Southeast Data, Assessment, and Review

SEDAR 56

Stock Assessment Report

South Atlantic Black Seabass

April 2018

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

Please cite this document as:

SEDAR. 2018. SEDAR 56 – South Atlantic Black Seabass Assessment Report. SEDAR, North Charleston SC. 164 pp. available online at: http://sedarweb.org/sedar-56.

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SEDAR

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

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

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

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

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

2. Management Overview

2.1 Fishery Management Plan and Amendments

The following summary describes only those management actions that likely affect black sea bass 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, established a management regime for the fishery for snappers, groupers and related demersal species of the Continental Shelf of the southeastern United States in the exclusive economic zone 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. In the case of the sea basses (black sea bass, bank sea bass, and rock sea bass), the fishery management unit/management regime applies only from Cape Hatteras, North Carolina south. Regulations apply only to federal waters.

Measures in the original FMP (effective 8/31/83) specified an 8-inch TL minimum size limit and a 4-inch trawl mesh size.

SAFMC FMP Amendments affecting black sea bass

Description of Action	FMP/Amendment	Effective Date
Prohibit trawls (roller rig trawls) from Cape Hatteras, NC to Cape Canaveral, FL.	Amendment 1	1/12/89
Established a 10-year rebuilding program for black sea bass; year 1=1991. Prohibited fish traps, entanglement nets, and longline gear within 50 fathoms; allowed BSB pots north of Cape Canaveral. Prohibited powerheads in SMZs off SC. Specified requirements for black sea bass pot permit, gear, vessel, and identification. Required that fish be landed with heads & fins attached. Permits - income requirement & required to exceed bag limits.	Amendment 4	1/1/92

Required dealer, charter and headboat federal permits.	Amendment 7	3/1/95
Established a limited entry program for the snapper grouper fishery: unlimited transferable permits and 225-lb non-transferable permits.	Amendment 8	12/14/98
10-inch TL minimum size limit recreational & commercial and 20 fish per person per day recreational bag limit; required escape vents and escape panels with degradable hinges and fasteners in black sea bass pots. Specified minimum dimensions of an escape vent opening (based on inside measurement): (*1*) 1 1⁄8 by 5 3⁄4 inches (2.9 by 14.6 cm) for a rectangular vent. (*2*) 1.75 by 1.75 inches (4.5 by 4.5 cm) for a square vent. (*3*) 2.0-inch (5.1-cm) diameter for a round vent.	Amendment 9	2/24/99
1. Specified a **commercial** quota of 477,000 lbs gutted weight (563,000 lbs whole weight) in year 1; 423,000 lbs gutted weight (499,000 lbs whole weight) in year 2; and 309,000 lbs gutted weight (364,000 lbs whole weight) in year 3 onwards until modified. 2. The commercial quota & recreational allocation were based on a **Total Allowable Catch (TAC)** of 1,110,000 lbs gutted weight (1,310,000 lbs whole weight) in year 1; 983,000 lbs gutted weight (1,160,000 lbs whole weight) in year 2; and 718,000 lbs gutted weight (847,000 lbs whole weight) in year 3 onwards until modified. 3. After the commercial quota is met, all purchase and sale is prohibited and harvest and/or possession is limited to the bag limit. 4. Required use of at least 2” mesh for the entire back panel of black sea bass pots. This measure was effective 10/23/06. 5. Specified a **recreational** allocation of 633,000 lbs gutted weight (746,000 lbs whole weight) in year 1; 560,000 lbs gutted weight (661,000 lbs whole weight) in year 2; and 409,000 lbs gutted weight (483,000 lbs whole weight) in year 3 onwards until modified. 6. Limited recreational landings to approximate this harvest level by increasing the recreational minimum size limit from 10 inches total length (TL) to 11 inches TL in year 1 and to 12 inches TL in year 2 onwards until modified, and reduced	Amendment 13C	10/23/06

the recreational bag limit from 20 to 15 black sea bass per person per day. 7. Changed the fishing year from the calendar year to June 1 through May 31. 8. Year 1 = 2006/07.		
1) Updated management reference points for black sea bass. 2) Modified rebuilding strategies for black sea bass. 3) Defined rebuilding strategies for black sea bass. None of the measures included in Amendment 15A involved changes to existing regulations; therefore, no proposed or final rule was required. 4) Established 10-year rebuilding schedule for black sea bass where 2006 is year 1.	Amendment 15A	3/20/08
1) Prohibited the sale of bag-limit caught snapper grouper species. 2) Changed the commercial permit renewal period and transferability requirements. 3) Implemented a plan to monitor and address bycatch.	Amendment 15B	12/16/09

1) Commercial annual catch limit (ACL) = 309,000 lbs gw 2) Recreational ACL = 409,000 lbs gw 3) The commercial accountability measure (AM) for black sea bass is to prohibit harvest, possession, and retention when the ACL is projected to be met. 4) The recreational AM for black sea bass is to compare the recreational ACL with 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. If black sea bass are *overfished* and the ACL is projected to be met, prohibit the harvest and retention of black sea bass. 5) If the recreational or commercial sector ACL is exceeded, independent of stock status, the Regional Administrator shall publish a notice to reduce the sector ACL in the following season by the amount of the overage. 6) Updated the framework procedure.	Amendment 17B	1/31/11
1) Updated the following for black sea bass: • Rebuilding strategy: Defined a rebuilding strategy that holds catch constant in fishing years 2012/2013 and 2013/2014 and then changes to $F_{rebuild}$ in 2014/2015.	Amendment 18A	7/1/12 *The commercial fishing season

($F_{rebuild}$ is defined as a constant fishing mortality strategy that maintains the 66% probability of recovery rate throughout the remaining fishing seasons of the rebuilding timeframe.) After the 2015/2016 fishing season the fishing mortality rate would be held constant until modified. • Acceptable biological catch (ABC): ABC=ACL=OY= 847,000 lbs ww • ACLs: 409,000 lbs gw recreational 309,000 lbs gw commercial • Annual catch target (recreational only): 357,548 lbs gw 2) Established an endorsement program for the commercial black sea bass pot segment of the snapper grouper fishery. 3) Established an appeals process for the black sea bass pot endorsement program. 4) Modified commercial accountability measures. 5) Established a limit of 35 black sea bass pot tags issued to each endorsement holder each permit year. 6) Established a requirement to bring black sea bass pots back to shore at the end of each trip. 6) Specified a 1,000 pounds gw (1,180 pounds ww) commercial trip limit for the black sea bass commercial sector. 7) Increased the commercial minimum size limit for black sea bass from 10 inches TL to 11 inches TL. 8) Increased the recreational minimum size limit for black sea bass from 12 inches TL to 13 inches TL. 9) Modified recreational accountability measures. 10) Specified a requirement for selected for-hire vessels to report landings information electronically on a weekly or daily basis.		for black sea bass in 2012 opened on July 1.

SAFMC FMP Regulatory Amendments affecting black sea bass

Regulatory Amendment #4 (1992)	07/06/93	FR: 58 FR 36155	-For Black Sea Bass: -Modified definition of bsb pot; -Allowed multi-gear trips for bsb; -Allowed retention of incidentally-caught fish on bsb trips.

Regulatory Amendment #9 (2011)	Bag limit: 6/22/11	PR: 76 FR 23930 FR: 76 FR 34892	-reduced recreational bag limit for black sea bass from 15 fish to 5 fish per person per day;
Regulatory Amendment #19 (2013)	ACL: 9/23/13 Pot closure: 10/23/13	PR: 78 FR 39700 FR: 78 FR 58249	-Specified ABC, and adjusted the ACL, recreational ACT and OY for black sea bass; -Implemented an annual closure on the use of black sea bass pots from November 1 to April 30.
Regulatory Amendment #14 (2013)	12/8/2014	PR: 79 FR 22936 FR: 79 FR 66316	-changed the commercial and recreational fishing years for black sea bass from Jun 1 through May 31, to Jan 1 through Dec 31 for the commercial sector and Apr 1 through Mar 31 for the recreational sector. -established a trip limit of 300 lbs ww, for the hook-and-line component of the commercial sector from Jan 1 through Apr 30 when fishing with pots is prohibited. The trip limit for the remainder of the fishing year for both pots and hook-and-line remained at 1,180 lbs ww. -revised recreational AM to specify the length of the recreational fishing season for black sea bass, as determined by NMFS an-d announced annually in the Federal Register, prior to the April 1 recreational fishing season start date.
Regulatory Amendment #25 (2016)	Effective 8/12/2016	PR:81 FR 34944 FR:81 FR 45245	-Increased the recreational bag limit for black sea bass from 5 fish to 7 fish per person per day
Vision Blueprint Regulatory Amendment 26 (2018)	TBD	TBD	-Modify the black sea bass recreational minimum size limit

Regulatory Amendment #16 (2016)	Prohibited area: 12/29/2016; Enhanced gear markings: 3/21/2017	NOI: 78 FR 72868 PR: 81 FR 53109 FR: 81 FR 95893	-Revised the area where fishing with black sea bass pots from Nov.1-April 30 is prohibited. -Add additional gear marking requirements for black sea bass pot gear.

2.2 Emergency and Interim Rules (if any)

SAFMC

Emergency Rule	8/31/92	57 FR 39365	For Black Sea Bass (bsb): -Modified definition of bsb pot; -Allowed multi-gear trips for bsb; -Allowed retention of incidentally-caught fish on bsb trips.
Emergency Rule Extension	11/30/92	57 FR 56522	For Black Sea Bass: -Modified definition of bsb pot; -Allowed multi-gear trips for bsb; -Allowed retention of incidentally-caught fish on bsb trips.
Emergency Action	9/3/99	64 FR 48326	-Reopened the Amendment 8 permit application process.

2.3 Secretarial Amendments (if any)

SAFMC None for black seabass

2.4 Control Date Notices (if any)

SAFMC:

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 (04/23/97 62 FR 22995) - Anyone entering **federal black sea bass pot fishery** off S. Atlantic states after 04/23/97 was not assured of future access if limited entry program developed.

3. 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.
4. Notice of Control Date (10/26/2007 72 FR 60794) - Considered measures to limit participation in the snapper grouper for-hire sector effective 3/8/07.
5. Notice of Control Date (02/20/09 74 FR 7849) - Anyone entering **federal black sea bass pot fishery** off S. Atlantic states after 12/04/08 was not assured of future access if limited entry program developed.
6. 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.
7. Notice of Control Date (06/15/2016 81 FR 66244) - fishermen who enter the federal for-hire recreational sector for the Snapper Grouper fishery after June 15, 2016, will not be assured of future access should a management regime that limits participation in the sector be prepared and implemented.

2.5 Management Program Specifications

Table 2.5.1. General Management Information
South Atlantic

Species	Black Sea Bass
Management Unit	Southeastern US
Management Unit Definition	Cape Hatteras, NC southward to the SAFMC/GMFMC boundary
Management Entity	South Atlantic Fishery Management Council
Management Contacts	SAFMC: Myra Brouwer/Brian Cheuvront SERO: Jack McGovern/Rick DeVictor
Current stock exploitation status	Not undergoing overfishing
Current stock biomass status	Not overfished

Table 2.5.2 Specific Management Criteria

Criteria	South Atlantic – Current (2013 SEDAR 25 Update)		
	Definition	Base Run Values	Median of Base Run MCBs
MSST[1] (1E10 eggs)	MSST = [(1-M) or 0.5 whichever is greater]*BMSY	159	
MFMT (per year)	F_{MSY}, if available	0.610	

F_{MSY} (per year)	F_{MSY}	0.610	
MSY (1000 lb)	Yield at F_{MSY}, landings and discards, pounds and numbers	1780	
B_{MSY}[1] (metric tons)	Total or spawning stock, to be defined	5617	
R_{MSY} (1000 age-0 fish)	Recruits at MSY	35843	
F Target			
Yield at F_{TARGET} (equilibrium) (1000 lb)	Landings and discards, pounds and numbers		
M	Natural mortality, average across ages	0.38	
Terminal F (F_{2012})	Exploitation	0.329	
Terminal Biomass[1] (SSB_{2012}; 1E10 eggs)	Biomass	265	
Exploitation Status	$F_{2011\text{-}2012}/F_{MSY}$	0.659	
	F_{2012}/F_{MSY}	0.539	
Biomass Status[1] (SSB)	SSB_{2012}/MSST	1.66	
	B/B_{MSY}	1.03	
Generation Time		7 years	
$T_{REBUILD}$ (if appropriate)		N/A	

Criteria	South Atlantic – Proposed (values from SEDAR 56)		
	Definition	Base Run Values	Median of Base Run MCBs
MSST[1]	(75% of SSB_{MSY})		
MFMT	F_{MSY}, if available		
F_{MSY}	F_{MSY}		
MSY	Yield at F_{MSY}, landings and discards, pounds and numbers		
B_{MSY}[1]	Total or spawning stock, to be defined		
R_{MSY}	Recruits at MSY		
F Target			
Yield at F_{TARGET} (equilibrium)	Landings and discards, pounds and numbers		

M	Natural mortality, average across ages		
Terminal F	Exploitation		
Terminal Biomass[1]	Biomass		
Exploitation Status	F/MFMT		
Biomass Status[1]	B/MSST		
	B/B_{MSY}		
Generation Time			
$T_{REBUILD}$ (if appropriate)			

1. Biomass values reported for management parameters and status determinations should be based on the biomass metric recommended through the Assessment process and SSC. This may be total, spawning stock or some measure thereof, and should be applied consistently in this table.

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. Please clarify whether landings parameters are 'landings' or 'catch' (Landings + Discard). If 'landings', please indicate how discards are addressed.

Table 2.5.3. Stock Rebuilding Information

The black sea bass stock is no longer under rebuilding.

Table 2.5.4. Stock Projection Information

South Atlantic

First Year of Management	2019
Interim basis	SEDAR 56 ToR ask the Panel to provide guidance on appropriate assumptions to address harvest and mortality levels in interim years; recent SEDAR assessments have asked for ACL, if landings are within 10% of the ACL; average landings otherwise
Projection Outputs	
Landings	Pounds and numbers
Discards	Pounds and numbers
Exploitation	F & Probability F>MFMT
Biomass (total or SSB, as appropriate)	B & Probability B>MSST (and Prob. $B>B_{MSY}$ if under rebuilding plan)
Recruits	Number

Table 2.5.5. Base Run Projections Specifications. Long Term and Equilibrium conditions.

Criteria	Definition	If overfished	If overfishing	Neither overfished nor overfishing
Projection Span	Years	$T_{REBUILD}$	10	10
Projection Values	$F_{CURRENT}$	X	X	X
	F_{MSY}	X	X	X
	75% F_{MSY}	X	X	X
	$F_{REBUILD}$	X		
	F=0	X		

NOTE: Exploitation rates for projections may be based upon point estimates from the base run (current process) or upon the median of such values from the MCBs evaluation of uncertainty. The critical point is that the projections be based on the same criteria as the management specifications.

Table 2.5.6. P-star projections. Short term specifications for OFL and ABC recommendations. Additional P-star projections may be requested by the SSC once the ABC control rule is applied.

Basis	Value	Years to project	P* applies to
P*	50%	Interim + 5	Probability of overfishing
P*	40%	Interim + 5	Probability of overfishing
Exploitation	Fmsy	Interim + 5	NA
Exploitation	75% Fmsy	Interim + 5	NA

Table 2.5.7. Quota Calculation Details

Regulatory Amendment 19 implemented a total ACL and OY of 1,814,000 lbs ww in 2013, 2014, and 2015. This value is equal to the projection at the 40% P* level for 2015 and is also the SSC's ABC recommendation for 2015. Beginning in 2016, the ABC (landings only) was reduced to 1,814,000 lbs ww and the total ACL was reduced to 1,756,450 lbs ww, which is the yield at 75%F_{MSY} when the stock is at equilibrium. Values below in lbs ww.

	Commercial	Recreational	Total Annual Catch Limit
Current Quota Value	755,274	1,001,177	1,756,450
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?	No	No	No

How is the quota calculated - conditioned upon exploitation or average landings?

Allowable catch from the projection was allocated to recreational and commercial sectors based on sector allocation of 43% commercial and 57% recreational (established through Amendment 13C in 2006).

Does the quota include bycatch/discard estimates? If so, what is the source of the bycatch/discard values? What are the bycatch/discard allowances?

The quota does not require monitoring of discards and is based on landed catch. Assessment takes into consideration bycatch and provides estimate of yield at F_{MSY} and F_{OY} as landed catch rather than landed catch and 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 South Atlantic Black Sea Bass Federal Commercial Regulatory History

prepared by: Myra Brouwer

Year	Quota (lbs ww)	ACL (lbs ww)	Days Open	fishing season	reason for closure	season start date (first day implemented)	season end date (last day effective)	Size limit (in TL)	size limit start date	size limit end date	Retention Limit (lbs ww)	Retention Limit Start Date	Retention Limit End Date
8/31/1983[A]	NA	NA	365	open	NA	1-Jan	31-Dec	8	31-Aug	31-Dec	none	NA	NA
1984	NA	NA	365	open	NA	1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1985	NA	NA	365	open	NA	1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1986	NA	NA	365	open	NA	1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1987	NA	NA	365	open	NA	1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1988	NA	NA	365	open	NA	1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1989	NA	NA	365	open	NA	1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1990	NA	NA	365	open	NA	1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1991	NA	NA	365	open	NA	1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1992	NA	NA	365	open	NA	1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1993	NA	NA	365	open	NA	1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1994	NA	NA	365	open	NA	1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1995	NA	NA	365	open	NA	1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1996	NA	NA	365	open	NA	1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1997	NA	NA	365	open	NA	1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1998	NA	NA	365	open	NA	1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1999[B]	NA	NA	365	open	NA	1-Jan	31-Dec	8	1-Jan	23-Feb	none	NA	NA
								10	24-Feb	31-Dec	none	NA	NA
2000	NA	NA	365	open	NA	1-Jan	31-Dec	10	1-Jan	31-Dec	none	NA	NA
2001	NA	NA	365	open	NA	1-Jan	31-Dec	10	1-Jan	31-Dec	none	NA	NA
2002	NA	NA	365	open	NA	1-Jan	31-Dec	10	1-Jan	31-Dec	none	NA	NA
2003	NA	NA	365	open	NA	1-Jan	31-Dec	10	1-Jan	31-Dec	none	NA	NA
2004	NA	NA	365	open	NA	1-Jan	31-Dec	10	1-Jan	31-Dec	none	NA	NA
2005	NA	NA	365	open	NA	1-Jan	31-Dec	10	1-Jan	31-Dec	none	NA	NA
2006	NA	NA	365	open	NA	1-Jan	22-Oct	10	1-Jan	22-Oct	none	1-Jan	22-Oct
2006/2007[C]	563,000					23-Oct	31-May	10	23-Oct	31-May	none	23-Oct	31-May
2007/2008	499,000	NA	365	open	NA	1-Jun	31-May	10	1-Jun	31-May	none	NA	NA
2008/2009	364,000	NA	350	open	NA	1-Jun	15-May	10	1-Jun	31-May	none	NA	NA
				closed	quota met	16-May	31-May						
2009/2010	364,000	NA	192	open	NA	1-Jun	9-Dec	10	1-Jun	9-Dec	none	NA	NA
				closed	quota met	10-Dec	31-May						
2010/2011	364,000	NA	129	open	NA	1-Jun	6-Oct	10	1-Jun	6-Oct	none	NA	NA
				closed	quota met	7-Oct	30-Nov						
			16	open	NA	1-Dec	15-Dec	10	1-Dec	15-Dec	none	NA	NA
				closed	quota met	16-Dec	31-May						
2011/2012	NA	364,000	45	open	NA	1-Jun	14-Jul	10	1-Jun	14-Jul	none	NA	NA
				closed	ACL met	15-Jul	31-May						
2012/2013[D]	NA	364,000	130	open	NA	7/1/2012[D]	7-Oct	11	1-Jul	7-Oct	1,180	1-Jul	7-Oct
				closed	ACL met	8-Oct	31-May						
2013/2014	NA	364,000	H&L: 365 Pot: 184	open	NA	1-Jun	22-Sep	11	1-Jun	12-Sep	1,180	1-Jun	31-Oct
	NA	780020[E]				23-Sep	H&L: 5/31/2014	11	13-Sep	H&L: 5/31/2014	1,180	13-Sep	H&L: 5/31/2014
				closed - pot only[F]	regulatory	1-Nov	30-Apr						
				open - pot and H&L		1-May	31-May	11	1-May	31-May	1,180	1-May	31-May
2014/2015	NA	780,020	H&L: 190 Pot: 153	open		1-Jun	H&L: 12/7/2014	11	1-Jun	H&L: 12/7/2014	1,180	1-Jun	H&L: 12/7/2014
				closed - pot only[F]	regulatory	1-Nov	7-Dec						
2014[G]	NA	780,020	H&L: 24 Pot: 0	open - H&L	NA	8-Dec	31-Dec	11	8-Dec	31-Dec	1,180	8-Dec	31-Dec
				closed - pot only[F]	regulatory	8-Dec	31-Dec						
2015	NA	780,020	H&L: 365 Pot: 184	open - H&L only	NA	1-Jan	30-Apr	11	1-Jan	31-Dec	354[G]	1-Jan	30-Apr
				closed - pot only	regulatory	1-Jan	30-Apr						
				open - H&L and pots		1-May	31-Oct	11	1-May	31-Oct	1,180	1-May	31-Oct
				open - H&L		1-Nov	31-Dec	11	1-Nov	31-Dec	1,180	1-Nov	31-Dec
				closed - pot only	regulatory	1-Nov	31-Dec						
2016[H]	NA	780,020	H&L: 365 Pot: 184	open H&L only	NA	1-Jan	30-Apr	11	1-Jan	31-Oct	354	1-Jan	30-Apr
				closed - pot only	regulatory	1-Jan	30-Apr						
				open H&L and pots		1-May	31-Oct	11	1-May	31-Oct	1,180	1-May	31-Oct
				open - H&L		1-Nov	31-Dec	11	1-Nov	31-Dec	1,180	1-Nov	31-Dec

A: Original SAFMC FMP effective 8/31/1983.

B: Amendment 9 (effective 2/24/1999) established 10 inch TL minimum size limit; required escape vents and escape panels with degradable hinges in BSB pots and specified minimum dimensions of an escape vent opening

C: Amendment 13C (effective 10/23/2006) changed fishing year from calendar year to June 1-May 31; specified commercial quota as indicated in table; required use of at least 2" mesh for entire back panel of BSB pots

D: Amendment 18 A (effective 7/1/12) included the establishment of an endorsement program for the commercial BSB pot fishery - more details on the pot fishery endorsement program can be found in the PDF doc and in Amendment 18A; also included change in size limit and established trip limit as indicated in table; commercial fishery didn't open until July 1 in 2012 (remained closed June 2012)

E: ACL adjustment effective on 9/23/12 with implementation of Regulatory Amendment 19.

F: Regulatory Amendment 19 implemented annual closure for pot fishery Nov 30 through April 1 (effective date for pot closure 10/23/2013)

G: Regulatory Amendment 14 (effective 12/8/2014) changed the fishing year back to calendar year; added H&L 300 lb gw trip limit Jan 1 - Apr 30

H: Regulatory Amendment 16 (pot prohibition changes effective 12/29/2016; gear marking changes effective 3/21/2017) changed the size of the seasonal prohibited fishing areas and required pot markings

lbs = pounds
ww = whole weight
H&L = hook and line gear

2.6.2 South Atlantic Black Sea Bass Federal Recreational Regulatory History

prepared by: Myra Brouwer

Year	Quota (lbs ww)	ACL (lbs ww)	Days Open	fishing season	reason for closure	season start date (first day implemented)	season end date (last day effective)	Size limit (in TL)	size limit start date	size limit end date	Retention Limit (# fish)	Retention Limit Start Date	Retention Limit End Date
8/31/1983[A]	NA	NA	365	open		1-Jan	31-Dec	8	31-Aug	31-Dec	none	NA	NA
1984	NA	NA	365	open		1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1985	NA	NA	365	open		1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1986	NA	NA	365	open		1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1987	NA	NA	365	open		1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1988	NA	NA	365	open		1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1989	NA	NA	365	open		1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1990	NA	NA	365	open		1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1991	NA	NA	365	open		1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1992	NA	NA	365	open		1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1993	NA	NA	365	open		1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1994	NA	NA	365	open		1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1995	NA	NA	365	open		1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1996	NA	NA	365	open		1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1997	NA	NA	365	open		1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1998	NA	NA	365	open		1-Jan	31-Dec	8	1-Jan	31-Dec	none	NA	NA
1999[B]	NA	NA	365	open		1-Jan	31-Dec	10	24-Feb	31-Dec	20/person/day	24-Feb	31-Dec
2000	NA	NA	365	open		1-Jan	31-Dec	10	1-Jan	31-Dec	20/person/day	1-Jan	31-Dec
2001	NA	NA	365	open		1-Jan	31-Dec	10	1-Jan	31-Dec	20/person/day	1-Jan	31-Dec
2002	NA	NA	365	open		1-Jan	31-Dec	10	1-Jan	31-Dec	20/person/day	1-Jan	31-Dec
2003	NA	NA	365	open		1-Jan	31-Dec	10	1-Jan	31-Dec	20/person/day	1-Jan	31-Dec
2004	NA	NA	365	open		1-Jan	31-Dec	10	1-Jan	31-Dec	20/person/day	1-Jan	31-Dec
2005	NA	NA	365	open		1-Jan	31-Dec	10	1-Jan	31-Dec	20/person/day	1-Jan	31-Dec
2006	NA	NA	365	open		1-Jan	22-Oct	10	1-Jan	22-Oct	20/person/day	1-Jan	22-Oct
2006/2007[C]	746,000	NA	365	open		23-Oct	31-May	11	23-Oct	31-May	15/person/day	23-Oct	31-May
2007/2008	661,000	NA	365	open		1-Jun	31-May	12	1-Jun	31-May	15/person/day	1-Jun	31-May
2008/2009	483,000	NA	365	open		1-Jun	31-May	12	1-Jun	31-May	15/person/day	1-Jun	31-May
2009/2010	483,000	NA	365	open		1-Jun	31-May	12	1-Jun	31-May	15/person/day	1-Jun	31-May
2010/2011	NA	483,000	257	open		1-Jun	12-Feb	12	1-Jun	12-Feb	15/person/day	1-Jun	12-Feb
				closed	ACL met	13-Feb	31-May						
2011/2012	NA	483,000	139	open		1-Jun	21-Jun	12	1-Jun	21-Jun	15/person/day	1-Jun	21-Jun
						22-Jun	17-Oct	12	22-Jun	17-Oct	5/person/day [D]	22-Jun	17-Oct
				closed	ACL met	18-Oct	31-May						
2012/2013		483,000	96	open		1-Jun	30-Jun	12	1-Jun	30-Jun	5/person/day	1-Jun	30-Jun
						1-Jul	4-Sep	13 [H]	1-Jul	4-Sep	5/person/day	1-Jul	4-Sep
				closed	ACL met	5-Sep	31-May						
2013/2014	NA	483,000	365	open		1-Jun	22-Sep	13	1-Jun	22-Sep	5/person/day	1-Jun	22-Sep
		1,033,980 [E]				23-Sep	31-May	13	23-Sep	31-May	5/person/day	23-Sep	31-May
2014/2015 [F]	NA	1,033,980	365	open		1-Jun	7-Dec	13	1-Jun	7-Dec	5/person/day	1-Jun	7-Dec
						8-Dec	31-Mar	13	8-Dec	31-Mar	5/person/day	8-Dec	31-Mar
2015/2016	NA	1,033,980	365	open		1-Apr	31-Mar	13	1-Apr	31-Mar	5/person/day	1-Apr	31-Mar
2016/2017	NA	1,001,177	365	open		1-Apr	11-Aug	13	1-Apr	11-Aug	5/person/day	1-Apr	11-Aug
						12-Aug	31-Mar	13	12-Aug	31-Mar	7/person/day [G]	12-Aug	31-Mar

A: Original SAFMC FMP effective 8/31/1983.

B: Amendment 9 (effective 2/24/1999) implemented 10inch TL size limit and 20 fish/person/day bag limit

C: Amendment 13C (effective 10/23/2006) changed the fishing year from the calendar year to June 1- May 31; also changed recreational quota, size limits, and bag limits as indicated in the table.

D: Regulatory Amendmnet 9 changed the bag limit to 5/person/day, effective 6/22/11

E: Regulatory Amendment 19 increased the ACL, effective 9/23/13

F: Regulatory Amendment 14 (effective 12/8/2014) changed the recreational fishing year from June 1-May 31 to **April 1-March 31**

G: Regulatory Amendment 25 revised the recreational bag limit to 7/person/day, effective 8/12/2016

H: Amendment 18A (effective 7/1/2012) included changing the recreational size limit to 13 in. TL; see PDF document for additional regulatory changes in 18A

2.6 Closures Due to Meeting Commercial Quota or Commercial/Recreational ACL

Commercial:
- 2008/2009 – Commercial closure, May 15, 2009 through May 31, 2009.
- 2009/2010 – Commercial closure, December 9, 2009 through May 31, 2010.
- 2010/2011 – Commercial closure October 7, 2010. Because projected landings estimated the quota would be met by that time. However, it was later determined to not have been met. Therefore, the commercial sector for black sea bass in federal waters was reopened December 1, 2010, through December 15, 2010. The fishery is closed from December 16, 2010 through May 31, 2011. The overage will be deducted from the 2011/2012 fishing year.
- 2011/2012 – Commercial closure July 15, 2011 through May 31, 2012.
- 2012/2013 – Commercial closure October 8, 2012 through May 31, 2013.

Recreational
- 2010/2011 – Recreational closure February 12, 2011 through May 31, 2011. The overage will be deducted from the 2011/2012 fishing year.
- 2011/2012 – Recreational closure October 17, 2011 through May 31, 2012.
- 2012/2013 – Recreational closure September 4, 2012 through May 31, 2013.

Table 7. State Regulatory History

North Carolina:
North Carolina General Statute (N.C.G.S.) 143B-289.52(e) states: "the Commission [N.C. Marine Fisheries Commission] may adopt rules to implement or comply with a fishery management plan adopted by the Atlantic States Marine Fisheries Commission or adopted by the United States Secretary of Commerce pursuant to the Magnuson-Steven Fishery Conservation and management Act, 1601 U.S.C. §1801 et seq."

The N.C. Marine Fisheries Commission has used this authority to develop rules that allow it to complement federal management measures for all snapper grouper species managed by the SAFMC, including black sea bass, in state waters. The first rule regarding snapper grouper species was adopted in 1991:

15A NCAC 03M .0506 Snapper-Grouper
The Fisheries Director may, by proclamation, until September 1, 1991, impose any or all of the following restrictions in the fishery for species of the snapper-grouper complex listed in the South Atlantic Fishery Management Council Fishery Management Plan for the Snapper-Grouper Fishery of the South Atlantic Region:
1) Specify size;

2) Specify seasons;
3) Specify areas;
4) Specify quantity;
5) Specify means and methods;
6) Require submission of statistical and biological data.

History Note: Statutory authority G.S. 113-134; 113-182; 113-221; 143B-289.4 Eff. January 1, 1991.

The above rule was modified in September 1991 to remove the phrase "until September 1, 1991". Any changes to federal snapper grouper rules were put into proclamation. Eventually, because the Division has a policy of putting long-standing proclamations (5 years or more) that have not changed into rule, the components of the proclamation dealing with size and retention limits for snapper grouper species were put into rule 15A NCAC 03M .0506 above, modifying the rule as of March 1, 1996. Below are the relevant portions of this rule pertaining to black sea bass:

15A NCAC 03M .0506 SNAPPER-GROUPER

(a) The Fisheries Director may, by proclamation, impose any or all of the following restrictions in the fishery for species of the snapper-grouper complex listed in the South Atlantic Fishery Management Council Fishery Management Plan for the Snapper-Grouper Fishery of the South Atlantic Region:
    (1) Specify size;
    (2) Specify seasons;
    (3) Specify areas;
    (4) Specify quantity;
    (5) Specify means and methods;
    (6) Require submission of statistical and biological data.

The species of the snapper-grouper complex listed in the South Atlantic Fishery Management Council Fishery Management Plan for the Snapper-Grouper Fishery of the South Atlantic Region is hereby incorporated by reference and copies are available at the Division of Marine Fisheries, P.O. Box 769, Morehead City, North Carolina 28557 at no cost.

(b) It is unlawful to possess black sea bass less than eight inches total length taken south of Cape Hatteras (35° 15' N, latitude).

…..

(s) Fish Traps/Pots:
    (1) It is unlawful to use or have on board a vessel fish traps for taking snappers and groupers except sea bass pots as allowed in Subparagraph (2) of this Paragraph.
    (2) Sea bass may be taken with pots that conform with federal rule requirements for mesh sizes and pot size as specified in 50 CFR Part 646.2 and openings and degradable fasteners specified in 50 CFR Part 646-22(c)(2)(i).

History Note: Statutory authority G.S. 113-134; 113-182; 113-221; 143B-289.4 Eff. January 1, 1991. Amended Eff. March 1, 1996; September 1, 1991.

At the same time (March 1996), the first version of rule 15A NCAC 03M .0512 was adopted to allow for the Fisheries Director to suspend existing rules in order to implement changes to comply with Atlantic States Marine Fisheries Commission FMPs or federal regulations as per below:

15A NCAC 03M .0512 COMPLIANCE WITH FISHERY MANAGEMENT PLANS
In order to comply with management requirements incorporated in Federal Fishery Management Council Management Plans or Atlantic States Marine Fisheries Commission Management Plans, the Fisheries director may, by proclamation, suspend the minimum size and harvest limits established by the Marine Fisheries Commission, and implement different minimum size and harvest limits. Proclamations issued under this Section shall be subject to approval, cancellation, or modification by the Marine Fisheries Commission at its next regularly scheduled meeting or an emergency meeting held pursuant to G.S. 113-221 (e1).
History Note: Authority G.S. 113-134; 113-182; 113-221; 143B-289.4; Eff. March 1, 1996.

Rule 15A NCAC 03M .0506 was modified effective December 23, 1996 to incorporate changes to black sea bass management north of Cape Hatteras as well. It was amended again effective August 1, 1998 to allow for incorporation of changes pursuant to the ASMFC plan for black sea bass north of Hatteras. The next set of changes to this rule that pertain specifically to black sea bass south of Hatteras became effective May 24, 1999. These reflect the increase in commercial size limit to 10 inches TL, and a 20 fish recreational bag limit, as well escape vent requirements for pots:

15A NCAC 03M .0506 SNAPPER-GROUPER

(a) The Fisheries Director may, by proclamation, impose any or all of the following restrictions in the fisheries for species of the snapper-grouper complex and black sea bass in order to comply with the management requirements incorporated in the Fishery Management Plans for Snapper-Grouper and Sea Bass developed by the South Atlantic Fishery Management Council or Mid-Atlantic Fishery Management Council and the Atlantic States Marine Fisheries Commission:
(1) Specify size;
(2) Specify seasons;
(3) Specify areas;
(4) Specify quantity;
(5) Specify means/methods; and
(6) Require submission of statistical and biological data.
The species of the snapper-grouper complex listed in the South Atlantic Fishery Management Council Fishery Management Plan for the Snapper-Grouper Fishery of the

South Atlantic Region is hereby incorporated by reference and copies are available via the Federal Register posted on the Internet at www.access.gpo.gov and at the Division of Marine Fisheries, P.O. Box 769, Morehead City, North Carolina 28557 at no cost.

(b) Black sea bass:

(1) It is unlawful to possess black sea bass less than ten inches total length taken south of Cape Hatteras (35° 15' N, latitude).

(2) It is unlawful to take or possess more than 20 black sea bass per person per day south of Cape Hatteras without a valid Federal Commercial Snapper-Grouper permit.

…..

(s) Fish Traps/Pots:

(1) It is unlawful to use or have on board a vessel fish traps for taking snappers and groupers except sea bass pots as allowed in Subparagraph (2) of this Paragraph.

(2) Sea bass may be taken with pots that conform with federal rule requirements for mesh sizes and pot size as specified in 50 CFR Part 646.2, openings and degradable fasteners specified in 50 CFR Part 646-22(c)(2)(i), and escape vents and degradable materials as specified in 50 CFR Part 622.40 (b)(3)(i) and rules published in 50 CFR pertaining to sea bass north of Cape Hatteras (35° 15'N Latitude). Copies of these rules are available via the Federal Register posted on the Internet at wwww.access.gpo.gov and at the Division of Marine Fisheries, P.O. Box 769, Morehead City, North Carolina 28557 at no cost.

History Note: Statutory authority G.S. 113-134; 113-182; 113-221; 143B-289.4
Eff. January 1, 1991.
Amended Eff. April 1, 1997; March 1, 1996; September 1, 1991;
Temporary Amendment Eff. December 23, 1996;
Amended Eff. August 1, 1998; April 1, 1997;
Temporary Amendment Eff. May 24, 1999.

Beginning in January 2002, part (s) of rule 15A NCAC 03M .0512 was removed and presumably placed into proclamation due to changes in materials and construction. Part (s) was reincorporated into rule as noted above as of May 1, 2004.

In June 2008, the N.C. Marine Fisheries Commission approved the first version of the Interjurisdictional Fishery Management Plan (IJ FMP), which incorporated all existing federal council and ASMFC FMPs as minimum standards for North Carolina's fisheries. Management changes to several ASMFC and Council-managed species were occurring at a higher rate of frequency, and the IJ FMP allowed for such changes to be implemented more efficiently through proclamation, rather than rulemaking. Effective October 1, 2008 all size limits, bag limits, seasons, gear restrictions, etc. were removed from rule 15A NCAC 03M .0506 and implemented under the authority of rule 15A NCAC 03M .0512. Both rules have not changed since then and are in their current form here:

15A NCAC 03M .0506 SNAPPER-GROUPER COMPLEX

(a) In the Atlantic Ocean, it is unlawful for an individual fishing under a Recreational Commercial Gear License with seines, shrimp trawls, pots, trotlines or gill nets to take any species of the Snapper-Grouper complex.

(b) The species of the snapper-grouper complex listed in the South Atlantic Fishery Management Council Fishery Management Plan for the Snapper-Grouper Fishery of the South Atlantic Region are hereby incorporated by reference and copies are available via the Federal Register posted on the Internet at www.safmc.net and at the Division of Marine Fisheries, P.O. Box 769, Morehead City, North Carolina 28557 at no cost.

History Note: Authority G.S. 113-134; 113-182; 113-221; 143B-289.52;
Eff. January 1, 1991;
Amended Eff. April 1, 1997; March 1, 1996; September 1, 1991;
Temporary Amendment Eff. December 23, 1996;
Amended Eff. August 1, 1998; April 1, 1997;
Temporary Amendment Eff. January 1, 2002; August 29, 2000; January 1, 2000; May 24, 1999;
Amended Eff. October 1, 2008; May 1, 2004; July 1, 2003; April 1, 2003; August 1, 2002.

15A NCAC 03M .0512 COMPLIANCE WITH FISHERY MANAGEMENT PLANS

(a) In order to comply with management requirements incorporated in Federal Fishery Management Council Management Plans or Atlantic States Marine Fisheries Commission Management Plans or to implement state management measures, the Fisheries Director may, by proclamation, take any or all of the following actions for species listed in the Interjurisdictional Fisheries Management Plan:

(1) Specify size;
(2) Specify seasons;
(3) Specify areas:
(4) Specify quantity;
(5) Specify means and methods; and
(6) Require submission of statistical and biological data.

(b) Proclamations issued under this Rule shall be subject to approval, cancellation, or modification by the Marine Fisheries Commission at its next regularly scheduled meeting or an emergency meeting held pursuant to G.S. 113-221.1.

History Note: Authority G.S. 113-134; 113-182; 113-221; 113-221.1; 143B-289.4;
Eff. March 1, 1996;
Amended Eff. October 1, 2008.

In July 2012, the provisions of Snapper Grouper Amendment 18A (black sea bass pot endorsement program, modification to recreational size limit) were implemented via proclamation FF-37-2012:
http://portal.ncdenr.org/web/mf/proclamation-ff-37-2012

In October 2013, the provisions of Snapper Grouper Regulatory Amendment 19 (prohibition on use of black sea bass pots from November through April) were implemented via proclamation FF-52-2013:
http://portal.ncdenr.org/web/mf/proclamation-ff-52-2013
From October 2008 through 2014, all commercial and recreational snapper grouper regulations were contained in the same proclamation. Beginning with the 2015 fishing year, snapper grouper regulations (including seasonal ACL closures) were issued via separate proclamations for the commercial and recreational sectors.

In December 2016, the provisions of Snapper Grouper Regulatory Amendment 16 (modifications to seasonal prohibition on use of black sea bass pots were implemented via proclamation FF-67-2016, and revised via proclamations FF-67-2016 (revised):
FF-67-2016 (http://portal.ncdenr.org/c/document_library/get_file?uuid=02e22a2e-a7e5-46a3-853e-e1d8dac6fed7&groupId=38337)

FF-67-2016 (REVISED) (http://portal.ncdenr.org/c/document_library/get_file?uuid=76a5853f-0a6f-49ae-85b7-47b14157de95&groupId=38337)

South Carolina:
1987: SC Code of Laws Section 50-17-55 established 8 inch minimum size limit for Black Sea Bass. (Added through H2612 during the 85/86 session of the SCGA?)

1989: SC Code of Laws Section 50-17-510(3) adopted to include size limits for many Council Snapper Grouper species, including 8 inch minimum size limit for Black Sea Bass.

1992: SC Code of Laws Section 50-5-510(C) adopted the federal minimum size limits automatically for all species managed under the Fishery Conservation and Management Act (PL94-265); and Section 50-5-510(F) adopted the federal catch and possession limits for all snapper grouper species managed under the Fishery Conservation and Management Act (PL94-265) as the Law of the State of SC. (Changes came through S788 during the 91/92 session of the SCGA?)

1999: SC Code of Laws Section 50-17-510(D)(4) established a 10 inch minimum size limit for Black Sea Bass; 510(E) established a requirement for Black Sea Bass to be sold (wholesale and retail) with head and fins intact. (A product of S1135 and H4843 of the 97/98 SCGA?)

2000: SC Marine-related Laws reorganized under SC Code of Laws Title 50 Chapter 5. Section 50-5-1710(4) retained the 10 inch minimum size limit for Black Sea Bass. 1710(4) maintained a requirement that "Black Seabass sold or offered for sale must be processed, marketed, and sold to the ultimate consumer with head and tail fins intact. A commercial retailer or restaurant may remove the head at the request of the ultimate consumer after completion of the transaction but before the transfer of the purchase or serving of the dish."

Added:

- SC Code of Laws Section 50-5-2730
  '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 black sea bass regulations are pulled directly from the federal regulations as promulgated under Magnuson.

2007: SC General Assembly repealed the code section that established a 10 inch minimum size limit on Black Sea Bass

2013: SC Code of Laws Section 50-5-2730 amended as follows:

SECTION 50-5-2730. Federal fishing regulations declared to be law of State; exception for black sea bass.

(A) Unless otherwise provided by law, any regulations promulgated by the federal government under the Fishery Conservation and Management Act (PL 94-265) 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.

(B) This provision does not apply to black sea bass (*Centropristis striata*) whose lawful catch limit is five fish per person per day or the same as the federal limit for black sea bass, whichever is higher. The lawful minimum size is thirteen inches total length. Additionally, there is no closed season on the catching of black sea bass (Centropristis striata).

Georgia:

Georgia began regulating Black Sea Bass in 1989.

Georgia General Assembly - O.C.G.A. 27-4-130.1 became effective April 18, 1989. It set the parameters around which the Board of Natural Resources could manage Black Sea Bass. those parameters were:

No Closed Season - No Limit on max Daily Creel - 8-15 inches minimum size

GA Board of Natural Resources then adopted Rule 391-2-4-.04 Saltwater Finfishing which became effective on. Sept. 13, 1989 - The original rule stated - No Closed Season - No Creel Limit - 8 inch minimum size

Since then, the following has been amended:
Effective Nov. 17, 1999 - 20 fish creel limit - 10 inch minimum size limit Effective Dec. 8, 2006 - 15 fish creel limit - 11 inches minimum size limit Effective July 1, 2007 - 12 inch minimum size

Commercial limits follow federal permit restrictions.

In May 2012, Georgia Gov. Nathan Deal signed into law House Bill 869 which moved managed saltwater species from O.C.G.A. 27-4-130.1 to a more comprehensive section, O.C.G.A. 27-4-10. This Code Section contains all fish species legislatively mandated for management and provided for greater flexibility by the Board of Natural Resources. The bill set the maximum daily creel at 15 and broadens the minimum size range from 0 to 15 inches. The bill also gave the commissioner of the Department of Natural Resources the ability to close the fishery for short durations, not to exceed six months. These changes will become effective January 1, 2013. Current management measures are 12 inches minimum size and a 15 fish creel limit in state waters.

Florida:

Black Sea Bass Regulation History (Atlantic only)

Year	Size Limit	Recreational Possession Limit	Regulation Changes
1980	None	None	Specified a 2x2x2 foot cube with a vertical throat of 5 inches high by 2 inches wide. Prohibited trap use below 27° latitude.
1981	None	None	
1982	None	None	
1983	None	None	
1984	None	None	

1985	8 in TL	None	
1986	8 in TL	None	
1987	8 in TL	None	
1988	8 in TL	None	
1989	8 in TL	None	
1990	8 in TL	None	Prohibited all commercial harvest of any species of snapper, grouper, and sea bass in state waters whenever harvest of that species is prohibited in adjacent federal waters.
1991	8 in TL	None	
1992	8 in TL	None	
1993	8 in TL	None	
1994	8 in TL	None	
1995	8 in TL	None	Established degradability requirements for black sea bass traps.
1996	8 in TL	None	
1997	8 in TL	None	
1998	10 in TL	20 fish per person per day	Required escape vents on sea bass pots. Black sea bass designated as a "restricted species." Required black sea bass to be landed in whole condition required.
1999	10 in TL	20 fish per person per day	Allowed the use of trap lid tie-down straps secured at one end by a loop composed of non-coated steel wire measuring 24 gauge or thinner, 2 X 3/8 inch non-treated pine dowels or squares to replace the hook on tie-down straps, a 3 X 6 inch panel attached to the trap opening with 24 gauge or less wire or single strand jute on black sea bass traps.

2000	10 in TL	20 fish per person per day	
2001	10 in TL	20 fish per person per day	
2002	10 in TL	20 fish per person per day	
2003	10 in TL	20 fish per person per day	
2004	10 in TL	20 fish per person per day	
2005	10 in TL	20 fish per person per day	Required each trap used for harvesting black sea bass to have the trap owner's Saltwater Products License (SPL) number permanently attached. Required a buoy or time-release buoy to be attached to each black sea bass trap or at each end of a weighted trap trotline. The buoy must be constructed of Styrofoam, cork, molded polyvinyl chloride, or molded polystyrene, be of sufficient strength and buoyancy to float, and be either white in color or the same color as the owner's blue crab or stone crab buoy colors. These buoys must be either spherical in shape with a diameter no smaller than six

2006	10 in TL	20 fish per person per day	inches, or some other shape that is no shorter than 10 inches in the longest dimension and the width at some point exceeds five inches. Required each buoy attached to these traps have the letter "B" and the owner's SPL number affixed to it in legible figures at least 1.5 inches high.
2007	Recreational: 11 inches TL Commercial: 10 inches TL	15 fish per person per day	Established a June 1 - May 31 harvest season. Required a minimum 2-inch mesh for the back panel of black sea bass traps in the Atlantic. Required removal of black sea bass traps in the Atlantic when the commercial quota is reached.
2008	Recreational: 12 inches TL Commercial: 10 inches TL	15 fish per person per day	Allowed the use of black sea bass traps to 8 cubic feet in volume.
2009	Recreational: 12 inches TL Commercial: 10 inches TL	15 fish per person per day	
2010	Recreational: 12 inches TL Commercial: 10 inches TL	15 fish per person per day	

2011	Recreational: 12 inches TL Commercial: 10 inches TL	15 fish per person per day	
2012	Recreational: 12 inches TL Commercial: 10 inches TL	15 fish per person per day	
2013	Recreational: 13 inches TL Commercial: 10 inches TL	5 fish per person per day	Required anyone fishing with black sea bass traps in Atlantic state waters to have a federal South Atlantic black sea bass pot endorsement and a commercial snapper grouper unlimited permit. Changed Atlantic state trap requirements to match federal trap specifications
2014	Recreational: 13 inches TL Commercial: 10 inches TL	5 fish per person per day	
2015	Recreational: 13 inches TL Commercial: 10 inches TL	5 fish per person per day	
2016	Recreational: 13 inches TL Commercial: 10 inches TL	5 fish per person per day	

[1980]

SNAPPER, GROUPER, AND SEA BASS, F.S.

- Eliminated finfish traps except for pinfish traps and black sea bass traps.
- Specified a 2x2x2 foot cube with a vertical throat of 5 inches high and 2 inches wide.
- Prohibited used below latitude of 27 degrees

- Federal rules prohibited all fish traps except black sea bass and pinfish

REEF FISH (formerly SNAPPER, GROUPER, AND SEA BASS), CH 46-14, F.A.C. (Effective July 29, 1985)
Minimum size limits:
- Black and southern sea bass - 8 inches

REEF FISH, CH 46-14, F.A.C. (Effective February 1, 1990)
- Minimum size limits:
  Sea basses - 8 inches
- All commercial harvest of any species of snapper, grouper, and sea bass is prohibited in state waters whenever harvest of that species is prohibited in adjacent federal waters

REEF FISH - BLACK SEA BASS TRAPS, CH 46-14, F.A.C. (Effective October 4, 1995)
Establishes degradability requirements for black sea bass traps. Such traps are considered to have a legal degradable panel if:
- The trap lid tie-down strap is secured to the trap by a single loop of untreated jute twine, and the trap lid is secured so that when the jute degrades, the lid will no longer be securely closed, or
- The trap lid tie-down strap is secured to one end with a corrodible hook composed of non-coated steel wire measuring 24 gauge or thinner, and the trap lid is secured so that when the hook degrades, the lid will no longer be securely closed, or
- The trap contains at least one sidewall with a vertical rectangular opening no smaller in either dimension than 6 inches high and 3 inches wide, and the opening is laced, sewn, or otherwise obstructed by a single length of untreated jute twine knotted only at each end and not tied or looped more than once around a single mesh bar; the opening in the sidewall of the trap must no longer be obstructed when the jute degrades, or
- The trap contains at least one sidewall with a vertical rectangular opening no smaller in either dimension than 6 inches high by 3 inches wide, and the opening must be obstructed with an untreated pine slat or slats no thicker than 3/8 inch; the opening in the sidewall of the trap must no longer be obstructed when the slat degrades, or
- The trap contains at least one sidewall with a vertical rectangular opening no smaller in either dimension than 6 inches high by 3 inches wide, and the opening must be laced, sewn, or otherwise obstructed by non-coated steel wire measuring 24 gauge or thinner or be obstructed with a panel of ferrous single-dipped galvanized wire mesh made of 24 gauge or thinner wire.

REEF FISH, CH 46-14, F.A.C. (Effective December 31, 1998)
- Increases the minimum size limit on black sea bass from 8 to 10 inches total length statewide, establishes a 20 fish daily recreational aggregate bag limit on black sea bass in Atlantic state waters only, and requires escape vents on sea bass pots statewide.

- Requires that all reef fish species managed in Florida be landed in a whole condition, and designate all such species as "restricted species."

REEF FISH - BLACK SEA BASS TRAP SPECIFICATIONS, CH 46-14, F.A.C. (Effective June 1, 1999)

- Allows the use on black sea bass traps of trap lid tie-down straps secured at one end by a loop composed of non-coated steel wire measuring 24 gauge or thinner, 2 X 3/8 inch non-treated pine dowels or squares to replace the hook on tie-down straps, a 3 X 6 inch panel attached to the trap opening with 24 gauge or less wire or single strand jute

REEF FISH - SEA BASSES & RED PORGY, CH 68B-14, F.A.C. (Effective June 1, 2001)

- Withdraws federal permit requirements for the commercial harvest of sea basses and red porgy in the Gulf of Mexico.

REEF FISH - BLACK SEA BASS TRAPS, CH 68B-14, F.A.C. (Effective July 15, 2004)

- Establishes a September 20 through October 4 closure to use of black sea bass traps in all Gulf of Mexico state waters between three and nine miles from shore.

REEF FISH - BLACK SEA BASS TRAPS, CH 68B-14, F.A.C. (Effective July 17, 2005)

- Requires each trap used for harvesting black sea bass to have the trap owner's Saltwater Products License (SPL) number permanently attached
- Each buoy attached to these traps shall have the letter "B" and the owner's SPL number affixed to it in legible figures at least 1.5 inches high
- Requires a buoy or time-release buoy must be attached to each black sea bass trap or at each end of a weighted trap trotline. The buoy must be constructed of Styrofoam, cork, molded polyvinyl chloride, or molded polystyrene, be of sufficient strength and buoyancy to float, and be either white in color or the same color as the owner's blue crab or stone crab buoy colors. These buoys must be either spherical in shape with a diameter no smaller than six inches, or some other shape that is no shorter than 10 inches in the longest dimension and the width at some point exceeds five inches

REEF FISH, CH 68B-14, F.A.C. (Effective July 1, 2007)

- Increases the recreational minimum size limit for Atlantic black sea bass from 10 inches total length to 11 inches total length in 2007, and then to 12 inches total length in 2008, and establishes a June 1 - May 31 harvest season
- Requires a minimum 2-inch mesh for the back panel of black sea bass traps in the Atlantic, and requires removal of black sea bass traps in the Atlantic when the commercial quota is reached

REEF FISH - BLACK SEA BASS TRAPS, CH 68B-14, F.A.C. (Effective March 12, 2008)

- Allows the use of black sea bass traps to 8 cubic feet in volume.

REEF FISH – BLACK SEA BASS CH 68B- 14, F.A.C. (Effective February 1, 2013)

- Increase the minimum size limits for commercial and recreational harvest to 11 inches TL and 13 inches TL respectively in the Atlantic
- Decrease the recreational bag limit from 15 to five fish per person per day in the Atlantic
- Require anyone fishing with black sea bass traps in Atlantic state waters to have a federal South Atlantic black sea bass pot endorsement and a commercial snapper grouper unlimited permit
- Change Atlantic state trap requirements to match federal trap specifications and requirements (this would include trap construction requirements, requiring traps to be set in waters north of Cape Canaveral, and requiring traps to be removed from the water and brought back to shore at the conclusion of each trip)

References

None provided.

3. Assessment History

Prior to the inception of SEDAR, this stock of black sea bass was assessed using tuned VPA models (FADAPT). With data through 1990, Vaughan et al. (1995) concluded that overfishing was occurring during the 1980s. Subsequently, with data through 1995, Vaughan et al. (1996) estimated that the rate of overfishing had increased during the 1990s.

This stock was first assessed through the SEDAR process in 2002 (SEDAR-02). The 2002 assessment applied a statistical catch-age formulation as the primary model (BAM). It estimated that the rate of overfishing had increased through the 1990s and that the stock was overfished. That assessment was updated in 2005 with data through 2003 (SEDAR Update Process #1). The update assessment estimated that the rate of overfishing continued to increase into the 2000s and that the stock remained overfished.

Several notable improvements in data content occurred between the 2005 update assessment and the 2011 benchmark, SEDAR 25. Studies on black sea bass provided information on fecundity, as well as total discards and discard mortality rates. Additional processed otolith shed light on the age compositions of landings and surveys. Natural mortality was reexamined and revised such that estimates were larger than previously thought and depended on age. SEDAR 25 also found the stock was overfished and undergoing overfishing.

In 2013, the SEDAR 25 update assessment used two additional years of data and maintained all of the assumptions and structure of the SEDAR 25 BAM model. The results were that the stock was no longer overfished and overfishing was not occurring.

This assessment, SEDAR 56, uses an updated BAM model with data through 2016 to assess the stock in a SEDAR standard framework. Notable improvements are the addition of a SERFS video index and the availability of new studies to inform the discard mortality. The assessment results show the stock is not undergoing overfishing, and, although the stock is below the SSBmsy threshold, it is not overfished.

SEDAR. 2011. SEDAR 25 – South Atlantic Black Sea Bass Assessment Report. SEDAR, North Charleston SC. 480 pp.

SEDAR. 2013. SEDAR Update Assessment – South Atlantic Black Sea Bass Assessment Report. SEDAR, North Charleston SC. 102 pp.

Vaughan, DS, MR Collins, and DJ Schmidt. 1995. Population characteristics of the black sea bass *Centropristis striata* from the southeastern U.S. Bulletin of Marine Science 56:250–267.

Vaughan, DS. 1996. Population characteristics of the black sea bass *Centropristis striata* from the U.S. southern Atlantic coast. Report to South Atlantic Fishery Management Council, Charleston, SC, 59 p.

4. Regional Maps

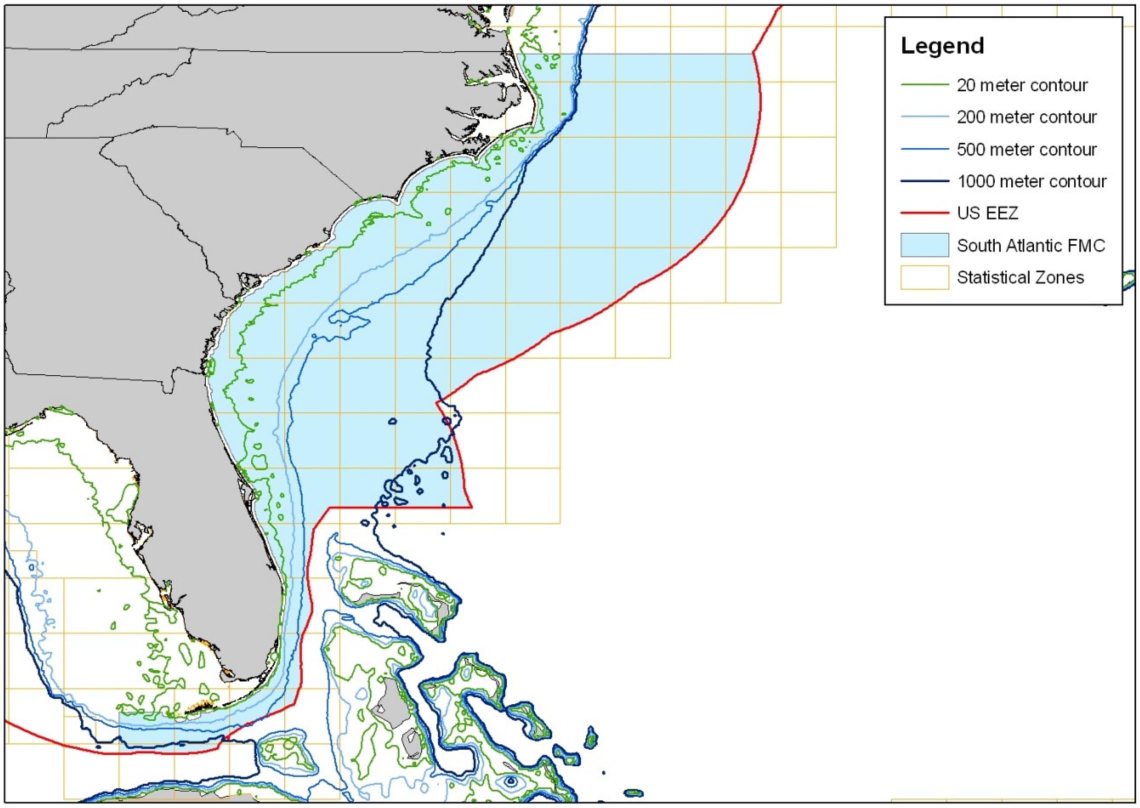

Figure 4.1: South Atlantic Fishery Management Council and EEZ boundaries.

5. SEDAR Abbreviations

APAIS	Access Point Angler Intercept Survey
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
AMRD	Alabama Marine Resources Division
AP	Advisory Panel
ASMFC	Atlantic States Marine Fisheries Commission
B	stock biomass level
BAM	Beaufort Assessment Model
BMSY	value of B capable of producing MSY on a continuing basis
CFMC	Caribbean Fishery Management Council
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 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
FL FWCC	Florida Fish and Wildlife Conservation Commission
FWRI	(State of) Florida Fish and Wildlife Research Institute
GA DNR	Georgia Department of Natural Resources
GLM	general linear model
GMFMC	Gulf of Mexico Fishery Management Council
GSMFC	Gulf States Marine Fisheries Commission
GULF FIN	GSMFC Fisheries Information Network
HMS	Highly Migratory Species

LDWF	Louisiana Department of Wildlife and Fisheries
M	natural mortality (instantaneous)
MARMAP	Marine Resources Monitoring, Assessment, and Prediction
MDMR	Mississippi Department of Marine Resources
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
SAS	Statistical Analysis Software, SAS Corporation
SC DNR	South Carolina Department of Natural Resources
SEAMAP	Southeast Area Monitoring and Assessment Program
SEDAR	Southeast Data, Assessment and Review
SEFIS	Southeast Fishery-Independent Survey
SEFSC	Fisheries Southeast Fisheries Science Center, National Marine Fisheries Service
SERO	Fisheries Southeast Regional Office, National Marine Fisheries Service
SG	Snapper Grouper
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.
TPWD	Texas Parks and Wildlife Department
Z	total mortality, the sum of M and F

SEDAR

Southeast Data, Assessment, and Review

SEDAR 56

South Atlantic Black Seabass

SECTION II: Assessment Report

April 2018

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

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Executive Summary

This standard assessment evaluated the stock of black sea bass, *Centropristis striata,* off the southeastern United States[1]. The primary objectives were to update and improve the 2011 SEDAR25 benchmark assessment of black sea bass and to conduct new stock projections. Using data through 2010, SEDAR25 had indicated that the stock was overfished and undergoing overfishing. For this assessment, data compilation and assessment methods were guided by methodology of SEDAR25, as well as by current SEDAR practices. The assessment period is 1978-2016.

Available data on this stock included indices of abundance, landings, discards, and samples of annual length and age compositions from fishery dependent and fishery independent sources. Four indices of abundance were fitted by the model: one from the recreational headboat fleet, one from the commercial handline fleet, one from the MARMAP blackfish/snapper trap survey, and one from the SERFS that combined chevron trap and video sampling. Data on landings and discards were available from recreational and commercial fleets.

The primary model used in the SEDAR25 benchmark and the update - and updated here - was the Beaufort Assessment Model (BAM), a statistical catch-age formulation. A base run of BAM was configured to provide point estimates of key management quantities, such as stock and fishery status. Uncertainty in estimates from the base run was evaluated through a mixed Monte Carlo/Bootstrap (MCB) procedure.

Results suggest that spawning stock declined until the early 1990s, remained relatively flat until the late-2000s, increased until 2012, and decreased again. The terminal (2016) base run estimate of spawning stock was above the MSST (SSB_{2016}/MSST =1.15) indicating that the stock is not overfished, though it is less than SSB_{MSY}. The estimated fishing rate is below F_{MSY}, though only fell below the overfishing threshold in the last two years. The terminal estimate, which is based on a three-year geometric mean, is below F_{MSY} in the base run ($F_{2014-2016}$/FMSY = 0.64). Thus, this assessment indicates that the stock is not overfished and not undergoing overfishing.

The MCB analysis indicates that these estimates of stock and fishery status are robust, but with some uncertainty in the conclusions. Of all MCB runs, 76.7% were in qualitative agreement that the stock is not overfished (SSB_{2016}/MSST > 1.0), and 95.1% that the stock is not undergoing overfishing ($F_{2014-2016}/F_{MSY} < 1.0$).

The estimated population trends of this standard assessment are quite similar to those from the SEDAR25 benchmark and the update. However, the three assessments did show some differences in results, which was not surprising given several modifications made to both the data and model (described throughout the report). Compared to the SEDAR25 benchmark and the update, this assessment suggests lower values of F_{MSY} and MSY, and a higher value of SSB_{MSY}.

[1]Abbreviations and acronyms used in this report are defined in Appendix A

1. Introduction

1.1 Workshop Time and Place

SEDAR 56 was conducted as a Standard Assessment through a series of webinars. The assessment originally had a terminal year of 2015 and was scheduled to occur over a series of webinars between February and August 2017. The Data Scoping webinar was held on February 24, 2017 and the first Assessment Scoping webinar was held May 12, 2017. In May 2017, the analytical team requested a delay in the assessment due to late data submissions. After consultation with the SEDAR Steering Committee and the SEDAR 56 panelists and data providers, the terminal year of the assessment was advanced to 2016 and the schedule was revised extending the series of assessment webinars through March 2018. A webinar was held to review the revised schedule on June 21, 2017. A second Assessment Scoping webinar was held November 15, 2017 and a series of four Assessment webinars were held on January 12, 2018; January 29, 2018; February 22, 2018; and March 2, 2018.

1.2 Terms of Reference

1. Update the approved 2013 SEDAR 25 South Atlantic Black Sea Bass Update assessment with data through 2015. Provide commercial and recreational landings and discards in pounds and numbers. Provide a model consistent with the 2013 SEDAR 25 Update assessment configuration and revise configurations as necessary to incorporate and evaluate any changes in model inputs or parameterization approved during this assessment.

2. Evaluate and document the following specific changes in input data or deviations from the update model. (List below each topic or new dataset that will be considered in this assessment.)
    - Consider the inclusion of the SERFS video index
    - Incorporate the latest BAM model configurations, and detail the changes made, and impacts of those changes, between the 2013 SEDAR 25 update model and the proposed SEDAR 56 model.
    - Re-consider use of age and length composition data

3. Document any changes or corrections made to the model and input datasets and provide updated input data tables. Fully document and describe the impacts (on population parameters and management benchmarks) of any changes to the model structure, methods, application or fitting procedures made between this assessment and the 2013 SEDAR 25 Update assessment.

4. Update model parameter estimates and their variances, model uncertainties, and estimates of stock status and management benchmarks. Compare population parameter trends and management benchmarks estimated in this assessment with values from the previous

assessment, and comment on the impacts of changes in data, assumptions or assessment methods on estimated population conditions and benchmarks.

5. Provide stock projections, including a pdf for biological reference point estimates and yield separated for landings and discards reported in pounds and numbers. Projection results are required through 2023, with projected fishing level changes beginning in 2019. However, it is possible the SAFMC could take action as early as mid-2018 and the panel is asked how this should be addressed in the projections. The panel shall provide guidance on appropriate assumptions to address harvest and mortality levels in the interim years between the assessment terminal year (2015) and the first year of management (2019). Projection criteria:
   - To determine OFL: (1) P* (annual probability of overfishing) = 50%; (2) Fmsy
   - To determine ABC: (1) P* = 40%; (2) F@75%F_{MSY}

6. Develop a stock assessment update report to address these TORS and fully document the input data, methods, and results of the stock assessment update.

1.3 List of Participants

ASSESSMENT PANELISTS		
Kate Siegfried	Lead analyst	SEFSC Beaufort
Rob Cheshire	Data compiler	SEFSC Beaufort
Joey Ballenger	Data provider	SC DNR
Jeff Buckel	SSC	SAFMC SSC
Julie DeFilippi-Simpson	Data provider	ACCSP
Anne Lange	SSC	SAFMC SSC
Vivian Matter	Data provider	SEFSC Miami
Beverly Sauls	Data provider	FL FWCC
George Sedberry	SSC	SAFMC SSC
Kyle Shertzer	Assessment Team	SEFSC Beaufort
Erik Williams	Assessment Team	SEFSC Beaufort
Beth Wrege	Data provider	SEFSC Miami
APPOINTED OBSERVERS		
Jimmy Hull	Fisherman	FL, SG AP
Dave Timpy	Fisherman	NC
David Tucker	Fisherman	NC
APPOINTED COUNCIL MEMBERS		
Charlie Phillips	Council member	SAMFC
Chris Conklin	Council member	SAMFC

STAFF

Julia Byrd	Coordinator	SEDAR
Myra Brouwer	Council lead	SAFMC
Mike Errigo	Observer	SAFMC
Nick Farmer/Alisha Gray-DiLeone	Observer	SERO

WEBINAR ATTENDEES

Nate Bacheler, SEFSC Beaufort
Peter Barile
Larry Beerkircher, SEFSC Miami
Alan Bianchi, NCDMF
Ken Brennan, SEFSC Beaufort
Mark Brown, SAFMC
Wally Bubley, SCDNR
Shannon Calay, SEFSC Miami
John Carmichael, SAFMC / SEDAR
Lora Clarke, PEW
Jack Cox, Snapper Grouper AP
Amy Dukes, SCDNR
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Rusty Hudson, Directed Sustainable Fisheries
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Walt Rogers, SEFSC Beaufort
McLean Seward, NCDMF
Tom Sminkey, NOAA S&T
Chris Wilson, NCDMF

1.4 Document List

SEDAR 56 Document List

Document #	Title	Authors
Documents Prepared for SEDAR 56		
SEDAR56-WP01	SCDNR State Finfish Survey: Black Seabass Data	Hiltz 2017
SEDAR56-WP02	Standardized video counts of Southeast U.S. Atlantic Black Sea Bass (*Centropristis striata*) from the Southeast Reef Fish Survey	Cheshire et al. 2017
SEDAR56-WP03	MRIP Recreational Estimates for Black Sea Bass in the South Atlantic	Matter 2017
SEDAR56-WP04	Discards of black seabass (*Centropristis striata*) for the headboat fishery in the US South Atlantic	FEB-NMFS 2017
SEDAR56-WP05	South Atlantic U.S. black sea bass *Centropristis striata*) age and length composition from the recreational fisheries	FEB-NMFS 2017
SEDAR56-WP06	Length and age distributions of Southeast U.S. Atlantic black seabass (*Centropristis striata*) from commercial fisheries	SEFSC 2017
SEDAR56-WP07	Black Seabass Length Frequencies and Condition of Released Fish from At-Sea Headboat Observer Surveys, 2005 to 2016	Lazarre et al. 2017
SEDAR56-WP08	Analysis of MRIP Black Seabass Catch in State vs. Federal Waters	Errigo 2017
SEDAR56-WP09	Evidence of increasing Black Seabass stock structure from commercial trip data in 2017	Hull 2017
Final Assessment Report		
SEDAR56-SAR1	Assessment of South Atlantic Black Seabass	To be prepared by SEDAR 56
Reference Documents		
SEDAR56-RD01	2013 SEDAR 25 South Atlantic Black Seabass Update Assessment Report	2013 SEDAR 25 Update
SEDAR56-RD02	SEDAR 25 South Atlantic Black Seabass Stock Assessment Report	SEDAR 25
SEDAR56-RD03	List of documents and working papers for SEDAR 25 (South Atlantic Black Seabass) – all documents available on the SEDAR website.	

SEDAR56-RD04	Southeast Reef Fish Survey Video Index Development Workshop	Bacheler and Carmichael 2014
SEDAR56-RD05	Overview of sampling gears and standard protocols used by the Southeast Reef Fish Survey and its partners	Smart et al. 2014
SEDAR56-RD06	Technical documentation of the Beaufort Assessment Model (BAM)	Williams and Shertzer 2015
SEDAR56-RD07	Age Workshop for Black Seabass (*Centropristis striata*)	Workshop Participants 2009
SEDAR56-RD08	Estimating reef fish discard mortality using surface and bottom tagging: effects of hook injury and barotrauma	Rudershausen et al. 2014
SEDAR56-RD09	Hierarchical analysis of multiple noisy abundance indices	Conn 2010
SEDAR56-RD10	SAFMC Snapper Group Advisory Panel Black Seabass Fishery Performance Report – November 2017	SAFMC Snapper Grouper AP 2017
SEDAR56-RD11	Data weighting in statistical fisheries stock assessment models	Francis 2011
SEDAR56-RD12	Corrigendum to Francis 2011 paper	Francis
SEDAR56-RD13	Replacing the multinomial in stock assessment models: A first step	Francis 2014
SEDAR56-RD14	Revisiting data weighting in fisheries stock assessment models	Francis 2017
SEDAR56-RD15	Model-based estimates of effective sample size in stock assessment models using the Dirichlet-multinomial distribution	Thorson et al. 2017
SEDAR56-RD16	Relating trap capture to abundance: a hierarchical state-space model applied to black seabass *(Centropristis striata*)	Shertzer et al. 2016

1.5 Statements Addressing Each Term of Reference

The following are the terms of reference with a statement explaining how each was addressed in the assessment report.

1. Update the approved 2013 SEDAR 25 South Atlantic Black Sea Bass Update assessment with data through 2015. Provide commercial and recreational landings and discards in pounds and numbers. Provide a model consistent with the 2013 SEDAR 25 Update assessment configuration and revise configurations as necessary to incorporate and evaluate any changes in model inputs or parameterization approved during this assessment.

The updated assessment model includes data through 2016. A sensitivity run (labeled S16) mimics the SEDAR25 configuration as closely as possible (Section 4.9).

2. Evaluate and document the following specific changes in input data or deviations from the update model. (List below each topic or new dataset that will be considered in this assessment.)
    - Consider the inclusion of the SERFS video index
    - Incorporate the latest BAM model configurations, and detail the changes made, and impacts of those changes, between the 2013 SEDAR 25 update model and the proposed SEDAR 56 model.
    - Re-consider use of age and length composition data

The SERFS video index was constructed (SEDAR56-WP02), considered by the Assessment Panel, and ultimately included in the assessment. The assessment model is the current version of BAM. The Dirichlet-multinomial likelihood was used to model length and age compositions, which provided an improved fit when compared to the SEDAR 25 benchmark and update. The use of length compositions when age compositions were available was reconsidered by the Panel, but there was no change made to the use of length compositions relative to the SEDAR 25 benchmark and update.

3. Document any changes or corrections made to the model and input datasets and provide updated input data tables. Fully document and describe the impacts (on population parameters and management benchmarks) of any changes to the model structure, methods, application or fitting procedures made between this assessment and the 2013 SEDAR 25 Update assessment.

Input data, including any deviations from the SEDAR25 benchmark and update, are described and tabulated in Section 2. The assessment model, including any deviations from SEDAR25, is documented in Section 3.

4. Update model parameter estimates and their variances, model uncertainties, and estimates of stock status and management benchmarks. Compare population parameter trends and management benchmarks estimated in this assessment with values from the previous assessment, and comment on the impacts of changes in data, assumptions or assessment methods on estimated population conditions and benchmarks.

Parameter estimates are provided in Appendix B. Status indicators and benchmarks, along with standard errors, are in Table 17. Comparisons between the SEDAR25 benchmark, update, and SEDAR56 assessments are in Section 4.9.2.

5. Provide stock projections, including a pdf for biological reference point estimates and yield separated for landings and discards reported in pounds and numbers. Projection results are required through 2023, with projected fishing level changes beginning in 2019. However, it is possible the SAFMC could take action as early as mid-2018 and the panel is asked how this should be addressed in the projections. The panel shall provide guidance on appropriate assumptions to address harvest and mortality levels in the interim years between the assessment terminal year (2015) and the first year of management (2019). Projection criteria:
   - To determine OFL: (1) P* (annual probability of overfishing) = 50%; (2) Fmsy
   - To determine ABC: (1) P* = 40%; (2) F@75%F_{MSY}

The projections are described in Sections 3.8.2 and 4.10, and illustrated in tables 18-20 and figures 37-39.

6. Develop a stock assessment update report to address these TORS and fully document the input data, methods, and results of the stock assessment update.

See this report.

2 Data Review and Update

In the SEDAR25 benchmark assessment, the assessment period was 1978–2010, and for the SEDAR25 update, the assessment period was 1978–2012. In this assessment, the terminal year was extended to 2016. Data sources from SEDAR25 were also considered here; however, all data were updated, including data prior to 2010, using current methodologies. The input data for this assessment are described below, with focus on modifications from the SEDAR25 benchmark and the update.

2.1 Data Review

In this standard assessment, the Beaufort assessment model (BAM) was fitted to data sources similar to those used in the SEDAR25 benchmark and update with some modifications and additions.

- Landings: Commercial handline; Commercial trawl, Commercial pots, Headboat, General recreational (charterboat and private boats)
- Discards: Commercial (handline and pots), Headboat, General recreational
- Indices of abundance: MARMAP blackfish/snapper trap, Combined SERFS chevron trap and video survey, Commercial handline, Headboat
- Length compositions of surveys or landings: MARMAP blackfish/snapper trap, Commercial handline, Commercial pots, Headboat, General recreational
- Length compositions of discards: Headboat, General recreational
- Age compositions of surveys or landings: MARMAP blackfish/snapper trap, SERFS chevron trap, Commercial handline, Commercial pots, Headboat

In addition to data fitted by the model, this assessment utilized life-history information that was treated as input. Such inputs remained the same for this assessment as were used in the SEDAR25 benchmark and the update, including natural mortality, fecundity at age, female maturity at age, sex ratio by age, and somatic growth. One exception is the discard mortality rates, which were modified using information from recent studies.

2.2 Data Update

The following is a summarization of the data differences between this assessment and the SEDAR25 benchmark and update. Data available for this assessment are summarized in Tables 1–5.

- Discards: Commercial handline and pot discards for both open and closed seasons were updated through 2016. Headboat and recreational discards were update through 2016. The estimates for commercial and recreational discards are either model- or ratio-based, therefore the entire time series of new estimates was replaced.
- Indices of abundance: The SERFS chevron trap index was updated through 2016 and the SERFS video index was standardized and provided for consideration. The SERFS indices were combined to form one index (CVID). Because of changing regulations since 2009, the commercial handline and headboat indices were not updated. The headboat at-sea discards index was not used

- Size/age compositions of surveys or landings: SERFS chevron trap age compositions were both updated through 2016 and corrected for previous years. Headboat age compositions were corrected and updated through 2016. Commercial handline, commercial pots, and general recreational composition data were corrected and updated through 2016 the terminal year of the assessment, though general recreational age compositions were not used. All of the updated composition data are subject to the same minimum sample size used in SEDAR25 (n=30 trips for lengths and n=10 trips for ages or for lengths from the MARMAP blackfish/snapper trap survey).
- The iterative reweighting method used in SEDAR25 was not used for composition data, as the Dirichlet multinomial distribution was used. The Dirichlet multinomial is a self-weighting distribution, thus removing the need for weights on the composition data. The same weight of 2.5 was applied to the four indices, which is consistent with SEDAR25.

In several cases, the SEDAR25 benchmark and update data did not require updating: landings from commercial trawl (1978–1990), MARMAP blackfish/snapper index values (1981–1987), and the headboat index values were all unchanged.

2.2.1 Discard Mortality

The discard mortalities for all the fleets were revisited due to the availability of new data, a new study (Rudershausen et al. 2014) and contributions from FWRI state partners. The Rudershausen et al. (2014) study determined average discard mortality rates based on disposition at release at sites in North Carolina. Disposition data from observers on recreational boats compiled by FWRI staff complemented the Rudershausen (2014) study by providing fleet specific information. The Rudershausen et al. (2008) study provided a comparison of discard mortality in pots with 1.5 inch mesh versus 2 inch mesh. After discussion with the Assessment Panel and industry experts, the following discard mortalities were applied to the data: 14% for commercial pot discard mortality prior to 2007 (when 1.5 inch mesh pots were used), 48.3% of 1.5 mesh pot mortality for 2007 to present (when the 2 inch back panel is required), 19% for commercial lines, 13.7% for the general recreational fleet, and 15.2% for the headboat fleet.

2.2.2 Recreational Landings and Discards

The landings and discards from the general recreational fleet were provided for SEDAR25 using MRFSS. The SEDAR25 update did not have complete general recreational data for the terminal year due to the timing of the assessment. Here, estimates were available from MRIP, and were used to update the landings and discards data for the general recreational fleet through 2016. Headboat landings were updated through 2016, and headboat discards were recalculated for the entire time series, as it is a model-based approach.

2.2.3 Commercial Landings and Discards

The commercial discards were revised for the entire time series, as it is a model-based approach, and provided through 2016. Commercial landings were updated through 2016.

2.2.4 Indices of Abundance

Following the SEDAR 56 Terms of Reference, the SERFS video data were considered as a new source of information for this assessment. The SERFS video index was added and merged with the chevron trap index using the Conn method (Conn 2010) to form the CVID index. The video cameras are mounted to the traps, and likely observe a similar portion of the population as the trap. Combining the indices using the Conn method better represents the observation and process error in the system. The effects of the video data on the base model results were examined with a sensitivity run that excluded video data, using only the standardized index from SERFS chevron trap data.

The fishery-dependent indices were considered in light of new management measures effected since the last assessment. Closures for the recreational season have been intermittent since 2011. The change in closures as well as new bag limits since SEDAR25 clearly affects catch per effort, and it likely invalidates catch per effort as a meaningful index of abundance. Thus, the headboat index was not updated for this assessment. Similarly, the commercial fishery has become subject to new regulations, and thus the commercial handline index of abundance was not updated. The last year of the commercial index used in the update to the SEDAR25 was removed. There was a partial closed season in 2010 that would affect the ability of the logbook data to capture abundance trends in that year. The new terminal year of the commercial index is 2009.

The headboat at-sea observer index was removed by panel consensus as the size composition data clearly overlapped with the chevron trap survey. The chevron trap survey data are available further back in time, fishery-independent data are considered better than fishery-dependent data for constructing an index of abundance, and it is not necessary to include an additional index.

The assessment panel considered the CVs provided during the standardization process to inadequately represent both the observation and process error in the system. They considered the advice provided by Francis (2003) and decided to set the CVs of the fishery dependent indices and the MARMAP blackfish/snapper trap index to the largest estimated from the CVID index (0.27). Prior to 1984, the CVs of the headboat index were assumed to be double that (0.54) of the more modern time period, which is consistent with the assumptions made in the SEDAR25 benchmark and update.

2.2.5 Length Compositions

Length compositions were corrected and updated through 2016. The length compositions were used in years with no age composition data, or when the age data were sparse. However, length compositions were not included during years of adequate age composition data (i.e. multiple consecutive years with greater than 10 trips). For the MARMAP blackfish/snapper trap index, length compositions were used from 1981–1987. For the commercial lines fleet, length compositions were used from 1984–2002. For the commercial pots fleet, length compositions were used from 1988, 2002, and 2003. For the headboat fleet, length compositions were used from 1978–2002. For the general recreational fleet, length compositions were used from 1981-2016. For discards from the headboat fleet, length compositions were used from 2005–2016. This is similar to the treatment of length compositions in SEDAR25.

2.2.6 Age Compositions

The Assessment panel reviewed in detail the sample size and spatial coverage of the four years of general recreational age compositions. The result was to remove those age compositions, as they were not representative of the fleet. The age compositions used for the CVID index are only from the SERFS chevron trap survey, as no size or age data are collected for the video survey.

3 Stock Assessment Methods

This assessment updates the primary model applied during the SEDAR25 benchmark and update for South Atlantic black sea bass. The methods are reviewed below, and any changes since the SEDAR25 benchmark or update are flagged.

3.1 Overview

This assessment used the Beaufort Assessment Model (BAM, Williams and Shertzer 2015), which applies a statistical catch-age formulation, implemented with the AD Model Builder software (Fournier et al. 2012). In essence, the model simulates a population forward in time while including fishing processes (Quinn and Deriso 1999; Shertzer et al. 2008). Quantities to be estimated are systematically varied until characteristics of the simulated population match available data on the real population. The model is similar in structure to Stock Synthesis (Methot and Wetzel 2013). Versions of BAM have been used in previous SEDAR assessments of reef fishes in the U.S. South Atlantic, such as red porgy, tilefish, blueline tilefish, gag, greater amberjack, snowy grouper, vermilion snapper, and red snapper, as well as in previous SEDAR assessments of black sea bass (SEDAR 2011).

3.2 Data Sources

The catch-age model included data from fishery independent surveys and from five fleets that caught black sea bass in southeastern U.S. waters: commercial lines (primarily handlines), commercial pots, commercial trawls, recreational headboats, and general recreational. The model was fitted to data on annual landings (in units of 1000 lb whole weight), annual discard mortalities (in units of 1000 fish), annual length compositions of landings, annual age compositions of landings, annual length compositions of discards, two fishery-independent indices of abundance (MARMAP blackfish/snapper traps and SERFS combined chevron traps and videos), and two fishery-dependent indices (commercial lines and headboat). Data used in the model are tabulated in §2 of this report.

3.3 Model Configuration

Model structure and equations of the BAM are detailed in Williams and Shertzer (2015). The assessment time period was 1978–2016. A general description of the assessment model follows.

3.3.1 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 $0 - 11^+$, where the oldest age class 11^+ allowed for the accumulation of fish (i.e., plus group).

3.3.2 Initialization

Initial (1978) abundance at age was estimated in the model as follows. First, the equilibrium age structure was computed for ages 1–11 based on natural and fishing mortality (F), where F was set equal to the geometric mean fishing mortality from the first three assessment years (1978-1980) scaled by an estimated multiplier (called $F_{\text{init.ratio}}$). Second, lognormal deviations around that equilibrium age structure were estimated. The deviations were lightly penalized, such that the initial abundance of each age could vary from equilibrium if suggested by early composition data, but remain estimable if data were uninformative. Given the initial abundance of ages 1–11, initial (1978) abundance of age-0 fish was computed using the same methods as for recruits in other years (described below).

3.3.3 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 (11 yr) as would occur with constant $M = 0.38$ from the SEDAR25 DW. This approach using cumulative mortality allows that fraction at the oldest age to be consistent with the findings of Hoenig (1983) and Hewitt and Hoenig (2005).

3.3.4 Growth

Mean size at age of the population (total length, TL) was modeled with the von Bertalanffy equation (Figure 1), and weight at age (whole weight, WW) was modeled as a function of total length. Parameters of growth and conversions (TL-WW) were estimated by the SEDAR25 DW and were treated as input to the assessment model. The von Bertalanffy parameter estimates from the DW were $L_\infty = 502.1$, $K = 0.173$, and $t_0 = -0.97$. 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.

3.3.5 Sex transition

Black sea bass is a protogynous hermaphrodite. Proportion female at age was modeled with a logistic function, estimated by the SEDAR25 DW. The age at 50% transition to male was estimated to be 3.83 years.

3.3.6 Female maturity and fecundity

Female maturity was modeled with a logistic function; the age at 50% female maturity was estimated to be ~ 1 year. Annual egg production by mature females was computed as eggs spawned per batch, a function of body weight, multiplied by the number of batches per year. Maturity and fecundity parameters were provided by the SEDAR25 DW and treated as input to the assessment model.

3.3.7 Spawning stock

Spawning stock was modeled as population fecundity of mature females (i.e., total annual egg production) measured at the time of peak spawning. For black sea bass, peak spawning was considered to occur at the end of March.

3.3.8 Recruitment

Expected recruitment of age-0 fish was predicted from spawning stock using the Beverton–Holt spawner-recruit model. Annual variation in recruitment was assumed to occur with lognormal deviations starting in 1978, when composition data could provide information on year-class strength.

For modeling recruitment, this standard assessment implemented one notable change to the SEDAR25 model. The previous assessment was able to estimate the steepness parameter ($\hat{h} = 0.48$) of the spawner-recruit model. In this assessment, steepness was not reliably estimated throughout the uncertainty analysis, even when applying a prior distribution to inform the estimation (Shertzer and Conn 2012). The Assessment Panel examined likelihood profiles on steepness, and found that the profile was relatively flat between 0.31 and 0.97, within two negative-log-likelihood points of the minimum at $h = 0.31$. Thus, the panel concluded that steepness is likely in the range (0.31, 0.97) and, for the base run, fixed steepness at the midpoint $h = 0.64$ of that range. Sensitivity runs examined values at the boundaries of that range, and uncertainty analyses included the full range.

3.3.9 Landings

The model included time series of landings from five fleets: commercial lines, commercial pots, commercial trawls, headboat, and general recreational (charterboat and private boats combined). The commercial trawl time series was used through 1990. Trawling was banned in January, 1989 within federal waters of the SAFMC's jurisdiction, but appears to have continued for another two years.

Landings were modeled with the Baranov catch equation (Baranov 1918) and were fitted in units of weight (1000 lb whole weight). Observed landings were provided back to the first assessment year (1978) for each fleet except general recreational, because the MRIP started in 1981. Thus for years 1978–1980, general recreational landings were predicted in the assessment model (but not fitted to data), by applying the geometric mean recreational F from the years 1981–1983.

3.3.10 Discards

As with landings, discard mortalities (in units of 1000 fish) were modeled with the Baranov catch equation (Baranov 1918), which required estimates of discard selectivities and release mortality probabilities. Discards were assumed to have gear-specific mortality probabilities, as suggested by the Assessment panel described in §2.2.1. Annual discard mortalities, as fitted by the model, were computed by multiplying total discards by the gear-specific release mortality probability.

For the commercial fleets, discards from handline and pot gears were combined, and were modeled starting in 1984 with implementation of the 8-inch size limit (TL). Commercial discards prior to 1984 were considered negligible and not modeled. Data on commercial discards were available starting in 1993. Thus for years 1984–1992, commercial discards were predicted in the assessment model (but not fitted to data), by applying the geometric mean commercial discard F from the years 1993–1998 (the 10-inch limit began in 1999).

For headboat and general recreational fleets, discard time series were assumed to begin in 1978, as observations from MRIP indicated the occurrence of recreational discards prior to implementation of the 8-inch size limit. Headboat discard estimates were separated from MRIP beginning in 1986, and were combined for 1978–1985. Because MRIP began in 1981, the 1978–1980 general recreational (plus headboat) discards were predicted in the assessment model (but not fitted to data), by applying the geometric mean recreational discard F from the years 1981–1983.

3.3.11 Fishing

For each time series of landings and discard mortalities, 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.

3.3.12 Selectivities

Selectivity curves applied to landings, MARMAP, SERFS survey gears, and the last two periods of recreational discards were estimated using a parametric approach. This approach applies plausible structure on the shape of the selectivity curves, and achieves greater parsimony than occurs with unique parameters for each age. Selectivities of landings from all fleets were modeled as flat-topped, using a two-parameter logistic function, as were selectivities of MARMAP and SERFS trap gears. Although selectivities of trap gear are often considered dome-shaped for other species, the AW of the SEDAR25 concluded that they were flat-topped for this stock SEDAR (2011). Selectivities of fishery-dependent indices were the same as those of the relevant fleet.

Selectivity of each fleet was fixed within each block of size-limit (in TL) regulations, but was permitted to vary among blocks where possible or reasonable. Commercial fisheries experienced four blocks of size-limit regulations: no limit prior to 1983, 8-inch limit during 1983–1999, 10-inch limit during 1999–2011, and 11-inch limit during 2012-2016. Recreational fisheries experience five blocks of size-limit regulations, which were the same as those of the commercial fisheries until 2007 with a 12-inch size limit implemented until 2012. From 2012-2016, a 13-inch size limit was in effect.

Age and length composition data are critical for estimating selectivity parameters, and ideally, a model would have sufficient composition data from each fleet over time to estimate distinct selectivities in each period of regulations. That was not the case here, and thus additional assumptions were applied to define selectivities as follows. Because no age and very few length composition data were available from commercial trawls, selectivity of this fleet was assumed equal to that of the commercial pots. With no composition data from commercial fleets prior to regulations, commercial line selectivities in the first and second regulatory blocks were set equal, as were commercial pot selectivities, consistent with the SEDAR25 DW recommendation that the 8-inch size limit had little effect on commercial fishing. Length and age composition data from both the headboat and general recreational fleets were sufficient to estimate selectivities in each time block.

Selectivities of commercial discards were assumed to be dome-shaped. They were partially estimated, assuming that discards consisted primarily of undersized fish, as implied by observed length compositions of discards. The general approach taken was that age-specific values for ages 0–2 were estimated, age 3 was assumed to have full selection, and selectivity for each age 4^+ was set equal to the age-specific probability of being below the size limit, given the estimated normal distribution of size at age. In this way, the descending limb of discard selectivities would change with modification in the size limit. The exception to the above approach was in years 2009–2016, when a commercial quota was in place. For those years, commercial discard selectivity included fish larger than the size limit that would have been released during the closed season. The commercial discard selectivity for these years was computed as the combined selectivities of sublegal-sized fish and landed fish from commercial lines and pots, weighted by the mean of fleet-specific observed discards or landings.

Similarly, selectivities of recreational discards were assumed to be dome-shaped. They were partially estimated, assuming that discards consisted primarily of undersized fish, as implied by observed length compositions of discards. The general approach taken for the first two time blocks was that age-specific values for ages 0–2 were estimated, age 3 was assumed to have full selection, and selectivity for each age 4^+ was set equal to the age-specific probability of being below the size limit, given the estimated normal distribution of size at age. In this way, the descending limb of discard selectivities would change with modification in the size limit. In the third and fourth time block, there were sufficient length compositions to estimate a logistic exponential, dome-shaped selectivity with age 3 fully selected.

3.3.13 Indices of abundance

The model was fit to two fishery independent indices of relative abundance (MARMAP blackfish/snapper traps (1981–1987) and SERFS CVID (1990–2016)) and two fishery dependent indices (headboat 1979–2010 and commercial lines 1993–2009) (Figure 2). 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. All indices were significantly positively correlated.

3.3.14 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. Catchability of the two fishery dependent indices varied over time, and was modeled with a random walk (Wilberg and Bence 2006; SEDAR Procedural Guidance 2009; Wilberg et al. 2010). This was a modification from the SEDAR25 benchmark and update, which assumed constant catchability for all indices.

3.3.15 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 population fecundity of mature females. These benchmarks are conditional on the estimated selectivity functions and the relative contributions of each fleet's fishing mortality. The selectivity pattern used here was the effort-weighted selectivities at age, with effort from each fishery (including discard mortalities) estimated as the full F averaged over the last three years of the assessment.

3.3.16 Fitting criterion

The fitting criterion was a penalized likelihood approach in which observed landings and discards were fit closely, and observed composition data and abundance indices were fit to the degree that they were compatible. Landings, discards, and index data were fitted using lognormal likelihoods. Length and age composition data were fitted using the Dirichlet-multinomial distribution, with sample size represented by the annual number of trips, adjusted by an estimated variance inflation factor.

The SEDAR25 benchmark and update fit composition data using the multinomial distribution, and many SEDAR assessments since then have applied a robust version of the multinomial likelihood, as recommended by Francis (2011). More recent work has questioned use of the multinomial distribution in stock assessment models (Francis 2014), and of the alternative distributions, two appear most promising, the Dirichlet-multinomial and logistic-normal (Francis 2017; Thorson et al. 2017). Both are self-weighting and therefore iterative re-weighting (e.g., (Francis 2011)) is unnecessary, and both better account for intra-haul correlations (i.e., fish caught in the same set are more alike in length or age than fish caught in a different set). The Dirichlet-multinomial allows for observed zeros (the logistic-normal does not), and has recently been implemented in Stock Synthesis (Methot and Wetzel 2013). This assessment used the Dirichlet-multinomial distribution in the base run, but considered the multinomial distribution in a sensitivity run.

The model includes the capability for each component of the likelihood to be weighted by user-supplied values. When applied to landings and indices, these weights modified the effect of the input CVs. In this application to black sea bass, CVs of landings and discards (in arithmetic space) were assumed equal to 0.05 to achieve a close fit to these data while allowing some imprecision. In practice, the small CVs are a matter of computational convenience, as they help achieve a close fit 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) were adjusted iteratively, starting from initial weights as follows. These initial weights were then adjusted in an attempt to achieve standard deviations of normalized residuals (SDNRs) near 1.0. This iterative reweighting failed to fit the CVID index well, which was discussed thoroughly by the Assessment Panel. By consensus, the Panel decided to remain consistent with the SEDAR25 benchmark and update and apply a weightof 2.5 to all four indices, in accordance with the principle that abundance data should be given primacy (Francis 2011).

In addition, a lognormal likelihood was applied to the spawner-recruit relationship. The compound objective function also included several penalties or prior distributions, applied to CV of growth (based on the empirical estimate), $F_{\mathrm{init.ratio}}$ (prior of 1.0), and selectivity parameters. 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.

3.3.17 Configuration of base run

The base run was configured as described above. However, the base run configuration was not considered to represent all uncertainty. Sensitivities, retrospective analyses, and a Monte Carlo bootstrap analysis was conducted to better characterize the uncertainty in base run point estimates.

3.3.18 Sensitivity analyses

Sensitivity runs were chosen to investigate issues that arose specifically with this standard assessment. They were intended to demonstrate directionality of results with changes in inputs or simply to explore model behavior, and not all were considered equally plausible. Sensitivity runs vary from the base run as follows.

- S1: High natural mortality $M = 0.53$ used to scale the Lorenzen (1996) age-based estimator.
- S2: Low natural mortality $M = 0.27$ used to scale the Lorenzen (1996) age-based estimator.
- S3: High weight on indices $w = 5.0$.
- S4: Low weight on indices $w = 1.0$.
- S5: Steepness $h = 0.97$, at the upper bound of the range identified by likelihood profiling.
- S6: Steepness $h = 0.31$, at the lower bound of the range identified by likelihood profiling.
- S7: Constant catchability for all indices.
- S8: The chevron trap index rather than the CVID index.
- S9: High recreational landings and all discards (+2 sd).
- S10: Low recreational landings and all discards (-2 sd).
- S11: High discard mortalities (38% and 33% for lines and pots, respectively).
- S12: Low discard mortalities (7% and 5% for lines and pots, respectively).
- S13: Continuity configuration, including the multinomial likelihood for composition data, discard mortalities from the benchmark assessment, including MRIP age comps, and a constant catchability for all indices.
- S14-16: Retrospectives, with 2015-2013 as the terminal year, respectively.

Retrospective analyses were run by incrementally dropping one year at a time for three iterations making the terminal years 2015, 2014, and 2013. Going further back in time would cause the SERFS Video index to be excluded entirely, and would encroach on a different regulatory period, rendering it incomparable.

3.4 Parameters Estimated

The model estimated annual fishing mortality rates of each fleet, selectivity parameters, Dirichlet-multinomial variance inflation factors, catchability coefficients associated with indices, parameters of the spawner-recruit model, annual recruitment deviations, and CV of size at age.

3.5 Per Recruit and Equilibrium Analyses

Yield per recruit and spawning potential ratio were computed as functions of F, as were equilibrium landings, discards, and spawning biomass. Equilibrium landings and discards were also computed as functions of biomass B, which itself is a function of F. As in computation of MSY-related benchmarks (described in §3.6), per recruit and equilibrium analyses applied the most recent selectivity patterns averaged across fleets, weighted by each fleet's F from the last three years of the assessment (2014–2016).

3.6 Benchmark/Reference Point Methods

In this assessment of black sea bass, the quantities F_{MSY}, SSB_{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,

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

where R_0 is virgin recruitment, h is steepness, and $\Phi_F = \phi_F/\phi_0$ is spawning potential ratio given growth, maturity, and total mortality at age (including natural, fishing, and discard mortality rates). The R_{eq} and mortality schedule imply an equilibrium age structure and an average sustainable yield (ASY). The estimate of F_{MSY} is the F giving the highest ASY (excluding discards), and the estimate of MSY is that ASY. The estimate of $\mathrm{SSB}_{\mathrm{MSY}}$ follows from the corresponding equilibrium age structure, as does the estimate of discard mortalities (D_{MSY}), here separated from ASY (and consequently, MSY).

Estimates of MSY and related benchmarks are conditional on selectivity pattern. The selectivity pattern used here was an average of terminal-year selectivities from each fleet, where each fleet-specific selectivity was weighted in proportion to its corresponding estimate of F averaged over the last three years (2014–2016). If the selectivities or relative fishing mortalities among fleets were to change, so would the estimates of MSY and related benchmarks.

The maximum fishing mortality threshold (MFMT) is defined by the SAFMC as F_{MSY}, and the minimum stock size threshold (MSST) as $\mathrm{MSST} = (1-M)\mathrm{SSB}_{\mathrm{MSY}}$ (Restrepo et al. 1998), with constant M here equated to 0.38. 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 (2016), and current status of the fishery is represented by the geometric mean of F from the latest three years (2014–2016).

3.7 Uncertainty and Measures of Precision

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, though parallel computing can somewhat mitigate those demands.

In this assessment, the BAM was successively re-fit in $n = 4000$ trials that differed from the original inputs by bootstrapping on data sources, and by Monte Carlo sampling of several key input parameters. The value of $n = 4000$ was chosen because at least 3000 runs were desired, and it was anticipated that not all runs would be valid. Of the 4000 trials, approximately 1.75% were discarded, based on a 0.5% trim on $R0$ or because the model did not properly converge. This left $n = 3930$ trials used to characterize uncertainty, which was sufficient for convergence of standard errors in management quantities.

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.

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

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

The term $\sigma^2_{s,y}/2$ is a bias correction that centers the multiplicative error on the value of 1.0. Standard deviations in log space were computed from CVs in arithmetic space, $\sigma_{s,y} = \sqrt{\log(1.0 + CV^2_{s,y})}$. As used for fitting the base run, CVs of commercial landings were assumed to be 0.05. The CVs for recreational landings and both commercial and recreational discards were those provided by the data providers or from Assessment Panel consensus (see Table 3). The CVs of indices of abundance were those provided by, or modified from, the data providers (see Table 4).

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.

3.7.2 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.

Natural mortality Point estimates of natural mortality ($M = 0.38$) were provided by the SEDAR25 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 [0.27, 0.53]) with mean equal to the point estimate ($M = 0.38$) and standard deviation set to provide a lower 95% confidence limit at 0.27 (the low end of the DW range). Each realized value of M was used to scale the age-specific Lorenzen M, as in the base run.

Discard mortalities Similarly, discard mortalities δ were subjected to Monte Carlo variation as follows. A new value for commercial lines discard mortality was drawn for each MCB trial from a truncated normal distribution (range [0.05, 0.33]) with mean equal to the point estimate ($\delta = 0.19$) and standard deviation set to provide a lower 95% confidence limit at 0.05 (the low end of the Rudershausen et al. (2014) range). General recreational and headboat lines discard mortality was estimated using information from both Rudershausen et al. (2014) and data provided by Panel members from FWRI. Actual trip samples and dispositions were provided by the FL partners from both charterboat and headboat trips. The disposition mortalities from Rudershausen et al. (2014) were applied to those fish using a truncated normal distribution for each disposition (1-4) as follows:

- For disposition 1, the range was [0.0, 0.33] with mean equal to the point estimate ($\delta = 0.13$) and standard deviation set to provide a lower 95% confidence limit at 0.00.
- For disposition 2, the range was [0.0, 0.31] with mean equal to the point estimate ($\delta = 0.09$) and standard deviation set to provide a lower 95% confidence limit at 0.00.
- For disposition 3, the range was [0.33, 0.83] with mean equal to the point estimate ($\delta = 0.64$) and standard deviation set to provide a lower 95% confidence limit at 0.33.
- For disposition 4, the range was [0.70, 0.92] with mean equal to the point estimate ($\delta = 0.84$) and standard deviation set to provide a lower 95% confidence limit at 0.70.

The fish from the samples were resampled using a multinomial distribution and combined into one mortality using the frequency of occurrence. A new estimate was drawn as described for each fleet for each MCB trial.

A new value for 1.5 in. commercial pots discard mortality was drawn for each MCB trial from a truncated normal distribution (range [0.01, 0.27]) with mean equal to the point estimate ($\delta = 0.14$) and standard deviation set to provide a lower 95% confidence limit at 0.01 (the low end of the Rudershausen et al. (2014) range). The 2 in. pots discard mortality was scaled to be 48.3% of the 1.5 in. pots draw (Rudershausen et al. 2008).

Weighting of indices In the base run, external weights applied to four indices (commercial, headboat, MARMAP blackfish/snapper, and SERFS CVID) were adjusted upward to a value of $\omega = 2.5$. In MCB trials, that weight was drawn from a uniform distribution with bounds at $\pm 25\%$ of 2.5.

Steepness Steepness was fixed at a new value drawn for each MCB trial from a truncated normal distribution (DW range [0.31, 0.97]) with mean equal to the central point (0.64) and standard deviation set to provide a lower 95% confidence limit at 0.31 (the low end of the likelihood profile range). In early MCB trials, the standard deviation of recruitment was hitting an upper bound. To prevent this behavior, it was fixed at the value estimated in the base run ($\sigma = 0.35$) for the MCB trials.

Recreational Landings and Discards CVs The recreational landings and all discards were allowed to vary based on the CV provided. If no CV was provided, fleet experts were consulted to determine a CV appropriate for the fleet and year. For example, the headboat program coordinator provided assumed CVs for the headboat landings and discards data. The 5% and 95% confidence intervals were used to calculate the lower and upper bound for each distribution.

3.8 Projections—Probabilistic Analysis

Projections were run to predict stock status in years after the assessment, 2017–2023, as requested in the TORs.

The structure of the projection model was the same as that of the assessment model, and parameter estimates were those from the assessment. Any time-varying quantities, such as selectivity, were fixed to the most recent values of the assessment period. A single selectivity curve was applied to calculate landings, and one applied to calculate dead discards, each computed by averaging selectivities across fleets using geometric mean Fs from the last three years of the assessment period, similar to computation of MSY benchmarks (§3.6).

Expected values of SSB (time of peak spawning), F, recruits, landings, and discards were represented by deterministic projections using parameter estimates from the base run. These projections were built on the estimated spawner-recruit relationship with bias correction, and were thus consistent with estimated benchmarks in the sense that long-term fishing at F_{MSY} would yield MSY from a stock size at $\mathrm{SSB}_{\mathrm{MSY}}$. Uncertainty in future time series was quantified through stochastic projections that extended the Monte Carlo/Bootstrap (MCB) fits of the stock assessment model.

3.8.1 Initialization of projections

Although the terminal year of the assessment is 2016, the assessment model computes abundance at age (N_a) at the start of 2017. For projections, those estimates were used to initialize N_a. However, the assessment has no information to inform the strength of 2017 recruitment, and thus it computes 2017 recruits (N_1) as the expected value, that is, without deviation from the spawner-recruit curve, and corrected to be unbiased in arithmetic space. In the stochastic projections, lognormal stochasticity was applied to these abundances after adjusting them to be unbiased in log space, with variability based on the estimate of σ_R. Thus, the initial abundance in year one (2017) of projections included this variability in N_1. The deterministic projections were not adjusted in this manner, because deterministic recruitment follows the bias-corrected (arithmetic space) spawner-recruit curve precisely, consistent with the assessment's 2017 predictions.

Fishing rates that define the projections were assumed to start in 2019. Because the assessment period ended in 2016, the projections required an initialization period (2017 and 2018). F_{current} was assumed during the interim period.

3.8.2 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 steepness, natural mortality, and discard mortality, as well as in estimated quantities such as remaining spawner-recruit parameters, selectivity curves, and in initial (start of 2017) 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 is used to compute mean annual recruitment values ($\bar{R}_y$). Variability is added to the mean values by choosing multiplicative deviations at random from a lognormal distribution,

$$R_y = \bar{R}_y \exp(\epsilon_y). \tag{3}$$

Here ϵ_y is drawn from a normal distribution with mean 0 and standard deviation σ_R, where σ_R is the standard deviation from the relevant MCB fit.

The procedure generated 20,000 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. Central tendencies were represented by the deterministic projections of the base run, as well as by medians of the stochastic projections. Precision of projections was represented graphically by the 5^{th} and 95^{th} percentiles of the replicate projections.

Projection scenarios The TORs for this assessment described four projections scenarios: $F = F_{\text{MSY}}$, $P^\star = 0.5$, $P^\star = 0.4$, and $F = 75\% F_{\text{MSY}}$. $F = F_{\text{MSY}}$ is identical to the $P^\star = 0.5$ projection, so three projection scenarios were considered. In each, the landings in the interim period were calculated based on F_{current}.

- Scenario 1: $F = F_{\text{MSY}}$, with F_{current} assumed for the interim period. (Identical to $P^\star = 0.5$)
- Scenario 2: $P^\star = 0.4$, with F_{current} assumed for the interim period.
- Scenario 3: $F = 75\% F_{\text{MSY}}$, with F_{current} assumed for the interim period

4 Stock Assessment Results

4.1 Measures of Overall Model Fit

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). The model was configured to fit observed commercial and recreational landings closely (Figures 4–8), as well as observed discards (Figures 9–11). Fits to indices of abundance generally captured the observed trends but not all annual fluctuations (Figures 12–15).

4.2 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.

4.3 Stock Abundance and Recruitment

Estimated abundance at age shows a decline until 1990, a leveling off through the mid-2000s, and an increase due to high recruitment in 2009 and 2010 (Figure 16; Table 6). Total estimated abundance at the end of the assessment period showed a sharp decline since 2010. Annual number of recruits is shown in Table 6 (age-0 column) and in Figure 17. In the most recent decade, a notably strong year class (age-0 fish) was predicted to have occurred in 2009 and 2010, but the rest of the years had lower than average reecruitment with the final four years being the lowest predicted for the whole assessment time period.

4.4 Total and Spawning Biomass

Estimated biomass at age followed a similar pattern as abundance at age (Figure 18; Table 7). Total biomass and spawning biomass showed similar trends—general decline from early 1980s until the mid-1990s, a relatively stable period from 1993–2006, and an increase followed by a decline since 2007 (Figure 19; Table 8). The decrease in biomass at age is less noticeable than in abundance at age due to the larger size of the older fish.

4.5 Selectivity

Estimated selectivities of the two fishery-independent gears were similar (Figures 20–21). Selectivities of landings from commercial and recreational fleets are shown in Figures 22–23. In general, selectivities shift toward older ages with increased size limits. In the most recent years, full selection occurred near age-4 for most gears, and age-5 for the commercial lines and general recreational fleets.

Selectivity of discard mortalities from commercial fleets was mostly on age-2 and age-3 fish, with relatively low selection of age-1 and age-4 fish (Figure 24). In 2009–2016, commercial discard selectivities included more older fish (fish of legal size), accounting for black sea bass caught during closed seasons, mostly from handlines. Selectivity of discard mortalities from the headboat and general recreational fleets was mostly of age-2 and age-3 fish; since 2007, it included more older fish with the increased size limits (Figure 24).

Average selectivities of landings and of discard mortalities were computed from F-weighted selectivities in the most recent period of regulations (Figure 25). These average selectivities were used to compute benchmarks. All selectivities from the most recent period, including average selectivities, are tabulated in Table 9.

4.6 Fishing Mortality, Landings, and Discards

The estimated fishing mortality rates (F) generally increased through the early 2000s, reaching a peak in 2006. Since then, the fishing mortality due to landings have all decreased(Figure 26). The general recreational fleet has been the largest contributor to total F (Table 10).

Estimates of total F at age are shown in Table 11. In any given year, the maximum F at age (i.e., apical F) may be less than that year's sum of fully selected Fs across fleets. This inequality is due to the combination of two features of estimated selectivities: full selection occurs at different ages among gears and several sources of mortality have dome-shaped selectivity.

Table 12 shows total landings at age in numbers, and Table 13 in weight. In general, the majority of estimated landings were from the recreational sector, i.e., headboat and general recreational fleets (Figures 27, 28; Tables 14, 15). Estimated discard mortalities occurred on a smaller scale than landings (Figure 29; Tables 16, 17)

4.7 Spawner-Recruitment Parameters

The estimated Beverton–Holt spawner-recruit curve is shown in Figure 30, along with the effect of density dependence on recruitment, depicted graphically by recruits per spawner as a function of spawners (population fecundity). Values of recruitment-related parameters were as follows: steepness $h = 0.64$, unfished age-0 recruitment $\widehat{R_0} = 35,928,120$, and standard deviation of recruitment residuals in log space $\widehat{\sigma_R} = 0.35$. Uncertainty in these quantities was estimated through the Monte Carlo/bootstrap (MCB) analysis (Figure 31).

4.8 Per Recruit and Equilibrium Analyses

Yield per recruit and spawning potential ratio were computed as functions of F (Figure 32). As in computation of MSY-related benchmarks, per recruit analyses applied the most recent selectivity patterns averaged across fleets, weighted by F from the last three years (2014–2016).

As in per recruit analyses, equilibrium landings and spawning biomass were computed as functions of F (Figure 33). By definition, the F that maximizes equilibrium landings is F_{MSY}, and the corresponding landings and spawning biomass are MSY and SSB_{MSY}.

4.9 Benchmarks / Reference Points

As described in §3.6, biological reference points (benchmarks) were derived analytically assuming equilibrium dynamics, corresponding to the expected spawner-recruit curve (Figure30). Reference points estimated were F_{MSY}, MSY, B_{MSY} and SSB_{MSY}. Based on F_{MSY}, three possible values of F at optimum yield (OY) were considered—$F_{\text{OY}} = 65\% F_{\text{MSY}}$, $F_{\text{OY}} = 75\% F_{\text{MSY}}$, and $F_{\text{OY}} = 85\% F_{\text{MSY}}$—and for each, the corresponding yield was computed. Standard deviations of benchmarks were approximated as those from Monte Carlo/bootstrap analysis (§3.7).

Estimates of benchmarks are summarized in Table 18. Point estimates of MSY-related quantities were $F_{\text{MSY}} = 0.31$ (y^{-1}), MSY = 935 (klb), $B_{\text{MSY}} = 6824$ (mt), and $\text{SSB}_{\text{MSY}} = 300$ (1E10 eggs). Distributions of these benchmarks from the MCB analysis are shown in Figure 35.

4.9.1 Status of the Stock and Fishery

Estimated time series of stock status (SSB/MSST and SSB/SSB$_{\mathrm{MSY}}$) showed general decline until the mid-1990s and some increase since (Figure 36, Table 8). The increase in stock status appears to have been initiated by strong year classes in 2008 and 2010, and perhaps reinforced by management regulations. Base-run estimates of spawning biomass have remained near MSST and below SSB$_{\mathrm{MSY}}$ since the early 1990s, increased substantially from 2008 to 2012, and then decreased again in the last three years. Current stock status was estimated in the base run to be SSB$_{2016}$/MSST = 1.15 and SSB$_{2016}$/SSB$_{\mathrm{MSY}}$ = 0.71 (Table 18), indicating that the stock is not overfished, but is below SSB$_{\mathrm{MSY}}$ for the stock. Uncertainty from the MCB analysis suggested that the estimate of SSB relative to SSB$_{\mathrm{MSY}}$ is robust, but that the status relative to MSST is less certain (Figures 37, 38). More specifically, about 99.8% of MCB runs indicate the stock is below SSB$_{\mathrm{MSY}}$, but only 23.4% of the MCB runs indicated an overfished status. Age structure estimated by the base run showed fewer older fish in the last decade than the (equilibrium) age structure expected at MSY (Figure 39), however with improvement in the terminal year (2016), particularly for ages younger than six.

The estimated time series of F/F_{MSY} suggests that overfishing has been occurring throughout most of the assessment period (Table 8), but with much uncertainty demonstrated by the MCB analysis (Figure 36). However, the fishery benchmark is based on the last three years of selectivity and fishing mortality, and may not be appropriate to compare to earlier years as the selectivity and the proportional contributions of the fleets to the total fishing mortality have changed through time. Current fishery status in the terminal year, with current F represented by the geometric mean from 2014–2016, was estimated by the base run to be $F_{2014-2016}/F_{\mathrm{MSY}} = 0.64$ (Table 18), and only 5.2% indicated that overfishing is still occurring (Figures 37, 38).

4.9.2 Comparison to previous assessment

When estimates from this assessment are compared to estimates from the SEDAR25 benchmark and update for black sea bass, a notable difference is the lack of high recruitment years in 1994 and 2001. In the SEDAR25 benchmark and update, the recruitment estimates from the early 1980s were lower than average, but the current assessment predicted higher than average recruitment prior to 1990 and average or lower than average until 2008. Length and age composition data fit better in this assessment than in the SEDAR25 benchmark and update (Figures 3 in all three reports). The general trends of abundance and biomass are similar between this assessment and the SEDAR25 benchmark and update, though MSY and F_{MSY} values are lower in this assessment, and the SSB$_{\mathrm{MSY}}$ and B_{MSY} values are higher.

4.10 Sensitivity and Retrospective Analyses

Sensitivity runs, described in §3.3, were used for exploring data or model issues that arose during the assessment process, for evaluating implications of assumptions in the base assessment model, and for interpreting MCB results in terms of expected effects of input parameters. Sensitivity runs are a tool for better understanding model behavior, and therefore should not be used as the basis for management. All runs are not considered equally plausible in the sense of alternative states of nature. Time series of F/F_{MSY} and SSB/SSB$_{\mathrm{MSY}}$ demonstrate sensitivity to natural mortality (Figure 40), index weighting (Figure 41), steepness (Figure 42), catchability (Figure 43), SEDAR25 configuration (Figure 44), the CVT index (Figure 45), higher landings and discards (Figure 46), and release mortality rate (Figure 47). The majority of these runs agreed with the status indicated by the base run (Figure 48, Table 19). Results appeared to be most sensitive to index weighting and steepness.

Retrospective analyses did not suggest any patterns of substantial over- or underestimation in terminal-year estimates starting in 2016 (Figure 49). However, prior to 2016, the analysis did reveal a pattern of overestimated recruitment in the terminal year. This resulted in a few years with overestimated SSB.

4.11 Projections

Projections based on $F = F_{\text{MSY}}$, which is higher than F_{current} drove the stock down and did not allow the stock to reach MSY with 50% probability by the terminal year of the projections (2023) (Figures 50, Table 20). The $P^{\star} = 0.40$ projection was similar to the $F = F_{\text{MSY}}$ scenario, as it was 93.8% of F_{MSY} (Figure 51, Table 21). The stock was near SSB_{MSY} by 2023 with 50% probability in the projection based on $F = 75\% F_{\text{MSY}}$ (Figure 52, Table 22).

5 Discussion

5.1 Comments on the Assessment

Estimated benchmarks played a central role in this assessment. Values of SSB_{MSY} and F_{MSY} were used to gauge the status of the stock and fishery. Computation of benchmarks was conditional on selectivity. If selectivity patterns change again 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 BAM indicated that the stock is not overfished ($\text{SSB}_{2016}/\text{MSST} = 1.15$), and that overfishing is not occurring ($F_{2014-2016}/F_{\text{MSY}} = 0.64$). These status indicators may be in qualitative agreement with management goals, however, they should be interpreted with two notes of caution. First, the MCB analysis indicated that the stock status is most likely between SSB_{MSY} and MSST with about 23.4% of the MCB runs indicating an overfished status. Only about 4.9% of the MCB runs indicate that the stock is experiencing overfishing, but only the last two years are below the fishing benchmark. Second, estimated trends of decreasing F correspond to strict management measures and are not informed in the last six years by fishery-dependent CPUE data. The decreasing trend for biomass is dependent on what appears to be below average recruitment in the last four years of the assessment. The stock has been declining over the last several years of the assessment, and this decline will likely continue if recruitment remains low.

The recent low recruitment may or may not continue into the future. No mechanism for the recent low recruitment has been identified, and the duration (since 2012) is short. Input from the stakeholders suggests the recent low recruitment was short lived, however monitoring the age compositions into the future will provide the data needed to make that determination. The possibility of sperm limitation was not accounted for, though protogynous species often experience disproportionate effects of exploitation between sexes.

In addition to more years of data, this standard assessment included several modifications to previous data. First, MRIP (instead of MRFSS) was used. Next, the SERFS chevron trap index was re-evaluated using updated modeling techniques and the SERFS video index was available for consideration. All composition data were updated and any needed corrections were made.

In general, fishery dependent indices of abundance may not track actual abundance well, because of factors such as hyperdepletion or hyperstability. Furthermore, this issue can be exacerbated by management measures. In this assessment, fishery dependent indices were not extended beyond 2010 (or 2009 for the commercial handline index), because of the implementation of restrictive bag, trip, or size limits, along with seasonal closures. Such regulations change fisher behavior, thus altering the portion of the population or habitat represented by the logbook data that would be used to create an index of abundance. As such management measures become more common in the southeast U.S., the continued utility of fishery dependent indices in SEDAR stock assessments will be questionable. This situation amplifies the importance of fishery independent sampling.

Most assessed stocks in the southeast U.S. have shown histories of heavy exploitation. High rates of fishing mortality can lead to adaptive responses in life-history characteristics, such as growth and maturity schedules. Such adaptations can affect expected yield and stock recovery, and thus resource managers might wish to consider possible evolutionary effects of fishing in their management plans (Dunlop et al. 2009; Enberg et al. 2009).

The weighting of the indices was carried out using the same methodology that was approved for SEDAR25. However, it should be noted that the additional weight applied to the indices (an additional weight of 2.5 consistent with SEDAR25) has a significant impact on the status of this stock. Should those additional weights be changed, the status of the stock would likely change as well.

Because steepness could not be estimated reliably in this assessment, its value in the base run was fixed at the midpoint (0.64) of the range implied by likelihood profiling. Thus MSY-based management quantities from the base run are conditional on that value of steepness (Mangel et al. 2013). 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, 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 (e.g., Shertzer and Conn 2012) or, in this assessment, through likelihood profiling with data on the stock being assessed.

5.2 Comments on the 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 no change in the selectivity applied to discards. As stock increase generally begins with the smallest size classes, management action may be needed to meet that assumption.
- 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. In this assessment, the lowest recruitment occurred in the terminal four years, and if this is not reversed, the stock projections are overly optimistic.
- Projections apply the Baranov catch equation to relate F and landings using a one-year time step, as in the assessment. The catch equation implicitly assumes that mortality occurs throughout the year. This assumption is violated when seasonal closures are in effect, introducing additional and unquantified uncertainty into the projection results.

5.3 Research Recommendations

- Establish a more comprehensive sampling program for ages and lengths of fish captured by the recreational fleet in all regions of the South Atlantic.
- Investigate discard mortality due to hooks in shallow waters (<10m)
- For this assessment, the age-dependent natural mortality rate was estimated by indirect methods. More direct methods, e.g. tag-recapture, might prove useful. Some tag-recapture studies have demonstrated relatively high tag return rates for black sea bass, at least compared to those of other reef fishes of the southeast U.S.
- Gather more depth data from private boat anglers.
- Investigate the potential for a range shift in the black sea bass population, and the potential causes, such as climate change.
- The following are from SEDAR25, and are still needed:

  The assessment panel recommended increasing the number of age samples collected from the general recreational sector.

  Black sea bass in the southeast U.S. were modeled in this assessment as a unit stock, as recommended by the DW and supported by genetic analysis (SEDAR 56-RD42). For any stock, variation in exploitation and life-history characteristics might be expected at finer geographic scales. Modeling such sub-stock structure would require more data, such as information on the movements and migrations of adults and juveniles, as well as spatial patterns of recruitment. Even when fine-scale spatial structure exists, incorporating it into a model may or may not lead to better assessment results (e.g., greater precision, less bias). Spatial structure in a black sea bass assessment model might range from the very broad (e.g., a single Atlantic stock) to the very narrow (e.g., a connected network of meta-populations living on individual reefs). What is the optimal level of spatial structure to model in an assessment of snapper-grouper species such as black sea bass?

  The assessment time period (1978–2010) is short relative to some other assessments of South Atlantic reef fishes. Extending the assessment back in time might provide improved understanding of the stock's potential productivity and therefore sustainable yield, assuming the historic productivity is still relevant. Such an extension would require historic landings estimates from all fleets in operation. Although historic estimates from the commercial sector are available, those from the recreational sector are not. Hindcasting the historic recreational landings might require the development of new methods, or at least analysis of existing methods.

  Protogynous life history: 1) Investigate possible effects of hermaphroditism on the steepness parameter; 2) Investigate the sexual transition for temporal patterns, considering possible mechanistic explanations if any patterns are identified; 3) Investigate methods for incorporating the dynamics of sexual transition in assessment models.

  In this assessment, the number of spawning events per mature female per year assumed a constant value of $X = 31$. That number was computed from the estimated spawning frequency and spawning season duration. If either of those characteristics depends on age or size, X would likely also depend on age or size. For black sea bass, does spawning frequency or spawning season duration (and therefore X) depend on age or size? Such dependence would have implications for estimating spawning potential as it relates to age structure in the stock assessment.

  For this assessment, the age-dependent natural mortality rate was estimated by indirect methods. More direct methods, e.g. tag-recapture, might prove useful. Some tag-recapture studies have demonstrated relatively high tag return rates for black sea bass, at least compared to those of other reef fishes of the southeast U.S.

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7 Tables

Table 1. Life-history characteristics at age, including average body length and weight (mid-year), annual fecundity per mature female (number batches X eggs per batch), proportion females mature, and natural mortality at age. The CV of length was estimated by the assessment model; other values were treated as input.

Age	Total length (mm)	Total length (in)	CV length	Whole wgt (kg)	Whole wgt (lb)	Fecundity (million eggs)	Fem. mat.	prop. fem.	M
0	112.7	4.4	0.1	0.02	0.05	0.08	0.00	0.963	0.93
1	174.6	6.9	0.1	0.08	0.18	0.10	0.52	0.918	0.64
2	226.6	8.9	0.1	0.17	0.37	0.17	0.90	0.827	0.51
3	270.4	10.6	0.1	0.27	0.60	0.29	0.98	0.671	0.44
4	307.2	12.1	0.1	0.39	0.86	0.54	1.00	0.465	0.39
5	338.2	13.3	0.1	0.51	1.12	1.01	1.00	0.270	0.36
6	364.2	14.3	0.1	0.62	1.38	1.86	1.00	0.136	0.34
7	386.1	15.2	0.1	0.73	1.62	3.33	1.00	0.063	0.32
8	404.5	15.9	0.1	0.84	1.84	5.70	1.00	0.028	0.31
9	420.0	16.5	0.1	0.93	2.04	9.26	1.00	0.012	0.30
10	433.1	17.1	0.1	1.01	2.22	14.30	1.00	0.005	0.29
11	444.0	17.5	0.1	1.08	2.38	20.99	1.00	0.002	0.29

Table 2. Observed time series of landings (L) and discards (D) for commercial lines (cl), commercial pots (cp), commercial historic trawl (ct), recreational headboat (hb), and general recreational (mrip). Landings are in units of 1000 lb whole weight, and discards are in units of 1000 fish. Discards include all released fish, live or dead.

Year	L.cl	L.cp	L.ct	L.hb	L.mrip	D.cl	D.cp	D.hb	D.mrip
1978	118.675	134.350	31.817	532.207	.	.	.	.	.
1979	140.539	676.696	27.327	571.238	.	.	.	.	.
1980	107.927	888.174	25.393	617.798	.	.	.	.	.
1981	163.821	1028.197	32.221	678.256	762.769	.	.	.	1937.672
1982	150.879	788.173	20.623	701.365	2377.209	.	.	.	1200.122
1983	145.746	484.284	8.527	690.327	1196.833	.	.	.	498.335
1984	194.532	410.419	17.778	661.070	2501.222	.	.	.	1263.455
1985	164.100	395.772	23.826	568.100	1556.479	.	.	.	1284.875
1986	163.256	502.508	22.346	536.798	792.728	.	.	128.267	1061.759
1987	149.296	403.407	7.474	616.518	1298.519	.	.	648.190	1490.302
1988	236.629	513.731	21.177	635.222	2444.504	.	.	1127.045	1299.328
1989	248.538	517.738	13.484	478.030	1269.805	.	.	81.276	1150.432
1990	258.736	684.587	13.576	379.573	797.639	.	.	5.087	608.161
1991	267.179	616.552	.	286.239	1252.788	.	.	552.651	1029.672
1992	226.570	546.323	.	215.877	870.621	.	.	78.207	1072.483
1993	188.927	508.023	.	143.026	609.142	15.234	105.026	57.997	964.140
1994	213.869	531.041	.	132.441	672.123	19.087	148.331	233.270	1693.220
1995	141.466	413.274	.	127.625	725.914	18.749	129.664	112.271	1254.929
1996	128.008	511.790	.	146.543	809.268	18.030	140.520	207.455	1044.594
1997	162.325	540.959	.	147.742	665.416	17.574	128.263	207.901	1411.552
1998	221.095	450.850	.	142.504	434.498	14.326	129.597	68.413	1011.117
1999	187.538	501.350	.	192.569	385.368	11.621	120.056	184.994	1483.950
2000	92.849	407.650	.	144.590	408.244	12.272	92.771	200.345	2033.693
2001	88.663	492.746	.	172.025	710.163	13.545	108.406	273.389	2247.767
2002	97.985	419.811	.	123.275	424.445	13.867	63.127	147.872	1511.444
2003	91.588	484.243	.	134.111	524.609	11.937	145.274	140.682	1757.042
2004	107.121	626.498	.	237.586	1487.077	5.121	93.359	83.372	3448.135
2005	66.911	384.384	.	179.660	937.125	7.847	120.498	52.788	2961.062
2006	62.169	483.272	.	174.066	805.528	15.316	171.686	124.684	3155.824
2007	54.915	351.913	.	162.070	641.334	7.595	44.925	117.444	3373.451
2008	57.594	360.016	.	99.311	492.255	3.764	45.704	167.385	3100.964
2009	87.707	564.614	.	163.170	409.818	20.672	72.897	238.967	2480.077
2010	71.207	408.269	.	289.235	770.552	5.126	25.296	334.806	3382.418
2011	46.373	342.497	.	232.569	602.456	5.435	9.054	545.689	3915.057
2012	106.971	269.160	.	128.369	592.019	16.425	49.310	675.410	6106.940
2013	195.304	274.330	.	117.913	294.447	29.575	48.496	500.845	2811.175
2014	295.891	181.308	.	104.870	476.204	25.928	36.504	470.873	4933.128
2015	152.330	171.621	.	80.771	292.148	8.627	26.656	462.935	3301.602
2016	157.401	103.479	.	66.698	247.875	8.878	13.490	444.760	3212.569

Table 3. CVs used in the MCB analysis for Headboat (HB) and general recreational (GR) landings and discards.

Year	HB Landings CVs	GR Landings CVs	HB Discards CVs	GR Discards CVs
1978	0.59	.	.	.
1979	0.59	.	.	.
1980	0.59	.	.	.
1981	0.15	0.12	.	0.24
1982	0.15	0.48	.	0.54
1983	0.15	0.27	.	0.52
1984	0.15	0.43	.	0.34
1985	0.15	0.41	.	0.28
1986	0.15	0.46	0.2	0.42
1987	0.15	0.29	0.2	0.30
1988	0.15	0.49	0.2	0.33
1989	0.15	0.24	0.2	0.29
1990	0.15	0.48	0.2	0.36
1991	0.15	0.43	0.2	0.31
1992	0.15	0.24	0.2	0.23
1993	0.15	0.23	0.2	0.31
1994	0.15	0.28	0.2	0.20
1995	0.15	0.29	0.2	0.28
1996	0.10	0.41	0.2	0.29
1997	0.10	0.33	0.2	0.19
1998	0.10	0.38	0.2	0.19
1999	0.10	0.39	0.2	0.19
2000	0.10	0.38	0.2	0.21
2001	0.10	0.32	0.2	0.17
2002	0.10	0.38	0.2	0.20
2003	0.10	0.31	0.2	0.19
2004	0.10	0.26	0.2	0.13
2005	0.10	0.19	0.2	0.11
2006	0.10	0.20	0.2	0.12
2007	0.10	0.17	0.2	0.11
2008	0.10	0.21	0.2	0.12
2009	0.10	0.21	0.2	0.12
2010	0.10	0.33	0.2	0.12
2011	0.10	0.23	0.2	0.10
2012	0.10	0.22	0.2	0.12
2013	0.10	0.25	0.2	0.09
2014	0.10	0.12	0.2	0.09
2015	0.10	0.13	0.2	0.08
2016	0.10	0.31	0.2	0.09

Table 4. Observed indices of abundance and CVs from MARMAP blackfish trap (Mbft), SERFS combined chevron trap and videos (CVID), commercial lines (cl), and headboats (hb).

Year	Mbft	Mbft CV	CVID	CVID CV	cl	cl CV	hb	hb CV
1979	.	.	.	.	.	.	2.17	0.54
1980	.	.	.	.	.	.	1.85	0.54
1981	1.07	0.27	.	.	.	.	2.13	0.54
1982	1.21	0.27	.	.	.	.	2.19	0.54
1983	1.10	0.27	.	.	.	.	1.98	0.54
1984	0.94	0.27	.	.	.	.	1.84	0.27
1985	1.09	0.27	.	.	.	.	1.99	0.27
1986	0.78	0.27	.	.	.	.	1.63	0.27
1987	0.81	0.27	.	.	.	.	1.56	0.27
1988	.	.	.	.	.	.	1.50	0.27
1989	.	.	.	.	.	.	1.23	0.27
1990	.	.	1.42	0.21	.	.	1.22	0.27
1991	.	.	1.07	0.21	.	.	1.01	0.27
1992	.	.	1.11	0.22	.	.	0.69	0.27
1993	.	.	0.65	0.24	1.15	0.27	0.44	0.27
1994	.	.	0.71	0.22	1.07	0.27	0.49	0.27
1995	.	.	0.49	0.24	0.67	0.27	0.50	0.27
1996	.	.	0.84	0.24	0.69	0.27	0.52	0.27
1997	.	.	0.84	0.22	0.88	0.27	0.57	0.27
1998	.	.	0.90	0.21	1.21	0.27	0.50	0.27
1999	.	.	1.19	0.22	1.26	0.27	0.56	0.27
2000	.	.	0.82	0.23	0.86	0.27	0.41	0.27
2001	.	.	1.20	0.23	0.93	0.27	0.43	0.27
2002	.	.	0.69	0.24	0.86	0.27	0.42	0.27
2003	.	.	0.57	0.25	1.10	0.27	0.48	0.27
2004	.	.	1.07	0.23	1.55	0.27	0.66	0.27
2005	.	.	0.79	0.23	1.11	0.27	0.58	0.27
2006	.	.	0.79	0.23	0.99	0.27	0.62	0.27
2007	.	.	0.39	0.27	0.60	0.27	0.38	0.27
2008	.	.	0.63	0.23	0.80	0.27	0.30	0.27
2009	.	.	0.52	0.24	1.27	0.27	0.46	0.27
2010	.	.	1.20	0.20	.	.	0.73	0.27
2011	.	.	2.44	0.17	.	.	.	.
2012	.	.	1.99	0.16	.	.	.	.
2013	.	.	1.68	0.16	.	.	.	.
2014	.	.	1.37	0.16	.	.	.	.
2015	.	.	0.98	0.15	.	.	.	.
2016	.	.	0.66	0.20	.	.	.	.

Table 5. Sample sizes (number of trips) of length compositions (len) or age compositions (age) by survey or fleet, including those of discards (D). Data sources are SERFS/MARMAP chevron trap (Mcvt), MARMAP blackfish/snapper trap (Mbft), commercial lines (cl), commercial pots(cp), headboats (hb), and general recreational (mrip).

Year	len.Mbft	len.cl	len.cp	len.hb	len.mrip	len.hbd	age.Mbft	age.Mcvt	age.cl	age.cp	age.hb
1978	.	.	.	327	.	.	.	.	.	.	.
1979	.	.	.	201	.	.	.	.	.	.	.
1980	.	.	.	277	.	.	.	.	.	.	.
1981	108	.	.	387	47	.	.	.	.	.	.
1982	120	.	.	439	89	.	.	.	.	.	.
1983	.	.	.	624	34	.	453	.	.	.	.
1984	62	63	.	695	57	.	.	.	.	.	.
1985	25	67	.	638	80	.	.	.	.	.	.
1986	26	64	.	683	128	.	.	.	.	.	.
1987	16	70	.	787	147	.	.	.	.	.	.
1988	.	62	103	545	162	.	.	.	.	.	.
1989	.	31	.	427	192	.	.	.	.	.	.
1990	.	58	.	481	126	.	.	215	.	.	.
1991	.	85	.	391	94	.	.	159	.	.	43
1992	.	71	.	400	152	.	.	191	.	.	31
1993	.	70	.	387	132	.	.	193	.	.	.
1994	.	65	.	350	112	.	.	140	.	.	.
1995	.	84	.	283	89	.	.	163	.	.	.
1996	.	68	.	276	110	.	.	163	.	.	.
1997	.	73	.	375	101	.	.	162	.	.	.
1998	.	102	.	460	111	.	.	168	.	.	.
1999	.	97	.	403	148	.	.	96	.	.	.
2000	.	93	.	333	109	.	.	109	.	.	.
2001	.	111	.	329	177	.	.	86	.	.	.
2002	.	87	596	305	124	.	.	83	.	.	.
2003	.	.	1011	.	157	.	.	58	19	.	31
2004	.	.	.	.	220	.	.	94	40	.	53
2005	.	.	.	.	169	114	.	119	79	21	104
2006	.	.	.	.	174	106	.	123	109	29	247
2007	.	.	.	.	128	116	.	110	114	82	234
2008	.	.	.	.	136	98	.	87	113	101	163
2009	.	.	.	.	140	98	.	118	104	108	214
2010	.	.	.	.	156	99	.	204	89	70	354
2011	.	.	.	.	69	96	.	316	46	49	131
2012	.	.	.	.	78	116	.	449	116	43	84
2013	.	.	.	.	102	88	.	453	155	36	242
2014	.	.	.	.	127	102	.	393	174	26	208
2015	.	.	.	.	113	79	.	483	171	33	158
2016	.	.	.	.	102	97	.	398	98	18	258

Table 6. Estimated total abundance at age (1000 fish) at start of year.

Year	0	1	2	3	4	5	6	7	8	9	10	11	Total
1978	50489.57	21742.30	7295.03	4334.62	2608.14	1782.33	737.71	399.57	221.06	129.02	79.22	120.28	89938.86
1979	58099.93	19897.97	10731.96	3562.19	2214.29	1400.36	982.71	414.84	229.22	128.09	75.51	117.94	97855.02
1980	65690.79	22896.83	9810.97	5098.59	1678.95	1088.99	706.43	505.55	217.72	121.51	68.58	104.62	107989.53
1981	48310.20	25888.04	11277.54	4574.26	2302.64	791.32	526.72	348.47	254.41	110.66	62.38	89.82	94536.46
1982	47105.60	19046.46	13071.09	5442.01	2091.77	1099.10	386.64	262.41	177.10	130.60	57.38	79.71	88949.86
1983	45731.14	18547.97	8935.64	5433.34	2190.53	871.80	468.91	168.19	116.45	79.38	59.13	62.69	82665.16
1984	47551.04	18022.56	9131.63	4192.31	2548.10	1058.50	431.25	236.50	86.54	60.52	41.67	64.59	83425.20
1985	59614.73	18742.70	9302.99	3922.30	1476.59	913.55	387.07	160.75	89.93	33.24	23.48	41.63	94708.96
1986	45297.91	23503.65	9723.89	4233.71	1534.42	589.43	371.81	160.58	68.03	38.44	14.35	28.39	85564.62
1987	38959.61	17865.07	12275.86	4788.92	1899.73	703.57	275.56	177.18	78.06	33.40	19.06	21.41	77097.44
1988	41646.14	15362.82	9302.02	5878.34	2079.06	854.09	323.03	128.98	84.60	37.65	16.27	19.91	75732.91
1989	39642.51	16414.30	7920.34	3923.57	1991.10	714.87	298.26	114.94	46.82	31.02	13.94	13.53	71125.20
1990	36775.77	15630.57	8528.15	3667.76	1549.37	786.64	286.25	121.67	47.83	19.68	13.17	11.78	67438.63
1991	23523.43	14503.50	8157.18	4174.28	1548.70	644.85	331.30	122.80	53.24	21.14	8.78	11.25	53100.47
1992	22840.07	9274.52	7528.37	3811.42	1620.75	596.79	251.06	131.37	49.67	21.75	8.72	8.35	46142.86
1993	30773.97	9006.80	4833.38	3726.32	1649.91	702.97	262.32	112.42	60.01	22.92	10.14	8.04	51169.19
1994	30545.29	12136.84	4705.11	2484.57	1739.75	785.64	340.50	129.48	56.61	30.52	11.77	9.43	52975.52
1995	23684.45	12044.57	6317.49	2307.38	1076.76	785.78	360.41	159.16	61.74	27.26	14.85	10.42	46850.26
1996	24443.76	9339.67	6276.41	3161.76	1034.05	498.93	371.16	173.52	78.17	30.63	13.66	12.79	45434.50
1997	29924.42	9638.90	4864.22	3100.09	1368.01	460.49	226.56	171.79	81.93	37.28	14.75	12.87	49901.33
1998	27403.16	11800.06	5019.39	2384.12	1329.24	606.48	207.61	104.09	80.51	38.78	17.83	13.34	49004.62
1999	31571.21	10807.57	6165.19	2564.10	1095.91	614.89	283.92	99.00	50.63	39.56	19.25	15.62	53326.85
2000	29673.83	12454.55	5680.44	3537.70	1222.87	423.53	231.48	108.35	38.52	19.90	15.70	13.98	53420.86
2001	29294.40	11705.74	6542.24	3238.75	1758.98	530.23	183.27	101.86	48.63	17.46	9.11	13.73	53444.39
2002	28159.16	11555.89	6146.92	3709.31	1491.19	667.05	200.78	70.60	40.02	19.30	7.00	9.25	52076.46
2003	30778.94	11108.84	6077.02	3556.30	1926.90	683.94	306.23	93.76	33.62	19.25	9.38	7.97	54602.15
2004	22541.22	12142.05	5838.93	3493.10	1828.21	881.84	314.66	143.40	44.78	16.22	9.38	8.54	47262.33
2005	27957.16	8891.09	6363.59	3220.93	1350.89	524.92	251.83	91.40	42.49	13.40	4.90	5.47	48718.08
2006	30775.09	11027.83	4664.02	3556.82	1370.90	461.87	179.83	87.81	32.51	15.26	4.86	3.80	52180.60
2007	30929.06	12138.63	5777.75	2575.91	1782.69	387.36	109.88	43.29	21.56	8.06	3.82	2.19	53780.20
2008	34566.53	12197.75	6371.18	3325.37	1227.60	587.15	114.60	32.93	13.23	6.66	2.51	1.89	58447.40
2009	54494.33	13633.67	6408.91	3701.30	1679.74	462.51	204.24	40.43	11.85	4.81	2.44	1.63	80645.86
2010	45189.41	21495.20	7168.40	3740.56	1883.09	634.80	163.59	73.26	14.79	4.38	1.79	1.54	80370.80
2011	32335.64	17823.65	11294.26	4161.93	1857.35	640.36	194.52	50.80	23.20	4.73	1.41	1.09	68388.94
2012	31075.65	12753.90	9365.76	6568.10	2138.17	747.88	242.14	74.69	19.89	9.18	1.89	1.01	62998.25
2013	20634.39	12255.51	6694.14	5402.57	3426.24	1125.04	294.54	73.69	21.91	5.85	2.72	0.87	49937.47
2014	13676.29	8136.07	6437.41	3933.16	3074.92	1962.43	594.99	144.93	36.31	10.88	2.93	1.82	38012.13
2015	17672.28	5388.75	4257.61	3719.24	2067.07	1753.57	1053.55	296.38	72.24	18.24	5.52	2.44	36306.88
2016	20625.99	6965.08	2824.17	2479.32	2039.76	1248.16	1061.16	623.37	177.36	43.62	11.12	4.90	38104.01

Table 7. Estimated biomass at age (1000 lb) at start of year

Year	0	1	2	3	4	5	6	7	8	9	10	11	Total
1978	2701.1	3906.6	2699.6	2615.8	2241.4	1998.5	1015.9	646.8	407.2	263.7	176.4	286.8	18959.8
1979	3108.3	3575.2	3971.2	2149.7	1903.0	1570.1	1353.2	671.5	422.2	261.9	168.0	281.3	19436.0
1980	3514.4	4114.0	3630.6	3076.8	1442.9	1221.1	972.9	818.4	401.0	248.5	152.6	249.6	19842.5
1981	2584.7	4651.5	4173.1	2760.4	1978.9	887.4	725.3	564.2	468.7	226.2	138.9	214.1	19373.1
1982	2520.1	3422.2	4836.9	3284.0	1797.6	1232.4	532.4	424.8	326.3	267.0	127.6	190.0	18961.5
1983	2446.7	3332.7	3306.5	3278.7	1882.5	977.5	645.7	272.3	214.5	162.3	131.6	149.5	16800.6
1984	2543.9	3238.4	3379.0	2529.8	2189.9	1187.0	593.9	382.9	159.4	123.7	92.8	154.1	16574.6
1985	3189.4	3367.8	3442.5	2366.9	1269.0	1024.3	533.1	260.1	165.6	67.9	52.2	99.2	15838.2
1986	2423.5	4223.2	3598.2	2554.9	1318.6	660.9	512.1	259.9	125.2	78.5	32.0	67.7	15854.8
1987	2084.3	3209.9	4542.6	2889.8	1632.5	788.8	379.4	286.8	143.7	68.3	42.3	51.1	16120.2
1988	2228.0	2760.4	3442.1	3547.5	1786.6	957.7	444.9	208.8	155.9	76.9	36.2	47.4	15692.5
1989	2120.8	2949.3	2930.8	2367.8	1711.2	801.6	410.7	186.1	86.2	63.5	31.1	32.2	13691.1
1990	1967.6	2808.5	3155.7	2213.4	1331.6	882.1	394.2	196.9	88.2	40.1	29.3	28.0	13135.6
1991	1258.6	2606.1	3018.6	2519.0	1330.9	723.1	456.1	198.9	98.1	43.2	19.6	26.9	12298.7
1992	1222.0	1666.5	2785.8	2300.1	1392.9	669.1	345.7	212.7	91.5	44.5	19.4	19.8	10770.0
1993	1646.4	1618.4	1788.6	2248.7	1418.0	788.2	361.3	182.1	110.5	47.0	22.5	19.2	10250.4
1994	1634.3	2180.8	1741.0	1499.4	1495.2	881.0	468.9	209.7	104.3	62.4	26.2	22.5	10325.4
1995	1267.2	2164.1	2337.8	1392.4	925.3	881.0	496.3	257.7	113.8	55.8	33.1	24.9	9949.2
1996	1307.8	1678.2	2322.6	1908.1	888.7	559.5	511.0	280.9	144.0	62.6	30.4	30.4	9724.2
1997	1601.0	1732.0	1800.1	1870.8	1175.7	516.3	312.0	278.2	151.0	76.3	32.8	30.6	9576.4
1998	1466.1	2120.2	1857.4	1438.7	1142.4	680.1	285.9	168.4	148.4	79.4	39.7	31.7	9458.3
1999	1689.0	1941.8	2281.3	1547.4	941.8	689.4	390.9	160.3	93.3	80.9	42.8	37.3	9896.3
2000	1587.5	2237.9	2102.1	2135.0	1050.9	474.9	318.8	175.5	71.0	40.8	34.8	33.3	10262.1
2001	1567.3	2103.2	2420.9	1954.4	1511.7	594.6	252.4	164.9	89.5	35.7	20.3	32.6	10747.8
2002	1506.4	2076.3	2274.7	2238.4	1281.5	748.0	276.5	114.2	73.6	39.5	15.7	22.0	10667.1
2003	1646.6	1996.1	2248.7	2146.0	1655.9	767.0	421.7	151.9	61.9	39.5	20.9	19.0	11175.0
2004	1205.9	2181.7	2160.8	2107.8	1571.2	988.8	433.4	232.1	82.5	33.1	20.9	20.3	11038.5
2005	1495.6	1597.5	2354.8	1943.8	1161.0	588.6	346.8	147.9	78.3	27.3	10.8	13.0	9765.6
2006	1646.4	1981.5	1725.8	2146.4	1178.2	517.9	247.6	142.2	60.0	31.3	10.8	9.0	9697.0
2007	1654.8	2181.0	2138.0	1554.5	1532.0	434.3	151.2	70.1	39.7	16.5	8.6	5.3	9785.9
2008	1849.2	2191.6	2357.6	2006.6	1054.9	658.3	157.9	53.4	24.5	13.7	5.5	4.4	10377.8
2009	2915.4	2449.8	2371.5	2233.5	1443.6	518.5	281.3	65.5	21.8	9.9	5.5	4.0	12320.1
2010	2417.6	3862.3	2652.6	2257.3	1618.4	711.9	225.3	118.6	27.3	9.0	4.0	3.7	13907.6
2011	1730.0	3202.4	4179.3	2511.5	1596.1	718.0	267.9	82.2	42.8	9.7	3.1	2.6	14345.9
2012	1662.5	2291.7	3465.7	3963.7	1837.6	838.6	333.6	120.8	36.6	18.7	4.2	2.4	14576.1
2013	1103.9	2202.0	2477.1	3260.2	2944.5	1261.5	405.7	119.3	40.3	11.9	6.0	2.0	13834.7
2014	731.7	1461.9	2382.1	2373.5	2642.5	2200.4	819.5	234.6	66.8	22.3	6.6	4.4	12946.2
2015	945.6	968.3	1575.4	2244.5	1776.5	1966.3	1450.9	479.7	133.2	37.3	12.3	5.7	11595.4
2016	1103.4	1251.6	1045.0	1496.3	1752.9	1399.5	1461.2	1009.3	326.7	89.1	24.7	11.7	10971.5

Table 8. 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, population fecundity, 1E10 eggs) at the time of peak spawning (end of March). The MSST *is defined by* $\mathrm{MSST} = (1 - M)\mathrm{SSB}_{\mathrm{MSY}}$*, with constant* $M = 0.38$*. Prop.fem is proportion of age-*2^+ *population that is female.*

Year	F	F/F_{MSY}	B	B/B_{unfished}	SSB	$\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$	SSB/MSST	Prop.fem
1978	0.236	0.759	8600	0.736	367	1.222	1.97	0.608
1979	0.325	1.046	8816	0.754	361	1.203	1.94	0.647
1980	0.367	1.181	9000	0.770	363	1.211	1.95	0.657
1981	0.357	1.150	8788	0.752	384	1.281	2.07	0.678
1982	0.492	1.587	8601	0.736	373	1.243	2.01	0.693
1983	0.344	1.110	7621	0.652	336	1.119	1.80	0.673
1984	0.647	2.084	7518	0.643	315	1.049	1.69	0.667
1985	0.540	1.739	7184	0.615	294	0.980	1.58	0.693
1986	0.401	1.293	7192	0.615	323	1.076	1.74	0.705
1987	0.419	1.351	7312	0.626	340	1.134	1.83	0.715
1988	0.693	2.234	7118	0.609	310	1.034	1.67	0.688
1989	0.557	1.794	6210	0.531	273	0.910	1.47	0.687
1990	0.506	1.632	5958	0.510	267	0.892	1.44	0.698
1991	0.585	1.885	5579	0.477	261	0.871	1.40	0.696
1992	0.464	1.493	4885	0.418	230	0.768	1.24	0.694
1993	0.366	1.179	4650	0.398	206	0.687	1.11	0.659
1994	0.421	1.355	4683	0.401	202	0.673	1.09	0.645
1995	0.391	1.260	4513	0.386	204	0.679	1.10	0.679
1996	0.430	1.387	4411	0.377	198	0.659	1.06	0.686
1997	0.438	1.411	4344	0.372	186	0.621	1.00	0.668
1998	0.401	1.291	4290	0.367	188	0.628	1.01	0.670
1999	0.624	2.010	4489	0.384	196	0.652	1.05	0.689
2000	0.481	1.550	4655	0.398	212	0.706	1.14	0.690
2001	0.614	1.979	4875	0.417	222	0.741	1.20	0.689
2002	0.422	1.359	4838	0.414	227	0.756	1.22	0.686
2003	0.419	1.350	5069	0.434	233	0.778	1.25	0.672
2004	0.896	2.888	5007	0.428	226	0.752	1.21	0.661
2005	0.714	2.300	4430	0.379	199	0.663	1.07	0.694
2006	1.084	3.494	4398	0.376	192	0.640	1.03	0.678
2007	0.865	2.788	4439	0.380	199	0.662	1.07	0.696
2008	0.702	2.262	4707	0.403	213	0.710	1.14	0.706
2009	0.686	2.209	5588	0.478	234	0.780	1.26	0.697
2010	0.830	2.674	6308	0.540	281	0.938	1.51	0.695
2011	0.617	1.989	6507	0.557	320	1.066	1.72	0.724
2012	0.914	2.946	6612	0.566	329	1.096	1.77	0.698
2013	0.390	1.258	6275	0.537	322	1.074	1.73	0.651
2014	0.379	1.221	5872	0.502	296	0.985	1.59	0.618
2015	0.195	0.627	5260	0.450	247	0.825	1.33	0.575
2016	0.200	0.643	4977	0.426	214	0.713	1.15	0.521

Table 9. Selectivity at age for MARMAP blackfish/snapper traps (Mbft), MARMAP chevron traps (Mcvt), commercial lines (cl), commercial pots (cp), headboat (hb), commercial discard mortalities (D.comm), headboat discard mortalities (D.hb), selectivity of landings averaged across fisheries (L.avg), and selectivity of discard mortalities averaged across fisheries (D.avg). Selectivities of discards from the general recreational fleet were assumed equal to those from the headboat fleet. Similarly, selectivity from the commercial trawl fleet (1978–1990) mirrored that of the commercial pot fleet. TL is total length. For time-varying selectivities, values shown are from the terminal assessment year.

Age	TL(mm)	TL(in)	Mbft	Mcvt	cl	cp	hb	D.comm	D.hb	L.avg	D.avg	L.avg+D.avg
0	112.7	4.4	0.000	0.001	0.000	0.000	0.000	0.004	0.008	0.000	0.007	0.007
1	174.6	6.9	0.044	0.041	0.002	0.004	0.001	0.076	0.043	0.001	0.038	0.039
2	226.6	8.9	0.947	0.562	0.017	0.052	0.017	0.947	0.202	0.013	0.181	0.194
3	270.4	10.6	1.000	0.975	0.155	0.419	0.227	1.000	1.000	0.115	0.885	1.000
4	307.2	12.1	1.000	0.999	0.664	0.904	0.835	0.264	0.262	0.386	0.232	0.618
5	338.2	13.3	1.000	1.000	0.955	0.992	0.989	0.143	0.005	0.694	0.005	0.698
6	364.2	14.3	1.000	1.000	0.996	0.999	0.999	0.114	0.000	0.900	0.000	0.900
7	386.1	15.2	1.000	1.000	1.000	1.000	1.000	0.108	0.000	0.941	0.000	0.942
8	404.5	15.9	1.000	1.000	1.000	1.000	1.000	0.106	0.000	0.947	0.000	0.947
9	420.0	16.5	1.000	1.000	1.000	1.000	1.000	0.105	0.000	0.947	0.000	0.947
10	433.1	17.1	1.000	1.000	1.000	1.000	1.000	0.105	0.000	0.947	0.000	0.948
11	444.0	17.5	1.000	1.000	1.000	1.000	1.000	0.105	0.000	0.947	0.000	0.948

Table 10. Estimated time series of fully selected fishing mortality rates for commercial lines (F.cl), commercial pots (F.cp), commercial trawl (F.ct), headboat (F.hb), general recreational (F.rec), commercial discard mortalities (F.comm.D), headboat discard mortalities (F.hb.D), general recreational discard mortalities (F.rec.D). Also shown is apical F, the maximum F at age summed across fleets, which may not equal the sum of fully selected F's because of dome-shaped selectivities.

Year	F.cl	F.cp	F.ct	F.hb	F.rec	F.comm.D	F.hb.D	F.rec.D	Apical F
1978	0.021	0.017	0.004	0.057	0.135	0.000	0.000	0.013	0.236
1979	0.028	0.095	0.004	0.062	0.135	0.000	0.000	0.013	0.325
1980	0.025	0.132	0.004	0.071	0.135	0.000	0.000	0.013	0.367
1981	0.041	0.158	0.005	0.078	0.075	0.000	0.000	0.023	0.357
1982	0.041	0.124	0.003	0.081	0.244	0.000	0.000	0.014	0.492
1983	0.041	0.080	0.001	0.088	0.135	0.000	0.000	0.007	0.344
1984	0.057	0.075	0.003	0.094	0.417	0.003	0.000	0.020	0.647
1985	0.061	0.085	0.005	0.091	0.298	0.003	0.000	0.020	0.540
1986	0.063	0.105	0.005	0.082	0.146	0.003	0.002	0.014	0.401
1987	0.053	0.074	0.001	0.081	0.210	0.003	0.007	0.018	0.419
1988	0.084	0.097	0.004	0.092	0.416	0.003	0.015	0.019	0.693
1989	0.099	0.116	0.003	0.082	0.257	0.003	0.001	0.020	0.557
1990	0.110	0.161	0.003	0.066	0.167	0.003	0.000	0.010	0.506
1991	0.118	0.147	0.000	0.051	0.270	0.003	0.008	0.017	0.585
1992	0.100	0.133	0.000	0.039	0.191	0.003	0.001	0.019	0.464
1993	0.078	0.123	0.000	0.028	0.137	0.003	0.001	0.022	0.366
1994	0.087	0.141	0.000	0.029	0.164	0.004	0.006	0.045	0.421
1995	0.064	0.117	0.000	0.027	0.183	0.003	0.002	0.028	0.391
1996	0.062	0.140	0.000	0.031	0.198	0.003	0.004	0.022	0.430
1997	0.079	0.153	0.000	0.033	0.172	0.003	0.005	0.035	0.438
1998	0.110	0.137	0.000	0.034	0.120	0.004	0.002	0.026	0.401
1999	0.126	0.254	0.000	0.070	0.174	0.003	0.004	0.032	0.624
2000	0.065	0.198	0.000	0.047	0.172	0.002	0.004	0.041	0.481
2001	0.057	0.221	0.000	0.054	0.282	0.002	0.005	0.043	0.614
2002	0.059	0.174	0.000	0.035	0.154	0.001	0.003	0.028	0.422
2003	0.046	0.172	0.000	0.035	0.166	0.003	0.002	0.034	0.419
2004	0.060	0.250	0.000	0.069	0.517	0.002	0.002	0.071	0.896
2005	0.049	0.193	0.000	0.063	0.409	0.002	0.001	0.060	0.714
2006	0.053	0.266	0.000	0.100	0.665	0.004	0.003	0.072	1.084
2007	0.048	0.199	0.000	0.095	0.524	0.001	0.005	0.158	0.865
2008	0.048	0.196	0.000	0.057	0.401	0.000	0.006	0.119	0.702
2009	0.064	0.259	0.000	0.080	0.284	0.001	0.008	0.087	0.686
2010	0.048	0.176	0.000	0.130	0.476	0.001	0.010	0.111	0.830
2011	0.028	0.137	0.000	0.096	0.356	0.001	0.013	0.108	0.617
2012	0.047	0.076	0.000	0.046	0.745	0.001	0.013	0.136	0.914
2013	0.059	0.059	0.000	0.030	0.242	0.001	0.011	0.067	0.390
2014	0.072	0.034	0.000	0.022	0.250	0.001	0.013	0.155	0.379
2015	0.034	0.032	0.000	0.016	0.112	0.000	0.015	0.121	0.195
2016	0.034	0.019	0.000	0.013	0.081	0.001	0.020	0.161	0.200

Table 11. Estimated instantaneous fishing mortality rate (per yr) at age, including discard mortality

Year	0	1	2	3	4	5	6	7	8	9	10	11
1978	0.001	0.066	0.207	0.232	0.232	0.235	0.236	0.236	0.236	0.236	0.236	0.236
1979	0.001	0.067	0.234	0.312	0.320	0.324	0.325	0.325	0.325	0.325	0.325	0.325
1980	0.001	0.068	0.253	0.355	0.362	0.366	0.367	0.367	0.367	0.367	0.367	0.367
1981	0.001	0.043	0.219	0.342	0.350	0.356	0.357	0.357	0.357	0.357	0.357	0.357
1982	0.002	0.117	0.368	0.470	0.485	0.492	0.492	0.492	0.492	0.492	0.492	0.492
1983	0.001	0.069	0.247	0.317	0.337	0.344	0.344	0.344	0.344	0.344	0.344	0.344
1984	0.001	0.021	0.335	0.604	0.636	0.646	0.647	0.647	0.647	0.647	0.647	0.647
1985	0.001	0.016	0.277	0.499	0.528	0.539	0.540	0.540	0.540	0.540	0.540	0.540
1986	0.000	0.010	0.198	0.361	0.390	0.400	0.401	0.401	0.401	0.401	0.401	0.401
1987	0.001	0.013	0.226	0.394	0.409	0.418	0.419	0.419	0.419	0.419	0.419	0.419
1988	0.001	0.023	0.353	0.643	0.678	0.692	0.693	0.693	0.693	0.693	0.693	0.693
1989	0.001	0.015	0.260	0.489	0.539	0.555	0.557	0.557	0.557	0.557	0.557	0.557
1990	0.000	0.010	0.204	0.422	0.487	0.505	0.506	0.506	0.506	0.506	0.506	0.506
1991	0.001	0.016	0.251	0.506	0.564	0.583	0.585	0.585	0.585	0.585	0.585	0.585
1992	0.001	0.012	0.193	0.397	0.445	0.462	0.463	0.464	0.464	0.464	0.464	0.464
1993	0.000	0.009	0.155	0.322	0.352	0.365	0.366	0.366	0.366	0.366	0.366	0.366
1994	0.001	0.013	0.203	0.396	0.405	0.419	0.420	0.421	0.421	0.421	0.421	0.421
1995	0.001	0.012	0.182	0.363	0.379	0.390	0.391	0.391	0.391	0.391	0.391	0.391
1996	0.001	0.012	0.195	0.398	0.419	0.429	0.430	0.430	0.430	0.430	0.430	0.430
1997	0.001	0.012	0.203	0.407	0.423	0.437	0.438	0.438	0.438	0.438	0.438	0.438
1998	0.000	0.009	0.162	0.337	0.381	0.399	0.401	0.401	0.401	0.401	0.401	0.401
1999	0.000	0.003	0.045	0.300	0.561	0.617	0.623	0.624	0.624	0.624	0.624	0.624
2000	0.000	0.004	0.052	0.259	0.446	0.478	0.481	0.481	0.481	0.481	0.481	0.481
2001	0.000	0.004	0.057	0.336	0.580	0.611	0.614	0.614	0.614	0.614	0.614	0.614
2002	0.000	0.003	0.037	0.215	0.389	0.419	0.422	0.422	0.422	0.422	0.422	0.422
2003	0.000	0.003	0.044	0.225	0.392	0.416	0.419	0.419	0.419	0.419	0.419	0.419
2004	0.000	0.006	0.085	0.510	0.858	0.893	0.896	0.896	0.896	0.896	0.896	0.896
2005	0.000	0.005	0.072	0.414	0.683	0.711	0.714	0.714	0.714	0.714	0.714	0.714
2006	0.000	0.006	0.084	0.251	0.874	1.076	1.084	1.084	1.084	1.084	1.084	1.084
2007	0.000	0.005	0.042	0.301	0.721	0.858	0.865	0.865	0.865	0.865	0.865	0.865
2008	0.000	0.004	0.033	0.243	0.586	0.696	0.702	0.702	0.702	0.702	0.702	0.702
2009	0.000	0.003	0.028	0.236	0.583	0.679	0.685	0.686	0.686	0.686	0.686	0.686
2010	0.000	0.004	0.034	0.260	0.689	0.823	0.830	0.830	0.830	0.830	0.830	0.830
2011	0.000	0.003	0.032	0.226	0.520	0.613	0.617	0.617	0.617	0.617	0.617	0.617
2012	0.000	0.005	0.040	0.211	0.252	0.572	0.850	0.906	0.913	0.914	0.914	0.914
2013	0.001	0.004	0.022	0.124	0.167	0.277	0.369	0.388	0.390	0.390	0.390	0.390
2014	0.001	0.008	0.039	0.203	0.172	0.262	0.357	0.376	0.379	0.379	0.379	0.379
2015	0.001	0.006	0.031	0.161	0.114	0.142	0.185	0.193	0.194	0.195	0.195	0.195
2016	0.001	0.008	0.039	0.200	0.108	0.110	0.140	0.146	0.147	0.147	0.147	0.147

Table 12. Estimated total landings at age in numbers (1000 fish)

Year	0	1	2	3	4	5	6	7	8	9	10	11
1978	36.11	1013.85	1010.98	690.20	450.37	316.11	132.18	72.25	40.15	23.54	14.52	22.05
1979	42.20	942.85	1677.18	748.97	506.89	328.85	233.07	99.28	55.10	30.93	18.32	28.61
1980	48.20	1101.97	1649.67	1202.41	427.42	283.58	185.74	134.11	58.01	32.52	18.44	28.13
1981	21.10	779.14	1568.62	1012.00	568.85	201.27	135.34	90.35	66.25	28.95	16.39	23.60
1982	60.62	1546.37	3083.59	1629.92	676.33	363.86	129.22	88.47	59.97	44.41	19.60	27.23
1983	33.59	904.68	1505.12	1182.57	524.99	215.23	116.96	42.33	29.44	20.16	15.08	15.99
1984	28.18	256.91	1927.31	1510.57	1013.07	431.16	177.31	98.06	36.03	25.31	17.50	27.12
1985	25.57	198.33	1642.30	1210.22	510.39	324.78	138.97	58.21	32.71	12.14	8.61	15.27
1986	10.00	138.31	1250.00	995.87	415.28	165.26	105.36	45.91	19.54	11.09	4.16	8.23
1987	11.86	136.80	1730.31	1189.91	535.51	204.55	80.94	52.50	23.23	9.99	5.72	6.43
1988	24.82	220.87	1979.87	2176.22	865.81	365.64	139.62	56.22	37.03	16.55	7.18	8.79
1989	14.99	155.29	1305.96	1188.26	698.63	260.03	109.63	42.62	17.43	11.60	5.24	5.08
1990	9.54	106.75	1167.05	1004.89	502.09	265.78	97.78	41.93	16.56	6.84	4.60	4.11
1991	9.43	143.16	1273.17	1288.15	562.60	243.50	126.44	47.27	20.58	8.21	3.43	4.39
1992	6.60	67.10	918.71	963.61	489.28	187.99	79.97	42.22	16.03	7.05	2.84	2.72
1993	6.48	48.36	459.67	771.27	409.98	182.45	68.86	29.78	15.97	6.12	2.72	2.16
1994	7.67	76.99	502.41	574.70	485.86	228.78	100.27	38.47	16.89	9.15	3.54	2.84
1995	6.45	81.29	681.67	521.93	284.86	215.61	99.96	44.54	17.36	7.70	4.21	2.95
1996	7.23	68.99	750.64	788.46	297.03	148.16	111.37	52.53	23.77	9.35	4.19	3.92
1997	7.87	64.53	560.10	760.23	396.40	138.61	68.93	52.74	25.26	11.55	4.59	4.00
1998	5.23	58.79	481.55	507.83	352.96	169.56	58.74	29.72	23.09	11.17	5.16	3.86
1999	0.29	2.08	41.27	475.69	395.43	242.02	113.60	39.97	20.53	16.11	7.87	6.39
2000	0.16	1.61	29.34	540.48	367.76	136.92	75.93	35.87	12.81	6.65	5.27	4.69
2001	0.15	1.68	42.84	642.85	650.35	207.20	72.51	40.65	19.49	7.03	3.68	5.55
2002	0.14	1.34	27.86	497.12	401.94	193.88	59.24	21.02	11.97	5.80	2.11	2.79
2003	0.13	1.19	27.36	484.10	521.45	197.92	89.85	27.76	10.00	5.75	2.81	2.39
2004	0.13	2.21	54.56	981.79	892.69	448.79	161.84	74.36	23.32	8.48	4.92	4.48
2005	0.13	1.27	47.76	759.21	563.74	228.99	111.09	40.66	18.98	6.01	2.21	2.46
2006	0.26	2.34	26.96	443.02	677.49	263.61	103.93	51.15	19.01	8.96	2.87	2.24
2007	0.23	2.18	27.86	250.87	746.73	192.10	55.24	21.94	10.97	4.12	1.96	1.12
2008	0.21	1.81	25.87	282.36	443.15	252.33	49.97	14.48	5.84	2.95	1.12	0.84
2009	0.44	2.62	32.88	377.11	609.21	195.32	87.53	17.48	5.14	2.10	1.07	0.72
2010	0.37	4.21	36.44	371.29	770.15	306.21	80.00	36.13	7.32	2.18	0.90	0.77
2011	0.18	2.53	42.74	315.68	609.19	250.75	77.26	20.35	9.33	1.91	0.57	0.44
2012	1.03	5.52	49.30	294.27	358.75	278.10	120.30	39.01	10.48	4.86	1.00	0.54
2013	0.47	3.80	26.01	183.31	384.85	230.08	77.86	20.48	6.14	1.65	0.77	0.25
2014	0.25	1.98	18.93	99.89	299.64	381.53	152.89	39.27	9.93	2.99	0.81	0.50
2015	0.22	0.90	8.93	67.40	127.70	195.17	151.41	44.82	11.03	2.80	0.85	0.38
2016	0.19	0.84	4.23	32.25	97.61	108.26	118.07	72.93	20.95	5.18	1.33	0.58

Table 13. Estimated total landings at age in whole weight (1000 lb)

Year	0	1	2	3	4	5	6	7	8	9	10	11
1978	1.93	182.17	374.10	416.51	387.04	354.45	182.02	116.97	73.97	48.13	32.31	52.57
1979	2.26	169.41	620.63	451.97	435.62	368.73	320.96	160.72	101.51	63.23	40.75	68.21
1980	2.58	198.00	610.45	725.60	367.32	317.97	255.78	217.12	106.87	66.48	41.02	67.07
1981	1.13	139.99	580.45	610.70	488.87	225.68	186.38	146.26	122.05	59.18	36.47	56.27
1982	3.24	277.85	1141.06	983.59	581.23	407.99	177.95	143.23	110.47	90.80	43.61	64.92
1983	1.80	162.55	556.96	713.63	451.17	241.34	161.07	68.53	54.23	41.21	33.56	38.13
1984	1.69	49.53	753.10	954.21	906.41	501.47	252.45	162.84	66.63	50.06	36.01	57.21
1985	1.53	38.24	641.74	764.48	456.66	377.75	197.87	96.67	60.49	24.02	17.73	32.22
1986	0.60	26.67	488.44	629.08	371.56	192.21	150.01	76.23	36.13	21.93	8.56	17.35
1987	0.71	26.37	676.13	751.66	479.13	237.91	115.24	87.18	42.96	19.75	11.78	13.56
1988	1.49	42.58	773.64	1374.70	774.66	425.27	198.79	93.35	68.47	32.73	14.78	18.54
1989	0.90	29.94	510.31	750.61	625.07	302.44	156.09	70.77	32.24	22.94	10.78	10.72
1990	0.57	20.58	456.03	634.78	449.23	309.12	139.23	69.62	30.61	13.53	9.46	8.68
1991	0.57	27.60	497.50	813.72	503.37	283.21	180.03	78.50	38.07	16.24	7.05	9.25
1992	0.40	12.94	358.99	608.71	437.77	218.64	113.86	70.10	29.65	13.95	5.85	5.74
1993	0.39	9.32	179.62	487.20	366.81	212.21	98.05	49.45	29.53	12.12	5.60	4.55
1994	0.46	14.84	196.32	363.03	434.71	266.09	142.76	63.88	31.24	18.10	7.30	5.99
1995	0.39	15.67	266.37	329.70	254.87	250.78	142.33	73.96	32.09	15.23	8.67	6.23
1996	0.43	13.30	293.32	498.07	265.76	172.33	158.57	87.23	43.96	18.50	8.63	8.27
1997	0.47	12.44	218.86	480.23	354.67	161.21	98.15	87.57	46.71	22.84	9.45	8.44
1998	0.31	11.33	188.17	320.79	315.80	197.21	83.64	49.35	42.70	22.10	10.62	8.14
1999	0.02	0.40	16.13	300.49	353.80	281.49	161.74	66.38	37.97	31.87	16.20	13.48
2000	0.01	0.31	11.46	341.42	329.04	159.25	108.11	59.56	23.69	13.15	10.84	9.89
2001	0.01	0.32	16.74	406.08	581.88	240.99	103.24	67.51	36.04	13.90	7.58	11.71
2002	0.01	0.26	10.89	314.02	359.63	225.49	84.34	34.91	22.14	11.47	4.35	5.89
2003	0.01	0.23	10.69	305.80	466.55	230.20	127.93	46.10	18.49	11.38	5.79	5.05
2004	0.01	0.43	21.32	620.19	798.70	521.98	230.43	123.48	43.12	16.77	10.13	9.45
2005	0.01	0.25	18.66	479.59	504.39	266.33	158.16	67.52	35.10	11.89	4.55	5.20
2006	0.02	0.45	10.54	279.85	606.16	306.60	147.98	84.94	35.16	17.72	5.90	4.73
2007	0.01	0.42	10.89	158.47	668.11	223.43	78.65	36.43	20.29	8.15	4.04	2.37
2008	0.01	0.35	10.11	178.36	396.49	293.48	71.15	24.05	10.81	5.84	2.30	1.78
2009	0.03	0.51	12.85	238.22	545.07	227.17	124.63	29.02	9.51	4.15	2.20	1.51
2010	0.02	0.81	14.24	234.54	689.07	356.15	113.91	59.99	13.54	4.31	1.84	1.62
2011	0.01	0.49	16.70	199.41	545.05	291.64	110.01	33.79	17.26	3.78	1.18	0.93
2012	0.06	1.06	19.26	185.89	320.98	323.45	171.28	64.77	19.38	9.61	2.07	1.13
2013	0.03	0.73	10.16	115.80	344.33	267.60	110.86	34.00	11.36	3.26	1.59	0.52
2014	0.02	0.38	7.40	63.10	268.10	443.75	217.69	65.20	18.37	5.92	1.67	1.06
2015	0.01	0.17	3.49	42.58	114.25	226.99	215.59	74.43	20.40	5.54	1.75	0.79
2016	0.01	0.16	1.65	20.37	87.34	125.92	168.12	121.09	38.74	10.24	2.73	1.23

Table 14. Estimated time series of landings in numbers (1000 fish) for commercial lines (L.cl), commercial pots (L.cp), commercial trawl (L.ct), headboat (L.hb), and general recreational (L.rec)

Year	L.cl	L.cp	L.ct	L.hb	L.rec	Total
1978	110.86	160.86	38.09	803.10	2709.39	3822.30
1979	128.33	835.04	33.69	926.46	2788.71	4712.24
1980	101.01	1148.03	32.85	1036.34	2851.96	5170.20
1981	159.77	1383.61	43.62	1205.35	1719.51	4511.86
1982	152.97	1113.26	29.19	1273.92	5160.25	7729.58
1983	151.92	674.52	11.87	1205.23	2562.60	4606.14
1984	195.16	545.19	23.61	1051.65	3732.92	5548.52
1985	166.42	552.40	33.27	958.32	2467.11	4177.52
1986	171.68	727.27	32.36	932.58	1305.12	3169.00
1987	160.33	593.70	11.04	1093.29	2129.40	3987.75
1988	255.49	732.81	30.30	1064.66	3815.33	5898.60
1989	265.38	730.01	19.04	799.68	2000.66	3814.76
1990	274.66	986.67	19.49	654.83	1292.26	3227.92
1991	287.68	898.25	0.00	492.66	2051.74	3730.33
1992	244.08	786.91	0.00	367.15	1385.99	2784.13
1993	198.96	686.59	0.00	222.05	896.22	2003.82
1994	213.77	678.41	0.00	199.59	955.80	2047.58
1995	137.58	546.21	0.00	206.41	1078.33	1968.54
1996	127.86	691.95	0.00	240.09	1205.75	2265.66
1997	165.49	720.38	0.00	232.62	976.32	2094.81
1998	224.20	604.15	0.00	226.99	652.30	1707.65
1999	176.77	530.46	0.00	229.03	425.01	1361.27
2000	91.98	458.99	0.00	183.41	483.10	1217.49
2001	89.47	553.67	0.00	214.37	836.49	1694.00
2002	98.75	472.03	0.00	155.25	499.16	1225.19
2003	90.68	524.81	0.00	163.34	591.90	1370.73
2004	103.99	662.56	0.00	284.67	1606.34	2657.57
2005	66.64	422.93	0.00	223.87	1069.08	1782.52
2006	64.99	559.10	0.00	201.96	775.80	1601.84
2007	59.12	408.86	0.00	188.57	658.77	1315.32
2008	61.47	417.04	0.00	116.34	486.08	1080.94
2009	93.74	641.92	0.00	189.92	406.04	1331.62
2010	75.80	464.80	0.00	331.96	743.38	1615.95
2011	49.89	401.98	0.00	274.01	605.06	1330.94
2012	121.36	347.92	0.00	149.78	544.09	1163.15
2013	210.91	327.21	0.00	129.65	267.91	935.67
2014	293.43	194.66	0.00	105.24	415.30	1008.62
2015	137.41	170.10	0.00	74.82	229.28	611.61
2016	131.91	94.17	0.00	57.51	178.84	462.41

Table 15. Estimated time series of landings in whole weight (1000 lb) for commercial lines (L.cl), commercial pots (L.cp), commercial trawl (L.ct), headboat (L.hb), and general recreational (L.rec)

Year	L.cl	L.cp	L.ct	L.hb	L.rec	Total
1978	118.71	134.36	31.82	532.17	1405.11	2222.17
1979	140.63	677.33	27.33	571.19	1387.53	2804.01
1980	107.96	887.31	25.39	617.03	1338.57	2976.26
1981	163.67	1021.93	32.21	676.13	759.49	2653.44
1982	150.74	786.51	20.62	701.02	2367.04	4025.93
1983	145.77	484.69	8.53	690.38	1194.80	2524.16
1984	194.59	410.57	17.78	661.53	2507.15	3791.63
1985	163.89	395.58	23.83	568.92	1557.17	2709.38
1986	162.84	502.23	22.35	538.04	793.33	2018.78
1987	148.70	401.99	7.47	615.78	1288.44	2462.39
1988	235.39	512.11	21.17	634.28	2416.05	3819.00
1989	247.94	517.09	13.48	477.75	1266.56	2522.82
1990	258.54	687.19	13.58	380.63	801.51	2141.45
1991	267.70	622.59	0.00	287.51	1277.30	2455.10
1992	226.89	551.00	0.00	216.56	882.14	1876.59
1993	189.11	510.36	0.00	143.17	612.21	1454.85
1994	213.35	529.31	0.00	132.37	669.70	1544.72
1995	141.08	410.58	0.00	127.33	717.29	1396.28
1996	127.56	504.05	0.00	145.94	790.81	1568.36
1997	161.81	535.18	0.00	147.30	656.76	1501.05
1998	221.64	451.59	0.00	142.40	434.54	1250.16
1999	188.65	508.73	0.00	193.32	389.26	1279.96
2000	93.12	413.74	0.00	145.38	414.50	1066.73
2001	88.84	499.74	0.00	172.80	724.62	1486.01
2002	98.17	423.54	0.00	123.55	428.11	1073.38
2003	91.51	481.69	0.00	133.83	521.19	1228.22
2004	106.94	617.92	0.00	235.99	1435.16	2396.01
2005	66.89	382.18	0.00	179.14	923.44	1551.65
2006	62.08	479.28	0.00	173.53	785.16	1500.04
2007	54.91	352.53	0.00	162.18	641.63	1211.26
2008	57.47	355.00	0.00	98.93	483.33	994.73
2009	87.24	546.57	0.00	161.61	399.43	1194.86
2010	70.90	399.45	0.00	284.75	734.93	1490.03
2011	46.35	342.57	0.00	232.56	598.77	1220.25
2012	107.64	273.17	0.00	129.35	608.80	1118.95
2013	198.34	279.36	0.00	118.95	303.59	900.25
2014	302.15	183.21	0.00	105.57	501.71	1092.64
2015	153.45	172.79	0.00	81.06	298.70	706.00
2016	157.81	103.63	0.00	66.77	249.41	577.60

Table 16. Estimated time series of dead discards in numbers (1000 fish) for commercial (D.comm), headboat (D.hb), and general recreational (D.rec). D.rec and D.hb are combined under D.rec prior to 1986.

Year	D.comm	D.hb	D.rec	Total
1978	0.00	0.00	124.81	124.81
1979	0.00	0.00	145.11	145.11
1980	0.00	0.00	151.83	151.83
1981	0.00	0.00	294.30	294.30
1982	0.00	0.00	182.41	182.41
1983	0.00	0.00	75.72	75.72
1984	32.74	0.00	192.05	224.79
1985	33.69	0.00	195.47	229.16
1986	37.47	17.57	161.58	216.62
1987	43.06	88.85	226.83	358.74
1988	35.72	154.54	197.71	387.97
1989	30.13	11.14	174.93	216.19
1990	31.49	0.70	92.49	124.68
1991	30.72	75.76	156.73	263.21
1992	28.31	10.72	163.26	202.29
1993	17.60	7.95	146.63	172.18
1994	24.40	31.96	257.48	313.84
1995	21.72	15.38	190.50	227.59
1996	23.10	28.41	158.44	209.95
1997	21.30	28.48	214.15	263.92
1998	20.87	9.37	153.48	183.72
1999	19.02	25.34	225.59	269.95
2000	15.32	27.45	309.86	352.64
2001	17.75	37.46	342.15	397.36
2002	11.47	20.26	229.78	261.51
2003	22.60	19.27	266.36	308.23
2004	14.04	11.42	521.72	547.18
2005	18.36	7.23	450.01	475.60
2006	26.96	17.09	482.72	526.76
2007	4.50	16.09	513.69	534.28
2008	3.82	22.92	467.20	493.94
2009	10.78	32.72	374.07	417.56
2010	5.72	45.85	511.35	562.92
2011	8.31	74.83	599.41	682.55
2012	10.60	92.69	945.13	1048.43
2013	10.72	68.66	429.16	508.54
2014	7.41	64.52	751.10	823.03
2015	3.49	63.42	501.84	568.75
2016	2.61	60.92	487.60	551.13

Table 17. Estimated time series of dead discards in whole weight (1000 lb) for commercial (D.comm), headboat (D.hb), and general recreational (D.rec). D.rec and D.hb are combined under D.rec prior to 1986.

Year	D.comm	D.hb	D.rec	Total
1978	0.00	0.00	55.01	55.01
1979	0.00	0.00	61.07	61.07
1980	0.00	0.00	66.37	66.37
1981	0.00	0.00	125.20	125.20
1982	0.00	0.00	79.79	79.79
1983	0.00	0.00	34.21	34.21
1984	14.09	0.00	82.61	96.70
1985	14.35	0.00	83.23	97.58
1986	15.97	7.49	68.89	92.36
1987	18.67	38.52	98.33	155.51
1988	16.17	69.94	89.49	175.59
1989	13.11	4.84	76.10	94.05
1990	13.60	0.30	39.93	53.83
1991	13.57	33.47	69.24	116.29
1992	12.74	4.82	73.45	91.00
1993	8.21	3.70	68.37	80.28
1994	10.57	13.84	111.53	135.94
1995	9.21	6.52	80.80	96.53
1996	10.29	12.66	70.59	93.54
1997	9.61	12.85	96.66	119.13
1998	9.00	4.04	66.22	79.27
1999	8.24	10.98	97.76	116.99
2000	6.93	12.41	140.09	159.43
2001	7.86	16.59	151.49	175.93
2002	5.23	9.23	104.67	119.13
2003	10.27	8.76	121.08	140.11
2004	6.27	5.10	233.12	244.50
2005	8.20	3.23	200.94	212.37
2006	12.48	7.91	223.45	243.83
2007	1.95	8.58	273.81	284.34
2008	1.70	12.35	251.73	265.78
2009	4.93	17.75	202.91	225.58
2010	2.54	24.26	270.63	297.43
2011	3.67	39.30	314.85	357.82
2012	5.11	52.56	535.91	593.59
2013	5.52	40.14	250.86	296.51
2014	3.84	37.72	439.13	480.69
2015	1.92	37.45	296.32	335.69
2016	1.47	35.47	283.91	320.86

Table 18. Estimated status indicators, benchmarks, and related quantities from the base run of the Beaufort Assessment Model, conditional on estimated current selectivities averaged across fleets. Median values and standard deviations (SD) approximated from Monte Carlo/Bootstrap analysis are also provided. Estimates of yield do not include discards; D_{MSY} *represents discard mortalities expected when fishing at* F_{MSY}*. Rate estimates (F) are in units of* y^{-1}*; status indicators are dimensionless; and biomass estimates are whole weight in units of metric tons or pounds, as indicated. Spawning stock biomass (SSB) is measured as population fecundity.*

Quantity	Units	Estimate	Median	SD
F_{MSY}	y^{-1}	0.31	0.34	0.07
$85\%F_{\mathrm{MSY}}$	y^{-1}	0.26	0.29	0.06
$75\%F_{\mathrm{MSY}}$	y^{-1}	0.23	0.26	0.06
$65\%F_{\mathrm{MSY}}$	y^{-1}	0.20	0.22	0.05
B_{MSY}	mt	6824	6992	1272
$\mathrm{SSB}_{\mathrm{MSY}}$	1E10 eggs	300	304	50.57
MSST	1E10 eggs	186	186	35.73
MSY	1000 lb	935	968	208.16
D_{MSY}	1000 fish	1421	1414	278.44
R_{MSY}	1000 age-0 fish	36400	36919	12947
Y at $85\%F_{\mathrm{MSY}}$	1000 lb	793.90	960.27	206.56
Y at $75\%F_{\mathrm{MSY}}$	1000 lb	701.25	943.10	203.32
Y at $65\%F_{\mathrm{MSY}}$	1000 lb	607.75	915.01	197.78
$F_{2014-2016}/F_{\mathrm{MSY}}$	—	0.64	0.58	0.21
$\mathrm{SSB}_{2016}/\mathrm{MSST}$	—	1.15	1.16	0.22
$\mathrm{SSB}_{2016}/\mathrm{SSB}_{\mathrm{MSY}}$	—	0.71	0.71	0.11

Table 19. Results from sensitivity runs of the Beaufort catch-age model. Current F represented by geometric mean of last three assessment years.

Run	Description	F_{MSY}	$\mathrm{SSB}_{\mathrm{MSY}}$ (mt)	MSY(1000 lb)	$\mathrm{F}_{2014-2016}/F_{\mathrm{MSY}}$	$\mathrm{SSB}_{2016}/\mathrm{SSB}_{\mathrm{MSY}}$	steep	R0(1000)
Base	—	0.31	299.91	934	0.64	0.71	0.64	35928
S1	scaled to M=0.53	0.431	417.64	847	0.5	0.39	0.64	65660
S2	scaled to M=0.27	0.245	292.44	1208	0.98	0.58	0.64	17412
S3	high weight on indices (5.0)	0.384	293.92	734	0.6	0.65	0.64	34221
S4	low weight on indices (1.0)	0.4	300.69	1080	0.68	0.69	0.64	35834
S5	h=0.97	0.338	286.28	909	0.58	0.74	0.97	33146
S6	h=0.31	0.192	521.33	1314	1.09	0.37	0.31	65660
S7	constant q	0.31	300.19	935	0.64	0.71	0.64	35906
S8	CVT instead	0.343	301.48	856	0.54	0.73	0.64	35756
S9	high MRIP L and D	0.305	395.43	1230	0.61	0.66	0.64	46214
S10	low MRIP L and D	0.313	200.5	645	0.79	0.75	0.64	24757
S11	high Disc M	0.358	334.76	718	1.09	0.64	0.64	40861
S12	low Disc M	0.444	286.19	1162	0.36	0.75	0.64	34135
S13	continuity	0.394	307.86	1207	0.41	0.7	0.48	37835
S14	retro1	0.364	314.05	1098	0.6	0.87	0.64	37563
S15	retro2	0.507	325.32	1353	0.51	1.11	0.64	39487
S16	retro3	0.613	331.24	1490	0.54	1.24	0.64	40713

Table 20. Projection results with fishing mortality rate fixed at $F = F_{\mathrm{MSY}}$ starting in 2019. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (mt), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb*), and D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), pr.reb = proportion of stochastic projection replicates with* $\mathrm{SSB} \geq \mathrm{SSB}_{\mathrm{MSY}}$. *The extension* b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b(mt)	S.med(mt)	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2017	20626	31382	0.22	0.23	212	215	635	633	792	789	582	557	338	313	0.001
2018	33872	31347	0.23	0.25	191	213	597	595	792	789	505	509	262	252	0.012
2019	32977	31072	0.31	0.34	201	227	657	677	899	916	794	872	393	419	0.060
2020	33430	31726	0.31	0.34	221	242	555	604	739	777	976	1197	483	620	0.119
2021	34199	32162	0.31	0.34	242	257	540	612	663	730	1274	1234	674	655	0.186
2022	34897	32609	0.31	0.34	258	268	581	655	669	752	1300	1240	699	656	0.253
2023	35370	33015	0.31	0.34	271	276	635	694	718	793	1318	1255	706	664	0.304

Table 21. Projection results with fishing mortality rate fixed at $P^{\star}$=0.40 (which is about 93.8% of $F = F_{\mathrm{MSY}}$) starting in 2019. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (mt), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), pr.reb = proportion of stochastic projection replicates with $\mathrm{SSB} \geq \mathrm{SSB}_{\mathrm{MSY}}$. The extension b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b(mt)	S.med(mt)	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2017	20626	31382	0.22	0.23	212	215	635	633	792	789	582	557	338	313	0.001
2018	33872	31347	0.23	0.25	191	213	597	595	792	789	505	509	262	252	0.012
2019	32977	31072	0.29	0.32	202	228	621	640	850	866	748	821	371	395	0.061
2020	33449	31744	0.29	0.32	223	244	532	578	710	745	922	1132	458	588	0.126
2021	34254	32222	0.29	0.32	245	259	522	592	644	709	1207	1169	640	622	0.203
2022	34971	32690	0.29	0.32	262	272	566	637	655	736	1233	1175	664	623	0.276
2023	35459	33117	0.29	0.32	275	280	620	678	706	780	1250	1190	671	631	0.332

Table 22. Projection results with fishing mortality rate fixed at $F = 75\% F_{\mathrm{MSY}}$ starting in 2019. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (mt), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), pr.reb = proportion of stochastic projection replicates with $\mathrm{SSB} \geq \mathrm{SSB}_{\mathrm{MSY}}$. The extension b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b(mt)	S.med(mt)	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2017	20626	31382	0.22	0.23	212	215	635	633	792	789	582	557	338	313	0.001
2018	33872	31347	0.23	0.25	191	213	597	595	792	789	505	509	262	252	0.012
2019	32977	31072	0.23	0.26	203	229	508	523	696	709	608	667	302	322	0.065
2020	33507	31793	0.23	0.26	228	249	454	493	609	639	756	930	378	486	0.153
2021	34425	32404	0.23	0.26	252	268	459	520	574	631	995	964	531	517	0.256
2022	35197	32938	0.23	0.26	272	283	506	570	599	672	1019	970	553	518	0.354
2023	35732	33445	0.23	0.26	287	293	561	615	655	724	1035	984	560	525	0.427

8 Figures

Figure 1. Mean length at age (mm) and estimated upper and lower 95% confidence intervals of the population.

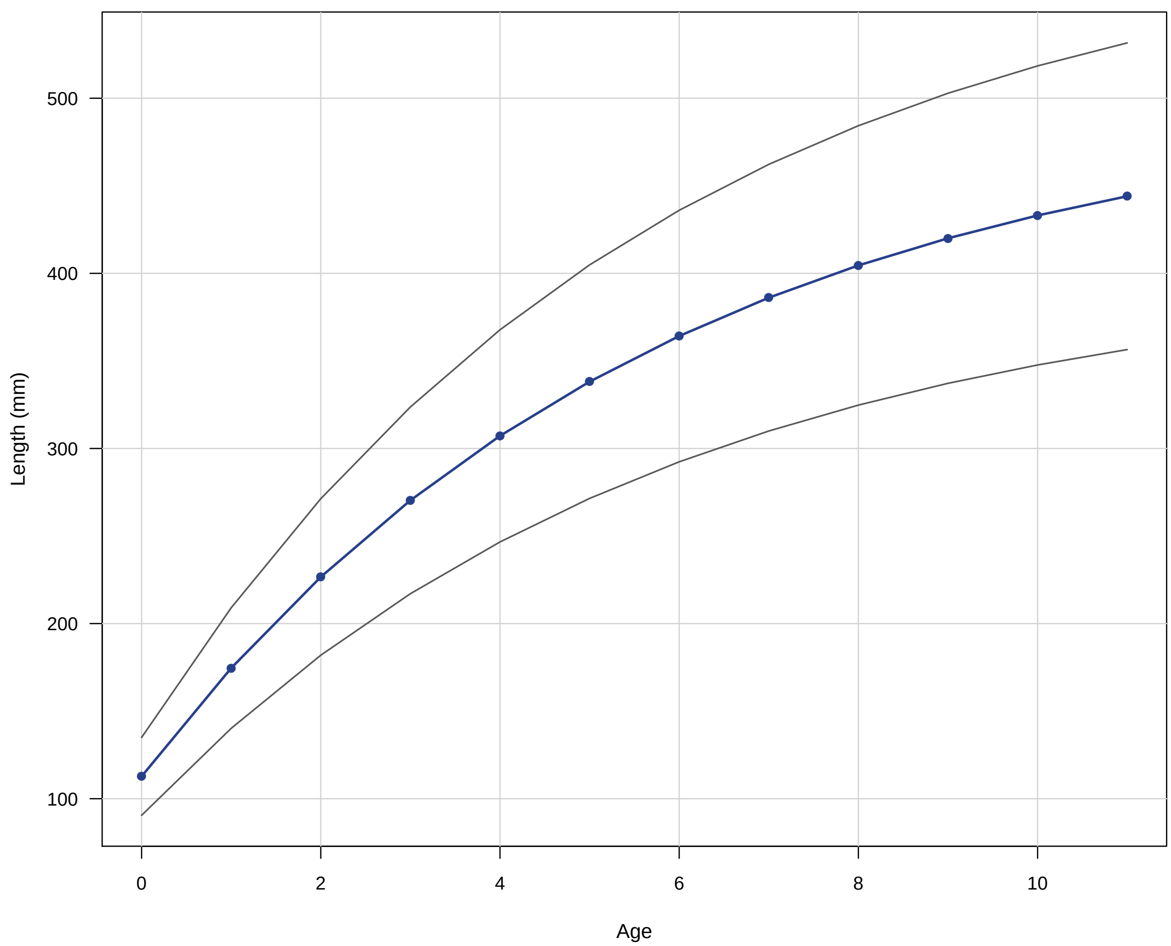


Figure 2. Indices of abundance used in fitting the assessment model. U.MBFT indicates the MARMAP blackfish/snapper trap survey; U.CVID indicates the SERFS chevron trap/video survey; U.HB the headboat logbook data; and U.cH the commercial handline logbook data.

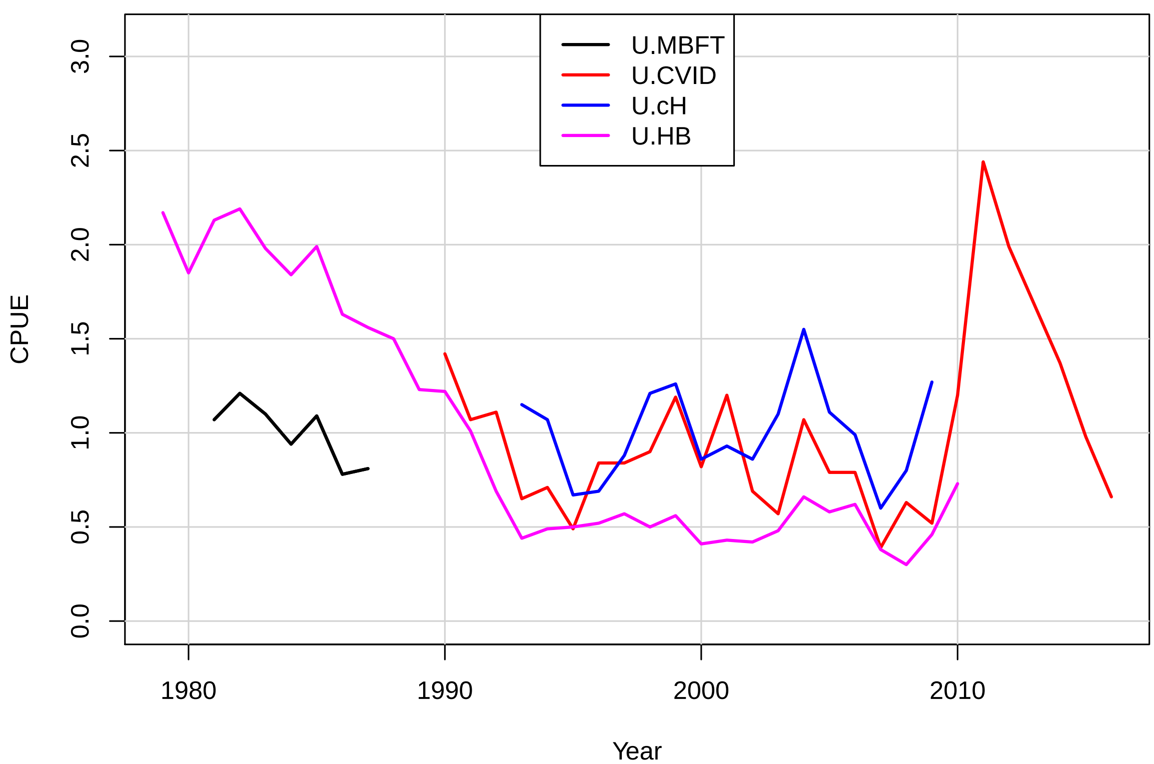


Figure 3. Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey from the base run. In panels indicating the data set, lcomp refers to length compositions, acomp to age compositions, Mbft to MARMAP blackfish/snapper traps, Mcvt to MARMAP chevron traps, cl to commercial lines, cp to commercial pots, hb to headboat, mrip to general recreational, and hb.D to headboat discards. N indicates the number of trips from which individual fish samples were taken.

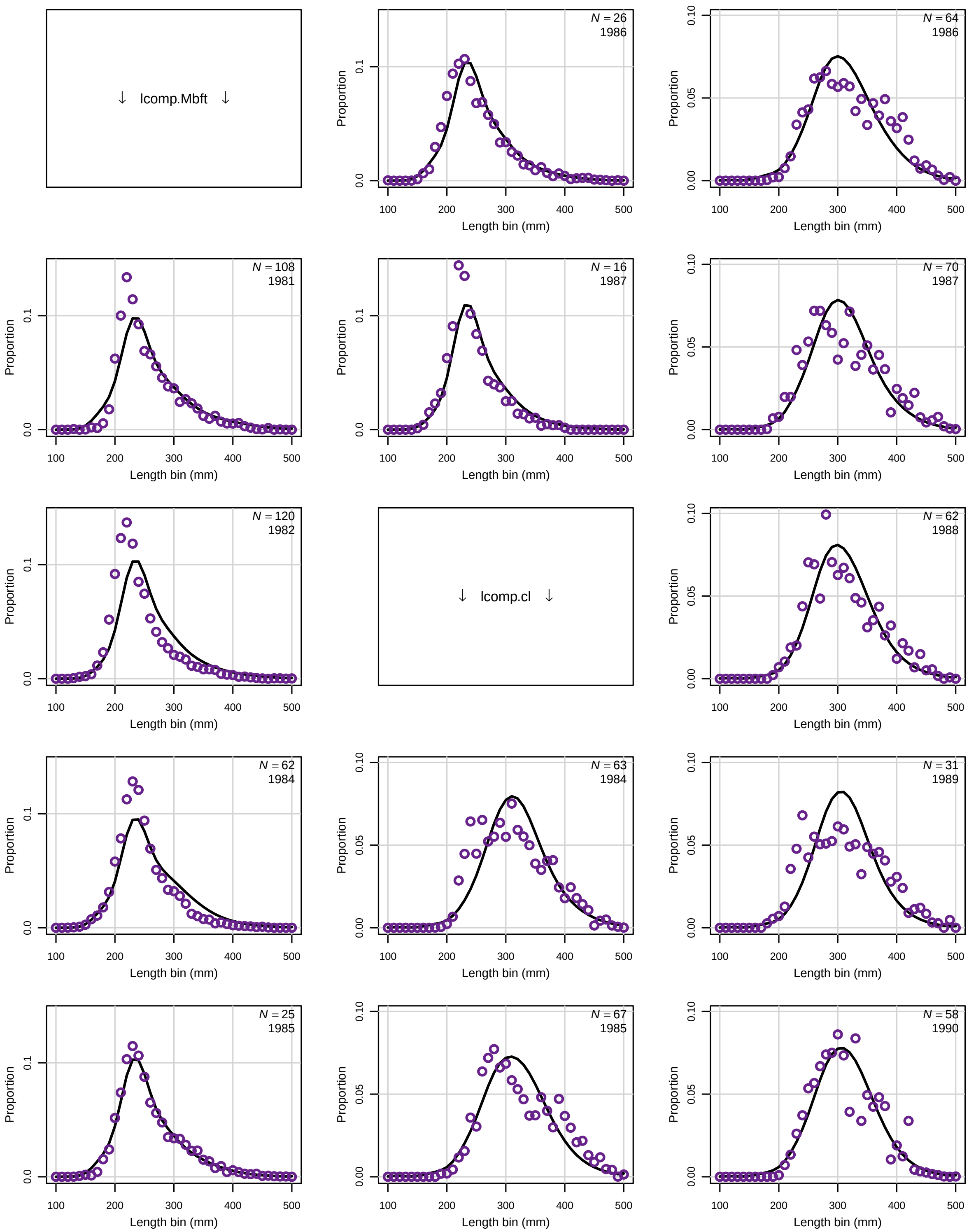


Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey from the base run.

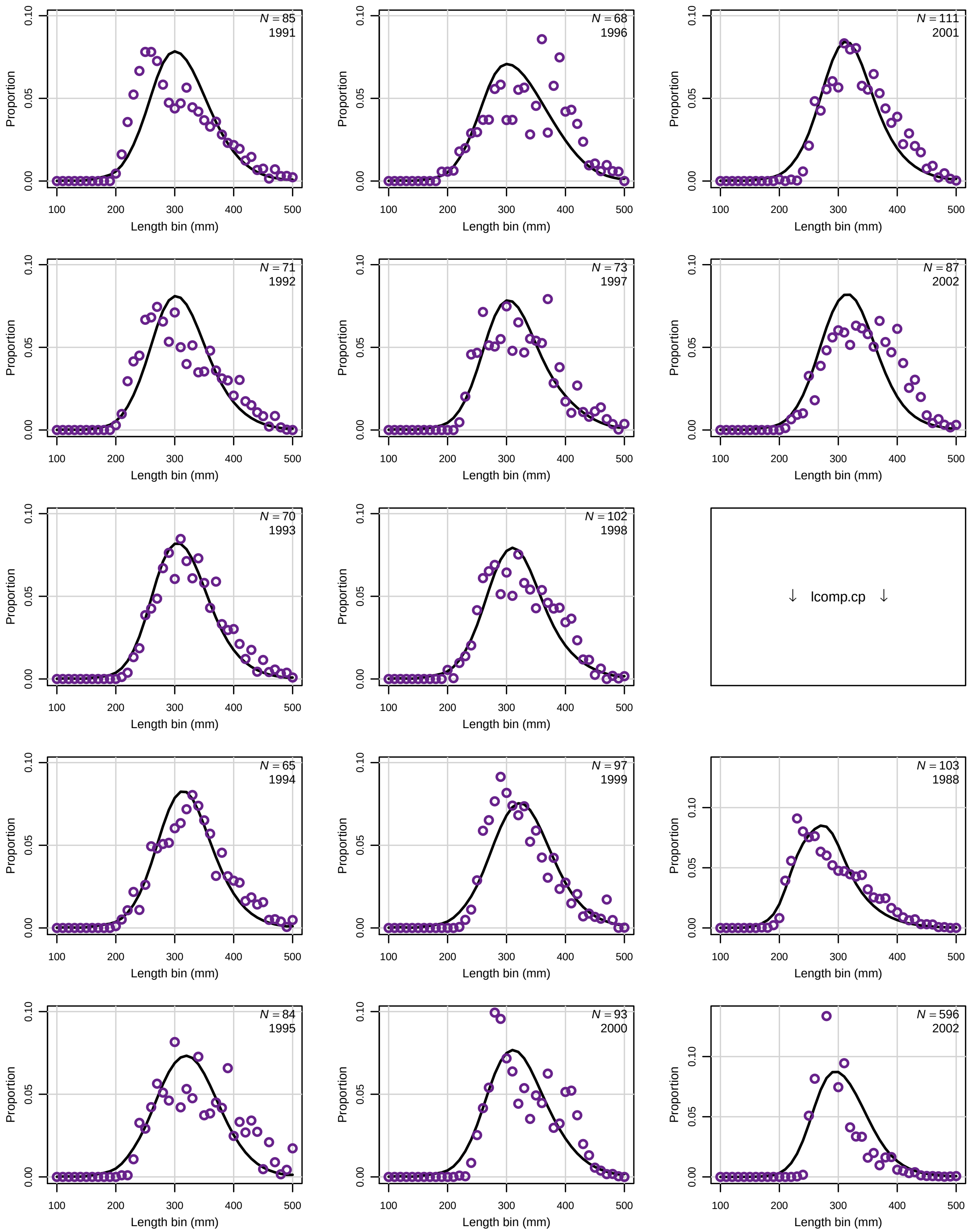


Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey from the base run.

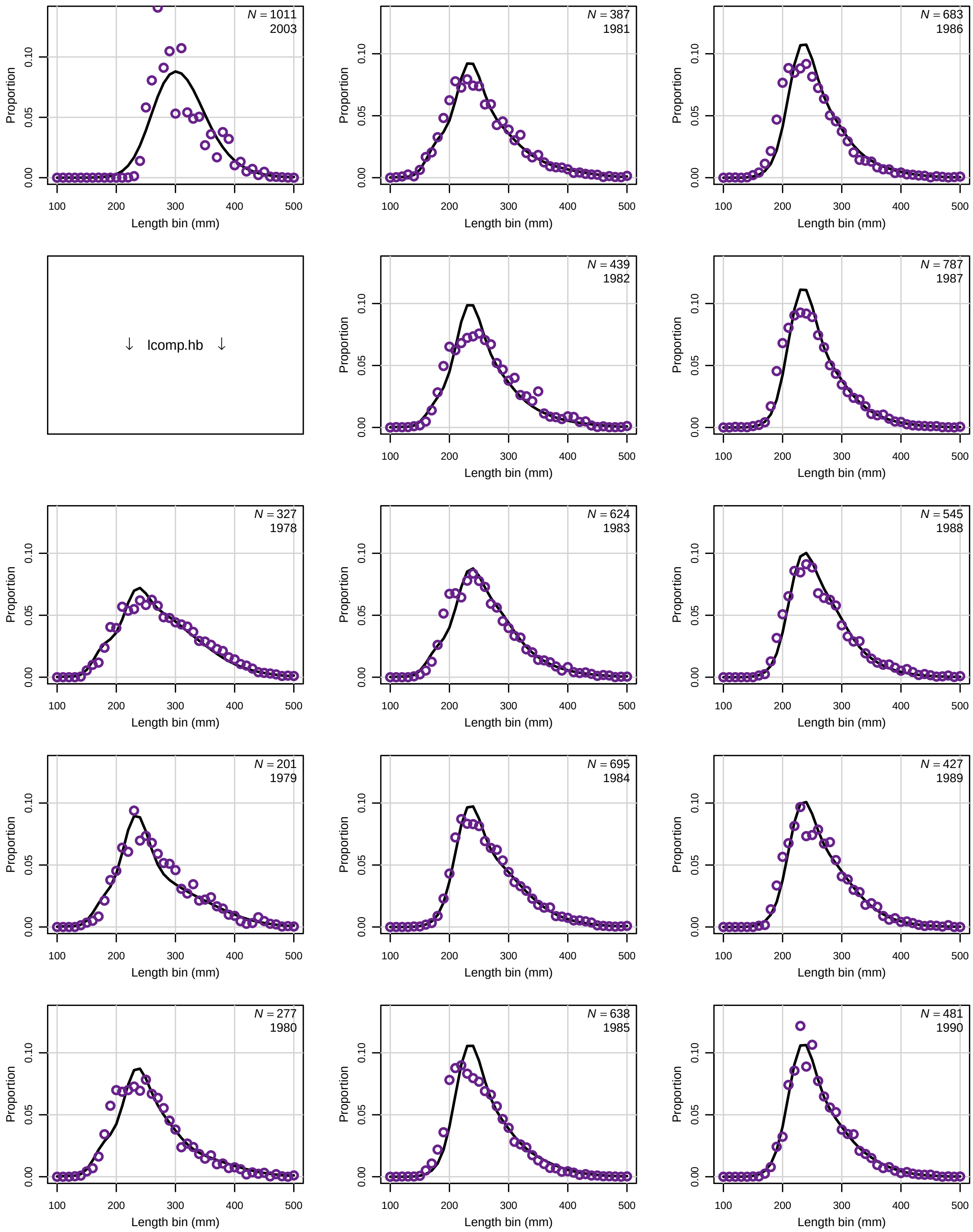


Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey from the base run.

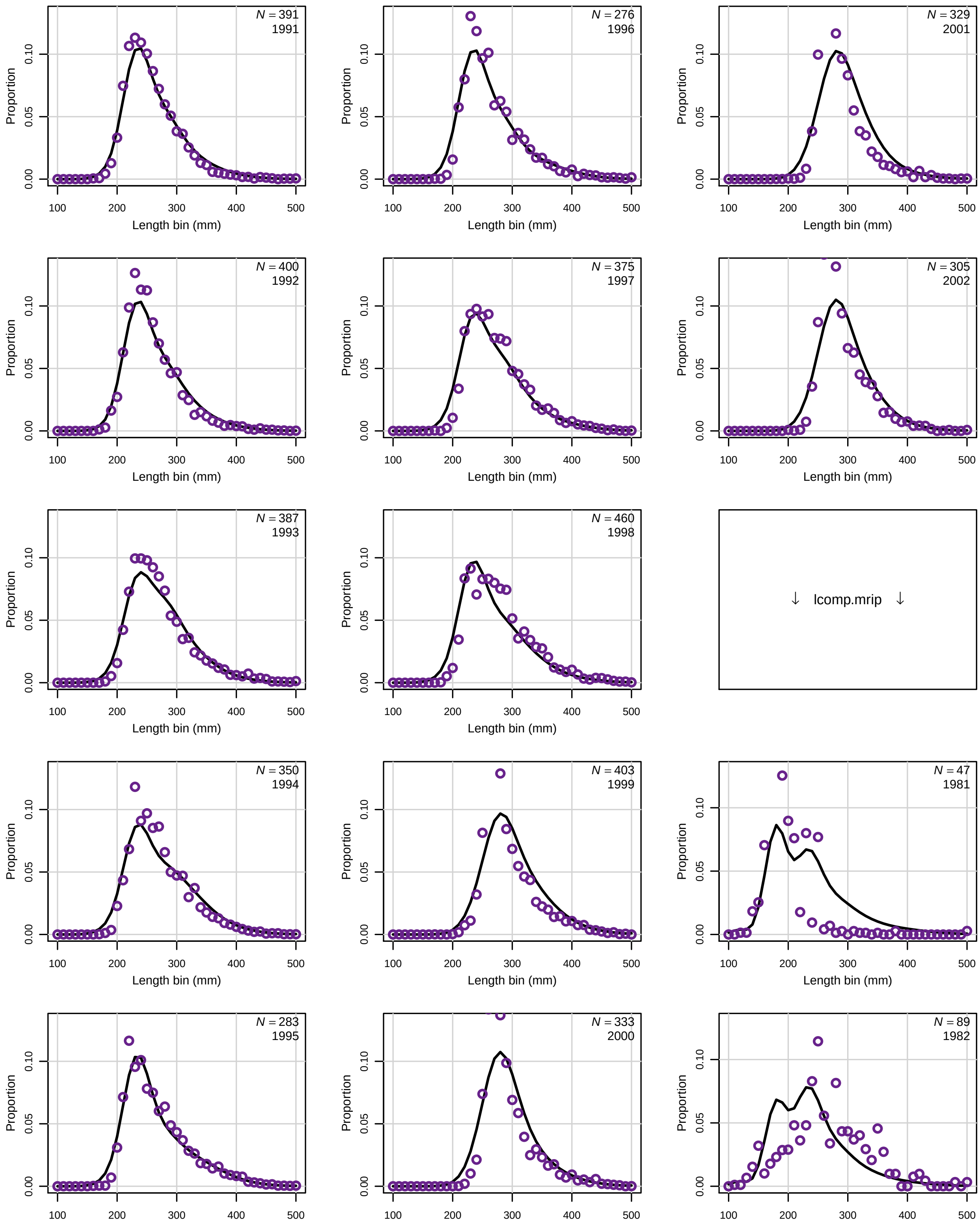


Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey from the base run.

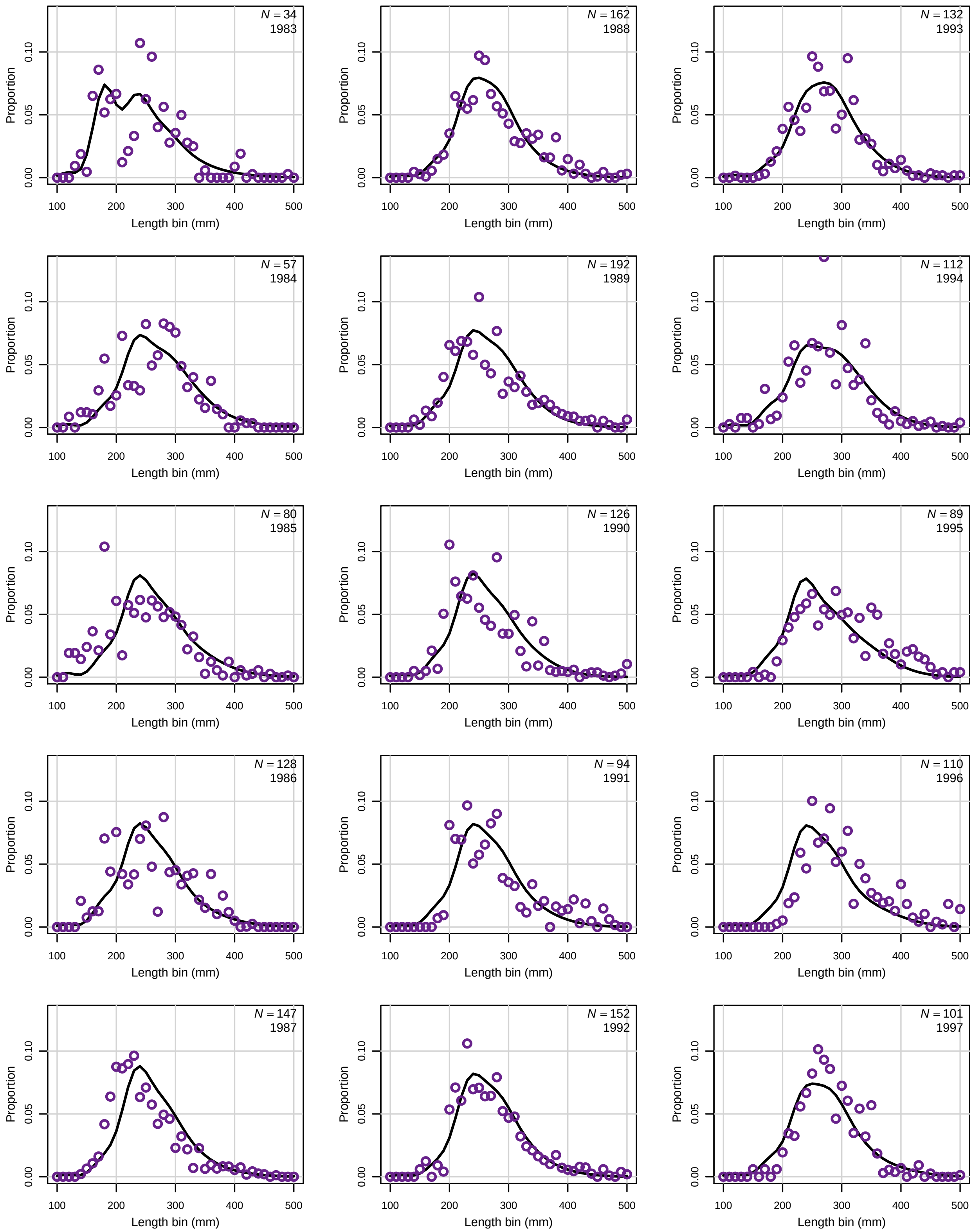


Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey from the base run.

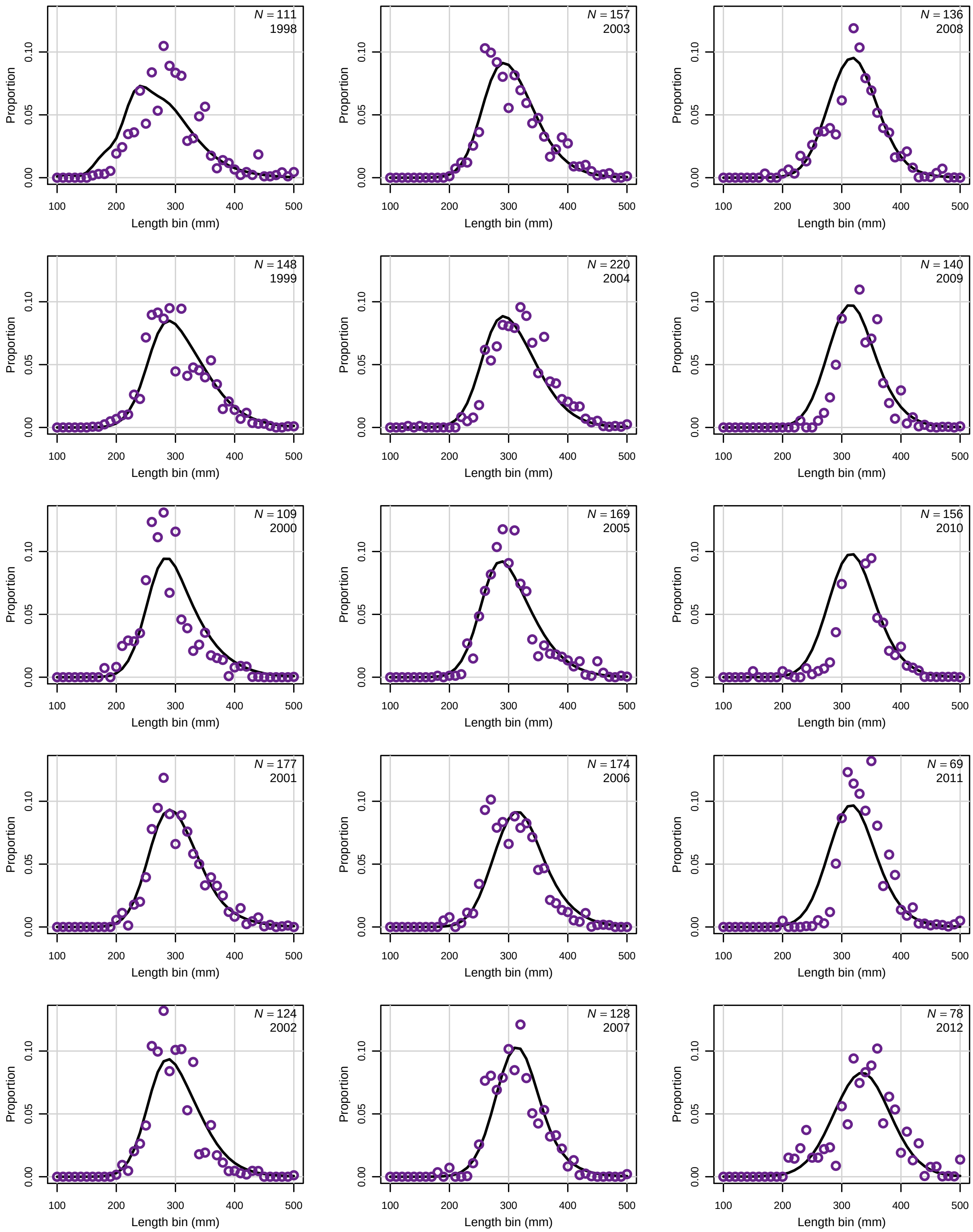


Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey from the base run.

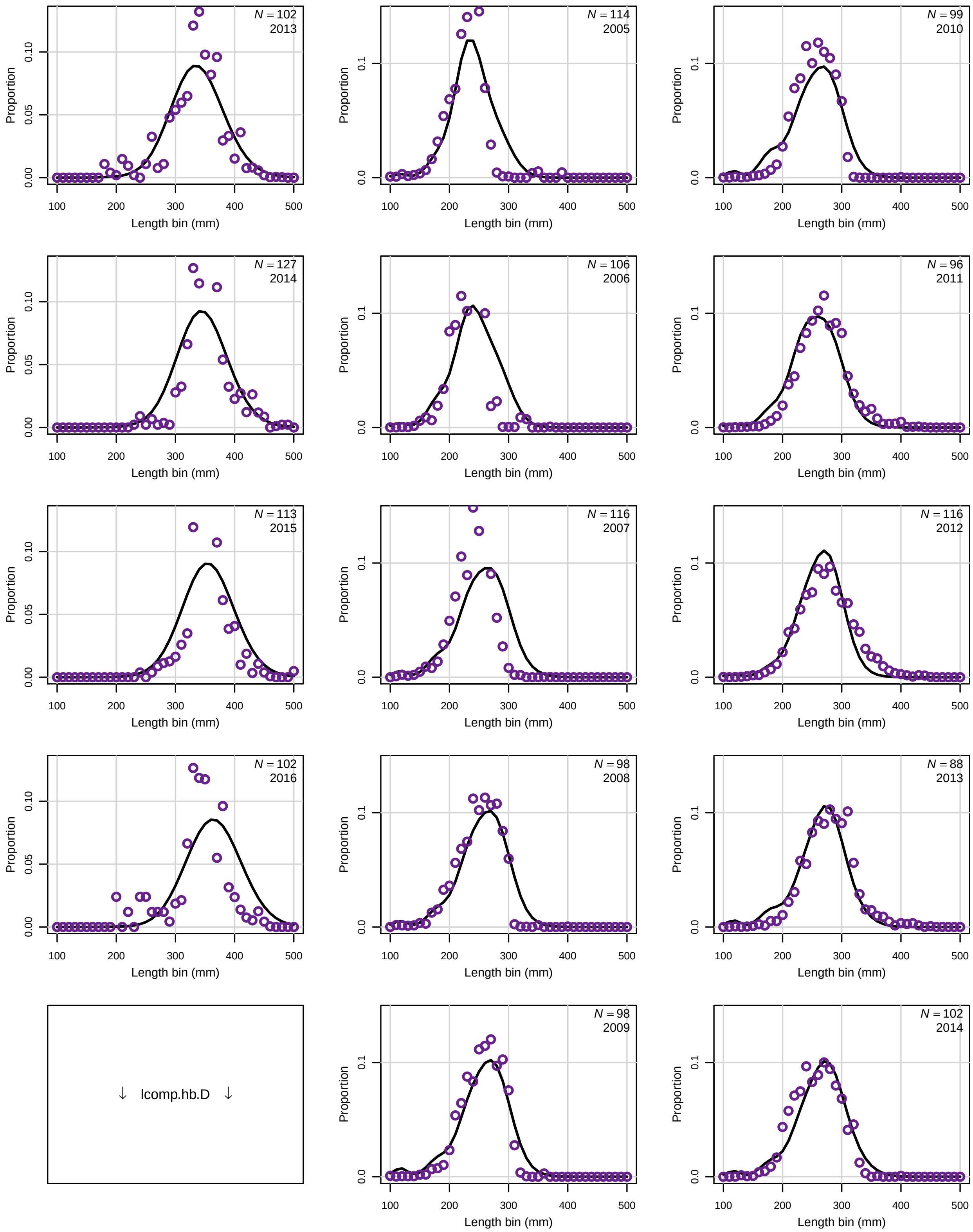


Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey from the base run.

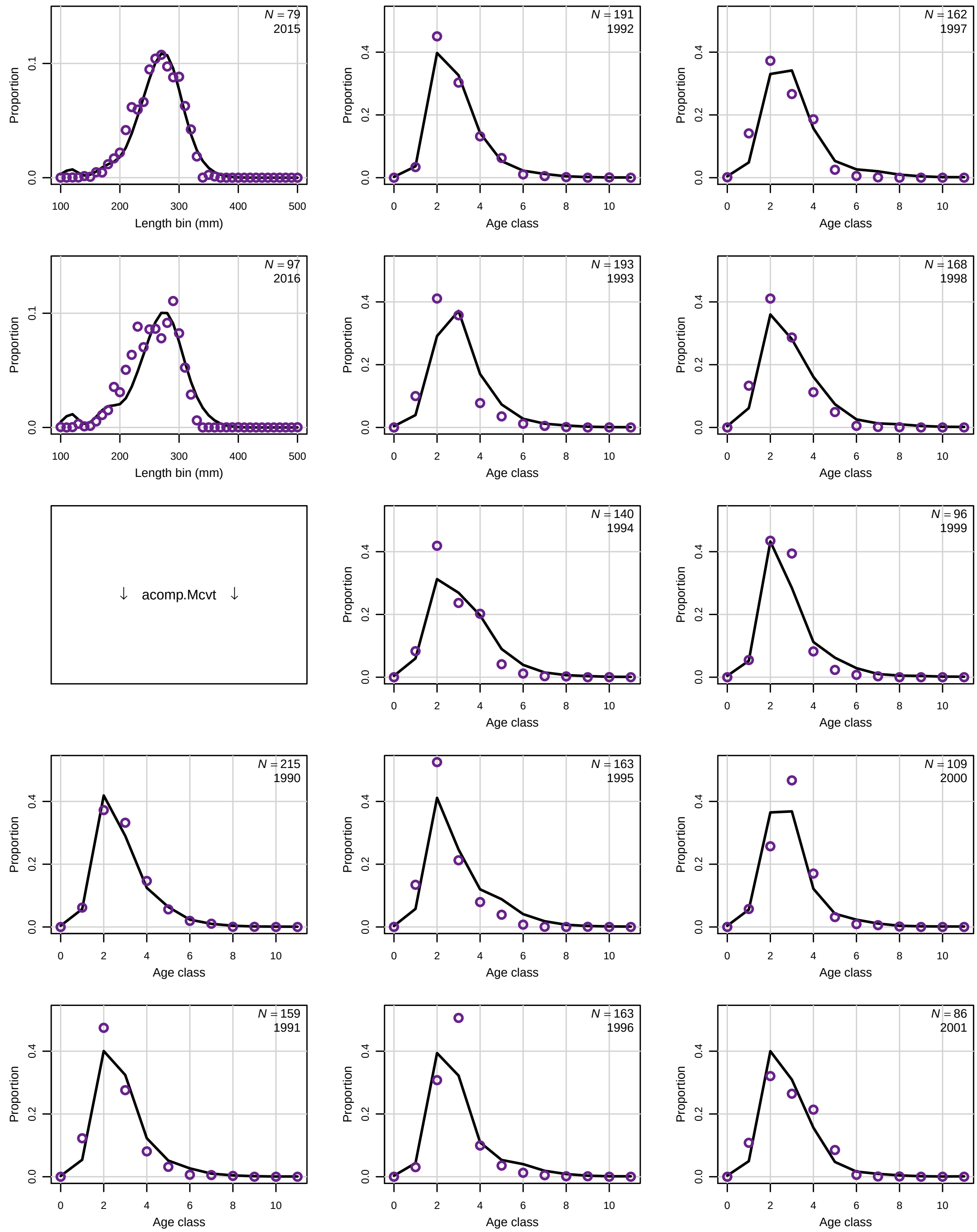


Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey from the base run.

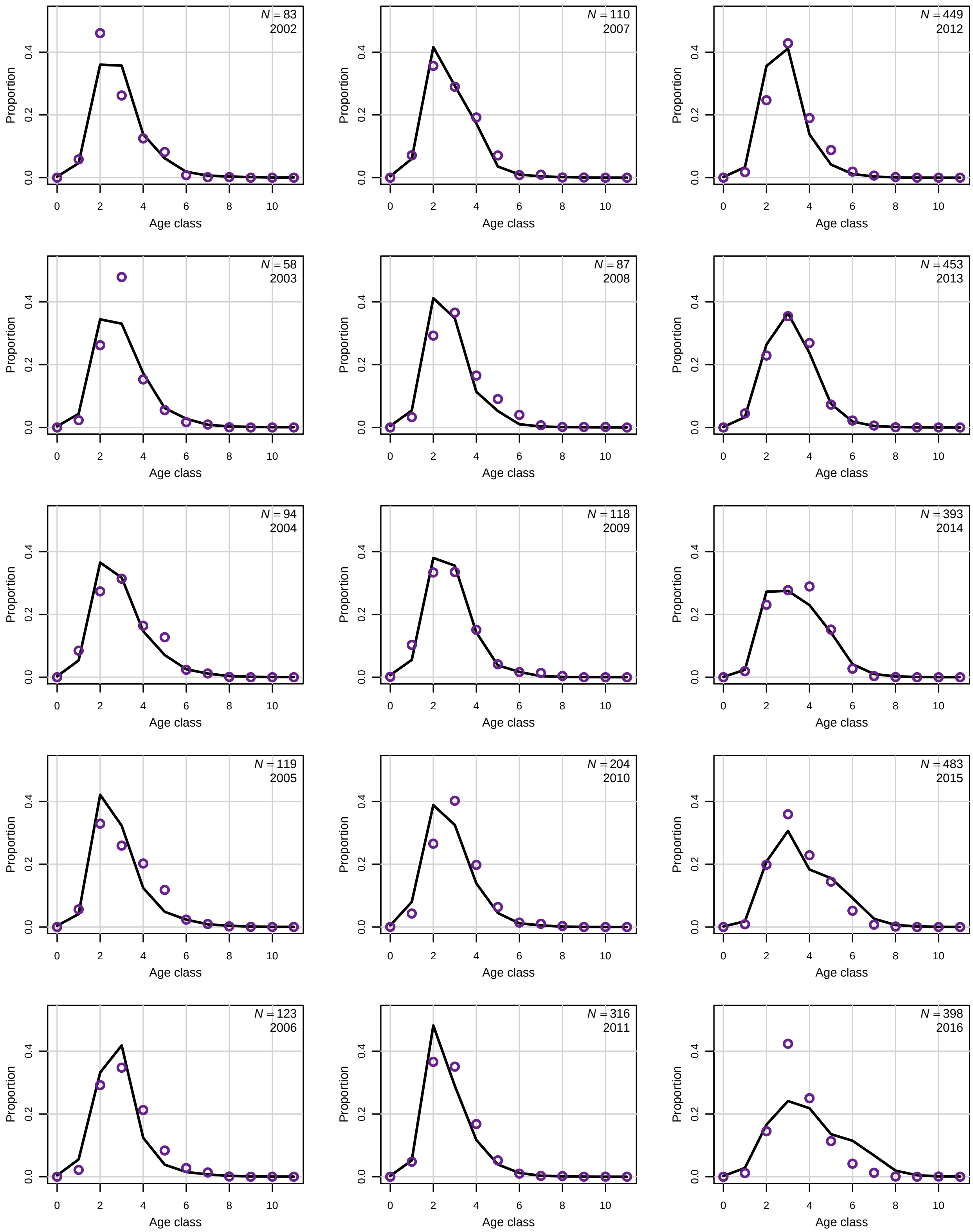


Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey from the base run.

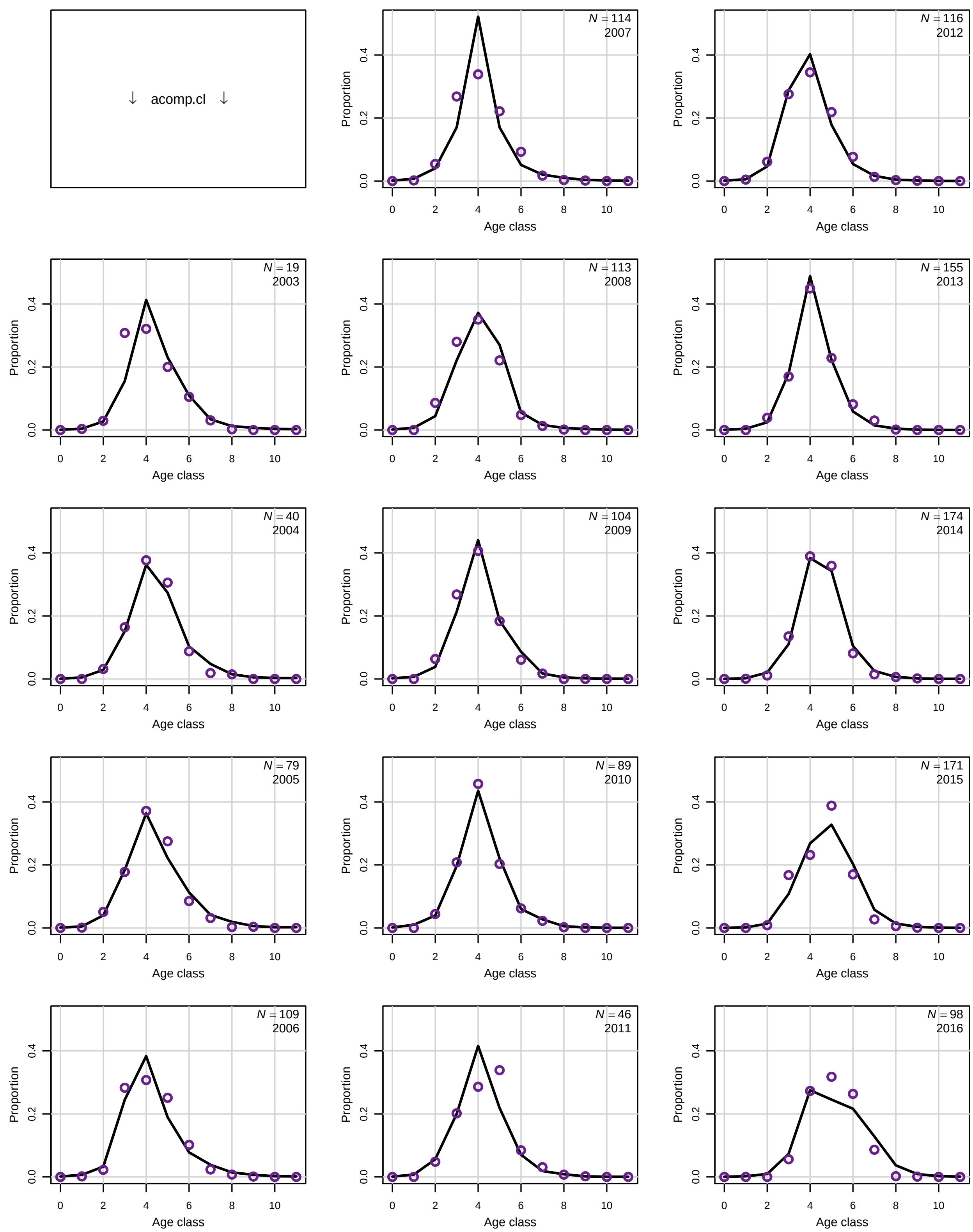


Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey from the base run.

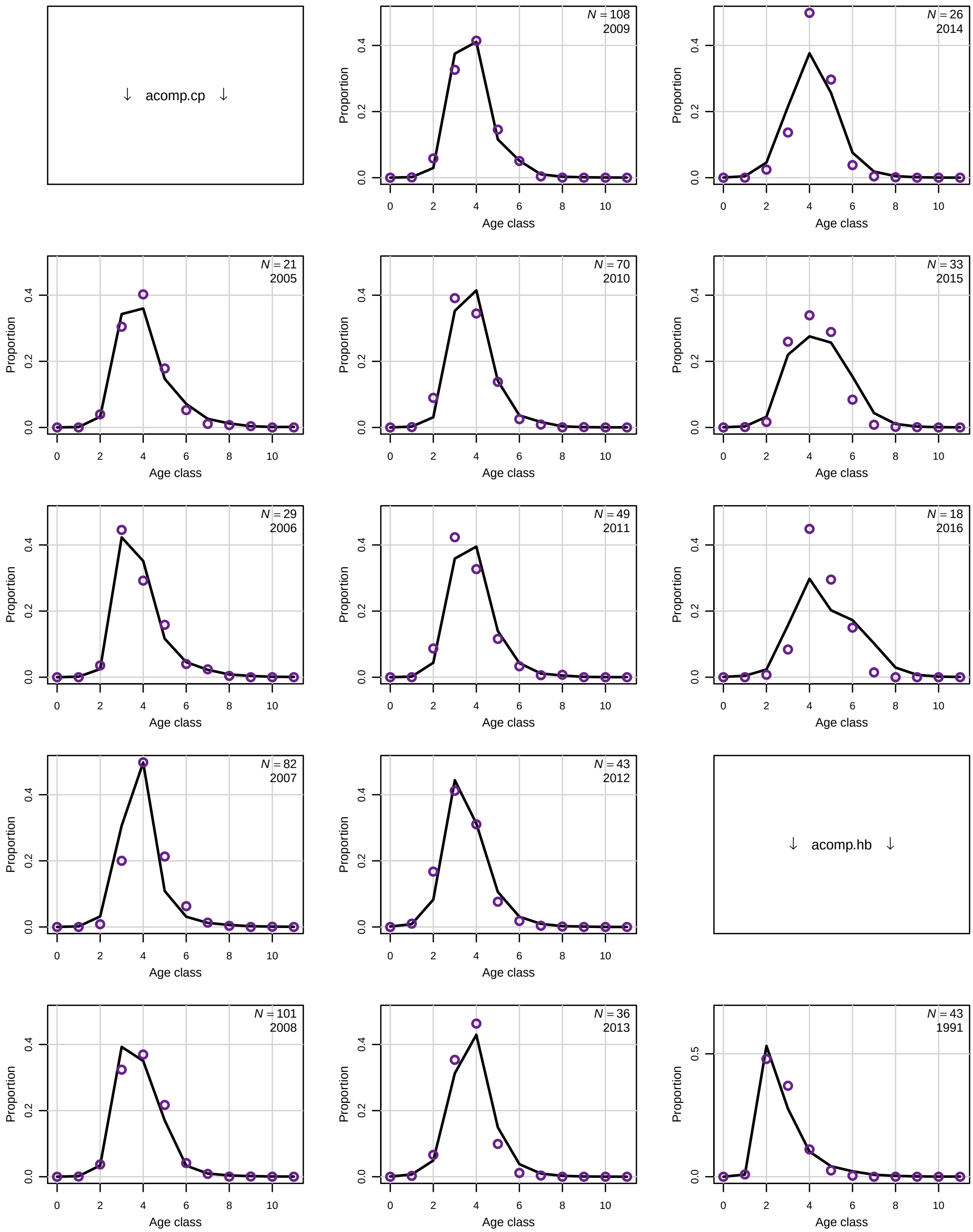


Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey from the base run.

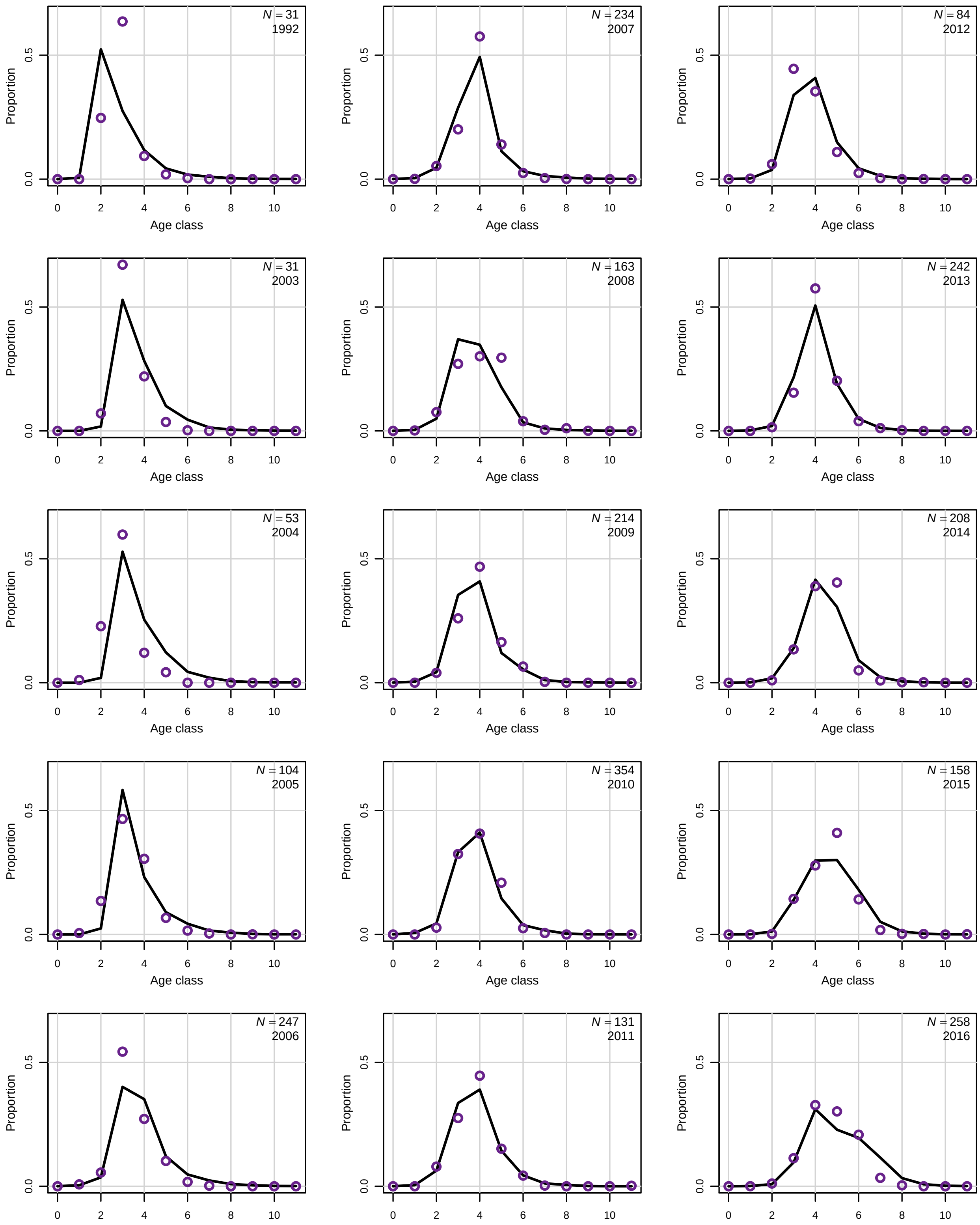


Figure 4. Observed (open circles) and estimated (line, solid circles) commercial lines landings (1000 lb whole weight).

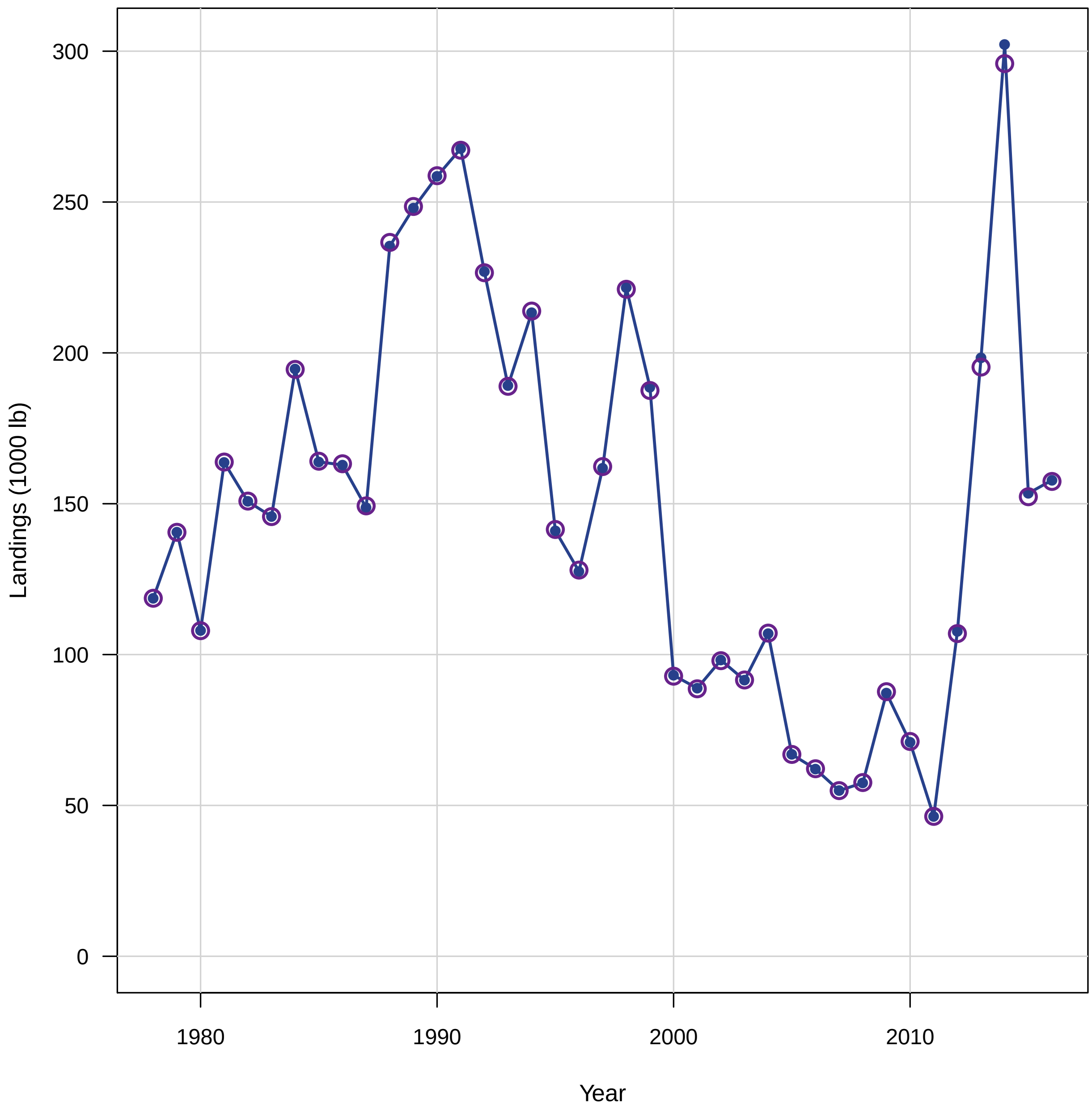


Figure 5. Observed (open circles) and estimated (line, solid circles) commercial pot landings (1000 lb whole weight).

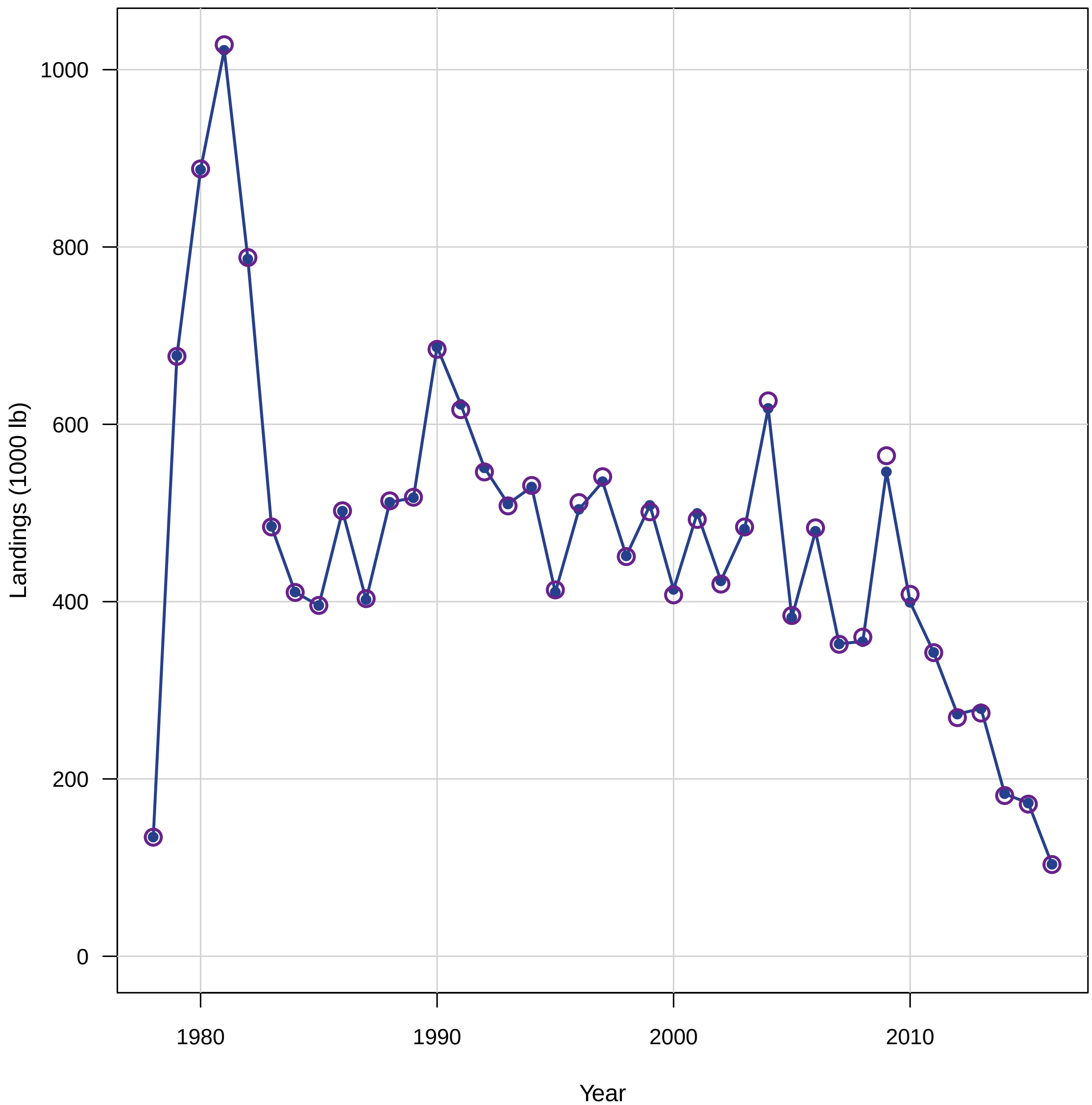


Figure 6. Observed (open circles) and estimated (line, solid circles) commercial trawl landings (1000 lb whole weight).

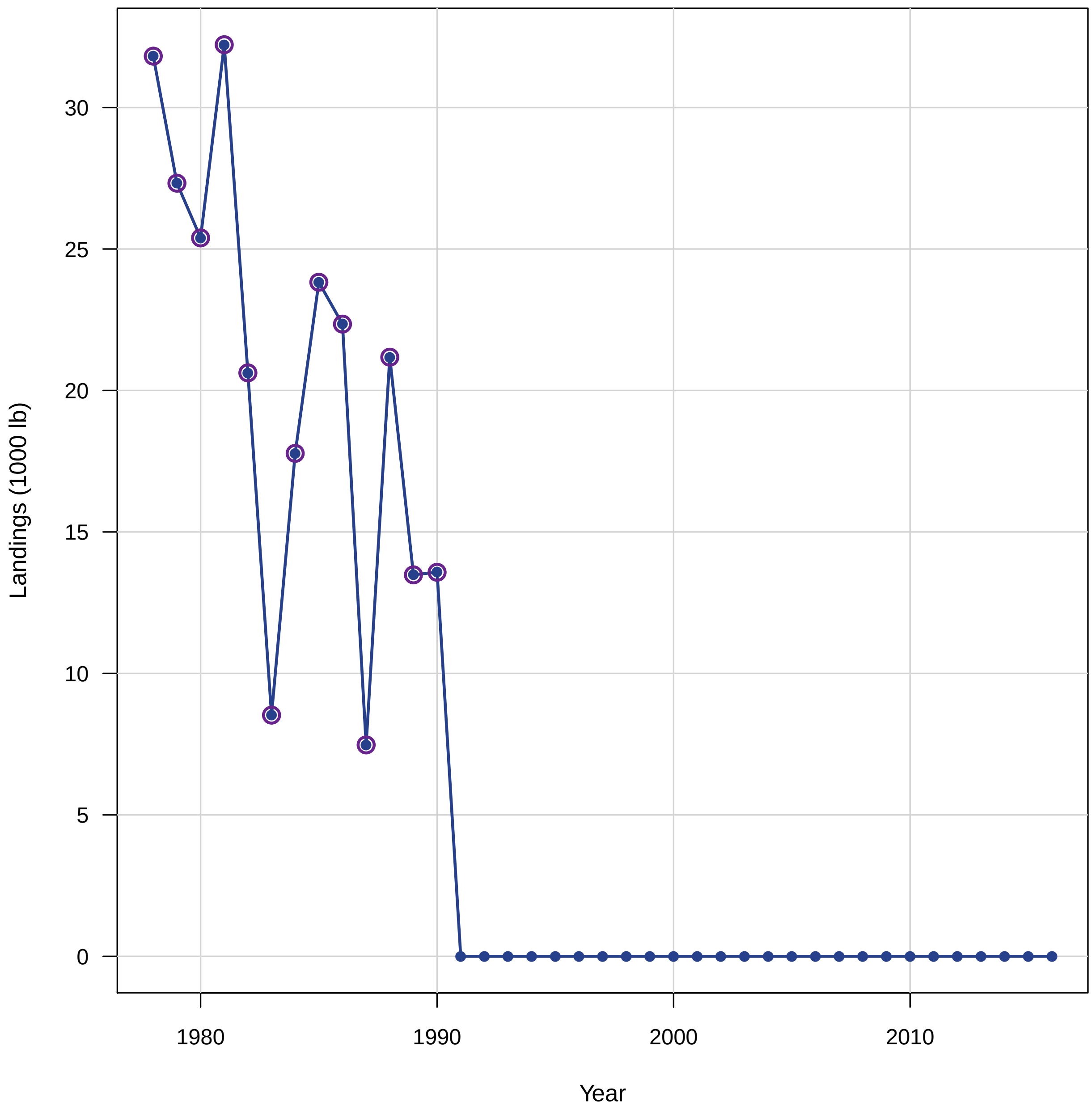


Figure 7. Observed (open circles) and estimated (line, solid circles) headboat landings (1000 lb whole weight).

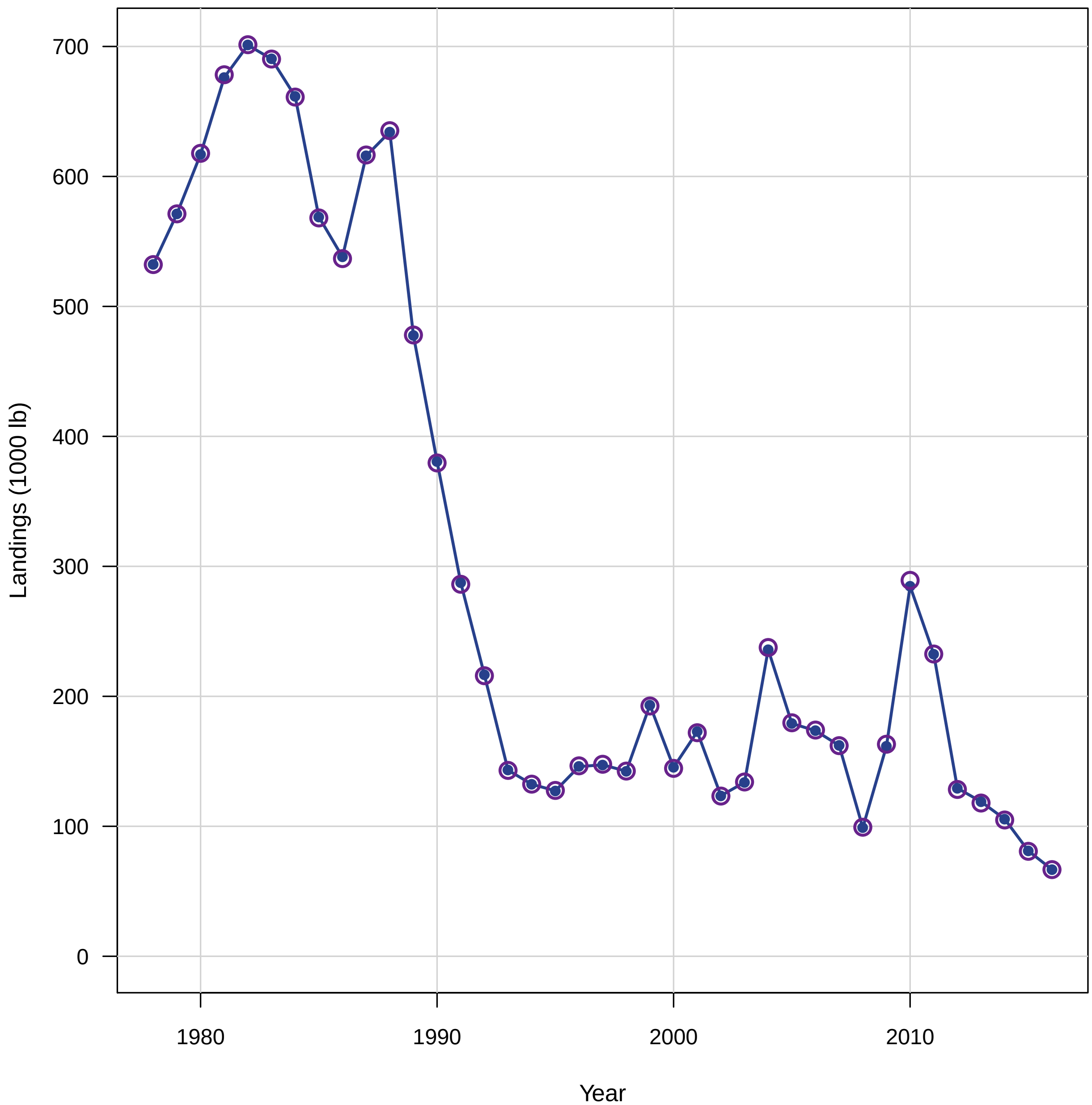


Figure 8. Observed (open circles) and estimated (line, solid circles) general recreational landings (1000 lb whole weight). In years without observations (1978–1980), values were predicted using average F (see §3.3 for details).

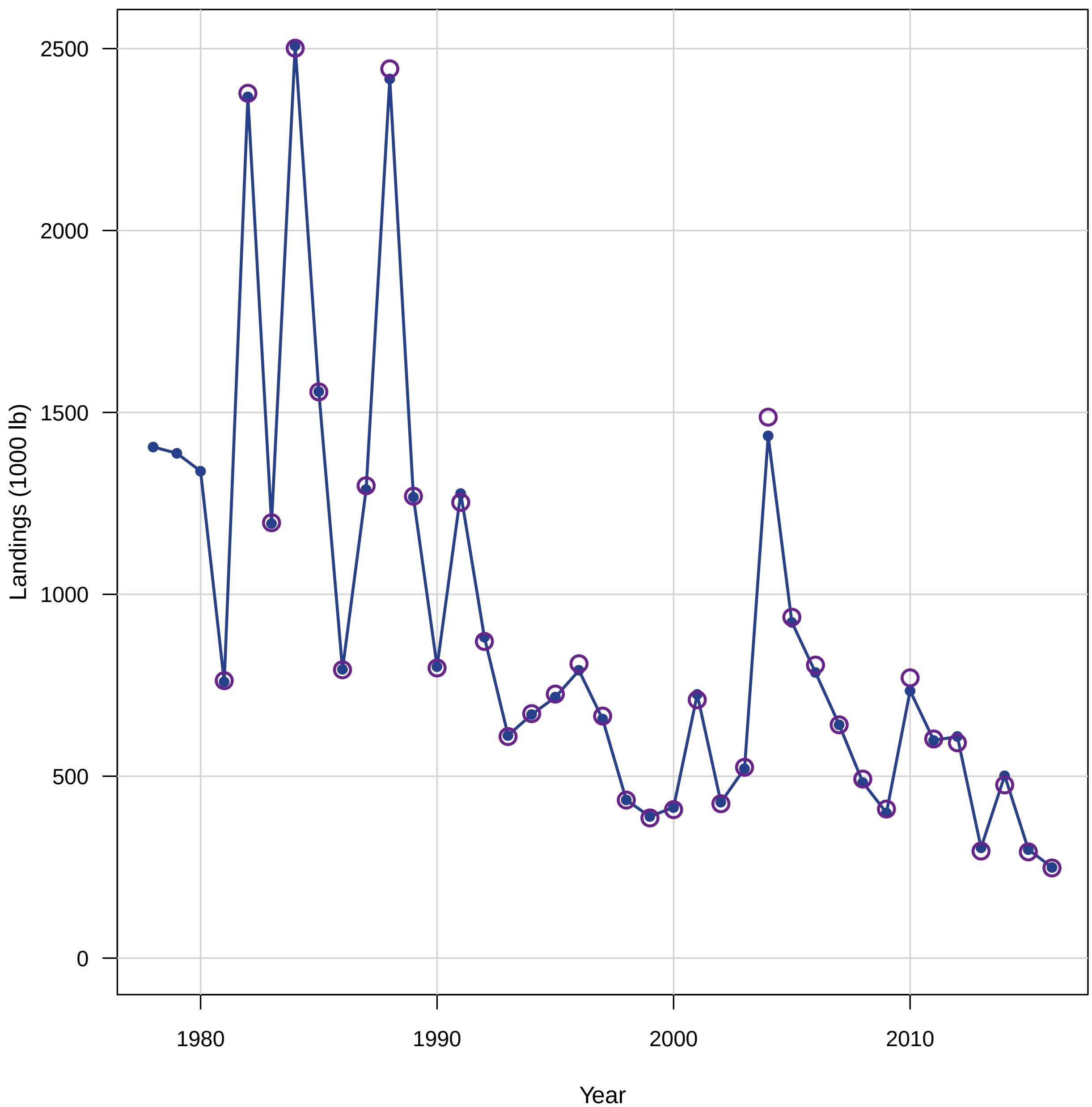


Figure 9. Observed (open circles) and estimated (line, solid circles) commercial (lines + pots) discard mortalities (1000 dead fish). In years without observations (1984–1992), values were predicted using average F (see §3.3 for details). Commercial discards were modeled starting in 1984 with implementation of the 8-inch size limit.

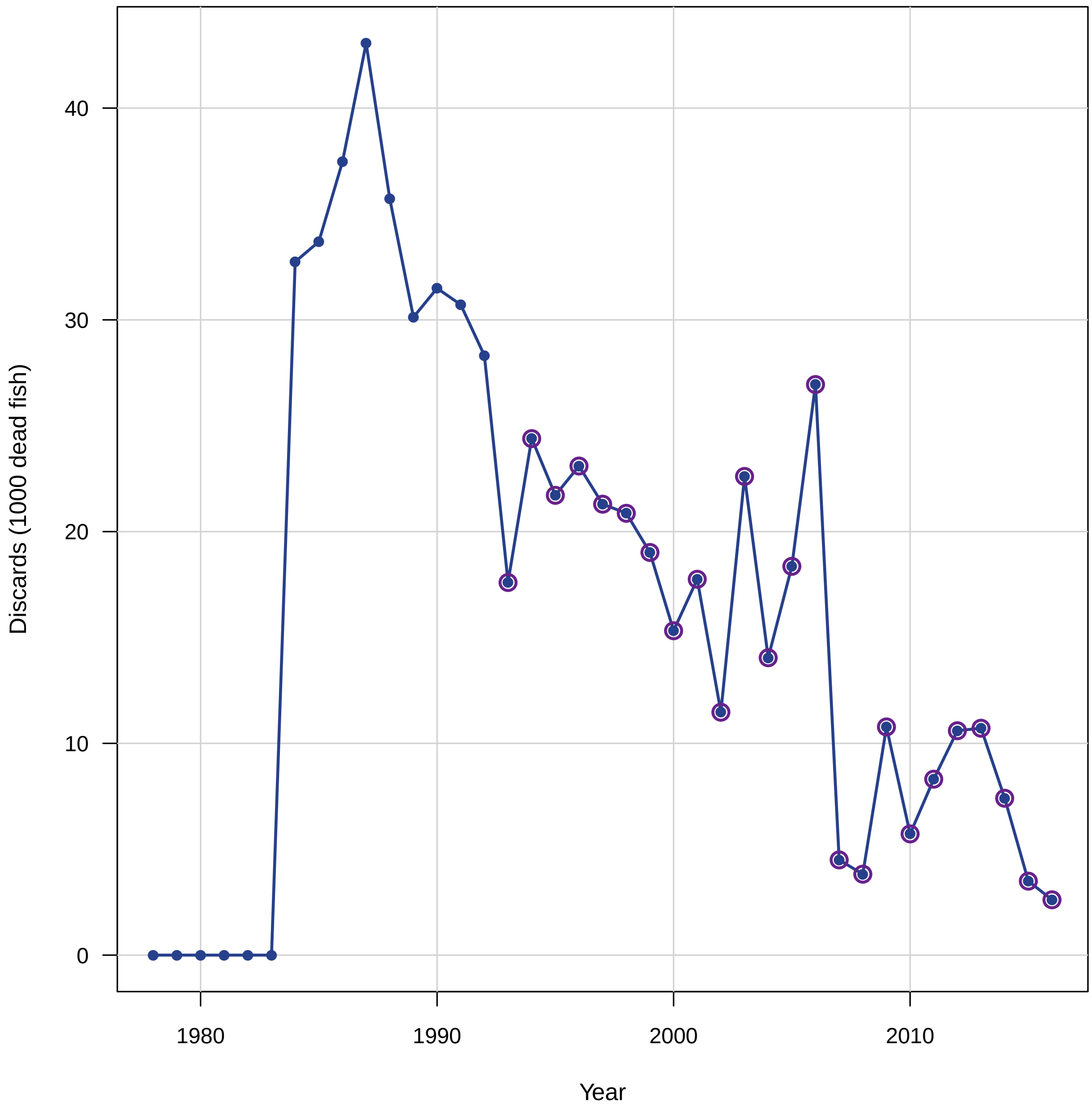


Figure 10. Observed (open circles) and estimated (line, solid circles) headboat discard mortalities (1000 dead fish). Estimates prior to 1986 were combined with the general recreational discards.

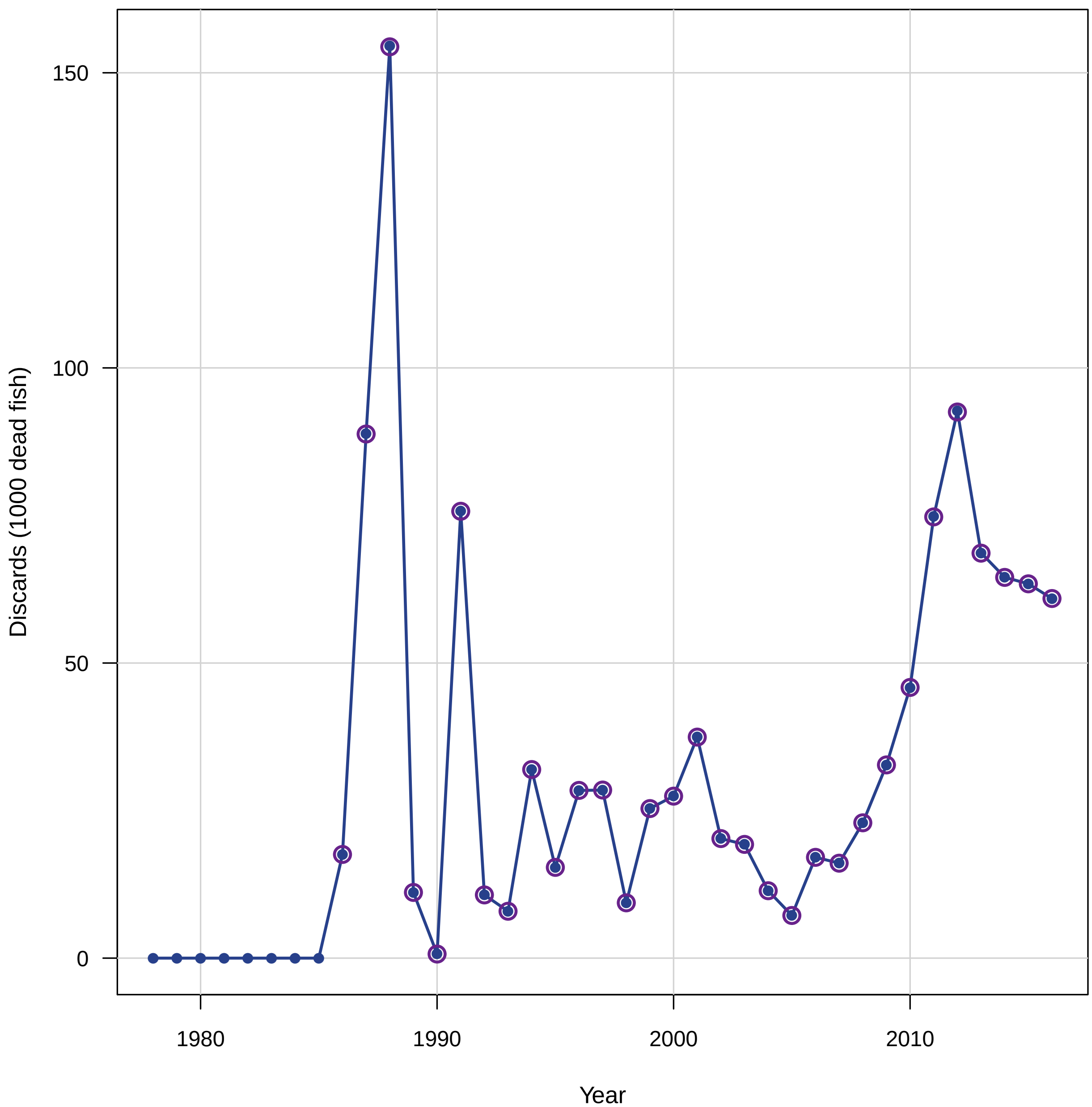


Figure 11. Observed (open circles) and estimated (line, solid circles) general recreational discard mortalities (1000 dead fish). Estimates prior to 1986 include headboat discard mortalities. In years without observations (1978–1980), values were predicted using average F (see §3.3 for details).

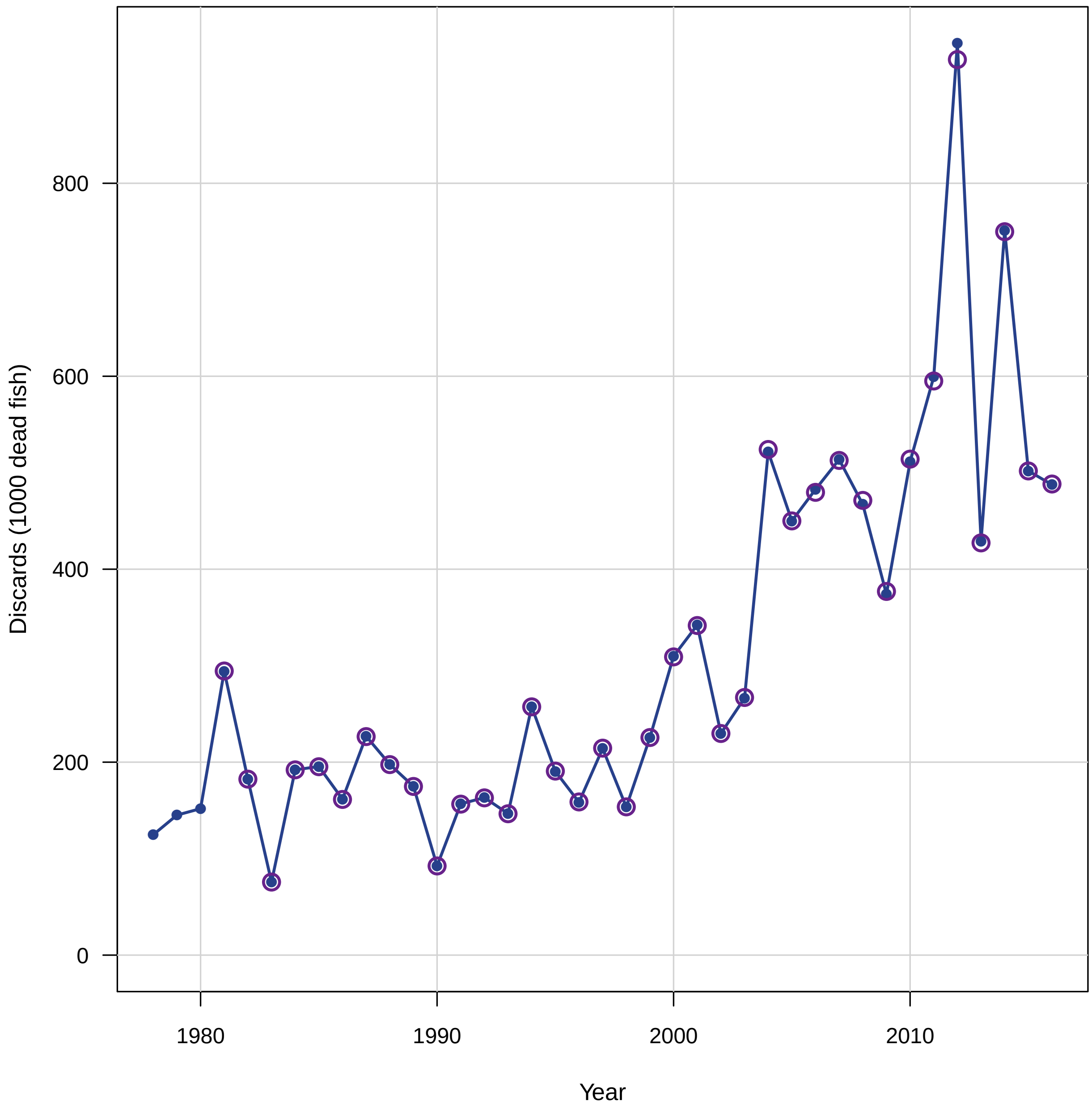


Figure 12. Observed (open circles) and estimated (line, solid circles) index of abundance from MARMAP blackfish/snapper traps.

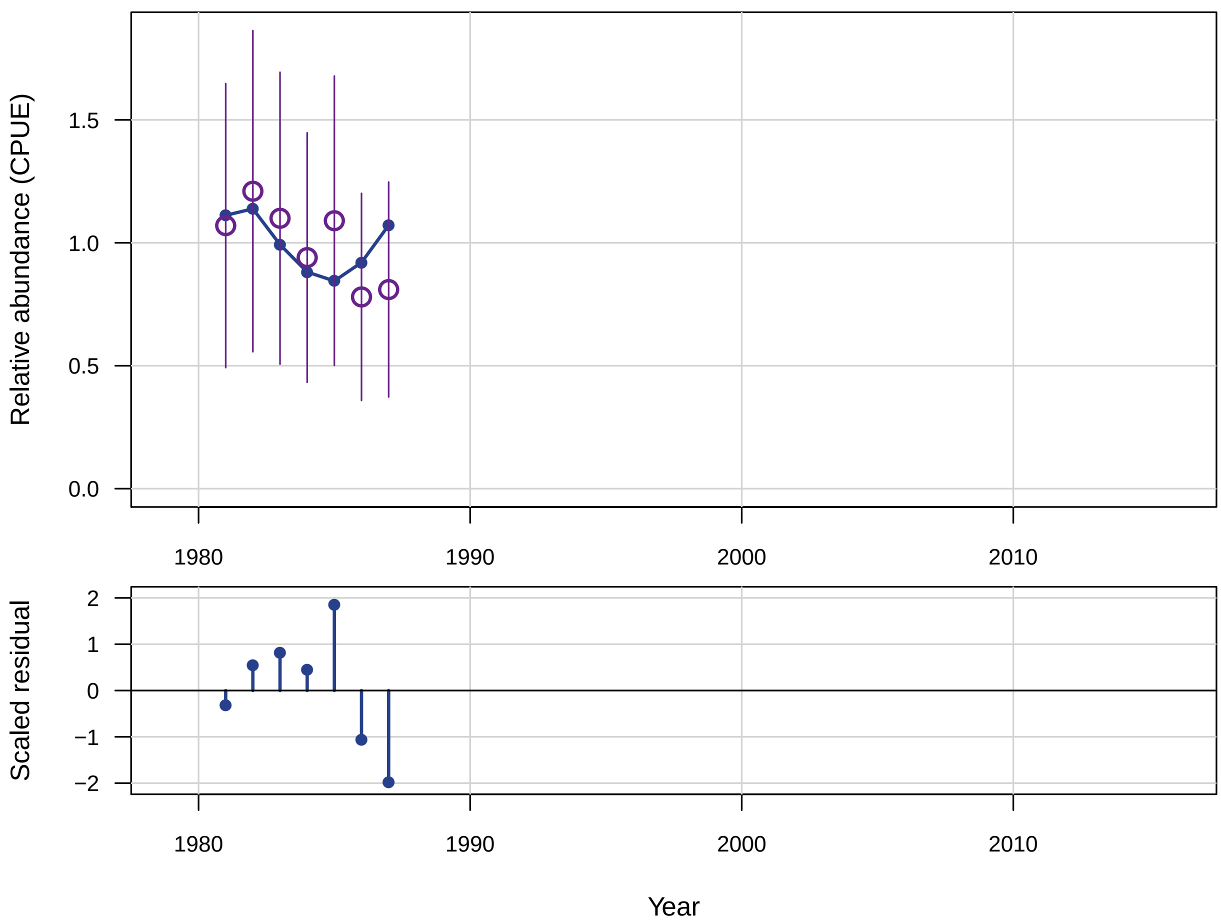


Figure 13. Observed (open circles) and estimated (line, solid circles) index of abundance from SERFS chevron trap index and SERFS Video index combined (CVID).

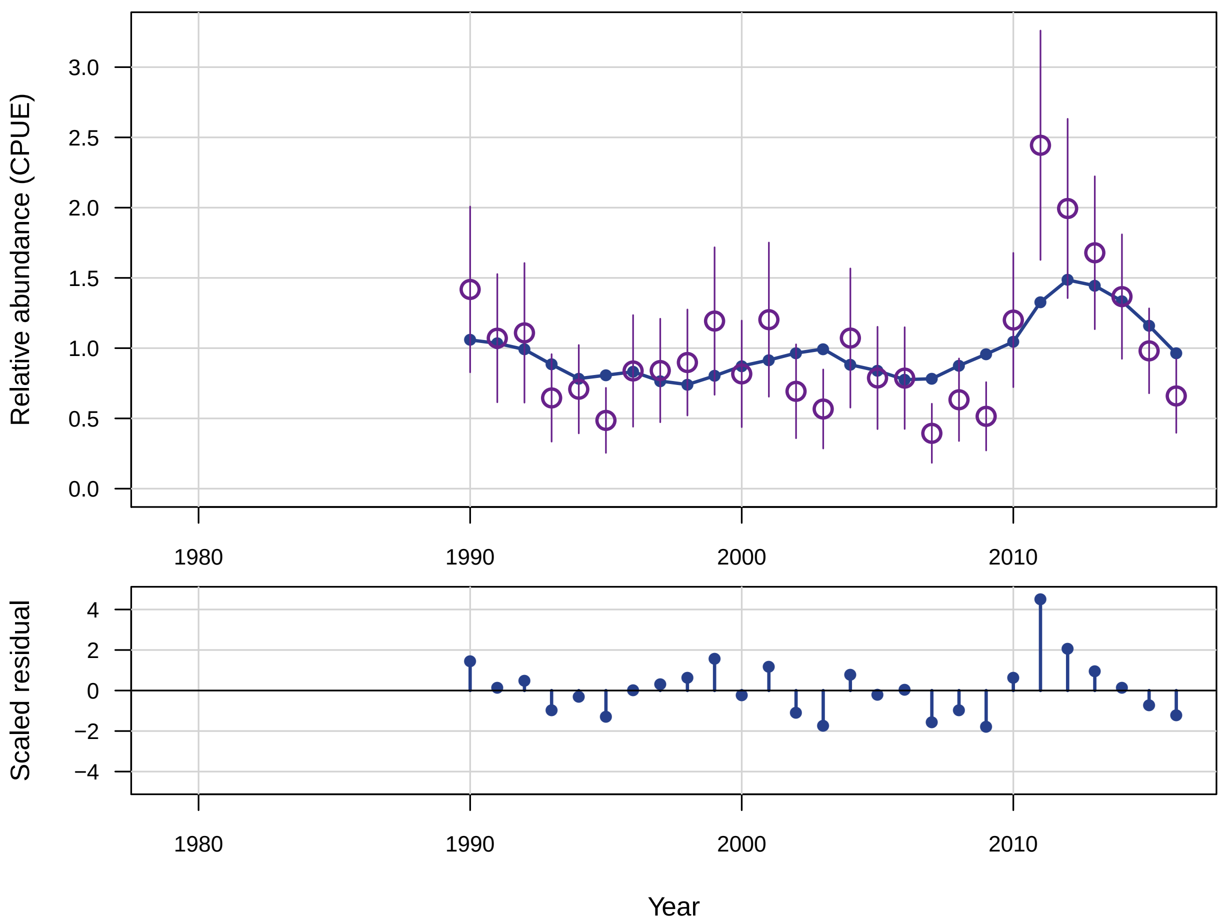


Figure 14. Observed (open circles) and estimated (line, solid circles) index of abundance from commercial lines.

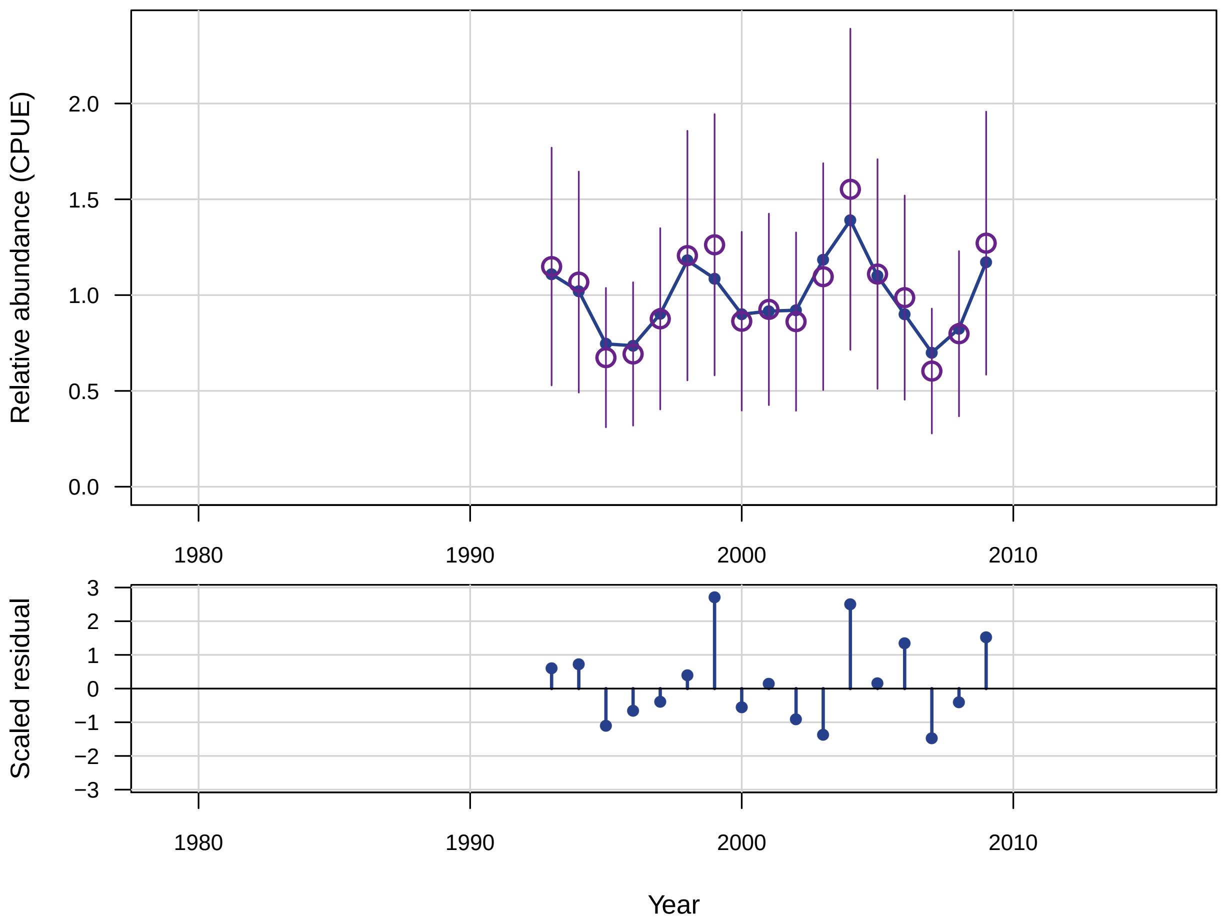


Figure 15. Observed (open circles) and estimated (line, solid circles) index of abundance from the headboat fleet.

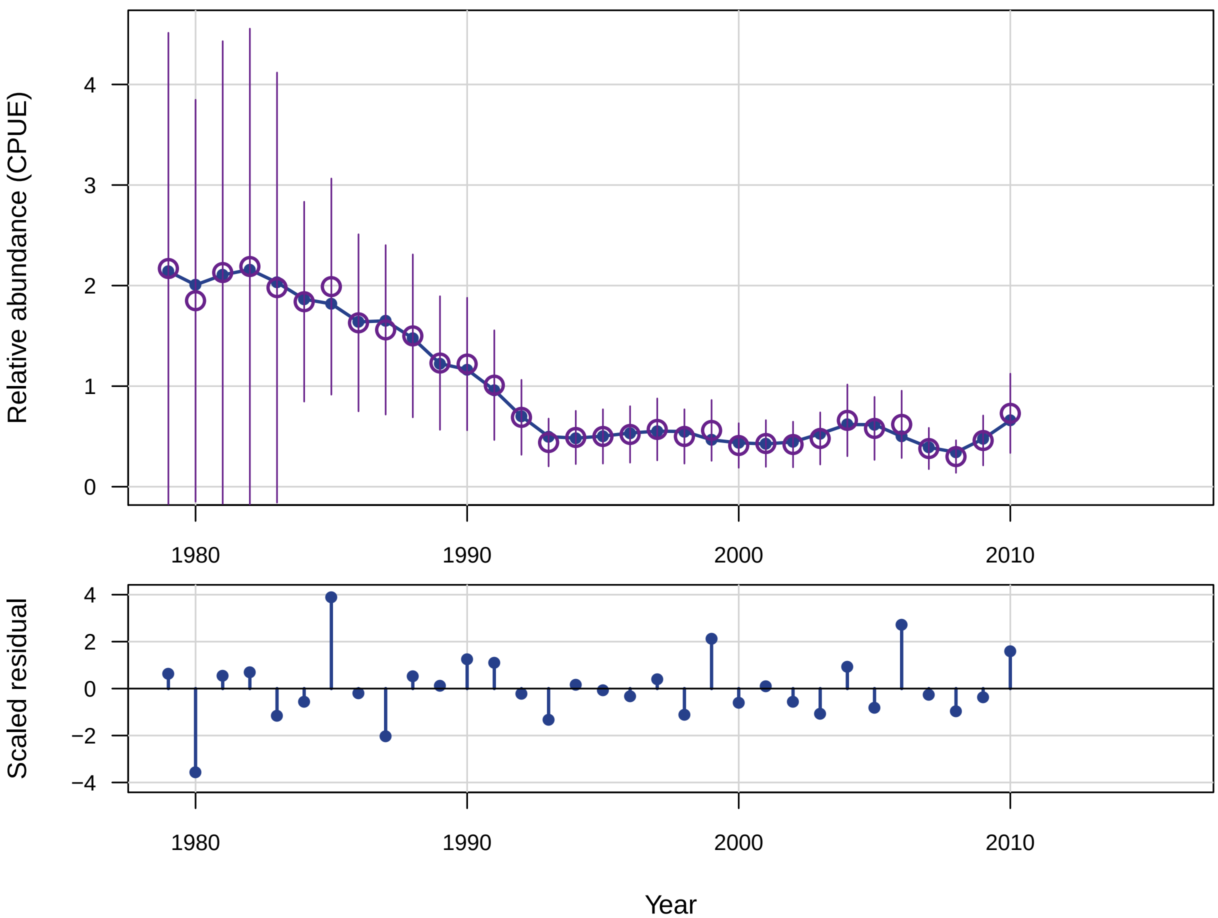


Figure 16. Estimated abundance at age at start of year.

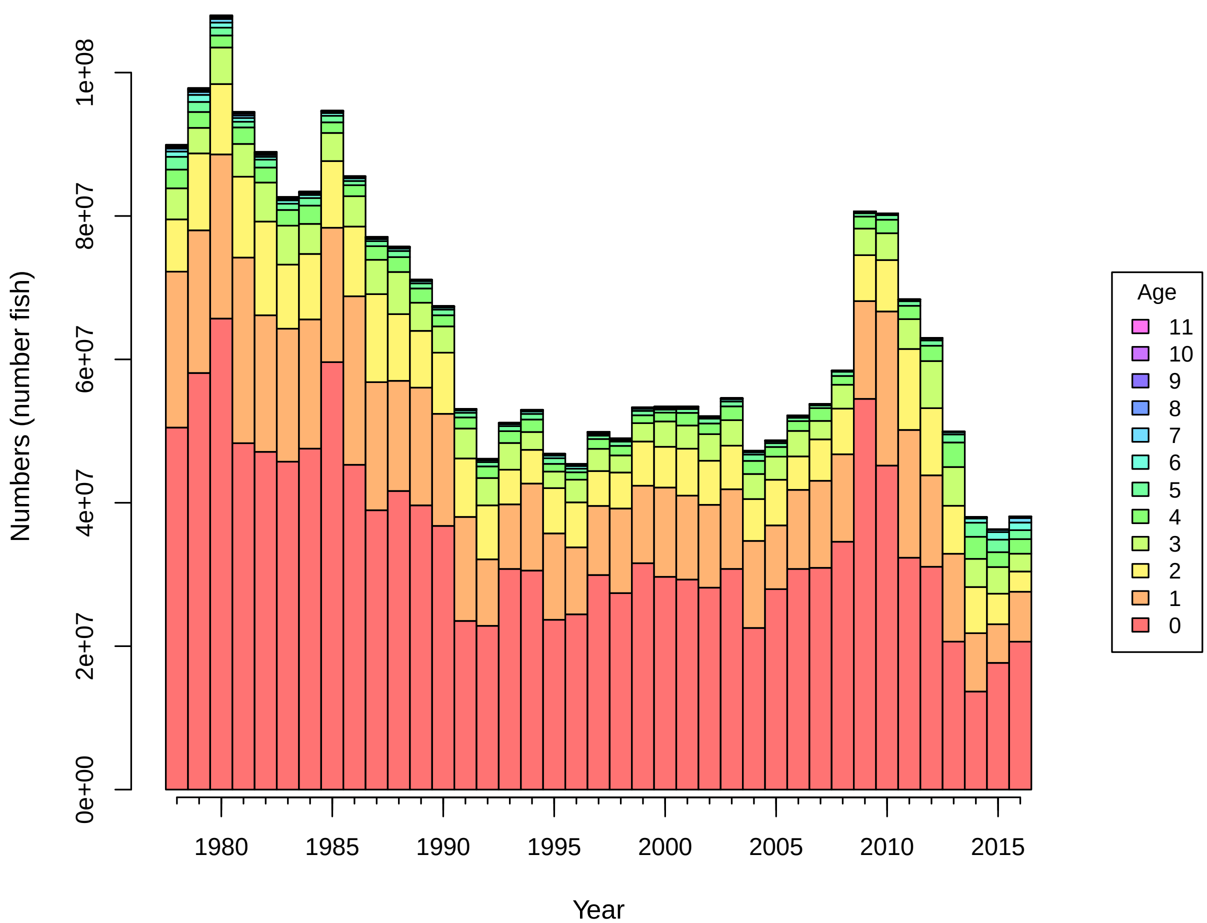


Figure 17. Top panel: Estimated recruitment of age-0 fish. Horizontal dashed line indicates R_{MSY}. Bottom panel: log recruitment residuals.

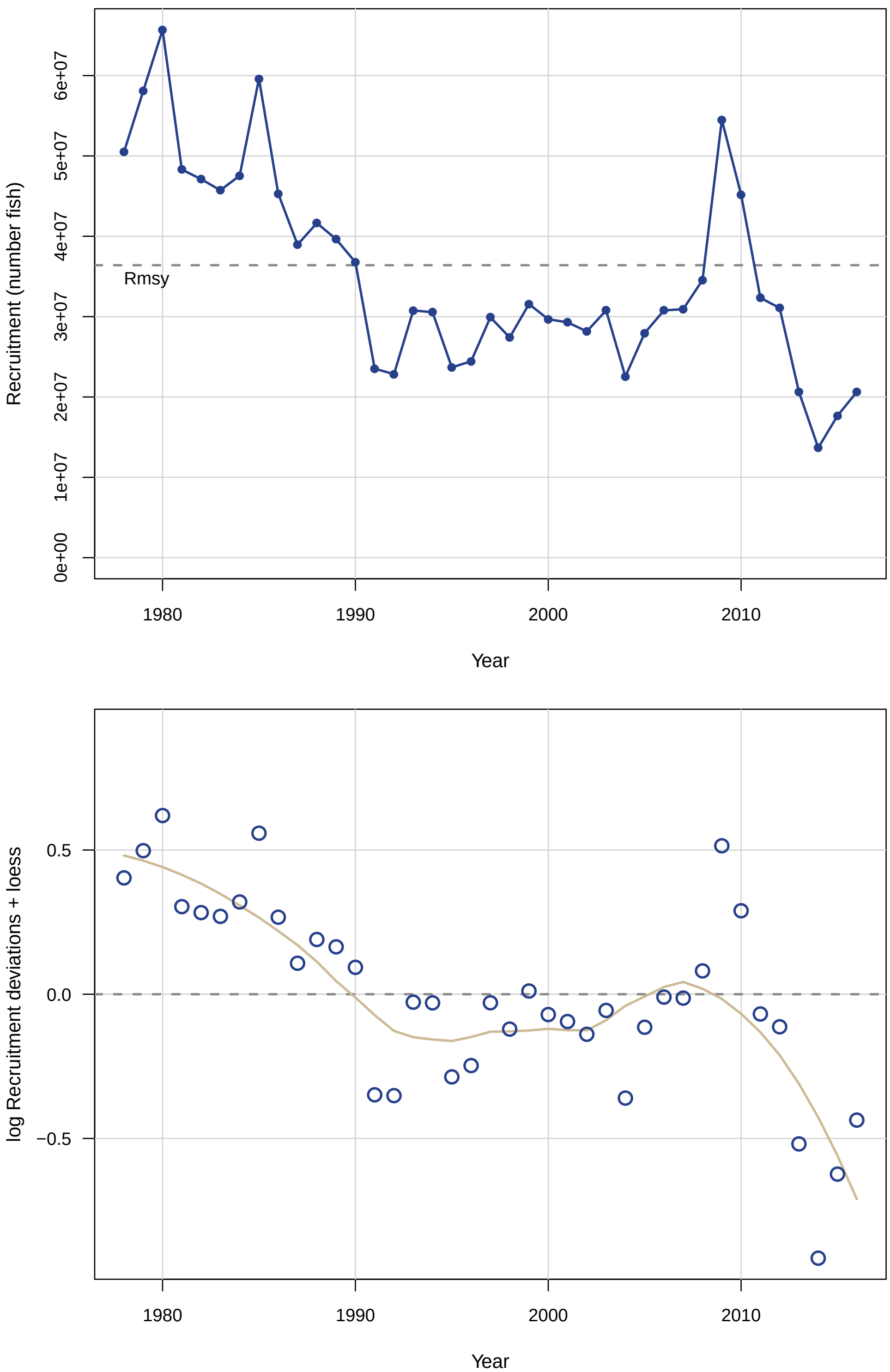


Figure 18. Estimated biomass at age at start of year.

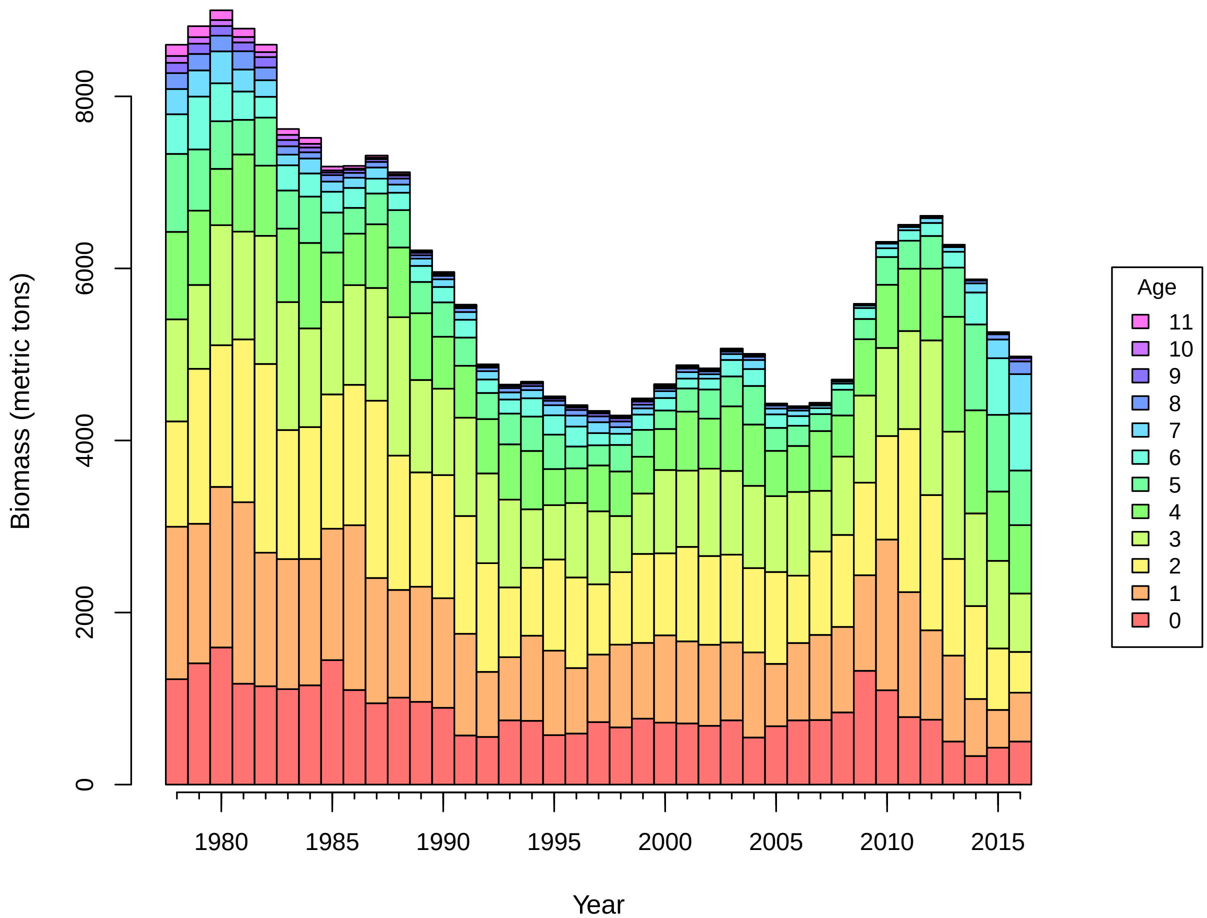


Figure 19. Top panel: Estimated total biomass (metric tons) at start of year. Horizontal dashed line indicates B_{MSY}. Bottom panel: Estimated spawning stock (population fecundity) at time of peak spawning.

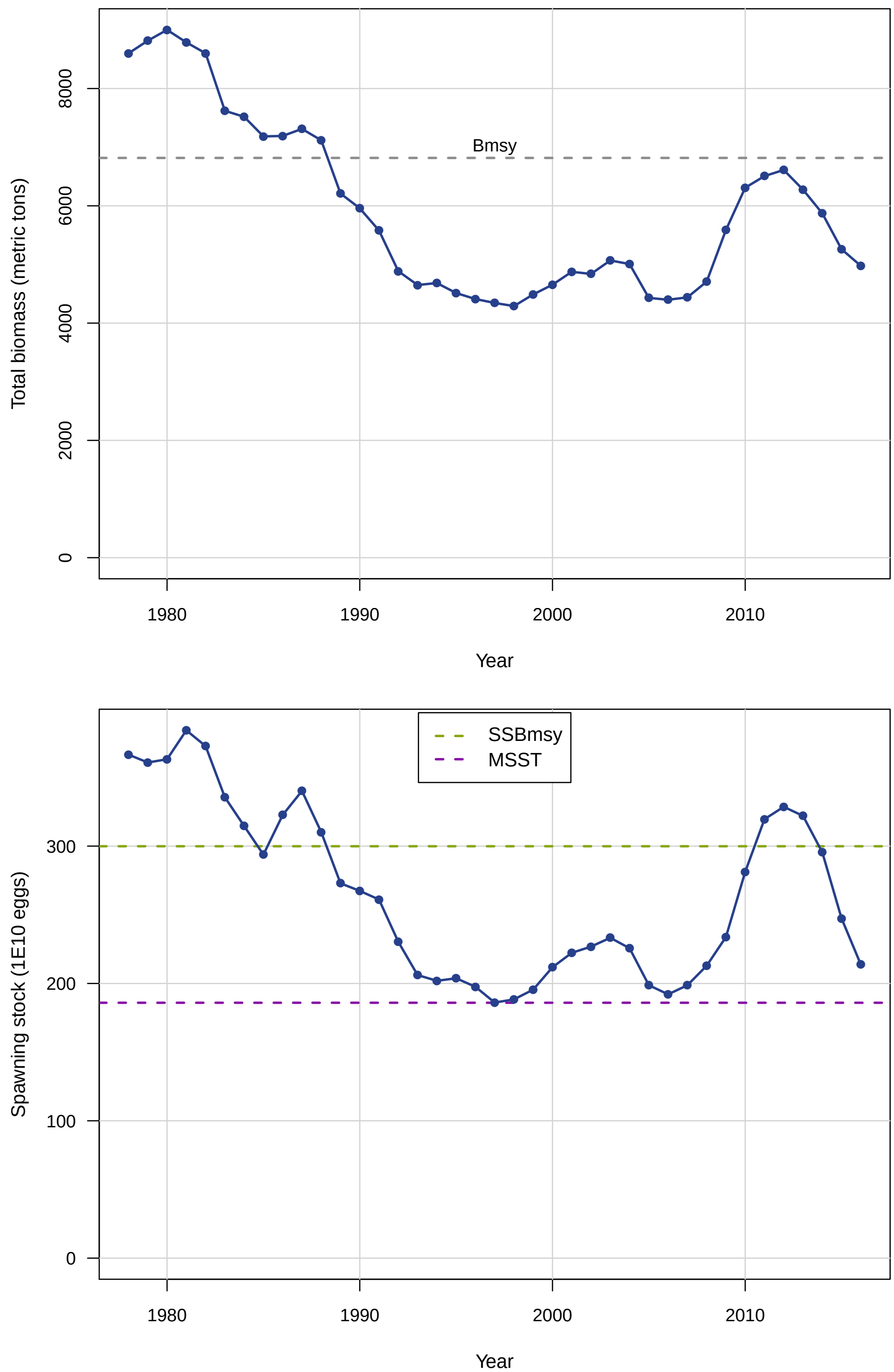


Figure 20. Selectivity (time-invariant) of SERFS chevron trap/video gear.

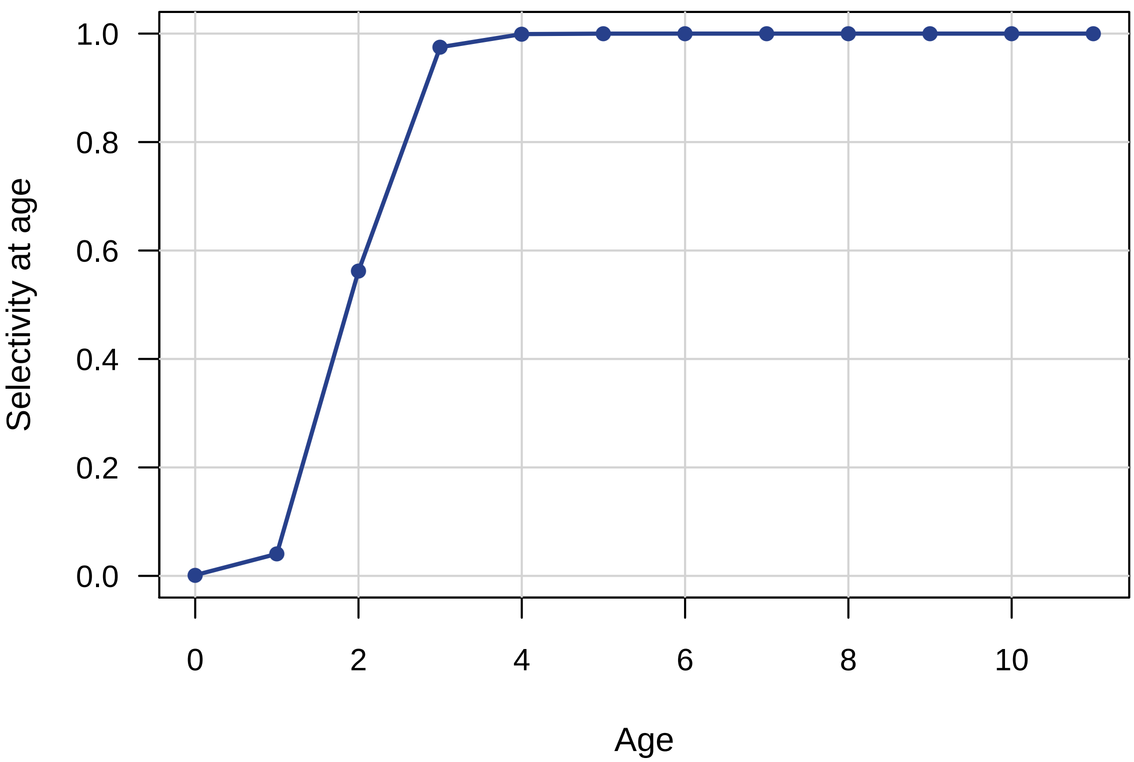


Figure 21. Selectivity (time-invariant) of MARMAP blackfish trap gear.

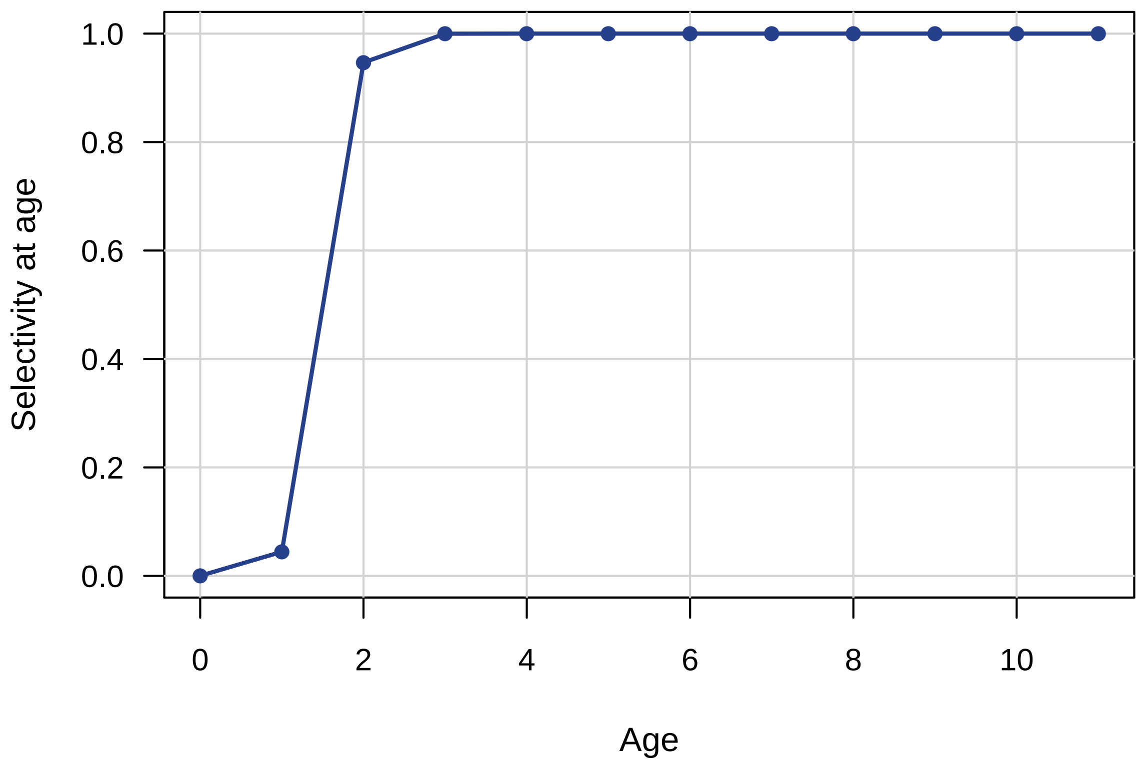
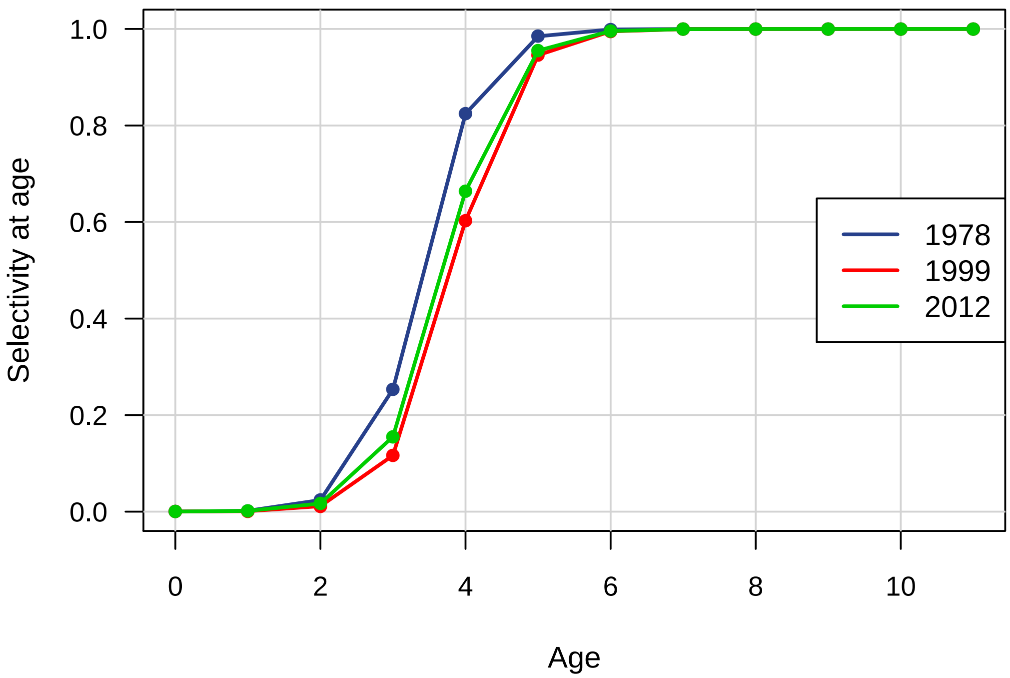


Figure 22. Estimated selectivities of commercial fleets. Commercial trawl fleet selectivity mirrors the pot fleet. Years indicated on panels signify the first year of a time block. Top panel: commercial lines. Bottom panel: commercial pots.



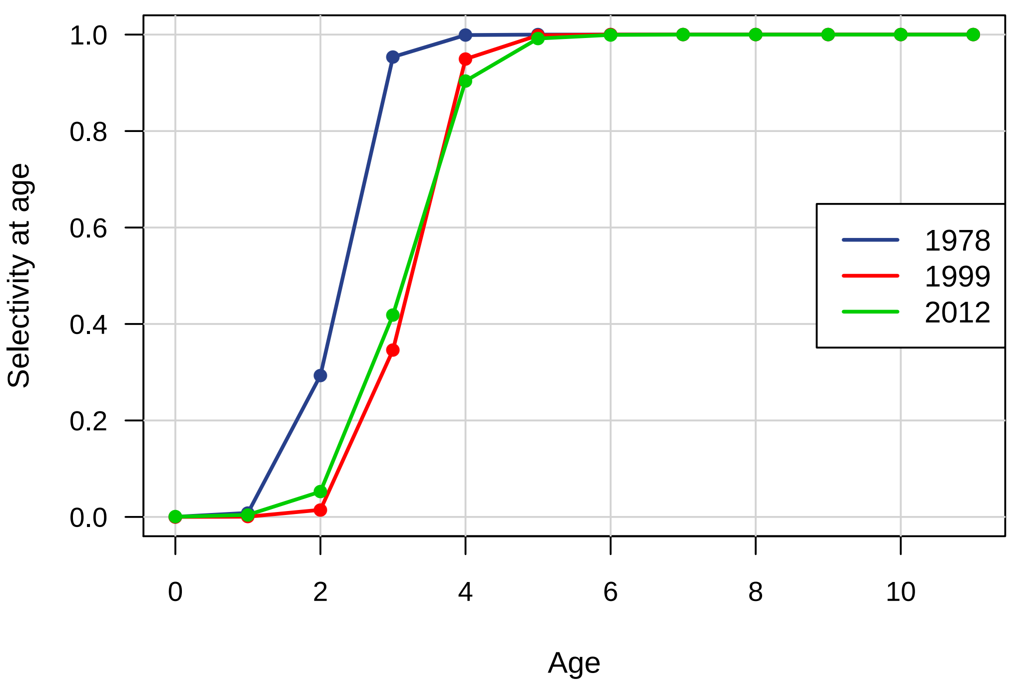


Figure 23. Estimated selectivities of headboat and general recreational fleets. Years indicated on panels signify the first year of a time block. Top panel: headboat. Bottom panel: general recreational.

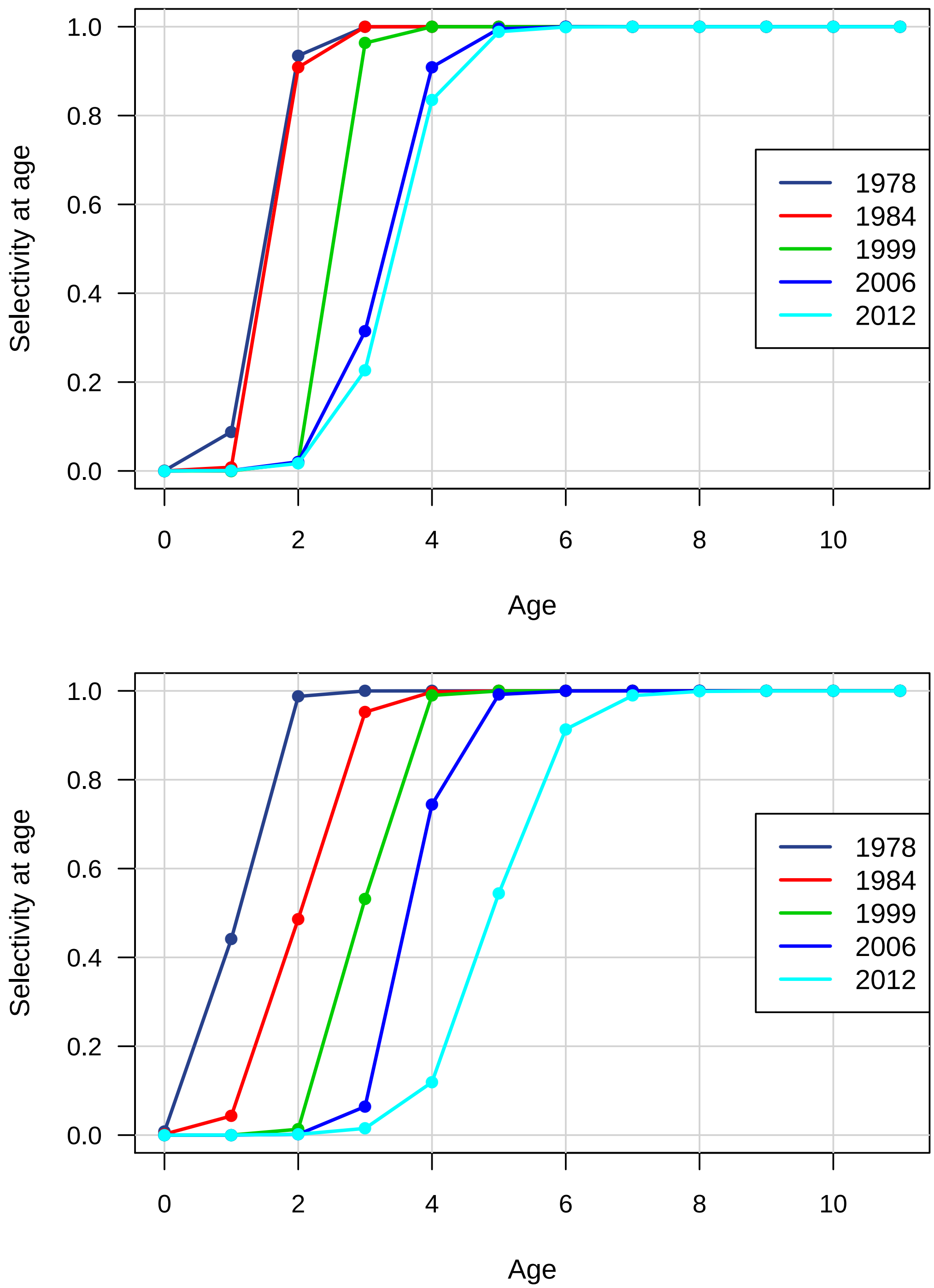
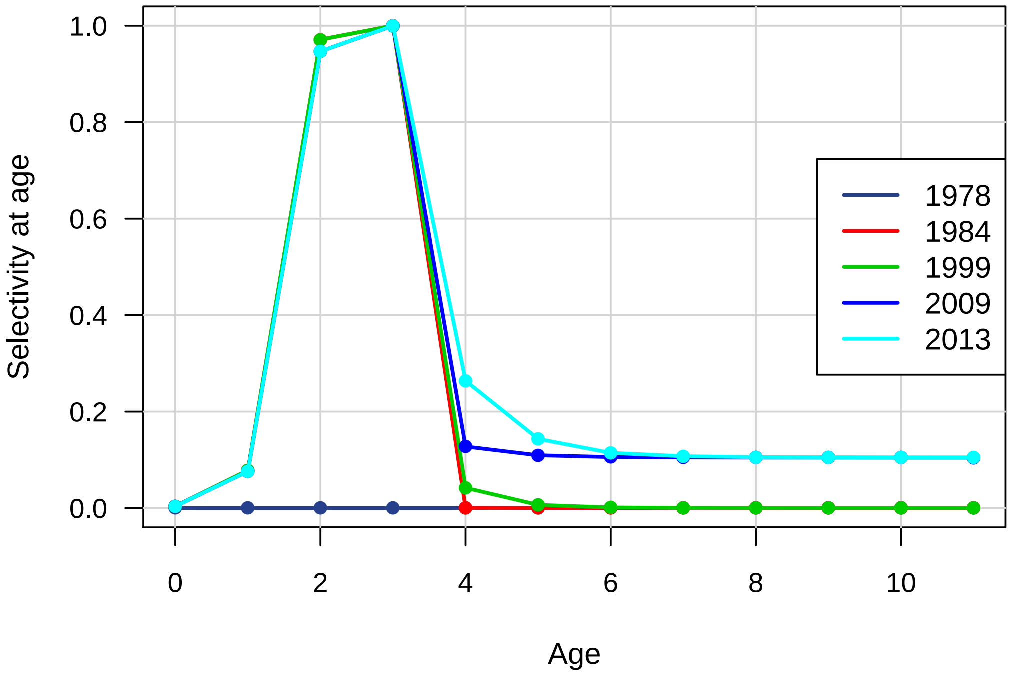


Figure 24. Estimated selectivity of discard mortalities from commercial lines (top panel) and headboat (bottom panel). The General recreational fleet mirrors the headboat fleet. Years indicated on panels signify the first year of a time block.



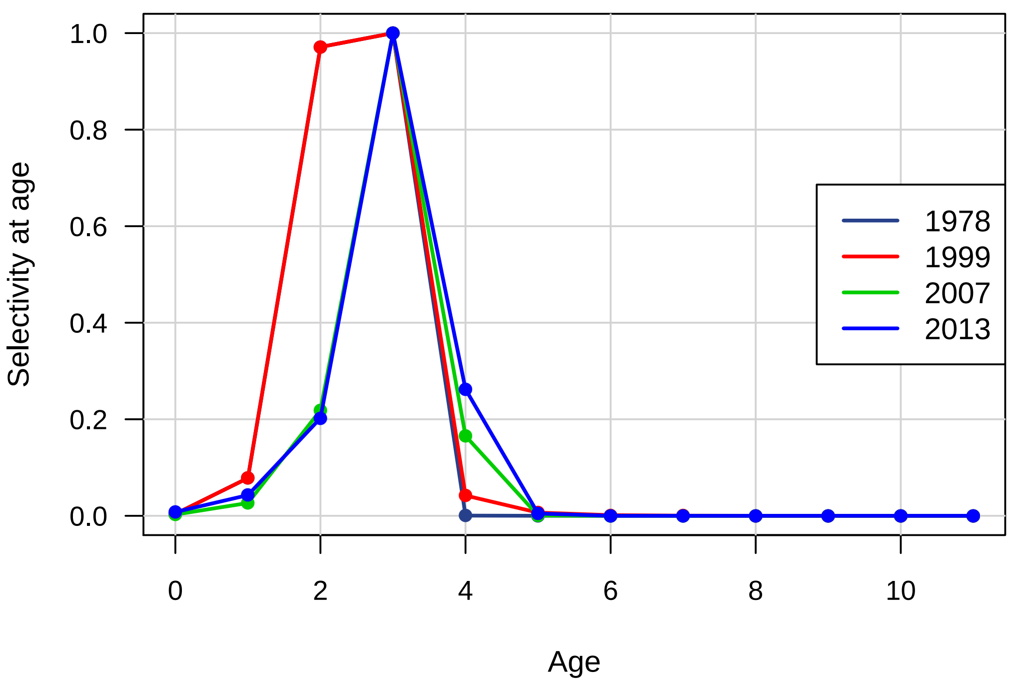


Figure 25. Average selectivities from the terminal assessment years, weighted by geometric mean Fs from the last three assessment years, and used in computation of benchmarks and projections. Top panel: average selectivity applied to landings. Middle panel: average selectivity applied to discard mortalities. Bottom panel: total average selectivity.

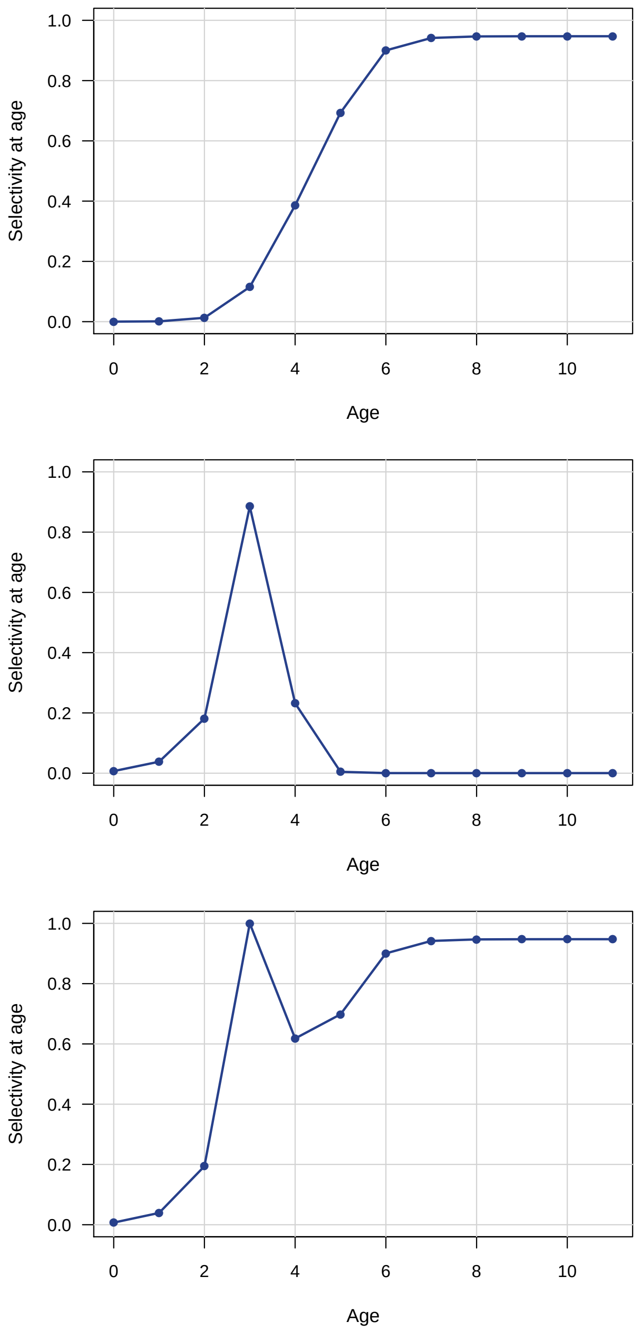


Figure 26. Estimated fully selected fishing mortality rate (per year) by fishery. cl refers to commercial lines, cp to commercial pots, ct to commercial trawl, hb to headboat, mrip to general recreational, comm.D to commercial discard mortalities, hb.D to headboat discard mortalities, and mrip.D to general recreational discard mortalities.

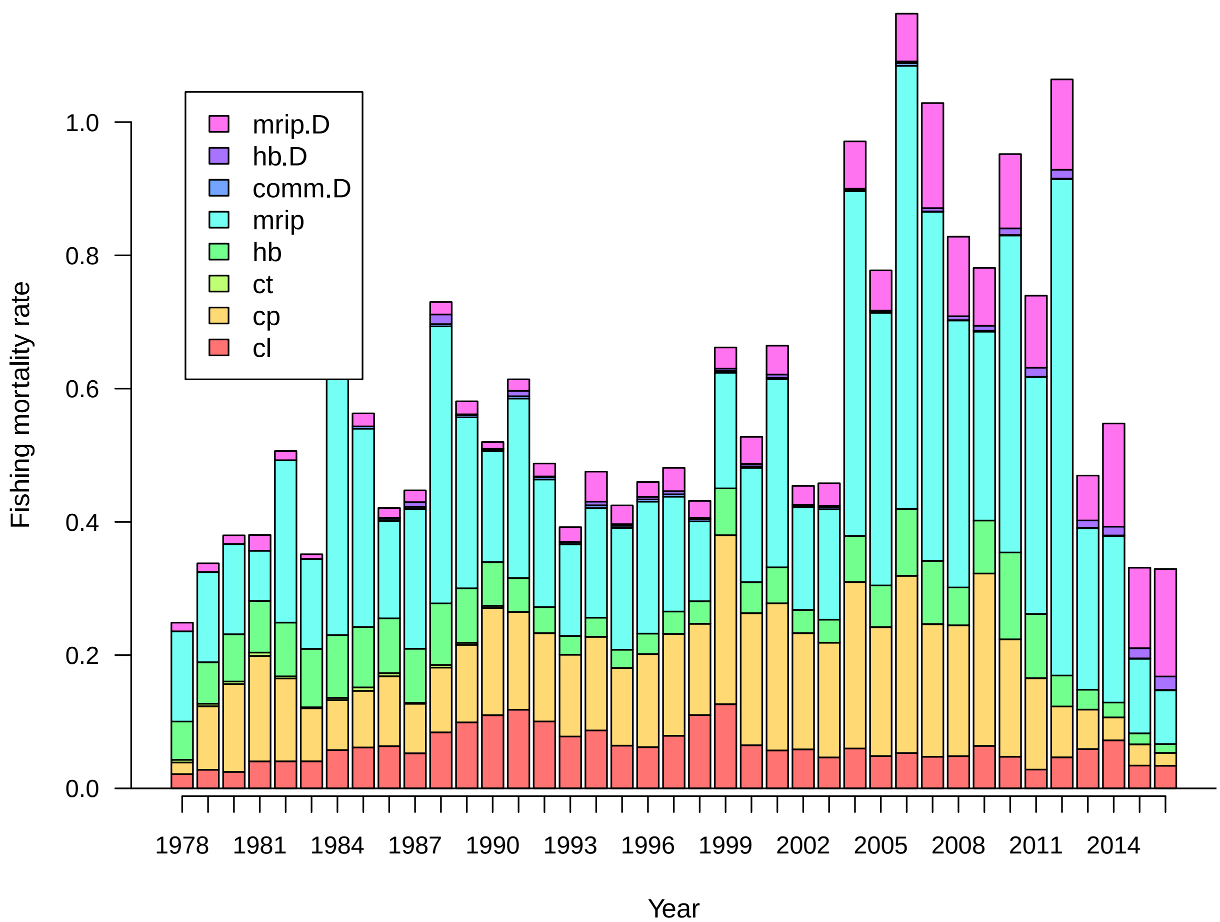


Figure 27. Estimated landings in numbers by fishery from the catch-age model. cl refers to commercial lines, cp to commercial pots, ct to commercial trawl, hb to headboat, mrip to general recreational.

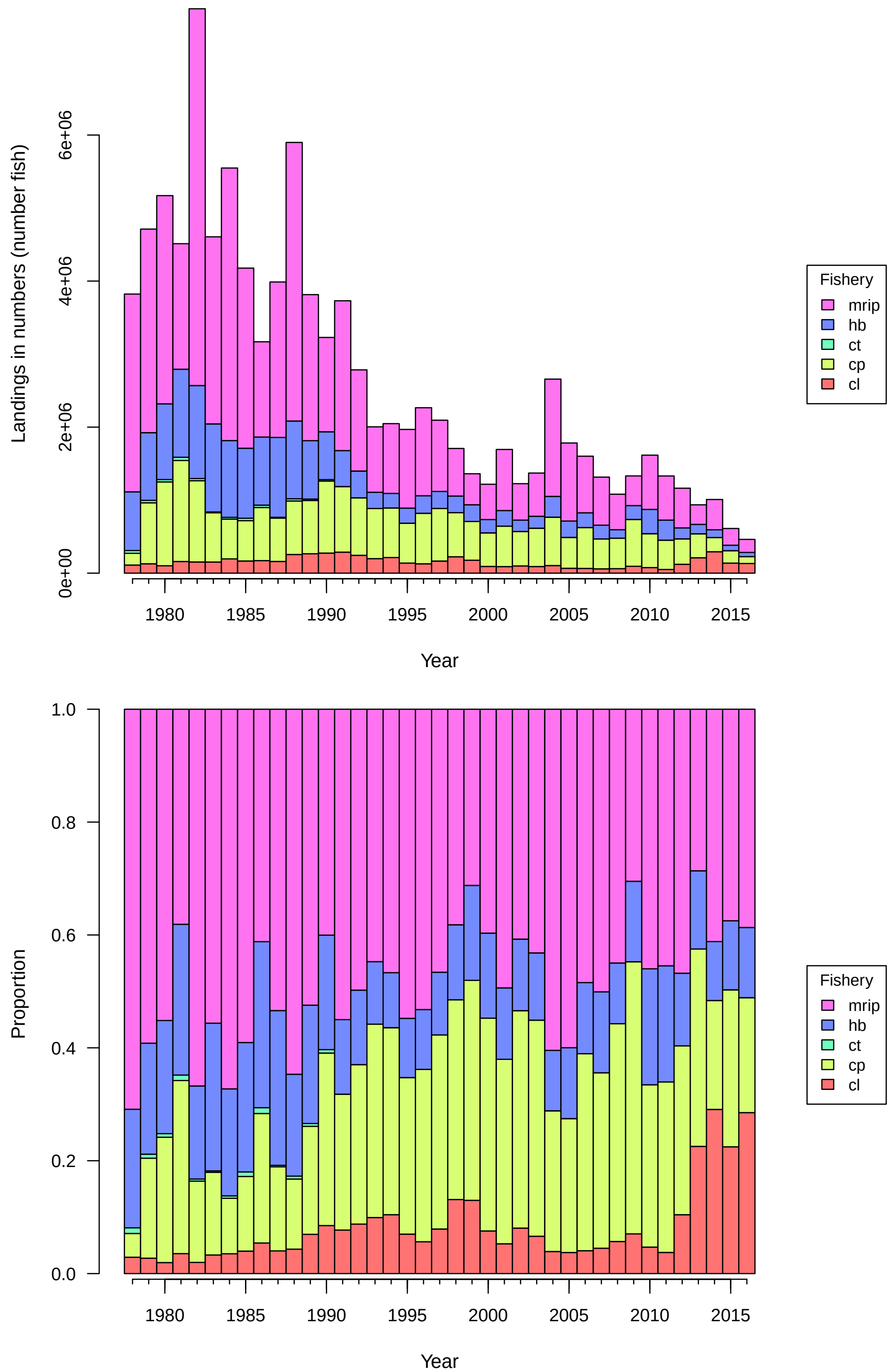


Figure 28. Estimated landings in whole weight by fishery from the catch-age model. cl refers to commercial lines, cp to commercial pots, ct to commercial trawl, hb to headboat, mrip to general recreational. Horizontal dashed line in the top panel corresponds to the point estimate of MSY.

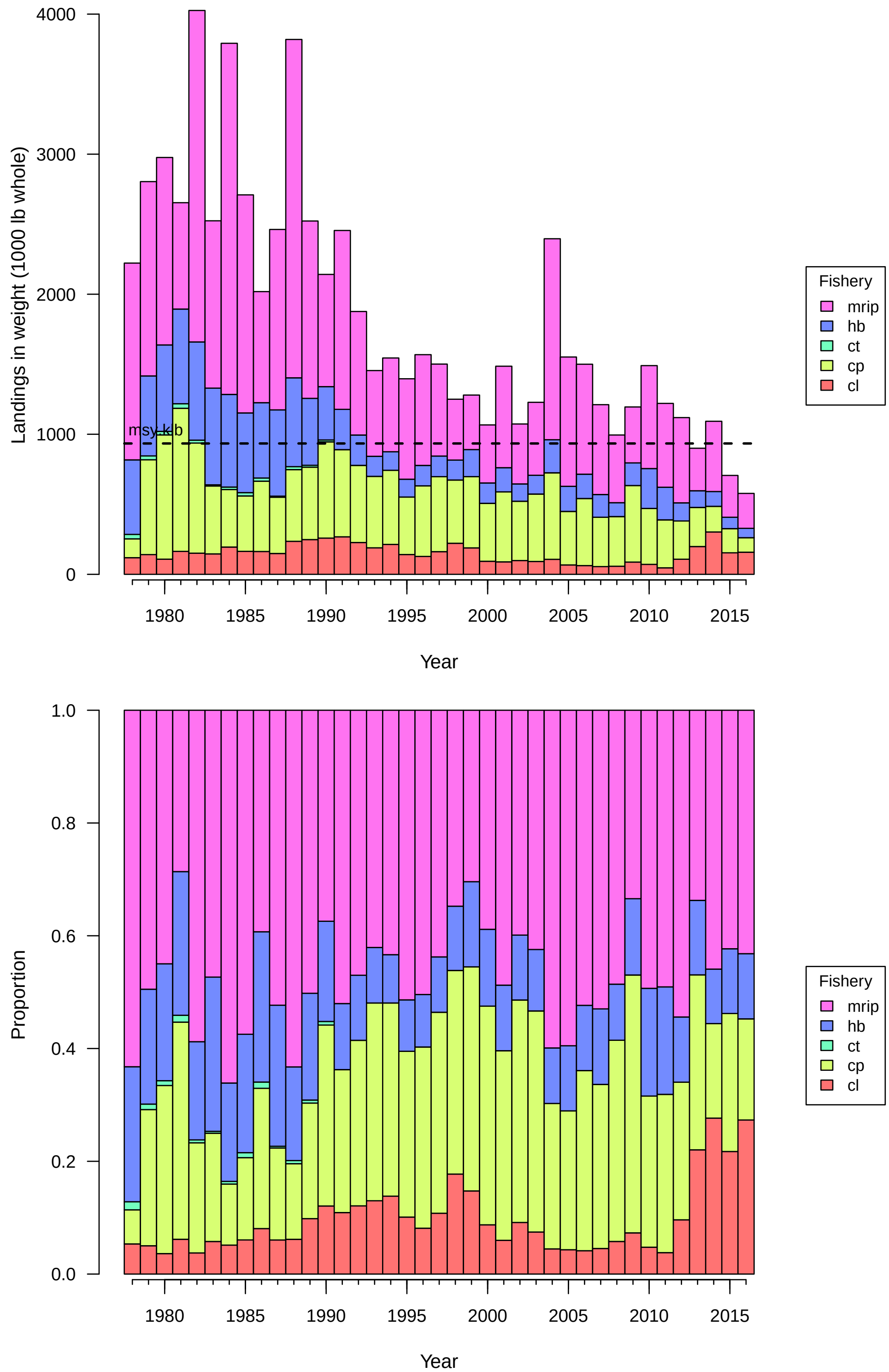


Figure 29. Estimated discard mortalities by fishery from the catch-age model. comm refers to commercial (lines and pots combined), hb to headboat, mrip to general recreational. Discards from hb were included with mrip prior to 1986.

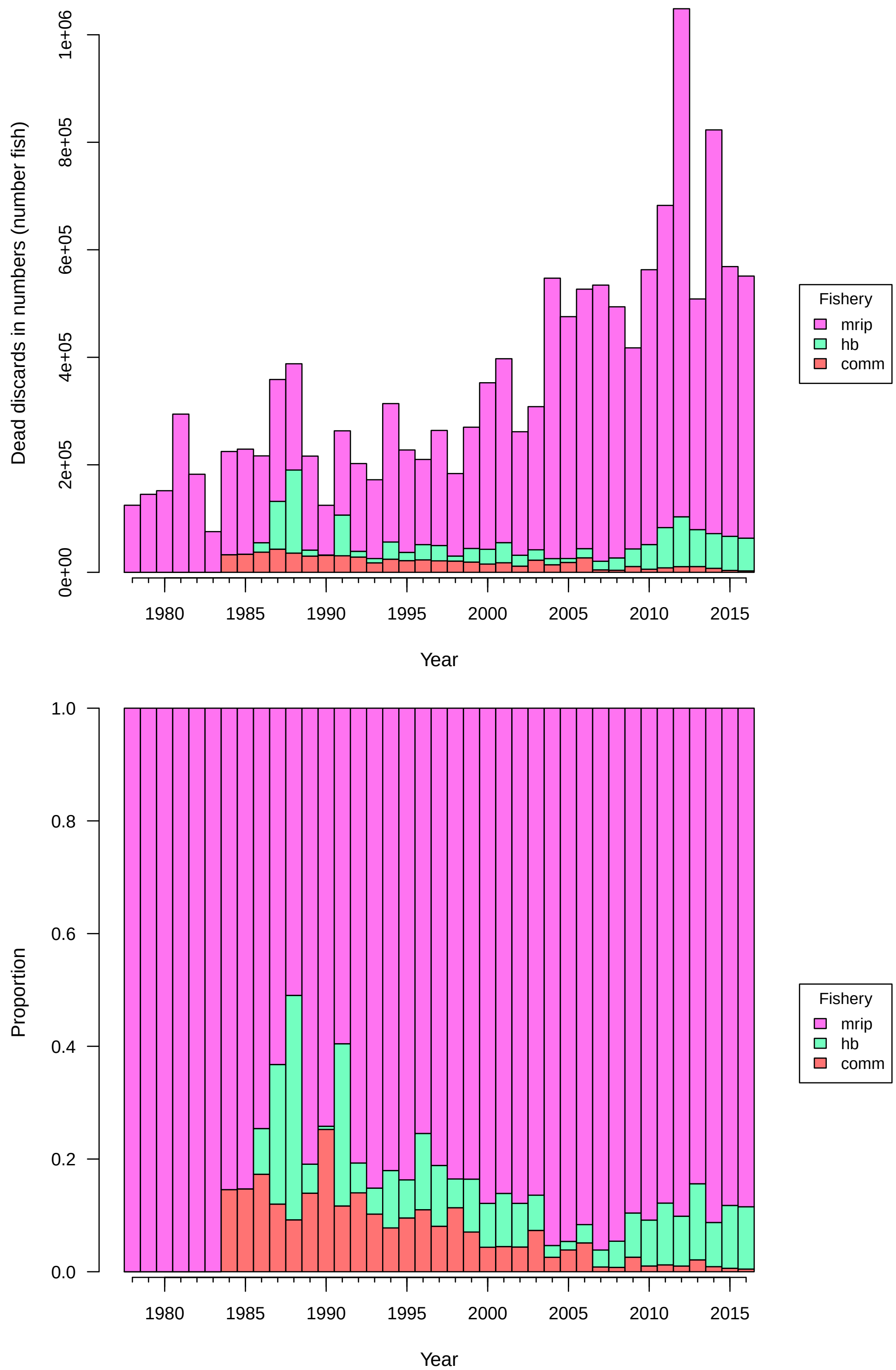


Figure 30. Top panel: Beverton–Holt spawner-recruit curves, with and without lognormal bias correction. The expected (upper) curve was used for computing management benchmarks. Years within panel indicate year of recruitment generated from spawning biomass. Bottom panel: log of recruits (number age-0 fish) per spawner as a function of spawners.

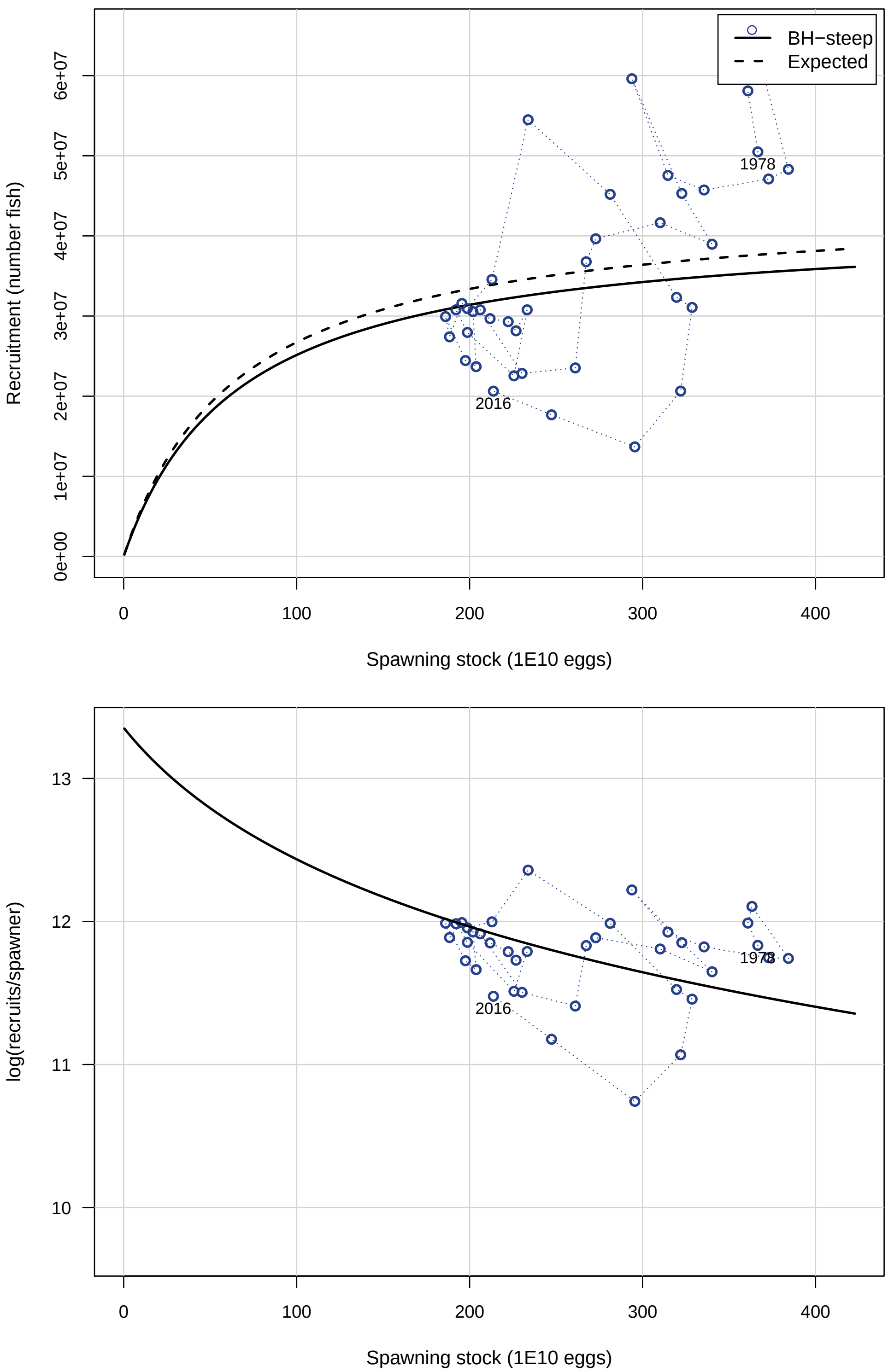


Figure 31. Probability densities of spawner-recruit quantities R0 (unfished recruitment of age-0 fish), steepness, and unfished spawners per recruit. Vertical lines represent point estimates or values from the base run of the Beaufort Assessment Model.

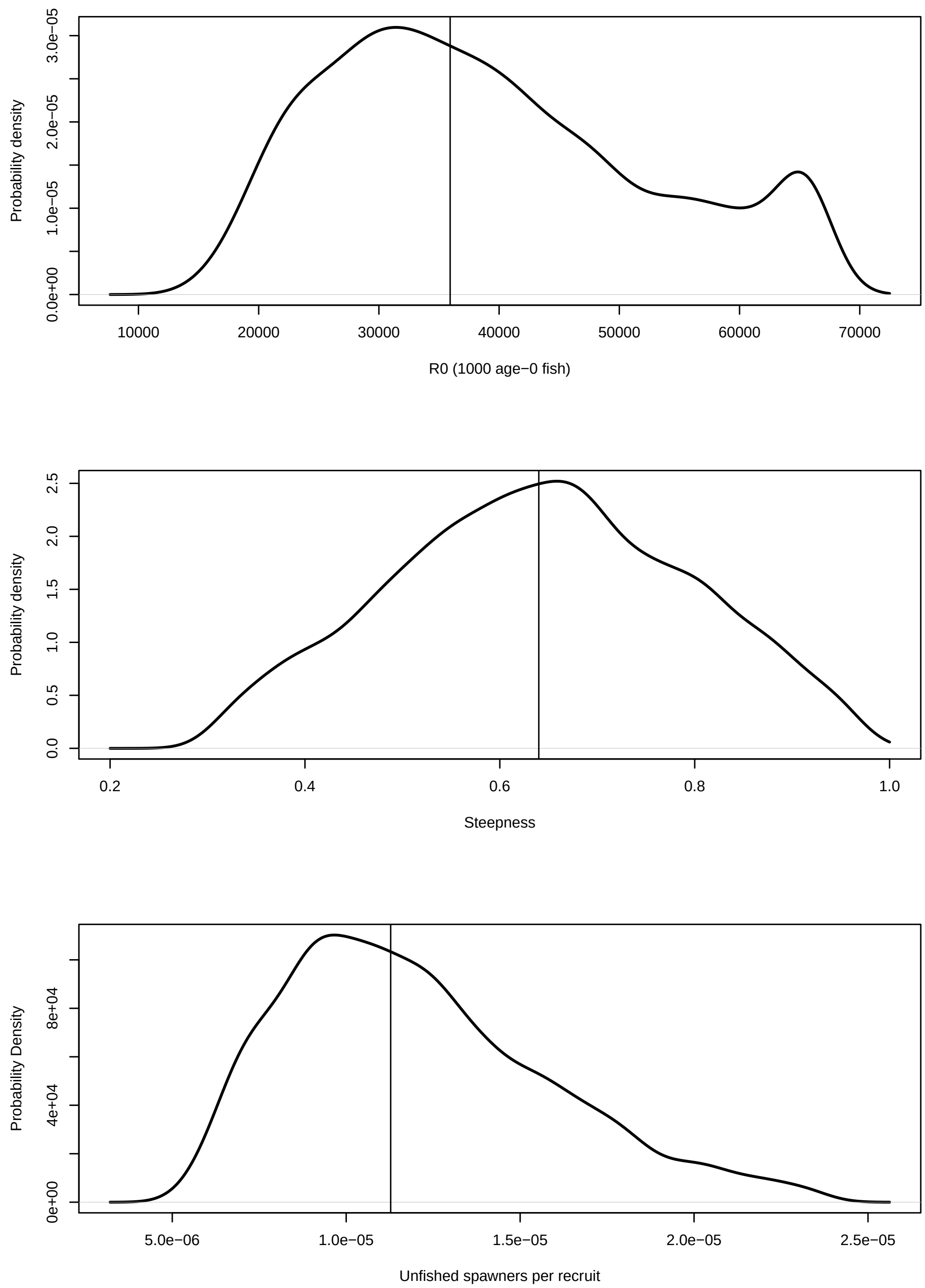


Figure 32. Top panel: yield per recruit. Bottom panel: spawning potential ratio (spawning biomass per recruit relative to that at the unfished level), from which the X% level of SPR provides $F_{X\%}$. Both curves are based on average selectivity from the end of the assessment period.

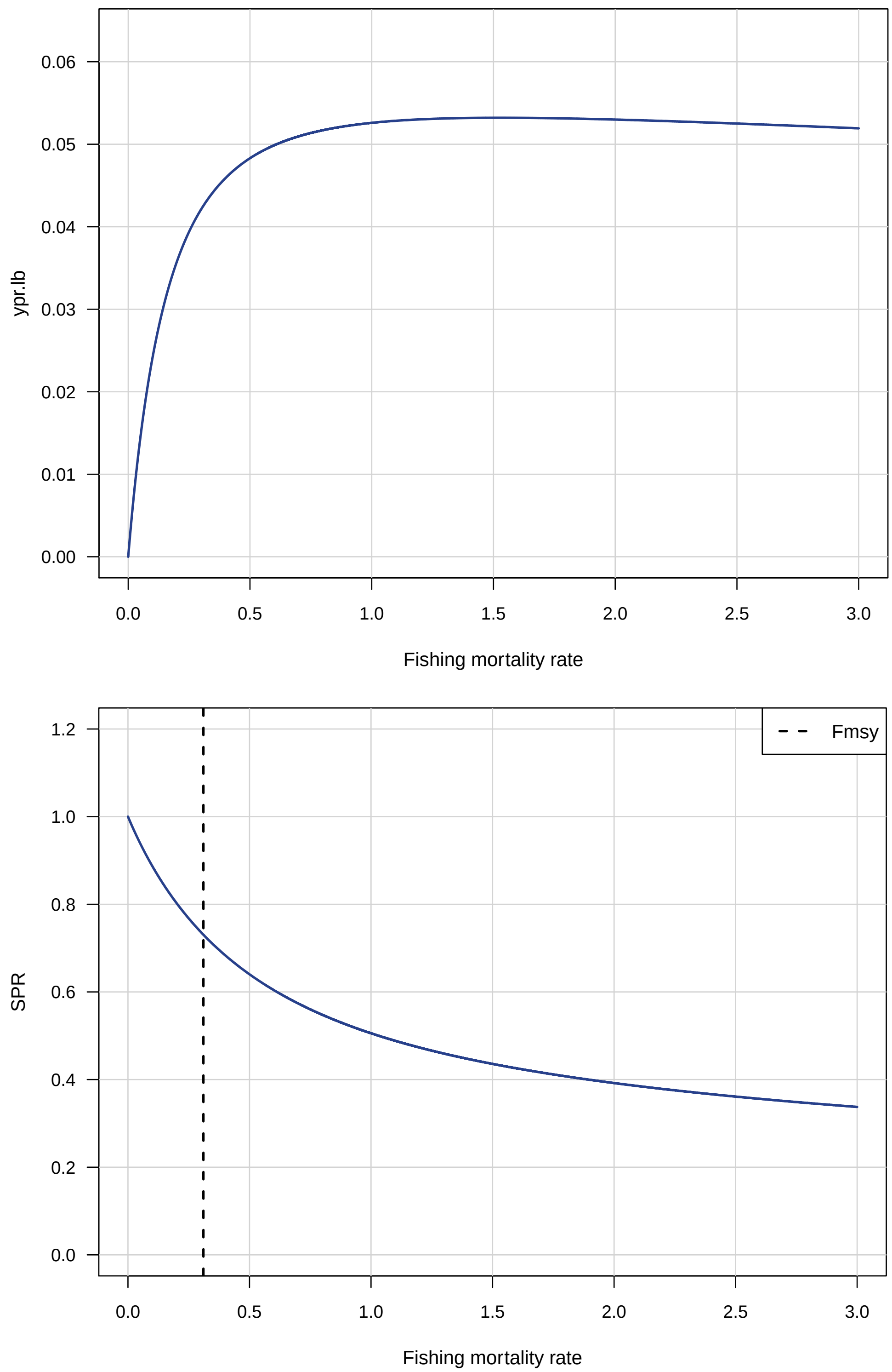


Figure 33. Top panel: equilibrium landings. The peak occurs where fishing rate is $F_{\mathrm{MSY}} = 0.31$ *and equilibrium landings are* MSY = 935 *(1000 lb). Bottom panel: equilibrium spawning biomass. Both curves are based on average selectivity from the end of the assessment period.*

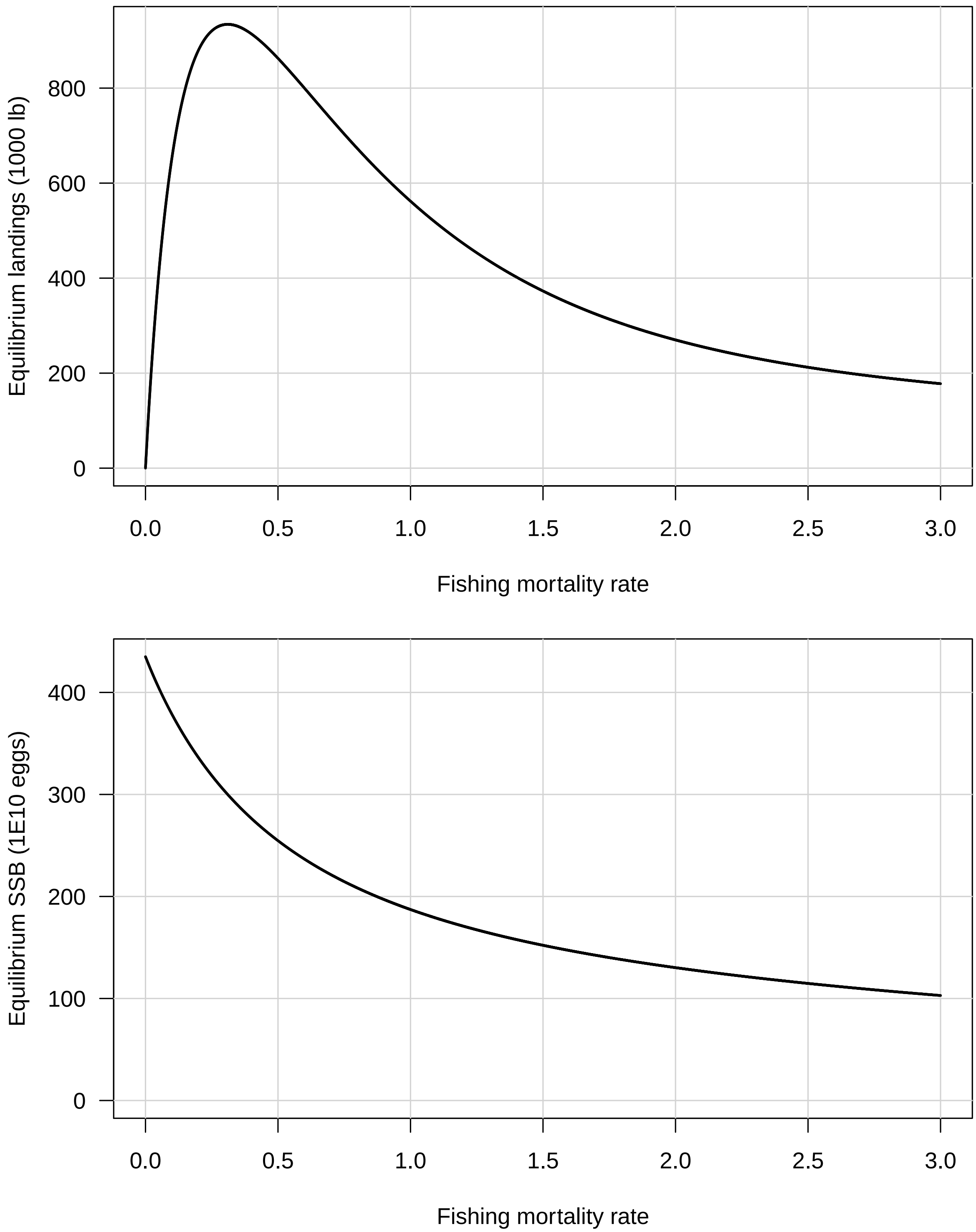


Figure 34. Top panel: equilibrium landings as a function of equilibrium biomass, which itself is a function of fishing mortality rate. The peak occurs where equilibrium biomass is $B_{\mathrm{MSY}} = 6824$ *mt and equilibrium landings are* $\mathrm{MSY} = 935$ *(1000 lb). Bottom panel: equilibrium discard mortality as a function of equilibrium biomass.*

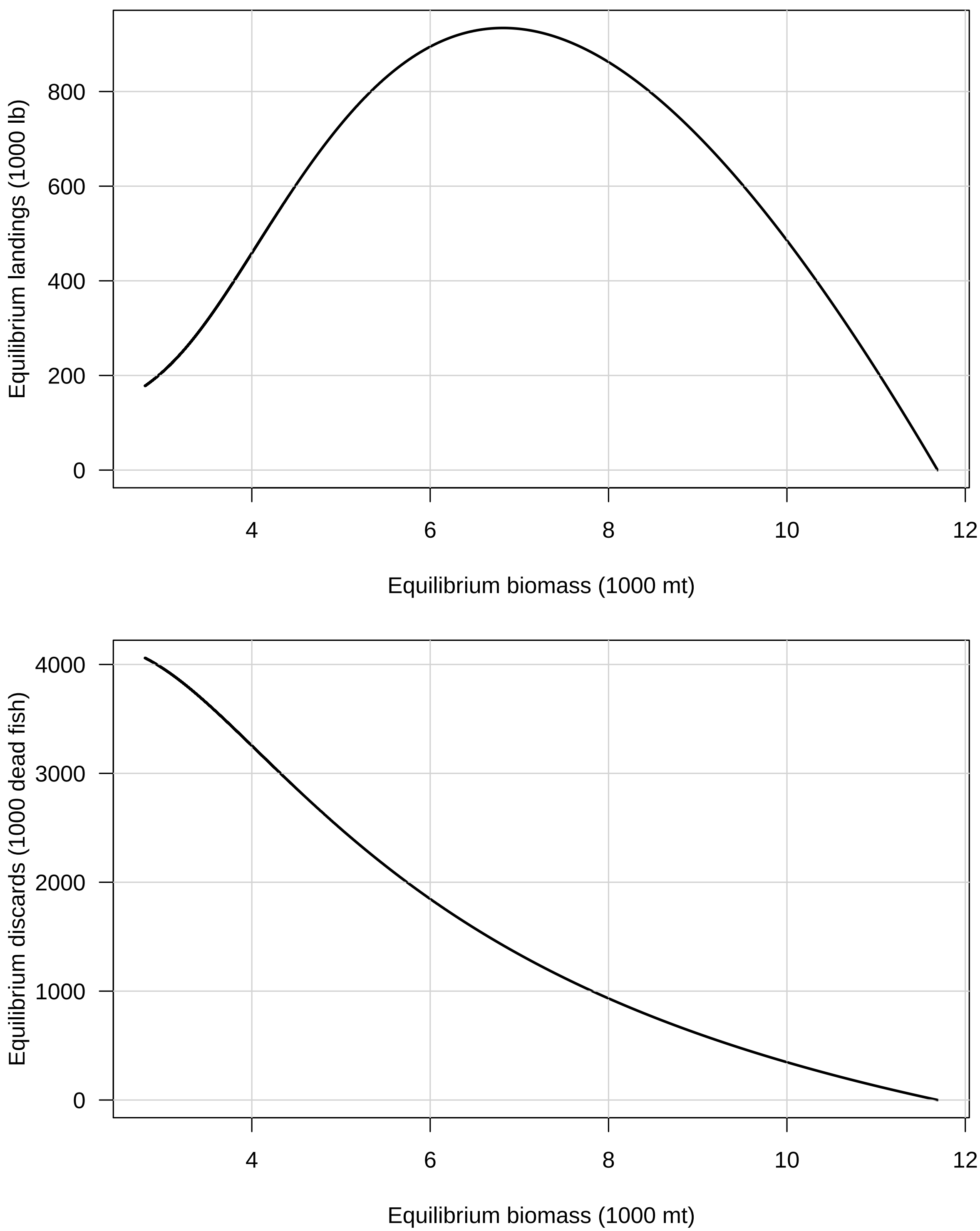


Figure 35. Probability densities of MSY*-related benchmarks from MCB analysis of the Beaufort Assessment Model. Vertical lines represent point estimates from the base run.*

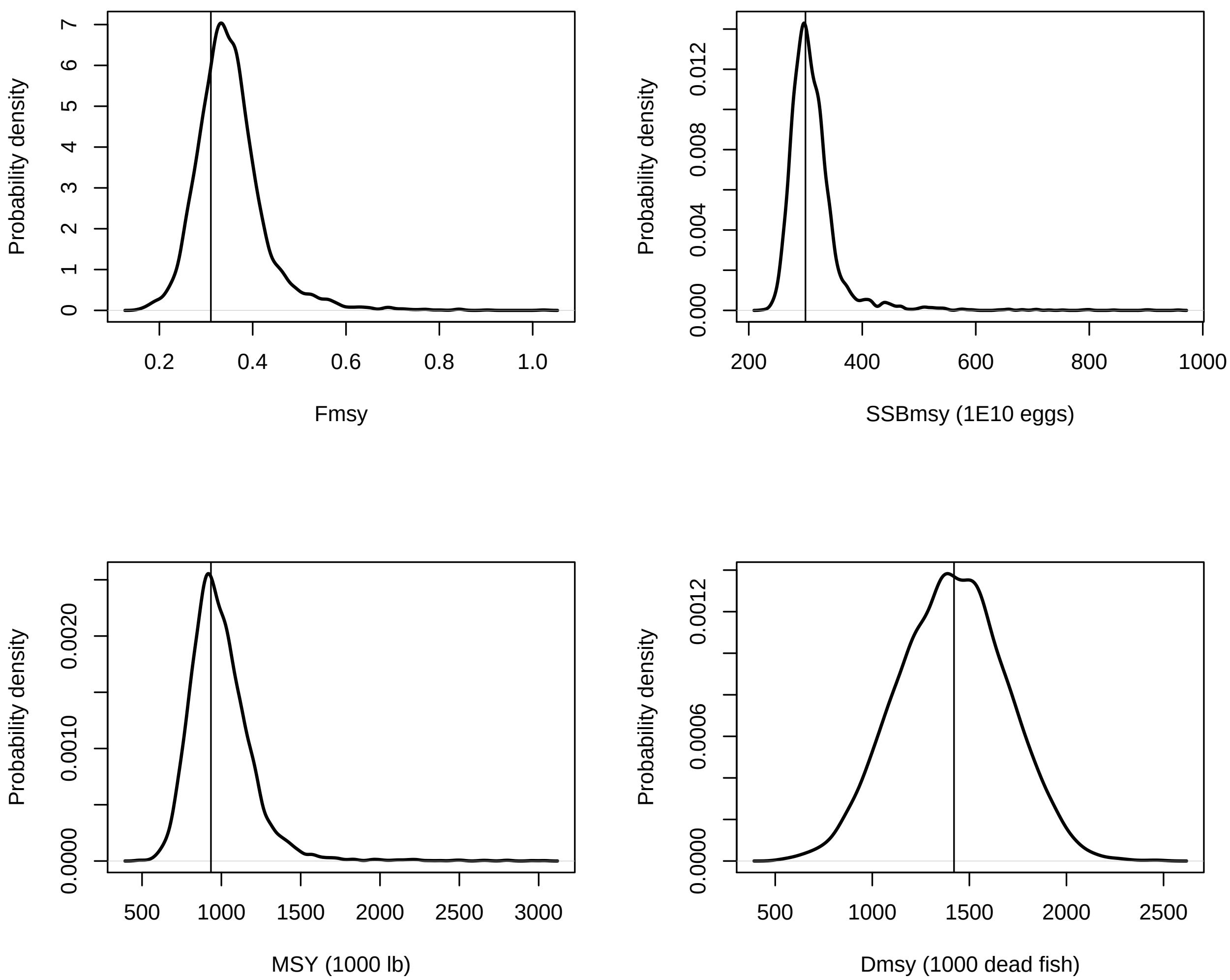


*Figure 36. Estimated time series relative to benchmarks. Solid line indicates estimates from base run of the Beaufort Assessment Model; gray error bands indicate 5^{th} and 95^{th} percentiles of the MCB trials. Top panel: spawning biomass relative to the minimum stock size threshold (*MSST*). Middle panel: spawning biomass relative to* $\mathrm{SSB}_{\mathrm{MSY}}$*. Bottom panel: F relative to* F_{MSY}.

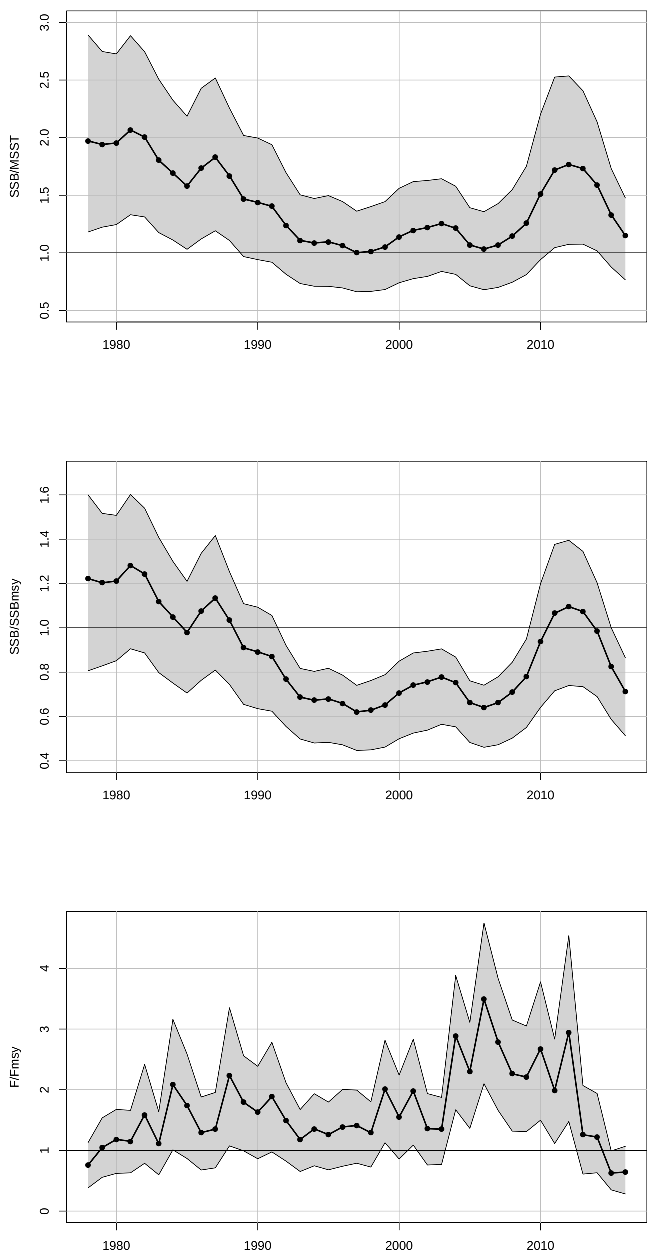


Figure 37. Probability densities of terminal status estimates from MCB analysis of the Beaufort Assessment Model. Vertical lines represent point estimates from the base run.

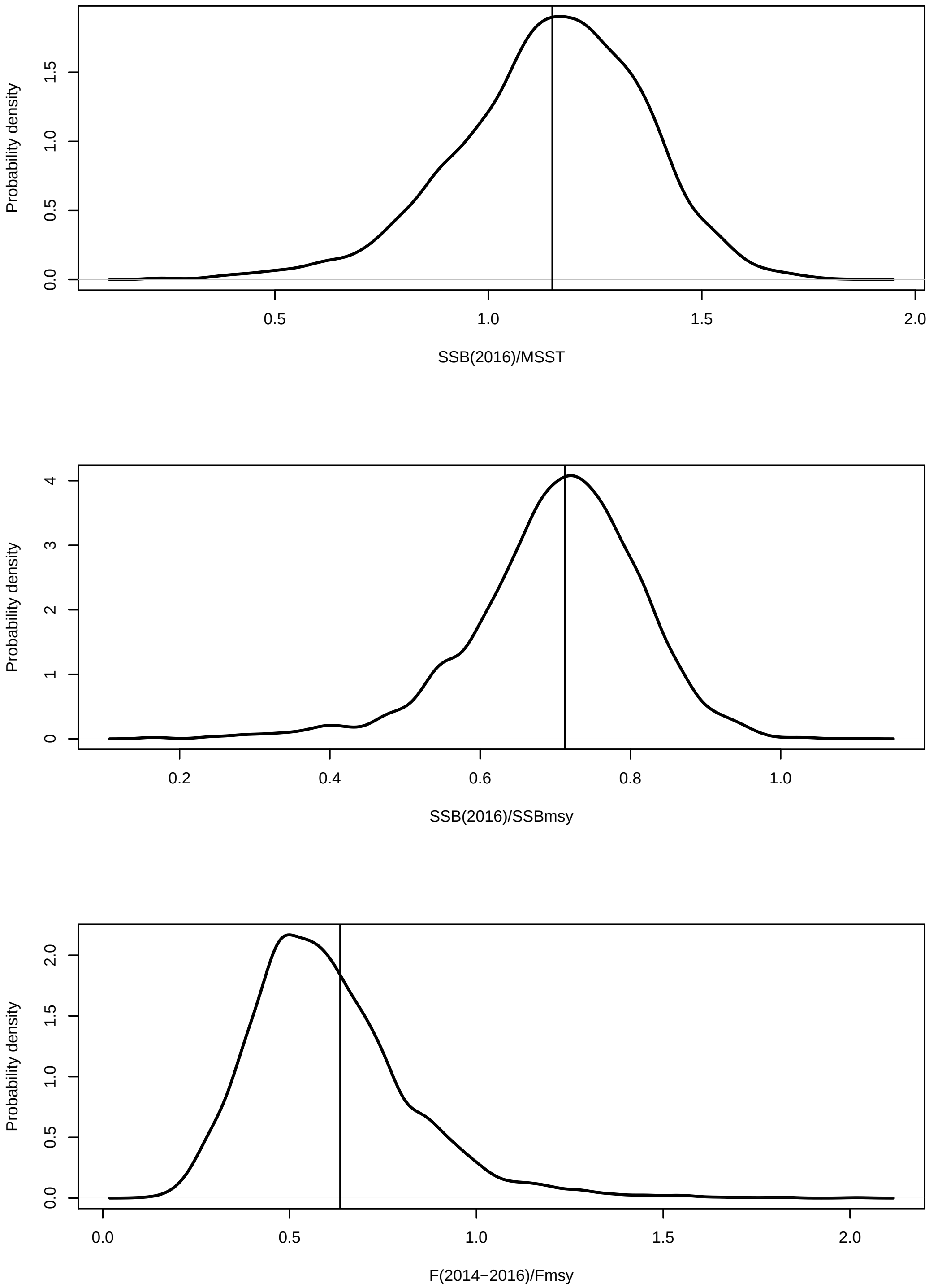


Figure 38. Phase plots of terminal status estimates from MCB analysis of the Beaufort Assessment Model. Top panel is status relative to MSST*, and the bottom panel is status relative to* MSY*. The intersection of crosshairs indicates estimates from the base run; lengths of crosshairs defined by* 5^{th} *and* 95^{th} *percentiles.*

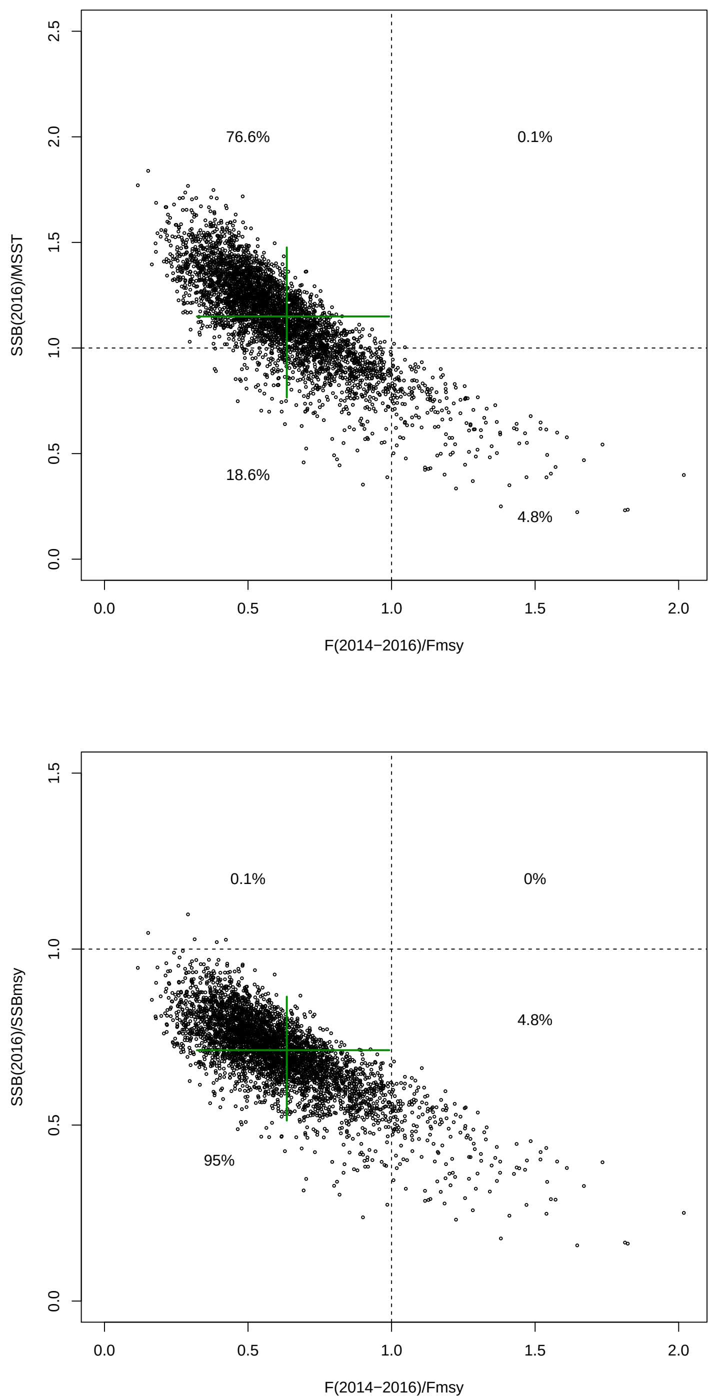


Figure 39. Age structure relative to the equilibrium expected at MSY.

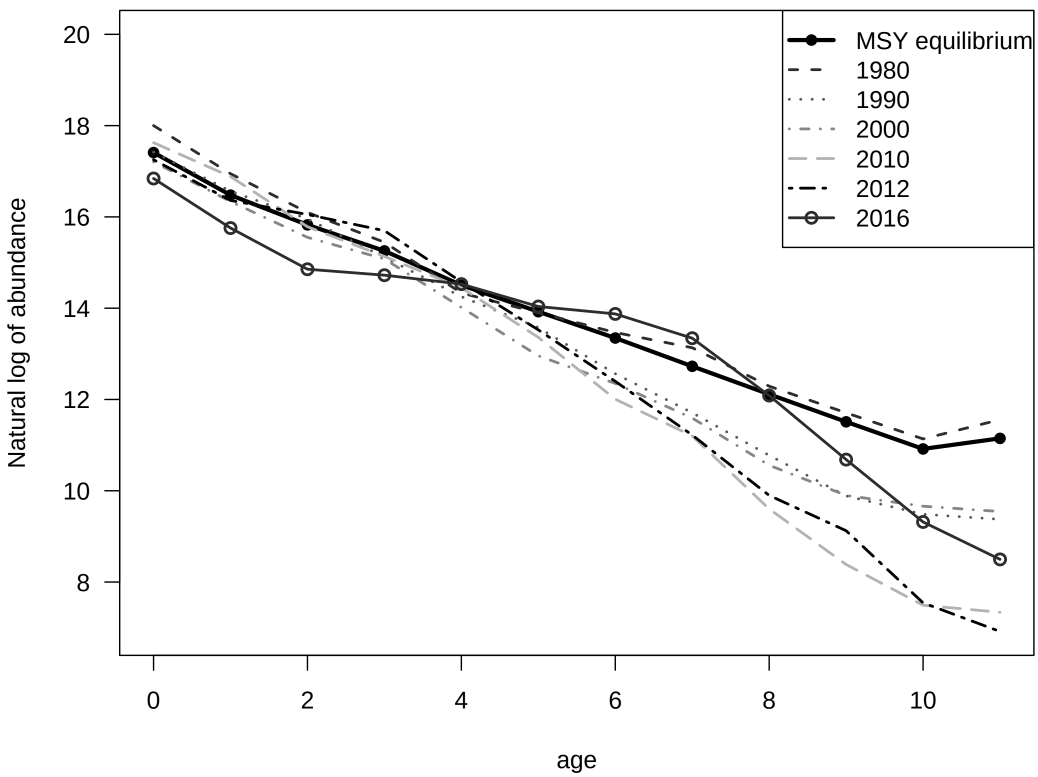


Figure 40. Sensitivity to changes in natural mortality (sensitivity runs S1–S2). Top panel: Ratio of F to F_{MSY}. *Bottom panel: Ratio of* SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$.

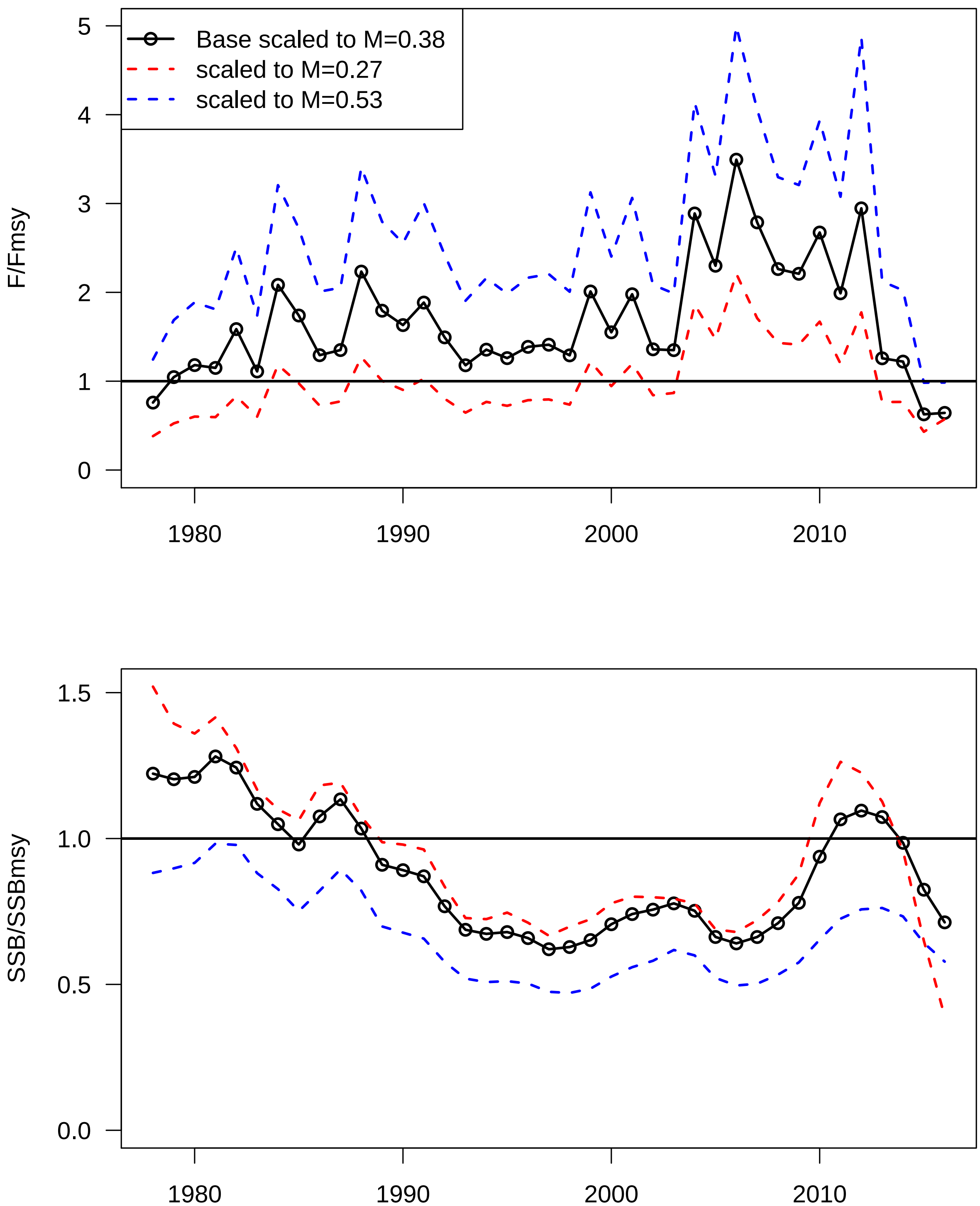
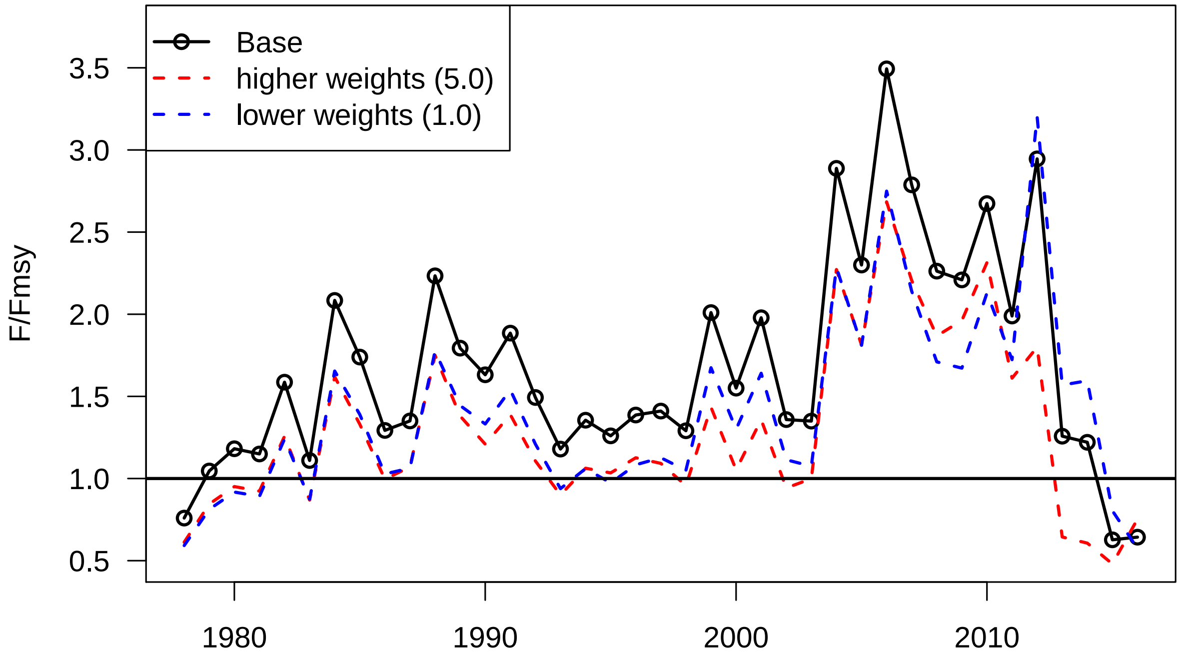


Figure 41. Sensitivity to index weights (sensitivity runs S3–S4). Top panel: Ratio of F to F_{MSY}*. Bottom panel: Ratio of* SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$.



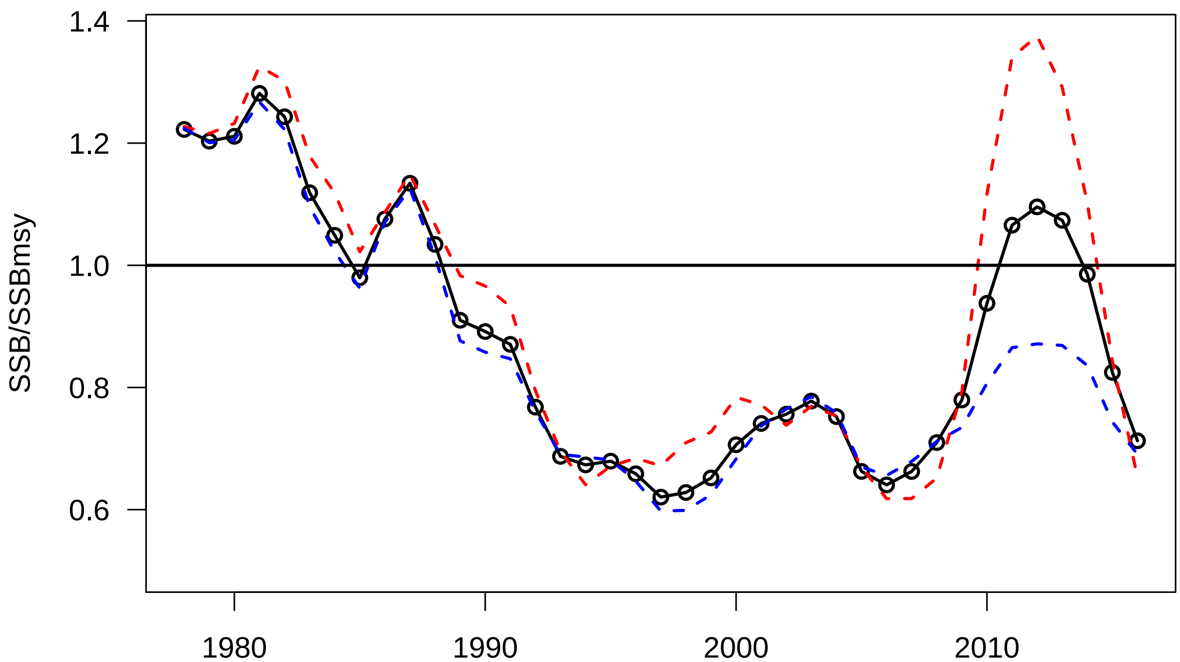


Figure 42. Sensitivity to steepness (sensitivity runs S5–S6). Top panel: Ratio of F to F_{MSY}*. Bottom panel: Ratio of* SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$.

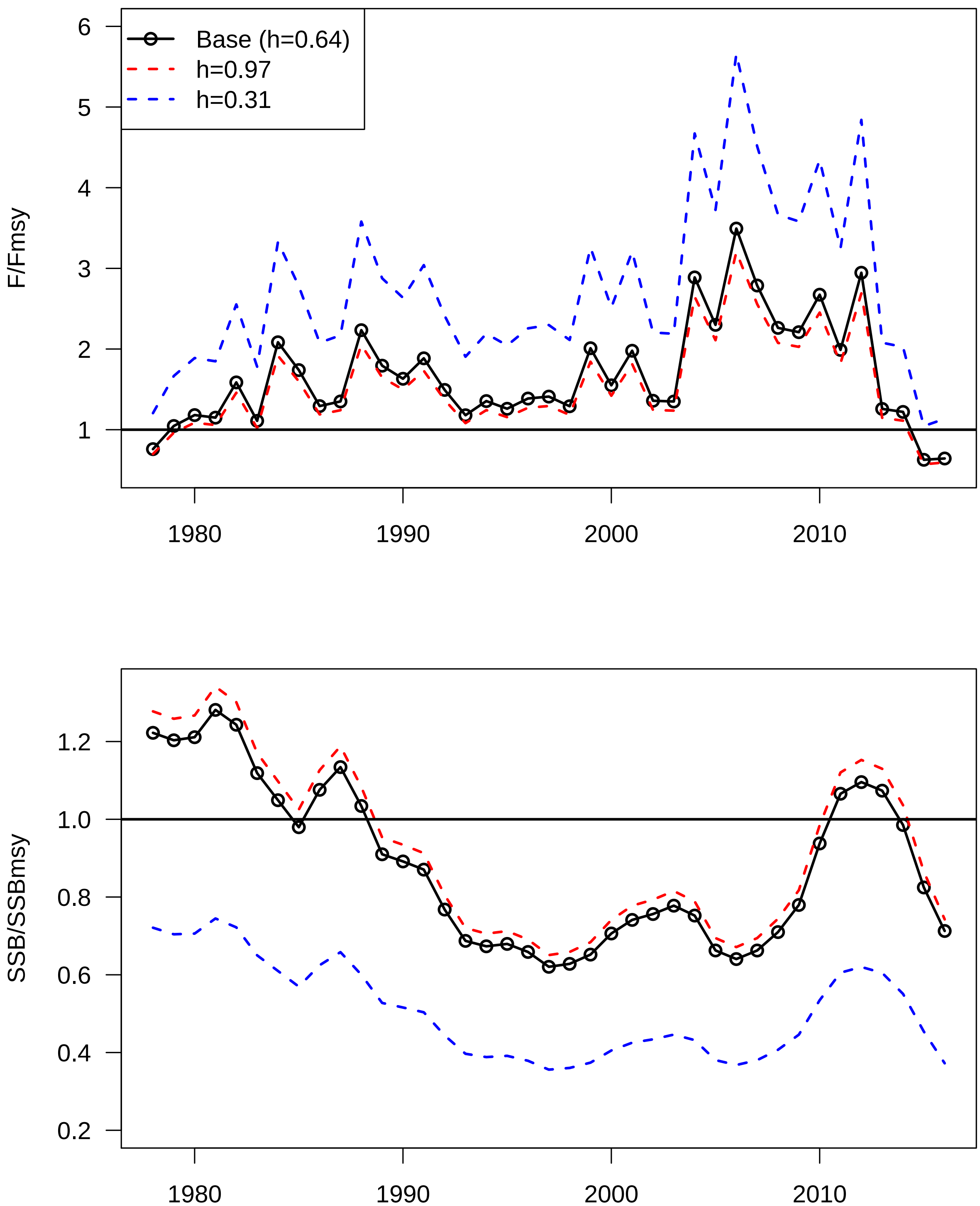
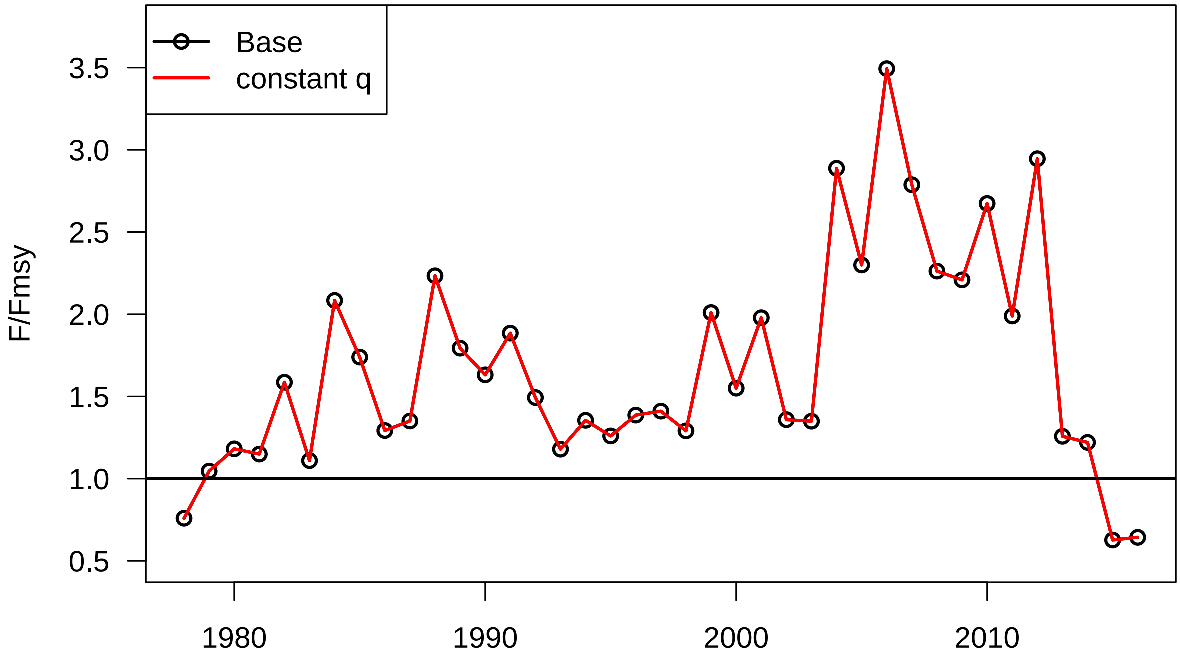


Figure 43. Sensitivity to catchability assumptions (sensitivity run S7). Top panel: Ratio of F to F_{MSY}*. Bottom panel: Ratio of* SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$*.*



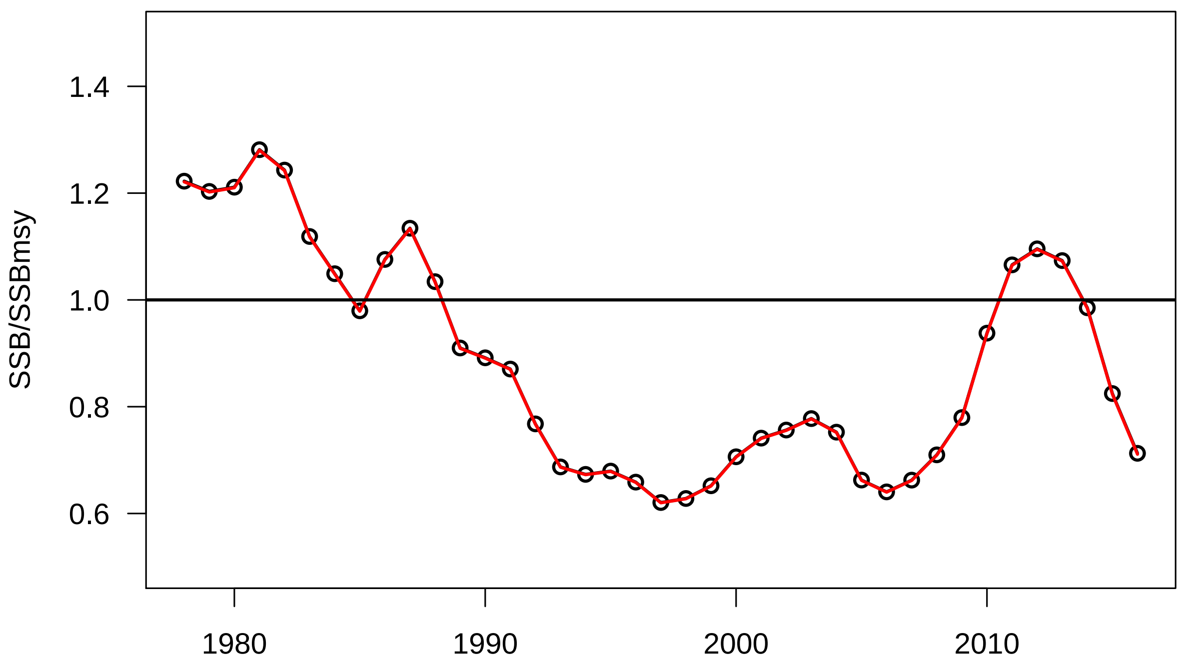
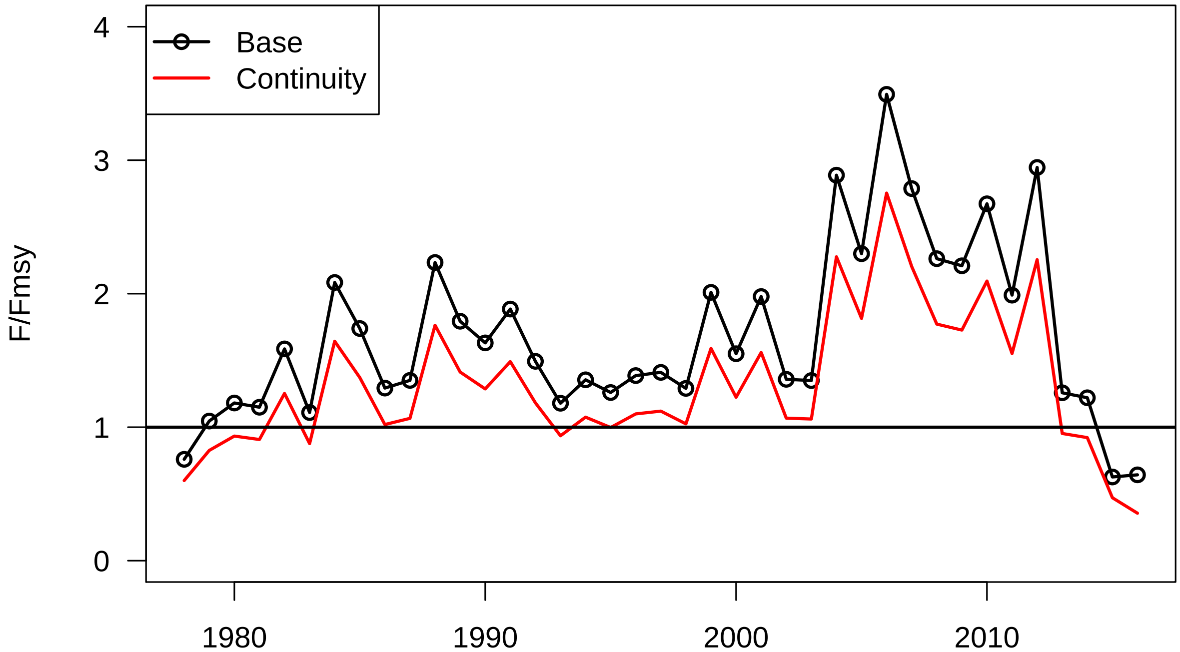


Figure 44. Comparison to continuity assumptions (sensitivity run S16). Top panel: Ratio of F to F_{MSY}. Bottom panel: Ratio of SSB *to* SSB_{MSY}.



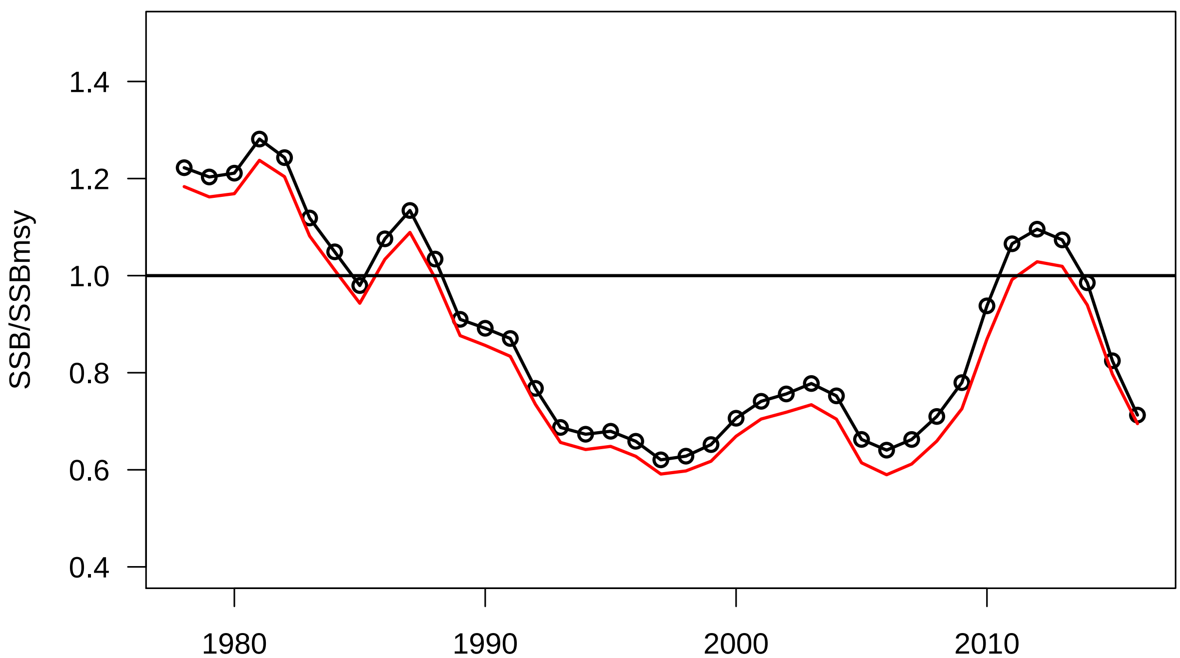


Figure 45. Sensitivity to the Chevron trap index rather than the CVID index (sensitivity runs S8). Top panel: Ratio of F to F_{MSY}. Bottom panel: Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$*. Any lines not visible overlap results of the base run.*

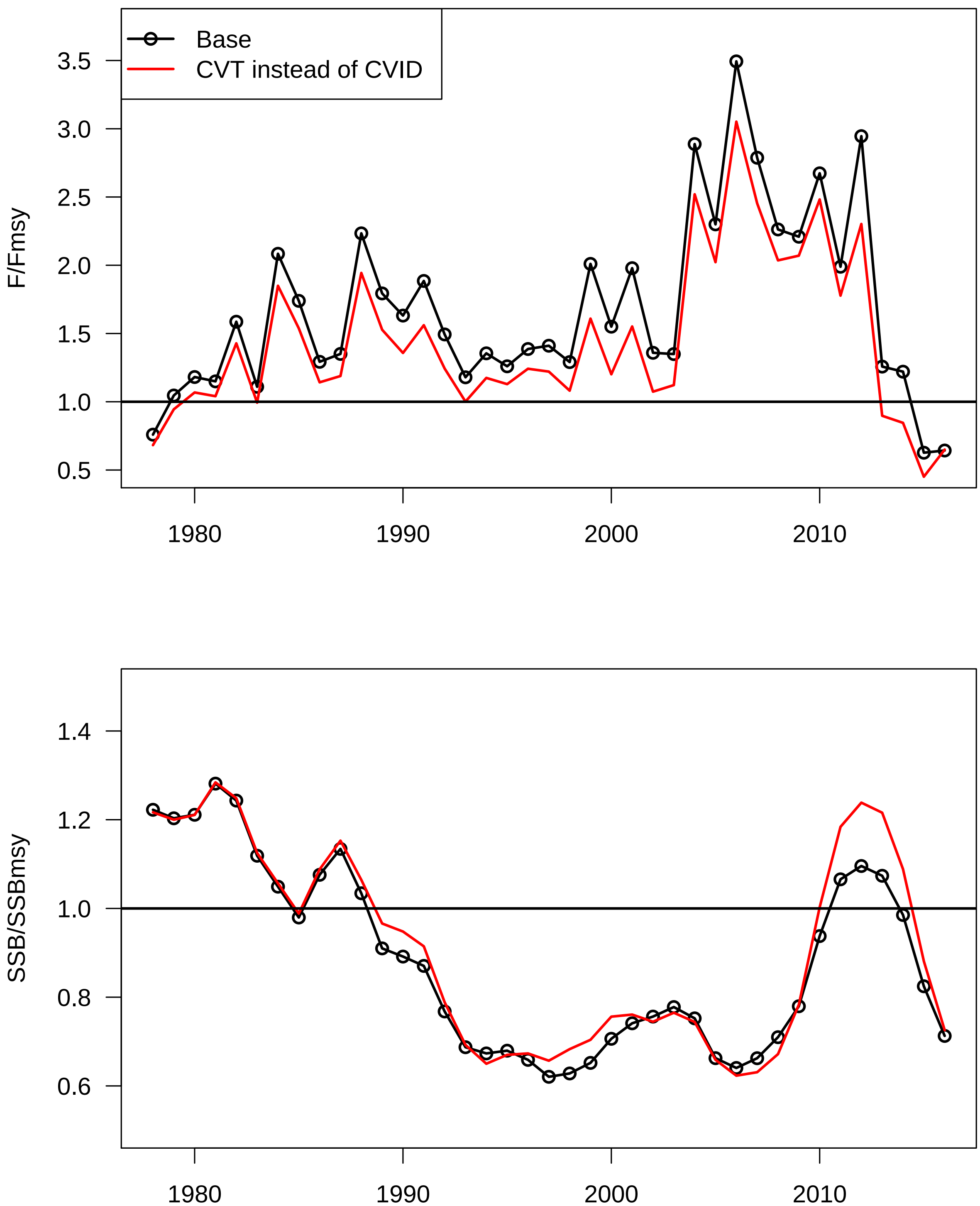
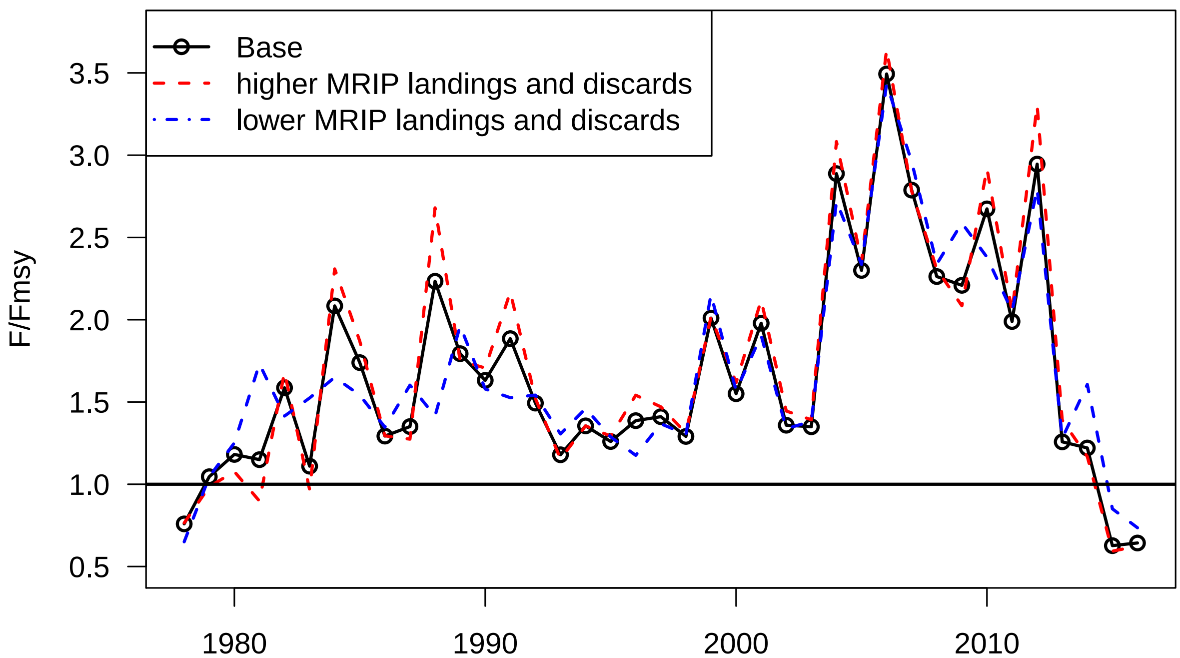


Figure 46. Sensitivity to higher and lower recreational landings and all discards (sensitivity runs S9–S10). Top panel: Ratio of F to F_{MSY}. Bottom panel: Ratio of SSB to $\mathrm{SSB}_{\mathrm{MSY}}$. Any lines not visible overlap results of the base run.



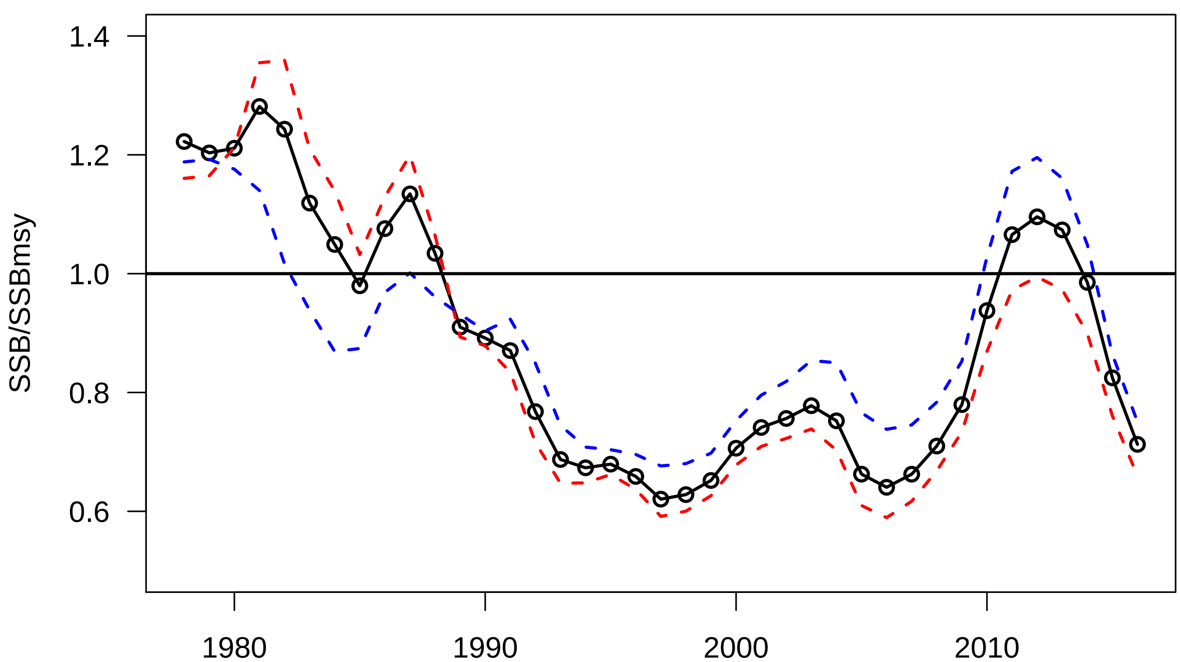


Figure 47. Sensitivity to higher and lower discard mortalities (sensitivity runs S11–S12). Top panel: Ratio of F to F_{MSY}*. Bottom panel: Ratio of* SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$*. Any lines not visible overlap results of the base run.*

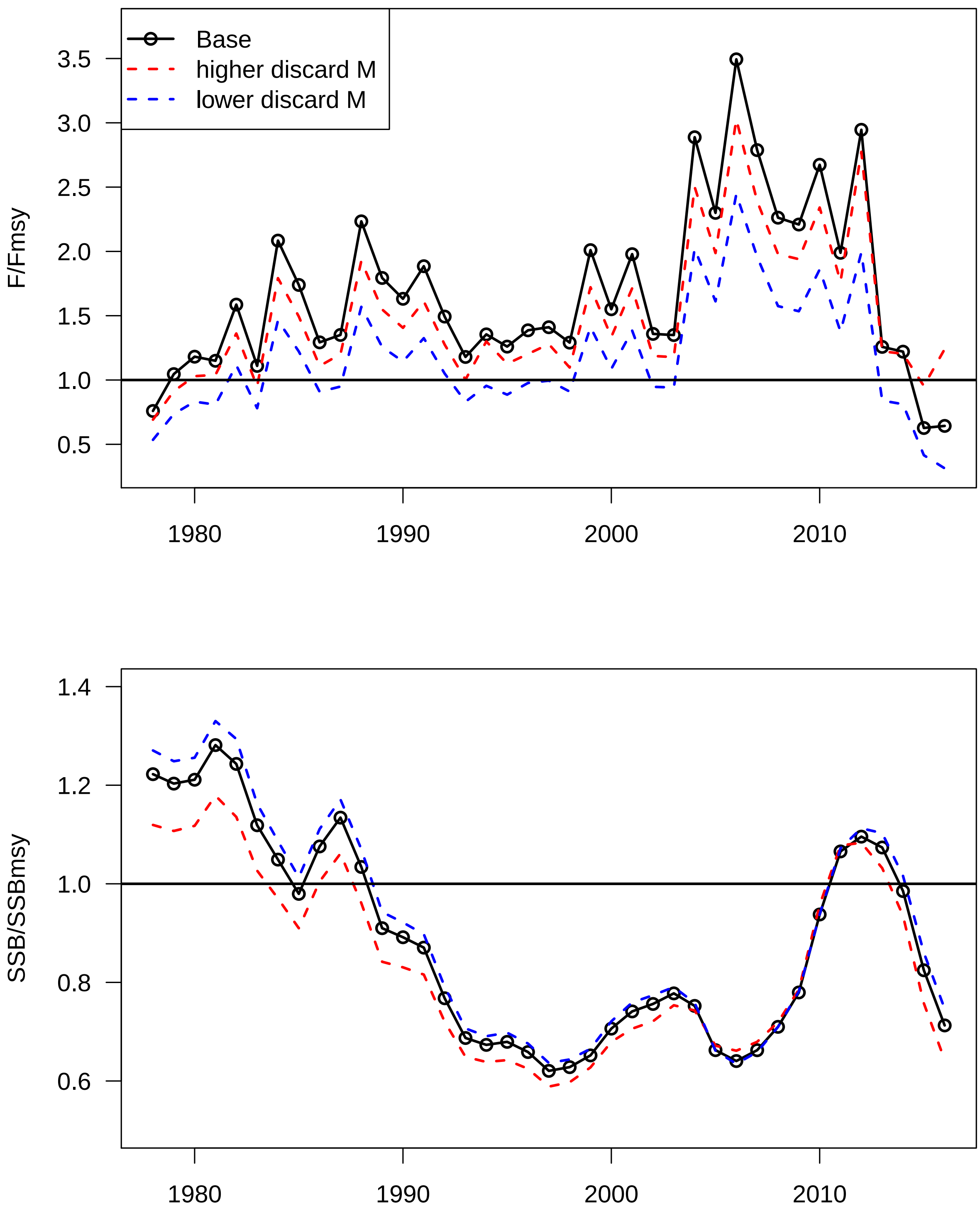


Figure 48. Phase plot of terminal status estimates from sensitivity runs of the Beaufort Assessment Model.

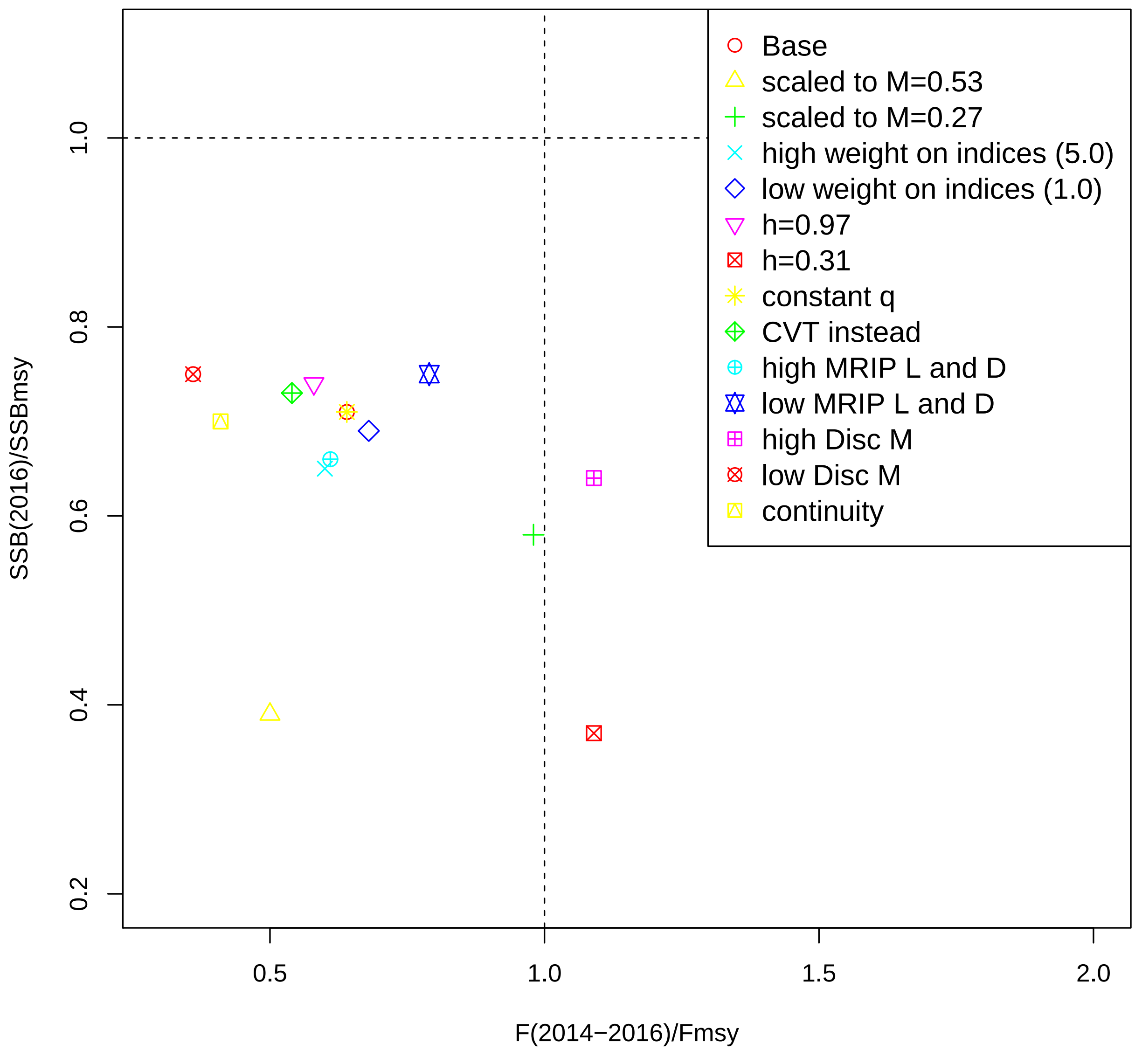


Figure 49. Retrospective analyses. Sensitivity to terminal year of data (sensitivity runs S13–S15). Top panel: Fishing mortality rates. Middle panel: Recruits. Bottom panel: Spawning biomass. Closed circles show terminal-year estimates. Imperceptible lines overlap results of the base run.

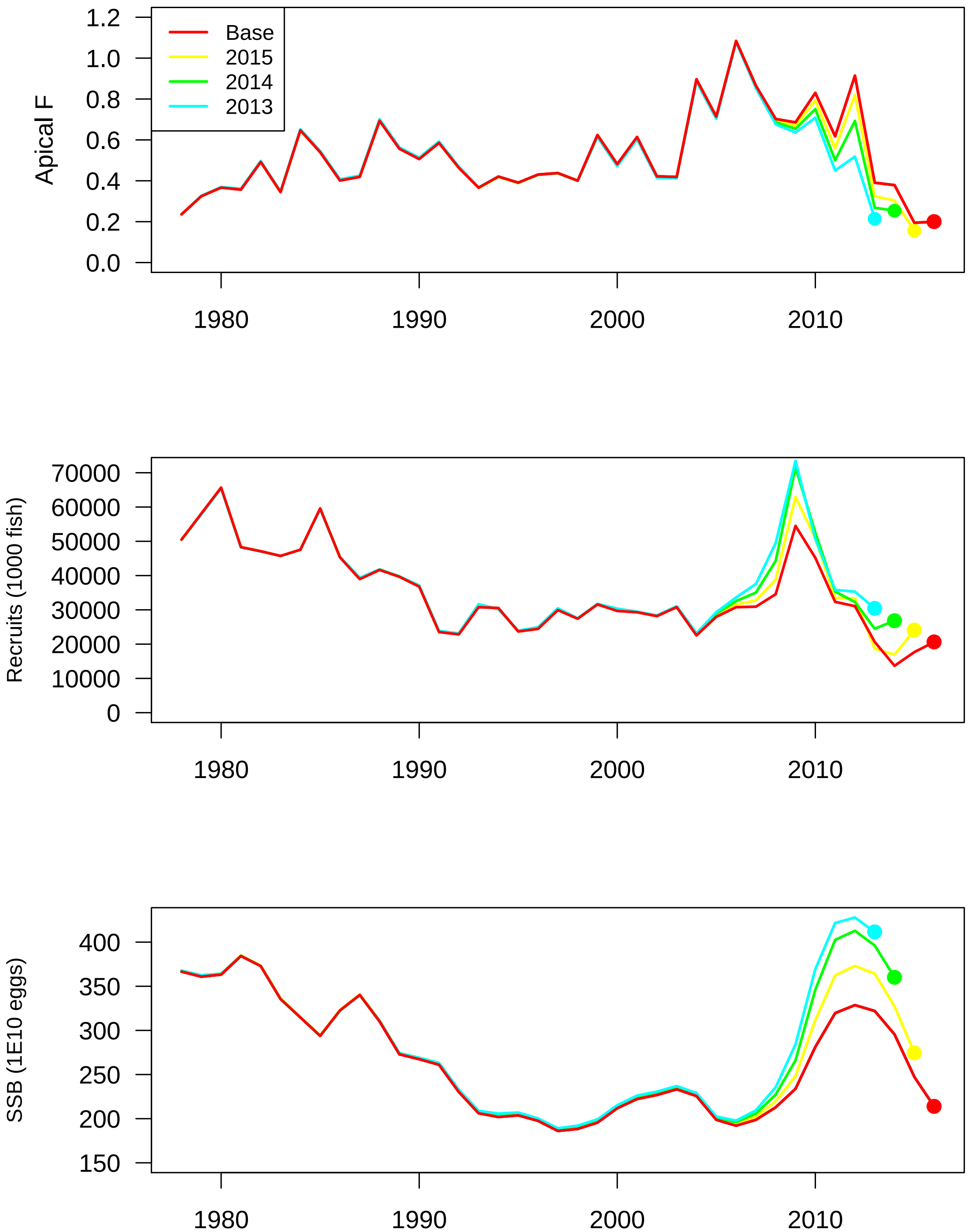


Figure 50. Projection results under scenario 1—fishing mortality rate fixed at $F = F_{\mathrm{MSY}}$, with 2019 as the first year of new regulations. In all panels except the bottom right, expected values represented by solid lines, median values represented by dashed lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities from the base run (solid blue lines) and medians from the MCB runs(dashed green lines). Spawning stock (SSB) is at time of peak spawning. In the bottom right panel, the curve represents the proportion of projection replicates for which SSB has reached at least* $\mathrm{SSB_{MSY}}$.

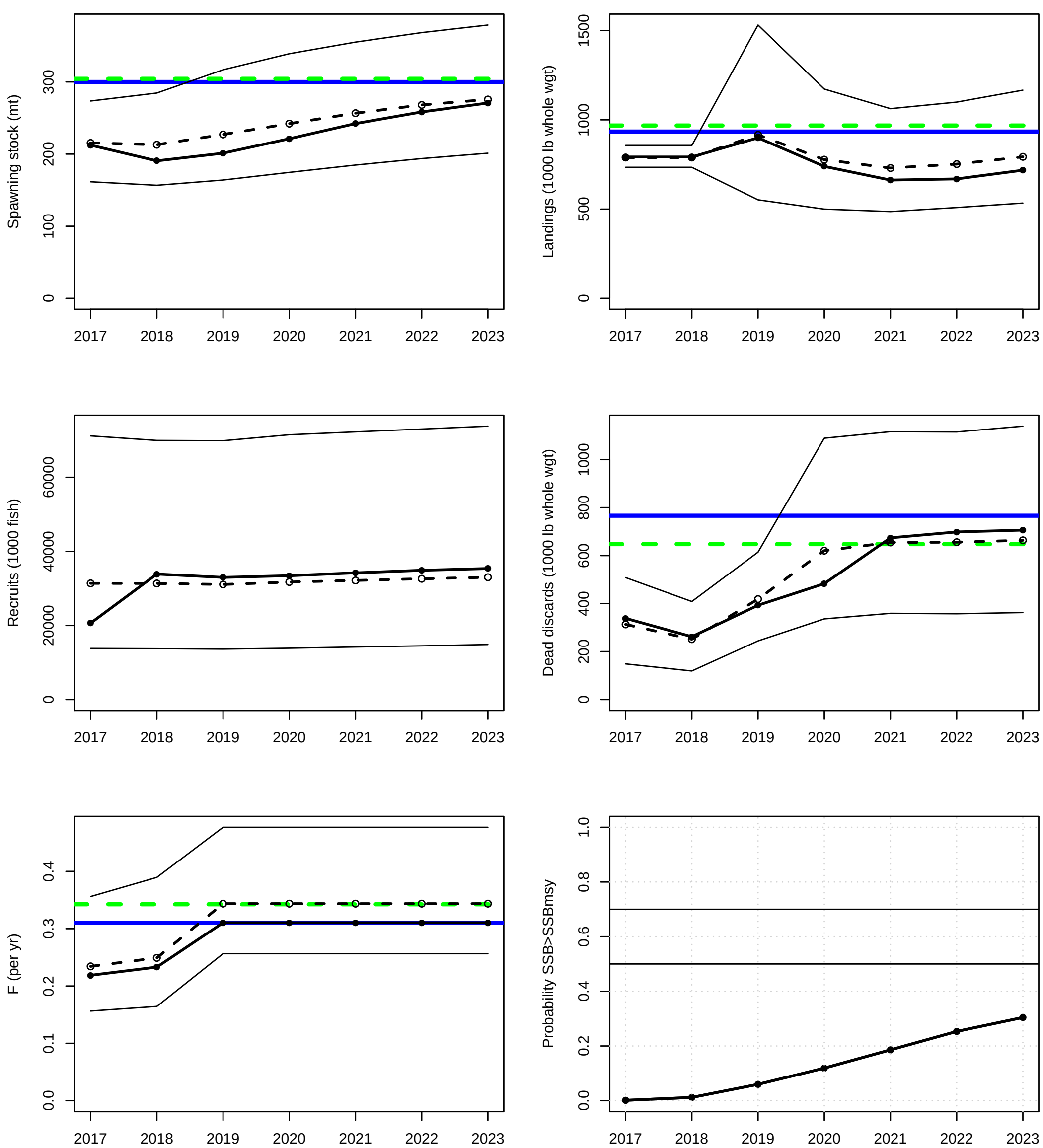


Figure 51. Projection results under scenario 2—fishing mortality rate fixed at $P^{\star}=0.4$, with 2019 as the first year of new regulations. In all panels except the bottom right, expected values represented by solid lines, median values represented by dashed lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities from the base run (solid blue lines) and medians from the MCB runs(dashed green lines). Spawning stock (SSB) is at time of peak spawning. In the bottom right panel, the curve represents the proportion of projection replicates for which SSB has reached at least* $\mathrm{SSB_{MSY}}$.

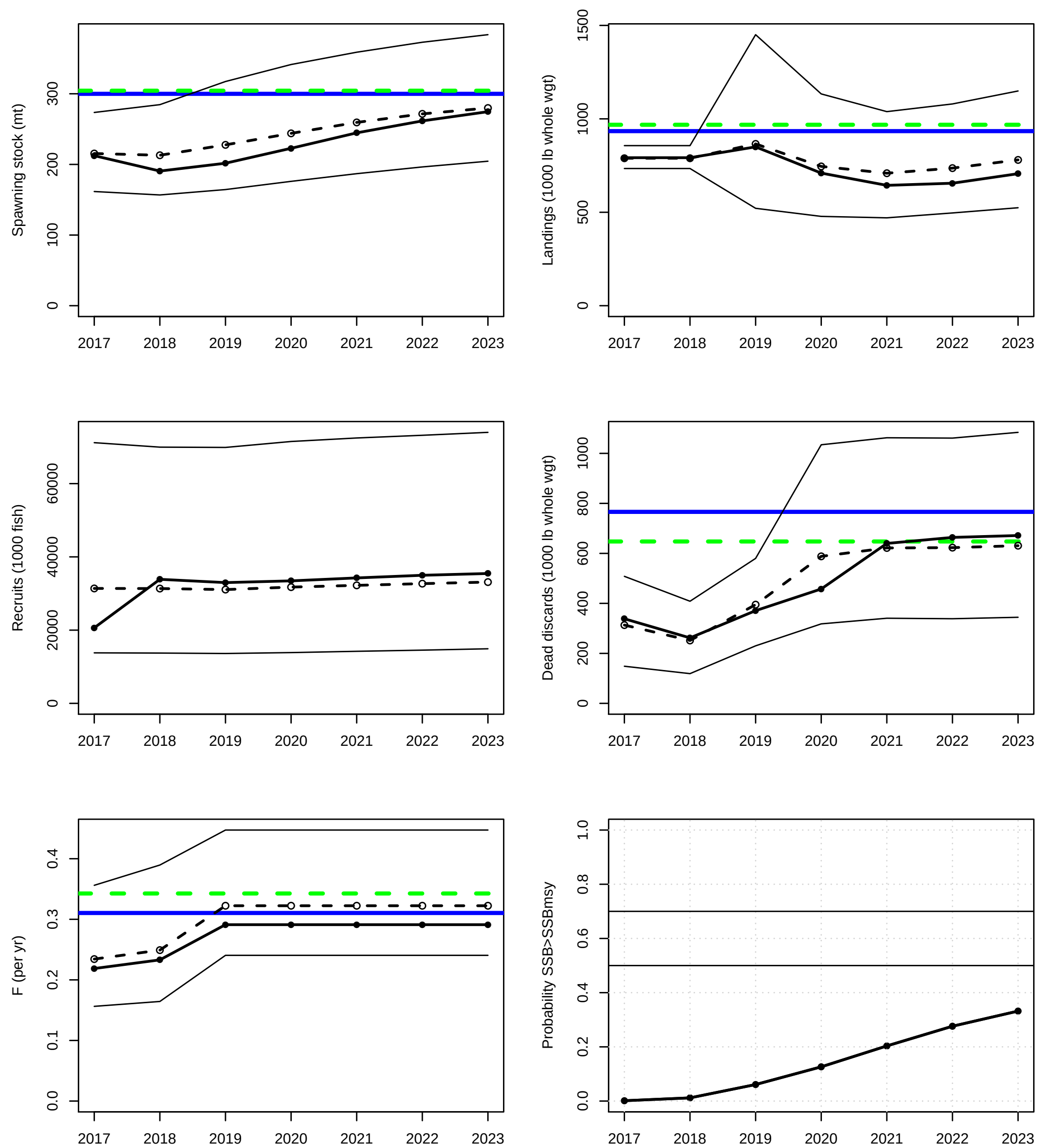
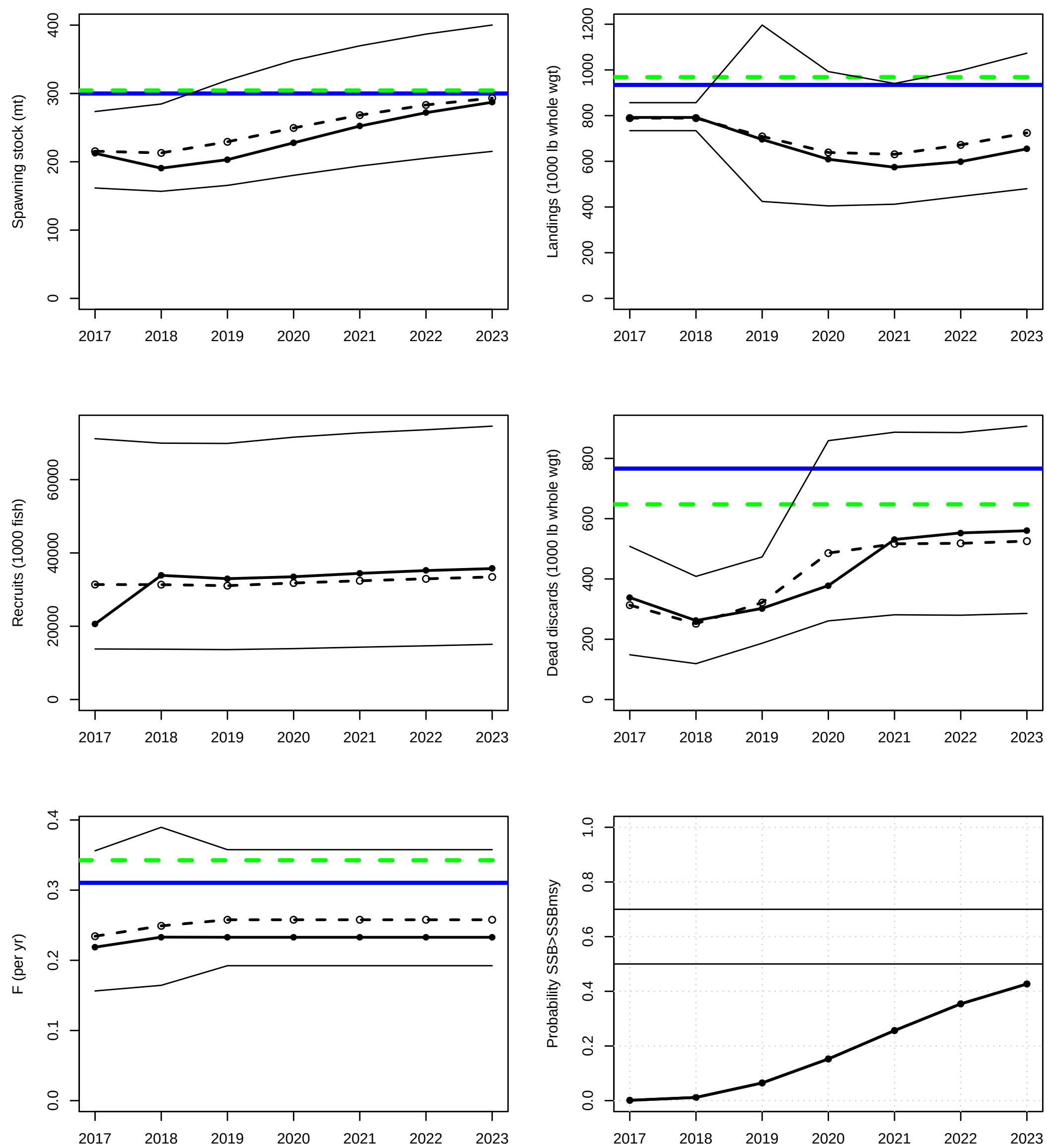


Figure 52. Projection results under scenario 3—fishing mortality rate fixed at $F = 75\%F_{\mathrm{MSY}}$, with 2019 as the first year of new regulations. In all panels except the bottom right, expected values represented by solid lines, median values represented by dashed lines, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities from the base run (solid blue lines) and medians from the MCB runs(dashed green lines). Spawning stock (SSB) is at time of peak spawning. In the bottom right panel, the curve represents the proportion of projection replicates for which SSB has reached at least* $\mathrm{SSB_{MSY}}$.



Appendix A Abbreviations and symbols

Table 23. Acronyms and abbreviations used in this report

Symbol	Meaning
ABC	Acceptable Biological Catch
AW	Assessment Workshop (here, for black sea bass)
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 black sea bass)
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/Bootstrap, 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 black sea bass 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
SEFIS	SouthEast Fishery-Independent Survey
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 = 421  Objective function value = 74370.4  Maximum gradient component = 0.0420422
# Linf:
502.100000000
# K:
0.173000000000
# t0:
-0.970000000000
# len_cv_val:
0.100607650172
# log_Nage_dev:
 0.491650384423 0.0825259201820 0.214226386376 0.317986499346 0.501240600370 0.155798693303 0.0593286601611 -0.0359178560939
 -0.0875720204499 -0.0984763411761 -0.200337815936
# log_R0:
17.3970309366
# steep:
0.640000000000
# rec_sigma:
0.350000000000
# R_autocorr:
0.00000000000
# log_rec_dev:
 0.403414348250 0.497781387147 0.619562970227 0.303748531071 0.283011414715 0.270044240749 0.319970485013 0.558344369540
 0.267094951372 0.107538943449 0.189882611835 0.164331724397 0.0932941050667 -0.348754746641 -0.351501289565 -0.0274852173678
 -0.0298845820768 -0.286523045510 -0.247303064717 -0.0296433740231 -0.120821285941 0.0111966021029 -0.0704491367066 -0.0946135209656
 -0.138748088297 -0.0560656514182 -0.360112188952 -0.114517637615 -0.00986779542734 -0.0134294076439 0.0809010311121 0.514670166317
 0.289517408977 -0.0682888041363 -0.112747938857 -0.518815621873 -0.914910292038 -0.623506761873 -0.436315839698
# log_dm_Mbft_lc:
9.99000000000
# log_dm_Mcvt_lc:
0.00000000000
# log_dm_cL_lc:
5.09707333371
# log_dm_cP_lc:
-1.61849250744
# log_dm_HB_lc:
5.18434819978
# log_dm_HB_D_lc:
9.99000000000
# log_dm_mrip_lc:
9.99000000000
# log_dm_Mbft_ac:
-3.47570783931
# log_dm_Mcvt_ac:
-0.721967748464
# log_dm_cL_ac:
9.99000000000
# log_dm_cP_ac:
9.99000000000
# log_dm_HB_ac:
-0.829246631705
# selpar_A50_Mbft:
1.51623574523
# selpar_slope_Mbft:
5.94722005628
# selpar_A50_Mcvt:
1.92695013796
# selpar_slope_Mcvt:
3.41343648713
# selpar_A50_cL2:
3.41120968095
# selpar_slope_cL2:
2.62639633008
# selpar_A50_cL3:
3.82922778772
# selpar_slope_cL3:
2.44156712735
# selpar_A50_cL4:
3.71298996362
# selpar_slope_cL4:
2.37557834294
# selpar_A50_cP2:
2.22519167373
# selpar_slope_cP2:
3.90287905811
# selpar_A50_cP3:
3.17847040352
# selpar_slope_cP3:
3.56553553687
# selpar_A50_cP4:
3.12752210167
# selpar_slope_cP4:
2.56773897232
# selpar_A50_HB1:
1.46754125101
# selpar_slope_HB1:
4.99623355993
# selpar_A50_HB2:
1.67569328715
# selpar_slope_HB2:
```

```
7.07388061065
# selpar_A50_HB3:
2.54991013585
# selpar_slope_HB3:
7.26057769275
# selpar_A50_HB4:
3.25302452794
# selpar_slope_HB4:
3.08235502607
# selpar_A50_HB5:
3.43058681968
# selpar_slope_HB5:
2.84856734880
# selpar_A50_HBD4:
2.54743495102
# selpar_slope_HBD4:
2.32805817104
# selpar_A502_HBD4:
0.745544123669
# selpar_slope2_HBD4:
3.00000000000
# selpar_A50_HBD5:
2.79102488700
# selpar_slope_HBD5:
1.73412020680
# selpar_A502_HBD5:
0.864184962209
# selpar_slope2_HBD5:
3.00000000000
# selpar_Age0_HB_D_logit:
-5.55923264585
# selpar_Age1_HB_D_logit:
-2.46682436891
# selpar_Age2_HB_D_logit:
3.52041633716
# selpar_A50_mrip1:
1.05118330302
# selpar_slope_mrip1:
4.61056318825
# selpar_A50_mrip2:
2.01802683880
# selpar_slope_mrip2:
3.04635196816
# selpar_A50_mrip3:
2.97130187774
# selpar_slope_mrip3:
4.44983478301
# selpar_A50_mrip4:
3.71506546889
# selpar_slope_mrip4:
3.74706230432
# selpar_A50_mrip5:
4.91835946806
# selpar_slope_mrip5:
2.17952750256
# q_rate:
0.00000000000
# log_q_Mbft:
-16.3812207880
# log_q_Mcvt:
-15.8388508902
# log_q_cL:
-7.66918692866
# log_q_HB:
-8.34233963024
# q_RW_log_dev_cL:
 -0.0902996908487 -0.206759027379 0.0545096336801 0.210079580294 0.283836173426 0.228390792880 -0.160209783570 -0.0539391644025
 -0.0799815984860 0.0920961967980 0.293831549756 0.00859108167752 -0.0151190072196 -0.255098224862 0.126047783933 0.209772923135
# q_RW_log_dev_HB:
 -0.00851629355377 0.0450430969668 0.0375665862142 0.0283029761927 0.0449606356399 0.0797173249842 -0.153942136446 -0.139522256599
 0.00506892549373 -0.0356623452575 -0.0474803750879 -0.167204700360 -0.295335063924 -0.257730608737 0.0659609093936 0.0290016991141
 0.0432102773816 0.112387820920 0.0313825496262 0.273805882092 -0.200848375214 -0.0408162144971 -0.0682733301125 0.0800085569466
 0.320949143544 0.155386722667 0.312970220400 -0.242138690647 -0.165758379248 0.174983669964 0.262463564600
# M_constant:
0.380000000000
# log_avg_F_cL:
-2.86805457712
# log_F_dev_cL:
 -0.974896083116 -0.707754616141 -0.828524310600 -0.337819227948 -0.336178168350 -0.335259110633 0.0118067260073 0.0775253217241
 0.109469380380 -0.0757449645957 0.391855588298 0.555898531316 0.659128718345 0.732063096382 0.570000547035 0.315025500902
 0.425253381736 0.121596621499 0.0858301472183 0.329933026891 0.661550554807 0.799231004824 0.130731294544 0.00227732738871
 0.0297954447592 -0.200889227493 0.0526094414817 -0.157341802801 -0.0671049920985 -0.178316640203 -0.160071583926 0.116808657233
 -0.178000077013 -0.699814968282 -0.197792290962 0.0393240433143 0.237962924235 -0.507471831367 -0.512697384793
# log_avg_F_cP:
-2.15168018075
# log_F_dev_cP:
 -1.90008163309 -0.199318830022 0.125195821530 0.308603532260 0.0664365529493 -0.378089089386 -0.436516497352 -0.313103191773
 -0.102916387918 -0.446861421525 -0.179140968903 0.00117470743740 0.325347807327 0.233627312237 0.130782104242 0.0550060586297
 0.190456366832 0.00322308393868 0.183493986555 0.273771416676 0.164380194958 0.779823594304 0.533141782078 0.641197440768
 0.405678676136 0.393019319035 0.764676356818 0.509141804533 0.827634986445 0.537159563514 0.524032945294 0.799456688718
 0.415465191668 0.165201109567 -0.420801253069 -0.675660467821 -1.21631588774 -1.29255585652 -1.79576691932
# log_avg_F_cT:
-5.71135291389
# log_F_dev_cT:
 0.219065006918 0.150114488145 0.131115788552 0.411250251323 -0.0151425643844 -0.858681076812 -0.0164240835260 0.436967894714
```

```
 0.344323410590 -0.872260286742 0.194784964379 -0.0858981926837 -0.0392156004716
# log_avg_F_HB:
-2.93413348016
# log_F_dev_HB:
 0.0760143257442 0.156897447369 0.288461415350 0.377824692838 0.417215977738 0.500716478595 0.571947390073 0.533601353499
 0.435272091408 0.422680671396 0.551589390103 0.429968661408 0.209457116543 -0.0511639391043 -0.306460075903 -0.634722397083
 -0.618644832264 -0.666263387670 -0.549219471439 -0.462195346953 -0.455362666421 0.278990286018 -0.133137922787 0.0155848298530
 -0.421655704945 -0.431739456693 0.264634425972 0.162486314051 0.634595375140 0.580515810090 0.0657116969637 0.402613693809
 0.896439057806 0.594923440547 -0.136006499112 -0.575556731296 -0.870616848819 -1.17158666620 -1.38380999562
# log_avg_F_mrip:
-1.45459895385
# log_F_dev_mrip:
 -1.13040045953 0.0424437174525 -0.547465540562 0.579476161921 0.242927280661 -0.468355099122 -0.107671786442 0.577022580383
 0.0940658091757 -0.336038798408 0.143716935062 -0.198694830275 -0.531843570425 -0.351173847313 -0.244180249695 -0.164411392038
 -0.303107472556 -0.667464070238 -0.295928406237 -0.307221493091 0.190342012221 -0.416891375359 -0.343413321970 0.795754348890
 0.561123012711 1.04657219630 0.807912996725 0.540132297869 0.194324125286 0.711969113110 0.420776830156 1.16017389282
 0.0364437858326 0.0681700014932 -0.735149676140 -1.06393570867
# F_init_ratio:
0.642799300255
# log_avg_F_comm_D:
-6.46285974016
# log_F_dev_comm_D:
 0.531355977284 1.00471098125 0.721332296667 0.732964717427 0.805730520190 0.809000415256 0.534554763694 0.256739739155
 0.364705812056 -0.0972208505095 0.605385030957 0.204788375366 0.454226933562 0.942569524586 -0.880646025150 -1.18447620220
 -0.203441668493 -0.946308823548 -0.865172991164 -0.625381645998 -0.419288684549 -0.606927476985 -1.09779655544 -1.04140416341
# log_avg_F_HB_D:
-5.55355190633
# log_F_dev_HB_D:
 -0.898764008287 0.582490867984 1.32298475337 -1.13708755602 -3.95258464726 0.761039791103 -1.11349171454 -1.17344095061
 0.365267636030 -0.533085728900 0.0306780307671 0.186852863064 -0.900795363271 -0.0874740475623 -0.0693397298786 0.202192857992
 -0.437904775683 -0.463392614710 -0.911097998082 -1.38677793335 -0.422698417483 0.242922263533 0.413919134649 0.672326666578
 0.947819724027 1.24722277110 1.23406717998 1.02409509114 1.23304738904 1.37156597934 1.64944248595
# log_avg_F_mrip_D:
-3.25441271948
# log_F_dev_mrip_D:
 -0.497632011348 -1.02625928934 -1.72888977390 -0.671895026581 -0.682791666057 -0.979364060201 -0.779381993399 -0.729768631572
 -0.681923865729 -1.36350435576 -0.811201816174 -0.688957903243 -0.557293327497 0.152598549627 -0.315621538871 -0.549822635779
 -0.0946572581363 -0.404070294760 -0.200440666722 0.0551733889625 0.115016708071 -0.308522272329 -0.136234561198 0.611451468986
 0.444848797403 0.619366874072 1.40716677498 1.12944296207 0.809759190938 1.06044553906 1.02885870418 1.25694553932
 0.557564272419 1.38848688668 1.14089236023 1.43021493159
```