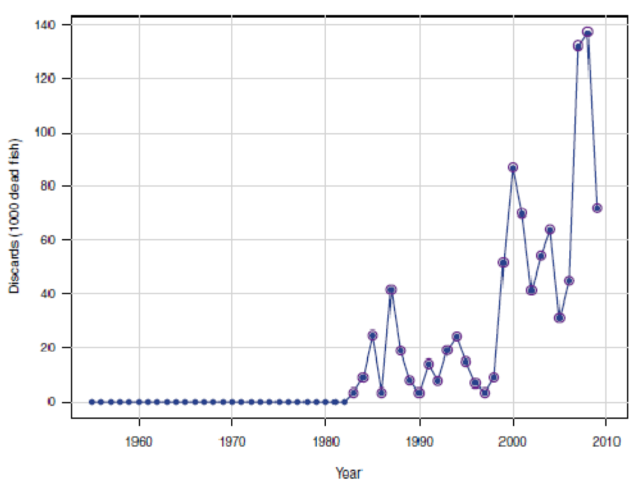


Figure 5.3. Estimated fully selected fishing mortality rate (per year) by fishery. cl refers to commercial lines, cd to commercial dive, hb to for-hire, pvt to private recreational, cl.D to commercial discard mortalities, hb.D to for-hire discard mortalities, and pvt.D to private recreational discard mortalities.

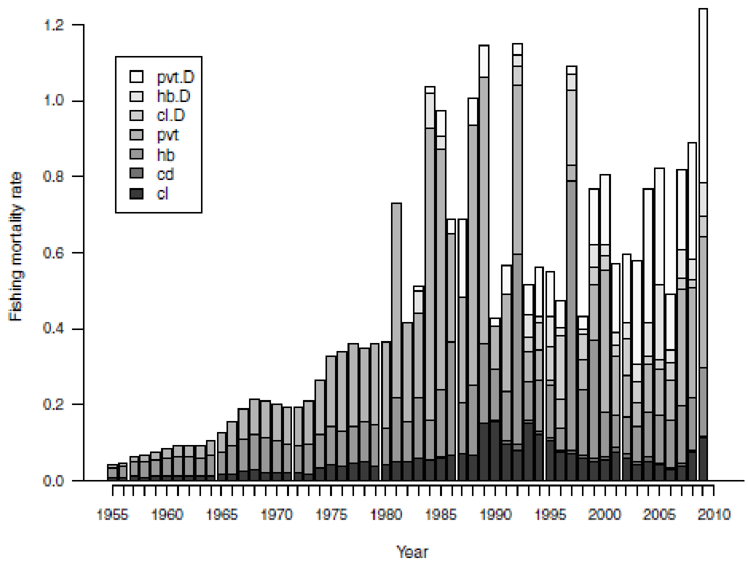
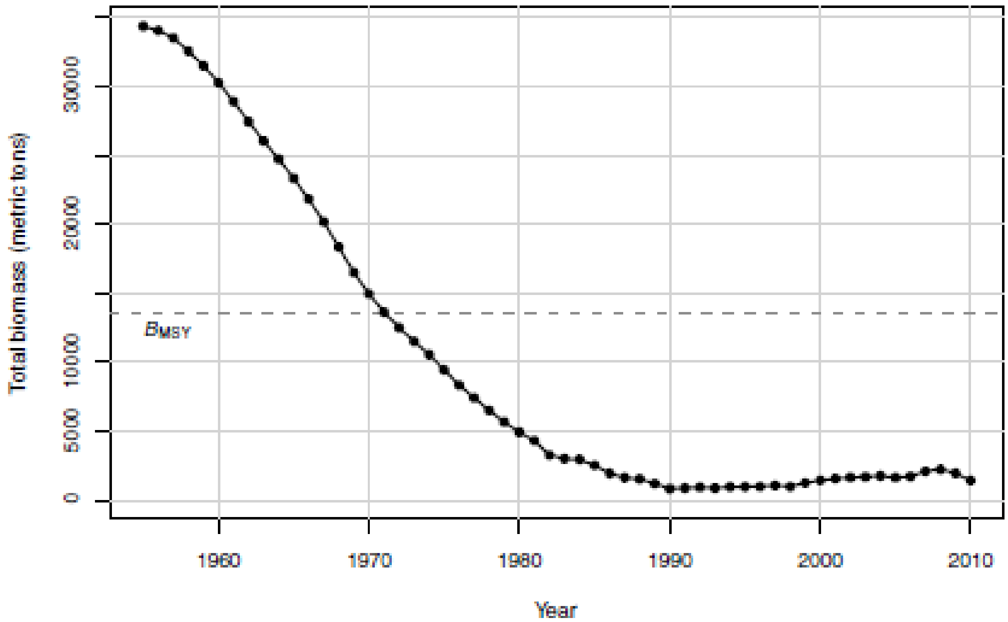


Figure 5.4. Top panel: Estimated total biomass (metric tons) at start of year. Horizontal dashed line indicated B_{MSY}. Bottom panel: Estimated spawning stock (gonad biomass of mature females) at time of peak spawning.



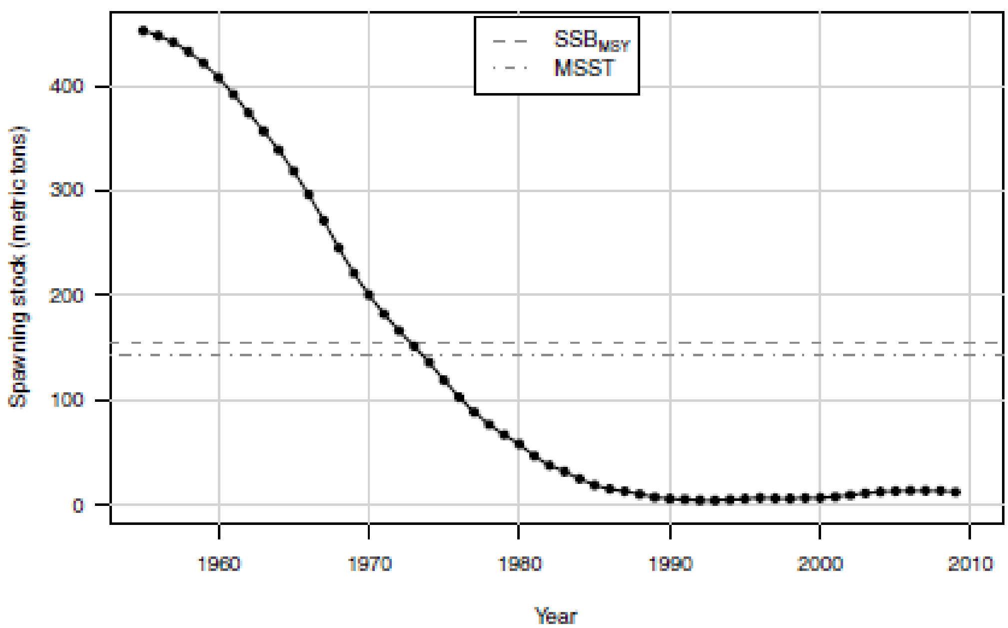


Figure 5.5. Abundance Indices

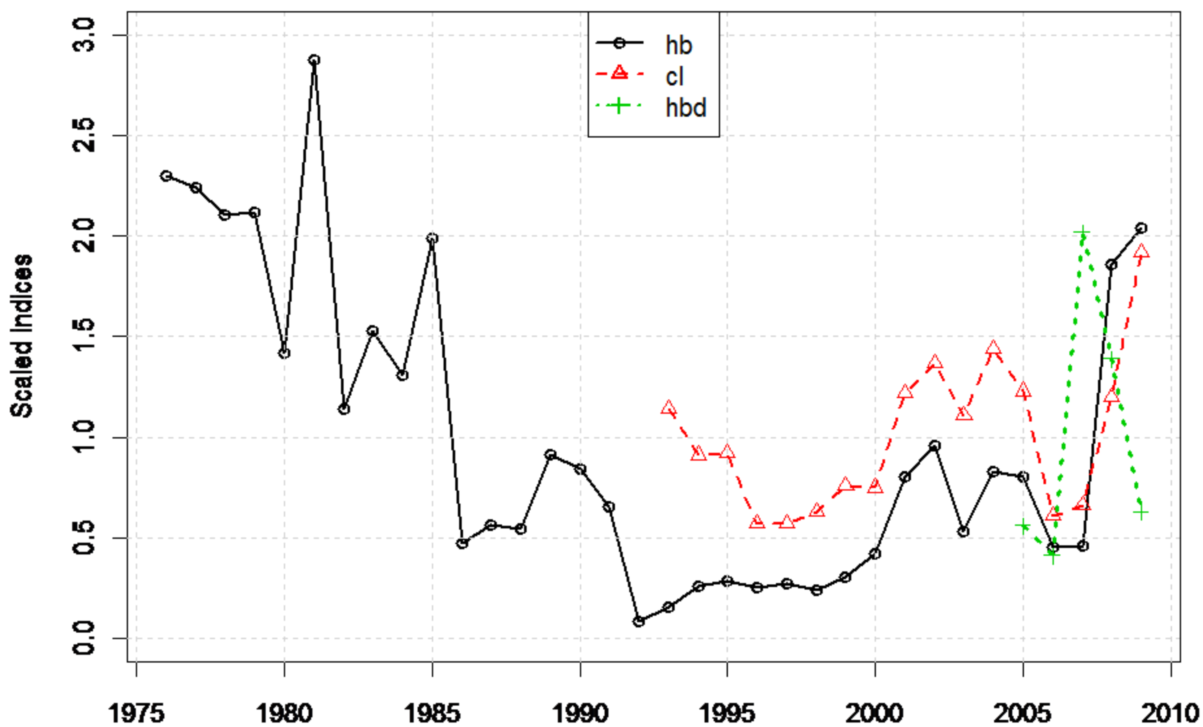


Figure 5.6. Top panel: Beverton–Holt spawner-recruit curves, with and without lognormal bias correction. The expected (upper) curve was used for computing management benchmarks. Years within panel indicate year of recruitment generated from spawning biomass one year prior. Diagonal line indicates MSY-level replacement. Bottom panel: log of recruits (number age-1 fish) per spawner (mature female gonad weight) as a function of spawners.

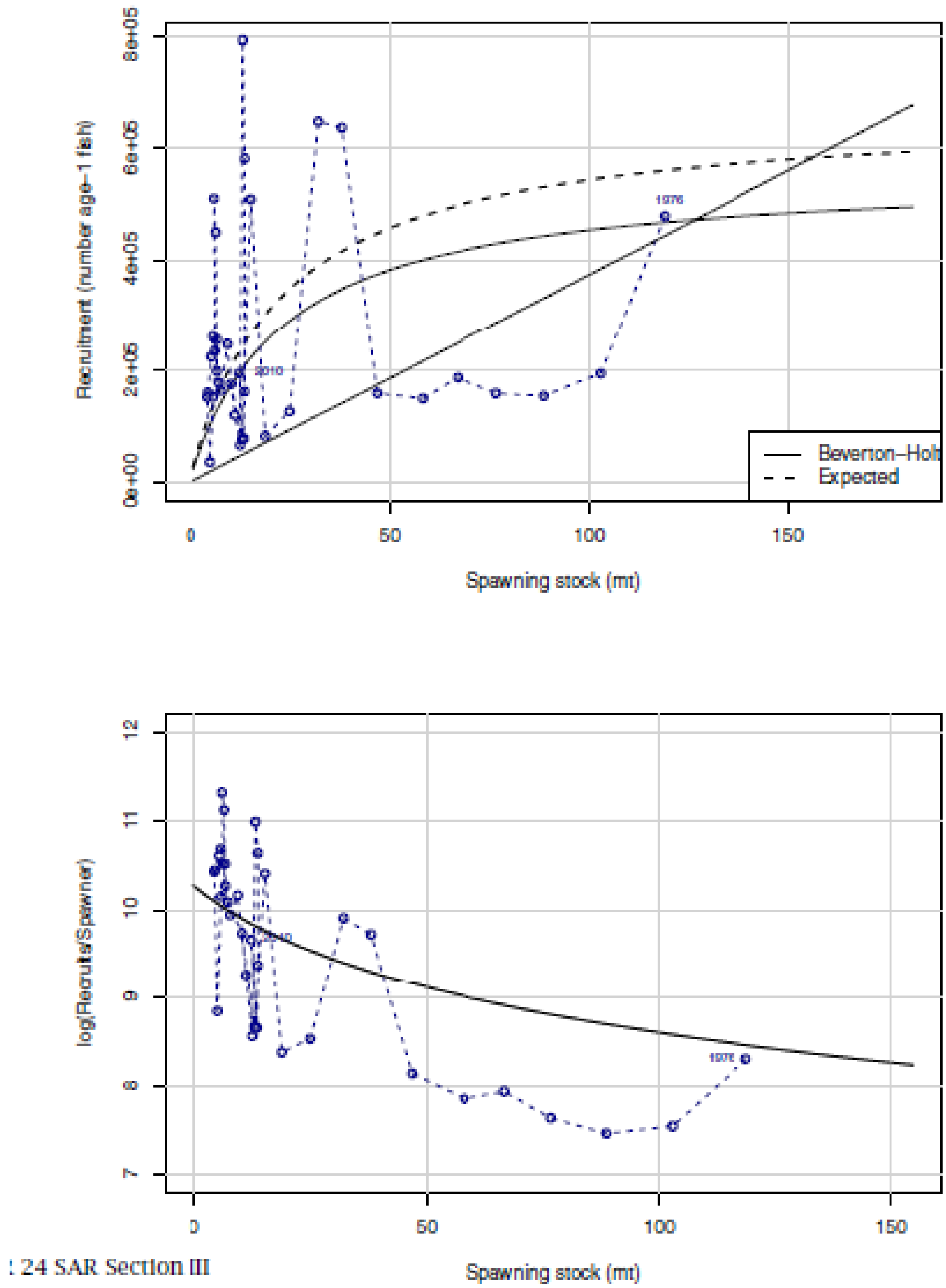


Figure 5. 7. Yield per Recruit

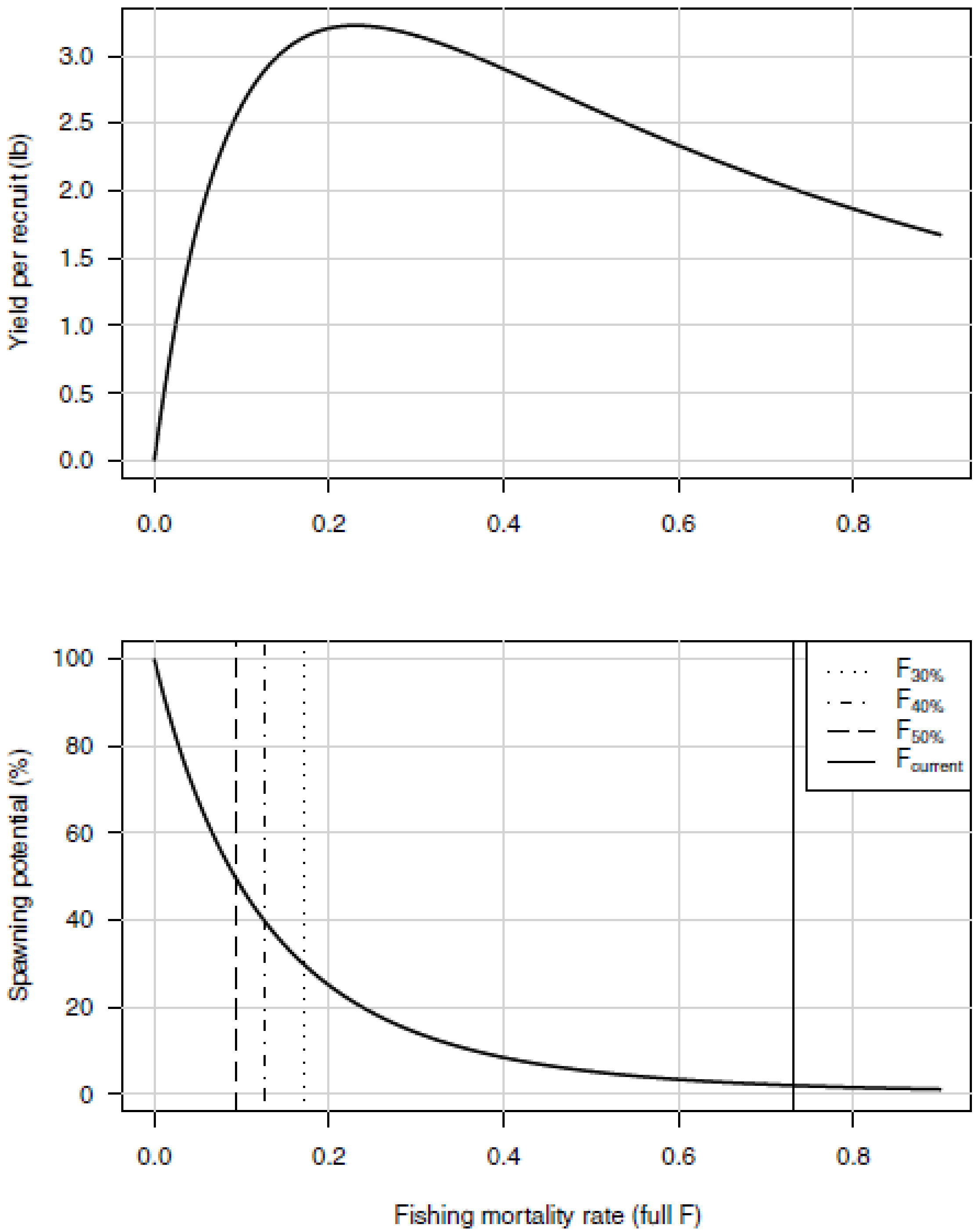


Figure 5.8a. Estimated time series relative to benchmarks. Solid line indicates estimates from base run of the Beaufort Assessment Model; gray error bands indicate 5th and 95th percentiles of the MCB trials. Top panel: spawning biomass relative to the minimum stock size threshold (MSST). Bottom panel: F relative to F_{MSY}.

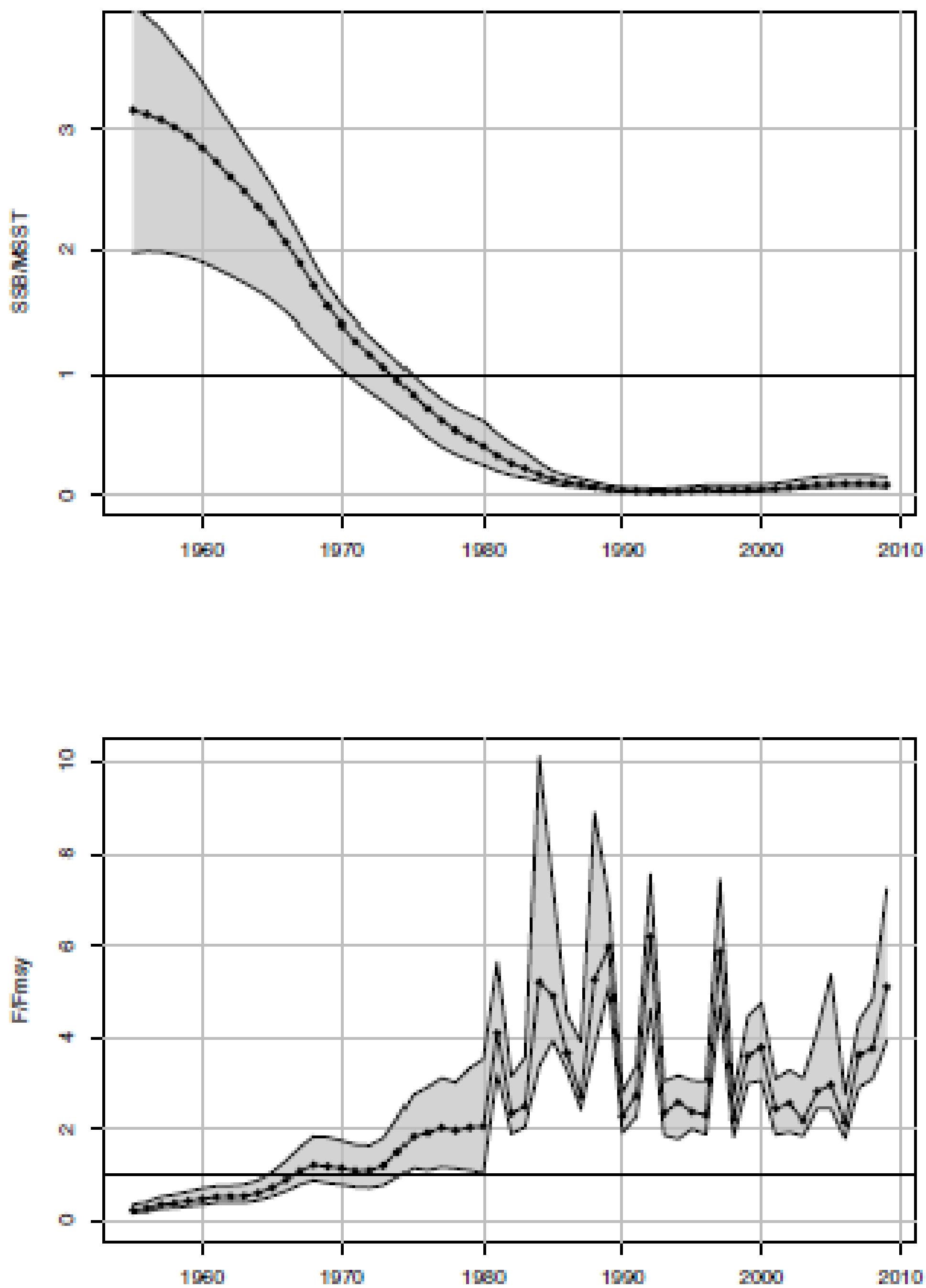


Figure 5.8b. Phase plot of stock and fishery status estimated by the base run and by forty-four sensitivity runs.

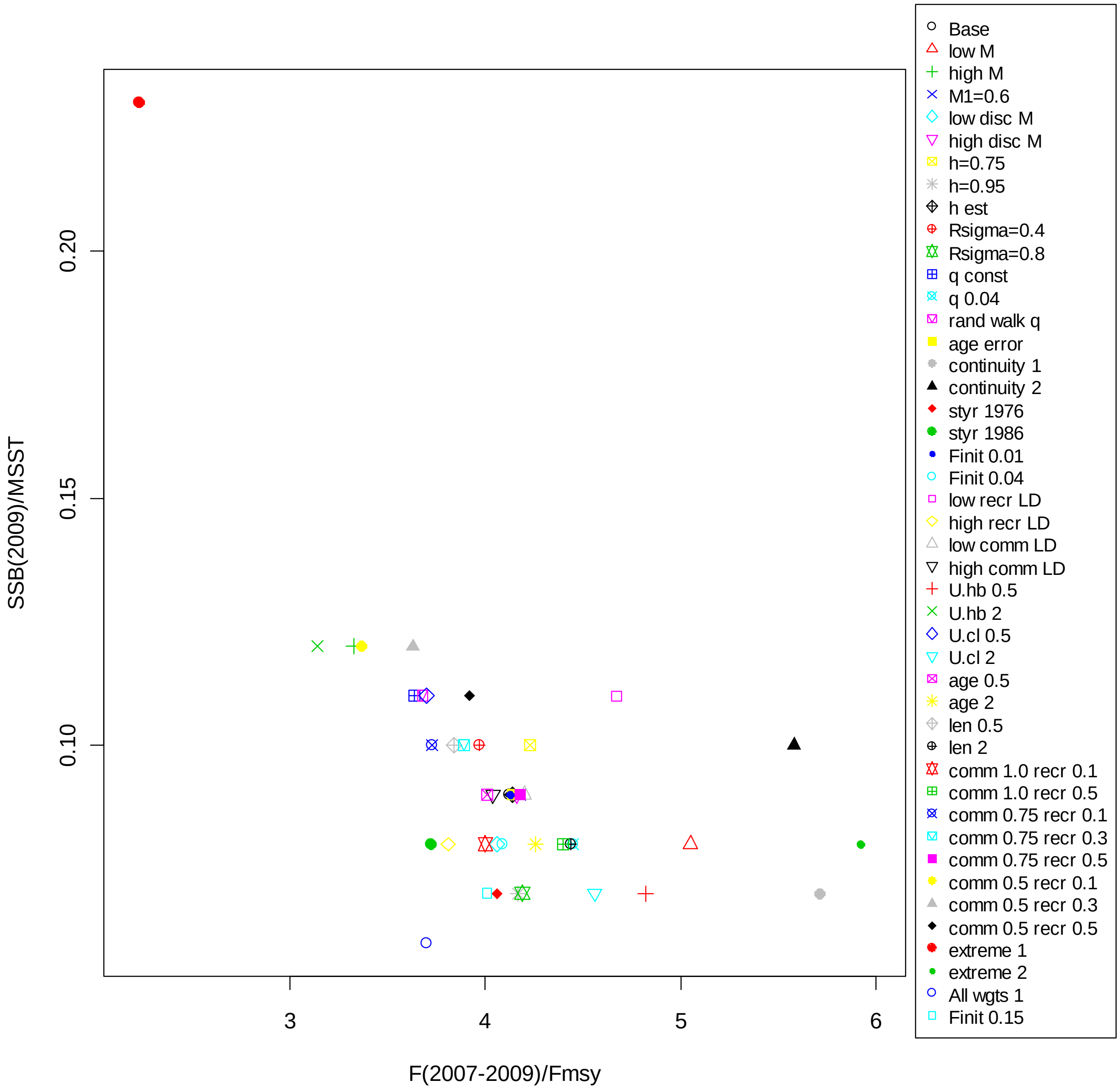


Figure 5.9. Projections

Figure 3.62. Projection results under scenario 1—fishing mortality rate fixed at $F = 0$. Curve represents the proportion of projection replicates for which SSB(mid-year) has reached at least $SSB_{MSY} = 156$.

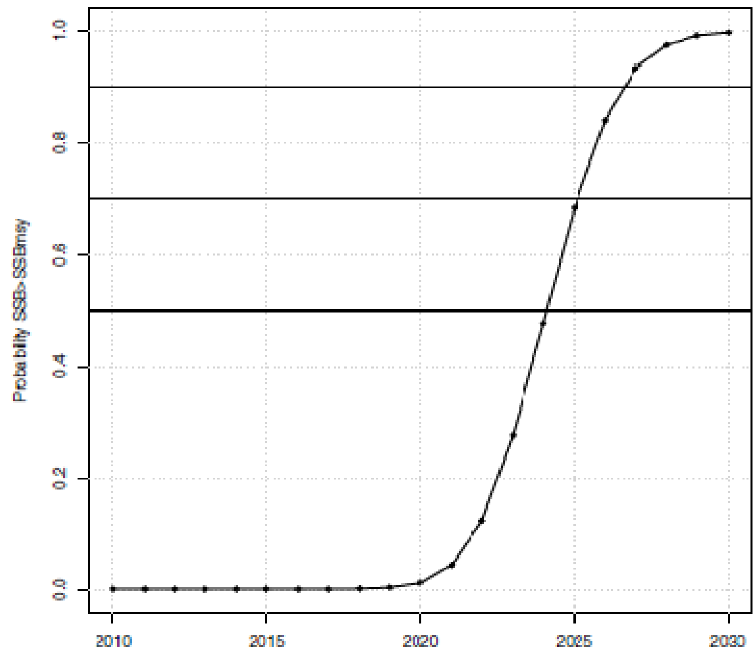


Figure 3.63. Projection results under scenario 2—fishing mortality rate fixed at $F = F_{current}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY-related quantities. Spawning stock (SSB) is at mid-year.

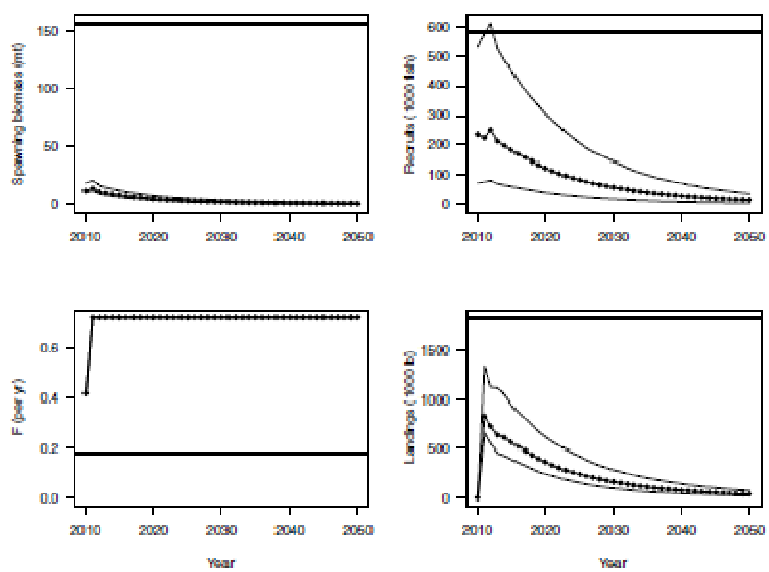


Figure 3.64. Projection results under scenario 3—fishing mortality rate fixed at F = 65%F_{MSY}. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY-related quantities. Spawning stock (SSB) is at mid-year.

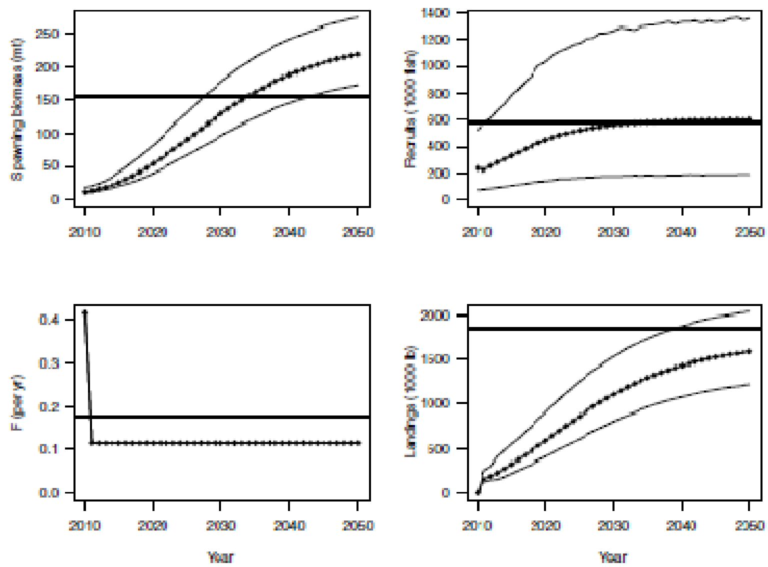


Figure 3.65. Projection results under scenario 4—fishing mortality rate fixed at F = 75%F_{MSY}. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY-related quantities. Spawning stock (SSB) is at mid-year.

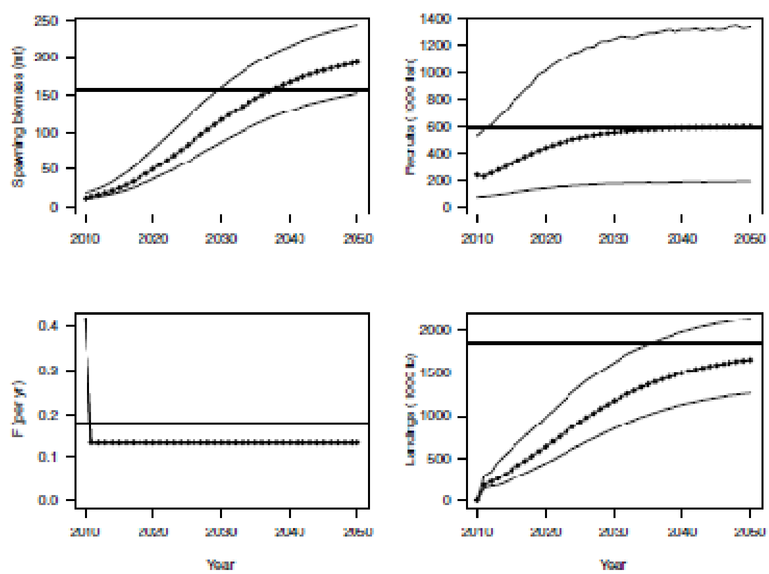


Figure 3.66. Projection results under scenario 5—fishing mortality rate fixed at $F = 85\%F_{MSY}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY-related quantities. Spawning stock (SSB) is at mid-year.

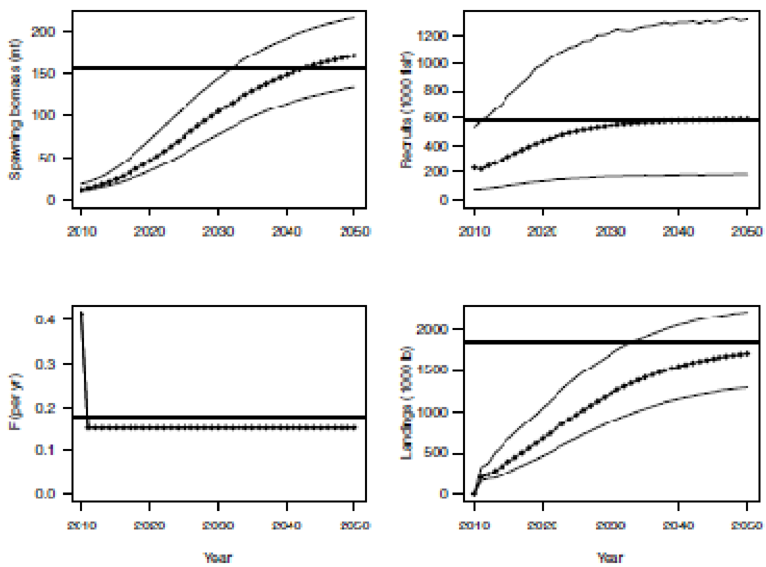


Figure 3.67. Projection results under scenario 6—fishing mortality rate fixed at $F = F_{MSY}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY-related quantities. Spawning stock (SSB) is at mid-year.

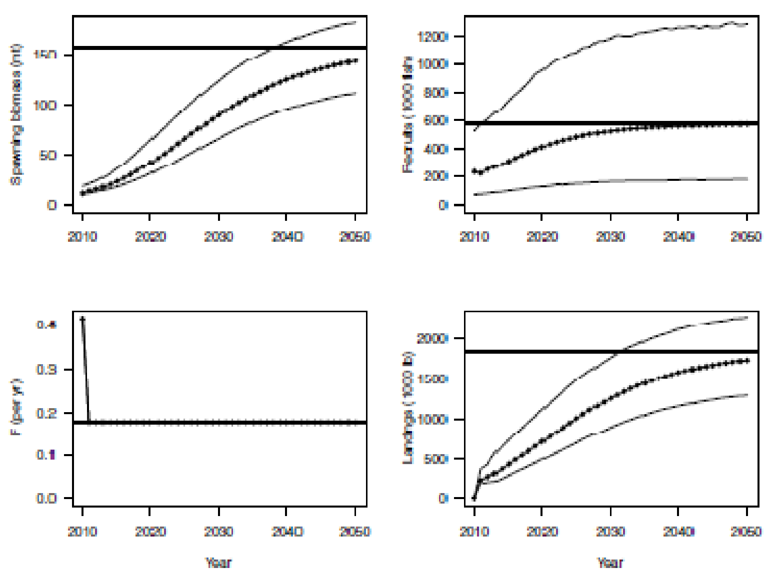


Figure 3.68. Projection results under scenario 7—moratorium projection (all potential landings converted to discards). Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY-related quantities. Spawning stock (SSB) is at mid-year.

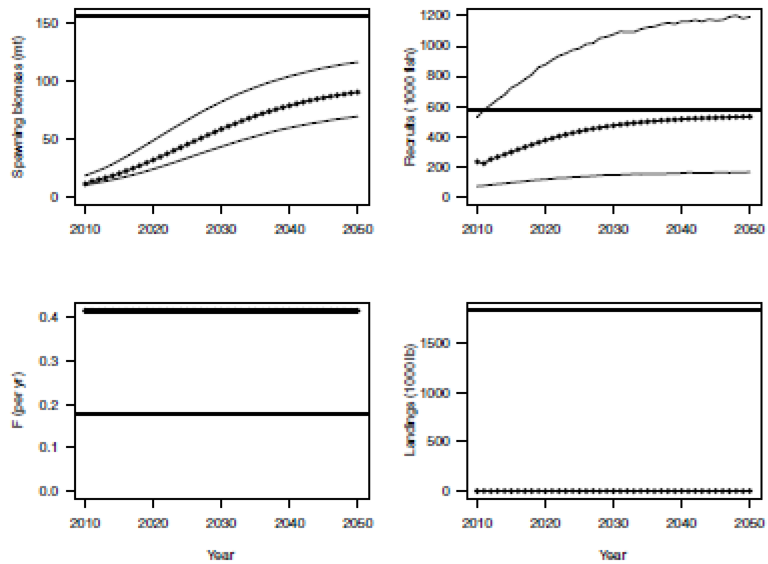


Figure 3.69. Projection results under scenario 8—fishing mortality rate fixed at $F = F_{rebuild}$, with rebuilding probability of 0.5 in 2047. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY-related quantities. Spawning stock (SSB) is at mid-year.

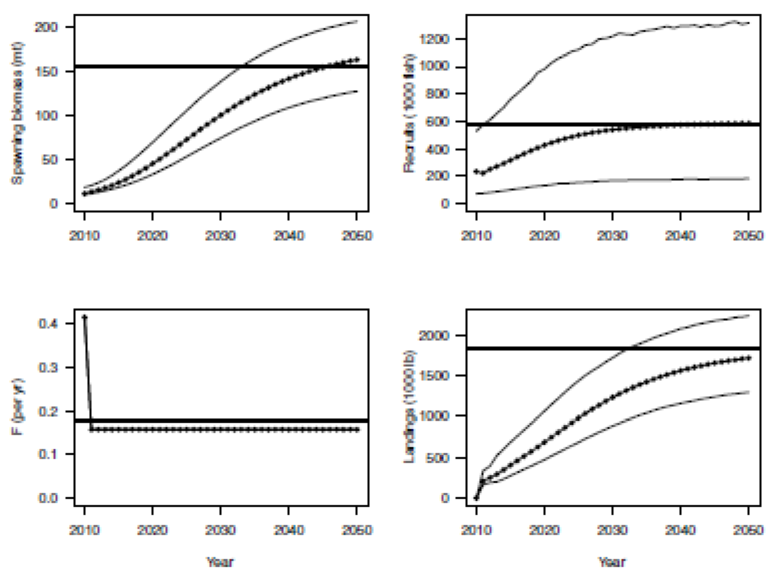


Figure 3.70. Projection results under scenario 9—fishing mortality rate fixed at $F = F_{rebuild}$, with rebuilding probability of 0.70 in 2047. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections. Horizontal lines mark MSY-related quantities. Spawning stock (SSB) is at mid-year.

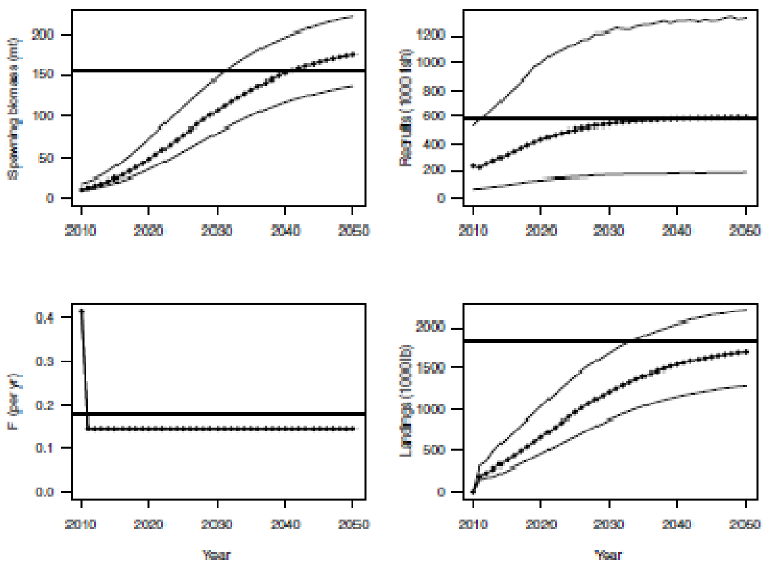
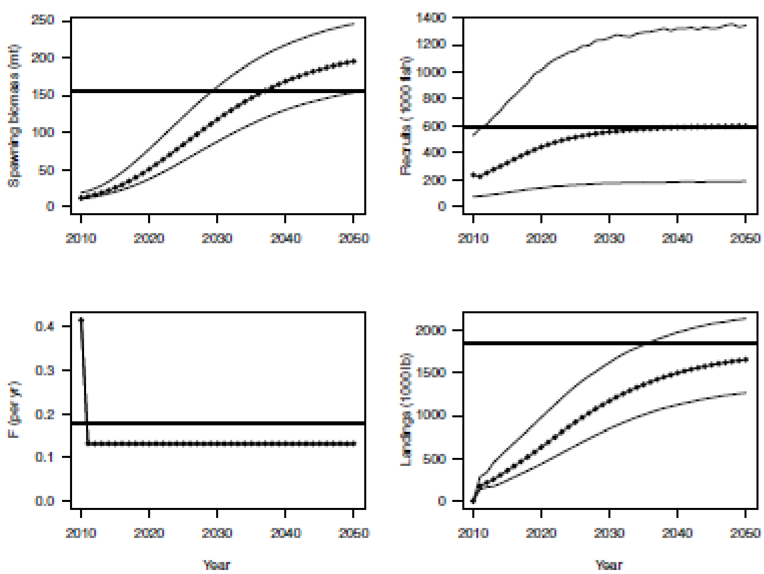


Figure 3.71. Projection results under scenario 10—fishing mortality rate fixed at $F = F_{rebuild}$, with rebuilding probability of 0.90 in 2047. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections. Horizontal lines mark MSY-related quantities. Spawning stock (SSB) is at mid-year.



S E D A R

Southeast Data, Assessment, and Review

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SEDAR 24

South Atlantic Red Snapper

Data Workshop Report

(Stock Assessment Report Section II)

June 25, 2010

(Corrected June 29, 2010 and July 30, 2010)

SEDAR is a Cooperative Initiative of:

The Caribbean Fishery Management Council
The Gulf of Mexico Fishery Management Council
The South Atlantic Fishery Management Council
NOAA Fisheries Southeast Regional Office
NOAA Fisheries Southeast Fisheries Science Center
The Atlantic States Marine Fisheries Commission
The Gulf States Marine Fisheries Commission

SEDAR
The South Atlantic Fishery Management Council
4055 Faber Place #201
North Charleston, SC 29405
(843) 571-4366

Revision of June 29, 2010: Correction of conversion value used when converting calculated mean weights in kg to pounds for discarded commercial handline data (Section 3.4.2). The previous version of the DW report listed an average weight of 0.6 pounds, this version corrects the value to 2.9 pounds.

Revision of July 30, 2010: Update and correction of the DW participant list (Section 1.3).

Table of Contents

1 Introduction

1.1 Workshop Time and Place

The SEDAR 24 Data Workshop was held May 24-28, 2010, in Charleston, SC.

1.2 Terms of Reference

Data Workshop Terms of Reference – SAFMC Approved March 5, 2010

1. Review stock structure and unit stock definitions and consider whether changes are required.
2. Review, discuss, and tabulate available life history information (e.g., age, growth, natural mortality, reproductive characteristics); provide appropriate models to describe growth, maturation, and fecundity by age, sex, or length as applicable. Evaluate the adequacy of available life-history information for conducting stock assessments and recommend life history information for use in population modeling. Provide a written description of the biological sampling programs.
3. Compare and contrast life history parameter recommendations between the Gulf and South Atlantic populations of red snapper, and consider whether greater consistency between assessments of Gulf and South Atlantic stocks is appropriate.
4. Evaluate expanded otolith sampling efforts conducted during 2009 and consider which samples are appropriate as indicators of fishery and population age structure. Consider whether revisions of growth models are justified based on these additional samples.
5. Review available research and published literature on discard mortality rates, considering efforts for red snapper and similar species from the Atlantic as well as other areas such as the Gulf of Mexico, and considering recommendations on discard mortality provided through SEDAR 7 (Gulf of Mexico Red Snapper). Provide estimates of discard mortality rates by fishery, gear type, depth, and other feasible strata. Include thorough rationale for recommended discard mortality rates. Provided justification for any recommendations that deviate from the range of discard mortality provided in available research and published literature.
6. Provide measures of population abundance that are appropriate for stock assessment. Consider and discuss all available and relevant fishery dependent and independent data sources. Document all programs evaluated, addressing program objectives, methods, coverage, sampling intensity, and other relevant characteristics. Provide maps of survey coverage. Develop CPUE and index values by appropriate strata (e.g., age, size, area, and fishery); provide measures of precision and accuracy. Evaluate the degree to which available indices adequately represent fishery and population conditions. Recommend which data sources are considered adequate and reliable for use in assessment modeling.

7. Review the application of pre-MRFSS recreational catch records in the SEDAR 15 benchmark assessment and recommend appropriate use of pre-MRFSS data for assessment of red snapper.
8. Characterize commercial and recreational catch, including both landings and discards in both pounds and number. Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector. Provide observed length and age distributions if feasible. Provide maps of fishery effort and harvest. Provide a written description of the discard sampling programs.
9. Review SEDAR 15 and SEDAR 7 approaches to selectivity of red snapper, post-SEDAR 15 evaluations of fishery selectivity patterns for Atlantic red snapper, and available length and age composition information to develop recommendations for addressing fishery selectivity in the assessment model. Specifically address the degree to which domed shape selectivity should be applied to hook and line fisheries.
10. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Include specific guidance on sampling intensity (number of samples including age and length structures) and appropriate strata and coverage.
11. Develop a spreadsheet of assessment model input data that reflects the decisions and recommendations of the Data Workshop. Review and approve the contents of the input spreadsheet by June 4.
12. No later than June 18, 2010, prepare the Data Workshop report providing complete documentation of workshop actions and decisions (Section II. of the SEDAR assessment report). Develop a list of tasks to be completed following the workshop

1.3 List of Participants

SEDAR 24 Participants List

South Atlantic Red Snapper

Data Evaluation Workshop
May 24-28, 2010
Charleston, SC

Chairman Dale Theiling, SEDAR 24 Coordinator

Appointee	Function	Affiliation
DATA WORKSHOP PANEL		
Data Management		
Rob Cheshire	Data Compiler	SEFSC, Beaufort
Life History Workgroup		
Jennifer Potts	Leader and Editor	SEFSC, Beaufort
Dan Carr	Rapporteur and Data Provider	SEFSC, Beaufort
Chip Collier	Data Provider	NC DMF, SAFMC SSC
Marcel Reichert	Data Provider	MARMAP, SAFMC SSC
*Eric Robillard	Data Provider	GA DNR
Janet Tunnell	Data Provider	FL FWCC
Dave Wyanski	Data Provider	SC DNR
Laurie DiJoy	Data Provider	SC DNR
Commercial Statistics Workgroup		
Doug Vaughan	Leader and Editor	SEFSC, Beaufort
Stephanie McInerny	Rapporteur and Data Provider	NC DMF
Steve Brown	Data Provider	FL FWCC
*Julie Califf	Data Provider	GA DNR
Julie DeFilippi	Data Provider	ACCSP
David Gloeckner	TIP Data Provider	SEFSC, Beaufort
Jack Holland	Data Provider	NC DMF
Kevin McCarthy	Logbook Data Provider	SEFSC, Miami
David Player	Data Provider	SC DNR
Recreational Statistics Workgroup		
Ken Brennan	Leader, Editor, & Headboat Data	SEFSC, Beaufort
Kathy Knowlton	Rapporteur and Data Provider	GA DNR
Richard Cody	Data Provider	FL FWCC
*Doug Mumford	Data Provider	NC DMF
Beverly Sauls	Data Provider	FL FWCC
Tom Sminkey	Data Provider	MRIP
Chris Wilson	Data Provider	NC DMF
Julia Byrd	Data Provider	SC DNR

Indices Workgroup

Amy Schueller	Leader and Editor	SEFSC, Beaufort
Brian Linton	Rapporteur & Gulf RS Ass't Advice	SEFSC, Miami
Julie DeFilippi	Data Provider	ACCSP
Paul Spencer	Assessment Advice	AFSC
Jessica Stephen	Data Provider	SC DNR/MARMAP

Analytical Team Representative

Kyle Shertzer	Lead Analyst and Model Editor	SEFSC, Beaufort

Fishery Representatives

Steve Amick	Charter/Headboat GA	SAFMC SG AP
Zack Bowen	Charter/Headboat GA	SAFMC SG AP
Gregory DeBrango	Commercial, FL	SAFMC SG AP
David Crisp	Recreational, FL	Individual
Kenny Fex	Commercial, NC	SAFMC SG AP
Frank Hester	Industry Scientist	Industry Consultant
Rusty Hudson	Fishery Consultant	Directed Sustainable Fisheries, Inc.
Robert Johnson	Charter/Headboat N FL	SAFMC SG AP
Rodney Smith	Recreational, FL	SAFMC SG AP

* panel members not attending the workshop

APPOINTED OBSERVER

Kevin Stokes	Data Process Evaluation	CIE

COUNCIL REPRESENTATIVES

George Geiger	Council Member	SAFMC
Ben Hartig	Council Member	SAFMC
Charles Phillips	Council Member	SAFMC

COUNCIL AND AGENCY STAFF

Myra Brouwer	Observer	SAFMC
John Carmichael	Observer	SAFMC/SEDAR
Rick DeVictor	Red Snapper Council Lead	SAFMC
Kari Fenske	Observer	SAFMC
Patrick Gilles	Observer	SEFSC
Rachael Lindsay	Administrative Support	SEDAR
Anna Martin	Observer	SAFMC
Julie Neer	Observer	SEDAR
Andy Strelcheck	Observer	SERO
Gregg Waugh	Observer	SAFMC
Erik Williams	Observer	SEFSC, Beaufort

OBSERVERS

Joseph Ballenger
Jim Busse

Sera Drevenak
David Grubbs
Jimmy Hull
Kevin Kolmos
Josh Loefer
David Nelson
Paul Nelson
Ron Surreny
Gregg Swanson
Robert Welch
Byron White

Acronyms
SEDAR 24 Participants List
South Atlantic Red Snapper

ACCSP	Atlantic Coastal Cooperative Statistics Program
AFSC	Alaska Fisheries Science Center
CIE	Center for Independent Experts
FL FWCC	Florida Fish and Wildlife Conservation Commission
GA DNR	Georgia Department of Natural Resources
MARMAP	Marine Resources Monitoring, Assessment, and Prediction
MRIP	Marine Recreational Information Program
NC DMF	North Carolina Division of Marine Fisheries
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
RS	Red Snapper
SEFSC	Southeast Fisheries Science Center, National Marine Fisheries Service
SERO	Southeast Regional Office, National Marine Fisheries Service
SC DNR	South Carolina Department of Natural Resources
SEDAR	Southeast Data, Assessment, and Review
SG AP	Snapper Grouper Advisory Panel
SSC	Science and Statistics Committee
TBN	To be named
TIP	Trip Interview Program, National Marine Fisheries Service

1.4 List of Working Papers and Reference Documents

SEDAR24
South Atlantic Red Snapper
Workshop Document List

Document #	Title	Authors
Documents Prepared for the Data Workshop		
SEDAR24-DW01	Discards of Red Snapper Calculated for Vessels with Federal Fishing Permits in the US South Atlantic	K. McCarthy 2010
SEDAR24-DW02	SEDAR 24 South Atlantic Red Snapper Management Summary	J. McGovern 2010
SEDAR24-DW03	Standardized catch rates of U.S. Atlantic red snapper (*Lutjanus campechanus*) from headboat data	Sustainable Fisheries Division, NMFS 2010
SEDAR24-DW04	Standardized catch rates of U.S. Atlantic red snapper (*Lutjanus campechanus*) from commercial logbook data	Sustainable Fisheries Division, NMFS 2010
SEDAR24-DW05	Red snapper standardized catch rates from the Marine Recreational Fisheries Statistics Survey for the U.S. Atlantic Ocean, 1981-2009	Indices Group MRFSS 2010
SEDAR24-DW06	Distribution of red snapper catches from headboats operating in the South Atlantic	Sustainable Fisheries Division, NMFS 2010
SEDAR24-DW07	Georgia Headboat Red Snapper Catch & Effort Data, 1983-2009	S. Amick, K. Knowlton 2010
SEDAR24-DW08	Sampling Procedures Used in the Trip Interview Program (TIP)	Sustainable Fisheries Division, NMFS 2010
SEDAR24-DW09	Pre-Data Workshop Development of Commercial Landings for the Red Snapper Fishery	D. Vaughan, D. Gloeckner 2010
SEDAR24-DW10	Age Workshop for Red Snapper	J. Potts, editor 2009
SEDAR24-DW11	Review and Analysis of Methods to Estimate Historic Recreational Red Snapper Landings in the South Atlantic	SEDAR24 Historic Rec Catch Group 2010
SEDAR24-DW12	Red Snapper Discard Mortality Working Paper	SEDAR24 Discard Mortality Group

		2010
SEDAR24-DW13	South Atlantic Red Snapper Marine Recreational Fishery Landings: FHS-conversion of Historic MRFSS Charter Boat Catches	T. Sminkey 2010
SEDAR24-DW14	Marine Resources Monitoring, Assessment and Prediction Program: Report on Atlantic Red Snapper, *Lutjanus campechanus,* for the SEDAR 24 Data Workshop	MARMAP 2010
SEDAR24-DW15	Red Snapper Length Frequencies and Condition of Released Fish from At-Sea Headboat Observer Surveys, 2004 to 2009.	B. Sauls and C. Wilson 2010
Documents Prepared for the Assessment Workshop		
SEDAR24-AW01	Assessment History of Red Snapper (*Lutjanus campechanus*) in the U.S. Atlantic	Sustainable Fisheries Branch, NMFS 2010
Documents Prepared for the Review Workshop		
SEDAR24-RW01		
Final Assessment Reports		
SEDAR24-SAR	Assessment of Red Snapper in the US South Atlantic	To be prepared by SEDAR 24
Reference Documents		
SEDAR24-RD01	Age, Growth, And Reproduction Of The Red Snapper, *Lutjanus Campechanus,* From The Atlantic Waters Of The Southeastern U.S.	D. B. White, S. M. Palmer 2004
SEDAR24-RD02	Age and growth of red snapper, *Lutjanus Campechanus*, from the southeastern United States	S. McInerny 2007
SEDAR24-RD03	Commercial catch composition with discard and immediate release mortality proportions off the southeastern coast of the United States	J. A. Stephen, P. J. Harris 2010
SEDAR24-RD04	The 1960 Salt-Water Angling Survey, USFWS Circular 153	J. R. Clark c.1962
SEDAR24-RD05	The 1965 Salt-Water Angling Survey, USFWS Resource Publication 67	D. G. Deuel, J. R. Clark 1968
SEDAR24-RD06	1970 Salt-Water Angling Survey, NMFS Current Fisheries Statistics Number 6200	D. G. Deuel 1973
SEDAR24-RD07	Lecture Notes on Coastal and Estuarine Studies, #10 Fisheries Management, Ch VII Marine Sport Fisheries	J. L. McHugh 1984
SEDAR24-RD08	Survey of Offshore Fishing in Florida	M. A. Moe, Jr. 1963

SEDAR24-RD09	Geographic Comparison of Age, Growth, Reproduction, Movement, and Survival of Red Snapper off the State of Florida	K. M. Burns, N. J. Brown-Petterson, R. M. Overstreet 2006
SEDAR24-RD10	Regional Differences in Florida Red Snapper Reproduction	N. J. Brown-Petterson, K. M. Burns, R. M. Overstreet 2008
SEDAR24-RD11	Evaluation of the Efficacy of the Minimum Size Rule in the Red Grouper and Red Snapper Fisheries With Respect to J and Circle Hook Mortality and Barotrauma and the Consequences for Survival and Movement	K. M. Burns 2009
SEDAR24-RD12	Survival of Released Red Snapper progress Report	R. O. Parker, Jr. 1985
SEDAR24-RD13	Survival of Released Reef Fish—A Summary of Available Data (Preliminary)	R. O. Parker, Jr. 1991
SEDAR24-RD14	Incorporating Mortality from Catch and Release into Yield-per-Recruit Analyses of Minimum-Size Limits	J. R. Waters, G. R. Huntsman 1986
SEDAR24-RD15	Modified hooks reduce incidental mortality of snapper (*Pagrus auratus*: Sparidae) in the New Zealand commercial longline fishery	T. J. Willis, R. B. Millar 2001
SEDAR24-RD16	Key principles for understanding fish bycatch discard mortality	M. W. Davis 2002
SEDAR24-RD17	Indirect Estimation of Red Snapper (Lutjanus campechanus) and gray Triggerfish (*Balistes capriscus*) Release Mortality	W. F. Patterson, III, G. W. Ingram, Jr., R. L. Shipp, J. H. Cowan, Jr. 2002
SEDAR24-RD18	Red Snapper Discards in Texas Coastal waters-a Fishery Dependent Onboard Survey of Recreational Headboat Discards and Landings	B. A. Dorf 2003
SEDAR24-RD19	Partitioning Release Mortality in the Undersized Red snapper Bycatch: Comparison of Depth vs. Hooking Effects	K. M. Burns, N. F. Parnell, R. R. Wilson, Jr. 2004
SEDAR24-RD20	Catch-and-release science and its application to conservation and management of recreational fisheries	S. J. Cooke, H. L. Schramm 2007
SEDAR24-RD21	Discard composition and release fate in the snapper and grouper commercial hook-and-line fishery in North Carolina, USA	P. J. Rudershausen, J. A. Buckel, E. H. Williams 2007

SEDAR24-RD22	Evaluating the physiological and physical consequences of capture on post-release survivorship in large pelagic fishes	G. B. Skomal 2007
SEDAR24-RD23	Release Mortality of Undersized Fish from the Snapper–Grouper Complex off the North Carolina Coast	A. S. Overton, J. Zabawski, K. L. Riley 2008
SEDAR24-RD24	Capture depth related mortality of discarded snapper (*Pagrus auratus*) and implications for management	J. Stewart 2008
SEDAR24-RD25	Linking ''Sink or Swim'' Indicators to Delayed Mortality in Red Snapper by Using a Condition Index	S. L. Diamond, M. D. Campbell 2009
SEDAR24-RD26	Does Venting Promote Survival of Released Fish?	G. R. Wilde 2009
SEDAR24-RD27	Field Experiments on Survival Rates of Caged and Released Red Snapper	G. R. Gitschlag, M. L. Renaud 1994
SEDAR24-RD28	Red Snapper in the Northern Gulf of Mexico: Age and Size Composition of the Commercial Harvest and Mortality of Regulatory Discards	D. L. Nieland, A. J. Fischer, M. S. Baker, Jr., C. A. Wilson, III 2007
SEDAR24-RD29	Factors Affecting Catch and Release (CAR) Mortality in Fish: Insight into CAR Mortality in Red Snapper and the Influence of Catastrophic Decompression	J. L. Rummer 2007
SEDAR24-RD30	Evaluation of The Efficacy of the Current Minimum Size Regulation for Selected Reef Fish Based on Release Mortality and Fish Physiology	K. M. Burns, N. J. Brown-Peterson, R. M. Overstreet 2008
SEDAR24-RD31	American Fishes - A Popular Treatise upon the Game and Food Fishes of North America with Especial Reference to Habits and Methods of Capture	G. B. Goode, T. Gill 1903
SEDAR24-RD32	Proceedings: Colloquium on Snapper-Grouper Fishery Resources of the Western Central Atlantic Ocean	H. R. Bullis, Jr., A. C. Jones 1976
SEDAR24-RD33	Growth and Mortality of Red Snappers in the West-Central Atlantic Ocean and Northern Gulf of Mexico	R. S. Nelson, C. S. Manooch, III 1982
SEDAR24-RD34	Yield Per Recruit Models of Some Reef Fishes of the U. S. South Atlantic Bight	G. R. Huntsman, C. S. Manooch, III, C. B. Grimes 1983
SEDAR24-RD35	Population Assessment of the Red Snapper, *Lutjanus campechanus*, from the Southeastern United States	C. S. Manooch, III, J. C. Potts, D. S. Vaughan, M. L.

		Burton 1997
SEDAR24-RD36	Executive Summary: Review of Recreational Fisheries Survey Methods	National Research Council 2006
SEDAR24-RD37	Spawning Locations for Atlantic Reef Fishes off the Southeastern U.S.	G. R. Sedberry, O. Pashuk, D. M. Wyanski, J. A. Stephen, P. Weinbach 2006
SEDAR24-RD38	More Red Snapper Discussion	J. H. Cowan, Jr. 2009
SEDAR24-RD39	A Perspective of the Importance of Artificial Habitat on the Management of Red Snapper in the Gulf of Mexico	R. L. Shipp, S. A. Bartone 2009
SEDAR24-RD40	National Survey of Fishing and Hunting	Dept Interior 1955
SEDAR24-RD41	National Survey of Fishing and Hunting 1960	Dept Interior 1960
SEDAR24-RD42	FMP, Regulatory Impact Review, and Final Environmental Impact Statement for the SG Fishery of the South Atlantic Region	SAFMC 1983
SEDAR24-RD43	Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Gulf of Mexico) – Red Snapper	D. Morgan 1988
SEDAR24-RD44	Evaluation of Multiple Factors Involved in Release Mortality of Undersized Red Grouper, Gag, Red Snapper and Vermilion Snapper	K. M. Burns, C. C. Koenig, F. C. Coleman 2002
SEDAR24-RD45	Physiological Effects of Swim Bladder Overexpansion and Catastrophic Decompression on Red Snapper	J. L. Rummer, W. A. Bennet 2005
SEDAR24-RD46	A Review of Movement in Gulf of Mexico Red Snapper: Implications for Population Structure	W. F. Patterson, III 2007
SEDAR24-RD47	J and Circle Hook Mortality and Barotrauma and the Consequences for Red Snapper Survival	K. M. Burns 2009
SEDAR24-RD48	Procedural Guidance Document 2 - Addressing Time-Varying Catchability	SEDAR 2009
SEDAR24-RD49	Final Report on Bioeconomic Analysis of the Red Snapper Rebuilding Plan and Transferable Rights Policies in the Gulf of Mexico <u>with</u> Supplementary Technical Document to the Final Report	W. L. Griffin, R. T. Woodward 2009
SEDAR24-RD50	Comments On SPR-Based Benchmarks For Red Snapper Stocks in the Southeastern USA	R. Methot, P. Rago, G. Scott

		2009
SEDAR24-RD51	The Recreational fishery in South Carolina: The Little River Story	V. G. Burrell 2000
SEDAR24-RD52	Southeastern U.S. Deepwater Reef Fish Assemblages, Habitat characteristics, Catches, and Life History Summaries	R. O. Parker, R. W. Mays 1998
SEDAR24-RD53	American Game and Food Fishes pp 410-412	D. S. Jordan, B. W. Evermann 1908
SEDAR24-RD54	Comparison of two approaches for estimating natural mortality based on longevity.	D. A. Hewitt, J. M. Hoenig 2005.
SEDAR24-RD55	Notes on the red snapper fishery	J. W. Collins 1886
SEDAR24-RD56	Southeast Region Headboat Survey Program Description	K. Brennan 2010
SEDAR24-RD57	Biological-Statistical Census of the Species Entering Fisheries in the Cape Canaveral Area	W. W. Anderson, J. W. Gehringer 1965
SEDAR24-RD58	Abundance Indices Workshop: Developing protocols for submission of abundance indices to the SEDAR process. SEDAR Procedures Workshop 1	SEDAR 2008
SEDAR24-RD59	Source Document for the Snapper-Grouper Fishery of the South Atlantic Region	SAFMC 1983
SEDAR24-RD60	Projected Combined Effects of Amendments 13C, 16, and 17A Regulations on south Atlantic Red Snapper Removals. SERO-LAPP-2009-07(Rev)	SERO v Jan 2010
SEDAR24-RD61	Catch Characterization and Discards within the Snapper Grouper Vertical Hook-and-Line Fishery of the South Atlantic United States	Gulf & SA Fisheries Foundation 2008
SEDAR24-RD62	Returns from the 1965 Schlitz Tagging Program Including a Cumulative Analysis of Previous Results	D. S. Beaumariage 1969
SEDAR24-RD63	Length of Recall Period and Accuracy of Estimates from the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation	W. L. Fisher, A.E. Grambsch, D.L. Eisenhower, D.R. Morganstein 1991
Previous SEDARs Documents of Interest		
SEDAR7-DW13	The steepness stock-recruit parameter for red snapper in the Gulf of Mexico (Lutjanus campechanus): what can be learned from other fish stocks?	M. K. McAllister 2004
SEDAR7-DW19	Estimating Catches and fishing Effort of the Southeast United States Headboat Fleet, 1972-1982	R. L. Dixon, G. R. Huntsman, Undated Draft

SEDAR7-AW16	Estimates of Historical Red Snapper Recreational Catch Levels Using US Census Data and Recreational Survey Information	G. P. Scott 2004
SEDAR7-SAR1	Stock Assessment Report Gulf of Mexico Red Snapper, SEDAR7 Assessment Report 1	SEDAR 2005
SEDAR17-RD18	The summer flounder chronicles: Science, politics, and litigation, 1975-2000.	M. Teceiro 2002
SEDAR17-RD20	Comparing 1994 angler catch and harvest rates from on-site and mail surveys on selected lakes.	B. Roach, J. Trial, and K. Boyle 1999.
SEDAR17-RD23	Effects of recall bias and nonresponse bias on self-report estimates of angling participation.	M. A. Tarrant, M. J. Manfredo, P. B. Bayley, R. Hess 1993
SEDAR19-DW05	Evaluation of the 1960, 1965, and 1970 U.S. Fish and Wildlife Service salt-water angling survey data for use in the stock assessment of red grouper (Southeast US Atlantic) and black grouper (Southeast US Atlantic and Gulf of Mexico)	R. Cheshire, J. O'Hop 2009
SEDAR7-DW51	MSY, Bycatch and Minimization to the "Extent Practicable"	J. E. Powers 2004
SEDAR19-RD27	The Natural Mortality Rate of Gag Grouper: A Review of Estimators for Data-Limited Fisheries.	T. J. Kenchington

1.5 Itemized List of Tasks for Completion following Workshop

SEDAR 24 Data Workshop

Post-Workshop Tasks List

Workgroup	Task	Principal	Due
Indices	Attempt to compute the standardized headboat at sea observer discards index	A. Schueller	June 18
Indices	Draft of Indices section text to work group	A. Schueller	June 2
Indices	Comments on text to work group leader	Indices panelists	June 9
Indices	Final Indices section text to SEDAR	A. Schueller	June 11
Commercial	Take S24DW09 and remove title page, begin rewrite by redrafting Decisions based on rapporteur notes (S. McInerny) and Leader notes (D. Vaughan)	D. Vaughan	June 4
Commercial	Update landings tables and figures based on work at DW	D. Vaughan	June 4
Commercial	Include material on discard estimates, including brief comments on S24DW01 report	K. McCarthy	June 4
Commercial	Include write up concerning discard mortality calculations done during the DW and length comp for discards from observer data	D. Vaughan	June 4
Commercial	Finalize landings in numbers at age and length compositions	D. Gloeckner	June 4
Commercial	Finalize age compositions	D. Vaughan/ D. Gloeckner	June 4
Commercial	Describe various selectivity discussions, including contribution from K. Fex	D. Vaughan	June 4
Commercial	Include research recommendations in draft section	D. Vaughan	June 4
Commercial	Look into GIS mapping for logbook landings/trips by latitude/longitude; and depth contour map (showing bottom features and/or currents?), at NMFS Beaufort Lab, if needed check with NC DMF	D. Vaughan S. McInerny	June 9
Commercial	Send out a completed draft of the Commercial section of the DW report	D. Vaughan	June 4

Commercial	Submit comments on draft Commercial section	Commercial panelists	June 9
Commercial	Commercial input data (landings in numbers and weight & CVs, discard estimates and SE, length and age comps) will be provided to R. Cheshire for excel data (workbook)	D. Vaughan	June 7
Recreational	Writing assignments due to K. Brennan	Recreational panelists	June 4
Recreational	Send a rough draft of the Recreational section to the Recreational group for review	K. Brennan	June 4
Recreational	Data to R. Cheshire for data workbook	K. Brennan	June 4
Recreational	Recreational Group report section final review due	Recreational panelists	June 10
Recreational	Writing assignments: At-Sea Observer Program Length Comps, FL At-Sea Observer Program, Historical data review, working paper review	B. Sauls	June 4
Recreational	Writing assignments: At-Sea Observer Program Length Comps	C. Wilson	June 4
Recreational	Writing assignments: working paper review	K. Knowlton	June 4
Recreational	Writing assignments: working paper review, MRFSS data summaries	T. Sminkey	June 4
Recreational	Writing assignments: Historic landings\ratio method, Discard Mortality	E. Williams	June 4
Recreational	Writing assignments: Headboat Program Length\Age Comps, working paper review	R. Cheshire	June 4
Recreational	Draft Recreational report section due to SEDAR	K. Brennan	June 11
Life History	Submit a critique of SEDAR 24-DW #12	J. Ballenger	June 1
Life History	Submit a critique of SEDAR 24-DW#14	J. Potts	June 1
Life History	Send a rough draft of the Life History section to the Life History group for review	J. Potts	June 4
Life History	Data to R. Cheshire for data workbook	J. Potts	June 4
Life History	Life History Group report section final review due	Life History panelists	June 10
Life History	Final Life History report section to SEDAR	J. Potts	June 11

2 Life History

2.1 Overview (Group Membership, Leader, Issues)

State and federal biologist and industry representatives comprised the Life History Work Group (LHWG)

Jennifer Potts – NMFS, Beaufort, NC, Leader of LHWG
Joseph Ballenger – SCDNR, Charleston, SC
Daniel Carr – NMFS, Beaufort, NC, Rapporteur
Chip Collier – NCDMF, Wilmington, NC
David Crisp – Industry Representative, Florida
Laurie DiJoy – SCDNR, Charleston, SC
Josh Loefer – SCDNR, Charleston, SC
Robert Johnson – Industry Representative, Florida
Janet Tunnell – FL FWC, St. Petersburg, FL
Byron White – SCNDNR, Charleston, SC
David Wyanski – SCDNR, Charleston, SC

The LHWG was tasked with combining age data from SEDAR15 with new age data sets from four sources: National Marine Fisheries Service Beaufort Laboratory (NMFS), South Carolina Department of Natural Resources (SCDNR), Georgia Department of Natural Resources (GADNR), and Florida Fish and Wildlife Conservation Commission (FL FWC). In order to combine age data from all sources, the LHWG needed to be sure that aging methodology between agencies was consistent. The four laboratories involved in aging US South Atlantic red snapper participated in an age workshop, followed by an exchange of otolith sections, to determine consistency in aging this species. A document was prepared (SEDAR24-DW10) and all four laboratories were consistently aging the fish. The data from the exchanges were provided to Dr. A. Schueller, NMFS, who created an age error matrix for use in the assessment model.

During the 2009 fishing year, dock side sampling for age structures was greatly increased. The LHWG was tasked with evaluating the expanded otolith sampling efforts conducted during 2009 and was to consider which samples were appropriate as indicators of fishery and population age structure (SEDAR24-DW-TOR #4).

The LHWG was also tasked with comparing and contrasting life history parameters between the US South Atlantic stock and the Gulf of Mexico stock (SEDAR24-DW-TOR #3). These comparisons will be addressed in the appropriate sections.

2.2 Review of Working Papers

2.2.1 Age workshop for red snapper (SEDAR24-DW-10)

Abstract

Age processing techniques and estimation can vary among labs leading to differences in demographic parameters used in stock assessment models. An age workshop was conducted to ensure that red snapper age sample preparation techniques and estimation are similar among labs that age red snapper in the US South Atlantic. Topics covered during the age workshop were methodology for preparing samples for aging, interpretation of the otolith macro-structure, and conversion of increment counts to ages. An initial APE of 11.3% between readers was calculated. Most of the potential differences were due to interpretation of the first annulus. Other issues with reading red snapper otoliths identified during the workshop were check mark or false annuli, determining otolith edge type, and aging only otoliths with sections taken from near the core. After the workshop, a second reference otolith set was sent to each aging lab and the overall average percent error improved to 6.15%. No bias was detected, and the data was symmetrically spread across the 1:1 diagonal. Because of these results, no ageing error correction is needed for the age data submitted for the SEDAR24 assessment.

Critique

SEDAR 24 DW Reference Document 10 was reviewed and deemed pertinent for the SEDAR process. This document described otolith preparation, annuli interpretation, edge type assignment, and age assignment.

2.2.2 Marine Resources Monitoring, Assessment and Prediction Program: Report on Atlantic red snapper, *Lutjanus campechanus*, for the SEDAR24 Data Workshop (SEDAR24-DW-14).

Abstract

During 2000 – 2009, MARMAP collected fishery-dependent and fishery-independent biological samples from red snapper inhabiting waters off North Carolina through the Florida Keys. The samples (n = 447) were used for age and growth and reproductive biology studies. These fish were caught using a variety of gears including trawls, traps, hook and line, spear, and longlines. MARMAP supplied two readers each for ageing and reproductive state. Ages ranged from 0 to 35 years (190 – 920 mm TL), but age 0 and 1 year old fish were very rare in the samples. These age data will be combined with other age data sets provided to SEDAR24. The reproductive data in this report is the most comprehensive information on Atlantic red snapper that exists. Overall sex ratio of Atlantic red snapper is 1:1 with age at 50% maturity for females at 1.87 years. For males, 50% were mature at age 1, though the low sample size of males in the younger ages may not give a true estimate of the male maturity schedule.

Critique

SEDAR24-DW-14 provides a good overview of the sampling efforts of MARMAP for age and reproductive biology data. The reproductive data are the most reliable data to use in SEDAR24, thus this report is pertinent to SEDAR24 Data Workshop.

2.3 Stock Definition and Description

No new evidence is available that suggests the Atlantic and Gulf should be managed as a single stock, and no new evidence of regional separation within the Atlantic is available. The Life History group recommends that the Atlantic be recognized as a single stock. The Gulf of Mexico is currently divided into eastern and western gulf components, but the sub-stocks are managed as a single unit (SEDAR7).

2.3.1 Population genetics

Evidence does not exist for separate Gulf of Mexico and Atlantic populations. Garber et al. (2004) described the population ranging from the Gulf of Mexico to the Atlantic coast of Florida as a “single, panmictic population”. A study by Saillant et al. (2010) based on nuclear-encoded microsatellites found that “spatial genetic structuring among young-of-the-year red snapper in the Gulf occurs at small geographic scales and is consistent with a metapopulation stock-structure model of partially connected populations.” Investigation of Atlantic Coast population genetics is under way (J.R. Gold, Texas A&M, personal communication, April 2010).

2.3.2 Demographic patterns

The LHWG investigated the potential for spatial differences in maturity, growth, and length at age. There was evidence that fish in the Florida-Georgia (South) region may mature younger and smaller than in the Carolinas (North) region (See section 2.8) There was no difference in mean length-at-age or growth between the two regions (Figure 2.7.1).

2.3.3 Otolith microchemistry

In order to further clarify the issue of separate stocks within the SA, the LHWG recommend that further research should be focused on otolith micro-chemistry. The use of otolith microchemistry may make it possible to distinguish Gulf of Mexico and Atlantic coast fish, as well as investigate regional recruitment in the Atlantic.

2.3.4 Tagging

Tagging studies do not provide any new evidence that suggests movement between Gulf of Mexico and Atlantic stocks, other than one fish tagged off Pensacola, FL, and recaptured off St. Augustine, FL (Burns et al. 2008). Fishermen have suggested that seasonal migration of fish occurs among regions of the South Atlantic. Telemetry studies are recommended to investigate movement of fish along the Atlantic coast.

2.4 Natural Mortality

2.4.1 Juvenile (YOY)

Juvenile red snapper are rarely encountered (n = 0 to 4 per year) in a nearshore (<30 ft) fishery-independent trawling program (SEAMAP) in the Atlantic. Fishermen reported observing juvenile red snapper on artificial reefs in shallow water. Estimates of juvenile red snapper mortality have been developed in the Gulf of Mexico; however, little information is available for the US South Atlantic. Data on age 0 fish will not be included as inputs into the stock assessment model.

2.4.2 Adult

Natural mortality of red snapper was estimated using several methods. Initially, natural mortality (M) of red snapper was estimated to be 0.08 using both a regression model for a variety of taxa and a regression model for teleosts reported by Hoenig (1983):

$\ln(M) = 1.44\text{-}0.982*\ln(t_{max})$ Variety of Taxa (M=0.08397 rounded to 0.08)

$\ln(M) = 1.46\text{-}1.01*\ln(tmax)$ Teleosts (M=0.07662 rounded to 0.08)

Maximum observed age (t_{max}) was 54 years old. The maximum calendar age of red snapper in the Gulf of Mexico was reported as 57 yr (Allman et al. 2002), which differs slightly from the maximum age of 54 yr in the Atlantic (SEDAR15-RD06). Natural mortality was also estimated using a variety of models based on von Bertalanffy growth or reproductive parameters (Table 2.4.2.1). Using these alternative models (Alverson and Carney 1975, Beverton 1992, Pauly 1980, and Ralston 1987), M ranged from 0.01 – 1.27 along the Atlantic coast. The Lorenzen (1996) model provides an age-specific estimate of natural mortality that ranged from 0.90 – 0.21 for fish aged 2 to 54. These estimates of natural mortality for the oldest age classes (0.21) correspond to a fish with a maximum age of 19. Therefore the Lorenzen (1996) estimate was scaled to 1.4% surviving to maximum age based on Hoenig (1983) natural mortality estimate of 0.08. This resulted in a scaled estimate of natural mortality at age ranging from 0.30 to 0.07 (Table 2.4.2.2). Manooch et al. (1998) reported an estimate of M = 0.25, but the maximum age in their study was 25 yr. An atypically low natural mortality estimate (M = 0.005) for Atlantic red snapper was derived from the Alverson and Carney (1975) equation. High estimates of natural mortality (>0.3) were derived from Pauly (1980), Ralston (1987), and Beverton (1992) with values of 0.41, 0.57, and 1.27, respectively. The uncommonly high estimate (M = 1.27) from the equation by Beverton (1992) may be due to the unique life history of red snapper. Red snapper mature at an early age ($A_{50}\%$ =1.87 years) but have the potential to live >50 yr. With respect to age at maturity relative to maximum age, red snapper do not follow the regression relationship previously established for some long-lived fishes (Beverton 1992). Regression analysis of the fully recruited ages, 4-54 years, in the population based on the aged samples estimated total mortality to be 0.44, which is close to the Pauly estimate and below the Ralston estimates of natural mortality.

Issues

1. What value of maximum age of red snapper should be used?

2. Natural mortality estimates using models based on growth and reproductive parameters were highly variable.

Recommendations

1. The DW recommended using the observed maximum age of 54 years. Although there were few fish over the age of 20, two fish were harvested from the South Atlantic over 50 years old and the maximum age observed in the Gulf of Mexico was 57.

2. The DW recommended using the scaled age-specific Lorenzen natural mortality estimate for age 1+ since this is a commonly used method to estimate natural mortality. There was some discussion on the differences between the Atlantic and Gulf of Mexico SEDARs approximation of natural mortality. The update of the SEDAR 7 assessment is using a natural mortality of 1.2 for age 1 fish and 0.1 for ages 2+. However the DW felt the scaled Lorenzen model was most appropriate. This model is able to account for changing natural mortality rates with age and can be scaled to a point natural mortality estimate based on both of Hoenig's (1983) equations: teleosts and all taxa. It was recommended to use a natural mortality rate of 0.6 for age 1 fish as a sensitivity run. The DW recommended sensitivity runs using a range of M, 0.05-0.12, about the Hoenig point estimate. These sensitivity runs will encompass the estimates of M used in the Gulf red snapper update assessment (2009).

2.5 Discard Mortality

Red Snapper Discard Mortality Working Paper (SEDAR24-DW-12)

Abstract

SEDAR 24-DW-12 provides a thorough overview of what we know regarding the discard mortality rates for red snapper in the South Atlantic region. It provides background information on what factors can affect discard mortality rates as well as the discard mortality rates that were used in previous SEDAR stock assessments of red snapper. Subsequently, it summarizes the discard mortality rates calculated for red snapper in various studies, with the caveat that researchers conducted most of these studies in the Gulf of Mexico. Because the Gulf of Mexico red snapper fisheries act much differently than the South Atlantic red snapper fisheries, the validity of applying data from these studies to the South Atlantic is potentially in question. Thus, a great deal of emphasis is placed on understanding the causes of discard mortality (primary causes: hooking related injuries and barotraumas; secondary causes: temperature, predation, and size), so that data from the Gulf region can be used to estimate the discard mortality rates in the South Atlantic. Concerning hooking related injuries, this appears to be the major factor causing discard mortality in headboat fisheries, as researchers attributed almost 50% of mortalities to hooking injuries. For barotraumas, it appears that red snapper are slightly less susceptible to death from the injuries, due to the structure of their swim bladder compared to many other fish species, but that size (smaller = greater survival, larger = lower survival) can have an effect as well. In addition, most studies indicated that depth of capture was a significant factor in determining whether barotrauma injuries would

result in mortality, with chance of death increasing with increasing depth. Thus, to account for this increasing discard mortality rate with depth of capture, researchers had investigated three separate models to predict mortality rate at depth of capture. Finally, the working paper discusses several additional secondary factors (e.g. air exposure, hook type, temperature, predation) affecting the discard mortality rate. It appears that we need to obtain and analyze more data to provide estimates of the discard mortality rates associated with each of these secondary factors.

Critique

Overall, this is a vital document that we should consider when determining appropriate discard mortality rates for red snapper in the South Atlantic region. The working paper coalesces several different sources of information in a summary working paper. Though the data on some factors potentially affecting the discard mortality rates of South Atlantic red snapper is sparse to non-existent, the model fits provided seem to reasonably fit the data and be in general agreement over the depth ranges that red snapper are often captured in the South Atlantic region. More work should be put forward trying to obtain estimates of the effect that the various secondary factors identified have on overall discard mortality rates. These estimates will allow more precise estimates of discard mortality rates in the South Atlantic region. In addition, it remains unclear from the working document how one should include hooking related mortality in the overall discard mortality rates, as the models presented only accounted for mortality related to barotraumas.

2.6 Age

The NMFS, the SCDNR, the GADNR and the FL FWC contributed both fishery dependent and fishery independent age data for this assessment. The final age data set included all age data from SEDAR15, which included age data from 1977 – 2006, and the new age data collected from 2006-2009. Most of the age samples were randomly collected by port agents intercepting fishing trips: commercial n = 5,671; charter boat n = 2,012; private boat n = 85; headboat n = 5,716. (See Tables 2.6.1 and 2.6.2 for randomly collected commercial and recreational fishery age samples and number of trips intercepted.) An additional 586 samples came from fishery-independent studies. All 2006 – 2009 age data included an increment count, an adjusted calendar age based on timing of annulus formation and an estimate of the amount of translucent edge present, and the determined fractional age using a July 1 birth date. The SEDAR15 age data were updated to include calendar age and fractional age.

Sampling intensity for age structures greatly increased during the 2009 fishing year and during the summer months in particular. Concern was raised about any potential length bias in the random sampling during that time. A comparison of the length composition of the age samples from 2009 versus the 2007 and 2008 fishing years was done for the commercial sector and the recreational sector separately. Length frequencies from 2009 mirrored those from 2007 and 2008 in both sectors and thus all of the age data from 2009 was usable for the assessment model.

Issues

GADNR conducted a complete census of red snapper landed during May 2009 by three recreational vessels. Concern was raised that the high number of samples (n_{May} = 284) from one month in the year may bias the overall age structure of the red snapper landings for the entire year (n_{year} = 679). This issue was particularly noted by industry representatives who have commented that red snapper seem to move through the fishing grounds either latitudinally or longitudinally.

A few of the 2009 samples (n = 68) from the commercial and headboat fisheries were selected by fishermen for the largest fish in the catch.

Recommendations

1. GADNR May census data were plotted against the GADNR random samples for the entire year. No discernable difference was noted in the age frequency or the length distribution between the two sets of data. LHWG recommended keeping the May census data in the dataset used for age composition of the recreational fishery.

2. The fishermen selected samples were identified and will not be used in the age composition data to characterize the fishery, but will be used in the growth model and analysis of fishing by depth of water.

2.6.1 Age Reader Precision and Aging Error Matrix

The data for the aging error analysis comes from otoliths which were read by four readers, who each represented a lab. The labs involved included the National Marine Fisheries Service (NMFS), Florida, Georgia, and the Marine Resources Monitoring, Assessment and Prediction program (MARMAP). As part of a workshop to improve precision between labs, a set of otoliths from the South Carolina Department of Natural Resources (n=95) reference collection was aged at the start of the workshop, and a set of otoliths from the Florida reference collection (n=100) was aged after the workshop. See data working paper SEDAR24-DW-10 for more information.

Based on the paired age reads from the workshop, some concern existed that previous to the workshop calibration, the MARMAP age estimates may have had a bias associated with them as compared to the estimates from the other labs. To explore whether or not a bias likely existed, the average age estimated from NMFS, FL, and GA, was compared to the age estimated by MARMAP. The distribution of average ages when compared to the ages estimated by MARMAP were scattered about the 1:1 line, which indicates that a bias is likely not occurring (Figure 2.6.1.1). With the absence of bias, the aging error matrix can be estimated directly from the paired age estimates from the otoliths.

Data from NMFS, Florida, and MARMAP were used to estimate the aging error matrix. The paired age reads from Georgia were not included in the analysis because Georgia has a low number of age samples over a small location that will be contributed to the age compositions for the assessment. In addition, the samples from Georgia were excluded mainly because of similarity to Florida, because the age reader in Florida trained the reader in Georgia. This would minimize any potential differences that would arise between the labs that age otoliths and would reduce the error to levels likely lower than what the overall data exhibit.

Accounting for error in age estimation is important for age composition data used in stock assessments (Punt et al. 2008). Thus, to account for any error associated with the age estimation process for south Atlantic red snapper and to get contemporary precision estimates, an aging error analysis was completed using a program called "agemat" provided by André Punt. Agemat can use age estimation data from multiple readers in order to estimate the coefficient of variation and standard deviation associated with age estimates and to provide an aging error matrix. This program has been used by other SEDAR assessments (ASFMC 2010).

Agemat requires some model specifications, such as the minimum and maximum age of the species, a reference age, and the type of standard deviation to be estimated, in addition to inputting the aging data and number of readers in the appropriate format. The minimum age used for this analysis was age 0, and the maximum age used for this analysis was 54. The reference age was age 4. The standard deviation was estimated using an asymptotic function. The maximum allowable standard deviation was input as 5; however, the model did not come near that bound.

The standard deviation was an increasing, asymptotic curve, which started at a low of 0.43 at age 0 and increased to maximum of 0.82 for fish age 54 (Figure 2.6.1.2). The coefficient of variation was a decreasing, asymptotic curve, which started at a high of 0.43 at age 0 and decreased to a minimum of 0.02 at age 54 (Figure 2.6.1.2). The aging error matrix is provided in Table 2.6.1.1.

Research recommendation: Continuing the age reading comparisons and calibrations between labs on a reference collection of known age fish would be beneficial for determining a more accurate aging error matrix and would provide accuracy to the age composition data.

2.6.2 Year Class Strength

Several strong year classes were evident for Atlantic red snapper between 1977 and 2009. These strong year classes were present in 1983, 1984, 1986 – 1989, 1991 – 1993, 1996, 1999 – 2001, and 2005 (Figure 2.6.2.1). These cohorts could be followed through the fishery for as long as 5 – 8 yr, first appearing most commonly as age 2 and 3 fish. Moderate to strong year classes appeared to occur on average every 2 yr. Prior to 1983, large pulses of 2 and 3 year old red snapper were entering the fishery indicating possible strong year classes, but these cohorts could not be followed after age 3 (SEDAR15-RD06; SEDAR24 new data).

2.7 Growth

Researchers have published several age and growth studies on red snapper in the U.S. South Atlantic (Nelson and Manooch 1982; Manooch and Potts 1997; SEDAR15-RD04; McInerny 2007). The updated age data sets used for the assessment includes 6,107 newly processed samples along with samples from three out of the four previous aging studies (Manooch and Potts 1997; McInerny 2007, SEDAR15-RD04), thus allowing a more complete analysis of red snapper age and growth along the Atlantic coast with increased spatial and temporal coverage. To develop an overall growth model for Atlantic red snapper, we combined all data available from the previously mentioned sources, resulting in a sample size of 13,431 fish.

As dimorphic growth is often apparent between sexes, we initially investigated the potential of dimorphic growth between male and female Atlantic red snapper. Using the age data for which sex was determined, we compared male and female von Bertalanffy growth models using Kimura's (1980) likelihood ratio test, Akaike's (1974) information criterion (AIC), and the Bayesian information criterion (BIC; Schwarz 1978). Resulting statistics (Table 2.7.1) suggested that there was no dimorphic growth between the sexes, thus we pooled the data to develop a sexes combined growth model.

In addition, it was thought that Atlantic red snapper growth may be region specific, with two regions being defined, one along the South Carolina and North Carolina coast (North region) and the other along the Georgia and Florida coast (South region). The age samples are assigned to states based on where fish were landed as opposed to actual fishing locations, which may differ considerably. With that caveat, Atlantic red snapper growth between the two regions was investigated and compared using the same techniques used to investigate the potential for dimorphic growth between the sexes. Though resulting statistics (Table 2.7.2) suggested that dimorphic growth occurred among the regions, plots of region specific growth curves (Figure 2.7.1) suggested little biological difference in the growth models.

We also investigated the potential for differences in growth among the types of data available (commercial (n = 5,480), recreational (n = 7,365), and fishery-independent (n = 586)). Plots of the growth models by fishery type (Figure 2.7.2) suggested no difference in the growth models developed for the commercial or recreational fisheries. While the fishery-independent data growth model varied slightly, this was probably due to the much smaller sample size available and the lack of older fish, which affects the estimate of the L_∞ parameter of the fishery-independent model (Figure 2.7.3).

Finally, because growth models can be influenced by the use of size-biased samples, for example, due to minimum size limits affecting fishery-dependent sampling, an overall, unweighted von Bertalanffy growth model that corrects for size-selective data and assumes a constant standard deviation (SD) was constructed (L_∞ = 902 (SE = 4.29 mm), k = 0.245 (SE = 0.0038), t_0 = -0.03 (SE = 0.0303), SD = 78.72 (SE = 0.615); Figure 2.7.4; Diaz et al. 2004). The model was fit using temporal specific size-limits (1983 to 1991, 12 inches total length (TL); 1992 to 2009, 20 inches TL), observed or fork length converted total lengths and fractional ages determined based on the month of peak spawning (July).

US South Atlantic red snapper appear to grow faster and attain a larger maximum size than the Gulf of Mexico (GOM) stock (figure 2.7.5). The GOM stock is predicted to be 80-90 mm shorter than the Atlantic stock for the first four years, 50mm shorter at age 10 and 30 mm shorter by age 20. The GOM model may have had more young-of-the-year fish that went into the model accounting for the different estimates of t_0 and the other parameters. When looking at the fit of von Bertalanffy model to the Atlantic data, the LHWG felt that the model was a good fit and recommended its use in the Atlantic assessment.

Issues

1. The potential for dimorphic growth between sexes for Atlantic red snapper resulting in sex-specific growth models.

2. The potential for regional differences in the growth of Atlantic red snapper, resulting in region specific growth models. Growth may vary among Atlantic red snapper along a North/South gradient.

3. The potential for differences in growth models among commercial, recreational, and fishery-independent samples.

4. Size limit regulations for Atlantic red snapper changed within the study time period of 1977 to 2009 resulting in size-selective fishery-dependent samples (SEDAR15-RD06). The von Bertalanffy growth model may be influenced by size-selective sampling and may not appropriately represent the growth of the population.

Recommendations

1. Based on the results of growth model comparisons between sexes (Table 2.7.1), the LHWG recommended that a sex pooled growth model be developed for Atlantic red snapper to be used in the assessment model.

2. Though model comparisons suggest there may be regional differences in growth of Atlantic red snapper, the LHWG recommended that a region pooled growth model be developed for Atlantic red snapper because of several concerns. First, there was no biological reason for separating the regions along the Georgia/South Carolina border. Second, inclusion of data in one region or the other was determined based on the state in which the fish were landed, not necessarily the location where the fish were caught. Thus, the state landed may not accurately represent the region where the individual fish was caught. Finally, few young fish (< 3 years old, Figure 5) were landed in the northern region, thus affecting the estimate of t_0 of the von Bertalanffy growth equation for the northern region, resulting in an estimated t_0 parameter of -1.9 years, which is not biologically realistic. The LHWG felt the statistical difference in region specific growth models were likely driven by the estimate of the t_0 parameter, and upon visual inspection of the growth model at older ages saw little indication of differences in growth pattern.

3. Based on the plots of fishery specific growth models for Atlantic red snapper, the LHWG recommended developing a fishery pooled growth curve for Atlantic red snapper. There was no difference between the growth of commercially and recreationally caught Atlantic red snapper, and the observed difference in predicted growth of fishery-

independent caught Atlantic red snapper was likely due to the smaller sample size and lack of older fish in the sample (Figure 2.7.6).

4. The LHWG recommended developing a modified von Bertalanffy growth model correcting for size limited data for all data combined to represent the growth of red snapper in the U.S. South Atlantic (Diaz et al. 2004). This type of model was previously used to estimate growth curves for Atlantic and Gulf of Mexico gag grouper (SEDAR 10) as well as Gulf of Mexico (SEDAR 7) and Atlantic red snapper (SEDAR 15). The von Bertalanffy growth parameters are L_{∞} = 902 (SE = 4.29 mm), k = 0.245 (SE = 0.0038), t_0 = -0.03 (SE = 0.0303), SD = 78.72 (SE = 0.615).

2.8 Reproduction

The MARMAP study by White and Palmer (SEDAR24-RD01) provides the most extensive information on the reproductive biology of red snapper along the Atlantic coast of the southeastern U.S. Specimens were collected during 1979-2000 and the majority (64%) of the specimens for the study came from a fishery-dependent source, primarily commercial snapper reel catches. Additional fishery-dependent (Project T12; years 2000-2001) and fishery-independent data (MARMAP chevron trap; years 2001-2009) were added to the dataset prepared for the current stock assessment. All commercial fishermen involved in the collection of specimens since 1999 were permitted to land undersized specimens. All age-related results presented in this section were based on calendar age. Information below on spawning seasonality, sexual maturity, sex ratio, and spawning frequency is based on the most accurate technique (histology) utilized to assess reproductive condition in fishes. Red snapper do not change sex during their lifetime (gonochorism).

2.8.1 Spawning Seasonality

Based on the occurrence of hydrated oocytes and/or postovulatory follicles, spawning along the Atlantic coast of the southeastern U.S. occurs from May through October and peaks during July through September (SEDAR24-RD01, Brown-Peterson et al. 2009). Mean values of a female gonadosomatic index based on specimens collected primarily off the Carolinas peaked in June and July, whereas an index for females based on specimens collected off the east coast of Florida (St. Augustine to Melbourne) had peaks in July and September. Spawning females were captured in mid-shelf to shelf-break (23-72 m) from Cape Fear, NC, to Melbourne, FL (SEDAR24-RD01).

2.8.2 Sexual Maturity

Region wide maturity ogives for male maturity at TL are available in tabular format in SEDAR24-RD14 (see Table 2.8.2.1). The smallest mature male was 210 mm TL and the youngest was age 1; and the largest immature male was 418 mm TL, the oldest was age 5. All males were mature at 451-500 mm TL and age 6. The estimates of A_{50} (0.32 yr) and L_{50} (199 mm TL) for males were unrealistic owing to the low number of smaller and younger (Ages 0 and 1) specimens. The smallest mature female was 265 mm TL, and the youngest was age 2; the size at 50% maturity was 370 mm TL (95% CI = 354-381), and the largest immature female was 435 mm TL, the oldest was age 4. All females were mature by 451-500 mm TL and age 5. Age at 50% maturity (A_{50}) for females was 1.87 yr (logistic; 95% CI = 1.48-2.12). The logistic equation (1-1/(1+exp(a+b*age); a = -2.71, b = 1.453) and normal equation (Prob(a+b*age); a = -8.11, b = 0.021) were used to estimate A_{50} and length at 50% maturity (L_{50}) for females.

Recommendation

The LHWG recommended the use of maturity ogives generated for specimens collected throughout the region in the assessment. Recommendation was accepted at the plenary session of the Data Workshop.

2.8.3 Sex ratio

Tables with sex ratio by length class (mm TL), year, and age class are available in SEDAR24-DW-14 (see Tables 2.8.3.1, 2.8.3.2,and 2.8.3.3). The male:female sex ratio for all adult red snapper in fishery-independent and fishery-dependent collections from 1977-2009 was **1:0.98**, which was not significantly different from a 1:1 ratio (Chi-square = 0.11, 0.75> p > 0.50, n = 1113). An analysis of the two best years (1999-2000) of data revealed the same result (**1:1.00**, n = 545).

Recommendation

The LHWG recommended the use of a sex ratio of 1:1 (male:female) in the assessment. Recommendation was accepted at the plenary session of the Data Workshop.

2.8.4 Spawning Frequency

Only limited information is available for red snapper along the Atlantic coast of the U.S. Brown-Peterson et al. (2009) report that spawning occurs every 2.2 days based on a sample of 66 specimens collected during June through November. Estimates from Gulf of Mexico revealed that spawning frequency increases until about Age 6; little information is available for older ages (see Woods 2003; SEDAR7-DW-35).

2.8.5 Batch Fecundity (BF)

Only limited information is available for red snapper along the Atlantic coast of the U.S; the relationship between batch fecundity and TL (BF = 9548*TL – 5,224,104; r^2 = 0.67) was estimated for 12 specimens, 560-937 mm (Brown-Peterson et al. 2009). The small sample size and the lack of specimens < 560 mm make this equation of minimal use for the SEDAR24 assessment. An estimate of fecundity at age is available from Gulf of Mexico, but they are not as predictive as an estimate of fecundity at length (see Woods 2003; SEDAR7-DW-35) because batch fecundity reaches an asymptote at an age of approximately 10-12 yr.

Given the lack of a usable fecundity estimate from the Atlantic region, three proxies to estimate fecundity were considered: 1) gonad weight vs. age, 2) gonad weight vs. whole fish weight, and 3) gonad weight vs. total length (Figure 2.8.5.1). The first proxy (gonad weight vs. age; Fig. 2.8.5.1A) is not adequate because of a large gap in the age data, and, secondly, the linear nature of the relationship is inconsistent with the non-linear relationship evident between gonad weight and fish size (whole weight or TL) as fish grow (Figs. 2.8.5.1B and C). The second proxy is probably a better option, given the need to relate gonad weight to spawning biomass. The gonad weight (W_g) - whole fish weight (W_f) relationship is expressed as a power function:

$$W_g = 3.1416x10^{-5}\ W_f^{\ 1.743};\ \ SE_a = 3.1836x10^{-5},\ \ SE_b = 0.1107.$$

The gonad weight (W_g) - total length (L_t) relationship, third proxy, is expressed as a power function:

$$W_g = 1.207x10^{-11}\ L_t^{\ 4.524};\ \ SE_a = 3.16x10^{-11},\ \ SE_b = 0.3923.$$

Recommendation

The LHWG recommended the use of the second proxy, gonad weight – fish weight, as an estimate of fecundity in the assessment. Recommendation was accepted at plenary session of Data Workshop.

2.9 Movements & Migrations

Research on red snapper movements/migrations in Atlantic waters is limited. A few tagging studies have indicated high site fidelity. Anecdotal information suggests that larger red snapper spend most of their time in deeper water (>200 ft) than the majority of red snapper. These large, presumably older red snapper may move to shallower water during the spawning season. In an attempt to elucidate these statements concerning offshore migration, the total length of the fish in the age data were plotted against reported depth of capture (Figure 2.9.1a), as well as age versus depth of capture (Figure 2.9.1b). All fishery-dependent and fishery-independent data were combined. If a range of depths were reported for a trip, the midpoint of the range was used. There was no discernable difference in the distribution of fish by size or age over different depths. The LHWG acknowledges that the depth data reported in the fishery statistics is generalized for a trip. Also, the geography of the US South Atlantic varies widely from North Carolina to the Florida Keys. The data suggest that all sizes and ages of red snapper are available to all fisheries, but at what rate of availability we cannot say.

In the largest tagging study, Burns et al. (2004) tagged and released 5,272 red snapper in the Gulf of Mexico (from Naples, FL, to the eastern border of Texas) and Atlantic (from Cape Canaveral, FL, to Georgia) over a 13 yr period. Approximately 40% of these fish were tagged in the Atlantic. Forty-four percent of the specimens were recaptured within 1.9 km of the tagging site. Less than 10 of the 410 recapture events showed movement >100 miles and movement between the Gulf of Mexico and the Atlantic coast is not mentioned in the report.

In a later study, Burns et al (2008) reported 529 Gulf and Atlantic red snapper recaptures. Approximately 28.7% were recaptured within 3km, 15.1% were recaptured within 10 km, and only 3.8% were recaptured more than 50 km of the original tag site. In general, recaptures indicated north/south movement on the Atlantic coast and east and southeast movement (from the Panhandle) in the Gulf of Mexico. A single red snapper tagged in the Florida panhandle (during a previous study) was recaptured on the Atlantic coast of Florida.

The results of two smaller studies also indicate minimal movement in Atlantic red snapper. The SC Marine Gamefish Tagging Program reports 1,597 red snapper tagged with 171 recaptures. Ninety-three percent were recaptured within 2 km of the tagging site. SCDNR (MARMAP) data indicates 45 red snapper tagged with two recaptures, one of which was recaptured in the same vicinity as tagged. The other recapture had no location data.

Numerous publications have reported on red snapper tagging and movements in the Gulf of Mexico (Fable 1980; Szedlmayer 1997; Watterson et al. 1998; Ingram and Patterson 2001; Patterson et al. 2001b; Patterson and Cowan 2003; Szedlmayer and Schropfer 2005; Schropfer and Szedlmayer 2006). Four studies from the Gulf of Mexico (Fable 1980; Szedlmayer 1997; Szedlmayer and Schropfer 2005; Schropfer and Szedlmayer 2006) found that red snapper have high site fidelity, moving less than 0.2 km to 1.6 km from the original location tagged. Four other publications (Watterson et al. 1998; Ingram and Patterson 2001; Patterson et al. 2001b; Patterson and Cowan 2003) found that red snapper have low site fidelity (24.8-46% site fidelity estimates) in the Gulf of Mexico. However, three of those publications (Watterson et al. 1998; Ingram and Patterson 2001; Patterson et al. 2001b) state that the low fidelity was due to hurricanes. Watterson et al. (1998) report that 80% of the recaptured red snapper that were not at liberty during Hurricane Opal were recaptured at their site of release. Red snapper that were at liberty during Hurricane Opal had a significantly higher likelihood ($P < 0.001$) of movement away from their site.

Recommendation

More research on red snapper movements/migrations in Atlantic waters is needed. Available data and the results of studies in the Gulf of Mexico indicate high site fidelity. Tropical storms may cause greater than normal movement.

2.10 Meristics & Conversion factors

Red snapper lengths and weights were collected from fish landed in the recreational and commercial fisheries as well as fishery-independent sources operating along the US South Atlantic. Data sets included NFMS Headboat Survey, FL FWC fishery-dependent samples, GADNR fishery-dependent samples, and SCDNR fishery-dependent and fishery-independent samples. Length/length, weight/length, and weight/weight relationships were calculated for total length (TL), fork length (FL), standard length (SL), whole weight (WW) and gutted weight (GW) (Table 2.10.1).

2.11 Comments on adequacy of data for assessment analyses

The life history data provided to SEDAR24 is adequate for inputs to the assessment model.

2.12 Itemized list of tasks for completion following workshop

See Section 1.5

2.13 Literature Cited

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2.14 Tables –refer to numbered Life History paragraphs

Table 2.4.2.1. Point estimates of natural mortality for red snapper and life history parameters that were used in analyses.

Author	Natural Mortality (M)	Model Equation
Alverson and Carney	0.005	M = 3k/(exp(0.38*tmax*k)-1)
Hoenig	0.08	M=exp(1.46-1.01*ln(tmax)) (teleost)
	0.08	M=exp(1.44-0.982*ln(tmax)) (all taxa)
Pauly	0.41	M=exp(-0.0152+0.6543*ln(k)-0.279*ln(Linf, cm)+0.4634*lnT(^{o}C))
Ralston	0.51	M=0.0189+2.06*k
Beverton	1.27	M = 3k/(exp(am*k)-1)

Parameters used in the natural mortality models. Bottom temperature was taken from Packer et al. (2003).

Max Age	Linf_mm	Linf_cm	k	t_0	Age of 50% Maturity	Temperature
54	902	90.20	0.24	-0.03	1.87 years	17

Table 2.4.2.2. Age specific natural mortality estimated from the scaled Lorenzen (1996) model (Equation: $M=3.69*W^{-0.305}$), scaled to M = 0.08.

Age	Scaled M	Age	Scaled M
1	0.30	28	0.07
2	0.17	29	0.07
3	0.13	30	0.07
4	0.11	31	0.07
5	0.10	32	0.07
6	0.09	33	0.07
7	0.09	34	0.07
8	0.08	35	0.07
9	0.08	36	0.07
10	0.08	37	0.07
11	0.08	38	0.07
12	0.07	39	0.07
13	0.07	40	0.07
14	0.07	41	0.07
15	0.07	42	0.07
16	0.07	43	0.07
17	0.07	44	0.07
18	0.07	45	0.07
19	0.07	46	0.07
20	0.07	47	0.07
21	0.07	48	0.07
22	0.07	49	0.07
23	0.07	50	0.07
24	0.07	51	0.07
25	0.07	52	0.07
26	0.07	53	0.07
27	0.07	54	0.07

Table 2.6.1. Number of randomly sampled commercial fishing trips (# of age samples) to collected snapper landed in the US South Atlantic by year, state and gear.

	Florida		Georgia		North Carolina		South Carolina						Grand Total
Year	**Diver**	**Hook and Line**	**Diver**	**Hook and Line**	**Hook and Line**	**Traps**	**Unknown**	**Diver**	**Hook and Line**	**HL/Diver**	**Traps**	**Trawls**	**# of Samples**
1979							2 (6)		5 (39)			2 (19)	64
1980				1 (2)					4 (9)			1 (5)	16
1981									1 (1)				1
1986							1 (7)						7
1988									9 (38)		1 (5)		43
1989									7 (9)		1 (1)		10
1990									12 (28)				28
1991									7 (24)		3 (5)		29
1992		3 (16)							15 (33)				49
1993		1 (7)							12 (30)				37
1994		1 (1)							22 (48)				49
1995		2 (16)					1 (4)		8 (12)				32
1996		18 (131)		1 (8)					17 (39)				178
1997		16 (64)		1 (5)					39 (139)				208
1998		16 (57)							2 (23)				80
1999		5 (13)							10 (155)				168
2000	6 (137)	8 (105)		2 (28)				1 (1)	13 (173)				444
2001	1 (16)	21 (155)	2 (35)										206
2002		7 (37)							2 (3)				40
2003		9 (49)			1 (2)								51
2004		8 (66)			22 (39)								105
2005		7 (47)			37 (62)				12 (34)				143
2006		8 (54)			30 (44)			1 (1)	50 (119)				218
2007	1 (1)	14 (87)			55 (92)			1 (3)	70 (114)		1 (1)		298
2008		7 (60)			69 (174)	2 (2)			86 (205)		1 (1)		442
2009	14 (47)	116 (2219)			56 (162)		2 (2)	4 (9)	111 (283)	1 (3)			2725

Table 2.6.2. Number of randomly sampled recreational fishing trips (# of age samples) to collect snapper landed in the US South Atlantic by year, state and sector.

	North Carolina	**South Carolina**	**Georgia**			**Florida**			
Year	**Headboat**	**Headboat**	**Headboat**	**Charter Boat**	**Private**	**Headboat**	**Charter Boat**	**Private**	**Unidentified Recreational**
1977		5 (12)				17 (62)			
1978	1 (1)	2 (2)	3 (4)			78 (276)			
1979		1 (1)				31 (46)			
1980	2 (2)	4 (6)				31 (90)			
1981	3 (3)					144 (424)			
1982	1 (3)					56 (133)			
1983	2 (3)	4 (5)				168 (766)			
1984		20 (30)				159 (609)			
1985		10 (13)				156 (527)			
1986	1 (2)	4 (8)	1 (1)			95 (187)			
1987	1 (1)					67 (100)			
1988	4 (4)					17 (19)			
1989	4 (11)	17 (23)				11 (26)			
1990	6 (11)	3 (4)				14 (22)			
1991	5 (5)	2 (2)				14 (21)			
1992	4 (6)	2 (3)				4 (4)			
1993	2 (2)	6 (9)				6 (9)			
1994	3 (5)	1 (1)				6 (9)	2 (10)		
1995	2 (3)	1 (1)				8 (15)			
1996	3 (3)	36 (89)	1 (1)			19 (32)			
1997						13 (16)			
1998						6 (8)			
1999									
2000						2 (2)	1 (3)		
2001						2 (2)	26 (75)	1 (2)	
2002		4 (4)				4 (10)	94 (400)		2 (2)
2003	1 (1)	1 (1)				6 (15)	76 (397)		
2004	3 (3)					8 (25)	69 (314)	1 (3)	
2005	2 (5)	1 (1)				8 (12)	67 (261)		
2006	3 (3)	8 (8)	3 (3)			13 (20)			
2007	1 (1)	12 (12)	4 (4)			24 (67)	11 (29)	1 (2)	
2008	6 (10)	4 (6)	1 (1)			44 (148)			
2009	8 (9)	10 (16)	55 (628)	26 (196)	4 (60)	218 (1018)	56 (327)	7 (20)	

Table 2.6.1.1. Red snapper aging error matrix from the ages determined by NMFS, Florida, and MARMAP.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0.88	0.12	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
1	0.12	0.75	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	0.00
2	0.00	0.12	0.72	0.15	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	0.00	0.00	0.14	0.69	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.15	0.66	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.17	0.64	0.18	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.18	0.62	0.19	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.61	0.20	0.01	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.59	0.20	0.01	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.20	0.58	0.21	0.01	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.20	0.57	0.21	0.01	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.21	0.55	0.21	0.01	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.21	0.55	0.22	0.02	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.21	0.54	0.22	0.02
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	0.01	0.22	0.53	0.22
15	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	0.01	0.22	0.52
16	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	0.02	0.22
17	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	0.02
18	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
19	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
20	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
21	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
22	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
23	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
24	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
25	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
26	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
27	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

Table 2.6.1.1. continued

28	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
29	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
30	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
31	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
32	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
33	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
34	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
35	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
36	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
37	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
38	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
39	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
40	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
41	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
42	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
43	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
44	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
45	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
46	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
47	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
48	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
49	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
50	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
51	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
52	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
53	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
54	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

Table 2.6.1.1. continued

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
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	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	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	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	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	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	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	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	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	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	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	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	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
0.02	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
0.22	0.02	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
0.52	0.23	0.02	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
0.22	0.51	0.23	0.02	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
0.02	0.23	0.51	0.23	0.02	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	0.02	0.23	0.50	0.23	0.02	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	0.02	0.23	0.50	0.23	0.02	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	0.02	0.23	0.49	0.23	0.02	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	0.02	0.23	0.49	0.23	0.03	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	0.02	0.23	0.49	0.23	0.03	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	0.02	0.23	0.49	0.23	0.03	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	0.02	0.23	0.48	0.23	0.03	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	0.03	0.23	0.48	0.23	0.03	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	0.03	0.23	0.48	0.23	0.03	0.00	0.00	0.00	0.00	0.00

Table 2.6.1.1. continued

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.23	0.48	0.23	0.03	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	0.03	0.23	0.47	0.23	0.03	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	0.03	0.23	0.47	0.23	0.03	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	0.03	0.23	0.47	0.23	0.03	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	0.03	0.23	0.47	0.24	0.03
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	0.03	0.23	0.47	0.24
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	0.03	0.24	0.47
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	0.03	0.24
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	0.03
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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	0.00	0.00	0.00	0.00	0.00	0.00

Table 2.6.1.1. continued

35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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
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	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	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	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	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	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	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

Table 2.6.1.1. continued

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	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	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	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	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
0.03	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
0.24	0.03	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
0.47	0.24	0.03	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
0.24	0.47	0.24	0.03	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
0.03	0.24	0.47	0.24	0.03	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	0.03	0.24	0.46	0.24	0.03	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	0.03	0.24	0.46	0.24	0.03	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	0.03	0.24	0.46	0.24	0.03	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	0.03	0.24	0.46	0.24	0.03	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	0.03	0.24	0.46	0.24	0.03	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	0.03	0.24	0.46	0.24	0.03	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	0.03	0.24	0.46	0.24	0.03	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	0.03	0.24	0.46	0.24	0.03	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	0.03	0.24	0.46	0.24	0.03	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	0.03	0.24	0.46	0.24	0.03	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	0.03	0.24	0.46	0.24	0.03	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	0.03	0.24	0.46	0.24	0.03	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	0.03	0.24	0.46	0.24	0.03	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	0.03	0.24	0.46	0.24	0.03	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	0.03	0.24	0.46	0.24	0.03
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	0.03	0.24	0.46	0.24
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	0.03	0.27	0.73

Table 2.7.1: von Bertalanffy growth curves for male and female Atlantic red snapper, uncorrected for minimum size limit bias. The p-value is the calculated p-value from Kimura's (1980) likelihood ratio test while AIC and BIC refer to the AIC and BIC values calculated for sexes combined and sexes separate growth models, respectively.

Group	n	L_∞	K	t0	p-value	AIC	BIC
Male	1931	926	0.176	-1.830	0.44	45450 vs. 45447	45494 vs 45472
Female	2007	956	0.156	-2.176			

Table 2.7.2: von Bertalanffy growth curves for the North and South region, uncorrected for minimum size limit bias. The p-value is the calculated p-value from Kimura's (1980) likelihood ratio test while AIC and BIC refer to the AIC and BIC values calculated for regions combined and regions separate growth models, respectively.

Region	n	$L\infty$	K	t0	p-value	AIC	BIC
North	2416	902	0.184	-1.876	<0.001	144414 v 144608	144466 v 144638
South	10429	907	0.231	-0.689			

Table 2.8.2.1. Percentage of mature red snapper by size class from 1977 – 2009.

	Female		Male	
TL	**% Mature**	*n*	**% Mature**	*n*
<=250	0	19	50	10
251-300	15.79	19	86.21	29
301-350	28.57	28	87.5	32
351-400	50.82	61	95.16	62
401-450	90	70	98.39	62
451-500	100	47	100	39
501-550	100	144	100	130
551-600	100	101	100	109
601-650	100	49	100	39
651-700	100	20	100	17
701-750	100	29	100	17
751-800	100	16	100	12
801-850	100	5	100	5
851-900	100	8	100	3
901-950	100	3	100	0
951-1000	100	1	100	0
Totals		**620**		**566**

Table 2.8.3.1. Chi-square analysis of sex ratios for adult red snapper by Total Length (TL, mm) from 1977 – 2009. H_o: Male to Female is 1:1. *p < 0.01 **p < 0.05

TL	Female	Male	Sex Ratio (M:F)	X^2
<=250	0	5		
251-300	3	25	1:0.1	8.64*
301-350	9	28	1:0.3	4.88**
351-400	34	61	1:0.6	3.84**
401-450	64	61	1:1.1	0.04
451-500	48	39	1:1.2	0.47
501-550	144	131	1:1.1	0.31
551-600	105	110	1:1	0.06
601-650	54	41	1:1.3	0.89
651-700	22	18	1:1.2	0.20
701-750	29	17	1:1.7	1.57
751-800	17	13	1:1.3	0.27
801-850	5	5	1:1	0.00
851-900	8	3	1:2.7	1.14
901-950	3	1	1:3	0.50
951-1000	1	0		0.50
Total	**546**	**558**	**1:1**	**0.07**

Table 2.8.3.2. Chi-square analysis of sex ratios for adult red snapper by year, 1977 – 2009. H_o: Male to Female is 1:1.

Year	Female	Male	Sex Ratio (M:F)	X^2
1977	0	0		
1978	2	1	1:2	0.17
1979	8	2	1:4	1.80
1980	9	4	1:2.3	0.96
1981	3	5	1:0.6	0.25
1982	1	0		
1983	0	0		
1984	9	9	1:1	0.00
1985	0	0		
1986	1	0		
1987	0	1		
1988	17	20	1:0.9	0.12
1989	4	3	1:1.3	0.07
1990	7	16	1:0.4	1.76
1991	0	12		
1992	12	13	1:0.9	0.02
1993	18	12	1:1.5	0.60
1994	23	28	1:0.8	0.25
1995	8	6	1:1.3	0.14
1996	17	10	1:1.7	0.91
1997	39	28	1:1.4	0.90
1998	21	23	1:0.9	0.05
1999	75	87	1:0.9	0.44
2000	197	186	1:1.6	0.16
2001	26	23	1:1.1	0.09
2002	9	19	1:0.5	1.79
2003	0	0		
2004	0	4		
2005	7	6	1:1.2	0.04
2006	1	4	1:0.3	0.90
2007	15	17	1:0.9	0.06
2008	12	14	1:0.9	0.08
2009	10	9	1:1.1	0.03
Total	**551**	**562**	**1:1**	**0.05**

Table 2.8.3.3. Chi-square analysis of sex ratios for red snapper by age (year), 1977 – 2009. H_o: Male to Female is 1:1. *p < 0.10, **p < 0.05

Age	Female	Male	Sex Ratio (M:F)	X^2
0	0	0		
1	0	1		
2	44	75	1:	4.04**
3	194	197	1:0.6	0.01
4	144	163	1:0.9	0.59
5	51	36	1:1.4	1.29
6	24	18	1:1.3	0.43
7	17	5	1:3.4	3.27*
8	4	6	1:0.7	0.20
9	5	3	1:1.7	0.25
10	5	3	1:1.7	0.25
11	2	0		
12	1	0		
18	1	0		
19	1	0		
22	1	0		
23	1	0		
27	0	1		
28	1	0		
35	0	1		
36	1	0		
38	1	0		
46	0	1		
Total	**498**	**510**	1:1	0.07

Table 2.10.1. US South Atlantic red snapper meristic conversions.

Regression Equation	n	r^2	Range			
TL = 3.77473 + 1.05992*FL	3,275	99.5%	TL range	70 - 976	FL range	64 - 942
TL = 16.3669 + 1.23047*SL	1,492	99.4%	TL range	70 - 976	SL range	54 - 825
FL = -1.07382 + 0.938899*TL	3,275	99.5%	FL range	64 - 942	TL range	70 - 976
FL = 14.5046 + 1.15125*SL	1,438	99.4%	FL range	64 - 942	SL range	54 - 825
SL = -10.7205 + 0.807653*TL	1,492	99.4%	SL range	54 - 825	TL range	70 - 976
SL = -10.3081 + 0.863854*FL	1,438	99.5%	SL range	54 - 825	FL range	64 - 942
TotWW = 1.076*GutWW	30	99.9%	TotWW range	1,740 - 11,500	GutWW range	1,590 - 10,800
TotWW = 0.00000715386*TL^3.11796	2,520	96.2%	TotWW range	12 - 15,090	TL range	90 - 947
TotWW = 0.0000111897*FL^3.07891	2,450	97.0%	TotWW range	12 - 15,090	FL range	86 - 902
TotWW = 0.0000722071*SL^2.86328	996	97.6%	TotWW range	12 - 15,090	SL range	73 - 772

TL=Total length in mm
FL=Fork length in mm
SL=Standard length in mm
TotWW=Total wet weight in grams
GutWW=Gutted wet weight in grams

2.15 Figures – refer to numbered Life History paragraphs

Figure 2.6.1.1. The MARMAP age estimate compared to an average age estimate for the samples from the SC DNR reference collection. The average age is the average from NMFS, FL, and GA, and the line is the 1:1 line.

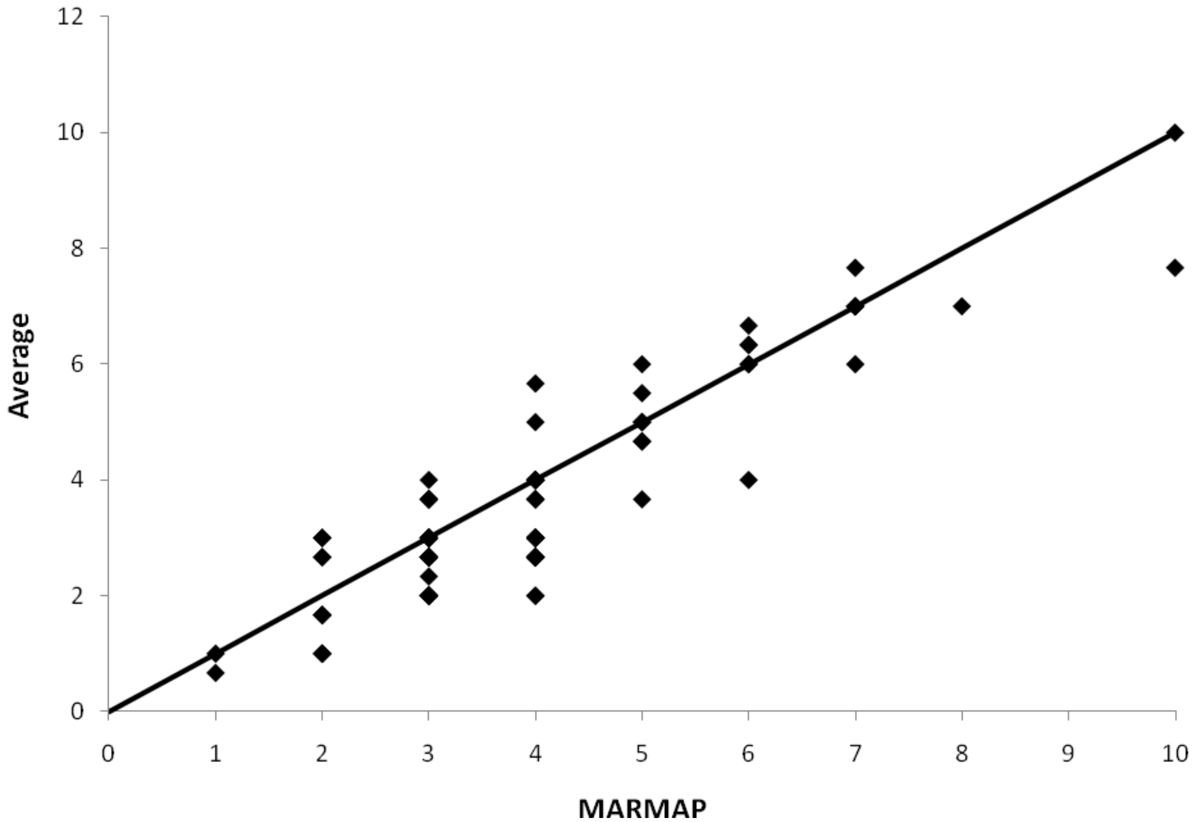


Figure 2.6.1.2. The estimated standard deviation (SD) and coefficient of variation (CV) for south Atlantic red snapper using data from paired age estimates and the program agemat.

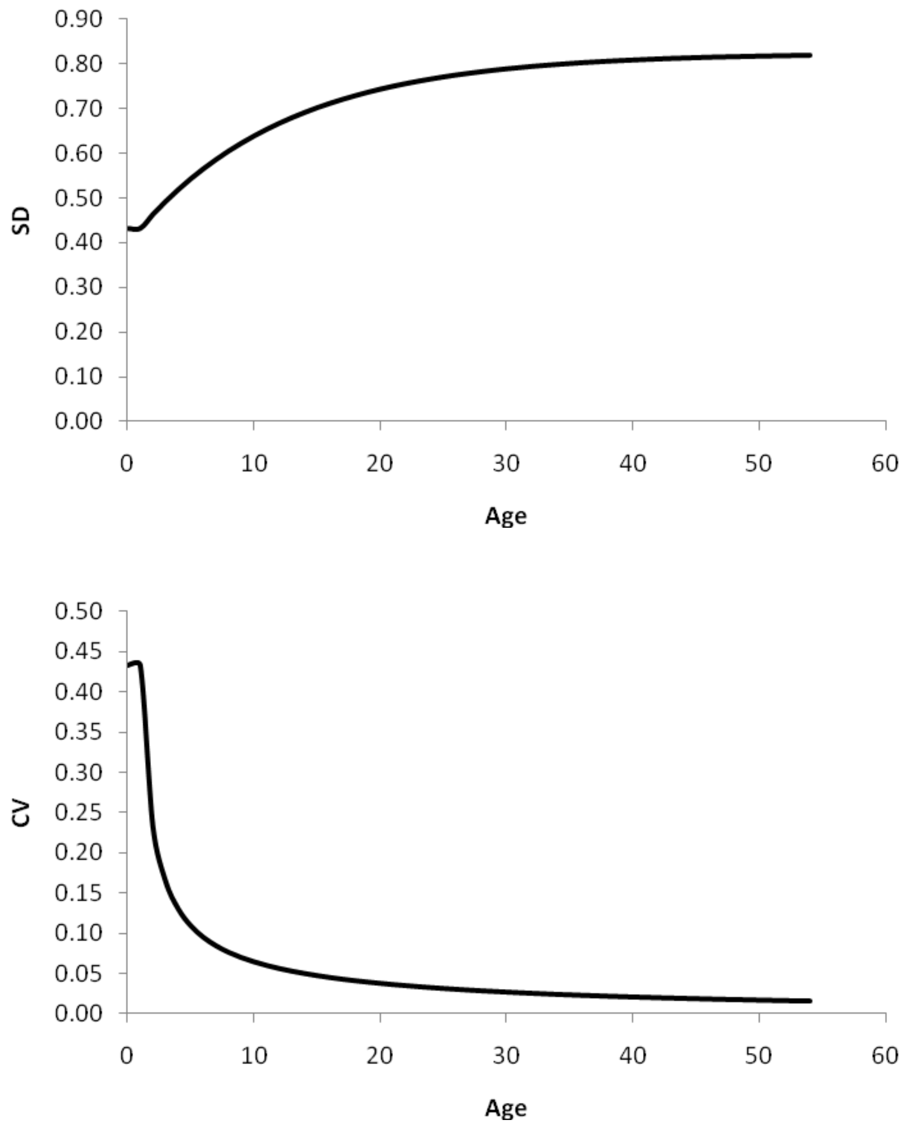
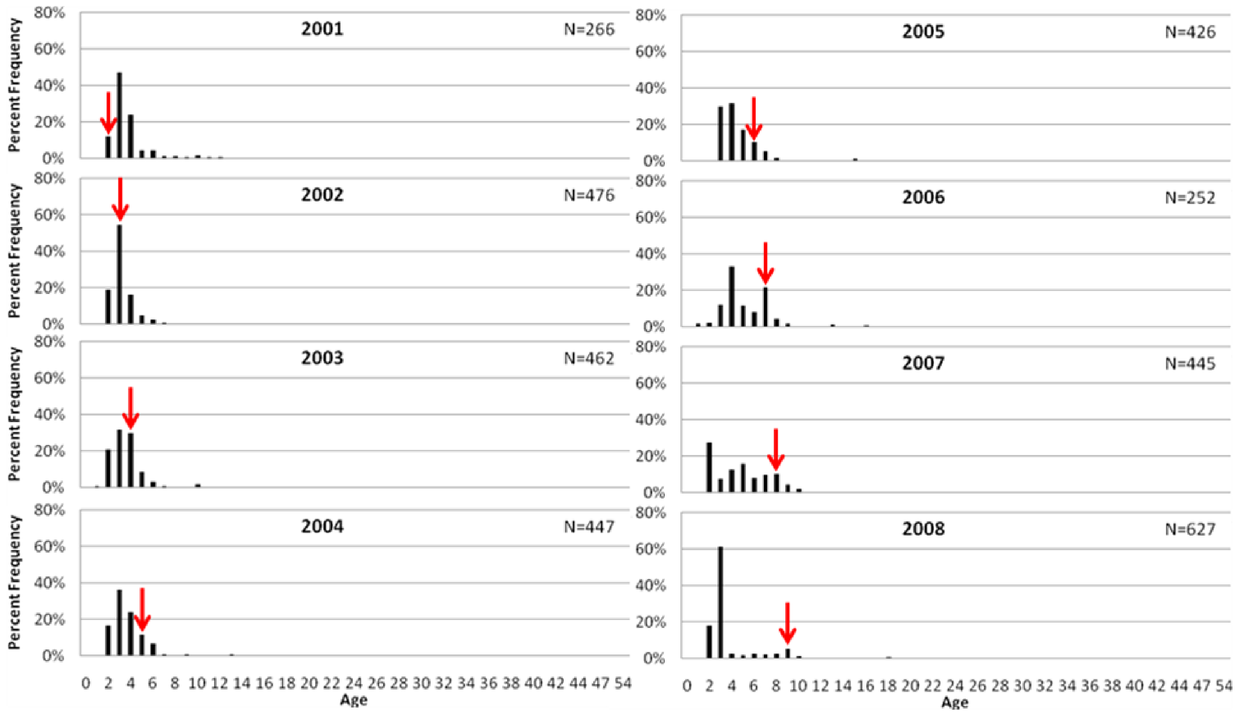


Figure 2.6.2.1. 1999 (a) year class and 2005 (b) year class of US South Atlantic red snapper.

a.



b.

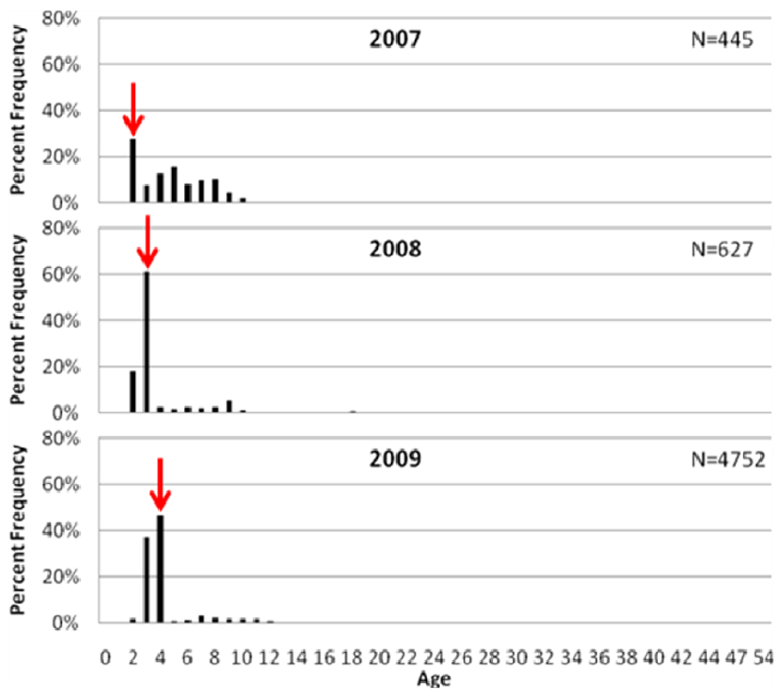


Figure 2.7.1: Region specific von Bertalanffy growth models for Atlantic red snapper, uncorrected for minimum size limit size bias.

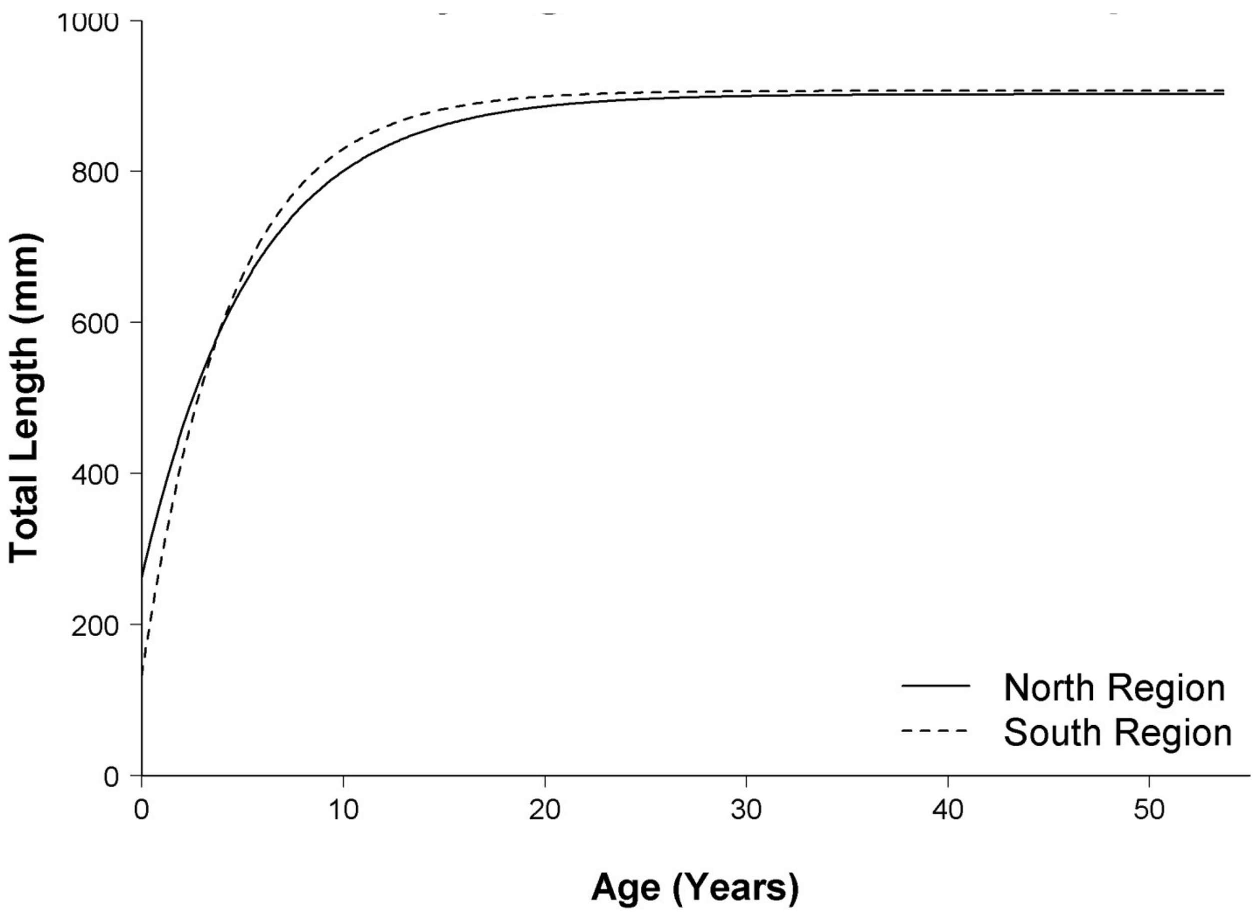


Figure 2.7.2: Fishery type specific von Bertalanffy growth curve for Atlantic red snapper, uncorrected for minimum size limit size bias.

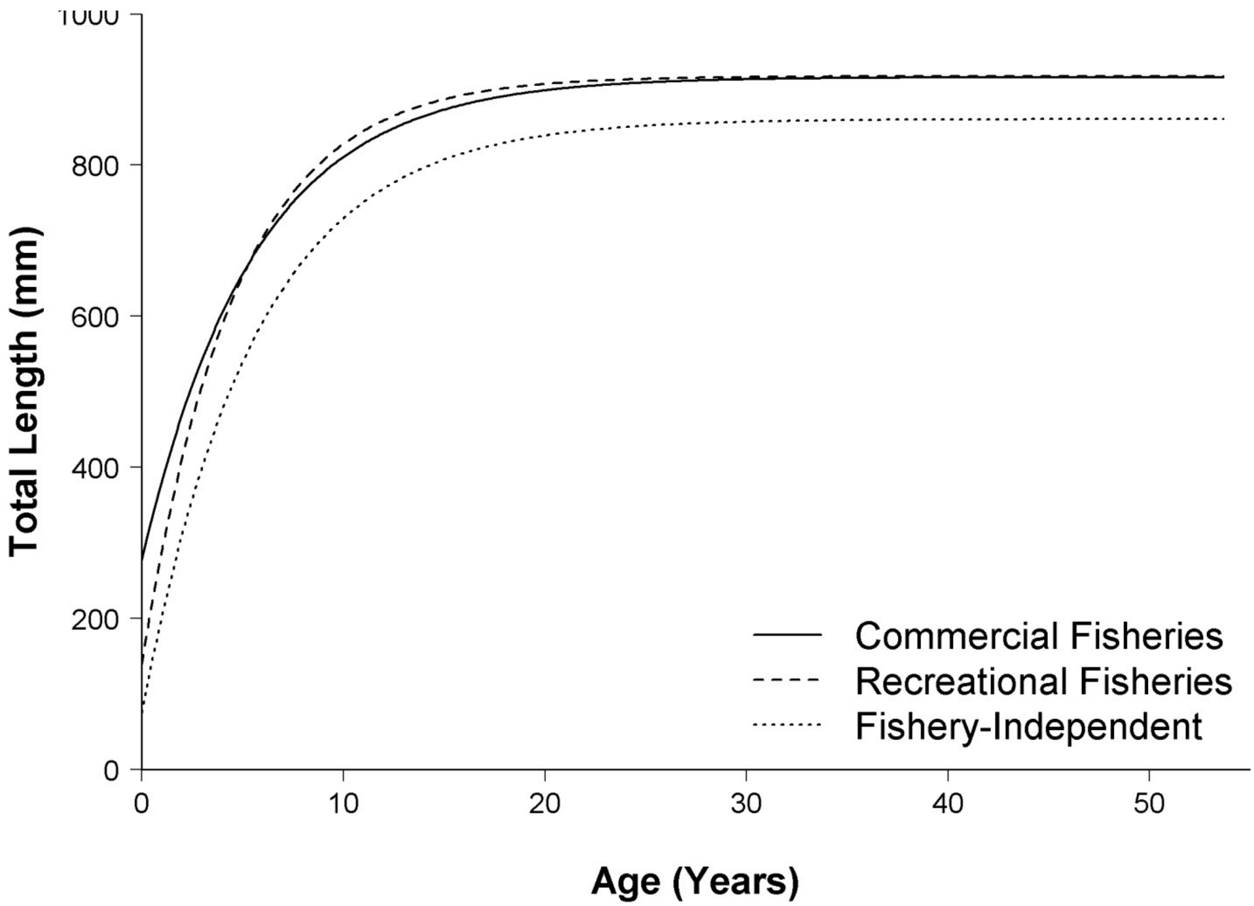


Figure 2.7.3: von Bertalanffy growth model developed for Atlantic red snapper collected via fishery-independent sampling, uncorrected for minimum size limit size bias.

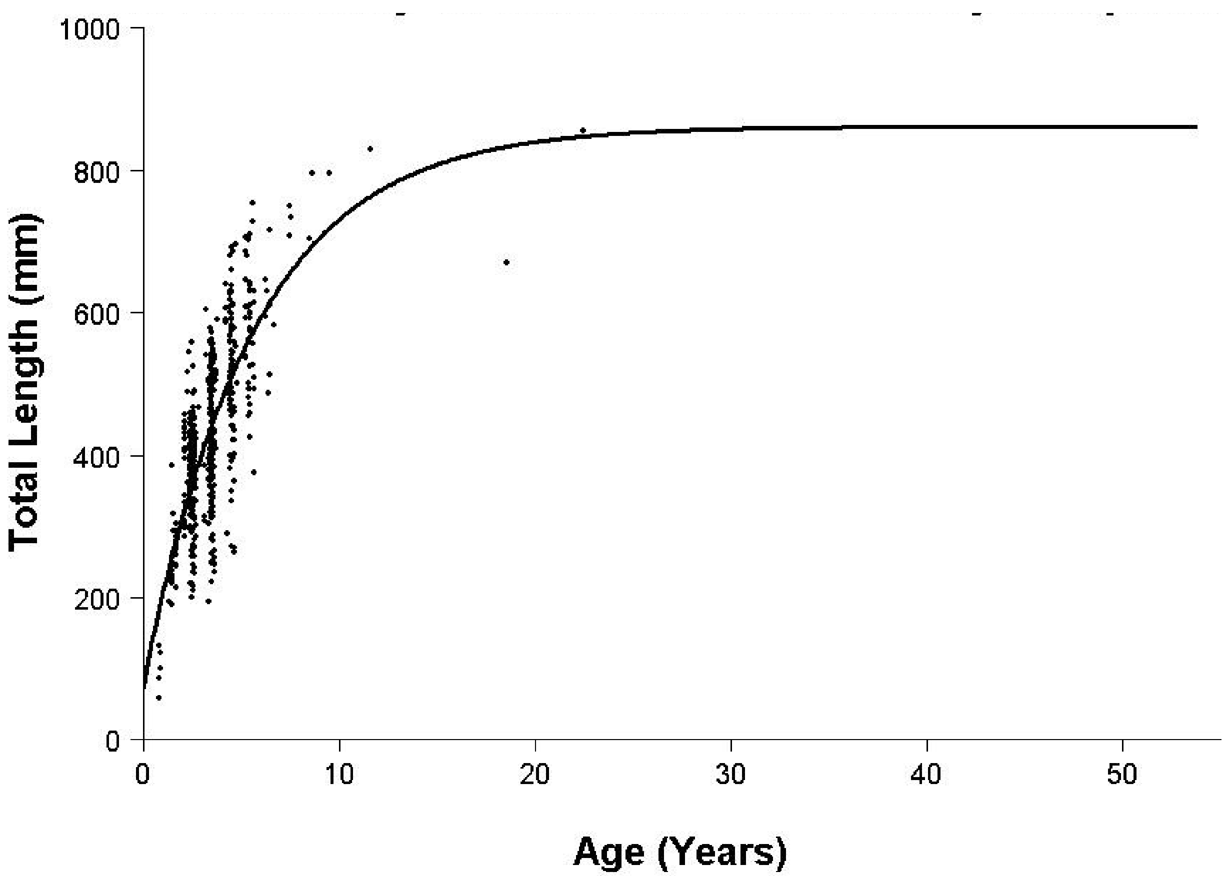


Figure 2.7.4: von Bertalanffy growth model for all data combined, corrected for minimum size limit size bias (Diaz et al. 2004). Dark (or black) diamonds represent fishery-dependent age samples. Light (or yellow) diamonds represent fishery-independent age samples.

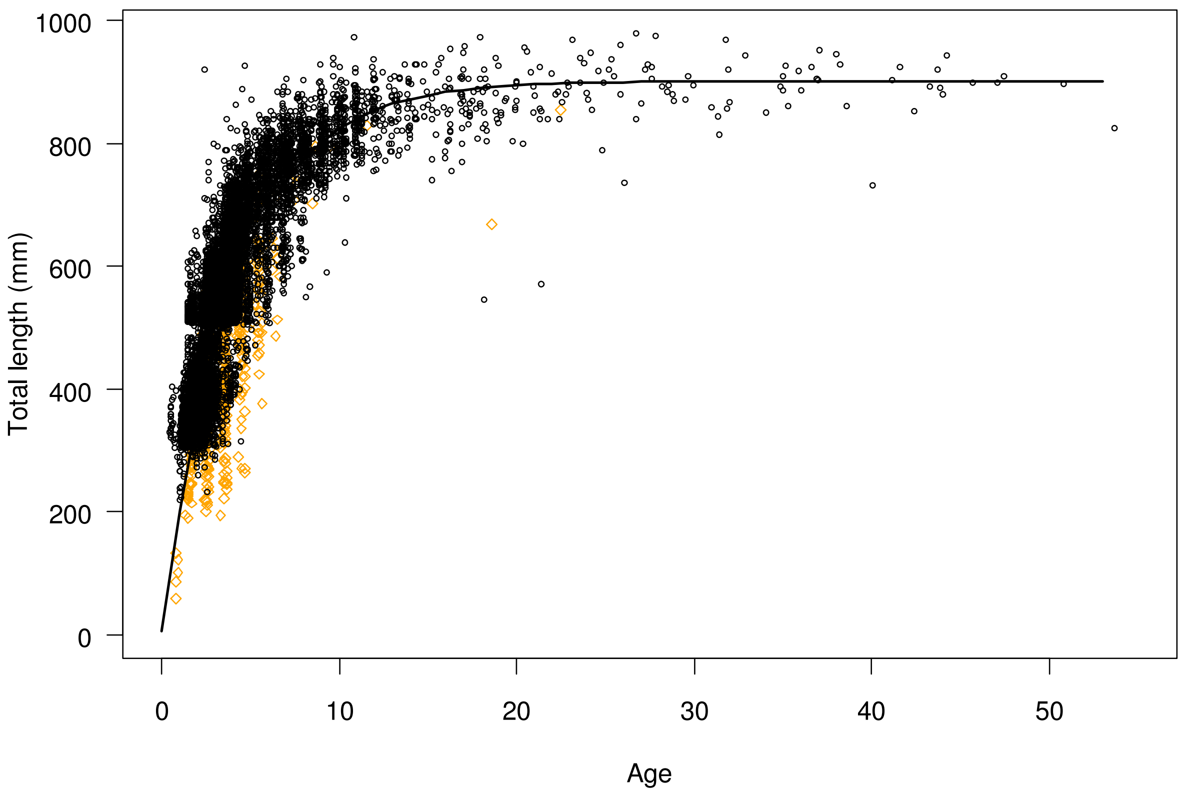


Figure 2.7.5: Comparison of Gulf of Mexico and South Atlantic red snapper von Bertalanffy growth curve.

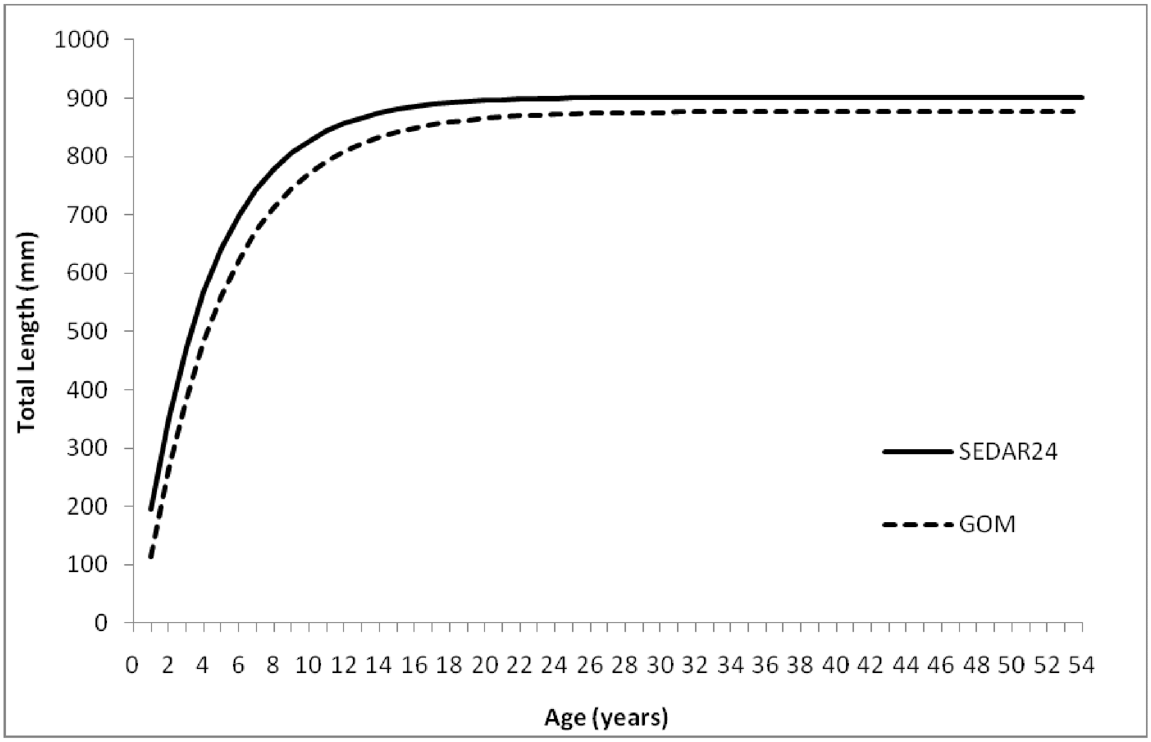
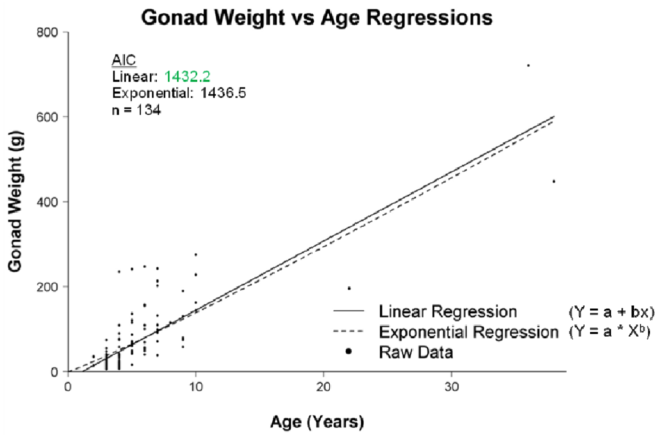
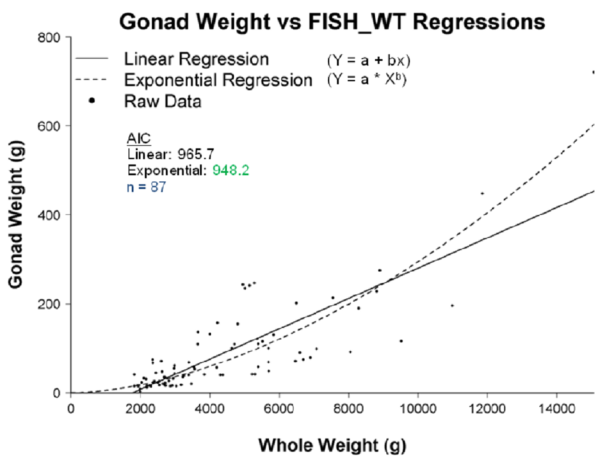


Figure 2.8.5.1. Three proxies to estimate red snapper fecundity that were generated from MARMAP data. A) Gonad weight vs. calendar age, B) Gonad weight vs. whole fish weight, and C) Gonad weight vs. total length (TL).

A)



B)



C)

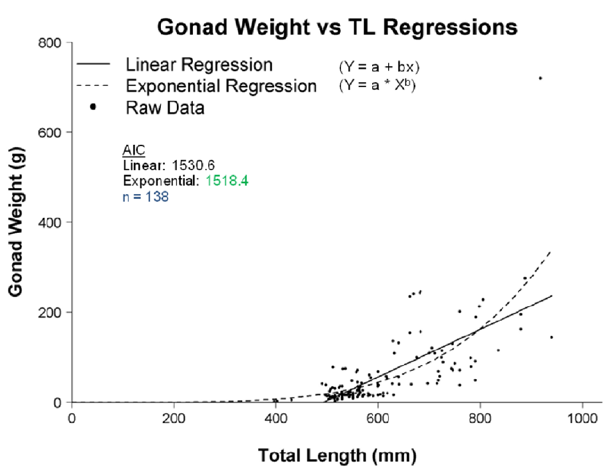
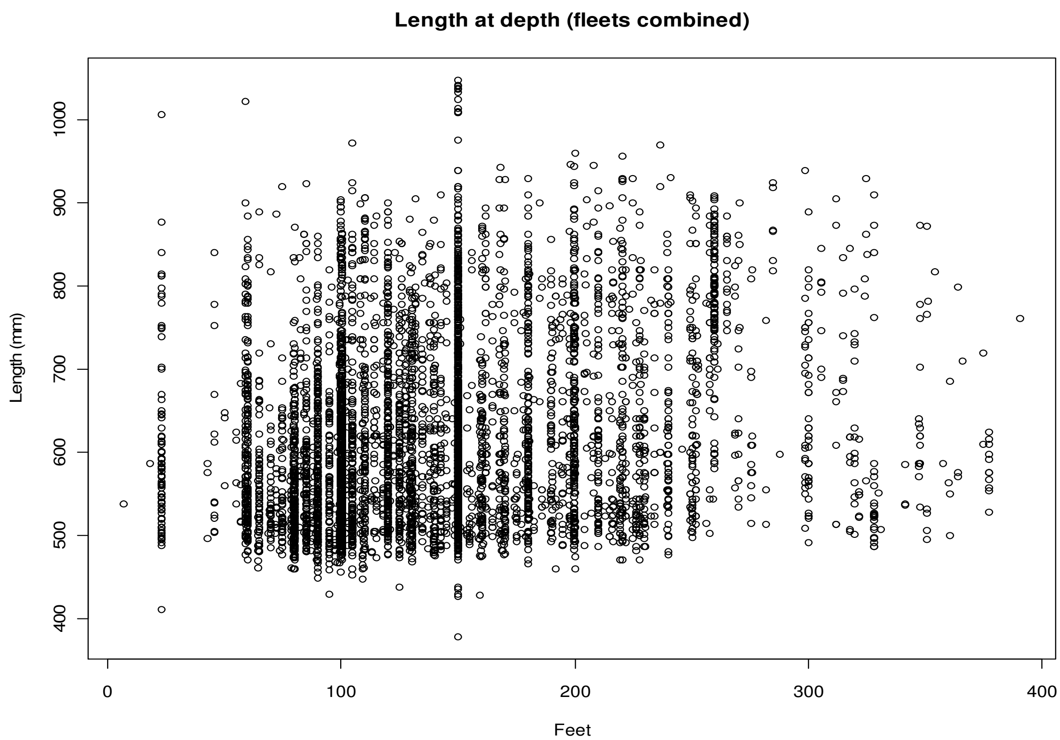
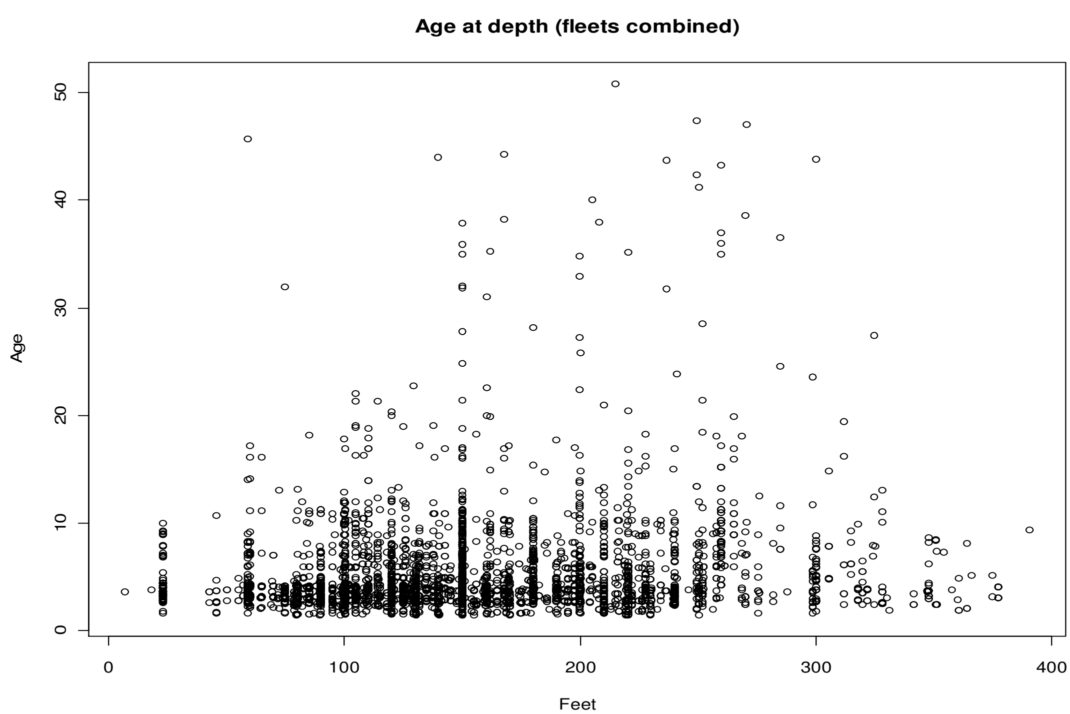


Figure 2.9.1. Depth distribution of US South Atlantic red snapper by a) size (TL mm) and b) age.

a.



b.



3. Commercial Fishery Statistics

3.1 Overview

Topics discussed by the Commercial Workgroup began with a discussion of stock boundaries, both the southern boundary with the Gulf of Mexico and the northern boundary (north of North Carolina).

To develop annual landings by gear and state, no adjustments were deemed necessary for misidentification of red snapper with other snapper species or inclusion of unclassified snappers that would have been analogous to SEDAR assessments for other snapper-grouper species. Commercial landings for the U.S. South Atlantic red snapper stock were developed by gear (handline and diving) in whole weight for the period 1950 through 2009 based on federal and state data bases. Intermittent landings estimates from historical reports were also consulted for 1902-1949. Corresponding landings in numbers were estimated from mean weights estimated from TIP by gear, state and year for 1950-2009.

Discards, developed from the snapper-grouper logbook, were estimated for recent years (1992-2009) subsequent to the last change in minimum size limit for red snapper along the U.S. South Atlantic coast. Limited observer discard data (2007-2009) permitted development of length composition of discarded red snapper, and estimation of discard mortality from a depth-mortality relationship adopted by the plenary for commercial handlines.

Sampling intensity for lengths and age by gear, state and year were considered, and length and age compositions were developed by gear and year for which sample size was deemed adequate.

Other topics discussed during this workshop included consideration of market category for post-stratification of length composition data, and discussion of selectivity appropriate for handline gear. Several research recommendations were updated and amended from SEDAR 15.

3.1.1 Participants in SEDAR 24 Data Workshop Commercial Workgroup:

Douglas Vaughan, NMFS, Beaufort, NC (leader)
Stephanie McInerney, NC DMF, Morehead City, NC (rapporteur)
Steve Brown, FL MRRI, St. Petersburg, FL
Julie Defilippi, ACCSP, Washington, DC
Kenny Fex, Commercial Fisherman, NC
David Gloeckner, NMFS, Beaufort, NC
Jack Holland, NC DMF, Wilmington, NC
Kevin McCarthy, NMFS, Miami, NC
Dave Player, SC DMF, Charleston, SC

3.1.2 Preliminary Commercial Gears Considered

In preparation for the SEDAR 24 Data Workshop, the commercial working group settled on the following numerical gear codes (ALS) for dividing red snapper commercial landings into six categories for consideration by the Workgroup. These gears included:

Handline (600-616, 660, 665),

Longline (675-677),

Diving (760, 941-943),

Trawl (200-220),

Traps (325-390), and

Other (remaining gear codes including unknown).

Although reported separately here, the small quantities of longline, trawl, and trap landings were pooled with "other" gear type, which in turn was pooled with handlines, the dominant gear (see **Decision 6**).

3.1.3 Stock Boundaries

Data Workshop Term of Reference #1: Review stock structure and unit stock definitions and consider whether changes are required. **(Decisions 1 & 2)**

Initial discussion and decisions concerned setting the geographic boundaries for the south Atlantic red snapper stock. Landings were obtained from the states north of North Carolina (ACCSP). Prior to 1987, reported red snapper landings were infrequent, occurring only in 1950 (300 lbs whole weight), 1970 (300 lbs), and 1983 (100 lbs). Landings became more frequent beginning in 1987, with positive landings for 1987-1988, 1992-1999, 2001-2002, 2004, and 2007. If we assume landings were truly 0 in those years none were reported for 1950-2008, then the average annual reported landings of red snapper from north of North Carolina was 46 pounds (whole weight). If we just compute the average landings beginning in 1987, we obtain 92 pounds.

3.1.3.1 Decision 1.

Because very few red snapper landings were reported north of North Carolina, the Workgroup recommends using the VA/NC line as the northern boundary for the South Atlantic red snapper stock. This decision was approved by the plenary.

The Commercial Workgroup considered several approaches for splitting the Atlantic and Gulf of Mexico stocks. Monroe County, Florida, has been the focal point for the stock boundary between the U.S. South Atlantic and Gulf of Mexico waters. During SEDAR 15, the Workgroup chose an approach that paralleled that of the last Gulf of Mexico red snapper assessment (SEDAR 7). All Florida landings with water body codes 0010, 0019, 0029, and 7xxx and higher, with exception of 7441 and 7481 (Florida Bay), were considered South Atlantic catch. Also included were the small amount of landings from state 12 which represent Florida interior counties landed on Florida east coast. If water body code was unknown (0 or 9999) it was retained for state 10 (Florida, Atlantic coast), but deleted for state 11 (Florida, Gulf coast). See maps showing shrimp statistical areas for the Gulf of Mexico and U.S. Atlantic coasts (Figure 3.1) and Florida statistical areas (Figure 3.2). For detailed description of the Accumulated Landing System (ALS), see Addendum 3.1 to this section. For the years 1992-2009 water body and jurisdiction allocations are based on water body ratios as reported in the Fishery Logbook data and applied to the landings by gear reported in the ALS as in SEDAR 15 for Monroe County. The group consensus was data reported directly by fishermen in the logbook program versus data reported third person by dealers and associated staff submitted to the states/ALS would be more precise in assigning area of capture to catch.

The Commercial Workgroup discussed alternative approaches for splitting landings between the South Atlantic and Gulf of Mexico. We decided to go with what was in SEDAR 15 because the differences using the Dade/Monroe County line were greater than 5% (CV) in some years. Furthermore, there were small differences between Florida Trip Ticket and ALS (less than 1%), so we continue to use the ALS data as the basis for Florida landings. As in SEDAR 15, this method essentially does the complementary calculation for what was used in the Gulf of Mexico Red Snapper Assessment (SEDAR 7).

3.1.3.2 Decision 2.

The Workgroup recommends application of the same approach for dividing red snapper into South Atlantic and Gulf of Mexico stocks as for the previous red snapper assessment (SEDAR 15). This decision was approved by the plenary.

3.2 Review of Working Papers Assigned to Commercial Workgroup

SEDAR24-DW01: The analyses contained in this report are based on self-reporting of discards in the commercial logbook data base. Two methods were presented to the Commercial Workgroup for discussion. Section 3.3.1 contains a summary of this report and the discussion and conclusions of the Commercial Workgroup that it generated. The results of these analyses were accepted by the Commercial Workgroup and the Plenary as best available data for estimating discards from the commercial handlines.

SEDAR24-DW08: This report presents a description of the Trip Interview Program (TIP) of NMFS. TIP is not specific to red snapper and is intended to provide sampling coverage for all species. This data base is the primary source of lengths as sampled from commercial gears with concomitant trip information. See section 3.4 on biological sampling.

SEDAR24D-W09: This report provided a framework for discussions by the Commercial Workgroup during the SEDAR 24 Data Workshop. For this preliminary report, red snapper landings from NMFS Accumulated Landing System (ALS) were used in the tables and figures for 1962-2009. This report will not be updated following Data Workshop, but instead is superseded by the Commercial Section 3 of the Data Workshop Report (this report).

3.3 Characterizing Commercial Landings

Data Workshop Term of Reference #8: Characterize commercial and recreational catch, including both landings and discards in both pounds and number. Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector. Provide observed length and age distributions if feasible. Provide maps of fishery effort and harvest. Provide a written description of the discard sampling programs. (Decisions 3-8)

3.3.1 Mis-identification and Unclassified Snappers

The next topics of discussion included whether misidentification of red snapper with other snapper species was a concern and whether red snapper landings may be incorporated in significant quantities in the unclassified snapper category. Neither of these issues was considered significant by the SEDAR 15 Commercial Workgroup. The Commercial WG discussed and agreed with this decision. There are similar species to red snapper being landed but markets and regulations are different so there should be no misidentifications. Also red snapper have always been kept separate from the unclassified snappers because of their value. If any unclassified snappers were actually red snapper then it was insignificant. Data supporting this is anecdotal.

3.3.1.1 Decision 3.

The Workgroup concurs with prior SEDAR 15 decision that concerns about mis-identification and unclassified snappers are not significant, and no adjustments are needed. This decision was approved by the plenary.

3.3.2 Historical Commercial Landings

Next, historical landings of red snapper for 1902-1989 were obtained from Fisheries Statistics Division (1990). These landings, without any attempt at interpolation, are provided for 1927-1949 (Table 3.1) to provide insight into historical red snapper landings prior to the beginning of data provided by ACCSP and NMFS ALS data bases (1950 to present). Commercial landings by state are summarized in Figure 3.3 for the full time series provided in this document (1902-1989).

From Red Grouper SEDAR 19:

"The annual data on commercial landings begins in 1950, while previous to that year, data collection was inconsistent, but collected by federal agencies starting 1880. Prior to 1950, there may be gaps of up to 10 years between the collection of landings statistics in some states and even these years may not be complete. The use of interpolation to fill in years where data were not collected has been discouraged because of the annual variations in landings, which could lead to erroneous or misleading estimates (Chestnut & Davis, 1975)."

3.3.2.1 Decision 4.

Because available red snapper landings for 1927-1949 were significant, but with some missing years of data, the Workgroup concluded that it was still useful to report these earlier red snapper landings for better understanding the potential magnitude during this earlier period. Historical commercial landings data prior to 1927 are too sparse and difficult to interpret.

The Commercial Workgroup discussed and agreed to this decision. For SEDAR 24, Commercial Workgroup suggests only presenting landings prior to 1950 because uncertainty in these data is high. A caveat should be included that some of these landings were driven by incomplete data collection, with NMFS collecting data more consistently beginning in 1950, therefore, increases in the data could be due to increased data collection. After 1950, there is more consistency in the data and the WG has greater confidence in these data. The Workgroup suggests some consideration of sensitivity runs to determine the impact of the data from years prior to 1950. This decision was approved by the plenary.

3.3.3 Development of Commercial Landings by Gear and State

Historical commercial landings (1950 to present) for the Atlantic coast are maintained in the Atlantic Coastal Cooperative Statistics Program (ACCSP) Data Warehouse. The Data Warehouse is on-line data base of fisheries dependent data provided by the ACCSP partners. Data sources and collection methods are illustrated by state in Figure 3.4. The Data Warehouse was queried in May 2010 for all red snapper landings (annual summaries by state and gear category) from 1950 to present for Florida (east coast), Georgia, South Carolina, North Carolina, Virginia, Maryland, New Jersey, New York, Connecticut, Rhode Island, New Hampshire and Maine (ACCSP, 2010). Data are presented using the gear categories as determined at the workshop. The specific ACCSP gears in each category are listed in Table 3.2. Commercial landings in pounds (whole weight) were developed based on classified red snapper by the Working Group from each state as available by gear for 1950-2009.

Historically, conversions between whole and gutted weight have been based on state specific values. The standard conversion of snappers for Georgia and Florida from gutted weight to whole weight is by multiplying gutted weight by 1.11. South Carolina uses a conversion of about 1.075, obtained by dividing gutted weight by 0.93. North Carolina uses a conversion multiplier of 1.08. During SEDAR 15, conversions from gutted back to whole weight were based on data from the South Carolina MARMAP program. Although the sample size was still somewhat small (N=30) the R^2 value was high (0.9996) with no value having high leverage. The no-intercept regression estimate for slope is 1.076 (the ratio of means for whole weight to gutted weight) (see **Table 2.10.1** in Section 2).

Concern was raised about the possibility of double counting; i.e., inclusion of recreationally-caught fish in the commercial landings. The consensus of the Workgroup was that this was not significant issue. Furthermore, there are no means for identifying recreationally caught fish in the commercial data bases. Selling of recreationally-caught red snappers without a commercial snapper-grouper permit has recently been banned (Amendment 15B).

3.3.3.1 Florida

Prior to 1986, Florida commercial landings data were collected through the NMFS General Canvass via monthly dealer reports. In 1984, the state of Florida instituted a mandatory trip level reporting program to report harvest of commercial marine fisheries products in Florida via a marine fisheries trip ticket. The program requires seafood dealers to report all transactions of marine fisheries products purchased from commercial fishers, and to interview fishers for pertinent effort data. Trip tickets are required to be received monthly, or weekly for federally managed species. Data reported on trip tickets include participant identifiers, dates of activity, effort and location data, gear used, and composition and disposition of catch. The program encompasses commercial fishery activity in waters of the Gulf of Mexico and South Atlantic from the Alabama-Florida line to the Florida-Georgia line. The first full year of available data from Florida trip tickets is 1986.

A data set was provided to the commercial workgroup of summarized red snapper landings by year, area fished, county landed, and gear with whole pounds and number of trips from Florida South Atlantic waters. The data set also includes associated species groups from all snapper trips. Gear categories include hook & line, long line, diving, trap, trawl and other/unknown. NMFS logbook data will be used to further define Florida landings from South Atlantic waters. Comparisons were made between Florida trip ticket data and NMFS ALS, and because they showed very little difference, the Workgroup agreed to use the ALS data as modified for Monroe County for Florida commercial landings for 1962-2009. Landings from the ACCSP data base were selected for 1950-1961.

3.3.3.2 Georgia

GA DNR provided landings by gear back to 1989 (state reported landings were almost identical to ALS landings), and the landings maintained in the ACCSP data base were selected for 1950-2009.

3.3.3.3 South Carolina

The landings data for South Carolina comes from two different sources. The first, 1980-2003, is from the old NMFS Canvass data system. This system involved wholesale seafood dealers reporting total monthly landings by species to the state. The second, 2004-present, is the ACCSP Trip Ticket System. This requires wholesale seafood dealers to fill out an individual Trip Ticket for each trip that each commercial Snapper Grouper boat makes. The landings are broken down by species, gear type, and area fished. The landings maintained in the ACCSP data base were selected for 1950-2009.

3.3.3.4 North Carolina

Prior to 1978, the National Marine Fisheries Service collected commercial landings data for North Carolina. Port agents would conduct monthly surveys of the state's major commercial seafood dealers to determine the commercial landings for the state. Starting in 1978, the North Carolina Division of Marine Fisheries entered into a cooperative program with the National Marine Fisheries Service to maintain the monthly surveys of North Carolina's major commercial seafood dealers and to obtain data from more dealers.

The North Carolina Division of Marine Fisheries Trip Ticket Program (NCTTP) began on 1 January 1994. The NCTTP was initiated due to a decrease in cooperation in reporting under the voluntary NMFS/North Carolina Cooperative Statistics Program in place prior to 1994, as well as an increase in demand for complete and accurate trip-level commercial harvest statistics by fisheries managers. The detailed data obtained through the NCTTP allows for the calculation of effort (i.e. trips, licenses, participants, vessels) in a given fishery that was not available prior to 1994 and provides a much more detailed record of North Carolina's seafood harvest.

Three datasets were provided to the commercial group for the SEDAR 24 Data Workshop. North Carolina commercial landings of red snapper were provided for 1950-2009 by year and gear type. Gears were grouped into the following categories: Handlines, Longlines, Pots, Trawls, Spears, and Others[1]. Commercial landings for red snapper from the NC trip ticket

---

[1] SAS code used to group trip ticket gears into these categories:

```
If Gear1 in (210,215) Then Delete;
If Gear1=480 and Gear2=610 and Gear3=. Then Gear1=610;
If Gear1=676 and Gear2=660 and Gear3=. Then Gear1=610;
If Gear1=677 and Gear2=610 and Gear3=. Then Gear1=610;
Length Geartype $ 15;
If (200 LE GEAR1 LE 220) Then Geartype='Trawls';
Else if (320 LE GEAR1 LE 390) Then Geartype='Pots';
Else if (600 LE GEAR1 LE 616) Or Gear1 in (660,665) Then Geartype='Handlines';
Else if Gear in (675,676,677) then Geartype='Longlines';
Else if Gear1 in (760,943) Then Geartype='Spears';
Else Geartype='Others';
```

program were also provided by month and market grade for only handlines and spears from 1994-2009. These landings were selected for use in this assessment.

3.3.3.5 Combined State Results

The decision of the Commercial workgroup was to use landings data provided by the ACCSP for Georgia and South Carolina for all years (1950-2009) and data from 1950 – 1961 from all states (including Florida and North Carolina). The Workgroup used landings data from NC DMF for 1962-2009. Finally, Florida landings from 1962-2009 were based on ALS data base as modified above for Monroe County (logbook was used for proportions from 1992-2009).

Landings are presented in Table 3.3 and Figure 3.5. Note that landings for the states of Georgia through North Carolina are combined for confidential reasons in Table 3.3. Since 1950, Florida produced 83% of the commercial harvest, Georgia 4.3%, South Carolina 7.1%, and North Carolina 5.6%. Since 1984 when diving appeared in the data set, handlines have represented about 95.4% of the catch compared with 4.6% for diving (Table 3.4 and Figure 3.6). Diving has risen to as high as 13% of the total commercial landings in some years. Trivial amount of landings by other gears have been pooled with the handline gear, including longline (0.8%), traps (0.6%), trawls (0.6%), and other (1.6%, mostly combined or mixed gears).

3.3.4 Decisions Related To Commercial Landings by Gear and State

3.3.4.1 Decision 5.

The Workgroup recommends that landings by fishing gear be reduced to two categories, the dominant handline gear and diving/spear gear. The small percentage from miscellaneous other gears (e.g., longline, trawls and traps) should be pooled with handlines.

The Commercial Workgroup makes this recommendation largely because of the small amount of other miscellaneous gears. The Workgroup notes that discard data from the snapper-grouper logbook (2002-2009) showed that only handline gears reported discards. Separating handline and diving gears is done because there are differences in the discard mortality and there may be differences in the selectivity and, therefore, length data between the two gears. Diving gear typically would catch larger red snapper on average. This decision was approved by the plenary.

3.3.4.2 Decision 6.

The Workgroup made the following decisions for reporting of commercial landings:

- Landings should be reported as whole weight (rather than gutted)
- Landings by state should be separated into Florida (South Atlantic) and Georgia-North Carolina to maintain confidentiality for Georgia landings.
- Discussion concerning development of GIS maps of effort from logbook data set.

Whole vs Gutted Weight – The Commercial Workgroup discussed the topic of what units to use to report commercial landings. Although landings were reported in gutted weight in SEDAR 15, it was agreed to report them in whole weight in this report. Red snapper are typically landed gutted and converted by the states to whole weight. For this analysis, states provided their landings in gutted weight or if in whole weight, were converted back to gutted weight using the state specific conversion given earlier. Once the state landings were all in gutted weight, they were all converted to whole weight using the whole weight-gutted weight conversion developed from MARMAP data (see Life History Workgroup, Section 2). Early landings data for 1950-1961 were received in whole weight from ACCSP and no modifications were made to these.

This decision was approved by the plenary.

Confidentiality Issues – The Commercial Workgroup agreed to pool Georgia commercial landings with one or more of the other states because of confidentiality issues. The Workgroup recommended that Georgia landings be pooled with South and North Carolina (the rule of “3”) as the simplest approach. Also, Florida landings went through additional processing for splitting out Monroe County described during Decision 2.

This decision was approved by the plenary.

GIS Maps – The Commercial Workgroup discussed an addition embedded within this ToR (*Provide maps of fishery effort and harvest*) and determined that it would be possible to develop maps of effort and catch from logbook data, but the plot could pose confidentiality issues. A table of trips and catch organized by latitude and longitude (in reverse numeric order to line up with the coast) was created in Excel by color coding trip and landings summed across years 1993-2009 (Figure 3.7). Only latitude/longitude combinations that had less than 10 trips or 100 lbs for the time period was dropped from the analysis.

In addition, a bathymetric map of the South Atlantic coastline was provided (Figure 3.8). Depth zones are highlighted in this figure. The zone in yellow represents depths from 30 m to 60 m (98 – 197 ft), and the zone in red represents depths from 60 m to 80 m (197 – 263 ft). The yellow zone includes the depths where most red snapper are caught by handline according to the logbook data (2004-2009).

A recommendation was approved by the plenary to seek GIS help to overlay these latitude/ longitude data onto a geographic map, and develop a bathymetric map of the U.S. South Atlantic coast. This task was completed after the workshop.

3.3.5 Converting Landings in Weight to Landings in Numbers

Commercial landings in weight were converted to commercial landings in numbers based on average weight (in pounds whole weight) from the TIP data for each state, gear, and year. These data were generally available from 1984 to 2009 for handlines (19,251 lengths). Data for the remaining gear types were sparse, with much more limited data from diving (502), longlines (165), traps (284), and trawls (289), and other (2) gear types available (annual sample sizes by gear, state and year are summarized in Table 3.5). Annual estimates of mean weight by gear, state and year are applied to the corresponding landings in weight when sample size greater than or equal to 20 were available (Table 3.6). When sample size did not meet this criterion, then averages across state and years for each gear were used. Because of a change in minimum size limits in 1992, mean weights calculated before 1992 were applied to years prior to 1992, and means for 1992 and later were applied for years 1992 and later. Red snapper landings in numbers are summarized by gear in Table 3.7 and in Figure 3.9.

Commercial Workgroup discussed uncertainty for landings by year and state and reported that increased uncertainty should be noted as one goes back in time (Table 3.8). CVs were developed from expert opinion recognizing these time breaks that reflect improvements in data collection methodologies leading to smaller CVs over time. Between 1950 and 1961, there was consistent reporting of commercial landings (CV = 50%). The ALS system began in 1962 (first reduction in uncertainty to 40%). Georgia, South Carolina and North Carolina began collecting data under the Cooperative Statistics Program in 1981, while Florida began its Trip Ticket Program in 1986 (fully instituted). CV was reduced to 20% following these actions. North Carolina introduced their Trip Ticket Program in 1994, Georgia in 2002, and South Carolina in 2004; while Florida's Trip Ticket Program was adopted by the ALS in 1997. CV was lowered to 10% with these dates. The information summarized in Table 3.9 parallel that used in SEDAR 20 for red grouper. This approach was recommended by the Commercial Workgroup.

3.4 Commercial Discards

3.4.1 Commercial Discard Estimates from Logbook

Commercial discards were calculated for vertical line (handline and electric reel) vessels in the US South Atlantic using methods described in SEDAR 24-DW01. Other gears reported fewer than 10 trips (per gear) with red snapper discards during the period 2002-2009. Longline vessels (162 trips reporting some discards) never reported red snapper discards to the discard logbook program, however, underreporting of discards may have occurred given that more than 250 longline trips reported no discards of any species.

Two methods were used to calculate total discards. A continuity approach followed the methods of SEDAR 15 and included a bootstrap resampling procedure to estimate possible variability in the discard estimate. An alternative method using delta-lognormal model generated least squares means of year-specific discard rate was also used to calculate total yearly discards for the period 2002-2009 (when discard data were reported). Discard rate for the period 1992-2001 (prior to discard reporting) was assumed to be the mean discard rate over the years 2002-2009, weighted by sample size. Both methods used calculated discard rates along with vertical line effort reported to the coastal logbook program as ratio estimators of total discards. Discards were reported in numbers of red snapper.

The working group recommended using the delta-lognormal method of calculating discard rates. Data included in that calculation were filtered to remove records from fishers who reported "no discards" of any species for 75% or more of reported trips during years with four or more trips reported by the fisher. This data filter was necessary due to consistent nonreporting of discards by some fishers. Including effort from those fishers would have resulted in discard rates that were erroneously low. The working group also recommended using the data filtering methods used in SEDAR 15 when summing total effort. More restrictive data filters were rejected by the group as likely to result in an under estimate of total discards. The working group noted that no regulatory changes occurred during the period 1992-2009 that would have affected red snapper discard rate. The working group, therefore, accepted the method of using the 2002-2009 weighted mean discard rate for calculating 1992-2001 discards.

Total discards, calculated using SEDAR 15 methods (continuity case), bootstrapped estimates, the 2010 delta-lognormal method, and the SEDAR 15 calculated discards, are included in Table 3.9.

3.4.1.1 Decision 7a.

The Workgroup accepts the discard estimates of red snapper for 1992-2009 as developed in S24DW01.

The commercial working group accepted the methods of SEDAR24-DW01 for calculating commercial vertical line vessel red snapper discards for the years 1992-2009. Fewer than 10 trips by any other gear reported red snapper discards, suggesting that discards from other commercial gears was minimal. The specific method chosen by the working group was the use of a delta-lognormal model to calculate year-specific least squares means of red snapper discard rate. Those discard rates were used with yearly total vertical line effort reported to the coastal logbook program as a ratio estimator of total discards. The working group also endorsed using the mean discard rate over the years 2002-2009, weighted by sample size, as the discard rate for the period 1992-2001 (prior to discard reporting). No effort data were available for calculating discards prior to 1992 and the working grouper recognized that changes in minimum size regulations in 1991 would have made such calculations unreliable.

The discard calculations rely on self-reported discard and effort data. Perhaps the most important source of error in the commercial discard calculations was misreporting and non-reporting of discards, both of red snapper and other species. An effort was made to minimize that potential error by filtered the discard data to remove records from fishers who reported "no discards" of any species for 75% or more of reported trips during years with four or more trips reported by the fisher. Including effort from those fishers would have resulted in discard rates that were erroneously low. Although such clear instances of discard non-reporting were identified and excluded, other cases of non-reporting and misreporting have not been quantified. The degree to which this may have affected the discard calculations is unknown.

Actual red snapper discards may be higher than the calculated totals presented in SEDAR 24-DW01. In the limited observer data available discarded red snapper were more common than retained red snapper (60% to 40% of 644 fish). Self-reported discards were reported in numbers of fish and lack length information making a similar comparison with landings data difficult. Discards and landings of red snapper from the commercial fishery, however, appear to be relatively low, particularly when compared to the recreational fishery. The total commercial discards from SEDAR 24-DW01 may represent a minimum estimate of the number of red snapper discarded from the commercial fishery. The conclusion of the commercial working group was that SEDAR 24-DW01 represents the best available information on commercial red snapper discards.

This decision was approved by the plenary.

3.4.2 Discard Length Frequency

Observer discard data were made available during the Data Workshop to the Commercial Workgroup. Procedures relevant to the collection of these data are reported in GSAFF (2008). These data were collected from vertical line gear (handline) between latitudes 30 and 33 (Table 3.10) during 2007-2009. An un-weighted length composition was developed from these data (Figure 3.10) and added to the Excel Input Data File. The average weight of these fish was 2.9 pounds.

3.4.3 Discard Mortality Estimates

The work reported in this subsection falls under **Terms of Reference #5**. The plenary decided to develop discard mortality estimates based on the relationship of discard mortality with depth (Burns et al. 2004). Given this decision by the plenary, the Commercial Workgroup considered two approaches for estimating overall discard mortality from the commercial handline gear based on available depth information. One method considered logbook depth profile information relative to catch (not discard). The second method, used observer data having depth information for released fish (GSAFF 2008). These observer data were collected during 2007-2009 between latitudes 30 and 33. Estimates of mortality were obtained by calculating a weighted average of mortality from the Burns et al. equation, weighted by depth profile. The profiles were computed in 25 ft intervals while the mortality estimates from Burns et al. (2004) were computed at the mid-points of these intervals. These estimates were relatively insensitive to interval width since approximately the same result (same whole percent) was obtained with 1 ft intervals from the observer data. Computed values by depth interval are summarized in Table 3.11, while these values are plotted in Figure 3.11.

For representing discard mortality of red snapper discarded from 1992-2009, the WG recommended the mortality estimate based on discard fish (48%).

3.4.3.1 Decision 7b

The Workgroup also recommended using observed discard information with depth to estimate commercial handline discard mortality (48%).

This decision was approved by the plenary.

3.5 Biological Sampling

Length frequency data were extracted from the TIP Online data base. Data from the VA/NC line through Monroe County in FL were included in the extraction. Those data from Monroe County that were attributable to the Gulf were deleted from the data. All lengths were converted to TL in mm using conversions derived from the Life History Group. We had no conversions for standard length, so these were deleted. Lengths greater than 2,000 mm (2 m) were deleted, as the group felt that these extreme lengths may be errors and did not represent those lengths observed in the commercial fishery. Lengths were converted to cm and assigned to 1 cm length bins with a floor of 0.5 cm and a ceiling of 0.4 cm. Weights were converted to whole weight in grams using the length/weight relationship supplied by the Life History Group and then converted to whole weight in pounds. Mean weights were then calculated across year, state and gear.

3.5.1 Sampling Intensity for Lengths

Annual sample sizes are summarized in Table 3.5 by gear, state, and year for length data available for red snapper in the U.S. South Atlantic from the TIP data base for 1984-2009.

3.5.2 Length/Age Distribution

Annual length compositions were created for each commercial gear using the following approach for weighting lengths across individual trips and by state:

- Trips: expand lengths by trip catch in numbers,

- State: expand lengths by landings in numbers.

Annual length compositions for commercial handlines are shown weighted by the product of the landings in numbers and trip catch in numbers (for 1985-1986, 1988-2004, 2007, and 2009 in Figure 3.12). Annual length compositions for commercial diving (for 1999-2001, 2003, and 2009 in Figure 3.13), are also summarized using weighting by landings in numbers and by trip catch in numbers.

Sample size of red snapper ages are summarized by gear from commercial landings in the U.S. South Atlantic for 1984-2009 (Table 3.12). Age compositions were developed for handline (1992-2009 with exceptions in Figure 3.14) and diving (2000-2009, Figure 3.15) gear types. Weighting is by length compositions shown in Figures 3.12 and 3.13, respectively. This corrects for a potential sampling bias of age samples relative to length samples (see Section 3 in SEDAR10 for South Atlantic gag).

3.5.3 Adequacy for characterizing lengths

Generally sample sizes for length composition may be adequate for the handline component of the commercial fishery (Table 3.5). Overall 19,251 fish lengths were collected from handlines during1984-2009. However, no lengths were collected from Florida in 1984 and 1987. Less than 10 fish were collected from Florida in 1988, 2005-2006, and 2008. Useful length compositions are generally available for handlines for 1985-1986, 1989-2004, 2007, and 2009.

Much more limited length compositions are available for diving (502 lengths), longlines (167 lengths), traps (284 lengths), and trawls (289 lengths) for the period 1984-2009. Potentially useful length compositions would be available from diving for 1999-2003 (except 2002), from longlines for 1987 (NC only), from traps for 1991 (almost all from SC), and from trawls for 1984, 1986-1988 (principally from SC). With such limited length compositions from longlines, traps and trawls, the small amount of samples from these gears should be pooled with others and then incorporated with handlines per **Decision 6**.

Annual length compositions were developed for handline and diving gear types. Handline length compositions should be applied to ‘other’ gear types to represent length compositions.

3.5.3.1 Decision 8.

The Workgroup reviewed the adequacy of biological sampling regime (TIP):

- Rules were recommended that define minimum length and age composition data based on sample sizes and geographic coverage and recommended to the plenary.
- Market categories were found to be too limited in their availability for use in post-stratifying TIP length data.

<u>Sampling Adequacy for Lengths</u>: Sample size of length data available from TIP are summarized in Table 3.5. For handline samples sizes, the Commercial Workgroup agreed that at least 20 lengths were required from Florida for an annual length or age composition to be developed for that year. Since 1984, data were insufficient for 1984, 1987-1988, 2005-2006, and 2008. For diving gear, the group agreed that at least 20 fish overall were needed to develop length compositions. Adequate samples sizes were available for 1999-2003, excluding 2002.

Mean weights were calculated by state, gear, year from the TIP length samples where sample sizes were sufficient (Table 3.6). These mean weights were used to convert landings in weight to landings in numbers as described in Section 3.2.4. As noted earlier, prior to 1992 and after 1992 were treated separately because of the increase in size limit for red snapper from 12 to 20 inches that occurred in 1992.

Sampling Adequacy for Ages: Red snapper age data from commercial gears were provided by the life history group and presented to the Commercial Workgroup (Table 3.12). The Workgroup recommended that at least 10 fish be the minimum requirement for use in developing age compositions. The Workgroup further stipulated that at least 10 aged fish from Florida handline be required. No samples were available from Florida until 1992. In addition, 1993 and 1994 for handlines were dropped, because only 7 and 1 fish, respectively, were available from Florida. Otherwise samples sizes generally exceed 50 from Florida between 1996 and 2009. Only four years of age data from diving gear were available: 2000, 2001, 2007, and 2009. Year 2007 was dropped due to low sample size.

Market Category: The topic of whether to use market category to post-stratify length data has been raised in past SEDARs. Unfortunately, both ALS landings and TIP length samples having market category other than unsorted were extremely limited (Figure 3.16). Years 2006-2009 from ALS landings data was generally greater than or equal to 90% unsorted. Length samples between 1984 and 2009 from TIP were all above 65% unsorted and almost all 100% unsorted especially in most recent years from 1996 to 2009. As a result, the Commercial Workgroup decided that sampling was not adequate to post stratify by market grade.

The decisions above were approved by the plenary.

3.6 Relative selectivity for commercial gears

Data Workshop Term of Reference #9: Review SEDAR 15 and SEDAR 7 approaches to selectivity of red snapper, post-SEDAR 15 evaluations of fishery selectivity patterns for Atlantic red snapper, and available length and age composition information to develop recommendations for addressing fishery selectivity in the assessment model. Specifically address the degree to which domed shape selectivity should be applied to hook and line fisheries.

3.6.1 Statement from Commercial Fishermen

Rationalize why the older red snapper, which are usually larger, are not being caught by the commercial fisherman in the South Atlantic.

First of all the older red snapper have been observed moving offshore into deeper water as they grow. Also, older Red Snapper become less gregarious and live a more solitary life.

The older red snapper are not being harvested by the divers due to their limited depth to spear. Most divers dive in 120 ft of water and shallower which would limit their ability to even interact with the older deep water red snapper.

The long liners have been historically known to catch the older red snapper (SEDAR - GoM). In 1992 the long liners were forced to fish in 300 ft of water and deeper; this limited their chance of interacting with red snapper. They were not allowed to possess any shallow water species. These regulations would eliminate any records of red snapper landing by the long liners.

As for the commercial fisherman that specifically target red snapper, their techniques have changed through the years. The fisherman are now utilizing rod and reels instead of the traditionally used bandit gear. They use lighter mono to generated more bites and be more productive. The fisherman is targeting large schools of 5 to 10 pound fish which are favored more by the fish markets. Although when a large 20 to 30 pound red snapper is hooked, the lighter tackle is less likely to land the fish (FL fisherman attendee's demonstration).

As for the fisherman who use bandit gear and catch red snapper, they too have switched to smaller mono to get more bites. This would also limit their ability to land older red snapper. My experience is that most of the large red snapper hooked act considerably like a shark on bandit gear. So sometimes landing the suspected shark is not so important and most likely to break off the gear (Ken Fex, AP member, NC fisherman).

The bandit gear is also limited by stronger current in the deeper depth. Anchoring in the Gulf Stream currents is sometimes too challenging and risky to gear. The ability to anchor the vessel to get the baited hooks to the fish that might be several yards behind the boat. Also bottom structure like ledges, pinnacles, and steeples limit anchoring ability (workshop comment by Rusty Hudson).

So in conclusion, the fishermen believe that older red snapper are not being landed due to evolving fishing techniques, market demand, depth, and regulations restricting long liners.

3.6.2 Preliminary Logbook Discussions

Include discussion of longline landings on Atlantic, comparison of effort between handlines and longlines by depth.

A preliminary consideration of depth, effort and landings data available from logbooks was presented to the Commercial Workgroup. Depth started being recorded on logbooks in 2004 so comparisons were for the years of 2004-2009 combined. Handlines and longlines were broken out and analyzed further because handlines are the dominant gear in the SA for red snapper and longlines were included because it is an important gear in the GOM for red snapper. The trips with depth for red snapper were compared for a variety of other species (red snapper, scamp, snowy grouper, speckled hind, tilefish, vermilion snapper, and yellowedge grouper). A comparison was also made between areas (SA, GA-FL, and GoM) by depth for all gears. These depth profiles were plotted and presented to the group before being presented to plenary.

Observer data was considered as an alternate data set for more detailed study concerning depth information, but does not include other gears besides handline and has very limited number of observations (and trips). The Commercial Workgroup agreed that, in general, the logbook is the best data on depth available because the observer data does not have any other gears besides handline and has limited amount of trips and observations.

A working paper exploring the logbook data base will be prepared for the assessment workshop including the caveats of the logbook data discussed during the Workgroup meetings.

3.6.2.1 Decision 9.

The Commercial Workgroup agreed that, in general, the logbook is the best data on depth available for analyses investigating landings and effort by depth.

This decision was approved by the plenary.

Landings of red snapper from the longline gear have never been large, certainly not compared to the handline gear (Table 3.13). Note that the SAFMC in Snapper Grouper Amendment 4, prohibited use of longline gear inside 50 fathoms (300 ft) in 1992. In 1999, they prohibited vessels with longline gear aboard from possession of red snapper with Snapper Grouper Amendment 9.

Sampling of red snapper for lengths from longline gear has been equally infrequent (Table 3.14). Sample sizes suggest that the only valid comparison between handline and longline that might be conducted would be limited to the North Carolina samples in 1987. In 1987, there were 81 fish collected in North Carolina longline and a corresponding 277 fish collected from handline. A plot of the cumulative proportion with increasing length suggests that longline catch larger fish than handline (Figure 3.17). This should be expected since most (not all) handline gear is found in shallower water than longline gear. The Commercial Workgroup considered the limited nature of these data, and suggested that they are probably insufficient to settle the issue of whether the selectivity of handline gear is more dome-shaped than the presumed flat-topped shape for longline gear. The limited nature of these data and small sample sizes for longlines are too low to determine selectivity.

3.7 Itemized list of tasks for completion following workshop

See Section 1.5

3.8 Literature Cited

Atlantic Coastal Cooperative Statistics Program. 2010. (1950-2009) Annual landings by state and custom gear category; generated by Julie Defilippi; using ACCSP Data Warehouse, Washington, D.C: accessed May, 2010.

Burns, Karen M, Nicholas F. Parnell, Raymond R. Wilson. 2004. Partitioning release mortality in the undersized red snapper bycatch: Comparison of depth vs. hooking effects. MARFIN Grant No. NA97FF0349, Mote Marine Laboratory Tech. Rep. No. 932, Sarasota, FL.

Fisheries Statistics Division. 1990. Historical Catch Statistics, Atlantic and Gulf Coast States, 1879-1989. Current Fishery Statistics No. 9010, Historical Series Nos. 5-9 Revised. (NTIS No. PB-93-174274)

Gulf and South Atlantic Fisheries Foundation (GSAFF). 2008. Catch characterization and discard within the snapper grouper vertical hook-and-line fishery of the South Atlantic United States. Final Report, Gulf and South Atlantic Fisheries Foundation, 5401 W. Kennedy Blvd, Suite 740, Tamp, Florida 33609-2447 (SEDAR24-RD61).

3.9 Tables

Table 3.1. Historical red snapper landings (pounds, whole weight) by state from 1927-1949. (Source: Fisheries Statistics Division. 1990. *Historical Catch Statistics, Atlantic and Gulf Coast States, 1879-1989*, US DOC/NOAA/NMFS, Current Fishery Statistics No. 9010, Historical Series Nos. 5-9).

Year	NC	SC	GA	FL(E)	Total
1927	1,000		64,000	59,000	124,000
1928	2,000		22,000	47,000	71,000
1929	15,000		33,000	19,000	67,000
1930	5,000		30,000	34,000	69,000
1931	2,000			112,000	114,000
1932				49,000	49,000
1933					
1934				152,000	152,000
1935					
1936				140,000	140,000
1937				210,000	210,000
1938	1,000			117,000	118,000
1939	2,000			96,000	98,000
1940				14,000	14,000
1941					
1942					
1943					
1944					
1945	4,000			246,000	250,000
1946					
1947					
1948					
1949					

Table 3.2. Specific ACCSP gears in each gear category for red snapper commercial landings.

ACCSP_GEAR_CODE	ACCSP_GEAR_NAME	ACCSP_TYPE_NAME	SEDAR24_CATEGORY
000	NOT CODED	NOT CODED	OTHER GEARS
010	HAUL SEINES	HAUL SEINES	OTHER GEARS
020	OTHER SEINES	HAUL SEINES	OTHER GEARS
050	POUND NETS	FIXED NETS	OTHER GEARS
073	FLOATING TRAPS (SHALLOW)	FIXED NETS	POTS AND TRAPS
091	OTTER TRAWL BOTTOM, CRAB	TRAWLS	TRAWLS
092	OTTER TRAWL BOTTOM, FISH	TRAWLS	TRAWLS
093	OTTER TRAWL BOTTOM, LOBSTER	TRAWLS	TRAWLS
095	OTTER TRAWL BOTTOM, SHRIMP	TRAWLS	TRAWLS
110	OTHER TRAWLS	TRAWLS	TRAWLS
118	BUTTERFLY NETS	TRAWLS	OTHER GEARS
130	POTS AND TRAPS	POTS AND TRAPS	POTS AND TRAPS
132	POTS AND TRAPS, BLUE CRAB	POTS AND TRAPS	POTS AND TRAPS
139	POTS AND TRAPS, FISH	POTS AND TRAPS	POTS AND TRAPS
140	POTS AND TRAPS, SPINY LOBSTER	POTS AND TRAPS	POTS AND TRAPS
200	GILL NETS	GILL NETS	OTHER GEARS
201	GILL NETS, FLOATING DRIFT	GILL NETS	OTHER GEARS
204	GILL NETS, SINK ANCHOR	GILL NETS	OTHER GEARS
205	GILL NETS, RUNAROUND	GILL NETS	OTHER GEARS
300	HOOK AND LINE	HOOK AND LINE	HAND LINE
301	HOOK AND LINE, MANUAL	HOOK AND LINE	HAND LINE
302	HOOK AND LINE, ELECTRIC	HOOK AND LINE	HAND LINE
303	ELECTRIC/HYDRAULIC, BANDIT REELS	HOOK AND LINE	HAND LINE
320	TROLL LINES	HOOK AND LINE	HAND LINE
400	LONG LINES	LONG LINES	LONG LINES
401	LONG LINES, VERTICAL	LONG LINES	LONG LINES
402	LONG LINES, SURFACE	LONG LINES	LONG LINES
403	LONG LINES, BOTTOM	LONG LINES	LONG LINES
404	LONG LINES, SURFACE, MIDWATER	LONG LINES	LONG LINES
550	DIP NETS	DIP NETS AND CAST NETS	OTHER GEARS
551	CAST NETS	DIP NETS AND CAST NETS	OTHER GEARS
600	TONGS	RAKES, HOES, AND TONGS	OTHER GEARS
660	SPEARS	SPEARS AND GIGS	DIVING
661	SPEARS, DIVING	SPEARS AND GIGS	DIVING
700	HAND LINE	HAND LINE	HAND LINE
701	TROLL AND HAND LINES CMB	HAND LINE	HAND LINE
750	BY HAND, DIVING GEAR	BY HAND	DIVING
760	BY HAND, NO DIVING GEAR	BY HAND	OTHER GEARS
800	OTHER GEARS	OTHER GEARS	OTHER GEARS
801	UNSPECIFIED GEAR	OTHER GEARS	OTHER GEARS
802	COMBINED GEARS	OTHER GEARS	OTHER GEARS
804	CHEMICAL, OTHER	OTHER GEARS	OTHER GEARS

Table 3.3. Red snapper landings (pounds whole weight) by region from the U.S. South Atlantic, 1950-2009.

Year	Florida	GA-NC	Total
1950	358,200	0	358,200
1951	510,100	7,500	517,600
1952	384,300	5,000	389,300
1953	401,900	0	401,900
1954	595,600	3,000	598,600
1955	497,800	0	497,800
1956	341,900	142,400	484,300
1957	642,900	226,000	868,900
1958	589,400	27,900	617,300
1959	629,100	33,600	662,700
1960	666,900	10,200	677,100
1961	678,200	121,600	799,800
1962	652,500	10,046	662,546
1963	500,700	4,139	504,839
1964	550,400	9,056	559,456
1965	640,500	16,226	656,726
1966	729,200	10,857	740,057
1967	903,500	60,192	963,692
1968	973,200	95,970	1,069,170
1969	670,900	29,523	700,423
1970	613,600	27,266	640,866
1971	482,900	60,499	543,399
1972	402,400	66,135	468,535
1973	350,800	36,470	387,270
1974	578,200	54,250	632,450
1975	710,000	35,339	745,339
1976	526,100	92,742	618,842
1977	504,906	144,038	648,943
1978	374,454	215,046	589,500
1979	247,289	162,433	409,723
1980	231,071	149,283	380,355
1981	198,893	172,248	371,140

Table 3.3 continued

1982	160,617	145,251	305,868
1983	168,216	141,777	309,993
1984	141,946	107,320	249,266
1985	152,896	90,453	243,349
1986	134,200	81,942	216,143
1987	125,358	61,748	187,106
1988	100,566	63,389	163,954
1989	116,793	141,330	258,123
1990	106,372	110,245	216,617
1991	74,082	65,685	139,767
1992	57,967	40,611	98,578
1993	59,518	135,739	195,257
1994	80,290	112,189	192,479
1995	104,302	72,340	176,643
1996	88,554	48,148	136,702
1997	80,447	28,252	108,699
1998	62,176	25,841	88,017
1999	48,035	42,342	90,377
2000	69,249	33,159	102,408
2001	113,677	79,646	193,323
2002	90,748	94,233	184,981
2003	71,035	65,085	136,120
2004	97,898	71,348	169,246
2005	71,526	55,671	127,198
2006	55,910	28,468	84,377
2007	85,062	27,123	112,186
2008	186,042	60,916	246,958
2009	291,812	57,338	349,151

Table 3.4. Red snapper landings (pounds whole weight) by gear (handline and diving) from the U.S. South Atlantic, 1950-2009. Percent of landings in numbers by handline also shown.

Year	Handline	Diving	Total	%Handline
1950	358,200	0	358,200	100.00%
1951	517,600	0	517,600	100.00%
1952	389,300	0	389,300	100.00%
1953	401,900	0	401,900	100.00%
1954	598,600	0	598,600	100.00%
1955	497,800	0	497,800	100.00%
1956	484,300	0	484,300	100.00%
1957	868,900	0	868,900	100.00%
1958	617,300	0	617,300	100.00%
1959	662,700	0	662,700	100.00%
1960	677,100	0	677,100	100.00%
1961	799,800	0	799,800	100.00%
1962	662,546	0	662,546	100.00%
1963	504,839	0	504,839	100.00%
1964	559,456	0	559,456	100.00%
1965	656,726	0	656,726	100.00%
1966	740,057	0	740,057	100.00%
1967	963,692	0	963,692	100.00%
1968	1,069,170	0	1,069,170	100.00%
1969	700,423	0	700,423	100.00%
1970	640,866	0	640,866	100.00%
1971	543,399	0	543,399	100.00%
1972	468,535	0	468,535	100.00%
1973	387,270	0	387,270	100.00%
1974	632,450	0	632,450	100.00%
1975	745,339	0	745,339	100.00%
1976	618,842	0	618,842	100.00%
1977	648,943	0	648,943	100.00%
1978	589,500	0	589,500	100.00%
1979	409,723	0	409,723	100.00%
1980	380,355	0	380,355	100.00%

Table 3.4 continued

1981	371,140	0	371,140	100.00%
1982	305,868	0	305,868	100.00%
1983	309,993	0	309,993	100.00%
1984	247,949	1,317	249,266	99.47%
1985	240,803	2,547	243,349	98.95%
1986	215,634	508	216,143	99.76%
1987	187,076	30	187,106	99.98%
1988	163,942	13	163,954	99.99%
1989	258,117	6	258,123	100.00%
1990	214,759	1,859	216,617	99.14%
1991	133,869	5,898	139,767	95.78%
1992	88,964	9,614	98,578	90.25%
1993	189,646	5,611	195,257	97.13%
1994	179,363	13,116	192,479	93.19%
1995	166,605	10,037	176,643	94.32%
1996	130,549	6,153	136,702	95.50%
1997	101,169	7,531	108,699	93.07%
1998	79,954	8,063	88,017	90.84%
1999	80,403	9,974	90,377	88.96%
2000	92,032	10,376	102,408	89.87%
2001	175,085	18,238	193,323	90.57%
2002	162,886	22,095	184,981	88.06%
2003	118,669	17,451	136,120	87.18%
2004	149,603	19,643	169,246	88.39%
2005	117,857	9,341	127,198	92.66%
2006	80,216	4,161	84,377	95.07%
2007	104,672	7,514	112,186	93.30%
2008	240,655	6,303	246,958	97.45%
2009	341,142	8,009	349,151	97.71%

Table 3.5. Sample size of red snapper collected for lengths by gear (handline and diving) and state from the U.S. South Atlantic TIP data base, 1984-2009.

Sum of sum	Column Labels								
	DIVING			DIVING Total	HAND LINES				HAND LINES Total
Row Labels	FL	GA	SC		FL	GA	NC	SC	
1984						206	109	987	1302
1985					639	146	489	1276	2550
1986					24	110	507	267	908
1987						403	277	385	1065
1988					5	233	169	259	666
1989					37	191	471	330	1029
1990					164		412	128	704
1991					70	199	159	400	828
1992					90	110	55	99	354
1993	1			1	189	128	188	280	785
1994		1		1	89	77	448	211	825
1995	4			4	365	36	118	132	651
1996					21	40	54	232	347
1997					27	7	1	190	225
1998					156		16	143	315
1999	81			81	216		180	494	890
2000	87			87	234	24	59	427	744
2001	53			53	373	257	279	450	1359
2002	9			9	87	68	193	447	795
2003	197			197	303	43	164	620	1130
2004			15	15	31	132	71	444	678
2005			7	7	7	94	96	362	559
2006			15	15	8	13	62	114	197
2007					41		97	141	279
2008					7		172	223	402
2009			21	21	64		163	359	586
Grand Total	**432**	**1**	**58**	**491**	**3247**	**2517**	**5009**	**9400**	**20173**

Table 3.6. Mean whole weight (pounds) of red snapper by gear (handline and diving) from the U.S. South Atlantic TIP data base, 1984-2009. Average weights by gear applied to earlier years, 1950-1983.

Sum of MEAN_weight	Column Labels							
	DIVING				HAND LINES			
Row Labels	FL	GA	NC	SC	FL	GA	NC	SC
1984	6.346	6.346	6.346	6.346	4.948	3.355	6.059	3.701
1985	6.346	6.346	6.346	6.346	4.294	5.456	4.925	5.361
1986	6.346	6.346	6.346	6.346	8.971	7.571	4.618	5.922
1987	6.346	6.346	6.346	6.346	4.948	4.579	6.275	6.539
1988	6.346	6.346	6.346	6.346	4.948	6.333	3.703	4.886
1989	6.346	6.346	6.346	6.346	12.275	5.048	5.127	6.089
1990	6.346	6.346	6.346	6.346	5.673	4.948	4.934	2.991
1991	6.346	6.346	6.346	6.346	8.330	6.234	5.488	3.717
1992	8.257	8.257	8.257	8.257	12.173	8.770	8.176	7.719
1993	8.257	8.257	8.257	8.257	12.961	6.844	5.853	5.971
1994	8.257	8.257	8.257	8.257	11.099	6.619	6.732	6.308
1995	8.257	8.257	8.257	8.257	9.318	7.360	11.734	8.099
1996	8.257	8.257	8.257	8.257	10.928	7.134	7.499	9.471
1997	8.257	8.257	8.257	8.257	8.693	8.089	8.089	10.873
1998	8.257	8.257	8.257	8.257	7.174	8.089	8.089	10.353
1999	9.761	8.257	8.257	8.257	6.834	8.089	4.059	8.592
2000	6.072	8.257	8.257	8.257	7.719	6.543	8.654	10.511
2001	8.059	8.257	8.257	8.257	6.789	3.553	6.208	7.783
2002	8.257	8.257	8.257	8.257	8.435	5.589	6.669	7.383
2003	8.408	8.257	8.257	8.257	9.441	7.883	9.685	7.994
2004	8.257	8.257	8.257	8.257	9.931	9.328	12.174	9.068
2005	8.257	8.257	8.257	8.257	8.089	10.093	11.777	10.359
2006	8.257	8.257	8.257	8.257	8.089	8.089	12.467	12.130
2007	8.257	8.257	8.257	8.257	7.766	8.089	5.351	10.459
2008	8.257	8.257	8.257	8.257	8.089	8.089	6.039	7.451
2009	8.257	8.257	8.257	7.456	10.227	8.089	5.262	9.389

Table 3.7. Red snapper landings (in numbers) by gear from the U.S. South Atlantic, 1950-2009. Percent of landings in numbers by handline also shown.

Year	Handline	Diving	Total	%Handline
1950	72,386	0	72,386	100.00%
1951	104,598	0	104,598	100.00%
1952	78,671	0	78,671	100.00%
1953	81,217	0	81,217	100.00%
1954	120,967	0	120,967	100.00%
1955	100,597	0	100,597	100.00%
1956	97,869	0	97,869	100.00%
1957	175,590	0	175,590	100.00%
1958	124,746	0	124,746	100.00%
1959	133,921	0	133,921	100.00%
1960	136,831	0	136,831	100.00%
1961	161,626	0	161,626	100.00%
1962	133,899	0	133,899	100.00%
1963	102,030	0	102,030	100.00%
1964	113,065	0	113,065	100.00%
1965	132,728	0	132,728	100.00%
1966	149,554	0	149,554	100.00%
1967	195,088	0	195,088	100.00%
1968	216,198	0	216,198	100.00%
1969	141,640	0	141,640	100.00%
1970	129,616	0	129,616	100.00%
1971	110,156	0	110,156	100.00%
1972	95,020	0	95,020	100.00%
1973	78,396	0	78,396	100.00%
1974	128,081	0	128,081	100.00%
1975	150,815	0	150,815	100.00%
1976	125,433	0	125,433	100.00%
1977	131,638	0	131,638	100.00%
1978	119,815	0	119,815	100.00%
1979	83,010	0	83,010	100.00%
1980	77,016	0	77,016	100.00%
1981	75,190	0	75,190	100.00%

Table 3.7 continued

1982	61,923	0	61,923	100.00%
1983	62,734	0	62,734	100.00%
1984	56,014	209	56,223	99.63%
1985	52,308	401	52,710	99.24%
1986	29,455	80	29,535	99.73%
1987	36,163	5	36,168	99.99%
1988	33,564	2	33,566	99.99%
1989	34,782	1	34,783	100.00%
1990	49,550	293	49,842	99.41%
1991	23,227	929	24,156	96.15%
1992	9,052	1,164	10,216	88.61%
1993	26,843	680	27,523	97.53%
1994	23,393	1,568	24,961	93.72%
1995	18,675	1,215	19,890	93.89%
1996	13,472	742	14,214	94.78%
1997	11,460	910	12,370	92.64%
1998	10,432	974	11,407	91.46%
1999	11,751	1,022	12,772	92.00%
2000	11,427	1,702	13,129	87.04%
2001	29,168	2,226	31,395	92.91%
2002	22,384	2,666	25,050	89.36%
2003	13,660	2,069	15,729	86.84%
2004	15,449	2,358	17,808	86.76%
2005	13,075	1,129	14,204	92.05%
2006	8,971	503	9,474	94.69%
2007	13,405	899	14,304	93.72%
2008	30,448	760	31,208	97.56%
2009	35,219	972	36,192	97.31%

Table 3.8. Estimated coefficients of variation to be applied to commercial landings.

Year	Florida	Georgia	South Carolina	North Carolina
1950	50%	50%	50%	50%
1951	50%	50%	50%	50%
1952	50%	50%	50%	50%
1953	50%	50%	50%	50%
1954	50%	50%	50%	50%
1955	50%	50%	50%	50%
1956	50%	50%	50%	50%
1957	50%	50%	50%	50%
1958	50%	50%	50%	50%
1959	50%	50%	50%	50%
1960	50%	50%	50%	50%
1961	50%	50%	50%	50%
1962	40%	40%	40%	40%
1963	40%	40%	40%	40%
1964	40%	40%	40%	40%
1965	40%	40%	40%	40%
1966	40%	40%	40%	40%
1967	40%	40%	40%	40%
1968	40%	40%	40%	40%
1969	40%	40%	40%	40%
1970	40%	40%	40%	40%
1971	40%	40%	40%	40%
1972	40%	40%	40%	40%
1973	40%	40%	40%	40%
1974	40%	40%	40%	40%
1975	40%	40%	40%	40%
1976	40%	40%	40%	40%
1977	40%	40%	40%	40%
1978	40%	40%	40%	40%
1979	40%	40%	40%	40%
1980	40%	40%	40%	40%
1981	40%	20%	20%	20%

Table 3.8 continued

1982	40%	20%	20%	20%
1983	40%	20%	20%	20%
1984	40%	20%	20%	20%
1985	40%	20%	20%	20%
1986	20%	20%	20%	20%
1987	20%	20%	20%	20%
1988	20%	20%	20%	20%
1989	20%	20%	20%	20%
1990	20%	20%	20%	20%
1991	20%	20%	20%	20%
1992	20%	20%	20%	20%
1993	20%	20%	20%	20%
1994	20%	20%	20%	10%
1995	20%	20%	20%	10%
1996	20%	20%	20%	10%
1997	10%	20%	20%	10%
1998	10%	20%	20%	10%
1999	10%	20%	20%	10%
2000	10%	20%	20%	10%
2001	10%	20%	20%	10%
2002	10%	10%	20%	10%
2003	10%	10%	20%	10%
2004	10%	10%	10%	10%
2005	10%	10%	10%	10%
2006	10%	10%	10%	10%
2007	10%	10%	10%	10%
2008	10%	10%	10%	10%
2009	10%	10%	10%	10%

Table 3.9. Calculated yearly South Atlantic vertical line vessel red snapper discards from SEDAR 15, continuity case, bootstrapped values of discards, and delta-lognormal method. Discards are reported in number of fish.

Year	Calculated Discards 2007	Calculated Discards 2010 (2007 method)	Calculated Discards 2010 (bootstrap median)	Calculated Discards 2010 (bootstrap 5th percentile)	Calculated Discards 2010 (bootstrap 95th percentile)	Calculated Discards 2010 (delta-lognormal method)**
1992*	18,292	15,370	15,354	13,237	17,674	14,233
1993	17,860	19,198	19,185	16,745	21,857	14,926
1994	24,459	25,068	25,056	21,972	28,428	20,638
1995	24,153	28,683	28,657	24,820	32,865	19,437
1996	32,254	39,624	39,586	34,192	45,506	24,867
1997	33,725	38,405	38,373	33,303	43,935	27,458
1998	25,524	27,691	27,672	24,135	31,546	21,106
1999	22,959	24,129	24,112	21,030	27,492	19,387
2000	21,810	22,859	22,844	19,970	25,991	18,975
2001	23,680	24,828	24,817	21,741	28,177	19,014
2002	22,133	24,275	24,260	21,155	27,657	42,356
2003	18,937	20,297	20,284	17,704	23,109	13,973
2004	15,813	17,017	17,005	14,836	19,381	5,170
2005	15,272	16,593	16,583	14,478	18,884	4,999
2006	16,914	18,800	18,789	16,410	21,389	7,425
2007		23,610	23,588	20,394	27,090	14,759
2008		22,360	22,342	19,388	25,578	15,512
2009		22,180	22,165	19,288	25,315	20,402

* In 1992 only 20% of vessels in Florida were required to report to the logbook program; calculated discards for areas off Florida (region 1) were expanded by a factor of five.

** As recommended by the Commercial Workgroup and accepted by the Plenary

Table 3.10. Sample size for fish lengths from observer data with associated depth distributed by latitude and longitude, 2007-2009.

Sample Size	Longitude				
Latitude	77	78	79	80	Latitude Total
30			6	253	259
31			53	38	91
32		1	29		30
33	3				3
Longitude Total	3	1	88	291	383

Table 3.11. Percent logbook catch and observer discards by 25 ft depth intervals and corresponding discard mortality calculated from Burns et al (= 1/(1 + exp(-2.3915 + 0.0592*depth in meters))). Weighted average discard mortality is shown at bottom, weighted either by logbook catch (depth information for 2004-2009) or observer discards (2007-2009). [1 meter = 39.37 inches]

Depth Intervals Mid-pt (ft)	Logbook Catch	Observer Discards	Burns et al. Discard-M
12.5	0.6%		10.3%
37.5	0.1%		15.3%
62.5	1.9%	0.8%	22.0%
87.5	3.3%	4.4%	30.7%
112.5	30.1%	47.5%	41.1%
137.5	22.6%	25.3%	52.2%
162.5	20.8%	19.1%	63.2%
187.5	10.0%	1.8%	72.9%
212.5	8.0%	1.0%	80.9%
237.5	0.8%		86.9%
262.5	1.4%		91.3%
287.5	0.4%		94.2%
312.5	0.1%		96.3%
337.5	0.0%		97.6%
362.5	0.0%		98.4%
387.5	0.0%		99.0%
412.5	0.0%		99.4%
462.5	0.0%		99.7%
487.5	0.0%		99.8%
512.5	0.0%		99.9%
612.5	0.0%		100.0%
812.5	0.0%		100.0%
912.5	0.0%		100.0%
	55.0%	48.5%	

Table 3.12. Sample size of aged red snapper by gear, state and year from commercial landings in the U.S. South Atlantic, 1980-2009 provided by the Life History Workgroup [see text for minimum sample size discussion].

Count of Source	Pooled Gears State							
	Diver			Handline				Grand Total
Year	FL	GA	SC	FL	GA	NC	SC	
1980					2		12	14
1981							1	1
1988							41	41
1989							8	8
1990							28	28
1991							28	28
1992				15			33	48
1993				7			30	37
1994				1			48	49
1995				16			12	28
1996				131	8		32	171
1997				63	5		123	191
1998				54			21	75
1999				13			151	164
2000	123		1	97	28		169	418
2001	4	26		151				181
2002				35			3	38
2003				49		2		51
2004				64		39		103
2005				46		61	34	141
2006				53		44	114	211
2007	1		3	86		91	115	296
2008				58		175	203	436
2009	46		12	2187		161	276	2682
Grand Total	174	26	16	3126	43	573	1482	5440

Table 3.13. Red snapper longline landings (pounds) from the NMFS ALS data base, 1962-2009. No red snapper longline landings were reported in 1962, 1964-1968, 1970-1977, and 1979.

Sum of WHOLE_POUNDS	Column Labels				
Row Labels	FL	GA	SC	NC	Grand Total
1963	1,500				1,500
1969		1,900			1,900
1978				124	124
1980	654			508	1,162
1981		76			76
1982			573		573
1983		739	1,198	85	2,021
1984	1,612	890	224	72	2,798
1985			157		157
1986	275		207	77	559
1987	61	3	12	1,685	1,761
1988	110		6	1,403	1,518
1989	33		63	209	305
1990	1,862		2,665	135	4,662
1991	1,514		51	420	1,985
1992	259	22		160	442
1993	251	25		235	511
1994	610	17		49	676
1995	104				104
1996	1,460			11	1,471
1997	4,982		15		4,996
1998	2,831				2,831
1999	1,109				1,109
2000	1,280				1,280
2001	1,555				1,555
2002	429	86	1,170		1,685
2003	1,997		120		2,116
2004	699				699
2005	208				208
2006	521				521
2007	230				230
2008			58		58
2009	148				148
Grand Total	**26,294**	**3,758**	**6,518**	**5,171**	**41,741**

Table 3.14. TIP red snapper samples available from the longline gear by state.

Sum of sum	Column Labels				
	LONG LINES			LONG LINES Total	Grand Total
Row Labels	FL	NC	SC		
1986		1		1	1
1987		81		81	81
1988		12	1	13	13
1989		8		8	8
1990	17	5	1	23	23
1991		2		2	2
1992	3			3	3
1993	4			4	4
1994	2			2	2
1995	8			8	8
1996	8			8	8
1997	10			10	10
1998	2			2	2
Grand Total	**54**	**109**	**2**	**165**	**165**

3.10 Figures

Figure 3.1. Map of U.S. Atlantic and Gulf coast with shrimp area designations.

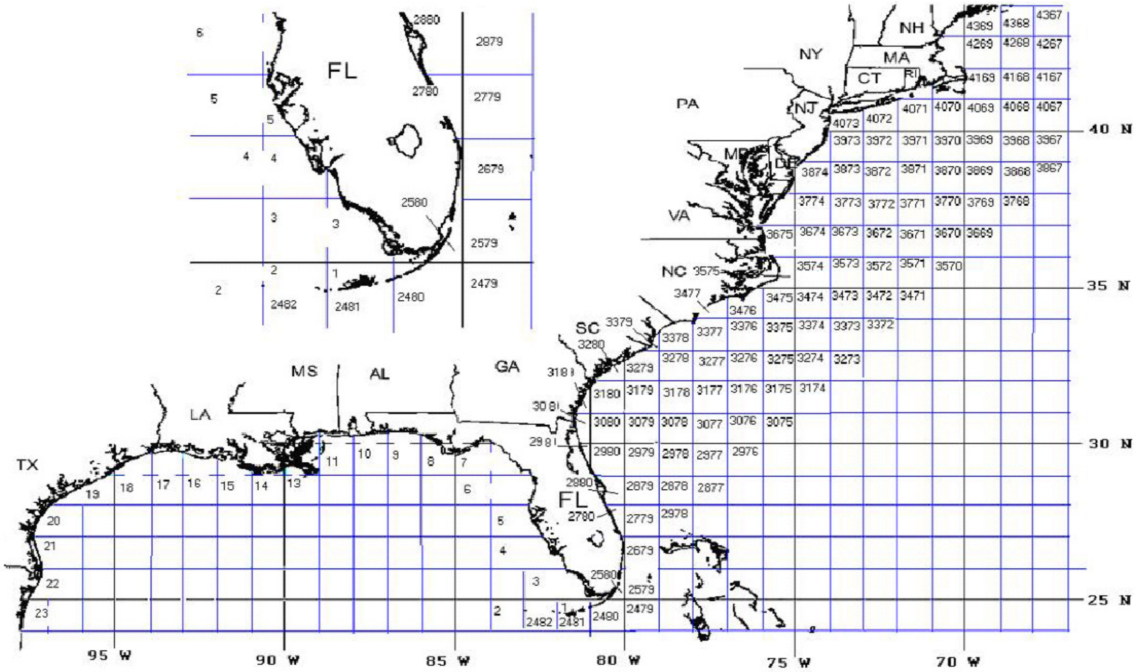


Figure 3.2. Map showing marine fisheries trip ticket fishing area code map for Florida.

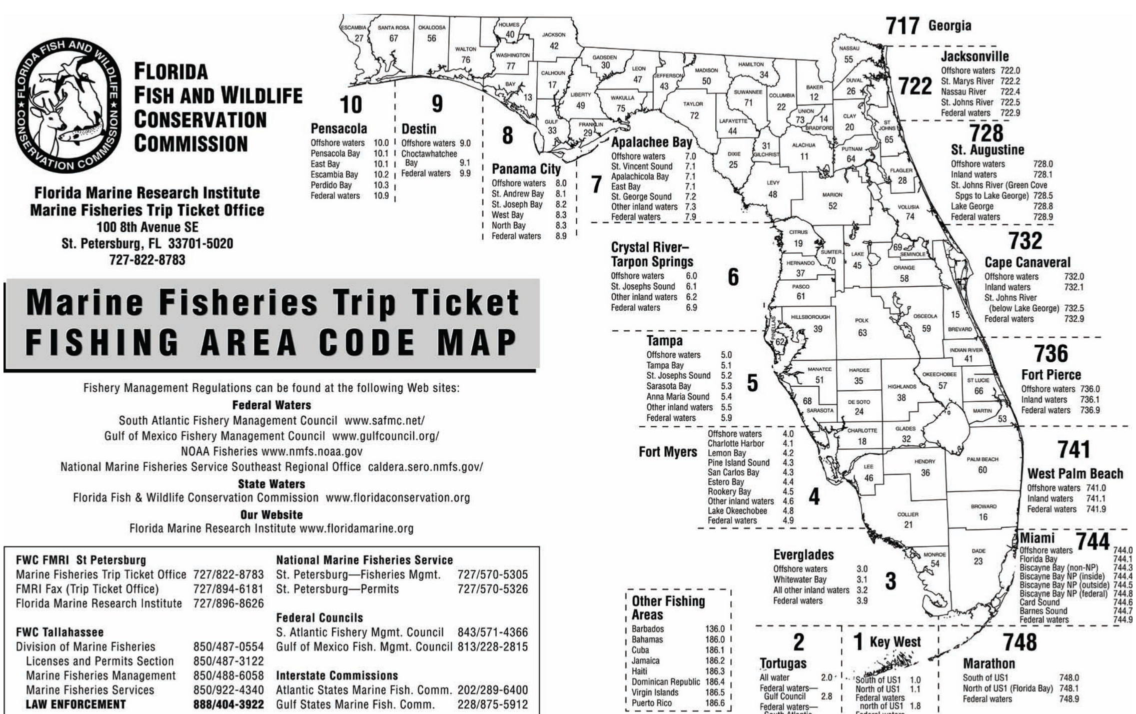


Figure 3.3. Historical red snapper landings by gear from the U.S. South Atlantic, 1902-1989. (Source: Fisheries Statistics Division. 1990. *Historical Catch Statistics, Atlantic and Gulf Coast States, 1879-1989*, US DOC/NOAA/NMFS, Current Fishery Statistics No. 9010, Historical Series Nos. 5-9).

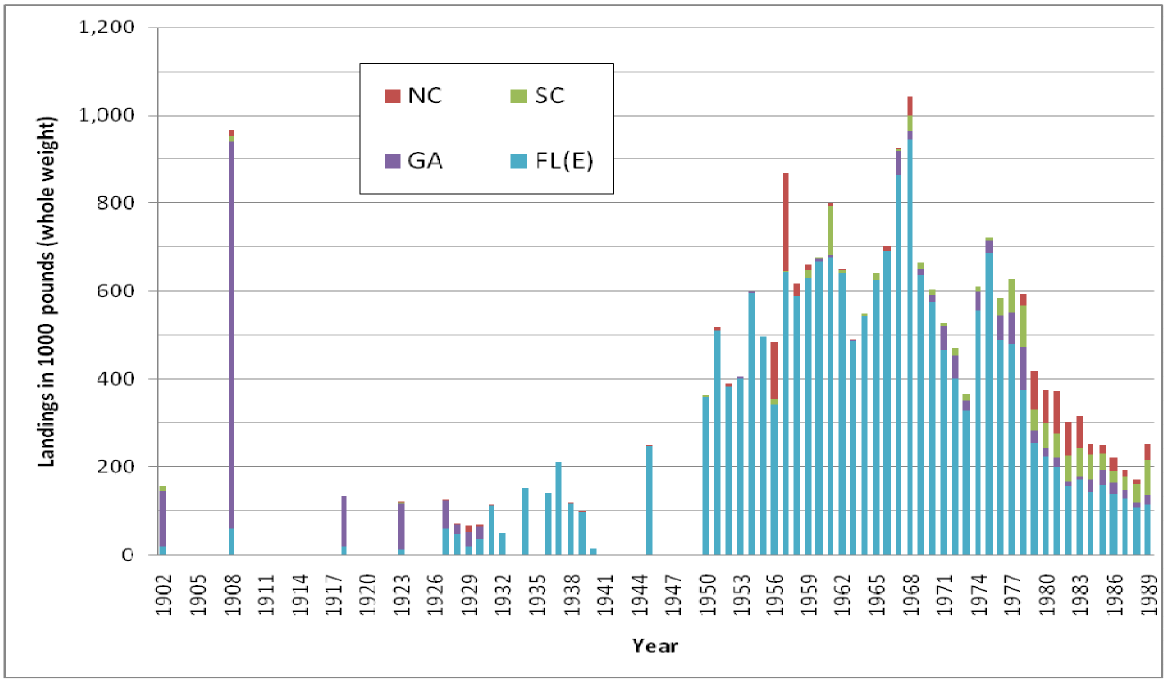


Figure 3.4. Atlantic Coastal Cooperative Statistics Program (ACCSP) Data Warehouse - data sources and collection methods by state.

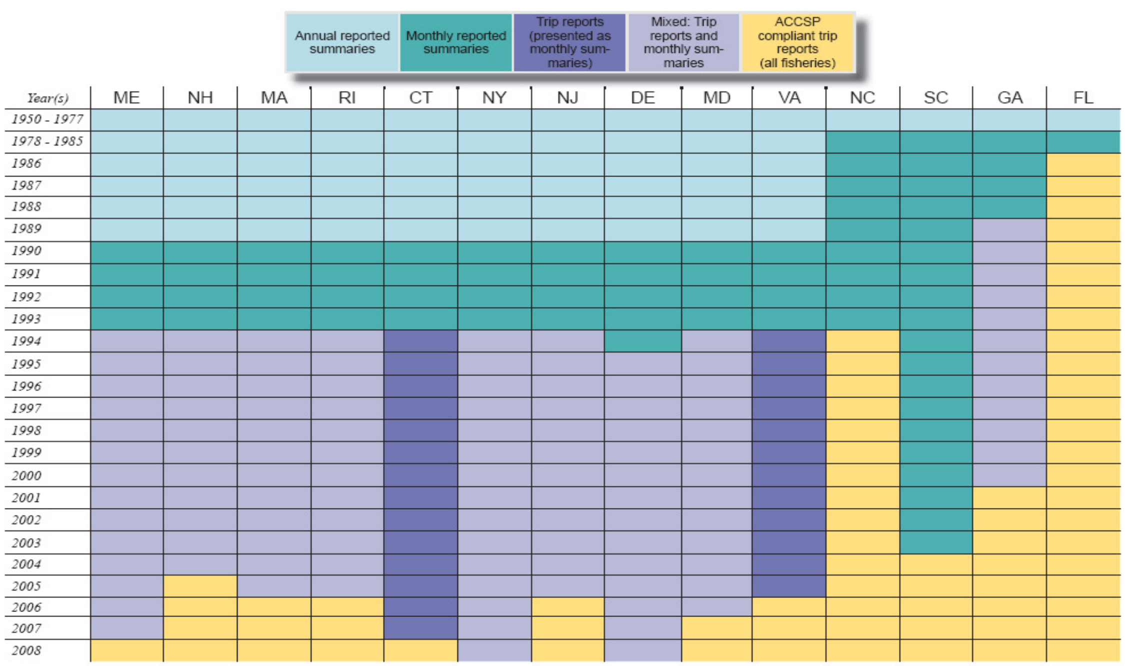


Figure 3.5. Red snapper landings in pounds (whole weight) by state from the U.S. South Atlantic, 1950-2010.

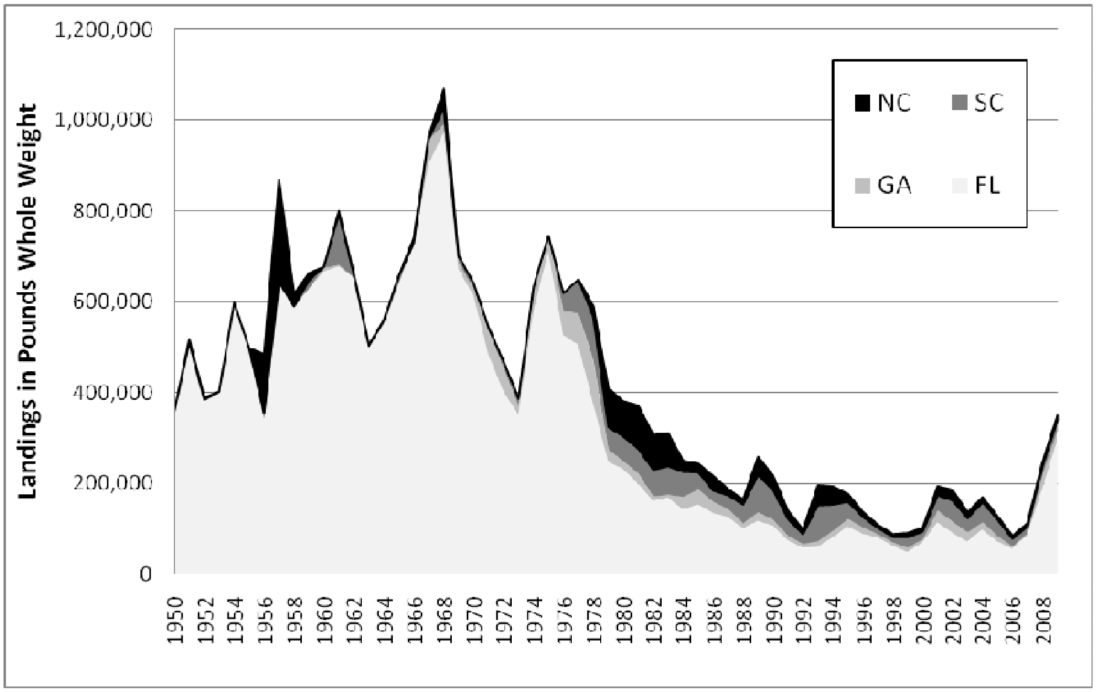


Figure 3.6. Red snapper landings in pounds (whole weight) by gear (reduced to handline and diving) from the U.S. South Atlantic, 1950-2010.

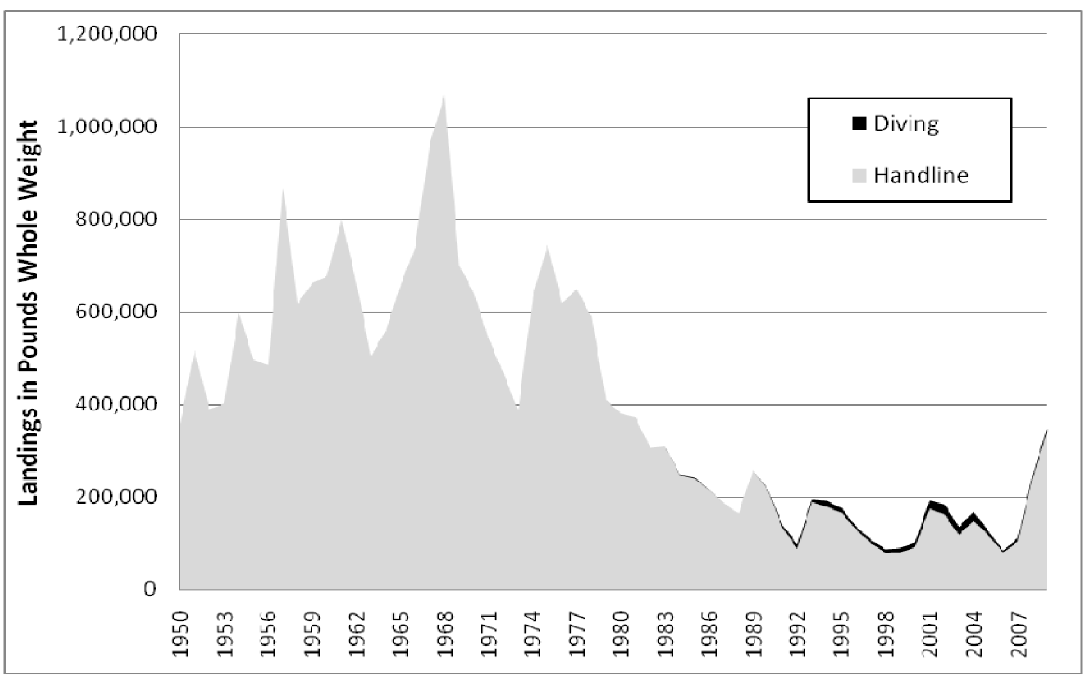


Figure 3.7. Red snapper (a) trips and (b) catchesby latitude and longitude from the snapper grouper logbook data base for 1993-2009.

(a) Trips

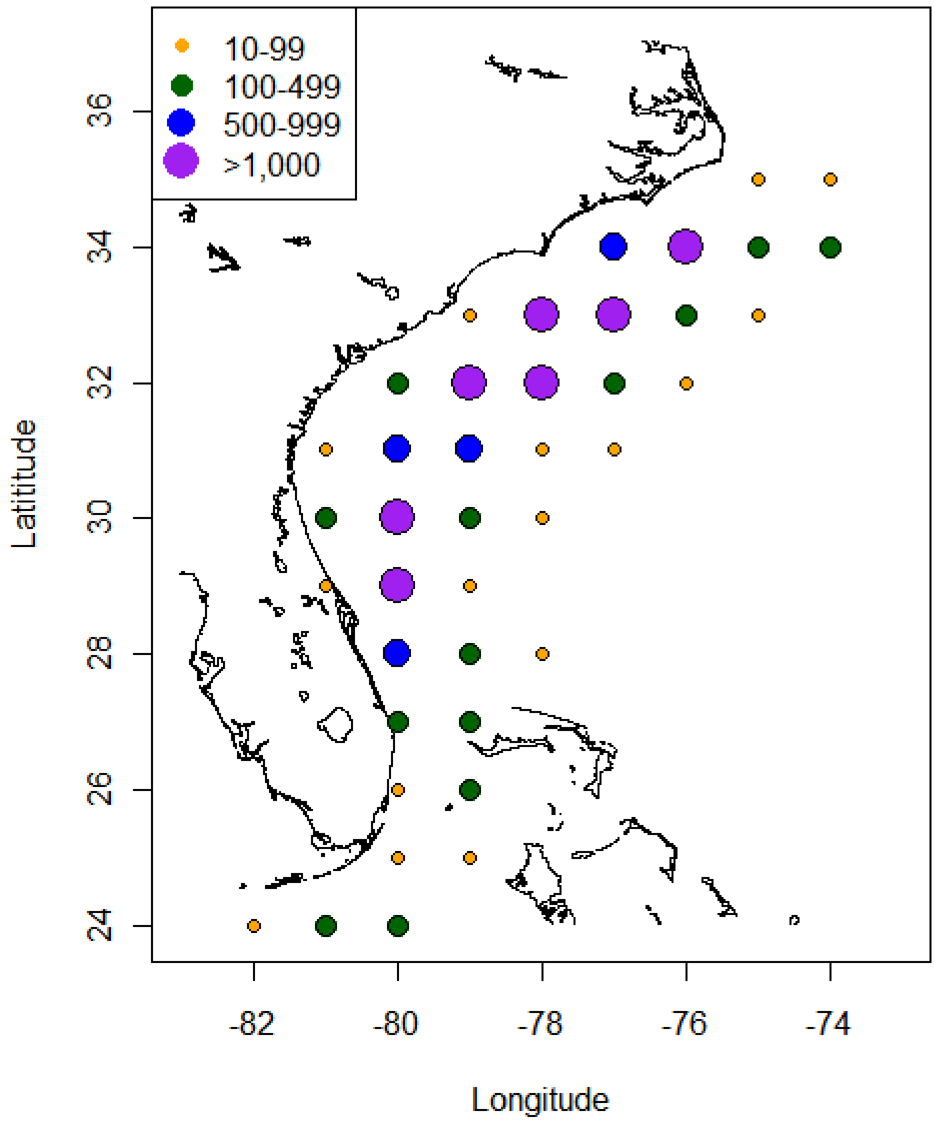


Figure 3.7. (cont.)

(b) Catches (pounds)

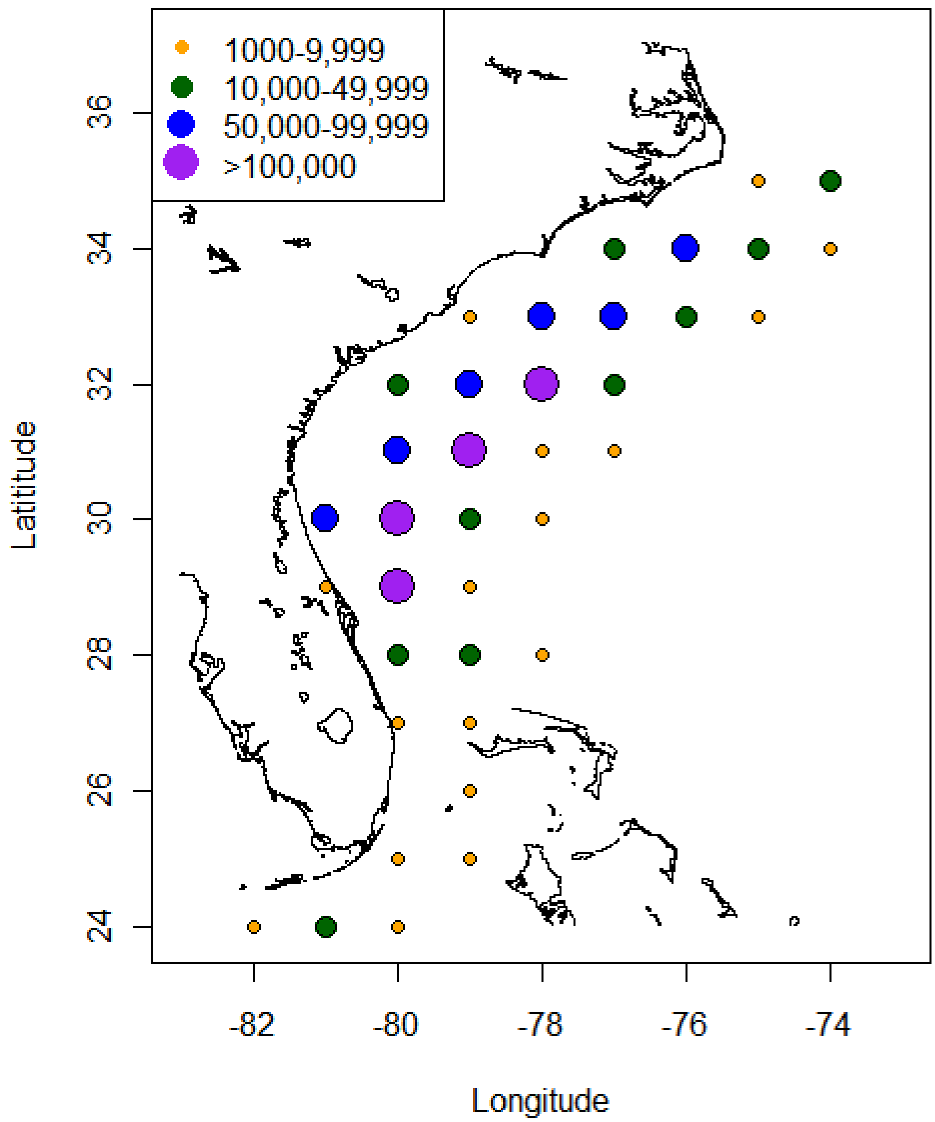


Figure 3.8. Map of U.S. South Atlantic coast showing 30 m – 60 m (yellow) representing contour where most of the commercial handline landing come from according to logbook data, and 60 m – 80 m (red). [Provided by Dr. Don Field, NOS, Beaufort, NC]

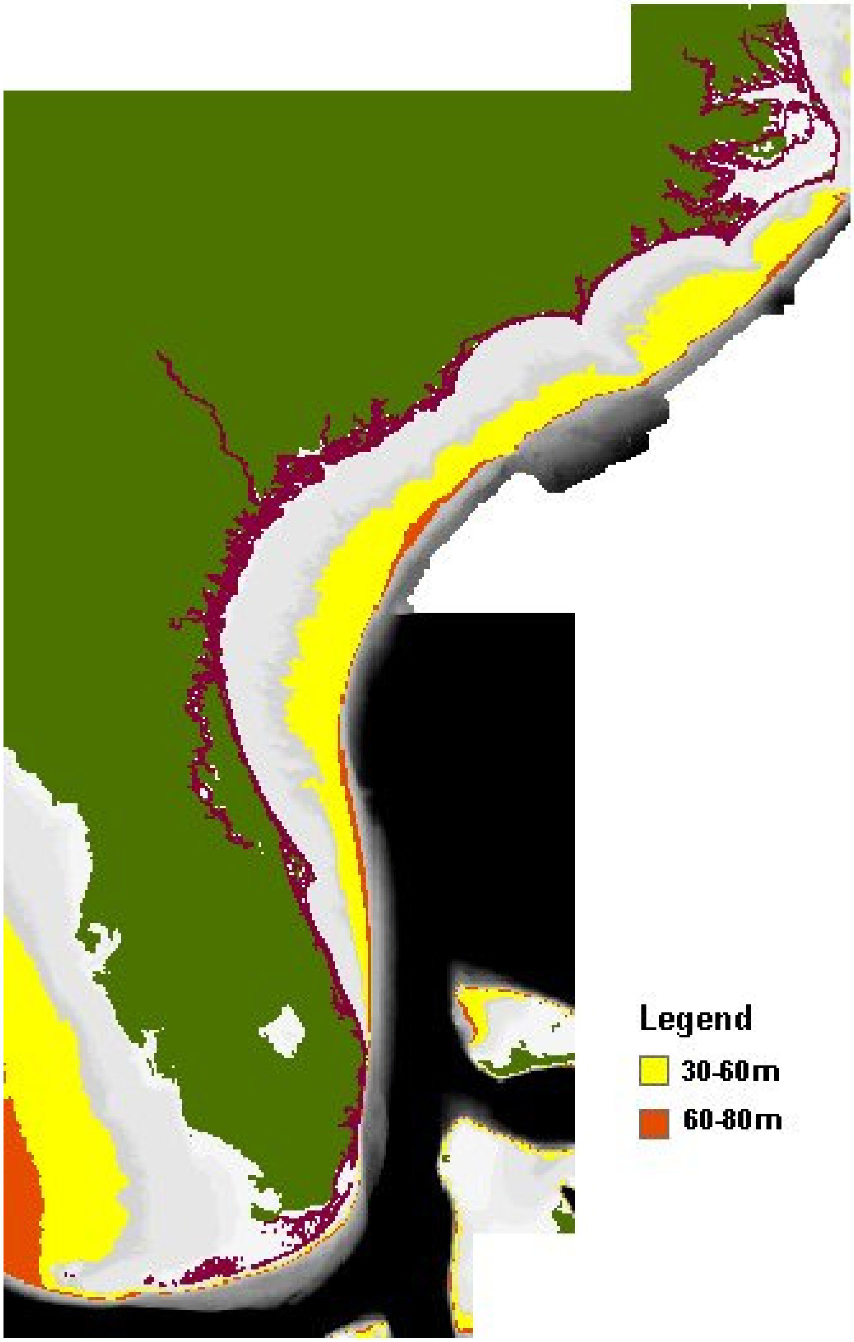


Figure 3.9. Red snapper landings in numbers by gear (handline and diving) from the U.S. South Atlantic, 1950-2010.

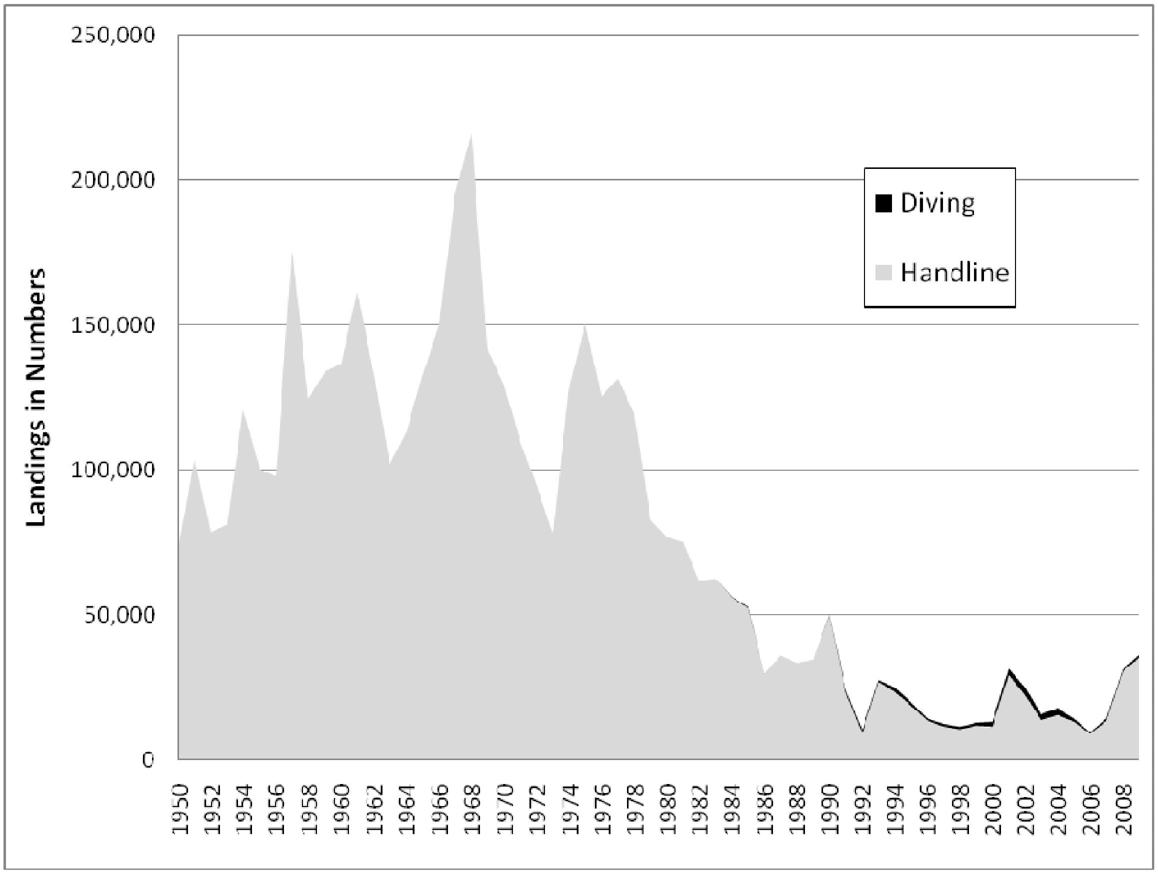


Figure 3.10. Length composition of discarded red snapper from handline gear based on observer data collected 2007-2009 (n = 145) (reference GSAFF 2008 for sampling details). [Converted from FL to TL based on TL-FL relationship in Section 2]

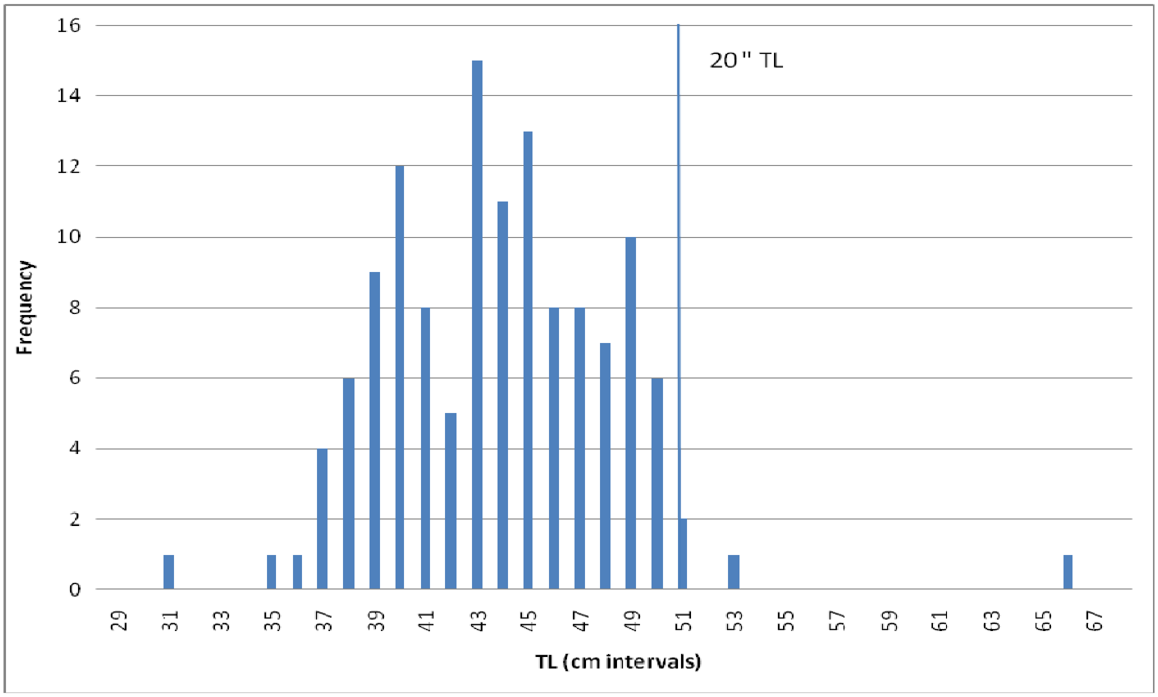


Figure 3.11. Comparison of logbook landings and observer discard depth profiles, combined with discard mortality estimates from Burns et al. Depth profile percentages are on left scale and mortality is on right scale. SA stands for South Atlantic logbook landings and Observer to discard fish.

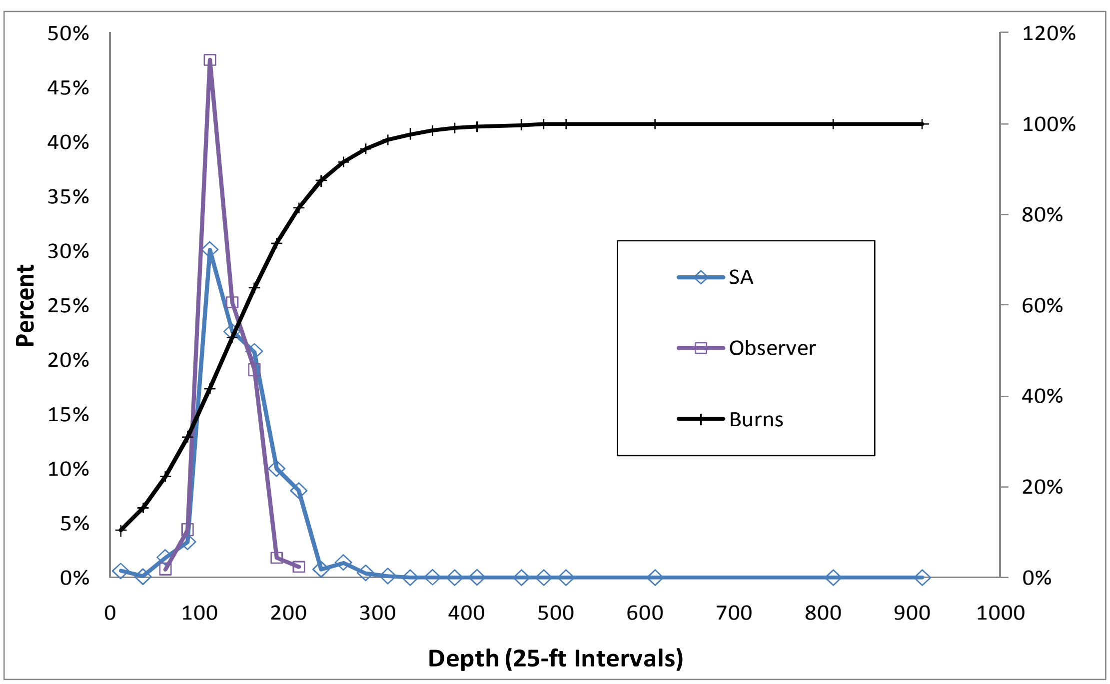


Figure 3.12. Annual length composition of red snapper for commercial handline from TIP, 1985-1986, 1989-2004, 2007, and 2009. Weighting based on landings and trip catch in numbers. Sample size and year are shown on each subplot.

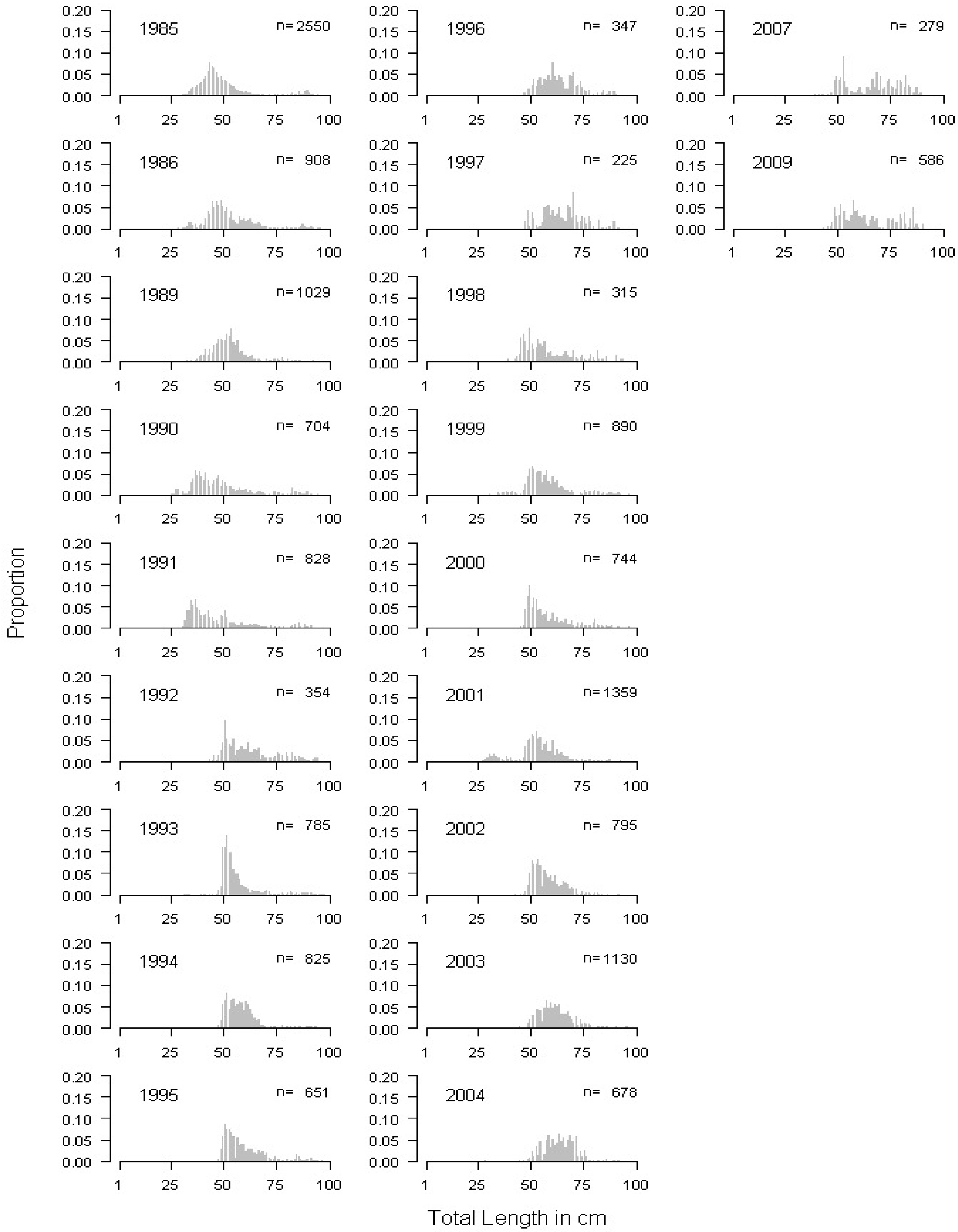


Figure 3.13. Annual length composition of red snapper for commercial diving from TIP, 1999-2001. 2003, and 2009. Weighting based on landings in numbers and trip catch in numbers. Sample size and year are shown on each subplot.

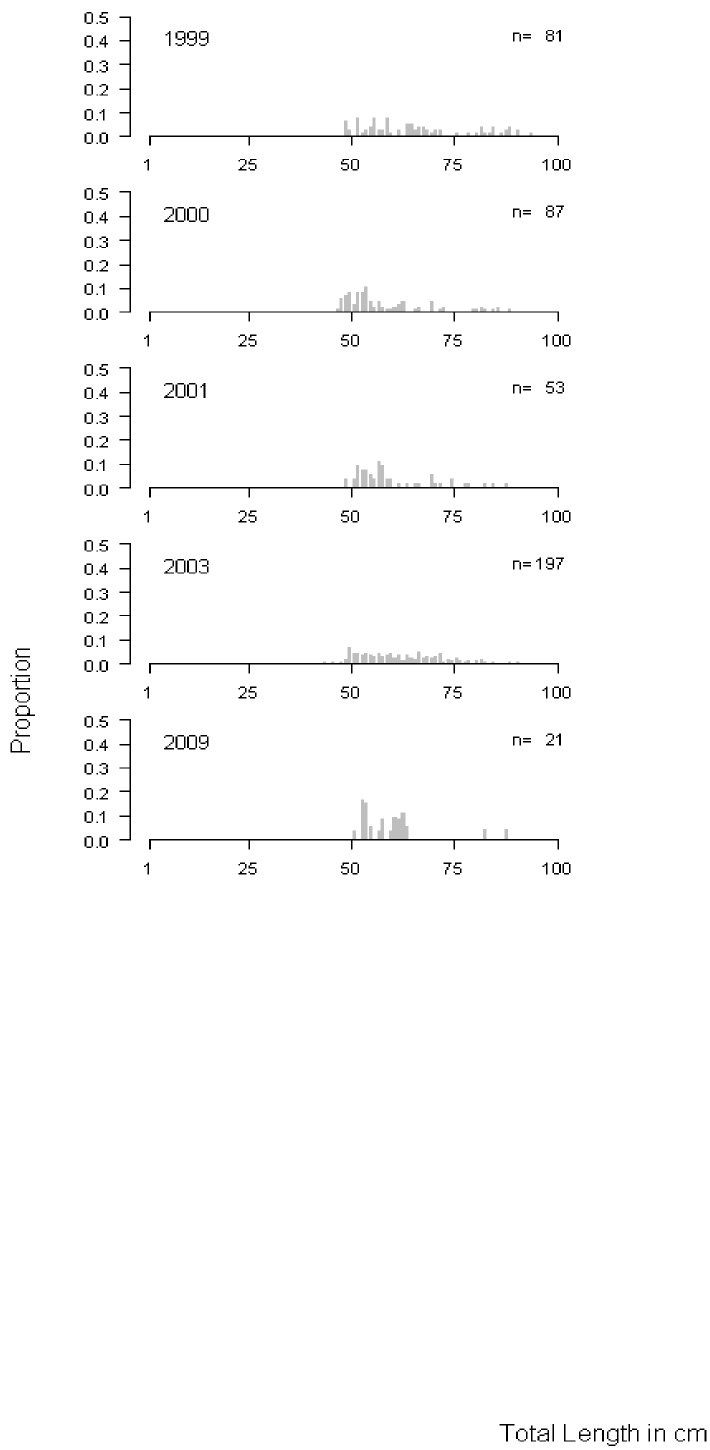


Figure 3.14. Age composition of red snapper for commercial handline from TIP, 1992, 1995-2009. Weighting based on corresponding length composition availability. Sample size and year are shown on each subplot.

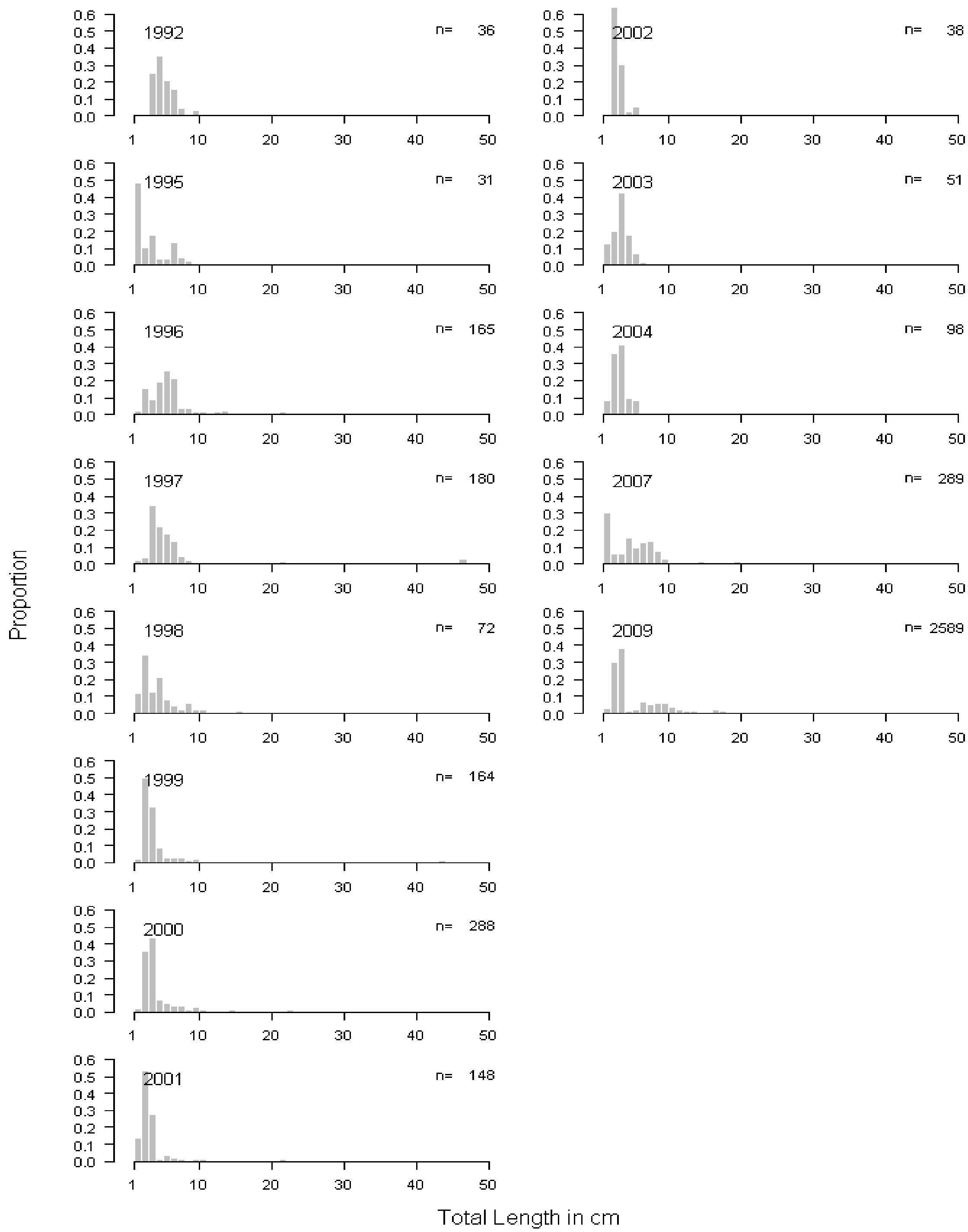


Figure 3.15. Age composition of red snapper for commercial diving from TIP, 2000-2001, and 2009. Weighting based on corresponding length composition availability. Sample size and year are shown on plots.

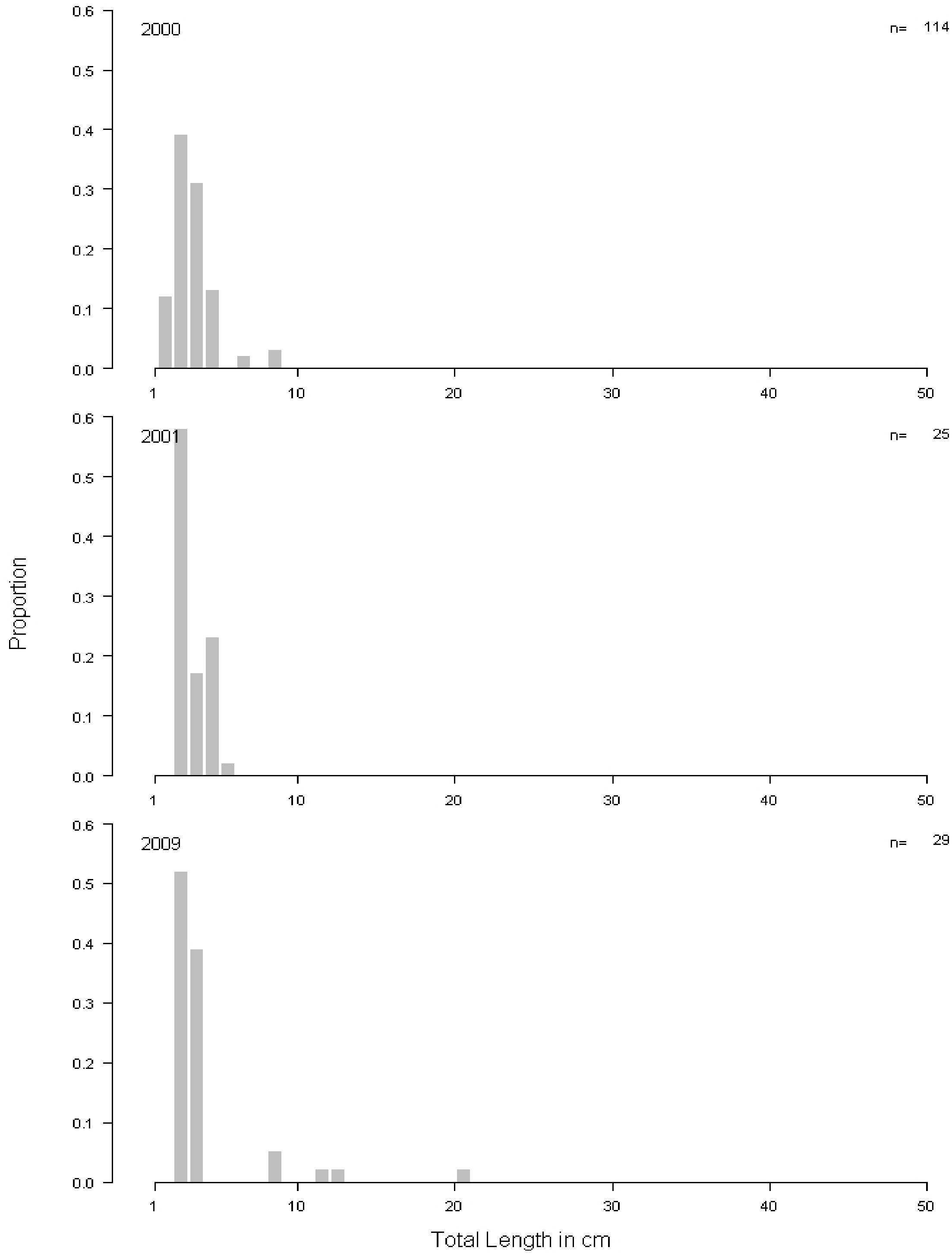
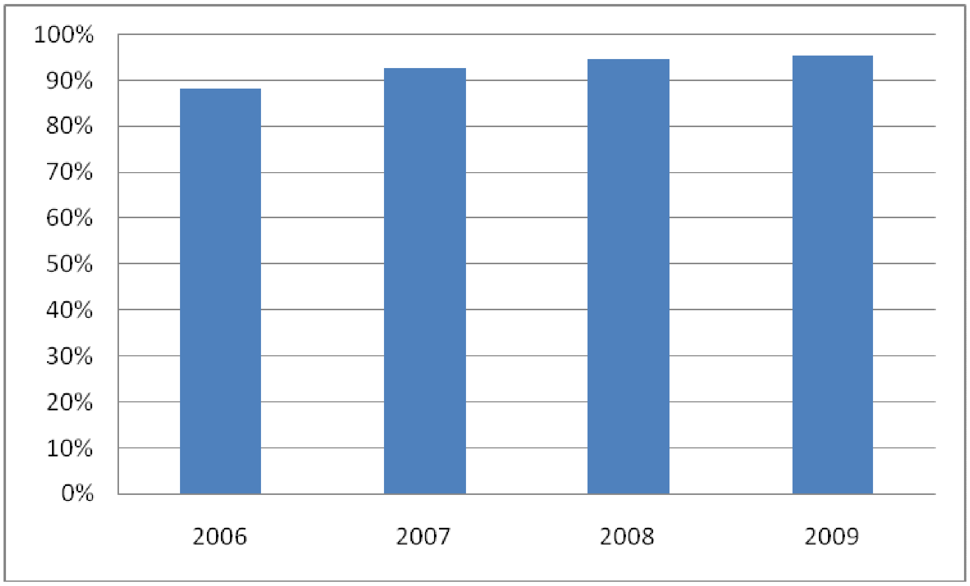


Figure 3.16. Proportion of landings (a) and length samples (b) that are unsorted relative to market category.

(a) Landings (ALS data base)



(b) Length samples (TIP data base)

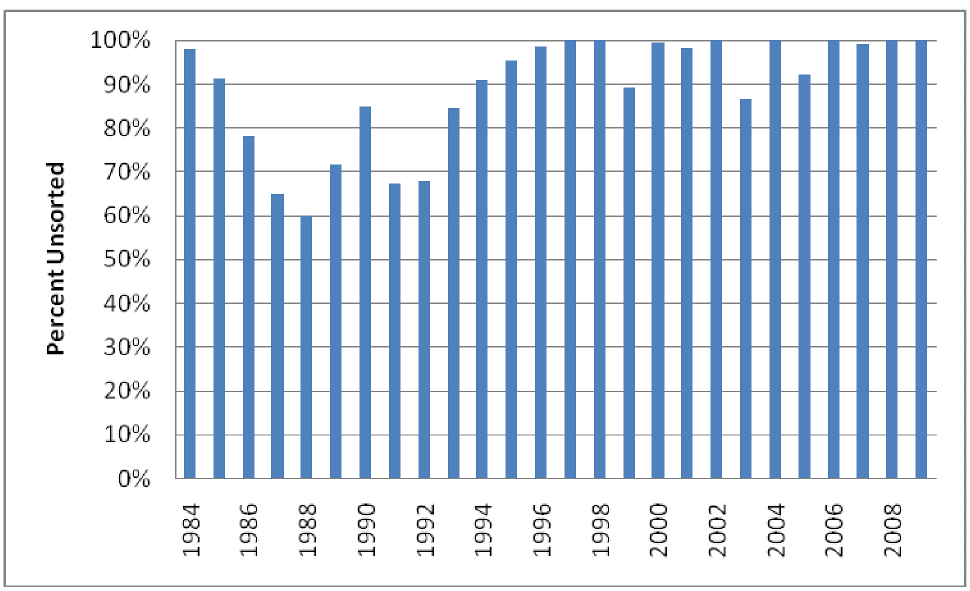
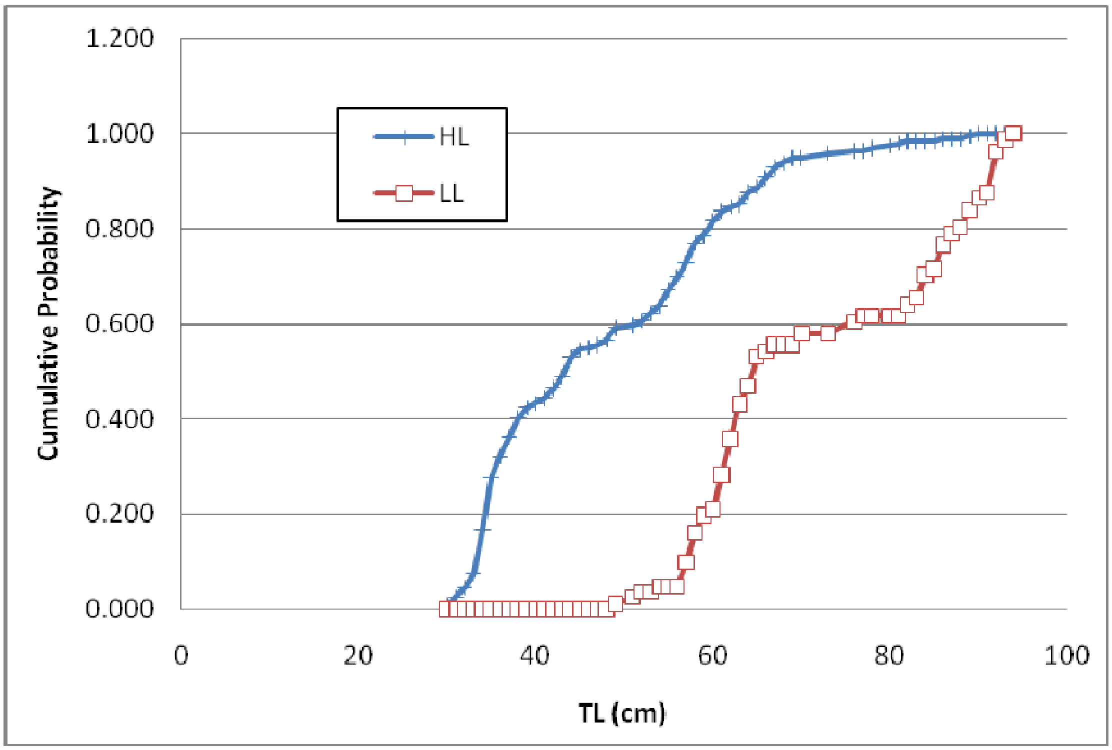


Figure 3.17. Direct comparison of cumulative probability (Pr(X<TL) for handline and longline lengths (TL, cm) from TIP based on limited samples from North Carolina in 1987. There were 81 fish lengths from longline and 277 fish lengths from handline. These data are treated as a random sample from this state-year cell, and no post-stratification weighting is applied.



Addendum 3.1

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Refer to Commercial Landings (Section 3.1)

NMFS SEFIN Accumulated Landings (ALS)

Information on the quantity and value of seafood products caught by fishermen in the U.S. has been collected as early as the late1890s. Fairly serious collection activity began in the 1920s.

The data set maintained by the Southeast Fisheries Science Center (SEFSC) in the SEFIN data base management system is a continuous data set that begins in 1962.

In addition to the quantity and value, information on the gear used to catch the fish, the area where the fishing occurred and the distance from shore are also recorded. Because the quantity and value data are collected from seafood dealers, the information on gear and fishing location are estimated and added to the data by data collection specialists. In some states, this ancillary data are not available.

Commercial landings statistics have been collected and processed by various organizations during the 1962-to-present period that the SEFIN data set covers. During the 16 years from 1962 through

1978, these data were collected by port agents employed by the Federal government and stationed at major fishing ports in the southeast. The program was run from the Headquarters Office of the Bureau of Commercial Fisheries in Washington DC. Data collection procedures were established by Headquarters and the data were submitted to Washington for processing and computer storage. In 1978, the responsibility for collection and processing were transferred to the SEFSC.

In the early 1980s, the NMFS and the state fishery agencies within the Southeast began to develop a cooperative program for the collection and processing of commercial fisheries statistics. With the exception of two counties, one in Mississippi and one in Alabama, all of the general canvass statistics are collected by the fishery agency in the respective state and provided to the SEFSC under a comprehensive Cooperative Statistics Program (CSP).

The purpose of this documentation is to describe the current collection and processing procedures that are employed for the commercial fisheries statistics maintained in the SEFIN data base.

1960 - Late 1980s
==

Although the data processing and data base management responsibility were transferred from the Headquarters in Washington DC to the SEFSC during this period, the data collection procedures remained essentially the same. Trained data collection personnel, referred to as fishery reporting specialists or port agents, were stationed at major fishing ports throughout the Southeast Region. The data collection procedures for commercial landings included two parts.

The primary task for the port agents was to visit all seafood dealers or fish houses within their assigned areas at least once a month to record the pounds and value for each species or product type that were purchased or handled by the dealer or fish house. The agents summed the landings and value data and submitted these data in monthly reports to their area supervisors. All of the monthly data were submitted in essentially the same form.

The second task was to estimate the quantity of fish that were caught by specific types of gear and the location of the fishing activity. Port agents provided this gear/area information for all of the landings data that they collected. The objective was to have gear and area information assigned to all monthly commercial landings data.

There are two problems with the commercial fishery statistics that were collected from seafood dealers. First, dealers do not always record the specific species that are caught and second, fish or shellfish are not always purchased at the same location where they are unloaded, i.e., landed.

Dealers have always recorded fishery products in ways that meet their needs, which sometimes make it ambiguous for scientific uses. Although the port agents can readily identify individual species, they usually were not at the fish house when fish were being unloaded and thus, could not observe and identify the fish.

The second problem is to identify where the fish were landed from the information recorded by the dealers on their sales receipts. The NMFS standard for fisheries statistics is to associate commercial statistics with the location where the product was first unloaded, i.e., landed, at a shore-based facility. Because some products are unloaded at a dock or fish house and purchased and transported to another dealer, the actual 'landing' location may not be apparent from the dealers' sales receipts. Historically, communications between individual port agents and the area supervisors were the primary source of information that was available to identify the actual unloading location.

Cooperative Statistics Program

In the early 1980s, it became apparent that the collection of commercial fisheries statistics was an activity that was conducted by both the Federal government and individual state fishery agencies. Plans and negotiations were initiated to develop a program that would provide the fisheries statistics that are needed for management by both Federal and state agencies. By the mid- 1980s, formal cooperative agreements had been signed between the NMFS/SEFSC and each of the eight coastal states in the southeast, Puerto Rico and the US Virgin Islands.

Initially, the data collection procedures that were used by the states under the cooperative agreements were essentially the same as the historical NMFS procedures. As the states developed their data collection programs, many of them promulgated legislation that authorized their fishery agencies to collect fishery statistics. Many of the state statutes include mandatory data submission by seafood dealers.

Because the data collection procedures (regulations) are different for each state, the type and detail of data varies throughout the Region. The commercial landings data base maintained in SEFIN contains a standard set of data that is consistent for all states in the Region.

A description of the data collection procedures and associated data submission requirements for each state follows.

Florida

Prior to 1986, commercial landings statistics were collected by a combination of monthly mail submissions and port agent visits. These procedures provided quantity and value, but did not provide information on gear, area or distance from shore. Because of the large number of dealers, port agents were not able to provide the gear, area and distance information for monthly data. This information, however, is provided for annual summaries of the quantity and value and known as the Florida Annual Canvas data (see below).

Beginning in 1986, mandatory reporting by all seafood dealers was implemented by the State of Florida. The State requires that a report (ticket) be completed and submitted to the State for every trip. Dealers have to report the type of gear as well as the quantity (pounds) purchased for each species. Information on the area of catch can also be provided on the tickets for individual trips. As of 1986 the ALS system relies solely on the Florida trip ticket data to create the ALS landings data for all species other than shrimp.

Georgia

Prior to 1977, the National Marine Fisheries Service collected commercial landings data Georgia. From 1977 to 2001 state port agents visited dealers and docks to collect the information on a regular basis. Compliance was mandatory for the fishing industry. To collect more timely and accurate data, Georgia initiated a trip ticket program in 1999, but the program was not fully implemented to allow complete coverage until 2001. All sales of seafood products landed in Georgia must be recorded on a trip ticket at the time of the sale. Both the seafood dealer and the seafood harvester are responsible for insuring the ticket is completed in full

South Carolina

Prior to 1972, commercial landings data were collected by various federal fisheries agents based in South Carolina, either U.S. Fish or Wildlife or National Marine Fisheries Service personnel. In 1972, South Carolina began collecting landings data from coastal dealers in cooperation with federal agents. Mandatory monthly landings reports on forms supplied by the Department are required from all licensed wholesale dealers in South Carolina. Until fall of 2003, those reports were summaries collecting species, pounds landed, disposition (gutted or whole) and market category, gear type and area fished; since September 2003, landings have been reported by a mandatory trip ticket system collecting landings by species, disposition and market category, pounds landed, ex-vessel prices with associated effort data to include gear type and amount, time fished, area fished, vessel and fisherman information. South Carolina began collecting TIP length frequencies in 1983 as part of the Cooperative Statistics Program.

Target species and length quotas were supplied by NMFS and sampling targets of 10% of monthly commercial trips by gear were set to collect those species and length frequencies. In 2005, South Carolina began collecting age structures (otoliths) in addition to length frequencies, using ACCSP funding to supplement CSP funding.

North Carolina

The National Marine Fisheries Service prior to 1978 collected commercial landings data for North Carolina. Port agents would conduct monthly surveys of the state's major commercial seafood dealers to determine the commercial landings for the state. Starting in 1978, the North Carolina Division of Marine Fisheries entered into a cooperative program with the National Marine Fisheries Service to maintain the monthly surveys of North Carolina's major commercial seafood dealers and to obtain data from more dealers.

The North Carolina Division of Marine Fisheries Trip Ticket Program (NCTTP) began on 1 January 1994. The NCTTP was initiated due to a decrease in cooperation in reporting under the voluntary NMFS/North Carolina Cooperative Statistics Program in place prior to 1994, as well as an increase in demand for complete and accurate trip-level commercial harvest statistics by fisheries managers. The detailed data obtained through the NCTTP allows for the calculation of effort (i.e. trips, licenses, participants, vessels) in a given fishery that was not available prior to 1994 and provides a much more detailed record of North Carolina's seafood harvest.

NMFS SEFIN Annual Canvas Data for Florida

The Florida Annual Data files from 1976 – 1996 represent annual landings by county (from dealer reports) which are broken out on a percentage estimate by species, gear, area of capture, and distance from shore. These estimates are submitted by Port agents, which were assigned responsibility for the particular county, from interviews and discussions from dealers and fishermen collected throughout the year. The estimates are processed against the annual landings totals by county on a percentage basis to create the estimated proportions of catch by the gear, area and distance from shore. (The sum of percentages for a given Year, State, County, Species combination will equal 100.)

Area of capture considerations: ALS is considered to be a commercial landings data base which reports where the marine resource was landed. With the advent of some State trip ticket programs as the data source the definition is more loosely applied. As such one cannot assume reports from the ALS by State or county will accurately inform you of Gulf vs South Atlantic vs Foreign catch. To make that determination you must consider the area of capture.

4. Recreational Fishery Statistics

4.1 Overview

4.1 Group membership

Members- Ken Brennan (Leader\NMFS Beaufort), Kathy Knowlton (Rapporteur\GADNR), Steve Amick (SAFMC Appointee/Industry rep GA), Zack Bowman (SAFMC Appointee/Industry rep GA), Julia Byrd (SCDNR), Rob Cheshire (NMFS Beaufort), Richard Cody (FWRI), Greg DeBrango (SAFMC Appointee/Industry rep FL), Frank Hester (Industry Consultant), Rusty Hudson (SAFMC Appointee/Industry rep FL), Beverly Sauls (FWRI), Tom Sminkey (NMFS Silver Spring), Rodney Smith (SAFMC Appointee/Industry rep FL), Erik Williams (NMFS Beaufort), Chris Wilson (NCDNR).

4.1.2 Issues

(1) Red snapper Charter Boat Landings: 1986-2003 & 2004-2009, survey methods changed.

(2) Red snapper Party/Charter Landings: 1981-1985; headboat landings are used from the Southeast Region Headboat survey (SRHS) program so we must parse out the headboat from party/charter during period when MRFSS did not stratify.

(3) Headboat landings data available for SEDAR 24 from 1976 for GA/NEFL and 1978 for SEFL through 1980, that was not available for SEDAR 15.

(4) Estimating red snapper headboat landings from 1972 to 1976 or 1978 (date dependent on region) for periods of partial geographic coverage in the SRHS.

(5) Headboat discards prior to 2007.

(6) Usefulness of historical data sources such as the 1960, 1965, and 1970 U.S. Fish and Wildlife Service (FWS) surveys to generate estimates of recreational red snapper landings prior to 1972. Compare these sources to other historical data sources, including commercial landings and Florida Sport Fishing Association (FSFA) catch program.

(7) Uncertainty estimates for headboat landings and discards

(8) Methods for estimating for-hire effort in the MRFSS survey changed to the new For-Hire Survey (FHS) methodology in 2003. For SEDAR 24, there was sufficient overlap in the two time-series to adjust old MRFSS estimates for the new FHS methodology; whereas, only the old method could be used in SEDAR 15.

(9) MRFSS for-hire estimates for SC were highly variable and much higher in some years than the SC state logbook for charter vessels.

4.2 Review of Working Papers

SEDAR24-DW06, *Distribution of red snapper catches from headboats operating in the South Atlantic. Erik Williams, Rob Cheshire and Ken Brennan.*

The Southeast Region Headboat Survey (SRHS) which collects trip level catch information through monthly logbook reporting was briefly discussed. Logbook reports provide a single location (10 min^2 grid) for all reported catch within each trip. Although logbooks are required for all head boats, compliance has varied over the years. Recent years have seen improvements in reporting in terms of fleet compliance and trip level information provided and although only 3% of reported trips in 2009 (compared to 26% in 2004) were either missing or had incomplete trip information, reporting bias remained a concern. In addition to catch from an entire trip being associated with a single location, the potential for misreporting location, under-reporting of discards, and a lack of discard information prior to 2007 were important considerations in the use of these data to characterize red snapper catch distribution. Trip length and physical location of the vessel provide an alternative to reported location and allows for characterization of red snapper catch distribution by inlet with respect to distance traveled, minimum species depth and maximum depth fished. Distributions are presented in SEDAR24-DW06, which was available for review.

SEDAR24-DW07, Georgia Headboat Red Snapper Catch & Effort Data, 1983-2009 Steve Amick and Kathy Knowlton.

This working paper presents detailed red snapper catch records from a GA headboat. The captain, Steve Amick, recorded his catch records in personal logbooks at the end of every fishing day, including number of released fish (a data element not available for headboats from the NMFS survey until 2004). Captain Amick offered to provide these data through a cooperative effort with personnel at the Georgia Department of Natural Resources for consideration at SEDAR24. Data elements included vessel name, trip type, number red snapper released alive, number red snapper harvested, number of anglers, and number of vessel trips. Throughout the time period (1983 through 2009), Captain Amick typically fished southeast of Savannah, GA at depths of 90-120 feet in the NMFS headboat survey grid 31-80. Combined, these data represent ~4,000 snapper-grouper fishing trips for which ~41,000 anglers caught ~46,000 and harvested ~21,000 red snapper. The RFWG accepted this working paper and data contained within for further detailed review.

SEDAR24-DW11, Estimation of Historic Recreational Landings 2010. Historical Fisheries Working Group.

The Terms of Reference (TOR) for the SEDAR 24 Data Workshop (DW) list as a product to "Review the application of pre-MRFSS recreational catch records in the SEDAR 15 benchmark assessment and recommend appropriate use of pre-MRFSS data for assessment of red snapper" (SEDAR24, DW TOR number 7). The Historic Fisheries Working Group (HFWG) was formed in advance of the SEDAR 24 Data Workshop to begin this task. A description of the analyses conducted by the HFWG is presented in SEDAR24-DW11 and the results of those analyses were reviewed by the Recreational Work Group (RWG).

The HFWG explored the following methods for generating estimates of historic recreational red snapper catches:

1) Ratio Method: Compares ratios of commercial red snapper landings in the South Atlantic to recreational red snapper harvest estimates for years in which both are available to perform back calculations of recreational landings.
2) Saltwater Angling Survey Method: U.S. Fish and Wildlife Saltwater Angling Surveys (SWAS) were conducted in 1960, 1965, and 1970. Neither the HFWG nor the RWG

recommended using these point estimates without accounting for species mis-identifications and probable over-estimations related to recall bias and survey design limitations.

3) Census Method: Use U.S. Census data as a proxy for recreational fishing effort to produce regression based estimates for red snapper catches. The HFWG did not recommend using this method without an abundance index to include in the regression model.
4) Historic Documentation: Developing a timeline for the development and growth of the recreational red snapper fisheries in the South Atlantic for comparison with estimates of historic landings. This timeline included valuable anchor points that were discussed extensively by the RWG and compared to back-calculated landings estimates for trends and magnitude.

Results using the ratio method and adjusted Saltwater Angling Survey estimates indicate that catches for red snapper were high in the 1970s, dropped to lower levels in the 1980s, decreased through the 1990s, and moderately increased during the 2000s. This also agrees with landings constructed by the Commercial Workgroup, which peaked in 1968. The HFWG also reviewed a dataset available online from a Florida sport fishing club that indicated a similar trend in recreational catches based on club records. The two trends also track well with the timeline for early development and growth of red snapper recreational fisheries in the South Atlantic. There was disagreement within the RWG on the magnitude of estimated landings. In particular, several participants felt that private recreational effort was not high enough to generate such a high peak in the estimated recreational landings in the 1970s. One method that was explored by the RWG was to account for exponential growth in the human population by scaling the ratio method using U.S. Census data. The ratio of commercial to private landings declined from 1980 to 1950 relative to the population. Scaled landings for the private sector were then interpolated to 0 in 1950 when it is generally accepted that private recreational fishing effort was very low. The result of this change reduced the slope and magnitude of peak landings for the private sector. RWG participants were in agreement that the for-hire sector was well developed in earlier years, and for-hire landings were not scaled to Census data or interpolated to 0 in 1950

SEDAR24-DW13*,* South Atlantic Red Snapper Marine Recreational Fishery Landings: FHS-conversion of Historic MRFSS Charterboat Catches, T. R. Sminkey, NMFS, ST1, Silver Spring, MD. 2009.

From 2004 to 2007, the NMFS estimated charter boat effort using both the MRFSS (old) and the For-Hire Survey (FHS = new) protocols. Thus, differences in effort estimates for each stratum between both methodologies can be directly compared only for that period of time. Each stratum is defined by a unique combination of sub-region, state, year, 'wave', and fishing-area, where a 'wave' is a bimonthly sampling period (Jan.-Feb. = wave 1). The MRFSS defined fishing areas for most states as: a) Inshore waters, b) ocean, state territorial seas (< 3 miles from shore), and c) ocean, EEZ (> 3 miles from shore). For the period 1986-2003, charter boat effort was estimated using only the MRFSS protocol. To calibrate MRFSS charter boat effort estimates (1986-2003) to FHS levels, conversion factors (ratios) between FHS and MRFSS charter boat effort were estimated using 2003-2007 data and applied to the 1986-2003 MRFSS effort estimates. To estimate the conversion factors, a ratio of FHS/MRFSS effort estimates was calculated for each stratum using only the estimates from the period 2003-2007. A generalized linear model (GLM procedure, SAS Inst.) was used to identify significant factors and to estimate predicted ratios.

The factors included in the model were year, wave, fishing area, state and the interaction terms. In the event that a factor was found non-significant (Pr > 0.05), it was removed and the regression re-run until all (highest order) model terms were significant. The predicted ratios were used as the conversion factors to produce an adjusted time series of charter boat angler effort, and subsequently, catches.

SEDAR24-DW15, Red Snapper Length Frequencies and Condition of Released Fish from At-Sea Headboat Observer Surveys, 2004 to 2009. B. Sauls and C. Wilson 2010.

From 2004 to 2009, headboats in South Carolina and North Carolina participated in an at-sea observer survey. From 2005 to 2009, headboats along the Atlantic coast of Florida and Georgia also participated in an at-sea observer survey. The purpose of the Headboat At-Sea Survey was to collect detailed information on both harvested and discarded fish during recreational fishing trips on board working headboats. This report is a summary of information collected on the size, release condition, and final disposition of red snapper collected by trained observers during at-sea surveys on board headboats. While this information is specific to the recreational headboat fishery, it provides valuable information on the size of discarded fish from the recreational fishery, which historically has not been collected in other surveys of recreational fishing.

4.3 Recreational Landings

4.3.1 Marine Recreational Fisheries Statistics Survey (MRFSS)

Introduction

The Marine Recreational Fisheries Statistics Survey (MRFSS) provides a long time series of estimated catch per unit effort, total effort, landings, and discards for six two-month periods (waves) each year. The survey provides estimates for three recreational fishing modes: shore-based fishing (SH), private and rental boat fishing (PR), and for-hire charter and guide fishing (CH). When the survey first began in Wave 2 (Mar/Apr), 1981, head boats were included in the for-hire mode, but were excluded after 1985 to avoid overlap with the Head boat Logbook Survey conducted by the NMFS Beaufort, NC lab.

The MRFSS survey covers coastal Atlantic states from Maine to Florida. The state of Florida is sampled independently as two sub-regions. The east Florida sub-region includes counties adjacent to the Atlantic coast from Nassau County south through Miami-Dade County, and the west Florida sub-region includes Monroe County (Florida Keys) and counties adjacent to the Gulf of Mexico (Collier-Escambia). Separate estimates are generated for each Florida sub-region, and those estimates may be post-stratified into smaller regions based on proportional sampling. With the exception of North Carolina, since 2006, sampling has not been conducted on the Atlantic coast, north of Florida in Wave 1 (Jan/Feb) because fishing effort is very low or non-existent.

The MRFSS design incorporates three complementary survey methods for estimating catch and effort. Catch data are collected through dockside angler intercept surveys of completed, recreational fishing trips. Effort data are collected using two telephone surveys. The Coastal Household Telephone Survey (CHTS) uses random digit dialing of coastal households to obtain from anglers detailed information about the previous two months of recreational fishing trips. The weekly For-Hire Survey interviews Charter boat operators (captains or owners) to obtain the trip information with a one-week recall period. These effort data and estimates are aggregated to produce the wave estimates. Catch rates from dockside intercept surveys are combined with estimates of effort from telephone interviews to estimate total landings and discards by wave, mode, and area fished (inland, state, and federal waters). Catch estimates from early years of the survey are highly variable with high percent standard errors (PSE's), and sample sizes in the dockside intercept portion have been increased over time to improve precision of catch estimates. Full survey documentation and ongoing efforts to review and improve survey methods are available on the NOAA Fisheries Office of Science and Technology website at: http://www.st.nmfs.gov/st1/recreational.

New For-Hire Survey Methodology

Survey methods for the for-hire fishing mode have seen the most improvement over time. Catch data were improved through increased sample quotas and state add-ons to the intercept portion of the survey. It was also recognized that CHTS intercepts for for-hire anglers were sporadic, and sample sizes were low. As a result, the For-Hire Telephone Survey (FHS) was developed to estimate effort in the for-hire mode. The new method draws a random sample of known for-hire charter and guide vessels each week and vessel operators are called and asked directly to report their fishing activity. The FHS was piloted in east Florida in 2000 and officially adopted in all the Atlantic coast states in 2003. A further improvement in the FHS method was the stratification of Florida into smaller sub-regions for estimating for-hire effort. The FHS sub-regions include three distinct regions bordering the Atlantic coast: Monroe County (sub-region 3), southeast Florida from Dade through Indian River Counties (sub-region 4), and northeast Florida from Brevard through Nassau Counties (sub-region 5). The coastal household telephone survey method for the for-hire fishing mode continues to run concurrently with new FHS method.

The recreational statistics workgroup of SEDAR 15 recommended a comparison of the two methods of estimation of charter boat effort be conducted so that CHTS estimates from earlier years can be adjusted and the new FHS estimates used for later years. This comparison was made at SEDAR 16 (DW-15, Sminkey, 2008) and applied to South Atlantic charter boat effort and king mackerel catches. The same conversion ratios were used in this data workshop to produce a time series of adjusted charter boat landings and live discards of red snapper (SEDAR 24- DW13, Sminkey 2010, Tables 4.1a, 4.1b, 4.2).

Missing cells in MRFSS estimates

The MRFSS calculates estimated landings in numbers and weight for each year, fishing mode, state, wave, and area fished (inshore, state waters, federal waters) combination, and each combination is referred to as a cell. Landings by weight are calculated by multiplying the average weight for all fish in a given cell by the estimated number of fish in the same cell. When no fish are weighed in a given cell, the estimated weight of fish landed is not generated for that cell. When there is an estimated number of fish landed, but no corresponding estimate for weight, that cell is referred to as a "missing cell". It is inappropriate to add cells together when there are missing weight estimates; therefore, weight estimates were filled in for missing cells by pooling cells and applying a pooled average weight to the number of fish in the cell with missing estimated weight. Weight landings were substituted in cells (Sub-reg, St, Year, Wave, Mode_fx, Area_x) that did not have >1 fish weighed. Average weight from sampled fish was calculated at the state or sub-region within the sampled wave and applied to the number sampled for those cells that lacked sufficient sampled weights. The new weight estimates were substituted and included in the annual weight estimates for red snapper. For the 1981 to 2009 time series, there were only four cells with missing mean weights (no substitution at state or sub-region level) in the private/rental boat mode, so annual mean weights for the sub-region were substituted and the wave weight landings were estimated. For the for-hire modes (PC in 1981-1985 and CH for 1986-2009) the landed weights were estimated from the modeled number landings using annual mean weights from observed data for the sub-region.

Wave 1 estimates were not generated from Virginia to Georgia due to low fishing activity during January and February. In east Florida, no landings estimates are available for Wave 1, except the first year of the time series in 1981. Wave 1 estimates for 1981 for Florida were generated for A+B1 and B2 catch for red snapper using the average Wave 1 portions of annual catch estimates for the 1980s. The 1981 annual landings were increased by the mean value that Wave 1 contributed during that decade.

Shore Estimates

Because red snapper is an offshore species with a strong association with reefs and hard bottom, the group felt that this species would not be landed from shore. Therefore, shore landings for red snapper were omitted from total landings estimates. Several species of nearshore fish are often referred to as "red snapper" by anglers, which may explain the infrequent red snapper shore landing estimates in the MRFSS time series.

Monroe County

Monroe county landings estimates from the MRFSS are included in the total landings for the Gulf of Mexico. While Monroe County landings can be post-stratified, they cannot be partitioned into fish from waters of the Atlantic Ocean or Gulf of Mexico. Because red snapper are less common on the extreme south Atlantic coast of Florida, Atlantic Coast landings from Monroe County likely contribute only a very small amount to recreational red snapper landings from the Atlantic. Because Gulf of Mexico red snapper could not be partitioned out of the Monroe County landings, the recreational workgroup decided not to include Monroe County MRFSS estimates. Head boat landings from Monroe County are separated by area fished, and trips that occurred on the Atlantic side of Keys and Dry Tortugas were included in head boat landings.

4.3.2 Southeast Region Headboat Survey (SRHS)

Introduction

The Southeast Region Headboat Survey estimates landings and effort for headboats in the South Atlantic and Gulf of Mexico. To determine red snapper landings estimates for the earliest possible year, the recreational working group first considered the areas of coverage in the early years of the Survey. The Headboat Survey was started in 1972 but only included vessels from North Carolina and South Carolina until 1975. In 1976 the survey was expanded to northeast Florida (Nassau-Indian River counties) and Georgia, followed by southeast Florida (St. Lucie-Monroe counties) in 1978. Red snapper landings estimates in the South Atlantic are only available for those years when coverage occurred.

Headboat data prior to 1981, not available for SEDAR 15, were considered for inclusion for SEDAR 24. Based on data tabulated on paper copies and recently key-entered, these data included estimated red snapper landings from 1976-1980 for GA/NEFL and 1978-1980 for SEFL. These data were verified with previous Headboat Survey personnel as having been collected during those time periods. NC and SC landings already key-entered and used in SEDAR15 were compared and matched to the hard copies of the recovered tabulated data for the time period 1972-1980 to check for accuracy. These updated estimates are highlighted in Table 4.3.

Issue 1: Headboat landings data available for SEDAR 24 from 1976 for GA/NEFL and 1978 for SEFL through 1980 that were not available for SEDAR 15.

Option 1: Include the new data in the assessment in place of the estimates used in the previous assessment.

Option 2: Do not include the new data in the assessment in place of the estimates used in the previous assessment.

Decision: Option 1 to include the newly key-entered data for 1976 for GA/NEFL and 1978 for SEFL through 1980.

Issue 2: The Headboat Survey had partial geographic coverage. Reported data are not available for GA/NEFL from 1972-1975 or SEFL from 1972-1977.

Estimates for these area/time periods can be calculated from several methods using the ratio of NC and SC landings from 1972-1977 for periods of partial coverage. Three and five year averages were used to estimate landings for the areas and time periods without coverage. After comparing both methods, the RWG concluded the three year average was less likely to mask real annual variability. These ratios were compared in Table 4.4.

Option 1: Three-year average ratio of NC & SC

Option 2: Five-year average ratio of NC & SC

Option 3: 1972-1980 ratio of NC & SC (used in SEDAR15)

Decision: Option 1 for estimating both number and weight to predict landings for GA/EFL 1972-1975 and SEFL for 1972-1977.

Based on this decision the 3 year average ratio was applied to the areas and periods when partial coverage occurred. The complete time series of red snapper estimated headboat landings from 1972-2009 are summarized in Table 4.5.

4.3.3 Historic Recreational Landings

Introduction

The historic recreational catch time period will be defined as pre-1981 for the charter and private boat sectors, which represents the start of the Marine Recreational Fisheries Statistics Survey (MRFSS). The headboat data in the South Atlantic for red snapper has been extended back in time to 1972, which represents the beginning of Southeast Region Headboat Survey. Therefore the historic period for the headboat sector is pre-1972.

During the SEDAR 24 data workshop the RWG reviewed the working paper on historical recreational red snapper catches (SEDAR24-DW11). It was agreed at the workshop that the preferred method for filling in the historic recreational catch would be to use the ratio of recreational to commercial catches in numbers (with the private sector scaled to US Census data, see Section 4.2 for discussion). This choice was based in part on the ability to split the historical catch into for-hire and private boat modes. It is also a continuous series of data points, whereas the SWAS produce estimates for only three years. Within the ratio method, concerns over species misidentification are far less likely when based on commercial landings, as opposed to the SWAS. The large adjustment factors necessary for estimating red snapper landings using the SWAS data points caused a great deal of concern among participants. However, the RWG recommends that the adjusted SWAS historical landings be included in a sensitivity run. At that point, the two methods could be further reviewed. The RWG agreed that only the numbers of fish should be extended back in time because of uncertainty in average weights of fish landed in the recreational sector in the historic time period.

Ratio method

Following the rationale laid out in the historic recreational landings working paper (SEDAR24-DW11), the years pre-1992 were used for computing the average ratio between recreational and commercial landings. It was also agreed at the data workshop that a reasonable representation of the uncertainty could be obtained by using the minimum and maximum ratio values to represent confidence bounds. Further detail on the justification and other analyses for using the ratio method are provided in the historic recreational landings working paper (SEDAR24-DW11). It should be noted that most of the catch times series used in SEDAR24-DW11 have been updated and the values contained in that working paper should not be used as actual catch estimates.

For the for-hire sector (headboat and charter boat combined) the average ratio was assumed constant for all years back to 1950, the earliest year of data provided by the commercial working group. There was considerable debate at the data workshop about how to extend the private boat landings back in time. The SEDAR24-DW11 working paper assumed a linear decline to zero in 1950 in the private boat to commercial ratio. The RWG agreed that it was likely near zero in 1950. However, there was concern among some participants about the apparent peak in 1968 in private boat landings. The timeline in SEDAR24-DW11 suggested that private boats, in particular fiberglass boats, did not begin rapid expansion until the early 1970s. In part to accommodate this concern, the RWG decided to make the declining ratio of private boat to commercial from 1980 to 1950 follow the human population trends in Northeast Florida and Georgia (from US Census data) for those same years. The effect of this ratio trend was to reduce the landings in the 1950s and 1960s relative to the linear declining ratio estimated landings so that the peak for the private landings occurs in the mid-1970s.

The final ratio statistics are shown in Table 4.6 and clearly indicate that the recreational sector is more than double the commercial catch. There is considerable variability in the ratio estimates as seen in the range of values. It is recommended that the assessment workshop consider using the minimum and maximum ratios applied to the commercial catch time series to represent the range of uncertainty in these historic recreational catch time series. The estimated landings of red snapper in numbers from the recreational sectors and the potential range of values are indicated in Figure 4.1a and Tables 4.7 and 4.8.

Saltwater Angling Surveys (SWAS)

The recreational working group recommended the USFWS saltwater angling survey estimates be adjusted and used in a sensitivity run of the red snapper stock assessment model. The details of the adjustments made to these estimates are discussed in SEDAR24-DW11. The resulting estimates for use in the stock assessment model are listed in Table 4.9. A comparison of the estimated historic recreational landings from both the ratio method and adjusted SWAS are presented in Figure 4.12.1b.

4.3.4 Additional Potential Data Sources

4.3.4.1 SCDNR Charterboat Logbook Program Data, 1993 – 2009

Introduction
SCDNR issues three types of charter vessel licenses: V1 (vessels carrying six or fewer passengers), V2 (vessels carrying 7 to 49 passengers), and V3 (vessels carrying 50 or more passengers). In 1993, SCDNR's Marine Resources Division (MRD) initiated a mandatory logbook reporting system for all charter vessels to collect basic catch and effort data. Under state law, vessel owners/operators purchasing South Carolina Charter Vessel Licenses (V1, V2, or V3) and carrying fishermen on a for-hire basis are required to submit trip level reports of their fishing activity in waters off of SC. Logbook reports are submitted by mail or fax to the SCDNR Fisheries Statistics section monthly. Compliance is tracked by staff and charter vessel owners/operators failing to submit reports can be charged with a misdemeanor. The charter boat logbook program is a complete census and should theoretically represent the total catch and effort of the charter boat trips in waters off of SC.

Logbook Data:

The charter logbook reports include: date, number of fishermen, fishing locale (inshore, 0-3 miles, >3miles), fishing location (based on a 10x10 mile grid map), fishing method, hours fished, target species, and catch (number of landed and released fish by species) per vessel per trip. The logbook forms have remained similar throughout the program's existence with a few exceptions: in 1999 the logbooks forms were altered to begin collecting the number of fish released alive and the number of fish released dead (prior to 1999 only the total number of fish released were recorded) and in 2008 additional fishing methods were added to the logbook forms (including 4) cast, 5) cast and bottom, and 6) gig).

After being tracked for compliance each V1 charter boat log book report is coded and key entered into an existing Access database. (V2 and V3 charter boat logbook reports are tracked for compliance but are currently not coded and entered electronically.) Since the inception of the program, a variety of staff have coded the charterboat log book data. From ~1999 to 2006, only information that was explicitly filled out by the charterboat owners/operators on the logbook forms was coded and entered into the database. No efforts were made to fill in incomplete reports. From 2007 to the present, staff have tried to fill in incomplete trips reports through conversations with charterboat owners/operators and by making assumptions based on the submitted data (i.e. if a location description was given instead of a grid location – a grid location was determined, if fishing method was left blank – it was determined based on catch, etc.). From 1999 to 2006 each individual trip record was reviewed to look for anomalies in the data. Starting in 2007 queries were used to look for and correct anomalous data and staff began checking a component of the database records against the raw logbook reports. Coding and QA/QC measures prior to 1999 were likely similar to those used from 1999 to the present. However, details on these procedures were not available since staff members working on this project prior to 1998 are no longer with the SCDNR. Data are not validated and currently no correction factors are used to account for reporting errors. Recall periods for logbook records are typically one month or less – however can potentially be up to a year for delinquent charter boat licensees.

Data Summary:

SCDNR logbook vessel trips represent snapper grouper fishing trips where at least one of a suite of bottom fishes (likely, or even possibly, to occur in association with red snapper) were caught.

Trips that were combination of trolling and bottom fishing were included. These logbook data represent 15,260 fishing trips in which 65,215 anglers caught 10,114 red snapper and harvested 4,368 red snapper.

Table 4.10. presents measures of angler, trip, and catch statistics for each year from 1993 – 2009.

- Vessel trips – total number of trips where at least one of a suite of bottom fishes (likely, or even possibly, to occur in association with red snapper) was caught; includes both nearshore and offshore trips
- Average number of anglers per vessel trip – sum of the total number of anglers divided by the sum of the total vessel trips.
- Total catch per angler trip – sum of total number of red snapper caught divided by sum of total number of anglers (Figure 4.2).
- Total harvest per angler trip – sum of total number of red snapper harvested divided by the sum of total number of anglers (Figure 4.2).
- % released – sum of total number of red snapper released divided by the sum of the total of red snapper caught (Figure 4.3).
- % vessel trips with catch – sum of total number of vessel trips with at least one red snapper caught (released or harvested) divided by the sum of the total number of vessel trips (Figure 4.4).

SCDNR charter boat logbook data were compared with MRFSS charter boat estimates. Large scale differences were seen in total catch, with the SCDNR charter boat logbook catch being orders of magnitude smaller than MRFSS estimates, particularly in 1997 and 1999. These datasets were also compared to the NMFS headboat logbook estimates which were found to be similar in magnitude to SCDNR's charter boat logbook estimates (Figure 4.5). The RWG considered using the SCDNR charter logbook estimates, but decided not to substitute SC logbook data for MRFSS charter boat estimates in SC since there was no valid basis to indicate MRFSS estimates were incorrect.

4.3.4.2 SCDNR State Finfish Survey (SFS)

The collection of finfish intercept data in South Carolina was conducted through a non-random intercept survey at public boat landings along the SC coast. The survey focuses on known productive sample sites and was conducted during January through December using a questionnaire and interview procedure similar to those of MRFSS. Implemented in 1989, the State Finfish Survey (SFS) was designed to address specific data gaps, within the MRFSS, as identified by SCDNR staff. These data gaps included the lack of length data from species of concern to the SCDNR and the lack of seasonal and area-specific catch frequencies. Another concern was the lack of catch and effort data from private boat anglers, which make up a majority of the angling trips in South Carolina coastal waters. These data gaps were initially addressed by interviewing inshore anglers targeting red drum and spotted seatrout at specific sample locations. Since 2002, more emphasis has been placed on acquiring length data from all finfish retained by anglers, canvassing at additional sampling locations, and interviewing all private fishing boats within all SC coastal areas. Broadening the scope of the survey may decrease some of the bias associated with the previous SFS protocol, which could potentially allow for better catch estimates and length frequency data.

During the period 1989-2009 a total of 182 red snapper were caught by fishing parties interviewed through the SFS survey. Of those fish, a total of 108 were harvested and 82 length measurements were obtained.) Based on the small sample size and the fact this survey does not typically interview offshore anglers, it was the decision of the RWG that this data set should not be used in recreational catch estimates for SEDAR 24.

4.3.4.3 South Carolina's Angler-based Tagging Program

Since 1974, the South Carolina Marine Resources Division's Office of Fisheries Management has operated a tagging program that utilizes recreational anglers as a means for deploying external tags in marine game fish. The angler-based tagging program has proven to be a useful tool for promoting the conservation of marine game fish and increasing public resource awareness. In addition, the program has provided biologists with valuable data on movement and migration rates between stocks, growth rates, habitat utilization, and mortality associated with both fishing and natural events.

Select marine finfish species are targeted for tag and release based on their importance both recreationally and commercially to the State and South Atlantic region. The list of target species is further narrowed down based on the amount of historical data on that species with regards to seasonal movements, habitat requirements, growth rates and release mortality. Although red drum constitutes the majority of fish tagged and released by recreational anglers, program participants are encouraged to tag other eligible species where data gaps may exist. The South Carolina angler based tagging program will occasionally utilize volunteers that tag and release fish in waters other than SC, but is limited to only those anglers fishing offshore waters in the South Atlantic. These individuals usually are the most experienced in a particular fishery for which a directed tag and release effort is needed, and as is the case with red snapper tagging, a Florida based charter captain proved to be the most qualified to provide information on his fishing activity.

During 1991 to 2009, 1,644 red snapper were tagged and 181 recoveries were reported (Table 4.11). Median days at large were 170 days and ranged from 0 to 2,239 days. Twenty seven percent of red snapper recaptures were fish tagged off Sebastian Inlet, Florida, and recaptured in the same general area. However, between 1996 and 2002, there were 7 reported recaptures of red snapper off Cape Canaveral, FL that had initially been tagged off Sebastian Inlet, FL; a distance traveled of approximately 68 miles. Most location information included with the initial tag events and subsequent recaptures is not detailed making it difficult to determine exact fishing location and to track red snapper movements. When available, fishing depth and condition of released fish will be reviewed for all red snapper recaptures to assist with discard mortality estimates.

4.3.4.4 GADNR Marine Sportfish Carcass Recovery Program

Since 1997, the GADNR has conducted the Marine Sportfish Carcass Recovery Project.

Rather than discarding, anglers place filleted fish carcasses in chest freezers located at participating marinas. Chest freezers are placed near the fish cleaning stations at selected locations along the Georgia coast. Each freezer is marked with an identifying sign and a list of target fish species. Inside the freezer is a supply of plastic bags, information cards, and pens. Cooperating anglers can place the filleted carcasses, with head and tail intact, in a bag, drop in a completed angler information card, and then place the bag in the freezer. Since 1997 the number of red snapper donated to the carcass program has been insignificant. Designed to target inshore species, the top species are usually red drum, spotted seatrout and southern kingfish. The RWG was in agreement that this data set should not be used in recreational catch estimates for SEDAR 24.

4.3.4.5 SCDNR Fish Rack Recycling Program

Since 1996, the SCDNR has conducted the Fish Rack Recycling Program. Rather than discarding, anglers place filleted fish carcasses in freezers maintained at participating marinas, public boat landings, and private fishing clubs. The majority of freezers are placed within the Charleston area; however in the past freezers have been placed throughout coastal South Carolina. Cooperating anglers place the filleted carcasses, with head and tail intact, in a bag, with catch information (when, how, and where the fish were caught) in the freezer. Racks are collected monthly from the freezers and brought back to the lab for analysis. Cooperating anglers are asked to target five species: speckled sea trout, red drum, black drum, southern flounder and sheepshead. Since 1996 the number of red snapper donated to the Fish Rack Recycling Program has been insignificant. The RWG was in agreement that this data set should not be used in recreational catch estimates for SEDAR 24.

4.4 Recreational Discards

4.4.1 MRFSS discards

Discarded live fish (both number of fish and disposition are reported by the anglers interviewed in the MRFSS dockside intercept survey. The recall period for self-reported discard data is the day the fishing trip ended. Length and/or weight are unknown for all modes of fishing covered by the MRFSS in the South Atlantic sub-region. All live released fish statistics (B2 fish) in charter or party/charter mode were adjusted in the same manner as the landings (described in Section 4.2; SEDAR24-DW13). Size or weight of discarded fishes is not estimated in the MRFSS. At-sea sampling of headboat discards was initiated (NC/SC in 2004, GA/FL in 2005) as part of the improved for-hire surveys to characterize the size distribution of live discarded fishes in the headboat fishery.

Annual numbers of red snapper discards varied greatly in the 1980s, peaking for the for-hire sector in 1984 with more than 100,000 and similarly in 1986 for the private-rental mode (Table 4.2). Where estimates for numbers of discards are available, variance estimates are high. The occurrence of zero discards in some years coupled with high variances for other years are probably indicative of sample size issues in earlier years of the MRFSS for effort and catch estimates. More consistent discard estimates from 1991 onwards may relate to regulatory changes implemented in 1992. However, variance remained high throughout the 1990s. It should be noted that estimates of red snapper discards from shore mode have been excluded.

4.4.2 Headboat Logbook Discards

The Southeast Region Headboat Survey logbook form was modified in 2004 to include a category to collect self-reported discards for each reported trip. This category is described on the form as the number of fish by species released alive and number released dead. Port agents instructed each captain on criteria for determining the condition of discarded fish. A fish is considered "released alive" if it is able to swim away on its own. If the fish floats off or is obviously dead or unable to swim, it is considered "released dead". This self-reported data are currently unvalidated within the Headboat Survey. The RWG compared red snapper discard data from the MRFSS At-Sea Observer Headboat program to the Headboat Survey logbook and determined that the logbook discard data were underreported from 2004-2006. However, as reporting compliance improved in recent years (2007-2009), discard reporting on logbooks has also improved. Based on the results of this comparison, it was concluded that discard reporting on headboat logbooks is representative of the headboat fishery from 2007-2009. For years prior to 2007 the RWG considered 6 possible data sources to be used as a proxy for estimated headboat discards (Figure 4.6).

Comparison of discards (percent released) from numerous datasets during 2004-2009 to determine if any can be used as a proxy for HB discards prior to 2007.

- Capt. Steve Amick data (described Section 4.2, SEDAR24-DW07) – Data are limited to just one boat in one state within the region. However, it does extend back through time until the early 1980s. The data do match the scale and pattern from both the region-wide headboat logbook and GA/FL at-Sea observer data for the 2007-2009 time period.
- SC At-sea – Not recommended for use since it is a short time series (2004-2009) with extremely small sample sizes.
- GA/FL At-sea Observer (described Section 4.2, SEDAR-24-DW15) – Because the data are collected by observers, this is the data set in which the RWG has the highest confidence. However, it is a short time series (2005-2009) that does not extend back in time and therefore was not recommended for use.
- SC MRFSS CH – The data set is constrained by small sample size and was not recommended for use.
- FL MRFSS CH – Though it does extend back to 1986, there are sample size concerns and it does not follow the pattern exhibited in the GA/FL at-sea observer data which was the most trusted data set for the 2005-2009 time period. It was not recommended for use.
- SC logbook – Though it does extend back to 1993, it does not follow the pattern exhibited in the GA/FL at-sea observer data which was the most trusted data set for the 2005-2009 time period. Additionally, it is limited to one state that does not contribute a large portion of the red snapper landings. It was not recommended for use.

Issue 1: Proxy for estimated headboat discards prior to 2007.

Option 1: Use Amick's discard data to estimate headboat discards prior to 2007.
Option 2: Use a flat ratio based on the 2007-2009 headboat logbook time series.
Option 3: Do not attempt to estimate discards for the HB sector prior to 2004.

Decision: Option 1, but also conduct sensitivity runs for Options 2 & 3.

4.4.3 Headboat At-Sea Observer Survey Discards

An observer survey of the recreational headboat fishery was launched in NC and SC in 2004 and in GA and FL in 2005 to collect more detailed information on recreational headboat catch, particularly for discarded fish. Headboat vessels are randomly selected throughout the year in each state, and the east coast of Florida is further stratified into northern and southern sample regions. Biologists board selected vessels with permission from the captain and observe anglers as they fish on the recreational trip. Data collected include number and species of fish landed and discarded, size of landed and discarded fish, and the release condition of discarded fish (FL only). Data are also collected on the length of the trip, area fished (inland, state, and federal waters) and, in Florida, the minimum and maximum depth fished. In the Florida Keys (sub-region 3) some vessels that run trips that span more than 24 hours are also sampled to collect information on trips that fish farther offshore and for longer durations, primarily in the vicinity of the Dry Tortugas. This data set provides valuable quantitative information on the ratio of harvested to discarded fish, depths fished, and release condition of fish discarded in the recreational headboat fishery and provides the only available time series on the size distribution of discards (Table 4.12). Survey methods, sample sizes and size distributions of discarded fish are described in detail in SEDAR24-DW15.

4.4.3.1 Discard Mortality

The SEDAR 24 discard mortality working sub-group recommended the use of a depth specific discard mortality rate. This approach was discussed during a plenary session of the SEDAR 24 data workshop. During this plenary session the workshop participants agreed that applying the depth specific discard mortality function to a distribution of depths fished for each gear/sector would be the best approach. This 'integrated' approach was applied to the recreational headboat, charter boat, and private boat modes of fishing.

The depth equation used for this analysis was provided by the discard mortality working sub-group and is as follows:

$$D = 1 \Big/ \left(1 + e^{(-(-2.3915+0.0592*d))}\right)$$

where D is the discard mortality rate and d is the depth in meters.

The depth distributions for each sector of the recreational fishery were developed from data provided by the life history working group. This is composed of fish samples collected through dockside sampling, from the SC tagging program, and by FL headboat observers. For each sample there was an associated length measurement. For the charter boat and headboat sectors there were enough samples to limit the depth analysis to fish equal to or less than 20 inches, the current minimum size limit. Unfortunately the sample sizes for the private boat sector were too small to limit the analysis to just undersized fish and therefore all the samples were used for the depth analysis of the private boat sector. However, the number of fish over 20 inches in the private boat sector represented only about 10% of the fish. A breakdown of the sample sizes by sector and by state is shown in Table 4.13.

One concern with these samples is that the geographic range is limited to primarily GA and FL. Fortunately, the bulk of the red snapper fishery also occurs in these areas. Another concern was that the private recreational sample size was very low (only 55 fish), but still adequate for characterizing the depth of capture of red snapper.

The frequency of depth samples by sector were binned into 25 feet increments and then standardized to sum to unity (Figure 4.7). The pattern from this figure suggests headboats are fishing the shallowest depths, followed by private boats, with charter boats fishing some of the deepest waters. In discussions with fishermen in attendance, this pattern was not unexpected as it largely reflects the speed of boats and their ability to get to deeper waters in a given day of fishing. It was noted that the deeper charter boat fishing is likely a result of some boats heading to offshore waters to troll for pelagic species then switching to bottom fishing during some part of the trip.

The RWG had made a decision to combine the headboat and charter boat sectors into one sector (based on overall data availability), but separate the private boat sector. Because the sampling of fish with depth measurements was not done in proportion to the fishery landings, the depth distributions for charter boat and headboat sectors needed to be weighted before combining into one discard mortality estimate. The charter boat and headboat depth profiles were weighted by the proportion of landings (in numbers) for each sector for years 1986-2006 (the data available at the time these calculations were made). The average ratio of charter:headboat landings in numbers was 0.58 for the years 1986-2006.

Using this ratio for weighting the depth profiles from Figure 4.7, the discard mortality equation above was then applied. Not only were the depth profiles weighted for the combined charter and headboat sectors, but the modes of the distributions were also; but in this case the modes were identical. The results are shown in Table 4.14. It should be noted that the big difference between the mode and integrated estimates for the combined charter/headboat sector is due to the asymmetrical depth distributions for those sectors, which also suggests the use of the integrated method is more appropriate.

4.5 Biological Sampling

MRFSS Charter and Private

The MRFSS angler intercept survey includes the collection of fish lengths from the harvested (landed, whole condition) catch. Up to 15 of each species landed per angler interviewed are measured to the nearest mm along a center line (defined as tip of snout to center of tail along a straight line, not curved over body). Center line lengths (also called mid-line lengths) were converted to maximum total length using the length/length regression provided by the SEDAR24 Life History Workgroup. Weights are typically collected for the same fish measured; however weights are given priority when time is constrained. Ageing structures and other biological samples are rarely collected during MRFSS assignments because of concerns over the introduction of bias to survey data collection.

Headboat Survey Biological Sampling

Lengths were collected from 1972-2009 by headboat dockside samplers. From 1972-1975, only North Carolina and South Carolina were sampled whereas Georgia and northeast Florida were sampled beginning in 1976. The Southeast Region Headboat Survey conducted dockside sampling for the entire range of Atlantic waters along the southeast portion of the US from the NC-VA border through the Florida Keys beginning in 1978. Weights are typically collected for the same fish measured during dockside sampling. Also, biological samples (scales, otoliths, spines, stomachs and gonads) are collected routinely and processed for aging, food analysis and maturity studies.

Georgia Department of Natural Resources

Per a request from the NMFS Southeast Regional Office in Spring 2009, GADNR initiated red snapper biological data collection in Georgia from May through November. This effort was independent of dockside interviews with recreational anglers through the MRFSS and sampling the commercial industry through the Trip Interview Program (TIP). In Georgia, per MRFSS estimates, private boat mode fishing effort in federal waters accounted for ~7% of annual angler trips from 2004-2008. Due to expected low incidence rate of trips that were both offshore and in which red snapper were harvested, interviews outside regularly scheduled MRFSS dockside assignments were not conducted. Biological sampling for length is conducted through the TIP program with a goal of sampling a minimum of 10% of the commercial finfish trips landed in Georgia. However, otoliths are not available for those collections. Thus the majority of biological data collected in 2009 (608 fish, 90%) came from three for-hire vessels operating from Tybee Island, Georgia (near Savannah). The captains consistently caught red snapper and were very supportive of the cooperative research effort. The remaining 10% of the sample consisted of carcasses donated by recreational anglers and for-hire captains through the existing GADNR carcass freezer program, though this program did not specifically target red snapper.

The Tybee Island for-hire data collection included several components. During May, data represent a census of all snapper-grouper trips prosecuted by the three vessels (14 sampling days, 284 fish). This initial effort was in preparation for the June SAFMC meeting. Data collected from June through November represent random sampling of the snapper-grouper trips prosecuted by the same three for-hire vessels (22 sampling days, 304 fish). Data from these 588 fish were collected dockside by GADNR personnel. Data elements included length, weight, gender, average trip depth and age (determined from otoliths). Throughout this period, the captains also provided measurements and otoliths from 20 larger fish (30 inches or greater) on days in which GADNR personnel were not available to collect data.

For samples collected from the for-hire vessels in May, FL FWC personnel collaborated with GADNR to process and age one otolith per fish so that comparison age readings between agencies could be produced. This effort was repeated for the Sept-Nov sample. There was an overall 92% agreement, with no difference greater than one year.

Florida FWC Biological Sampling

Beginning in July, 2009, Florida’s Fish and Wildlife Research Institute (FWRI) personnel on the east coast of Florida began to actively sample recreational and commercial catches to collect enhanced biological samples specifically from red snapper. This sampling continued through the month of September, 2009.

During the period, FWRI/FWC staff made routine visits to known red snapper landing sites for for-hire vessels and headboats. These visits were not conducted as part of MRFSS dockside intercept assignments, but were conducted independently and directed towards intercepting red snapper trips. Similar attempts were made to sample red snapper at private boat landing sites, but targeting this fishing mode was not conducive to intercepting red snapper in adequate numbers. For-hire vessels were sampled as they returned from daily fishing trips, and FWC staff sampled all available sizes of red snapper from returned vessels. A total of 328 red snapper otoliths were collected from commercial landing sites, 789 were collected from for-hire landing sites, and 20 were collected from private boat landing sites.

As part of FWC biological sampling efforts a sizeable number (N= 1,479) of red snapper otoliths were available for years 2000-2007 for the East Florida for-hire fishery and included in this analysis. The majority of these fish were collected independently of the MRFSS. Although managed species were targeted, sampling assignments were issued proportionally to fishing effort at MRFSS intercept sites to geographically distribute sampling effort among fishing modes.

4.5.1 Sampling Intensity Length/Age/Weight

At-Sea Observer Program - Lengths of red snapper discards were collected during headboat at-sea observer trips. Table 4.12, provides the numbers of sampled trips in each state and numbers of red snapper discard lengths by state and year. Midline lengths were converted to maximum total length using the length/length regression equation provided by the SEDAR24 Life History Workgroup. Discard lengths were summed for each 1cm total length category and entered into the Excel Worksheet for SEDAR24 Data Workshop data inputs.

Dockside Surveys - Annual numbers of red snapper measured for lengths and the number of trips from which red snapper were measured in MRFSS charter fleet intercepts are summarized in Table 4.15 Annual numbers of red snapper measured for length in the MRFSS private-rental mode and the number of trips from which red snapper were measured are summarized in Table 4.16. Annual numbers of red snapper measured for length in the headboat fleet and the number of trips from which red snapper were measured are summarized in Table 4.17. The number of red snapper aged from the headboat and charter fleets by year and state are summarized in Table 4.18. The number of trips from which red snapper were aged from the headboat and charter fleets by year and state is summarized in Table 4.19. The number of red snapper and the number of trips from which red snapper were aged from the private fleet by year and state is summarized in Table 4.20. Table 4.21 provides details on the numbers of MRFSS intercept surveys conducted by mode and year in each state and the percentage of intercepts that encountered red snapper.

4.5.2. Length – Age distributions

MRFSS Length Frequency Analysis Private and Charter Fleets Protocol

The angler intercept survey is stratified by wave (2-month period), state, and fishing mode (shore, charter boat, party boat, private or rental boat) so simple aggregations of fish lengths across strata cannot be used to characterize a regional, annual length distribution of landed fish. A weighting scheme is needed to representatively include the distributions of each stratum value. The MRFSS angler intercept length frequency analysis produces unbiased estimates of length-class frequencies for more than one strata by summing respectively weighted relative length-class frequencies across strata. The steps utilized are:

1) output a distribution of measured fish among state/mode/area/wave strata,

2) output a distribution of estimated catch among state/mode/area/wave strata,

3) calculate and output relative length-class frequencies for each state/mode/area/wave stratum,

4) calculate appropriate relative weighting factors to be applied to the length-class frequencies for each state/mode/area/wave stratum prior to pooling among strata,

5) sum across strata as defined, e.g., annual, sub-region length frequencies.

Headboat Fleet Length Distributions Protocol

Headboat landings (1981-2009) were pooled across five time intervals (Jan-May, Jun,July,Aug,Sep-Dec) because landings were not estimated by month until 1996. The headboat landings were only estimated annually prior to 1981 so, no intra-annual weightings were developed for 1972-1980. Spatial weighting was developed by region for the headboat survey by pooling landings by region: NC, SC, NF (GA and North FL), and SF (South FL). For each measured fish a landings value was assigned based on month of capture and region. The landings associated with each length measurement were summed by year in 1-cm length bins. These landings were typically then converted to annual proportion in each size bin.

Headboat and Charter Fleet Combined Length Frequency

The headboat and charter boat lengths were weighted temporally and spatially by landings as described above. The scales were slightly different for the surveys due primarily to availability of landings estimates and sampling intensity. The length compositions from each of the fleets were combined at the level of summed landings by year and length bin. This weights the length composition not only temporally and spatially but also provides weighting relative to each of the charter and headboat fleets. These combined values were then converted to an annual proportion at length in 1-cm bins (Figure 4.8, see data summary workbook RS_DW_Summary.xlsx for values).

Private Fleet Length Frequency

The private fleet length frequency is plotted in Figure 4.9. The table of length compositions is large and provided in the data summary workbook from the SEDAR 24 Data Workshop (RS_DW_Summary.xlsx).

Headboat and Charter Fleet Combined Age Frequency

The calendar age for each red snapper was matched to the corresponding annual proportion at age in the combined age composition for headboat and charter fleets combined. These ages matched the length of the aged fish and year captured. The annual proportion at age (age frequency) was developed as the sum of the length bin proportion assigned to each fish by year and age normalized to sum to one annually (Figure 4.10, see SEDAR 24 data summary workbook for data). Ages 1-20 were plotted although ages were observed in very small numbers to age 54. This weighting adjusts for any bias in sampling otoliths from a distribution of different sized fish.

Private Fleet Age Frequency

The calendar age for each red snapper was matched to the corresponding annual proportion at length in the length composition for the private fleet that matched the length of the aged fish. The annual proportion at age (age frequency) was developed as the sum of the length bin proportion assigned to each fish by year and age normalized to sum to one annually (Figure 4.10, see SEDAR 24 data summary workbook for data). Ages 1-20 were plotted although ages were observed in very small numbers to age 54. This weighting adjusts for any bias in sampling otoliths from a distribution of different sized fish.

4.5.3 Adequacy for Characterizing Catch

Headboat and Charter Fleet Length Composition

The RWG agreed that the headboat and charter fleet length composition from years with incomplete spatial coverage should not be used to characterize the red snapper population. The length composition prior to 1978 is strictly from the headboat fleet and has limited spatial coverage. The RWG recommends starting the length compositions for assessment model HB input in 1978. From 1978-1980 the length composition is only from the headboat fleet since CH data were not collected until the MRFSS started in 1981. The recreational data working group supports the assumption the headboat length composition from 1978-80 should characterize the charter fleet.

The 12-inch size limit implemented in 1983 had little influence on the size of fish landed from headboat vessels (Figure 4.8). Influence of the 20-inch size limit implemented in 1992 is apparent in the length compositions (Figure 4.8).

Private Fleet Length Composition

The private fleet length compositions are inadequate to capture the size distribution of red snapper with the possible exception of 2008 and 2009 when sample sizes are higher. It may be possible to increase the sample size by including lengths of aged fish that were not included as MRFSS length samples. This would require additional effort and a preliminary look at the potential increase in sample size would be useful to decide if this exercise would benefit the assessment.

Headboat and Charter Fleet Age Composition

The headboat and charter fleet age compositions have sufficient samples to represent the catch during the 1970s and 1980s. However, the sampling declines in the 1990's and may not represent the headboat and charter catch. The sample sizes increase in 2001 and continue through 2009. The age compositions from 2001-2009 are adequate to characterize the red snapper catch.

Private Fleet Age Composition

The private fleet age compositions are inadequate to capture the age distribution of red snapper with the possible exception of 2009 when sample sizes are higher. State port agents were targeting red snapper for high frequency sampling in 2009 but the samples were selected randomly.

4.5.4 Alternatives for characterizing discards

The RWG had no input on this issue.

4.6 Recreational Catch-at-Age/Length; directed and discard

The RWG had no input on this issue.

4.7 Recreational Effort

MRFSS Recreational & Charter Effort

Effort estimation for the recreational fishery surveys are produced via telephone surveys of both anglers (private/rental boats and shore fishers) and for-hire boat operators (charter boat anglers, and in early years, party or charter anglers). The methods have changed during the full time series (see section 4.3 for descriptions of survey method changes and adjustments to survey estimates for uniform time-series of catch estimates). The adjusted charter boat angler effort estimates and the private/rental boat angler estimates are tabulated in Table 4.22 and 4.23. An angler-trip is a single day of fishing in the specified mode, not to exceed 24 hours. Because this data review is for red snapper in the South Atlantic sub-region and shore landings have specifically been excluded (non-reliable identification; red snapper are not considered to be accessible to shore anglers) the shore angling effort has not been included in any tables of angling effort.

Headboat Effort

Catch and effort data are reported on logbooks provided to all headboats in the SRHS. These forms are completed by the captain or designated crew member after each trip and represent the total number and weight of all the species kept, along with the total number of fish discarded for each species. Data on effort are provided as number of anglers on a given trip. Numbers of anglers are standardized, depending on the type of trip (length in hours), by converting number of anglers to "angler days" (e.g., 40 anglers on a half-day trip would yield 40 * 0.5 = 20 angler days). Angler days are summed by month for individual vessels. Each month, port agents collect these logbook trip reports and check for accuracy and completeness. Although reporting via the logbooks is mandatory, compliance is not 100% and is variable by location. To account for non-reporting, a correction factor is developed based on sampler observations, angler numbers from office books and all available information. This information is used to provide estimates of total catch by month and area, along with estimates of effort.

Estimated headboat angler days have decreased in the South Atlantic in recent years (Table 4.24). The most obvious factor which impacted the headboat fishery in both the Atlantic and Gulf of Mexico was the high price of fuel. This coupled with the economic down turn in 2008 and 2009 has resulted in a marked decline in angler days in the South Atlantic headboat fishery. Reports from industry staff, captains\owners, and port agents indicated throughout the 2008 and 2009 season, fuel prices, the economy and fishing regulations are the factors that most affected the amount of trips, number of passengers, and overall fishing effort.

4.8 Comments on adequacy of data for assessment analyses

Regarding the adequacy of the available recreational data for assessment analyses, the RWG discussed the following:

- The RWG discussed the possibility of smoothing MRFSS estimates to overcome high amounts of annual variability in the estimates. It was decided by the group to leave this decision to smooth or not to smooth up to the assessment group.
- Landings, as adjusted, appear to be adequate for the time period covered.
- Size data appear to adequately represent the landed catch for the charter and headboat sector, however, the private sector is lacking in both length and age data.

4.9 Itemized list of tasks for completion following workshop

See Section 1.5

4.10 Literature Cited

Amick ,S. and K. Knowlton, 2010 SEDAR24-DW-07, Georgia Headboat Red Snapper Catch & Effort Data, 1983-2009 Steve and Kathy Knowlton.

Historical Fisheries Working Group (HFWG) 2010. SEDAR24-DW-11, Estimation of Historic Recreational Landings 2010.

Sauls, B. and C. Wilson, 2010 SEDAR24-DW-15, Red Snapper Length Frequencies and Condition of Released Fish from At-Sea Headboat Observer Surveys, 2004 to 2009.

Sminkey, T. R. 2010. SEDAR24-DW-13. South Atlantic Red Snapper Marine Recreational Fishery Landings: FHS-conversion of Historic MRFSS Charter Boat Catches. Charleston, SC. May 2010.

Williams, E., R. Cheshire, and K. Brennan, 2010 SEDAR24-DW-06, Distribution of red snapper catches from headboats operating in the South Atlantic.

4.11 Tables

Table 4.1a. South Atlantic red snapper landings (numbers of fish) by fishing mode (charter boats and private/rental boats) (MRFSS, NMFS, 1981-2009).

	Number (x1000)			
	Landings		CV(=Percent Standard Error)	
Year	MRFSS-CH	MRFSS-PR	MRFSS-CH	MRFSS-PR
1981	63.9	123.6	42.2	31.3
1982	5.8	54.8	47.1	33.4
1983	137.7	37.3	22.4	47.0
1984	209.4	223.8	17.4	29.7
1985	302.7	260.6	20.8	32.7
1986	82.4	69.2	43.7	38.2
1987	15.3	50.9	39.2	23.3
1988	26.1	95.7	42.8	33.8
1989	21.0	127.7	32.4	22.9
1990	5.7	10.5	36.5	41.7
1991	16.8	34.1	25.4	44.0
1992	40.3	39.0	19.6	32.7
1993	7.6	10.8	31.8	29.0
1994	14.4	13.9	34.1	44.1
1995	13.6	2.4	32.0	59.0
1996	3.1	11.6	40.5	50.0
1997	57.2	3.5	61.9	60.8
1998	13.4	7.6	32.8	37.5
1999	42.5	22.4	40.7	25.8
2000	11.1	60.3	22.6	24.4
2001	9.9	39.5	21.9	20.5
2002	17.2	34.3	18.7	22.6
2003	18.2	16.0	27.9	24.2
2004	14.0	25.5	14.1	20.4
2005	14.2	21.1	16.1	28.5
2006	11.3	14.6	16.5	31.4
2007	10.4	30.8	15.7	26.2
2008	22.8	86.9	19.2	18.7
2009	28.7	91.9	22.1	18.4

Table 4.1b. South Atlantic red snapper landings (pounds of fish) by fishing mode (charter boats and private/rental boats) (MRFSS, NMFS, 1981-2009).

Weight lbs. (x1000)				
	Landings		CV(=Percent Standard Error)	
Year	MRFSS-CH	MRFSS-PR	MRFSS-CH	MRFSS-PR
1981	70.4	349.1	41.6	37.4
1982	15.2	151.2	63.5	28.3
1983	151.8	88.3	20.7	54.2
1984	230.8	246.3	16.8	28.4
1985	333.7	1015.3	22.9	37.6
1986	36.3	66.9	30.6	41.2
1987	43.8	97.5	34.3	24.3
1988	69.1	74.6	40.3	34.5
1989	64.8	185.8	32.9	38.6
1990	5.1	172.0	30.2	50.0
1991	73.9	89.7	28.9	48.3
1992	284.4	320.2	53.6	54.6
1993	67.0	98.6	33.6	38.3
1994	126.7	80.4	30.0	80.5
1995	63.0	13.2	33.7	37.9
1996	20.1	89.0	42.3	59.3
1997	126.0	22.4	56.5	42.4
1998	88.4	54.1	44.4	45.3
1999	112.5	75.8	22.8	28.4
2000	53.7	434.0	22.0	27.3
2001	67.3	267.1	21.8	23.8
2002	106.1	274.9	18.2	22.8
2003	120.3	147.2	19.5	27.9
2004	120.0	173.1	16.3	23.4
2005	119.0	139.5	15.4	28.8
2006	102.6	138.9	17.2	40.3
2007	73.6	243.8	19.2	36.6
2008	151.0	534.9	23.5	19.7
2009	221.5	645.7	30.3	19.7

Table 4.2. South Atlantic red snapper discards by fishing mode (charter boats and private/rental boats) (MRFSS, NMFS, 1981-2009).

Number (x1000)				
	Discards		CV(=Percent Standard Error)	
Year	MRFSS-CH	MRFSS-PR	MRFSS-CH	MRFSS-PR
1981	2.3	0.0	100.0	
1982	0.0	0.0		
1983	42.3	0.0	37.1	
1984	121.7	22.8	35.4	51.6
1985	27.8	63.5	54.8	58.8
1986	0.0	0.0		
1987	0.2	106.6	100.0	57.9
1988	0.0	48.4		47.3
1989	0.0	20.0		41.9
1990	0.0	0.0		
1991	0.1	35.9	99.8	51.7
1992	13.3	19.5	47.8	38.8
1993	27.5	49.0	49.2	32.5
1994	2.0	62.6	51.2	29.5
1995	19.5	37.9	40.2	24.4
1996	2.8	17.6	41.4	42.6
1997	14.2	8.7	44.4	35.2
1998	5.0	23.0	45.1	38.1
1999	42.2	132.7	23.0	19.5
2000	25.1	223.3	18.5	16.9
2001	24.1	179.3	14.8	15.9
2002	20.2	105.9	13.3	22.4
2003	18.5	139.4	22.0	18.3
2004	30.2	164.0	15.4	16.4
2005	43.3	79.7	15.6	18.9
2006	19.0	115.6	16.4	21.4
2007	112.3	339.1	27.3	14.5
2008	48.4	352.2	17.1	11.8
2009	26.1	183.9	27.1	13.7

4.3. Estimated number of red snapper - headboat landings 1972-1980.

Year	NC	SC	NEFL	SEFL	Total
1972	1222	965			2187
1973	2367	1615			3982
1974	1885	1511			3396
1975	1351	3872			5223
1976	2212	3546	59473		65231
1977	1049	1316	42110		44475
1978	959	1248	43228	407	45842
1979	441	668	30924	333	32366
1980	424	2893	17840	441	21598

Years\areas not covered by the Headboat Survey

Estimated landings not available for SEDAR 15

Table 4.4 Comparison of 3 and 5 year ratios for estimated red snapper headboat landings 1972-1980.

Year	Total # 3 yr ratio	Total # 5 yr ratio	Total lbs 3 yr ratio	Total lbs 5 yr ratio
1972	37426	38204	165049	178729
1973	68144	69560	286232	311141
1974	58115	59323	229560	250803
1975	89381	91238	336252	368923
1976	66105	66691	234941	233966
1977	45071	45470	195198	194696
1978	45842	45842	171454	171454
1979	32366	32366	183519	183519
1980	21598	21598	74501	74501

Table 4.5. Estimated landings of red snapper in the South Atlantic headboat fishery 1972-2009.

Area	North Carolina		South Carolina		Georgia \NE Florida		SE Florida	
Year	Number	Weight (lbs)	Number	Weight (lbs)	Number	Weight (lbs)	Number	Weight (lbs)
1972	1222	22042	965	18874	34789	120028	450	4105
1973	2367	32456	1615	27758	63342	218543	820	7474
1974	1885	22727	1511	14077	54020	186382	699	6375
1975	1351	12842	3872	26954	83082	286652	1075	9804
1976	2212	14961	3546	39959	59473	172053	874	7969
1977	1049	7233	1316	11083	42110	171449	596	5433
1978	959	12421	1248	8962	43228	146380	407	3691
1979	441	5101	668	9127	30924	165827	333	3463
1980	424	2950	2893	11649	17840	56425	441	3477
1981	1194	7742	1371	8762	32415	98464	1051	3062
1982	747	10487	1612	14535	16412	69778	782	3224
1983	416	5316	1844	10179	27124	55365	1314	3143
1984	740	4582	1841	6875	27934	68115	631	1846
1985	8426	31330	2183	11768	38072	83964	1655	5022
1986	997	7129	881	4515	14286	40495	461	2241
1987	5346	21518	1934	6310	17155	52327	561	1685
1988	9555	36829	5235	15250	13589	50201	8148	27791
1989	1134	6691	6207	26459	15114	35984	998	1662
1990	525	2749	3650	13341	15422	46076	1322	3520
1991	725	15991	3290	21781	9580	33128	262	1131
1992	2306	12049	1275	5924	1310	8412	410	2531
1993	1639	9043	3623	19866	1541	10598	544	3211
1994	567	3632	2454	6349	3576	21909	1628	11127
1995	3791	23728	866	6340	3634	23732	535	3674
1996	335	3130	2374	23837	2683	18300	151	968
1997	1779	20969	557	6746	2794	20316	640	3174
1998	445	1082	696	6235	3426	18591	174	939
1999	973	6957	1749	11257	3559	22153	555	3192
2000	777	5946	984	6562	6463	35818	213	1076
2001	1816	9605	3878	20513	6023	36403	311	1864
2002	2637	14194	4345	21727	5722	33993	227	883
2003	399	3679	1346	12133	3910	25242	51	299
2004	1274	12300	1672	16111	7786	51081	110	857
2005	106	1114	1004	10399	6681	40742	1116	6441
2006	33	384	303	3540	5393	36050	216	1458
2007	52	389	701	5016	5311	27861	825	4193
2008	162	888	1551	8076	17028	105436	202	908
2009	263	2368	373	5105	20107	127587	764	6028

Table 4.6. Statistics for ratios of recreational to commercial landings data based on the number of fish landed**.**

Ratio	Mean	StDev	Min	Max
For-Hire:Commercial	2.27	1.90	0.41	6.75
Private:Commercial	2.19	1.53	0.21	4.98

Table 4.7 Estimated historical recreational landings (numbers) of red snapper for the charter boat, total for-hire (charter and headboat combined), and private boat sectors in the U.S. South Atlantic using the ratio method

Year	Charter Boat	Total For-Hire	Private Boat
1950		164,137	0
1951		237,178	6,190
1952		178,388	9,311
1953		184,161	14,418
1954		274,294	28,633
1955		228,105	29,765
1956		221,919	34,749
1957		398,153	72,735
1958		282,863	59,056
1959		303,667	71,324
1960		310,265	80,971
1961		366,490	105,977
1962		303,617	96,356
1963		231,355	79,946
1964		256,377	95,820
1965		300,963	120,970
1966		339,115	145,865
1967		442,365	202,748
1968		490,230	238,508
1969		321,170	165,311
1970		293,906	159,564
1971		249,779	146,145
1972	178,032		135,153
1973	109,621		119,008
1974	232,309		206,683
1975	252,594		257,796
1976	218,316		226,409
1977	253,420		250,202
1978	225,839		239,191
1979	155,860		173,656
1980	153,036		168,484

Table 4.8. Estimated range of historical recreational landings (numbers) of red snapper for the charter boat, total for-hire (charter and headboat combined), and private boat sectors in the U.S. South Atlantic using the ratio method.

Year	Minimum Charter Boat	Maximum Charter Boat	Minimum Total For-Hire	Maximum Total For-Hire	Minimum Private Boat	Maximum Private Boat
1950			29,586	488,562	0	0
1951			42,751	705,973	602	14,094
1952			32,154	530,980	906	21,200
1953			33,195	548,166	1,402	32,830
1954			49,442	816,452	2,785	65,197
1955			41,116	678,967	2,895	67,772
1956			40,001	660,554	3,379	79,121
1957			71,767	1,185,123	7,074	165,614
1958			50,986	841,957	5,743	134,467
1959			54,736	903,880	6,937	162,401
1960			55,925	923,520	7,875	184,366
1961			66,060	1,090,875	10,307	241,303
1962			54,727	903,731	9,371	219,397
1963			41,702	688,640	7,775	182,031
1964			46,212	763,119	9,319	218,177
1965			54,249	895,833	11,765	275,440
1966			61,126	1,009,394	14,186	332,126
1967			79,736	1,316,723	19,718	461,646
1968			88,364	1,459,196	23,196	543,068
1969			57,891	955,980	16,077	376,404
1970			52,977	874,828	15,518	363,318
1971			45,023	743,481	14,213	332,763
1972	1,410	603,896			13,144	307,736
1973	0	460,981			11,574	270,974
1974	0	806,347			20,101	470,604
1975	0	928,524			25,072	586,986
1976	0	780,490			22,019	515,519
1977	8,732	843,404			24,333	569,694
1978	3,129	762,832			23,262	544,623
1979	1,562	527,898			16,889	395,405
1980	9,880	498,208			16,386	383,627

Table 4.9. Estimated historical recreational landings (numbers) of red snapper from the 1960, 1965, and 1970 US Fish and Wildlife Service Salt-water Angling Surveys (SWAS) for the U.S. South Atlantic.

Year	Total Recreational (1000s)
1946	0.00
1947	20.22
1948	40.44
1949	60.67
1950	80.89
1951	101.11
1952	121.33
1953	141.55
1954	161.77
1955	182.00
1956	202.22
1957	222.44
1958	242.66
1959	262.88
1960	283.10
1961	262.78
1962	242.46
1963	222.14
1964	201.82
1965	181.50
1966	280.50
1967	379.50
1968	478.50
1969	577.50
1970	676.50
1971	635.20
1972	593.91
1973	552.61
1974	511.31
1975	470.02
1976	428.72
1977	387.42
1978	346.12
1979	304.83
1980	263.53

Table 4.10. Annual red snapper catch and harvest per unit of effort from SCDNR Charter boat logbook program, 1993 – 2009.

Year	Vessel Trips	Average Number Anglers per Vessel Trip	Total Catch per Angler Trip	Total Harvest per Angler Trip	% Released	% Vessel Trips With Catch
1993	565	4.46	0.21	0.11	45.97	17.17
1994	655	4.46	0.13	0.06	54.26	15.42
1995	531	4.43	0.08	0.04	45.26	11.86
1996	696	4.41	0.06	0.05	11.05	8.05
1997	749	4.55	0.02	0.01	45.57	5.34
1998	903	4.39	0.10	0.06	44.61	11.96
1999	844	4.48	0.18	0.12	32.79	17.42
2000	997	4.33	0.28	0.08	72.25	15.75
2001	980	4.42	0.42	0.14	67.72	19.08
2002	937	4.33	0.30	0.14	53.53	17.61
2003	898	4.36	0.14	0.06	54.02	12.81
2004	1044	4.10	0.09	0.05	43.13	9.67
2005	1130	4.09	0.08	0.04	42.54	9.73
2006	1142	4.11	0.05	0.02	53.51	6.04
2007	1172	4.10	0.09	0.04	57.31	9.47
2008	1150	4.03	0.18	0.05	72.43	12.78
2009	867	4.10	0.19	0.07	62.39	13.73

Table 4.11. SC angler based tagging program, number of fish measured (excludes estimated measurements), mean size (inches), and minimum and maximum size range (inches), 1991 – 2009.

Year	Number of Fish Measured	Mean Length (inches)	Range (inches)
1991	2	12.8	11.5-14.0
1992	57	16.8	12.0-20.0
1993	117	16.9	10.0-21.0
1994	81	17.1	11.0-19.5
1995	66	17.2	11.0-20.0
1996	52	17.9	9.0-24.0
1997	71	17.1	11.0-22.0
1998	147	16.4	9.0-21.0
1999	155	16.6	10.5-29.8
2000	95	16.7	10.0-22.0
2001	166	17.4	12.5-33.0
2002	81	18.6	13.0-29.5
2003	28	17.2	12.0-19.5
2004	34	18.9	14.0-30.0
2005	41	18.3	14.0-22.0
2006	13	17.2	13.5-19.5
2007	23	17.4	14.0-23.0
2008	16	18.2	15.0-20.5
2009	6	18.3	17.0-19.5

Table 4.12. Numbers of headboat at-sea observer trips and red snapper discards measured during headboat at-sea observer trips in the South Atlantic.

State	Year	Observed Headboat Trips	Number measured	Minimum (mm FL)	Maximum (mm FL)	Mean (mm FL)
Florida	2005	172	490	93	548	382.767
	2006	161	664	182	550	325.571
	2007	166	1,474	190	544	357.021
	2008	128	1,615	180	522	360.958
	2009	128	402	142	508	379.293
Georgia	2005	1	2	437	485	461.000
	2006	3	8	209	482	354.875
	2007	2	8	343	429	390.500
	2008	2	38	237	581	382.579
	2009	6	71	204	461	311.732
South Carolina	2004	3	2	375	445	410.000
	2005	57	0	-	-	-
	2006	44	0	-	-	-
	2007	52	1	455	455	455.000
	2008	39	0	-	-	-
	2009	34	0	-	-	-
North Carolina	2004	29	0	-	-	-
	2005	97	0	-	-	-
	2006	82	0	-	-	-
	2007	89	13	280	435	350.154
	2008	77	23	265	468	388.739
	2009	69	3	420	480	454.333

Table 4.13. Number of recreational samples with depth records by state and sector.

	State			
Recreational Sector	**FL**	**GA**	**SC**	**Grand Total**
Charter Boat (≤ 20 inches)	360	26	40	426
Headboat (≤ 20 inches)	4718	41		4759
Private Boat (all)	25	9	24	58
Grand Total	5103	76	64	5243

Table 4.14. Estimated discard mortality rates for the recreational sectors are indicated. The mode was applied as a single point estimate to the mortality equation, while the integrated method used the depth profiles. The charter and headboat sectors were combined using an average weighting method based on the ratio of the sector's landings in numbers.

	Mode	**Integrated**
Charter and Headboat (fish ≤ 20")	30.7%	41.3%
Private Boat (all)	41.1%	38.9%

Table 4.15. Number of red snapper measured and number of trips with red snapper in the MRFSS charter fleet by year and state.

	Number of Fish					Number of Trips				
Year	NC	SC	GA	FL	Total	NC	SC	GA	FL	Total
1981	0	6	0	13	19	0	1	0	7	8
1982	0	1	0	0	1	0	1	0	0	1
1983	0	39	0	109	148	0	9	0	46	55
1984	7	10	10	302	329	2	9	1	80	92
1985	35	0	5	173	213	7	0	2	57	66
1986	0	1	0	205	206	0	1	0	73	74
1987	24	0	1	0	25	5	0	1	0	6
1988	13	0	0	8	21	7	0	0	4	11
1989	8	4	4	5	21	6	3	1	2	12
1990	14	0	0	0	14	3	0	0	0	3
1991	10	0	3	0	13	5	0	2	0	7
1992	3	0	1	4	8	3	0	1	2	6
1993	4	0	11	0	15	3	0	8	0	11
1994	14	0	18	3	35	10	0	10	2	22
1995	11	0	9	4	24	5	0	4	1	10
1996	4	2	3	0	9	1	2	3	0	6
1997	0	16	2	2	20	0	2	2	1	5
1998	0	11	11	4	26	0	3	4	2	9
1999	8	68	17	14	107	3	10	3	7	23
2000	1	20	4	51	76	1	3	2	18	24
2001	7	8	3	70	88	6	1	2	24	33
2002	12	4	2	181	199	8	2	1	32	43
2003	21	1	9	126	157	7	1	4	34	46
2004	1	6	37	83	127	1	6	11	23	41
2005	2	0	11	50	63	1	0	4	18	23
2006	12	3	10	38	63	3	3	4	13	23
2007	0	1	18	26	45	0	1	7	9	17
2008	10	2	49	34	95	5	1	12	8	26
2009	5	0	60	39	104	3	0	12	9	24

Table 4.16. Number of red snapper measured and number of trips with red snapper in the MRFSS private fleet by year and state.

	Number of Fish					Number of Trips				
Year	NC	SC	GA	FL	Total	NC	SC	GA	FL	Total
1981	0	0	0	25	25	0	0	0	10	10
1982	0	0	0	28	28	0	0	0	10	10
1983	0	0	2	11	13	0	0	1	2	3
1984	0	0	0	41	41	0	0	0	9	9
1985	0	0	4	32	36	0	0	3	11	14
1986	0	0	1	19	20	0	0	1	8	9
1987	12	0	9	17	38	3	0	2	5	10
1988	14	0	0	38	52	4	0	0	12	16
1989	0	1	0	32	33	0	1	0	11	12
1990	2	0	0	2	4	2	0	0	2	4
1991	2	0	0	1	3	1	0	0	1	2
1992	2	0	1	6	9	1	0	1	3	5
1993	0	0	0	8	8	0	0	0	4	4
1994	0	0	0	2	2	0	0	0	2	2
1995	0	0	0	2	2	0	0	0	2	2
1996	2	0	0	4	6	1	0	0	2	3
1997	0	0	0	0	0	0	0	0	0	0
1998	0	1	0	6	7	0	1	0	4	5
1999	0	0	0	25	25	0	0	0	11	11
2000	0	2	0	14	16	0	1	0	12	13
2001	0	0	0	32	32	0	0	0	14	14
2002	0	0	0	33	33	0	0	0	9	9
2003	0	2	0	7	9	0	1	0	5	6
2004	1	0	3	25	29	1	0	1	10	12
2005	2	0	0	11	13	2	0	0	5	7
2006	1	0	4	9	14	1	0	1	6	8
2007	0	2	1	15	18	0	1	1	6	8
2008	0	0	8	91	99	0	0	3	28	31
2009	4	0	1	108	113	3	0	1	21	25

Table 4.17. Number of red snapper measured and number of trips with red snapper in the headboat fleet by year and state.

	Number of Fish					Number of Trips				
Year	NC	SC	NF	SF	Total	NC	SC	NF	SF	Total
1972	20	30			50	12	19			31
1973	20	20			40	12	18			30
1974	27	65			92	17	32			49
1975	57	91			148	36	39			75
1976	120	51	303		474	42	28	45		115
1977	54	82	577		713	27	43	125		195
1978	49	45	643	3	740	22	25	159	2	208
1979	7	8	226	4	245	5	6	77	3	91
1980	10	14	213	22	259	9	10	68	6	93
1981	17	3	611	43	674	13	3	172	12	200
1982	30	6	415	6	457	16	5	132	1	154
1983	53	24	903	26	1006	32	18	191	12	253
1984	48	103	1063	106	1320	26	59	208	21	314
1985	169	51	894	76	1190	59	22	190	27	298
1986	51	30	334	20	435	35	16	128	11	190
1987	50	53	197	6	306	30	28	96	4	158
1988	64	43	95	4	206	37	29	48	3	117
1989	50	53	250	21	374	26	33	92	9	160
1990	31	43	293		367	17	19	101		137
1991	7	29	113	3	152	7	14	41	2	64
1992	20	25	28		73	16	16	17		49
1993	22	128	43	10	203	15	52	27	2	96
1994	14	58	54	6	132	11	21	27	2	61
1995	13	41	91	2	147	9	22	41	2	74
1996	7	106	55		168	6	38	29		73
1997	4	14	53	5	76	3	12	31	3	49
1998	11	33	112	1	157	7	20	55	1	83
1999	7	14	139	1	161	6	11	72	1	90
2000	7	9	105	2	123	6	5	57	2	70
2001	17		230	7	254	15		99	4	118
2002	8	12	333	8	361	7	8	137	5	157
2003	9	21	297	2	329	8	16	120	1	145
2004	5	10	267	22	304	5	7	100	1	113
2005	3	3	171	16	193	1	2	84	8	95
2006	4	9	149	10	172	4	7	83	8	102
2007	2	15	149	4	170	2	12	51	4	69
2008	10	12	426	7	455	6	4	77	4	91
2009	16	12	712	25	765	12	8	157	9	186

Table 4.18. Number of red snapper aged from the headboat and charter fleets (combined) by year and state.

Year	NC	SC	GA	FL	Total
1977		12		60	72
1978	1	2	4	272	279
1979		1		46	47
1980	2	5		87	94
1981	3			412	415
1982	3			131	134
1983	3	5		746	754
1984		29		590	619
1985		13		498	511
1986	2	8	1	181	192
1987	1			92	93
1988	4			19	23
1989	11	23		23	57
1990	11	4		22	37
1991	5	2		21	28
1992	6	3		2	11
1993	2	9		9	20
1994	5	1		19	25
1995	3			13	16
1996	3	88	1	31	123
1997				13	13
1998				7	7
1999					0
2000				4	4
2001				73	73
2002		4		384	388
2003	1			397	398
2004	3			323	326
2005	5	1		254	260
2006	2	8	3	20	33
2007	1	12	4	89	106
2008	10	6	1	143	160
2009	9	16	816	1278	2119

Table 4.19. Number of trips from which red snapper were aged from the headboat and charter fleets (combined) by year and state.

Year	NC	SC	GA	FL	Total
1977		5		17	22
1978	1	2	3	77	83
1979		1		31	32
1980	2	4		30	36
1981	3			142	145
1982	1			55	56
1983	2	4		167	173
1984		19		159	178
1985		10		151	161
1986	1	4	1	94	100
1987	1			63	64
1988	4			17	21
1989	5	17		10	32
1990	6	3		14	23
1991	5	2		14	21
1992	4	2		2	8
1993	2	6		6	14
1994	3	1		8	12
1995	2			6	8
1996	3	35	1	19	58
1997				12	12
1998				6	6
1999					0
2000				3	3
2001				27	27
2002		4		96	100
2003	1			80	81
2004	3			76	79
2005	2	1		73	76
2006	2	8	3	13	26
2007	1	12	4	33	50
2008	6	4	1	41	52
2009	8	10	80	260	358

Table 4.20. Number of red snapper aged and number of trips from which red snapper were aged from the private fleets by year and state.

	Number of Fish			Number of Trips		
Year	FL	GA	Total	FL	GA	Total
2004	3		3	1		0
2005			0			0
2006			0			1
2007	2		2	1		0
2008			0			0
2009	19	58	77	7	4	11

Table 4.21. Total MRFSS angler intercepts in Atlantic Ocean waters by state and year; and numbers (RS Intercepts) and percents (% RS) of MRFSS angler intercepts with red snapper catch or harvest - Florida

		Charter Mode			Private Boat Mode		
YEAR	State	Total Intercepts	RS Intercepts	% RS	Total Intercepts	RS Intercepts	% RS
1982	FL	249	1	0.40	1,825	14	0.77
1983	FL	1,024	84	8.20	1,303	2	0.15
1984	FL	1,427	114	7.99	1,679	18	1.07
1985	FL	727	70	9.63	1,440	19	1.32
1986	FL	741	73	9.85	3,355	13	0.39
1987	FL	315		0.00	3,592	17	0.47
1988	FL	604	6	0.99	3,624	20	0.55
1989	FL	680	4	0.59	3,226	28	0.87
1990	FL	600		0.00	2,974	6	0.20
1991	FL	625	2	0.32	3,646	11	0.30
1992	FL	1,127	36	3.19	6,559	17	0.26
1993	FL	668	2	0.30	5,768	26	0.45
1994	FL	661	3	0.45	6,658	28	0.42
1995	FL	648	1	0.15	6,116	25	0.41
1996	FL	718	1	0.14	6,998	13	0.19
1997	FL	965	1	0.10	6,985	11	0.16
1998	FL	1,241	3	0.24	8,000	26	0.33
1999	FL	1,258	31	2.46	11,033	87	0.79
2000	FL	1,621	61	3.76	10,763	93	0.86
2001	FL	2,519	100	3.97	11,946	116	0.97
2002	FL	3,078	143	4.65	12,338	93	0.75
2003	FL	2,553	104	4.07	11,305	79	0.70
2004	FL	1,895	90	4.75	9,731	98	1.01
2005	FL	2,069	85	4.11	9,697	63	0.65
2006	FL	1,813	69	3.81	12,095	80	0.66
2007	FL	1,694	51	3.01	11,019	114	1.03
2008	FL	1,319	49	3.71	9,779	147	1.50
2009	FL	1,030	22	2.14	9,031	132	1.46

Table 4.21. continued - Georgia

		Charter Mode			Private Boat Mode		
YEAR	State	Total Intercepts	RS Intercepts	% RS	Total Intercepts	RS Intercepts	% RS
1982	GA	19		0.00	459		0.00
1983	GA	121		0.00	274	2	0.73
1984	GA	99	3	3.03	275		0.00
1985	GA	275	2	0.73	1,550	7	0.45
1986	GA	373	4	1.07	1,774	2	0.11
1987	GA	548	1	0.18	2,448	3	0.12
1988	GA	261	3	1.15	1,207		0.00
1989	GA	207	1	0.48	1,196	1	0.08
1990	GA	169		0.00	425		0.00
1991	GA	224	2	0.89	626	1	0.16
1992	GA	501	39	7.78	1,094	2	0.18
1993	GA	251	25	9.96	645		0.00
1994	GA	311	16	5.14	586		0.00
1995	GA	220	18	8.18	595		0.00
1996	GA	243	10	4.12	776	1	0.13
1997	GA	275	2	0.73	917		0.00
1998	GA	345	25	7.25	756		0.00
1999	GA	279	30	10.75	658		0.00
2000	GA	293	25	8.53	874		0.00
2001	GA	243	14	5.76	1,003	1	0.10
2002	GA	260	7	2.69	918		0.00
2003	GA	466	26	5.58	1,027		0.00
2004	GA	474	55	11.60	985	8	0.81
2005	GA	489	39	7.98	805	1	0.12
2006	GA	513	57	11.11	753	2	0.27
2007	GA	483	28	5.80	834	6	0.72
2008	GA	554	45	8.12	772	9	1.17
2009	GA	497	35	7.04	783	2	0.26

Table 4.21. continued – North Carolina

		Charter Mode			Private Boat Mode		
YEAR	State	Total Intercepts	RS Intercepts	% RS	Total Intercepts	RS Intercepts	% RS
1982	NC	101		0.00	770		0.00
1983	NC	186		0.00	386		0.00
1984	NC	316	2	0.63	348		0.00
1985	NC	237	7	2.95	590		0.00
1986	NC	547	2	0.37	1,450		0.00
1987	NC	1,941	21	1.08	3,471	7	0.20
1988	NC	1,668	23	1.38	3,916	4	0.10
1989	NC	2,433	21	0.86	4,637	4	0.09
1990	NC	2,163	15	0.69	5,643	2	0.04
1991	NC	2,714	12	0.44	5,212	1	0.02
1992	NC	2,604	14	0.54	4,446	2	0.04
1993	NC	2,688	5	0.19	4,584	2	0.04
1994	NC	4,574	21	0.46	6,274	2	0.03
1995	NC	4,033	17	0.42	6,093		0.00
1996	NC	6,448	4	0.06	5,927	2	0.03
1997	NC	6,371		0.00	6,083		0.00
1998	NC	5,815	1	0.02	5,464	1	0.02
1999	NC	3,747	5	0.13	4,498		0.00
2000	NC	4,357	3	0.07	4,534	3	0.07
2001	NC	4,311	10	0.23	6,849	2	0.03
2002	NC	3,792	12	0.32	5,115		0.00
2003	NC	3,102	10	0.32	4,905		0.00
2004	NC	2,986	1	0.03	5,151	1	0.02
2005	NC	2,679	1	0.04	4,880	2	0.04
2006	NC	2,553	3	0.12	6,949	2	0.03
2007	NC	2,249	1	0.04	5,635		0.00
2008	NC	2,314	6	0.26	5,374		0.00
2009	NC	1,905	8	0.42	4,798	3	0.06

Table 4.21. continued – South Carolina

		Charter Mode			Private Boat Mode		
YEAR	State	Total Intercepts	RS Intercepts	% RS	Total Intercepts	RS Intercepts	% RS
1989	SC	752	9	1.20	1,151	1	0.09
1990	SC	357	1	0.28	992		0.00
1991	SC	230	4	1.74	528		0.00
1992	SC	439		0.00	1,390		0.00
1993	SC	264		0.00	958	2	0.21
1994	SC	276	1	0.36	840		0.00
1995	SC	271		0.00	985		0.00
1996	SC	374	2	0.53	1,665		0.00
1997	SC	413	14	3.39	1,964		0.00
1998	SC	426	7	1.64	1,886	1	0.05
1999	SC	433	34	7.85	1,297	3	0.23
2000	SC	796	28	3.52	1,310	7	0.53
2001	SC	361	10	2.77	1,256		0.00
2002	SC	279	4	1.43	1,103	2	0.18
2003	SC	263	10	3.80	493	2	0.41
2004	SC	410	9	2.20	1,036		0.00
2005	SC	499	18	3.61	1,160		0.00
2006	SC	427	6	1.41	1,172	1	0.09
2007	SC	584	11	1.88	1,180	1	0.08
2008	SC	598	13	2.17	1,295	2	0.15
2009	SC	484	10	2.07	1,338	3	0.22

Table 4.22. For-Hire recreational angler effort in the South Atlantic sub-region.

Year	Charter Boat Mode (1981-85 = Party/Charter Boat Mode) Number of Angler-Trips (1986-2003 adjusted, FHS-ratios)									
	FL		GA		NC		SC		S. Atlantic Total	
	Number Trips	PSE	Number Trips	PSE	Number Trips	PSE	Number Trips	PSE	Number Trips	PSE
1981	184,293	12.9	218	101.3	303,979	38.2	19,182	35.3	507,671	23.4
1982	433,888	11.1	26,037	32.1	282,247	19.9	76,877	40.6	819,048	9.8
1983	321,582	11.3	23,528	27.2	525,693	41.4	45,513	23.3	916,317	24.1
1984	402,050	12.3	30,312	22.7	286,190	16.2	123,433	23.3	841,985	8.8
1985	477,455	10.8	30,330	25.2	375,880	18.4	105,658	24.9	989,323	9.1
1986	355,365	22.7	38,530	43	536,544	26.8	90,654	26.5	1,021,092	16.4
1987	372,786	20.9	33,454	34.8	212,576	29.6	96,032	27.5	714,848	14.6
1988	496,631	19	52,256	39.4	190,185	23.6	281,299	27.9	1,020,371	13
1989	367,403	19.6	42,142	41.1	156,848	21.2	260,325	32.3	826,718	14.1
1990	232,142	16.3	15,062	65.6	123,367	23.4	130,856	30.4	501,428	12.6
1991	217,271	12.2	33,381	50.2	127,026	20.4	146,636	26	524,314	10.6
1992	243,543	10.9	34,897	28	143,661	18.6	185,038	27.4	607,138	10.5
1993	320,428	8.9	45,424	27.8	188,358	17.4	232,984	25.6	787,194	9.5
1994	379,235	8	64,182	29.6	292,303	16	254,409	17.7	990,129	7.5
1995	424,181	7.1	82,357	32.8	331,480	15.5	296,509	17	1,134,527	7.3
1996	452,686	8.1	69,248	29.7	364,147	16	374,985	18.8	1,261,065	8
1997	460,128	7.5	49,631	31.2	455,973	15.3	230,787	17.8	1,196,518	7.5
1998	389,157	6.5	31,253	32.5	448,074	12.9	144,631	19.5	1,013,115	6.9
1999	319,527	7.3	19,101	21.2	346,701	14	97,433	20.6	782,763	7.3
2000	238,008	6.5	11,873	20	282,812	16.8	68,773	18.8	601,465	8.6
2001	217,224	6.1	11,922	20.2	314,978	15.7	62,332	20.7	606,455	8.7
2002	190,302	6	17,191	20.5	303,956	15.1	59,931	17	571,380	8.5
2003	186,678	9.4	22,413	21.3	260,191	17.5	71,310	21.3	540,592	9.5
2004	198,004	8.3	18,511	17.9	178,335	6.7	39,279	12.8	434,129	4.9
2005	200,910	6	25,081	10.8	253,162	10.3	28,889	15.9	508,042	5.7
2006	173,465	4.8	28,003	9	229,179	6.6	28,592	23.7	459,239	4.1
2007	177,725	5.2	26,302	10.6	212,284	7.3	84,307	15.1	500,619	4.4
2008	160,530	5.8	17,005	10	189,757	7.8	71,712	13.2	439,003	4.6
2009	179,654	5.9	16,193	10.1	146,331	6.1	79,561	13.2	421,738	4.1

Table 4.23. Private / Rental boat recreational angler effort in the South Atlantic sub-region.

	Private/Rental Boat Mode Number of Angler-Trips (x1000)									
	FL		GA		NC		SC		S. Atlantic Total	
Year	Number Trips	PSE	Number Trips	PSE	Number Trips	PSE	Number Trips	PSE	Number Trips	PSE
1981	1,973	8.4	119	25	617	12.1	333	15.7	3,042	6.3
1982	2,975	8.1	284	13.9	1,227	12.8	455	14	4,941	6
1983	3,482	7.6	186	25.1	1,436	9.4	619	17.4	5,724	5.6
1984	4,337	6.5	195	17.3	1,395	12.5	480	13.5	6,406	5.3
1985	4,357	8.2	199	17.3	1,182	10.2	549	12.7	6,287	6.1
1986	4,380	6.7	372	12.1	1,012	10.8	719	12.4	6,485	5.1
1987	5,045	4.8	449	11.6	1,374	4.9	887	10.5	7,754	3.5
1988	5,087	4	416	10.4	1,508	4.5	963	8.9	7,974	3
1989	4,883	5	410	13.7	1,273	5.5	507	14	7,073	3.8
1990	3,976	4.1	400	14.9	1,455	4.9	550	12.3	6,382	3.1
1991	4,738	3.7	356	17.5	1,151	5.2	977	11.4	7,222	3.1
1992	4,719	2.3	335	8.9	1,368	3.4	746	8.6	7,168	1.9
1993	4,162	2.3	440	9.2	1,436	3.7	808	7.9	6,846	1.9
1994	5,336	2	479	10	1,484	3.6	967	8.6	8,266	1.8
1995	5,242	2.1	432	8.3	1,315	3.3	677	7.8	7,667	1.8
1996	5,057	2.5	296	9.8	1,391	3.9	648	6.9	7,393	2
1997	5,622	2.5	352	9.8	1,570	3.7	732	5.3	8,276	1.9
1998	4,890	2.9	345	9.9	1,638	4.1	661	5.9	7,535	2.2
1999	4,196	3	292	11.1	1,861	4.3	587	7.3	6,935	2.3
2000	5,753	3	435	10.5	2,224	4.6	707	8.6	9,119	2.4
2001	5,994	3	449	14.9	2,169	4.2	954	8.2	9,565	2.4
2002	5,430	2.9	338	10.2	1,941	4.3	557	7.4	8,266	2.3
2003	6,212	3	549	11	2,181	4.5	1,021	8.3	9,963	2.3
2004	5,313	3.5	442	11.9	2,543	4.4	1,070	8.7	9,369	2.6
2005	6,230	3.5	501	10.5	2,354	4.2	989	7.8	10,073	2.6
2006	6,503	2.9	472	9.5	2,656	4.2	1,118	6.7	10,749	2.2
2007	8,317	2.9	553	7.9	2,784	4.4	1,483	6.3	13,137	2.2
2008	6,451	3	747	8.2	2,550	4.5	1,260	7.6	11,009	2.3
2009	5,401	3.2	503	9	2,032	4.6	1,051	6.2	8,988	2.4

Table 4.24. South Atlantic headboat estimated angler days 1981-2009.

Year	NC	SC	GA\NEFL	SEFL	Grand Total
1981	19372	59030	72069	226456	376927
1982	26939	67539	66961	226172	387611
1983	23830	65713	83499	194364	367406
1984	28865	67313	95234	193760	385172
1985	31346	66001	94446	186398	378191
1986	31187	67227	113101	203960	415475
1987	35261	78806	114144	218897	447108
1988	42421	76468	109156	192618	420663
1989	38678	62708	102920	213944	418250
1990	43240	57151	98234	224661	423286
1991	40936	67982	85111	194911	388940
1992	41177	61790	90810	173714	367491
1993	42785	64457	74494	162478	344214
1994	36693	63231	65745	177035	342704
1995	40294	61739	59104	142507	303644
1996	35142	54929	47236	152617	289924
1997	37189	60147	52756	120510	270602
1998	37399	61342	51790	103551	254082
1999	31596	55499	56770	107042	250907
2000	31323	40291	59771	122478	253863
2001	31779	49263	55795	107592	244429
2002	27601	42467	48911	102635	221614
2003	22998	36556	52795	92216	204565
2004	27255	50461	50544	123157	251417
2005	31573	34036	47778	123300	236687
2006	25730	56070	48943	126607	257350
2007	28997	60725	53759	103386	246867
2008	17156	47285	52338	71593	188372
2009	19463	40916	66442	66971	196792

4.12 Figures

Figure 4.1a Estimated red snapper landings (numbers) time series for recreational private, for-hire and commercial (handline) sectors. Pre-1981 recreational data was estimated from a ratio with commercial landings (see text for description). For-hire estimates include both CH and HB.

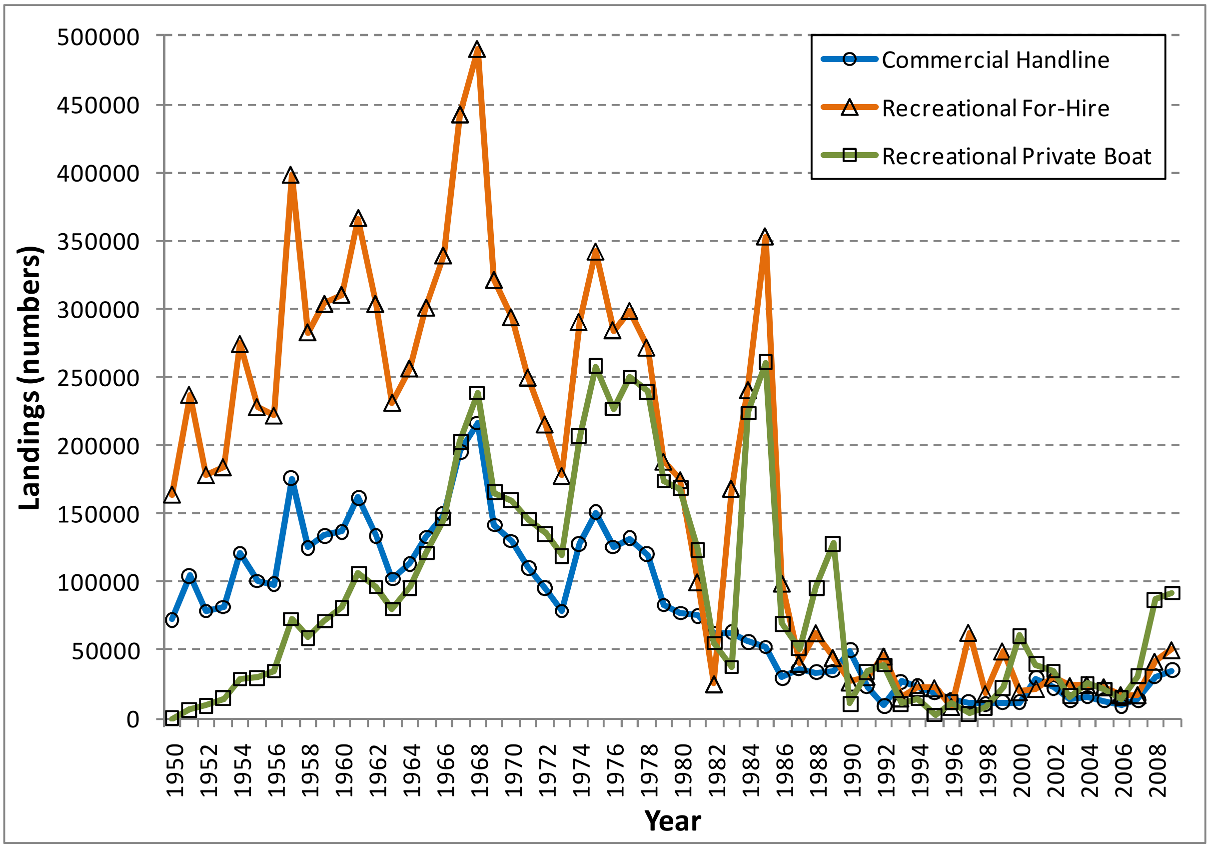


Figure 4.1b. Estimated historic red snapper landings (numbers) from both the ratio method and the adjusted SWAS.

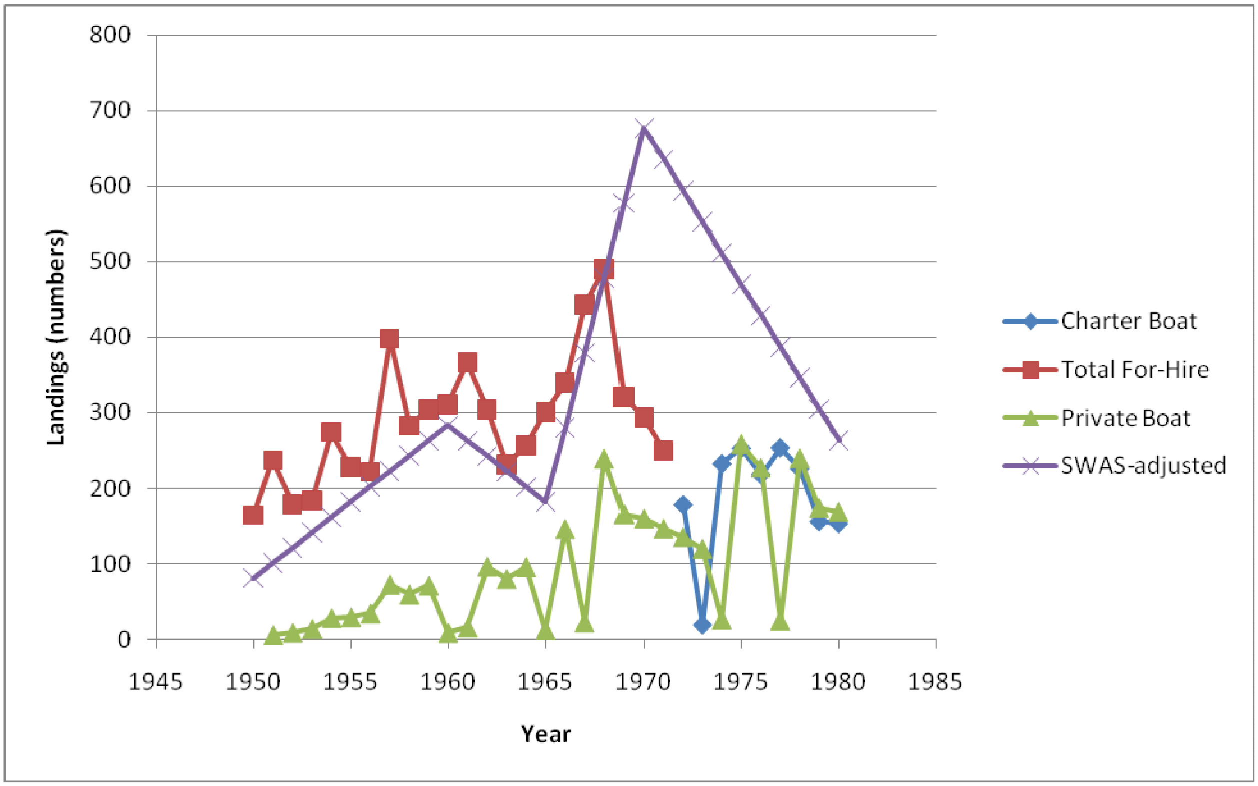


Figure 4.2. Red snapper CPUE and HPUE for SCDNR charter boat logbook data, 1993-2009.

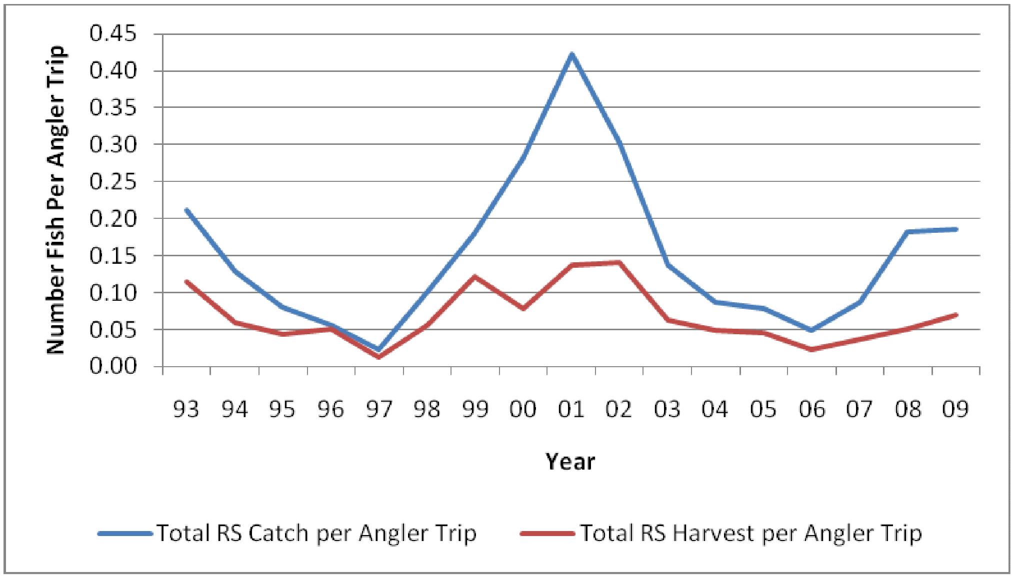


Figure 4.3. Percent of red snapper released for SCDNR charter boat logbook data, 1993-2009.

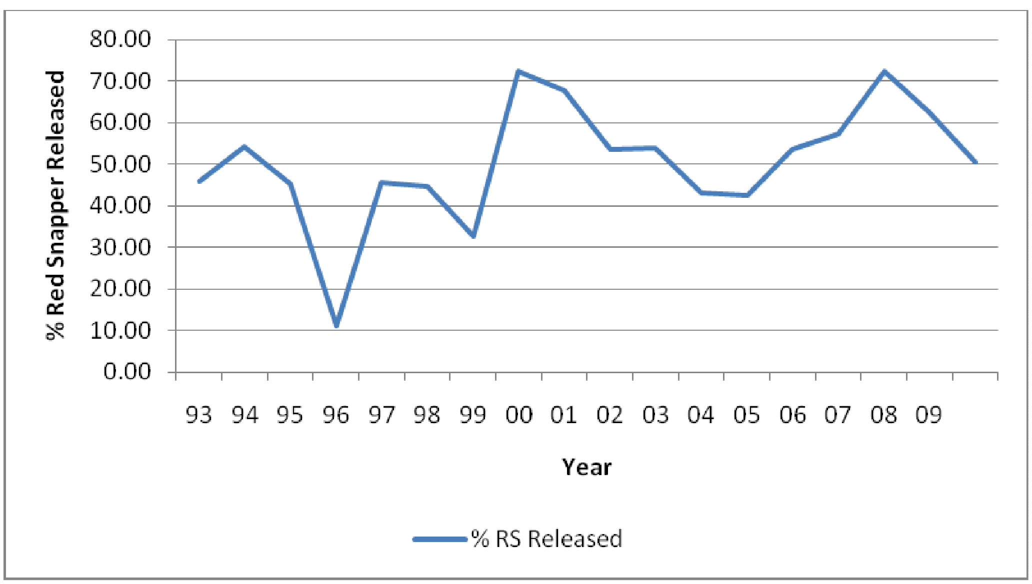


Figure 4.4. Percent of SC charter boat trips with at least one red snapper caught per trip.

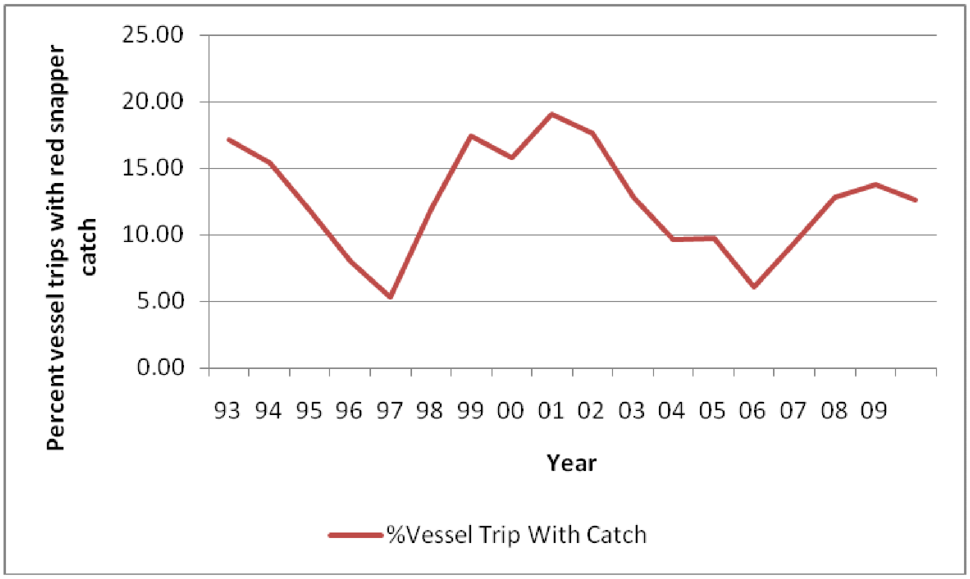


Figure 4.5. Comparison of SC red snapper total catch from MRFSS charter mode, NMFS headboat logbook, and SCDNR charterboat logbook program, 1991 – 2009.

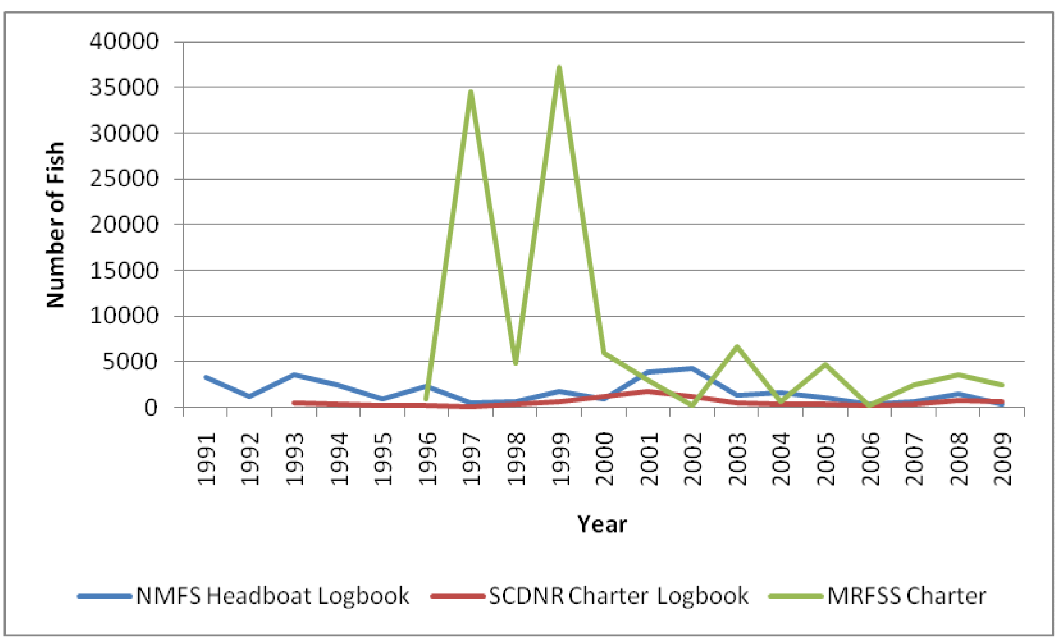


Figure 4.6. Percent red snapper discards in the recreational fishery 2004-2009.

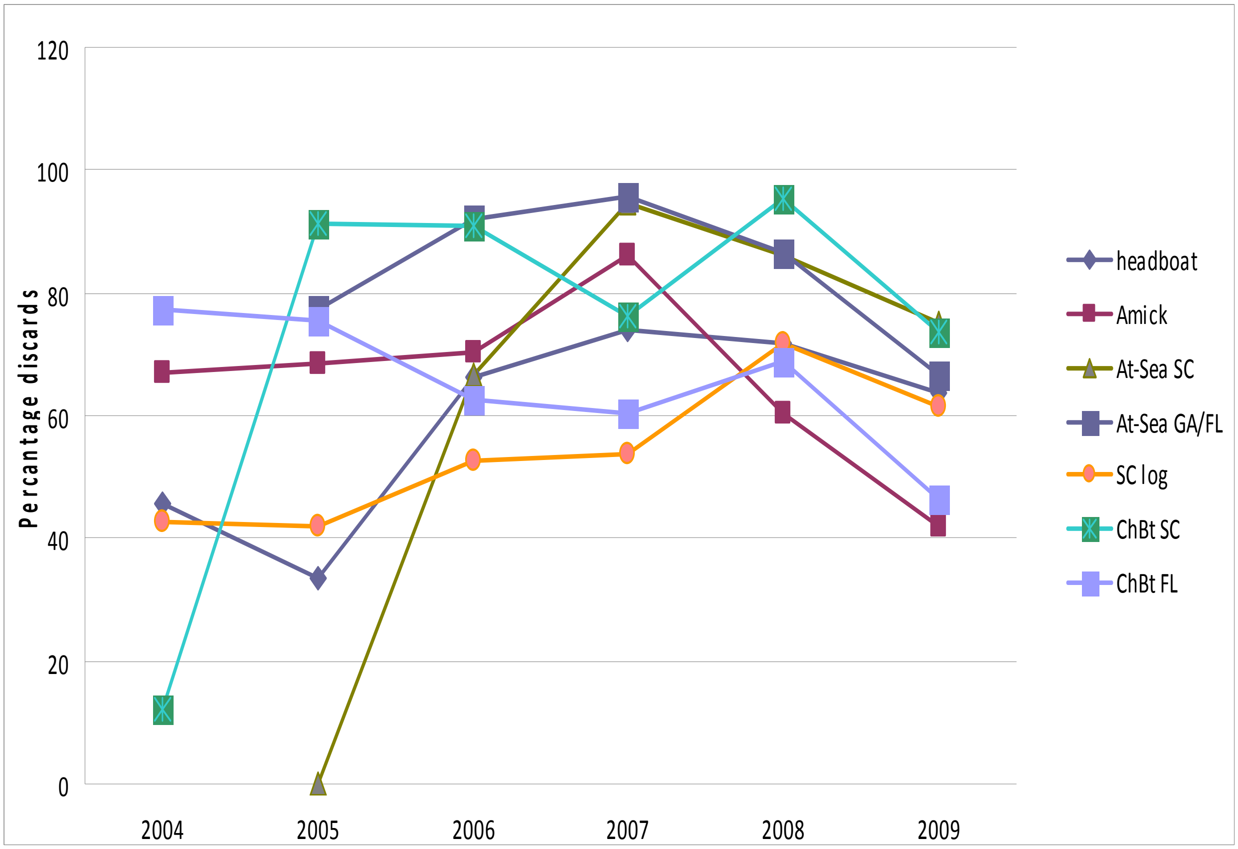


Figure 4.7. Proportion of red snapper samples by reported depths of capture for the charter boat, headboat, and private boat recreational sectors.

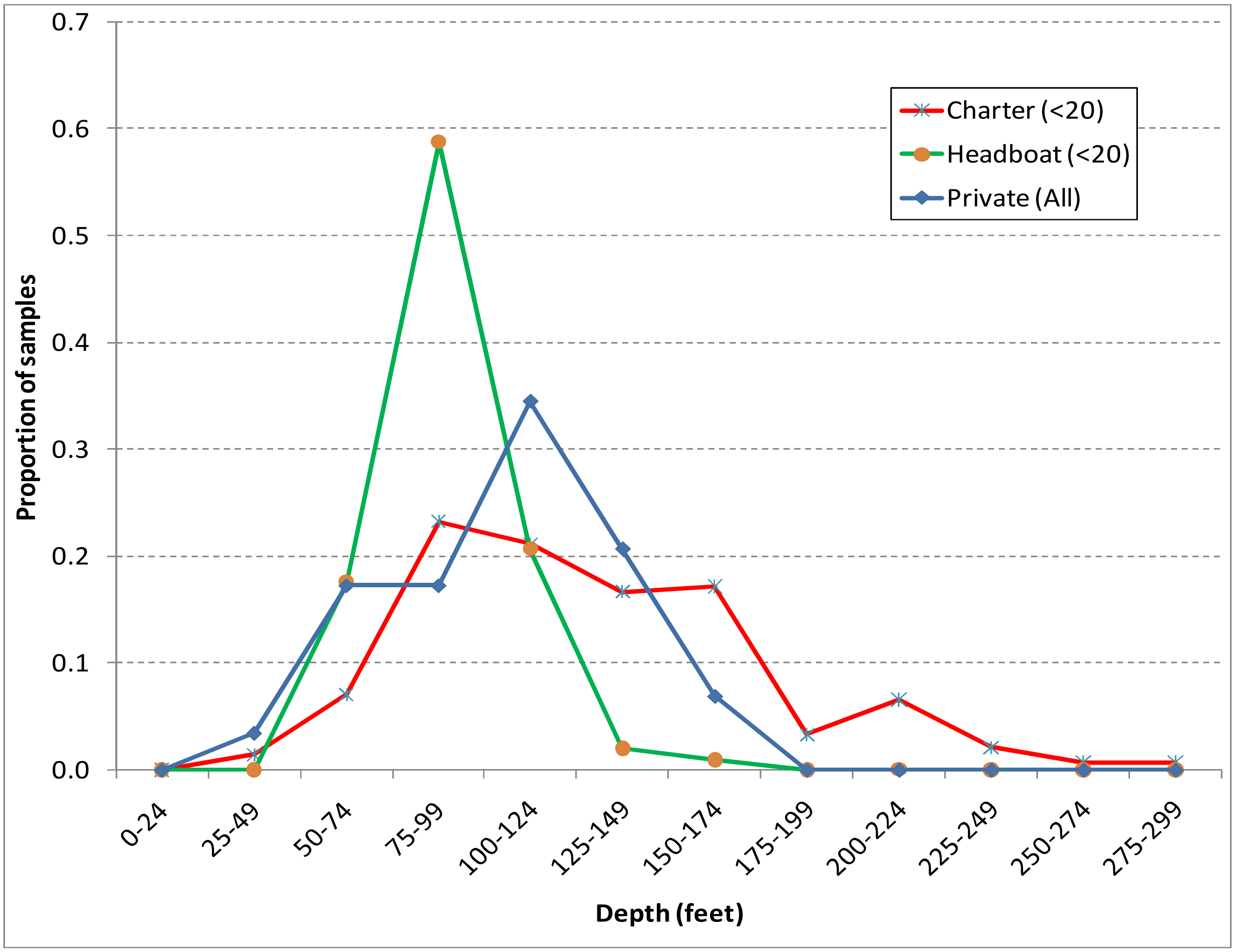


Figure 4.8. Headboat and MRFSS Charter combined length composition 1972-2009 .

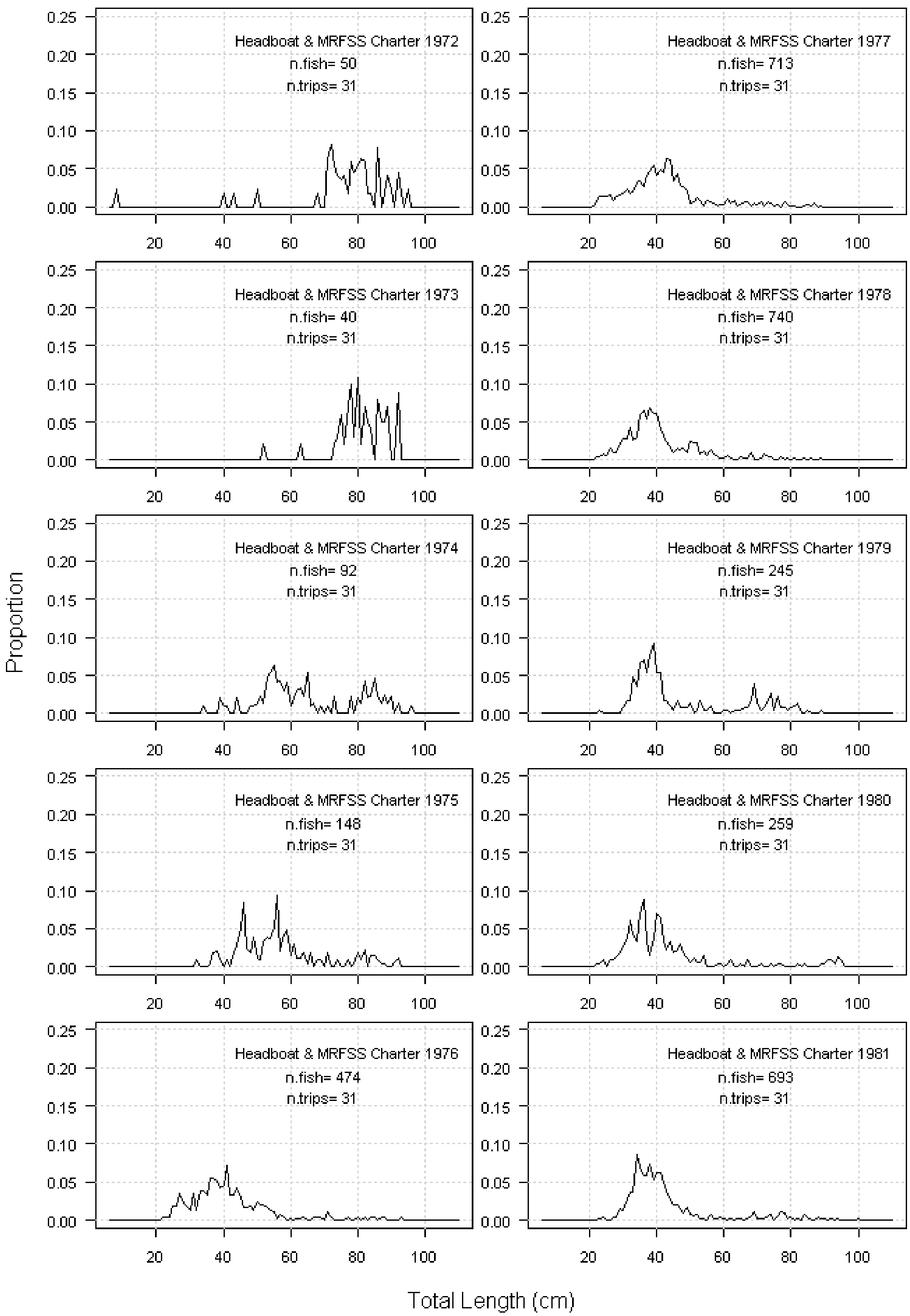


Figure 4.8. continued

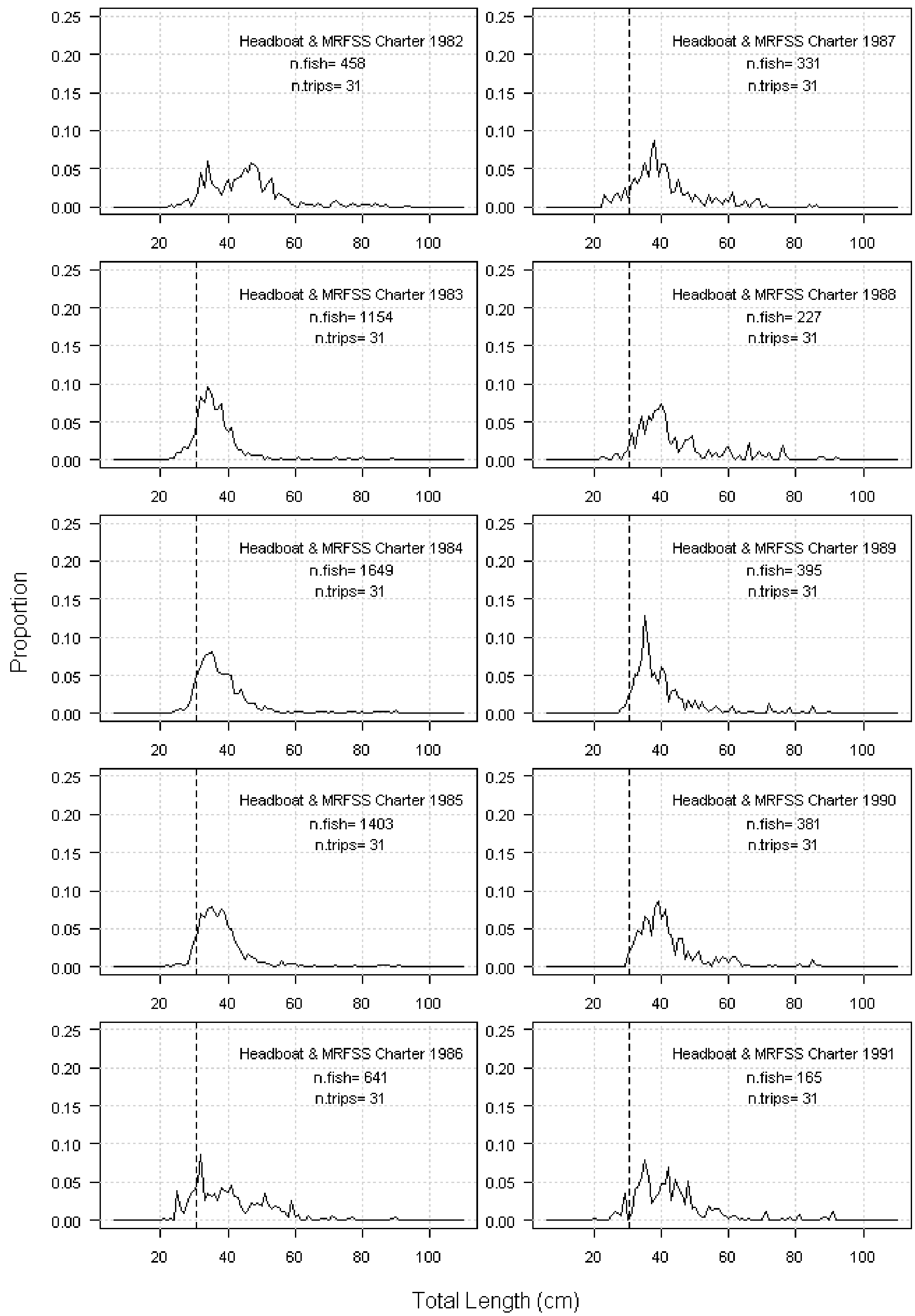


Figure 4.8. continued.

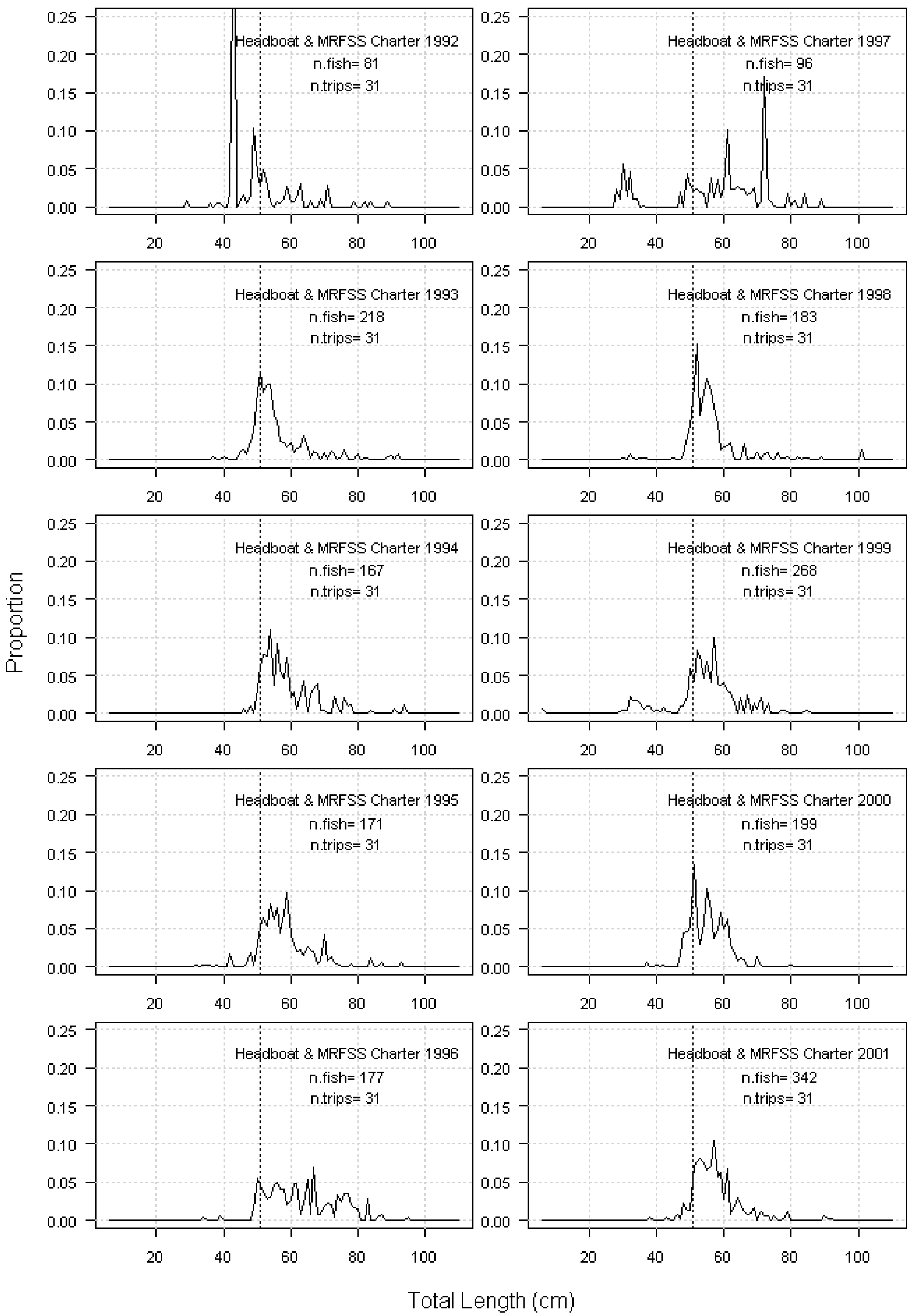


Figure 4.8. (continued).

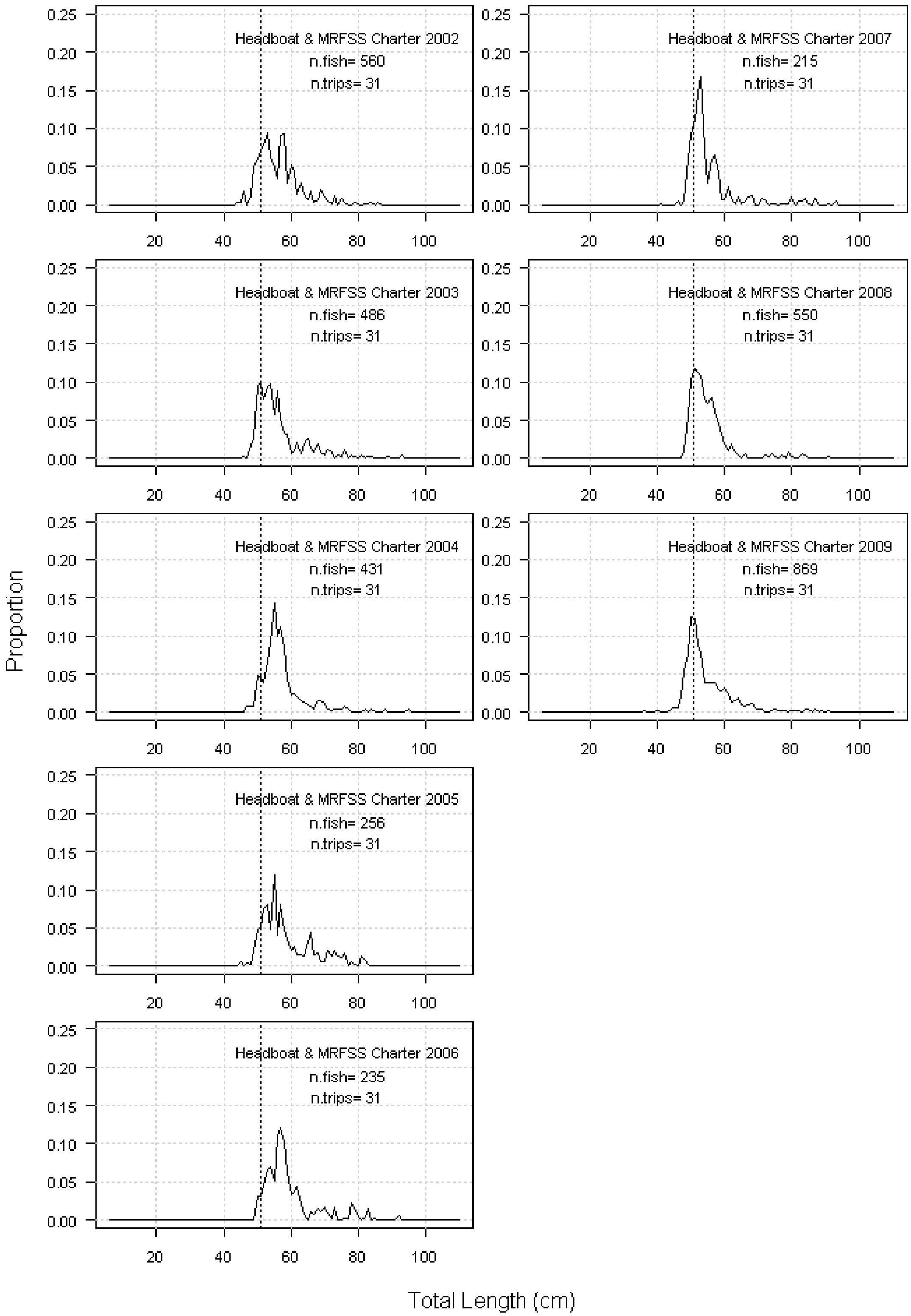


Figure 4.9. Private fleet length composition from the MRFSS 1981-2009.

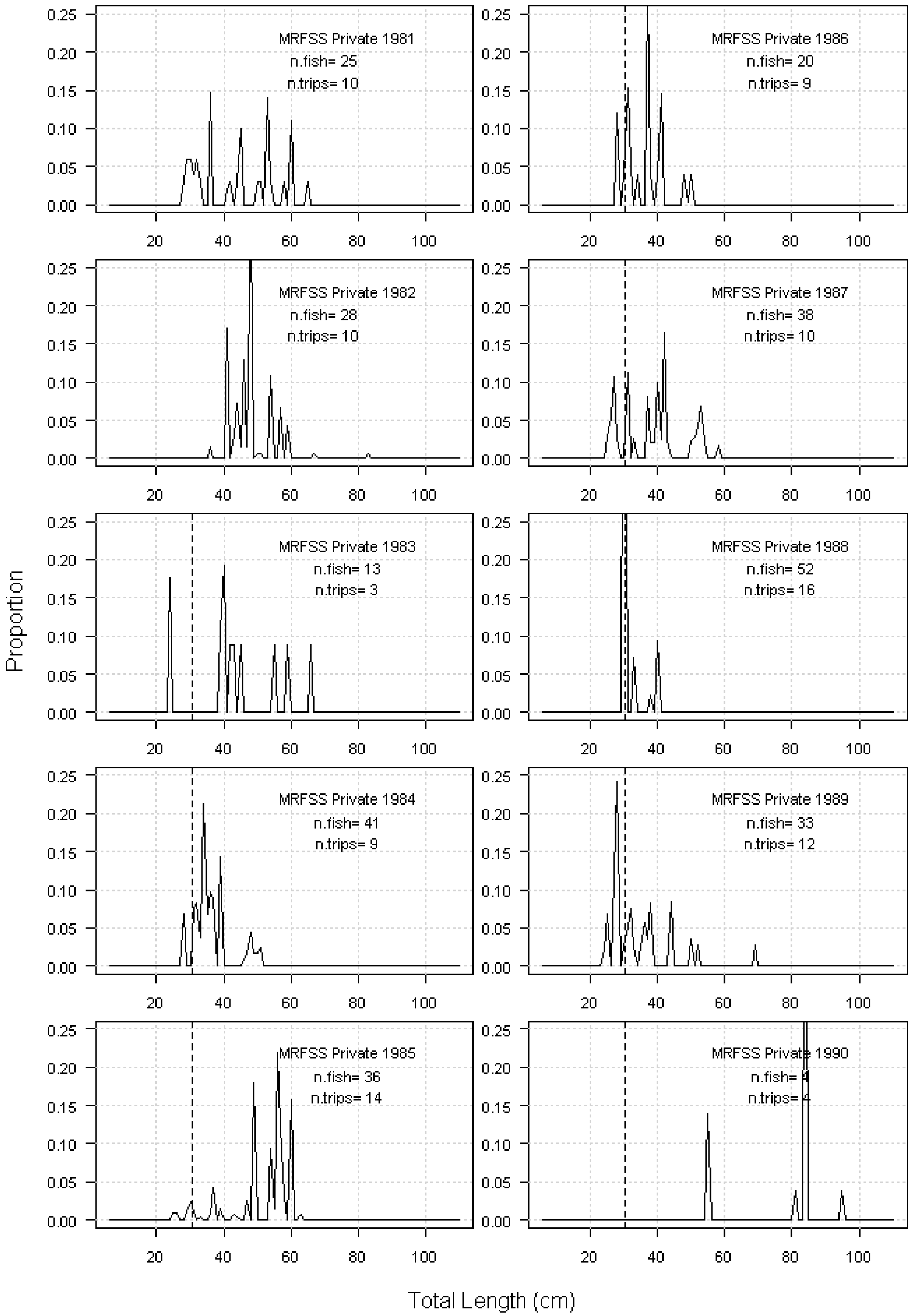


Figure 4.9. continued.

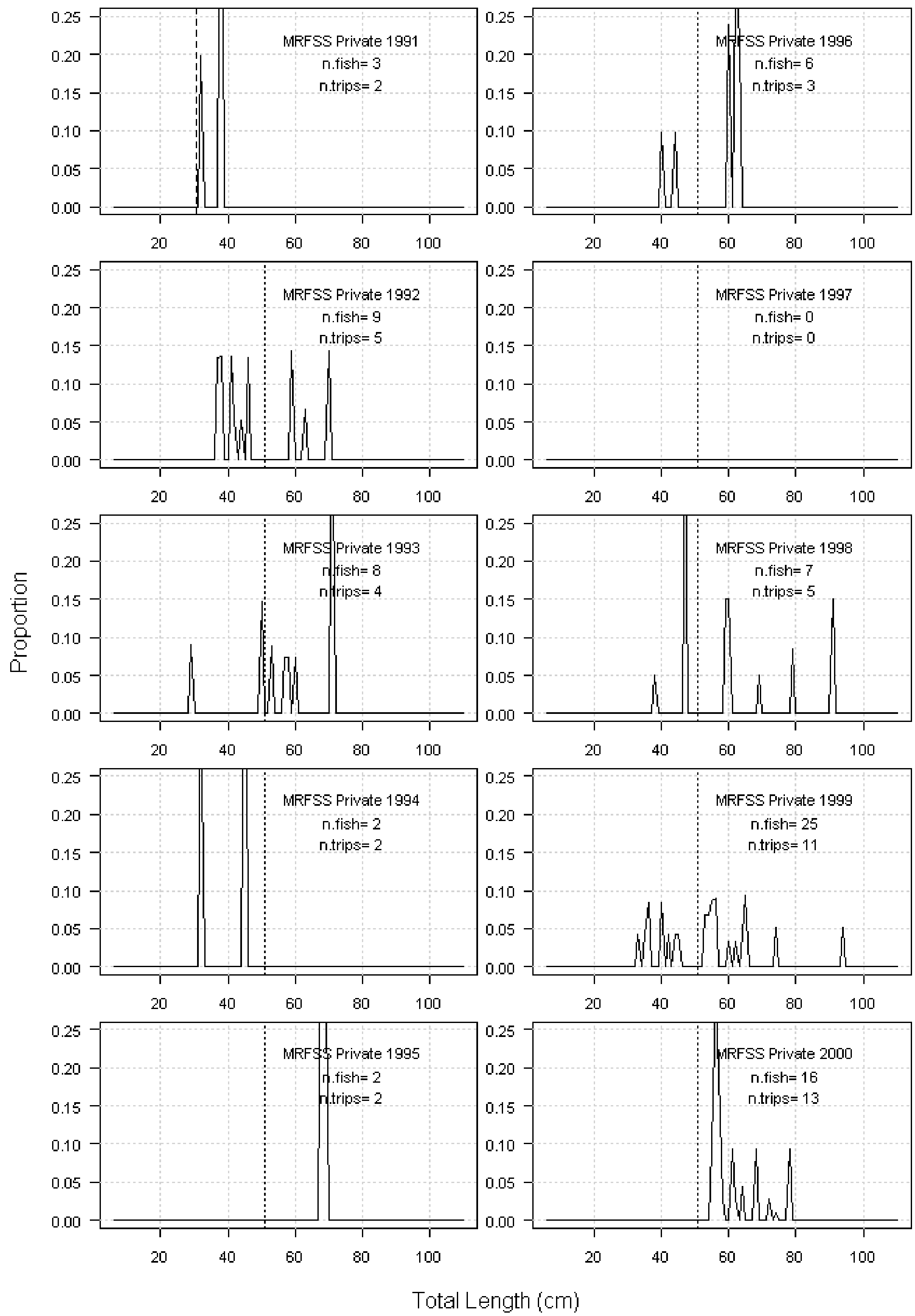


Figure 4.9. continued.

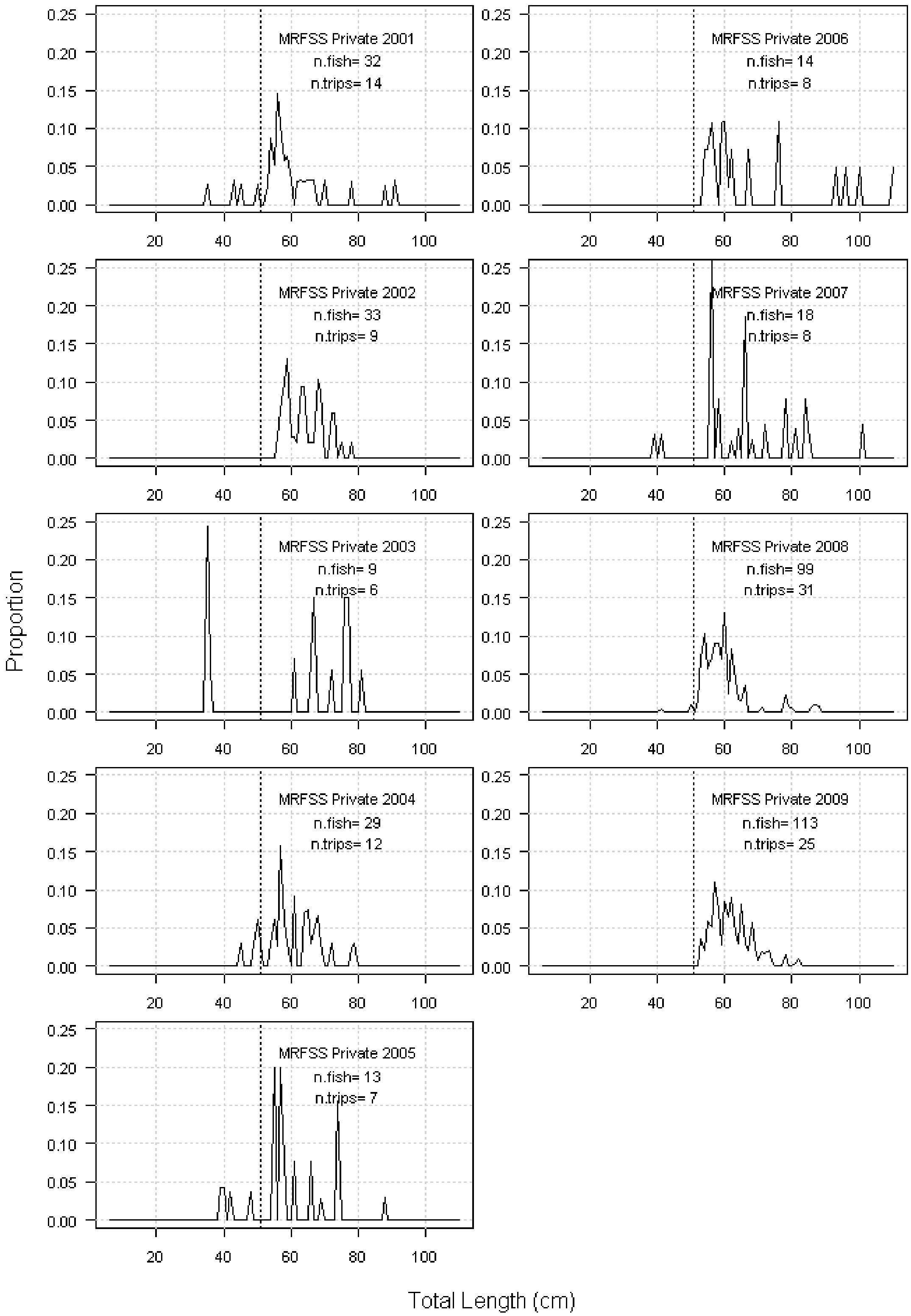


Figure 4.10. Headboat and MRFSS Charter combined age composition 1977-2009 and private fleet age composition from 2004, 2007, and 2009. Ages are plotted to 20 years

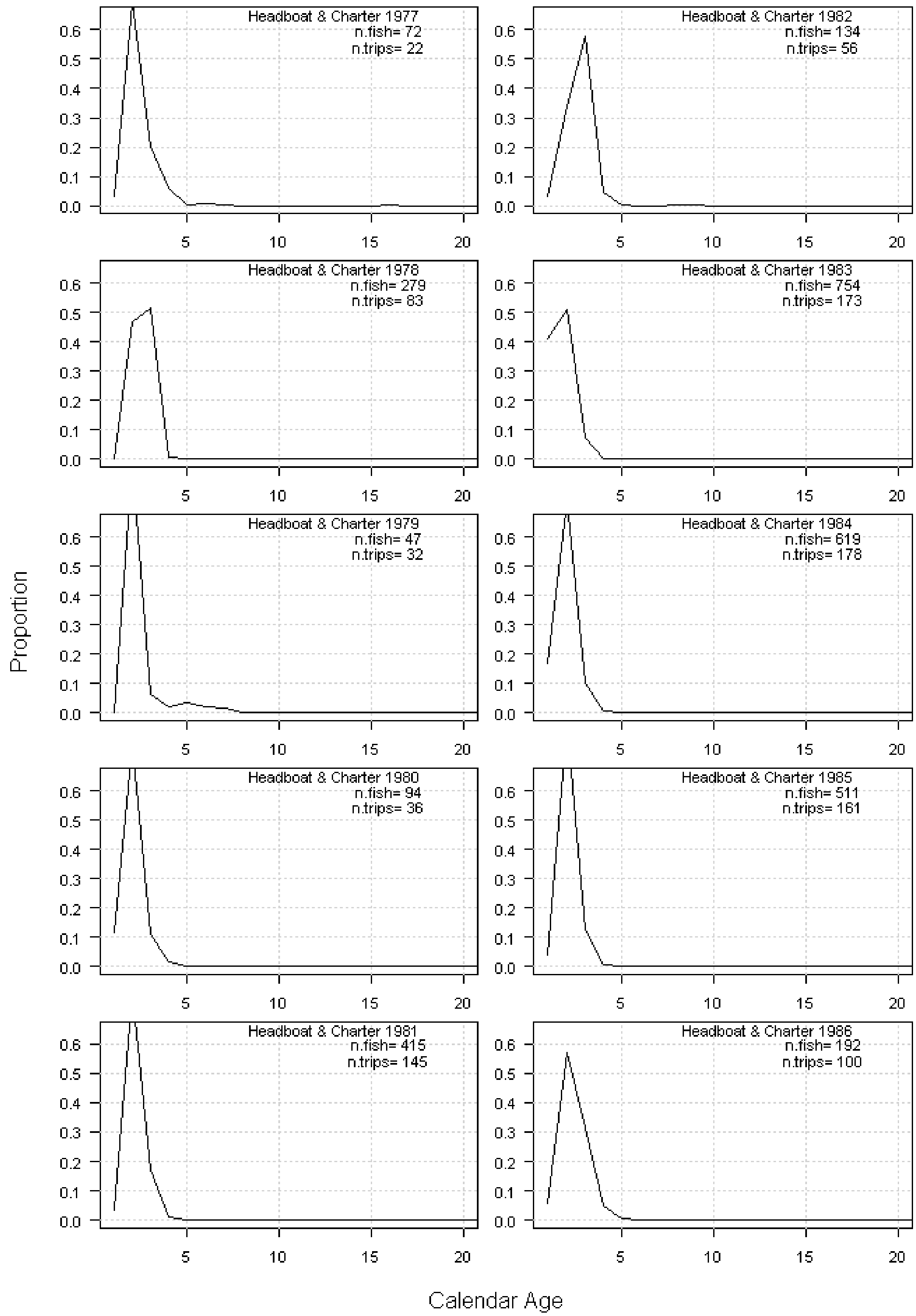


Figure 4.10. continued.

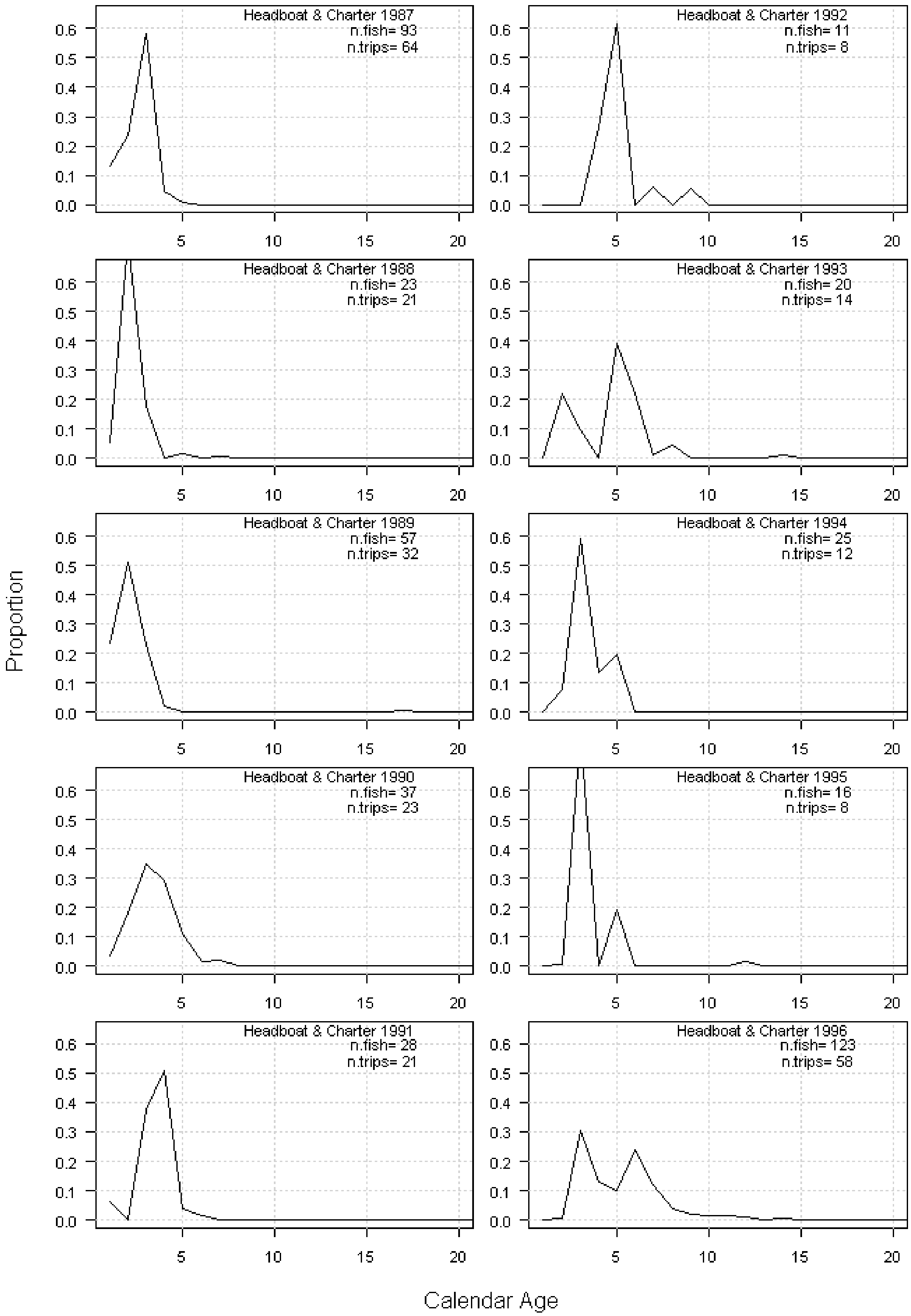


Figure 4.10. continued.

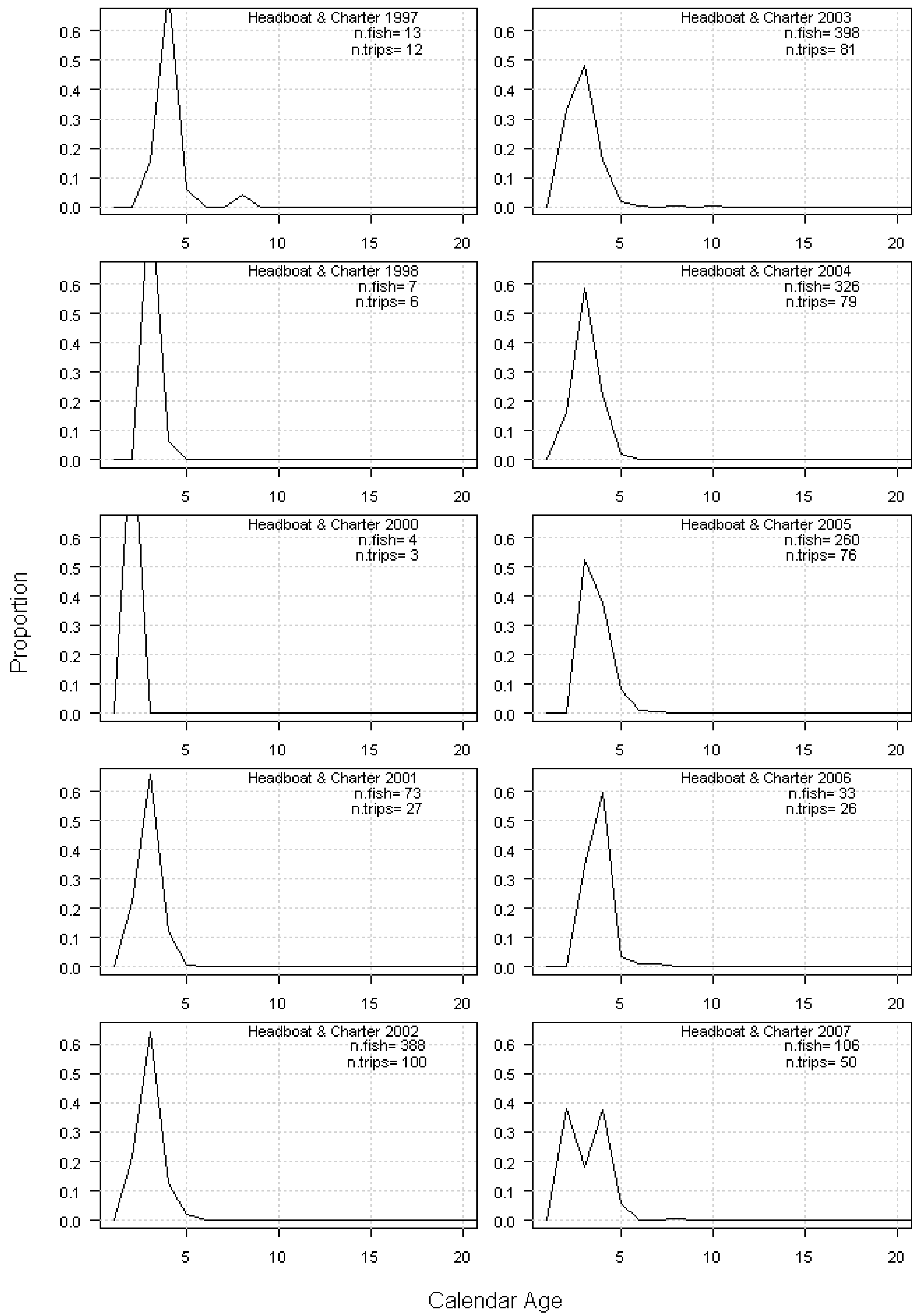
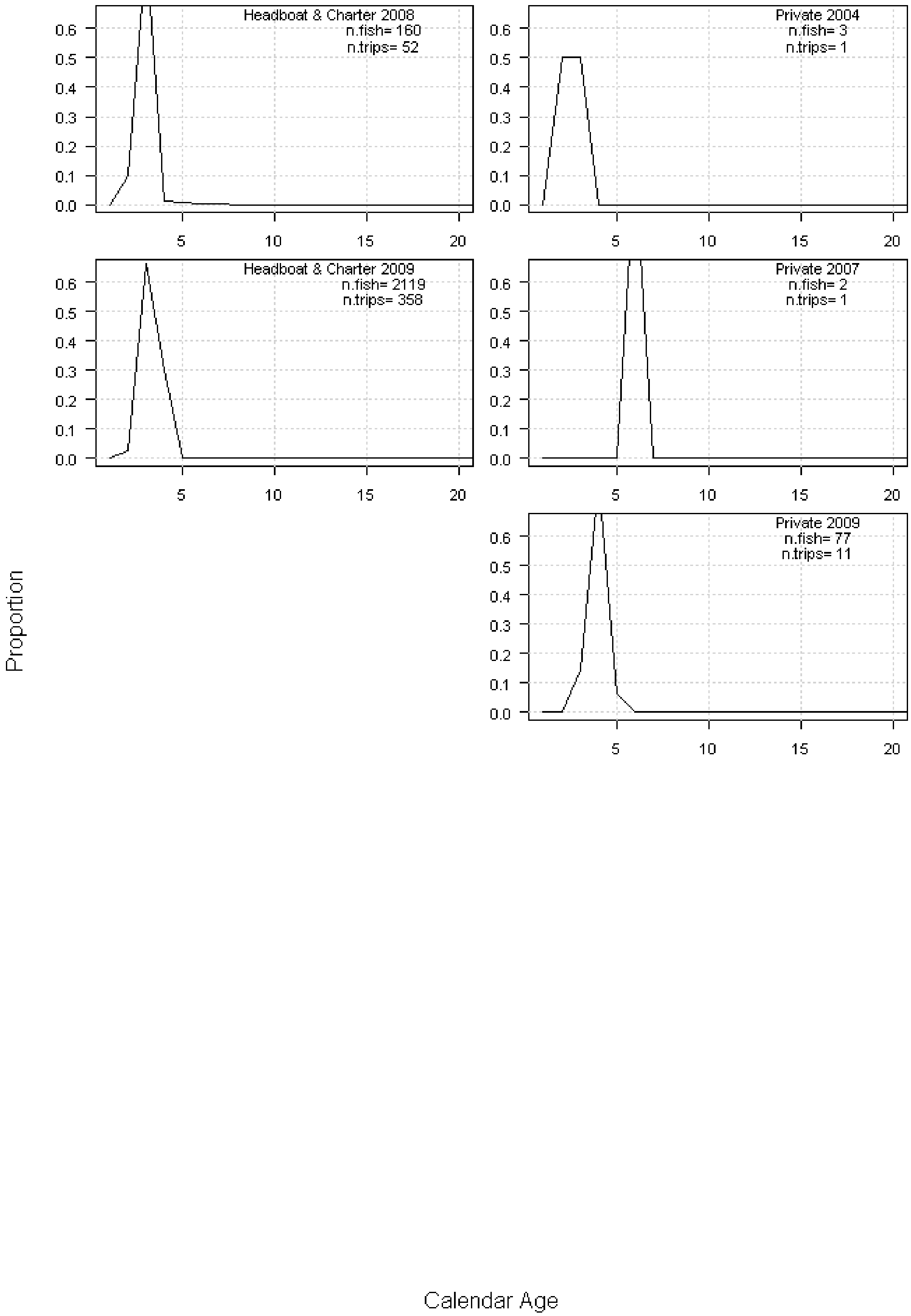


Figure 4.10. Continued.



5. Measures of Population Abundance

5.1 Overview

Several indices of abundance were considered for use in the South Atlantic red snapper assessment model. These indices are listed in Table 5.1.1, with pros and cons of each in Table 5.1.2. The possible indices came from fishery independent and fishery dependent data. The DW recommended the use of three fishery dependent indices (recreational headboat index, commercial logbook index, and headboat observer discards index; Tables 5.1.1 and 5.1.2). The discard index from headboat observers was not available prior to the DW and, although explored by the indices group, could not be standardized during the DW. Thus, the indices work group recommended that the assessment panel consider use of that index more fully. The group's recommendation is fully detailed below.

Group membership

Membership of this DW working group included Julie DeFilippi, Brian Linton (Rapporteur), Amy Schueller (Work group leader), Kyle Shertzer, Paul Spencer, and Jessica Stephen. Several other participants of the data workshop also participated in the indices work group discussions throughout the week.

5.2 Review of Working Papers

The working group reviewed a number of working papers describing index construction, including: SEDAR24-DW03; SEDAR24-DW04; and SEDAR25-DW05. SEDAR24-DW03 was a data working paper describing the computation of a fishery dependent index from the recreational headboat data. This working paper was helpful for determining if the index should be recommended for use and no revisions were required. SEDAR24-DW04 was a data working paper describing the computation of a fishery dependent index from the commercial logbook data. This working paper was helpful for determining if the index should be recommended for use and no revisions were required. SEDAR24-DW05 was a data working paper describing the computation of a fishery dependent index from the recreational MRFSS/MRIP data for the charter and private modes combined. This working paper was a helpful starting point for determining if the index should be recommended for use. The group discussion, documented below, led to this index not be recommended for use and thus, no revisions were required.

5.3 Fishery Independent Indices

Index report cards for all fishery independent data considered at the data workshop can be found in Appendix 5. All fishery independent surveys considered were MARMAP (Marine Resources Monitoring Assessment and Prediction) surveys. Red snapper have been sampled in low numbers by the MARMAP program with a variety of gear types (Table 5.3.1), although mainly with the Chevron trap and Yankee trawl. Although these gear types and sampling methodologies are not specifically designed to sample red snapper populations, the DW considered the data as a possible source to develop an index of abundance.

5.3.1 MARMAP Chevron trap

5.3.1.1 Methods, Gears, and Coverage

Chevron traps were baited with cut clupeids and deployed at stations randomly selected by computer from a database of approximately 2,500 live bottom and shelf edge locations and buoyed ("soaked") for approximately 90 minutes. During the 1990s, additional sites were selected, based on scientific and commercial fisheries sources, off North Carolina and south Florida to facilitate expanding the overall sampling coverage. Spatial coverage included areas from Florida through North Carolina.

5.3.1.2 Sampling intensity and time series

Chevron traps were deployed from 1990 through 2008. The CPUE from MARMAP chevron trap data was computed in units of number of fish caught per trap. In spite of relatively extensive regional coverage (Figure 5.3.1.1), there were few traps that captured red snapper (1-18 per year; Table 5.3.1.1) and few fish caught (4-44 red snapper caught per year).

5.3.1.3 Size/Age data

Not applicable

5.3.1.4 Catch Rates – Number and Biomass

The average nominal CPUE was 0.035 fish/trap-hr (range 0.007 – 0.066).

5.3.1.5 Uncertainty and Measures of Precision

Not applicable

5.3.1.6 Comments on Adequacy for assessment

Among the concerns with the index from chevron traps was that spatial variability in abundance and sampling locations would mask any temporal trends. Because of the low catches and the high variability in the data, the DW did not recommend using MARMAP chevron trap samples to develop an index of abundance for red snapper off the southeastern U.S.

5.3.2 MARMAP hook and line gears

5.3.2.1 Methods, Gears, and Coverage

Hook and line gears included Electramate rods or manual rods. There was much variation in fishing times, number of anglers, configuration of terminal tackle and bait (live and artificial) used. Hook and line collections were any haphazardly deployed angling gear used by either the scientific party or boat crew.

5.3.2.2 Sampling intensity and time series

Hook and line gears were deployed from 1983 through 2009. Due to the variation in fishing methodology, CPUE was not calculated for this gear.

5.3.2.3 Size/Age data

Not applicable

5.3.2.4 Catch Rates – Number and Biomass

Not applicable

5.3.2.5 Uncertainty and Measures of Precision

Not applicable

5.3.2.6 Comments on Adequacy for assessment

Personnel and level of effort have changed over time, compromising the utility of the hook and line survey as an index. Much of the hook and line effort was conducted over mid-shelf depths, and as such may not provide an adequate representation of the complete range of red snapper. As a result, the DW did not recommend using the MARMAP hook and line samples to develop an index of abundance.

5.3.3 MARMAP Short longlines

5.3.3.1 Methods, Gears, and Coverage

The short bottom long line was deployed to catch grouper/snapper over high relief and rough bottom types at depths of 90 to 200 m. This bottom line consisted of 25.6 m of 6.4 mm solid braid dacron groundline dipped in green copper naphenate. The line was deployed by stretching the groundline along the vessel's gunwale with 11 kg weights attached at the ends of the line. Twenty gangions baited with whole squid were placed 1.2 m apart on the groundline which was then attached to an appropriate length of poly warp and buoyed to the surface with a Hi-Flyer. Sets were made for 90 minutes and the gear was retrieved using a pot hauler.

5.3.3.2 Sampling intensity and time series

Short longlines were deployed from 1996 through 2009, and during that time only captured 1 red snapper.

5.3.3.3 Size/Age data

Not applicable

5.3.3.4 Catch Rates – Number and Biomass

Not applicable

5.3.3.5 Uncertainty and Measures of Precision

Not applicable

5.3.3.6 Comments on Adequacy for assessment

Because of the extremely low catches, the DW did not recommend using the MARMAP short bottom long line samples to develop an index of abundance for red snapper.

5.3.4 MARMAP Yankee Trawl

5.3.4.1 Methods, Gears, and Coverage

Yankee trawls were towed for 30 minutes at 6.5 km/h (3.5 knots). This gear was primarily used on regional sand-bottom surveys of the continental shelf and upper slope. The sweep of the Yankee Trawl was 8.748 m, and 3.241 km was the distance covered during a standard 30-min tow (Wenner et al. 1979a), resulting in a swept area of 2.835 ha/tow.

5.3.4.2 Sampling intensity and time series

Yankee trawls were used from 1973 to 1979. In spite of relatively extensive regional coverage, there were few Yankee trawls that captured red snapper (3-10 per year) and low sample sizes per year (3-37 per year).

5.3.4.3 Size/Age data

Not applicable

5.3.4.4 Catch Rates – Number and Biomass

Not applicable

5.3.4.5 Uncertainty and Measures of Precision

Not applicable

5.3.4.6 Comments on Adequacy for assessment

Because of the low catches, high variability, and short time series, the DW did not recommend using the MARMAP Yankee trawl samples to develop an index of abundance for red snapper.

5.3.5 MARMAP Blackfish traps

5.3.5.1 Methods, Gears, and Coverage

Blackfish traps were baited with cut herrings (Brevoortia or Alosa spp., family Clupeidae), placed in the bait wells. Traps were deployed on buoyed lines (2 to a buoy or individually) usually separated by 30.5-m line, or tied off to an anchored vessel (1988 – 1989). Traps were generally set on live-bottom reef areas at depths < 50 m. Each trap soaked for approximately 90 minutes and was retrieved using a hydraulic pot hauler.

5.3.5.2 Sampling intensity and time series

Blackfish traps were used from 1977 to 1989, and in 2006, 2007 and 2008 (for a trap comparison study). Only 7 red snapper was collected with the MARMAP blackfish trap.

5.3.5.3 Size/Age data

Not applicable

5.3.5.4 Catch Rates – Number and Biomass

Not applicable

5.3.5.5 Uncertainty and Measures of Precision

Not applicable

5.3.5.6 Comments on Adequacy for assessment

Because of the low catches and high variability, the DW did not recommend using the MARMAP blackfish trap samples to develop an index of abundance for red snapper.

5.3.6 MARMAP Florida Antillean traps

5.3.6.1 Methods, Gears, and Coverage

Florida Antillean traps were baited with cut herrings (Brevoortia or Alosa spp., family Clupeidae) placed in the bait wells. Traps were deployed individually with 8-mm (5/16-inch) polypropylene line attached to a Hi-Flyer buoy or tied off an anchored vessel (1988-1989). Traps were generally set on live-bottom reef areas on the continental shelf and upper slope. Each trap soaked between 90 and 120 minutes and retrieved with a hydraulic pot hauler.

5.3.6.2 Sampling intensity and time series

Florida Antillean Traps were used from 1980 through 1989, and in 2006, 2007 and 2008 (for a trap comparison study). Only 14 red snapper was collected with the MARMAP Florida Antillean trap.

5.3.6.3 Size/Age data

Not applicable

5.3.6.4 Catch Rates – Number and Biomass

Not applicable

5.3.6.5 Uncertainty and Measures of Precision

Not applicable

5.3.6.6 Comments on Adequacy for assessment

Because of the low catches and high variability, the DW did not recommend using the MARMAP Florida Antillean trap samples to develop an index of abundance for red snapper.

5.4 Fishery Dependent Indices

Index report cards for all fishery dependent data considered at the data workshop can be found in Appendix 5.

5.4.1 Recreational Headboat

The headboat fishery in the south Atlantic includes for-hire vessels that typically accommodate 11-70 passengers and charge a fee per angler. The fishery uses hook and line gear, generally targets hard bottom reefs as the fishing grounds, and generally targets species in the snapper-grouper complex. This fishery is sampled separately from other fisheries, and the available data were used to generate a fishery dependent index, with the size and age range of fish the same as that of landings from the headboat fishery.

Headboats in the south Atlantic are sampled from North Carolina to the Florida Keys (Figure 5.4.1.1). Data have been collected since 1972, but logbook reporting did not start until 1973. In addition, only North Carolina and South Carolina were included in the earlier years of the data set. In 1976, data were collected from North Carolina, South Carolina, Georgia, and northern Florida, and starting in 1978, data were collected from southern Florida (areas 11, 12, and 17).

Variables reported in the data set include year, month, day, area, location, trip type, number of anglers, species, catch, and vessel id. Biological data and discard data were recorded for some trips in some years.

The development of the CPUE index is described in more detail in SEDAR24-DW03. The size and age range of fish included in the index is the same as that of landings from this same fleet. The time series used for construction of the index spanned 1976–2009 because the area with the highest red snapper catches was covered during this entire time series.

5.4.1.1 Methods of Estimation

Subsetting trips

Trips to be included in the computation of the index need to be determined based on effort directed at red snapper. Effort can be determined directly for trips which had positive red snapper catches, but some trips likely directed effort at red snapper, but were unsuccessful at landing red snapper. Given that information on directed effort for trips without red snapper harvest is not available, another method must be used to compute total effort.

In order to determine effort that was likely directed at red snapper and which trips should be used to compute an index, the method of Stephens and MacCall (2004) was applied. The Stephens and MacCall method uses multiple logistic regression to estimate a probability for each trip that the focal species was caught, given other species caught on that trip. Species compositions differ across the south Atlantic; thus, the method was applied separately for two different regions: north (areas 2-10) and south (areas 11, 12, and 17; Shertzer and Williams 2009). To avoid computation errors, the number of species in each analysis was limited to those species that occurred in 1% or more of trips. The most general model therefore included all species in the snapper-grouper complex which occurred in 1% or more of trips as main effects, excluding red porgy. Red porgy was eliminated because of regulation changes, which could erroneously remove trips likely to have caught red snapper in recent years. A backwards stepwise AIC procedure (Venables and Ripley 1997) was then used to perform further selection among possible species as predictor variables. In this procedure, a generalized linear model with Bernoulli response was used to relate presence/absence of red snapper in headboat trips to presence/absence of other species. A trip was included as effort if the trip's probability of catching red snapper was higher than a threshold probability.

Standardization method

Catch per unit effort (CPUE) has units of fish/angler-hour and was calculated as the number of red snapper landed divided by the product of the number of anglers and the number of trip hours. CPUE was modeled using the delta-glm approach (cf., Lo et al. 1992; Dick 2004; Maunder and Punt 2004). Factors included in the glm included year, area, season, trip type, and number of anglers as a categorical variable. The effort by factor and landings by factor are shown in Table 5.4.1.3, as well as the proportion of positive effort by factor. In particular, fits of lognormal and gamma models were compared for positive CPUE, and the predictor variables described above were examined to determine which best explained CPUE patterns (both for positive CPUE and 0/1 CPUE). Jackknife estimates of variance were computed using the 'leave one out' estimator (Dick 2004).

The Bernoulli sub-model was fit with all main effects in order to determine which should remain in the binomial component of the delta-GLM. Stepwise AIC (Venables and Ripley1997) with a backwards selection algorithm was then used to eliminate those that did not improve model fit. In this case, the stepwise AIC procedure did not remove any predictor variables.

The positive portion of the model was fit with all main effects using both the lognormal and gamma distributions. Stepwise AIC (Venables and Ripley1997) with a backwards selection algorithm was then used to eliminate those that did not improve model fit. Backwards model selection eliminated only the trip type variable for the lognormal distribution and did not eliminate any of the predictor variables for the gamma distribution.

The lognormal model with all factors except trip type was used for computing the positive component of the index, and the binomial with all factors was used for computing the Bernoulli component of the index.

5.4.1.2 Sampling Intensity

The resulting data set, after applying the Stephens and MacCall method, contained 46,404 trips in the northern region and 29,548 (64%) of those trips were positive, and 1,662 trips in the southern region and 413 (25%) of those trips were positive. A summary of the total number of trips with red snapper effort per year is provided in Table 5.4.1.1, and a summary of the total number of trips with positive red snapper catch per year is provided in Table 5.4.1.2.

5.4.1.3 Size/Age data

The sizes/ages represented in this index should be the same as those of landings from the corresponding fleet (See section 4 of this report).

5.4.1.4 Catch Rates

Nominal and standardized catch rates are shown in Figure 5.4.1.2 and are tabulated in Table 5.4.1.4.

5.4.1.5 Uncertainty and Measures of Precision

Measures of precision were computed using a jackknife procedure. Annual CVs of catch rates are tabulated in Table 5.4.1.4.

5.4.1.6 Comments on Adequacy for Assessment

The index of abundance from the headboat data was considered by the indices working group to be adequate for use in this assessment. The data cover the full range of the stock for the South Atlantic and is a complete census of the headboats. The data set has an adequately large sample size and has a long enough time series to provide potentially meaningful information for the assessment. The sampling was consistent over time, and some of the data were verified by port samplers and observers. These data represent effort for snapper-grouper species and not necessarily for the focal species, which should minimize changes in catchability relative to fishery dependent indices that target specific species. The primary caveat about this index is that it was derived from fishery dependent data.

5.4.1.7 Decision to have headboat index represent both headboat and MRFSS charterboats

The recreational fishery working group made a recommendation that the recreational fishery be split into private boat and for-hire (charterboat and headboat) fisheries, which was accepted by the data workshop panel. There were two potential indices that could be used to represent the for-hire fishery: the recreational headboat index and an index constructed from MRFSS charterboat data. A MRFSS charterboat index was not constructed, because the indices working group felt that the recreational headboat index would better represent the for-hire recreational fishery. If a MRFSS charterboat index were constructed, and it agreed with the headboat index, then likely only the headboat index would be recommended for use in the assessment. Likewise, if the MRFSS charterboat index did not agree with the headboat index, then only the headboat index would be recommended for use in the assessment. In both cases, the headboat index would be recommended over the MRFSS charterboat index, because MRFSS charterboat data have much smaller sample sizes, higher uncertainty, and a shorter time series than the headboat data (a MRFSS index would begin in 1991, when data could be identified to the level of trip). MRFSS discards are self-reported and less reliable than the headboat data. In addition, the headboat fishery targets the entire snapper-grouper complex rather than specifically targeting red snapper, which should minimize changes in catchability over time. The data workshop panel accepted this recommendation from the indices working group.

5.4.2 Index of Abundance from commercial logbook data

Landings and fishing effort of commercial vessels operating in the southeast U.S. Atlantic have been monitored by the NMFS Southeast Fisheries Science Center through the Coastal Fisheries Logbook Program (CFLP). The program collects information about each fishing trip from all vessels holding federal permits to fish in waters managed by the Gulf of Mexico and South Atlantic Fishery Management Councils. Initiated in the Gulf in 1990, the CFLP began collecting logbooks from Atlantic commercial fishers in 1992, when 20% of Florida vessels were targeted. Beginning in 1993, sampling in Florida was increased to require reports from all vessels permitted in coastal fisheries, and since then has maintained the objective of a complete census of federally permitted vessels in the southeast U.S.

As described in SEDAR24-DW04, catch per unit effort (CPUE) from the logbooks was used to develop an index of abundance for red snapper landed with vertical lines (manual handline and electric reel), the dominant gear for this red snapper stock. Thus, the size and age range of fish included in the index is the same as that of landings from this same fleet. The time series used for construction of the index spanned 1993–2009, when all vessels with federal snapper-grouper permits were required to submit logbooks describing each fishing trip.

5.4.2.1 Methods of Estimation

Available data and treatment

For each fishing trip, the CFLP database included a unique trip identifier, the landing date, fishing gear deployed, areas fished, number of days at sea, number of crew, gear-specific fishing effort, species caught, and weight of the landings. Fishing effort data available for vertical line gear included number of lines fished, hours fished, and number of hooks per line. For this southeast U.S. Atlantic stock, areas used in analysis were those between 24 and 36 degrees latitude, inclusive of the boundaries (Figure 5.4.2.1).

Effective effort was based on those trips from areas where red snapper were available to be caught. Without fine-scale geographic information on fishing location, trips to be included in the analysis must be inferred, which was done here using the method of Stephens and MacCall (2004). The method uses multiple logistic regression to estimate a probability for each trip that the focal species was caught, given other species caught on that trip. Because a zoogeographic boundary is apparent near Cape Canaveral (Shertzer et al., 2009), the method was applied separately to data from regions north and south of 28 degrees latitude (near Cape Canaveral). A backward stepwise AIC procedure (Venables and Ripley, 1997) was then used to perform further selection among possible species as predictor variables, where the most general model included all listed species as main effects. In this procedure, a generalized linear model with Bernoulli response was used to relate presence/absence of red snapper in each trip to presence/absence of other species. A trip was then included if its associated probability of catching red snapper was higher than a threshold probability.

Standardization methods

CPUE was modeled using the delta-GLM approach (Lo et al., 1992; Dick, 2004; Maunder and Punt, 2004). This approach combines two separate generalized linear models (GLMs), one to describe presence/absence of the focal species, and one to describe catch rates of successful trips (trips that caught the focal species). The response variable, CPUE, was calculated for each trip as,

CPUE = pounds of red snapper landed/hook-hours

where hook-hours is the product of number of lines fished, number of hooks per line, and total hours fished. Explanatory variables, all categorical, are described below. Estimates of variance were based on the jackknife “leave one out” estimator. All analyses were programmed in R, with much of the code adapted from Dick (2004).

A Bernoulli sub-model was used to describe the presence/absence of red snapper caught on each trip. Lognormal and gamma sub-models were considered to explain the distribution of catch rates on trips successful for red snapper, and the lognormal model was selected based on AIC.

Explanatory variables (levels) considered were year (1993─2009), season (spring, summer, fall, winter), area (NC, SC, GA, North FL, South FL), days at sea (1, 2─4, 5+), and crew size (1, 2, 3+). Applied separately to the Bernoulli and lognormal sub-models, backward stepwise AIC was used to select explanatory variables. In each case, all explanatory variables were retained. Total effort and landings by factor are shown in Table 5.4.2.1.

5.4.2.2 Sampling Intensity

After applying the Stephens and MacCall method, the resulting subsetted data set contained 17,692 trips in the northern sampling areas (NC─North FL), of which ~63% were positive, and 2,603 trips from the southern sampling area (South FL), of which ~35% were positive. Annual number of trips on which the index is based are shown in Table 5.4.2.2, as well as annual proportion positive.

5.4.2.3 Size/Age data

The sizes/ages represented in this index should be the same as those of landings from the corresponding fleet (commercial vertical lines, i.e., handlines).

5.4.2.4 Catch Rates

Nominal and standardized catch rates are shown in Figure 5.4.2.2 and are tabulated in Table 5.4.2.2.

5.4.2.5 Uncertainty and Measures of Precision

As described previously, measures of precision were computed using a jackknife procedure. Annual CVs of catch rates are tabulated in Table 5.4.2.2.

5.4.2.5 Comments on Adequacy for Assessment

The index of abundance from commercial logbook data was considered by the indices working group to be adequate for use in assessment. The data cover the full range of the stock and, because the logbooks are intended to be a complete census of commercial fishermen with snapper-grouper permits, have an adequately large sample size. In addition, the time series has a long enough duration (17 years) to provide potentially meaningful information for the assessment. The primary caveat about this index is that it was derived from fishery dependent data.

5.4.3 MRFSS/MRIP Recreational Intercepts
(Private mode only - See section 5.4.1.7 for charter boat mode discussion.)

The Marine Recreational Fisheries Statistics Survey (MRFSS) samples the general recreational fishery. This national survey intercepts anglers fishing from shore, man-made structures, private/rental boats, and charter boats. Headboats are another component of recreational fishing, but they are sampled by a separate headboat survey. Based on the recommendations of the recreational workgroup (see section 4: headboats and charter boats were combined into a for-hire sector and private boats were left as a separate sector) only private boats were included in calculating the landings and thus were considered for this index. Because red snapper in the South Atlantic are considered distinct from those in the Gulf of Mexico, only MRFSS intercepts from North Carolina through Miami-Dade county in Florida were included in this analysis (Figure 5.4.3.1). Although MRFSS intercepts began in 1979, MRFSS changed their sampling protocol in 1991 to link additional interviews from the same trip together. Additionally, 1991 was the first full year after the extensive training of samplers had been implemented. Therefore, the index of abundance discussed only used data from 1991 through 2009 for the private boat mode only. However, the indices workgroup thought that, if a MRFSS private boat index were used, it should begin in 1999, because before 1999, the samples sizes were low.

5.4.3.1 Methods of Estimation

There were 112,123 MRFSS intercepts in the private boat mode from nearshore (state) and offshore waters (federal), and 73 species including red snapper occurred on at least 0.25% of those intercepts. In this analysis, those additional intercepts from the same fishing trip that caught fish but were unavailable to the creel sampler were linked back to the main intercept for the party.

Over the 19 years from 1991 through 2009, there were 846 trips that caught red snapper in the study area. Including trips with discards did not greatly increase sample size. However, there were trips that could have caught red snapper, but didn't. To identify that effort and include it in the catch rate standardization process, Stephens and MacCall (2004) logistic regressions (S&M) were employed. The rationale of S&M is to identify a homogeneous group of intercepts that are believed to reflect the abundance of the target species. The S&M method uses a logistic regression of presence or absence by species on each intercept to predict whether the target species (red snapper) could be caught on the trip. Following Stephens and MacCall's example, species that occurred on less than 1% of the total number of intercepts were omitted.

For the S&M method, the intercept data were rearranged to one record per intercept with binomial (presence or absence) information for each of the 73 species. The response variable in the logistic regression was the presence (1) or absence (0) of red snapper on each intercept and the predictor variables in the full model were the presence or absence of the other 72 species. There were 27 species (Figure 5.4.3.2) whose regression coefficients were significant at the $\alpha = 0.05$ level and those species were used in the final, reduced model.

Potential thresholds (estimated probability of catching red snapper) for choosing whether to include an intercept in the catch rate analysis ranged from 0.01 to 0.99 and the critical value was based on the minimum absolute difference between observed number of intercepts with red snapper and the predicted number of intercepts. The smallest absolute difference occurred with a threshold of 0.160. There were 850 intercepts that exceeded the 0.160 threshold.

Standardization was not performed because it was determined at this point that sample size issues would make the index inadequate for use in the model.

5.4.3.2 Sampling Intensity

Sampling intensity (number of intercepted trips) in the study area by year is shown in Table 5.4.3.1.

5.4.4.3 Size/Age Data

Sizes and ages of fish represented by this index are the same as those of the recreational fishery as sampled by the MRFSS (see Chapter 4 of this DW report).

5.4.3.4 Catch Rates – Number and Biomass

Table 5.4.3.1 and Figure 5.4.3.3 show the nominal red snapper catch rate (number/trip).

5.4.3.5 Uncertainty and Measures of Precision

Table 5.4.3.1 and Figure 5.4.3.3 show the coefficient of variation for the nominal red snapper catch rate.

5.4.3.6 Comments on Adequacy for Assessment

MRFSS private boat mode only intercepts anglers at public landings, missing anglers that launch from private landings. Therefore, MRFSS may not represent the entire private boat fishery. Given the relatively low sample size and high variability for a fishery dependent index and the suspected lack of representation of the fishery, the indices work group does not feel that this index is adequate for the assessment and does not recommend it for inclusion in the model. This recommendation was accepted at the plenary session.

5.4.4 Recreational SC V1 Vessel Logbook Data

In 1993, SCDNR's Marine Resources Division (MRD) initiated a mandatory logbook reporting system for all charter vessels to collect basic catch and effort data. Under state law, vessel owners/operators carrying fishermen on a for-hire basis are required to submit monthly trip level reports of their fishing activity in waters off of SC. The charter boat logbook program is a complete census and should theoretically represent the total catch and effort of the charter boat trips in waters off of SC. The charter logbook reports include: date, number of fishermen, fishing locale (inshore, 0-3 miles, >3miles), fishing location (based on a 10x10 mile grid map), fishing method, hours fished, target species, and catch (number of landed and released fish by species) per vessel per trip. The logbook forms have remained similar throughout the program's existence with a few exceptions: in 1999 the logbooks forms were altered to begin collecting the number of fish released alive and the number of fish released dead (prior to 1999 only the total number of fish released were recorded) and in 2008 additional fishing methods were added to the logbook forms, including cast, cast and bottom, and gig.

5.4.4.1 Methods of Estimation

A subset of the data was created using the Stephens and MacCall (2004) method. To be included, the species had to be present in a minimum of 1% of the trips. Species were then selected by backward stepwise AIC. The subsetting method effectively removed all inshore trips. Data was standardized with delta-GLM standardization method. The predictors included were year, season, number of anglers, and method of fishing. Variance was estimated using a jackknife procedure.

5.4.4.2 Sampling Intensity

SCDNR logbook vessel trips represent snapper grouper fishing trips where at least one of a suite of bottom fishes (likely, or even possibly, to occur in association with red snapper) were caught. Trips that were a combination of trolling and bottom fishing were included. These raw logbook data represent 15,260 fishing trips in which 65,215 anglers caught 10,114 red snapper and harvested 4,368 red snapper before the Stephens and MacCall selection procedure (Table 5.4.4.1).

5.4.4.3 Size/Age data

Not applicable.

5.4.4.4 Catch Rates – Number and Biomass

Catch per unit effort was calculated as the number of fish kept per angler-hour. Table 5.4.4.2 and Figure 5.4.4.1 show the nominal and standardized red snapper catch rates.

5.4.4.5 Uncertainty and Measures of Precision

Table 5.4.4.2 and Figure 5.4.4.1 show the coefficients of variation.

5.4.4.6 Comments on Adequacy for Assessment

Because the data only cover one area and are already reported in other datasets, the DW did not recommend using SC Charter logbook data to develop an index of abundance for red snapper off the southeastern U.S. The DW did note that it followed similar trends seen in the other indices, particularly the nominal index for South Carolina headboats.

5.4.5 Other Data Sources Considered

Several fishery-dependent datasets were introduced at the SEDAR 24 data workshop and considered by the Indices Workgroup. South Atlantic landings data from commercial logbooks from 1975-1990 were presented, but no fishing effort was available to compute a CPUE index.

Captain Steve Amick also presented records of his headboat fishing catch and effort in Georgia from 1983-2009. The overall pattern of this index appeared consistent with the more comprehensive headboat logbook records, which contained the latter portion (1994-2009) of the index. Additionally, the Indices Workgroup was concerned with the limited geographic coverage and the limited sample size (containing only records from one fisherman). Thus, the indices work group did not recommend these data for inclusion as an index, and this recommendation was accepted by the data workshop panel.

5.4.5.1 Headboat at-sea observer data

At-sea observer sampling of anglers in the headboat fishery was conducted from 2005-2009 in Florida and Georgia, and from 2004-2009 in North and South Carolina. These data are more fully described in SEDAR24-DW15. The dataset available at the workshop was the data from Florida, and a nominal CPUE index of discards was computed from the Florida data. Because the observers recorded the number and lengths of all fish caught, this index provides valuable information on both the amount and size composition of the discarded catch. This index could provide information on the relative strengths of young age classes observed by the fishery, and thus could provide the assessment with recruitment signals in recent years. However, this index was not standardized prior to the DW, and there is limited time and resources to do so in time for the assessment workshop. Options include (in order of increasing work): 1) not include the index; 2) include the nominal CPUE index; 3) conduct a standardization of only the trips that caught red snapper; and 4) conduct a standardization of all trips that could be considered effort for red snapper, with effort identified with the Stephens and MacCall (2004) approach. The Indices Workgroup recommends that an attempt be made to standardize the index, but use the nominal CPUE if the standardization cannot be completed in time. Although this data set was available for review by the Indices Group, the standardized index itself was not, and thus the group further recommends that this index receive additional evaluation from the assessment panel.

5.5 Consensus Recommendations and Survey Evaluations

No fishery independent indices were recommended for use in the assessment, and three fishery dependent indices were recommended: recreational headboat index; commercial logbook index; and headboat at sea observer discards index. The two indices that have been computed are compared graphically in Figure 5.5.1. A summary of each index and their CVs are presented in Table 5.5.1. The correlation between the two indices was 0.767 (P-value=0.00; H_A: true correlation is not equal to 0).

The relative ranking of the reliability of the recommended indices was discussed. Based on these discussions, the indices recommended for the assessment were ranked as follows:

1. Headboat index
    - Longest time series
    - Operates in a manner more similar to fishery independent data collection because the fishery targets the snapper-grouper complex in general rather than the focal species specifically
2. Commercial logbook index
3. Headboat at sea observer discard index
    - Shortest time series
    - Lower representation from other states in south Atlantic compared to Florida (for example, 36 trips total in Georgia: SEDAR24-DW15).

Finally, as part of the data workshop, the work group discussed potential changes in red snapper catchability with approximately 6-9 fishermen who participated in the data workshop. We thank those fishermen for taking the time to discuss this topic, as fishermen have firsthand knowledge on potential changes in catchability over time. For more general changes in catchability for the south Atlantic, please see SEDAR 2009, and for a longer history of the red snapper fishery see SEDAR24-DW11. Based on this discussion of red snapper specific catchability changes from the 1970s to the present, below is a list of potential factors that could have changed catchability and when those changes occurred:

- 1970's Loran C was introduced and increased catchability for those who were entering or newer in the fishery
- 2000 GPS was becoming prevalent and likely increased the catchability for casual and newer fishermen
- Gear has not changed much-in northern part of region (for the commercial fishery)
- Gear in the southern part of the region (FL; for the commercial fishery) has changed from bandits to rod and reels with the change occurring in 2004/2005.
- The recreational headboat gear has not changed much over time.
- The fishermen felt that the overall expertise of fishermen as a collective group was pretty constant over time as members left the fishery and as new members joined the fishery.

- Thermoclines (i.e. Labrador current upwelling) have become more frequent in last few years and occur during a larger part of the year in recent years. This has caused reduced catchability as fish do not want to bite and are more inactive.
- 2003/2004 were active hurricane years with 4-6 weeks of fishing time lost after hurricanes.
- Fuel prices since 2005 have increased and have reduced the number of trips. This should be accounted for in reported fishing effort.
- A red tide event in 2007 which ranged up to northern FL and GA
-

5.6 Itemized List of Tasks for Completion following Workshop

- Draft of indices work group text to work group by end of day June 2
- Comments on text to work group leader by end of day on June 9
- Final text to SEDAR by June 11
- Attempt to compute the standardized headboat at sea observer discards index, Amy Schueller, deadline: June 18, 2010

5.7 Literature Cited

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5.8 Tables

Table 5.1.1. Table of the data considered for the construction of a CPUE index.

Fishery Type	Data Source	Area	Years	Units	Standardization Method	Issues	Use?
Independent	MARMAP Chevron Trap	NC – FL	1990-2009	Fish / trap hour	-	Low catch High variance	No
Independent	MARMAP Yankee Trawl	NC-FL	1973-1979	Number / trawl	-	Low catch High variance	No
Independent	MARMAP Blackfish	NC-FL	1978-1988	Number / trap hour	-	Low catch	No
Independent	MARMAP FL Antillian trap	NC-FL	1981-1987	Number / trap hour	-	Low catch	No
Independent	MARMAP Short longline	NC-FL	1980-2009	Number / hook hour	-	1 red snapper caught	No
Independent	MARMAP Hook and line	NC-FL	1983-2009	Number / hook hour	-	Change in methodology over time Designed to supplement age-growth datasets	No
Recreational	Headboat	NC-FL	1976-2009	Fish/ angler-hour	Delta glm	Fishery dependent	***Yes***
Recreational	MRFSS: private boat	NC-FL	1991-2009 1999-2009	Fish/angler-trip Fish/angler-trip	- -	Low sample; high variability Low sample size, high variability, whether or not representative of private boats	No
Commercial	SC Charter Boat	SC	1993-2009	Number fish kept/angler hrs	Delta glm	Only one state represented Captured in other dataset	No
Commercial	Commercial Logbook	NC-FL	1993-2009	Lbs kept/hook hours	Delta glm	Fishery dependent	***Yes***
Recreational	Steve Amick Headboat logbook data	GA	1983-2009	Fish /angler-trip	-	One fisherman only Contained within headboat database in recent years Limited geographic coverage (GA)	No
Commercial	Logbook landings	NC-FL	1975-1990	No CPUE index	-	No CPUE index because no effort data available	No
Recreational	Headboat at sea Observer Discard Data	NC-FL	2005-2009	Fish/ angler-hour	Delta glm	Using discards, fishery dependent	***Yes***

Table 5.2.1. Table of the pros and cons for each data set considered at the data workshop.

Fishery dependent indices

Commercial Logbook – Handline (*Recommended for use*)

Pros:
- Complete census
- Covers entire management area
- Continuous, 17-year time series
- Large sample size

Cons:
- Fishery dependent
- Data are self-reported and largely unverified
- Little information on discard rates
- Catchability may vary over time or with abundance

Issues Discussed:
- Possible shift in fisherman preference may have been addressed by Stephens and MacCall (2004) approach
- In some cases, self-reported landings have been compared to TIP data, and they appear reliable
- Changes in catchability over time (e.g., due to advances in technology or knowledge) might be addressed in the assessment model

Recreational Headboat (*Recommended for use*)

Pros:
- Complete census
- Covers entire management area
- Longest time series available
- Some data are verified by port samplers and observers
- Consistent sampling
- Large sample size
- Non-targeted for focal species, which should minimize changes in catchability relative to fishery dependent indices that target specific species

Cons:
- Fishery dependent
- Little information on discard rates
- Catchability may vary over time or with abundance

- **Table 5.2.1 continued**
  Issues Addressed:
  - Possible shift in fisherman preference may have been addressed by Stephens and MacCall (2004) approach
  - Changes in catchability over time (e.g., due to advances in technology or knowledge) might be addressed in the assessment model

MRFSS-private mode (*Not recommended for use*)
  Pros:
  - Only data available on private boats

  Cons:
  - Fishery dependent
  - Low sample sizes, particularly for a fishery dependent data set
  - High uncertainty in MRFSS data
  - Data may not be representative of private boat mode

SC logbook data for V1 vessels *(Not recommended for use)*
  Pros:
  - Census of charter vessels with 1-6 passengers in SC
  - Continuous, 17-year time series
  - Relatively large sample size

  Cons:
  - Fishery dependent
  - Data are self-reported and largely unverified
  - Only one state, doesn't cover entire management area
  - Included in other data sets potentially
  - Catchability may vary over time or with abundance

1975-1990 commercial logbook landings *(Not recommended for use)*
  Cons:
  - No effort data available, thus no CPUE index could be computed

S. Amick Headboat logbook data 1983-2009 *(Not recommended for use)*
  Cons:
  - Included in the headboat database in more recent years (1994-2009)
  - Limited geographic coverage (Georgia)
  - Limited sample size (only trips from one fisherman)

  Issues discussed:
  - The HPUE trends are similar to the trends in the HB index

Table 5.2.1 continued

Florida headboat observer data

Pros:

- Observer program
- Good discard data (provides amount of discards and length frequency)
- Random sampling design
- Matches well with headboat logbooks
- More reliable depth recordings

Cons:

- Good coverage in Florida, but not as good in other states
- Short time series

Issues Discussed:

- Limited amount of time to compute a standardized index

<u>Fishery independent indices</u>

MARMAP

Chevron Trap Index (*Not recommended for use*)

Pros:

- Fishery independent random hard bottom survey
- Adequate regional coverage
- Standardized sampling techniques

Cons:

- Low sample sizes. Only 4-44 fish caught per year. Only 1-18 traps caught red snapper per year.
- High standard errors

Hook and Line Index (*Not recommended for use*)

Pros:

- Fishery independent random hard bottom survey
- Adequate regional coverage

Cons:

- Was not designed to compute an index, it was designed to collect biological samples
- Low sample sizes with frequent zeros.
- Restricted depth coverage (midshelf sampled)
- High standard errors
- Methodology has changed over time (bait types, number of hooks which wasn't recorded, ability of samplers, etc…)
- Level of effort has decreased over time

Table 5.2.1 continued

Short Bottom Longline Index (*Not recommended for use*)

Pros:
- Fishery independent random hard bottom survey
- Adequate regional coverage
- Standardized sampling techniques

Cons:
- Extremely low sample size. Only 1 fish caught in 1 year.
- No standard error

Blackfish trap (*Not recommended for use*)

Pros:
- Fishery independent random hard bottom survey
- Adequate regional coverage
- Standardized sampling techniques

Cons:
- Extremely low sample sizes. Only 1-2 fish caught per year.
- Short time series (1981-1988)
- High standard errors

Florida Antillean trap (*Not recommended for use*)

Pros:
- Fishery independent random hard bottom survey
- Adequate regional coverage
- Standardized sampling techniques

Cons:
- Extremely low sample sizes. Only 1-8 fish caught per year.
- Short time series (1981-1988)
- High standard errors

Yankee trawl (*Not recommended for use*)

Pros:
- Fishery independent random hard bottom survey
- Adequate regional coverage
- Standardized sampling techniques

Cons:
- Low sample sizes. Only 3-37 fish caught per year.
- Short time series (1973-1979)
- High standard errors

Table 5.3.1. MARMAP gear list. The total number of red snapper caught for each gear and year.

Year	All gears	Blackfish trap, baited	Chevron trap	Fl Antillean trap	Hook and Line	Short long line	Yankee trawl, MARMAP
1973	37						37
1974	36						36
1975	17						17
1976	5						5
1977	5						3
1978	18						14
1979	10						7
1981	13	1		8			
1982	40			1			
1983	6	1		1			
1984	3			1			
1985	3	2		1			
1986	3	1		1			
1987	5	1			2		
1988	40	1	24	1			
1989	6		4				
1990	27		24		2		
1991	17		17				
1992	26		21		5		
1993	31		31				
1994	54		45		3		
1995	13		13				
1996	10		10				
1997	27		26				
1998	27		25		2		
1999	22		22				
2000	17		17				
2001	11		9				
2002	40		40				
2003	7		7				
2004	5		5				
2005	12		12				
2006	6		6				
2007	32		31			1	
2008	31		29		2		
2009	21		11		3		

Total	**589**	**7**	**429**	**14**	**19**	**1**	**119**

Table 5.3.1.1. Chevron trap catches: By year, the total number of chevron traps set (Coll.), the number of traps that caught red snapper (Coll. W RS), the CPUE (number of fish per trap-hour), and the number of red snapper caught (fish).

Year	Collections	Collections with red snapper	CPUE	Fish
1990	318	7	0.046	23
1991	281	6	0.053	17
1992	302	9	0.043	21
1993	393	12	0.049	31
1994	408	18	0.066	44
1995	453	7	0.016	13
1996	441	5	0.007	5
1997	430	6	0.034	24
1998	483	8	0.029	25
1999	231	4	0.055	22
2000	279	7	0.030	14
2001	233	7	0.025	9
2002	205	9	0.066	21
2003	203	1	0.018	7
2004	265	3	0.009	4
2005	288	7	0.025	12
2006	287	4	0.011	5
2007	318	7	0.055	28
2008	296	7	0.039	19
2009	390	8	0.016	10

Table 5.4.1.1. The total number of headboat trips with red snapper effort per year for each region.

Year	NC	SC	GA-NFL	SFL	Total
1976	144	226	440	-	810
1977	62	177	576	-	815
1978	147	236	1041	4	1428
1979	162	77	967	33	1239
1980	115	177	989	57	1338
1981	106	50	821	75	1052
1982	191	217	858	65	1331
1983	175	207	1108	70	1560
1984	84	189	1057	93	1423
1985	79	247	1181	162	1669
1986	97	247	1484	190	2018
1987	116	310	1487	178	2091
1988	119	348	1466	97	2030
1989	49	192	1062	51	1354
1990	66	252	1075	24	1417
1991	142	284	982	12	1420
1992	244	227	1519	67	2057
1993	178	259	1388	59	1884
1994	182	224	1101	59	1566
1995	182	209	1042	25	1458
1996	173	198	697	20	1088
1997	120	113	527	13	773
1998	210	209	1125	6	1550
1999	164	206	1166	5	1541
2000	188	202	982	15	1387
2001	157	274	1051	14	1496
2002	167	274	952	11	1404
2003	123	154	779	17	1073
2004	197	269	898	20	1384
2005	90	182	902	25	1199
2006	98	213	854	30	1195
2007	69	271	988	39	1367
2008	97	170	941	50	1258
2009	105	124	1086	76	1391
Total	4598	7214	34592	1662	48066

Table 5.4.1.2. The total number of headboat trips with positive red snapper catch per year for each region.

Year	NC	SC	GA-NFL	SFL	Total
1976	37	116	417	-	570
1977	32	61	514	-	607
1978	68	96	888	1	1053
1979	79	31	778	3	891
1980	49	104	752	11	916
1981	68	26	738	29	861
1982	110	112	710	6	938
1983	90	107	947	8	1152
1984	37	124	851	21	1033
1985	39	163	1043	46	1291
1986	62	110	953	27	1152
1987	45	149	1012	25	1231
1988	63	192	885	16	1156
1989	21	127	823	4	975
1990	21	168	806	2	997
1991	49	137	670	0	856
1992	75	110	392	17	594
1993	80	208	411	16	715
1994	55	135	569	22	781
1995	56	103	601	6	766
1996	41	59	425	8	533
1997	24	31	319	3	377
1998	32	80	665	1	778
1999	61	137	690	0	888
2000	55	86	643	7	791
2001	103	170	720	3	996
2002	96	205	664	2	967
2003	46	112	534	0	692
2004	42	168	725	2	937
2005	8	83	753	6	850
2006	11	69	606	12	698
2007	2	86	722	31	841
2008	22	65	856	26	969
2009	33	34	990	52	1109
Total	1712	3764	24072	413	29961

Table 5.4.1.3. Distribution of total effort (angler-hours), proportion effort positive, and landings by factor in the recreational headboat data set used to construct the index of abundance (i.e., after applying the Stephens and MacCall method).

Factor	Total angler hours	Proportion effort positive	Landings (number)
Year			
1976	308008	0.722	12996
1977	288094	0.750	12419
1978	468120	0.738	20400
1979	428553	0.723	19117
1980	425192	0.708	11096
1981	363419	0.836	15965
1982	565967	0.695	9279
1983	605272	0.740	13948
1984	576131	0.729	14883
1985	616558	0.796	20460
1986	742626	0.579	7205
1987	814520	0.592	8832
1988	698509	0.599	9375
1989	460382	0.725	8763
1990	525113	0.751	8688
1991	527628	0.633	7139
1992	732217	0.303	1891
1993	641294	0.429	3304
1994	534995	0.526	3101
1995	479419	0.547	3097
1996	395288	0.478	1650
1997	260285	0.468	1133
1998	500820	0.500	2593
1999	505470	0.620	3322
2000	449937	0.577	3689
2001	495936	0.675	6665
2002	455406	0.712	7091
2003	375825	0.657	3618

Table 5.4.1.3 continued

2004	468961	0.689	6341
2005	394777	0.696	4573
2006	398933	0.575	3972
2007	446960	0.616	4125
2008	413071	0.756	12619
2009	449443	0.808	12451
Season			
fall	2322037	0.684	62484
spring	6521819	0.655	100310
summer	5396101	0.571	64856
winter	2573172	0.686	58150
Area			
GF	10870402	0.734	244860
NC	2059356	0.392	7920
SC	2936582	0.554	30266
SF	946789	0.312	2754
Anglers			
large	12360503	0.645	176161
small	4452626	0.613	109639
Trip type			
full	15702560	0.649	271307
half	1110569	0.462	14493

Table 5.4.1.4. The relative nominal CPUE, number of trips with positive effort, portion of trips with positive red snapper catches, standardized index, and CV for the headboat fishery in the south Atlantic.

Year	Relative nominal CPUE	N	Proportion N positive	Standardized index	CV (index)
1976	2.333825	810	0.703704	2.301045	0.068914
1977	2.384366	815	0.744785	2.241804	0.066364
1978	2.410424	1428	0.737395	2.113801	0.051756
1979	2.467378	1239	0.719128	2.118015	0.055641
1980	1.443451	1338	0.684604	1.418691	0.052292
1981	2.429863	1052	0.818441	2.87604	0.051011
1982	0.90684	1331	0.704733	1.139134	0.049624
1983	1.274623	1560	0.738462	1.528256	0.047318
1984	1.42886	1423	0.725931	1.308457	0.051759
1985	1.835491	1669	0.773517	1.991512	0.046176
1986	0.536642	2018	0.570862	0.474538	0.052209
1987	0.599761	2091	0.588714	0.559273	0.049132
1988	0.742369	2030	0.569458	0.539267	0.05508
1989	1.052822	1354	0.720089	0.912407	0.054955
1990	0.91514	1417	0.703599	0.836733	0.051824
1991	0.748394	1420	0.602817	0.654579	0.055796
1992	0.142847	2057	0.28877	0.078295	0.073775
1993	0.284973	1884	0.379512	0.150414	0.071758
1994	0.320607	1566	0.498723	0.259337	0.065835
1995	0.357311	1458	0.525377	0.277886	0.063292
1996	0.230882	1088	0.48989	0.253117	0.068558
1997	0.240769	773	0.48771	0.265594	0.08029
1998	0.286379	1550	0.501935	0.235547	0.059401
1999	0.363517	1541	0.576249	0.298236	0.058135
2000	0.4535	1387	0.570296	0.418363	0.060791
2001	0.743353	1496	0.665775	0.803709	0.059722
2002	0.86125	1404	0.688746	0.963951	0.059374
2003	0.53248	1073	0.644921	0.530603	0.065141
2004	0.747897	1384	0.677023	0.829492	0.05305
2005	0.640722	1199	0.708924	0.803434	0.055258
2006	0.550719	1195	0.5841	0.454168	0.062385
2007	0.510477	1367	0.615216	0.462045	0.055522
2008	1.689744	1258	0.77027	1.858984	0.049069
2009	1.532322	1391	0.797268	2.043275	0.045586

Table 5.4.2.1. Distribution of total effort (hook-hours), proportion effort positive, landings, and nominal CPUE by factor in the commercial logbook data set used to construct the index of abundance (i.e., after applying the Stephens and MacCall method).

Factor	Effort (hook-hours)	Proportion effort positive	Landings (lb)	Nominal CPUE (lb/hook-hr)
year				
1993	287270	0.86	46145	0.16
1994	537264	0.83	74476	0.14
1995	563254	0.79	82824	0.15
1996	531406	0.70	47796	0.09
1997	572568	0.65	50289	0.09
1998	385714	0.61	35597	0.09
1999	307274	0.60	35930	0.12
2000	287046	0.63	40337	0.14
2001	395724	0.74	85942	0.22
2002	442453	0.79	87538	0.20
2003	373747	0.74	70294	0.19
2004	326351	0.77	79034	0.24
2005	306796	0.71	61529	0.20
2006	334822	0.57	33028	0.10
2007	376422	0.56	45452	0.12
2008	302664	0.65	108573	0.36
2009	298868	0.67	145816	0.49
season				
fall	1513375	0.68	294852	0.19
spring	1954222	0.74	326846	0.17
summer	1904370	0.65	243126	0.13
winter	1257675	0.77	265775	0.21
area				
GA	913864	0.89	169539	0.19
NC	748402	0.53	63005	0.08
NF	1824230	0.84	554221	0.30
SC	3016545	0.61	287494	0.10
SF	126602	0.61	56341	0.45
crew size				
one	176308	0.64	53565	0.30
threeplus	4930509	0.73	763866	0.15
two	1522825	0.63	313169	0.21
days at sea				
fiveplus	4581099	0.76	657847	0.14
one	140936	0.44	104201	0.74
twotofour	1907607	0.60	368552	0.19

Table 5.4.2.2. Standardized index of red snapper from commercial logbook data.

Year	Relative Nominal CPUE	N	Proportion N Positive	Relative Standardized Index	CV (Index)
1993	0.885	843	0.708	1.137	0.060
1994	0.764	1357	0.704	0.914	0.048
1995	0.810	1528	0.656	0.922	0.047
1996	0.496	1240	0.582	0.573	0.056
1997	0.484	1479	0.546	0.567	0.059
1998	0.508	1365	0.495	0.632	0.058
1999	0.644	1172	0.520	0.756	0.062
2000	0.774	1160	0.521	0.745	0.060
2001	1.197	1381	0.663	1.218	0.050
2002	1.090	1430	0.706	1.365	0.047
2003	1.036	1178	0.626	1.111	0.054
2004	1.334	1059	0.630	1.440	0.053
2005	1.105	1068	0.582	1.228	0.060
2006	0.543	950	0.483	0.608	0.068
2007	0.665	1123	0.477	0.664	0.066
2008	1.976	1013	0.560	1.201	0.068
2009	2.688	948	0.631	1.918	0.073

Table 5.4.3.1. Nominal catch rates of red snapper from private boat MRFSS mode from nearshore and offshore waters from North Carolina through the Atlantic Florida using intercepts selected with the Stephens and MacCall logistic regression.

Year	N	Mean	CV	Scaled to Mean
1991	12	0.33	0.14	0.25
1992	15	2.60	1.90	1.97
1993	16	1.06	0.29	0.81
1994	17	1.47	0.90	1.12
1995	18	1.00	0.59	0.76
1996	12	5.25	3.84	3.98
1997	7	4.71	3.14	3.57
1998	17	1.29	0.43	0.98
1999	71	0.80	0.20	0.61
2000	77	0.87	0.22	0.66
2001	89	0.80	0.28	0.60
2002	64	0.91	0.23	0.69
2003	67	1.58	0.41	1.20
2004	72	1.86	0.65	1.41
2005	38	1.95	0.76	1.48
2006	60	1.68	0.70	1.28
2007	63	1.03	0.26	0.78
2008	73	1.34	0.27	1.02
2009	62	1.11	0.23	0.84

Table 5.4.4.1. Annual red snapper catch and harvest per unit of effort from SCDNR Charter boat logbook program, 1993 – 2009.

Year	Vessel Trips	Average Number Anglers per Vessel Trip	Total Catch per Angler Trip	Total Harvest per Angler Trip	% Released	% Vessel Trips With Catch
1993	565	4.46	0.21	0.11	45.97	17.17
1994	655	4.46	0.13	0.06	54.26	15.42
1995	531	4.43	0.08	0.04	45.26	11.86
1996	696	4.41	0.06	0.05	11.05	8.05
1997	749	4.55	0.02	0.01	45.57	5.34
1998	903	4.39	0.10	0.06	44.61	11.96
1999	844	4.48	0.18	0.12	32.79	17.42
2000	997	4.33	0.28	0.08	72.25	15.75
2001	980	4.42	0.42	0.14	67.72	19.08
2002	937	4.33	0.30	0.14	53.53	17.61
2003	898	4.36	0.14	0.06	54.02	12.81
2004	1044	4.10	0.09	0.05	43.13	9.67
2005	1130	4.09	0.08	0.04	42.54	9.73
2006	1142	4.11	0.05	0.02	53.51	6.04
2007	1172	4.10	0.09	0.04	57.31	9.47
2008	1150	4.03	0.18	0.05	72.43	12.78
2009	867	4.10	0.19	0.07	62.39	13.73

Table 5.4.4.2. Nominal CPUE, proportion positive, standardized index and CV for each year for SC charter boat logbooks.

Year	Relative nominal CPUE	N	Proportion N positive	Standardized index	CV (index)
1993	1.40	75	0.33	1.55	0.22
1994	0.52	91	0.22	0.58	0.28
1995	0.57	77	0.26	0.52	0.28
1996	0.46	105	0.28	0.52	0.21
1997	0.13	81	0.11	0.11	0.42
1998	0.96	101	0.38	0.85	0.19
1999	2.01	105	0.52	2.14	0.17
2000	1.02	93	0.43	0.90	0.20
2001	2.57	96	0.60	2.51	0.17
2002	2.06	108	0.54	2.07	0.16
2003	1.00	84	0.43	0.97	0.20
2004	0.83	77	0.47	0.81	0.18
2005	0.57	81	0.30	0.72	0.24
2006	0.38	74	0.32	0.47	0.21
2007	0.63	79	0.38	0.65	0.21
2008	0.90	100	0.39	0.72	0.20
2009	0.99	68	0.49	0.91	0.20

Table 5.5.1. The standardized CPUE and associated CVs for the recreational headboat fishery and the commercial hook and line fishery.

Year	Headboat	Headboat (CV)	Commercial Hook and Line	Commercial Hook and Line (CV)
1976	2.301	0.069		
1977	2.242	0.066		
1978	2.114	0.052		
1979	2.118	0.056		
1980	1.419	0.052		
1981	2.876	0.051		
1982	1.139	0.050		
1983	1.528	0.047		
1984	1.308	0.052		
1985	1.992	0.046		
1986	0.475	0.052		
1987	0.559	0.049		
1988	0.539	0.055		
1989	0.912	0.055		
1990	0.837	0.052		
1991	0.655	0.056		
1992	0.078	0.074		
1993	0.150	0.072	1.137	0.060
1994	0.259	0.066	0.914	0.048
1995	0.278	0.063	0.922	0.047
1996	0.253	0.069	0.573	0.056
1997	0.266	0.080	0.567	0.059
1998	0.236	0.059	0.632	0.058
1999	0.298	0.058	0.756	0.062
2000	0.418	0.061	0.745	0.060
2001	0.804	0.060	1.218	0.050
2002	0.964	0.059	1.365	0.047
2003	0.531	0.065	1.111	0.054
2004	0.829	0.053	1.440	0.053
2005	0.803	0.055	1.228	0.060
2006	0.454	0.062	0.608	0.068
2007	0.462	0.056	0.664	0.066
2008	1.859	0.049	1.201	0.068
2009	2.043	0.046	1.918	0.073

5.9 Figures

Figure 5.3.1.1. Spatial coverage of Chevron traps over time with yellow circles denoting traps that did not catch red snapper and with red circles denoting traps that did catch red snapper.

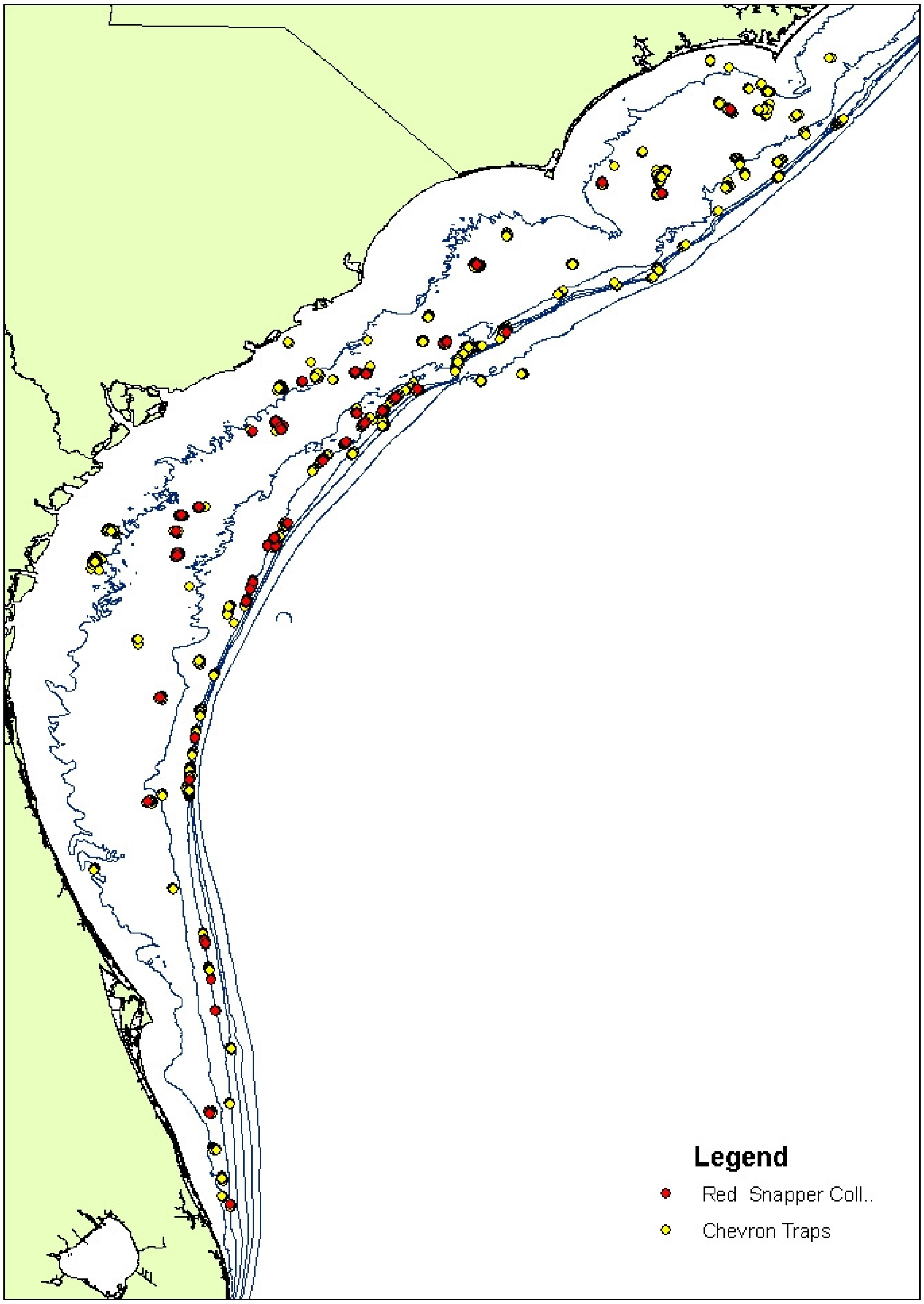


Figure 5.4.1.1. Spatial sampling strata from the headboat survey off the southeast Atlantic coast of the U.S. The northern region consisted of areas 2-10, and the southern region consisted of areas 11, 12, and 17.

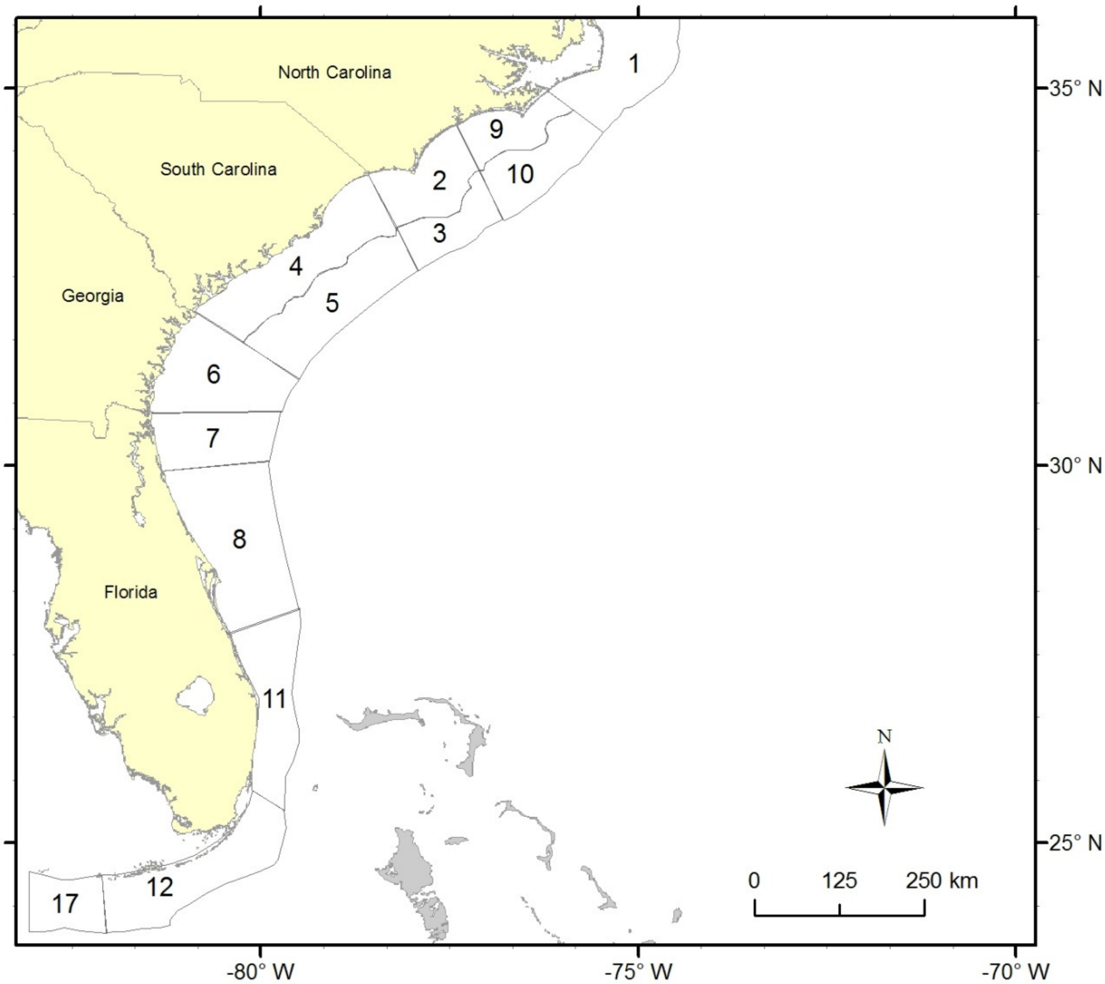


Figure 5.4.1.2. The standardized and nominal headboat index computed for red snapper in the south Atlantic during 1976-2009.

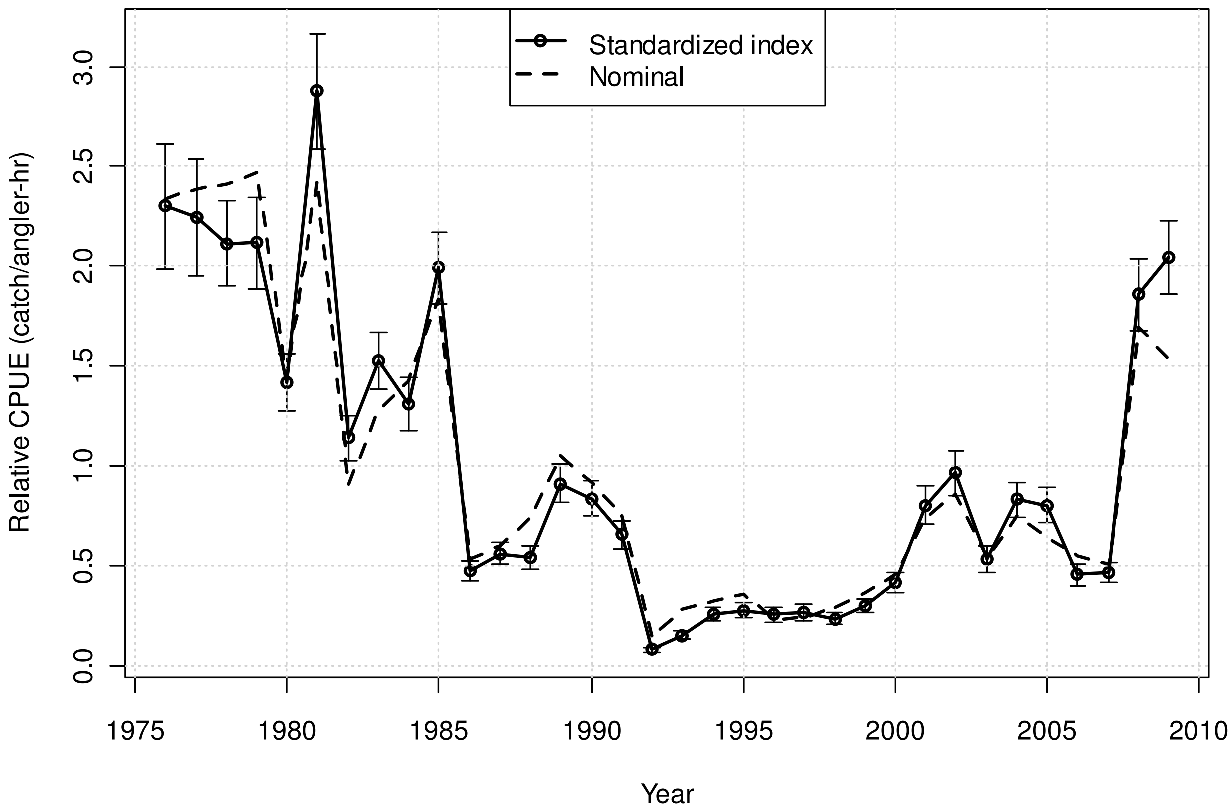


Figure 5.4.2.1. Areas reported in commercial logbooks. First two digits signify degrees latitude, second two degrees longitude. Areas were excluded from the analysis if north of 36 degrees latitude or if in the Gulf of Mexico. In analyses, south Florida was treated separately from north Florida, with the boundary occurring at 28 degrees latitude (break near Cape Canaveral; boundary included in the south).

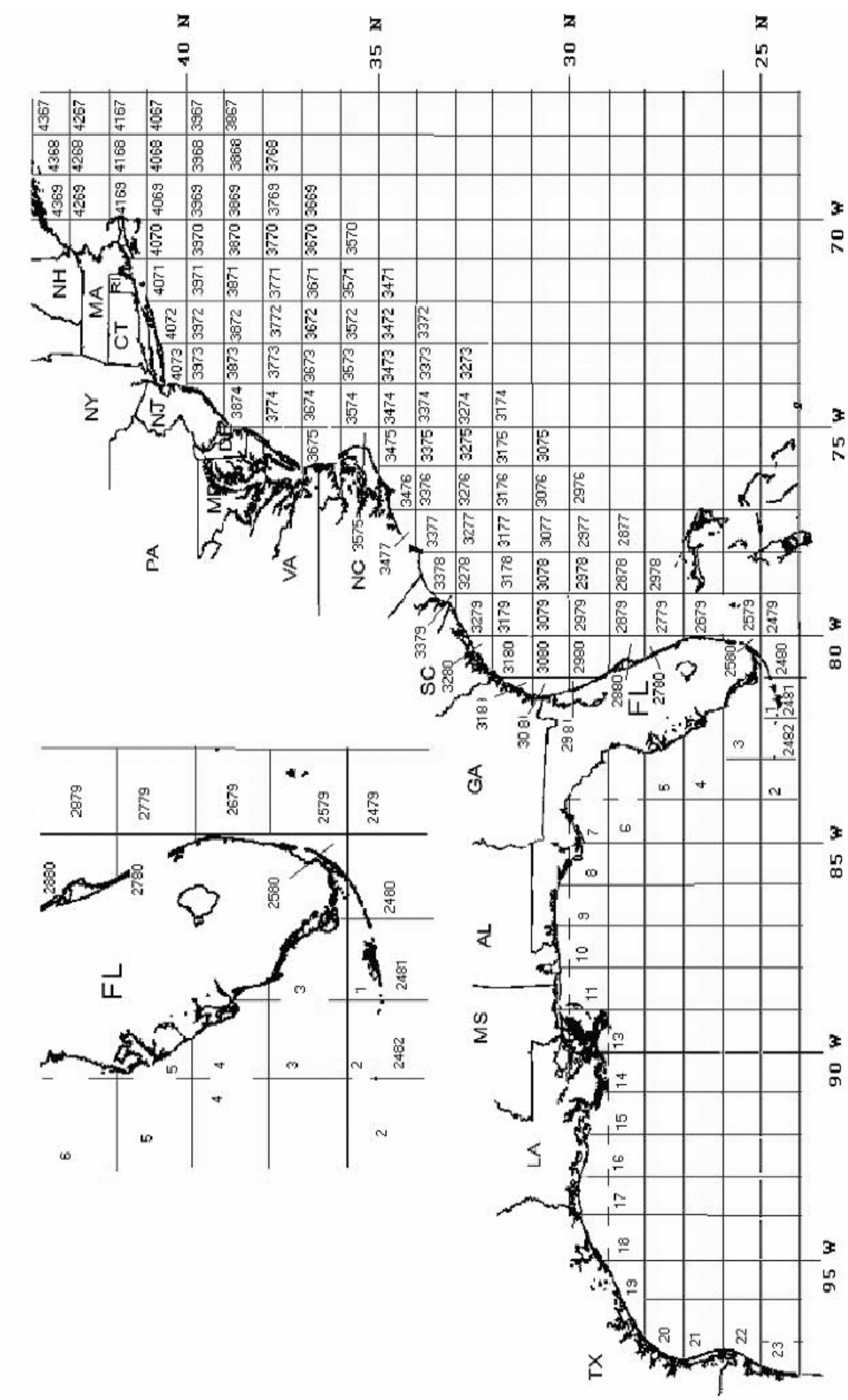


Figure 5.4.2.2. Relative standardized index (solid line, black circles, 95% error bars) and relative nominal index (dashed).

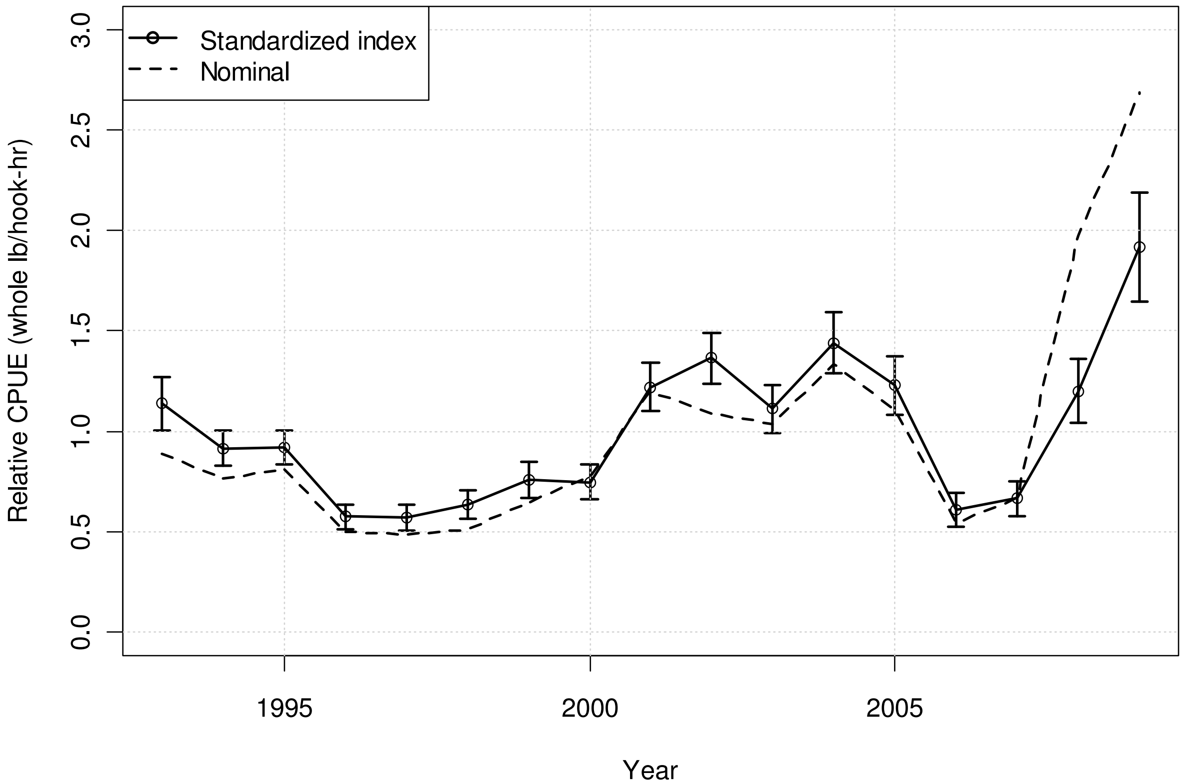


Figure 5.4.3.1. Map of the MRFSS/MRIP study area from NC to Miami-Dade County, Florida.

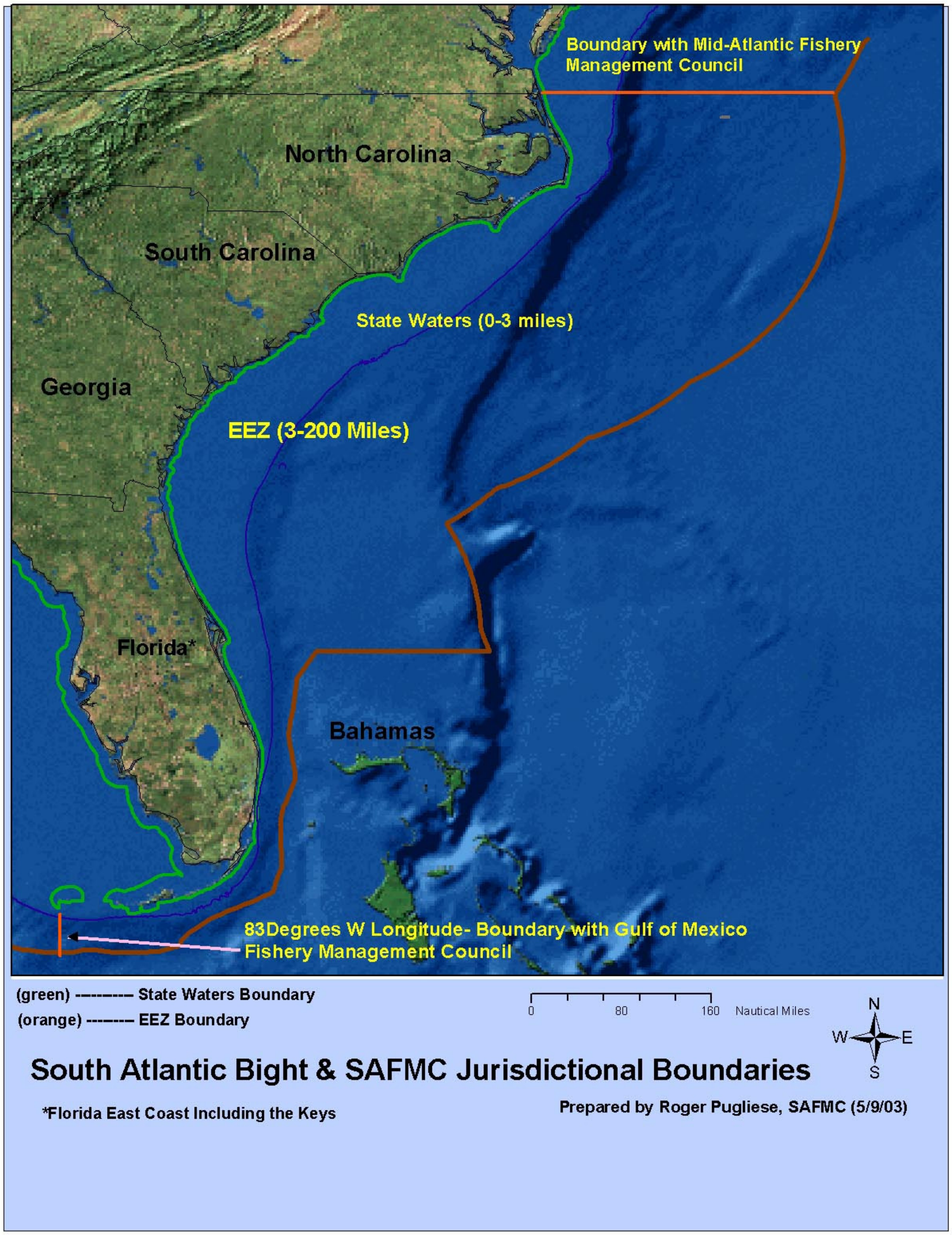


Figure 5.4.3.2. Regression coefficients for species selected by the Stephens and MacCall method for the private boat MRFSS/MRIP data.

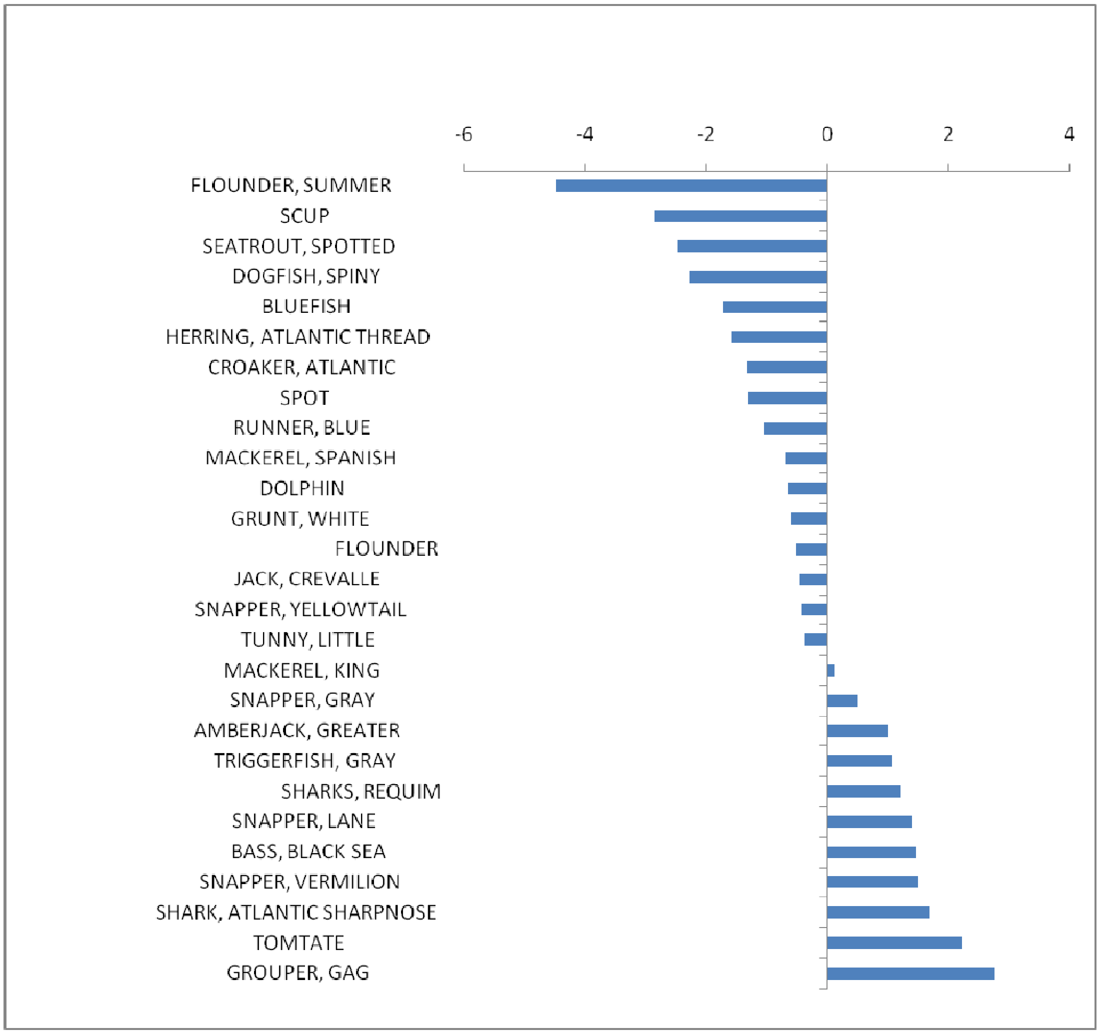


Figure 5.4.3.3. Nominal catch rate of red snapper by year from North Carolina to southern Florida. The vertical lines are the 95% confidence interval and the circle is the mean.

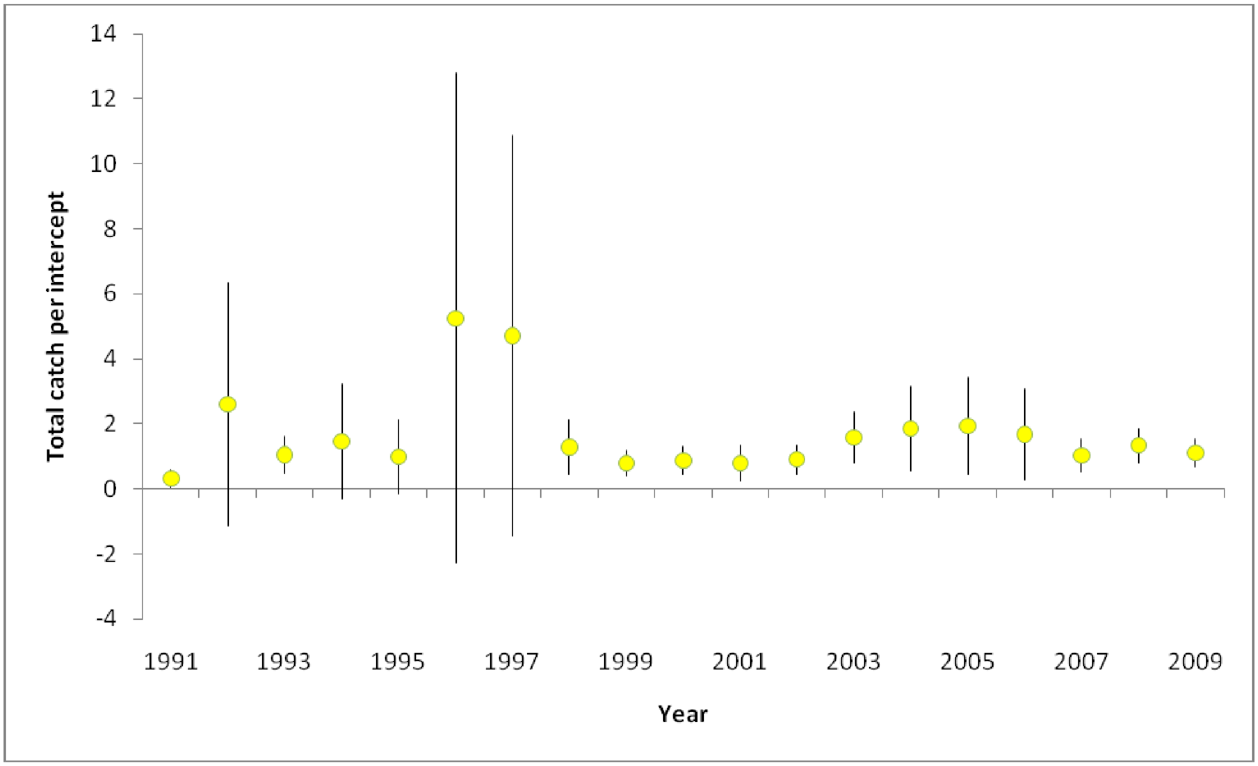


Figure 5.4.4.1. Nominal and standardized CPUE for the SC Charter logbook data.

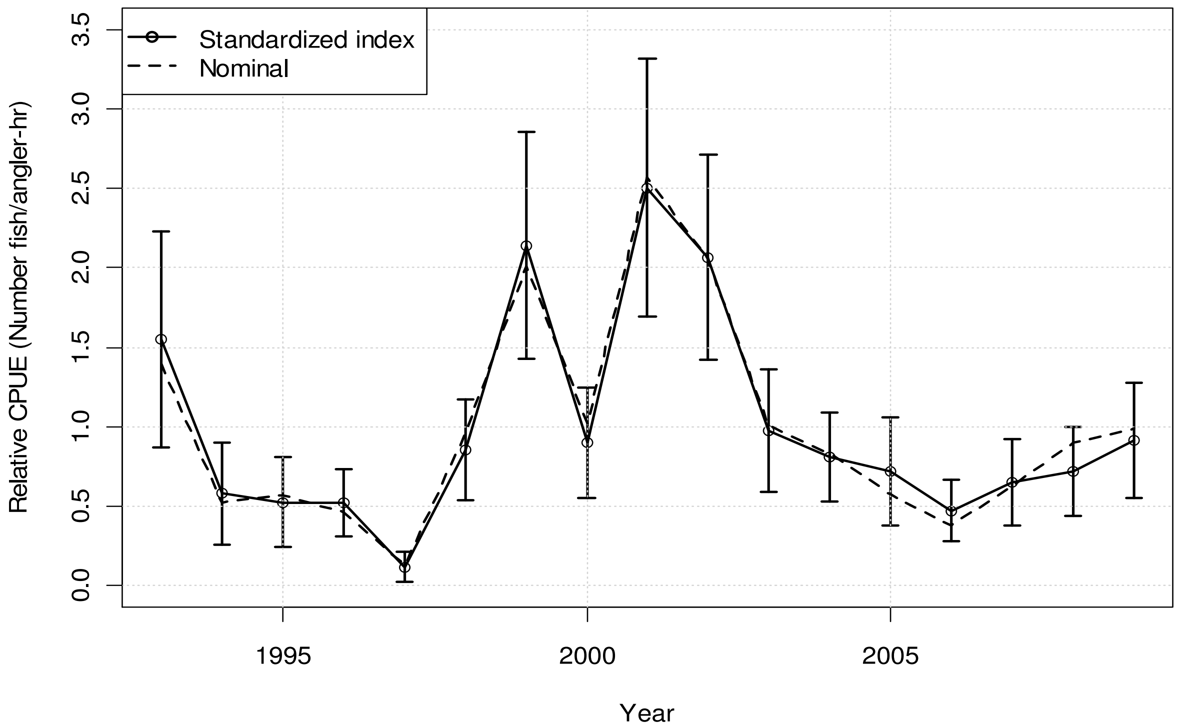
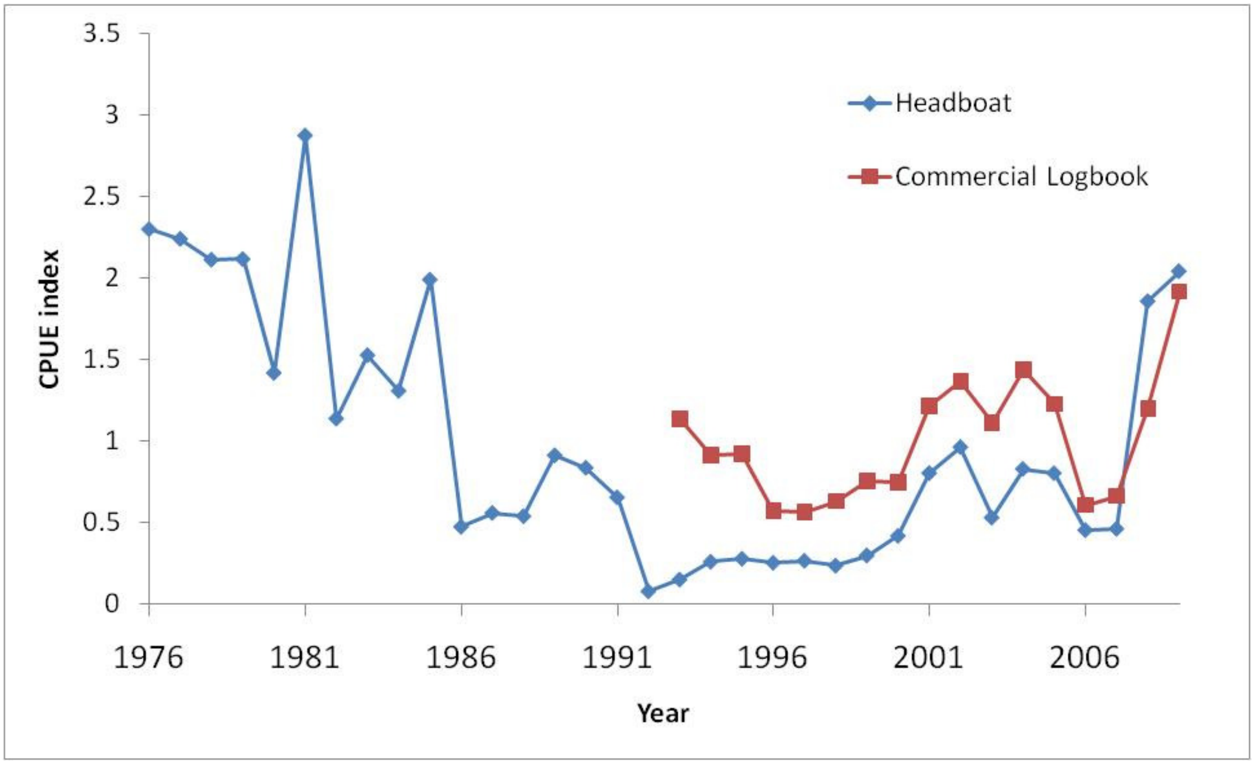

Standardized index
Nominal
Relative CPUE (Number fish/angler-hr)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
1995
2000
2005
Year

Figure 5.5.1. The standardized CPUE index for the recreational headboat fishery data and the commercial logbook data.



Section 5 Appendix - Index Report Cards

Review of the usefulness of the report card and some suggestions for improvement:

- Didn't serve the purpose it was intended for: report cards were not filled out prior to the workshop and the Indices group was left to fill out the report card. We didn't find it very useful in making our decisions, thereby filling out the worksheet after the fact.
- If the Indices group is filling out the report card, it would be helpful to have two options: one report card for data not used and one for data used to create an index.
- Groups submitting the report card may not understand many of the requirements, particularly the Model Standardization and Diagnostics sections. An attempt to simplify the report card would be more useful
- The categories of NA, Absent, Incomplete, and Complete were not helpful. Often things were either given or not given. A better explanation or guidance of these categories is needed.
- It is not clear what the minimum requirements are based only on this document. Perhaps it needs to be more cleanly laid out.
- If the report card is filled out prior to the workshop, then the justification is not needed, as the data workgroup will be compiling the justifications for or against the index.
- A checklist clearly listing the minimum data requirements instead of a report card is more worthwhile. This should be the first two sections of the report card (Description of the Data Source and Data reductions sections).

Appendix 5.1 MARMAP

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				X	
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				X	
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				X	
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				X	
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				X	
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				X	

2. Fishery Dependent Indices

	Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).					
B. Describe any changes to reporting requirements, variables reported, etc.					
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).					
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.					

METHODS

1. Data Reduction and Exclusions

	Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.	X				
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species	X				

assemblage etc).					
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?	X				

2. Management Regulations (for FD Indices)	Applicabl e	Absent	Incomplet e	Complete	Working Group Comments:
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	X				
B. Describe the effects (if any) of management regulations on CPUE	X				
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	X				

3. Describe Analysis Dataset (after exclusions and other treatments)

A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				X	
B. Include tables and/or figures of number of positive observations by factors and interaction terms.	X				
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.	X				
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.				X	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				X	
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.	X				
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				X	

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Describe model structure (e.g. delta-lognormal)	X				
B. Describe construction of GLM components (e.g. forward selection from null etc.)	X				
C. Describe inclusion criteria for factors and interactions terms.	X				
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?	X				
E. Provide a table summarizing the construction of the GLM components.	X				
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)	X				
G. Report convergence statistics.	X				

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
1. Binomial Component					
A. Include plots of the chi-square residuals by factor.	X				
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)	X				
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	X				
2. Lognormal/Gamma Component					
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.	X				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	X				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	X				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	X				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	X				
F. Include plots of the residuals by factor	X				

3. Poisson Component

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	X				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	X				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	X				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	X				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	X				***The feasibility of this diagnostic is still under review.***

4. Zero-inflated model

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Include ROC curve to quantify goodness of fit.	X				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).	X				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.	X				

MODEL DIAGNOSTICS (CONT.)

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	X				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	X				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report	X			
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).	X			

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance	X			
2. Table of model statistics (e.g. AIC criteria)	X			

	Date Received	***Workshop Recommendation***	***Revision Deadline ******	***Author and Rapporteur Signatures***
First Submission	5/26/2010	Not recommended for use		
Revision				

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Because of the low catches and high variability in the data, the DW did not recommend using any of the MARMAP samples to develop an index of abundance for red snapper.

Appendix 5.2 Headboat

DESCRIPTION OF THE DATA SOURCE	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
1. Fishery Independent Indices					
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.	x				
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)	x				
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)	x				
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).	x				
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).	x				
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.	x				
2. Fishery Dependent Indices					
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				x	
B. Describe any changes to reporting requirements, variables reported, etc.				x	
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				x	
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				x	
METHODS					
1. Data Reduction and Exclusions					
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.			x		The exact number of records was not reported for each step.
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear				x	

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments
configuration, species assemblage etc).					
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?				x	

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).				x	Looked at bag limits
B. Describe the effects (if any) of management regulations on CPUE				x	
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	x				

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				x	
B. Include tables and/or figures of number of positive observations by factors and interaction terms.				x	
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.				x	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.				x	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).			x		A map of the survey area was provided. A data workshop report contains some maps of most recent years.
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				x	
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				x	

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments
A. Describe model structure (e.g. delta-lognormal)				x	
B. Describe construction of GLM components (e.g.				x	

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
forward selection from null etc.)					
C. Describe inclusion criteria for factors and interactions terms.				x	
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?		x			
E. Provide a table summarizing the construction of the GLM components.				x	
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				x	
G. Report convergence statistics.			x		

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
1. Binomial Component					
A. Include plots of the chi-square residuals by factor.				x	
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)				x	
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).		x			
2. Lognormal/Gamma Component					
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				x	
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				x	
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				x	
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.		x			

E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.		x			
F. Include plots of the residuals by factor				x	

3. Poisson Component

A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	x				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	x				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	x				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	x				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	x				***The feasibility of this diagnostic is still under review.***

4. Zero-inflated model

A. Include ROC curve to quantify goodness of fit.	x				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).	x				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.	x				

MODEL DIAGNOSTICS (CONT.)	**Not Applicable**	**Absent**	**Incomplete**	**Complete**	**Working Group Comments:**
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	x				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	x				

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				x
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				x

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance		x		
2. Table of model statistics (e.g. AIC criteria)				x

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	5/26/2010	Recommended for use		
Revision				

*The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author **DOES NOT** commit to any **LEGAL OBLIGATION** by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Much of the information for the HB index can be found in the SEDAR24-DW03 data working paper.

Appendix 5.3 Commercial Logbook

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.					
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)					
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)					
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).					
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).					
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.					

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				X	
B. Describe any changes to reporting requirements, variables reported, etc.				X	
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				X	
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				x	

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records				X	

	Not Applicable	Absent	Incomplete	Complete
removed and justify removal.				
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				X
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?				x

Working Group Comments:

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).		X		
B. Describe the effects (if any) of management regulations on CPUE		X		
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.		X		

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				X
B. Include tables and/or figures of number of positive observations by factors and interaction terms.				X
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.				X
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.				X
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).			X	
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				X
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				X

4. Model Standardization

A. Describe model structure (e.g. delta-lognormal)				X
B. Describe construction of GLM components (e.g. forward selection from null etc.)				X
C. Describe inclusion criteria for factors and interactions terms.				X
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?		X		
E. Provide a table summarizing the construction of the GLM components.				X
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				X
G. Report convergence statistics.		X		

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

Working Group Comments:

1. Binomial Component

	Not Applicable	Absent	Incomplete	Complete
A. Include plots of the chi-square residuals by factor.				X
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)				X
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).		X		

2. Lognormal/Gamma Component

	Not Applicable	Absent	Incomplete	Complete
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				X
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				X
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected				X

distribution.					
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.		X			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.		X			
F. Include plots of the residuals by factor				X	

3. Poisson Component

A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	X				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	X				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	X				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	X				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	X				***The feasibility of this diagnostic is still under review.***

4. Zero-inflated model

A. Include ROC curve to quantify goodness of fit.	X				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).	X				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.	X				

MODEL DIAGNOSTICS (CONT.)	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	X				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	X				
MODEL RESULTS					
A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				X	
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				X	
IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED: (***Note: this is always recommended but required when model diagnostics are poor***.)					
1. Plot of resulting indices and estimates of variance		x			
2. Table of model statistics (e.g. AIC criteria)				x	

	Date Received	*Workshop Recommendation*	*Revision Deadline* ***	*Author and Rapporteur Signatures*
First Submission	5/26/2010	Recommended for Use		
Revision				

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation ***None***

Appendix 5.4 MRFSS/MRIP (private mode only)

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
DESCRIPTION OF THE DATA SOURCE					
1. Fishery Independent Indices					
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.	X				
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)	X				
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)	X				
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).	X				
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).	X				
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.	X				
2. Fishery Dependent Indices					
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				X	
B. Describe any changes to reporting requirements, variables reported, etc.				X	
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				X	
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				X	
METHODS					
1. Data Reduction and Exclusions					
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				X	
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				X	
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?				X	

2. Management Regulations (for FD Indices)	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).				X	
B. Describe the effects (if any) of management regulations on CPUE				X	
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	X				
3. Describe Analysis Dataset (after exclusions and other treatments)					
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				X	
B. Include tables and/or figures of number of positive observations by factors and interaction terms.				X	
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.				X	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.				X	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).	X				
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				X	
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				X	
4. Model Standardization					
A. Describe model structure (e.g. delta-lognormal)				X	
B. Describe construction of GLM components (e.g. forward selection from null etc.)				X	
C. Describe inclusion criteria for factors and interactions terms.				X	
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				X	
E. Provide a table summarizing the construction of the GLM components.				X	
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				X	
G. Report convergence statistics.				X	

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
1. Binomial Component					
A. Include plots of the chi-square residuals by factor.	X				
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)	X				
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	X				
2. Lognormal/Gamma Component					
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.	X				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	X				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	X				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	X				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	X				
F. Include plots of the residuals by factor	X				
3. Poisson Component					
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	X				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	X				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	X				

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	X				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	X				***The feasibility of this diagnostic is still under review.***

4. Zero-inflated model

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Include ROC curve to quantify goodness of fit.	X				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).	X				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.	X				

MODEL DIAGNOSTICS (CONT.)

	Not Applicable	**Absent**	**Incomplete**	**Complete**	**Working Group Comments:**
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	X				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	X				

MODEL RESULTS

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				X	
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				X	

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
1. Plot of resulting indices and estimates of variance	X				
2. Table of model statistics (e.g. AIC criteria)	X				

	Date Received	***Workshop Recommendation***	***Revision Deadline*** ***	***Author and Rapporteur Signatures***
First Submission	5/26/2010	Not recommended for use		
Revision				

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Given the relatively low sample size, the high variability for a fishery dependent index, and the suspected lack of representation of the fishery, the indices work group does not feel that this index is adequate for the assessment and does not recommend it for inclusion in the model.

Appendix 5.5 Recreational SC V1 Vessel Logbook Data

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.	X				
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)	X				
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)	X				
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).	X				
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).	X				
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.	X				

2. Fishery Dependent Indices

	Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				X	
B. Describe any changes to reporting requirements, variables reported, etc.				X	
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				X	
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.	X				

METHODS

1. Data Reduction and Exclusions

	Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify				X	

					Working Group Comments:
removal.					
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				X	
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?				X	

2. Management Regulations (for FD Indices)	Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	X				
B. Describe the effects (if any) of management regulations on CPUE	X				
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	X				

3. Describe Analysis Dataset (after exclusions and other treatments)

	Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				X	
B. Include tables and/or figures of number of positive observations by factors and interaction terms.				X	
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.				X	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.				X	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).		X			
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				X	
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms,				X	

pounds).					
4. Model Standardization					
A. Describe model structure (e.g. delta-lognormal)				X	
B. Describe construction of GLM components (e.g. forward selection from null etc.)				X	
C. Describe inclusion criteria for factors and interactions terms.	X				
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?	X				
E. Provide a table summarizing the construction of the GLM components.	X				
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)	X				
G. Report convergence statistics.	X				

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
1. Binomial Component					
A. Include plots of the chi-square residuals by factor.	X				
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)	X				
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	X				
2. Lognormal/Gamma Component					
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.	X				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	X				
	X				

C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.					
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	X				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	X				
F. Include plots of the residuals by factor	X				
3. Poisson Component					
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	X				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	X				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	X				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	X				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	X				***The feasibility of this diagnostic is still under review.***
4. Zero-inflated model					
A. Include ROC curve to quantify goodness of fit.	X				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).	X				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.	X				

MODEL DIAGNOSTICS (CONT.)	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	X				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	X				
MODEL RESULTS					
A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				X	
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				X	
IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:					
(***Note: this is always recommended but required when model diagnostics are poor***.)					
1. Plot of resulting indices and estimates of variance	X				
2. Table of model statistics (e.g. AIC criteria)	X				

	Date Received	***Workshop Recommendation***	***Revision Deadline ******	***Author and Rapporteur Signatures***
First Submission	5/26/2010	Not recommended for use		
Revision				

*The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author **DOES NOT** commit to any **LEGAL OBLIGATION** by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

These data were not recommended for use because they include only one state and therefore, do not cover the entire management area. In addition, the data are potentially included in other reviewed data sets. Finally, data are self-reported and largely unverified.

Appendix 5.6 Steve Amick Headboat Data

DESCRIPTION OF THE DATA SOURCE

	Not Applicable	Absent	Incomplete	Complete
1. Fishery Independent Indices				
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				
2. Fishery Dependent Indices				
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).			x	
B. Describe any changes to reporting requirements, variables reported, etc.			x	
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).			x	
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.			x	

METHODS

	Not Applicable	Absent	Incomplete	Complete
1. Data Reduction and Exclusions				
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?				

Working Group Comments:

Working Group Comments:

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).				
B. Describe the effects (if any) of management regulations on CPUE				
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.				

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				
B. Include tables and/or figures of number of positive observations by factors and interaction terms.				
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.				
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.				
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				
B. Describe construction of GLM components (e.g. forward selection from null etc.)				
C. Describe inclusion criteria for factors and interactions terms.				
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				
E. Provide a table summarizing the construction of the GLM components.				
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				
G. Report convergence statistics.				

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
1. Binomial Component					
A. Include plots of the chi-square residuals by factor.					
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)					
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).					
2. Lognormal/Gamma Component					
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.					
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.					
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.					
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.					
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.					
F. Include plots of the residuals by factor					
3. Poisson Component					
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).					
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.					
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.					
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.					
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.					***The feasibility of this diagnostic is still under review.***
4. Zero-inflated model					
A. Include ROC curve to quantify goodness of fit.					
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).					
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.					

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
MODEL DIAGNOSTICS (CONT.)					
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.					
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.					
MODEL RESULTS					
A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report					
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).					
IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED: (***Note: this is always recommended but required when model diagnostics are poor***.)					
1. Plot of resulting indices and estimates of variance					
2. Table of model statistics (e.g. AIC criteria)					

	Date Received	*Workshop Recommendation*	*Revision Deadline* ***	*Author and Rapporteur Signatures*
First Submission	5/26/2010	Not recommended for use		
Revision				

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Captain Steve Amick also presented records of his headboat fishing catch and effort in Georgia from 1983-2009. The overall pattern of this index appeared consistent with the more comprehensive headboat logbook records, which contained the latter portion (1994-2009) of the index. Additionally, the Indices Workgroup was concerned with the limited geographic coverage and the limited sample size (containing only records from one fisherman).

Appendix 5.7 Commercial Landing Data 1975-1990

DESCRIPTION OF THE DATA SOURCE	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
1. Fishery Independent Indices					
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.					
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)					
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)					
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).					
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).					
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.					
2. Fishery Dependent Indices					
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				x	
B. Describe any changes to reporting requirements, variables reported, etc.			x		
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).			x		
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.			x		
METHODS					
1. Data Reduction and Exclusions					
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.					
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).					
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?					

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
2. Management Regulations (for FD Indices)					
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).					
B. Describe the effects (if any) of management regulations on CPUE					
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.					
3. Describe Analysis Dataset (after exclusions and other treatments)					
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.					
B. Include tables and/or figures of number of positive observations by factors and interaction terms.					
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.					
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.					
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).					
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.					
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).					
4. Model Standardization					
A. Describe model structure (e.g. delta-lognormal)					
B. Describe construction of GLM components (e.g. forward selection from null etc.)					
C. Describe inclusion criteria for factors and interactions terms.					
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?					
E. Provide a table summarizing the construction of the GLM components.					
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)					
G. Report convergence statistics.					

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
1. Binomial Component					
A. Include plots of the chi-square residuals by factor.					
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)					
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).					
2. Lognormal/Gamma Component					
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.					
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.					
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.					
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.					
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.					
F. Include plots of the residuals by factor					
3. Poisson Component					
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).					
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.					
C. Include QQ-plot – (e.g. Student deviance residuals					

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
vs. theoretical quantiles), Overlay expected distribution.					
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.					
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.					***The feasibility of this diagnostic is still under review.***

4. Zero-inflated model

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Include ROC curve to quantify goodness of fit.					
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).					
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.					

MODEL DIAGNOSTICS (CONT.)

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.					
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.					

MODEL RESULTS

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report					
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).					

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
1. Plot of resulting indices and estimates of variance					
2. Table of model statistics (e.g. AIC criteria)					

	Date Received	*Workshop Recommendation*	*Revision Deadline* ***	*Author and Rapporteur Signatures*
First Submission	5/26/2010	Not recommended for use		
Revision				

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

South Atlantic landings data from commercial logbooks from 1975-1990 were presented, but no fishing effort was available to compute a CPUE index. The “sampling methodology” and “variables reported” were scored as “incomplete” for these reasons.

Appendix 5.8 Headboat at Sea Observer Discard Data

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
DESCRIPTION OF THE DATA SOURCE					
1. Fishery Independent Indices					
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.					
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)					
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)					
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).					
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).					
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.					
2. Fishery Dependent Indices					
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				x	
B. Describe any changes to reporting requirements, variables reported, etc.			x		
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).			x		
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				x	
METHODS					
1. Data Reduction and Exclusions					
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.			X		
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).			X		
C. Discuss procedures used to identify outliers. How many			X		

	Not Applicable	Absent	Incomplete	Complete
were identified? Were they excluded?				

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).			X		
B. Describe the effects (if any) of management regulations on CPUE	X				
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	X				

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.			X	
B. Include tables and/or figures of number of positive observations by factors and interaction terms.			X	
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.			X	
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.			X	
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).			X	
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				X
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				X

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)			X	
B. Describe construction of GLM components (e.g. forward selection from null etc.)			X	
C. Describe inclusion criteria for factors and interactions terms.			X	
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?			X	
E. Provide a table summarizing the construction of the GLM components.			X	
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)			X	

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
G. Report convergence statistics.			X		

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
1. Binomial Component					
A. Include plots of the chi-square residuals by factor.			X		
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)			X		
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).			X		
2. Lognormal/Gamma Component					
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.			X		
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.			X		
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.			X		
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.			X		
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.			X		
F. Include plots of the residuals by factor			X		
3. Poisson Component					
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	X				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	X				

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	X				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	X				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	X				***The feasibility of this diagnostic is still under review.***

4. Zero-inflated model

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Include ROC curve to quantify goodness of fit.	X				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).	X				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.	X				

MODEL DIAGNOSTICS (CONT.)

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	X				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	X				

MODEL RESULTS

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report			X		
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).			X		

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
1. Plot of resulting indices and estimates of variance	X				

2. Table of model statistics (e.g. AIC criteria)	X				

	Date Received	*Workshop Recommendation*	*Revision Deadline* ***	*Author and Rapporteur Signatures*
First Submission	5/27/2010	Recommended for use		
Revision				

*The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author **DOES NOT** commit to any **LEGAL OBLIGATION** by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

At-sea observer sampling of anglers in the headboat fishery was conducted from 2005-2009 in Florida and Georgia, and from 2004-2009 in North and South Carolina. The sampling was predominately located in Florida (and the data available for review at the data workshop was the Florida data), which resulted in a mark of “incomplete” with regard to the sampling design. A nominal CPUE index was computed from the Florida data. Because the observers recorded the number and lengths of all fish caught, this index provides valuable information on both the amount and size composition of the discarded catch. This index could provide information on the relative strengths of young age classes observed by the fishery, and should improve estimates of the headboat size selectivity for the discarded catch. However, a substantial amount of work is required to standardize the index, which resulted in marks of “incomplete” or “not applicable” for most of the items on this spreadsheet. The Indices Workgroup recommends that an attempt be made to standardize the index, and use the nominal CPUE if the standardization cannot be completed in time.

6. Discard Mortality

6.1 Overview (Membership, Charge)

In preparation for the benchmark assessment, an informal *ad hoc* working group was assembled to advise the Data Workshop Panel on use of the commercial and recreational discard mortalities employed in the SEDAR 15 red snapper benchmark assessment and on their effect on projections during the benchmark.

Members of the *ad hoc* working group were:

Chip Collier - Leader, NC DMF, SAFMC SSC

Jeff Buckle – North Carolina State University

Karen Burns – Gulf of Mexico Fishery Management Council

Kenny Fex - SAFMC SG AP

Robert Johnson - SAFMC SG AP

Stephanie McInerny - NC DMF

Zack Bowen - SAFMC SG AP

The working group's purposes were:

- to make recommendations related to the justification given in the SEDAR 15 benchmark for discard rates used in the benchmark;
- to review any relevant, new research results pertaining to discard mortalities;
- to identify a range of mortality estimates to be used in sensitivities in the red snapper assessment;
- to identify the effect of mortality estimates on projections in the red snapper assessment.

The working group goal was to build a record relating if and why discard mortality rates different from those used in the benchmark should be used in the update, with the recommendations noted above. The group operated via email and conference call. Its work was completed and reported to the panel as a data workshop working paper (SEDAR24-DW12).

In order to deal with the special discard mortality topic during the workshop and in the data workshop report, a more formal DW work group composed of SAFMC-appointed DW panelists was named. Those who served were:

Chip Collier - Leader, NC DMF, SAFMC SSC

Zack Bowen - SAFMC SG AP

Dave Crisp – Recreational fisherman, Florida

Kenny Fex - SAFMC SG AP

Robert Johnson - SAFMC SG AP

Kevin McCarthy - SEFSC, Miami
Stephanie McInerny - Rapporteur, NC DMF
Beverly Sauls - FL FWCC
Kyle Shertzer – SEFSC, Beaufort
Jessica Stephen – SC DNR
Chris Wilson – NC DMF

A plenary session dedicated to the discards mortality topic reviewed SEDAR24-DW12 and developed recommendations for discard mortality to be employed by Data Panel work groups in determination of mortality rates to be recommended to the Assessment Panel.

6.2 Discussion

Discard mortality is an important estimation included in stock assessments and should be considered in evaluating the effectiveness of regulatory actions to reduce harvest. Several studies have been conducted to estimate a discard mortality rate for red snapper with values varying from 1 to 93% (Table 1). Most of these studies have focused on red snapper in the Gulf of Mexico where the commercial red snapper fishery operates much differently from the snapper grouper fishery off the US South Atlantic both in depths fished and gear used to target red snapper. The estimates of discard mortality used in SEDAR 15 were 90% for the commercial fishery and 40% for the recreational fishery. The recreational estimate (40%) matched the discard mortality estimate for red snapper from the Gulf of Mexico for fish caught in waters deeper than 20 meters (SEDAR 7). A formal working paper (SEDAR 24 DW 12) was developed for SEDAR 24 and includes a more in depth discussion of discard mortality.

Several studies have focused on depth as an important factor in determining discard mortality due to the visible impact of barotrauma. Studies conducted in depth of less than 35 meters (115 feet) estimated discard mortality rates of 20% or less (Parker 1985, Render and Wilson 1994, Patterson et al. 2002, Burns et al. 2006). Studies conducted in greater than 35 meters generally estimated higher discard mortality rates ranging from 17% to 93% (Gitschlag and Renaud 1994, Burns et al. 2004, Nieland et al. 2007, Burns 2009, Diamond and Campbell 2009, Stephen and Harris 2009). This increase in discard mortality rate with increasing depth is an expected result and has been described for red snapper and other snapper grouper species (Patterson et al. 2001, Burns et al. 2002, Patterson et al. 2002, Rudershausen et al. 2007, Stephen and Harris 2009).

To account for increasing discard mortality rate with increasing depth, three models were investigated to describe these depth effects (Figure 1). Two of the models (Burns et al. 2002, Diamond et al. unpublished data) used a logistic regression function to model the mortality rate and one used a linear trend (Nieland et al. 2007). All three of the models had overlap in the estimation of discard mortality particularly between 50 and 90 meters (see SEDAR 24 DW 12 reference for plots). The linear model had a higher discard mortality rate for red snapper caught in depths less than 40 meters than the other two studies (Nieland et al. 2007). This was likely due to the commercial fishing practices they observed in the GOM. These fishermen were fishing with bandit fishing reels with terminal gear consisting of 20 hooks spread over 4.5 to 6 meters (S. Baker, Jr, personal communication). Typical recreational fishermen in the South Atlantic and GOM as well as commercial fishermen in the South Atlantic fish for snapper/grouper species with terminal gear having less than 5 hooks (Gulf and South Atlantic

Fisheries Foundation 2008). The other two models describing discard mortality also included delayed discard mortality in their discard mortality estimate. Koenig (Burns et al. 2002) used a cage study to determine the effects of depth on red snapper. Additionally, red snapper and gag grouper data were combined in the model since there was no significant difference in the percent mortality at depth. The Diamond et al. (unpublished) combined data from several different studies including the Burns et al. (2002) and Nieland et al. (2007). The discard mortality curves from these two studies were similar with less than 20% discard mortality for fish caught in less than 20 meters increasing to 100% mortality for fish caught in greater than 90 meters.

Hooking related injuries are also important when trying to determine discard mortality (Rummer 2007, Burns et al. 2008). Necropsy results from headboat caught fish showed red snapper suffered greatest from acute hook trauma (49.1%), almost equaling all other sources (50.9%) of red snapper mortality combined in the headboat fishery in waters less than 42 meters (Burns et al. 2008). These hook related injuries caused both immediate and delayed mortality in red snapper. The delayed mortality was a result of the hook nicking an internal organ. This caused the fish to slowly bleed internally eventually leading to death after a few days (Burns et al. 2004). Circle hooks are generally thought to reduce discard mortality rate for red snapper (SEDAR 7; Rummer 2007); however, Burns et al. (2004) did not observe decreased discard mortality rate when comparing recapture rates of red snapper caught on circle and j-hooks.

Additional factors that influence discard mortality rate, such as size of the fish, temperature, and predation, have been considered for red snapper but currently data is too limited to include these parameters in a quantifiable estimation of discard mortality. However it appears smaller red snapper generally survive better than larger red snapper (Patterson et al. 2002).

Temperature has been noted in some studies as a significant factor determining discard mortality rate for red snapper (Render and Wilson 1994, Rummer 2007, Diamond and Campbell 2009). In these studies, the discard mortality rate increased with increasing temperature. More importantly, both Rummer (2007) and Diamond and Campbell (2009) found the temperature differential between surface and bottom water was more important in determining the discard mortality rate than water temperature alone. A greater differential between the surface and bottom temperature will cause a higher discard mortality rate.

Red snapper are preyed upon by several different species including barracuda, sharks, and amberjack (Parker 1985). Dolphins have been listed as a predator in the Gulf of Mexico but this behavior has not been observed in the South Atlantic. In the South Atlantic, the predators of red snapper are generally present during months when water temperatures are warmer (personal communication with commercial fishermen).

6.3 Recommendations

6.3.1 Use discard mortality estimate based on immediate or delayed mortality

The DW recommended using delayed mortality since this would be a better estimate of discard mortality. Immediate mortality is easier to quantify and can be observed at the surface but this value is unlikely to be an accurate estimate of discard mortality for red snapper. Delayed mortality is able to incorporate mortality due to hook related injuries, predation, and barotraumas that are not observed at the surface or on board boats. The group felt that delayed mortality rate was more appropriate to describe the fate of discarded red snapper.

6.3.2 Use a point estimate of discard mortality or use a discard mortality model that included depth as a factor.

The DW recommended using a discard mortality model since depth is an important factor in determining discard mortality rate. Some of the participants mentioned that few fish die in the shallow water typically fished for red snapper. The plenary decided on using the depth model presented in Burns et al. 2002 to estimate discard mortality. The model was selected due to differences in predation in the Gulf of Mexico (dolphin) and South Atlantic, differences in commercial gear in the Gulf of Mexico (rally rig) and South Atlantic (usually less than 5 hooks), and likely differences in temperature between Gulf of Mexico and South Atlantic.

6.3.3 How should fishing effort/catch of red snapper by depth be combined with depth-varying discard mortality rates?

The DW recommended integrating the fishing effort and catch of red snapper with the depth-varying discard mortality rate to determine the mean discard mortality. This method is able to use data collected from the different fishing sectors (commercial, private boat, charter and head boat) to describe the average depth of trips that collected red snapper. Different sources of information were analyzed including logbook and observer data. Depth information was analyzed for the commercial fishery for all trips that caught red snapper, trips that landed over 100 pounds of red snapper, and observer data where red snapper were observed. The commercial workgroup recommended using the observer data from the Gulf and South Atlantic Observer study (2008) since this study had depth information combined with catch information. The discard mortality rate estimate of the commercial fishery was 49%. The headboat at sea observer program and logbook data was used to estimate the headboat and charter boat depth distribution. The discard mortality rate estimate for these two sectors was 41.3%. Private boat depth data was very limited but used depth information from South Carolina DNR tagging study and depths recorded from biological samples from Florida and Georgia fishermen. The private boat discard mortality rate estimate was 38.8%. More information on the discard mortality rates by sector can be found in the commercial and recreational section.

6.3.4 Range of discard mortality rates to be used in the assessment for uncertainty estimates.

The DW recommended using a range of discard mortality rates to estimate uncertainty in the parameter estimates. The group recommended using the 95% confidence interval based on the Burns et al. 2002 model as opposed to a range based on a certain percentage of the discard mortality estimate (ex. +/- 50% of the discard mortality rate estimate). The group felt that the 95% confidence interval should represent uncertainty in the model and was based on empirical data. It was pointed out the uncertainty represented by this estimate was only based on the discard mortality rate estimate and did not include uncertainty around the depth distribution of discarded red snapper.

6.3.5 Sensitivity runs should include an estimate of discard mortality based on doubling the upper bound of the confidence interval for the commercial and recreational discard mortality estimate.

The DW recommended using this estimate for sensitivity runs to determine the overall influence of the discard mortality rate on the model output. The doubling of the upper bound of the discard mortality rate estimate was selected because many of the discard mortality studies underestimate the delayed mortality a species is likely to experience. The studies may limit the influence of predation, handling stress, or gear related issues. Some members felt that the current estimate derived from the Burns et al. 2002 model may be too high but these concerns were based on surface observations. A doubling of the discard mortality rate estimate for commercial and recreational fisheries was discussed as a sensitivity run but this estimate was determined to be too extreme and may be biased.

6.4 Research Recommendations

- More hooking, size, and depth related discard mortality studies
- Angler education
- More accurate depths by species from logbooks
- Survey of fishermen and scientists to possibly get information on depth of areas fished and species abundance
- More species specific depth information collected by port agents

6.5 Itemized list of tasks for completion following workshop

See Section 1.5

6.6 Literature Cited

6.8 Tables

Table 1. Red snapper discard mortality studies, fishing sector, type of study, gear used in study, sample size (N), depth range of the study, and mortality type reported. Type of study includes a literature search (lit), laboratory (L), surface observation (S), cage study (C), metadata (M) and tagging study (T). Gears include hook and line gears and bandit reels. Mortality rates were separated into surface mortality, delayed mortality, and total mortality.

							Depth Range		Mortality Type		
Research Documents	Year	Sector	Area	Type	Gear	N	Meters (range)	Feet	Surface	Delayed	Total
Parker	1985		GOM/SA	L S C	H&L	44	30			11-12%	
Parker	1991		GOM/SA	Lit							
Gitschlag and Renaud*	1994	Rec	GOM	C	H&L	55	50	164		36%	
Gitschlag and Renaud*	1994	Rec	GOM	S	H&L	232	21-40	69-131	1-44%		
Render and Wilson	1994	Rec	GOM	C	H&L	282	21	69		20%	
Burns et al.	2002	Rec	GOM/SA	S C	H&L				See Figure 1		
Patterson et al.	2002	Rec	GOM	T S	H&L	2,232	21-32	69-105	14%		
Burns et al.	2004	Rec	GOM/SA	L S C	H&L		0-61.3+	0-201			64%
Rummer and Bennett	2005		GOM	L			0-110	0- 361			25-90%
Burns et al.	2006	Rec	GOM/SA	T S	H&L	590	0-30.8+	0-101	12%		
Nieland et al.	2007	Com	GOM	S	Bandit	2,900	43 (9-83)	141	69%		
Burns et al.	2008	Rec	GOM/SA	L T S	H&L	5,317	10.4-42.7	34-140			
Burns	2009	Rec	GOM/SA	L T S	H&L	1,259	10.4-42.7	34-140	13.60%	57%	
Diamond and Campbell	2009	Rec	GOM	C	H&L	320	30, 40, 50	98, 131, 164	17%	64%	
Stephen and Harris	2009	Com	SA	S	Bandit	67	50-70 (20-300)	164-230	93%		

Diamond et al. (unpubl)		Both	GOM/SA	M				See Figure 1

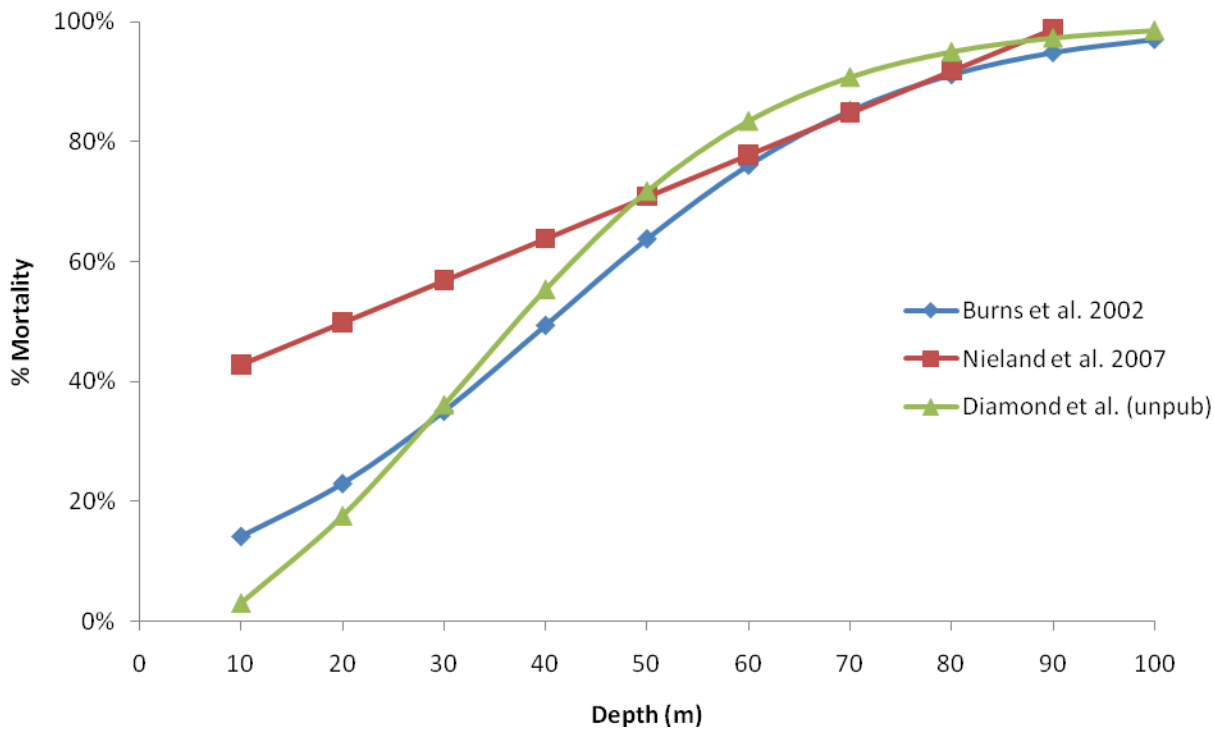
Table 1. continued

Assessments								
Manooch et al.	1998	Both	SA	Lit	All	All		10-25%
SEDAR 7	2005	Com	GOM	Lit	All	50-80+		71-88%
SEDAR 7	2005	Rec	GOM	Lit	All	20-40+		15-40%
SEDAR 15	2009	Com	SA	Lit	All	43-71 (18-823)	141-233	90%
SEDAR 15	2009	Rec	SA	Lit	All	43-58 (20-274)	141-190	40%

*Same paper

6.9 Figures

Figure 1. Discard mortality functions by depth (m) for red snapper derived from Burns et al. (2002), Nieland et al. (2007), and Diamond et al (unpublished data).



7 Analytic Approach

7.1 Overview

Group membership consisted of Brian Linton, Amy Schueller, Kyle Shertzer (leader), Paul Spencer, and Jessica Stephen. The group discussed possible assessment approaches, given the data sources presented at the DW. Our suggestions should not be considered directives, as assessment modeling decisions are the purview of the assessment workshop.

7.2 Suggested Analytic Approach Given the Data

The group suggested that a statistical catch-age model, such as the Beaufort Assessment Model (BAM), be considered. The BAM can accommodate the various sources of data discussed (landings, discards, indices, length compositions, and age compositions), and is flexible enough to include many of the details specific to this red snapper stock. Other models that could be considered, perhaps as supplemental, are stock reduction analysis and surplus production models.

8. Research Recommendations

Workshop Term of Reference #10 called for the Data Panel to provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment; and to include specific guidance on sampling intensity (number of samples including age and length structures) and appropriate strata and coverage.

8.1 Life History

8.1.1 Age Reading Comparisons

Continuing the age reading comparisons and calibrations between labs on a reference collection of known age fish would be beneficial for determining a more accurate aging error matrix and would provide accuracy to the age composition data.

8.1.2 Movements and Migrations

More research on red snapper movements/migrations in Atlantic waters is needed. Available data and the results of studies in the Gulf of Mexico indicate high site fidelity. Tropical storms may cause greater than normal movement.

8.2 Commercial Statistics

8.2.1 Decision 10 of the Commercial Statistics Work Group.

The Workgroup reviewed recommendations from SEDAR 15 and offers additional recommendations.
First, the Commercial WG notes that Sea Grant is currently funding a video monitoring program for observing the snapper-grouper fishery using exemption permits with 7 total vessels participating (1 in NC, 2 each in SC, GA, and FL).

The Commercial WG recommended the following:

- Electronic Logbooks
- More observers
  - 5-10% allocated by strata within states
  - Possible to use exemption to bring in everything with no sale
  - Get maximum information from fish
- Angler education with regards to recording depths on paper logbooks
- More precise depths by species from port agents (would require data base change)
- Expand TIP sampling
  - Reallocate samplers for at-sea observer trips
  - Improve sampling from Florida's handline and dive gear where most of the effort and landings are from.
- Continue to sample more ages (proportional to effort), although large numbers of ages were sampled in the most recent years, especially 2009.

These recommendations were approved by the plenary.

8.3 Recreational Statistics

The research recommendations of the Recreational Work Group are:

- In order to separate PR and CH catch data, more age data are needed, particularly from the PR mode.
- Continued research efforts to incorporate/require logbook reporting from recreational anglers.
- Quantify historical fishing photos for use in future SEDARS.
- MRFSS At-SEA observer program in NC, SC and GA should collect depth fished data. Standardize data elements within this program.
- Headboat Survey logbook should also collect depth information.
- Continued research efforts to collect discard length and age data from the private sector.
- Improve metadata collection in the recreational fishery.

8.4 Indices

The research recommendations of the Indices Work Group are:

- More fishery independent data collection
- Exploration of the Stephens and MacCall trip selection method and alternatives methods
    - Explore the use of actual landings rather than presence/absence for other species for trip selection
- Evaluate how fishermen preferences change over time and whether such changes affect CPUE
- Increase observer coverage, including information on area fished and depth
- Examine how catchability has changed over time with increases in technology and potential changes in fishing practices. This is of particular importance when considering fishery dependent indices
- Investigate potential density-dependent changes in catchability

8.5 Analytic Approach

There are no research recommendations from the Analytic Approach working group.

8.6 Discards Mortality

The research recommendations of the Discards Mortality Work Group are:

- More hooking, size, and depth related discard mortality studies
- Angler education
- More accurate depths by species from logbooks
- Survey of fishermen and scientists to possibly get information on depth of areas fished and species abundance
- More species specific depth information collected by port agents

9. Submitted Comment from Appointed Panelists

9.1 Fishery-dependent and fishery-independent data collection programs

9.1.1 Inquiry on May 24 by Gregg Waugh, SAFMC Staff

What document or documents describe the current fishery-dependent and fishery-independent data collection programs? I have looked at SEDAR24-RD56 which provides a general description of the headboat survey program and SEDAR24-DW08 which provides a general description of the TIP program. However, neither of these describe the specific target sampling levels for red snapper.

9.1.2 Reply on May 24 by Marcel Reichert, MARMAP

MARMAP's annual cruise reports (as submitted to the NMFS, normally at the end of November each year) describe the methods and efforts for our sampling, plus an overview of collected and processed species. In addition, our status of the stocks reports have described methods and some analyses of our data for a selected group of species.

To address the question about "target levels"; MARMAP is charged with sampling (natural live bottom) habitat and we do not "set targets" for any particular species. Having said that, due to the recently added SEAMAP funding we are now trying to expand our sampling areas. Within that effort we are specifically looking for areas that are known to have yielded red snapper in the past.

9.1.3 Reply on May 28 by Erik Williams, SEFSC, NMFS, Beaufort

South Atlantic Fishery Independent Monitoring Program (SAFIMP) update

1 June 2010

In 2010, efforts will focus on three main components:

Component 1: MARMAP supplement and new gear introduction

Need addressed: The purpose of this component is to add a second survey vessel (in addition to the MARMAP vessel *RV Palmetto*) to supplement MARMAP fishery-independent sampling efforts in southeast US continental shelf waters. Surveys on the second vessel will utilize general MARMAP methodologies (but see below), *resulting in increased sample size and spatial coverage (and thus statistical power) of fishery-independent surveys*, with related increases in otolith and gonad samples, addressing data needs for multiple species. Video camera gear will be tested and, once a suitable deployment methodology is established, incorporated into surveys to address current gear selectivity issues associated with the main MARMAP survey gear (chevron traps). In 2010, the second survey vessel will focus surveys in areas off of GA and northeastern FL to provide as much data as possible for red snapper.

Component 2: Assessing red snapper abundance and age structure in shelf-break waters

Need addressed: This component will involve a partnership with industry (i.e., use of commercial vessels and gear) to address the following questions: (1) is there a "cryptic biomass" of red snapper in continental shelf-break waters (referred to by commercial fishers as the "roll-down") off of GA and northeastern FL that is comprised of older and larger individuals than exist in continental shelf waters, and, if so, (2) what proportion of the overall stock (continental shelf plus roll-down) does this cryptic biomass represent? Bottom longline sampling from contracted commercial vessels will be replicated across three depth zones (< 16 fathoms, 16-27 fathoms and 27-100 fathoms, with focus in the last depth zone on depths ~ 35-50 fathoms) in areas off GA and northeastern FL. This project will be supplemented by remotely operated vehicle (ROV) surveys of shelf-break waters to further assess red snapper abundance in those waters (see Component 3).

Component 3: Research to assess and improve sampling program efficiency and power

Need addressed: Research cruises aboard the *NOAA Ship Pisces* will focusing on (1) the assessment of spatial variability in red snapper habitat distribution and abundance, including ROV surveys in shelf-break waters and multi-gear surveys to identify red snapper juvenile habitat, (2) comparative analysis of fish traps, video cameras, and acoustics for fishery-independent data collection, and (3) bathymetric data collection (for subsequent habitat mapping) over hardbottom habitats. As with Components 1 and 2, in 2010 *Pisces* cruise efforts will occur predominantly in areas off of northern FL and GA to provide as much data as possible for red snapper.

9.2 Red Snapper depth ranges for the Cape Canaveral to St. Augustine region and north to South Carolina – Rusty Hudson

Historically I have personally caught Red Snapper of all sizes from depths of 60 feet in the near shore areas, offshore to 200 feet on both commercial & the for-hire vessels and caught predominately large Red Snapper from 200 to 300 feet of water commercially. I have fished spawning aggregations of large Red Snapper in depths from 60 feet to 110 feet that occur in the summer months in my home region offshore of Volusia County, Florida. Most of the for-hire fishing on head boats and charter boats bottom fishing has occurred on popular reefs found in 60 feet of depth out to 90 feet of depth.

I have fished the "Big Ledge" or Continental shelf that occurs at 165 feet on top of the ledge and drops to about 200 feet on the bottom side from South Florida, North to the Carolinas. I have fished this area since the 1970's and caught a lot of Red Snapper. The Big Ledge is found about 30 miles offshore of the Cape Canaveral area and up to 80 miles or more from the beach from North Florida up to the South Carolina region.

Offshore of the Big Ledge from South of Cape Canaveral North to offshore of Daytona Beach are natural features called "The Steeples" usually 40 feet in height up to 75 feet that are found usually at 240 feet of depth and offshore to 300 feet in depth. The Red Snapper found there are usually very large animals that range from 20 pounds to 40 pounds whole weight.

9.3 Summary of SEDAR24-RD57 – Frank Hester

Biological-Statistical Census of the Species Entering Fisheries in the Cape Canaveral Area, SSR-Fisheries No. 514 by William W Anderson and Jack W. Gerhinger, 79 pp

Area covered: From Melbourne to North of Ponce de Leon Inlet to 29º N.

Recreational Fishery 1962 and 1963 and Commercial 4-year Average

Fishery	year	Catch Wt.	Catch #	Avg.Wt.	Method
Sport	1962	302,987	78,239	5.02	Field survey*
Commercial	1959-62	251,475**	NA	NA	4-yr. average of landing records
Sport	1963	101,426	12,779	7.93	Field survey

Appendix A

Observer Report – NOAA Center for Independent Experts

SEDAR

SouthEast Data, Assessment, and Review

South Atlantic Red Snapper

SECTION III: Assessment Report

September 2010

NOTE: Updates to the base model figures and tables reported in this report were made during the Review Workshop held 12-14 October 2010. For complete results reflecting those changes, please see the Addendum of this Stock Assessment Report (Section VI).

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Table of Contents

1 Workshop Proceedings

1.1 Introduction

1.1.1 Assessment times and places

The SEDAR 24 Assessement Stage I was conducted through a series of webinars between June 18 and August 24, 2010. Specific assessment webinar dates were June 18, July 14, August 6, August 9, August 11, August 13, August 18, August 20, and August 24, 2010.

The SEDAR 24 Assessment Stage II occurred during September 7-29, 2010, and addressed comments on the Assessment report. Specific assessment webinar dates were September 9 and September 21, 2010.

1.1.2 Terms of Reference

Assessment Process I

1. Review any changes in data following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.
2. Develop population assessment models that are compatible with available data and recommend which model and configuration is deemed most reliable or useful for providing advice. Document all input data, assumptions, and equations. Include a model configuration consistent with the SEDAR 15 base run and additional recent data observations.
3. Provide estimates of stock population parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, etc); include appropriate and representative measures of precision for parameter estimates.
4. Characterize uncertainty in the assessment and estimated values, considering components such as input data, modeling approach, and model configuration. Provide appropriate measures of model performance, reliability, and 'goodness of fit'.
5. Provide yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations including figures and tables of complete parameters.
6. Provide estimates for SFA criteria consistent with applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards. This may include evaluating existing SFA benchmarks, estimating alternative SFA benchmarks, and recommending proxy values; specific criteria for evaluation will be specified in the management summary.
7. Provide declarations of stock status relative to SFA benchmarks, considering both existing and proposed management parameters.
8. Perform a probabilistic analysis of proposed reference points and provide the probability of overfishing at various harvest or exploitation levels and, if the stock is determined to be overfished, the probability of rebuilding within mandated time periods as described in the management summary.
9. Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules if warranted; include estimated generation time. Stock projections shall be developed in accordance with the following:

   a. If stock is overfished:
      $F=0$, F=current, $F=F_{msy}$, F_{target} (OY),
      $F=F_{rebuild}$ (max that rebuild in allowed time)
   b. If stock is overfishing
      $F=F_{current}$, $F=F_{msy}$, $F= F_{target}$ (OY)
   c. If stock is neither overfished nor overfishing
      $F=F_{current}$, $F=F_{msy}$, $F=F_{target}$ (OY)
10. Provide recommendations for future research and data collection (field and assessment); be as specific as practicable in describing sampling design and sampling intensity and emphasize items which will improve future assessment capabilities and reliability.
11. Prepare an accessible, documented, labeled, and formatted spreadsheet containing all model parameter estimates and all relevant population information resulting from model estimates and any projection and simulation exercises. Include all data included in assessment report tables and all data that support assessment workshop figures.
12. No later than September 27, 2010, complete the Assessment Workshop Report (Section III of the SEDAR Stock Assessment Report).

Assessment Process II
1. Review comments submitted during the open pre-review period and review prior recommendations and assessment results in light of submitted comments.
2. Consider whether corrections, revisions, or additional analyses are justified.
3. Address submitted comments as appropriate and document results through working papers, addenda to the assessment report, or corrections to the assessment report.

1.1.3 List of Participants

x = present

	Date:	18-Jun	14-Jul	6-Aug	9-Aug	11-Aug	13-Aug	18-Aug	20-Aug	9-Sep	21-Sep
First	Last	Web1	Web2	Web 2b	Web 2c	Web 2d	Web 3	Web 3b	Web 3c	Web	Web
PANELISTS											
Steve	Amick										
Luiz	Barbieri	x	x	x	x			x	x	x	x
Zach	Bowen										
Bobby	Cardin				x	x	x	x			x
Rob	Cheshire	x	x	x	x	x	x	x	x	x	x
Chip	Collier	x	x	x				x	x	x	x
Andy	Cooper	x		x	x			x	x	x	x
Kenny	Fex	x		x					x		
Frank	Hester		x	x	x	x	x	x	x	x	x
Jim	Ianelli	x	x	x	x	x		x		x	x
Paul	Spencer		x			x		x	x	x	
Robert	Johnson							x	x		
Brian	Linton	x	x		x			x	x		x
Mike	Murphy	x	x		x	x				x	x
Behzad	Mahmoudi		x				x	x		x	x
Jennifer	Potts		x								x
Amy	Schueller	x	x	x	x	x	x	x	x	x	x
Kyle	Shertzer	x	x	x	x	x	x	x	x	x	x
Rodney	Smith										
Doug	Vaughan	x	x	x	x	x	x	x	x		x
Erik	Williams	x	x	x	x	x	x	x	x	x	x
John	Quinlan	x	x	x	x	x		x	x	x	x

COUNCIL											
George	Geiger	x	x	x	x	x	x	x	x	x	x
Charlie	Phillips	x		x	x	x	x	x	x	x	x
STAFF											
John	Carmichael	x	x		x	x		x		x	x
Rick	DeVictor		x			x				x	
Kari	Fenske	x	x	x	x	x	x	x	x	x	x
Rachael	Lindsay								x		
Bob	Mahood					x				x	
Julie	Neer	x	x	x	x	x		x	x	x	x
Dale	Theiling	x	x								
Gregg	Waugh							x	x		
Myra	Brouwer									x	
OBSERVERS											
Joey	Ballenger	x	x	x				x			
Dick	Brame		x	x	x	x		x	x	x	x
Chester	Brewer			x							
Richard	Cody	x									
Roy	Crabtree		x								
Scott	Crosson			x	x						
David	Cupka				x						
Mac	Currin							x	x	x	x
Sera	Drevenak	x	x	x	x	x	x	x	x		x
Nick	Farmer							x			x
Ted	Forsgren	x	x	x		x	x			x	x
Bob	Gill			x	x					x	
Rebekah	Hamed				x	x					
Mathew	Hardy		x								

Ben	Hartig			x							
Rusty	Hudson	x	x	x	x	x	x	x	x	x	x
Jimmy	Hull		x		x	x		x	x	x	x
John	Larson		x	x		x	x		x	x	x
Michael	Kennedy	x	x	x	x	x	x				
Anne	Lange	x									
Patrick	Magrady		x								
Jack	McGovern		x			x		x	x	x	x
Jack	Mountford		x								
David	Nelson		x		x	x	x	x	x	x	x
Don	Newhauser		x	x			x				
Bonnie	Ponwith			x							
Marcel	Reichert		x	x						x	x
Jessica	Stephen		x	x							
Andy	Strelcheck		x			x					
Ken	Stump				x						
Jon	Turner		x								
Jim	Waters		x	x			x	x		x	
Karl	Wickstrom		x	x	x	x	x			x	x

1.1.4 List of assessment working papers and reference documents added since the data workshop report

Documents Prepared for the Assessment Workshop		
SEDAR24-AW01	Assessment History of Red Snapper (*Lutjanus campechanus*) in the U.S. Atlantic	Sustainable Fisheries Branch, NMFS 2010
SEDAR24-AW02	The Beaufort Assessment Model (BAM) with application to red grouper1: mathematical description, implementation details, and computer code	Sustainable Fisheries Branch, NMFS 2010
SEDAR24-AW03	Standardized discard rates of U.S. Atlantic red snapper (*Lutjanus campechanus*) from headboat at sea observer data.	Sustainable Fisheries Branch, NMFS 2010
SEDAR24-AW04	Additional age data of south Atlantic red snapper (*Lutjanus campechanus*) from Florida Fish and Wildlife's dependent monitoring program	J. Tunnell, 2010
SEDAR24-AW05	Selectivity of red snapper in the southeast U.S. Atlantic: dome-shaped or flat-topped?	Sustainable Fisheries Branch, NMFS 2010
SEDAR24-AW06	Spawner-recruit relationships of demersal marine fishes: Prior distribution of steepness for possible use in SEDAR stock assessments	Sustainable Fisheries Branch, NMFS 2010
SEDAR24-AW07	Red snapper: Regression and Chapman-Robson estimators of total mortality from catch curve data	Sustainable Fisheries Branch, NMFS 2010
SEDAR24-AW08	Overviews of NMFS fishery-dependent data source surveys referenced in the SEDAR 24 data workshop report	SEDAR 2010, Compiled by J. Carmichael
SEDAR24-AW09	Vulnerability to Capture of Red Snapper (*Lutjanus campechanus*) in the Fisheries of the Southeast United States - a Preliminary look	F. Hester and D. Nelson, 2010
SEDAR24-AW10	South Atlantic Red Snapper Fishery – A Fisherman's Perspective	D. Nelson, 2009
SEDAR24-AW11	Additional information for red snapper selectivity	F. Hester, 2010
SEDAR24-AW12	Selectivity of red snapper in the South Atlantic More than Just Depth	D. Nelson, 2010
SEDAR24-AW13	Pre-review draft of the Assessment Report, public comment version 8-26-10	SEDAR 2010
Reference Documents		
SEDAR24-RD64	Shelf -edge and upper slope reef fish assemblages in the South Atlantic Bight: habitat characteristics, spatial variation, and reproductive behavior	C. M. Schobernd, G. R. Sedberry 2009

SEDAR24-RD65	A survey of the number of anglers and of their fishing effort and expenditures in the coastal recreational fishery of Florida	Ellis et al., 1958

1.2 Terms of Reference Roadmap

Assessment Process I

1. Review any changes in data following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.

Data are summarized in the DW report, and updates to data are described in section 2 of the AW report.

2. Develop population assessment models that are compatible with available data and recommend which model and configuration is deemed most reliable or useful for providing advice. Document all input data, assumptions, and equations. Include a model configuration consistent with the SEDAR 15 base run and additional recent data observations.

The assessment models are described in section 3 of the AW report. A continuity run was configured as a sensitivity run of the SEDAR 24 implementation.

3. Provide estimates of stock population parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, etc); include appropriate and representative measures of precision for parameter estimates.

These estimates are described in section 3 of the AW report.

4. Characterize uncertainty in the assessment and estimated values, considering components such as input data, modeling approach, and model configuration. Provide appropriate measures of model performance, reliability, and ‘goodness of fit’.

Uncertainty and performance metrics are described in section 3 of the AW report.

5. Provide yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations including figures and tables of complete parameters.

These estimates are provided in section 3 of the AW report.

6. Provide estimates for SFA criteria consistent with applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards. This may include evaluating existing SFA benchmarks, estimating alternative SFA benchmarks, and recommending proxy values; specific criteria for evaluation will be specified in the management summary.

Estimated management benchmarks and alternatives are provided in section 3 of the AW report.

7. Provide declarations of stock status relative to SFA benchmarks, considering both existing and proposed management parameters.

Estimates of stock status are provided in section 3 of the AW report.

8. Perform a probabilistic analysis of proposed reference points and provide the probability of overfishing at various harvest or exploitation levels and, if the stock is determined to be overfished, the probability of rebuilding within mandated time periods as described in the management summary.

Probabilistic analyses were performed as part of the rebuilding projections, described in section 3 of the AW report.

9. Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules if warranted; include estimated generation time. Stock projections shall be developed in accordance with the following:
A) If stock is overfished:
F=0, F=current, F=Fmsy, Ftarget (OY),
F=Frebuild (max that rebuild in allowed time)
B) If stock is overfishing
F=Fcurrent, F=Fmsy, F= Ftarget (OY)
C) If stock is neither overfished nor overfishing
F=Fcurrent, F=Fmsy, F=Ftarget (OY)

Projections are described in section 3 of the AW report. The scenarios examined fall into category A (overfished) and additionally include a scenario that simulates the current moratorium.

10. Provide recommendations for future research and data collection (field and assessment); be as specific as practicable in describing sampling design and sampling intensity and emphasize items which will improve future assessment capabilities and reliability.

Research recommendations are listed in Section IV.

11. Prepare an accessible, documented, labeled, and formatted spreadsheet containing all model parameter estimates and all relevant population information resulting from model estimates and any projection and simulation exercises. Include all data included in assessment report tables and all data that support assessment workshop figures.

An ASCII file of model output was supplied. This file could be read into spreadsheet software such as Excel.

12. No later than September 27, 2010, complete the Assessment Workshop Report (Section III of the SEDAR Stock Assessment Report).

The report will be available on September 29, 2010.

Assessment Process II

1. Review comments submitted during the open pre-review period and review prior recommendations and assessment results in light of submitted comments.

Submitted comments were reviewed and discussed during a webinar on September 9, 2010. A summary of comments is included in section 4.2 of the assessment report.

2. Consider whether corrections, revisions, or additional analyses are justified.

During the September 9, 2010 webinar the assessment panelists discussed whether changes to the model were necessary. Specific changes to the model that were made as a result of comments are detailed in section 4.3 of the assessment report.

3. Address submitted comments as appropriate and document results through working papers, addenda to the assessment report, or corrections to the assessment report.

Section 4.3 of the assessment report contains responses to public comments.

2 Data Review and Update

Processing of data for the assessment is described in the SEDAR 24 Red Snapper Data Workshop Report. This section summarizes the data input for the Beaufort Assessment Model (BAM) base run and describes additional processing prior to and during the AW. A summary of the base run model input is given in Tables 1-5. The units and significant digits are consistent with the input values.

2.1 Additional Data Several data elements were discussed and recommended at the SEDAR 24 DW but were not completed by the DW panel. The headboat discard index was completed and approved for use by the SEDAR 24 AW panel. (Table 1). The upper and lower bounds of the point estimates of discard mortality for the for-hire, private, and commercial line gears were provided and approved for use in sensitivity runs and bootstrap procedures. The sample sizes of annual headboat discard length compositions were provided and approved by the AW panel (Table 2). Additional recreational age samples from Florida were discovered after the SEDAR 24 DW. The AW panel recommended including these additional samples. The age compositions and sample size were updated accordingly (see Table 2 for sample sizes).

2.2 Data Updates and Revisions

2.2.1 Landings An inconsistency in the 1981-85 MRFSS charter landings estimates was discovered during the AW. For these years headboat landings were included with charter landings and represented the primary source for dockside sampling for those years. MRFSS personnel were contacted but were unable to separate the headboat and charter landings for SEDAR. The AW panel recommended applying the geometric mean of the ratio of charter landings to headboat landings from 1986-1991 to the headboat landings for 1981-85 to generate the charter boat landings. These values were combined with the headboat landings to give the for-hire landings estimates (Table 3).

For estimating historical recreational landings, the SEDAR 24 DW applied a ratio method (described later). This method was applied in numbers of fish, which required converting commercial landings from weight to numbers. The SEDAR 24 DW converted commercial line landings from pounds to numbers using an average weight. For early years with poor or no sampling the average weight was borrowed from later years. The SEDAR 24 AW panel agreed with this approach but disagreed with the value used for average red snapper weight because the average size of landed fish has decreased due to the limited number of older fish. Comments from experienced fishermen indicated that the historical recreational landings provided by the DW were too high. The average weight was changed from 4.2 pounds to 9 pounds for 1955-1980, as suggested by fishermen on the panel. The net effect of this change was a reduction in estimated for-hire and private recreational landings from the commercial ratio method. The commercial landings were input the BAM in the units in which they were reported (pounds) and remained unchanged.

The SEDAR 24 AW panelists were concerned about the spike in MRFSS charter and private landings in 1984-85 which were not reflected to the same degree in the other sectors. The panel wanted to preserve the increase in landings but deflate the magnitude of the increase.

Examination of age and length compositions showed evidence of a strong year class recruiting to the fishery but the panel generally thought the MRFSS estimates exaggerated the increase. Several methods were examined for removing the spikes including smoothing options and averaging adjacent years landings. The panel recommended smoothing the MRFSS private landings (1981-2009) using a cubic spline procedure weighted by the inverse of the annual CVs. This was implemented in R programming software with the smoothing parameter (spar) set to 0. The correction of the 1981-85 landings scaled the 1984-85 spike in MRFSS charter landings to the headboat and no smoothing was required. These changes were incorporated in the for-hire and private recreational landings for input into the model (Table 3).

The commercial ratio method estimates of historical recreational landings were recalculated with the adjusted recreational data from 1981-2009 and the adjusted commercial landings in number. The SEDAR 24 AW panel chose to use the median instead of the mean ratio of commercial line to recreational fleets in estimating recreational.

The SEDAR 24 AW panel agreed with the DW CIE reviewer that the commercial ratio method used to estimate historical landings was inadequate to capture the inter-annual variability displayed in the predicted estimates, but it might well approximate the scale of the historical landings. The panel recommended smoothing the historical recreational landings with a cubic spline procedure to be consistent with the smoothing of later data. The smoothing parameter was set slightly higher (0.5) than the smoothing parameter used for the 1981-2009 private landings to reflect the inability of the commercial ratio method to predict the inter-annual variability in landings.

2.2.2 Discards MRFSS charter and private estimates of discards had missing values for several years in the early MRFSS estimates (early 1980s). Analysts felt this would cause problems within the model and that it zero discards was unlikely, particularly following a year with discards and no regulation change. The AW panel considered options for filling in the missing values and recommended the minimum discard estimate from the entire series for each sector be substituted for missing values.

2.2.3 Length and Age Compositions Age compositions were pooled at 20 years. The ageing error matrix was adjusted to a maximum age of 20 years to match the age compositions. Length composition bins were pooled into 3 cm bins from 18cm to 101cm labeled at the midpoint. Lengths less than 18cm were dropped from composition and lengths greater than 101 cm were pooled into the 100 cm bin. The private recreational length composition sample sizes were low and therefore pooled across years to match regulation periods (1983-1991 and 1992-2009). The commercial lines length composition was reduced to just 2007 instead of pooling across years since almost all the samples in the pooled composition came from 2007.

Following advice of the CIE reviews of the draft assessment report, length composition data were removed if corresponding (same fleet, year) age composition data were available. Exceptions were made in favor of length composition data if the sample size of age composition data was small (N<30). However, for commercial diving in 2009m age compositions were retained despite N<30, because age composition N exceeded length composition N.

2.2.4 Life History Generation time is not typically computed at the data workshop but may be required for stock projection.
Generation time (G) was estimated from Eq. 3.4 in Gotelli (1998, p. 57).

$G = \mathrm{P} l_x b_x x / \mathrm{P} l_x b_x$

where summation was over ages x=1 through 100 (by which age cumulative survival is essentially zero), l_x is the number of fish at age starting with 1 fish at age 1 and decrementing based on natural mortality only, and b_x is per capita birth rate at age. Because biomass is used as a proxy for reproduction in our model, we substitute the product of $P_{fx}M_{fx}W_x$ for b_x in this equation, where P_{fx} is the proportion female at age, M_{fx} is the proportion of mature females at age, and W_x is expected gonad weight at age. This weighted average of age for mature biomass yields an estimate of 22 years (rounded up from 21.7 yrs.).

References

Gotelli, N. J. 1998. A Primer of Ecology 2nd Edition. Sinauer Associates, Inc., Sunderland, MA, 236p.

	Recreational				Commercial	
	Indices					
Year	Headboat	CV Headboat	Headboat discard	CV-Headboat discard	Lines	CV Lines
1976	2.30	0.07				
1977	2.24	0.07				
1978	2.11	0.05				
1979	2.12	0.06				
1980	1.42	0.05				
1981	2.88	0.05				
1982	1.14	0.05				
1983	1.53	0.05				
1984	1.31	0.05				
1985	1.99	0.05				
1986	0.47	0.05				
1987	0.56	0.05				
1988	0.54	0.06				
1989	0.91	0.05				
1990	0.84	0.05				
1991	0.65	0.06				
1992	0.08	0.07				
1993	0.15	0.07			1.14	0.06
1994	0.26	0.07			0.91	0.05
1995	0.28	0.06			0.92	0.05
1996	0.25	0.07			0.57	0.06
1997	0.27	0.08			0.57	0.06
1998	0.24	0.06			0.63	0.06
1999	0.30	0.06			0.76	0.06
2000	0.42	0.06			0.75	0.06
2001	0.80	0.06			1.22	0.05
2002	0.96	0.06			1.37	0.05
2003	0.53	0.07			1.11	0.05
2004	0.83	0.05			1.44	0.05
2005	0.80	0.06	0.56	0.30	1.23	0.06
2006	0.45	0.06	0.41	0.37	0.61	0.07
2007	0.46	0.06	2.02	0.17	0.66	0.07
2008	1.86	0.05	1.39	0.21	1.20	0.07
2009	2.04	0.05	0.63	0.27	1.92	0.07

Table 1. Red snapper indices of abundance in fish/angler (headboat and headboat discard) and pounds/hook hour (lines). Headboat indices were applied to the for-hire sector.

	Recreational			Commercial			Recreational		Commercial	
	Length Comp. Sample Size (trips)						Age Comp. Sample Size (trips)			
Year	ForHire	Private	Headboat discard	Lines	Diving	Lines discard	ForHire	Private	Lines	Diving
1976	115									
1977	195						~~22~~			
1978	~~208~~						83			
1979	~~91~~						32			
1980	~~93~~						36			
1981	~~208~~						145			
1982	~~155~~						56			
1983	~~308~~	79 pooled					173			
1984	~~406~~						178			
1985	~~364~~			153			161			
1986	~~264~~			90			100			
1987	~~164~~						64			
1988	128			105			~~20~~			
1989	~~172~~						32			
1990	140			98			23			
1991	71			149			~~20~~			
1992	55	165 pooled		89			~~10~~		~~18~~	
1993	107			128			~~14~~			
1994	83			132			~~11~~			
1995	84			145			~~11~~		~~13~~	
1996	~~79~~			~~115~~			58		58	
1997	54			84			~~12~~		144	
1998	92			~~106~~					37	
1999	113			~~153~~	13				156	
2000	94			~~133~~	9				257	124
2001	151			168	~~6~~		~~27~~		~~28~~	30
2002	~~200~~			167			105		~~10~~	
2003	~~191~~			223	12		108		~~10~~	
2004	~~154~~			~~174~~			98		30	
2005	~~118~~		44				130			
2006	~~125~~		30				123			
2007	~~86~~		65	~~142~~		6	51		138	
2008	~~117~~		63				52			
2009	~~210~~		56	~~135~~	~~10~~		359	11	294	17

Table 2. Red Snapper length and age composition sample sizes (number of trips sampled). A strikethrough indicates data that were excluded from the BAM (see text).

	Recreational				Commercial		
	Landings		Discards		Landings		Discards
	Numbers (1000's)				Whole Pounds (1000's)		
Year	ForHire	Private	ForHire	Private	Lines	diving	Lines
1955	48.540	0.000			497.800		
1956	51.832	1.899			484.300		
1957	54.379	4.206			868.900		
1958	57.889	6.894			617.300		
1959	62.884	10.093			662.700		
1960	68.301	13.763			677.100		
1961	74.807	18.067			799.800		
1962	81.321	22.657			662.577		
1963	84.472	26.582			504.840		
1964	85.598	30.115			559.491		
1965	85.480	33.277			656.795		
1966	83.527	35.672			740.057		
1967	79.441	37.195			963.706		
1968	76.530	39.544			1069.332		
1969	78.771	44.904			700.493		
1970	86.525	53.626			640.918		
1971	96.861	64.051			543.433		
1972	104.809	72.901			468.602		
1973	104.716	76.108			387.344		
1974	95.537	72.701			632.507		
1975	82.889	66.731			745.363		
1976	71.743	62.080			619.011		
1977	65.493	61.735			649.273		
1978	65.872	67.536			589.918		
1979	71.612	78.477			409.939		
1980	77.286	89.063			380.596		
1981	78.829	94.852			371.379		
1982	75.868	95.145			306.128		
1983	68.640	89.822	42.281	8.679	310.268		
1984	58.535	80.445	121.668	22.845	248.195	1.317	
1985	47.760	69.978	27.775	63.501	240.971	2.547	
1986	69.519	121.730	0.158	8.679	215.743	0.508	
1987	37.726	52.932	0.158	106.560	187.211	0.030	
1988	59.229	43.885	0.158	48.373	164.123	0.013	
1989	60.094	161.385	0.158	20.038	258.478	0.006	
1990	97.119	178.659	0.158	8.679	215.047	1.859	
1991	98.995	78.195	0.697	35.853	134.032	5.898	
1992	40.286	51.281	17.936	19.492	89.062	9.614	14.233
1993	62.664	98.608	33.397	48.989	189.994	5.611	14.926
1994	44.461	107.354	7.359	62.577	179.615	13.116	20.638
1995	26.656	11.091	24.366	37.932	166.772	10.037	19.437
1996	30.623	31.351	5.053	17.628	130.650	6.153	24.867
1997	45.611	38.345	19.038	8.679	101.232	7.531	27.458
1998	14.948	10.864	8.856	22.970	80.009	8.063	21.106
1999	22.589	13.567	47.594	132.663	80.506	9.974	19.387
2000	22.423	2.386	32.530	223.334	92.109	10.376	18.975
2001	8.681	11.419	32.845	179.264	175.233	18.238	19.014
2002	62.935	3.545	25.886	105.891	163.092	22.097	42.356
2003	18.112	7.585	21.700	139.401	118.803	17.454	13.973
2004	49.363	22.660	37.465	163.953	149.791	19.647	5.170
2005	19.508	57.664	49.435	79.725	118.015	9.344	4.999
2006	21.879	40.185	23.194	115.593	80.291	4.163	7.425
2007	30.115	33.865	118.249	339.128	104.737	7.514	14.759
2008	23.899	16.111	59.846	352.213	240.735	6.304	15.512
2009	24.796	25.390	35.131	183.886	341.241	8.011	20.402

Table 3. Red snapper landings as input into the BAM base model.

Equation/Conversion	units	Linf	k	t0	a	b
von Bertalanffy growth	mm	902.00(4.29)	0.24(0.004)	-0.03(0.03)		
WW-FL Conversion	mm,grams				7.150E-06	3.12
WW-GW conversion	grams				3.142E-05	1.743
Equation/Conversion	model					
von Bertalanffy growth	$L(t)=L_\infty*[1-\exp(-K*(age-t_0))]$					
WW-FL Conversion	W=aFL^b					
WW-GW conversion	Gt=aWt^b					

Table 4. Red snapper input parameters for the von Bertalanffy growth equation, whole weight-fork length conversion, and whole weight-gonad weight conversion. The standard error of the growth parameters are in parentheses.

Age	Percent Females Mature	Natural Mortality
1	22.1%	0.3
2	54.9%	0.17
3	83.9%	0.13
4	95.7%	0.11
5	99.0%	0.1
6	99.8%	0.09
7	99.9%	0.09
8	100.0%	0.08
9	100.0%	0.08
10	100.0%	0.08
11	100.0%	0.08
12	100.0%	0.07
13	100.0%	0.07
14	100.0%	0.07
15	100.0%	0.07
16	100.0%	0.07
17	100.0%	0.07
18	100.0%	0.07
19	100.0%	0.07
20+	100.0%	0.07

Table 5. Red snapper female maturity and age-dependent natural mortality as input to the BAM base run.

3 Stock Assessment Models and Results

Four different models were discussed for red snapper during the Assessment Workshop (AW): the Beaufort statistical catch-age model (BAM), virtual population analysis (VPA), stochastic stock reduction analysis (SSRA), and surplus-production models (ASPIC). The BAM was selected at the AW to be the primary assessment model. This report focuses on the BAM, as well as surplus-production models. In addition, catch curve analysis was used to examine mortality (SEDAR-24-AW07). An SSRA application received preliminary examination by the AW panel, but was not completed in time for this report. Abbreviations used herein are defined in Appendix A.

A VPA was not pursued, for several reasons. A major assumption of VPAs is that catch at age of each fleet in each year is known precisely, which is not a valid assumption for U.S. Atlantic snapper-grouper stocks in general, and the red snapper stock in particular. For example, only seven private recreational (a dominant fleet for red snapper) fishing trips were sampled for red snapper ages prior to 2009. Thus, developing catch-age matrices would require strong assumptions to fill in the data gaps; this obstacle is not insurmountable in principle, but if pursued, should likely be done at a Data Workshop by data providers who are most familiar with the strengths and weaknesses of each data set. Relaxing the assumption of known catch at age was one reason for the advent of statistical catch-age models (e.g., BAM). The AW panel thought that committing its limited resources to the BAM, SSRA, and surplus-production models would be more productive.

A draft assessment report was issued on August 26, 2010. This revised report includes changes that were made in response to comments from the public, AW panelists, and an independent (CIE) reviewer. Although a second draft was not issued for additional comment, all changes in methods and base-run results were reviewed and accepted by the AW panel during its final webinar on September 21, 2010.

3.1 Model 1: Beaufort Assessment Model

3.1.1 Model 1 Methods

3.1.1.1 **Overview** The primary model in this assessment was the Beaufort statistical catch-age model (BAM). The model was implemented with the AD Model Builder software (ADMB Foundation 2009), and its structure and equations are detailed in SEDAR-24-RW-01. In essence, a statistical catch-age model simulates a population forward in time while including fishing processes (Quinn and Deriso 1999; Shertzer et al. 2008*a*). Quantities to be estimated are systematically varied until characteristics of the simulated populations match available data on the real population. Statistical catch-age models share many attributes with ADAPT-style tuned and untuned VPAs.

The method of forward projection has a long history in fishery models. It was introduced by Pella and Tomlinson (1969) for fitting production models and then used by Fournier and Archibald (1982), Deriso et al. (1985) in their CAGEAN model, and Methot (1989; 2009) in his stock-synthesis model. The catch-age model of this assessment is similar in structure to the CAGEAN and stock-synthesis models. Versions of this assessment model have been used in previous SEDAR assessments of reef fishes in the U.S. South Atlantic, such as red porgy, black sea bass, tilefish, snowy grouper, gag grouper, greater amberjack, vermilion snapper, Spanish mackerel, and red grouper, as well as in the previous (SEDAR-15) benchmark assessment of red snapper.

3.1.1.2 **Data Sources** The catch-age model included data from four fleets that caught southeastern U.S. red snapper: commercial lines (primarily handlines), commercial dive, recreational for-hire (headboats and charterboats), and recreational private boats. The model was fit to data on annual landings (in units of 1000 lb whole weight for commercial fleets, 1000 fish for recreational fleets), annual discard mortalities (in units of 1000 fish for commercial lines and recreational fleets), annual length compositions of landings, annual age compositions of landings, annual length compositions of discards, three fishery dependent indices of abundance (commercial lines, headboat, and headboat discards). Not all of the above data sources were available for all fleets in all years. Data used in the model are tabulated in the DW report and in §III(2) of this report.

3.1.1.3 **Model Configuration and Equations** Model structure and equations of the BAM are detailed in SEDAR-24-RW01, along with AD Model Builder code for implementation. The assessment time period was 1976–2009, with an initialization period of 1955–1975. A general description of the assessment model follows:

Natural mortality rate The natural mortality rate (M) was assumed constant over time, but decreasing with age. The form of M as a function of age was based on Lorenzen (1996). The Lorenzen (1996) approach inversely relates the natural mortality at age to mean weight at age W_a by the power function $M_a = \alpha W_a^{\beta}$, where α is a scale parameter and β is a shape parameter. Lorenzen (1996) provided point estimates of α and β for oceanic fishes, which were used for this assessment. As in previous SEDAR assessments, the Lorenzen estimates of M_a were rescaled to provide the same fraction of fish surviving through the oldest observed age (54 years) as would occur with constant $M = 0.08$ from the DW. This approach using cumulative mortality is consistent with the findings of Hoenig (1983) and Hewitt and Hoenig (2005).

Stock dynamics In the assessment model, new biomass was acquired through growth and recruitment, while abundance of existing cohorts experienced exponential decay from fishing and natural mortality. The population was assumed closed to immigration and emigration. The model included age classes $1 - 20^+$, where the oldest age class 20^+ allowed for the accumulation of fish (i.e., plus group).

Initialization period Initial (1955) numbers at age assumed the stable age structure computed from expected recruitment and the initial, age-specific total mortality rate. That initial mortality was the sum of natural mortality and fishing mortality, where fishing mortality was the product of an initial fishing rate (F_{init}) and catch-weighted average selectivity. The initial fishing rate was chosen using an iterative approach. First, the assessment model was run using the nearly complete catch history (starting from the year 1901) provided by the DW, to indicate a plausible level of biomass depletion in 1955 ($B_{1955}/B_0 \approx 0.8$). Then, F_{init} was adjusted to approximate that level; the value used in the base model run was $F_{init} = 0.02$.

The initial recruitment in 1955 was assumed to be the expected value from the spawner-recruit curve. For the remainder of the initialization period (1955–1975), recruitment was permitted to deviate from the spawner-recruit curve. However, without CPUE or age/length composition data prior to 1976, there is little information to estimate those historic recruitment deviations with accuracy. Thus, the estimates of historic recruitment should not be considered reliable. Instead, the deviations were permitted to allow the model maximum flexibility to match CPUE and age/length composition data near the onset of the assessment period (1976–2009), as well as to minimize influence of the historic (initialization) period on the estimated spawner-recruit curve and thus management benchmarks. For this latter reason, recruitment deviations were estimated in two stanzas, 1956–1974 and 1975–2009. The log recruitment deviations in the early stanza were not constrained to sum to zero (although values were penalized for deviating from zero to provide some response in the likelihood surface). The likelihood component used to estimate the spawner-recruit curve included recruitment deviations only from the second stanza.

Growth Mean size at age of the population (total length, TL) was modeled with the von Bertalanffy equation, and weight at age (whole weight, WW) was modeled as a function of total length (Figure 3.1, Table 3.1). Parameters of growth and conversions (TL-WW) were estimated by the DW and were treated as input to the assessment model. For fitting length composition data, the distribution of size at age was assumed normal with standard deviation estimated by the assessment model. Assuming a constant standard deviation provided age-specific coefficients of variation that decreased until reaching an asymptote (where growth saturated), as was observed in size at age data. For fishery length composition data collected under a size limit regulation, the normal distribution of size at age was truncated at the size limit, such that length compositions of landings would include only fish of legal size. Similarly, length compositions of discards would include only fish below the size limit. Mean length at age of landings and discards were computed from these truncated distributions, and thus average weight at age of landings and discards would differ from those in the population at large.

Sex ratio The sex ratio was assumed to be 50:50, as suggested by the DW.

Female maturity Female maturity was modeled with a logistic function; parameters for this model were provided by the DW and treated as input to the assessment model (Table 3.1).

Spawning biomass Spawning biomass was modeled as total gonad biomass of mature females measured at the time of peak spawning. For red snapper, peak spawning was considered to occur at the end of July.

Ideally, recruitment would be predicted from population fecundity, but the DW believed that fecundity data were too sparse for use in the assessment. Without data on fecundity, many assessments apply the proxy of spawning biomass. Often, spawning biomass is defined as total body weight of mature females, as was done in SEDAR-15. However, in this assessment, the DW recommended total gonad biomass of mature females as a more direct measure of egg production.

Recruitment Expected recruitment of age-1 fish was predicted from spawning biomass using the Beverton–Holt spawner-recruit model. Steepness, h, is a key parameter of this model, and unfortunately it is often difficult to estimate reliably (Conn et al. 2010). In this assessment, many initial attempts to estimate steepness resulted in a value near its upper bound of 1.0, indicating that the data were insufficient for estimation. Thus, steepness was fixed at $h = 0.85$, the mode of a beta distribution estimated through meta-analysis (SEDAR-24-AW06).

Annual variation in recruitment was assumed to occur with lognormal deviations. The spawner-recruit curve was estimated using the lognormal residuals only from years when composition data could provide information on year-class strength (1975–2009) (as described above in the *Initialization period* section).

Landings Time series of landings from four fleets were modeled: commercial lines, commercial dive, for-hire, and private recreational. Landings were modeled with the Baranov catch equation (Baranov 1918) and were fitted in either weight or numbers, depending on how the data were collected (1000 lb whole weight for commercial fleets, and 1000 fish for recreational fleets). The DW provided observed landings back to the first assessment year (1955) for each fleet. However, sampling of headboats began in 1972 and other recreational sectors in 1981. Thus, historic landings of for-hire and private fleets were estimated indirectly by the DW using a ratio method, subsequently refined by the AW. Historic landings were considered (and treated) in this assessment as a primary source of uncertainty.

Discards As with landings, discard mortalities (in units of 1000 fish) were modeled with the Baranov catch equation (Baranov 1918), which required estimates of discard selectivities and release mortality probabilities. Discards were assumed to have fleet-specific mortality probabilities, as suggested by the DW (commercial lines, 0.48; for-hire, 0.41; private, 0.39). Annual discard mortalities, as fit by the model, were computed by multiplying total discards (tabulated in the DW report) by the fleet-specific release mortality probability. For for-hire and private fleets, discard time series were assumed to begin in 1983, with the start of the 12-inch size limit; for the commercial lines fleet, discards were modeled starting in 1992 with the 20-inch size limit. Discards from the commercial dive fleet were assumed negligible and not modeled.

Fishing For each time series of landings and discard mortalities, a separate full fishing mortality rate (F) was estimated. Age-specific rates were then computed as the product of full F and selectivity at age. Apical F was computed as the maximum of F at age summed across fleets.

Selectivities Selectivity curves applied to landings were estimated using a parametric approach. This approach applies plausible structure on the shape of the curves, and achieves greater parsimony than occurs with unique parameters for each age. Flat-topped selectivities were modeled as a two-parameter logistic function. Dome-shaped selectivities were modeled by combining two logistic functions: a two-parameter logistic function to describe the ascending limb of the curve, and a three-parameter logistic function to describe the descending limb. The two functions were joined at the age of full selection, which was fixed for each model run. Choice of this age was made iteratively, first by fitting all fleets with flat-topped selectivities to indicate the onset age of full selection, and then by comparing fits (likelihood values from age compositions) of dome-shaped selectivities with the peak near that onset. To model landings, the AW Panel recommended flat-topped selectivity for commercial lines and dome-shaped selectivity for commercial dive, for-hire, and private recreational fleets.

The assessment panel devoted substantial discussion and exploration to the pattern (flat-topped or dome-shaped) of selectivity at age. Several working papers (SEDAR24-AW05, SEDAR24-AW09, SEDAR24-AW12) helped guide the panel's decisions by providing insight into selectivity based on length and age compositions, depth distributions of fishing effort, skill levels of fishermen, and how circumstances contrasted between the Atlantic and Gulf of Mexico. The choice of flat-topped selectivity for commercial lines landings and dome-shaped for all others was based on several criteria. Two related considerations were the fleet-specific depths of fishing effort and the distribution of age at depth. In general, the commercial lines fleet fish in deeper water than other fleets, and although there was only weak correlation between depth and age of older fish (5^+), younger fish (1–5) were more readily caught in shallower depths (SEDAR24-AW05). It was also suggested that commercial gear and fishermen can better handle larger fish (SEDAR24-AW12). Catch curve data were consistent with the hypothesis that older fish are more vulnerable to the commercial lines fleet than to recreational fleets (SEDAR24-AW05, SEDAR24-AW07).

Selectivity of each fleet was fixed within each block of size-limit regulations, but was permitted to vary among blocks where possible or reasonable. Fisheries experienced three blocks of size-limit regulations (no limit prior to 1983, 12-inch limit during 1983–1991, and 20-inch limit during 1992–2009). Age and length composition data are critical for estimating selectivity parameters, and ideally, a model would have sufficient composition data from each fleet over time to estimate distinct selectivities in each period of regulations. That was not the case here, and thus additional assumptions were applied to define selectivities, as follows. Because the private recreational fleet had little age or length composition data, this fleet assumed no change in selectivity with implementation of the 12-inch size limit, but did allow a change with the 20-inch limit. Furthermore, the descending limb of this selectivity mirrored that of the for-hire fleet. With no composition data for commercial dive prior to the last regulatory block, commercial dive selectivity was assumed constant over time. Commercial lines selectivities in the first and second regulatory blocks were set equal, consistent with the DW recommendation that the 12-inch size limit had little effect on commercial line fishing. Selectivities of fishery dependent indices were the same as those of the relevant fleet.

Selectivities of discards were partially estimated, assuming that discards consisted primarily of undersized fish, as implied by observed length compositions of discards. The general approach taken for for-hire discard selectivity was that the value for age 1 was estimated, age 2 was assumed to have full selection, and selectivity for each age 3^+ was set equal to the age-specific probability of being below the size limit, given the estimated normal distribution of size at age. In this way, selectivity would change with modification in the size limit. A similar approach was taken for commercial line discard selectivity, but distinct values for age 1 and age 2 were estimated, age 3 was assumed to have full selection, and ages 4^+ were set to probabilities of being below the size limit. For private recreational discards, no age or length composition data were available, and thus selectivity of those discards mirrored that of the for-hire fleet.

Indices of abundance The model was fit to three fishery dependent indices of relative abundance (headboat 1976–2009; headboat discards 2005–2009; and commercial lines 1993–2009). Predicted indices were conditional on selectivity of the corresponding fleet (for-hire, for-hire discards, or commercial lines) and were computed from abundance at the midpoint of the year or, in the case of commercial lines, biomass. The for-hire discard index, although short in duration, tracks young fish and was included as a measure of recruitment strength at the end of the assessment period.

Catchability In the BAM, catchability scales indices of relative abundance to estimated population abundance at large. Several options for time-varying catchability were implemented in the BAM following recommendations of the 2009 SEDAR procedural workshop on catchability (SEDAR Procedural Guidance 2009). In particular, the BAM allows for density dependence, linear trends, and random walk, as well as time-invariant catchability. Parameters for these models could be estimated or fixed based on *a priori* considerations. The AW considered time-varying catchability, but did not believe that the data were sufficient for estimating annual variation, particularly without reliable fishery independent indices of abundance. However, the AW did believe that catchability has generally increased over time as a result of improved technology (SEDAR Procedural Guidance 2009) and as estimated for reef fishes (including red snapper) in the Gulf of Mexico (Thorson and Berkson 2010). Thus, the AW recommended linearly increasing catchability with a slope in the range of [0%, 4%]. The increase was assumed to begin with the first year of the index (1976 for headboat; 1993 for commercial lines) and continue until 2003, after which catchability was assumed constant. Choice of the year 2003 was based on recommendations from fishermen regarding when the effects of Global Positioning Systems likely saturated in the southeast U.S. Atlantic (SEDAR 2009). Catchability of the headboat discard index, which started in 2005, was assumed constant.

Biological reference points Biological reference points (benchmarks) were calculated based on maximum sustainable yield (MSY) estimates from the Beverton–Holt spawner-recruit model with bias correction. Computed benchmarks included MSY, fishing mortality rate at MSY (F_{MSY}), and spawning biomass at MSY ($\mathrm{SSB}_{\mathrm{MSY}}$). In this assessment, spawning biomass measures total gonad weight of mature females. These benchmarks are conditional on the estimated selectivity functions and the relative contributions of each fleet's fishing mortality. The selectivity pattern used here was the effort-weighted selectivities at age, with effort from each fishery (including discard mortalities) estimated as the full F averaged over the last three years of the assessment.

Fitting criterion The fitting criterion was a penalized likelihood approach in which observed landings and discards were fit closely, and observed composition data and abundance indices were fit to the degree that they were compatible. Landings, discards, and index data were fit using lognormal likelihoods. Length and age composition data were fit using multinomial likelihoods.

The model includes the capability for each component of the likelihood to be weighted by user-supplied values (for instance, to give more influence to desired data sources). For data components, these weights were applied by either adjusting CVs (lognormal components) or adjusting effective sample sizes (multinomial components). In this application to red snapper, CVs of landings and discards (in arithmetic space) were assumed equal to 0.05, to achieve a close fit to these time series yet allowing some imprecision. In practice, the small CVs are a matter of computational convenience, as they help achieve the desired result of close fits to the landings, while avoiding having to solve the Baranov equation iteratively (which is complex when there are multiple fisheries). Weights on other data components (indices, age/length compositions) were adjusted iteratively, starting from initial weights as follows. The CVs of indices were set equal to the values estimated by the DW. Effective sample sizes of the multinomial components were assumed equal to the number of trips sampled annually, rather than the number of fish measured, reflecting the belief that the basic sampling unit occurs at the level of trip. These initial weights were then adjusted until standard deviations of normalized residuals were near 1.0 (SEDAR24-RW03).

In addition, a lognormal likelihood was applied to the spawner-recruit relationship. The compound objective function also included several penalties or prior distributions (e.g., on estimated parameters selectivity functions). Penalties or priors were applied to maintain parameter estimates near reasonable values, and to prevent the optimization routine from drifting into parameter space with negligible gradient in the likelihood.

Configuration of base run The base run was configured as described above with data provided by the DW. Some key features include 1) discard mortalities of 0.48 for commercial lines fleet, 0.41 for the for-hire fleet, and 0.39 for the private recreational fleet; 2) age-dependent natural mortality scaled to M=0.08; 3) steepness fixed at $h = 0.85$; 4) linearly increasing catchability with slope of 2% until 2003 and constant after then; and 5) dome-shaped selectivities of commercial dive, for-hire, and private recreational landings (for-hire and private selectivities assumed to saturate at 0.3), and flat-topped selectivity of commercial lines. The AW did not consider this configuration to represent reality better than all other possible configurations, and attempted to portray uncertainty in point estimates through sensitivity analyses and through a Monte-Carlo/bootstrap approach (described below).

Sensitivity and retrospective analyses Sensitivity of results to some key model inputs and assumptions was examined through sensitivity analyses. These model runs, as well as retrospective analyses, vary from the base run as follows.

- S1: Low M at age (Lorenzen estimates rescaled so as to provide the same cumulative survival through the oldest observed age as would constant $M = 0.05$)
- S2: High M at age (Lorenzen estimates rescaled so as to provide the same cumulative survival through the oldest observed age as would constant $M = 0.12$)
- S3: High age-1 M ($M_1 = 0.6$, and M_{2+} scaled from the base run such that M_{1+} provides the same cumulative survival through the oldest observed age as would constant $M = 0.08$)
- S4: Low discard mortality probabilities (commercial lines $\delta = 0.34$, for-hire $\delta = 0.29$, private $\delta = 0.27$)
- S5: High discard mortality probabilities (commercial lines $\delta = 0.62$, for-hire $\delta = 0.54$, private $\delta = 0.52$)
- S6: Steepness $h = 0.75$
- S7: Steepness $h = 0.95$
- S8: Steepness h estimated
- S9: Standard deviation of recruitment residuals in log space $\sigma = 0.4$
- S10: Standard deviation of recruitment residuals in log space $\sigma = 0.8$
- S11: Constant catchability
- S12: Linearly increasing catchability with slope of 4% until 2003 and constant after then
- S13: Random walk catchability for each index of abundance (standard deviation of 0.1)

- S14: Ageing error matrix included
- S15: Continuity run 1. Features include linearly increasing catchability with slope of 2% throughout the entire assessment period, and flat-topped selectivities for for-hire and recreational fleets. In this run, spawning biomass is based on gonad weight.
- S16: Continuity run 2. Features include linearly increasing catchability with slope of 2% throughout the entire assessment period, flat-topped selectivities for for-hire and recreational fleets, and spawning biomass based on mature female body weight rather than gonad weight.
- S17: Starting year of the model was 1976. Initial (1976) numbers at age were estimated in this sensitivity run, with penalized deviation from the stable age structure that corresponded to the initialization fishing mortality rate ($F_{init} = 0.12$, the geometric mean of base-run full F in years prior to 1976).
- S18: Starting year of the model was 1986. Initial (1986) numbers at age were estimated in this sensitivity run, with penalized deviation from the stable age structure that corresponded to the initialization fishing mortality rate ($F_{init} = 0.19$, the geometric mean of base-run full F in years prior to 1986).
- S19: Initialization (1955) fishing mortality rate $F_{init} = 0.01$, which provides an approximate initial depletion level of $B_{1955}/B_0 \approx 0.9$.
- S20: Initialization (1955) fishing mortality rate $F_{init} = 0.04$, which provides an approximate initial depletion level of $B_{1955}/B_0 \approx 0.6$.
- S21: Low landings and discards for for-hire and private recreational fleets (historic values equal to 0.3 (for-hire) or 0.2 (private) times the base levels, 1981–2009 values equal to point estimates minus 1 standard error)
- S22: High landings and discards for for-hire and private recreational fleets (historic values equal to 1.7 (for-hire) or 1.8 (private) times the base levels, 1981–2009 values equal to point estimates plus 1 standard error)
- S23: Low landings and discards for commercial lines and dive fleets (values based on point estimates minus 1 standard error)
- S24: High landings and discards for commercial lines and dive fleets (values based on point estimates plus 1 standard error)
- S25: Headboat index de-emphasized by halving its likelihood weight
- S26: Headboat index emphasized by doubling its likelihood weight
- S27: Commercial lines index de-emphasized by halving its likelihood weight
- S28: Commercial lines index emphasized by doubling its likelihood weight
- S29: Age composition data de-emphasized by halving their likelihood weights
- S30: Age composition data emphasized by doubling their likelihood weights
- S31: Length composition data de-emphasized by halving their likelihood weights
- S32: Length composition data emphasized by doubling their likelihood weights
- S33: Flat-topped commercial lines selectivity; descending limb of recreational selectivities saturates at 0.1
- S34: Flat-topped commercial lines selectivity; descending limb of recreational selectivities saturates at 0.5
- S35: Dome-shaped commercial lines selectivity, descending limb saturates at 0.75; descending limb of recreational selectivities saturates at 0.1

- S36: Dome-shaped commercial lines selectivity, descending limb saturates at 0.75; descending limb of recreational selectivities saturates at 0.3
- S37: Dome-shaped commercial lines selectivity, descending limb saturates at 0.75; descending limb of recreational selectivities saturates at 0.5
- S38: Dome-shaped commercial lines selectivity, descending limb saturates at 0.5; descending limb of recreational selectivities saturates at 0.1
- S39: Dome-shaped commercial lines selectivity, descending limb saturates at 0.5; descending limb of recreational selectivities saturates at 0.3
- S40: Dome-shaped commercial lines selectivity, descending limb saturates at 0.5; descending limb of recreational selectivities saturates at 0.5
- S41: Compound extreme 1: high bound on natural mortality (S2), low bounds on discard mortalities (S4), constant catchability (S11), lowest dome-shaped selectivities (S238)
- S42: Compound extreme 2: low bound on natural mortality (S1), high bounds on discard mortalities (S5), increasing catchability of 4% (S12), highest selectivities (S34)
- S43: Retrospective run with data through 2008
- S44: Retrospective run with data through 2007
- S45: Retrospective run with data through 2006
- S46: Retrospective run with data through 2005

Retrospective analyses should be interpreted with caution, because several data sources were removed by the successive truncations. Age composition data from the private fleet were available only in 2009, and were therefore removed from all retrospective runs. Length composition data from commercial lines discards were available only in 2007, and were therefore removed from runs S45 and S46. Consequently, in those two runs, the discard selectivity of commercial lines was fixed at the ogive of the base run. The headboat discard index began in 2005 and thus, as a single-year index in run S46, provided no information on relative abundance.

3.1.1.4 **Parameters Estimated** The model estimated annual fishing mortality rates of each fishery, selectivity parameters, catchability coefficients associated with indices, asymptotic recruitment of the spawner-recruit model, annual recruitment deviations, and standard deviation of size at age. Estimated parameters are described mathematically in the document, SEDAR-24-RW01.

3.1.1.5 **Catch Curve Analysis** Catch curve analysis was conducted to provide estimates of total mortality ($Z = F + M$) from age composition data. These analyses are detailed in SEDAR-24-AW07. In short, catch curves were represented by synthetic cohorts (i.e., proportions at age within years) and limited true cohorts, and were analyzed using the Chapman–Robson estimator and using linear regression of the log-transformed proportions at age. Catch curve analysis requires the assumptions that mortality and catchability remain constant with age, and when using synthetic cohorts, that recruitment is constant. These assumptions are rarely met, if ever, by fish populations. Thus, the application of catch curve analysis here is for diagnostic purposes, primarily for comparing the general range of estimated mortality rates of catch curves with those of other models.

3.1.1.6 **Per Recruit and Equilibrium Analyses** Static spawning potential ratio (static SPR) of each year was computed as the asymptotic spawners per recruit given that year's fishery-specific Fs and selectivities, divided by spawners per recruit that would be obtained in an unexploited stock. In this form, static SPR ranges between zero and one, and it represents SPR that would be achieved under an equilibrium age structure given the year-specific F (hence the word *static*).

Yield per recruit and spawning potential ratio were computed as functions of F, as were equilibrium landings and spawning biomass. Equilibrium landings and discards were also computed as functions of biomass B, which itself is a function of F. As in computation of MSY-related benchmarks (described in §3.1.1.7), per recruit and equilibrium analyses applied the most recent selectivity patterns averaged across fisheries, weighted by each fleet's F from the last three years (2007–2009).

3.1.1.7 **Benchmark/Reference Point Methods** In this assessment of red snapper, the quantities F_{MSY}, $\mathrm{SSB}_{\mathrm{MSY}}$, B_{MSY}, and MSY were estimated by the method of Shepherd (1982). In that method, the point of maximum yield is identified from the spawner-recruit curve and parameters describing growth, natural mortality, maturity, and selectivity. The value of F_{MSY} is the F that maximizes equilibrium landings.

On average, expected recruitment is higher than that estimated directly from the spawner-recruit curve, because of lognormal deviation in recruitment. Thus, in this assessment, the method of benchmark estimation accounted for lognormal deviation by including a bias correction in equilibrium recruitment. The bias correction (ς) was computed from the variance (σ^2) of recruitment deviation in log space: $\varsigma = \exp(\sigma^2/2)$. Then, equilibrium recruitment (R_{eq}) associated with any F is,

$$R_{eq} = \frac{R_0\,[\varsigma 0.8h\Phi_F - 0.2(1-h)]}{(h-0.2)\Phi_F} \tag{1}$$

where R_0 is virgin recruitment, h is steepness, and Φ_F is spawning potential ratio given growth, maturity, and total mortality at age (including natural, fishing, and discard mortality rates). The R_{eq} and mortality schedule imply an equilibrium age structure and an average sustainable yield (ASY). The estimate of F_{MSY} is the F giving the highest ASY (excluding discards), and the estimate of MSY is that ASY. The estimate of $\mathrm{SSB}_{\mathrm{MSY}}$ follows from the corresponding equilibrium age structure, as does the estimate of discard mortalities (D_{MSY}), here separated from ASY (and consequently, MSY).

Estimates of MSY and related benchmarks are conditional on selectivity pattern. The selectivity pattern used here was an average of terminal-year selectivities from each fishery, where each fishery-specific selectivity was weighted in proportion to its corresponding estimate of F averaged over the last three years (2007–2009). If the selectivities or relative fishing mortalities among fleets were to change, so would the estimates of MSY and related benchmarks.

The maximum fishing mortality threshold (MFMT) is defined by the SAFMC as F_{MSY}, and the minimum stock size threshold (MSST) as $\mathrm{MSST} = (1-M)\mathrm{SSB}_{\mathrm{MSY}}$ (Restrepo et al. 1998), with constant M here equated to 0.08. Overfishing is defined as $F >$ MFMT and overfished as SSB $<$ MSST. Current status of the stock is represented by SSB in the latest assessment year (2009), and current status of the fishery is represented by the geometric mean of F from the latest three years (2007–2009). The geometric mean, rather than arithmetic, was chosen because it tends to be more robust to outliers.

In addition to the MSY-related benchmarks, proxies were computed based on per recruit analyses. These proxies include $F_{30\%}$, $F_{40\%}$, and $F_{50\%}$ along with their associated yields. The values of $F_{X\%}$ are defined as those Fs corresponding to X% spawning potential ratio (i.e., spawners per recruit relative to that at the unfished level). These quantities may serve as proxies for F_{MSY}, if the spawner-recruit relationship cannot be estimated reliably. Mace (1994) recommended $F_{40\%}$ as a proxy; however, later studies have found that $F_{40\%}$ is too high of a fishing rate across many life-history strategies (Williams and Shertzer 2003; Brooks et al. 2009) and can lead to undesirably low levels of biomass and recruitment (Clark 2002).

3.1.1.8 **Uncertainty and Measures of Precision** Uncertainty was in part examined through use of multiple models and sensitivity runs. For the base run of the catch-age model (BAM), uncertainty in results and precision of estimates was computed more thoroughly through a mixed Monte Carlo and bootstrap (MCB) approach. Monte Carlo and bootstrap methods (Efron and Tibshirani 1993; Manly 1997) are often used to characterize uncertainty in ecological studies, and the mixed approach has been applied successfully in stock assessment (Restrepo et al. 1992; Legault et al. 2001; SEDAR 2004; 2009). The approach translates uncertainty in model input into uncertainty in model output, by fitting the model many times with different values of "observed" data and key input parameters. A chief advantage of the approach is that the results describe a range of possible outcomes, so that uncertainty is characterized more thoroughly than it could be by any single fit or handful of sensitivity runs. A minor disadvantage of the approach is that computational demands are relatively high.

In this assessment, the BAM was successively re-fit n=3000 trials that differed from the original inputs by bootstrapping on data sources, and by Monte Carlo sampling of natural mortality, discard mortality, spawner-recruit parameters (h and σ), catchability increase, initialization fishing rate, recreational selectivity, and historical recreational landings (implementations described below). This number of trials was sufficient for convergence of standard errors in management quantities (Figure 3.2).

The MCB analysis should be interpreted as providing an approximation to the uncertainty associated with each output. The results are approximate for two related reasons. First, not all combinations of Monte Carlo parameter inputs are equally likely, as biological parameters might be correlated. Second, all runs are given equal weight in the results, yet some might provide better fits to data than others.

3.1.1.8.1 **Bootstrap of observed data** To include uncertainty in time series of observed landings, discards, and indices of abundance, multiplicative lognormal errors were applied through a parametric bootstrap. To implement this approach in the MCB trials, random variables ($x_{s,y}$) were drawn for each year y of time series s from a normal distribution with mean 0 and variance $\sigma^2_{s,y}$ [that is, $x_{s,y} \sim N(0, \sigma^2_{s,y})$]. Annual observations were then perturbed from their original values ($\hat{O}_{s,y}$),

$$O_{s,y} = \hat{O}_{s,y}[\exp(x_{s,y}) - \sigma^2_{s,y}/2] \tag{2}$$

The term $\sigma^2_{s,y}/2$ is a bias correction that centers the multiplicative error on the value of 1.0. Standard deviations in log space were computed from CVs in arithmetic space, $\sigma_{s,y} = \sqrt{\log(1.0 + CV^2_{s,y})}$. As used for fitting the base run, CVs of landings and discards were assumed to be 0.05, and CVs of indices of abundance were those provided by the DW.

Uncertainty in age and length compositions were included by drawing new distributions for each year of each data source, following a multinomial sampling process. Ages (or lengths) of individual fish were drawn at random with replacement using the probabilities and sample sizes (number trips) of the original data.

3.1.1.8.2 **Monte Carlo sampling** In each successive fit of the model, several parameters were fixed (i.e., not estimated) at values drawn at random from distributions described below.

Natural mortality Point estimates of natural mortality ($M = 0.08$) were provided by the DW, but with some uncertainty. To carry forward this source of uncertainty, Monte Carlo sampling was used to generate deviations from the point estimate. A new M value was drawn for each MCB trial from a truncated normal distribution (range [0.05, 0.12]) with mean equal to the point estimate ($M = 0.08$) and standard deviation set to provide a lower 95% confidence limit at 0.05 (the low end of the DW range). Each realized value of M was used to scale the age-specific Lorenzen M, as in the base run.

Discard mortalities Similarly, for discard mortalities, new δ values were drawn from normal distributions for each fleet, for each MCB trial. Each distribution was centered on the point estimates provided by the DW (commercial lines, 0.48; for-hire, 0.41; private, 0.39) and had standard deviations computed by the AW (~ 0.05 for each fleet). The distributions were truncated at their 95% confidence limits (commercial lines, [0.34, 0.62]; for-hire, [0.29, 0.54]; private, [0.27, 0.52]).

Spawner-recruit model Steepness was drawn from the beta distribution $\beta(5.50, 1.81)$, as estimated through meta-analysis (SEDAR24-AW06). That distribution was truncated to the range [0.6, 0.999], in part because the model performed better at the higher values, but also because that range was believed to capture the bulk of uncertainty in steepness for this stock. Standard deviation (σ) of recruitment residuals in log space, as used in the lognormal likelihood to estimate the spawner-recruit model, was drawn from a uniform distribution in the range [0.4, 0.8].

Increase in catchability The slope of linear increase in catchability was drawn from a uniform distribution in the range [0%, 4%]. In all cases, catchability was assumed constant after 2003.

Initial fishing mortality rate The initial fishing mortality rate (F_{init}) was drawn from a uniform distribution in the range [0.01, 0.04], which provided an initial biomass depletion level (B_{1955}/B_0) on the approximate range of [0.6, 0.9].

For-hire and private recreational selectivity The asymptote of the descending limb of the for-hire and private recreational selectivity was drawn at random from a uniform distribution spanning the range [0.1, 0.5].

Historical recreational landings The DW provided historical recreational (for-hire and private) landings estimates using ratios to commercial landings (in addition, the private fleet landings were interpolated linearly to zero in 1950). Uncertainty in these ratios was based on the percentiles of observed ratios from which the point estimates (medians) were generated. With each MCB run, a uniform random number, centered on one, was drawn and applied as a multiplier to the historical time series (this approach conveniently preserves the smoothed structure). The bounds of the uniform distributions were computed using the distance from the median of either the 20^{th} or 80^{th} percentile, whichever was greater, and were then standardized around the value of one (from the median). For for-hire historical landings, the multiplier was drawn from the range [0.3, 1.7], and for private historical landings, the multiplier was drawn from the range [0.2, 1.8].

3.1.1.9 **Acceptable Biological Catch** When a stock is not overfished, acceptable biological catch (ABC) could be computed through probability-based approaches, such as that of Shertzer et al. (2008*b*), designed to avoid overfishing. However, for overfished stocks, rebuilding projections would likely supersede other approaches for computing ABCs.

3.1.1.10 **Projection Methods** Projections were run to predict stock status in years after the assessment, 2010–2050. In most projections, this time frame included one year (2010) with fishing at the current fishing rate, but with landings converted to discards (to reflect the 2010 moratorium on red snapper), and the remaining years at the projection rate.

The structure of the projection model was the same as that of the assessment model, and parameter estimates were those from the assessment results. Time-varying quantities, such as fishery selectivity curves, were fixed to the most recent values of the assessment period. Fully selected F was apportioned between landings and discard mortalities according to the selectivity curves averaged across fisheries, using geometric mean F from the last three years of the assessment period.

Central tendencies of SSB (mid-year), F, recruits, landings, and discards were represented by deterministic projections using parameter estimates from the base run. These projections were built on the estimated spawner-recruit relationship with bias correction, and were thus consistent with estimated benchmarks in the sense that long-term fishing at F_{MSY} would yield MSY from a stock size at $\mathrm{SSB}_{\mathrm{MSY}}$. Uncertainty in future time series was quantified through projections that extended the Monte Carlo/Bootstrap (MCB) fits of the stock assessment model.

Initialization of projections Fishing rates that define the projections were assumed to start in 2011, which is the earliest year management could react to this assessment. Because the assessment period ended in 2009, the projections required an initialization period (2010). Point estimates of initial abundance at age in the projection (start of 2010), other than at age 1, were taken to be the 2009 estimates from the assessment, discounted by 2009 natural and fishing mortalities. The initial abundance at age 1 was computed using the estimated spawner-recruit model and the 2009 estimate of SSB. The fully selected fishing mortality rate applied in the initialization period was $F = F_{\mathrm{current}}$ (geometric mean of fully selected F during 2007–2009), but without mortality from the commercial dive fleet.

Moratorium In 2010, a moratorium on red snapper was implemented. This was modeled in a three-step process. First, the current fishing rates by fleet, discounted by expected reduction in fishing effort, were applied to estimate landings by fleet. Second, all caught fish were assumed released, and fleet-specific discard mortality probabilities were applied to convert the potential landings to dead discards. Third, an optimization procedure was used to estimate the fishing mortality rates that produce those dead discards, as well as the mortality rates associated with undersized fish. That is, six mortality rates were estimated: the Fs of legal-sized discards and undersized discards from commercial lines, for-hire, and private recreational fleets. These rates were then applied to compute the total dead discards and total mortality rates used to project the population forward in time. For most projection scenarios (described below), these mortality rates applied only in 2010, but one projection scenario (Scenario 7) applied the moratorium mortality rates throughout.

Because red snapper are but one species of a multispecies fishery, the AW believed that the moratorium on red snapper would not have a large effect on fishing effort. Thus fishing effort during the moratorium was assumed to be 80%–100% of current fishing effort. The central-tendency projections used the midpoint (90%) of that range.

Uncertainty of projections To characterize uncertainty in future stock dynamics, stochasticity was included in replicate projections, each an extension of a single MCB assessment model fit. Thus, projections carried forward uncertainties in natural mortality and in discard mortality, as well as in estimated quantities such as spawner-recruit parameters, selectivity curves, and in initial (start of 2010) abundance of ages 2^+. Initial and subsequent recruitment values were generated with stochasticity using a Monte Carlo procedure, in which the estimated Beverton–Holt model of each MCB fit was used to compute mean annual recruitment values ($\bar{R}_y$).

Variability was added to the mean values by choosing multiplicative deviations at random from a lognormal distribution,

$$R_y = \bar{R}_y \exp(\epsilon_y). \tag{3}$$

Here ϵ_y was drawn from a normal distribution with mean 0 and standard deviation σ, where σ is the standard deviation from the base assessment model. In addition, moratorium fishing effort relative to the current level was drawn for each replicate projection from a uniform distribution spanning the range [0.8, 1.0].

The procedure generated 30,000 replicate projections of MCB model fits drawn at random (with replacement) from the MCB runs. In cases where the same MCB run was drawn, projections would still differ as a result of stochastic recruitment streams and stochastic effort reduction during the moratorium. Precision of projections was represented graphically by the 5^{th} and 95^{th} percentiles of the replicate projections.

Rebuilding time frame Based on the 2008 (SEDAR-15) benchmark assessment of red snapper, a rebuilding plan is now under consideration by the SAFMC. Under this rebuilding plan, year one is 2010 and the target time frame for rebuilding is by the start of 2045 (i.e., during the year 2044). Rebuilding is defined by the criterion that X% of projection replicates achieve stock recovery (i.e., SSB ≥ SSB_{MSY}).

The rebuilding time frame was re-examined based on results of this assessment. Under U.S. regulations, if a stock can rebuild within 10 years under $F = 0$, the maximum allowable rebuilding time frame is 10 years. If not, the maximum allowable rebuilding time frame is one generation time (estimated to be 22 years; see §III(2)) plus the time required to achieve rebuilding under $F = 0$. This time was based on the proportion $X = 50\%$ of successfully rebuilt replicates.

Projection scenarios Ten constant-F projection scenarios were considered. In each, the fishing rate in 2010 applied the moratorium based on F_{current}(as described above). The F_{rebuild} is defined as the maximum F that achieves rebuilding (0.5, 0.7, or 0.9 probability) in the allowable time frame.

- Scenario 1: $F = 0$
- Scenario 2: $F = F_{\text{current}}$
- Scenario 3: $F = 65\% F_{\text{MSY}}$
- Scenario 4: $F = 75\% F_{\text{MSY}}$
- Scenario 5: $F = 85\% F_{\text{MSY}}$
- Scenario 6: $F = F_{\text{MSY}}$
- Scenario 7: $F = F_{\text{current}}$, but reduced to account for continued moratorium throughout the projection
- Scenario 8: $F = F_{\text{rebuild}}$, with probability 0.5 in the year 2047
- Scenario 9: $F = F_{\text{rebuild}}$, with probability 0.7 in the year 2047
- Scenario 10: $F = F_{\text{rebuild}}$, with probability 0.9 in the year 2047

3.1.2 Model 1 Results

3.1.2.1 Measures of Overall Model Fit Generally, the Beaufort Assessment Model (BAM) fit well to the available data. Predicted length compositions from each fishery were reasonably close to observed data in most years, as were predicted age compositions (Figure 3.3). Residuals of fits to age and length compositions, by year and fishery, are summarized with bubble plots; differences between annual observed and predicted vectors are summarized with angular deviation (Figure 3.4–3.13). Angular deviation (measured in degrees) is defined as the arc cosine of the dot product of two vectors. A value of 0° indicates perfect agreement between the two vectors, and a value of 90° indicates perfect disagreement (i.e., the vectors are perpendicular).

The residuals from fits to length compositions show some consistent patterns of positive and negative values across years for the same length bins. These patterns might in part be a reflection of simplifying assumptions for modeling growth. For instance, the transition from age to length applied an age-length transition matrix, constructed with fixed growth parameters and one estimated parameter for standard deviation of length at age. More complex growth models are possible but would likely require additional data to support estimation of additional parameters. Furthermore, this model assumes that only legal-sized fish were retained, which would result in negative residuals for any observed fish below the minimum size limit.

The model was configured to fit observed commercial and recreational landings closely (Figures 3.14–3.17), as well as observed discards (Figures 3.18–3.20).

Fits to indices of abundance captured the general trends but not all annual fluctuations (Figures 3.21–3.23). Since the early 1990s, the general trend in the commercial and for-hire indices is one of increase.

3.1.2.2 Parameter Estimates Estimates of all parameters from the catch-age model are shown in Appendix B. Estimates of management quantities and some key parameters, such as those of the spawner-recruit model, are reported in sections below.

3.1.2.3 Stock Abundance and Recruitment In general, estimated abundance at age shows a truncation of the older ages (Figure 3.24; Table 3.2). Total estimated abundance at the end of the assessment period shows sharp increase, reaching levels not seen since the late 1970s, albeit with a quite different age structure. This increase appears to be driven by recent recruitment. Annual number of recruits is shown in Table 3.2 (age-1 column) and in Figure 3.25. Notably strong year classes (age-1 fish) were predicted to have occurred in 2006 and 2007.

3.1.2.4 Total and Spawning Biomass Estimated biomass at age follows a similar pattern as abundance at age (Figure 3.26; Table 3.3). Total biomass and spawning biomass show similar trends—general decline until the mid-1990s, and general increase since then but with a downturn at the end of the time series (Figure 3.27; Table 3.4).

3.1.2.5 **Selectivity** Selectivity of landings from commercial lines shifted to older ages with implementation of the 20-inch size limit in 1992 (shown in Figure 3.28). In the most recent period, fish were estimated to be near fully selected by age 4. Selectivity of landings from commercial dive was dome-shaped, saturating by age 10 at a value near 0.2 (Figure 3.28). Selectivities of landings from the for-hire fleet are shown in Figure 3.29, and those of the private recreational fleet in Figure 3.30. For both of these fleets, the descending limb saturates at 0.3 (assumed), with an estimated descent from the age at full selection (age 3).

Selectivity of discard mortalities from the commercial line was mostly on age-2 and age-3 fish, with relatively small (but positive) selection of age-1 and age-4 fish (Figure 3.31). Selectivity of discard mortalities from the recreational (for-hire and private) fleets was mostly of age 2-fish but included age-1 fish; since 1992, it included age-3 and some age-4 fish. For the 20-inch size limit in place at the end of the assessment period, few age-5^+ fish were undersized.

Average selectivities of landings and of discard mortalities were computed from F-weighted selectivities in the most recent period of regulations (Figure 3.32). These average selectivities were used to compute benchmarks and central-tendency projections. All selectivities from the most recent period, including average selectivities, are tabulated in Table 3.5.

3.1.2.6 **Fishing Mortality** The estimated fishing mortality rates (F) increased through the 1970s, and since then have been quite variable (Figure 3.33). Recreational fleets dominate the total F (Table 3.6).

Estimates of total F at age are shown in Table 3.7. In any given year, the maximum F at age (i.e., apical F) may be less than that year's sum of fully selected Fs across fleets. This inequality is due to the combination of two features of estimated selectivities: full selection occurs at different ages among gears and several sources of mortality have dome-shaped selectivity.

Table 3.8 shows total landings at age in numbers, and Table 3.9 in 1000 lb. In general, the majority of estimated landings are from for-hire and private recreational fleets (Figures 3.34, 3.35; Tables 3.10, 3.11). Estimated discard mortalities occur on a smaller scale than landings (Figure 3.36; Tables 3.12, 3.13)

3.1.2.7 **Catch Curve Analysis** Catch curve analysis suggested total mortality rate ($Z = F + M$) ranged from near 0.0 to greater than 1.0, but the bulk of the point estimates were between 0.4 and 1.0 (SEDAR-24-AW07). Based on the constant estimate of natural mortality, $M = 0.08$, these values of Z suggest that fully selected fishing mortality rate is on the scale of $F = 0.32$ to $F = 0.92$, generally consistent with estimates from the catch-age model (Figure 3.33, Table 3.4). Nonetheless, estimates of mortality from catch curve analysis are not readily comparable to those from the BAM because of dome-shaped selectivity.

3.1.2.8 **Spawner-Recruitment Parameters** The estimated Beverton–Holt spawner-recruit curve is shown in Figure 3.37, along with the effect of density dependence on recruitment, depicted graphically by recruits per spawner as a function of spawners. Values of recruitment-related parameters were as follows: assumed steepness $h = 0.85$, unfished age-1 recruitment $\widehat{R_0} = 534,756$, unfished spawning biomass per recruit $\phi_0 = 9.322e{-4}$, and assumed standard deviation of recruitment residuals in log space $\sigma = 0.6$ (which resulted in bias correction $\varsigma = 1.20$). The empirical standard deviation of recruitment residuals in log space was $\hat{\sigma} = 0.83$. Uncertainty in these quantities was estimated through the Monte Carlo/bootstrap (MCB) analysis (Figure 3.38).

3.1.2.9 **Per Recruit and Equilibrium Analyses** Static spawning potential ratio (static SPR) shows a general trend of decline until the early 1980s, and since then a stable trend at low values, perhaps some small increase (Figure 3.39, Table 3.4). Values lower than the MSY level imply that, given estimated fishing rates, population equilibria would be lower than desirable (as defined by MSY).

Yield per recruit and spawning potential ratio were computed as functions of F (Figure 3.40). As in computation of MSY-related benchmarks, per recruit analyses applied the most recent selectivity patterns averaged across fisheries, weighted by F from the last three years (2007–2009). The Fs that provide 30%, 40%, and 50% SPR are 0.17, 0.13, and 0.09, respectively. For comparison, F_{MSY} corresponds to about 29% SPR. Although this rate of fishing appears high relative to $F_{X\%}$ proxies, it occurs here because red snapper mature relatively quickly, the size limit offers some protection for spawners, and because the assumed steepness of $h = 0.85$ relates to a relatively productive stock.

As in per recruit analyses, equilibrium landings and spawning biomass were computed as functions of F (Figures 3.41). By definition, the F that maximizes equilibrium landings is F_{MSY}, and the corresponding landings and spawning biomass are MSY and $\mathrm{SSB}_{\mathrm{MSY}}$. Equilibrium landings and discards could also be viewed as functions of biomass B, which itself is a function of F (Figure 3.42).

3.1.2.10 **Benchmarks / Reference Points** As described in §3.1.1.7, biological reference points (benchmarks) were derived analytically assuming equilibrium dynamics, corresponding to the expected spawner-recruit curve (Figure 3.37). This approach is consistent with methods used in rebuilding projections (i.e., fishing at F_{MSY} yields MSY from a stock size of $\mathrm{SSB}_{\mathrm{MSY}}$). Reference points estimated were F_{MSY}, MSY, B_{MSY} and $\mathrm{SSB}_{\mathrm{MSY}}$. Based on F_{MSY}, three possible values of F at optimum yield (OY) were considered—$F_{\mathrm{OY}} = 65\% F_{\mathrm{MSY}}$, $F_{\mathrm{OY}} = 75\% F_{\mathrm{MSY}}$, and $F_{\mathrm{OY}} = 85\% F_{\mathrm{MSY}}$—and for each, the corresponding yield was computed. Standard errors of benchmarks were approximated as those from Monte Carlo/bootstrap analysis (§3.1.1.8).

Estimates of benchmarks are summarized in Table 3.14. Point estimates of MSY-related quantities were $F_{\mathrm{MSY}} = 0.178\ \mathrm{y}^{-1}$, MSY = 1842 klb, $B_{\mathrm{MSY}} = 13632$ mt, and $\mathrm{SSB}_{\mathrm{MSY}} = 156$ mt. Distributions of these benchmarks are shown in Figure 3.43.

3.1.2.11 **Status of the Stock and Fishery** Estimated time series of stock status (SSB/MSST) shows decline until the late 1980s, and then some increase since the mid-1990s, (Figure 3.44, Table 3.4). The increase in stock status appears to have been initiated by the 1992 management regulations, and then perhaps reinforced by strong recruitment events. Base-run estimates of spawning biomass have remained below MSST throughout most of the time series. Current stock status was estimated in the base run to be $\mathrm{SSB}_{2009}/\mathrm{MSST} = 0.09$ (Table 3.14). Uncertainty from the MCB analysis suggests that the estimate of overfished status (i.e., SSB < MSST) is robust (Figures 3.45, 3.46). Age structure estimated by the base run shows fewer older fish than the (equilibrium) age structure expected at MSY (Figure 3.47). However, in the terminal year (2009), ages 3 and 4 approach the MSY age structure as a result of recent strong year classes.

The estimated time series of F/F_{MSY} suggests that overfishing has been occurring throughout most of the assessment period (Figure 3.44, Table 3.4). Spikes in 1992 and 1997 are due primarily to recreational fleets (Figure 3.33), occurring because increased landings (both years for for-hire; 1992 for private) coincided with relatively low abundances of the ages most exploited by these fleets. Current fishery status in the terminal year, with current F represented by the geometric mean from 2007–2009, is estimated by the base run to be $F_{2007-2009}/F_{\mathrm{MSY}} = 4.12$ (Table 3.14). This estimate indicates current overfishing and appears robust across MCB trials (Figures 3.45, 3.46). It might, however, be subject to some retrospective error, as described below.

3.1.2.12 **Sensitivity and Retrospective Analyses** Sensitivity runs, described in §3.1.1.3, may be useful for evaluating implications of assumptions in the base assessment model, and for interpreting MCB results in terms of expected effects from input parameters. Plotted are time series of F/F_{MSY} and SSB/MSST for sensitivity to natural mortality (Figure 3.48), discard mortality (Figure 3.49), spawner-recruit parameters (Figure 3.50), catchability (Figure 3.51), ageing error (Figure 3.52), continuity assumptions (Figure 3.53), starting year of the assessment model (Figure 3.54), initialization fishing mortality rate (Figure 3.55), landings streams (Figure 3.56), component weights of data sources (Figure 3.57), selectivity patterns (Figure 3.58), and compound extremes (Figure 3.59). The quantitative results appeared most sensitive to the scale of natural mortality, steepness, recreational landings and discards, and compound extremes. (Note that the sensitivity runs with alternative recreational landings and discards considered the full time series, not just the historic portion as applied in the MCB analysis.) The qualitative results, however, were the same across all sensitivity runs; the tendency was toward the status estimates of overfished and overfishing (Figure 3.60, Table 3.15). In concert, sensitivity analyses suggested that qualitative results of the base run and MCB analysis were robust.

Retrospective analyses suggested a pattern of overestimating terminal fishing rate, and a small degree of underestimating terminal spawning biomass (Figure 3.61). The high estimated fishing rates in the terminal year were due primarily to F's associated with recreational discard mortality. These terminal F's were high because discards comprised young fish (almost entirely), yet predicted terminal recruitments were typically underestimated. Although this pattern is indicative of retrospective error, the concern may be minimized here for two reasons. First, the headboat discard index suggests that recruitment actually did decrease in the terminal year, and thus the low 2009 recruitment estimate may be realistic. Second, the overfishing status is gauged by the geometric mean of the terminal three years, which would dampen any overestimation in the terminal year F. If 2009 were excluded from the estimate of F_{current}, the base-run estimate of terminal fishery status would change from $F_{2007-2009}/F_{\text{MSY}} = 4.1$ to $F_{2007-2008}/F_{\text{MSY}} = 3.7$. Also, as mentioned previously, retrospective results should be interpreted with caution as not all data sources survived the truncation of terminal years.

3.1.2.13 **Projections** Projection scenario 1, in which $F = 0$, predicted the chance of rebuilding to reach at least 50% in the year 2025 (Figure 3.62). If used to define the rebuilding time frame, this result plus one generation time (22 years) would suggest that rebuilding should occur in 2047 (or by the start of 2048).

The projection with F at F_{current} predicted the stock to remain at low levels (Figure 3.63, Table 3.16). It suggests further that the F_{current} is not sustainable without consistently higher than expected recruitment, as has occurred near the end of the assessment period. Projections with F at 65%, 75%, 85%, or 100% of F_{MSY} predicted increased biomass and landings (Figures 3.64–3.67, Tables 3.17–3.20). The continued moratorium projection also predicted increased biomass, but suggested that the moratorium alone is insufficient for stock recovery (Figure 3.68, Table 3.21). The F_{rebuild} projections did allow stock recovery (by design) in the year 2047 (Figures 3.69–3.71, Tables 3.22–3.24).

3.2 Model 2: Surplus Production Model

3.2.1 Model 2 Methods

3.2.1.1 **Overview** Assessments based on age or length structure are often favored because they incorporate more data on the structure of the population. However, these approaches typically involve fitting a large number of parameters and decomposing population dynamics into multiple processes including growth, mortality, and recruitment. A simplified approach is to aggregate data across age or length classes, and to summarize the relationship among complex population processes by using a simple mathematical model such as a logistic population model.

A logistic surplus production model, implemented in ASPIC (Prager 2005), was used to estimate stock status of red snapper off the southeastern U.S. While primary assessment of the stock was performed via the age-structured BAM, the surplus production approach was intended as a complement, and for additional verification that the age-structured approach was providing reasonable results.

3.2.1.2 **Data Sources** For use in the production model, data developed at the DW required some additional formatting, described below.

Landings The landings input to ASPIC must be in units of biomass. Headboat (1976–present) and MRFSS Private and Charter mode (1981–present) recreational landings in numbers and whole pounds were developed at the SEDAR-24 DW and adjusted during the development of data for input into the age–structured model. Historical landings (1950–1980) in numbers were developed during the SEDAR-24 DW using ratios to commercial lines landings (see SEDAR-24 DW report). These ratios and resulting estimates were adjusted by the SEDAR-24 AW panel. The for–hire fleet and private fleet landings in number were converted to pounds using the annual average weight of red snapper from the headboat survey during 1972–1980. The 1950–1971 estimated recreational for-hire and private landings in number were converted to weight using the average of the 1972–1974 annual headboat mean weights (4.2 lb). Commercial landings were developed in pounds and required no conversions. The recommended removals and three alternate series of landings were developed at the SEDAR-24 DW and adjusted by the SEDAR-24 AW panel for input to the age–structured model. These include lower and upper bounds for the commercial ratio method and the adjusted saltwater angling survey (SWAS) estimates of historical landings. The upper and lower bounds were converted to pounds as described above. The SWAS estimates were converted using the headboat average weights for the entire series. The commercial and recreational landings were combined with discards in weight for total removals (Table 3.25).

Dead Discards Discard estimates were generated in numbers at the SEDAR-24 DW and adjusted during the development of data for input into the age–structured model. The for–hire and private discard estimates began in 1981. The commercial lines discard estimates (in numbers) started in 1992 when the 20-inch size limit was enacted. The weight of recreationally discarded fish was determined for each regulation period (1983-1991,1992-present) by calculating the sum of the products of the mean weight at each length bin (using the weight–length relationship) by the proportion of fish in that bin up to the size limit. Discards prior to the 1983 regulation were given the same average weight as the 1983-1991 period since there was little change in the length compositions from 1982–1983. The average weight of commercially discarded fish from 1992-present was determined from observed fish (2.9 lbs). For ASPIC, the dead discards were combined with landings in weight to represent total removals (Table 3.25).

Indices of Abundance The headboat index for red snapper was developed in numbers of landed fish per angler hour. The surplus–production model requires input in pounds and therefore the headboat index was converted by multiplying the annual index by the annual mean weight from the headboat survey and scaling the series to the mean. The commercial lines index was developed in pounds per hook hour. (Table 3.25).

The headboat and commercial line indices were adjusted during the SEDAR 24 AW to reflect an assumption of 2% catchability increase per year from the beginning of the earliest index (1976) until 2003 and then saturating until present.

3.2.1.3 **Model Configuration and Equations** Production modeling used the model formulation and ASPIC software of Prager (1994; 2005). This is an observation-error estimator of the continuous-time form of the Schaefer (logistic) production model (Schaefer 1954; 1957). Estimation was conditioned on catch.

The logistic model for population growth is the simplest form of a differential equation which satisfies a number of ecologically realistic constraints, such as a carrying capacity (a consequence of limited resources). When written in terms of stock biomass, this model specifies that

$$\frac{dB_t}{dt} = rB_t - \frac{r}{K}B_t^2, \tag{4}$$

where B_t is biomass in year t, r is the intrinsic rate of increase in absence of density dependence, and K is carrying capacity (Schaefer 1954; 1957). This equation may be rewritten to account for the effects of fishing by introducing an instantaneous fishing mortality term, F_t:

$$\frac{dB_t}{dt} = (r - F_t)B_t - \frac{r}{K}B_t^2. \tag{5}$$

By writing the term F_t as a function of catchability coefficients and effort expended by fishermen in different fisheries, Prager (1994) showed how to estimate model parameters from time series of yield and effort. Nonparametric confidence intervals on parameters were estimated through bootstrap.

For red snapper, the model was configured using various combinations of removals, starting dates, and assumptions about changes in catchability resulting in 75 configurations. Three of these runs are presented here as many of the early runs became obsolete with changes to the historical recreational landings during the SEDAR-24 AW. The model was configured to use the total removals as recommended by the SEDAR-24 AW panel and the adjusted SWAS landings. Another run using the recommended removals without increasing catchability was completed to evaluate the effect of catchability assumptions. A run starting in 1976 was completed to determine the influence of the highly uncertain historical recreational landings. With the exception of the run incorporating the SWAS removal estimates, 1000 bootstrap runs were conducted to evaluate the confidence in the model fit and parameter estimates. The bias-corrected bootstrap confidence intervals were wide and irregular for some runs. For this reason, simple percentile confidence intervals were calculated. Subsets of the bootstrap runs were examined to determine the influence of estimated $B1/k$ values on the parameter estimates and stock status.

3.2.2 Model 2 Results

3.2.2.1 **Model Fit** The fit to the indices were similar across runs. Truncating the model to start in 1976 had almost no effect on the fit to the indices (Figure 3.72). The runs with no catchability increase fit the early headboat index slightly better than the runs with catchability increase (Figure 3.72). All runs missed the reduction in CPUE in 2006 and subsequent increase until 2009 for both indices (Figure 3.72). CPUE was estimated to increase linearly from about 2004 until 2007 and then decrease slightly in 2008 and 2009 for all runs. Because all runs were conditioned on catch, landings were fit exactly.

3.2.2.2 **Parameter Estimates and Uncertainty** Confidence intervals on the parameters and stock status were evaluated by bootstrapping 1000 runs for each model configuration. No bootstrap runs were completed for configuration using the SWAS landings estimates. It is presented here primarily because it was suggested by the DW as an alternative time series of historical landings.

Estimated values of $B1/K$ varied widely across bootstrap runs of a single model configuration and across runs (Table 3.26 and Figures 3.73 – 3.75). However, the value of $B1/K$ had little influence on the status of the stock and fishery with a few extreme cases. Of the bootstrap runs matched to the BAM base run, only the 69 with $B1/K$ estimated above 0.5 had a slightly different relative biomass distribution and higher average B/B_{MSY}. The estimated F/F_{MSY} was similar across all values of $B1/K$ (Figure 3.73). In the model configuration with no catchability increase there were 194 runs with $B1/K$ estimated below 0.25 which showed slightly different distribution of B/B_{MSY} but no difference in F/F_{MSY} (Figure 3.74). No estimates of $B1/K$ were below 0.25 for the configuration starting in 1976. The distribution of status values from the different levels of $B1/K$ were very similar (Figure 3.75).

Output from the ASPIC bootstrap runs configured as closely as possible to the base run of the BAM is in Appendix C.

3.2.2.3 **Status of the Stock and Fishery** Across a range of historical landings and assumptions of catchability and initial biomass, the models estimated red snapper are overfished and current fishing mortality (2009) is above levels that optimize sustained yield (Table 3.26 and Figure 3.76). Estimates of F/F_{MSY} for all runs range from 3.47 to 4.78 and B_{2010}/B_{MSY} ranges from 0.16 to 0.29. The bootstrap run matched to the BAM base run estimated the 80% bias-corrected confidence interval of F/F_{MSY} between 2.28 and 8.05 and B_{2010}/B_{MSY} between 0.08 and 0.53. The recent trends in B/B_{MSY} and F/F_{MSY} are very similar across runs. Confidence intervals (80%) for B/B_{MSY} and F/F_{MSY} from the 1000 bootstrap runs show increased uncertainty in the biomass estimate at the beginning and end of the series and little uncertainty in the F/F_{MSY} estimate (Figure 3.76).

3.2.2.4 **Discussion — Surplus Production Model** The production model estimates that current stock size is below MSY and that the current level of fishing is above the limit reference point F_{MSY} across all runs, similar to results from the BAM (Figure 3.77). The general effect of including an increase in catchability increased the estimate of current F/F_{MSY} and decreased the estimate of current stock status B/B_{MSY}. The surplus production model, because it omits population age and size structure, does not make use of data on those characteristics. Because such data are available for red snapper, a model that uses them would normally be preferred for a detailed assessment on which to base management.

3.3 Discussion

3.3.1 Comments on Assessment Results

Estimated benchmarks played a central role in this assessment. Values of SSB_{MSY} and F_{MSY} were used to gauge status of the stock and fishery, and for rebuilding projections, SSB reaching SSB_{MSY} was the criterion that defined a successfully rebuilt stock. Computation of benchmarks was conditional on selectivity. If selectivity patterns change in the future, for example as a result of new size limits or different relative catch allocations among sectors, estimates of benchmarks would likely change as well.

The base run of the Beaufort catch-age assessment model indicated that the stock is overfished ($SSB_{2009}/MSST$ = 0.09), and that overfishing is occurring ($F_{2007-2009}/F_{MSY}$ = 4.12). These results were consistent across all configurations used in sensitivity runs. In addition, the same qualitative findings resulted from the production model applications. It should be noted that overfishing can be sustainable, but in the long-term, it tends to result in lower than desirable levels of stock size. The increase in biomass since the mid-1990s could indicate that the federal regulations implemented in 1992 have been effective, however those regulations do not appear adequate for rebuilding the stock.

Although qualitative results were robust, uncertainties remain, as in all assessments. Several sources of uncertainty are discussed below.

This assessment lacked a reliable fishery independent index of abundance. Thus, the fishery dependent indices were the primary source of information on relative abundance. In general, fishery independent indices are preferable. Nonetheless, steps were taken to make the available fishery dependent indices as reliable as possible (using trip selection and standardization methods to develop the indices, and using time-varying catchability to fit them). In addition, the headboat index was developed from a multispecies fishery, which would tend to minimize effects of targeting that could otherwise occur with fleets focused primarily on the species of interest. A new fishery independent sampling program was initiated in the summer of 2010, and this new data source is expected to be available for the next benchmark assessment.

Compared to other fishes, the South Atlantic and Gulf of Mexico stocks of red snapper demonstrate rapid body growth and early maturity relative to their potential longevity (Charnov 1993; Beverton 1992). This could indicate that life-history characteristics, such as growth and maturity schedules, have adapted over time in response to exploitation. Resource managers might wish to consider possible evolutionary effects of fishing (Dunlop et al. 2009).

A source of uncertainty not modeled here is the aggregation of headboats and charterboats into the for-hire fleet, which was recommended by the DW. It was recognized by the AW that charterboats generally fish in deeper water than headboats. Depth of the entire for-hire fleet was accounted for when estimating discard mortality rates, by aggregating the depth distributions of the two components (headboats and charterboats) weighted by their respective landings. However, if selectivities differ between headboats and charterboats, the estimated selectivity of the for-hire fleet should be considered to represent the "average." Charterboat landings were generally higher than those of headboats, so if depths fished by charterboats resulted in selectivity that is less dome-shaped than the pattern used here, results of this assessment would likely be overly optimistic.

Among the many decisions deliberated over by the AW panel was choice of the starting year of the model. The panel thought that it was important to include the 1960s, when landings appeared to have peaked, and to examine sensitivity to those landings through sensitivity and uncertainty analyses. Ignoring this early time frame could have ignored potential stock productivity (Rosenberg et al. 2005). However, the historical period (pre-1976) did not include CPUE or composition data, and thus the model had little or no information to estimate variability of year-class strength in the 1950s and 1960s. Thus, the estimates of historic recruitment should not be considered reliable. Instead, the historic period was viewed by the AW panel as an initialization era leading up to the assessment period of 1976–2009, used to estimate age structure at the onset of CPUE and composition data. Those early recruitment deviations were excluded from the likelihood component of the spawner-recruit curve. Sensitivity runs starting in 1976 or 1986 provided results similar to those of the base run starting in 1955.

Perhaps the greatest uncertainty in this assessment was the spawner-recruit relationship. Steepness could not be estimated reliably (tended toward its upper bound), and R_0, although estimated, relied on predicted recruitment events that occurred at low stock sizes. Potential stock productivity at high stock sizes remains to be observed. It is possible that this assessment under-predicted potential productivity by underestimating R_0, or perhaps over-predicted productivity at high stock sizes, if increased spawners were to have an increasing deleterious effect on recruitment (although mechanisms underlying Ricker dynamics are not known to occur for this stock). Either way, the long-term potential for MSY is, for now, uncertain. Still, the stock dynamics and productivity in recent years might be more relevant to current environmental or ecological conditions, and therefore the results from this assessment would represent our best estimate for the near future.

Because steepness could not be estimated reliably in this assessment, its value was fixed at the mode of its prior distribution. Thus MSY-based management quantities are conditional on that value of steepness. An alternative approach would be to choose a proxy for F_{MSY}, most likely $F_{X\%}$ (such as $F_{30\%}$ or $F_{40\%}$). However, such proxies do not provide biomass-based benchmarks. If managers wish to gauge stock status, further assumptions about equilibrium recruitment levels would be necessary. Furthermore, choice of X% implies an underlying steepness, as described by Brooks et al. (2009). Thus, choosing a proxy equates to choosing steepness. Given the two alternative approaches, it seems preferable to focus on steepness, as its value is less arbitrary, coming from a prior distribution estimated through meta-analysis.

The assessment predicted relatively high abundance in recent years. This prediction is consistent with reports from fishermen of increased abundance. However, this increase appears to be the result of unusually strong year classes (age-1) in 2006 and 2007. The observed age structure of landings remains more truncated than would be expected from a healthy population of a fish with maximum age that exceeds 50 years.

3.3.2 Comments on Projections

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

- In general, projections of fish stocks are highly uncertain, particularly in the long term (e.g., beyond 5–10 years).
- Although projections included many major sources of uncertainty, they did not include structural (model) uncertainty. That is, projection results are conditional on one set of functional forms used to describe population dynamics, selectivity, recruitment, etc.
- Fisheries were assumed to continue fishing at their estimated current proportions of total effort, using the estimated current selectivity patterns. New management regulations that alter those proportions or selectivities would likely affect projection results.
- During the moratorium, fishing effort was assumed to range between 80% and 100% of the current level. This range should be examined when data become available to do so.
- Discard mortality rates during the moratorium were assumed to be those estimated from the DW. However, the depth distributions used to estimate those discard mortality rates were based on fish released because of the size-limit regulation. If fish of all sizes are released, as in a moratorium, those depth distributions would likely shift toward deeper waters, resulting in higher discard mortality rates. Thus, the moratorium projection values likely underestimate the effects of release mortality.
- The projections assumed that the estimated spawner-recruit relationship applies in the future and that past residuals represent future uncertainty in recruitment. If future recruitment is characterized by runs of large or small year classes, possibly due to environmental or ecological conditions, stock trajectories may be affected.

3.4 References

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3.5 Tables

Table 3.1. Life-history characteristics at age of the population, including average body size and weight (mid-year), gonad weight, and proportion females mature.

Age	Total length (mm)	Total length (in)	CV length	Whole weight (kg)	Whole weight (lb)	Gonad weight (kg)	Female maturity
1	277.2	10.9	0.18	0.30	0.66	0.00	0.22
2	410.5	16.2	0.12	1.02	2.25	0.01	0.55
3	515.4	20.3	0.10	2.07	4.57	0.02	0.84
4	597.9	23.5	0.08	3.29	7.26	0.04	0.96
5	662.8	26.1	0.08	4.54	10.01	0.07	0.99
6	713.8	28.1	0.07	5.72	12.61	0.11	1.00
7	754.0	29.7	0.07	6.79	14.96	0.15	1.00
8	785.6	30.9	0.06	7.71	17.01	0.19	1.00
9	810.4	31.9	0.06	8.50	18.74	0.22	1.00
10	829.9	32.7	0.06	9.16	20.19	0.25	1.00
11	845.3	33.3	0.06	9.70	21.38	0.28	1.00
12	857.4	33.8	0.06	10.14	22.35	0.30	1.00
13	866.9	34.1	0.06	10.49	23.13	0.32	1.00
14	874.4	34.4	0.06	10.78	23.76	0.34	1.00
15	880.3	34.7	0.06	11.00	24.26	0.35	1.00
16	884.9	34.8	0.06	11.19	24.66	0.36	1.00
17	888.6	35.0	0.06	11.33	24.98	0.37	1.00
18	891.4	35.1	0.06	11.44	25.23	0.37	1.00
19	893.7	35.2	0.06	11.53	25.43	0.38	1.00
20	895.5	35.3	0.06	11.61	25.59	0.38	1.00

Table 3.2. Estimated total abundance at age (1000 fish) at start of year.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
1955	637.38	468.18	388.12	334.06	293.53	260.85	234.66	211.56	192.85	175.86	160.39	146.28	134.76	124.14	114.37	105.36	97.06	89.41	82.37	963.36	5214.55
1956	367.65	462.59	382.49	327.84	288.42	256.90	232.05	210.00	191.80	175.02	159.66	145.63	134.16	123.59	113.86	104.89	96.63	89.02	82.00	959.07	4903.26
1957	360.67	265.82	376.04	320.87	281.23	250.99	227.56	207.05	189.95	173.71	158.58	144.68	133.29	122.80	113.13	104.21	96.01	88.44	81.48	952.92	4649.42
1958	353.87	259.46	213.70	311.03	271.52	241.65	219.90	201.14	185.67	170.61	156.10	142.53	131.34	121.01	111.48	102.70	94.61	87.16	80.29	939.07	4394.87
1959	347.09	253.64	208.06	175.86	261.99	232.46	211.30	194.30	180.45	166.89	153.44	140.41	129.50	119.34	109.95	101.29	93.31	85.96	79.19	926.18	4170.62
1960	340.27	247.94	202.26	169.69	146.89	222.61	202.05	185.86	173.66	161.63	149.58	137.55	127.14	117.26	108.06	99.56	91.72	84.50	77.84	910.39	3956.44
1961	333.23	242.39	196.80	163.64	140.67	123.97	192.48	177.03	165.58	155.08	144.44	133.70	124.19	114.80	105.88	97.57	89.90	82.82	76.29	892.30	3752.75
1962	326.21	236.94	191.46	157.94	134.60	117.87	106.54	167.79	157.00	147.23	138.00	128.56	120.21	111.66	103.22	95.20	87.73	80.82	74.46	870.86	3554.29
1963	319.21	231.94	187.31	153.45	129.76	112.70	101.28	92.91	148.91	139.71	131.12	122.93	115.68	108.16	100.47	92.88	85.66	78.94	72.73	850.63	3376.37
1964	311.96	226.92	183.54	149.89	125.90	108.54	96.82	88.37	82.53	132.65	124.56	116.93	110.73	104.21	97.44	90.51	83.67	77.17	71.11	831.80	3215.24
1965	304.46	221.04	178.43	145.14	121.60	104.26	92.50	83.96	78.10	73.16	117.71	110.56	104.84	99.29	93.44	87.37	81.16	75.02	69.19	809.58	3050.78
1966	296.76	214.19	171.62	138.07	115.36	98.86	87.56	79.33	73.51	68.63	64.37	103.60	98.30	93.21	88.28	83.08	77.68	72.16	66.70	781.34	2872.63
1967	288.81	206.71	163.53	129.04	106.80	91.53	81.45	74.02	68.64	63.90	59.74	56.06	91.13	86.47	82.00	77.66	73.08	68.34	63.48	746.02	2678.40
1968	280.56	199.06	154.56	118.80	96.59	82.26	73.61	67.56	62.99	58.73	54.77	51.23	48.57	78.96	74.92	71.05	67.29	63.32	59.21	701.37	2465.43
1969	272.52	192.15	146.79	109.59	86.89	72.85	65.02	60.22	56.81	53.30	49.79	46.46	43.90	41.61	67.66	64.20	60.88	57.66	54.26	651.73	2254.27
1970	263.45	186.99	142.79	104.63	80.60	65.92	57.95	53.56	50.99	48.41	45.50	42.53	40.09	37.89	35.91	58.39	55.41	52.54	49.76	609.30	2082.60
1971	252.87	181.78	139.94	102.59	77.52	61.54	52.69	47.89	45.47	43.56	41.42	38.96	36.79	34.68	32.77	31.07	50.51	47.93	45.45	570.07	1935.47
1972	240.23	175.52	137.23	101.52	76.71	59.69	49.52	43.77	40.84	39.00	37.42	35.61	33.83	31.95	30.11	28.46	26.98	43.86	41.62	534.53	1808.39
1973	228.93	167.12	132.90	99.49	75.87	59.04	48.03	41.15	37.34	35.05	33.52	32.19	30.94	29.40	27.76	26.17	24.73	23.44	38.11	500.65	1691.82
1974	261.71	158.59	125.75	94.51	73.03	57.49	46.97	39.61	34.92	31.89	29.99	28.70	27.84	26.76	25.43	24.01	22.64	21.39	20.28	466.05	1617.58
1975	281.23	179.44	116.04	84.69	65.86	52.77	43.97	37.53	32.69	29.04	26.59	25.02	24.20	23.47	22.56	21.44	20.24	19.08	18.03	409.98	1533.90
1976	479.75	190.79	127.81	73.63	55.77	45.22	38.73	34.03	30.14	26.50	23.61	21.64	20.57	19.89	19.30	18.55	17.63	16.64	15.69	351.91	1627.79
1977	195.67	327.75	136.77	79.95	47.85	37.86	32.92	29.82	27.23	24.35	21.48	19.16	17.74	16.86	16.31	15.82	15.21	14.45	13.64	301.36	1392.19
1978	155.53	132.78	231.52	83.83	50.94	31.90	27.13	25.02	23.58	21.75	19.52	17.24	15.53	14.38	13.67	13.22	12.83	12.33	11.72	255.40	1169.82
1979	159.85	104.85	93.22	143.53	53.98	34.27	23.01	20.71	19.84	18.89	17.48	15.70	14.01	12.62	11.69	11.11	10.75	10.42	10.02	217.07	1003.02
1980	187.97	107.66	73.84	57.11	91.47	36.02	24.63	17.57	16.46	15.94	15.22	14.10	12.80	11.42	10.29	9.53	9.06	8.76	8.50	185.13	913.47
1981	150.71	127.65	76.30	45.02	36.23	60.77	25.79	18.73	13.91	13.18	12.81	12.24	11.46	10.40	9.28	8.36	7.74	7.36	7.12	157.34	812.39
1982	160.20	95.63	79.15	32.35	20.29	17.79	34.52	16.63	13.01	9.88	9.43	9.18	8.87	8.30	7.54	6.72	6.06	5.61	5.33	119.16	665.64
1983	637.20	107.99	66.34	45.90	19.56	12.91	12.30	25.55	12.86	10.19	7.77	7.42	7.30	7.05	6.60	5.99	5.35	4.82	4.46	99.01	1106.57
1984	647.89	436.89	66.47	37.49	27.07	12.17	8.75	8.96	19.48	9.94	7.90	6.03	5.82	5.73	5.53	5.18	4.70	4.19	3.78	81.17	1405.13
1985	126.93	435.52	246.68	23.10	14.00	11.27	6.09	5.15	5.79	12.96	6.67	5.32	4.10	3.96	3.90	3.77	3.53	3.20	2.85	57.82	982.61
1986	82.45	84.57	236.84	90.48	9.07	6.09	5.82	3.66	3.38	3.90	8.80	4.54	3.66	2.83	2.73	2.68	2.59	2.43	2.20	41.77	600.49
1987	509.49	55.31	46.40	108.47	43.78	4.73	3.60	3.84	2.58	2.43	2.82	6.38	3.33	2.68	2.07	2.00	1.97	1.90	1.78	32.21	837.77
1988	76.67	332.58	29.87	25.12	61.42	26.23	3.11	2.56	2.87	1.95	1.84	2.14	4.90	2.56	2.06	1.59	1.53	1.51	1.46	26.11	608.08
1989	176.82	51.50	182.28	10.28	9.29	25.29	12.97	1.81	1.63	1.88	1.29	1.22	1.44	3.29	1.72	1.38	1.07	1.03	1.01	18.51	505.74
1990	178.60	116.37	25.11	55.29	3.36	3.40	11.21	6.82	1.05	0.97	1.13	0.78	0.75	0.88	2.01	1.05	0.84	0.65	0.63	11.93	422.84
1991	261.90	124.99	72.29	14.72	33.53	2.12	2.27	7.86	4.94	0.77	0.71	0.83	0.58	0.55	0.65	1.49	0.78	0.63	0.48	9.30	541.38
1992	225.84	179.69	75.77	39.04	8.28	19.90	1.37	1.59	5.75	3.67	0.57	0.53	0.63	0.44	0.42	0.49	1.12	0.59	0.47	7.38	573.54
1993	161.26	162.73	135.37	22.08	13.04	3.12	9.17	0.76	0.97	3.63	2.34	0.36	0.34	0.40	0.28	0.27	0.32	0.73	0.38	5.07	522.62
1994	153.34	112.85	115.14	78.47	14.19	8.69	2.18	6.64	0.56	0.73	2.73	1.76	0.28	0.26	0.31	0.21	0.21	0.24	0.55	4.14	503.48
1995	36.10	106.73	77.96	63.92	50.15	9.45	6.12	1.60	5.04	0.43	0.56	2.09	1.36	0.21	0.20	0.24	0.17	0.16	0.19	3.63	366.32
1996	153.35	24.64	69.77	44.97	43.98	35.78	7.04	4.70	1.26	3.99	0.34	0.44	1.68	1.09	0.17	0.16	0.19	0.13	0.13	3.07	396.90
1997	256.49	108.63	17.26	40.71	32.57	32.92	27.82	5.62	3.84	1.04	3.28	0.28	0.37	1.39	0.91	0.14	0.13	0.16	0.11	2.65	536.33
1998	236.47	183.33	75.60	5.33	16.49	14.62	17.38	16.94	3.72	2.61	0.71	2.25	0.20	0.25	0.97	0.63	0.10	0.09	0.11	1.92	579.72
1999	511.16	171.30	140.91	44.77	3.52	11.36	10.72	13.39	13.52	2.99	2.10	0.57	1.84	0.16	0.21	0.79	0.51	0.08	0.08	1.65	931.65
2000	450.85	348.44	113.10	65.26	24.47	2.06	7.38	7.60	10.03	10.29	2.29	1.61	0.44	1.42	0.12	0.16	0.61	0.40	0.06	1.34	1047.94
2001	199.79	306.34	230.05	50.72	34.37	13.87	1.31	5.13	5.60	7.51	7.75	1.73	1.23	0.34	1.08	0.09	0.12	0.47	0.30	1.07	868.87
2002	164.90	135.98	203.78	131.17	33.02	23.40	10.03	0.99	4.03	4.43	5.97	6.16	1.39	0.99	0.27	0.87	0.08	0.10	0.37	1.10	729.01
2003	248.12	111.36	86.64	113.62	89.28	23.48	17.56	7.84	0.80	3.28	3.62	4.87	5.07	1.14	0.81	0.22	0.72	0.06	0.08	1.22	719.78
2004	120.23	161.70	65.85	51.71	82.75	67.62	18.56	14.33	6.57	0.67	2.77	3.05	4.15	4.33	0.97	0.69	0.19	0.61	0.05	1.11	607.91
2005	66.28	74.84	85.91	34.98	34.15	57.57	50.02	14.41	11.52	5.33	0.55	2.25	2.51	3.41	3.56	0.80	0.57	0.16	0.50	0.95	450.26
2006	793.57	40.23	37.25	44.79	23.39	24.10	43.15	39.31	11.72	9.45	4.38	0.45	1.87	2.09	2.84	2.96	0.67	0.47	0.13	1.21	1084.01
2007	582.30	546.85	27.53	22.36	31.03	16.92	18.45	34.54	32.50	9.77	7.89	3.66	0.38	1.58	1.76	2.40	2.50	0.56	0.40	1.13	1344.52
2008	162.97	385.01	338.24	12.70	12.33	18.36	11.10	13.21	26.10	24.95	7.54	6.10	2.86	0.30	1.23	1.38	1.87	1.95	0.44	1.20	1029.83
2009	78.20	104.63	221.04	152.33	6.95	7.23	11.87	7.78	9.75	19.55	18.77	5.68	4.64	2.18	0.23	0.94	1.05	1.42	1.49	1.25	656.97
2010	196.24	46.66	48.91	78.31	72.92	3.63	4.24	7.68	5.35	6.82	13.75	13.23	4.04	3.31	1.55	0.16	0.67	0.75	1.01	1.94	511.19

Table 3.3. Estimated biomass at age (1000 lb) at start of year

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
1955	420.4	1051.2	1772.1	2423.8	2937.4	3290.2	3511.1	3597.7	3614.0	3550.1	3428.6	3268.8	3116.7	2949.3	2774.5	2598.1	2424.4	2256.0	2094.6	24650.1	75729.0
1956	242.5	1038.6	1746.3	2378.8	2886.3	3240.4	3471.8	3571.3	3594.4	3533.3	3413.0	3254.2	3102.8	2936.1	2762.2	2586.5	2413.6	2245.8	2085.4	24540.3	75043.4
1957	237.9	596.8	1717.0	2328.1	2814.2	3165.8	3404.8	3521.0	3559.8	3506.7	3390.0	3232.9	3082.9	2917.4	2744.3	2569.9	2398.0	2231.5	2071.9	24382.9	73873.8
1958	233.5	582.5	975.8	2256.9	2717.2	3048.1	3290.2	3420.5	3479.6	3444.3	3337.1	3184.8	3037.8	2874.8	2704.4	2532.7	2363.1	2199.1	2041.9	24028.6	71752.3
1959	228.8	569.5	950.0	1276.0	2621.7	2932.1	3161.4	3304.1	3381.7	3369.1	3280.0	3137.6	2995.0	2835.1	2667.4	2497.8	2330.7	2168.9	2013.9	23698.8	69419.8
1960	224.4	556.7	923.5	1231.3	1469.8	2807.8	3023.2	3160.5	3254.5	3262.8	3197.6	3073.7	2940.7	2785.8	2621.5	2455.1	2291.0	2131.9	1979.5	23294.7	66685.7
1961	219.8	544.1	898.6	1187.4	1407.7	1563.7	2879.9	3010.4	3103.0	3130.6	3087.8	2987.7	2872.4	2727.3	2568.6	2406.1	2245.4	2089.5	1940.1	22831.7	63701.7
1962	215.2	532.0	874.1	1146.0	1347.0	1486.8	1593.9	2853.4	2942.3	2972.1	2950.0	2872.8	2780.3	2652.8	2504.0	2347.5	2191.2	2039.3	1893.6	22283.2	60477.2
1963	210.5	520.7	855.2	1113.3	1298.5	1421.5	1515.2	1580.1	2790.6	2820.4	2803.0	2747.0	2675.5	2569.7	2437.4	2290.4	2139.6	1991.7	1849.5	21765.6	57395.2
1964	205.7	509.5	838.0	1087.5	1259.9	1369.1	1448.7	1502.9	1546.8	2677.7	2662.7	2612.9	2561.1	2475.8	2363.8	2232.0	2089.8	1946.9	1808.5	21283.7	54482.4
1965	200.8	496.3	814.6	1053.1	1216.7	1315.1	1384.1	1427.9	1463.6	1476.9	2516.1	2470.5	2424.6	2358.7	2266.8	2154.6	2027.2	1892.7	1759.5	20715.3	51435.0
1966	195.8	480.8	783.5	1001.8	1154.3	1246.9	1310.0	1349.0	1377.7	1385.6	1376.1	2315.1	2273.4	2214.5	2141.6	2048.8	1940.3	1820.6	1696.2	19992.6	48104.9
1967	190.5	464.1	746.7	936.3	1068.6	1154.6	1218.7	1258.8	1286.4	1289.9	1277.1	1252.7	2107.8	2054.3	1989.2	1915.2	1825.4	1724.0	1614.2	19088.9	44463.1
1968	185.0	446.9	705.7	862.0	966.5	1037.5	1101.2	1148.8	1180.6	1185.6	1170.9	1144.9	1123.3	1875.7	1817.5	1752.0	1680.6	1597.7	1505.5	17946.3	40434.8
1969	179.7	431.4	670.2	795.2	869.5	918.9	972.9	1024.0	1064.6	1075.9	1064.4	1038.2	1015.2	988.6	1641.3	1583.1	1520.5	1454.6	1379.9	16676.2	36364.4
1970	173.7	419.8	651.9	759.3	806.5	831.4	867.1	910.7	955.7	977.1	972.7	950.4	927.3	900.1	871.3	1439.8	1383.8	1325.6	1265.5	15590.4	32980.3
1971	166.7	408.1	638.9	744.3	775.8	776.2	788.4	814.4	852.1	879.2	885.4	870.6	850.8	823.9	795.0	766.1	1261.5	1209.2	1155.7	14586.7	30049.2
1972	158.5	394.0	626.6	736.6	767.6	752.9	741.0	744.3	765.4	787.3	800.1	795.6	782.4	759.1	730.6	701.7	674.0	1106.7	1058.4	13677.5	27559.6
1973	151.0	375.2	606.7	721.8	759.3	744.7	718.5	699.7	699.7	707.5	716.7	719.1	715.6	698.4	673.5	645.3	617.7	591.5	969.2	12810.4	25341.7
1974	172.6	356.0	574.1	685.9	730.8	725.1	702.8	673.7	654.3	643.7	641.1	641.3	644.0	635.8	616.9	592.2	565.5	539.7	515.7	11925.2	23236.3
1975	185.4	402.8	529.8	614.4	659.2	665.6	657.9	638.2	612.7	586.2	568.4	559.1	559.5	557.5	547.4	528.7	505.7	481.5	458.6	10490.5	20809.4
1976	316.4	428.4	583.6	534.2	558.0	570.3	579.6	578.7	564.8	535.1	504.6	483.5	475.8	472.7	468.0	457.5	440.3	420.0	399.0	9004.6	18374.9
1977	129.0	735.9	624.3	580.0	478.8	477.5	492.5	507.1	510.1	491.6	459.2	428.1	410.3	400.6	395.7	390.0	379.9	364.6	347.0	7711.1	16313.5
1978	102.5	298.1	1057.1	608.3	509.7	402.3	406.1	425.5	441.8	439.2	417.3	385.1	359.1	341.7	331.8	326.1	320.3	311.1	297.8	6534.9	14315.9
1979	105.4	235.5	425.7	1041.5	540.1	432.3	344.4	352.1	371.9	381.4	373.7	351.0	323.9	299.8	283.5	274.0	268.3	263.0	254.9	5554.3	12476.4
1980	123.9	241.6	337.1	414.5	915.4	454.4	368.6	298.7	308.4	321.9	325.4	315.3	296.1	271.2	249.6	235.0	226.2	221.1	216.1	4737.1	10877.2
1981	99.4	286.6	348.3	326.7	362.4	766.5	385.8	318.6	260.8	266.1	273.8	273.6	265.0	247.1	225.1	206.1	193.3	185.6	181.0	4025.9	9498.0
1982	105.6	214.7	361.3	234.8	203.0	224.4	516.5	282.9	243.8	199.5	201.5	205.0	205.0	197.3	182.8	165.8	151.2	141.5	135.6	3049.2	7221.5
1983	420.2	242.5	302.9	333.1	195.8	162.9	184.1	434.3	241.2	205.7	166.0	165.8	168.9	167.6	160.3	147.7	133.6	121.5	113.5	2533.6	6600.6
1984	427.3	980.8	303.6	272.1	270.9	153.4	131.0	152.3	365.1	200.6	168.9	134.7	134.5	136.0	134.3	127.6	117.5	105.8	96.1	2077.0	6489.5
1985	83.8	977.8	1126.3	167.6	140.2	142.2	91.1	87.7	108.5	261.7	142.6	118.8	94.8	94.1	94.6	92.8	88.0	80.7	72.5	1479.3	5545.1
1986	54.5	189.8	1081.4	656.5	90.8	76.7	87.1	62.2	63.3	78.7	188.3	101.4	84.7	67.0	66.1	66.1	64.8	61.3	56.0	1069.0	4265.7
1987	336.0	124.1	211.9	787.1	438.1	59.7	54.0	65.3	48.3	48.9	60.2	142.6	76.9	63.7	50.3	49.2	49.2	47.8	45.2	824.3	3583.0
1988	50.5	746.7	136.5	182.3	614.6	330.9	46.5	43.4	53.8	39.5	39.5	47.8	113.3	60.6	50.0	39.2	38.4	38.1	37.0	668.2	3376.8
1989	116.6	115.5	832.2	74.5	93.0	319.0	194.2	30.9	30.6	37.9	27.6	27.3	33.3	78.0	41.7	34.2	26.7	26.0	25.8	473.8	2638.7
1990	117.7	261.2	114.6	401.2	33.7	42.8	167.8	116.0	19.6	19.6	24.3	17.4	17.2	20.9	48.7	25.8	21.2	16.5	16.1	305.1	1807.6
1991	172.6	280.6	330.0	106.9	335.5	26.7	34.0	133.6	92.6	15.4	15.2	18.5	13.4	13.2	15.9	36.6	19.4	15.9	12.3	237.9	1926.4
1992	149.0	403.4	345.9	283.3	82.9	251.1	20.5	26.9	107.8	74.1	12.1	11.9	14.6	10.4	10.1	12.1	28.0	14.8	11.9	188.7	2059.6
1993	106.3	365.3	618.0	160.3	130.5	39.2	137.1	12.8	18.1	73.2	50.0	8.2	7.9	9.7	6.8	6.6	7.9	18.3	9.7	129.9	1916.0
1994	101.2	253.3	525.6	569.2	142.0	109.6	32.6	112.9	10.6	14.8	58.2	39.2	6.4	6.2	7.5	5.3	5.1	6.2	14.1	105.8	2126.1
1995	23.8	239.6	355.8	463.9	501.8	119.3	91.5	27.3	94.4	8.8	11.9	46.7	31.5	5.1	4.9	6.0	4.2	4.0	4.9	93.0	2138.0
1996	101.2	55.3	318.6	326.3	440.0	451.3	105.4	79.8	23.6	80.7	7.3	9.9	38.8	26.0	4.2	4.0	4.9	3.3	3.3	78.5	2162.3
1997	169.1	243.8	78.7	295.4	326.1	415.4	416.2	95.5	71.9	20.9	70.1	6.4	8.6	33.1	22.0	3.5	3.3	4.0	2.9	67.9	2354.8
1998	155.9	411.6	345.2	38.8	164.9	184.3	260.1	288.1	69.7	52.7	15.2	50.3	4.4	6.0	23.4	15.4	2.4	2.4	2.9	48.9	2142.9
1999	337.1	384.7	643.3	324.7	35.3	143.3	160.5	227.7	253.3	60.4	45.0	12.8	42.5	3.7	5.1	19.4	12.8	2.0	2.0	42.3	2758.2
2000	297.4	782.4	516.3	473.6	244.9	26.0	110.5	129.2	188.1	207.7	48.9	35.9	10.4	33.7	3.1	4.0	15.2	9.9	1.5	34.2	3172.9
2001	131.8	687.8	1050.3	368.0	343.9	174.8	19.6	87.3	104.9	151.7	165.6	38.6	28.4	7.9	26.2	2.4	3.1	11.7	7.7	27.3	3439.2
2002	108.7	305.3	930.4	951.7	330.5	295.2	149.9	16.8	75.4	89.5	127.4	137.6	32.0	23.4	6.6	21.4	2.0	2.4	9.5	28.2	3644.2
2003	163.6	250.0	395.5	824.3	893.3	296.1	262.8	133.4	15.0	66.1	77.4	108.7	117.3	27.1	19.6	5.5	17.9	1.5	2.0	31.1	3708.8
2004	79.4	363.1	300.7	375.2	828.1	853.0	277.8	243.6	123.2	13.7	59.1	68.1	95.9	102.7	23.6	17.0	4.9	15.4	1.3	28.2	3874.0
2005	43.7	168.0	392.2	253.8	341.7	726.2	748.2	245.2	215.8	107.6	11.7	50.3	58.0	81.1	86.4	19.8	14.3	4.0	12.8	24.5	3605.0
2006	523.4	90.4	170.0	325.0	234.1	304.0	645.5	668.4	219.6	190.7	93.7	10.1	43.2	49.6	68.8	73.0	16.5	11.9	3.3	31.1	3772.3
2007	384.0	1227.8	125.7	162.3	310.4	213.4	276.0	587.3	609.1	197.1	168.7	81.8	8.8	37.5	42.8	59.1	62.4	14.1	10.1	28.9	4607.9
2008	107.6	864.4	1544.3	92.2	123.2	231.7	166.0	224.7	489.2	503.8	161.2	136.2	66.1	7.1	30.0	34.0	46.7	49.2	11.2	30.6	4919.0
2009	51.6	235.0	1009.3	1105.4	69.7	91.3	177.7	132.3	182.8	394.6	401.2	126.8	107.4	51.8	5.5	23.1	26.2	35.9	37.7	32.0	4296.8
2010	129.4	104.7	223.3	568.1	729.7	45.9	63.5	130.7	100.3	137.8	294.1	295.6	93.5	78.5	37.7	4.0	16.8	18.7	25.8	49.8	3147.8

Table 3.4. Estimated time series and status indicators. Fishing mortality rate is apical F, which includes discard mortalities. Total biomass (B, mt) is at the start of the year, and spawning biomass (SSB, female gonad weight, mt) at the end of July (time of peak spawning). The MSST *is defined by* $\mathrm{MSST} = (1 - M)\mathrm{SSB}_{\mathrm{MSY}}$, *with constant* $M = 0.08$. *SPR is static spawning potential ratio.*

Year	F	F/F_{MSY}	B	B/B_{unfished}	SSB	$\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$	SSB/MSST	SPR
1955	0.0388	0.219	34350	0.7791	452.75	2.9021	3.1544	0.65635
1956	0.0457	0.257	34039	0.7721	448.13	2.8724	3.1222	0.61984
1957	0.0598	0.337	33509	0.7600	441.81	2.8320	3.0782	0.52642
1958	0.0649	0.366	32546	0.7382	433.00	2.7755	3.0168	0.51935
1959	0.0738	0.416	31488	0.7142	421.94	2.7046	2.9398	0.48047
1960	0.0818	0.461	30248	0.6861	408.15	2.6162	2.8437	0.44972
1961	0.0900	0.507	28895	0.6554	391.82	2.5115	2.7299	0.41530
1962	0.0913	0.514	27432	0.6222	374.36	2.3996	2.6083	0.41744
1963	0.0929	0.523	26034	0.5905	357.01	2.2884	2.4874	0.42062
1964	0.1048	0.590	24713	0.5605	338.88	2.1722	2.3610	0.38126
1965	0.1264	0.712	23331	0.5292	318.82	2.0436	2.2213	0.32023
1966	0.1552	0.874	21820	0.4949	296.53	1.9007	2.0660	0.25749
1967	0.1895	1.068	20168	0.4575	271.67	1.7414	1.8928	0.19712
1968	0.2139	1.205	18341	0.4160	245.38	1.5729	1.7096	0.16464
1969	0.2085	1.175	16495	0.3741	221.35	1.4188	1.5422	0.17815
1970	0.2007	1.130	14960	0.3393	200.54	1.2855	1.3972	0.18817
1971	0.1909	1.076	13630	0.3092	182.43	1.1693	1.2710	0.20315
1972	0.1916	1.080	12501	0.2835	166.49	1.0672	1.1600	0.20473
1973	0.2109	1.188	11495	0.2607	151.76	0.9727	1.0573	0.18398
1974	0.2653	1.494	10540	0.2391	136.08	0.8723	0.9481	0.12473
1975	0.3249	1.830	9439	0.2141	118.98	0.7627	0.8290	0.08656
1976	0.3391	1.911	8335	0.1890	102.92	0.6597	0.7171	0.08276
1977	0.3595	2.026	7400	0.1678	88.76	0.5690	0.6184	0.07211
1978	0.3481	1.961	6494	0.1473	76.87	0.4927	0.5356	0.07450
1979	0.3599	2.027	5659	0.1284	66.92	0.4290	0.4663	0.07320
1980	0.3647	2.055	4934	0.1119	58.18	0.3729	0.4053	0.07206
1981	0.7281	4.102	4308	0.0977	46.82	0.3001	0.3262	0.01518
1982	0.4148	2.337	3276	0.0743	37.98	0.2435	0.2646	0.05481
1983	0.4408	2.484	2994	0.0679	32.13	0.2060	0.2239	0.04348
1984	0.9267	5.221	2944	0.0668	24.99	0.1602	0.1741	0.00864
1985	0.8729	4.918	2515	0.0570	18.96	0.1215	0.1321	0.00934
1986	0.6509	3.667	1935	0.0439	15.35	0.0984	0.1069	0.01759
1987	0.4836	2.724	1625	0.0369	13.15	0.0843	0.0916	0.02992
1988	0.9366	5.276	1532	0.0347	10.43	0.0668	0.0727	0.00810
1989	1.0629	5.988	1197	0.0271	7.41	0.0475	0.0517	0.00525
1990	0.4038	2.275	820	0.0186	5.93	0.0380	0.0413	0.04084
1991	0.4860	2.738	874	0.0198	5.54	0.0355	0.0386	0.03275
1992	1.1032	6.215	934	0.0212	4.65	0.0298	0.0324	0.00889
1993	0.4153	2.340	869	0.0197	4.53	0.0290	0.0315	0.05614
1994	0.4585	2.583	964	0.0219	5.18	0.0332	0.0361	0.05538
1995	0.4201	2.367	970	0.0220	5.97	0.0383	0.0416	0.07241
1996	0.4086	2.302	981	0.0222	6.87	0.0441	0.0479	0.10884
1997	1.0441	5.882	1068	0.0242	6.39	0.0410	0.0445	0.01162
1998	0.3940	2.220	972	0.0220	6.19	0.0397	0.0431	0.09093
1999	0.6398	3.604	1251	0.0284	6.62	0.0425	0.0462	0.03161
2000	0.6720	3.786	1439	0.0326	6.91	0.0443	0.0481	0.02719
2001	0.4318	2.433	1560	0.0354	7.92	0.0508	0.0552	0.06411
2002	0.4542	2.559	1653	0.0375	9.54	0.0612	0.0665	0.07510
2003	0.3862	2.175	1682	0.0382	11.34	0.0727	0.0790	0.10326
2004	0.5026	2.832	1757	0.0399	12.66	0.0812	0.0882	0.05114
2005	0.5278	2.974	1635	0.0371	13.33	0.0854	0.0928	0.05022
2006	0.3803	2.142	1711	0.0388	13.83	0.0887	0.0964	0.10552
2007	0.6439	3.627	2090	0.0474	13.81	0.0885	0.0962	0.03007
2008	0.6677	3.762	2231	0.0506	13.62	0.0873	0.0949	0.02422
2009	0.9076	5.113	1949	0.0442	12.43	0.0797	0.0866	0.01003
2010	.	.	1428	0.0324	.	.	.	.

Table 3.5. Selectivity at age (end-of-assessment time period) for commercial lines (cl), commercial dive (cd), for-hire (hb), private recreational (pvt), commercial lines discard mortalities (D.cl), for-hire discard mortalities (D.hb), private recreational discard mortalities (D.pvt), selectivity of landings averaged across fisheries (L.avg), and selectivity of discard mortalities averaged across fisheries (D.avg). TL is total length.

Age	TL(mm)	TL(in)	cl	co	hb	rec	D.cl	D.hb	D.rec	L.avg	D.avg	L.avg+D.avg
1	277.2	10.9	0.001	0.001	0.003	0.000	0.046	0.390	0.390	0.001	0.208	0.209
2	410.5	16.2	0.079	0.050	0.036	0.005	0.501	1.000	1.000	0.018	0.549	0.567
3	515.4	20.3	0.880	0.706	1.000	1.000	1.000	0.416	0.416	0.738	0.262	1.000
4	597.9	23.5	0.998	1.000	0.940	0.940	0.030	0.030	0.030	0.712	0.017	0.729
5	662.8	26.1	1.000	0.897	0.828	0.828	0.001	0.001	0.001	0.638	0.000	0.639
6	713.8	28.1	1.000	0.697	0.629	0.629	0.000	0.000	0.000	0.507	0.000	0.507
7	754.0	29.7	1.000	0.427	0.442	0.442	0.000	0.000	0.000	0.384	0.000	0.384
8	785.6	30.9	1.000	0.269	0.348	0.348	0.000	0.000	0.000	0.322	0.000	0.322
9	810.4	31.9	1.000	0.217	0.315	0.315	0.000	0.000	0.000	0.300	0.000	0.300
10	829.9	32.7	1.000	0.203	0.304	0.304	0.000	0.000	0.000	0.293	0.000	0.293
11	845.3	33.3	1.000	0.199	0.301	0.301	0.000	0.000	0.000	0.291	0.000	0.291
12	857.4	33.8	1.000	0.198	0.300	0.300	0.000	0.000	0.000	0.291	0.000	0.291
13	866.9	34.1	1.000	0.198	0.300	0.300	0.000	0.000	0.000	0.290	0.000	0.290
14	874.4	34.4	1.000	0.198	0.300	0.300	0.000	0.000	0.000	0.290	0.000	0.290
15	880.3	34.7	1.000	0.198	0.300	0.300	0.000	0.000	0.000	0.290	0.000	0.290
16	884.9	34.8	1.000	0.198	0.300	0.300	0.000	0.000	0.000	0.290	0.000	0.290
17	888.6	35.0	1.000	0.198	0.300	0.300	0.000	0.000	0.000	0.290	0.000	0.290
18	891.4	35.1	1.000	0.198	0.300	0.300	0.000	0.000	0.000	0.290	0.000	0.290
19	893.7	35.2	1.000	0.198	0.300	0.300	0.000	0.000	0.000	0.290	0.000	0.290
20	895.5	35.3	1.000	0.198	0.300	0.300	0.000	0.000	0.000	0.290	0.000	0.290

Table 3.6. Estimated time series of fully selected fishing mortality rates for commercial lines (F.cl), commercial dive (F.cd), for-hire (F.hb), private recreational (F.pvt), commercial lines discard mortalities (F.cl.D), for-hire discard mortalities (F.hb.D), private recreational discard mortalities (F.pvt.D). Also shown is apical F, the maximum F at age summed across fleets, which may not equal the sum of fully selected F's because of dome-shaped selectivities.

Year	F.cl	F.cd	F.hb	F.pvt	F.cl.D	F.hb.D	F.pvt.D	Apical F
1955	0.007	0.000	0.025	0.007	0.000	0.000	0.000	0.039
1956	0.007	0.000	0.030	0.009	0.000	0.000	0.000	0.046
1957	0.012	0.000	0.035	0.012	0.000	0.000	0.000	0.060
1958	0.009	0.000	0.040	0.016	0.000	0.000	0.000	0.065
1959	0.010	0.000	0.044	0.020	0.000	0.000	0.000	0.074
1960	0.011	0.000	0.047	0.024	0.000	0.000	0.000	0.082
1961	0.013	0.000	0.049	0.027	0.000	0.000	0.000	0.090
1962	0.012	0.000	0.049	0.030	0.000	0.000	0.000	0.091
1963	0.009	0.000	0.050	0.034	0.000	0.000	0.000	0.093
1964	0.011	0.000	0.053	0.040	0.000	0.000	0.000	0.105
1965	0.014	0.000	0.062	0.051	0.000	0.000	0.000	0.126
1966	0.017	0.000	0.073	0.065	0.000	0.000	0.000	0.155
1967	0.024	0.000	0.085	0.081	0.000	0.000	0.000	0.190
1968	0.029	0.000	0.092	0.093	0.000	0.000	0.000	0.214
1969	0.021	0.000	0.091	0.097	0.000	0.000	0.000	0.209
1970	0.021	0.000	0.084	0.096	0.000	0.000	0.000	0.201
1971	0.020	0.000	0.076	0.095	0.000	0.000	0.000	0.191
1972	0.019	0.000	0.073	0.100	0.000	0.000	0.000	0.192
1973	0.017	0.000	0.078	0.116	0.000	0.000	0.000	0.211
1974	0.030	0.000	0.088	0.147	0.000	0.000	0.000	0.265
1975	0.040	0.000	0.099	0.185	0.000	0.000	0.000	0.325
1976	0.038	0.000	0.089	0.211	0.000	0.000	0.000	0.339
1977	0.046	0.000	0.097	0.217	0.000	0.000	0.000	0.360
1978	0.047	0.000	0.106	0.195	0.000	0.000	0.000	0.348
1979	0.038	0.000	0.107	0.215	0.000	0.000	0.000	0.360
1980	0.040	0.000	0.096	0.229	0.000	0.000	0.000	0.365
1981	0.048	0.000	0.169	0.511	0.000	0.000	0.000	0.728
1982	0.049	0.000	0.103	0.263	0.000	0.000	0.000	0.415
1983	0.058	0.000	0.161	0.222	0.000	0.059	0.012	0.441
1984	0.053	0.001	0.106	0.768	0.000	0.092	0.016	0.927
1985	0.059	0.002	0.178	0.635	0.000	0.031	0.067	0.873
1986	0.066	0.000	0.297	0.288	0.000	0.001	0.038	0.651
1987	0.069	0.000	0.135	0.279	0.000	0.000	0.204	0.484
1988	0.068	0.000	0.182	0.687	0.000	0.000	0.069	0.937
1989	0.148	0.000	0.212	0.702	0.000	0.001	0.084	1.063
1990	0.156	0.003	0.134	0.112	0.000	0.000	0.022	0.404
1991	0.095	0.009	0.128	0.257	0.000	0.002	0.076	0.486
1992	0.080	0.015	0.500	0.446	0.052	0.029	0.030	1.103
1993	0.150	0.007	0.103	0.078	0.040	0.058	0.081	0.415
1994	0.119	0.012	0.132	0.081	0.070	0.017	0.133	0.458
1995	0.102	0.008	0.140	0.015	0.088	0.080	0.118	0.420
1996	0.074	0.005	0.058	0.076	0.167	0.022	0.072	0.409
1997	0.068	0.008	0.713	0.042	0.197	0.043	0.019	1.044
1998	0.056	0.011	0.173	0.077	0.068	0.014	0.034	0.394
1999	0.047	0.010	0.309	0.147	0.049	0.056	0.148	0.640
2000	0.052	0.009	0.119	0.373	0.038	0.029	0.187	0.672
2001	0.076	0.012	0.083	0.156	0.029	0.034	0.178	0.432
2002	0.058	0.011	0.098	0.111	0.093	0.046	0.179	0.454
2003	0.040	0.008	0.093	0.064	0.054	0.045	0.276	0.386
2004	0.050	0.010	0.120	0.126	0.022	0.086	0.356	0.503
2005	0.040	0.006	0.128	0.118	0.026	0.200	0.306	0.528
2006	0.028	0.003	0.125	0.108	0.046	0.031	0.148	0.380
2007	0.039	0.007	0.149	0.309	0.027	0.077	0.209	0.644
2008	0.073	0.004	0.140	0.291	0.019	0.055	0.308	0.668
2009	0.111	0.004	0.184	0.342	0.054	0.091	0.454	0.908

Table 3.7. Estimated instantaneous fishing mortality rate (per yr) at age, including discard mortality

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1955	0.021	0.032	0.039	0.037	0.033	0.027	0.021	0.018	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
1956	0.024	0.037	0.046	0.043	0.039	0.031	0.024	0.020	0.019	0.019	0.019	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
1957	0.029	0.048	0.060	0.057	0.052	0.042	0.033	0.029	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027
1958	0.033	0.051	0.065	0.062	0.055	0.044	0.034	0.029	0.027	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
1959	0.036	0.056	0.074	0.070	0.063	0.050	0.038	0.032	0.030	0.030	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029
1960	0.039	0.061	0.082	0.078	0.070	0.055	0.042	0.036	0.033	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
1961	0.041	0.066	0.090	0.085	0.077	0.062	0.047	0.040	0.037	0.037	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
1962	0.041	0.065	0.091	0.087	0.078	0.062	0.047	0.039	0.037	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
1963	0.041	0.064	0.093	0.088	0.079	0.062	0.046	0.038	0.036	0.035	0.035	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
1964	0.045	0.070	0.105	0.099	0.089	0.070	0.052	0.044	0.040	0.040	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
1965	0.052	0.083	0.126	0.120	0.107	0.085	0.064	0.053	0.049	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
1966	0.062	0.100	0.155	0.147	0.131	0.104	0.078	0.065	0.060	0.059	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
1967	0.072	0.121	0.190	0.180	0.161	0.128	0.097	0.081	0.076	0.074	0.074	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073
1968	0.079	0.135	0.214	0.203	0.182	0.145	0.111	0.093	0.087	0.085	0.085	0.085	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084
1969	0.077	0.127	0.209	0.197	0.176	0.139	0.104	0.086	0.080	0.078	0.078	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077
1970	0.071	0.120	0.201	0.190	0.170	0.134	0.101	0.084	0.078	0.076	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
1971	0.065	0.111	0.191	0.181	0.161	0.127	0.095	0.079	0.074	0.072	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071
1972	0.063	0.108	0.192	0.181	0.162	0.127	0.095	0.079	0.073	0.071	0.071	0.071	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070
1973	0.067	0.114	0.211	0.199	0.177	0.139	0.103	0.084	0.078	0.076	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
1974	0.077	0.142	0.265	0.251	0.225	0.178	0.134	0.112	0.104	0.102	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101
1975	0.088	0.169	0.325	0.308	0.276	0.219	0.166	0.139	0.130	0.127	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
1976	0.081	0.163	0.339	0.321	0.287	0.227	0.171	0.143	0.133	0.130	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129
1977	0.088	0.178	0.360	0.341	0.306	0.243	0.184	0.155	0.144	0.141	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140
1978	0.094	0.184	0.348	0.330	0.296	0.236	0.180	0.152	0.142	0.139	0.138	0.138	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137
1979	0.095	0.181	0.360	0.341	0.304	0.240	0.180	0.150	0.139	0.136	0.135	0.134	0.134	0.134	0.134	0.134	0.134	0.134	0.134	0.134
1980	0.087	0.174	0.365	0.345	0.309	0.244	0.184	0.153	0.142	0.139	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138	0.138
1981	0.155	0.308	0.728	0.687	0.611	0.476	0.349	0.285	0.262	0.255	0.253	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
1982	0.094	0.196	0.415	0.393	0.352	0.279	0.211	0.177	0.164	0.161	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159	0.159
1983	0.077	0.315	0.441	0.418	0.375	0.299	0.227	0.191	0.178	0.174	0.173	0.173	0.173	0.173	0.173	0.173	0.173	0.173	0.173	0.173
1984	0.097	0.402	0.927	0.875	0.777	0.602	0.439	0.357	0.328	0.319	0.316	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
1985	0.106	0.439	0.873	0.825	0.734	0.571	0.419	0.342	0.315	0.307	0.304	0.303	0.303	0.303	0.303	0.303	0.303	0.303	0.303	0.303
1986	0.099	0.430	0.651	0.616	0.550	0.434	0.325	0.269	0.250	0.244	0.242	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241
1987	0.127	0.446	0.484	0.459	0.412	0.330	0.253	0.214	0.200	0.195	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194
1988	0.098	0.431	0.937	0.884	0.787	0.614	0.452	0.370	0.341	0.332	0.329	0.329	0.328	0.328	0.328	0.328	0.328	0.328	0.328	0.328
1989	0.118	0.548	1.063	1.008	0.906	0.723	0.553	0.467	0.436	0.427	0.424	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423	0.423
1990	0.057	0.306	0.404	0.390	0.362	0.313	0.266	0.242	0.234	0.231	0.231	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230
1991	0.077	0.331	0.486	0.466	0.422	0.343	0.269	0.231	0.218	0.214	0.213	0.212	0.212	0.212	0.212	0.212	0.212	0.212	0.212	0.212
1992	0.028	0.113	1.103	0.987	0.876	0.685	0.504	0.413	0.381	0.371	0.368	0.367	0.367	0.367	0.367	0.366	0.366	0.366	0.366	0.366
1993	0.057	0.176	0.415	0.332	0.306	0.268	0.233	0.214	0.208	0.206	0.206	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
1994	0.062	0.200	0.458	0.338	0.306	0.261	0.218	0.196	0.188	0.186	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185
1995	0.082	0.255	0.420	0.264	0.238	0.205	0.174	0.158	0.152	0.151	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
1996	0.045	0.186	0.409	0.213	0.190	0.162	0.135	0.122	0.117	0.116	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115
1997	0.036	0.192	1.044	0.794	0.701	0.549	0.406	0.333	0.308	0.300	0.297	0.297	0.297	0.296	0.296	0.296	0.296	0.296	0.296	0.296
1998	0.022	0.093	0.394	0.304	0.272	0.220	0.171	0.146	0.137	0.134	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133
1999	0.083	0.245	0.640	0.494	0.435	0.341	0.254	0.209	0.193	0.188	0.187	0.187	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186
2000	0.086	0.245	0.672	0.531	0.468	0.368	0.274	0.226	0.209	0.203	0.202	0.202	0.201	0.201	0.201	0.201	0.201	0.201	0.201	0.201
2001	0.085	0.238	0.432	0.319	0.284	0.234	0.187	0.162	0.154	0.151	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
2002	0.093	0.281	0.454	0.275	0.241	0.197	0.155	0.134	0.126	0.124	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123	0.123
2003	0.128	0.355	0.386	0.207	0.178	0.145	0.113	0.097	0.092	0.090	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089
2004	0.174	0.462	0.503	0.305	0.263	0.212	0.163	0.138	0.129	0.127	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
2005	0.199	0.528	0.521	0.292	0.249	0.198	0.151	0.127	0.118	0.116	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115
2006	0.072	0.209	0.380	0.257	0.224	0.177	0.133	0.110	0.102	0.100	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099	0.099
2007	0.114	0.310	0.644	0.486	0.425	0.332	0.244	0.200	0.184	0.179	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.178
2008	0.143	0.385	0.668	0.493	0.433	0.346	0.265	0.224	0.209	0.205	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203
2009	0.216	0.590	0.908	0.627	0.550	0.444	0.345	0.295	0.277	0.272	0.270	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269

Table 3.8. Estimated total landings at age in numbers (1000 fish)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1955	11.19	13.62	13.86	11.46	9.16	6.64	4.67	3.63	3.12	2.79	2.53	2.31	2.13	1.96	1.81	1.67	1.53	1.41	1.30	15.24
1956	7.63	15.51	16.03	13.18	10.50	7.56	5.27	4.07	3.48	3.11	2.82	2.58	2.37	2.19	2.01	1.86	1.71	1.57	1.45	16.96
1957	9.02	11.51	20.48	16.84	13.48	9.93	7.15	5.68	4.93	4.43	4.02	3.68	3.39	3.12	2.88	2.65	2.44	2.25	2.07	24.23
1958	9.93	11.82	12.61	17.60	13.91	10.00	6.99	5.44	4.70	4.22	3.84	3.52	3.24	2.98	2.75	2.53	2.33	2.15	1.98	23.16
1959	10.73	12.80	13.90	11.27	15.20	10.89	7.60	5.94	5.16	4.67	4.26	3.91	3.61	3.32	3.06	2.82	2.60	2.39	2.20	25.79
1960	11.31	13.51	14.92	12.00	9.41	11.49	7.99	6.24	5.44	4.96	4.56	4.20	3.88	3.58	3.30	3.04	2.80	2.58	2.38	27.79
1961	11.59	14.22	15.89	12.69	9.90	7.08	8.50	6.68	5.85	5.37	4.97	4.61	4.28	3.96	3.65	3.37	3.10	2.86	2.63	30.78
1962	11.35	13.73	15.68	12.40	9.57	6.75	4.67	6.23	5.44	4.99	4.65	4.34	4.06	3.77	3.48	3.21	2.96	2.73	2.51	29.38
1963	11.15	13.24	15.60	12.24	9.33	6.47	4.39	3.37	5.01	4.59	4.28	4.02	3.78	3.54	3.28	3.04	2.80	2.58	2.38	27.81
1964	11.76	14.20	17.14	13.41	10.17	7.01	4.73	3.63	3.15	4.94	4.61	4.34	4.10	3.86	3.61	3.35	3.10	2.86	2.63	30.82
1965	13.26	16.21	19.90	15.52	11.76	8.09	5.45	4.16	3.60	3.30	5.27	4.96	4.70	4.45	4.19	3.92	3.64	3.36	3.10	36.29
1966	15.34	18.75	23.17	17.88	13.53	9.32	6.28	4.79	4.13	3.77	3.51	5.66	5.37	5.09	4.82	4.54	4.24	3.94	3.64	42.66
1967	17.39	21.66	26.53	20.12	15.13	10.52	7.21	5.56	4.82	4.39	4.08	3.84	6.23	5.91	5.61	5.31	5.00	4.67	4.34	51.00
1968	18.34	23.11	27.97	20.69	15.33	10.65	7.39	5.79	5.06	4.61	4.28	4.01	3.80	6.18	5.86	5.56	5.27	4.95	4.63	54.88
1969	17.41	21.10	25.97	18.61	13.38	9.05	6.15	4.79	4.20	3.85	3.57	3.34	3.16	2.99	4.86	4.61	4.38	4.14	3.90	46.84
1970	15.64	19.46	24.40	17.17	11.99	7.91	5.31	4.13	3.66	3.40	3.17	2.97	2.80	2.65	2.51	4.08	3.87	3.67	3.48	42.56
1971	13.80	17.61	22.85	16.08	11.01	7.04	4.59	3.51	3.10	2.90	2.74	2.58	2.44	2.30	2.17	2.06	3.35	3.18	3.01	37.79
1972	12.67	16.57	22.49	15.96	10.92	6.83	4.30	3.19	2.76	2.58	2.46	2.34	2.22	2.10	1.98	1.87	1.77	2.88	2.74	35.14
1973	12.85	16.65	23.75	17.05	11.76	7.32	4.48	3.20	2.69	2.46	2.34	2.25	2.16	2.05	1.94	1.83	1.73	1.64	2.66	34.94
1974	16.88	19.39	27.55	19.93	14.02	8.98	5.65	4.04	3.32	2.97	2.77	2.66	2.58	2.48	2.36	2.22	2.10	1.98	1.88	43.17
1975	20.52	25.76	30.29	21.31	15.15	9.95	6.45	4.70	3.83	3.33	3.03	2.86	2.77	2.68	2.58	2.45	2.31	2.18	2.06	46.84
1976	32.32	26.43	34.60	19.21	13.29	8.81	5.84	4.37	3.61	3.11	2.75	2.53	2.40	2.32	2.25	2.16	2.06	1.94	1.83	41.07
1977	14.23	49.17	38.88	21.93	12.02	7.82	5.31	4.12	3.52	3.08	2.70	2.42	2.24	2.13	2.06	1.99	1.92	1.82	1.72	37.99
1978	12.12	20.55	64.07	22.39	12.47	6.43	4.29	3.39	3.00	2.71	2.42	2.14	1.93	1.78	1.70	1.64	1.59	1.53	1.45	31.70
1979	12.58	15.98	26.52	39.35	13.52	7.01	3.63	2.77	2.48	2.31	2.12	1.91	1.70	1.53	1.42	1.35	1.31	1.27	1.22	26.37
1980	13.55	15.87	21.24	15.84	23.19	7.48	3.96	2.40	2.10	1.99	1.89	1.75	1.59	1.42	1.28	1.18	1.13	1.09	1.06	23.00
1981	18.74	31.25	37.29	21.32	15.84	22.07	7.28	4.47	3.09	2.86	2.76	2.64	2.47	2.24	2.00	1.80	1.67	1.59	1.53	33.92
1982	12.50	15.68	25.31	9.99	5.74	4.15	6.29	2.59	1.90	1.41	1.34	1.31	1.26	1.18	1.07	0.96	0.86	0.80	0.76	16.94
1983	26.43	20.92	22.28	14.90	5.84	3.19	2.40	4.28	2.02	1.57	1.19	1.14	1.12	1.08	1.01	0.92	0.82	0.74	0.68	15.19
1984	29.32	97.54	38.03	20.86	14.00	5.29	2.99	2.59	5.24	2.61	2.06	1.58	1.52	1.50	1.45	1.35	1.23	1.10	0.99	21.21
1985	7.05	111.11	135.95	12.38	6.97	4.71	2.00	1.44	1.51	3.30	1.68	1.35	1.04	1.00	0.99	0.95	0.89	0.81	0.72	14.63
1986	5.73	24.93	107.00	39.62	3.67	2.05	1.55	0.83	0.72	0.81	1.82	0.94	0.76	0.59	0.57	0.56	0.54	0.50	0.46	8.66
1987	19.36	9.96	16.77	37.95	14.13	1.28	0.77	0.71	0.45	0.42	0.48	1.09	0.57	0.46	0.35	0.34	0.33	0.32	0.30	5.49
1988	4.50	90.59	17.20	14.08	32.05	11.56	1.09	0.76	0.80	0.53	0.50	0.58	1.33	0.69	0.56	0.43	0.42	0.41	0.40	7.07
1989	12.34	17.04	113.15	6.24	5.31	12.52	5.29	0.65	0.56	0.63	0.43	0.41	0.48	1.10	0.57	0.46	0.36	0.34	0.34	6.18
1990	7.22	26.23	7.86	16.97	0.97	0.87	2.51	1.41	0.21	0.19	0.22	0.16	0.15	0.17	0.40	0.21	0.17	0.13	0.13	2.37
1991	10.12	24.86	26.23	5.21	11.02	0.59	0.51	1.56	0.93	0.14	0.13	0.15	0.11	0.10	0.12	0.28	0.14	0.12	0.09	1.72
1992	0.39	4.31	44.69	23.32	4.63	9.48	0.52	0.52	1.75	1.09	0.17	0.16	0.19	0.13	0.12	0.15	0.33	0.17	0.14	2.19
1993	0.07	2.24	33.12	5.82	3.28	0.70	1.82	0.14	0.18	0.65	0.42	0.07	0.06	0.07	0.05	0.05	0.06	0.13	0.07	0.91
1994	0.08	1.43	28.41	20.95	3.57	1.92	0.41	1.14	0.09	0.12	0.44	0.29	0.05	0.04	0.05	0.03	0.03	0.04	0.09	0.68
1995	0.02	1.18	15.01	13.62	10.10	1.68	0.93	0.23	0.68	0.06	0.07	0.28	0.18	0.03	0.03	0.03	0.02	0.02	0.03	0.49
1996	0.04	0.18	10.93	7.87	7.23	5.12	0.85	0.52	0.13	0.42	0.04	0.05	0.18	0.11	0.02	0.02	0.02	0.01	0.01	0.32
1997	0.56	2.90	8.34	21.07	15.71	13.35	8.90	1.53	0.98	0.26	0.81	0.07	0.09	0.35	0.23	0.04	0.03	0.04	0.03	0.66
1998	0.14	1.87	18.03	1.31	3.75	2.77	2.61	2.21	0.46	0.31	0.09	0.27	0.02	0.03	0.12	0.08	0.01	0.01	0.01	0.23
1999	0.51	2.28	49.69	16.35	1.19	3.15	2.30	2.43	2.29	0.49	0.35	0.09	0.30	0.03	0.03	0.13	0.08	0.01	0.01	0.27
2000	0.25	3.11	42.35	25.23	8.73	0.61	1.69	1.48	1.82	1.82	0.40	0.28	0.08	0.25	0.02	0.03	0.11	0.07	0.01	0.24
2001	0.07	2.62	55.26	12.87	8.11	2.77	0.21	0.74	0.77	1.01	1.04	0.23	0.17	0.05	0.15	0.01	0.02	0.06	0.04	0.14
2002	0.06	1.02	41.33	28.89	6.74	4.01	1.38	0.12	0.46	0.50	0.67	0.69	0.16	0.11	0.03	0.10	0.01	0.01	0.04	0.12
2003	0.08	0.63	13.41	19.08	13.85	3.03	1.80	0.70	0.07	0.27	0.30	0.40	0.42	0.09	0.07	0.02	0.06	0.01	0.01	0.10
2004	0.05	1.14	14.49	12.32	18.22	12.35	2.67	1.78	0.77	0.08	0.31	0.35	0.47	0.49	0.11	0.08	0.02	0.07	0.01	0.13
2005	0.03	0.47	17.99	7.96	7.16	9.91	6.71	1.65	1.24	0.56	0.06	0.24	0.26	0.36	0.37	0.08	0.06	0.02	0.05	0.10
2006	0.34	0.25	7.59	9.38	4.48	3.74	5.13	3.95	1.10	0.86	0.40	0.04	0.17	0.19	0.26	0.27	0.06	0.04	0.01	0.11
2007	0.34	4.54	9.53	8.02	10.24	4.58	3.83	6.02	5.26	1.54	1.24	0.58	0.06	0.25	0.28	0.38	0.39	0.09	0.06	0.18
2008	0.09	3.71	115.93	4.59	4.13	5.15	2.47	2.55	4.74	4.44	1.33	1.08	0.51	0.05	0.22	0.24	0.33	0.35	0.08	0.21
2009	0.06	1.28	86.12	65.64	2.81	2.49	3.32	1.91	2.27	4.48	4.28	1.30	1.06	0.50	0.05	0.21	0.24	0.33	0.34	0.28

Table 3.9. Estimated total landings at age in whole weight (1000 lb)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1955	7.38	30.58	63.26	83.16	91.64	83.76	69.92	61.81	58.46	56.32	54.08	51.73	49.30	46.64	43.88	41.09	38.34	35.68	33.13	389.83
1956	5.03	34.83	73.17	95.62	105.10	95.38	78.80	69.14	65.19	62.74	60.23	57.60	54.90	51.94	48.86	45.75	42.69	39.73	36.89	434.08
1957	5.95	25.85	93.52	122.17	134.94	125.26	107.04	96.58	92.37	89.40	85.97	82.26	78.41	74.19	69.79	65.35	60.98	56.74	52.69	620.03
1958	6.55	26.54	57.55	127.70	139.23	126.08	104.61	92.51	88.04	85.29	82.11	78.60	74.93	70.90	66.70	62.46	58.28	54.23	50.35	592.57
1959	7.07	28.74	63.45	81.76	152.14	137.30	113.69	100.97	96.63	94.20	91.12	87.43	83.41	78.94	74.27	69.55	64.90	60.39	56.07	659.85
1960	7.46	30.34	68.11	87.10	94.14	144.94	119.57	106.03	101.99	100.03	97.39	93.90	89.79	85.05	80.03	74.95	69.94	65.08	60.43	711.11
1961	7.64	31.93	72.57	92.10	99.10	89.29	127.18	113.58	109.71	108.40	106.25	103.13	99.09	94.08	88.60	82.99	77.45	72.07	66.92	787.51
1962	7.48	30.83	71.58	90.01	95.76	85.14	69.85	105.91	101.96	100.73	99.32	97.01	93.83	89.51	84.49	79.21	73.94	68.81	63.89	751.87
1963	7.36	29.73	71.22	88.79	93.39	81.61	65.61	57.27	93.93	92.68	91.45	89.87	87.48	84.01	79.68	74.87	69.94	65.11	60.46	711.52
1964	7.75	31.88	78.25	97.29	101.77	88.48	70.82	61.65	58.97	99.71	98.45	96.88	94.91	91.72	87.57	82.69	77.42	72.13	66.99	788.50
1965	8.75	36.41	90.84	112.58	117.63	102.03	81.54	70.76	67.49	66.53	112.56	110.84	108.72	105.74	101.61	96.58	90.87	84.85	78.87	928.59
1966	10.12	42.09	105.79	129.76	135.36	117.58	93.95	81.42	77.38	76.03	74.99	126.51	124.17	120.93	116.94	111.87	105.95	99.41	92.62	1091.67
1967	11.47	48.62	121.13	145.99	151.44	132.70	107.82	94.57	90.28	88.57	87.11	85.70	144.12	140.45	136.00	130.92	124.80	117.87	110.35	1304.97
1968	12.09	51.88	127.71	150.11	153.36	134.27	110.53	98.44	94.74	93.16	91.41	89.66	87.91	146.79	142.23	137.10	131.51	125.01	117.82	1404.31
1969	11.48	47.38	118.56	135.06	133.93	114.09	91.95	81.41	78.72	77.72	76.34	74.67	72.99	71.06	117.96	113.78	109.29	104.55	99.16	1198.49
1970	10.32	43.69	111.38	124.55	120.02	99.83	79.40	70.28	68.66	68.60	67.82	66.45	64.79	62.88	60.87	100.59	96.68	92.60	88.40	1089.11
1971	9.10	39.55	104.34	116.68	110.22	88.83	68.67	59.70	58.11	58.58	58.58	57.76	56.41	54.61	52.70	50.78	83.63	80.15	76.61	966.92
1972	8.35	37.20	102.67	115.83	109.32	86.17	64.33	54.22	51.80	52.03	52.49	52.36	51.46	49.90	48.03	46.14	44.30	72.76	69.58	899.24
1973	8.47	37.38	108.42	123.68	117.65	92.36	67.06	54.39	50.36	49.65	49.92	50.24	49.95	48.74	47.00	45.03	43.11	41.28	67.64	893.97
1974	11.13	43.54	125.80	144.58	140.30	113.23	84.50	68.68	62.27	59.91	59.26	59.47	59.67	58.90	57.15	54.86	52.38	50.00	47.77	1104.74
1975	13.53	57.84	138.29	154.60	151.60	125.53	96.50	79.92	71.81	67.26	64.80	63.93	63.95	63.71	62.53	60.40	57.77	55.01	52.40	1198.55
1976	21.31	59.35	157.95	139.36	132.98	111.18	87.44	74.24	67.69	62.71	58.78	56.47	55.54	55.16	54.63	53.38	51.38	49.01	46.56	1050.87
1977	9.38	110.39	177.52	159.11	120.27	98.67	79.46	69.98	65.97	62.24	57.77	54.01	51.73	50.51	49.88	49.18	47.89	45.96	43.75	972.19
1978	7.99	46.14	292.51	162.42	124.74	81.14	64.14	57.68	56.20	54.72	51.68	47.84	44.59	42.40	41.17	40.47	39.76	38.61	36.98	811.09
1979	8.30	35.87	121.09	285.51	135.27	88.43	54.36	47.12	46.41	46.53	45.30	42.65	39.35	36.42	34.43	33.28	32.60	31.94	30.95	674.64
1980	8.94	35.64	96.99	114.93	232.05	94.32	59.24	40.80	39.35	40.15	40.34	39.18	36.78	33.70	31.00	29.18	28.11	27.45	26.84	588.43
1981	12.36	70.17	170.27	154.73	158.55	278.42	108.98	76.02	57.86	57.65	58.90	59.02	57.14	53.26	48.52	44.44	41.68	40.03	39.02	867.81
1982	8.24	35.20	115.57	72.48	57.48	52.38	94.12	44.04	35.55	28.48	28.58	29.18	29.16	28.04	25.99	23.56	21.51	20.12	19.28	433.40
1983	30.04	47.43	101.74	108.13	58.43	40.29	35.84	72.73	37.89	31.67	25.42	25.45	25.90	25.70	24.57	22.67	20.48	18.64	17.40	388.60
1984	33.33	221.18	173.64	151.34	140.13	66.70	44.67	44.03	98.20	52.69	44.05	35.25	35.17	35.55	35.08	33.38	30.69	27.65	25.11	542.74
1985	8.02	251.93	620.71	89.82	69.74	59.39	29.93	24.48	28.22	66.53	36.01	30.09	24.02	23.81	23.92	23.50	22.28	20.43	18.37	374.33
1986	6.52	56.52	488.51	287.49	36.74	25.91	23.13	14.14	13.47	16.39	38.94	21.06	17.55	13.92	13.71	13.72	13.43	12.70	11.62	221.62
1987	22.00	22.59	76.57	275.38	141.38	16.09	11.54	12.10	8.42	8.38	10.24	24.29	13.10	10.85	8.55	8.39	8.36	8.16	7.70	140.35
1988	5.12	205.40	78.54	102.14	320.73	145.81	16.25	12.97	14.95	10.72	10.66	12.98	30.70	16.44	13.53	10.62	10.38	10.32	10.05	180.98
1989	14.03	38.63	516.62	45.28	53.12	157.95	79.18	11.06	10.42	12.71	9.20	9.14	11.11	26.09	13.90	11.38	8.90	8.68	8.61	158.14
1990	8.20	59.47	35.86	123.17	9.76	11.03	37.54	24.02	3.94	3.91	4.80	3.47	3.44	4.15	9.69	5.14	4.20	3.27	3.18	60.69
1991	11.50	56.37	119.75	37.82	110.24	7.44	7.69	26.57	17.46	2.86	2.81	3.44	2.47	2.43	2.92	6.79	3.59	2.92	2.27	44.02
1992	1.86	21.14	248.93	172.30	46.36	119.60	7.81	8.80	32.88	22.09	3.61	3.53	4.30	3.07	3.01	3.59	8.33	4.39	3.56	56.06
1993	0.35	11.00	184.47	43.03	32.80	8.87	27.29	2.39	3.28	13.14	8.93	1.46	1.43	1.73	1.23	1.19	1.42	3.28	1.73	23.30
1994	0.38	7.03	158.26	154.81	35.77	24.16	6.13	19.37	1.75	2.40	9.49	6.42	1.05	1.01	1.22	0.86	0.84	0.99	2.29	17.31
1995	0.09	5.79	83.59	100.68	101.17	21.16	13.98	3.83	12.84	1.17	1.60	6.29	4.24	0.69	0.66	0.79	0.56	0.54	0.64	12.51
1996	0.19	0.87	60.90	58.19	72.43	64.53	12.77	8.83	2.52	8.48	0.77	1.04	4.08	2.73	0.44	0.42	0.50	0.35	0.34	8.25
1997	2.64	14.23	46.45	155.72	157.28	168.41	133.17	26.09	18.35	5.22	17.39	1.56	2.11	8.22	5.46	0.88	0.84	0.99	0.70	16.85
1998	0.67	9.18	100.42	9.72	37.51	34.92	39.11	37.56	8.56	6.34	1.82	6.06	0.54	0.73	2.82	1.87	0.30	0.28	0.34	5.90
1999	2.41	11.16	276.77	120.84	11.88	39.76	34.43	41.33	42.83	9.98	7.38	2.11	6.99	0.62	0.83	3.20	2.11	0.34	0.32	6.96
2000	1.16	15.24	235.87	186.43	87.41	7.68	25.33	25.14	34.07	36.80	8.61	6.35	1.81	5.96	0.53	0.70	2.69	1.77	0.28	6.04
2001	0.35	12.84	307.83	95.09	81.20	34.99	3.19	12.57	14.38	20.45	22.23	5.19	3.82	1.08	3.54	0.31	0.41	1.58	1.04	3.68
2002	0.30	4.99	230.19	213.48	67.49	50.59	20.67	2.03	8.62	10.05	14.24	15.42	3.59	2.62	0.74	2.40	0.21	0.28	1.06	3.16
2003	0.38	3.11	74.72	141.00	138.62	38.19	26.93	11.88	1.26	5.46	6.35	8.96	9.67	2.23	1.62	0.45	1.48	0.13	0.17	2.56
2004	0.24	5.57	80.70	91.02	182.41	155.75	40.00	30.26	14.39	1.56	6.73	7.79	10.96	11.74	2.70	1.95	0.54	1.76	0.15	3.23
2005	0.13	2.29	100.19	58.84	71.72	125.06	100.36	28.08	23.16	11.30	1.22	5.27	6.07	8.49	9.03	2.07	1.49	0.41	1.34	2.55
2006	1.62	1.23	42.26	69.35	44.81	47.20	76.80	67.11	20.54	17.43	8.50	0.92	3.94	4.51	6.26	6.63	1.51	1.09	0.30	2.82
2007	1.61	22.28	53.11	59.30	102.57	57.73	57.33	102.45	98.65	31.17	26.48	12.88	1.39	5.90	6.72	9.29	9.81	2.23	1.60	4.56
2008	0.44	18.19	645.75	33.92	41.39	64.97	37.02	43.32	88.80	89.66	28.51	24.19	11.73	1.25	5.31	6.02	8.29	8.73	1.98	5.43
2009	0.27	6.27	479.73	485.06	28.14	31.40	49.71	32.54	42.57	90.36	91.40	28.99	24.52	11.81	1.25	5.29	5.97	8.21	8.63	7.28

Table 3.10. Estimated time series of landings in numbers (1000 fish) for commercial lines (L.cl), commercial combined (L.cd), for-hire (L.hb), and private recreational (L.pvt)

Year	L.cl	L.cd	L.hb	L.pvt	Total
1955	29.95	0.00	68.34	13.76	112.05
1956	28.94	0.00	74.85	18.07	121.86
1957	50.16	0.00	81.38	22.66	154.20
1958	34.58	0.00	84.54	26.59	145.71
1959	36.31	0.00	85.67	30.12	152.11
1960	36.53	0.00	85.56	33.29	155.37
1961	42.71	0.00	83.61	35.69	162.00
1962	35.17	0.00	79.52	37.21	151.90
1963	26.73	0.00	76.60	39.57	142.90
1964	29.62	0.00	78.85	44.93	153.41
1965	34.82	0.00	86.63	53.67	175.12
1966	39.30	0.00	97.00	64.12	200.42
1967	51.33	0.00	104.99	72.99	229.31
1968	57.23	0.00	104.90	76.22	238.35
1969	37.79	0.00	95.70	72.80	206.30
1970	34.99	0.00	83.02	66.82	184.84
1971	30.12	0.00	71.85	62.16	164.13
1972	26.37	0.00	65.59	61.82	153.78
1973	22.09	0.00	65.97	67.65	155.71
1974	36.55	0.00	71.73	78.64	186.93
1975	44.37	0.00	77.39	89.30	211.05
1976	38.95	0.00	78.86	95.09	212.90
1977	45.85	0.00	75.90	95.31	217.06
1978	40.67	0.00	68.69	89.94	199.30
1979	27.17	0.00	58.58	80.57	166.33
1980	25.12	0.00	47.79	70.10	143.00
1981	25.05	0.00	69.61	122.19	216.85
1982	21.19	0.00	37.77	53.07	112.03
1983	24.42	0.00	59.31	43.99	127.72
1984	30.00	0.13	60.08	162.25	252.45
1985	34.43	0.35	97.04	178.65	310.48
1986	24.85	0.07	99.10	78.28	202.30
1987	19.91	0.00	40.29	51.32	111.52
1988	24.51	0.00	62.54	98.49	185.54
1989	32.42	0.00	44.46	107.51	184.40
1990	30.55	0.23	26.68	11.10	68.55
1991	21.31	0.78	30.64	31.40	84.13
1992	9.08	1.21	45.73	38.44	94.46
1993	23.30	0.81	14.94	10.86	49.91
1994	21.91	1.80	22.59	13.57	59.87
1995	18.65	1.24	22.42	2.39	44.70
1996	13.29	0.70	8.68	11.41	34.08
1997	8.75	0.75	62.89	3.54	75.94
1998	7.71	0.94	18.10	7.58	34.34
1999	8.78	1.33	49.25	22.64	81.99
2000	10.24	1.38	19.49	57.46	88.57
2001	21.75	2.57	21.87	40.16	86.35
2002	19.56	2.95	30.09	33.84	86.44
2003	12.36	2.04	23.89	16.11	54.39
2004	13.73	2.04	24.77	25.37	65.90
2005	10.08	0.94	23.09	21.16	55.27
2006	6.15	0.40	17.29	14.54	38.37
2007	8.06	0.74	17.32	31.31	57.43
2008	25.40	0.86	41.72	84.24	152.22
2009	35.20	1.05	50.14	92.57	178.97

Table 3.11. Estimated time series of landings in whole weight (1000 lb) for commercial lines (L.cl), commercial other (L.cd), for-hire (L.hb), and private recreational (L.pvt)

Year	L.cl	L.cd	L.hb	L.pvt	Total
1955	497.92	0.00	703.84	188.24	1390.00
1956	484.42	0.00	824.35	248.89	1557.66
1957	869.31	0.00	952.27	317.92	2139.50
1958	617.52	0.00	1032.46	395.25	2045.22
1959	662.96	0.00	1073.06	465.85	2201.87
1960	677.39	0.00	1082.99	526.99	2287.38
1961	800.22	0.00	1058.43	570.93	2429.59
1962	662.89	0.00	1001.28	596.96	2261.12
1963	505.03	0.00	957.22	633.77	2096.01
1964	559.74	0.00	976.81	717.28	2253.84
1965	657.16	0.00	1063.03	853.59	2573.78
1966	740.55	0.00	1177.49	1016.48	2934.52
1967	964.60	0.00	1256.95	1153.34	3374.89
1968	1070.51	0.00	1231.92	1197.62	3500.05
1969	701.03	0.00	1095.58	1131.97	2928.58
1970	641.40	0.00	923.86	1021.66	2586.93
1971	543.81	0.00	777.41	930.71	2251.93
1972	468.90	0.00	693.13	906.15	2068.18
1973	387.56	0.00	684.07	974.66	2046.29
1974	633.14	0.00	706.54	1118.46	2458.14
1975	746.32	0.00	706.34	1247.28	2699.93
1976	619.61	0.00	573.93	1252.47	2446.00
1977	649.73	0.00	571.33	1154.81	2375.86
1978	590.31	0.00	564.67	987.29	2142.26
1979	410.17	0.00	502.53	957.76	1870.46
1980	380.83	0.00	389.89	872.70	1643.42
1981	371.67	0.00	548.41	1534.75	2454.84
1982	306.45	0.00	268.07	627.82	1202.34
1983	310.67	0.00	381.76	466.58	1159.02
1984	248.37	1.32	260.55	1360.31	1870.56
1985	241.02	2.55	430.42	1171.53	1845.52
1986	215.76	0.51	592.84	537.97	1347.08
1987	187.17	0.03	226.51	420.71	834.43
1988	163.97	0.01	284.61	770.69	1219.28
1989	258.29	0.01	235.14	710.72	1204.15
1990	214.96	1.86	122.02	80.10	418.93
1991	133.98	5.90	128.81	202.68	471.37
1992	89.03	9.61	363.59	313.00	775.24
1993	189.81	5.61	102.03	74.86	372.31
1994	179.57	13.12	161.33	97.50	451.52
1995	166.70	10.04	177.09	18.98	372.80
1996	130.61	6.15	74.12	97.78	308.66
1997	101.24	7.53	637.11	36.67	782.55
1998	80.02	8.06	151.57	64.99	304.64
1999	80.52	9.97	362.88	168.86	622.24
2000	92.13	10.38	146.29	441.08	689.87
2001	175.32	18.24	151.48	280.75	625.78
2002	163.11	22.10	219.31	247.60	652.12
2003	118.79	17.45	202.00	136.94	475.19
2004	149.73	19.65	236.07	244.04	649.48
2005	117.99	9.34	224.78	206.96	559.07
2006	80.29	4.16	183.87	156.50	424.82
2007	104.72	7.51	187.91	366.92	667.06
2008	240.48	6.30	301.94	616.19	1164.92
2009	340.89	8.01	382.32	708.17	1439.40

Table 3.12. Estimated time series of dead discards in numbers (1000 fish) for commercial lines (D.cl), for-hire (D.hb), and private recreational (D.pvt)

Year	D.cl	D.hb	D.pvt	Total
1983	0.00	17.33	3.38	20.72
1984	0.00	49.82	8.91	58.72
1985	0.00	11.39	24.75	36.14
1986	0.00	0.06	3.38	3.45
1987	0.00	0.06	41.51	41.58
1988	0.00	0.06	18.85	18.91
1989	0.00	0.06	7.81	7.88
1990	0.00	0.06	3.38	3.45
1991	0.00	0.29	13.98	14.27
1992	6.83	7.35	7.60	21.78
1993	7.16	13.68	19.08	39.92
1994	9.90	3.02	24.35	37.27
1995	9.32	9.98	14.78	34.08
1996	11.92	2.07	6.87	20.86
1997	13.16	7.80	3.38	24.35
1998	10.12	3.63	8.95	22.70
1999	9.30	19.49	51.56	80.35
2000	9.10	13.33	86.74	109.17
2001	9.12	13.46	69.61	92.19
2002	20.30	10.61	41.18	72.08
2003	6.70	8.89	54.17	69.77
2004	2.48	15.35	63.71	81.54
2005	2.40	20.26	31.07	53.73
2006	3.56	9.51	45.04	58.11
2007	7.08	48.40	131.63	187.11
2008	7.44	24.51	136.62	168.58
2009	9.79	14.40	71.59	95.77

Table 3.13. Estimated time series of dead discards in whole weight (1000 lb) for commercial lines (D.cl), for-hire (D.hb), and private recreational (D.pvt)

Year	D.cl	D.hb	D.pvt	Total
1983	0.00	9.13	1.78	10.92
1984	0.00	28.80	5.15	33.95
1985	0.00	7.08	15.39	22.46
1986	0.00	0.04	2.01	2.04
1987	0.00	0.03	21.29	21.33
1988	0.00	0.04	11.78	11.82
1989	0.00	0.04	4.24	4.28
1990	0.00	0.04	1.96	1.99
1991	0.00	0.16	7.91	8.07
1992	16.99	13.42	13.88	44.29
1993	20.26	28.34	39.53	88.12
1994	28.43	6.11	49.31	83.85
1995	26.67	23.00	34.05	83.72
1996	35.55	3.49	11.56	50.60
1997	28.43	11.81	5.12	45.37
1998	25.95	6.71	16.56	49.22
1999	24.69	31.43	83.17	139.30
2000	22.52	24.02	156.32	202.87
2001	25.81	29.15	150.80	205.76
2002	61.00	23.25	90.28	174.53
2003	18.51	15.79	96.22	130.53
2004	6.58	30.99	128.66	166.23
2005	7.12	44.70	68.56	120.38
2006	7.34	9.14	43.31	59.80
2007	15.24	85.09	231.43	331.76
2008	21.44	55.76	310.78	387.97
2009	30.33	34.88	173.44	238.65

Table 3.14. Estimated status indicators, benchmarks, and related quantities from the Beaufort catch-age model, conditional on estimated current selectivities averaged across fisheries. Precision is represented by standard errors (SE) approximated from Monte Carlo/Bootstrap analysis. Estimates of yield do not include discards; D_{MSY} represents discard mortalities expected when fishing at F_{MSY}. Rate estimates (F) are in units of y^{-1}; status indicators are dimensionless; and biomass estimates are in units of metric tons or pounds, as indicated. Spawning stock biomass (SSB) is measured by total gonad weight of mature females. Symbols, abbreviations, and acronyms are listed in Appendix A.

Quantity	Units	Estimate	SE
F_{MSY}	y^{-1}	0.178	0.029
$85\%F_{MSY}$	y^{-1}	0.151	0.025
$75\%F_{MSY}$	y^{-1}	0.133	0.022
$65\%F_{MSY}$	y^{-1}	0.115	0.019
$F_{30\%}$	y^{-1}	0.170	0.024
$F_{40\%}$	y^{-1}	0.125	0.019
$F_{50\%}$	y^{-1}	0.092	0.014
B_{MSY}	mt	13632	4768
SSB_{MSY}	mt	156	65
MSST	mt	144	61
MSY	1000 lb	1842	311
D_{MSY}	1000 fish	67	17
R_{MSY}	1000 age-1 fish	584	157
Y at $85\%F_{MSY}$	1000 lb	1821	301
Y at $75\%F_{MSY}$	1000 lb	1780	299
Y at $65\%F_{MSY}$	1000 lb	1712	287
$F_{2007-2009}/F_{MSY}$	—	4.12	0.54
SSB_{2009}/MSST	—	0.09	0.03

Table 3.15. Results from sensitivity runs of the Beaufort catch-age model. Current F represented by geometric mean of last three assessment years. Spawning biomass was based on total gonad weight of mature females, with the exception of S16 (*) which used body weight of mature females. See text for full description of sensitivity runs.

Run	Description	F_{MSY}	SSB_{MSY} (mt)	B_{MSY} (mt)	MSY(1000 lb)	$F_{2007-2009}/F_{MSY}$	SSB_{2009}/MSST	steep	R0(1000)
Base	—	0.178	156	13632	1842	4.12	0.09	0.85	535
S1	low M	0.154	239	18242	1726	5.05	0.08	0.85	330
S2	high M	0.209	81	8620	1620	3.33	0.12	0.85	734
S3	M1=0.6	0.175	164	14142	1865	4.18	0.09	0.85	690
S4	low disc M	0.176	145	12808	1888	4.06	0.08	0.85	514
S5	high disc M	0.18	167	14440	1798	4.16	0.09	0.85	555
S6	h=0.75	0.163	203	17104	1838	4.23	0.1	0.75	609
S7	h=0.95	0.197	96	8894	1598	4.17	0.07	0.95	395
S8	h est	0.207	66	6298	1274	4.14	0.09	0.98	296
S9	Rsigma=0.4	0.171	153	13273	1720	3.97	0.1	0.85	571
S10	Rsigma=0.8	0.184	162	14255	2016	4.19	0.07	0.85	491
S11	q const	0.176	157	13662	1814	3.64	0.11	0.85	535
S12	q 0.04	0.179	156	13628	1863	4.45	0.08	0.85	535
S13	rand walk q	0.178	157	13636	1792	3.68	0.11	0.85	532
S14	age error	0.181	155	13564	1822	4.14	0.09	0.85	530
S15	continuity 1	0.083	160	14599	2331	5.71	0.07	0.85	557
S16	continuity 2	0.092	5415*	12460	2163	5.58	0.1	0.85	497
S17	styr 1976	0.168	189	16596	2297	4.06	0.07	0.85	659
S18	styr 1986	0.14	190	16844	2416	3.72	0.08	0.85	671
S19	Finit 0.01	0.179	151	13235	1785	4.13	0.09	0.85	518
S20	Finit 0.04	0.176	164	14374	1948	4.09	0.08	0.85	565
S21	low recr LD	0.183	86	7555	1023	4.67	0.11	0.85	293
S22	high recr LD	0.177	223	19477	2630	3.81	0.08	0.85	768
S23	low comm LD	0.178	145	12659	1711	4.2	0.09	0.85	497
S24	high comm LD	0.177	168	14661	1980	4.04	0.09	0.85	574
S25	U.hb 0.5	0.175	152	13338	1821	4.82	0.07	0.85	527
S26	U.hb 2	0.191	164	14285	1899	3.14	0.12	0.85	549
S27	U.cl 0.5	0.182	158	13783	1807	3.7	0.11	0.85	535
S28	U.cl 2	0.168	153	13471	1920	4.56	0.07	0.85	538
S29	age 0.5	0.178	154	13460	1816	4.01	0.09	0.85	528
S30	age 2	0.178	159	13914	1881	4.26	0.08	0.85	545
S31	len 0.5	0.177	150	13099	1758	3.84	0.1	0.85	512
S32	len 2	0.18	162	14132	1924	4.44	0.08	0.85	555
S33	comm 1.0 recr 0.1	0.191	148	13020	1791	4	0.08	0.85	521
S34	comm 1.0 recr 0.5	0.15	160	14198	2015	4.4	0.08	0.85	548
S35	comm 0.75 recr 0.1	0.206	144	12539	1681	3.73	0.1	0.85	502
S36	comm 0.75 recr 0.3	0.19	152	13272	1754	3.89	0.1	0.85	516
S37	comm 0.75 recr 0.5	0.156	156	13815	1932	4.18	0.09	0.85	530
S38	comm 0.5 recr 0.1	0.234	137	11792	1513	3.37	0.12	0.85	475
S39	comm 0.5 recr 0.3	0.201	147	12758	1655	3.63	0.12	0.85	494
S40	comm 0.5 recr 0.5	0.162	151	13276	1830	3.92	0.11	0.85	508
S41	extreme 1	0.305	63	6573	1246	2.23	0.23	0.85	603
S42	extreme 2	0.129	254	19515	1854	5.92	0.08	0.85	345

Table 3.16. Projection results under scenario 2—fishing mortality rate fixed at $F = F_{current}$. F = fishing mortality rate (per year), Pr(SSB > SSB_{MSY}) = proportion of stochastic projection replicates exceeding SSB_{MSY}, SSB = mid-year spawning stock (mt), R = recruits (1000 age-1 fish), D = discard mortalities (1000 fish or 1000 lb whole weight), L = landings (1000 fish or 1000 lb whole weight), and Sum L = cumulative landings (1000 lb). For reference, estimated benchmarks are F_{MSY} = 0.178 (per yr), SSB_{MSY} = 156 (mt), and MSY = 1842 (1000 lb). Expected values presented are from deterministic projections (klb = 1000 lb).

Year	F(per yr)	Pr(SSB > SSB_{MSY})	SSB(mt)	R(1000)	D(1000)	D(klb)	L(1000)	L(klb)	Sum L(klb)
2010	0.416	0	11.49	235	62	306	0	0	0
2011	0.727	0	13.76	223	79	137	75	837	837
2012	0.727	0	10.72	251	85	153	71	726	1563
2013	0.727	0	9.6	213	85	159	66	641	2204
2014	0.727	0	8.65	197	77	146	67	615	2820
2015	0.727	0	7.79	183	70	132	62	569	3389
2016	0.727	0	7.01	169	65	122	57	524	3913
2017	0.727	0	6.31	156	60	113	53	481	4393
2018	0.727	0	5.7	144	56	105	49	440	4834
2019	0.727	0	5.16	133	51	97	45	404	5238
2020	0.727	0	4.69	123	47	89	42	371	5608
2021	0.727	0	4.27	113	44	82	38	340	5949
2022	0.727	0	3.89	105	40	76	35	313	6261
2023	0.727	0	3.56	97	37	70	32	288	6549
2024	0.727	0	3.26	90	34	65	30	265	6814
2025	0.727	0	2.99	83	32	60	28	244	7059
2026	0.727	0	2.75	77	30	56	26	226	7284
2027	0.727	0	2.53	71	27	52	24	208	7492
2028	0.727	0	2.33	66	25	48	22	193	7685
2029	0.727	0	2.15	62	24	44	20	178	7863
2030	0.727	0	1.98	57	22	41	19	165	8028
2031	0.727	0	1.83	53	20	38	17	153	8181
2032	0.727	0	1.69	49	19	36	16	142	8322
2033	0.727	0	1.56	46	18	33	15	131	8454
2034	0.727	0	1.45	43	16	31	14	122	8575
2035	0.727	0	1.34	40	15	29	13	113	8688
2036	0.727	0	1.24	37	14	27	12	105	8793
2037	0.727	0	1.15	34	13	25	11	97	8891
2038	0.727	0	1.07	32	12	23	10	90	8981
2039	0.727	0	0.99	30	11	21	10	84	9065
2040	0.727	0	0.92	28	11	20	9	78	9143
2041	0.727	0	0.85	26	10	19	8	73	9216
2042	0.727	0	0.79	24	9	17	8	68	9284
2043	0.727	0	0.74	22	9	16	7	63	9347
2044	0.727	0	0.69	21	8	15	7	59	9405
2045	0.727	0	0.64	19	7	14	6	54	9460
2046	0.727	0	0.59	18	7	13	6	51	9510
2047	0.727	0	0.55	17	6	12	5	47	9558
2048	0.727	0	0.51	16	6	11	5	44	9601
2049	0.727	0	0.48	15	6	10	5	41	9642
2050	0.727	0	0.44	14	5	10	4	38	9681

*Table 3.17. Projection results under scenario 3—fishing mortality rate fixed at $F = 65\% F_{MSY}$. F = fishing mortality rate (per year), Pr(*SSB > SSB_{MSY}*) = proportion of stochastic projection replicates exceeding* SSB_{MSY}*, SSB = mid-year spawning stock (mt), R = recruits (1000 age-1 fish), D = discard mortalities (1000 fish or 1000* lb *whole weight), L = landings (1000 fish or 1000* lb *whole weight), and Sum L = cumulative landings (1000* lb*). For reference, estimated benchmarks are F_{MSY} = 0.178 (per yr),* SSB_{MSY} = 156 *(mt), and* MSY = 1842 *(1000 lb). Expected values presented are from deterministic projections (klb = 1000 lb).*

Year	F(per yr)	Pr(SSB > SSB_{MSY})	SSB(mt)	R(1000)	D(1000)	D(klb)	L(1000)	L(klb)	Sum L(klb)
2010	0.416	0	11.49	235	62	306	0	0	0
2011	0.115	0	13.76	223	14	25	14	156	156
2012	0.115	0	16.21	251	18	35	20	190	346
2013	0.115	0	18.93	277	19	38	25	227	573
2014	0.115	0	22.25	302	22	43	30	275	847
2015	0.115	0	26.17	329	24	47	35	325	1172
2016	0.115	0	30.66	356	26	51	39	374	1547
2017	0.115	0	35.73	383	28	55	44	425	1972
2018	0.115	0	41.38	407	30	59	48	477	2449
2019	0.115	0	47.52	430	32	63	53	532	2981
2020	0.115	0	54.08	451	33	67	58	588	3569
2021	0.115	0	61.04	470	35	70	62	645	4213
2022	0.115	0	68.32	486	36	73	67	702	4915
2023	0.115	0	75.86	501	38	76	71	759	5674
2024	0.115	0	83.59	514	39	78	75	815	6489
2025	0.115	0.01	91.43	525	40	81	79	869	7358
2026	0.115	0.02	99.3	535	41	82	83	922	8279
2027	0.115	0.04	107.13	544	41	84	86	972	9252
2028	0.115	0.07	114.88	551	42	85	89	1021	10,273
2029	0.115	0.11	122.5	558	43	87	92	1068	11,341
2030	0.115	0.17	129.92	564	43	88	94	1112	12,453
2031	0.115	0.25	137.11	569	44	89	97	1154	13,607
2032	0.115	0.34	144.04	574	44	90	99	1194	14,801
2033	0.115	0.43	150.69	578	44	90	101	1231	16,032
2034	0.115	0.52	157.03	581	45	91	103	1266	17,298
2035	0.115	0.61	163.06	584	45	92	105	1299	18,597
2036	0.115	0.69	168.78	587	45	92	107	1330	19,928
2037	0.115	0.75	174.17	589	45	93	108	1359	21,287
2038	0.115	0.8	179.25	592	46	93	110	1386	22,673
2039	0.115	0.85	184.02	594	46	93	111	1411	24,083
2040	0.115	0.89	188.48	595	46	94	112	1434	25,518
2041	0.115	0.92	192.66	597	46	94	113	1456	26,973
2042	0.115	0.94	196.55	598	46	94	114	1476	28,449
2043	0.115	0.95	200.18	600	46	94	115	1494	29,944
2044	0.115	0.96	203.55	601	46	95	116	1512	31,455
2045	0.115	0.97	206.68	602	47	95	117	1527	32,983
2046	0.115	0.98	209.58	603	47	95	117	1542	34,525
2047	0.115	0.98	212.28	604	47	95	118	1556	36,080
2048	0.115	0.99	214.77	604	47	95	119	1568	37,649
2049	0.115	0.99	217.07	605	47	95	119	1580	39,228
2050	0.115	0.99	219.2	606	47	96	120	1590	40,819

Table 3.18. Projection results under scenario 4—fishing mortality rate fixed at $F = 75\%F_{MSY}$. F = fishing mortality rate (per year), Pr(SSB > SSB_{MSY}) = proportion of stochastic projection replicates exceeding SSB_{MSY}, SSB = mid-year spawning stock (mt), R = recruits (1000 age-1 fish), D = discard mortalities (1000 fish or 1000 lb whole weight), L = landings (1000 fish or 1000 lb whole weight), and Sum L = cumulative landings (1000 lb). For reference, estimated benchmarks are F_{MSY} = 0.178 (per yr), SSB_{MSY} = 156 (mt), and MSY = 1842 (1000 lb). Expected values presented are from deterministic projections (klb = 1000 lb).

Year	F(per yr)	Pr(SSB > SSB_{MSY})	SSB(mt)	R(1000)	D(1000)	D(klb)	L(1000)	L(klb)	Sum L(klb)
2010	0.416	0	11.49	235	62	306	0	0	0
2011	0.133	0	13.76	223	16	29	16	179	179
2012	0.133	0	16.02	251	20	40	23	216	395
2013	0.133	0	18.54	275	22	44	28	256	650
2014	0.133	0	21.61	299	24	48	33	307	957
2015	0.133	0	25.21	324	27	53	38	361	1318
2016	0.133	0	29.3	350	29	57	43	413	1731
2017	0.133	0	33.89	375	31	62	48	465	2196
2018	0.133	0	38.97	399	33	66	53	520	2717
2019	0.133	0	44.46	421	35	71	58	577	3294
2020	0.133	0	50.31	441	37	75	63	635	3929
2021	0.133	0	56.48	460	39	78	68	694	4623
2022	0.133	0	62.92	476	41	82	72	753	5376
2023	0.133	0	69.56	490	42	85	77	812	6188
2024	0.133	0	76.34	503	43	87	81	869	7057
2025	0.133	0	83.21	515	45	90	85	925	7983
2026	0.133	0.01	90.09	525	46	92	89	980	8962
2027	0.133	0.01	96.93	534	46	94	92	1032	9995
2028	0.133	0.02	103.68	541	47	96	96	1082	11,077
2029	0.133	0.04	110.31	548	48	97	99	1130	12,207
2030	0.133	0.07	116.77	554	49	98	101	1175	13,382
2031	0.133	0.1	123.01	560	49	99	104	1219	14,601
2032	0.133	0.15	129.02	564	50	100	106	1259	15,860
2033	0.133	0.21	134.78	568	50	101	109	1297	17,157
2034	0.133	0.27	140.28	572	50	102	111	1333	18,491
2035	0.133	0.34	145.5	575	51	103	113	1367	19,858
2036	0.133	0.41	150.44	578	51	103	114	1398	21,256
2037	0.133	0.48	155.1	581	51	104	116	1428	22,684
2038	0.133	0.55	159.48	583	51	104	117	1455	24,139
2039	0.133	0.6	163.59	585	52	105	119	1481	25,620
2040	0.133	0.66	167.44	587	52	105	120	1504	27,124
2041	0.133	0.71	171.03	589	52	106	121	1526	28,650
2042	0.133	0.76	174.38	590	52	106	122	1546	30,196
2043	0.133	0.79	177.49	592	52	106	123	1565	31,761
2044	0.133	0.82	180.38	593	52	106	124	1582	33,344
2045	0.133	0.85	183.07	594	52	107	125	1598	34,942
2046	0.133	0.87	185.55	595	53	107	125	1613	36,555
2047	0.133	0.89	187.85	596	53	107	126	1627	38,182
2048	0.133	0.91	189.98	597	53	107	127	1639	39,821
2049	0.133	0.92	191.94	597	53	107	127	1651	41,472
2050	0.133	0.93	193.75	598	53	107	128	1661	43,133

Table 3.19. Projection results under scenario 5—fishing mortality rate fixed at $F = 85\%F_{MSY}$. F = fishing mortality rate (per year), Pr(SSB > SSB_{MSY}) = proportion of stochastic projection replicates exceeding SSB_{MSY}, SSB = mid-year spawning stock (mt), R = recruits (1000 age-1 fish), D = discard mortalities (1000 fish or 1000 lb whole weight), L = landings (1000 fish or 1000 lb whole weight), and Sum L = cumulative landings (1000 lb). For reference, estimated benchmarks are F_{MSY} = 0.178 (per yr), SSB_{MSY} = 156 (mt), and MSY = 1842 (1000 lb). Expected values presented are from deterministic projections (klb = 1000 lb).

Year	F(per yr)	Pr(SSB > SSB_{MSY})	SSB(mt)	R(1000)	D(1000)	D(klb)	L(1000)	L(klb)	Sum L(klb)
2010	0.416	0	11.49	235	62	306	0	0	0
2011	0.151	0	13.76	223	19	33	19	201	201
2012	0.151	0	15.82	251	23	45	25	241	443
2013	0.151	0	18.17	273	25	49	31	283	726
2014	0.151	0	21	295	27	54	37	337	1063
2015	0.151	0	24.29	320	30	58	42	393	1456
2016	0.151	0	28	344	32	63	47	447	1903
2017	0.151	0	32.15	368	34	68	52	501	2404
2018	0.151	0	36.7	390	37	73	57	557	2961
2019	0.151	0	41.61	412	39	77	62	615	3576
2020	0.151	0	46.81	431	41	82	67	674	4250
2021	0.151	0	52.26	449	43	86	72	734	4984
2022	0.151	0	57.94	465	45	89	77	794	5777
2023	0.151	0	63.77	479	46	93	81	853	6630
2024	0.151	0	69.72	492	48	96	86	911	7541
2025	0.151	0	75.72	504	49	98	90	968	8509
2026	0.151	0	81.72	514	50	101	94	1023	9532
2027	0.151	0	87.67	523	51	103	97	1075	10,607
2028	0.151	0.01	93.55	531	52	105	101	1126	11,734
2029	0.151	0.01	99.31	538	53	106	104	1174	12,908
2030	0.151	0.02	104.9	544	53	108	107	1220	14,128
2031	0.151	0.03	110.32	549	54	109	110	1263	15,391
2032	0.151	0.05	115.52	554	55	110	112	1304	16,695
2033	0.151	0.08	120.51	559	55	111	114	1343	18,038
2034	0.151	0.11	125.26	562	55	112	116	1379	19,417
2035	0.151	0.14	129.77	566	56	113	118	1412	20,829
2036	0.151	0.18	134.04	569	56	114	120	1444	22,273
2037	0.151	0.22	138.07	572	56	114	122	1473	23,747
2038	0.151	0.27	141.85	574	57	115	123	1501	25,247
2039	0.151	0.32	145.4	576	57	115	125	1526	26,773
2040	0.151	0.36	148.71	578	57	116	126	1550	28,323
2041	0.151	0.41	151.81	580	57	116	127	1572	29,895
2042	0.151	0.46	154.69	582	58	117	128	1592	31,486
2043	0.151	0.5	157.37	583	58	117	129	1610	33,097
2044	0.151	0.54	159.86	584	58	117	130	1628	34,725
2045	0.151	0.58	162.16	585	58	118	131	1644	36,368
2046	0.151	0.61	164.29	587	58	118	132	1658	38,026
2047	0.151	0.64	166.26	587	58	118	132	1672	39,698
2048	0.151	0.67	168.08	588	58	118	133	1684	41,382
2049	0.151	0.69	169.76	589	58	118	134	1695	43,077
2050	0.151	0.71	171.31	590	58	119	134	1706	44,783

*Table 3.20. Projection results under scenario 6—fishing mortality rate fixed at $F = F_{MSY}$. F = fishing mortality rate (per year), Pr(*SSB > SSB_{MSY}*) = proportion of stochastic projection replicates exceeding* SSB_{MSY}*, SSB = mid-year spawning stock (mt), R = recruits (1000 age-1 fish), D = discard mortalities (1000 fish or 1000* lb *whole weight), L = landings (1000 fish or 1000* lb *whole weight), and Sum L = cumulative landings (1000* lb*). For reference, estimated benchmarks are F_{MSY} =* 0.178 *(per yr),* SSB_{MSY} = 156 *(mt), and* MSY = 1842 *(1000 lb). Expected values presented are from deterministic projections (klb = 1000 lb).*

Year	F(per yr)	Pr(SSB > SSB_{MSY})	SSB(mt)	R(1000)	D(1000)	D(klb)	L(1000)	L(klb)	Sum L(klb)
2010	0.416	0	11.49	235	62	306	0	0	0
2011	0.178	0	13.76	223	22	39	22	235	235
2012	0.178	0	15.53	251	26	52	29	278	513
2013	0.178	0	17.62	270	29	56	35	321	834
2014	0.178	0	20.11	290	31	62	41	378	1212
2015	0.178	0	22.98	312	34	66	47	436	1648
2016	0.178	0	26.17	335	36	71	52	491	2139
2017	0.178	0	29.71	356	39	76	57	546	2685
2018	0.178	0	33.56	377	41	81	62	602	3287
2019	0.178	0	37.68	397	44	86	67	660	3947
2020	0.178	0	42.01	416	46	91	72	718	4665
2021	0.178	0	46.52	433	48	95	77	778	5443
2022	0.178	0	51.19	448	50	99	82	837	6280
2023	0.178	0	55.97	462	52	103	86	895	7175
2024	0.178	0	60.82	475	53	106	91	953	8128
2025	0.178	0	65.7	486	55	109	95	1009	9137
2026	0.178	0	70.56	496	56	112	99	1063	10,199
2027	0.178	0	75.37	505	57	115	103	1115	11,314
2028	0.178	0	80.11	513	58	117	106	1164	12,478
2029	0.178	0	84.75	520	59	119	110	1212	13,690
2030	0.178	0	89.26	527	60	120	113	1257	14,947
2031	0.178	0	93.61	533	61	122	115	1299	16,247
2032	0.178	0.01	97.79	538	61	123	118	1340	17,586
2033	0.178	0.01	101.79	542	62	125	120	1377	18,963
2034	0.178	0.02	105.61	546	62	126	122	1413	20,376
2035	0.178	0.02	109.23	550	63	127	124	1446	21,822
2036	0.178	0.03	112.65	553	63	128	126	1477	23,299
2037	0.178	0.04	115.87	556	64	128	128	1505	24,804
2038	0.178	0.05	118.9	559	64	129	129	1532	26,336
2039	0.178	0.06	121.74	561	64	130	131	1557	27,893
2040	0.178	0.08	124.4	563	65	130	132	1580	29,473
2041	0.178	0.09	126.88	565	65	131	133	1601	31,075
2042	0.178	0.11	129.18	567	65	131	134	1621	32,696
2043	0.178	0.13	131.32	569	65	132	135	1639	34,335
2044	0.178	0.14	133.31	570	65	132	136	1656	35,991
2045	0.178	0.16	135.15	571	66	132	137	1672	37,663
2046	0.178	0.18	136.85	572	66	133	138	1686	39,349
2047	0.178	0.2	138.43	573	66	133	139	1699	41,048
2048	0.178	0.21	139.88	574	66	133	139	1711	42,759
2049	0.178	0.23	141.22	575	66	133	140	1722	44,481
2050	0.178	0.25	142.45	576	66	134	141	1732	46,213

Table 3.21. Projection results under scenario 7—fishing mortality rate fixed at $F = F_{\text{current}}$, but all potential landings converted to discards (continued moratorium). F = fishing mortality rate (per year), Pr(SSB > SSB_{MSY}) = proportion of stochastic projection replicates exceeding SSB_{MSY}, SSB = mid-year spawning stock (mt), R = recruits (1000 age-1 fish), D = discard mortalities (1000 fish or 1000 lb whole weight), L = landings (1000 fish or 1000 lb whole weight), and Sum L = cumulative landings (1000 lb). For reference, estimated benchmarks are F_{MSY} = 0.178 (per yr), SSB_{MSY} = 156 (mt), and MSY = 1842 (1000 lb). Expected values presented are from deterministic projections (klb = 1000 lb).

Year	F(per yr)	Pr(SSB > SSB_{MSY})	SSB(mt)	R(1000)	D(1000)	D(klb)	L(1000)	L(klb)	Sum L(klb)
2010	0.416	0	11.49	235	62	306	0	0	0
2011	0.416	0	13.76	223	78	344	0	0	0
2012	0.416	0	15.21	251	91	395	0	0	0
2013	0.416	0	16.81	267	99	427	0	0	0
2014	0.416	0	18.59	283	108	473	0	0	0
2015	0.416	0	20.52	299	116	519	0	0	0
2016	0.416	0	22.57	316	124	563	0	0	0
2017	0.416	0	24.77	332	131	606	0	0	0
2018	0.416	0	27.12	347	139	650	0	0	0
2019	0.416	0	29.57	362	146	693	0	0	0
2020	0.416	0	32.1	377	153	736	0	0	0
2021	0.416	0	34.7	390	160	779	0	0	0
2022	0.416	0	37.35	403	167	821	0	0	0
2023	0.416	0	40.04	414	173	863	0	0	0
2024	0.416	0	42.75	425	179	904	0	0	0
2025	0.416	0	45.47	435	184	943	0	0	0
2026	0.416	0	48.16	445	189	981	0	0	0
2027	0.416	0	50.82	453	194	1018	0	0	0
2028	0.416	0	53.44	461	199	1053	0	0	0
2029	0.416	0	56.01	468	203	1086	0	0	0
2030	0.416	0	58.52	475	207	1118	0	0	0
2031	0.416	0	60.96	481	211	1149	0	0	0
2032	0.416	0	63.31	486	214	1177	0	0	0
2033	0.416	0	65.58	491	217	1205	0	0	0
2034	0.416	0	67.75	496	220	1230	0	0	0
2035	0.416	0	69.84	500	223	1255	0	0	0
2036	0.416	0	71.82	504	225	1277	0	0	0
2037	0.416	0	73.71	507	227	1299	0	0	0
2038	0.416	0	75.5	510	229	1319	0	0	0
2039	0.416	0	77.2	513	231	1337	0	0	0
2040	0.416	0	78.8	516	233	1355	0	0	0
2041	0.416	0	80.31	518	235	1371	0	0	0
2042	0.416	0	81.73	521	236	1386	0	0	0
2043	0.416	0	83.07	523	238	1401	0	0	0
2044	0.416	0	84.32	524	239	1414	0	0	0
2045	0.416	0	85.48	526	240	1426	0	0	0
2046	0.416	0	86.58	528	241	1438	0	0	0
2047	0.416	0	87.6	529	242	1448	0	0	0
2048	0.416	0	88.55	530	243	1458	0	0	0
2049	0.416	0	89.44	532	244	1467	0	0	0
2050	0.416	0	90.26	533	245	1475	0	0	0

Table 3.22. Projection results under scenario 8—fishing mortality rate fixed at $F = F_{\text{rebuild}}$, *with rebuilding probability of 0.5 in 2047. F = fishing mortality rate (per year), Pr(*$\text{SSB} > \text{SSB}_{\text{MSY}}$*) = proportion of stochastic projection replicates exceeding* SSB_{MSY}, *SSB = mid-year spawning stock (mt), R = recruits (1000 age-1 fish), D = discard mortalities (1000 fish or 1000* lb *whole weight), L = landings (1000 fish or 1000* lb *whole weight), and Sum L = cumulative landings (1000* lb*). For reference, estimated benchmarks are* $F_{\text{MSY}} = 0.178$ *(per yr),* $\text{SSB}_{\text{MSY}} = 156$ *(mt), and* MSY = 1842 *(1000 lb). Expected values presented are from deterministic projections (klb = 1000 lb).*

Year	F(per yr)	Pr(SSB > SSB_{MSY})	SSB(mt)	R(1000)	D(1000)	D(klb)	L(1000)	L(klb)	Sum L(klb)
2010	0.416	0	11.49	235	62	306	0	0	0
2011	0.158	0	13.76	223	19	34	19	211	211
2012	0.158	0	15.74	251	24	46	26	251	462
2013	0.158	0	18.02	272	26	51	32	293	755
2014	0.158	0	20.76	294	28	56	38	348	1103
2015	0.158	0	23.93	318	31	60	43	405	1509
2016	0.158	0	27.5	341	33	65	48	460	1968
2017	0.158	0	31.47	365	35	70	53	514	2482
2018	0.158	0	35.83	387	38	75	58	570	3053
2019	0.158	0	40.52	408	40	80	63	628	3681
2020	0.158	0	45.47	427	42	84	68	687	4368
2021	0.158	0	50.66	445	44	88	73	747	5116
2022	0.158	0	56.05	461	46	92	78	807	5923
2023	0.158	0	61.58	475	48	96	83	866	6789
2024	0.158	0	67.22	488	49	99	87	925	7714
2025	0.158	0	72.9	499	51	101	91	981	8695
2026	0.158	0	78.58	509	52	104	95	1036	9731
2027	0.158	0	84.2	518	53	106	99	1089	10,820
2028	0.158	0	89.75	526	54	108	103	1139	11,960
2029	0.158	0.01	95.19	533	55	110	106	1187	13,147
2030	0.158	0.01	100.48	539	55	111	109	1233	14,380
2031	0.158	0.02	105.58	545	56	113	111	1276	15,657
2032	0.158	0.03	110.5	550	56	114	114	1317	16,974
2033	0.158	0.05	115.2	554	57	115	116	1356	18,329
2034	0.158	0.07	119.68	558	57	116	118	1392	19,721
2035	0.158	0.09	123.94	562	58	117	120	1425	21,146
2036	0.158	0.12	127.96	565	58	118	122	1457	22,603
2037	0.158	0.15	131.76	568	59	118	124	1486	24,089
2038	0.158	0.19	135.32	570	59	119	125	1513	25,602
2039	0.158	0.22	138.66	572	59	119	127	1539	27,140
2040	0.158	0.26	141.79	574	59	120	128	1562	28,702
2041	0.158	0.3	144.7	576	60	120	129	1584	30,286
2042	0.158	0.34	147.42	578	60	121	130	1604	31,890
2043	0.158	0.38	149.94	579	60	121	131	1622	33,512
2044	0.158	0.41	152.28	581	60	121	132	1640	35,152
2045	0.158	0.45	154.45	582	60	122	133	1655	36,807
2046	0.158	0.48	156.46	583	60	122	134	1670	38,477
2047	0.158	0.51	158.31	584	60	122	134	1683	40,160
2048	0.158	0.54	160.02	585	60	122	135	1696	41,856
2049	0.158	0.56	161.6	586	61	123	136	1707	43,563
2050	0.158	0.59	163.06	586	61	123	136	1717	45,280

Table 3.23. Projection results under scenario 9—fishing mortality rate fixed at $F = F_{rebuild}$, with rebuilding probability of 0.7 in 2047. F = fishing mortality rate (per year), Pr(SSB > SSB_{MSY}) = proportion of stochastic projection replicates exceeding SSB_{MSY}, SSB = mid-year spawning stock (mt), R = recruits (1000 age-1 fish), D = discard mortalities (1000 fish or 1000 lb whole weight), L = landings (1000 fish or 1000 lb whole weight), and Sum L = cumulative landings (1000 lb). For reference, estimated benchmarks are F_{MSY} = 0.178 (per yr), SSB_{MSY} = 156 (mt), and MSY = 1842 (1000 lb). Expected values presented are from deterministic projections (klb = 1000 lb).

Year	F(per yr)	Pr(SSB > SSB_{MSY})	SSB(mt)	R(1000)	D(1000)	D(klb)	L(1000)	L(klb)	Sum L(klb)
2010	0.416	0	11.49	235	62	306	0	0	0
2011	0.147	0	13.76	223	18	32	18	197	197
2012	0.147	0	15.86	251	22	43	25	236	432
2013	0.147	0	18.25	273	24	48	30	277	709
2014	0.147	0	21.13	296	27	53	36	331	1040
2015	0.147	0	24.48	321	29	57	41	386	1426
2016	0.147	0	28.28	345	31	62	46	440	1866
2017	0.147	0	32.52	369	34	67	51	494	2360
2018	0.147	0	37.19	392	36	71	56	550	2909
2019	0.147	0	42.22	414	38	76	61	607	3517
2020	0.147	0	47.55	434	40	80	66	666	4183
2021	0.147	0	53.16	451	42	84	71	726	4909
2022	0.147	0	58.99	467	44	88	76	786	5694
2023	0.147	0	64.99	482	45	91	80	845	6539
2024	0.147	0	71.11	495	47	94	85	903	7442
2025	0.147	0	77.3	506	48	97	89	960	8402
2026	0.147	0	83.48	516	49	99	93	1015	9417
2027	0.147	0	89.62	525	50	101	96	1067	10,484
2028	0.147	0.01	95.67	533	51	103	100	1118	11,602
2029	0.147	0.02	101.61	540	52	104	103	1166	12,768
2030	0.147	0.03	107.39	546	52	106	106	1212	13,980
2031	0.147	0.04	112.98	552	53	107	108	1255	15,235
2032	0.147	0.07	118.35	556	53	108	111	1296	16,531
2033	0.147	0.1	123.5	561	54	109	113	1334	17,865
2034	0.147	0.13	128.4	565	54	110	115	1370	19,236
2035	0.147	0.17	133.06	568	55	111	117	1404	20,640
2036	0.147	0.22	137.47	571	55	111	119	1436	22,076
2037	0.147	0.27	141.62	574	55	112	121	1465	23,541
2038	0.147	0.32	145.53	576	56	113	122	1493	25,034
2039	0.147	0.38	149.19	578	56	113	123	1518	26,552
2040	0.147	0.43	152.62	580	56	114	125	1542	28,093
2041	0.147	0.48	155.81	582	56	114	126	1564	29,657
2042	0.147	0.52	158.79	584	56	114	127	1584	31,241
2043	0.147	0.57	161.56	585	57	115	128	1602	32,843
2044	0.147	0.61	164.13	586	57	115	129	1620	34,463
2045	0.147	0.64	166.51	587	57	115	130	1636	36,098
2046	0.147	0.68	168.71	588	57	115	130	1650	37,749
2047	0.147	0.71	170.75	589	57	116	131	1664	39,413
2048	0.147	0.73	172.64	590	57	116	132	1676	41,089
2049	0.147	0.76	174.37	591	57	116	132	1688	42,777
2050	0.147	0.78	175.97	592	57	116	133	1698	44,475

Table 3.24. Projection results under scenario 10—fishing mortality rate fixed at $F = F_{\mathrm{rebuild}}$, *with rebuilding probability of 0.9 in 2047. F = fishing mortality rate (per year), Pr(*$\mathrm{SSB} > \mathrm{SSB_{MSY}}$*) = proportion of stochastic projection replicates exceeding* $\mathrm{SSB_{MSY}}$, *SSB = mid-year spawning stock (mt), R = recruits (1000 age-1 fish), D = discard mortalities (1000 fish or 1000* lb *whole weight), L = landings (1000 fish or 1000* lb *whole weight), and Sum L = cumulative landings (1000* lb*). For reference, estimated benchmarks are* $F_{\mathrm{MSY}} = 0.178$ *(per yr),* $\mathrm{SSB_{MSY}} = 156$ *(mt), and* MSY = 1842 *(1000 lb). Expected values presented are from deterministic projections (klb = 1000 lb).*

Year	F(per yr)	Pr(SSB > $\mathrm{SSB_{MSY}}$)	SSB(mt)	R(1000)	D(1000)	D(klb)	L(1000)	L(klb)	Sum L(klb)
2010	0.416	0	11.49	235	62	306	0	0	0
2011	0.132	0	13.76	223	16	29	16	177	177
2012	0.132	0	16.03	251	20	39	22	215	392
2013	0.132	0	18.57	275	22	43	28	254	646
2014	0.132	0	21.65	299	24	48	33	305	951
2015	0.132	0	25.27	325	26	52	38	358	1309
2016	0.132	0	29.38	351	29	57	43	410	1719
2017	0.132	0	34	376	31	61	48	463	2183
2018	0.132	0	39.12	399	33	66	53	518	2700
2019	0.132	0	44.65	422	35	70	58	574	3275
2020	0.132	0	50.54	442	37	74	62	632	3907
2021	0.132	0	56.76	460	39	78	67	691	4598
2022	0.132	0	63.24	477	40	81	72	750	5349
2023	0.132	0	69.94	491	42	84	76	809	6157
2024	0.132	0	76.78	504	43	87	81	866	7024
2025	0.132	0	83.71	515	44	89	85	922	7946
2026	0.132	0.01	90.65	525	45	91	88	977	8923
2027	0.132	0.01	97.54	534	46	93	92	1029	9951
2028	0.132	0.03	104.36	542	47	95	95	1079	11,030
2029	0.132	0.04	111.05	549	48	96	98	1127	12,157
2030	0.132	0.07	117.56	555	48	98	101	1172	13,329
2031	0.132	0.11	123.86	560	49	99	104	1215	14,544
2032	0.132	0.16	129.93	565	49	100	106	1256	15,800
2033	0.132	0.22	135.74	569	50	101	108	1294	17,094
2034	0.132	0.28	141.28	573	50	101	110	1330	18,423
2035	0.132	0.35	146.55	576	50	102	112	1363	19,787
2036	0.132	0.43	151.54	579	51	103	114	1395	21,182
2037	0.132	0.5	156.24	581	51	103	115	1424	22,606
2038	0.132	0.56	160.67	584	51	104	117	1451	24,057
2039	0.132	0.62	164.82	586	51	104	118	1477	25,534
2040	0.132	0.68	168.7	588	51	104	119	1500	27,035
2041	0.132	0.73	172.33	589	52	105	121	1522	28,557
2042	0.132	0.77	175.71	591	52	105	122	1543	30,100
2043	0.132	0.81	178.85	592	52	105	123	1561	31,661
2044	0.132	0.84	181.77	593	52	106	123	1579	33,240
2045	0.132	0.86	184.48	595	52	106	124	1595	34,834
2046	0.132	0.88	186.99	595	52	106	125	1609	36,444
2047	0.132	0.9	189.31	596	52	106	126	1623	38,067
2048	0.132	0.92	191.46	597	52	106	126	1636	39,702
2049	0.132	0.93	193.44	598	52	107	127	1647	41,350
2050	0.132	0.94	195.27	599	52	107	127	1658	43,007

Table 3.25. Input for Surplus-production model runs. Total removals in million pounds from the historical time period (1950–1980) and adjusted Saltwater Angling Survey (SWAS) recreational estimates. The removals from 1981–2009 are identical for all runs. The indices for headboat and commercial logbook are in units of pounds per angler hour and pounds per hook hour. An alternate series with a 2% increase in catchability starting in 1976 and saturating in 2003 after which there is no increase was developed by the SEDAR-24 AW panel.

	Historic Removals (million pounds)		Indices			Removals (million pounds)	Indices			
Year	Proposed	SWAS	Headboat	Headboat 2%catch inc.	Year	Proposed	Headboat	Headboat 2% catch. Inc.	Com. Logbook	Com. Logbook 2% catch. Inc.
1950	0.807	0.697			1981	1.011	2.07	1.87		
1951	1.014	0.941			1982	0.798	1.26	1.11		
1952	0.930	0.897			1983	0.566	0.81	0.70		
1953	1.000	0.995			1984	0.827	0.75	0.63		
1954	1.271	1.276			1985	0.965	1.15	0.94		
1955	1.254	1.260			1986	0.376	0.34	0.27		
1956	1.340	1.331			1987	0.438	0.40	0.31		
1957	1.826	1.800			1988	0.451	0.42	0.32		
1958	1.639	1.633			1989	0.585	0.61	0.45		
1959	1.727	1.763			1990	0.462	0.58	0.42		
1960	1.769	1.862			1991	0.385	0.75	0.52		
1961	1.895	1.900			1992	0.761	0.09	0.06		
1962	1.734	1.678			1993	0.466	0.19	0.13	1.14	0.75
1963	1.570	1.435			1994	0.497	0.30	0.19	0.91	0.58
1964	1.694	1.404			1995	0.358	0.40	0.25	0.92	0.57
1965	1.942	1.417			1996	0.310	0.46	0.28	0.57	0.34
1966	2.216	1.914			1997	0.330	0.52	0.30	0.57	0.33
1967	2.593	2.553			1998	0.282	0.29	0.16	0.63	0.35
1968	2.727	3.073			1999	0.459	0.42	0.23	0.76	0.41
1969	2.243	3.118			2000	0.835	0.54	0.28	0.75	0.39
1970	2.013	3.473			2001	0.758	1.01	0.50	1.22	0.61
1971	1.770	3.203			2002	0.738	1.16	0.56	1.37	0.66
1972	1.625	3.088			2003	0.568	0.85	0.39	1.11	0.51
1973	1.447	2.709			2004	0.696	1.35	0.62	1.44	0.66
1974	1.988	2.652			2005	0.542	1.17	0.54	1.23	0.56
1975	2.238	2.514			2006	0.473	0.70	0.32	0.61	0.28
1976	1.952	2.143	1.80	1.80	2007	0.813	0.55	0.25	0.66	0.31
1977	2.313	2.327	2.14	2.10	2008	1.362	2.49	1.15	1.20	0.55
1978	1.924	1.884	1.74	1.67	2009	1.525	2.95	1.36	1.92	0.88
1979	2.034	2.138	2.64	2.49						
1980	1.262	1.290	1.08	0.99						

Table 3.26. Red snapper–Parameter estimates and status values from the surplus-production model runs with the 10th and 90th bias-corrected confidence limits where bootstrap runs were completed.

Run	Value	B1/K	MSY	K	q(headboat)	q(Comm.Line)	B(2010)/Bmsy	F(2009)/Fmsy
Match to BAM base run	Estimate	0.36	1.251E+06	1.248E+07	2.65E-07	2.46E-07	0.25	3.85
	10% CL	0.35	9.974E+05	1.096E+07	1.67E-07	1.31E-07	0.08	2.25
	90% CL	1.02	1.266E+06	2.041E+07	3.44E-07	3.42E-07	0.53	8.05
Match to BAM base run	Estimate	0.61	9.288E+05	7.747E+06	2.95E-07	2.73E-07	0.23	4.78
no catchability increase	10% CL	0.57	8.293E+05	6.602E+06	1.94E-07	1.72E-07	0.06	2.31
	90% CL	0.97	9.525E+05	1.152E+07	3.82E-07	3.90E-07	0.67	9.13
Match to BAM base run	Estimate	0.43	1.054E+06	7.152E+06	3.67E-07	3.59E-07	0.29	3.62
Start in 1976	10% CL	0.29	1.037E+06	6.613E+06	3.05E-07	3.00E-07	0.06	2.36
	90% CL	0.45	1.513E+06	9.752E+06	4.94E-07	5.41E-07	0.52	7.51
SWAS removals	Estimate	0.38	2.216E+06	1.840E+07	3.21E-07	5.21E-07	0.16	3.47

3.6 Figures

Figure 3.1. Mean length at age (mm) and estimated 95% confidence interval of the population.

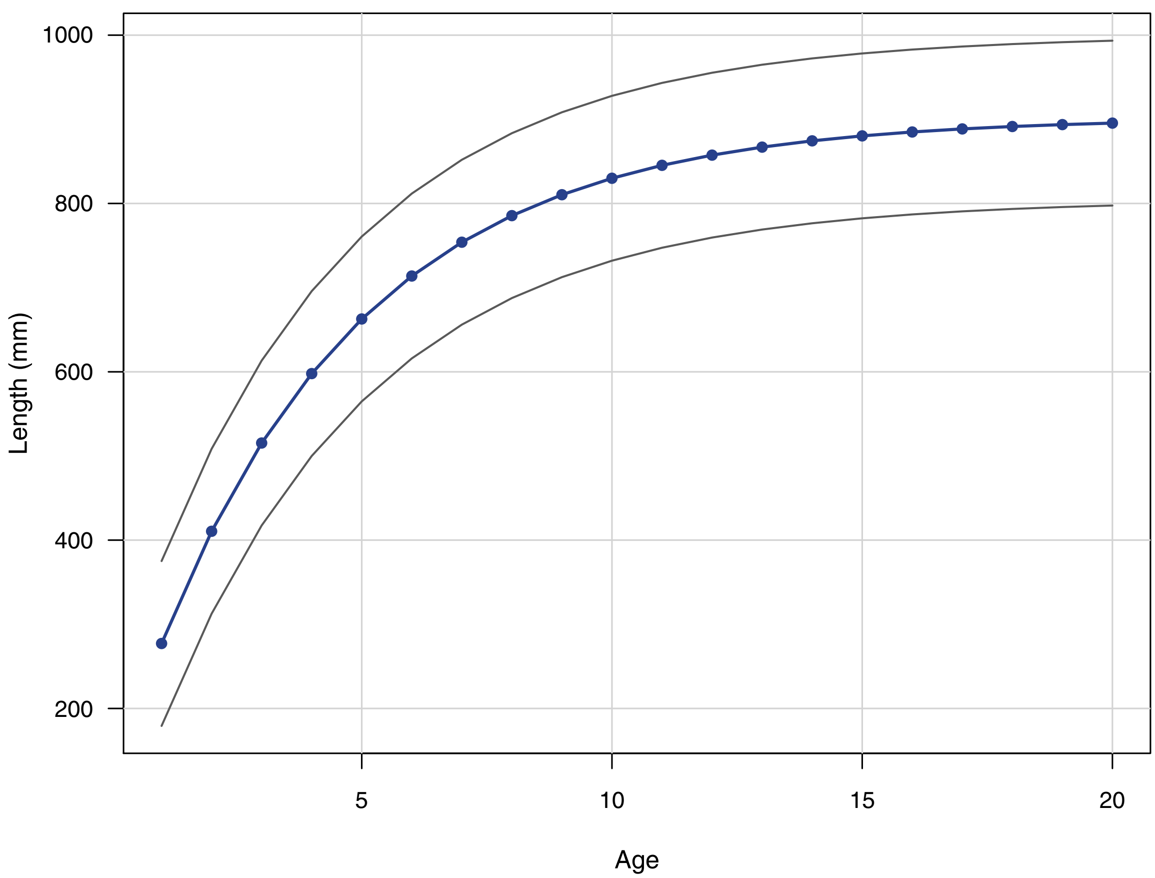


Figure 3.2. Standard errors of management quantities with increased number of Monte Carlo/bootstrap trials.

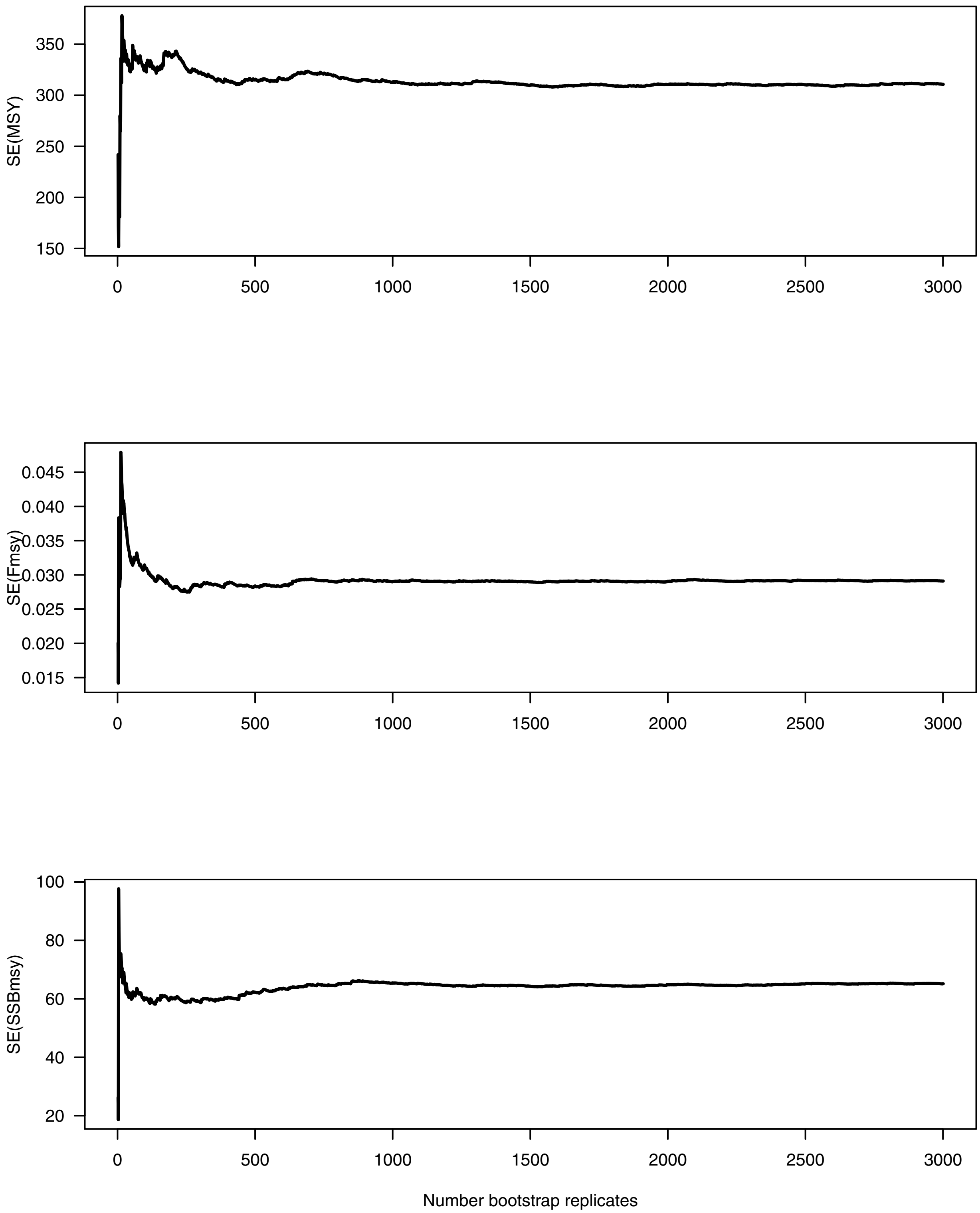


Figure 3.3. Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey. In panels indicating the data set, lcomp refers to length compositions, acomp to age compositions, cl to commercial lines, cd to commercial dive, hb to for-hire, pvt to private recreational, cl.D to commercial discards, and hb.D to for-hire discards. The two years of pvt length compositions represent compositions pooled across years within the relevant time block of size-limit regulations. N indicates the number of trips from which individual fish samples were taken.

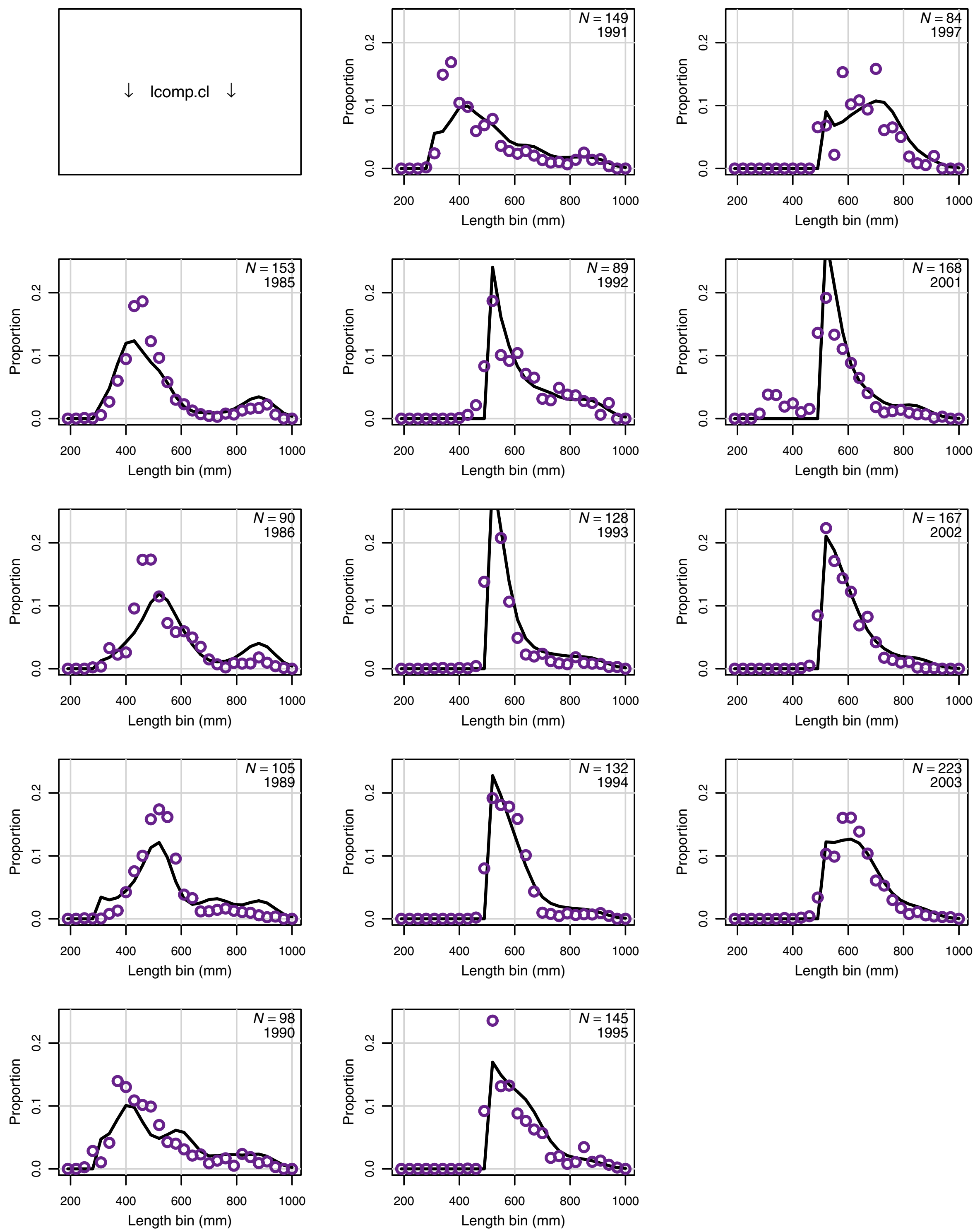


Figure 3.3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.

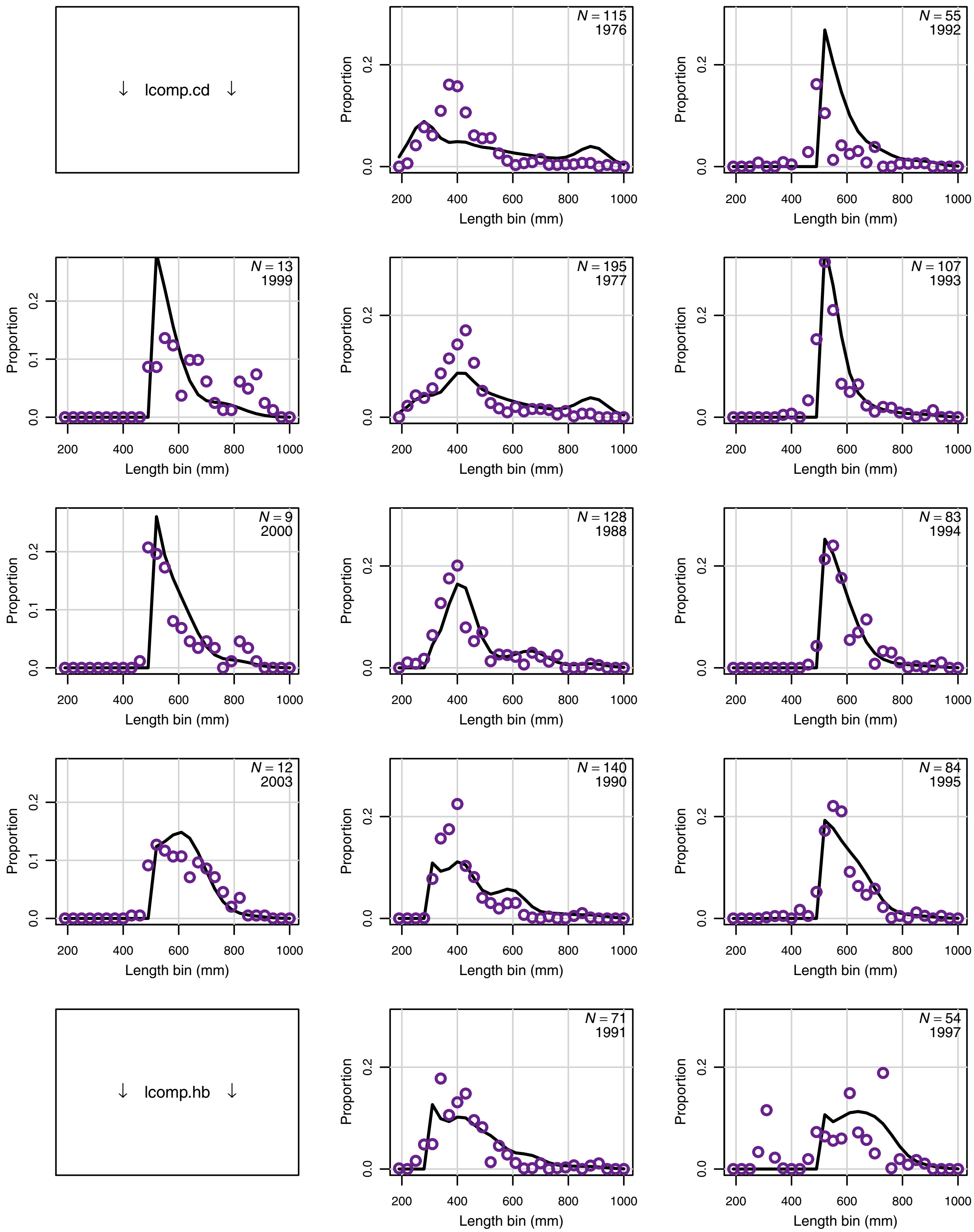


Figure 3.3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.

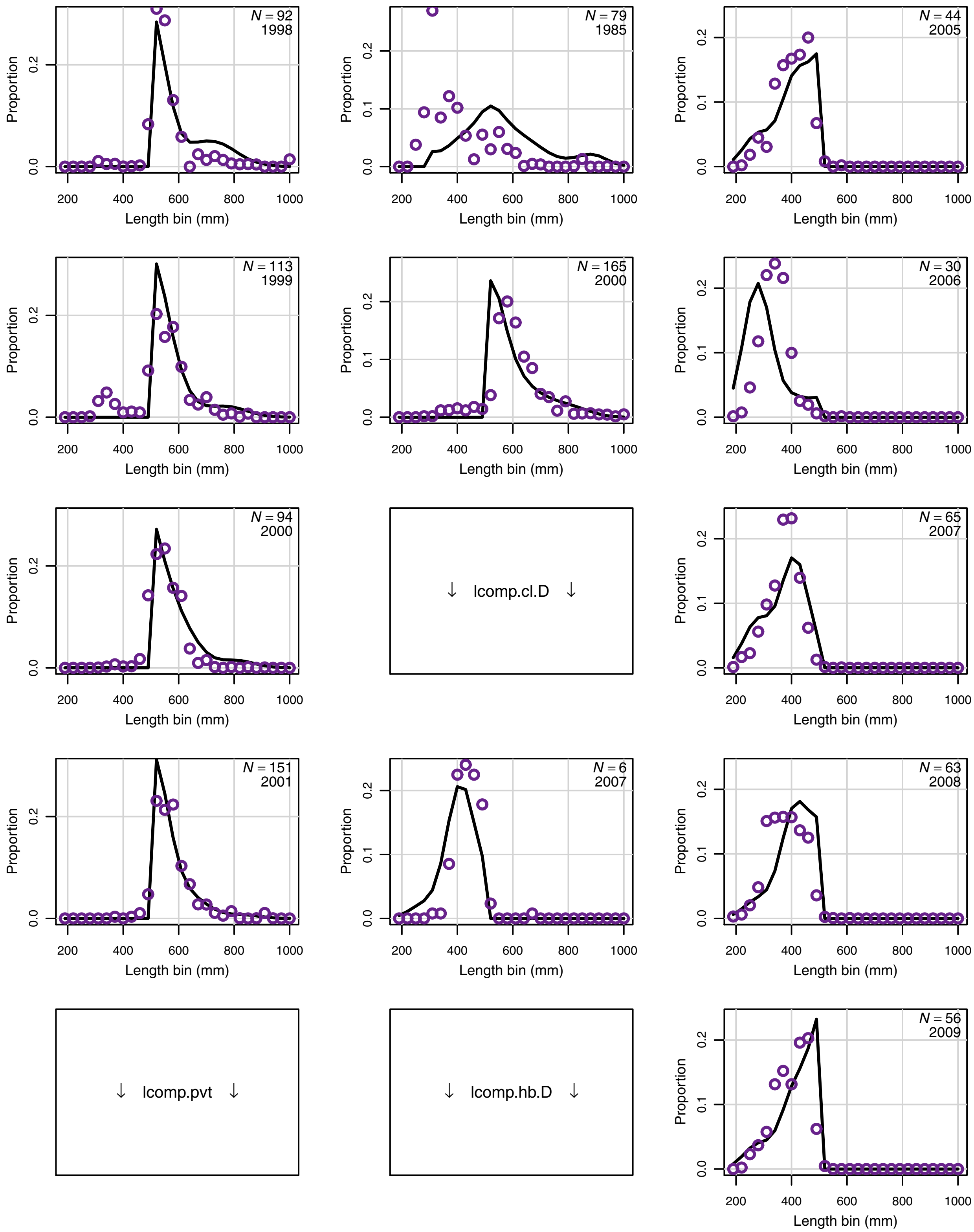


Figure 3.3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.

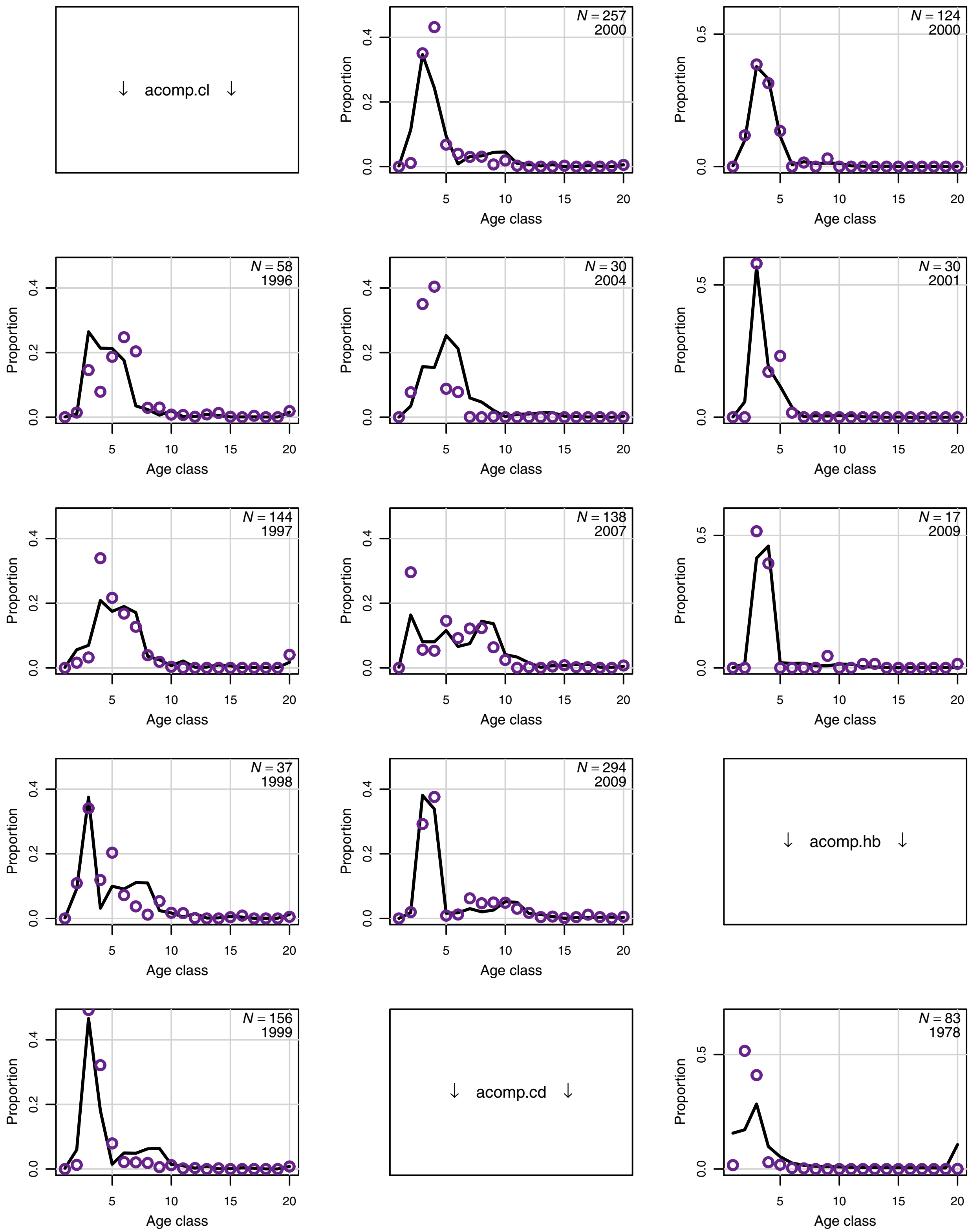


Figure 3.3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.

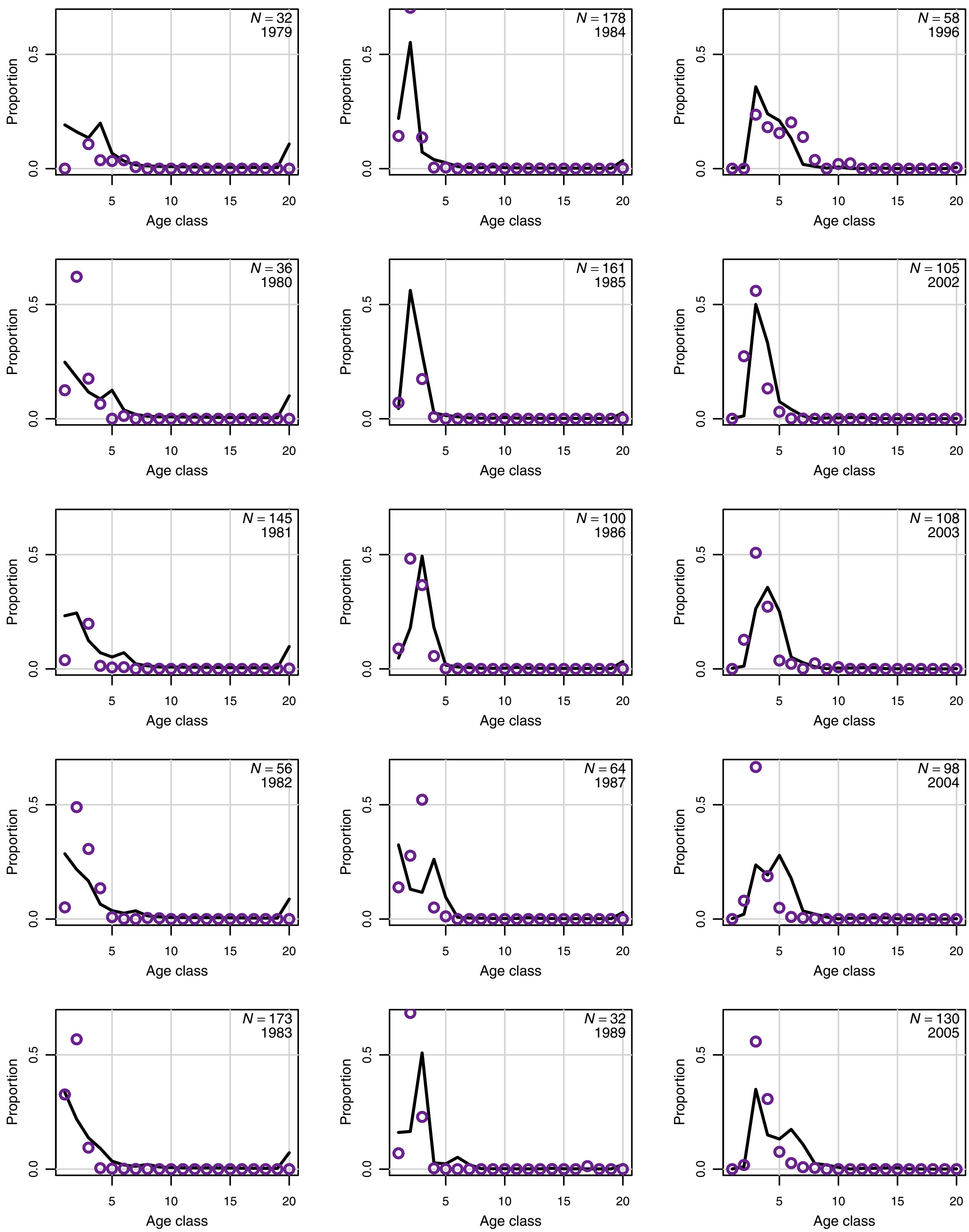


Figure 3.3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.

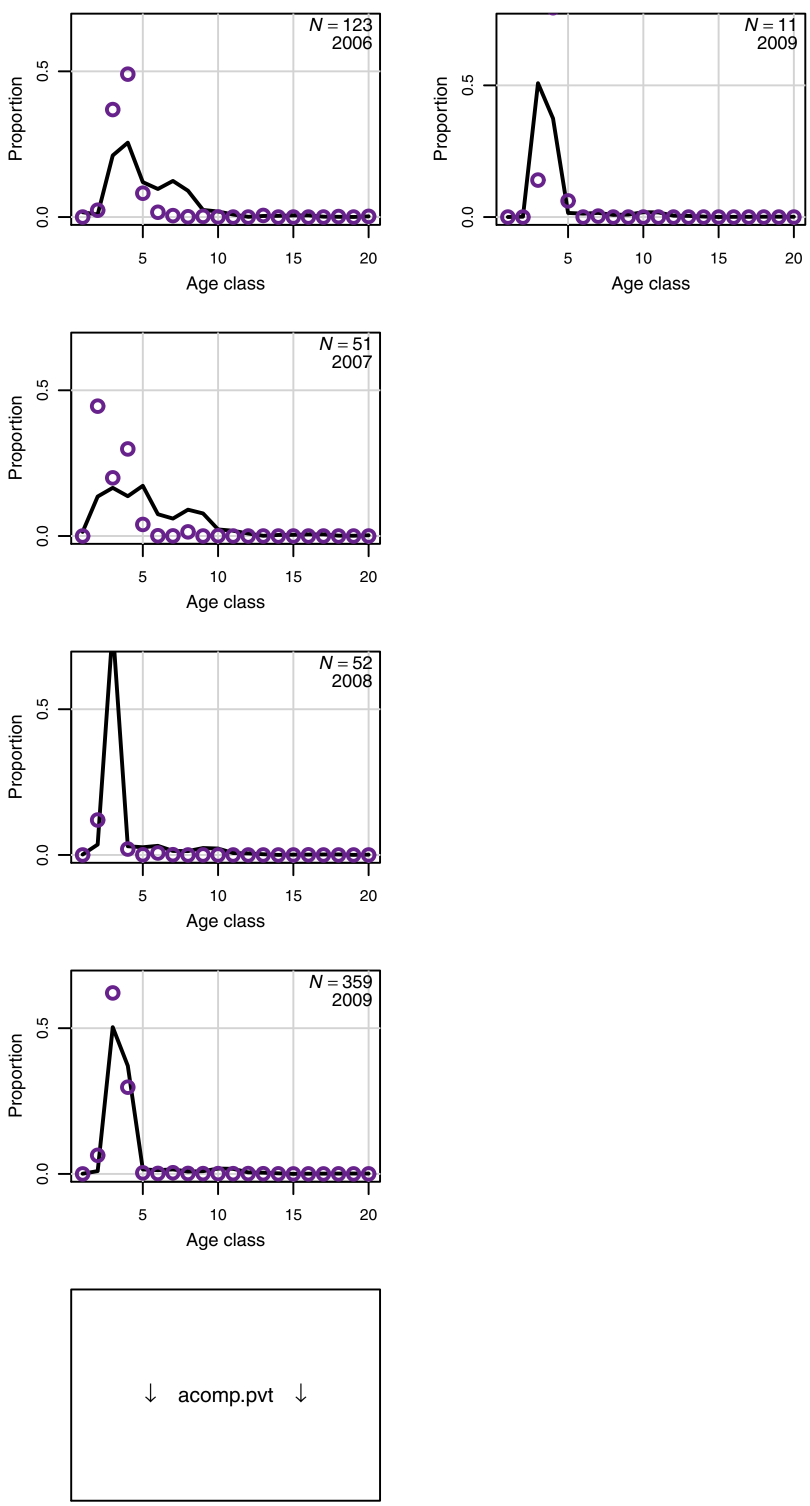


Figure 3.4. Top panel is a bubble plot of length composition residuals from commercial lines landings; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

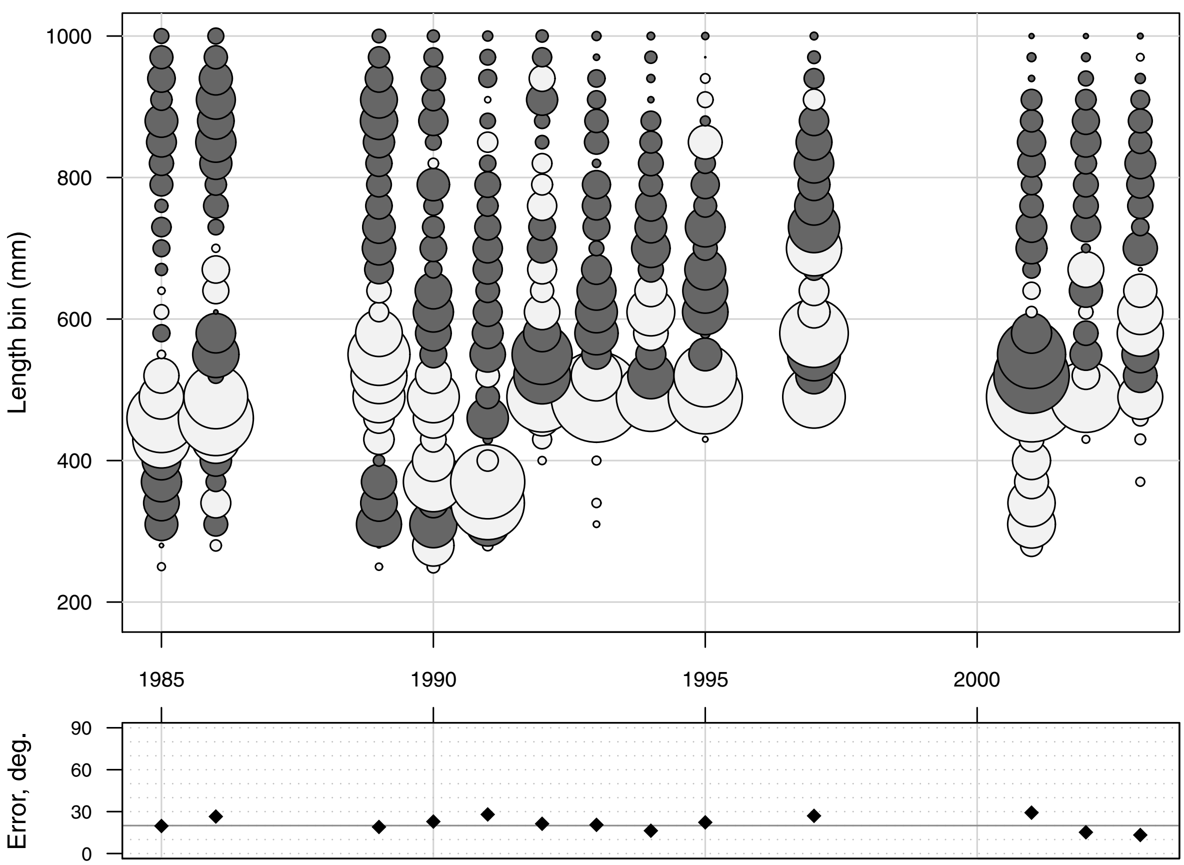


Figure 3.5. Top panel is a bubble plot of length composition residuals from commercial dive landings; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

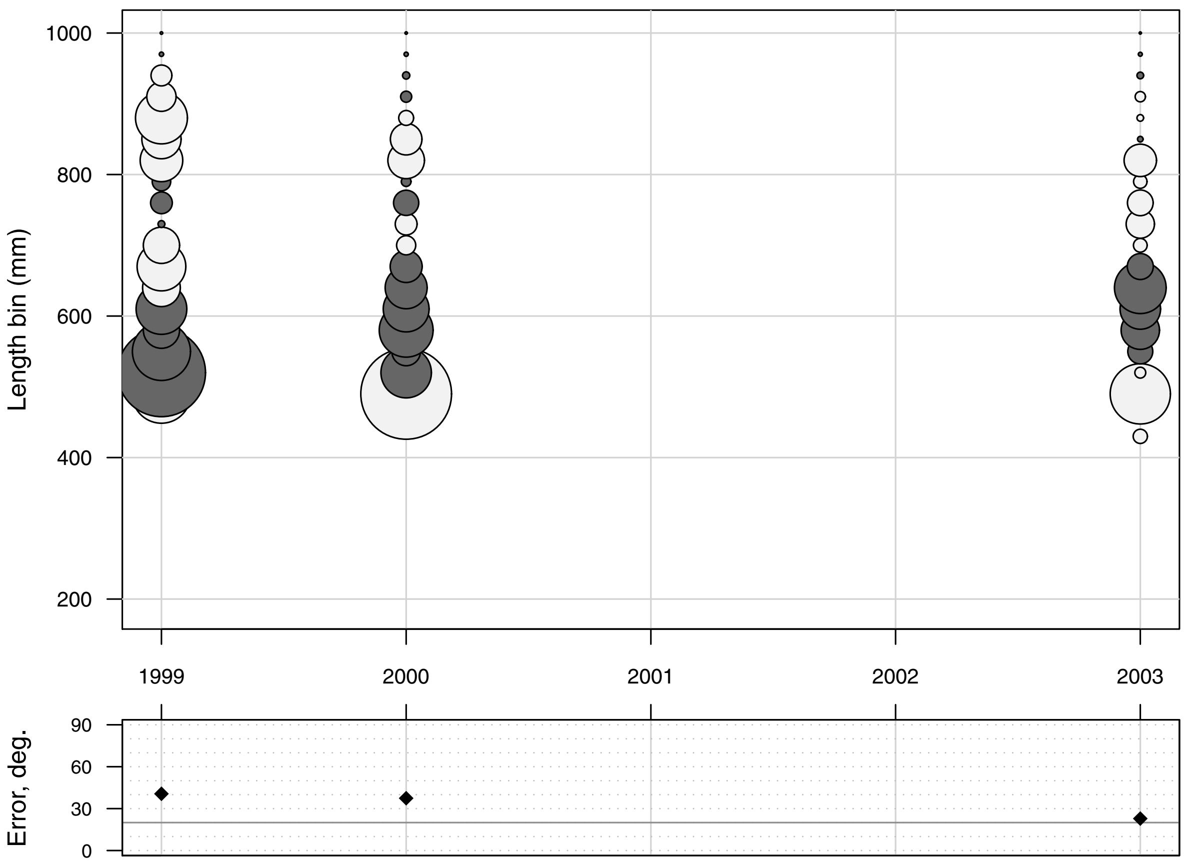


Figure 3.6. Top panel is a bubble plot of length composition residuals from for-hire landings; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

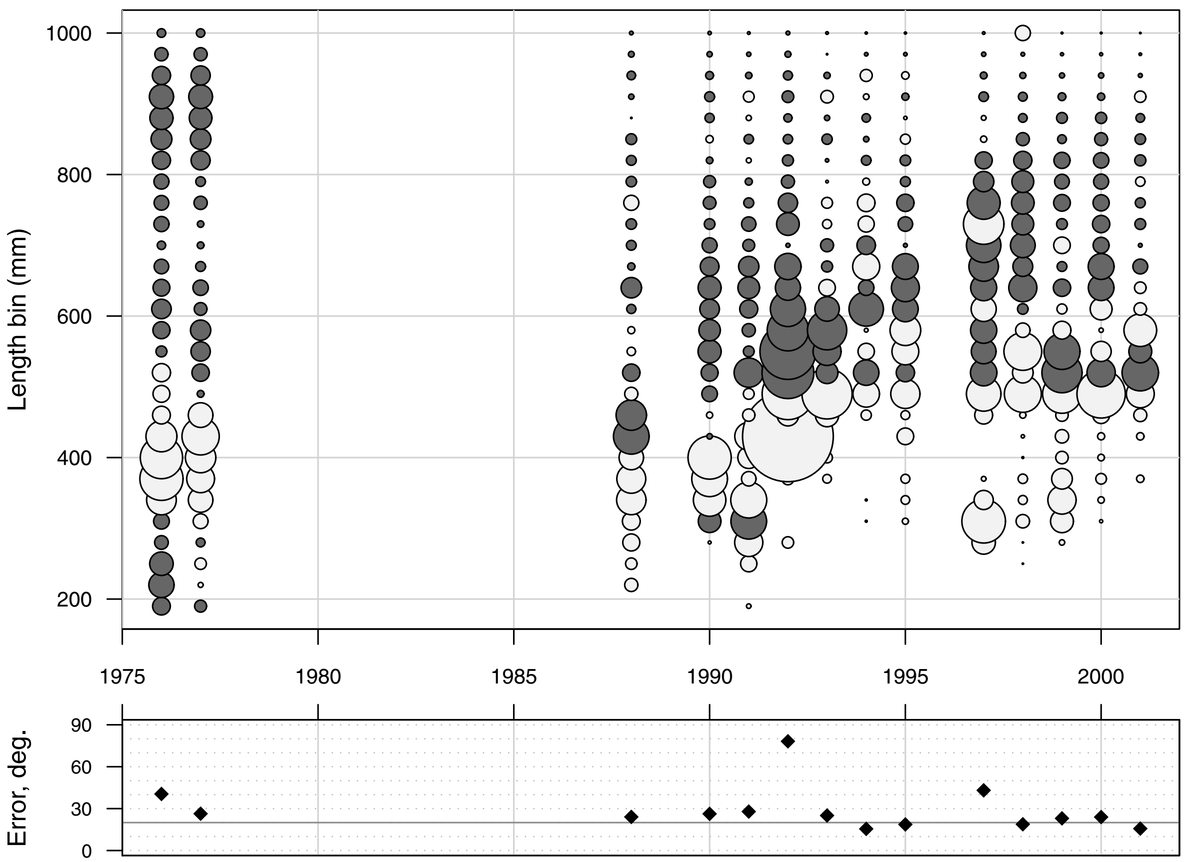


Figure 3.7. Top panel is a bubble plot of length composition residuals from private recreational landings; Dark represents overestimates and light underestimates. The two years shown represent length compositions pooled across years within the relevant time block of size-limit regulations. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

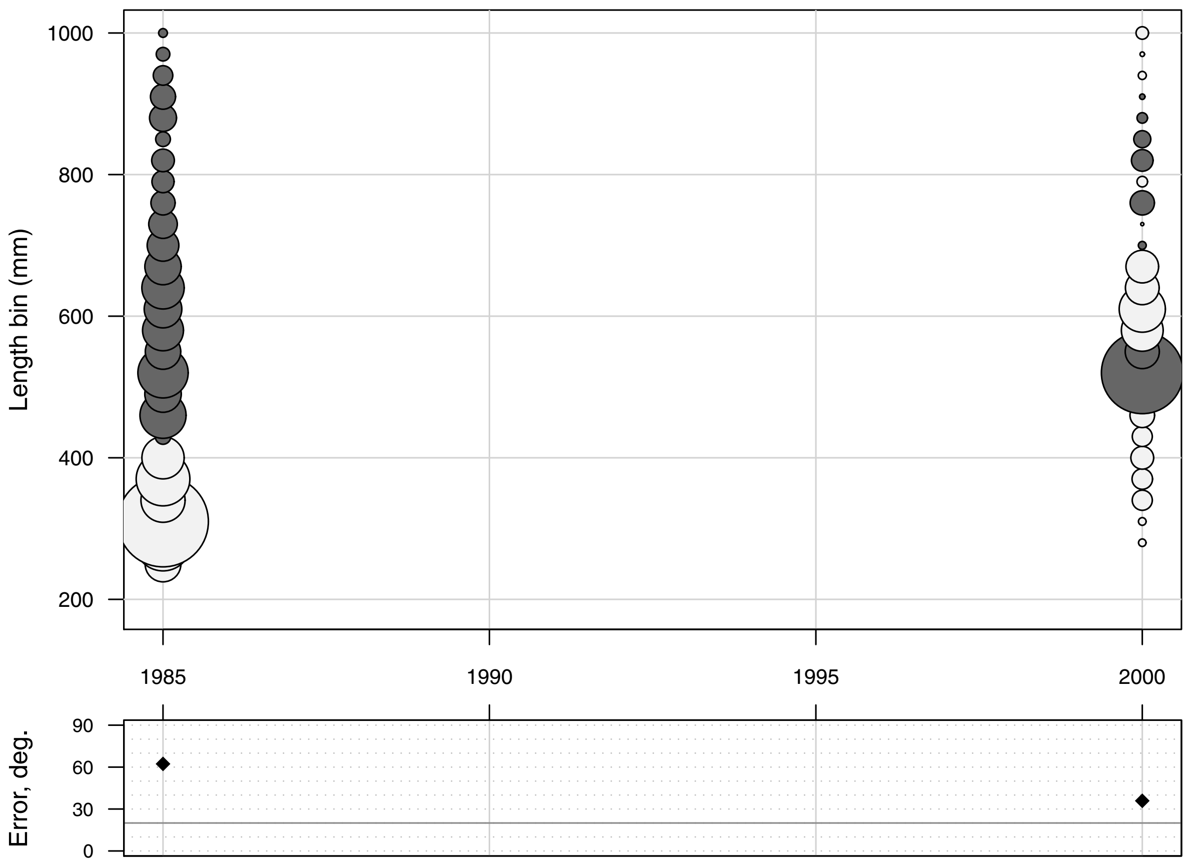


Figure 3.8. Top panel is a bubble plot of length composition residuals from commercial lines discards; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

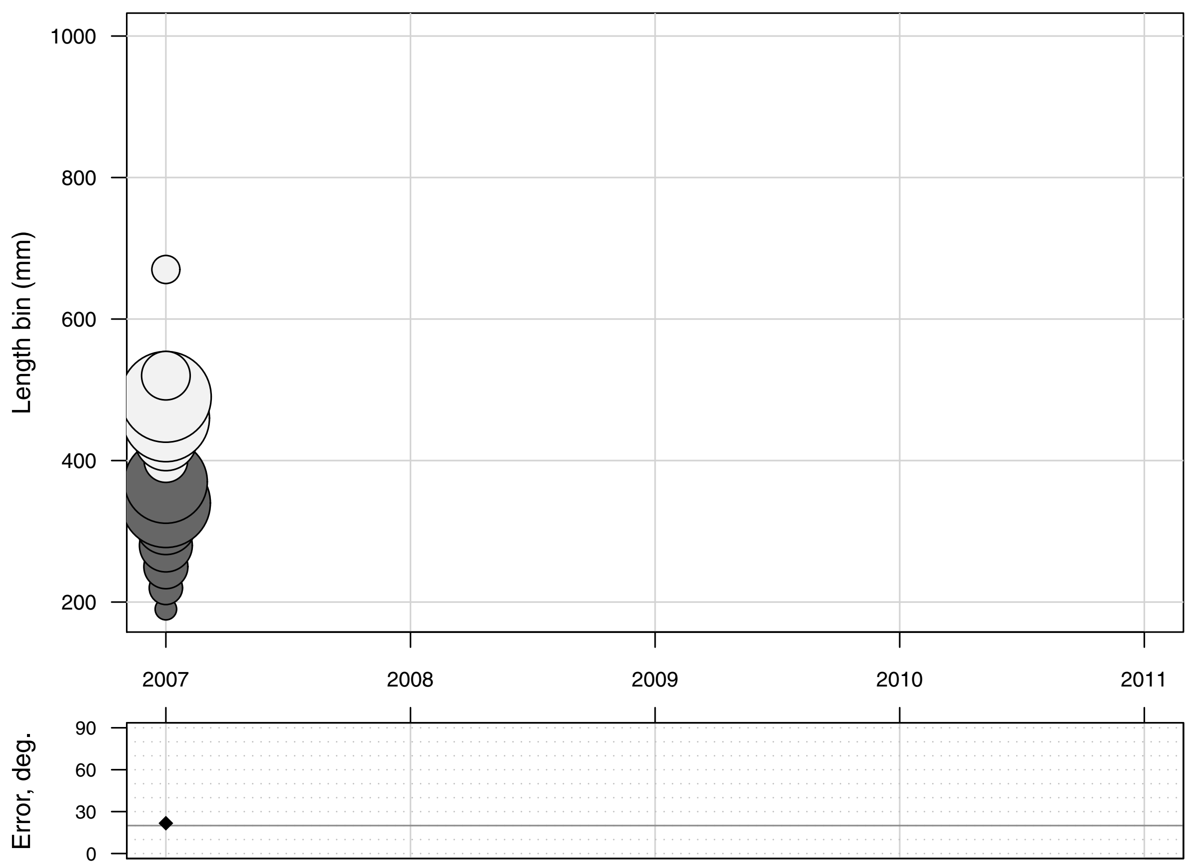


Figure 3.9. Top panel is a bubble plot of length composition residuals from for-hire discards; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

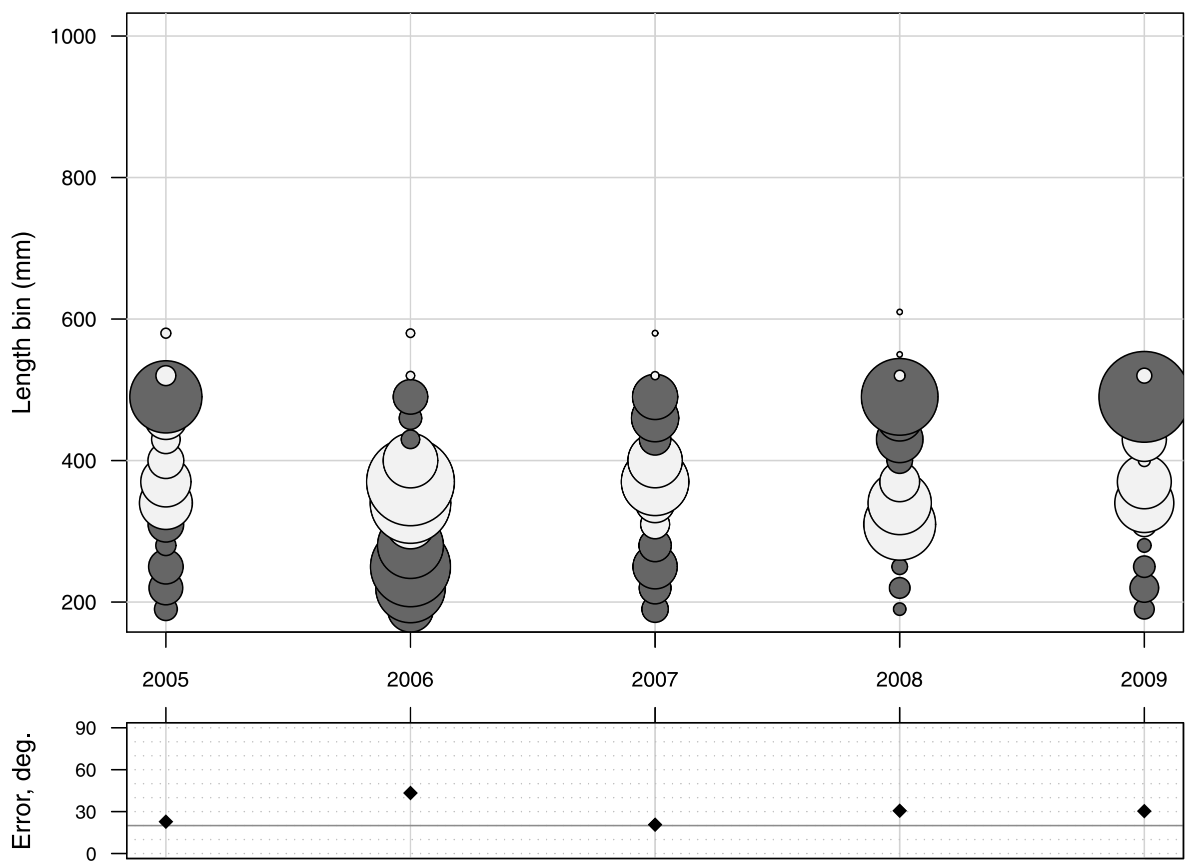


Figure 3.10. Top panel is a bubble plot of age composition residuals from commercial lines landings; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

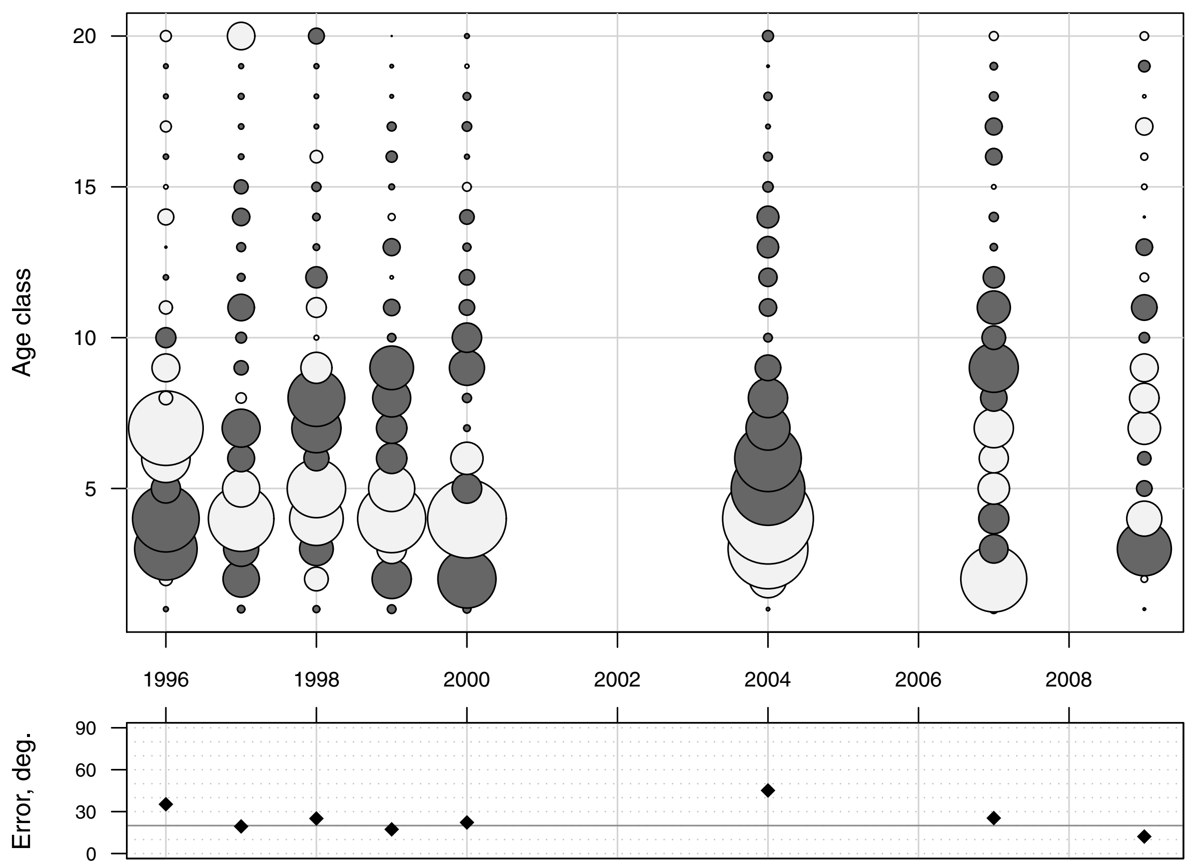


Figure 3.11. Top panel is a bubble plot of age composition residuals from commercial dive landings; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

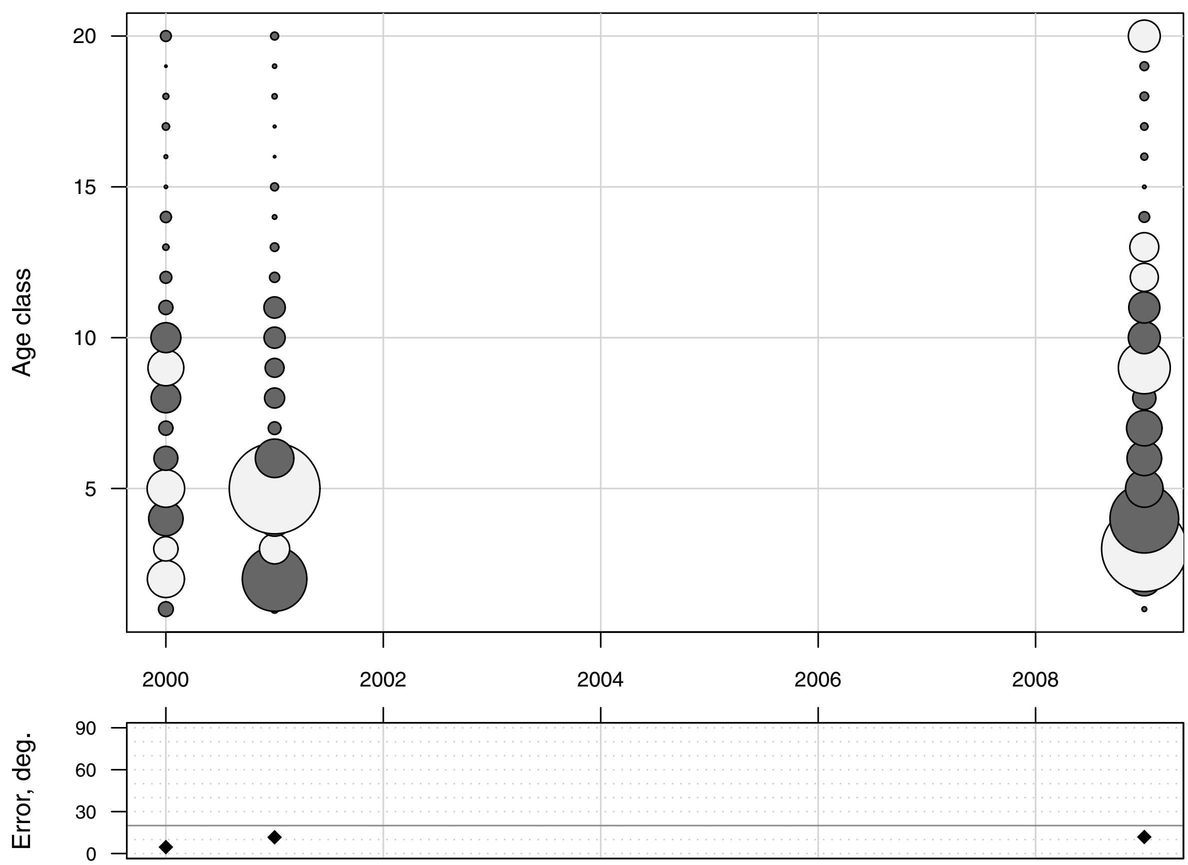


Figure 3.12. Top panel is a bubble plot of age composition residuals from for-hire landings; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

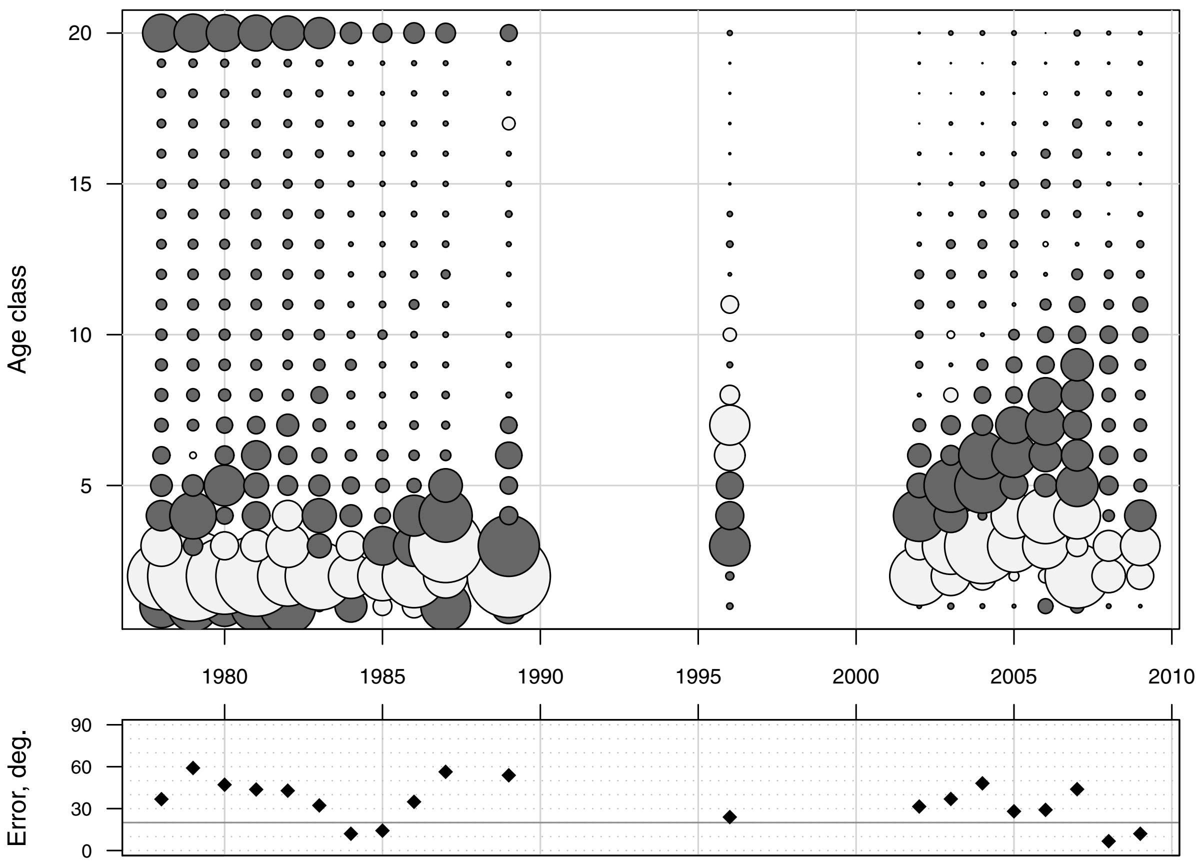


Figure 3.13. Top panel is a bubble plot of age composition residuals from private recreational landings; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

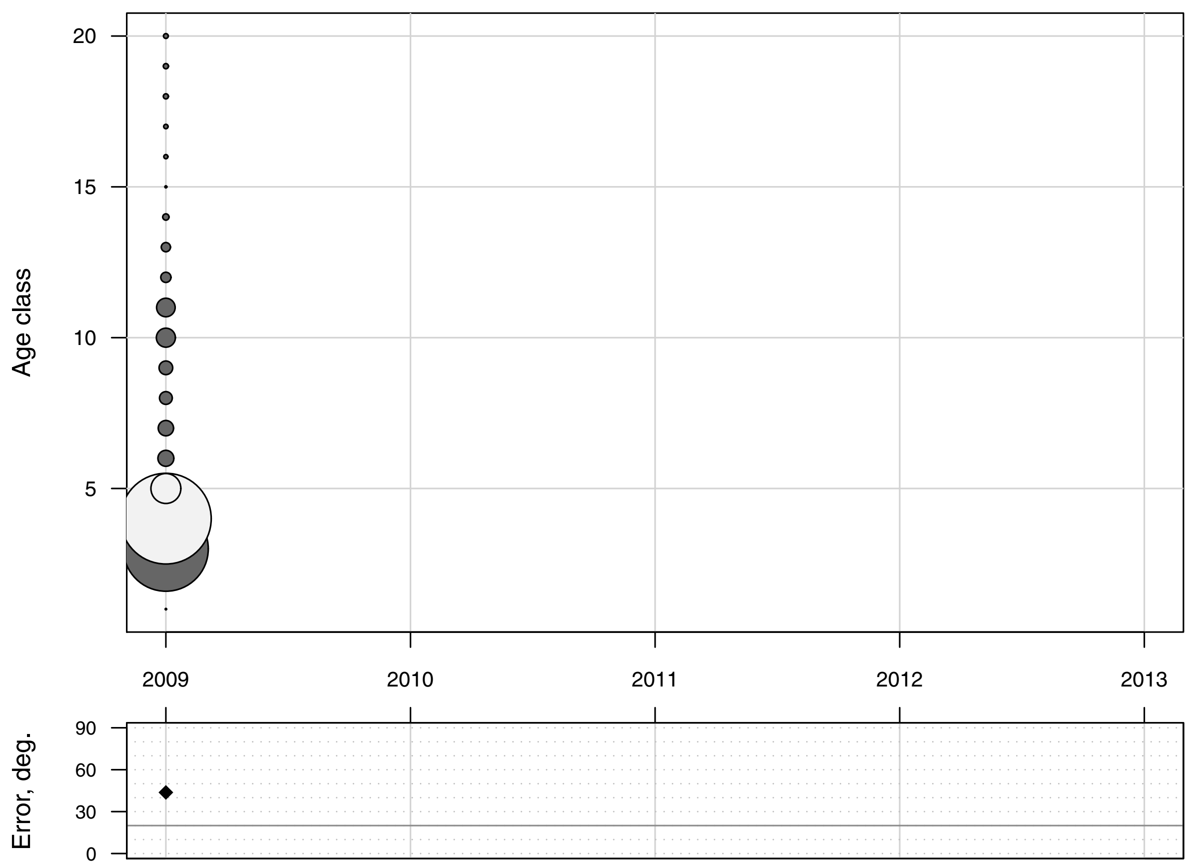


Figure 3.14. Observed (open circles) and estimated (line, solid circles) commercial lines landings (1000 lb whole weight).

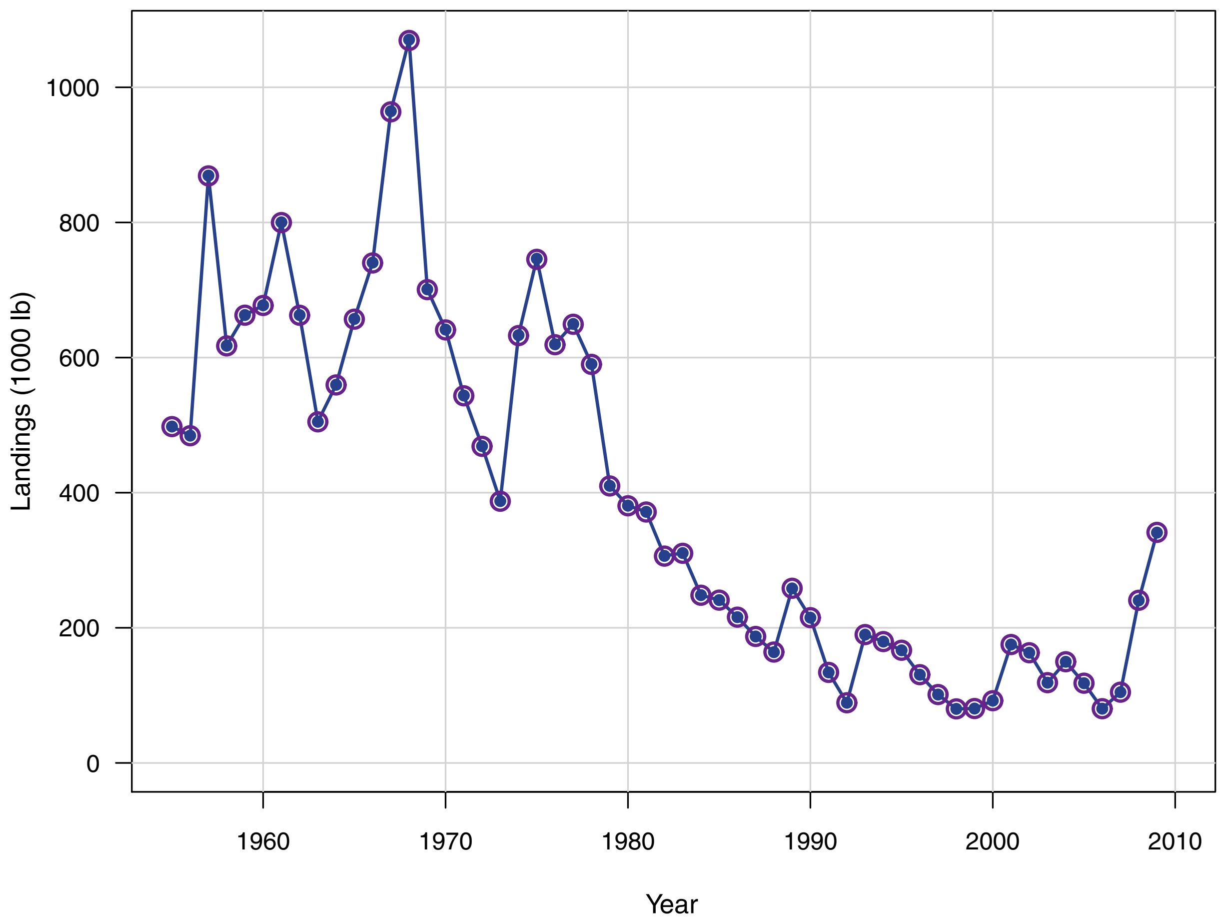


Figure 3.15. Observed (open circles) and estimated (line, solid circles) commercial dive (1000 lb whole weight).

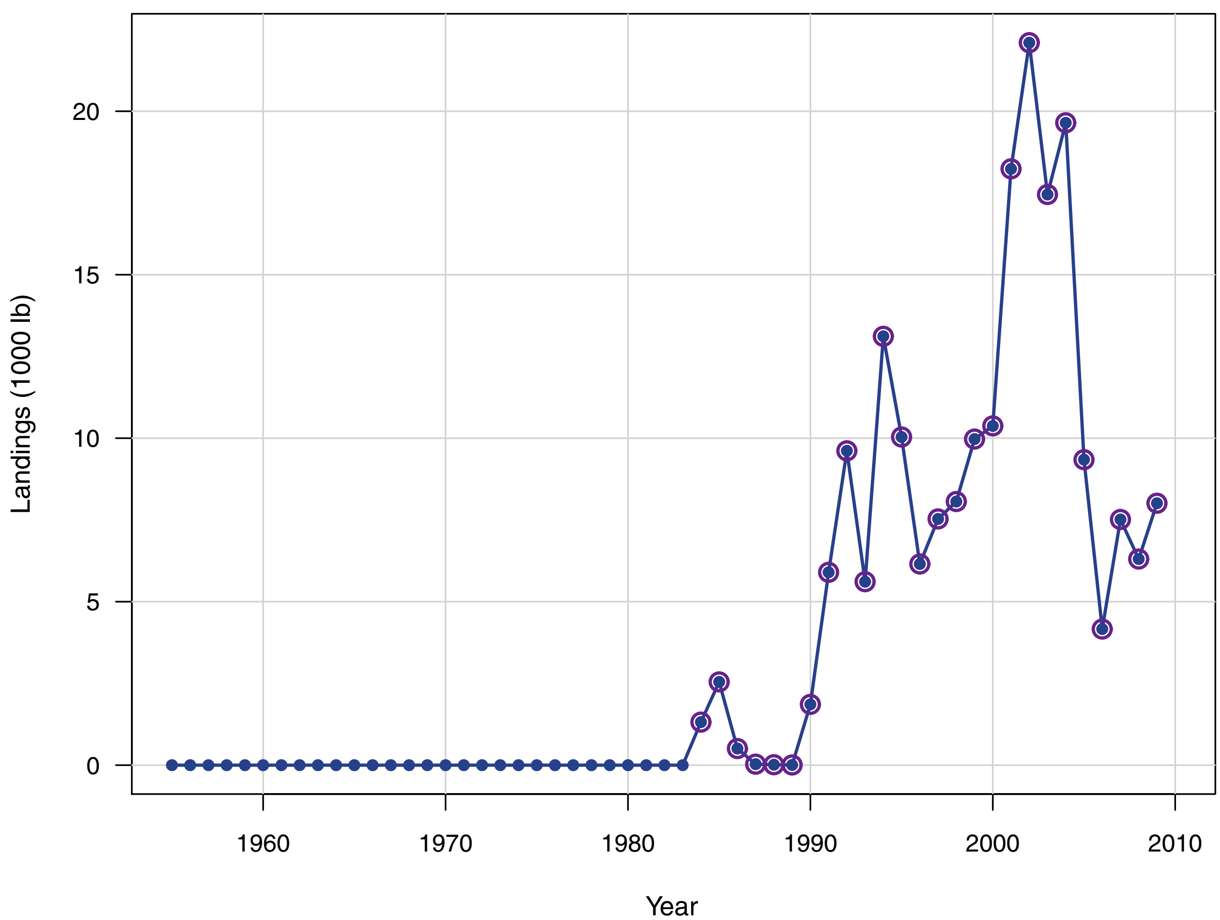


Figure 3.16. Observed (open circles) and estimated (line, solid circles) for-hire landings (1000 fish).

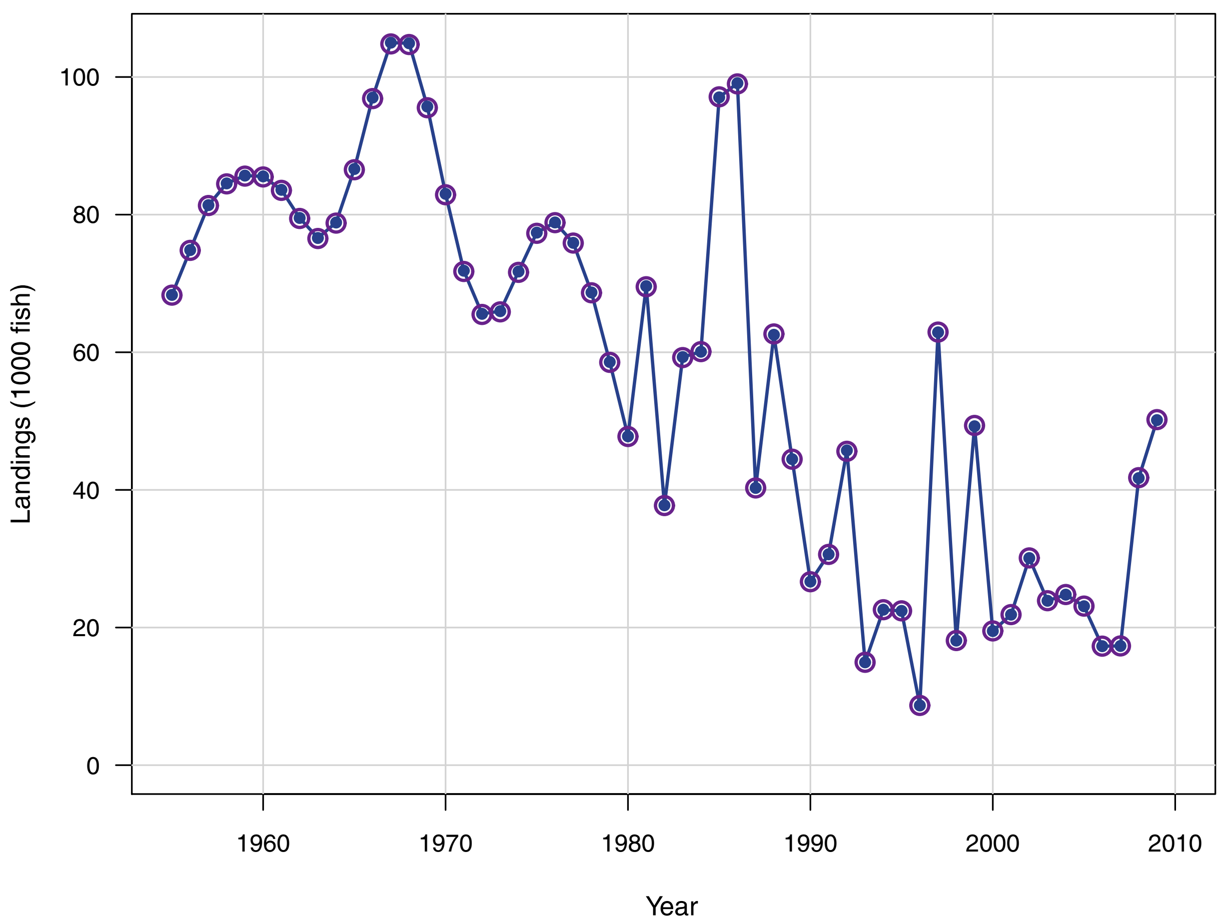


Figure 3.17. Observed (open circles) and estimated (line, solid circles) private recreational landings (1000 fish). In years without observations, values were predicted using average F (see §3.1.1.3 for details).

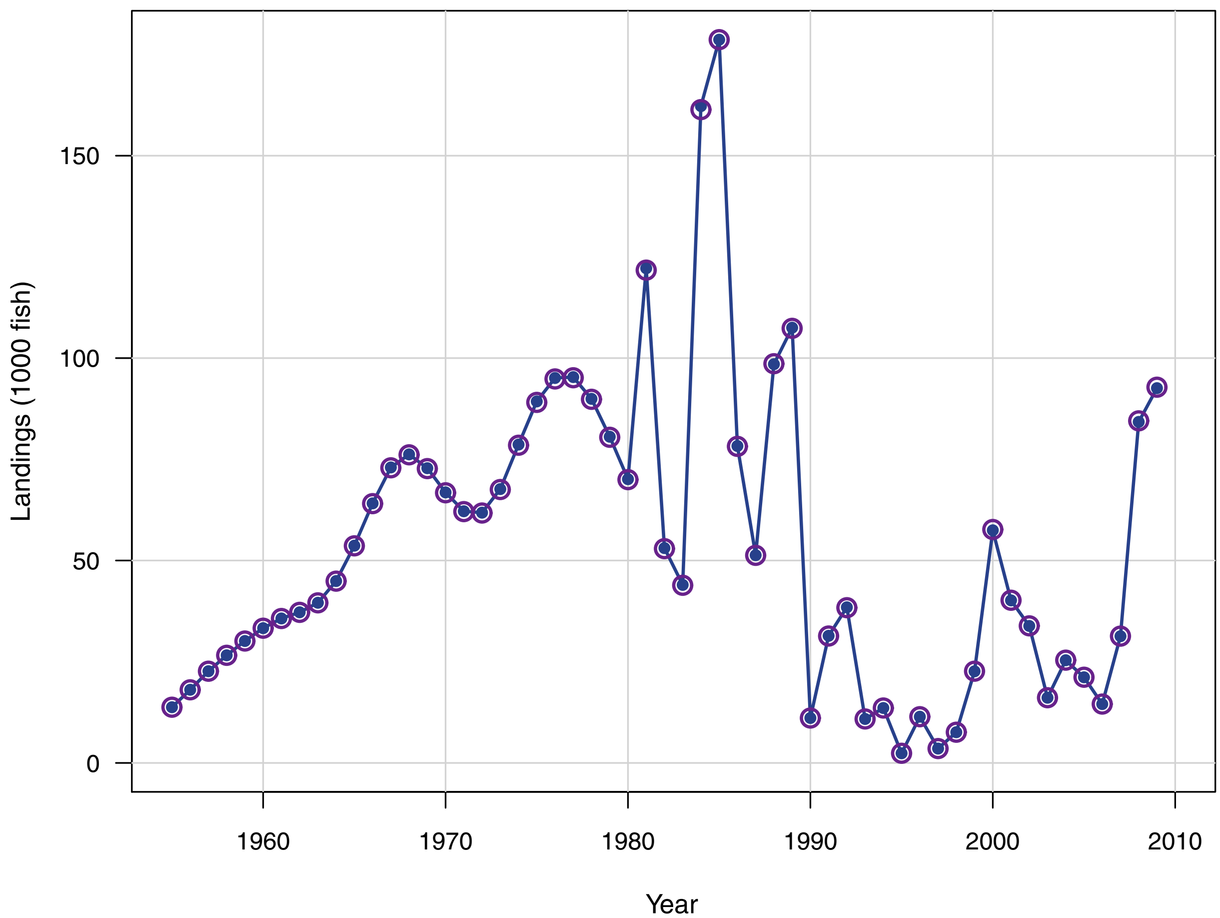


Figure 3.18. Observed (open circles) and estimated (line, solid circles) commercial lines discard mortalities (1000 dead fish).

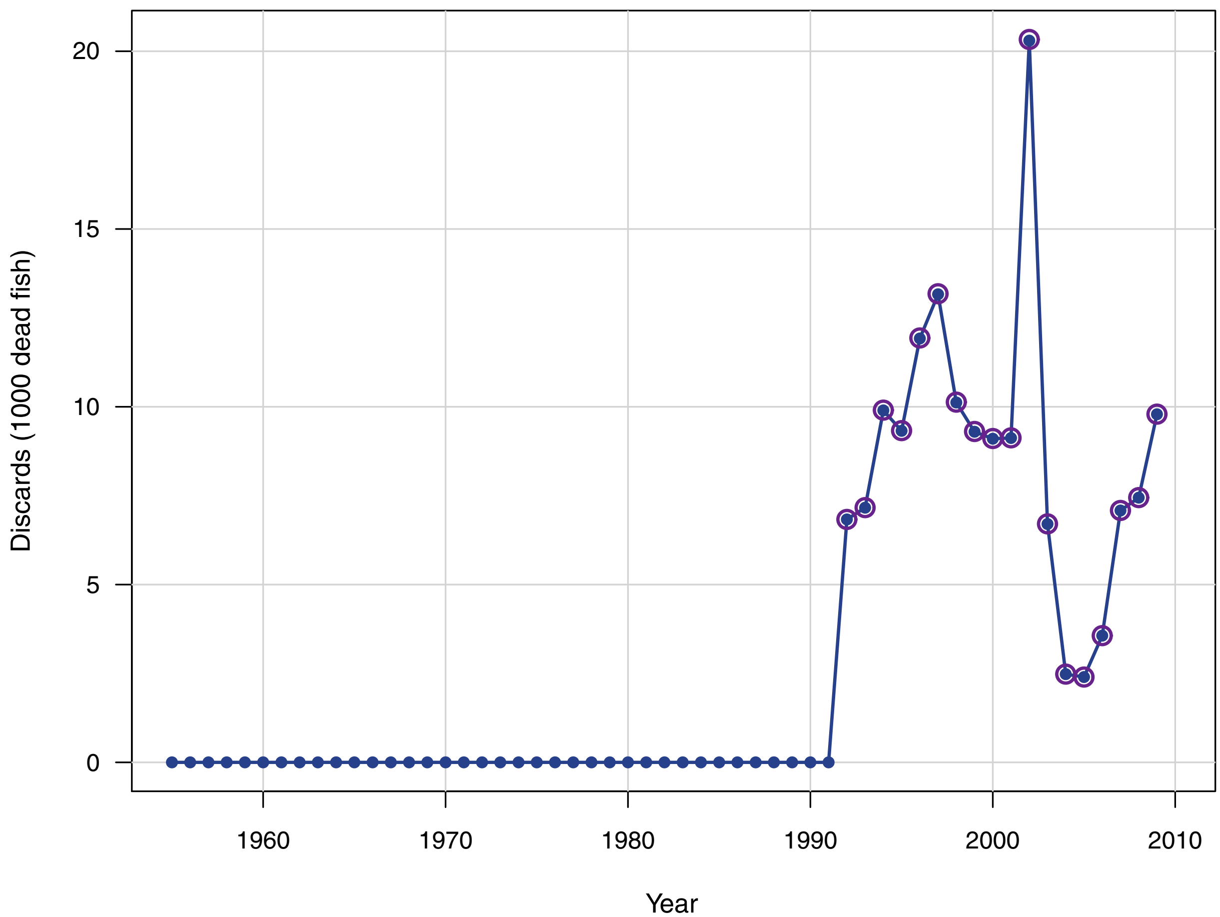


Figure 3.19. Observed (open circles) and estimated (line, solid circles) for-hire discard mortalities (1000 dead fish).

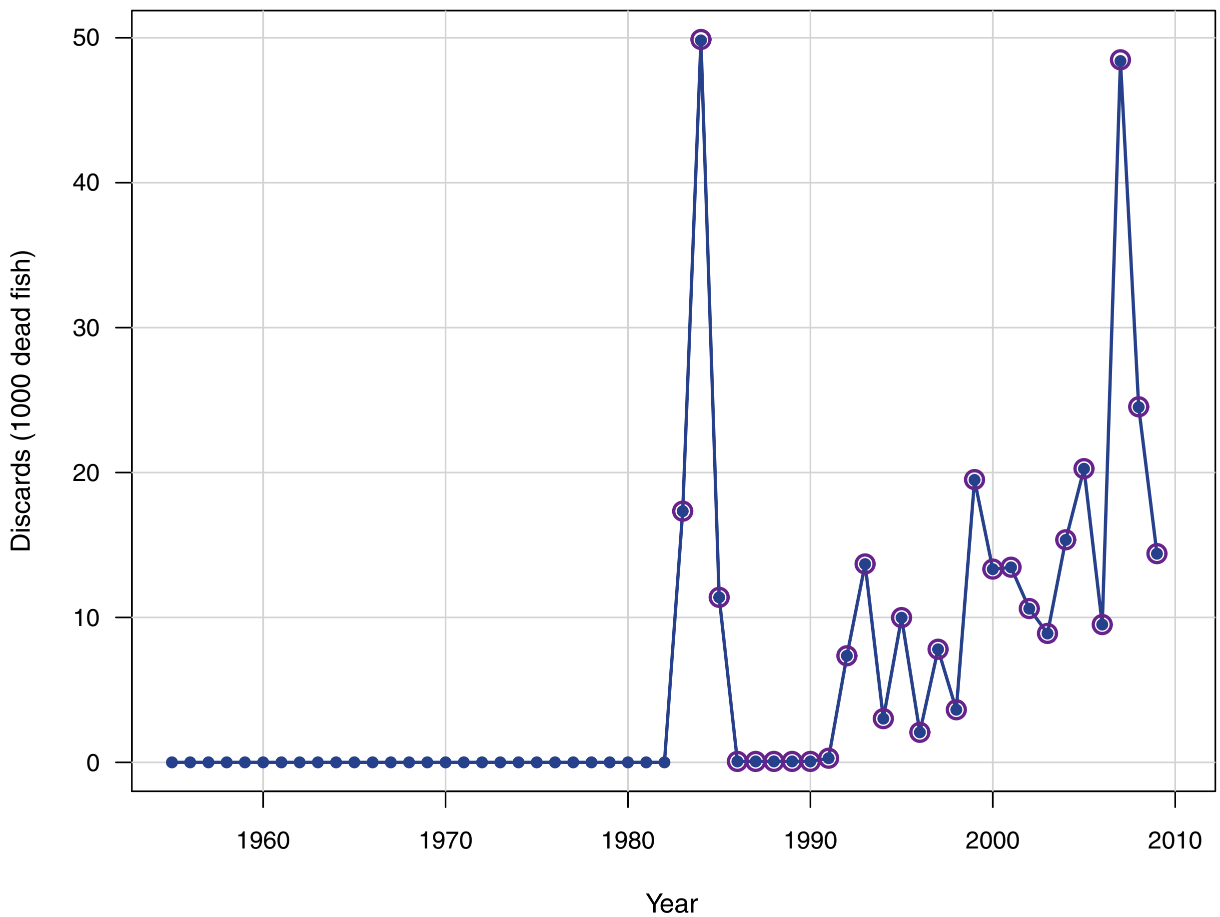


Figure 3.20. Observed (open circles) and estimated (line, solid circles) private recreational discard mortalities (1000 dead fish).

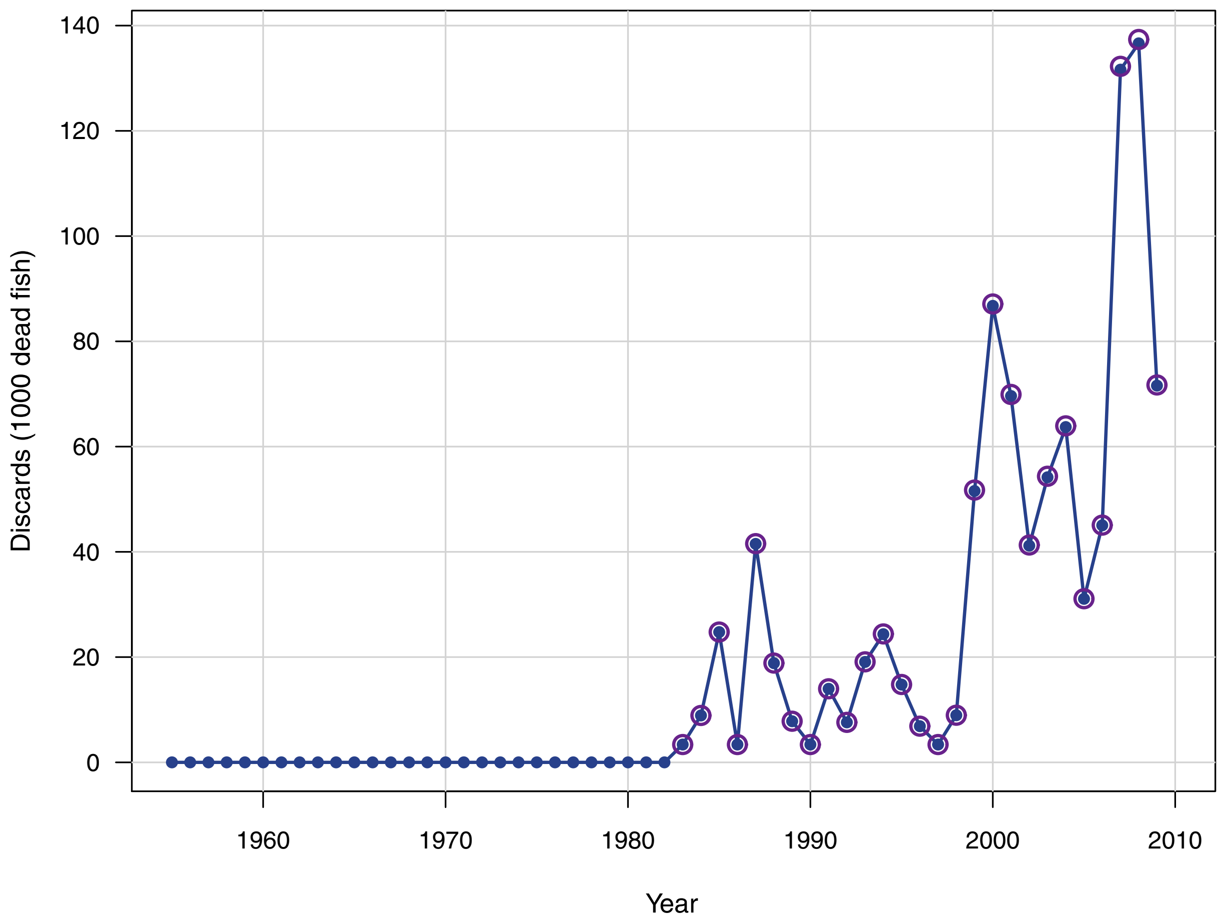


Figure 3.21. Observed (open circles) and estimated (line, solid circles) index of abundance from commercial lines.

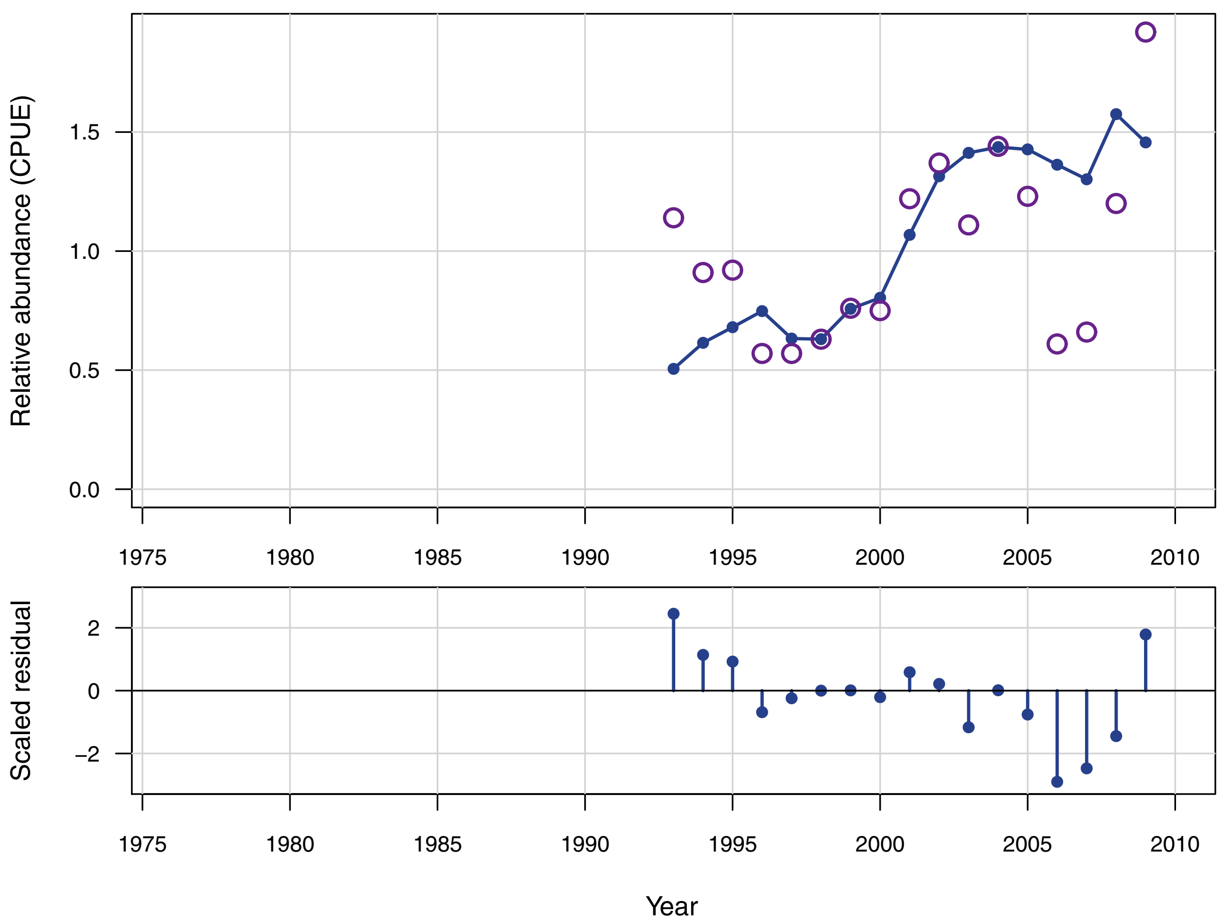


Figure 3.22. Observed (open circles) and estimated (line, solid circles) index of abundance from the for-hire (headboats) fleet.

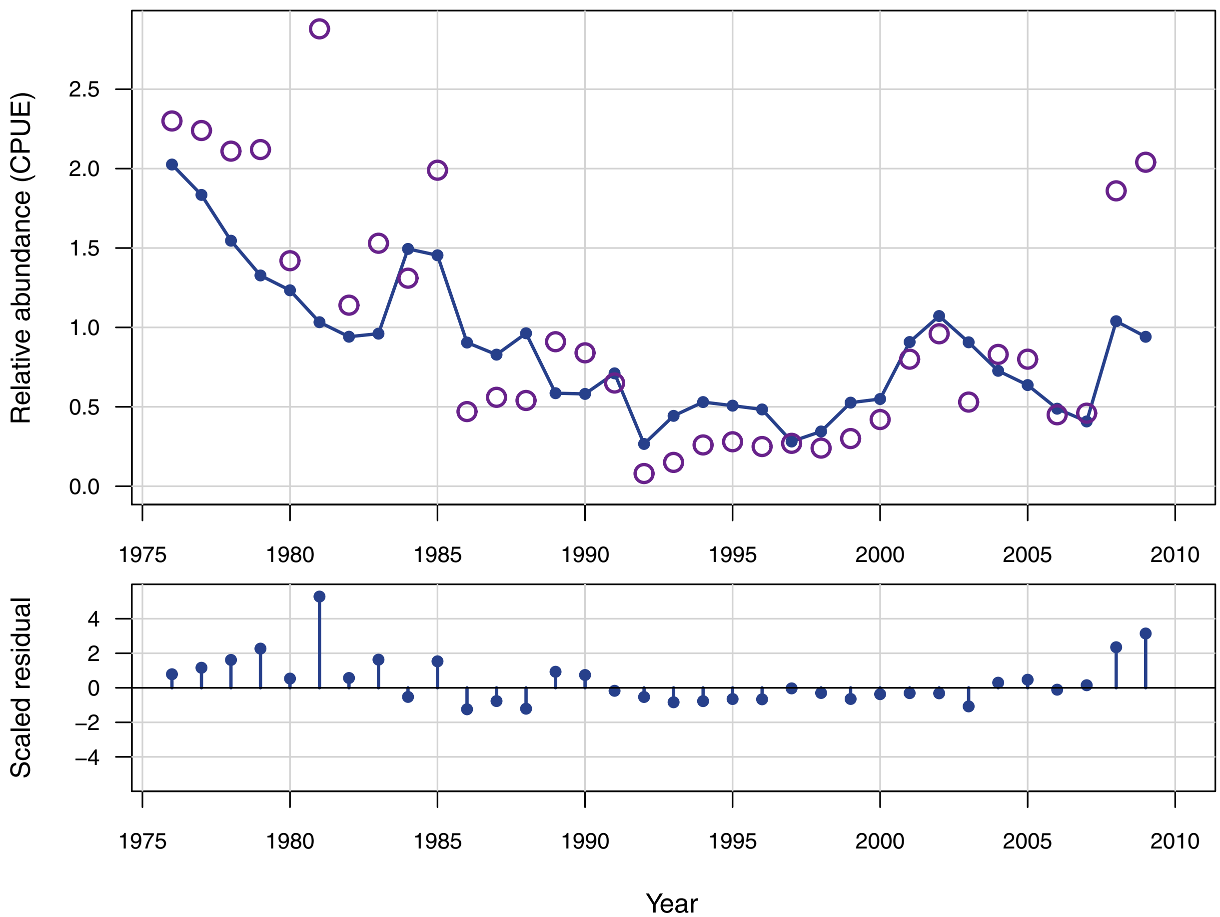


Figure 3.23. Observed (open circles) and estimated (line, solid circles) abundance from for-hire (headboat) discards.

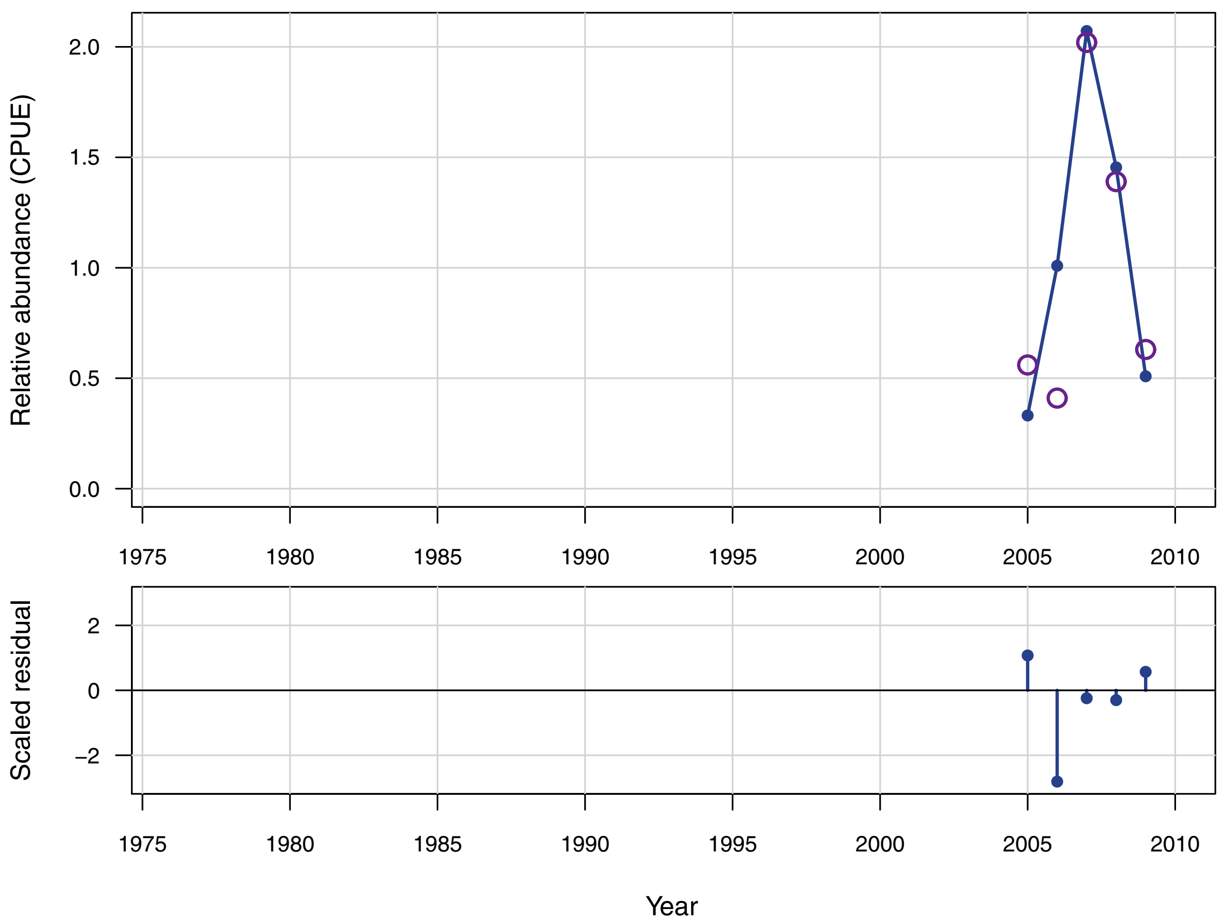


Figure 3.24. Estimated abundance at age at start of year.

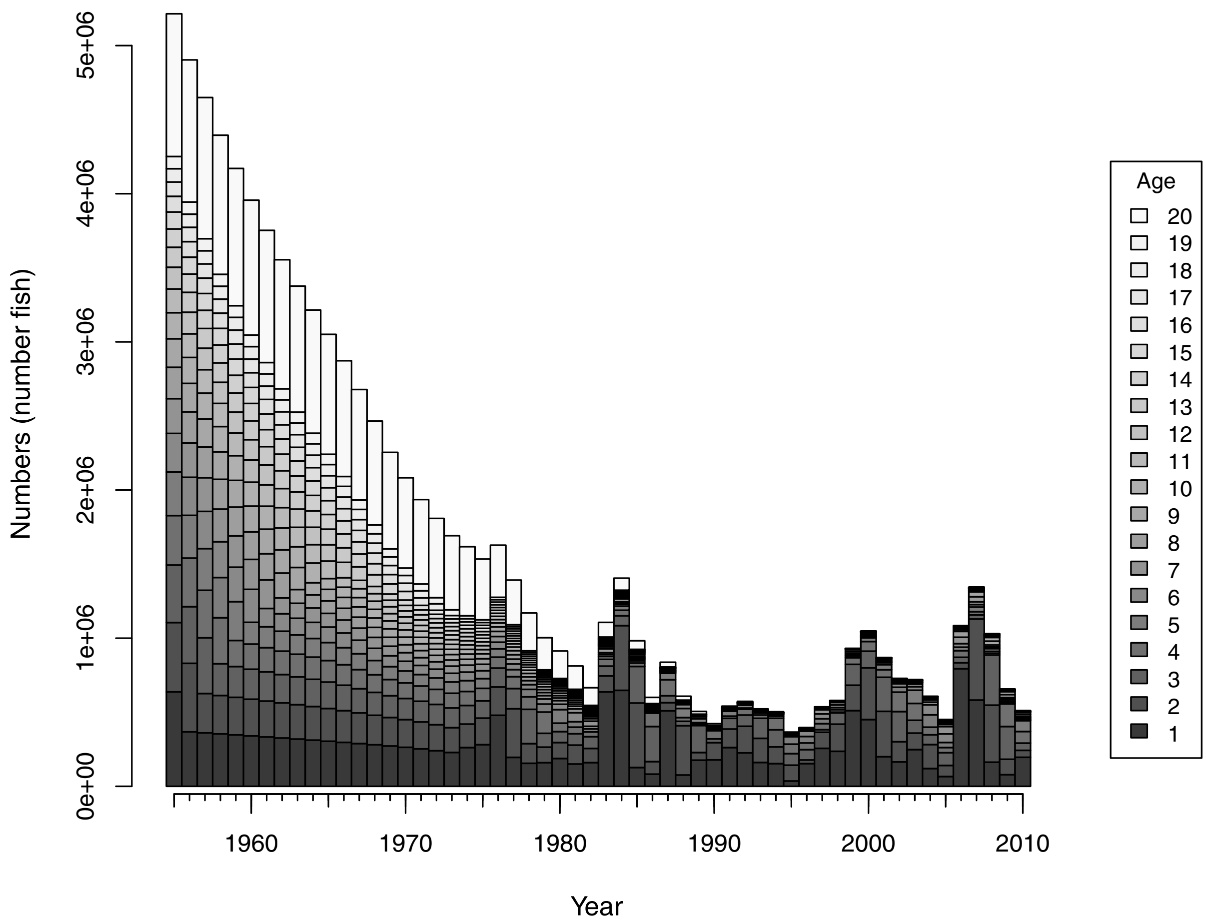


Figure 3.25. Top panel: Estimated recruitment of age-1 fish. Horizontal dashed line indicates R_{MSY}. Bottom panel: log recruitment residuals.

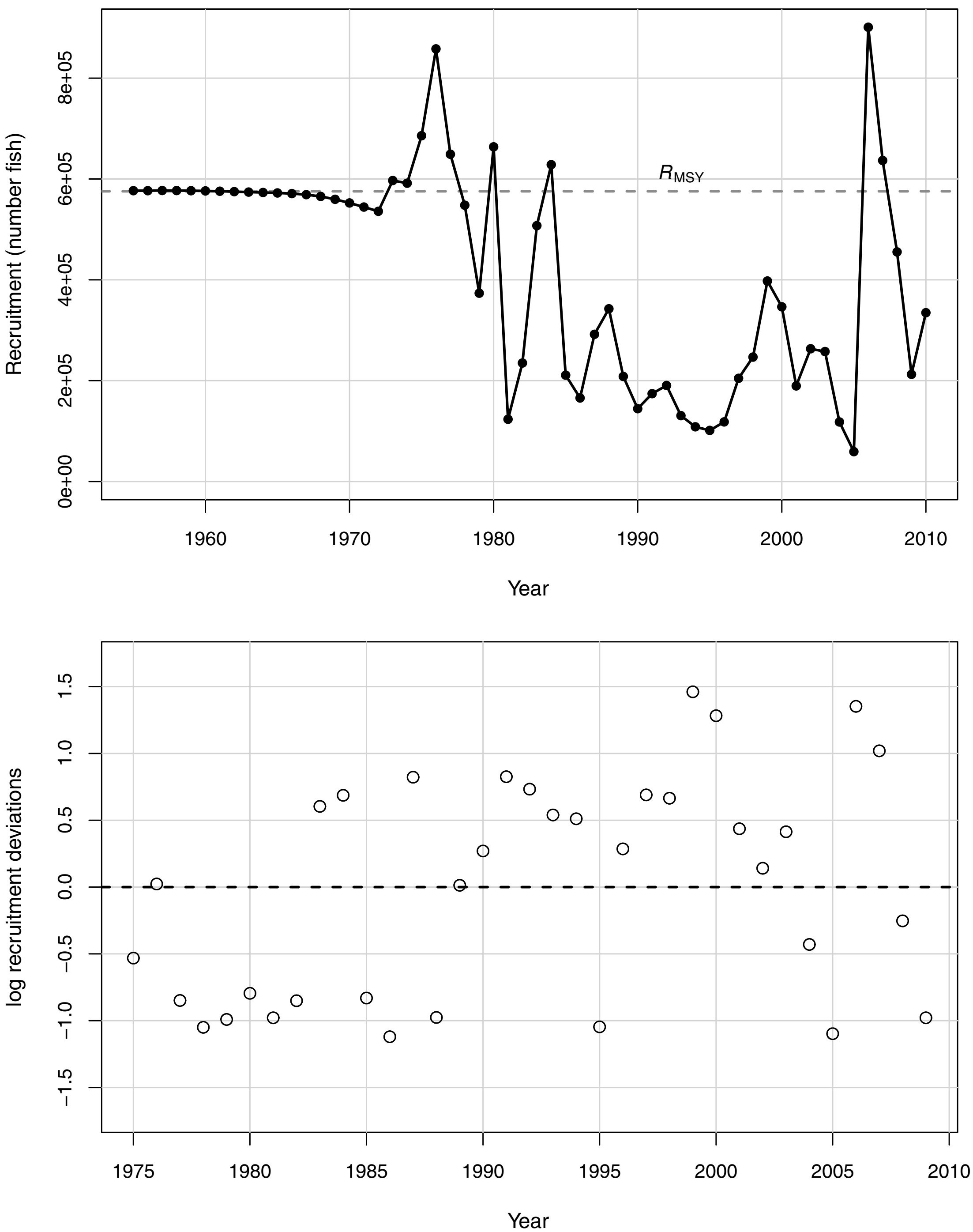


Figure 3.26. Estimated biomass at age at start of year.

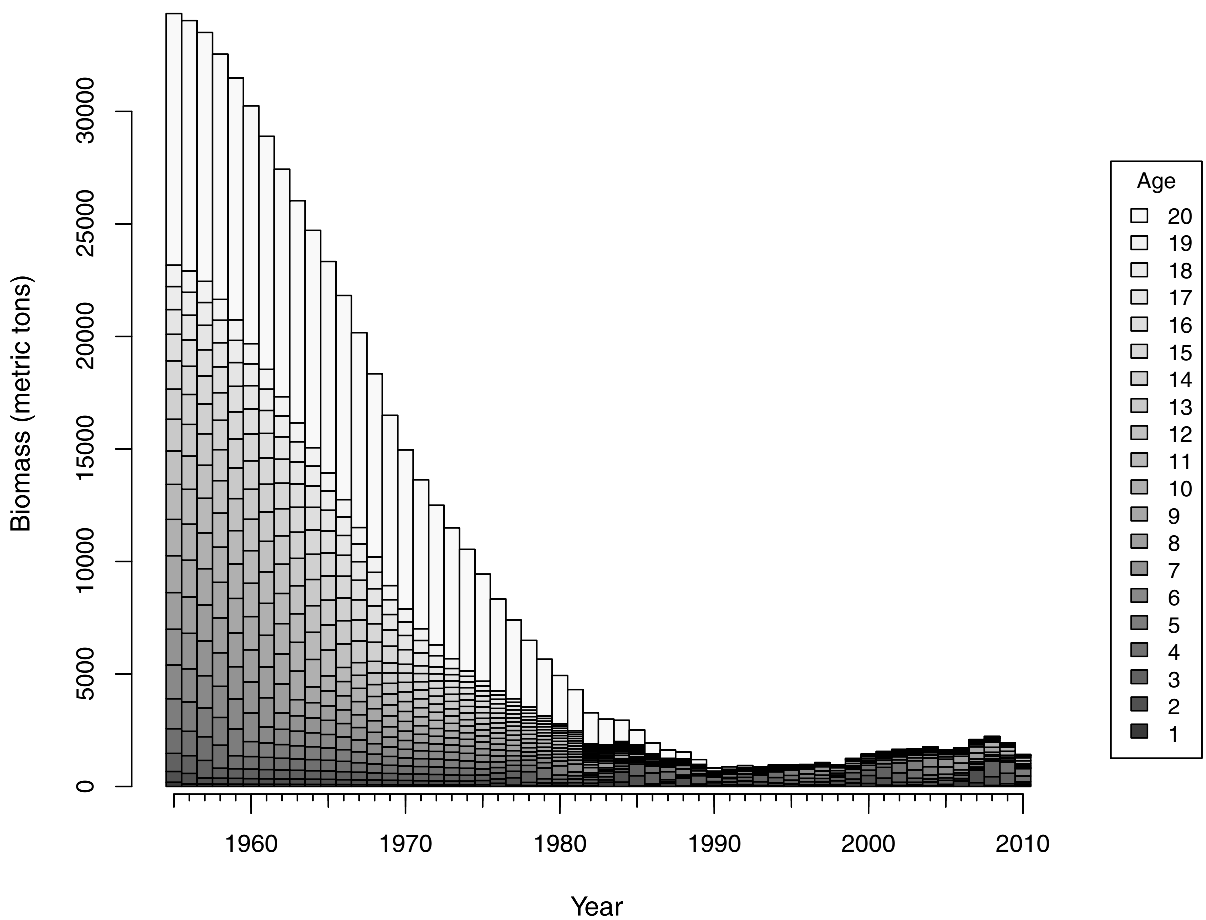
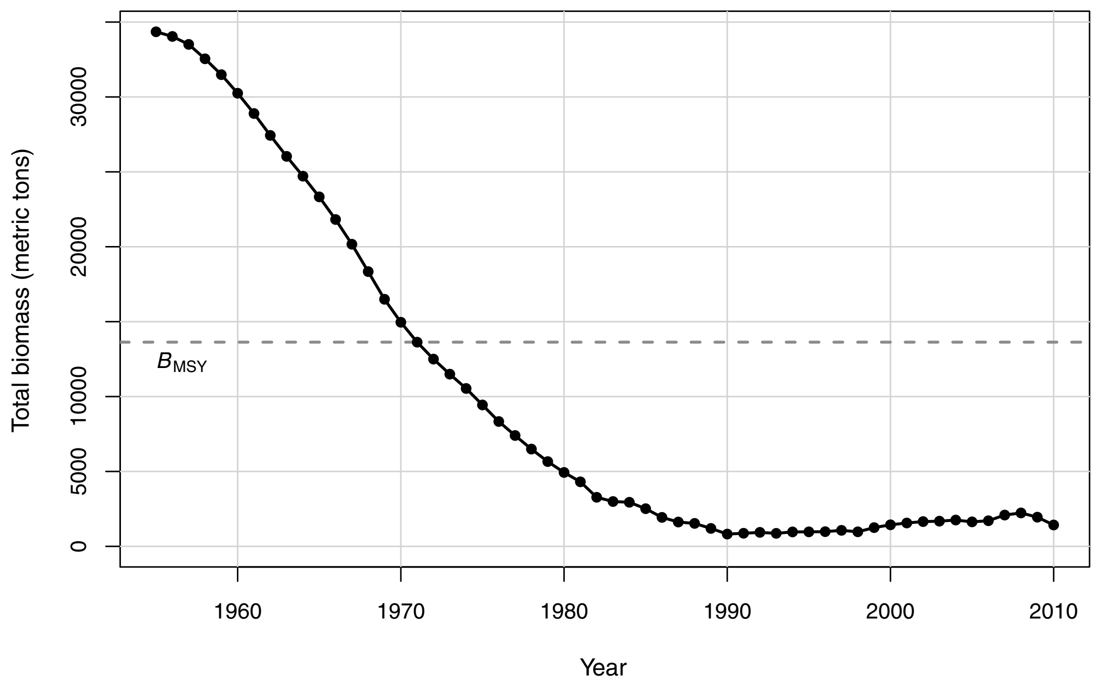


Figure 3.27. Top panel: Estimated total biomass (metric tons) at start of year. Horizontal dashed line indicates B_{MSY}. Bottom panel: Estimated spawning stock (gonad biomass of mature females) at time of peak spawning.



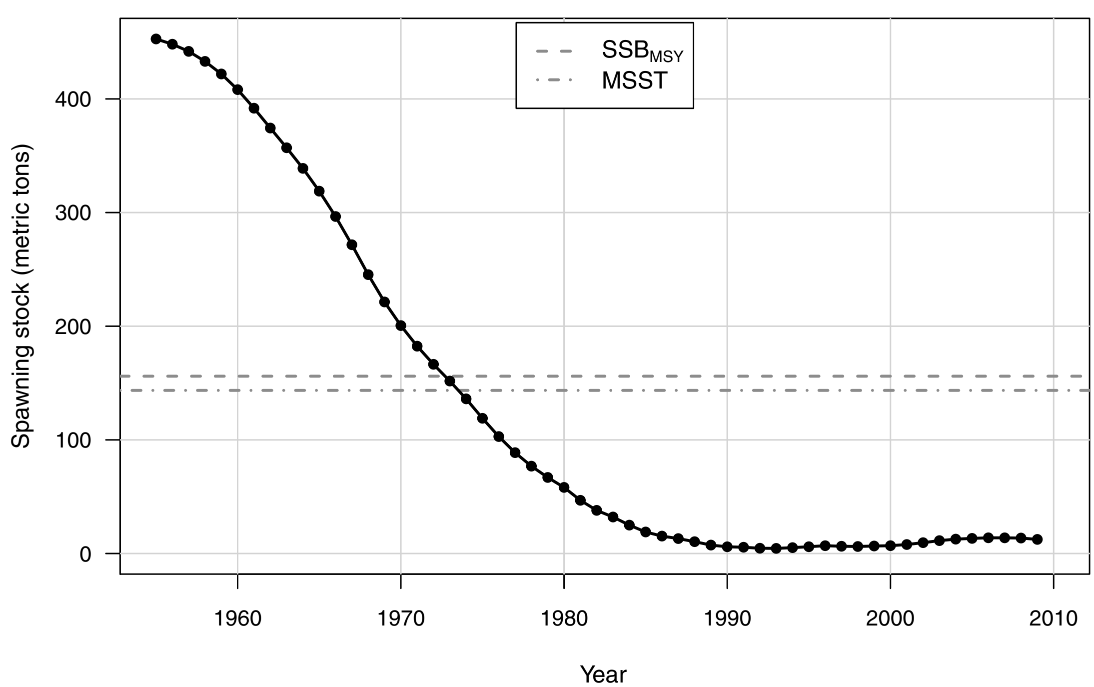


Figure 3.28. Selectivities of commercial fleets. Top panel: commercial lines, 1955–1991. Middle panel: commercial lines, 1992–2009. Bottom panel: commercial dive.

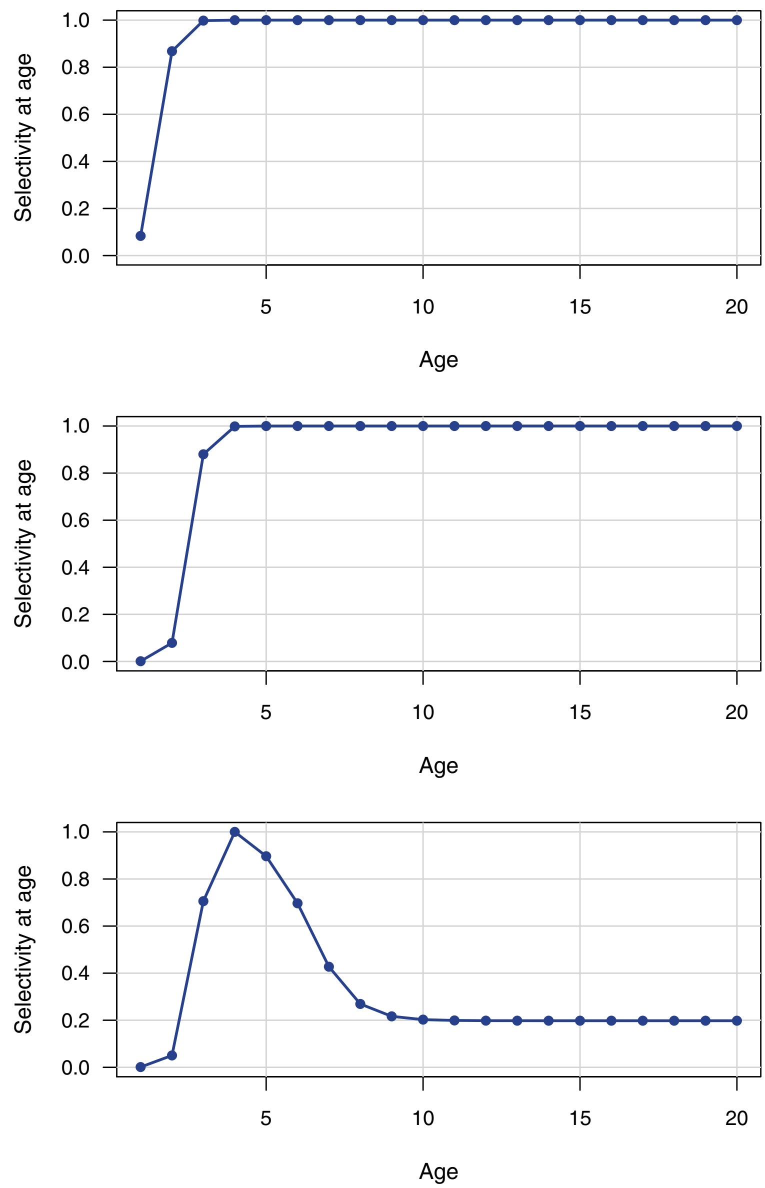


Figure 3.29. Selectivities of the for-hire fleet. Top panel: 1955–1983. Middle panel: 1983–1991. Bottom panel: 1992–2009.

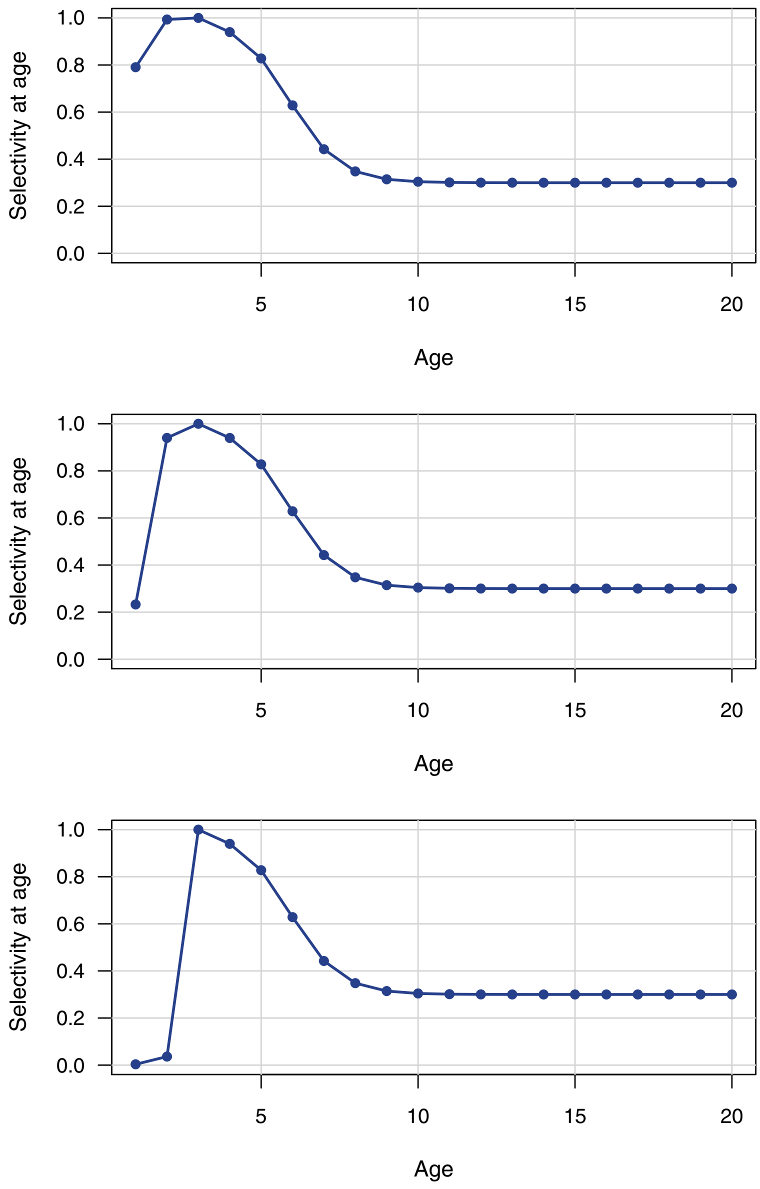


Figure 3.30. Selectivities of the private recreational fleet. Top panel: 1955–1983. Bottom panel: 1992–2009.

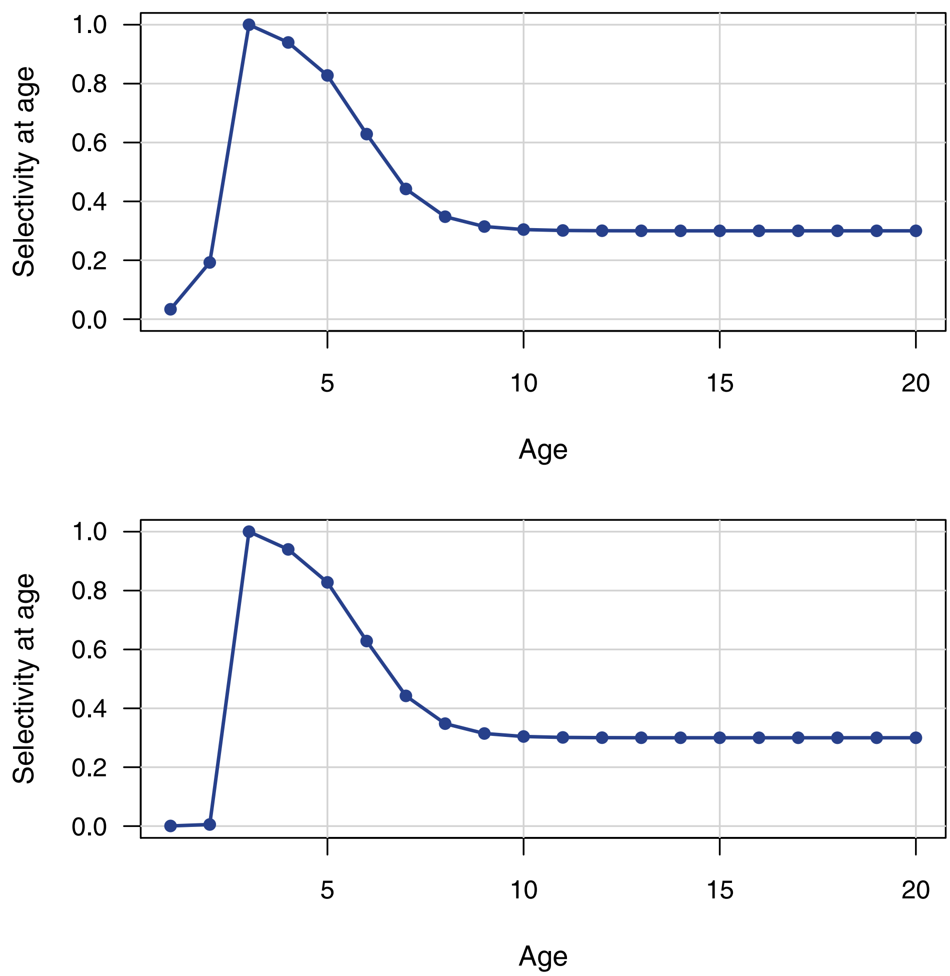


Figure 3.31. Selectivities of discard mortalities. Top panel: commercial lines, 1992–2009. Middle panel: recreational (for-hire and private), 1983–1991. Bottom panel: recreational (for-hire and private), 1992–2009.

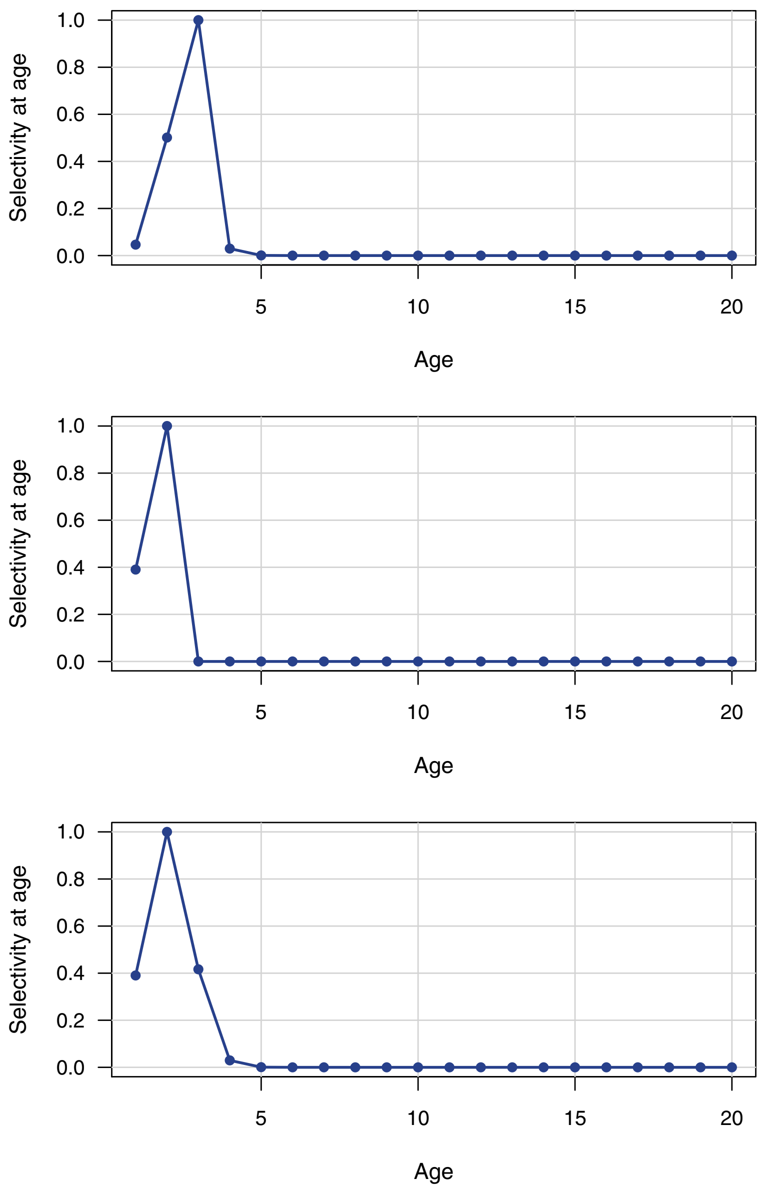


Figure 3.32. Average selectivities from the terminal assessment year (2009, 20-inch limit), weighted by geometric mean Fs from the last three assessment years, and used in computation of benchmarks and central-tendency projections. Top panel: average selectivity applied to landings. Middle panel: average selectivity applied to discard mortalities. Bottom panel: total average selectivity.

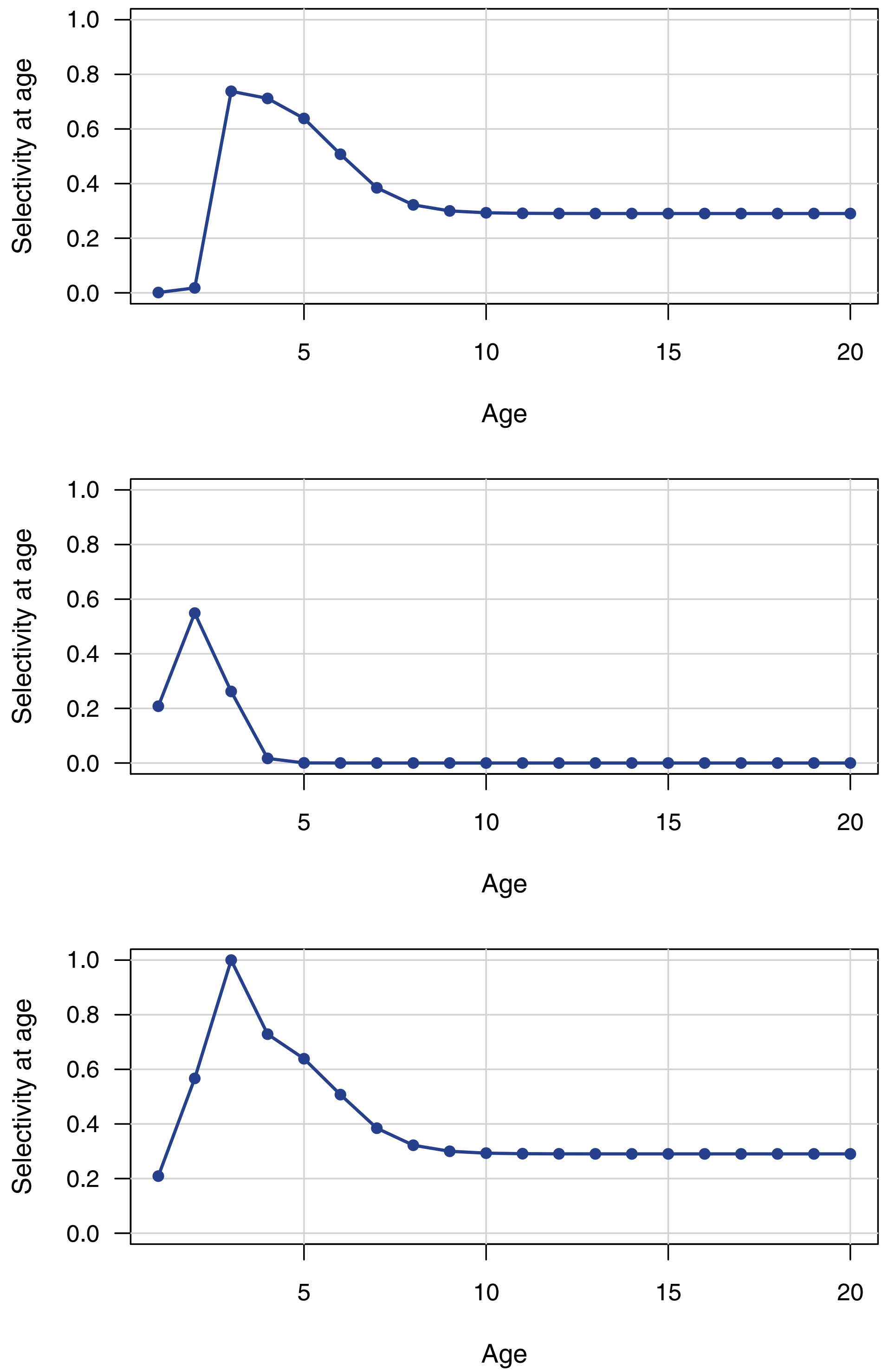


Figure 3.33. Estimated fully selected fishing mortality rate (per year) by fishery. cl refers to commercial lines, cd to commercial dive, hb to for-hire, pvt to private recreational, cl.D to commercial discard mortalities, hb.D to for-hire discard mortalities, and pvt.D to private recreational discard mortalities.

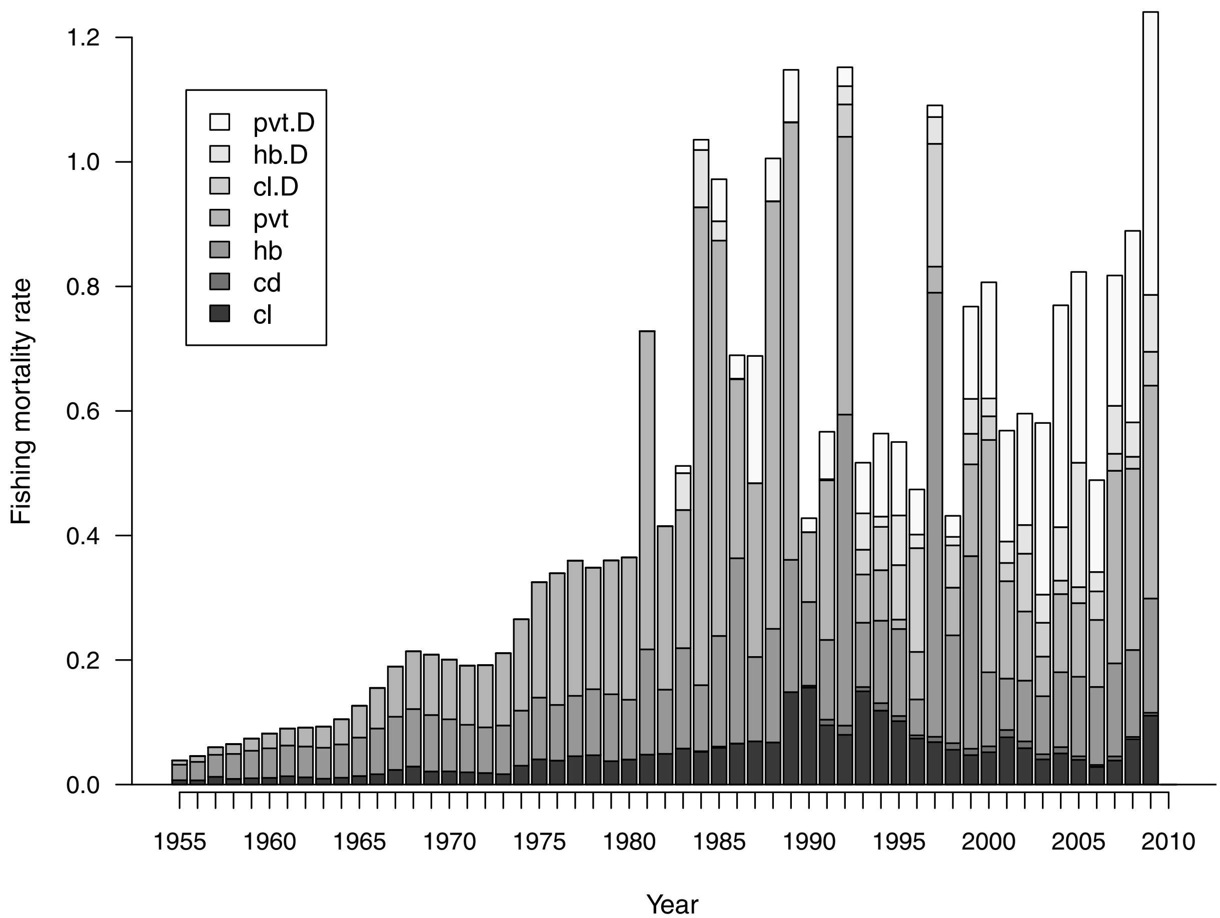


Figure 3.34. Estimated landings in numbers by fishery from the catch-age model. cl refers to commercial lines, cd to commercial dive, hb to for-hire, pvt to private recreational.

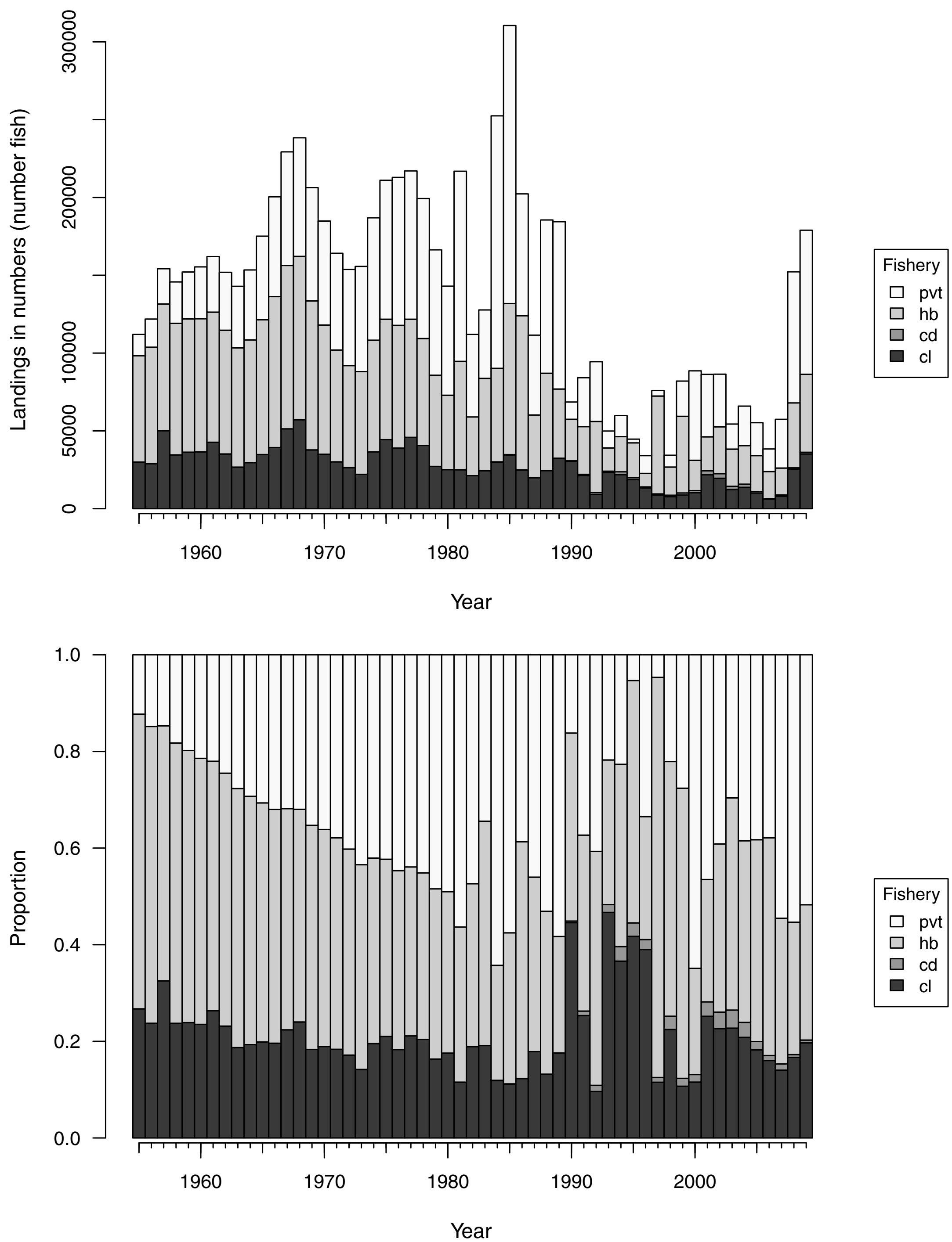


Figure 3.35. Estimated landings in whole weight by fishery from the catch-age model. cl refers to commercial lines, cd to commercial dive, hb to for-hire, pvt to private recreational. Horizontal dashed line in the top panel corresponds to the point estimate of MSY.

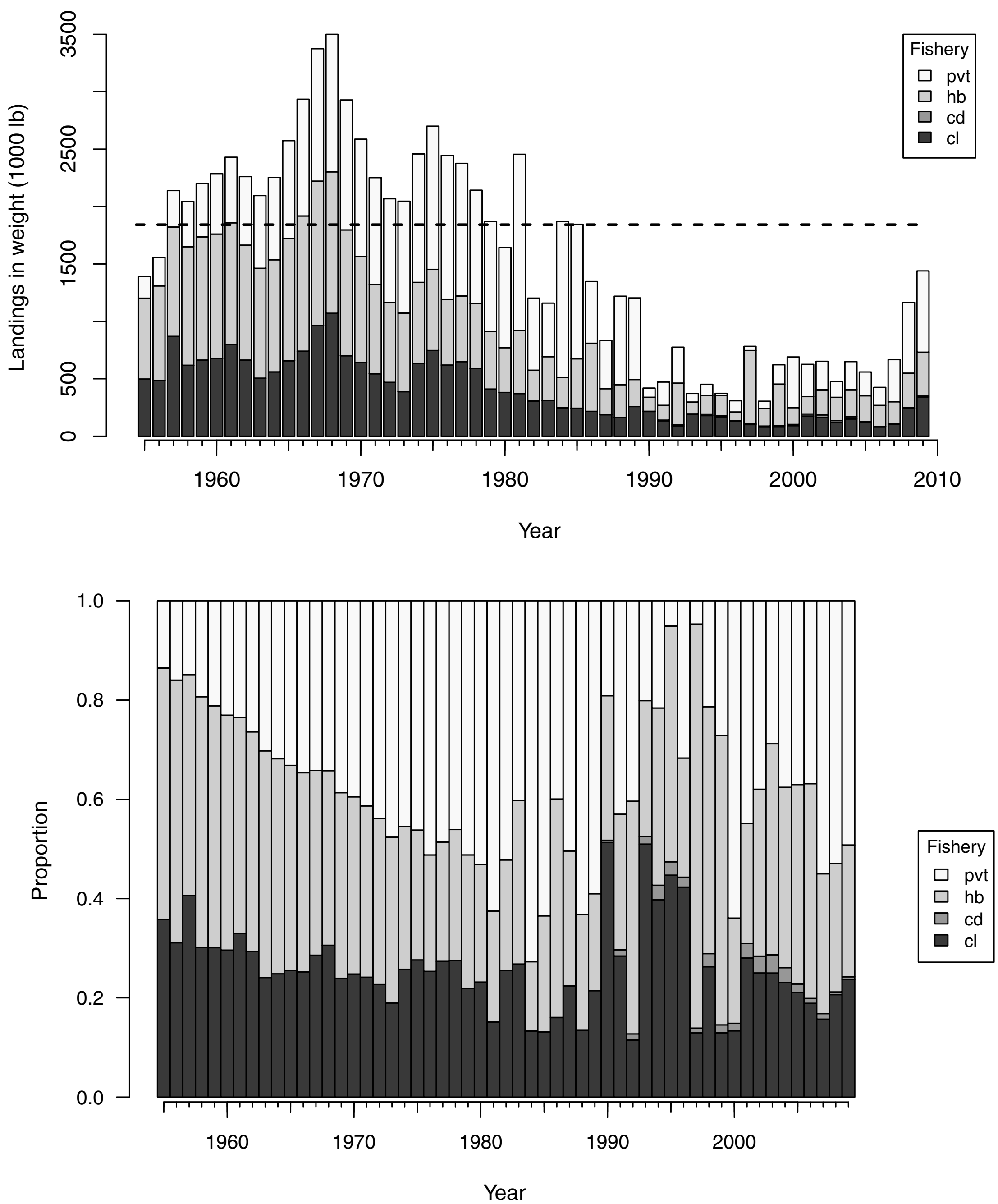


Figure 3.36. Estimated discard mortalities by fishery from the catch-age model. cl refers to commercial lines, hb to for-hire, pvt to private recreational.

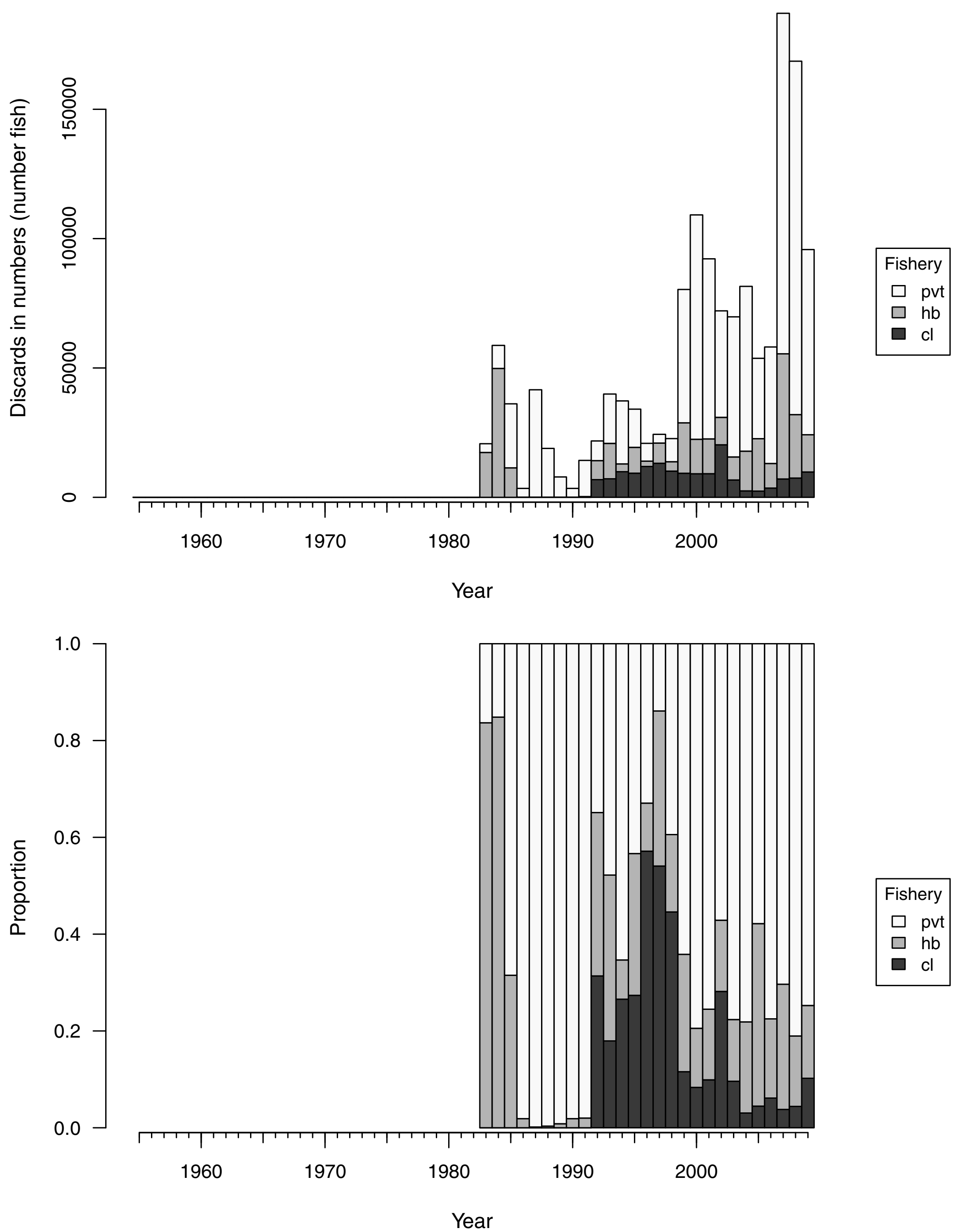
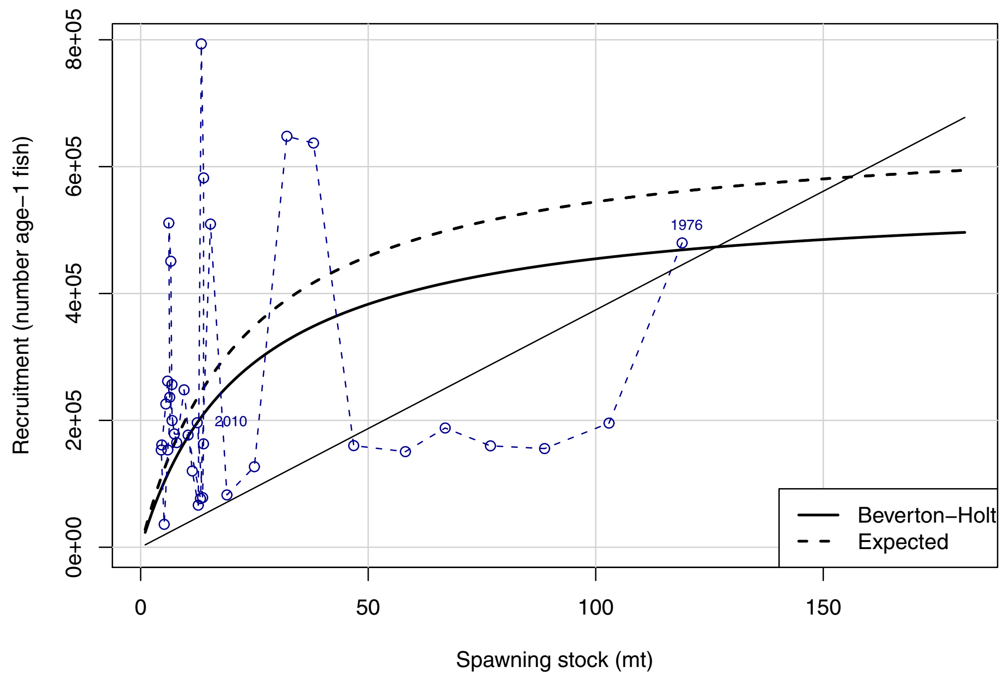


Figure 3.37. Top panel: Beverton–Holt spawner-recruit curves, with and without lognormal bias correction. The expected (upper) curve was used for computing management benchmarks. Years within panel indicate year of recruitment generated from spawning biomass one year prior. Diagonal line indicates MSY-level replacement. Bottom panel: log of recruits (number age-1 fish) per spawner (mature female gonad weight) as a function of spawners.



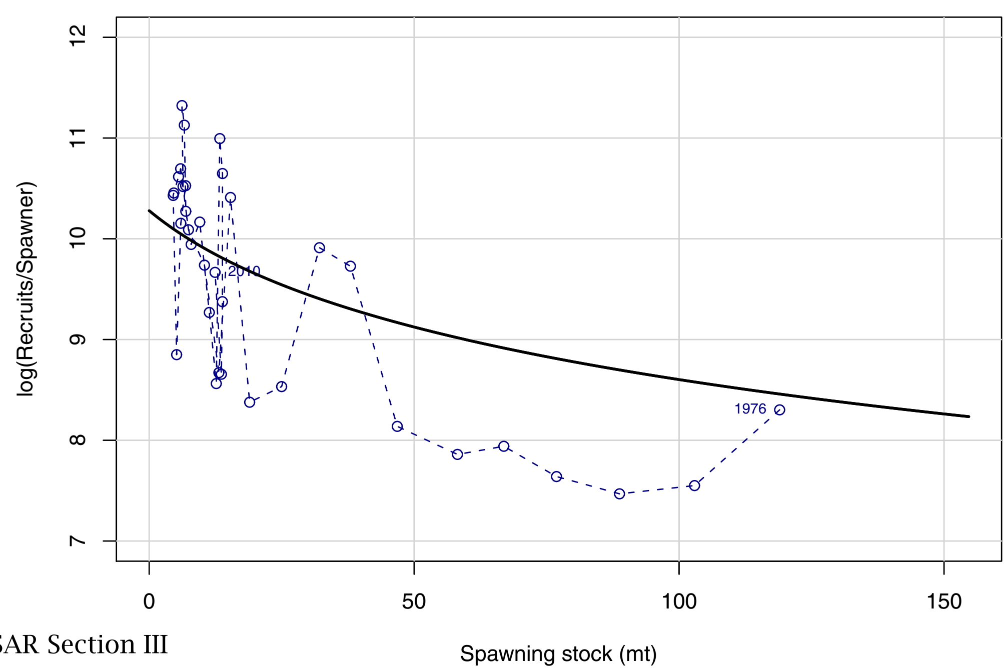


Figure 3.38. Probability densities of spawner-recruit quantities R0 (unfished recruitment of age-1 fish), steepness, unfished spawners per recruit, and standard deviation of recruitment residuals in log space. Vertical lines represent point estimates or values from the base run of the Beaufort Assessment Model.

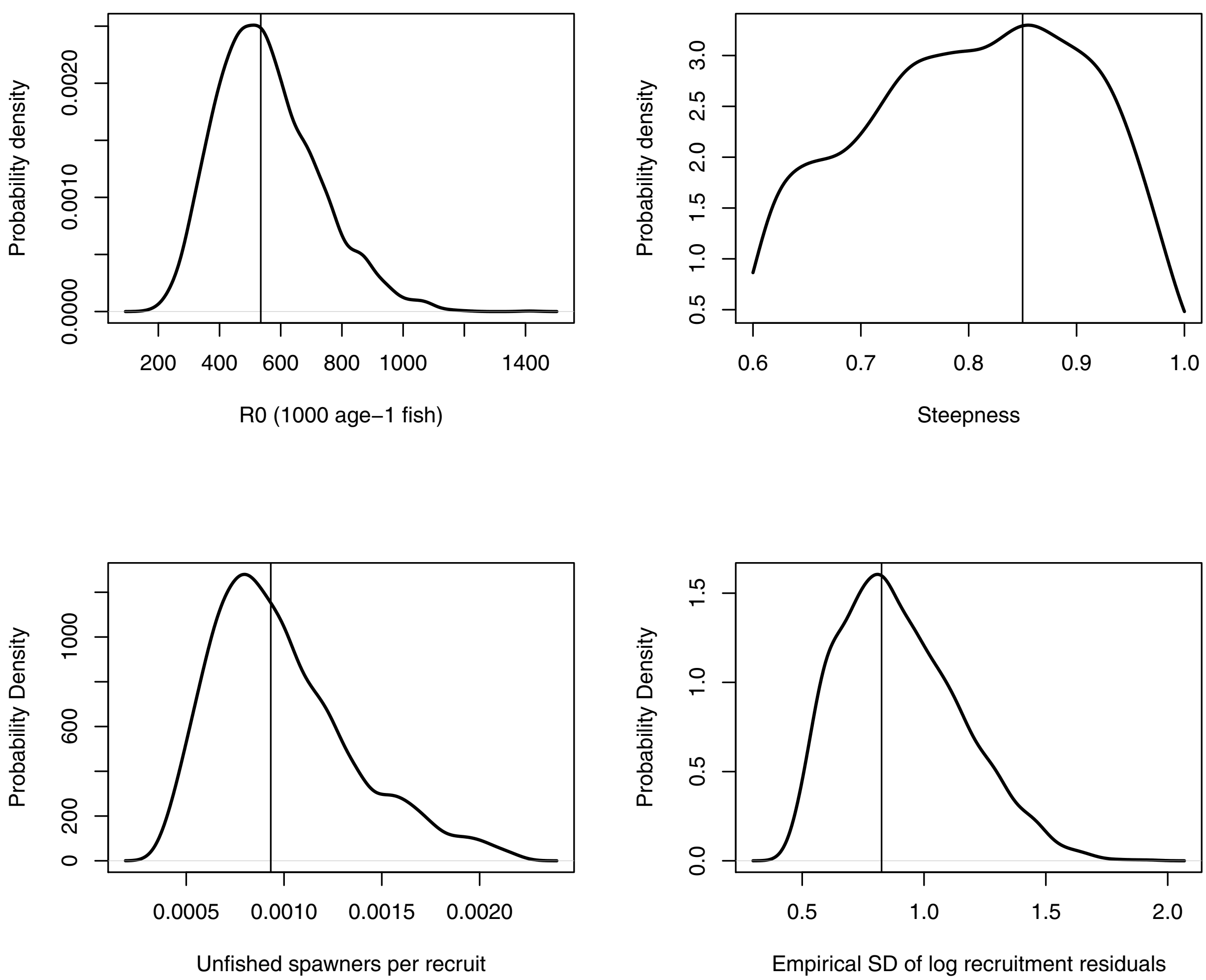


Figure 3.39. Estimated time series of static spawning potential ratio, the annual equilibrium spawners per recruit relative to that at the unfished level. Horizontal dashed line indicates the equilibrium MSY level.

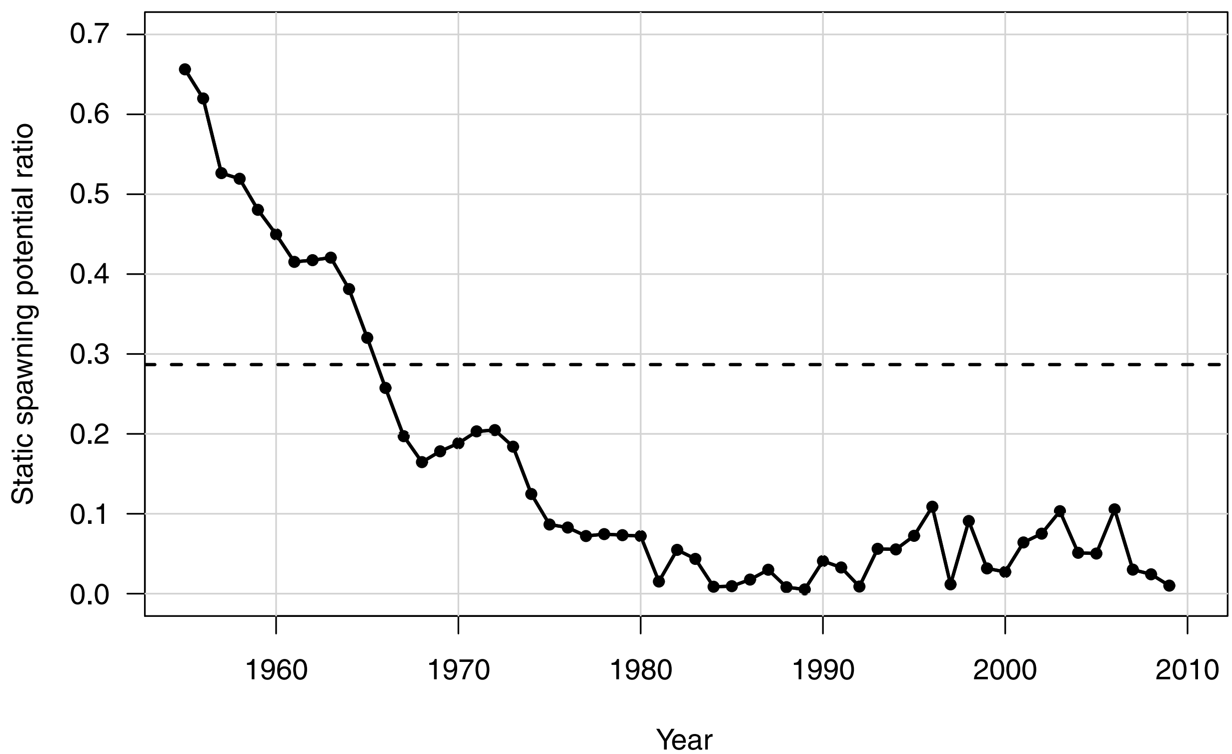


Figure 3.40. Top panel: yield per recruit. Bottom panel: spawning potential ratio (spawning biomass per recruit relative to that at the unfished level), from which the y% levels provide $F_{y\%}$. Both curves are based on average selectivity from the end of the assessment period.

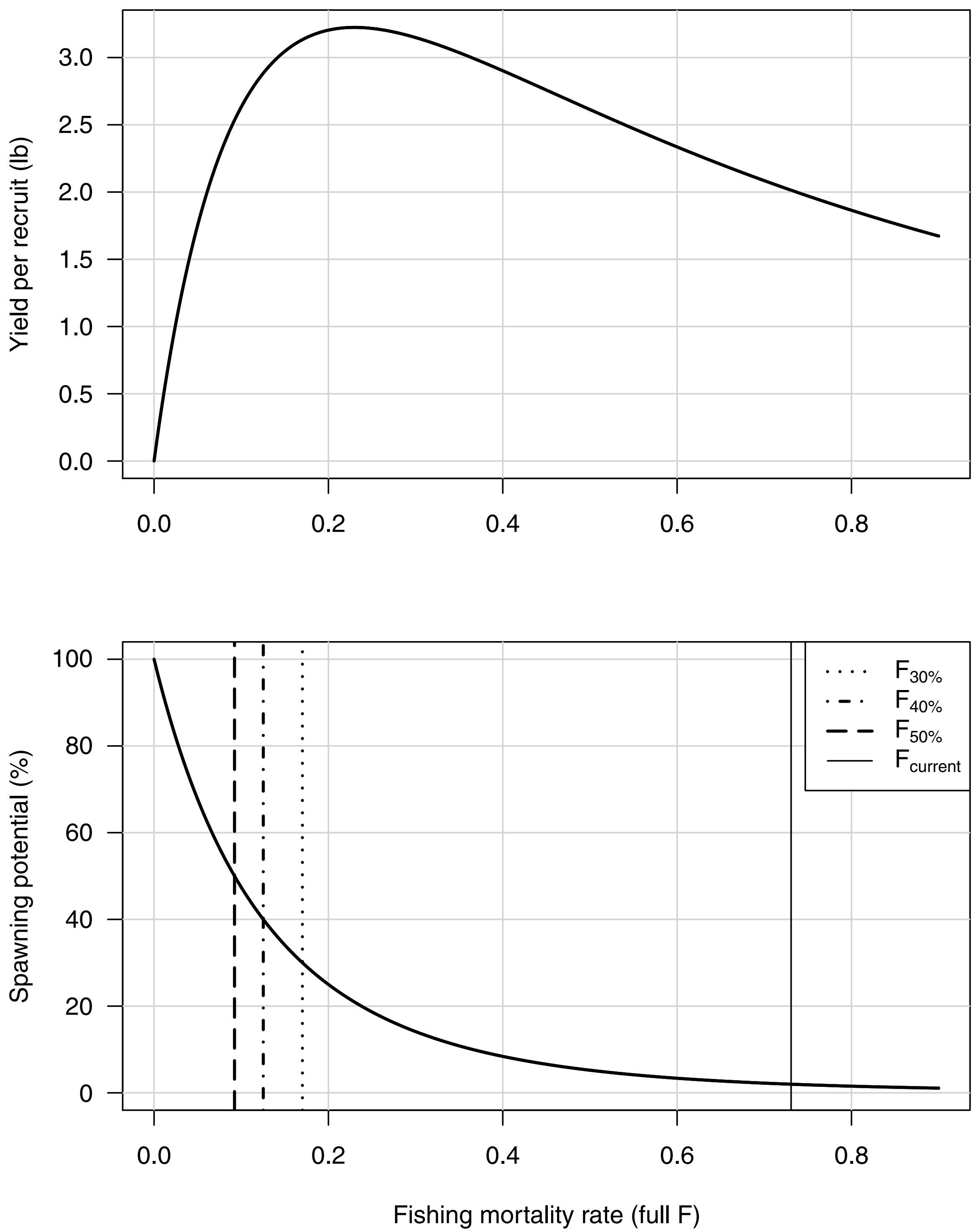


Figure 3.41. Top panel: equilibrium landings. The peak occurs where fishing rate is $F_{\mathrm{MSY}} = 0.178$ *and equilibrium landings are* MSY = 1842 *(1000 lb). Bottom panel: equilibrium spawning biomass. Both curves are based on average selectivity from the end of the assessment period.*

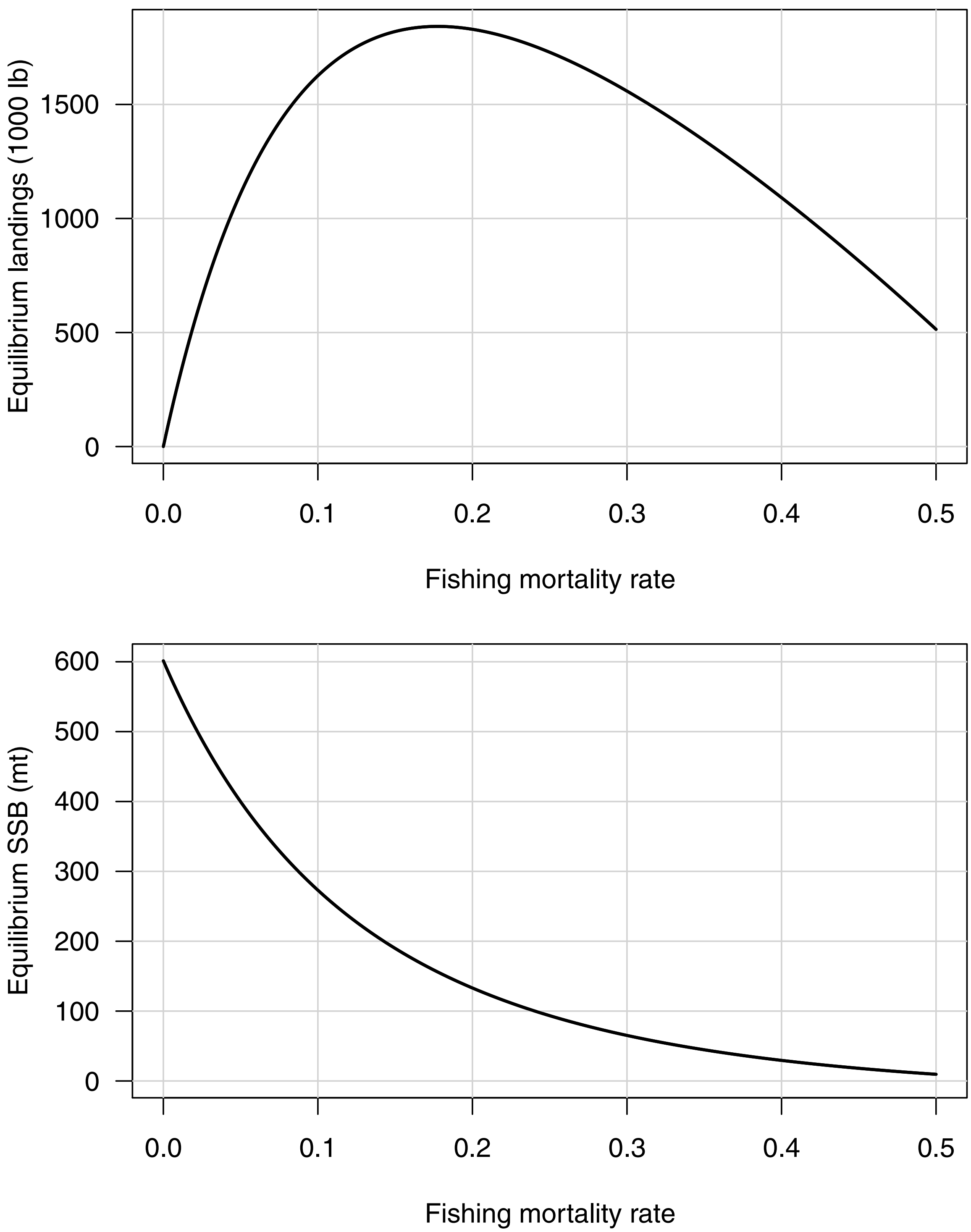


Figure 3.42. Top panel: equilibrium landings as a function of equilibrium biomass, which itself is a function of fishing mortality rate. The peak occurs where equilibrium biomass is $B_{\mathrm{MSY}} = 13632$ *mt and equilibrium landings are* MSY = 1842 *(1000 lb). Bottom panel: equilibrium discard mortality as a function of equilibrium biomass.*

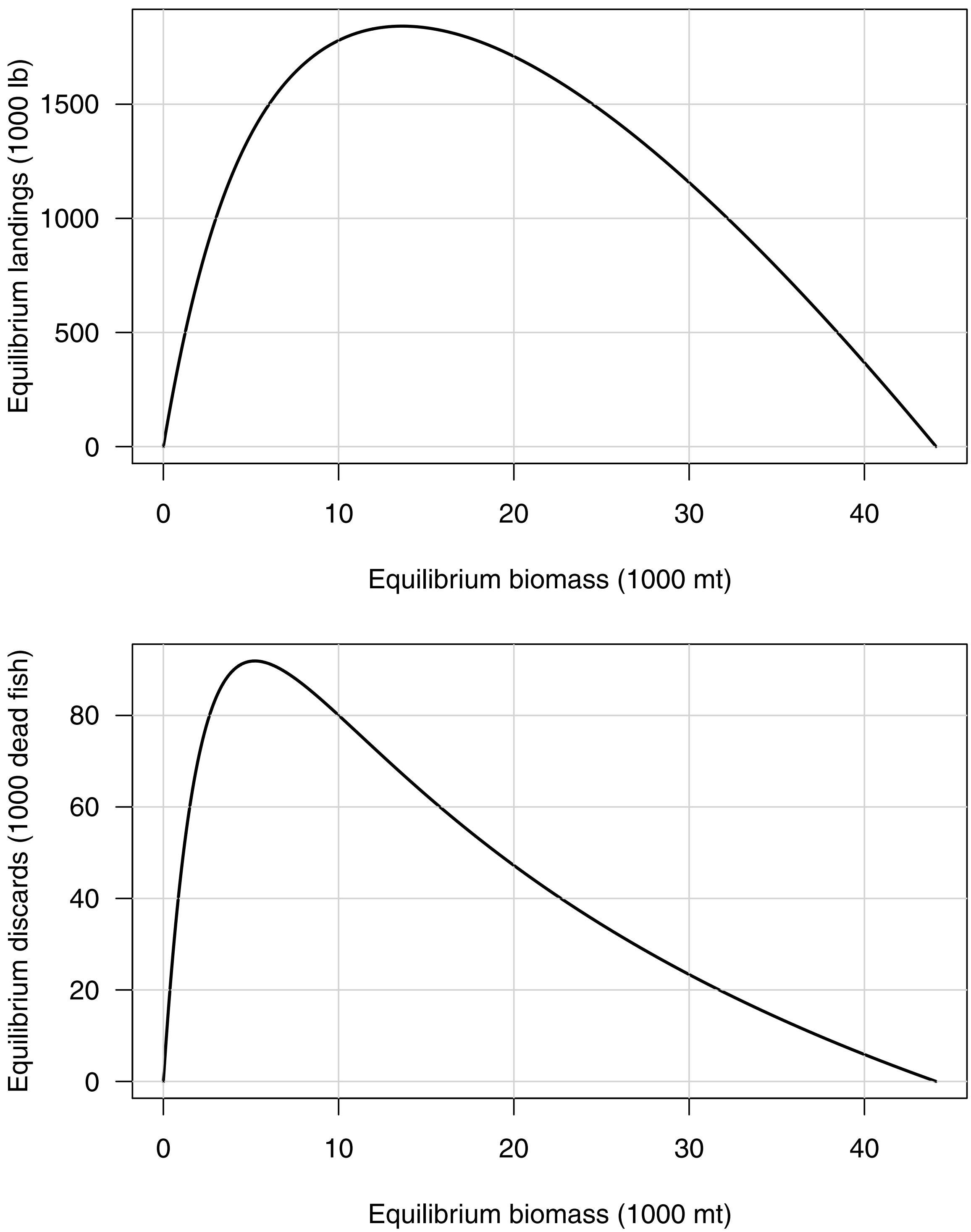


Figure 3.43. Probability densities of MSY*-related benchmarks from MCB analysis of the Beaufort Assessment Model. Vertical lines represent point estimates from the base run.*

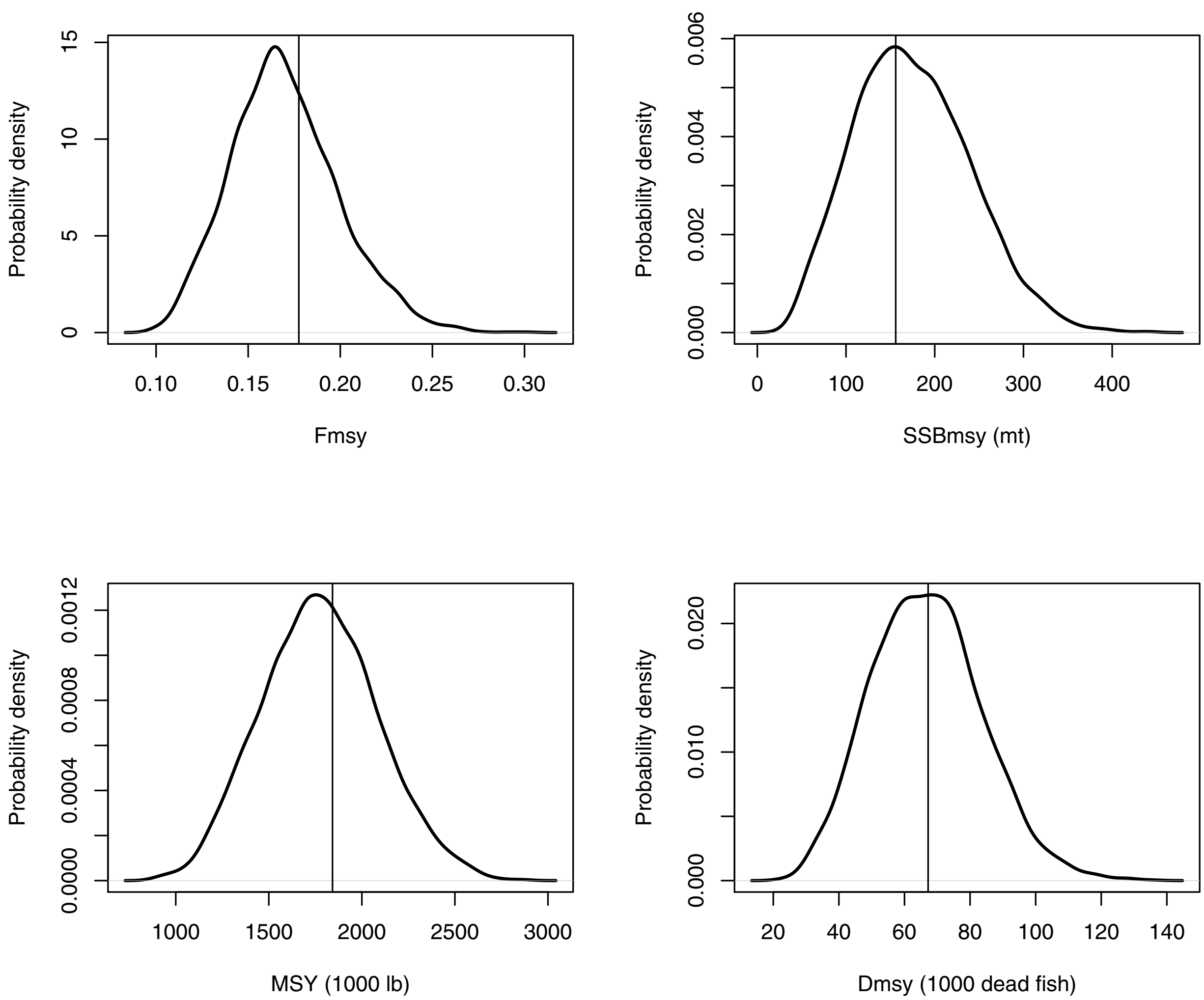


*Figure 3.44. Estimated time series relative to benchmarks. Solid line indicates estimates from base run of the Beaufort Assessment Model; gray error bands indicate 5^{th} and 95^{th} percentiles of the MCB trials. Top panel: spawning biomass relative to the minimum stock size threshold (*MSST*). Bottom panel: F relative to F_{MSY}.*

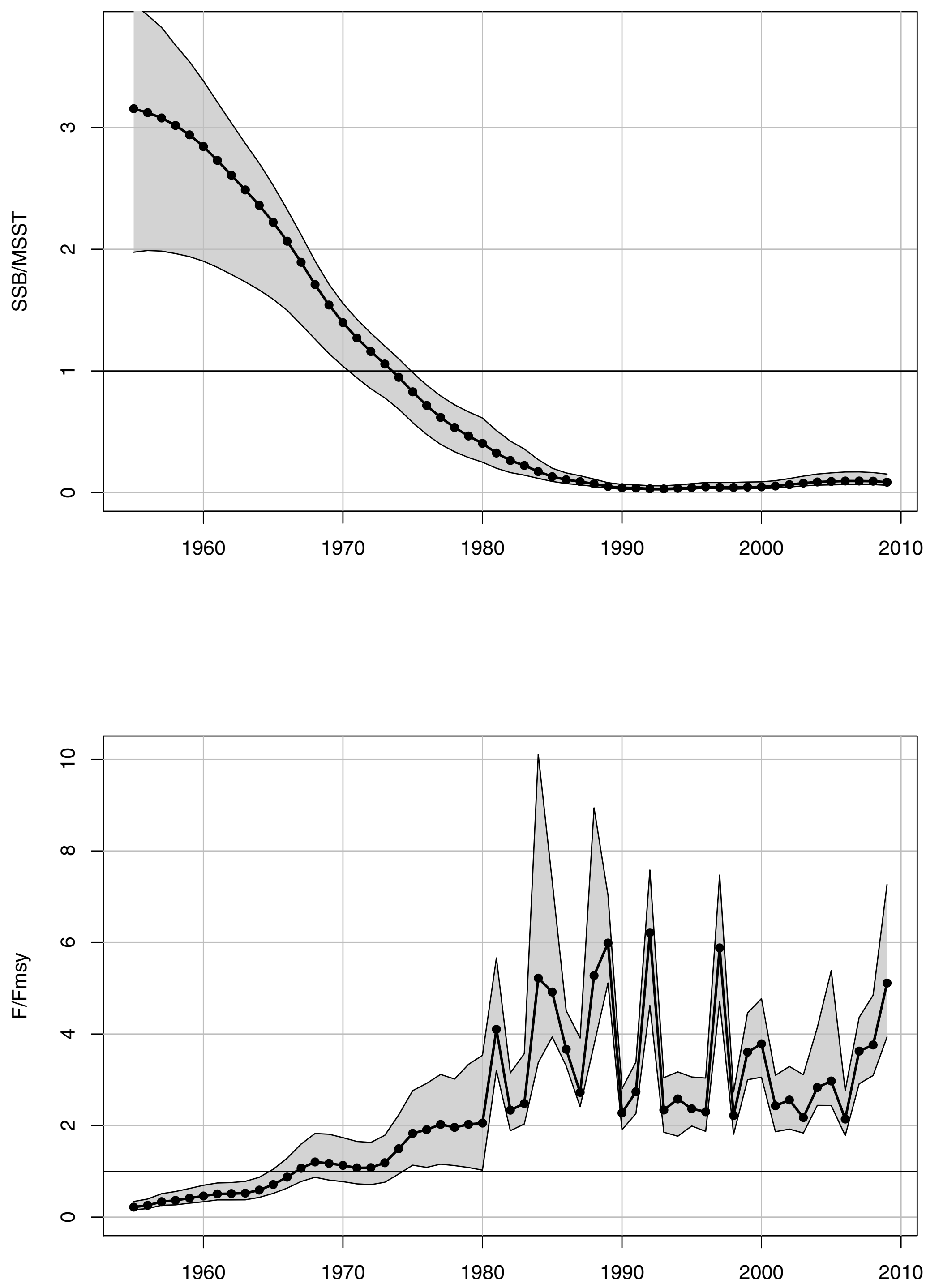


Figure 3.45. Probability densities of terminal status estimates from MCB analysis of the Beaufort Assessment Model. Vertical lines represent point estimates from the base run.

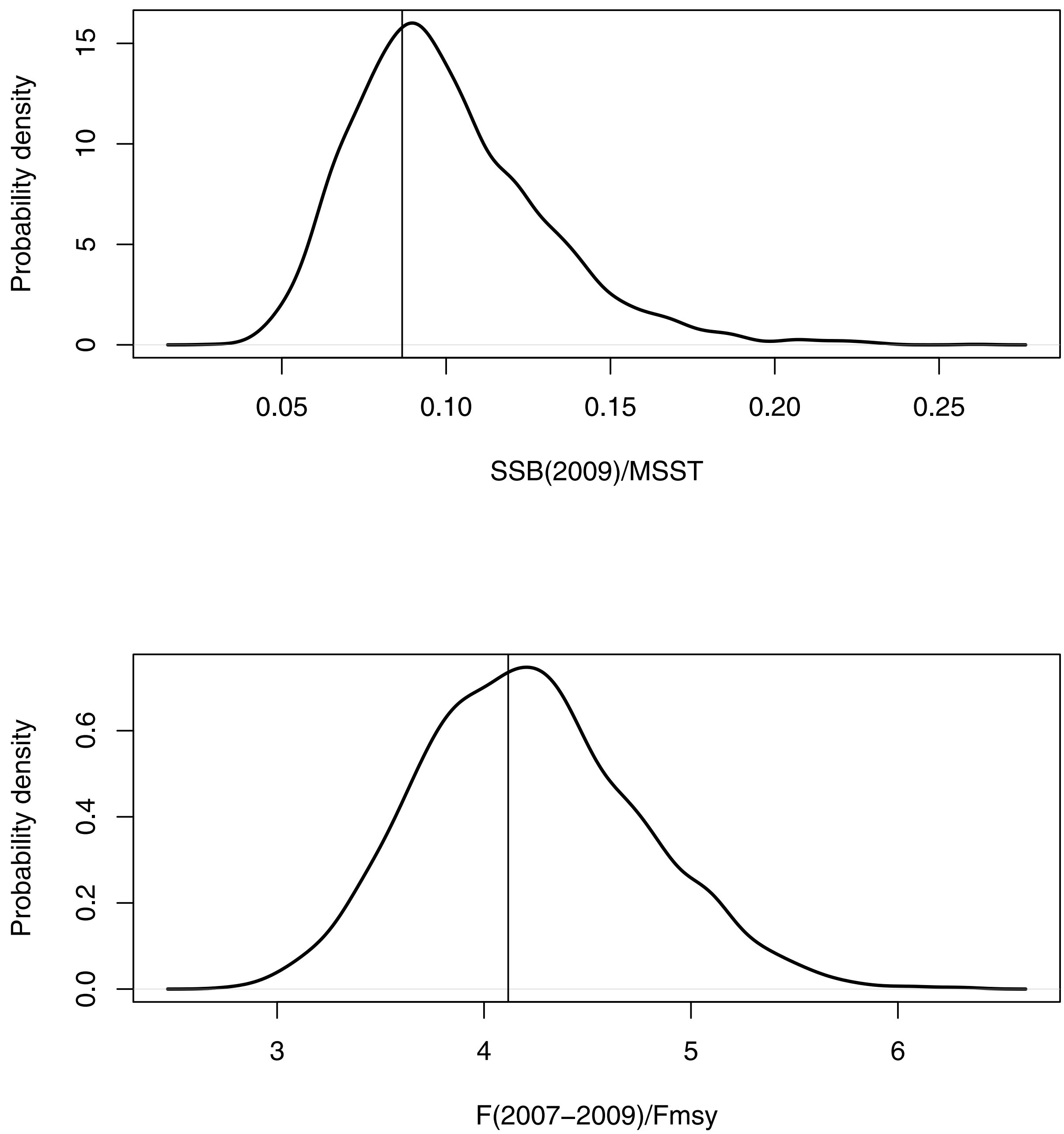


Figure 3.46. Phase plot of terminal status estimates from MCB analysis of the Beaufort Assessment Model. The intersection of crosshairs indicates estimates from the base run; lengths of crosshairs defined by 5^{th} *and* 95^{th} *percentiles.*

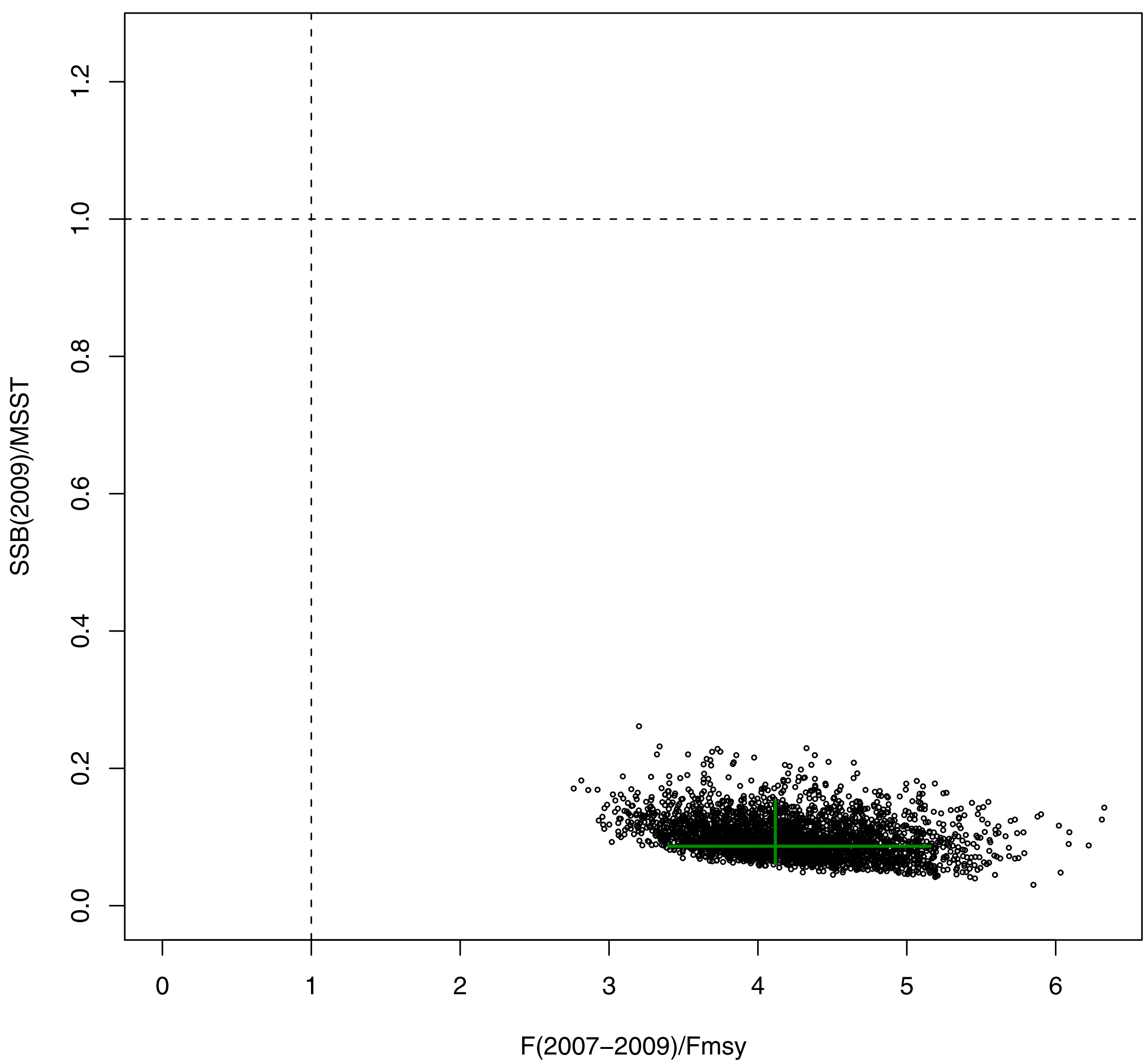


Figure 3.47. Age structure relative to the equilibrium expected at MSY*.*

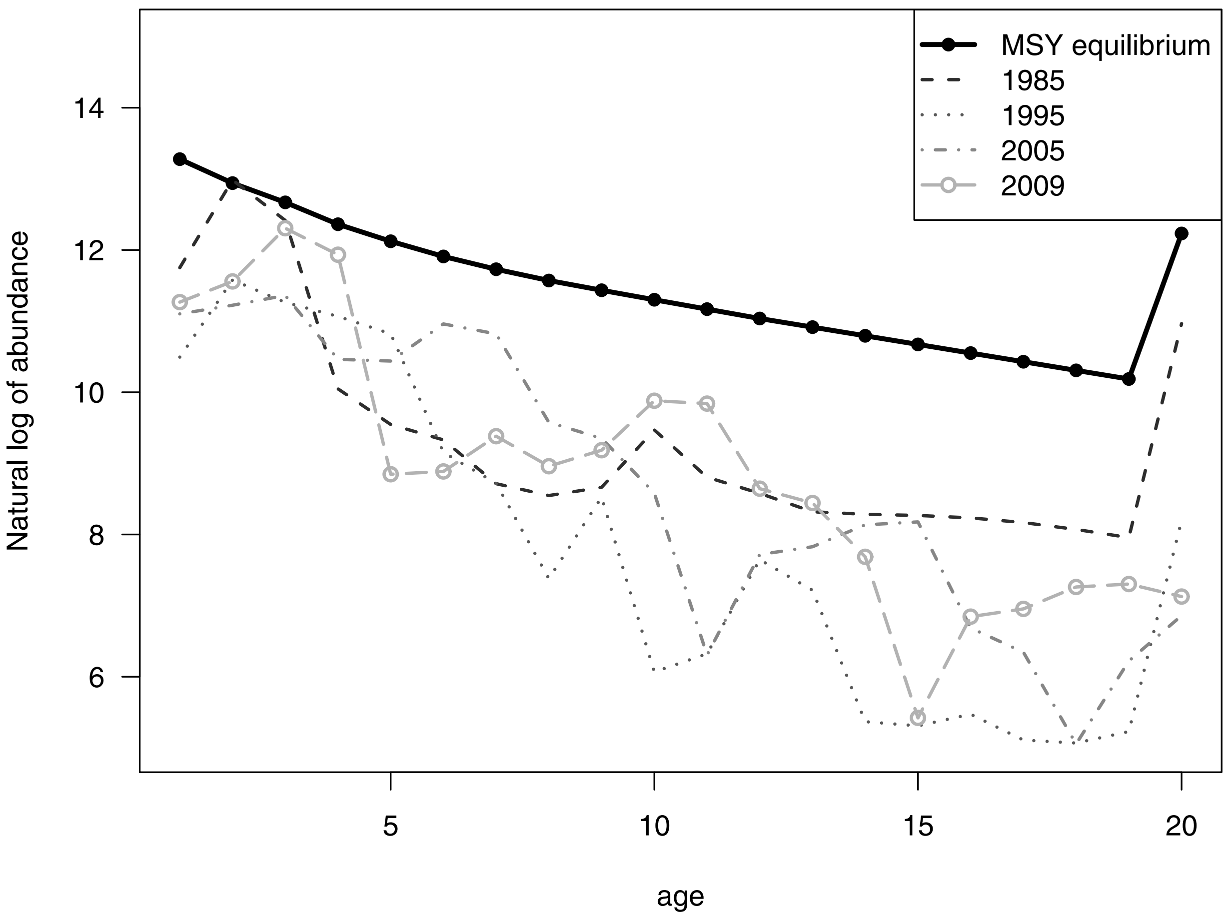


Figure 3.48. Sensitivity to changes in natural mortality (sensitivity runs S1–S3). Top panel: Ratio of F to F_{MSY}. Bottom panel: Ratio of SSB *to* MSST*. Imperceptible lines overlap results of the base run.*

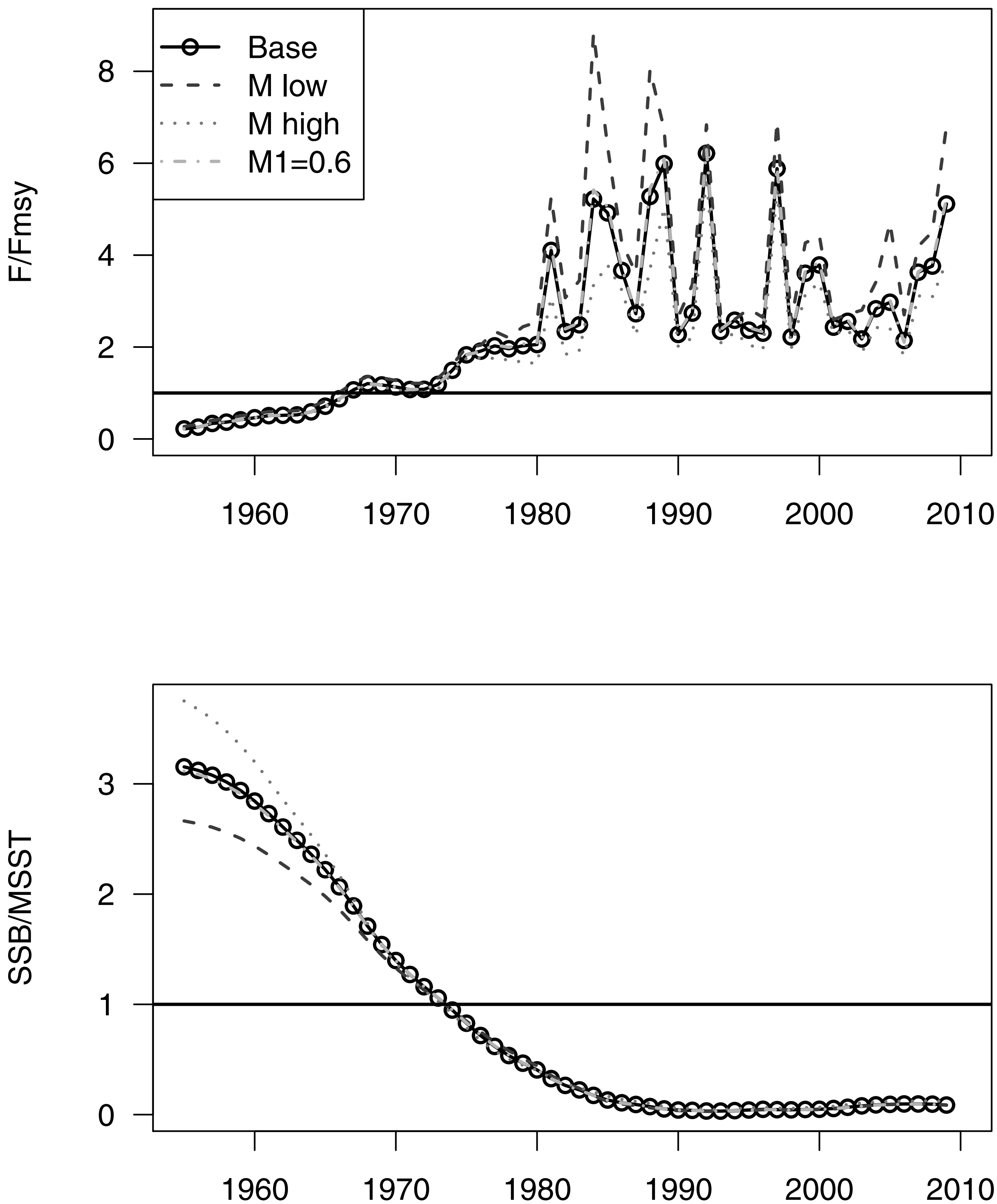


Figure 3.49. Sensitivity to discard mortality rates (sensitivity runs S4 and S5). Top panel: Ratio of F to F_{MSY}. Bottom panel: Ratio of SSB *to* MSST. *Imperceptible lines overlap results of the base run.*

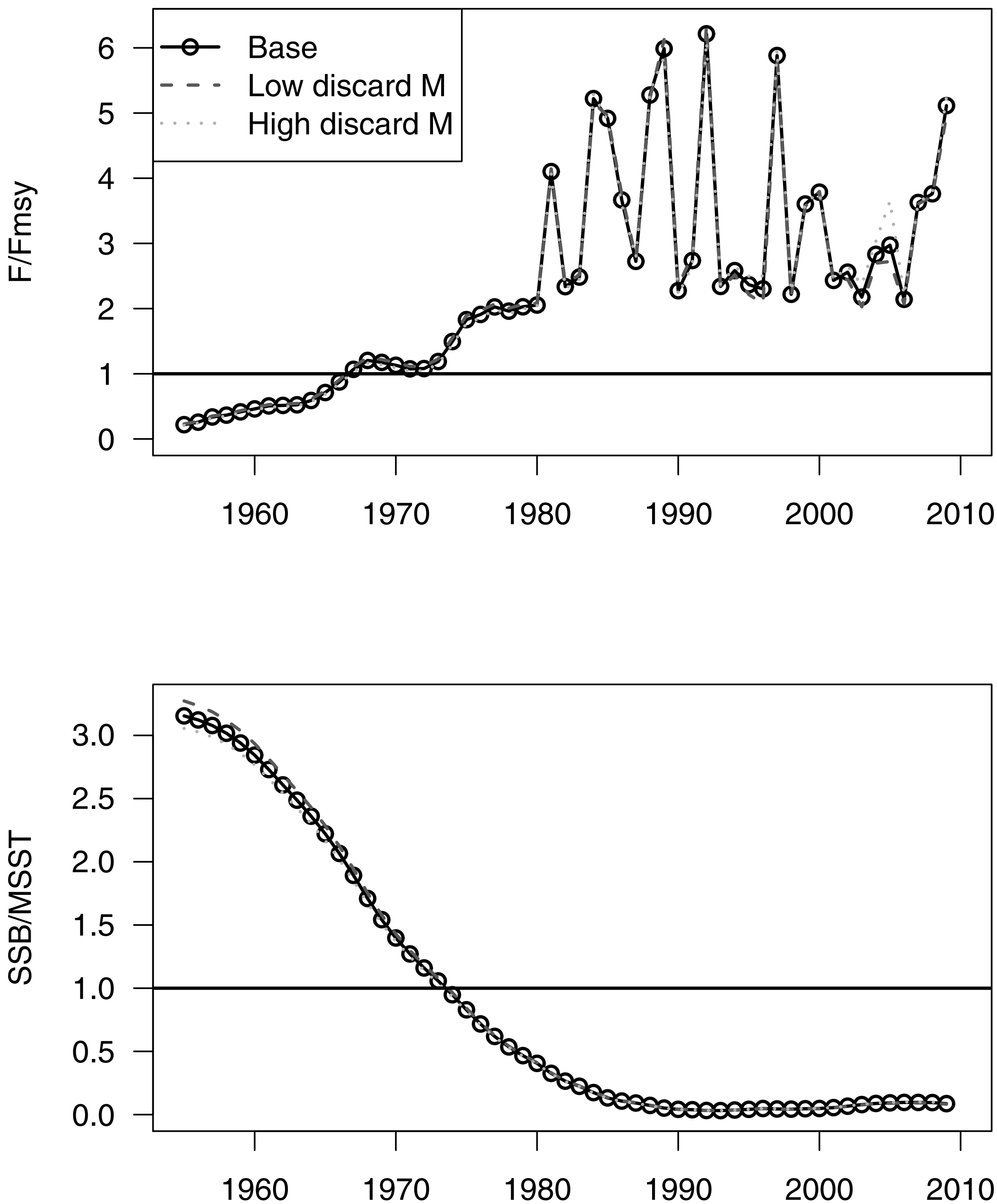


Figure 3.50. Sensitivity to spawner-recruit parameters (sensitivity runs S6–S10). Top panel: Ratio of F to F_{MSY}. Bottom panel: Ratio of SSB *to* MSST. *Imperceptible lines overlap results of the base run.*

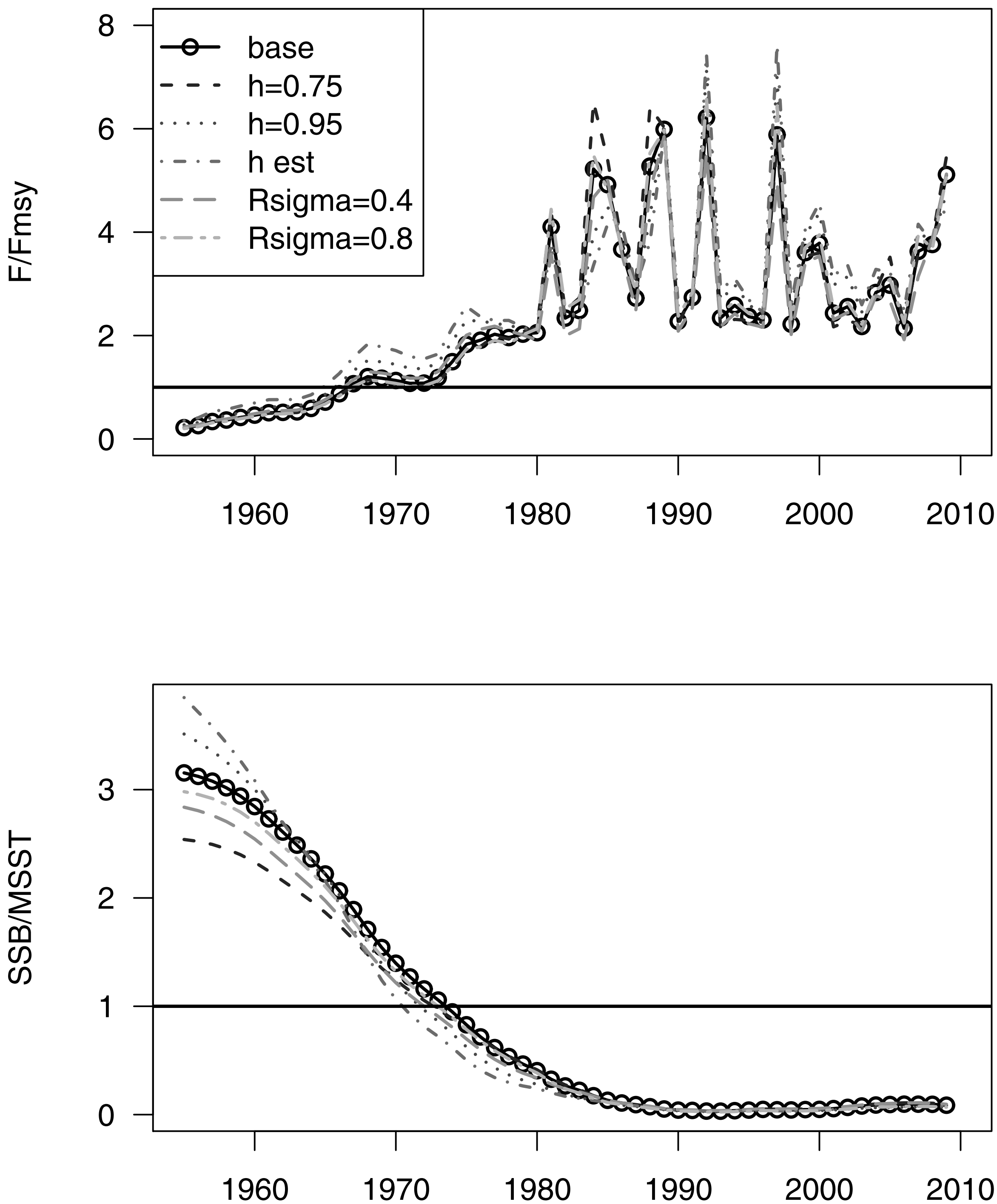


Figure 3.51. Sensitivity to catchability assumptions (sensitivity runs S11–S13). Top panel: Ratio of F to F_{MSY}*. Bottom panel: Ratio of* SSB *to* MSST*. Imperceptible lines overlap results of the base run.*

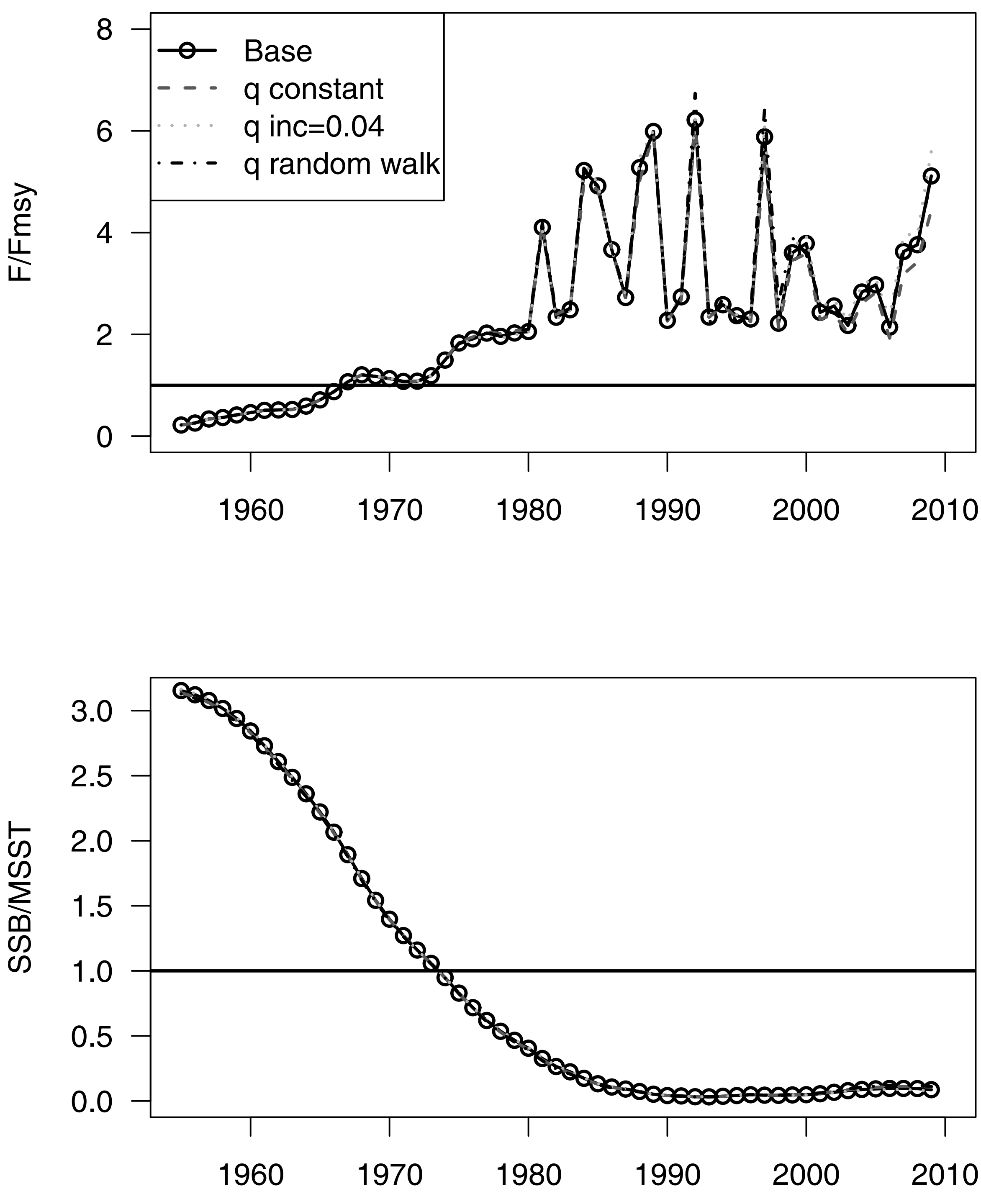


Figure 3.52. Sensitivity to ageing error (sensitivity run S14). Top panel: Ratio of F to F_{MSY}. Bottom panel: Ratio of SSB *to* MSST*. Imperceptible lines overlap results of the base run.*

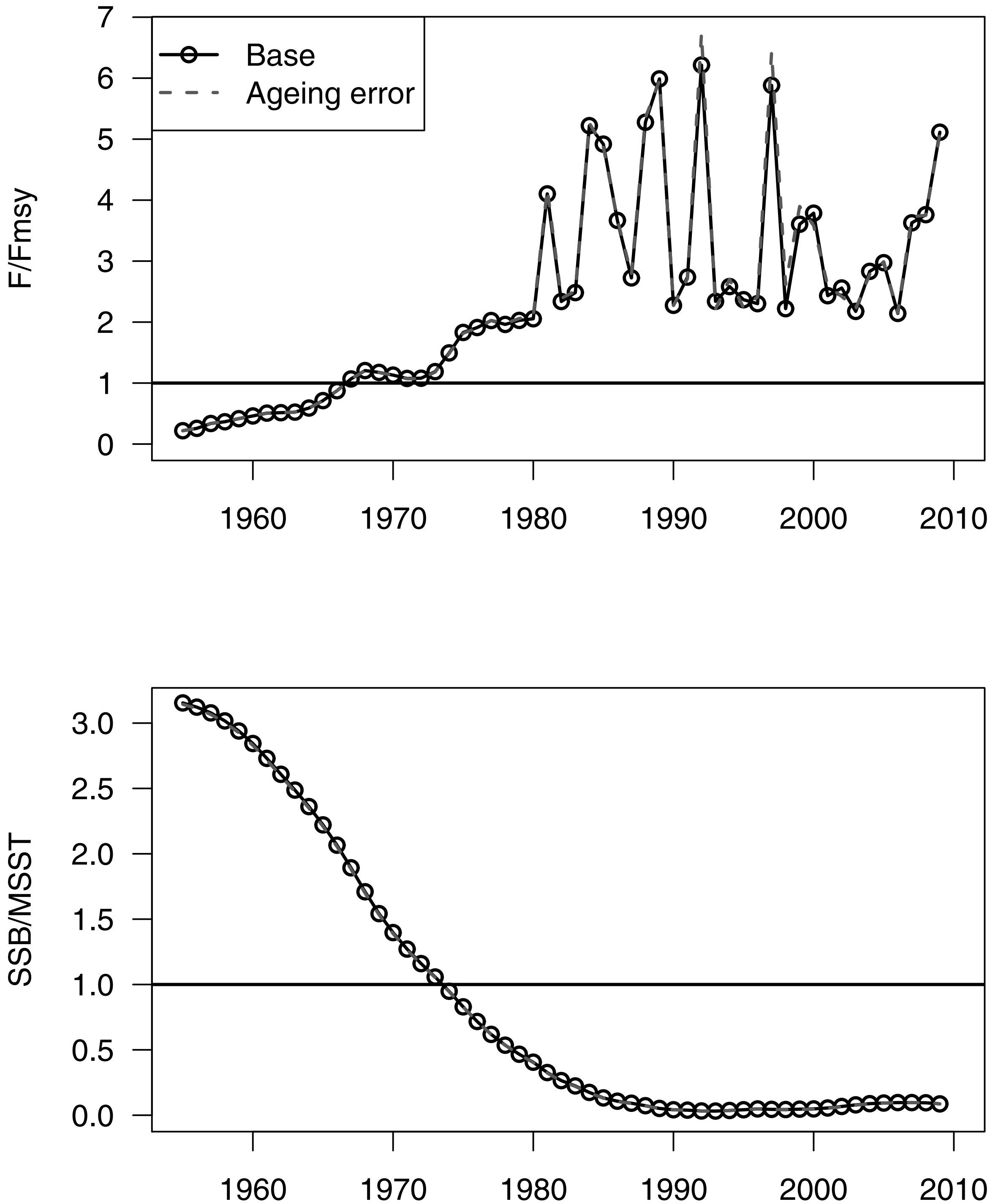
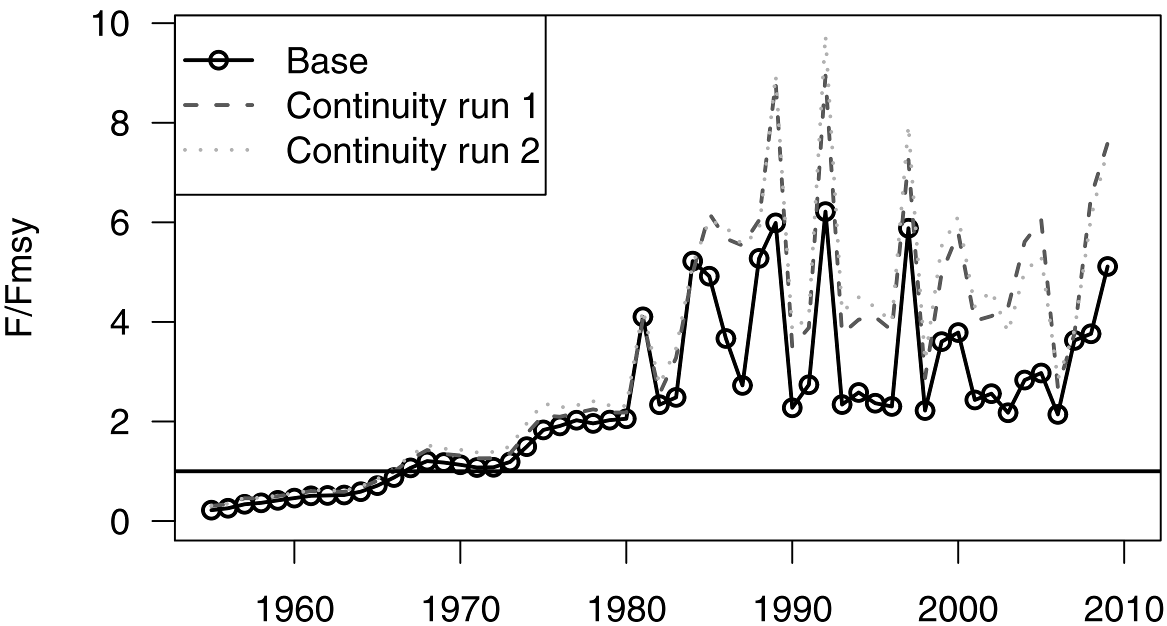


Figure 3.53. Comparison to continuity assumptions (sensitivity runs S15 and S16). Top panel: Ratio of F to F_{MSY}. Bottom panel: Ratio of SSB to MSST. Imperceptible lines overlap results of the base run.



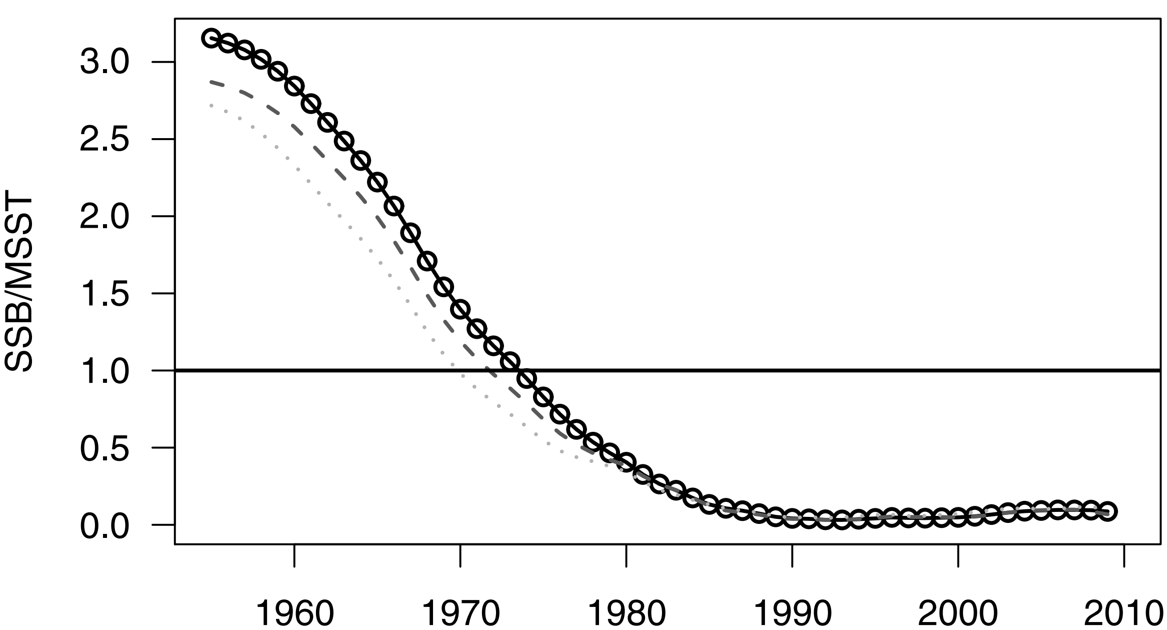


Figure 3.54. Sensitivity to starting year of the assessment model (sensitivity runs S17 and S18). Top panel: Ratio of F to F_{MSY}. Bottom panel: Ratio of SSB *to* MSST. *Imperceptible lines overlap results of the base run.*

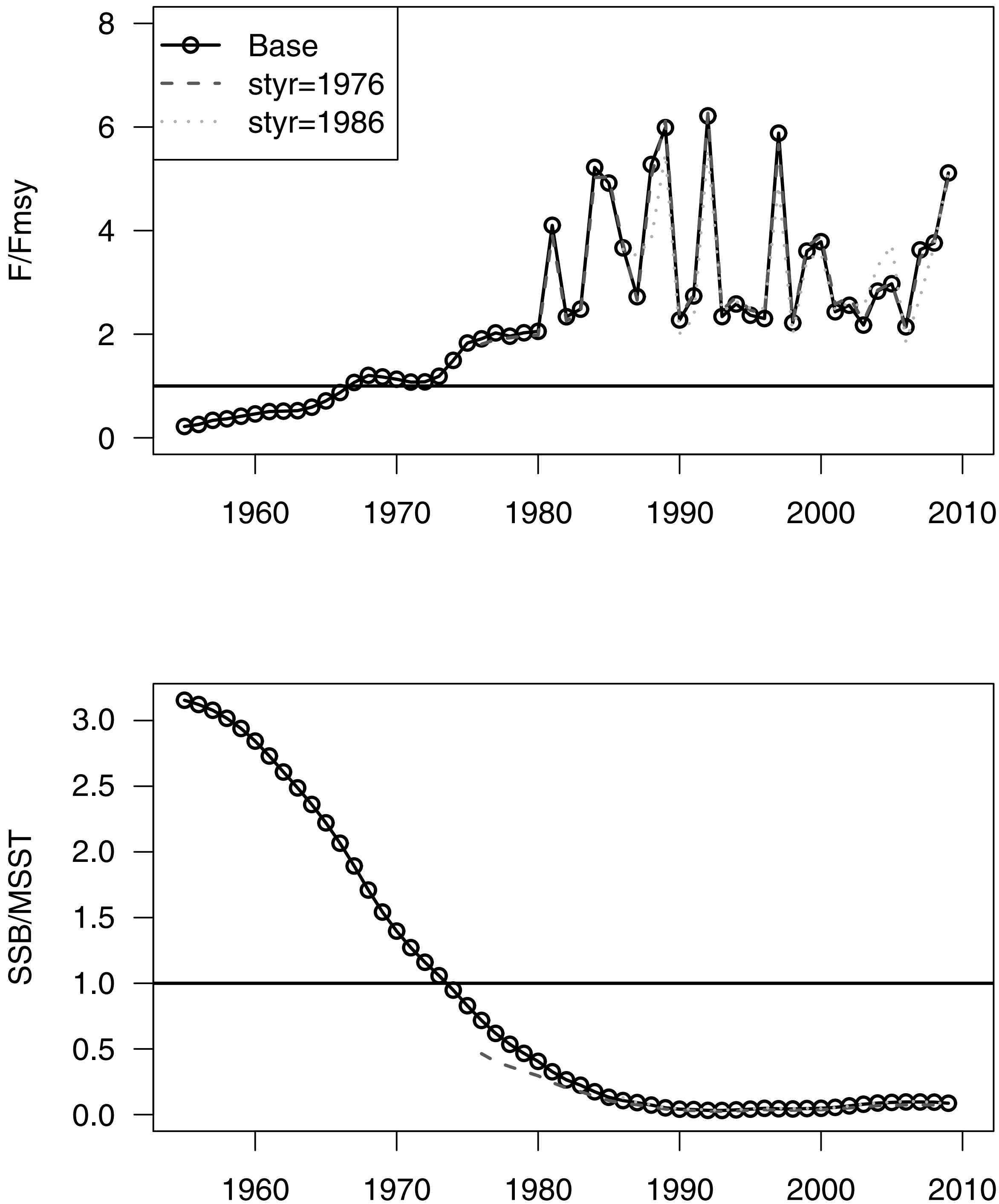


Figure 3.55. Sensitivity to the initialization fishing mortality rate (sensitivity runs S19 and S20). Top panel: Ratio of F *to* F_{MSY}*. Bottom panel: Ratio of* SSB *to* MSST*. Imperceptible lines overlap results of the base run.*

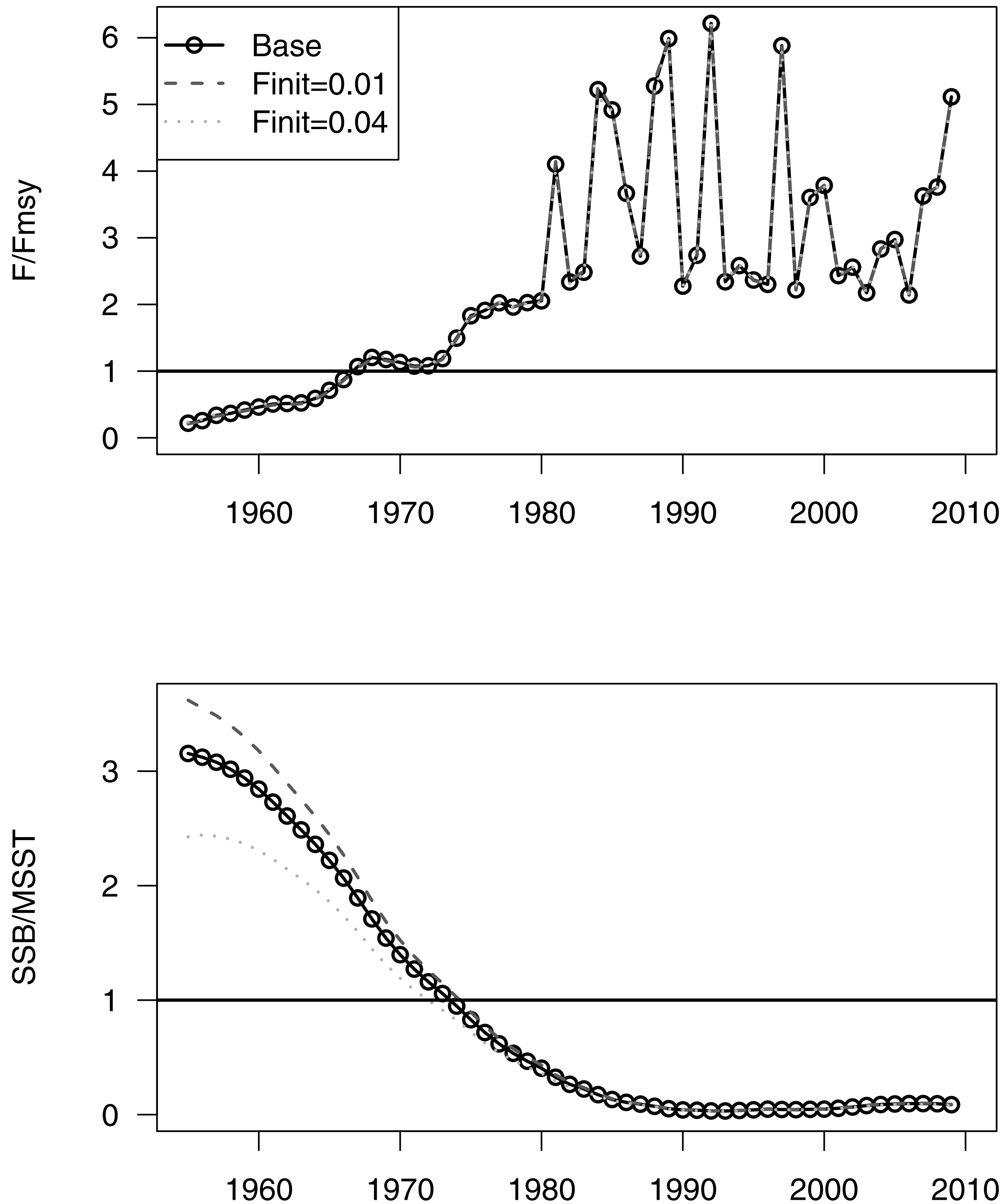


Figure 3.56. Sensitivity to landings streams (sensitivity runs S21–S24). Top panel: Ratio of F to F_{MSY}. Bottom panel: Ratio of SSB *to* MSST. *Imperceptible lines overlap results of the base run.*

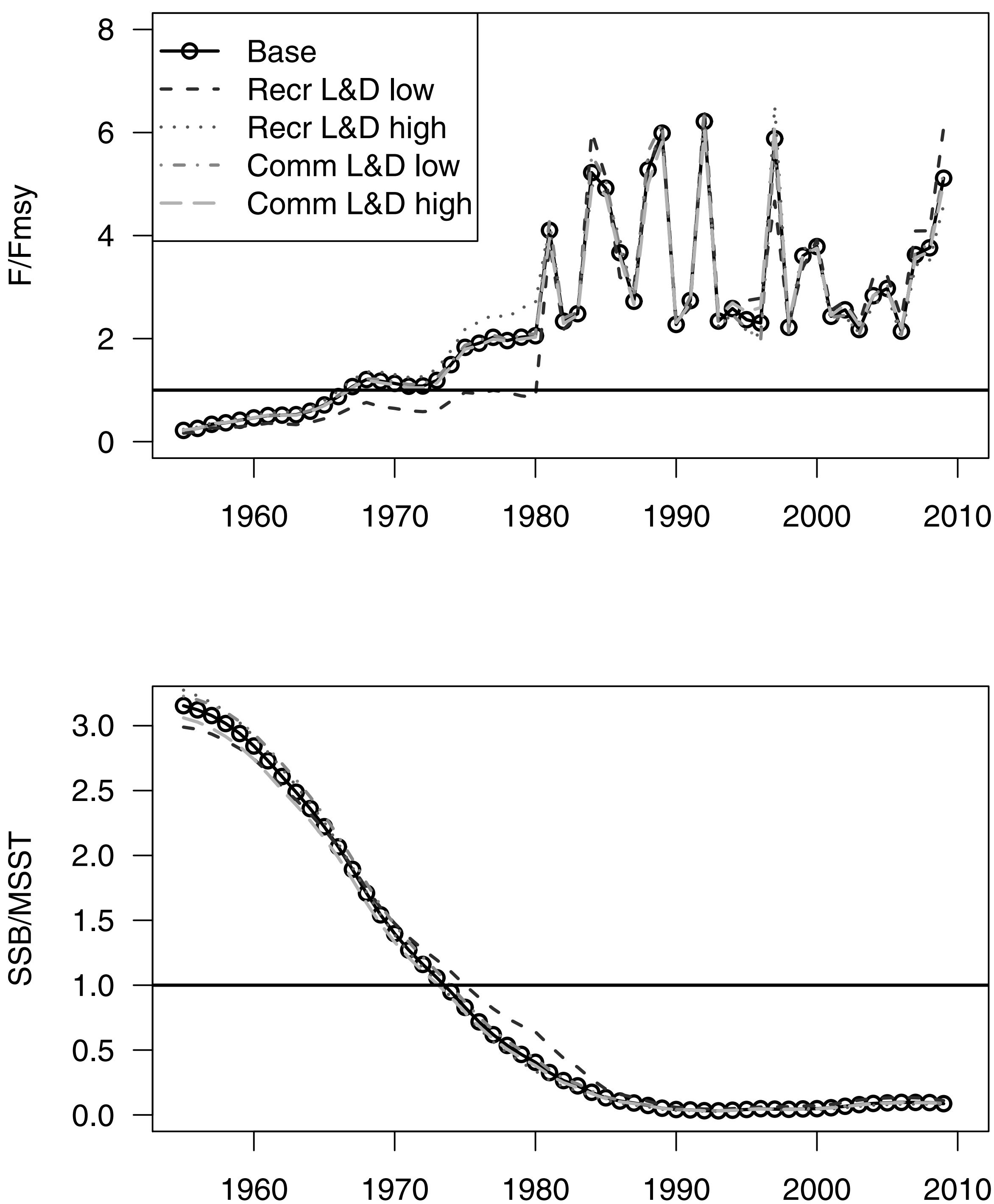
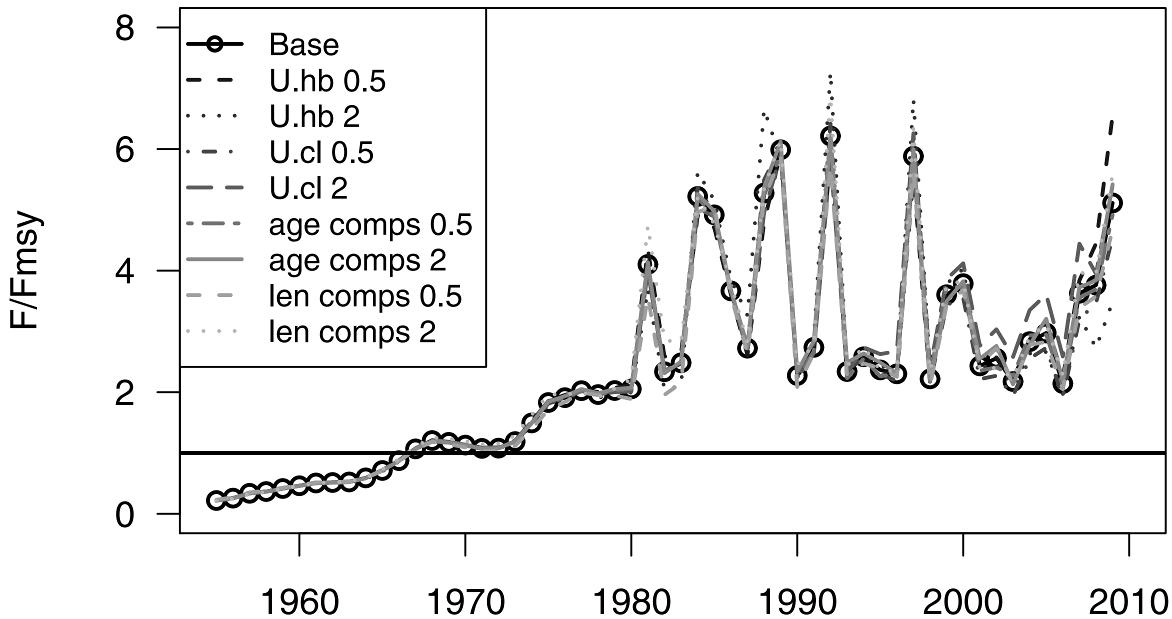


Figure 3.57. Sensitivity to component weights of data sources (sensitivity runs S25–S32). Top panel: Ratio of F to F_{MSY}. Bottom panel: Ratio of SSB *to* MSST. *Imperceptible lines overlap results of the base run.*



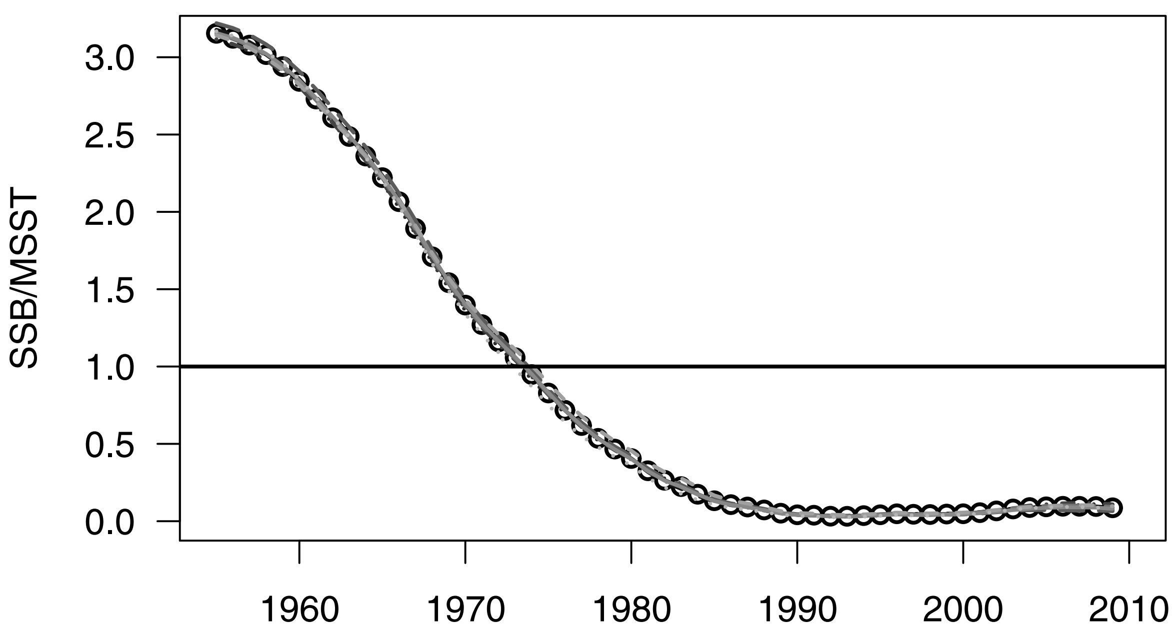


Figure 3.58. Sensitivity to selectivity patterns (sensitivity runs S33–S40). Top panel: Ratio of F to F_{MSY}. Bottom panel: Ratio of SSB *to* MSST. *Imperceptible lines overlap results of the base run.*

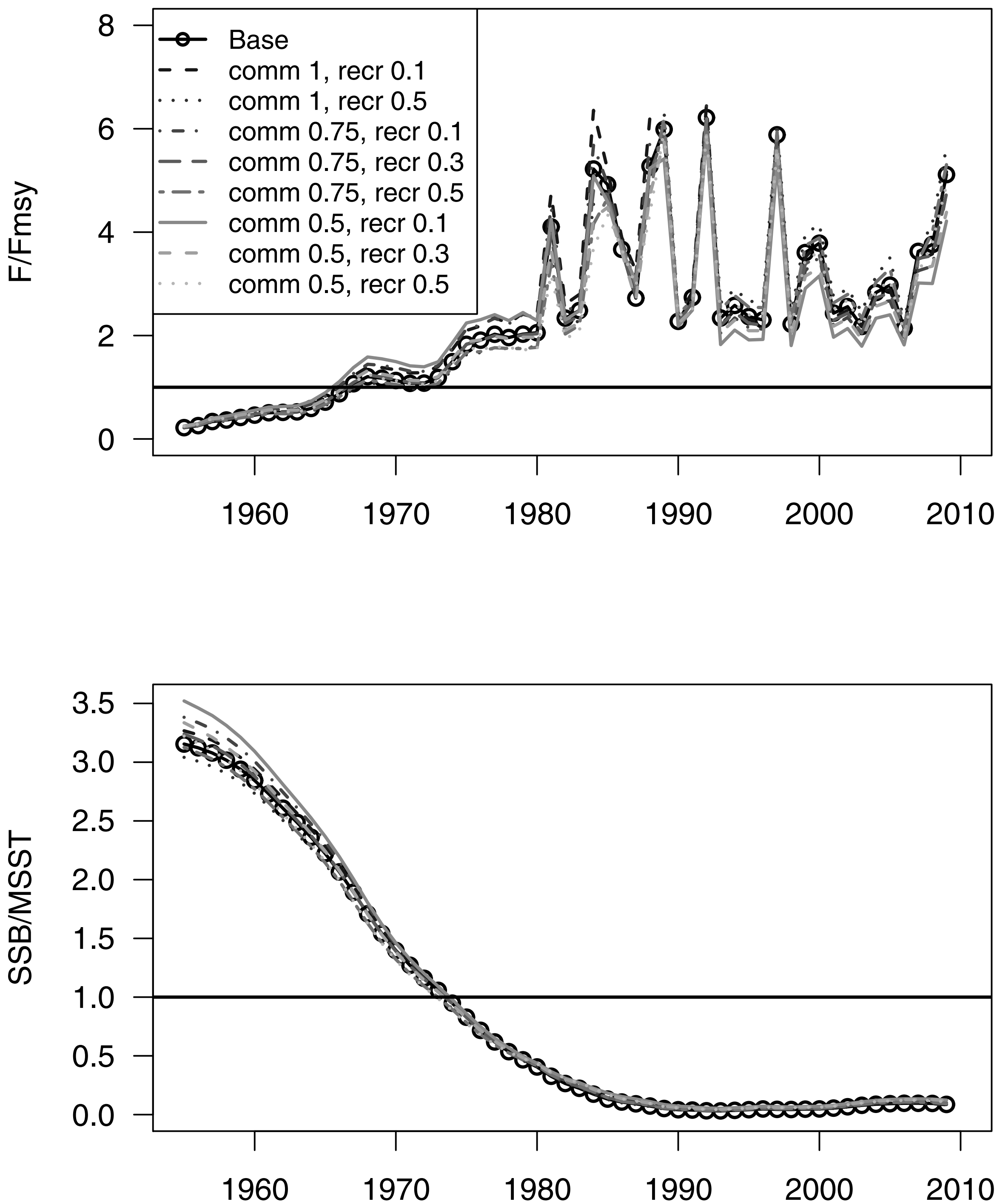
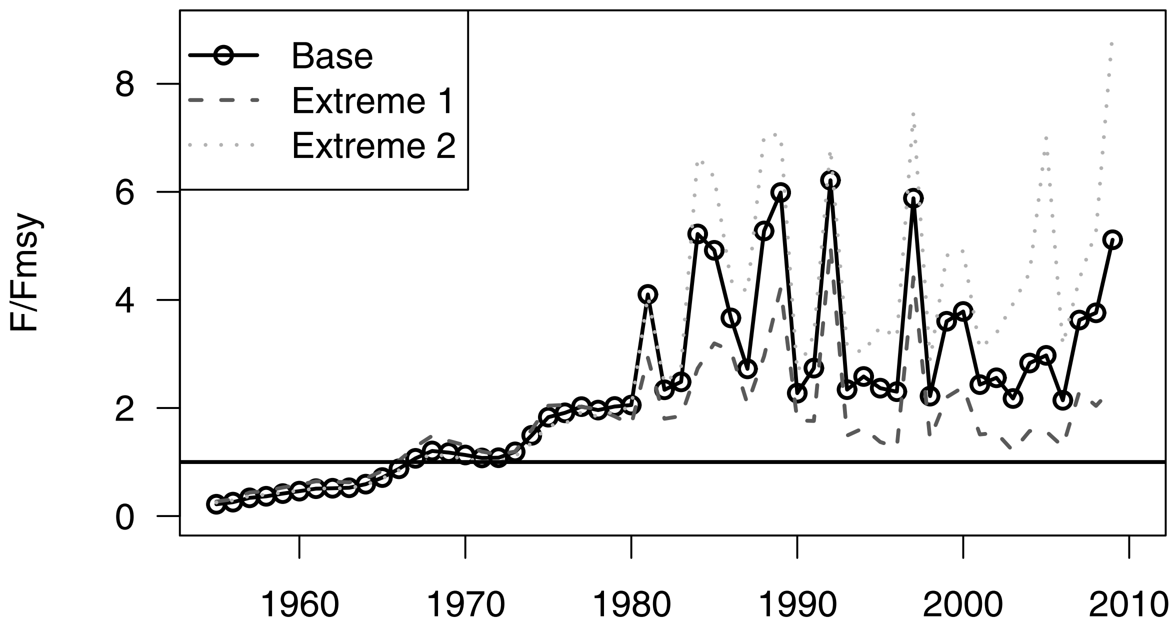


Figure 3.59. Sensitivity to compound extremes (sensitivity runs S41 and S42). Top panel: Ratio of F to F_{MSY}. Bottom panel: Ratio of SSB *to* MSST*. Imperceptible lines overlap results of the base run.*



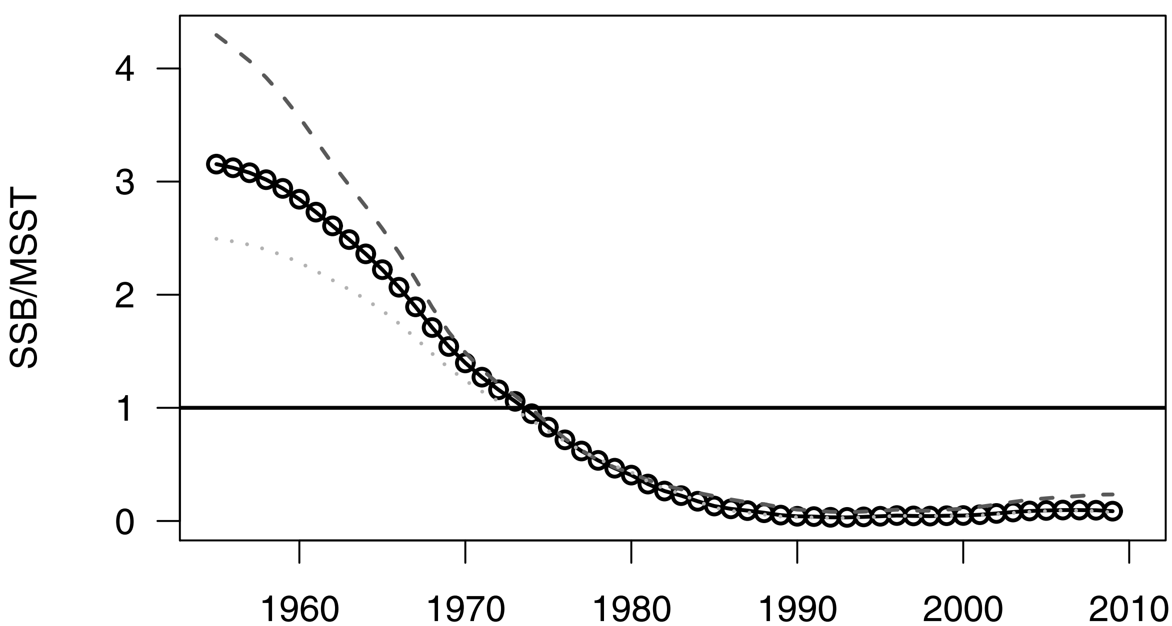


Figure 3.60. Phase plot of terminal status estimates from sensitivity runs of the Beaufort Assessment Model.

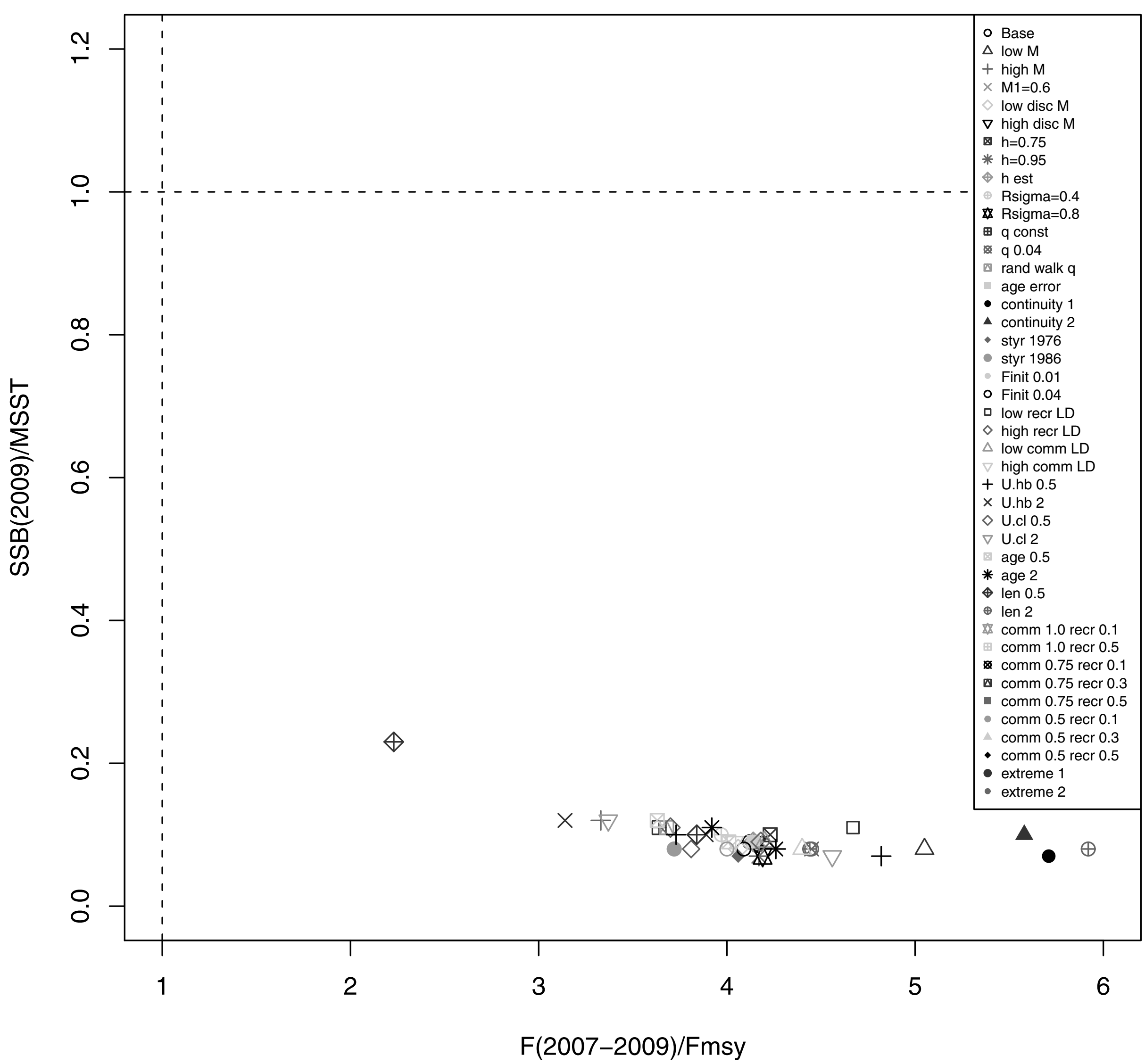
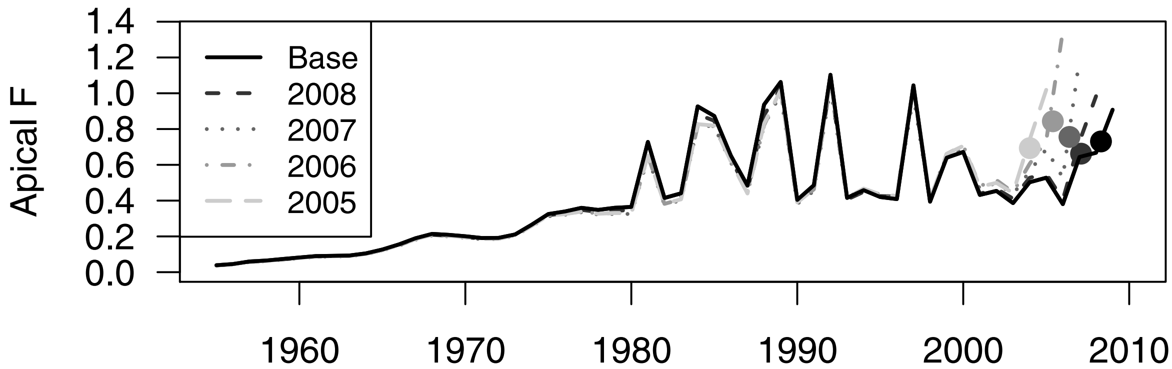
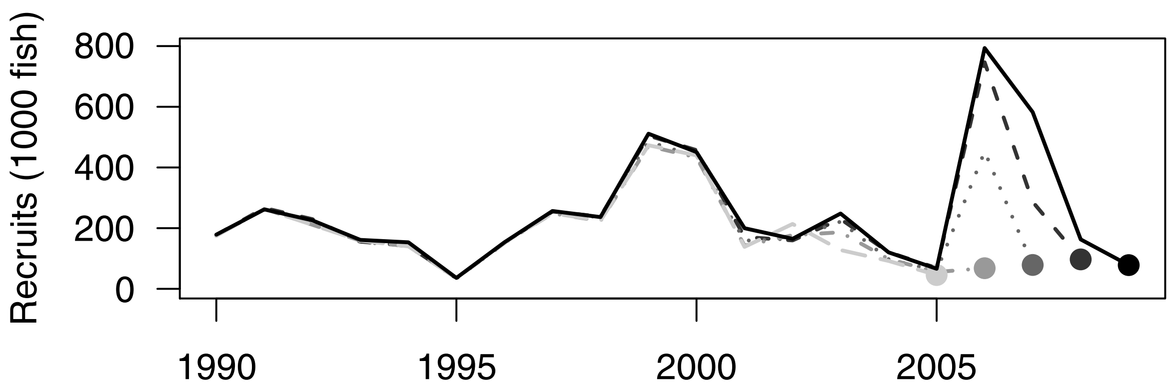


Figure 3.61. Retrospective analyses. Sensitivity to terminal year of data (sensitivity runs S43–S46). Top panel: Fishing mortality rate, where solid circles show geometric mean of terminal three years, as used to compute fishing status. Middle panel: Recruits. Bottom panel: Spawning biomass. Imperceptible lines overlap results of the base run.





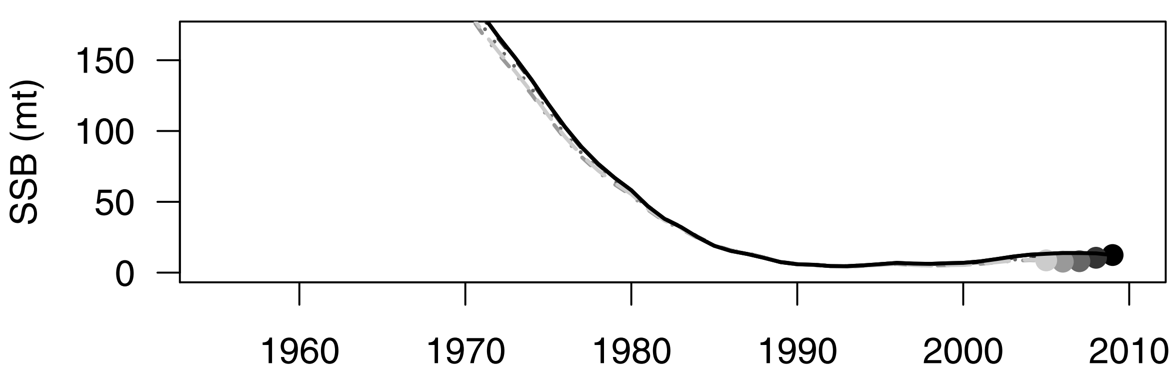


Figure 3.62. Projection results under scenario 1—fishing mortality rate fixed at F = 0. Curve represents the proportion of projection replicates for which SSB(mid-year) has reached at least $\mathrm{SSB}_{\mathrm{MSY}} = 156$.

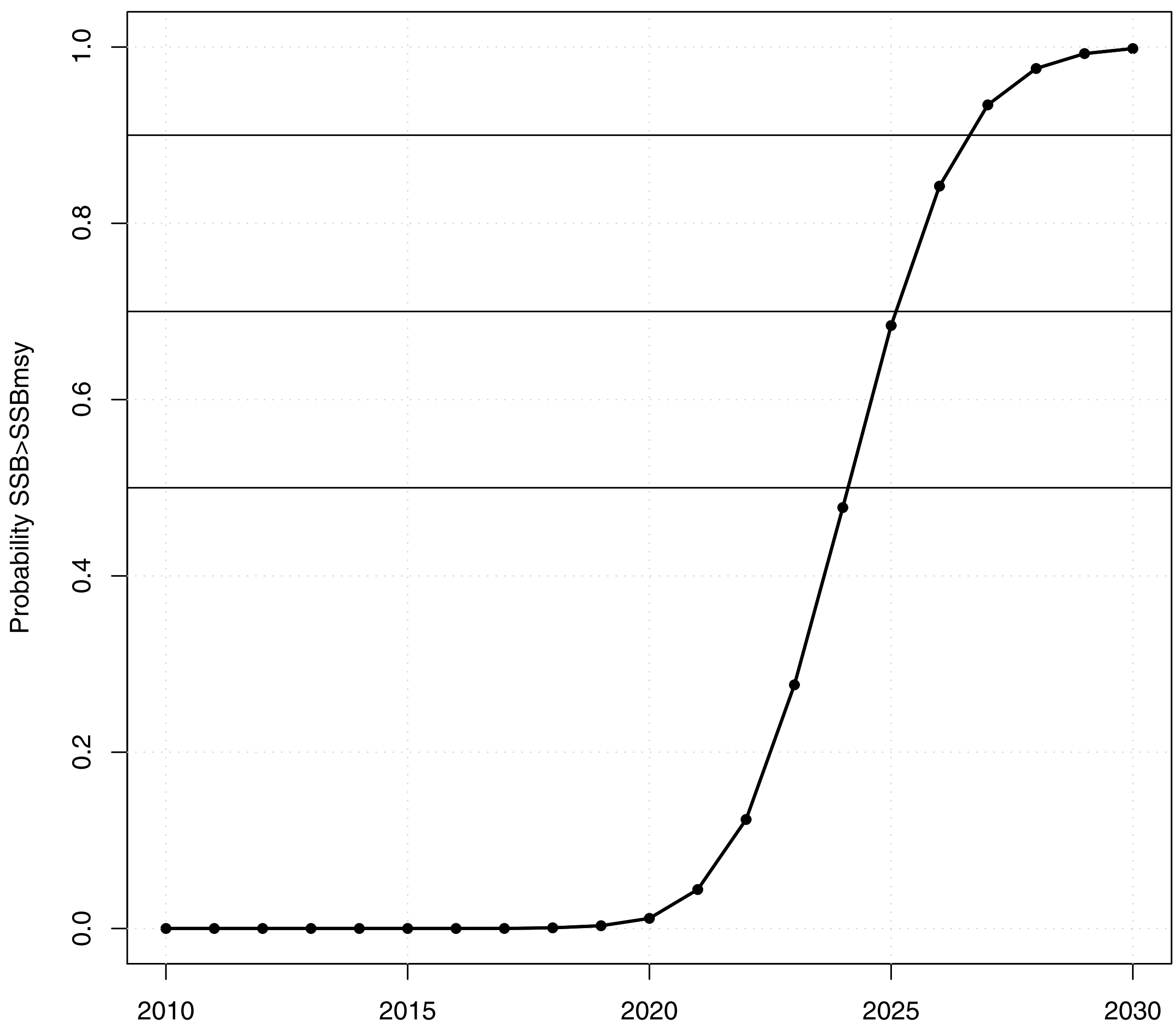


Figure 3.63. Projection results under scenario 2—fishing mortality rate fixed at $F = F_{\text{current}}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock (SSB) is at mid-year.*

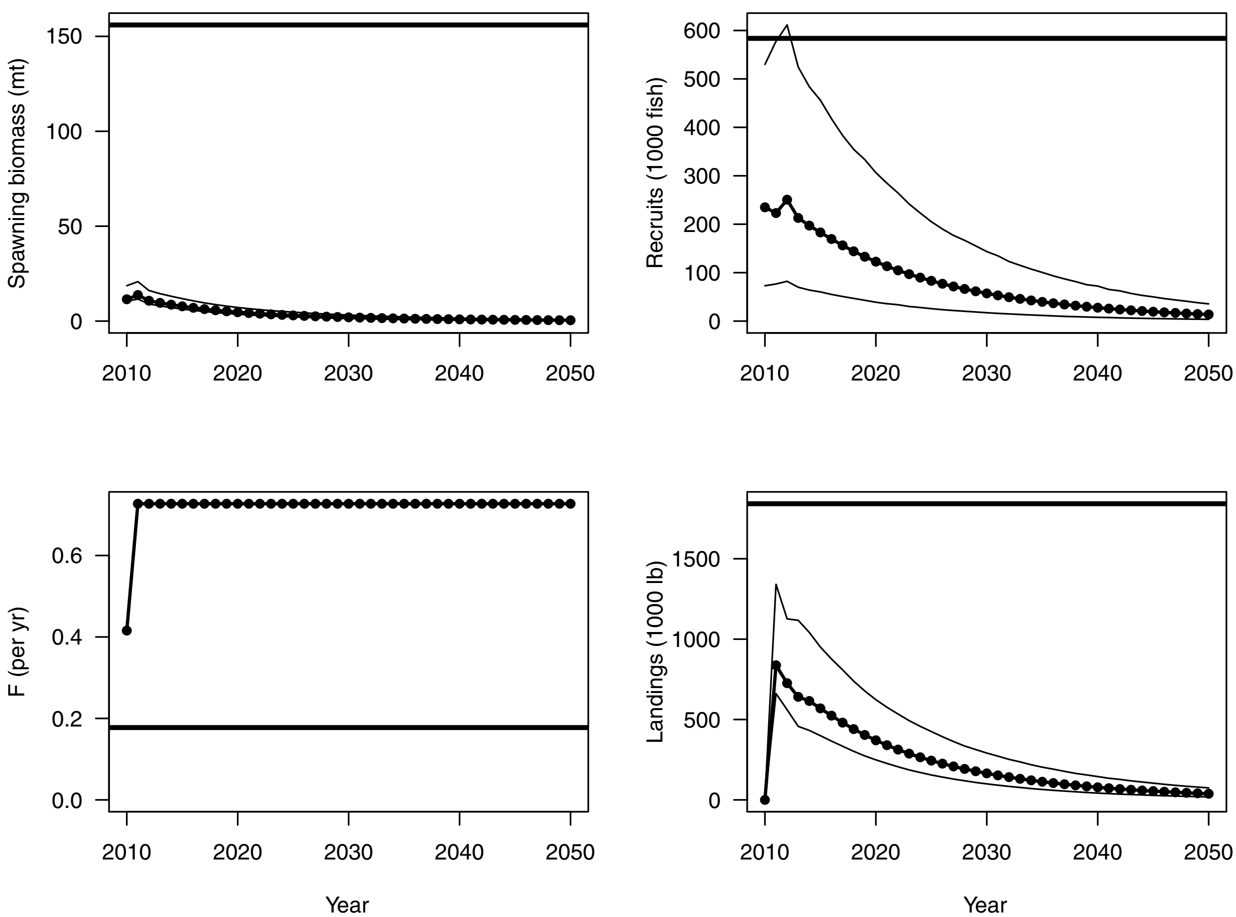


Figure 3.64. Projection results under scenario 3—fishing mortality rate fixed at $F = 65\%F_{\mathrm{MSY}}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock (SSB) is at mid-year.*

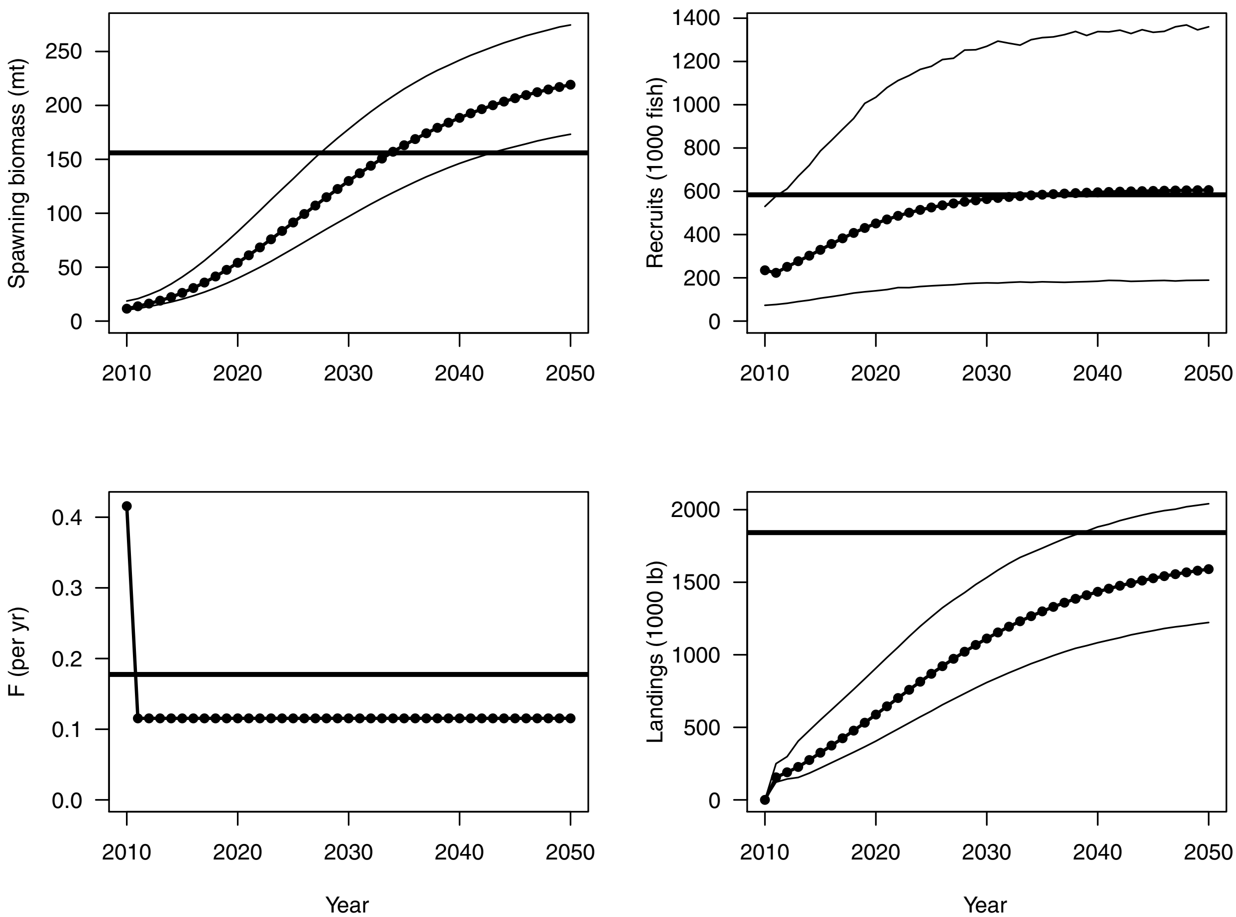


Figure 3.65. Projection results under scenario 4—fishing mortality rate fixed at $F = 75\%F_{\mathrm{MSY}}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock (SSB) is at mid-year.*

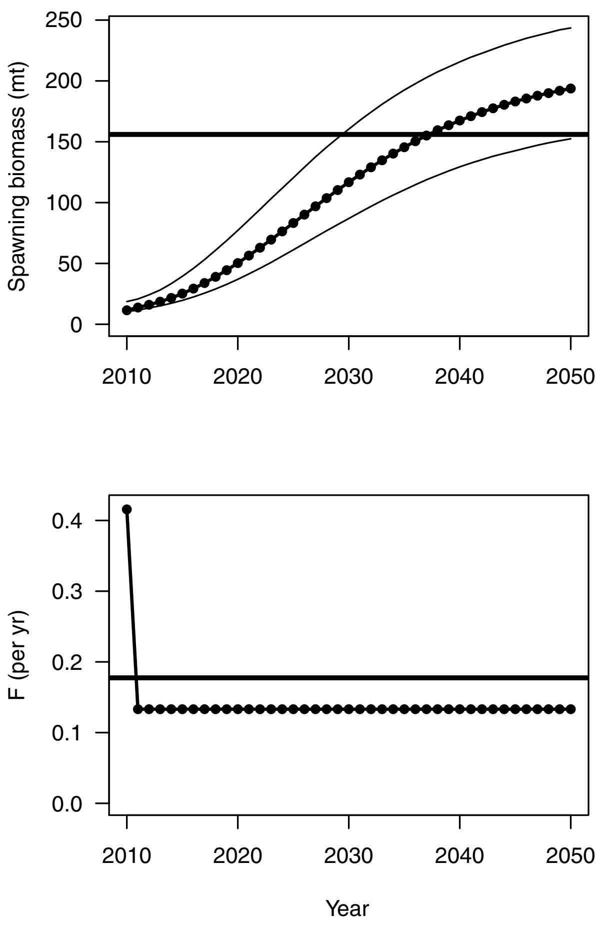


Figure 3.66. Projection results under scenario 5—fishing mortality rate fixed at $F = 85\%F_{\mathrm{MSY}}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock (SSB) is at mid-year.*

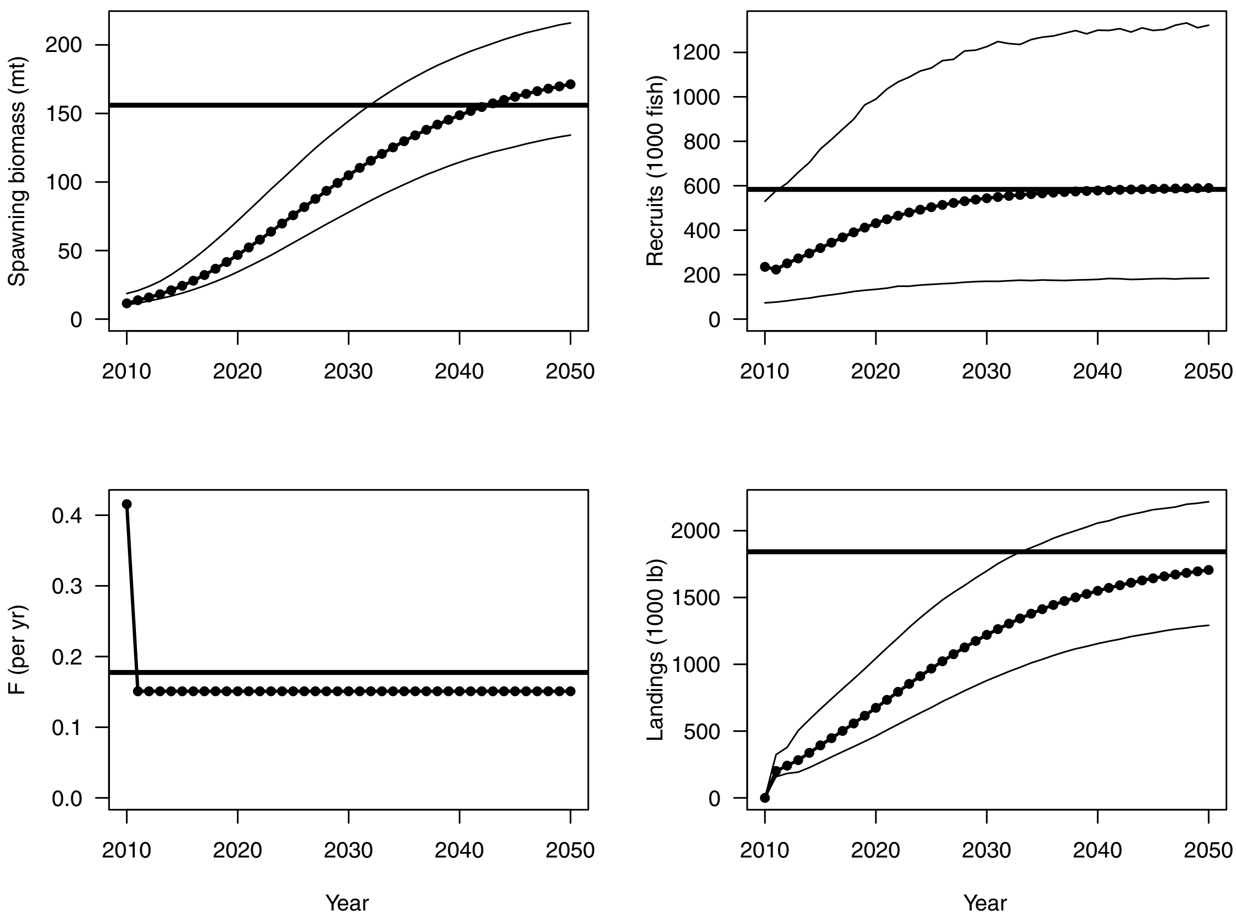


Figure 3.67. Projection results under scenario 6—fishing mortality rate fixed at $F = F_{\mathrm{MSY}}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock (SSB) is at mid-year.*

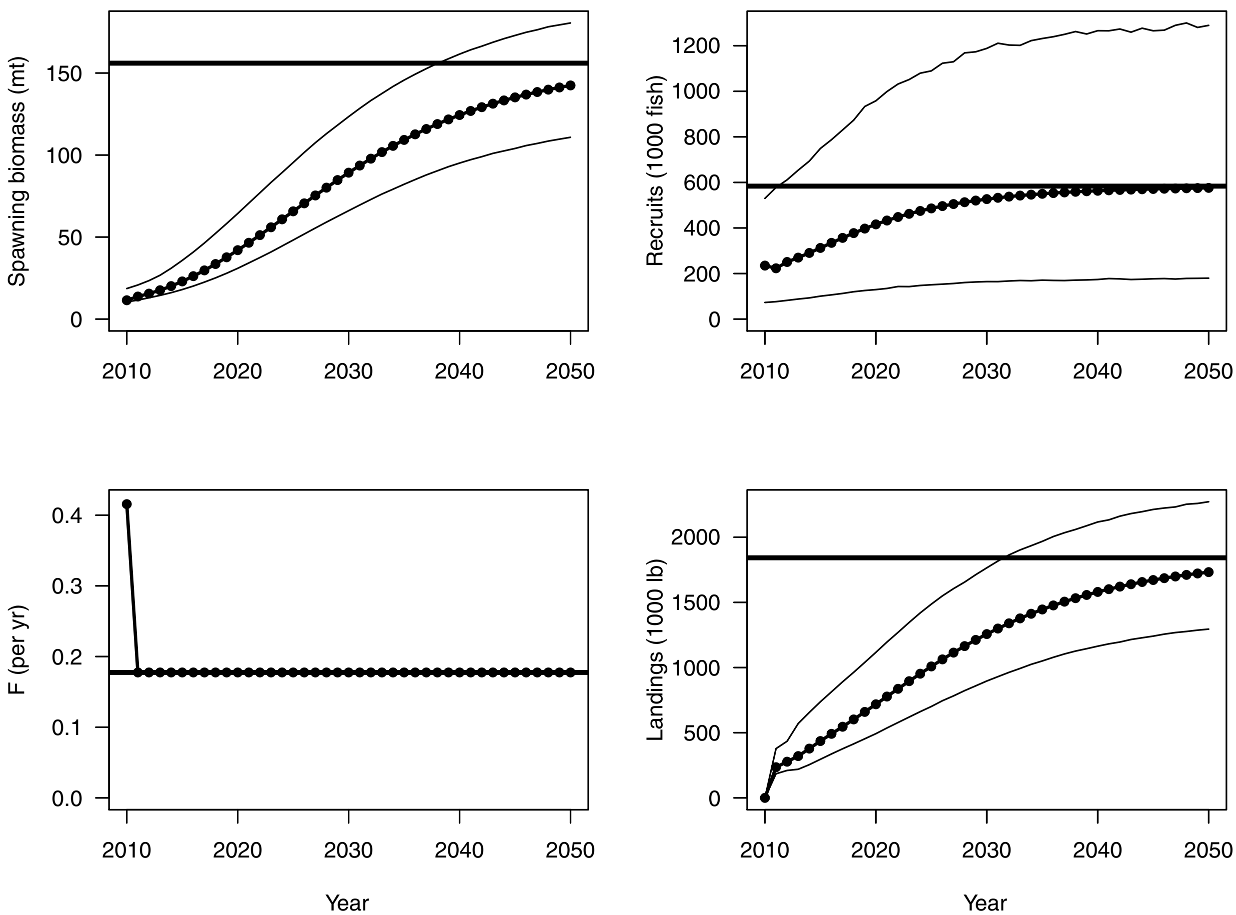


Figure 3.68. Projection results under scenario 7—moratorium projection (all potential landings converted to discards). Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock (SSB) is at mid-year.*

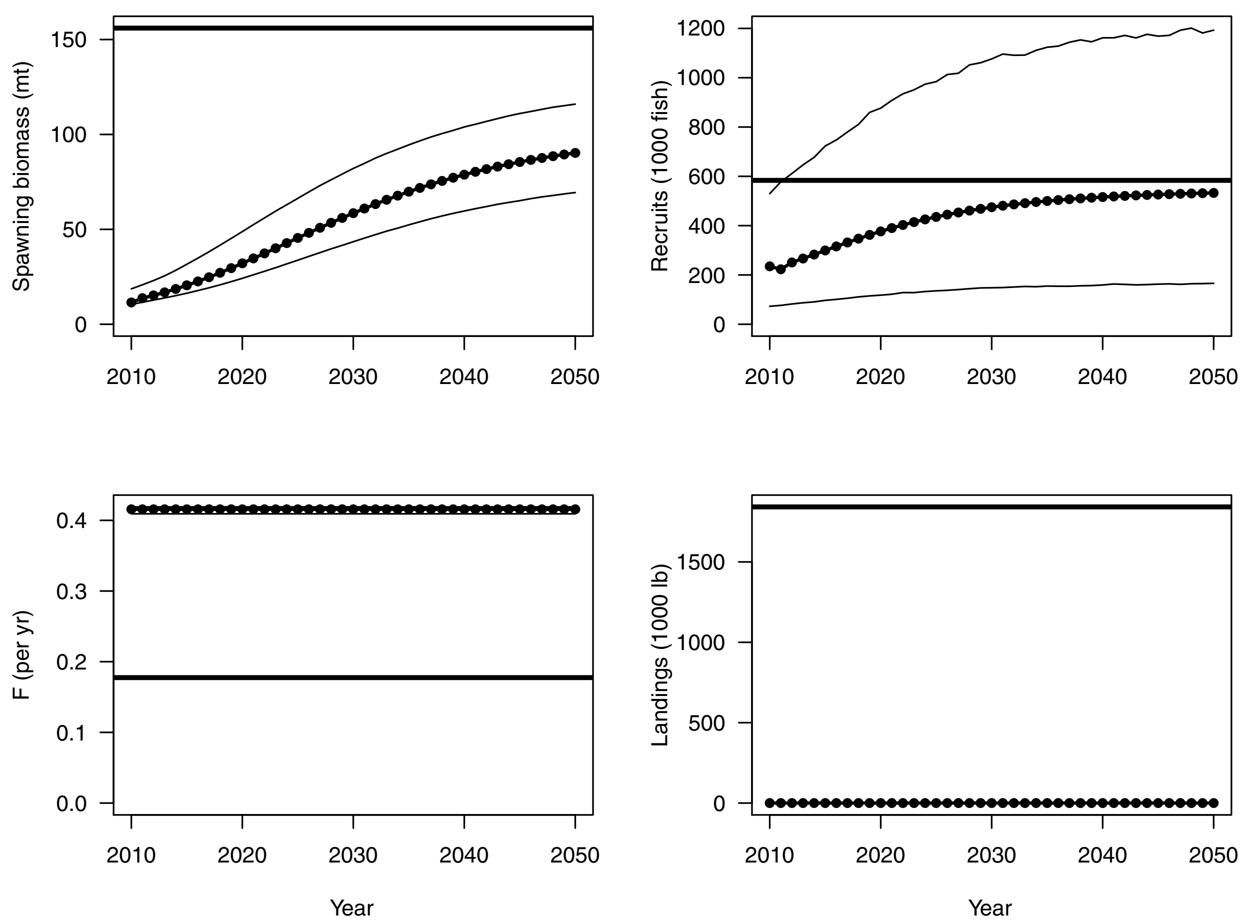


Figure 3.69. Projection results under scenario 8—fishing mortality rate fixed at $F = F_{\text{rebuild}}$, with rebuilding probability of 0.5 in 2047. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock (SSB) is at mid-year.*

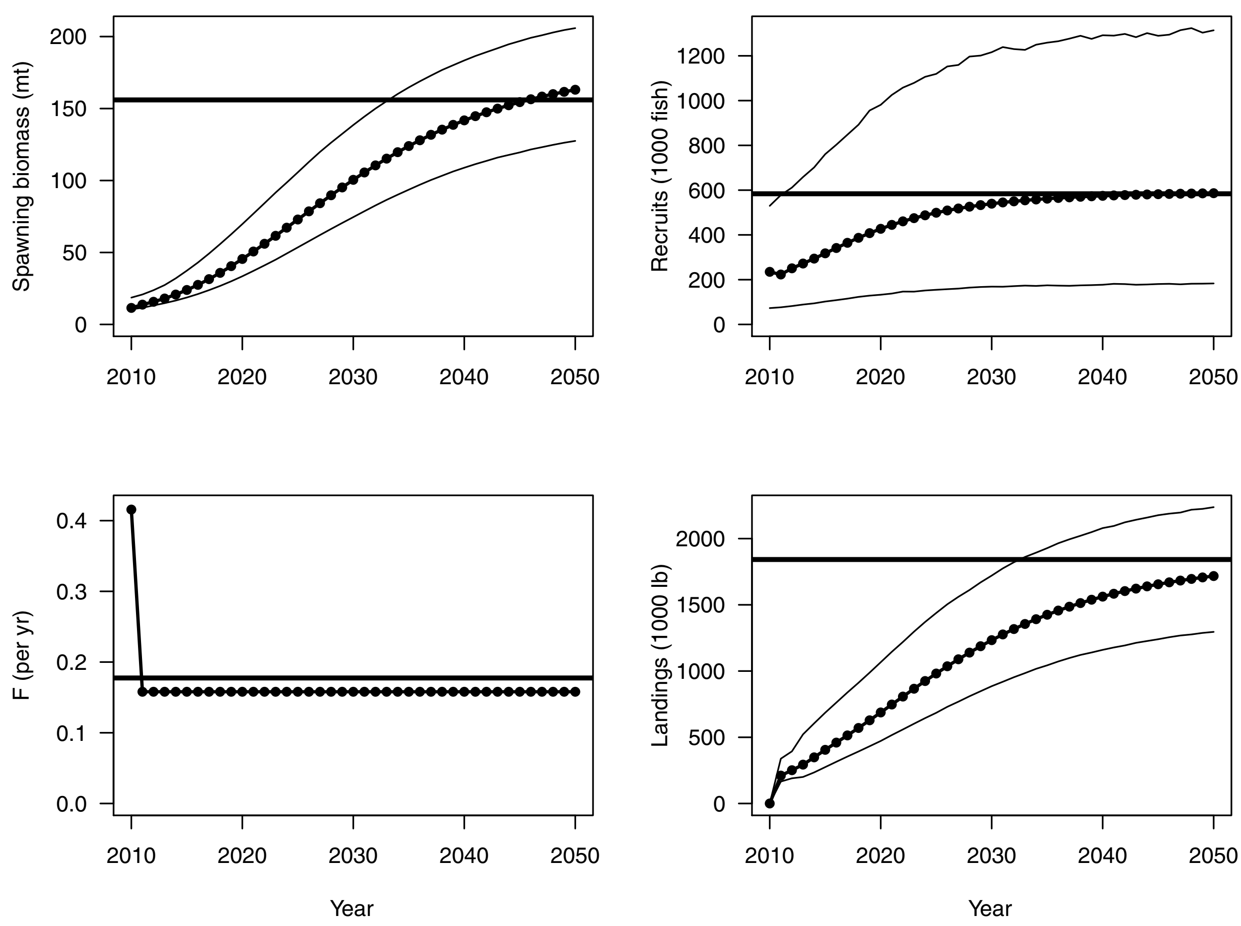


Figure 3.70. Projection results under scenario 9—fishing mortality rate fixed at $F = F_{\text{rebuild}}$, with rebuilding probability of 0.70 in 2047. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock (SSB) is at mid-year.*

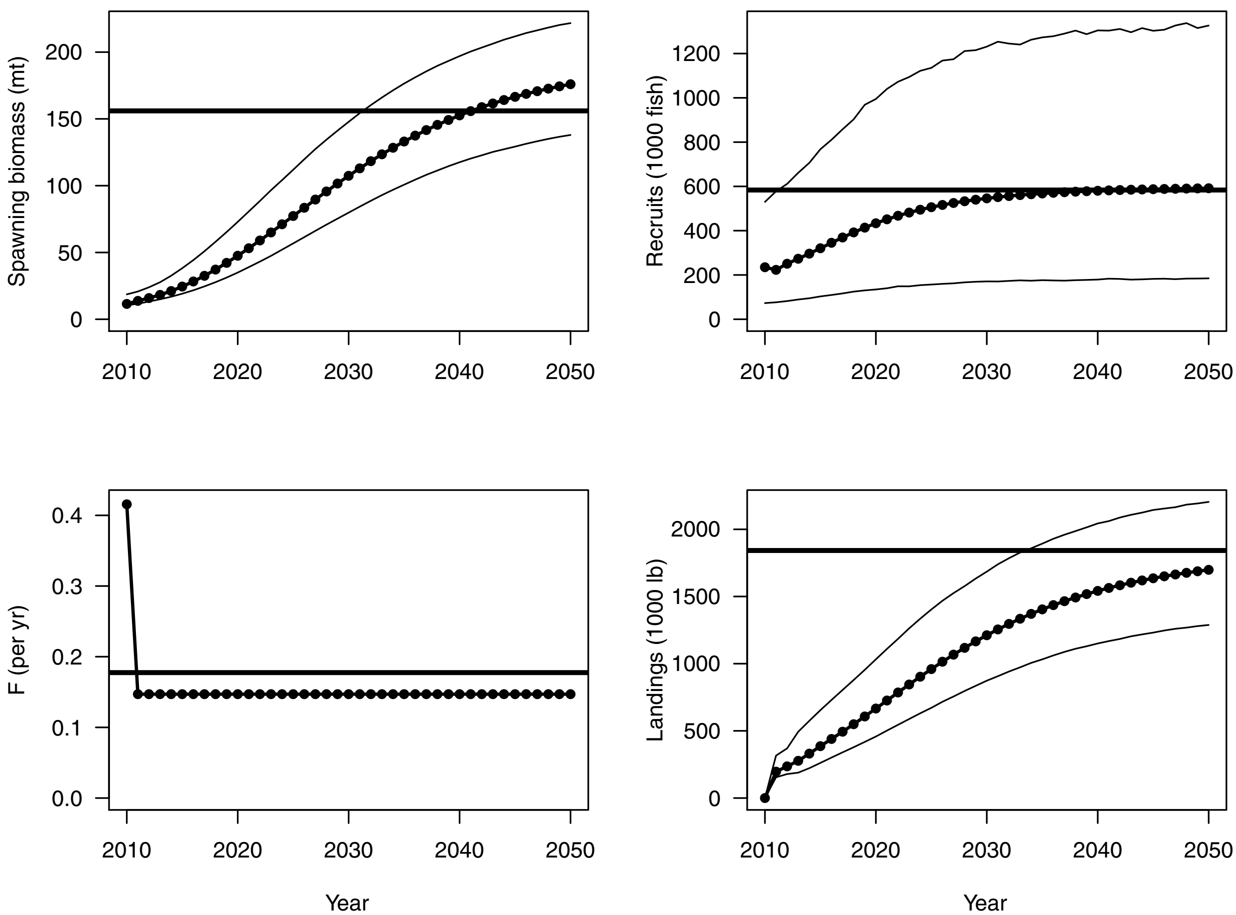


Figure 3.71. Projection results under scenario 10—fishing mortality rate fixed at $F = F_{\text{rebuild}}$, with rebuilding probability of 0.90 in 2047. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock (SSB) is at mid-year.*

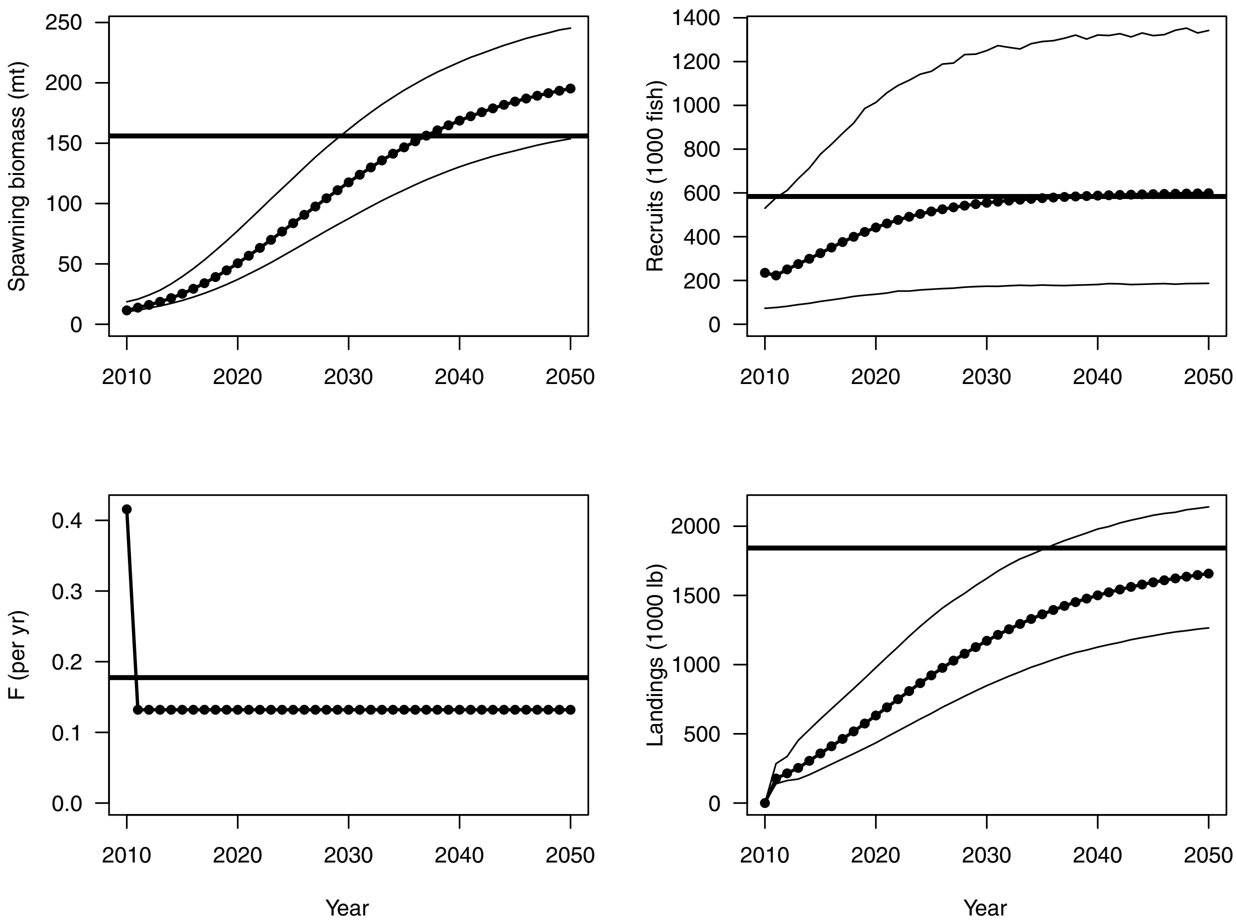


Figure 3.72. Red Snapper in Atlantic: Fit of production model to the headboat and commercial line indices with and without a 2% catchability increase since 1976 saturating in 2003.

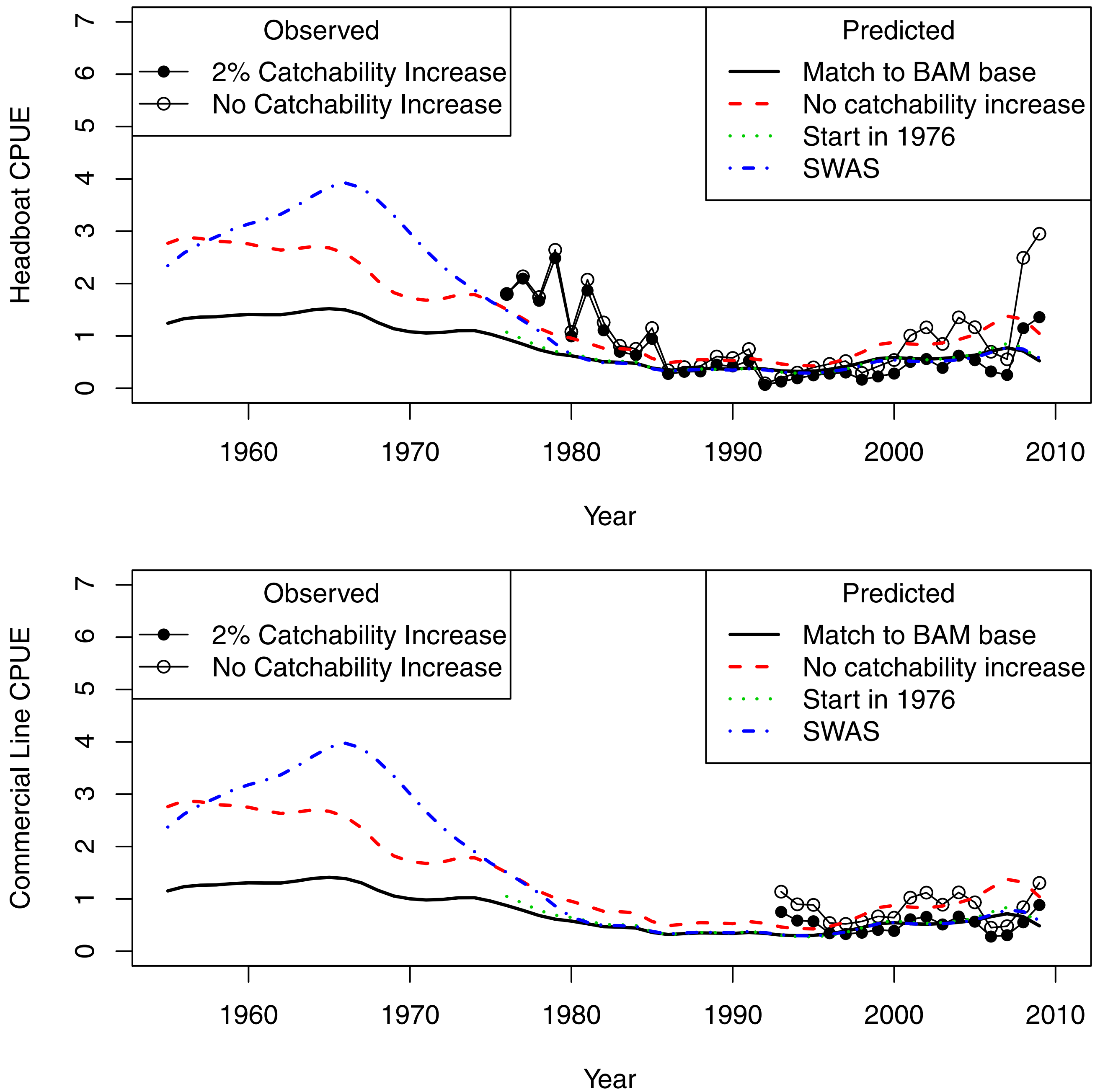


Figure 3.73. Red Snapper in Atlantic: Production model kernel density plots of parameters and status from 1000 bootstrap runs of the model configured to match the BAM data input as closely as possible. Subsets of the model runs are grouped together by estimates of $B1/K$ to evaluate its influence on parameter estimates and status.

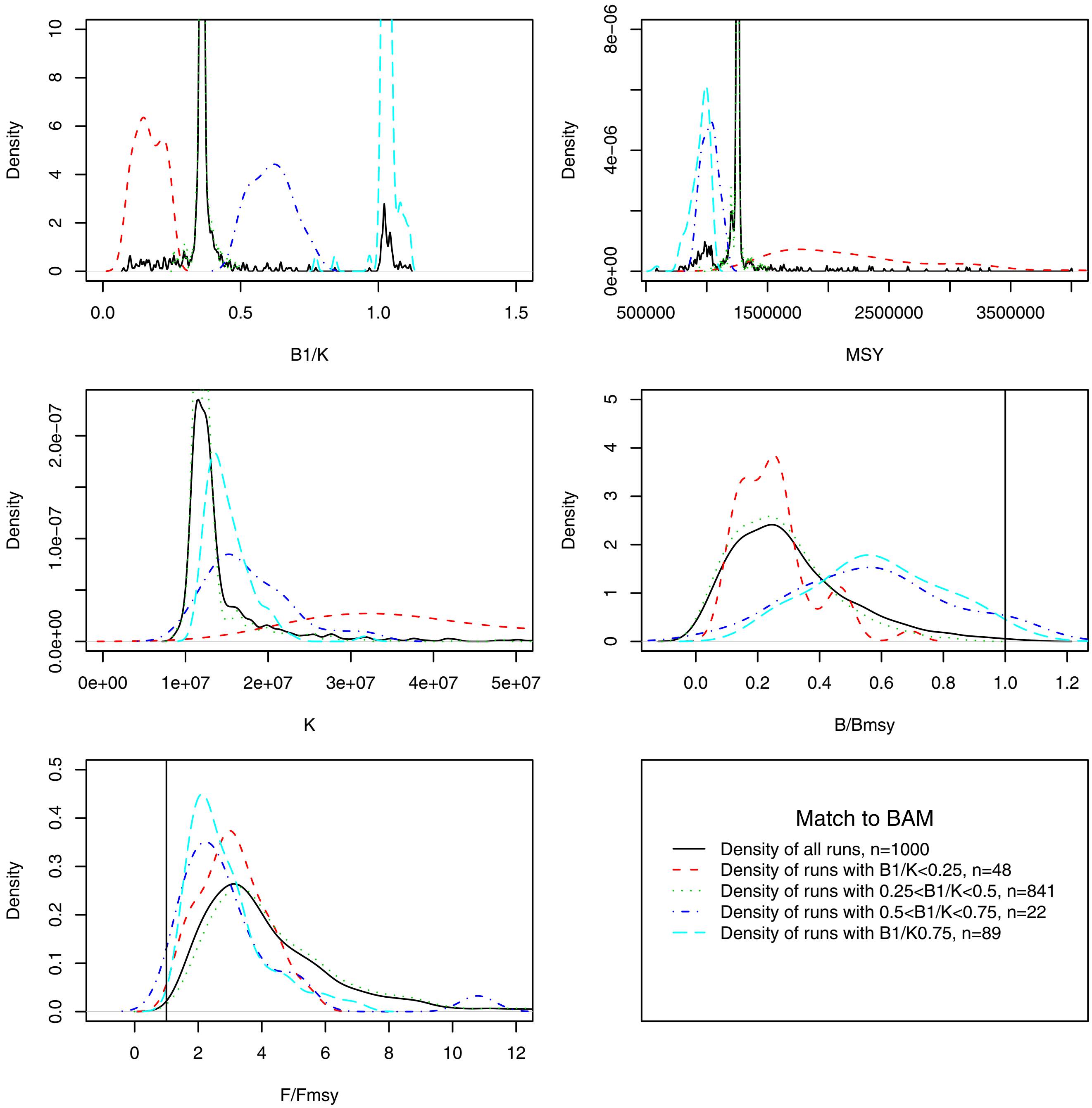


Figure 3.74. Red Snapper in Atlantic: Production model kernel density plots of parameters and status from 1000 bootstrap runs of the model configured to match the BAM data input as closely as possible without a 2 percent increase in catchability. Subsets of the model runs are grouped together by estimates of $B1/K$ to evaluate its influence on parameter estimates and status.

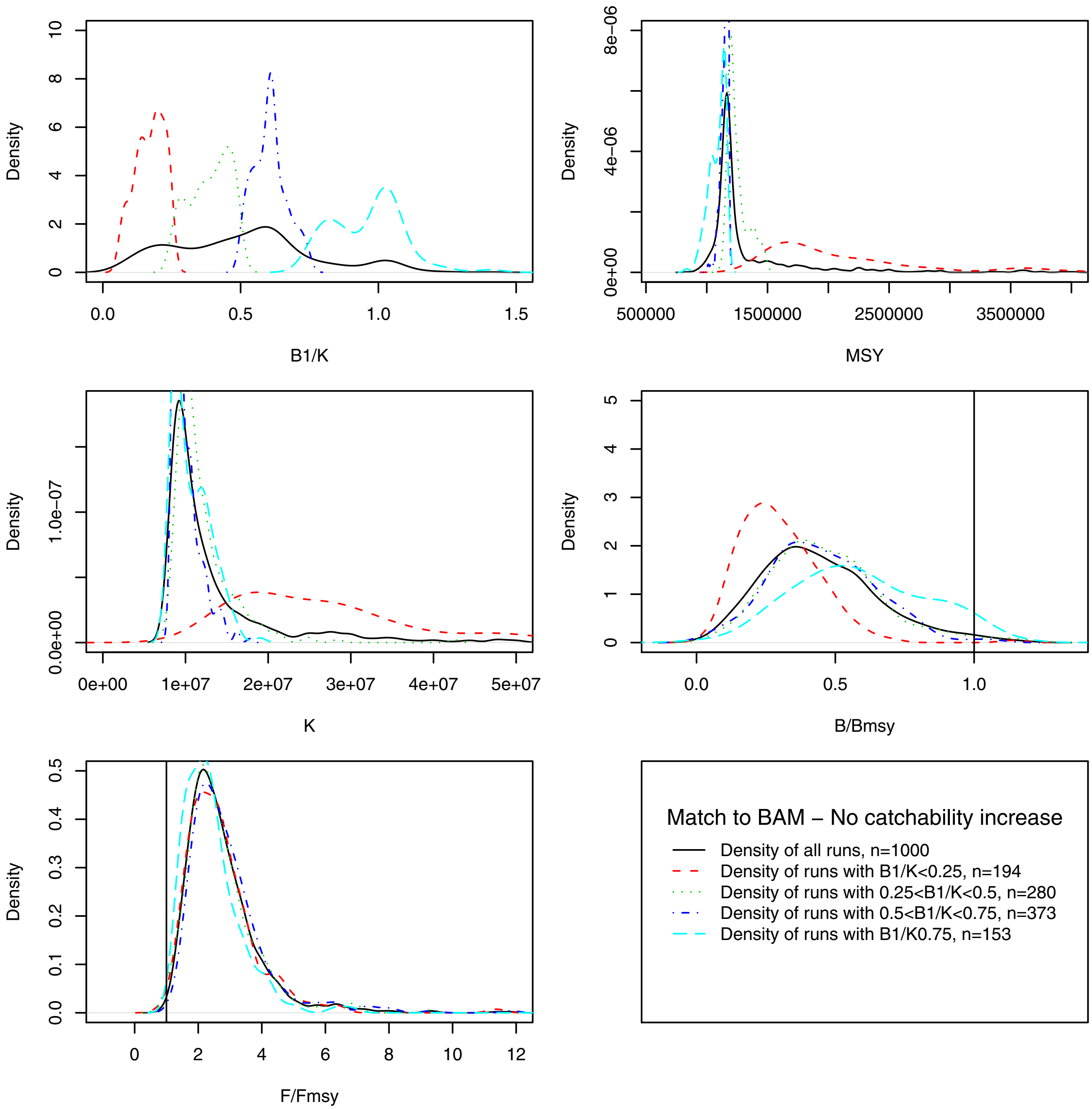


Figure 3.75. Red Snapper in Atlantic: Production model kernel density plots of parameters and status from 1000 bootstrap runs of the model configured to match the BAM data input as closely as possible and starting in 1976. Subsets of the model runs are grouped together by estimates of $B1/K$ to evaluate its influence on parameter estimates and status.

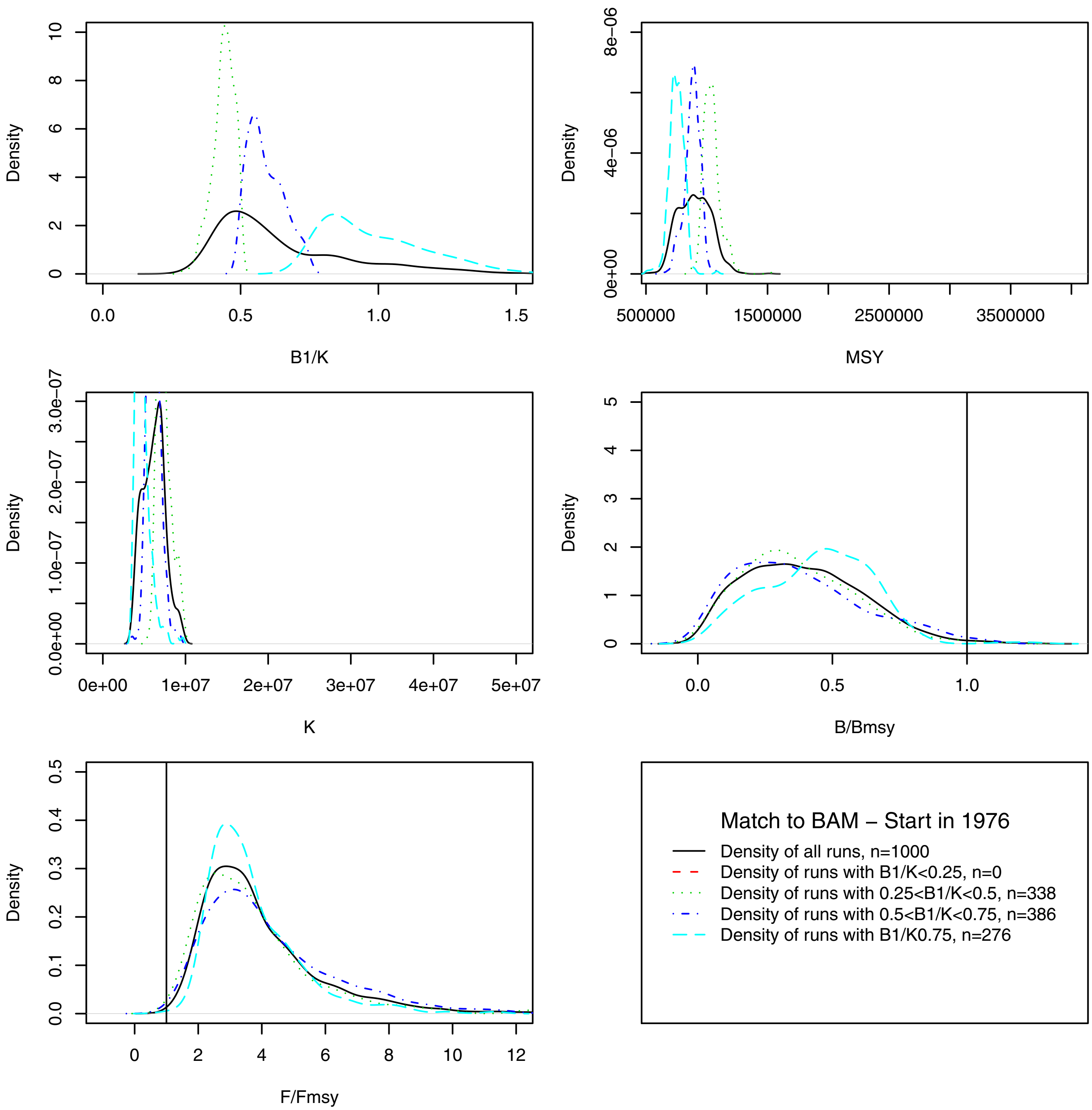


Figure 3.76. Red Snapper in Atlantic: Production model estimates of relative fishing rate F/F_{MSY} and biomass, B/B_{MSY}. Alternate runs were without the 2% catchability increase and with the model starting in 1976.

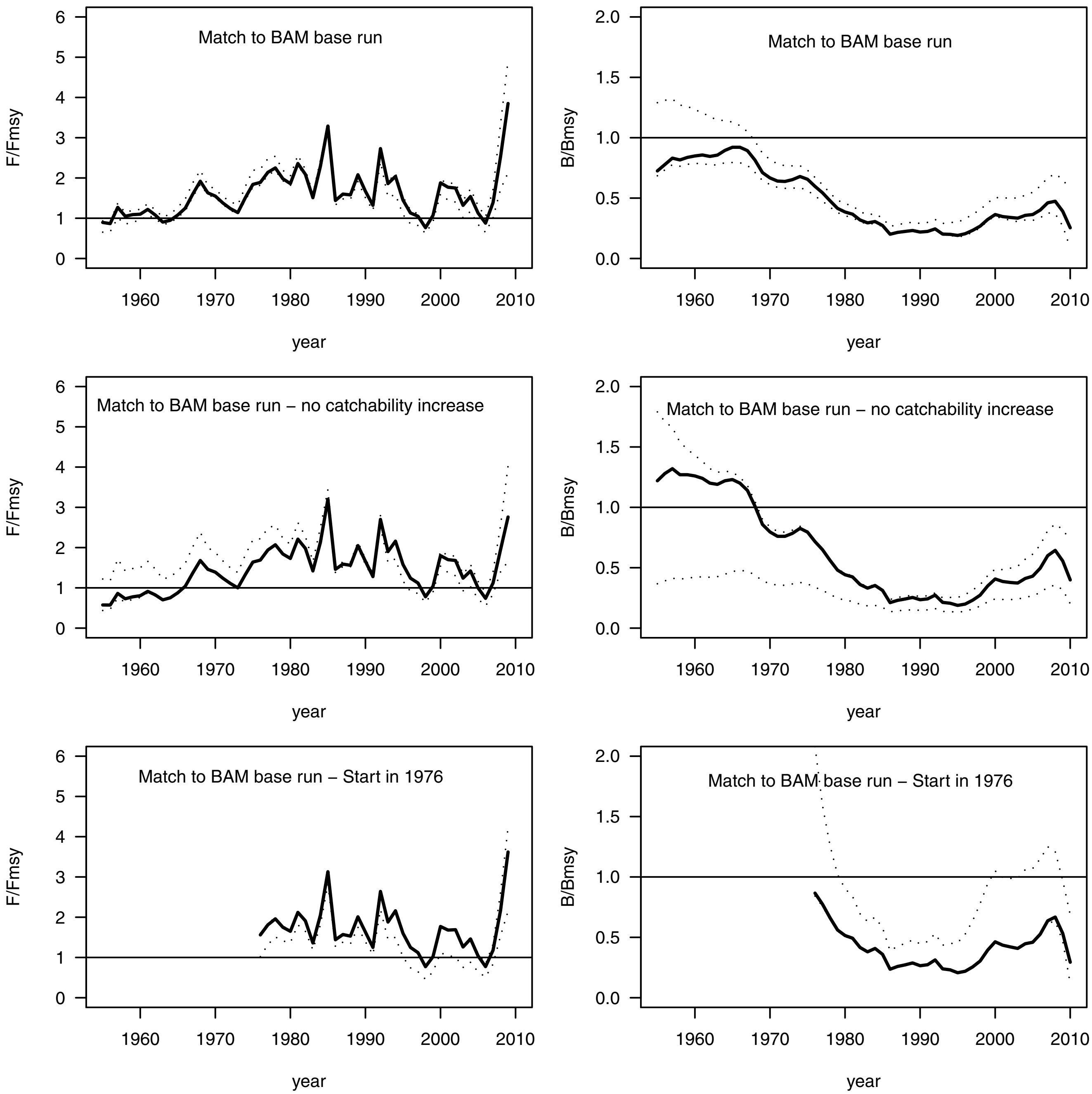
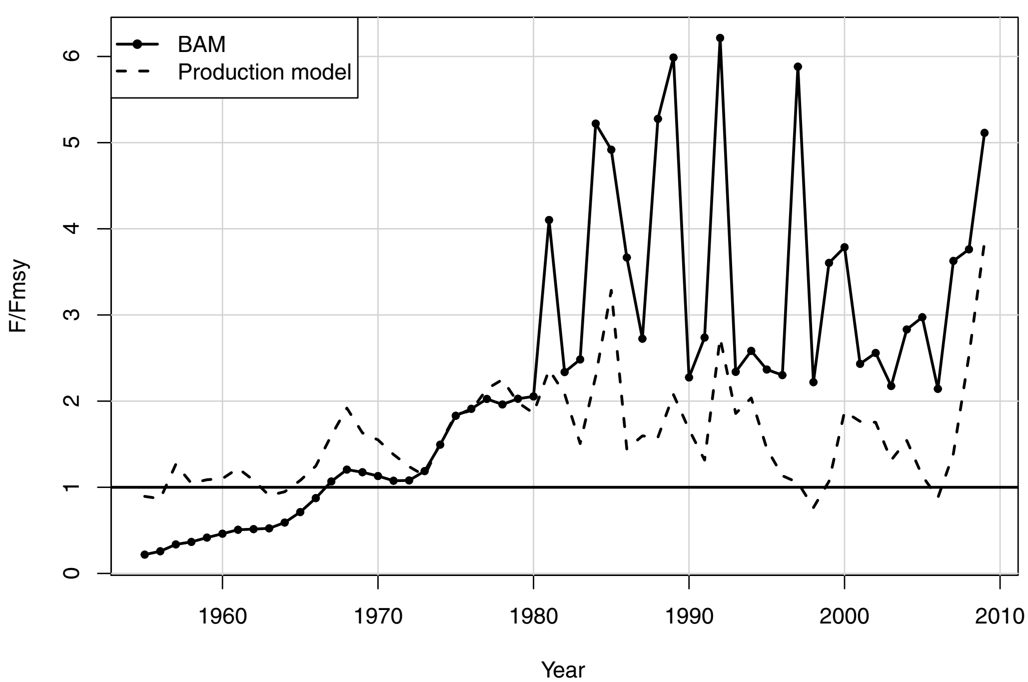


Figure 3.77. Red Snapper in Atlantic: Production model estimates of relative fishing rate F/F_{MSY} compared to the base-run estimates from the BAM. The production model run plotted is the one with inputs that resemble those of the BAM as closely as possible.



Appendix A Abbreviations and symbols

Table A.1. Acronyms and abbreviations used in this report

Symbol	Meaning
ABC	Acceptable Biological Catch
AW	Assessment Workshop (here, for red snapper)
ASY	Average Sustainable Yield
B	Total biomass of stock, conventionally on January 1r
BAM	Beaufort Assessment Model (a statistical catch-age formulation)
CPUE	Catch per unit effort; used after adjustment as an index of abundance
CV	Coefficient of variation
DW	Data Workshop (here, for red snapper)
F	Instantaneous rate of fishing mortality
F_{MSY}	Fishing mortality rate at which MSY can be attained
FL	State of Florida
GA	State of Georgia
GLM	Generalized linear model
K	Average size of stock when not exploited by man; carrying capacity
kg	Kilogram(s); 1 kg is about 2.2 lb.
klb	Thousand pounds; thousands of pounds
lb	Pound(s); 1 lb is about 0.454 kg
m	Meter(s); 1 m is about 3.28 feet.
M	Instantaneous rate of natural (non-fishing) mortality
MARMAP	Marine Resources Monitoring, Assessment, and Prediction Program, a fishery-independent data collection program of SCDNR
MFMT	Maximum fishing-mortality threshold; a limit reference point used in U.S. fishery management; often based on F_{MSY}
mm	Millimeter(s); 1 inch = 25.4 mm
MRFSS	Marine Recreational Fisheries Statistics Survey, a data-collection program of NMFS
MSST	Minimum stock-size threshold; a limit reference point used in U.S. fishery management. The SAFMC has defined MSST for red snapper as $(1-M)\mathrm{SSB}_{\mathrm{MSY}} = 0.7\mathrm{SSB}_{\mathrm{MSY}}$.
MSY	Maximum sustainable yield (per year)
mt	Metric ton(s). One mt is 1000 kg, or about 2205 lb.
N	Number of fish in a stock, conventionally on January 1
NC	State of North Carolina
NMFS	National Marine Fisheries Service, same as “NOAA Fisheries Service”
NOAA	National Oceanic and Atmospheric Administration; parent agency of NMFS
OY	Optimum yield; SFA specifies that OY ≤ MSY.
PSE	Proportional standard error
R	Recruitment
SAFMC	South Atlantic Fishery Management Council (also, Council)
SC	State of South Carolina
SCDNR	Department of Natural Resources of SC
SEDAR	SouthEast Data Assessment and Review process
SFA	Sustainable Fisheries Act; the Magnuson–Stevens Act, as amended
SL	Standard length (of a fish)
SPR	Spawning potential ratio
SRA	Stock reduction analysis
SS3	Stock Synthesis version 3, stock assessment software
SSB	Spawning stock biomass; mature biomass of males and females
$\mathrm{SSB}_{\mathrm{MSY}}$	Level of SSB at which MSY can be attained
SW	Scoping workshop; first of 3 workshops in SEDAR updates
TIP	Trip Interview Program, a fishery-dependent biodata collection program of NMFS
TL	Total length (of a fish), as opposed to FL (fork length) or SL (standard length)
VPA	Virtual population analysis, an age-structured assessment
WW	Whole weight, as opposed to GW (gutted weight)
yr	Year(s)

Appendix B Parameter estimates from the Beaufort Assessment Model

```
# Number of parameters = 355  Objective function value = 889.041  Maximum gradient component = 0.000735754
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49.9660752327
# log_R0:
13.1895667752
# log_rec_dev:
 -0.531531756462 0.0231140920057 -0.848755947452 -1.04958761708 -0.990878618859 -0.795173830122 -0.978367466829 -0.850790789831 0.603766943419
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 0.413902348920 -0.429485879495 -1.09743582951 1.35265415550 1.01957851121 -0.252843803092 -0.978437114409
# log_rec_historic_dev:
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 -0.542701008955 -0.564309783851 -0.586443983458 -0.608832640936 -0.629579427335 -0.654160866069 -0.685434813735 -0.726565394353 -0.764069771182 -0.618510945590
# selpar_L50_cL2:
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# selpar_slope_cL2:
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# selpar_L50_cL3:
2.55243464666
# selpar_slope_cL3:
4.45097975081
# selpar_Age1_cL_D3_logit:
-3.02328478552
# selpar_Age2_cL_D3_logit:
0.00544702618681
# selpar_L50_cD3:
2.77036240917
# selpar_slope_cD3:
3.81007477503
# selpar_L502_cD:
6.35217698895
# selpar_slope2_cD:
1.41347967002
# selpar_min_cD:
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# selpar_L50_HB1:
0.636183916459
# selpar_slope_HB1:
3.65195960932
# selpar_L50_HB2:
1.30241965151
# selpar_slope_HB2:
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# selpar_L50_HB3:
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# selpar_slope_HB3:
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# selpar_L502_HB:
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# selpar_slope2_HB:
1.24309387399
# selpar_Age1_HB_D3_logit:
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# selpar_L50_PVT2:
2.74442218976
# selpar_slope_PVT2:
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# selpar_L50_PVT3:
4.15814039656
# selpar_slope_PVT3:
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# log_q_cL:
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# log_q_HB:
-12.9786293855
# log_q_HBD:
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# log_avg_F_cL:
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# log_F_dev_cL:
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 -0.245371298622 0.0631787541055 0.697084960956 1.11799285109
# log_avg_F_cD:
-5.88055575438
# log_F_dev_cD:
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 1.46016834107 1.09344944302 0.578958420921 1.10693228556 1.33469989513 1.29281289762 1.22393166095 1.43626169630 1.35936350183 1.08260051879 1.28993572983
 0.710015224106 0.112275667933 0.869477094374 0.301704525608 0.474001034739
# log_avg_F_HB:
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# log_F_dev_HB:
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# log_avg_F_PVT:
-2.21953991460
# log_F_dev_PVT:
 -2.75339926218 -2.46373560948 -2.19919128293 -1.93423559964 -1.71253245837 -1.52509582414 -1.38164562548 -1.27924876808 -1.16697625583 -0.990332651023
 -0.756319172451 -0.510246206521 -0.297444075336 -0.159050663388 -0.114167794185 -0.124740607571 -0.134669795768 -0.0847810888897 0.0657745800244
 0.299411242981 0.533724504878 0.665134518109 0.692523659363 0.585372085951 0.682407343049 0.743607472211 1.54845832019 0.882111878663 0.713999028344
 1.95503034554 1.76533710073 0.973661167221 0.942500117702 1.84358889018 1.86627516523 0.0284084588703 0.859156544631 1.41248800895 -0.337696779046
 -0.292801200658 -1.97173987112 -0.352974953529 -0.954344160865 -0.349578614773 0.304834451129 1.23378622230 0.364069825123 0.0220689098347 -0.534907121998
 0.144301634861 0.0843713788973 -0.00906577884814 1.04636073674 0.985693458052 1.14646417236
# F_init:
0.0200000000000
# log_avg_F_cL_D:
-2.97433171792
# log_F_dev_cL_D:
 0.0159363505310 -0.250619810313 0.309702477446 0.538294086062 1.18275316082 1.35090096003 0.283838964884 -0.0390494673706 -0.295791881578 -0.554954500262
 0.596806786146 0.0615216561931 -0.858505997911 -0.687722938020 -0.109050372375 -0.626804249114 -0.978280749108 0.0610255239301
# log_avg_F_HB_D:
-4.05351591651
# log_F_dev_HB_D:
 1.22685582718 1.66762029730 0.580851765615 -3.18434898700 -3.99725282007 -4.29866568485 -3.21721005688 -3.70188478851 -2.41127080500 0.525028897532
 1.21212148248 -0.0500009161306 1.52420892327 0.228145030065 0.908229844808 -0.235919483127 1.17162805524 0.501560914842 0.684604042567 0.975966961208
 0.957976897370 1.59808936504 2.44314037504 0.584214900831 1.48907769796 1.15647379948 1.66075846375
# log_avg_F_PVT_D:
-2.36284823955
# log_F_dev_PVT_D:
 -2.09704289926 -1.74451756674 -0.333136131231 -0.918979473537 0.774825459068 -0.316094510407 -0.115407186389 -1.43656148675 -0.211750178904
 -1.13246689786 -0.145787368025 0.347895228993 0.225769841335 -0.263349128668 -1.61762578392 -1.02388593522 0.453935268783 0.683896874053 0.637514484215
 0.641820237125 1.07432830190 1.33084036551 1.18014886638 0.448991899948 0.798946438731 1.18383213114 1.57385914974
```

Appendix C ASPIC Output: Results of production model run matched to the base run of the BAM with a 2% increase in catchability and starting in 1955.

```
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                                                                                   Tuesday, 28 Sep 2010 at 11:47:20
ASPIC -- A Surplus-Production Model Including Covariates (Ver. 5.31)
                                                                                                   BOT program mode
Author:     Michael H. Prager; NOAA Center for Coastal Fisheries and Habitat Research              LOGISTIC model mode
            101 Pivers Island Road; Beaufort, North Carolina  28516  USA                           YLD conditioning
            Mike.Prager@noaa.gov                                                                   SSE optimization

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

CONTROL PARAMETERS (FROM INPUT FILE)                                   Input file: e:\sedar 24\aspic\rs2010_301ic_boot.inp
-------------------------------------------------------------------------------------------------------------------------
Operation of ASPIC:  Fit logistic (Schaefer) model by direct optimization with bootstrap.
Number of years analyzed:                     55          Number of bootstrap trials:                        1000
Number of data series:                         2          Bounds on MSY (min, max):       8.000E+03     7.000E+06
Objective function:                Least squares          Bounds on K (min, max):         8.000E+06     9.000E+07
Relative conv. criterion (simplex):      1.000E-08          Monte Carlo search mode, trials:        0        100000
Relative conv. criterion (restart):      3.000E-08          Random number seed:                              82184571
Relative conv. criterion (effort):       1.000E-04          Identical convergences required in fitting:            6
Maximum F allowed in fitting:            8.000


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


CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)
-------------------------------------------------------------------------------------------------------------------------
                                       |
 1  Headboat Index (1976-2009), Tota...|   1.000
                                       |      34
                                       |
 2  Commercial                         |   0.563   1.000
                                       |      17      17
                                       --------------------------------------------------
                                               1       2


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

Loss(-1)  SSE in yield                             0.000E+00
Loss(0)   Penalty for B1 > K                       0.000E+00       1           N/A    1.000E+00          N/A
Loss(1)   Headboat Index (1976-2009), Total Ldgs   1.744E+01      34     5.450E-01    1.000E+00    7.307E-01        0.155
Loss(2)   Commercial                               3.882E+00      17     2.588E-01    1.000E+00    1.539E+00       -0.967
.............................................................................................
TOTAL OBJECTIVE FUNCTION, MSE, RMSE:          2.13207919E+01           4.635E-01    6.808E-01
Estimated contrast index (ideal = 1.0):               0.3652           C* = (Bmax-Bmin)/K
Estimated nearness index (ideal = 1.0):               0.9605           N* = 1 - |min(B-Bmsy)|/K
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MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)
-------------------------------------------------------------------------------------------------------------------------
Parameter                                           Estimate     User/pgm guess    2nd guess    Estimated   User guess

B1/K      Starting relative biomass (in 1955)      3.625E-01          5.000E-01    7.071E-01            1            1
MSY       Maximum sustainable yield                1.251E+06          9.000E+05    7.731E+05            1            1
K         Maximum population size                  1.248E+07          1.000E+07    2.440E+07            1            1
phi       Shape of production curve (Bmsy/K)       0.5000             0.5000            ----            0            1
```

--------- Catchability Coefficients by Data Series ---------------

q(1)	Headboat Index (1976-2009), Total Ldgs	2.646E-07	5.000E-08	4.750E-06	1	1
q(2)	Commercial	2.455E-07	5.000E-08	4.750E-06	1	1

MANAGEMENT and DERIVED PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Logistic formula	General formula
MSY	Maximum sustainable yield	1.251E+06	----	----
Bmsy	Stock biomass giving MSY	6.240E+06	K/2	K*n**(1/(1-n))
Fmsy	Fishing mortality rate at MSY	2.005E-01	MSY/Bmsy	MSY/Bmsy
n	Exponent in production function	2.0000	----	----
g	Fletcher's gamma	4.000E+00	----	[n**(n/(n-1))]/[n-1]
B./Bmsy	Ratio: B(2010)/Bmsy	2.535E-01	----	----
F./Fmsy	Ratio: F(2009)/Fmsy	3.849E+00	----	----
Fmsy/F.	Ratio: Fmsy/F(2009)	2.598E-01	----	----
Y.(Fmsy)	Approx. yield available at Fmsy in 2010	3.170E+05	MSY*B./Bmsy	MSY*B./Bmsy
	...as proportion of MSY	2.535E-01	----	----
Ye.	Equilibrium yield available in 2010	5.537E+05	4*MSY*(B/K-(B/K)**2)	g*MSY*(B/K-(B/K)**n)
	...as proportion of MSY	4.427E-01	----	----

--------- Fishing effort rate at MSY in units of each CE or CC series ---------

fmsy(1)	Headboat Index (1976-2009), Total Ldgs	7.576E+05	Fmsy/q(1)	Fmsy/q(1)

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ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1955	0.179	4.524E+06	4.692E+06	8.414E+05	8.414E+05	1.174E+06	8.945E-01	7.250E-01
2	1956	0.174	4.856E+06	5.024E+06	8.731E+05	8.731E+05	1.203E+06	8.670E-01	7.783E-01
3	1957	0.254	5.186E+06	5.138E+06	1.304E+06	1.304E+06	1.212E+06	1.266E+00	8.311E-01
4	1958	0.210	5.093E+06	5.160E+06	1.082E+06	1.082E+06	1.213E+06	1.046E+00	8.163E-01
5	1959	0.218	5.225E+06	5.262E+06	1.147E+06	1.147E+06	1.220E+06	1.088E+00	8.373E-01
6	1960	0.221	5.297E+06	5.323E+06	1.174E+06	1.174E+06	1.224E+06	1.101E+00	8.490E-01
7	1961	0.245	5.347E+06	5.308E+06	1.299E+06	1.299E+06	1.223E+06	1.221E+00	8.569E-01
8	1962	0.217	5.271E+06	5.308E+06	1.151E+06	1.151E+06	1.223E+06	1.082E+00	8.448E-01
9	1963	0.181	5.343E+06	5.466E+06	9.908E+05	9.908E+05	1.231E+06	9.043E-01	8.563E-01
10	1964	0.190	5.584E+06	5.667E+06	1.077E+06	1.077E+06	1.240E+06	9.483E-01	8.949E-01
11	1965	0.216	5.747E+06	5.746E+06	1.244E+06	1.244E+06	1.243E+06	1.080E+00	9.210E-01
12	1966	0.250	5.746E+06	5.656E+06	1.414E+06	1.414E+06	1.240E+06	1.247E+00	9.209E-01
13	1967	0.321	5.572E+06	5.319E+06	1.708E+06	1.708E+06	1.223E+06	1.602E+00	8.930E-01
14	1968	0.385	5.087E+06	4.748E+06	1.826E+06	1.826E+06	1.178E+06	1.919E+00	8.153E-01
15	1969	0.327	4.439E+06	4.297E+06	1.405E+06	1.405E+06	1.129E+06	1.631E+00	7.114E-01
16	1970	0.311	4.163E+06	4.078E+06	1.267E+06	1.267E+06	1.101E+06	1.550E+00	6.673E-01
17	1971	0.277	3.997E+06	3.989E+06	1.104E+06	1.104E+06	1.088E+06	1.380E+00	6.405E-01
18	1972	0.249	3.981E+06	4.028E+06	1.001E+06	1.001E+06	1.094E+06	1.240E+00	6.380E-01
19	1973	0.228	4.073E+06	4.157E+06	9.459E+05	9.459E+05	1.111E+06	1.135E+00	6.528E-01
20	1974	0.303	4.239E+06	4.162E+06	1.261E+06	1.261E+06	1.112E+06	1.511E+00	6.794E-01
21	1975	0.370	4.090E+06	3.900E+06	1.442E+06	1.442E+06	1.075E+06	1.844E+00	6.555E-01
22	1976	0.379	3.723E+06	3.554E+06	1.346E+06	1.346E+06	1.019E+06	1.890E+00	5.967E-01
23	1977	0.429	3.396E+06	3.180E+06	1.365E+06	1.365E+06	9.495E+05	2.142E+00	5.442E-01
24	1978	0.451	2.980E+06	2.779E+06	1.253E+06	1.253E+06	8.656E+05	2.250E+00	4.776E-01
25	1979	0.398	2.592E+06	2.493E+06	9.918E+05	9.918E+05	7.999E+05	1.984E+00	4.154E-01
26	1980	0.373	2.400E+06	2.344E+06	8.735E+05	8.735E+05	7.632E+05	1.859E+00	3.846E-01
27	1981	0.474	2.290E+06	2.133E+06	1.011E+06	1.011E+06	7.088E+05	2.364E+00	3.670E-01
28	1982	0.418	1.987E+06	1.911E+06	7.985E+05	7.985E+05	6.487E+05	2.085E+00	3.185E-01
29	1983	0.302	1.838E+06	1.874E+06	5.661E+05	5.661E+05	6.385E+05	1.507E+00	2.945E-01
30	1984	0.459	1.910E+06	1.802E+06	8.272E+05	8.272E+05	6.182E+05	2.289E+00	3.061E-01
31	1985	0.659	1.701E+06	1.464E+06	9.647E+05	9.647E+05	5.177E+05	3.286E+00	2.726E-01
32	1986	0.290	1.254E+06	1.299E+06	3.761E+05	3.761E+05	4.666E+05	1.444E+00	2.010E-01
33	1987	0.320	1.344E+06	1.370E+06	4.383E+05	4.383E+05	4.889E+05	1.596E+00	2.155E-01

34	1988	0.317	1.395E+06	1.422E+06	4.506E+05	4.506E+05	5.052E+05	1.580E+00	2.236E-01
35	1989	0.416	1.450E+06	1.406E+06	5.852E+05	5.852E+05	5.003E+05	2.076E+00	2.323E-01
36	1990	0.335	1.365E+06	1.380E+06	4.620E+05	4.620E+05	4.920E+05	1.670E+00	2.187E-01
37	1991	0.264	1.395E+06	1.460E+06	3.851E+05	3.851E+05	5.169E+05	1.316E+00	2.235E-01
38	1992	0.548	1.526E+06	1.388E+06	7.607E+05	7.607E+05	4.944E+05	2.734E+00	2.446E-01
39	1993	0.372	1.260E+06	1.253E+06	4.663E+05	4.663E+05	4.519E+05	1.856E+00	2.020E-01
40	1994	0.408	1.246E+06	1.217E+06	4.969E+05	4.969E+05	4.404E+05	2.036E+00	1.997E-01
41	1995	0.290	1.189E+06	1.233E+06	3.580E+05	3.580E+05	4.455E+05	1.448E+00	1.906E-01
42	1996	0.227	1.277E+06	1.364E+06	3.102E+05	3.102E+05	4.870E+05	1.134E+00	2.046E-01
43	1997	0.211	1.454E+06	1.561E+06	3.298E+05	3.298E+05	5.474E+05	1.054E+00	2.330E-01
44	1998	0.153	1.671E+06	1.841E+06	2.822E+05	2.822E+05	6.289E+05	7.647E-01	2.679E-01
45	1999	0.214	2.018E+06	2.143E+06	4.593E+05	4.593E+05	7.115E+05	1.069E+00	3.234E-01
46	2000	0.377	2.270E+06	2.217E+06	8.350E+05	8.350E+05	7.310E+05	1.879E+00	3.638E-01
47	2001	0.354	2.166E+06	2.142E+06	7.581E+05	7.581E+05	7.115E+05	1.765E+00	3.472E-01
48	2002	0.352	2.120E+06	2.100E+06	7.384E+05	7.384E+05	7.004E+05	1.754E+00	3.397E-01
49	2003	0.264	2.082E+06	2.155E+06	5.682E+05	5.682E+05	7.147E+05	1.315E+00	3.336E-01
50	2004	0.309	2.228E+06	2.250E+06	6.959E+05	6.959E+05	7.394E+05	1.543E+00	3.571E-01
51	2005	0.227	2.272E+06	2.387E+06	5.418E+05	5.418E+05	7.739E+05	1.132E+00	3.641E-01
52	2006	0.176	2.504E+06	2.688E+06	4.731E+05	4.731E+05	8.452E+05	8.779E-01	4.013E-01
53	2007	0.279	2.876E+06	2.918E+06	8.135E+05	8.135E+05	8.963E+05	1.391E+00	4.609E-01
54	2008	0.507	2.959E+06	2.688E+06	1.362E+06	1.362E+06	8.449E+05	2.528E+00	4.742E-01
55	2009	0.772	2.441E+06	1.976E+06	1.525E+06	1.525E+06	6.648E+05	3.849E+00	3.913E-01
56	2010		1.581E+06						2.535E-01

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RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) Headboat Index (1976-2009), Total Ldgs w

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

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale	Statist weight
1	1955	*	1.242E+00	0.1793	8.414E+05	8.414E+05	0.00000	1.000E+00
2	1956	*	1.329E+00	0.1738	8.731E+05	8.731E+05	0.00000	1.000E+00
3	1957	*	1.360E+00	0.2538	1.304E+06	1.304E+06	0.00000	1.000E+00
4	1958	*	1.366E+00	0.2097	1.082E+06	1.082E+06	0.00000	1.000E+00
5	1959	*	1.392E+00	0.2180	1.147E+06	1.147E+06	0.00000	1.000E+00
6	1960	*	1.409E+00	0.2206	1.174E+06	1.174E+06	0.00000	1.000E+00
7	1961	*	1.405E+00	0.2447	1.299E+06	1.299E+06	0.00000	1.000E+00
8	1962	*	1.405E+00	0.2168	1.151E+06	1.151E+06	0.00000	1.000E+00
9	1963	*	1.446E+00	0.1813	9.908E+05	9.908E+05	0.00000	1.000E+00
10	1964	*	1.500E+00	0.1901	1.077E+06	1.077E+06	0.00000	1.000E+00
11	1965	*	1.521E+00	0.2164	1.244E+06	1.244E+06	0.00000	1.000E+00
12	1966	*	1.497E+00	0.2500	1.414E+06	1.414E+06	0.00000	1.000E+00
13	1967	*	1.407E+00	0.3211	1.708E+06	1.708E+06	0.00000	1.000E+00
14	1968	*	1.256E+00	0.3847	1.826E+06	1.826E+06	0.00000	1.000E+00
15	1969	*	1.137E+00	0.3270	1.405E+06	1.405E+06	0.00000	1.000E+00
16	1970	*	1.079E+00	0.3108	1.267E+06	1.267E+06	0.00000	1.000E+00
17	1971	*	1.055E+00	0.2767	1.104E+06	1.104E+06	0.00000	1.000E+00
18	1972	*	1.066E+00	0.2486	1.001E+06	1.001E+06	0.00000	1.000E+00
19	1973	*	1.100E+00	0.2275	9.459E+05	9.459E+05	0.00000	1.000E+00
20	1974	*	1.101E+00	0.3029	1.261E+06	1.261E+06	0.00000	1.000E+00
21	1975	*	1.032E+00	0.3697	1.442E+06	1.442E+06	0.00000	1.000E+00
22	1976	1.801E+00	9.404E-01	0.3788	1.346E+06	1.346E+06	-0.64979	1.000E+00
23	1977	2.095E+00	8.414E-01	0.4294	1.365E+06	1.365E+06	-0.91240	1.000E+00
24	1978	1.671E+00	7.352E-01	0.4511	1.253E+06	1.253E+06	-0.82117	1.000E+00
25	1979	2.486E+00	6.598E-01	0.3978	9.918E+05	9.918E+05	-1.32642	1.000E+00
26	1980	9.914E-01	6.202E-01	0.3727	8.735E+05	8.735E+05	-0.46912	1.000E+00
27	1981	1.867E+00	5.645E-01	0.4740	1.011E+06	1.011E+06	-1.19627	1.000E+00
28	1982	1.107E+00	5.056E-01	0.4179	7.985E+05	7.985E+05	-0.78332	1.000E+00
29	1983	6.977E-01	4.959E-01	0.3021	5.661E+05	5.661E+05	-0.34148	1.000E+00
30	1984	6.327E-01	4.770E-01	0.4589	8.272E+05	8.272E+05	-0.28255	1.000E+00
31	1985	9.436E-01	3.875E-01	0.6587	9.647E+05	9.647E+05	-0.89000	1.000E+00
32	1986	2.734E-01	3.437E-01	0.2896	3.761E+05	3.761E+05	0.22874	1.000E+00
33	1987	3.145E-01	3.624E-01	0.3200	4.383E+05	4.383E+05	0.14181	1.000E+00
34	1988	3.214E-01	3.764E-01	0.3168	4.506E+05	4.506E+05	0.15790	1.000E+00
35	1989	4.488E-01	3.722E-01	0.4161	5.852E+05	5.852E+05	-0.18730	1.000E+00
36	1990	4.166E-01	3.651E-01	0.3348	4.620E+05	4.620E+05	-0.13185	1.000E+00
37	1991	5.245E-01	3.864E-01	0.2638	3.851E+05	3.851E+05	-0.30564	1.000E+00
38	1992	6.395E-02	3.673E-01	0.5480	7.607E+05	7.607E+05	1.74806	1.000E+00

39	1993	1.271E-01	3.316E-01	0.3722	4.663E+05	4.663E+05	0.95875	1.000E+00
40	1994	1.912E-01	3.221E-01	0.4082	4.969E+05	4.969E+05	0.52175	1.000E+00
41	1995	2.471E-01	3.262E-01	0.2903	3.580E+05	3.580E+05	0.27803	1.000E+00
42	1996	2.790E-01	3.609E-01	0.2274	3.102E+05	3.102E+05	0.25768	1.000E+00
43	1997	3.010E-01	4.130E-01	0.2113	3.298E+05	3.298E+05	0.31631	1.000E+00
44	1998	1.645E-01	4.871E-01	0.1533	2.822E+05	2.822E+05	1.08571	1.000E+00
45	1999	2.260E-01	5.671E-01	0.2143	4.593E+05	4.593E+05	0.92008	1.000E+00
46	2000	2.805E-01	5.867E-01	0.3766	8.350E+05	8.350E+05	0.73789	1.000E+00
47	2001	5.031E-01	5.669E-01	0.3539	7.581E+05	7.581E+05	0.11942	1.000E+00
48	2002	5.578E-01	5.558E-01	0.3516	7.384E+05	7.384E+05	-0.00373	1.000E+00
49	2003	3.895E-01	5.702E-01	0.2637	5.682E+05	5.682E+05	0.38103	1.000E+00
50	2004	6.227E-01	5.954E-01	0.3093	6.959E+05	6.959E+05	-0.04485	1.000E+00
51	2005	5.363E-01	6.317E-01	0.2270	5.418E+05	5.418E+05	0.16367	1.000E+00
52	2006	3.206E-01	7.113E-01	0.1760	4.731E+05	4.731E+05	0.79684	1.000E+00
53	2007	2.545E-01	7.720E-01	0.2788	8.135E+05	8.135E+05	1.10976	1.000E+00
54	2008	1.146E+00	7.113E-01	0.5067	1.362E+06	1.362E+06	-0.47719	1.000E+00
55	2009	1.358E+00	5.229E-01	0.7716	1.525E+06	1.525E+06	-0.95431	1.000E+00

* Asterisk indicates missing value(s).

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RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED) Commercial

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

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Statist weight
1	1955	0.000E+00	0.000E+00	--	*	1.152E+00	0.00000	1.000E+00
2	1956	0.000E+00	0.000E+00	--	*	1.233E+00	0.00000	1.000E+00
3	1957	0.000E+00	0.000E+00	--	*	1.261E+00	0.00000	1.000E+00
4	1958	0.000E+00	0.000E+00	--	*	1.267E+00	0.00000	1.000E+00
5	1959	0.000E+00	0.000E+00	--	*	1.292E+00	0.00000	1.000E+00
6	1960	0.000E+00	0.000E+00	--	*	1.307E+00	0.00000	1.000E+00
7	1961	0.000E+00	0.000E+00	--	*	1.303E+00	0.00000	1.000E+00
8	1962	0.000E+00	0.000E+00	--	*	1.303E+00	0.00000	1.000E+00
9	1963	0.000E+00	0.000E+00	--	*	1.342E+00	0.00000	1.000E+00
10	1964	0.000E+00	0.000E+00	--	*	1.391E+00	0.00000	1.000E+00
11	1965	0.000E+00	0.000E+00	--	*	1.411E+00	0.00000	1.000E+00
12	1966	0.000E+00	0.000E+00	--	*	1.388E+00	0.00000	1.000E+00
13	1967	0.000E+00	0.000E+00	--	*	1.306E+00	0.00000	1.000E+00
14	1968	0.000E+00	0.000E+00	--	*	1.165E+00	0.00000	1.000E+00
15	1969	0.000E+00	0.000E+00	--	*	1.055E+00	0.00000	1.000E+00
16	1970	0.000E+00	0.000E+00	--	*	1.001E+00	0.00000	1.000E+00
17	1971	0.000E+00	0.000E+00	--	*	9.791E-01	0.00000	1.000E+00
18	1972	0.000E+00	0.000E+00	--	*	9.888E-01	0.00000	1.000E+00
19	1973	0.000E+00	0.000E+00	--	*	1.021E+00	0.00000	1.000E+00
20	1974	0.000E+00	0.000E+00	--	*	1.022E+00	0.00000	1.000E+00
21	1975	0.000E+00	0.000E+00	--	*	9.573E-01	0.00000	1.000E+00
22	1976	0.000E+00	0.000E+00	--	*	8.724E-01	0.00000	1.000E+00
23	1977	0.000E+00	0.000E+00	--	*	7.805E-01	0.00000	1.000E+00
24	1978	0.000E+00	0.000E+00	--	*	6.821E-01	0.00000	1.000E+00
25	1979	0.000E+00	0.000E+00	--	*	6.121E-01	0.00000	1.000E+00
26	1980	0.000E+00	0.000E+00	--	*	5.753E-01	0.00000	1.000E+00
27	1981	0.000E+00	0.000E+00	--	*	5.237E-01	0.00000	1.000E+00
28	1982	0.000E+00	0.000E+00	--	*	4.691E-01	0.00000	1.000E+00
29	1983	0.000E+00	0.000E+00	--	*	4.600E-01	0.00000	1.000E+00
30	1984	0.000E+00	0.000E+00	--	*	4.425E-01	0.00000	1.000E+00
31	1985	0.000E+00	0.000E+00	--	*	3.595E-01	0.00000	1.000E+00
32	1986	0.000E+00	0.000E+00	--	*	3.189E-01	0.00000	1.000E+00
33	1987	0.000E+00	0.000E+00	--	*	3.362E-01	0.00000	1.000E+00
34	1988	0.000E+00	0.000E+00	--	*	3.491E-01	0.00000	1.000E+00
35	1989	0.000E+00	0.000E+00	--	*	3.452E-01	0.00000	1.000E+00
36	1990	0.000E+00	0.000E+00	--	*	3.387E-01	0.00000	1.000E+00
37	1991	0.000E+00	0.000E+00	--	*	3.584E-01	0.00000	1.000E+00
38	1992	0.000E+00	0.000E+00	--	*	3.408E-01	0.00000	1.000E+00
39	1993	1.000E+00	1.000E+00	--	7.504E-01	3.076E-01	0.89191	1.000E+00
40	1994	1.000E+00	1.000E+00	--	5.850E-01	2.988E-01	0.67176	1.000E+00
41	1995	1.000E+00	1.000E+00	--	5.716E-01	3.027E-01	0.63591	1.000E+00
42	1996	1.000E+00	1.000E+00	--	3.438E-01	3.348E-01	0.02638	1.000E+00

43	1997	1.000E+00	1.000E+00	--	3.289E-01	3.832E-01	-0.15285	1.000E+00
44	1998	1.000E+00	1.000E+00	--	3.539E-01	4.519E-01	-0.24441	1.000E+00
45	1999	1.000E+00	1.000E+00	--	4.082E-01	5.261E-01	-0.25360	1.000E+00
46	2000	1.000E+00	1.000E+00	--	3.874E-01	5.443E-01	-0.33999	1.000E+00
47	2001	1.000E+00	1.000E+00	--	6.090E-01	5.259E-01	0.14663	1.000E+00
48	2002	1.000E+00	1.000E+00	--	6.552E-01	5.156E-01	0.23964	1.000E+00
49	2003	1.000E+00	1.000E+00	--	5.111E-01	5.290E-01	-0.03443	1.000E+00
50	2004	1.000E+00	1.000E+00	--	6.624E-01	5.523E-01	0.18172	1.000E+00
51	2005	1.000E+00	1.000E+00	--	5.649E-01	5.860E-01	-0.03673	1.000E+00
52	2006	1.000E+00	1.000E+00	--	2.797E-01	6.599E-01	-0.85840	1.000E+00
53	2007	1.000E+00	1.000E+00	--	3.054E-01	7.162E-01	-0.85223	1.000E+00
54	2008	1.000E+00	1.000E+00	--	5.525E-01	6.598E-01	-0.17763	1.000E+00
55	2009	1.000E+00	1.000E+00	--	8.823E-01	4.850E-01	0.59827	1.000E+00

* Asterisk indicates missing value(s).

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ESTIMATES FROM BOOTSTRAPPED ANALYSIS

Param name	Point estimate	Estimated bias in pt estimate	Estimated relative bias	Bias-corrected approximate confidence limits 80% lower	80% upper	50% lower	50% upper	Inter-quartile range	Relative IQ range
B1/K	3.625E-01	5.486E-02	15.13%	3.491E-01	1.020E+00	3.574E-01	3.811E-01	2.372E-02	0.065
K	1.248E+07	2.563E+06	20.54%	1.096E+07	2.041E+07	1.137E+07	1.410E+07	2.726E+06	0.218
q(1)	2.646E-07	-2.457E-08	-9.28%	1.668E-07	3.442E-07	2.374E-07	3.084E-07	7.096E-08	0.268
q(2)	2.455E-07	-1.624E-08	-6.62%	1.306E-07	3.423E-07	1.927E-07	2.984E-07	1.057E-07	0.431
MSY	1.251E+06	1.281E+04	1.02%	9.973E+05	1.266E+06	1.227E+06	1.257E+06	2.942E+04	0.024
Ye(2010)	5.537E+05	4.346E+04	7.85%	1.731E+05	8.992E+05	3.261E+05	7.203E+05	3.942E+05	0.712
Y.@Fmsy	3.170E+05	5.981E+04	18.86%	8.833E+04	6.103E+05	1.732E+05	4.336E+05	2.604E+05	0.821
Bmsy	6.240E+06	1.282E+06	20.54%	5.480E+06	1.020E+07	5.687E+06	7.050E+06	1.363E+06	0.218
Fmsy	2.005E-01	-1.454E-02	-7.25%	1.192E-01	2.317E-01	1.695E-01	2.217E-01	5.217E-02	0.260
fmsy(1)	7.576E+05	3.822E+04	5.05%	6.395E+05	8.966E+05	6.830E+05	8.172E+05	1.342E+05	0.177
fmsy(2)	8.166E+05	4.608E+04	5.64%	6.242E+05	1.105E+06	7.101E+05	9.445E+05	2.344E+05	0.287
B./Bmsy	2.535E-01	5.465E-02	21.56%	7.884E-02	5.272E-01	1.402E-01	3.629E-01	2.227E-01	0.879
F./Fmsy	3.849E+00	5.564E-01	14.46%	2.251E+00	8.048E+00	2.966E+00	5.636E+00	2.669E+00	0.693
Ye./MSY	4.427E-01	4.086E-02	9.23%	1.515E-01	7.764E-01	2.608E-01	5.942E-01	3.334E-01	0.753
q2/q1	9.277E-01	3.104E-02	3.35%	7.019E-01	1.213E+00	7.888E-01	1.064E+00	2.753E-01	0.297

INFORMATION FOR REPAST (Prager, Porch, Shertzer, & Caddy. 2003. NAJFM 23: 349-361)

Unitless limit reference point in F (Fmsy/F.): 0.2598
CV of above (from bootstrap distribution): 0.5149

NOTES ON BOOTSTRAPPED ESTIMATES:

- Bootstrap results were computed from 1000 trials.
- Results are conditional on bounds set on MSY and K in the input file.
- All bootstrapped intervals are approximate. The statistical literature recommends using at least 1000 trials for accurate 95% intervals. The default 80% intervals used by ASPIC should require fewer trials for equivalent accuracy. Using at least 500 trials is recommended.
- Bias estimates are typically of high variance and therefore may be misleading.

Trials replaced for lack of convergence: 0
Trials replaced for MSY out of bounds: 2
Trials replaced for q out-of-bounds: 0
Trials replaced for K out-of-bounds: 28
Residual-adjustment factor: 1.0529

Elapsed time: 1 hours, 8 minutes, 43 seconds.

4 Comments and the Pre-Review Process

4.1 Comments from Panel Members

Submitted by Panelist Dr. Frank Hester on 9-28-10:
One panelist was concerned that the most recent changes made in the base case could not be reviewed by the AW before the document was released. The panelist has, where possible, joined in consensus building for SEDAR 24, but cannot accept unseen the new base case without an opportunity to review the changes and their results.

4.2 Pre-Review Process Introduction

A draft assessment report was made available for public comment from August 26 – September 6, 2010. The intent of public comment was to allow interested parties the opportunity to address the draft report of a SEDAR stock assessment before the report and assessment went to the Review Panel. The assessment panel made changes to the draft report in response to comments received.

Comments were made available to Assessment Process panelists as they were received. On September 9, 2010, the assessment panel met via webinar to review comments and recommend changes to the model and report. At the webinar panelists reviewed a summary of the comments and the recommended model and report changes are described in section 4.2.

During the September 9 webinar the panel also reviewed extensive comments provided by AW panelists. Changes resulting from this component of the pre-review are summarized in section 4.3.

4.3 Summary of Comments Received and Responses

A total of 43 comments (from 19 individuals) were received during the comment period. The comments were summarized and broken down into four general categories: 1) comments on data, 2) comments on model results, 3) comments on the SEDAR process, and 4) miscellaneous comments.

4.3.1 Comments on data

- Questioning the use and accuracy of historical data; suggest starting the model in later years (1986 was one suggestion)
- Questioning the use and accuracy of MRFSS data and MRFSS sample size adequacy
- Independent surveys are not very accurate for red snapper and fishery dependent monitored tagging and onboard observer programs would be better
- General comment that the assessment did not use real/relevant/sound science/data
- Concern that primarily fishery-dependent landings data are used for model inputs

- Dome shaped selectivity should be used
- Remove all effort data from south of X county (Martin County and Broward were suggested)
- Headboat and charter boat catch data should be separated
- Concern SEDAR did include recreational anecdotal information
- Discard mortality is too high and needs to be revisited
- Natural mortality is too low and needs to be revisited

Responses to comments on data

The data workshop panel and assessment panel acknowledge that there is uncertainty around early years of data. MRFSS data and associated uncertainty about the data are well documented. The data workshop panelists and the assessment panelists recommended the MRFSS data be used for the SEDAR 24 assessment.

The assessment panel recommended a sensitivity run that uses only data from 1976-2009. This is explained in the SEDAR 24 assessment report, section 3.1.1.3, Sensitivity #10: "S10: Starting year of the model was 1976. Initial (1976) numbers at age were estimated in this sensitivity run, with penalized deviation from the stable age structure that corresponded to the initial, estimated mortality rate." The results of the model beginning in 1976 were similar to the "base" model beginning in 1955 (Table 3.15 of the assessment report). In addition, based on public comment the panel recommended an additional sensitivity run that begins the model in 1986.

Existing independent surveys do not adequately capture red snapper, therefore no fishery independent surveys were included in the assessment model. New fishery independent sampling program efforts are underway that expand independent surveys and future programs will consider a variety of sampling gears. Many prior assessments have recommended an increase in observer coverage. The panel agreed that increased observer coverage would be useful.

In SEDAR 24 the assessment panel recommended that dome shaped selectivity be used for commercial dive, for-hire, and private recreational fleets. Only the commercial handline was not modeled with dome shaped selectivity. Separation of the headboat and chartboat data was discussed in the data workshop and again in the assessment webinars and was not recommended by either group.

The panel recommended contacting MRFSS to find out what level of post-stratification of MRFSS data was applied. The following is an excerpt of the response.

> "The catch rate sampling will appropriately include sample catches and sample effort (number of anglers interviewed) throughout the coast-wide unit based on the weighted representative sample design with respect to site selection. If the estimated activities at the sites and the resultant samples accurately represent that distribution of effort, then the state estimate will be unbiased even if regions within the state have variable catch rates."

> "… To conclude, our surveys were designed to sample and produce estimates at the state level. In Florida, the state-level has been set at East Florida, Nassau to Miami-Dade county. Although we are aware of potential biases in our design due to assumptions in sample distribution that may not be accurate, to divide our data via a stratification process will only produce less precise estimates of catch-rates that may or may not reflect true regional catch rates. We do not support any further post-stratification of EFL survey results. (post-stratification is generally only used for stock delineation, e.g., north and south of Hatteras, or to exclude Monroe county, FL from WFL 'state')."

Changes made to the model and report

- The panel recommended a sensitivity analysis starting the model in 1986.
- Add "improve fishery independent sampling" as research recommendation.

4.3.2 Comments on model results

- Questioning how estimated biomass could be below MSY in early years (1960) when there is a perception that few boats were operating over only the shallow part of habitat
- Questioning how abundance at age can be so low for old fish in recent years
- Questioning the difference in biomass/spawning stock/abundance-at-age estimated between SEDAR 15 and SEDAR 24 for given years
- Questioning how SA red snapper can have a small year class when at a healthy level of biomass

Responses to comments on model results

Several comments were received comparing the SEDAR 24 assessment to SEDAR 15 (South Atlantic red snapper 2008 assessment) and SEDAR 7 (Gulf of Mexico red snapper 2005 assessment). The data and decisions made about selectivity, catchability, landings, and discards in these models are very different and render comparison of results invalid.

Recruitment is driven by many factors, including environmental conditions and spawning stock biomass. A large spawning biomass does not guarantee high recruitment nor does a low SSB guarantee poor recruitment.

The Panel discussed perceived difficulties in estimating abundance of older fish in recent years, and the possibility that current values are underestimated. This is difficult to adequately evaluate due to the lack of independent abundance indices.

4.3.3 Comments on SEDAR process

- Questioning the degree of public input in the SEDAR process
- Suggestion that an independent review of red snapper should be done by a 3rd party.
- The assessment report if too long and too unreadable.
- Physical meetings are preferred for assessments, preference for a combination of webinars and physical meetings
- Not enough webinars were scheduled
- SEDAR is cutting corners because they are trying to reduce costs
- SEDAR 24 was rushed
- SEDAR 24 comment period was too short

Responses to comments on SEDAR process

SouthEast Data, Assessment and Review is a process that is continually evaluated and improved. The SEDAR steering committee will evaluate the webinar process and make suggestions on future directions. The SEDAR assessment process was moved to a webinar-only format to try to increase participation by fishermen and to reduce travel costs. The webinar format allows the analysts to get recommendations from the panel then go back to make changes to the model.

The SEDAR 24 red snapper assessment will be reviewed by an independent panel of experts from the Center for Independent Experts (CIE) in October, 2010. The assessment report released on August 26, 2010 was also reviewed by a CIE expert who is an experienced stock assessment scientist from outside the US.

The SEDAR process is intended to be open and transparent. Recreational and commercial fishermen were appointed as panelists to both the data workshop and the assessment process. All data workshop meetings and assessment webinars are open to the public and observers have been present at all red snapper assessment webinars.

The assessment report is necessarily long and detailed to cover all of the required detail that the reviewers will need to assess the validity of the work. We try to make the document as clear as possible, but acknowledge that the language and concepts of stock assessments are complex.

SEDAR 24 was rushed, intentionally, both in its initial planning and its completion date. Elevating the planned update to a benchmark in early 2010 significantly reduced the advance planning time that is devoted to most benchmarks. Furthermore, by requesting final results by December 2010, the Council knowingly imposed a strict and essentially rushed schedule to the entire process. Under normal circumstance the Council would have received results of SEDAR 24 in June 2011. The Council and all participants in the process were informed of the realities such a schedule imposed on the process and on their time to review various components of the assessment.

Changes made to the model and report

- Add "examine or develop ways to include anecdotal information in SEDAR assessments" as a research recommendation.

4.3.4 Miscellaneous comments

- The SEDAR 24 final report should specifically address the items in the Stokes CIE reviewer report
- Comment that additional models should be run (VPA and SVPA were suggested)
- Comment that constituents will not know whether a 10 year rebuilding time will be required before the end of the assessment process and comment period
- The panel should conduct a 16-inch minimum size analysis for red snapper

Responses to miscellaneous comments

Two models were prepared for SEDAR 24: the Beaufort Assessment Model, which is a forward-projecting statistical catch-at-age model, and a Surplus Production Model. The requests for a VPA have not been ignored and the reasons for not conducting a VPA model are discussed in Section 3 of the report, copied here.

> "A VPA was not pursued, for several reasons. A major assumption of VPAs is that catch at age of each fleet in each year is known precisely, which is not a valid assumption for U.S. Atlantic snapper-grouper stocks in general, and the red snapper stock in particular. For example, only seven private recreational (a dominant fleet for red snapper) fishing trips were sampled for red snapper ages prior to 2009. Thus, developing catch-age matrices would require strong assumptions to fill in the data gaps; this obstacle is not insurmountable in principle, but if pursued, should likely be done at a Data Workshop by data providers who are most familiar with the strengths and weaknesses of each data set. Relaxing the assumption of known catch at age was one reason for the advent of statistical catch-age models (e.g., BAM). The AW panel thought that committing its limited resources to the BAM, SSRA, and surplus-production models would be more productive."

The South Atlantic Council determines rebuilding probability, and a rebuilding plan must have at least a 50% chance of success. The management actions or analysis of alternatives that come from any SEDAR assessment are implemented outside the SEDAR process and cannot be done by SEDAR panels or through the SEDAR process.

The panel recommends that the SEDAR process develop a mechanism for dealing with CIE reviewer suggestions.

Changes made to the model and report

- Add elaboration in the data update section indicating the smoothing was done as a response to the data workshop CIE reviewer report.

4.4 Recommendations from the AW panel

4.4.1 Comments from panelists There was some overlap in public comment and panelist comments on the draft assessment report. For brevity, the duplicate issues are not reiterated here. After discussion, the following changes were made to the model:

- The panel recommended changing the commercial:recreational landings ratios back in time, using 9 lb for historical average commercial weight. This will reduce historical recreational (for-hire and private) landings
- Add more summary of the selectivity discussions by the panel to the AW report
- Add figure with total landings and MSY line superimposed on it to the AW report
- Explain the metric for SSB better in report
- Add explanation of the MC bootstraps and what they really mean (uncertainty estimates not probabilities)
- Give clearer explanation for initial F estimation
- Remove unused parameters in Appendix B

SEDAR

SouthEast Data, Assessment, and Review

South Atlantic Red Snapper
SECTION IV: Research Recommendations

October 2010

SEDAR
4055 Faber Place Drive, Suite 201
North Charleston, SC 29405

Section IV: Research Recommendations

Contents

1 Data Workshop Research Recommendations

Workshop Term of Reference #10 called for the Data Panel to provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment; and to include specific guidance on sampling intensity (number of samples including age and length structures) and appropriate strata and coverage.

1.1 Life History Work Group

The life history WG recommended the following:

- Age Reading Comparisons Continuing the age reading comparisons and calibrations between labs on a reference collection of known age fish would be beneficial for determining a more accurate aging error matrix and would provide accuracy to the age composition data.

- Movements and Migrations More research on red snapper movements/migrations in Atlantic waters is needed. Available data and the results of studies in the Gulf of Mexico indicate high site fidelity. Tropical storms may cause greater than normal movement.

1.2 Commercial Statistics

The Workgroup reviewed recommendations from SEDAR 15 and offers additional recommendations. The Commercial WG notes that Sea Grant is currently funding a video monitoring program for observing the snapper-grouper fishery using exemption permits with 7 total vessels participating (1 in NC, 2 each in SC, GA, and FL).

The commercial WG recommended the following:

- Electronic Logbooks
- More observers
    - 5-10% allocated by strata within states
    - Possible to use exemption to bring in everything with no sale
    - Get maximum information from fish
- Angler education with regards to recording depths on paper logbooks
- More precise depths by species from port agents (would require data base change)
- Expand TIP sampling
    - Reallocate samplers for at-sea observer trips
    - Improve sampling from Florida's handline and dive gear where most of the effort and landings are from.
- Continue to sample more ages (proportional to effort), although large numbers of ages were sampled in the most recent years, especially 2009.

1.3 Recreational Statistics

The recreational WG recommended the following:

- In order to separate PR and CH catch data, more age data are needed, particularly from the PR mode.
- Continued research efforts to incorporate/require logbook reporting from recreational anglers.
- Quantify historical fishing photos for use in future SEDARS.
- MRFSS At-SEA observer program in NC, SC and GA should collect depth fished data. Standardize data elements within this program.
- Headboat Survey logbook should also collect depth information.
- Continued research efforts to collect discard length and age data from the private sector.
- Improve metadata collection in the recreational fishery.

1.4 Indices

The indices Work Group recommended the following:

- More fishery independent data collection
- Exploration of the Stephens and MacCall trip selection method and alternatives methods
    - Explore the use of actual landings rather than presence/absence for other species for trip selection
- Evaluate how fishermen preferences change over time and whether such changes affect CPUE
- Increase observer coverage, including information on area fished and depth
- Examine how catchability has changed over time with increases in technology and potential changes in fishing practices. This is of particular importance when considering fishery dependent indices
- Investigate potential density-dependent changes in catchability

1.5 Analytic Approach

There were no research recommendations from the Analytic Approach working group.

1.6 Discards Mortality

The discards mortality WG recommended the following:

- More hooking, size, and depth related discard mortality studies
- Angler education
- More accurate depths by species from logbooks
- Survey of fishermen and scientists to possibly get information on depth of areas fished and species abundance
- More species specific depth information collected by port agents

2 Assessment Research Recommendations

Assessment Process I Term of Reference #10 called for the Assessment Panel to provide recommendations for future research and data collection.

The assessment panel recommended the following:

- Fishery independent surveys of reef fishes in the Southeast were expanded in 2010 and continued expansion is recommended. These data should be made available for future assessments of red snapper.
- More information on age/length composition of discards from various fleets would improve stock assessment of reef fishes in the Southeast, including red snapper. A recreational discard reporting system would benefit future assessments.
- More information on discard mortality rates would improve stock assessment of reef fishes in the Southeast, including red snapper.
- More detailed spatial and temporal resolution of fishing effort for each fleet would likely improve assessments.
- Methods to characterize uncertainty in assessment results deserve further consideration. For avoiding overfishing, characterizing uncertainty is more than an academic exercise, particularly when relying on probabilistic methods to set catch levels.
- Compared to other fishes, red snapper mature very young relative to their life span. This is consistent with the hypothesis that maturation, as a character trait, is influenced by exploitation. Assessments and management could be improved by better understanding plasticity in life-history traits (such as maturation), as well as evolutionary effects of exploitation.
- Depth appears to be important component of population and fishery dynamics for red snapper. Spatial assessment models might be able to address depth explicitly, if migration rates among strata were better understood.
- Increased fishery independent sampling of larvae and juveniles.
- Increased TIP sampling.
- Increased sampling of recreational sector.
- Examine or develop ways to include anecdotal information in SEDAR assessments.

3 Review Panel Research Recommendations

The Review Panel suggested some recommendations, categorized as more important (Tier 1) and less important (Tier 2).

Tier 1

- Investigate alternate stock recruitment models, and in particular the robustness of stock status conclusions to reasonable alternative stock-recruit assumptions.
- Consider estimating missing catch (e.g., recreational) within the model to improve consistency. An example of such an approach is the B-ADAPT model applied to North Sea cod.
- Review historical records for determining historical average weights of fish. This is consistent with a DW recommendation.
- The Review Panel agreed with the DW and AW recommendations to improve age sampling. In particular, this should improve the estimation of fishing mortality in BAM.
- The Review Panel agreed with the DW and AW recommendations to continue developing fishery-independent abundance indices, especially because assumed changes in catchability of CPUE indices for red snapper are uncertain.
- Explore changes in catchability in light of other species involved in the mixed species fisheries that catch red snapper. The Review Panel anticipates that changes in catchability may be consistent among some of these species.

Tier 2

- Consistent with the AW recommendation regarding "plasticity in life-history traits", the Review Panel recommends investigating for temporal variation in growth and maturation rates, especially when such characteristics often show a density-dependent response.
- Tagging studies can provide relatively direct estimates of fishing mortality and selectivity, growth rates, and other stock assessment parameters. Where possible, information from tagging studies that are representative of the stock as a whole should be incorporated into the assessment.

SEDAR

SouthEast Data, Assessment, and Review

SEDAR 24

South Atlantic Red Snapper
SECTION V: Review Workshop Report

October 2010

SEDAR
4055 Faber Place Dr., Suite 201
North Charleston, SC 29405

Section V: Review Workshop Report

Contents

1 Introduction

1.1 Workshop Time and Place

The SEDAR 24 Review Workshop was held October 12-14, 2010, in Savannah, Georgia.

1.2 Terms of Reference

Review Workshop Terms of Reference

1. Evaluate the adequacy, appropriateness, and application of data used in the assessment.
2. Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.
3. Recommend appropriate estimates of stock abundance, biomass, and exploitation.
4. Evaluate the methods used to estimate population benchmarks and management parameters (*e.g., MSY, Fmsy, Bmsy, MSST, MFMT, or their proxies*); recommend appropriate management benchmarks, provide estimated values for management benchmarks, and provide declarations of stock status.
5. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; recommend appropriate estimates of future stock condition (e.g., exploitation, abundance, biomass).
6. Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters. Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty. Ensure that the implications of uncertainty in technical conclusions are clearly stated.
7. Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations.*
8. Evaluate the SEDAR Process as applied to the reviewed assessment and identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops.
9. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted. Clearly denote research and monitoring needs that could improve the reliability of future assessments. Recommend an appropriate interval for the next assessment, and whether a benchmark or update assessment is warranted.
10. Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks to be completed following the workshop. Complete and submit the Peer Review Summary Report no later than November 1, 2010.

* The panel shall ensure that corrected estimates are provided by addenda to the assessment report in the event corrections are made in the assessment, alternative model configurations are recommended, or additional analyses are prepared as a result of review panel findings regarding the TORs above.

1.3 List of Participants

Attendees	Role	Affiliation
Michael Armstrong	Review panelist	CIE
John Boreman	Review panelist	SA SSC
Noel Cadigan	Review panelist	CIE
Robin Cook	Review panelist	CIE
Anne Lange	Review chair	SA SSC
Rob Cheshire	Analyst	SEFSC - Beaufort
Kyle Shertzer	Analyst	SEFSC - Beaufort
Erik Williams	Analyst	SEFSC - Beaufort
Kenny Fex	Appointed observer	Snapper/Grouper AP
George Geiger	Council representative	SA Council
Charlie Phillips	Council representative	SA Council
Myra Brouwer	Council staff	SAFMC
John Carmichael	Council staff	SAFMC
David Cupka	Observer	SA Council
Nick Farmer	Observer	SERO
Kari Fenske	SEDAR 24 coordinator	SEDAR
Patrick Gilles	IT support	SEFSC - Miami
Rachael Lindsay	Administrative support	SEDAR
Julie Neer	SEDAR coordinator	SEDAR
Gregg Waugh	Council staff	SAFMC
Rusty Hudson	Observer	
Kathy Knowlton	Observer	

1.4 List of Review Workshop Working Papers and Documents

Documents Prepared for the Review Workshop		
SEDAR24-RW01	The Beaufort Assessment Model (BAM) with application to red snapper: mathematical description, implementation details, and computer code	Sustainable Fisheries Branch, NMFS 2010
SEDAR24-RW02	Paper not completed, withdrawn on 9-29-10	
SEDAR24-RW03	Red snapper: Iterative re-weighting of data components in the Beaufort Assessment Model	Sustainable Fisheries Branch, NMFS 2010

2. Red Snapper Review Panel Summary Report

The stock assessment presented by the SEDAR 24 Assessment Workshop (AW) provided the Review Panel with outputs and results from two statistical assessment models and a catch curve analysis. The primary model was the Beaufort Assessment Model (BAM), while a secondary, surplus-production model (ASPIC) provided a comparison of model results. Based on the assessment provided, the Review Panel concludes that the stock is overfished and overfishing is occurring. The current level of spawning stock biomass (SSB_{2009}) is estimated to be about 10% of MSST (SSB_{2009}/MSST= 0.09), and the current level of fishing is four times F_{MSY} ($F_{2007\text{-}2009}/F_{MSY}$= 4.12). Numerous sensitivity analyses were also presented in the assessment, all of which agreed with the base model run conclusions of stock status. However, there were significant areas of uncertainty identified in both the data and in components to the model. The most significant sources of this uncertainty include: landings, the stock-recruitment relationship, and CPUE catchability.

The terms of reference from the Data Workshop (DW) and AW, in general, were met.

2.1. Terms of Reference

2.1.1. Evaluate the adequacy, appropriateness, and application of data used in the assessment.

Overall, the Review Panel concluded that the data used in the assessment are adequate and appropriate for that purpose. The Review Panel did note some caveats that should be considered when interpreting the results of the assessment. First, and foremost, there is no reliable set of fishery-independent indices of abundance for red snapper in the region, which prevents validation of the fishery-dependent indices used in the assessment. Use of CPUEs from the commercial and recreational fisheries lack the adequate statistical design and spatial coverage that one would expect from a fishery-independent survey.

The data sets used in the assessment had gaps in historical information on catch, discards, and key biological characteristics, requiring use of various methods to fill in the missing data points. Although the methods used (indexing against commercial landings, averaging adjacent years, etc.) were adequate, the Review Panel notes that the methods required pragmatic assumptions that cannot be verified.

Data-smoothing techniques (cubic spline fits) were used to reduce the influence of “spikes” in the catch history data. The Review Panel questions the use of smoothing, since the smoothing process masks uncertainty associated with variability in the landings data stream. Caution should be used in the interpretation of the smoothed data sets in that regard.

Although the Data Workshop addressed potential spatial differences in growth and maturation rates of red snapper throughout its range in the South Atlantic, changes in those rates over time were not examined. One might expect to see a change in the rates as the overall population abundance declined to its current low levels.

The Review Panel noted that a more detailed review of the catch-at-age data might have helped to understand why the age data were down-weighted in the BAM. For example, an examination would be useful of how well age sampling tracked year classes through the fishery.

To account for improvements in technology (notably, GPS systems), catchability was linearly increased by 2% per year, beginning in 1976 for headboats and 1993 for commercial lines, until 2003 and holding it constant thereafter. The Review Panel questions the decision to hold catchability constant since 2003, feeling it is somewhat counter-intuitive since factors other than GPS proficiency (e.g., rising fuel costs, improved means of communications) may also have affected catchability in recent years. It also might be useful to explore catchability of other species in mixed fisheries to determine if trends are evident.

2.1.2. Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.

The assessment presentation included three methods: the Beaufort statistical catch-age model (BAM), surplus-production models (ASPIC), and catch curve analyses. The BAM was selected at the AW to be the primary assessment model. Catch curve analyses were presented as a check of mortality estimates from BAM.

Beaufort statistical catch-age model (BAM)

BAM was the primary model in the assessment, and was the recommended approach in the last assessment of red snapper (SEDAR 15). It is a statistical catch-at-age model implemented in ADMB, and developed by staff at the Beaufort laboratory. The software was customized to deal with the specifics of the red snapper stock, which is an advantage of using “inhouse” software. BAM has previously been applied to other SEDAR assessments of reef fishes in the U.S. South Atlantic, such as red porgy, black sea bass, tilefish, snowy grouper, gag grouper, greater amberjack, vermilion snapper, Spanish mackerel, and red grouper.

The implementation of BAM for SEDAR 24 was improved in several aspects compared to the version used in SEDAR 15. Most improvements were in response to CIE reviews at SEDAR 15 and the assessment workshop of SEDAR 24. The improvements were: (1) more plausible dome-shaped selectivity models for recreational fisheries; (2) the addition of the headboat discard recruitment index; (3) avoidance of using length and age data from the same sources; and (4) iterative re-weighting of the contribution of data components to the statistical likelihood used for estimating model parameters.

It is noteworthy that the selectivity assumptions were well motivated in a working paper from the assessment workshop (AW-05).

The Review Panel concluded that BAM was adequate and appropriate for this assessment. The method was developed specifically to accommodate the available assessment data for this stock. The Review Panel concluded that BAM was applied correctly.

Surplus Production model (ASPIC)

The Review Panel concluded that ASPIC was an adequate and appropriate method to explore the robustness of the results from the BAM to other structural assumptions. ASPIC was applied correctly. Note that BAM fits to the available fishery catch statistics in the form in which they were collected (biomass for commercial landings and numbers for recreational landings), whereas ASPIC requires conversion of catch numbers to catch weight.

The F/F_{msy} values from ASPIC were at a lower scale compared to BAM, indicating a lower level of over-fishing. The values of B/B_{msy} from ASPIC were below 1.0 over the entire assessment time frame (1955-2009), whereas BAM indicated biomass above B_{msy} prior to 1970. BAM also indicated that current (2009) biomass is much less than B_{msy} (i.e., 10%), whereas ASPIC is somewhat more optimistic (B_{2009}/B_{msy} = 0.39; B_{2010}/B_{msy} = 0.25). ASPIC is run from January 1, so the 2009 and 2010 biomass ratios bracket the BAM estimate, which is computed at the time of peak spawning (mid-year).

The differences between BAM and ASPIC results are partially related to differences in the catch biomass time-series used by ASPIC, and the catch biomass time series inferred by BAM (see additional analyses requested: Section 2.2). ASPIC is a more limited stand-alone assessment model for red snapper because it does not use available age and length data.

Catch curve analyses

The Review Panel concluded that the catch curve analyses were adequate and appropriate for checking mortality rates estimated by BAM. The methods were applied correctly.

The catch curve values of Z and values for natural mortality suggested that the fully-selected fishing mortality rate was on the scale of 0.32 to 0.92, which is generally consistent with estimates from BAM.

These analyses also support the conclusion that the selectivity of the headboat fisheries was more domed-shaped than the selectivity of commercial fisheries.

Other methods

A virtual population analysis (VPA) was not considered, primarily because catch age composition data are only available for years with adequate sampling for age, resulting in blocks of years with missing data for the dominant fleets. The review group agreed that any reconstruction of the catch at age over the assessment time series (1955-2009) would contain substantial uncertainty in catches such that the application of standard VPA packages (e.g., ADAPT) would be tenuous, at best. It may be possible to develop a shorter, contemporary time series of catch at age with sufficient precision for the application of VPA, but this would be less useful for evaluating current stock status relative to MSY benchmarks.

A stochastic stock reduction analysis (SSRA) was briefly reviewed at the assessment workshop, but not included in the workshop report or Review Panel presentation. The Review Panel could offer no conclusions on this application.

2.1.3. Recommend appropriate estimates of stock abundance, biomass, and exploitation.

All sensitivity runs of the BAM model carried out by the AW, and additional ones requested by the Review Panel, show the same qualitative results indicating the stock is overfished and suffering from overfishing. A range of model configurations provided apparently plausible interpretations of the underlying data sets that could lead to qualitatively different projection results; however, the panel found it difficult, on the basis of the material provided, to identify a unique 'best estimate' model run. For example, the iterative re-weighting procedure introduced following the AW meeting is an appropriate method for fitting this type of statistical model, but may need reconfiguring to avoid over-fitting the very short headboat discards index series, which includes a year with apparently large recruitment. Model runs with and without iterative re-weighting provide different interpretations of current abundance and fishing mortality that could affect projections, but there are equally valid arguments for either model formulation.

The panel suggests using the AW base case model to provide historical and current estimates of stock abundance, biomass, and exploitation (AW Table 3.4), but cautions that this is one realization of a number of plausible runs and is conditioned on particular assumptions made about the data and population dynamics model that may change in future assessments.

The panel considered the ASPIC model runs could potentially provide useful supporting information, as it is a quite different type of model that excludes length and age data. However, information requested by the Review Panel showed that the removals weights up to 1990 in the ASPIC input data were about half what the BAM predicted, whilst the recent data were more comparable (also see Sections 2.1.1 and 2.2, below). This leads to quite different interpretations of historical stock trends and initial stock depletion. ASPIC estimates of F/F_{msy} since the 1980s are around 50% of the BAM estimates, and the estimated rate of decline in biomass between the 1960s and the 1990s is an order of magnitude less than given by BAM. The base ASPIC run nonetheless indicates a very high probability that the stock is overfished and that overfishing is occurring, although the estimates of current stock status are relatively imprecise.

2.1.4. Evaluate the methods used to estimate population benchmarks and management parameters (*e.g., MSY, F_{msy}, B_{msy}, MSST, MFMT, or their proxies*); recommend appropriate management benchmarks, provide estimated values for management benchmarks, and provide declarations of stock status.

The most important aspect of population benchmarks and management parameters is to be able to judge relative position of the current stock to the benchmarks. In this context, absolute values of F_{msy}, SSB_{msy} are less important than the ratios $F_{current}/F_{msy}$ and $SSB_{current}/SSB_{msy}$. In all the model sensitivity runs and the ASPIC model the ratios estimated the stock to be overfished and experiencing overfishing, despite the absolute values of the individual quantities varying substantially. The conclusion of the status of the stock therefore appears quite robust to a wide range of model configurations and the panel felt this was the appropriate classification given our current knowledge of the stock.

One of the principal difficulties with the BAM model estimate of the stock recruitment parameters is that the steepness estimate appears unrealistically high. To address this, the AW used the mode of steepness values from a meta-analysis (0.85, while the mean in that analysis was 0.75). In addition, there are no data in the assessment to adequately define the asymptote of the Beverton-Holt function, and hence estimates of MSY indicators cannot be considered reliable. During the RW the Review Panel requested that the BAM model be run using a Ricker stock-recruit model in a base model configuration. Preliminary results from this analysis suggested a substantial change in the estimated stock-recruitment relationship, and a substantial change in the assessment of stock status (e.g., Fs much closer to F_{msy}). This suggests that the calculation of MSY benchmarks is sensitive to the choice of recruitment function and needs to be investigated further.

The ASPIC runs indicated that the stock status was closer to F_{msy} than given by the BAM. This could partially result from the different catch streams used in the respective stock assessment models (see section on uncertainty below, Section 2.1.6, and 2.2), although additional runs using BAM-predicted landings, requested by the Review Panel, indicated that post-1980 estimates of F/F_{msy} from ASPIC were relatively insensitive to the catch streams used.

A general difficulty with the BAM-estimated MSY benchmarks is that the implied stock sizes lie well beyond the range of the data. It should be noted that these quantities are theoretical values derived from estimated population dynamics observed since the mid-1970s, and the assumptions currently used to derive MSY (M, maturity, growth, selectivity, productivity, etc.) may not hold at substantially higher stock sizes.

The benchmark values in the assessment are point estimates that do not consider stochasticity in recruitment. Values derived from a stochastic analysis would differ.

2.1.5. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; recommend appropriate estimates of future stock condition (e.g., exploitation, abundance, biomass).

Projections carried out by the AW are conditioned on the base run of the BAM, which the panel considers adequate and appropriate for characterizing the current stock abundance, age structure, and fishing mortality rates as one of a range of plausible runs. The method involves a deterministic projection assuming a 10% reduction in fishing mortality in 2010 caused by the moratorium, and an assumption that all catches under a moratorium would be discarded and subject to the discard mortality rate used in the assessment. A stochastic model was also used to project the Monte Carlo and bootstrap runs of the base case model with additional uncertainty in the F reduction in 2010 (reduction to between 80% and 100% of current estimates) and process error in recruitment based on the assumed variance of log recruitment residuals (σ^2). The panel considers that the methods used in the projection are adequate and appropriate, but had a number of concerns regarding the application:

- The anticipated reduction in F under the moratorium was based on expert opinion, but the basis for that decision is not clear;
- Future stock growth is critically dependent on the values of predicted recruitment. The deterministic projection uses a bias-corrected stock recruit function according to the assumed $\sigma^{2,}$ rather than the non-bias corrected version that might be considered to provide the most probable values. The AW did not provide the criteria for this choice, although it is likely to be to ensure compatibility between the future abundance and catches from deterministic projection and the arithmetic means from the stochastic projections. The choice of σ^2 also affects the estimation of benchmarks.
- Although the stochastic projections include uncertainty obtained from the Monte Carlo bootstrap runs, the panel considers these to substantially underestimate the true uncertainty in the current stock status used to initiate the projections (see 2.1.6). This reduces the accuracy of the projections aimed at estimating the probability of achieving management target.

The use of deterministic projections to evaluate the relative rebuilding time under different management scenarios remain useful as a guideline. It is clear that current levels of exploitation are likely to lead to further stock depletion in the long term and, given the present level of depletion relative to the estimated B_{msy}, rebuilding times under the explored scenarios of reduced exploitation will be very long (on the order of decades).

The BAM model estimates of population numbers indicate the current stock is mainly fish of ages 1 to 12, and hence the estimated current population numbers will contribute substantially to the short-term projections. Therefore, the short-term projections are more reliable.

A moratorium or other measures restricting retained catches of red snapper without an equivalent reduction in effort will cause discarding over the full size range, and thus the accuracy of the projection outcomes become critically dependent on the accuracy of the discard mortality estimates. The projections indicate that under an assumed 10% reduction in F during a continued moratorium, discard mortality will prevent recovery to B_{msy}. Any future measures to reduce discard mortality will benefit the stock, but it has not been possible to explore possible scenarios for this in the present projections.

2.1.6. Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters. Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty. Ensure that the implications of uncertainty in technical conclusions are clearly stated.

Uncertainty in the assessment has been explored using three general approaches:

- a Monte Carlo bootstrap of the assessment;
- a sensitivity analysis around the base BAM run; and
- the use of alternative assessment models.

These approaches are appropriate given their limiting conditioning assumptions. Overall, the Review Panel felt that the analyses were probably somewhat restricted in the range of uncertainty explored.

The base BAM assessment run was bootstrapped using a Monte-Carlo parametric bootstrap procedure, drawing values from predefined distributions on some of the input values. These runs provide distributions for management values of interest such as MSY benchmarks. Some of the CVs set for the input parameters appear to be rather small, especially on quantities such as landings and F_{init} that are not well known and which will likely underestimate the uncertainty in the MSY quantities. Also, the bootstrap procedure only included the measurement error CVs for CPUEs, and not the larger source of variation related to the precision of CPUEs for measuring trends in stock size (i.e., model residual variations).

Sensitivity runs were comprehensive in investigating the likely areas of uncertainty in the BAM model, and all sensitivity runs resulted in the same stock status of overfished and suffering ‘overfishing’. However, the range of perturbation for each parameter was generally quite small. This means the analysis will provide estimates of the direction and rate of change near the nominal values, but will not necessarily explore the full range of plausible assessment runs. Areas where the Review Panel felt more analyses are required are the structural assumption about recruitment, F_{init}, and the effect of iterative re-reweighting on the model fit. A trial run of the BAM with a Ricker curve for recruitment suggested this effect could be large and merits further investigation.

Model uncertainty was explored mainly through the application of a surplus production model (ASPIC, see 2.1.2 and 2.1.3). Unlike BAM, ASPIC cannot use age-structured data and relies on aggregate catch and CPUE indices alone. Nevertheless, it provides a valuable comparison, especially as the implied stock-recruit function in the model differs from the Beverton-Holt model implemented in BAM. While the ASPIC runs also place the stock in the 'overfished-overfishing' category, it is noticeable that F is much closer to F_{msy} than given by the BAM model. The difference between the ASPIC analysis and the BAM is at least in part the result of the way the catch data enter the respective models (see Section 2.1.2 and 2.1.3).

In addition to ASPIC, a simple catch curve analysis was performed that tended to support the Z values estimated from the BAM (see Section 2.1.2 for a description of this comparison).

The use of three different approaches is important in exploring model uncertainty and is a valuable element of the assessment report, especially in getting some insight into the uncertainty in the catch and how this affects the level of stock depletion. However, it makes sense to try other models that make different structural assumptions to get a wider view of the robustness of the assessment. One obvious candidate would be a state-space (e.g., Kalman filter) analysis.

2.1.7. Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations.

The Review Panel ensured that the stock assessment results were clearly and accurately presented in the SEDAR Summary Report for Red Snapper and that the results were consistent with the Review Panel recommendations.

2.1.8. Evaluate the SEDAR Process as applied to the reviewed assessment and identify any Terms of Reference which were not adequately addressed by the Data or Assessment Workshops.

The Review Panel members noted that the documents relevant to the Review Workshop were received approximately one week before the panel convened, rather than the two weeks stipulated in the Terms of Reference. This delay hampered a more thorough review by some of the panel members, although this was mitigated by the thorough presentations provided by the stock experts.

During the course of the Assessment Review Workshop members of the Review Panel received hard copies and e-mails from the fishing public that contained new data to consider during their deliberations. The Review Panel considers it more appropriate that this type of information be submitted during the data review workshop, where it can be evaluated along with other data sets being considered for use in the stock assessment.

While recognizing that resources within the government available to conduct stock assessment are limited, the Review Panel felt the assessment of red snapper would have benefitted by having more than one assessment team deriving the benchmarks. This would broaden perspectives, and use of alternative models and data structures to cross-validate the information that is ultimately used to provide the scientific basis for management advice.

The Review Panel suggests that future Assessment Workshop reports contain only figures and tables that are most important to the assessment, and put the remaining ones in an appendix.

Finally, the Review Panel encourages re-thinking of the way in which CIE expertise is used during the Stock Assessment Workshop. Having only one CIE expert reviewing the draft assessment report runs the risk of the expert's comments being biased in the direction of personal preferences and philosophy. Also, the CIE expert is asked to review and provide a critique of the draft report emanating from the assessment workshop, leaving little time for the analytical team to respond to the reviewer's suggestions, especially if major changes are made to the assessment model formulation and input data, before the assessment report is due to the Review Panel (a "sequential" review). Having CIE and some other form of independent expertise at the assessment workshop, even perhaps functioning on the assessment panel where they can interact directly with the other panel members (an "integrated" review), might allow more time to improve the assessment before it is delivered to the Review Panel.

2.1.9. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted. Clearly denote research and monitoring needs that could improve the reliability of future assessments. Recommend an appropriate interval for the next assessment, and whether a benchmark or update assessment is warranted.

The next benchmark should not be done until sufficient new data/information are available to warrant a full assessment. For example, if a fishery-independent survey is initiated for red snapper, it will take several years before data collected in that survey are useful for assessment purposes.

Research Recommendations

The Review Panel agreed with the DW and AW recommendations. However, the Review Panel was unsure of the specific benefits of pursuing spatial assessment models, which tend to be very hard to implement.

The Review Panel added some additional recommendations, categorized as more important (Tier 1) and less important (Tier 2).

Tier 1

- Investigate alternate stock recruitment models, and in particular the robustness of stock status conclusions to reasonable alternative stock-recruit assumptions.
- Consider estimating missing catch (e.g., recreational) within the model to improve consistency. An example of such an approach is the B-ADAPT model applied to North Sea cod.
- Review historical records for determining historical average weights of fish. This is consistent with a DW recommendation.
- The Review Panel agreed with the DW and AW recommendations to improve age sampling. In particular, this should improve the estimation of fishing mortality in BAM.
- The Review Panel agreed with the DW and AW recommendations to continue developing fishery-independent abundance indices, especially because assumed changes in catchability of CPUE indices for red snapper are uncertain.
- Explore changes in catchability in light of other species involved in the mixed species fisheries that catch red snapper. The Review Panel anticipates that changes in catchability may be consistent among some of these species.

Tier 2

- Consistent with the AW recommendation regarding "plasticity in life-history traits", the Review Panel recommends investigating for temporal variation in growth and maturation rates, especially when such characteristics often show a density-dependent response.
- Tagging studies can provide relatively direct estimates of fishing mortality and selectivity, growth rates, and other stock assessment parameters. Where possible, information from tagging studies that are representative of the stock as a whole should be incorporated into the assessment.

2.1.10. Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks to be completed following the workshop. Complete and submit the Summary Report no later than October 28, 2010.

This report constitutes the Review Panel's summary evaluation of the stock assessment and discussion of the Terms of Reference. The Review Panel will complete edits to its report and submit to SEDAR by 10/28/10.

2.2. Summary Results of Analytical Requests *(Sensitivities, corrections, additional analyses, etc.)*

The Review Panel suggested using the AW base-case model to provide an assessment of the red snapper stock, but cautions that this was one realization of a number of plausible runs. During the Review Panel's deliberations a number of analyses were requested to clarify model results and to explore a number of the areas of uncertainty that were identified by the assessment. The following summarizes the issues for which the Review Panel required additional information and the analyses requested to address them.

1) The iterative re-weighting of the contribution of data components to the statistical likelihood has some well-known problems when the lengths of the data component series are quite different. For tuning indices, it is well known that iterative re-weighting can give too much weight to short time-series. The problem may be related to well-known biases in maximum likelihood estimates of variance parameters, in which variances are under-estimated when sample sizes are small and the number of model parameters is high.

The iterative re-weighting may have given too much weight to the HB discard index, which was a very short time-series. Also, the HB recreational index was given less weight, although the DW felt that this was the best among the three indices they recommended. The Review Panel requested the following analyses:

a- Provide MSEs for all components of the base (iterative re-weighting) and the equal-internal weight model runs, and runs with increased weights given to the HB index relative to the iterative re-weighted run.

Table 2.2.1. Mean Square Errors for headboat CPUE, commercial line CPUE and headboat discards under varying input weights, compared to base model.

Runs	weights	HB CPUE MSE	CL CPUE MSE	HB discard MSE
1	Base (iterated) hb=0.11	0.247	0.122	0.087
2	all 1	0.103	0.125	0.053
3	hb=0.2	0.165	0.158	0.085
4	hb=0.25	0.133	0.203	0.084
5	hb=0.3	0.108	0.257	0.08

The results demonstrated that the mean squared error (MSE) for HB CPUE residuals from the iterative re-weighted base run were over double the MSEs derived from the equal-weighted run. The HB discard index was actually fitted worse with re-weighting. The down-weighting of the HB CPUE may be related to 1-2 large residuals early in the time series. The Review Panel could not determine if any of the weighting schemes in the above table were more appropriate, and concluded that the base run (with iterative re-weighting) should be used to estimate stock status.

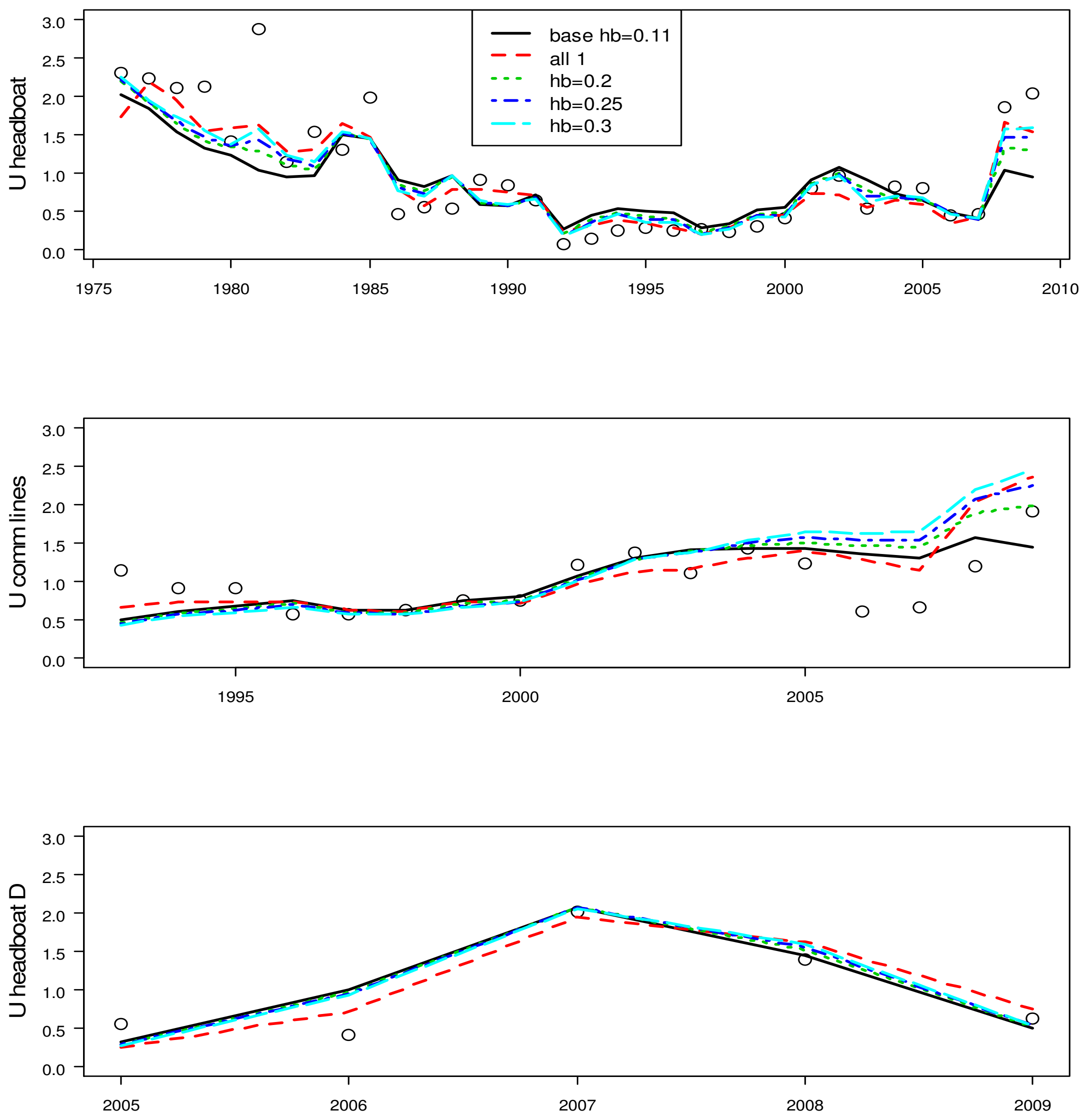
Perhaps one of the bigger consequences of re-weighting was the large reduction in weighting given to the recreational landings age-compositions. Age compositions are usually an important source of information for estimating F.

b- Rerun the base configuration model, while increasing the internal weight of the HB landings index, until the MSEs fall between the base run and the equal-internal weight runs resulting from task 1a.

Table 2.2.2. Standard deviation of normalized residuals (SDNRs) from data components, as indicated in row and column headings, using different configurations of data-component weighting. In the column labeled Iteration, "base" indicates base-run weights, including the headboat index weight of 0.11; "all 1" indicates all weights equal to one; "hb=0.X" indicates base-run weights, but with the headboat index weight increased to the value shown.

		For hire		Commercial	
Iteration	Data type	Landings	Discards	Lines	Dive
1 Base	CPUE	1.04	1.00	1.01	-
	Length comp	0.96	0.92	1.00	1.00
	Age Comp	1.05	-	1.01	1.00
2 All = 1	CPUE	5.60	1.67	5.20	-
	Length comp	2.93	2.96	2.84	1.04
	Age Comp	10.02	-	3.55	1.38
3 hb=0.2	CPUE	1.46	1.06	1.12	-
	Length comp	0.95	1.02	1.02	0.99
	Age Comp	1.02	-	.099	1.02
4 hb=0.25	CPUE	1.62	1.07	1.20	-
	Length comp	0.96	1.04	1.10	0.98
	Age Comp	1.01	-	0.96	1.00
5 hb=0.3	CPUE	1.73	1.07	1.29	-
	Length comp	0.97	1.05	1.22	0.96
	Age Comp	1.00	-	0.93	0.99

Figure 2.2.1 Fits to indices of abundance using different configurations of data-component weighting. In the legend, "base" indicates base-run weights, including the headboat index weight of 0.11; "all 1" indicates all weights equal to one; "hb=0.X" indicates base-run weights, but with the headboat index weight increased to the value shown. Top panel shows fits to the headboat index; middle panel shows fits to the commercial line index; and bottom panel shows fits to the headboat discard index.



2) Initial numbers at age in 1955 (first year used in the BAM model) were derived from the stable age structure computed from expected recruitment and the initial age-specific total mortality rate. This mortality rate was the sum of natural mortality and fishing mortality, where fishing mortality was the product of an initial fishing rate (F_{init}) and catch-weighted average selectivity. The initial fishing rate was chosen using an iterative approach. First, the assessment model was run using the nearly complete catch history (starting from the year 1901) provided by the DW, to indicate a plausible level of biomass depletion in 1955 (B1955/B0 ≈ 0.8). Then, F_{init} was adjusted to approximate that level; the value used in the base model run was $F_{init} = 0.02$. The model using the complete catch history to indicate the level of depletion in 1955 was not reviewed by the Review Panel. However, the low value of F_{init} resulted in a large plus group (i.e., age 20+) abundance, and was not consistent with the age composition information for the for-hire recreational landings during 1976-1990, which did not indicate a large plus group. This was the only source of age-composition data for this period.

To address concerns that the F_{init} appeared lower than would have been expected, the Review Panel requested that the base model configuration be rerun while increasing the value of F_{init}, until the plus group residuals are removed.

Table 2.2.3. Sensitivity analysis for BAM runs with increasing values of F_{init}

Sensitivity to F.init values

F.init	Fmsy	SSBmsy	MSY	F.Fmsy	SSB.MSST	steep	R0(1000)	B(1955)/B0	Avg 1978-83 HB ac resid 20+
0.02	0.178	156.01	1842	4.12	0.09	0.85	535	0.78	-0.095
0.05	0.175	168.35	1997	4.08	0.08	0.85	579	0.56	-0.076
0.1	0.173	186.32	2222	4.04	0.07	0.85	643	0.34	-0.055
0.15	0.172	203.74	2439	4.01	0.07	0.85	704	0.21	-0.04
0.2	0.17	223.91	2694	3.97	0.06	0.85	776	0.13	-0.029
0.25	0.168	255.52	3098	3.94	0.05	0.85	890	0.08	-0.017

F.init	nLL(data)	nLL(penalized)	nLL(SR)	U.cl	U.fh	U.fhd
0.02	858.838	889.041	15.902	8.259	17.758	2.013
0.05	856.753	885.547	14.816	8.259	17.456	1.961
0.1	854.43	881.513	13.629	8.273	17.04	1.904
0.15	852.803	878.459	12.759	8.288	16.699	1.863
0.2	851.451	875.627	11.958	8.292	16.371	1.829
0.25	850.107	872.358	11.03	8.269	15.963	1.791

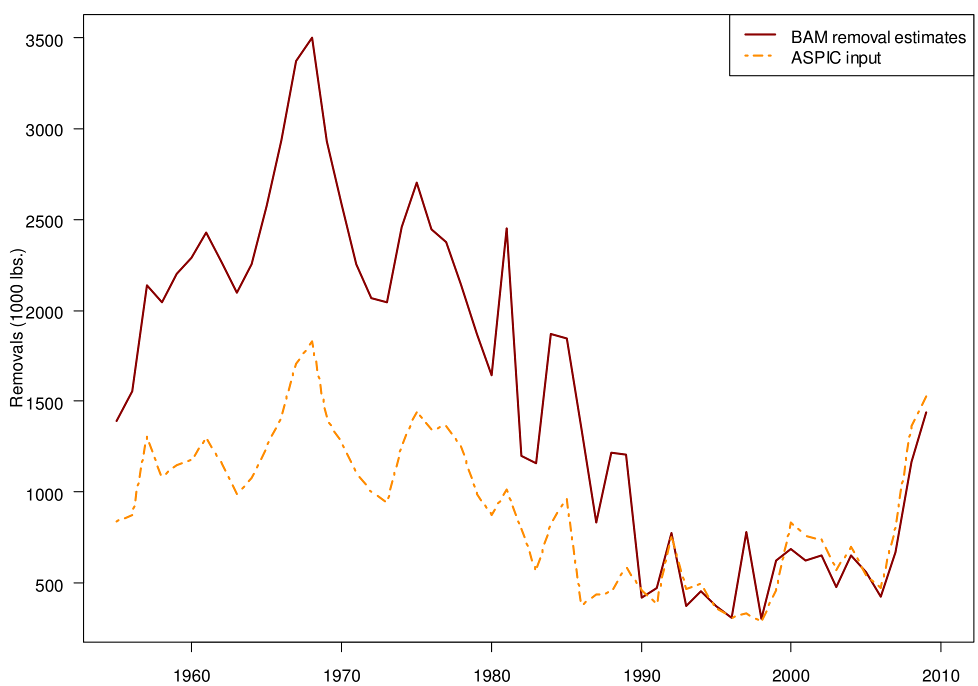
These results demonstrate that higher values of F_{init} resulted in a better fit to the HB 20+ age compostions, and a better fit to the data overall. However, the implied depletion of the stock in 1955 seemed implausible for values of F_{init} greater than 0.1. Because the poor fit in the base run may also be explained by a misspecification of the for-hire fishery selectivity, the Review Panel decided not to recommend a change to the F_{init} value used in the base run.

F.init	len.cl	len.cd	len.fh	len.pvt	len.cl.D	len.hb.D	age.cl	age.cd	age.fh	age.pvt
0.02	585.626	34.59	137.387	24.515	1.207	5.497	14.623	18.082	9.141	0.054
0.05	584.825	34.603	136.843	24.304	1.197	5.485	14.403	18.186	9.102	0.053
0.1	583.959	34.616	136.254	24.072	1.187	5.467	14.19	18.293	9.058	0.052
0.15	583.359	34.623	135.872	23.897	1.18	5.452	14.047	18.368	9.041	0.051
0.2	582.841	34.627	135.634	23.726	1.173	5.44	13.902	18.437	9.071	0.051
0.25	582.262	34.625	135.585	23.508	1.165	5.43	13.69	18.516	9.201	0.05

3) In order to better understand the differences in the results from the surplus production (ASPIC) and BAM models, the analysts were asked to provide total annual weights of landings that went into ASPIC, and annual total landings in weight estimated in the BAM base model run.

The analysts presented a plot of these catch streams and also reran ASPIC using each catch stream.

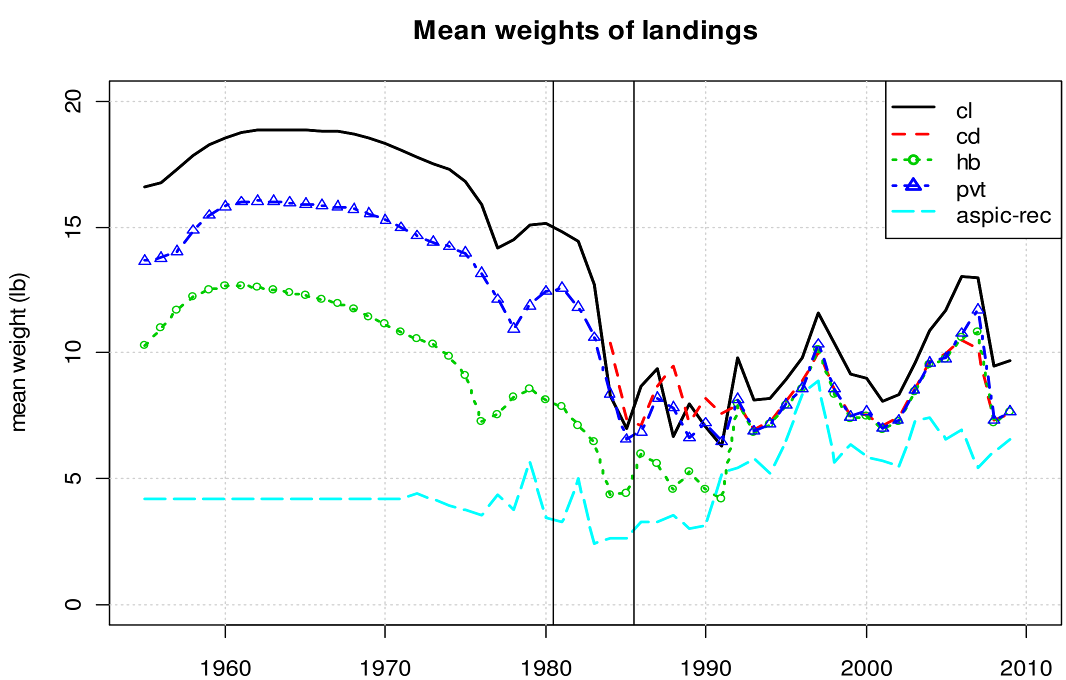
Figure 2.2.2 Landings (1000 lbs) as input to the ASPIC model and as estimated in BAM, 1955-2009.



The two landings series are very similar from 1990 onwards, but the BAM estimates for previous years are around double the figures used for the ASPIC run.

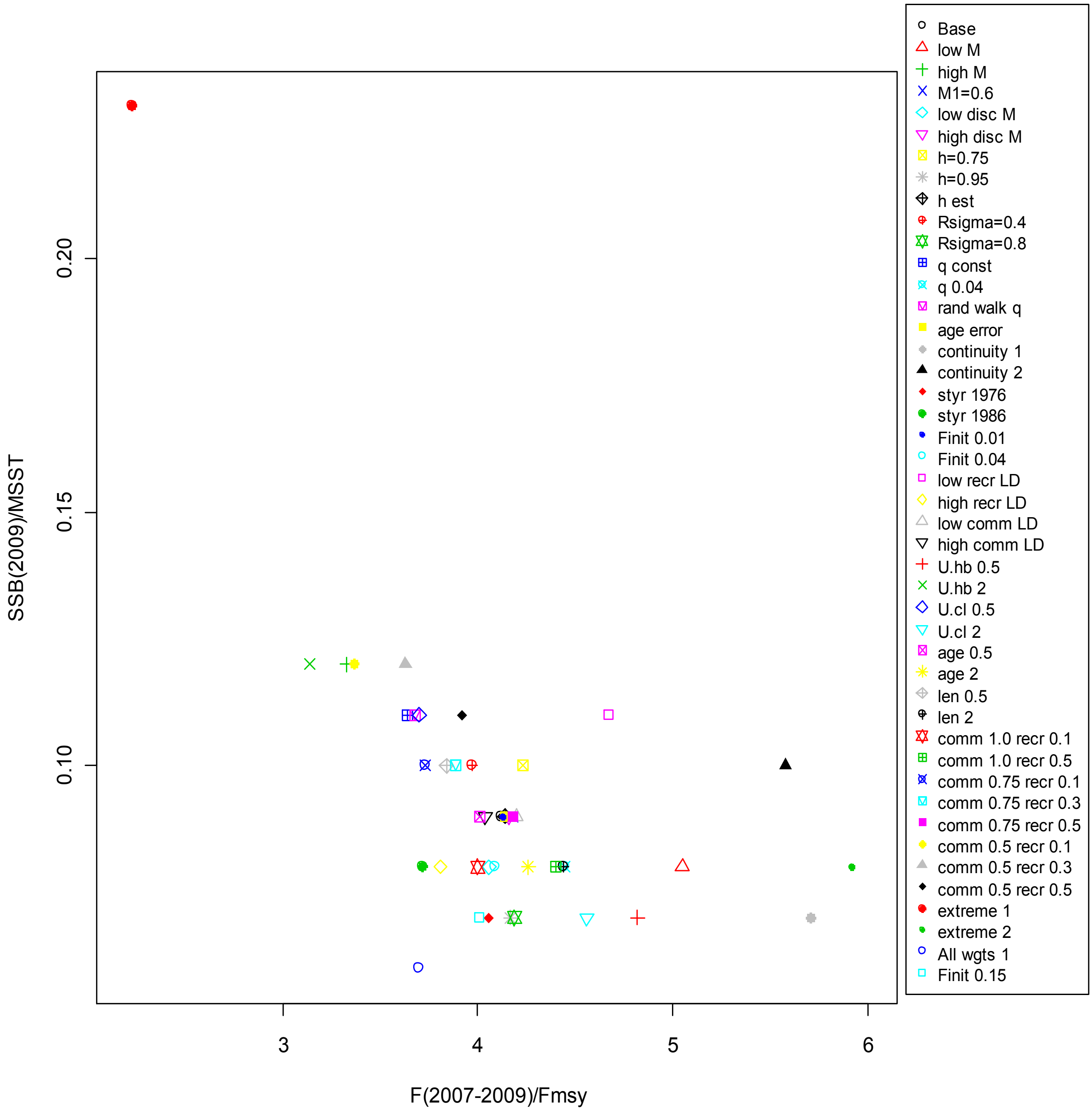
4) To help describe the differences between the ASPIC output and the base BAM results, the Review Panel requested that the analysts provide a plot of annual average fish weights in the landings by fleet from the BAM outputs and the equivalent average values for the recreational fleet from the ASPIC input data. The plots below show that the mean weights in the ASPIC data are much lower than the BAM model predictions for the commercial and recreational fleets, particularly during the early decades of the series. The Review Panel noted that an average weight of 9 lb had been used by the AW to convert commercial landings estimates into fish numbers for the 1955-80 period for use in predicting recreational catch numbers using the ratio method. If the model estimates of mean fish weight (14-18 lb) in the commercial landings are correct, this would imply a large overestimate of the historical recreational catch numbers using the 9-lb figure in the ratio method. The estimated age compositions of recreational catches, combined with the estimated selectivity parameters, lead to mean weights in historical recreational catches that are well above the 4.2 lb figure assumed for the ASPIC input data. The inconsistent treatment of weights in the BAM model appears responsible for the large differences in landings biomass trends from the ASPIC data and BAM estimates. Model estimates of mean weight for the commercial line fleet are also influenced by the choice of asymptotic selectivity. The Review Panel recommends that the historical mean fish weights for the different fleets are thoroughly reviewed using additional evidence that may be available, and that the BAM model is adapted to ensure consistency in the way mean fish weights are estimated from input values.

Figure 2.2.3. Comparison of mean fish weights in landings, by fleet from BAM outputs and for recreational fleet from ASPIC input data.



5) The Review Panel also requested that the phase-plot (SSB/MSST by F/F_{msy}) figure be redone so the data points are more clearly visible. In addition, the analysts were requested to include results from runs using a higher F_{init} value (0.15) and all weights set to 1 (equally weighted). The analysts provided the following plot to address the Review Panel request.

Figure 2.2.4. Phase plot of terminal status estimates from sensitivity runs of the Beaufort Assessment Model, updated to more clearly show various points, and to include F_{init} = 0.15, and with all components equally weighted (from Figure 3.60 in AWR).



6) The Review Panel also requested that the analysts run BAM using the Ricker spawner-recruit model, fit internally to the model. They reported back to the Review Panel that this approach was tested but the model would not converge, and provided an implausibly large R_0.

2.3. Additional Comments (*if necessary, to address issues or discussions not encompassed above)*

The current configuration of BAM excluded length frequencies in years when adequate age compositions were also available, because these two data sources are not independent. A better approach would be to only exclude those length frequencies for which ages were obtained.

Presentation of sensitivity analyses would have been clearer if results were provided for both absolute stock size estimates and stock size estimates relative to reference points. This could occur in 2x2 panels of: (1,1) SSB with SSB_{ref} as a horizontal line; (1,2) SSB relative to SSB_{ref}; (2,1) F with F_{ref} as a horizontal line; and (2,2) F relative to F_{ref}.

The barplots of apical Fs by fleet should be better described in the figure caption.

SEDAR

SouthEast Data, Assessment, and Review

South Atlantic Red Snapper
SECTION VI: Addendum

October 2010

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This addendum documents several corrections made to tables and figures from Section III of the assessment report. The corrections are as follows.

• Section III.2 Table 2: This table was revised to include a strikethrough for 1990 age compositions from the for-hire fleet. The strikethrough indicates that those 1990 data were not used in the assessment. This revision applies to the table only; the assessment model had used data in the correct years.

• Section III.2 Table 3: In the previous version of this table, landings values had been inadvertently shifted by five years. The assessment model had used the correct values, now shown in the revised table.

• Section III.3 Figure 3.60: This figure was revised to correct recycling of symbols used to indicate various sensitivity runs. Also, two sensitivity runs requested by the Review Panel were added to this figure. These additional runs (Sensitivity Runs 43 and 44) were defined by either all data-component weights set to one (S43) or by initial F equal to 0.15 (S44), as indicated in the figure legend. Sensitivity Runs 1–42 are described in the assessment report.

Section III.2 Table 2 (revised). Red Snapper length and age composition sample sizes (number of trips sampled). A strikethrough indicates data that were excluded from the BAM (see text).

	Length Comp. Sample Size (trips)						Age Comp. Sample Size (trips)			
	Recreational			Commercial			Recreational		Commercial	
Year	ForHire	Private	Headboat discard	Lines	Diving	Lines discard	ForHire	Private	Lines	Diving
1976	115									
1977	195						~~22~~			
1978	~~208~~						83			
1979	~~91~~						32			
1980	~~93~~						36			
1981	~~208~~						145			
1982	~~155~~						56			
1983	~~308~~	79 pooled					173			
1984	~~406~~						178			
1985	~~364~~			153			161			
1986	~~264~~			90			100			
1987	~~164~~						64			
1988	128			105			~~20~~			
1989	~~172~~						32			
1990	140			98			~~23~~			
1991	71			149			~~20~~			
1992	55	165 pooled		89			~~10~~		~~18~~	
1993	107			128			~~14~~			
1994	83			132			~~11~~			
1995	84			145			~~11~~		~~13~~	
1996	~~79~~			~~115~~			58		58	
1997	54			84			~~12~~		144	
1998	92			~~106~~					37	
1999	113			~~153~~	13				156	
2000	94			~~133~~	9				257	124
2001	151			168	~~6~~		~~27~~		~~28~~	30
2002	~~200~~			167			105		~~10~~	
2003	~~191~~			223	12		108		~~10~~	
2004	~~154~~			~~174~~			98		30	
2005	~~118~~		44				130			
2006	~~125~~		30				123			
2007	~~86~~		65	~~142~~		6	51		138	
2008	~~117~~		63				52			
2009	~~210~~		56	~~135~~	~~10~~		359	11	294	17

Section III.2 Table 3 (revised). Red snapper landings as input into the BAM base model.

	Recreational				Commercial		
	Landings		Discards		Landings		Discards
	Numbers (1000's)				Whole Pounds (1000's)		
Year	ForHire	Private	ForHire	Private	Lines	diving	Lines
1955	68.301	13.763			497.800		
1956	74.807	18.067			484.300		
1957	81.321	22.657			868.900		
1958	84.472	26.582			617.300		
1959	85.598	30.115			662.700		
1960	85.480	33.277			677.100		
1961	83.527	35.672			799.800		
1962	79.441	37.195			662.577		
1963	76.530	39.544			504.840		
1964	78.771	44.904			559.491		
1965	86.525	53.626			656.795		
1966	96.861	64.051			740.057		
1967	104.809	72.901			963.706		
1968	104.716	76.108			1069.332		
1969	95.537	72.701			700.493		
1970	82.889	66.731			640.918		
1971	71.743	62.080			543.433		
1972	65.493	61.735			468.602		
1973	65.872	67.536			387.344		
1974	71.612	78.477			632.507		
1975	77.286	89.063			745.363		
1976	78.829	94.852			619.011		
1977	75.868	95.145			649.273		
1978	68.640	89.822			589.918		
1979	58.535	80.445			409.939		
1980	47.760	69.978			380.596		
1981	69.519	121.730			371.379		
1982	37.726	52.932			306.128		
1983	59.229	43.885	42.281	8.679	310.268		
1984	60.094	161.385	121.668	22.845	248.195	1.317	
1985	97.119	178.659	27.775	63.501	240.971	2.547	
1986	98.995	78.195	0.158	8.679	215.743	0.508	
1987	40.286	51.281	0.158	106.560	187.211	0.030	
1988	62.664	98.608	0.158	48.373	164.123	0.013	
1989	44.461	107.354	0.158	20.038	258.478	0.006	
1990	26.656	11.091	0.158	8.679	215.047	1.859	
1991	30.623	31.351	0.697	35.853	134.032	5.898	
1992	45.611	38.345	17.936	19.492	89.062	9.614	14.233
1993	14.948	10.864	33.397	48.989	189.994	5.611	14.926
1994	22.589	13.567	7.359	62.577	179.615	13.116	20.638
1995	22.423	2.386	24.366	37.932	166.772	10.037	19.437
1996	8.681	11.419	5.053	17.628	130.650	6.153	24.867
1997	62.935	3.545	19.038	8.679	101.232	7.531	27.458
1998	18.112	7.585	8.856	22.970	80.009	8.063	21.106
1999	49.363	22.660	47.594	132.663	80.506	9.974	19.387
2000	19.508	57.664	32.530	223.334	92.109	10.376	18.975
2001	21.879	40.185	32.845	179.264	175.233	18.238	19.014
2002	30.115	33.865	25.886	105.891	163.092	22.097	42.356
2003	23.899	16.111	21.700	139.401	118.803	17.454	13.973
2004	24.796	25.390	37.465	163.953	149.791	19.647	5.170
2005	23.113	21.172	49.435	79.725	118.015	9.344	4.999
2006	17.293	14.541	23.194	115.593	80.291	4.163	7.425
2007	17.326	31.324	118.249	339.128	104.737	7.514	14.759
2008	41.780	84.502	59.846	352.213	240.735	6.304	15.512
2009	50.210	92.814	35.131	183.886	341.241	8.011	20.402

Section III.3 Figure 3.60 (revised). Phase plot of terminal status estimates from sensitivity runs of the Beaufort Assessment Model.