Southeast Data, Assessment, and Review

SEDAR 25

Stock Assessment Report

South Atlantic Tilefish

October 2011

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

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Section I: Introduction

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I. Introduction

1. SEDAR Process Description

SouthEast Data, Assessment, and Review (SEDAR) is a cooperative Fishery Management Council scientific process initiated in 2002 to improve the quality and reliability of fishery stock assessments in the South Atlantic, Gulf of Mexico, and US Caribbean. 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. Stock assessments from the SEDAR process provide quality scientific information to address fishery management issues.

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, and a representative of the HMS Division; 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 may be conducted via a workshop and several 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 three workshops and all supporting documentation, is then forwarded to the Council SSC. The SSC will consider whether the assessment represents Best Scientific Information Available and develop fishing level recommendations for Council consideration.

SEDAR workshops are public meetings organized by SEDAR. Workshop participants appointed by the lead Council 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 this scientific process by preparing working papers, contributing data, providing assessment analyses, evaluating and discussing information presented 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 typically a member of that council's SSC. Participating councils may appoint representatives of their SSC, Advisory, and other panels as observers.

2. Management Overview

2.1. Fishery Management Plan and Amendments

The following summary describes only those management actions that likely affect golden tilefish fisheries and harvest.

Original SAMFC FMP

The Fishery Management Plan (FMP), Regulatory Impact Review, and Final Environmental Impact Statement for the Snapper Grouper Fishery of the South Atlantic Region, approved in 1983 and implemented in August of 1983, establishes a management regime for the fishery for snappers, groupers and related demersal species of the Continental Shelf of the southeastern United States in the fishery conservation zone (FCZ) under the area of authority of the South Atlantic Fishery Management Council and the territorial seas of the states, extending from the North Carolina/Virginia border through the Atlantic side of the Florida Keys to 83^{o} W longitude.

Measures in the original FMP that would have affected golden tilefish include data reporting and research needs. No regulations specific to golden tilefish were included.

SAFMC FMP Amendments affecting golden tilefish

Description of Action	FMP/Amendment	Effective Date
Prohibit fish traps, entanglement nets, and longline gear within 50 fathoms. Landed with heads & fins attached. Permits - income requirement & required to exceed bag limits.	Amendment 4	1/1/92
Establish Total Allowable Catch (TAC) and adjust the annual TAC downward by reserving a portion based on bycatch. Phase-in reduction over 3 years; year 1=1994 fishing year (calendar year). Logbook 1992 landings 1,777,772 lbs) used as base year: 1994 = 1,540,795 1995 = 1,303,818 1996 = 1,066,663 -allow retention of now more than 300 pounds of golden tilefish when the directed golden tilefish quota is filled; set the golden tilefish incidental catch at 65,000 pounds and deduct it from the quota as a set-aside for after the directed quota is filled -establish a 5,000 pound (gutted weight) golden tilefish trip limit while the directed golden tilefish quota is open -include all tilefish species in the current 5 grouper aggregate bag limit -100% logbook coverage upon renewal of permit -creation of the *Oculina* Experimental Closed Area	Amendment 6	6/27/94

-data collection needs specified for evaluation of possible future IFQ system		
Bottom longline gear is allowed only north of St. Lucie Inlet, FL ($27^{o}10$'N. latitude)	Amendment 7	1/23/95
Limited entry program: transferable permits and 225-lb non-transferable permits.	Amendment 8	12/14/98
Vessels with longline gear aboard may only possess snowy, warsaw, yellowedge, and misty grouper, and golden, blueline and sand tilefish. Specify that within the 5-fish aggregate grouper bag limit (which currently includes tilefish and excludes goliath grouper and Nassau grouper), no more than 2 fish may be gag or black grouper (individually or in combination).	Amendment 9	2/24/99
-commercial quota = 295,000 lbs gw -commercial trip limit of 4,000 lbs gw until 75% of quota is taken then reduce to 300 lbs; do not adjust trip limit downwards unless 75% is captured on or before September 1 -recreational bag limit of 1/person/day and included within 5 grouper aggregate bag limit	Amendment 13C	10/23/06
established eight marine protected areas (MPAs) in which fishing for or possession of South Atlantic snapper grouper are prohibited	Amendment 14	2/12/09
1) prohibited sale the sale of bag-limit caught snapper grouper species, 2) reduced the effects of incidental hooking on sea turtles and smalltooth sawfish, 3) changed the commercial permit renewal period and transferability requirements, 4) implemented a plan to monitor and address bycatch, and 5) established management reference points, such as MSY and OY for golden tilefish. MSY equals the yield produced by F_{MSY}. MSY and F_{MSY} are defined by the most recent SEDAR. F_{MSY} = 0.043 = 336,425 lbs whole weight. If a stock is overfished, F_{OY} equals the fishing mortality rate specified by the rebuilding plan designed to rebuild the stock to SSB_{MSY} within the approved schedule. After the stock is rebuilt, F_{OY} = a fraction of F_{MSY}. Golden tilefish is not overfished. Therefore, F_{OY} = 75% F_{MSY} = 326,554 lbs whole weight. MSST equals $SSB_{MSY}(0.75)$ = 1,454,063 lbs whole weight.	Amendment 15B	12/16/09
1) Defined allocations for golden tilefish based upon landings from the ALS, MRFSS, and headboat databases. The allocation would be based on the	Amendment 17B	1/31/11

following formula for each sector: Sector apportionment = (50% * average of long catch range (lbs) 1986-2008) + (50% * average of recent catch trend (lbs) 2006-2008). 97% com/3% rec. 2) Established the ACL at the FOY level (Total ACL = 326,554 lbs whole weight or 291,566 lbs gutted weight). 3) The commercial ACL (282,819 lbs gutted weight) is based on the allocation alternative selected (97% commercial: 3% recreational). 4) The commercial AM for this stock is to prohibit harvest, possession, and retention when the quota is projected to be met. All purchase and sale is prohibited when the quota is projected to be met. 5) Specify a recreational ACL in numbers of fish (1,578 fish) based upon the allocation decision (97% commercial: 3% recreational) and the yield at FOY. 6) Implement accountability measures (AMs) for the recreational sector for golden tilefish. If the ACL is exceeded, the Regional Administrator shall publish a notice to reduce the length of the following fishing season by the amount necessary to ensure landings do not exceed the sector ACL for the following fishing season. Compare the recreational ACL with projected recreational landings over a range of years. For 2010, use only 2010 landings. For 2011, use the average landings of 2010 and 2011. For 2012 and beyond, use the most recent three-year running average. 7) Updated the framework procedure.		

2.2. Emergency and Interim Rules

SAFMC None.

2.3. Secretarial Amendments

SAFMC None.

2.4. Control Date Notices

1. Notice of Control Date (07/30/91 56 FR 36052) - Anyone entering **federal snapper grouper fishery (other than for wreckfish)** in the EEZ off S. Atlantic States after 07/30/91 was not assured of future access if limited entry program developed.

2. Notice of Control Date (10/14/05 70 FR 60058) - Anyone entering **federal snapper grouper fishery** off S. Atlantic states after 10/14/05 was not assured of future access if limited entry program developed.
3. Notice of Control Date (2/20/09 74 FR 7849) - Anyone entering **federal golden tilefish segment of the snapper grouper fishery** off S. Atlantic states after 12/4/08 was not assured of future access if limited entry program developed.
4. Notice of Control Date (01/31/11 76 FR 5325) - Anyone **entering federal snapper grouper fishery** off S. Atlantic states after 09/17/10 was not assured of future access if limited entry program developed.

The net effect of these various control dates is that there are two control dates:

1. Federal Snapper Grouper Fishery – 1/31/2011
2. Federal Golden Tilefish Segment of the Snapper Grouper Fishery – 2/20/2009

2.5. Management Program Specifications

Table 2.5.1. General Management Information

South Atlantic

Species	
Management Unit	Southeastern US
Management Unit Definition	All waters within South Atlantic Fishery Management Council Boundaries (VA/FL boundary south to the SAMFC/GMFMC boundary)
Management Entity	South Atlantic Fishery Management Council
Management Contacts SERO / Council	Myra Brouwer or Gregg Waugh Jack McGovern/Rick DeVictor
Current stock exploitation status	Overfishing
Current stock biomass status	Not overfished

Table 2.5.2. Specific Management Criteria

Criteria	South Atlantic - Current		South Atlantic - Proposed	
	Definition	Value	Definition	Value
MSST	$SSB_{MSY}(0.75)$	1,454,063 lbs whole weight	$SSB_{MSY}(0.75)$	SEDAR 25
MFMT	F_{MSY}	0.043	F_{MSY}	SEDAR 25
MSY	Yield at F_{MSY}	336,425 lbs whole weight	Yield at F_{MSY}	SEDAR 25
F_{MSY}	F_{MSY}	0.043	F_{MSY}	SEDAR 25
OY	Yield at F_{OY}	326,554 lbs whole weight	Yield at F_{OY}	SEDAR 25
F_{OY}	75%F_{MSY}	0.03225	F_{OY} = 65%,75%, 85% F_{MSY}	SEDAR 25
M	n/a	0.08	M	SEDAR 25

NOTE: "Proposed" columns are for indicating any definitions that may exist in FMPs or amendments that are currently under development and should therefore be evaluated in the current assessment. "Current" is those definitions in place now.

Table 2.5.3. Stock Rebuilding Information

N/A

Table 2.5.4. Stock projection information

South Atlantic

Requested Information	Value
First Year of Management	2012
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.

First year of Management: Earliest year in which management changes resulting from this assessment are expected to become effective

Interim years: those between the terminal assessment year and the first year that any management could realistically become effective.

Projection Criteria: The parameter which should be used to determine population removals, typically either an exploitation rate or an average landings value or a pre-specified landings target.

Table 2.5.5. Quota Calculation Details

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

	Commercial ACL	Recreational ACL	Total ACL
Current Quota Value	282,819 lbs gutted weight	1,578 fish (based on 3% of Total ACL)	326,554 lbs whole weight (291,566 lbs whole weight)
Next Scheduled Quota Change	NA	NA	NA
Annual or averaged quota ?	annual	annual	annual
If averaged, number of years to average	NA	NA	NA
Does the quota account for bycatch/discard ?	Yes	Yes	Yes

How is the quota calculated - conditioned upon exploitation or average landings? Commercial ACL (282,819 lbs gutted weight) and Recreational ACL (1,578 fish) is based on yield at F_{OY} and assumes population biomass at equilibrium. Yield at F_{OY} is allocated to commercial and recreation sectors based on the following formula for each sector: Sector apportionment = (50% * average of long catch range (lbs) 1986-2008) + (50% * average of recent catch trend (lbs) 2006-2008). The allocation is 97% commercial and 3% recreational. This allocation was established in Amendment 17B (effective 1/31/11).

Amendment 13C established a quota (295,000 lbs gutted weight) based on the yield at F_{MSY}. 98% of the yield at F_{MSY} was determined to be the commercial quota in Amendment 13C based on historical landings from 1999-2003.

Does the quota include bycatch/discard estimates? If so, what is the source of the bycatch/discard values? What are the bycatch/discard allowances? Commercial and Recreational ACLs do not require monitoring of discards and are based on landed catch. Assessment takes into consideration bycatch and provides estimates of yield at F_{MSY} and F_{OY} as landed catch rather than landed catch plus dead discards.

Are there additional details of which the analysts should be aware to properly determine quotas for this stock? No.

2.6. Management and Regulatory Timeline

The following tables provide a timeline of Federal management actions by fishery.

Table 2.6.1. Annual Commercial Golden Tilefish Regulatory Summary

No size limit has been established or considered for golden tilefish given the high discard mortality in this deep water fishery.

	Fishing Year	Gear Regulations	Possession Limit
1992	Calendar Year	Prohibited longline gear within 50 fathoms	None
1993	Calendar Year	Prohibited longline gear within 50 fathoms	None
1994	Calendar Year	Prohibited longline gear within 50 fathoms	1,540,795 lb quota; 5,000 pound (gutted weight) golden tilefish trip limit; allow retention of no more than 300 pounds when quota filled
1995	Calendar Year	Prohibited longline gear within 50 fathoms and south of St. Lucie Inlet, FL (27°10'N. latitude)	1,303,818 lb quota; 5,000 pound (gutted weight) golden tilefish trip limit; allow retention of no more than 300 pounds when quota filled
1996	Calendar Year	Prohibited longline gear within 50 fathoms and south of St. Lucie Inlet, FL (27°10'N. latitude)	1,066,663 lb quota; 5,000 pound (gutted weight) golden tilefish trip limit; allow retention of no more than 300 pounds when quota filled
1997	Calendar Year	Prohibited longline gear within 50 fathoms and south of St. Lucie Inlet, FL (27°10'N. latitude)	1,066,663 lb quota; 5,000 pound (gutted weight) golden tilefish trip limit; allow retention of no more than 300 pounds when quota filled
1998	Calendar Year	Prohibited longline gear within 50 fathoms and south of St. Lucie Inlet, FL (27°10'N. latitude)	1,066,663 lb quota; 5,000 pound (gutted weight) golden tilefish trip limit; allow retention of no more than 300 pounds when quota filled
1999	Calendar Year	Prohibited longline gear within 50 fathoms and south of St. Lucie Inlet, FL (27°10'N. latitude). Vessels with longline gear aboard may only possess snowy, warsaw, yellowedge, and misty grouper, and golden, blueline and sand tilefish.	1,066,663 lb quota; 5,000 pound (gutted weight) golden tilefish trip limit; allow retention of no more than 300 pounds when quota filled
2000	Calendar Year	Prohibited longline gear within 50 fathoms and south of St. Lucie Inlet, FL (27°10'N. latitude). Vessels with longline gear aboard may only possess snowy, warsaw, yellowedge, and misty grouper, and golden, blueline and sand	1,066,663 lb quota; 5,000 pound (gutted weight) golden tilefish trip limit; allow retention of no more than 300 pounds when quota filled

		tilefish.	
2001	Calendar Year	Prohibited longline gear within 50 fathoms and south of St. Lucie Inlet, FL (27°10'N. latitude). Vessels with longline gear aboard may only possess snowy, warsaw, yellowedge, and misty grouper, and golden, blueline and sand tilefish.	1,066,663 lb quota; 5,000 pound (gutted weight) golden tilefish trip limit; allow retention of no more than 300 pounds when quota filled
2002	Calendar Year	Prohibited longline gear within 50 fathoms and south of St. Lucie Inlet, FL (27°10'N. latitude). Vessels with longline gear aboard may only possess snowy, warsaw, yellowedge, and misty grouper, and golden, blueline and sand tilefish.	1,066,663 lb quota; 5,000 pound (gutted weight) golden tilefish trip limit; allow retention of no more than 300 pounds when quota filled
2003	Calendar Year	Prohibited longline gear within 50 fathoms and south of St. Lucie Inlet, FL (27°10'N. latitude). Vessels with longline gear aboard may only possess snowy, warsaw, yellowedge, and misty grouper, and golden, blueline and sand tilefish.	1,066,663 lb quota; 5,000 pound (gutted weight) golden tilefish trip limit; allow retention of no more than 300 pounds when quota filled
2004	Calendar Year	Prohibited longline gear within 50 fathoms and south of St. Lucie Inlet, FL (27°10'N. latitude). Vessels with longline gear aboard may only possess snowy, warsaw, yellowedge, and misty grouper, and golden, blueline and sand tilefish.	1,066,663 lb quota; 5,000 pound (gutted weight) golden tilefish trip limit; allow retention of no more than 300 pounds when quota filled
2005	Calendar Year	Prohibited longline gear within 50 fathoms and south of St. Lucie Inlet, FL (27°10'N. latitude). Vessels with longline gear aboard may only possess snowy, warsaw, yellowedge, and misty grouper, and golden, blueline and sand tilefish.	1,066,663 lb quota; 5,000 pound (gutted weight) golden tilefish trip limit; allow retention of no more than 300 pounds when quota filled
2006	Calendar Year	Prohibited longline gear within 50 fathoms and south of St. Lucie Inlet, FL (27°10'N. latitude). Vessels with longline gear aboard may only possess snowy, warsaw, yellowedge, and misty grouper, and golden, blueline and sand tilefish.	295,000 lbs gw -commercial trip limit of 4,000 lbs gw until 75% of quota is taken then reduce to 300 lbs

2007	Calendar Year	Prohibited longline gear within 50 fathoms and south of St. Lucie Inlet, FL (27°10'N. latitude). Vessels with longline gear aboard may only possess snowy, warsaw, yellowedge, and misty grouper, and golden, blueline and sand tilefish.	295,000 lbs gw -commercial trip limit of 4,000 lbs gw until 75% of quota is taken then reduce to 300 lbs
2008	Calendar Year	Prohibited longline gear within 50 fathoms and south of St. Lucie Inlet, FL (27°10'N. latitude). Vessels with longline gear aboard may only possess snowy, warsaw, yellowedge, and misty grouper, and golden, blueline and sand tilefish.	295,000 lbs gw -commercial trip limit of 4,000 lbs gw until 75% of quota is taken then reduce to 300 lbs
2009	Calendar Year	Prohibited longline gear within 50 fathoms and south of St. Lucie Inlet, FL (27°10'N. latitude). Vessels with longline gear aboard may only possess snowy, warsaw, yellowedge, and misty grouper, and golden, blueline and sand tilefish.	295,000 lbs gw -commercial trip limit of 4,000 lbs gw until 75% of quota is taken then reduce to 300 lbs
2010	Calendar Year	Prohibited longline gear within 50 fathoms and south of St. Lucie Inlet, FL (27°10'N. latitude). Vessels with longline gear aboard may only possess snowy, warsaw, yellowedge, and misty grouper, and golden, blueline and sand tilefish.	295,000 lbs gw -commercial trip limit of 4,000 lbs gw until 75% of quota is taken then reduce to 300 lbs
2011	Calendar Year	Prohibited longline gear within 50 fathoms and south of St. Lucie Inlet, FL (27°10'N. latitude). Vessels with longline gear aboard may only possess snowy, warsaw, yellowedge, and misty grouper, and golden, blueline and sand tilefish.	282,819 lbs gw -commercial trip limit of 4,000 lbs gw until 75% of quota is taken then reduce to 300 lbs

Table 2.6.2. Annual Recreational Golden Tilefish Regulatory Summary

No size limit has been established or considered for golden tilefish given the high discard mortality in this deep water fishery.

Year	Fishing Year	Bag Limit	Other Regulations
1992	Calendar Year	None	Landed heads & fins intact
1993	Calendar Year	Aggregate grouper bag limit (including golden, blueline & sand tilefish) – 5/person/day	Landed heads & fins intact
1994	Calendar Year	Aggregate grouper bag limit (including golden, blueline & sand tilefish) – 5/person/day	Landed heads & fins intact
1995	Calendar Year	Aggregate grouper bag limit (including golden, blueline & sand tilefish) – 5/person/day	Landed heads & fins intact
1996	Calendar Year	Aggregate grouper bag limit (including golden, blueline & sand tilefish) – 5/person/day	Landed heads & fins intact
1997	Calendar Year	Aggregate grouper bag limit (including golden, blueline & sand tilefish) – 5/person/day	Landed heads & fins intact
1998	Calendar Year	Aggregate grouper bag limit (including golden, blueline & sand tilefish) – 5/person/day	Landed heads & fins intact
1999	Calendar Year	Aggregate grouper bag limit (including golden, blueline & sand tilefish) – 5/person/day	Landed heads & fins intact
2000	Calendar Year	Aggregate grouper bag limit (including golden, blueline & sand tilefish) – 5/person/day	Landed heads & fins intact
2001	Calendar Year	Aggregate grouper bag limit (including golden, blueline & sand tilefish) – 5/person/day	Landed heads & fins intact
2002	Calendar Year	Aggregate grouper bag limit (including golden, blueline & sand tilefish) – 5/person/day	Landed heads & fins intact
2003	Calendar Year	Aggregate grouper bag limit (including golden, blueline & sand tilefish) – 5/person/day	Landed heads & fins intact
2004	Calendar Year	Aggregate grouper bag limit (including golden, blueline & sand tilefish) – 5/person/day	Landed heads & fins intact
2005	Calendar Year	Aggregate grouper bag limit (including golden, blueline & sand tilefish) – 5/person/day	Landed heads & fins intact
2006	Calendar Year	Limit possession to 1 golden tilefish in 5 grouper per person/day aggregate bag limit.	Landed heads & fins intact
2007	Calendar Year	Limit possession to 1 golden tilefish in 5 grouper per person/day aggregate bag limit.	Landed heads & fins intact
2008	Calendar Year	Limit possession to 1 golden tilefish in 5 grouper per person/day aggregate bag limit.	Landed heads & fins intact
2009	Calendar Year	Limit possession to 1 golden tilefish in 5 grouper per person/day aggregate bag limit.	Landed heads & fins intact Prohibited sale of bag-limit caught golden tilefish

2010	Calendar Year	Limit possession to 1 golden tilefish in 5 grouper per person/day aggregate bag limit.	Landed heads & fins intact Prohibited sale of bag-limit caught golden tilefish
2011	Calendar Year	Limit possession to 1 golden tilefish in 5 grouper per person/day aggregate bag limit. Recreational ACL in numbers of fish (1,578 fish); AM is if exceeded, Regional Administrator shall publish a notice to reduce the length of the following fishing season to ensure ACL is not exceeded	Landed heads & fins intact Prohibited sale of bag-limit caught golden tilefish

2.6. Closures Due to Meeting Quota / ACL

Commercial:

- 2006 – Closed October 23, 2006 through December 31, 2006.
- 2007 – Closed October 3, 2007 through December 31, 2007.
- 2008 – Closed August 17, 2008 through December 31, 2008.
- 2009 – Closed July 15, 2009 through December 31, 2009.
- 2010 – Closed April 10, 2010 through December 31, 2010.

Table 7. State Regulatory History

North Carolina:

Rule 15A NCAC 03M .0506 was amended effective May 24, 1999 (following Amendment 9 to the SAFMC Snapper-Grouper FMP, eff. 2/24/99) to include the following Sub-item: (q) It is unlawful to possess any species of the Snapper-grouper complex except snowy, warsaw, yellowedge, and misty groupers; blueline, **golden** and sand tilefishes; while having longline gear aboard a vessel.

This Sub-item was removed from this rule effective April 1, 2009 and the same regulation was placed in proclamation at that time, per the authority of Rule 15A NCAC 03M .0512. This item is still included in the current Snapper-Grouper proclamation, FF-22-2011.

NC state fishery proclamations can be seen at: www.ncdmf.net/procs/index.html.

South Carolina:

Sec. 50-5-2730 of the SC Code states:

"Unless otherwise provided by law, any regulations promulgated by the federal government under the Fishery Conservation and Management Act (PL94-265) or the Atlantic Tuna Conservation Act (PL 94-70) which establishes seasons, fishing periods, gear restrictions, sales restrictions, or bag, catch, size, or possession limits on fish are declared to be the law of this State and apply statewide including in state waters."

As such, SC golden tilefish regulations are (and have been) pulled directly from the federal regulations as promulgated under Magnuson. I am not aware of any separate golden tilefish regulations that have been codified in the SC Code.

References

None Provided

3. Assessment History & Review

The tilefish, *Lopholatilus chamaeleonticeps*, stock has been assessed for the 1988, 1990 and 1999 fishing years (Staff 1991; Huntsman et al. 1992; Potts and Brennan 2001). The assessments of 1988 and 1990 fishing year data used limited age information from Georgia and reproductive biology data were not available. The assumption of ½ L_∞ as the age of maturity was used for estimating the static SPR. Static SPR values were 31% and 21% for 1988 and 1990, respectively. The assessment of the 1999 fishing year used age and reproductive biology data from North Carolina and South Carolina. The resulting static SPR was 27%.

In 2004 tilefish was assessed as part of SEDAR 4, using landings, age, length, and abundance index data through 2002. For this assessment two models were considered: (1) a statistical catch-at-age (SCAA) model and (2) an age-aggregated production model. The results of the primary SCAA model indicated overfishing of the resource post-1988 with spawning stock biomass hovering right around the value corresponding to MSY for that same time period. The terminal 2002 model estimates suggested the tilefish stock was overfishing and that the stock was very close to the overfished definition. Static SPR in this assessment was estimated to be about 31% in 2002.

References

Huntsman, G. R., J. C. Potts, R. Mays, R. L. Dixon, P. W. Willis, M. Burton, and B. W. Harvey. 1992. A stock assessment of the Snapper-Grouper Complex in the U.S. South Atlantic based on the fish caught in 1990. Report to the South Atlantic Fishery Management Council, One Southpark Circle, Suite 306, Charleston, SC 29407, 104p.

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 to the South Atlantic Fishery Management Council, One Southpark Circle, Suite 306, Charleston, SC 29407. 41 p.

Staff of Beaufort Laboratory, Southeast Fisheries Science Center. 1991. South Atlantic snapper grouper assessment 1991. Report to the South Atlantic Fishery Management Council, One Southpark Circle, Suite 306, Charleston, SC 29407. 21 p., 4 Tables, 39 Figures.

4. Regional Maps

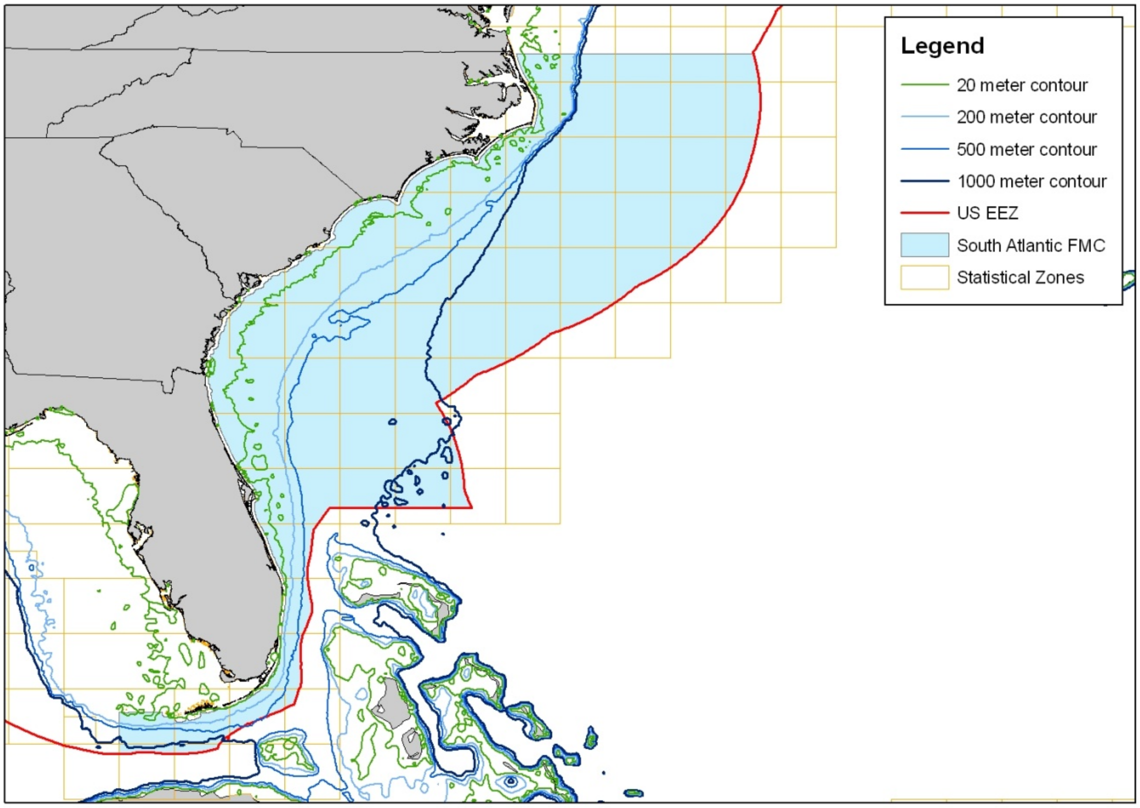


Figure 4.1 South Atlantic Fishery Management Council and EEZ boundaries.

5. Assessment Summary Report

The Summary Report provides a broad but concise view of the salient aspects of the 2011 tilefish stock assessment (SEDAR 25). 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 tilefish (*Lopholatilus chamaeleonticeps*) is currently not overfished and overfishing is not occurring.

Estimated time series of stock status (SSB/MSST) shows decline in the early 1980s, and then increase since the mid-2000s, (Table 5.3). Base-run estimates of spawning biomass have remained below MSST throughout the 1990s and early 2000s. Current stock in the base run status was estimated to be $SSB_{2010}/MSST = 2{:}43$ (Table 5.3). Uncertainty from the MCB analysis suggests that the estimate of a stock that is not overfished (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 (2010), ages 1-7 approach the MSY age structure.

The estimated time series of F/F_{MSY} suggests that overfishing has occurred throughout some of the assessment period (Figure 5.7, Table 5.3). Spikes in the early 1980s through 2004 are due primarily to the longline fleet (Figure 5.2). Current fishery status in the terminal year, with current *F* represented by the geometric mean from 2008-2010, is estimated by the base run to be $F_{2008\text{-}2010}/F_{MSY} = 0.36$ (Table 5.1). This estimate indicates that overfishing is not occurring and appears robust across MCB trials. However, it should be noted that the base run tended to result in higher $SSB_{2010}/MSST$ and lower $F_{2008\text{-}2010}/F_{MSY}$ values relative to all the MCB values (i.e. the base run does not equal the mode or the mean of the MCB values).

Table 5.1. Summary of stock status determination criteria. Estimated status indicators, benchmarks, and related quantities from the Beaufort catch-age model, conditional on estimated current selectivities averaged across fisheries. 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) and minimum stock size threshold (MSST) are measured by total gonad weight of mature females.

Criteria	Recommended Values from SEDAR 25	
	Definition	Value
M (Instantaneous natural mortality; per year)	Average of Lorenzen M	0.10
$F_{current}$ (per year)	Geometric mean of the apical fishing mortality rates in 2008 - 2010	0.070
F_{MSY} (per year)	F_{MSY}	0.185
B_{MSY} (metric tons)	Biomass at MSY	2918
SSB_{2010} (metric tons)	Spawning stock biomass (female gonad wt, mt) in 2010	54.8
SSB_{MSY} (metric tons)	SSB_{MSY}	25.3
MSST (metric tons)	$(1-M)*SSB_{MSY}$	22.6
MFMT (per year)	F_{MSY}	0.185
MSY (1000 pounds)	Yield at MSY	638
OY (1000 pounds)	Yield at F_{OY}	OY (65% F_{MSY})= 610 OY (75% F_{MSY})= 625 OY (85% F_{MSY})= 634
F_{OY} (per year)	F_{OY} = 65%,75%, 85% F_{MSY}	65% F_{MSY}= 0.120 75% F_{MSY}= 0.139 85% F_{MSY}= 0.157
Biomass Status	SSB_{2010}/MSST	2.43
Exploitation Status	$F_{current}/F_{MSY}$	0.36

Stock Identification and Management Unit

Based on the genetic study by Katz et al. (1983) and the limited movement cited in Grimes (1983), the data workshop recommended defining the U.S. South Atlantic stock as those fish caught from the VA/NC border southward through the east coast of Florida to south of the Florida keys.

Species Distribution

Tilefish in U.S. territorial waters are distributed south of Nova Scotia through the Gulf of Mexico. This fish has been managed as three separate stocks by three separate management councils: MAFMC, SAFMC and GMFMC.

Stock Life History

- Tilefish are deep-water, demersal fish that have distinct habitat requirements that include stable temperatures (9-14 C) and clay-like substrate in which to construct burrows/shelter (Grimes et al., 1986).
- The SEDAR 25 data workshop recommended model runs using M calculated as an age-variable value (Lorenzen M) scaled to $Hoenig_{fish}$ (1983) value (M = 0.10).
- The maximum aged tilefish was age 40.
- Tilefish exhibit dimorphic growth with males attaining larger sizes at age than females.
- Tilefish in spawning condition have been collected in all months except October and December (Sedberry et al. 2006). The peak of spawning occurs in April through June, primarily on the upper slope of the continental shelf.

Assessment Methods

Following the Terms of Reference, two stock assessment models of tilefish were discussed during the Assessment Workshop (AW): the Beaufort assessment model (BAM) and a surplus-production model (ASPIC).

The primary model in this assessment was the Beaufort assessment model (BAM), which applies a statistical catch-age formulation. The model was implemented with the AD Model Builder software (ADMB Foundation 2011), and its structure and equations are detailed in SEDAR25-RW04. In essence, a statistical catch-age model simulates a population forward in time while including fishing processes (Quinn and Deriso 1999; Shertzer et al. 2008a). 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.

A logistic surplus production model, implemented in ASPIC (Prager 2005), was also used to estimate stock status of tilefish of 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 verifcation that the age-structured approach was providing reasonable results.

Assessment Data

The catch-age model included data from a fishery independent survey, a fishery dependent survey, and from three fleets that caught southeastern U.S. tilefish: commercial longline, commercial handlines, and the recreational fishery. The model was fitted to data on annual landings (in units of 1000 lbs gutted weight), annual length compositions of landings, annual age compositions of landings, and two indices of abundance (MARMAP longline and the commercial logbook). 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 Section III (part2) of the stock assessment report.

The combined recreational landings estimates include headboat landings estimates, developed by the headboat survey, and the general recreational landings estimates. The general recreational fleet was sampled by the Marine Recreational Fishing Statistical Survey (MRFSS) starting in 1981.

Data used for production modeling were total landings and two abundance indices, the MARMAP longline index and the commercial logbook index.

Release Mortality

Bycatch and discards of tilefish were thought to be low overall in the South Atlantic and the Data Workshop panel recommended a discard mortality rate for tilefish of 100%. No discard estimates were included in the assessment model as discards are assumed to be negligible in all sectors of the tilefish fishery.

Landings Trends

See Figure 5.1 panels *a*-*c* for detail on landings trends. Commercial longline landings peaked in early 1980s then generally declined. Commercial landline landings also peaked in the early 1980s then generally declined through 2010. Recreational landings were highly variable, particularly in years since 2000.

Fishing Mortality Trends

The estimated fishing mortality rates (*F*) increased in the early 1980s, and since then have been quite variable (Figure 5.2, Table 5.3). The commercial longline fleet dominates the total *F* (Figure 5.2).

Stock Abundance and Biomass Trends

In general, estimated abundance at age shows a slight truncation of the older ages. Total estimated abundance at the end of the assessment period shows sharp increase, reaching levels not seen since the early 1980s, albeit with a quite different age structure. This increase is driven by recruitment estimates in the early 2000s. Annual number of recruits is shown in Table 5.4*a* (age-1 column). A notably strong year class (age-1 fish) was predicted to have occurred in 2001 and is driving the increase in the population size in the last 6-8 years.

Estimated biomass at age exhibits a different pattern than does abundance at age. Total biomass declines in the early 1980's and then remains relatively low until 2001, when one big year class is predicted and biomass climbs to moderate levels in the terminal year. Abundance at age trends are greatly affected by the very large recruitment event estimated by the model in 2001. Total and spawning biomass show very similar trends (Figure 5.3).

Projections

There are only slight differences in the F_{MSY}, $F_{65\%MSY}$, $F_{75\%MSY}$, and $F_{85\%MSY}$ projection scenarios (Figures 5.8 *a*-*d*). The $F_{current}$ projection maintained SSB above SSB_{MSY} and landings slightly below landings at MSY (Figure 5.8*b*).

Scientific Uncertainty

Sensitivity runs, described in Section III, part 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 the sensitivity of the model on recruitment (see Section III, Figure 3.28), and relationship of relative F to relative SSB (see Section III, Figure 3.29). The tendency was toward the status estimates of not overfished with no overfishing. In concert, sensitivity analyses suggested that qualitative results of the base run and MCB analysis were robust, although the bulk of the sensitivity runs suggested a stock status that was closer to overfished and overfishing compared to the base run.

Retrospective analyses suggested no pattern in F, B, SSB, recruits, SSB/SSB_{MSY}, or F/F_{MSY} and seemed to indicate no retrospective error.

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 commercial longline fishery dependent index was 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 index as reliable as possible (using trip selection and standardization methods to develop the indices, and using time-varying catchability to fit them). A new fishery independent sampling program was initiated in the summer of 2010, but this new data source is not expected to be useful for the next benchmark assessment, since the methods being deployed do not cover tilefish habitats suffciently.

Perhaps the greatest uncertainty in this assessment was the spawner-recruit relationship. Steepness could not be estimated reliably (tended toward its upper bound), and therefore had to be 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 (Shertzer and Conn *In Press*).

The assessment predicted relatively high abundance in recent years. This prediction is consistent with reports from fishermen of increased abundance of larger individuals. However, this increase appears to be the result of one unusually strong year class (age-1) in 2001. MCB results and sensitivity runs agreed with strong pulses in recruitment, but showed much uncertainty in the temporal pattern. The observed data clearly shows an increase in abundance in the most recent years. Both the commercial longline and MARMAP indices show this increase. The observed age composition data also suggests a shift in the age structure to older ages, which could be suggestive of an increased abundance.

What is not clear is whether these observed patterns in the data are the result of (1) a single large year class, (2) several moderate to large year classes, or (3) an immigration of fish into the fished area. The third hypothesis was discussed on several occasions by the assessment panel and participating fishermen. Fishemen have noted a change in the fishery after 2003-04, which happened to correspond to a large cold water event in the U.S. South Atlantic. In general, tilefish are not known to migrate as adults, but perhaps extreme environmental events instigate undocumented behavior.

The age composition data do not support a single strong year class and do not really indicate any year classes passing through the years. But ageing error for this species is high and could be masking year class signals. In the end, the data cannot give us a clear indication if (1), (2), or (3) listed above is the correct explanation of the increased abundance and shift in age structure. The base run model has chosen (1), but managers should note the risks involved if (2) or (3) are correct and management actions are based on (1).

Significant Assessment Modifications

The review panel accepted the base run as developed by the assessment panel.

Sources of Information

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

Tables

List of tables

Table 5.2. Annual landings estimates input to the Tilefish model. Some data included in the input are confidential due to the number of vessels reporting landings and are denoted with an "*". Commercial landings were input as gutted weight and converted to whole weight in the model. *(Extracted from Table 2.2 of the Assessment Report.)*

	Thousand Pounds		
Year	whole Recreational	gutted Handline	gutted Longline
1962		0.468	2.934
1963		0.443	2.776
1964		0.138	0.862
1965		3.208	20.096
1966		0.602	3.773
1967		1.426	8.931
1968		0.873	5.467
1969		0.713	4.466
1970		1.413	8.854
1971		2.618	16.400
1972		1.561	9.778
1973		5.469	34.263
1974		12.425	77.843
1975		21.571	133.968
1976		21.928	129.789
1977		25.734	62.760
1978		91.554	92.140
1979		55.857	114.232
1980		148.605	177.797
1981	0.412	334.407	783.689
1982	0.018	596.732	2774.404
1983	3.199	263.259	1630.174
1984	0.726	202.687	1108.276
1985	47.293	146.993	989.904
1986	0.319	133.884	985.575
1987	0.148	24.751	247.343
1988	3.967	50.228	452.719
1989	0.014	92.611	743.915
1990	0.349	86.061	757.825
1991	0.390	82.346	822.714
1992	7.273	81.527	887.374
1993	0.020	171.108	866.091
1994	12.778	105.428	702.016
1995	0.020	82.718	591.458
1996	3.520	*	*
1997	29.583	34.133	328.338
1998	1.238	28.891	334.574
1999	8.227	38.104	473.771
2000	14.314	54.204	666.858
2001	35.179	38.550	389.574
2002	17.742	*	*
2003	45.419	18.760	222.235
2004	7.758	29.127	231.878
2005	28.507	*	*
2006	51.076	26.594	379.476
2007	9.775	49.747	260.570
2008	0.020	*	*
2009	54.514	*	*
2010	27.747	*	*

Table 5.3. 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 MSST = (1 - M)SSB_{MSY}, with constant M = 0.10. SPR is static spawning potential ratio. *(Extracted from Table 3.4 of the Assessment Report.)*

Year	F	F/Fmsy	B	SSB	SSB/SSBmsy	SSB/MSST	SPR
1962	2.60E-04	0.001403	7838	108.5	4.287	4.808	0.996
1963	2.44E-04	0.001316	7899	109.9	4.343	4.870	0.997
1964	7.49E-05	0.000405	7956	110.9	4.381	4.913	0.999
1965	1.73E-03	0.009372	8012	111.7	4.416	4.952	0.977
1966	3.24E-04	0.001748	8053	112.5	4.447	4.987	0.996
1967	7.61E-04	0.004111	8100	113.3	4.479	5.023	0.990
1968	4.63E-04	0.002501	8141	114.1	4.509	5.057	0.994
1969	3.76E-04	0.002031	8180	114.8	4.538	5.089	0.995
1970	7.42E-04	0.004007	8218	115.5	4.565	5.119	0.990
1971	1.37E-03	0.007391	8250	116.1	4.588	5.145	0.982
1972	8.13E-04	0.004390	8275	116.6	4.609	5.168	0.989
1973	2.84E-03	0.015340	8302	117.0	4.625	5.187	0.963
1974	6.45E-03	0.034865	8313	117.1	4.629	5.191	0.918
1975	1.12E-02	0.060348	8299	116.7	4.613	5.174	0.865
1976	1.10E-02	0.059239	8223	116.1	4.586	5.143	0.867
1977	6.42E-03	0.034687	8120	115.6	4.568	5.122	0.919
1978	1.34E-02	0.072403	8021	115.0	4.543	5.095	0.842
1979	1.25E-02	0.067526	7854	113.5	4.487	5.032	0.851
1980	2.44E-02	0.131627	7683	111.4	4.402	4.936	0.742
1981	8.96E-02	0.484177	7440	105.5	4.168	4.674	0.414
1982	3.40E-01	1.834391	6824	87.0	3.437	3.855	0.140
1983	2.59E-01	1.398076	5149	65.1	2.573	2.885	0.178
1984	2.18E-01	1.180433	4288	52.6	2.078	2.330	0.207
1985	3.25E-01	1.758024	3785	42.4	1.675	1.878	0.147
1986	2.84E-01	1.531918	3198	33.8	1.334	1.496	0.164
1987	7.33E-02	0.395989	2876	30.6	1.208	1.355	0.468
1988	1.41E-01	0.760100	3005	30.4	1.203	1.349	0.298
1989	2.30E-01	1.240526	3086	28.7	1.135	1.273	0.198
1990	2.53E-01	1.368120	3025	26.2	1.037	1.163	0.181
1991	2.99E-01	1.613842	2949	24.1	0.953	1.068	0.157
1992	3.78E-01	2.044518	2826	22.3	0.882	0.989	0.128
1993	4.20E-01	2.268922	2642	20.0	0.791	0.887	0.117
1994	3.53E-01	1.906439	2451	18.2	0.718	0.806	0.136
1995	2.69E-01	1.451046	2313	17.3	0.684	0.768	0.172
1996	1.48E-01	0.797665	2258	17.9	0.707	0.793	0.287
1997	2.29E-01	1.238663	2353	18.9	0.746	0.837	0.200
1998	1.37E-01	0.742598	2345	19.6	0.773	0.866	0.304
1999	1.96E-01	1.061410	2443	20.3	0.801	0.898	0.227

Year	F	F/Fmsy	B	SSB	SSB/SSBmsy	SSB/MSST	SPR
2001	2.84E-01	1.534505	2733	18.4	0.728	0.816	0.166
2003	2.42E-01	1.307453	3620	20.0	0.790	0.886	0.192
2004	1.20E-01	0.647155	4061	26.7	1.054	1.182	0.338
2005	1.56E-01	0.840875	4553	32.7	1.291	1.448	0.277
2006	1.25E-01	0.674299	4856	38.1	1.507	1.690	0.329
2007	5.12E-02	0.276555	4961	43.3	1.713	1.921	0.566
2008	4.21E-02	0.227349	5168	49.0	1.936	2.171	0.616
2009	9.36E-02	0.505768	5343	52.9	2.091	2.345	0.403
2010	7.48E-02	0.404355	5268	54.8	2.167	2.430	0.463
2011	.	.	5244	.	.	.	.

Table 5.4a. Estimated total abundance at age (1000 fish) at start of year. Age-1 estimated abundance is estimated recruitment. *(Extracted from Table 3.2 of the Assessment Report.)*

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1962	443.19	329.38	265.01	221.71	189.73	164.52	143.54	125.81	110.80	97.98	86.92	77.31	68.90
1963	443.19	329.38	265.01	221.72	189.80	164.86	144.42	126.93	111.87	98.94	87.77	78.07	69.58
1964	443.48	329.38	265.01	221.73	189.82	164.92	144.72	127.71	112.87	99.89	88.63	78.83	70.26
1965	443.67	329.59	265.01	221.73	189.82	164.94	144.79	127.99	113.58	100.80	89.50	79.62	70.96
1966	443.84	329.73	265.18	221.72	189.81	164.89	144.65	127.86	113.64	101.27	90.17	80.27	71.55
1967	443.99	329.86	265.30	221.87	189.82	164.93	144.74	127.91	113.69	101.47	90.71	80.98	72.23
1968	444.14	329.97	265.40	221.96	189.94	164.92	144.73	127.93	113.68	101.46	90.85	81.43	72.84
1969	444.29	330.09	265.49	222.05	190.02	165.03	144.75	127.96	113.73	101.48	90.87	81.58	73.27
1970	444.42	330.19	265.58	222.12	190.09	165.11	144.86	127.99	113.76	101.54	90.90	81.61	73.41
1971	444.55	330.29	265.67	222.20	190.16	165.16	144.89	128.04	113.75	101.53	90.92	81.60	73.41
1972	444.65	330.39	265.75	222.27	190.22	165.20	144.88	127.99	113.73	101.46	90.86	81.57	73.36
1973	444.74	330.46	265.82	222.34	190.28	165.27	144.96	128.05	113.75	101.49	90.84	81.56	73.37
1974	444.82	330.53	265.88	222.40	190.33	165.26	144.84	127.88	113.57	101.31	90.69	81.38	73.21
1975	444.83	330.59	265.94	222.45	190.35	165.19	144.50	127.35	113.02	100.78	90.19	80.95	72.78
1976	254.95	330.60	265.98	222.49	190.36	165.06	144.01	126.50	112.02	99.82	89.31	80.13	72.06
1977	263.47	189.48	265.99	222.52	190.40	165.08	143.92	126.10	111.30	98.97	88.47	79.36	71.34
1978	283.69	195.81	152.45	222.54	190.47	165.28	144.34	126.54	111.44	98.77	88.11	78.97	70.98
1979	303.78	210.83	157.54	127.54	190.46	165.23	143.87	126.06	111.06	98.21	87.33	78.10	70.14
1980	316.79	225.77	169.63	131.80	109.15	165.19	143.92	125.77	110.74	97.96	86.91	77.48	69.43
1981	357.71	235.44	181.65	141.91	112.77	94.54	142.79	124.39	109.19	96.53	85.67	76.20	68.07
1982	343.56	265.84	189.42	151.91	121.18	96.61	78.42	116.14	101.25	89.18	79.08	70.36	62.71
1983	346.20	255.32	213.83	158.18	128.57	99.05	68.48	50.65	73.87	64.44	56.91	50.59	45.10
1984	340.25	257.29	205.38	178.64	134.21	106.53	73.89	47.69	34.89	50.96	44.58	39.47	35.16
1985	339.04	252.87	206.97	171.62	151.79	112.05	81.51	53.40	34.19	25.06	36.70	32.19	28.56
1986	354.26	251.96	203.41	172.92	145.70	125.79	79.98	53.07	34.41	22.06	16.22	23.81	20.93
1987	361.06	263.28	202.67	169.90	146.54	120.00	92.41	54.47	35.68	23.16	14.89	10.97	16.14
1988	419.50	268.34	211.81	169.49	145.06	125.54	100.61	76.41	45.07	29.62	19.29	12.43	9.18
1989	815.60	311.77	215.87	177.07	144.40	122.84	100.88	78.14	59.15	34.98	23.06	15.05	9.72
1990	313.87	606.13	250.79	180.36	150.33	120.09	93.36	72.22	55.41	42.01	24.92	16.47	10.77
1991	221.89	233.26	487.57	209.50	152.99	124.44	89.93	65.41	50.03	38.44	29.22	17.38	11.51
1992	290.13	164.90	187.62	407.18	177.39	125.46	90.57	60.44	43.33	33.17	25.55	19.47	11.60
1993	408.48	215.61	132.63	156.63	343.97	143.64	86.82	56.49	37.00	26.53	20.36	15.72	12.01
1994	432.63	303.56	173.41	110.71	132.20	277.12	96.79	52.05	33.19	21.73	15.62	12.02	9.30
1995	270.06	321.51	244.17	144.82	93.70	108.07	194.71	61.68	32.67	20.84	13.68	9.86	7.60
1996	217.29	200.70	258.62	203.96	122.79	77.39	80.14	134.45	42.09	22.32	14.28	9.40	6.79
1997	327.45	161.48	161.46	216.20	173.73	103.86	61.91	61.84	103.36	32.44	17.25	11.07	7.30
1998	379.26	243.36	129.91	134.97	184.11	146.39	78.77	44.08	43.81	73.43	23.11	12.32	7.92
1999	348.98	281.86	195.78	108.60	114.97	155.81	117.90	61.40	34.23	34.12	57.35	18.10	9.67
2000	345.87	259.36	226.74	163.62	92.35	96.42	120.87	86.94	44.98	25.13	25.12	42.33	13.39
2001	2935.78	257.04	208.62	189.40	138.70	76.14	70.15	81.11	57.62	29.84	16.72	16.76	28.29
2002	367.67	2181.81	206.77	174.36	161.09	116.04	55.76	47.42	54.43	38.75	20.13	11.31	11.35
2003	376.58	273.24	1755.15	172.82	148.31	135.05	87.54	39.41	33.30	38.31	27.35	14.24	8.02
2004	334.47	279.87	219.83	1467.54	147.37	125.67	101.46	61.38	27.56	23.35	26.95	19.29	10.07
2005	384.21	248.58	225.16	183.81	1251.93	125.61	102.27	80.24	48.49	21.84	18.56	21.48	15.40
2006	397.10	285.54	199.98	188.28	156.88	1067.88	99.81	77.99	61.15	37.07	16.75	14.27	16.55
2007	405.74	295.12	229.73	167.24	160.74	134.12	865.69	78.43	61.29	48.22	29.32	13.28	11.34
2008	412.20	301.55	237.44	192.16	142.97	138.55	113.99	729.92	66.31	52.01	41.05	25.03	11.36
2009	417.82	306.35	242.61	198.61	164.25	123.23	118.47	97.00	622.80	56.79	44.69	35.36	21.60
2010	421.07	310.52	246.47	202.93	169.76	141.31	101.87	95.79	78.60	506.59	46.34	36.56	28.98
2011	389.51	312.94	249.83	206.15	173.42	146.03	118.27	83.94	79.10	65.15	421.21	38.63	30.54

Table 5.4a. Continued - Estimated total abundance at age (1000 fish) at start of year. Age-1 estimated abundance is estimated recruitment. *(Extracted from Table 3.2 of the Assessment Report.)*

Year	14	15	16	17	18	19	20	21	22	23	24	25	Total
1962	61.51	54.98	49.19	44.05	39.48	35.40	31.76	28.50	25.58	22.97	20.63	182.47	2921.32
1963	62.11	55.51	49.67	44.48	39.86	35.75	32.07	28.78	25.83	23.20	20.83	184.25	2933.90
1964	62.72	56.06	50.16	44.92	40.26	36.10	32.38	29.06	26.09	23.43	21.04	186.06	2945.50
1965	63.34	56.62	50.66	45.37	40.66	36.46	32.70	29.35	26.35	23.66	21.25	187.92	2956.33
1966	63.87	57.09	51.08	45.74	40.99	36.76	32.98	29.59	26.57	23.86	21.43	189.48	2964.01
1967	64.49	57.64	51.58	46.19	41.39	37.12	33.30	29.88	26.82	24.09	21.63	191.32	2972.93
1968	65.08	58.18	52.06	46.62	41.78	37.46	33.61	30.16	27.07	24.31	21.83	193.09	2980.50
1969	65.64	58.73	52.55	47.06	42.18	37.82	33.93	30.45	27.33	24.54	22.04	194.94	2987.84
1970	66.04	59.24	53.05	47.52	42.59	38.19	34.26	30.74	27.60	24.78	22.26	196.83	2994.68
1971	66.14	59.58	53.50	47.95	42.98	38.54	34.57	31.03	27.85	25.01	22.46	198.66	3000.45
1972	66.10	59.63	53.77	48.33	43.35	38.87	34.87	31.30	28.10	25.23	22.66	200.38	3004.89
1973	66.09	59.62	53.85	48.60	43.71	39.23	35.19	31.59	28.35	25.46	22.87	202.23	3009.72
1974	65.96	59.50	53.73	48.57	43.86	39.47	35.44	31.81	28.56	25.64	23.03	203.69	3011.36
1975	65.58	59.17	53.42	48.29	43.68	39.47	35.54	31.92	28.66	25.74	23.11	204.41	3007.92
1976	64.89	58.55	52.88	47.79	43.23	39.12	35.37	31.86	28.62	25.70	23.09	204.17	2808.56
1977	64.26	57.95	52.34	47.31	42.78	38.72	35.06	31.71	28.57	25.68	23.06	203.97	2667.81
1978	63.91	57.64	52.04	47.04	42.55	38.50	34.86	31.58	28.57	25.75	23.14	204.70	2579.67
1979	63.14	56.93	51.40	46.44	42.01	38.02	34.42	31.18	28.25	25.56	23.04	204.00	2514.60
1980	62.46	56.30	50.82	45.92	41.52	37.58	34.03	30.81	27.92	25.31	22.90	203.47	2469.58
1981	61.10	55.03	49.66	44.86	40.56	36.69	33.23	30.10	27.27	24.71	22.40	200.48	2452.95
1982	56.11	50.43	45.47	41.07	37.12	33.59	30.40	27.54	24.95	22.61	20.50	184.92	2340.38
1983	40.26	36.07	32.46	29.29	26.47	23.94	21.67	19.62	17.78	16.12	14.61	132.73	2022.23
1984	31.40	28.06	25.17	22.66	20.47	18.51	16.75	15.17	13.74	12.45	11.29	103.22	1867.80
1985	25.48	22.78	20.38	18.30	16.49	14.90	13.48	12.20	11.05	10.01	9.08	83.51	1783.59
1986	18.60	16.61	14.87	13.32	11.96	10.78	9.75	8.82	7.99	7.24	6.56	60.68	1691.72
1987	14.21	12.64	11.31	10.13	9.08	8.16	7.36	6.66	6.03	5.46	4.95	45.95	1653.10
1988	13.53	11.92	10.62	9.50	8.52	7.64	6.87	6.20	5.61	5.08	4.60	42.92	1765.37
1989	7.19	10.61	9.36	8.34	7.47	6.70	6.01	5.41	4.88	4.42	4.00	37.47	2220.41
1990	6.97	5.16	7.62	6.73	6.00	5.38	4.83	4.33	3.90	3.52	3.19	29.91	2024.27
1991	7.54	4.88	3.62	5.35	4.73	4.22	3.78	3.40	3.05	2.75	2.48	23.31	1800.67
1992	7.70	5.05	3.27	2.43	3.59	3.18	2.84	2.54	2.29	2.05	1.85	17.36	1690.97
1993	7.17	4.76	3.12	2.03	1.51	2.23	1.97	1.76	1.58	1.42	1.27	11.94	1696.64
1994	7.11	4.25	2.83	1.86	1.21	0.90	1.33	1.17	1.05	0.94	0.85	7.88	1701.69
1995	5.89	4.51	2.70	1.80	1.18	0.77	0.57	0.85	0.75	0.67	0.60	5.56	1549.22
1996	5.24	4.07	3.12	1.87	1.24	0.82	0.53	0.40	0.59	0.52	0.46	4.28	1413.32
1997	5.28	4.08	3.17	2.43	1.46	0.97	0.64	0.42	0.31	0.46	0.41	3.71	1462.68
1998	5.23	3.79	2.93	2.28	1.75	1.05	0.70	0.46	0.30	0.22	0.33	2.97	1523.47
1999	6.22	4.12	2.98	2.31	1.80	1.38	0.83	0.55	0.36	0.24	0.18	2.61	1562.34
2000	7.16	4.62	3.06	2.22	1.72	1.34	1.03	0.62	0.41	0.27	0.18	2.08	1567.80
2001	8.96	4.80	3.10	2.05	1.49	1.16	0.90	0.69	0.42	0.28	0.18	1.52	4131.71
2002	19.20	6.09	3.27	2.11	1.40	1.02	0.79	0.61	0.47	0.28	0.19	1.16	3483.49
2003	8.06	13.65	4.33	2.33	1.50	1.00	0.73	0.56	0.44	0.34	0.20	0.97	3143.44
2004	5.67	5.71	9.69	3.08	1.65	1.07	0.71	0.52	0.40	0.31	0.24	0.83	2874.71
2005	8.05	4.54	4.58	7.77	2.47	1.33	0.86	0.57	0.42	0.32	0.25	0.86	2759.63
2006	11.89	6.22	3.52	3.55	6.02	1.92	1.03	0.67	0.44	0.32	0.25	0.87	2655.96
2007	13.17	9.47	4.96	2.81	2.83	4.81	1.53	0.82	0.53	0.35	0.26	0.89	2542.73
2008	9.72	11.30	8.13	4.26	2.41	2.44	4.14	1.32	0.71	0.46	0.31	0.99	2510.72
2009	9.82	8.41	9.79	7.05	3.70	2.10	2.12	3.60	1.15	0.62	0.40	1.13	2499.44
2010	17.74	8.07	6.92	8.06	5.81	3.05	1.73	1.75	2.97	0.95	0.51	1.26	2445.63
2011	24.25	14.86	6.77	5.81	6.77	4.89	2.57	1.45	1.47	2.50	0.80	1.49	2388.36

Table 5.4b. Estimated biomass at age (1000 lb) at start of year. Age-1 estimated biomass is estimated recruitment biomass. *(Extracted from Table 3.3 of the Assessment Report.)*

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1962	157.4	324.5	500.0	657.4	783.1	871.7	922.2	940.1	933.2	908.3	870.6	824.3	772.9
1963	157.4	324.5	500.0	657.4	783.3	873.5	927.7	948.4	942.3	917.3	879.0	832.2	780.4
1964	157.4	324.5	500.0	657.4	783.3	873.7	929.7	954.4	950.9	926.2	887.6	840.4	788.2
1965	157.6	324.7	500.0	657.4	783.3	873.9	930.1	956.4	956.8	934.5	896.4	848.8	795.9
1966	157.6	324.7	500.2	657.4	783.3	873.7	929.2	955.5	957.2	938.9	903.0	855.8	802.5
1967	157.6	325.0	500.4	657.9	783.3	873.7	929.9	955.7	957.7	940.7	908.5	863.3	810.2
1968	157.6	325.0	500.7	658.1	784.0	873.7	929.7	955.9	957.5	940.7	909.8	868.2	817.0
1969	157.9	325.2	500.9	658.3	784.2	874.4	929.9	956.1	958.1	940.9	910.1	869.7	821.9
1970	157.9	325.2	501.1	658.5	784.6	874.8	930.6	956.4	958.3	941.4	910.5	869.9	823.4
1971	157.9	325.4	501.1	658.7	784.8	875.0	930.8	956.8	958.1	941.4	910.5	869.9	823.4
1972	157.9	325.4	501.3	659.0	785.1	875.2	930.8	956.4	957.9	940.7	910.1	869.7	822.8
1973	157.9	325.6	501.6	659.2	785.3	875.7	931.2	956.8	958.1	940.9	909.8	869.5	823.0
1974	158.1	325.6	501.6	659.4	785.5	875.5	930.6	955.5	956.6	939.2	908.3	867.5	821.2
1975	158.1	325.6	501.8	659.6	785.5	875.2	928.4	951.5	952.0	934.3	903.2	862.9	816.4
1976	90.6	325.6	501.8	659.6	785.7	874.6	925.1	945.3	943.6	925.5	894.4	854.3	808.2
1977	93.5	186.7	501.8	659.8	785.7	874.6	924.6	942.3	937.6	917.6	886.0	846.1	800.3
1978	100.8	192.9	287.7	659.8	786.2	875.7	927.3	945.6	938.7	915.8	882.5	841.9	796.1
1979	107.8	207.7	297.2	378.1	785.9	875.5	924.2	942.0	935.4	910.5	874.6	832.7	786.8
1980	112.4	222.4	320.1	390.9	450.4	875.2	924.6	939.8	932.8	908.3	870.4	826.1	778.9
1981	127.0	231.9	342.6	420.9	465.4	500.9	917.3	929.5	919.8	894.9	858.0	812.4	763.5
1982	121.9	261.9	357.4	450.4	500.0	511.9	503.8	867.7	853.0	826.7	792.1	750.2	703.5
1983	123.0	251.5	403.4	468.9	530.7	524.7	440.0	378.5	622.1	597.5	569.9	539.5	506.0
1984	120.8	253.5	387.4	529.6	553.8	564.4	474.7	356.3	293.9	472.5	446.4	420.9	394.4
1985	120.4	249.1	390.4	508.8	626.3	593.7	523.6	399.0	287.9	232.4	367.5	343.3	320.3
1986	125.9	248.2	383.8	512.8	601.2	666.5	513.9	396.6	289.9	204.6	162.5	254.0	234.8
1987	128.3	259.3	382.3	503.8	604.7	635.8	593.7	407.0	300.5	214.7	149.0	117.1	181.0
1988	149.0	264.3	399.5	502.4	598.6	665.1	646.4	571.0	379.6	274.7	193.1	132.5	103.0
1989	289.7	307.1	407.2	524.9	595.9	650.8	648.2	583.8	498.2	324.3	231.0	160.5	109.1
1990	111.6	597.0	473.1	534.8	620.4	636.3	599.9	539.7	466.7	389.6	249.6	175.5	120.8
1991	78.7	229.7	919.8	621.3	631.4	659.2	577.8	488.8	421.5	356.5	292.8	185.2	129.0
1992	103.0	162.5	353.8	1207.3	732.2	664.7	581.8	451.5	364.9	307.5	256.0	207.7	130.1
1993	145.1	212.3	250.2	464.3	1419.6	761.0	557.8	422.2	311.7	246.0	203.9	167.6	134.7
1994	153.7	298.9	327.2	328.3	545.6	1468.1	621.7	388.9	279.5	201.5	156.5	128.1	104.3
1995	95.9	316.8	460.5	429.5	386.7	572.5	1250.9	461.0	275.1	193.1	137.1	105.2	85.3
1996	77.2	197.8	487.9	604.7	506.8	410.1	514.8	1004.6	354.5	207.0	143.1	100.1	76.1
1997	116.2	159.2	304.7	641.1	716.9	550.3	397.7	462.1	870.6	300.7	172.8	117.9	81.8
1998	134.7	239.6	245.2	400.1	759.9	775.6	506.0	329.4	369.1	680.8	231.5	131.4	88.8
1999	123.9	277.6	369.3	322.1	474.4	825.4	757.3	458.8	288.4	316.4	574.3	192.9	108.5
2000	122.8	255.5	427.7	485.0	381.2	510.8	776.5	649.7	378.8	233.0	251.5	451.3	150.1
2001	1042.6	253.1	393.5	561.5	572.5	403.4	450.6	606.1	485.5	276.7	167.6	178.6	317.2
2002	130.5	2149.1	390.0	517.0	664.9	614.9	358.3	354.3	458.6	359.4	201.5	120.6	127.4
2003	133.8	269.2	3311.1	512.4	612.0	715.4	562.4	294.5	280.4	355.2	274.0	151.9	89.9
2004	118.8	275.6	414.7	4351.0	608.3	665.8	651.9	458.6	232.1	216.5	269.8	205.7	112.9
2005	136.5	244.9	424.8	545.0	5166.8	665.4	657.0	599.7	408.5	202.4	185.8	229.1	172.8
2006	141.1	281.3	377.2	558.2	647.5	5657.5	641.1	582.7	515.0	343.7	167.8	152.1	185.6
2007	144.2	290.8	433.4	495.8	663.4	710.5	5561.4	586.0	516.3	447.1	293.7	141.5	127.2
2008	146.4	297.0	448.0	569.7	590.0	733.9	732.4	5454.0	558.7	482.2	411.2	266.8	127.4
2009	148.4	301.8	457.7	588.9	677.9	652.8	761.0	724.9	5246.1	526.5	447.5	377.0	242.3
2010	149.5	305.8	465.0	601.6	700.6	748.7	654.3	715.8	662.0	4696.7	464.1	389.8	325.2
2011	138.2	308.2	471.3	611.1	715.8	773.6	759.9	627.2	666.2	604.1	4218.5	411.8	342.6

Table 5.4b. Continued - Estimated biomass at age (1000 lb) at start of year. Age-1 estimated biomass is estimated recruitment biomass. *(Extracted from Table 3.3 of the Assessment Report.)*

Year	14	15	16	17	18	19	20	21	22	23	24	25	Total
1962	719.1	664.9	611.8	560.4	511.9	466.1	423.5	384.0	347.7	314.6	284.2	2525.4	17279.0
1963	726.2	671.5	617.7	565.9	516.8	470.7	427.7	387.8	351.2	317.7	287.0	2550.1	17413.7
1964	733.3	678.1	623.9	571.4	521.8	475.3	431.9	391.5	354.7	320.8	289.7	2575.0	17541.1
1965	740.5	684.8	630.1	577.2	527.1	479.9	436.1	395.5	358.3	323.9	292.6	2600.8	17662.8
1966	746.7	690.5	635.4	582.0	531.5	483.9	439.8	398.8	361.1	326.5	295.0	2622.4	17752.9
1967	754.0	697.3	641.5	587.8	536.6	488.8	444.0	402.8	364.6	329.8	297.8	2647.8	17856.8
1968	760.8	703.7	647.5	593.0	541.7	493.2	448.2	406.5	368.0	332.9	300.7	2672.4	17946.7
1969	767.4	710.3	653.7	598.8	546.7	498.0	452.4	410.3	371.5	336.0	303.6	2698.0	18034.5
1970	772.1	716.5	659.8	604.5	552.0	502.9	456.8	414.2	375.2	339.3	306.4	2724.0	18116.7
1971	773.4	720.7	665.4	610.2	557.3	507.5	461.0	418.2	378.5	342.4	309.3	2749.4	18187.3
1972	772.7	721.4	668.7	614.9	562.0	511.9	465.0	421.7	381.8	345.5	312.2	2773.4	18243.3
1973	772.7	721.1	669.8	618.4	566.6	516.5	469.4	425.7	385.4	348.6	315.0	2799.0	18302.3
1974	771.2	719.6	668.2	618.0	568.6	519.9	472.7	428.8	388.2	351.2	317.2	2819.1	18327.0
1975	766.8	715.6	664.5	614.4	566.4	519.6	474.0	430.1	389.6	352.3	318.3	2829.0	18295.3
1976	758.8	708.1	657.6	608.0	560.4	515.0	471.6	429.2	389.1	351.9	317.9	2825.7	18128.0
1977	751.3	700.8	651.0	602.1	554.7	509.9	467.6	427.3	388.5	351.6	317.7	2823.0	17901.5
1978	747.4	697.3	647.1	598.6	551.6	506.8	465.0	425.5	388.2	352.5	318.8	2833.2	17682.6
1979	738.3	688.7	639.3	590.8	544.8	500.7	459.0	420.2	384.0	350.1	317.5	2823.5	17315.3
1980	730.2	681.0	632.1	584.2	538.1	494.7	453.7	415.4	379.6	346.6	315.5	2816.2	16939.0
1981	714.3	665.6	617.5	570.8	525.8	483.3	443.1	405.7	370.6	338.4	308.6	2774.7	16402.4
1982	656.1	610.0	565.5	522.5	481.3	442.2	405.4	371.0	339.3	309.5	282.4	2559.3	15045.0
1983	470.7	436.3	403.7	372.6	343.3	315.3	289.0	264.3	241.6	220.7	201.1	1837.1	11351.4
1984	367.1	339.5	313.1	288.4	265.4	243.6	223.3	204.4	186.7	170.4	155.4	1428.6	9454.5
1985	297.8	275.6	253.5	232.8	213.8	196.2	179.7	164.5	150.1	137.1	125.0	1155.9	8344.9
1986	217.4	200.8	185.0	169.5	155.0	142.0	130.1	118.8	108.7	99.2	90.4	839.7	7050.6
1987	166.2	153.0	140.7	129.0	117.7	107.4	98.1	89.7	82.0	74.7	68.1	636.0	6339.6
1988	158.1	144.2	132.1	121.0	110.5	100.5	91.7	83.6	76.3	69.4	63.3	594.1	6624.2
1989	84.0	128.3	116.4	106.3	97.0	88.2	80.2	73.0	66.4	60.4	55.1	518.5	6804.6
1990	81.6	62.4	94.8	85.5	77.8	70.8	64.4	58.4	52.9	48.3	43.9	414.0	6669.4
1991	88.2	59.1	45.0	68.1	61.3	55.6	50.5	45.9	41.4	37.5	34.2	322.8	6500.8
1992	89.9	61.1	40.8	30.9	46.5	41.9	37.9	34.4	31.1	28.0	25.4	240.3	6231.1
1993	83.8	57.5	38.8	25.8	19.6	29.3	26.2	23.8	21.4	19.4	17.6	165.1	5824.8
1994	83.1	51.4	35.1	23.6	15.7	11.9	17.6	15.9	14.3	12.8	11.7	109.1	5404.6
1995	68.8	54.7	33.5	22.9	15.2	10.1	7.7	11.5	10.1	9.3	8.4	76.9	5098.4
1996	61.3	49.2	38.8	23.8	16.1	10.8	7.1	5.3	7.9	7.1	6.4	59.1	4977.4
1997	61.7	49.4	39.5	30.9	19.0	12.8	8.6	5.5	4.2	6.2	5.5	51.4	5186.8
1998	61.1	45.9	36.4	29.1	22.7	13.9	9.3	6.2	4.0	3.1	4.6	41.0	5169.4
1999	72.8	49.8	37.0	29.3	23.4	18.3	11.0	7.5	4.9	3.3	2.4	36.2	5385.2
2000	83.8	55.8	37.9	28.2	22.3	17.6	13.7	8.4	5.5	3.7	2.4	28.7	5382.4
2001	104.7	58.0	38.6	26.0	19.4	15.2	11.9	9.3	5.7	3.7	2.4	20.9	6025.2
2002	224.4	73.6	40.6	26.9	18.1	13.4	10.6	8.4	6.4	4.0	2.6	16.1	6891.2
2003	94.4	165.1	54.0	29.5	19.4	13.2	9.7	7.5	6.0	4.6	2.9	13.4	7981.8
2004	66.4	69.2	120.4	39.2	21.4	14.1	9.5	7.1	5.5	4.2	3.3	11.5	8953.6
2005	94.1	54.9	56.9	99.0	32.0	17.4	11.5	7.7	5.7	4.4	3.5	11.9	10037.9
2006	138.9	75.2	43.7	45.2	78.0	25.1	13.7	9.0	6.0	4.4	3.5	11.9	10706.1
2007	153.9	114.6	61.7	35.7	36.8	63.5	20.5	11.0	7.3	4.9	3.5	12.3	10936.9
2008	113.5	136.7	101.2	54.2	31.3	32.2	55.3	17.9	9.7	6.4	4.2	13.7	11393.7
2009	114.9	101.6	121.7	89.7	48.1	27.6	28.2	48.5	15.7	8.4	5.5	15.7	11778.4
2010	207.5	97.7	86.0	102.5	75.4	40.1	23.1	23.6	40.3	13.0	7.1	17.4	11613.1
2011	283.5	179.7	84.2	73.9	87.7	64.4	34.2	19.6	20.1	34.2	11.0	20.7	11562.1

Figures

List of figures

Figure 5.1a. Observed (open circles) and estimated (line, solid circles) commercial longline landings (1000 lb whole weight). *(Extracted from Figure 3.3 of the Assessment Report.)*

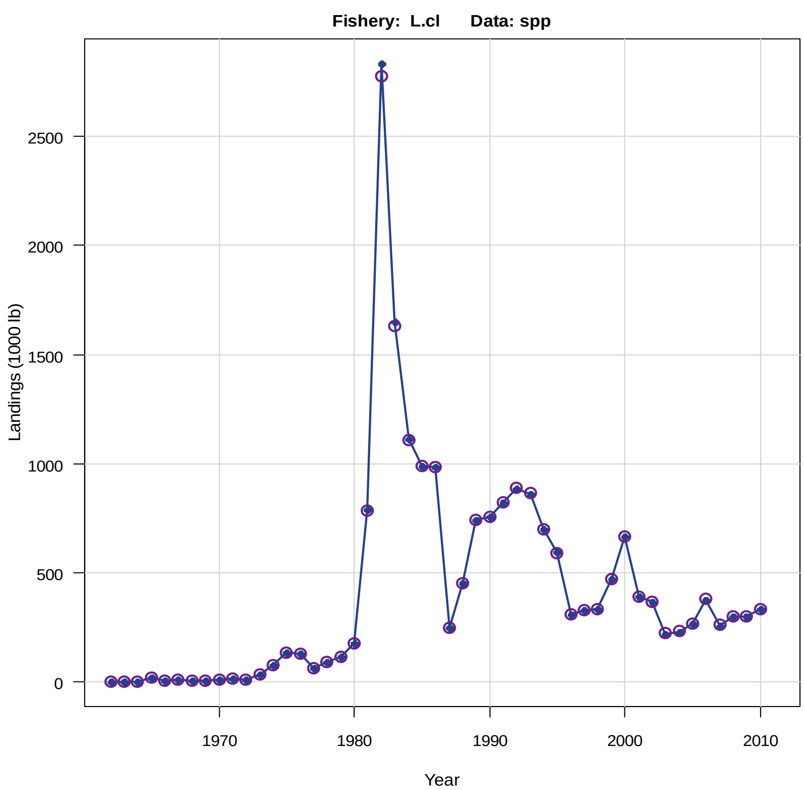


Figure 5.1b. Observed (open circles) and estimated (line, solid circles) commercial handline landings (1000 lb whole weight). *(Extracted from Figure 3.4 of the Assessment Report.)*

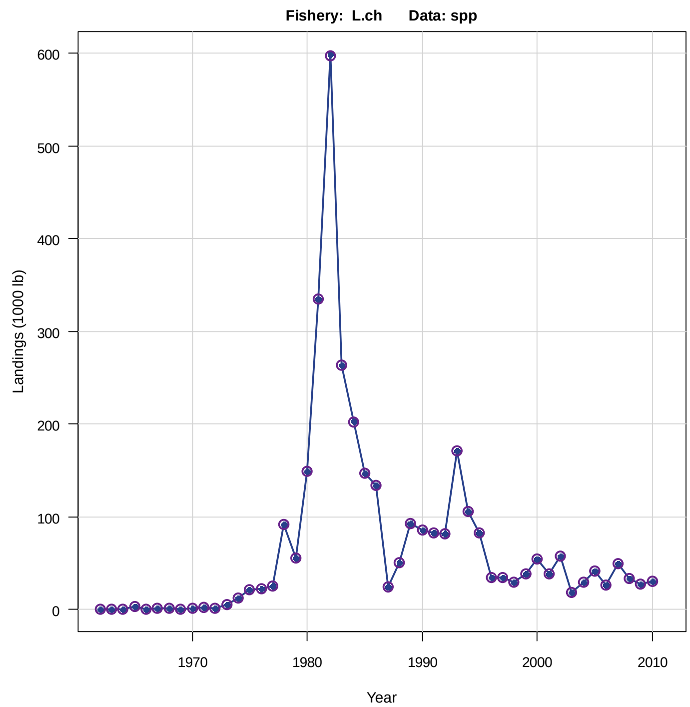


Figure 5.1c. Observed (open circles) and estimated (line, solid circles) recreational landings (1000 fish). *(Extracted from Figure 3.5 of the Assessment Report.)*

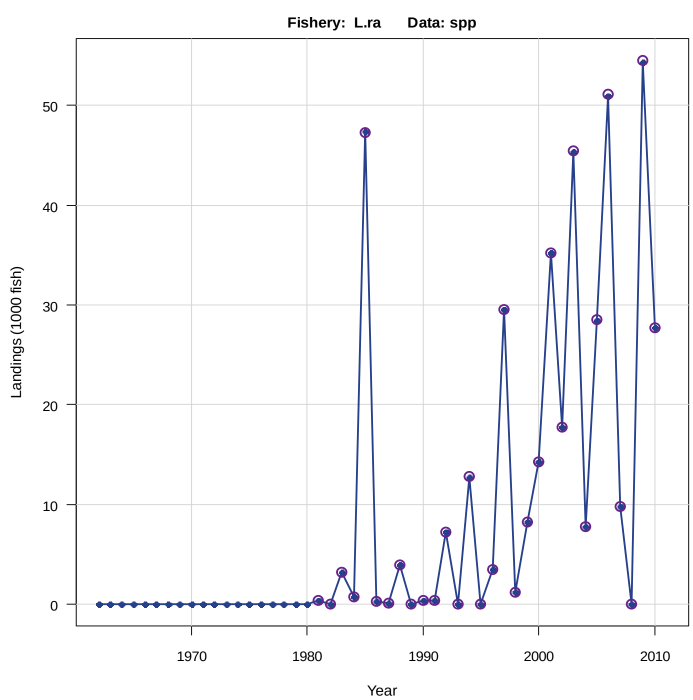


Figure 5.2. Estimated fully selected fishing mortality rate (per year) by fishery. *cl* refers to commercial longline, *ch* to commercial handline, and *ra* for recreational. ***(Extracted from Figure 3.14 of the Assessment Report.)***

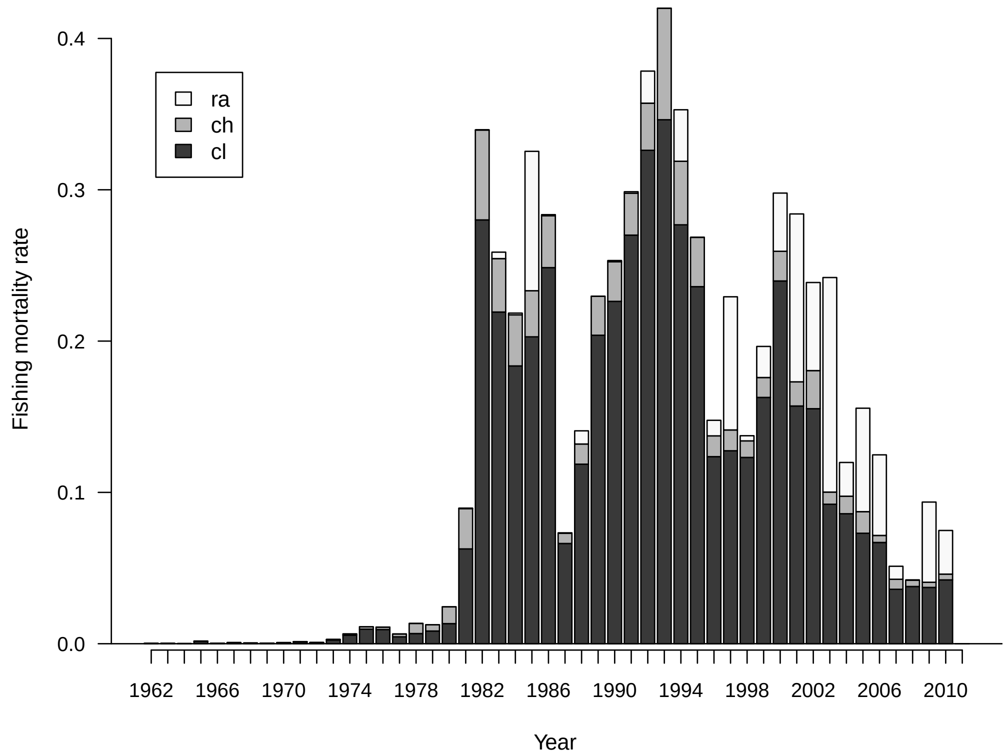
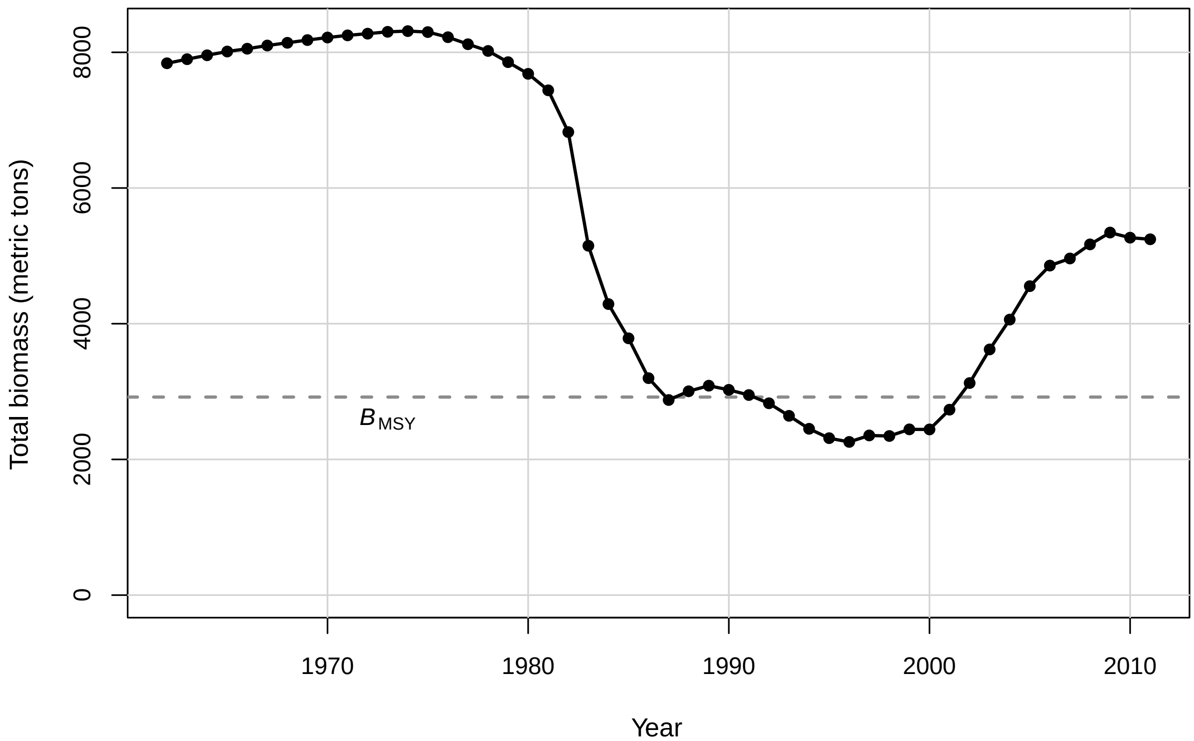


Figure 5.3. Top panel. Estimated total biomass (metric tons) at start of year. Horizontal dashed line indicates B_{MSY}. Bottom panel. Estimated spawning stock (gonad biomass of mature females) at time of peak spawning. (*Extracted from Figure 3.11 of the Assessment Report.*)



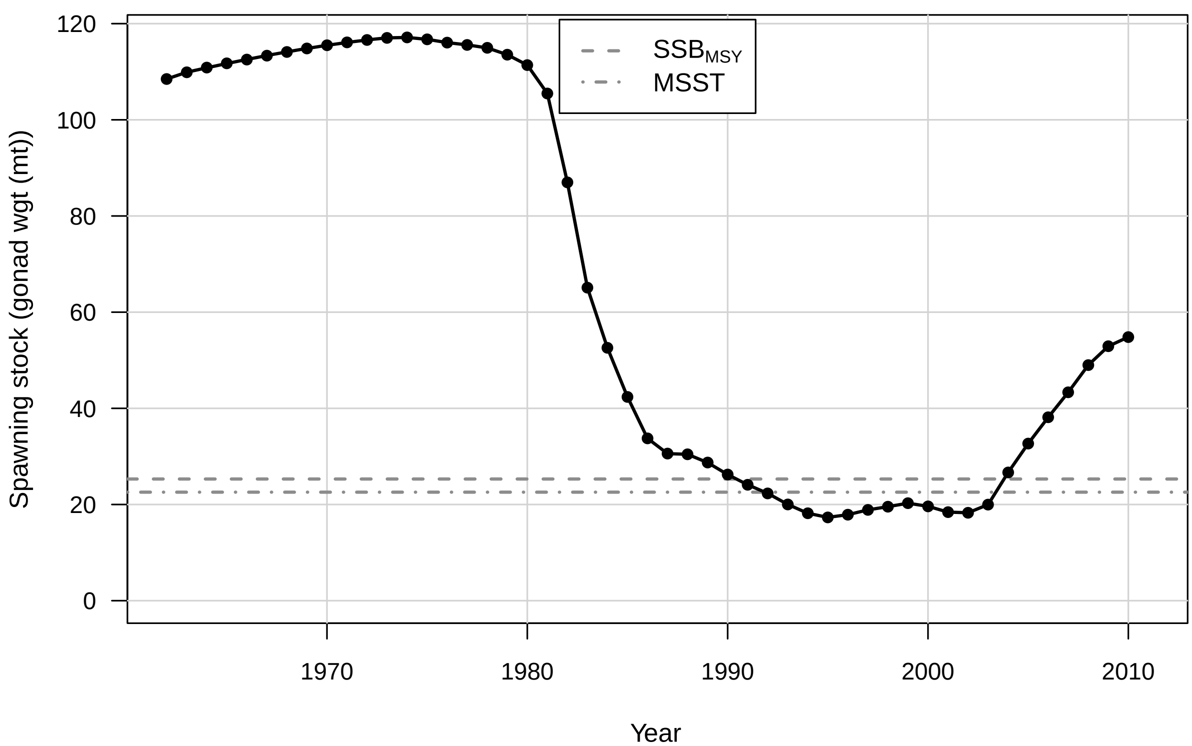


Figure 5.4. Abundance Indices

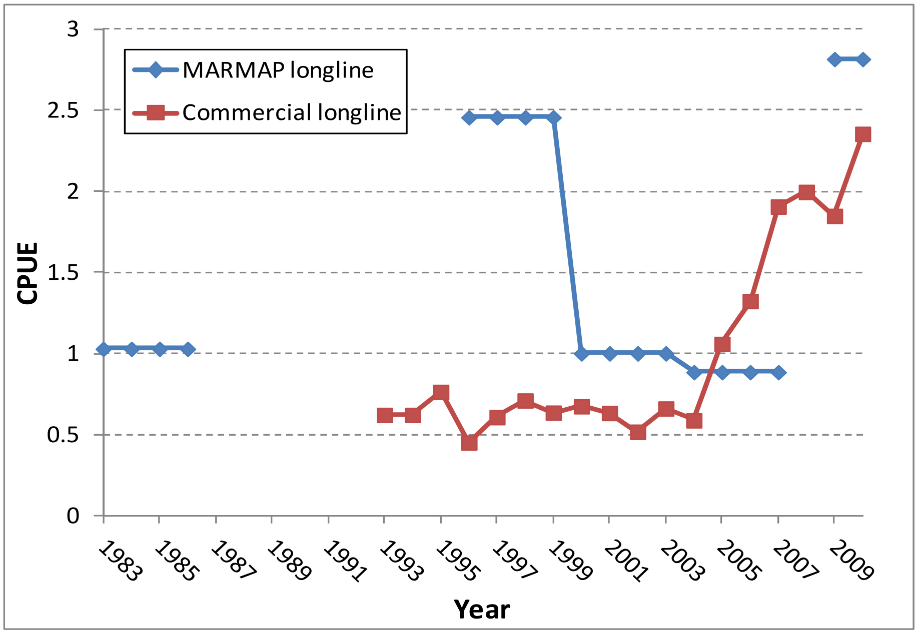


Figure 5.5. Beverton-Holt spawner-recruit curves, with and without lognormal bias correction. The expected (upper) curve was used for computing management benchmarks. Years within panel indicate year of recruitment generated from spawning biomass one year prior. (*Extracted from Figure 3.17 of the Assessment Report.*)

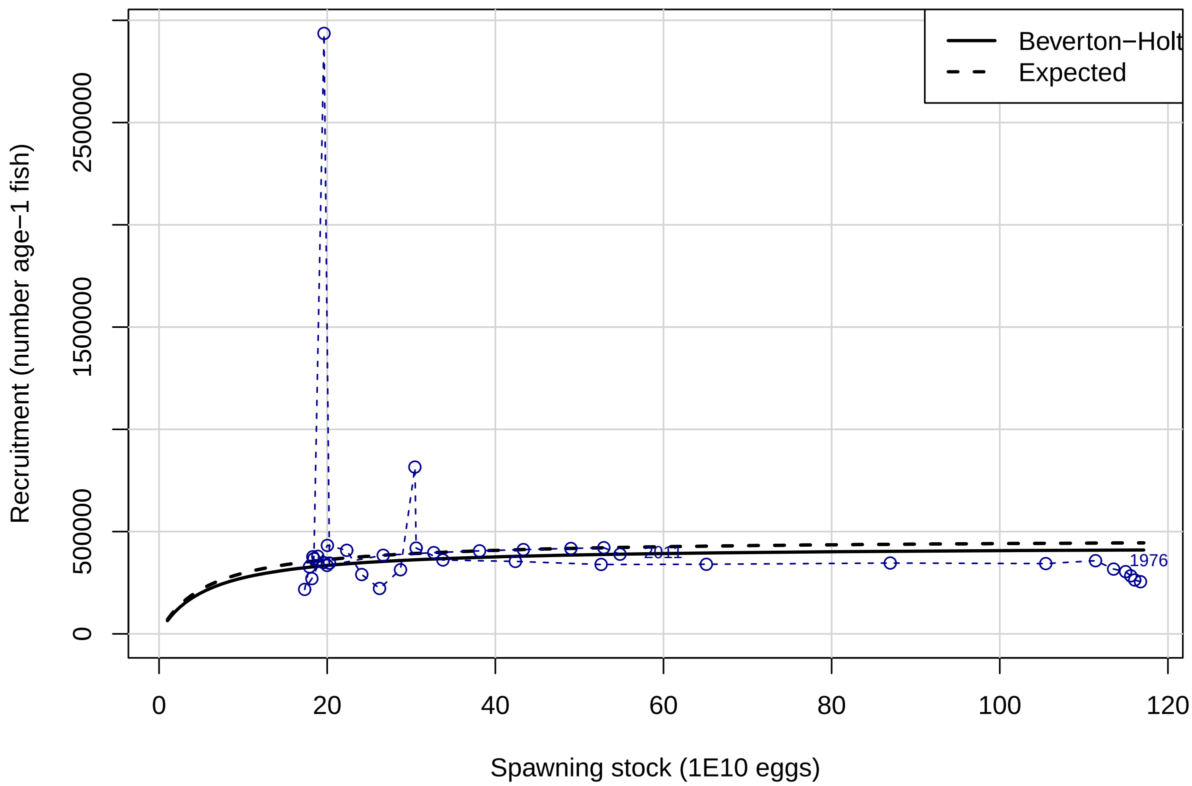


Figure 5.6. Top panel: yield per recruit. Bottom panel: spawning potential ratio (spawning biomass per recruit relative to that at the unfished level), from which the *y%* levels provide $F_{y\%}$. Both curves are based on average selectivity from the end of the assessment period. (*Extracted from Figure 3.20 of the Assessment Report.*)

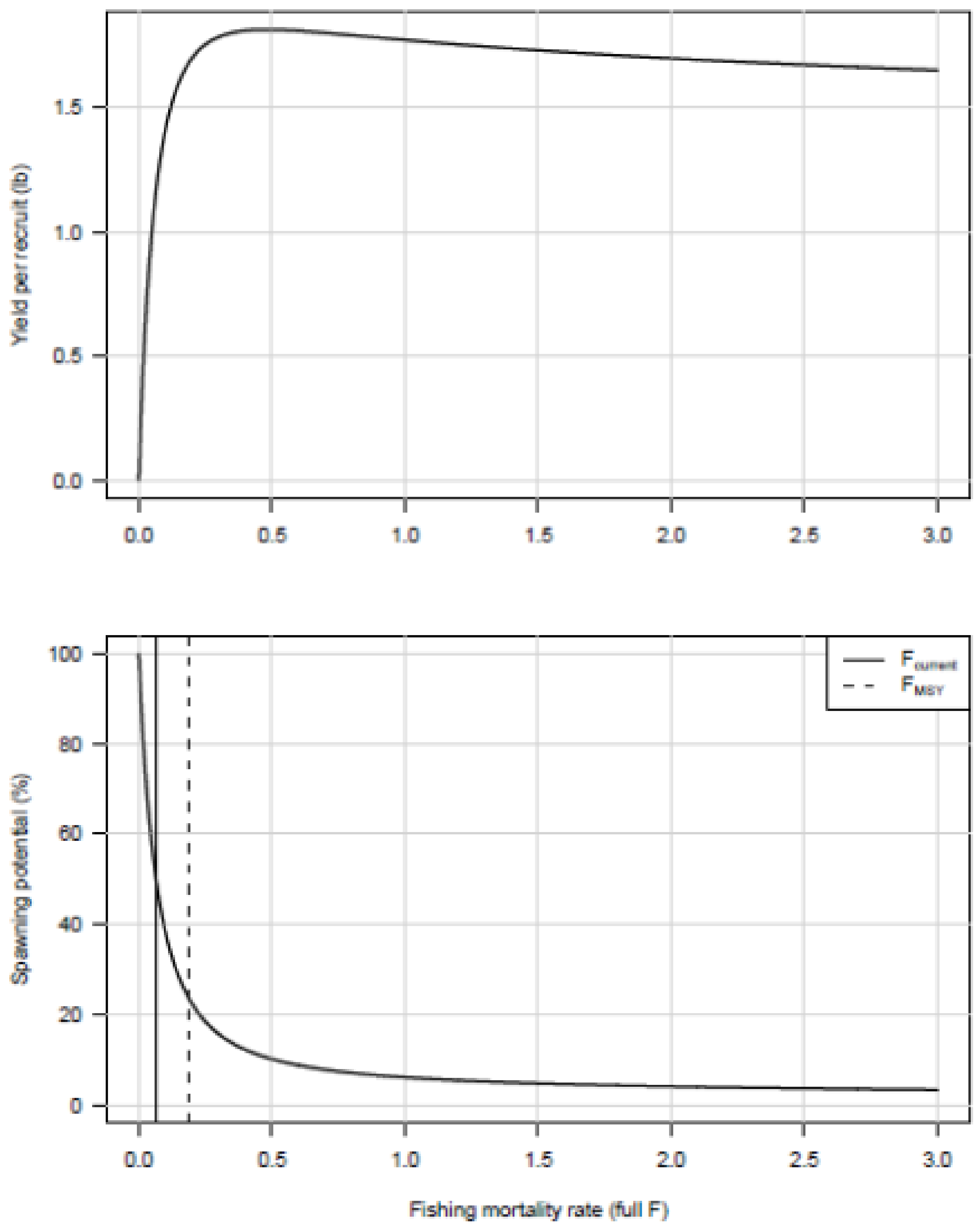
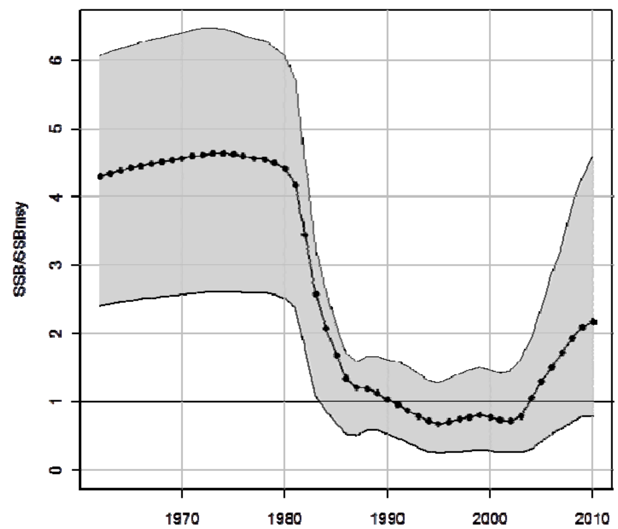


Figure 5.7. Estimated time series relative to benchmarks. Solid line indicates estimates from base run of the Beaufort Assessment Model; gray error bands indicate 5th and 95th percentiles of the MCB trials. Top panel. spawning biomass relative to the minimum stock size threshold (MSST). Bottom panel. *F* relative to F_{MSY}. (*Extracted from Figure 3.24 of the Assessment Report.*)



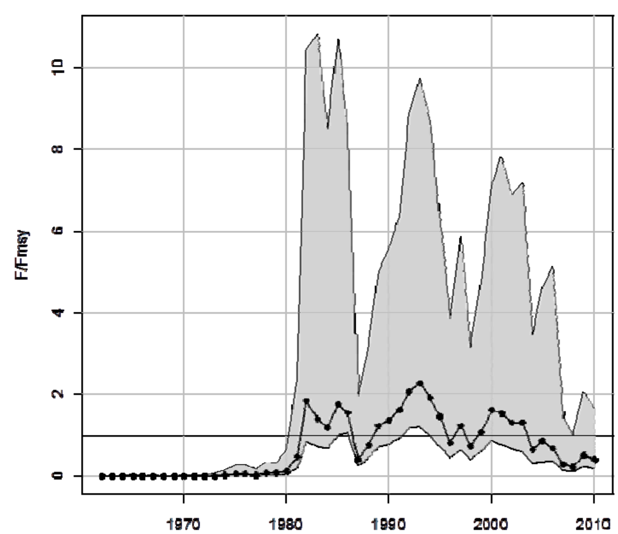


Figure 5.8a. Projection results under scenario 1 - fishing mortality rate fixed at $F = F_{MSY}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY-related quantities. Spawning stock (SSB) is at time of peak spawning. (*Extracted from Figure 3.36 of the Assessment Report.*)

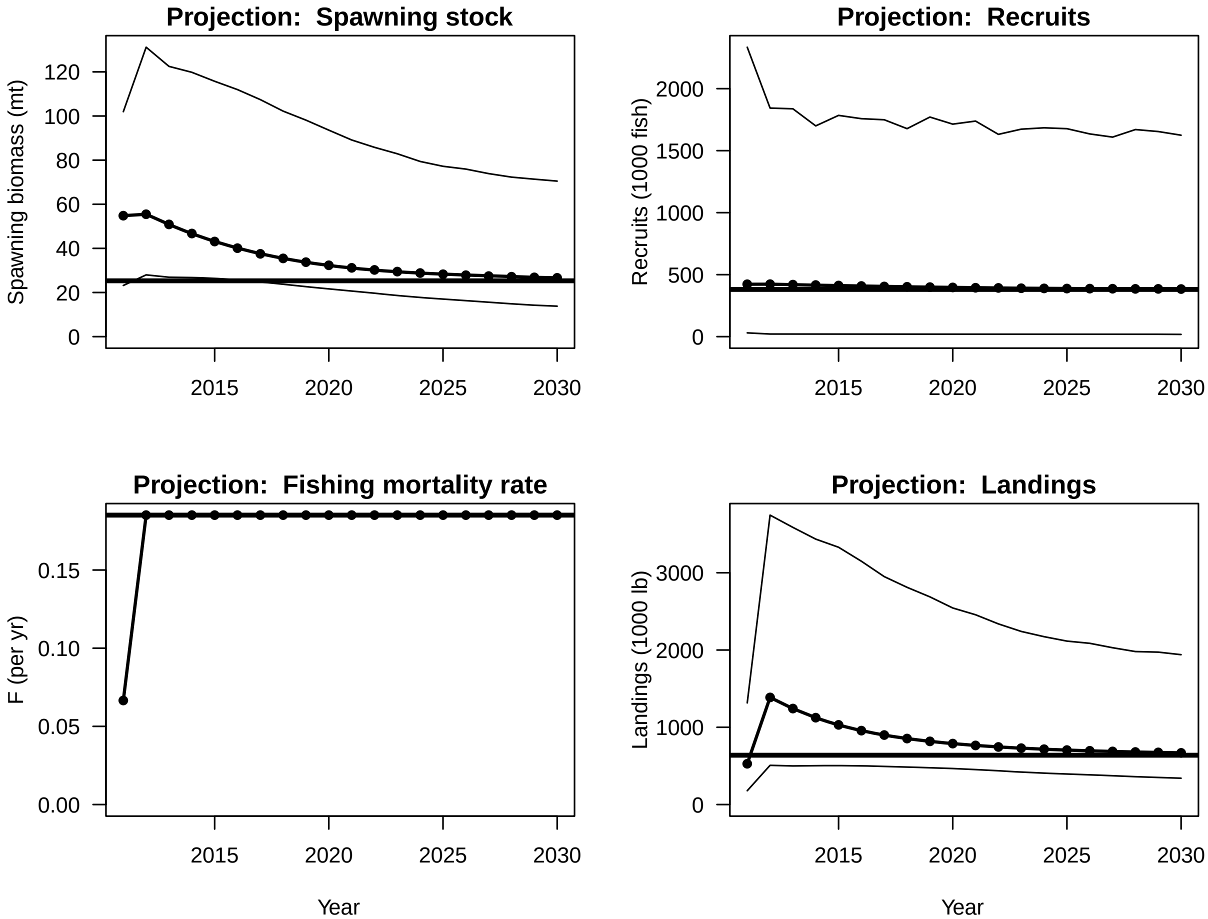


Figure 5.8b. Projection results under scenario 2 – fishing mortality rate fixed at $F = F_{\mathrm{current}}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY-related quantities. Spawning stock (SSB) is at time of peak spawning. (*Extracted from Figure 3.37 of the Assessment Report.*)

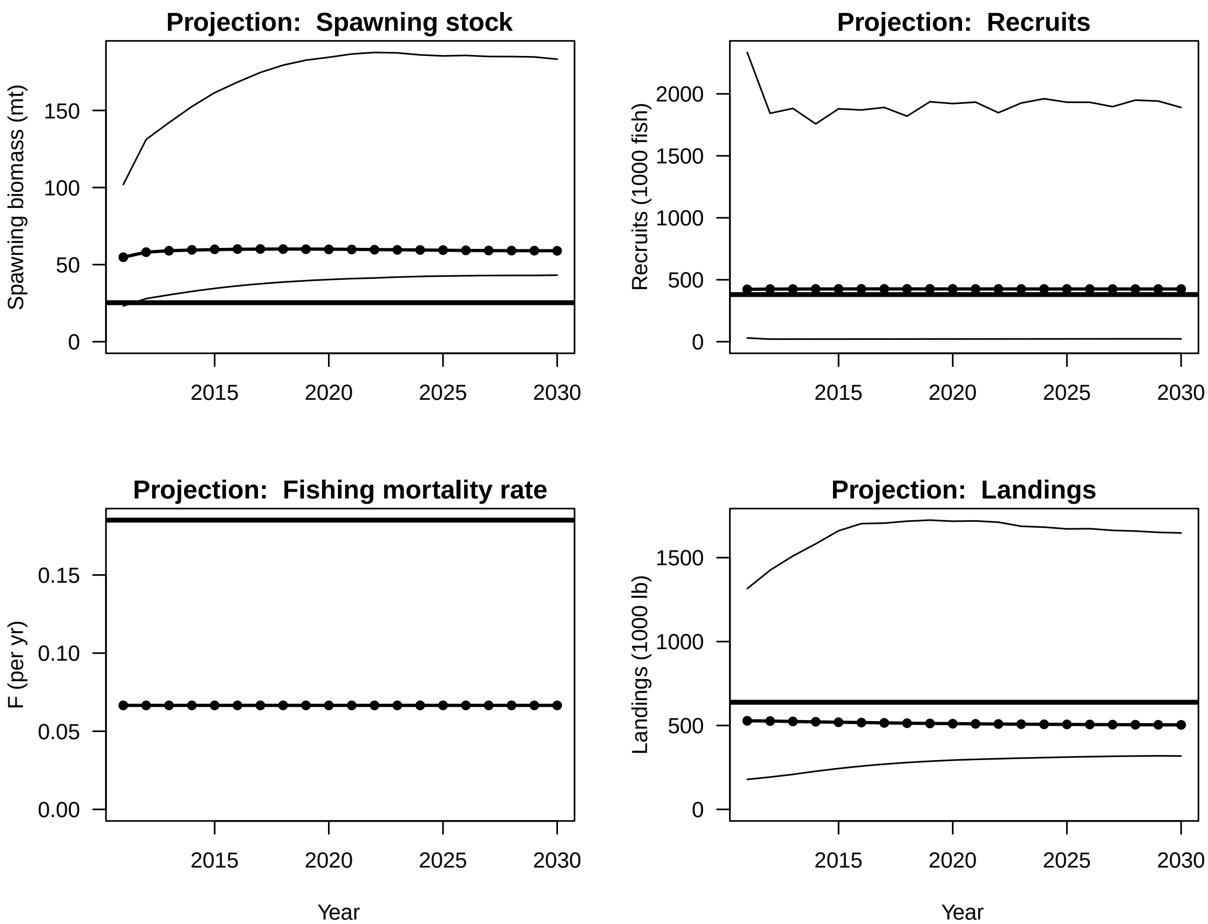


Figure 5.8c. Projection results under scenario 3 – fishing mortality rate fixed at $F = 65\%F_{MSY}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections. Horizontal lines mark MSY-related quantities. Spawning stock (SSB) is at time of peak spawning. (*Extracted from Figure 3.38 of the Assessment Report.*)

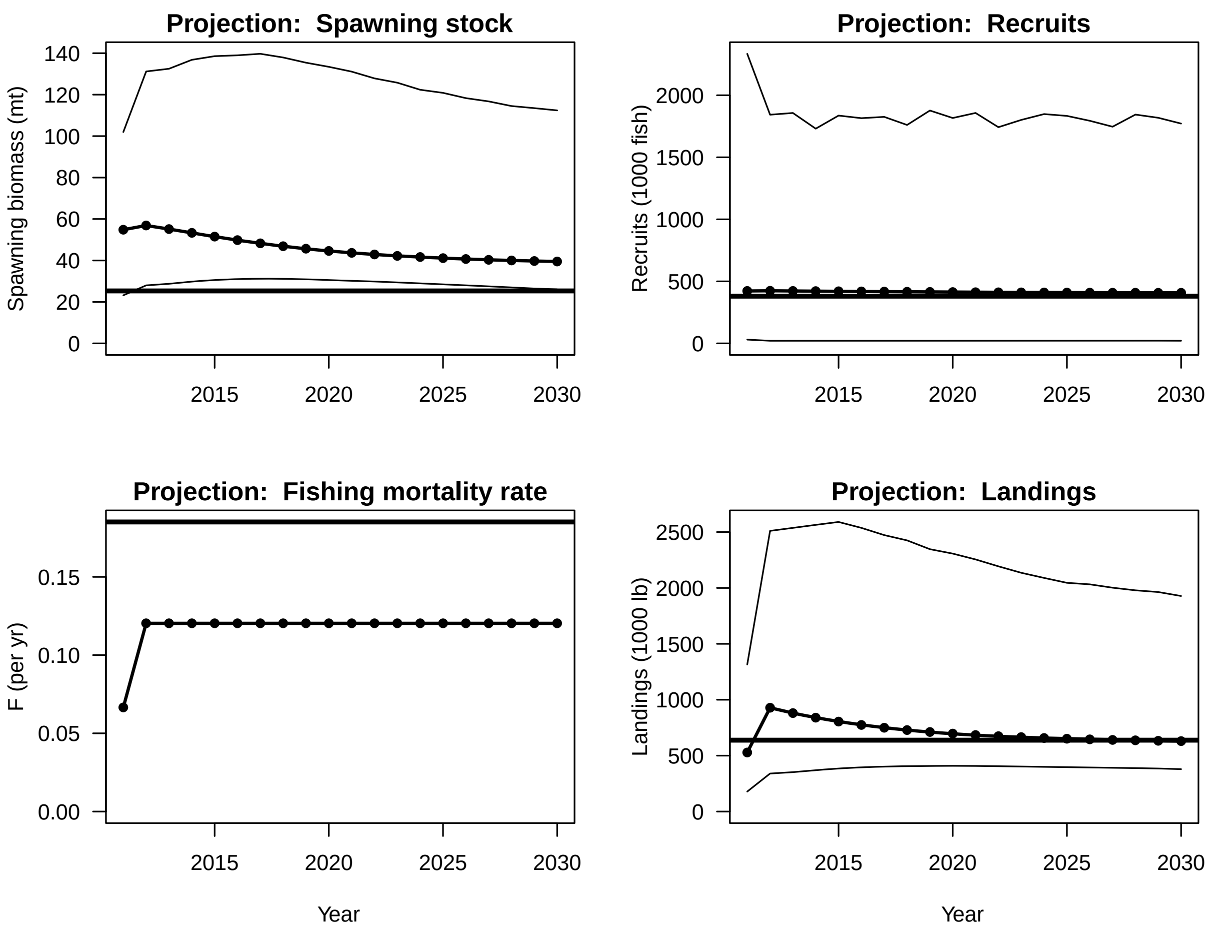


Figure 5.8d. Projection results under scenario 4 – fishing mortality rate fixed at F = 75%F_{MSY}. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections. Horizontal lines mark MSY-related quantities. Spawning stock (SSB) is at time of peak spawning. (*Extracted from Figure 3.39 of the Assessment Report.*)

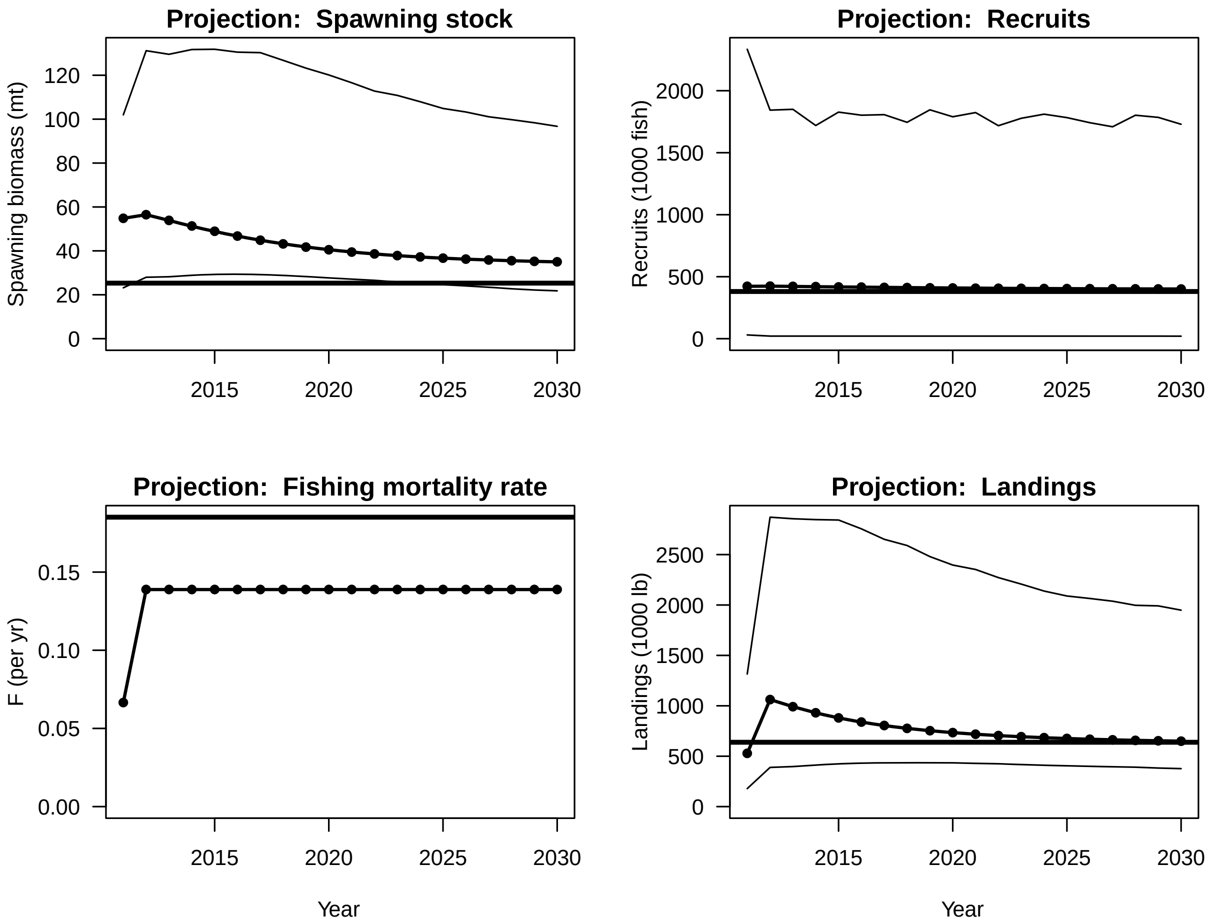
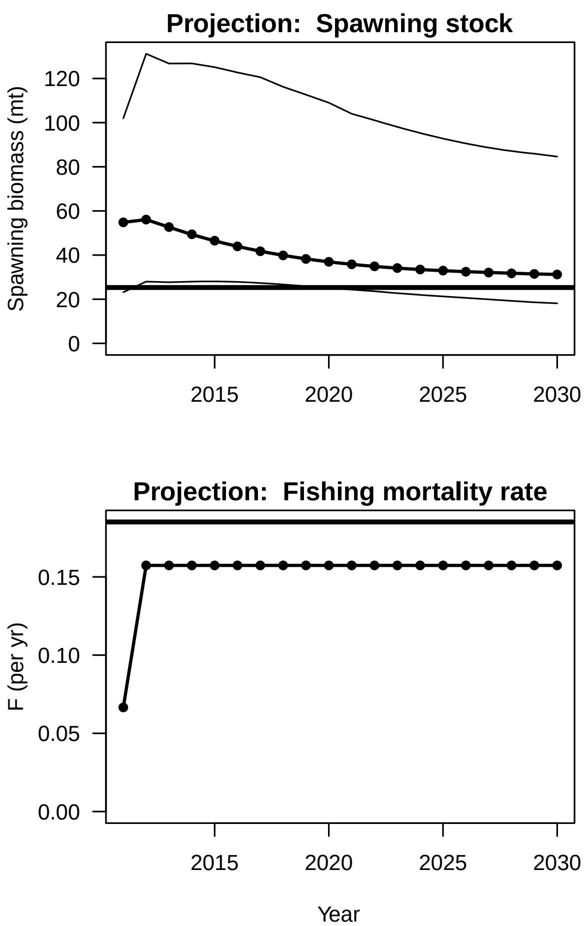


Figure 5.8d. Projection results under scenario 5 – fishing mortality rate fixed at $F = 85\%F_{\mathrm{MSY}}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections. Horizontal lines mark MSY-related quantities. Spawning stock (SSB) is at time of peak spawning. (*Extracted from Figure 3.40 of the Assessment Report.*)



6. SEDAR Abbreviations

ABC	Allowable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
ADMB	AD Model Builder software program
ALS	Accumulated Landings System; SEFSC fisheries data collection program
B	stock biomass level
BMSY	value of B capable of producing MSY on a continuing basis
CIE	Center for Independent Experts
CPUE	catch per unit of effort
EEZ	exclusive economic zone
F	fishing mortality (instantaneous)
FMSY	fishing mortality to produce MSY under equilibrium conditions
FOY	fishing mortality rate to produce Optimum Yield under equilibrium
FXX% SPR	fishing mortality rate that will result in retaining XX% of the maximum spawning production per recruit under equilibrium conditions
FMAX	fishing mortality that maximizes the average weight yield per fish recruited to the fishery
F0	a fishing mortality close to, but slightly less than, Fmax
GA DNR	Georgia Department of Natural Resources
GLM	general linear model
M	natural mortality (instantaneous)
MARMAP	Marine Resources Monitoring, Assessment, and Prediction
MFMT	maximum fishing mortality threshold, a value of F above which overfishing is deemed to be occurring
MRFSS	Marine Recreational Fisheries Statistics Survey; combines a telephone survey of households to estimate number of trips with creel surveys to estimate catch and effort per trip
MRIP	Marine Recreational Information Program
MSST	minimum stock size threshold, a value of B below which the stock is deemed to be overfished
MSY	maximum sustainable yield
NC DMF	North Carolina Division of Marine Fisheries
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration

OY	optimum yield
SAFMC	South Atlantic Fishery Management Council
SC DNR	South Carolina Department of Natural Resources
SEDAR	Southeast Data, Assessment and Review
SEFSC	Southeast Fisheries Science Center, National Marine Fisheries Service
SERO	Southeast Regional Office, National Marine Fisheries Service
SPR	spawning potential ratio, stock biomass relative to an unfished state of the stock
SSB	Spawning Stock Biomass
SSC	Science and Statistics Committee
TIP	Trip Incident Program; biological data collection program of the SEFSC and Southeast States.
Z	total mortality, the sum of M and F

SEDAR

Southeast Data, Assessment, and Review

SEDAR 25

South Atlantic Golden Tilefish

SECTION II: Data Workshop Report

June 2011

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

Table of Contents

1 Introduction

1.1 Workshop Time and Place

The SEDAR 25 Data Workshop was held April 26-28, 2011 in Charleston, South Carolina.

1.2 Terms of Reference

1. Review stock structure and unit stock definitions and consider whether changes are required.
2. Review, discuss, and tabulate available life history information if new information is available.
   - 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.
3. Recommend discard mortality rates.
   - Review available research and published literature
   - Consider research directed at golden tilefish as well as similar species from the Atlantic and other areas.
   - Provide estimates of discard mortality rate by fishery, gear type, depth, and other feasible or appropriate strata.
   - Include thorough rationale for recommended discard mortality rates.
   - Provided justification for any recommendations that deviate from the range of discard mortality provided in the last benchmark and update (SEDAR 4).
4. 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; address 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) and include measures of precision and accuracy.
   - Discuss 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.
5. Provide commercial catch statistics, 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 or gear.
   - Provide length and age distributions if feasible.
   - Provide maps of fishery effort and harvest.

6. Provide recreational catch statistics, 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 or gear.
   - Provide length and age distributions if feasible.
   - Provide maps of fishery effort and harvest.
7. 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.
8. 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 TBD.
9. Develop a list of tasks to be completed following the workshop.
10. No later than May 25, 2011, prepare the Data Workshop report providing complete documentation of workshop actions and decisions (Section II. of the SEDAR assessment report).

1.3 List of Participants

Data Workshop Panel

Kate Andrews…………………………….NMFS/SEFSC
Tony Austin…………………………NC Commercial
Nate Bacheler……………………………NMFS/SEFSC
Joey Ballenger……………………………………SC DNR
Alan Bianchi……………………………………..NC DMF
Zach Bowen…………………………..GA Recreational
Ken Brennan……………………………..NMFS/SEFSC
Steve Brown………………………………………FL FWC
Julia Byrd…………………………………………..SC DNR
Julie Califf…………………………………………..GA DNR
Bobby Cardin…………………………FL Commercial
Dan Carr…………………………………….NMFS/SEFSC
Rob Cheshire……………………………..NMFS/SEFSC
Chip Collier………………………………………..NC DMF
Kevin Craig…………………………………NMFS/SEFSC
Julie Defilippi……………………………………….ACCSP
Laurie DiJoy………………………………………..SC DNR
Kenny Fex………………………………NC Commercial
Eric Fitzpatrick…………………………..NMFS/SEFSC
Kelly Fitzpatrick…………………………..NMFS/SEFSC
David Gloeckner…………………………NMFS/SEFSC
Rusty Hudson …………………………FL Recreational
Jimmy Hull………………………………FL Commercial
Walter Ingram…………………………….NMFS/SEFSC
Nikolai Klibanski ………………………………. UNCW
Joe Klosterman…………………………FL Commercial
Kathy Knowlton…………………………………..GA DNR
Chad Lee…………………………………FL Commercial
Linda Lombardi……………………………NMFS/SEFSC
Vivian Matter…………………………………………..MRIP
Kevin McCarthy…………………………NMFS/SEFSC
Ron McPherson………………………NC Recreational
Paulette Mikell……………………………………SC DNR
Michelle Pate……………………………………..SC DNR
David Player………………………………………..SC DNR
Jennifer Potts ……………………………NMFS/SEFSC
Marcel Reichert…………………………………..SC DNR
Paul Rudershausen…………………………………NCSU
Beverly Sauls……………………………………..FL FWC
Kyle Shertzer……………………………….NMFS/SEFSC
Tom Sminkey…………………………………………..MRIP
Jessica Stephen …………………………..NMFS/SERO
Erik Williams ……………………………….NMFS/SEFSC
Chris Wilson………………………………………..NC DMF
Dave Wyanski……………………………………..SC DNR

Council Representatives

Tom Burgess.....SAFMC

Council & Agency Staff

Kari Fenske.....SEDAR
Gregg Waugh.....SAFMC
Mike Errigo.....SAMFC
Tyree Davis.....NMFS/SEFSC
Rachael Silvas.....SEDAR
Myra Brouwer.....SAFMC
John Carmichael.....SEDAR
Julie Neer.....SEDAR
Amy Dukes.....NMFS
Claudia Dennis.....NMFS/SEFSC

Data workshop observers

Eric Hiltz
Kevin Kolmos
Rodolfo Serra
Renzo Tascheri
Max Zilleruelo
Frank Hester
Peter Barile
Mark Brown

Data webinar observers

Betsy Laban
Gregg Davis
Byron White
Eric Hiltz
Kevin Kolmos
Tracy McCulloch
Frank Hester
Peter Barile
Jim Busse
David Nelson

1.4 Data Workshop Working Papers and Reference Documents

Document #	Title	Authors
Documents Prepared for the Data Workshop		
SEDAR25-DW01	Black sea bass length frequencies and condition of released fish from at-sea headboat observer surveys, 2004-2010	Sauls, Wilson, and Brennan 2011
SEDAR25-DW02	Standardized CPUE of black sea bass (*Centripristis striata*) caught in blackfish and Florida snapper traps deployed by MARMAP	Bacheler, Shertzer, Reichert, Stephen, and Pate 2011
SEDAR25-DW03	Standardized CPUE of black sea bass (*Centropristis striata*) from chevron trapping by MARMAP	Bacheler, Shertzer, Reichert, Stephen, and Pate 2011
SEDAR25-DW04	Catch-per-unit-effort of golden tilefish from MARMAP bottom longlining	Bacheler, Reichert, Stephen, and Pate 2011
SEDAR25-DW05	Klibansky and Scharf batch fecundity methods	Klibansky and Scharf 2011
SEDAR25-DW06	The Regulations that have already affected the Black Sea Bass rebuilding	Fex 2011
SEDAR25-DW07	Commercial Longline Vessel Standardized Catch Rates of Tilefish in the US South Atlantic, 1993-2010	McCarthy 2011
SEDAR25-DW08	The potential for using the sea bass pot fishery to assess changes in abundance of black sea bass (Centropristis striata) in the South Atlantic region	Hull and Hester 2011
SEDAR25-DW09	Fisheries-dependent landings data for the east Florida golden tilefish (L*opholatilus chamaeleonticeps*) fishery	Hull and Barile 2011
SEDAR25-DW10	Black sea bass and tilefish discard mortality working paper	Collier, Fex, Rudershausen, and Sauls 2011
SEDAR25-DW11	Bottom longline fishery bycatch of golden tilefish from observer data	Hale 2011
SEDAR25-DW12	Abundance indices of black sea bass collected during SEAMAP shallow water trawl surveys in the South Atlantic Bight (1990-2010)	Ingram 2011
SEDAR25-DW13	Standardized discard rates of US black sea bass (*Centropristis striata*) from headboat at-sea observer data	Sustainable Fisheries Branch, NMFS 2011
SEDAR25-DW14	Preliminary standardized catch rates of Southeast	Sustainable

	US Atlantic black sea bass (*Centropristis striata*) from headboat data	Fisheries Branch, NMFS 2011
SEDAR25-DW15	South Carolina Department of Natural Resources State Finfish survey (SFS)	Hiltz and Byrd 2011
SEDAR25-DW16	SCDNR Charterboat Logbook Program Data, 1993-2010	Errigo et al. 2011
SEDAR25-DW17	A note on the occurrence of bank sea bass (*Centropristis ocyurus*) in the Florida hook and line and black sea bass pot fisheries	Nelson 2011
SEDAR25-DW18	Commercial vertical line vessel standardized catch rates of black sea bass in the US South Atlantic, 1993-2010	McCarthy 2011
SEDAR25-DW19	Calculated discards of black sea bass and tilefish from commercial fishing vessels in the US South Atlantic	McCarthy
SEDAR25-DW20	Summary of black sea bass (*Centropristis striata*) length composition sampling from the Gulf and South Atlantic Fisheries Foundation observer program, 2007-2009	Gloeckner 2011
SEDAR25-DW21	Summary of black sea bass (*Centropristis striata*) length composition sampling from the Trip Interview Program (TIP) 1981-2010	Gloeckner 2011
SEDAR25-DW22	Summary of golden tilefish (*Lopholatilus chamaeleonticeps*) length composition sampling from the Trip Interview Program (TIP) 1981-2010	Gloeckner 2011
SEDAR25-DW23	Revised working paper: SCDNR Charterboat logbook program data, 1993-2010 (replaces SEDAR25-DW16)	Errigo et al 2011
SEDAR25-DW24	Standardized catch rates of black sea bass from commercial fish traps in the US South Atlantic, 1993-2010	McCarthy 2011

Reference Documents		
SEDAR25-RD01	Tilefish off South Carolina and Georgia	Low et al. 1983
SEDAR25-RD02	Temporal and spatial variation in habitat characteristics of tilefish (*Lopholatilus chamaeleonticeps*) off the east coast of Florida	Able et al. 1993
SEDAR25-RD03	The fishery for tilefish, *Lopholatilus chamaeleonticeps*, off South Carolina and Georgia	Low et al. 1982
SEDAR25-RD04	The complex life history of tilefish *Lopholatilus chamaeleonticeps* and vulnerability to exploitation	Grimes and Turner 1999
SEDAR25-RD05	South Carolina Sea Grant Project: To investigate and document legal and undersized fish (Black	D. Lombardi 2008

	Sea Bass) and injuries to released fish.	
SEDAR25-RD06	The 1882 tilefish kill – a cold event in shelf waters off north-eastern United States?	March et al. 1999
SEDAR25-RD07	Contributions to the life history of black sea bass, *Centropristis striata*, off the Southeastern United States	Wenner et al. 1986
SEDAR25-RD08	Population characteristics of the black sea bass *Centropristis striata* from the Southeastern US	Vaughan et al. 1995
SEDAR25-RD09	The summer flounder, scup, and black sea bass fishery of the Middle Atlantic Bight and southern New England waters	Shepherd and Terceiro 1994
SEDAR25-RD10	Estimating discard mortality of black sea bass (*Centropristis striata*) and other reef fish in North Carolina using a tag-return approach	Rudershausen et al. 2010
SEDAR25-RD11	List of working papers for SEDAR 4 (Atlantic and Caribbean deepwater snapper and grouper) – all documents are available on the SEDAR website	SEDAR 4
SEDAR25-RD12	List of reference documents for SEDAR 4 (Atlantic and Caribbean deepwater snapper and grouper) – all documents are available on the SEDAR website	SEDAR 4
SEDAR25-RD13	Evaluation of multiple survey indices in assessment of black sea bass from the US South Atlantic Coast	Vaughan et al. 1997
SEDAR25-RD14	Seasonal distribution and movement of black sea bass (*Centropristis striata*) in the northwest Atlantic as determined from a mark-recapture experiment	Moser and Shepherd 2009
SEDAR25-RD15	Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (South Atlantic) – Black sea bass	Mercer et al. 1989
SEDAR25-RD16	Black sea bass	Shepherd 2006
SEDAR25-RD17	Seafood Watch – Black Sea Bass (*Centropristis striata*), northeast region	Kerkering 2004
SEDAR25-RD18	Dispersal of black sea bass (*Centropristis striata*) larvae on the southeast US continental shelf: results of a coupled vertical larval behavior – 3D circulation model	Edwards et al. 2008
SEDAR25-RD19	List of working paper for SEDAR 2 (SA Black sea bass) – all documents are available on the SEDAR website	SEDAR 2
SEDAR25-RD20	Catch rates and selectivity among three trap types in the US South Atlantic black sea bass commercial trap fishery	Rudershausen et al. 2008

SEDAR25-RD21	Lead-radium dating of golden tilefish (*Lopholatilus chamaeleonticeps*)	Andrews 2009
SEDAR25-RD22	Black sea bass, *Centropristis striata*, life history and habitat characteristics (second edition)	Drohan et al. 2007
SEDAR25-RD23	Spawning locations for Atlantic reef fishes off the Southeastern US	Sedberry et al. 2006
SEDAR25-RD24	Growth of black sea bass (*Centropristis striata*) in recirculating aquaculture systems	Perry et al. 2007
SEDAR25-RD25	American food and game fishes. A popular account of all the species found in America north of the equator, with keys for ready identification, life histories and methods of capture – *Tilefish excerpt*	Jordan and Evermann 1908
SEDAR25-RD26	American fishes: A popular treatise upon the game and food fishes of North America with especial reference to habits and methods of capture – *Sea basses excerpt*	Goode and Gill 1903
SEDAR25-RD27	American food and game fishes. A popular account of all the species found in America north of the equator, with keys for ready identification, life histories and methods of capture – *Centropristes excerpt*	Jordan and Evermann 1908
SEDAR25-RD28	Returns from the 1965 Schlitz tagging program including a cumulative analysis of previous results	Beaumariage 1969
SEDAR25-RD29	Source Document for the Snapper-Grouper Fishery of the South Atlantic region	SAFMC 1983
SEDAR25-RD30	FMP, Regulatory Impact Review, and final Environmental Impact Statement for the SG fishery of the South Atlantic region	SAFMC 1983
SEDAR25-RD31	Biological-statistical census of the species entering fisheries in the Cape Canaveral area	Anderson and Gehringer 1965
SEDAR25-RD32	Survey of offshore fishing in Florida	Moe 1963
SEDAR25-RD33	Southeastern US Deepwater reef fish assemblages, habitat characteristics, catches, and life history summaries	Parker and Mays 1998
SEDAR25-RD34	Sea bass pots: bigger mesh may yield larger fish	Lee 2007
SEDAR25-RD35	Migration and standing stock of fishes associated with artificial and natural reefs on Georgia's outer continental shelf	Ansley and Harris 1981
SEDAR25-RD36	The South Carolina fishery for black sea bass (*Centropristis striata*), 1977-1981	Low 1982
SEDAR25-RD37	Age sampling of the commercial snapper grouper fishery and age description of the black sea bass	Collier and Stewart, 2010

	fishery in North Carolina	
SEDAR25-RD38	Black sea bass 2009 stock assessment update (Northeast Fisheries Science Center Reference Document 09-16)	Shepherd 2009
SEDAR25-RD39	The recreational fishery in South Carolina: The Little River story	Burrell
SEDAR25-RD40	Otolith and histology interpretation workshop for golden tilefish and snowy grouper	Joint agency report 2009
SEDAR25-RD41	Age workshop for black sea bass (*Centropristis striata*)	Joint agency report 2009
SEDAR25-RD42	Population genetic structure of black seabass (*Centropristis striata*) on the eastern US coast, with an analysis of mixing between stocks north and south of Cape Hatteras, North Carolina	McCartney and Burton 2011
SEDAR25-RD43	Delineation of tilefish, *Lopholatilus chamaeleonticpes*, stocks along the United States east coast and in the Gulf of Mexico	Katz et al 1982
SEDAR25-RD44	Foreign fishing off the southeastern United States under the currently accepted contiguous sea limitation	Fuss
SEDAR25-RD45	Black sea bass, managing a fishery. A case study. *website document*	Camblos et al. 2005
SEDAR25-RD46	SAFMC Science and Statistics Committee, Bio-Assessment sub-committee	SA SSC 2003

2 Life History

2.1 Overview

State and federal biologists, academic representatives and industry representatives comprised the Life History Work Group (WG)

Jennifer Potts – NMFS, Beaufort, NC, Co-leader of LHWG
Joseph Ballenger – SCDNR, Charleston, SC, Co-leader of LHWG
Peter Barile – Industry Scientist, Florida
Tom Burgess – Industry Representative
Daniel Carr – NMFS, Beaufort, NC, Rapporteur
Chip Collier – NCDMF, Wilmington, NC
Kevin Craig – NMFC, Beaufort, NC
Laurie DiJoy – SCDNR, Charleston, SC
Nikolai Klibanski – UNC-Wilmington, Wilmington, NC
Kevin Kolmos – SCDNR, Charleston, SC
Linda Lombardi – NMFS, Panama City, FL
Paulette Mikell – SCDNR, Charleston, SC
Marcel Reichert – SCDNR, Charleston, SC
Rodolfo Serra – Instituto de Fomento Pesquero, Valparaiso, Chile
David Wyanski – SCDNR, Charleston, SC

The WG was tasked with combining life history data from SEDAR 4 with updated and new life history data from three sources: National Marine Fisheries Service Beaufort Laboratory (NMFS-BFT), National Marine Fisheries Service Panama City Laboratory (NMFS-PC), and South Carolina Department of Natural Resources (SCDNR).

During the last benchmark assessment of tilefish in the South Atlantic, SEDAR 4, some issues were raised regarding the age data. NMFS-BFT and SCDNR appeared to be interpreting the structure of the otoliths differently. As a follow up to SEDAR 4, a validation study was undertaken using radiometric aging technique comparing the otolith radioactive $^{210}Pb/^{226}Ra$ ratio over time to annual age counts from opaque zones on the otoliths (SEDAR25-RD21). The results of that study were more promising, indicating annual increment formation and NMFS-PC interpretation of those increments were correct. NMFS-BFT, NMFS-PC, and SCDNR then held an age workshop and all tilefish age readers were instructed by NMFS-PC personnel on how to read the otolith sections. Results can be found in SEDAR25-RD40. Following the age workshop, NMFS-BFT re-aged all otolith sections supplied for SEDAR 4 and found that many of the otolith samples were originally over-aged. The age data set available for this SEDAR 25 is more consistent between laboratories and more comprehensive of the tilefish stock in the US South Atlantic.

The reproductive biology of tilefish was also reviewed during a workshop held at the same time as the age workshop. Discussion centered around the consistency in assigning reproductive stage and whether the male gonadal tissue containing female tissue and vice versa was an indication of hermaphroditism or protogyny. This discussion is contained in SEDAR25-RD40.

The WG was also tasked with reviewing the stock structure and unit stock definitions (SEDAR25-DW-TOR #1), reviewing, discussing and tabulating life history information where new information was available (SEDAR25-DW-TOR #2), and recommend discard mortality rates (SEDAR25-DW-TOR #3) to be applied to the various fisheries. These discussions will be addressed in their appropriate sections.

Finally, the WG was also tasked with providing recommendations for future research (SEDAR25-DW-TOR #7). Research recommendations stemming from discussions within the LHWG are tabulated and can be found in Section 7 of this Data Workshop Report.

2.2 Review of Working Papers

There were no tilefish working papers to review.

2.3 Stock Definition and Description

Tilefish in U.S. territorial waters are distributed south of Nova Scotia through the Gulf of Mexico. This fish has been managed as three separate stocks by three separate management councils: MAFMC, SAFMC and GMFMC. The questions asked is "what truly is the stock structure of tilefish in the Northwest Atlantic?"

Tilefish are deep-water, demersal fish that have distinct habitat requirements that include stable temperatures (9-14^{o} C) and clay-like substrate in which to construct burrows/shelter (Grimes et al., 1986). Submersible operations (Able et al., 1982) and tagging studies (Grimes, 1983) suggest that adult tilefish do not move any great distance (< 2 km). These fish can also be caught year round in the mid-Atlantic where temperatures may fluctuate more, again suggesting a resident population.

A genetic study of tilefish stocks along the U. S. east coast and Gulf of Mexico was conducted using electrophoresis of liver, eye and muscle tissue was conducted by Katz et al. (1983). The results of this study support the separation of stocks between the mid-Atlantic and the South Atlantic. The samples taken along the east coast of the U.S. did not include fish from North Carolina or the southern portion of Virginia. Thus, there was not a clear indication of where the stocks are separated. Katz et al. (1983) did not find definitive separation of the South Atlantic and Gulf of Mexico stocks, but geographic barriers may keep the stocks separated. The Life History Work Group of SEDAR22 recommended that the Gulf of Mexico stock be treated as a unit stock separate from the Atlantic stocks.

Recommendation: Based on the genetic study by Katz et al. (1983) and the limited movement cited in Grimes (1983), the WG recommends defining the U.S. South Atlantic stock as those fish caught from the VA/NC border southward through the east coast of Florida to south of the Florida keys.

Research Recommendation: An updated genetic study needs to be undertaken on tilefish from the east coast of the U.S. and the U.S. Gulf of Mexico. The study needs to more clearly define where the stock delineation between the mid-Atlantic and South Atlantic jurisdictions (e.g., Hatteras, NC break or VA/NC border).

2.4 Natural Mortality

The life history work group (WG) reviewed estimates of natural mortality (M) computed using various equations (Table 1). The panel developed a table of estimated M values (Table 2).

Several life history parameters (L_∞, k, age at maturity, maximum age) were necessary to calculate point estimates of natural mortality (Table 3). Refer to other sections of this life history section report for the methodologies used to calculate each of those parameters. Average water temperatures were obtained from SCDNR MARMAP cruise data where the tilefish were collected.

One of the caveats that should be mentioned here is that golden tilefish are outer continental shelf / shelf break / continental slope species, while most of the published literature for natural mortality considers species that occur in more coastal zones. This may be pertinent to many aspects of the life history, since these deeper waters may be more constant in temperature and salinity than the coastal waters, and those factors may contribute to development of successful life history strategies.

Thirty-six estimates of natural mortality (M) were derived using different functions and different growth curve parameters (Table 2). Separate natural mortality estimates were calculated for all data combined, males and females. The highest M for all data combined was calculated using Beverton and Holt 1956 (M = 0.743, Figure 1) that relies on an accurate estimate of growth based on the von Bertalanffy growth model and the age that 50% of the population is mature, based on females. The Alverson and Carney (1975) method calcuated the lowest M of 0.034 that also relies on an accurate esimate of growth and longevity. The WG recommend to use the $\text{Hoenig}_{\text{fish}}$ point estimate of M = 0.10. This regression is the recommended model over the 'rule of thumb' approach, which also calculated M = 0.10 (Hewett and Hoenig 2005). Both of these regressions rely on an accurate estimate of longevity. The assessment of the mid-Atlantic stock also used an M value of 0.10. The WG also recommends modeling the uncertainity in natural mortality through senstivities runs with M ranging from 0.03 to 0.21 (M = 0.21 is the overall average of the twelve natural mortality regressions without the Beverton Holt outlier).

The 2004 SEDAR 4 data workshop recommended a point estimate of M = 0.14 with a range of 0.10-0.25, based on a review of literature and a maximum age of 33 (SEDAR 2004, p. II-16, Table 4). However, during the assessment workshop (AW) the panel recommended the use of a maximum age of 54 (M = 0.08) from the MARMAP data rather than 44 from the NMFS Beaufort data (SEDAR 2004, p. III.B-9).

It has been discussed that it is unlikely that there is a constant natural mortality rate across all sizes and ages and thus an age-variable approach has been advocated (e.g., SEDARs 4,10, 12,15A, 19, and 22). A method for estimating mortality rates by age was developed by Lorenzen 2005. The reference age for all data combined and sex-specific Lorenzen M curves was set to age 4. There is no accepted methodology for determining what the reference age should be, but a tilefish age 4 are frequently caught by the fishery. Based upon WG recommendations, Lorenzen estimates were computed for ages 0+ scaled to Hoenig_{fish} estimates of M for all available records regardless of whether sex was noted (Figure 2).

During SEDAR 4, the assessment workshop recalibrated the Lorenzen (1996) age-dependent estimates of M at the oldest ages given the extremely small cumulative survival at these ages. The age-dependent curve calculated for this assessment uses Lorenzen (2005) regression which is scaled on a reference age and calculated for length not weight. The Lorenzen (2005) age-dependent mortality curve calculated higher mortality at age compared to the age-dependent mortality curve in SEDAR04 (Figure 2). This difference was most likely due to the change in aging methodology that resulted in a lower max age than in SEDAR4.

WG Recommendation:

Natural Mortality: The WG panel recommends model runs using M calculated as an age-variable value (Lorenzen M)scaled to $Hoenig_{fish}$ (1983) value (M = 0.10).

2.5 Discard Mortality

Bycatch and discards of tilefish were thought to be low overall in the South Atlantic and the panel recommended a discard mortality rate for tilefish of 100%. SEDAR 4 assumed 100% discard mortality rate for released tilefish (B2) from the recreational fishery and did not have data on commercial discards. Two tilefish assessments have been conducted in other regions. The Mid-Atlantic stock assessment did not include discard mortality since the numbers of discards were very low in the dominant fishery. The Gulf of Mexico assessment assumed 100% discard mortality for tilefish based on the depth where fish have been caught. No assessment has used a discard mortality value less than 100% for tilefish if discard mortality was included in the model.

In addition to discussing the rate of discard mortality, it was noted that the liver of tilefish suffer barotraumas due to rapid decompression. Venting tilefish likely would not increase survivorship of released fish and delayed mortality may result despite any recompression technique used.

2.6 Age

Age data for tilefish, *Lopholatilus chamaeleonticeps*, from the US South Atlantic have been compiled from three different laboratories that include National Marine Fisheries Service Beaufort Laboratory (NMFS Bft), NMFS Panama City Laboratory (NMFS PC), and South Carolina Department of Natural Resources (SCDNR). The maximum aged tilefish was age 40. This age differs from the maximum aged used in the previous assessment (SEDAR 4, age 54). The results of a validation study completed after SEDAR 4 assisted in the interpretation of otolith growth increments (SEDAR25-RD21). Age samples have been collected predominantly from the commercial fishery operating off southern North Carolina through the east coast of Florida since 1980 (N = 12,278; Table 5). SCDNR Marine Monitoring and Prediction (MARMAP) fishery-independent survey has collected tilefish age samples with vertical hook and line gear and longlines since 1982 (N = 1,327; Table 6). The age data available for SEDAR 25 also include 72 aged samples collected from charter boats (n=5), which includes a few samples caught off Virginia, and unidentified fishery-dependent port samples (n = 67; Table 7).

2.7 Growth

Tilefish exhibit dimorphic growth with males attaining larger sizes at age than females. The range of total lengths of females sampled for ageing was 299 – 1,127 mm and similar to that of males, 294-1,155 mm, though the means differed some: 621.5 mm for females and 702.5 for males (Figure 3). The age range for both was also similar with females ranging from 2 to 40 years (mean = 9.5 years) and males ranging from 2 to 34 years (mean = 9.0 years; Figure 4). The most dramatic difference between males and females is their size-at-age and overall growth (Figure 5). Most of the fish landed in the commercial fishery are gutted at sea; thus, the sex of the fish cannot be determined. Due to this fact, we estimated growth from all fish aged regardless of sex (Table 8; Figure 5). We did model growth for males and females separately to illustrate the difference in growth.

During the analysis of the age data, we made note of the selectivity of the gear used to catch tilefish. Because there is no minimum size limit on this species, all fish should be available in the landings. Just two fish were smaller than 300 mm TL: 294 and 299 mm TL, and no fish under the age of two years were landed. Because of the selectivity of the gear, we made the assumption that only the fastest growers at the youngest ages would recruit to the fishery. Thus, we applied the Diaz et al. (2004) correction to the growth models, using 290 mm TL as the arbitrary minimum size limit. The model assumed a constant CV across ages and was inverse weighted by sample size at each age. The results of the growth model for all samples combined regardless of sex appeared to be a good overall fit to the data (Figure 5). The initial model runs on the males and females resulted in biologically unrealistic t_o values (< -4 years). To give more biological meaning to the size of the fish at age 0 years, we fixed t_o at the value estimated in the all data combined model run, -0.47, for the male and female growth estimates (Figures 6 and 7, respectively). This t_o value is close to the fixed t_o value used in model runs for SEDAR 4. The inverse weighting by sample size at each age helped the model to better fit the size of the fish at the oldest ages. See Table 8 for parameter estimates.

Recommendation: Use the von Bertalanffy growth model for all data, regardless of sex, in the assessment model. Use the inverse weighted Diaz et al. (2004) corrected female growth model with t_o fixed at -0.47 to estimate female spawning stock biomass if fecundity estimate is not available.

2.8 Reproduction

Tilefish is thought to be a gonochorist species (Erickson and Grossman 1986), although other investigators have suggested that the species exhibits protogynous hermaphroditism because smaller individuals are disproportionately female and larger individuals disproportionately male (Dooley 1978). Turner et al. (1983) and Erickson and Grossman (1986) also observed similar skewed sex ratios in golden tilefish but concluded that the skewness was probably the result of a difference in male and female growth rates. Erickson and Grossman (1986) did note the presence of previtellogenic oocytes in approximately 1% of 571 testes, but no additional structural evidence for hermaphroditism (i.e., presence of vitellogenic or alpha-stage atretic oocytes in an ovotestis, presence of an ovarian lumen) was observed. For tilefish caught off the east coast of Florida (n = 950, statistical fishing grids 732, 736-737) 87% of males had of a variety of female oocyte development (primary to hydrated oocytes) and 38% of the females (n = 432) had residual male tissue. The occurrence of opposite sex tissue within the gonad at such high percentages was also discovered in tilefish caught in the Gulf of Mexico (SEDAR 2010a).

Tilefish exhibit an asynchronous ovarian organization with the result that eggs are released in batches (MARMAP, unpublished data), but the fecundity pattern (determinate vs. indeterminate) has yet to be determined. They are known to be territorial, as they construct burrows in the soft sediments of the upper continental slope. Larger individuals, which tend to be males, are probably more aggressive and out-compete smaller fish for bait and territory (Grimes et al. 1988; Harris et al. 2001).

In the workshop dataset, eighty-one percent of the 4,635 specimens examined histologically came from fishery-dependent sources, primarily the commercial bottom longline fishery. The MARMAP Program in Charleston, SC, collected and processed 3,690 of the specimens, the remainder (n = 945; fishery-dependent) being collected and processed by the NMFS-PC. The information below on spawning seasonality, sexual maturity, and sex ratio is based on the most accurate technique (histology) used to assess reproductive condition in fishes.

2.8.1 Spawning season

Tilefish in spawning condition have been collected in all months except October and December (Sedberry et al. 2006). The peak of spawning occurs in April through June, primarily on the upper slope of the continental shelf. Spawning females have been captured off Florida through South Carolina at depths of 190-300 m (Sedberry et al. 2006) where the bottom temperature was 10.2-14.9 ^{o}C.

2.8.2 Fecundity

No estimates of annual fecundity at age are available for tilefish along the Atlantic coast of the southeastern U.S. Erickson and Grossman (1986) produced equations relating fecundity to body weight, total length, and age, but those equations yield a point estimate of fecundity (i.e., number of vitellogenic oocytes in ovary), not an estimate of batch size that can then be used to estimate annual fecundity. Although an equation to estimate annual fecundity was included with caveats in the data summary of SEDAR 4, recent analyses by MARMAP personnel determined that the tissue sub-sample weight was too small to yield reliable results. In lieu of a fecundity at age equation, the WG is providing three proxies for fecundity (see Figure 8): A) gonad weight vs increment count, B) gonad weight vs whole fish weight, and C) gonad weight vs total length. Option A yielded a very weak relationship (adj r^2 = -0.004.), therefore the workgroup recommends that Option B or C be used in the assessment because both equations have an adjusted r^2 > 0.6.

2.8.3 Age and size at maturity

It should be noted that the traditional definition of maturity has been used, such that inactive mature females have been included in the numerator and denominator of the proportion mature calculation. An acceptable level of accuracy in distinguishing the immature and regenerating/CAO categories of reproductive development in females was indicated by the general overlap in the left tail of age frequency plots for definitely mature and regenerating/CAO categories (Figure 9). The presence of immature females as old as age 11 resulted in a greater degree of overlap than is typically seen between the frequency plots for immature and the two categories of mature specimens. The smallest mature female was 329 mm TL, and the youngest was age 2; the largest immature female was 612 mm TL and the oldest was age 11 (Tables 9 and 11). The smallest mature male was 311 mm TL, and the youngest was age 2; the largest immature male was 718 mm TL and the oldest was age 12 (Tables 10 and 11). It should be noted that the age of the largest immature female and male are both higher than the values of age 7 and age 10, respectively, reported during the workshop; the change is due to the omission of data from 2008 to 2009 from the original dataset.

Attempts to model size (L_{50}) and age (A_{50}) at maturity for females and males were not successful, as the estimates of A_{50} and L50 were unrealistic, negative values in the case of A_{50}. In lieu of model-based estimates of maturity, the Life History workgroup recommends an estimate (owing to uncertainties inherent in the data) of age 3 for A50 for both sexes based on empirical data (Tables 9 and 10).

It should be noted that the estimate of female A_{50} is two years less than the estimate of age 5 that was used in SEDAR 4. A different method was used to generate the estimate in SEDAR 4 because MARMAP age data at that time were considered to have bias (potentially underaged by 5-10 years based on radio-carbon age validation) and thus not used in the assessment. For SEDAR 4, fish length was converted to a Beaufort age and then the logistic model was applied to estimate age at maturity. The estimate of age 3 for A_{50} is probably more realistic in light of the empirical data presented in this document. This value is similar to the estimate of age 2 for female A_{50} (via logistic model) that was used in the most recent Gulf of Mexico tilefish assessment (SEDAR 22); immature females were also rare among the Gulf samples (n = 4) and ranged in size 301-414 mm TL and age 4-6.

Because of the lack of immature tilefish in the sample data, the WG needed to develop a maturity schedule, drawing on the limited data for this assessment, data from the Gulf of Mexico and professional opinion. The assessment model for this assessment will start at age 1 year; thus the maturity schedule will start at age 1. The A_{50} in the Gulf of Mexico was age 2, but age 3 for the South Atlantic. By taking the maturity schedule developed for the SEDAR 22 and pushing it forward a year, the WG proposed a maturity schedule of 10% at age 1, 25% at age 2, 50% at age 3 and 100% for fish age 4 and older. This recommendation was approved by the panel during the May 25, 2011 webinar.

2.8.4 Sex ratio

In the combined dataset (MARMAP + NOAA PC), the sex ratio was generally 1:1 from age 2 through age 17, at which time females become much more prevalent in the population (Figure 10). In two subsets of the combined dataset, both of which represent the most recent data, a similar upward trend in the proportion of females with age was noted (Figure 11), although the trend started earlier (in the youngest age classes). An examination of sex ratio data by month revealed that there is some evidence for spatial segregation of the sexes. The specimens collected from fishery-dependent sources during the 1990s were caught in deeper water and had a noticeably higher proportion of females than was noted in specimens collected during fishery-independent sampling in the same area but at shallower depths (Figure 12). Additional evidence of spatial segregation is the lower proportion of females (0.34-0.42) noted in the combined dataset during August, September, and November.

The WG recommends using a sex ratio of 1:1.

2.9 Movements & Migrations

Little is known on the movements and migrations of tilefish. Grimes (1983) conducted a study in the North Atlantic which used experimental break off tags to determine movement patterns of tilefish. The study estimated 386 fish were tagged and 7 were recaptured (2% recovery rate). Fish were at large for 115 to 557 days. Movements and migrations appeared to be minimal with the greatest distance traveled being 1.9 km. Limited migrations and movements by tilefish may be due to their narrow depth and thermal range and specific habitat preference (mud burrows).

More studies are needed to address the movements and migrations of tilefish. The panel discussed using break off tags using similar methods described by Grimes (1983) and natural tags such as otolith microchemistry.

2.10 Meristics & Conversion factors

Length – length, whole weight – gutted weight, and weight – length conversions are needed for tilefish. No new data are available for analyzing the relations between lengths and weight - length. Thus, the WG recommends using the regression equations described in SEDAR 4 (Table 12). SCDNR provided 991 samples with paired whole weights and gutted weights. A no-intercept conversion equation was derived from the data and included in Table 12. Consensus agreement was reached on this issue.

2.11 Comments on adequacy of data for assessment analyses

An issue regarding the age data was raised during SEDAR 4 that pertained to the distribution of lengths of fish from the commercial fishery versus the lengths of fish collected for age samples. The age samples appeared to be collected from the largest fish in the catch as opposed to random samples across all lengths of fish encountered by the port agents. A comparison of annual length compositions of commercial age samples versus all commercial samples by gear type revealed that 1996, 1998, and 1999 showed a pattern of age samples coming from more of the larger fish caught by longline gear (Figure 13). All other years showed a more even distribution of age samples compared to all fish measured.

2.12 Itemized list of tasks for completion following workshop

I. Tilefish Life History Analysis

a. Fecundity – Dave Wyanski is finishing up his analysis of the limited fecundity data available for tilefish (~ 10 samples). If he is unable to develop a fecundity vs. size/age relationship, he will develop a proxy measure looking at gonad weight vs. size/age.
b. Age-at-maturity
    i. Paulette Mikell and Laurie DiJoy are working on incorporating the newly incorporated sex and maturity data into our age-at-maturity analysis. Because these new samples included 64 immature fish, it may be possible that we can provide a better estimate of age-at-maturity for female and male tilefish based on analysis. If estimates are not improved, we will report the findings that were recommended and accepted in Wednesday afternoon plenary session.
c. Sex Ratio
    i. Paulette Mikell and Laurie DiJoy are working on develop sex ratio tables for golden tilefish for inclusion in the data workshop report.
d. Female growth curve
    i. Marcel Reichert is going to use the updated sex data to develop a new female length-at-age von Bertalanffy growth curve. With the addition of new samples, initial concerns regarding the t0 parameter may be alleviated. If concerns regarding the t0 parameter remain, he will fix the t0 parameter for the female growth curve to the t0 parameter estimated when all data is combined (~-0.61 years).

II. Draft Sections for the Data Workshop Report Pertaining to the Life History Working Group
a. Overview (group membership, leader, issues)
    Joey Ballenger and Jennifer Potts assigned section
b. Stock Definition and Description
    Jennifer Potts
c. Natural Mortality
    Linda Lombardi
d. Discard Mortality
    Chip Collier
e. Age
    Paulette Mikell
f. Growth
    Marcel Reichert
g. Reproduction
    i. Spawning Seasonality
    Paulette Mikell and Laurie DiJoy
    ii. Sexual Maturity
    Paulette Mikell and Laurie DiJoy
    iii. Sex Ratio
    Paulette Mikell and Laurie DiJoy
    iv. Batch Fecundity and/or Fecundity Proxies
    Dave Wyanski
h. Movements and Migration

Chip Collier

i. Meristics and Conversion Factors

Jennifer Potts

j. Comments on Adequacy of Data for Assessment Analyses

Comments will be made throughout the various sections, but overall comment will be formulated based on consensus of life history workgroup panel members.

k. Literature Cited

Author of each section responsible for providing literature cited for their section to life history working group co-leaders.

l. Tables

Author of each section responsible for providing tables pertinent to their section

m. Figures

Author of each section responsible for providing tables pertinent to their section

III. Life History Data Input File

Submit data to data compiler for inclusion in data workbook

Drafts of all outstanding tasks are due to the work group co-leaders by Wednesday May 4, 2011. Workgroup co-leaders will disseminate draft life history working group report to the life history work group on Friday, May 6, 2011 for review. Draft report to be submitted to data workshop panelist by May 11, 2011. Data for inclusion in respective data workbooks submitted to data compiler by May 13, 2011.

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2.14 Tables

Table 1. List of age based natural mortality (M) point estimate methods in order of year of publication. Parameters: k – von Bertalanffy growth coefficient (yr^{-1}), age mat – age at 50% maturity, tmax – maximum age (yr), L_∞ - asymptotic length (mm) determined from on Bertalanffy growth model, temp – average water temperature (^oC), S – survivorship. Equations provided in Microsoft Excel notation.

Method	Parameters	Equation
Alverson & Carney (1975)	k, tmax	M = 3*k/[exp(0.38*tmax*k)-1]
Beverton & Holt (1956)	k, age mat	M = 3*k/[exp(age mat*k)-1])
Hoenig fish (1983)	tmax	M=exp(1.46 - 1.01*ln(tmax))
Hoenig all taxa (1983)	tmax	M=exp(1.44-0.982*ln(tmax))
Pauly I (1980)	k, L∞, temp	M=exp[-0.0152+0.6543*ln(k)-0.279*ln(L∞) +0.4634*ln(temp)]
Pauly II (Pauly & Binohlan 1996)	k, L∞, temp	M=exp[-0.1464+0.6543*ln(k)-0.279*ln(L∞) +0.4634*ln(temp)]
Ralston I (1987)	k	M=0.0189 + 2.06*k
Ralston I (1987) (geometric mean)	k	M=0.666 + 2.52*k
Ralston II (Pauly & Binohlan 1996)	k	M=-0.1778+3.1687*k
Jensen (1996)	k	M = 1.5*k
Hewitt & Hoenig (2005)	tmax	M = 4/tmax
Alagaraja (1984)	S, tmax	M=-(lnS)/tmax

Table 2. Point estimates of natural morality (M) using multiple regressions (see Table 1 for equations and citations). Data set refers to the input data for the estimates of growth for all data, males, and females using the Diaz correction for size-selective fishery.

Data Set	Alverson & Carney	Beverton & Holt	Hoenig fish	Hoenig all taxa	Pauly I	Pauly II	Ralston I	Ralston (geometric mean)	Ralston Method II	Jensen	Hewitt & Hoenig	Alagaraja 0.01, 0.02, 0.05		
All data combined Diaz method	0.034	0.743	0.104	0.113	0.309	0.271	0.408	0.410	0.421	0.284	0.100	0.115	0.098	0.075
Males Diaz method	0.043	0.770	0.104	0.113	0.287	0.252	0.363	0.354	0.351	0.251	0.100	0.115	0.098	0.075
Females Diaz method	0.080	0.800	0.122	0.132	0.246	0.216	0.316	0.296	0.278	0.216	0.118	0.135	0.115	0.088

Table 3. Life history parameters used in fitting natural mortality regressions for each dataset.

Data Set	Sample size	L_∞ (mm)	k (yr^{-1})	Max Age (yr)	Age (yr) at 50% maturity	Water temperature °C	Survivorship (S)
All data combined Diaz method	13,676	825.1	0.189	40	3	12.28	0.01, 0.02, 0.05
Males Diaz method	2,922	986.1	0.144	34	3	12.28	0.01, 0.02, 0.05
Females Diaz method	2,612	806.3	0.167	40	3	12.28	0.01, 0.02, 0.05

Table 4. Published estimates of natural mortality (M) used in previous assessments.

Citation	M	Rational
Harris and Grossman 1985	0.163 (Males - Pauly) 0.118 (Males – AC) 0.126 (Males – H) 0.175 (Females – Pauly) 0.107 (Females – AC) 0.130 (Females – H)	Alverson and Carney method (AC), Pauly method and $\text{Hoenig}_{\text{fish}}$ (H) Parameters: water temperature 13°C Males: L∞ = 922 mm, k = 0.088, maximum age = 33 yrs Females: L∞ = 792 mm, k = 0.090, maximum age = 32 yrs
Hightower and Grossman 1988	0.10-0.25	Based on Harris and Grossman 1985
NEFSC 2002	0.10	No rational
SEDAR 2004	0.10-0.25	Based on Harris and Grossman 1985 and data available at SEDAR04, longevity of 33 yrs M = 0.126 ($\text{Hoenig}_{\text{fish}}$) Assessment workshop, longevity of 54 yrs M = 0.08
NEFSC 2009	0.10 (all data combined) 0.15 (males) 0.11 (females)	Based on data from Turner 1986 (citation not recovered). Regression used not stated.
SEDAR 2010a and 2010b	0.031-0.242 range 0.11 central tendency	Based on data available at SEDAR22 (Gulf of Mexico) using the same regressions used in this report (see Table 1). Natural mortality estimates higher than Z from catch curve calculations were discounted.

Table 5. Count of samples aged (and number of trips) of tilefish commercially landed by state and gear ($N_{samples}$ = 12,278; N_{trips} = 748).

HL = vertical hook and line gear; LL = bottom longline gear; N/A = gear not available

	Florida			North Carolina	South Carolina	
Year	**HL**	**LL**	**N/A**	**LL**	**HL**	**LL**
1980					79 (4)	
1981					578 (90)	
1982					180 (80)	
1983					62 (40)	
1984						
1985						
1986					1 (1)	
1987					3 (2)	28 (4)
1988						
1989						(2)
1990						
1991						
1992	6 (3)	99 (7)			2 (1)	25 (3)
1993	1 (1)	207 (16)	10 (1)			2 (1)
1994	8 (1)	8 (1)	18 (2)			
1995		373 (25)				
1996		229 (11)				507 (17)
1997	44 (6)	187 (7)			99 (5)	595 (17)
1998	61 (6)	141 (10)				97 (3)
1999	35 (5)	190 (8)				

2000	222 (11)	312 (13)				
2001	46 (5)	234 (11)				
2002	202 (28)	32 (3)	1 (1)			
2003	61 (4)	167 (10)				
2004	255 (10)			119 (5)		145 (7)
2005	255 (10)	60 (12)				308 (17)
2006	196 (7)	610 (31)			17 (1)	210 (11)
2007	274 (13)	1094 (45)				26 (1)
2008	46 (2)	749 (28)			(1)	421 (12)
2009	37 (2)	683 (22)			49 (3)	651 (8)
2010	30 (1)	709 (25)			37 (3)	145 (5)

Table 6. Count of samples aged of tilefish collected by fishery-independent surveys by year (N = 1,327).

HL = Vertical hook and line gear; LL = Bottom longline gear.

Year	HL	LL	Traps
1982	6	10	
1983	66	61	
1984	16	137	
1985	20	47	
1986	2	24	
1987			
1988			
1989			
1990			
1991			
1992			
1993			
1994			
1995			
1996		46	
1997		126	
1998		31	5
1999		160	3
2000		26	
2001		62	
2002		25	

2003		10	
2004			
2005		42	
2006	1	22	
2007		33	
2008		2	
2009		209	
2010		135	

Table 7. Count of samples aged of tilefish collected from Charter Boat trips and other unidentified fishery-dependent trips by state and year.

	Charter Boat		**Unknown Fishery**	
Year	**FL**	**VA**	**FL**	**SC**
1992				58
1995			9	
2007		1		
2008	1	3		

Table 8. Diaz et al. (2004) corrected, inverse weighted von Bertalanffy growth parameters of tilefish from the U.S. South Atlantic.

Data Source	L_∞ (S.E.) (TL, mm)	K (S.E.)	t_o (S.E.) (years)	CV
All SEDAR25 age data	825.1 (19.21)	0.189 (0.043)	-0.47 (1.38)	0.133 (0.012)
Female SEDAR25 age data	806.3 (17.21)	0.167 (0.025)	-0.47 (fixed)	0.104 (0.011)
Male SEDAR25 age data	986.1 (38.42)	0.144 (0.032)	-0.47 (fixed)	0.137 (0.014)

Table 9. Age (increment count) at maturity of female tilefish based on MARMAP data.

		Females (1980-2010)			(2008-2010)	
Inc	Imm	Mat	Total	Prop. Mat	Total	Prop. Mat
2	1	4	5	0.800		
3	1	19	20	0.950		
4		27	27	1.000		
5		76	76	1.000	3	1.000
6	2	143	145	0.986	11	1.000
7	1	215	216	0.995	21	0.950
8	1	186	187	0.995	41	0.980
9	4	185	189	0.979	49	0.920
10	2	123	125	0.984	49	0.960
11	1	85	86	0.988	39	0.970
12		68	68	1.000	45	1.000
13		46	46	1.000	25	1.000
14		42	42	1.000	27	1.000
15		32	32	1.000	22	1.000
16		33	33	1.000	16	1.000
17		18	18	1.000	12	1.000
18		23	23	1.000	16	1.000
19		12	12	1.000	6	1.000
20		13	13	1.000	4	1.000
21		9	9	1.000	5	1.000
22		11	11	1.000	6	1.000
23		5	5	1.000	3	1.000
24		3	3	1.000	1	1.000
25		3	3	1.000	3	1.000
26		3	3	1.000		
27		3	3	1.000	1	1.000
28		1	1	1.000		
29		1	1	1.000		
30		1	1	1.000	1	1.000
32		3	3	1.000	1	1.000
33		1	1	1.000		
40		1	1	1.000		
			1408		407	

Model	A_{50}	95% CI
Gompertz	-42.9	n/a
Logistic	-18.1	n/a

Table 10. Age (increment count) at maturity of male tilefish based on MARMAP data.

	Males (1980-2010)				(2008-2010)	
Inc	Imm	Mat	Total	Prop. Mat	Total	Prop. Mat
2	2	1	3	0.333		
3	5	17	22	0.773		
4	2	38	40	0.950		
5	2	74	76	0.974	12	0.917
6	2	160	162	0.988	35	0.971
7	2	196	198	0.990	61	0.984
8	14	292	306	0.954	141	0.908
9	11	250	261	0.958	122	0.918
10	10	213	223	0.955	129	0.922
11	1	153	154	0.994	91	0.989
12	2	105	107	0.981	75	0.973
13		77	77	1.000	53	1.000
14		42	42	1.000	33	1.000
15		29	29	1.000	25	1.000
16		32	32	1.000	23	1.000
17		20	20	1.000	14	1.000
18		11	11	1.000	9	1.000
19		7	7	1.000	4	1.000
20		4	4	1.000	3	1.000
21		4	4	1.000	3	1.000
22		4	4	1.000	2	1.000
23		1	1	1.000		
24		2	2	1.000	2	1.000
26		1	1	1.000	1	1.000
27		3	3	1.000	1	1.000
30		1	1	1.000	1	1.000
31		1	1	1.000		
32		2	2	1.000	1	1.000
Total			1793		841	

Model	A_{50}	95% CI
Gompertz	-20.4	94.9 to -8.3
Logistic	-8.7	46.2 to -1.8

Table 11. Size at maturity of female and male tilefish based on MARMAP data. Bin values represent upper limit.

Females (1980-2010)				
TL (mm)	Imm	Mat	Total	Prop. Mat
350		1	1	1.000
400	1	5	6	0.833
450	3	45	48	0.938
500	2	97	99	0.980
550	5	173	178	0.972
600	0	284	284	1.000
650	2	312	314	0.994
700		258	258	1.000
750		156	156	1.000
800		140	140	1.000
850		53	53	1.000
900		21	21	1.000
>900		6	6	1.000
Total	13	1551	1564	
Model	L_{50}	95% CI		
Gompertz	57	-409 to 218		
Logistic	249	36-334		

Males (1980-2010)				
TL (mm)	Imm	Mat	Total	Prop. Mat
350		1	1	1.000
400	3	5	8	0.625
450	3	30	33	0.909
500	14	59	73	0.808
550	10	112	122	0.918
600	12	201	213	0.944
650	8	235	243	0.967
700	3	252	255	0.988
750	1	229	230	0.996
800		179	179	1.000
850		149	149	1.000
900		136	136	1.000
950		125	125	1.000
1000		91	91	1.000
1050		61	61	1.000
1100		16	16	1.000
>1100		3	3	1.000
Total	54	1884	1938	
Model	L_{50}	95% CI		
Gompertz	232	103-309		
Logistic	332	260-378		

Table 12. Meristic conversions for tilefish.

	Length - length					
Source	Equation	Units	n	R^2	SE	Range of X
MARMAP data	TL = -15.031 + 1.082(FL)	mm	1919	1.00	0.690, 0.001	309-1108, all
	TL = 3.729 + 1.212(SL)	mm	3035	0.99	1.159, 0.002	254-925, all

	Weight - Length (weight = aL^b unless noted)					
Source	a (SD)	b (SE)	Units	n	R^2	MSE
Combined MARMAP and headboat data sets:	4.040E-12 (7.558E-13)	3.155 (0.015)	WW, mt TL, mm	3047	0.94	0.0344

Source	Whole Weight – Gutted weight			
		n	r^2	SE
MARMAP data	$W_{whole} = 1.06 * W_{gutted}$	991	1.00	0.001

2.15 Figures

Figure 1. Point estimates of natural mortality (M) for tilefish from the South Atlantic for all data combined. Mean with (square) and without (diamond) the outlier Beverton and Holt method is provided. The WG recommends using the Hoenig$_{fish}$ point estimate methods.

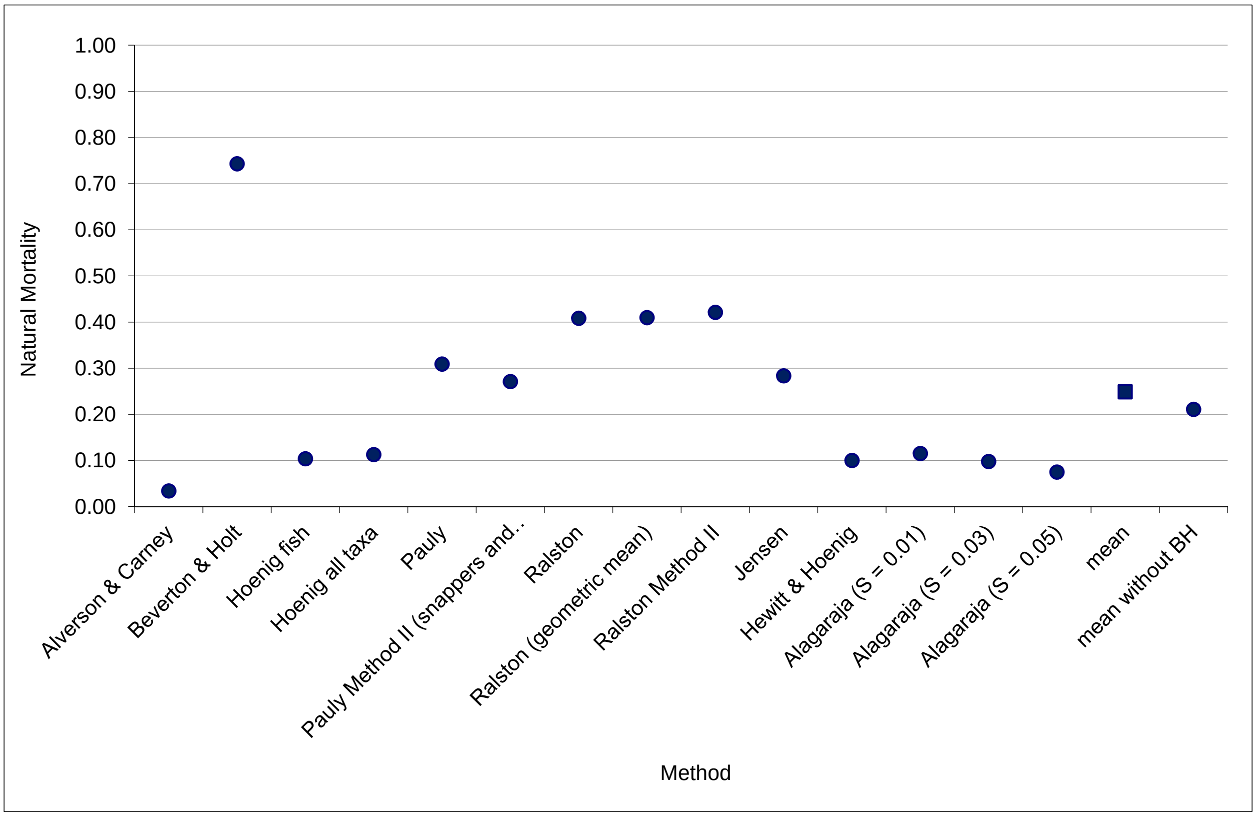


Figure 2. Age-specific natural mortality using Lorenzen (2005) method for all data combined. The grey line represents the Lorenzen age-dependent curve used during the 2004 SEDAR04 for all data combined.

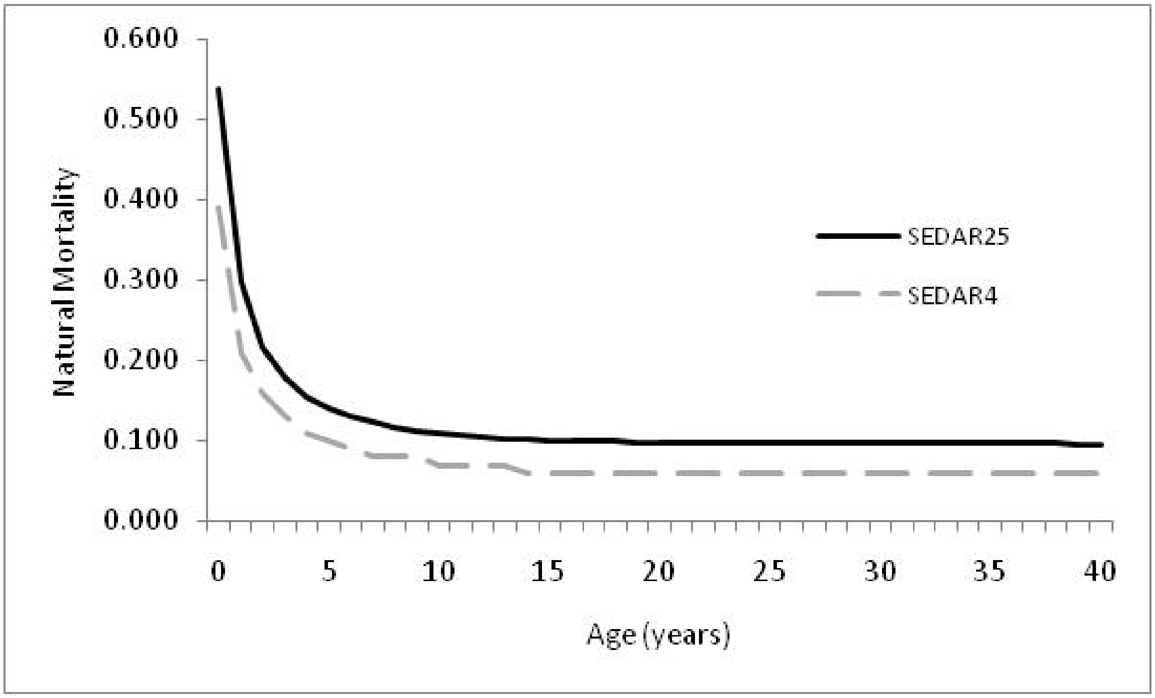


Figure 3. Total length frequency from the age data of male and female tilefish caught off the U. S. South Atlantic.

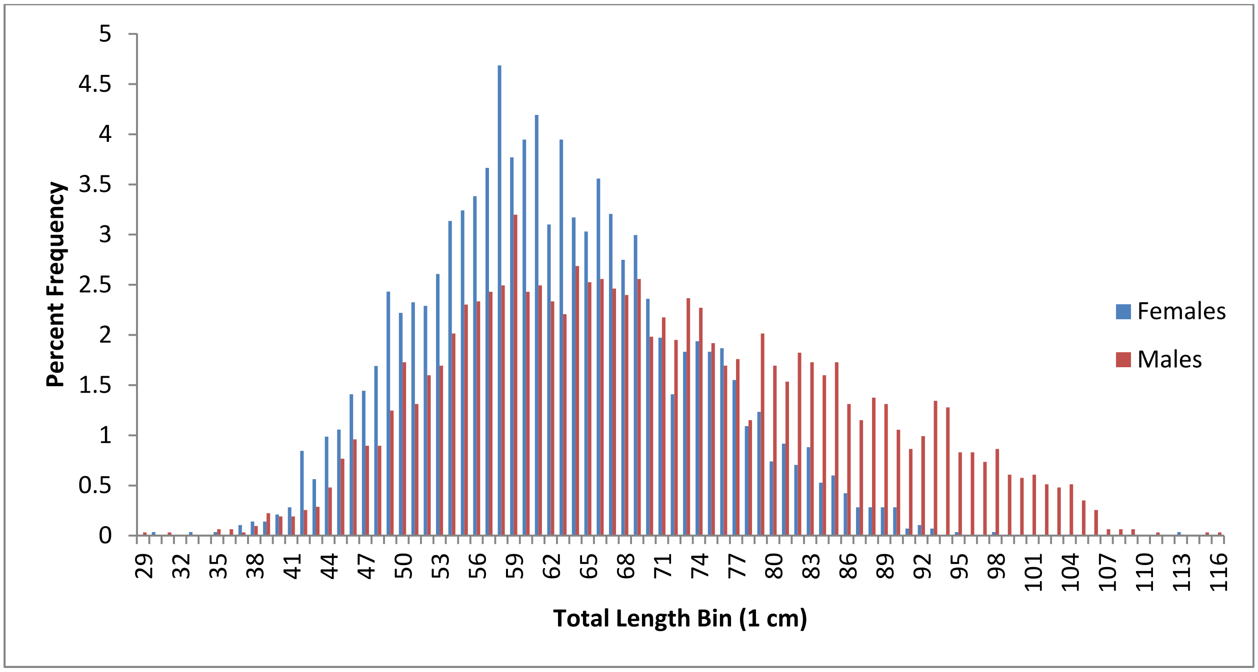


Figure 4. Age frequency of male and female tilefish caught off the U. S. South Atlantic.

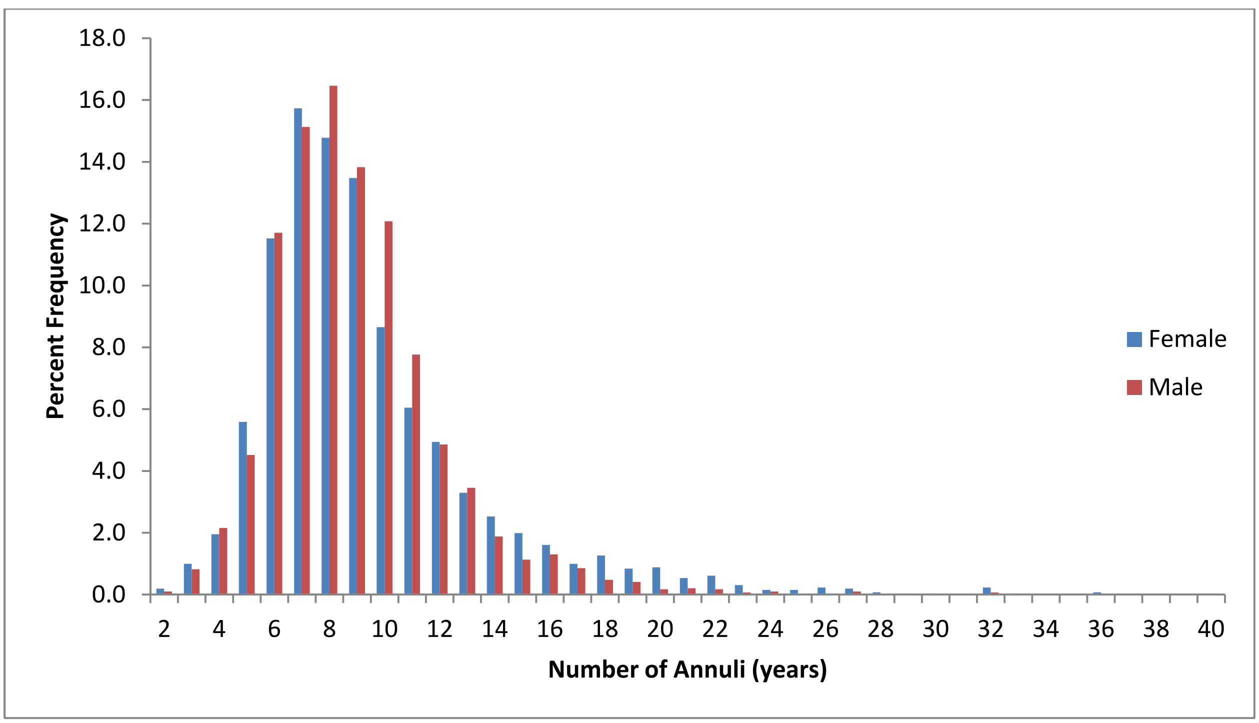


Figure 5. Total length-at-age of tilefish males, females, and unknown gender caught off the U.S. South Atlantic.

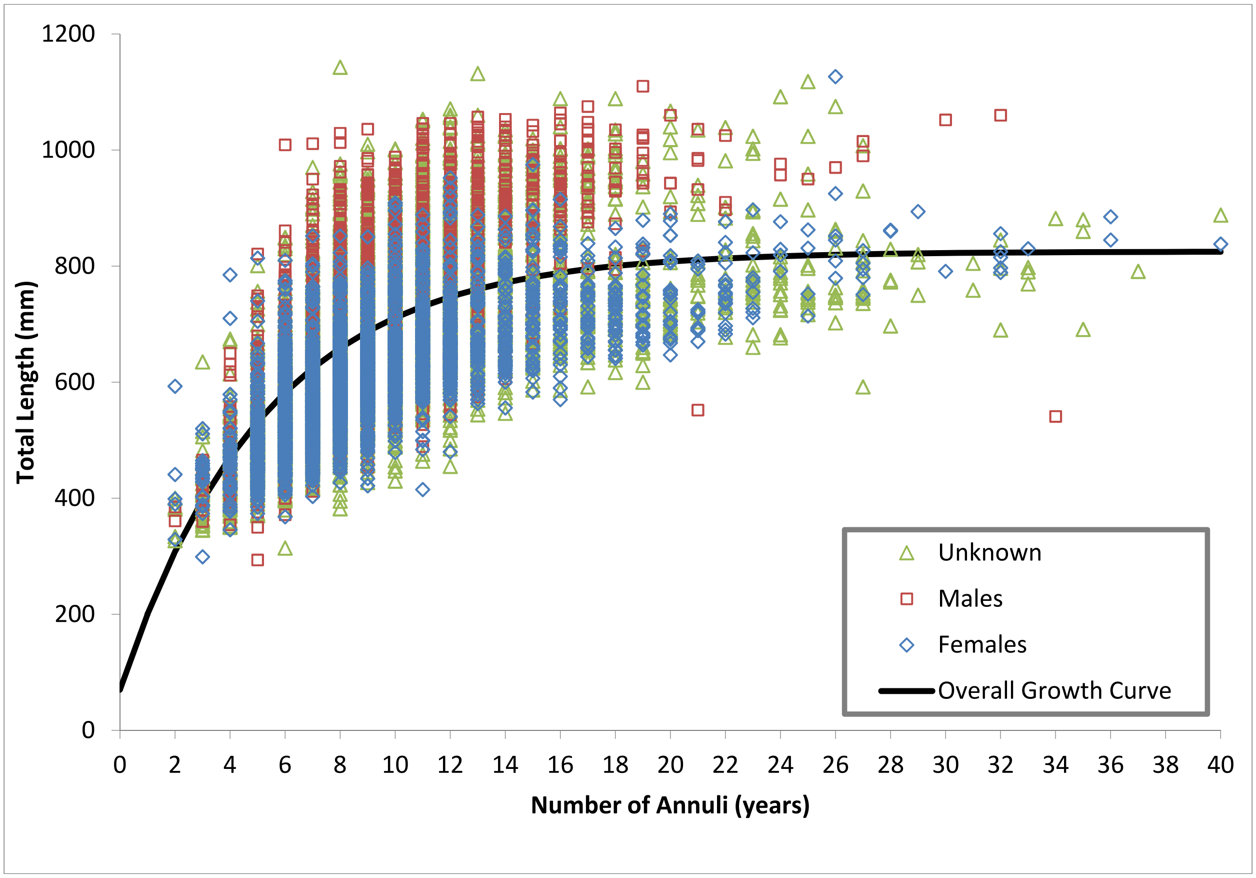


Figure 6. Male tilefish length-at-age and estimated growth curve.

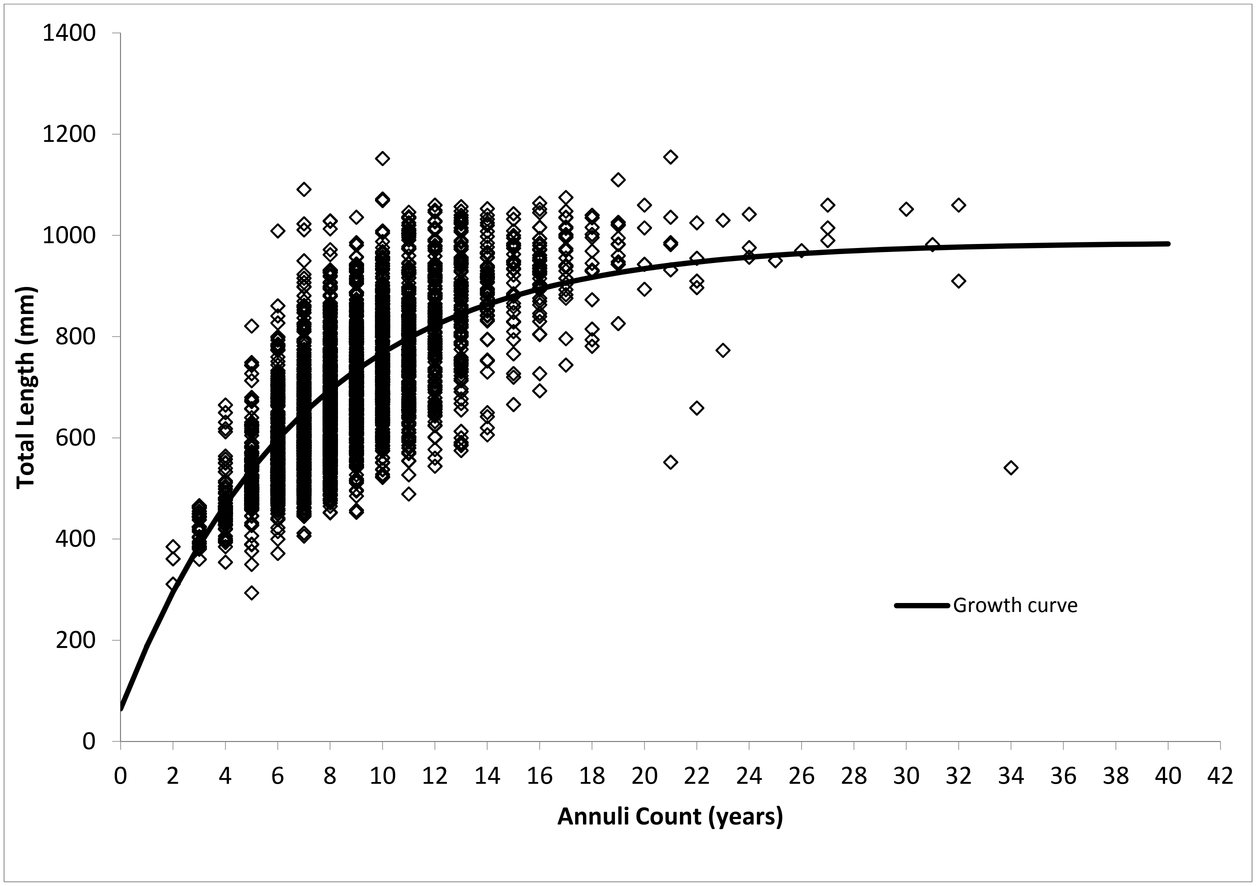


Figure 7. Female tilefish length-at-age and estimated growth curve.

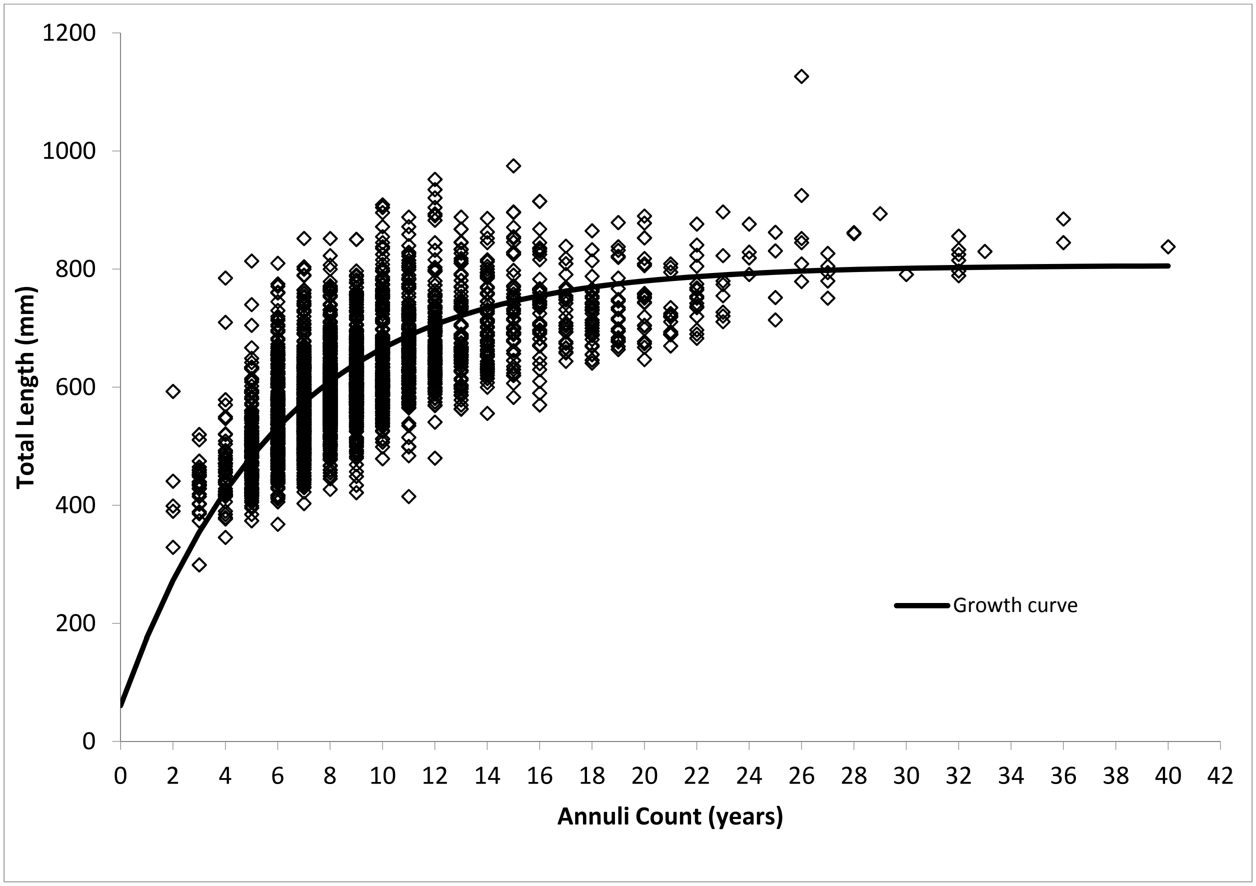
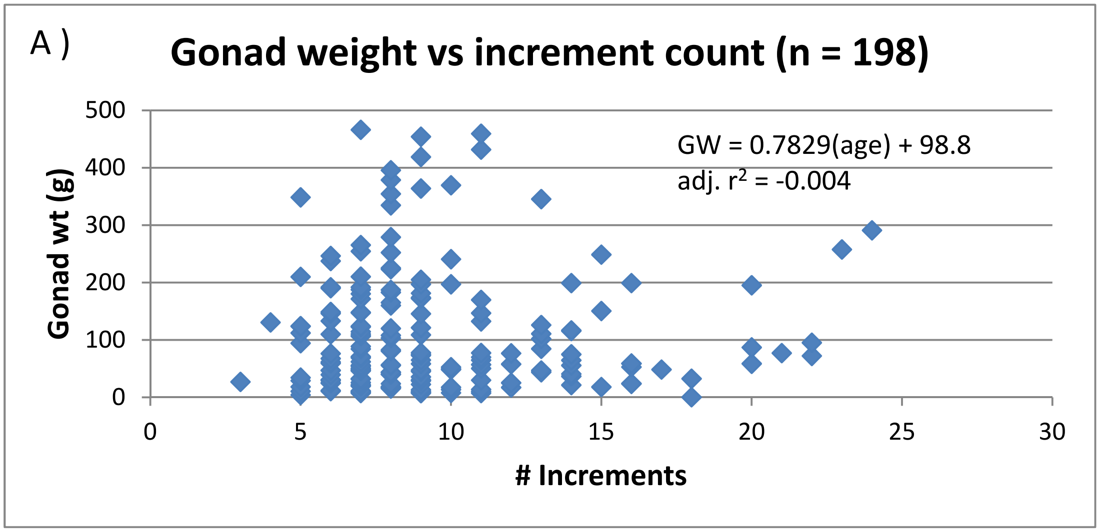
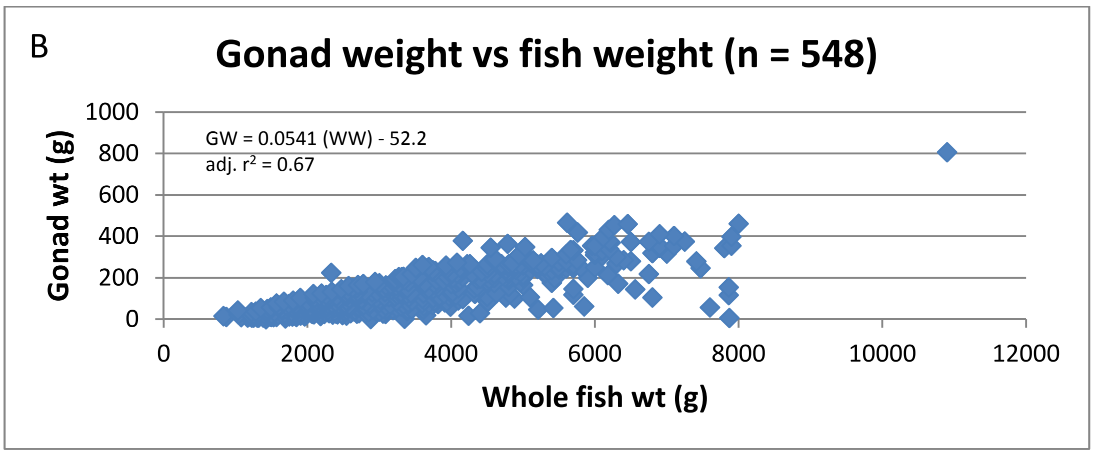


Figure 8. Proxies for an equation to estimate fecundity at age (increment count).





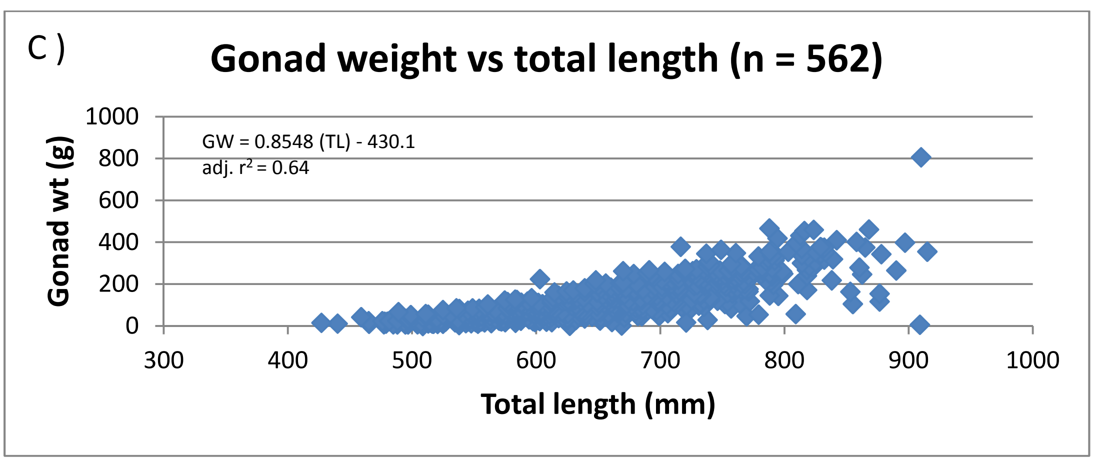


Figure 9. Age frequencies of female golden tilefish of differing maturity status (gonads categorized as immature, definitely mature [developing, spawning capable, or regressing], or regenerating/CAO. CAO = cortical alveolar oocyte. Data were collected by the MARMAP Program, Charleston, SC.

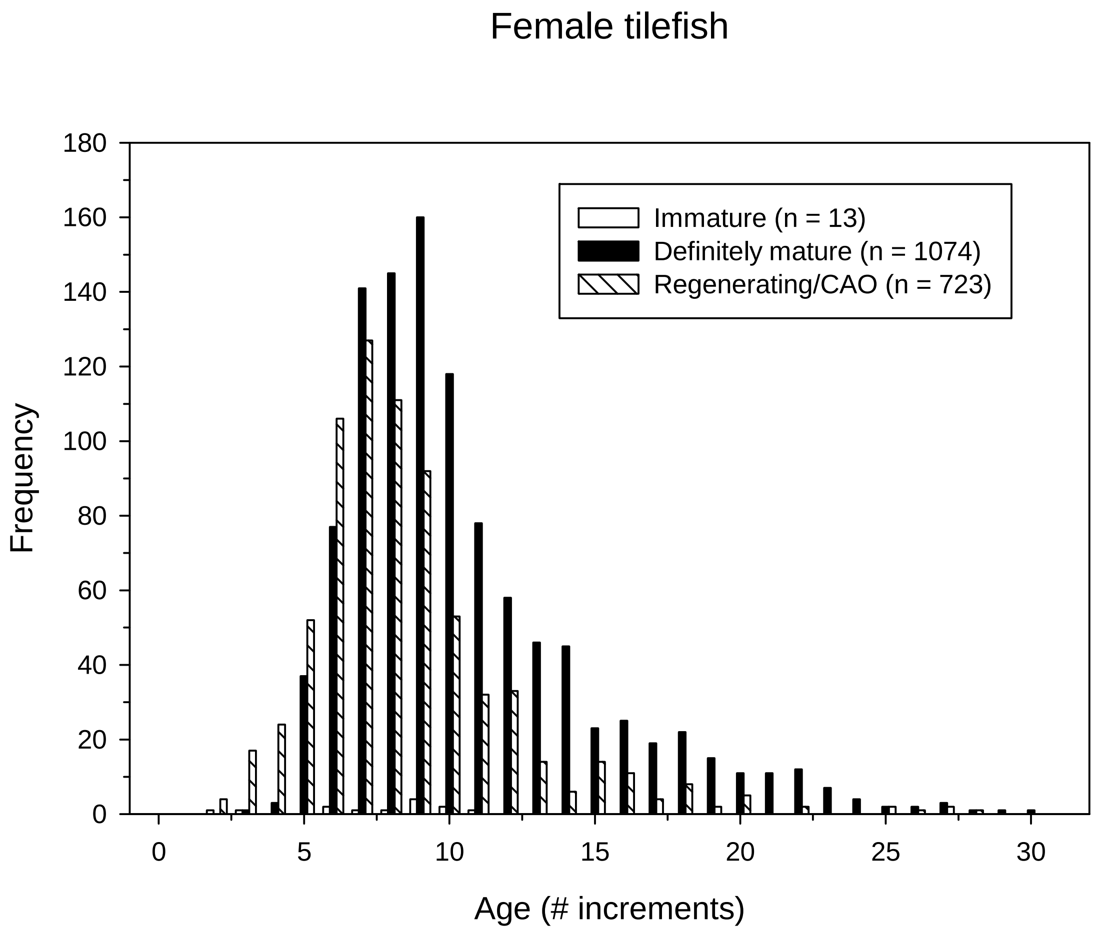


Figure 10. Proportion of female golden tilefish by growth increment based on all data (n = 4635) from the MARMAP program and the NOAA Fisheries Panama City Laboratory.

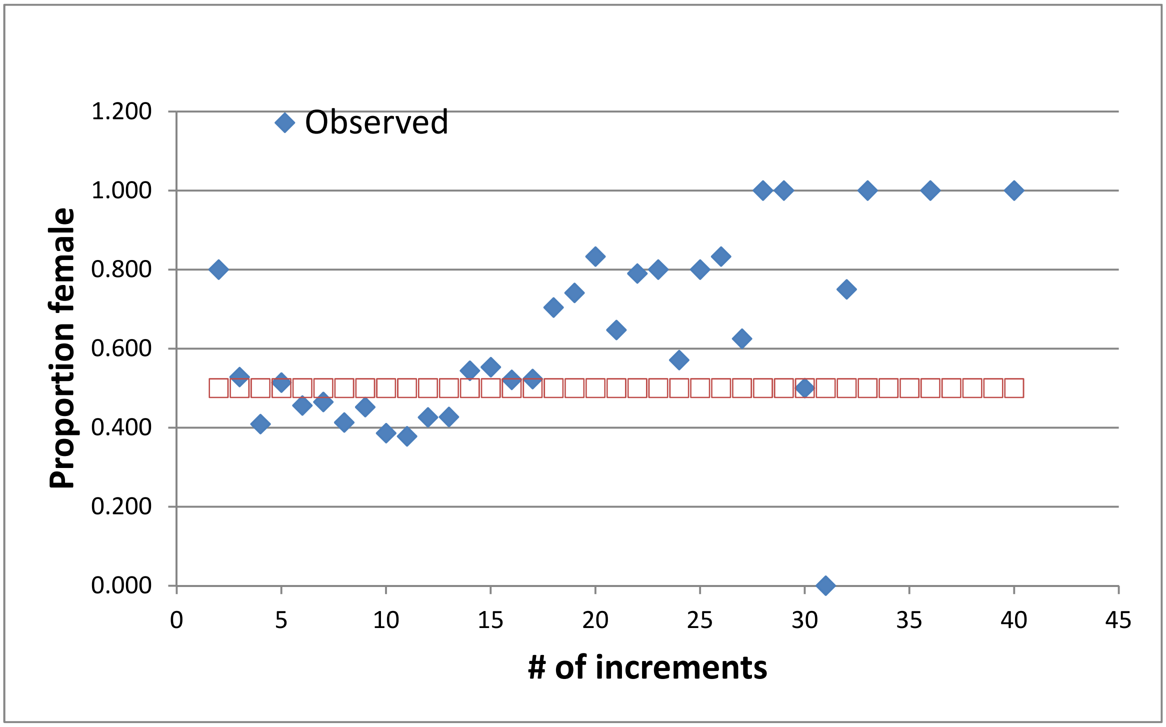


Figure 11. Proportion of female golden tilefish by growth increment in 2008-2010 based on data from the MARMAP program (n = 1205) and the NOAA Fisheries Panama City Laboratory (n = 945).

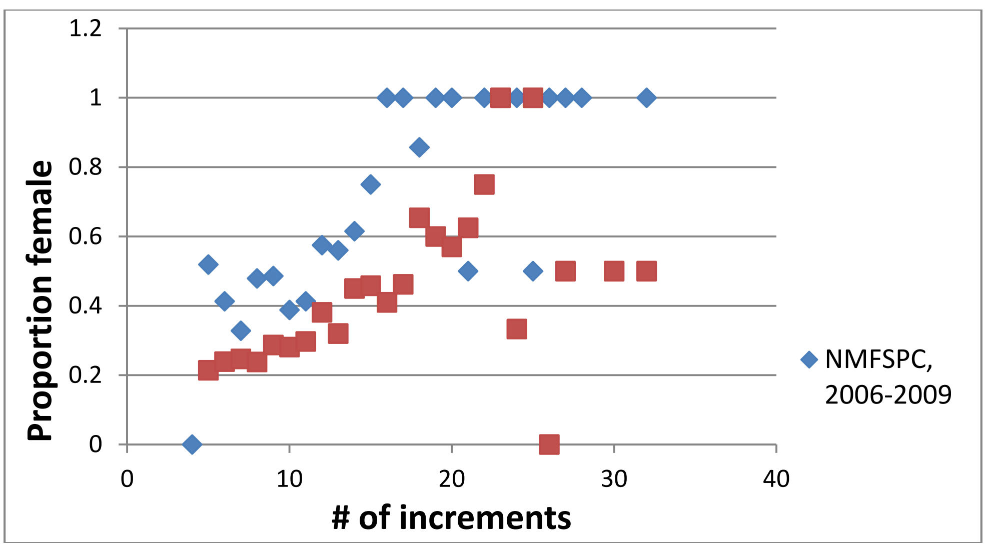


Figure 12. Proportion of female golden tilefish by month based on data from the MARMAP program and the NOAA Fisheries Panama City Laboratory. The 1996-98 data were collected by MARMAP. F-I = fishery-independent, F-D = fishery-dependent.

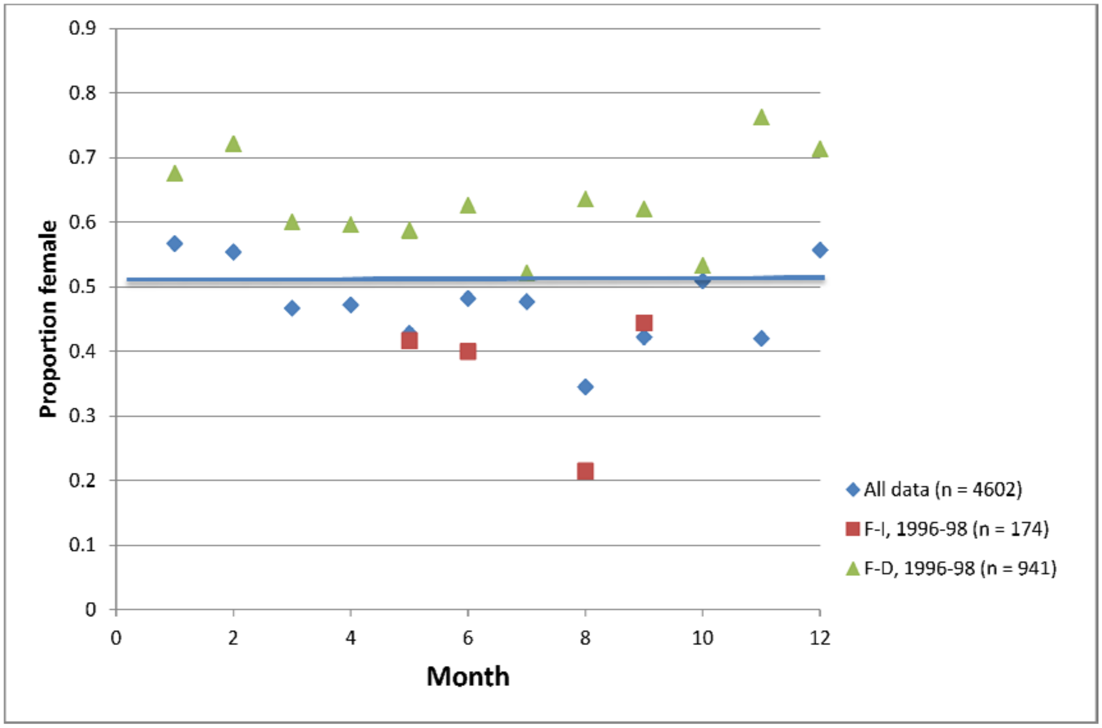
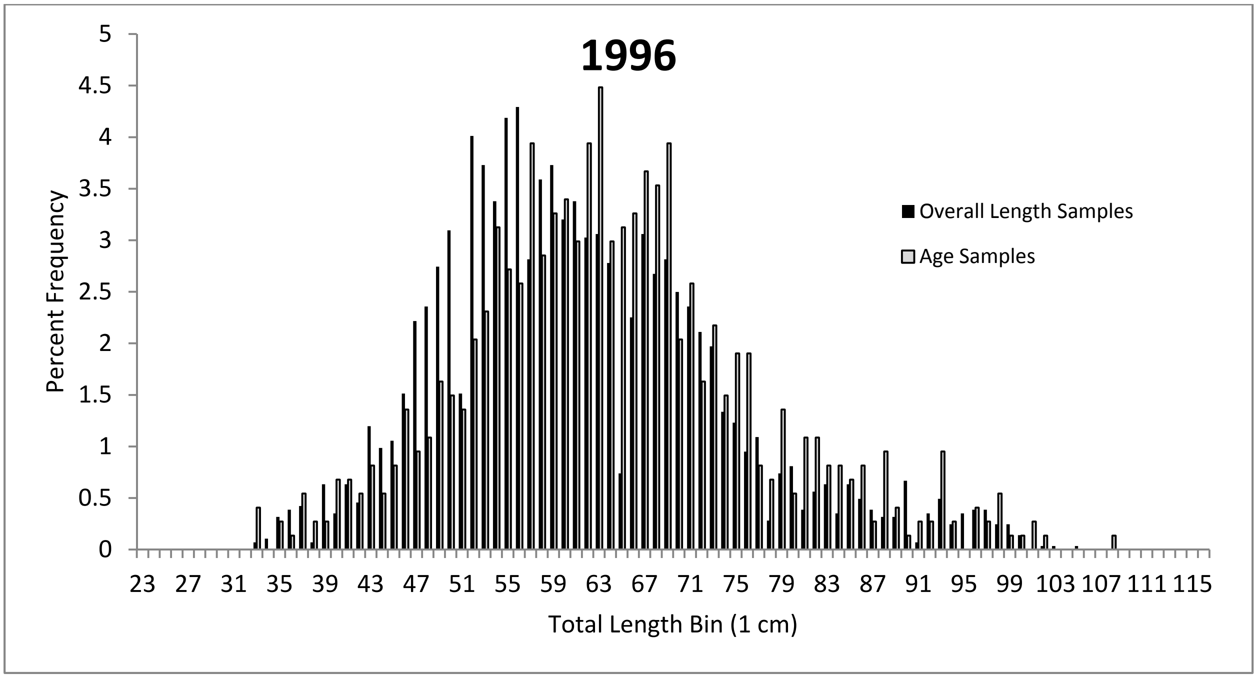


Figure 13. Length frequency of all tilefish caught on longlines and intercepted by port agents from North Carolina through the east coast of Florida versus those fish that were selected for age samples. 1996, 1998 and 1999 indicate those years were the fish selected for age samples were skewed to the largest fish in the overall sample.



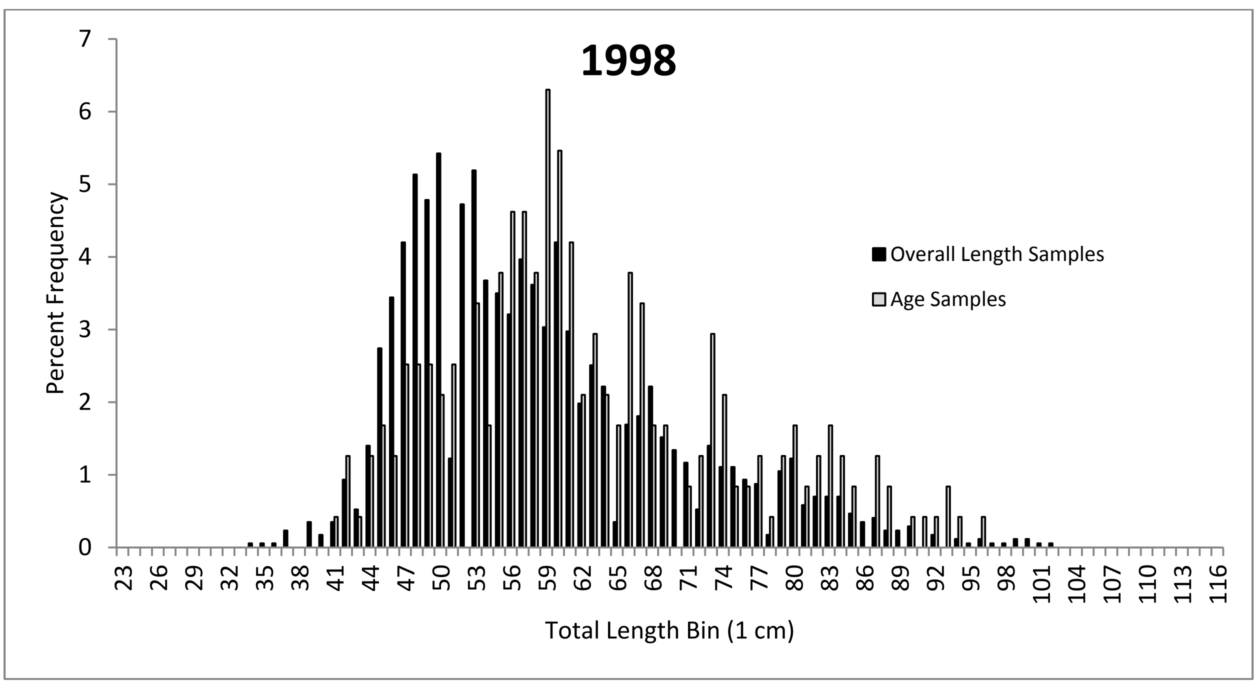
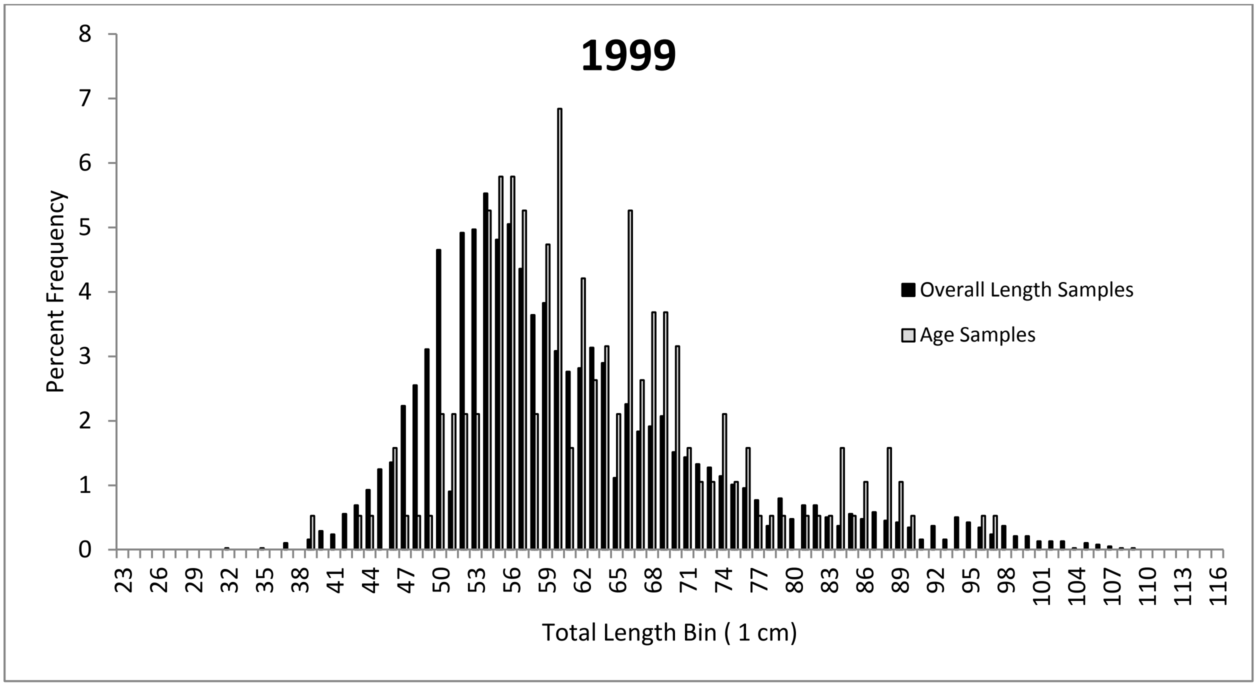


Figure 13 (cont.). Length frequency of all tilefish caught on longlines and intercepted by port agents from North Carolina through the east coast of Florida versus those fish that were selected for age samples. 1996, 1998 and 1999 indicate those years were the fish selected for age samples were skewed to the largest fish in the overall sample.



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 Carolina state line).

To develop annual landings by gear and state, adjustments were deemed necessary for misidentification or misreporting of golden tilefish with goldface tilefish and inclusion of unclassified tilefish. Commercial landings for the U.S. South Atlantic golden tilefish stock were developed by gear (long line, handline and other) in gutted weight (state specific conversions are found in Section 3.3.3) for the period 1958 through 2010 based on federal and state databases. Corresponding landings in numbers were estimated from mean weights estimated from TIP by gear, state and year for 1958 to 2010.

Discards could not be calculated for the commercial fishery due to very low sample size.

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.

3.1.1 Participants in SEDAR 25 Data Workshop Commercial Workgroup:

Erik Williams, NMFS, Beaufort, NC (co-leader)
Alan Bianchi, NC DMF, Morehead City, NC (co-leader)
David Gloeckner, NMFS, Miami, FL (co-leader – not present)
Julie Defilippi, ACCSP, Arlington, VA (rapporteur)
Tony Austin, Commercial Fisher, NC, BSB
Steve Brown, FL MRRI, St. Petersburg, FL
Claudia Dennis, NMFS, FL
Kenny Fex, Commercial Fisher, NC, BSB
Jimmy Hull, Commercial Fisher, FL, BSB
Max Zilleruelo, IFOP Chile
Joe Klosterman, Commercial Fisher, FL, GT
Chad Lee, Commercial Fisher, FL, GT
Kevin McCarthy, NMFS, Miami, FL
Dave Player, SC DNR, Charleston, SC

3.1.2 Commercial Gears Considered

Decision 1: The group discussed the gear groups used in SEDAR 4 (long line, handline and other) and determined that these categories were still characteristic of the fishery and appropriate for use in this assessment. It was noted that while there were some trawl landings, long line and handline were still the dominant gear.

This decision was approved by the plenary.

3.1.3 Stock Boundaries

DW ToR #1: Review stock structure and unit stock definitions and consider whether changes are required (Decisions 2 & 3).

Initial discussion and decisions concerned setting the geographic boundaries for the South Atlantic golden tilefish stock. The group particularly discussed the issue of using the North Carolina state line as the northern boundary. As many similar species use Cape Hatteras, which is a biogeographic boundary, the issue of the northern boundary was brought into question. The group brought the issue to plenary discussion. The life history group had no evidence to suggest changing the existing line. The Workgroup determined that an investigation of the boundary was necessary and would be put forth as a research recommendation.

Decision 2: Because no evidence exists to change the existing line, the Workgroup recommends using the VA/NC line as the northern boundary for the South Atlantic golden tilefish stock.

This decision was approved by the plenary.

The Commercial Workgroup considered the southern boundary and determined that Monroe County, FL would be used as the dividing line between the South Atlantic and Gulf Stocks. Prior to 1996, landings would include all of Monroe County. From 1996 to 2010, only South Atlantic landings from Monroe Country would be included. This decision is based on the granularity of data available. The trip ticket data provide more detailed information and were not required until 1995. The data are considered reliable for this purpose from 1996.

Decision 3: The Workgroup recommends using Monroe County, FL inclusive as the southern boundary for the South Atlantic golden tilefish stock.

This decision was approved by the plenary.

Maps of the entire fishing area and specific areas in Florida can be found in Figures 3.1 and 3.2.

3.2 Review of Data Workshop Reports Assigned to Commercial Workgroup:

SEDAR25DW19: This report presents a description of commercial discards for both golden tilefish and black sea bass. As commercial discards could not be calculated for golden tilefish, the Workgroup had no discussion on this topic.

SEDAR25DW22: This report presents a description of the length composition sampling from the Trip Interview Program from 1981 to 2010. Specific methodologies are described in Section 3.4. The Commercial Workgroup recommended the use of these data and determined that they are representative for the species.

3.3. Characterizing Commercial Landings

DW ToR #8: Provide commercial catch statistics, 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 or gear. Provide length and age distributions if feasible. Provide maps of fishery effort and harvest. (Decisions 4-7)

3.3.1 Misidentification and Unclassified Tilefish

The next topics of discussion included whether misidentification of golden tilefish with other tilefish species was a concern and whether golden tilefish landings may be incorporated in significant quantities in the unclassified tilefish category. Both of these issues were considered significant by the SEDAR 4 Commercial Workgroup. The current Workgroup discussed and agreed with this decision.

During examination of the landings, it was noted that goldface tilefish appeared in North Carolina in 1986 and 1987. Based on discussion of the decision in SEDAR 4 to treat these as golden tilefish landings, the group determined that previous reasoning was sound and the previous decision should hold.

Decision 4: The Workgroup concurs with prior SEDAR 4 decision to treat goldface tilefish landings from North Carolina in 1986 and 1987 as golden tilefish.

This decision was approved by the plenary.

Inclusion of golden tilefish landings in unclassified tilefish landings pertained to landings from North Carolina and Georgia. There was discussion of the proportioning of unclassified landings into golden and blueline tilefish, as was done in SEDAR 4. The group determined that this course of action remained appropriate and that the group would proportion landings based on the following set of guidelines. Data were originally queried by state, year, species/species group (golden, blueline and unclassified), and gear. For each row of data, if data existed for golden, blueline and unclassified, then unclassified landings would be proportioned by the ratio of existing golden to blueline data. This application applied to rows from North Carolina for 1985-1993 and from Georgia for 1985-1995. In rare cases where golden and blueline data did not exist for some, but not all, gear categories this line was dropped from the analysis. This situation occurred for 6 rows of data from North Carolina and 1 row from Georgia. The dropped landings were insignificant compared to annual state totals for the year. For Georgia 1984, no golden or blueline data existed in any gear category so unclassified tilefish landings by gear for that year were proportioned based on the average proportion from 1985 to 1995. Upper and lower limits of data were calculated as plus or minus two standard deviations respectively.

Decision 5: The Workgroup concurs with SEDAR 4 decision to proportion unclassified tilefish landings. This method will be applied to North Carolina landings from 1985 to 1993 and Georgia landings from 1984-1995.

This decision was approved by the plenary.

3.3.2 Time Series for Commercial Landings

Next, the time series for commercial landings was discussed. Landings for SEDAR 4 were presented back to 1962. The Workgroup made the decision to examine landings back to 1950 because these data were available and considered reliable. Compiled data revealed that only minimal landings (<500 lbs for North Carolina in 1958 and 1959) were reported. It was decided that all available landings would be presented.

Decision 6: The Commercial Workgroup decided to provide all available data from 1950 to 2010.

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 all species on the Atlantic coast are maintained in the Atlantic Coastal Cooperative Statistics Program (ACCSP) Data Warehouse. The Data Warehouse is on-line database of fisheries dependent data provided by the ACCSP state and federal partners. Data sources and collection methods are illustrated by state in Figure 3.3. The Data Warehouse was queried in April 2011 for all golden, blueline, goldface and unclassified tilefish landings (annual summaries by state and gear category) from 1950 to present for Florida (east coast including Monroe County), Georgia, South Carolina and North Carolina (ACCSP, 2011). Data are presented using the gear categories as determined at the workshop. The specific ACCSP gears in each category are listed in Table 3.1. Commercial landings in pounds (gutted weight) were developed based on methodologies for species and gear as defined by the Working Group for each state as available by gear for 1958-2010.

Conversions between whole and gutted weight are based on state specific values. When landings were reported in whole weights, the gutted weight was calculated based on the conversion factors provided by each state. North Carolina and Georgia whole weight landings were divided by 1.09, Florida by 1.12 and South Carolina by 1.1.

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 golden tilefish landings by year, and gear with pounds (gutted weight) from Florida South Atlantic waters (Monroe county landings in total if before 1996; landings from Atlantic fishing zones for Monroe county thereafter). Gear categories include long line, handline and other/unknown. Gear for pre-1992 landings was proportioned from 1992-2001 averages by gear. There were no issues with unclassified landings. Florida trip ticket did not allow reporting of unclassified tilefish and a code specific to golden tilefish has been in use since the beginning of the trip ticket program.

NMFS logbook data were evaluated and it was decided to use Florida trip ticket data from 1986 forward for landings, area and gear distributions, and NMFS ALS landings from data prior to 1986. While landings and gear distributions from logbook data were nearly identical to Florida trip ticket data for most years, the logbook data did not start until 1992.

Georgia – GA DNR staff examined ACCSP landings and compared them to state held versions. It was determined that ACCSP landings were a match and would be used in place of state provided data for the entire time series.

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 made. The landings are broken down by species, gear type, and area fished. The ALS data base was used to extend landings back to 1962.

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 25 Data Workshop. North Carolina commercial landings of golden tilefish were provided for 1972-2010 by year and gear type. Gears were grouped into the following categories: Handlines, Long lines, and Others.

Combined State Results –Landings by gear category are presented in Table 3.2 and Figure 3.4. Long lines have been the dominant gear and account for 84.1% of landings over the period with handline making up 13.9% and other gears accounting for only 2%.

Decision 7: The Workgroup made the following decisions for reporting of commercial landings:

- Landings should be reported as gutted weight (rather than whole)
- Landings by state should be separated into Florida (South Atlantic)/Georgia, South Carolina and North Carolina to maintain confidentiality for Georgia landings.
- Final landings data would come from the following sources:
  - NC:
  - 1958-1993 (ACCSP)
  - 1994-2010 (NC DMF)
  - SC:
  - 1958-1979 (ACCSP)
  - 1980-2010 (SC DNR)
  - GA:
  - 1958-2010 (ACCSP)
  - FL:
  - 1958-1985 (ACCSP)
  - 1986-2010 (FL trip ticket)

Whole vs Gutted Weight – The Commercial Workgroup discussed the topic of what units to use to report commercial landings. Golden tilefish are typically landed gutted and converted by the states to whole weight. For this analysis, landings were provided in gutted weight. Landings stored as whole weight were converted back to gutted weight using the state specific conversions given earlier.

This decision was approved by the plenary.

Confidentiality Issues – The Commercial Workgroup agreed that it was necessary 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 Florida to meet the rule of 3.

This decision was approved by the plenary.

3.2.4 Converting Landings in Weight to Landings in Numbers

Length was converted to weight (whole weight in pounds) using conversions provided by the life history group for the SEDAR 4 Stock Assessment Report 1 (SEDAR, 2004). The weight in pounds for each sample was calculated and the mean weight by gear and year (weighted by weight of fish in the sample at length in pounds whole weight, trip weight in pounds whole weight and landing weight in pounds whole weight) were calculated. Where the sample size was less than 20, the mean across all years for that gear was used (Table 3.3). The landings in pounds whole weight were then divided by the mean weight for that stratum to derive landings in numbers (Table 3.4).

3.3 Commercial Discards

Tilefish discards could not be calculated for the commercial fishery due to very low sample size. Fewer than 10 trips reported tilefish discards during the period 2002-2010. That total included all commercial fishing gears. Several factors suggest that few tilefish are discarded in the commercial fishery. Tilefish have very specific habitat requirements and commercial fishermen report that they are able to eliminate bycatch of tilefish during closed seasons by avoiding known tilefish habitat. Barotrauma likely results in high fishing mortality because tilefish habitat is relatively deep (300 feet or deeper) and those fish were retained rather than discarded dead. In addition, there is no minimum size for tilefish. Given the rare reporting of tilefish discards, the ease with which tilefish bycatch can be avoided, the likely high mortality of caught fish, and the lack of minimum size which would require discarding; the working group recognized that tilefish discards are probably few in number and were unlikely to affect the assessment.

Decision 8: The Commercial Workgroup reported the above information to the plenary and recommended that no discard information be calculated.

This decision was approved by the plenary.

3.4 Biological Sampling

Biological sample data were obtained from the TIP sample data at NMFS/SEFSC. Data were filtered to eliminate those records that included a size or effort bias, non-random collection of length data, were not from commercial trips, fish were selected by quota sampling or the data were not collected by the TIP program. Codes are embedded in TIP to allow the identification of these records.

- IF SAMPLE_METHOD_TYPE = ‘QUOTA SAMPLING’ THEN DELETE
- IF IS_RANDOM = ‘NO’ THEN DELETE;
- IF SUB_SAMPLE_IS_RANDOM = ‘NO’ THEN DELETE IF TRIP WAS SUB SAMPLED
- IF FISHING_MODE NOT EQUAL TO ‘COMMERCIAL’ THEN DELETE
- IF INTERVIEW_TYPE = ‘OBSERVER’ THEN DELETE (NOT PART OF TIP PROGRAM)
- IF BIAS_TYPE = ‘SIZE BIAS’ OR ‘SIZE AND EFFORT BIAS’ THEN DELETE

These data were further limited to those that could be assigned a year, gear, and state. Data that had an unknown sampling year, gear, or sampling state were deleted from the file. These data must be weighted by trip, so where no trip landings data were available, the sample was excluded. TIP data must also be weighted spatially by the landings for the particular year, state and gear stratum. TIP data were joined with landings data by year, gear, and state. Landings data were also limited to only those data that could be assigned a year, gear, and state. Landings and biological data were assigned a state based on landing location or sample location if there was no landing location assigned. Records were the length was greater than 3 standard deviations from the mean length for the year, gear and state were eliminated as outliers.

3.4.1 Sampling Intensity for Lengths

The number of trips with useable samples ranged from a high of 141 for hand line gear in 1993 to a low of zero for other gear in most years (Table 3.5). The number of trips with useable samples was consistently greater than 10 trips for long line gear except 1987-1990. Hand line trips with useable samples were consistently less than 10 trips except for 2002 (13). Other gears were rarely sampled. Table 3.5 displays number of trips that caught golden tilefish, number of trips targeting golden tilefish, number of valid samples and number of samples used (trip weights available).

The number of fish sampled had a high of 26,441 for long line gear in 1993 to lows of zero for many years in the other gear (Table 3.6). The number of lengths sampled was predominantly greater than 100 for long line, while hand line gear only had samples of greater than 100 for 1991, 1995, 2000, 2002 and 2005. For other gears, the numbers of length samples available were all below 100, as there were only samples available in 1997 and 2007. Table 3.6 displays the number of lengths used and the number and reason for those not used by year for each gear. An improvement to the number of useable lengths could be accomplished by ensuring that samplers enter the trip landing weights for fish that are sampled.

3.4.2 Length/Age Distribution

All lengths were converted to TL in mm using the formula provided in the SEDAR 4 Stock Assessment Report 1 (SEDAR, 2004) and binned into one centimeter groups with a floor of 0.6 cm and a ceiling of 0.5 cm. The length data and landings data were divided into hand line, long line, and other gears. Length compositions were weighted by the trip landings in numbers and the landings in numbers by strata (state, year, gear). Annual length compositions of golden tilefish are summarized in Figures 3.5-3.7.

Sample size of tilefish ages are summarized by gear from commercial landings in the U.S. South Atlantic for 1980-2010 (Table 3.8). Age compositions were developed for handline (1984-2010 with exceptions in Figure 3.8) and long line (1984-2010 with exceptions in Figure 3.9) gear types. Weighting is by length compositions shown in Figures 3.5 and 3.6, respectively. This corrects for a potential sampling bias of age samples relative to length samples (see Section 3 in SEDAR10 for South Atlantic gag).

3.4.3 Adequacy for characterizing lengths

Length sampling has been inadequate for gears other than hand line and long line for a large fraction of years. Sampling fractions are less than 0.05 for many years in the hand line and long line gear categories. Sample size needs to be paid particular attention when using the length compositions. Length sampling fractions are displayed in Table 3.7. The number of samples for other gears may indicate that length compositions for this gear category should be supplemented with hand line and long line length compositions to obtain a reasonable sample size.

3.6 Research Recommendations for golden tilefish

DW ToR #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.*

Decision 10. The Workgroup determined the following recommendations be added to any pending recommendations issued in SEDAR 4 that have not been addressed.

The Commercial Workgroup recommends exploration of the definition of the stock, particularly with respect to the northern boundary. Additionally, the group would suggest examining the impact/landings of the historical foreign fleet in the South Atlantic. Finally, collection of better spatial information in the fishery to determine potential localized depletion effects is recommended.

These recommendations were approved by the plenary.

3.7 References

Atlantic Coastal Cooperative Statistics Program. 2011. (1950-2010) Annual landings by state and custom gear category; generated by Julie Defilippi; using ACCSP Data Warehouse, Arlington, VA: accessed April, 2011.

SEDAR. 2004. Stock Assessment of the Deepwater Snapper-Grouper Complex in the South Atlantic: SEDAR 4 Stock Assessment Report 1.

(http://www.sefsc.noaa.gov/sedar/download/SEDAR4-FinalSAR%20200606.pdf?id=DOCUMENT).

Addendum to Commercial Landings (Section 3.2):

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 database 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 database.

1960 - Late 1980s

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Although the data processing and database 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 database 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

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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.

Table 3.1. Specific ACCSP gears in each gear category for golden tilefish commercial landings.

ACCSP_GEAR_CODE	ACCSP_GEAR_NAME	ACCSP_TYPE_NAME	SEDAR25_GEAR_CATEGORY
000	NOT CODED	NOT CODED	OTHER
092	OTTER TRAWL BOTTOM, FISH	TRAWLS	OTHER
094	OTTER TRAWL BOTTOM, SCALLOP	TRAWLS	OTHER
095	OTTER TRAWL BOTTOM, SHRIMP	TRAWLS	OTHER
110	OTHER TRAWLS	TRAWLS	OTHER
139	POTS AND TRAPS, FISH	POTS AND TRAPS	OTHER
301	HOOK AND LINE, MANUAL	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
403	LONG LINES, BOTTOM	LONG LINES	LONG LINES
404	LONG LINES, SURFACE, MIDWATER	LONG LINES	LONG LINES
700	HAND LINE	HAND LINE	HAND LINE
701	TROLL AND HAND LINES CMB	HAND LINE	HAND LINE
802	COMBINED GEARS	OTHER GEARS	OTHER

Table 3.2. Golden tilefish landings (pounds gutted weight) by gear (long line, handline and other) from the U.S. South Atlantic, 1958-2010.

Year	Gutted Weight	Longline	Other	Handline
1958	367			367
1959	275		92	183
1962	3,403	2,553	442	408
1963	3,219	2,553	258	408
1964	999	300	651	48
1965	23,304	19,601	574	3,129
1966	4,375	3,680	108	587
1967	10,357	8,711	255	1,391
1968	6,339	5,332	156	851
1969	5,179	4,356	128	695
1970	10,268	8,636	253	1,379
1971	19,018	15,996	469	2,553
1972	11,339	9,537	280	1,522
1973	39,732	33,418	979	5,334
1974	90,268	75,924	2,225	12,119
1975	155,539	130,670	3,829	21,039
1976	151,718	126,615	3,711	21,392
1977	88,494	61,355	1,981	25,158
1978	183,694	81,279	21,653	80,762
1979	170,089	110,178	6,036	53,875
1980	326,401	174,613	5,845	145,943

1981	1,118,096	763,533	28,756	325,807
1982	3,371,136	2,714,197	73,157	583,782
1983	1,893,433	1,601,929	32,806	258,698
1984	1,310,963	1,092,149	19,076	199,737
1985	1,136,897	970,528	22,253	144,116
1986	1,119,460	965,388	22,930	131,142
1987	272,094	243,839	3,855	24,400
1988	502,947	444,689	8,921	49,337
1989	836,526	727,344	18,634	90,548
1990	843,886	744,318	15,041	84,527
1991	905,060	781,196	45,673	78,191
1992	968,902	815,720	78,238	74,944
1993	1,037,199	835,539	36,588	165,072
1994	807,444	700,382	1,879	105,183
1995	674,176	591,154	347	82,675
1996	344,960	310,936	*	34,024
1997	362,472	324,024	4,763	33,685
1998	363,464	333,649	1,005	28,811
1999	511,875	468,268	5,946	37,661
2000	721,062	662,423	4,795	53,844
2001	428,124	388,414	1,275	38,435
2002	425,678	368,099	*	57,579
2003	240,995	222,226	10	18,759
2004	261,005	231,671	233	29,101
2005	307,178	265,752	*	41,426

2006	406,070	379,260	231	26,579
2007	310,317	260,561	10	49,746
2008	334,390	300,497	*	33,893
2009	328,089	300,673	*	27,416
2010	365,939	335,747	*	30,192

Table 3.3. Mean weights in pounds whole weight used to derive landings in numbers by year and gear.

	GEAR		
YEAR	HAND LINES	LONG LINES	OTHER
1983	11.891	11.545	11.478
1984	11.891	14.654	11.478
1985	13.484	13.914	11.478
1986	11.952	12.274	11.478
1987	13.330	13.408	11.478
1988	11.891	11.125	11.478
1989	11.891	12.726	11.478
1990	11.891	13.573	11.478
1991	13.226	10.747	11.478
1992	11.891	11.671	11.478
1993	21.079	10.940	11.478
1994	7.474	8.497	11.478
1995	9.743	9.521	11.478
1996	11.891	11.668	11.478
1997	11.274	10.667	11.477
1998	13.328	8.735	11.478
1999	20.899	10.301	11.478
2000	9.629	9.951	11.478
2001	19.484	10.419	11.478
2002	15.849	11.320	11.478

2003	11.891	7.757	11.478
2004	11.891	14.814	11.478
2005	20.285	11.837	11.478
2006	9.597	13.760	11.478
2007	11.891	12.257	11.478
2008	11.891	12.487	11.478
2009	11.891	14.487	11.478
2010	11.891	13.868	11.478

Table 3.4. Commercial landings by gear and year in numbers (thousands)

	GEAR		
YEAR	HAND LINES	LONG LINES	OTHER
1983	24.366	155.408	3.201
1984	18.813	83.473	1.861
1985	11.970	78.125	2.172
1986	12.289	88.094	2.238
1987	2.050	20.369	0.376
1988	4.647	44.770	0.871
1989	8.528	64.011	1.818
1990	7.916	61.420	1.468
1991	6.621	81.413	4.457
1992	7.059	78.281	7.634
1993	8.771	85.538	3.570
1994	15.763	92.321	0.183
1995	9.503	69.543	0.034
1996	3.205	29.846	**
1997	3.346	34.020	0.465
1998	2.421	42.782	0.098
1999	2.018	50.912	0.580
2000	6.263	74.559	0.468
2001	2.209	41.753	0.124
2002	4.069	36.420	**

2003	1.767	32.087	0.001
2004	2.741	17.516	0.023
2005	2.287	25.144	**
2006	3.102	30.869	0.023
2007	4.685	23.809	0.001
2008	3.192	26.953	**
2009	2.582	23.245	**
2010	2.844	27.116	**

**=data deemed confidential have been removed

Table 3.5. Number of trips from logbooks landing any amount of golden tilefish, where golden tilefish was targeted (golden tilefish was at least 30% of catch) and the number of trips with valid samples (no biases) and number of trips with samples usable for analysis of length composition (trip weights available) by year and gear.

YEAR	HAND LINES				LONG LINES				OTHER			
	ALL LOGBOOK	LOGBOOK TARGET	TRIPS WITH VALID SAMPLES	TRIPS WITH SAMPLES FOR ANALYSIS	ALL LOGBOOK	LOGBOOK TARGET	TRIPS WITH VALID SAMPLES	TRIPS WITH SAMPLES FOR ANALYSIS	ALL LOGBOOK	LOGBOOK TARGET	TRIPS WITH VALID SAMPLES	TRIPS WITH SAMPLES FOR ANALYSIS
1983			0	0			0	0			0	0
1984			2	2			24	24			0	0
1985			6	6			37	37			0	0
1986			2	2			25	25			0	0
1987			2	2			7	7			0	0
1988			1	1			8	8			0	0
1989			1	1			5	5			0	0
1990			4	1			7	7			0	0
1991	0	0	7	7	**	**	40	40	0	0	0	0

YEAR	HAND LINES				LONG LINES				OTHER			
	ALL LOGBOOK	LOGBOOK TARGET	TRIPS WITH VALID SAMPLES	TRIPS WITH SAMPLES FOR ANALYSIS	ALL LOGBOOK	LOGBOOK TARGET	TRIPS WITH VALID SAMPLES	TRIPS WITH SAMPLES FOR ANALYSIS	ALL LOGBOOK	LOGBOOK TARGET	TRIPS WITH VALID SAMPLES	TRIPS WITH SAMPLES FOR ANALYSIS
1992	68	35	1	1	251	219	100	100	**	**	0	0
1993	176	71	3	3	641	545	141	141	14	**	0	0
1994	213	141	2	2	528	438	59	59	15	**	0	0
1995	229	132	5	5	453	361	64	64	6	**	2	0
1996	176	82	2	2	327	250	30	30	8	**	0	0
1997	250	125	5	5	295	188	19	19	**	**	1	1
1998	185	117	2	2	253	190	15	15	**	**	0	0
1999	243	169	8	8	263	203	26	26	38	26	0	0
2000	334	237	8	8	341	286	13	13	34	20	0	0
2001	169	81	7	7	282	223	23	23	**	**	0	0
2002	298	197	13	13	247	184	19	19	22	11	0	0
2003	170	92	1	1	211	153	10	10	**	**	0	0
2004	193	136	1	1	142	106	15	15	**	**	1	0

2005	224	163	5	5	118	89	16	16	13	6	2	0
2006	165	101	2	2	149	116	36	36	17	9	0	0
2007	302	228	1	1	**	**	35	35	**	**	1	1
2008	144	109	1	1	**	**	20	20	22	6	6	0
2009	117	78	1	1	**	**	25	25	5	**	2	0
2010	126	106	2	2	212	209	24	24	11	**	13	0

**=data deemed confidential have been removed

Table 3.6a. Number of length samples (fish measured) retained for length composition and number of length samples deleted and reason by year and state for hand line gear.

	NO LANDINGS				NO TRIP WEIGHTS				NON-COMMERCIAL				OUTLIER LENGTH				SIZE BIAS				TOTAL	RETAINED				
YEAR	FL	GA	NC	SC	FL	GA	NC	SC	FL	GA	NC	SC	FL	GA	NC	SC	FL	GA	NC	SC	EXCLUDED	FL	GA	NC	SC	TOTAL
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	16	19
1985	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	41	10	1	52
1986	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	78	79
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	58	0	0	58
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5
1990	0	0	11	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	3	3
1991	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	121	12	1	0	134
1992	0	0	0	0	19	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	41	8	0	0	0	8
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	52	0	54
1994	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	68	0	0	0	68
1995	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	438	0	0	0	438
1996	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	13	0	0	0	13

1997	0	0	0	0	95	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	98	84	0	0	0	84
1998	0	0	0	0	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	43	0	0	0	43
1999	0	0	0	0	57	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	58	81	0	0	3	84
2000	0	0	0	0	530	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	532	322	0	0	0	322
2001	0	0	0	0	296	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	296	66	0	0	0	66
2002	0	0	0	0	205	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	209	160	0	0	0	160
2003	0	0	0	0	76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	76	0	0	0	1	1
2004	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	1
2005	0	0	0	0	42	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	43	103	0	0	0	103
2006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	52	59
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	7
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	13

Table 3.6b. Number of length samples (fish measured) retained for length composition and number of length samples deleted and reason by year and state for long line gear.

YEAR	NO TRIP WEIGHTS				NON-COMMERCIAL				NONRANDOM SAMPLE				OUTLIER LENGTH				SIZE BIAS				TOTAL	RETAINED				
	FL	GA	NC	SC	FL	GA	NC	SC	FL	GA	NC	SC	FL	GA	NC	SC	FL	GA	NC	SC	EXCLUDED	FL	GA	NC	SC	TOT
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	804	288	1,243	2,33
1985	0	0	98	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	99	4,819	24	0	424	5,26
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1,735	0	172	3,428	5,33
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	172	312	484
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	253	0	591	213	1,05
1989	0	0	501	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	501	0	0	328	0	328
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0	360	355	738
1991	0	0	369	364	0	0	0	0	0	0	0	0	0	0	0	0	186	0	0	0	919	3,529	584	1,102	76	5,29
1992	124	0	217	1,423	0	0	51	0	0	0	0	0	1	0	0	0	22	0	0	0	1,838	11,121	192	1,070	175	12,5
1993	1,843	0	88	786	0	0	0	0	0	0	0	0	9	0	2	0	203	0	0	0	2,931	25,930	58	452	1	26,4
1994	1,223	0	98	662	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,983	9,547	41	253	102	9,94
1995	2,171	33	0	1,373	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3,578	7,328	0	145	0	7,47

1996	92	0	1	994	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,087	1,827	0	20	0	1,84
1997	45	0	0	1,126	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	1,174	1,193	0	79	116	1,38
1998	242	0	0	591	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	833	881	0	0	0	881
1999	0	0	0	951	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	955	2,807	0	0	0	2,80
2000	2,186	0	0	1,202	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,388	1,300	0	303	0	1,60
2001	8	0	292	409	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	710	1,301	0	15	172	1,48
2002	62	0	0	928	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	990	987	0	0	0	987
2003	29	0	0	410	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	439	254	0	0	0	254
2004	0	0	0	439	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	440	158	0	198	0	356
2005	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	312	0	0	92	404
2006	4	0	0	63	0	0	0	0	34	0	0	0	0	0	0	0	0	0	0	0	101	567	0	0	254	821
2007	0	0	0	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	945	0	0	0	945
2008	0	0	0	23	0	0	0	0	90	0	0	0	1	0	0	0	0	0	0	0	114	554	0	0	0	554
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	682	0	0	198	880
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	528	0	0	175	703

Table 3.6c. Number of length samples (fish measured) retained for length composition and number of length samples deleted and reason by year and state for other gear.

YEAR	NO LANDINGS				NO TRIP WEIGHTS				NONRANDOM SAMPLE				TOTAL	NONE				
	FL	GA	NC	SC	FL	GA	NC	SC	FL	GA	NC	SC	EXCLUDED	FL	GA	NC	SC	TOTAL
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	11	0	0	80	0	0	0	0	91	0	0	0	0	0

1994	0	0	0	0	23	0	0	0	0	0	0	0	23	0	0	0	0	0
1995	356	0	0	0	174	0	0	0	0	0	0	0	530	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	18	0	0	0	0	0	0	0	18	70	0	0	0	70
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	102	0	0	0	0	0	0	0	102	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	104	0	0	0	0	0	0	0	104	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	47	0	0	0	208	0	0	0	14	0	0	0	269	0	0	0	0	0
2005	20	0	0	0	221	0	0	0	0	0	0	0	241	0	0	0	0	0
2006	0	0	0	0	211	0	0	0	0	0	0	0	211	0	0	0	0	0
2007	0	0	0	0	315	0	0	0	0	0	0	0	315	24	0	0	0	24
2008	146	0	0	0	16	0	0	0	0	0	0	0	162	0	0	0	0	0
2009	54	0	0	0	0	0	0	0	0	0	0	0	54	0	0	0	0	0
2010	377	0	0	0	0	0	0	0	0	0	0	0	377	0	0	0	0	0

Table 3.7. Commercial length sampling fractions (number of fish lengths used for length composition/landings in numbers) by gear and year.

	GEAR		
YEAR	HAND LINES	LONG LINES	OTHER
1983	0.000	0.000	0.000
1984	0.001	0.028	0.000
1985	0.004	0.067	0.000
1986	0.006	0.061	0.000
1987	0.028	0.024	0.000
1988	0.001	0.024	0.000
1989	0.001	0.005	0.000
1990	0.000	0.012	0.000
1991	0.020	0.065	0.000
1992	0.001	0.160	0.000
1993	0.006	0.309	0.000
1994	0.004	0.108	0.000
1995	0.046	0.107	0.000
1996	0.004	0.062	**
1997	0.025	0.041	0.151
1998	0.018	0.021	0.000
1999	0.042	0.055	0.000
2000	0.051	0.021	0.000
2001	0.030	0.036	0.000
2002	0.039	0.027	**

2003	0.001	0.008	0.000
2004	0.000	0.020	0.000
2005	0.045	0.016	**
2006	0.019	0.027	0.000
2007	0.000	0.040	1.000
2008	0.000	0.021	**
2009	0.003	0.038	**
2010	0.005	0.026	**

**=data deemed confidential have been removed

Table 3.8. U.S. South Atlantic commercial tilefish age samples by gear and year. No age samples were available from the gear labeled as "other."

YEAR	LONG LINES	HAND LINES
1980	-	79
1981	-	578
1982	10	186
1983	61	128
1984	137	16
1985	47	20
1986	24	3
1987	28	3
1988	-	-
1989	-	-
1990	-	-
1991	-	-
1992	124	8
1993	209	1
1994	8	8
1995	373	-
1996	782	-
1997	908	143
1998	269	61
1999	350	35

2000	338	222
2001	296	46
2002	57	202
2003	177	61
2004	264	255
2005	410	255
2006	842	214
2007	1153	275
2008	1172	50
2009	1542	86
2010	989	67

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

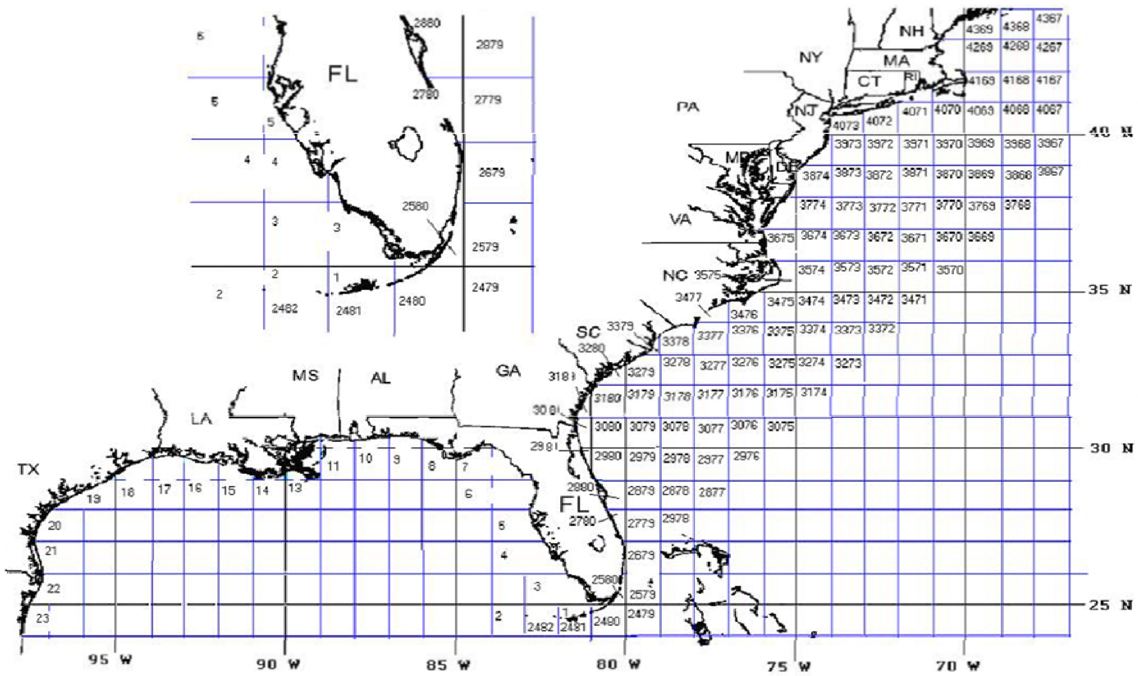


Figure 3.2. Map showing marine fisheries trip ticket fishing area code map for Florida.

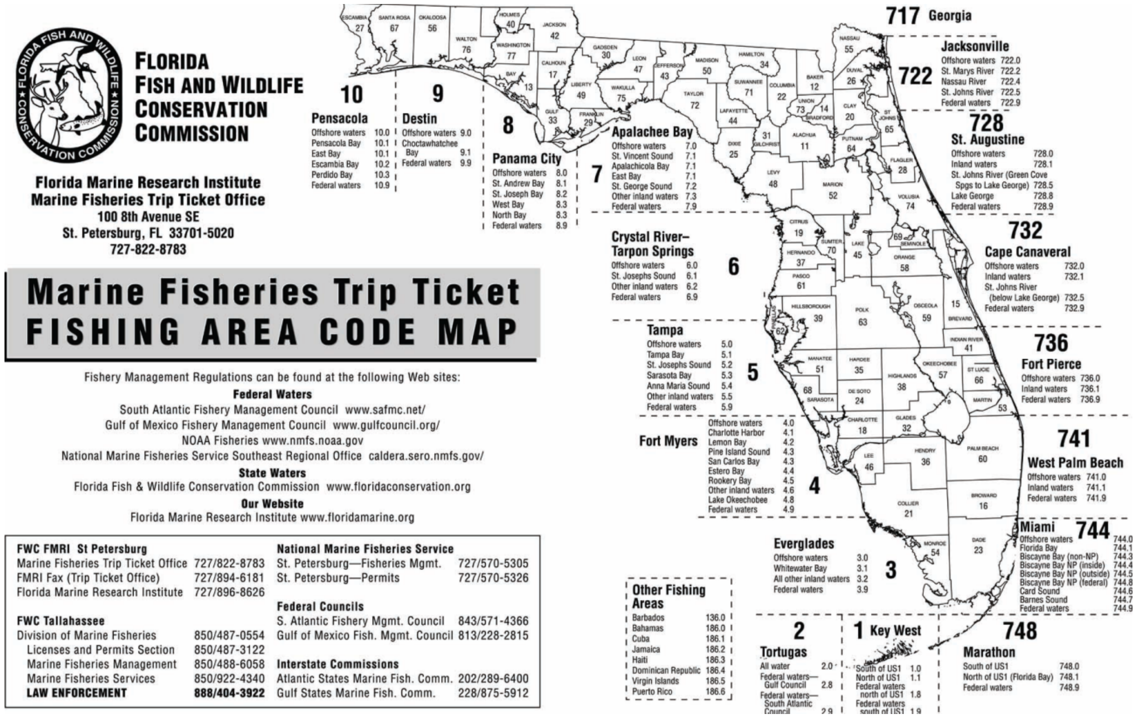


Figure 3.3. Atlantic Coastal Cooperative Statistics Program (ACCSP) Data Warehouse - data sources and collection methods by state. Early summaries are provided by the NMFS.

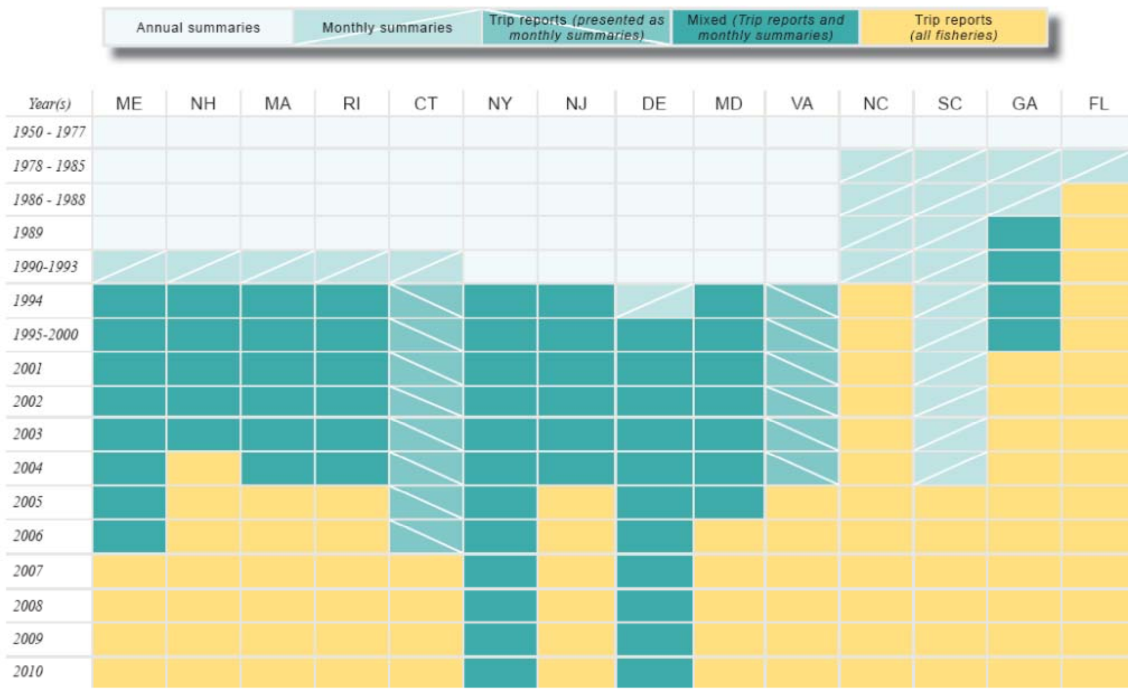
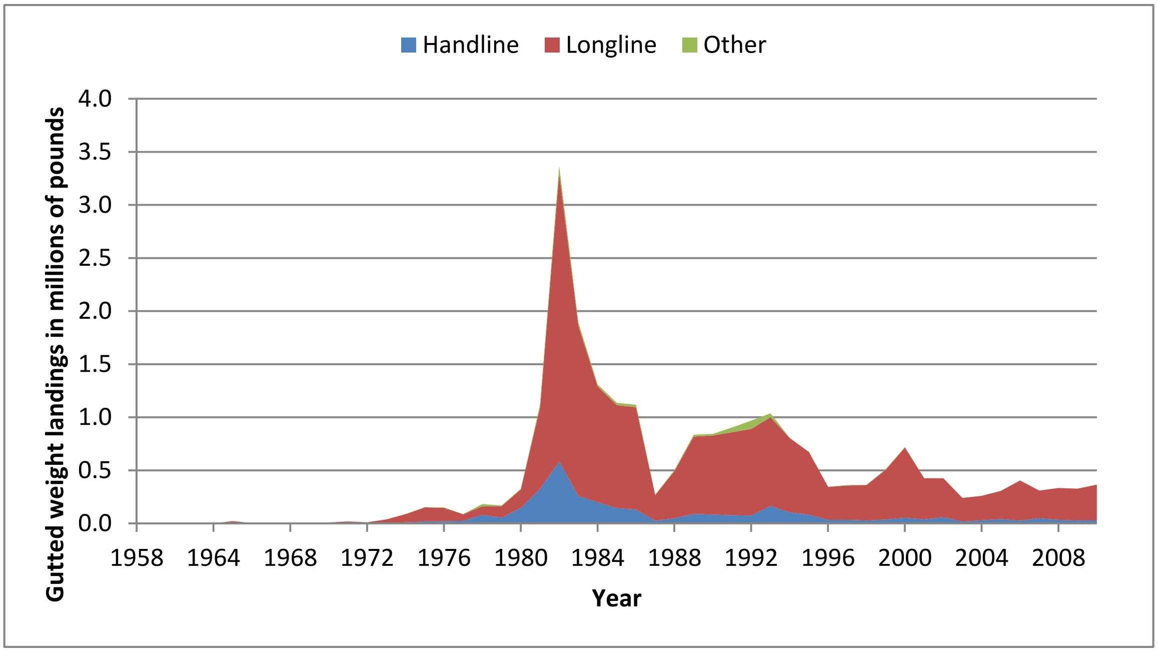


Figure 3.4. Golden tilefish landings in millions of pounds (gutted weight) by gear (long line, handline and other) from the U.S. South Atlantic, 1958-2010.



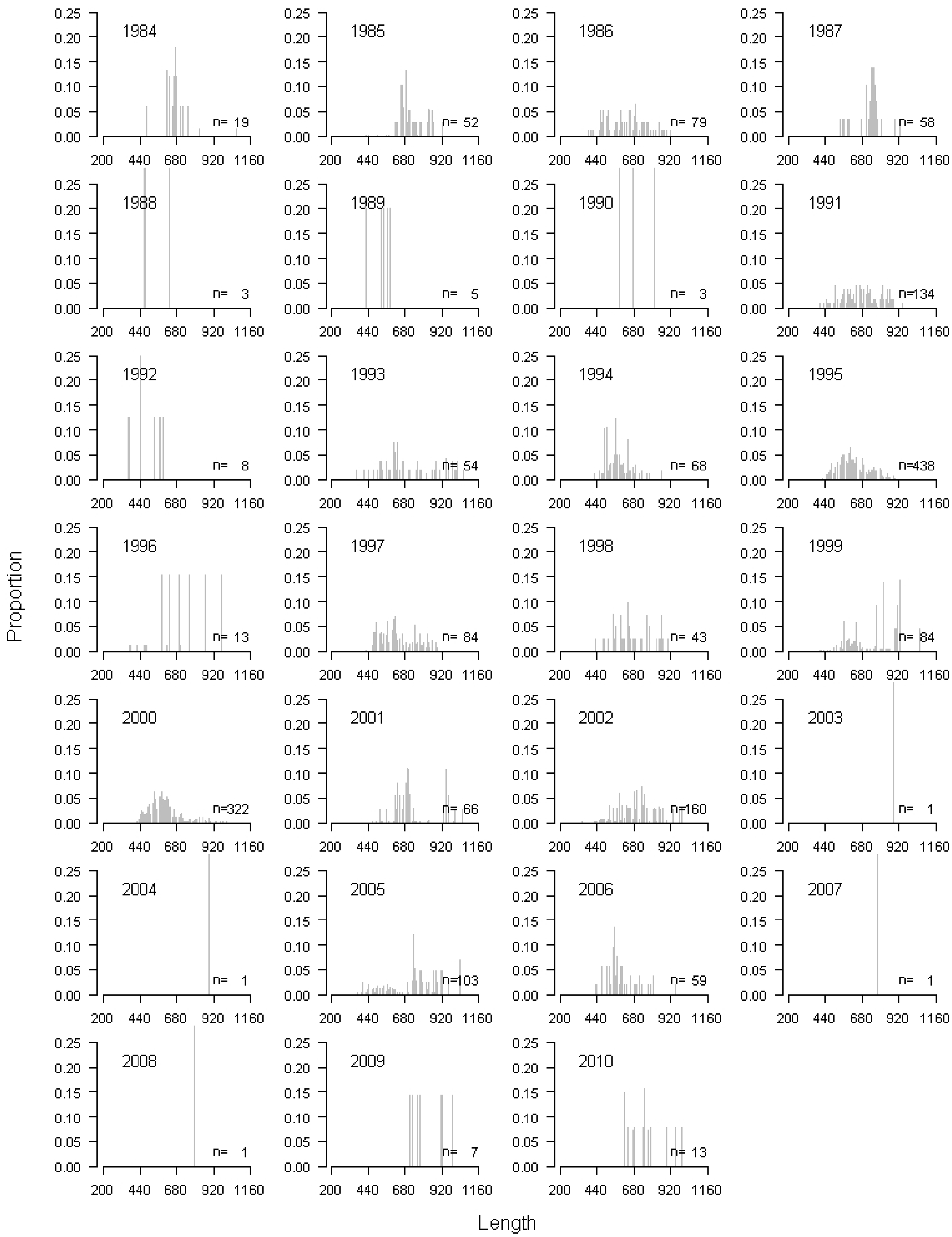


Figure 3.5. Relative length composition (TL in mm) of commercial length samples by year for hand line. N = number of fish.

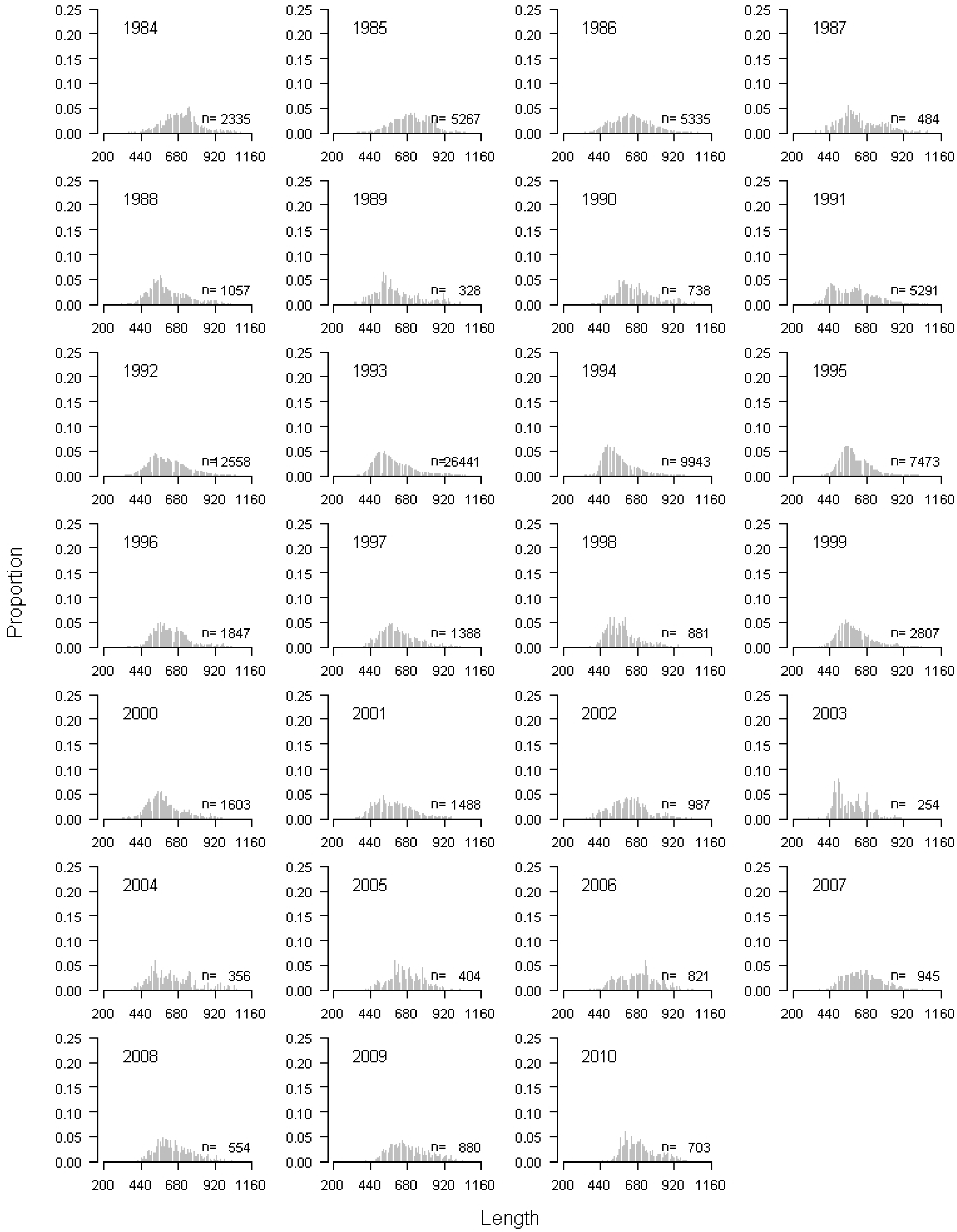


Figure 3.6. Relative length composition (TL in mm) of commercial length samples by year for long line gear. N = number of fish.

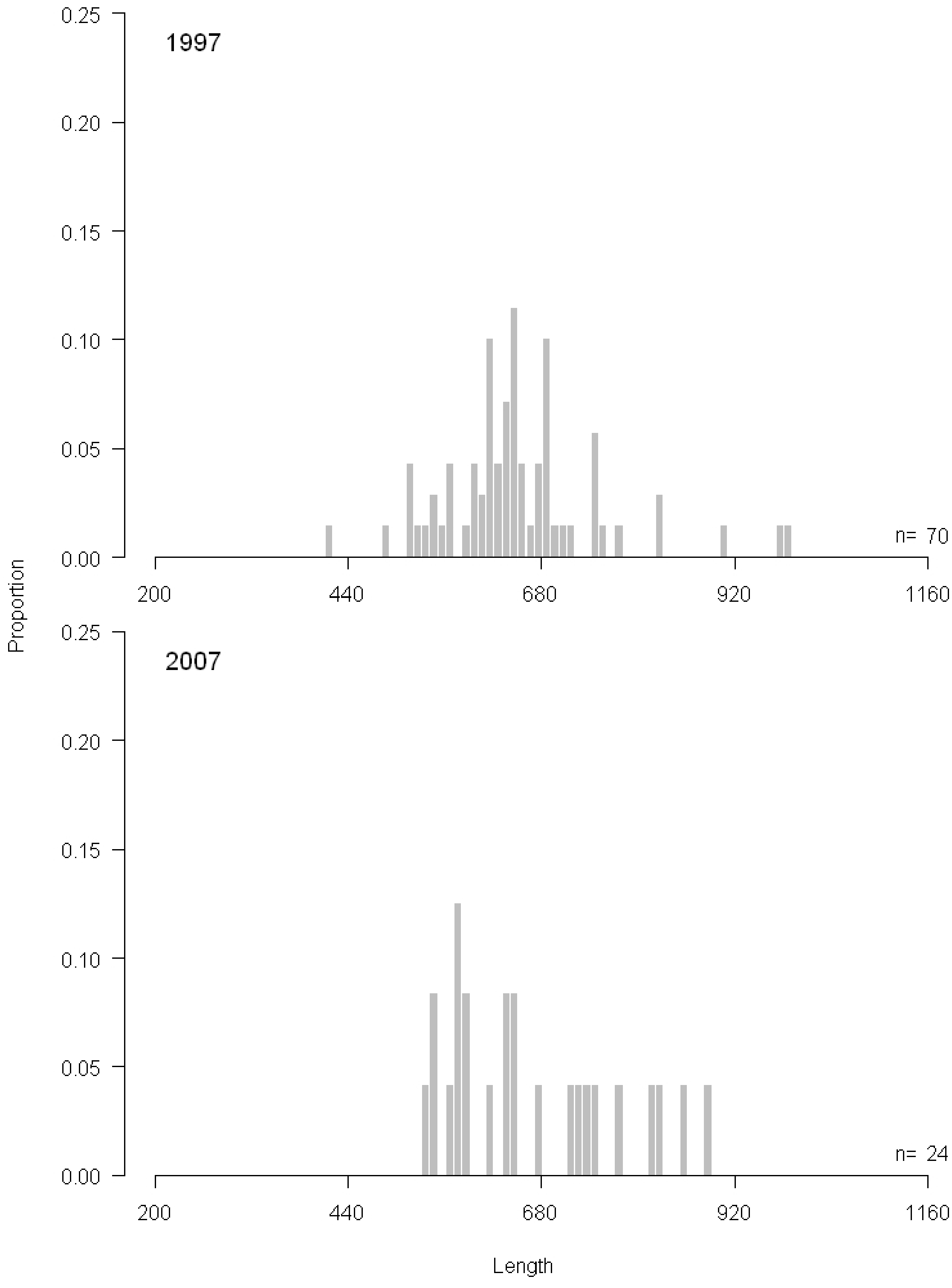


Figure 3.7. Relative length composition (TL in mm) of commercial length samples by year for other gear. N = number of fish.

Figure 3.8a. Relative age composition of commercial tilefish age samples by year for handline gear.

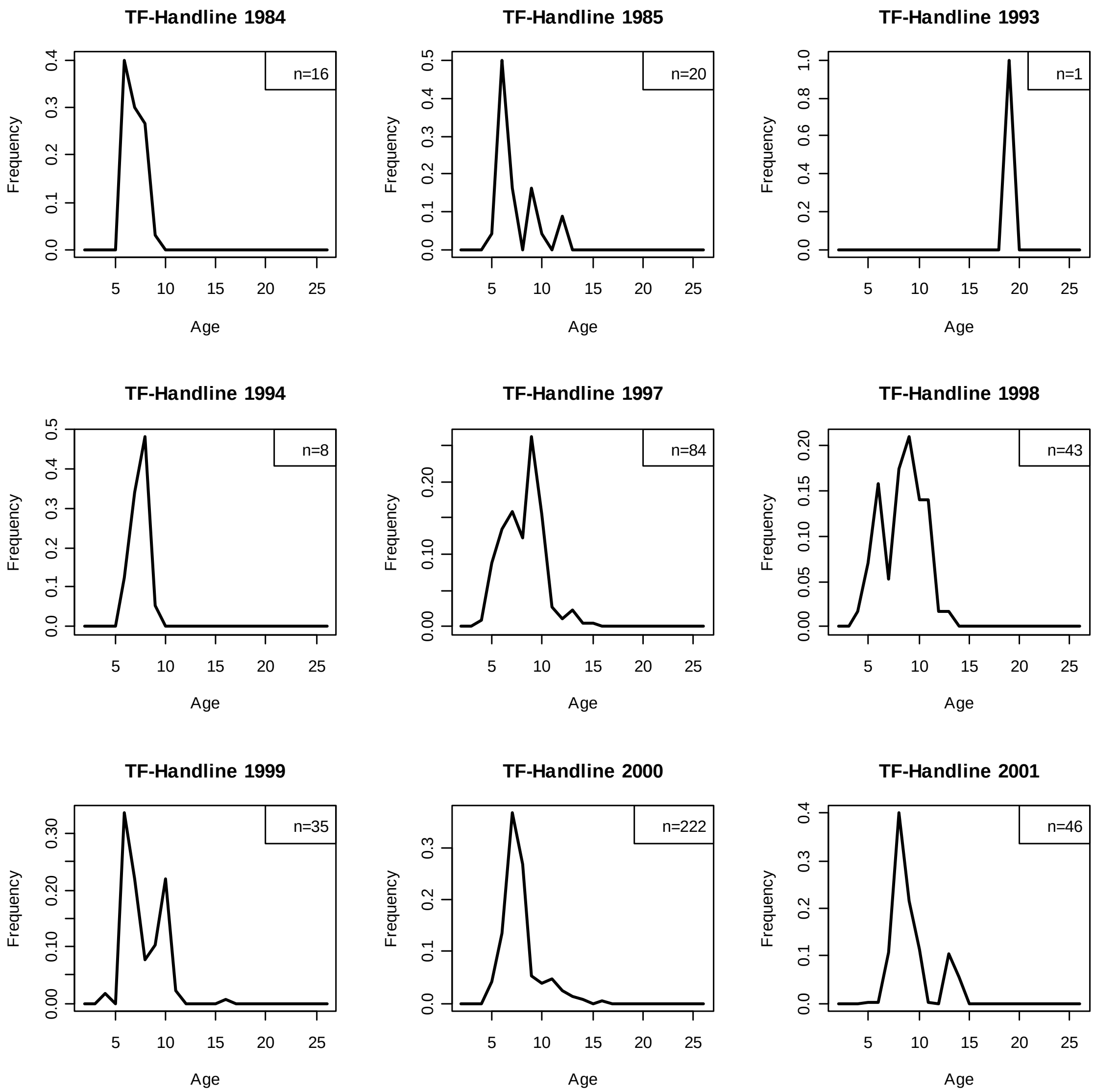


Figure 3.8b. Relative age composition of commercial tilefish age samples by year for handline gear.

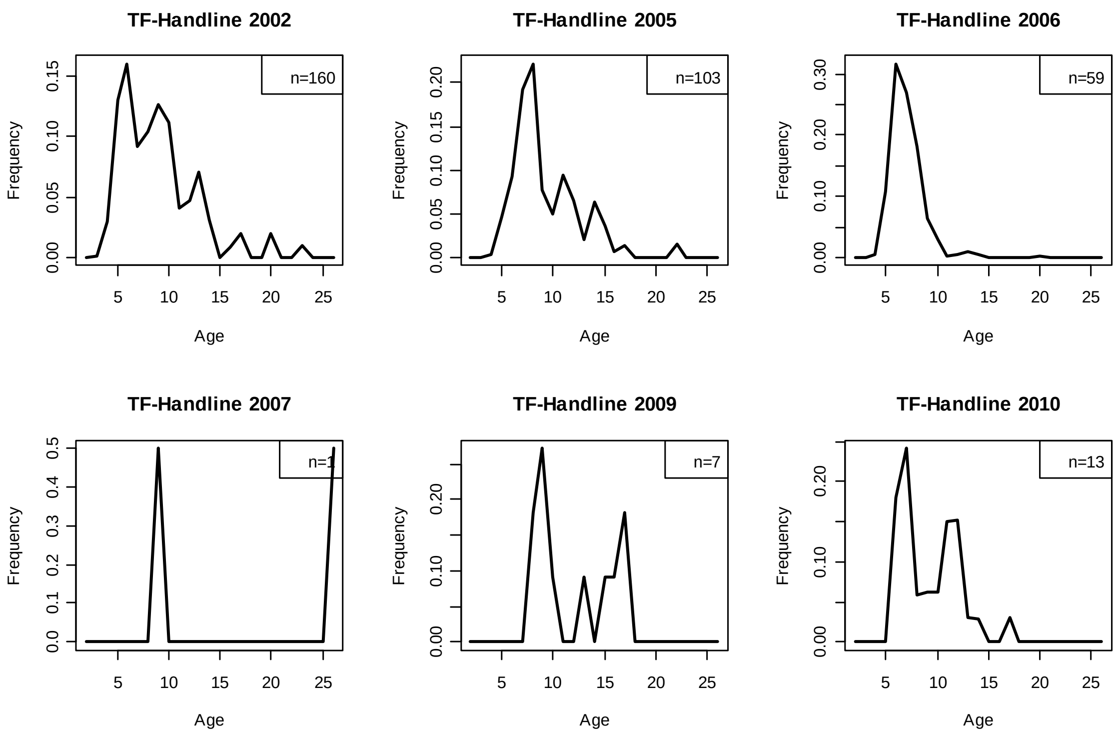


Figure 3.9a. Relative age composition of commercial tilefish age samples by year for longline gear.

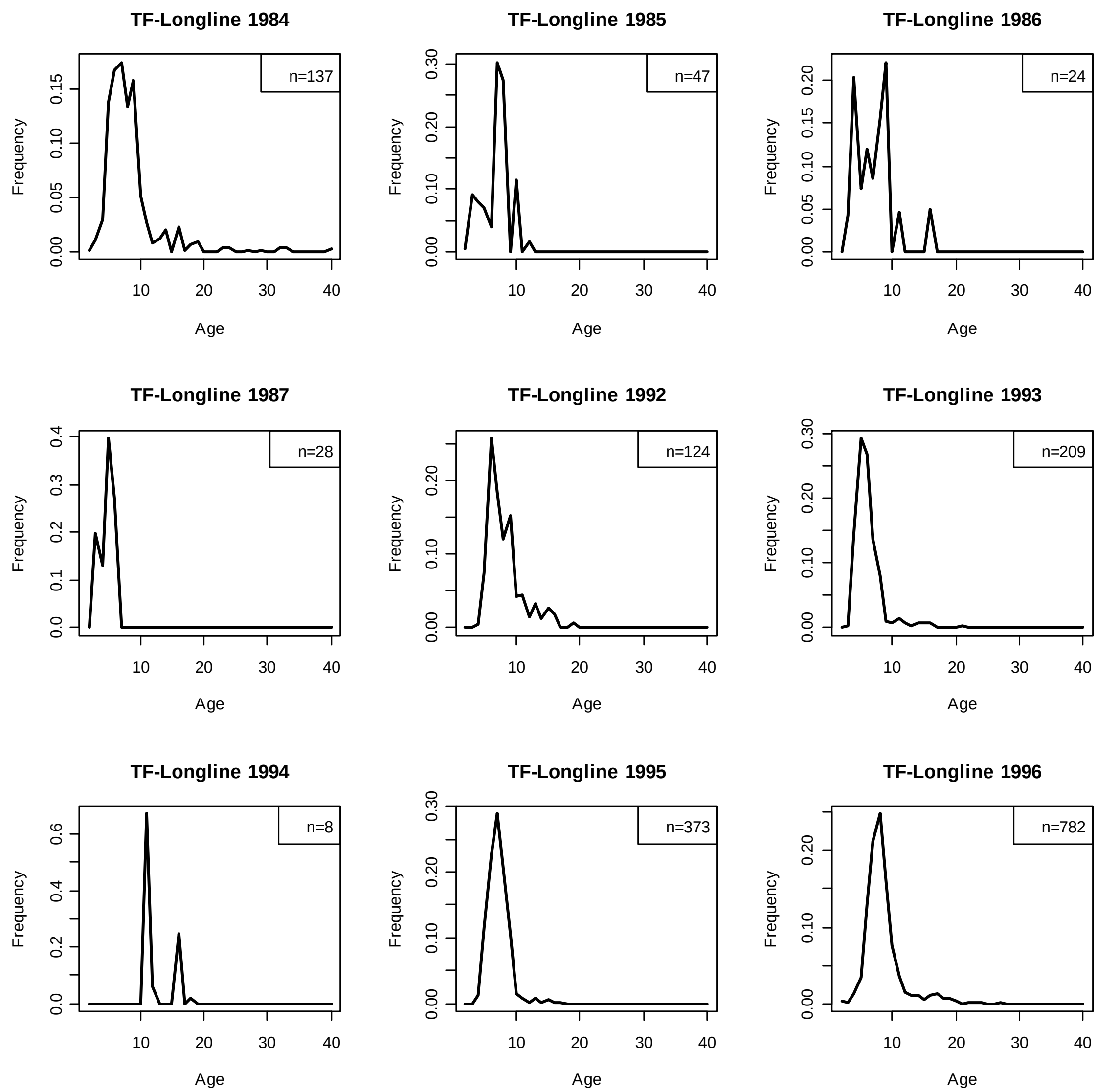


Figure 3.9b. Relative age composition of commercial tilefish age samples by year for longline gear.

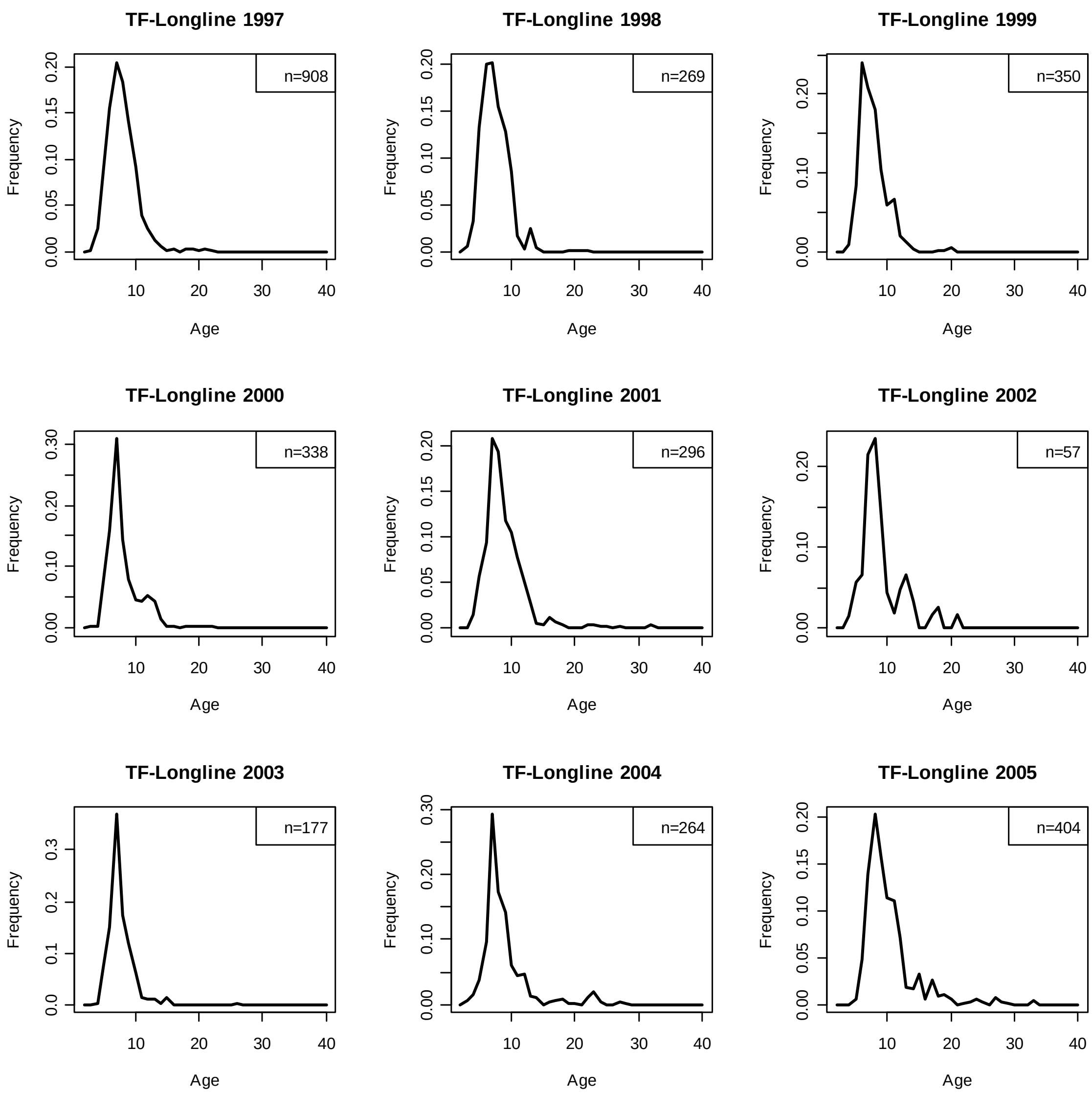
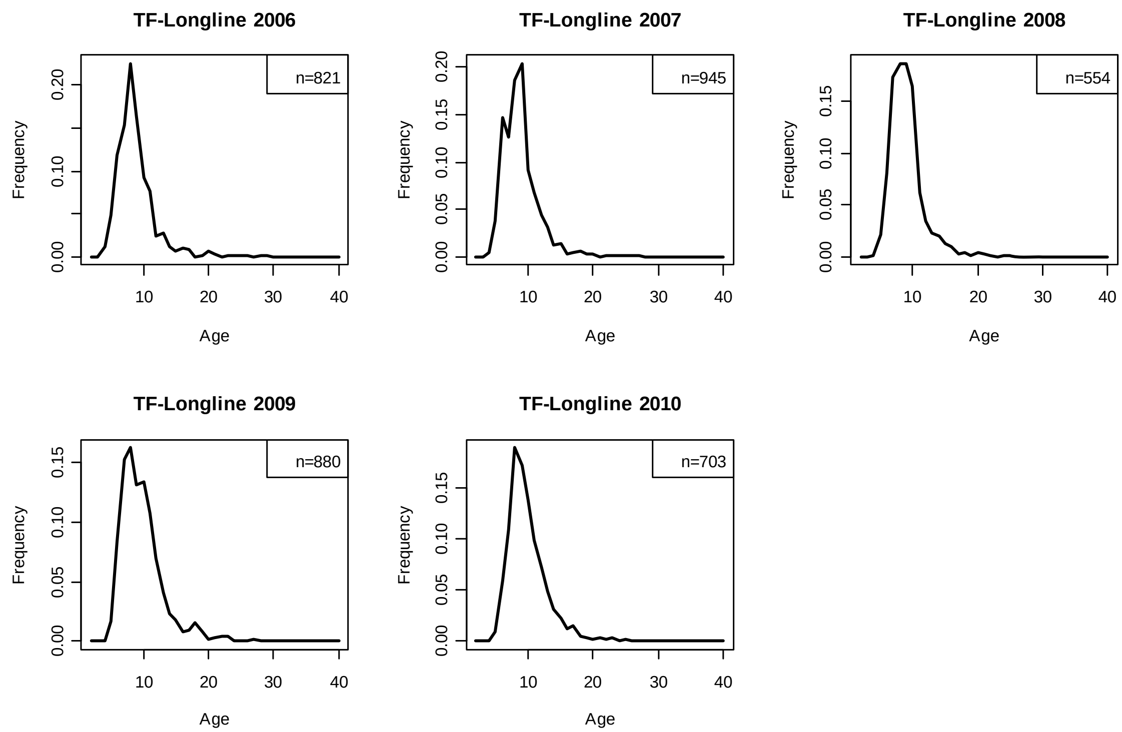


Figure 3.9c. Relative age composition of commercial tilefish age samples by year for longline gear.



4 Recreational

4.1 Overview

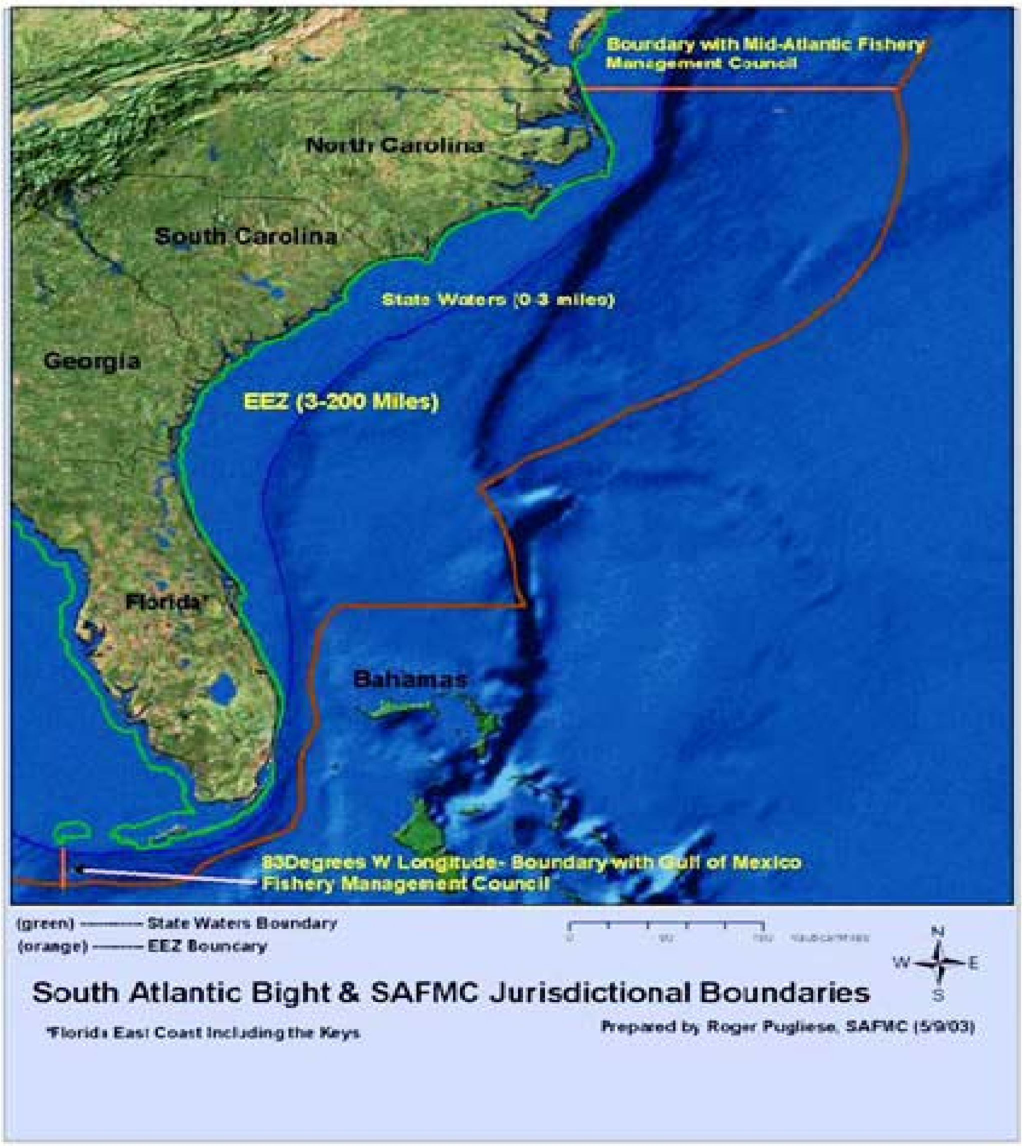
4.1.1. Group membership

Members- Ken Brennan (Leader\NMFS Beaufort), Kathy Knowlton (Rapporteur\GADNR), Zach Bowen (SAFMC Appointee/Industry rep GA), Julia Bryd (SCDNR), Kelly Fitzpatrick (NMFS Beaufort), Eric Hiltz (SCDNR), Rusty Hudson (SAFMC Appointee/Industry rep FL), Vivian Matter (NMFS Miami), Robert McPherson (SAFMC Appointee/Industry rep FL), Beverly Sauls (FWRI), Tom Sminkey (NMFS Silver Spring), Chris Wilson (NCDNR).

4.1.2 Issues

1) Catch within Monroe County, FL: Determine whether there is significant catch, and if so, whether it can be parsed out between Gulf and Atlantic and added to rest of South Atlantic catch.
2) Landings, discards, and biological samples information are limited because tilefish is a deepwater species that is not routinely caught recreationally. High variance of landings based on relative rarity of species in MRFSS landings. Review whether smoothing of data should be considered. Missing weight estimates for some MRFSS "cells" (i.e., specific year, state, fishing mode, wave combinations). Minimal MRFFS length samples necessary to produce length frequencies. Review whether they should be combined with headboat length samples.
3) Uncertainty estimates for headboat landings and discards.
4) Charter Boat Landings: 1986-2003 & 2004-2009, MRFSS survey methods changed.
5) Party/Charter Landings: 1981-1985; Headboat landings, obtained from SEHB survey, must be parsed out from combined MRFSS party/charter landings during the 1981-1985 time periods during which MRFSS did not stratify.

4.1.3 South Atlantic Fishery Management Council Jurisdictional Boundries



4.2 Review of Working Papers

There were no working papers submitted for tilefish by the Recreational Working Group (RWG).

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 is not 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 recreational completed 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 size 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.

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, 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 there in 2003. The FHS was then expanded to the rest of the Atlantic (GA and north) in 2005, wave 2. There is one unofficial year of FHS for this group of states from 2004, which has been used in

SEDARs for other species (SEDAR 16 king mackerel). 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 for red snapper at the SEDAR 24 data workshop to produce a time series of adjusted charter boat landings and live discards (SEDAR24- DW13, Sminkey, 2010). For this data workshop similar methods were employed to the extended overlapping survey years of 2004-2010 to produce more robust ratios for adjusting the earlier time series, and the adjusted effort was used to produce the adjusted landings and discards of tilefish in NC to East Florida. Landings estimates for charter boat and private/rental boat modes are summarized in Table 4.11.1 and 4.11.2, respectively.

Missing cells in MRFSS estimates

MRFSS weight estimates must be treated with caution due to the occurrence of missing weight estimates in some strata. MRFSS weight estimates are calculated by multiplying the estimated number harvested in a cell (year/wave/state/mode/area/species) by the mean weight of the measured fish in that cell. When there are no fish measured in the cell (fish were gutted or too big for the sampler to weigh, harvest was all self-reported, etc) estimates of landings in number are provided but there are no corresponding estimates of landings in weight.

The MRFSS tilefish estimates of landings in weight are used when provided by the survey. In cases where there is an estimate of landings in number but not weight, it was proposed to use the MRFSS sample data to obtain an average weight using the following hierarchy: species, region, year, state, mode, and wave (SEDAR22-DW16). The minimum number of weights used at each level of substitution would be 30 fish, except for the final species level, where the minimum is 1 fish. Average weights would then multiplied by the landings estimates in number to obtain estimates of landings in weight.

The recreational working group did not feel it was appropriate to use this substitution method because the hierarchy and minimum number of weights used would necessitate the use of pooled average weights over all years in some cases. Therefore, the tilefish weight estimates provided are those estimated by the MRFSS survey, with no weight estimates filled in. In each table of landings by mode a N/A under the pounds column indicates a missing weight estimate. A weight estimate in italics indicates that there are missing weight estimates in some strata. Table 4.11.3 shows the number of landed fish with no corresponding weight estimate.

Shore Estimates

The shore mode was excluded since tilefish are a deepwater species and are not caught by this mode.

Monroe County

Monroe County landings can be post-stratified to separate them from the MRFSS West Florida estimates. Tilefish are less common on the extreme south Atlantic coast of Florida and this is evident from the sparse Monroe county post-stratified landings shown in Table 4.11.4. In addition, Monroe county landings cannot be partitioned into those from the Atlantic Ocean and those from the Gulf of Mexico. For these reasons, the recreational workgroup decided not to include Monroe County MRFSS estimates. Headboat 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)

The Southeast Region Headboat Survey estimates landings and effort for headboats in the South Atlantic and Gulf of Mexico. Headboat estimated landings for tilefish are extremely low for the entire time series 1981 to 2010 (N =361) (Table 4.11.5). These low incidents of landings on headboats are similar to other deepwater species, such as snowy grouper and blueline tilefish. Headboats do not routinely fish in depths greater than 250-300 feet (76-91 meters) due to the effort required by the angler to reel fish to the surface. Another problem encountered by headboats attempting to fish in greater depths, is the increased effect of current which causes more tangling between anglers. These and other factors greatly limit recreational fishing from headboats for deepwater species such as tilefish.

Although tilefish were encountered in the SRHS dockside sampling no landings were reported in 1984, 1996, and 1998.

4.3.3 Historic Recreational Landings

No sources of historical recreational tilefish landings were identified by the RWG.

4.3.4 Additional Potential Data Sources

No additional sources of recreational tilefish data were identified by the RWG.

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 so both the identity and quantities reported are unverified. 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; SEDAR 24 DW 13). Size or weight of discarded fishes is not estimated in the MRFSS. At-sea sampling of head boat 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 head boat fishery.

Where estimates for numbers of discards are available, variance estimates are high (Table 4.11.6). It should be noted that estimates of tilefish discards from shore mode have been excluded.

4.4.2 Headboat Logbook Discards

No headboat logbook discards are available.

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). In those fish with a forked tail, this measure would typically be referred to as a fork length, and in those fish that do not have a forked tail it would typically be referred to as a total length with the exception of some fishes that have a single, or few, caudal fin rays that extend further, e.g., the tilefish. Weights are typically collected for the same fish measured although weights are preferred 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 to 2010 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 analyzes and maturity studies.

4.5.1 Sampling Intensity Length/Age/Weight

Dockside Surveys - Annual numbers of tilefish measured for lengths and the number of trips from which tilefish were measured in MRFSS charter fleet intercepts are summarized in Table 4.11.7. Annual numbers of tilefish measured for length in the MRFSS private-rental mode and the number of trips from which tilefish were measured are summarized in Table 4.11.8. Annual numbers of tilefish measured for length in the Southeast Region Headboat Survey and the number tilefish positive trips are summarized in Table 4.11.9 (1981, 1984, 1989, 1990, 1992, 1996-1999, 2001, 2009). For years in which fish were weighed, annual mean weights of tilefish measured in the MRFSS charter fleet and private/rental mode, as well as headboat fleet, are summarized in Tables 4.11.10-12. There were no tilefish aged in the headboat fleet.

4.5.2. Length – Age distributions

Length Frequency Analysis

Headboat landings of tilefish during 1975 to 2010 were negligible. Due to small sample sizes of tilefish in the recreational fishery weighted length distributions were not conducted. The cumulative length frequency was developed for the recreational fishery (Figure 4.12.1).

The number of vessel trips sampled were not available from the MRFSS. However, the number of trips sampled in the SRHS are vessel trips. Therefore the total number of trips with tilefish length measurements taken is an amalgam of vessel and angler trips (Figure 4.12.1).

Age Frequency Analysis

There were no tilefish aged in the headboat fleet. Due to small sample sizes in the charter and private/rental fleets age frequency analysis of tilefish were not conducted.

4.5.3 Adequacy for characterizing catch

The RWG discussed and had no input on this issue.

4.5.4 Alternatives for characterizing discards

The RWG discussed and had no input on this issue.

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

The RWG discussed and 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 and private/rental boat mode estimates are tabulated in Table 4.11.13 and 4.11.14, respectively. An angler-trip is a single day of fishing in the specified mode, not to exceed 24 hours. Because this data review is for tilefish in the South Atlantic sub-region and shore landings have specifically been excluded (tilefish are a deepwater species and 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 Survey. 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 4.11.15). 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 starting in 2008 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 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:

- Recreational landings are limited for this species over the entire time series for the MRFSS and the Southeast Region Headboat Survey.

4.9 Itemized list of tasks for completion following workshop

No tasks remain to be completed.

4.10 Literature Cited

No literature was cited in this report.

4.11 Tables

Table 4.11.1 South Atlantic tilefish landings (numbers of fish and whole weight in pounds) for charter boat mode (MRFSS, NMFS, 1981-2010). 1981-1985 Charter boat and headboat modes are combined. Charter boat and charter/headboat modes adjusted for FHS conversion. N/A indicates a weight estimate is missing. *Italics indicates there are missing cells in some strata.*

	Estimated MRFSS CH Landings		
Year	Number	CV	Pounds
1981	-	-	-
1982	-	-	-
1983	367	1.00	3,199
1984	-	-	-
1985	577	1.00	N/A
1986	58	1.07	319
1987	52	1.14	69
1988	-	-	-
1989	-	-	-
1990	119	0.56	342
1991	142	0.72	390
1992	1,069	0.63	N/A
1993	-	-	-
1994	2,626	0.46	12,766
1995	-	-	-
1996	112	1.05	N/A
1997	958	0.80	*1,312*
1998	259	1.04	1,238
1999	2,007	0.76	*6,261*

2000	1,143	0.51	*3,270*
2001	3,350	0.70	29,908
2002	3,515	0.54	*14,708*
2003	12,396	0.54	*43,660*
2004	9,947	0.54	*14,060*
2005	55,188	0.42	195,807
2006	10,063	0.54	33,908
2007	1,222	0.73	N/A
2008	-	-	-
2009	1,678	0.67	12,300
2010	511	0.45	*1,437*

Table 4.11.2 South Atlantic tilefish landings (numbers of fish and whole weight in pounds) for private/rental boat mode (MRFSS, NMFS, 1981-2010). N/A indicates a weight estimate is missing. *Italics indicates there are missing cells in some strata.*

	Estimated MRFSS PR Landings		
Year	Number	CV	Pounds
1981	-	-	-
1982	-	-	-
1983	-	-	-
1984	1,648	0.77	726
1985	20,384	0.60	44,938
1986	-	-	-
1987	-	-	-
1988	900	0.56	3,967
1989	-	-	-
1990	-	-	-
1991	-	-	-
1992	706	1.00	N/A
1993	-	-	-
1994	-	-	-
1995	-	-	-
1996	1,069	1.00	3,065
1997	6,165	0.72	*14,726*
1998	-	-	-
1999	-	-	-
2000	2,410	1.00	N/A
2001	687	0.73	5,271

2002	-	-	-
2003	-	-	-
2004	1,939	0.77	*5,544*
2005	15,116	0.99	44,433
2006	2,659	0.73	*10,152*
2007	943	1.00	4,782
2008	-	-	-
2009	6,454	0.63	42,213
2010	3,879	0.66	*15,297*

Table 4.11.3. South Atlantic tilefish landings (numbers of fish) where a corresponding weight estimate is missing by year and mode (MRFSS, NMFS 1981-2010).

YEAR	Cbt	Priv	Total
1985	577		577
1992	1,069	706	1,774
1993	-	-	-
1996	112		112
1997	660	2,419	3,079
1999	480		480
2000	294	2,410	2,704
2002	743		743
2003	481		481
2004	3,249	542	3,791
2005	-	-	-
2006	-	1,718	1,718
2007	1,222		1,222
2010	402	2,295	2,696

Table 4.11.4 Tilefish MRFSS landings (numbers of fish) from Monroe County 1981-2010.

Year	Harvested (A+B1)	Discards (B2)
1981	48977	-
1987	3351	-
1992	741	-
2000	37	56
2001	66	-
2005	89	31
2006	-	317
2008	29	-

Table 4.11.5 Estimated headboat landings of tilefish in the South Atlantic 1975-2010.*

	Headboat Landings	
Year	Number	Pounds
1975	-	-
1976	-	-
1977	-	-
1978	-	-
1979	-	-
1980	-	-
1981	94	412
1982	12	18
1983	-	-
1984	-	-
1985	-	-
1986	-	-
1987	10	79
1988	-	-
1989	10	14
1990	14	7
1991	-	-
1992	20	26
1993	-	-
1994	8	12
1995	-	-
1996	-	-

1997	190	968
1998	-	-
1999	3	5
2000	-	-
2001	-	-
2002	-	-
2003	-	-
2004	-	-
2005	-	-
2006	-	-
2007	-	-
2008	-	-
2009	-	-
2010	-	-

*****No tilefish landings were reported in 1984, 1996, and 1998.

Table 4.11.6 Estimated tilefish discards for the recreational sectors by year and fishing mode.

	MRFSS CH Discards		MRFSS PR Discards	
Year	Number	CV	Number	CV
1981	-	-	-	-
1982	-	-	-	-
1983	-	-	-	-
1984	-	-	-	-
1985	-	-	-	-
1986	-	-	-	-
1987	-	-	-	-
1988	-	-	-	-
1989	-	-	-	-
1990	-	-	-	-
1991	-	-	-	-
1992	-	-	-	-
1993	-	-	700	1.00
1994	-	-	-	-
1995	-	-	-	-
1996	-	-	-	-
1997	-	-	-	-
1998	-	-	-	-
1999	-	-	-	-
2000	-	-	845	1.00
2001	-	-	-	-
2002	-	-	-	-

2003	-	-	2,088	0.75
2004	-	-	-	-
2005	-	-	1,036	1.00
2006	-	-	-	-
2007	-	-	-	-
2008	-	-	-	-
2009	-	-	-	-
2010	-	-	-	-

Table 4.11.7 Number of tilefish measured and number of trips with measured tilefish in the MRFSS charter fleet by year and state.

	Fish(N)					Trips(N)				
Year	NC	SC	GA	FL	Total	NC	SC	GA	FL	Total
1983	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-
1987	1	-	-	-	1	1	-	-	-	1
1988	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-	-
1990	1	-	-	-	1	-	-	-	-	-
1991	2	-	-	-	2	1	-	-	-	1
1992	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	2	2	-	-	-	2	2
1995	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	1	1	-	-	-	1	1
1998	-	-	-	3	3	-	-	-	1	1
1999	-	-	-	2	2	-	-	-	1	1
2000	4	-	-	1	5	1	-	-	1	2
2001	10	-	-	7	17	1	-	-	3	4
2002	28	-	-	-	28	6	-	-	-	6
2003	63	-	-	1	64	6	-	-	1	7
2004	26	-	-	-	26	3	-	-	-	3

2005	115	-	-	-	115	8	-	-	-	8
2006	11	-	-	4	15	2	-	-	1	3
2007	-	-	-	-	-	-	-	-	-	-
2008	-	-	-	-	-	-	-	-	-	-
2009	-	-	-	4	4	-	-	-	1	1
2010	5	-	-	4	9	2	-	-	1	3
Total	266	-	-	29	295	31	-	-	13	44

Table 4.11.8 Number of tilefish measured and number of trips with measured tilefish in the MRFSS private fleet by year and state.

	Fish(N)					Trips(N)				
Year	NC	SC	GA	FL	Total	NC	SC	GA	FL	Total
1981	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	1	1	-	-	-	1	1
1985	-	-	-	1	1	-	-	-	1	1
1986	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-
1988	1	-	-	-	1	1	-	-	-	1
1989	-	-	-	-		-	-	-	-	-
1990	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	1	1	-	-	-	1	1
1997	13	-	-	-	13	2	-	-	-	2
1998	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-
2001	1	-	-	-	1	1	-	-	-	1
2002	-	-	-	-	-	-	-	-	-	-

2003	-	-	-	-	-	-	-	-	-	-
2004	-	-	-	2	2	-	-	-	1	1
2005	15	-	-	-	15	1	-	-	-	1
2006	-	-	-	2	2	-	-	-	1	1
2007	-	-	-	1	1	-	-	-	1	1
2008	-	-	-	-	-	-	-	-	-	-
2009	-	-	-	6	6	-	-	-	3	3
2010	-	-	-	2	2	-	-	-	2	2
Total	30	-	-	16	46	5	-	-	11	16

Table 4.11.9 Number of tilefish measured and number of tilefish positive trips in the SRHS by year and area.*

	Fish (N)					Trips (N)				
Year	NC	SC	GA/NEFL	SEFL	Total	NC	SC	GA/NEFL	SEFL	Total
1981	-	1	-	-	1	-	1	-	-	1
1982	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-
1984	-	9	-	-	9	-	1	-	-	1
1985	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-
1989	-	1	-	16	17	-	1	-	9	10
1990	-	-	-	13	13	-	-	-	6	6
1991	-	-	-	-	-	-	-	-	-	-
1992	-	1	-	-	1	-	1	-	-	1
1993	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-
1996	-	52	-	-	52	-	5	-	-	5
1997	-	112	-	-	112	-	6	-	-	6
1998	-	45	-	-	45	-	4	-	-	4
1999	2	-	-	-	2	1	-	-	-	1
2000	-	-	-	-	-	-	-	-	-	-
2001	-	-	-	2	2	-	-	-	2	2
2002	-	-	-	-	-	-	-	-	-	-

2003	-	-	-	-	-	-	-	-	-	-
2004	-	-	-	-	-	-	-	-	-	-
2005	-	-	-	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-	-	-	-
2008	-	-	-	-	-	-	-	-	-	-
2009	-	-	-	2	2	-	-	-	1	1
2010	-	-	-	-	-	-	-	-	-	-
Total	2	221	-	33	256	1	19	-	18	38

*****No tilefish landings were reported in 1984, 1996, and 1998.

Table 4.11.10. Mean weight (kg) of tilefish measured in the charter boat fleet by year and state, 1981-2010.

	NC				SC				GA				EFL			
Year	N	Mean (kg)	Min (kg)	Max (kg)	N	Mean (kg)	Min (kg)	Max (kg)	N	Mean (kg)	Min (kg)	Max (kg)	N	Mean (kg)	Min (kg)	Max (kg)
1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	1	2.50	2.50	2.50	-	-	-	-	-	-	-	-
1987	1	0.60	0.60	0.60	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990	1	1.30	1.30	1.30	-	-	-	-	-	-	-	-	-	-	-	-
1991	2	1.25	1.10	1.40	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-	-	-	3	2.83	1.10	5.40
1995	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-	1	2.00	2.00	2.00
1998	-	-	-	-	-	-	-	-	-	-	-	-	3	2.17	1.50	3.00
1999	-	-	-	-	-	-	-	-	-	-	-	-	2	1.86	1.52	2.20
2000	4	1.75	1.00	3.00	-	-	-	-	-	-	-	-	1	1.72	1.72	1.72
2001	-	-	-	-	-	-	-	-	-	-	-	-	7	3.29	1.32	8.50
2002	25	2.40	0.80	5.10	-	-	-	-	-	-	-	-	-	-	-	-

2003	63	1.66	1.00	4.10	-	-	-	-	-	-	-	-	1	2.20	2.20	2.20
2004	26	0.97	0.40	2.70	-	-	-	-	-	-	-	-	-	-	-	-
2005	115	1.60	0.90	4.00	-	-	-	-	-	-	-	-	-	-	-	-
2006	11	1.99	1.25	4.25	-	-	-	-	-	-	-	-	3	0.94	0.57	1.58
2007	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2009	-	-	-	-	-	-	-	-	-	-	-	-	4	3.32	1.96	4.64
2010	5	6.60	5.00	8.20	-	-	-	-	-	-	-	-	-	-	-	-

Table 4.11.11. Mean weight (kg) of tilefish measured in the private/rental boat fleet by year and state, 1981-2010.

	NC				SC				GA				EFL			
Year	N	Mean (kg)	Min (kg)	Max (kg)	N	Mean (kg)	Min (kg)	Max (kg)	N	Mean (kg)	Min (kg)	Max (kg)	N	Mean (kg)	Min (kg)	Max (kg)
1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	1	0.20	0.20	0.20
1985	-	-	-	-	-	-	-	-	-	-	-	-	1	1.00	1.00	1.00
1986	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	1	2.00	2.00	2.00	-	-	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-	2	1.30	0.60	2.00
1997	3	1.78	1.40	2.15	-	-	-	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2001	1	1.20	1.20	1.20	-	-	-	-	-	-	-	-	-	-	-	-

2002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2004	-	-	-	-	-	-	-	-	-	-	-	-	1	1.80	1.80	1.80
2005	15	1.33	0.90	1.70	-	-	-	-	-	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-	-	-	-	-	2	4.89	2.58	7.20
2007	-	-	-	-	-	-	-	-	-	-	-	-	1	2.30	2.30	2.30
2008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2009	-	-	-	-	-	-	-	-	-	-	-	-	6	3.17	0.92	8.12
2010	-	-	-	-	-	-	-	-	-	-	-	-	2	3.95	3.40	4.50

Table 4.11.12. Mean weight (kg) of tilefish measured in the headboat fleet by year and area, 1981-2010.

	NC				SC				GA/NEFL				SEFL			
Year	N	Mean (kg)	Min (kg)	Max (kg)	N	Mean (kg)	Min (kg)	Max (kg)	N	Mean (kg)	Min (kg)	Max (kg)	N	Mean (kg)	Min (kg)	Max (kg)
1981	-	-	-	-	1	1.99	1.99	1.99	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1990	-	-	-	-	1	2.79	2.79	2.79	-	-	-	-	16	0.64	0.09	3.93
1991	-	-	-	-	-	-	-	-	-	-	-	-	12	0.24	0.08	0.43
1992	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	1	0.22	0.22	0.22	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	52	3.74	0.97	12.95	-	-	-	-	-	-	-	-
1998	-	-	-	-	111	2.37	0.44	11.31	-	-	-	-	-	-	-	-
1999	-	-	-	-	48	3.56	0.53	13.02	-	-	-	-	-	-	-	-
2000	2	1.45	1.42	1.47	-	-	-	-	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-	-	-	-	-	2	0.35	0.20	0.49

2002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2004	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2005	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2009	-	-	-	-	-	-	-	-	-	-	-	-	2	1.87	1.51	2.22
2010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 4.11.13 For-Hire recreational angler effort in the South Atlantic sub-region. Charter boat mode (1981-85 = Party/Charter boat mode; 1986-2003 adjusted FHS-ratios).

	NC		SC		GA		EFL		South Atlantic	
Year	Trips	PSE	Trips	PSE	Trips	PSE	Trips	PSE	Trips	PSE
1981	119,545	32.3	19,182	35.3	218	101.3	184,293	12.9	323,238	14.2
1982	58,836	30.8	76,877	40.6	26,037	32.1	433,888	11.1	595,638	10.2
1983	155,971	49.3	45,513	23.3	23,528	27.2	321,582	11.3	546,594	15.7
1984	60,946	20.5	123,433	23.3	30,312	22.7	402,050	12.3	616,741	9.6
1985	53,719	24.7	105,658	24.9	30,330	25.2	477,455	10.8	667,162	9.0
1986	43,468	16.4	72,051	15.6	26,198	24.0	295,693	38.0	437,411	25.9
1987	85,480	9.5	77,575	17.4	26,512	39.1	332,514	29.6	522,082	19.2
1988	135,211	12.6	230,049	23.8	40,925	39.0	444,313	30.6	850,499	17.4
1989	69,155	9.6	210,832	21.4	31,145	28.3	314,261	32.4	625,394	17.9
1990	86,118	8.2	103,326	17.9	10,056	21.8	195,687	18.0	395,187	10.3
1991	63,248	5.7	113,238	13.6	27,353	47.9	188,383	13.7	392,222	8.4
1992	76,667	5.7	152,262	20.5	26,139	14.4	169,238	10.3	424,306	8.5
1993	63,051	4.4	183,422	10.5	34,984	14.2	224,116	6.3	505,572	4.8
1994	88,942	3.1	200,725	9.5	51,394	14.1	324,640	4.7	665,701	3.9
1995	115,443	3.7	239,234	11.1	66,723	12.7	357,617	4.5	779,017	4.2
1996	101,555	3.7	291,853	8.8	55,910	11.6	395,043	3.9	844,360	3.6
1997	86,099	3.1	177,252	8.0	39,859	11.5	384,522	4.1	687,732	3.2
1998	69,518	3.0	115,146	10.5	23,904	12.2	324,374	4.6	532,941	3.7
1999	60,280	3.5	77,512	10.3	14,793	11.8	277,296	7.1	429,881	5.0
2000	26,674	4.1	54,396	9.5	9,019	9.9	201,378	5.4	291,466	4.2
2001	55,357	3.7	49,862	9.4	9,348	10.7	177,111	5.6	291,677	3.8
2002	70,186	3.2	45,543	9.0	13,064	9.6	150,874	4.7	279,666	3.1
2003	51,416	4.2	54,805	9.7	17,390	11.8	152,287	4.9	275,898	3.5
2004	32,155	10.8	122,473	22.9	29,502	12.6	198,004	8.3	382,134	8.6
2005	30,937	12.0	28,889	15.9	25,081	10.8	200,910	6.0	285,817	4.8
2006	16,488	10.6	28,592	23.7	28,003	9.0	173,465	4.8	246,548	4.6
2007	17,760	10.8	84,307	15.1	26,302	10.6	177,725	5.2	306,094	5.3
2008	19,481	11.1	71,712	13.2	17,005	10.0	160,530	5.8	268,728	5.1
2009	22,319	8.8	79,561	13.2	16,193	10.1	179,654	5.9	297,727	5.1
2010	27,584	6.6	71,221	10.0	8,417	12.4	135,826	6.2	243,048	4.6

Table 4.11.14 Private / Rental boat recreational angler effort in the South Atlantic sub-region.

	NC		SC		GA		EFL		South Atlantic	
Year	Trips	PSE	Trips	PSE	Trips	PSE	Trips	PSE	Trips	PSE
1981	323,568	10.9	332,825	15.7	119,379	25.0	1,973,018	8.4	2,748,790	6.5
1982	683,854	11.1	455,386	14.0	283,532	13.9	2,974,778	8.1	4,397,550	6.0
1983	880,701	9.8	619,188	17.4	185,863	25.1	3,482,077	7.6	5,167,829	5.9
1984	925,864	11.3	479,536	13.5	194,959	17.3	4,336,598	6.5	5,936,957	5.2
1985	780,364	9.5	548,617	12.7	199,197	17.3	4,356,877	8.2	5,885,055	6.3
1986	431,906	10.0	719,438	12.4	372,494	12.1	4,380,415	6.7	5,904,253	5.3
1987	1,187,849	3.4	886,502	10.5	449,256	11.6	5,044,634	4.8	7,568,241	3.6
1988	1,082,928	3.6	962,733	8.9	415,860	10.4	5,086,710	4.0	7,548,231	3.0
1989	923,499	3.8	506,772	14.0	409,934	13.7	4,883,028	5.0	6,723,233	3.9
1990	1,029,579	3.6	550,496	12.3	399,931	14.9	3,976,094	4.1	5,956,100	3.2
1991	749,618	3.8	977,119	11.4	355,832	17.5	4,738,486	3.7	6,821,055	3.2
1992	874,501	2.8	745,871	8.6	334,761	8.9	4,719,286	2.3	6,674,419	2.0
1993	876,259	3.2	807,638	7.9	439,918	9.2	4,162,425	2.3	6,286,240	2.0
1994	985,411	2.6	966,955	8.6	479,172	10.0	5,336,003	2.0	7,767,541	1.9
1995	1,053,539	2.4	677,163	7.8	432,017	8.3	5,242,230	2.1	7,404,949	1.8
1996	798,271	3.1	648,453	6.9	296,255	9.8	5,057,284	2.5	6,800,263	2.0
1997	898,759	2.8	731,897	5.3	352,097	9.8	5,622,174	2.5	7,604,927	2.0
1998	918,714	3.4	661,423	5.9	345,219	9.9	4,890,020	2.9	6,815,376	2.2
1999	881,752	3.5	586,501	7.3	292,109	11.1	4,196,050	3.0	5,956,412	2.3
2000	1,235,251	3.5	707,203	8.6	435,250	10.5	5,752,689	3.0	8,130,393	2.4
2001	1,283,732	3.2	953,558	8.2	448,507	14.9	5,994,125	3.0	8,679,922	2.5
2002	1,156,461	3.7	557,165	7.4	338,104	10.2	5,429,728	2.9	7,481,458	2.3
2003	1,425,803	3.5	1,020,784	8.3	549,099	11.0	6,212,067	3.0	9,207,753	2.4
2004	1,598,595	3.3	1,070,368	8.7	442,083	11.9	5,313,366	3.5	8,424,412	2.6
2005	1,637,317	3.2	988,887	7.8	500,607	10.5	6,230,328	3.5	9,357,139	2.6
2006	1,704,244	3.3	1,118,469	6.7	471,562	9.5	6,502,930	2.9	9,797,205	2.2
2007	1,954,431	3.2	1,483,233	6.3	552,638	7.9	8,317,491	2.9	12,307,793	2.2
2008	1,879,036	3.6	1,260,154	7.6	747,311	8.2	6,451,381	3.0	10,337,882	2.3
2009	1,629,005	3.5	1,051,366	6.2	503,246	9.0	5,401,059	3.2	8,584,676	2.3
2010	1,800,635	3.5	1,044,558	7.6	556,325	8.4	5,674,994	3.4	9,076,512	2.4

Table 4.11.15 South Atlantic headboat estimated angler days 1981-2010.

Year	NC	SC	GA/NEFL	SEFL	South Atlantic
1981	19,372	59,030	72,069	226,456	376,927
1982	26,939	67,539	66,961	226,172	387,611
1983	23,830	65,713	83,499	194,364	367,406
1984	28,865	67,313	95,234	193,760	385,172
1985	31,346	66,001	94,446	186,398	378,191
1986	31,187	67,227	113,101	203,960	415,475
1987	35,261	78,806	114,144	218,897	447,108
1988	42,421	76,468	109,156	192,618	420,663
1989	38,678	62,708	102,920	213,944	418,250
1990	43,240	57,151	98,234	224,661	423,286
1991	40,936	67,982	85,111	194,911	388,940
1992	41,177	61,790	90,810	173,714	367,491
1993	42,785	64,457	74,494	162,478	344,214
1994	36,693	63,231	65,745	177,035	342,704
1995	40,294	61,739	59,104	142,507	303,644
1996	35,142	54,929	47,236	152,617	289,924
1997	37,189	60,147	52,756	120,510	270,602
1998	37,399	61,342	51,790	103,551	254,082
1999	31,596	55,499	56,770	107,042	250,907
2000	31,323	40,291	59,771	122,478	253,863
2001	31,779	49,263	55,795	107,592	244,429
2002	27,601	42,467	48,911	102,635	221,614
2003	22,998	36,556	52,795	92,216	204,565
2004	27,255	50,461	50,544	123,157	251,417
2005	31,573	34,036	47,778	123,300	236,687
2006	25,730	56,070	48,943	126,607	257,350
2007	28,997	60,725	53,759	103,386	246,867
2008	17,156	47,285	52,338	71,593	188,372
2009	19,463	40,916	66,442	66,971	196,792
2010	21,066	44,947	53,672	69,983	189,668

4.12 Figures

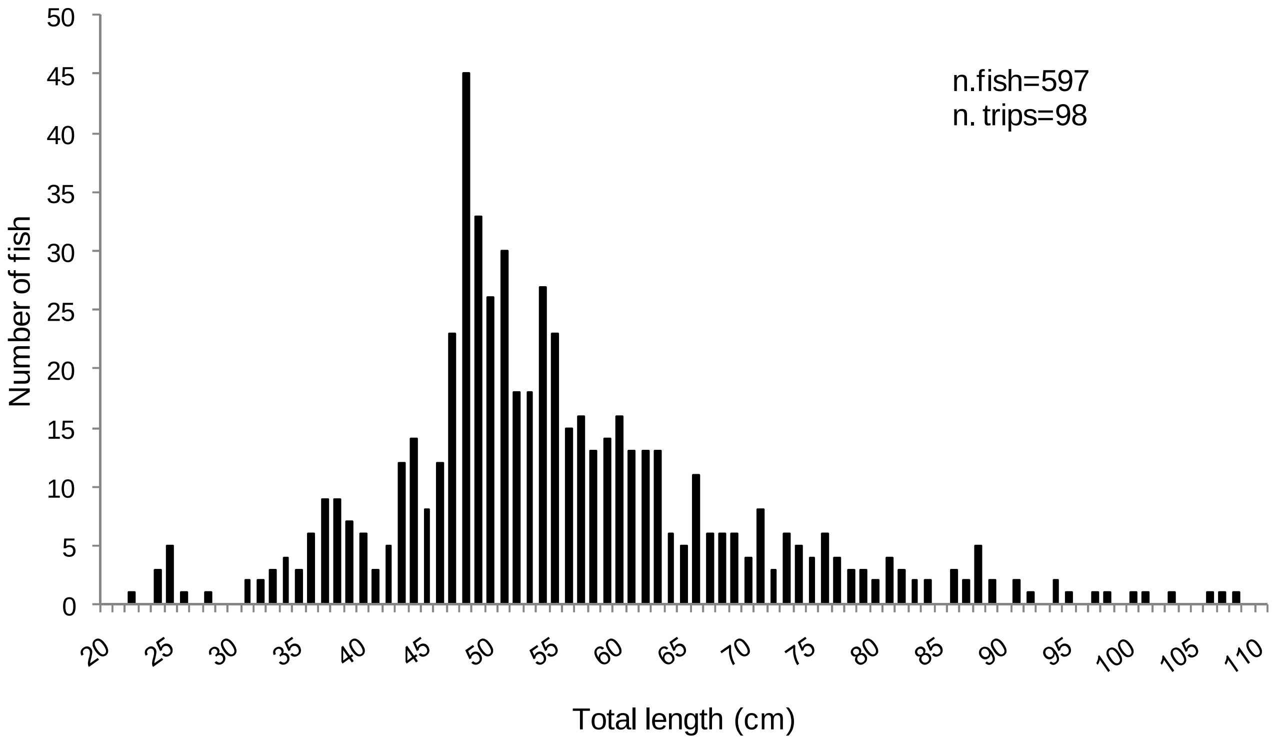


Figure 4.12.1 Cumulative length frequency of tilefish landed in the recreational fishery. The number of trips is a combination of vessel (SRHS) and angler trips (MRFSS).

5 Measures of Population Abundance

5.1 Overview

Several indices of abundance were considered for use in the South Atlantic (golden) tilefish assessment model. These indices are listed in Table 5.1.1, with pros and cons of each in Table 5.1.2. The indices were generated from fishery independent and fishery dependent data. The DW recommended the use of one fishery dependent index and one fishery independent index (commercial longline and MARMAP bottom longline, respectively). Of the two indices, the commercial logbook index was given higher priority, because the fishery independent data had relatively low sample sizes from geographic areas not considered central to tilefish range. Additionally, fisheries dependent data from two tilefish vessels were examined (but not recommend for use) and results mirrored the logbook index.

Group membership
Membership of this DW Index Working Group (IWG) included Kevin McCarthy (work group leader), Kate Andrews (Rapporteur), Nate Bacheler, Walter Ingram, Michelle Pate, Jessica Stephen, Rob Cheshire, Kyle Shertzer, Eric Fitzpatrick, Mike Errigo, Julia Byrd and Jimmy Hull. Several other participants of the data workshop contributed in the IWG discussions throughout the week.

5.2 Review of Working Papers

The working group reviewed three working papers describing index construction, including: SEDAR25-DW04; SEDAR25-DW07; and SEDAR25-DW09. SEDAR25-DW04 described the computation of a fishery independent index from the MARMAP bottom longline data. This working paper was helpful for determining if the index should be recommended for use and revisions are described in Addendum 4 of the working paper. SEDAR25-DW07 described 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. SEDAR25-DW09 described the computation of a fishery dependent index from vessels fishing off the east coast of Florida.

Indices report cards for both fishery independent and dependent data considered at the data workshop can be found in Appendix 5. These report cards were submitted by individual analysts after the DW, and thus were not available for the IWG to review or use for informing decisions.

5.3 Fishery Independent Indices

5.3.1 MARMAP bottom longline

5.3.1.1 Methods, Gears, and Coverage

Tilefish catch-per-unit effort was calculated from MARMAP bottom longlining data. Sampling occurred primarily off of South Carolina, but in one year ranged as far south as central Florida.

Catch-per-unit-effort (CPUE; number of tilefish caught per hour soak time) was not standardized using a delta-GLM model due to few longline sets and concomitant low catches of tilefish in some years. For further description concerning this index refer to working paper SEDAR25-DW04.

5.3.1.2 Sampling intensity and time series

In years in which longlining occurred, between 5 and 57 longlines were fished. The time series ranged from 1983–1986, 1996–2007, and 2009–2010.

5.3.1.3. Size/Age data

Age data is provided in Figure 5 of SEDAR25-DW04. All tilefish caught in this program were aged.

5.3.1.4. Catch Rates – Number and Biomass

Index results are listed in Table 5.3.1 and shown graphically in Figure 5.3.1.

5.3.1.5. Uncertainty and Measures of Precision

Standard error of the mean was calculated and listed in Table 5.3.1.

5.3.1.6 Comments on Adequacy for assessment

We removed anomalous samples from Florida in 1999 because they were inconsistent to the sampling locations in the rest of the time series. Also, due to low sample sizes in many years, we calculated tilefish CPUE within four year bins (two years for the terminal bin): 1983 – 1986, 1996 – 1999, 2000 – 2003, 2004 – 2007, and 2009 – 2010. Thus, these CPUE data are not yearly point estimates, but rather mean CPUE values calculated for groups of years. The values should be treated accordingly in the assessment. The data workshop accepted this index to be included in the assessment.

The binned index (4-year bins) is recommended for use in the assessment. The binning does not imply a yearly value is repeated in each of the four years, but rather represents relative abundance among blocks of years.

5.4 Fishery Dependent Indices

5.4.1 Index of Abundance from commercial logbook data -longline

Handline, electric reel (bandit rig), and longline landings and fishing effort of commercial vessels operating in the Gulf of Mexico and U.S. South Atlantic have been reported to the National Marine Fisheries Service (NMFS) through the Coastal Fisheries Logbook Program (CFLP) maintained by the NMFS Southeast Fisheries Science Center. The program collects landings and effort data by fishing trip from vessels that are federally permitted to fish in a number of fisheries managed by the Gulf of Mexico and South Atlantic Fishery Management Councils.

Longline catch rate was calculated as weight of tilefish per hook fished (hours fished were not consistently reported for longline gear to the CFLP and could not be reliably included in the analysis).

CPUE = pounds of tilefish/ (number of sets*number of hooks per set)

Seven factors were considered as possible influences on the proportion of trips that landed tilefish and on the catch rate of tilefish. An additional factor, number of hooks fished, was examined for its affect on the proportion of positive trips. Refer to working paper SEDAR25-DW07 for further description.

5.4.1.1 Methods of Estimation

Available data and treatment

For each fishing trip, the coastal logbook 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 longline gear included number of sets and number of hooks fished per set. Multiple areas fished and multiple gears fished may be recorded for a single fishing trip. In such cases, assigning catch and effort to specific locations or gears was not possible; therefore, only trips which reported one area (i.e., subregion, as defined below) and one gear fished were included in these analyses.

Management measures, specifically closed seasons, required that additional data be excluded from the analyses. Closed seasons occurred yearly beginning in 2006 due to quota restrictions and data reported during the two closed seasons were excluded from the analyses. No minimum size was in effect for the commercial tilefish fishery during the period 1993-2010 and therefore had no effect on the analysis. Trip limit restrictions, however, were in effect beginning in 1994. Targeting of trips may have been affected if a trip limit was met. Coastal logbook data are trip-based, therefore, effort cannot be unambiguously apportioned if targeting changed during a trip. Effects of trip limits were examined by identifying those trips that met or exceeded the trip limit (5,000 pounds gutted weight from 1994-2005; 4,000 pounds from 2006-2010). For those trips that met or exceeded the trip limit, the proportion of tilefish to all other species landed was determined. It was assumed that targeting did not change during a trip if a small proportion of other species were landed from the trip. In such cases, the trip was retained for the analysis.

Tilefish trips were identified using a data subsetting technique (modified from Stephens and MacCall, 2004) intended to restrict the data set to trips with fishing effort in presumptive tilefish habitat. Such an approach was necessary because fishing location was not reported to the CFLP at a spatial scale adequate to identify targeting based upon the habitat where the fishing occurred. The modified Stephens and MacCall method was an objective approach in which a logistic regression was applied to estimate the probability that tilefish could have been encountered given the presence or absence of other species reported from the trip. As a function of the species reported from a trip, a score was assigned to the trip and that score was converted into the probability of observing tilefish. Trips with scores above a critical value were included in the CPUE analysis. That critical value was set at the score that minimized the number of predictions of tilefish occurring when the species was actually absent (false positives) while also minimizing incorrect predictions of tilefish absence when the species was actually present (false negatives).

Figure 2 of the working paper provides species-specific regression coefficients. The magnitude of the coefficients indicates the predictive impact of each species.

Sampling Intensity and time series

Data were further restricted to include only those trips with landings and effort data reported within 45 days of the completion of the trip. Reporting delays beyond 45 days (some reporting delays were longer than one year) likely resulted in less reliable effort data. Landings data, however, may have been reliable even with lengthy reporting delays if trip ticket reports were referenced by the reporting fisher.

Clear outliers in the data, e.g. values falling outside the 99.5 percentile of the data, were excluded from the analyses. These included longline data from trips reporting more than 24 sets per day, more than 3,500 hooks per set, fewer than 25 hooks per set, or longline lengths more than 20 miles or less than 1 mile. Data from trips with reported crews of more than 5 or trips of more than 14 days at sea were also excluded from the analyses. Approximately 67 percent of longline trips were retained for analyses following all data filtering.

5.4.1.2 Size/Age data

The sizes/ages represented in this index should be the same as those of landings from the corresponding fleet (commercial longlines).

5.4.1.3 Catch Rates

Indices results are listed in Table 5.4.1 and shown graphically in Figure 5.4.1.

5.4.1.4 Uncertainty and Measures of Precision

Coefficients of variation (CV) were in the range 0.18-0.27 over the entire time series.

5.4.4.5 Comments on Adequacy for Assessment

The index of abundance from commercial logbook data was considered by the index 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, it is a relatively long time series and will likely provide meaningful information to the assessment. The primary caveat about this index is that it was derived from fishery dependent data.

A suggestion from the working group was made to run positive only model due to such high proportion positives and to subset the logbook data to determine if trends in areas match the MARMAP longline series. Nearly identical results were generated from this exercise.

5.4.2 Other Data Sources Considered

An industry representative made available a commercial longline CPUE calculated from two boats for a short time series. These data were made available for the workshop as SEDAR25 DW09. The IWG was concerned with the limited geographic coverage and the limited sample size, and recognized that these data should already be included in the broader logbook data set (CFLP) described above. Thus, the IWG did not recommend this index for inclusion in the assessment, and this recommendation was accepted by the data workshop panel. For full description refer to working paper SEDAR25 DW09.

5.5 Consensus Recommendations and Survey Evaluation

One fishery independent index was recommended for use in the assessment: MARMAP longline index. One fishery dependent index was recommended: commercial logbook index. Sampling coverage for each index is shown for comparison in Figure 5.5.1. All indices considered are compared graphically in Figure 5.5.2.

5.6 Itemized List of Tasks for Completion following Workshop

- The report cards and synopses by index need to be **completed by the author** of each index.

5.7 Literature Cited

Stephens, A., and A. MacCall. 2004. A multispecies approach to subsetting logbook data for purposes of estimating CPUE. Fish. Res. 70:299−310.

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 Longline	NC – FL	1983-2010	Fish / hour soak time	Nominal CPUE	Low catch, High variance	Yes
Commercial	Commercial Logbook	NC-FL	1993-2010	Lbs kept/number of sets*number of hooks per set	Delta glm	Fishery dependent	Yes
Commercial	J.Hull & P. Barile	FL	2002-2011	Lbs/number of hooks*number of sets	nominal	Small sample size Captured in other dataset Small spatial coverage	No

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

<u>Fishery dependent indices</u>
Commercial Logbook – Longline (*Recommended for use*)
Pros:
- Complete census
- Covers entire management area
- Continuous, 18-year time series
- Large sample size

Cons:
- Fishery dependent
- Data are self-reported and largely unverified
- 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

J. Hull and P. Barile logbook data 2003-2011 *(Not recommended for use)*
Cons:
- Included in the logbook data series in more recent years
- Limited geographic coverage (Florida only)
- Limited sample size (only trips from two fishermen)

Issues discussed:
- The CPUE trends are similar to the trends in the commercial logbook

<u>Fishery independent indices</u>
MARMAP *(recommended for use)*
Longline
Pros:
- Fishery-independent
- Consistent sampling techniques

Cons:
- Low samples sizes
- High standard errors
- Concern that survey occurs outside the primary range where the bulk of the landings occur (FL)

Table 5.3.1. Tilefish catch information from the MARMAP longline database, summarized by the groups of years used in the analysis. All CPUE calculations are number of tilefish caught per hour soak time.

Year	# sets	# tilefish caught	Proportion positive longline sets	Mean (SE) CPUE (catch · hr^{-1})	Minimum CPUE (catch · hr^{-1})	Maximum CPUE (catch · hr^{-1})
1983-1986	155	314	0.53	1.03 (0.135)	0.00	9.32
1996-1999	70	301	0.47	2.46 (0.467)	0.00	15.35
2000-2003	56	97	0.43	1.00 (0.234)	0.00	9.03
2004-2007	52				0.00	
		80	0.27	0.89 (1.704)		5.45
2009-2010	76	336	0.59	2.82 (0.486)	0.00	19.78

Table 5.4.1. Longline relative nominal CPUE, number of trips, proportion positive trips, and standardized abundance index for tilefish (1993-2010) in the South Atlantic.

YEAR	Normalized Nominal CPUE	Trips	Proportion Successful Trips	Standardized Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1993	0.713455	223	0.955157	0.623027	0.418142	0.928305	0.201383
1994	0.644691	311	0.900322	0.623359	0.432052	0.899374	0.184838
1995	0.723717	260	0.888462	0.765415	0.516622	1.134019	0.198467
1996	0.49463	192	0.885417	0.452756	0.284306	0.721013	0.235836
1997	0.444536	208	0.875	0.609743	0.404116	0.919999	0.207862
1998	0.622591	158	0.797468	0.712064	0.447211	1.133771	0.235749
1999	1.229995	198	0.818182	0.636855	0.370461	1.094808	0.275943
2000	0.986446	228	0.877193	0.676573	0.410235	1.115827	0.25412
2001	0.663059	191	0.905759	0.635274	0.414456	0.973742	0.216002
2002	0.458428	137	0.854015	0.519392	0.31795	0.84846	0.249123
2003	0.551598	132	0.863636	0.662369	0.426945	1.027609	0.222257
2004	0.409837	113	0.787611	0.589789	0.354317	0.981749	0.258977
2005	0.985622	66	0.848485	1.060471	0.631062	1.782073	0.263964
2006	0.836367	105	0.733333	1.324642	0.87967	1.994699	0.206838
2007	2.391053	145	0.917241	1.907125	1.232525	2.950955	0.220892
2008	1.649657	105	0.67619	1.996987	1.219977	3.26888	0.250192
2009	1.090824	154	0.441558	1.849201	1.112741	3.073083	0.258114
2010	3.103493	138	0.985507	2.354958	1.600827	3.464351	0.194812

5.9 Figures

Figure 5.3.1. The nominal CPUE of tilefish caught in MARMAP bottom longlining within the groups of years used in the analysis.

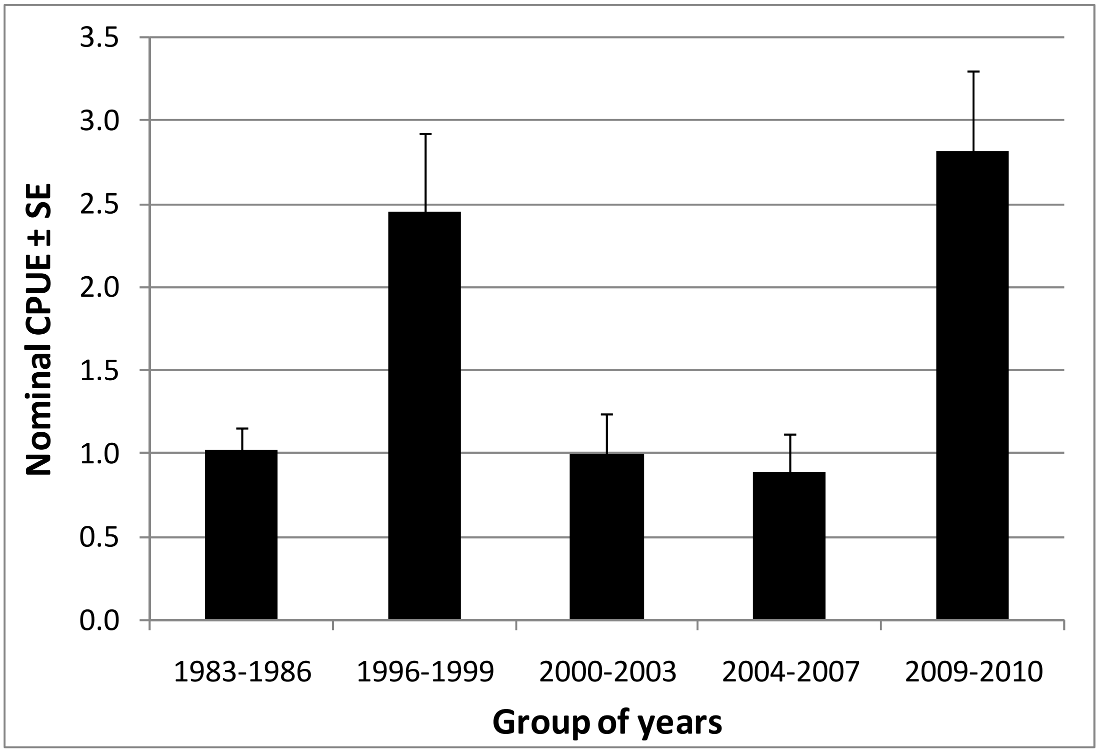


Figure 5.4.1. Tilefish nominal CPUE (solid circles), standardized CPUE (open diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dashed lines) for commercial vessels fishing longline gear in the South Atlantic.

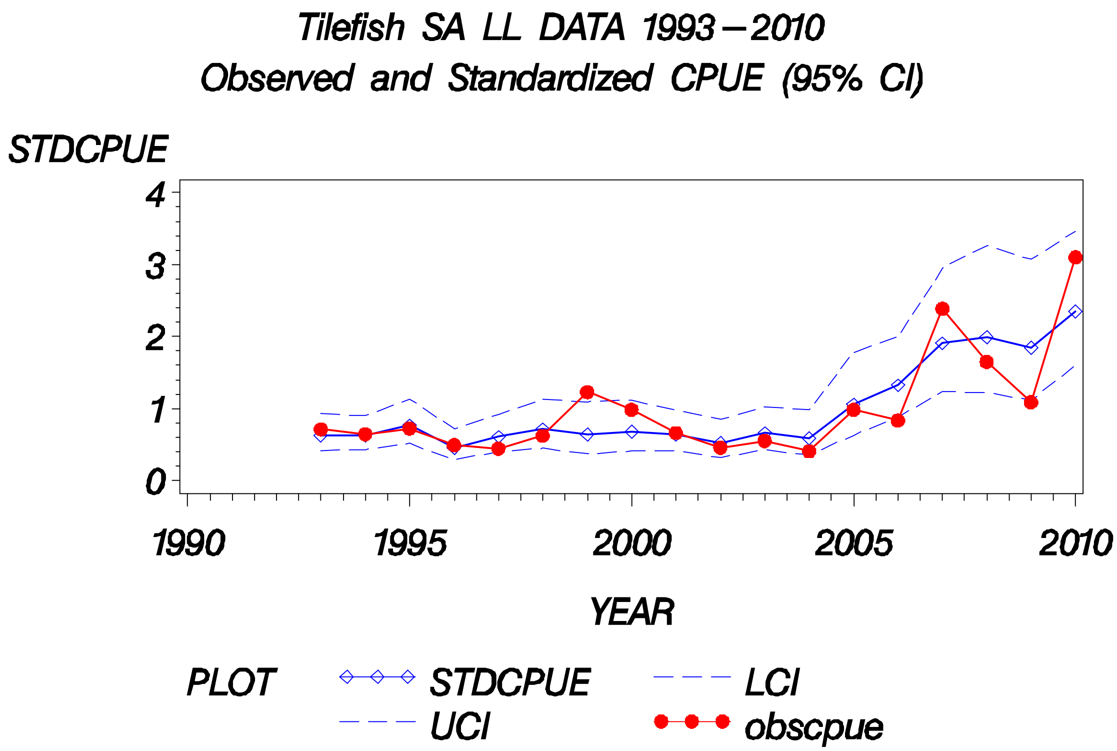


Figure 5.5.1. Sampling coverage for tilefish indices for SEDAR 25.

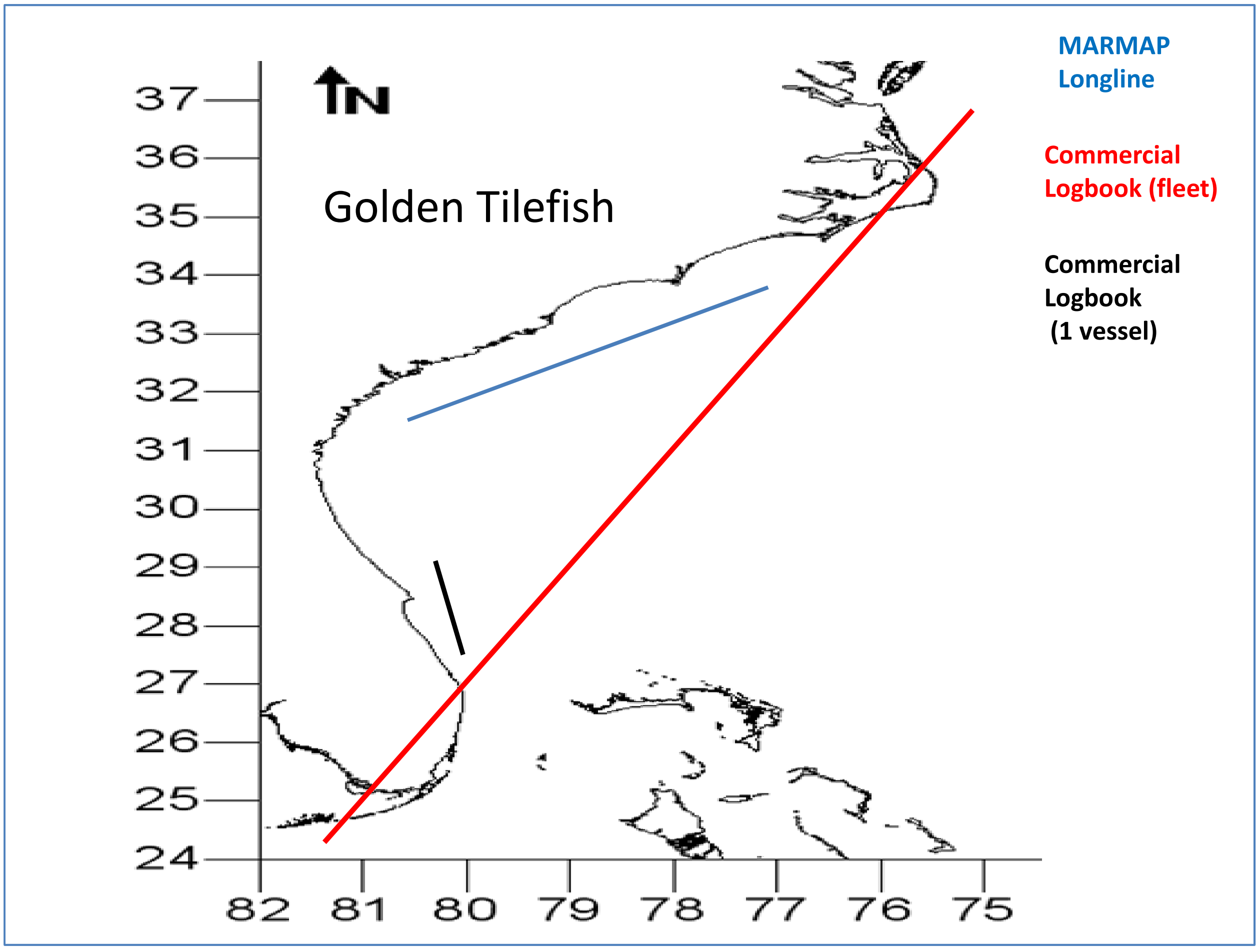
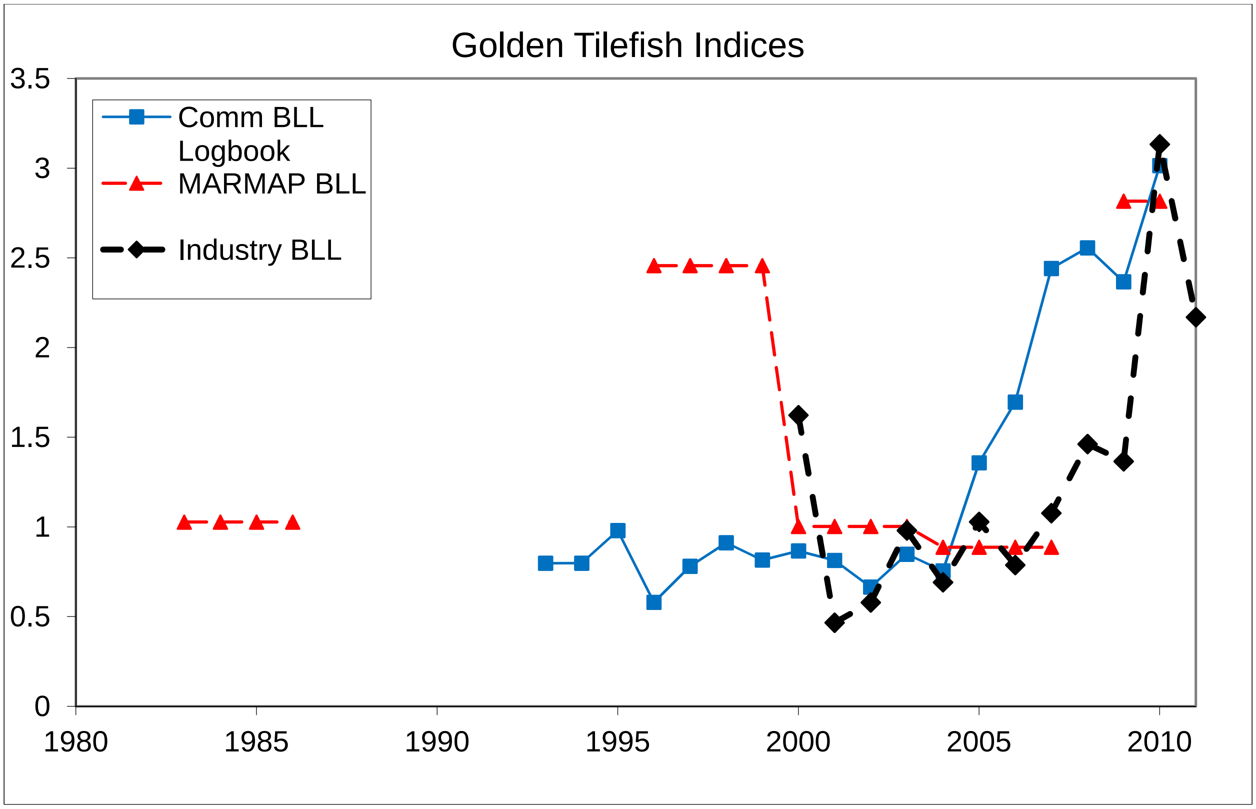


Figure 5.5.2. Three indices considered at SEDAR 25 for tilefish assessment (commercial logbook, MARMAP bottom longline, and industry longline indices). Commercial logbook and MARMAP were recommended for use.



6 Analytic Approach

6.1 Overview

The lead analyst for this species is Erik Williams and the data compiler is Rob Cheshire.

6.2 Suggested analytic approach given the data

The assessment models to be used for SEDAR 25 golden tilefish are specified in the Assessment Workshop Terms of Reference. BAM and ASPIC models will be developed.

7 Research Recommendations

7.1 Life History

Research Recommendations

- Investigate the movements and migrations of Tilefish using Otolith microchemistry
- Investigate the stock definition through genetic studies to establish if biogeographic boundary exists at Cape Hatteras or if future assessments will use the NC/VA border.
- Fishery-dependent and fishery-independent sampling to include the entire Southeast Region throughout a longer time period.
- Analyze size or age specific spawning frequency and spawning seasonality.

7.2 Commercial Statistics

- The Commercial Workgroup recommends exploration of the definition of the stock, particularly with respect to the northern boundary.
- Additionally, the group would suggest examining the impact/landings of the historical foreign fleet in the South Atlantic.
- Finally, collection of better spatial information in the fishery to determine potential localized depletion effects is recommended.

7.3 Recreational Statistics

- Continue development of standardized method for calculating incomplete weight data
- Develop method for capturing depth at capture within MRFSS At-Sea observer program and Headboat Survey.
- Conduct study looking at current compliance rates in logbook programs, develop recommendations for improving them, including increased education directed toward effect of not reporting accurately.
- Continued development of electronic reporting of headboat logbook for full implementation
- Continued development of higher degree of information of condition of released fish e.g. FL as the model

7.4 Indices

- None provided.

Appendix 1 - Index Report Cards

Appendix 5.1 MARMAP longline index
Appendix 5.2 Commercial longline index
Appendix 5.3 Industry (Two vessel) commercial index

SEDAR

Southeast Data, Assessment, and Review

SEDAR 25

South Atlantic Tilefish

SECTION III: Assessment Workshop Report

Revised October 2011

(Original report received September 2011)

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

1 Workshop Proceedings

1.1 Introduction

1.1.1 Workshop Time and Place The SEDAR 25 Assessment workshop for black sea bass (*Centropristis striata*) and tilefish (*Lopholatilus chamaeleonticeps*) was conducted as a workshop held June 21-23, 2011 in at the NMFS Laboratory in Beaufort, NC and five webinars. The webinars were held July 12, July 25, August 19, and September 2, 2011.

1.1.2 Terms of Reference

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 BAM and ASPIC assessment models.
   - Document all input data, assumptions, and equations for each model.
   - Include a model configuration consistent with the SEDAR 2 benchmark as subsequently updated ("Continuity run") incorporating additional data observations.
3. Provide estimates of stock population parameters.
   - Include 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.
   - Consider uncertainty in input data, modeling approach, and model configuration.
   - Consider other sources as appropriate for this assessment.
   - Provide appropriate measures of model performance, reliability, and 'goodness of fit'
5. Provide evaluations of yield and productivity.
   - Include yield-per-recruit, spawner-per-recruit, and stock-recruitment models.
6. Provide estimates for SFA criteria consistent with applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards.
   - Evaluating existing or proposed SFA benchmarks as specified in the management summary.
   - Recommend proxy values when necessary.
7. Provide declarations of stock status relative to SFA benchmarks.
8. Perform a probabilistic analysis of proposed reference points, stock status, and yield.
   - Provide the probability of overfishing at various harvest or exploitation levels.
   - Provide a probability density function for biological reference point estimates.
   - If the stock is overfished, provide the probability of rebuilding within mandated time periods as described in the management summary or applicable federal regulations.
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)

10. Provide recommendations for future research and data collection.
    - Be as specific as practicable in describing sampling design and sampling intensity.
    - Emphasize items which will improve future assessment capabilities and reliability.
    - Consider data, monitoring, and assessment needs.
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 23, 2011 complete the Assessment Workshop Report (Section III of the SEDAR Stock Assessment Report).

1.1.3 List of Participants

Appointee	Function	Affiliation
PANELISTS		
Kyle Shertzer	Lead analyst, BSB	SEFSC Beaufort
Erik Williams	Lead analyst, GT	SEFSC Beaufort
Kevin Craig	Assessment team, BSB	SEFSC Beaufort
Kate Andrews	Assessment team, GT	SEFSC Beaufort
Eric Fitzpatrick	Data compiler, BSB	SEFSC Beaufort
Rob Cheshire	Data compiler, GT	SEFSC Beaufort
John Boreman	SSC member	SAFMC
Chip Collier	SSC member	SAFMC
Andy Cooper	SSC member	SAFMC
Marcel Reichert	SSC member	SAFMC
Nikolai Klibanski	Academic	UNCW
COUNCIL REPRESENTATIVES		
Tom Burgess	Council member	SAFMC
Ben Hartig	Council member	SAFMC
APPOINTED OBSERVERS		
Tony Austin	Commercial	NC, BSB
Bobby Cardin	Commercial	FL, GT
Kenny Fex	Commercial	NC, BSB
Jimmy Hull	Commercial	FL, BSB
Joe Klosterman	Commercial	FL, GT
STAFF		
Kari Fenske	Coordinator	SEDAR
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Gregg Waugh	Fishery biologist	SAFMC
Mike Errigo	Fishery biologist	SAFMC
Tyree Davis	IT support	SEFSC
John Carmichael		SAFMC
Brian Cheuvront		SAFMC
Jessica Stephen		SERO
Andy Strelcheck		SERO
Dan Carr		SEFSC
Gretchen Bath Martin		SEFSC
Jeff Kipp		SEFSC
Jennifer Potts		SEFSC
Lew Coggins		SEFSC

ATTENDEES
Samantha Port-Minner
Rusty Hudson
Peter Barile
Renzo Taschieri
Frank Hester
Brian Paul
Joey Ballenger
Paul Nelson

1.1.4 List of Assessment Workshop Working Papers

SEDAR25-AW01	Is pooling MARMAP chevron trap data justifiable for Black Sea Bass (*Centropristis striata*) in the South Atlantic Region?	Hull and Hester 2011

1.2 Statements Addressing each Term of Reference

Assessment Workshop TOR

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 BAM and ASPIC assessment models.
    - Document all input data, assumptions, and equations for each model.
    - Include a model configuration consistent with the SEDAR 2 benchmark as subsequently updated ("Continuity run") incorporating additional data observations.

    BAM and ASPIC implementations are described in section 3 of the AW report. Input data are documented in the DW report and in section2 of the AW report. Model assumptions and equations of BAM are documented in SEDAR25-RW03, and those of ASPIC in the Prager (2005). A continuity run of BAM was configured as a sensitivity run of the SEDAR 25 implementation (Retrospective 2002 sensitivity run).

3. Provide estimates of stock population parameters.
    - Include fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, etc
    - Include appropriate and representative measures of precision for parameter estimates.

These estimates and measures of precision are described in section 3 of the AW report.

4. Characterize uncertainty in the assessment and estimated values.
    - Consider uncertainty in input data, modeling approach, and model configuration.
    - Consider other sources as appropriate for this assessment.
    - Provide appropriate measures of model performance, reliability, and 'goodness of fit'

    Measures of precision are described in section 3 of the AW report.

5. Provide evaluations of yield and productivity.
    - Include yield-per-recruit, spawner-per-recruit, and stock-recruitment models.

    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.
    - Evaluating existing or proposed SFA benchmarks as specified in the management summary.
    - Recommend proxy values when necessary.

    Estimated management benchmarks and alternatives are provided in section 3 of the AW report.

7. Provide declarations of stock status relative to SFA benchmarks.

    Estimates of stock status are provided in section 3 of the AW report.

8. Perform a probabilistic analysis of proposed reference points, stock status, and yield.
    - Provide the probability of overfishing at various harvest or exploitation levels.
    - Provide a probability density function for biological reference point estimates.
    - If the stock is overfished, provide the probability of rebuilding within mandated time periods as described in the management summary or applicable federal regulations.

    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 evaluate the rebuilding schedule. 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 C (not overfished nor overfishing).

10. Provide recommendations for future research and data collection.
    - Be as specific as practicable in describing sampling design and sampling intensity.
    - Emphasize items which will improve future assessment capabilities and reliability.
    - Consider data, monitoring, and assessment needs.

Research recommendations are listed in section 3.4.

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 Excel file of model output was supplied. Input data were included in this file, with the exception of some years observed landings (removed to avoid any possibility of breaching confidentiality requirements).

12. No later than TBD complete the Assessment Workshop Report (Section III of the SEDAR Stock Assessment Report).

This report was provided within an extended time period approved by the AW panel.

2 Data Review and Updates

Several of the data inputs to the BAM model were modified from the decisions made by the SEDAR 25 DW presented in the DW report. These changes were implemented for several reasons including, corrections supplied by DW workshop participants, previous model constructs, standard procedures which are decided based on finalized data such as binning and pooling composition data, or unrealistic values. An explanation of these changes and a summary of the data used in modeling tilefish for SEDAR 25 are presented in this section.

2.1 Life History

A gutted weight to whole weight conversion was created after the data workshop by the life history group. This equation, $Wholeweight = 1.05893 * guttedweight$, was applied to the commercial gutted weight landings developed at the DW. The relationship between weight and length, $WetWeight(mt) = 4.04^{-12} * TotalLength(mm)^{3.155}$, was defined at the DW and input to the model. Age–based natural morality estimates were developed during the SEDAR-25 DW (Table 2.1). A point estimate of natural mortality, 0.10, was used to scale the age–based estimates of natural mortality. Total and female–only von Bertalanffy growth equations were provided by the DW and used in the model. The L_{inf}, K, and t_0 were estimated to be (825.1, 0.189, -0.47) for male and female, and (806.3, 0.167, -0.47) for females only. The female growth estimates were used to model SSB and the female growth parameters were used to calculate generation time. Length at age for both growth models are given in Table 2.1. The sex ratio was assumed equal. Females were assumed fully mature at age 4 and the proportion mature at ages 1, 2, and 3 were assumed to be 0.1, 0.25, and 0.5 respectively (Table 2.1).

Generation time is not typically computed at the data workshop but may be required for stock projections. Generation time (G) was estimated from Eq. 3.4 in Gotelli (Gotelli (1998), p. 57):

$$G = \sum l(x)b(x)x / \sum l(x)b(x) \tag{1}$$

where summation was over ages x=1 through 100 (by which age cumulative survival is essentially zero), $l(x)$ is the probability of survival of fish at age starting with 1 for 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 reproductive potential 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 female gonad weight at age. This weighted average of age for mature biomass yields an estimated generation time of 20 years (rounded up from 19.5 yrs.).

2.2 Landings

Landings estimates provided by the SEDAR-25 DW were combined into three categories. Recreational landings include estimates of headboat and MRFSS private and charter landings. The SEDAR-25 AW considered the 2005 MRFSS landings to be unrealistic and replaced it with the average of the 2003, 04, 06, and 07 estimated landings. The commercial handline and longline gear estimated landings were input as gutted pounds and converted to whole pounds in the model. The commercial "other" estimated landings were divided between commercial handline and commercial longline based on the annual proportion of each. The recreational, commercial handline, and commercial longline estimates were input into the model in thousands of pounds (Table 2.2).

2.3 Discards

No discard estimates were included in the model as discards are assumed to be negligible in all sectors of the tilefish fishery.

2.4 Length Composition

Lengths were available from the commercial handline, commercial longline, and MARMAP longline. The DW developed annual length compositions for all years that fish were measured. Many years had very small sample sizes. Usually fish that are aged also have lengths available. To avoid using ages and lengths from the same fish to inform the model, age compositions were preferred if 10 or more fish were aged in a year. Length compositions were used for years when fewer than 10 fish were aged and for years when age data was not available (Table 2.3). The 1–cm bins were pooled to 3–cm bins and input into the model in mm. The 3–cm bins extended from 340 mm to 1000 mm, pooling the extreme values at both the upper and lower end of the range. The number of fish and and number of trips, used to compute effective sample size, were provided by the DW. MRFSS could not identify the number of trips by vessel for some years. The number of trips reported for MRFSS are either vessel trips or angler trips depending on the year.

2.5 Age Composition

Age data were available from the commercial handline, commercial longline and MARMAP longline sampling programs. The term "age" refers to increment count as calendar age could not be determined for tilefish. The annual age composition was developed for tilefish by the SEDAR-25 DW. Ages greater than 25 were pooled to age 25 creating a plus group (Table 2.4).

SEDAR-25 AW panelists discussed the difficulty in ageing tilefish. Researchers with experience sectioning and reading tilefish otoliths were present at the AW. The SEDAR-25 DW did not develop an ageing error matrix. The SEDAR-25 AW decided to include the ageing error matrix from a recent SEDAR 22 Gulf of Mexico tilefish assessment (SEDAR 2011) as input to the tilefish model. The AW panel discussed adjustments to the ageing error matrix based on unrealistic fits to composition data. After several levels of adjustment were evaluated, the final decision was to reduce the ageing error input by half to improve fits to age compositions. (Table 2.5).

2.6 Indices of abundance

The SEDAR-25 DW recommended using the fishery–independent MARMAP horizontal longline index and the fishery dependent logbook index (Table 2.6). Limited samples were available from the MARMAP longline index and data were pooled across years at the DW. The MARMAP longline standard deviation estimates developed at the DW were converted to CV (CPUE/SD) for input to the model.

2.7 Tables

Table 2.1. Life history values at age input to the Tilefish model. Lorenzen–based natural mortality, length at age for both sexes and for females only derived from the growth equations. Female–only growth is used to calculate spawning stock biomass in the model. Female maturity scheduled developed at the DW.

	Natural	Total Length (mm)		Female
Age	Mortality	Male and Female	Female	Maturity
1	0.297	256.5	226.0	0.10
2	0.217	354.4	315.3	0.25
3	0.178	435.5	390.8	0.50
4	0.155	502.6	454.7	1.00
5	0.140	558.1	508.8	1.00
6	0.130	604.1	554.5	1.00
7	0.123	642.2	593.3	1.00
8	0.117	673.7	626.0	1.00
9	0.113	699.7	653.8	1.00
10	0.110	721.3	677.2	1.00
11	0.107	739.2	697.1	1.00
12	0.105	754.0	713.9	1.00
13	0.104	766.2	728.1	1.00
14	0.102	776.4	740.1	1.00
15	0.101	784.8	750.3	1.00
16	0.100	791.7	758.9	1.00
17	0.100	797.5	766.2	1.00
18	0.099	802.2	772.4	1.00
19	0.099	806.2	777.6	1.00
20	0.098	809.4	782.0	1.00
21	0.098	812.1	785.7	1.00
22	0.098	814.4	788.9	1.00
23	0.097	816.2	791.6	1.00
24	0.097	817.7	793.8	1.00
25	0.097	819.0	795.8	1.00

Table 2.2. Annual landings estimates input to the Tilefish model. Some data included in the input are confidential due to the number of vessels reporting landings and are denoted with an "". Commercial landings were input as gutted weight and converted to whole weight in the model.*

	Thousand Pounds		
	whole	gutted	gutted
Year	Recreational	Handline	Longline
1962		0.468	2.934
1963		0.443	2.776
1964		0.138	0.862
1965		3.208	20.096
1966		0.602	3.773
1967		1.426	8.931
1968		0.873	5.467
1969		0.713	4.466
1970		1.413	8.854
1971		2.618	16.400
1972		1.561	9.778
1973		5.469	34.263
1974		12.425	77.843
1975		21.571	133.968
1976		21.928	129.789
1977		25.734	62.760
1978		91.554	92.140
1979		55.857	114.232
1980		148.605	177.797
1981	0.412	334.407	783.689
1982	0.018	596.732	2774.404
1983	3.199	263.259	1630.174
1984	0.726	202.687	1108.276
1985	47.293	146.993	989.904
1986	0.319	133.884	985.575
1987	0.148	24.751	247.343
1988	3.967	50.228	452.719
1989	0.014	92.611	743.915
1990	0.349	86.061	757.825
1991	0.390	82.346	822.714
1992	7.273	81.527	887.374
1993	0.020	171.108	866.091
1994	12.778	105.428	702.016
1995	0.020	82.718	591.458
1996	3.520	*	*
1997	29.583	34.133	328.338
1998	1.238	28.891	334.574
1999	8.227	38.104	473.771
2000	14.314	54.204	666.858
2001	35.179	38.550	389.574
2002	17.742	*	*
2003	45.419	18.760	222.235
2004	7.758	29.127	231.878
2005	28.507	*	*
2006	51.076	26.594	379.476
2007	9.775	49.747	260.570
2008	0.020	*	*
2009	54.514	*	*
2010	27.747	*	*

Table 2.3. Annual proportion at length input to the tilefish model. The sample sizes are: n.fish–number of fish measured, n.trips–number of trips from which fish were measured, n.sets–number of individual MARMAP longlines.

Recreational														
Year	n.fish	n.trips	340	370	400	430	460	490	520	550	580	610	640	670
1984	10	2	0.1000	0.0000	0.0000	0.0000	0.1000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1989	17	10	0.2941	0.2353	0.1176	0.1176	0.0000	0.0588	0.0000	0.0000	0.1176	0.0000	0.0000	0.0588
1990	14	6	0.8571	0.0714	0.0000	0.0000	0.0000	0.0714	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1996	53	6	0.0000	0.0000	0.0000	0.0000	0.0189	0.0377	0.0189	0.0755	0.1132	0.0377	0.1321	0.1132
1997	126	9	0.0000	0.0317	0.0397	0.0556	0.0794	0.0952	0.1032	0.1270	0.0476	0.1190	0.0635	0.0635
1998	48	5	0.0000	0.0208	0.0208	0.0417	0.0833	0.1042	0.0417	0.0417	0.0833	0.0417	0.0417	0.0417
2001	20	7	0.1000	0.0000	0.1000	0.0000	0.0000	0.3000	0.2000	0.1000	0.1000	0.0000	0.0000	0.0000
2002	28	6	0.0000	0.0000	0.0000	0.0357	0.0357	0.1786	0.0357	0.1786	0.1429	0.1429	0.0714	0.1071
2003	64	7	0.0000	0.0000	0.0000	0.0781	0.1875	0.2969	0.0781	0.1406	0.0938	0.1094	0.0156	0.0000
2004	28	4	0.1071	0.3571	0.1071	0.0357	0.0000	0.1429	0.2143	0.0000	0.0000	0.0357	0.0000	0.0000
2005	130	9	0.0000	0.0000	0.0000	0.0615	0.0846	0.3538	0.2154	0.1308	0.0692	0.0462	0.0231	0.0154
2006	17	4	0.0588	0.2353	0.0588	0.1176	0.0588	0.1176	0.1176	0.0588	0.0000	0.0588	0.0000	0.0000
2009	12	5	0.0000	0.0000	0.0000	0.0000	0.0833	0.0000	0.1667	0.1667	0.0833	0.2500	0.0000	0.0000
2010	11	5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0909	0.0000	0.1818	0.0909	0.0000	0.0909
Commercial Handline														
Year	n.fish	n.trips	340	370	400	430	460	490	520	550	580	610	640	670
1984	19	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0598	0.0000	0.0000	0.0000	0.1340	0.1794	0.4186
1985	52	6	0.0000	0.0000	0.0000	0.0010	0.0000	0.0010	0.0000	0.0002	0.0007	0.0518	0.1294	0.2919
1986	79	2	0.0000	0.0128	0.0256	0.0000	0.0897	0.0897	0.0641	0.0384	0.0897	0.0513	0.0769	0.1031
1987	58	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0345	0.0690	0.0690	0.0000	0.0000	0.0345
1991	134	7	0.0000	0.0000	0.0090	0.0269	0.0269	0.0537	0.0269	0.0805	0.0716	0.0805	0.0537	0.0910
1993	54	3	0.0000	0.0186	0.0186	0.0186	0.0186	0.0186	0.0929	0.0372	0.0372	0.1487	0.0929	0.0743
1994	68	2	0.0000	0.0000	0.0000	0.0121	0.0284	0.2195	0.0774	0.2038	0.1264	0.0732	0.1094	0.0526
1995	438	5	0.0000	0.0000	0.0000	0.0119	0.0460	0.0657	0.0642	0.1465	0.1216	0.1426	0.0753	0.0763
1996	13	2	0.0000	0.0215	0.0000	0.0108	0.0108	0.0108	0.0000	0.0000	0.1541	0.0108	0.1541	0.0000
Commercial Longline														
Year	n.fish	n.trips	340	370	400	430	460	490	520	550	580	610	640	670
1988	1057	8	0.0020	0.0048	0.0116	0.0373	0.0641	0.0710	0.1224	0.1465	0.1042	0.0866	0.0607	0.0569
1989	328	5	0.0074	0.0037	0.0324	0.0414	0.0635	0.0561	0.1489	0.1208	0.1062	0.0799	0.0541	0.0494
1990	738	7	0.0000	0.0017	0.0042	0.0043	0.0287	0.0499	0.0400	0.0886	0.1237	0.1197	0.0801	0.0797
1991	5291	40	0.0064	0.0107	0.0353	0.1034	0.1116	0.0836	0.0475	0.0725	0.0793	0.0959	0.0744	0.0595
1994	9943	59	0.0011	0.0013	0.0068	0.0600	0.1494	0.1761	0.1130	0.1264	0.0971	0.0628	0.0354	0.0477
MARMAP Longline														
Year	n.fish	n.sets	340	370	400	430	460	490	520	550	580	610	640	670
1983	313	63	0.0000	0.0064	0.0192	0.0351	0.0671	0.0479	0.0256	0.0511	0.0703	0.0607	0.0703	0.0575
1996	350	38	0.0000	0.0029	0.0286	0.0457	0.0943	0.1429	0.1943	0.1114	0.0971	0.0486	0.0543	0.0400
2000	97	24	0.0000	0.0103	0.0000	0.0412	0.0722	0.0722	0.0722	0.1340	0.0515	0.0619	0.1237	0.0619
2004	81	14	0.0000	0.0000	0.0247	0.0494	0.0494	0.0864	0.0617	0.0864	0.0247	0.0494	0.0370	0.0988
2009	340	45	0.0000	0.0000	0.0000	0.0000	0.0000	0.0059	0.0118	0.0147	0.0412	0.0441	0.0353	0.1059

Table 2.3. (continued)Annual proportion at length input to the tilefish model. The sample sizes are: n.fish–number of fish measured, n.trips–number of trips from which fish were measured, n.sets–number of individual MARMAP longlines.

Recreational

Year	n.fish	n.trips	700	730	760	790	820	850	880	910	940	970	1000
1984	10	2	0.1000	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1000	0.2000	0.2000
1989	17	10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1990	14	6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1996	53	6	0.0566	0.1321	0.0755	0.0566	0.0566	0.0000	0.0189	0.0377	0.0000	0.0000	0.0189
1997	126	9	0.0476	0.0079	0.0317	0.0000	0.0159	0.0238	0.0317	0.0000	0.0079	0.0000	0.0079
1998	48	5	0.1042	0.0417	0.0417	0.0417	0.0625	0.0000	0.0625	0.0208	0.0208	0.0000	0.0417
2001	20	7	0.0000	0.0000	0.0500	0.0000	0.0000	0.0000	0.0500	0.0000	0.0000	0.0000	0.0000
2002	28	6	0.0000	0.0000	0.0000	0.0714	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2003	64	7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2004	28	4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2005	130	9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2006	17	4	0.0588	0.0000	0.0000	0.0000	0.0588	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2009	12	5	0.1667	0.0000	0.0000	0.0000	0.0000	0.0833	0.0000	0.0000	0.0000	0.0000	0.0000
2010	11	5	0.0000	0.1818	0.1818	0.0909	0.0000	0.0909	0.0000	0.0000	0.0000	0.0000	0.0000

Commercial Handline

Year	n.fish	n.trips	700	730	760	790	820	850	880	910	940	970	1000
1984	19	2	0.0598	0.0598	0.0598	0.0000	0.0144	0.0000	0.0000	0.0000	0.0000	0.0000	0.0144
1985	52	6	0.1294	0.0777	0.0556	0.0259	0.0800	0.1294	0.0000	0.0259	0.0000	0.0000	0.0000
1986	79	2	0.1025	0.0513	0.0769	0.0256	0.0128	0.0384	0.0384	0.0128	0.0000	0.0000	0.0000
1987	58	2	0.1035	0.2414	0.3104	0.0690	0.0000	0.0000	0.0345	0.0345	0.0000	0.0000	0.0000
1991	134	7	0.1081	0.0753	0.0448	0.0455	0.0805	0.0805	0.0358	0.0000	0.0090	0.0000	0.0000
1993	54	3	0.0372	0.0000	0.0743	0.0186	0.0106	0.0186	0.0558	0.0186	0.0417	0.0558	0.0929
1994	68	2	0.0405	0.0163	0.0121	0.0121	0.0000	0.0163	0.0000	0.0000	0.0000	0.0000	0.0000
1995	438	5	0.0557	0.0542	0.0573	0.0411	0.0152	0.0191	0.0073	0.0000	0.0000	0.0000	0.0000
1996	13	2	0.1649	0.0000	0.1541	0.0000	0.0000	0.1541	0.0000	0.0000	0.0000	0.1541	0.0000

Commercial Longline

Year	n.fish	n.trips	700	730	760	790	820	850	880	910	940	970	1000
1988	1057	8	0.0491	0.0484	0.0369	0.0252	0.0119	0.0141	0.0150	0.0181	0.0066	0.0052	0.0014
1989	328	5	0.0366	0.0332	0.0410	0.0154	0.0095	0.0210	0.0191	0.0369	0.0185	0.0022	0.0030
1990	738	7	0.0937	0.0650	0.0592	0.0327	0.0358	0.0146	0.0191	0.0141	0.0245	0.0138	0.0069
1991	5291	40	0.0511	0.0450	0.0361	0.0245	0.0209	0.0140	0.0111	0.0064	0.0031	0.0026	0.0051
1994	9943	59	0.0394	0.0244	0.0165	0.0087	0.0109	0.0078	0.0062	0.0032	0.0031	0.0022	0.0007

MARMAP Longline

Year	n.fish	n.sets	700	730	760	790	820	850	880	910	940	970	1000
1983	313	63	0.0703	0.0639	0.0671	0.1086	0.0607	0.0256	0.0319	0.0032	0.0128	0.0064	0.0383
1996	350	38	0.0514	0.0286	0.0229	0.0200	0.0086	0.0057	0.0029	0.0000	0.0000	0.0000	0.0000
2000	97	24	0.0928	0.0309	0.0309	0.0412	0.0309	0.0412	0.0103	0.0103	0.0000	0.0103	0.0000
2004	81	14	0.0494	0.0370	0.0494	0.1111	0.0864	0.0370	0.0370	0.0000	0.0123	0.0000	0.0000
2009	340	45	0.0912	0.0912	0.0971	0.0500	0.0529	0.0735	0.0618	0.0471	0.0794	0.0353	0.0441

Table 2.4. Annual proportion at age input to the tilefish model. The sample size columns represent: n.fish.age-number of fish aged, n.f.len–number of fish measured, n.t.len–number of trips with fish measured, n.sets–number of individual MARMAP longlines.

							Commercial Handline									
Year	n.f.age	n.f.len	n.t.len	1	2	3	4	5	6	7	8	9	10	11	12	13
1997	84	5	5	0.0000	0.0000	0.0000	0.0083	0.0880	0.1334	0.1586	0.1231	0.2620	0.1549	0.0261	0.0118	0.0233
1998	43	2	2	0.0000	0.0000	0.0000	0.0175	0.0700	0.1581	0.0530	0.1751	0.2106	0.1406	0.1401	0.0175	0.0175
1999	35	8	8	0.0000	0.0000	0.0000	0.0167	0.0000	0.3357	0.2188	0.0772	0.1032	0.2185	0.0225	0.0000	0.0000
2000	222	8	8	0.0000	0.0000	0.0000	0.0000	0.0407	0.1354	0.3657	0.2680	0.0541	0.0379	0.0460	0.0249	0.0139
2001	46	7	7	0.0000	0.0000	0.0000	0.0000	0.0016	0.0013	0.1082	0.4005	0.2144	0.1132	0.0032	0.0000	0.1037
2002	160	13	13	0.0000	0.0000	0.0012	0.0298	0.1292	0.1598	0.0908	0.1033	0.1258	0.1111	0.0412	0.0476	0.0704
2005	103	5	5	0.0000	0.0000	0.0000	0.0037	0.0460	0.0934	0.1922	0.2220	0.0770	0.0503	0.0947	0.0658	0.0204
2006	59	2	2	0.0000	0.0000	0.0000	0.0058	0.1081	0.3178	0.2682	0.1807	0.0640	0.0291	0.0029	0.0058	0.0087
2010	13	2	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.1808	0.2417	0.0591	0.0627	0.0627	0.1495	0.1513	0.0313
							Commercial Longline									
Year	n.f.age	n.f.len	n.t.len	1	2	3	4	5	6	7	8	9	10	11	12	13
1987	28	484	7	0.0000	0.0000	0.1993	0.1313	0.3979	0.2715	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1992	124	12558	100	0.0000	0.0000	0.0000	0.0045	0.0754	0.2587	0.1848	0.1208	0.1536	0.0426	0.0445	0.0157	0.0334
1993	209	26441	141	0.0000	0.0000	0.0029	0.1446	0.2937	0.2695	0.1373	0.0795	0.0097	0.0078	0.0148	0.0085	0.0038
1995	373	7473	64	0.0000	0.0000	0.0000	0.0137	0.1159	0.2277	0.2885	0.2057	0.1044	0.0149	0.0078	0.0026	0.0075
1996	782	1847	30	0.0000	0.0025	0.0005	0.0089	0.0300	0.1285	0.2101	0.2487	0.1661	0.0799	0.0366	0.0151	0.0123
1997	908	1388	19	0.0000	0.0000	0.0021	0.0266	0.0714	0.1371	0.2186	0.1904	0.1533	0.0883	0.0367	0.0287	0.0146
1998	269	881	15	0.0000	0.0000	0.0070	0.0375	0.1555	0.1964	0.1960	0.1427	0.1128	0.0951	0.0172	0.0010	0.0284
1999	350	2807	26	0.0000	0.0000	0.0001	0.0191	0.1437	0.3382	0.1283	0.0954	0.0752	0.0621	0.0744	0.0268	0.0102
2000	338	1603	13	0.0000	0.0000	0.0026	0.0043	0.0864	0.1708	0.3229	0.1264	0.0730	0.0383	0.0432	0.0523	0.0396
2001	296	1488	23	0.0000	0.0000	0.0000	0.0180	0.0696	0.1177	0.2461	0.1965	0.0990	0.0664	0.0593	0.0360	0.0299
2002	57	987	19	0.0000	0.0000	0.0000	0.0232	0.0596	0.0585	0.2390	0.1820	0.1160	0.0000	0.0216	0.0689	0.0952
2003	177	254	10	0.0000	0.0000	0.0002	0.0006	0.0800	0.1507	0.3706	0.1719	0.1158	0.0577	0.0136	0.0110	0.0111
2004	264	356	15	0.0000	0.0000	0.0065	0.0141	0.0387	0.0969	0.2925	0.1724	0.1415	0.0613	0.0452	0.0470	0.0133
2005	410	404	16	0.0000	0.0000	0.0000	0.0000	0.0036	0.0387	0.1377	0.2071	0.1496	0.1137	0.1110	0.0763	0.0187
2006	842	821	36	0.0000	0.0000	0.0001	0.0124	0.0474	0.1204	0.1510	0.2279	0.1648	0.0904	0.0744	0.0255	0.0282
2007	1153	945	35	0.0000	0.0000	0.0000	0.0047	0.0386	0.1516	0.1229	0.1844	0.2009	0.0939	0.0667	0.0442	0.0319
2008	1172	554	20	0.0000	0.0000	0.0000	0.0013	0.0224	0.0810	0.1732	0.1862	0.1871	0.1641	0.0627	0.0342	0.0229
2009	1542	880	25	0.0000	0.0000	0.0000	0.0000	0.0114	0.0679	0.1407	0.1580	0.1336	0.1423	0.1148	0.0753	0.0450
2010	989	703	24	0.0000	0.0000	0.0000	0.0000	0.0089	0.0564	0.1087	0.1745	0.1705	0.1407	0.1014	0.0744	0.0532
							MARMAP Longline									
Year	n.f.age	n.sets		1	2	3	4	5	6	7	8	9	10	11	12	13
1983	269	59		0.0000	0.0000	0.0000	0.0223	0.0892	0.0818	0.1041	0.1190	0.1413	0.1375	0.1190	0.0446	0.0260
1996	344	38		0.0000	0.0000	0.0000	0.0029	0.0087	0.0494	0.1134	0.1715	0.2064	0.1831	0.1134	0.0552	0.0640
2000	94	23		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0213	0.0213	0.1277	0.2447	0.1596	0.1809	0.1170
2004	80	14		0.0000	0.0000	0.0000	0.0000	0.0000	0.0125	0.0625	0.1250	0.1750	0.1375	0.2250	0.1000	0.1000
2009	332	44		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0361	0.1114	0.1536	0.2259	0.1476	0.1386	0.0633

Table 2.4. (continued) Annual proportion at age input to the tilefish model. The sample size columns represent: n.fish.age–number of fish aged, n.f.len–number of fish measured, n.t.len–number of trips with fish measured, n.sets–number of individual MARMAP longlines.

							Commercial Handline							
Year	n.f.age	n.f.len	n.t.len	14	15	16	17	18	19	20	21	22	23	24	25
1997	84	5	5	0.0039	0.0052	0.0013	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1998	43	2	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1999	35	8	8	0.0000	0.0000	0.0074	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2000	222	8	8	0.0069	0.0000	0.0060	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2001	46	7	7	0.0539	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2002	160	13	13	0.0304	0.0003	0.0086	0.0202	0.0000	0.0000	0.0202	0.0000	0.0000	0.0099	0.0000	0.0000
2005	103	5	5	0.0638	0.0354	0.0068	0.0136	0.0000	0.0000	0.0000	0.0000	0.0149	0.0000	0.0000	0.0000
2006	59	2	2	0.0058	0.0000	0.0000	0.0000	0.0000	0.0000	0.0029	0.0000	0.0000	0.0000	0.0000	0.0000
2010	13	2	2	0.0295	0.0000	0.0000	0.0313	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
							Commercial Longline								
Year	n.f.age	n.fh.len	n.t.len	14	15	16	17	18	19	20	21	22	23	24	25
1987	28	484	7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1992	124	12558	100	0.0135	0.0257	0.0194	0.0000	0.0000	0.0073	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1993	209	26441	141	0.0075	0.0085	0.0082	0.0001	0.0000	0.0000	0.0000	0.0035	0.0000	0.0000	0.0000	0.0000
1995	373	7473	64	0.0024	0.0051	0.0006	0.0015	0.0003	0.0001	0.0002	0.0000	0.0000	0.0000	0.0000	0.0011
1996	782	1847	30	0.0116	0.0047	0.0113	0.0125	0.0084	0.0064	0.0030	0.0000	0.0008	0.0005	0.0006	0.0011
1997	908	1388	19	0.0082	0.0016	0.0045	0.0006	0.0045	0.0031	0.0019	0.0029	0.0025	0.0006	0.0006	0.0012
1998	269	881	15	0.0046	0.0000	0.0000	0.0000	0.0000	0.0010	0.0010	0.0010	0.0027	0.0000	0.0000	0.0000
1999	350	2807	26	0.0085	0.0000	0.0000	0.0009	0.0046	0.0028	0.0092	0.0000	0.0005	0.0000	0.0000	0.0000
2000	338	1603	13	0.0144	0.0042	0.0024	0.0000	0.0032	0.0044	0.0045	0.0028	0.0023	0.0006	0.0000	0.0013
2001	296	1488	23	0.0051	0.0041	0.0091	0.0098	0.0057	0.0015	0.0009	0.0005	0.0042	0.0053	0.0032	0.0121
2002	57	987	19	0.0476	0.0000	0.0000	0.0241	0.0381	0.0000	0.0000	0.0260	0.0000	0.0000	0.0000	0.0000
2003	177	254	10	0.0016	0.0132	0.0000	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0016
2004	264	356	15	0.0103	0.0000	0.0033	0.0063	0.0086	0.0011	0.0017	0.0000	0.0104	0.0197	0.0032	0.0060
2005	410	404	16	0.0179	0.0344	0.0055	0.0281	0.0097	0.0111	0.0064	0.0000	0.0017	0.0026	0.0069	0.0191
2006	842	821	36	0.0107	0.0071	0.0099	0.0091	0.0000	0.0020	0.0077	0.0030	0.0000	0.0011	0.0015	0.0056
2007	1153	945	35	0.0128	0.0141	0.0034	0.0046	0.0072	0.0036	0.0030	0.0004	0.0019	0.0016	0.0014	0.0062
2008	1172	554	20	0.0205	0.0132	0.0096	0.0029	0.0041	0.0022	0.0041	0.0025	0.0014	0.0006	0.0016	0.0022
2009	1542	880	25	0.0253	0.0200	0.0090	0.0100	0.0171	0.0094	0.0013	0.0040	0.0055	0.0044	0.0010	0.0040
2010	989	703	24	0.0341	0.0226	0.0129	0.0163	0.0057	0.0025	0.0020	0.0036	0.0016	0.0039	0.0009	0.0053
							MARMAP Longline								
Year	n.fish.age	n.sets		14	15	16	17	18	19	20	21	22	23	24	25
1983	269	59		0.0186	0.0074	0.0112	0.0000	0.0223	0.0074	0.0074	0.0112	0.0037	0.0074	0.0037	0.0112
1996	344	38		0.0203	0.0116	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2000	94	23		0.0745	0.0426	0.0000	0.0000	0.0106	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2004	80	14		0.0375	0.0125	0.0000	0.0125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2009	332	44		0.0542	0.0151	0.0181	0.0090	0.0151	0.0060	0.0030	0.0030	0.0000	0.0000	0.0000	0.0000

Table 2.5. Ageing error matrix input to the tilefish model. The ageing error was input without rounding. Many of the 0 values are actually very small non–zero values.

Age	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	1.0000	0.0929	0.0082	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.8139	0.2006	0.0256	0.0026	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0929	0.5823	0.2320	0.0441	0.0056	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0001	0.2006	0.4836	0.2410	0.0588	0.0091	0.0010	0.0001	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0082	0.2320	0.4244	0.2418	0.0702	0.0130	0.0016	0.0002	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0256	0.2410	0.3873	0.2397	0.0798	0.0166	0.0024	0.0003	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0007	0.0441	0.2418	0.3610	0.2364	0.0865	0.0203	0.0033	0.0004
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0026	0.0588	0.2397	0.3395	0.2331	0.0925	0.0236	0.0042
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0056	0.0702	0.2364	0.3243	0.2294	0.0968	0.0268
11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0091	0.0798	0.2331	0.3105	0.2261	0.1007
12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0130	0.0865	0.2294	0.3000	0.2227
13	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0010	0.0166	0.0925	0.2261	0.2901
14	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0016	0.0203	0.0968	0.2227
15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0024	0.0236	0.1007
16	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0033	0.0268
17	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0042
18	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004
19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
23	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Age	14	15	16	17	18	19	20	21	22	23	24	25
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0052	0.0007	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	0.0298	0.0061	0.0009	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
12	0.1038	0.0324	0.0071	0.0012	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
13	0.2196	0.1063	0.0349	0.0082	0.0014	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
14	0.2819	0.2169	0.1085	0.0374	0.0092	0.0017	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
15	0.2196	0.2751	0.2141	0.1104	0.0395	0.0102	0.0019	0.0003	0.0000	0.0000	0.0000	0.0000
16	0.1038	0.2169	0.2686	0.2114	0.1120	0.0416	0.0111	0.0022	0.0003	0.0000	0.0000	0.0000
17	0.0298	0.1063	0.2141	0.2625	0.2090	0.1133	0.0433	0.0121	0.0026	0.0004	0.0001	0.0000
18	0.0052	0.0324	0.1085	0.2114	0.2574	0.2067	0.1144	0.0451	0.0132	0.0030	0.0006	0.0001
19	0.0005	0.0061	0.0349	0.1104	0.2090	0.2525	0.2048	0.1156	0.0474	0.0149	0.0038	0.0009
20	0.0000	0.0007	0.0071	0.0374	0.1120	0.2067	0.2486	0.2033	0.1180	0.0516	0.0181	0.0055
21	0.0000	0.0001	0.0009	0.0082	0.0395	0.1133	0.2048	0.2454	0.2041	0.1251	0.0607	0.0252
22	0.0000	0.0000	0.0001	0.0012	0.0092	0.0416	0.1144	0.2033	0.2449	0.2128	0.1442	0.0823
23	0.0000	0.0000	0.0000	0.0001	0.0014	0.0102	0.0433	0.1156	0.2041	0.2541	0.2423	0.1915
24	0.0000	0.0000	0.0000	0.0000	0.0001	0.0017	0.0111	0.0451	0.1180	0.2128	0.2880	0.3180
25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0019	0.0121	0.0474	0.1251	0.2423	0.3765

Table 2.6. MARMAP horizontal longline and commercial logbook indices of abundance and coefficient of variation (CV)input to the tilefish model. MARMAP values are combined across years: 1983–86 for 1985, 1996–99 for 1998, 2000–03 for 2002, 2004–07 for 2006 and 2009–10 for 2010.

Year	MARMAP	C.Logbook	MARMAP CV	C.Logbook CV
1985	1.03		1.63	
1986				
1993		0.623		0.201
1994		0.623		0.185
1995		0.765		0.198
1996		0.453		0.236
1997		0.610		0.208
1998	2.46	0.712	1.59	0.236
1999		0.637		0.276
2000		0.677		0.254
2001		0.635		0.216
2002	1.00	0.519	1.75	0.249
2003		0.662		0.222
2004		0.590		0.259
2005		1.060		0.264
2006	0.89	1.325	1.92	0.207
2007		1.907		0.221
2008		1.997		0.250
2009		1.849		0.258
2010	2.82	2.355	1.51	0.195

3 Stock Assessment Models and Results

Following the Terms of Reference, two stock assessment models of tilefish were discussed during the Assessment Workshop (AW): the Beaufort assessment model (BAM) and a surplus-production model (ASPIC).

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 tilefish stock in particular. Few or no ages were available for many years of the commercial longline and handline sectors. Developing catch–age matrices may not be appropriate for tilefish given the current data gaps. If pursued, catch–age matrices should 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, and surplus-production models would be more productive.

The BAM was selected at the AW to be the primary assessment model, although results from both models are reported here. Abbreviations used herein are defined in Appendix A.

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 assessment model (BAM), which applies a statistical catch-age formulation. The model was implemented with the AD Model Builder software (ADMB Foundation 2011), and its structure and equations are detailed in SEDAR-25-RW-04. 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, among many applications, used by Fournier and Archibald (1982), by Deriso et al. (1985) in their CAGEAN model, and by 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 seabass, snowy grouper, gag grouper, greater amberjack, vermilion snapper, Spanish mackerel, red grouper, and red snapper, as well as in the previous tilefish benchmark (SEDAR 4).

3.1.1.2 **Data Sources** The catch-age model included data from a fishery independent survey, a fishery dependent survey, and from three fleets that caught southeastern U.S. tilefish: commercial longline, commercial handlines, and the recreational fishery. The model was fitted to data on annual landings (in units of 1000 lbs gutted weight), annual length compositions of landings, annual age compositions of landings, and two indices of abundance (MARMAP longline and the commercial logbook). 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 §II of this assessment report.

The combined recreational landings estimates include headboat landings estimates, developed by the headboat survey, and the general recreational landings estimates. The general recreationsl fleet was sampled by the Marine Recreational Fishing Statistical Survey (MRFSS) starting in 1981. That sampling program is undergoing modifications, including a change of name to Marine Recreational Information Program (MRIP). In this report, acronyms MRFSS and MRIP are used synonymously to refer to sampling of the general recreational fleet. However, the sampling and estimation methodology for this assessment is that of MRFSS.

3.1.1.3 **Model Configuration and Equations** Model structure and equations of the BAM are detailed in SEDAR-25-RW04, along with AD Model Builder code for implementation. The assessment time period was 1962–2010. A general description of the assessment model follows.

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 $1 - 25^{+}$, where the oldest age class 25^{+} allowed for the accumulation of fish (i.e., plus group).

Initialization Initial (1962) abundance at age was estimated in the model as follows. First, the equilibrium age structure was computed for ages 1–25 based on natural and fishing mortality (F), where F was set equal to a value that resulted in the 1962 biomass level equaling 90% of the unfished level. This was based on the assumption by the assessment workshop panel that the stock was lightly exploited prior to the 1960's.

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 $\mathrm{M}_a=\alpha W_a^{\beta}$, 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 from age-1 through the oldest observed age (40 yr) as would occur with constant $M = 0.10$ from the DW. This approach using cumulative mortality is consistent with the findings of Hoenig (1983) and Hewitt and Hoenig (2005).

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. The von Bertalanffy parameter estimates from the DW were $L_\infty = 825.1$, $k = 0.189$, and $t_0 = -0.47$. For fitting length composition data, the distribution of size at age was assumed normal with coefficient of variation (CV) estimated by the assessment model. A constant CV, rather than constant standard deviation, was suggested by the size at age data.

Female maturity Females were modeled to be fully mature at age 4 and the proportion mature at ages 1, 2, and 3 were estimated to be 0.1, 0.25, and 0.5 respectively (Table 3.1).

Spawning stock Spawning stock was modeled using mature female gonad weight measured at the time of peak spawning. For tilefish, peak spawning was considered to occur in May. In cases when reliable estimates of fecundity are unavailable, spawning biomass, and in this case, female gonad weight, is commonly used as a proxy for population fecundity.

Recruitment Expected recruitment of age-1 fish was predicted from spawning stock using the Beverton–Holt spawner-recruit model. Annual variation in recruitment was assumed to occur with lognormal deviations for years 1976–2003 only. The start of recruitment residuals in 1976 was based on examination of a series of different starting years and the start of the age and length composition data that have information on year class strength. The ending year of estimated recruitment residuals (2003) is based on the age at full selection in the fisheries and the last year of age composition data.

Because the age at full selection for the tilefish fisheries generally occurs at age 7 and the last year of composition data in the model is 2010, the assessment panel agreed that recruitment deviations during 2004–2010 could not be reliably estimated.

Landings The model included time series of landings from three fleets: commercial longlines (1962-2010), commercial handlines (1962-2010), and general recreational (1981-2010). An "other" category in the reported landings was distributed by year between handlines and longlines based on the yearly ratio of handline to longline landings.

Landings were modeled with the Baranov catch equation (Baranov 1918) and were fitted in units of weight (1000 lb whole weight). The DW provided observed landings back to the first assessment year (1962) for each fleet except general recreational, because the MRFSS estimates started in 1981.

Fishing Mortality For each time series of landings, the assessment model estimated a separate full fishing mortality rate (F). 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 and CPUE series 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. Selectivity of landings from all fleets were modeled as flat-topped, using a two parameter logistic function. Selectivities of the fishery-dependent index was the same as that of the longline fleet. The MARMAP index was also modeled as a flat-topped, two parameter logistic function. However, a selectivity curve was not estimated for the recreational fleet due to low sample sizes and noisy composition data. Instead, the recreational selectivity was assumed to be equal to the commercial handline fishery, since both sectors use vertical hook and line.

Indices of abundance The model was fit to two indices of relative abundance: MARMAP longline (binned years between 1985 and 2010) and commercial lines (1993–2010). Predicted indices were conditional on selectivity of the corresponding fleet or survey and were computed from abundance or biomass (as appropriate) at the midpoint of the year.

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. For the base model, the AW assumed time-invariant catchability, following SEDAR 4. For a sensitivity run, however, the AW considered linearly increasing catchability with a slope of 2%, constant after 2003. 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). This trend reflects the belief that catchability has generally increased over time as a result of improved technology (SEDAR Procedural Guidance 2009) and as estimated for reef fishes in the Gulf of Mexico (Thorson and Berkson 2010). Another sensitivity run applied a random walk to catchability. This is notoriously difficult to estimate, often resulting in just an absorption of noise from the index. The random walk sensitivity run should not be considered a viable model run.

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 (expected values in arithmetic space). Computed benchmarks included MSY, fishing mortality rate at MSY (F_{MSY}), and spawning stock at MSY ($\mathrm{SSB}_{\mathrm{MSY}}$). In this assessment, spawning stock 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 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 were fit closely, and observed composition data and abundance indices were fit to the degree that they were compatible.

Landings and index data were fitted using lognormal likelihoods. Length and age composition data were fitted 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 stronger 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 tilefish, CVs of landings (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 (SEDAR25-RW04, SEDAR25-RW06). The weight on the commercial longline index was then adjusted upward to a value of 3 (SEDAR25-RW06), in accordance with the principle that abundance data should be given primacy (Francis 2011). A range of weights for the commercial longline index component were considered (ranging from 1.0 to 6.0) before the final 3.0 weight was selected by the AW panel.

In addition, the compound objective function included several penalties or prior distributions, applied to CV of growth (based on the empirical estimate), selectivity parameters, and recruitment standard deviation based on Beddington and Cooke (1983) and Mertz and Myers (1996). 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. The AW did not necessarily 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). Steepness was not estimated for tilefish, but rather the paramenter was fixed at 0.84. When there were attempts to estimate steepness, the model would force the parameter to reach the upper bound. The value of 0.84 is the mode of the prior from the meta–analysis described in Shertzer and Conn (In Press).

Autocorrelation of the recruitment deviations in the base run model was assumed to be zero. When this parameter was freely estimated, it tended toward the upper bound of 0.99, which was deemed unrealistic by the assessment panel.

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 $M = 0.03$)
- S2: High M at age (Lorenzen estimates rescaled so as to provide the same cumulative survival through the oldest observed age as would constant $M = 0.21$)
- S3: Steepness $h = 0.94$
- S4: Steepness $h = 0.74$
- S5: Model component weights unadjusted (e.g. all weight multipliers set to 1.0)
- S6: Linearly increasing catchability with slope of 2% until 2003 and constant thereafter

- S7: No MARMAP index.
- S8: No commercial longline index.
- S9: Selectivity split – 2003.
- S10: Selectivity split – 2004.
- S11: Selectivity split – 2005.
- S12: Selectivity split – 2006.
- S13: Selectivity split – 2007.
- S14: Time–varying L50 (1995 – 2010).
- S15: Random walk in commercial longline catchability.
- S16: Drop 2004–2006 commercial longline age compositions.
- S17: Retrospective run with data through 2009
- S18: Retrospective run with data through 2008
- S19: Retrospective run with data through 2007
- S20: Retrospective run with data through 2006
- S21: Retrospective run with data through 2005
- S22: Retrospective run with data through 2004
- S23: Retrospective run with data through 2003
- S24: Retrospective run with data through 2002

Retrospective analyses should be interpreted with caution, because several data sources appear only near the end of the full time series. Also, some data are not continuous across years which removes information in larger intervals than a single year. Commercial handline age composition data and MARMAP index, age and length composition data are not continuous by year from 2002 to 2010.

3.1.1.4 **Parameters Estimated** The model estimated annual fishing mortality rates of each fishery, selectivity parameters, catchability coefficients associated with indices, parameters of the spawner-recruit model, annual recruitment deviations, and CV of size at age. Estimated parameters are described mathematically in the document, SEDAR-25-RW04.

3.1.1.5 **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 were also computed as functions of biomass B, which itself is a function of F. As in computation of MSY-related benchmarks (described in §3.1.1.6), 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 (2008–2010).

3.1.1.6 Benchmark/Reference Point Methods In this assessment of tilefish, 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_R^2) of recruitment deviation in log space: $\varsigma = \exp(\sigma_R^2/2)$. Then, equilibrium recruitment (R_{eq}) associated with any F is,

$$R_{eq} = \frac{R_0 \left[\varsigma 0.8 h \Phi_F - 0.2(1-h)\right]}{(h-0.2)\Phi_F} \tag{2}$$

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 and fishing 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 and the estimate of MSY is that ASY. The estimate of $\mathrm{SSB}_{\mathrm{MSY}}$ follows from the corresponding equilibrium age structure.

Estimates of MSY and related benchmarks are conditional on selectivity patterns. 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 (2008–2010). 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 equal to 0.10. 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 (2010), and current status of the fishery is represented by the geometric mean of F from the latest three years (2008–2010).

3.1.1.7 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; 2010). The approach is among those recommended for use in SEDAR assessments (SEDAR Procedural Guidance 2010). 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 several key input parameters. Initial runs of the MCB approach resulted in unrealistically high values of F for some of the years in the longline fishery. These were exceeding 10.0 in some cases. For a species with a natural mortality rate of 0.1, it is not unreasonable to limit total F to be less then 10 times that amount, in this case 1.0.

A rapidly increasing penalty function was added to the total likelihood value to limit the number of MCB runs where $F > 1.0$. This penalty increased the likelihood using the following function $L = L + 10(e^{[F_y - 1.0]} - 1.0)$, in years when total F exceeded 1.0.

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.

3.1.1.7.1 **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 ($\hat{O}_{s,y}$),

$$O_{s,y} = \hat{O}_{s,y}[\exp(x_{s,y}) - \sigma^2_{s,y}/2] \tag{3}$$

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 (tabulated in §III(2) of this assessment report).

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 cell probabilities of the original data. For each year of each data source, the number of individuals sampled was the same as in the original data (number of fish), and the effective sample sizes used for fitting (number of trips) was unmodified.

3.1.1.7.2 **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.

Steepness The steepness stock–recruit parameter was fixed at 0.84 in the base run based on a meta–analysis (Shertzer and Conn In Press). Uncertainty in this parameter was characterized by drawing random values from the beta distribution prior developed using beta distribution parameters $\alpha = 5.94$ and $\beta = 1.97$ for each MCB run.

Natural mortality Point estimates of natural mortality ($M = 0.10$) 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 [0.03, 0.21]) with mean equal to the point estimate ($M = 0.10$) and standard deviation set to provide a lower 95% confidence limit at 0.03 (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.

Weighting of indices In the base run, external weights applied to the commercial longline index was adjusted upward to a value of $\omega = 3.0$. In MCB trials, that weight was drawn from a uniform distribution with bounds at ±25% of 3.0.

3.1.1.8 **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.

3.1.1.9 Projection Methods

Projections were run to predict stock status in years after the assessment, 2011–2030.

The structure of the projection model was the same as that of the assessment model, and parameter estimates were those from the assessment. Fully selected F was apportioned between landings 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 (time of peak spawning), F, recruits, and landings 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 SSB_{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 Point estimates of initial abundance at age in the projection (start of 2011), other than at age 1, were taken to be the 2010 estimates from the assessment, discounted by 2010 natural and fishing mortalities. The initial abundance at age 1 was computed using the estimated spawner-recruit model and a 2010 estimate of SSB.

Fishing rates or catch levels that define the projections were assumed to start in 2012, which is the earliest year management could react to this assessment. Because the assessment period ended in 2010, the projections required an initialization period (2011). Fishing mortality in 2011 was assumed equal to the geometric mean F from the last three years of the assessment period.

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, as well as in estimated quantities such as spawner-recruit parameters, selectivity curves, and in initial (start of 2011) abundance at age. 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 the recruitment deviations estimated for that chosen MCB run.

Because the base run model assumed no recruitment deviation for years 2004–2010, the initial projection year (start of 2011) ages 2–7 included additional variability in recruitment following the same method for subsequent years at age–1.

The procedure generated 10,000 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 stochasticity in projected recruitment streams. Precision of projections was represented graphically by the 5^{th} and 95^{th} percentiles of the replicate projections.

Rebuilding time frame Based on results from previous SEDAR assessments, tilefish was not overfished and no rebuilding plan is necessary.

Projection scenarios Five constant-F projection scenarios were considered. In each, the fishing rate in 2010 applied the moratorium based on F_{current}(as described above).

- Scenario 1: $F = F_{\text{MSY}}$
- Scenario 2: $F = F_{\text{current}}$
- Scenario 3: $F = 65\% F_{\text{MSY}}$
- Scenario 4: $F = 75\% F_{\text{MSY}}$
- Scenario 5: $F = 85\% F_{\text{MSY}}$

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 3.2).

Considerable discussion during the AW centered around the fit of age composition data for the commercial longline fishery in 2004–2006. Several sensitivity runs were completed to address this poor fit, but in the end the AW agreed that these alternative runs were not an improvement over the base run.

The model was configured to fit observed commercial and recreational landings closely (Figures 3.3–3.5).

Fits to indices of abundance captured the general trends but not all annual fluctuations (Figures 3.6–3.7). Since the early 2000s, the general trend in the commercial longline index is increasing.

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 slight truncation of the older ages (Figure 3.8; Table 3.2). Total estimated abundance at the end of the assessment period shows sharp increase, reaching levels not seen since the early 1980s, albeit with a quite different age structure. This increase is driven by recruitment estimates in the early 2000s. Annual number of recruits is shown in Table 3.2 (age-1 column) and in Figure 3.9. A notably strong year class (age-1 fish) was predicted to have occurred in 2001 and is driving the increase in the population size in the last 6–8 years.

3.1.2.4 Total and Spawning Biomass Estimated biomass at age exhibits a different pattern than does abundance at age (Figure 3.10; Table 3.3). Total biomass declines in the early 1980's and then remains relatively low until 2001, when one big year class is predicted and biomass climbs to moderate levels in the terminal year. Abundance at age trends are greatly affected by the very large recruitment event estimated by the model in 2001. Total and spawning biomass show very similar trends (Figure 3.11; Table 3.4).

3.1.2.5 Selectivity Selectivity estimates among all fisheries and surveys estimated are very similar (shown in Figure 3.12). Fish were estimated to be near fully selected by age 7. Results were similar for commercial handline, the recreational fleet and the MARMAP index (Figure 3.12).

Average selectivities of landings were computed from F-weighted selectivities in the most recent period (Figure 3.13). 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 in the early 1980s, and since then have been quite variable (Figure 3.14). The commercial longline fleet dominates 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 full selection occuring at different ages among gears in the estimated selectivities.

Table 3.8 shows total landings at age in numbers, and Table 3.9 in weight. In general, the majority of estimated landings were from the commercial longline sector (Figures 3.15, 3.16; Tables 3.10, 3.11).

3.1.2.7 **Spawner-Recruitment Parameters** The estimated Beverton–Holt spawner-recruit curve is shown in Figure 3.17, 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 $h = 0.84$, unfished age-1 recruitment $\widehat{R_0} = 416,140$, unfished spawning biomass per recruit $\phi_0 = 9.322e{-}4$, and assumed standard deviation of recruitment residuals in log space $\sigma = 0.4$ (which resulted in bias correction $\varsigma = 1.08$). The empirical standard deviation of recruitment residuals in log space was $\widehat{\sigma} = 0.99$. Uncertainty in these quantities was estimated through the Monte Carlo/bootstrap (MCB) analysis (Figure 3.18).

3.1.2.8 **Per Recruit and Equilibrium Analyses** Static spawning potential ratio (static SPR) shows a general trend of decline during the 1970s and early 1980s, followed by a relatively stable period and an increasing trend since 2000 (Figure 3.19, 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 3.20). 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 (2008–2010). The Fs that provide 30%, 40%, and 50% SPR are 0.14, 0.09, and 0.07, respectively. For comparison, F_{MSY} corresponds to about 23% SPR. Although this rate of fishing appears high relative to $F_{X\%}$ proxies, it occurs here because tilefish mature relatively quickly, age at full maturity is a few years after maturation, and because the assumed steepness of $h = 0.84$ relates to a relatively productive stock.

As in per recruit analyses, equilibrium landings and spawning biomass were computed as functions of F (Figures 3.21). 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 3.22).

3.1.2.9 **Benchmarks / Reference Points** As described in §3.1.1.6, biological reference points (benchmarks) were derived analytically assuming equilibrium dynamics, corresponding to the expected spawner-recruit curve (Figure 3.17). 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 (§3.1.1.7).

Estimates of benchmarks are summarized in Table 3.12. Point estimates of MSY-related quantities were $F_{\mathrm{MSY}} = 0.185\ \mathrm{y}^{-1}$, MSY = 638 klb, $B_{\mathrm{MSY}} = 2918$ mt, and $\mathrm{SSB}_{\mathrm{MSY}} = 25.3$ mt. Distributions of these benchmarks are shown in Figure 3.23.

3.1.2.10 **Status of the Stock and Fishery** Estimated time series of stock status (SSB/MSST) shows decline in the early 1980s, and then increase since the mid-2000s, (Figure 3.24, Table 3.4). Base-run estimates of spawning biomass have remained below MSST throughout the 1990s and early 2000s. Current stock in the base run status was estimated to be $\mathrm{SSB}_{2010}/\mathrm{MSST} = 2.43$ (Table 3.12). Uncertainty from the MCB analysis suggests that the estimate of a stock that is not overfished (i.e., SSB > MSST) is robust (Figures 3.25, 3.26). Age structure estimated by the base run shows fewer older fish than the (equilibrium) age structure expected at MSY (Figure 3.27). However, in the terminal year (2010), ages 1–7 approach the MSY age structure.

The estimated time series of F/F_{MSY} suggests that overfishing has occurred throughout some of the assessment period (Figure 3.24, Table 3.4). Spikes in the early 1980s through 2004 are due primarily to the longline fleet (Figure

3.14). Current fishery status in the terminal year, with current F represented by the geometric mean from 2008–2010, is estimated by the base run to be $F_{2008-2010}/F_{\mathrm{MSY}} = 0.36$ (Table 3.12). This estimate indicates that overfishing is not occurring and appears robust across MCB trials (Figures 3.25, 3.26). However, it should be noted that the base run tended to result in higher SSB_{2010}/MSST and lower $F_{2008-2010}/F_{\mathrm{MSY}}$ values relative to all the MCB values (i.e. the base run does not equal the mode or the mean of the MCB values).

3.1.2.11 **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 the sensitivity of the model on recruitment (Figure 3.28), and relationship of relative F to relative SSB (Figure 3.29). The tendency was toward the status estimates of not overfished with no overfishing (Figure 3.29 and Table 3.13). In concert, sensitivity analyses suggested that qualitative results of the base run and MCB analysis were robust, although the bulk of the sensitivity runs suggested a stock status that was closer to overfished and overfishing compared to the base run.

Retrospective analyses suggested no pattern in F, B, SSB, recruits, $\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$, or F/F_{MSY} and seemed to indicate no retrospective error (Figures 3.30 – 3.34).

3.1.2.12 **Projections** There are only slight differences in the F_{MSY}, $F_{65\% MSY}$, $F_{75\% MSY}$, and $F_{85\% MSY}$ projection scenarios (Figures 3.36 – 3.40 and Tables 3.14 – 3.18). The $F_{current}$ projection maintained SSB above $\mathrm{SSB}_{\mathrm{MSY}}$ and landings slightly below landings at MSY (Table 3.15 and Figure3.37).

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 tilefish 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** Data used for production modeling were total landings and two abundance indices, the MARMAP longline index and the commercial logbook index.

Landings The landings input to ASPIC must be in units of biomass. The commercial longline, handline and recreational landings were all reported in pounds. No discards were used for the surplus production modeling. (Table 2.2).

Indices of Abundance The MARMAP index for tilefish was developed in fish per hour of soak time. The surplus production model requires input in pounds and therefore the index was converted by multiplying the annual index by the annual mean weight from the MARMAP survey and scaling the series to the mean. The commercial logbook index was developed in pounds kept per number of sets × number of hooks per set. (Table 2.6).

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 the 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 bootstrapping.

For tilefish, the model was configured similarly to that of the SEDAR 4. $B1/k$ starting values and bounds on MSY and K were identical. $B1/k$ was estimated in the model.

3.2.2 Model 2 Results

3.2.2.1 Model Fit

The fit to the commercial logbook index was quite good (Figure 3.41). The fit to the MARMAP index is approximate, as the index is highly variable and contains sharp year-to-year changes not expected in a slow growing species with an extended age structure (Figure 3.41). The indices are not well correlated with one another, so that fitting one necessarily results in lack of fit to another (see correlation matrix in ASPIC output file, Appendix C). Because all runs were conditioned on catch, landings were fit exactly. The estimate of MSY is 965 thousand pounds. The current F_{2010}/F_{MSY} is 0.37 and the B_{2011}/B_{MSY} is 1.17.

3.2.2.2 Status of the Stock and Fishery

The base model configuration for the surplus production model for tilefish indicates a stock that is not overfished and the current fishing mortality (2010) is below levels that optimize sustained yield (Figure 3.42). The estimate of F/F_{MSY} is 0.37 and B_{2011}/B_{MSY} is 1.18. Confidence intervals (80%) for B/B_{MSY} from the 500 bootstrap runs show increased uncertainty in the biomass estimate at the beginning and end of the series. For the F/F_{MSY} bootstrap runs, there is little uncertainty in the F/F_{MSY} estimate until 1995, after which the uncertainty is moderate until the terminal year (Figure 3.42).

3.2.2.3 Discussion — Surplus Production Model

The production model indicates that the current stock is not overfished or undergoing overfishing. The surplus production model, because it omits population age and size structure, does not make use of data for those characteristics. Because such data are available for tilefish, 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. 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 not overfished ($\text{SSB}_{2010}/\text{MSST} = 2.43$), and that overfishing is not occurring ($F_{2010}/F_{\text{MSY}} = 0.40$). These qualitative conclusions 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 the sensitivity runs and MCB results tended toward values that were closer to overfished and overfishing relative to the base run. This could be an indication of bias in the base run model.

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 commercial longline fishery dependent index was 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 index as reliable as possible (using trip selection and standardization methods to develop the indices, and using time-varying catchability to fit them). A new fishery independent sampling program was initiated in the summer of 2010, but this new data source is not expected to be useful for the next benchmark assessment, since the methods being deployed do not cover tilefish habitats sufficiently.

Perhaps the greatest uncertainty in this assessment was the spawner-recruit relationship. Steepness could not be estimated reliably (tended toward its upper bound), and therefore had to be 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 (Shertzer and Conn In Press).

The assessment predicted relatively high abundance in recent years. This prediction is consistent with reports from fishermen of increased abundance of larger individuals. However, this increase appears to be the result of one unusually strong year class (age–1) in 2001. MCB results and sensitivity runs agreed with strong pulses in recruitment, but showed much uncertainty in the temporal pattern. The observed data clearly shows an increase in abundance in the most recent years. Both the commercial longline and MARMAP indices show this increase. The observed age composition data also suggests a shift in the age structure to older ages, which could be suggestive of an increased abundance.

What is not clear is whether these observed patterns in the data are the result of (1) a single large year class, (2) several moderate to large year classes, or (3) an immigration of fish into the fished area. The third hypothesis was discussed on several occasions by the assessment panel and participating fishermen. Fishemen have noted a change in the fishery after 2003–04, which happened to correspond to a large cold water event in the U.S. South

Atlantic. In general, tilefish are not known to migrate as adults, but perhaps extreme environmental events instigate undocumented behavior.

The age composition data do not support a single strong year class and do not really indicate any year classes passing through the years. But ageing error for this species is high and could be masking year class signals. In the end, the data cannot give us a clear indication if (1), (2), or (3) listed above is the correct explanation of the increased abundance and shift in age structure. The base run model has chosen (1), but managers should note the risks involved if (2) or (3) are correct and management actions are based on (1).

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.
- 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.
- Projections were based on the calendar year, because they are extensions of the assessment model. A shift in the fishing year relative to calendar year may introduce some unquantified disconnect between projection results and management implementation. However, if quotas are reached each year prior to December 31, as might be expected, all fishing mortality within a fishing year would also occur within the same calendar year.

3.4 Research Recommendations

The assessment panel made the following recommendations.

- Increasing the number of age samples collected from the main part of the species' range
- Investigate reproductive characteristics, particulary regarding whether senescence or hermaphrodism occurs in the species
- Improve the genetic data available by conducting studies of gene similarities by region.
- Investigate whether a climate-recruitment link exists.
- Investigate whether time varying M may be appropriate for tilefish
- Evaluate patterns in ageing error at the data workshop including development of an ageing error matrix
- Obtain MRIP intercept numbers at the DW for tilefish and other rarely caught species

3.5 References

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3.6 Tables

Table 3.1. Life-history characteristics at age of the tilefish, including average body size in total length (TL) and weight (mid-year), gonad weight (GW), and proportion females mature (F.mat).

Age	TL (mm)	TL (in)	CV length	Whole weight (kg)	Whole weight (lb)	GW (kg)	F.mat
1	256.5	10.1	0.15	0.16	0.36	0.00	0.10
2	354.4	14.0	0.15	0.45	0.99	0.00	0.25
3	435.5	17.1	0.15	0.86	1.89	0.01	0.50
4	502.6	19.8	0.15	1.34	2.96	0.01	1.00
5	558.1	22.0	0.15	1.87	4.13	0.02	1.00
6	604.1	23.8	0.15	2.40	5.30	0.04	1.00
7	642.2	25.3	0.15	2.91	6.42	0.05	1.00
8	673.7	26.5	0.15	3.39	7.47	0.07	1.00
9	699.7	27.5	0.15	3.82	8.42	0.09	1.00
10	721.3	28.4	0.15	4.21	9.27	0.11	1.00
11	739.2	29.1	0.15	4.54	10.02	0.13	1.00
12	754.0	29.7	0.15	4.84	10.66	0.15	1.00
13	766.2	30.2	0.15	5.09	11.22	0.17	1.00
14	776.4	30.6	0.15	5.30	11.69	0.18	1.00
15	784.8	30.9	0.15	5.49	12.10	0.19	1.00
16	791.7	31.2	0.15	5.64	12.44	0.21	1.00
17	797.5	31.4	0.15	5.77	12.72	0.22	1.00
18	802.2	31.6	0.15	5.88	12.96	0.23	1.00
19	806.2	31.7	0.15	5.97	13.17	0.24	1.00
20	809.4	31.9	0.15	6.05	13.34	0.24	1.00
21	812.1	32.0	0.15	6.11	13.48	0.25	1.00
22	814.4	32.1	0.15	6.17	13.59	0.25	1.00
23	816.2	32.1	0.15	6.21	13.69	0.26	1.00
24	817.7	32.2	0.15	6.25	13.77	0.26	1.00
25	819.0	32.2	0.15	6.28	13.84	0.27	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
1962	443.19	329.38	265.01	221.71	189.73	164.52	143.54	125.81	110.80	97.98	86.92	77.31	68.90
1963	443.19	329.38	265.01	221.72	189.80	164.86	144.42	126.93	111.87	98.94	87.77	78.07	69.58
1964	443.48	329.38	265.01	221.73	189.82	164.92	144.72	127.71	112.87	99.89	88.63	78.83	70.26
1965	443.67	329.59	265.01	221.73	189.82	164.94	144.79	127.99	113.58	100.80	89.50	79.62	70.96
1966	443.84	329.73	265.18	221.72	189.81	164.89	144.65	127.86	113.64	101.27	90.17	80.27	71.55
1967	443.99	329.86	265.30	221.87	189.82	164.93	144.74	127.91	113.69	101.47	90.71	80.98	72.23
1968	444.14	329.97	265.40	221.96	189.94	164.92	144.73	127.93	113.68	101.46	90.85	81.43	72.84
1969	444.29	330.09	265.49	222.05	190.02	165.03	144.75	127.96	113.73	101.48	90.87	81.58	73.27
1970	444.42	330.19	265.58	222.12	190.09	165.11	144.86	127.99	113.76	101.54	90.90	81.61	73.41
1971	444.55	330.29	265.67	222.20	190.16	165.16	144.89	128.04	113.75	101.53	90.92	81.60	73.41
1972	444.65	330.39	265.75	222.27	190.22	165.20	144.88	127.99	113.73	101.46	90.86	81.57	73.36
1973	444.74	330.46	265.82	222.34	190.28	165.27	144.96	128.05	113.75	101.49	90.84	81.56	73.37
1974	444.82	330.53	265.88	222.40	190.33	165.26	144.84	127.88	113.57	101.31	90.69	81.38	73.21
1975	444.83	330.59	265.94	222.45	190.35	165.19	144.50	127.35	113.02	100.78	90.19	80.95	72.78
1976	254.95	330.60	265.98	222.49	190.36	165.06	144.01	126.50	112.02	99.82	89.31	80.13	72.06
1977	263.47	189.48	265.99	222.52	190.40	165.08	143.92	126.10	111.30	98.97	88.47	79.36	71.34
1978	283.69	195.81	152.45	222.54	190.47	165.28	144.34	126.54	111.44	98.77	88.11	78.97	70.98
1979	303.78	210.83	157.54	127.54	190.46	165.23	143.87	126.06	111.06	98.21	87.33	78.10	70.14
1980	316.79	225.77	169.63	131.80	109.15	165.19	143.92	125.77	110.74	97.96	86.91	77.48	69.43
1981	357.71	235.44	181.65	141.91	112.77	94.54	142.79	124.39	109.19	96.53	85.67	76.20	68.07
1982	343.56	265.84	189.42	151.91	121.18	96.61	78.42	116.14	101.25	89.18	79.08	70.36	62.71
1983	346.20	255.32	213.83	158.18	128.57	99.05	68.48	50.65	73.87	64.44	56.91	50.59	45.10
1984	340.25	257.29	205.38	178.64	134.21	106.53	73.89	47.69	34.89	50.96	44.58	39.47	35.16
1985	339.04	252.87	206.97	171.62	151.79	112.05	81.51	53.40	34.19	25.06	36.70	32.19	28.56
1986	354.26	251.96	203.41	172.92	145.70	125.79	79.98	53.07	34.41	22.06	16.22	23.81	20.93
1987	361.06	263.28	202.67	169.90	146.54	120.00	92.41	54.47	35.68	23.16	14.89	10.97	16.14
1988	419.50	268.34	211.81	169.49	145.06	125.54	100.61	76.41	45.07	29.62	19.29	12.43	9.18
1989	815.60	311.77	215.87	177.07	144.40	122.84	100.88	78.14	59.15	34.98	23.06	15.05	9.72
1990	313.87	606.13	250.79	180.36	150.33	120.09	93.36	72.22	55.41	42.01	24.92	16.47	10.77
1991	221.89	233.26	487.57	209.50	152.99	124.44	89.93	65.41	50.03	38.44	29.22	17.38	11.51
1992	290.13	164.90	187.62	407.18	177.39	125.46	90.57	60.44	43.33	33.17	25.55	19.47	11.60
1993	408.48	215.61	132.63	156.63	343.97	143.64	86.82	56.49	37.00	26.53	20.36	15.72	12.01
1994	432.63	303.56	173.41	110.71	132.20	277.12	96.79	52.05	33.19	21.73	15.62	12.02	9.30
1995	270.06	321.51	244.17	144.82	93.70	108.07	194.71	61.68	32.67	20.84	13.68	9.86	7.60
1996	217.29	200.70	258.62	203.96	122.79	77.39	80.14	134.45	42.09	22.32	14.28	9.40	6.79
1997	327.45	161.48	161.46	216.20	173.73	103.86	61.91	61.84	103.36	32.44	17.25	11.07	7.30
1998	379.26	243.36	129.91	134.97	184.11	146.39	78.77	44.08	43.81	73.43	23.11	12.32	7.92
1999	348.98	281.86	195.78	108.60	114.97	155.81	117.90	61.40	34.23	34.12	57.35	18.10	9.67
2000	345.87	259.36	226.74	163.62	92.35	96.42	120.87	86.94	44.98	25.13	25.12	42.33	13.39
2001	2935.78	257.04	208.62	189.40	138.70	76.14	70.15	81.11	57.62	29.84	16.72	16.76	28.29
2002	367.67	2181.81	206.77	174.36	161.09	116.04	55.76	47.42	54.43	38.75	20.13	11.31	11.35
2003	376.58	273.24	1755.15	172.82	148.31	135.05	87.54	39.41	33.30	38.31	27.35	14.24	8.02
2004	334.47	279.87	219.83	1467.54	147.37	125.67	101.46	61.38	27.56	23.35	26.95	19.29	10.07
2005	384.21	248.58	225.16	183.81	1251.93	125.61	102.27	80.24	48.49	21.84	18.56	21.48	15.40
2006	397.10	285.54	199.98	188.28	156.88	1067.88	99.81	77.99	61.15	37.07	16.75	14.27	16.55
2007	405.74	295.12	229.73	167.24	160.74	134.12	865.69	78.43	61.29	48.22	29.32	13.28	11.34
2008	412.20	301.55	237.44	192.16	142.97	138.55	113.99	729.92	66.31	52.01	41.05	25.03	11.36
2009	417.82	306.35	242.61	198.61	164.25	123.23	118.47	97.00	622.80	56.79	44.69	35.36	21.60
2010	421.07	310.52	246.47	202.93	169.76	141.31	101.87	95.79	78.60	506.59	46.34	36.56	28.98
2011	389.51	312.94	249.83	206.15	173.42	146.03	118.27	83.94	79.10	65.15	421.21	38.63	30.54

Table 3.2. Continued – Estimated total abundance at age (1000 fish) at start of year.

Year	14	15	16	17	18	19	20	21	22	23	24	25	Total
1962	61.51	54.98	49.19	44.05	39.48	35.40	31.76	28.50	25.58	22.97	20.63	182.47	2921.32
1963	62.11	55.51	49.67	44.48	39.86	35.75	32.07	28.78	25.83	23.20	20.83	184.25	2933.90
1964	62.72	56.06	50.16	44.92	40.26	36.10	32.38	29.06	26.09	23.43	21.04	186.06	2945.50
1965	63.34	56.62	50.66	45.37	40.66	36.46	32.70	29.35	26.35	23.66	21.25	187.92	2956.33
1966	63.87	57.09	51.08	45.74	40.99	36.76	32.98	29.59	26.57	23.86	21.43	189.48	2964.01
1967	64.49	57.64	51.58	46.19	41.39	37.12	33.30	29.88	26.82	24.09	21.63	191.32	2972.93
1968	65.08	58.18	52.06	46.62	41.78	37.46	33.61	30.16	27.07	24.31	21.83	193.09	2980.50
1969	65.64	58.73	52.55	47.06	42.18	37.82	33.93	30.45	27.33	24.54	22.04	194.94	2987.84
1970	66.04	59.24	53.05	47.52	42.59	38.19	34.26	30.74	27.60	24.78	22.26	196.83	2994.68
1971	66.14	59.58	53.50	47.95	42.98	38.54	34.57	31.03	27.85	25.01	22.46	198.66	3000.45
1972	66.10	59.63	53.77	48.33	43.35	38.87	34.87	31.30	28.10	25.23	22.66	200.38	3004.89
1973	66.09	59.62	53.85	48.60	43.71	39.23	35.19	31.59	28.35	25.46	22.87	202.23	3009.72
1974	65.96	59.50	53.73	48.57	43.86	39.47	35.44	31.81	28.56	25.64	23.03	203.69	3011.36
1975	65.58	59.17	53.42	48.29	43.68	39.47	35.54	31.92	28.66	25.74	23.11	204.41	3007.92
1976	64.89	58.55	52.88	47.79	43.23	39.12	35.37	31.86	28.62	25.70	23.09	204.17	2808.56
1977	64.26	57.95	52.34	47.31	42.78	38.72	35.06	31.71	28.57	25.68	23.06	203.97	2667.81
1978	63.91	57.64	52.04	47.04	42.55	38.50	34.86	31.58	28.57	25.75	23.14	204.70	2579.67
1979	63.14	56.93	51.40	46.44	42.01	38.02	34.42	31.18	28.25	25.56	23.04	204.00	2514.60
1980	62.46	56.30	50.82	45.92	41.52	37.58	34.03	30.81	27.92	25.31	22.90	203.47	2469.58
1981	61.10	55.03	49.66	44.86	40.56	36.69	33.23	30.10	27.27	24.71	22.40	200.48	2452.95
1982	56.11	50.43	45.47	41.07	37.12	33.59	30.40	27.54	24.95	22.61	20.50	184.92	2340.38
1983	40.26	36.07	32.46	29.29	26.47	23.94	21.67	19.62	17.78	16.12	14.61	132.73	2022.23
1984	31.40	28.06	25.17	22.66	20.47	18.51	16.75	15.17	13.74	12.45	11.29	103.22	1867.80
1985	25.48	22.78	20.38	18.30	16.49	14.90	13.48	12.20	11.05	10.01	9.08	83.51	1783.59
1986	18.60	16.61	14.87	13.32	11.96	10.78	9.75	8.82	7.99	7.24	6.56	60.68	1691.72
1987	14.21	12.64	11.31	10.13	9.08	8.16	7.36	6.66	6.03	5.46	4.95	45.95	1653.10
1988	13.53	11.92	10.62	9.50	8.52	7.64	6.87	6.20	5.61	5.08	4.60	42.92	1765.37
1989	7.19	10.61	9.36	8.34	7.47	6.70	6.01	5.41	4.88	4.42	4.00	37.47	2220.41
1990	6.97	5.16	7.62	6.73	6.00	5.38	4.83	4.33	3.90	3.52	3.19	29.91	2024.27
1991	7.54	4.88	3.62	5.35	4.73	4.22	3.78	3.40	3.05	2.75	2.48	23.31	1800.67
1992	7.70	5.05	3.27	2.43	3.59	3.18	2.84	2.54	2.29	2.05	1.85	17.36	1690.97
1993	7.17	4.76	3.12	2.03	1.51	2.23	1.97	1.76	1.58	1.42	1.27	11.94	1696.64
1994	7.11	4.25	2.83	1.86	1.21	0.90	1.33	1.17	1.05	0.94	0.85	7.88	1701.69
1995	5.89	4.51	2.70	1.80	1.18	0.77	0.57	0.85	0.75	0.67	0.60	5.56	1549.22
1996	5.24	4.07	3.12	1.87	1.24	0.82	0.53	0.40	0.59	0.52	0.46	4.28	1413.32
1997	5.28	4.08	3.17	2.43	1.46	0.97	0.64	0.42	0.31	0.46	0.41	3.71	1462.68
1998	5.23	3.79	2.93	2.28	1.75	1.05	0.70	0.46	0.30	0.22	0.33	2.97	1523.47
1999	6.22	4.12	2.98	2.31	1.80	1.38	0.83	0.55	0.36	0.24	0.18	2.61	1562.34
2000	7.16	4.62	3.06	2.22	1.72	1.34	1.03	0.62	0.41	0.27	0.18	2.08	1567.80
2001	8.96	4.80	3.10	2.05	1.49	1.16	0.90	0.69	0.42	0.28	0.18	1.52	4131.71
2002	19.20	6.09	3.27	2.11	1.40	1.02	0.79	0.61	0.47	0.28	0.19	1.16	3483.49
2003	8.06	13.65	4.33	2.33	1.50	1.00	0.73	0.56	0.44	0.34	0.20	0.97	3143.44
2004	5.67	5.71	9.69	3.08	1.65	1.07	0.71	0.52	0.40	0.31	0.24	0.83	2874.71
2005	8.05	4.54	4.58	7.77	2.47	1.33	0.86	0.57	0.42	0.32	0.25	0.86	2759.63
2006	11.89	6.22	3.52	3.55	6.02	1.92	1.03	0.67	0.44	0.32	0.25	0.87	2655.96
2007	13.17	9.47	4.96	2.81	2.83	4.81	1.53	0.82	0.53	0.35	0.26	0.89	2542.73
2008	9.72	11.30	8.13	4.26	2.41	2.44	4.14	1.32	0.71	0.46	0.31	0.99	2510.72
2009	9.82	8.41	9.79	7.05	3.70	2.10	2.12	3.60	1.15	0.62	0.40	1.13	2499.44
2010	17.74	8.07	6.92	8.06	5.81	3.05	1.73	1.75	2.97	0.95	0.51	1.26	2445.63
2011	24.25	14.86	6.77	5.81	6.77	4.89	2.57	1.45	1.47	2.50	0.80	1.49	2388.36

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
1962	157.4	324.5	500.0	657.4	783.1	871.7	922.2	940.1	933.2	908.3	870.6	824.3	772.9
1963	157.4	324.5	500.0	657.4	783.3	873.5	927.7	948.4	942.3	917.3	879.0	832.2	780.4
1964	157.4	324.5	500.0	657.4	783.3	873.7	929.7	954.4	950.9	926.2	887.6	840.4	788.2
1965	157.6	324.7	500.0	657.4	783.3	873.9	930.1	956.4	956.8	934.5	896.4	848.8	795.9
1966	157.6	324.7	500.2	657.4	783.3	873.7	929.2	955.5	957.2	938.9	903.0	855.8	802.5
1967	157.6	325.0	500.4	657.9	783.3	873.7	929.9	955.7	957.7	940.7	908.5	863.3	810.2
1968	157.6	325.0	500.7	658.1	784.0	873.7	929.7	955.9	957.5	940.7	909.8	868.2	817.0
1969	157.9	325.2	500.9	658.3	784.2	874.4	929.9	956.1	958.1	940.9	910.1	869.7	821.9
1970	157.9	325.2	501.1	658.5	784.6	874.8	930.6	956.4	958.3	941.4	910.5	869.9	823.4
1971	157.9	325.4	501.1	658.7	784.8	875.0	930.8	956.8	958.1	941.4	910.5	869.9	823.4
1972	157.9	325.4	501.3	659.0	785.1	875.2	930.8	956.4	957.9	940.7	910.1	869.7	822.8
1973	157.9	325.6	501.6	659.2	785.3	875.7	931.2	956.8	958.1	940.9	909.8	869.5	823.0
1974	158.1	325.6	501.6	659.4	785.5	875.5	930.6	955.5	956.6	939.2	908.3	867.5	821.2
1975	158.1	325.6	501.8	659.6	785.5	875.2	928.4	951.5	952.0	934.3	903.2	862.9	816.4
1976	90.6	325.6	501.8	659.6	785.7	874.6	925.1	945.3	943.6	925.5	894.4	854.3	808.2
1977	93.5	186.7	501.8	659.8	785.7	874.6	924.6	942.3	937.6	917.6	886.0	846.1	800.3
1978	100.8	192.9	287.7	659.8	786.2	875.7	927.3	945.6	938.7	915.8	882.5	841.9	796.1
1979	107.8	207.7	297.2	378.1	785.9	875.5	924.2	942.0	935.4	910.5	874.6	832.7	786.8
1980	112.4	222.4	320.1	390.9	450.4	875.2	924.6	939.8	932.8	908.3	870.4	826.1	778.9
1981	127.0	231.9	342.6	420.9	465.4	500.9	917.3	929.5	919.8	894.9	858.0	812.4	763.5
1982	121.9	261.9	357.4	450.4	500.0	511.9	503.8	867.7	853.0	826.7	792.1	750.2	703.5
1983	123.0	251.5	403.4	468.9	530.7	524.7	440.0	378.5	622.1	597.5	569.9	539.5	506.0
1984	120.8	253.5	387.4	529.6	553.8	564.4	474.7	356.3	293.9	472.5	446.4	420.9	394.4
1985	120.4	249.1	390.4	508.8	626.3	593.7	523.6	399.0	287.9	232.4	367.5	343.3	320.3
1986	125.9	248.2	383.8	512.8	601.2	666.5	513.9	396.6	289.9	204.6	162.5	254.0	234.8
1987	128.3	259.3	382.3	503.8	604.7	635.8	593.7	407.0	300.5	214.7	149.0	117.1	181.0
1988	149.0	264.3	399.5	502.4	598.6	665.1	646.4	571.0	379.6	274.7	193.1	132.5	103.0
1989	289.7	307.1	407.2	524.9	595.9	650.8	648.2	583.8	498.2	324.3	231.0	160.5	109.1
1990	111.6	597.0	473.1	534.8	620.4	636.3	599.9	539.7	466.7	389.6	249.6	175.5	120.8
1991	78.7	229.7	919.8	621.3	631.4	659.2	577.8	488.8	421.5	356.5	292.8	185.2	129.0
1992	103.0	162.5	353.8	1207.3	732.2	664.7	581.8	451.5	364.9	307.5	256.0	207.7	130.1
1993	145.1	212.3	250.2	464.3	1419.6	761.0	557.8	422.2	311.7	246.0	203.9	167.6	134.7
1994	153.7	298.9	327.2	328.3	545.6	1468.1	621.7	388.9	279.5	201.5	156.5	128.1	104.3
1995	95.9	316.8	460.5	429.5	386.7	572.5	1250.9	461.0	275.1	193.1	137.1	105.2	85.3
1996	77.2	197.8	487.9	604.7	506.8	410.1	514.8	1004.6	354.5	207.0	143.1	100.1	76.1
1997	116.2	159.2	304.7	641.1	716.9	550.3	397.7	462.1	870.6	300.7	172.8	117.9	81.8
1998	134.7	239.6	245.2	400.1	759.9	775.6	506.0	329.4	369.1	680.8	231.5	131.4	88.8
1999	123.9	277.6	369.3	322.1	474.4	825.4	757.3	458.8	288.4	316.4	574.3	192.9	108.5
2000	122.8	255.5	427.7	485.0	381.2	510.8	776.5	649.7	378.8	233.0	251.5	451.3	150.1
2001	1042.6	253.1	393.5	561.5	572.5	403.4	450.6	606.1	485.5	276.7	167.6	178.6	317.2
2002	130.5	2149.1	390.0	517.0	664.9	614.9	358.3	354.3	458.6	359.4	201.5	120.6	127.4
2003	133.8	269.2	3311.1	512.4	612.0	715.4	562.4	294.5	280.4	355.2	274.0	151.9	89.9
2004	118.8	275.6	414.7	4351.0	608.3	665.8	651.9	458.6	232.1	216.5	269.8	205.7	112.9
2005	136.5	244.9	424.8	545.0	5166.8	665.4	657.0	599.7	408.5	202.4	185.8	229.1	172.8
2006	141.1	281.3	377.2	558.2	647.5	5657.5	641.1	582.7	515.0	343.7	167.8	152.1	185.6
2007	144.2	290.8	433.4	495.8	663.4	710.5	5561.4	586.0	516.3	447.1	293.7	141.5	127.2
2008	146.4	297.0	448.0	569.7	590.0	733.9	732.4	5454.0	558.7	482.2	411.2	266.8	127.4
2009	148.4	301.8	457.7	588.9	677.9	652.8	761.0	724.9	5246.1	526.5	447.5	377.0	242.3
2010	149.5	305.8	465.0	601.6	700.6	748.7	654.3	715.8	662.0	4696.7	464.1	389.8	325.2
2011	138.2	308.2	471.3	611.1	715.8	773.6	759.9	627.2	666.2	604.1	4218.5	411.8	342.6

Table 3.3. Estimated biomass at age (1000 lb) at start of year

Year	14	15	16	17	18	19	20	21	22	23	24	25	Total
1962	719.1	664.9	611.8	560.4	511.9	466.1	423.5	384.0	347.7	314.6	284.2	2525.4	17279.0
1963	726.2	671.5	617.7	565.9	516.8	470.7	427.7	387.8	351.2	317.7	287.0	2550.1	17413.7
1964	733.3	678.1	623.9	571.4	521.8	475.3	431.9	391.5	354.7	320.8	289.7	2575.0	17541.1
1965	740.5	684.8	630.1	577.2	527.1	479.9	436.1	395.5	358.3	323.9	292.6	2600.8	17662.8
1966	746.7	690.5	635.4	582.0	531.5	483.9	439.8	398.8	361.1	326.5	295.0	2622.4	17752.9
1967	754.0	697.3	641.5	587.8	536.6	488.8	444.0	402.8	364.6	329.8	297.8	2647.8	17856.8
1968	760.8	703.7	647.5	593.0	541.7	493.2	448.2	406.5	368.0	332.9	300.7	2672.4	17946.7
1969	767.4	710.3	653.7	598.8	546.7	498.0	452.4	410.3	371.5	336.0	303.6	2698.0	18034.5
1970	772.1	716.5	659.8	604.5	552.0	502.9	456.8	414.2	375.2	339.3	306.4	2724.0	18116.7
1971	773.4	720.7	665.4	610.2	557.3	507.5	461.0	418.2	378.5	342.4	309.3	2749.4	18187.3
1972	772.7	721.4	668.7	614.9	562.0	511.9	465.0	421.7	381.8	345.5	312.2	2773.4	18243.3
1973	772.7	721.1	669.8	618.4	566.6	516.5	469.4	425.7	385.4	348.6	315.0	2799.0	18302.3
1974	771.2	719.6	668.2	618.0	568.6	519.9	472.7	428.8	388.2	351.2	317.2	2819.1	18327.0
1975	766.8	715.6	664.5	614.4	566.4	519.6	474.0	430.1	389.6	352.3	318.3	2829.0	18295.3
1976	758.8	708.1	657.6	608.0	560.4	515.0	471.6	429.2	389.1	351.9	317.9	2825.7	18128.0
1977	751.3	700.8	651.0	602.1	554.7	509.9	467.6	427.3	388.5	351.6	317.7	2823.0	17901.5
1978	747.4	697.3	647.1	598.6	551.6	506.8	465.0	425.5	388.2	352.5	318.8	2833.2	17682.6
1979	738.3	688.7	639.3	590.8	544.8	500.7	459.0	420.2	384.0	350.1	317.5	2823.5	17315.3
1980	730.2	681.0	632.1	584.2	538.1	494.7	453.7	415.4	379.6	346.6	315.5	2816.2	16939.0
1981	714.3	665.6	617.5	570.8	525.8	483.3	443.1	405.7	370.6	338.4	308.6	2774.7	16402.4
1982	656.1	610.0	565.5	522.5	481.3	442.2	405.4	371.0	339.3	309.5	282.4	2559.3	15045.0
1983	470.7	436.3	403.7	372.6	343.3	315.3	289.0	264.3	241.6	220.7	201.1	1837.1	11351.4
1984	367.1	339.5	313.1	288.4	265.4	243.6	223.3	204.4	186.7	170.4	155.4	1428.6	9454.5
1985	297.8	275.6	253.5	232.8	213.8	196.2	179.7	164.5	150.1	137.1	125.0	1155.9	8344.9
1986	217.4	200.8	185.0	169.5	155.0	142.0	130.1	118.8	108.7	99.2	90.4	839.7	7050.6
1987	166.2	153.0	140.7	129.0	117.7	107.4	98.1	89.7	82.0	74.7	68.1	636.0	6339.6
1988	158.1	144.2	132.1	121.0	110.5	100.5	91.7	83.6	76.3	69.4	63.3	594.1	6624.2
1989	84.0	128.3	116.4	106.3	97.0	88.2	80.2	73.0	66.4	60.4	55.1	518.5	6804.6
1990	81.6	62.4	94.8	85.5	77.8	70.8	64.4	58.4	52.9	48.3	43.9	414.0	6669.4
1991	88.2	59.1	45.0	68.1	61.3	55.6	50.5	45.9	41.4	37.5	34.2	322.8	6500.8
1992	89.9	61.1	40.8	30.9	46.5	41.9	37.9	34.4	31.1	28.0	25.4	240.3	6231.1
1993	83.8	57.5	38.8	25.8	19.6	29.3	26.2	23.8	21.4	19.4	17.6	165.1	5824.8
1994	83.1	51.4	35.1	23.6	15.7	11.9	17.6	15.9	14.3	12.8	11.7	109.1	5404.6
1995	68.8	54.7	33.5	22.9	15.2	10.1	7.7	11.5	10.1	9.3	8.4	76.9	5098.4
1996	61.3	49.2	38.8	23.8	16.1	10.8	7.1	5.3	7.9	7.1	6.4	59.1	4977.4
1997	61.7	49.4	39.5	30.9	19.0	12.8	8.6	5.5	4.2	6.2	5.5	51.4	5186.8
1998	61.1	45.9	36.4	29.1	22.7	13.9	9.3	6.2	4.0	3.1	4.6	41.0	5169.4
1999	72.8	49.8	37.0	29.3	23.4	18.3	11.0	7.5	4.9	3.3	2.4	36.2	5385.2
2000	83.8	55.8	37.9	28.2	22.3	17.6	13.7	8.4	5.5	3.7	2.4	28.7	5382.4
2001	104.7	58.0	38.6	26.0	19.4	15.2	11.9	9.3	5.7	3.7	2.4	20.9	6025.2
2002	224.4	73.6	40.6	26.9	18.1	13.4	10.6	8.4	6.4	4.0	2.6	16.1	6891.2
2003	94.4	165.1	54.0	29.5	19.4	13.2	9.7	7.5	6.0	4.6	2.9	13.4	7981.8
2004	66.4	69.2	120.4	39.2	21.4	14.1	9.5	7.1	5.5	4.2	3.3	11.5	8953.6
2005	94.1	54.9	56.9	99.0	32.0	17.4	11.5	7.7	5.7	4.4	3.5	11.9	10037.9
2006	138.9	75.2	43.7	45.2	78.0	25.1	13.7	9.0	6.0	4.4	3.5	11.9	10706.1
2007	153.9	114.6	61.7	35.7	36.8	63.5	20.5	11.0	7.3	4.9	3.5	12.3	10936.9
2008	113.5	136.7	101.2	54.2	31.3	32.2	55.3	17.9	9.7	6.4	4.2	13.7	11393.7
2009	114.9	101.6	121.7	89.7	48.1	27.6	28.2	48.5	15.7	8.4	5.5	15.7	11778.4
2010	207.5	97.7	86.0	102.5	75.4	40.1	23.1	23.6	40.3	13.0	7.1	17.4	11613.1
2011	283.5	179.7	84.2	73.9	87.7	64.4	34.2	19.6	20.1	34.2	11.0	20.7	11562.1

Table 3.4. Estimated time series and status indicators. Fishing mortality rate is apycal 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* $M = 0.10$. *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
1962	$2.60e-04$	0.001403	7838	0.903	108.5	4.287	4.808	0.996
1963	$2.44e-04$	0.001316	7899	0.911	109.9	4.343	4.870	0.997
1964	$7.49e-05$	0.000405	7956	0.917	110.9	4.381	4.913	0.999
1965	$1.73e-03$	0.009372	8012	0.924	111.7	4.416	4.952	0.977
1966	$3.24e-04$	0.001748	8053	0.928	112.5	4.447	4.987	0.996
1967	$7.61e-04$	0.004111	8100	0.934	113.3	4.479	5.023	0.990
1968	$4.63e-04$	0.002501	8141	0.938	114.1	4.509	5.057	0.994
1969	$3.76e-04$	0.002031	8180	0.943	114.8	4.538	5.089	0.995
1970	$7.42e-04$	0.004007	8218	0.947	115.5	4.565	5.119	0.990
1971	$1.37e-03$	0.007391	8250	0.951	116.1	4.588	5.145	0.982
1972	$8.13e-04$	0.004390	8275	0.954	116.6	4.609	5.168	0.989
1973	$2.84e-03$	0.015340	8302	0.957	117.0	4.625	5.187	0.963
1974	$6.45e-03$	0.034865	8313	0.958	117.1	4.629	5.191	0.918
1975	$1.12e-02$	0.060348	8299	0.957	116.7	4.613	5.174	0.865
1976	$1.10e-02$	0.059239	8223	0.948	116.1	4.586	5.143	0.867
1977	$6.42e-03$	0.034687	8120	0.936	115.6	4.568	5.122	0.919
1978	$1.34e-02$	0.072403	8021	0.925	115.0	4.543	5.095	0.842
1979	$1.25e-02$	0.067526	7854	0.905	113.5	4.487	5.032	0.851
1980	$2.44e-02$	0.131627	7683	0.886	111.4	4.402	4.936	0.742
1981	$8.96e-02$	0.484177	7440	0.858	105.5	4.168	4.674	0.414
1982	$3.40e-01$	1.834391	6824	0.787	87.0	3.437	3.855	0.140
1983	$2.59e-01$	1.398076	5149	0.594	65.1	2.573	2.885	0.178
1984	$2.18e-01$	1.180433	4288	0.494	52.6	2.078	2.330	0.207
1985	$3.25e-01$	1.758024	3785	0.436	42.4	1.675	1.878	0.147
1986	$2.84e-01$	1.531918	3198	0.369	33.8	1.334	1.496	0.164
1987	$7.33e-02$	0.395989	2876	0.331	30.6	1.208	1.355	0.468
1988	$1.41e-01$	0.760100	3005	0.346	30.4	1.203	1.349	0.298
1989	$2.30e-01$	1.240526	3086	0.356	28.7	1.135	1.273	0.198
1990	$2.53e-01$	1.368120	3025	0.349	26.2	1.037	1.163	0.181
1991	$2.99e-01$	1.613842	2949	0.340	24.1	0.953	1.068	0.157
1992	$3.78e-01$	2.044518	2826	0.326	22.3	0.882	0.989	0.128
1993	$4.20e-01$	2.268922	2642	0.305	20.0	0.791	0.887	0.117
1994	$3.53e-01$	1.906439	2451	0.283	18.2	0.718	0.806	0.136
1995	$2.69e-01$	1.451046	2313	0.267	17.3	0.684	0.768	0.172
1996	$1.48e-01$	0.797665	2258	0.260	17.9	0.707	0.793	0.287
1997	$2.29e-01$	1.238663	2353	0.271	18.9	0.746	0.837	0.200
1998	$1.37e-01$	0.742598	2345	0.270	19.6	0.773	0.866	0.304
1999	$1.96e-01$	1.061410	2443	0.282	20.3	0.801	0.898	0.227
2000	$2.98e-01$	1.608966	2441	0.281	19.6	0.775	0.870	0.158
2001	$2.84e-01$	1.534505	2733	0.315	18.4	0.728	0.816	0.166
2002	$2.39e-01$	1.289636	3126	0.360	18.3	0.723	0.810	0.192
2003	$2.42e-01$	1.307453	3620	0.417	20.0	0.790	0.886	0.192
2004	$1.20e-01$	0.647155	4061	0.468	26.7	1.054	1.182	0.338
2005	$1.56e-01$	0.840875	4553	0.525	32.7	1.291	1.448	0.277
2006	$1.25e-01$	0.674299	4856	0.560	38.1	1.507	1.690	0.329
2007	$5.12e-02$	0.276555	4961	0.572	43.3	1.713	1.921	0.566
2008	$4.21e-02$	0.227349	5168	0.596	49.0	1.936	2.171	0.616
2009	$9.36e-02$	0.505768	5343	0.616	52.9	2.091	2.345	0.403
2010	$7.48e-02$	0.404355	5268	0.607	54.8	2.167	2.430	0.463
2011	.	.	5244	0.605	.	.	.	.

Table 3.5. Selectivity at age (end-of-assessment time period) for commercial longlines (cl), commercial handline (ch), recreational (rec), MARMAP (mm), and selectivity of landings averaged across fisheries (L.avg). TL is total length.

Age	TL(mm)	TL(in)	cl	ch	rec	mm	L.avg
1	256.5	10.1	0.000	0.000	0.000	0.000	0.000
2	354.4	14.0	0.001	0.000	0.000	0.000	0.001
3	435.5	17.1	0.007	0.000	0.000	0.000	0.006
4	502.6	19.8	0.041	0.001	0.001	0.001	0.035
5	558.1	22.0	0.210	0.039	0.039	0.013	0.185
6	604.1	23.8	0.625	0.655	0.655	0.189	0.629
7	642.2	25.3	0.912	0.989	0.989	0.806	0.924
8	673.7	26.5	0.985	1.000	1.000	0.987	0.987
9	699.7	27.5	0.998	1.000	1.000	0.999	0.998
10	721.3	28.4	1.000	1.000	1.000	1.000	1.000
11	739.2	29.1	1.000	1.000	1.000	1.000	1.000
12	754.0	29.7	1.000	1.000	1.000	1.000	1.000
13	766.2	30.2	1.000	1.000	1.000	1.000	1.000
14	776.4	30.6	1.000	1.000	1.000	1.000	1.000
15	784.8	30.9	1.000	1.000	1.000	1.000	1.000
16	791.7	31.2	1.000	1.000	1.000	1.000	1.000
17	797.5	31.4	1.000	1.000	1.000	1.000	1.000
18	802.2	31.6	1.000	1.000	1.000	1.000	1.000
19	806.2	31.7	1.000	1.000	1.000	1.000	1.000
20	809.4	31.9	1.000	1.000	1.000	1.000	1.000
21	812.1	32.0	1.000	1.000	1.000	1.000	1.000
22	814.4	32.1	1.000	1.000	1.000	1.000	1.000
23	816.2	32.1	1.000	1.000	1.000	1.000	1.000
24	817.7	32.2	1.000	1.000	1.000	1.000	1.000
25	819.0	32.2	1.000	1.000	1.000	1.000	1.000

Table 3.6. Estimated time series of fully selected fishing mortality rates for commercial longline (F.cl), commercial handline (F.ch), and recreational (F.rec) 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.ch	F.rec	Apical F
1962	0.000	0.000	0.000	0.000
1963	0.000	0.000	0.000	0.000
1964	0.000	0.000	0.000	0.000
1965	0.001	0.000	0.000	0.002
1966	0.000	0.000	0.000	0.000
1967	0.001	0.000	0.000	0.001
1968	0.000	0.000	0.000	0.000
1969	0.000	0.000	0.000	0.000
1970	0.001	0.000	0.000	0.001
1971	0.001	0.000	0.000	0.001
1972	0.001	0.000	0.000	0.001
1973	0.002	0.000	0.000	0.003
1974	0.006	0.001	0.000	0.006
1975	0.010	0.002	0.000	0.011
1976	0.009	0.002	0.000	0.011
1977	0.005	0.002	0.000	0.006
1978	0.007	0.007	0.000	0.013
1979	0.008	0.004	0.000	0.012
1980	0.013	0.011	0.000	0.024
1981	0.063	0.027	0.000	0.090
1982	0.280	0.059	0.000	0.340
1983	0.219	0.035	0.004	0.259
1984	0.184	0.034	0.001	0.218
1985	0.203	0.030	0.092	0.325
1986	0.249	0.034	0.001	0.284
1987	0.066	0.007	0.000	0.073
1988	0.119	0.013	0.009	0.141
1989	0.204	0.026	0.000	0.230
1990	0.226	0.026	0.001	0.253
1991	0.270	0.028	0.001	0.299
1992	0.326	0.031	0.021	0.378
1993	0.346	0.074	0.000	0.420
1994	0.277	0.042	0.034	0.353
1995	0.236	0.033	0.000	0.269
1996	0.124	0.014	0.010	0.148
1997	0.128	0.014	0.088	0.229
1998	0.123	0.011	0.003	0.137
1999	0.163	0.013	0.021	0.196
2000	0.240	0.020	0.038	0.298
2001	0.157	0.016	0.111	0.284
2002	0.155	0.025	0.058	0.239
2003	0.092	0.008	0.142	0.242
2004	0.086	0.012	0.022	0.120
2005	0.073	0.014	0.068	0.156
2006	0.067	0.005	0.053	0.125
2007	0.036	0.007	0.009	0.051
2008	0.038	0.004	0.000	0.042
2009	0.037	0.003	0.053	0.094
2010	0.042	0.004	0.029	0.075

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
1962	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1963	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1964	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1965	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002
1966	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1967	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1968	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1969	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1970	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1971	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1972	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1973	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003
1974	0.000	0.000	0.000	0.000	0.001	0.004	0.006	0.006	0.006	0.006	0.006	0.006	0.006
1975	0.000	0.000	0.000	0.000	0.002	0.007	0.010	0.011	0.011	0.011	0.011	0.011	0.011
1976	0.000	0.000	0.000	0.000	0.002	0.007	0.010	0.011	0.011	0.011	0.011	0.011	0.011
1977	0.000	0.000	0.000	0.000	0.001	0.004	0.006	0.006	0.006	0.006	0.006	0.006	0.006
1978	0.000	0.000	0.000	0.000	0.002	0.009	0.013	0.013	0.013	0.013	0.013	0.013	0.013
1979	0.000	0.000	0.000	0.000	0.002	0.008	0.012	0.012	0.012	0.012	0.012	0.012	0.012
1980	0.000	0.000	0.000	0.001	0.003	0.016	0.023	0.024	0.024	0.024	0.024	0.024	0.024
1981	0.000	0.000	0.000	0.003	0.014	0.057	0.084	0.089	0.089	0.090	0.090	0.090	0.090
1982	0.000	0.000	0.002	0.011	0.061	0.214	0.314	0.335	0.339	0.339	0.340	0.340	0.340
1983	0.000	0.000	0.001	0.009	0.048	0.163	0.239	0.255	0.258	0.259	0.259	0.259	0.259
1984	0.000	0.000	0.001	0.008	0.040	0.138	0.202	0.216	0.218	0.218	0.218	0.218	0.218
1985	0.000	0.000	0.001	0.008	0.047	0.207	0.306	0.322	0.325	0.325	0.325	0.325	0.325
1986	0.000	0.000	0.002	0.010	0.054	0.178	0.261	0.280	0.283	0.283	0.284	0.284	0.284
1987	0.000	0.000	0.000	0.003	0.014	0.046	0.067	0.072	0.073	0.073	0.073	0.073	0.073
1988	0.000	0.000	0.001	0.005	0.026	0.089	0.130	0.139	0.140	0.141	0.141	0.141	0.141
1989	0.000	0.000	0.001	0.008	0.044	0.144	0.211	0.227	0.229	0.230	0.230	0.230	0.230
1990	0.000	0.000	0.002	0.009	0.049	0.159	0.233	0.250	0.253	0.253	0.253	0.253	0.253
1991	0.000	0.000	0.002	0.011	0.058	0.188	0.275	0.295	0.298	0.299	0.299	0.299	0.299
1992	0.000	0.000	0.002	0.013	0.071	0.238	0.349	0.374	0.378	0.378	0.378	0.378	0.378
1993	0.000	0.000	0.002	0.014	0.076	0.265	0.389	0.415	0.419	0.420	0.420	0.420	0.420
1994	0.000	0.000	0.002	0.011	0.061	0.223	0.328	0.349	0.352	0.353	0.353	0.353	0.353
1995	0.000	0.000	0.002	0.010	0.051	0.169	0.248	0.265	0.268	0.268	0.269	0.269	0.269
1996	0.000	0.000	0.001	0.005	0.027	0.093	0.137	0.146	0.147	0.148	0.148	0.148	0.148
1997	0.000	0.000	0.001	0.005	0.031	0.146	0.217	0.227	0.229	0.229	0.229	0.229	0.229
1998	0.000	0.000	0.001	0.005	0.026	0.086	0.127	0.136	0.137	0.137	0.137	0.137	0.137
1999	0.000	0.000	0.001	0.007	0.036	0.124	0.182	0.194	0.196	0.196	0.196	0.196	0.196
2000	0.000	0.000	0.002	0.010	0.053	0.188	0.276	0.294	0.297	0.298	0.298	0.298	0.298
2001	0.000	0.000	0.001	0.007	0.038	0.181	0.269	0.282	0.284	0.284	0.284	0.284	0.284
2002	0.000	0.000	0.001	0.006	0.036	0.152	0.224	0.236	0.238	0.239	0.239	0.239	0.239
2003	0.000	0.000	0.001	0.004	0.025	0.156	0.232	0.241	0.242	0.242	0.242	0.242	0.242
2004	0.000	0.000	0.001	0.004	0.019	0.076	0.112	0.118	0.120	0.120	0.120	0.120	0.120
2005	0.000	0.000	0.000	0.003	0.019	0.100	0.148	0.155	0.155	0.156	0.156	0.156	0.156
2006	0.000	0.000	0.000	0.003	0.016	0.080	0.118	0.124	0.125	0.125	0.125	0.125	0.125
2007	0.000	0.000	0.000	0.001	0.008	0.032	0.048	0.051	0.051	0.051	0.051	0.051	0.051
2008	0.000	0.000	0.000	0.002	0.008	0.026	0.039	0.042	0.042	0.042	0.042	0.042	0.042
2009	0.000	0.000	0.000	0.002	0.010	0.060	0.090	0.093	0.094	0.094	0.094	0.094	0.094
2010	0.000	0.000	0.000	0.002	0.010	0.048	0.071	0.074	0.075	0.075	0.075	0.075	0.075

Table 3.7. Continued – Estimated instantaneous fishing mortality rate (per yr) at age, including discard mortality

Year	14	15	16	17	18	19	20	21	22	23	24	25
1962	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1963	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1964	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1965	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
1966	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1967	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1968	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1969	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1970	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1971	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1972	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1973	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
1974	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
1975	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
1976	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
1977	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
1978	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
1979	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
1980	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
1981	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
1982	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340
1983	0.259	0.259	0.259	0.259	0.259	0.259	0.259	0.259	0.259	0.259	0.259	0.259
1984	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218
1985	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325
1986	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284
1987	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073
1988	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141
1989	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230
1990	0.253	0.253	0.253	0.253	0.253	0.253	0.253	0.253	0.253	0.253	0.253	0.253
1991	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299
1992	0.378	0.378	0.378	0.378	0.378	0.378	0.378	0.378	0.378	0.378	0.378	0.378
1993	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420
1994	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
1995	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
1996	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148
1997	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229
1998	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.137
1999	0.196	0.196	0.196	0.196	0.196	0.196	0.196	0.196	0.196	0.196	0.196	0.196
2000	0.298	0.298	0.298	0.298	0.298	0.298	0.298	0.298	0.298	0.298	0.298	0.298
2001	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284	0.284
2002	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239
2003	0.242	0.242	0.242	0.242	0.242	0.242	0.242	0.242	0.242	0.242	0.242	0.242
2004	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120
2005	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156
2006	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
2007	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
2008	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
2009	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094
2010	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075

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
1962	0.00	0.00	0.00	0.00	0.01	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02
1963	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02
1964	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1965	0.00	0.00	0.00	0.01	0.06	0.17	0.22	0.21	0.19	0.17	0.15	0.13	0.12
1966	0.00	0.00	0.00	0.00	0.01	0.03	0.04	0.04	0.03	0.03	0.03	0.02	0.02
1967	0.00	0.00	0.00	0.01	0.03	0.07	0.10	0.09	0.08	0.07	0.07	0.06	0.05
1968	0.00	0.00	0.00	0.00	0.02	0.05	0.06	0.06	0.05	0.04	0.04	0.04	0.03
1969	0.00	0.00	0.00	0.00	0.01	0.04	0.05	0.04	0.04	0.04	0.03	0.03	0.03
1970	0.00	0.00	0.00	0.01	0.02	0.07	0.09	0.09	0.08	0.07	0.06	0.06	0.05
1971	0.00	0.00	0.00	0.01	0.05	0.13	0.17	0.16	0.15	0.13	0.12	0.11	0.10
1972	0.00	0.00	0.00	0.01	0.03	0.08	0.10	0.10	0.09	0.08	0.07	0.06	0.06
1973	0.00	0.00	0.00	0.02	0.09	0.28	0.36	0.34	0.30	0.27	0.24	0.22	0.20
1974	0.00	0.00	0.01	0.05	0.21	0.63	0.81	0.77	0.69	0.62	0.55	0.50	0.45
1975	0.00	0.00	0.02	0.08	0.37	1.08	1.40	1.32	1.18	1.06	0.95	0.85	0.77
1976	0.00	0.00	0.02	0.08	0.36	1.06	1.37	1.29	1.15	1.03	0.92	0.83	0.75
1977	0.00	0.00	0.01	0.04	0.18	0.63	0.81	0.75	0.67	0.60	0.54	0.48	0.43
1978	0.00	0.00	0.01	0.06	0.30	1.32	1.72	1.58	1.40	1.25	1.11	1.00	0.90
1979	0.00	0.00	0.01	0.04	0.34	1.22	1.58	1.46	1.30	1.16	1.03	0.92	0.83
1980	0.00	0.00	0.01	0.07	0.33	2.39	3.09	2.83	2.52	2.23	1.98	1.77	1.59
1981	0.00	0.01	0.07	0.34	1.49	4.90	10.82	9.97	8.84	7.84	6.97	6.20	5.55
1982	0.01	0.07	0.33	1.61	6.71	17.49	19.97	31.32	27.60	24.38	21.66	19.29	17.20
1983	0.01	0.05	0.29	1.31	5.58	13.99	13.74	10.80	15.94	13.94	12.33	10.97	9.79
1984	0.01	0.05	0.23	1.24	4.90	12.86	12.75	8.75	6.48	9.49	8.31	7.37	6.57
1985	0.01	0.05	0.26	1.33	6.56	19.69	20.30	13.93	8.99	6.61	9.70	8.51	7.56
1986	0.01	0.06	0.31	1.62	7.10	19.29	17.36	12.26	8.04	5.17	3.81	5.60	4.92
1987	0.00	0.02	0.08	0.43	1.93	5.06	5.67	3.59	2.38	1.55	1.00	0.74	1.08
1988	0.01	0.03	0.16	0.76	3.45	9.99	11.56	9.36	5.59	3.69	2.40	1.55	1.15
1989	0.02	0.06	0.27	1.36	5.78	15.50	18.14	14.98	11.48	6.81	4.50	2.94	1.90
1990	0.01	0.13	0.35	1.54	6.66	16.59	18.31	15.10	11.73	8.92	5.30	3.50	2.29
1991	0.01	0.06	0.81	2.13	8.03	19.99	20.39	15.80	12.23	9.42	7.18	4.27	2.83
1992	0.01	0.05	0.38	5.00	11.29	24.98	25.22	17.84	12.93	9.93	7.66	5.84	3.48
1993	0.02	0.07	0.28	2.04	23.40	31.41	26.43	18.17	12.03	8.65	6.65	5.14	3.93
1994	0.02	0.08	0.30	1.16	7.32	52.02	25.54	14.51	9.35	6.14	4.42	3.40	2.63
1995	0.01	0.07	0.36	1.29	4.34	15.77	40.28	13.59	7.28	4.66	3.06	2.21	1.70
1996	0.00	0.02	0.20	0.95	3.04	6.45	9.64	17.23	5.46	2.90	1.86	1.23	0.89
1997	0.01	0.02	0.13	1.06	4.91	13.28	11.39	11.89	20.04	6.31	3.36	2.16	1.42
1998	0.01	0.03	0.10	0.63	4.48	11.36	8.82	5.28	5.32	8.94	2.82	1.50	0.97
1999	0.01	0.04	0.20	0.67	3.74	17.03	18.48	10.24	5.77	5.77	9.72	3.07	1.64
2000	0.01	0.06	0.34	1.48	4.42	15.51	27.53	20.97	10.97	6.15	6.15	10.38	3.28
2001	0.07	0.04	0.20	1.14	4.82	11.86	15.61	18.84	13.49	7.01	3.93	3.94	6.66
2002	0.01	0.33	0.20	1.03	5.30	15.34	10.56	9.44	10.94	7.81	4.06	2.28	2.30
2003	0.01	0.02	1.00	0.62	3.44	18.30	17.12	7.97	6.78	7.81	5.59	2.91	1.64
2004	0.00	0.02	0.12	4.79	2.64	8.62	10.12	6.48	2.94	2.50	2.89	2.07	1.08
2005	0.00	0.02	0.10	0.52	21.47	11.19	13.29	10.86	6.61	2.99	2.54	2.94	2.11
2006	0.00	0.02	0.08	0.48	2.37	76.81	10.49	8.58	6.78	4.12	1.87	1.59	1.85
2007	0.00	0.01	0.05	0.23	1.22	4.02	38.10	3.66	2.89	2.28	1.39	0.63	0.54
2008	0.00	0.01	0.06	0.27	1.08	3.39	4.08	28.02	2.58	2.03	1.60	0.98	0.44
2009	0.00	0.01	0.06	0.29	1.53	6.76	9.58	8.14	52.63	4.81	3.79	3.00	1.84
2010	0.00	0.01	0.06	0.33	1.60	6.18	6.56	6.47	5.36	34.62	3.17	2.50	1.99

Table 3.8. Contninued – Estimated total landings at age in numbers (1000 fish)

Year	14	15	16	17	18	19	20	21	22	23	24	25
1962	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05
1963	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.04
1964	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
1965	0.10	0.09	0.08	0.07	0.07	0.06	0.05	0.05	0.04	0.04	0.04	0.31
1966	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.06
1967	0.05	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.14
1968	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.09
1969	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.07
1970	0.05	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.14
1971	0.09	0.08	0.07	0.06	0.06	0.05	0.05	0.04	0.04	0.03	0.03	0.26
1972	0.05	0.05	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.16
1973	0.18	0.16	0.15	0.13	0.12	0.11	0.10	0.09	0.08	0.07	0.06	0.55
1974	0.40	0.36	0.33	0.30	0.27	0.24	0.22	0.19	0.18	0.16	0.14	1.25
1975	0.69	0.63	0.56	0.51	0.46	0.42	0.38	0.34	0.30	0.27	0.24	2.16
1976	0.67	0.61	0.55	0.50	0.45	0.41	0.37	0.33	0.30	0.27	0.24	2.12
1977	0.39	0.35	0.32	0.29	0.26	0.24	0.21	0.19	0.17	0.16	0.14	1.24
1978	0.81	0.73	0.66	0.60	0.54	0.49	0.44	0.40	0.36	0.33	0.29	2.60
1979	0.75	0.67	0.61	0.55	0.50	0.45	0.41	0.37	0.33	0.30	0.27	2.42
1980	1.43	1.29	1.16	1.05	0.95	0.86	0.78	0.71	0.64	0.58	0.53	4.67
1981	4.98	4.49	4.05	3.66	3.31	3.00	2.72	2.46	2.23	2.02	1.83	16.39
1982	15.40	13.85	12.49	11.28	10.20	9.23	8.36	7.57	6.86	6.22	5.64	50.87
1983	8.75	7.84	7.06	6.37	5.76	5.21	4.72	4.27	3.87	3.51	3.18	28.90
1984	5.87	5.25	4.71	4.24	3.83	3.47	3.14	2.84	2.57	2.33	2.11	19.34
1985	6.75	6.03	5.40	4.85	4.37	3.95	3.58	3.24	2.93	2.66	2.41	22.16
1986	4.37	3.91	3.50	3.14	2.82	2.54	2.30	2.08	1.88	1.71	1.55	14.31
1987	0.96	0.85	0.76	0.68	0.61	0.55	0.50	0.45	0.41	0.37	0.33	3.10
1988	1.69	1.49	1.33	1.19	1.07	0.96	0.86	0.78	0.70	0.64	0.58	5.37
1989	1.41	2.07	1.83	1.63	1.46	1.31	1.18	1.06	0.96	0.87	0.78	7.34
1990	1.48	1.10	1.63	1.44	1.28	1.15	1.03	0.93	0.83	0.75	0.68	6.39
1991	1.86	1.20	0.89	1.32	1.17	1.04	0.93	0.84	0.75	0.68	0.61	5.75
1992	2.31	1.52	0.98	0.73	1.08	0.96	0.85	0.77	0.69	0.62	0.56	5.23
1993	2.34	1.56	1.02	0.66	0.49	0.73	0.65	0.58	0.52	0.47	0.42	3.91
1994	2.02	1.21	0.80	0.53	0.34	0.25	0.38	0.33	0.30	0.27	0.24	2.24
1995	1.32	1.01	0.61	0.40	0.27	0.17	0.13	0.19	0.17	0.15	0.14	1.25
1996	0.68	0.53	0.41	0.24	0.16	0.11	0.07	0.05	0.08	0.07	0.06	0.56
1997	1.03	0.80	0.62	0.48	0.28	0.19	0.12	0.08	0.06	0.09	0.08	0.73
1998	0.64	0.46	0.36	0.28	0.21	0.13	0.09	0.06	0.04	0.03	0.04	0.36
1999	1.06	0.70	0.51	0.39	0.31	0.24	0.14	0.09	0.06	0.04	0.03	0.44
2000	1.76	1.13	0.75	0.55	0.42	0.33	0.25	0.15	0.10	0.07	0.04	0.51
2001	2.11	1.13	0.73	0.48	0.35	0.27	0.21	0.16	0.10	0.07	0.04	0.36
2002	3.88	1.23	0.66	0.43	0.28	0.21	0.16	0.12	0.10	0.06	0.04	0.24
2003	1.65	2.80	0.89	0.48	0.31	0.20	0.15	0.12	0.09	0.07	0.04	0.20
2004	0.61	0.61	1.04	0.33	0.18	0.12	0.08	0.06	0.04	0.03	0.03	0.09
2005	1.10	0.62	0.63	1.07	0.34	0.18	0.12	0.08	0.06	0.04	0.03	0.12
2006	1.33	0.69	0.39	0.40	0.67	0.21	0.12	0.07	0.05	0.04	0.03	0.10
2007	0.62	0.45	0.24	0.13	0.13	0.23	0.07	0.04	0.03	0.02	0.01	0.04
2008	0.38	0.44	0.32	0.17	0.09	0.10	0.16	0.05	0.03	0.02	0.01	0.04
2009	0.83	0.72	0.83	0.60	0.32	0.18	0.18	0.31	0.10	0.05	0.03	0.10
2010	1.22	0.55	0.48	0.55	0.40	0.21	0.12	0.12	0.20	0.07	0.04	0.09

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
1962	0.00	0.00	0.00	0.01	0.03	0.13	0.20	0.21	0.22	0.21	0.20	0.19	0.18
1963	0.00	0.00	0.00	0.00	0.03	0.12	0.19	0.20	0.20	0.20	0.19	0.18	0.17
1964	0.00	0.00	0.00	0.00	0.01	0.04	0.06	0.06	0.06	0.06	0.06	0.06	0.05
1965	0.00	0.00	0.00	0.04	0.22	0.84	1.32	1.46	1.48	1.45	1.39	1.32	1.24
1966	0.00	0.00	0.00	0.01	0.04	0.16	0.25	0.27	0.28	0.27	0.26	0.25	0.23
1967	0.00	0.00	0.00	0.02	0.10	0.37	0.58	0.64	0.65	0.64	0.62	0.59	0.55
1968	0.00	0.00	0.00	0.01	0.06	0.23	0.35	0.39	0.39	0.39	0.38	0.36	0.34
1969	0.00	0.00	0.00	0.01	0.05	0.18	0.29	0.32	0.32	0.32	0.31	0.29	0.28
1970	0.00	0.00	0.00	0.02	0.10	0.36	0.57	0.62	0.63	0.62	0.60	0.58	0.55
1971	0.00	0.00	0.00	0.03	0.18	0.67	1.04	1.15	1.17	1.15	1.11	1.07	1.01
1972	0.00	0.00	0.00	0.02	0.10	0.40	0.62	0.68	0.69	0.68	0.66	0.63	0.60
1973	0.00	0.00	0.01	0.06	0.37	1.38	2.17	2.39	2.42	2.39	2.31	2.21	2.09
1974	0.00	0.00	0.02	0.13	0.83	3.14	4.91	5.41	5.48	5.40	5.23	5.00	4.74
1975	0.00	0.00	0.03	0.23	1.44	5.43	8.46	9.30	9.42	9.28	8.99	8.59	8.14
1976	0.00	0.00	0.03	0.22	1.41	5.32	8.28	9.07	9.17	9.02	8.74	8.35	7.91
1977	0.00	0.00	0.01	0.11	0.71	3.14	4.92	5.32	5.35	5.25	5.08	4.85	4.59
1978	0.00	0.00	0.01	0.16	1.16	6.62	10.43	11.13	11.15	10.90	10.52	10.05	9.51
1979	0.00	0.00	0.01	0.11	1.33	6.13	9.57	10.32	10.36	10.11	9.73	9.27	8.77
1980	0.00	0.00	0.02	0.19	1.28	11.97	18.75	20.00	20.03	19.55	18.77	17.83	16.82
1981	0.00	0.01	0.13	0.95	5.79	24.52	65.63	70.36	70.36	68.67	65.93	62.49	58.77
1982	0.00	0.07	0.58	4.50	26.16	87.50	121.16	221.02	219.59	213.49	204.82	194.18	182.22
1983	0.00	0.05	0.52	3.67	21.75	70.04	83.46	76.30	126.89	122.20	116.75	110.60	103.82
1984	0.00	0.04	0.42	3.47	19.12	64.35	77.36	61.77	51.54	83.10	78.65	74.20	69.59
1985	0.00	0.05	0.46	3.72	25.67	100.22	125.31	99.93	72.75	58.84	93.23	87.12	81.38
1986	0.00	0.06	0.56	4.54	27.67	96.54	105.34	86.50	63.96	45.28	36.01	56.34	52.13
1987	0.00	0.02	0.15	1.19	7.51	25.33	34.43	25.32	18.95	13.58	9.45	7.42	11.49
1988	0.00	0.03	0.28	2.13	13.45	50.16	70.42	66.31	44.63	32.39	22.81	15.67	12.18
1989	0.01	0.06	0.48	3.81	22.54	77.53	110.02	105.70	91.29	59.61	42.52	29.57	20.11
1990	0.00	0.12	0.62	4.31	25.95	83.00	111.13	106.58	93.30	78.10	50.11	35.29	24.30
1991	0.00	0.06	1.45	5.97	31.30	100.03	123.72	111.48	97.29	82.53	67.87	43.00	29.99
1992	0.00	0.05	0.67	14.00	44.01	125.43	153.53	126.30	103.21	87.22	72.69	59.03	37.03
1993	0.01	0.07	0.51	5.72	91.20	157.13	160.32	128.22	95.66	75.70	62.86	51.72	41.59
1994	0.01	0.08	0.53	3.24	28.56	261.80	155.89	102.97	74.77	54.04	42.02	34.45	28.07
1995	0.00	0.07	0.63	3.61	16.91	78.89	244.40	95.86	57.92	40.79	28.98	22.25	18.06
1996	0.00	0.02	0.35	2.67	11.87	32.40	58.74	122.12	43.61	25.53	17.67	12.39	9.42
1997	0.00	0.02	0.23	2.96	19.26	67.98	70.73	85.82	163.06	56.47	32.49	22.20	15.42
1998	0.00	0.03	0.18	1.76	17.47	56.93	53.60	37.32	42.35	78.38	26.69	15.17	10.26
1999	0.00	0.04	0.35	1.87	14.61	85.76	112.86	72.68	46.21	50.85	92.47	31.10	17.49
2000	0.00	0.06	0.60	4.15	17.26	78.23	168.36	149.10	87.90	54.21	58.62	105.26	35.05
2001	0.02	0.04	0.36	3.19	18.91	60.75	96.96	136.01	109.80	62.74	38.03	40.60	72.19
2002	0.00	0.31	0.35	2.89	20.73	77.88	65.05	67.58	88.27	69.35	38.97	23.33	24.66
2003	0.00	0.02	1.79	1.74	13.59	94.75	107.53	58.20	55.78	70.78	54.67	30.33	17.98
2004	0.00	0.02	0.21	13.43	10.31	43.60	62.10	46.23	23.65	22.12	27.61	21.06	11.57
2005	0.00	0.02	0.18	1.45	84.40	57.49	82.79	78.61	53.96	26.81	24.65	30.39	22.95
2006	0.00	0.02	0.15	1.36	9.30	394.23	65.33	62.07	55.33	37.01	18.09	16.43	20.05
2007	0.00	0.01	0.09	0.64	4.76	20.30	233.56	26.06	23.21	20.15	13.26	6.40	5.75
2008	0.00	0.01	0.10	0.77	4.20	16.95	24.73	197.70	20.52	17.77	15.18	9.86	4.71
2009	0.00	0.01	0.10	0.81	6.02	34.95	60.10	59.36	432.62	43.52	37.04	31.23	20.09
2010	0.00	0.01	0.11	0.92	6.26	31.65	40.72	46.69	43.58	309.95	30.67	25.78	21.53

Table 3.9. Continued – Estimated total landings at age in whole weight (1000 lb)

Year	14	15	16	17	18	19	20	21	22	23	24	25
1962	0.17	0.16	0.14	0.13	0.12	0.11	0.10	0.09	0.08	0.07	0.07	0.59
1963	0.16	0.15	0.14	0.12	0.11	0.10	0.09	0.08	0.08	0.07	0.06	0.56
1964	0.05	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.17
1965	1.15	1.07	0.98	0.90	0.82	0.75	0.68	0.62	0.56	0.51	0.46	4.06
1966	0.22	0.20	0.18	0.17	0.15	0.14	0.13	0.12	0.11	0.10	0.09	0.76
1967	0.51	0.48	0.44	0.40	0.37	0.33	0.30	0.28	0.25	0.23	0.20	1.81
1968	0.32	0.29	0.27	0.25	0.23	0.21	0.19	0.17	0.15	0.14	0.13	1.11
1969	0.26	0.24	0.22	0.20	0.18	0.17	0.15	0.14	0.13	0.11	0.10	0.91
1970	0.51	0.48	0.44	0.40	0.37	0.34	0.30	0.28	0.25	0.23	0.20	1.82
1971	0.95	0.88	0.82	0.75	0.68	0.62	0.57	0.51	0.47	0.42	0.38	3.38
1972	0.56	0.53	0.49	0.45	0.41	0.37	0.34	0.31	0.28	0.25	0.23	2.03
1973	1.97	1.84	1.71	1.58	1.44	1.32	1.20	1.09	0.98	0.89	0.80	7.14
1974	4.45	4.16	3.86	3.57	3.29	3.01	2.73	2.48	2.25	2.03	1.84	16.32
1975	7.65	7.14	6.63	6.14	5.66	5.19	4.74	4.30	3.89	3.52	3.18	28.28
1976	7.43	6.94	6.44	5.96	5.50	5.05	4.63	4.21	3.82	3.45	3.12	27.73
1977	4.32	4.03	3.74	3.46	3.19	2.93	2.69	2.46	2.24	2.02	1.83	16.26
1978	8.93	8.34	7.74	7.16	6.60	6.07	5.57	5.10	4.65	4.22	3.82	33.95
1979	8.23	7.68	7.14	6.60	6.08	5.59	5.13	4.70	4.29	3.91	3.55	31.57
1980	15.78	14.72	13.67	12.64	11.65	10.71	9.83	8.99	8.22	7.51	6.83	61.01
1981	55.02	51.30	47.61	44.02	40.57	37.28	34.20	31.31	28.61	26.12	23.82	214.25
1982	170.05	158.18	146.71	135.59	124.93	114.82	105.27	96.39	88.11	80.42	73.34	664.92
1983	96.66	89.63	82.95	76.61	70.57	64.84	59.45	54.41	49.74	45.41	41.40	378.11
1984	64.82	59.97	55.32	50.98	46.92	43.10	39.51	36.16	33.04	30.17	27.51	252.86
1985	75.73	70.08	64.50	59.25	54.42	49.95	45.78	41.88	38.27	34.93	31.85	294.52
1986	48.31	44.67	41.13	37.70	34.51	31.61	28.94	26.48	24.19	22.07	20.12	187.06
1987	10.55	9.72	8.94	8.19	7.49	6.83	6.24	5.71	5.21	4.76	4.34	40.49
1988	18.73	17.08	15.65	14.34	13.10	11.93	10.87	9.91	9.05	8.25	7.52	70.50
1989	15.51	23.69	21.50	19.62	17.91	16.32	14.83	13.48	12.28	11.19	10.20	95.92
1990	16.40	12.57	19.10	17.26	15.69	14.29	12.99	11.78	10.69	9.72	8.85	83.53
1991	20.49	13.74	10.47	15.85	14.27	12.94	11.75	10.66	9.66	8.76	7.96	75.18
1992	25.62	17.39	11.60	8.81	13.28	11.93	10.79	9.78	8.86	8.02	7.26	68.56
1993	25.88	17.79	12.02	7.98	6.04	9.08	8.14	7.35	6.65	6.02	5.44	51.17
1994	22.39	13.85	9.47	6.37	4.22	3.18	4.77	4.27	3.85	3.48	3.14	29.43
1995	14.60	11.57	7.12	4.85	3.25	2.15	1.62	2.42	2.16	1.94	1.76	16.36
1996	7.59	6.10	4.81	2.95	2.00	1.34	0.88	0.66	0.99	0.88	0.79	7.35
1997	11.63	9.31	7.44	5.84	3.57	2.41	1.61	1.06	0.79	1.19	1.06	9.70
1998	7.07	5.30	4.22	3.36	2.63	1.60	1.08	0.72	0.47	0.35	0.53	4.76
1999	11.74	8.04	6.00	4.75	3.77	2.94	1.79	1.20	0.80	0.52	0.39	5.84
2000	19.56	13.05	8.89	6.60	5.21	4.12	3.21	1.95	1.31	0.87	0.57	6.73
2001	23.85	13.23	8.78	5.95	4.41	3.47	2.74	2.13	1.29	0.87	0.57	4.80
2002	43.50	14.28	7.88	5.21	3.52	2.60	2.04	1.61	1.25	0.75	0.51	3.12
2003	18.86	33.05	10.79	5.93	3.91	2.63	1.94	1.52	1.20	0.93	0.56	2.68
2004	6.80	7.09	12.37	4.02	2.20	1.45	0.97	0.71	0.56	0.44	0.34	1.18
2005	12.51	7.31	7.58	13.16	4.27	2.33	1.53	1.02	0.75	0.59	0.46	1.59
2006	15.02	8.14	4.73	4.88	8.45	2.73	1.49	0.97	0.65	0.48	0.37	1.30
2007	6.97	5.19	2.80	1.62	1.67	2.87	0.93	0.50	0.33	0.22	0.16	0.56
2008	4.20	5.06	3.75	2.01	1.16	1.19	2.05	0.66	0.36	0.23	0.16	0.51
2009	9.53	8.44	10.11	7.46	3.99	2.29	2.35	4.04	1.30	0.70	0.46	1.30
2010	13.74	6.47	5.71	6.80	5.00	2.67	1.53	1.56	2.68	0.86	0.47	1.16

Table 3.10. Estimated time series of landings in numbers (1000 fish) for commercial longline (L.cl), commercial handline (L.ch), and recreational (L.rec)

Year	L.cl	L.ch	L.rec	Total
1962	0.31	0.05	0.00	0.36
1963	0.29	0.05	0.00	0.34
1964	0.09	0.01	0.00	0.10
1965	2.10	0.33	0.00	2.43
1966	0.39	0.06	0.00	0.45
1967	0.93	0.15	0.00	1.08
1968	0.57	0.09	0.00	0.66
1969	0.46	0.07	0.00	0.54
1970	0.92	0.14	0.00	1.06
1971	1.70	0.27	0.00	1.97
1972	1.01	0.16	0.00	1.17
1973	3.54	0.56	0.00	4.10
1974	8.05	1.27	0.00	9.32
1975	13.85	2.20	0.00	16.05
1976	13.42	2.24	0.00	15.66
1977	6.49	2.63	0.00	9.12
1978	9.53	9.35	0.00	18.88
1979	11.81	5.71	0.00	17.52
1980	18.28	15.19	0.00	33.47
1981	79.98	33.75	0.41	114.14
1982	285.93	59.69	0.02	345.64
1983	168.53	26.45	3.20	198.18
1984	117.15	20.83	0.73	138.70
1985	108.84	15.65	47.34	171.82
1986	114.31	15.03	0.32	129.66
1987	30.03	2.91	0.15	33.09
1988	56.30	6.06	3.97	66.33
1989	94.24	11.38	0.01	105.63
1990	98.02	10.75	0.35	109.12
1991	109.29	10.50	0.39	120.19
1992	122.97	10.68	7.27	140.91
1993	128.02	23.51	0.02	151.56
1994	107.26	15.76	12.77	135.79
1995	88.40	12.01	0.02	100.43
1996	44.69	4.69	3.52	52.91
1997	46.41	4.61	29.51	80.53
1998	47.74	3.97	1.24	52.95
1999	66.90	5.27	8.23	80.40
2000	91.72	7.29	14.30	113.31
2001	53.42	5.06	35.16	93.63
2002	51.61	7.67	17.73	77.01
2003	32.33	2.57	45.31	80.20
2004	35.70	4.03	7.76	47.48
2005	44.66	5.94	28.46	79.05
2006	63.75	4.44	50.97	119.16
2007	39.72	7.53	9.77	57.02
2008	41.68	4.65	0.02	46.35
2009	38.88	3.50	54.29	96.67
2010	41.50	3.67	27.71	72.89

Table 3.11. Estimated time series of landings in whole weight (1000 lb) for commercial longline (L.cl), commercial handline (L.ch), and recreational (L.rec)

Year	L.cl	L.ch	L.rec	Total
1962	2.93	0.47	0.00	3.40
1963	2.78	0.44	0.00	3.22
1964	0.86	0.14	0.00	1.00
1965	20.10	3.21	0.00	23.30
1966	3.77	0.60	0.00	4.38
1967	8.93	1.43	0.00	10.36
1968	5.47	0.87	0.00	6.34
1969	4.47	0.71	0.00	5.18
1970	8.85	1.41	0.00	10.27
1971	16.40	2.62	0.00	19.02
1972	9.78	1.56	0.00	11.34
1973	34.27	5.47	0.00	39.74
1974	77.87	12.43	0.00	90.30
1975	134.05	21.57	0.00	155.63
1976	129.88	21.93	0.00	151.81
1977	62.78	25.74	0.00	88.52
1978	92.19	91.60	0.00	183.80
1979	114.32	55.88	0.00	170.19
1980	178.01	148.76	0.00	326.77
1981	788.17	335.22	4.33	1127.72
1982	2834.39	599.45	0.19	3434.03
1983	1648.34	263.73	33.78	1945.85
1984	1113.61	202.87	7.49	1323.97
1985	991.77	147.04	471.04	1609.85
1986	984.82	133.87	3.01	1121.70
1987	247.22	24.75	1.33	273.30
1988	452.36	50.22	34.79	537.37
1989	742.99	92.60	0.12	835.71
1990	756.68	86.05	2.96	845.69
1991	820.85	82.33	3.24	906.42
1992	884.78	81.51	58.79	1025.07
1993	863.08	171.01	0.15	1034.24
1994	699.09	105.36	90.41	894.87
1995	595.22	82.79	0.15	678.16
1996	312.06	34.04	27.04	373.14
1997	327.04	34.12	231.09	592.25
1998	333.81	28.89	9.54	372.24
1999	472.97	38.10	63.02	574.09
2000	664.17	54.19	112.53	830.88
2001	389.26	38.55	283.89	711.69
2002	367.19	57.56	140.90	565.64
2003	221.87	18.76	350.54	591.17
2004	231.53	29.12	59.41	320.06
2005	265.16	41.41	210.24	516.81
2006	378.49	26.59	323.51	728.58
2007	259.98	49.73	68.30	378.01
2008	299.81	33.89	0.15	333.85
2009	299.93	27.42	450.47	777.81
2010	335.20	30.20	241.15	606.55

Table 3.12. Estimated status indicators, benchmarks, and related quantities from the Beaufort catch-age model, conditional on estimated current selectivities averaged across fisheries. 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) and minimum stock size threshold (MSST) are measured by total gonad weight of mature females. Symbols, abbreviations, and acronyms are listed in Appendix A.*

Quantity	Units	Estimate
F_{MSY}	y^{-1}	0.185
$85\%F_{\mathrm{MSY}}$	y^{-1}	0.157
$75\%F_{\mathrm{MSY}}$	y^{-1}	0.139
$65\%F_{\mathrm{MSY}}$	y^{-1}	0.120
$F_{30\%}$	y^{-1}	0.140
$F_{40\%}$	y^{-1}	0.094
$F_{50\%}$	y^{-1}	0.065
B_{MSY}	mt	2918
$\mathrm{SSB}_{\mathrm{MSY}}$	mt	25.3
MSST	mt	22.6
MSY	1000 lb	638
D_{MSY}	1000 fish	67
R_{MSY}	1000 age-1 fish	381
Y at $85\%F_{\mathrm{MSY}}$	1000 lb	634
Y at $75\%F_{\mathrm{MSY}}$	1000 lb	625
Y at $65\%F_{\mathrm{MSY}}$	1000 lb	610
$F_{2008-2010}/F_{\mathrm{MSY}}$	—	0.360
$F_{2010}/F_{\mathrm{MSY}}$	—	0.404
$\mathrm{SSB}_{2010}/\mathrm{MSST}$	—	2.43

Table 3.13. Results from sensitivity runs of the Beaufort catch-age model. Current F represented by geometric mean of last three assessment years. See text for full description of sensitivity runs.

Run	Description	F_{MSY}	$\mathrm{SSB}_{\mathrm{MSY}}$ (mt)	MSY(1000 lb)	$F_{2008-2010}/F_{\mathrm{MSY}}$	SSB_{2010}/MSST	steep	R0(1000)	R sigma
Base	Base Run	0.19	25.30	638	0.36	2.43	0.84	409	0.40
Run1	M low bound	0.07	37.84	317	0.93	1.73	0.84	57	0.76
Run2	M upper bound	0.54	13.04	943	0.11	4.71	0.84	1899	0.38
Run3	Steep $\bar{0}$.94	0.36	16.31	669	0.34	2.29	0.94	380	0.28
Run4	Steep $\bar{0}$.74	0.13	33.34	622	0.41	2.14	0.74	435	0.48
Run5	Unwgt Likelihoods	0.18	23.37	588	0.70	1.42	0.84	384	0.36
Run6	2% Catchability	0.18	25.06	630	0.40	2.20	0.84	408	0.38
Run7	No MARMAP Index	0.18	24.96	637	0.55	1.59	0.84	409	0.40
Run8	No Longline Index	0.17	25.50	615	0.71	1.37	0.84	431	0.20
Run9	Selectivity split – 2003	0.22	23.70	619	0.58	1.46	0.84	403	0.29
Run10	Selectivity split – 2004	0.27	23.79	631	0.54	1.48	0.84	409	0.26
Run11	Selectivity split – 2005	0.17	24.63	605	0.54	1.73	0.84	404	0.35
Run12	Selectivity split – 2006	0.12	25.77	537	0.88	1.31	0.84	407	0.25
Run13	Selectivity split – 2007	0.12	26.95	569	0.53	2.07	0.84	411	0.38
Run14	Time–varying L50 (1995–2010)	0.18	23.92	586	0.83	1.24	0.84	405	0.20
Run15	Random walk in Com.Longline catchability	0.17	25.58	617	0.70	1.39	0.84	432	0.20
Run16	Drop 2004–06 Com.Longline age comps	0.18	25.66	655	0.37	2.27	0.84	416	0.42
Run17	Retrospective 2009	0.19	25.30	638	0.40	2.43	0.84	410	0.40
Run18	Retrospective 2008	0.18	25.14	631	0.53	2.36	0.84	403	0.43
Run19	Retrospective 2007	0.18	25.14	631	0.23	2.20	0.84	401	0.44
Run20	Retrospective 2006	0.20	24.21	635	0.33	1.75	0.84	399	0.38
Run21	Retrospective 2005	0.21	23.07	599	1.22	1.08	0.84	395	0.24
Run22	Retrospective 2004	0.17	24.85	615	0.82	1.18	0.84	421	0.20
Run23	Retrospective 2003	0.16	25.09	608	0.54	1.10	0.84	423	0.20
Run24	Retrospective 2002	0.16	25.17	615	1.04	1.09	0.84	424	0.20

Table 3.14. Projection results under scenario 1—fishing mortality rate fixed at $F = F_{\mathrm{MSY}}$. F = fishing mortality rate (per year), Pr($\mathrm{SSB} > \mathrm{SSB_{MSY}}$*) = proportion of stochastic projection replicates exceeding* $\mathrm{SSB_{MSY}}$*, SSB = spawning stock (gonad weight, mt) at time of peak spawning, R = recruits (1000 age-1 fish), L = landings (1000 fish or 1000* lb *whole weight), and Sum L = cumulative landings (1000* lb*). For reference, estimated benchmarks are* $F_{\mathrm{MSY}} = 0.185$ *(per yr),* $\mathrm{SSB_{MSY}} = 25.3$ *(mt), and* $\mathrm{MSY} = 638$ *(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)	L(1000)	L(klb)	Sum L(klb)
2011	0.067	0.92	54.82	423	63	528	528
2012	0.185	0.98	55.47	423	163	1386	1915
2013	0.185	0.97	50.86	419	146	1242	3156
2014	0.185	0.97	46.72	416	133	1124	4281
2015	0.185	0.96	43.13	412	123	1031	5311
2016	0.185	0.96	40.09	408	116	957	6268
2017	0.185	0.94	37.55	405	111	900	7168
2018	0.185	0.92	35.46	402	107	854	8022
2019	0.185	0.9	33.74	399	104	818	8840
2020	0.185	0.88	32.34	396	101	789	9629
2021	0.185	0.85	31.19	394	99	765	10,394
2022	0.185	0.83	30.24	392	97	746	11,140
2023	0.185	0.8	29.47	391	95	730	11,870
2024	0.185	0.78	28.83	389	94	716	12,586
2025	0.185	0.76	28.29	388	93	705	13,291
2026	0.185	0.75	27.84	387	92	695	13,986
2027	0.185	0.73	27.46	386	91	687	14,673
2028	0.185	0.72	27.14	385	90	680	15,353
2029	0.185	0.71	26.88	385	90	674	16,027
2030	0.185	0.69	26.65	384	89	669	16,697

*Table 3.15. Projection results under scenario 2—fishing mortality rate fixed at $F = F_{\text{current}}$. F = fishing mortality rate (per year), Pr(*SSB > SSB_{MSY}*) = proportion of stochastic projection replicates exceeding* SSB_{MSY}, *SSB = spawning stock (gonad weight, mt)at time of peak spawning, R = recruits (1000 age-1 fish), L = landings (1000 fish or 1000* lb *whole weight), and Sum L = cumulative landings (1000* lb*). For reference, estimated benchmarks are* $F_{\text{MSY}} = 0.185$ *(per yr),* $\text{SSB}_{\text{MSY}} = 25.3$ *(mt), and* MSY = 638 *(1000 lb). Expected values presented are from deterministic projections (klb = 1000 lb).*

Year	F(per yr)	Pr(SSB > SSB_{MSY})	SSB(mt)	R(1000)	L(1000)	L(klb)	Sum L(klb)
2011	0.067	0.92	54.82	423	63	528	528
2012	0.067	0.98	58.07	425	62	527	1055
2013	0.067	0.99	59.02	425	61	524	1579
2014	0.067	1	59.6	426	60	522	2101
2015	0.067	1	59.93	426	60	520	2620
2016	0.067	1	60.09	426	59	517	3138
2017	0.067	1	60.13	426	59	515	3653
2018	0.067	1	60.1	426	59	514	4167
2019	0.067	1	60.02	426	59	512	4679
2020	0.067	1	59.92	426	59	511	5189
2021	0.067	1	59.82	426	59	510	5699
2022	0.067	1	59.71	426	58	509	6208
2023	0.067	1	59.61	426	58	508	6715
2024	0.067	1	59.51	426	58	507	7222
2025	0.067	1	59.41	426	58	506	7728
2026	0.067	1	59.29	426	58	506	8234
2027	0.067	1	59.19	425	58	505	8739
2028	0.067	1	59.1	425	58	505	9243
2029	0.067	1	59.04	425	58	504	9748
2030	0.067	1	58.98	425	58	504	10,251

Table 3.16. Projection results under scenario 3—fishing mortality rate fixed at $F = 65\%F_{\text{MSY}}$. F = fishing mortality rate (per year), Pr($\text{SSB} > \text{SSB}_{\text{MSY}}$*) = proportion of stochastic projection replicates exceeding* SSB_{MSY}*, SSB = spawning stock (gonad weight, mt) at time of peak spawning, R = recruits (1000 age-1 fish), L = landings (1000 fish or 1000* lb *whole weight), and Sum L = cumulative landings (1000* lb*). For reference, estimated benchmarks are* $F_{\text{MSY}} = 0.185$ *(per yr),* $\text{SSB}_{\text{MSY}} = 25.3$ *(mt), and* MSY = 638 *(1000 lb). Expected values presented are from deterministic projections (klb = 1000 lb).*

Year	F(per yr)	Pr(SSB > SSB_{MSY})	SSB(mt)	R(1000)	L(1000)	L(klb)	Sum L(klb)
2011	0.067	0.92	54.82	423	63	528	528
2012	0.12	0.98	56.88	424	109	928	1456
2013	0.12	0.98	55.16	423	103	881	2337
2014	0.12	0.99	53.32	421	98	840	3177
2015	0.12	0.99	51.51	420	94	804	3981
2016	0.12	0.99	49.81	419	91	775	4756
2017	0.12	0.99	48.26	417	89	750	5505
2018	0.12	0.99	46.87	416	87	729	6234
2019	0.12	0.99	45.65	415	85	712	6946
2020	0.12	0.99	44.6	414	84	697	7643
2021	0.12	0.98	43.68	413	83	685	8328
2022	0.12	0.98	42.89	412	82	674	9002
2023	0.12	0.98	42.22	411	81	665	9667
2024	0.12	0.98	41.64	410	81	658	10,325
2025	0.12	0.98	41.14	410	80	651	10,976
2026	0.12	0.97	40.7	409	80	646	11,622
2027	0.12	0.97	40.32	409	79	641	12,263
2028	0.12	0.96	40.01	408	79	637	12,900
2029	0.12	0.96	39.74	408	78	633	13,533
2030	0.12	0.96	39.51	408	78	630	14,163

*Table 3.17. Projection results under scenario 4—fishing mortality rate fixed at $F = 75\%F_{\mathrm{MSY}}$. F = fishing mortality rate (per year), Pr(*SSB > $\mathrm{SSB_{MSY}}$*) = proportion of stochastic projection replicates exceeding* $\mathrm{SSB_{MSY}}$*, SSB = spawning stock (gonad weight, mt) at time of peak spawning, R = recruits (1000 age-1 fish), L = landings (1000 fish or 1000* lb *whole weight), and Sum L = cumulative landings (1000* lb*). For reference, estimated benchmarks are* $F_{\mathrm{MSY}} = 0.185$ *(per yr),* $\mathrm{SSB_{MSY}} = 25.3$ *(mt), and* MSY = 638 *(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)	L(1000)	L(klb)	Sum L(klb)
2011	0.067	0.92	54.82	423	63	528	528
2012	0.139	0.98	56.47	424	125	1062	1590
2013	0.139	0.98	53.89	422	116	991	2581
2014	0.139	0.98	51.34	420	109	931	3512
2015	0.139	0.98	48.94	418	104	880	4393
2016	0.139	0.98	46.77	416	100	839	5231
2017	0.139	0.98	44.85	414	96	805	6036
2018	0.139	0.98	43.18	412	94	777	6812
2019	0.139	0.98	41.75	410	92	753	7566
2020	0.139	0.97	40.52	409	90	734	8300
2021	0.139	0.97	39.49	408	89	718	9018
2022	0.139	0.96	38.61	406	88	705	9723
2023	0.139	0.96	37.87	405	86	693	10,416
2024	0.139	0.95	37.24	404	86	684	11,100
2025	0.139	0.94	36.7	404	85	676	11,775
2026	0.139	0.94	36.24	403	84	669	12,444
2027	0.139	0.93	35.84	402	84	663	13,106
2028	0.139	0.92	35.51	402	83	658	13,764
2029	0.139	0.91	35.23	401	83	653	14,417
2030	0.139	0.9	34.99	401	82	649	15,066

Table 3.18. Projection results under scenario 5—fishing mortality rate fixed at $F = 85\%F_{\mathrm{MSY}}$. F = fishing mortality rate (per year), Pr(SSB > $\mathrm{SSB_{MSY}}$) = proportion of stochastic projection replicates exceeding $\mathrm{SSB_{MSY}}$, SSB = spawning stock (gonad weight, mt) at time of peak spawning, R = recruits (1000 age-1 fish), L = landings (1000 fish or 1000 lb whole weight), and Sum L = cumulative landings (1000 lb). For reference, estimated benchmarks are $F_{\mathrm{MSY}} = 0.185$ (per yr), $\mathrm{SSB_{MSY}} = 25.3$ (mt), and MSY = 638 (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)	L(1000)	L(klb)	Sum L(klb)
2011	0.067	0.92	54.82	423	63	528	528
2012	0.157	0.98	56.07	423	140	1194	1722
2013	0.157	0.98	52.66	421	128	1096	2817
2014	0.157	0.98	49.43	418	119	1014	3831
2015	0.157	0.98	46.51	416	112	947	4778
2016	0.157	0.98	43.94	413	107	893	5671
2017	0.157	0.97	41.73	410	103	849	6520
2018	0.157	0.96	39.85	408	100	814	7334
2019	0.157	0.96	38.26	406	97	785	8119
2020	0.157	0.95	36.94	404	95	762	8880
2021	0.157	0.94	35.83	402	93	742	9623
2022	0.157	0.92	34.9	401	92	726	10,349
2023	0.157	0.91	34.13	400	91	713	11,061
2024	0.157	0.9	33.48	399	90	701	11,763
2025	0.157	0.88	32.94	398	89	692	12,454
2026	0.157	0.87	32.47	397	88	684	13,138
2027	0.157	0.86	32.07	396	87	677	13,815
2028	0.157	0.85	31.74	395	87	671	14,485
2029	0.157	0.84	31.46	395	86	666	15,151
2030	0.157	0.83	31.23	394	86	661	15,812

3.7 Figures

Figure 3.1. Mean length at age (mm) and estimated 95% confidence interval of the population.

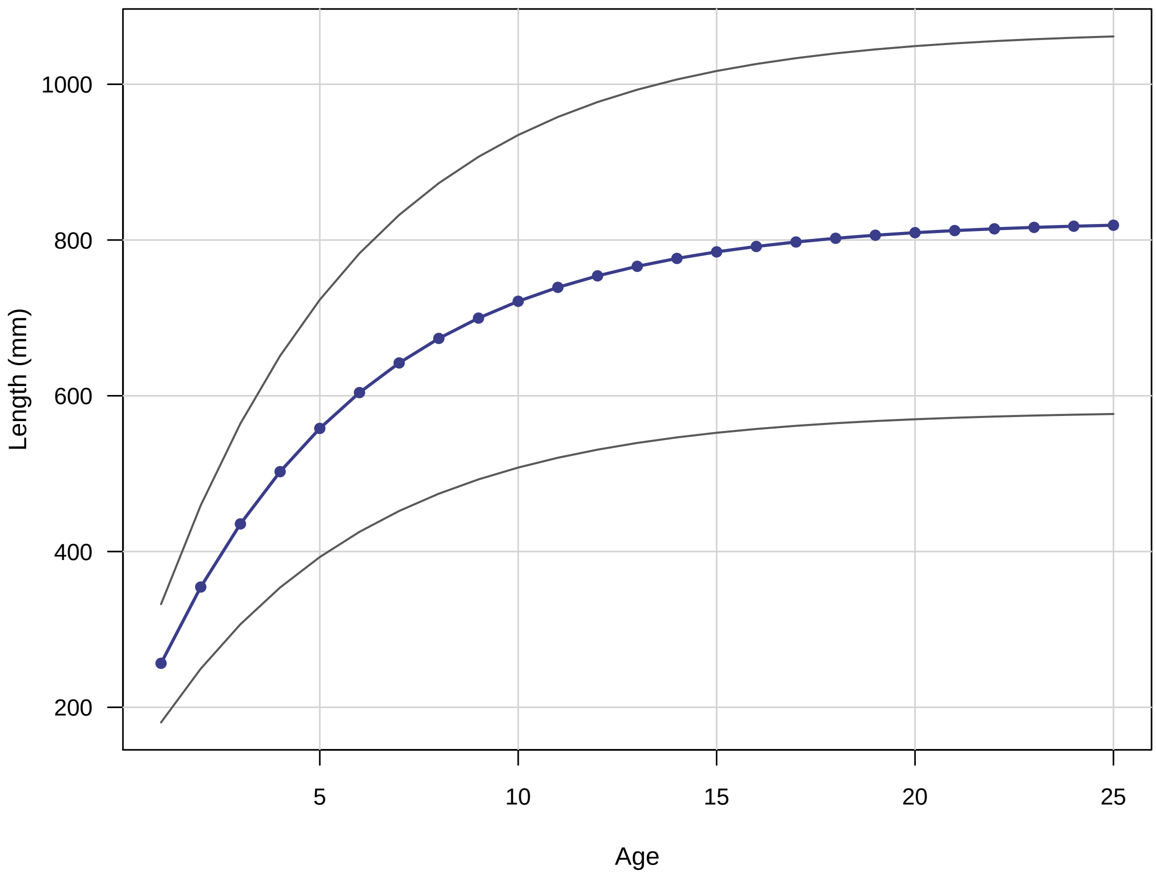


Figure 3.2. Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey. In panels indicating the data set, lcomp refers to length compositions, acomp to age compositions, cl to commercial longline, ch to commercial handline, ra to recreational, and mm to MARMAP. N indicates the number of trips from which individual fish samples were taken.

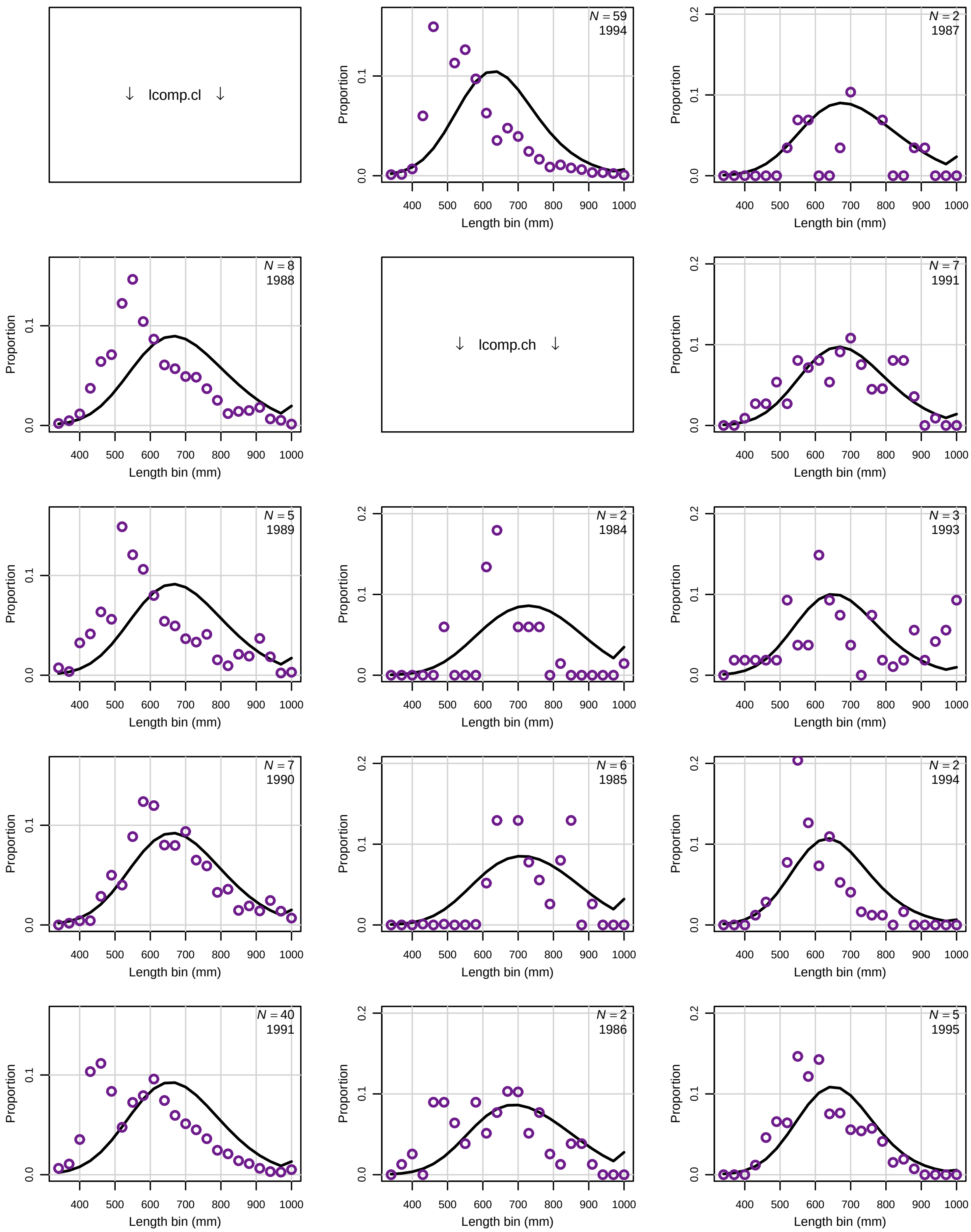


Figure 3.2. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.

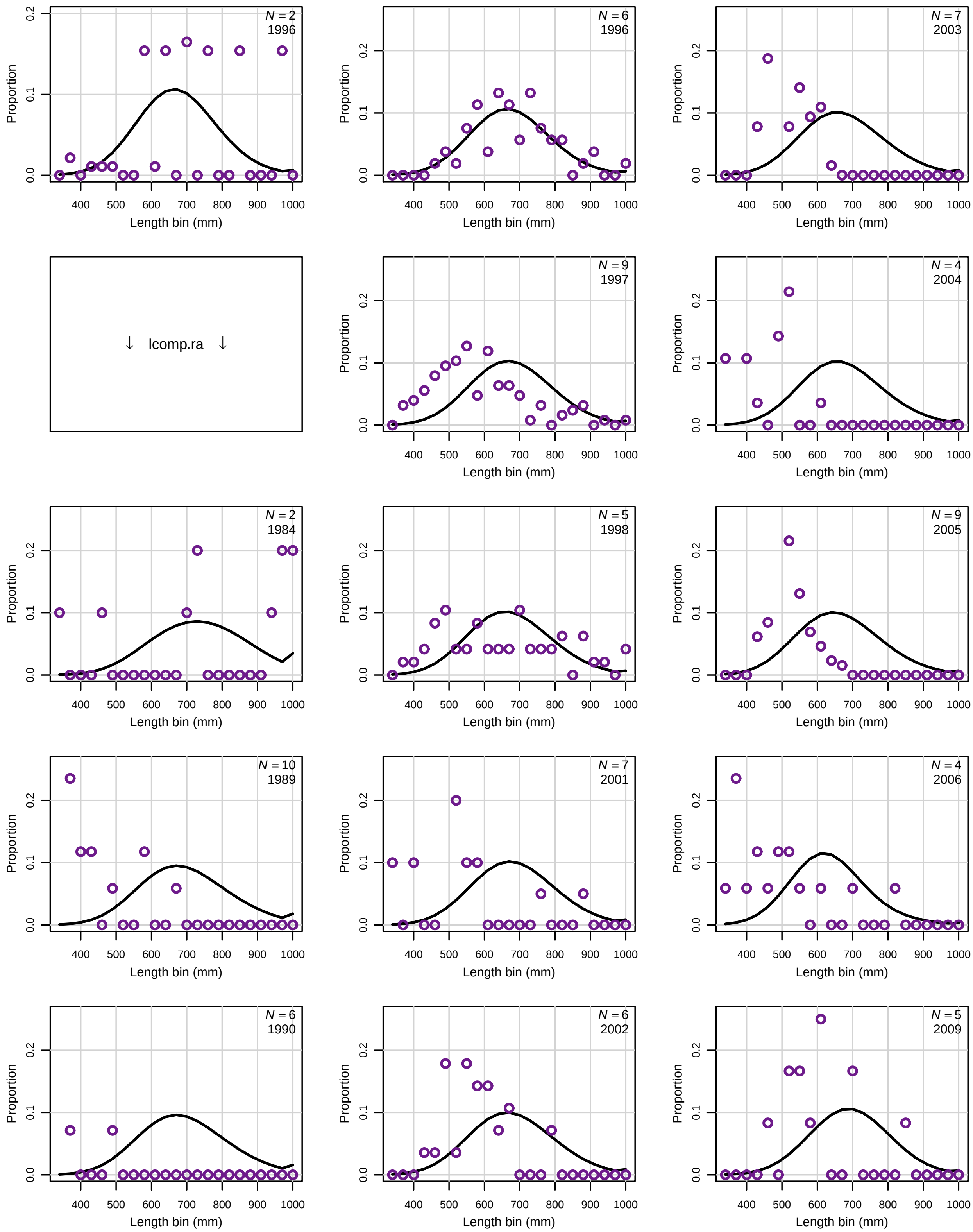


Figure 3.2. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.

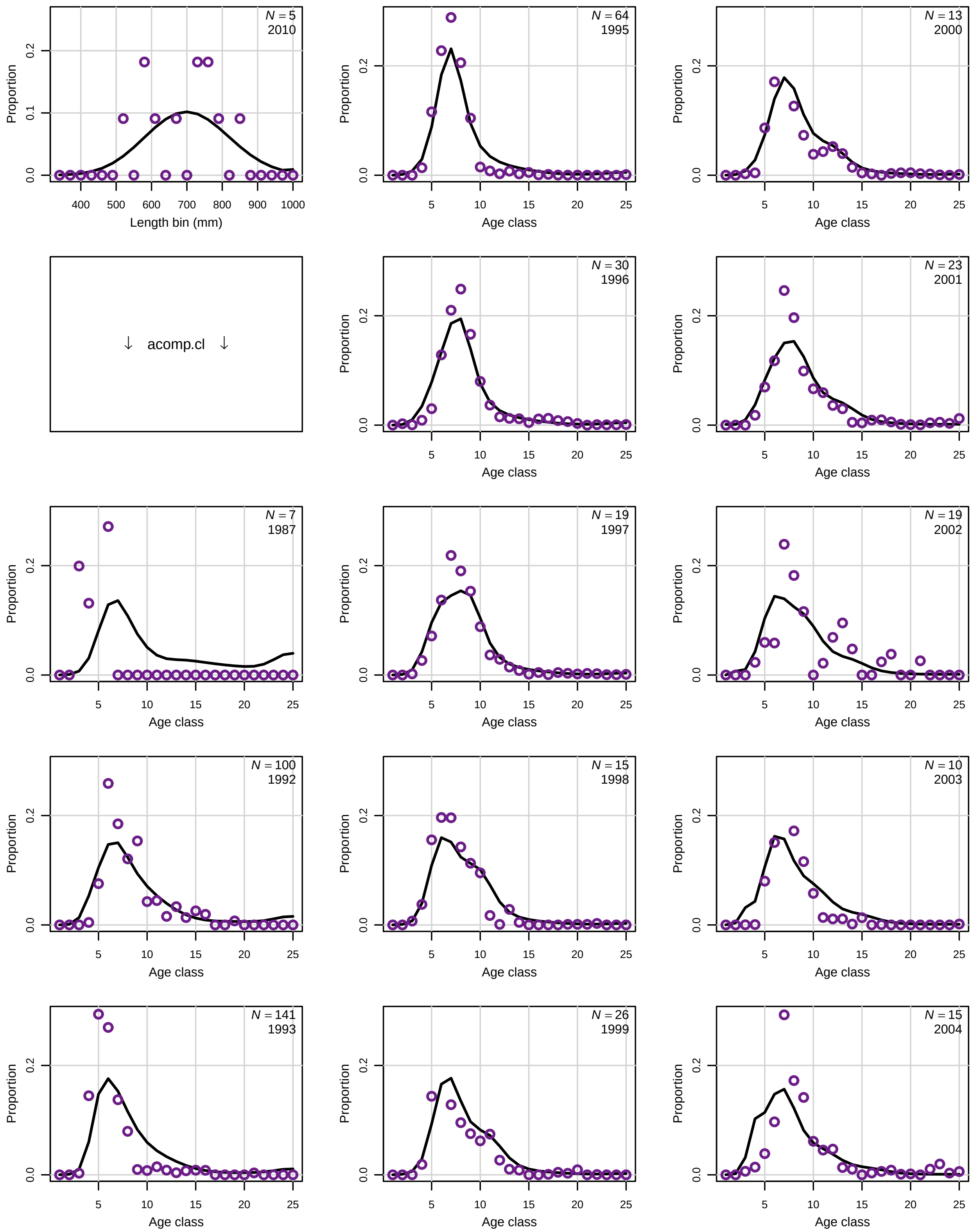


Figure 3.2. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.

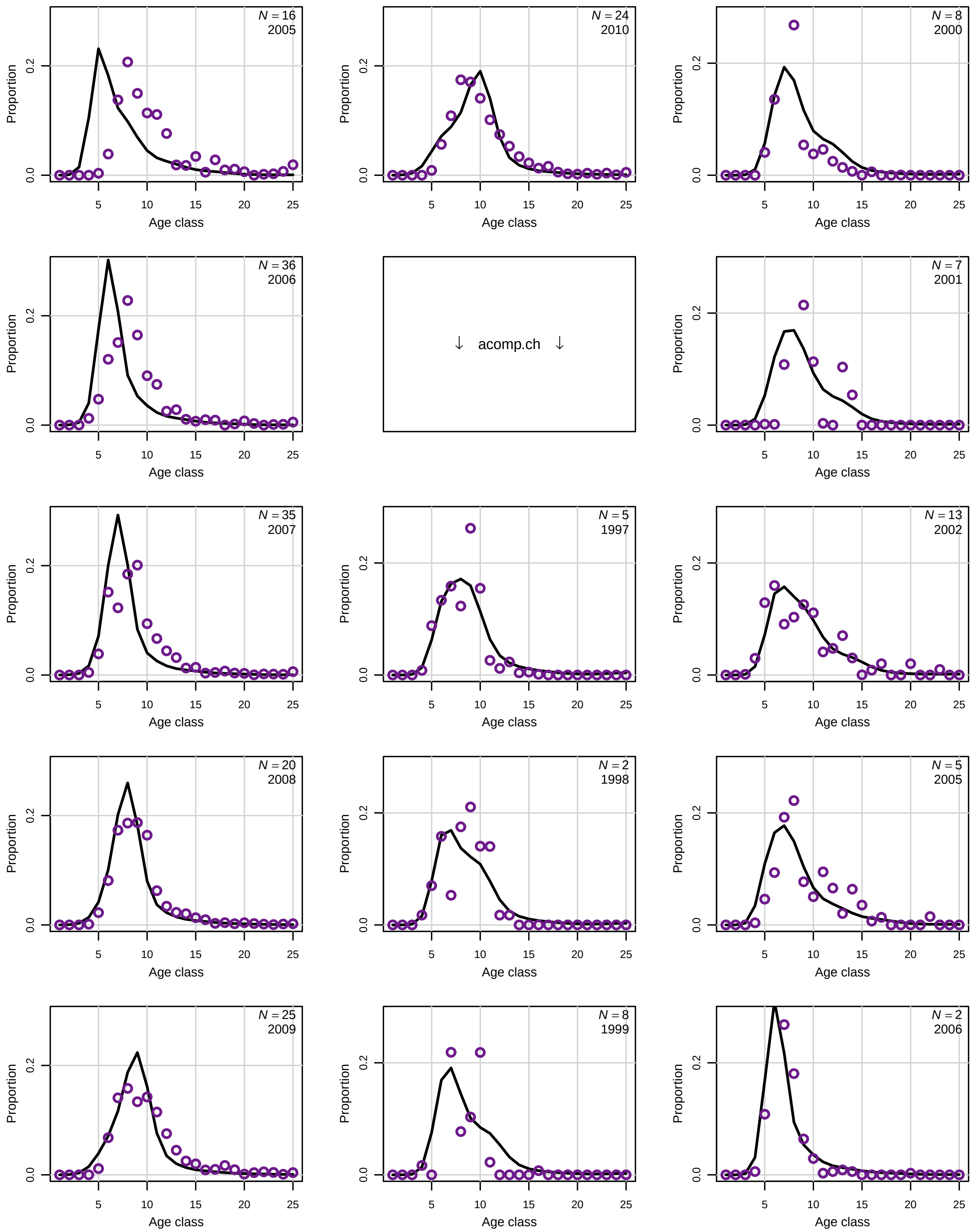


Figure 3.2. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.

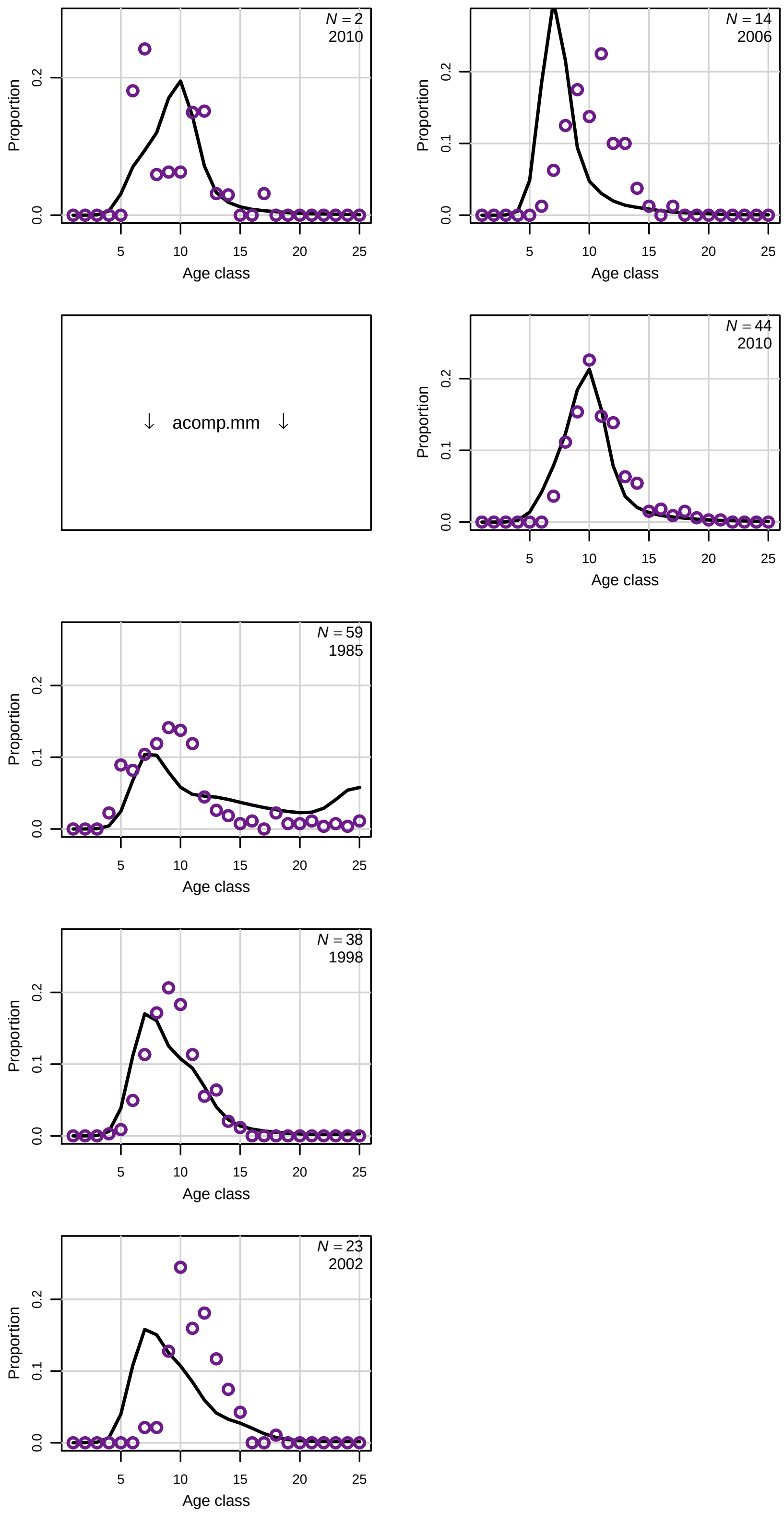


Figure 3.3. Observed (open circles) and estimated (line, solid circles) commercial longline landings (1000 lb whole weight).

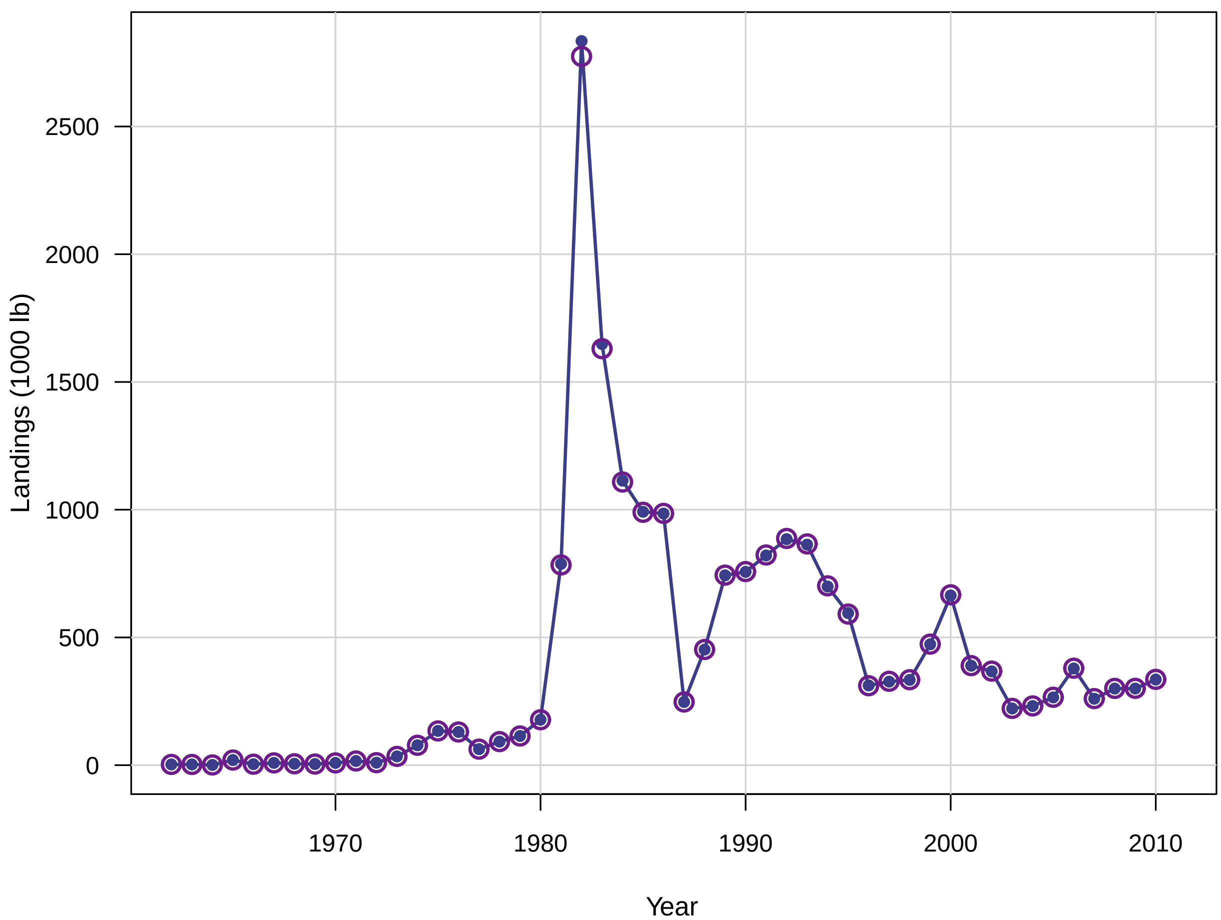


Figure 3.4. Observed (open circles) and estimated (line, solid circles) commercial handline landings (1000 lb whole weight).

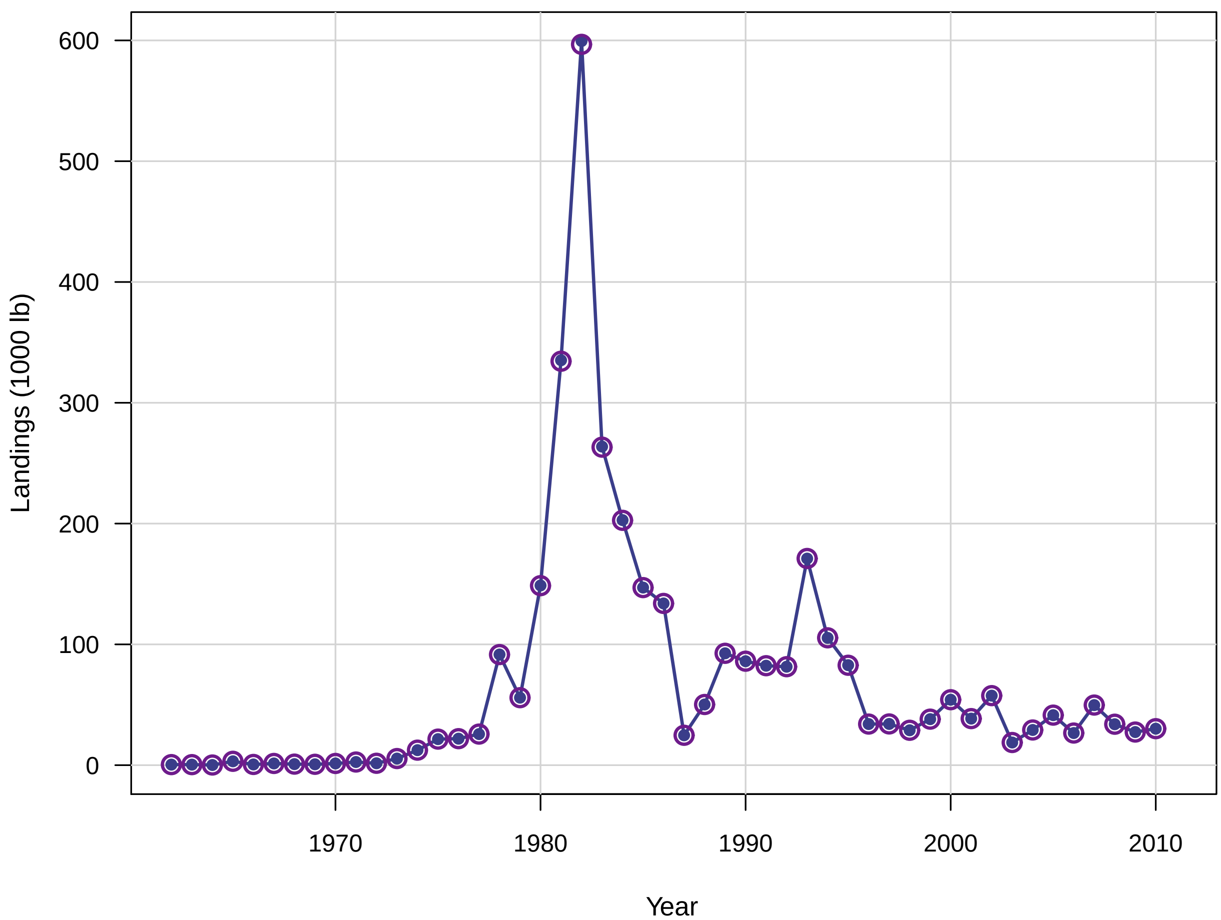


Figure 3.5. Observed (open circles) and estimated (line, solid circles) recreational landings (1000 fish).

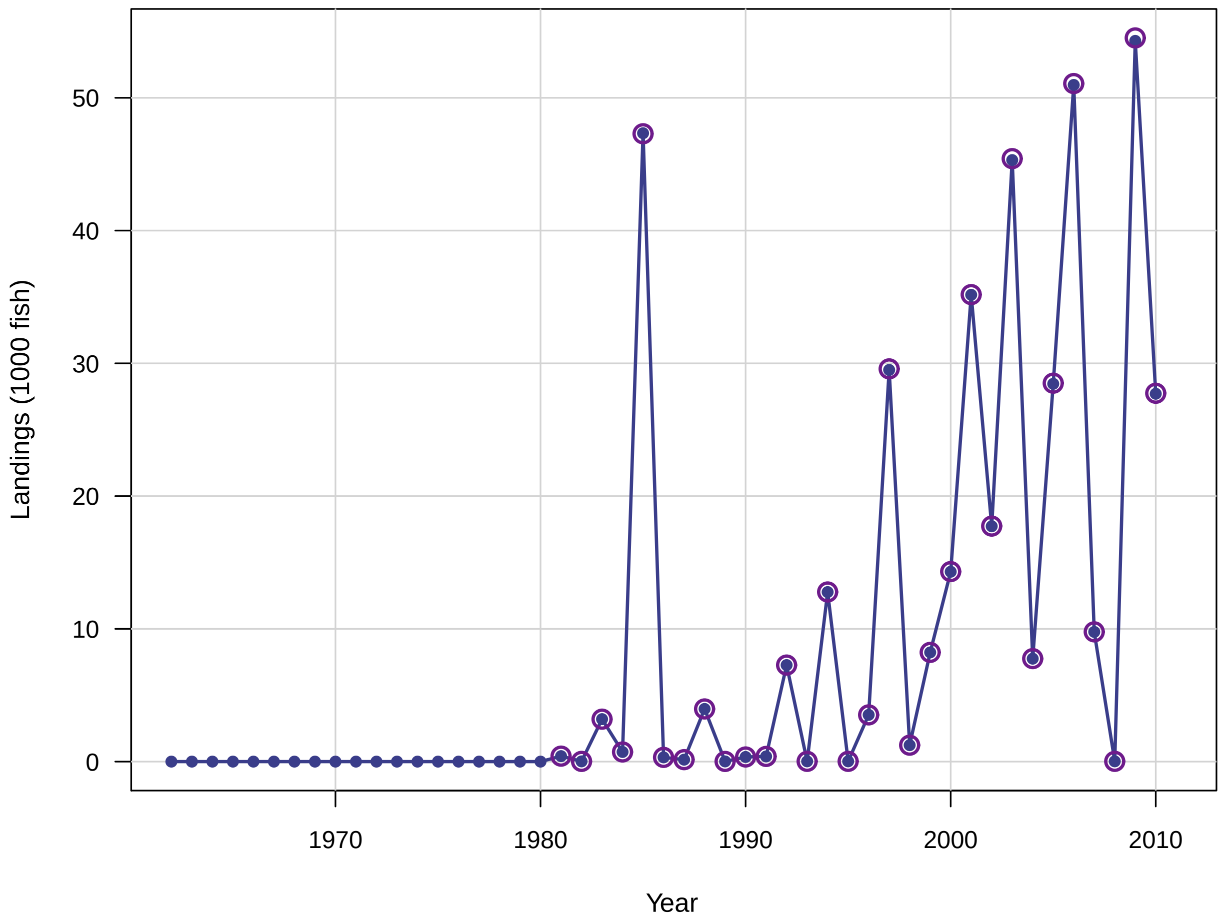


Figure 3.6. Observed (open circles) and estimated (line, solid circles) index of abundance from commercial longline.

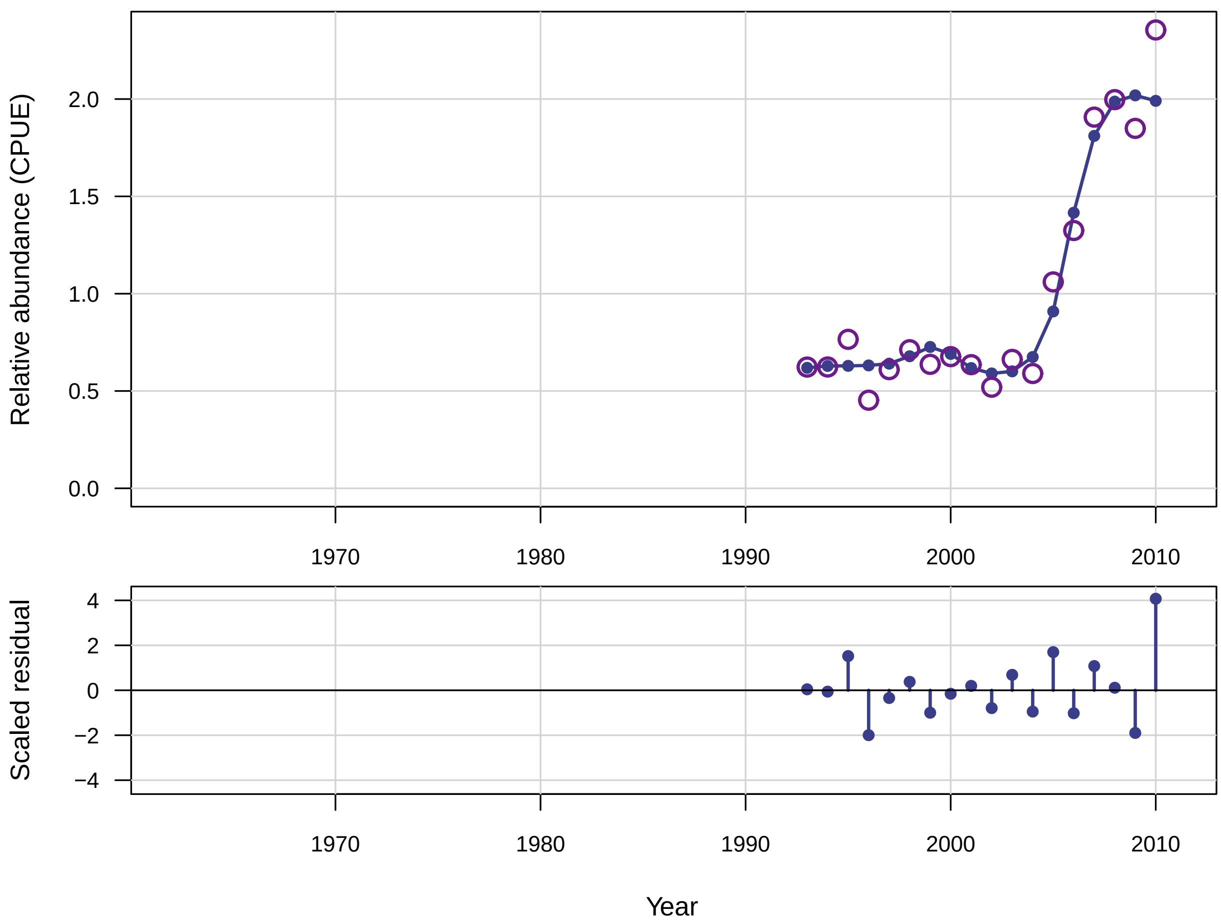


Figure 3.7. Observed (open circles) and estimated (line, solid circles) index of abundance MARMAP horizontal longline.

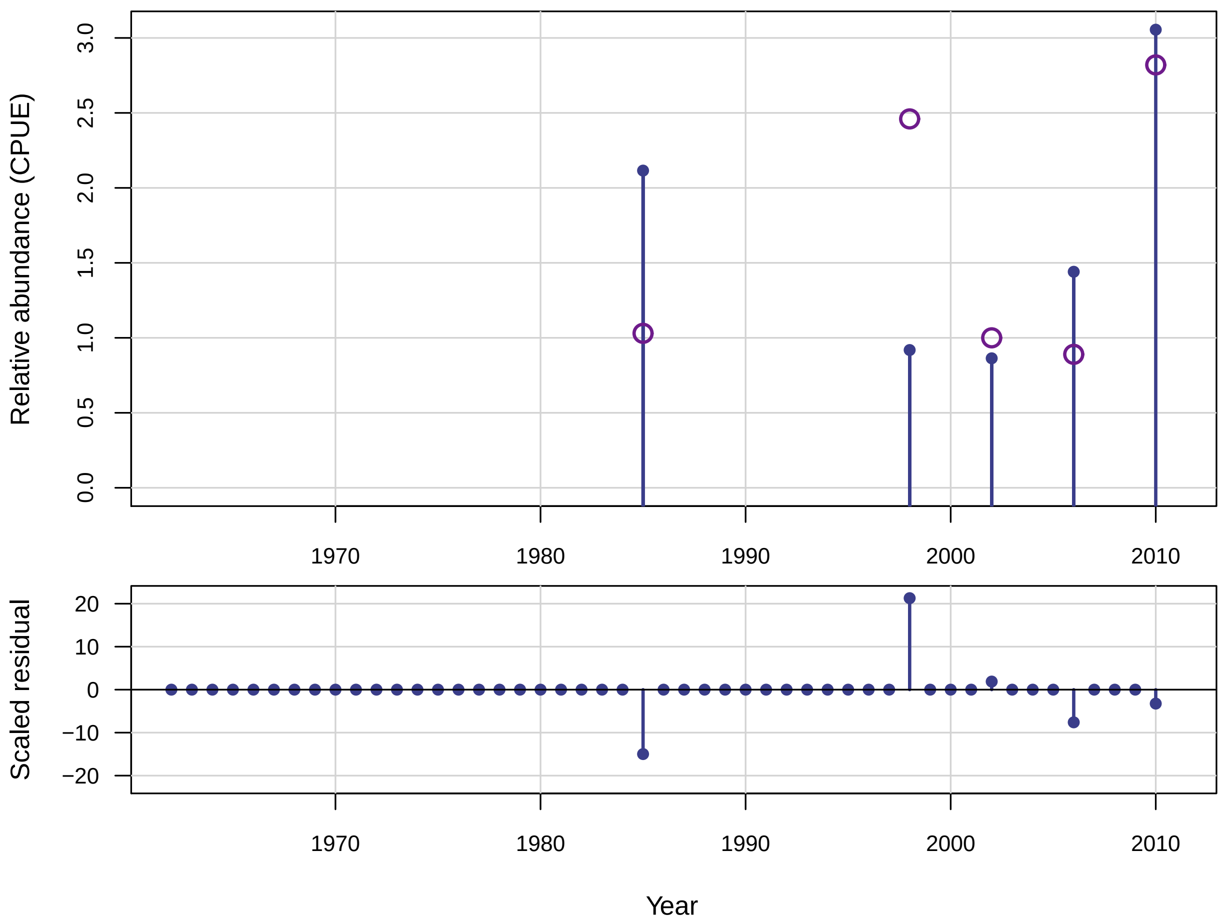


Figure 3.8. Estimated abundance at age at start of year.

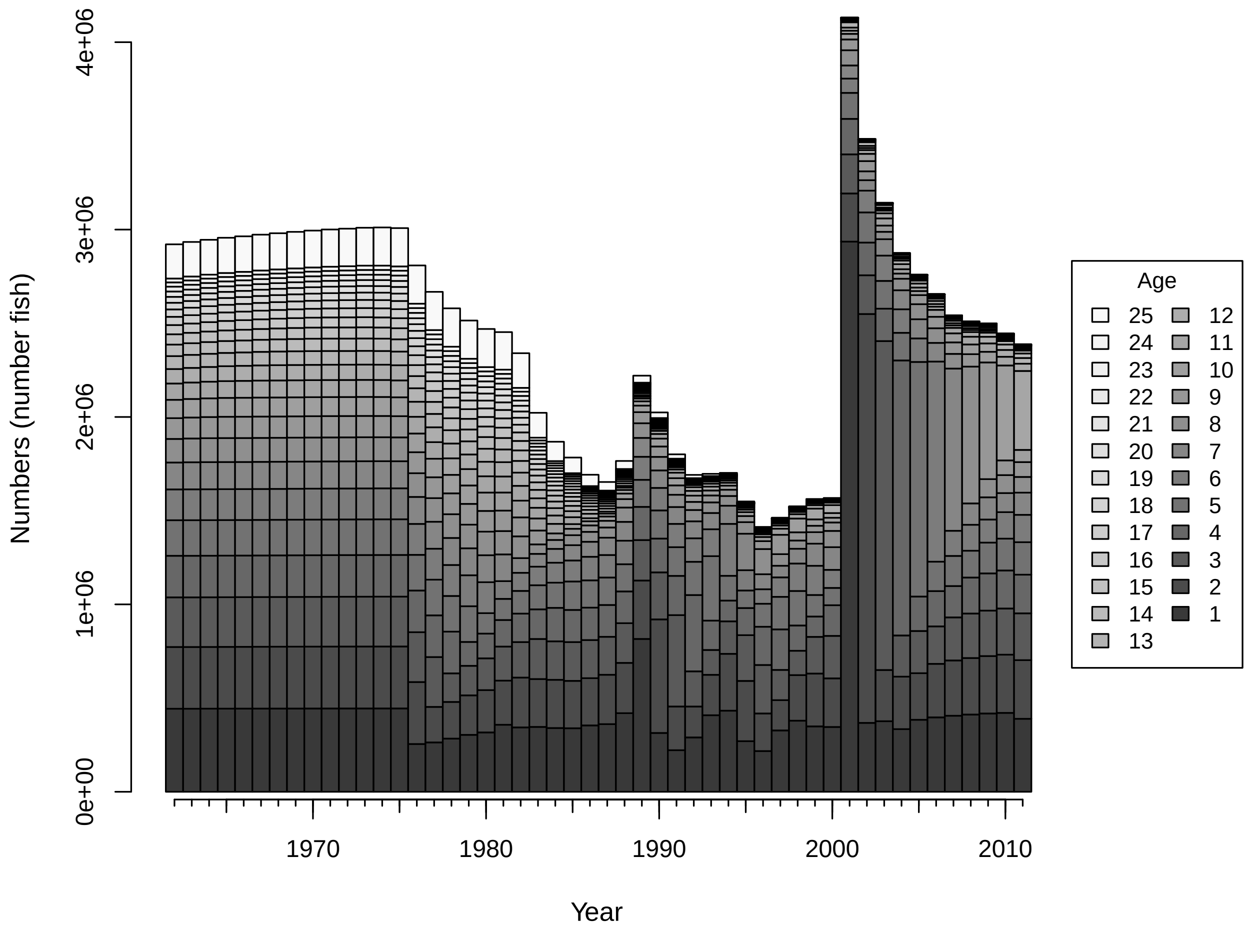


Figure 3.9. Top panel: Estimated recruitment of age-1 fish. Horizontal dashed line indicates R_{MSY}. Bottom panel: log recruitment residuals.

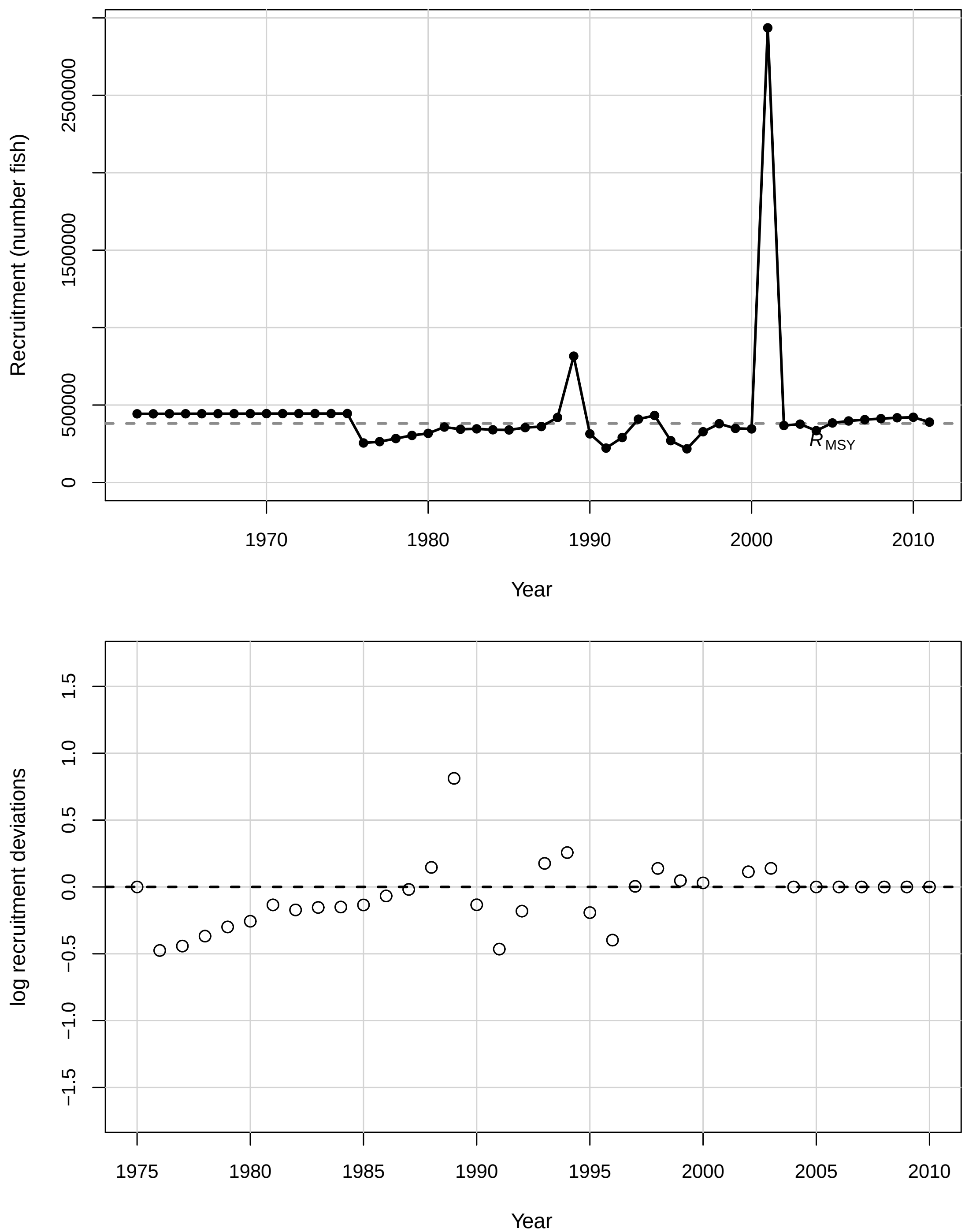


Figure 3.10. Estimated biomass at age at start of year.

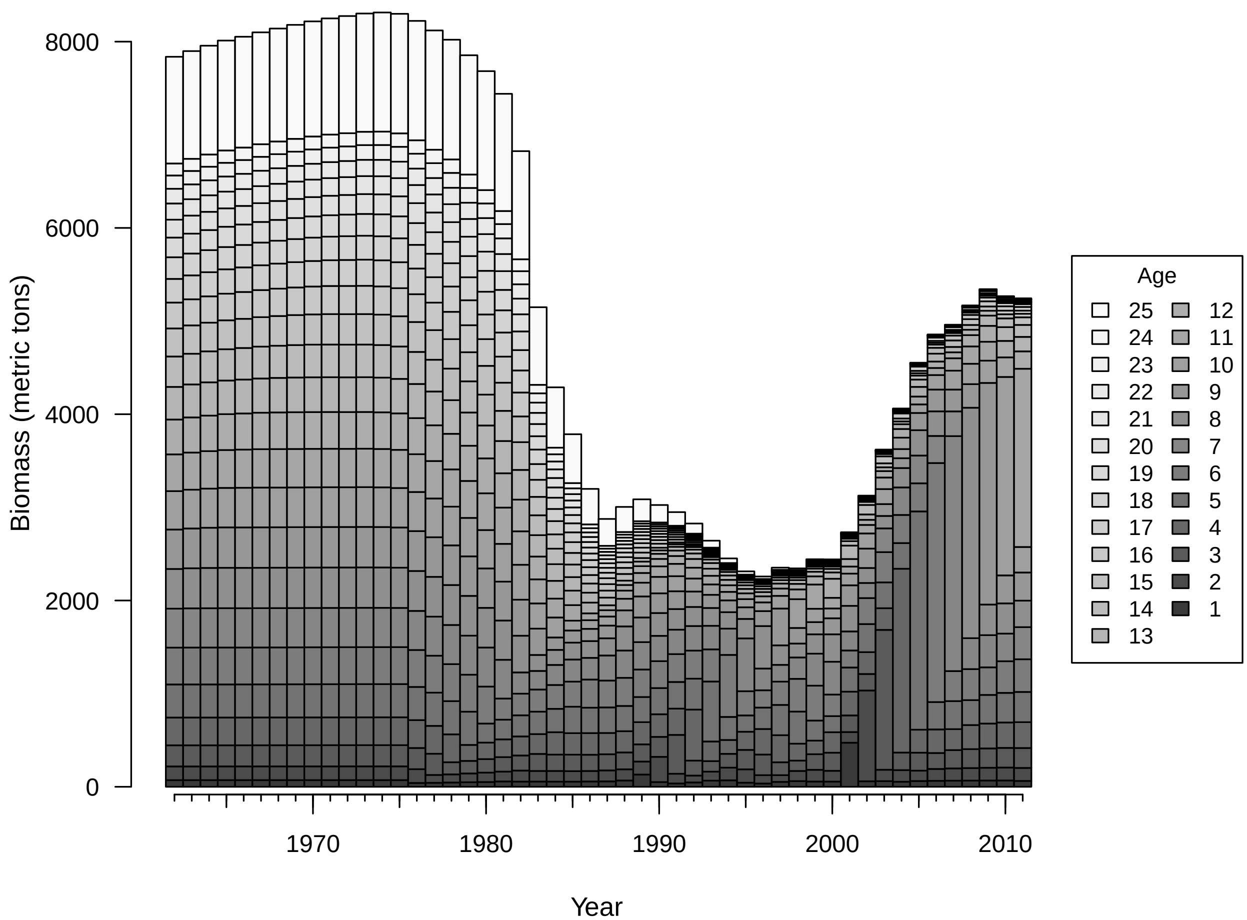


Figure 3.11. Top panel: Estimated total biomass (metric tons) at start of year. Horizontal dashed line indicates B_{MSY}*. Bottom panel: Estimated spawning stock (gonad biomass of mature females) at time of peak spawning.*

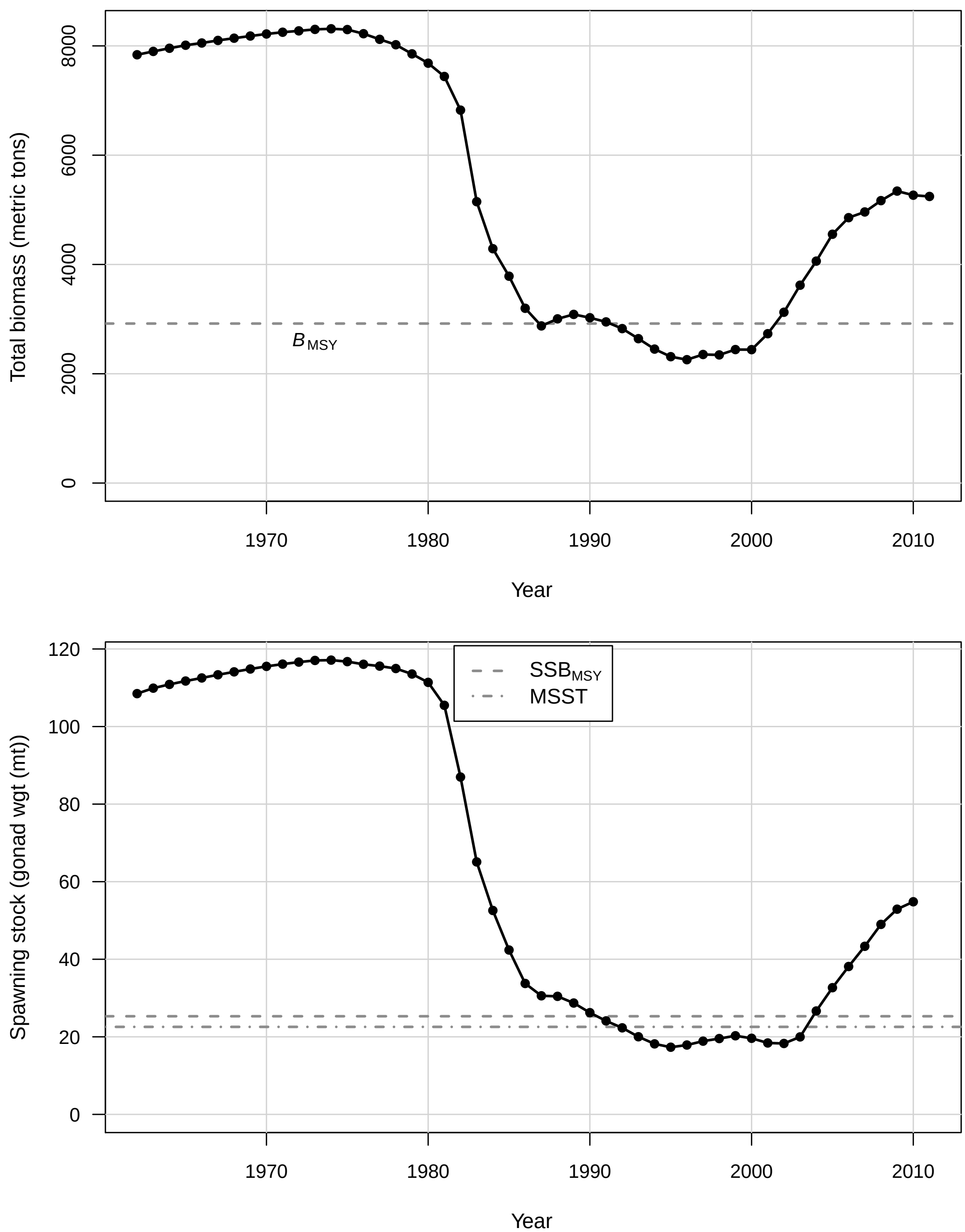


Figure 3.12. Selectivities of fleets 1962–2010. Top panel: commercial longline. Second panel: commercial handline, Third panel: recreational, Bottom panel: MARMAP longline.

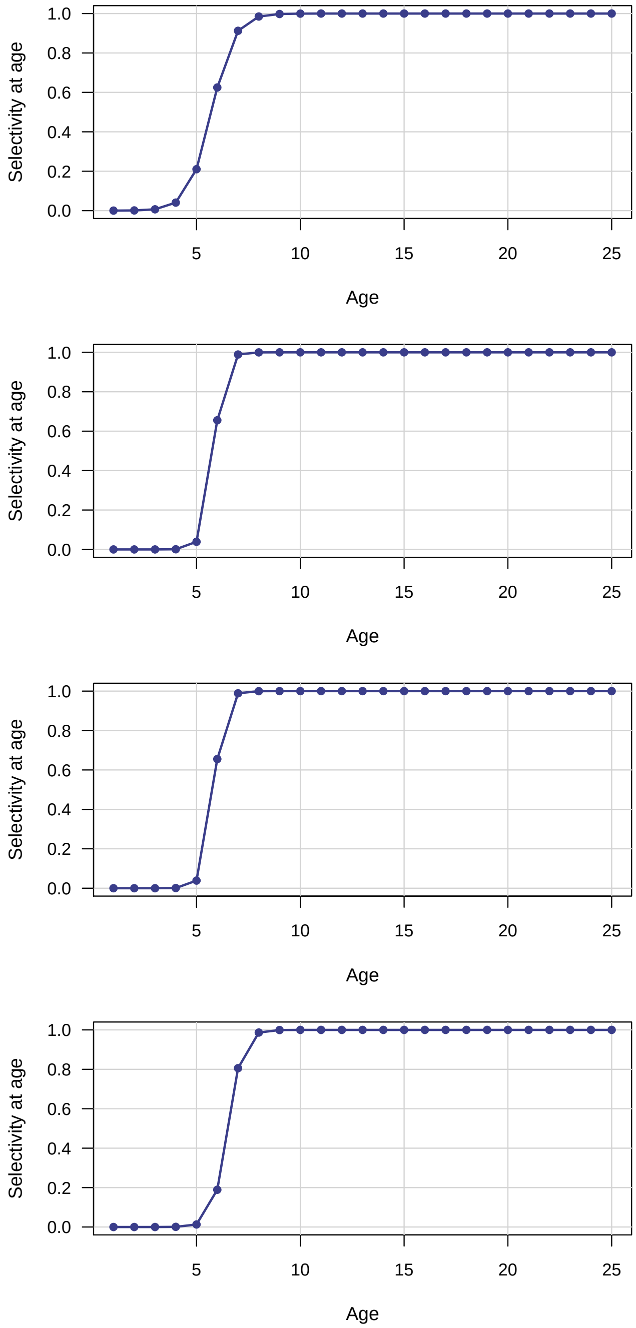


Figure 3.13. Average selectivity from the terminal assessment year weighted by geometric mean Fs from the last three assessment years, and used in computation of benchmarks and central-tendency projections.

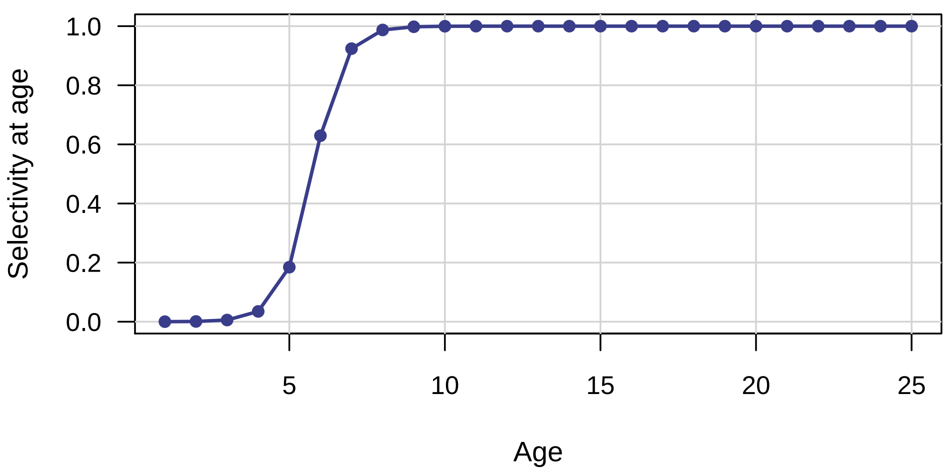


Figure 3.14. Estimated fully selected fishing mortality rate (per year) by fishery. cl refers to commercial longline, ch to commercial handline, and ra for recreational.

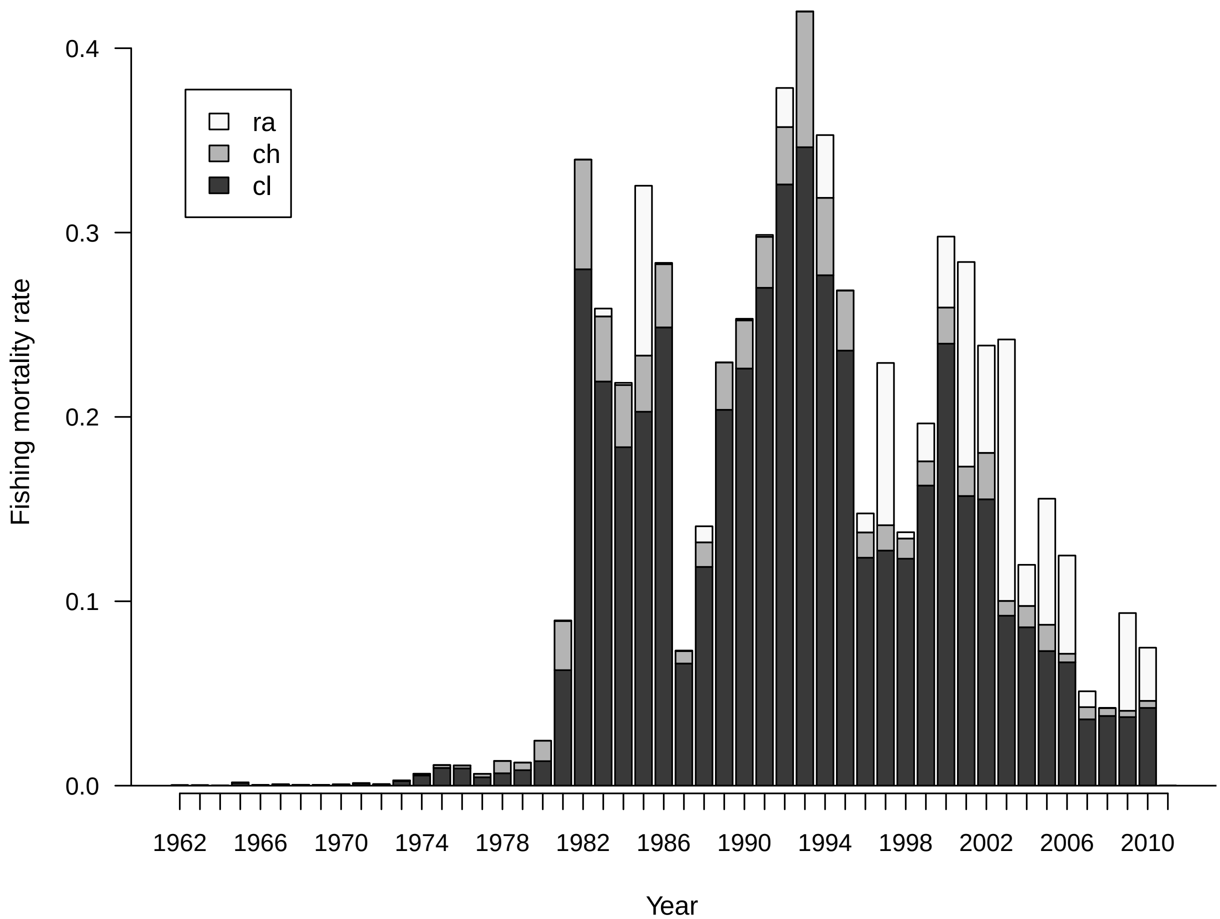


Figure 3.15. Estimated landings in numbers by fishery from the catch-age model. cl refers to commercial longline, ch to commercial handline, and ra for recreational.

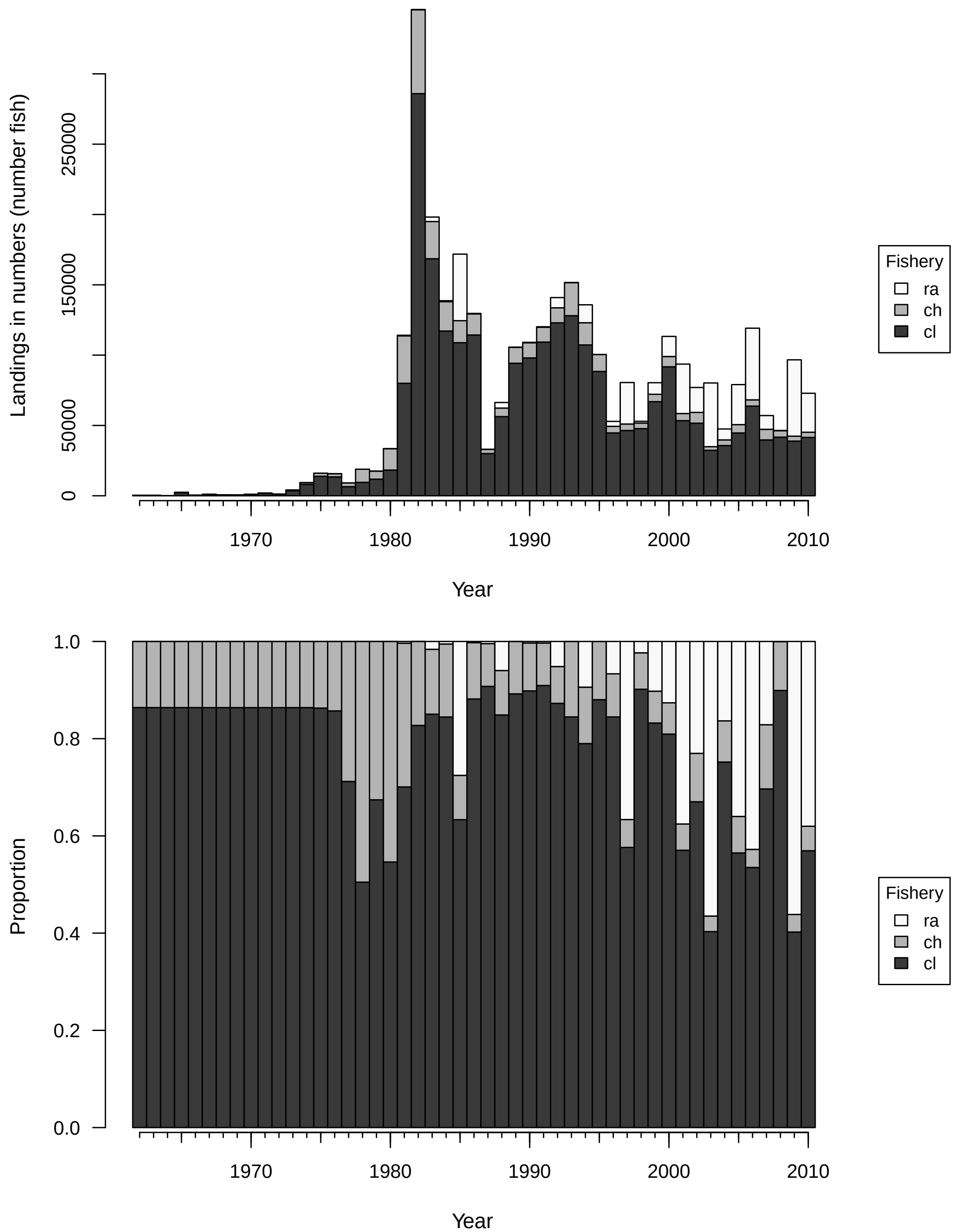


Figure 3.16. Estimated landings in whole weight by fishery from the catch-age model. cl refers to commercial longline, ch to commercial handline, and ra for recreational. Horizontal dashed line in the top panel corresponds to the point estimate of MSY.

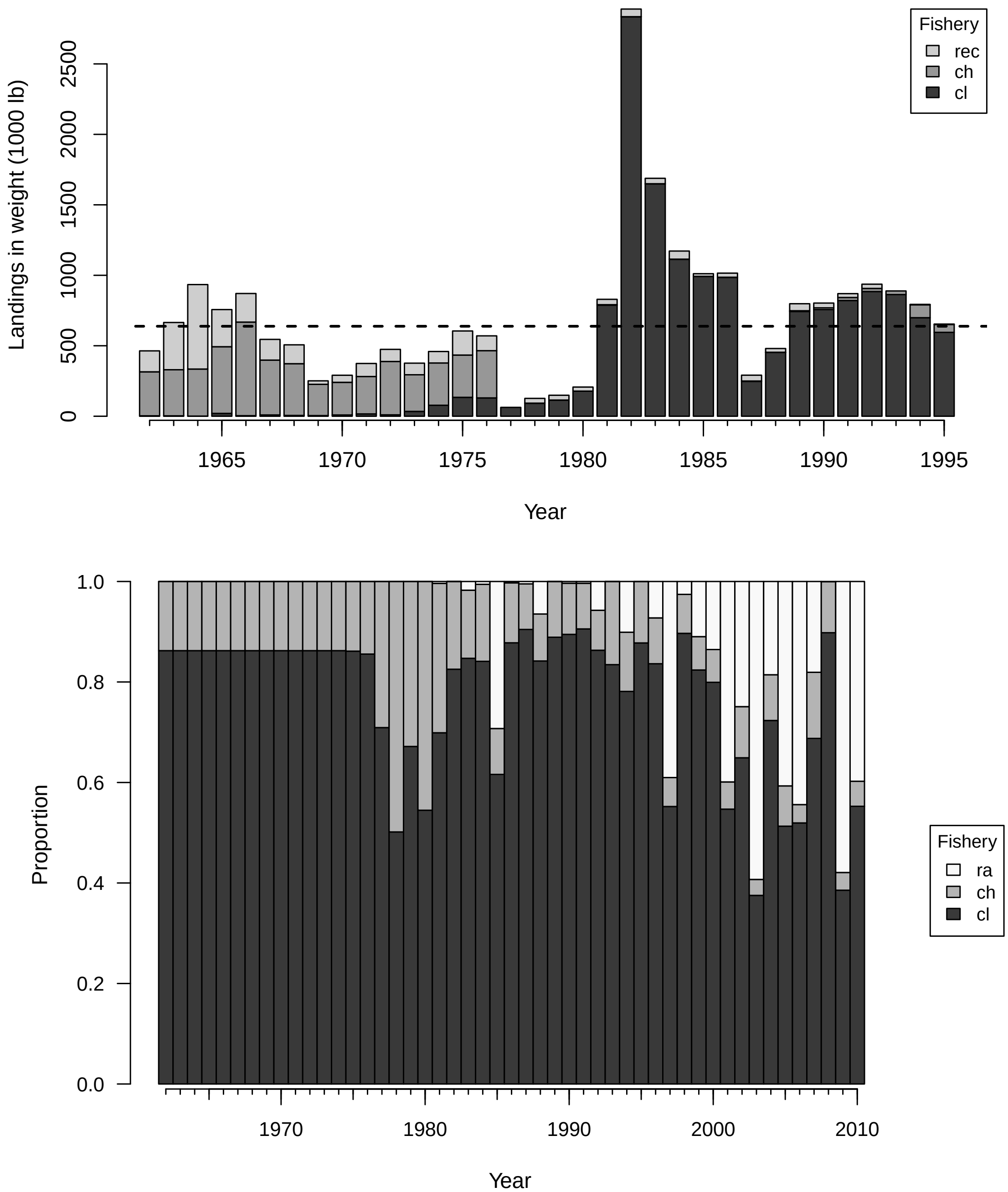


Figure 3.17. Top panel: Beverton–Holt spawner-recruit curves, with and without lognormal bias correction. The expected (upper) curve was used for computing management benchmarks. Years within panel indicate year of recruitment generated from spawning biomass one year prior. Bottom panel: log of recruits (number age-1 fish) per spawner (mature female gonad weight) as a function of spawners.

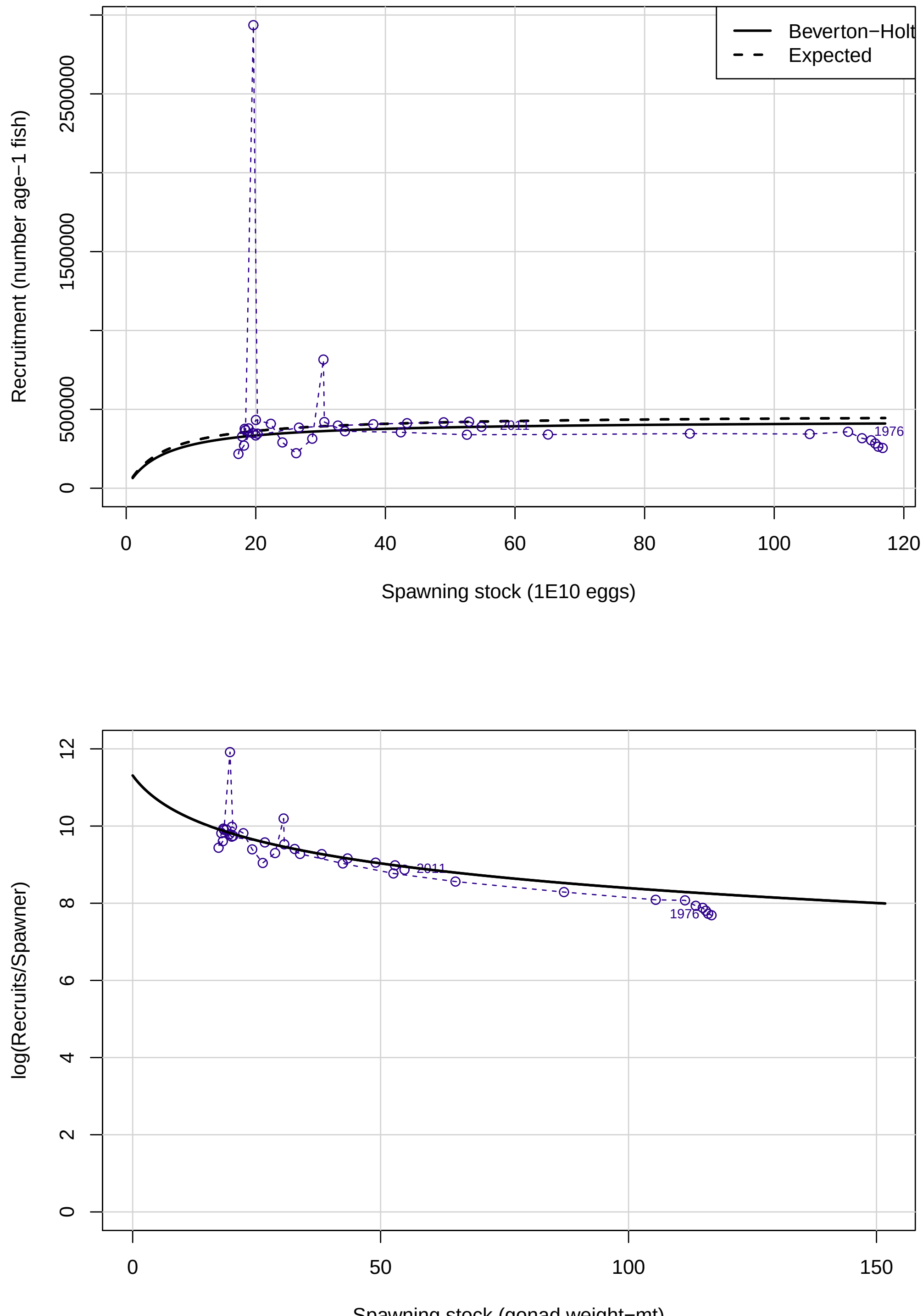


Figure 3.18. Probability densities of spawner-recruit quantities R0 (unfished recruitment of age-1 fish), steepness, unfished spawners per recruit, and standard deviation of recruitment residuals in log space. Vertical lines represent point estimates or values from the base run of the Beaufort Assessment Model.

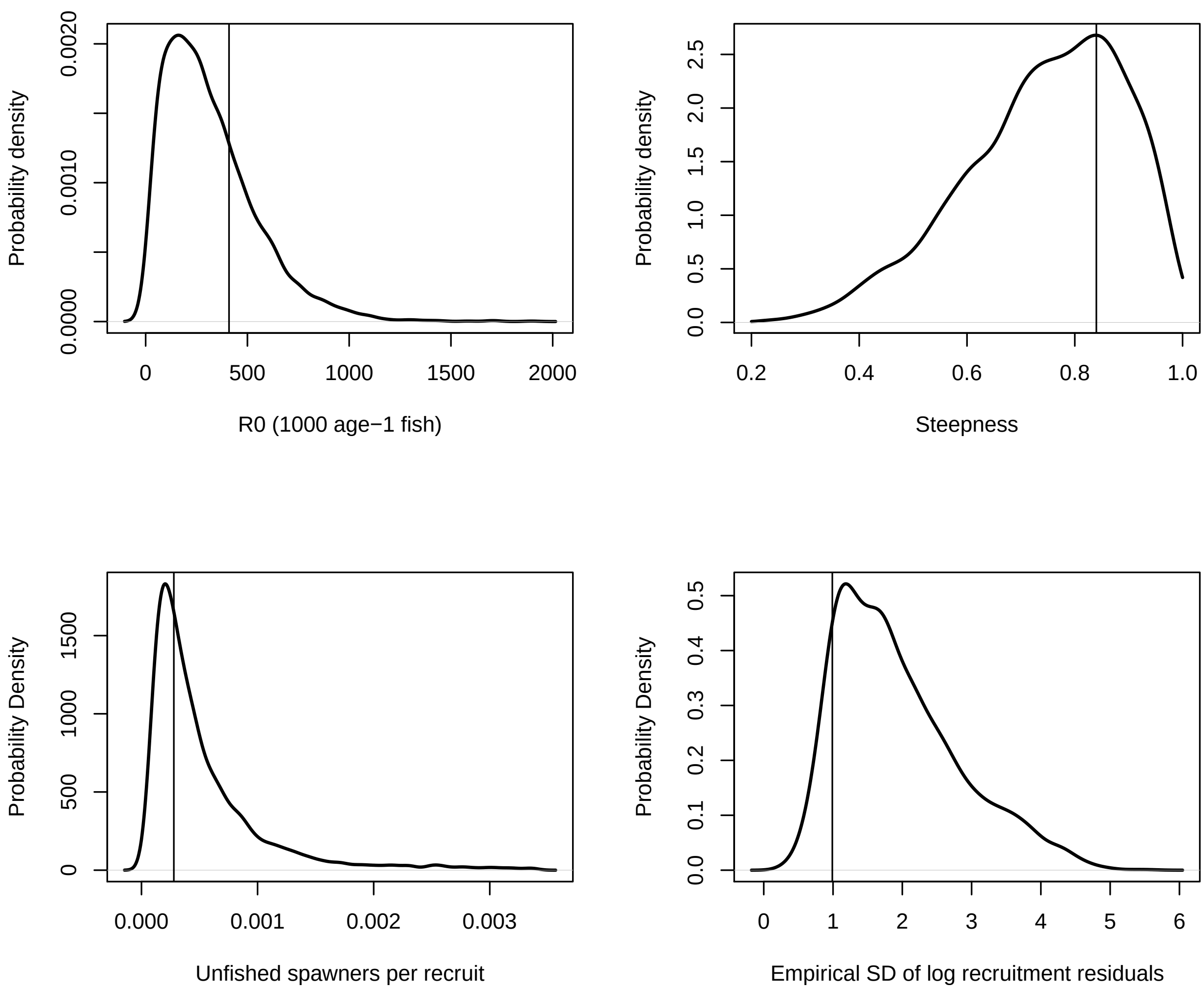


Figure 3.19. Estimated time series of static spawning potential ratio, the annual equilibrium spawners per recruit relative to that at the unfished level. Horizontal dashed line indicates the equilibrium MSY level.

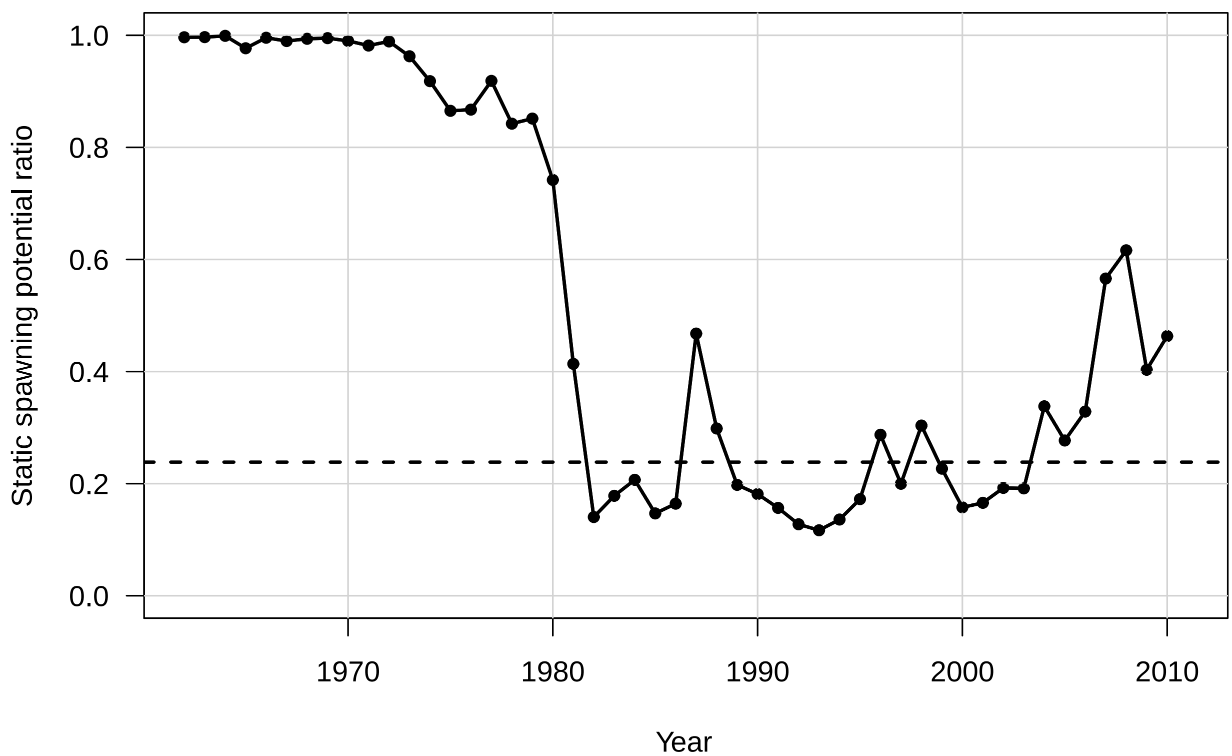


Figure 3.20. Top panel: yield per recruit. Bottom panel: spawning potential ratio (spawning biomass per recruit relative to that at the unfished level), from which the y% levels provide $F_{y\%}$. Both curves are based on average selectivity from the end of the assessment period.

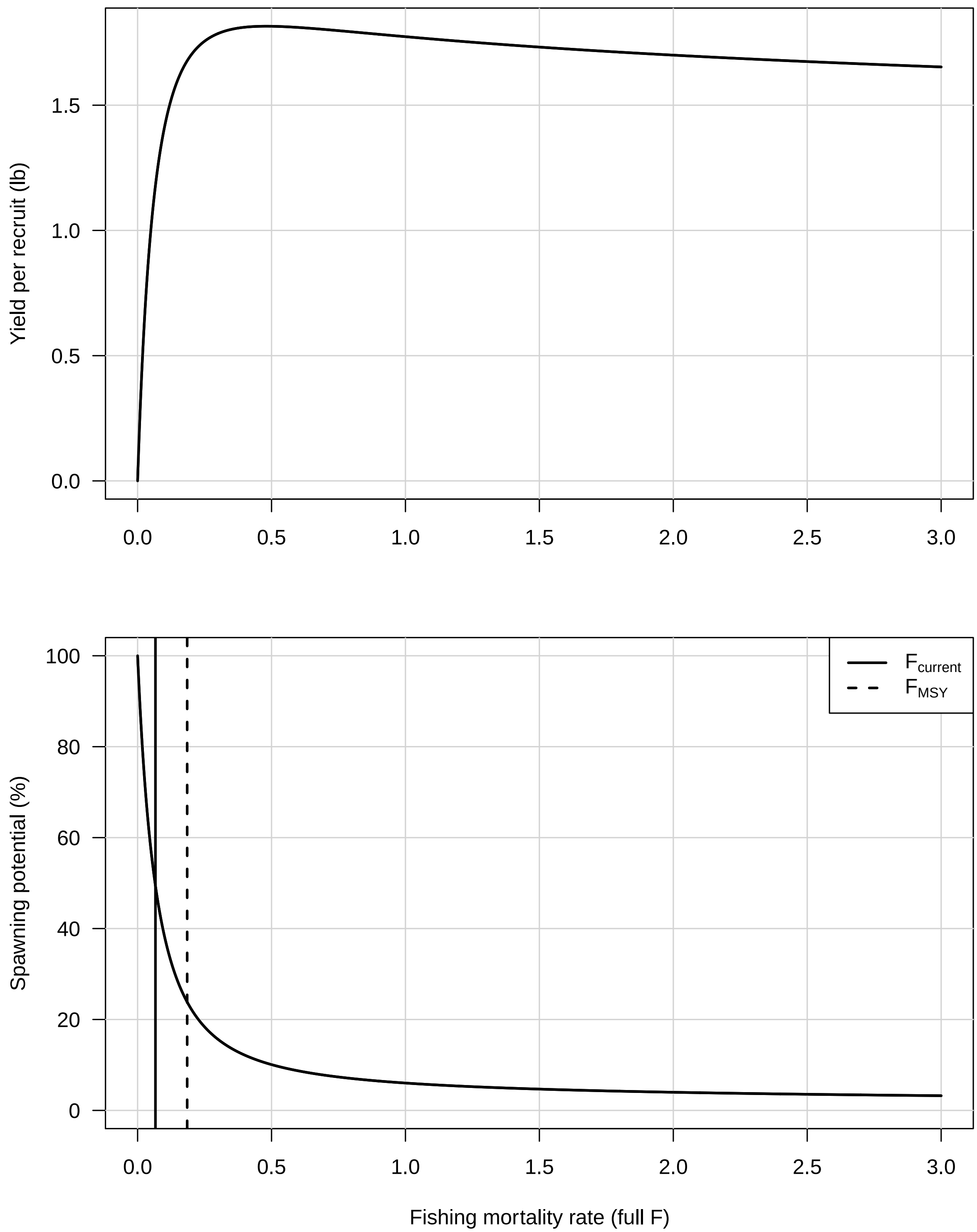


Figure 3.21. Top panel: equilibrium landings. The peak occurs where fishing rate is $F_{\mathrm{MSY}} = 0.185$ *and equilibrium landings are* $\mathrm{MSY} = 638$ *(1000 lb). Bottom panel: equilibrium spawning biomass. Both curves are based on average selectivity from the end of the assessment period.*

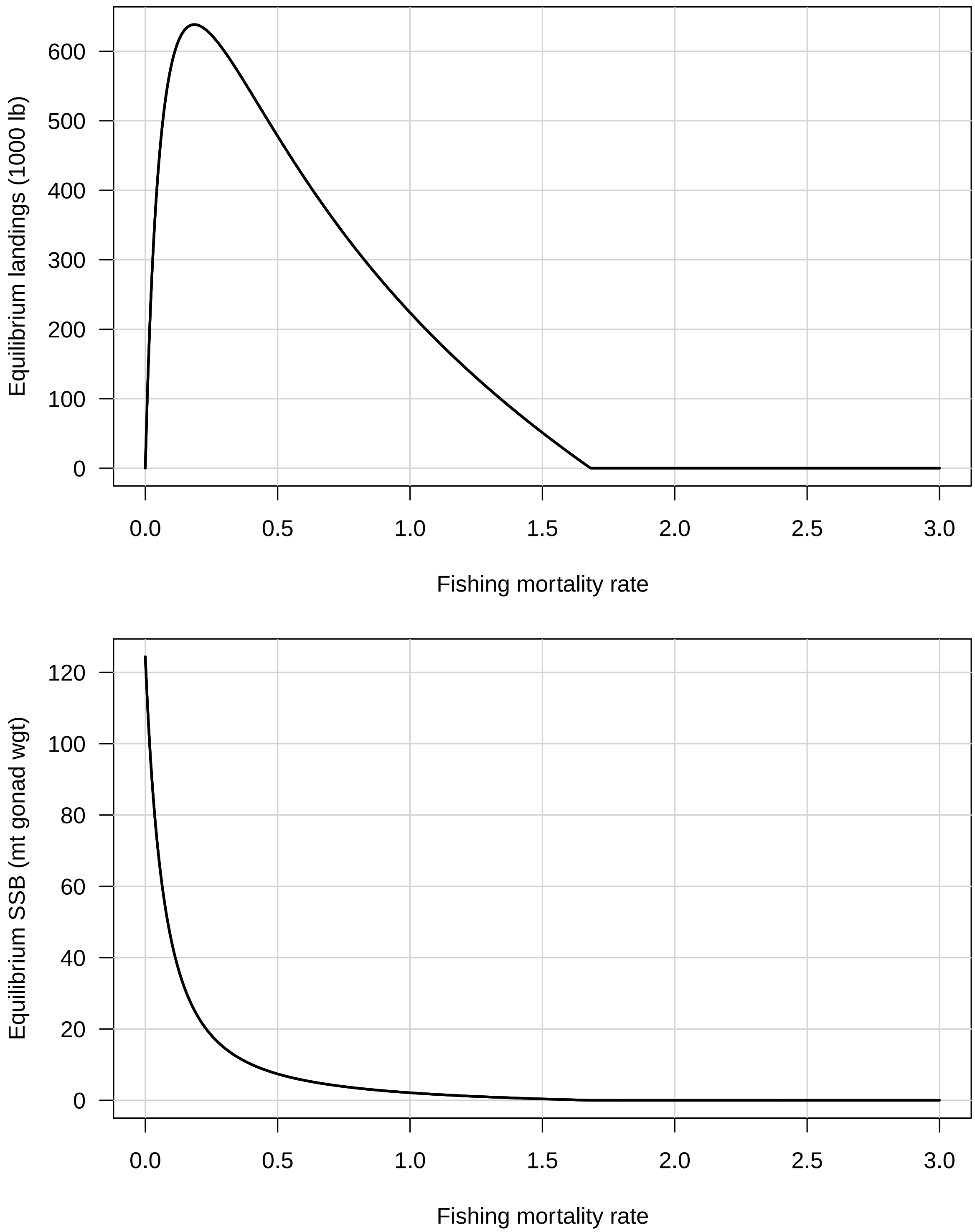


Figure 3.22. Equilibrium landings as a function of equilibrium biomass, which itself is a function of fishing mortality rate. The peak occurs where equilibrium biomass is $B_{\mathrm{MSY}} = 2918$ *mt and equilibrium landings are* $\mathrm{MSY} = 638$ *(1000 lb).*

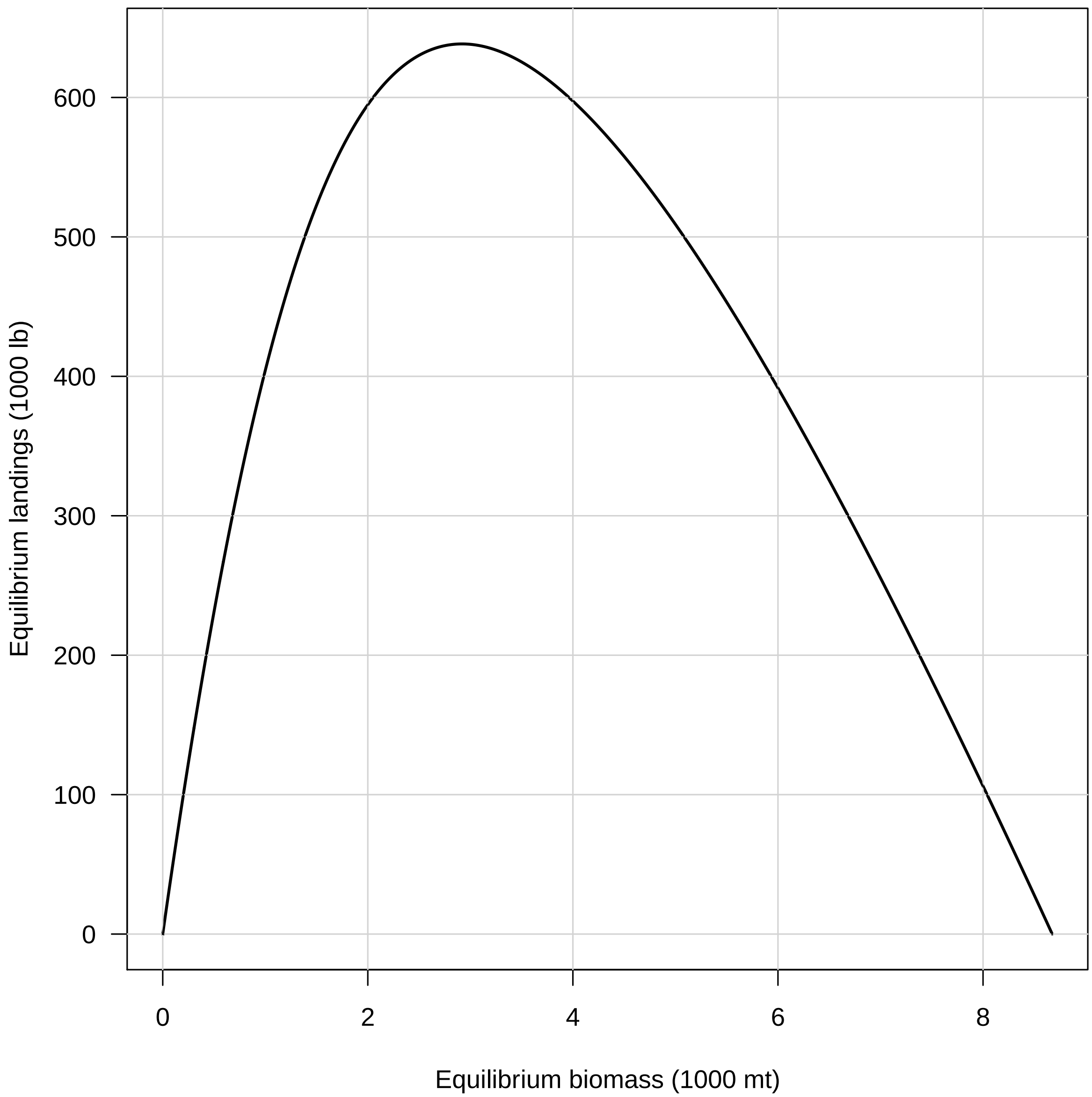


Figure 3.23. Probability densities of MSY*-related benchmarks from MCB analysis of the Beaufort Assessment Model. Vertical lines represent point estimates from the base run.*

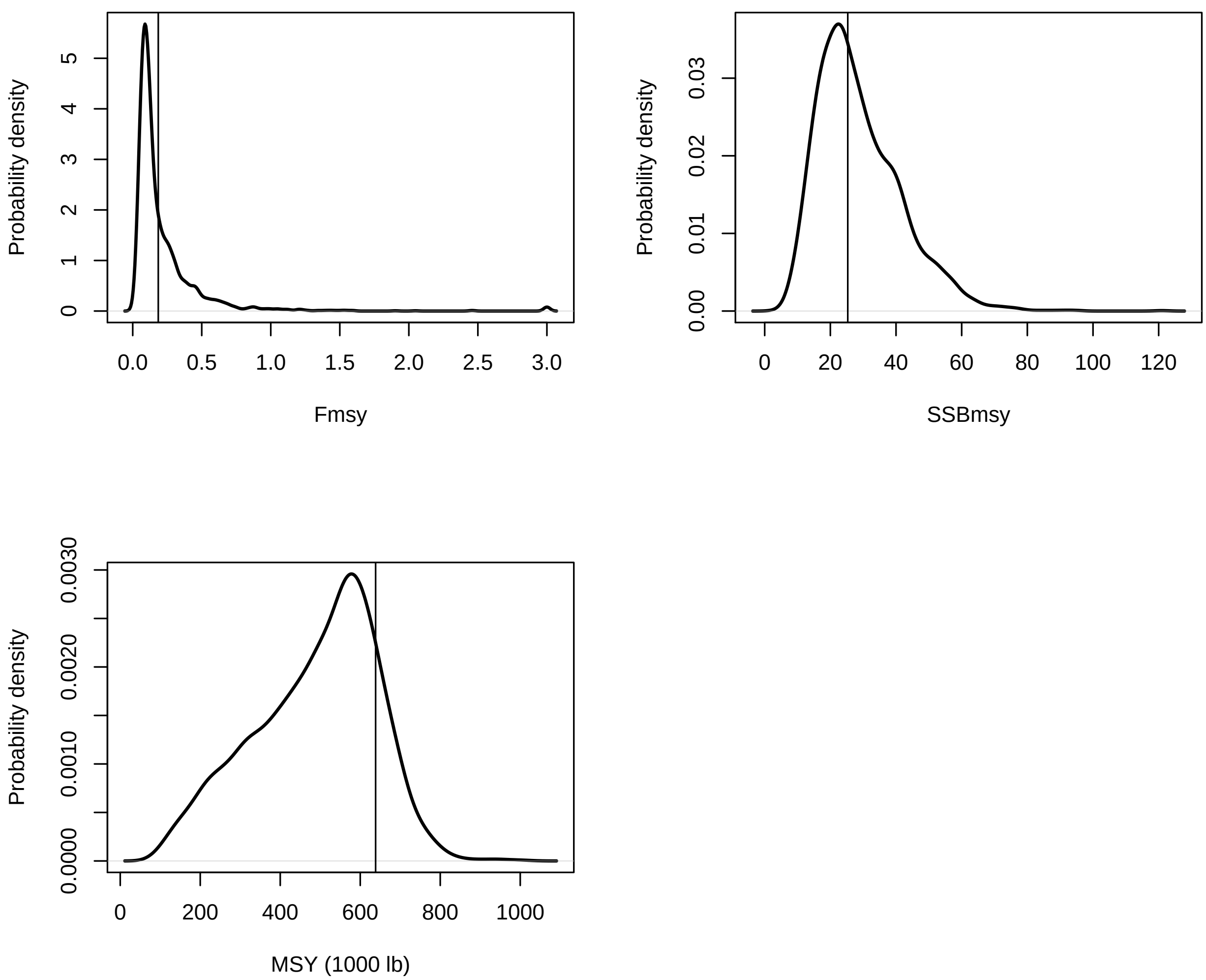
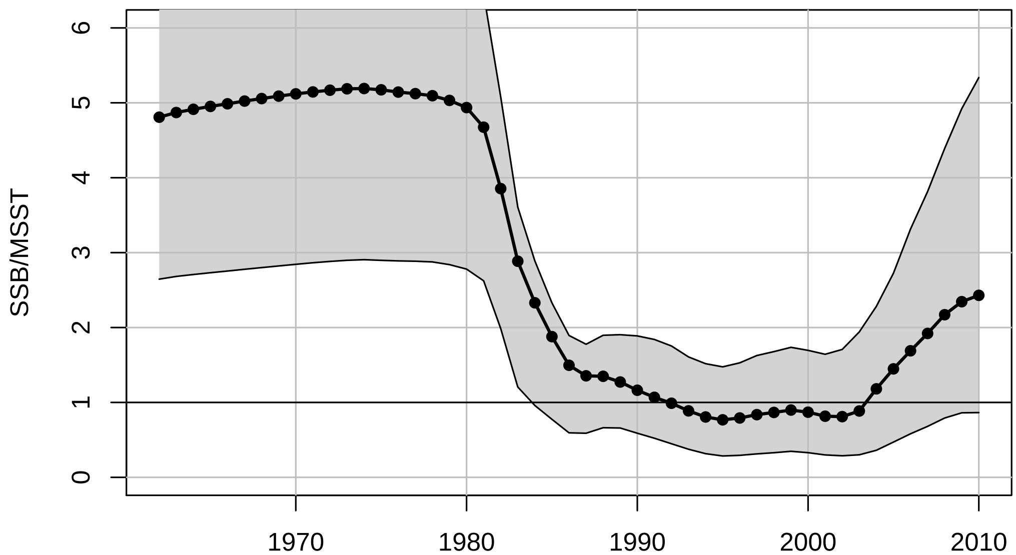


Figure 3.24. Estimated time series relative to benchmarks. Solid line indicates estimates from base run of the Beaufort Assessment Model; gray error bands indicate 5^{th} *and* 95^{th} *percentiles of the MCB trials. Top panel: spawning biomass relative to the minimum stock size threshold (*MSST*). Bottom panel: F relative to* F_{MSY}.



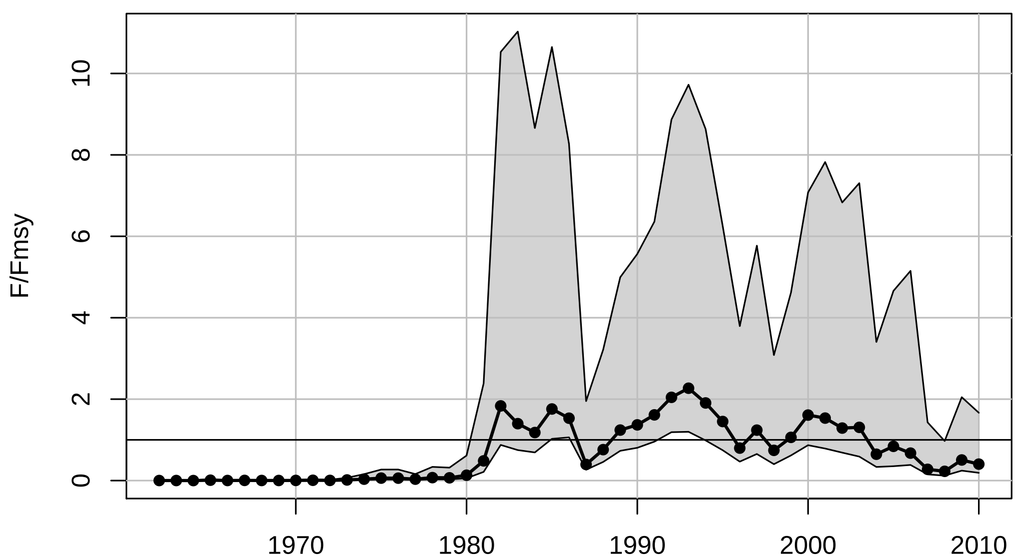


Figure 3.25. Probability densities of terminal status estimates from MCB analysis of the Beaufort Assessment Model. Vertical lines represent point estimates from the base run.

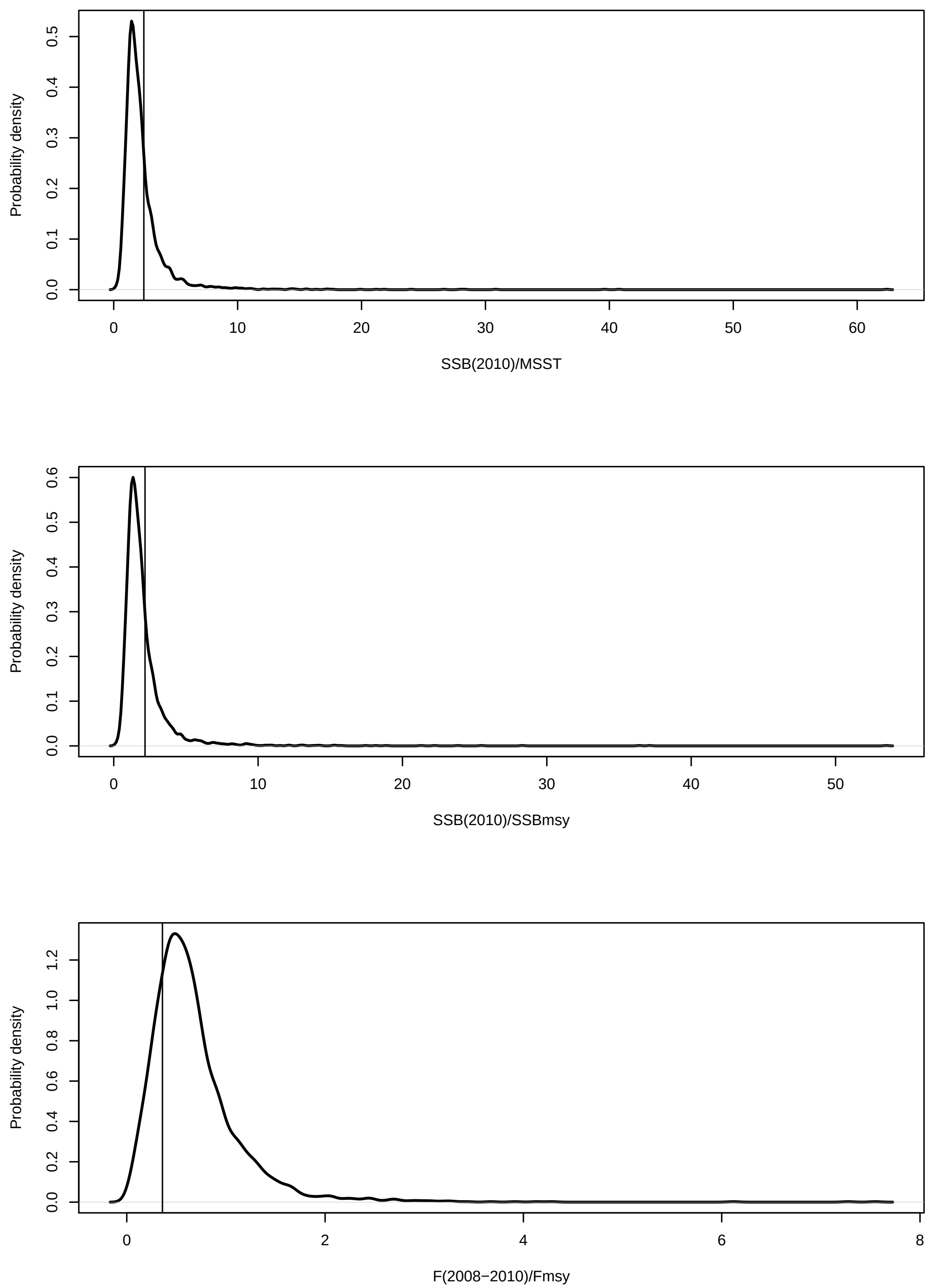


Figure 3.26. Phase plot of terminal status estimates from MCB analysis of the Beaufort Assessment Model. The intersection of crosshairs indicates estimates from the base run; lengths of crosshairs defined by 5^{th} *and* 95^{th} *percentiles.*

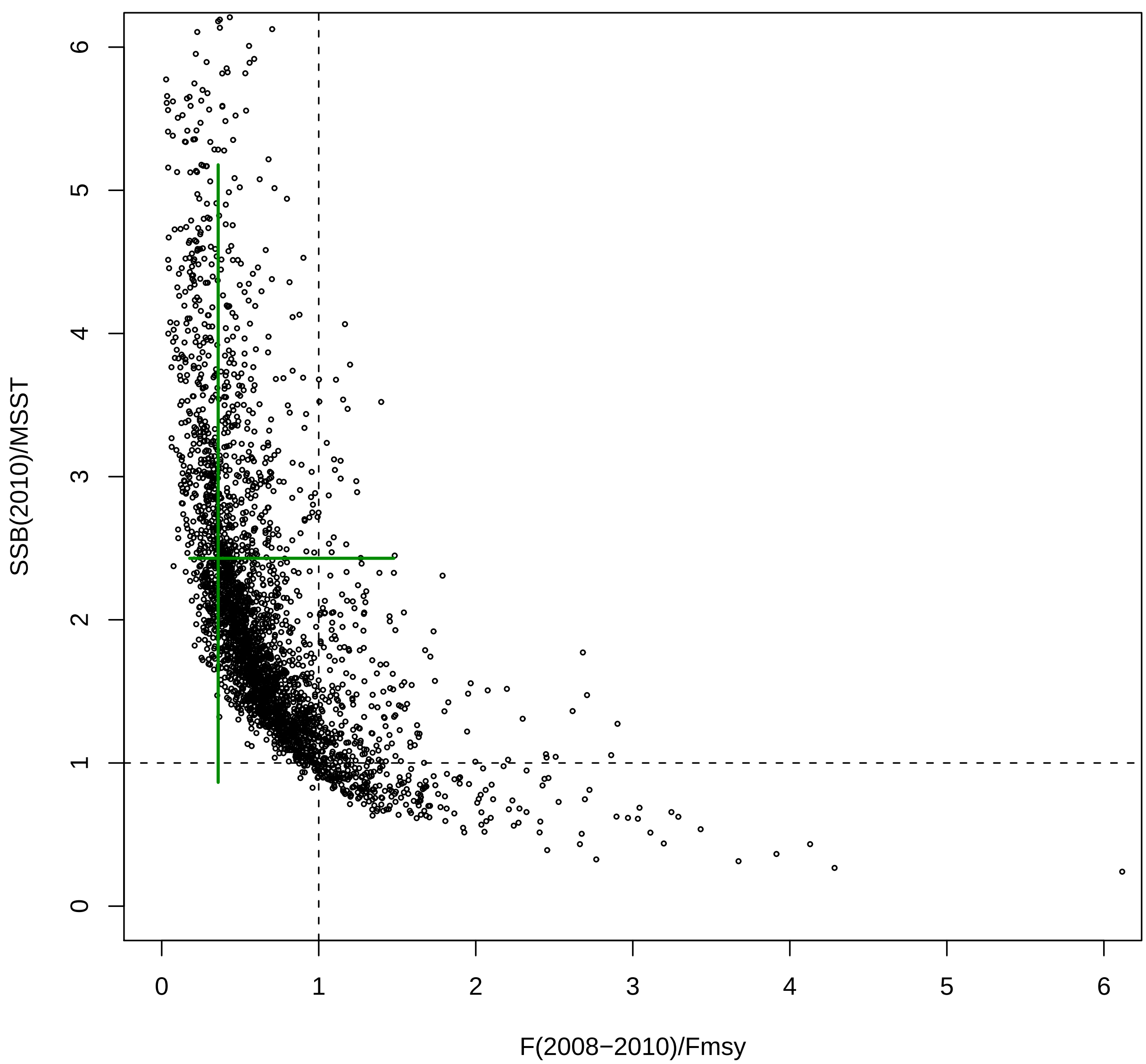


Figure 3.27. Age structure relative to the equilibrium expected at MSY*.*

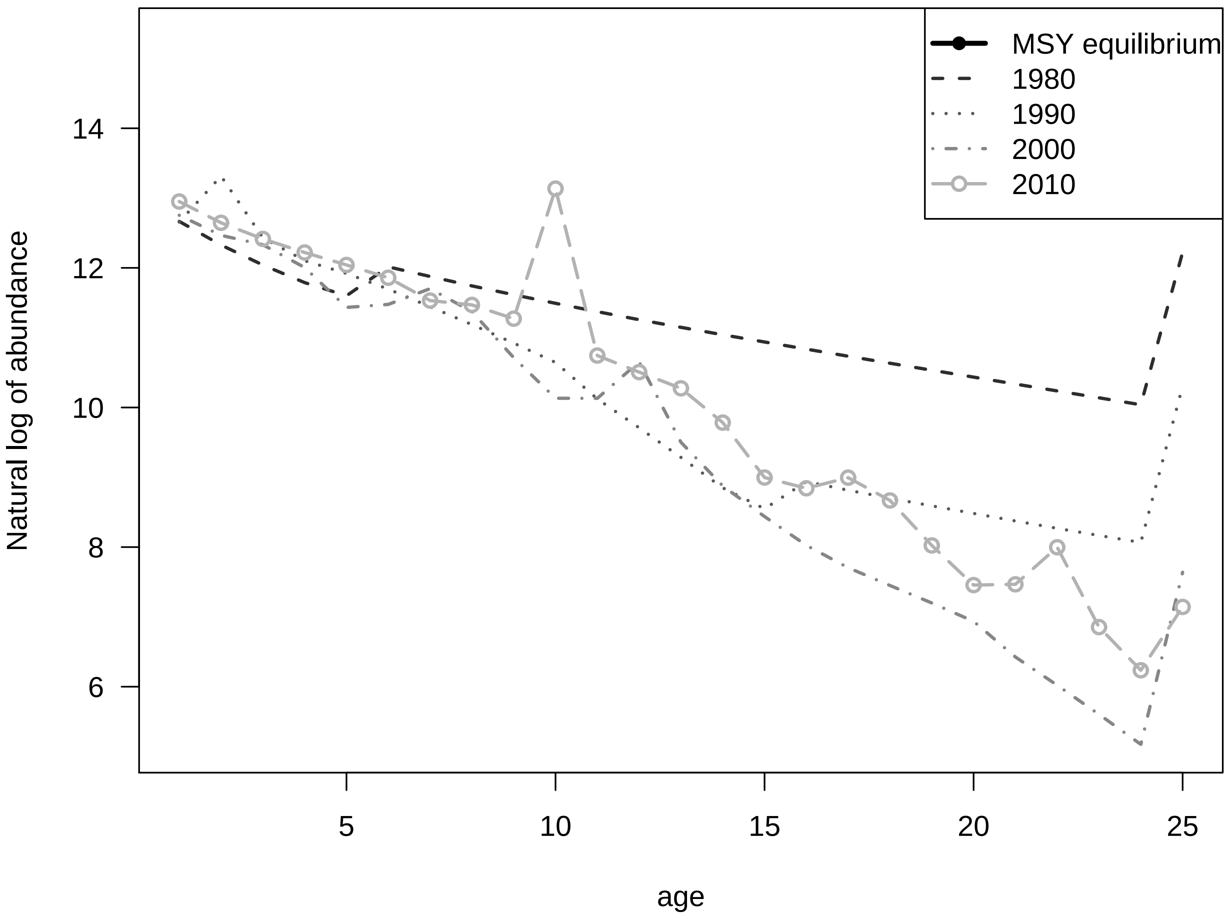


Figure 3.28. Sensitivity results on the recruitment time series.

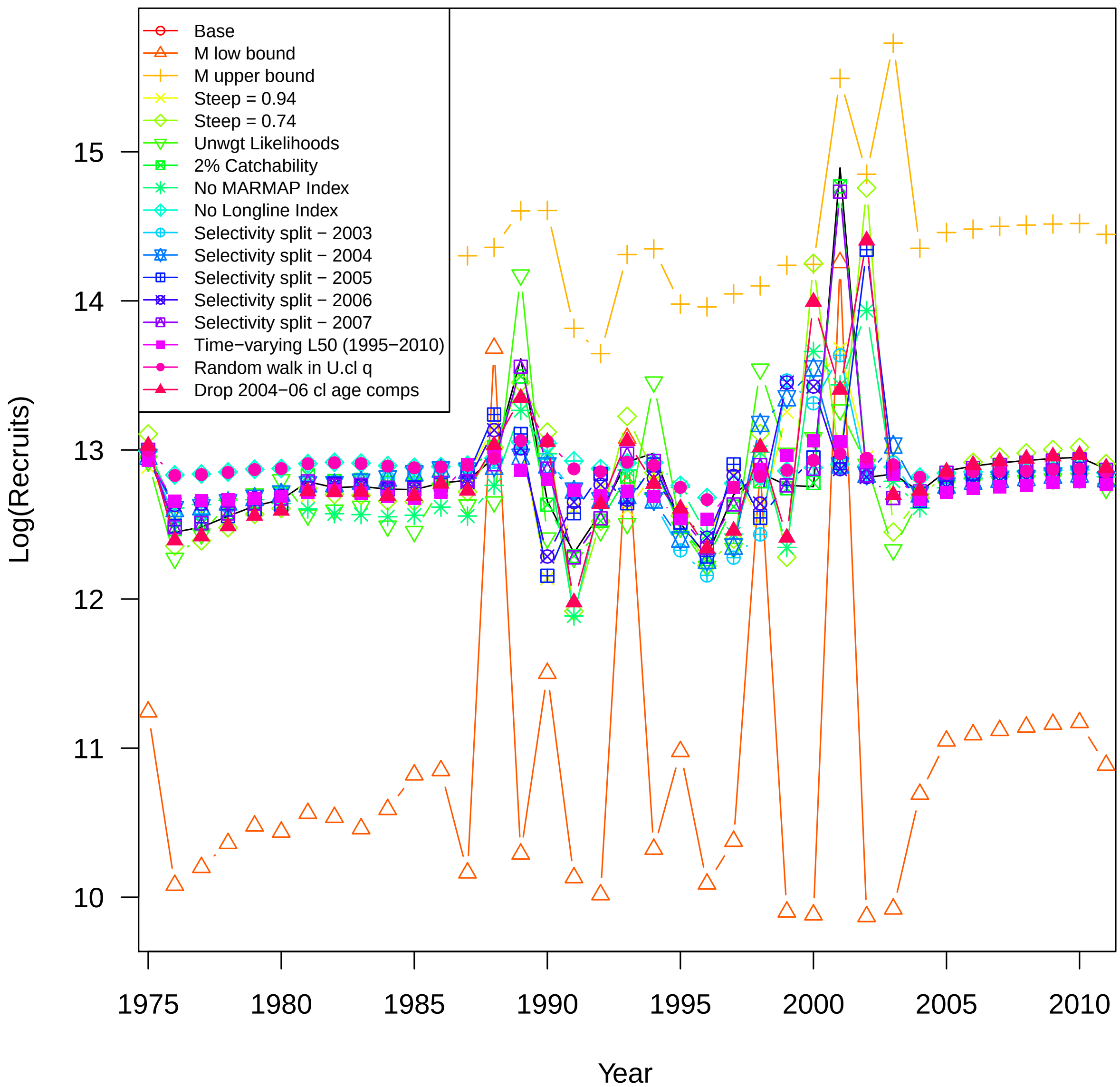


Figure 3.29. Phase plot of terminal status estimates from sensitivity runs of the Beaufort Assessment Model.

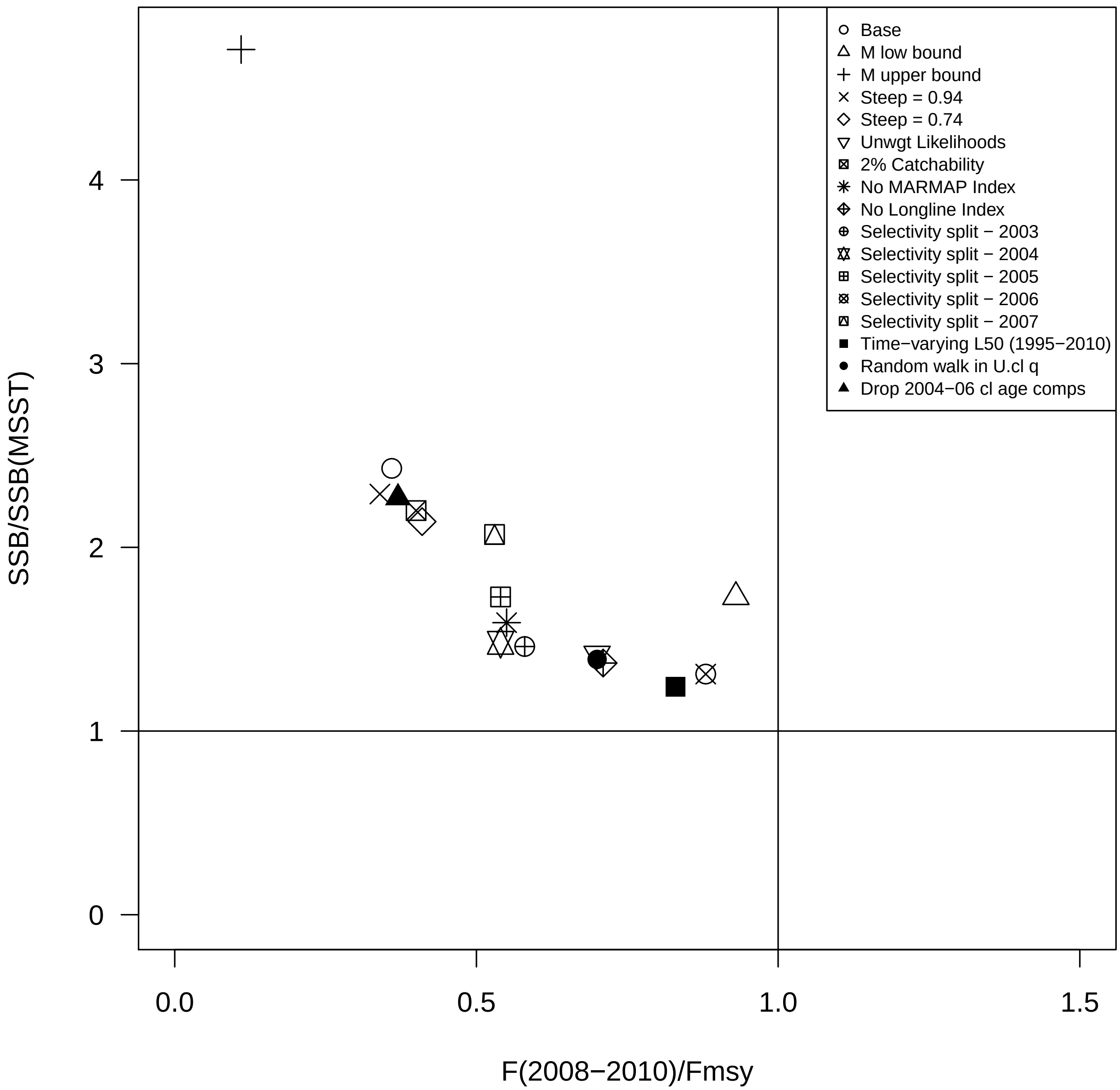


Figure 3.30. Retrospective analyses. Sensitivity to terminal year of data (sensitivity runs S17–S24). Fishing mortality rate, where solid circles show geometric mean of terminal three years, as used to compute fishing status.

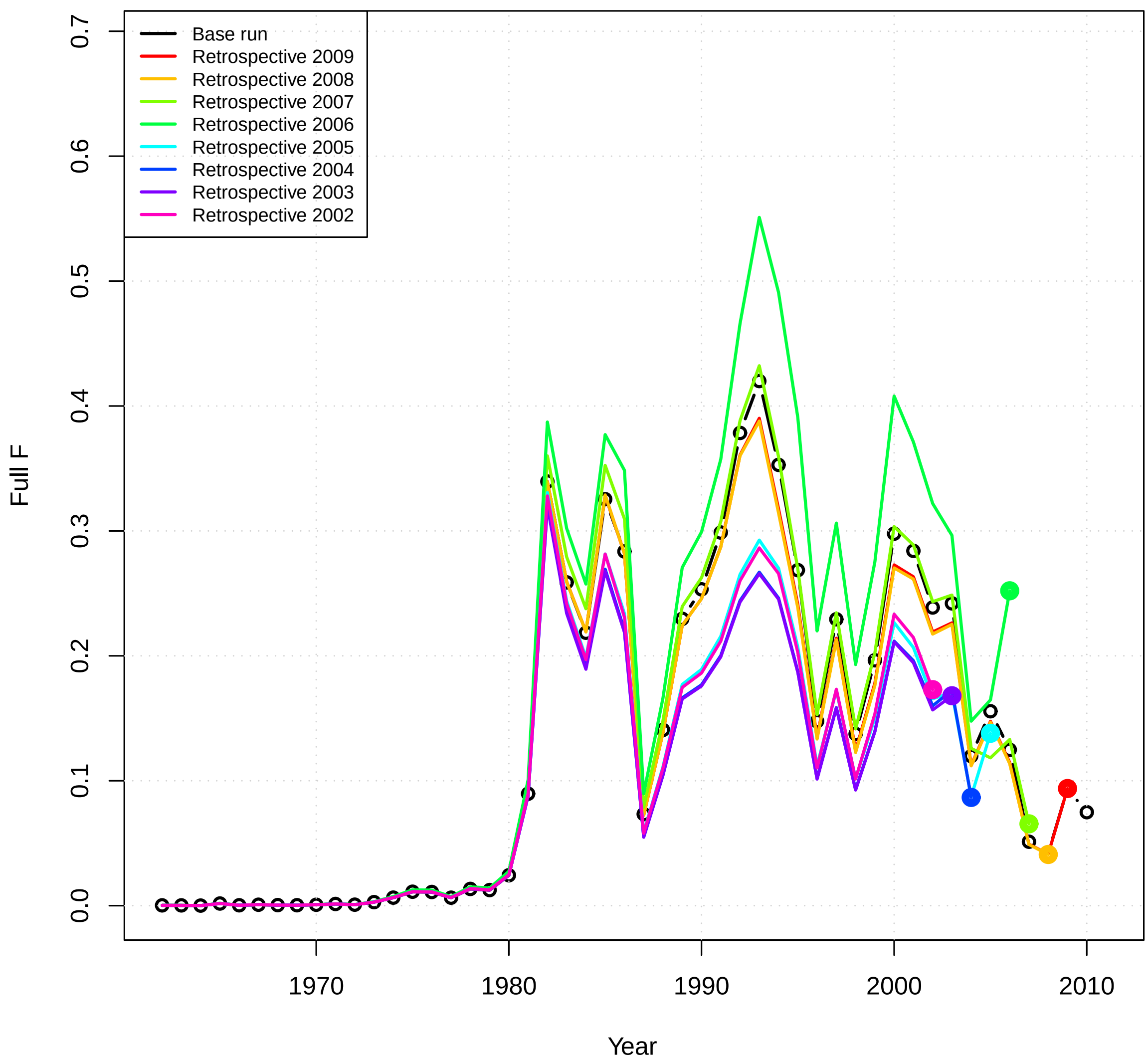


Figure 3.31. Retrospective analyses. Sensitivity to terminal year of data (sensitivity runs S17–S24). Biomass time series.

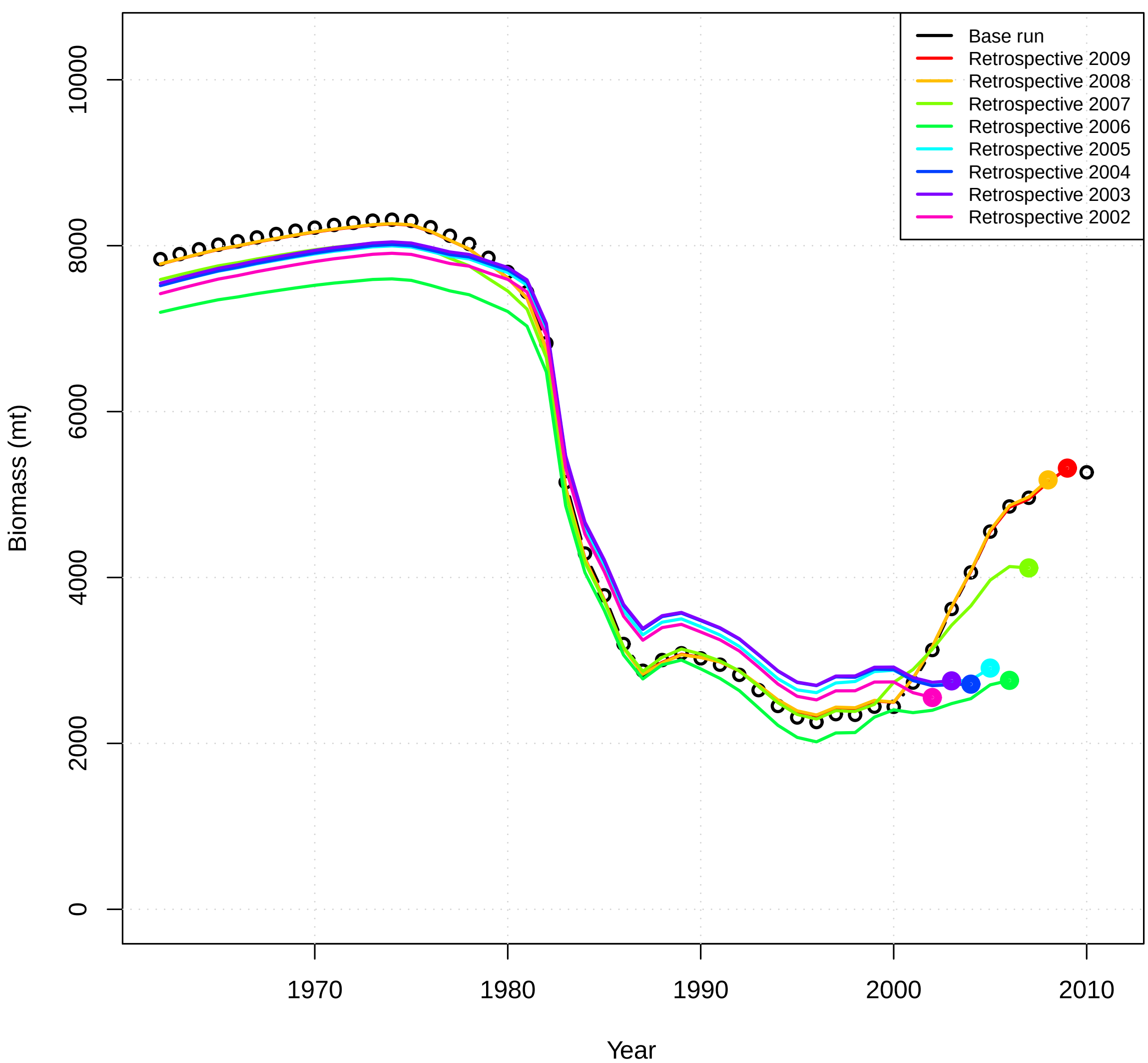


Figure 3.32. Retrospective analyses. Sensitivity to terminal year of data (sensitivity runs S17–S24). Spawning stock biomass time series.

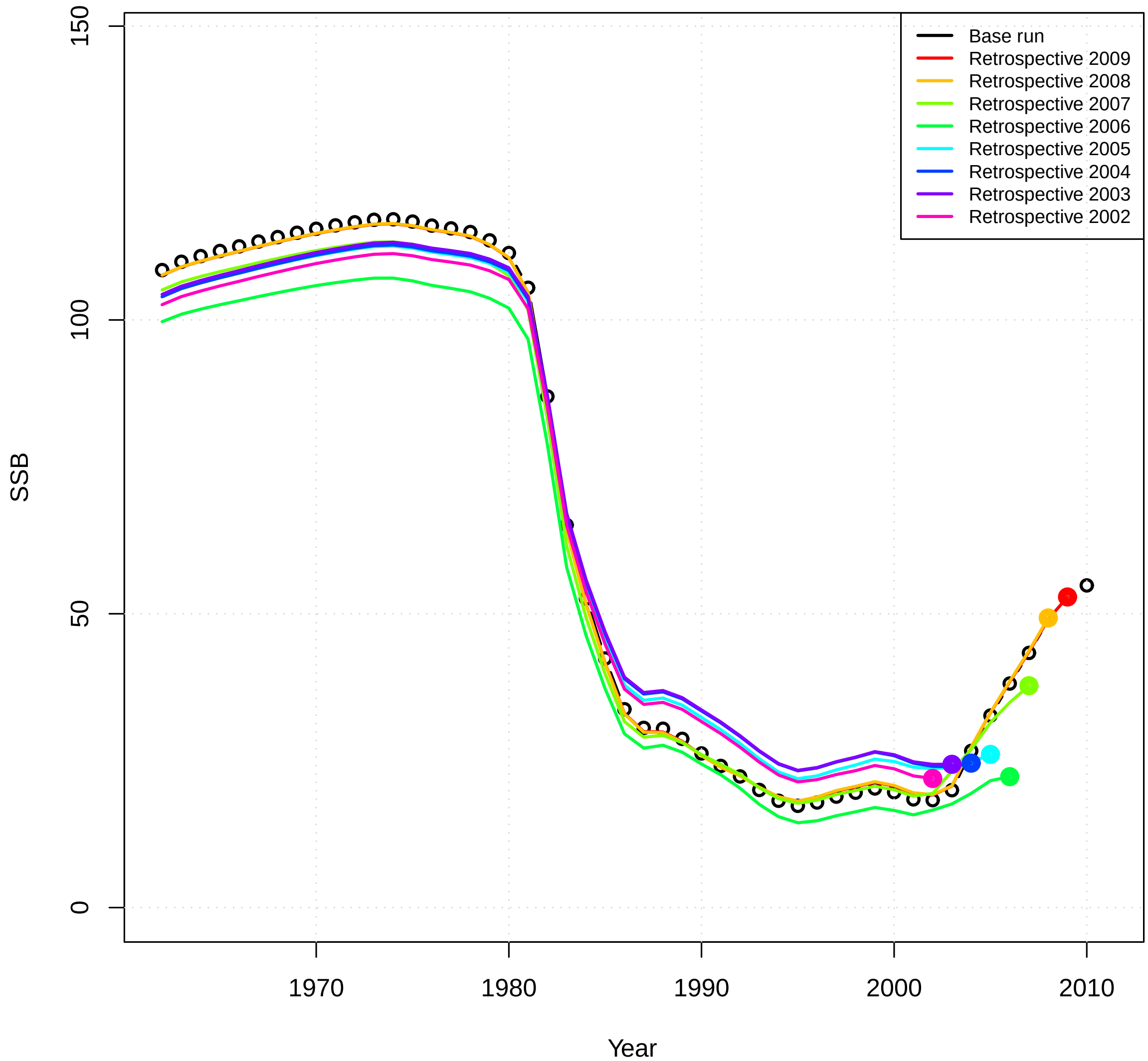


Figure 3.33. Retrospective analyses. Sensitivity to terminal year of data (sensitivity runs S17–S24). Recruitment time series.

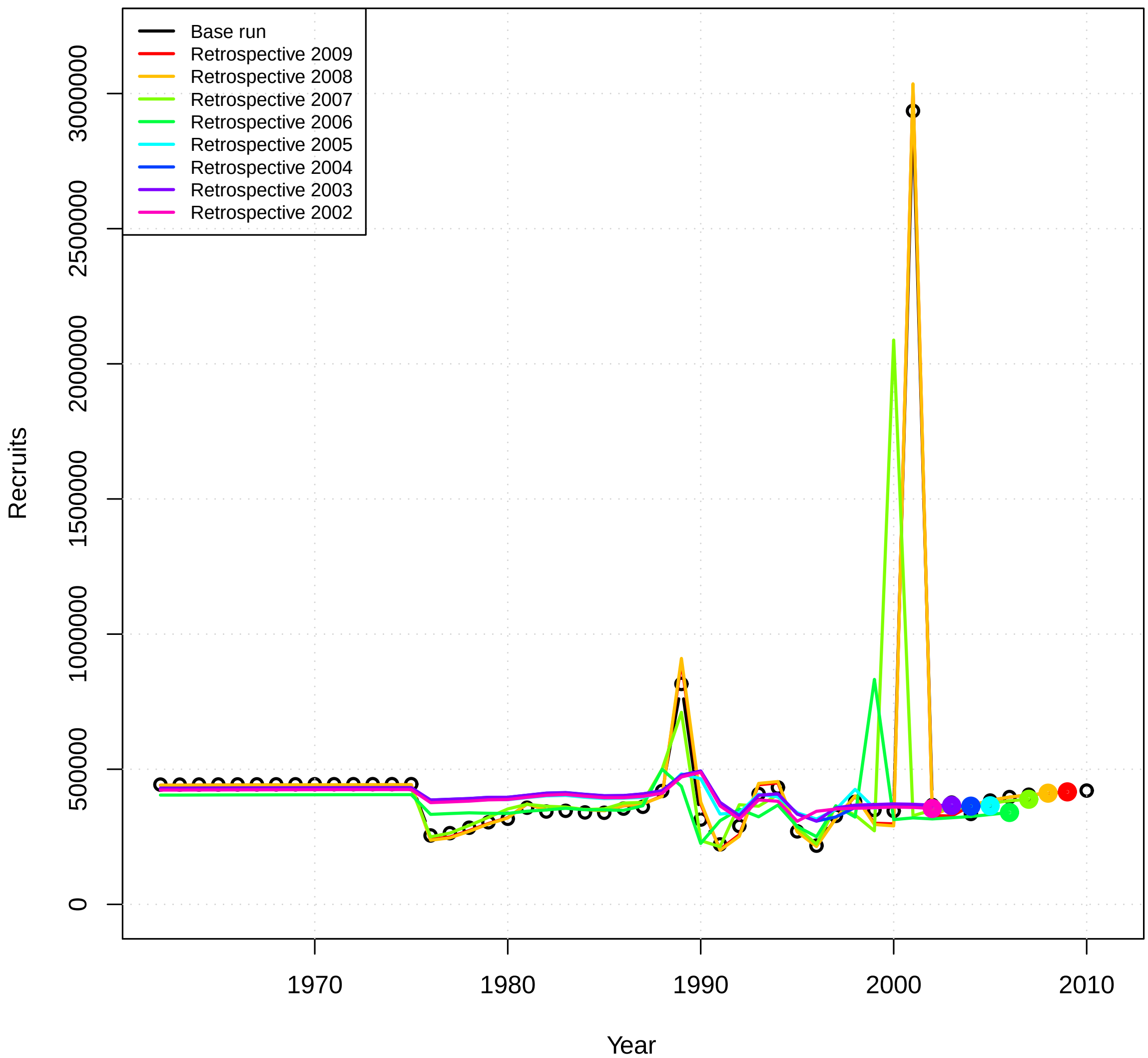


Figure 3.34. Retrospective analyses. Sensitivity to terminal year of data (sensitivity runs S17–S24). Relative spawning stock biomass time series

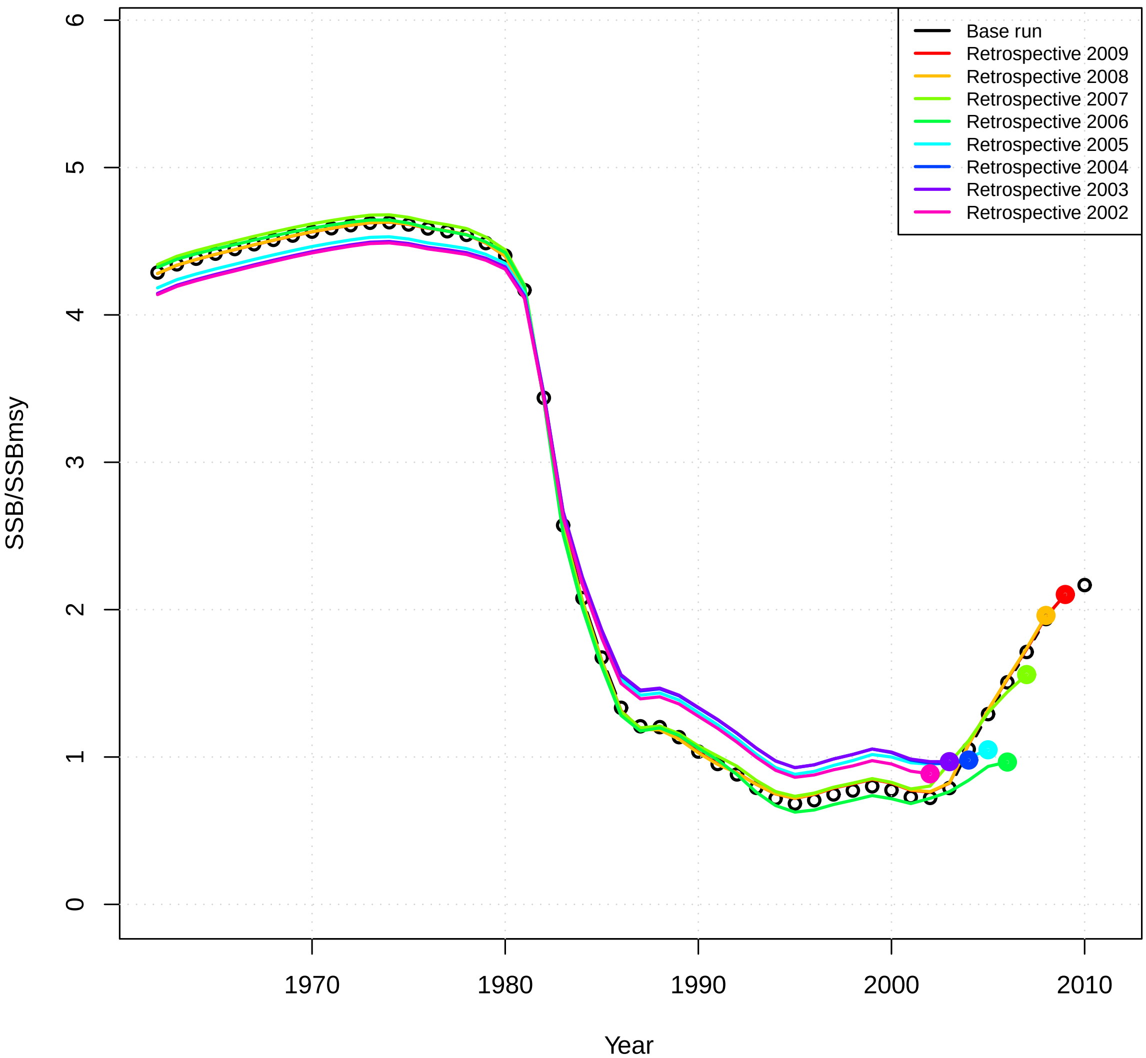


Figure 3.35. Retrospective analyses. Sensitivity to terminal year of data (sensitivity runs S17–S24). Relative fishing mortality rate time series.

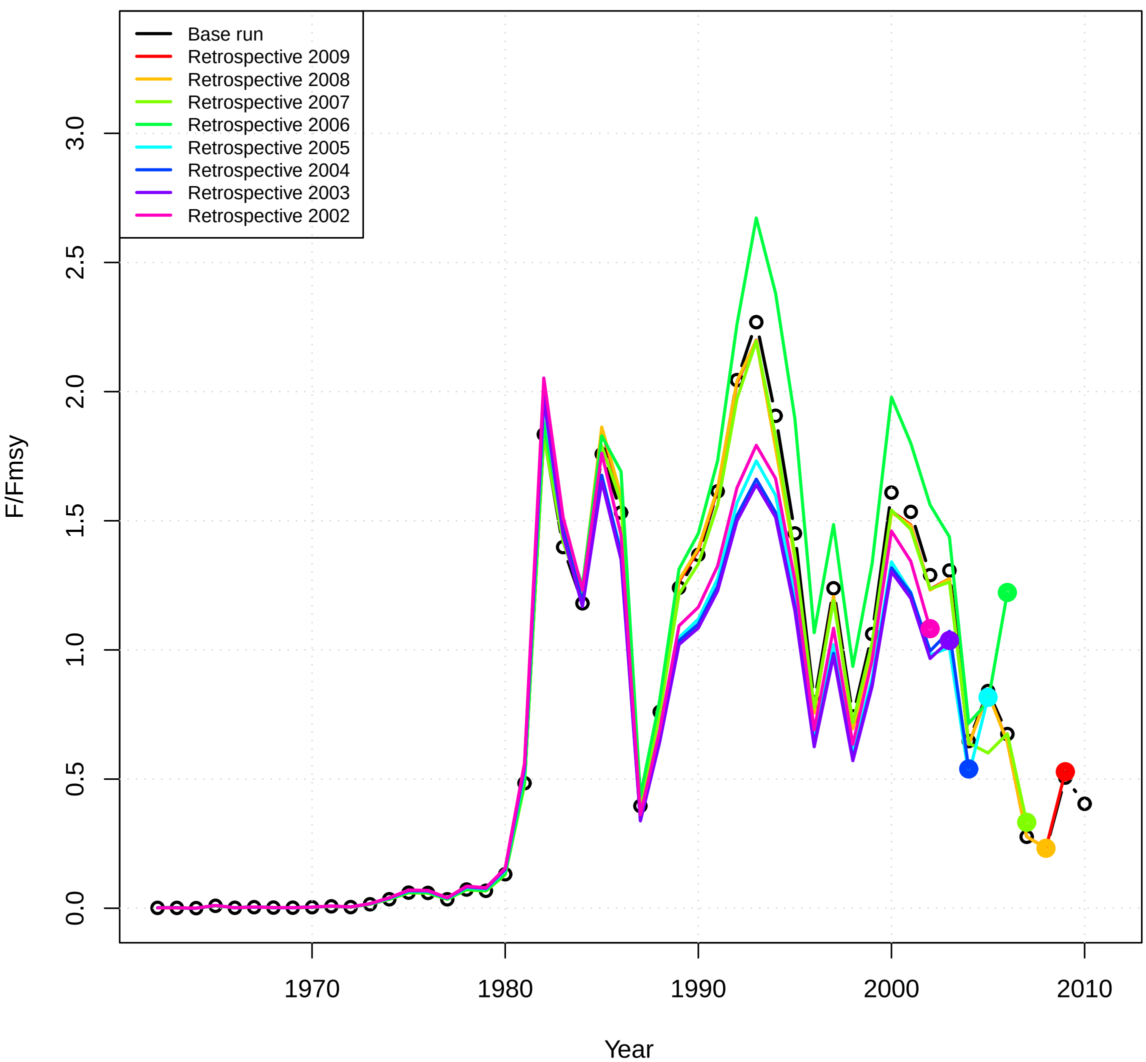


Figure 3.36. Projection results under scenario 1—fishing mortality rate fixed at $F = F_{\mathrm{MSY}}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock (SSB) is at time of peak spawning.*

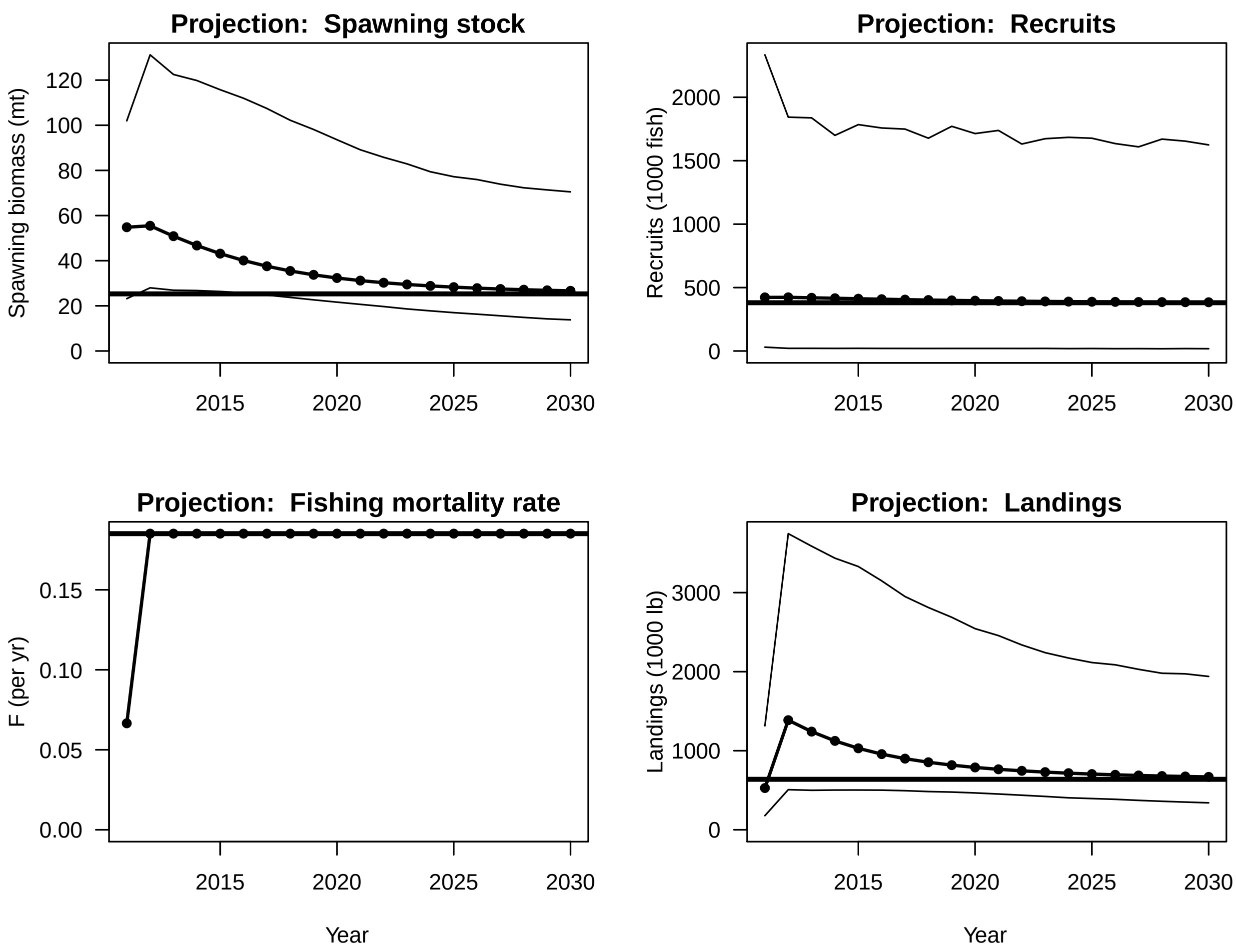


Figure 3.37. Projection results under scenario 2—fishing mortality rate fixed at $F = F_{\text{current}}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock (SSB) is at time of peak spawning.*

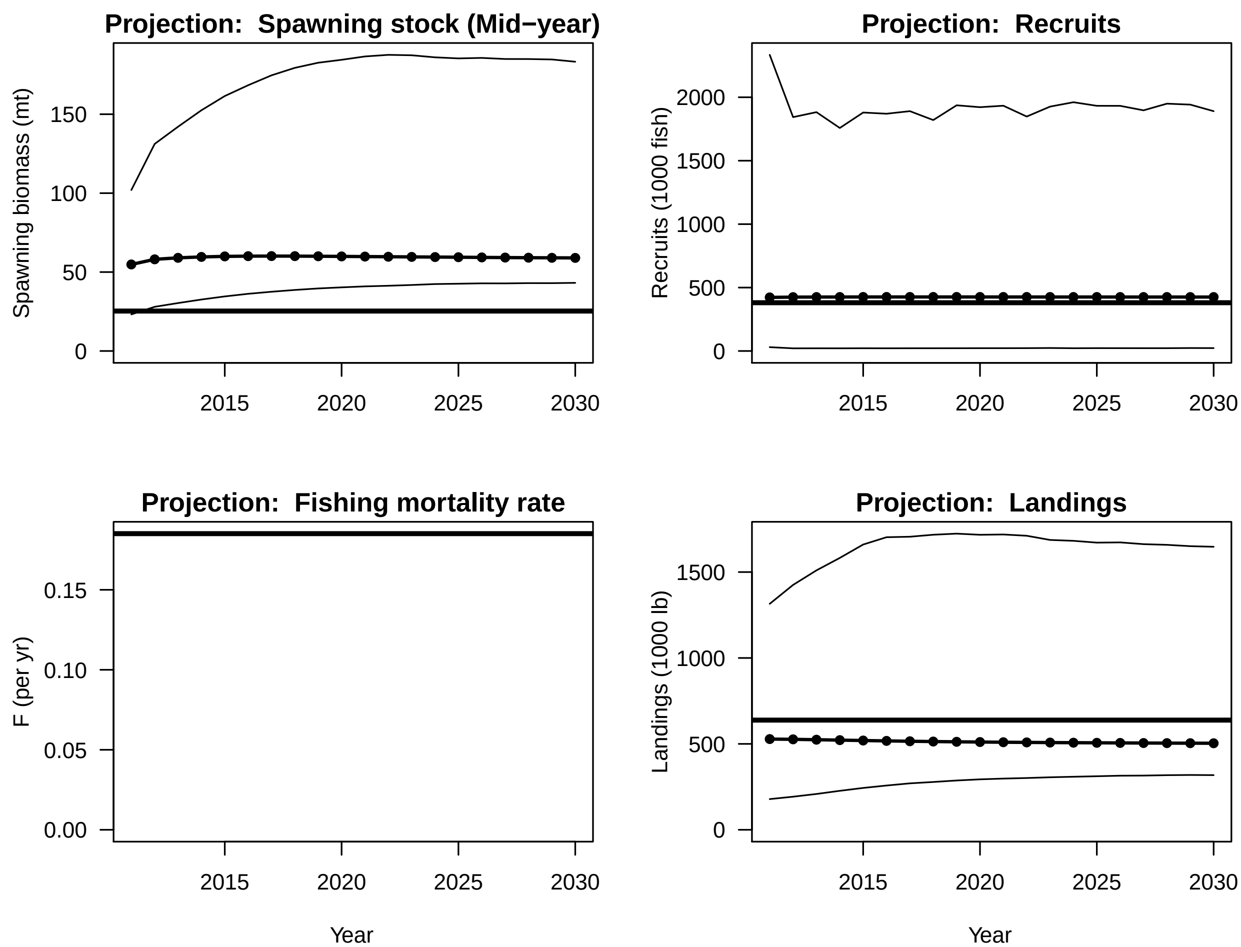


Figure 3.38. Projection results under scenario 3—fishing mortality rate fixed at $F = 65\% F_{\mathrm{MSY}}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock (SSB) is at time of peak spawning.*

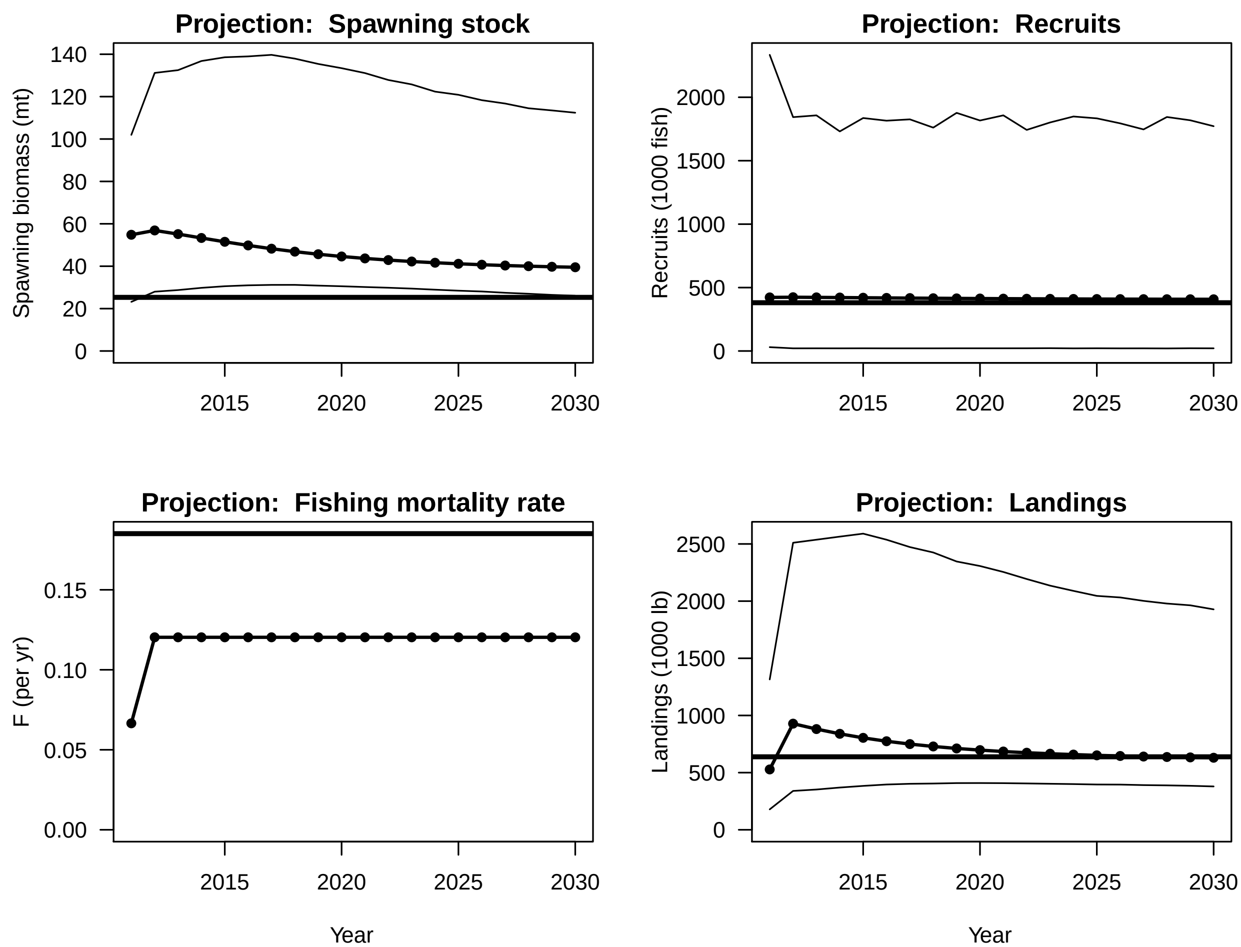


Figure 3.39. Projection results under scenario 4—fishing mortality rate fixed at $F = 75\% F_{\mathrm{MSY}}$. *Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to* 5^{th} *and* 95^{th} *percentiles of replicate projections. Horizontal lines mark* MSY*-related quantities. Spawning stock (SSB) is at time of peak spawning.*

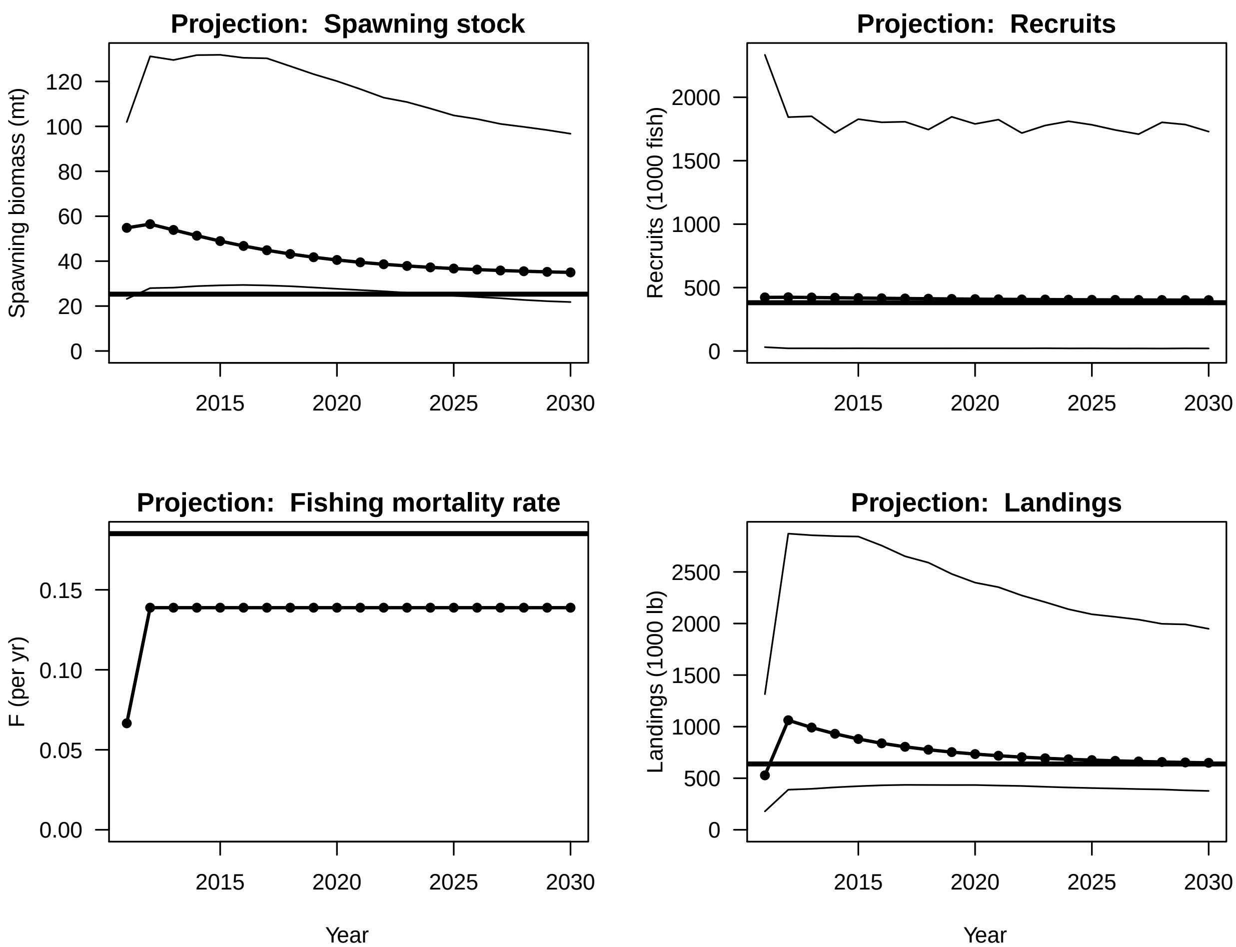


Figure 3.40. Projection results under scenario 5—fishing mortality rate fixed at $F = 85\% F_{\mathrm{MSY}}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock (SSB) is at time of peak spawning.*

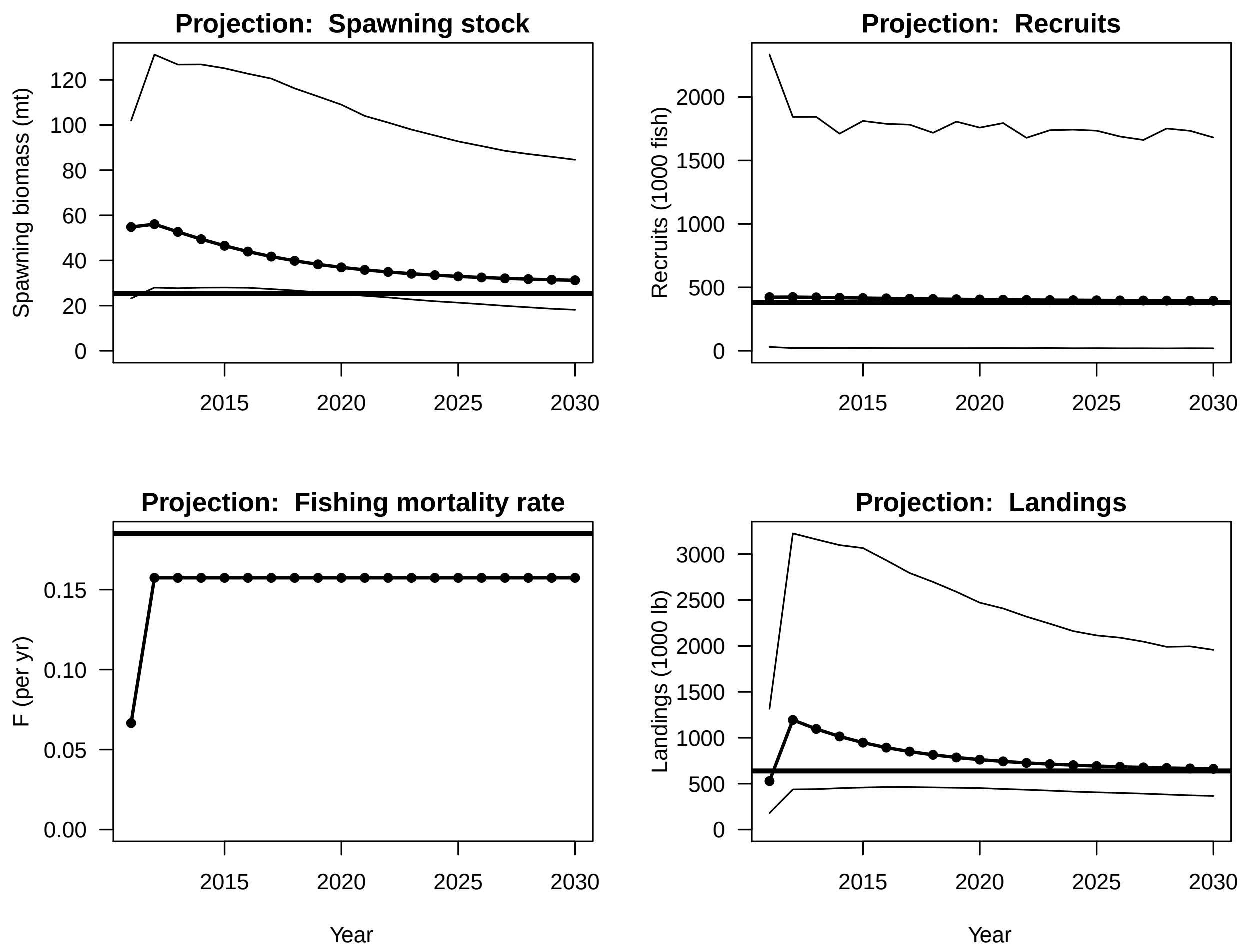


Figure 3.41. Fit of production model to the commercial longline and MARMAP longline indices.

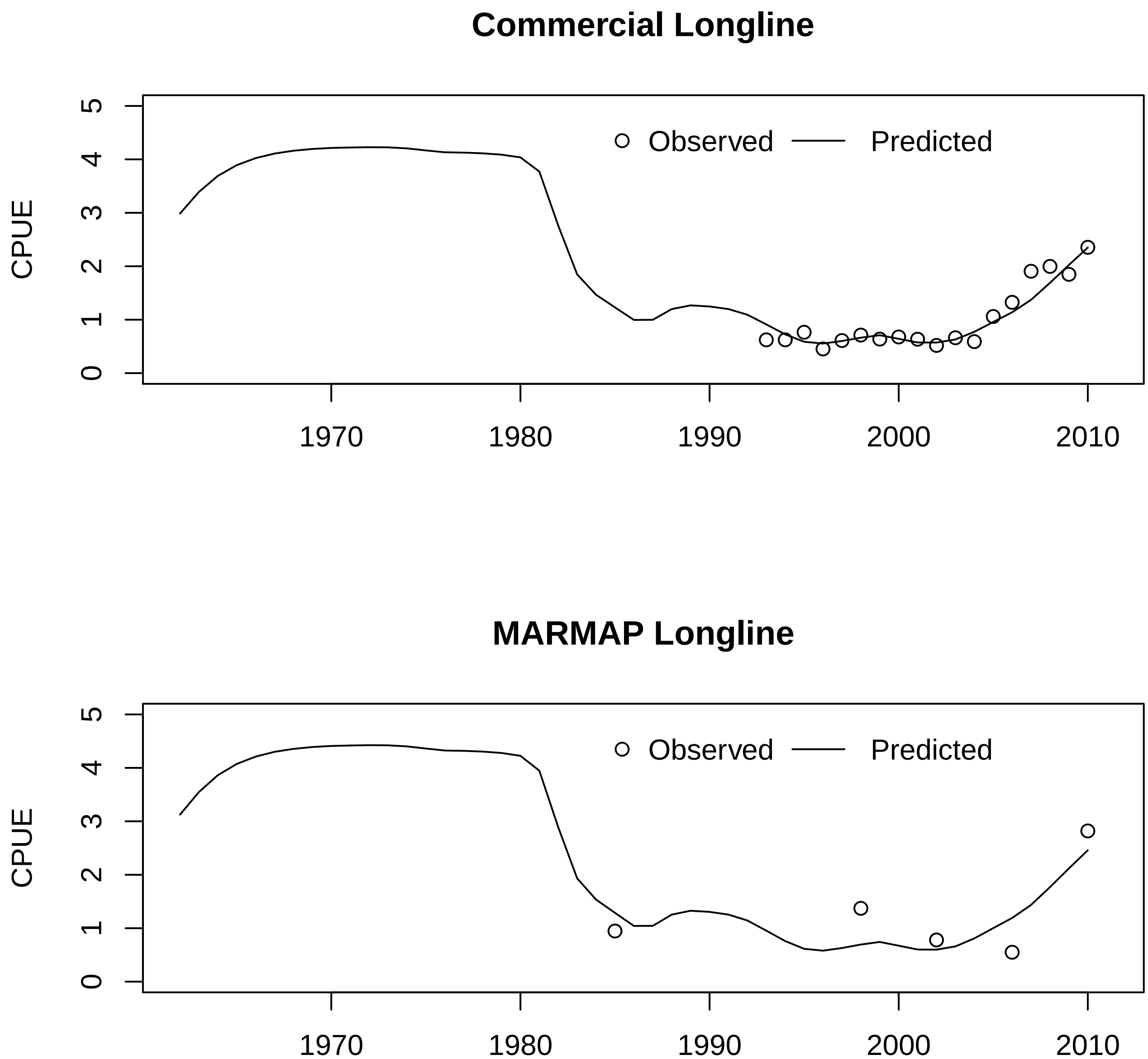
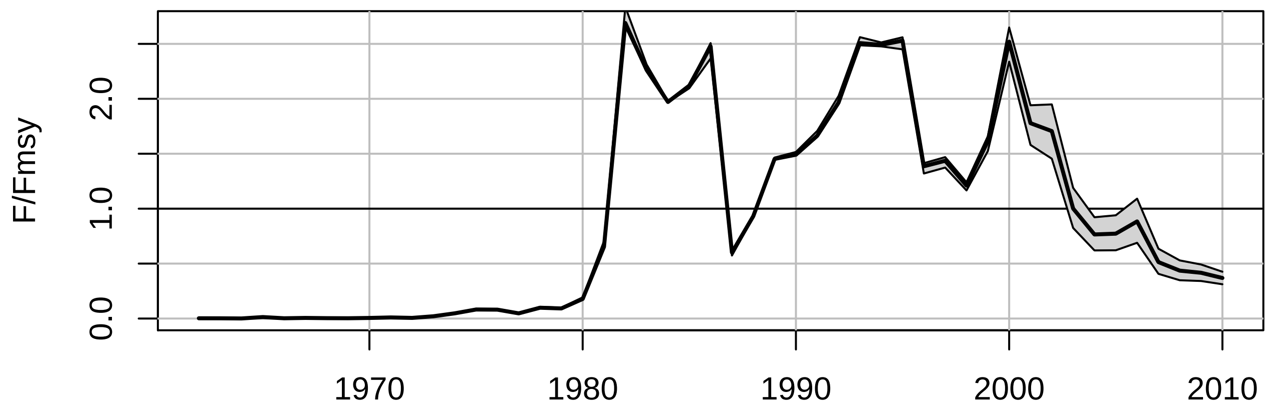
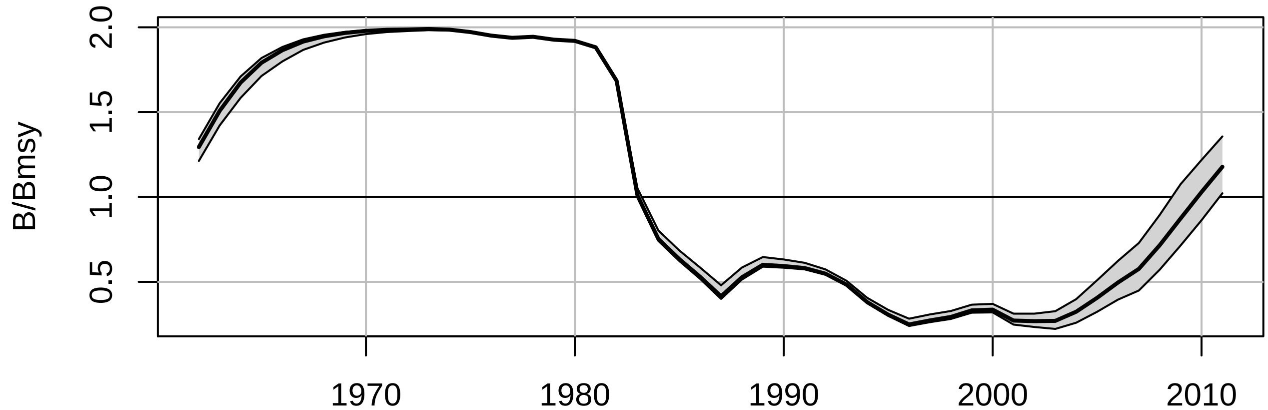


Figure 3.42. Production model estimates of relative fishing rate F/F_{MSY} and biomass, B/B_{MSY} with 80% confidence interval.





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 tilefish)
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 tilefish)
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
MCB	Monte Carlo/Boostrap, an approach to quantifying uncertainty in model results
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, predecessor of MRIP
MRIP	Marine Recreational Information Program, a data-collection program of NMFS, descended from MRFSS
MSST	Minimum stock-size threshold; a limit reference point used in U.S. fishery management. The SAFMC has defined MSST for tilefish 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 $\leq$ 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
SDNR	Standard deviation of normalized residuals
SEDAR	SouthEast Data Assessment and Review process
SFA	Sustainable Fisheries Act; the Magnuson–Stevens Act, as amended
SL	Standard length (of a fish)
SPR	Spawning potential ratio
SSB	Spawning stock biomass; mature biomass of males and females
$\mathrm{SSB}_{\mathrm{MSY}}$	Level of SSB at which MSY can be attained
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 = 170  Objective function value = 92.7886  Maximum gradient component = 8.48512e-005
# len_cv_val:
0.151006529104
# log_R0:
12.9229491949
# steep:
0.840000000000
# rec_sigma:
0.403314864035
# log_rec_dev:
 -0.475162252221 -0.442002760708 -0.367883473358 -0.299175272550 -0.256657720747 -0.134267207581 -0.171886047503 -0.153359077103 -0.150190156251 -0.134752974153
 -0.0675191353840 -0.0185909186444 0.146335172661 0.811919184358 -0.133576674030 -0.464813933517 -0.181003912210 0.176317718230 0.256909783099 -0.192122797883
 -0.397744161675 0.00452864834777 0.138498417285 0.0473504577851 0.0302898789026 2.17622620503 0.113332248325 0.139000761499
# R_autocorr:
0.00000000000
# selpar_L50_cL:
5.72194180667
# selpar_slope_cL:
1.83372132177
# selpar_L50_cH:
5.83326322238
# selpar_slope_cH:
3.85175058572
# selpar_L50_rA:
6.00000000000
# selpar_slope_rA:
2.00000000000
# selpar_L50_mm:
6.50572035679
# selpar_slope_mm:
2.87954459621
# log_q_cL:
-8.29081470063
# log_q_mm:
-7.86705624442
# q_rate:
0.00000000000
# q_DD_beta:
0.00000000000
# q_RW_log_dev_cL:
 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000
 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000
# log_avg_F_cL:
-3.80783530467
# log_F_dev_cL:
 -4.59655736403 -4.66106419855 -5.83949740623 -2.69753404856 -4.37692739445 -3.52173766286 -4.01865677468 -4.22659512960 -3.54720730641 -2.93503974723
 -3.45598459230 -2.20478270212 -1.38378343753 -0.836309238653 -0.861686365405 -1.58490175372 -1.19603228876 -0.973021891649 -0.513634100058 1.03765238433
 2.53513139357 2.29006195136 2.11271119260 2.21237684895 2.41575016704 1.09332487443 1.67629264444 2.21754317588 2.32168947185 2.49865321467 2.68726714937
 2.74736632659 2.52352479324 2.36383043128 1.71740517187 1.74822729090 1.71309229627 1.99238382604 2.37957927447 1.95696319894 1.94555135161 1.42380776618
 1.35331960929 1.19071077619 1.10333744347 0.482764705732 0.532563343487 0.516241344617 0.641829984148
# log_avg_F_cH:
-5.66755454673
# log_F_dev_cH:
 -4.56848444793 -4.63306059481 -5.81153673778 -2.66963262864 -4.34901687975 -3.49386031109 -3.99078612565 -4.19873865869 -3.51937906050 -2.90724554503
 -3.42818283832 -2.17707165539 -1.35622737468 -0.800281685305 -0.777485665334 -0.613723150619 0.660399909124 0.173305958989 1.16528973992 2.04241164146
 2.84501014841 2.32406579776 2.27862579131 2.17608346636 2.29417054482 0.664790225911 1.34935451770 2.00721003433 2.02353591257 2.07955489208 2.19823297588
 3.05873606700 2.49752554243 2.24268712883 1.37879143075 1.38159325143 1.15222668803 1.33656968550 1.73626072190 1.52971192565 1.98591723109 0.843558111536
 1.20885295328 1.41731390746 0.293751367909 0.650763928420 0.208480211780 -0.0115266607232 0.101458310649
# log_avg_F_rA:
-5.43119021657
# log_F_dev_rA:
 -2.59958132084 -5.49796051182 -0.0247441285473 -1.31367263576 3.04672932985 -1.79399790138 -2.55289696556 0.688670770911 -4.92956649494 -1.64031100474
 -1.44923658102 1.57780145349 -4.24724261292 2.05091714335 -4.39144134947 0.854802471389 3.00091092697 -0.248982340784 1.54619791995 2.17343755573
 3.23278069387 2.58753458326 3.47782713471 1.62830098374 2.74840873964 2.49885176548 0.674569537704 -5.47746929506 2.49384916882 1.88551296398
# F_init:
0.0100000000000
```

Appendix C ASPIC Output: Results of production model run for tilefish.

```
Tilefish - June, 2011 - SEDAR 25 AW                                                                                  Page 1
                                                                                         Wednesday, 24 Aug 2011 at 13:14:08
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: til1bot.inp
----------------------------------------------------------------------------------------------------------------------------
Operation of ASPIC:  Fit logistic (Schaefer) model by direct optimization with bootstrap.
Number of years analyzed:                      49            Number of bootstrap trials:                              500
Number of data series:                          2            Bounds on MSY (min, max):       2.000E+01     1.000E+03
Objective function:                 Least squares            Bounds on K (min, max):         3.000E+01     5.000E+04
Relative conv. criterion (simplex):     1.000E-08            Monte Carlo search mode, trials:        1         10000
Relative conv. criterion (restart):     3.000E-08            Random number seed:                                4120359
Relative conv. criterion (effort):      1.000E-04            Identical convergences required in fitting:              8
Maximum F allowed in fitting:              10.000


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


CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)
----------------------------------------------------------------------------------------------------------------------------
                                       |
 1  TIL Comm LL logs, Total Landings   |   1.000
                                       |      18
                                       |
 2  TIL MARMAP LL                      |   0.780   1.000
                                       |       4       5
                                       --------------------------------------------------
                                               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)   TIL Comm LL logs, Total Landings         5.710E-01     18     3.569E-02    1.000E+00     1.248E+00        0.897
Loss(2)   TIL MARMAP LL                            1.245E+00      5     4.150E-01    1.000E+00     1.073E-01        0.648
.......................................................................................
TOTAL OBJECTIVE FUNCTION, MSE, RMSE:          1.81607202E+00          1.009E-01    3.176E-01
Estimated contrast index (ideal = 1.0):               0.8706          C* = (Bmax-Bmin)/K
Estimated nearness index (ideal = 1.0):               1.0000          N* = 1 - |min(B-Bmsy)|/K
Tilefish - June, 2011 - SEDAR 25 AW                                                                                 Page 2


MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)
----------------------------------------------------------------------------------------------------------------------------
Parameter                                           Estimate     User/pgm guess    2nd guess    Estimated   User guess

B1/K      Starting relative biomass (in 1962)      6.469E-01          8.000E-01    3.852E-01            1            1
MSY       Maximum sustainable yield                9.650E+02          4.100E+02    4.202E+02            1            1
K         Maximum population size                  7.465E+03          2.050E+03    2.521E+03            1            1
phi       Shape of production curve (Bmsy/K)       0.5000             0.5000            ----            0            1

--------- Catchability Coefficients by Data Series ---------------
```

```
q(1)      TIL Comm LL logs, Total Landings         5.695E-04         5.000E-04    4.750E-02            1            1
q(2)      TIL MARMAP LL                            5.961E-04         5.000E-04    4.750E-02            1            1


MANAGEMENT and DERIVED PARAMETER ESTIMATES (NON-BOOTSTRAPPED)
------------------------------------------------------------------------------------------------------------------------
Parameter                                          Estimate                Logistic formula          General formula

MSY       Maximum sustainable yield                9.650E+02                           ----                     ----
Bmsy      Stock biomass giving MSY                 3.732E+03                            K/2         K*n**(1/(1-n))
Fmsy      Fishing mortality rate at MSY            2.585E-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(2011)/Bmsy                      1.178E+00                           ----                     ----
F./Fmsy   Ratio: F(2010)/Fmsy                      3.692E-01                           ----                     ----
Fmsy/F.   Ratio: Fmsy/F(2010)                      2.708E+00                           ----                     ----

Y.(Fmsy)  Approx. yield available at Fmsy in 2011  1.137E+03                    MSY*B./Bmsy              MSY*B./Bmsy
          ...as proportion of MSY                  1.178E+00                           ----                     ----
Ye.       Equilibrium yield available in 2011      9.343E+02          4*MSY*(B/K-(B/K)**2)     g*MSY*(B/K-(B/K)**n)
          ...as proportion of MSY                  9.682E-01                           ----                     ----

--------- Fishing effort rate at MSY in units of each CE or CC series ---------
fmsy(1)   TIL Comm LL logs, Total Landings         4.540E+02                     Fmsy/q( 1)               Fmsy/q( 1)
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ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)
------------------------------------------------------------------------------------------------------------------------

          Estimated  Estimated   Estimated    Observed       Model   Estimated    Ratio of    Ratio of
     Year     total   starting     average       total       total     surplus      F mort     biomass
Obs  or ID   F mort    biomass     biomass       yield       yield  production     to Fmsy     to Bmsy

  1   1962    0.001  4.829E+03   5.243E+03   3.403E+00   3.403E+00   8.032E+02   2.510E-03   1.294E+00
  2   1963    0.001  5.629E+03   5.954E+03   3.219E+00   3.219E+00   6.210E+02   2.091E-03   1.508E+00
  3   1964    0.000  6.247E+03   6.481E+03   9.993E-01   9.993E-01   4.407E+02   5.964E-04   1.674E+00
  4   1965    0.003  6.687E+03   6.834E+03   2.330E+01   2.330E+01   2.982E+02   1.319E-02   1.791E+00
  5   1966    0.001  6.962E+03   7.065E+03   4.375E+00   4.375E+00   1.957E+02   2.395E-03   1.865E+00
  6   1967    0.001  7.153E+03   7.215E+03   1.036E+01   1.036E+01   1.249E+02   5.553E-03   1.916E+00
  7   1968    0.001  7.268E+03   7.307E+03   6.339E+00   6.339E+00   7.980E+01   3.356E-03   1.947E+00
  8   1969    0.001  7.341E+03   7.366E+03   5.179E+00   5.179E+00   5.068E+01   2.719E-03   1.967E+00
  9   1970    0.001  7.386E+03   7.399E+03   1.027E+01   1.027E+01   3.372E+01   5.368E-03   1.979E+00
 10   1971    0.003  7.410E+03   7.414E+03   1.902E+01   1.902E+01   2.626E+01   9.922E-03   1.985E+00
 11   1972    0.002  7.417E+03   7.423E+03   1.134E+01   1.134E+01   2.170E+01   5.909E-03   1.987E+00
 12   1973    0.005  7.428E+03   7.419E+03   3.973E+01   3.973E+01   2.372E+01   2.072E-02   1.990E+00
 13   1974    0.012  7.412E+03   7.385E+03   9.027E+01   9.027E+01   4.102E+01   4.728E-02   1.986E+00
 14   1975    0.021  7.362E+03   7.318E+03   1.555E+02   1.555E+02   7.437E+01   8.221E-02   1.972E+00
 15   1976    0.021  7.281E+03   7.256E+03   1.517E+02   1.517E+02   1.051E+02   8.088E-02   1.951E+00
 16   1977    0.012  7.234E+03   7.246E+03   8.849E+01   8.849E+01   1.099E+02   4.724E-02   1.938E+00
 17   1978    0.025  7.256E+03   7.222E+03   1.837E+02   1.837E+02   1.215E+02   9.838E-02   1.944E+00
 18   1979    0.024  7.194E+03   7.179E+03   1.701E+02   1.701E+02   1.424E+02   9.165E-02   1.927E+00
 19   1980    0.046  7.166E+03   7.089E+03   3.264E+02   3.264E+02   1.845E+02   1.781E-01   1.920E+00
 20   1981    0.169  7.024E+03   6.622E+03   1.119E+03   1.119E+03   3.836E+02   6.533E-01   1.882E+00
 21   1982    0.695  6.289E+03   4.847E+03   3.371E+03   3.371E+03   8.430E+02   2.690E+00   1.685E+00
 22   1983    0.585  3.761E+03   3.243E+03   1.897E+03   1.897E+03   9.432E+02   2.262E+00   1.008E+00
 23   1984    0.510  2.808E+03   2.574E+03   1.312E+03   1.312E+03   8.710E+02   1.971E+00   7.522E-01
 24   1985    0.548  2.367E+03   2.161E+03   1.184E+03   1.184E+03   7.929E+02   2.120E+00   6.341E-01
 25   1986    0.640  1.976E+03   1.748E+03   1.120E+03   1.120E+03   6.912E+02   2.477E+00   5.293E-01
 26   1987    0.155  1.547E+03   1.753E+03   2.722E+02   2.722E+02   6.926E+02   6.007E-01   4.145E-01
 27   1988    0.241  1.967E+03   2.105E+03   5.069E+02   5.069E+02   7.810E+02   9.315E-01   5.271E-01
 28   1989    0.376  2.242E+03   2.227E+03   8.365E+02   8.365E+02   8.080E+02   1.453E+00   6.005E-01
 29   1990    0.385  2.213E+03   2.190E+03   8.442E+02   8.442E+02   8.002E+02   1.491E+00   5.929E-01
 30   1991    0.430  2.169E+03   2.105E+03   9.055E+02   9.055E+02   7.814E+02   1.664E+00   5.811E-01
 31   1992    0.508  2.045E+03   1.920E+03   9.762E+02   9.762E+02   7.372E+02   1.966E+00   5.479E-01
 32   1993    0.648  1.806E+03   1.601E+03   1.037E+03   1.037E+03   6.493E+02   2.507E+00   4.838E-01
 33   1994    0.644  1.418E+03   1.274E+03   8.202E+02   8.202E+02   5.458E+02   2.491E+00   3.799E-01
 34   1995    0.654  1.144E+03   1.031E+03   6.742E+02   6.742E+02   4.593E+02   2.529E+00   3.064E-01
 35   1996    0.358  9.286E+02   9.729E+02   3.485E+02   3.485E+02   4.374E+02   1.386E+00   2.488E-01
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36	1997	0.371	1.018E+03	1.056E+03	3.921E+02	3.921E+02	4.687E+02	1.436E+00	2.726E-01
37	1998	0.313	1.094E+03	1.166E+03	3.647E+02	3.647E+02	5.085E+02	1.210E+00	2.931E-01
38	1999	0.417	1.238E+03	1.246E+03	5.201E+02	5.201E+02	5.369E+02	1.614E+00	3.317E-01
39	2000	0.651	1.255E+03	1.129E+03	7.354E+02	7.354E+02	4.951E+02	2.520E+00	3.362E-01
40	2001	0.460	1.014E+03	1.008E+03	4.633E+02	4.633E+02	4.509E+02	1.778E+00	2.718E-01
41	2002	0.441	1.002E+03	1.005E+03	4.434E+02	4.434E+02	4.497E+02	1.706E+00	2.684E-01
42	2003	0.259	1.008E+03	1.107E+03	2.864E+02	2.864E+02	4.873E+02	1.001E+00	2.701E-01
43	2004	0.198	1.209E+03	1.358E+03	2.688E+02	2.688E+02	5.740E+02	7.653E-01	3.239E-01
44	2005	0.200	1.514E+03	1.680E+03	3.357E+02	3.357E+02	6.727E+02	7.726E-01	4.057E-01
45	2006	0.228	1.851E+03	2.001E+03	4.571E+02	4.571E+02	7.568E+02	8.837E-01	4.960E-01
46	2007	0.133	2.151E+03	2.410E+03	3.201E+02	3.201E+02	8.422E+02	5.138E-01	5.763E-01
47	2008	0.113	2.673E+03	2.967E+03	3.344E+02	3.344E+02	9.224E+02	4.359E-01	7.162E-01
48	2009	0.108	3.261E+03	3.554E+03	3.827E+02	3.827E+02	9.608E+02	4.165E-01	8.737E-01
49	2010	0.095	3.839E+03	4.126E+03	3.938E+02	3.938E+02	9.525E+02	3.692E-01	1.029E+00
50	2011		4.398E+03						1.178E+00

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RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) TIL Comm LL logs, Total Landings

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	1962	*	2.986E+00	0.0006	3.403E+00	3.403E+00	0.00000	1.000E+00
2	1963	*	3.391E+00	0.0005	3.219E+00	3.219E+00	0.00000	1.000E+00
3	1964	*	3.691E+00	0.0002	9.993E-01	9.993E-01	0.00000	1.000E+00
4	1965	*	3.892E+00	0.0034	2.330E+01	2.330E+01	0.00000	1.000E+00
5	1966	*	4.023E+00	0.0006	4.375E+00	4.375E+00	0.00000	1.000E+00
6	1967	*	4.109E+00	0.0014	1.036E+01	1.036E+01	0.00000	1.000E+00
7	1968	*	4.162E+00	0.0009	6.339E+00	6.339E+00	0.00000	1.000E+00
8	1969	*	4.195E+00	0.0007	5.179E+00	5.179E+00	0.00000	1.000E+00
9	1970	*	4.214E+00	0.0014	1.027E+01	1.027E+01	0.00000	1.000E+00
10	1971	*	4.222E+00	0.0026	1.902E+01	1.902E+01	0.00000	1.000E+00
11	1972	*	4.227E+00	0.0015	1.134E+01	1.134E+01	0.00000	1.000E+00
12	1973	*	4.225E+00	0.0054	3.973E+01	3.973E+01	0.00000	1.000E+00
13	1974	*	4.206E+00	0.0122	9.027E+01	9.027E+01	0.00000	1.000E+00
14	1975	*	4.168E+00	0.0213	1.555E+02	1.555E+02	0.00000	1.000E+00
15	1976	*	4.132E+00	0.0209	1.517E+02	1.517E+02	0.00000	1.000E+00
16	1977	*	4.127E+00	0.0122	8.849E+01	8.849E+01	0.00000	1.000E+00
17	1978	*	4.113E+00	0.0254	1.837E+02	1.837E+02	0.00000	1.000E+00
18	1979	*	4.088E+00	0.0237	1.701E+02	1.701E+02	0.00000	1.000E+00
19	1980	*	4.037E+00	0.0460	3.264E+02	3.264E+02	0.00000	1.000E+00
20	1981	*	3.771E+00	0.1689	1.119E+03	1.119E+03	0.00000	1.000E+00
21	1982	*	2.761E+00	0.6955	3.371E+03	3.371E+03	0.00000	1.000E+00
22	1983	*	1.847E+00	0.5848	1.897E+03	1.897E+03	0.00000	1.000E+00
23	1984	*	1.466E+00	0.5095	1.312E+03	1.312E+03	0.00000	1.000E+00
24	1985	*	1.230E+00	0.5481	1.184E+03	1.184E+03	0.00000	1.000E+00
25	1986	*	9.957E-01	0.6405	1.120E+03	1.120E+03	0.00000	1.000E+00
26	1987	*	9.984E-01	0.1553	2.722E+02	2.722E+02	0.00000	1.000E+00
27	1988	*	1.199E+00	0.2408	5.069E+02	5.069E+02	0.00000	1.000E+00
28	1989	*	1.268E+00	0.3757	8.365E+02	8.365E+02	0.00000	1.000E+00
29	1990	*	1.247E+00	0.3854	8.442E+02	8.442E+02	0.00000	1.000E+00
30	1991	*	1.199E+00	0.4302	9.055E+02	9.055E+02	0.00000	1.000E+00
31	1992	*	1.094E+00	0.5083	9.762E+02	9.762E+02	0.00000	1.000E+00
32	1993	6.230E-01	9.115E-01	0.6480	1.037E+03	1.037E+03	0.38055	1.000E+00
33	1994	6.230E-01	7.254E-01	0.6439	8.202E+02	8.202E+02	0.15223	1.000E+00
34	1995	7.650E-01	5.872E-01	0.6539	6.742E+02	6.742E+02	-0.26448	1.000E+00
35	1996	4.530E-01	5.541E-01	0.3583	3.485E+02	3.485E+02	0.20139	1.000E+00
36	1997	6.100E-01	6.013E-01	0.3713	3.921E+02	3.921E+02	-0.01433	1.000E+00
37	1998	7.120E-01	6.638E-01	0.3129	3.647E+02	3.647E+02	-0.07013	1.000E+00
38	1999	6.370E-01	7.098E-01	0.4173	5.201E+02	5.201E+02	0.10825	1.000E+00
39	2000	6.770E-01	6.428E-01	0.6515	7.354E+02	7.354E+02	-0.05180	1.000E+00
40	2001	6.350E-01	5.741E-01	0.4596	4.633E+02	4.633E+02	-0.10081	1.000E+00
41	2002	5.190E-01	5.724E-01	0.4412	4.434E+02	4.434E+02	0.09797	1.000E+00
42	2003	6.620E-01	6.304E-01	0.2587	2.864E+02	2.864E+02	-0.04891	1.000E+00
43	2004	5.900E-01	7.736E-01	0.1979	2.688E+02	2.688E+02	0.27095	1.000E+00
44	2005	1.060E+00	9.571E-01	0.1998	3.357E+02	3.357E+02	-0.10217	1.000E+00
45	2006	1.325E+00	1.140E+00	0.2285	4.571E+02	4.571E+02	-0.15082	1.000E+00
46	2007	1.907E+00	1.372E+00	0.1328	3.201E+02	3.201E+02	-0.32895	1.000E+00

47	2008	1.997E+00	1.690E+00	0.1127	3.344E+02	3.344E+02	-0.16693	1.000E+00
48	2009	1.849E+00	2.024E+00	0.1077	3.827E+02	3.827E+02	0.09049	1.000E+00
49	2010	2.355E+00	2.350E+00	0.0955	3.938E+02	3.938E+02	-0.00234	1.000E+00

* Asterisk indicates missing value(s).

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RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED) TIL MARMAP LL

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	1962	0.000E+00	0.000E+00	--	*	3.125E+00	0.00000	1.000E+00
2	1963	0.000E+00	0.000E+00	--	*	3.549E+00	0.00000	1.000E+00
3	1964	0.000E+00	0.000E+00	--	*	3.863E+00	0.00000	1.000E+00
4	1965	0.000E+00	0.000E+00	--	*	4.073E+00	0.00000	1.000E+00
5	1966	0.000E+00	0.000E+00	--	*	4.211E+00	0.00000	1.000E+00
6	1967	0.000E+00	0.000E+00	--	*	4.300E+00	0.00000	1.000E+00
7	1968	0.000E+00	0.000E+00	--	*	4.356E+00	0.00000	1.000E+00
8	1969	0.000E+00	0.000E+00	--	*	4.390E+00	0.00000	1.000E+00
9	1970	0.000E+00	0.000E+00	--	*	4.410E+00	0.00000	1.000E+00
10	1971	0.000E+00	0.000E+00	--	*	4.419E+00	0.00000	1.000E+00
11	1972	0.000E+00	0.000E+00	--	*	4.424E+00	0.00000	1.000E+00
12	1973	0.000E+00	0.000E+00	--	*	4.422E+00	0.00000	1.000E+00
13	1974	0.000E+00	0.000E+00	--	*	4.402E+00	0.00000	1.000E+00
14	1975	0.000E+00	0.000E+00	--	*	4.362E+00	0.00000	1.000E+00
15	1976	0.000E+00	0.000E+00	--	*	4.325E+00	0.00000	1.000E+00
16	1977	0.000E+00	0.000E+00	--	*	4.319E+00	0.00000	1.000E+00
17	1978	0.000E+00	0.000E+00	--	*	4.305E+00	0.00000	1.000E+00
18	1979	0.000E+00	0.000E+00	--	*	4.279E+00	0.00000	1.000E+00
19	1980	0.000E+00	0.000E+00	--	*	4.225E+00	0.00000	1.000E+00
20	1981	0.000E+00	0.000E+00	--	*	3.947E+00	0.00000	1.000E+00
21	1982	0.000E+00	0.000E+00	--	*	2.889E+00	0.00000	1.000E+00
22	1983	0.000E+00	0.000E+00	--	*	1.933E+00	0.00000	1.000E+00
23	1984	0.000E+00	0.000E+00	--	*	1.534E+00	0.00000	1.000E+00
24	1985	1.000E+00	1.000E+00	--	9.470E-01	1.288E+00	-0.30738	1.000E+00
25	1986	0.000E+00	0.000E+00	--	*	1.042E+00	0.00000	1.000E+00
26	1987	0.000E+00	0.000E+00	--	*	1.045E+00	0.00000	1.000E+00
27	1988	0.000E+00	0.000E+00	--	*	1.255E+00	0.00000	1.000E+00
28	1989	0.000E+00	0.000E+00	--	*	1.327E+00	0.00000	1.000E+00
29	1990	0.000E+00	0.000E+00	--	*	1.306E+00	0.00000	1.000E+00
30	1991	0.000E+00	0.000E+00	--	*	1.255E+00	0.00000	1.000E+00
31	1992	0.000E+00	0.000E+00	--	*	1.145E+00	0.00000	1.000E+00
32	1993	0.000E+00	0.000E+00	--	*	9.540E-01	0.00000	1.000E+00
33	1994	0.000E+00	0.000E+00	--	*	7.593E-01	0.00000	1.000E+00
34	1995	0.000E+00	0.000E+00	--	*	6.146E-01	0.00000	1.000E+00
35	1996	0.000E+00	0.000E+00	--	*	5.799E-01	0.00000	1.000E+00
36	1997	0.000E+00	0.000E+00	--	*	6.294E-01	0.00000	1.000E+00
37	1998	1.000E+00	1.000E+00	--	1.372E+00	6.947E-01	0.68051	1.000E+00
38	1999	0.000E+00	0.000E+00	--	*	7.429E-01	0.00000	1.000E+00
39	2000	0.000E+00	0.000E+00	--	*	6.728E-01	0.00000	1.000E+00
40	2001	0.000E+00	0.000E+00	--	*	6.009E-01	0.00000	1.000E+00
41	2002	1.000E+00	1.000E+00	--	7.800E-01	5.991E-01	0.26386	1.000E+00
42	2003	0.000E+00	0.000E+00	--	*	6.598E-01	0.00000	1.000E+00
43	2004	0.000E+00	0.000E+00	--	*	8.097E-01	0.00000	1.000E+00
44	2005	0.000E+00	0.000E+00	--	*	1.002E+00	0.00000	1.000E+00
45	2006	1.000E+00	1.000E+00	--	5.500E-01	1.193E+00	-0.77400	1.000E+00
46	2007	0.000E+00	0.000E+00	--	*	1.436E+00	0.00000	1.000E+00
47	2008	0.000E+00	0.000E+00	--	*	1.769E+00	0.00000	1.000E+00
48	2009	0.000E+00	0.000E+00	--	*	2.118E+00	0.00000	1.000E+00
49	2010	1.000E+00	1.000E+00	--	2.820E+00	2.459E+00	0.13697	1.000E+00

* Asterisk indicates missing value(s).

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ESTIMATES FROM BOOTSTRAPPED ANALYSIS

Estimated Estimated Bias-corrected approximate confidence limits Inter-

Param name	Point estimate	bias in pt estimate	relative bias	80% lower	80% upper	50% lower	50% upper	quartile range	Relative IQ range
B1/K	6.469E-01	-1.157E-02	-1.79%	6.061E-01	6.706E-01	6.317E-01	6.581E-01	2.646E-02	0.041
K	7.465E+03	2.548E+02	3.41%	7.316E+03	8.147E+03	7.316E+03	7.723E+03	4.064E+02	0.054
q(1)	5.695E-04	-3.494E-05	-6.14%	4.763E-04	6.947E-04	5.377E-04	6.480E-04	1.103E-04	0.194
q(2)	5.961E-04	-2.485E-05	-4.17%	4.745E-04	7.952E-04	5.400E-04	7.156E-04	1.756E-04	0.295
MSY	9.650E+02	-2.489E+01	-2.58%	8.935E+02	9.825E+02	9.362E+02	9.825E+02	4.627E+01	0.048
Ye(2011)	9.343E+02	-3.577E+01	-3.83%	8.776E+02	9.819E+02	9.190E+02	9.766E+02	5.758E+01	0.062
Y.@Fmsy	1.137E+03	-4.376E+01	-3.85%	9.937E+02	1.327E+03	1.083E+03	1.264E+03	1.814E+02	0.160
Bmsy	3.732E+03	1.274E+02	3.41%	3.658E+03	4.074E+03	3.658E+03	3.861E+03	2.032E+02	0.054
Fmsy	2.585E-01	-1.345E-02	-5.20%	2.194E-01	2.686E-01	2.425E-01	2.686E-01	2.604E-02	0.101
fmsy(1)	4.540E+02	1.309E+01	2.88%	3.874E+02	5.252E+02	4.184E+02	4.875E+02	6.912E+01	0.152
fmsy(2)	4.337E+02	9.368E+00	2.16%	3.473E+02	5.272E+02	3.851E+02	4.792E+02	9.409E+01	0.217
B./Bmsy	1.178E+00	-1.590E-02	-1.35%	1.022E+00	1.357E+00	1.105E+00	1.286E+00	1.809E-01	0.154
F./Fmsy	3.692E-01	2.031E-02	5.50%	3.121E-01	4.260E-01	3.280E-01	3.907E-01	6.269E-02	0.170
Ye./MSY	9.682E-01	-1.245E-02	-1.29%	8.749E-01	9.978E-01	9.226E-01	9.885E-01	6.599E-02	0.068
q2/q1	1.047E+00	2.796E-02	2.67%	8.448E-01	1.250E+00	9.215E-01	1.141E+00	2.198E-01	0.210

```
INFORMATION FOR REPAST (Prager, Porch, Shertzer, & Caddy. 2003. NAJFM 23: 349-361)
-----------------------------------------------------------------------------------------------------------------------
Unitless limit reference point in F (Fmsy/F.):              2.708
CV of above (from bootstrap distribution):                  0.1290


NOTES ON BOOTSTRAPPED ESTIMATES:
-----------------------------------------------------------------------------------------------------------------------
- Bootstrap results were computed from 500 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:              112
Trials replaced for q out-of-bounds:          0
Trials replaced for K out-of-bounds:          0          Residual-adjustment factor:                      1.1304

Elapsed time: 0 hours, 1 minutes, 14 seconds.
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SEDAR

Southeast Data, Assessment, and Review

SEDAR 25

South Atlantic Tilefish

SECTION IV: Research Recommendations

October 2011

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

Section IV: Research Recommendations

Contents

Data Workshop Research Recommendations

Life History

- Investigate the movements and migrations of Tilefish using Otolith microchemistry
- Investigate the stock definition through genetic studies to establish if biogeographic boundary exists at Cape Hatteras or if future assessments will use the NC/VA border.
- Fishery-dependent and fishery-independent sampling to include the entire Southeast Region throughout a longer time period.
- Analyze size or age specific spawning frequency and spawning seasonality.

Commercial Statistics

- The Commercial Workgroup recommends exploration of the definition of the stock, particularly with respect to the northern boundary.
- Additionally, the group would suggest examining the impact/landings of the historical foreign fleet in the South Atlantic.
- Finally, collection of better spatial information in the fishery to determine potential localized depletion effects is recommended.

Recreational Statistics

- Continue development of standardized method for calculating incomplete weight data
- Develop method for capturing depth at capture within MRFSS At-Sea observer program and Headboat Survey.
- Conduct study looking at current compliance rates in logbook programs, develop recommendations for improving them, including increased education directed toward effect of not reporting accurately.
- Continued development of electronic reporting of headboat logbook for full implementation
- Continued development of higher degree of information of condition of released fish e.g. FL as the model

Indices

- None provided.

Assessment Workshop Research Recommendations

- The assessment panel made the following recommendations.
- Increasing the number of age samples collected from the main part of the species' range
- Investigate reproductive characteristics, particulary regarding whether senescence or hermaphrodism occurs in the species
- Improve the genetic data available by conducting studies of gene similarities by region
- Investigate whether a climate-recruitment link exists
- Investigate whether time varying M may be appropriate for tilefish
- Evaluate patterns in ageing error at the data workshop including development of an ageing error matrix
- Obtain MRIP intercept numbers at the DW for tilefish and other rarely caught species

Review Workshop Research Recommendations

The RP was in agreement with the research recommendations from the Data Workshop and Assessment Workshop reports. These identify the main shortcomings in the data and assessment which might be improved by research. However, the recommendations are extensive and some priority may be placed so that research having the greatest impact on the assessment might be given the greatest priority.

High Priority

Life history: There are a number of uncertainties over the life history of this species which are critical in setting up reliable age-structured stock assessment models. Some of this basic information is lacking, such as whether the species exhibits hermaphroditism. For example, in the Gulf of Mexico tilefish assessment (SEDAR 22), protogynous hermaphroditism was included in the model, whereas in this assessment it was not. Any studies that improve understanding of size or age specific spawning frequency, spawning seasonality, and functions modeling sex change should be given high priority, particularly because they are critical in defining SSB and therefore stock status.

Movement: Several recommendations relate to fish movement. The RP recommends research on local population structure related to residence times and local migration, whether by tagging or alternative methods. Understanding fish movement should help understand how catches might cause local depletion and over what area. This could lead to improved data collection and use of spatial data in tractable way within the model.

Indices: Abundance indices are usually the main information drivers in the stock assessments in these fisheries. The RP recommends developing a fishery independent index, which eventually would greatly improve the determination of stock status. Also, local absolute stock size estimates might be obtained from underwater video surveys (e.g. counting fish burrows), tagging, depletion fishing experiments within a small area, or some combination of these three. Estimating absolute biomass should be done in a way which is informative on catchability and selectivity in the model (could be included as a prior, for example). This last method may be particularly suitable for tilefish, which is probably a relatively sedentary species.

Medium Priority

Stock structure: A number of research recommendations by the DW and AW indicate possible ways to improve definitions of stock structure (e.g. genetic analyses). The RP found no very significant problem with this issue in this assessment. However, it may be that tilefish could be included in a wider program looking at stock structure of a variety of species which perhaps could also include Gulf of Mexico as well as the southern North Atlantic.

Recreational Statistics: The RP believed that research recommendations with the objective of improving recreational statistics would most likely have limited impact on the tilefish stock assessment, and hence these only have medium priority. However, any program to improve recreational fishery data is likely to cover a wide number of other stocks where such data may be more critical. Therefore, any such program as a whole may be given high priority.

Low Priority

The Commercial Statistics working group suggested examining the impact of the historical foreign fleet. However, the RP believed that the impact of any activities on tilefish would be low, obtaining data would be difficult and could be unsuccessful.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 25

South Atlantic Tilefish

SECTION V: Review Workshop Report

October 2011

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

Section V: Review Workshop Report

Table of Contents

1 Introduction

1.1 Workshop Time and Place

The SEDAR 25 Review Workshop was held October 11-13, 2011, in North Charleston, SC.

1.2 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 TBD.

* 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

Appointee	Function	Affiliation
REVIEW PANEL		
Anne Lange	Review Panel Chair	SAFMC SSC
Michael Bell	Reviewer	CIE
Jim Berkson	Reviewer	SAFMC SSC
Steve Cadrin	Reviewer	SAFMC SSC
Paul Medley	Reviewer	CIE
Michael Smith	Reviewer	CIE
ASSESSMENT WORKSHOP REPRESENTATIVES		
Kyle Shertzer	Lead analyst, BSB	SEFSC Beaufort
Erik Williams	Lead analyst, GT	SEFSC Beaufort
Rob Cheshire	Data compiler, GT	SEFSC Beaufort
Eric Fitzpatrick	Data compiler, BSB	SEFSC Beaufort
Kate Andrews	Assessment team, GT	SEFSC Beaufort
Kevin Craig	Assessment team, BSB	SEFSC Beaufort
COUNCIL REPRESENTATIVES		
Tom Burgess	Council member	SAFMC
Ben Hartig	Council member	SAFMC
STAFF & AGENCY		
Kari Fenske	Coordinator	SEDAR
Rachael Silvas	Administrative assistant	SEDAR
Tyree Davis	IT support	SEFSC Miami
Myra Brouwer		SAFMC
John Carmichael		SAFMC
Brian Cheuvront		SAFMC
Mike Errigo		SAFMC
Julie Neer		SEDAR
Bonnie Ponwith		SEFSC Miami
Jessica Stephen		SERO
Gregg Waugh		SAFMC
OBSERVERS		
Joey Ballenger		
Peter Barile		
Rusty Hudson		
Marcel Reichert		
Helen Takade-Heumacher		
Renzo Tascheri		
Tracey Smart		

1.4 List of Review Workshop Working Papers & Documents

Documents Prepared for the Review Workshop		
SEDAR25-RW01	Comments and notes received during the data, assessment and review for SEDAR 25	Multiple authors
SEDAR25-RW02	Comments and notes received during the assessment and review for SEDAR 25	Multiple authors
SEDAR25-RW03	The Beaufort Assessment Model (BAM) with application to black sea bass: model description, implementation details, and computer code	Sustainable Fisheries Branch, NMFS 2011
SEDAR25-RW04	The Beaufort Assessment Model (BAM) with application to tilefish: model description, implementation details, and computer code	Sustainable Fisheries Branch, NMFS 2011
SEDAR25-RW05	Development and diagnostics of the Beaufort assessment model applied to black sea bass	Sustainable Fisheries Branch, NMFS 2011
SEDAR25-RW06	Development and diagnostics of the Beaufort assessment model applied to tilefish	Sustainable Fisheries Branch, NMFS 2011
SEDAR25-RW07	Use of MARMAP age compositions in SEDAR 25 – Methods of addressing sub-sampling concerns from SEDAR 2 and SEDAR 17	Ballenger, Reichert, and Stephen, 2011
SEDAR25-RW08	Fisheries management actions confound the ability of the Beaufort Assessment Model (BAM) to explain dynamics of the Golden Tilefish fishery off of east Florida	Hull and Barile, 2011
SEDAR25-RW09	A note on the use of flat-topped selectivity curves in SEDAR 25	Hull and Hester, 2011
SEDAR25-RW10	On steepness	Hull and Hester, 2011
SEDAR25-RW11	Some considerations of area interactions	Hull and Hester, 2011

2. Review Panel Report

The South Atlantic tilefish stock assessment presented by the SEDAR 25 Assessment Workshop (AW) provided the Review Panel (RP) with outputs and results from two statistical assessments models. 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 RP concludes that the stock is not overfished and not subject to overfishing. The current level of spawning stock biomass (SSB_{2010}) is estimated to be well above MSST (SSB_{2010}/MSST = 2.43), and the current level of fishing is slightly higher than one-third of F_{MSY} ($F_{2008\text{-}2010}/F_{MSY}$ = 0.36). Both estimates appear robust across Monte Carlo/bootstrap (MCB) trials and sensitivity analyses, however it should be noted that the base run tended to result in high SSB_{2010}/MSST and low $F_{2008\text{-}2010}/F_{MSY}$ values relative to the central tendency of values from both the MCB runs (i.e. the base run does not equal the mode or the mean of the MCB values) and the sensitivity analyses. However, there were significant areas of uncertainty identified both in the data and in components of the model. The most significant sources of this uncertainty include the lack of a reliable fishery independent index of abundance, and the spawner-recruit relationship (e.g. steepness could not be estimated reliably). Results of the ASPIC model qualitatively agreed with those of the BAM model.

The terms of reference from the Data Workshop (DW) and AW were met.

2.1. Terms of Reference

2.1.1. Evaluate the adequacy, appropriateness, and application of data used in the assessment.

Stock definition for South Atlantic tilefish remains unchanged from SEDAR 4, extending from the North Carolina/Virginia border in the north to the Florida Keys in the south. The RP noted that the northern boundary is confirmed by a recent assessment for the Mid-Atlantic/Southern New England stock indicating slower growth and later sexual maturity to the north of this location. The RP supported the choice of updated values for several life-history parameters underlying the assessment. These included modeling natural mortality as an inverse function of length, scaled to a higher value than previously used based on downward revision of age determinations since SEDAR4. Growth appears to vary between males and females, but lack of data on sex composition of catches dictated the use of a combined sex growth curve for most purposes. Also for this reason, population sex ratios were treated as fixed at 50:50. Spawning biomass was measured in terms of female gonad weight. Paucity of data on immature fish precludes calculation of a parametric maturity ogive for female tilefish and the RP accepted the use of assumptions about maturity at age recommended from the DW, based on limited data.

Tilefish landings are dominated by the commercial longline fleet, with some handline landings and a small proportion contributed by recreational fishing. The RP supported separate treatment of these three fleets in the assessment. Data on length and age composition of landings were incorporated in the age-based BAM model. Data were selected for inclusion avoiding double counting of fish that were both aged and measured but giving primacy to age compositions. Two abundance indices were developed for the assessment. Standardized CPUE from the commercial longline fleet provided the most information (1993 onwards). A fishery-independent index based on MARMAP longline data provided data back to the mid-1980s, but small sample sizes led to low confidence in estimates for individual years. The RP supported the use of 4-year blocks (2-year block for the most recent two years) for inclusion of the MARMAP indices in the assessment models. Some conflicts about trends in stock abundance were seen between the commercial longline and MARMAP indices. The RP noted that the bulk of the fishery occurs off north Florida, well represented in the commercial longline index, whereas MARMAP data pertain to the Carolinas, north of most of the fishery. This disparity possibly accounts partly for differences in trend between the indices. Little is otherwise known about the spatial distribution of the fishery and the stock. Fishery logbook data do not provide good spatial definition, being based on 10 minute blocks. Limited tagging data suggest little movement of adults, but there is generally a lack of information on movement and migration.

Overall, the RP concluded that, whilst there are limitations in what is known about tilefish life-history, and limited data from which to draw conclusions about stock trends, such data as are available have been used appropriately and the assessment makes best use of them.

2.1.2. Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.

The BAM was used as the principal assessment method. It is an age-structured population assessment model implemented using ADMB. This permitted the use of all available types of data, including total annual landings and discards, age and length compositions, and indices of biomass abundance.

The model was fitted to the data using appropriate methods. The model uses lognormal likelihood to fit to abundance indices and catches, and the multinomial likelihood to fit to compositions. The fitting criterion was a penalized likelihood approach, with additional penalty functions to avoid unrealistic results and give higher weight to abundance indices. These penalties generally only applied during some of the Monte Carlo simulations and avoided numerical errors.

Not all data series were complete for the assessment time period and some data were not used. Where data were absent, such as landings or discards data missing from some fleets early in the time series, reasonable decisions were made in filling these gaps to allow the model to fit. Where age and length composition data occurred in the same stratum, only the age data were used to avoid “double counting” the same sample.

The treatment of the data and the relative importance given to the various components were appropriate:

- The landings and discards are fitted very closely (effectively exactly), because they are measured with relatively high accuracy.
- Annual CVs for the landings and discard components were fixed small values, and for the annual values abundance indices were derived from the delta-lognormal GLM used to standardise the indices.
- The effective multinomial observation variance was based on sample size as number of trips rather than numbers of individual fish measured, because fish within the same trip are not independent.
- The weights between the likelihood components were fitted using an iterative scheme, but which actively maintained appropriate fits to the indices and did not allow the compositions to dominate the likelihood.

The model structure was adequate to capture the main patterns in the data:

- Selectivity was modelled as a logistic function of age. The RP discussed the possibility of dome-shape selectivity, but no mechanism for dome-shaped selectivity was identified (e.g. gear, selectivity, spatial availability or ontogenetic movement of exploited sizes).
- Model estimates of abundance indices were conditional on selectivity of the corresponding fleet or survey and were computed from abundance or biomass (as appropriate) at the midpoint of the year.
- For the base model, time invariant catchability was assumed within blocks, although some reasonable alternative sensitivity scenarios were considered where catchability was allowed to change.
- Uncertainty in model results was evaluated using sensitivity analyses and Monte Carlo bootstraps.

Some improvements in the model might be possible in future. For example, lengths might be fitted within the model conditional upon age in those cases where both age and length are present. However, it is not expected that such improvements would have significant impact of the model results.

While there might be other important processes in the stock dynamics, such as spatial changes (e.g. local depletion), there are not sufficient data to support including these in the stock assessment at this time.

The RP concluded that the BAM was appropriate for the data and adequate for providing management advice.

An alternative biomass dynamics stock assessment was carried out using the software ASPIC. Biomass dynamics models require fewer parameters and fit only to the total catch weight and abundance indices. This assessment also used a bootstrap to characterize uncertainty, but considered fewer sources of uncertainty than the BAM model and thus provided narrower confidence intervals around estimates.

The biomass dynamics model was considered as a confirmatory analysis, because the BAM alternative made effective use of additional data and represented a more detailed investigation of population dynamics. However, the ASPIC model provided a useful comparison with the BAM results, which it broadly supports, showing the similar status of the stock in relation to MSY benchmarks.

2.1.3. Recommend appropriate estimates of stock abundance, biomass, and exploitation.

The RP accepted estimates from the base run of the BAM as final estimates of spawning stock biomass (SSB – measured in terms of gonad weight) and fishing mortality (F). The assessment indicated that SSB_{2010} was substantially higher than SSB_{MSY} (and therefore also substantially higher than MSST) and $F_{2008\text{-}2010}$ was substantially lower than F_{MSY}. It was noted, however, that expressed on a relative scale these estimates were optimistic compared with the central tendency of estimates from uncertainty (MCB) runs. The same applies in relation to the outcomes of sensitivity analyses, but it is worth noting that not all sensitivity runs should be considered as valid alternatives to the base run.

A biomass dynamic assessment (ASPIC) based on the same indices and landings data generated the same general pattern of relative outcomes as the BAM base model run, although the absolute estimates differ. Given the broad level of consistency also between the base run and sensitivity runs in terms of the relative positions of estimates and reference points (differences in central tendency notwithstanding), the RP concurred that SSB_{2010} was likely above SSB_{MSY} and MSST and $F_{2008\text{-}2010}$ was likely below F_{MSY}, but absolute values of biomass, fishing mortality and their reference points remain uncertain (see 2.1.4).

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 RP supports the approach of estimating MSY reference points and derived management benchmarks using equilibrium expectations derived from the base model (BAM).

- MSY=638k lb whole weight
- F_{MSY}=0.185
- B_{MSY}=2918mt=6.4M lb whole weight
- SSB_{MSY}=25.3mt gonad weight
- MSST=22.6mt gonad weight

Several aspects of reference point estimation were discussed related to estimates of steepness and comparison to the biomass dynamics model.

F_{MSY} is largely determined by steepness of the stock-recruitment relationship. Steepness could not be freely estimated, largely because of the estimate of strong recruitment produced at low stock size (though the strong recruitment is not consistently supported in the age composition data). Therefore, steepness was assumed to be 0.84 based on a meta-analysis of fishes with similar life histories. The AW explored several alternatives in an attempt to estimate steepness, including increasingly greater weights on the prior distribution of steepness from the meta-analysis and increasing weights on the stock-recruitment penalty function to force the estimate of 2000 yearclass to be less of a positive deviation. Sensitivity analyses with increased penalties were rejected by the AW because those models did not fit the commercial longline index well. (see Section 2.2)

Relative stock status (F/F_{MSY} and B/B_{MSY}) is generally consistent between the age-based assessment and a biomass dynamics model (ASPIC). However, absolute reference points and population estimates were less consistent: ASPIC had greater MSY (965k lb), greater F_{MSY} (0.26) and lower B_{MSY} (3.7M lb) estimates (see Section 2.2). The Review Workshop agreed that the age-based analysis (BAM) provided more informative reference point estimates than the biomass dynamics model, but relative stock status may be more reliable than absolute estimates for both models.

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).

The MCB methodology for carrying out projections for tilefish involved generating a large number of replicate projections by sampling from the MCB assessment runs, in each case stochastically projecting forward the terminal populations at age and fishing mortality.

The MCB incorporated stochasticity on natural mortality, stock recruit parameters, selectivity curves and abundance at age (for ages >7). Variability was added to ages 2-7 of the initial population numbers because the assessment assumed no recruitment deviation for years 2004-2010. Recruitment variation was provided by randomly sampling multiplicative residuals from the SR fit for each MCB run and applying them to the SR fit expected values. Initial populations were the point estimates for 2010 abundance at age and fishing mortality was the geometric mean of the last 3 years of the assessment period (2008-2010). Management consisted of 5 fixed F scenarios (F_{MSY}, $F_{current}$, 65%F_{MSY}, 75%F_{MSY} and 85%F_{MSY}) applied from 2012 to 2030 and the intermediate year (2011) was projected forward using current F (0.067).

The RP agreed that the MCB approach as outlined in the report is rational and appropriate, constituting current best practice and providing a good basis for projection. However, the RP also agreed with the assessment experts that the plausibility of the exceptionally strong 2000 year class was questionable and that this model estimate may reflect several stronger year classes and/or ageing errors rather than a single dominant year class.

The RP asked whether the sampling of recruitment residuals resulted in uncharacteristically large recruitments being carried forward into the projection. It was pointed out that highly skewed CIs for recruitment and other output variables suggested this was the case but that the nonparametric approach had nevertheless been considered more appropriate given the poor SR fit.

The RP agreed that despite some issues with the SR relationship the projections provided appropriate estimates of future stock condition.

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.

MCB was carried out using the BAM base run. A penalty function was added to the likelihood to limit the number of runs tending to unreasonably high fishing mortality (F>1.0). Observed data for landings, discards and abundance indices were bootstrapped parametrically by applying multiplicative lognormal errors based on their CVs. Uncertainty in age and length compositions was provided by randomly sampling (with replacement) fish from the original data using the sample cell probabilities following a multinomial process. The number of fish drawn was the same as in the original data for each year and data source and the effective sample size (number of trips) was retained. Fixed input parameters (natural mortality, weightings on abundance indices and the SR steepness parameter) were drawn at random from distributions derived by Monte Carlo simulation and centered around the base run fixed input values. The distribution for natural mortality consisted of a truncated normal, weightings for indices were drawn from a uniform distribution and the SR steepness parameter was drawn from a beta distribution and the SR steepness parameter was drawn from a beta distribution. A more detailed specification is provided in the AW report.

Twenty four sensitivity runs were carried out to investigate alternative BAM model configurations including alternative values for M, steepness, model weightings, catchability increasing through time, removal of each abundance index, splitting selectivity in various years, time varying L50 for selectivity, a random walk in commercial longline catchability and removing longline age compositions in 2004-2006. Eight of the sensitivity runs were retrospective analyses sequentially removing data back to 2003.

Results from the sensitivity runs were all qualitatively similar to the base run, indicative of overfishing not occurring and the stock not being overfished. However, the base run was with one exception the most optimistic of the sensitivity runs. This concurs with results from the MCB analysis, the central tendency of which showed lower SSB_{2010} estimates relative to MSST and higher $F_{2008\text{-}2010}$ estimates relative to F_{MSY} compared with the base run. Retrospective analyses did not indicate strong bias associated with the most recent data points.

The RP agreed that the MCB approach as outlined in the report provided a rational and appropriate method for estimating and quantifying uncertainty in the assessment output metrics and projections. The report recognized that this will not acknowledge all sources of uncertainty and that possible covariances between input random variables may not be accounted for.

A series of sensitivity runs examining the impacts of different model configurations provided a comparative analysis of structural uncertainty in model outputs. Outputs presented included terminal status estimates (tabulated and SSB/MSST versus F/F_{MSY} phase plot) and the recruitment time series.

The use of two different models (ASPIC and BAM) provided a further comparison between different population dynamics models applied to very similar data.

The RP noted some inconsistencies and uncertainties including:

i) the exceptional 2000 year class, which both the RP and assessment experts felt was questionable and possibly related to several strong year classes and aging errors,

ii) the probability density distribution for the stock recruitment parameter, R0, indicated that R0 was substantially biased from the mode, whilst the steepness parameter needed to be fixed *a priori* for the base run,

iii) modes of probability density distributions for MSY benchmarks also tended to depart from the deterministic values, in particular F_{MSY} where the mode was substantially below the point estimate,

iv) the MCB phase plot (Fig 3.26) showed that although the majority of runs fell in the SSB>MSST and $F<F_{MSY}$ region, a significant proportion also fell in the over-fishing region and many of these also indicated that SSB was over-fished. The base run estimate was not central to the MCB distribution, being optimistic for both SSB and F.

v) the sensitivity runs also indicated that the base run was optimistic in relation to other BAM configurations, although deterministic outputs for all runs were in the SSB>MSST and F<FMSY region.

vi) ASPIC produced qualitatively similar results, but with narrow CIs on biomass and F relative to MSY reference points.

The RP commented on the difficulties with fitting the stock recruitment relationship and asked about the attempts made by the AW to fit the steepness parameter. They requested that the SR penalty be increased to evaluate the sensitivity to this. This output was produced (Table 1, Section 2.2) and showed that increasing the SR weighting resulted in a deterioration in the likelihoods for fitting the commercial longline abundance index and to a lesser extent the commercial longline age compositions.

The RP discussed the ability of the BAM to support a P* approach to setting ABC or OFL and concluded that the MCB provided a characterization of the uncertainty as a whole and was suitable.

The RP commented that the SR curve was rather flat and asked for a comparison of productivity between the BAM and ASPIC models. The lead assessor undertook additional analyses showing comparative production curves for the two models (see Section 2.2). Both these are to some extent predicated by assumptions regarding initial biomasses, set close to unfished levels in both cases, and functional forms of models, with ASPIC having a fixed functional form (logistic), while the BAM is driven by the Beverton and Holt SR function. Although they produce different absolute outputs they are similar in terms of status relative to MSY reference points.

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 RP recommendations.

The RP felt that the workshop reports were extremely well organized, clear and concise. The consistency of format among the two SEDAR 25 assessments and previous SEDAR assessments helped to make the review more efficient. Data and assessment methods and decisions were clearly documented, and the reports help to achieve a transparent process. In addition, the summary indicating whether each of the TOR were met or not, which appeared in the AW report was extremely helpful. The RP recommends the continuation of this section in future AW reports and the addition of this section to future DW reports.

2.1.8. 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.

The RP found the SEDAR process to be highly effective as structured for the tilefish and black sea bass assessments. The DW addressed all of its terms of reference with the exception of providing maps of fishery effort and harvest for commercial catch statistics and recreational catch statistics, due to insufficient time. The AW addressed all of its terms of reference.

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 RP was in agreement with the research recommendations from the Data Workshop and Assessment Workshop reports. These identify the main shortcomings in the data and assessment which might be improved by research. However, the recommendations are extensive and some priority may be placed so that research having the greatest impact on the assessment might be given the greatest priority.

High Priority

Life history: There are a number of uncertainties over the life history of this species which are critical in setting up reliable age-structured stock assessment models. Some of this basic information is lacking, such as whether the species exhibits hermaphroditism. For example, in the Gulf of Mexico tilefish assessment (SEDAR 22), protogynous hermaphroditism was included in the model, whereas in this assessment it was not. Any studies that improve understanding of size or age specific spawning frequency, spawning seasonality, and functions modeling sex-change should be given high priority, particularly because they are critical in defining SSB and therefore stock status.

Movement: Several recommendations relate to fish movement. The RP recommends research on local population structure related to residence times and local migration, whether by tagging or alternative methods. Understanding fish movement should help understand how catches might cause local depletion and over what area. This could lead to improved data collection and use of spatial data in tractable way within the model.

Indices: Abundance indices are usually the main information drivers in the stock assessments in these fisheries. The RP recommends developing a fishery independent index, which eventually would greatly improve the determination of stock status. Also, local absolute stock size estimates might be obtained from underwater video surveys (e.g. counting fish burrows), tagging, depletion fishing experiments within a small area, or some combination of these three. Estimating absolute biomass should be done in a way which is informative on catchability and selectivity in the model (could be included as a prior, for example). This last method may be particularly suitable for tilefish, which is probably a relatively sedentary species.

Medium Priority

Stock structure: A number of research recommendations by the DW and AW indicate possible ways to improve definitions of stock structure (e.g. genetic analyses). The RP found no very significant problem with this issue in this assessment. However, it may be that tilefish could be included in a wider program looking at stock structure of a variety of species which perhaps could also include Gulf of Mexico as well as the southern North Atlantic.

Recreational Statistics: The RP believed that research recommendations with the objective of improving recreational statistics would most likely have limited impact on the tilefish stock assessment, and hence these only have medium priority. However, any program to improve recreational fishery data is likely to cover a wide number of other stocks where such data may be more critical. Therefore, any such program as a whole may be given high priority.

Low Priority

The Commercial Statistics working group suggested examining the impact of the historical foreign fleet. However, the RP believed that the impact of any activities on tilefish would be low, obtaining data would be difficult and could be unsuccessful.

Ultimately the interval between the current and next assessment is a policy decision, requiring scientific input. The Peer RP wants to highlight scientific factors that should be taken into consideration when making this decision. The current tilefish assessment indicates the stock is not overfished and not undergoing overfishing, and has experienced high levels of recruitment in one or more recent years. This indicates the stock is likely not in need of a new benchmark assessment in the short term, in the absence of changes to management actions. No new data sources are expected to be available, at least in the short term, limiting the utility of conducting a new benchmark assessment in the short term.

If management actions change, conducting a new assessment after their implementation has the potential to identify the impacts of the new management actions on the stock, as well as better identify the stock's dynamics. A new assessment could provide improved information on benchmarks such as MSY or status indicators such as B/B_{MSY}.

The RP recommends that assessment updates be conducted to regularly, at the interval of a low-risk stock, or more often in response to changes in management regulations. If an update assessment indicates the stock's status is declining or new data become available, the RP recommends moving forward with a full benchmark 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 Peer Review Summary Report no later than October 28, 2011.

This report constitutes the RP's summary evaluation of the tilefish stock assessment and discussion of the Terms of Reference. The RP will complete edits to its report and submit to SEDAR by 10/28/11.

2.2. Summary Results of Analytical Requests *(Sensitivities, corrections, additional analyses etc)*

The SEDAR 25 RP requested additional information from the tilefish stock assessment. Specifically, they requested, (1) a comparison of the BAM and ASPIC model estimates and (2) an analysis of the effects of increasing weight on the stock-recruit deviation likelihood component on the model fit for the BAM model.

Item (1) was addressed by providing the RP with graphic model results as shown in Figures 1-3 (see below). These figures indicate that although the absolute values of biomass and F differ (Figures 1 and 2) in magnitude, both the trend and relative measures with respect to the benchmarks were similar (Figure 3).

Figure 1. Comparison of BAM and ASPIC annual estimates of biomass (1000 mt) and fishing mortality (yr^{-1}).

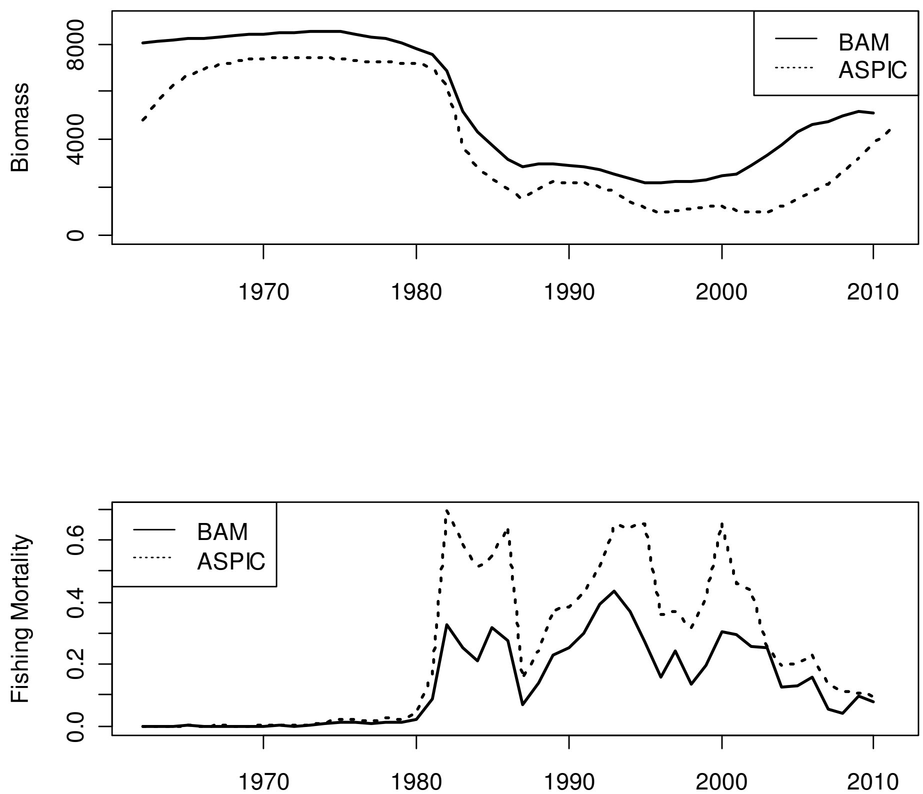


Figure 2. Comparison of BAM and ASPIC annual estimates of F/F_{MSY}.

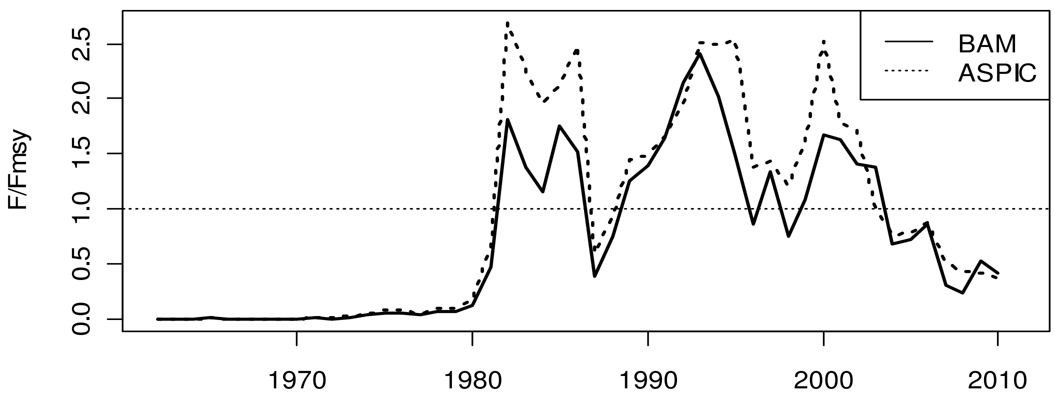
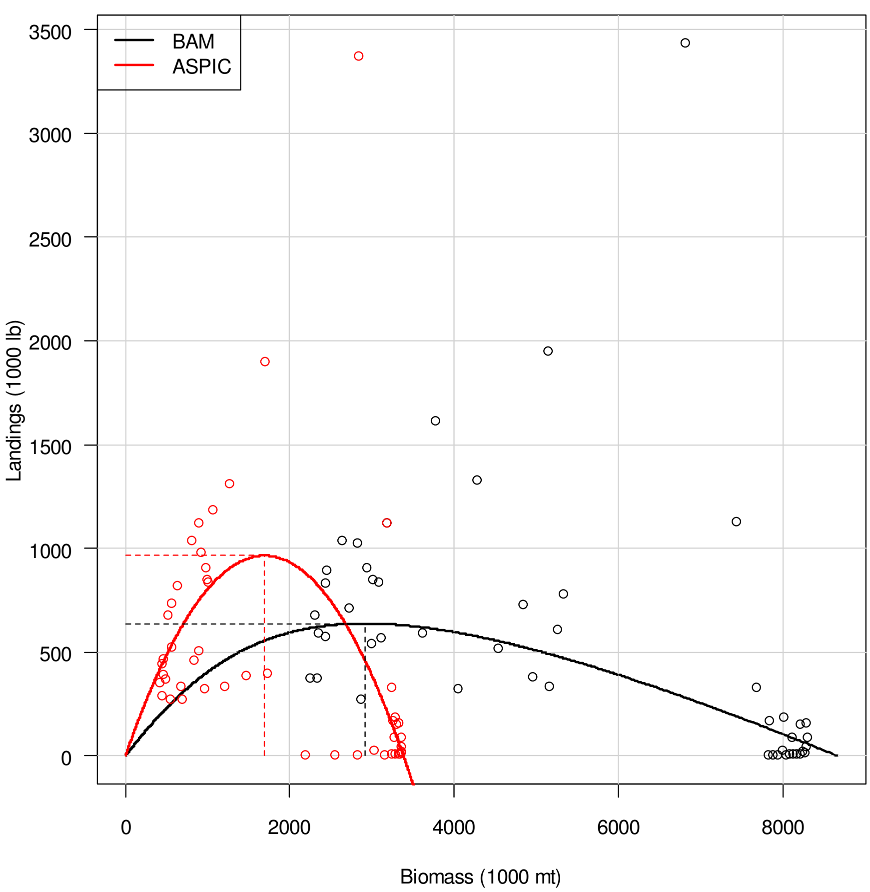


Figure 3. Comparison of BAM and ASPIC estimates of production curves with associated annual estimates of landings (lbs) and biomass (1000 mt). Horizontal and vertical dashed lines represent the estimates of MSY and B_{MSY}, respectively.



Item (2) was addressed by referencing a table of BAM model runs that were conducted during the assessment workshop. During the assessment workshop profiles were run for various parameters and likelihood component weights, including a profile on the weight applied to the stock-recruit likelihood component. A table of individual likelihood component estimates for a range of stock-recruit component weights (SR weight) were presented to the RP (Table 1). The base model run applied a weight of 1.0 to the stock-recruit likelihood component. In Table 1, a smaller likelihood value indicates a relatively better fit.

An increase in the SR weight translates into more restriction in the annual recruitment deviations from the underlying stock-recruit curve. The results of this profile of likelihood component responses to change in the SR weight indicate that there is a trade-off in restricting the recruitment deviations (SRwgt) and the fit to the commercial longline CPUE index (lk.U.cl). There is also some erosion of the commercial longline age composition (lk.agec.cl) fit when the SR weight is increased. The conclusion that can be drawn from this is that the freedom in the annual recruitment deviation estimates, made possible by lower SR weights, allows a better fit to the commercial longline CPUE index and a slightly better fit to the commercial longline age composition data.

Table 1. Likelihood values for various weights applied to the stock-recruit likelihood component (SRwgt). lk indicates negative log-likelihood, U indicates indices, lenc indicates length compositions, and agec indicates age compositions (cl=commercial longline, ch=commercial handline, ra=recreational, and mm=MARMAP longline).

SRwgt	lk.total	lk.unwgt.data	lk.U.cl	lk.U.mm	lk.L.cl	lk.L.ch	lk.L.ra	lk.lenc.cl	lk.lenc.ch	lk.agec.cl	lk.agec.ch	lk.agec.mm	lk.priors	lk.SRfit
0.5	92.4	89.5	17.1	18.0	0.1	0.0	0.0	3.3	21.2	6.4	18.4	5.0	-2.9	11.7
1	92.8	106.4	24.4	25.1	0.2	0.0	0.0	5.3	21.6	6.1	19.3	4.4	-3.7	-10.0
1.5	86.4	113.5	26.1	28.0	0.3	0.0	0.0	6.2	21.7	6.3	19.5	5.3	-3.8	-15.5
2	74.8	125.8	24.9	30.3	0.8	0.0	0.1	8.6	21.9	10.4	21.2	7.6	-3.0	-24.0
2.5	52.4	158.6	45.3	28.7	3.1	0.1	0.5	11.2	22.0	18.6	24.0	5.2	-1.9	-41.7
3	31.0	164.0	48.9	28.5	3.8	0.1	0.6	11.5	21.9	19.7	24.0	5.0	-1.9	-43.7
3.5	8.7	169.0	52.2	28.3	4.5	0.1	0.7	11.8	21.9	20.8	24.0	4.7	-1.9	-45.3
4	-14.3	173.5	55.4	28.1	5.0	0.1	0.9	12.0	21.8	21.7	24.0	4.5	-1.9	-46.5
4.5	-37.8	177.8	58.5	28.0	5.5	0.1	1.0	12.2	21.8	22.4	23.9	4.4	-1.8	-47.6
5	-61.8	181.8	61.5	27.8	6.0	0.1	1.1	12.3	21.8	23.1	23.9	4.2	-1.8	-48.4
5.5	-86.2	185.6	64.4	27.6	6.4	0.1	1.3	12.5	21.7	23.8	23.8	4.1	-1.8	-49.2
6	-111.0	189.1	66.7	27.3	6.9	0.1	1.3	12.6	21.7	24.5	23.9	3.9	-1.8	-49.9
6.5	-136.1	192.3	68.9	27.2	7.3	0.1	1.4	12.7	21.7	25.2	23.9	3.8	-1.8	-50.6
7	-161.5	195.0	70.8	27.2	7.7	0.2	1.5	12.7	21.6	25.3	24.1	3.8	-1.8	-51.0
7.5	-187.1	197.7	72.8	27.1	8.1	0.2	1.6	12.8	21.6	25.7	24.0	3.8	-1.8	-51.4
8	-212.5	199.7	73.6	27.4	8.7	0.2	1.8	12.8	21.7	25.6	24.1	3.9	-1.8	-51.6
8.5	-238.8	202.7	76.4	27.0	8.8	0.2	1.8	12.9	21.6	26.1	24.1	3.8	-1.8	-52.0
9	-264.9	204.9	78.1	27.0	9.1	0.2	1.9	12.9	21.6	26.3	24.1	3.7	-1.8	-52.3
9.5	-291.1	207.1	79.6	26.9	9.5	0.2	2.0	12.9	21.6	26.4	24.2	3.7	-1.8	-52.5
10	-317.4	209.2	81.1	26.9	9.8	0.2	2.1	13.0	21.6	26.5	24.2	3.7	-1.8	-52.8

2.3. Additional Comments
None provided

3. Submitted Comment
(Any written comment or opinion statements submitted by appointed observers)
None provided

VI. Addenda

Revisions or corrections to preceding sections.
None provided

Additional documentation of final review model configuration if required.
None provided