SEDAR

Southeast Data, Assessment, and Review

SEDAR 60

South Atlantic Red Porgy

Stock Assessment Report

April 2020

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

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Section I: Introduction

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I. Introduction

1. SEDAR Process Description

SouthEast Data, Assessment, and Review (SEDAR) is a cooperative Fishery Management Council 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 60 addressed the stock assessment for South Atlantic Red Porgy. The assessment process consisted of a series of webinars held from June 2018 – February 2020 and an in person workshop held in Beaufort, North Carolina on December 10-12, 2019. The Stock Assessment Report is organized into 2 sections. Section I –Introduction contains a brief description of the SEDAR Process, Assessment and Management Histories for the species of interest, and the management specifications requested by the Cooperator. Section II is the Assessment Process report. This section details the assessment model, as well as documents any data recommendations that arise for new data sets presented during this assessment process, or changes to data sets used previously.

The final Stock Assessment Reports (SAR) for South Atlantic Red Porgy was disseminated to the public in April 2020. The Council's Scientific and Statistical Committee (SSC) will review the SAR for its stock. The SSCs are tasked with recommending whether the assessments represent Best Available Science, whether the results presented in the SARs are useful for providing management advice and developing fishing level recommendations for the Council. An SSC may request additional analyses be conducted or may use the information provided in the SAR as the basis for their Fishing Level Recommendations (e.g., Overfishing Limit and Acceptable Biological Catch). The South Atlantic Fishery Management Council's SSC will review the assessment at its April 2020 meeting, followed by the Council receiving that information at its June 2020 meeting. Documentation on SSC recommendations is not part of the SEDAR process and is handled through each Council.

2. Management Overview:

2.1 SAFMC Fishery Management Plan and Amendments

The following summary describes only those management actions that likely affect Red Porgy fisheries and harvest.

Original SAMFC FMP

The Fishery Management Plan (FMP), Regulatory Impact Review, and Final Environmental Impact Statement for the Snapper Grouper Fishery of the South Atlantic Region, approved in 1983 and implemented in August of 1983, establishes a management regime for the fishery for snappers, groupers and related demersal species of the Continental Shelf of the southeastern United States in the exclusive economic zone (EEZ) under the area of authority of the South Atlantic Fishery Management Council (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. Regulations apply only to federal waters.

SAFMC FMP Amendments affecting Red Porgy

Description of Action	FMP/Amendment	Effective Date
-4” Trawl mesh size -Gear limitations (poisons, explosives, fish traps, trawls) -Designated modified habitats or artificial reefs as Special Management Zones	Snapper Grouper FMP	8/31/1983
-Prohibit trawls to harvest snapper grouper species south of Cape Hatteras, NC and north of Cape Canaveral, FL -Defined directed fishery as vessel with trawl gear and at least 200 pounds of snapper grouper species on board	Amendment 1	1/12/1989
-Prohibited gear: fish traps except black sea bass pots north of Cape Canaveral, FL; entanglement nets; longlines inside 50 fathoms; powerheads in designated SMZs off SC -Defined overfishing/overfished established rebuilding timeframe: red porgy ≤ 10 years (year 1=1991) -Required permits (commercial and for-hire) and specified data collection regulations -No retention of snapper grouper species caught in other fisheries with gear prohibited in snapper grouper fishery if captured snapper grouper had no bag limit or harvest was prohibited. If had a bag limit, could retain only the bag limit; -12” TL limit – red porgy	Amendment 4	1/1/1992

-Required 100% logbook coverage upon renewal of commercial permit -Oculina Experimental Closed Area	Amendment 6	7/27/1994
-Required dealer, charter and headboat federal permits -Specified allowable gear and made allowance for experimental gear -Restricted sale/purchase of snapper grouper species -Adjusted requirements for possessing multi-day bag limits	Amendment 7	1/23/1995
-Established limited entry for commercial snapper grouper fishery	Amendment 8	12/14/1998
-Increased red porgy minimum size limit to 14" TL (commercial and recreational) -Specified red porgy bag limit of 5 fish per person per day. -No harvest and possession of red porgy above the bag limit and no purchase or sale in March and April.	Amendment 9	2/24/1999
-Approved definitions for overfished and overfishing. -MSST = [(1-M) or 0.5, whichever is greater]*B^{MSY}. -MFMT = F_{MSY}. -Overfished/overfishing evaluations: red porgy overfished (static SPR = 14-19%)	Amendment 11	12/2/1999
For Red porgy: -MSY=4.38 mp; OY=45% static SPR; MFMT=0.43; MSST=7.34 mp; rebuilding timeframe=18 years (1999=year 1); -No sale of red porgy during Jan-April; -1 fish bag limit; -50 lb. bycatch commercial trip limit May-December	Amendment 12	9/22/2000
-Extended for an indefinite period the regulation prohibiting fishing for and possessing snapper grouper species within the *Oculina* Experimental Closed Area.	Amendment 13A	4/26/2004

Red Porgy: Commercial and recreational: -Retained 14" TL size limit and seasonal closure (retention limited to the bag limit); -Specified a commercial quota of 127,000 lbs gw and prohibit sale/purchase and prohibit harvest and/or possession beyond the bag limit when quota is taken and/or during January through April; -Increased commercial trip limit from 50 lbs ww to 120 fish (210 lbs gw) during May through December -Increased recreational bag limit from one to three red porgy per person per day or per trip, whichever is more restrictive.	Amendment 13C	10/23/2006
-Established eight deepwater Type II marine protected areas (MPAs) to protect a portion of the population and habitat of long-lived deepwater snapper grouper species.	Amendment 14	2/12/2009
-Updated management reference points and defined rebuilding strategy for red porgy.	Amendment 15A	3/14/2008
-Established recreational and commercial shallow water grouper spawning closure January through April to address overfishing of gag -Established recreational closed season for vermilion snapper from November through March. -Required venting and dehooking tools when catching snapper grouper species to reduce recreational and commercial bycatch mortality.	Amendment 16	2/29/2009
-Prohibited the sale of snapper grouper species harvested or possessed in the EEZ under the bag limits and prohibited the sale of snapper grouper species harvested or possessed under the bag limits by vessels with a Federal charter vessel/headboat permit for South Atlantic snapper grouper regardless of where harvested. -Established allocations for red porgy (50% commercial & 50% recreational). Commercial quota = 190,050 lbs gutted weight (197,652 lbs whole weight). Recreational quota = 190,050 lbs gutted weight.	Amendment 15B	2/15/2010
-Required use of non-stainless-steel circle hooks when fishing for snapper grouper species with hook-and-line gear north of 28 deg. N latitude in the South Atlantic EEZ -Implemented an area closure for snapper-grouper species.	Amendment 17A	3/3/2011

-Limit harvest of snapper grouper species in SC SMZs to the bag limit;	Amendment 23 (Comprehensive Ecosystem-based Amendment 2)	1/30/2012
-Reorganized FMU into 6 complexes (deepwater, jacks, snappers, grunts, shallow-water groupers, porgies) (see final rule for species list); -Established acceptable biological catch (ABC) control rules and established ABCs, ACLs, and AMs for species not undergoing overfishing; -Established commercial quota as commercial ACL for red porgy and specified recreational ACL (197,652 lbs ww).	Amendment 25 (Comprehensive ACL Amendment)	4/16/2012
-Modified the restriction on retention of bag limit quantities of some snapper grouper species by captain and crew of for-hire vessels;	Amendment 27	1/27/2014
-Required headboat vessels to report electronically at weekly intervals.	Amendment 31 (Joint South Atlantic and Gulf of Mexico Generic Headboat Reporting Amendment)	1/27/2014
-Modified accountability measures for snapper grouper species, including red porgy	Amendment 34 (Generic Accountability Measures and Dolphin Allocation Amendment)	2/22/2016
-Established SMZs to enhance protection for snapper-grouper species in spawning condition	Amendment 36	7/31/2017

SAFMC Regulatory Amendments affecting Red Porgy

Description of Action	Amendment	Effective Date
-Prohibited fishing in SMZs except with hand-held hook-and-line and spearfishing gear	Regulatory Amendment 1	3/27/1987
-Allowed multi-gear trips for black sea bass and allowed retention of incidentally-caught snapper grouper species on black sea bass trips -As FYI - from 1990 through 2017, red porgy were incidentally caught in 46% of hook-and-line black sea bass trips and 13% of trips with pot gear.	Regulatory Amendment 4	7/6/1993
-Eliminated closed area for snapper grouper species approved in Amendment 17A.	Regulatory Amendment 10	5/31/2011
-MSY=834,000 lbs whole weight -OY=ACL=ABC 2013=306,000 lbs ww 2014=309,000 lbs ww	Regulatory Amendment 18	9/5/2013
2015 and subsequent years=328,000 lbs ww; -Revised commercial/recreational ACL (as FYI – gutted weight determined with conversion factor of 1.04 from commercial logbooks): 2013=147,115 lbs gw (153,000 lbs ww) 2014=148,558 lbs gw (154,500 lbs ww) 2015 and subsequent years=157,692 lbs gw (164,000 lbs ww) -Removed vermilion snapper November through March recreational closure		
-Modified the gag commercial AM to remove the requirement that all other shallow water groupers (black grouper, red grouper, scamp, red hind, rock hind, graysby, coney, yellowmouth grouper, and yellowfin grouper) are prohibited from harvest in the South Atlantic when the gag commercial ACL is met or projected to be met.	Regulatory Amendment 15	9/12/2013
-Implemented an annual closure on the use of black sea bass pots from November 1 to April 30.	Regulatory Amendment 19	10/23/13
-Modified the definition of the overfished threshold (MSST) for several snapper grouper species, including red porgy. $MSST=75\%SSB_{MSY}$	Regulatory Amendment 21	11/6/2014
-Revise the area where fishing with black sea bass pots is prohibited from Nov.1-April 30.	Regulatory Amendment 16	12/29/2016

2.1.1 Emergency and Interim Rules

- For Black Seabass – modified definition of bsb pot; allowed multi-gear trips for bsb; allowed retention of incidentally-caught fish on bsb trips
  Initial emergency rule 8/31/1992; emergency rule extension 11/30/1992

- Prohibited harvest or possession of red porgy effective 9/8/1999 – Rule expired on 8/28/2000

2.1.2 Secretarial Amendments

None

2.1.3 Control Date Notices

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.

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.

Notice of Control Date (3/8/07 72 FR 60794) - Considered measures to limit participation in the snapper grouper for-hire sector effective 3/8/07.

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.

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.

2.1.4 Management Program Specifications

Table 2.1.4.1. General Management Information South Atlantic

Species	Red Porgy (*Pagrus pagrus*)
Management Unit	Southeastern US
Management Unit Definition	All waters within South Atlantic Fishery Management Council Boundaries
Management Entity	South Atlantic Fishery Management Council
Management Contacts SERO / Council	SAFMC: Myra Brouwer SERO: Rick DeVictor
Current stock exploitation status	Not undergoing overfishing
Current stock biomass status	Overfished

Table 2.1.4.2. Management Parameters

Criteria		South Atlantic – Current (2012 SEDAR 1 Update)		
	Definition	Base Run Values	Units	Median of Base Run MCBs
MSST	$(1-M)*SSB_{MSY}$	3,048	mt of all mature fish	
MFMT	F_{MSY}, if available; F_{MSY} proxy if not	0.17	per year	
F_{MSY}	F_{MSY}	0.17	per year	
MSY	Yield at F_{MSY}, landings	834	1,000 lbs.	
B_{MSY}[1]	Spawning stock biomass	4,254	mt of all mature fish	
R_{MSY}	Recruits at MSY	2,222	1,000 age-0 fish	
F Target	75% F_{MSY}	0.13	per year	
Yield at F_{TARGET} (equilibrium)	Landings	810	1,000 lbs.	
M	Natural mortality, constant across ages	0.225	per year	
$F_{Current}$ (2009-2011)	Geometric mean of F in last 3 years	0.11	per year	
Terminal Biomass (2011)[1]	Spawning Stock Biomass in terminal year	2,018	mt of all mature fish	
Exploitation Status	$F_{2009-2011}/F_{MSY}$	0.64		
Biomass Status[1]	$SSB_{2011}/MSST$ SSB_{2011}/SSB_{MSY}	0.61 0.47		
Generation Time		8	years	
$T_{REBUILD}$ (if appropriate)		18*	years	

* Am 12 established 18-year rebuilding schedule with 1991 = year 1

Table 2.1.4.2 Continued Management Parameters

Criteria	South Atlantic – Proposed (values from SEDAR 60)		
	Definition	Base Run Values	Median of Base Run MCBs
MSST[1]	75%SSB_{MSY}		
MFMT	F_{MSY}, if available; $F_{30\%\ SPR}$ proxy [2]		
F_{MSY}	F_{MSY}		
MSY	Yield at F_{MSY}, landings in pounds		
B_{MSY}[1]	Spawning stock biomass		
R_{MSY}	Recruits at MSY		
F Target	75% F_{MSY}		
Yield at F_{TARGET} (equilibrium)	Landings in pounds		
M	Natural mortality, average across ages		
$F_{Current}$	Geometric mean of F in last 3 years		
Terminal Biomass[1]	Spawning Stock Biomass in terminal year		
Exploitation Status	$F_{Current}$/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.

2.1.5 Stock Rebuilding Information

Amendment 12 (SAFMC 2000) established an 18-year rebuilding schedule for red porgy with 1991 being year 1.

The most recent assessment update (SEDAR 1 update 2012) included data through 2011, adding an additional six years of landings information to the 2006 update. The South Atlantic Council's SSC reviewed the 2012 assessment update for red porgy in October 2012. The National Standard 1 Guidelines state that, for overfished stocks and stock complexes, a rebuilding ABC must be set to reflect the annual catch that is consistent with the schedule of fishing mortality rates in the rebuilding plan. None of the projection scenarios in the assessment update demonstrated that red porgy could be rebuilt by the end of the rebuilding schedule (2018) even in the absence of fishing mortality. Hence, the SSC recommended using a provision of the NMFS National Standard 1 (NS1) that states "if the stock or stock complex has not rebuilt by T_{MAX}, then the fishing mortality rate should be maintained at $F_{REBUILD}$ or 75% of the maximum fishing mortality threshold (MFMT), whichever is less." Since F at 75% of F_{MSY} estimated in the model is very close to the level associated with red porgy bycatch harvest, the SSC recommended using this value in setting the acceptable biological catch (ABC).

Table 2.1.5.1. General Projection Specifications

South Atlantic

First Year of Management	Assume management begins in 2020. However, if there are no changes to the reference points, a projection with the revised ABC and OFL should be provided assuming that landings limits are changed in the 2019 fishing year.
Interim basis	SEDAR 60 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 ACL is met Average exploitation, if ACL is not met
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 2.1.5.2 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 2.1.5.3. 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*	35%	Interim + 5	Probability of overfishing
Exploitation	F_{MSY}	Interim + 5	NA
Exploitation	75% of F_{MSY}	Interim + 5	NA

Table 2.1.5.4. Quota Calculation Details
If the stock is managed by quota, please provide the following information

Current Acceptable Biological Catch (ABC) and Total Annual Catch Level (ACL) Value for Red Porgy	328,000 lbs ww
Commercial ACL for Red Porgy	164,000 lbs ww
Recreational ACL for Red Porgy	164,000 lbs ww
Next Scheduled Quota Change	N/A
Annual or averaged quota?	annual
If averaged, number of years to average	N/A
Does the quota include bycatch/discard?	No

How is the quota calculated - conditioned upon exploitation or average landings?
The ACL is set equal to the ABC, which comes directly from the assessment projections. The sector allocations were set by the Council at 50% commercial and 50% recreational. These allocations were chosen because they were closest to the status quo at the time allocations were being discussed for Red Porgy (average landings 1999-2003 were 49% commercial:51% recreational).

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 explicitly include estimates of discards in it. However, the projections assume a certain number of dead discards will occur when the quota is met and that the total F associated with both the landings and discards will not result in overfishing.

Are there additional details of which the analysts should be aware to properly determine quotas for this stock?

2.2 SAFMC Management and Regulatory Timeline

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

Table 2.2.1 South Atlantic Red Porgy Federal Commercial Regulatory History

prepared by: Myra Brouwer

Year	Quota (lbs)	ACL (lbs)	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	Retention Limit Start Date	Retention Limit End Date
1983[A]	NA	NA	365	open	NA	1-Jan	31-Dec	NA	31-Aug	31-Dec	none	NA	NA
1984	NA	NA	365	open	NA	1-Jan	31-Dec	NA	1-Jan	31-Dec	none	NA	NA
1985	NA	NA	365	open	NA	1-Jan	31-Dec	NA	1-Jan	31-Dec	none	NA	NA
1986	NA	NA	365	open	NA	1-Jan	31-Dec	NA	1-Jan	31-Dec	none	NA	NA
1987	NA	NA	365	open	NA	1-Jan	31-Dec	NA	1-Jan	31-Dec	none	NA	NA
1988	NA	NA	365	open	NA	1-Jan	31-Dec	NA	1-Jan	31-Dec	none	NA	NA
1989	NA	NA	365	open	NA	1-Jan	31-Dec	NA	1-Jan	31-Dec	none	NA	NA
1990	NA	NA	365	open	NA	1-Jan	31-Dec	NA	1-Jan	31-Dec	none	NA	NA
1991	NA	NA	365	open	NA	1-Jan	31-Dec	NA	1-Jan	31-Dec	none	NA	NA
1992[B]	NA	NA	365	open	NA	1-Jan	31-Dec	12[B]	1-Jan	31-Dec	none	NA	NA
1993	NA	NA	365	open	NA	1-Jan	31-Dec	12	1-Jan	31-Dec	none	NA	NA
1994	NA	NA	365	open	NA	1-Jan	31-Dec	12	1-Jan	31-Dec	none	NA	NA
1995	NA	NA	365	open	NA	1-Jan	31-Dec	12	1-Jan	31-Dec	none	NA	NA
1996	NA	NA	365	open	NA	1-Jan	31-Dec	12	1-Jan	31-Dec	none	NA	NA
1997	NA	NA	365	open	NA	1-Jan	31-Dec	12	1-Jan	31-Dec	none	NA	NA
1998	NA	NA	365	open	NA	1-Jan	31-Dec	12	1-Jan	31-Dec	none	NA	NA
1999[C]	NA	NA	53	open	NA	1-Jan	23-Feb	12	1-Jan	23-Feb	none	NA	NA
			4	open	NA	24-Feb	28-Feb	14[C]	24-Feb	28-Feb	none	NA	NA
			61	closed	seasonal	1-Mar	30-Apr	14	1-Mar	30-Apr	5 fish[C]	1-Mar	30-Apr
			129	open	NA	1-May	7-Sep	14	1-May	31-Dec	none	NA	NA
			114	closed	emergency rule[D]	8-Sep	31-Dec						
2000[D, E]	NA	NA	239	closed	emergency rule	1-Jan	27-Aug						
			24	open	NA	28-Aug	21-Sep	14	28-Aug	21-Sep	none	NA	NA
			100	open		22-Sep	31-Dec	14	22-Sep	31-Dec	50 lbs ww[E]	22-Sep	31-Dec
2001	NA	NA	119	closed	seasonal	1-Jan	30-Apr	14	1-Jan	30-Apr	1 fish[E]	1-Jan	30-Apr
			244	open	NA	1-May	31-Dec	14	1-May	31-Dec	50 lbs ww	1-May	31-Dec
2002	NA	NA	119	closed	seasonal	1-Jan	30-Apr	14	1-Jan	31-Dec	1 fish	1-Jan	30-Apr
			244	open	NA	1-May	31-Dec	14	1-May	31-Dec	50 lbs ww	1-May	31-Dec
2003	NA	NA	119	closed	seasonal	1-Jan	30-Apr	14	1-Jan	30-Apr	1 fish	1-Jan	30-Apr
			244	open	NA	1-May	31-Dec	14	1-May	31-Dec	50 lbs ww	1-May	31-Dec
2004	NA	NA	120	closed	seasonal	1-Jan	30-Apr	14	1-Jan	30-Apr	1 fish	1-Jan	30-Apr
			244	open	NA	1-May	31-Dec	14	1-May	31-Dec	50 lbs ww	1-May	31-Dec
2005	NA	NA	119	closed	seasonal	1-Jan	30-Apr	14	1-Jan	30-Apr	1 fish	1-Jan	30-Apr
			244	open	NA	1-May	31-Dec	14	1-May	31-Dec	50 lbs ww	1-May	31-Dec
2006[F]	NA	NA	119	closed	seasonal	1-Jan	30-Apr	14	1-Jan	30-Apr	1 fish	1-Jan	30-Apr
			174	open	NA	1-May	22-Oct	14	1-May	22-Oct	50 lbs ww	1-May	22-Oct
	127,000 lbs gw[F]	NA	69	open	NA	23-Oct	31-Dec	14	23-Oct	31-Dec	120 fish[F]	23-Oct	31-Dec
2007			119	closed	seasonal	1-Jan	30-Apr	14	1-Jan	30-Apr	3 fish[F]	1-Jan	30-Apr
	127,000 lbs gw		244	open	NA	1-May	31-Dec	14	1-May	31-Dec	120 fish	1-May	31-Dec
2008		NA	120	closed	seasonal	1-Jan	30-Apr	14	1-Jan	30-Apr	3 fish	1-Jan	30-Apr
	127,000 lbs gw		244	open	NA	1-May	31-Dec	14	1-May	31-Dec	120 fish	1-May	31-Dec
2009[G]			119	closed	seasonal	1-Jan	30-Apr	14	1-Jan	30-Apr	3 fish	1-Jan	30-Apr
	127,000 lbs gw		244	open	NA	1-May	31-Dec	14	1-May	31-Dec	120 fish	1-May	31-Dec
2010[H]		NA	119	closed	seasonal	1-Jan	30-Apr	14	1-Jan	30-Apr	3 fish	1-Jan	30-Apr
	190,050 lbs gw[H]		244	open	NA	1-May	31-Dec	14	1-May	31-Dec	120 fish	1-May	31-Dec
2011[I]		NA	119	closed	seasonal	1-Jan	30-Apr	14	1-Jan	30-Apr	3 fish	1-Jan	30-Apr
	190,050 lbs gw		244	open	NA	1-May	31-Dec	14	1-May	31-Dec	120 fish	1-May	31-Dec
2012[J]	NA		120	closed	seasonal	1-Jan	30-Apr	14	1-Jan	30-Apr	3 fish	1-Jan	30-Apr
		190,050 lbs gw[J]	244	open	NA	1-May	31-Dec	14	1-May	31-Dec	120 fish	1-May	31-Dec
2013[K]	NA	190,050 lbs gw	119	closed	seasonal	1-Jan	30-Apr	14	1-Jan	30-Apr	3 fish	1-Jan	30-Apr
			126	open	NA	1-May	4-Sep	14	1-May	4-Sep	120 fish	1-May	4-Sep
		153,000 lbs gw[K]	87	open	NA	5-Sep	1-Dec	14	5-Sep	31-Dec	120 fish	5-Sep	31-Dec
			29	closed	met ACL	2-Dec	31-Dec	14	5-Sep	31-Dec	120 fish	5-Sep	31-Dec
2014[K, L]		154,500 lbs ww	119	closed	seasonal	1-Jan	30-Apr	14	1-Jan	30-Apr	3 fish	1-Jan	30-Apr
			244	open	NA	1-May	31-Dec	14	1-May	31-Dec	120 fish	1-May	31-Dec
2015[K]		164,000 lbs ww	119	closed	seasonal	1-Jan	30-Apr	14	1-Jan	30-Apr	3 fish	1-Jan	30-Apr
			244	open	NA	1-May	31-Dec	14	1-May	31-Dec	120 fish	1-May	31-Dec
2016		164,000 lbs ww	120	closed	seasonal	1-Jan	30-Apr	14	1-Jan	30-Apr	3 fish	1-Jan	30-Apr
			244	open	NA	1-May	31-Dec	14	1-May	31-Dec	120 fish	1-May	31-Dec
2017		164,000 lbs ww	119	closed	seasonal	1-Jan	30-Apr	14	1-Jan	30-Apr	3 fish	1-Jan	30-Apr
			244	open	NA	1-May	31-Dec	14	1-May	31-Dec	120 fish	1-May	31-Dec

A: Original SAFMC FMP effective 8/31/1983 included the 4" trawl mesh size regulation.
B: Amendment 4 (effective date 1/1/92) included establishment of commercial 12 in TL size limit. Established rebuilding timeframe for red porgy <= 10 yrs (year 1=1991)
C: Amendment 9 (effecive 2/24/1999) increased the commercial minimum size limit to 14 inches TL; harvest and retention during March and April limited to the bag limit (5 per person per day) and no purchase and sale.
D: Emergency Rule prohibited harvest and possession of red porgy from 9/8/1999 through 8/28/2000
E: Amendment 12(effective 9/22/2000) included rebuilding timeframe=18 years (1999=year 1); no sale of red porgy during Jan-April; 50-pound (ww) commercial trip limit; retention limited to bag limit during seasonal closure
F: Amendment 13C (effective 10/23/06) retained recreational 14 in TL size limit and established commmercial quota of 127,000 gw; increased trip limit to 120 fish May-Dec; increased retention limit to 3 fish (ppd or ppt, whichever more restrictive)
G: Amendment 16 (gag and vermilion snapper management measures; effective 2/29/2009) established Jan-April SWG closure and commercial split season for VS
H: Amendment 15B (effective 2/15/2010): established 50/50 sector allocations; comm quota=190,050 lbs gw
I: Amendment 17 A (effective 3/3/2011): required the use of non-stainless steel circle hooks when fishing for SG species with natural baits north of 28 degrees N Latitude
J: Comprehensive ACL Amendment (effective 4/16/2012): Established commercial quota as commercial ACL for red porgy
K: Regulatory Amendment 18 (effective 9/5/2013): adjusted MSY, OY, ABC, and ACLs through 2015 and thereafter
L: Regulatory Amendmnt 21 (effective 11/6/2014): modified MSST to 75% SSBmsy for red porgy

lbs = pounds
gw = gutted weight
ww = whole weight

2.2.2 South Atlantic Red Porgy Federal Recreational Regulatory History
prepared by: Myra Brouwer

Year	Quota (lbs)	ACL (lbs)	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
1983[A]	NA	NA	365	open	NA	1-Jan	31-Dec	NA	31-Aug	31-Dec	NA	NA	NA
1984	NA	NA	365	open	NA	1-Jan	31-Dec	NA	1-Jan	31-Dec	NA	NA	NA
1985	NA	NA	365	open	NA	1-Jan	31-Dec	NA	1-Jan	31-Dec	NA	NA	NA
1986	NA	NA	365	open	NA	1-Jan	31-Dec	NA	1-Jan	31-Dec	NA	NA	NA
1987	NA	NA	365	open	NA	1-Jan	31-Dec	NA	1-Jan	31-Dec	NA	NA	NA
1988	NA	NA	365	open	NA	1-Jan	31-Dec	NA	1-Jan	31-Dec	NA	NA	NA
1989	NA	NA	365	open	NA	1-Jan	31-Dec	NA	1-Jan	31-Dec	NA	NA	NA
1990	NA	NA	365	open	NA	1-Jan	31-Dec	NA	1-Jan	31-Dec	NA	NA	NA
1991	NA	NA	365	open	NA	1-Jan	31-Dec	NA	1-Jan	31-Dec	NA	NA	NA
1992[B]	NA	NA	365	open	NA	1-Jan	31-Dec	12[B]	1-Jan	31-Dec	NA	NA	NA
1993	NA	NA	365	open	NA	1-Jan	31-Dec	12	1-Jan	31-Dec	NA	NA	NA
1994	NA	NA	365	open	NA	1-Jan	31-Dec	12	1-Jan	31-Dec	NA	NA	NA
1995	NA	NA	365	open	NA	1-Jan	31-Dec	12	1-Jan	31-Dec	NA	NA	NA
1996	NA	NA	365	open	NA	1-Jan	31-Dec	12	1-Jan	31-Dec	NA	NA	NA
1997	NA	NA	365	open	NA	1-Jan	31-Dec	12	1-Jan	31-Dec	NA	NA	NA
1998	NA	NA	365	open	NA	1-Jan	31-Dec	12	1-Jan	31-Dec	NA	NA	NA
1999[C, D]	NA	NA	250	open	NA	1-Jan	23-Feb	12	1-Jan	23-Feb	NA	1-Jan	23-Feb
						24-Feb	7-Sep	14[C]	24-Feb	7-Sep	5[C]	24-Feb	7-Sep
			115	closed	emergency rule[D]	8-Sep	31-Dec						
2000[D, E]	NA	NA	239	closed	emergency rule	1-Jan	27-Aug						
	NA	NA	126	open	NA	28-Aug	21-Sep	14	28-Aug	21-Sep	5	28-Aug	21-Sep
				open	NA	22-Sep	31-Dec	14	22-Sep	31-Dec	1[E]	22-Sep	31-Dec
2001	NA	NA	365	open	NA	1-Jan	31-Dec	14	1-Jan	31-Dec	1	1-Jan	31-Dec
2002	NA	NA	365	open	NA	1-Jan	31-Dec	14	1-Jan	31-Dec	1	1-Jan	31-Dec
2003	NA	NA	365	open	NA	1-Jan	31-Dec	14	1-Jan	31-Dec	1	1-Jan	31-Dec
2004	NA	NA	365	open	NA	1-Jan	31-Dec	14	1-Jan	31-Dec	1	1-Jan	31-Dec
2005	NA	NA	365	open	NA	1-Jan	31-Dec	14	1-Jan	31-Dec	1	1-Jan	31-Dec
2006[F]	NA	NA	365	open	NA	1-Jan	22-Oct	14	1-Jan	22-Oct	1	1-Jan	22-Oct
						23-Oct	31-Dec	14	23-Oct	31-Dec	3[F]	23-Oct	31-Dec
2007	NA	NA	365	open	NA	1-Jan	31-Dec	14	1-Jan	31-Dec	3	1-Jan	31-Dec
2008	NA	NA	365	open	NA	1-Jan	31-Dec	14	1-Jan	31-Dec	3	1-Jan	31-Dec
2009	NA	NA	365	open	NA	1-Jan	31-Dec	14	1-Jan	31-Dec	3	1-Jan	31-Dec
2010[G]	NA	NA	365	open	NA	1-Jan	14-Feb	14	1-Jan	14-Feb	3	1-Jan	14-Feb
	190,050 gw[G]	NA				15-Feb	31-Dec	14	15-Feb	31-Dec	3	15-Feb	31-Dec
2011[H]	190,050 gw	NA	365	open	NA	1-Jan	31-Dec	14	1-Jan	31-Dec	3	1-Jan	31-Dec
2012[I]	190,050 gw	NA	365	open	NA	1-Jan	15-Apr	14	1-Jan	15-Apr	3	1-Jan	15-Apr
	NA	197,652 ww[I]				16-Apr	31-Dec	14	16-Apr	31-Dec	3	16-Apr	31-Dec
2013[J]	NA	197,652 ww	365	open	NA	1-Jan	4-Sep	14	1-Jan	4-Sep	3	1-Jan	4-Sep
		153,000 ww[J]				5-Sep	31-Dec	14	5-Sep	31-Dec	3	5-Sep	31-Dec
2014	NA	154,500 ww	365	open	NA	1-Jan	31-Dec	14	1-Jan	31-Dec	3	1-Jan	31-Dec
2015	NA	164,000 ww	365	open	NA	1-Jan	31-Dec	14	1-Jan	31-Dec	3	1-Jan	31-Dec
2016	NA	164,000ww	365	open	NA	1-Jan	31-Dec	14	1-Jan	31-Dec	3	1-Jan	31-Dec
2017	NA	164,000 ww	365	open	NA	1-Jan	31-Dec	14	1-Jan	31-Dec	3	1-Jan	31-Dec

A: Original SAFMC FMP effective 8/31/1983 -included the 4" trawl mesh size regulation
B: Amendment 4 (effective date 1/1/92) included establishment of recreational 12 in TL size limit and rebuilding timeframe <= 10 years (year 1 = 1991)
C: Amendment 9 (effective 2/24/99) included increase in recreational minimum size limit to 14 in TL and established recreational bag limit of 5 fish per person per day
D: Emergency Rule prohibited harvest and possession of red porgy from 9/8/1999 through 8/28/2000
E: Amendment 12(effective 9/22/2000) included rebuilding timeframe=18 years (1999=year 1); no sale of red porgy during Jan-April; 1 fish recreational bag limit
F: Amendment 13C (effective 10/23/06) retained recreational 14 in TL size limit and increased bag limit to 3 per person per day or per trip, whichever is more restrictive
G: Amendment 15B (effective 2/15/2010) prohibited the sale of snapper grouper species harvested or possessed in the EEZ under the bag limits and prohibited the sale of snapper grouper species harvested or possessed under the bag limits by vessels with a Federal charter vessel/headboat permit for South Atlantic snapper grouper regardless of where harvested.
Established allocations for red porgy (50% commercial & 50% recreational). Recreational quota = 190,050 lbs gutted weight.
H: Amedment 17A (effective 3/3/2011) required use of circle hooks when fishing for sg species with hook-and-line gear and natural baits north of 28 degrees N Latitude
I: Comprehensive ACL Amendment (effective 4/16/2012) established quota as ACL
J: Regulatory Amendment 18 (effective 9/5/13) revised MSY, OY, ABC and ACLs
gw = gutted weight
ww = whole weight

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

Commercial closure – 12/02/2013 – exceeded commercial ACL

2.3 . State Regulatory History

2.3.1 North Carolina:

There are currently no North Carolina state-specific regulations for red porgy. North Carolina has complemented federal regulations, including quota and/or annual catch limit closures, for all snapper grouper species via proclamation authority since January 1991, when rule 15A NCAC 03M .0506 was first implemented:

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/methods; and
(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 rule was modified slightly to remove the phrase "until September 1, 1991" effective September 1, 1991. The first proclamation (FF-19-94) pertaining to red porgy was issued under the authority of this rule effective July 1, 1994 and established a 12-inch total length minimum size limit (both sectors).

Rule 15A NCAC 03M .0506 remained unchanged until March 1, 1996 when species-specific regulations for all snapper grouper species were added to the proclamation authority contained in the rule. Specific to red porgy, the rule was amended to include the minimum size limit initially established in FF-19-94:

15A NCAC 03M .0506 SNAPPER-GROUPER

…

(n) It is unlawful to possess red porgy (pink or silver snapper) less than 12 inches total length.

…

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.

In addition to the above change, rule 15A NCAC 03M .0512 was implemented effective March 1, 1996 and provided supplementary proclamation authority to the Fisheries Director to modify any existing size and harvest limits for species subject to interstate and federal management:

15A NCAC 03M .0152 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; 143B-289.4; Eff. March 1, 1996.

Proclamation FF-11-99 was issued effective March 1, 1999 and established a prohibition on the sale and purchase of red porgy during the months of March and April to complement the federal spawning closure. This was subsequently incorporated into modifications to rule 15A NCAC 03M .0506 that became effective in May 1999; these included additional restrictions on harvest of red porgy and movement of regulations to a different sub-item within the rule:

15A NCAC 03M .0506 SNAPPER-GROUPER
…
(o) Red Porgy:
(1) It is unlawful to possess red porgy (pink or silver snapper) less than 14 inches total length.
(2) It is unlawful to possess more than five red porgy per person per day without a valid Federal Commercial Snapper-Grouper permit.
(3) It is unlawful to possess more than five red porgy per person per day during the months of March and April.
(4) It is unlawful to sell or purchase red porgy taken from waters under the jurisdiction of North Carolina or the South Atlantic Fishery Management Council during the months of March and April.
…
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. Temporary Amendment Eff.

December 23, 1996; Amended Eff. August 1, 1998; April 1, 1997; Temporary Amendment Eff.

May 24, 1999.

Proclamation FF-20-99 was issued effective September 15, 1999 which prohibited all commercial and recreational harvest and possession, complementing the federal emergency closure of the fishery.

On August 29, 2000 rule 15A NCAC 03M .0506 was amended to reflect the reopening of the commercial and recreational fisheries and additional changes in red porgy harvest seasons and possession limits:

15A NCAC 03M .0506 SNAPPER-GROUPER

(o) Red Porgy (*Pagrus pagrus*):

(1) It is unlawful to possess red porgy (pink or silver snapper) less than 14 inches total length.

(2) It is unlawful to possess more than one red porgy per person per day without a valid Federal Commercial Snapper-Grouper permit.

(3) It is unlawful to sell or offer for sale red porgy from January 1 through April 30.

(4) It is unlawful to land more than 50 pounds of red porgy from May 1 through December 31 in a commercial fishing operation.

…

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. Temporary Amendment Eff.

December 23, 1996; Amended Eff. August 1, 1998; April 1, 1997; Temporary Amendment Eff.

August 29, 2000; January 1, 2000; May 24, 1999.

No further modifications to rule 15A NCAC 03M .0506 pertaining to red porgy were implemented. In 2002, North Carolina adopted its Inter-Jurisdictional Fishery Management Plan (IJ FMP), which incorporates all Atlantic States Marine Fisheries Commission and council- managed species by reference and adopts all federal regulations as minimum standards for management, as appropriate. In 2007, the statutorily-mandated five-year review of the IJ FMP began, with final adoption of the updated plan in 2008. Changes to the FMP included removal of all species-specific regulations from rule 15A NCAC 03M .0506 effective October 1, 2008, and proclamation authority to implement changes for all species under federal or interstate management was moved to rule 15A NCAC 03M .0512.

Because the 2007/2008 review of the IJ FMP occurred during the time when additional changes in federal management of red porgy were implemented, several proclamations were issued in 2007 to suspend the relevant portions of rule 15A NCAC 03M .0506 and issue compatible regulations to reflect changes in commercial and recreational possession limits. (Because of requirements that continuing rule suspensions require N.C. Marine Fisheries Commission review and approval, issuance of multiple proclamations was required):

- FF-19-2007, FF-38-2007, FF-46-2007, FF-55-2007, FF-60-2007, FF-11-2008, FF-55-2008, FF-63-2008: Suspended relevant portions of 15A NCAC 03M .0506
- FF-20-2007, FF-39-2007, FF-42-2007, FF-47-2007, FF-56-2007, FF-60-2007, FF-10-2008, FF-54-2008, FF-64-2008: Implemented a three-fish/person daily possession limit for persons without a federal commercial snapper grouper permit; implemented a commercial trip limit of 120 red porgy (effective 2/26/2007 via FF-20-2007; maintained through subsequently dated proclamations)

Once the changes to rules 15A NCAC 03M .0506 and 03M .0512 described above were implemented, proclamation FF-66-2008 was issued effective October 1, 2008 and contained all relevant commercial and recreational regulations for all snapper grouper species. The portion of the proclamation specific to red porgy is excerpted as follows:

VIII. **Red Porgy**

A. It is unlawful to possess red porgy less than 14 inches total length.
B. It is unlawful to possess more than three red porgies per person per day without a valid Federal Commercial Snapper-Grouper permit.
C. It is unlawful to sell or offer for sale or purchase red porgy from January 1 through April 30.
D. It is unlawful for a vessel with a valid Federal Commercial Snapper-Grouper permit to possess or land more than 120 individual red porgy per vessel per trip from May 1 through December 31.

Because there have been no additional modifications to federal management of red porgy, the above regulations have been maintained in subsequent proclamations since 2008. Proclamation FF-66-2009 added the prohibition on sale of fish harvested under the recreational bag limit without a federal commercial snapper grouper permit (as per Amendment 15B) to the general regulations for the entire fishery. Future proclamations modified the construction of the regulations slightly to clarify commercial vs. recreational restrictions:

Red Porgy
A. For **recreational** purposes:
1. It is unlawful to possess red porgy less than 14 inches total length.
2. It is unlawful to possess more than three red porgies per person per day without a valid Federal Commercial Snapper-Grouper permit.

B. For **commercial** purposes:
1. It is unlawful to possess red porgy less than 14 inches total length.
2. It is unlawful to sell or offer for sale or purchase red porgy from January 1 through April 30.
3. It is unlawful for a vessel with a valid Federal Commercial South Atlantic Snapper-Grouper permit to possess or land more than 120 individual red porgy per vessel per trip from May 1 through December 31.

An information update to the IJ FMP was completed and approved in November 2015 and contained no additional modifications to rules 15A NCAC 03M .0506 and 15A NCAC 03M .0512. The only procedural modifications that have occurred are starting in 2013, proclamations establishing the size limits, possession limits and seasons for the upcoming calendar year ("season-opening" proclamations) have been issued in December of the preceding year; and beginning in 2015, commercial and recreational regulations have been moved into separate proclamations for ease of use by the public. The most current Snapper Grouper proclamations, as well as previous versions from 2001 onward, can be found online using this link: http://portal.ncdenr.org/web/mf/proclamations. Proclamations issued prior to 2001 are contained in hard copy archives.

Tables 1 and 2 contain a summary of recreational and commercial regulations, respectively. Because many snapper grouper proclamations are issued throughout the year to complement federal management measures, only those proclamations that were issued specific to red porgy in any one year are listed.

The current versions of rules 15A NCAC 03M .0506 and 15A NCAC 03M .0512 are below:

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.

Table 2.3.1.1. North Carolina recreational red porgy regulations in state waters 1991-2018. (TL = total length)

Year	Season	Min. Size (TL)	Daily Possession Limit	Regulation(s)
1991	Year-round	n/a	n/a	15A NCAC 03M .0506
1992	Year-round	n/a	n/a	15A NCAC 03M .0506
1993	Year-round	n/a	n/a	15A NCAC 03M .0506
1994	Year-round	12 inches	n/a	15A NCAC 03M .0506/FF-19-94 (eff. 7/1/1994)
1995	Year-round	12 inches	n/a	15A NCAC 03M .0506/FF-19-94
1996	Year-round	12 inches	n/a	15A NCAC 03M .0506/03M .0512/FF-19-94
1997	Year-round	12 inches	n/a	15A NCAC 03M .0506/03M .0512
1998	Year-round	12 inches	n/a	15A NCAC 03M .0506/03M .0512
1999*	Closed 9/15/1999	12/14 inches	5 fish/person	15A NCAC 03M .0506/03M .0512/FF-11-99, FF-20-99
2000**	Year-round	14 inches	1 fish/person	15A NCAC 03M .0506/03M .0512
2001	Year-round	14 inches	1 fish/person	15A NCAC 03M .0506/03M .0512
2002	Year-round	14 inches	1 fish/person	15A NCAC 03M .0506/03M .0512
2003	Year-round	14 inches	1 fish/person	15A NCAC 03M .0506/03M .0512
2004	Year-round	14 inches	1 fish/person	15A NCAC 03M .0506/03M .0512
2005	Year-round	14 inches	1 fish/person	15A NCAC 03M .0506/03M .0512
2006	Year-round	14 inches	1 fish/person	15A NCAC 03M .0506/03M .0512
2007***	Year-round	14 inches	3 fish/person	15A NCAC 03M .0506/03M .0512/FF-19-2007, FF-20-2007
2008	Year-round	14 inches	3 fish/person	15A NCAC 03M .0506/03M .0512/FF-10-2008, FF-11-2008, FF-66-2008
2009	Year-round	14 inches	3 fish/person	15A NCAC 03M .0506/03M .0512/FF-48-2009, FF-66-2009
2010	Year-round	14 inches	3 fish/person	15A NCAC 03M .0506/03M .0512/FF-60-2010
2011	Year-round	14 inches	3 fish/person	15A NCAC 03M .0506/03M .0512/FF-19-2011
2012	Year-round	14 inches	3 fish/person	15A NCAC 03M .0506/03M .0512/FF-10-2012
2013	Year-round	14 inches	3 fish/person	15A NCAC 03M .0506/03M .0512/FF-5-2013
2014	Year-round	14 inches	3 fish/person	15A NCAC 03M .0506/03M .0512/FF-76-2013
2015	Year-round	14 inches	3 fish/person	15A NCAC 03M .0506/03M .0512/FF-94-2014
2016	Year-round	14 inches	3 fish/person	15A NCAC 03M .0506/03M .0512/FF-71-2015
2017	Year-round	14 inches	3 fish/person	15A NCAC 03M .0506/03M .0512/FF-68-2016
2018	Year-round	14 inches	3 fish/person	15A NCAC 03M .0506/03M .0512/FF-57-2017(revised)

*FF-11-99 established March/April spawning closure (effective 3/1/1999); minimum size limit increase and possession limit established in changes to 15A NCAC 03M .0506 (effective 5/24/1999); federal emergency closure complemented via FF-20-99 (effective 9/15/1999)

**Possession limit change effective August 29, 2000

***Possession limit change effective February 26, 2007

Table 2.3.1.2. North Carolina commercial red porgy regulations in state waters 1991-2018. (TL = total length)

Year	Season	Min. Size (TL)	Trip/Possession Limit	Regulation(s)
1991	Year-round	n/a	n/a	15A NCAC 03M .0506
1992	Year-round	n/a	n/a	15A NCAC 03M .0506
1993	Year-round	n/a	n/a	15A NCAC 03M .0506
1994	Year-round	12 inches	n/a	15A NCAC 03M .0506/FF-19-94 (eff. 7/1/1994)
1995	Year-round	12 inches	n/a	15A NCAC 03M .0506/FF-19-94
1996	Year-round	12 inches	n/a	15A NCAC 03M .0506/03M .0512/FF-19-94
1997	Year-round	12 inches	n/a	15A NCAC 03M .0506/03M .0512
1998	Year-round	12 inches	n/a	15A NCAC 03M .0506/03M .0512
1999*	Closed March/April; fishery closure 9/15/1999	12/14 inches		15A NCAC 03M .0506/03M .0512/FF-11-99, FF-20-99
2000**	Closed January -April	14 inches	50 pounds	15A NCAC 03M .0506/03M .0512
2001	Closed January -April	14 inches	50 pounds	15A NCAC 03M .0506/03M .0512
2002	Closed January -April	14 inches	50 pounds	15A NCAC 03M .0506/03M .0512
2003	Closed January -April	14 inches	50 pounds	15A NCAC 03M .0506/03M .0512
2004	Closed January -April	14 inches	50 pounds	15A NCAC 03M .0506/03M .0512
2005	Closed January -April	14 inches	50 pounds	15A NCAC 03M .0506/03M .0512
2006	Closed January -April	14 inches	50 pounds	15A NCAC 03M .0506/03M .0512
2007***	Closed January -April	14 inches	120 fish	15A NCAC 03M .0506/03M .0512/FF-19-2007, FF-20-2007
2008	Closed January -April	14 inches	120 fish	15A NCAC 03M .0506/03M .0512/FF-10-2008, FF-11-2008, FF-66-2008
2009	Closed January -April	14 inches	120 fish	15A NCAC 03M .0506/03M .0512/FF-48-2009, FF-66-2009
2010	Closed January -April	14 inches	120 fish	15A NCAC 03M .0506/03M .0512/FF-60-2010
2011	Closed January -April	14 inches	120 fish	15A NCAC 03M .0506/03M .0512/FF-19-2011
2012	Closed January -April	14 inches	120 fish	15A NCAC 03M .0506/03M .0512/FF-10-2012
2013^	Closed January -April	14 inches	120 fish	15A NCAC 03M .0506/03M .0512/FF-5-2013, FF-64-2013
2014	Closed January -April	14 inches	120 fish	15A NCAC 03M .0506/03M .0512/FF-76-2013
2015	Closed January -April	14 inches	120 fish	15A NCAC 03M .0506/03M .0512/FF-93-2014
2016	Closed January -April	14 inches	120 fish	15A NCAC 03M .0506/03M .0512/FF-70-2015
2017	Closed January -April	14 inches	120 fish	15A NCAC 03M .0506/03M .0512/FF-67-2016
2018	Closed January -April	14 inches	120 fish	15A NCAC 03M .0506/03M .0512/FF-58-2017

*FF-11-99 established March/April spawning closure (effective 3/1/1999); minimum size limit increase and possession limit established in changes to 15A NCAC 03M .0506 (effective 5/24/1999); federal emergency closure complemented via FF-20-99 (effective 9/15/1999)

**Effective August 29, 2000

***Effective February 26, 2007

^ Commercial closure due to annual catch limit being met (effective December 2, 2013)

2.3.2 South Carolina:

1992: SC Code of Laws Section 50-17-510(C) adopted the federal minimum size limits automatically for all species managed under the Fishery Conservation and Management Act (PL94-265); and Section 50-17-510(F) adopted the federal catch and possession limits for a number of listed species managed under the Fishery Conservation and Management Act (PL94-265) as the Law of the State of SC, with all managed species of porgy specifically mentioned.

2001: SC Marine-related Laws reorganized under SC Code of Laws Title 50 Chapter 5. SC Code of Laws Section 50-5-2730 reads – "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 red porgy–related regulation is pulled directly from the federal regulations as promulgated under Magnuson. No changes have been made to this approach in covering red porgy since the Chapter 5 rewrite.

2.3.3 Georgia:

In Georgia current regulations for Red Porgy are 3 fish per person, 14 inch TL, open all year (GA DNR Reg, 391-2-4-.04 (3)(n)).

2.3.4 Florida:

Atlantic Red Porgy Regulation History

Year	Minimum Size Limit	Recreational Daily Harvest Limits	Commercial Daily Harvest Limits	Regulation Changes	Rule Change Effective Date
1980	None	None	None		
1981	None	None	None		
1982	None	None	None		
1983	None	None	None		
1984	None	None	None		
1985	None	None	None		
1986	None	None	None		
1987	None	2 fish or 250 pounds per person, whichever is greater	None		
1988	None	2 fish or 250 pounds per person, whichever is greater	None		

1989	None	2 fish or 100 pounds per person, whichever is greater	None		
1990	None	2 fish or 100 pounds per person, whichever is greater	None		
1991	None	2 fish or 100 pounds per person, whichever is greater	None		
1992	None	2 fish or 100 pounds per person, whichever is greater	None		
1993	None	2 fish or 100 pounds per person, whichever is greater	None		
1994	12 inches TL	2 fish or 100 pounds per person, whichever is greater	None	Established a minimum size limit of 12 inches for red porgy in Atlantic state waters. Modified rule language to provide the same definitions of Gulf of Mexico and Atlantic Ocean regions.	March 1, 1994
1995	12 inches TL	2 fish or 100 pounds per person, whichever is greater	None		
1996	12 inches TL	2 fish or 100 pounds per person, whichever is greater	None		

1997	12 inches TL	2 fish or 100 pounds per person, whichever is greater	None		
1998	14 inches TL	5 fish per person	5 fish per person	Increased the minimum size limit for Atlantic red porgy to 14 inches TL. Established a recreational bag limit for red porgy of 5 fish per person in Atlantic state waters. Allowed a two-day possession limit for red porgy for persons aboard charter and headboats on trips exceeding 24 hours provided the vessel is equipped with a permanent berth for each passenger aboard, and each passenger has a receipt verifying the trip length. Prohibited the harvest and sale of Atlantic red porgy in excess of the bag limit. Prohibited the sale of Atlantic red porgy in March and April. Established that if commercial harvest of red porgy is closed in adjacent federal waters, commercial harvest will close in state waters five days after the federal closure date and remain closed until federal waters reopen. Required that all reef fish species managed in Florida, including red porgy, be landed in whole condition. Designated allowable gear for all reef fish species, including red porgy, as hook-and-line, black sea bass traps, and spearing (does not include powerheads, bangsticks, or handheld devices employing an explosive charge).	December 31, 1998

1998 cont.	14 inches TL	5 fish per person	5 fish per person	Retention is limited to the recreational bag and possession limits when red porgy is harvested as incidental bycatch with gear that is not allowed. Designated red porgy as a "restricted species." This means harvesters must possess a Florida Saltwater Products License and Restricted Species Endorsement, as well as a federal snapper grouper commercial permit, to exceed the recreational bag limit and sell reef fish.	December 31, 1998
1999	14 inches TL	5 fish per person	5 fish per person	Closed Atlantic state waters to the recreational harvest of red porgy through March 5, 2000.	October 22, 1999
2000	Closed	Closed	Closed	(1) Eliminated the 5-day commercial closure extension. (2) Prohibited all harvest of red porgy from Atlantic state waters.	(1) January 1, 2000 (2) March 6, 2000
2001	14 inches TL	1 fish per person	50 lbs. per vessel	Allowed a one-fish per person daily recreational bag limit and a 50-pound commercial vessel limit for Atlantic red porgy. Established a minimum size limit of 14 inches total length for Atlantic red porgy. Prohibited commercial harvest and sale of Atlantic red porgy January through April. Permitted persons harvesting other species for commercial purposes during the closure to harvest and possess the recreational bag limit of red porgy.	March 1, 2001

2002	14 inches TL	1 fish per person	50 lbs. per vessel		
2003	14 inches TL	1 fish per person	50 lbs. per vessel		
2004	14 inches TL	1 fish per person	50 lbs. per vessel		
2005	14 inches TL	1 fish per person	50 lbs. per vessel		
2006	14 inches TL	1 fish per person	50 lbs. per vessel	Provided that, for purposes of determining the legal size of reef fish species, “total length” means the straight-line distance from the most forward point of the head with the mouth closed, to the farthest tip of the tail with the tail compressed or squeezed, while the fish is lying on its side.	July 1, 2006
2007	14 inches TL	3 fish per person	50 lbs. per vessel	Increased the daily recreational bag limit for Atlantic red porgy to 3 fish per person.	July 1, 2007
2008	14 inches TL	3 fish per person	50 lbs. per vessel		
2009	14 inches TL	3 fish per person	50 lbs. per vessel		
2010	14 inches TL	3 fish per person	50 lbs. per vessel	Required dehooking tools to be aboard commercial and recreational vessels for anglers to use as needed to remove hooks from Atlantic reef fish.	January 19, 2010
2011	14 inches TL	3 fish per person	50 lbs. per vessel		
2012	14 inches TL	3 fish per person	50 lbs. per vessel	Removed red porgy from the exception allowing a two-day possession limit for reef fish statewide for persons aboard charter and headboats on trips exceeding 24 hours.	July 1, 2012
2013	14 inches TL	3 fish per person	50 lbs. per vessel		
2014	14 inches TL	3 fish per person	50 lbs. per vessel		

2015	14 inches TL	3 fish per person	50 lbs. per vessel		
2016	14 inches TL	3 fish per person	50 lbs. per vessel		
2017	14 inches TL	3 fish per person	50 lbs. per vessel		
2018	14 inches TL	3 fish per person	50 lbs. per vessel		

References
None provided.

3. Assessment History

An early stock assessment of South Atlantic red porgy (Vaughan et al. 2001), conducted before the SEDAR process existed used age-aggregated and age-structured production models to determine status of the stock and the fishery. This assessment found the stock to be overfished (SSB_{2000}/MSST = 0.13 − 0.25) but not undergoing overfishing (F_{2000}/F_{MSY} = 0.34 −0.44).

The first SEDAR stock assessment of red porgy was a benchmark assessment which used the fully age-structured Beaufort Assessment Model (BAM) to model the population from 1972-2001 (SEDAR 01; SEDAR 2002). As of 2001, the stock was overfished (SSB_{2001}/MSST = 0.55; SSB_{2001}/SSB_{MSY} = 0.43), but overfishing was not occurring (F_{2001}/F_{MSY} = 0.45; SEDAR 2002). Following the benchmark, there have been two update assessments (SEDAR 2006; 2012) prior to the current standard assessment, both of which have also used the BAM as the primary model. Assessment model timelines for the update assessments are as follows: SEDAR 1, 2006 Update assessment (1972-2004; SEDAR 2006) and SEDAR 1, 2012 Update assessment (1972-2011; SEDAR 2012). The SEDAR 1, 2006 Update assessment found that the red porgy stock was not rebuilt (SSB_{2005}/SSB_{MSY} = 0.66), but was not undergoing overfishing (F_{2004}/F_{MSY} = 0.45). The SEDAR 1, 2012 Update assessment also found that the red porgy stock was not rebuilt (SSB_{2011}/SSB_{MSY} = 0.47) but was not undergoing overfishing ($F_{2009-2011}/F_{MSY}$ = 0.64).

Input values of constant M were the same for the three previous red porgy assessments (terminal years: 2001, 2004, 2011; M: 0.225, 0.225, 0.225). Steepness was estimated in all assessments and has decreased between the 2006 and 2012 updates (h: 0.48, 0.50, 0.41). Estimates of F_{MSY} have remained in a similar range (F_{MSY}: 0.19, 0.20, 0.17). Estimates of MSY have fluctuated [MSY (1000 lb): 826, 626, 834] and estimates of SSB_{MSY} have generally increased over the course of the three previous SEDAR assessments [SSB_{MSY}, (mt): 3050, 3236, 3933].

References

SEDAR, 2002. SEDAR 1: Stock Assessment of South Atlantic Red Porgy.
SEDAR, 2006. SEDAR 1 Update Assessment: Stock Assessment of Red Porgy off the Southeastern United States.
SEDAR, 2012. Stock Assessment of Red Porgy off the Southeastern United States: SEDAR Update Assessment.
Vaughan, D. S., E. H. Williams, and M. H. Prager. 2001. Updated status of red porgy off southeastern United States. Unpublished manuscript dated November 7, 2001. NOAA Center for Coastal Fisheries and Habitat Research, Beaufort, NC 28516. Prepared for the South Atlantic Fishery Management Council. One Southpark Circle, Suite 306. Charleston, SC 29407. .

4. Regional Maps

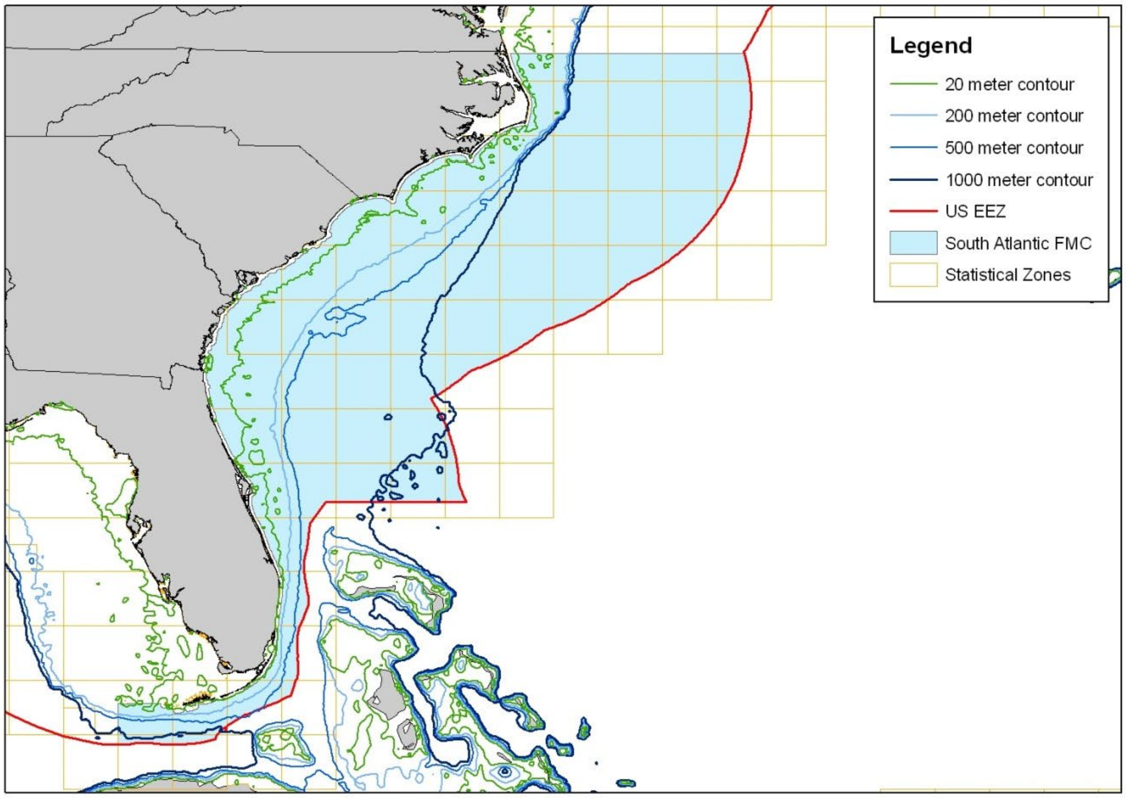

Figure 4.1: South Atlantic Fishery Management Council and EEZ boundaries.

5. 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
ASMFC	Atlantic States Marine Fisheries Commission
ASPIC	a stock production model incorporating covariates
ASPM	age-structured production model
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)
MAFMC	Mid-Atlantic Fishery Management Council
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
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 60

South Atlantic Red Porgy

Section II: Assessment Report

April 2020

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

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1 Introduction

1.1 Executive Summary

This standard assessment evaluated the stock of Red Porgy (*Pagrus pagrus*) off the southeastern United States. The primary objectives of this assessment were to update the 2002 SEDAR-1 benchmark, and 2006 and 2012 update assessments of Red Porgy and to conduct fresh stock projections. Data compilation and assessment methods were guided by methods used in previous Red Porgy assessments. The benchmark assessment included data from 1972–2001, the 2006 update contained data through 2004, the 2012 update included data through 2011 and this assessment contained data through 2017. This assessment was conducted by the Southeast Fisheries Science Center in cooperation with regional data providers.

Available data on this stock included indices of abundance, landings, discards, and samples of annual length compositions and age compositions from fishery-dependent and fishery-independent sources. Two indices of abundance were developed during the SEDAR process and fitted by the model: one from the NMFS headboat survey and one from the fishery-independent SouthEast Reef Fish Survey (SERFS: MARMAP, SEAMAP-SA, and SEFIS) program, combined chevron trap and video data. Landings data were available from all recreational and commercial fleets.

The model used in all previous assessments of this stock—and updated here—was the Beaufort Assessment Model (BAM), a statistical catch-age formulation. A base run of BAM was configured to provide 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 biomass has decreased considerably since the terminal year of the previous assessment (2011) and the 2017 value of SSB ($\mathrm{SSB}_{2017} = 780$ klb) was below the minimum stock size threshold (MSST = 2249 klb) using the Council's definition of MSST as $(1 - M)\mathrm{SSB}_{\mathrm{MSY}}$ and assuming a natural mortality rate of $M = 0.22$. This resulted in a terminal stock status estimate of $\mathrm{SSB}_{2017}/\mathrm{MSST} = 0.347$ and rebuild status estimate of $\mathrm{SSB}_{2017}/\mathrm{SSB}_{\mathrm{MSY}} = 0.27$. Though fishing mortality F was generally below or near $F_{\mathrm{MSY}} = 0.18$ between 2009 and 2015, it was substantially higher and above F_{MSY} in 2016 and 2017, with the terminal F-status estimate $F_{2015-2017}/F_{\mathrm{MSY}} = 1.73$. Recruitment has generally been declining throughout the time series, and has been below the recruitment level corresponding to MSY (R_{MSY}) for most of the past three decades. Thus, this assessment indicates that the stock is overfished, and undergoing overfishing.

The MCB analysis indicates that these estimates of stock and fishery status are robust, with little uncertainty in the conclusions. Of all MCB runs, 100% were in qualitative agreement that the stock is overfished ($\mathrm{SSB}_{2017}/\mathrm{MSST} < 1.0$), and 98.2% that the stock is experiencing overfishing ($F_{2015-2017}/F_{\mathrm{MSY}} \geq 1.0$).

The estimated trends from this standard assessment are similar to those from the SEDAR 1, 2002 Benchmark, and the 2006 and 2012 updates. However, this assessment did show some differences from previous assessments, which was not surprising, given modifications made to both the data and model (described throughout the report).

1.2 Workshop Time and Place

The SEDAR 60 South Atlantic Red Porgy Assessment took place over a series of webinars held January 29, 2018; March 25, 2019; November 15, 2019; January 22, 2020; February 6, 2020; and February 28, 2020 and an in-person workshop held December 10-12, 2019 at Beaufort NC.

1.3 Terms of Reference

1. Prepare a standard assessment, based on the approved 2012 SEDAR 1 South Atlantic Red Porgy Update assessment with data through 2017. Provide commercial and recreational landings and discards in pounds and numbers.

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 including the SERFS video index
   - Incorporate the latest BAM model configurations and updates to data calculation methodologies, detailing the changes made and the impacts of those changes, between the 2012 SEDAR 1 South Atlantic Red Porgy Update assessment model and the proposed SEDAR 60 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 2012 SEDAR 1 South Atlantic Red Porgy 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 (probability density function) for biological reference point estimates and yield separated for landings and discards reported in pounds and numbers. Projection results are required through 2024, with projected fishing level changes beginning in late 2019. The panel shall provide guidance on appropriate assumptions to address harvest and mortality levels in the interim years between the assessment terminal year (2017) and the first year of management (2019). Projection criteria:

   - To determine OFL: (1) P* = 50%; (2) F_{MSY}
   - To evaluate the existing rebuilding plan: base on fixed exploitation at $75\% F_{\mathrm{MSY}}$. In addition to reporting yield and stock status as described above, for this projection also report the probability that SSB > $\mathrm{SSB}_{\mathrm{MSY}}$.

6. Review, evaluate, and report on the status and progress of all research recommendations listed in the last assessment, peer review reports, and SSC report concerning this stock.

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

1.4 List of Participants

Appointee	Function	Affiliation
ANALYTICAL TEAM		
Nikolai Klibansky	Lead analyst	SEFSC Beaufort
Rob Cheshire	Data compiler	SEFSC Beaufort
Kyle Shertzer	Analytical Team	SEFSC Beaufort
Erik Williams	Analytical Team	SEFSC Beaufort
PANELISTS		
Nate Bacheler	Data provider	SEFSC Beaufort
Wally Bubley	Data Provider	SCDNR
Scott Crosson*	SSC	SAFMC SSC
Julie DeFilippi-Simpson*	Data Provider	ACCSP
Joe Evans	Data Provider	SCDNR
Kelly Fitzpatrick	Data Provider	SEFSC Beaufort
Vivian Matter*	Data provider	SEFSC Miami
Kevin McCarthy*	Data provider	SEFSC Miami
Jennifer Potts	Data provider	SEFSC Beaufort
Marcel Reichert*	SSC	SAFMC SSC
Fred Scharf	SSC	SAFMC SSC
George Sedberry	SSC	SAFMC SSC
Amanda Tong	Data provider	NC DMF
Beth Wrege*	Data provider	SEFSC Miami
Dave Wyanski	Data Provider	SCDNR
APPOINTED OBSERVERS		
Jack Cox*	Fisherman	NC; SG AP
Kenny Fex*	Fisherman	NC
Bobby Freeman*	Fisherman	NC; SG AP
Ben Hartig*	Fisherman	FL
APPOINTED COUNCIL MEMBERS		
Tim Griner	Council member	SAFMC
STAFF		
Myra Brouwer*	Council lead	SAFMC
Julia Byrd*	Citizen Science Coordinator	SAFMC
Mike Errigo	Fishery Biologist	SAFMC
Cierra Graham	Administrator	SAFMC
Kathleen Howington	Coordinator	SEDAR
Jeff Pulver	Fishery Biologist	SERO

Appointees marked with an * were unable to attend the in-person workshop

Appointee	**Function**	**Affiliation**
OTHER		
Roger Brothers	Observer	SEFSC Beaufort
Matt Damiano	Observer	NC State
Eric Fitzpatrick	Observer	SEFSC Beaufort
Dalton Knight	Observer	SEFSC Beaufort
Stephen Long	Observer	SCDNR
Stephanie Martinez	Observer	
Tracy McCulloch	Observer	SEFSC Beaufort
Andy Ostrowski	Observer	SEFSC Beaufort
Cassidy Peterson	Observer	SEFSC Beaufort
Walter Rogers	Observer	SEFSC Beaufort
Mclean Seward	Observer	NCDMF
Tracy Smart	Observer	SCDNR
Kevin Spanik	Observer	SCDNR
NON-PANEL DATA PROVIDERS		
Larry Beerkircher	Data Provider	SEFSC Miami
Alan Bianchi	Data Provider	NC DMF
Ken Brennan	Data Provider	SEFSC Beaufort
Steve Brown	Data Provider	FL FWCC
Julie Califf	Data Provider	GA DNR
Andrew Cathey	Data Provider	NCDMF
Amy Dukes	Data Provider	SC DNR
Eric Hiltz	Data Provider	SC DNR
Dominique Lazarre	Data Provider	FL FWCC
Kayla Rudnay	Data Provider	SC DNR
Beverly Sauls	Data Provider	FL FWCC
Chris Wilson	Data Provider	NC DMF

Appointees marked with an * were unable to attend the in-person workshop

1.5 Document List

Document number	Title	Authors
	Documents Prepared for SEDAR 60	
SEDAR60-WP01	Red Porgy Fishery-Independent Index of Abundance in US South Atlantic Waters Based on a Chevron Trap Survey (1990-2017)	Bubley and Smart 2019
SEDAR60-WP02	Update of Red Porgy, *Pagrus pagrus*, Reproductive Life History from the MARMAP/SERFS program.	Wyanski et al. 2019
SEDAR60-WP03	Changes to NMFS age readings of U.S. South Atlantic Red Porgy (*Pagrus pagrus*)	Potts et al. 2018
SEDAR60-WP04	South Atlantic Red Porgy Commercial Hook-and-Line Discard Mortality Estimates Based on Observer Data	Pulver 2018
SEDAR60-WP05	Red Porgy Edge Analysis Memo	Bubley et al. 2018
SEDAR60-WP06	Commercial landings - Not Received	
SEDAR60-WP07	Standardized video counts of Southeast U.S. Atlantic red porgy (*Pagrus pagrus*) from the Southeast Reef Fish Survey	Cheshire and Bacheler 2018
SEDAR60-WP08	Red Porgy Length Frequency Distributions from At-Sea Headboat and Charter Observer Surveys in the South Atlantic, 2005 to 2017	Lazarre et al. 2019
SEDAR60-WP09	Using Historical Data to Assign a Calendar Age to Red Porgy Otoliths without an Edge Type Assigned - revised May 3, 2019	Bubley et al. 2019*a*
	Reference Documents	
SEDAR60-RD01	2012 SEDAR 1 South Atlantic Red Porgy Update Assessment Report	SEDAR 2012
SEDAR60-RD02	2006 SEDAR 1 South Atlantic Red Porgy Update Assessment Report	SEDAR 2006
SEDAR60-RD03	SEDAR 1 Stock Assessment Report: South Atlantic Red Porgy	SEDAR 2002
SEDAR60-RD04	List of documents and working papers for SEDAR 1 (South Atlantic Red Porgy) - most documents available on the SEDAR website.	SEDAR 2002
SEDAR60-RD05	Southeast Reef Fish Survey Video Index Development Workshop	Bacheler and Carmichael 2014
SEDAR60-RD06	Overview of sampling gears and standard protocols used by the Southeast Reef Fish Survey and its partners	Smart et al. 2014
SEDAR60-RD07	Technical documentation of the Beaufort Assessment Model (BAM)	Williams and Shertzer 2015
SEDAR60-RD08	Assessing barotrauma among angled red snapper (*Pagrus auratus*) and the utility of release methods	Butcher et al. 2012
SEDAR60-RD09	Survival estimates for demersal reef fishes released by anglers	Collins 1996

Document number	Title	Authors
SEDAR60-RD10	Age validation, movements and growth rates of tagged gag (*Mycteroperca microlepis*), Black Sea Bass (*Centropristis striata*) and Red Porgy (*Pagrus pagrus*)	Collins et al. 1996
SEDAR60-RD11	Excerpt from October 2017 SAFMC SSC Minutes (pages 37-66 where SEDAR activities were discussed)	SAFMC SSC
SEDAR60-RD12	Commercial catch composition with discard and immediate release mortality proportions off the southeastern coast of the United States	Stephen and Harris 2010
SEDAR60-RD13	Release mortality of undersized fish from the snapper-grouper complex off the North Carolina coast	Overton et al. 2008
SEDAR60-RD14	Discard composition and release fate in the snapper and grouper commercial hook-and-line fishery in North Carolina, USA	Rudershausen et al. 2007
SEDAR60-RD15	Snapper Grouper Advisory Panel Red Porgy Fishery Performance Report: April 2018	SAMFC Snapper Grouper AP
SEDAR60-RD16	Survival estimates for demersal reef fishes released by anglers	Collins 1996
SEDAR60-RD17	SEDAR1-DW6 - 2002 Tuesday Life History Group Discussion	SEDAR 01 Life History Group
SEDAR60-RD18	2016 MRIP Red Porgy Data Point Discussion Compiled by Mike Errigo	SSC MRIP Workshop August 2019
SEDAR60-RD19	Evaluating the Efficacy of Descender Devices in Increasing the Survival of Deepwater Groupers Using Telemetry	Brendan J. Runde and Jeffrey A. Buckel

1.6 Statements Addressing Each Term of Reference

Note: Original ToRs are in normal font. Statements addressing ToRs are in italics and preceded by a dash (−).

1. Prepare a standard assessment, based on the approved 2012 SEDAR 1 South Atlantic Red Porgy Update assessment with data through 2017. Provide commercial and recreational landings and discards in pounds and numbers.

− *This report documents the preparation of a standard assessment, based on the approved SEDAR 1, 2012 Update assessment (SEDAR 2012) with data through 2017. Observed time series of landings and discards are presented in Table 10, with associated CVs in Table 11. Estimated time series of landings are presented in numbers (Tables 25) and pounds (Table 26). Estimated time series of discards are presented in numbers (Tables 27) and pounds (Table 28).*

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 including the SERFS video index

   − *The SEDAR 60 panel agreed that the SERFS video index should be included in the current assessment by combining it with the SERFS chevron trap index to produce the SERFS chevron trap/video index. This index is included in the SEDAR 60 base model (Figure 13; Table 14).*

   - Incorporate the latest BAM model configurations and updates to data calculation methodologies, detailing the changes made and the impacts of those changes, between the 2012 SEDAR 1 South Atlantic Red Porgy Update assessment model and the proposed SEDAR 60 model.

   − *The latest BAM model configurations and updates to data calculation methodologies have been considered and included the the SEDAR 60 base model.*

   - Re-consider use of age and length composition data.

   − *Use of age and length composition data sets has been reconsidered. Age composition data for recent years have been added, and in most cases the same age composition data sets were used as in the SEDAR 1, 2012 Update, while most length composition data is no longer included in the model (Figure 4).*

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 2012 SEDAR 1 South Atlantic Red Porgy Update assessment.

− *Changes made to the model and input datasets are documented throughout this report. Direct comparisons between the SEDAR 60 and SEDAR 1 2012 update models are described in in §3.7 and 4.11*

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.

− *Estimates of all model paramaters are presented in Appendix B. Estimates of stock status and management benchmarks are presented in Table 29. Direct comparisons between the SEDAR 60 and SEDAR 1 2012 update models are described in in §3.7 and 4.11*

5. Provide stock projections, including a pdf (probability density function) for biological reference point estimates and yield separated for landings and discards reported in pounds and numbers. Projection results are required through 2024, with projected fishing level changes beginning in late 2019. The panel shall provide guidance on appropriate assumptions to address harvest and mortality levels in the interim years between the assessment terminal year (2017) and the first year of management (2019). Projection criteria:
   - To determine OFL: (1) P* = 50%; (2) F_{MSY}
   - To evaluate the existing rebuilding plan: base on fixed exploitation at $75\% F_{\mathrm{MSY}}$. In addition to reporting yield and stock status as described above, for this projection also report the probability that SSB > $\mathrm{SSB}_{\mathrm{MSY}}$.

– *Projection results are described in §4.14. Relevant figures and tables are cited therein.*

6. Review, evaluate, and report on the status and progress of all research recommendations listed in the last assessment, peer review reports, and SSC report concerning this stock.

– *No research recommendations were made in the last assessment report (SEDAR 2012). I am not aware of research recommendations made in peer review reports or the SSC report associated with the last assessment.*

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

– *This SEDAR 60 Standard Assessment Report satisfies this ToR.*

2 Data Review and Update

The benchmark assessment for Red Porgy, SEDAR-1, considered data from 1972-2001 (SEDAR 2002). An update to SEDAR-1 was completed in 2006 and considered data from 1972-2004 (SEDAR 2006). In another update, completed in 2012, the terminal year was extended to 2011 (SEDAR 2012). In the current SEDAR 60 assessment data up through 2017 were considered. For most data sources, the data were simply updated with the additional years of data (2012-2017) using the same methods as in the prior assessments. However, for some sources, it was necessary to update data prior to 2012 as well. The input data for this assessment are described below, with focus on the data that required modification beyond just the addition of years.

2.1 Data Review

In this standard assessment, the Beaufort assessment model (BAM) was fitted to many of the same data sources as in SEDAR-1 and the 2006 and 2012 updates.

- Landings: commercial handline, commercial trawl, headboat, general recreational (MRIP)
- Discards: commercial handline, headboat, general recreational (MRIP)
- Indices of abundance: SERFS chevron trap/video (formerly MARMAP chevron trap), headboat
- Length compositions of landings: commercial trawl
- Age compositions of surveys or landings: SERFS chevron trap (formerly MARMAP chevron trap), commercial handline, headboat

Contrasts to data used in the 2012 update assessment include:

- Commercial trap landings have now been combined with commercial handline landings
- The MARMAP Florida trap index and associated composition data are no longer included in the model.
- The MARMAP Chevron trap index was modified by the addition of video data since 2011 and is now known as the "SERFS chevron trap/video index"
- All sources of length composition data fitted to in the previous assessment have been excluded from the current assessment except for commercial trawl
- Commercial trawl length composition data has been pooled into a single year, due to small sample sizes.
- The limited data for age-0 fish were not included, as the current model starts at age-1
- Ages are now in calendar age compared with increment ages used in previous Red Porgy assessments

In addition to data fitted by the model, prior assessments utilized life-history information that was treated as input, much of which has been updated in SEDAR 60. The same length-weight and male maturity at age relationships used in the 2012 update were used here. Estimates of proportion male at age were updated for SEDAR 60 with more recent data. Whereas prior assessments of Red Porgy included time blocks for female maturity at age, in SEDAR 60 a single time-invariant vector of female maturity at age was developed including the most recent data. Also new to SEDAR 60, age-varying estimates of natural mortality rate have been developed included, whereas prior assessments treated it as constant across ages. Discard mortality rates have also been reevaluated and modified for this assessment. In SEDAR 1, 2012 Update, empirical estimates of growth model parameters were used as starting values in the assessment model, and the parameters were estimated in the assessment. By constrast, in SEDAR 60, updated estimates of growth model parameters were fixed in the base model.

2.2 Data Update

2.2.1 Life History

All of the life history inputs have been updated since the SEDAR 1, 2012 Update assessment with additional data from 2011-2017 (SEDAR 2012) and include changes to age data for the full time series of the assessment, reproductive parameters and natural mortality. The primary change was to the age data. NMFS Beaufort Laboratory staff conducted an age validation study, refining the methodology for ageing Red Porgy, specifically regarding first annulus. Since SEDAR 1 (2002), all age data were recorded as increment, or annuli count, with no additional adjustment. Age samples processed and read since the SEDAR 1, 2012 Update have edge types included. As a result of the age validation study, NMFS Beaufort re-read all their old samples and included edge types (Potts et al. 2018). Thus, NMFS Beaufort was able to assign calendar ages to all samples. SCDNR did not have funding and time to re-age their historic samples, originally using whole otoliths, for this SEDAR, but in a comparison of 265 samples that were sectioned, read and compared to whole otolith readings, SCDNR determined that the original ages were consistent with the ages from the sections. It was agreed that SCDNR did not need to re-age the historic samples at this time, but would in the future, provided available funding and time. One issue with those samples was the readings did not include edge types. SCDNR provided a proxy method to assign edge types to samples and then calculated calendar age using this method (Bubley and Smart 2019). The SEDAR 60 panel accepted this method as an appropriate way to convert increment counts to calendar age, and as a result the current age data set for SEDAR 60 is based on calendar age. Updated analyses of life history parameters that rely on the new age data were completed. A population growth model, reproductive parameters and natural mortality were all updated.

Changes to the population growth model used in the SEDAR 1, 2012 Update include the use of fractional, or biological, age and inclusion of the correction for the minimum size-limit bias on the size-at-age distribution of the fishery-dependent samples following McGarvey and Fowler (2002). The data for the population growth model included 42,434 samples, spanning years from 1979 through 2017, collected by MARMAP and the SERFS and from the commercial and recreational fisheries. The calendar age for each fish was converted to a fractional age based on the month of capture and month of peak spawning (February), using the following formula:

$$A_f = A_c + [(M_c - M_s)/12] \tag{1}$$

where, A_f = Fractional, or biological, age; A_c = Calendar, or cohort, age; M_c = month of capture, and M_s = month of peak spawning.

A minimum size limit was assigned to each sample from the fishery based on the management history. The parameter values for the von Bertalanffy growth model (± standard error) are $L_\infty = 422.6$ (1.25; TL, mm), $k = 0.30$ (0.004), and $t_0 = -1.47$ (0.036, years; Figure 1).

The SEDAR 60 Data/Assessment panel had a robust discussion of natural mortality (M), which included maximum age of the population, single point estimate of M and equations, age-varying M and whether to scale the age-varying M to the point estimate. With the updated age data for this assessment, the max age of Red Porgy in the US South Atlantic has increased from 19 years to 25 years. Consideration was given to what max age we should use for calculation of a point estimate of M. The staff engaged in aging Red Porgy have confidence in the oldest ages because of an age validation study and the repeatability of reading of the samples from the old fish across time and multiple readers. Though only 12 fish in the entire age data set were age-20 or older, they occur in every fishery sector and the fishery-independent survey. Those fish were collected in the most recent years, 2011 - 2017 and have birth years of 1988 - 1997 with 5 of 12 in 1993. The fish were from a time of heavy exploitation and the maximum observed age may actually be an underestimate of the true max age. A recommendation was made to use a range of max age of 20 to 30 years with the mid-point of the range for the base run of the assessment model. The panel had most confidence in using point estimates of M calculated from equations using max age rather than those using von Bertalanffy growth parameters, because of the confidence of the experts assigning the ages to each sample. The panel considered estimates generated from Hoenig's (1983) original equation, as used in SEDAR01, and Then et al. (2014). During discussion of what equation to use for the point estimate of M, the estimates calculated from the Then et al. (2014) age based equation (0.26, max age = 25) were considerably higher than those using the original Hoenig (1983) equation (0.17, max age = 25). Table 1 shows the range of M for ages 20, 25 and 30. Annual total mortality (Z) from the age composition data were calculated for comparison to the point estimates of M. In some years, Z was less than M of 0.32 as calculated from Then et al. (2014) for max age of 20. The panel recommended using $M = 0.22$, the average of the values in Table 1, as the point estimate for the base run of the assessment model.

To be consistent with recent stock assessments, the panel proposed to use an age-varying M based on Charnov et al. (2013), but whether to scale the estimates to the point estimate based on the fully recruited ages was discussed by the panel. An age-varying M has the advantage of recognizing that the smallest fish are subjected to a higher rate of natural mortality than larger fish. The age specific estimates of M saturated around 0.33 at age-14, but is still higher than Z for some years. For this reason, the panel recommended to scale the age specific estimates of M to the point estimate using age-3+ as the fully recruited ages (Table 2). The fully recruited age was determined from the age composition from the fishery-independent chevron trap data set. The scaling provided equivalent cumulative survival across ages as would be achieved with the age-invariant point estimate of M.

Reproductive biology parameters were updated with additional data collected between 2012 and 2016, which included female and male maturity at age with the new calendar ages. Some members of the panel expressed concern at the SEDAR 60 Red Porgy in-person Workshop (December 2019) about using period-specific estimates of life history parameters in the model for only female maturity, as was done in the 2006 and 2012 assessments. It is possible that other parameters such as growth and sex ratio also exhibit the plasticity seen in female maturity, which could affect these maturity estimates. In addition, a panel member asked if the period-specific maturity ogives are statistically different.

To address the question of statistical significance, female maturity data from MARMAP and SERFS sampling were grouped into three periods (1979-1987, 1990-2002, and 2003-2016), with the latter two periods representing data from chevron traps. Maturity ogives for the three periods were compared using a Probit analysis with the logistic distribution function. The results showed that the proportion of mature females at calendar age decreased significantly ($P < 0.001$) between the early and middle periods and then increased significantly ($P < 0.001$) between the middle and latter periods, with the differences in maturity ogives for the early and latter periods not being statistically significant ($P = 0.067$; Table 7 in addendum of Wyanski et al. 2019).

Although there is statistical evidence for the use of period-specific maturity ogives, the consensus of the workshop panel was to shift to an overall (1979-2016) maturity ogive in the model until temporal trends in other life history parameters can be investigated. Parameter estimates for the overall ogive are presented in the updates of Tables 4 and 5 (addendum of Wyanski et al. 2019).

2.2.2 Life History Tables and Figures

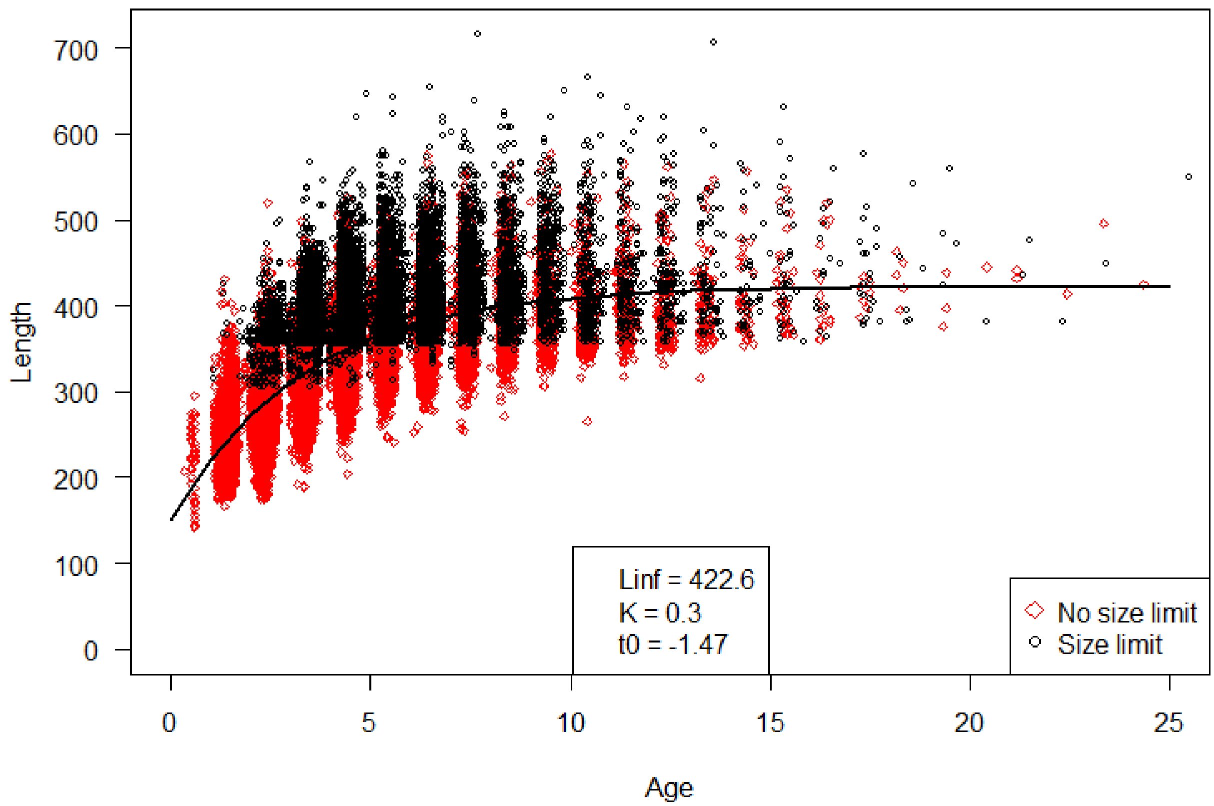
Table 1. Point estimates of natural mortality (M) based on equations using maximum age in the population from Then et al. (2014) and Hoenig (1983) for South Atlantic Red Porgy.

Maximum Age (years)	Then et al. (2014)	Hoenig (1983)
20	0.32	0.21
25	0.26	0.17
30	0.22	0.14

Table 2. Age specific estimates of natural mortality (M) calculated from the Charnov et al. (2013) equation and scaled to the cumulative survival of fish ages 3+ from the recommended point estimate of $M = 0.22$.

Age	M
1	0.455
2	0.355
3	0.302
4	0.271
5	0.251
6	0.238
7	0.229
8	0.223
9	0.218
10	0.215
11	0.212
12	0.211
13	0.209
14	0.209

Figure 1. Population growth model of Red Porgy (n = 42,434; TL mm) including size-limit correction on fishery-dependent samples.



2.2.3 Commercial Landings and Discards

Red Porgy commercial landings were compiled for years 1972 - 2017 with a U.S. Atlantic Coast stock boundary from the Virginia southern border down through to the southern tip of Florida: North Carolina, South Carolina, Georgia, east coast of Florida. Landings totals from 1972-2001 were left unchanged from SEDAR01. Years 2002-2017 were updated. Combined annual landings are provided in Table 3.

Direct sources for the landings included the Atlantic Coastal Cooperative Statistics Program (ACCSP), the North Carolina Division of Marine Fisheries (NCDMF), and the South Carolina Department of Natural Resources (SCDNR).

Statistics on commercial landings (1972 to present) for all species on the Atlantic coast are maintained in the ACCSP Data Warehouse. The Data Warehouse is an online database of fisheries dependent data provided by the ACCSP state and federal partners. The Data Warehouse was queried for all Red Porgy landings (annual summaries by gear category) from 1972 – 2017 from North Carolina through Florida (ACCSP 2019). Commercial landings in pounds (whole weights using state specific conversion factors) were provided. All landings were then aggregated into year and state summaries. Georgia (GADNR) and Florida Fish and Wildlife (FWC) staff examined ACCSP landings and compared them to state held versions. It was determined that ACCSP landings were a match and would be used in place of state provided data for the entire time series.

The NCDMF provided North Carolina's landings data from 1972 – 2017. This data set was a collective grouping of historical data collection by the NMFS/NCDMF Cooperative Statistics Program, its predecessors, and the NC Trip Ticket Program. Data continuity and accuracy dramatically increased over time. From 1994 – 2017 landings data collection was provided by the NC Trip Ticket Program and considered the most consistent and inclusive portion of the NC dataset. Landings were reported in both whole and gutted conditions. The landings reported in gutted weight, were converted to whole with a state conversion factor of 1.25 per pound. Whole weight records were directly supplied without conversion.

In 1972, South Carolina began collecting landings data from coastal dealers in cooperation with federal agents. Mandatory monthly landings reports on forms supplied by the Department are required from all licensed wholesale dealers in South Carolina. Until fall of 2003, those monthly reports were summaries collecting species, pounds landed, disposition (gutted or whole) and market category, gear type and area fished; since September 2003, landings have been reported by a mandatory trip ticket system collecting landings by species, disposition and market category, pounds landed, ex-vessel prices with associated effort data to include gear type and amount, time fished, area fished, vessel and fisherman information.

SCDNR provided landings data for Red Porgy from 1972 – 2017. Data from 1978 – 2003 were collected in monthly totals through collaborative efforts by SCDNR and the NMFS Cooperative Statistics Program and data collected from 2004 – 2017 were more comprehensive, as SCDNR instituted a mandatory Trip Ticket Program in late 2003. Landed weights were collected as both gutted and whole. Annual Catch Limits are categorized as "landed weight" since both categories are present in the fishery. All gutted weights were converted to whole weight using the state conversion factor.

Commercial gear

Initial commercial fleets for Red Porgy consisted of trap, trawl, and handline, which included hook and line, diving, spear, other, and unreported gears. Upon reviewing gear selectivity and the small scale of the trap landings, the trap fleet was combined with the handline fleet. The trawl fleet was determined to generally use gear that targets smaller fish and therefore was kept as a separate fleet.

Commercial discards

Two approaches were investigated for the calculation of Red Porgy discards from the commercial handline fishery. Both methods calculate total discards as discard rate*total effort of the fishery. The first technique (continuity method) followed the methods used in the SEDAR 1, 2006 Updateassessment by modeling discard rates. The second technique followed the methods recommended in SEDAR 32 and subsequent South Atlantic SEDAR assessments (standard method) where discard rates were directly calculated from discard logbook data. Total effort data were available from commercial logbook data for both methods. Although the results of both analyses were available for the assessment, the standard method was recommended as the preferred method for commercial discard calculation.

Red Porgy discard calculation used data reported by fishers between January 1, 2002 and December 31, 2017 in the US South Atlantic (south of US1 in the Florida Keys to 37° N) from vertical line (handline and electric/hydraulic gears) trips. Approximately 98% of reported Red Porgy discards were from vessels fishing vertical line gear. Data filtering followed the methods recommended during SEDARs 32 and 41 (McCarthy 2013; 2015). Effort data were also filtered to exclude trips landing only mackerel because the SEDAR 32 and 41 panels noted that for trips targeting mackerel only, the likelihood of catching species other than mackerel was extremely low. To avoid removing mixed effort trips, however, only trips with 100% mackerel landings were excluded from the analysis.

A final data filter designed to address possible underreporting of commercial discards was included following the recommendation of the SEDARs 32 and 41 commercial work groups. The percentage of discard reports returned with “no discards” from vertical line trips has increased from 33 to 73 percent in the US South Atlantic over the period $2002-2017$. The data were filtered to remove records from vessels that never reported discards of any species during a year. Following the SEDAR 32 and 41 commercial working groups’ recommendations, data from vessels that reported many more trips than the fleet average before a discard was reported (the mean number of trips prior to the first trip with reported discards plus two standard deviations above that mean) were excluded.

Yearly discard rates of vertical line vessels were calculated as the mean rate (discards per hook hour fished) during the years $2002-2017$. Discard rates were calculated separately for open and closed Red Porgy seasons. Yearly total effort (hook hours, available from commercial logbook reports) of all trips, by season (open/closed), was multiplied by the yearly season specific mean discard rate to calculate total discards of Red Porgy by vertical line vessels:

$$\textit{Calculated discards per region} = \textit{yearly mean Red Porgy discard rate per season} \times \textit{total effort per season} \tag{2}$$

where *total effort per season* indicates total effort post filtering.

For years prior to 2002 (the first year of discard data), the mean discard rate, by season, for the years $2002-2006$ was used to calculate discards for the years $1993-2001$ when only effort data were available.

$$\textit{Calculated discards per region} = \textit{02-06 mean Red Porgy discard rate per season} \times \textit{total effort per season} \tag{3}$$

where *total effort per season* indicates total effort post filtering.

Total discards are provided in Table 4 for combined seasons in number (1,000s) of fish. The very high number of estimated discards in 2002 was due to a number of trips with much higher discard rates than those reported from trips in other years (Table 5 and Figure 2). Year 2002 was determined to be the best data available and was not adjusted or weighted differently.

The discard calculations rely on self-reported discard and effort data. Perhaps the most important source of error in the commercial discard calculations was misreporting and nonreporting of discards, both of Red Porgy and other species. An effort was made to minimize that potential error by removing data from vessels that never reported discards of any species during a year or reported many more trips than the fleet average before a discard was reported. Although such clear instances of discard non-reporting were identified and excluded, other cases of non-reporting and misreporting have not been quantified. The degree to which continued non or misreporting may have affected the discard calculations is unknown. The discard totals provided may represent a minimum estimate of the number of Red Porgy discarded from the commercial vertical line fishery.

2.2.4 Commercial Landings and Discards Tables and Figures

Table 3. Annual commercial landing totals of Red Porgy from all fisheries reported in 1000 pounds and metric tons.

Year	Landings (lb)	Landings (mt)
1972	32.84	14.90
1973	27.60	12.52
1974	108.35	49.14
1975	198.90	90.22
1976	250.96	113.83
1977	437.10	198.26
1978	726.39	329.48
1979	1066.67	483.83
1980	1233.80	559.64
1981	1571.19	712.68
1982	1606.09	728.51
1983	1295.81	587.77
1984	1124.96	510.27
1985	863.58	391.71
1986	921.25	417.87
1987	787.13	357.03
1988	893.05	405.08
1989	924.36	419.28
1990	1138.59	516.45
1991	832.44	377.59
1992	516.53	234.30
1993	470.08	213.22
1994	436.36	197.93
1995	432.07	195.98
1996	429.61	194.87
1997	425.70	193.09
1998	317.99	144.24
1999	105.14	47.69
2000	26.21	11.89
2001	66.17	30.02
2002	58.17	26.39
2003	50.37	22.85
2004	49.68	22.54
2005	48.66	22.07
2006	83.81	38.02
2007	144.29	65.45
2008	171.96	78.00
2009	164.53	74.63
2010	158.83	72.04
2011	202.83	92.00
2012	162.26	73.60
2013	171.46	77.77
2014	158.15	71.74
2015	154.82	70.22
2016	127.44	57.81
2017	129.81	58.88

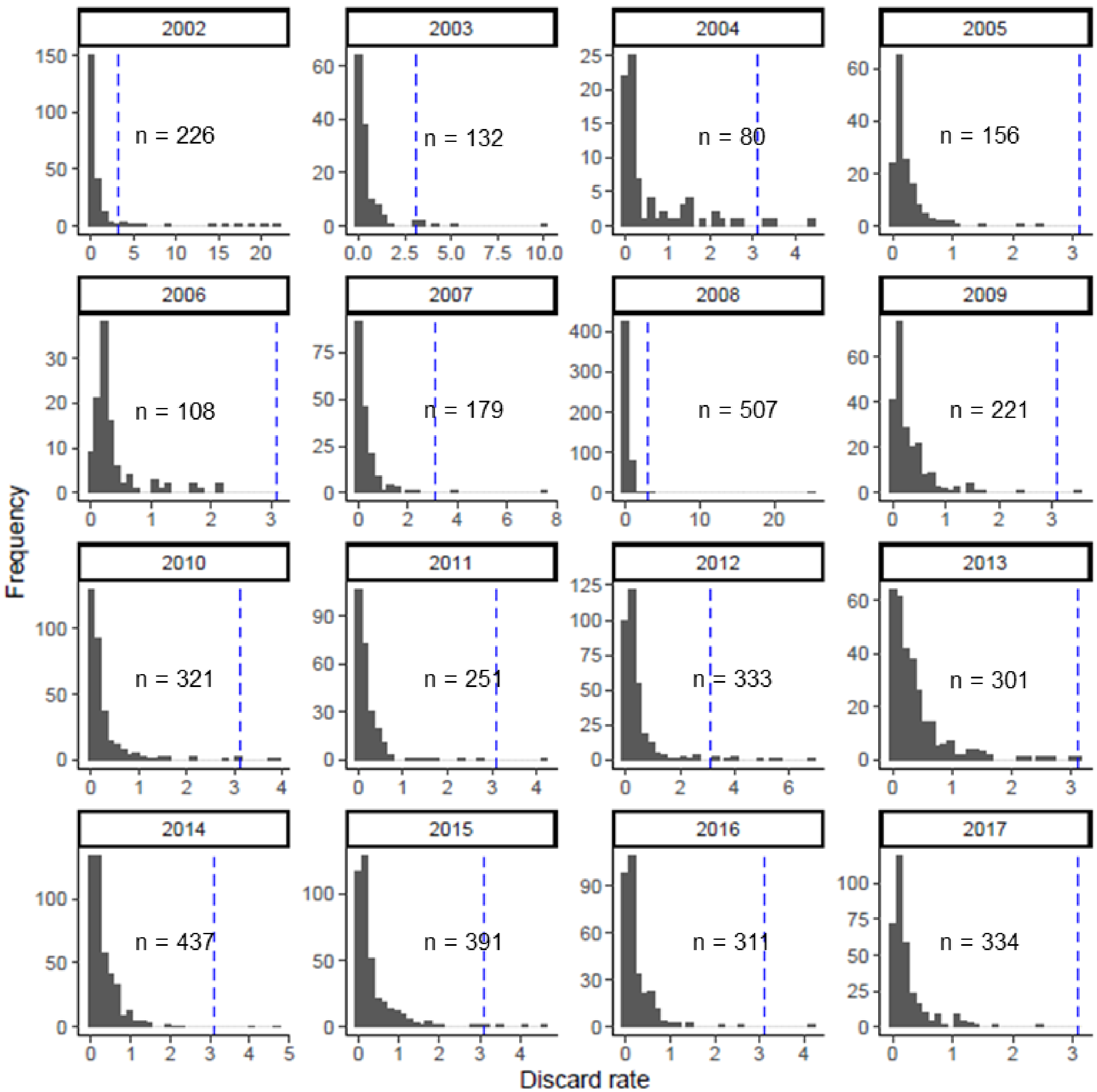
Table 4. Yearly calculated total discards of Red Porgy from vertical line vessels, seasons (open/closed) combined, using SEDAR 32 methods. Discards are reported as number of fish in 1,000s.

Year	Total discards (1000 fish)
1993	78.26
1994	96.75
1995	101.04
1996	100.07
1997	102.78
1998	78.52
1999	79.91
2000	87.67
2001	81.61
2002	250.94
2003	45.92
2004	39.10
2005	25.03
2006	40.23
2007	25.33
2008	40.18
2009	33.59
2010	21.02
2011	11.94
2012	27.83
2013	26.37
2014	28.11
2015	30.37
2016	16.77
2017	18.43

Table 5. Comparison of Red Porgy commercial discard rates (DR; number of fish discarded per hook hour fished) by year (2002-2017). The discard rate mean and standard deviation (SD) were calculated for each year. The bound (B) of the mean was calculated as two times the SD. A high rate for each year was calculated by adding the B and the mean discard rate. The number of trips with discard rates greater than the yearly high rate are provided in the NG_{yearly} column (NG = Number Greater). The number of trips with discard rates greater than the total mean high rate (0.638) are provided in the NG_{mean} column. All trips were used for the calculations including trips with a discard rate of zero.

Year	Mean Discard Rate	SD Discard Rate	B (2*SD)	High Rate (B+Mean)	NG_{yearly}	NG_{mean}
2002	0.208	1.447	2.894	3.102	17	58
2003	0.043	0.361	0.721	0.764	22	25
2004	0.044	0.291	0.582	0.626	21	21
2005	0.030	0.142	0.285	0.315	35	11
2006	0.041	0.185	0.369	0.410	21	12
2007	0.030	0.233	0.466	0.497	30	22
2008	0.046	0.464	0.928	0.973	21	54
2009	0.036	0.171	0.341	0.377	61	27
2010	0.027	0.185	0.369	0.396	54	31
2011	0.016	0.123	0.246	0.262	62	11
2012	0.042	0.282	0.564	0.607	51	46
2013	0.036	0.188	0.377	0.413	92	53
2014	0.036	0.179	0.359	0.395	116	58
2015	0.042	0.222	0.445	0.487	82	64
2016	0.023	0.137	0.274	0.297	83	27
2017	0.028	0.133	0.266	0.295	72	32
Total Mean	0.046	0.296	0.593	0.638	53	35

Figure 2. Frequency plot of Red Porgy commercial discard rates (number of fish discarded per hook hour fished) by year (2002 – 2017) with calculated high rate (3.102, as defined in Table 5) for the year 2002 (blue dashed line). All trips with a discard rate of zero were removed for these plots. Panels have different x-axis and y-axis ranges.



2.2.5 Recreational Fisheries

The primary recreational modes of fishing for South Atlantic Red Porgy are private, charter, and headboat. Estimates of the catch of Red Porgy come from a combination of results from two surveys: (1) the Marine Recreational Information Program (MRIP), formerly the Marine Recreational Fisheries Statistics Survey (MRFSS), conducted by NMFS; and (2) the Southeast Region Headboat Survey (SRHS) conducted by NMFS, Southeast Fisheries Science Center Beaufort Laboratory in North Carolina. The MRIP survey is sampling-based, whereas the SRHS is a census of headboats using logbooks. The two surveys together provide estimates of catch in numbers, estimates of effort, length and weight samples, and catch-effort observations for recreational fishing.

MRIP transition

The Marine Recreational Information Program completed a three year transition in 2018 (NOAA Fisheries 2018). Estimates of fishing effort for the private and shore modes are now obtained from a Fishing Effort Survey conducted via mail, which uses angler license and registration information to identify and contact anglers as well as supplemental data from the U.S. Postal Service that includes nearly all U.S. households. Effort estimates for charter and party boats are still obtained from the For-Hire Telephone Survey and are not affected by the new Fishing Effort Survey. Previously, estimates of private and shore fishing effort came from the legacy Coastal Household Telephone Survey, which used random-digit dialing of homes in coastal counties to contact anglers. Concerns over low response rates, the gatekeeper effect (i.e., speaking to someone other than the angler), the tendency to ignore unknown callers, and coverage limited to only coastal counties in the Coastal Household Telephone Survey were motivation for the new survey, which is considered to provide more accurate estimates of trips. By design, the Fishing Effort Survey is reaching more anglers, getting into the right hands, providing a higher response rate, and extracting more information from anglers with an improved survey questionnaire. Benchmarking of the Fishing Effort Survey alongside the Coastal Household Telephone Survey for three years allowed for apples-to-apples comparisons between data from the two different surveys and the creation of a peer-reviewed calibration model. The calibration model was peer reviewed by reviewers appointed by the Center for Independent Experts (see Rago et al. 2017). Additional details can be found at: https://www.fisheries.noaa.gov/event/fishing-effort-survey-calibration-model-peer-review.

The MRIP transition also accounted for the 2013 design change in the Access Point Angler Intercept Survey (Foster et al. 2018). Improved survey procedures were incorporated that better account for all types of completed trips and remove potential sources of bias from the survey design. For example, the new sampling design provides more complete coverage of angler fishing trips ending throughout the day and night, whereas the old design often missed nighttime trips or off-peak daytime trips. In addition, conversion factors were developed to account for any consistent effects of the redesign on catch rate estimates produced by the Access Point Angler Intercept Survey. The new Access Point Angler Intercept Survey design uses a sample weight adjustment method and is more statistically sound because it more strictly adheres to formal probability sampling protocols. The Access Point Angler Intercept Survey calibration model developed by MRIP and the statistical approach proposed for the conversion of catch estimates by MRIP were peer reviewed by reviewers appointed by the Center for Independent Experts. Additional details can be found at: https://www.fisheries.noaa.gov/event/access-point-angler-intercept-survey-calibration-workshop.

Charter calibration

The MRIP transition resulted in the release of new recreational catch estimates for all species and all modes, including charter mode estimates. As a result, the SEFSC conducted a calibration analysis using the newly released data to correct for this change from the Coastal Household Telephone Survey to the For-Hire Telephone Survey (Dettloff and Matter 2019). The analysis uses a statistically sound, consistent methodology to provide improved calibrations for estimating For-Hire Telephone Survey charterboat effort and landings with associated uncertainties from Coastal Household Telephone Survey estimates. Additional details are provided in Dettloff and Matter (2019).

Recreational Fisheries

Recreational landings in number were aggregated into two separate recreational fleets, headboat and general recreational (charterboat and private boat) and used in the SEDAR 60 assessment model. The headboat (1981 − 2017) and general recreational (1981-2017) landings and discards were updated based on data from the SRHS and from MRIP. Recreational discards in numbers of Red Porgy by the headboat, charter, and private modes were used in the assessment model. MRIP estimates of live released fish (B2) for charter, private, and headboat (1981 − 1985 only) were adjusted in the same manner as landings (i.e., discussed above) and did include Monroe County. Self-reported discards have been reported in the SRHS logbook since 2004 and were validated using the At-Sea Observer Program. As a result, headboat discards from 2004-present were derived directly from the SRHS. Headboat discards were recalculated for the entire time series, as it is a model-based approach. The accepted SEDAR Best Practice method MRIP Charter:SRHS discard ratio was recommended as a proxy to estimate Red Porgy discards from headboats for years prior to 2004 (Fisheries Ecosytems Branch, National Marine Fisheries Service, Southeast Fisheries Science Center, Beaufort, NC 2017). Recreational landings and discards, as provided, are shown in Tables 6 and 7, respectively.

2.2.6 Recreational Fisheries Tables

Table 6. Red Porgy landings in numbers (n) and pounds (lb) from the recreational fishery (1981 – 2017).

Year	Headboat (n)	Charter boat (n)	Private boat (n)	Headboat (lb)	Charter boat (lb)	Private boat (lb)
1981	168,286	45,223	10,951	325,458	63,116	15,718
1982	272,883	46,577	8,319	431,938	72,166	13,294
1983	155,738	18,805	2,477	261,450	33,223	4,277
1984	129,970	252,002	6,262	217,036	344,189	8,773
1985	176,576	12,955	182,719	260,381	16,844	247,131
1986	161,041	16,874	19,429	222,088	25,630	29,737
1987	173,568	43,912	26,689	220,476	61,827	41,170
1988	168,556	27,736	180,805	215,534	39,527	219,920
1989	146,488	103,168	35,326	165,050	172,263	46,149
1990	104,762	51,150	56,275	125,265	85,643	71,210
1991	129,879	19,251	41,281	140,820	37,506	59,328
1992	85,893	54,466	104,152	109,858	90,178	120,823
1993	81,695	36,656	17,925	101,027	50,286	24,889
1994	70,390	30,206	40,111	87,572	43,566	50,320
1995	70,713	39,061	5,880	93,032	54,357	8,186
1996	64,907	23,117	42,886	82,218	33,122	64,357
1997	53,865	12,536	8,211	75,298	17,123	13,189
1998	53,878	22,011	9,089	69,262	22,354	10,242
1999	31,954	14,939	13,444	48,657	21,241	20,537
2000	8,036	1,041	9,516	13,906	2,095	19,149
2001	28,862	29,483	10,887	46,308	56,791	20,566
2002	20,925	50,742	6,873	33,341	127,190	15,896
2003	20,174	30,273	25,491	34,743	66,532	57,078
2004	23,461	24,962	49,575	49,309	49,056	90,873
2005	24,777	10,484	39,544	42,143	20,774	73,941
2006	40,222	19,120	10,853	67,679	41,539	24,011
2007	74,937	40,046	14,483	117,255	73,359	27,844
2008	32,521	25,065	82,006	52,598	44,511	150,684
2009	19,541	4,262	48,765	33,752	7,011	88,167
2010	21,924	10,150	19,093	37,413	20,077	37,645
2011	21,091	6,526	45,810	39,191	11,205	80,206
2012	23,220	21,489	28,258	41,086	36,320	49,732
2013	17,711	9,031	26,705	31,716	20,014	56,222
2014	17,173	9,516	14,197	30,042	17,071	25,749
2015	15,546	32,002	33,940	28,968	63,125	67,092
2016	15,315	7,491	271,002	25,717	14,138	545,738
2017	12,333	15,398	45,042	23,042	30,863	90,284

Table 7. Red Porgy discards in numbers (n) from the recreational fishery (1981 − 2017) released alive or dead.

Year	Headboat (alive)	Headboat (dead)	Charter boat (alive)	Private boat (alive)
1981	2,823		1,263	
1982	1,593		487	1,483
1983	3,621		705	
1984	1,511		1,492	
1985	4,542		541	14,520
1986				547
1987				22,635
1988				671
1989	632		105	20,966
1990				
1991	825		203	
1992	8,594		7,737	5,288
1993	11,600		8,158	
1994	2,038		1,542	1,042
1995	17,501		12,748	9,452
1996	2,144		946	6,067
1997				1,759
1998				6,500
1999	81,463		41,167	19,474
2000	32,147		6,422	16,201
2001	56,794		93,330	24,397
2002	9,291		53,758	8,153
2003	10,235		27,629	69,304
2004	61,341	2,397	53,893	37,882
2005	18,216	560	27,862	23,630
2006	42,338	957	5,718	2,494
2007	42,069	503	19,956	32,131
2008	26,784	1,038	20,534	92,078
2009	14,531	237	1,694	9,326
2010	12,827	93	2,326	20,891
2011	14,795	299	2,678	19,265
2012	16,488	417	5,693	3,036
2013	13,908		3,579	10,859
2014	17,844		3,942	31,638
2015	18,782		36,203	30,930
2016	15,457		1,023	272,938
2017	11,202		1,492	34,376

2.2.7 Indices of Abundance

The 2012 SEDAR-01 update assessment of Red Porgy included three indices of abundance: one derived from the headboat fleet (1973−1998), one from MARMAP sampling with chevron traps (1990−2011), and one from MARMAP sampling with Florida traps (1983 − 1987). The headboat index was standardized using a delta-GLM approach. Neither MARMAP index was standardized, however a sensitivity run of the 2012 assessment model was conducted using a standardized version of the chevron trap index.

For this SEDAR-60 assessment, the headboat index was left intact at values from the previous 2012 assessment. The index was not reevaluated with more recent years for reasons stated in the 2012 update report, primarily that harvest regulations since 1999 have likely compromised fishery dependent catch per unit effort as a meaningful measure of abundance. Data from the chevron trap survey were updated through 2017 and include sampling from SERFS (MARMAP, SEAMAP-SA, and SEFIS). The chevron trap index was standardized using a zero-inflated negative binomial model (Bubley and Smart 2019). Additionally, video sampling from SERFS was included, spanning 2011 − 2017. The video index was also standardized using a zero-inflated negative binomial model (Cheshire and Bacheler 2018). The two indices from SERFS gears (chevron traps and video) were combined using the method of Conn (2010), as has been done in several recent SEDAR assessments. The MARMAP Florida trap index was excluded from this assessment, for the following reasons: 1) the index was not standardized but rather was simple nominal catch per effort, as developed during SEDAR-01, 2) the 5-year time-series was relatively short, 3) geographic coverage, depth coverage, and sampling intensity were less extensive than for other indices, 4) the index occurred during a time period that already contained what is believed to be a reliable index (headboat), and 5) the index was not informative for the assessment model (as indicated by model runs with and without the index).

2.2.8 Length Compositions

Length compositions in total length (TL) for all data sources were developed in 1-cm bins over the entire size range. These were later pooled at the tails to a range 12-72 cm (labeled at bin center). All fishery-dependent length compositions were weighted by regional landings defined by sample size for each fleet. A 30 fish minimum sample size for each region and year was used to prevent spikes in the compositions when length sampling was disproportionally small relative to landings.

The commercial handline lengths were weighted by the regional landings. The regions were defined by sample size as NC, SC, and combined GA and FL. For many state and year combinations, the commercial lengths were collected in centimeters fork length. Problems with missing or heaped bins can result from applying a conversion developed to data collected on a different scale (mm vs. cm). A random tenth decimal was added to these values prior to conversion to total length. Some states collected lengths in half or quarter centimeter bins in early years. For these values a similar approach was used to distribute lengths in half-centimeter increments to the adjacent bins. The commercial trap length data was minimal. Commercial trap lengths were very similar to commercial handline for the few years with adequate trap samples for comparison. The trap lengths were removed from the model based on the decision to combine handline and trap fleets. The few annual commercial trawl length compositions used in previous Red Porgy assessments were discovered to be from very few trips each year and were pooled across years.

Headboat and general recreational length compositions were developed and weighted regionally. However, the general recreational lengths were not retained due to minimal sample sizes. The headboat lengths were weighted by the regional landings at the same spatial strata as commercial data.

Red Porgy length compositions were provided for the chevron trap time series 1990-2017. All Red Porgy collected in chevron traps for monitoring purposes were enumerated and measured to produce length compositions, with FL measurements converted to TL based on a meristic conversion as needed (Bubley et al. (2019*b*); $TL = \frac{(FL+3.4449)}{0.8744}$, $r^2 = 0.997$, $n = 25,789$). There were two time periods regarding length measurements, with measurements being in fork length (FL) to the whole centimeter from 1990 to 2011 and maximum total length (TL) from 2012 to present. The length compositions from fishery-independent chevron traps were developed and discussed at the data workshop. An issue with the compositions was discussed but no action was needed because they were not recommended for use based on other criteria. The length compositions from the Florida snapper trap used in the previous assessments were no longer needed based on the decision to exclude the Florida snapper trap index.

Including both length and age compositions from the same fleet can result in overweighting of composition data, and recent SEDAR assessments have removed length composition data when sufficient age composition data are available (e.g., SEDAR 41, SEDAR 55, SEDAR 56, and SEDAR 58). Age compositions were not fit well when length compositions were included. The SEDAR 60 panel recommended excluding all length composition data with the exception of commercial trawl where no ages were available. This pooled composition was recommended to inform trawl selectivity only.

2.2.9 Age Compositions

Fishery-dependent age compositions were weighted by the region- and fleet-specific length compositions to address potential disproportionate sampling among regions and bias in selection of fish to be aged (see Sustainable Fisheries Branch - NMFS 2017; Fisheries Ecosytems Branch, National Marine Fisheries Service, Southeast Fisheries Science Center, Beaufort, NC 2017, for methods). Annual region-fleet sampling with fewer than 10 fish were excluded to limit problems with up-weighting small samples.

Red Porgy age compositions were provided for the chevron trap time series 1990-2017. Red Porgy age compositions had to account for differing sub-sampling routines and length measurements during the survey. There were two time periods for life history subsampling routines, with 1990 to 2007 having nonrandom subsampling based on tallies within length bins and 2008-present having random subsampling or no subsampling. Age compositions in the early time period had to be corrected using methods developed for Black Sea Bass during SEDAR 25 (Ballenger et al. 2011), while those for the most recent time period were summarized and did not have to be corrected. Because age compositions from earlier time periods required a correction utilizing length compositions, FL measurements ($1990 - 2011$) were converted to TL based on the meristic conversion above, while TL measurements ($2012 - \text{present}$) were unchanged. Age compositions for SEDAR 60 differed from the SEDAR 1, 2012 Updatedue to differences in ageing structure, ageing methodology, and the use of calendar age instead of increment count (Bubley et al. 2019*a*).

2.2.10 Discard Mortality

Discard mortality estimates were proposed for the commercial hook-and-line and recreational sectors. Logistic models based on observer data from the Gulf of Mexico were used to estimate a range of immediate mortality rates for each sector (Pulver 2018). In addition to immediate mortality, delayed mortality rates were estimated from literature and depredation mortality rates were proposed at the SEDAR 60 workshop. Depredation mortality rates from 5 to 10% were estimated for both sectors based on panelist input at the workshop. The total commercial hook-and-line mortality estimate ranged from 45 to 64% with a proposed midpoint value of 53% (Table 8). The commercial immediate mortality estimates are the weighted logistic predictions from the SEFSC logbook with the midpoint value (25%) assuming the majority of Red Porgy are being vented. The delayed mortality lower bounds of 26% is based on Rudershausen et al. (2007) and the upper bounds of 35% is based on 24-hour cage survival at $46 - 54$ m from Collins (1996). The total recreational hook-and-line mortality estimate ranged from 27 to 53% with a proposed midpoint value of 41% (Table 9). The recreational immediate mortality estimates are the weighted logistic prediction from the SRHS eLog data with the midpoint value assuming 50% of Red Porgy are being vented. The delayed mortality lower bounds of 8% is based on 24-hour cage survival at 36 m from Collins (1996) and the upper bounds of 26% is based on Rudershausen et al. (2007).

2.2.11 Discard Mortality Tables

Table 8. Red porgy commercial hook-and-line total discard mortality estimates (%) based on a range of immediate, delayed, and depredation mortality values.

Immediate	Delayed	Depredation	Total Discard
20	26	5.0	45
25	30	7.5	53
35	35	10.0	64

Table 9. Red porgy recreational hook-and-line total discard mortality estimates (%) based on a range of immediate, delayed, and depredation mortality values.

Immediate	Delayed	Depredation	Total Discard
16	8	5.0	27
22	17	7.5	41
28	26	10.0	53

3 Stock Assessment Methods

This assessment updates the primary model applied during the SEDAR 1, 2002 Benchmark, the SEDAR 1, 2006 Update and the SEDAR 1, 2012 Update for Red Porgy off the southeast United States. The methods are reviewed below, and any changes since the SEDAR 1, 2012 Update are emphasized.

3.1 Overview

The primary model in this assessment was the Beaufort assessment model (BAM), which applies a statistical catch-age formulation. The model was implemented with the AD Model Builder software (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 populations match available data on the real population. Statistical catch-age models share many attributes with ADAPT-style tuned and untuned VPAs.

The method of forward projection has a long history in fishery models. It was introduced by Pella and Tomlinson (1969) for fitting production models and then, among many applications, used by Fournier and Archibald (1982), by Deriso et al. (1985) in their CAGEAN model, and by Methot (1989; 2009) in his Stock Synthesis model. The catch-age model of this assessment is similar in structure to the CAGEAN and Stock Synthesis models. Versions of this assessment model have been used in previous SEDAR assessments of reef fishes in the U.S. South Atlantic, such as Vermilion Snapper, Black Sea Bass, Golden Tilefish, Snowy Grouper, Gag Grouper, Greater Amberjack, Spanish Mackerel, Red Grouper, and Red Snapper, as well as in previous SEDAR assessments of Red Porgy (SEDAR 2002; 2006; 2012).

3.2 Data Sources

The catch-age model included data from four fleets that caught Red Porgy in southeastern U.S. waters: commercial hook-and-line (handline), commercial trawl, general recreational, and recreational headboat. The model was fitted to data on annual landings (in whole weight for commercial fleets and in numbers for recreational fleets), annual discard mortalities (in numbers for commercial handline and recreational fleets; Table 10). Data providers also provided CVs associated with landings and discards (Table 11), though these were only used to generate bootstrap data sets during the ensemble model analysis. The model was also fitted to annual length compositions of commercial trawl landings, annual age compositions of commercial handline and recreational headboat landings and SERFS Chevron trap catches. Samples sizes associated with composition data are provided in numbers of trips (Table 12) and numbers of fish (Table 13). The model was also fitted to one fishery dependent (Southeast Regional Headboat Survey) and one fishery independent (SERFS Chevron trap/video) index of abundance (Table 14). Data used in the model are tabulated in §2 of this report.

The general recreational fleet was sampled from 1981-2007 by the Marine Recreational Fishery Statistics Survey (MRFSS) and by the Marine Recreational Information Program (MRIP) since 2008. For years from 1972-1980, and as in SEDAR-1 and the 2006 and 2012 updates, landings values were assumed to be equal to the average landings from 1981–1990.

Data on annual discard mortalities, as fitted by the model, were computed by multiplying total discards (tabulated in §2) by the fleet-specific release mortality rates of 0.53 for the commercial handline fleet and 0.41 for the headboat and general recreational fleet (Pulver 2018).

3.3 Model Configuration and Equations

Model structure and equations of the BAM are detailed in Williams and Shertzer (2015). The assessment time period for this assessment was 1972-2017. A general description of the assessment model follows.

Stock dynamics In the assessment model, new biomass was acquired through growth and recruitment, while abundance of existing cohorts experienced exponential decay from fishing and natural mortality. The population was assumed closed to immigration and emigration. The model included age classes $1 - 14^{+}$, where the oldest age class 14^{+} allowed for the accumulation of fish (i.e., plus group).

Initialization Initial (1972) abundance at age was estimated in the model as follows. First, the equilibrium age structure was computed for ages 1–14 based on natural and fishing mortality (F_{init}), where F_{init} was assumed equal to the geometric mean of estimated F for the period 1972–1974. 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 2–14, initial (1972) abundance of age-1 fish was computed using the same methods as for recruits in other years (described below).

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 Charnov et al. (2013), a change from the SEDAR 1, 2012 Update which assumed natural mortality was constant across ages. The Charnov et al. (2013) approach inversely relates the natural mortality at age to somatic growth. As in previous SEDAR assessments, the age-dependent estimates of M_a were rescaled to provide the same fraction of fish surviving from age 3 through the oldest observed age (25 yr) as would occur with constant $M = 0.22$. The constant value of M was determined at the SEDAR 60 Workshop panel, as the average of six values, calculated from all combinations of three estimates of maximum age ($t_{max} = 20, 25, 30$) and two methods of calculating M as a function of t_{max} (Hoenig 1983; Then et al. 2014). This set of values was also used to develop a truncated normal distribution for the MCB analysis defined by the mean and standard deviation ($s = 0.063$) of these values truncated to a range of $0.14 - 0.32$.

Growth Mean length (mm) at age of the population (total length, TL) was modeled with the von Bertalanffy equation, and weight at age (whole weight, WW) was modeled as a function of total length (Table 15, Figure 3). Parameters of the relationship between TL and WW were specified by the SEDAR-1 DW and were treated as fixed input to the assessment model ($WW = (2.7e-08)TL^{2.894}$). Parameters of the von Bertalanffy equation relating TL and age ($TL = L_{\infty}(1 - e^{-K(a-t_0)})$) were estimated external to the assessment model during the SEDAR 60 process, and input into the model as fixed values where $a = age + 0.5 =$ age at midyear, $L_{\infty} = 422.6$, $K = 0.3$, and $t_0 = -1.47$. For fitting length composition data, the distribution of size at age was assumed normal with CV estimated external to the assessment model during the SEDAR 60 process ($\widehat{\text{CV}} = 0.136$).

Spawning stock Spawning biomass was modeled as the biomass of mature female and male fish as in prior assessments of Red Porgy. Additionally, for protogynous fish like Red Porgy, computing spawning potential as a function of mature fish biomass has been shown to better account for the contribution of males when estimating biological reference points (Brooks et al. 2008). The sex ratio at age was assumed constant over time and estimated from fish captured in the MARMAP fishery independent monitoring program. This program also supplied the proportion of mature females at age (Table 15). Spawning biomass was computed at the approximate time of peak spawning in each year (February 1^{st}; $spawn\_time\_frac = 0.167$; Klibansky and Scharf 2013; MARMAP unpublished data).

Recruitment Expected recruitment of age-1 fish was predicted from spawning stock (biomass of mature fish) using the Beverton–Holt spawner-recruit model. As in the previous assessment, annual variation in recruitment was assumed to occur with lognormal deviations starting in 1975, when composition data could provide information on year-class strength. In years prior, recruitment followed the Beverton–Holt model precisely, similar to an age-structured production model. Recruitment deviations in the last two years of the model were lightly constrained, penalizing extreme values, since the model has less information to inform recruitment deviations at the end of the time series.

Landings Time series of landings from four fleets were modeled (Table 10): commercial handline (1972–2017), commercial trawl (1972-1988), headboat (1972-2017), and general recreational (1972–2017). A zero value in trawl landings in 1974 was replaced with the smallest non-zero value in the time series (675 lb, reported for 1972). This has almost no effect on model results and was done largely for convenience. Landings were modeled with the Baranov catch equation (Baranov 1918) and were fitted in either weight or numbers, depending on how the data were collected [whole weight (mt) for commercial fleets and 1000 fish for recreational fleets)].

Discards In 1992 a 12" size-limit went into effect for Red Porgy, and 1999 the size limit was increased to 14". Discard mortality data were available for commercial handline (1999–2017), recreational headboat (2001–2017), and general recreational fleets (1981–2017). The model estimated discards for all those years, and also estimated discards during the 12" size-limit for commercial handline and recreational headboat (1992-1998), and during the beginning of the 14" size-limit for recreational headboat (1999-2000; Table 10). During these periods, discards weren't available but were likely to have occurred. In years without observed discards, predicted discards were generated in the assessment model, by applying the fleet-specific geometric mean discard F from years with data. A zero value in general recreational discards in 1990 was replaced with the smallest non-zero value in the time series (200 fish, reported for 1991). This has almost no effect on model results and was done largely for convenience. 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 (described below) and release mortality rates. New discard mortality rate estimates were developed for this SEDAR 60 assessment. Fleet-specific release mortality rates were 0.53 for the commercial handline fleet and 0.41 for the headboat and general recreational fleets (Pulver 2018)

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.

Selectivities In all cases, selectivity at age was estimated using a two-parameter logistic model. This parametric approach reduces the number of estimated parameters and imposes theoretical structure on selectivity. Age and size composition data are critical for estimating selectivity functions.

Selectivity of each fishery was generally fixed within each period of size-limit regulations, but was permitted to vary among periods. With the exception of the commercial trawl fishery, all fisheries experienced three periods of size-limit regulations (no limit prior to 1992, 12" limit during 1992–1998, 14" limit 1999-2017). Ideally, a model would have sufficient age composition data from each fishery over time to estimate selectivities in each period of regulations. That was not the case here, and thus additional assumptions were applied to define selectivities, as follows.

Logistic selectivity functions were estimated for the commercial handline fleet informed by age composition data during two regulatory periods (1972-1998, 1999-2017). No age composition data were available during 1972-1991 for commercial handline to estimate a separate selectivity for this period. A logistic selectivity function was estimated for the commercial trawl fleet during the first regulatory period based on length composition data pooled across years of available data (1977, 1979, 1984, 1986-1988). A logistic selectivity function was estimated for the headboat fleet during each regulatory time period and informed by age composition data. Following previous assessments, the selectivity of the general recreational fleet was set equal to the headboat fleet during each regulatory period. The SERFS chevron trap/video selectivity was estimated to be logistic based solely on age composition data from chevron trap catches (no age or length data is collected directly from videos), departing from the use of dome-shaped selectivity in previous assessments of Red Porgy. The change was made based on examination of the age composition data and the consensus of panel members that the chevron traps do not exclude large Red Porgy.

Similar to the methods in previous assessments of Red Porgy, discard selectivities of the commercial handline and recreational fleets were informed by the selectivities of the landings. For each fleet, the discard selectivity at each age was assumed to be the maximum landing selectivity at age across the all regulatory time periods. Since the selectivity of landings were identical for the headboat and general recreational fleets, the discard selectivities were also identical.

In this assessment, no selectivity parameters were fixed, but normal prior distributions were applied to slope parameters during estimation. Priors were relatively light ($CV = 1.0$), only loosely guiding the estimation of these slope parameters.

Indices of abundance The model was fitted to one fishery dependent index of abundance (headboat 1973–1998) and one fishery independent index of abundance (SERFS Chevron trap/video 1990–2017; Table 14). Predicted indices were computed from numbers at age at the beginning of the year.

Catchability In the BAM, catchability scales indices of relative abundance to the estimated vulnerable population at large. As in prior assessments, catchability coefficients of both indices (fishery independent and fishery dependent) were assumed constant. Thus, the fishery dependent index (headboat fleet) was not assumed to have a technologically induced trend in catchability as has been hypothesized in some SEDAR assessments (SEDAR Procedural Guidance 2009).

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

Fitting criterion The fitting criterion was a likelihood approach in which observed landings and discards were fit closely, and observed composition data and abundance indices were fit to the degree that they were compatible. Landings, discards, and index data were fit using lognormal likelihoods. Length and age composition data were fit using the Dirichlet-multinomial distribution, with sample size represented by the annual number of trips (Table 14), adjusted by an estimated variance inflation factor. The previous assessment fit composition data using multinomial likelihoods, 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).

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 modify the effect of the input CVs. In this application to Red Porgy, CVs of landings (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). In contrast to the previous assessment of Red Porgy, weights of likelihood components were not varied during model development, and were all equal in the base model.

Configuration of base run The base run was configured as described above. However, the base run configuration was not considered to represent all uncertainty. Sensitivity analyses, retrospective analyses, and ensemble modeling was conducted to better characterize the uncertainty in base run point estimates.

Sensitivity analyses Sensitivity of results to some key model inputs and assumptions was examined through sensitivity analyses. Sensitivity runs were chosen to investigate issues that arose specifically with SEDAR 60. These model runs vary from the base run as follows.

- S1: Low value of natural mortality ($M = 0.14$)
- S2: High value of natural mortality ($M = 0.32$)
- S3: Low value of (fixed) steepness ($h = 0.25$)
- S4: High value of (fixed) steepness ($h = 0.51$)
- S5: Low value of (fixed) R_0 ($log(R_0) = 13.9$)
- S6: Include MARMAP Florida Snapper Trap Index and age composition data
- S7: Include female maturity at age as a time-varying vector
- S8-S9: Upweight headboat index: 2×, 3×
- S10: Replace 2016 MRIP landings and discards values, with average of values from 2015 and 2017

Retrospective analyses Retrospective analyses were run by reducing the terminal year of the model from 2017 to 2011-2016, thereby trimming all time series accordingly, and rerunning the assessment model. This analysis facilitates investigation of patterns in model results, particularly terminal status estimates, that may occur when recent data are excluded.

3.4 Parameters Estimated

The model estimated deviations in the initial age structure (13 parameters), average fishing mortality rates (7 parameters) and annual fishing mortality rates (228 parameters) for each fleet, selectivity parameters (12 parameters), Dirichlet-multinomial variance inflation factors (4 parameters), a catchability coefficient associated with each index (2 parameters), steepness of the stock-recruit relationship and initial mean recruitment (2 parameters), variance of the recruitment deviations (1 parameter), and annual recruitment deviations (43 parameters).

3.5 Per Recruit and Equilibrium Analyses

Yield per recruit and spawning potential ratio were computed as functions of F, as were equilibrium landings and spawning biomass. Equilibrium landings and discards were also computed as functions of biomass B, which itself is a function of F. As in computation of MSY-related benchmarks (described in §3.6), 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 (2015–2017) of the assessment.

3.6 Benchmark/Reference Point Methods

In this assessment of Red Porgy, the quantities F_{MSY}, $\mathrm{SSB}_{\mathrm{MSY}}$, B_{MSY}, and MSY were estimated by the method of Shepherd (1982). In that method, the point of maximum yield is calculated from the spawner-recruit curve and parameters describing growth, natural mortality, maturity, and selectivity. The value of F_{MSY} is the F that maximizes equilibrium landings.

On average, expected recruitment is higher than that estimated directly from the spawner-recruit curve, because of lognormal deviation in recruitment. Thus, in this assessment, the method of benchmark estimation accounted for lognormal deviation by including a bias correction in equilibrium recruitment. The bias correction (ς) was computed from the variance (σ_R^2) of recruitment deviation in log space: $\varsigma = \exp(\sigma_R^2/2)$. Then, equilibrium recruitment (R_{eq}) associated with any F is,

$$R_{eq} = \frac{R_0 \left[\varsigma 0.8 h \Phi_F - 0.2(1-h)\right]}{(h-0.2)\Phi_F} \tag{4}$$

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

Estimates of MSY and related benchmarks are conditional on selectivity pattern. The selectivity pattern used here was an average of terminal-year selectivities from each fleet, where each fleet-specific selectivity was weighted in proportion to its corresponding estimate of F averaged over the last three years (2015–2017) of the assessment. 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 0.22. Overfishing is defined as $F > \mathrm{MFMT}$ and overfished as $\mathrm{SSB} < \mathrm{MSST}$. Current status of the stock is represented by SSB in the last assessment year (2017), and current status of the fishery is represented by the geometric mean of F from the last three years (2015–2017).

In addition to the MSY-related benchmarks, the assessment considered proxies based on per recruit analyses (e.g., $F_{40\%}$). The values of $F_{X\%}$ are defined as those Fs corresponding to X% spawning potential ratio, i.e., spawners (spawning biomass) per recruit relative to that at the unfished level. These quantities may serve as proxies for F_{MSY}, if the spawner-recruit relationship cannot be estimated reliably. Mace (1994) recommended $F_{40\%}$ as a proxy; however, later studies have found that $F_{40\%}$ is too high of a fishing rate across many life-history strategies (Williams and Shertzer 2003; Brooks et al. 2009) and can lead to undesirably low levels of biomass and recruitment (Clark 2002).

3.7 Comparison to Previous Assessments

This SEDAR 60 standard assessment builds upon the SEDAR 1, 2012 Update with an additional 6 years of data, substantial improvements to the structure of the Beaufort Assessment Model, and several changes to the configuration of the model, generally simplifying the data structure. The only new data source included in SEDAR 60 was the SERFS video index, which showed a similar trend as the SERFS chevron trap, and was combined with it.

Changes to the life history information used in the model included:

1. Updated estimates of constant natural mortality based on new estimates of maximum age
2. Included age-varying natural mortality, following current SEDAR standards for most assessments
3. Updated most estimates of life history parameters, including more recent data
4. Treated female maturity-at-age as constant over time
5. Time of spawning changed from default January 1^{st} to a value of February 1^{st} based on empirical data
6. Much more uncertainty in M incorporated into MCB analysis in SEDAR 60 ($0.14 - 0.32$) than in the 2012 update (0.20-0.25)

Changes to model configuration include:

1. The youngest age modeled is age-1 (there were very few age-0 fish in the age composition data)
2. Initialization of numbers at age in 1972 was done using a method used in SEDAR (2017), where equilibrium age structure is computed and deviations at age were estimated. In contrast, in the SEDAR 1, 2012 Update assessment, the model started in 1958 assuming the population was at 90% of virgin biomass, and estimated recruitment deviations for these 14 early years to inform age structure in 1972.
3. Growth model parameters are fixed (i.e. not estimated) within the model
4. Selectivity of commercial handline included only two time blocks, since there was not age composition data available to inform selectivity in the earliest time block
5. Selectivity of SERFS chevron trap was changed from dome-shaped to flat-topped (logistic)
6. Length and age compositions were fit using Dirichlet multinomial likelihoods, compared with multinomial likelihoods used in the SEDAR 1, 2012 Update
7. Data sources being fitted were not re-weighted by user-supplied weights. In the SEDAR 1, 2012 Update assessment, data weights were treated as inputs and varied across data sources.

Changes in data structure include:

1. A zero value in trawl landings in 1974 was replaced with the smallest non-zero value in the time series (675 lb, as reported for 1972). This has almost no effect on model results and was done largely for convenience. The SEDAR 1, 2012 Update assessment made several changes to the model to allow the model to run properly with a zero landings value.

2. Combined the relatively small amount (3% of total commercial landings) of commercial trap landings with commercial handline landings

3. Excluded most length composition information data, which conflicted with age composition data

4. Pooled annual commercial trawl length composition data into a single composition

5. Excluded MARMAP Florida snapper trap index and corresponding age and length composition data

3.8 Uncertainty and Measures of Precision

For the base run of the catch-age model (BAM), uncertainty in results and precision of estimates was computed thoroughly through an ensemble modeling approach (Scott et al. 2016) using a mixed Monte Carlo and bootstrap framework (Efron and Tibshirani 1993; Manly 1997). Monte Carlo and bootstrap methods 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; SEDAR4 2004; SEDAR19 2009; SEDAR24 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 small set of sensitivity runs. A minor disadvantage of the approach is that computation times can be long, though current parallel computing techniques largely mitigate those demands [i.e. computing results many times (e.g. 40×) as fast as a single processor].

In this assessment, the BAM was 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. Of the 4000 trials, 3350 were ultimately retained in the uncertainty analysis. The remaining runs were discarded because of poor model convergence or because values of R_0 were in the extreme tails of the distribution among all runs (lower and upper 0.5%).

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.

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

$$O_{s,y} = \hat{O}_{s,y}[\exp(x_{s,y} - \sigma^2_{s,y}/2)] \quad (5)$$

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, $\sigma_{s,y} = \sqrt{\log(1.0 + CV^2_{s,y})}$. The CVs used to generate bootstrap data sets of landings and discards were supplied by the data providers (Table 11). Note that these values are different and generally higher than the CVs used to estimate landings and discards when fitting the assessment model (i.e. 0.05 for all years and fleets). The CVs used to generate bootstrap data sets of indices of abundance were the same as those used when fitting the assessment model (Table 14).

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 (Table 13) were drawn at random with replacement using the cell probabilities of the original data. For each year of each data source, the number of fish sampled was the same as in the original data (Table 14).

3.8.2 Monte Carlo Sampling

In each successive fit of the model, several parameters were fixed (i.e., not estimated) at values drawn at random from distributions described below.

Natural mortality The point estimate of natural mortality ($M = 0.22$) was provided by the SEDAR 60 Workshop Panel 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 (described above) defined by the mean of 0.22 and standard deviation of 0.063, and truncated to a range of $0.14 - 0.32$. In each run of the ensemble, a drawn value of constant M was then used to rescale natural mortality at age, as described for the base model above.

Discard mortalities Similarly, discard mortalities δ were subjected to Monte Carlo variation as follows. New values for commercial handline were drawn for each MCB trial from a uniform distribution (range [0.45, 0.64]), and new values for recreational fleets (headboat and general recreational) were drawn from a uniform distribution (range [0.27, 0.53]).

3.9 Projection Methods

Projections were run to determine the overfishing limit (OFL) and evaluate the existing rebuilding plan 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 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, and landings were represented by deterministic projections using parameter estimates from the base run. These projections were built on the estimated spawner-recruit relationship with bias correction, and were thus consistent with estimated benchmarks in the sense that long-term fishing at F_{MSY} would yield MSY from a stock size at SSB_{MSY}. Uncertainty in future time series was quantified through stochastic projections that extended the ensemble model fits of the stock assessment model.

3.9.1 Initialization of Projections

Although the terminal year of the assessment is 2017, the assessment model computes abundance at age (N_a) at the start of 2018. For projections, those estimates were used to initialize N_a. However, the assessment has no information to inform the strength of 2018 recruitment, and thus it computes 2018 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 (2018) of projections included this variability in N_1. The deterministic projections were not adjusted in this manner, because deterministic recruitment follows Beverton-Holt expectation.

Fishing rates that define the projections were assumed to start in 2021. Because the assessment period ended in 2017, the projections required an interim period (2018–2020). Fishing mortality during this interim period was set at $F_{\text{current}} = 0.31$.

3.9.2 Uncertainty of Projections

To characterize uncertainty in future stock dynamics, stochasticity was included in replicate projections, each an extension of a single assessment fit from the ensemble. Thus, projections carried forward uncertainties in natural mortality and discard mortality, as well as in estimated quantities such as spawner-recruit parameters (R_0 and σ_R, selectivity curves, and in initial (start of 2018) abundance at age.

Initial and subsequent recruitment values were generated with stochasticity using a Monte Carlo procedure, in which the estimated recruitment of each model within the ensemble 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,

$$R_y = \bar{R}_y \exp(\epsilon_y). \tag{6}$$

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 ensemble model component.

The procedure generated $20,000$ replicate projections of models within the ensemble drawn at random (with replacement). In cases where the same model 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.

3.9.3 Projection Scenarios

Projections were run to determine the overfishing limit (OFL) and evaluate the existing rebuilding plan as requested in the TORs. In the projections, management started in 2021, the earliest year possible at the time of writing. Projections were made out to 2026 or 2032, Scenarios 1 and 2 were considered to determine the OFL and scenarios 3 and 4 were considered to evaluate the existing rebuilding plan:

- Scenario 1: $F = F_{\text{P}^*_{50\%}}$ from 2021 to 2026, and with $F = F_{\text{current}}$ from 2018 to 2020.
- Scenario 2: $F = F_{\text{MSY}}$ from 2021 to 2026, with $F = F_{\text{current}}$ from 2018 to 2020.
- Scenario 3: $F = 75\% F_{\text{MSY}}$ from 2021 to 2026, with $F = F_{\text{current}}$ from 2018 to 2020.
- Scenario 4: $F = 0$ from 2021 to 2032, with $F = F_{\text{current}}$ from 2018 to 2020.

4 Stock Assessment Results

4.1 Measures of Overall Model Fit

The Beaufort assessment model (BAM) generally fit well to the available data. Predicted age compositions from each fishery were reasonably close to observed data in most years, as were predicted length compositions for the commercial trawl fleet (Figure 4). The model was configured to fit observed commercial and recreational landings closely (Figures 5, 6, 7, 8), as well as observed discards (Figures 9, 10, 11). Fits to indices of abundance captured the general trends but not all annual fluctuations (Figures 12, 13). The model tended to overestimate the headboat index from 1990-1998, years which overlapped with the SERFS chevron trap/video index.

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 showed truncation of the older ages beginning in the 1980s (Figure 14; Table 16). The model predicted a large recruitment event in 1977 driving high abundance for several subsequent years. Total abundance was high during the 1970s peaking in 1977 and declining to a low in 2000. Abundance increased modestly during the 2000s to a peak in 2011, but has been declining from 2012 to the end of the assessment period. Total estimated abundance was at its lowest values at the end of the time series. Annual number of recruits is shown in Table 16 (age-1 column) and in Figure 16. In the most recent decade, the strongest year class (age-1 fish) was predicted to have occurred in 2010. The SEDAR 1, 2012 Update assessment report (SEDAR 2012) noted below average recruitment during the last five years (2007-2011). In the current assessment, predicted recruitment values during the last six years (2013-2018) are among the lowest for the entire time series.

4.4 Total and Spawning Biomass

Estimated biomass at age followed a similar pattern as abundance at age (Figure 15; Tables 17, 18). Total biomass and spawning biomass showed similar trends—general decline from the late 1970s to 2000, followed by a gradual recovery through 2011, followed by a rapid decline to the end of the time series (Figure 17; Table 19).

4.5 Selectivity

Selectivity of the SERFS chevron trap/video survey is shown in (Figure 18), selectivities of landings from commercial and recreational fleets are shown in Figures 19 and 20. In the most recent years, full selection occurred near age-5 to age-6, depending on the fleet. Selectivities of discard mortalities were a function of logistic shaped landings selectivities (Figures 21).

Average selectivities of landings and of discard mortalities were computed from F-weighted selectivities in the most recent period of regulations (Figure 22). These average selectivities were used to compute point estimates of benchmarks. All selectivities from the most recent period, including average selectivities, are tabulated in Table 20.

4.6 Fishing Mortality, Landings, and Discards

The estimated fishing mortality rates (F) showed an increasing trend from the early 1970s to peak levels in 1990. Subsequently, F declined to lower levels since 2000, with two high values at the end of the time series largely attributed to the general recreational fleet (Figure 23). The commercial handline fleet had been the largest contributor to total F during much of the 1980s and 1990s, but since 2000 large and sometimes predominant proportions of total fishing mortality have been attributed to recreational fleets (Table 21).

The overall pattern in landings over time is similar to the pattern in F, though the decrease in total landings since 2000 compared with earlier landings, is more substantial than the corresponding decrease in F. Landings have been low in the past two decades, but so has abundance, so the F is still comparatively higher. A majority of estimated landings during the 1980s and 1990s were from the commercial sector, but since the early 2000s, larger proportions of Red Porgy landings have come from the recreational sector in many years (Figures 24, 25; Tables 25, 26). Estimated discard mortalities occurred on a much smaller scale than landings (5% of removals by numbers). Both the commercial and recreational sectors contribute substantially to discards. Dead discards have been highly variable with a notable peak in 2002 largely attributed to the commercial handline fleet and peaks in 2008 and 2016 largely attributed to the general recreational fleet (Figures 26 and 27; Tables 27, 28).

4.7 Spawner-Recruitment Parameters

The estimated Beverton–Holt spawner-recruit curve is shown in Figure 28, along with the effect of density dependence on recruitment, depicted graphically by recruits per spawner as a function of spawners (spawning biomass). Values of recruitment-related parameters were as follows: steepness $\hat{h} = 0.38$, unfished age-1 recruitment $\widehat{R}_0 = 3,430,000$, unfished spawning biomass (mt) per recruit $\phi_0 = 0.00174$, and standard deviation of recruitment residuals in log space $\widehat{\sigma}_R = 0.45$ (which resulted in bias correction of $\varsigma = 1.11$). Uncertainty in these quantities was estimated through the Monte Carlo/bootstrap (MCB) analysis (Figure 29).

4.8 Per Recruit and Equilibrium Analyses

Yield per recruit and spawning potential ratio were computed as functions of F (Figure 30). As in computation of MSY-related benchmarks, per recruit analyses applied the most recent selectivity patterns averaged across fisheries, weighted by F from the last three years (2015 – 2017). The F that provides 40% SPR is $F_{40\%} = 0.6$, 30% is $F_{30\%} = 1.21$, and 20% is $F_{20\%} = 3.12$.

As in per recruit analyses, equilibrium landings and spawning biomass were computed as functions of F (Figure 31). 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 (Figure 28). 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. Estimates of benchmarks are summarized in Table 29. Standard errors of benchmarks were approximated as those from Monte Carlo/bootstrap analysis (§3.8).

Maximum likelihood estimates (base run) of benchmarks, as well as median values from MCB analysis, are summarized in Table 29. Point estimates of MSY-related quantities were $F_{\text{MSY}} = 0.18$ (y^{-1}), MSY = 531 (1000 lb), $B_{\text{MSY}} = 3605$ (mt), MSST = 2249 (mt), and $\text{SSB}_{\text{MSY}} = 2884$ (mt). The estimate of SSB_{MSY} is about 48% of the unfished spawning biomass. Median estimates were $F_{\text{MSY}} = 0.18$ (y^{-1}), MSY = 538 (1000 lb), $B_{\text{MSY}} = 3594$ (mt), MSST = 2261, and $\text{SSB}_{\text{MSY}} = 2903$ (mt). Distributions of these benchmarks from the MCB analysis are shown in Figure 32.

4.10 Status of the Stock and Fishery

Estimated time series of stock status (SSB/MSST and $\text{SSB}/\text{SSB}_{\text{MSY}}$) showed a rapid decline from favorable stock sizes in the 1970s to low levels in the late 1990s. From 1999 to 2011 stock status was gradually recovering, but has been in decline again since 2012 (Figure 33, Table 19). The increasing trend observed from 1998 to 2011 appears to have been driven largely by decreases in landings, while being hampered by low recruitment.

Current stock status was estimated in the base run to be $\text{SSB}_{2017}/\text{MSST} = 0.347$ and $\text{SSB}_{2017}/\text{SSB}_{\text{MSY}} = 0.27$ (Table 29), indicating that the stock remains in an overfished state. Results from the MCB analysis suggested that the estimate of SSB relative to SSB_{MSY} and the status relative to MSST are robust, and there is little uncertainty in the overfished status (Figures 34, 35). Age structure estimated by the base run during 2017 suggests that the age composition of the population above age-5 has been recovering toward what is expected at MSY, but abundances at age-1 to age-5 are as low as they have ever been (Figure 36). This finding further suggests that reduced fishing mortalities have been promoting recovery of older age classes but below average recruitment has stifled recovery for younger age classes.

The estimated time series of F/F_{MSY} suggests that overfishing has been occurring throughout most of the assessment period (Table 19), but with some uncertainty demonstrated by the MCB analysis (Figure 33). Current fishery status in the terminal year, with current F represented by the geometric mean from $2015 - 2017$, was estimated by the base run to be $F_{2015-2017}/F_{\text{MSY}} = 1.73$ (Table 29). Thus at the end of the assessment Red Porgy was undergoing overfishing. Results from the MCB analysis show that there is little uncertainty in the status of the fishery (Figures 34, 35). Note that F_{MSY} is based on average F's from last three years of the assessment and thus it is not the technically correct denominator for all years going back in time. Thus caution should be applied when interpreting F status back in time.

4.11 Comparison to Previous Assessments

In 1992, an initial rebuilding plan was put into effect for Red Porgy (SAFMC Amendment 4, 01/01/1992) with a rebuilding time frame of 10 years, beginning in 1991. In 2000, a new rebuilding plan was put into effect (SAFMC Amendment 12, 09/12/2000) with a rebuilding time frame of 18 years, beginning in 1999.

The first SEDAR stock assessment of Red Porgy (SEDAR 01; SEDAR 2002) modeled the population from 1972-2001. Assessment model timelines for subsequent assessments are as follows: SEDAR 01, 2006 update assessment (1972-2004 SEDAR 2006), SEDAR 01, 2012 update assessment (1972-2011 SEDAR 2012), and the current SEDAR 60 standard assessment (1972-2017).

As of 2001, the stock was overfished ($\text{SSB}_{2001}/\text{MSST} = 0.55$; $\text{SSB}_{2001}/\text{SSB}_{\text{MSY}} = 0.43$), but overfishing was not occurring ($F_{2001}/F_{\text{MSY}} = 0.45$; SEDAR 2002). Projections from SEDAR-1 found that under the Amendment 12 scenario, the probability of being rebuilt by the terminal years of subsequent assessments (2004, 2011, or 2017) to be $\approx 0\%$, $\approx 5\%$, and $\approx 38\%$. Terminal status estimates the 2006 and 2012 updates found that the Red Porgy stock was not rebuilt ($\mathrm{SSB}_{2005}/\mathrm{SSB}_{\mathrm{MSY}} = 0.66$ and $\mathrm{SSB}_{2011}/\mathrm{SSB}_{\mathrm{MSY}} = 0.47$), but was also not undergoing overfishing ($F_{2004}/F_{\mathrm{MSY}} = 0.45$ and $F_{2009-2011}/F_{\mathrm{MSY}} = 0.64$).

Values from the current SEDAR 60 assessment support the stock status designations from all three previous SEDAR assessments, with values in similar ranges for $\mathrm{SSB}_{2001}/\mathrm{SSB}_{\mathrm{MSY}} = 0.36$, $\mathrm{SSB}_{2005}/\mathrm{SSB}_{\mathrm{MSY}} = 0.43$, and $\mathrm{SSB}_{2011}/\mathrm{SSB}_{\mathrm{MSY}} = 0.51$ (Table 19). However, the current assessement results suggest that overfishing was occurring in 2001 and 2004 ($F_{2001}/F_{\mathrm{MSY}} = 1.19$, $F_{2004}/F_{\mathrm{MSY}} = 1.27$) and at the end of SEDAR 1, 2012 Update ($F_{2009-2011}/F_{\mathrm{MSY}} = 1.05$). In general, time series of $\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$ and F/F_{MSY} produced in SEDAR 60 are similar to time series from previous assessments, where they overlapped. However, compared with SEDAR 1, 2012 Update estimates from SEDAR 60 of biomass and SSB were higher early in the time series (e.g. 1972-1980) and lower from 1990-2000, while full F was higher from 1990-2000. These differences may be due in part to differences in initialization methods and weighting of the headboat index in SEDAR 1, 2012 Update, but are probably mostly due to the revised MRIP estimates, which are higher now.

Input values of constant M have been similar over the four Red Porgy assessments (terminal years: 2001, 2004, 2011, 2017; M: 0.225, 0.225, 0.225, 0.22). Steepness has been estimated in all assessments and estimates have generally decreased over time (h: 0.48, 0.50, 0.41, 0.38). The contrast in SSB over time is generally considered to be a scenario that is informative of steepness. Estimates of F_{MSY} have remained in a similar range (F_{MSY}: 0.19, 0.20, 0.17, 0.18). Estimates of MSY and $\mathrm{SSB}_{\mathrm{MSY}}$ are lower in the current assessment [MSY (1000 lb): 826, 626, 834, 531; $\mathrm{SSB}_{\mathrm{MSY}}$, (mt): 3050, 3236, 3933, 2884].

4.12 Sensitivity Analyses

Sensitivity runs, described in §3.3, may be useful for evaluating implications of assumptions in the base assessment model, and for interpreting MCB results in terms of expected effects from input parameters. Time series of F/F_{MSY}, SSB/MSST, B, and recruitment are plotted to demonstrate sensitivity to natural mortality (Figure 37), the steepness of the stock-recruit relationship (Figure 38), virgin recruitment (R_0; Figure 39), inclusion of the MARMAP Florida snapper trap index and composition data (Figure 40), time varying female maturity (Figure 41), upweighting the headboat index (Figure 42), replacing 2016 MRIP landings and discards with the average of adjacent years (Figure 43).

The qualitative results on terminal stock status were the same across all sensitivity runs, supporting the results of the base model that the stock is currently overfished ($\mathrm{SSB}_{2017} < \mathrm{MSST}$). Mosts runs also supported the result of the base model, that overfishing is occurring (Figure 44, Table 30). The exceptions were runs $S4$ (high steepness), $S5$ (low virgin recruitment; R_0), and $S9$ ($3\times$ weight on headboat index). In concert, sensitivity analyses were in general agreement with those of the MCB analysis.

4.13 Retrospective Analyses

Retrospective analyses did not suggest any patterns of substantial over- or underestimation in terminal-year estimates of F/F_{MSY} or recruitment, but terminal values of SSB/MSST and biomass (B) consistently underestimated analogous values from the base run (Figure 45).

4.14 Projections

Projections results for Red Porgy are shown in Figures 46, 47, 48, and 49, and Tables 31, 32, 33, and 34. Among all scenarios considered, the Red Porgy stock exhibits a range of 0.5 to 6.2% probability of rebuilding by 2026. Thus under no management prescription, including $F = 0$, is the Red Porgy population projected to have a 50% or greater chance of SSB > SSB_{MSY} by 2026. At $F = 0$, the probability that SSB > SSB_{MSY} exceeds 50% in 2032. However it is only theoretically possible to achieve $F = 0$ owing to discard mortality that will inevitably occur by fisheries targeting other stocks.

5 Discussion

5.1 Comments on Assessment Results

Estimated benchmarks played a central role in this assessment. Values of MSST and F_{MSY} were used to gauge the status of the stock and fishery. For rebuilding projections, SSB reaching SSB_{MSY} was the criterion that defined a successfully rebuilt stock. Computation of benchmarks was conditional on selectivity. If selectivity patterns change in the future, for example as a result of new size limits or different relative catch allocations among sectors, including discards, estimates of benchmarks would likely change as well.

The base run of the BAM indicated that the stock is not yet rebuilt ($\text{SSB}_{2017}/\text{SSB}_{\text{MSY}} = 0.27$), and that overfishing is occurring ($F_{2015-2017}/F_{\text{MSY}} = 1.73$). These results were generally consistent across sensitivity runs and MCB analyses, but with slightly more uncertainty in the overfishing status than in the stock status. Of the sensitivity runs conducted with the BAM, results were least sensitive to inclusion of the MARMAP Florida snapper trap data, smoothing of the 2016 value of MRIP landings and discards, including time varying female maturity, and 2× upweighting of the headboat index. Results were most sensitive to alternate values of steepness and R_0, and 3× upweighting of the headboat index, and somewhat sensitive to alternative values of natural mortality.

Low sensitivity to the MARMAP Florida snapper trap data is not very surprising as this index was a fairly short time series and the model didn't seem to fit it very well in the previous assessment. Lack of sensitivity to the 2016 value of MRIP landings and discards was reassuring since these values are large and have been scrutinized heavily at various steps in the SEDAR process. Counter to expectations, these values were not very influential. Sensitivity to steepness and natural mortality are common in stock assessment. In this assessment, likelihood profiles suggested that it was very unlikely for steepness to be much lower than the base run value, so the sensitivity run fixing steepness at a lower value, which resulted in much poorer SSB and F-status seems less likely than the run with higher steepness. The run with natural mortality set at a higher value, which resulted in much better SSB and slightly better F-status seems less likely than the run with a lower natural mortality, since estimates of natural mortality tend to get lower over time as older fish are discovered, and are less commonly found to be higher.

Model parameters and biological reference point estimates were similar in precision to other SEDAR assessments, but notably less precise than in the 2012 update. The increased uncertainty in the current assessment is probably due in part to a substantial increase in the uncertainty in natural mortality modeled in SEDAR 60 ($0.14 \leq M \leq 0.32$) than in the 2012 update ($0.20 \leq M \leq 0.25$).

South Atlantic Red Porgy is not currently rebuilt, which is consistent with projections made in SEDAR 1, 2002 Benchmark(SEDAR 2002), which estimated the probability of the stock being rebuilt by 2017 was ≈ 0.38. The recent history of F in the South Atlantic stock of Red Porgy is most similar to projection scenario 4 from the 2012 update (SEDAR 2012), with projections at $F_{2013-2017} = F_{\text{MSY}} = 0.17$. The projection from the SEDAR 1, 2012 Update estimated $\text{SSB}_{2017}/\text{SSB}_{\text{MSY}} = 0.57$ and the probability that SSB > SSB_{MSY} by 2017 to be 0.01. This 2012 projection also predicted that the stock would not be rebuilt by now, but substantially overestimated rebuilding status compared to the SEDAR 60 estimate ($\text{SSB}_{2017}/\text{SSB}_{\text{MSY}} = 0.27$). The overly optimistic projection may have been partly due to the fact that recruitment has continued to decline since the 2012 update, so observed recruitment values for $2013 - 2017$ were lower than the average expected from the stock-recruit curve.

5.2 Comments on Projections

As usual, projections should be interpreted in light of the model assumptions and key aspects of the data. Some major considerations are the following:

- In general, projections of fish stocks are highly uncertain, particularly in the long term (e.g., beyond 5–10 years).
- Although projections included many major sources of uncertainty, they did not include structural (model) uncertainty. That is, projection results are conditional on one set of functional forms used to describe population dynamics, selectivity, recruitment, etc.
- Fisheries were assumed to continue fishing at their estimated current proportions of total effort, using the estimated current selectivity patterns. Benchmarks (e.g. MSY, D_{MSY}) are conditional on the estimated selectivity functions and the relative contributions of each fleet's fishing mortality. Selectivity patterns of landings and discards are different, and therefore projections of landings and discards are not interchangeable. New management regulations that reallocate harvest in a way that alters proportions of F by fleet or selectivity patterns would likely affect projection results.
- The projections assumed that the estimated spawner-recruit relationship applies in the future and that past residuals represent future uncertainty in recruitment. If future recruitment is characterized by runs of large or small year classes, possibly due to environmental or ecological conditions, stock trajectories may be affected.
- Projections 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.

6 Research Recommendations

- Investigate temporal trends in growth, sex at age, and female maturity at age. In the previous assessments, female maturity at age was estimated for several time blocks and included in the model as a time-varying relationship. During the current assessment process, the basis for modeling only female maturity as time-varying was called into question, given that life history parameters are often linked. The decision was made to use only a single female maturity at age relationship. However the panel judged this to be an important area of future research.

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8 Tables

Table 10. Observed time series of landings (L) and dead discards (D) for commercial handline (cHl), commercial trawl (cTw), recreational headboat (rHb), and MRIP (rGe). Commercial landings are in units of 1000 lb whole weight. Recreational landings and all discards are in units of 1000 fish. Discards include fish released dead.

Year	L.cHl	L.cTw	L.rHb	L.rGe	D.cHl	D.rHb	D.rGe
1972	32.17	0.67	219.90	81.54	.	.	.
1973	14.65	12.95	299.60	81.54	.	.	.
1974	108.35	0.67	219.80	81.54	.	.	.
1975	197.74	1.16	215.50	81.54	.	.	.
1976	211.70	39.26	186.70	81.54	.	.	.
1977	288.62	148.47	243.60	81.54	.	.	.
1978	718.95	7.44	223.70	81.54	.	.	.
1979	983.55	83.11	156.50	81.54	.	.	.
1980	940.98	292.82	168.40	81.54	.	.	.
1981	1268.05	303.13	168.29	56.17	.	.	0.52
1982	1382.73	223.35	272.88	54.90	.	.	0.81
1983	1182.07	113.74	155.74	21.28	.	.	0.29
1984	1062.89	62.07	129.97	258.26	.	.	0.61
1985	847.75	15.83	176.58	195.67	.	.	6.17
1986	906.18	15.06	161.04	36.30	.	.	0.23
1987	777.44	9.68	173.57	70.60	.	.	9.28
1988	868.35	24.71	168.56	208.54	.	.	0.27
1989	924.36	.	146.49	138.49	.	.	8.64
1990	1138.58	.	104.76	107.43	.	.	0.08
1991	832.44	.	129.88	60.53	.	.	0.08
1992	516.53	.	85.89	158.62	.	.	5.34
1993	470.08	.	81.69	54.58	.	.	3.35
1994	436.36	.	70.39	70.32	.	.	1.06
1995	432.07	.	70.71	44.94	.	.	9.10
1996	429.61	.	64.91	66.00	.	.	2.87
1997	425.70	.	53.87	20.75	.	.	0.72
1998	317.98	.	53.88	31.10	.	.	2.66
1999	105.14	.	31.95	28.38	42.35	.	24.86
2000	26.21	.	8.04	10.56	46.47	.	9.27
2001	66.17	.	28.86	40.37	43.25	17.96	48.27
2002	58.17	.	20.93	57.61	133.00	13.02	25.38
2003	50.37	.	20.17	55.76	24.34	12.56	39.74
2004	49.68	.	23.46	74.54	20.72	26.13	37.63
2005	48.66	.	24.78	50.03	13.27	7.70	21.11
2006	83.81	.	40.22	29.97	21.32	17.75	3.37
2007	144.29	.	74.94	54.53	13.42	17.45	21.36
2008	171.96	.	32.52	107.07	21.30	11.41	46.17
2009	164.53	.	19.54	53.03	17.80	6.05	4.52
2010	158.82	.	21.92	29.24	11.14	5.30	9.52
2011	202.83	.	21.09	52.34	6.33	6.19	9.00
2012	162.26	.	23.22	49.75	14.75	6.93	3.58
2013	171.46	.	17.71	35.74	13.98	5.70	5.92
2014	158.14	.	17.17	23.71	14.90	7.32	14.59
2015	154.81	.	15.55	65.94	16.10	7.70	27.52
2016	127.44	.	15.31	278.49	8.89	6.34	112.32
2017	129.80	.	12.33	60.44	9.77	4.59	14.71

Table 11. Observed time series of CVs used in ensemble modeling (MCB) associated with landings (L) and discards (D) for commercial handline (cHl), commercial trawl (cTw), recreational headboat (rHb), and MRIP (rGe). These CVs were used to generate bootstrap data sets in the ensemble model analysis only. When fitting the assessment model, CVs of 0.05 were used for estimating landings and discards, in all cases.

Year	L.cHl	L.cTw	L.rHb	L.rGe	D.cHl	D.rHb	D.rGe
1972	0.30	0.30	0.10	0.42	.	.	.
1973	0.30	0.30	0.10	0.42	.	.	.
1974	0.30	0.30	0.10	0.42	.	.	.
1975	0.30	0.30	0.10	0.42	.	.	.
1976	0.30	0.30	0.10	0.42	.	.	.
1977	0.30	0.30	0.10	0.42	.	.	.
1978	0.30	0.30	0.10	0.42	.	.	.
1979	0.30	0.30	0.10	0.42	.	.	.
1980	0.30	0.30	0.10	0.42	.	.	.
1981	0.30	0.30	0.05	0.57	.	.	1.00
1982	0.30	0.30	0.05	0.60	.	.	0.79
1983	0.30	0.30	0.05	0.52	.	.	1.00
1984	0.28	0.28	0.05	0.16	.	.	0.68
1985	0.25	0.25	0.05	0.50	.	.	0.81
1986	0.23	0.23	0.05	0.51	.	.	1.00
1987	0.21	0.21	0.05	0.46	.	.	0.69
1988	0.19	0.19	0.05	0.65	.	.	1.00
1989	0.16	.	0.05	0.29	.	.	1.00
1990	0.14	.	0.05	0.32	.	.	1.00
1991	0.12	.	0.05	0.32	.	.	1.00
1992	0.10	.	0.05	0.47	.	.	0.42
1993	0.07	.	0.05	0.29	.	.	0.55
1994	0.05	.	0.05	0.24	.	.	0.56
1995	0.05	.	0.05	0.39	.	.	0.57
1996	0.05	.	0.05	0.59	.	.	0.88
1997	0.05	.	0.05	0.38	.	.	1.00
1998	0.05	.	0.05	0.50	.	.	0.71
1999	0.05	.	0.05	0.30	0.10	.	0.66
2000	0.05	.	0.05	0.66	0.10	.	0.50
2001	0.05	.	0.05	0.24	0.10	0.10	0.34
2002	0.05	.	0.05	0.25	0.10	0.10	0.33
2003	0.05	.	0.05	0.28	0.10	0.10	0.42
2004	0.05	.	0.05	0.28	0.10	0.10	0.30
2005	0.05	.	0.05	0.40	0.10	0.10	0.54
2006	0.05	.	0.05	0.32	0.10	0.10	0.51
2007	0.05	.	0.05	0.31	0.10	0.10	0.45
2008	0.05	.	0.05	0.26	0.10	0.10	0.42
2009	0.05	.	0.05	0.35	0.10	0.10	0.85
2010	0.05	.	0.05	0.36	0.10	0.10	0.60
2011	0.05	.	0.05	0.48	0.10	0.10	0.69
2012	0.05	.	0.05	0.27	0.10	0.10	0.44
2013	0.05	.	0.05	0.45	0.10	0.10	0.42
2014	0.05	.	0.05	0.33	0.10	0.10	0.48
2015	0.05	.	0.05	0.45	0.10	0.10	0.47
2016	0.05	.	0.05	0.37	0.10	0.10	0.52
2017	0.05	.	0.05	0.41	0.10	0.10	0.57

Table 12. Sample sizes (number of trips) of length compositions (lcomp) or age compositions (acomp) by survey or fleet. Data sources are commercial trawl (cTw), commercial handline (cHl), recreational headboats (rHb), and SERFS chevron trap (sCT).

Year	lcomp.cTw	acomp.cHl	acomp.rHb	acomp.sCT
1972	.	.	.	.
1973	.	.	.	.
1974	.	.	.	.
1975	.	.	.	.
1976	.	.	.	.
1977	15	.	.	.
1978	.	.	.	.
1979	.	.	10	.
1980	.	.	.	.
1981	.	.	.	.
1982	.	.	.	.
1983	.	.	9	.
1984	.	.	17	.
1985	.	.	13	.
1986	.	.	15	.
1987	.	.	34	.
1988	.	.	.	.
1989	.	.	.	.
1990	.	.	.	138
1991	.	.	21	122
1992	.	.	7	96
1993	.	.	.	106
1994	.	.	.	86
1995	.	.	.	131
1996	.	.	.	207
1997	.	6	.	124
1998	.	8	58	155
1999	.	.	.	101
2000	.	8	.	127
2001	.	14	3	114
2002	.	7	.	118
2003	.	7	.	102
2004	.	42	.	153
2005	.	60	23	158
2006	.	172	25	119
2007	.	260	64	148
2008	.	264	26	96
2009	.	204	24	114
2010	.	158	21	191
2011	.	257	29	217
2012	.	193	23	295
2013	.	154	58	275
2014	.	141	38	307
2015	.	103	26	395
2016	.	125	45	400
2017	.	115	16	334

Table 13. Sample sizes (number of fish) of length compositions (lcomp) or age compositions (acomp) by survey or fleet. Data sources are commercial trawl (cTw), commercial handline (cHl), recreational headboats (rHb), and SERFS chevron trap (sCT).

Year	lcomp.cTw	acomp.cHl	acomp.rHb	acomp.sCT
1972	.	.	.	.
1973	.	.	.	.
1974	.	.	.	.
1975	.	.	.	.
1976	.	.	.	.
1977	2538	.	.	.
1978	.	.	.	.
1979	.	.	10	.
1980	.	.	.	.
1981	.	.	.	.
1982	.	.	.	.
1983	.	.	19	.
1984	.	.	30	.
1985	.	.	18	.
1986	.	.	28	.
1987	.	.	86	.
1988	.	.	.	.
1989	.	.	.	.
1990	.	.	.	953
1991	.	.	54	831
1992	.	.	12	1111
1993	.	.	.	722
1994	.	.	.	1115
1995	.	.	.	891
1996	.	.	.	1026
1997	.	309	.	601
1998	.	37	198	733
1999	.	.	.	470
2000	.	407	.	522
2001	.	307	10	720
2002	.	37	.	581
2003	.	75	.	491
2004	.	191	.	1084
2005	.	264	24	1115
2006	.	624	25	756
2007	.	1015	92	1154
2008	.	1227	26	411
2009	.	740	34	426
2010	.	678	29	785
2011	.	1070	49	1032
2012	.	723	77	1677
2013	.	578	188	1305
2014	.	670	168	1836
2015	.	482	122	1975
2016	.	506	128	1896
2017	.	456	44	1583

Table 14. Observed indices of abundance and CVs from recreational headboats (rHb) and SERFS chevron trap/video (sCT).

Year	rHb	sCT	cv.rHb	cv.sCT
1972	.	.	.	.
1973	1.990	.	0.177	.
1974	1.994	.	0.156	.
1975	1.395	.	0.181	.
1976	1.175	.	0.134	.
1977	1.986	.	0.096	.
1978	2.825	.	0.063	.
1979	1.888	.	0.088	.
1980	1.905	.	0.088	.
1981	1.384	.	0.132	.
1982	1.388	.	0.137	.
1983	0.677	.	0.232	.
1984	0.673	.	0.232	.
1985	0.797	.	0.188	.
1986	1.055	.	0.126	.
1987	0.930	.	0.138	.
1988	0.718	.	0.188	.
1989	0.753	.	0.206	.
1990	0.426	0.87	0.332	0.16
1991	0.386	1.38	0.348	0.16
1992	0.310	1.34	0.349	0.16
1993	0.235	0.82	0.410	0.17
1994	0.237	0.96	0.406	0.16
1995	0.183	1.26	0.472	0.17
1996	0.222	0.87	0.424	0.16
1997	0.275	0.66	0.415	0.18
1998	0.195	0.73	0.447	0.17
1999	.	0.87	.	0.17
2000	.	0.81	.	0.19
2001	.	1.13	.	0.18
2002	.	1.01	.	0.19
2003	.	0.80	.	0.18
2004	.	1.41	.	0.16
2005	.	1.44	.	0.16
2006	.	1.00	.	0.18
2007	.	1.41	.	0.16
2008	.	0.72	.	0.19
2009	.	0.62	.	0.19
2010	.	1.04	.	0.16
2011	.	1.22	.	0.13
2012	.	1.21	.	0.11
2013	.	0.93	.	0.13
2014	.	1.07	.	0.11
2015	.	0.89	.	0.11
2016	.	0.79	.	0.11
2017	.	0.74	.	0.12

Table 15. Life-history characteristics at age. Variables include total length (TL) in millimeters (mm) and inches (in) and weight (mid-year), and inches (in), the coefficient of variation (CV) of TL, total weight (W) in kilograms (kg) and pounds (lb), proportion (P) female, and mature by sex, spawning stock biomass (SSB; sum product of the proportion and maturity of each sex and the average weight), and natural mortality. All values were fixed model input.

Age	TL (mm)	TL (in)	TL CV	W (kg)	W (lb)	P(female)	P(mature female)	P(mature male)	SSB (kg)	M
1	249	9.8	0.14	0.23	0.51	0.82	0.30	1	0.10	0.46
2	294	11.6	0.14	0.38	0.83	0.71	0.69	1	0.29	0.36
3	327	12.9	0.14	0.51	1.13	0.57	0.92	1	0.49	0.30
4	352	13.9	0.14	0.63	1.40	0.42	0.98	1	0.63	0.27
5	370	14.6	0.14	0.73	1.62	0.28	1.00	1	0.73	0.25
6	384	15.1	0.14	0.81	1.79	0.17	1.00	1	0.81	0.24
7	394	15.5	0.14	0.88	1.93	0.10	1.00	1	0.88	0.23
8	401	15.8	0.14	0.92	2.04	0.06	1.00	1	0.92	0.22
9	407	16.0	0.14	0.96	2.12	0.03	1.00	1	0.96	0.22
10	411	16.2	0.14	0.99	2.18	0.02	1.00	1	0.99	0.22
11	414	16.3	0.14	1.01	2.23	0.01	1.00	1	1.01	0.21
12	416	16.4	0.14	1.03	2.26	0.00	1.00	1	1.03	0.21
13	418	16.5	0.14	1.04	2.29	0.00	1.00	1	1.04	0.21
14	419	16.5	0.14	1.05	2.31	0.00	1.00	1	1.05	0.21

Table 16. Estimated total abundance at age (1000 fish) at start of year.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1972	3331.19	1850.29	1216.43	859.43	629.90	471.37	356.91	272.17	208.35	159.96	122.94	94.64	72.83	231.71	9878.10
1973	3197.94	2083.78	1233.52	853.91	622.29	465.31	352.76	269.52	206.76	159.07	122.49	94.43	72.76	234.61	9969.15
1974	3212.00	1991.94	1373.71	856.88	611.85	454.90	344.60	263.60	202.61	156.22	120.55	93.10	71.84	234.33	9988.13
1975	1786.68	2009.70	1320.19	955.67	614.87	447.92	337.38	257.88	198.46	153.30	118.55	91.76	70.94	233.76	8597.05
1976	2885.46	1117.15	1318.54	905.80	676.32	443.93	327.62	249.00	191.47	148.09	114.74	89.00	68.95	229.42	8765.50
1977	10259.32	1799.14	728.07	897.53	635.96	484.44	322.14	239.89	183.42	141.75	109.96	85.46	66.35	222.89	16176.31
1978	3664.74	6360.90	1153.80	485.62	617.46	446.36	344.46	231.13	173.15	133.05	103.14	80.25	62.43	211.71	14068.19
1979	2019.83	2300.56	4069.89	757.97	329.03	426.81	312.57	243.39	164.30	123.70	95.34	74.13	57.73	197.62	11172.87
1980	3572.65	1262.61	1438.90	2592.57	497.97	220.53	289.81	214.16	167.77	113.82	85.95	66.44	51.71	178.49	10753.37
1981	3002.69	2194.05	758.73	877.31	1630.23	319.45	143.32	190.05	141.29	111.24	75.69	57.33	44.36	154.01	9699.76
1982	1978.11	1836.23	1248.10	428.28	510.68	968.13	192.19	87.01	116.07	86.72	68.48	46.74	35.44	122.86	7725.03
1983	2930.16	1200.32	971.17	641.83	227.10	276.27	530.59	106.28	48.41	64.90	48.63	38.52	26.32	89.31	7199.80
1984	2659.18	1805.36	644.95	502.55	342.46	123.62	152.35	295.25	59.50	27.23	36.62	27.53	21.82	65.64	6764.07
1985	2745.00	1616.16	902.06	307.82	247.31	171.93	62.88	78.19	152.44	30.87	14.17	19.12	14.38	45.79	6408.14
1986	2468.55	1676.24	823.93	442.51	155.70	127.62	89.88	33.17	41.49	81.30	16.52	7.60	10.27	32.39	6007.17
1987	2160.14	1530.30	870.84	405.75	224.68	80.65	66.97	47.60	17.67	22.22	43.66	8.90	4.10	23.04	5506.51
1988	3671.58	1331.01	791.59	430.53	206.83	116.85	42.49	35.60	25.45	9.50	11.98	23.61	4.81	14.72	6716.56
1989	2748.34	2227.10	618.23	341.65	191.57	93.89	53.74	19.72	16.62	11.94	4.47	5.65	11.15	9.25	6353.32
1990	2482.05	1692.42	1072.59	275.86	157.16	89.91	44.64	25.78	9.52	8.06	5.81	2.18	2.76	9.99	5878.72
1991	2200.15	1535.94	768.64	435.68	115.50	67.14	38.91	19.49	11.32	4.20	3.57	2.58	0.97	5.68	5209.77
1992	1447.94	1363.14	756.73	351.23	205.24	55.51	32.69	19.11	9.63	5.63	2.09	1.78	1.29	3.33	4255.36
1993	1432.21	911.61	729.45	361.23	171.98	102.51	28.09	16.69	9.82	4.97	2.91	1.09	0.93	2.41	3775.91
1994	1595.39	903.32	503.82	371.60	189.15	91.86	55.47	15.34	9.17	5.42	2.75	1.62	0.60	1.86	3747.38
1995	2210.05	1006.19	495.63	252.79	191.56	99.46	48.94	29.82	8.29	4.98	2.95	1.51	0.89	1.35	4354.41
1996	1116.35	1392.87	552.65	250.80	131.50	101.65	53.47	26.55	16.27	4.55	2.74	1.63	0.83	1.24	3653.08
1997	1310.35	704.27	780.74	287.48	134.10	71.73	56.17	29.81	14.89	9.17	2.57	1.55	0.93	1.18	3404.94
1998	1460.59	827.67	399.99	418.59	158.64	75.49	40.91	32.32	17.26	8.66	5.35	1.51	0.91	1.23	3449.11
1999	999.40	922.29	485.03	223.73	240.90	93.13	44.90	24.55	19.52	10.47	5.27	3.27	0.92	1.31	3074.70
2000	552.64	629.95	616.06	318.84	139.64	148.08	57.58	27.98	15.39	12.29	6.62	3.34	2.07	1.42	2531.90
2001	1141.59	349.45	427.19	430.26	225.06	99.63	106.83	41.90	20.48	11.32	9.07	4.90	2.48	2.59	2872.76
2002	1696.23	715.08	228.63	281.00	274.89	142.37	63.44	68.57	27.05	13.29	7.37	5.92	3.20	3.32	3530.36
2003	1236.74	1067.84	453.60	142.10	168.05	161.78	84.23	37.82	41.12	16.30	8.03	4.47	3.59	3.96	3429.65
2004	1242.61	778.02	716.64	306.81	92.37	107.32	103.80	54.46	24.60	26.88	10.69	5.28	2.94	4.98	3477.40
2005	1507.88	780.47	520.38	482.67	196.86	57.83	67.39	65.67	34.66	15.73	17.24	6.88	3.40	5.11	3762.18
2006	1781.72	952.25	534.01	362.98	328.50	132.66	39.22	46.08	45.16	23.95	10.91	11.99	4.79	5.94	4280.16
2007	1199.71	1126.60	652.19	370.23	245.31	220.55	89.73	26.74	31.60	31.13	16.56	7.56	8.32	7.46	4033.70
2008	817.48	756.72	765.39	437.76	232.43	149.91	135.18	55.40	16.61	19.72	19.49	10.40	4.75	9.94	3431.18
2009	1214.85	513.99	506.61	501.58	265.68	136.80	88.42	80.32	33.11	9.98	11.88	11.78	6.29	8.90	3390.19
2010	1927.83	768.74	352.28	345.04	327.72	172.15	89.29	58.18	53.16	22.03	6.66	7.95	7.89	10.20	4149.11
2011	1851.05	1219.60	528.05	241.70	229.40	217.52	115.27	60.29	39.52	36.29	15.08	4.57	5.47	12.46	4576.28
2012	1156.83	1170.93	837.66	356.33	154.35	144.84	138.28	73.87	38.86	25.60	23.58	9.83	2.98	11.72	4145.67
2013	620.61	732.33	805.89	574.32	234.53	100.72	95.19	91.62	49.24	26.03	17.20	15.89	6.63	9.93	3380.14
2014	839.32	392.85	504.39	557.22	387.00	158.05	68.50	65.29	63.21	34.14	18.10	12.00	11.10	11.59	3122.76
2015	613.05	530.48	269.11	349.08	379.79	265.10	109.37	47.81	45.84	44.61	24.16	12.85	8.53	16.15	2715.93
2016	782.93	386.39	359.14	182.15	227.89	246.09	173.05	71.98	31.65	30.50	29.77	16.17	8.61	16.57	2562.89
2017	345.47	483.87	243.81	214.20	91.23	103.61	110.46	78.06	32.64	14.42	13.94	13.65	7.42	11.58	1764.35

Table 17. Estimated total abundance at age (mt) at start of year.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1972	775.76	696.15	624.15	544.09	461.65	383.27	312.68	251.69	200.41	158.37	124.33	97.21	75.68	242.81	4948.24
1973	744.73	784.00	632.92	540.60	456.07	378.34	309.04	249.23	198.89	157.49	123.87	96.99	75.60	245.85	4993.64
1974	748.00	749.45	704.86	542.48	448.42	369.88	301.89	243.76	194.89	154.66	121.90	95.63	74.65	245.56	4996.03
1975	416.08	756.13	677.39	605.02	450.63	364.20	295.57	238.47	190.90	151.78	119.89	94.25	73.71	244.95	4678.97
1976	671.96	420.32	676.55	573.45	495.67	360.96	287.02	230.26	184.18	146.62	116.03	91.42	71.64	240.41	4566.49
1977	2389.16	676.91	373.57	568.21	466.09	393.90	282.22	221.84	176.43	140.34	111.20	87.78	68.94	233.57	6190.16
1978	853.43	2393.22	592.02	307.44	452.53	362.93	301.77	213.73	166.56	131.73	104.30	82.43	64.86	221.86	6248.81
1979	470.37	865.56	2088.27	479.86	241.14	347.04	273.84	225.08	158.04	122.47	96.42	76.14	59.99	207.09	5711.30
1980	831.99	475.04	738.30	1641.32	364.95	179.31	253.90	198.04	161.38	112.69	86.92	68.25	53.73	187.04	5352.86
1981	699.26	825.49	389.31	555.41	1194.78	259.75	125.56	175.75	135.91	110.13	76.54	58.89	46.10	161.39	4814.26
1982	460.66	690.86	640.40	271.14	374.27	787.19	168.38	80.46	111.65	85.86	69.25	48.01	36.82	128.75	3953.68
1983	682.37	451.61	498.31	406.33	166.44	224.63	464.84	98.29	46.56	64.25	49.18	39.57	27.34	93.59	3313.30
1984	619.26	679.25	330.93	318.16	250.98	100.52	133.47	273.03	57.23	26.96	37.03	28.27	22.68	68.78	2946.56
1985	639.25	608.06	462.85	194.88	181.25	139.80	55.09	72.31	146.63	30.57	14.33	19.64	14.95	47.99	2627.58
1986	574.87	630.67	422.76	280.15	114.11	103.77	78.75	30.67	39.91	80.49	16.70	7.81	10.67	33.94	2425.27
1987	503.05	575.76	446.83	256.87	164.67	65.58	58.67	44.01	17.00	21.99	44.15	9.14	4.26	24.15	2236.12
1988	855.03	500.78	406.17	272.56	151.58	95.01	37.23	32.92	24.49	9.40	12.11	24.25	5.00	15.43	2441.95
1989	640.03	837.92	317.21	216.29	140.40	76.34	47.08	18.23	15.99	11.82	4.52	5.81	11.59	9.69	2352.92
1990	578.01	636.76	550.35	174.64	115.18	73.10	39.11	23.84	9.15	7.98	5.88	2.24	2.87	10.46	2229.58
1991	512.36	577.88	394.39	275.82	84.65	54.59	34.09	18.03	10.89	4.16	3.61	2.65	1.01	5.95	1980.08
1992	337.19	512.87	388.28	222.36	150.42	45.14	28.64	17.68	9.27	5.57	2.12	1.83	1.34	3.49	1726.19
1993	333.53	342.98	374.28	228.69	126.05	83.35	24.61	15.43	9.44	4.92	2.95	1.12	0.96	2.52	1550.85
1994	371.53	339.87	258.51	235.25	138.62	74.69	48.60	14.18	8.82	5.37	2.79	1.66	0.63	1.95	1502.47
1995	514.67	378.57	254.31	160.04	140.39	80.87	42.87	27.58	7.98	4.93	2.99	1.55	0.92	1.42	1619.08
1996	259.97	524.05	283.57	158.78	96.37	82.65	46.84	24.55	15.65	4.50	2.77	1.67	0.86	1.30	1503.54
1997	305.15	264.97	400.60	182.00	98.28	58.32	49.21	27.57	14.32	9.08	2.60	1.60	0.96	1.23	1415.90
1998	340.14	311.40	205.23	265.00	116.26	61.38	35.84	29.89	16.60	8.58	5.41	1.55	0.95	1.29	1399.53
1999	232.74	347.00	248.87	141.64	176.55	75.73	39.34	22.70	18.77	10.37	5.33	3.36	0.96	1.38	1324.73
2000	128.70	237.01	316.10	201.85	102.34	120.41	50.44	25.87	14.80	12.17	6.69	3.43	2.15	1.49	1223.47
2001	265.85	131.48	219.19	272.39	164.94	81.01	93.59	38.75	19.70	11.21	9.17	5.03	2.57	2.72	1317.61
2002	395.01	269.04	117.31	177.89	201.46	115.76	55.58	63.41	26.02	13.16	7.45	6.08	3.33	3.48	1455.00
2003	288.01	401.76	232.74	89.96	123.16	131.54	73.79	34.98	39.56	16.14	8.12	4.59	3.73	4.15	1452.25
2004	289.38	292.72	367.71	194.24	67.70	87.26	90.94	50.36	23.66	26.61	10.81	5.43	3.05	5.22	1515.09
2005	351.15	293.64	267.01	305.57	144.28	47.02	59.04	60.73	33.34	15.58	17.43	7.06	3.53	5.36	1610.75
2006	414.92	358.27	274.00	229.80	240.76	107.87	34.36	42.61	43.44	23.71	11.03	12.31	4.97	6.22	1804.28
2007	279.39	423.87	334.64	234.39	179.79	179.33	78.61	24.73	30.40	30.82	16.75	7.77	8.65	7.82	1836.94
2008	190.37	284.71	392.72	277.14	170.35	121.89	118.43	51.23	15.98	19.53	19.71	10.68	4.94	10.41	1688.08
2009	282.91	193.38	259.94	317.54	194.71	111.23	77.47	74.28	31.85	9.88	12.02	12.10	6.53	9.33	1593.17
2010	448.95	289.23	180.76	218.44	240.18	139.97	78.22	53.81	51.14	21.81	6.73	8.17	8.20	10.69	1756.28
2011	431.07	458.86	270.95	153.02	168.13	176.86	100.99	55.75	38.02	35.93	15.25	4.69	5.68	13.05	1928.25
2012	269.40	440.55	429.81	225.59	113.12	117.77	121.14	68.31	37.38	25.35	23.85	10.10	3.10	12.28	1897.74
2013	144.53	275.53	413.51	363.59	171.88	81.90	83.40	84.73	47.36	25.77	17.40	16.32	6.89	10.41	1743.21
2014	195.46	147.81	258.81	352.77	283.63	128.51	60.01	60.38	60.80	33.80	18.31	12.32	11.53	12.14	1636.27
2015	142.77	199.59	138.08	220.99	278.34	215.55	95.82	44.21	44.10	44.16	24.44	13.20	8.86	16.93	1487.04
2016	182.33	145.37	184.28	115.32	167.02	200.09	151.61	66.56	30.45	30.20	30.10	16.61	8.95	17.36	1346.24
2017	80.45	182.05	125.10	135.61	66.86	84.25	96.77	72.18	31.40	14.28	14.10	14.02	7.71	12.13	936.90

Table 18. Estimated total abundance at age (1000 lb) at start of year.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1972	1710.20	1534.70	1376.00	1199.50	1017.80	845.00	689.30	554.90	441.80	349.10	274.10	214.30	166.80	535.30	10908.90
1973	1641.80	1728.40	1395.30	1191.80	1005.50	834.10	681.30	549.50	438.50	347.20	273.10	213.80	166.70	542.00	11009.00
1974	1649.00	1652.20	1553.90	1196.00	988.60	815.40	665.50	537.40	429.70	341.00	268.70	210.80	164.60	541.40	11014.20
1975	917.30	1667.00	1493.40	1333.80	993.50	802.90	651.60	525.70	420.90	334.60	264.30	207.80	162.50	540.00	10315.30
1976	1481.40	926.60	1491.50	1264.20	1092.80	795.80	632.80	507.60	406.00	323.20	255.80	201.50	157.90	530.00	10067.30
1977	5267.10	1492.30	823.60	1252.70	1027.50	868.40	622.20	489.10	389.00	309.40	245.20	193.50	152.00	514.90	13646.80
1978	1881.50	5276.10	1305.20	677.80	997.60	800.10	665.30	471.20	367.20	290.40	229.90	181.70	143.00	489.10	13776.10
1979	1037.00	1908.20	4603.80	1057.90	531.60	765.10	603.70	496.20	348.40	270.00	212.60	167.90	132.30	456.60	12591.10
1980	1834.20	1047.30	1627.70	3618.50	804.60	395.30	559.70	436.60	355.80	248.40	191.60	150.50	118.50	412.30	11800.90
1981	1541.60	1819.90	858.30	1224.50	2634.00	572.60	276.80	387.50	299.60	242.80	168.70	129.80	101.60	355.80	10613.50
1982	1015.60	1523.10	1411.80	597.80	825.10	1735.40	371.20	177.40	246.10	189.30	152.70	105.80	81.20	283.80	8716.30
1983	1504.40	995.60	1098.60	895.80	366.90	495.20	1024.80	216.70	102.60	141.60	108.40	87.20	60.30	206.30	7304.50
1984	1365.20	1497.50	729.60	701.40	553.30	221.60	294.20	601.90	126.20	59.40	81.60	62.30	50.00	151.60	6496.00
1985	1409.30	1340.50	1020.40	429.60	399.60	308.20	121.50	159.40	323.30	67.40	31.60	43.30	33.00	105.80	5792.80
1986	1267.40	1390.40	932.00	617.60	251.60	228.80	173.60	67.60	88.00	177.40	36.80	17.20	23.50	74.80	5346.80
1987	1109.00	1269.30	985.10	566.30	363.00	144.60	129.30	97.00	37.50	48.50	97.30	20.20	9.40	53.20	4929.80
1988	1885.00	1104.00	895.40	600.90	334.20	209.50	82.10	72.60	54.00	20.70	26.70	53.50	11.00	34.00	5383.50
1989	1411.00	1847.30	699.30	476.80	309.50	168.30	103.80	40.20	35.30	26.10	10.00	12.80	25.60	21.40	5187.20
1990	1274.30	1403.80	1213.30	385.00	253.90	161.20	86.20	52.60	20.20	17.60	13.00	4.90	6.30	23.10	4915.30
1991	1129.50	1274.00	869.50	608.10	186.60	120.30	75.20	39.70	24.00	9.20	8.00	5.80	2.20	13.10	4365.30
1992	743.40	1130.70	856.00	490.20	331.60	99.50	63.10	39.00	20.40	12.30	4.70	4.00	3.00	7.70	3805.60
1993	735.30	756.10	825.10	504.20	277.90	183.80	54.30	34.00	20.80	10.80	6.50	2.50	2.10	5.60	3419.00
1994	819.10	749.30	569.90	518.60	305.60	164.70	107.10	31.30	19.40	11.80	6.20	3.70	1.40	4.30	3312.30
1995	1134.60	834.60	560.70	352.80	309.50	178.30	94.50	60.80	17.60	10.90	6.60	3.40	2.00	3.10	3569.40
1996	573.10	1155.30	625.20	350.00	212.50	182.20	103.30	54.10	34.50	9.90	6.10	3.70	1.90	2.90	3314.70
1997	672.70	584.20	883.20	401.20	216.70	128.60	108.50	60.80	31.60	20.00	5.70	3.50	2.10	2.70	3121.50
1998	749.90	686.50	452.50	584.20	256.30	135.30	79.00	65.90	36.60	18.90	11.90	3.40	2.10	2.80	3085.40
1999	513.10	765.00	548.70	312.30	389.20	167.00	86.70	50.00	41.40	22.90	11.80	7.40	2.10	3.00	2920.50
2000	283.70	522.50	696.90	445.00	225.60	265.50	111.20	57.00	32.60	26.80	14.70	7.60	4.70	3.30	2697.30
2001	586.10	289.90	483.20	600.50	363.60	178.60	206.30	85.40	43.40	24.70	20.20	11.10	5.70	6.00	2904.80
2002	870.80	593.10	258.60	392.20	444.10	255.20	122.50	139.80	57.40	29.00	16.40	13.40	7.30	7.70	3207.70
2003	634.90	885.70	513.10	198.30	271.50	290.00	162.70	77.10	87.20	35.60	17.90	10.10	8.20	9.10	3201.60
2004	638.00	645.30	810.70	428.20	149.30	192.40	200.50	111.00	52.20	58.70	23.80	12.00	6.70	11.50	3340.20
2005	774.10	647.40	588.70	673.70	318.10	103.70	130.20	133.90	73.50	34.30	38.40	15.60	7.80	11.80	3551.10
2006	914.70	789.80	604.10	506.60	530.80	237.80	75.80	93.90	95.80	52.30	24.30	27.10	11.00	13.70	3977.70
2007	615.90	934.50	737.70	516.70	396.40	395.40	173.30	54.50	67.00	67.90	36.90	17.10	19.10	17.20	4049.70
2008	419.70	627.70	865.80	611.00	375.60	268.70	261.10	112.90	35.20	43.10	43.50	23.50	10.90	22.90	3721.50
2009	623.70	426.30	573.10	700.00	429.30	245.20	170.80	163.80	70.20	21.80	26.50	26.70	14.40	20.60	3512.30
2010	989.80	637.60	398.50	481.60	529.50	308.60	172.40	118.60	112.70	48.10	14.80	18.00	18.10	23.60	3871.90
2011	950.30	1011.60	597.30	337.30	370.70	389.90	222.60	122.90	83.80	79.20	33.60	10.30	12.50	28.80	4251.00
2012	593.90	971.20	947.60	497.30	249.40	259.60	267.10	150.60	82.40	55.90	52.60	22.30	6.80	27.10	4183.80
2013	318.60	607.40	911.60	801.60	378.90	180.60	183.90	186.80	104.40	56.80	38.40	36.00	15.20	22.90	3843.10
2014	430.90	325.90	570.60	777.70	625.30	283.30	132.30	133.10	134.00	74.50	40.40	27.20	25.40	26.80	3607.30
2015	314.80	440.00	304.40	487.20	613.60	475.20	211.20	97.50	97.20	97.40	53.90	29.10	19.50	37.30	3278.30
2016	402.00	320.50	406.30	254.20	368.20	441.10	334.20	146.70	67.10	66.60	66.40	36.60	19.70	38.30	2967.90
2017	177.40	401.30	275.80	299.00	147.40	185.70	213.30	159.10	69.20	31.50	31.10	30.90	17.00	26.70	2065.50

Table 19. Estimated time series of status indicators. Fishing mortality rate is apical F, which includes discard mortalities. Total and spawning stock biomass (B and SSB, mt) are at the start of the year. The MSST *is defined by* $\text{MSST} = (1 - M)\text{SSB}_{\text{MSY}}$, *with constant* $M = 0.22$. *SPR is static spawning potential ratio.*

Year	F	F/F_{MSY}	B	B/B_{unfished}	SSB	SSB/SSB$_{\text{MSY}}$	SSB/MSST	SPR
1972	0.0519	0.288	4948	0.632	4089	1.418	1.818	0.778
1973	0.0623	0.346	4994	0.638	4125	1.430	1.834	0.743
1974	0.0609	0.338	4996	0.638	4130	1.432	1.836	0.752
1975	0.0747	0.415	4679	0.598	4003	1.388	1.780	0.715
1976	0.0827	0.459	4566	0.583	3825	1.327	1.701	0.693
1977	0.1030	0.572	6190	0.791	4367	1.515	1.942	0.645
1978	0.1183	0.657	6249	0.798	4868	1.688	2.164	0.627
1979	0.1491	0.828	5711	0.730	4799	1.664	2.134	0.572
1980	0.1929	1.072	5353	0.684	4380	1.519	1.947	0.501
1981	0.2701	1.501	4814	0.615	3858	1.338	1.715	0.425
1982	0.3634	2.019	3954	0.505	3166	1.098	1.408	0.360
1983	0.3572	1.984	3313	0.423	2533	0.878	1.126	0.371
1984	0.4381	2.434	2947	0.377	2170	0.752	0.965	0.325
1985	0.4106	2.281	2628	0.336	1891	0.656	0.841	0.339
1986	0.4068	2.260	2425	0.310	1740	0.604	0.774	0.348
1987	0.4028	2.238	2236	0.286	1616	0.560	0.719	0.347
1988	0.5388	2.993	2442	0.312	1613	0.559	0.717	0.290
1989	0.5055	2.808	2353	0.301	1587	0.550	0.706	0.306
1990	0.5996	3.331	2230	0.285	1518	0.526	0.675	0.281
1991	0.4817	2.676	1980	0.253	1370	0.475	0.609	0.317
1992	0.4432	2.462	1726	0.221	1254	0.435	0.558	0.349
1993	0.3761	2.089	1551	0.198	1143	0.396	0.508	0.379
1994	0.3917	2.176	1502	0.192	1084	0.376	0.482	0.372
1995	0.3827	2.126	1619	0.207	1112	0.386	0.494	0.375
1996	0.3551	1.973	1504	0.192	1110	0.385	0.493	0.391
1997	0.3236	1.798	1416	0.181	1057	0.367	0.470	0.409
1998	0.2816	1.564	1400	0.179	1030	0.357	0.458	0.440
1999	0.2442	1.357	1325	0.169	1024	0.355	0.455	0.555
2000	0.0889	0.494	1223	0.156	1019	0.353	0.453	0.733
2001	0.2145	1.192	1318	0.168	1045	0.362	0.465	0.562
2002	0.2884	1.602	1455	0.186	1071	0.372	0.476	0.495
2003	0.2073	1.152	1452	0.186	1107	0.384	0.492	0.593
2004	0.2291	1.273	1515	0.194	1180	0.409	0.524	0.575
2005	0.1514	0.841	1611	0.206	1248	0.433	0.555	0.665
2006	0.1541	0.856	1804	0.231	1381	0.479	0.614	0.659
2007	0.2534	1.408	1837	0.235	1456	0.505	0.647	0.567
2008	0.2918	1.621	1688	0.216	1383	0.480	0.615	0.531
2009	0.1897	1.054	1593	0.204	1283	0.445	0.570	0.619
2010	0.1638	0.910	1756	0.224	1334	0.463	0.593	0.644
2011	0.2161	1.201	1928	0.246	1461	0.507	0.649	0.596
2012	0.1827	1.015	1898	0.242	1521	0.527	0.676	0.630
2013	0.1482	0.823	1743	0.223	1481	0.513	0.658	0.665
2014	0.1306	0.726	1636	0.209	1388	0.481	0.617	0.679
2015	0.1895	1.053	1487	0.190	1262	0.438	0.561	0.608
2016	0.5679	3.155	1346	0.172	1070	0.371	0.476	0.409
2017	0.2807	1.559	937	0.120	780	0.271	0.347	0.542

Table 20. Selectivity at age for landings from commercial handline (cHl), commercial trawl (cTw), recreational headboat (rHb), and recreational MRIP (rGe) fleets, discards for commercial handline (cHl.D), recreational headboat (rHb.D), and recreational MRIP (rGe.D) fleets, selectivity for the SERFS chevron trap (sCT) survey, selectivity of landings averaged across fisheries (L.avg), selectivity of discard mortalities averaged across fisheries (D.avg), and selectivity of total removals (Total = L.avg+D.avg). Selectivities of landings and discards from the MRIP fleet were assumed equal to those from the headboat fleet. For time-varying selectivities (cHl, rHb, and rGe), values shown are from the first year of each constant selectivity time period.

Age	TL (mm)	TL (in)	cHl-1972	cHl-1999	cTw	rHb-1972	rHb-1992	rHb-1999	rGe-1972	rGe-1992	rGe-1999	cHl.D	rHb.D	rGe.D	sCT	L.avg	D.avg	Total
1	249	9.81	0.01	0.01	0.62	0.30	0.03	0.01	0.30	0.03	0.01	0.01	0.30	0.30	0.14	0.01	0.03	0.03
2	294	11.58	0.69	0.08	0.99	1.00	0.46	0.04	1.00	0.46	0.04	0.69	1.00	1.00	0.38	0.05	0.12	0.16
3	327	12.89	1.00	0.54	1.00	1.00	0.97	0.21	1.00	0.97	0.21	1.00	1.00	1.00	0.71	0.29	0.13	0.41
4	352	13.86	1.00	0.94	1.00	1.00	1.00	0.64	1.00	1.00	0.64	1.00	1.00	1.00	0.91	0.66	0.13	0.78
5	370	14.58	1.00	1.00	1.00	1.00	1.00	0.92	1.00	1.00	0.92	1.00	1.00	1.00	0.98	0.83	0.13	0.96
6	384	15.11	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	0.99	1.00	1.00	1.00	0.99	0.87	0.13	0.99
7	394	15.51	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.87	0.13	1.00
8	401	15.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.87	0.13	1.00
9	407	16.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.87	0.13	1.00
10	411	16.18	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.87	0.13	1.00
11	414	16.30	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.87	0.13	1.00
12	416	16.39	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.87	0.13	1.00
13	418	16.45	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.87	0.13	1.00
14	419	16.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.87	0.13	1.00

Table 21. Estimated time series of fully selected fishing mortality rates for commercial handline (F.cHl), commercial trawl (F.cTw), recreational headboat (F.rHb), recreational MRIP (F.rGe), commercial handline dead discards (F.cHl.D), recreational headboat dead discards (F.rHb.D), MRIP dead discards (F.rGe.D). Also shown is apical F, the maximum F at age summed across fleets.

Year	F.cHl	F.cTw	F.rHb	F.rGe	F.cHl.D	F.rHb.D	F.rGe.D	Apical F
1972	0.004	0.000	0.035	0.013	0.000	0.000	0.000	0.052
1973	0.002	0.001	0.046	0.013	0.000	0.000	0.000	0.062
1974	0.014	0.000	0.034	0.013	0.000	0.000	0.000	0.061
1975	0.026	0.000	0.035	0.013	0.000	0.000	0.000	0.075
1976	0.030	0.005	0.033	0.014	0.000	0.000	0.000	0.083
1977	0.043	0.015	0.033	0.011	0.000	0.000	0.000	0.103
1978	0.085	0.001	0.024	0.009	0.000	0.000	0.000	0.118
1979	0.111	0.008	0.020	0.010	0.000	0.000	0.000	0.149
1980	0.122	0.033	0.026	0.012	0.000	0.000	0.000	0.193
1981	0.193	0.039	0.029	0.010	0.000	0.000	0.000	0.270
1982	0.258	0.036	0.058	0.012	0.000	0.000	0.000	0.363
1983	0.289	0.022	0.040	0.005	0.000	0.000	0.000	0.357
1984	0.315	0.014	0.036	0.072	0.000	0.000	0.000	0.438
1985	0.292	0.004	0.053	0.059	0.000	0.000	0.002	0.411
1986	0.340	0.004	0.051	0.011	0.000	0.000	0.000	0.407
1987	0.314	0.003	0.059	0.024	0.000	0.000	0.003	0.403
1988	0.404	0.007	0.057	0.071	0.000	0.000	0.000	0.539
1989	0.413	0.000	0.046	0.044	0.000	0.000	0.003	0.505
1990	0.526	0.000	0.036	0.037	0.000	0.000	0.000	0.600
1991	0.410	0.000	0.049	0.023	0.000	0.000	0.000	0.482
1992	0.263	0.000	0.057	0.105	0.012	0.004	0.002	0.443
1993	0.260	0.000	0.059	0.040	0.012	0.004	0.002	0.376
1994	0.262	0.000	0.056	0.056	0.012	0.004	0.001	0.392
1995	0.267	0.000	0.058	0.037	0.012	0.004	0.004	0.383
1996	0.241	0.000	0.048	0.049	0.012	0.004	0.001	0.355
1997	0.250	0.000	0.041	0.016	0.012	0.004	0.000	0.324
1998	0.194	0.000	0.045	0.026	0.012	0.004	0.001	0.282
1999	0.091	0.000	0.056	0.050	0.029	0.004	0.013	0.244
2000	0.020	0.000	0.012	0.016	0.031	0.004	0.005	0.089
2001	0.046	0.000	0.040	0.056	0.033	0.011	0.029	0.215
2002	0.045	0.000	0.032	0.087	0.104	0.007	0.014	0.288
2003	0.041	0.000	0.033	0.092	0.016	0.006	0.019	0.207
2004	0.036	0.000	0.036	0.114	0.013	0.012	0.018	0.229
2005	0.031	0.000	0.033	0.066	0.008	0.003	0.009	0.151
2006	0.050	0.000	0.048	0.036	0.012	0.007	0.001	0.154
2007	0.082	0.000	0.087	0.063	0.007	0.007	0.008	0.253
2008	0.095	0.000	0.037	0.123	0.011	0.005	0.020	0.292
2009	0.092	0.000	0.022	0.060	0.011	0.003	0.002	0.190
2010	0.092	0.000	0.025	0.033	0.007	0.002	0.004	0.164
2011	0.120	0.000	0.025	0.062	0.003	0.002	0.003	0.216
2012	0.089	0.000	0.027	0.057	0.007	0.003	0.001	0.183
2013	0.083	0.000	0.018	0.036	0.007	0.002	0.002	0.148
2014	0.074	0.000	0.016	0.022	0.008	0.003	0.007	0.131
2015	0.079	0.000	0.016	0.066	0.010	0.004	0.015	0.190
2016	0.087	0.000	0.021	0.374	0.007	0.004	0.075	0.568
2017	0.119	0.000	0.023	0.113	0.010	0.004	0.012	0.281

Table 22. Estimated instantaneous fishing mortality rate F (per yr) at age, including discard mortality

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1972	0.014	0.050	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052
1973	0.018	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062
1974	0.014	0.056	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061
1975	0.015	0.066	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
1976	0.017	0.073	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083
1977	0.023	0.089	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103
1978	0.011	0.092	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118
1979	0.015	0.114	0.149	0.149	0.149	0.149	0.149	0.149	0.149	0.149	0.149	0.149	0.149	0.149
1980	0.033	0.154	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193
1981	0.037	0.209	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270
1982	0.045	0.282	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363
1983	0.029	0.266	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357
1984	0.043	0.339	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438
1985	0.038	0.319	0.410	0.411	0.411	0.411	0.411	0.411	0.411	0.411	0.411	0.411	0.411	0.411
1986	0.023	0.300	0.406	0.407	0.407	0.407	0.407	0.407	0.407	0.407	0.407	0.407	0.407	0.407
1987	0.029	0.304	0.402	0.403	0.403	0.403	0.403	0.403	0.403	0.403	0.403	0.403	0.403	0.403
1988	0.045	0.412	0.538	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539
1989	0.030	0.376	0.505	0.505	0.505	0.505	0.505	0.505	0.505	0.505	0.505	0.505	0.505	0.505
1990	0.025	0.434	0.599	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600
1991	0.024	0.353	0.481	0.482	0.482	0.482	0.482	0.482	0.482	0.482	0.482	0.482	0.482	0.482
1992	0.008	0.270	0.437	0.443	0.443	0.443	0.443	0.443	0.443	0.443	0.443	0.443	0.443	0.443
1993	0.006	0.238	0.372	0.376	0.376	0.376	0.376	0.376	0.376	0.376	0.376	0.376	0.376	0.376
1994	0.006	0.245	0.388	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392
1995	0.007	0.244	0.379	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383
1996	0.006	0.224	0.352	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355
1997	0.004	0.211	0.321	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324
1998	0.005	0.179	0.279	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.282
1999	0.007	0.049	0.118	0.200	0.236	0.243	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244
2000	0.003	0.033	0.057	0.077	0.087	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089
2001	0.013	0.069	0.117	0.177	0.207	0.213	0.214	0.214	0.215	0.215	0.215	0.215	0.215	0.215
2002	0.008	0.100	0.174	0.243	0.279	0.287	0.288	0.288	0.288	0.288	0.288	0.288	0.288	0.288
2003	0.008	0.044	0.089	0.160	0.197	0.206	0.207	0.207	0.207	0.207	0.207	0.207	0.207	0.207
2004	0.010	0.047	0.093	0.173	0.217	0.227	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229
2005	0.005	0.024	0.058	0.114	0.144	0.150	0.151	0.151	0.151	0.151	0.151	0.151	0.151	0.151
2006	0.003	0.023	0.064	0.121	0.147	0.153	0.154	0.154	0.154	0.154	0.154	0.154	0.154	0.154
2007	0.006	0.032	0.097	0.195	0.242	0.252	0.253	0.253	0.253	0.253	0.253	0.253	0.253	0.253
2008	0.009	0.046	0.121	0.228	0.279	0.290	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292
2009	0.003	0.023	0.082	0.155	0.183	0.189	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190
2010	0.003	0.021	0.075	0.137	0.159	0.163	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
2011	0.003	0.021	0.091	0.177	0.209	0.215	0.216	0.216	0.216	0.216	0.216	0.216	0.216	0.216
2012	0.002	0.019	0.075	0.147	0.176	0.182	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183
2013	0.002	0.018	0.067	0.124	0.144	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148	0.148
2014	0.004	0.023	0.066	0.112	0.127	0.130	0.131	0.131	0.131	0.131	0.131	0.131	0.131	0.131
2015	0.007	0.035	0.088	0.155	0.183	0.189	0.189	0.190	0.190	0.190	0.190	0.190	0.190	0.190
2016	0.026	0.105	0.215	0.421	0.537	0.563	0.567	0.568	0.568	0.568	0.568	0.568	0.568	0.568
2017	0.006	0.037	0.118	0.224	0.270	0.279	0.280	0.281	0.281	0.281	0.281	0.281	0.281	0.281

Table 23. Estimated total landings at age in numbers (1000 fish)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1972	37.62	76.77	53.12	38.09	28.18	21.22	16.14	12.34	9.47	7.28	5.60	4.32	3.32	10.58
1973	46.86	105.09	64.44	45.27	33.30	25.06	19.08	14.62	11.24	8.66	6.68	5.15	3.97	12.81
1974	35.66	92.01	70.11	44.39	32.00	23.94	18.21	13.97	10.76	8.31	6.42	4.96	3.83	12.50
1975	20.79	108.99	82.18	60.39	39.22	28.75	21.75	16.67	12.86	9.95	7.70	5.97	4.62	15.21
1976	39.96	66.47	90.45	63.08	47.54	31.40	23.27	17.74	13.67	10.59	8.22	6.38	4.94	16.45
1977	187.71	129.64	61.64	77.14	55.18	42.29	28.24	21.09	16.16	12.51	9.72	7.56	5.87	19.73
1978	31.07	469.71	111.33	47.58	61.07	44.42	34.42	23.16	17.39	13.38	10.39	8.09	6.30	21.36
1979	23.91	209.83	487.99	92.28	40.43	52.77	38.81	30.30	20.50	15.46	11.93	9.28	7.24	24.77
1980	92.06	152.64	218.80	400.20	77.58	34.57	45.61	33.80	26.54	18.03	13.64	10.55	8.22	28.36
1981	87.21	350.52	155.89	182.95	343.08	67.63	30.47	40.51	30.19	23.80	16.22	12.29	9.52	33.04
1982	69.28	382.70	330.81	115.19	138.58	264.26	52.67	23.91	31.97	23.92	18.91	12.91	9.80	33.98
1983	68.00	237.91	253.75	170.18	60.76	74.35	143.37	28.80	13.14	17.65	13.24	10.49	7.18	24.35
1984	89.89	440.90	199.40	157.63	108.37	39.35	48.68	94.60	19.11	8.76	11.79	8.87	7.04	21.16
1985	81.63	372.59	263.48	91.22	73.94	51.70	18.98	23.67	46.25	9.38	4.31	5.82	4.38	13.95
1986	45.41	368.70	239.85	130.71	46.40	38.26	27.05	10.01	12.55	24.62	5.01	2.31	3.12	9.83
1987	48.45	337.35	249.58	117.99	65.92	23.80	19.84	14.14	5.26	6.62	13.03	2.66	1.23	6.89
1988	129.72	382.72	288.18	158.96	77.03	43.77	15.98	13.42	9.62	3.59	4.54	8.95	1.83	5.58
1989	63.23	589.27	213.09	119.45	67.57	33.30	19.14	7.04	5.95	4.28	1.60	2.03	4.01	3.32
1990	49.15	508.25	423.39	110.44	63.46	36.51	18.20	10.54	3.90	3.31	2.39	0.90	1.14	4.11
1991	41.48	388.41	256.44	147.46	39.44	23.05	13.41	6.74	3.92	1.46	1.24	0.90	0.34	1.98
1992	6.53	258.89	224.07	106.56	62.84	17.10	10.11	5.93	2.99	1.75	0.65	0.56	0.40	1.04
1993	4.63	153.91	188.13	95.24	45.76	27.44	7.55	4.50	2.65	1.35	0.79	0.29	0.25	0.65
1994	5.63	157.67	134.98	101.83	52.31	25.55	15.49	4.30	2.57	1.52	0.78	0.46	0.17	0.52
1995	7.05	172.07	128.89	67.18	51.38	26.83	13.26	8.10	2.26	1.36	0.81	0.41	0.24	0.37
1996	3.47	222.05	135.50	62.89	33.28	25.88	13.67	6.80	4.18	1.17	0.71	0.42	0.21	0.32
1997	3.09	106.38	177.01	66.50	31.31	16.84	13.24	7.05	3.53	2.18	0.61	0.37	0.22	0.28
1998	3.43	106.05	79.27	84.84	32.45	15.54	8.45	6.70	3.58	1.80	1.11	0.31	0.19	0.26
1999	0.95	8.50	28.16	27.46	36.07	14.52	7.07	3.88	3.09	1.66	0.84	0.52	0.15	0.21
2000	0.13	1.37	8.52	9.91	5.46	6.06	2.38	1.16	0.64	0.51	0.28	0.14	0.09	0.06
2001	0.76	2.05	15.54	36.29	24.29	11.30	12.25	4.82	2.36	1.31	1.05	0.57	0.29	0.30
2002	1.30	4.58	8.87	25.95	32.89	17.94	8.09	8.77	3.47	1.71	0.95	0.76	0.41	0.43
2003	0.96	6.98	18.05	13.72	21.20	21.54	11.34	5.11	5.57	2.21	1.09	0.61	0.49	0.54
2004	1.07	5.41	29.89	32.21	12.88	15.83	15.49	8.16	3.70	4.04	1.61	0.80	0.44	0.75
2005	0.92	4.01	16.36	37.26	19.99	6.20	7.31	7.16	3.79	1.72	1.89	0.75	0.37	0.56
2006	1.14	5.62	19.79	30.26	34.51	14.60	4.36	5.14	5.05	2.68	1.22	1.35	0.54	0.67
2007	1.32	11.28	40.38	51.18	42.60	40.10	16.48	4.93	5.84	5.76	3.07	1.40	1.54	1.38
2008	0.99	8.43	52.67	66.20	43.81	29.54	26.90	11.07	3.33	3.95	3.91	2.09	0.96	2.00
2009	1.02	4.42	27.88	56.70	36.03	19.25	12.55	11.44	4.73	1.43	1.70	1.69	0.90	1.28
2010	1.42	6.07	18.06	35.12	39.17	21.25	11.11	7.27	6.65	2.76	0.84	1.00	0.99	1.28
2011	1.87	12.96	35.97	32.82	36.77	36.05	19.26	10.11	6.64	6.11	2.54	0.77	0.92	2.10
2012	0.96	9.90	45.24	39.80	20.77	20.24	19.49	10.45	5.51	3.64	3.35	1.40	0.42	1.67
2013	0.42	5.24	37.48	53.32	25.63	11.38	10.84	10.47	5.64	2.99	1.98	1.83	0.76	1.14
2014	0.46	2.38	20.02	43.37	35.02	14.74	6.44	6.16	5.98	3.23	1.72	1.14	1.05	1.10
2015	0.47	4.09	13.22	35.94	47.44	34.44	14.34	6.29	6.05	5.89	3.20	1.70	1.13	2.14
2016	1.74	6.68	36.07	43.96	71.11	80.74	57.38	23.96	10.56	10.19	9.96	5.41	2.88	5.55
2017	0.42	5.81	18.36	33.63	17.37	20.52	22.07	15.65	6.56	2.90	2.81	2.75	1.50	2.34

Table 24. Estimated total landings at age in whole weight (1000 lb)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1972	19.31	63.67	60.09	53.16	45.53	38.04	31.17	25.16	20.08	15.89	12.49	9.77	7.62	24.43
1973	24.06	87.16	72.90	63.18	53.81	44.91	36.84	29.80	23.84	18.90	14.89	11.66	9.10	29.59
1974	18.31	76.32	79.31	61.96	51.70	42.91	35.17	28.48	22.83	18.14	14.32	11.24	8.78	28.88
1975	10.67	90.40	92.97	84.29	63.38	51.54	42.00	33.99	27.27	21.71	17.18	13.51	10.58	35.14
1976	20.51	55.13	102.32	88.04	76.82	56.29	44.95	36.16	28.99	23.11	18.32	14.44	11.33	38.01
1977	96.37	107.53	69.73	107.67	89.15	75.81	54.55	43.00	34.28	27.30	21.67	17.11	13.45	45.57
1978	15.95	389.61	125.94	66.41	98.67	79.62	66.48	47.22	36.88	29.21	23.16	18.31	14.43	49.34
1979	12.28	174.05	552.01	128.80	65.33	94.59	74.95	61.78	43.48	33.74	26.60	21.02	16.57	57.22
1980	47.26	126.61	247.51	558.56	125.35	61.96	88.10	68.91	56.28	39.36	30.40	23.88	18.82	65.51
1981	44.78	290.75	176.34	255.35	554.33	121.23	58.85	82.59	64.02	51.95	36.15	27.83	21.80	76.33
1982	35.57	317.44	374.21	160.77	223.91	473.71	101.74	48.75	67.80	52.21	42.17	29.24	22.45	78.50
1983	34.91	197.34	287.04	237.53	98.17	133.27	276.91	58.71	27.88	38.52	29.52	23.76	16.44	56.26
1984	46.15	365.71	225.56	220.00	175.09	70.53	94.03	192.85	40.52	19.11	26.29	20.08	16.12	48.89
1985	41.91	309.05	298.05	127.32	119.47	92.68	36.67	48.26	98.09	20.47	9.61	13.18	10.04	32.23
1986	23.32	305.83	271.32	182.43	74.97	68.58	52.25	20.41	26.61	53.75	11.17	5.23	7.14	22.72
1987	24.87	279.82	282.32	164.68	106.51	42.66	38.33	28.83	11.16	14.46	29.06	6.02	2.81	15.91
1988	66.60	317.46	325.99	221.87	124.47	78.45	30.86	27.37	20.40	7.84	10.12	20.26	4.18	12.90
1989	32.46	488.78	241.04	166.72	109.17	59.70	36.96	14.35	12.61	9.34	3.57	4.59	9.18	7.68
1990	25.24	421.58	478.94	154.14	102.53	65.44	35.15	21.48	8.27	7.22	5.32	2.03	2.60	9.49
1991	21.30	322.17	290.08	205.81	63.72	41.33	25.91	13.74	8.32	3.18	2.76	2.03	0.77	4.56
1992	3.35	214.74	253.47	148.73	101.54	30.64	19.52	12.08	6.35	3.82	1.45	1.26	0.92	2.40
1993	2.38	127.66	212.81	132.93	73.94	49.18	14.58	9.17	5.62	2.94	1.76	0.67	0.58	1.51
1994	2.89	130.78	152.69	142.13	84.52	45.81	29.93	8.76	5.46	3.33	1.73	1.03	0.39	1.21
1995	3.62	142.73	145.80	93.77	83.01	48.10	25.60	16.51	4.79	2.96	1.80	0.93	0.55	0.85
1996	1.78	184.18	153.28	87.78	53.77	46.39	26.40	13.87	8.86	2.55	1.57	0.95	0.49	0.74
1997	1.58	88.24	200.23	92.81	50.58	30.19	25.58	14.37	7.48	4.75	1.36	0.84	0.50	0.65
1998	1.76	87.97	89.67	118.41	52.44	27.85	16.33	13.65	7.60	3.93	2.49	0.71	0.44	0.59
1999	0.49	7.05	31.85	38.32	58.29	26.03	13.65	7.90	6.55	3.62	1.87	1.18	0.34	0.48
2000	0.07	1.13	9.63	13.83	8.82	10.87	4.60	2.37	1.36	1.12	0.62	0.32	0.20	0.14
2001	0.39	1.70	17.58	50.65	39.25	20.26	23.66	9.83	5.01	2.85	2.34	1.28	0.66	0.69
2002	0.67	3.80	10.04	36.22	53.15	32.17	15.62	17.88	7.36	3.73	2.11	1.73	0.94	0.99
2003	0.49	5.79	20.42	19.14	34.26	38.60	21.90	10.42	11.82	4.83	2.43	1.38	1.12	1.25
2004	0.55	4.49	33.81	44.95	20.81	28.37	29.92	16.64	7.84	8.82	3.59	1.80	1.02	1.74
2005	0.47	3.33	18.50	52.01	32.30	11.12	14.13	14.59	8.03	3.76	4.21	1.71	0.85	1.30
2006	0.58	4.66	22.39	42.23	55.75	26.18	8.43	10.49	10.72	5.86	2.73	3.05	1.23	1.54
2007	0.68	9.36	45.68	71.44	68.84	71.89	31.84	10.05	12.39	12.58	6.84	3.18	3.54	3.20
2008	0.51	6.99	59.58	92.39	70.79	52.95	51.96	22.56	7.05	8.63	8.72	4.73	2.19	4.62
2009	0.53	3.67	31.54	79.13	58.21	34.50	24.24	23.32	10.03	3.11	3.79	3.82	2.07	2.95
2010	0.73	5.04	20.43	49.02	63.28	38.09	21.46	14.81	14.11	6.03	1.86	2.26	2.27	2.96
2011	0.96	10.75	40.69	45.81	59.40	64.62	37.20	20.61	14.09	13.33	5.67	1.75	2.11	4.86
2012	0.49	8.21	51.18	55.55	33.56	36.28	37.65	21.31	11.69	7.94	7.48	3.17	0.97	3.85
2013	0.21	4.35	42.40	74.42	41.42	20.40	20.94	21.35	11.96	6.52	4.41	4.14	1.75	2.64
2014	0.24	1.97	22.64	60.54	56.58	26.42	12.43	12.55	12.67	7.05	3.83	2.58	2.41	2.54
2015	0.24	3.39	14.95	50.16	76.65	61.73	27.70	12.82	12.82	12.86	7.12	3.85	2.59	4.94
2016	0.89	5.54	40.80	61.35	114.90	144.73	110.83	48.84	22.39	22.24	22.20	12.25	6.61	12.82
2017	0.22	4.82	20.76	46.94	28.07	36.78	42.63	31.91	13.92	6.34	6.27	6.23	3.43	5.40

Table 25. Estimated time series of landings in numbers (1000 fish) for commercial handline (L.cHl), commercial trawl (L.cTw), recreational headboat (L.rHb), and MRIP (L.rGe)

Year	L.cHl	L.cTw	L.rHb	L.rGe
1972	21.89	0.56	220.03	81.56
1973	10.09	10.75	299.82	81.56
1974	74.92	0.56	220.04	81.57
1975	136.89	0.91	215.68	81.57
1976	140.57	31.27	186.77	81.55
1977	195.25	154.16	243.54	81.53
1978	587.17	7.15	223.80	81.55
1979	756.83	70.48	156.63	81.57
1980	663.61	246.86	168.55	81.57
1981	899.97	258.72	168.44	56.19
1982	993.15	187.60	273.23	54.91
1983	842.36	103.66	155.85	21.28
1984	806.95	60.45	129.95	258.18
1985	673.01	16.34	176.46	195.53
1986	750.58	15.89	161.06	36.30
1987	658.03	10.17	173.90	70.66
1988	737.26	28.89	168.81	208.93
1989	848.22	0.00	146.52	138.53
1990	1023.57	0.00	104.71	107.37
1991	736.14	0.00	129.65	60.48
1992	455.22	0.00	85.82	158.38
1993	396.86	0.00	81.70	54.58
1994	363.06	0.00	70.40	70.33
1995	364.60	0.00	70.68	44.93
1996	379.76	0.00	64.85	65.94
1997	353.96	0.00	53.89	20.75
1998	259.06	0.00	53.84	31.09
1999	72.85	0.00	31.88	28.33
2000	18.11	0.00	8.03	10.55
2001	43.98	0.00	28.85	40.35
2002	37.52	0.00	20.93	57.68
2003	33.48	0.00	20.17	55.76
2004	34.26	0.00	23.46	74.56
2005	33.23	0.00	24.83	50.24
2006	56.50	0.00	40.38	30.06
2007	97.42	0.00	75.20	54.67
2008	116.24	0.00	32.52	107.07
2009	108.47	0.00	19.54	53.00
2010	101.86	0.00	21.91	29.22
2011	131.73	0.00	21.05	52.11
2012	109.96	0.00	23.21	49.69
2013	115.63	0.00	17.72	35.78
2014	101.89	0.00	17.18	23.72
2015	94.94	0.00	15.54	65.84
2016	77.33	0.00	15.30	273.55
2017	80.15	0.00	12.32	60.23

Table 26. Estimated time series of landings in weight (1000 lb) for commercial handline (L.cHl), commercial trawl (L.cTw), recreational headboat (L.rHb), and MRIP (L.rGe)

Year	L.cHl	L.cTw	L.rHb	L.rGe
1972	32.17	0.67	287.14	106.43
1973	14.65	12.95	387.61	105.44
1974	108.37	0.67	284.01	105.29
1975	197.85	1.16	287.06	108.56
1976	211.77	39.26	252.94	110.45
1977	288.59	148.45	274.31	91.83
1978	719.96	7.44	244.69	89.16
1979	987.84	83.14	191.64	99.81
1980	944.75	293.14	216.06	104.57
1981	1275.95	303.49	212.10	70.76
1982	1390.24	223.53	345.28	69.39
1983	1187.81	113.78	188.85	25.79
1984	1062.43	62.06	146.12	290.31
1985	844.60	15.83	188.14	208.47
1986	906.14	15.06	166.89	37.62
1987	784.72	9.68	179.93	73.10
1988	879.70	24.71	162.82	201.52
1989	928.77	0.00	137.44	129.94
1990	1136.59	0.00	100.14	102.68
1991	822.40	0.00	124.98	58.31
1992	515.17	0.00	100.20	184.91
1993	470.26	0.00	99.19	66.27
1994	436.81	0.00	86.96	86.87
1995	430.89	0.00	85.67	54.46
1996	429.06	0.00	76.14	77.42
1997	427.22	0.00	66.39	25.56
1998	317.02	0.00	67.71	39.10
1999	104.75	0.00	49.18	43.69
2000	26.19	0.00	12.48	16.39
2001	66.16	0.00	45.86	64.13
2002	58.22	0.00	34.13	94.04
2003	50.37	0.00	32.81	90.68
2004	49.71	0.00	37.01	117.62
2005	48.79	0.00	38.86	78.64
2006	84.13	0.00	64.03	47.67
2007	144.62	0.00	119.79	87.08
2008	171.94	0.00	51.65	170.07
2009	164.46	0.00	31.37	85.09
2010	158.49	0.00	35.94	47.93
2011	201.63	0.00	34.60	85.63
2012	162.36	0.00	37.23	79.72
2013	171.72	0.00	28.21	56.96
2014	157.78	0.00	28.00	38.67
2015	154.07	0.00	26.31	111.46
2016	126.69	0.00	26.47	473.23
2017	129.21	0.00	21.15	103.36

Table 27. Estimated time series of dead discards in numbers (1000 fish) for commercial handline (L.cHl), recreational headboat (L.rHb), and MRIP (L.rGe)

Year	D.cHl	D.rHb	D.rGe
1972	0.00	0.00	0.00
1973	0.00	0.00	0.00
1974	0.00	0.00	0.00
1975	0.00	0.00	0.00
1976	0.00	0.00	0.00
1977	0.00	0.00	0.00
1978	0.00	0.00	0.00
1979	0.00	0.00	0.00
1980	0.00	0.00	0.00
1981	0.00	0.00	0.52
1982	0.00	0.00	0.81
1983	0.00	0.00	0.29
1984	0.00	0.00	0.61
1985	0.00	0.00	6.17
1986	0.00	0.00	0.23
1987	0.00	0.00	9.28
1988	0.00	0.00	0.27
1989	0.00	0.00	8.64
1990	0.00	0.00	0.08
1991	0.00	0.00	0.08
1992	20.57	10.55	5.34
1993	18.17	9.19	3.35
1994	16.46	8.71	1.06
1995	16.22	9.36	9.10
1996	18.76	9.60	2.87
1997	16.86	8.37	0.72
1998	15.90	8.31	2.66
1999	42.31	8.50	24.85
2000	46.43	7.93	9.27
2001	43.26	17.96	48.28
2002	133.27	13.02	25.39
2003	24.34	12.56	39.75
2004	20.73	26.14	37.65
2005	13.27	7.70	21.12
2006	21.34	17.76	3.37
2007	13.43	17.46	21.36
2008	21.30	11.41	46.19
2009	17.80	6.05	4.52
2010	11.14	5.30	9.52
2011	6.33	6.19	9.00
2012	14.75	6.93	3.58
2013	13.97	5.70	5.92
2014	14.89	7.31	14.58
2015	16.08	7.70	27.49
2016	8.88	6.33	111.57
2017	9.76	4.59	14.70

Table 28. Estimated time series of dead discards in weight (1000 lb) for commercial handline (L.cHl), recreational headboat (L.rHb), and MRIP (L.rGe)

Year	D.cHl	D.rHb	D.rGe
1972	0.00	0.00	0.00
1973	0.00	0.00	0.00
1974	0.00	0.00	0.00
1975	0.00	0.00	0.00
1976	0.00	0.00	0.00
1977	0.00	0.00	0.00
1978	0.00	0.00	0.00
1979	0.00	0.00	0.00
1980	0.00	0.00	0.00
1981	0.00	0.00	0.65
1982	0.00	0.00	1.02
1983	0.00	0.00	0.35
1984	0.00	0.00	0.69
1985	0.00	0.00	6.58
1986	0.00	0.00	0.23
1987	0.00	0.00	9.60
1988	0.00	0.00	0.26
1989	0.00	0.00	8.10
1990	0.00	0.00	0.08
1991	0.00	0.00	0.08
1992	23.27	10.59	5.36
1993	21.53	9.56	3.48
1994	19.80	9.00	1.09
1995	19.16	9.17	8.92
1996	21.19	9.70	2.90
1997	20.34	8.89	0.77
1998	19.46	8.75	2.81
1999	51.02	9.15	26.74
2000	58.75	9.29	10.86
2001	59.21	21.64	58.16
2002	176.65	14.39	28.05
2003	29.84	13.51	42.76
2004	25.89	29.00	41.76
2005	16.95	8.60	23.58
2006	27.21	19.62	3.72
2007	16.87	19.70	24.11
2008	27.63	13.60	55.08
2009	24.24	7.34	5.48
2010	15.02	6.04	10.85
2011	8.00	6.76	9.82
2012	18.41	7.83	4.04
2013	18.39	7.02	7.29
2014	21.17	9.57	19.08
2015	23.41	10.30	36.77
2016	12.95	8.25	145.36
2017	13.47	5.82	18.62

Table 29. Estimated status indicators, benchmarks, and related quantities from the base run of the Beaufort catch-age model, conditional on estimated current selectivities averaged across fleets. Also presented are median values and measures of precision (standard errors, SE) from the Monte Carlo/Bootstrap analysis. Rate estimates (F) are in units of y^{-1}*; status indicators are dimensionless; and biomass estimates are in units of metric tons or pounds, as indicated. Spawning stock biomass (SSB) is measured in metric tons*

Quantity	Units	Estimate	Median	SE
F_{MSY}	y^{-1}	0.18	0.18	0.027
$85\%F_{\mathrm{MSY}}$	y^{-1}	0.153	0.153	0.023
$75\%F_{\mathrm{MSY}}$	y^{-1}	0.135	0.135	0.02
$65\%F_{\mathrm{MSY}}$	y^{-1}	0.117	0.117	0.018
$F_{20\%}$	y^{-1}	3.115	3.022	1.425
$F_{30\%}$	y^{-1}	1.21	1.175	0.796
$F_{40\%}$	y^{-1}	0.6	0.585	0.326
B_{MSY}	metric tons	3604.6	3593.7	487.3
$\mathrm{SSB}_{\mathrm{MSY}}$	metric tons	2883.7	2902.6	337.3
MSST	metric tons	2249.3	2261	219
MSY	1000 lb whole	531.4	538.2	59.3
D_{MSY}	1000 lb dead fish	126.8	118.5	118.5
D_{MSY}	1000 dead fish	104	96.7	96.7
R_{MSY}	1000 fish	2641.2	2554.1	796.3
$L_{85\%\mathrm{MSY}}$	1000 lb whole	527.2	532.8	59.4
$L_{75\%\mathrm{MSY}}$	1000 lb whole	515.7	521.9	59.4
$L_{65\%\mathrm{MSY}}$	1000 lb whole	494.9	502.9	59.1
$F_{2015-2017}/F_{\mathrm{MSY}}$	—	1.73	1.664	0.304
$\mathrm{SSB}_{2017}/\mathrm{MSST}$	—	0.347	0.369	0.101
$\mathrm{SSB}_{2017}/\mathrm{SSB}_{\mathrm{MSY}}$	—	0.271	0.285	0.063

Table 30. Results from sensitivity runs of the Beaufort catch-age model. Current F represented by geometric mean of last three assessment years ($F/F_{\mathrm{MSY}} = F_{2015-2017}/F_{\mathrm{MSY}}$). Stock and rebuild status based on terminal year ($\mathrm{SSB}/\mathrm{MSST} = \mathrm{SSB}_{2017}/\mathrm{MSST}$; $\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}} = \mathrm{SSB}_{2017}/\mathrm{SSB}_{\mathrm{MSY}}$). h = Beverton-Holt steepness. See text for full description of sensitivity runs.

Description	F_{MSY}	$\mathrm{SSB}_{\mathrm{MSY}}$ (mt)	B_{MSY} (mt)	MSY (1000 lb)	D_{MSY} (1000 lb)	D_{MSY} (1000 fish)	F/F_{MSY}	SSB/MSST	$\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$	h	R_0 (1000$fish$)
Base	0.180	2884	3605	531	127	104	1.73	0.35	0.27	0.38	3430
S1 set M constant lo	0.190	2728	3203	619	138	104	2.05	0.25	0.21	0.56	1801
S2 set M constant up	0.125	3872	5225	418	104	91	1.64	0.50	0.34	0.26	7179
S3 set steep lo	0.070	8438	10105	686	156	116	4.32	0.12	0.09	0.25	6348
S4 set steep up	0.325	1732	2261	485	134	119	0.94	0.59	0.46	0.51	2218
S5 set log R0 lo	0.555	1317	1810	503	170	165	0.56	0.75	0.58	0.71	1759
S6 include sFT	0.175	2947	3677	532	126	104	1.78	0.34	0.26	0.37	3475
S7 FMatTimeVarying	0.200	2788	3410	541	132	110	1.55	0.37	0.29	0.39	3253
S8 wcpuerHb2	0.200	2419	3043	482	118	98	1.57	0.41	0.32	0.39	2825
S9 wcpuerHb3	0.355	1615	2124	474	136	118	0.90	0.60	0.47	0.52	2024
S10 smoothMRIP2016	0.175	2929	3660	547	116	95	1.38	0.36	0.28	0.38	3501

Table 31. Projection results with fishing mortality rate fixed at $F = F_{P^*_{50\%}}$ starting in 2021 and projecting forward to 2026. From 2018 to 2020 the fishing mortality rate was fixed at $F_{\text{current}} = 0.31$. 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 $\text{SSB} \geq \text{SSB}_{\text{MSY}}$. 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
2018	1019	965	0.31	0.30	723	768	140	142	230	235	42	39	52	49	0.000
2019	956	919	0.31	0.30	720	768	123	128	200	208	47	43	53	50	0.000
2020	951	911	0.31	0.30	751	803	121	125	187	195	51	47	56	53	0.000
2021	987	935	0.18	0.18	800	852	80	85	120	129	32	31	35	35	0.001
2022	1040	981	0.18	0.18	880	936	93	98	139	148	34	33	39	38	0.001
2023	1126	1046	0.18	0.18	956	1012	102	108	155	165	37	35	42	41	0.001
2024	1205	1119	0.18	0.18	1032	1086	111	116	169	180	40	38	45	44	0.002
2025	1282	1178	0.18	0.18	1110	1163	119	125	183	193	42	41	49	47	0.003
2026	1358	1239	0.18	0.18	1189	1240	128	133	197	207	45	43	52	50	0.005

Table 32. Projection results with fishing mortality rate fixed at $F = F_{\mathrm{MSY}}$ starting in 2021 and projecting forward to 2026. From 2018 to 2020 the fishing mortality rate was fixed at $F_{\mathrm{current}} = 0.31$. 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
2018	1019	966	0.31	0.30	723	767	140	142	230	235	42	39	52	49	0.000
2019	956	922	0.31	0.30	720	769	123	128	200	208	47	43	53	50	0.000
2020	951	913	0.31	0.30	751	804	121	125	187	196	51	47	56	52	0.000
2021	987	940	0.18	0.18	800	852	80	85	120	129	32	31	35	35	0.000
2022	1040	988	0.18	0.18	880	931	93	98	139	148	34	33	39	38	0.001
2023	1126	1067	0.18	0.18	956	1009	102	108	155	165	37	35	42	41	0.002
2024	1205	1123	0.18	0.18	1032	1087	111	116	170	179	40	38	45	44	0.003
2025	1282	1186	0.18	0.18	1109	1163	119	125	183	193	42	40	49	47	0.004
2026	1358	1238	0.18	0.18	1189	1238	128	134	197	207	45	43	52	50	0.006

Table 33. Projection results with fishing mortality rate fixed at $F = 0.75F_{\mathrm{MSY}}$ starting in 2021 and projecting forward to 2026. From 2018 to 2020 the fishing mortality rate was fixed at $F_{\mathrm{current}} = 0.31$. 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
2018	1019	971	0.31	0.30	723	768	140	142	230	235	42	39	52	49	0.000
2019	956	924	0.31	0.30	720	768	123	128	200	208	47	43	53	50	0.000
2020	951	915	0.31	0.30	751	803	121	125	187	195	51	47	56	53	0.000
2021	987	943	0.14	0.14	803	860	61	65	92	99	24	23	27	26	0.001
2022	1044	990	0.14	0.14	900	962	72	77	109	117	26	26	30	29	0.001
2023	1147	1084	0.14	0.14	992	1056	82	86	125	133	29	28	33	32	0.002
2024	1242	1159	0.14	0.14	1086	1151	90	94	139	147	31	30	36	35	0.004
2025	1336	1229	0.14	0.14	1184	1247	98	103	152	161	34	32	39	38	0.006
2026	1429	1305	0.14	0.14	1285	1345	106	111	166	175	37	35	43	41	0.011

Table 34. Projection results with fishing mortality rate fixed at $F = 0$ starting in 2021 and projecting forward to 2032. From 2018 to 2020 the fishing mortality rate was fixed at $F_{\text{current}} = 0.31$. 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 $\text{SSB} \geq \text{SSB}_{\text{MSY}}$. 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
2018	1019	972	0.31	0.3	723	770	140	142	230	235	42	39	52	49	0.000
2019	956	918	0.31	0.3	720	771	123	128	200	208	47	43	53	50	0.000
2020	951	917	0.31	0.3	751	806	121	125	187	196	51	47	56	53	0.000
2021	987	946	0.00	0.0	813	870	0	0	0	0	0	0	0	0	0.001
2022	1054	998	0.00	0.0	963	1029	0	0	0	0	0	0	0	0	0.002
2023	1213	1147	0.00	0.0	1117	1190	0	0	0	0	0	0	0	0	0.005
2024	1366	1266	0.00	0.0	1283	1361	0	0	0	0	0	0	0	0	0.014
2025	1521	1395	0.00	0.0	1463	1544	0	0	0	0	0	0	0	0	0.031
2026	1679	1517	0.00	0.0	1658	1739	0	0	0	0	0	0	0	0	0.062
2027	1838	1652	0.00	0.0	1865	1945	0	0	0	0	0	0	0	0	0.115
2028	1997	1757	0.00	0.0	2085	2164	0	0	0	0	0	0	0	0	0.185
2029	2154	1897	0.00	0.0	2314	2387	0	0	0	0	0	0	0	0	0.278
2030	2306	2014	0.00	0.0	2550	2616	0	0	0	0	0	0	0	0	0.382
2031	2452	2092	0.00	0.0	2792	2849	0	0	0	0	0	0	0	0	0.485
2032	2591	2235	0.00	0.0	3036	3090	0	0	0	0	0	0	0	0	0.583

9 Figures

Figure 3. Length, female maturity, and reproductive output at age. Top panel: Mean length at age (mm) and estimated 95% confidence interval of the population. Middle panel: Female maturity by age. Bottom panel: Reproductive output (mt) by age.

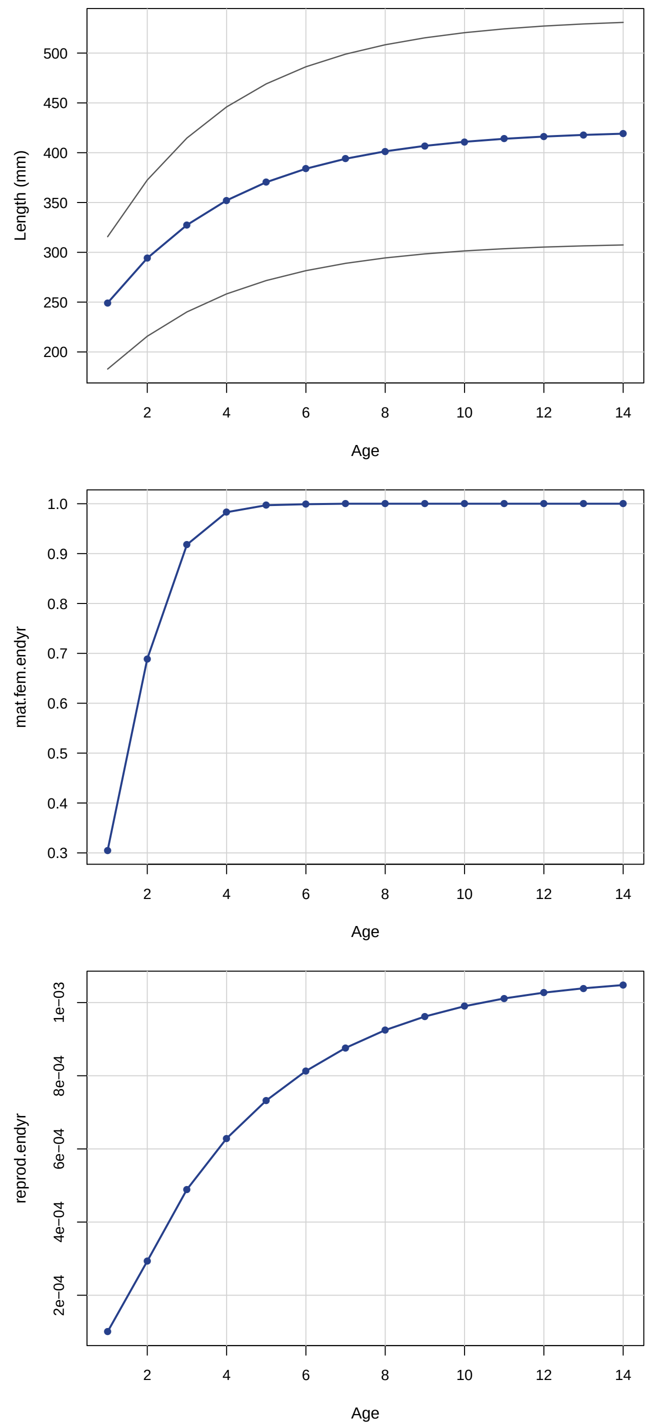


Figure 4. Observed (open circles) and estimated (solid line) annual and and length compositions by fleet. In panels indicating the data set: acomp = age compositions, lcomp = length compositions, cHl = commercial handline, rHb = recreational headboat, sCT = Chevron trap survey, cTw = commercial trawl. N indicates the number of trips from which individual fish samples were taken. The four digit number in upper right corner of each panel indicates year of sampling (e.g. 1983, 1984).

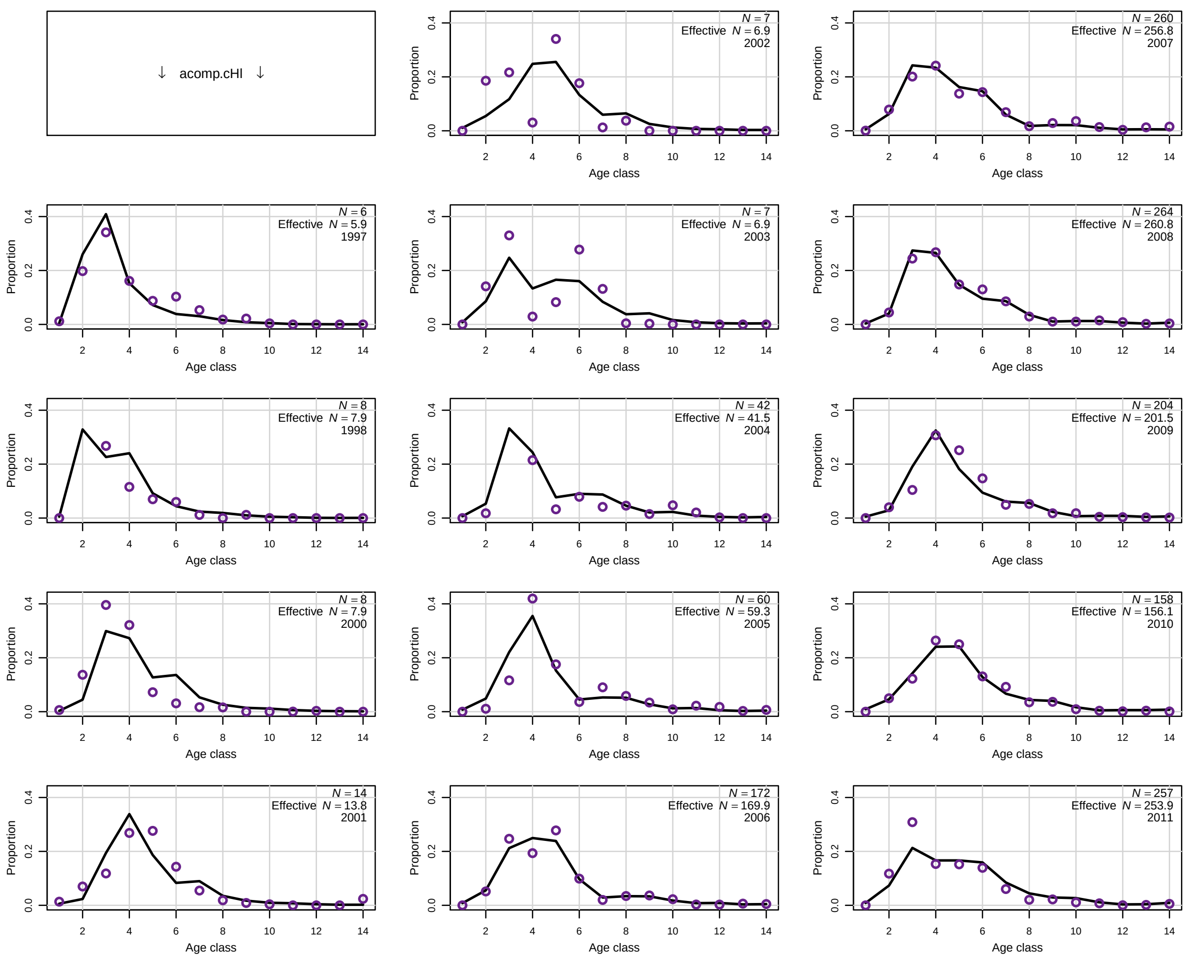


Figure 4. (cont.) Observed (open circles) and estimated (solid line) annual age and length compositions by fleet.

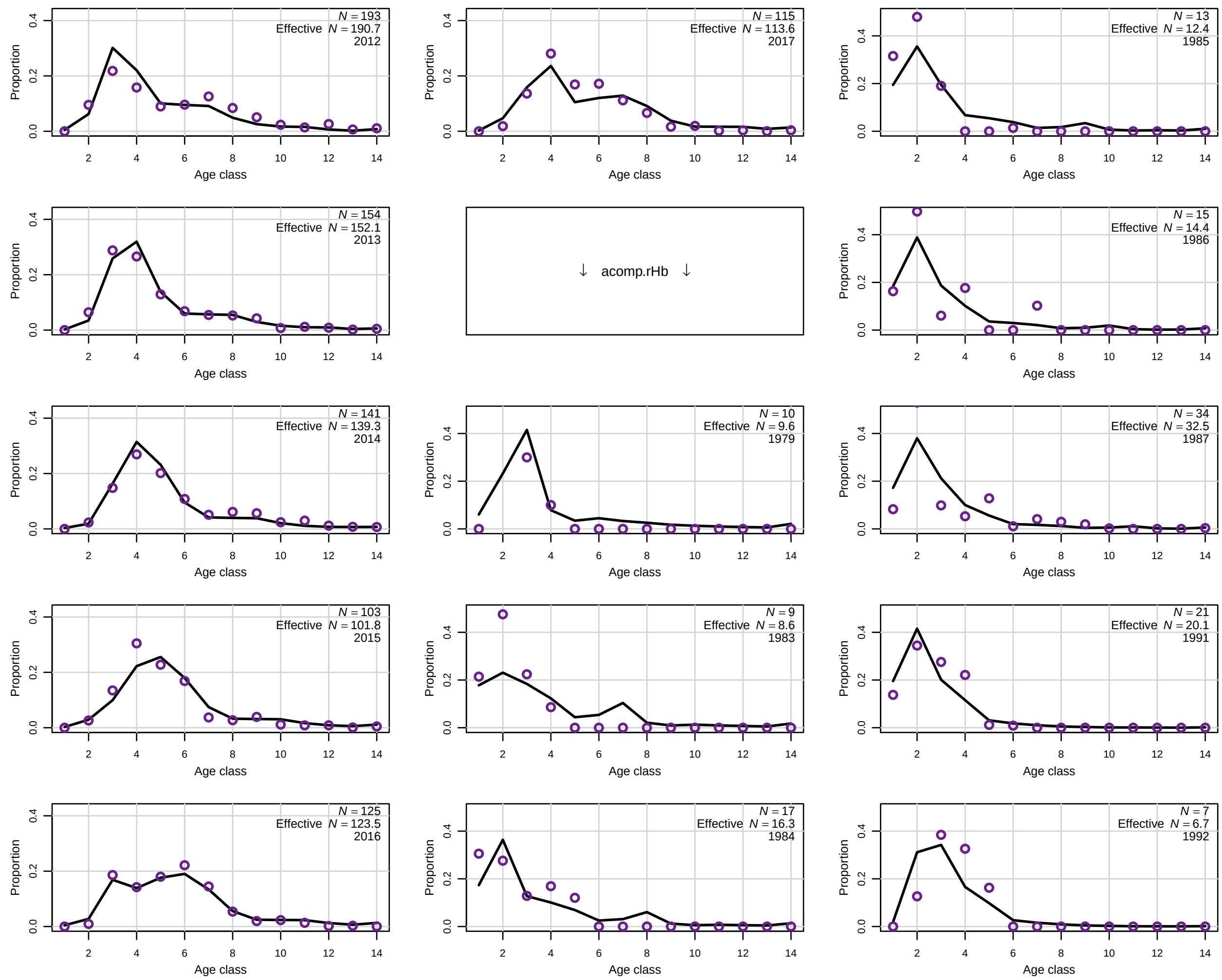


Figure 4. (cont.) Observed (open circles) and estimated (solid line) annual age and length compositions by fleet.

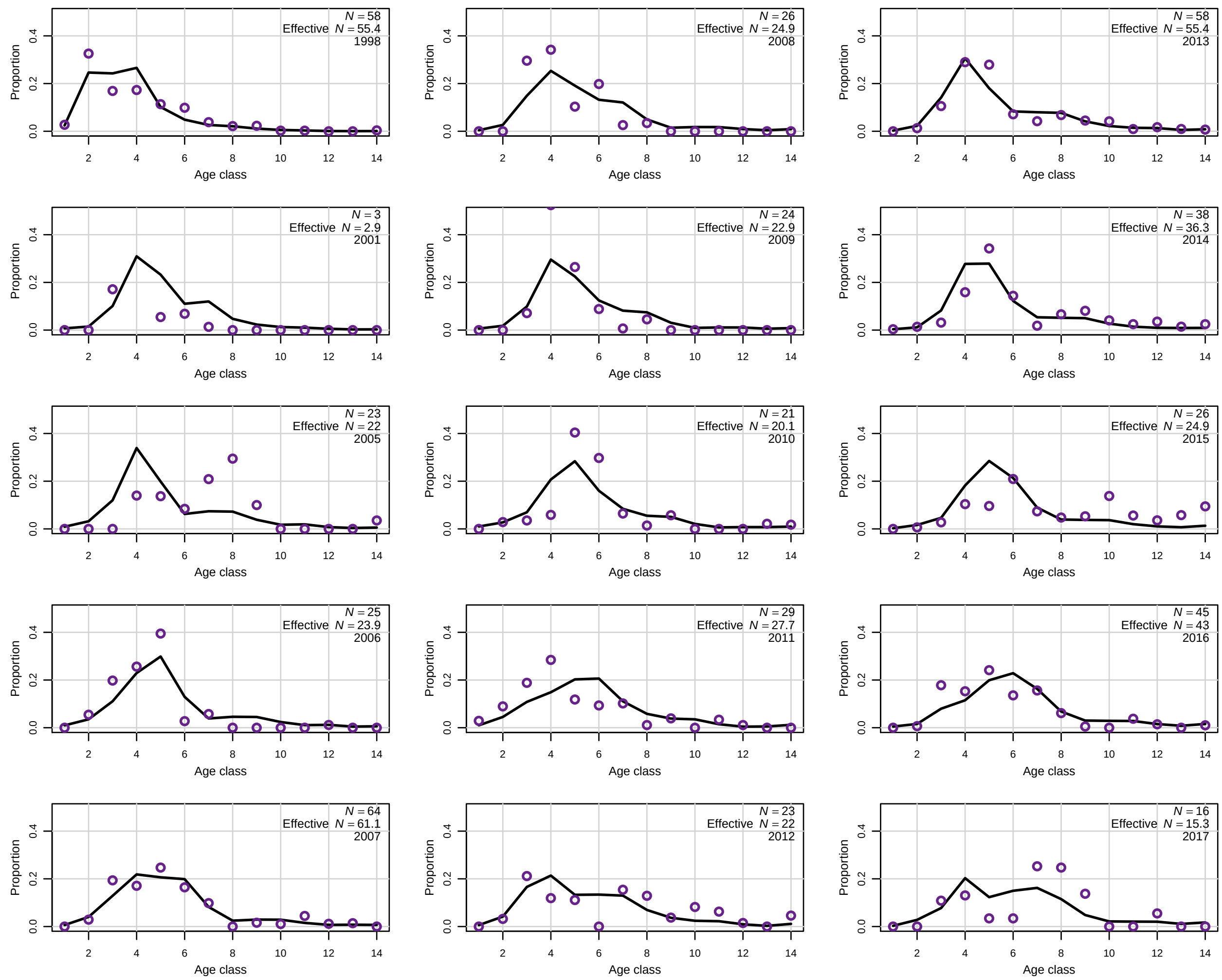


Figure 4. (cont.) Observed (open circles) and estimated (solid line) annual age and length compositions by fleet.

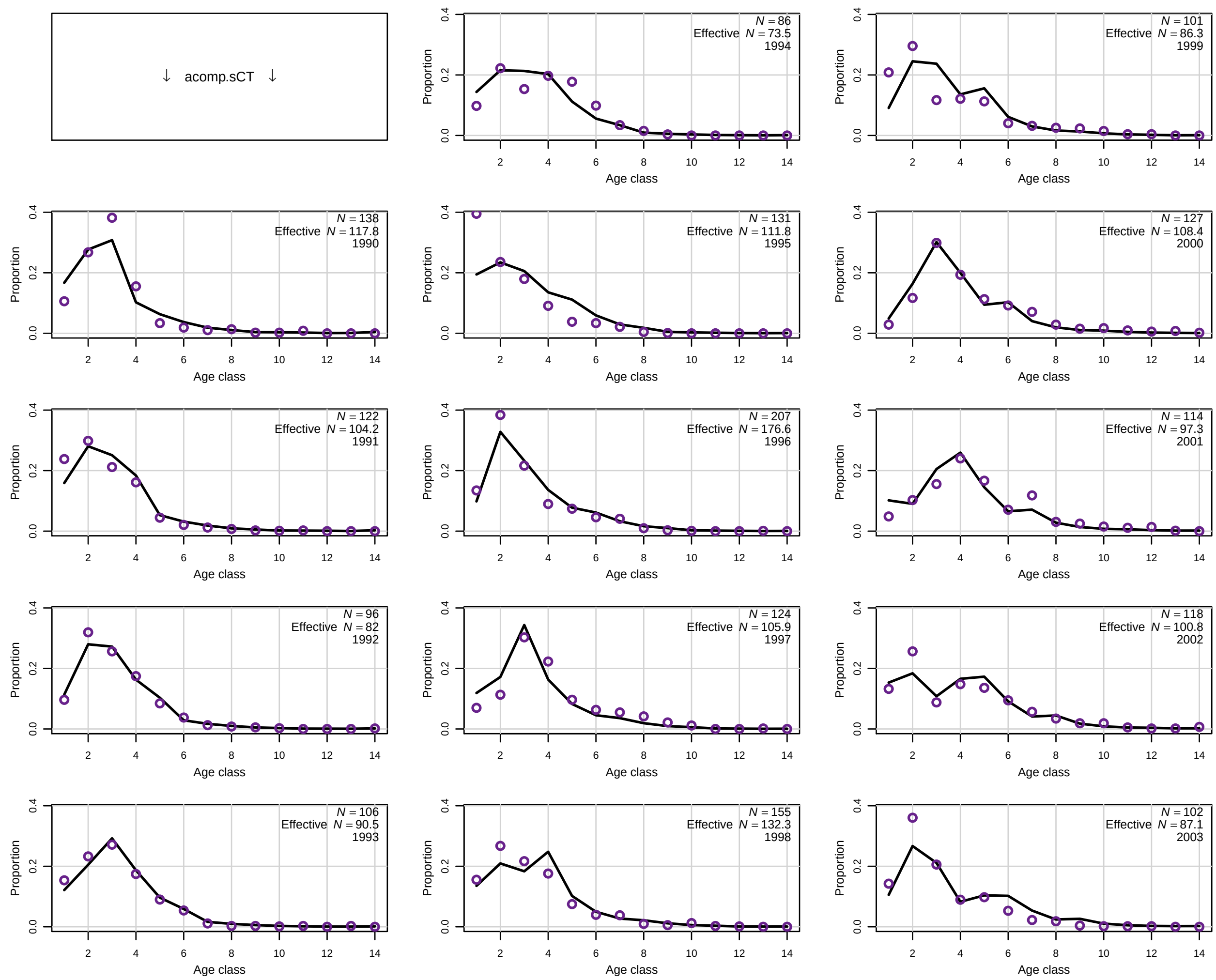


Figure 4. (cont.) Observed (open circles) and estimated (solid line) annual age and length compositions by fleet.

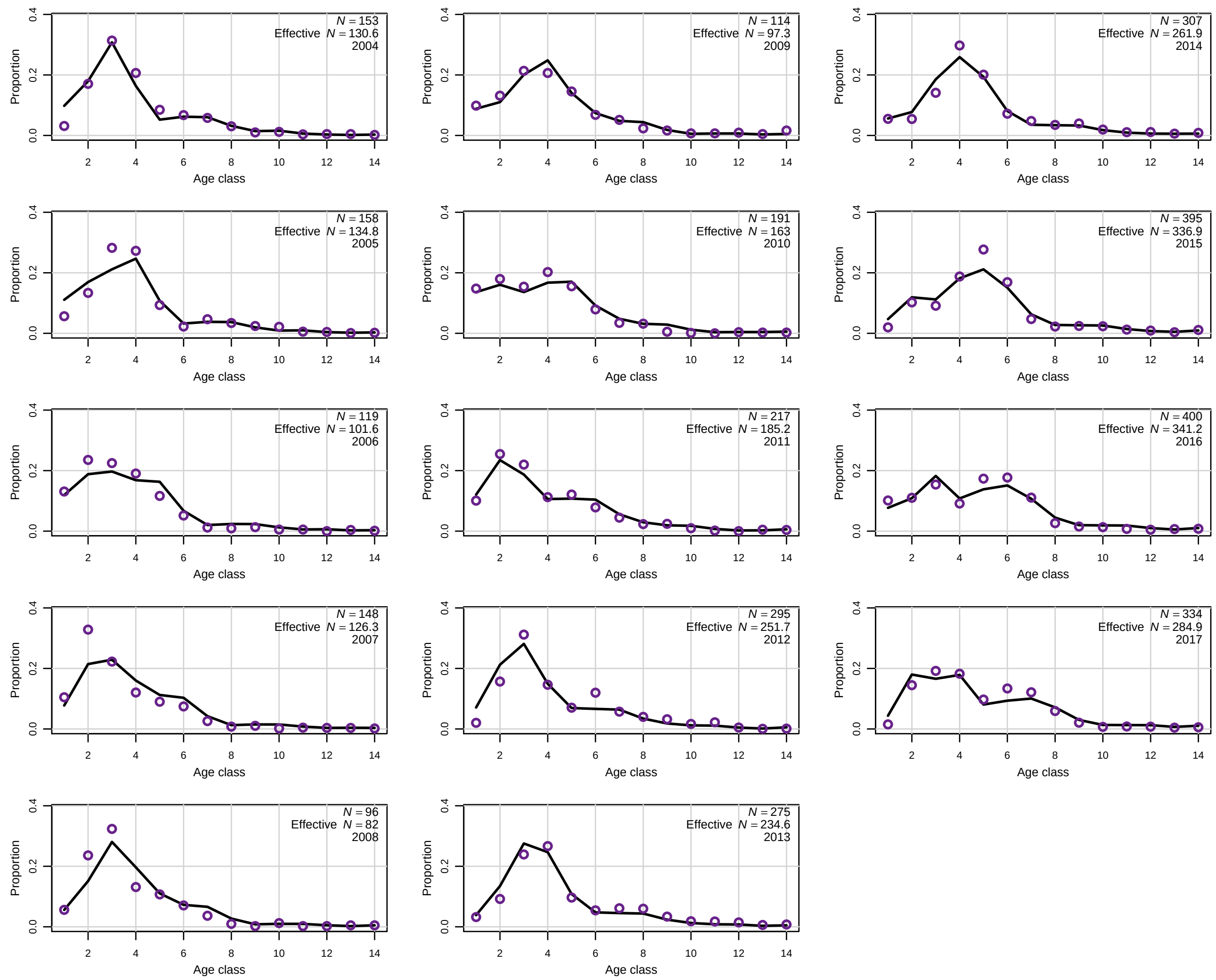
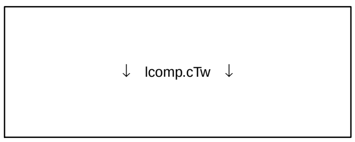


Figure 4. (cont.) Observed (open circles) and estimated (solid line) annual age and length compositions by fleet.



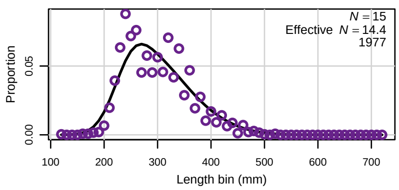


Figure 5. Observed (open circles) and estimated (line, solid circles) commercial handline landings (1000 lb whole weight).

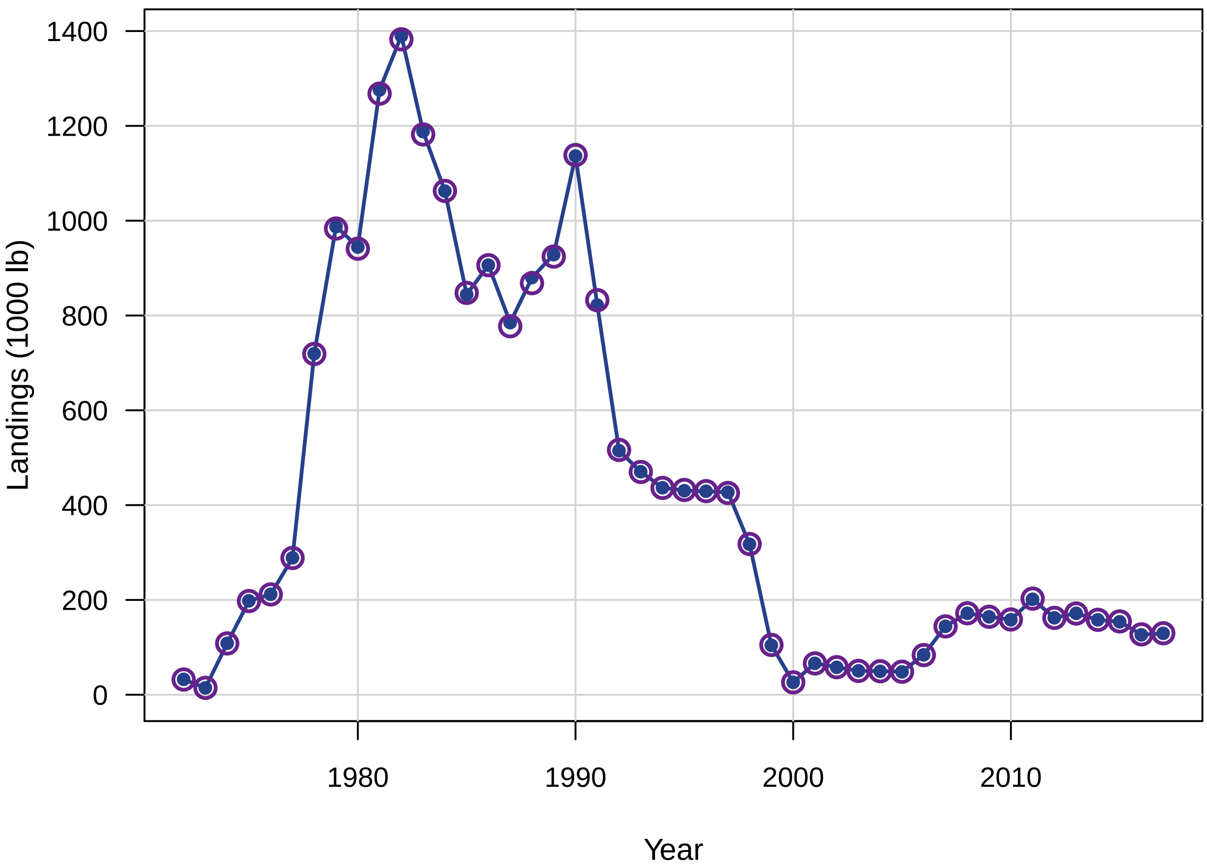


Figure 6. Observed (open circles) and estimated (line, solid circles) commercial trawl landings (1000 lb whole weight).

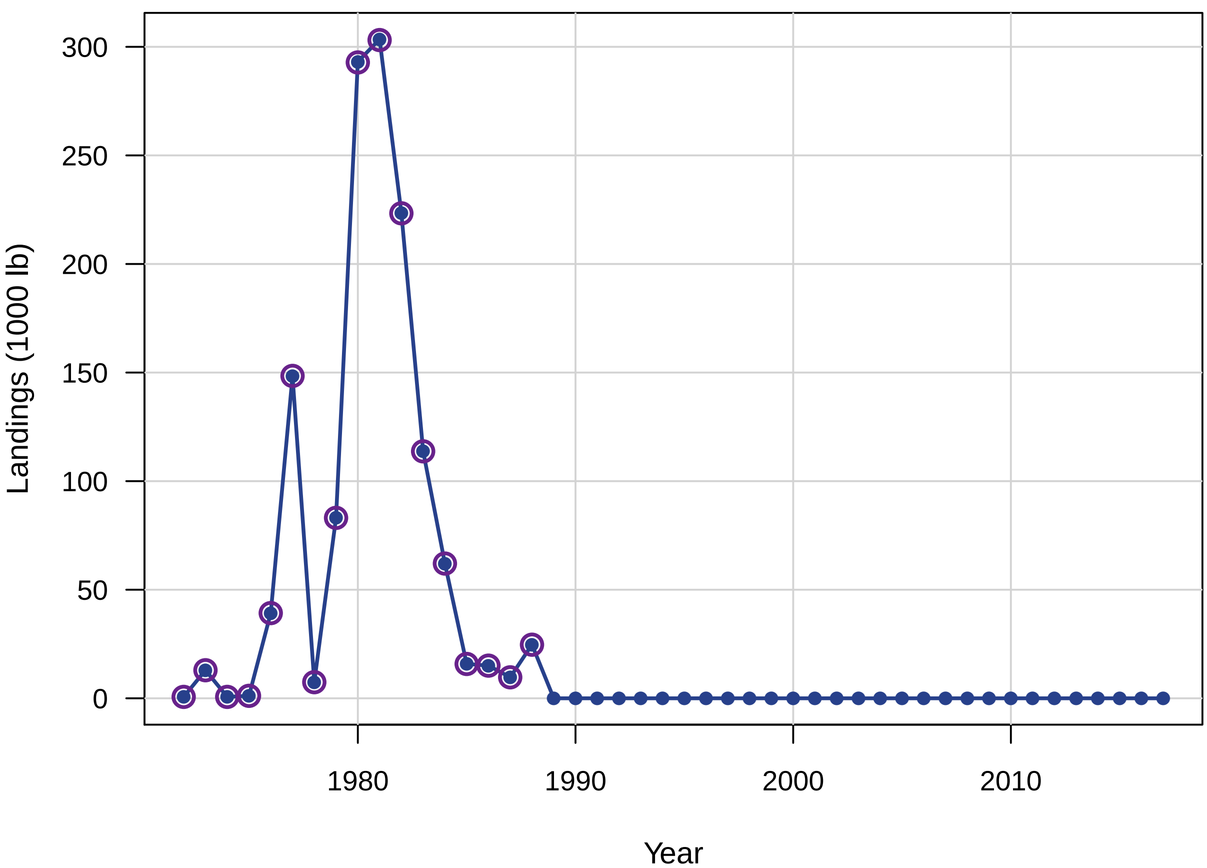


Figure 7. Observed (open circles) and estimated (line, solid circles) recreational MRIP landings (1000 fish).

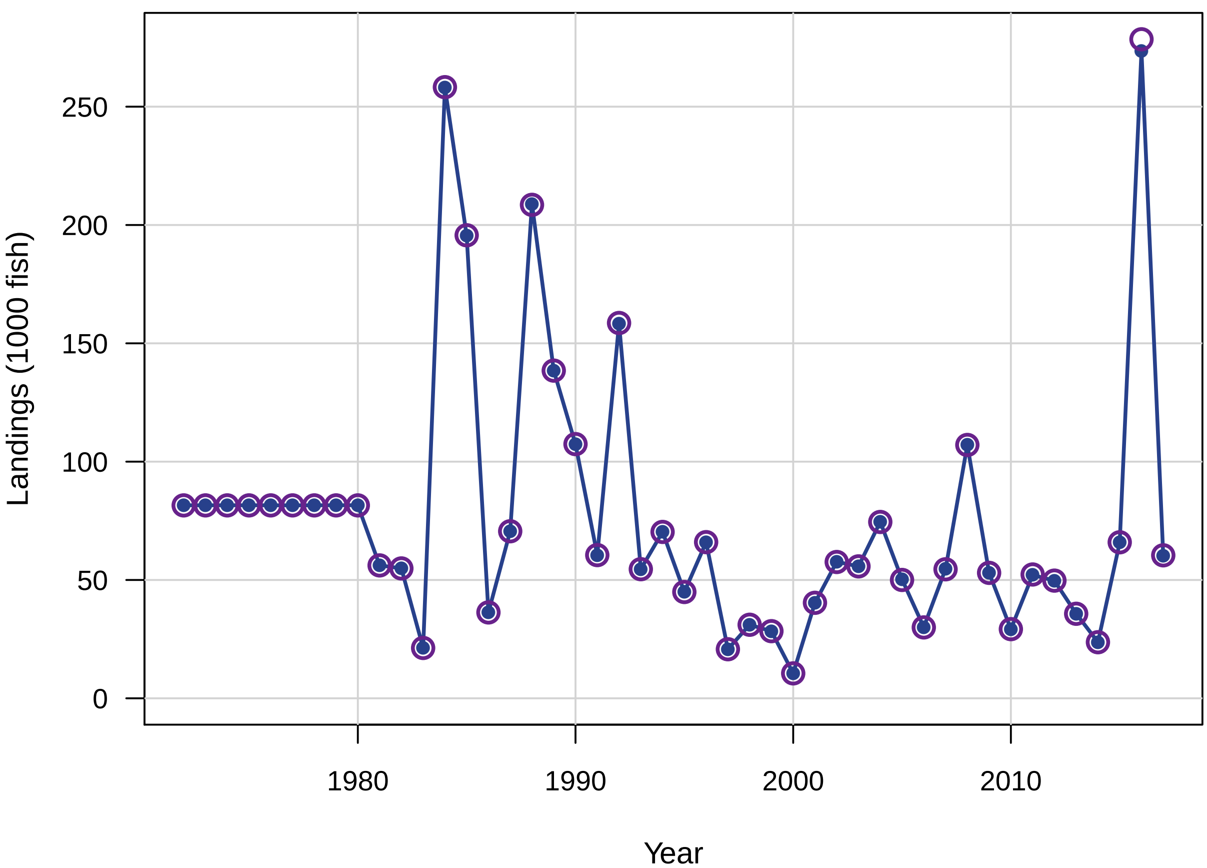


Figure 8. Observed (open circles) and estimated (line, solid circles) recreational headboat landings (1000 fish).

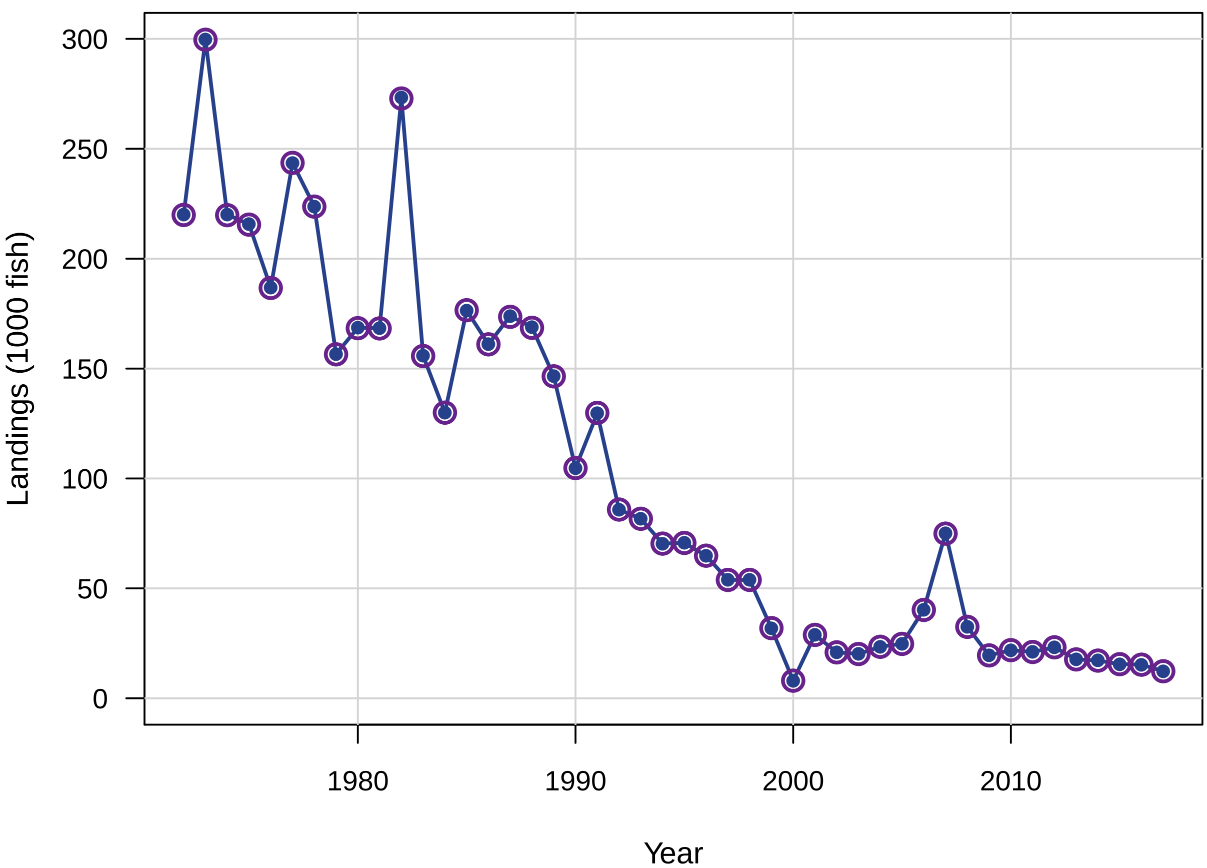


Figure 9. Observed (open circles) and estimated (line, solid circles) commercial handline discards (1000 fish).

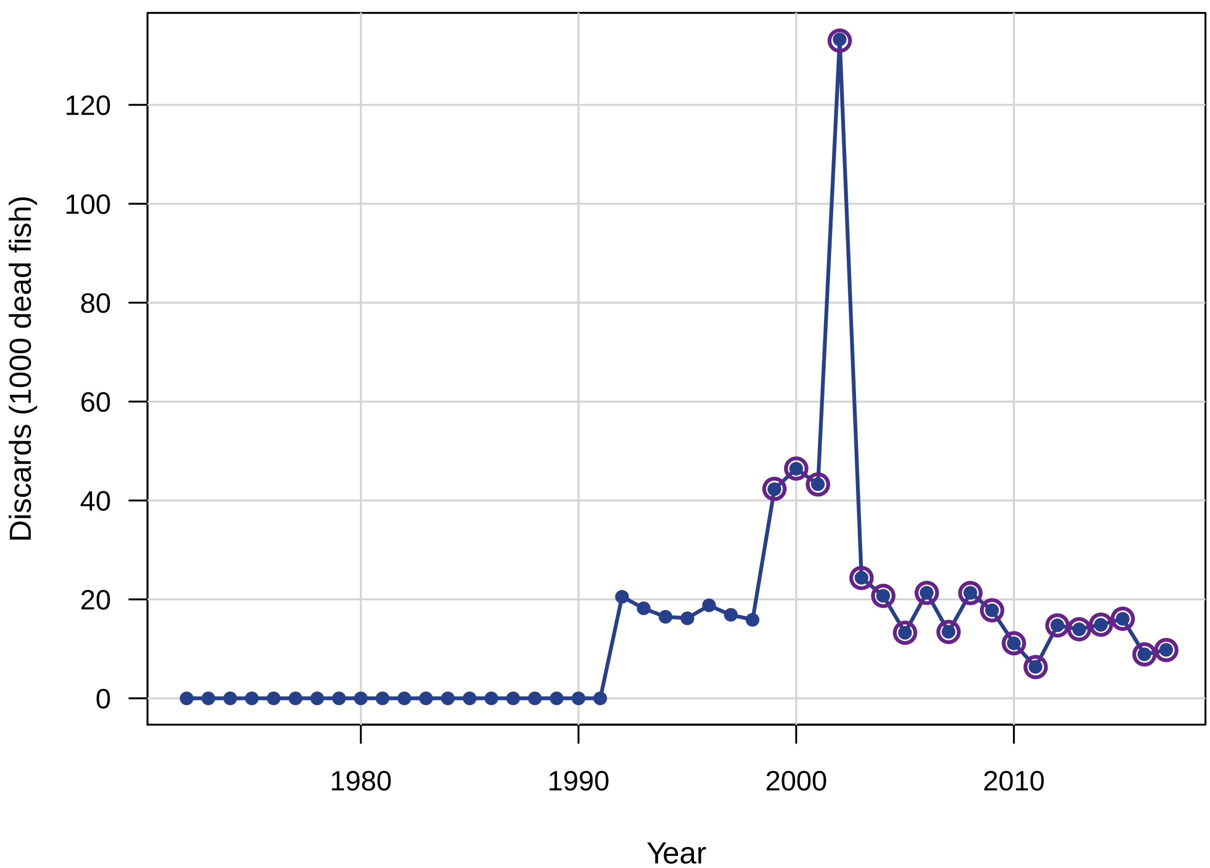


Figure 10. Observed (open circles) and estimated (line, solid circles) recreational MRIP discards (1000 fish).

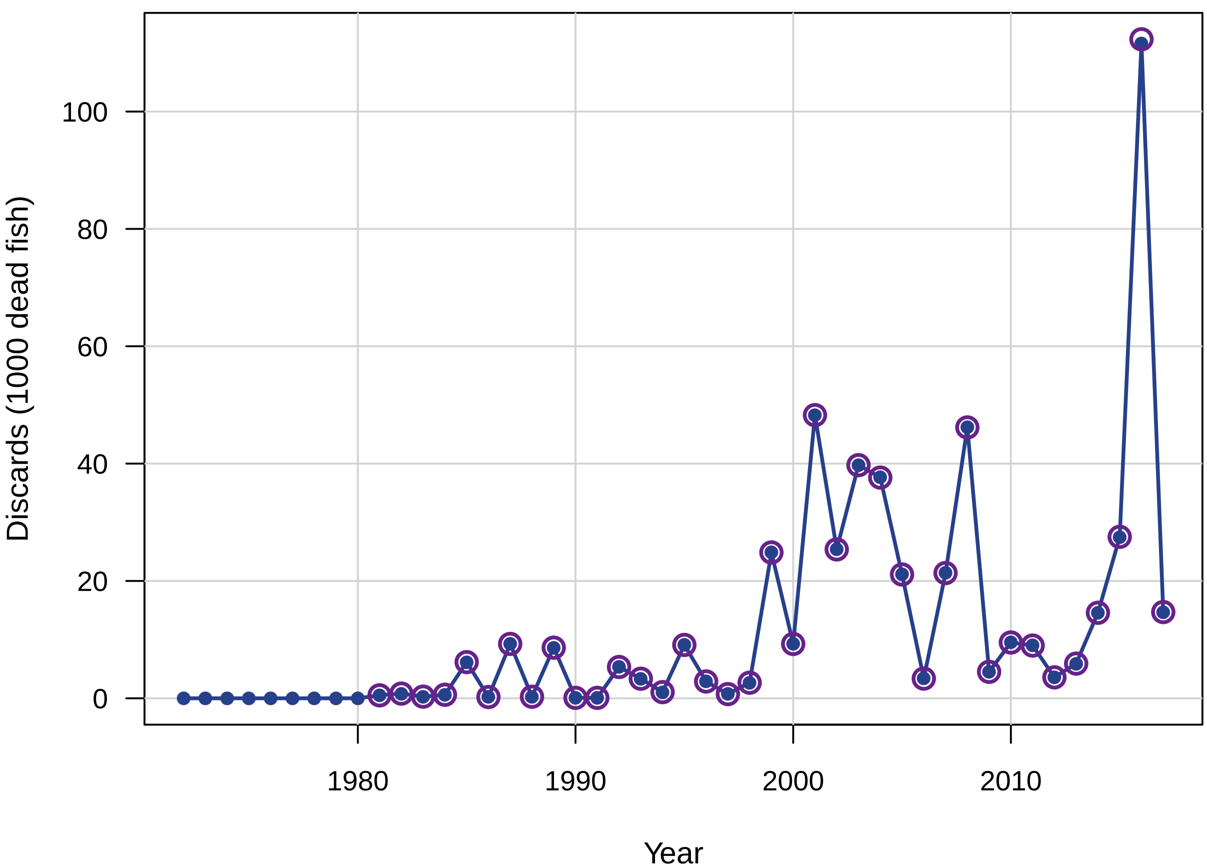


Figure 11. Observed (open circles) and estimated (line, solid circles) recreational headboat discards (1000 fish).

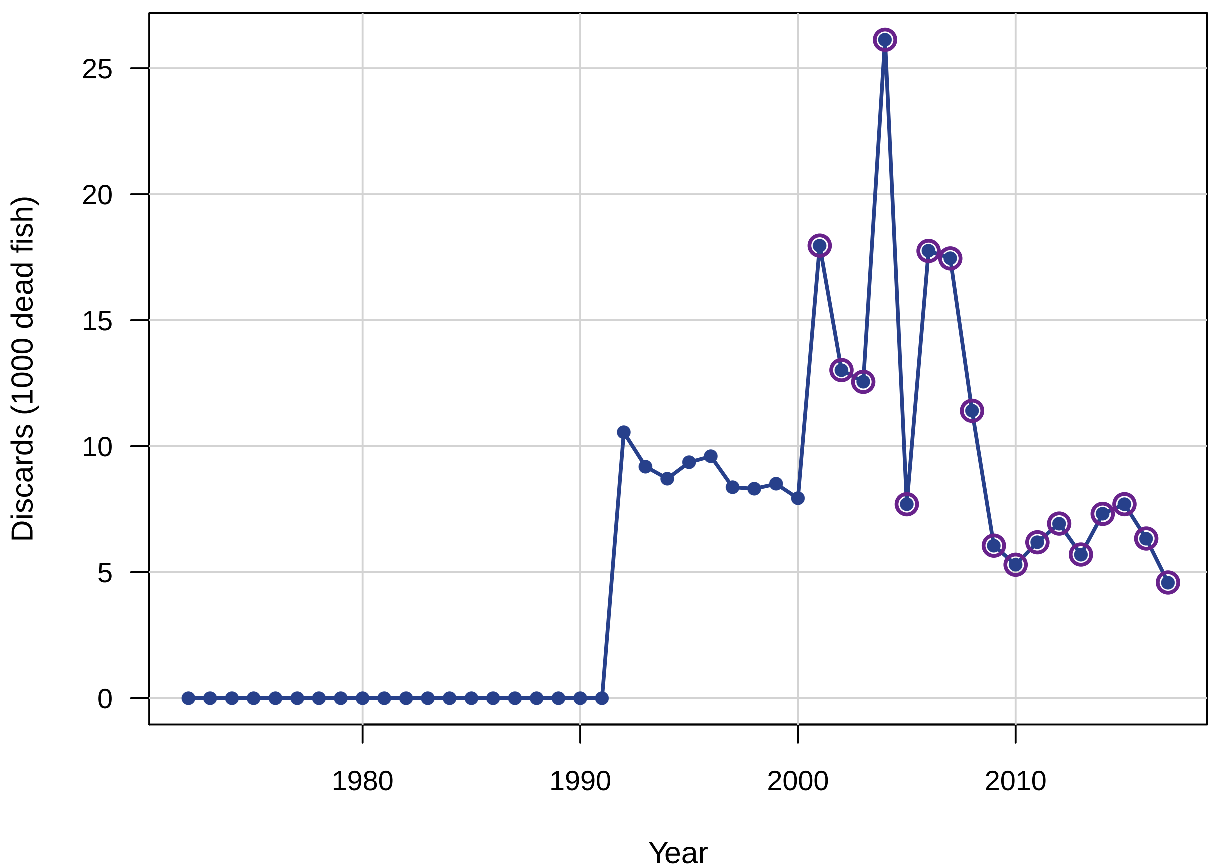


Figure 12. Observed (open circles) and estimated (line, solid circles) recreational headboat index of abundance .

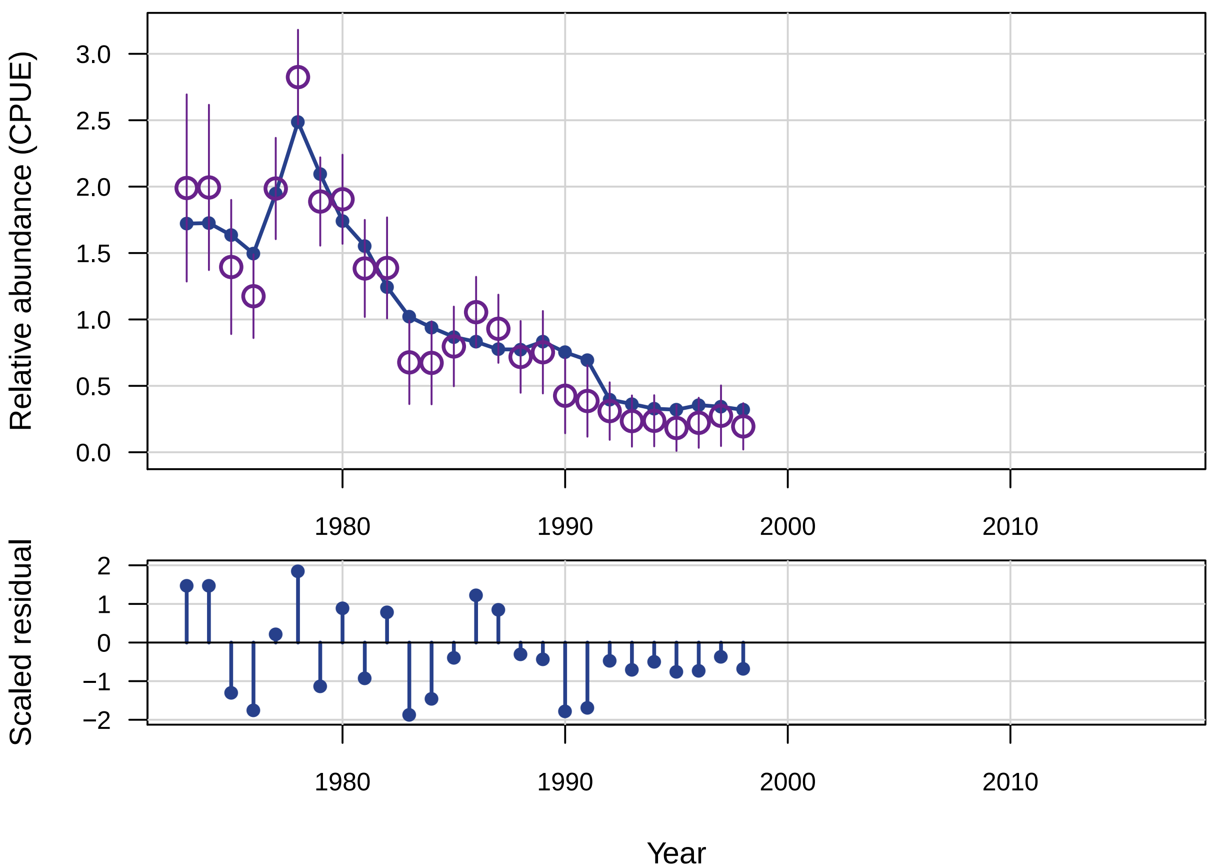


Figure 13. Observed (open circles) and estimated (line, solid circles) Chevron trap/video survey index of abundance
.

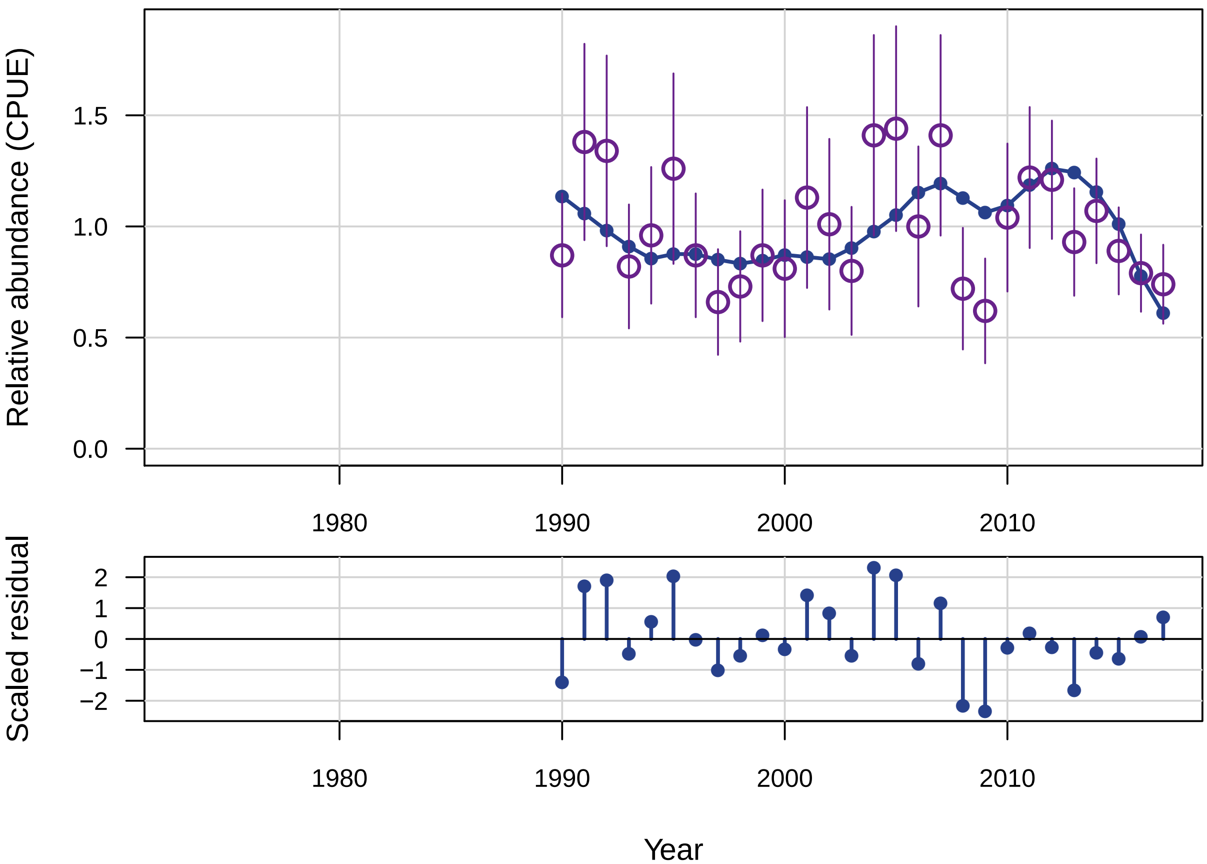


Figure 14. Estimated abundance at age at start of year

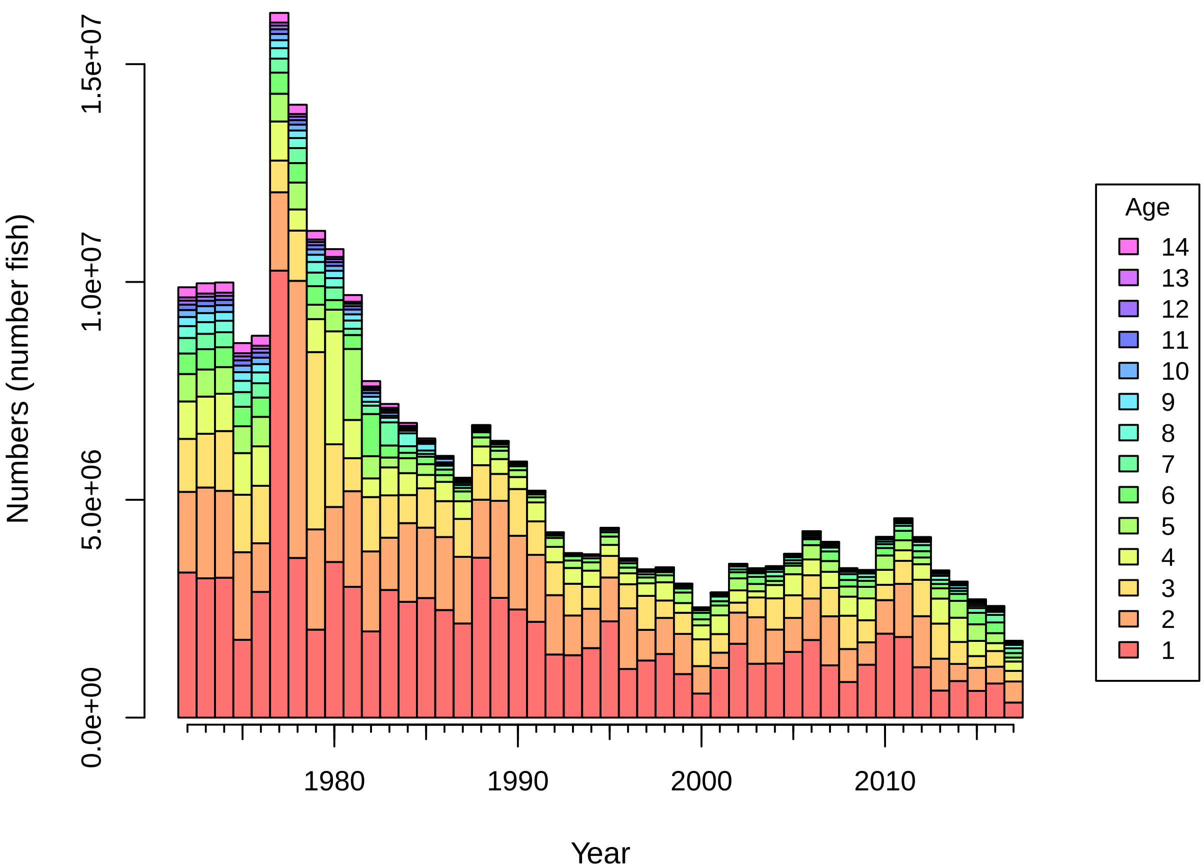


Figure 15. Estimated biomass at age at start of year.

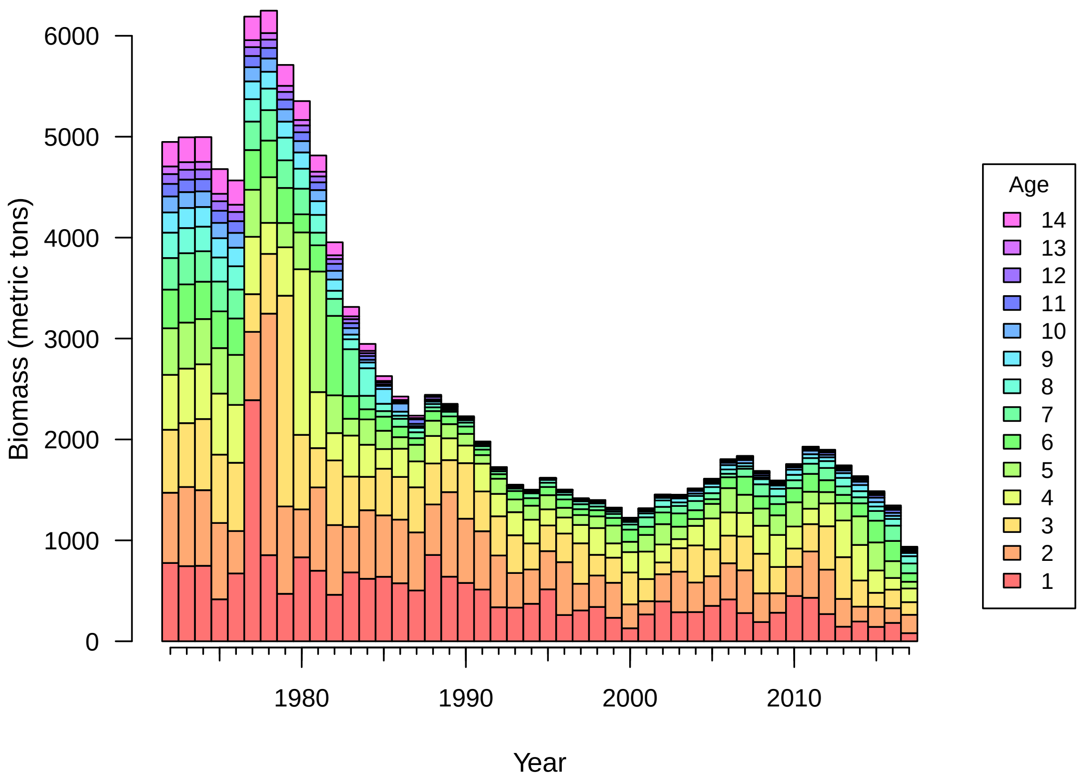


Figure 16. Estimated recruitment time series. Top panel: Estimated recruitment of age-1 fish. Horizontal dashed line indicates R_{MSY}. Bottom panel: log recruitment residuals.

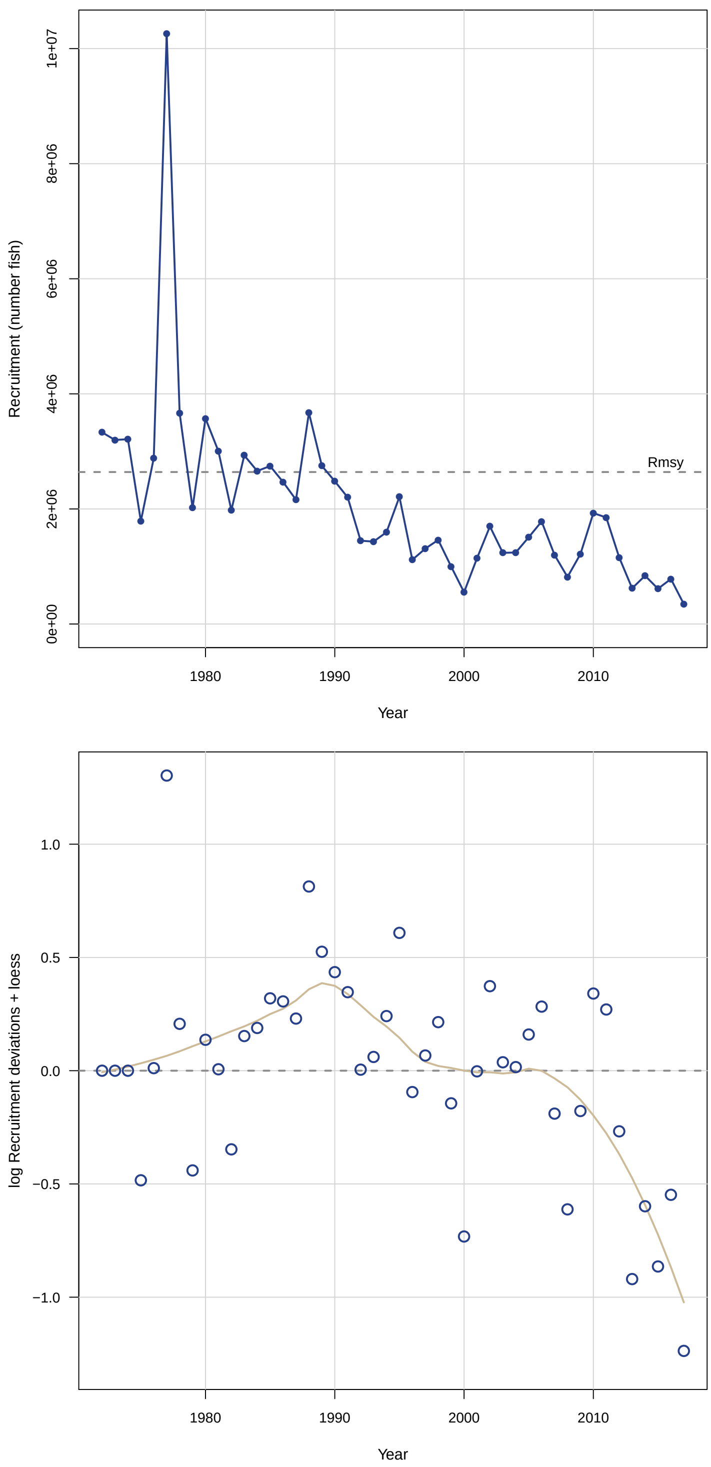


Figure 17. Estimated total biomass and spawning stock time series. Top panel: Estimated total biomass (metric tons) at start of year. Horizontal dashed line indicates B_{MSY}. Bottom panel: Estimated spawning stock (mt) at time of peak spawning.

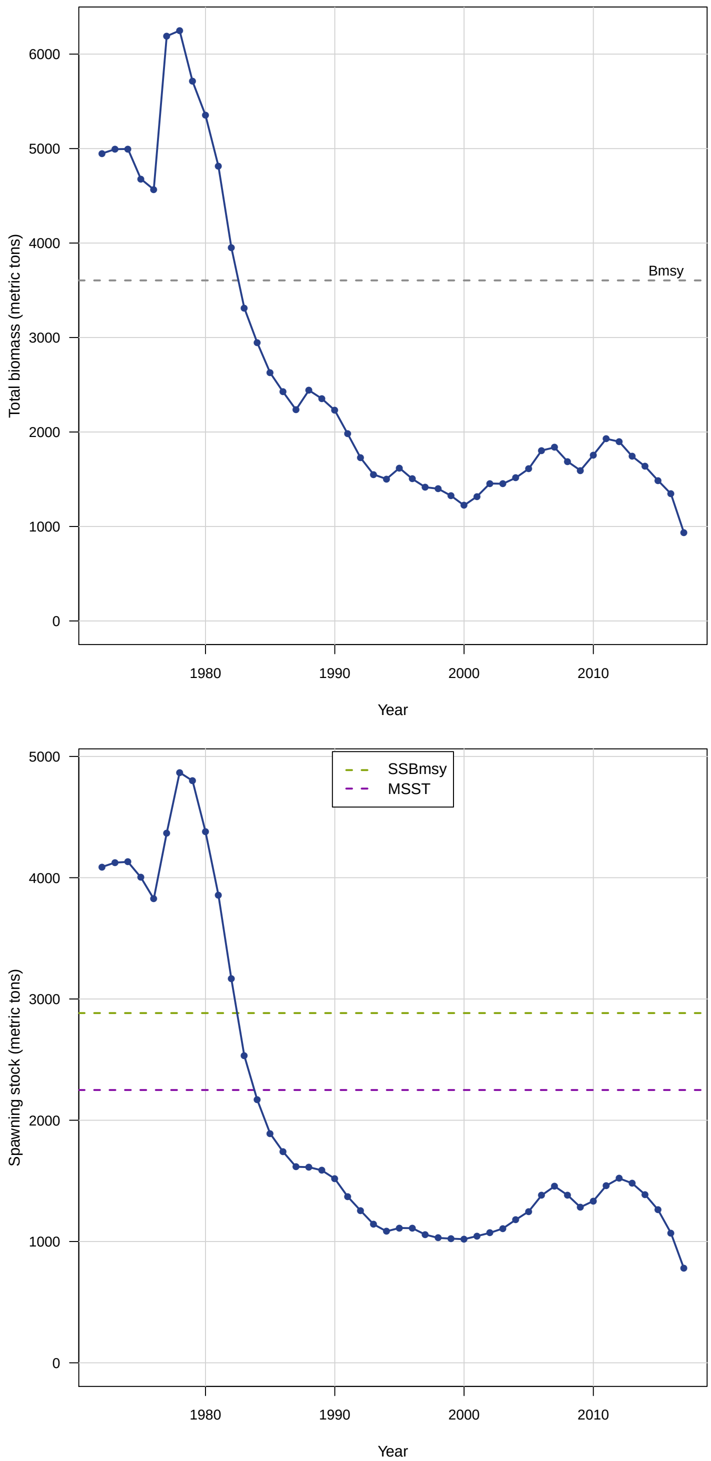


Figure 18. Selectivities of SERFS Chevron trap/video index. Different colored lines indicate different selectivity blocks. The first year of each selectivity block is indicated in the legend. In this case, there was only one selectivity block.

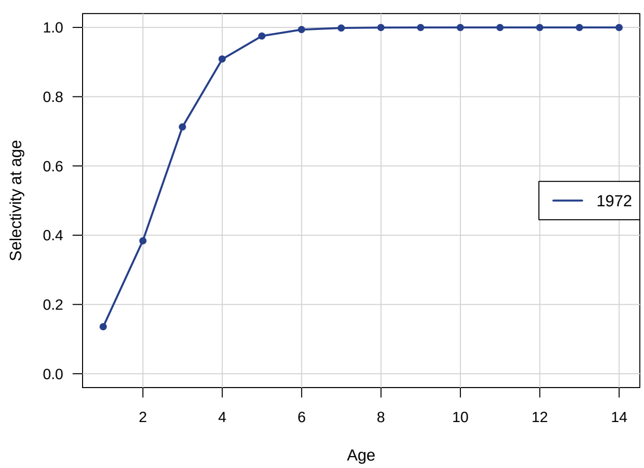


Figure 19. Selectivities of commercial handline landings (top) and trawl landings (bottom). Different colored lines indicate different selectivity blocks. The first year of each selectivity block is indicated in the legend.

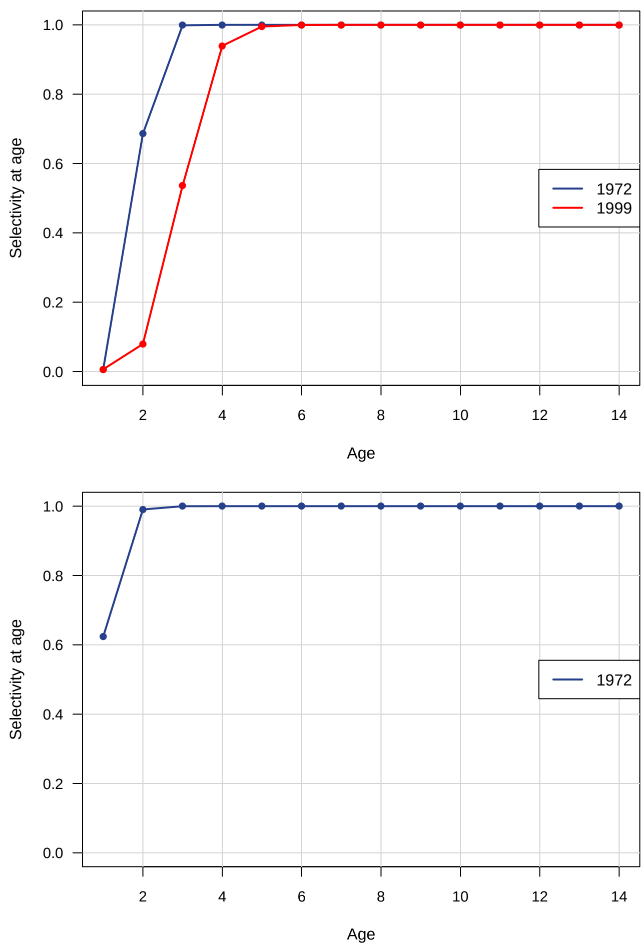
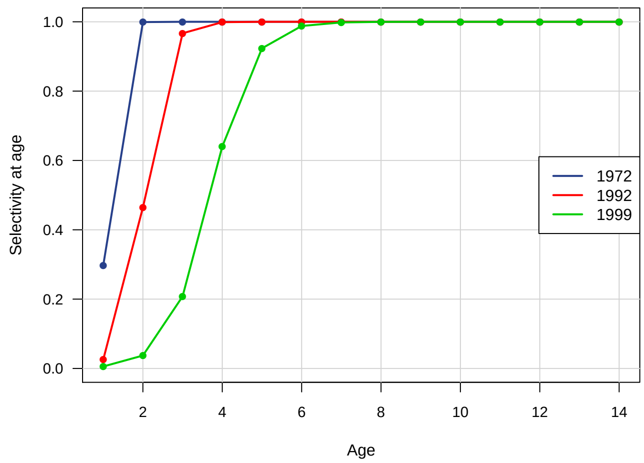


Figure 20. Selectivities of recreational MRIP (top) and headboat landings (bottom). Different colored lines indicate different selectivity blocks. The first year of each selectivity block is indicated in the legend. In this assessment, selectivities of these two fleets mirrored each other



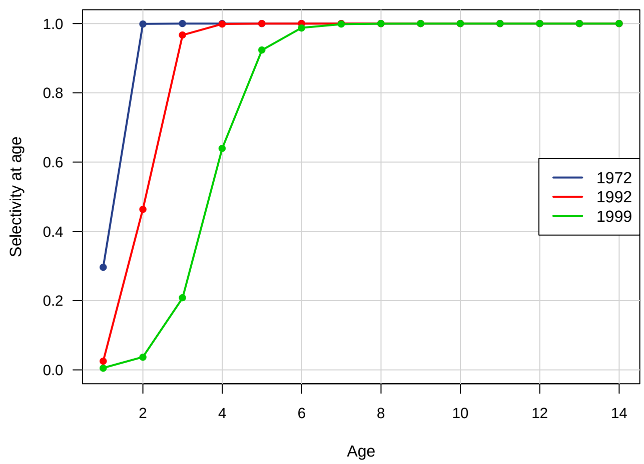


Figure 21. Selectivities of commercial handline (top), recreational MRIP (middle), and headboat discards (bottom) .

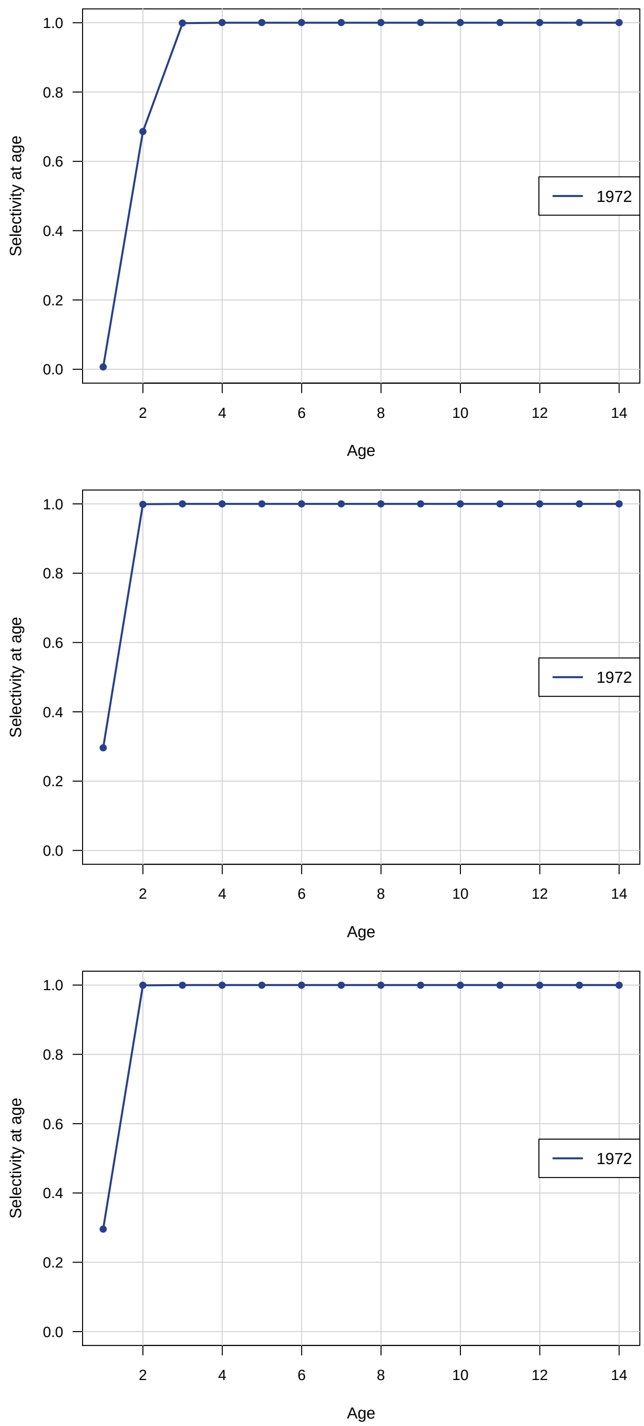


Figure 22. Average selectivity from the terminal assessment year weighted by geometric mean Fs from the last three assessment years, for landings (top), discards (middle), and total removals (bottom) . These selectivities are used in computation of benchmarks and central-tendency projections.

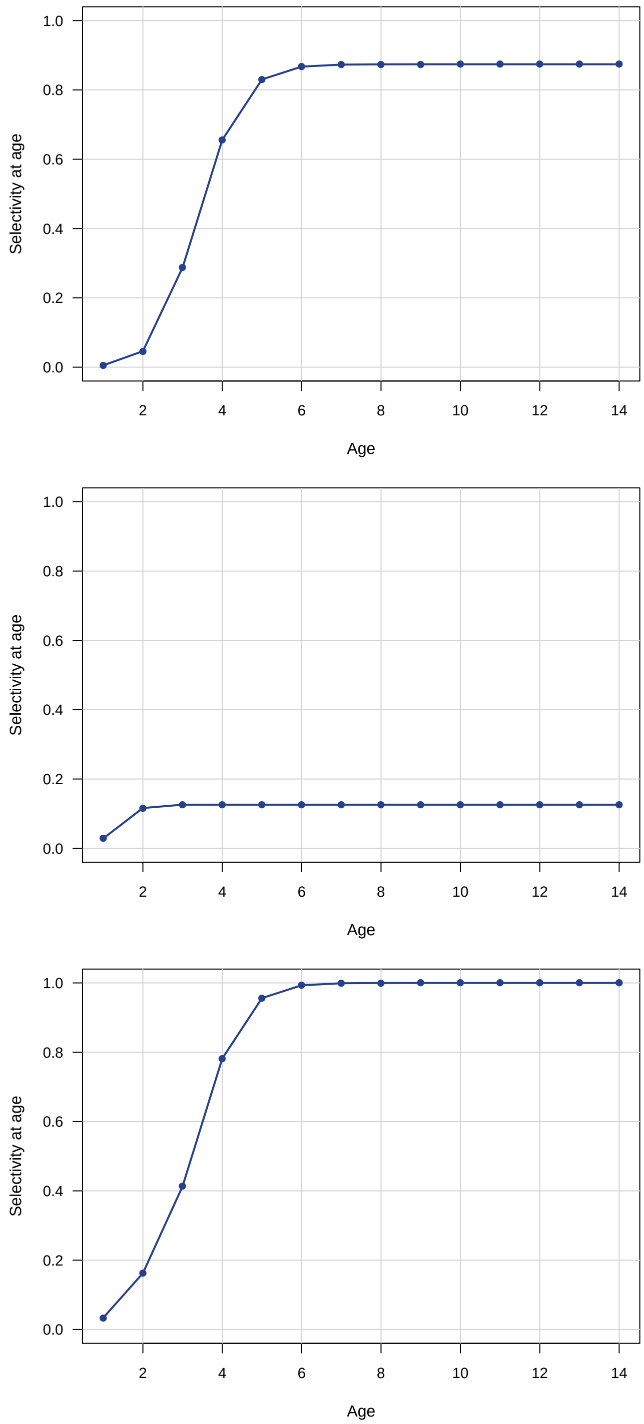


Figure 23. Estimated fully selected fishing mortality rate (per year) by fleet. rGe.D = recreational MRIP discards, rHb.D = recreational headboat discards, cHl.D = commercial handline discards, rGe = recreational MRIP landings, rHb = recreational headboat landings, cTw = commercial trawl landings, cHl = commercial handline landings.

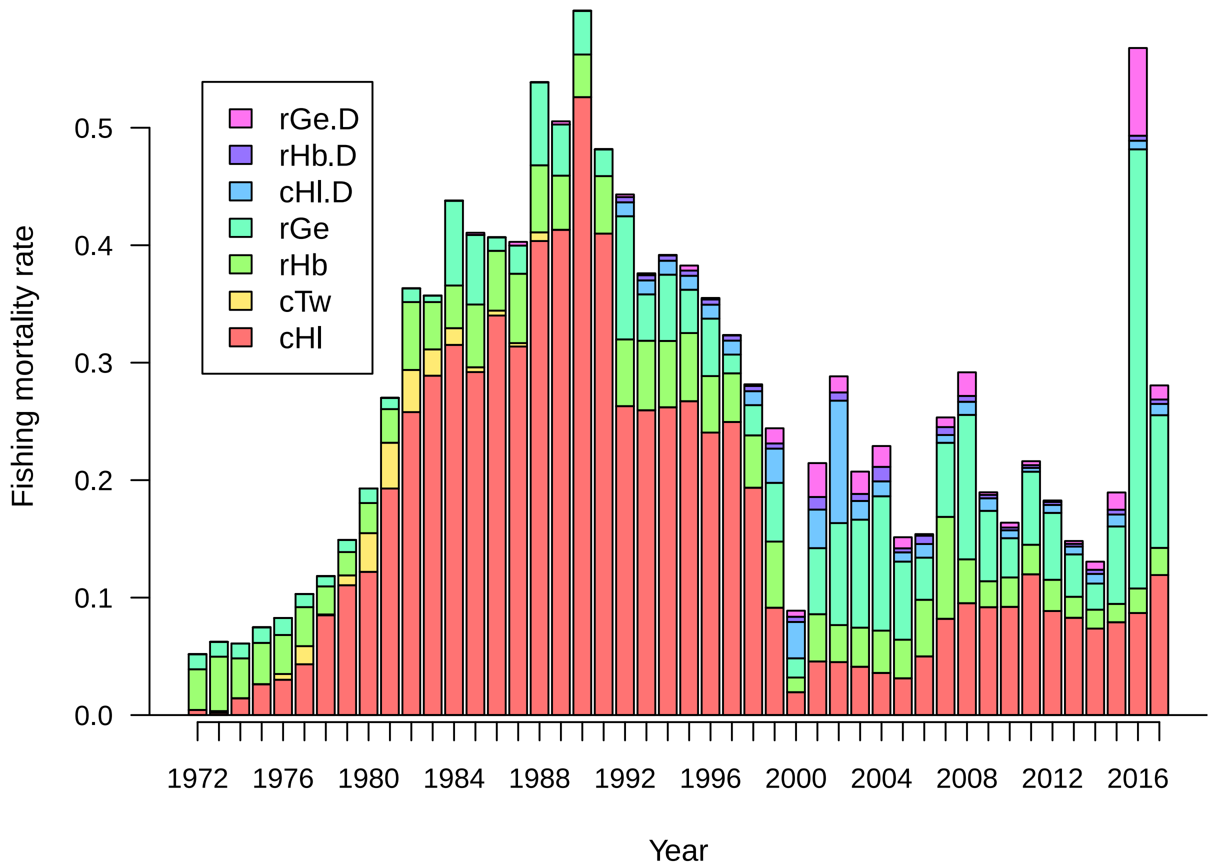


Figure 24. Estimated landings in absolute numbers (top) and proportion of total numbers (bottom) by fleet from the catch-at-age model. rGe = recreational MRIP landings, rHb = recreational headboat landings, cTw = commercial trawl landings, cHl = commercial handline landings.

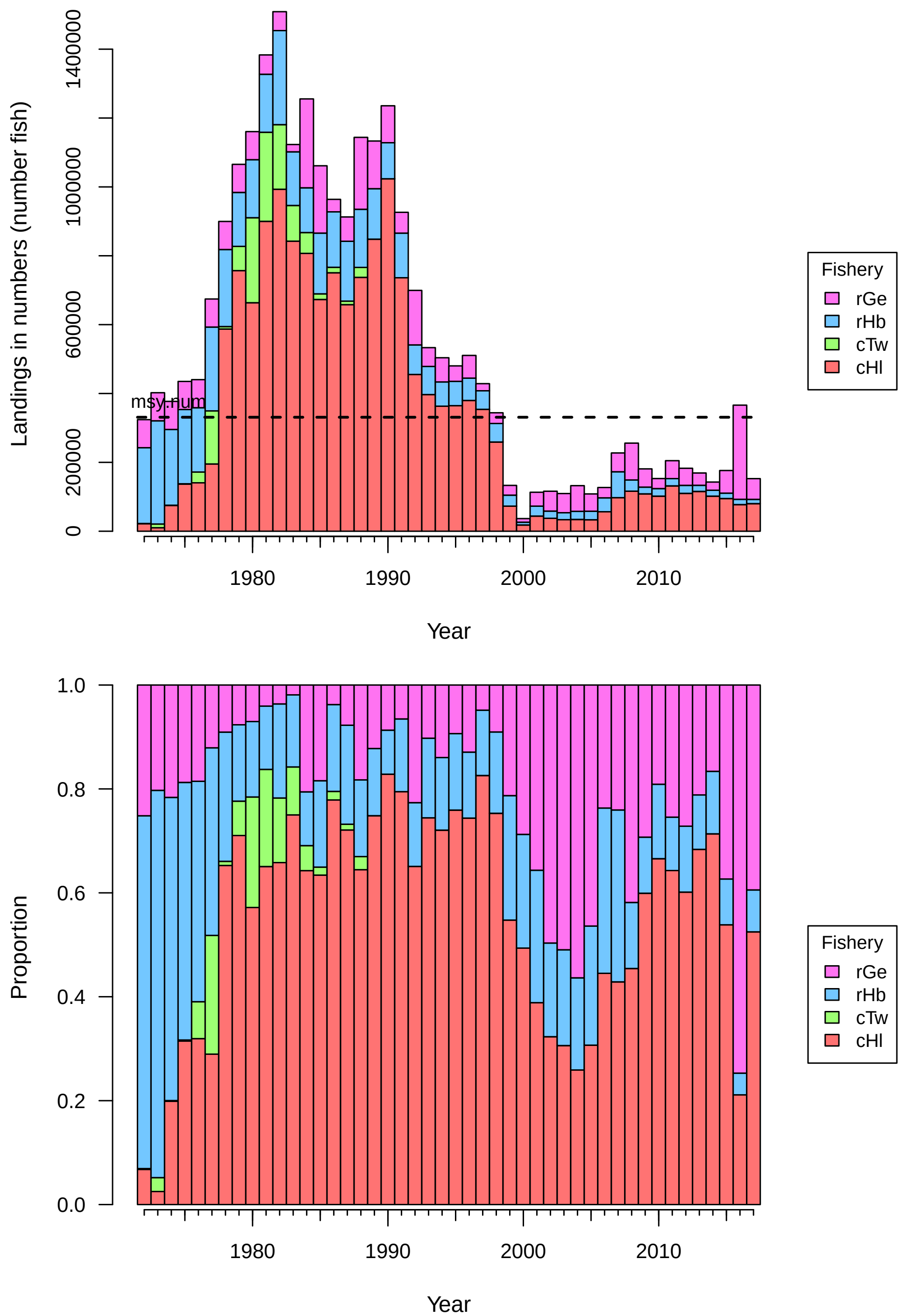


Figure 25. Estimated landings in absolute weight (top) and proportion of total weight (bottom) by fleet from the catch-at-age model. rGe = recreational MRIP landings, rHb = recreational headboat landings, cTw = commercial trawl landings, cHl = commercial handline landings.

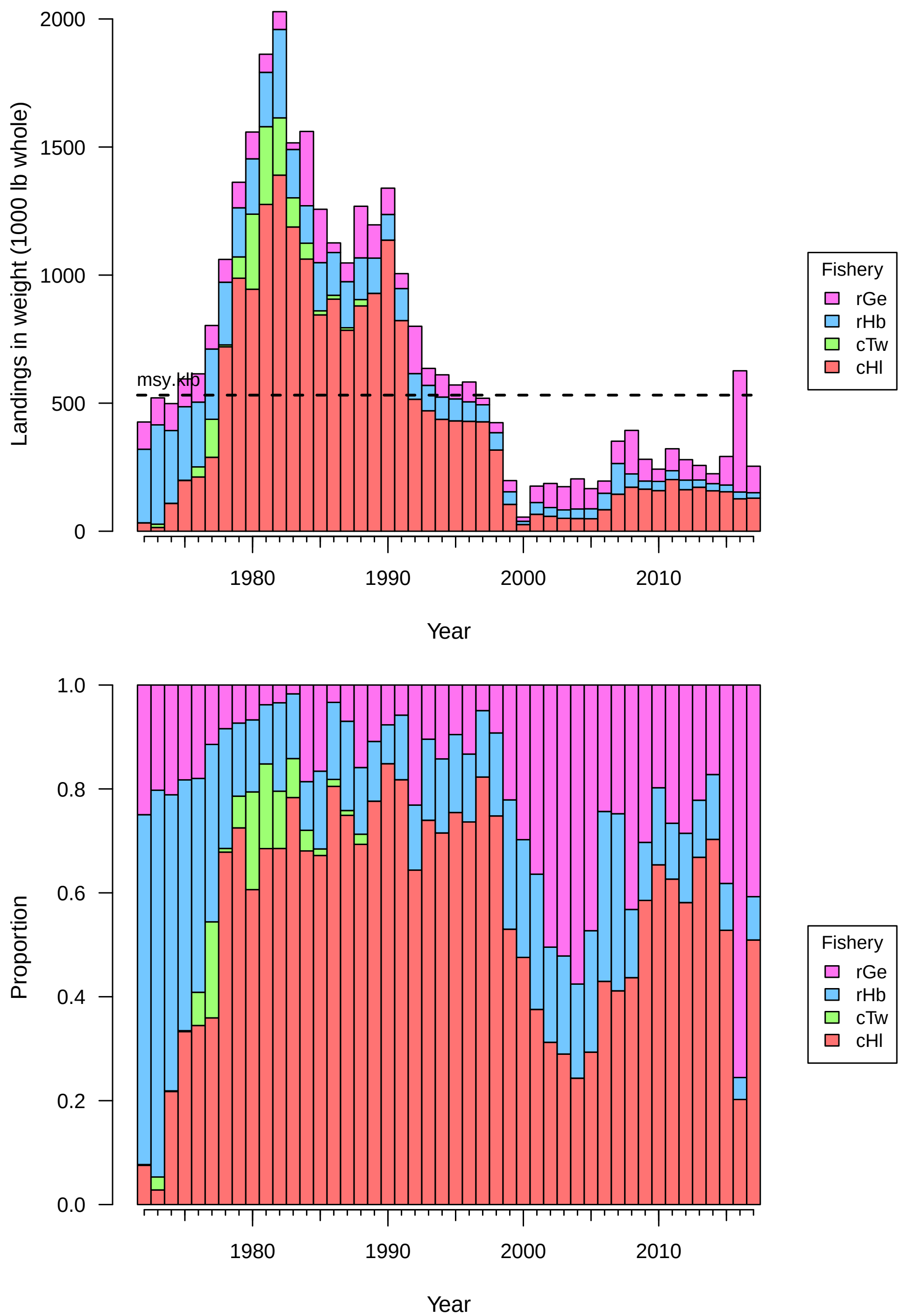
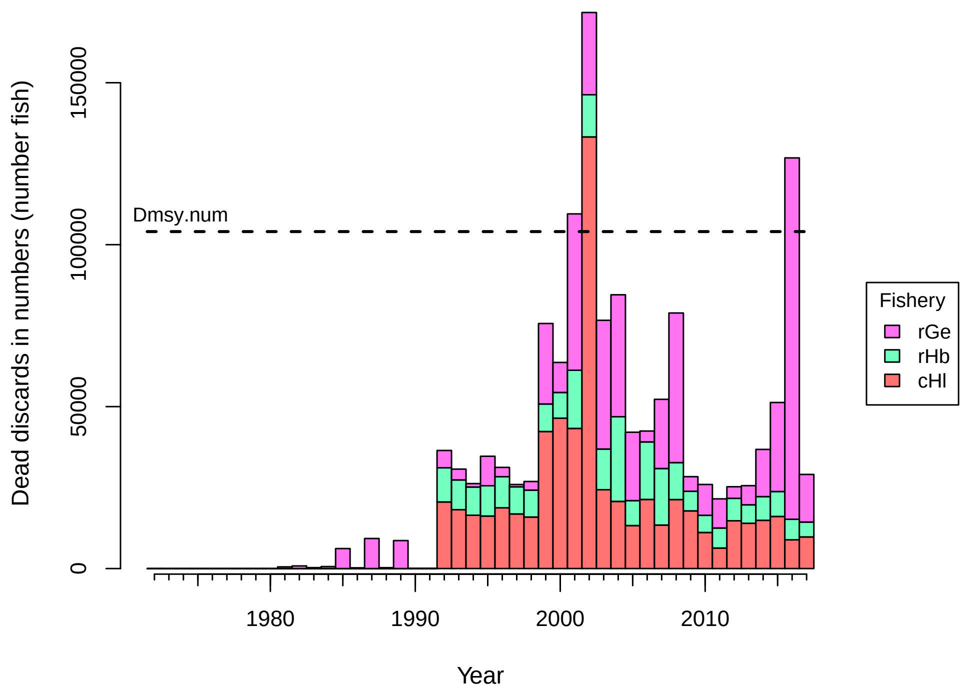


Figure 26. Estimated discards in absolute numbers (top) and proportion of total numbers (bottom) by fleet from the catch-at-age model. rGe = recreational MRIP discards, rHb = recreational headboat discards, cHl = commercial handline discards.



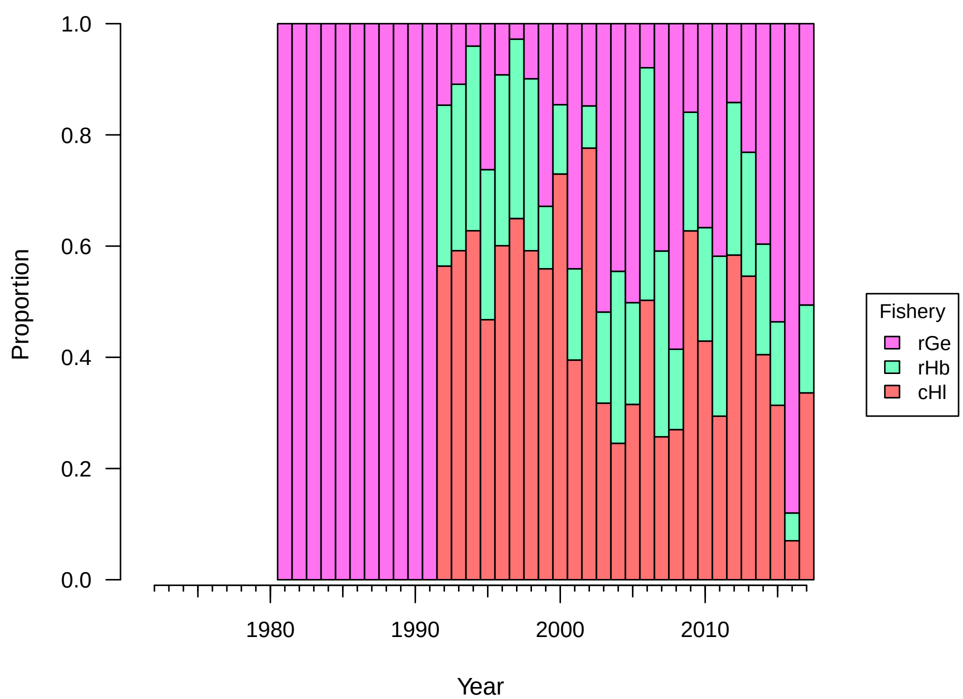


Figure 27. Estimated discards in absolute weight (top) and proportion of total weight (bottom) by fleet from the catch-at-age model. rGe = recreational MRIP discards, rHb = recreational headboat discards, cHl = commercial handline discards.

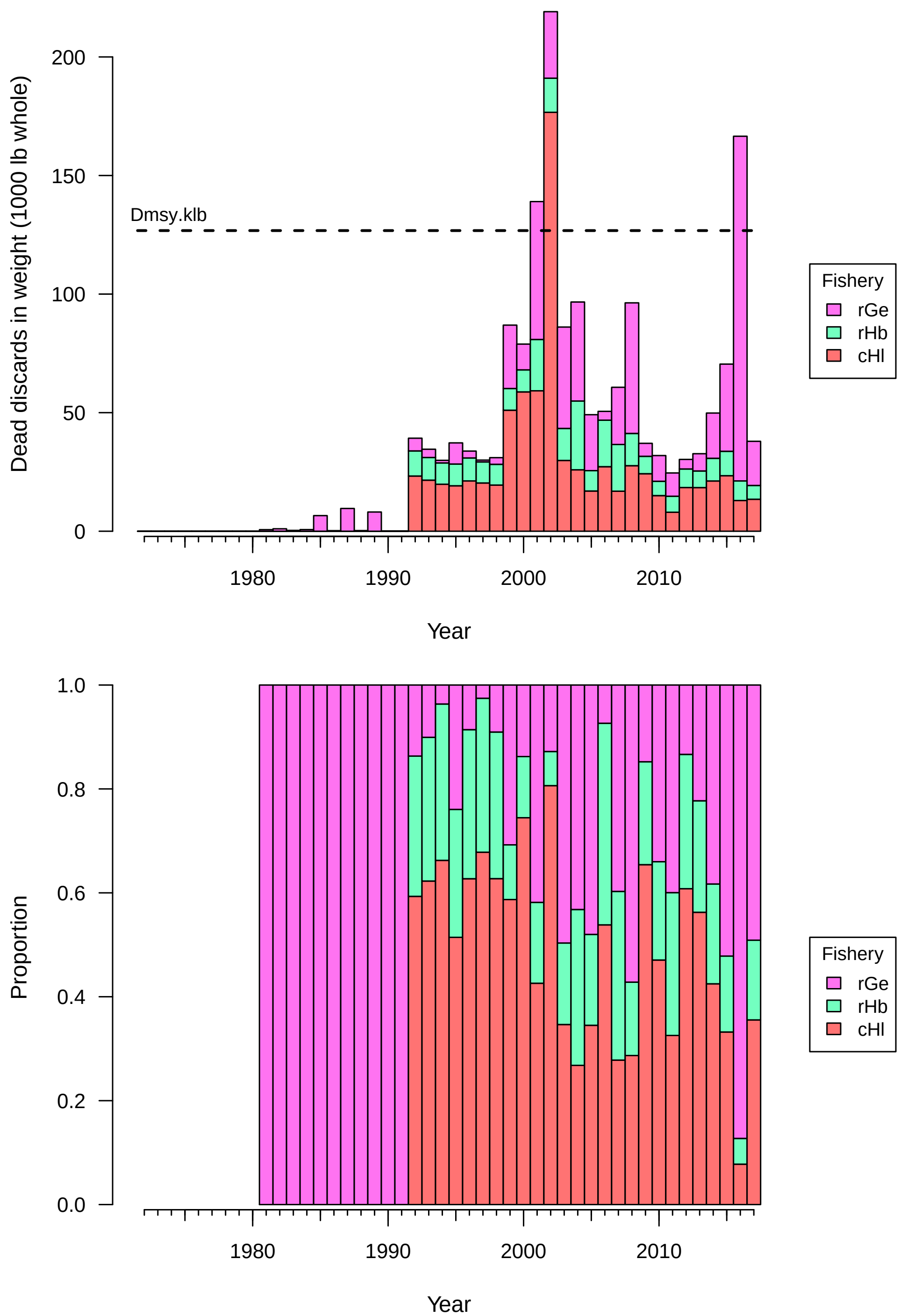


Figure 28. Beverton–Holt spawner-recruit curve (top) with and without lognormal bias correction. The expected (upper) curve was used for computing management benchmarks. Years within panel indicate year of recruitment generated from spawning biomass. Natural log of recruits (number of age-1 fish) per spawner is also plotted as function of the spawning stock (lower).

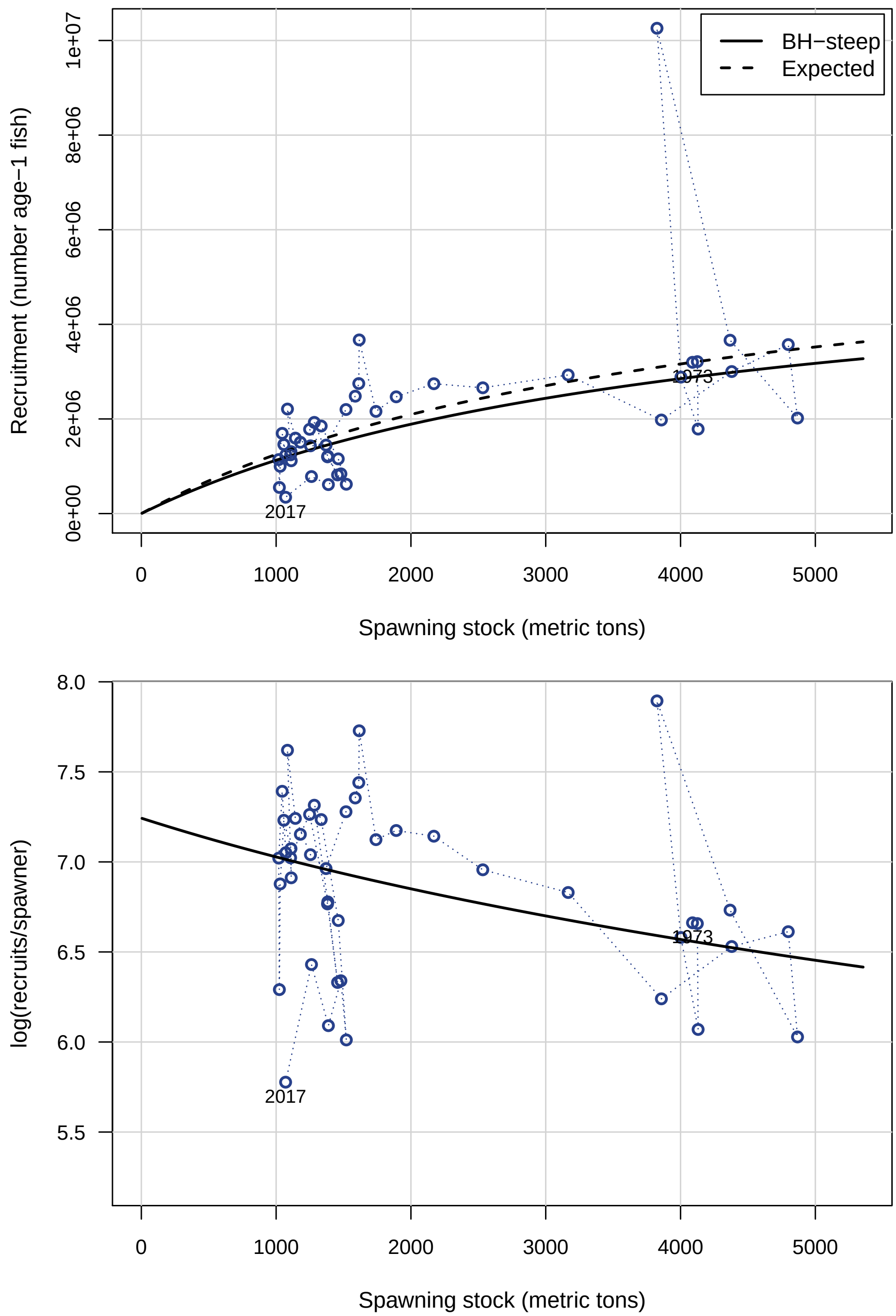


Figure 29. Probability densities of spawner-recruit quantities R0 (unfished recruitment of age-1 fish), steepness, unfished spawners per recruit, and standard deviation of recruitment residuals in log space. Solid vertical lines represent point estimates or values from the BAM base run; dashed vertical lines represent medians from the MCB runs (n = 3350).

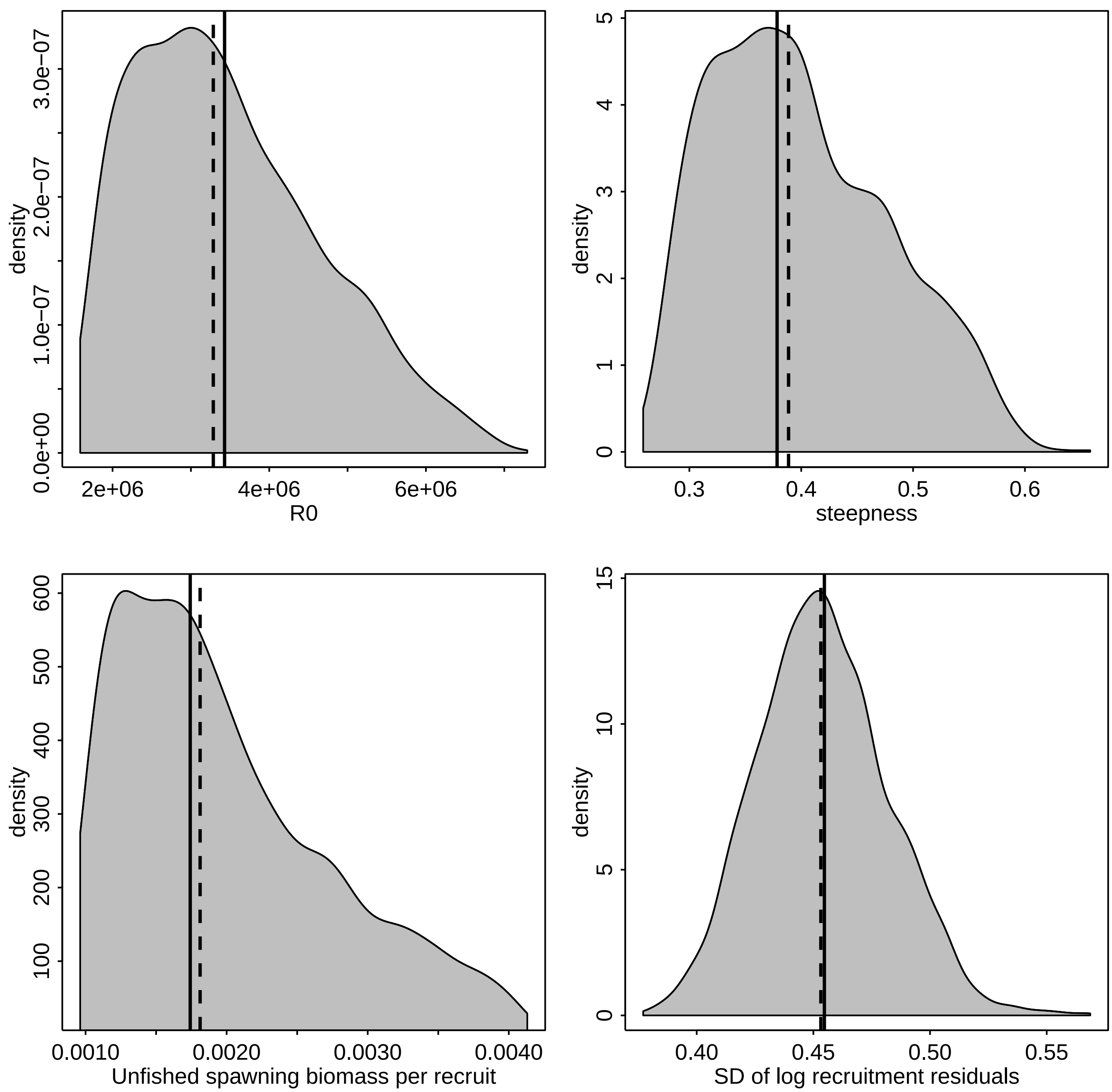


Figure 30. Yield per recruit (top) and spawning potential ratio (bottom; spawning biomass per recruit relative to that at the unfished level) over a range of F. Both curves are based on average selectivity from the end of the assessment period.

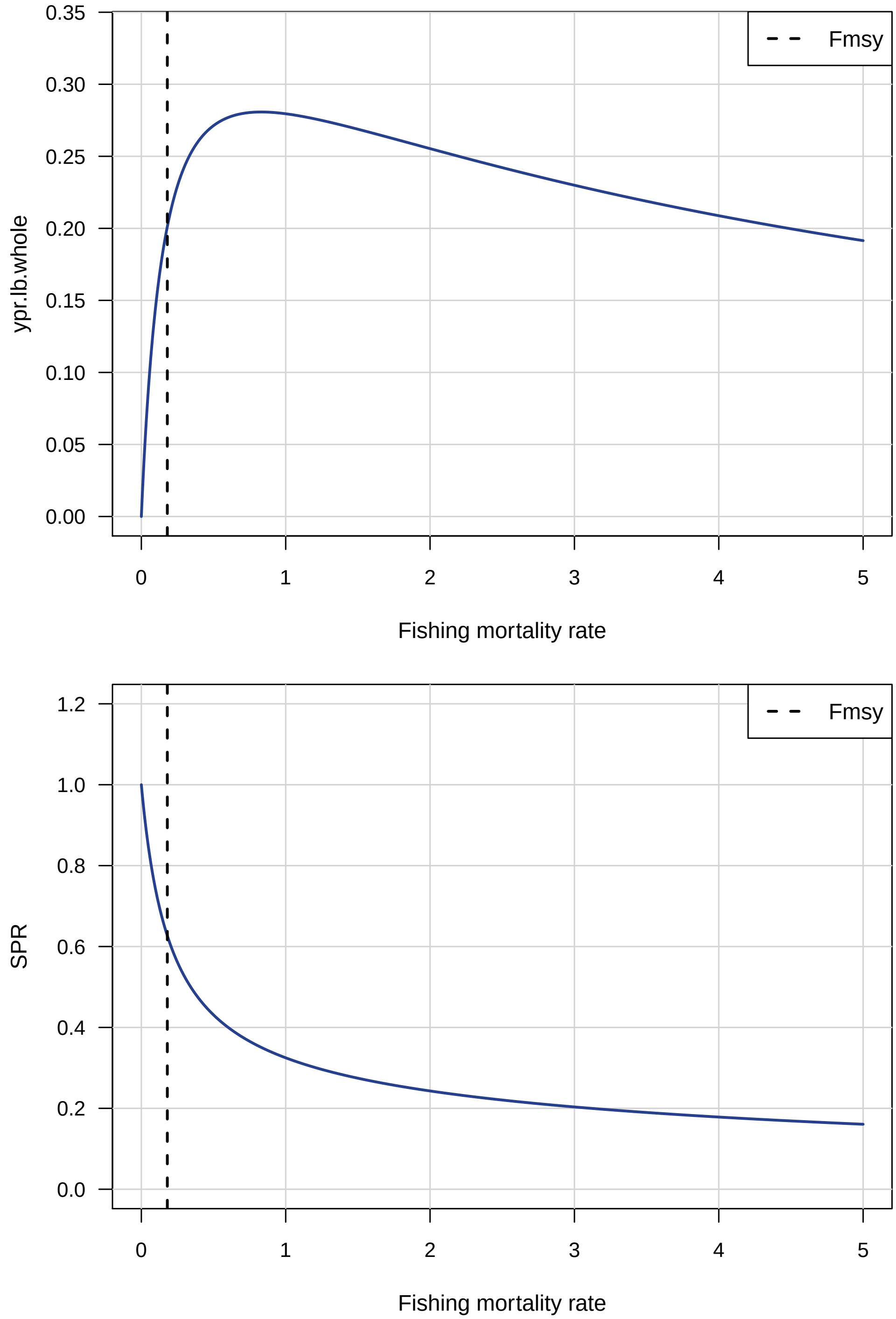


Figure 31. The top panels shows equilibrium landings at F. The peak occurs where fishing rate is $F_{\mathrm{MSY}} = 0.18$ *and equilibrium landings are* MSY = 531 *(1000 lb). The bottom panel shows equilibrium spawning biomass at F. Both curves are based on average selectivity from the end of the assessment period.*

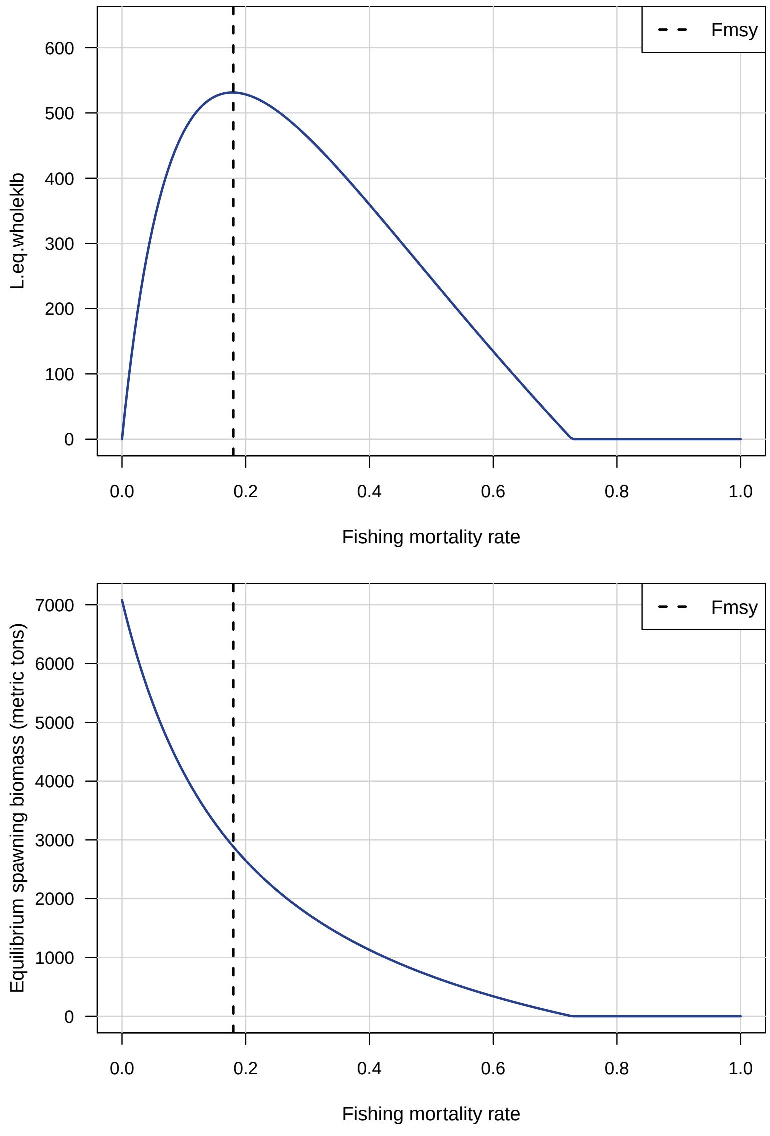


Figure 32. Probability densities of MSY*-related benchmarks from MCB analysis (n = 3350). Vertical lines represent point estimates from the BAM base run; dashed vertical lines represent medians from the MCB runs.*

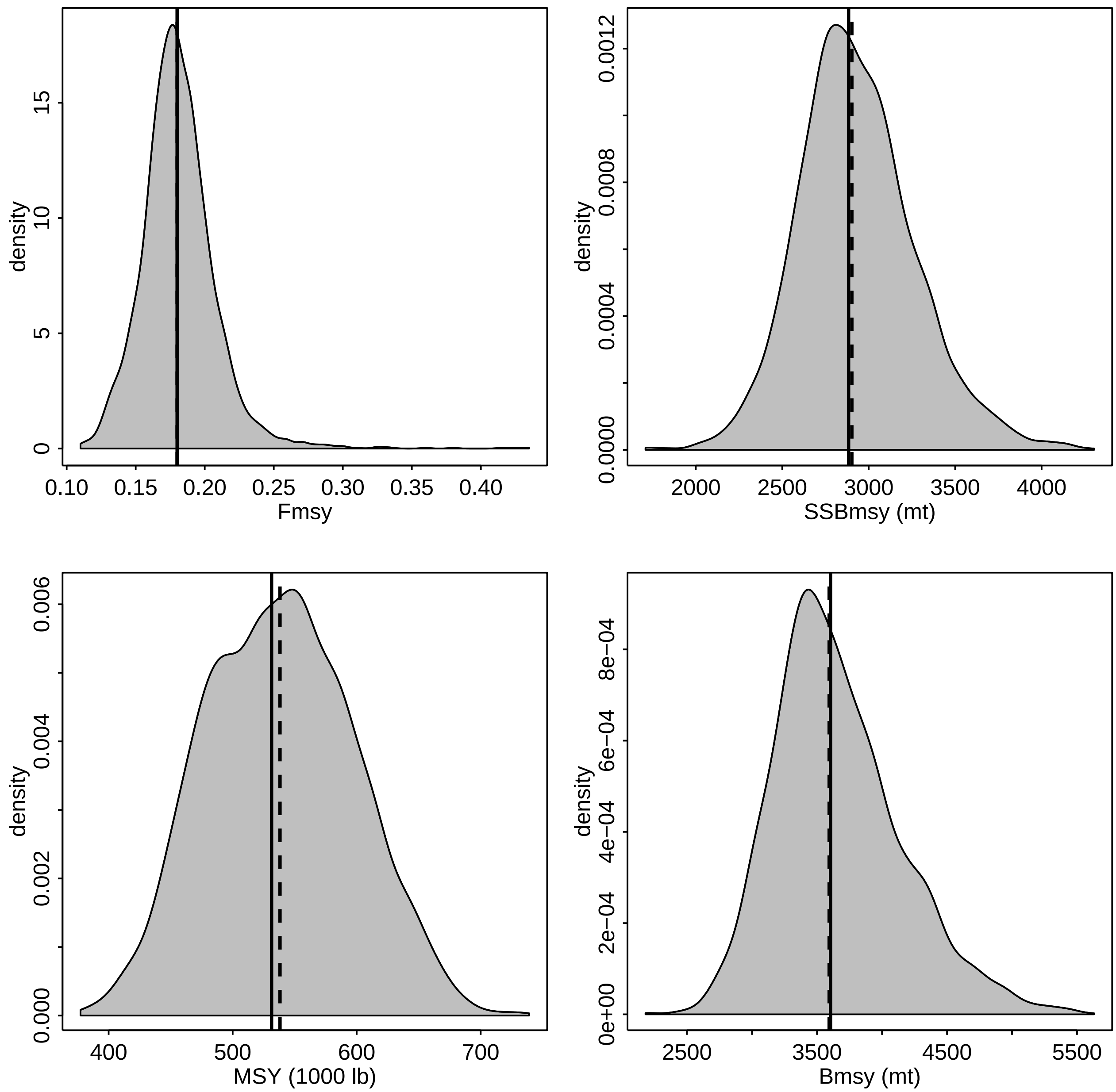


Figure 33. Estimated time series of SSB *and* F *relative to benchmarks: (top) spawning biomass relative to the minimum stock size threshold (*MSST*), (middle) spawning biomass relative to* $\mathrm{SSB}_{\mathrm{MSY}}$*, and (bottom)* F *relative to* F_{MSY}*. Shaded region represents 95% confidence bands from the MCB runs (*$n = 3350$*).*

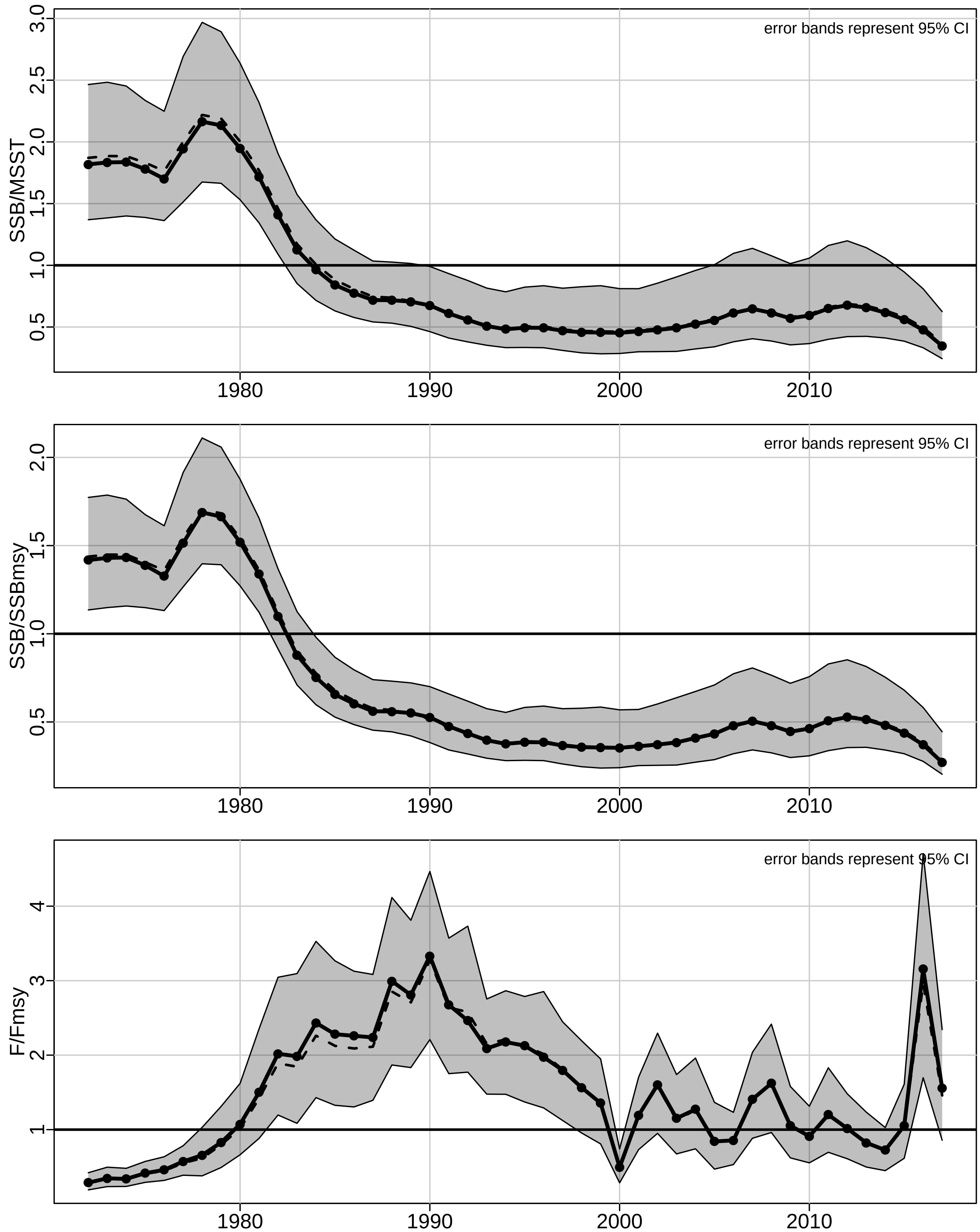


Figure 34. Probability densities of terminal status estimates from MCB analysis of the Beaufort Assessment Model ($n = 3350$). Vertical lines represent point estimates from the BAM base run; dashed vertical lines represent medians from the MCB runs.

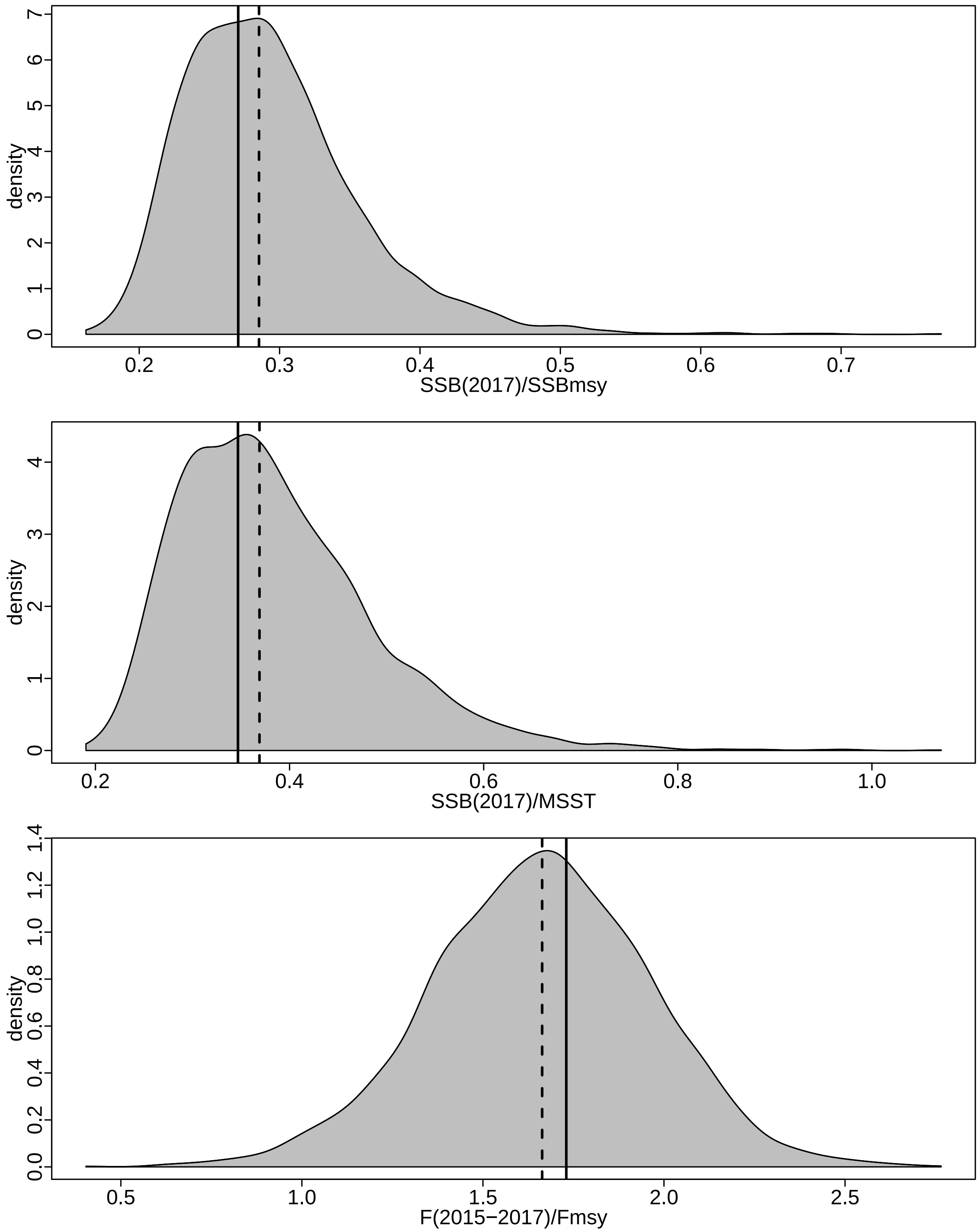


Figure 35. Phase plot of terminal status estimates from MCB analysis of the Beaufort Assessment Model ($n = 3350$). The intersection of crosshairs indicates estimates from the BAM base run; lengths of crosshairs defined by 5^{th} and 95^{th} percentiles of MCB runs.

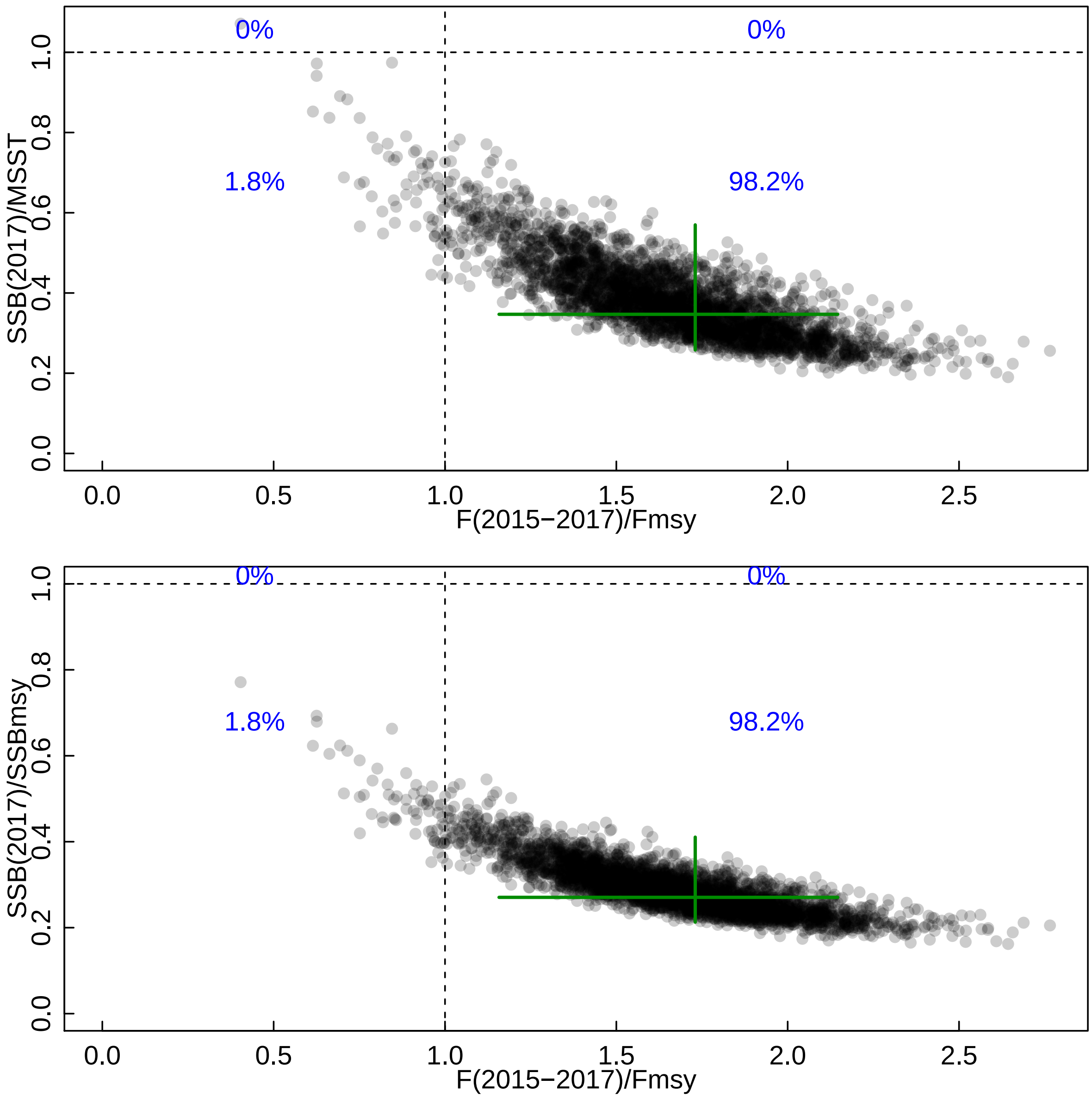


Figure 36. Age structure relative to the equilibrium expected at F_{MSY}.

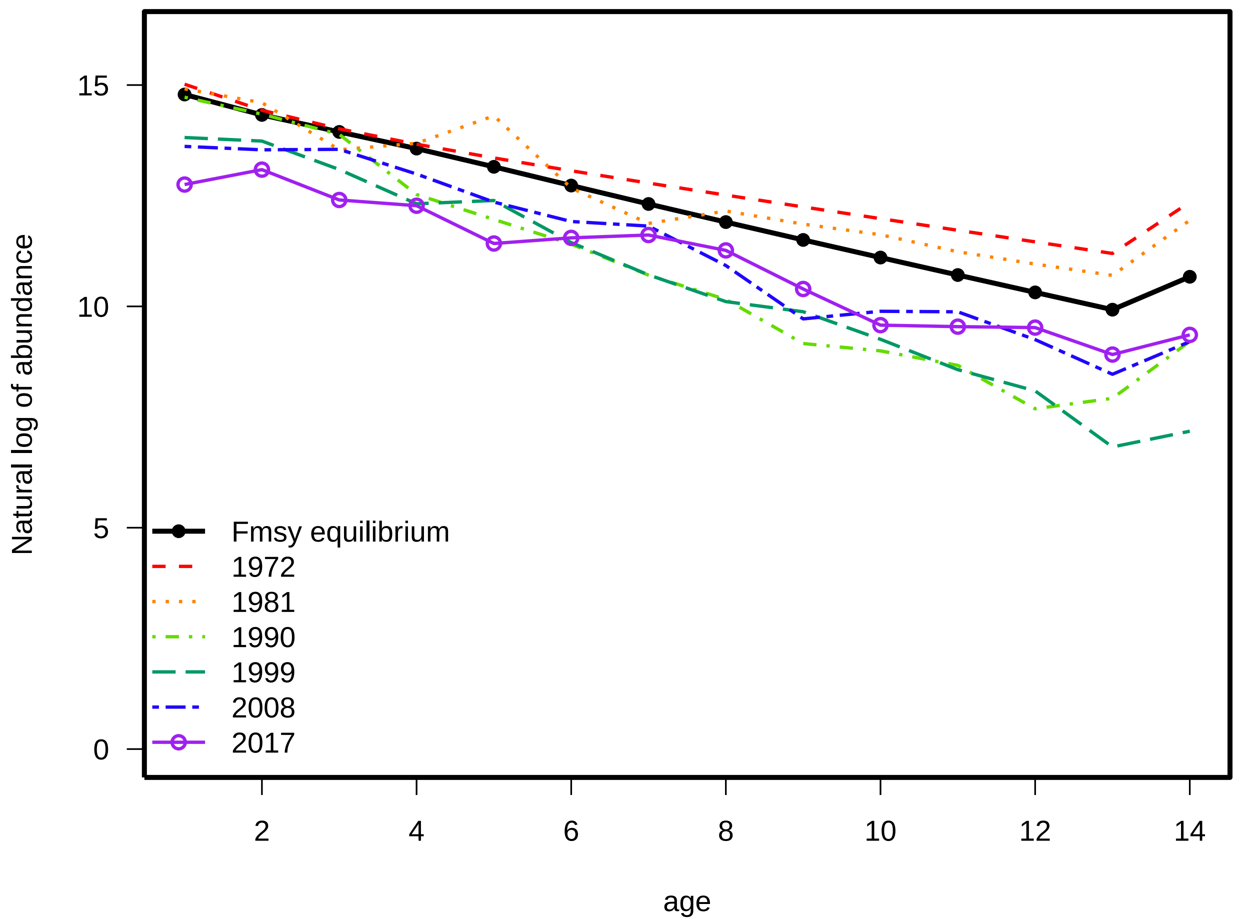


Figure 37. Sensitivity to low and high fixed values of natural mortality: sensitivity runs S1-S2. Estimated time series of F and SSB relative to benchmarks, as well as biomass (B) and number of recruits. Solid line and solid circles indicate estimates from the BAM base run. Sensitivity runs are indicated by colored broken lines, represented in the legend. (top left) F relative to F_{MSY}*. (top right) spawning stock biomass (*SSB*) relative to* MSST*. (bottom left) biomass (B). (bottom right) number of recruits.*

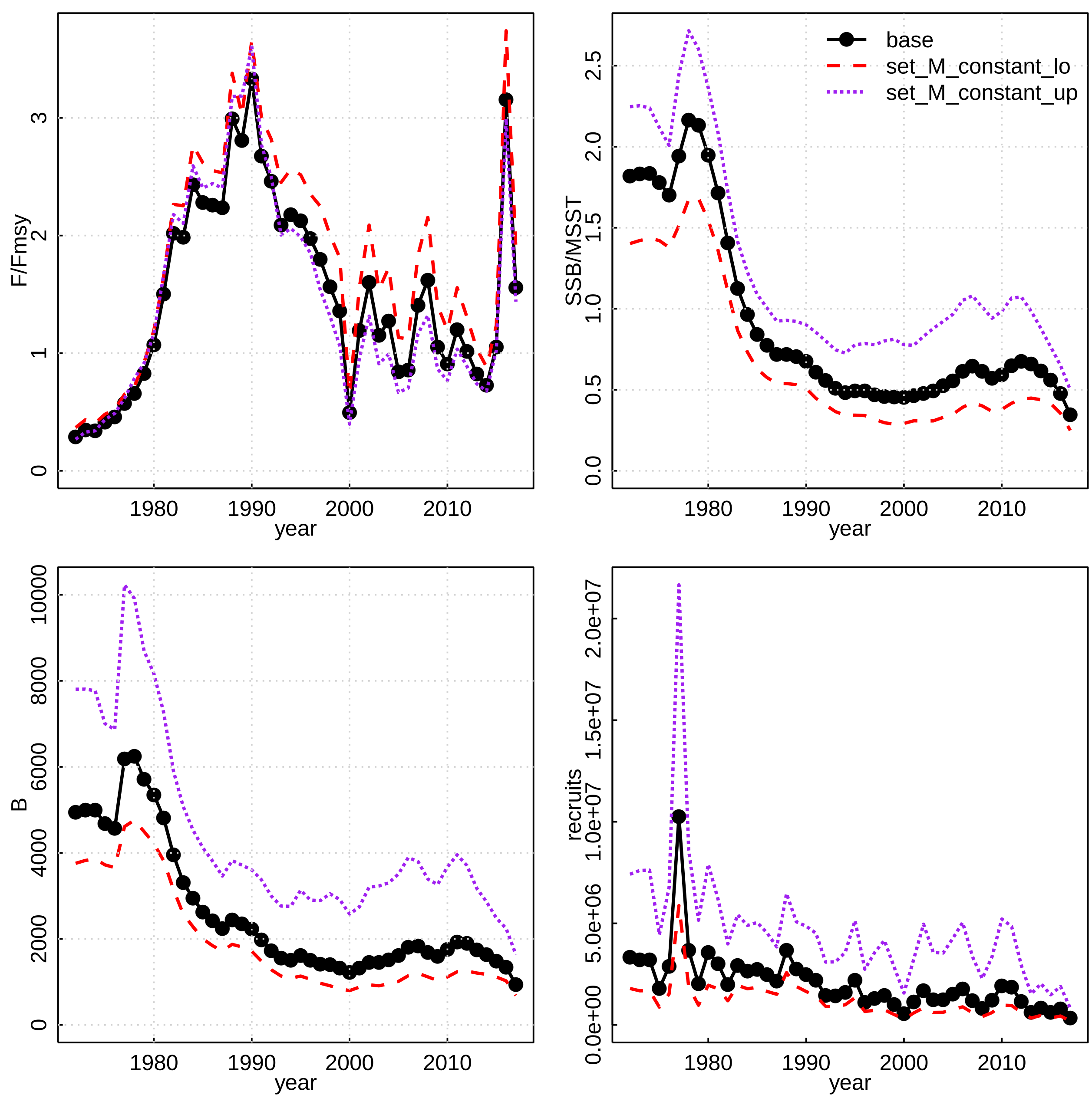


*Figure 38. Sensitivity to low and high fixed values of steepness: sensitivity runs S3-S4. Estimated time series of F and SSB relative to benchmarks, as well as biomass (B) and number of recruits. Solid line and solid circles indicate estimates from the BAM base run. Sensitivity runs are indicated by colored broken lines, represented in the legend. (top left) F relative to F_{MSY}. (top right) spawning stock biomass (*SSB*) relative to* MSST*. (bottom left) biomass (B). (bottom right) number of recruits.*

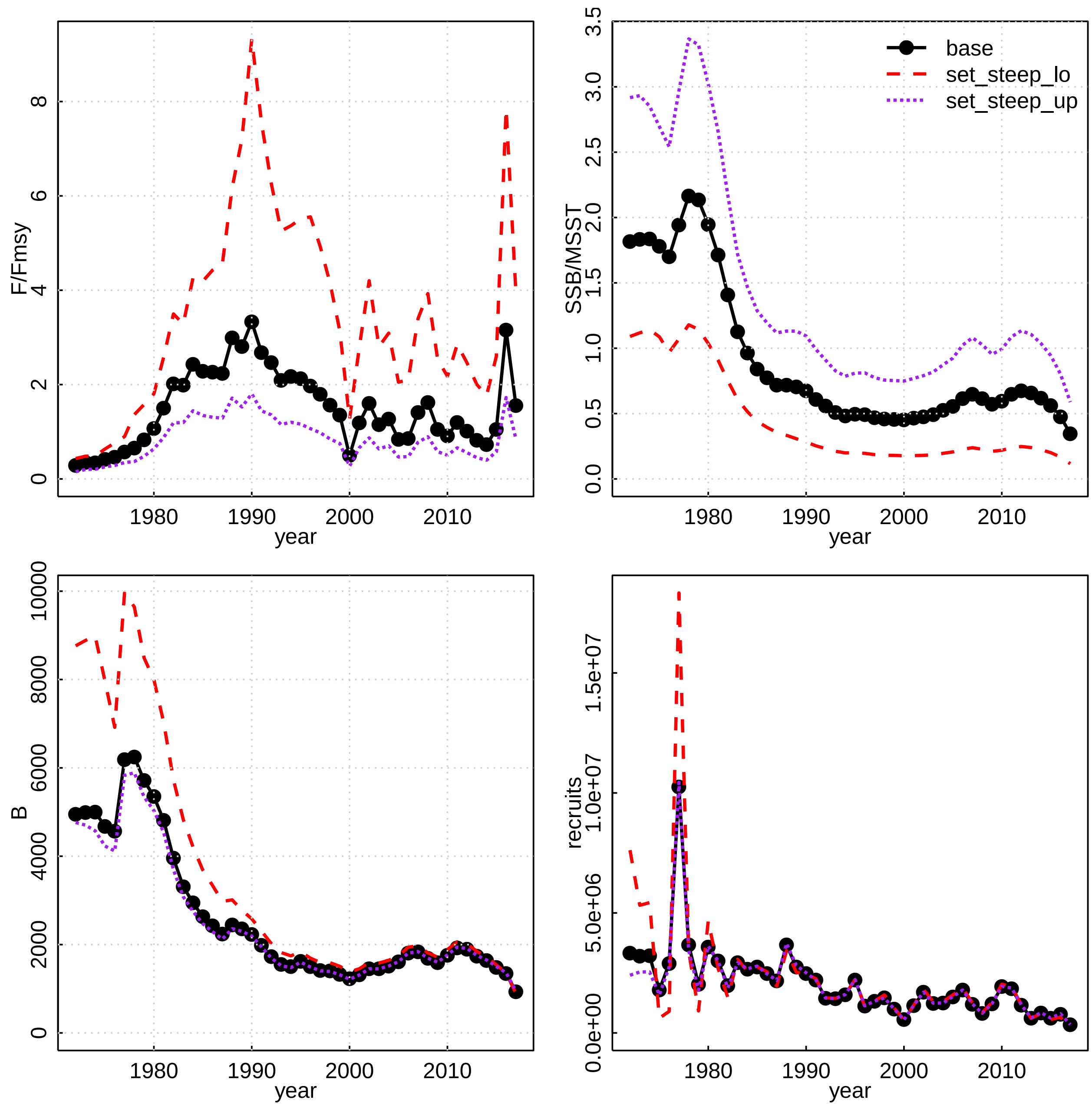


Figure 39. Sensitivity to a low value of R0 associated with the minimum likelihood of the age composition data likelihood component in likelihood profiling: sensitivity run S5. Estimated time series of F and SSB relative to benchmarks, as well as biomass (B) and number of recruits. Solid line and solid circles indicate estimates from the BAM base run. Sensitivity runs are indicated by colored broken lines, represented in the legend. (top left) F relative to F_{MSY}*. (top right) spawning stock biomass (*SSB*) relative to* MSST*. (bottom left) biomass (B). (bottom right) number of recruits.*

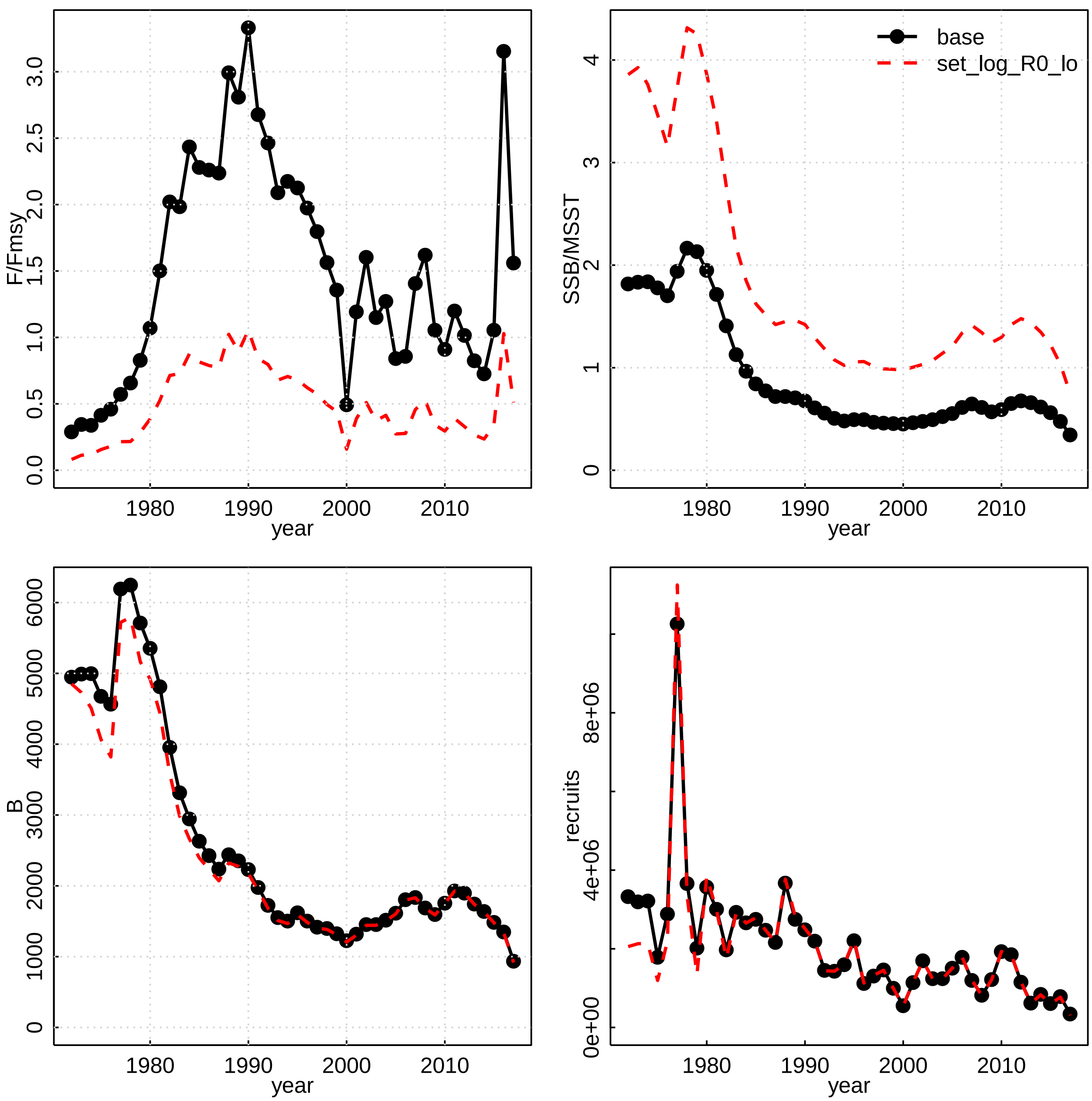


*Figure 40. Sensitivity to including the MARMAP Florida Snapper Trap Index and associated age composition data: sensitivity run S6. Estimated time series of F and SSB relative to benchmarks, as well as biomass (B) and number of recruits. Solid line and solid circles indicate estimates from the BAM base run. Sensitivity runs are indicated by colored broken lines, represented in the legend. (top left) F relative to F_{MSY}. (top right) spawning stock biomass (*SSB*) relative to* MSST*. (bottom left) biomass (B). (bottom right) number of recruits.*

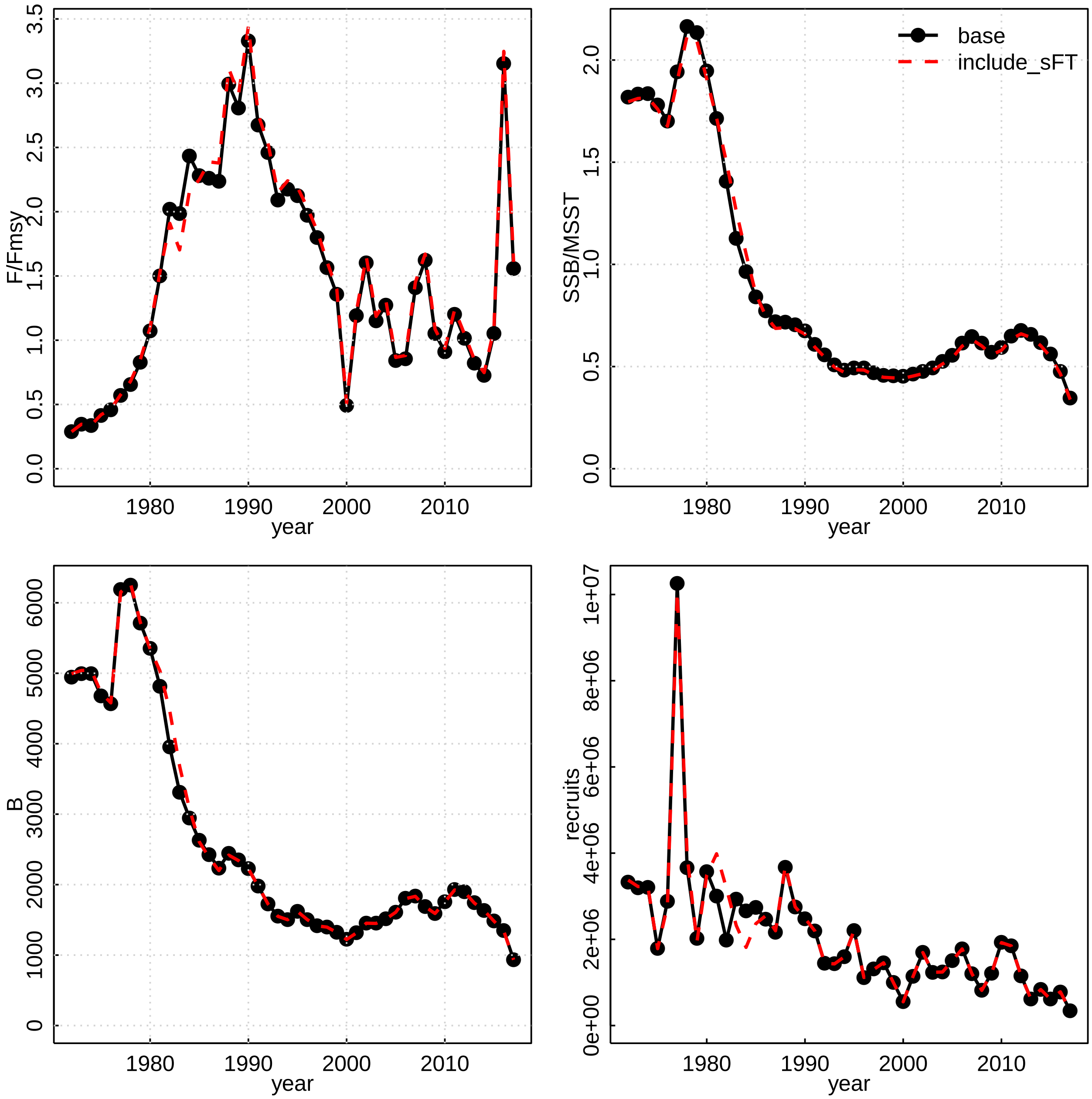


Figure 41. Sensitivity to including time-varying female maturity, similar to the previous assessment: sensitivity run S7. Estimated time series of F and SSB relative to benchmarks, as well as biomass (B) and number of recruits. Solid line and solid circles indicate estimates from the BAM base run. Sensitivity runs are indicated by colored broken lines, represented in the legend. (top left) F relative to F_{MSY}*. (top right) spawning stock biomass (*SSB*) relative to* MSST*. (bottom left) biomass (B). (bottom right) number of recruits.*

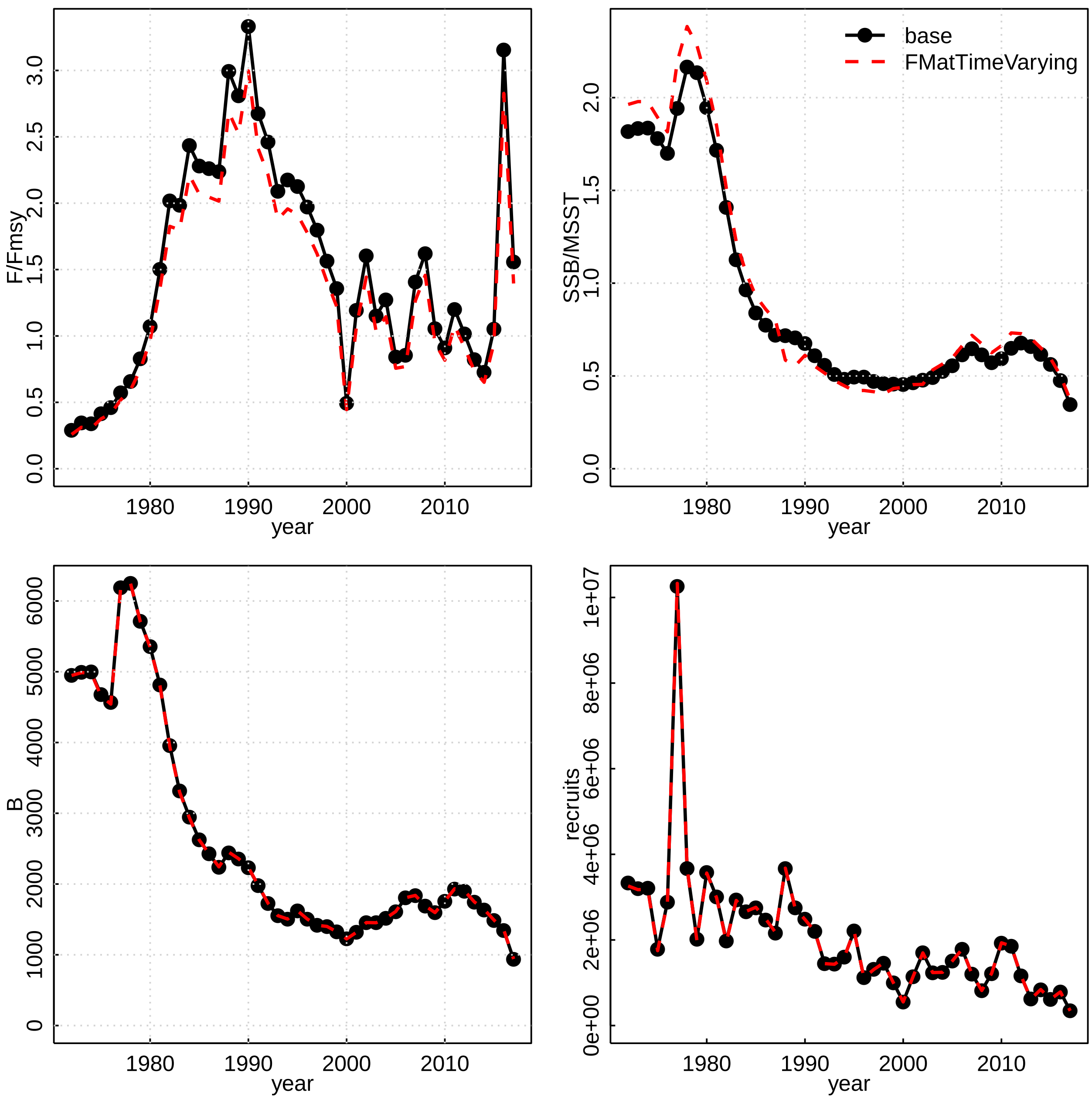


Figure 42. Sensitivity to upweighting the headboat index by a factor of 2 or 3: sensitivity runs S8-S9. Estimated time series of F and SSB relative to benchmarks, as well as biomass (B) and number of recruits. Solid line and solid circles indicate estimates from the BAM base run. Sensitivity runs are indicated by colored broken lines, represented in the legend. (top left) F relative to F_{MSY}. (top right) spawning stock biomass (SSB) relative to MSST. (bottom left) biomass (B). (bottom right) number of recruits.

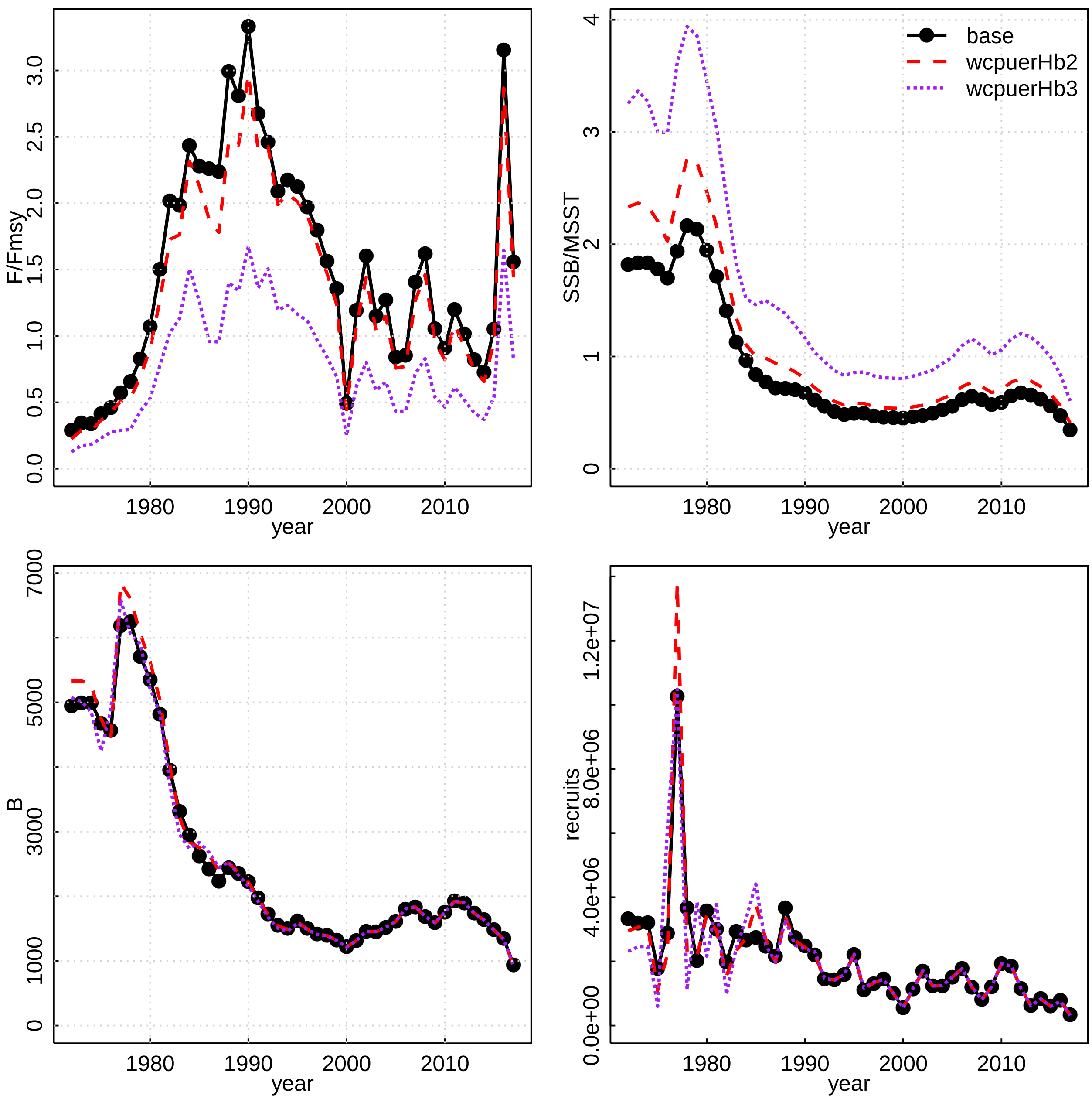


Figure 43. Sensitivity to 2016 MRIP landings and discards, investigated by replacing 2016 estimates with average values from 2015 and 2017: sensitivity run S10. Estimated time series of F and SSB relative to benchmarks, as well as biomass (B) and number of recruits. Solid line and solid circles indicate estimates from the BAM base run. Sensitivity runs are indicated by colored broken lines, represented in the legend. (top left) F relative to F_{MSY}. (top right) spawning stock biomass (SSB) relative to MSST. (bottom left) biomass (B). (bottom right) number of recruits.

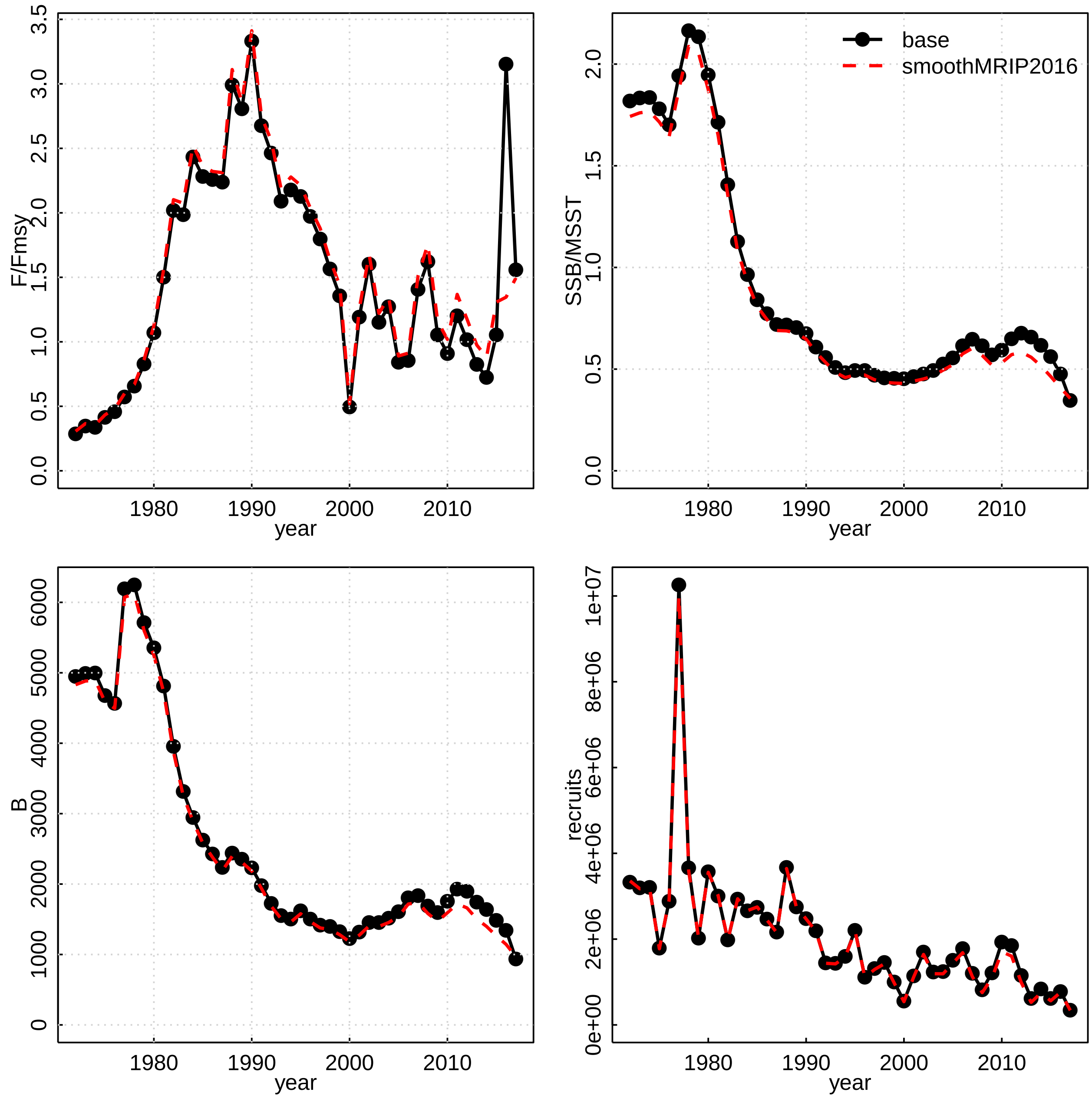


Figure 44. Phase plots of terminal status estimates from BAM sensitivity runs. Point colors and shapes are indicated in the legend. The number of each sensitivity run is also plotted in black text over each point. The base run is represented by a black point labeled "base".

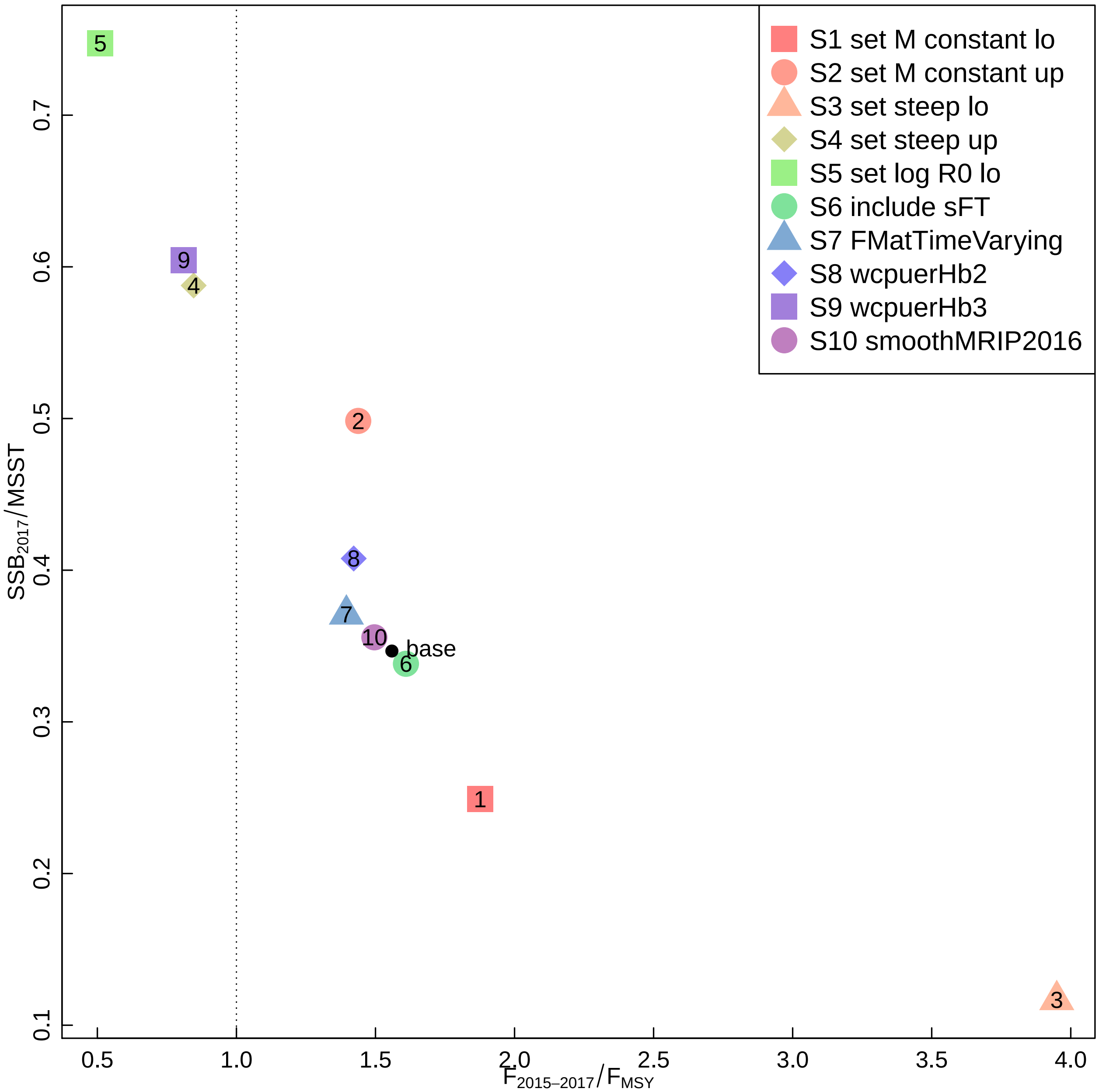


Figure 45. Retrospective analysis reducing the terminal year of the assessment from 2017 to values over a range from 2011 to 2016: . Estimated time series of F and SSB relative to benchmarks, as well as biomass (B) and number of recruits. Solid line and solid circles indicate estimates from the BAM base run. Retrospective runs are indicated by colored broken lines, represented in the legend. (top left) F relative to F_{MSY}*. (top right) spawning stock biomass (*SSB*) relative to* MSST*. (bottom left) biomass (B). (bottom right) number of recruits.*

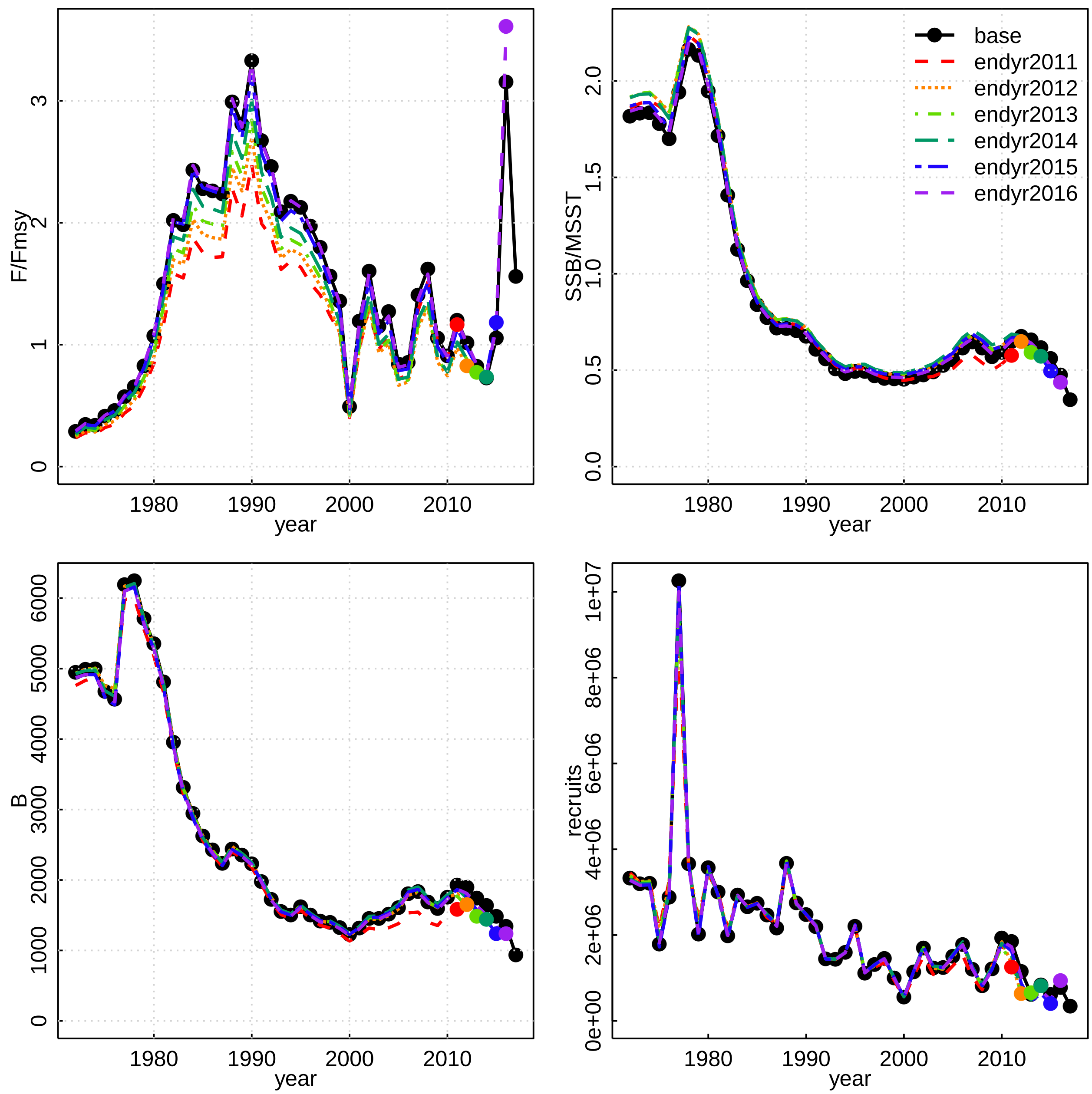


Figure 46. Plots of SSB*, landings, recruits, dead discards, F and the probability that* SSB > MSST *for projections with fishing mortality rate at fixed F that provides $P^* = 0.50$. In all panels except the bottom right, expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Solid horizontal blue lines mark* MSY*-related quantities; dashed horizontal green lines represent corresponding medians. 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 the replicate-specific* MSST*.*

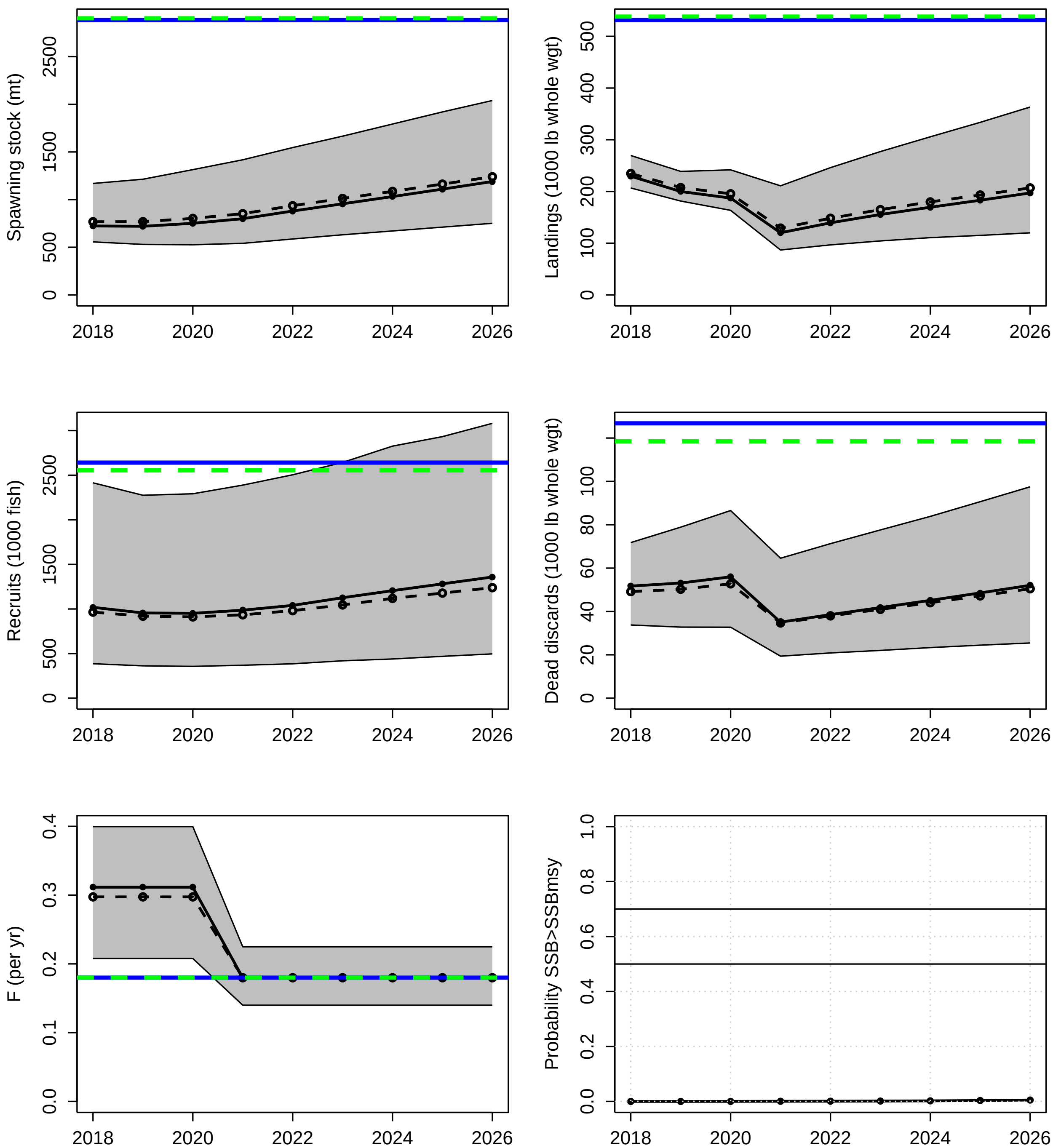


Figure 47. Plots of SSB*, landings, recruits, dead discards,* F *and the probability that* SSB > MSST *for projections with fishing mortality rate fixed at* $F = F_{\text{MSY}}$*. In all panels except the bottom right, expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to* 5^{th} *and* 95^{th} *percentiles of replicate projections. Solid horizontal blue lines mark* MSY*-related quantities; dashed horizontal green lines represent corresponding medians. 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 the replicate-specific* MSST.

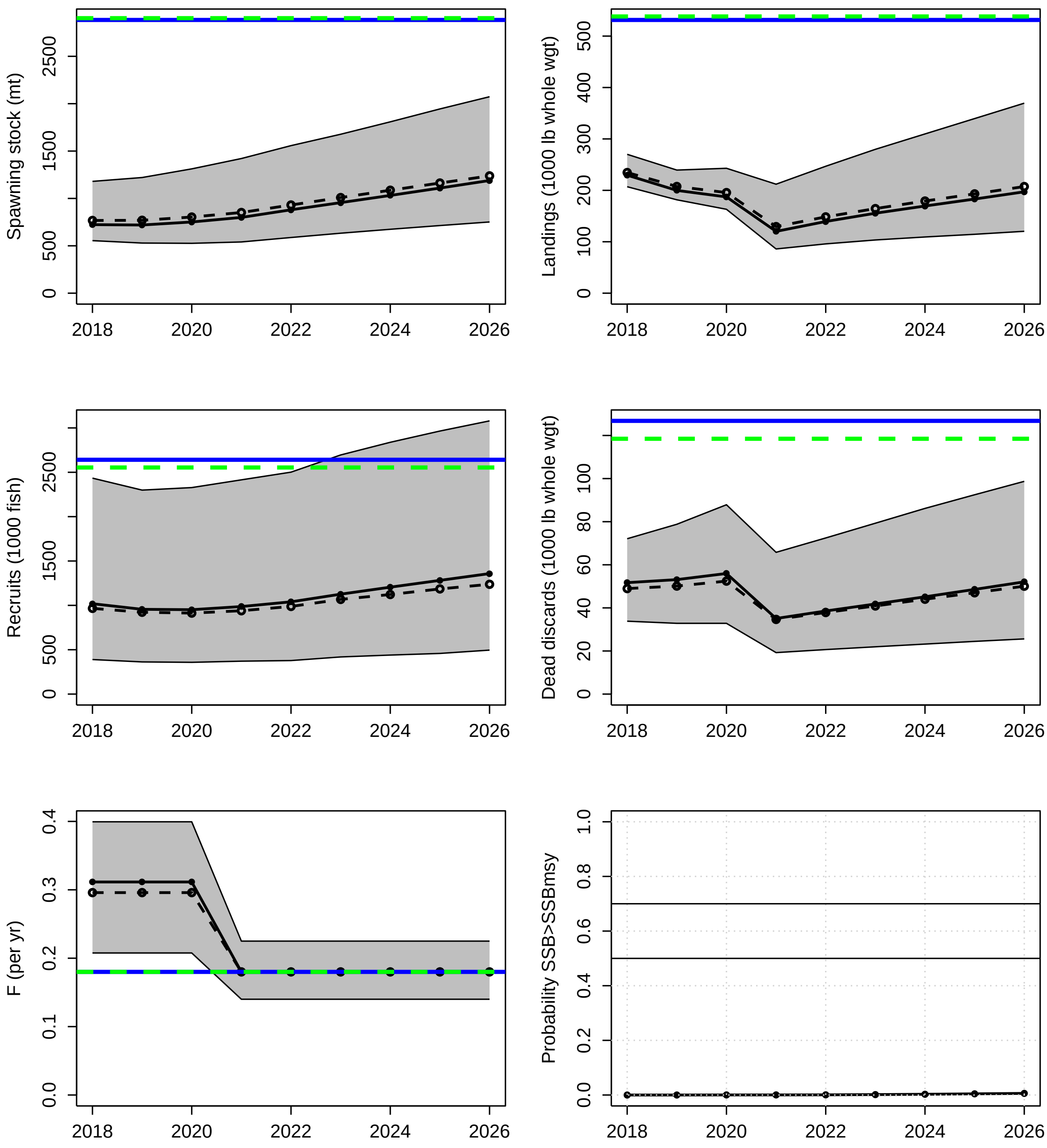


Figure 48. Plots of SSB*, landings, recruits, dead discards,* F *and the probability that* SSB > MSST *for projections with fishing mortality rate fixed at* $F = 75\%F_{\mathrm{MSY}}$*. In all panels except the bottom right, expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to* 5^{th} *and* 95^{th} *percentiles of replicate projections. Solid horizontal blue lines mark* MSY*-related quantities; dashed horizontal green lines represent corresponding medians. 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 the replicate-specific* MSST.

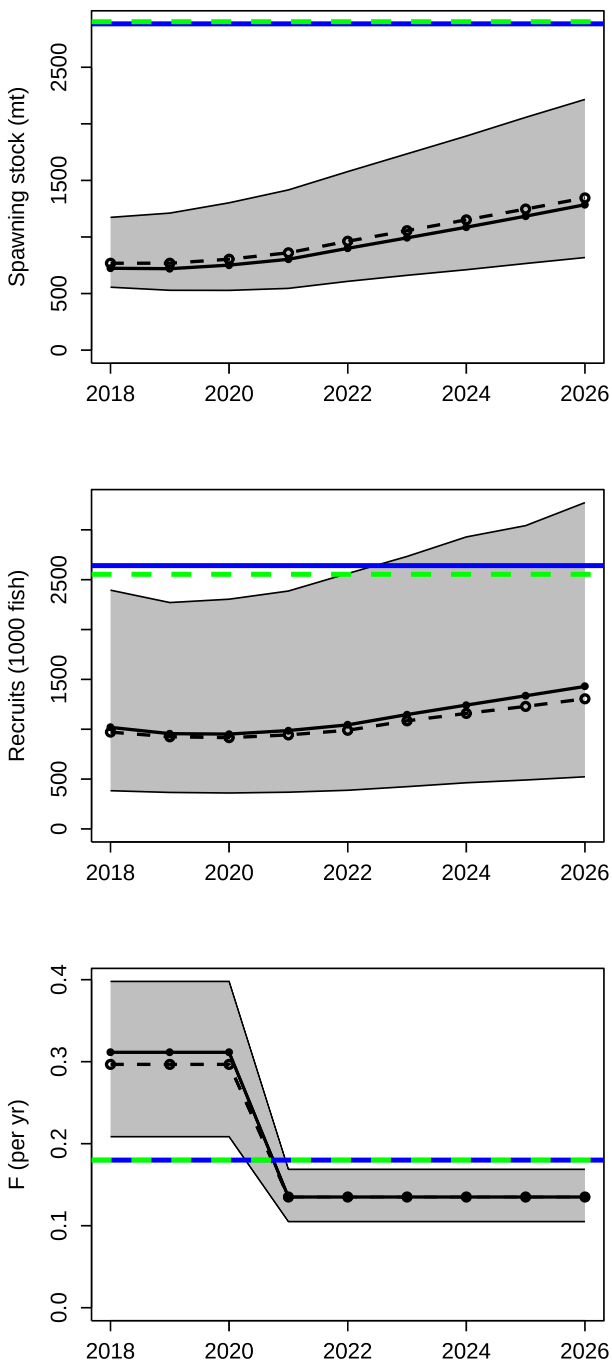
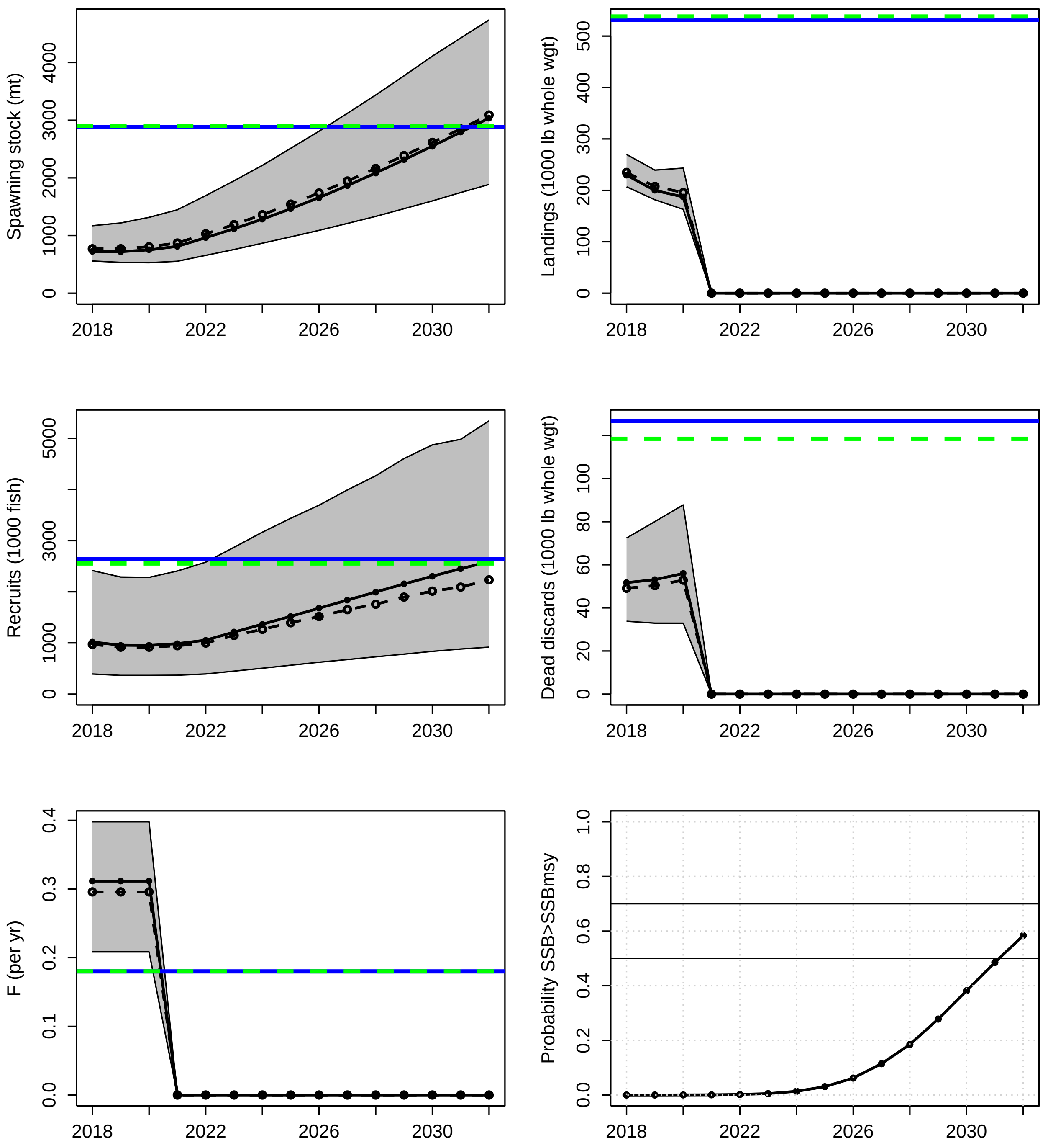


Figure 49. Plots of SSB*, landings, recruits, dead discards, F and the probability that* SSB > MSST *for projections with fishing mortality rate fixed at $F = 0$. In all panels except the bottom right, expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Solid horizontal blue lines mark* MSY*-related quantities; dashed horizontal green lines represent corresponding medians. 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 the replicate-specific* MSST.



Appendix A Abbreviations and Symbols

Table 35. Acronyms and abbreviations used in this report

Symbol	Meaning
ABC	Acceptable Biological Catch
AW	Assessment Workshop (here, for red porgy)
ASY	Average Sustainable Yield
B	Total biomass of stock, conventionally on January 1
BAM	Beaufort Assessment Model (a statistical catch-age formulation)
CPUE	Catch per unit effort; used after adjustment as an index of abundance
CV	Coefficient of variation
DW	Data Workshop (here, for red porgy)
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 red porgy as $(1 - M)\text{SSB}_{\text{MSY}} = 0.7\text{SSB}_{\text{MSY}}$.
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
SERFS	SouthEast Reef Fish 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
SSB_{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

Table 36. Names and estimated values of parameters estimated in the base run of the Beaufort Assessment Model.

ID	Parameter	Value
1	log.Nage.dev.age02	−0.1178400
2	log.Nage.dev.age03	−0.1281600
3	log.Nage.dev.age04	−0.1178800
4	log.Nage.dev.age05	−0.1018900
5	log.Nage.dev.age06	−0.0851260
6	log.Nage.dev.age07	−0.0695820
7	log.Nage.dev.age08	−0.0559360
8	log.Nage.dev.age09	−0.0444580
9	log.Nage.dev.age10	−0.0350730
10	log.Nage.dev.age11	−0.0275950
11	log.Nage.dev.age12	−0.0215640
12	log.Nage.dev.age13	−0.0167420
13	log.Nage.dev.age14	−0.0533490
14	log.R0	15.0480000
15	steep	0.3784400
16	rec.sigma	0.4547200
17	log.rec.dev.1975	−0.4838600
18	log.rec.dev.1976	0.0113270
19	log.rec.dev.1977	1.3032000
20	log.rec.dev.1978	0.2069300
21	log.rec.dev.1979	−0.4402700
22	log.rec.dev.1980	0.1365900
23	log.rec.dev.1981	0.0063075
24	log.rec.dev.1982	−0.3472300
25	log.rec.dev.1983	0.1530400
26	log.rec.dev.1984	0.1887700
27	log.rec.dev.1985	0.3195300
28	log.rec.dev.1986	0.3060000
29	log.rec.dev.1987	0.2302100
30	log.rec.dev.1988	0.8133900
31	log.rec.dev.1989	0.5251900
32	log.rec.dev.1990	0.4351100
33	log.rec.dev.1991	0.3468100
34	log.rec.dev.1992	0.0046042
35	log.rec.dev.1993	0.0607640
36	log.rec.dev.1994	0.2412300
37	log.rec.dev.1995	0.6085900
38	log.rec.dev.1996	−0.0943350
39	log.rec.dev.1997	0.0671870
40	log.rec.dev.1998	0.2144600

Table 36. (continued)

ID	Parameter	Value
41	log.rec.dev.1999	−0.1440900
42	log.rec.dev.2000	−0.7319700
43	log.rec.dev.2001	−0.0027692
44	log.rec.dev.2002	0.3732900
45	log.rec.dev.2003	0.0373090
46	log.rec.dev.2004	0.0159200
47	log.rec.dev.2005	0.1598300
48	log.rec.dev.2006	0.2830400
49	log.rec.dev.2007	−0.1894700
50	log.rec.dev.2008	−0.6122300
51	log.rec.dev.2009	−0.1780100
52	log.rec.dev.2010	0.3406900
53	log.rec.dev.2011	0.2702700
54	log.rec.dev.2012	−0.2676300
55	log.rec.dev.2013	−0.9199500
56	log.rec.dev.2014	−0.5984200
57	log.rec.dev.2015	−0.8643600
58	log.rec.dev.2016	−0.5478900
59	log.rec.dev.2017	−1.2371000
60	log.dm.lenc.cTw	3.0350000
61	log.dm.agec.cHl	4.3894000
62	log.dm.agec.rHb	3.0351000
63	log.dm.agec.sCT	1.7548000
64	A50.sel.cHl2	1.8675000
65	slope.sel.cHl2	5.8927000
66	A50.sel.cHl3	2.9444000
67	slope.sel.cHl3	2.5971000
68	A50.sel.cTw	0.8780300
69	slope.sel.cTw	4.1436000
70	A50.sel.rHb1	1.1089000
71	slope.sel.rHb1	7.9389000
72	A50.sel.rHb2	2.0408000
73	slope.sel.rHb2	3.5149000
74	A50.sel.rHb3	3.6992000
75	slope.sel.rHb3	1.9141000
76	A50.sel.sCT	2.3405000
77	slope.sel.sCT	1.3823000
78	log.q.cpue.rHb	−15.1340000
79	log.q.cpue.sCT	−14.1490000
80	log.avg.F.L.cHl	−2.3228000

Table 36. (continued)

ID	Parameter	Value
81	log.F.dev.L.cHl.1972	−3.1281000
82	log.F.dev.L.cHl.1973	−3.9212000
83	log.F.dev.L.cHl.1974	−1.9232000
84	log.F.dev.L.cHl.1975	−1.3176000
85	log.F.dev.L.cHl.1976	−1.1810000
86	log.F.dev.L.cHl.1977	−0.8172300
87	log.F.dev.L.cHl.1978	−0.1423500
88	log.F.dev.L.cHl.1979	0.1204800
89	log.F.dev.L.cHl.1980	0.2185500
90	log.F.dev.L.cHl.1981	0.6771300
91	log.F.dev.L.cHl.1982	0.9677800
92	log.F.dev.L.cHl.1983	1.0812000
93	log.F.dev.L.cHl.1984	1.1681000
94	log.F.dev.L.cHl.1985	1.0919000
95	log.F.dev.L.cHl.1986	1.2444000
96	log.F.dev.L.cHl.1987	1.1637000
97	log.F.dev.L.cHl.1988	1.4154000
98	log.F.dev.L.cHl.1989	1.4389000
99	log.F.dev.L.cHl.1990	1.6805000
100	log.F.dev.L.cHl.1991	1.4310000
101	log.F.dev.L.cHl.1992	0.9873300
102	log.F.dev.L.cHl.1993	0.9739500
103	log.F.dev.L.cHl.1994	0.9837200
104	log.F.dev.L.cHl.1995	1.0032000
105	log.F.dev.L.cHl.1996	0.8978500
106	log.F.dev.L.cHl.1997	0.9345900
107	log.F.dev.L.cHl.1998	0.6808000
108	log.F.dev.L.cHl.1999	−0.0695520
109	log.F.dev.L.cHl.2000	−1.6131000
110	log.F.dev.L.cHl.2001	−0.7631700
111	log.F.dev.L.cHl.2002	−0.7757000
112	log.F.dev.L.cHl.2003	−0.8673600
113	log.F.dev.L.cHl.2004	−1.0043000
114	log.F.dev.L.cHl.2005	−1.1397000
115	log.F.dev.L.cHl.2006	−0.6729900
116	log.F.dev.L.cHl.2007	−0.1782200
117	log.F.dev.L.cHl.2008	−0.0281710
118	log.F.dev.L.cHl.2009	−0.0645230
119	log.F.dev.L.cHl.2010	−0.0615060
120	log.F.dev.L.cHl.2011	0.2016100

Table 36. (continued)

ID	Parameter	Value
121	log.F.dev.L.cHl.2012	−0.1008900
122	log.F.dev.L.cHl.2013	−0.1679200
123	log.F.dev.L.cHl.2014	−0.2856400
124	log.F.dev.L.cHl.2015	−0.2143400
125	log.F.dev.L.cHl.2016	−0.1203500
126	log.F.dev.L.cHl.2017	0.1960400
127	log.avg.F.L.cTw	−5.6266000
128	log.F.dev.L.cTw.1972	−3.8410000
129	log.F.dev.L.cTw.1973	−0.8929900
130	log.F.dev.L.cTw.1974	−3.8491000
131	log.F.dev.L.cTw.1975	−3.2645000
132	log.F.dev.L.cTw.1976	0.3096500
133	log.F.dev.L.cTw.1977	1.4549000
134	log.F.dev.L.cTw.1978	−1.6443000
135	log.F.dev.L.cTw.1979	0.8452400
136	log.F.dev.L.cTw.1980	2.2138000
137	log.F.dev.L.cTw.1981	2.3811000
138	log.F.dev.L.cTw.1982	2.2993000
139	log.F.dev.L.cTw.1983	1.8288000
140	log.F.dev.L.cTw.1984	1.3734000
141	log.F.dev.L.cTw.1985	0.1257900
142	log.F.dev.L.cTw.1986	0.1507900
143	log.F.dev.L.cTw.1987	−0.2133400
144	log.F.dev.L.cTw.1988	0.7225100
145	log.avg.F.L.rHb	−3.3390000
146	log.F.dev.L.rHb.1972	−0.0236160
147	log.F.dev.L.rHb.1973	0.2668400
148	log.F.dev.L.rHb.1974	−0.0450960
149	log.F.dev.L.rHb.1975	−0.0107150
150	log.F.dev.L.rHb.1976	−0.0664090
151	log.F.dev.L.rHb.1977	−0.0661990
152	log.F.dev.L.rHb.1978	−0.3952600
153	log.F.dev.L.rHb.1979	−0.5809500
154	log.F.dev.L.rHb.1980	−0.3248000
155	log.F.dev.L.rHb.1981	−0.2139000
156	log.F.dev.L.rHb.1982	0.4878000
157	log.F.dev.L.rHb.1983	0.1265900
158	log.F.dev.L.rHb.1984	0.0238200
159	log.F.dev.L.rHb.1985	0.4094500
160	log.F.dev.L.rHb.1986	0.3616000

Table 36. (continued)

ID	Parameter	Value
161	log.F.dev.L.rHb.1987	0.5092000
162	log.F.dev.L.rHb.1988	0.4755600
163	log.F.dev.L.rHb.1989	0.2612200
164	log.F.dev.L.rHb.1990	0.0226940
165	log.F.dev.L.rHb.1991	0.3218300
166	log.F.dev.L.rHb.1992	0.4708400
167	log.F.dev.L.rHb.1993	0.5111400
168	log.F.dev.L.rHb.1994	0.4644200
169	log.F.dev.L.rHb.1995	0.4915300
170	log.F.dev.L.rHb.1996	0.3042400
171	log.F.dev.L.rHb.1997	0.1552700
172	log.F.dev.L.rHb.1998	0.2279400
173	log.F.dev.L.rHb.1999	0.4616900
174	log.F.dev.L.rHb.2000	−1.0465000
175	log.F.dev.L.rHb.2001	0.1252000
176	log.F.dev.L.rHb.2002	−0.1184800
177	log.F.dev.L.rHb.2003	−0.0643670
178	log.F.dev.L.rHb.2004	0.0147100
179	log.F.dev.L.rHb.2005	−0.0771180
180	log.F.dev.L.rHb.2006	0.3059400
181	log.F.dev.L.rHb.2007	0.8941700
182	log.F.dev.L.rHb.2008	0.0514170
183	log.F.dev.L.rHb.2009	−0.4739300
184	log.F.dev.L.rHb.2010	−0.3482400
185	log.F.dev.L.rHb.2011	−0.3449800
186	log.F.dev.L.rHb.2012	−0.2881000
187	log.F.dev.L.rHb.2013	−0.6852400
188	log.F.dev.L.rHb.2014	−0.7904400
189	log.F.dev.L.rHb.2015	−0.8239500
190	log.F.dev.L.rHb.2016	−0.5285100
191	log.F.dev.L.rHb.2017	−0.4282500
192	log.avg.F.L.rGe	−3.3895000
193	log.F.dev.L.rGe.1972	−0.9655600
194	log.F.dev.L.rGe.1973	−0.9844900
195	log.F.dev.L.rGe.1974	−0.9868900
196	log.F.dev.L.rGe.1975	−0.9325900
197	log.F.dev.L.rGe.1976	−0.8445100
198	log.F.dev.L.rGe.1977	−1.1099000
199	log.F.dev.L.rGe.1978	−1.3542000
200	log.F.dev.L.rGe.1979	−1.1828000

Table 36. (continued)

ID	Parameter	Value
201	log.F.dev.L.rGe.1980	−0.9999800
202	log.F.dev.L.rGe.1981	−1.2612000
203	log.F.dev.L.rGe.1982	−1.0663000
204	log.F.dev.L.rGe.1983	−1.8138000
205	log.F.dev.L.rGe.1984	0.7608700
206	log.F.dev.L.rGe.1985	0.5626100
207	log.F.dev.L.rGe.1986	−1.0777000
208	log.F.dev.L.rGe.1987	−0.3409400
209	log.F.dev.L.rGe.1988	0.7393200
210	log.F.dev.L.rGe.1989	0.2556300
211	log.F.dev.L.rGe.1990	0.0983180
212	log.F.dev.L.rGe.1991	−0.3901100
213	log.F.dev.L.rGe.1992	1.1341000
214	log.F.dev.L.rGe.1993	0.1583500
215	log.F.dev.L.rGe.1994	0.5139200
216	log.F.dev.L.rGe.1995	0.0889670
217	log.F.dev.L.rGe.1996	0.3715000
218	log.F.dev.L.rGe.1997	−0.7485700
219	log.F.dev.L.rGe.1998	−0.2707400
220	log.F.dev.L.rGe.1999	0.3939500
221	log.F.dev.L.rGe.2000	−0.7232500
222	log.F.dev.L.rGe.2001	0.5111700
223	log.F.dev.L.rGe.2002	0.9455700
224	log.F.dev.L.rGe.2003	1.0028000
225	log.F.dev.L.rGe.2004	1.2214000
226	log.F.dev.L.rGe.2005	0.6782400
227	log.F.dev.L.rGe.2006	0.0613540
228	log.F.dev.L.rGe.2007	0.6258400
229	log.F.dev.L.rGe.2008	1.2936000
230	log.F.dev.L.rGe.2009	0.5746100
231	log.F.dev.L.rGe.2010	−0.0098104
232	log.F.dev.L.rGe.2011	0.6118500
233	log.F.dev.L.rGe.2012	0.5237300
234	log.F.dev.L.rGe.2013	0.0678810
235	log.F.dev.L.rGe.2014	−0.4171200
236	log.F.dev.L.rGe.2015	0.6704200
237	log.F.dev.L.rGe.2016	2.4057000
238	log.F.dev.L.rGe.2017	1.2088000
239	log.avg.F.D.cHl	−4.4329000
240	log.F.dev.D.cHl.1999	0.8968800

Table 36. (continued)

ID	Parameter	Value
241	log.F.dev.D.cHl.2000	0.9572200
242	log.F.dev.D.cHl.2001	1.0157000
243	log.F.dev.D.cHl.2002	2.1717000
244	log.F.dev.D.cHl.2003	0.2927100
245	log.F.dev.D.cHl.2004	0.0668620
246	log.F.dev.D.cHl.2005	−0.4085700
247	log.F.dev.D.cHl.2006	−0.0227870
248	log.F.dev.D.cHl.2007	−0.5820100
249	log.F.dev.D.cHl.2008	−0.0626020
250	log.F.dev.D.cHl.2009	−0.1028300
251	log.F.dev.D.cHl.2010	−0.5642100
252	log.F.dev.D.cHl.2011	−1.2876000
253	log.F.dev.D.cHl.2012	−0.5606100
254	log.F.dev.D.cHl.2013	−0.5834600
255	log.F.dev.D.cHl.2014	−0.3657900
256	log.F.dev.D.cHl.2015	−0.1600300
257	log.F.dev.D.cHl.2016	−0.4867300
258	log.F.dev.D.cHl.2017	−0.2138300
259	log.avg.F.D.rHb	−5.4211000
260	log.F.dev.D.rHb.2001	0.8871300
261	log.F.dev.D.rHb.2002	0.4635100
262	log.F.dev.D.rHb.2003	0.3052400
263	log.F.dev.D.rHb.2004	1.0246000
264	log.F.dev.D.rHb.2005	−0.2501100
265	log.F.dev.D.rHb.2006	0.4734800
266	log.F.dev.D.rHb.2007	0.4195500
267	log.F.dev.D.rHb.2008	0.1171100
268	log.F.dev.D.rHb.2009	−0.4173300
269	log.F.dev.D.rHb.2010	−0.6517000
270	log.F.dev.D.rHb.2011	−0.6499100
271	log.F.dev.D.rHb.2012	−0.5627800
272	log.F.dev.D.rHb.2013	−0.6399200
273	log.F.dev.D.rHb.2014	−0.2412500
274	log.F.dev.D.rHb.2015	−0.0711900
275	log.F.dev.D.rHb.2016	−0.0421180
276	log.F.dev.D.rHb.2017	−0.1643100
277	log.avg.F.D.rGe	−6.2704000
278	log.F.dev.D.rGe.1981	−3.0696000
279	log.F.dev.D.rGe.1982	−2.4047000
280	log.F.dev.D.rGe.1983	−3.2250000

Table 36. (continued)

ID	Parameter	Value
281	log.F.dev.D.rGe.1984	−2.4048000
282	log.F.dev.D.rGe.1985	−0.0118470
283	log.F.dev.D.rGe.1986	−3.2783000
284	log.F.dev.D.rGe.1987	0.5098500
285	log.F.dev.D.rGe.1988	−3.0139000
286	log.F.dev.D.rGe.1989	0.3616600
287	log.F.dev.D.rGe.1990	−4.1982000
288	log.F.dev.D.rGe.1991	−4.1127000
289	log.F.dev.D.rGe.1992	0.1688500
290	log.F.dev.D.rGe.1993	−0.1613800
291	log.F.dev.D.rGe.1994	−1.2591000
292	log.F.dev.D.rGe.1995	0.8215800
293	log.F.dev.D.rGe.1996	−0.3566000
294	log.F.dev.D.rGe.1997	−1.6018000
295	log.F.dev.D.rGe.1998	−0.2882000
296	log.F.dev.D.rGe.1999	1.9218000
297	log.F.dev.D.rGe.2000	1.0056000
298	log.F.dev.D.rGe.2001	2.7250000
299	log.F.dev.D.rGe.2002	1.9803000
300	log.F.dev.D.rGe.2003	2.3069000
301	log.F.dev.D.rGe.2004	2.2386000
302	log.F.dev.D.rGe.2005	1.6084000
303	log.F.dev.D.rGe.2006	−0.3401900
304	log.F.dev.D.rGe.2007	1.4707000
305	log.F.dev.D.rGe.2008	2.3649000
306	log.F.dev.D.rGe.2009	0.1392200
307	log.F.dev.D.rGe.2010	0.7838100
308	log.F.dev.D.rGe.2011	0.5734000
309	log.F.dev.D.rGe.2012	−0.3743100
310	log.F.dev.D.rGe.2013	0.2469200
311	log.F.dev.D.rGe.2014	1.2979000
312	log.F.dev.D.rGe.2015	2.0510000
313	log.F.dev.D.rGe.2016	3.6758000
314	log.F.dev.D.rGe.2017	1.8486000