SEDAR

Southeast Data, Assessment, and Review

SEDAR 78

South Atlantic Spanish Mackerel

Stock Assessment Report

May 2022

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 78 addressed the stock assessment for South Atlantic Spanish Mackerel. The assessment process consisted of a series of webinars held from May 2021 – March 2022. 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 Spanish Mackerel was disseminated to the public in May 2022. 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 Summer 2022 meeting, followed by the Council receiving the SAR at the Fall 2022 meeting. Documentation on SSC recommendations is not part of the SEDAR process and is handled through each Council

2. Atlantic Spanish Mackerel Management Overview

2.1 Fishery Management Plan and Amendments

The following summary describes only those management actions that likely affect Atlantic Spanish mackerel fisheries and harvest.

FMP Amendments affecting Atlantic Spanish mackerel:

Description of Action	Amendment	Effective Date
• Set MSY = OY = TAC (27,000,000 pounds). • Minimum size limit for is 12 inches FL, except for incidental catch allowance of 5% of the total catch by weight aboard.	Original FMP (SAFMC 1982) 48 FR 5274	February 4, 1983
• Provided framework procedure for pre-season adjustment of TAC. • TAC = 27,000,000 pounds • Limited purse seine harvest to 300,000 lbs in Atlantic and 300,000 lbs in Gulf • Minimum size limit for the commercial and recreational sectors are 12 inches FL or 14 inches TL.	Amendment 1 (SAFMC 1985) 50 FR 34846	August 28, 1985
• Revised MSY and clarified TAC must be set below the upper range of the ABC. • Recognized two migratory groups, Gulf and South Atlantic, with Dade/Monroe county line as the migratory group boundary. • TAC = 2,900,000 pounds • Established allocations for TAC, commercial (2,200,000 pounds, 76%) and recreational (700,000 pounds, 24%). • Established April 1 to March 31 fishing year. • Recreational bag limit of 4 fish in FL and 10 in NC, SC, and GA. • Charter boat permits were required.	Amendment 2 (SAFMC 1987) 52 FR 23836	June 25,1987

Description of Action	**Amendment**	**Effective Date**
• Prohibited drift gill nets for coastal pelagics and purse seines for the overfished group of mackerels.	Amendment 3 (SAFMC 1989) 54 FR 29561	July 13, 1989
• Reallocated Atlantic group Spanish mackerel equally between recreational and commercial fishermen. • TAC = 6,000,000	Amendment 4 (SAFMC 1989) 54 FR 38526	September 19, 1989
• Extended the management area for the Atlantic groups of mackerels through the Mid Atlantic Fishery Management Council's area of jurisdiction. • Revised the definition of overfishing. • Redefined recreational bag limits as daily limits, and removed the provision specifying that bag limit caught mackerel may be sold. • Size limit for Spanish mackerel is 12 " FL or 14" TL. • Bag limit is 4 fish off FL and 10 fish north of FL.	Amendment 5 (SAFMC 1990) 55 FR 29370	July 19, 1990

Description of Action	**Amendment**	**Effective Date**
• Specified rebuilding periods for overfished mackerel stocks. • Provided for commercial Atlantic Spanish mackerel possession limits. • In the northern zone, boats are restricted to possession limits of 3,500 pounds. In the southern zone trip limit are 1,500 pounds per vessel per day from April 1 to November 30. From December 1 until 80% of quota is taken: unlimited harvest on Monday, Wednesday, and Friday; 1,500 pounds per vessel per day on Tuesday and Thursday; 500 pounds per vessel per day on Saturday and Sunday. Trip limit 1,000 pounds per vessel per day when 80% of quota is reached. The adjusted quota for Spanish mackerel is 3,250,000 pounds. • Discontinued the reversion of the bag limit to 0 when the recreational quota is filled. • Modified the recreational fishing year to the calendar year, • Changed commercial permit requirements to allow qualification in one of three preceding years. • Changed all size limits to fork length only. Minimum size limit is 12 inches FL.	Amendment 6 (SAFMC 1992) 57 FR 58151	December 9, 1992
• Modified requirements for a king or Spanish mackerel permit. • Set the OY target to 40% static SPR for the Atlantic. • Modified the seasonal framework adjustment measures.	Amendment 8 (SAFMC 1994) 63 FR 10561	March 4, 1998
• Allowed the retention and sale of damaged, legal sized king and Spanish mackerel within established trip limits.	Amendment 9 (SAFMC 1998) 64 FR 16336	March 28, 2000

Description of Action	Amendment	Effective Date
• Established EFH in the South Atlantic	Amendment 10 (SAFMC 1998) 65 FR 37292	July 14, 2000
• Addressed Sustainable Fishery Act definitions.	Amendment 11 (SAFMC 1999)	December 1999
• Changed the fishing year for Atlantic group Spanish mackerel to March 1 through February 28/29.	Amendment 15 SAFMC (2004) 70 FR 39187	July 7, 2005
• Stock ACL= 5,690,000 pounds. • Commercial = 3,130,000 pounds and recreational = 2,560,000 pounds • Accountability Measures (AMs): Commercial sector to close when commercial ACL will be met; payback when total ACL is exceeded (and overfished). Recreational sector to lower bag limit, if necessary, if total ACL is also exceeded.	Amendment 18 SAFMC 2011 76 FR 82058	January 20, 2012
• Established coral HAPCs.	Amendment 19 in CE-BA1 SAFMC 2009 75 FR 35330	July 22, 2010

Description of Action	Amendment	Effective Date
• Prohibits king mackerel and Spanish mackerel bag limit sales in Atlantic except state permitted tournaments. • Removes income requirements for CMP permits.	Amendment 20A SAFMC 2013 79 FR 34246	July 16, 2014
• Recreational fishing measures in SC SMZs.	Amendment 21 in CE-BA 2 SAFMC 2011 76 FR 82183	January 30, 2012
• Requires weekly electronic reporting for headboats in South Atlantic.	Amendment 22 in HB reporting amendment SAFMC 2013 78 FR 78779	January 27, 2014
• King mackerel and Spanish mackerel dealers must get the universal permit. • Federal king mackerel and Spanish mackerel permit holders must sell to federal dealer. • Requires weekly electronic reporting for federal dealers.	Amendment 23 in Generic Dealer Amendment	August 7, 2014

Description of Action	**Amendment**	**Effective Date**
	SAFMC 2013 79 FR 19490	
• Set Northern (NC/SC line north) and Southern (NC/SC line south) zones and associated commercial quotas. • Northern Zone- 622,870 pounds; Southern Zone - 2,507,130 pounds.	Amendment 20B SAFMC 2014 80 FR 4216	March 1, 2015
• For hire reporting requirements.	Amendment 27 SAFMC 2017	January 4, 2021

SAFMC Regulatory Amendments affecting Atlantic Spanish mackerel:

Description of Action	Amendment	Effective Date
• Commercial allocation is 2,360,000 pounds and recreational allocation is 740,000 pounds. • Bag limits is 4 fish off FL and 10 fish north of FL.	52 FR 25012	July 2, 1987
• Final Rule on technical amendment that allows catch of Spanish mackerel under minimum size limit equal to 5% by weight of total catch or Spanish mackerel on board.	52 FR 36578	September 30, 1987
• Changed TAC to 4,000,000 pounds with 960,000 pounds allocated to the recreational sector and 3,040,000 pounds allocated to the commercial sector.	53 FR 25611	July 8, 1988
• TAC increased to 6,000,000 pounds with 1,440,000 pounds allocated to the recreational sector and 4,600,00 pounds allocated to the commercial sector.	54 FR 24920	April 1, 1989
• TAC changed to 5,000,000 pounds with 3,140,000 pounds allocated to the commercial sector and 1,860,000 pounds allocated to the recreational sector.	55 FR 25986	June 26, 1990
• TAC increased to 7,000,000 pounds with 3,500,000 pounds allocated to commercial sector and 3,500,000 pounds allocated to recreational sector. • Bag limit is 10 fish for areas north of FL and 5 fish for FL.	56 FR 29920	July 1, 1991
• Increased bag limit in Florida to that adopted by the state of FL but not to exceed 10 fish.	57 FR 33924	July 31, 1992

Description of Action	**Amendment**	**Effective Date**
• TAC increased to 9,000,000 with 4,500,000 pounds commercial and 4,500,000 pounds recreational. • The initial change in the trip limit occurs when 75% of the quota is met instead of 80%.	58 FR 40613	July 29, 1993
• TAC for Atlantic Spanish mackerel is increased to 9,200,000 pounds (4,600,000 pounds commercial and 4,600,000 pounds recreational).	59 FR 40509	April 1, 1994
• TAC increased to 9,400,000 pounds (4,700,000 pounds commercial and 4,700,000 pounds recreational).	60 FR 39698	April 1, 1995
• Reduced to 7,000,000 (3,500,000 pounds commercial and 3,500,000 pounds recreational). • Modify trip regime for commercial vessels off Florida east coast: Nov 1 rather than Dec 1 start for unlimited harvest season and increase the Saturday-Sunday daily trip limit from 500 to 1,500 pounds during that season and increase the daily trip limit from 1,000 to 1,500 pounds for all days of the week during the period that follows the unlimited season and continues until the adjusted quota is taken.	62 FR 23671	May 1, 1997
• Increased the TAC l to 8,000,000 pounds (4,000,000 pounds commercial and 4,000,000 pounds recreational).	62 FR 53278	April 1, 1997
• Decrease the TAC to 6,600,000 pounds and change the allocation from 50/50 to 55% commercial (3,630,000 pounds) and 45% recreational (2,970,000 pounds).	64 FR 45457	August 20, 1999

Description of Action	Amendment	Effective Date
• Increase TAC to 7,040,000 pounds with 3,870,000 pounds commercial and 3,170,000 pounds recreational. • The trip limit from April 1 to November 30 would be 3,500 lb; from December 1 until 75% of the adjusted quota is taken there would be no trip limit on Monday through Friday and on Saturday and Sunday the trip limit would be 1,500 lbs. • The recreational bag limit is increased from 10 to 1S5 fish per person per day. • MSY = 5.7-7.5 million pounds, Bmsy = 12.2-15.8, MSST = 8.5-11.1, MFMT = 0.38-0.48.	65 FR 41015	July 3, 2000
• Reduce Atlantic Spanish mackerel trip limit to 1,500 lbs per day from March 1, 2004 to March 31, 2004.	69 FR 9969	March 3, 2004
• Reduce trip limit for Atlantic Spanish mackerel to 1,500 lbs from February 1, 2005 to March 31, 2005.	70 FR 5569	February 3, 2005
• Reduce Atlantic Spanish mackerel trip limit to 1,500 lbs from February 5, 2007 to February 28, 2007.	72 FR 5345	February 6, 2007
• Change start date for commercial trip limit of the Atlantic Spanish mackerel in southern zone (off FL) to March 1.	73FR439	January 3, 2008
• Provisions for transfer at sea for gillnets when one set exceeds Spanish mackerel trip limit	Framework Action SAFMC 2013 79 FR 68802	December 19, 2014

Description of Action	Amendment	Effective Date
• ACL= 6,063,000 pounds with commercial 3,330,000 pounds and recreational 2,727,000 pounds.	FW Amendment 1 SAFMC 2014 79 FR 69058	December 22, 2014
• Trip limits in Southern Zone (SC, GA, FL): 3,500lbs until 75% adjusted quota is met, then 1,500lbs until adjusted quota is met and then 500lbs until the full quota is met.	FW Amendment 2 SAFMC 2014 80 FR 40936	August 13, 2015
• Permit restrictions: removes the restriction on fishing for, or retaining, the recreational bag and possession limits of king and Spanish mackerel on a vessel with a Federal commercial permit for king or Spanish mackerel when commercial harvest of king or Spanish mackerel in a zone or region is closed.	FW Amendment 5 SAFMC 2016 82 FR 35658	August 31, 2017

2.2 Emergency and Interim Rules (if any)

Description of Action	FRN	Effective Date
• Divided 3.716 million pounds quota into three areas with 1.869 million pounds going to the Atlantic. ○ The Atlantic boundary was bounded by the North Carolina/Virginia state line and a line directly east of the Dade/Monroe County, Florida boundary. • Established a recreational bag limit of 4-fish per trip and allowed sale of recreationally caught Spanish mackerel under the bag limit. • January 1, 1987 to March 31, 1987	52 FR 290	January 5, 1987
• 90-day extension of January 1, 1987 to March 31, 1987 emergency rule for Spanish mackerel.	52 FR 10762	April 3, 1987

2.3 Secretarial Amendments (if any)

None for Atlantic Spanish mackerel.

2.4 Control Date Notices (if any)

March 7, 2019: participants who enter the commercial sector after March 7, 2019, will not be assured of future access if a management regime that limits participation in the sector is prepared and implemented.

2.5 Management Program Specifications

Table 2.5.1. General Management Information

Species	Spanish mackerel (*Scomberomorus maculatus*)
Management Unit	Atlantic migratory group Spanish mackerel
Management Unit Definition	All waters from the intersection of New York, Connecticut, and Rhode Island to a line extending due east of the Miami-Dade/Monroe County line
Management Entity	South Atlantic Fishery Management Council (Note: Mid-Atlantic Council participates as voting member on South Atlantic Council's Mackerel Cobia Committee.)
Management Contacts **SERO / Council**	SAFMC: Christina Wiegand SERO: Mary Vara/Karla Gore
Current stock exploitation status	Not undergoing overfishing
Current stock biomass status	Not overfished

Table 2.5.2. Management Parameters

Criteria	South Atlantic – Current (SEDAR 28)		
	Definition	**Values**	**Units**
M	Average of Lorenzen M (if used)	0.35	Instantaneous natural mortality; per year
$F_{CURRENT}$	Geometric mean of full fishing mortality rates for 2009-2011 ($F_{2009\text{-}2011}$)	0.36	Per year
F_{TARGET}			
Yield at F_{TARGET} (equilibrium)			
F_{MSY}	F_{MSY}	0.69	Per year
B_{MSY}	Biomass at MSY	9548	Metric tons
R_{2012}			
R_{MSY}			
$R_{UNFISHED}$			
SSB_{2011}	Spawning stock biomass in 2011	4862	Metric tons
SSB_{MSY}	Spawning stock biomass at MSY	3266	Metric tons
MSST[1]	MSST = [(1-M) or 0.7 whichever is greater]*B_{MSY}	2127	Metric tons
MFMT	F_{MSY}	0.69	Per year
MSY	Yield at F_{MSY}	2750	Metric tons
OY	Yield at F_{OY}		
F_{OY}	F_{OY} = 65%, 75%, 85% F_{MSY}	65% F_{OY} = 0.449 75% F_{OY} = 0.518 85% F_{OY} = 0.587	
Exploitation Status	$F_{2009\text{-}2011}/F_{MSY}$	0.526	
	F_{2011}/F_{MSY}	0.521	
Biomass Status	SSB_{2011}/MSST	2.29	
	SSB_{2011}/SSB_{MSY}	1.49	
Terminal F (2011)			
Terminal Biomass (2011) [1]			
Generation Time			
$T_{REBUILD}$ (if appropriate)			

Table 2.5.2. Management Parameters Continued				
Criteria	**South Atlantic – Proposed (SEDAR 78)**			
	Definition	**Base Run Values**	**Units**	**Median of Base Run MCBs**
M	Average of Lorenzen M (if used)			
$F_{CURRENT}$	Geometric mean of full fishing mortality rates for 2009-2011 ($F_{2009-2011}$)			
F_{TARGET}				
Yield at F_{TARGET} (equilibrium)				
F_{MSY}	F_{MSY}			
B_{MSY}[1]	Biomass at MSY			
R_{MSY}				
SSB				
SSB_{MSY}	Spawning stock biomass at MSY			
MSST[1]	MSST = [(1-M) or 0.7 whichever is greater]*B_{MSY}			
MFMT	F_{MSY}			
MSY	Yield at F_{MSY}			
OY	Yield at F_{OY}			
F_{OY}	F_{OY} = 65%, 75%, 85% F_{MSY}			
Exploitation Status				
Biomass Status[1]				
Terminal F	-			
Terminal Biomass [1]	-			
Generation Time	-			
$T_{REBUILD}$ (if appropriate)	-			

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

NOTE: “Proposed” columns are for indicating any definitions that may exist in FMPs or amendments that are currently under development and should therefore be evaluated in the current assessment. Please clarify whether landings parameters are ‘landings’ or ‘catch’ (Landings + Discard). If ‘landings’, please indicate how discards are addressed.

Table 2.5.3. Stock Rebuilding Information

None – Atlantic migratory group Spanish mackerel is not currently overfished.

Table 2.5.4. General Projection Specifications

South Atlantic

First Year of Management	2024/2025
Interim basis	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)	SSB & Probability SSB>MSST (and Prob. SSB>SSB_{MSY} if under rebuilding plan)
Recruits	Number

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

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

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

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

Basis	Value	Years to Project	P* applies to
P*	50%	Interim + 5	Probability of overfishing
P*	TBD[1]	Interim + 5	Probability of overfishing
Exploitation	F_{MSY}	Interim + 5	NA
Exploitation	75% of F_{MSY}	Interim + 5	NA

[1] To be determined by the SSC.

Table 2.5.7. Quota Calculation Details
If the stock is managed by quota, please provide the following information.

	Atlantic Spanish Mackerel
Current Acceptable Biological Catch (ABC) and Total Annual Catch Level (ACL) Value for Spanish Mackerel	ACL = ABC = OY ACL = 6,063,000 lbs.
Commercial ACL for Spanish Mackerel	ACL = 3,330,000 lbs.
Recreational ACL for Spanish Mackerel	ACL = 2,727,000 lbs.
Next Scheduled Quota Change	After assessment
Annual or averaged quota?	Annual
If averaged, number of years to average	-
Does the quota include bycatch/discard?	No

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

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 ABC, ACL, and recreational ACT values are based on landed catch only; discards are accounted for in specifying the ABC in terms of landed catch and not total mortality.

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

2.6 Management and Regulatory Timeline
See attached tables below.

Table 2.5.8 Atlantic Migratory Group Spanish Mackerel Commercial Regulatory History prepared by: Christina Wiegand, SAFMC staff

Year	Quota (lbs ww)	ACL (lbs ww)	Days Open	Fishing Season	Reason for Closure	Season Start Date (first day implemented)	Season end Date (last day effective)	Size Limit	Size Limit Start Date	Size Limit End Date	Retention Limit (# fish)	Retention Limit Start Date	Retention Limit End Date
1983 [1]	27,000,000	NA	365	OPEN	NA	2/4/1983	12/31/1983	12-in FL	2/4/1983	12/31/1983	N/A	2/4/1983	12/31/1983
1984 [2]	27,000,000	NA	365	OPEN	NA	1/1/1984	12/31/1984	12-in FL	1/1/1984	12/31/1984	N/A	1/1/1984	12/31/1984
1985 [4]	27,000,000	NA	365	OPEN	NA	1/1/1985	12/31/1985	12-in FL or 14-in TL	1/1/1985	12/31/1985	N/A	1/1/1985	12/31/1985
1986 [4]	27,000,000	NA	378	OPEN	NA	1/1/1986	1/14/1987	12-in FL or 14-in TL	1/1/1986	1/14/1987	N/A	1/1/1986	1/14/1987
1987	2,360,000	NA	272	CLOSED	QUOTA MET	4/1/1987	12/29/1987	12-in FL or 14-in TL	4/1/1987	12/29/1987	N/A	4/1/1987	12/29/1987
1988	3,040,000	NA	272	CLOSED	QUOTA MET	4/1/1988	12/29/1988	12-in FL or 14-in TL	4/1/1988	12/29/1988	N/A	4/1/1988	12/29/1988
1989	3,240,000	NA	365	OPEN	NA	4/1/1989	3/31/1990	12-in FL or 14-in TL	4/1/1989	3/31/1990	N/A	4/1/1989	3/31/1990
1990 [3]	3,140,000	NA	279	CLOSED	QUOTA MET	4/1/1990	1/25/1991	12-in FL or 14-in TL	4/1/1990	1/25/1991	N/A	4/1/1990	1/25/1991
1991	3,500,000	NA	263	CLOSED	QUOTA MET	4/1/1991	12/20/1991	12-in FL or 14-in TL	4/1/1991	12/20/1991	N/A	4/1/1991	12/20/1991
1992	3,500,000	NA	365	OPEN	NA	4/1/1992	3/31/1993	12-in FL	4/1/1992	3/31/1993	a, b	4/1/1992	3/31/1993
-	-	-	-	-	-	-	-	-	-	-	1,000	1/7/1993	2/19/1993
-	-	-	-	-	-	-	-	-	-	-	500	2/20/1993	3/31/1993
1993	3,500,000	NA	365	OPEN	NA	4/1/1993	3/31/1994	12-in FL	4/1/1993	3/31/1994	a, c	4/1/1993	12/21/1993
-	-	-	-	-	-	-	-	-	-	-	1,000	12/22/1993	2/17/1994
-	-	-	-	-	-	-	-	-	-	-	500	2/18/1994	3/31/1994
1994	4,600,000	NA	365	OPEN	NA	4/1/1994	3/31/1995	12-in FL	4/1/1994	3/31/1995	a,c	4/1/1994	1/28/1995
-	-	-	-	-	-	-	-	-	-	-	1,000	1/29/1995	3/31/1995
1995	4,700,000	NA	365	OPEN	NA	4/1/1995	3/31/1996	12-in FL	4/1/1995	3/31/1996	a, c	4/1/1995	3/31/1996
1996	3,500,000	NA	365	OPEN	NA	4/1/1996	3/31/1997	12-in FL	4/1/1996	3/31/1997	a,c	4/1/1996	3/31/1997
1997	3,500,000	NA	365	OPEN	NA	4/1/1997	3/31/1998	12-in FL	4/1/1997	3/31/1998	a,d	4/1/1997	12/15/1997
-	-	-	-	-	-	-	-	-	-	-	1,500	12/16/1997	3/31/1998
1998	4,000,000	NA	365	OPEN	NA	4/1/1998	3/31/1999	12-in FL	4/1/1998	3/31/1999	a,d	4/1/1998	2/9/1999
-	-	-	-	-	-	-	-	-	-	-	1,500	2/10/1999	3/31/1999
1999	3,630,000	NA	365	OPEN	NA	4/1/1999	3/31/2000	12-in FL	4/1/1999	3/31/2000	a,d	4/1/1999	3/31/2000
2000	3,870,000	NA	365	OPEN	NA	4/1/2000	3/31/2001	12-in FL	4/1/2000	3/31/2001	a, e	4/1/2000	3/31/2001
2001	3,870,000	NA	365	OPEN	NA	4/1/2001	3/31/2002	12-in FL	4/1/2001	3/31/2002	a, e	4/1/2001	3/31/2002
2002	3,870,000	NA	365	OPEN	NA	4/1/2002	3/31/2003	12-in FL	4/1/2002	3/31/2003	a, e	4/1/2002	3/31/2003
2003	3,870,000	NA	365	OPEN	NA	4/1/2003	3/31/2004	12-in FL	4/1/2003	3/31/2004	a, e	4/1/2003	2/28/2004
-	-	-	-	-	-	-	-	-	-	-	1,500	3/1/2004	3/31/2004
2004	3,870,000	NA	365	OPEN	NA	4/1/2004	3/31/2005	12-in FL	4/1/2004	3/31/2005	a, e	4/1/2004	1/31/2005
-	-	-	-	-	-	-	-	-	-	-	1,500	2/1/2005	3/31/2005
2005	3,870,000	NA	365	OPEN	NA	4/1/2005	3/31/2006	12-in FL	4/1/2005	3/31/2006	a, e	4/1/2005	3/31/2006
2006	3,870,000	NA	365	OPEN	NA	3/1/2006	2/28/2007	12-in FL	3/1/2006	2/28/2007	a, e	3/1/2006	2/4/2006
-	-	-	-	-	-	-	-	-	-	-	1,500	2/5/2007	2/28/2007
2007	3,870,000	NA	365	OPEN	NA	3/1/2007	2/29/2008	12-in FL	3/1/2007	2/29/2008	a, e	3/1/2007	2/29/2008
2008	3,870,000	NA	365	OPEN	NA	3/1/2008	2/28/2009	12-in FL	3/1/2008	2/28/2009	a, e	3/1/2008	2/28/2009
2009	3,870,000	NA	365	OPEN	NA	3/1/2009	2/28/2010	12-in FL	3/1/2009	2/28/2010	a, e	3/1/2009	2/28/2010
2010	3,870,000	NA	365	OPEN	NA	3/1/2010	2/28/2011	12-in FL	3/1/2010	2/28/2011	a, e	3/1/2010	2/21/2011
-	-	-	-	-	-	-	-	-	-	-	1,500	2/22/2011	2/28/2011
2011	3,870,000	NA	365	OPEN	NA	3/1/2011	2/29/2012	12-in FL	3/1/2011	2/29/2012	a, e	3/1/2011	1/26/2012
-	-	-	-	-	-	-	-	-	-	-	1,500	1/27/2012	2/29/2012
2012	SEE ACL	3,870,000	365	OPEN	NA	3/1/2012	2/28/2013	12-in FL	3/1/2012	2/28/2013	a, e	3/1/2012	1/5/2013
-	-	-	-	-	-	-	-	-	-	-	1,500	1/6/2013	2/28/2013

Table 2.5.8 Atlantic Migratory Group Spanish Mackerel Commercial Regulatory History prepared by: Christina Wiegand, SAFMC staff

Year	Quota (lbs ww)	ACL (lbs ww)	Days Open	Fishing Season	Reason for Closure	Season Start Date (first day implemented)	Season end Date (last day effective)	Size Limit	Size Limit Start Date	Size Limit End Date	Retention Limit (# fish)	Retention Limit Start Date	Retention Limit End Date
2013	SEE ACL	3,130,000	365	OPEN	NA	3/1/2013	2/28/2014	12-in FL	3/1/2013	2/28/2014	a, e	3/1/2013	1/16/2014
-	-	-	-	-	-	-	-	-	-	-	1,500	1/17/2014	2/28/2014
2014	SEE ACL	3,130,000	365	OPEN	NA	3/1/2014	2/28/2015	12-in FL	3/1/2014	2/28/2015	a, e	3/1/2014	2/19/2015
-	-	-	-	-	-	-	-	-	-	-	1,500	2/20/2015	2/28/2015
2015 [5]	SEE ACL	3,330,000	365	OPEN	NA	3/1/2015	2/29/2016	12-in FL	3/1/2015	2/29/2016	f, g	3/1/2015	2/29/2016
2016 [5]	SEE ACL	3,330,000	365	OPEN	NA	3/1/2016	2/28/2017	12-in FL	3/1/2016	2/28/2017	f, g	3/1/2016	2/28/2017
-	-	-	-	-	-	-	-	-	-	-	1,500	2/6/2017	2/28/2017
2017 [5]	SEE ACL	3,330,000	365	SZ OPEN	NA	3/1/2017	2/28/2018	12-in FL	3/1/2017	2/28/2018	f, g	3/1/2017	1/26/2018
-	-	-	-	-	-	-	-	-	-	-	1,500	1/27/2018	2/28/2018
-	-	-	251	NZ CLOSED	ZONE QUOTA MET	-	11/7/2017	-	-	-	-	-	-
2018 [5]	SEE ACL	3,330,000	-	NA	NA	3/1/2018	2/28/2019	12-in FL	3/1/2018	2/28/2019	f, g	3/1/2018	12/25/2018
-	-	-	-	-	-	-	-	-	-	-	1,500	12/26/2018	1/26/2019
-	-	-	-	-	-	-	-	-	-	-	500	1/27/2019	2/5/2019
-	-	-	248	NZ CLOSED	ZONE QUOTA MET	-	11/4/2018	-	-	-	-	-	-
-	-	-	341	SZ CLOSED	ZONE QUOTA MET	-	2/5/2019	-	-	-	-	-	-
2019 [5]	SEE ACL	3,330,000	365	SZ OPEN	NA	3/1/2019	2/29/2020	12-in FL	3/1/2019	2/29/2020	f, g		
-	-	-	-	-	-	-	-	-	-	-	1,500	12/24/2019	
-	-	-	-	-	-	-	-	-	-	-	500	1/29/2020	
-	-	-	156	NZ CLOSED	ZONE QUOTA MET	-	8/24/2019	-	-	-	-	-	-

Notes:
1 Spanish mackerel managed as a single stock throughout the Gulf and South Atlantic.
2 Spanish mackerel managed as two migratory groups (Atlantic and Gulf migratory) from this point forward.
3 Management area extended from TX through NC to TX through NY.
4 Stock quota
5 Separate Northern (20%) and Southern Zone (80%) quotas.

Trip Limit Codes:
a Northern Zone (north of Florida/Georgia): 3,500
b Southern Zone (east Florida): 1,500 pounds per vessel per day from April 1 to November 30. From December 1 until 80% of quota is taken: unlimited harvest on Monday, Wednesday, and Friday; 1,500 pounds per vessel per day on Tuesday and Thursday; 500 pounds per vessel per day on Saturday and Sunday. Trip limit 1,000 pounds per vessel per day when 80% of quota is reached.
c Southern Zone (east Florida): 1,500 pounds per vessel per day from April 1 to November 30. From December 1 until 80% of quota is taken: unlimited harvest on Monday, Wednesday, and Friday; 1,500 pounds per vessel per day on Tuesday and Thursday; 500 pounds per vessel per day on Saturday and Sunday. Trip limit 1,000 pounds per vessel per day when 75% of quota is reached.
d Southern Zone (east Florida): 1,500 pounds per vessel per day from April 1 to OCtober 31. From November 1 until 80% of quota is taken: unlimited harvest on Monday, Wednesday, and Friday; 1,500 pounds per vessel per day on Tuesday and Thursday; 1,500 pounds per vessel per day on Saturday and Sunday. Trip limit 1,500 pounds per vessel per day when 75% of quota is reached.
e Southern Zone (east Florida): April 1 to November 30 would be 3,500 lb; from December 1 until 75% of the adjusted quota is taken there would be no trip limit on Monday through Friday and on Saturday and Sunday the trip limit would be 1,500 lbs.
f Northern Zone (north of North Carolina/South Carolina): 3,500
g Southern Zone (SC, GA, east FL): 3,500lbs until 75% adjusted quota is met, then 1,500lbs until adjusted quota is met and then 500lbs until the full quota is met.

Table 2.5.9 Atlantic Migratory Group Spanish Mackerel Recreational Regulatory History prepared by: Christina Wiegand, SAFMC staff

Year	Quota (lbs ww)	ACL (lbs ww)	Days Open	Fishing Season	Reason for Closure	Season Start Date (first day implemented)	Season end Date (last day effective)	Size Limit	Size Limit Start Date	Size Limit End Date	Retention Limit (# fish)	Retention Limit Start Date	Retention Limit End Date
1983 [1a]	27,000,000	NA	365	OPEN	NA	2/4/1983	12/31/1983	12-in FL	2/4/1983	12/31/1983	NA	NA	NA
1984 [1a]	27,000,000	NA	365	OPEN	NA	1/1/1984	12/31/1984	12-in FL	1/1/1984	12/31/1984	NA	NA	NA
1985 [1a]	27,000,000	-	365	OPEN	NA	1/1/1985	12/31/1985	12-in FL or 14-in TL	8/28/1985	12/31/1985	NA	NA	NA
1986 [1a]	27,000,000	NA	455	OPEN	NA	1/1/1986	3/31/1987	12-in FL or 14-in TL	1/1/1986	12/31/1986	NA	NA	NA
1987 [2]	740,000	NA	365	OPEN	NA	4/1/1987	12/31/1987	12-in FL or 14-in TL	1/1/1987	12/31/1987	GA to NC = 10pp/trip FL = 4pp/trip	7/2/1987	12/31/1987
1988	960,000	NA	276	CLOSED	QUOTA MET	4/1/1988	10/3/1988	12-in FL or 14-in TL	4/1/1988	10/3/1988	GA to NC = 10pp/trip FL = 4pp/trip	4/1/1988	10/3/1988
1989	2,760,000	NA	365	OPEN	NA	4/1/1989	3/31/1990	12-in FL or 14-in TL	4/1/1989	3/31/1990	GA to NC = 10pp/trip FL = 4pp/trip	4/1/1989	3/31/1990
1990 [3]	1,860,000	NA	365	OPEN	NA	4/2/1990	3/31/1991	12-in FL or 14-in TL	4/2/1990	3/31/1991	GA to NY = 10pp/trip FL = 4pp/trip	4/2/1990	3/31/1991
1991	3,500,000	NA	365	OPEN	NA	4/3/1991	12/31/1991	12-in FL or 14-in TL	4/3/1991	12/31/1991	GA to NY = 10pp/trip FL = 5pp/trip	7/1/1991	12/31/1991
1992	3,500,000	NA	365	OPEN	NA	1/1/1992	12/31/1992	12-in FL	12/9/1992	12/31/1992	GA to NY = 10pp/trip FL = 10pp/trip	7/31/1992	12/31/1992
1993	3,500,000	NA	365	OPEN	NA	1/1/1993	12/31/1993	12-in FL	1/1/1993	12/31/1993	GA to NY = 10pp/trip FL = 10pp/trip	1/1/1993	12/31/1993
1994	4,600,000	NA	365	OPEN	NA	1/1/1994	12/31/1994	12-in FL	1/1/1994	12/31/1994	GA to NY = 10pp/trip FL = 10pp/trip	1/1/1994	12/31/1994
1995	4,700,000	NA	365	OPEN	NA	1/1/1995	12/31/1995	12-in FL	1/1/1995	12/31/1995	GA to NY = 10pp/trip FL = 10pp/trip	1/1/1995	12/31/1995
1996	3,500,000	NA	365	OPEN	NA	1/1/1996	12/31/1996	12-in FL	1/1/1996	12/31/1996	GA to NY = 10pp/trip FL = 10pp/trip	1/1/1996	12/31/1996
1997	3,500,000	NA	365	OPEN	NA	1/1/1997	12/31/1997	12-in FL	1/1/1997	12/31/1997	GA to NY = 10pp/trip FL = 10pp/trip	1/1/1997	12/31/1997
1998	4,000,000	NA	365	OPEN	NA	1/1/1998	12/31/1998	12-in FL	1/1/1998	12/31/1998	GA to NY = 10pp/trip FL = 10pp/trip	1/1/1998	12/31/1998
1999	2,970,000	NA	365	OPEN	NA	1/1/1999	12/31/1999	12-in FL	1/1/1999	12/31/1999	GA to NY = 10pp/trip FL = 10pp/trip	1/1/1999	12/31/1999
2000	3,170,000	NA	365	OPEN	NA	1/1/2000	12/31/2000	12-in FL	1/1/2000	12/31/2000	15 pp/trip	1/1/2000	12/31/2000
2001	3,170,000	NA	365	OPEN	NA	1/1/2001	12/31/2001	12-in FL	1/1/2001	12/31/2001	15 pp/trip	1/1/2001	12/31/2001
2002	3,170,000	NA	365	OPEN	NA	1/1/2002	12/31/2002	12-in FL	1/1/2002	12/31/2002	15 pp/trip	1/1/2002	12/31/2002
2003	3,170,000	NA	365	OPEN	NA	1/1/2003	12/31/2003	12-in FL	1/1/2003	12/31/2003	15 pp/trip	1/1/2003	12/31/2003
2004	3,170,000	NA	424	OPEN	NA	1/1/2004	2/28/2005	12-in FL	1/1/2004	12/31/2004	15 pp/trip	1/1/2004	12/31/2004
2005	3,170,000	NA	365	OPEN	NA	3/1/2005	2/28/2006	12-in FL	3/1/2005	2/28/2005	15 pp/trip	3/1/2005	2/28/2005
2006	3,170,000	NA	365	OPEN	NA	3/1/2006	2/28/2007	12-in FL	3/1/2006	2/28/2006	15 pp/trip	3/1/2006	2/28/2006
2007	3,170,000	NA	365	OPEN	NA	3/1/2007	2/29/2008	12-in FL	3/1/2007	2/28/2007	15 pp/trip	3/1/2007	2/28/2007
2008	3,170,000	NA	365	OPEN	NA	3/1/2008	2/28/2009	12-in FL	3/1/2008	2/29/2008	15 pp/trip	3/1/2008	2/29/2008
2009	3,170,000	NA	365	OPEN	NA	3/1/2009	2/28/2010	12-in FL	3/1/2009	2/28/2009	15 pp/trip	3/1/2009	2/28/2009
2010	3,170,000	NA	365	OPEN	NA	3/1/2010	2/28/2011	12-in FL	3/1/2010	2/28/2010	15 pp/trip	3/1/2010	2/28/2010

Table 2.5.9 Continued Atlantic Migratory Group Spanish Mackerel Recreational Regulatory History prepared by: Christina Wiegand, SAFMC staff

Year	Quota (lbs ww)	ACL (lbs ww)	Days Open	Fishing Season	Reason for Closure	Season Start Date (first day implemented)	Season end Date (last day effective)	Size Limit	Size Limit Start Date	Size Limit End Date	Retention Limit (# fish)	Retention Limit Start Date	Retention Limit End Date
2011	3,170,000	NA	365	OPEN	NA	3/1/2011	2/29/2012	12-in FL	3/1/2011	2/28/2011	15 pp/trip	3/1/2011	2/28/2011
2012	SEE ACL	2,560,000	365	OPEN	NA	3/1/2012	2/28/2013	12-in FL	3/1/2012	2/29/2012	15 pp/trip	3/1/2012	2/29/2012
2013	SEE ACL	2,560,000	365	OPEN	NA	3/1/2013	2/28/2014	12-in FL	3/1/2013	2/28/2013	15 pp/trip	3/1/2013	2/28/2013
2014	SEE ACL	2,727,000	365	OPEN	NA	3/1/2014	2/28/2015	12-in FL	3/1/2014	2/28/2014	15 pp/trip	3/1/2014	2/28/2014
2015	SEE ACL	2,727,000	365	OPEN	NA	3/1/2015	2/29/2016	12-in FL	3/1/2015	2/28/2015	15 pp/trip	3/1/2015	2/28/2015
2016	SEE ACL	2,727,000	365	OPEN	NA	3/1/2016	2/28/2017	12-in FL	3/1/2016	2/29/2016	15 pp/trip	3/1/2016	2/29/2016
2017	SEE ACL	2,727,000	365	OPEN	NA	3/1/2017	2/28/2018	12-in FL	3/1/2017	2/28/2017	15 pp/trip	3/1/2017	2/28/2017
2018	SEE ACL	2,727,000	365	OPEN	NA	3/1/2018	2/28/2019	12-in FL	3/1/2018	2/28/2018	15 pp/trip	3/1/2018	2/28/2018
2019	SEE ACL	2,727,000	365	OPEN	NA	3/1/2019	2/29/2020	12-in FL	3/1/2019	2/28/2019	15 pp/trip	3/1/2019	2/28/2019

Notes:

1 Spanish mackerel managed as a single stock throughout the Gulf and South Atlantic.

2 Spanish mackerel managed as two migratory groups (Atlantic and Gulf migratory) from this point forward.

3 Management area extended from TX through NC to TX through NY.

a Stock quota

2.7 State Regulatory History

Provided by the Atlantic States Marine Fisheries Commission

Table 2.2a. State Regulatory History – North Carolina and South Carolina as provided by the state management agencies.

Description of Action	State	Effective Date
1500 pounds max per day, land and sell aggregate king and Spanish mackerel combined	NC	08/04/80
2000 pounds max per day, land and sell aggregate king and Spanish mackerel combined	NC	10/01/81
3500 pounds max per day, land and sell aggregate king and Spanish mackerel combined	NC	10/01/82
Proclamation authority established to specify areas, seasons, quantity, means/methods, size limits	NC	12/01/87
Creel limit: 10 fish/person/fishing trip by hook and line	NC	6/15/88
Creel limit: 10 fish/person/fishing trip by hook and line unless person is in possession of Federal Permit to fish on Spanish mackerel quota. Charter boats with federal Coastal migratory Charter Permit shall not exceed 10 fish per person with more than 3 person on board including captain and mate.	NC	6/22/88
All coastal waters closed to harvest and retention of king and Spanish mackerel taken by any method. Proclamation expires 3/31/89	NC	3/7/89
Creel limit: 10 fish/person/dishing trip by hook and line unless person is in possession of Federal Permit to fish on Spanish mackerel quota. Charter boats with federal Coastal migratory Charter Permit shall not exceed 10 fish per person with more than 3 person on board including captain and mate. Creel limits do not apply to commercial fishermen using nets. Proclamation expires 3/31/90	NC	5/9/89
Creel limit: 10 fish/person/dishing trip by hook and line unless person is in possession of Federal Permit to fish on Spanish mackerel quota. Charter boats with federal Coastal migratory Charter Permit shall not exceed 10 fish per person with more than 3 person on board including captain and mate. Creel limits do not apply to commercial fishermen using nets.	NC	4/1/90
It is unlawful to have a purse gill net on board a vessel when taking or landing Spanish or King Mackerel.	NC	1/1/91
Commercial season closes, reopens 4/1/92	NC	1/5/92

Table 2.2a. State Regulatory History – North Carolina and South Carolina as provided by the state management agencies. Continued

12 inch FL minimum size.	NC	2/15/94
Creel limit: 10 fish/person/dishing trip by hook and line unless person is in possession of Federal Permit to fish on Spanish mackerel quota. Charter boats with federal Coastal migratory Charter Permit shall not exceed 10 fish per person with more than 3 person on board including captain and mate. Creel limits do not apply to commercial fishermen using nets except as specified by NCAC 3M/.0301.	NC	2/15/94
Proclamation authority for hook and line deleted. Entered into rule: Creel limit: 10 fish/person/dishing trip by hook and line unless person is in possession of Federal Permit to fish on Spanish mackerel quota. Charter boats with federal Coastal migratory Charter Permit shall not exceed 10 fish per person with more than 3 person on board including captain and mate	NC	3/1/96
Temporary rule change: Recreational purpose wording added and commercial gear working changed to commercial fishing operation. 12 inch minimum size Creel limit: 10 fish per person per day if taken by hook & line or for recreational purpose Holders of valid federal permits may exceed creel limit. Charterboats with valid federal permits shall not exceed 10 fish per person while fishing with more than 3 persons on board including captain and mate.	NC	7/1/99
It is unlawful to possess more than 15 Spanish mackerel per person per day taken for recreational purposes. It is unlawful to possess more than 15 Spanish mackerel per person per day in the Atlantic Ocean beyond three miles in a commercial fishing operation except for persons holding a valid National Marine Fisheries Service Spanish Mackerel Commercial Vessel Permit.	NC	4/1/01
Full consistency with federal regulations	SC	06/88-2007

Table 2.2b. State Regulatory History - North Carolina through Florida for Spanish mackerel as of 1990 as recorded in the Fishery Management Plan for Spanish Mackerel, Fishery Management Report No. 18, Atlantic States Marine Fisheries Commission, November 1990.

State	Bag Limit	Size Limit	Other
NC	10 fish	none	3,500 lb commercial trip limit
SC	10 fish	12" FL min.	Season closes with EEZ closure
GA	10 fish	12" FL min.	Recreational season open 3/16-11/30; 5% size tolerance by weight on trawlers
FL	5 fish	12" FL min.	1,850,000 lb quota for power assisted gill nets; season: Dec 15-Oct31. 205,000lb quota for all other forms of commercial fishing gears; season: Nov 1-Oct 31. 3 1/2 inch minimum stretched mesh.

Table 2.2c. State Regulatory History - New York through Florida, for Spanish Mackerel at specific times as taken from annual ASMFC FMP Reviews for Spanish Mackerel.

As of December 1995

State	Bag Limit	Size Limit	Other
NJ	10 fish	14" TL min.	
DE	10 fish	14" TL min.	
MD	10 fish	14" TL min.	Declaration allowing regulation through framework. Gill net mesh sizes for Chesapeake Bay.
VA	10 fish	14" TL min.	Size limit exemption for pound net fishery; closure when quota reached; 3500 lb trip limit.
NC	10 fish	12" FL min.	3,500 lb commercial trip limit (Spanish and king mackerel combined); finfish excluder devices required in shrimp trawls. Purse gill net prohibition.
SC	10 fish	12" FL min.	3,500 lb commercial trip limit tracking by reference the federal FMP.
GA	10 fish	12" FL min.	Season closed December 1 - March 15.
FL	10 fish	12" FL min.	3 1/2 inch minimum mesh size, 600 yd. maximum length net. Commercial daily trip limits: 1,500 lb April 1 - November 30; December 1 until 75% of adjusted quota reached-unlimited harvest on Monday, Wednesday, and Friday; 1,500 lb per vessel per day on Tuesday and Thursday; 500 lb per vessel per day on Saturday and Sunday; >75% adjusted quota until quota fulfilled-1,000 lb per vessel per day; >100% of adjusted quota-500 lb per vessel per day.

As of September 1998

State	Bag Limit	Size Limit	Other
NY	10 fish	14" TL min.	3,500 lb. commercial trip limit
NJ	10 fish	14" TL min	
DE	10 fish	14" TL min	
MD	10 fish	14" TL min	Declaration allowing regulation through framework. Gill net mesh sizes for Chesapeake Bay
VA	10 fish	14" TL min	Size limit exemption for pound net fishery; closure when quota reached; 3,500 lb. trip limit
NC	10 fish	12" FL min	3,500 lb. commercial trip limit (Spanish and king mackerel combined); finfish excluder devices required in shrimp trawls. Purse gill net prohibition.
SC	10 fish	12" FL min	3,500 lb. commercial trip limit tracking by reference the federal FMP.
GA	10 fish	12" FL min	Season closed December 1 - March 15.
FL	10 fish	12" FL min	3½ " minimum mesh size, 600 yd. maximum length net. Commercial daily trip limits: 1,500 lb. April 1 - November 30; December 1 until 75% of adjusted quota reached - unlimited harvest on Monday, Wednesday and Friday; 1,500 lb. per vessel per day on Tuesday and Thursday; 500 lb. per vessel on Saturday and Sunday; >75% adjusted quota until quota filled - 1,500 lb. per vessel per day; > 100%of adjusted quota - 500 lb. per vessel per day.

As of October 2001

State	Recreational	Commercial	Notes
NY	14"; 15 fish	14"	3,500 lb. commercial possession limit/vessel
NJ	14"; 10 fish	14" TL	
DE	14" TL; 10 fish	no fishery	
MD	14"; 15 fish	14"	Declaration allowing regulation through framework; gill net mesh sizes for Chesapeake Bay
PRFC	14"; 15 fish	14"	
VA	14" TL; 15 fish	14" TL	Size limit exemption for pound net fishery; closure when quota reached; 3,500 lb. trip limit
NC	12" FL; 15 fish	12" FL	3,500 lb. commercial trip limit (Spanish and king mackerel combined); finfish excluder devices required in shrimp trawls. Purse gill net prohibition.
SC	12" FL; 15 fish	12" FL	Federal commercial harvest restrictions apply; federal permit required to exceed bag limit; state license required to land/sell.
GA	12" FL; 15 fish	12" FL	Commercial landings from state waters limited to bag limits; gillnets/longline gear prohibited in state waters; state waters closed December 1 - March 15 for harvest of Spanish mackerel; commercial landings (3,500 lb. trip limit) from EEZ by federally permitted vessels allowed throughout year as long as the federal quota remains open.
FL	12" FL; 15 fish	12" FL	3½ " minimum mesh size, 600 yd. maximum length net; Commercial daily trip limits: 1,500 lb. April 1 - November 30; December 1 until 75% of adjusted quota reached - unlimited harvest Mon-Fri, 1,500 lb. per vessel/day Sat- Sun; >75% adjusted quota until quota filled - 1,500 lb. per vessel/day; > 100% of adjusted quota - 500 lb. per vessel/day.

As of October 2002

State	Recreational	Commercial	Notes
NY	14"; 15 fish	14"	3,500 lb. commercial possession limit/vessel
NJ	14"; 10 fish	14" TL	
DE	14" TL; 10 fish	no fishery	
MD	14"; 15 fish	14"	Declaration allowing regulation through framework; gill net mesh sizes for Chesapeake Bay
PRFC	14"; 15 fish	14"	
VA	14" TL; 15 fish	14" TL	Size limit exemption for pound net fishery; closure when quota reached; 3,500 lb. trip limit
NC	12" FL; 15 fish	12" FL	3,500 lb. commercial trip limit (Spanish and king mackerel combined); finfish excluder devices required in shrimp trawls. Purse gill net prohibition.
SC	12" FL; 15 fish	12" FL	Federal commercial harvest restrictions apply; federal permit required to exceed bag limit; state license required to land/sell.
GA	12" FL; 15 fish	12" FL	Commercial landings from state waters limited to bag limits; gillnets/longline gear prohibited in state waters; state waters closed December 1 - March 15 for harvest of Spanish mackerel; commercial landings (3,500 lb. trip limit) from EEZ by federally permitted vessels allowed throughout year as long as the federal quota remains open.
FL	12" FL; 15 fish	12" FL	3½ “ minimum mesh size, 600 yd. maximum length net; Commercial daily trip limits: 1,500 lb. April 1 - November 30; December 1 until 75% of adjusted quota reached - unlimited harvest Mon-Fri, 1,500 lb. per vessel/day Sat- Sun; >75% adjusted quota until quota filled - 1,500 lb. per vessel/day; > 100% of adjusted quota - 500 lb. per vessel/day.

As of October 2004

State	Recreational	Commercial	Notes
NY	14"; 15 fish	14"	3,500 lb. commercial possession limit/vessel
NJ	14"; 10 fish	14" TL	
DE	14" TL; 10 fish	no fishery	
MD	14"; 15 fish	14"	Declaration allowing regulation through framework; gill net mesh sizes for Chesapeake Bay
PRFC	14"; 15 fish	14"	
VA	14" TL; 15 fish	14" TL	Size limit exemption for pound net fishery; closure when quota reached; 3,500 lb. trip limit
NC	12" FL; 15 fish	12" FL	3,500 lb. commercial trip limit (Spanish and king mackerel combined); finfish excluder devices required in shrimp trawls. Purse gill net prohibition.
SC	12" FL; 15 fish	12" FL	Federal commercial harvest restrictions apply; federal permit required to exceed bag limit; state license required to land/sell.
GA	12" FL; 15 fish	12" FL	Commercial landings from state waters limited to bag limits; gillnets/longline gear prohibited in state waters; state waters closed December 1 - March 15 for harvest of Spanish mackerel; commercial landings (3,500 lb. trip limit) from EEZ by federally permitted vessels allowed throughout year as long as the federal quota remains open.
FL	12" FL; 15 fish	12" FL	3½ " minimum mesh size, 600 yd. maximum length net; Commercial daily trip limits: 1,500 lb. April 1 - November 30; December 1 until 75% of adjusted quota reached - unlimited harvest Mon-Fri, 1,500 lb. per vessel/day Sat- Sun; >75% adjusted quota until quota filled - 1,500 lb. per vessel/day; > 100% of adjusted quota - 500 lb. per vessel/day.

As of October 2005

State	Recreational	Commercial	Notes
NY	14" TL; 15 fish	14" TL	3,500 lb. commercial possession limit/vessel
NJ	14" TL; 10 fish	14" TL	
DE	14" TL; 10 fish	14" TL	Gill net and drift net restrictions
MD	14" TL; 15 fish	14" TL	Declaration allowing regulation through framework; gill net mesh sizes for Chesapeake Bay
PRFC	14" TL; 15 fish	14" TL	Closure when quota reached
VA	14" TL; 15 fish	14" TL	Size limit exemption for pound net fishery; closure when quota reached; 3,500 lb. trip limit
NC	12" FL; 15 fish	12" FL	3,500 lb. commercial trip limit (Spanish and king mackerel combined); finfish excluder devices required in shrimp trawls. Purse gill net prohibition.
SC	12" FL; 15 fish	12" FL	Federal commercial harvest restrictions apply; federal permit required to exceed bag limit; state license required to land/sell.
GA	12" FL; 15 fish	12" FL	Commercial landings from state waters limited to bag limits; gillnets/longline gear prohibited in state waters; state waters closed December 1 - March 15 for harvest of Spanish mackerel; commercial landings (3,500 lb. trip limit) from EEZ by federally permitted vessels allowed throughout year as long as the federal quota remains open.
FL	12" FL; 15 fish Transfer at sea prohibited.	12" FL	3½ " minimum mesh size, 600 yd. maximum length net. Commercial daily trip limits: 3,500 lb. April 1 - November 30; December 1 until 75% of adjusted quota reached - 3,500 lb. per vessel/day Mon-Fri, 1,500 lb. per vessel/day Sat-Sun; >75% adjusted quota until quota filled - 1,500 lb. per vessel/day; > 100% of adjusted quota - 500 lb. per vessel/day.

All information included in the following tables are pulled from annual state FMP compliance reports (NY-FL), and reported in annual ASMFC FMP Reviews for Spanish Mackerel.

As of 2006

Notes: commercial license required to sell Spanish mackerel in all states; other general gear restrictions apply to the harvest of Spanish mackerel.

State	Recreational	Commercial
NY	14" TL, 15 fish	14" TL. 3,500 lb. trip limit
NJ	14" TL, 10 fish	14" TL.
DE	14" TL, 10 fish	14" TL.
MD	14" TL, 15 fish	14" TL.
PRFC	14" TL, 15 fish	14" TL. Closure when quota reached.
VA	14" TL, 15 fish	14" TL; size limit exemption for pound net fishery. 3,500 lb. trip limit. Closure when quota reached.
NC	12" FL, 15 fish	12" FL. 3,500 lb. trip limit (Spanish and king mackerel combined). Purse gill nets prohibited.
SC	12" FL, 15 fish	12" FL, 15 fish
GA	12" FL, 15 fish	12" FL. State waters: 15 fish limit, closure from December 1 - March 15. 3,500 trip limit in federal waters. Closure when quota reached.
FL	12" FL, 15 fish	12" FL. Trip limits: April 1 – Nov. 30 - 3,500 lb.; Dec. 1 until 75% of adjusted quota reached - 3,500 lb. Mon-Fri. & 1,500 lb. Sat-Sun; >75% adjusted quota until quota filled -1,500 lb.; > 100% of adjusted quota - 500 lb.

As of 2007

Note: commercial license required to sell Spanish mackerel in all states; other general gear restrictions effect the harvest of Spanish mackerel		
State	**Recreational**	**Commercial**
NY	14" TL, 15 fish	14" TL. 3,500 lb trip limit
NJ	14" TL, 10 fish	14" TL.
DE	14" TL, 10 fish	14" TL.
MD	14" TL, 15 fish	14" TL.
PRFC	14" TL, 15 fish	14" TL. Closure if/when federal waters close.
VA	14" TL, 15 fish	14" TL. 3,500 lb trip limit. Closure if/when federal waters close.
NC	12" FL, 15 fish	12" FL. 3,500 lb trip limit (Spanish and king mackerel combined). Purse gill nets prohibited.
SC	12" FL, 15 fish	12" FL. 15 fish. Closure if/when federal waters close.
GA	12" FL, 15 fish	12" FL. 15 fish. Closure from December 1 - March 15.
FL	12" FL, 15 fish. Transfer to other vessels at sea is prohibited.	12" FL. Trip limits: April 1 – Nov. 30 - 3,500 lb; Dec. 1 until 75% of adjusted quota reached - unlimited Mon-Fri. & 1,500 lb Sat-Sun; >75% adjusted quota until quota filled -1,500 lb; > 100% of adjusted quota - 500 lb.

As of 2008

Note: commercial license required to sell Spanish mackerel in all states; other general gear restrictions effect the harvest of Spanish mackerel		
State	**Recreational**	**Commercial**
NY	14" TL, 15 fish	14" TL. 3,500 lb trip limit
NJ	14" TL, 10 fish	14" TL.
DE	14" TL, 10 fish	14" TL.
MD	14" TL, 15 fish	14" TL.
PRFC	14" TL, 15 fish	14" TL. Closure if/when federal waters close.
VA	14" TL, 15 fish	14" TL. 3,500 lb trip limit. Closure if/when federal waters close.
NC	12" FL, 15 fish	12" FL. 3,500 lb trip limit (Spanish and king mackerel combined). Purse gill nets prohibited.
SC	12" FL, 15 fish	12" FL. 15 fish. Closure if/when federal waters close.
GA	12" FL, 15 fish	12" FL. 15 fish. Closure from December 1 - March 15.
FL	12" FL, 15 fish. Transfer to other vessels at sea is prohibited.	12" FL. Trip limits: April 1 to Nov. 30 - 3500 lb; Dec. 1 until 75% of adjusted quota reached - 3500 lb Mon-Fri. & 1500 lb Sat-Sun; >75% adjusted quota until quota filled -1500 lb; > 100% of adjusted quota - 500 lb.

As of 2009

<table>
<tr><td colspan="3">Note: commercial license required to sell Spanish mackerel in all states; other general gear restrictions effect the harvest of Spanish mackerel</td></tr>
<tr><th>State</th><th>Recreational</th><th>Commercial</th></tr>
<tr><td>NY</td><td>14" TL, 15 fish</td><td>14" TL. 3,500 lb trip limit</td></tr>
<tr><td>NJ</td><td>14" TL, 10 fish</td><td>14" TL.</td></tr>
<tr><td>DE</td><td>14" TL, 10 fish</td><td>14" TL.</td></tr>
<tr><td>MD</td><td>14" TL, 15 fish</td><td>14" TL.</td></tr>
<tr><td>PRFC</td><td>14" TL, 15 fish</td><td>14" TL. Closure if/when federal waters close.</td></tr>
<tr><td>VA</td><td>14" TL, 15 fish</td><td>14" TL. 3,500 lb trip limit. Closure if/when federal waters close.</td></tr>
<tr><td>NC</td><td>12" FL, 15 fish</td><td>12" FL. 3,500 lb trip limit (Spanish and king mackerel combined). Purse gill nets prohibited.</td></tr>
<tr><td>SC</td><td>12" FL, 15 fish</td><td>12" FL. 15 fish. Closure if/when federal waters close.</td></tr>
<tr><td>GA</td><td>12" FL, 15 fish</td><td>12" FL. 15 fish. Closure from December 1 - March 15.</td></tr>
<tr><td rowspan="4">FL</td><td>12" FL, 15 fish. Transfer to other vessels at sea is prohibited.</td><td>12" FL. Trip limits: April 1 until Nov. 30 - 3500 lb; Dec. 1 until 75% of adjusted quota reached – 3500 lb Mon-Fri. & 1500 lb Sat-Sun; >75% adjusted quota until quota filled -1500 lb; > 100% of adjusted quota - 500 lb.</td></tr>
<tr><td>Cast nets less than 14’ and beach or haul seines with no greater than 2” stretched mesh allowed</td><td>Restricted Species Endorsement Required</td></tr>
<tr><td></td><td>Transfer of fish between vessels prohibited</td></tr>
<tr><td></td><td>Allowed gear: beach or haul seine, cast net, hook and line, or spearing</td></tr>
</table>

During the years 2010 and 2011 no FMP reviews were produced. All management changes were captured in the subsequent 2012 report

As of 2010

<table>
<tr><td colspan="3">Note: commercial license required to sell Spanish mackerel in all states; other general gear restrictions effect the harvest of Spanish mackerel</td></tr>
<tr><th>State</th><th>Recreational</th><th>Commercial</th></tr>
<tr><td>NY</td><td>14" TL, 15 fish</td><td>14" TL. 3,500 lb trip limit</td></tr>
<tr><td>NJ</td><td>14" TL, 10 fish</td><td>14" TL.</td></tr>
<tr><td>DE</td><td>14" TL, 10 fish</td><td>14" TL.</td></tr>
<tr><td>MD</td><td>14" TL, 15 fish</td><td>14" TL.</td></tr>
<tr><td>PRFC</td><td>14" TL, 15 fish</td><td>14" TL. Closure if/when federal waters close.</td></tr>
<tr><td>VA</td><td>14" TL, 15 fish</td><td>14" TL. 3,500 lb trip limit. Closure if/when federal waters close.</td></tr>
<tr><td>NC</td><td>12" FL, 15 fish</td><td>12" FL. 3,500 lb trip limit (Spanish and king mackerel combined). Purse gill nets prohibited.</td></tr>
<tr><td>SC</td><td>12" FL, 15 fish</td><td>12" FL. 15 fish. Closure if/when federal waters close.</td></tr>
<tr><td>GA</td><td>12" FL, 15 fish</td><td>12" FL. 15 fish. Closure from December 1 - March 15.</td></tr>
<tr><td>FL</td><td>12" FL, 15 fish. Transfer to other vessels at sea is prohibited.</td><td>12" FL. Trip limits: April 1 to Nov. 30 - 3500 lb; Dec. 1 until 75% of adjusted quota reached - 3500 lb Mon-Fri. & 1500 lb Sat-Sun; >75% adjusted quota until quota filled -1500 lb; > 100% of adjusted quota - 500 lb.</td></tr>
</table>

As of 2011

Note: commercial license required to sell Spanish mackerel in all states; other general gear restrictions effect the harvest of Spanish mackerel		
State	**Recreational**	**Commercial**
NY	14" TL, 15 fish	14" TL. 3,500 lb trip limit
NJ	14" TL, 10 fish	14" TL.
DE	14" TL, 10 fish	14" TL.
MD	14" TL, 15 fish	14" TL.
PRFC	14" TL, 15 fish	14" TL. Closure if/when federal waters close.
VA	14" TL, 15 fish	14" TL. 3,500 lb trip limit. Closure if/when federal waters close.
NC	12" FL, 15 fish	12" FL. 3,500 lb trip limit (Spanish and king mackerel combined). Purse gill nets prohibited.
SC	12" FL, 15 fish	12" FL. 15 fish. Closure if/when federal waters close.
GA	12" FL, 15 fish	12" FL. 15 fish. Closure from December 1 - March 15.
FL	12" FL, 15 fish. Transfer to other vessels at sea is prohibited.	12" FL. Trip limits: April 1 to Nov. 30 - 3500 lb; Dec. 1 until 75% of adjusted quota reached - 3500 lb Mon-Fri. & 1500 lb Sat-Sun; >75% adjusted quota until quota filled -1500 lb; > 100% of adjusted quota - 500 lb.

As of 2012

Note: commercial license required to sell Spanish mackerel in all states; other general gear restrictions effect the harvest of Spanish mackerel		
State	**Recreational**	**Commercial**
NY	14" TL, 15 fish	14" TL. 3,500 lb trip limit
NJ	14" TL, 10 fish	14" TL.
DE	14" TL, 15 fish	14" TL.
MD	14" TL, 15 fish	14" TL.
PRFC	14" TL, 15 fish	14" TL. Closure if/when federal waters close.
VA	14" TL, 15 fish	14" TL. 3,500 lb trip limit. Closure if/when federal waters close.
NC	12" FL, 15 fish	12" FL. 3,500 lb trip limit (Spanish and king mackerel combined). Purse gill nets prohibited.
SC	12" FL, 15 fish	12" FL. 15 fish. Closure if/when federal waters close.
GA	12" FL, 15 fish	12" FL. 15 fish. Closure from December 1 - March 15.
FL	12" FL, 15 fish. Transfer to other vessels at sea is prohibited. Cast nets less than 14' and beach or haul seines with no greater than 2" stretched mesh allowed	12" FL. Trip limits: April 1 to Nov. 30 - 3500 lb; Dec. 1 until 75% of adjusted quota reached - 3500 lb Mon-Fri. & 1500 lb Sat-Sun; >75% adjusted quota until quota filled -1500 lb; > 100% of adjusted quota - 500 lb. Restricted species endorsement required. Transfer between vessels prohibited. Allowed gear: beach or haul seine, cast net, hook and line, or spearing.

As of 2013

<table>
<tr><td colspan="3">Note: commercial license required to sell Spanish mackerel in all states; other general gear restrictions effect the harvest of Spanish mackerel</td></tr>
<tr><th>State</th><th>Recreational</th><th>Commercial</th></tr>
<tr><td>NY</td><td>14" TL, 15 fish</td><td>14" TL. 3,500 lb trip limit</td></tr>
<tr><td>NJ</td><td>14" TL, 10 fish</td><td>14" TL.</td></tr>
<tr><td>DE</td><td>14" TL, 10 fish</td><td>14" TL.</td></tr>
<tr><td>MD</td><td>14" TL, 15 fish</td><td>14" TL. 3,500 lb trip limit</td></tr>
<tr><td>PRFC</td><td>14" TL, 15 fish</td><td>14" TL. Closure if/when federal waters close.</td></tr>
<tr><td>VA</td><td>14" TL, 15 fish</td><td>14" TL. 3,500 lb trip limit. Closure if/when federal waters close.</td></tr>
<tr><td>NC</td><td>12" FL, 15 fish</td><td>12" FL. 3,500 lb trip limit (Spanish and king mackerel combined). Purse gill nets prohibited. 11½” FL for pound net fishery during August and September.</td></tr>
<tr><td>SC</td><td>12" FL, 15 fish</td><td>12" FL. 15 fish. Closure if/when federal waters close.</td></tr>
<tr><td>GA</td><td>12" FL, 15 fish</td><td>12" FL. 15 fish. Closure from December 1 - March 15.</td></tr>
<tr><td rowspan="4">FL</td><td>12" FL, 15 fish. Transfer to other vessels at sea is prohibited.</td><td>12" FL. Trip limits: April 1 until Nov. 30 - 3500 lb; Dec. 1 until 75% of adjusted quota reached – 3500 lb Mon-Fri. & 1500 lb Sat-Sun; >75% adjusted quota until quota filled - 1500 lb; > 100% of adjusted quota - 500 lb.</td></tr>
<tr><td>Cast nets less than 14’ and beach or haul seines with no greater than 2” stretched mesh allowed</td><td>Restricted Species Endorsement Required</td></tr>
<tr><td></td><td>Transfer of fish between vessels prohibited</td></tr>
<tr><td></td><td>Allowed gear: beach or haul seine, cast net, hook and line, or spearing</td></tr>
</table>

As of 2014

Note: commercial license required to sell Spanish mackerel in all states; other general gear restrictions effect the harvest of Spanish mackerel			
State	**Recreational**	**Commercial**	**Regulation Changes**
NY	14" TL, 15 fish	14" TL. 3,500 lb trip limit	
NJ	14" TL, 10 fish	14" TL.	
DE	14" TL, 15 fish	14" TL. 3,500 lb trip limit	
MD	14" TL, 15 fish	14" TL. 3,500 lb trip limit	
PRFC	14" TL, 15 fish	14" TL. Closure if/when federal waters close.	
VA	14" TL, 15 fish	14" TL. 3,500 lb trip limit. Closure if/when federal waters close.	
NC	12" FL, 15 fish	12" FL. 3,500 lb trip limit (Spanish and king mackerel combined). Purse gill nets prohibited. 11½" FL for pound net fishery July 3-Sept 30.	
SC	12" FL, 15 fish	12" FL. 15 fish. Closure if/when federal waters close.	
GA	12" FL, 15 fish	12" FL. 15 fish.	As of January 1, 2014, Spanish Mackerel no longer have a fishing season. Size and bag limits will stay the same.
FL	12" FL, 15 fish. Transfer to other vessels at sea is prohibited.	12" FL. Trip limits: April 1 until Nov. 30 - 3500 lb; Dec. 1 until 75% of adjusted quota reached – 3500 lb Mon-Fri. & 1500 lb Sat-Sun; >75% adjusted quota until quota filled -1500 lb; > 100% of adjusted quota - 500 lb.	Effective October 12, 2015:
	Cast nets less than 14’ and beach or haul seines with no greater than 2” stretched mesh allowed	Restricted Species Endorsement Required	68B-23.006 Other Prohibitions.
		Transfer of fish between vessels prohibited	(1) It is unlawful for any person to possess, transport, buy, sell, exchange or attempt to buy, sell or exchange any Spanish Mackerel harvested in violation of this chapter.
		Allowed gear: beach or haul seine, cast net, hook and line, or spearing	(2) The Commission shall issue a permit pursuant to Rule 68B-2.010, F.A.C., to authorize Spanish Mackerel caught in an organized tournament to be donated to a licensed wholesale dealer.
			(3) The prohibitions of this chapter apply as well to any and all persons operating a vessel in state waters, who shall be deemed to have violated any prohibition which has been violated by another person aboard such vessel.

As of 2015

Note: commercial license required to sell Spanish mackerel in all states; other general gear restrictions effect the harvest of Spanish mackerel			
State	**Recreational**	**Commercial**	**Regulation Changes**
NY	14" TL, 15 fish	14" TL. 3,500 lb trip limit.	*North Carolina*
NJ	14" TL, 10 fish	14" TL. 3,500 lb trip limit.	One proclamation was issued under rule 15A NCAC 03M .0512 to remain in compliance with the Atlantic States Marine Fishery Commission. Addendum I to the Omnibus Amendment establishes a pilot program that would allow states to reduce the Spanish mackerel minimum size limit for the commercial pound net fishery to 11 ½ inches during the summer months of July through September. The measure is intended to reduce waste of these shorter fish, which are discarded dead in the summer months, by converting them to landed fish that will be counted against the quota. The Division issued a proclamation suspending the 12-inch fork length size limit and adopting the 11 ½ inch fork length size limit in the commercial pound net fishery from July 4, 2016 to September 30, 2016.
DE	14" TL, 15 fish	14" TL. 3,500 lb trip limit.	
MD	14" TL, 15 fish	14" TL. 3,500 lb trip limit. March-Feb.	
PRFC	14" TL, 15 fish	14" TL. Closure if/when MD and VA fisheries close.	
VA	14" TL, 15 fish	14" TL. 3,500 lb trip limit. Closure if/when federal waters close.	
NC	12" FL, 15 fish	12" FL; 11.5" FL in pound net fishery July 4th – Sept 30th, 2016. 3,500 lb trip limit for combined Spanish and king mackerel landings.	
SC	12" FL, 15 fish	12" FL. 15 fish. 3,500 lb trip limit. March-Feb. Closure if/when federal waters close.	
GA	12" FL, 15 fish	12" FL. 3,500 lb trip limit.	
FL	12" FL or 14" TL, 15 fish. Cast nets less than 14' and beach or haul seines within 2" stretched mesh allowed	12" FL or 14" TL. Trip limits: April 1 until Nov. 30 - 3500 lb; Dec. 1 until 75% of adjusted quota reached – 3500 lb Mon-Fri. & 1500 lb Sat-Sun; >75% adjusted quota until quota filled -1500 lb; > 100% of adjusted quota - 500 lb.	
		Restricted Species Endorsement Required	
		Allowed gear: beach or haul seine, cast net, hook and line, or spearing.	

As of 2016

Note: commercial license required to sell Spanish mackerel in all states; other general gear restrictions effect the harvest of Spanish mackerel

State	Recreational	Commercial	Regulation Changes
NY	14" TL, 15 fish	14" TL. 3,500 lb trip limit.	No state regulatory changes were reported for 2016. In 2017, Framework Amendment 5 to the Fishery Management Plan for Coastal Migratory Pelagics in the Gulf of Mexico and Atlantic Regions was approved by the SAFMC and GMFMC. This Framework Amendment allows commercially permitted vessels to operate as private recreational vessels when the commercial season is closed for Spanish or king mackerel.
NJ	14" TL, 10 fish	14" TL. 3,500 lb trip limit.	
DE	14" TL, 15 fish	14" TL. 3,500 lb trip limit.	
MD	14" TL, 15 fish	14" TL. 3,500 lb trip limit. March-Feb.	
PRFC	14" TL, 15 fish	14" TL. Closure if/when MD and VA fisheries close.	
VA	14" TL, 15 fish	14" TL. 3,500 lb trip limit. Closure if/when federal waters close.	
NC	12" FL, 15 fish	12" FL; 11.5" FL in pound net fishery July 4th – Sept 30th, 2016. 3,500 lb trip limit for combined Spanish and king mackerel landings.	
SC	12" FL, 15 fish	12" FL. 15 fish. 3,500 lb trip limit. March-Feb. Closure if/when federal waters close.	
GA	12" FL, 15 fish	12" FL. 3,500 lb trip limit.	
FL	12" FL or 14" TL, 15 fish. Cast nets less than 14' and beach or haul seines within 2" stretched mesh allowed	12" FL or 14" TL. Trip limits: April 1 until Nov. 30 - 3500 lb; Dec. 1 until 75% of adjusted quota reached – 3500 lb Mon-Fri. & 1500 lb Sat-Sun; >75% adjusted quota until quota filled - 1500 lb; > 100% of adjusted quota - 500 lb.	
		Restricted Species Endorsement Required	
		Allowed gear: beach or haul seine, cast net, hook and line, or spearing.	

As of 2017

Note: commercial license required to sell Spanish mackerel in all states; other general gear restrictions effect the harvest of Spanish mackerel			
State	**Recreational**	**Commercial**	**Regulation Changes**
NY	14" TL, 15 fish	14" TL. 3,500 lb trip limit.	No state regulatory changes were reported for 2017. In 2017, Framework Amendment 5 to the Fishery Management Plan for Coastal Migratory Pelagics in the Gulf of Mexico and Atlantic Regions was approved by the SAFMC and GMFMC. This Framework Amendment allows commercially permitted vessels to operate as private recreational vessels when the commercial season is closed for Spanish or king mackerel.
NJ	14" TL, 10 fish	14" TL. 3,500 lb trip limit.	
DE	14" TL, 15 fish	14" TL. 3,500 lb trip limit.	
MD	14" TL, 15 fish	14" TL. 3,500 lb trip limit. March-Feb.	
PRFC	14" TL, 15 fish	14" TL. Closure if/when MD and VA fisheries close.	
VA	14" TL, 15 fish	14" TL. 3,500 lb trip limit. Closure if/when federal waters close.	
NC	12" FL, 15 fish	12" FL; 11.5" FL in pound net fishery July 4th – Sept 30th, 2016. 3,500 lb trip limit for combined Spanish and king mackerel landings.	
SC	12" FL, 15 fish	12" FL. 15 fish. 3,500 lb trip limit. March-Feb. Closure if/when federal waters close.	
GA	12" FL, 15 fish	12" FL. 3,500 lb trip limit.	
FL	12" FL or 14" TL, 15 fish. Cast nets less than 14' and beach or haul seines within 2" stretched mesh allowed	12" FL or 14" TL. Trip limits: April 1 until Nov. 30 - 3500 lb; Dec. 1 until 75% of adjusted quota reached – 3500 lb Mon-Fri. & 1500 lb Sat-Sun; >75% adjusted quota until quota filled -1500 lb; > 100% of adjusted quota - 500 lb.	
		Restricted Species Endorsement Required	
		Allowed gear: beach or haul seine, cast net, hook and line, or spearing.	

As of 2018

Note: commercial license required to sell Spanish mackerel in all states; other general gear restrictions effect the harvest of Spanish mackerel			
State	**Recreational**	**Commercial**	Regulation Changes
NY	14" TL, 15 fish	14" TL. 3,500 lb trip limit.	
NJ	14" TL, 10 fish	14" TL. 3,500 lb trip limit.	
DE	14" TL, 15 fish	14" TL. 3,500 lb trip limit.	
MD	14" TL, 15 fish	14" TL. 3,500 lb trip limit. March-Feb.	
PRFC	14" TL, 15 fish	14" TL. Closure if/when MD and VA fisheries close.	
VA	14" TL, 15 fish	14" TL. 3,500 lb trip limit.	
NC	12" FL, 15 fish	12" FL; 11.5" FL in pound net fishery July 4th – Sept 30th, 2018. 3,500 lb trip limit for combined Spanish and king mackerel landings.	
SC	12" FL, 15 fish	12" FL. 15 fish. 3,500 lb trip limit. March-Feb. Closure if/when federal waters close.	
GA	12" FL, 15 fish	12" FL. 3,500 lb trip limit.	In 2018, Georgia implemented a new seafood dealer license (O.C.G.A. 27-2-23 and Board Rule 391-2-4-.09).
FL	12" FL or 14" TL, 15 fish. Cast nets less than 14' and beach or haul seines within 2" stretched mesh allowed	12" FL or 14" TL. Trip limits: April 1 until Nov. 30 – 3500 lb; Dec. 1 until 75% of adjusted quota reached – 3500 lb Monday – Friday & 1500 lb Saturday – Sunday; >75% adjusted quota until quota filled – 1500 lb; > 100% of adjusted quota – 500 lb.	
		Restricted Species Endorsement Required	
		Allowed gear: beach or haul seine, cast net, hook and line, or spearing.	

As of 2019

<table>
<tr><td colspan="4">Note: commercial license required to sell Spanish mackerel in all states; other general gear restrictions effect the harvest of Spanish mackerel</td></tr>
<tr><th>State</th><th>Recreational</th><th>Commercial</th><th>Regulation Changes</th></tr>
<tr><td>NY</td><td>14" TL, 15 fish</td><td>14" TL. 3,500 lb trip limit.</td><td></td></tr>
<tr><td>NJ</td><td>14" TL, 10 fish</td><td>14" TL. 3,500 lb trip limit.</td><td></td></tr>
<tr><td>DE</td><td>14" TL, 15 fish</td><td>14" TL. 3,500 lb trip limit.</td><td></td></tr>
<tr><td>MD</td><td>14" TL, 15 fish</td><td>14" TL. 3,500 lb trip limit. March-Feb.</td><td></td></tr>
<tr><td>PRFC</td><td>14" TL, 15 fish</td><td>14" TL. Closure if/when MD and VA fisheries close.</td><td></td></tr>
<tr><td>VA</td><td>14" TL, 15 fish</td><td>14" TL. 3,500 lb trip limit.</td><td>In 2019, Virginia proposed to amend state management of Spanish mackerel to close state waters if federal waters close, beginning in September, 2019.</td></tr>
<tr><td>NC</td><td>12" FL, 15 fish</td><td>12" FL; 11.5” FL in pound net fishery July 4th – Sept 30th, 2018. 3,500 lb trip limit for combined Spanish and king mackerel landings.</td><td>North Carolina discontinued its Addendum I program, which reduced the minimum size limit to 11.5 in FL for the pound net fishery from July to September, beginning in 2019.</td></tr>
<tr><td>SC</td><td>12" FL, 15 fish</td><td>12" FL. 15 fish. 3,500 lb trip limit. March-Feb. Closure if/when federal waters close.</td><td></td></tr>
<tr><td>GA</td><td>12" FL, 15 fish</td><td>12" FL. 3,500 lb trip limit.</td><td></td></tr>
<tr><td rowspan="3">FL</td><td rowspan="3">12" FL or 14” TL, 15 fish. Cast nets less than 14’ and beach or haul seines within 2” stretched mesh allowed</td><td>12" FL or 14” TL. Trip limits: April 1 until Nov. 30 – 3500 lb; Dec. 1 until 75% of adjusted quota reached – 3500 lb Monday – Friday & 1500 lb Saturday – Sunday; >75% adjusted quota until quota filled – 1500 lb; > 100% of adjusted quota – 500 lb.</td><td>In 2019, Florida approved a rule to align their state regulations with those of the federal FMP, incorporating the step-down reductions of the in-season vessel limit as threshold levels of Spanish mackerel are harvested. This rule took effect in September, 2019.</td></tr>
<tr><td>Restricted Species Endorsement Required</td><td></td></tr>
<tr><td>Allowed gear: beach or haul seine, cast net, hook and line, or spearing.</td><td></td></tr>
</table>

As of 2020

No management changes were reported in 2020

References

All information included in the previous tables were pulled from the annual state FMP compliance reports (NY-FL), and reported in annual ASMFC FMP Reviews for Spanish Mackerel.

3. Assessment History

Full stock assessments of the south Atlantic Spanish mackerel were conducted by Powers et al. (1996), Legault et al. (1998) and the Sustainable Fisheries Division (2003 and 2007). Historically, the Mackerel Stock Assessment Panel (MSAP) met regularly to oversee and review these assessments and provide advice to the SAFMC and GMFMC.

The most recent full stock assessment for south Atlantic Spanish mackerel was conducted in 2007 in SEDAR 17 using three separate models: ASPIC , BAM, and SRA. The SEDAR 17 Review Panel was presented with a base model using BAM, as neither ASPIC nor SRA were considered appropriate to produce standalone representations of the stock dynamics. The BAM was used with the following as input data: five fisheries and their corresponding age and length compositions, three fishery discard series, shrimp bycatch, seven fishery-dependent indices, two fishery-independent indices, one combined index and discard mortality rates. The base run was configured as a two sex model incorporating differences in growth by sex. Natural mortality was constant through time, but varied by age. The panel did not accept the base model of the assessment as appropriate for making biomass determinations. They concluded that there is an overall increasing trend in biomass, but that a biomass decline was observed from 2003 to 2007. The panel noted that the fishing mortality at the terminal year of the model (2007) did not seem to be inhibiting stock growth. Although the panel did not accept the model conclusions regarding biomass, they accepted model results that the stock was not undergoing overfishing. The panel remarked that the major issues with the assessment were the shrimp bycatch uncertainty, the historical recreational catch derivation, and the lack of an objective likelihood weighting method. The assessment previous to SEDAR 17 was in 2003 through the Mackerel Stock Assessment Panel (MSAP), which included data through the 2001/2002 fishing year (Sustainable Fisheries Division 2003). Estimated fishing mortality for Atlantic group Spanish mackerel was found to be below FMSY and FOY since 1995. Estimated stock abundance had increased since 1995 and was found to be at a high for the analysis period. Probabilities that the Spanish mackerel was overfished were less than 1% and that overfishing had occurred in the most recent fishing year of the assessment were 3%; therefore, the MSAP concluded that south Atlantic Spanish mackerel was not overfished and overfishing did not occur in 2002/2003.

SEDAR-28 (SEDAR-28, 2012) was a benchmark assessment using the Beaufort Assessment Model (BAM) with data through 2011. BAM is an integrated catch-age model, and is customizable to the multiple data sources available (Williams and Shertzer, 2015). A surplus production model implemented with the ASPIC software (Prager 1994, Prager 2004 was used as a complement for comparison purposes. Based on the assessment provided from the BAM, the Review Panel concluded that the stock was not overfished and not undergoing overfishing. The stock biomass status in the base run from the BAM was estimated to be SSB2011/MSST=2.29. The level of fishing (exploitation rate) was F2009-2011/FMSY = 0.526, with F2011/FMSY = 0.521. The qualitative results on terminal stock status were similar across presented sensitivity runs, indicating that the stock status results were robust given the provided data and can be used for management. The outcomes of sensitivity analyses done with BAM were in general agreement with those of the Monte Carlo Bootstrap Ensemble analysis (an additional way to examine uncertainty) in BAM. In general, stock status results from ASPIC were qualitatively similar to those from BAM.

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NMFS SEFSC Miami Sustainable Fisheries Division Contribution MIA-97/98-15.
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Sustainable Fisheries Division. 2003. Stock assessment analyses on Spanish and king mackerel stocks. NMFS SEFSC Miami Sustainable Fisheries Division Contribution SFD-2003-0008, 147 pp.

SEFSC Miami Sustainable Fisheries Division Contribution MIA-95/96-11.
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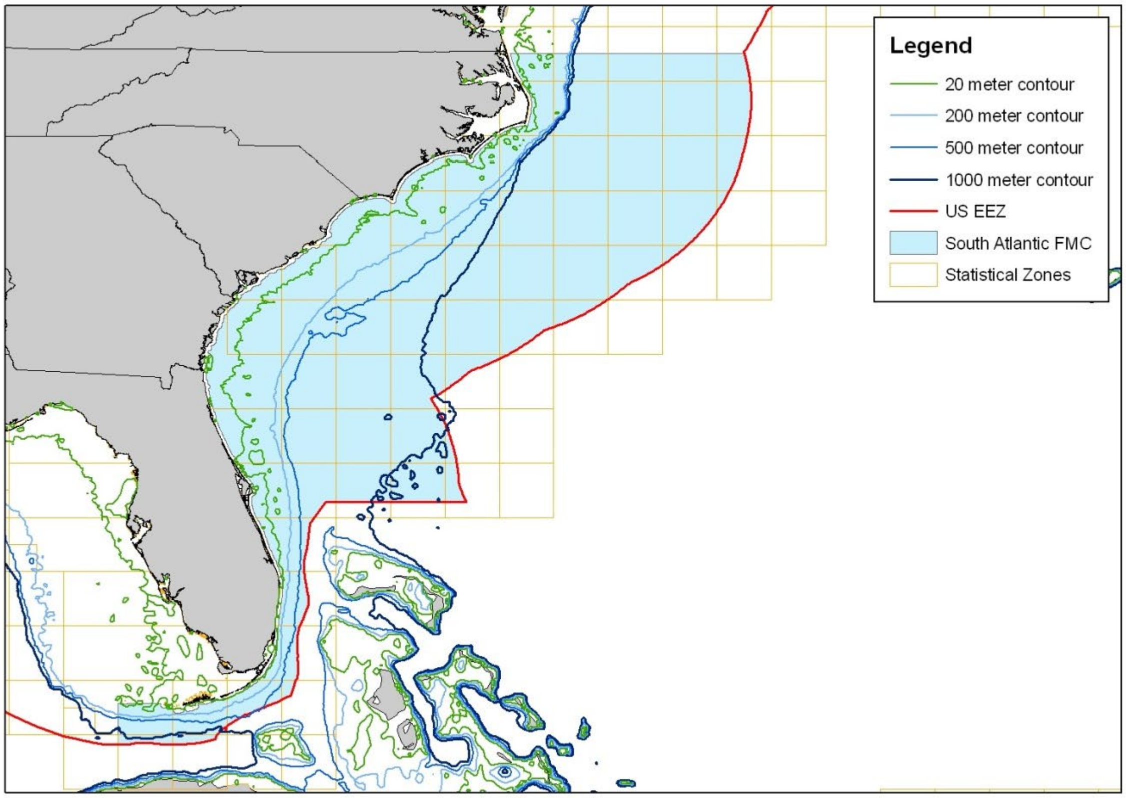
SEDAR. 2012. SEDAR 28 – South Atlantic Spanish mackerel Stock Assessment Report. SEDAR, North Charleston SC. 444 pp.

4. Regional Maps

Figure 3.1: 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 78

South Atlantic Spanish Mackerel

Section II: Assessment Report

May 2022

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

Document History

May, 2022 Original release.

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1.Introduction

This operational assessment evaluated the stock of Spanish mackerel (*Scomberomorus maculatus*) in the South Atlantic region of the southeastern United States. The primary objectives were to update and improve the 2012 SEDAR 28 benchmark assessment of and to conduct new stock projections. Using data through 2011, SEDAR 28 had indicated that the stock was not overfished and not undergoing overfishing. For this SEDAR 78 assessment, data compilation and assessment methods were guided by methodology of SEDAR 28, as well as by current SEDAR practices and recommendations by the SEDAR 28 review panel. The assessment period is 1986–2020.

Available data on this stock included indices of abundance, landings, discards, and samples of annual age compositions from fishery dependent sources. Three indices of abundance were fitted by the model: one from the Florida commercial trip tickets, one from the recreational MRIP intercepts for harvested fish, and one from the age-0 SEAMAP Coastal Trawl Survey. Data on landings and discards were modeled from five distinct fleets and two bycatch series: commercial handline, commercial gillnet, commercial pound net, commercial cast net, and general recreational (shore, private and charter modes) landings and discards.

The primary model used in SEDAR 28—and the one updated here—was the Beaufort Assessment Model (BAM), an integrated statistical catch-age formulation. A base run of BAM was configured to provide point estimates of key management quantities, such as stock and fishery status. Uncertainty in estimates from the base run was evaluated through a mixed Monte Carlo/Bootstrap Ensemble (MCBE) procedure. Median values from the uncertainty analysis are also provided. Sensitivity runs were developed to evaluate the model at the MCBE bounds for fixed natural mortality, steepness, and general recreational discard mortality parameters as well as exclusion of the commercial handline index.

The assessment estimated that spawning stock has fluctuated on a near-decadal cycle near or above the minimum stock size threshold (MSST) level. The base-run estimate of terminal (2020) spawning stock was above the MSST (SSB_{2020}/MSST = 1.40), as was the median estimate from the MCBE (SSB_{2020}/MSST = 1.42). The estimated fishing rate has been at or below the maximum fishing mortality threshold (MFMT), represented by F_{MSY} with the exception of the terminal year (2020). The terminal estimate, which is based on a three-year geometric mean, was below F_{MSY} in the base run ($F_{2018–2020}$/ F_{MSY} = 0.77) and in the median of the MCBE ($F_{2018–2020}$/ F_{MSY} = 0.74). Thus, this assessment indicated that the stock is not experiencing overfishing. However, this result requires caution: if the overfishing rate of 2020 continued in 2021, the geometric mean would indicate overfishing.

The MCBE analysis illustrated that these estimates of stock and fishery status are robust. Of all MCBE runs, 92.6% were in agreement that the stock is not overfished, and 90.0% were in agreement that overfishing is not occurring. Although qualitative results were robust, the primary sources of uncertainty in quantitative results (i.e., degree of overfishing or overfished) was natural mortality and steepness.

The estimated trends of this operational assessment were quite similar to those from the SEDAR28 benchmark. However, the two assessments did show some differences in results, which was not surprising given several modifications made to both the data and the model (described throughout the report). The two assessments showed similar stock status between 1986 and 2011, the terminal year of SEDAR28. Since then, SEDAR 78 indicated that the Spanish mackerel stock has fluctuated near the MSY reference point.

1.1 Workshop Time and Place

The SEDAR 78 South Atlantic Spanish Mackerel assessment took place over a series of webinars held from May 2021 to March 2022.

1.2 Terms of Reference

1. Update the approved SEDAR 28 Spanish Mackerel model with data through 2020. Apply the current BAM configuration incorporating approved improvements developed since SEDAR 28.
2. Evaluate and document the following specific changes in input data or deviations from the benchmark model.
   - Update growth and reproductive models if additional samples are available for fish below 275 mm
   - If available, include any improved information on steepness for similar pelagic species.
   - Evaluate data uncertainty with respect to the recreational landings
   - Calculate different F metrics (in addition to apical F) (to address shifts in the age of apical F towards the end of the assessment time series).
3. Document any changes or corrections made to model and input datasets and provide updated input data tables. Provide commercial and recreational landings and discards in pounds and numbers.
4. Update model parameter estimates and their variances, model uncertainties, estimates of stock status and management benchmarks, and provide the probability of overfishing occurring at specified future harvest and exploitation levels.
5. Convene a working group including SSC representatives to meet via webinar, as needed to review model development relative to terms of reference 1 through 4.
6. Develop a stock assessment report to address these ToRs and fully document the input data, methods, and results.

1.3 List of Participants

Appointee	Function	Affiliation
Rob Cheshire	Lead Analyst	SEFSC Beaufort
Matthew Vincent	Analytical Team	SEFSC Beaufort
Matt Nuttall	Analytical Team	SEFSC Miami
Kyle Shertzer	Analytical Team	SEFSC Beaufort
Chris Palmer	Analytical Team	SEFSC Panama City
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Ashley Pacicco	Analytical Team	SEFSC Panama City
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Refik Orhun	Analytical Team	SEFSC Miami
Kevin McCarthy	Analytical Team	SEFSC Miami
Eric Fitzpatrick	Data Compiler	SEFSC Beaufort
Mike Rinaldi	Panelist	ACCSP
Alan Bianchi	Panelist	NCDMF
Tracy Smart	Panelist	SCDNR
Amy Zimney	Panelist	SCDNR
Mclean Seward	Panelist	NCDMF
Dustin Addis	Panelist	SSC
Wilson Laney	Panelist	SSC
Fred Scharf	Panelist	SSC
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Thomas Newman	Observer	MCAP
Greg Peralta	Observer	MCAP
Appointed Council Members		
Tom Roller	Observer	MCAP AND SAFMC
Staff		
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Larry Beerkircher	Data Provider	SEFSC Miami
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Other		
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Chip Collier	Observer	SAFMC
Alan Lowther	Observer	NMFS
Beverly Barnett	Observer	NMFS
Brandon Foor	Observer	NMFS
Beverly Barnett	Observer	NMFS
Emilie Franke	Observer	ASMFC
Chris Swanson	Observer	FLFWC
Derek Cox	Observer	FLFWC
Elizabeth Gooding	Observer	SCDNR
Greg Peralta	Observer	Fisherman
Hannah Hart	Observer	FLFWC
Ira Laks	Observer	Fisherman
Jeff Pulver	Observer	NMFS
Jennifer Potts	Observer	NMFS
Julie Defilippi Simpson	Observer	ACCSP
Katie Drew	Observer	ASMFC
Rusty Hudson	Observer	Fisherman
Savannah Lewis	Observer	ASMFC
Scott Crosson	Observer	NMFS
Willow Patten	Observer	NCDMF

1.4 Document List

Document #	Title	Authors	Received
Documents Prepared for SEDAR 78			
SEDAR78-WP01	SEAMAP-SA Coastal Trawl Survey Data and Sample Collection Methods	Amy Zimney	7/29/2021
SEDAR78-WP02	Spanish Mackerel Indices of Abundance in U.S. South Atlantic Waters Based on the SEAMAP-SA Fishery-independent Coastal Trawl Survey	Tracey Smart and Amy Zimney	10/29/2021
SEDAR78-WP03	General Recreational Survey Data for Spanish Mackerel in the South Atlantic	Matt Nuttall	10/25/2021
SEDAR78-WP04	SEDAR 78 Spanish mackerel bycatch estimates from US Atlantic coast shrimp trawls	Eric Fitzpatrick	11/10/2021
SEDAR78-WP05	General recreational and commercial age and length composition weighting for Southeast U.S. Spanish mackerel (*Scomberomorus maculatus)*	Eric Fitzpatrick	11/10/2021
SEDAR78-WP06	Bycatch estimates of Spanish mackerel in the south Atlantic coastal gillnet fishery	John Carlson, Alyssa Mathers and Kevin McCarthy	10/28/2021
SEDAR78-WP07	Standardized Catch Rates of Spanish mackerel from the Southeast Coastal Gillnet Fishery	John Carlson and Alyssa Mathers	10/29/2021
SEDAR78-WP08	A Review of Atlantic Spanish mackerel (Scomberomorus maculatus) Age Data, 1986 – 2020, From Various Age-data Sources	Chris Palmer, Jennifer Potts, Beverly Barnett, and Rob Cheshire	10/29/2021
SEDAR78-WP09	Fishery-dependent CPUE index for Spanish mackerel derived from MRIP data	Katie Drew	10/29/2021
SEDAR78-WP10	Spanish Mackerel Length Frequency Distributions from At-Sea Headboat and Charter Observer Surveys in the South Atlantic, 2005 to 2020.	Dominique Lazarre Andrew Cathey and Kelly Fitzpatrick	11/3/2021

Document #	Title	Authors	Received
Documents Prepared for SEDAR 78 Cont.			
SEDAR78-WP11	Discards of Spanish Mackerel Calculated for Commercial Fishing Vessels with Federal Fishing Permits in the US South Atlantic	Kevin McCarthy and Jose Diaz	11/4/2021
SEDAR78-WP12	Annual indices of abundance of Spanish Mackerel from Florida commercial trip tickets, 1986-2020	Joe O'Hop and Steve Brown	11/12/2021
Final Assessment Report			
SEDAR78-SAR1	Assessment of South Atlantic Spanish Mackerel	To be prepared by SEDAR 78	May 2022

1.5 Statements Addressing Each Terms of Reference

Note: Original ToRs are in normal font. Statements addressing ToRs are in italics.

1. Update the approved SEDAR 28 Spanish mackerel model with data through 2020. Apply the current BAM configuration incorporating approved improvements developed since SEDAR 28.

SEDAR78 applied the current BAM configuration. The assessment model structure and data sources were very similar to those used in SEDAR28. Important modifications, such as selectivity functions were investigated through likelihood profiles and visual comparisons of model fit to the data. The decision to remove sex-specific growth and selectivity and modify the start year for the model were evaluated and shown to improve model performance.

2. Evaluate and document the following specific changes in input data or deviations from the benchmark model.

   - Update growth and reproductive models if additional samples are available for fish below 275 mm.
   - If available, include any improved information on steepness for similar pelagic species.
   - Evaluate data uncertainty with respect to the recreational landings.
   - Calculate different F metrics (in addition to apical F) (to address shifts in the age of apical F towards the end of the assessment time series).

All the above bullet points were addressed. Growth models were developed with increased age-0 samples primarily from the SEAMAP Coastal Trawl Survey. There was very limited reproduction information. There was no new information on steepness that could be applied in this assessment. Likelihood profiles on steepness had similar results to SEDAR28. Uncertainty in recreational landings was presented in the associated working paper. Years with large increases, such as 2020, were evaluated and discussed in greater detail. The spawning potential ratio conditional on annual F and exploitation rates were examined as additional F metrics.

3. Document any changes or corrections made to model and input datasets and provide updated input data tables. Provide commercial and recreational landings and discards in pounds and numbers.

Changes to data and model are documented in the report, along with tables of updated data input and removals in both pounds and numbers.

4. Update model parameter estimates and their variances, model uncertainties, estimates of stock status and management benchmarks, and provide the probability of overfishing occurring at specified future harvest and exploitation levels.

All of these key estimates and outputs are documented in the report.

5. Convene a working group including SAFMC Science and Statistical Committee representatives to meet via webinar, as needed to review model development relative to terms of reference 1 through 4.

The SEDAR78 panel did not suggest working groups were needed during model development.

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

Please see this report.

2 Data Review and Update

The input data for this assessment are described below, with focus on modifications from the SEDAR 28 benchmark assessment.

2.1 Data Review

In this operational assessment, the Beaufort assessment model (BAM) was fitted to data sources developed during the SEDAR 78 process, evaluated over several webinars. These data include updates to SEDAR 78 data, where appropriate, which are highlighted below.

Model inputs used in SEDAR 28 and SEDAR 78

- Life history: Meristics, population growth, fishery dependent size at age, female size at age, female maturity, proportion female, age-dependent natural mortality
- Landings and discards: Commercial handline, gillnet, pound net, and cast net combined landings and discards, shrimp bycatch, general recreational landings and discards
- Indices of abundance: Commercial handline, MRIP, SEAMAP YOY [1]
- Age compositions: Commercial handline, gillnet, pound net, and cast net landings, and general recreational landings
- Other: General recreational discard mortality

Updated data sources in SEDAR 78

- Life history: Population growth, fishery dependent size at age, female size at age, age-dependent natural mortality
- Landings and discards: Commercial handline, gillnet, pound net, and cast net combined landings and discards, shrimp bycatch, general recreational landings and discards
- Indices of abundance: Commercial handline, MRIP, SEAMAP YOY
- Age compositions: Commercial handline, gillnet, pound net, cast net, and general recreational

2.2 Data Update

2.3 Life History

A total of 32,348 (1986 — 2020) Spanish mackerel ages were prepared for SEDAR 78. Several data sources reevaluated age sample information for the entire time series. Gear identification was improved for some fishery dependent samples and deemed unreliable for others. In addition,many more YOY samples were collected since SEDAR 28 primarily from the SEAMAP Coastal Trawl Survey (see SCDNR sample sizes, mostly age–0 and age–1 fish, in (SEDAR78-WP08 2021)).

Estimates of the von Bertalanffy growth parameters updated for the population as a whole ($L_\infty = 582.5$ mm, $K = 0.6$ yr^{-1}, and $t_0 = -0.5$ yr), the female population ($L_\infty = 610.1$ mm, $K = 0.62$ yr^{-1}, and $t_0 = -0.5$ yr), and the fished

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

population ($L_\infty = 680.4$ mm, $K = 0.2$ yr^{-1}, and $t_0 = -2.77$ yr). For the population as a whole and the female population, the t_0 parameter was fixed, samples were weighted by the inverse of the number of samples at age, and a correction was applied for bias from fishery dependent samples (Diaz et al. 2004). Length at age for all growth models are given in Table 1.

Age–based (Lorenzen 1996) natural mortality estimates were updated using new population growth parameters for SEDAR 78. As in SEDAR28, the cumulative survival of age 2+ based on a point estimate of natural mortality, 0.35, was used to scale the age–based estimates of natural mortality (Table 1).

2.4 Landings

The fleet structure used in SEDAR 78 was the same as that of SEDAR 28, including commercial handline, gill net, cast net, pound net, and general recreational (including estimates of headboat and MRIP private, charter, and shore–based landings). General recreational landings and discards were estimated using the current MRIP methodology (SEDAR78-WP03 2021). The commercial estimated landings were input as whole pounds. The commercial "other" estimated landings were divided between commercial gears based on the annual proportion of each (Table 2). General recreational landings were input in numbers (thousands).

2.5 Discards and Bycatch

Discards were estimated for commercial gill net, handline, and trolling (included with handline) in numbers (SEDAR78-WP11 2021). The commercial discards were converted to pounds based on the average weight of fish less than the 12 inch size limit weighted by the observed proportion in the overall length composition. These minor removals were then combined with their respective catch time series. General recreational discards were estimated in numbers and were modeled separately as in SEDAR 28 (Table 2, SEDAR78-WP03 (2021)). Spanish mackerel are observed in the shrimp trawl fishery in the South Atlantic. Shrimp bycatch estimates were developed using methods consistent with SEDAR 28 (SEDAR78-WP04 2021). General recreational discards and shrimp bycatch were developed in numbers as input to the model (Table 2).

2.6 Indices of Abundance

Two fishery dependent indices and one fishery independent recruitment index were developed for SEDAR 78. The general recreational MRIP index and associated CVs for harvested fish were updated through 2020 (SEDAR78-WP09 2021). This index was later truncated to start in 1986 and renormalized to its mean to coincide with the start year of the model. An index from Florida commercial handline trip ticket records was developed (SEDAR78-WP12 2021). A recruitment index of age–0 fish from the SEAMAP Coastal Trawl Survey was formulated for 1989–2019 (SEDAR78-WP01 2021; SEDAR78-WP02 2021). All finalized indices for potential use in the Spanish mackerel stock assessment and associated CVs are in Table 3.

2.7 Length Composition

As in SEDAR 28, length data were not used to inform the model. However, length compositions can be used to remove bias in samples collected for age determination. Only the commercial gillnet collections had adequate samples to develop weighted length composition data (SEDAR78-WP05 2021). This composition was developed solely to weight the commercial gillnet age composition.

2.8 Age Composition

Age data were available from the commercial handline, pound net, gill net, cast net and general recreational sampling programs. Nominal age compositions were developed for Spanish mackerel except commercial gillnet which was weighted by the length composition (Chih 2009; SEDAR78-WP05 2021). Ages greater than 10 were pooled to age 10 creating a plus group (age 10+; Tables 4–8).

3 Stock Assessment Methods

3.1 Overview

This operational assessment updated the primary model applied in SEDAR28 (2012), an integrated model implemented using the BAM software (Williams and Shertzer 2015). BAM applies a statistical catch-age formulation, coded in AD Model Builder (Fournier et al. 2012). BAM is referred to as an integrated model because it uses multiple data sources relevant to population and fishery dynamics (e.g. removals, length and age compositions, and indices of abundance) in a single framework. In essence, the catch-age model simulates a population forward in time while including fishing processes (Quinn and Deriso 1999; Shertzer et al. 2008). The model is similar in structure to Stock Synthesis (Methot and Wetzel 2013) and other stock assessment models used in the United States (Dichmont et al. 2016; Li et al. 2021). Versions of BAM have been used in previous SEDAR assessments of reef fishes in the U.S. South Atlantic, such as black sea bass, blueline tilefish, gag, greater amberjack, red grouper, red porgy, snowy grouper, tilefish, and vermilion snapper, as well as in the previous SEDAR assessments of Spanish mackerel (SEDAR17 2008; SEDAR28 2012). The primary model in this assessment was a statistical catch-age model (Quinn and Deriso 1999), implemented with the AD Model Builder software (ADMB Foundation 2012). Statistical catch-age models share many attributes with ADAPT-style tuned and untuned VPAs.

3.2 Data Sources

The catch-age model was fit to data from one fishery independent recruitment index, two fishery dependent indices, estimates of bycatch in the shrimp fishery, and to data from each of the five primary fisheries on southeastern U.S. Spanish mackerel: commercial gill net, commercial pound net, commercial cast net, commercial handlines (including hook & line, trolling, and electric reels), and general recreational (including headboat). These data included annual landings by fishery (in total weight for commercial and in numbers for general recreational and shrimp bycatch), annual discards from the general recreational sector, and annual age composition of landings by fishery. Discards from the commercial fisheries were added to landings as they were not a large enough proportion of total catch to model separately (Table 2). Data on annual discard mortalities were not available, but an overall discard mortality rate of 0.2 for the general recreational sector was applied to total discards as per the recommendation of the SEDAR 28 DW. All shrimp bycatch was assumed dead.

3.3 Model Configuration

The assessment time period was 1986–2020. The initial year was modified from SEDAR 28 to begin when adequate information was available to inform the initial age structure of the population and fishing rates. These values were assumed and fixed in SEDAR 28 and age compositions are not available until 1990. SEDAR 28 had to make assumptions about population age structure and fishing mortality to initialize the model in 1950. The terminal year extended from 2012 to 2020. A general description of the assessment model follows.

3.4 Stock Dynamics

In the assessment model, new biomass was acquired through growth and recruitment, while abundance of existing cohorts experienced mortality from fishing and natural sources. The population was assumed closed to immigration and emigration. The model included age classes $0-10^{+}$, where the oldest age class 10^{+} allowed for the accumulation of fish (i.e., plus group).

3.5 Initialization

Initial (1986) numbers at age assumed the stable age structure computed from expected recruitment and the initial, age-specific total mortality rate. That initial mortality was the sum of natural mortality and fishing mortality, where fishing mortality was the product of an initial fishing rate (F_{init}) and F-weighted selectivity based on starting year landings. The initial fishing rate was estimated using a starting value of $F_{\text{init}} = 0.5$ and no prior. The initial recruitment in 1986 was estimated.

3.6 Natural Mortality Rate

The natural mortality rate (M) was assumed constant over time, but decreasing with age. The form of M as a function of age was based on Lorenzen (1996). The Lorenzen (1996) approach inversely relates the natural mortality at age to mean weight at age W_a by the power function $\mathrm{M}_a = \alpha W_a^{\beta}$, where α is a scale parameter and β is a shape parameter. Lorenzen (1996) provided point estimates of α and β for oceanic fishes, which were used for this assessment. As in previous SEDAR assessments, the age-dependent estimates of M_a were rescaled to provide the same fraction of fish surviving from age 2 through the oldest observed age (12 yr) as would occur with constant $M = 0.35$, which is consistent with the findings of Hoenig (1983) and discussed in Hewitt and Hoenig (2005). The scaled Lorenzen estimator has become common in SEDAR assessments as the most reliable approach to infer age-dependent natural mortality.

3.7 Growth

Mean size at age of the population, female population, and fishery removals under a 12-inch size limit (fork length, FL) were modeled with the von Bertalanffy equation, and weight at age (whole weight, WW) was modeled as a function of FL (Figure 1, Table 1). Parameters of growth and conversions (FL-WW) were treated as input to the assessment model.

3.8 Female Maturity and Sex Ratio

Female maturity was modeled with a logistic function; parameters for this model and a vector of maturity at age were provided by the SEDAR 28 DW and treated as input to the assessment model (Table 1). The sex ratio was assumed to be 50:50, as in SEDAR 28.

3.9 Spawning Biomass

Spawning biomass (in units of mt) was modeled as the mature female biomass. It was computed each year from number at age when spawning peaks. For Spanish mackerel, peak spawning was considered to occur on June 1^{st}.

3.10 Recruitment

Recruitment was predicted from spawning biomass using a Beverton–Holt spawner-recruit model. These stock-recruit parameters are median-unbiased values (Li et al. 2021). For all years in the model (1986–2020), estimated recruitment was conditioned on the Beverton–Holt model. Steepness was fixed at 0.75 for the base run.

3.11 Landings

Time series of landing from five fisheries were modeled: commercial handlines, commercial gillnet, commercial pound net, commercial cast net, and general recreational (including headboat). Landings were modeled via the Baranov catch equation (Baranov 1918), in units of 1000 lb whole weight for commercial fisheries and in units of 1000 fish for the general recreational fishery and bycatch.

3.12 Discards

Starting in 1986 with the implementation of size-limit regulations, time series of discard mortalities (in units of 1000 fish) were available for commercial handline and gill net fisheries. The magnitude of the commercial discards was trivial in comparison to the landings. As a result, the commercial discards were included with the landings rather than model the discards separately. General recreational discards were modeled seperately and decremented by the discard mortality rate (0.2) determined in SEDAR 28. As with landings, discard mortalities were modeled via the Baranov catch equation (Baranov 1918), which required estimates of discard selectivities (described below) and release mortality rates.

3.13 Bycatch

Spanish mackerel are observed in the shrimp trawl fishery in the South Atlantic. However, the observer coverage is extremely sparse and effort data are questionable. Estimates were provided by the data workshop that assumed a constant relationship over time between the rate of bycatch and effort by state (SEDAR78-WP04 2021). Bycatch was modeled via the Baranov catch equation (Baranov 1918), assuming that only age 0 fish and a small proportion of age 1 fish were selected with 100% mortality.

3.14 Fishing

For each time series of landings and discard mortalities, a separate full fishing mortality rate (F) was estimated. Age-specific rates were then computed as the product of full F and selectivity at age. The across-fleet annual F was represented by apical F, computed as the maximum of F at age summed across fleets.

3.15 Selectivities

Selectivity curves applied to landings were estimated using a parametric approach. This approach applies plausible structure on the shape of the curves, and achieves greater parsimony than occurs with unique parameters for each age. Flat-topped selectivities were modeled as a two-parameter logistic function (logistic). Dome-shaped selectivities were modeled by combining two logistic functions: a two-parameter logistic function to describe the ascending limb of the curve, and a two-parameter logistic function to describe the descending limb (double–logistic). Another type of domed–shaped selectivity allowed for a freely estimated logit parameter for age–0, a fixed peak at age–1, and an exponential decline for age 2^+ (logit–exponential).

To model landings, this assessment applied flat-topped selectivity for the commercial handline and cast net fleets, both pooled over years due to small sample sizes. Dome-shaped selectivity was used to model commercial gillnet landings. Commercial pound net and general recreational fleets were modeled using the logit–exponential selectivity. The approach to modeling each of these fleets was modified from decisions in SEDAR 28 to improve model fit and stability and based on total likelihood or likelihood profiles of specific parameters.

Selectivities of general recreational discards and shrimp bycatch could not be estimated directly, because composition data of discards were lacking. Fixed selectivities for these removals were the same as in SEDAR 28.

3.16 Indices of Abundance

The model was fit to two fishery dependent indices of relative abundance (MRIP (1986–2020) and commercial handline (1986–2020)), and one fishery independent index of age–0 recruitment (SEAMAP YOY (1989–2019)). The fishery dependent indices of abundance were limited to harvested fish. Predicted indices were conditional on selectivity of the corresponding fleet, and were computed from abundance (numbers of fish) at the midpoint of the year or, in the case of commercial handlines, biomass.

3.17 Catchability

In the BAM, catchability scales indices of relative abundance to the estimated population at large, adjusted by selectivity of the fleet or survey. For SEDAR 78, as in SEDAR 28, catchability (q) of each index was assumed to be time-invariant, and these parameters (one q per index) were estimated within BAM.

3.18 Biological Reference Points

Biological reference points (benchmarks) were calculated based on maximum sustainable yield (MSY) estimates from the Beverton–Holt spawner-recruit model with bias correction (expected values in arithmetic space). Computed benchmarks included MSY, fishing mortality rate at MSY (F_{MSY}), and spawning stock at MSY ($\mathrm{SSB}_{\mathrm{MSY}}$). In this assessment, spawning stock measures total biomass (mt) of mature females. These benchmarks are conditional on the estimated selectivity functions. The selectivity pattern used here were the selectivities at age (weighted by apical F), with effort from each fishery (including discard and bycatch mortalities) estimated as the full F averaged over the last three years of the assessment.

3.19 Fitting Criterion

Model parameters were estimated using a penalized likelihood approach in which observed removals (landings and discards) were fit closely, and observed composition data and abundance indices were fit to the degree that they were compatible. Removals and index data were fit using lognormal likelihoods. Age composition data were fit using the Dirichlet-multinomial likelihood, and only from years that met minimum sample size criteria ($nfish > 10$ and $ntrips \geq 10$.

SEDAR 28 fit composition data using the robust multinomial with iterative re-weighting (Francis 2011). Since Francis (2011), additional work on this topic has questioned the use of the multinomial distribution in stock assessment models (Francis 2014), and has recommended the Dirichlet-multinomial as an alternative (Francis 2017; Thorson et al. 2017; Fisch et al. 2021). A chief advantage of the Dirichlet-multinomial is that it is self-weighting through estimation of an additional variance inflation parameter for each composition component, making iterative re-weighting unnecessary. Another advantage is that it can better account for overdispersion, or, larger variance in the data than would be expected by the multinomial. Overdispersion can result from intra-haul correlation, which results when fish caught in the same set are more alike in length or age than fish caught in a different set (Pennington and Volstad 1994). The Dirichlet-multinomial has been implemented in Stock Synthesis (Methot and Wetzel 2013; Thorson et al. 2017) and in the BAM, and since SEDAR 41 has become the standard likelihood for fitting composition data in assessments of South Atlantic fishes.

The model includes the capability for each component of the likelihood to be weighted by user-supplied values. When applied to indices, these weights modifed the effects of the CVs derived from index standardization. CVs from index standardization are often smaller for fishery dependent indices than for fishery independent indices due to the typically larger sample sizes. Therefore, initial CVs for the fishery dependent indices were set to 0.2, similar to past SEDAR assessments, to ensure that the fishery independent index was not considered less certain than the fishery dependent index. In the base run, weights on the indices were adjusted iteratively from the initial values based on the index standardization (Table 3) until standard deviations of normalized residuals (SDNRs) were near 1.0, as recommended by Francis (2011).

For some parameters defining selectivities and Dirichlet-multinomial overdispersion parameters, normal priors were applied to maintain parameter estimates near reasonable values, and to prevent the gradient-based optimization routine from drifting into parameter space with negligible changes in the likelihood.

3.20 Configuration of a Base Run

The base run was configured as described above. This configuration does not necessarily represent reality better than all other possible configurations, and thus this assessment attempted to portray uncertainty in point estimates through sensitivity analyses and through a MCBE approach (described below).

3.21 Sensitivity Analyses

Sensitivity runs were chosen to investigate issues that arose specifically with this operational assessment. They were intended to demonstrate directionality of results with changes in inputs or simply to explore model behavior. These model runs vary from the base run as follows:

- S1: Removal of the commercial handline index
- S2: Use the Lorenzen M scaled to the low point estimate of M

- S3: Use the Lorenzen M scaled to the high point estimate of M
- S4: Steepness fixed at 0.6
- S5: Steepness fixed at 0.9
- S6: General recreational discard rate fixed at 0.1
- S7: General recreational discard rate fixed at 0.3

Retrospective analyses were also conducted by incrementally dropping one year at a time for five iterations. In these runs, the terminal years were 2019, 2018, 2017, 2016, or 2015.

3.22 Parameters Estimated

The model estimated annual fishing mortality rates of each fleet, selectivity parameters, catchability coefficients associated with indices, parameters of the mean recruitment model (R_0), annual recruitment deviations, and Dirichlet-multinomial variance inflation factors. Estimated parameters are listed in Appendix B.

3.23 Per Recruit and Equilibrium Analyses

Yield per recruit and spawning potential ratio were computed as functions of F, as were equilibrium landings, discards, and spawning biomass. Equilibrium landings and discards were also computed as functions of biomass B, which itself is a function of F. As in the computation of MSY-related benchmarks (described in §3.24), per recruit and equilibrium analyses applied the most recent selectivity patterns averaged across fleets, weighted by each fleet's F from the last three years of the assessment (2018–2020).

3.24 Benchmark/Reference Point Methods

In this assessment of Spanish mackerel, 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 removals.

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,

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

where R_0 is virgin recruitment, h is steepness, and $\Phi_F = \phi_F/\phi_0$ is spawning potential ratio given growth, maturity, and total mortality at age (including natural and fishing mortality rates). The R_{eq} and mortality schedule imply an equilibrium age structure and an average sustainable yield (ASY). The estimate of F_{MSY} is the F giving the highest ASY, and the estimate of MSY is that ASY. The estimate of $\mathrm{SSB}_{\mathrm{MSY}}$ follows from the corresponding equilibrium age structure, as does the benchmark 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 (2018–2020). If the selectivities or relative fishing mortalities among fleets were to change, so would the estimates of MSY and related benchmarks.

For this stock, the maximum fishing mortality threshold (MFMT) is defined by the SAFMC as F_{MSY}, and the minimum stock size threshold (MSST) as 75%$\mathrm{SSB}_{\mathrm{MSY}}$. Overfishing is defined as $F >$ MFMT and overfished as SSB $<$ MSST. Current status of the stock is represented by SSB in the latest assessment year (2020), and current status of the fishery is represented by the geometric mean of F from the latest three years (2018–2020).

3.25 Uncertainty and Measures of Precision

As in SEDAR 28, this assessment used a MCBE approach to characterize uncertainty in results of the base run. Monte Carlo and bootstrap methods (Efron and Tibshirani 1993; Manly 1997) are often used to characterize uncertainty in ecological studies, and the mixed approach has been applied successfully in stock assessment, including Restrepo et al. (1992), Legault et al. (2001), SEDAR4 (2004), and many South Atlantic SEDAR assessments since SEDAR19 (2009). The approach is among those recommended for use in SEDAR assessments (SEDAR Procedural Guidance 2010), and it is considered to be one of the more complete characterizations of uncertainty used in stock assessments across the United States.

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 main advantage of the approach is that the results describe a range of possible outcomes, so that the ensemble of models characterizes uncertainty in results more thoroughly than any single fit or handful of sensitivity runs (Scott et al. 2016; Jardim et al. 2021). A minor disadvantage of the approach is that computational demands are relatively high, but this can largely be mitigated through use of parallel processing.

In this assessment, the BAM was successively re-fit in $n = 4000$ trials that differed from the original inputs by bootstrapping on data sources, and by Monte Carlo sampling of several key input parameters. The value of $n = 4000$ was chosen because a minimum of 3000 runs were desired, and it was anticipated that not all runs would converge or otherwise be valid. Of the 4000 trials, approximately 1% were discarded, because the model did not properly converge (the Hessian was not positive definite or a parameter hit a bound). This left $n = 3957$ MCBE runs to characterize uncertainty, which was sufficient for convergence of standard errors in management quantities. All runs were given equal weight when forming the ensemble of results (Jardim et al. 2021).

The MCBE 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.

3.26 Bootstrap of Observed Data

To include uncertainty in time series of observed landings, discards, and indices of abundance, multiplicative lognormal errors were applied through a parametric bootstrap. To implement this approach in the MCB trials, random variables ($x_{s,y}$) were drawn for each year y of time series s from a normal distribution with mean 0 and variance $\sigma^2_{s,y}$ [that is, $x_{s,y} \sim N(0, \sigma^2_{s,y})$]. Annual observations were then perturbed from their original values ($\hat{O}_{s,y}$),

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

The term $\sigma_{s,y}^2/2$ 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, $\sigma_{s,y} = \sqrt{\log(1.0 + CV_{s,y}^2)}$. As used for fitting the base run, CVs of landings and discards were assumed to be 0.05, and CVs of indices of abundance were those provided by, or modified from, the DW (tabulated in §2 of this assessment report).

Uncertainty in age compositions were included by drawing new distributions for each year of each data source, following a multinomial sampling process. Ages of individual fish were drawn at random with replacement using the cell probabilities of the original data. For each year of each data source, the number of individuals sampled was the same as in the original data (number of fish).

3.27 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. The steepness, natural mortality, and general recreational discard mortality distributions are described below.

3.28 Steepness

As in SEDAR 28, steepness could not be estimated with stability in the model. Steepness values above 0.60 appeared to be equally likely in the likelihood profile. Steepness was fixed at 0.75 for the base run and uncertainty in the parameters was characterized by a truncated normal distribution with 0.6 and 0.9 as the lower and upper bounds respectively.

3.29 Natural Mortality

As in each model run, the vector of age-specific natural mortality (Lorenzen estimator) was scaled to the fish–only Hoenig (1983) age-invariant M as was done for the base run. The point estimate of natural mortality ($M = 0.35$) was based on a maximum age of 12. To estimate uncertainty, a new M value was drawn for each MCB trial from a truncated normal distribution of (range [0.30, 0.42]) with mean equal to the point estimate ($M = 0.35$) and standard deviation set to provide 95% confidence limits at the bounds. The range was reduced from SEDAR 28 and corresponds to maximum age $+/-2$ instead of the range of point estimates across many different methods to calculate M (range [0.16, 0.54]). Each realized value of M was used to scale the age-specific Lorenzen M, as in the base run.

3.30 General Recreational Discard Mortality

As in SEDAR 28, discard mortalities δ were subjected to Monte Carlo variation as follows. A new value for general recreational discard mortality was drawn for each MCB trial from a truncated normal distribution range [0.10, 0.30] with mean equal to the point estimate ($\delta = 0.20$) and standard deviation set to provide 95% confidence limits at the bounds.

3.31 Projection Methods

Projections were run to predict stock status in years after the assessment, 2021–2025.

The structure of the projection model was the same as that of the assessment model, and parameter estimates were those from the assessment. 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 (§3.24).

3.31.1 Initialization of Projections

Although the terminal year of the assessment is 2020, the assessment model computes abundance at age (N_a) at the start of 2021. For projections, those estimates were used to initialize N_a. However, the assessment has no information to inform the strength of 2021 recruitment, and thus it computes 2021 recruits (N_1) as the expected value, that is, without deviation from the estimate of mean recruitment, 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 (2021) of projections included this variability in N_1. The deterministic projections were not adjusted in this manner, because deterministic recruitment follows mean recruitment.

Fishing rates that define the projections were assumed to start in 2023. Because the assessment period ended in 2020, the projections required an initialization period (2021 and 2022). L_{current} (the average landings over the last 3 years in the assessment model) was assumed during the interim period.

3.31.2 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 2021) 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,

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

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

3.31.3 Projection Scenarios

The ToRs for this assessment did not define projections scenarios. The SEDAR 78 panel defined three scenarios: F_{current}, F_{MSY}, and $75\%F_{\text{MSY}}$. In each, the landings in the interim period (2021–2022) were calculated based on F_{current}.

- Scenario 1: $F = F_{\text{current}}$, with L_{current} also assumed for the interim period.
- Scenario 2: $F = F_{\text{MSY}}$, with L_{current} assumed for the interim period.
- Scenario 3: $F = 75\%F_{\text{MSY}}$, with L_{current} assumed for the interim period.

4 Stock Assessment Results

4.1 Measures of Overall Model Fit

In general, the BAM fit well to the available data. Predicted age compositions were reasonably close to observed data in most years (Figures 2 and 3). The model was configured to fit observed commercial and general recreational removals closely (Figures 4–10). Fits to indices of abundance were reasonable, though the commercial handline index was generally underfit between 2004 and 2020 (Figures 11–13). There was no clear explanation for this trend and a sensitivity run to evaluate the exclusion of the commercial handline index is discussed in 4.11. The SEAMAP YOY index suggests highly variable recruitment from year to year; however, mismatches between trawl surveys and the timing of migration are an alternative explanation for the variability.

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 are reported in sections below.

4.3 Stock Abundance and Recruitment

Estimated abundance at age shows a similar pattern across all years with most variation in youngest ages (Figure 14). Annual number of recruits is shown in Table 9 (age-0 column) and in Figure 15.

4.4 Total and Spawning Biomass

Estimated biomass at age follows a similar pattern as did abundance (Table 10 and Figure 16). Total biomass and spawning biomass show nearly identical trends with near–decadal fluctuation in overall landings. The relative contribution and annual variability of YOY fish is lower in the biomass at age due to non-linear size at age.

4.5 Fishery Selectivity

Selectivities of landings from commercial and general recreational fleets are shown in Figures 17, 18, 19, 20, and 21. Selectivities of discards from commercial and general recreational fleets are shown in Figures 22 and 23. Selectivities are tabulated in Table 12. Estimated selectivities of removals indicate that full selection occurs by age one for commercial pound net and general recreational fleets and age three for commercial handline, cast net, and gillnet fleets. General recreational discards and shrimp bycatch were assumed to be mostly YOY (Figures 23 and 23).

Average selectivities of landings, dead discards, and the total weighted average of all selectivities were computed from F-weighted selectivities in the most recent three assessment years (Figure 24, Table 12). These average selectivities were used in computation of point estimates of benchmarks, as well as in projections.

4.6 Fishing Mortality

Estimates of total F by fleet are shown in Figure 25 and Table 13, and estimates of F at age are shown in Table 14. In any given year, the maximum F at age (i.e., apical F) may be less than that year's sum of fully selected Fs across fleets. This inequality is due to the combination of two features of estimated selectivities: full selection occurs at different ages among gears and several sources of mortality have dome-shaped selectivity.

Alternative measures of fishing intensity have implications similar to those of apical F (Figure 26). The value of SPR_F has remained near or above the equilibrium MSY level with the exception of the terminal year which was dominated by removals from the general recreational fleet.

Throughout most of the assessment period, estimated landings and discard mortalities in number of fish have been split evenly between commercial and general recreational sectors (Figures 27 and 28). Early commercial landings were dominated by gillnet removals but shifted to a mix of cast net, gillnet, and handline starting in about 2004. Table 18 shows total landings at age in numbers, and Table 19 in 1000 lb. Table 20 shows total discards at age in numbers, and Table 21 in weight.

4.7 Stock-Recruitment Parameters

The estimated Beverton–Holt spawner-recruit curve is shown in Figure 31. Variability about the curve was estimated only at relatively low levels of spawning biomass, because composition data required for estimating recruitment deviations became available only after spawning stock had been diminished. The effect of density dependence on recruitment can be examined graphically via the estimated recruits per spawner as a function of spawners (Figure 31).

The mean recruit relationship and variability around that mean are shown in Figure 31. Values of recruitment–related parameters were as follows: unfished YOY recruitment $\widehat{R_0} = 21939130$, and standard deviation of recruitment residuals in log space was fixed at $\sigma_R = 0.6$ (which resulted in bias correction of $\varsigma = 1.20$). Uncertainty in these quantities was estimated through the MCBE analysis (Figure 32).

4.8 Per Recruit and Equilibrium Analyses

Yield per recruit and spawning potential ratio were computed as functions of F. These computations applied the most recent selectivity patterns averaged across fleets, weighted by F from the last three years (2018–2020) (Figure 33).

As in per recruit analyses, equilibrium spawning biomass was computed as a function of F (Figure 34). Similarly, equilibrium biomass and removals are functions of F, allowing for their relationships to be depicted together (Figure 35).

4.9 Benchmarks / Reference Point

As described in §3.24, biological reference points (benchmarks) were derived analytically assuming equilibrium dynamics, corresponding to the estimated spawner-recruit curve with bias correction (Figure 31). This approach is consistent with methods used in rebuilding projections (i.e., fishing at F_{MSY} yields MSY from a stock size of $\mathrm{SSB}_{\mathrm{MSY}}$). $F_{\mathrm{OY}} = 75\% F_{\mathrm{MSY}}$ was considered as another possible values of F at optimum yield (OY). Standard errors of benchmarks were approximated as those from ensemble modeling §3.25.

Maximum likelihood estimates (base run) of benchmarks, as well as median values from MCBE analysis, are summarized in Table 22. Point estimates of MSY-related quantities were $F_{\mathrm{MSY}} = 0.52$ (y^{-1}), MSY = 8210.19 (1000 lb), $B_{\mathrm{MSY}} = 19588.3$ (mt), and $\mathrm{SSB}_{\mathrm{MSY}} = 6405.87$ (mature female biomass, mt). Median estimates were $F_{\mathrm{MSY}} = 0.52$ (y^{-1}), MSY = 8351.35 (1000 lb), $B_{\mathrm{MSY}} = 19820.72$ (mt), and $\mathrm{SSB}_{\mathrm{MSY}} = 6410.25$ (mature female biomass, mt). Distributions of these benchmarks from the MCBE analysis are shown in Figure 36.

4.10 Status of the Stock and Fishery

Estimated time series of stock status SSB/MSST showed a near–decadal fluctuation above MSST (Figure 37, Table 11). Base-run estimates of spawning biomass have remained above $\mathrm{SSB}_{\mathrm{MSY}}$. Current stock status was estimated in the base run to be $\mathrm{SSB}_{2020}/\mathrm{MSST} = 1.4$ and $\mathrm{SSB}_{2020}/\mathrm{SSB}_{\mathrm{MSY}} = 1.05$ (Table 22), indicating that the stock is not overfished. Median values from the MCBE analysis indicated similar results SSB/MSST= 1.42 and $\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$= 1.07 (Figure 37). The uncertainty analysis suggested that the terminal estimate of stock status is robust (Figures 38 and 40). Of the MCBE runs, 92.6% indicated that the stock was above MSST in 2020.

The estimated time series of F/F_{MSY} suggests that overfishing has not occurred throughout most of the assessment period except for 2020 (Table 11, Figure 37). Current fishery status in the terminal year, with current F represented by the geometric mean from years 2018–2020, was estimated by the base run to be $F/F_{\mathrm{MSY}} = 0.77$ (Table 22). The fishery status was also robust (Figures 38 - 40). Of the MCBE runs, approximately 90% agreed with the base run that the stock is not currently experiencing overfishing.

Compared to SEDAR 28, the qualitative results of stock and fishery status are similar (Figure 41).

4.11 Sensitivities and Retrospective Runs

Sensitivity runs, described in §3.21, were used for exploring data or model issues that arose during the assessment process, for evaluating implications of assumptions in the base assessment model, and for interpreting MCBE results in terms of expected effects of input parameters. In some cases, sensitivity runs are simply a tool for better understanding model behavior, and therefore all runs are not considered equally plausible in the sense of alternative states of nature. Time series of F/F_{MSY} and $\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$ are plotted to demonstrate sensitivity to the changing conditions in each run. This operational assessment explored sensitivity of the base run to changes in data input, natural mortality, steepness, and general recreational discard mortality (Figures 42–45). Of these modifications, results were most sensitive to the scale of natural mortality and steepness.

Retrospective analyses suggest no concerning patterns of estimating F or SSB in the terminal year (Figure 46) or status indicators (Figure 47). Terminal-year recruitment was variable across retrospective peels.

4.12 Projections

Since the stock status is not overfished or undergoing overfishing, three projections are provided for completeness and were recommended by the SEDAR 78 panel.

Projection scenario 1, which assumed L_{current}(average landings over the last 3 years) during the interim period (2021-2022) and $F = F_{\text{current}}$ for following years, predicted the stock to decrease until management measure take place and then increase back to SSB_{MSY} (Figure 48, Table 24).

Projection scenario 2, which assumed L_{current}(average landings over the last 3 years) during the interim period (2021-2022) and $F = Fmsy$ for following years, predicted the stock to decrease until management measure take place and then increase but not recover to SSB_{MSY} in the terminal year (Figure 49, Table 25).

Projection scenario 3, which assumed L_{current}(average landings over the last 3 years) during the interim period (2021-2022) and $F = 75\%Fmsy$, predicted the stock to decrease until management measure take place and then increase back to SSB_{MSY} (Figure 50, Table 26).

4.13 Discussion

The base run of the BAM indicated that the stock is not overfished SSB/MSST =1.4, and that overfishing is not occuring based on the 3–year geometric mean F/F_{MSY} =0.77. The 2020 point estimate for F/F_{MSY} indicated overfishing primarily due to a large increase in the general recreational landings during the COVID-19 pandemic. Should this high rate of fishing continue after 2020, overfishing would likely ensure. Indeed, preliminary MRIP estimates of Spanish mackerel landings in 2021 were higher than in 2020. The stock continues to show resilience to fishing effort as in SEDAR 28 (Figure 41). Neither of these models show a stock that was overfished or near overfishing in 2007 as SEDAR17 (2008) indicated.

The Monte Carlo/bootstrap ensemble analyses showed widespread agreement with the qualitative results of the base run. Of all MCBE runs, 92.6% showed that the stock is not overfished, and 90.0% showed that overfishing is not occurring.

4.13.1 Comments on the Assessment

In addition to including the more recent years of data, this operational assessment contained several modifications to the previous data of SEDAR 28, such as the use of modern MRIP methodology, the use of the Dirichlet–multinomial distribution to fit age compositions, pooling age compositions across years for fleets with low annual sample sizes, modification to selectivity functions applied to landings, update of the growth models and natural mortality, removing sex–specific growth and selectivity, and changing the start year of the model. The assessment model itself was also modernized to the current version of BAM. The sum of these improvements should result in a more robust assessment.

There is a lack of available fishery independent indices of abundance for this species. The schooling behavior of Spanish mackerel makes a random survey of their population particularly difficult. The one fishery independent index used (SEAMAP YOY) was highly variable, as would be expected for a recruitment index.

In general, fishery dependent indices of abundance may not track actual abundance well, because of factors such as hyperdepletion or hyperstability. Furthermore, this issue can be exacerbated by management measures. In this assessment, the commercial handline index was generated from Florida trip ticket data. There was a shift in the commercial handline index in 2004 after which a run of positive residuals persisted in the model fit. A sensitivity run excluding the commercial handline index did not influence the results in the terminal year of the assessment. The index was included in the model but should be investigated further in future assessments. In general, management measures in the southeast U.S. have made the continued utility of fishery dependent indices questionable. This situation amplifies the importance of fishery independent sampling.

Natural mortality plays a driving role in this assessment, as it does in most. The pattern of natural mortality at age affects multiple outputs, including annual fishing rates, benchmarks, and equilibrium age structure expected at MSY. The model could estimate steepness at 0.73 but it was only weakly informed above 0.60 and would stay close to the starting value. As in SEDAR 28, steepness was fixed at 0.75 as a mid-point of the range over which no likelihood signal was available.

4.14 Comments on the Projections

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

- In general, projections of fish stocks are highly uncertain, particularly in the long term (e.g., beyond 5–10 years).
- Although projections included many major sources of uncertainty, they did not include structural (model) uncertainty. That is, projection results are conditional on one set of functional forms used to describe population dynamics, selectivity, recruitment, etc.
- Fisheries were assumed to continue fishing at their estimated current proportions of total effort, using the estimated current selectivity patterns. New management regulations that alter those proportions or selectivities would likely affect projection results.
- The projections assumed 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.

4.15 Research Recommendations

The research recommendations from the SEDAR 78 panel were as follows:

- Development of a fishery-independent survey for pelagic species would decrease reliance on a fishery-dependent index of abundance that has unexplained trends in residual values in recent years.
- Examine how schooling or migratory dynamics may influence the catchability of the species. In particular, research the assumption of the hyperstability of indices that sample the schooling portion of the stock.
- Age-dependent natural mortality was estimated by indirect methods (Lorenzen) for this assessment. Telemetry- and conventional-tagging programs can provide alternative estimates of natural mortality. Investigate new methods for determining point estimates for natural mortality.

4.16 Sampling Recommendations

- Limited information is available for shrimp bycatch in the Atlantic. Comprehensive observer coverage across space and time are needed to adequately capture the scale and size distribution of bycatch for Spanish mackerel and other species.
- The general recreational discards have increased dramatically in the last 2 years of this assessment. A better understanding of the size composition and mortality of discarded fish would improve the assessment, especially if discards continue to increase due to effort or future management changes.
- Implement systematic age sampling for the general recreational and commercial sectors. Age samples were important for this assessment for determining key parameters but sample sizes were limited, particularly for the general recreational sector, commercial handline and commercial cast net sectors, which account for the majority of the recent landings.

4.17 References

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4.18 Tables

Table 1. Size (FL) in inches and weight in pounds (lb) at age as applied to the population (Pop), female population (F), and fishery–dependent portion of the population (FD) with a 12–inch (FL) size limit, female maturity at age (Fem.mat), Lorenzen age–specific natural moratality (M) scaled to Hoenig point estimate of M.

Age	Pop.FL	Pop.lb	F.FL	F.lb	FD.FL	FD.lb	Fem.mat	M
0	10.32	0.38	11.10	0.46	12.72	0.68	0.00	0.68
1	16.00	1.31	17.07	1.58	15.24	1.14	0.94	0.46
2	19.12	2.18	20.28	2.58	17.30	1.64	1.00	0.40
3	20.84	2.78	22.01	3.25	19.00	2.14	1.00	0.37
4	21.78	3.16	22.94	3.66	20.39	2.62	1.00	0.36
5	22.30	3.38	23.44	3.89	21.53	3.06	1.00	0.35
6	22.58	3.50	23.71	4.02	22.47	3.45	1.00	0.34
7	22.74	3.57	23.85	4.09	23.25	3.80	1.00	0.34
8	22.83	3.61	23.93	4.13	23.88	4.10	1.00	0.34
9	22.88	3.63	23.97	4.15	24.40	4.36	1.00	0.34
10	22.90	3.64	23.99	4.16	24.83	4.58	1.00	0.34

Table 2. Observed time series of landings (L) and discards (D) for commercial handline (cH), commercial gill net (cG), commercial pound net(cP), commercial cast net(cC), shrimp bycatch (SB), and general recreational (GR) fisheries. Commercial landings are in units of 1000 lb whole weight; all others are in units of 1000 fish. Discards include all released fish, live or dead.

Year	L.cH	L.cG	L.cP	L.cC	L.GR	D.SB	D.GR
1986	78.442	4060.803	201.695	.	1758.446	293.467	99.901
1987	106.502	3616.669	470.433	.	1581.880	246.210	10.744
1988	64.864	3280.564	402.161	.	2748.961	295.158	26.275
1989	39.666	3180.917	509.040	.	2612.834	349.373	162.043
1990	111.857	2696.683	509.415	.	2607.275	270.381	164.992
1991	144.012	3798.801	468.247	.	3984.348	336.048	204.527
1992	50.239	2689.136	396.725	.	2627.843	253.739	141.393
1993	99.073	4415.277	328.326	.	1581.289	268.227	119.145
1994	58.246	3705.878	329.600	.	1871.097	300.299	235.680
1995	209.640	3236.730	199.030	15.419	1072.701	304.626	148.449
1996	139.445	2679.097	294.389	65.924	1403.063	247.772	225.914
1997	126.978	2674.398	207.188	210.195	1768.786	287.483	219.410
1998	149.026	2693.649	115.481	68.323	1567.478	259.449	99.250
1999	188.060	1887.672	271.264	66.391	2405.746	290.461	300.960
2000	311.524	1864.970	161.842	361.425	3124.254	270.720	369.641
2001	348.824	1705.127	196.164	892.775	2949.293	216.347	194.657
2002	438.663	1318.160	121.274	968.866	3360.141	237.459	360.647
2003	390.936	1092.515	90.685	1897.957	3324.354	184.847	503.116
2004	590.759	709.698	71.085	2242.104	1755.768	180.568	209.749
2005	841.431	1254.387	47.026	1574.132	2352.000	195.430	308.218
2006	707.656	1648.777	42.924	1524.472	1519.820	133.243	129.569
2007	775.882	1715.951	50.048	1268.365	2465.112	109.382	325.041
2008	869.796	1079.737	192.347	702.770	2648.595	118.257	451.296
2009	977.720	1439.248	363.026	966.518	3271.544	69.966	342.990
2010	1228.006	1346.147	144.150	1798.217	3704.510	112.672	457.321
2011	891.721	1084.574	87.480	1239.174	2770.439	116.988	294.592
2012	1118.972	1431.172	55.277	976.984	2072.331	132.276	239.588
2013	1359.102	1167.578	26.561	344.541	3902.423	94.578	544.831
2014	1748.908	941.229	33.890	562.620	2658.106	111.451	380.148
2015	1223.504	981.574	54.506	177.356	1496.388	126.194	213.302
2016	1401.609	1107.927	73.666	688.890	3447.737	125.049	426.454
2017	1379.049	1117.239	36.896	985.813	1786.717	113.893	298.662
2018	1600.541	1421.607	36.553	699.935	2472.430	89.469	628.452
2019	1382.207	1137.540	157.326	1234.201	4022.032	119.063	862.654
2020	1375.187	1569.859	82.623	666.309	6387.829	117.525	1058.072

Table 3. Observed indices of abundance and CVs from Florida commercial handline trip ticket(cH), MRIP general recreational (GR), and the SEAMAP YOY survey (YOY).

Year	cH	cH CV	GR	GR CV	YOY	YOY CV
1986	0.47	0.2	2.87	0.2	.	.
1987	0.60	0.2	1.18	0.2	.	.
1988	0.70	0.2	1.26	0.2	.	.
1989	0.65	0.2	1.39	0.2	1.16	0.26
1990	0.74	0.2	1.28	0.2	1.64	0.30
1991	0.53	0.2	1.11	0.2	2.21	0.34
1992	0.65	0.2	0.83	0.2	1.65	0.56
1993	1.01	0.2	0.64	0.2	0.79	0.12
1994	0.57	0.2	0.85	0.2	0.80	0.14
1995	0.83	0.2	0.59	0.2	1.36	0.22
1996	0.74	0.2	0.91	0.2	0.79	0.14
1997	0.67	0.2	1.11	0.2	0.36	0.12
1998	0.69	0.2	0.63	0.2	0.79	0.15
1999	0.78	0.2	1.19	0.2	0.86	0.18
2000	0.81	0.2	0.88	0.2	1.22	0.24
2001	0.82	0.2	0.94	0.2	1.89	0.52
2002	0.81	0.2	1.00	0.2	1.15	0.20
2003	0.96	0.2	0.94	0.2	0.72	0.16
2004	1.33	0.2	0.96	0.2	0.84	0.13
2005	1.29	0.2	0.82	0.2	1.00	0.17
2006	1.30	0.2	0.73	0.2	1.27	0.21
2007	1.14	0.2	0.73	0.2	1.32	0.19
2008	1.17	0.2	1.12	0.2	1.63	0.22
2009	1.44	0.2	0.94	0.2	1.18	0.23
2010	1.47	0.2	0.77	0.2	0.79	0.13
2011	1.33	0.2	0.90	0.2	0.40	0.09
2012	1.08	0.2	1.15	0.2	0.29	0.05
2013	1.11	0.2	1.07	0.2	0.82	0.17
2014	1.31	0.2	0.93	0.2	0.64	0.13
2015	1.18	0.2	0.74	0.2	0.46	0.09
2016	1.39	0.2	0.79	0.2	0.99	0.20
2017	1.34	0.2	0.75	0.2	0.96	0.26
2018	1.43	0.2	0.90	0.2	0.52	0.11
2019	1.42	0.2	1.18	0.2	0.45	0.10
2020	1.23	0.2	0.95	0.2	.	.

Table 4. Observed age composition from commercial handline (cH) pooled across all years. The year represents a mid–point of pooled years.

Year	trips	fish	0	1	2	3	4	5	6	7	8	9	10
2007	175	2953	0.0181	0.1384	0.2461	0.2452	0.1646	0.1044	0.0527	0.0207	0.0059	0.0028	0.0011

Table 5. Observed age composition from commercial gill net (cG).

Year	trips	fish	0	1	2	3	4	5	6	7	8	9	10
1992	13	190	0.0128	0.4021	0.3591	0.1109	0.0508	0.0325	0.0204	0.0114	0.0000	0.0000	0.0000
1993	14	150	0.0010	0.1735	0.3020	0.1930	0.1371	0.0538	0.0703	0.0547	0.0147	0.0000	0.0000
1995	11	167	0.0650	0.3532	0.2699	0.1830	0.0848	0.0115	0.0147	0.0097	0.0082	0.0000	0.0000
1996	14	414	0.0802	0.2440	0.3214	0.2718	0.0582	0.0175	0.0034	0.0026	0.0010	0.0000	0.0000
1997	15	246	0.0754	0.2728	0.3860	0.2043	0.0471	0.0035	0.0034	0.0054	0.0000	0.0021	0.0000
1998	24	363	0.2045	0.2007	0.3692	0.1440	0.0515	0.0186	0.0096	0.0020	0.0000	0.0000	0.0000
1999	20	447	0.0879	0.3803	0.1672	0.2052	0.0970	0.0447	0.0165	0.0011	0.0000	0.0000	0.0000
2000	40	588	0.0410	0.3292	0.3315	0.1125	0.1098	0.0364	0.0306	0.0078	0.0012	0.0000	0.0000
2001	37	315	0.2161	0.3698	0.2659	0.1095	0.0302	0.0017	0.0059	0.0000	0.0009	0.0000	0.0000
2002	19	365	0.1325	0.1256	0.2080	0.2478	0.1676	0.0970	0.0089	0.0025	0.0007	0.0095	0.0000
2003	24	365	0.0831	0.4116	0.1515	0.0827	0.1735	0.0701	0.0227	0.0017	0.0004	0.0020	0.0008
2004	30	551	0.0465	0.2861	0.3836	0.2146	0.0316	0.0228	0.0099	0.0038	0.0010	0.0000	0.0001
2005	10	249	0.1431	0.6156	0.1467	0.0678	0.0190	0.0013	0.0064	0.0000	0.0000	0.0000	0.0000
2006	20	355	0.0425	0.3598	0.3227	0.1607	0.0740	0.0273	0.0114	0.0000	0.0016	0.0000	0.0000
2007	18	234	0.2707	0.4321	0.1614	0.0560	0.0420	0.0131	0.0046	0.0118	0.0061	0.0018	0.0003
2008	32	288	0.0857	0.3605	0.2913	0.1273	0.0947	0.0326	0.0079	0.0000	0.0000	0.0000	0.0000
2009	37	348	0.0329	0.3710	0.2962	0.1922	0.0563	0.0418	0.0095	0.0000	0.0000	0.0000	0.0000
2010	42	287	0.1311	0.1857	0.2956	0.1987	0.1100	0.0657	0.0085	0.0046	0.0000	0.0000	0.0000
2011	34	389	0.0571	0.3634	0.2812	0.1821	0.0848	0.0248	0.0054	0.0011	0.0000	0.0000	0.0000
2012	16	208	0.0704	0.2532	0.3401	0.2302	0.0613	0.0343	0.0071	0.0034	0.0000	0.0000	0.0000
2013	15	201	0.2573	0.3884	0.1917	0.1131	0.0258	0.0237	0.0000	0.0000	0.0000	0.0000	0.0000
2014	21	203	0.0545	0.2984	0.3992	0.2028	0.0324	0.0127	0.0000	0.0000	0.0000	0.0000	0.0000
2015	21	205	0.2122	0.4356	0.2213	0.0902	0.0283	0.0119	0.0000	0.0000	0.0006	0.0000	0.0000
2016	14	228	0.0315	0.3419	0.4449	0.1122	0.0560	0.0127	0.0008	0.0000	0.0000	0.0000	0.0000
2017	14	136	0.0000	0.2247	0.5287	0.1525	0.0869	0.0072	0.0000	0.0000	0.0000	0.0000	0.0000
2018	13	31	0.0000	0.2352	0.5788	0.1767	0.0082	0.0011	0.0000	0.0000	0.0000	0.0000	0.0000
2019	19	30	0.0000	0.4373	0.4378	0.0759	0.0422	0.0000	0.0028	0.0040	0.0000	0.0000	0.0000
2020	19	68	0.0068	0.2654	0.5239	0.1383	0.0316	0.0316	0.0023	0.0000	0.0000	0.0000	0.0000

Table 6. Observed age composition from commercial pound net (cP).

Year	trips	fish	0	1	2	3	4	5	6	7	8	9	10
2002	57	773	0.0181	0.5925	0.0660	0.1837	0.0931	0.0323	0.0013	0.0065	0.0026	0.0039	0.000
2003	22	329	0.0000	0.7690	0.0729	0.0122	0.1155	0.0213	0.0061	0.0000	0.0000	0.0000	0.003
2004	18	400	0.0000	0.4775	0.3450	0.0950	0.0100	0.0600	0.0100	0.0000	0.0000	0.0025	0.000
2005	14	341	0.0235	0.7713	0.0850	0.0880	0.0147	0.0029	0.0059	0.0088	0.0000	0.0000	0.000
2006	20	286	0.0000	0.4930	0.3566	0.0839	0.0385	0.0105	0.0070	0.0000	0.0105	0.0000	0.000
2007	18	226	0.1858	0.6018	0.1283	0.0664	0.0000	0.0133	0.0044	0.0000	0.0000	0.0000	0.000
2008	13	110	0.1091	0.5091	0.2364	0.0636	0.0364	0.0091	0.0182	0.0000	0.0000	0.0182	0.000
2009	16	98	0.1020	0.5000	0.3367	0.0204	0.0204	0.0102	0.0000	0.0102	0.0000	0.0000	0.000
2010	25	187	0.0000	0.6257	0.2727	0.0856	0.0000	0.0107	0.0000	0.0000	0.0053	0.0000	0.000
2011	19	210	0.0000	0.4667	0.2048	0.1762	0.0857	0.0429	0.0048	0.0143	0.0000	0.0048	0.000
2012	17	166	0.0000	0.5301	0.3373	0.0602	0.0482	0.0241	0.0000	0.0000	0.0000	0.0000	0.000
2013	10	42	0.2619	0.5238	0.1429	0.0476	0.0000	0.0238	0.0000	0.0000	0.0000	0.0000	0.000
2014	19	172	0.0058	0.6512	0.2500	0.0581	0.0233	0.0058	0.0058	0.0000	0.0000	0.0000	0.000
2015	19	186	0.0000	0.6774	0.2366	0.0591	0.0108	0.0161	0.0000	0.0000	0.0000	0.0000	0.000
2016	22	175	0.0000	0.6514	0.2000	0.1086	0.0286	0.0057	0.0057	0.0000	0.0000	0.0000	0.000
2017	22	193	0.0000	0.4249	0.4715	0.0777	0.0104	0.0104	0.0000	0.0052	0.0000	0.0000	0.000
2018	18	111	0.0000	0.5225	0.2072	0.1892	0.0360	0.0180	0.0000	0.0270	0.0000	0.0000	0.000
2019	27	134	0.0000	0.5448	0.2090	0.1119	0.0896	0.0373	0.0075	0.0000	0.0000	0.0000	0.000
2020	15	78	0.1282	0.3205	0.4359	0.0641	0.0513	0.0000	0.0000	0.0000	0.0000	0.0000	0.000

Table 7. Observed age composition from commercial cast net (cC) pooled across all years. The year represents a mid–point of pooled years.

Year	trips	fish	0	1	2	3	4	5	6	7	8	9	10
2010	74	2215	0.0013	0.0453	0.2763	0.2504	0.2277	0.1165	0.048	0.0214	0.0081	0.0039	0.0012

Table 8. Observed age composition from the general recreational fishery (GR).

Year	trips	fish	0	1	2	3	4	5	6	7	8	9	10
1990	38	262	0.0649	0.4618	0.2672	0.1031	0.0191	0.0496	0.0191	0.0038	0.0038	0.0000	0.0076
1991	19	342	0.0468	0.5029	0.1901	0.1111	0.0614	0.0468	0.0292	0.0117	0.0000	0.0000	0.0000
1992	36	240	0.0083	0.4625	0.2000	0.1000	0.1125	0.0333	0.0375	0.0333	0.0125	0.0000	0.0000
1993	21	113	0.0354	0.4248	0.1150	0.0885	0.1327	0.0885	0.0354	0.0531	0.0088	0.0088	0.0088
1997	17	316	0.1392	0.6139	0.1930	0.0316	0.0063	0.0095	0.0063	0.0000	0.0000	0.0000	0.0000
1998	23	222	0.1171	0.4009	0.2658	0.1081	0.0631	0.0045	0.0045	0.0225	0.0090	0.0000	0.0045
1999	10	101	0.0198	0.7921	0.0297	0.0495	0.0297	0.0396	0.0297	0.0099	0.0000	0.0000	0.0000
2000	15	130	0.0000	0.3077	0.1538	0.0692	0.1769	0.1385	0.0923	0.0385	0.0077	0.0077	0.0077
2002	17	205	0.0683	0.4537	0.1610	0.1220	0.0976	0.0244	0.0146	0.0146	0.0293	0.0098	0.0049
2003	10	321	0.2399	0.6604	0.0748	0.0125	0.0062	0.0031	0.0000	0.0031	0.0000	0.0000	0.0000
2004	13	241	0.1037	0.6598	0.0996	0.0747	0.0373	0.0166	0.0041	0.0000	0.0000	0.0041	0.0000
2005	17	208	0.0144	0.9135	0.0240	0.0240	0.0144	0.0000	0.0048	0.0048	0.0000	0.0000	0.0000
2006	15	232	0.1121	0.7716	0.0388	0.0302	0.0302	0.0086	0.0043	0.0043	0.0000	0.0000	0.0000
2007	10	177	0.1921	0.7288	0.0508	0.0113	0.0000	0.0113	0.0000	0.0056	0.0000	0.0000	0.0000
2008	14	204	0.0980	0.7745	0.0784	0.0343	0.0147	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2010	12	295	0.0949	0.4373	0.2814	0.1017	0.0576	0.0203	0.0068	0.0000	0.0000	0.0000	0.0000
2011	13	348	0.1810	0.4971	0.1236	0.0805	0.0776	0.0230	0.0115	0.0029	0.0000	0.0000	0.0029
2012	31	489	0.0900	0.5460	0.2740	0.0286	0.0348	0.0123	0.0082	0.0061	0.0000	0.0000	0.0000
2013	29	328	0.0732	0.6890	0.1067	0.0671	0.0152	0.0122	0.0213	0.0152	0.0000	0.0000	0.0000
2014	47	494	0.0567	0.7024	0.0911	0.0547	0.0486	0.0162	0.0202	0.0020	0.0020	0.0020	0.0040
2015	38	358	0.2207	0.5810	0.1034	0.0363	0.0307	0.0084	0.0112	0.0028	0.0000	0.0028	0.0028
2016	40	525	0.1314	0.6724	0.0686	0.0324	0.0381	0.0286	0.0114	0.0095	0.0038	0.0019	0.0019
2017	32	331	0.0211	0.6798	0.2236	0.0453	0.0121	0.0060	0.0030	0.0060	0.0000	0.0000	0.0030
2018	58	392	0.0842	0.5051	0.1837	0.1378	0.0485	0.0306	0.0026	0.0026	0.0026	0.0026	0.0000
2019	64	401	0.0574	0.5661	0.1995	0.0898	0.0499	0.0150	0.0125	0.0075	0.0025	0.0000	0.0000
2020	50	250	0.0840	0.3800	0.1920	0.1080	0.1080	0.0600	0.0560	0.0080	0.0000	0.0000	0.0040

Table 9. Estimated total abundance at age (1000 fish) at start of year.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1986	17618.83	17806.94	3265.86	954.79	443.13	188.63	97.08	46.56	24.18	13.47	20.41	40479.87
1987	20083.54	8476.48	8599.45	1486.15	446.14	216.25	97.19	53.15	27.15	14.87	22.08	39522.45
1988	25256.30	9795.56	4207.35	4166.42	741.17	231.02	117.10	55.24	31.77	16.94	24.18	44643.04
1989	21747.10	12252.55	4548.99	1925.75	1967.24	363.78	118.72	63.25	31.44	18.93	25.86	43063.61
1990	21651.04	10445.38	5811.81	2144.68	936.42	992.88	191.81	65.61	36.71	19.05	28.52	42323.91
1991	18150.83	10460.30	5023.22	2817.86	1073.26	485.07	535.00	107.74	38.50	22.38	30.37	38744.53
1992	12465.06	8542.81	4333.16	2035.03	1179.72	470.21	224.63	263.45	56.60	21.43	31.48	29623.57
1993	18757.29	5906.23	3843.93	1942.30	941.92	567.93	237.14	119.14	147.33	33.17	32.82	32529.19
1994	18054.48	8929.19	2591.13	1548.96	804.43	410.87	264.80	119.28	64.85	85.81	41.25	32915.04
1995	18466.48	8511.74	3895.83	1055.08	648.84	354.29	192.87	133.61	64.88	37.64	78.49	33439.75
1996	20406.68	8856.09	4184.07	1827.38	507.86	325.38	186.90	107.62	79.02	40.31	76.22	36597.55
1997	13115.41	9834.42	4406.09	2047.73	916.99	264.09	176.55	106.16	64.11	49.03	75.77	31056.36
1998	25154.19	6214.76	4838.07	2145.00	1015.15	470.15	141.02	98.46	61.96	38.91	79.23	40256.90
1999	23951.30	12246.48	3106.71	2390.27	1087.41	532.42	256.64	80.34	58.66	38.35	76.53	43825.10
2000	14472.77	11550.40	6098.91	1581.65	1251.70	586.79	297.04	148.15	48.07	36.22	73.83	36145.53
2001	19374.13	6820.91	5553.03	3003.40	791.60	644.63	312.34	163.55	84.56	28.33	67.68	36844.16
2002	24012.75	9325.15	3195.47	2603.72	1402.55	379.99	320.31	160.85	87.50	46.81	55.74	41590.85
2003	15588.61	11494.24	4289.28	1475.00	1188.77	657.33	184.16	160.69	83.73	47.11	57.70	35226.61
2004	21462.74	7336.93	5372.95	1949.32	626.90	514.36	293.11	84.68	76.36	41.01	53.41	37811.77
2005	17178.74	10486.18	3856.97	2711.13	902.60	293.18	245.76	142.91	42.19	38.77	49.13	35947.55
2006	20860.77	8258.29	5268.46	1896.18	1270.28	430.61	143.77	123.89	74.19	22.47	48.38	38397.29
2007	26847.99	10254.57	4368.41	2694.79	927.88	633.07	220.59	75.72	67.18	41.24	40.62	46172.05
2008	23288.67	13084.20	5145.57	2152.38	1291.72	454.67	319.76	114.92	40.76	37.21	46.91	45976.78
2009	16683.91	11297.23	6757.72	2732.86	1145.03	701.92	253.15	182.20	67.11	24.32	51.63	39897.08
2010	19439.88	8061.20	5527.51	3363.75	1355.64	581.76	367.13	136.28	101.14	38.30	45.04	39017.62
2011	15155.47	9259.57	3681.57	2507.15	1474.44	607.93	269.41	175.71	67.57	51.81	44.57	33295.21
2012	13391.82	7288.22	4499.97	1798.63	1199.79	720.97	305.80	139.39	93.69	37.03	54.64	29529.95
2013	19195.66	6437.72	3621.22	2233.81	880.72	601.41	372.46	162.88	76.70	53.05	53.82	33689.46
2014	17716.95	8996.48	2633.52	1526.84	959.82	391.39	278.13	179.63	82.20	40.39	59.57	32864.93
2015	25749.22	8483.57	4251.31	1266.92	734.09	473.34	199.06	145.94	97.46	45.98	58.26	41505.15
2016	20926.00	12672.48	4557.95	2362.00	718.56	425.93	281.25	120.97	90.81	61.90	67.86	42285.71
2017	20518.31	10070.78	6139.85	2258.58	1170.04	364.51	222.28	150.96	66.92	51.63	76.44	41090.30
2018	25671.96	10032.73	5444.50	3371.52	1226.95	647.21	206.07	128.23	88.97	40.17	78.67	46936.99
2019	15643.59	12376.35	5182.47	2892.64	1802.07	670.58	362.80	118.38	75.61	53.67	73.90	39252.04
2020	18460.13	7228.16	5793.22	2506.16	1384.45	882.46	337.87	188.04	63.25	41.54	72.84	36958.11
2021	23015.23	8203.22	2486.24	2061.07	902.47	518.67	347.31	140.28	82.74	29.43	57.80	37844.45

Table 10. Estimated biomass at age (1000 lb) at start of year.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1986	6648.5	23377.6	7119.4	2658.1	1399.5	636.9	340.0	166.2	87.3	48.9	74.3	42556.9
1987	7578.6	11128.3	18746.6	4137.6	1409.0	730.2	340.4	189.8	98.1	54.0	80.5	44492.6
1988	9530.6	12860.0	9171.9	11599.6	2340.6	780.2	410.1	197.3	114.6	61.5	88.2	47154.5
1989	8206.3	16085.6	9916.6	5361.4	6212.8	1228.4	415.8	226.0	113.5	68.8	94.1	47929.2
1990	8170.1	13713.0	12669.5	5971.0	2957.3	3353.0	671.5	234.4	132.5	69.2	103.8	48045.3
1991	6849.3	13732.6	10950.4	7845.1	3389.4	1638.0	1873.3	384.7	138.9	81.4	110.7	46994.0
1992	4703.8	11215.4	9446.1	5665.7	3725.6	1588.0	786.6	940.7	204.4	77.8	114.6	38468.5
1993	7078.2	7753.9	8379.6	5407.5	2974.7	1917.8	830.3	425.5	531.8	120.4	119.5	35539.4
1994	6812.9	11722.4	5648.5	4312.5	2540.4	1387.6	927.3	425.9	234.1	311.5	150.4	34473.5
1995	6968.4	11174.6	8492.9	2937.4	2049.2	1196.4	675.3	477.1	234.1	136.7	285.9	34627.8
1996	7700.5	11626.5	9121.2	5087.6	1603.9	1098.8	654.3	384.3	285.3	146.4	277.8	37986.5
1997	4949.2	12910.9	9605.1	5701.2	2896.0	891.8	618.2	379.2	231.5	178.1	276.0	38636.9
1998	9492.0	8158.9	10546.7	5971.9	3206.0	1587.8	493.8	351.6	223.8	141.3	288.6	40462.3
1999	9038.1	16077.7	6772.6	6654.7	3434.1	1798.1	898.6	286.8	211.6	139.3	278.9	45590.3
2000	5461.3	15163.8	13295.4	4403.5	3953.1	1981.5	1040.1	529.1	173.5	131.6	269.0	46401.6
2001	7311.0	8954.7	12105.4	8361.7	2500.0	2176.8	1093.7	584.0	305.3	103.0	246.5	43741.9
2002	9061.2	12242.3	6965.9	7249.0	4429.3	1283.3	1121.5	574.5	315.9	170.0	203.0	43616.0
2003	5882.4	15090.0	9350.5	4106.6	3754.3	2219.8	644.9	573.9	302.3	171.1	210.3	42305.6
2004	8099.1	9632.2	11712.7	5427.1	1979.8	1737.0	1026.3	302.5	275.6	148.8	194.7	40535.7
2005	6482.5	13766.5	8408.0	7548.0	2850.6	990.1	860.5	510.4	152.3	140.9	179.0	41888.5
2006	7871.8	10841.7	11485.0	5279.2	4011.8	1454.2	503.3	442.5	267.9	81.6	176.1	42415.2
2007	10131.1	13462.5	9522.9	7502.6	2930.4	2137.8	772.3	270.5	242.5	149.7	147.9	47270.4
2008	8788.1	17177.3	11217.1	5992.4	4079.4	1535.5	1119.5	410.3	147.0	135.1	170.9	50772.9
2009	6295.7	14831.4	14731.5	7608.6	3616.2	2370.4	886.5	650.6	242.3	88.4	188.1	51509.5
2010	7335.7	10583.1	12049.8	9365.0	4281.4	1964.5	1285.5	486.8	365.1	139.1	164.0	48019.8
2011	5719.0	12156.3	8025.7	6980.1	4656.4	2052.9	943.4	627.4	243.8	188.1	162.5	41755.8
2012	5053.4	9568.3	9809.7	5007.6	3789.1	2434.8	1070.8	497.8	338.2	134.5	199.1	37903.0
2013	7243.5	8451.6	7894.1	6219.0	2781.4	2030.9	1304.3	581.6	276.9	192.7	196.0	37172.1
2014	6685.5	11810.8	5741.1	4250.7	3031.1	1321.7	973.8	641.5	296.7	146.6	216.9	35117.0
2015	9716.7	11137.5	9267.8	3527.2	2318.4	1598.6	697.1	521.2	351.9	166.9	212.3	39515.0
2016	7896.5	16636.7	9936.2	6575.9	2269.2	1438.3	984.8	431.9	327.8	224.7	247.1	46969.7
2017	7742.6	13221.1	13384.7	6288.0	3695.2	1231.1	778.2	539.0	241.6	187.4	278.4	47587.7
2018	9687.3	13171.3	11868.8	9386.6	3874.8	2185.7	721.6	457.9	321.2	145.9	286.6	52107.6
2019	5903.1	16248.1	11297.6	8053.3	5691.2	2264.6	1270.3	422.8	272.9	194.9	269.2	51887.8
2020	6965.9	9489.4	12629.0	6977.4	4372.2	2980.0	1183.0	671.5	228.4	150.8	265.4	45913.0
2021	8684.9	10769.4	5419.8	5738.2	2850.1	1751.6	1216.1	500.9	298.7	106.9	210.5	37547.1

Table 11. Estimated time series and status indicators. Fishing mortality rate is full F, which includes discard mortalities. Total biomass (B, mt) is at the start of the year, and spawning biomass (SSB, mt) at the end of July (time of peak spawning). The MSST *is defined by* $\mathrm{MSST} = 75\%\mathrm{SSB}_{\mathrm{MSY}}$. *SPR is static spawning potential ratio.*

Year	F	F/F_{MSY}	B	B/B_{unfished}	SSB	$\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$	SSB/MSST	SPR
1986	0.393	0.761	19303	0.334	6448	1.007	1.34	0.415
1987	0.328	0.635	20182	0.349	7259	1.133	1.51	0.461
1988	0.385	0.745	21389	0.370	7212	1.126	1.50	0.407
1989	0.355	0.688	21740	0.376	7683	1.199	1.60	0.423
1990	0.327	0.633	21793	0.377	7811	1.219	1.63	0.444
1991	0.507	0.982	21316	0.369	7352	1.148	1.53	0.324
1992	0.405	0.786	17449	0.302	6431	1.004	1.34	0.380
1993	0.513	0.995	16120	0.279	5270	0.823	1.10	0.341
1994	0.502	0.973	15637	0.271	5117	0.799	1.07	0.339
1995	0.363	0.704	15707	0.272	5389	0.841	1.12	0.433
1996	0.322	0.623	17230	0.298	5968	0.932	1.24	0.460
1997	0.334	0.647	17525	0.303	6606	1.031	1.38	0.442
1998	0.311	0.603	18353	0.318	6151	0.960	1.28	0.471
1999	0.279	0.540	20679	0.358	7248	1.131	1.51	0.481
2000	0.324	0.628	21047	0.364	8022	1.252	1.67	0.434
2001	0.393	0.762	19841	0.343	7033	1.098	1.46	0.405
2002	0.416	0.806	19784	0.342	6580	1.027	1.37	0.389
2003	0.488	0.945	19190	0.332	6860	1.071	1.43	0.371
2004	0.405	0.785	18387	0.318	6387	0.997	1.33	0.461
2005	0.390	0.756	19000	0.329	6892	1.076	1.43	0.437
2006	0.347	0.672	19239	0.333	6874	1.073	1.43	0.488
2007	0.367	0.712	21441	0.371	7265	1.134	1.51	0.450
2008	0.263	0.510	23030	0.399	8433	1.316	1.76	0.511
2009	0.333	0.645	23364	0.404	8891	1.388	1.85	0.449
2010	0.457	0.885	21781	0.377	7695	1.201	1.60	0.374
2011	0.369	0.715	18940	0.328	7010	1.094	1.46	0.430
2012	0.346	0.671	17193	0.298	6468	1.010	1.35	0.448
2013	0.477	0.924	16861	0.292	5535	0.864	1.15	0.326
2014	0.364	0.706	15929	0.276	5494	0.858	1.14	0.417
2015	0.199	0.386	17924	0.310	6126	0.956	1.28	0.584
2016	0.334	0.648	21305	0.369	7630	1.191	1.59	0.442
2017	0.242	0.469	21585	0.374	8147	1.272	1.70	0.553
2018	0.258	0.501	23636	0.409	8571	1.338	1.78	0.511
2019	0.369	0.715	23536	0.407	8887	1.387	1.85	0.399
2020	0.653	1.266	20826	0.360	6725	1.050	1.40	0.241
2021	.	.	17031	0.295	.	.	.	.

Table 12. Selectivity at age (end-of-assessment time period) for commercial handline (cH), commercial pound net (cP), commercial gill net (cG), commercial cast net (cC), and general recreational (GR) landings. Selectivity at age for general recreational discards (GR.D), shrimp bycatch discards (SB.D), and selectivity of landings averaged across fisheries (L.avg), discards averaged across fisheries (D.avg) and catches across fisheries (tot.avg).

Age	FL(mm)	cH	cP	cG	cC	GR	GR.D	SB.D	L.avg	D.avg	tot.avg
0	262.2	0.012	0.027	0.068	0.002	0.084	1.000	1.0	0.059	0.121	0.179
1	406.4	0.076	1.000	0.510	0.037	1.000	0.375	0.2	0.642	0.043	0.685
2	485.6	0.356	0.980	0.980	0.440	0.992	0.000	0.0	0.826	0.000	0.826
3	529.2	0.787	0.921	1.000	0.942	0.967	0.000	0.0	0.986	0.000	0.986
4	553.2	0.961	0.830	0.911	0.997	0.927	0.000	0.0	1.000	0.000	1.000
5	566.4	0.994	0.719	0.771	1.000	0.873	0.000	0.0	0.959	0.000	0.959
6	573.6	0.999	0.597	0.595	1.000	0.809	0.000	0.0	0.899	0.000	0.899
7	577.6	1.000	0.476	0.414	1.000	0.737	0.000	0.0	0.833	0.000	0.833
8	579.8	1.000	0.364	0.262	1.000	0.660	0.000	0.0	0.769	0.000	0.769
9	581.0	1.000	0.267	0.153	1.000	0.581	0.000	0.0	0.710	0.000	0.710
10	581.7	1.000	0.188	0.085	1.000	0.503	0.000	0.0	0.658	0.000	0.658

Table 13. Estimated time series of fully selected fishing mortality rates for commercial handline (F.cH), commercial pound net (F.cP), commercial gill net (F.cG), commercial cast net (F.cC), general recreational (F.GR), general recreational discards(F.GR.D), and shrimp bycatch (F.SB.D). Also shown is apical F (Full.F), the maximum F at age summed across fleets. Full F may not equal the sum of fully selected F's because of dome-shaped selectivities.

Year	F.cH	F.cP	F.cG	F.cC	F.GR	F.GR.D	F.SB.D	Full.F
1986	0.014	0.010	0.284	0.000	0.103	0.006	0.020	0.393
1987	0.013	0.023	0.204	0.000	0.106	0.001	0.016	0.328
1988	0.007	0.020	0.185	0.000	0.185	0.001	0.015	0.385
1989	0.004	0.023	0.175	0.000	0.162	0.009	0.020	0.355
1990	0.010	0.023	0.143	0.000	0.165	0.009	0.016	0.327
1991	0.014	0.023	0.217	0.000	0.274	0.013	0.024	0.507
1992	0.005	0.022	0.177	0.000	0.212	0.013	0.025	0.405
1993	0.012	0.023	0.342	0.000	0.156	0.008	0.019	0.513
1994	0.008	0.023	0.316	0.000	0.171	0.016	0.022	0.502
1995	0.030	0.013	0.260	0.002	0.093	0.010	0.021	0.363
1996	0.018	0.017	0.191	0.008	0.111	0.013	0.016	0.322
1997	0.015	0.011	0.175	0.023	0.132	0.018	0.027	0.334
1998	0.016	0.007	0.174	0.007	0.129	0.005	0.014	0.311
1999	0.019	0.013	0.112	0.006	0.154	0.015	0.015	0.279
2000	0.029	0.007	0.100	0.032	0.194	0.028	0.023	0.324
2001	0.032	0.010	0.098	0.074	0.224	0.013	0.015	0.393
2002	0.043	0.007	0.083	0.090	0.251	0.019	0.013	0.416
2003	0.043	0.005	0.070	0.201	0.232	0.036	0.015	0.488
2004	0.067	0.004	0.046	0.234	0.136	0.012	0.011	0.405
2005	0.091	0.002	0.078	0.159	0.166	0.021	0.014	0.390
2006	0.073	0.002	0.099	0.148	0.110	0.008	0.008	0.347
2007	0.076	0.002	0.098	0.117	0.162	0.015	0.005	0.367
2008	0.079	0.008	0.055	0.061	0.149	0.022	0.006	0.263
2009	0.080	0.015	0.068	0.073	0.189	0.023	0.005	0.333
2010	0.101	0.007	0.071	0.137	0.259	0.029	0.008	0.457
2011	0.082	0.004	0.065	0.107	0.206	0.022	0.010	0.369
2012	0.110	0.003	0.092	0.090	0.172	0.021	0.013	0.346
2013	0.148	0.002	0.086	0.035	0.368	0.036	0.007	0.477
2014	0.219	0.002	0.074	0.068	0.232	0.025	0.008	0.364
2015	0.145	0.003	0.067	0.020	0.114	0.010	0.006	0.199
2016	0.144	0.003	0.063	0.067	0.212	0.023	0.008	0.334
2017	0.124	0.002	0.057	0.083	0.109	0.017	0.007	0.242
2018	0.125	0.002	0.068	0.051	0.146	0.030	0.005	0.258
2019	0.106	0.006	0.054	0.089	0.233	0.061	0.009	0.369
2020	0.125	0.005	0.095	0.056	0.519	0.074	0.009	0.653

Table 14. Spanish mackerel: Estimated instantaneous fishing mortality rate (per yr) at age, including discard mortality

Year	0	1	2	3	4	5	6	7	8	9	10
1986	0.054	0.264	0.390	0.393	0.362	0.316	0.258	0.198	0.146	0.106	0.078
1987	0.040	0.236	0.328	0.328	0.303	0.266	0.221	0.174	0.132	0.099	0.075
1988	0.045	0.303	0.385	0.382	0.357	0.319	0.272	0.223	0.178	0.141	0.113
1989	0.055	0.282	0.355	0.353	0.329	0.293	0.249	0.203	0.161	0.127	0.101
1990	0.049	0.268	0.327	0.324	0.303	0.271	0.233	0.192	0.155	0.124	0.100
1991	0.076	0.417	0.507	0.503	0.470	0.423	0.364	0.303	0.246	0.199	0.161
1992	0.069	0.335	0.405	0.402	0.376	0.338	0.290	0.240	0.194	0.156	0.126
1993	0.064	0.360	0.512	0.513	0.475	0.416	0.343	0.267	0.201	0.149	0.112
1994	0.074	0.365	0.501	0.502	0.465	0.409	0.340	0.268	0.204	0.154	0.117
1995	0.057	0.246	0.360	0.363	0.335	0.293	0.239	0.184	0.136	0.099	0.073
1996	0.052	0.234	0.318	0.322	0.299	0.264	0.222	0.177	0.137	0.106	0.083
1997	0.069	0.245	0.323	0.334	0.313	0.280	0.240	0.197	0.159	0.129	0.106
1998	0.042	0.229	0.308	0.311	0.290	0.258	0.219	0.177	0.140	0.110	0.088
1999	0.051	0.233	0.278	0.279	0.262	0.237	0.205	0.172	0.142	0.117	0.096
2000	0.074	0.268	0.311	0.324	0.309	0.284	0.253	0.220	0.189	0.162	0.140
2001	0.053	0.294	0.360	0.393	0.379	0.352	0.320	0.285	0.251	0.222	0.197
2002	0.059	0.313	0.376	0.416	0.403	0.377	0.346	0.312	0.279	0.250	0.224
2003	0.076	0.296	0.392	0.488	0.483	0.461	0.433	0.403	0.374	0.348	0.324
2004	0.038	0.179	0.287	0.402	0.405	0.392	0.374	0.356	0.338	0.322	0.308
2005	0.054	0.224	0.313	0.390	0.385	0.366	0.341	0.315	0.290	0.268	0.250
2006	0.032	0.173	0.273	0.347	0.341	0.322	0.297	0.271	0.247	0.228	0.212
2007	0.041	0.226	0.311	0.367	0.358	0.336	0.308	0.278	0.251	0.227	0.208
2008	0.045	0.197	0.236	0.263	0.255	0.239	0.218	0.197	0.176	0.158	0.142
2009	0.049	0.251	0.301	0.333	0.322	0.301	0.275	0.248	0.221	0.197	0.177
2010	0.064	0.320	0.394	0.457	0.447	0.423	0.393	0.360	0.329	0.300	0.275
2011	0.054	0.258	0.319	0.369	0.360	0.340	0.315	0.288	0.262	0.238	0.217
2012	0.054	0.235	0.303	0.346	0.336	0.313	0.286	0.256	0.229	0.205	0.185
2013	0.080	0.430	0.467	0.477	0.456	0.424	0.385	0.343	0.301	0.263	0.228
2014	0.058	0.286	0.335	0.364	0.352	0.329	0.301	0.270	0.241	0.214	0.191
2015	0.031	0.157	0.191	0.199	0.189	0.174	0.154	0.133	0.114	0.097	0.084
2016	0.053	0.261	0.305	0.334	0.324	0.303	0.278	0.251	0.225	0.201	0.180
2017	0.037	0.151	0.202	0.242	0.237	0.223	0.206	0.188	0.170	0.155	0.143
2018	0.052	0.197	0.235	0.258	0.249	0.232	0.210	0.187	0.166	0.146	0.130
2019	0.094	0.295	0.330	0.369	0.359	0.338	0.313	0.286	0.259	0.234	0.212
2020	0.133	0.603	0.636	0.653	0.627	0.586	0.535	0.480	0.425	0.373	0.326

Table 15. Estimated instantaneous total mortality rate (per yr) at age, including discard mortality.

Year	0	1	2	3	4	5	6	7	8	9	10
1986	0.732	0.728	0.787	0.761	0.717	0.663	0.602	0.539	0.486	0.446	0.417
1987	0.718	0.700	0.725	0.696	0.658	0.613	0.565	0.515	0.472	0.439	0.414
1988	0.723	0.767	0.782	0.750	0.712	0.666	0.616	0.564	0.518	0.481	0.452
1989	0.733	0.746	0.752	0.721	0.684	0.640	0.593	0.544	0.501	0.467	0.440
1990	0.727	0.732	0.724	0.692	0.658	0.618	0.577	0.533	0.495	0.464	0.439
1991	0.754	0.881	0.904	0.871	0.825	0.770	0.708	0.644	0.586	0.539	0.500
1992	0.747	0.799	0.802	0.770	0.731	0.685	0.634	0.581	0.534	0.496	0.465
1993	0.742	0.824	0.909	0.881	0.830	0.763	0.687	0.608	0.541	0.489	0.451
1994	0.752	0.829	0.898	0.870	0.820	0.756	0.684	0.609	0.544	0.494	0.456
1995	0.735	0.710	0.757	0.731	0.690	0.640	0.583	0.525	0.476	0.439	0.412
1996	0.730	0.698	0.715	0.690	0.654	0.611	0.566	0.518	0.477	0.446	0.422
1997	0.747	0.709	0.720	0.702	0.668	0.627	0.584	0.538	0.499	0.469	0.445
1998	0.720	0.693	0.705	0.679	0.645	0.605	0.563	0.518	0.480	0.450	0.427
1999	0.729	0.697	0.675	0.647	0.617	0.584	0.549	0.513	0.482	0.457	0.435
2000	0.752	0.732	0.708	0.692	0.664	0.631	0.597	0.561	0.529	0.502	0.479
2001	0.731	0.758	0.757	0.761	0.734	0.699	0.664	0.626	0.591	0.562	0.536
2002	0.737	0.777	0.773	0.784	0.758	0.724	0.690	0.653	0.619	0.590	0.563
2003	0.754	0.760	0.789	0.856	0.838	0.808	0.777	0.744	0.714	0.688	0.663
2004	0.716	0.643	0.684	0.770	0.760	0.739	0.718	0.697	0.678	0.662	0.647
2005	0.732	0.688	0.710	0.758	0.740	0.713	0.685	0.656	0.630	0.608	0.589
2006	0.710	0.637	0.670	0.715	0.696	0.669	0.641	0.612	0.587	0.568	0.551
2007	0.719	0.690	0.708	0.735	0.713	0.683	0.652	0.619	0.591	0.567	0.547
2008	0.723	0.661	0.633	0.631	0.610	0.586	0.562	0.538	0.516	0.498	0.481
2009	0.727	0.715	0.698	0.701	0.677	0.648	0.619	0.589	0.561	0.537	0.516
2010	0.742	0.784	0.791	0.825	0.802	0.770	0.737	0.701	0.669	0.640	0.614
2011	0.732	0.722	0.716	0.737	0.715	0.687	0.659	0.629	0.602	0.578	0.556
2012	0.732	0.699	0.700	0.714	0.691	0.660	0.630	0.597	0.569	0.545	0.524
2013	0.758	0.894	0.864	0.845	0.811	0.771	0.729	0.684	0.641	0.603	0.567
2014	0.736	0.750	0.732	0.732	0.707	0.676	0.645	0.611	0.581	0.554	0.530
2015	0.709	0.621	0.588	0.567	0.544	0.521	0.498	0.474	0.454	0.437	0.423
2016	0.731	0.725	0.702	0.702	0.679	0.650	0.622	0.592	0.565	0.541	0.519
2017	0.715	0.615	0.599	0.610	0.592	0.570	0.550	0.529	0.510	0.495	0.482
2018	0.730	0.661	0.632	0.626	0.604	0.579	0.554	0.528	0.506	0.486	0.469
2019	0.772	0.759	0.727	0.737	0.714	0.685	0.657	0.627	0.599	0.574	0.551
2020	0.811	1.067	1.033	1.021	0.982	0.933	0.879	0.821	0.765	0.713	0.665

Table 16. Estimated total landings at age in numbers (1000 fish).

Year	0	1	2	3	4	5	6	7	8	9	10
1986	356.35	3275.06	893.88	270.19	118.98	45.56	19.89	7.65	3.07	1.31	1.54
1987	338.92	1426.61	2033.44	362.17	103.28	45.20	17.39	7.76	3.14	1.35	1.60
1988	519.27	2051.98	1129.36	1135.77	192.46	54.85	24.34	9.68	4.57	1.99	2.32
1989	405.24	2373.07	1139.29	488.56	473.80	79.78	22.66	10.09	4.08	1.98	2.19
1990	376.51	1942.47	1367.36	514.54	214.61	208.58	35.44	10.30	4.79	2.05	2.54
1991	493.44	2840.63	1691.25	965.88	353.18	147.61	144.88	25.12	7.56	3.67	4.17
1992	269.01	1912.71	1213.56	576.79	318.92	116.70	49.14	49.04	8.75	2.73	3.31
1993	492.89	1424.14	1302.97	674.59	310.93	169.84	60.84	24.89	24.14	4.21	3.26
1994	465.73	2159.21	862.20	525.94	259.49	120.26	66.75	24.64	10.60	10.97	4.16
1995	343.24	1465.95	1012.80	289.41	170.56	84.34	39.35	22.25	8.56	3.93	6.64
1996	334.26	1448.96	968.38	443.05	117.81	68.67	34.18	16.36	9.75	4.03	6.28
1997	217.76	1649.26	1030.39	507.93	218.75	57.85	34.03	17.40	8.78	5.62	7.37
1998	414.95	1012.68	1089.12	504.02	228.53	96.66	25.28	14.81	7.65	3.94	6.67
1999	361.12	1992.21	643.36	516.95	227.20	102.97	44.28	12.02	7.49	4.17	7.12
2000	242.05	2092.75	1406.17	396.29	308.02	136.07	63.07	28.24	8.14	5.45	9.90
2001	362.23	1381.94	1447.32	879.58	229.58	178.00	80.18	38.45	18.06	5.50	11.99
2002	470.86	1986.33	871.01	811.85	436.75	113.56	89.95	41.91	21.01	10.35	11.38
2003	278.11	2280.49	1207.66	517.03	422.02	227.08	60.95	50.57	24.96	13.31	15.50
2004	244.91	960.01	1209.25	617.73	205.95	166.49	92.19	25.76	22.43	11.65	14.72
2005	252.99	1673.08	953.85	877.41	301.29	95.58	76.81	42.50	11.91	10.42	12.64
2006	258.01	1062.59	1150.05	548.06	376.97	123.98	39.33	31.92	17.99	5.16	10.62
2007	413.41	1665.42	1058.13	815.41	286.31	188.89	62.27	20.01	16.58	9.54	8.88
2008	291.72	1848.93	1006.58	519.51	320.12	109.20	72.78	24.54	8.13	6.95	8.23
2009	262.09	1995.48	1600.62	777.50	331.65	196.44	66.97	45.06	15.44	5.21	10.34
2010	389.90	1760.86	1641.51	1229.00	507.49	212.40	128.34	45.23	31.73	11.35	12.65
2011	248.46	1672.40	916.03	768.90	462.47	185.34	78.29	48.21	17.44	12.58	10.22
2012	212.38	1224.19	1108.37	556.17	382.39	223.10	89.80	38.45	24.21	8.99	12.55
2013	522.94	1814.13	1259.35	894.56	360.89	239.44	140.93	57.89	25.42	16.36	15.44
2014	344.76	1843.04	770.76	580.92	386.95	155.51	106.50	65.75	28.67	13.44	18.96
2015	296.79	1031.25	779.01	302.81	186.02	117.19	46.86	32.33	20.28	9.02	10.86
2016	359.13	2355.92	1166.89	759.47	240.90	139.71	88.32	36.04	25.56	16.47	17.12
2017	217.58	1148.66	1139.28	574.83	314.81	96.35	56.46	36.57	15.44	11.38	16.20
2018	339.75	1424.21	1129.39	893.68	339.93	174.87	53.00	31.09	20.28	8.63	16.02
2019	272.54	2414.61	1352.43	925.12	593.08	215.22	111.34	34.42	20.73	13.87	18.03
2020	657.60	2591.67	2458.82	1179.97	658.38	407.12	148.26	77.55	24.30	14.79	23.99

Table 17. Estimated total landings at age in whole weight (1000 lb).

Year	0	1	2	3	4	5	6	7	8	9	10
1986	537.34	8251.13	3233.32	1275.22	686.79	307.15	151.41	64.13	27.76	12.58	15.57
1987	511.06	3594.17	7355.27	1709.34	596.15	304.75	132.41	65.07	28.39	13.00	16.14
1988	783.02	5169.73	4085.06	5360.53	1110.91	369.82	185.30	81.09	41.37	19.12	23.45
1989	611.06	5978.66	4121.02	2305.90	2734.88	537.86	172.47	84.55	36.91	19.06	22.14
1990	567.74	4893.82	4945.96	2428.52	1238.77	1406.21	269.78	86.29	43.31	19.72	25.69
1991	744.07	7156.62	6117.54	4558.73	2038.61	995.14	1102.91	210.51	68.38	35.32	42.09
1992	405.65	4818.85	4389.63	2722.29	1840.87	786.77	374.10	410.93	79.19	26.25	33.41
1993	743.23	3587.96	4713.06	3183.92	1794.76	1145.01	463.16	208.57	218.38	40.52	32.95
1994	702.28	5439.87	3118.73	2482.33	1497.81	810.79	508.17	206.50	95.89	105.53	41.99
1995	517.58	3693.29	3663.47	1365.96	984.49	568.62	299.53	186.42	77.44	37.83	67.10
1996	504.03	3650.49	3502.80	2091.08	680.04	462.98	260.18	137.10	88.20	38.80	63.50
1997	328.37	4155.12	3727.08	2397.30	1262.68	389.99	259.06	145.83	79.41	54.03	74.48
1998	625.70	2551.33	3939.51	2378.86	1319.10	651.65	192.46	124.14	69.23	37.91	67.38
1999	544.54	5019.13	2327.14	2439.86	1311.47	694.17	337.04	100.71	67.73	40.08	71.92
2000	364.99	5272.43	5086.35	1870.41	1777.96	917.36	480.09	236.63	73.64	52.38	100.06
2001	546.22	3481.64	5235.18	4151.39	1325.18	1200.03	610.39	322.16	163.38	52.88	121.11
2002	710.02	5004.32	3150.59	3831.74	2521.00	765.61	684.77	351.21	190.05	99.54	114.95
2003	419.36	5745.42	4368.30	2440.27	2435.98	1530.92	464.01	423.72	225.79	128.02	156.63
2004	369.30	2418.63	4374.04	2915.55	1188.79	1122.42	701.81	215.85	202.92	112.05	148.78
2005	381.48	4215.13	3450.24	4141.15	1739.10	644.39	584.75	356.12	107.75	100.24	127.73
2006	389.05	2677.07	4159.94	2586.69	2175.96	835.87	299.40	267.49	162.77	49.66	107.33
2007	623.38	4195.82	3827.42	3848.54	1652.62	1273.48	474.03	167.72	149.99	91.79	89.72
2008	439.89	4658.15	3640.97	2451.96	1847.77	736.20	554.04	205.60	73.54	66.80	83.15
2009	395.21	5027.37	5789.69	3669.62	1914.37	1324.38	509.79	377.59	139.68	50.13	104.51
2010	587.94	4436.27	5937.60	5800.58	2929.33	1431.97	977.01	378.98	286.99	109.19	127.82
2011	374.66	4213.40	3313.44	3629.02	2669.46	1249.54	595.95	404.02	157.73	120.99	103.25
2012	320.25	3084.21	4009.15	2624.97	2207.25	1504.08	683.57	322.19	218.97	86.47	126.78
2013	788.55	4570.48	4555.28	4222.10	2083.12	1614.26	1072.82	485.13	229.98	157.32	156.00
2014	519.87	4643.33	2787.97	2741.80	2233.53	1048.39	810.72	550.98	259.35	129.23	191.56
2015	447.54	2598.11	2817.82	1429.21	1073.75	790.09	356.69	270.91	183.44	86.79	109.75
2016	541.54	5935.47	4220.84	3584.53	1390.54	941.92	672.30	301.96	231.23	158.40	173.01
2017	328.09	2893.90	4120.96	2713.08	1817.14	649.57	429.76	306.41	139.64	109.48	163.67
2018	512.31	3588.13	4085.19	4217.94	1962.15	1178.95	403.47	260.52	183.42	82.99	161.88
2019	410.97	6083.33	4891.98	4366.35	3423.35	1450.99	847.56	288.44	187.52	133.36	182.13
2020	991.60	6529.41	8893.96	5569.19	3800.30	2744.72	1128.64	649.81	219.81	142.27	242.36

Table 18. Estimated time series of landings in number (1000s) for commercial handline (L.cH), commercial pound net (L.cP), commercial gill net (L.cG), commercial cast net (L.cC), general recreational (L.GR), general recreational discards (D.GR) and shrimp bycatch (D.SB), total landings and total discards.

Year	L.cH	L.cP	L.cG	L.cC	L.GR	D.GR	D.SB	Total.L	Total.D
1986	43.76	156.91	3029.99	0.00	1762.82	99.91	293.50	4993.48	393.40
1987	57.43	319.35	2379.32	0.00	1584.76	10.74	246.21	4340.86	256.95
1988	32.29	266.07	2074.59	0.00	2753.65	26.28	295.15	5126.59	321.43
1989	19.02	344.78	2023.18	0.00	2613.76	162.04	349.38	5000.74	511.42
1990	53.04	335.96	1683.20	0.00	2606.99	164.99	270.38	4679.19	435.38
1991	66.72	305.42	2327.83	0.00	3977.42	204.54	336.07	6677.39	540.61
1992	22.75	255.72	1619.31	0.00	2622.88	141.40	253.75	4520.66	395.15
1993	44.21	205.91	2662.81	0.00	1579.78	119.14	268.21	4492.71	387.36
1994	26.27	224.77	2389.20	0.00	1869.73	235.69	300.31	4509.97	536.00
1995	98.49	137.28	2131.71	6.91	1072.64	148.45	304.64	3447.03	453.09
1996	66.88	201.05	1750.23	30.26	1403.32	225.92	247.77	3451.74	473.69
1997	60.19	139.77	1689.89	96.38	1768.91	219.43	287.51	3755.14	506.94
1998	69.77	73.37	1664.24	30.99	1565.95	99.25	259.45	3404.31	358.70
1999	87.52	185.80	1215.59	29.33	2400.63	300.96	290.45	3918.87	591.41
2000	145.60	108.19	1165.20	164.17	3113.00	369.63	270.72	4696.15	640.35
2001	160.28	121.85	1014.81	401.46	2934.41	194.69	216.38	4632.82	411.06
2002	198.59	79.08	815.66	419.93	3351.70	360.66	237.46	4864.96	598.12
2003	180.68	61.99	697.47	839.64	3317.91	503.24	184.86	5097.68	688.11
2004	282.13	46.64	448.47	1035.30	1758.55	209.76	180.57	3571.09	390.32
2005	400.64	31.76	796.13	720.63	2359.33	308.26	195.44	4308.49	503.70
2006	336.64	28.13	1033.50	702.54	1523.89	129.57	133.24	3624.70	262.82
2007	369.14	33.44	1095.14	577.59	2469.54	325.08	109.39	4544.85	434.46
2008	415.91	131.35	694.74	321.72	2652.96	451.38	118.26	4216.68	569.64
2009	461.29	237.30	884.32	445.01	3278.89	343.04	69.97	5306.81	413.00
2010	562.27	89.66	797.50	806.49	3714.53	457.40	112.68	5970.46	570.08
2011	398.66	56.07	648.94	539.00	2777.68	294.60	116.99	4420.34	411.58
2012	496.34	34.76	847.97	425.19	2076.32	239.50	132.25	3880.59	371.75
2013	599.94	16.56	698.57	148.01	3884.27	544.81	94.58	5347.35	639.39
2014	782.93	22.88	599.27	240.39	2669.79	380.19	111.45	4315.26	491.64
2015	573.92	36.92	642.60	79.39	1499.61	213.29	126.19	2832.44	339.48
2016	668.95	50.89	722.46	314.35	3448.89	426.44	125.05	5205.55	551.49
2017	658.00	24.39	701.11	456.49	1787.55	298.65	113.89	3627.55	412.54
2018	747.54	23.53	871.03	317.09	2471.66	628.22	89.46	4430.85	717.69
2019	627.99	102.19	685.74	545.80	4009.68	862.39	119.06	5971.39	981.45
2020	612.61	50.51	918.60	291.61	6369.12	1058.02	117.52	8242.46	1175.55

Table 19. Estimated time series of landings in whole weight (1000 lb) for commercial handline (L.cH), commercial pound net (L.cP), commercial gill net (L.cG), commercial cast net (L.cC), general recreational (L.GR), general recreational discards (D.GR) and shrimp bycatch (D.SB), total landings and total discards.

Year	L.cH	L.cP	L.cG	L.cC	L.GR	D.GR	D.SB.D	Total.L	Total.D
1986	172.94	444.76	8996.42	0.00	4948.29	139.81	346.09	14562.40	485.90
1987	234.80	1037.53	8003.11	0.00	5050.32	11.99	244.64	14325.76	256.62
1988	143.00	886.76	7246.80	0.00	8952.84	28.63	288.59	17229.40	317.21
1989	87.45	1122.29	7015.58	0.00	8399.19	192.84	363.27	16624.51	556.10
1990	246.60	1123.06	5943.68	0.00	8612.47	189.30	273.92	15925.82	463.22
1991	317.49	1032.19	8362.47	0.00	13357.78	241.77	347.74	23069.93	589.52
1992	110.76	874.51	5919.04	0.00	8983.65	176.19	272.94	15887.96	449.13
1993	218.42	723.76	9721.69	0.00	5467.64	124.25	254.83	16131.51	379.08
1994	128.41	726.57	8159.82	0.00	5995.10	269.98	303.90	15009.90	573.88
1995	462.18	438.78	7131.85	33.99	3394.93	169.04	306.99	11461.73	476.04
1996	307.42	649.03	5906.66	145.34	4470.74	253.95	247.47	11479.19	501.42
1997	279.94	456.77	5895.00	463.38	5778.24	283.15	317.63	12873.34	600.78
1998	328.55	254.58	5930.33	150.62	5293.21	100.11	241.32	11957.28	341.43
1999	414.60	597.95	4155.13	146.35	7639.74	351.43	297.93	12953.78	649.36
2000	686.79	356.76	4106.73	796.50	10285.53	484.28	302.65	16232.31	786.93
2001	769.02	432.38	3749.34	1964.53	10294.29	208.30	209.04	17209.55	417.34
2002	967.09	267.35	2902.54	2130.53	11156.30	393.17	232.28	17423.80	625.44
2003	861.87	199.92	2407.04	4171.35	10698.26	642.94	202.66	18338.43	845.61
2004	1302.40	156.72	1565.03	4934.77	5811.21	225.09	174.79	13770.13	399.87
2005	1855.04	103.68	2768.70	3471.85	7648.83	376.75	207.22	15848.09	583.97
2006	1560.11	94.64	3642.15	3363.59	5050.75	143.33	131.63	13711.24	274.96
2007	1710.53	110.34	3786.82	2797.40	7989.42	355.39	107.20	16394.50	462.59
2008	1917.57	424.09	2380.98	1548.93	8486.50	541.26	123.64	14758.07	664.90
2009	2155.50	800.48	3174.87	2130.70	11040.81	429.28	75.50	19302.35	504.78
2010	2707.29	317.82	2969.28	3965.20	13044.09	505.46	111.23	23003.68	616.70
2011	1965.91	192.87	2392.67	2733.18	9546.84	358.76	123.70	16831.46	482.47
2012	2466.91	121.87	3158.17	2155.23	7285.70	283.99	137.15	15187.89	421.13
2013	2996.30	58.56	2573.44	759.67	13547.06	572.36	90.29	19935.03	662.65
2014	3855.68	74.72	2076.45	1240.31	8669.58	441.10	113.80	15916.73	554.90
2015	2697.36	120.17	2166.49	391.05	4789.03	227.52	121.67	10164.11	349.19
2016	3090.02	162.41	2443.43	1519.37	10936.52	517.92	131.97	18151.75	649.88
2017	3040.28	81.34	2463.22	2173.46	5913.39	347.87	116.61	13671.70	464.48
2018	3528.58	80.58	3134.04	1543.05	8350.70	692.70	88.19	16636.95	780.89
2019	3047.24	346.82	2506.72	2719.72	13645.48	1126.15	132.76	22265.97	1258.91
2020	3031.76	182.15	3459.57	1468.65	22769.95	1134.22	113.69	30912.08	1247.91

Table 20. Estimated total discards at age in numbers (1000 fish).

Year	0	1	2	3	4	5	6	7	8	9	10
1986	316.49	76.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1987	236.17	20.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	297.27	24.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1989	448.08	63.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1990	386.40	48.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1991	472.83	67.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	336.76	58.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	359.80	27.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	473.95	62.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	405.04	48.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	421.64	52.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	420.12	86.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	337.84	20.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	515.11	76.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	517.09	123.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	374.52	36.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	536.13	61.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	555.66	132.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	353.88	36.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	423.73	79.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	235.51	27.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	385.42	49.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2008	477.02	92.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2009	334.84	78.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	501.01	69.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2011	343.67	67.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	317.51	54.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2013	576.01	63.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2014	420.90	70.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2015	307.11	32.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2016	458.83	92.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2017	353.73	58.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2018	628.55	89.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2019	766.92	214.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2020	1044.65	130.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 21. Estimated total discards at age in whole weight (1000 lb).

Year	0	1	2	3	4	5	6	7	8	9	10
1986	263.30	222.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1987	196.48	60.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	247.31	69.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1989	372.77	183.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1990	321.45	141.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1991	393.36	196.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	280.16	168.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	299.33	79.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	394.29	179.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	336.96	139.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	350.77	150.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	349.51	251.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	281.05	60.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	428.53	220.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	430.18	356.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	311.57	105.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	446.02	179.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	462.26	383.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	294.40	105.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	352.51	231.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	195.93	79.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	320.64	141.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2008	396.85	268.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2009	278.56	226.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	416.80	199.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2011	285.91	196.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	264.14	156.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2013	479.19	183.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2014	350.16	204.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2015	255.49	93.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2016	381.71	268.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2017	294.28	170.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2018	522.91	257.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2019	638.02	620.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2020	869.07	378.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 22. 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 ensemble (MCBE) 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 as total mature female biomass. The definitions of MSST in this assessment is* $MSST = 75\% SSBMSY$.

Quantity	Units	Estimate	Median	SE
F_{MSY}	y^{-1}	0.516	0.523	0.111
$75\%F_{\mathrm{MSY}}$	y^{-1}	0.387	0.392	0.083
$F_{30\%}$	y^{-1}	0.608	0.615	0.059
$F_{40\%}$	y^{-1}	0.410	0.414	0.038
B_{MSY}	metric tons	19588	19821	2232
$\mathrm{SSB}_{\mathrm{MSY}}$	metric tons	6406	6410	1122
MSST	metric tons	4804	4808	842
MSY	1000 lb whole	8210	8351	411
R_{MSY}	thousands	22792	23392	3015
$L_{85\%}Fmsy$	1000 lb whole	8149	8287	410
$L_{75\%}Fmsy$	1000 lb whole	8024	8158	408
$L_{65\%}Fmsy$	1000 lb whole	7807	7932	407
$F[2018-2020]$	y^{-1}	0.40	0.39	0.05
$F_{2018-2020}/F_{\mathrm{MSY}}$	—	0.77	0.74	0.21
$\mathrm{SSB}_{2020}/\mathrm{MSST}$	—	1.40	1.42	0.34
$\mathrm{SSB}_{2020}/\mathrm{SSB}_{\mathrm{MSY}}$	—	1.05	1.07	0.25

Table 23. Results from sensitivity runs of the Beaufort Assessment Model. Current F represented by geometric mean of last three assessment years. Spawning stock was based on total (population) fecundity of mature females. Runs should not all be considered equally plausible.

Run	Description	F_{MSY}	$\mathrm{SSB}_{\mathrm{MSY}}$ (mt)	B_{MSY} (mt)	MSY (1000 lb)	$\mathrm{F}_{2018--2020}/F_{\mathrm{MSY}}$	$\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$	$\mathrm{SSB}_{2020}/\mathrm{MSST}$	R0 (1000)
Base	—	0.516	6406	19588	8210	0.77	1.05	1.4	21939
S1	Drop cH Index	0.541	6090	18647	7874	0.88	0.89	1.18	20835
S2	High M	0.661	5846	20962	9290	0.48	1.47	1.96	30852
S3	Low M	0.427	7408	20419	8085	1.06	0.78	1.05	18153
S4	High Steep	0.737	4727	16298	8477	0.54	1.42	1.89	20014
S5	Low Steep	0.369	9057	25444	8485	1.07	0.74	0.99	26379
S6	High GR Discard M	0.478	6703	20205	7996	0.83	1	1.33	22253
S7	Low GR Discard M	0.566	6066	18891	8467	0.7	1.11	1.48	21626

Table 24. Projection results with fishing mortality rate fixed at $F = F_{\text{current}}$ starting in 2023. Interim period (2021-2022) assumed constant landings based on the average of the last 3 years of the assessment. F = fishing mortality rate (per year), pr.rebuild = proportion of stochastic projection replicates with $\text{SSB} \geq \text{SSB}_{\text{MSY}}$, *S = spawning stock (mt) at peak spawning time, Rm = total removals (landings and dead discards) expressed in numbers (1000s) or whole weight (*lb*). Total removals presented here would need reduction if values are used to develop quotas based only on landings. The extension* base *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
2021	21287	21728	0.85	0.81	4761	4928	6575	6471	10556	10450	1777	1518	842	745	0.193
2022	20531	17043	1.10	1.03	4164	4383	7342	7198	10556	10441	2069	1725	1016	885	0.124
2023	18993	14749	0.40	0.39	3239	3259	2843	2557	3907	3732	741	557	375	296	0.113
2024	21667	17148	0.40	0.39	5109	4770	3459	3010	4930	4456	836	633	416	326	0.294
2025	22519	18049	0.40	0.39	6048	5567	4012	3470	5885	5225	880	676	447	353	0.403

Table 25. Projection results with fishing mortality rate fixed at $F = F_{\mathrm{MSY}}$ starting in 2023. Interim period (2021-2022) assumed constant landings based on the average of the last 3 years of the assessment. F = fishing mortality rate (per year), pr.rebuild = proportion of stochastic projection replicates with $\mathrm{SSB} \geq \mathrm{SSB}_{\mathrm{MSY}}$, *S = spawning stock (mt) at peak spawning time, Rm = total removals (landings and dead discards) expressed in numbers (1000s) or whole weight (*lb*). Total removals presented here would need reduction if values are used to develop quotas based only on landings. The extension* base *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
2021	21287	21728	0.85	0.81	4761	4928	6575	6471	10556	10450	1777	1518	842	745	0.193
2022	20531	17043	1.10	1.03	4164	4383	7342	7198	10556	10441	2069	1725	1016	885	0.124
2023	18993	14749	0.52	0.52	3239	3259	3570	3415	4891	4909	953	764	480	402	0.113
2024	21128	16681	0.52	0.52	4626	4149	4125	3757	5796	5440	1049	842	519	432	0.181
2025	21804	17407	0.52	0.52	5244	4552	4612	4118	6606	5996	1093	884	550	458	0.230

Table 26. Projection results with fishing mortality rate fixed at $F = 75\%F_{\mathrm{MSY}}$ starting in 2023. Interim period (2021-2022) assumed constant landings based on the average of the last 3 years of the assessment. F = fishing mortality rate (per year), pr.rebuild = proportion of stochastic projection replicates with $\mathrm{SSB} \geq \mathrm{SSB}_{\mathrm{MSY}}$, *S = spawning stock (mt) at peak spawning time, Rm = total removals (landings and dead discards) expressed in numbers (1000s) or whole weight (*lb*). Total removals presented here would need reduction if values are used to develop quotas based only on landings. The extension* base *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
2021	21287	21728	0.85	0.81	4761	4928	6575	6471	10556	10450	1777	1518	842	745	0.193
2022	20531	17043	1.10	1.03	4164	4383	7342	7198	10556	10441	2069	1725	1016	885	0.124
2023	18993	14749	0.39	0.39	3239	3259	2784	2667	3827	3850	725	582	367	307	0.113
2024	21708	17212	0.39	0.39	5149	4655	3401	3117	4853	4597	819	661	408	340	0.260
2025	22573	18160	0.39	0.39	6116	5374	3957	3573	5815	5342	863	704	438	368	0.360

4.19 Figures

Figure 1. Mean length at age (mm) of the population (purple, solid), females (green, dashed) and the fished population (yellow, dotted).

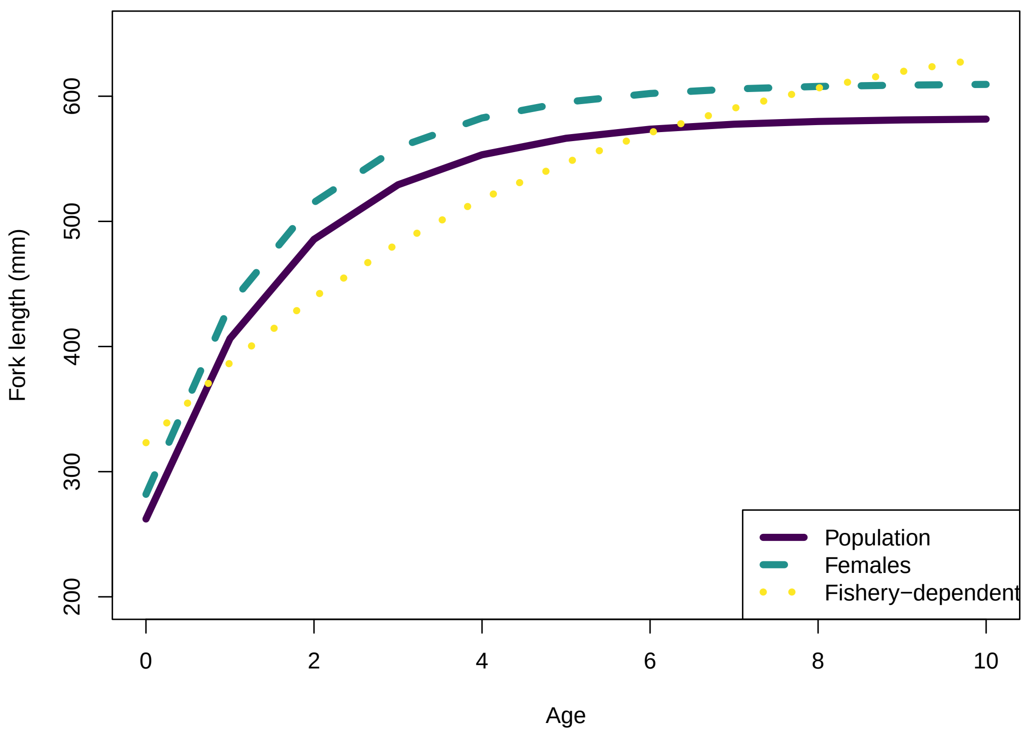


Figure 2. Observed (open circles) and estimated (solid line) annual age compositions by fleet. In panel definition of series; acomp refers to age compositions, cH to commercial handline, cP to pound nets, cG to gill nets, cC to cast nets, and GR to recreationl.

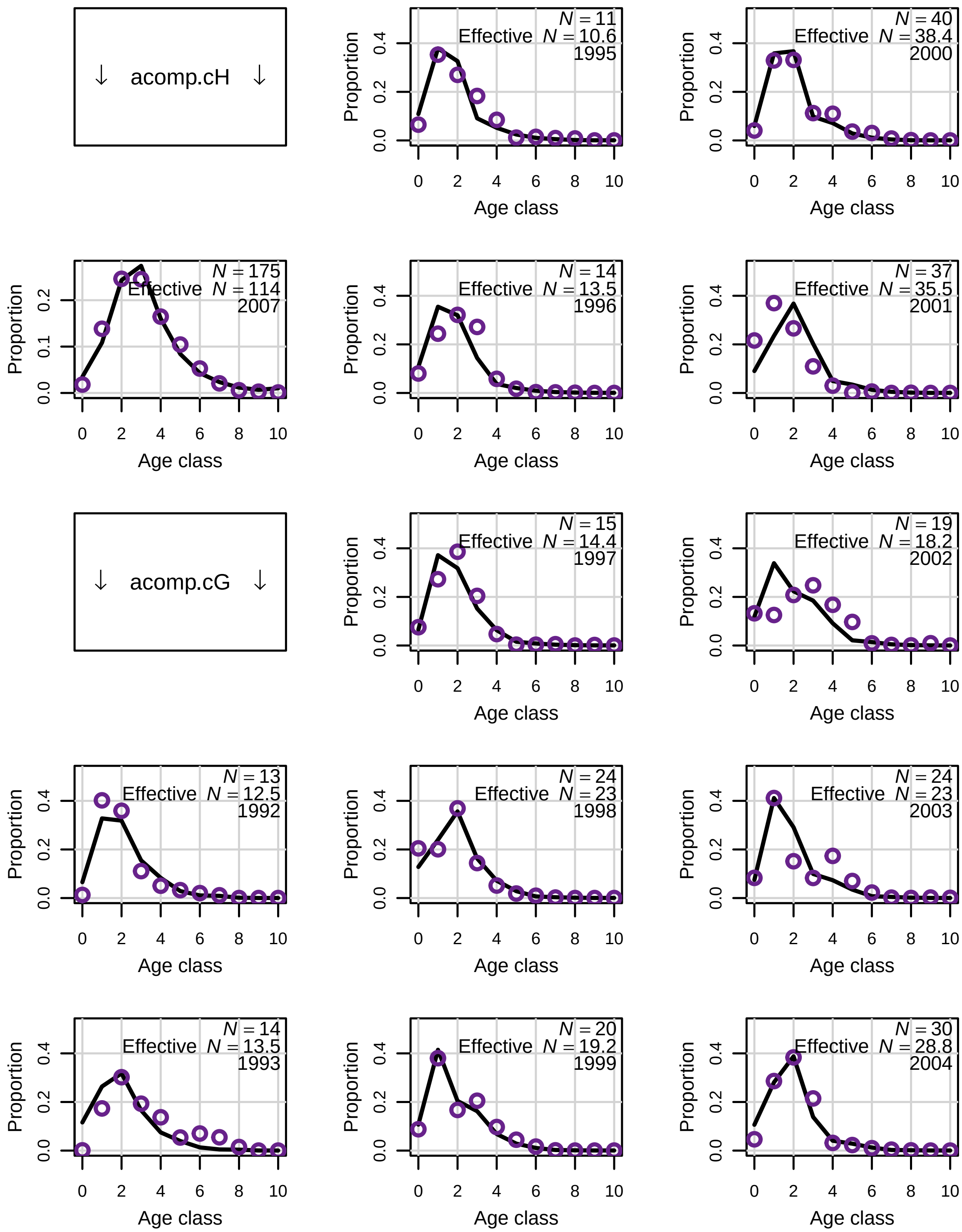


Figure 2. (cont.) Observed (open circles) and estimated (solid line) annual age compositions by fleet.

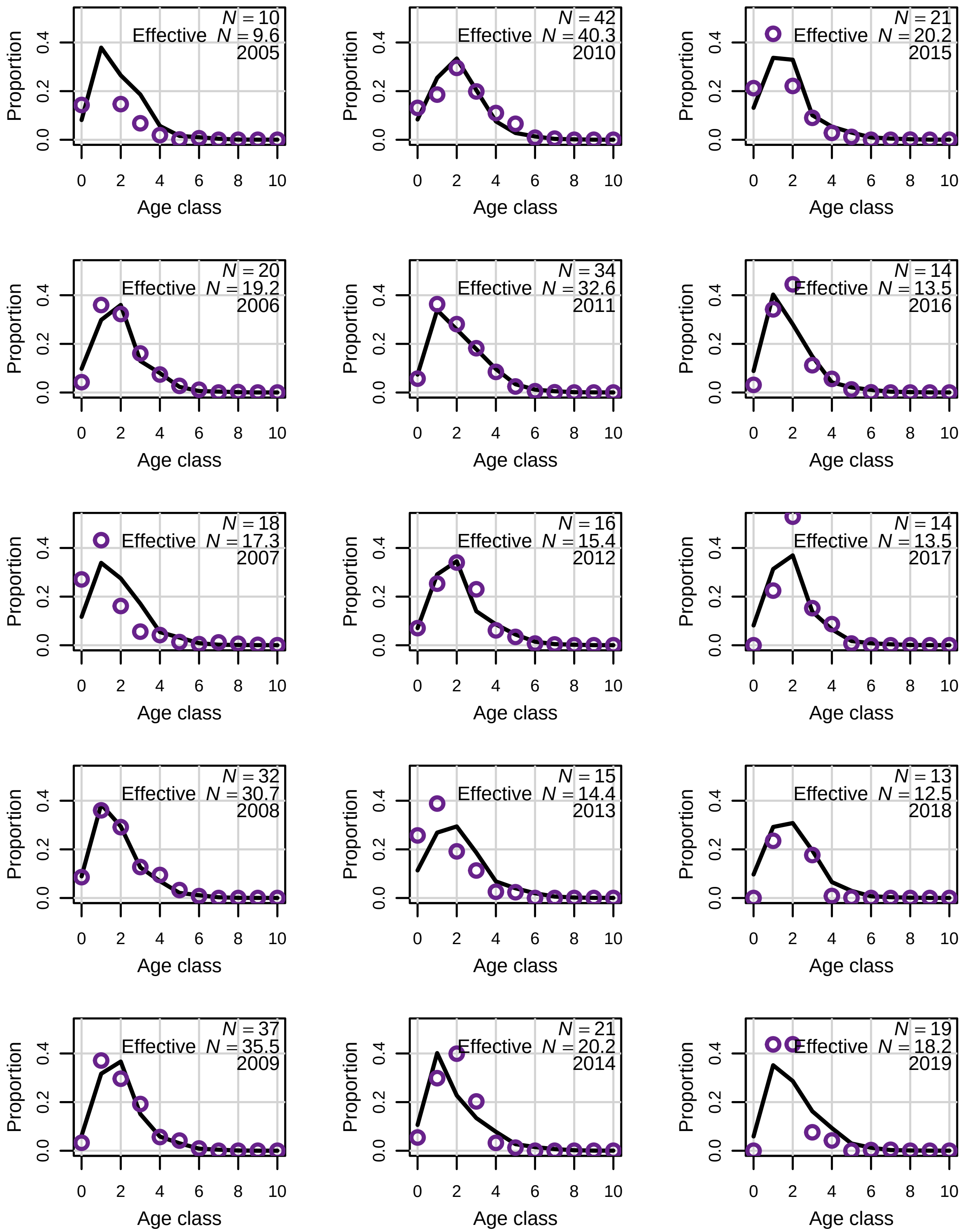


Figure 2. (cont.) Observed (open circles) and estimated (solid line) annual age compositions by fleet.

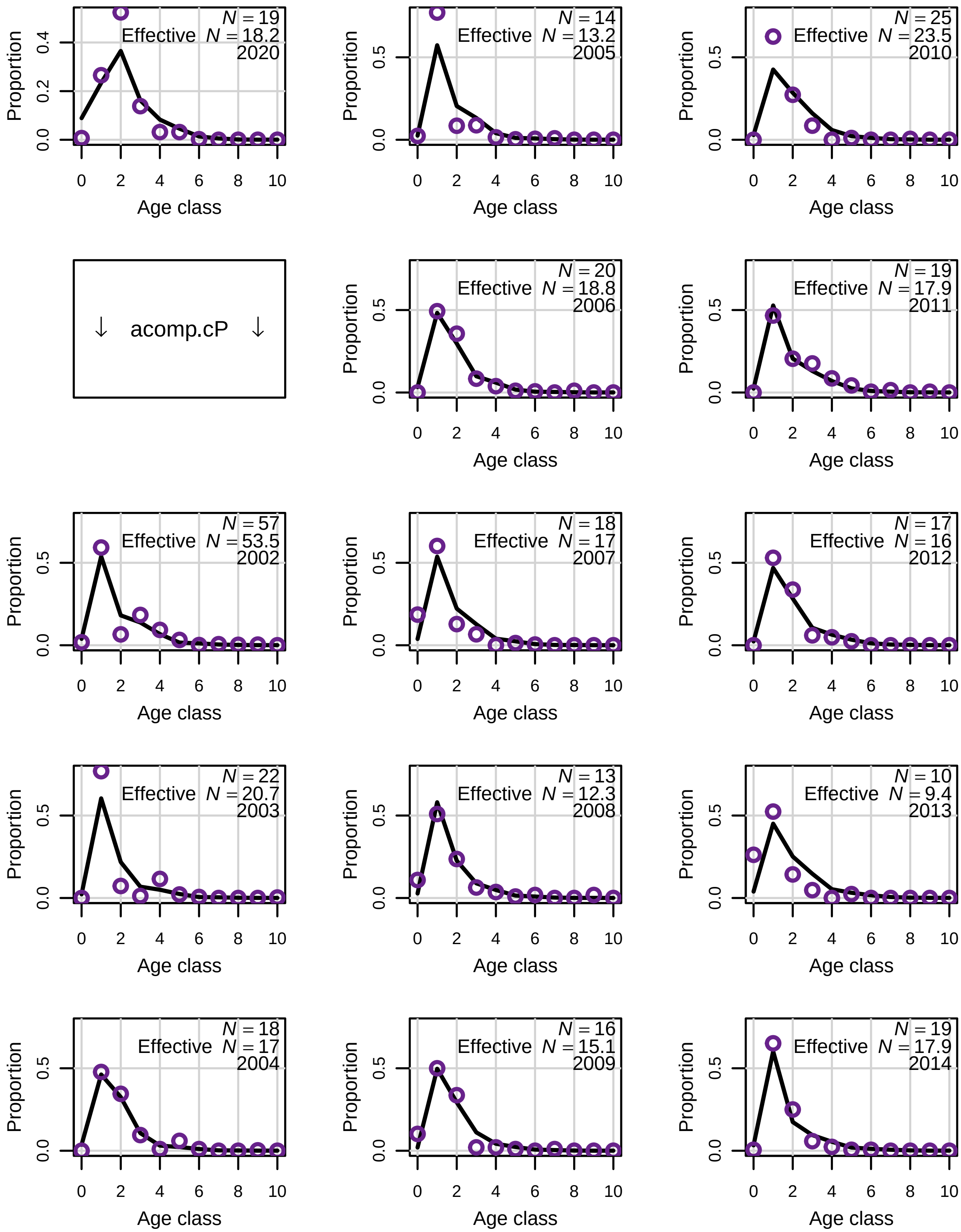


Figure 2. (cont.) Observed (open circles) and estimated (solid line) annual age compositions by fleet.

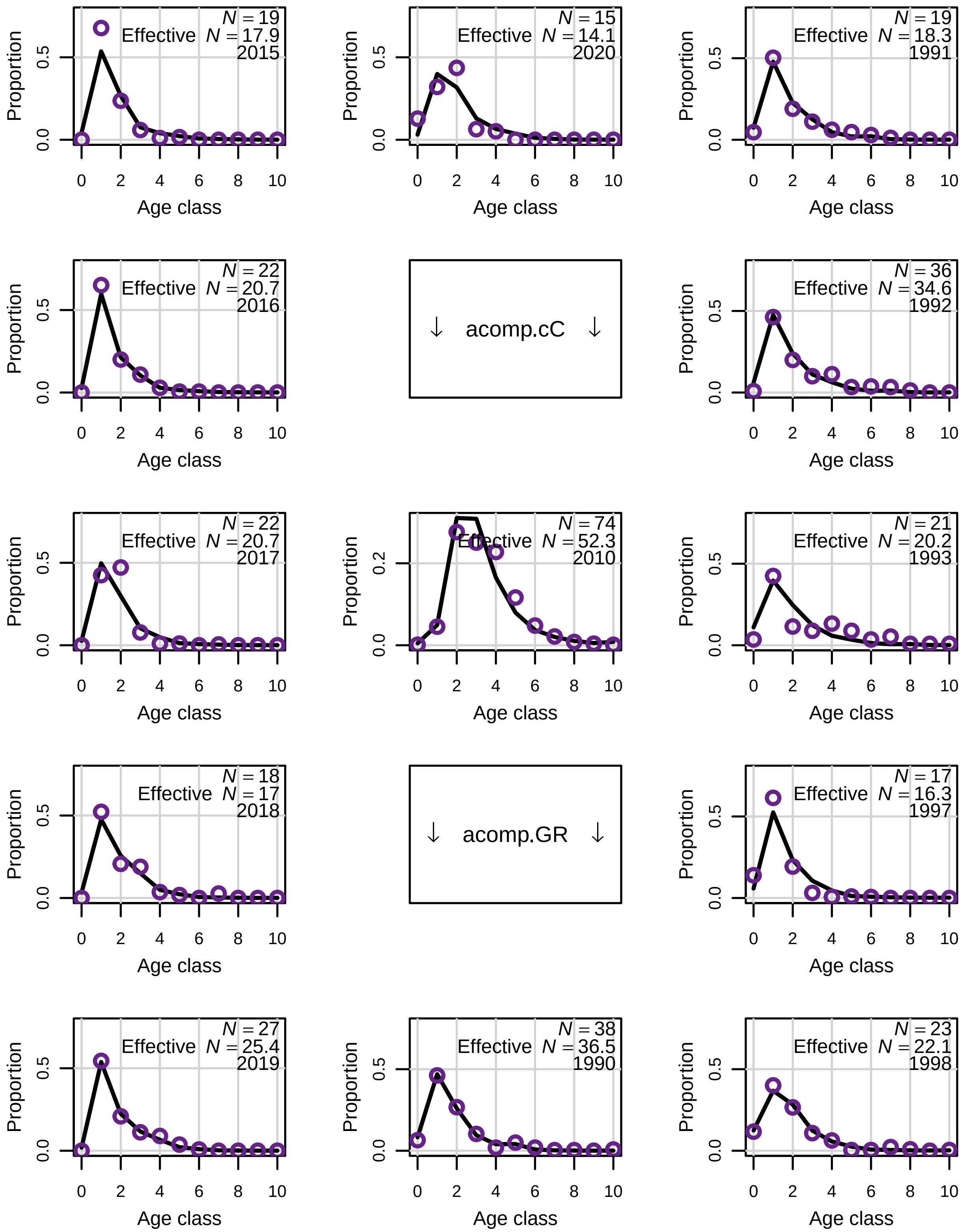


Figure 2. (cont.) Observed (open circles) and estimated (solid line) annual age compositions by fleet.

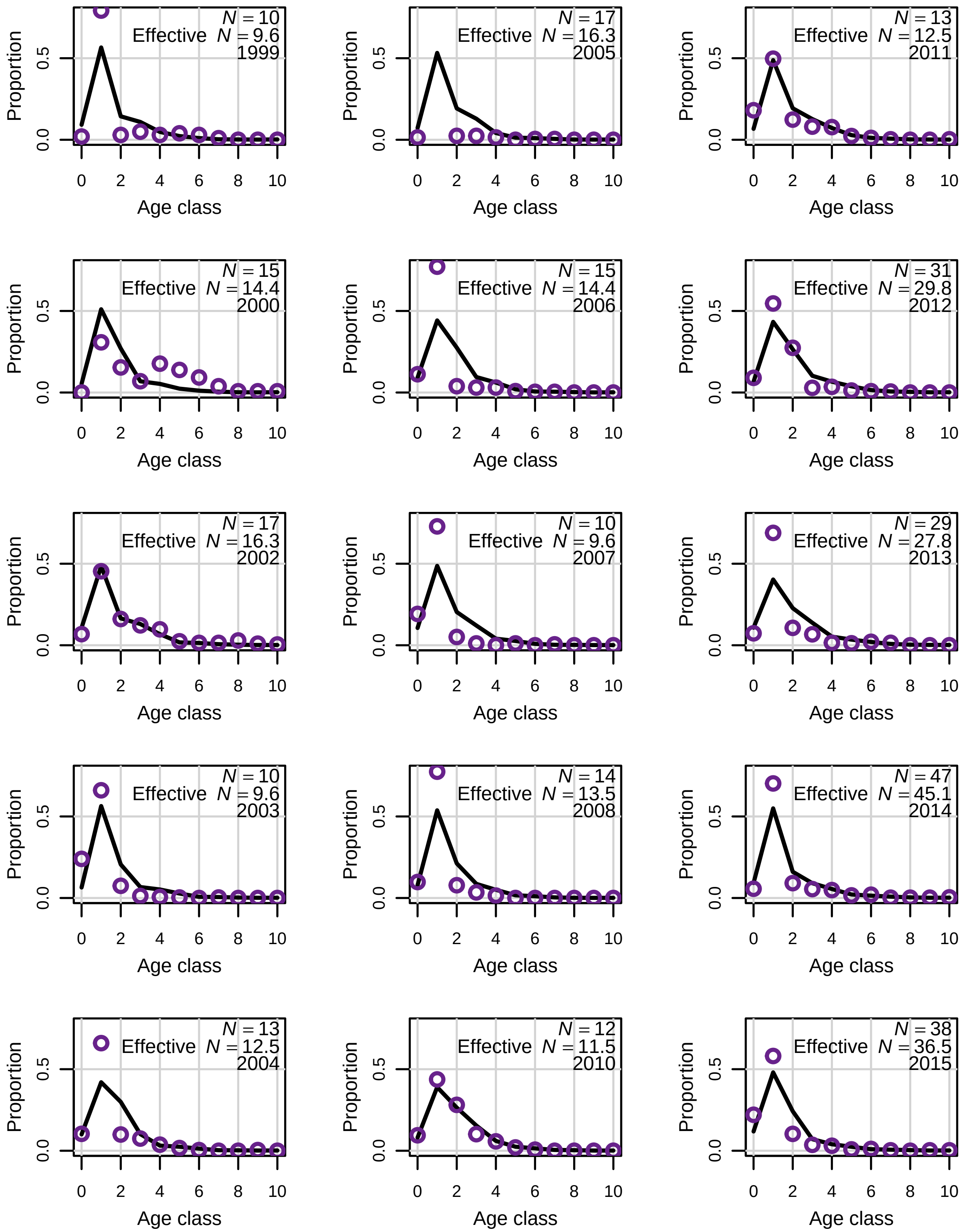


Figure 2. (cont.) Observed (open circles) and estimated (solid line) annual age compositions by fleet.

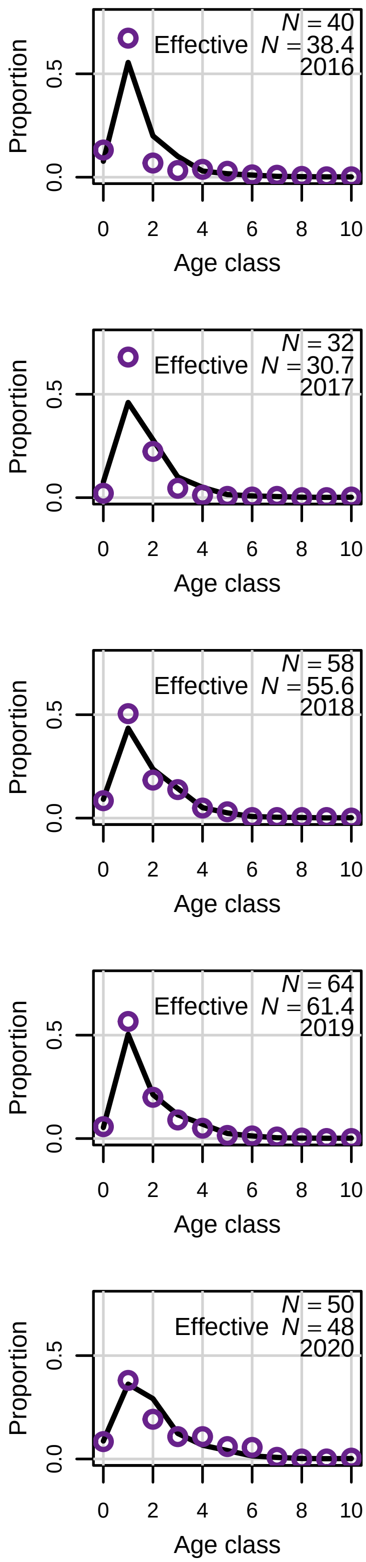


Figure 3. Top panel is a bubble plot of age composition residuals from commercial handline landings; blue represents overestimates and orange underestimates. Bottom panel shows correlation between predicted and observed values. The year is the approximate midpoint of the pooled annual compositions.

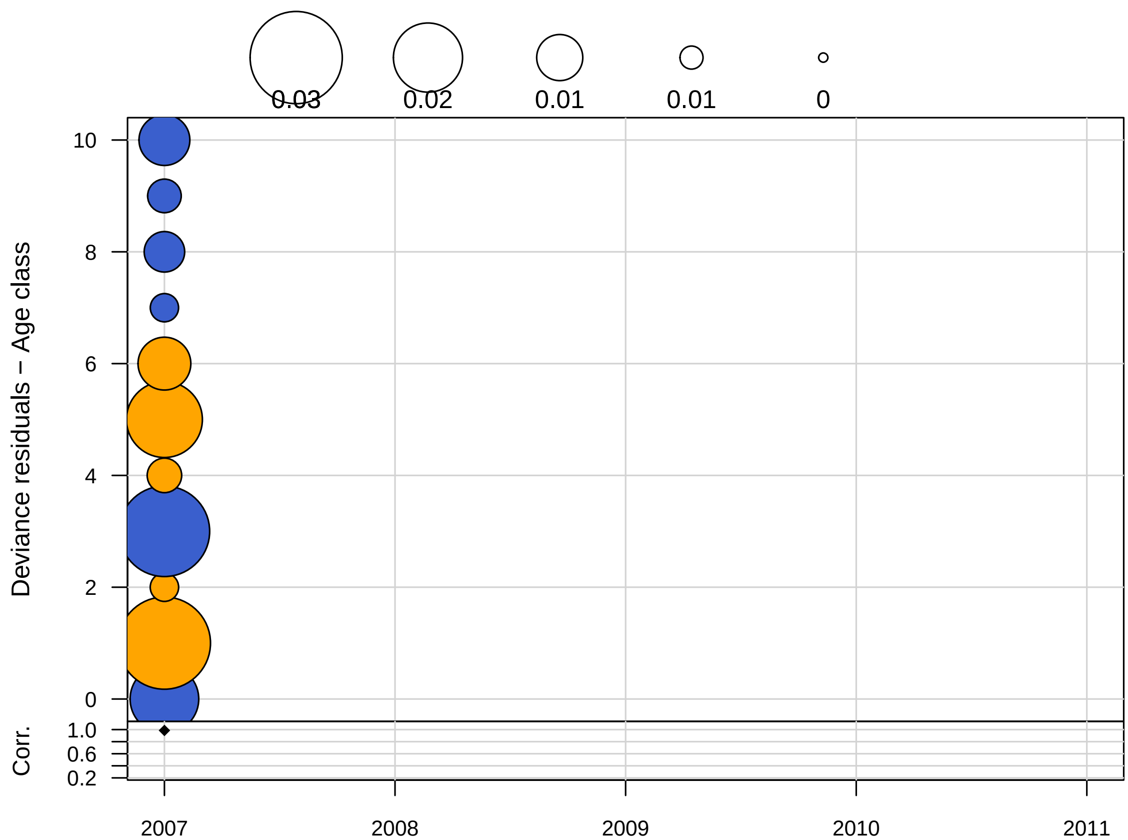


Figure 3. (cont.) Top panel is a bubble plot of age composition residuals from commercial pound net landings; blue represents overestimates and orange underestimates. Bottom panel shows correlation between predicted and observed values.

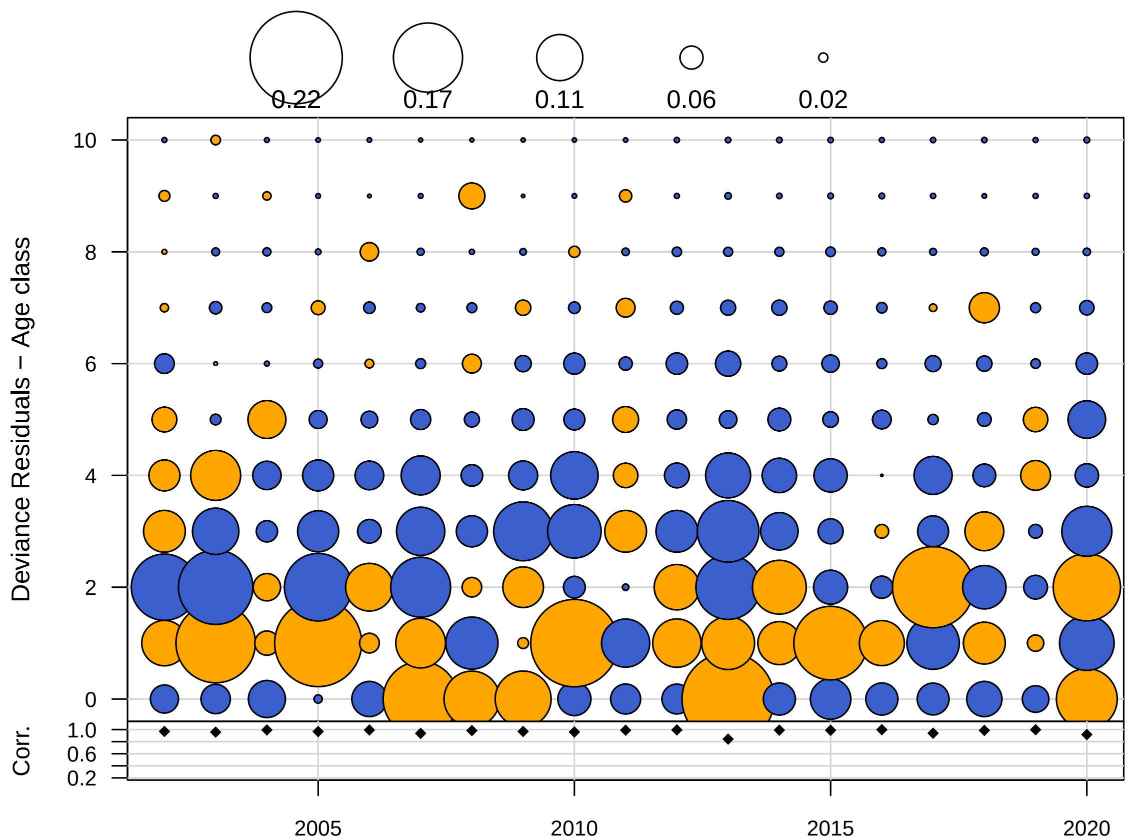


Figure 3. (cont.) Top panel is a bubble plot of age composition residuals from commercial gill net landings; blue represents overestimates and orange underestimates. Bottom panel shows correlation between predicted and observed values.

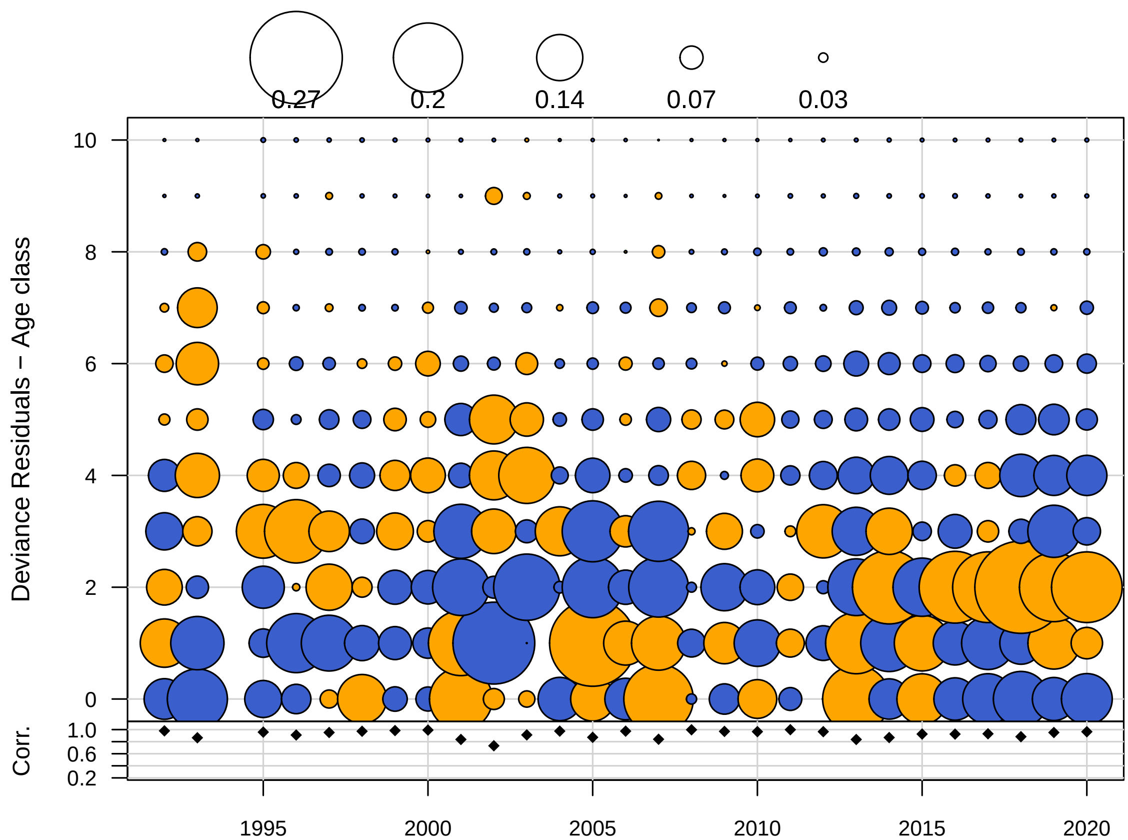


Figure 3. (cont.) Top panel is a bubble plot of age composition residuals from commercial cast net landings; blue represents overestimates and orange underestimates. Bottom panel shows correlation between predicted and observed values. The year is the approximate midpoint of the pooled annual compositions.

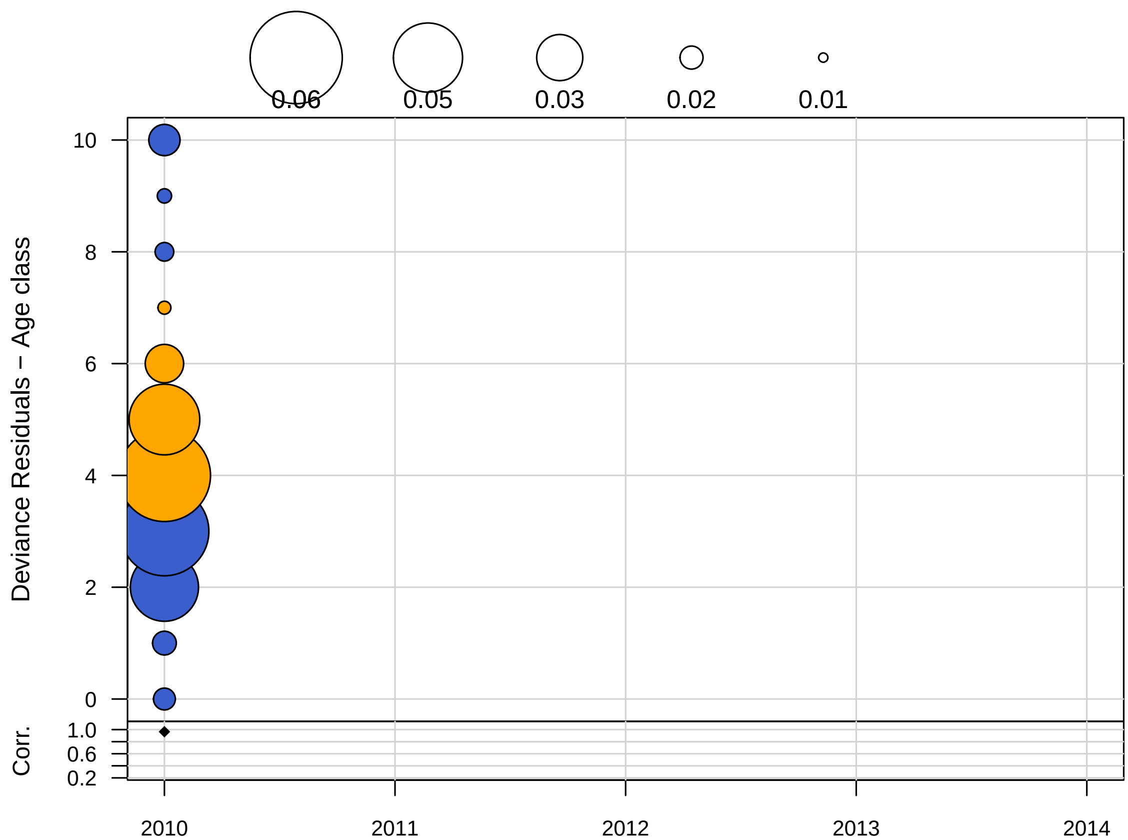


Figure 3. (cont.) Top panel is a bubble plot of age composition residuals from recreational landings; blue represents overestimates and orange underestimates. Bottom panel shows correlation between predicted and observed values.

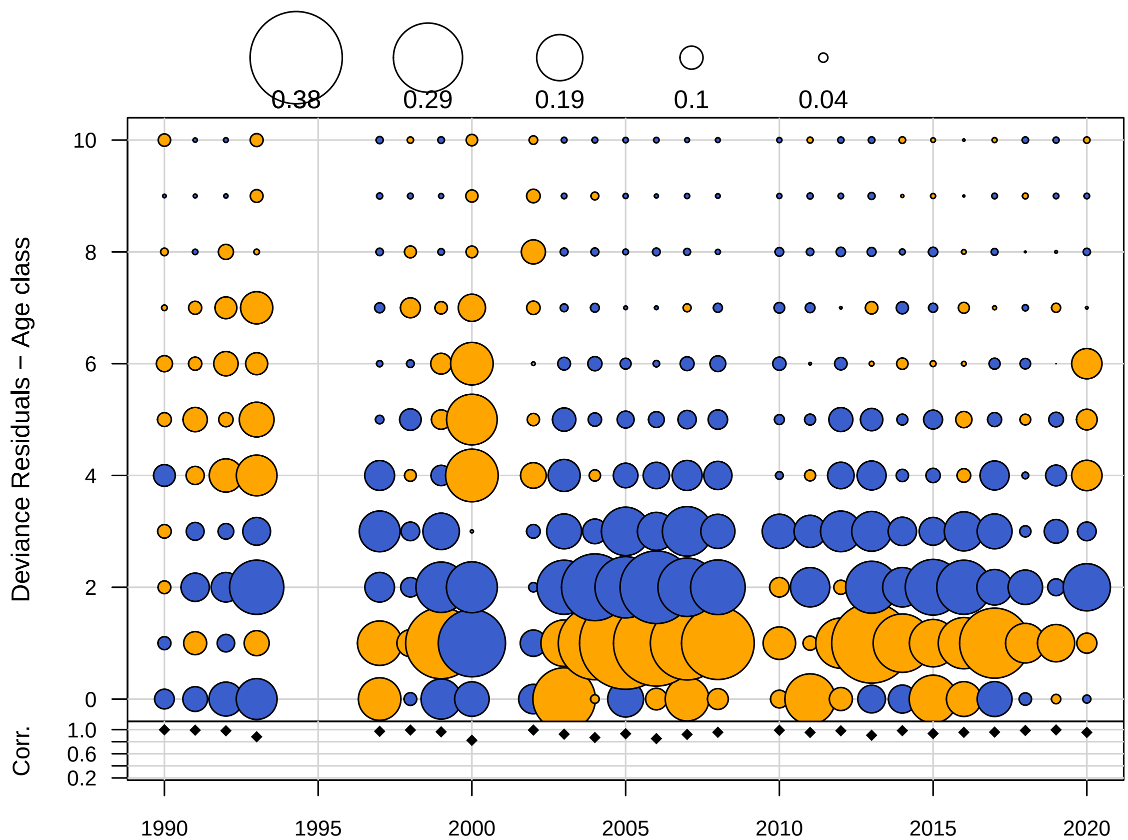


Figure 4. Observed (open circles) and estimated (line, solid circles) commercial handline landings (1000 lb whole weight).

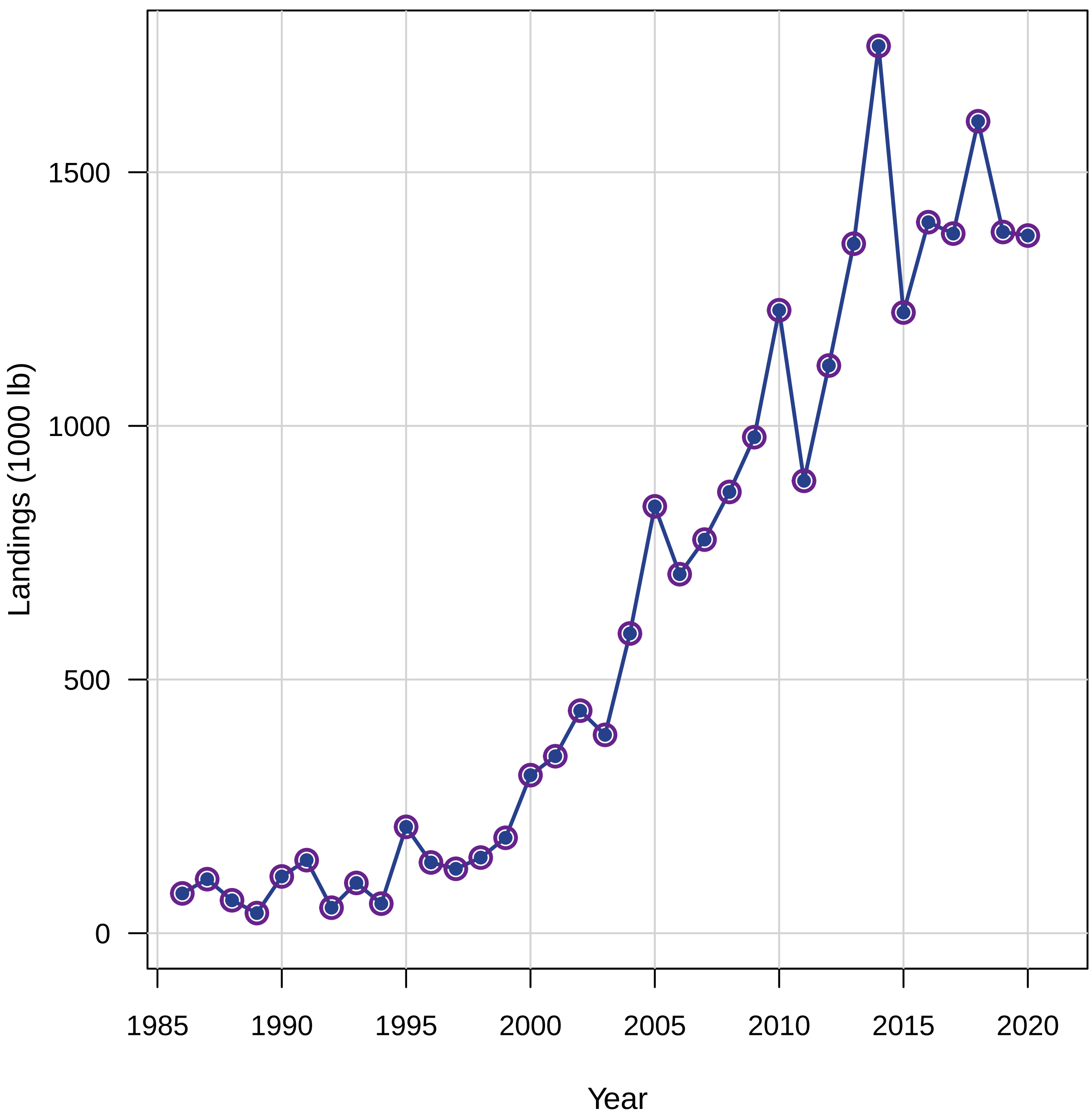


Figure 5. Observed (open circles) and estimated (line, solid circles) commercial pound net landings (1000 lb whole weight).

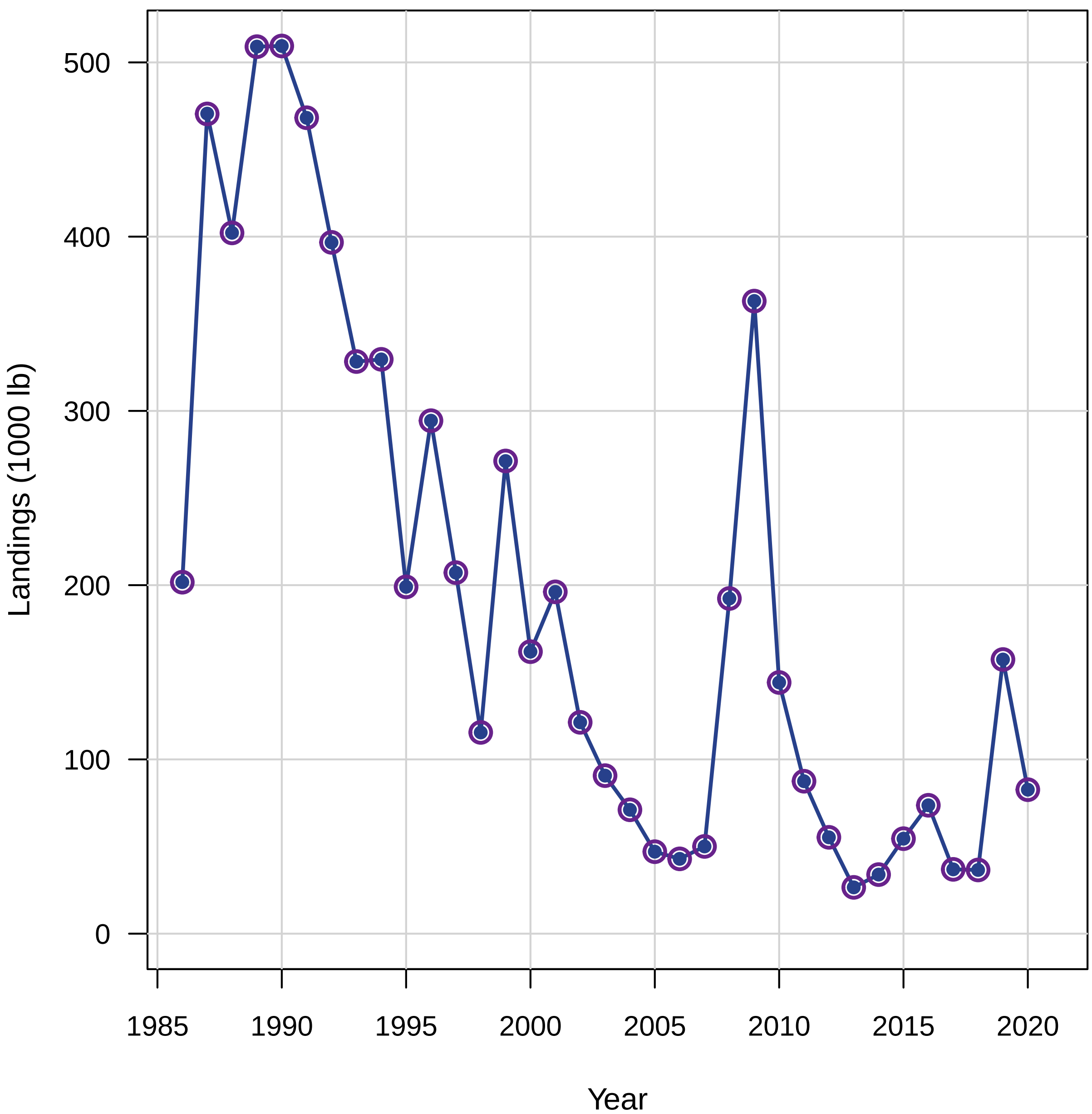


Figure 6. Observed (open circles) and estimated (line, solid circles) commercial gillnet landings (1000 lb whole weight).

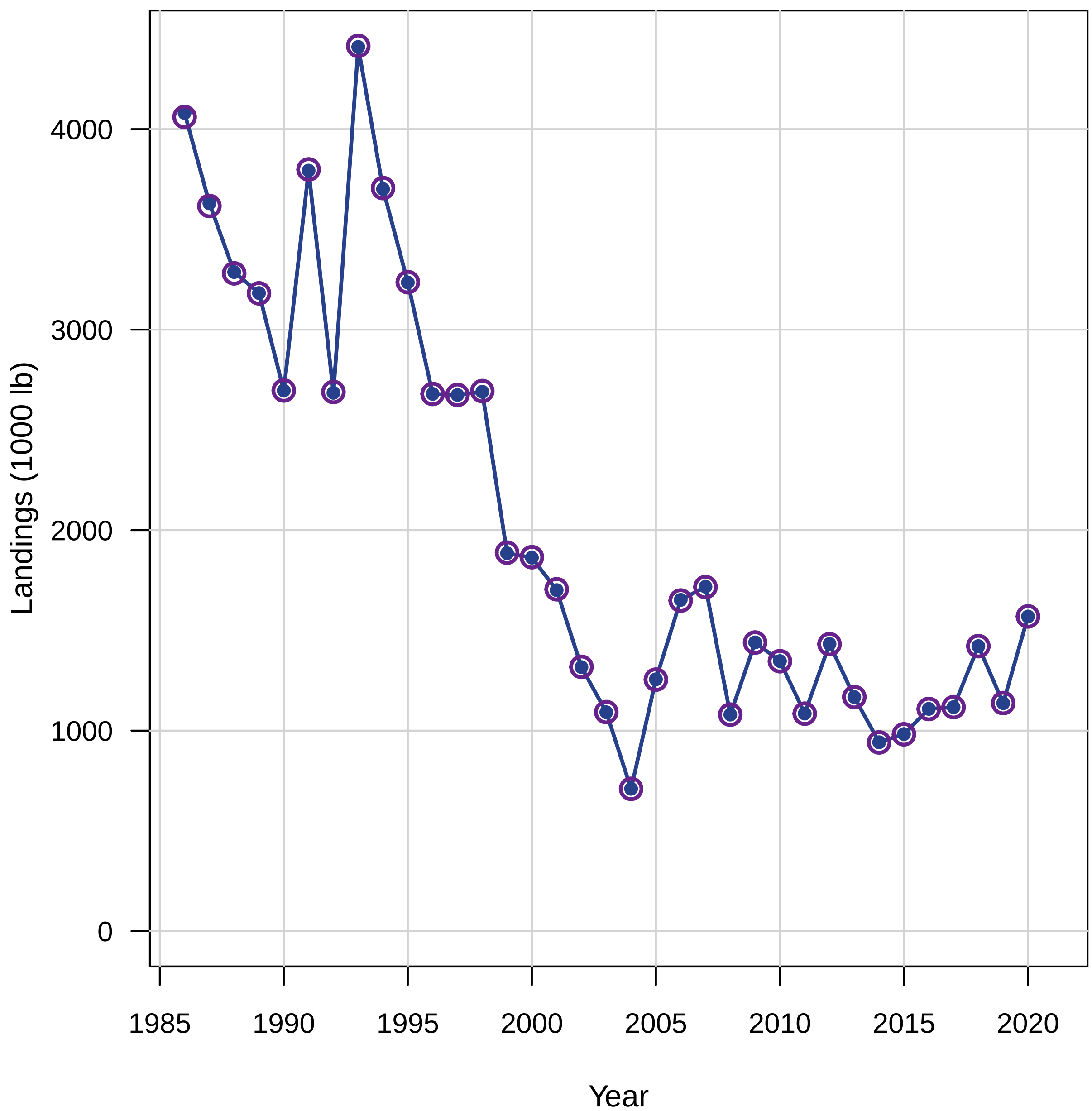


Figure 7. Observed (open circles) and estimated (line, solid circles) commercial cast net landings (1000 lb whole weight).

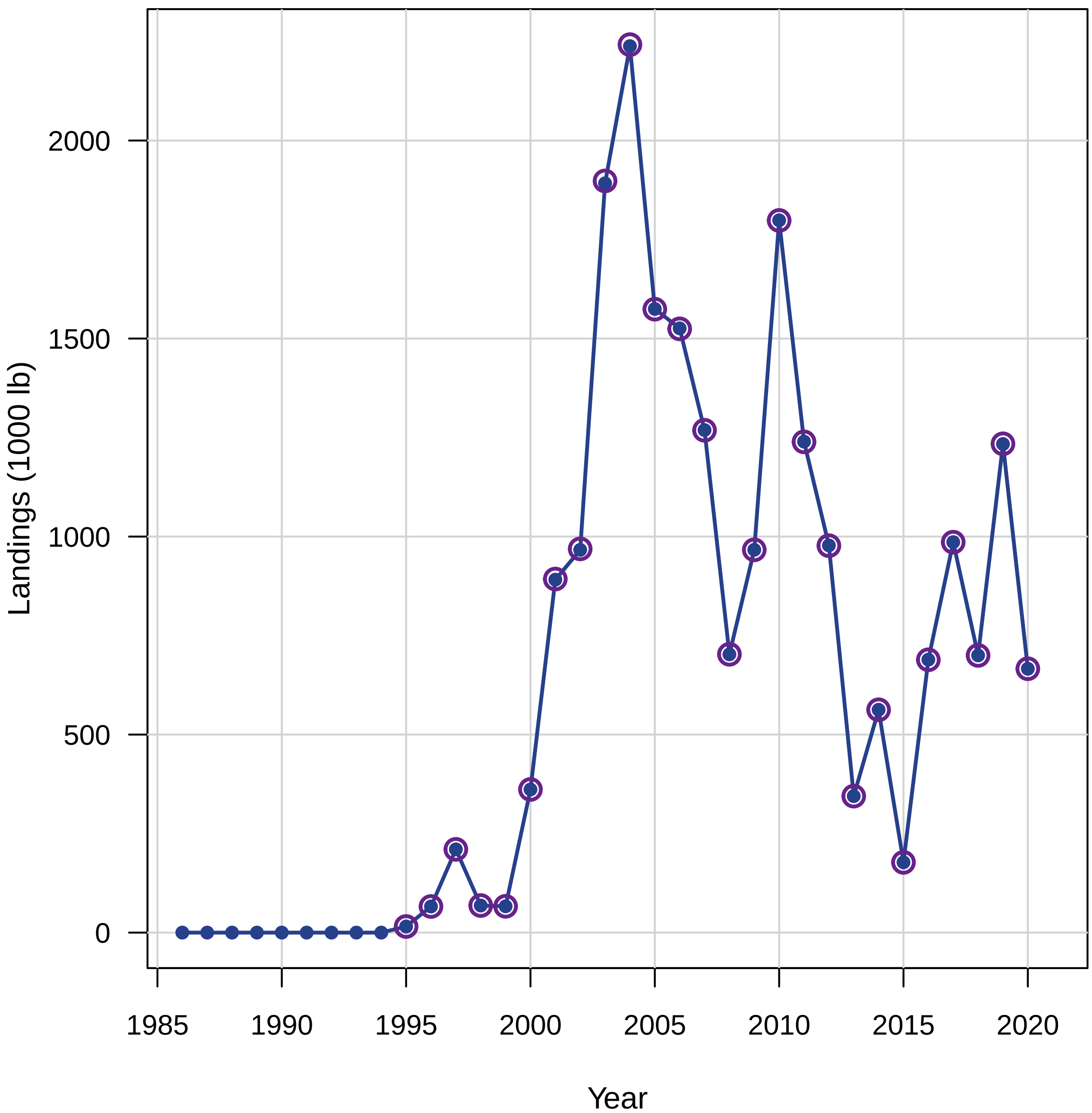


Figure 8. Observed (open circles) and estimated (line, solid circles) recreational landings (1000 fish).

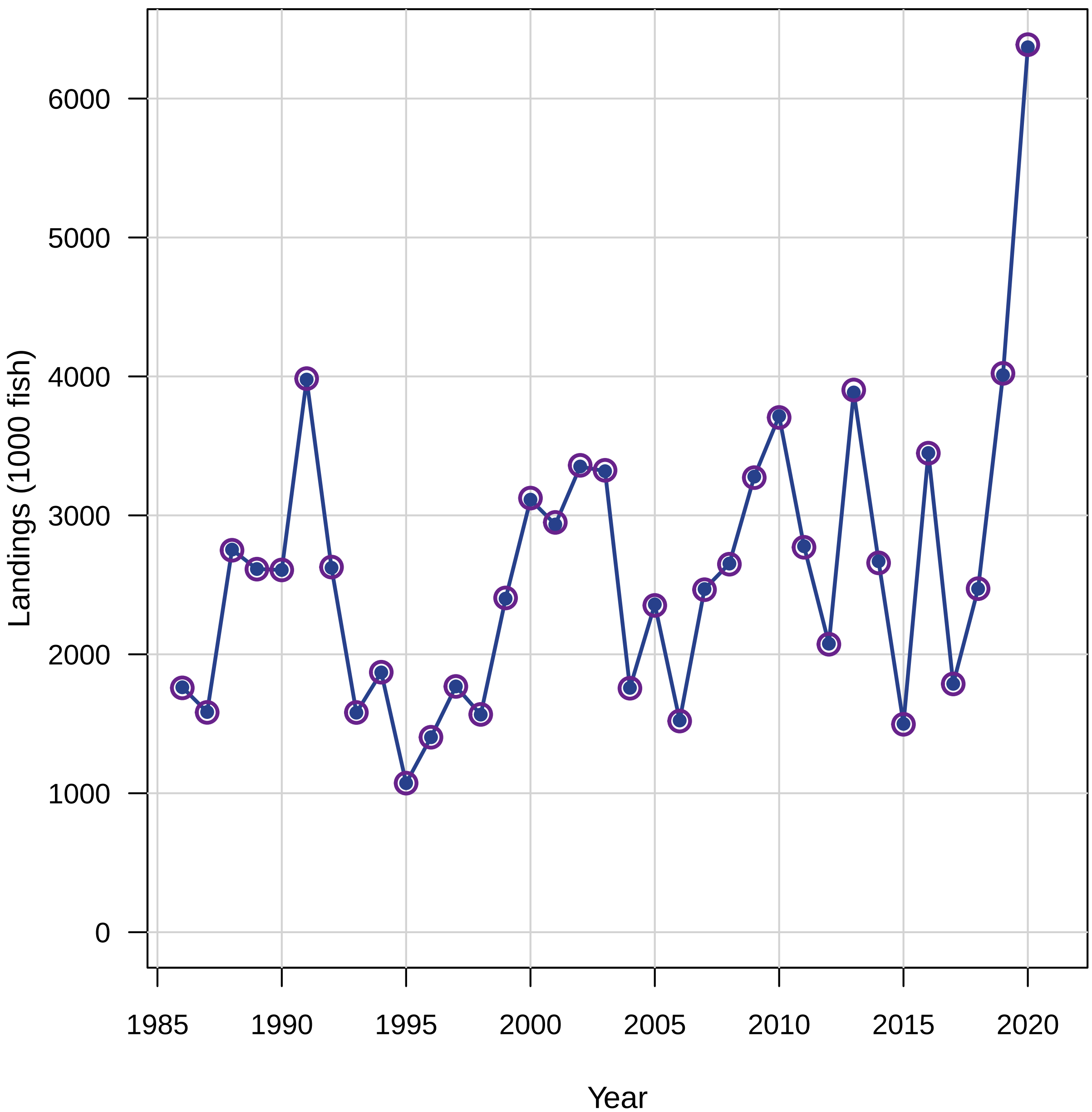


Figure 9. Observed (open circles) and estimated (line, solid circles) recreational discards (1000 fish).

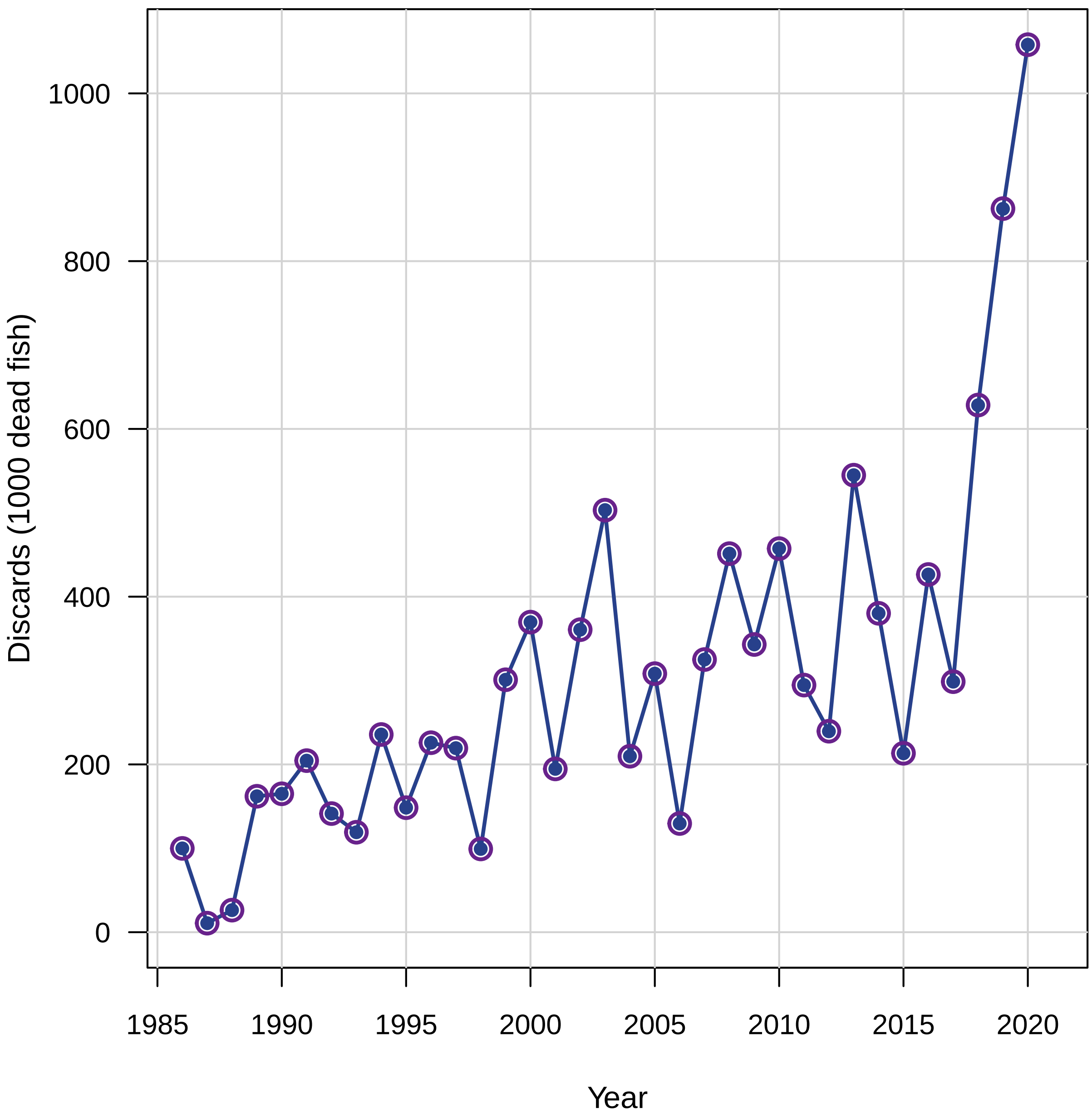


Figure 10. Observed (open circles) and estimated (line, solid circles) discards from shrimp bycatch (1000 fish).

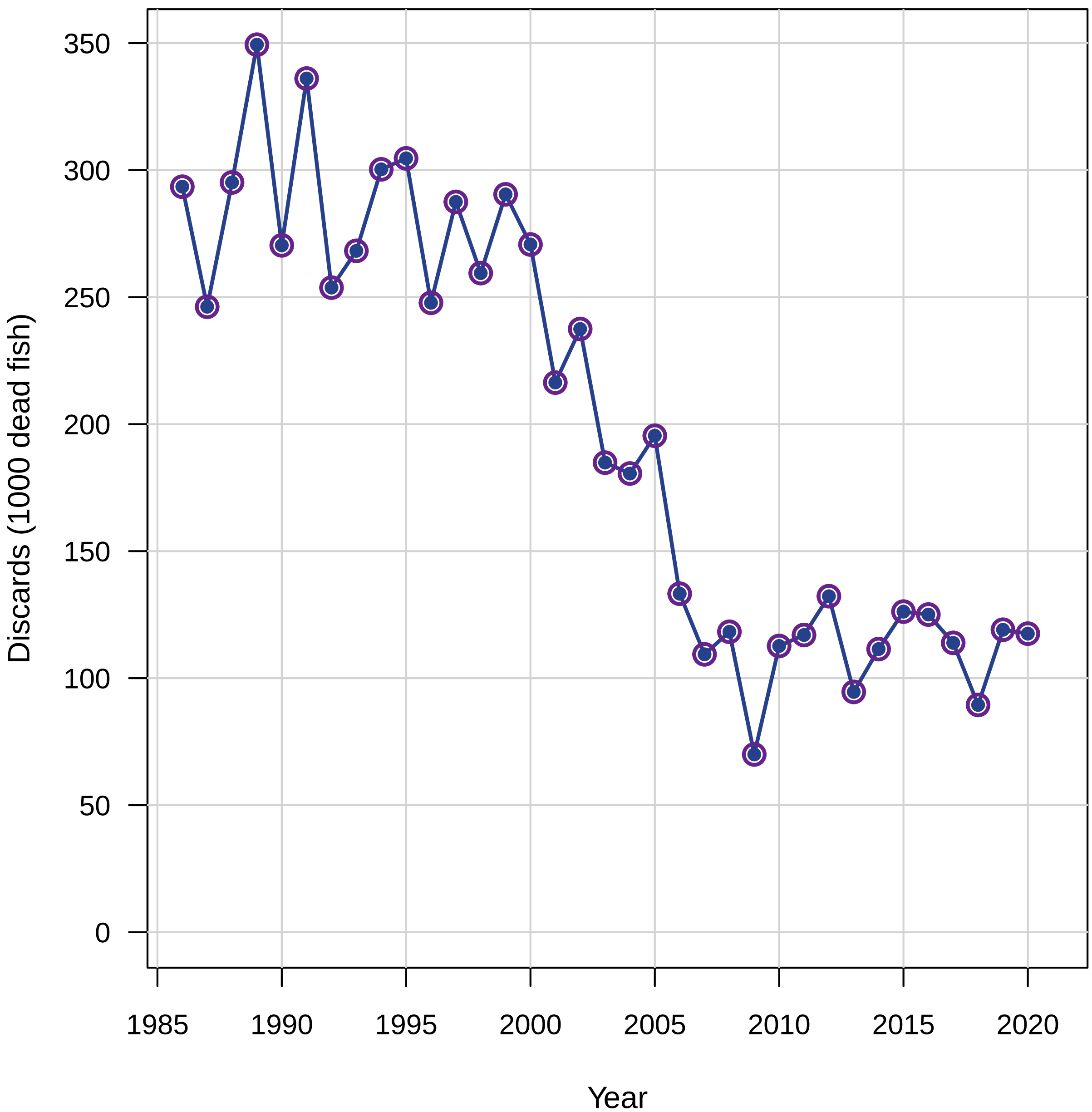


Figure 11. Top Panel: Observed (open circles) and estimated (line, solid circles) index of abundance from Florida commercial handline trip tickets. Bottom panel: Scaled residuals of estimated index of abundance. The model input CVs were modified from the input values by the SDNR weights.

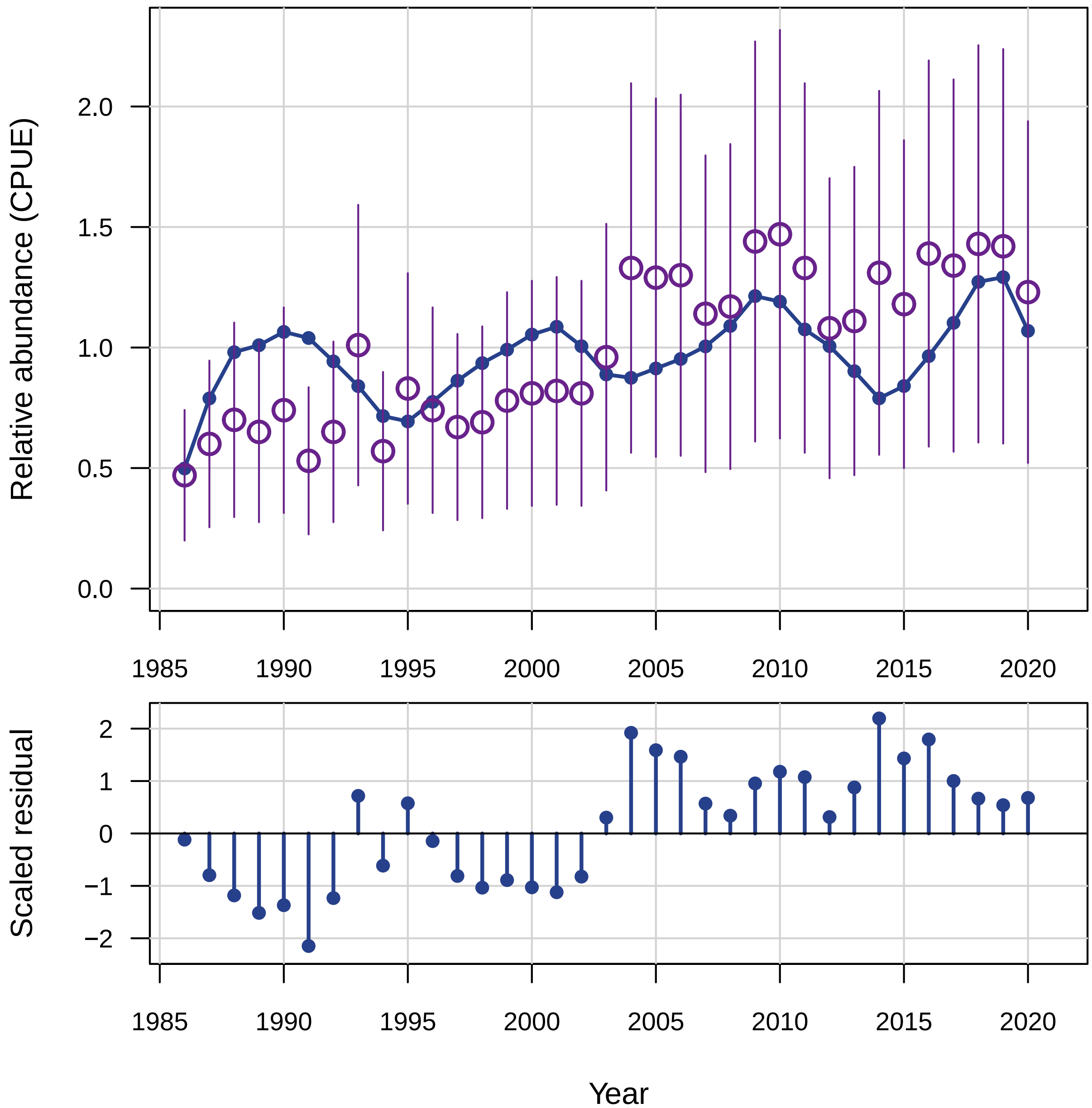


Figure 12. Top Panel: Observed (open circles) and estimated (line, solid circles) index of abundance from MRIP harvested fish. Bottom panel: Scaled residuals of estimated index of abundance. The model input CVs were modified from the input values by the SDNR weights.

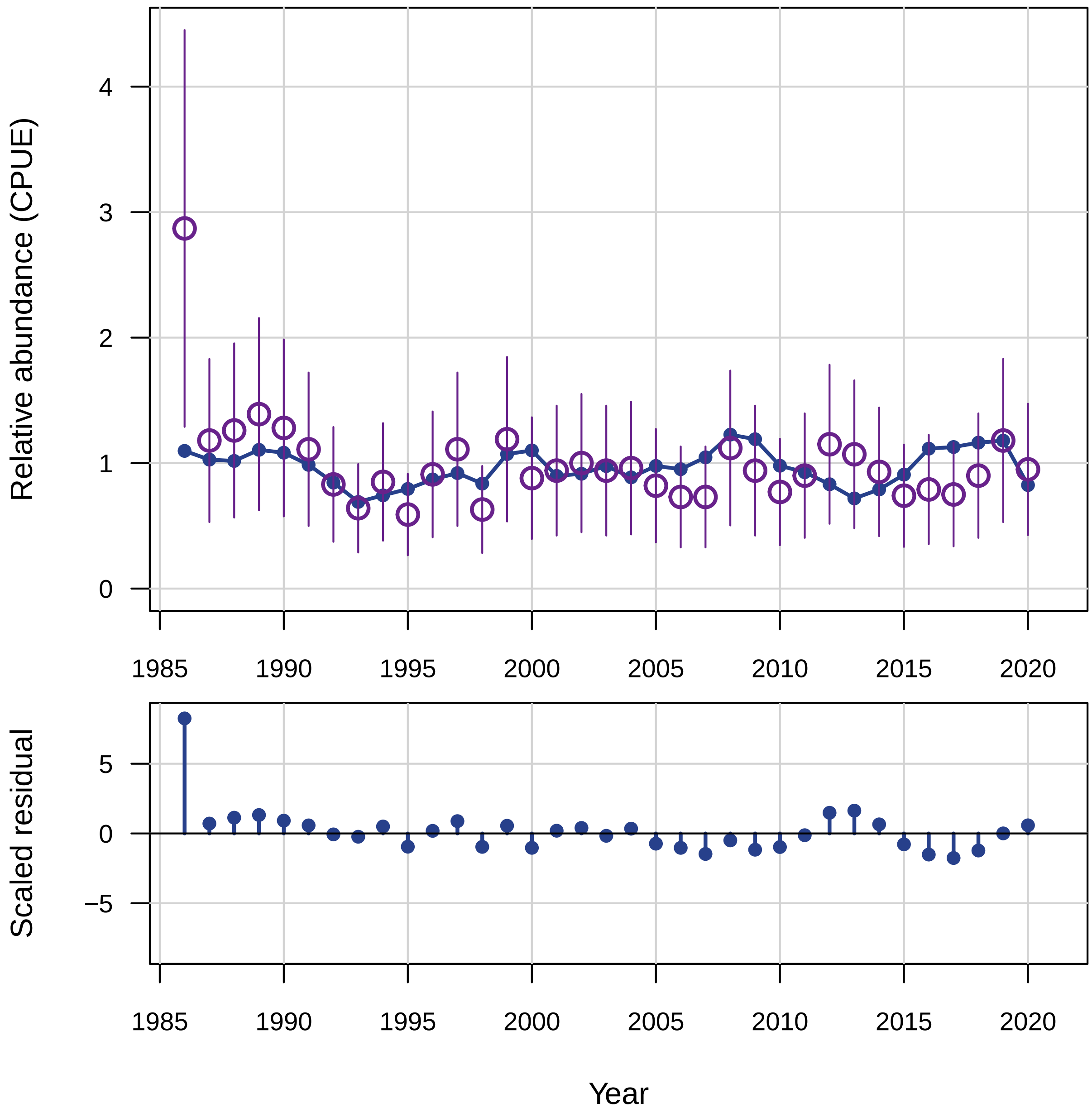


Figure 13. Top Panel: Observed (open circles) and estimated (line, solid circles) index of abundance from SEAMAP YOY samples. Bottom panel: Scaled residuals of estimated index of abundance. The model input CVs were modified from the input values by the SDNR weights.

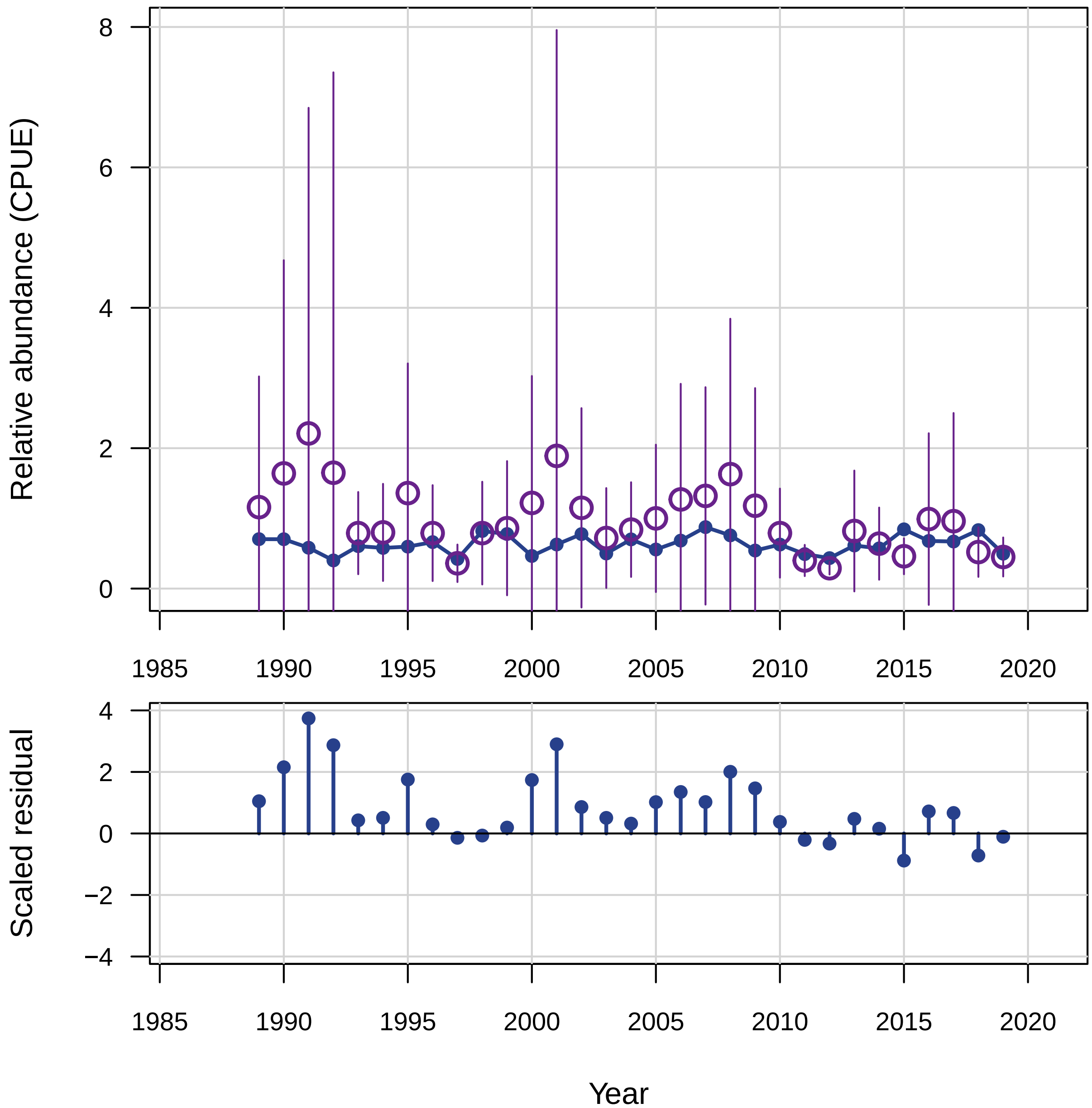


Figure 14. Estimated abundance at age at start of year.

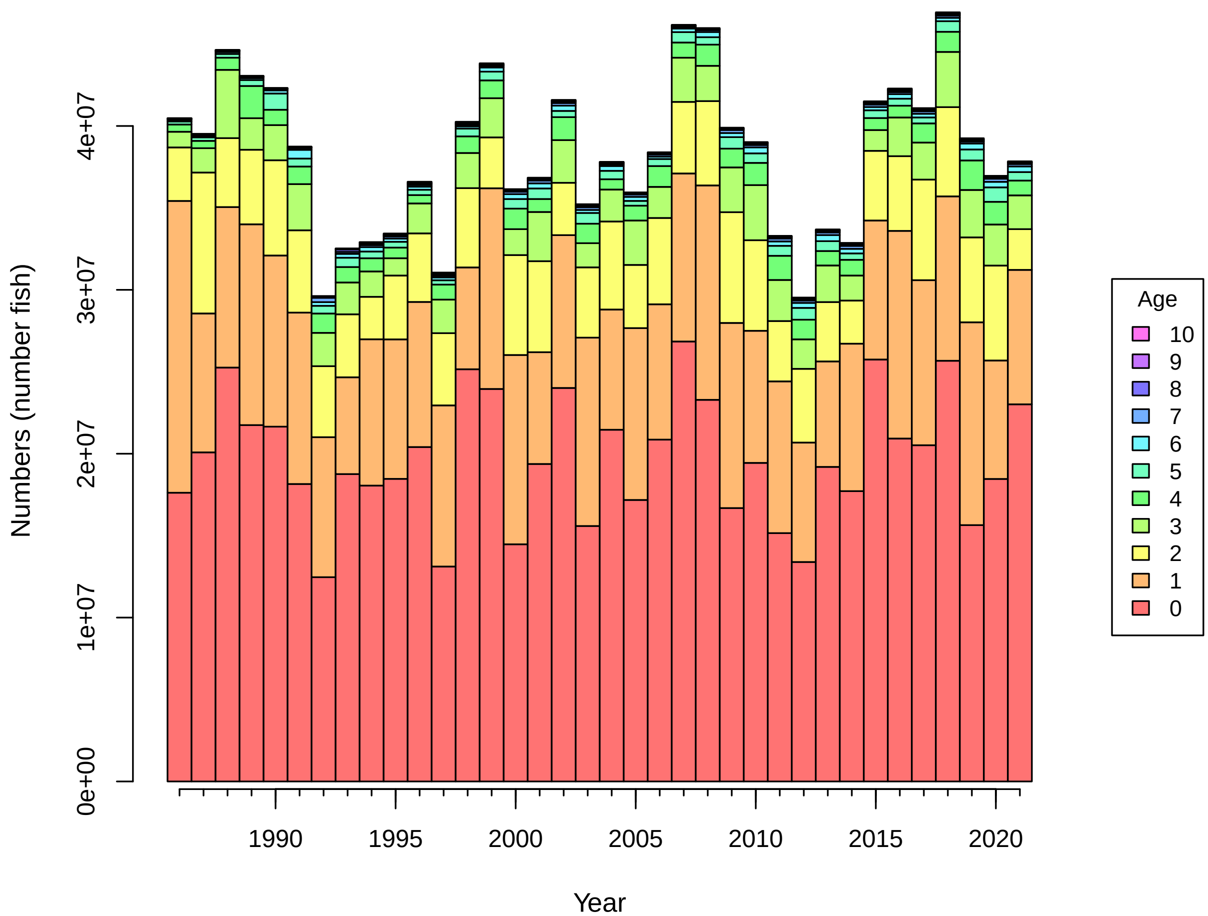


Figure 15. Top panel: Estimated recruitment of age-0 fish. Horizontal dashed line indicates R_{MSY}*. Bottom panel: log recruitment residuals.*

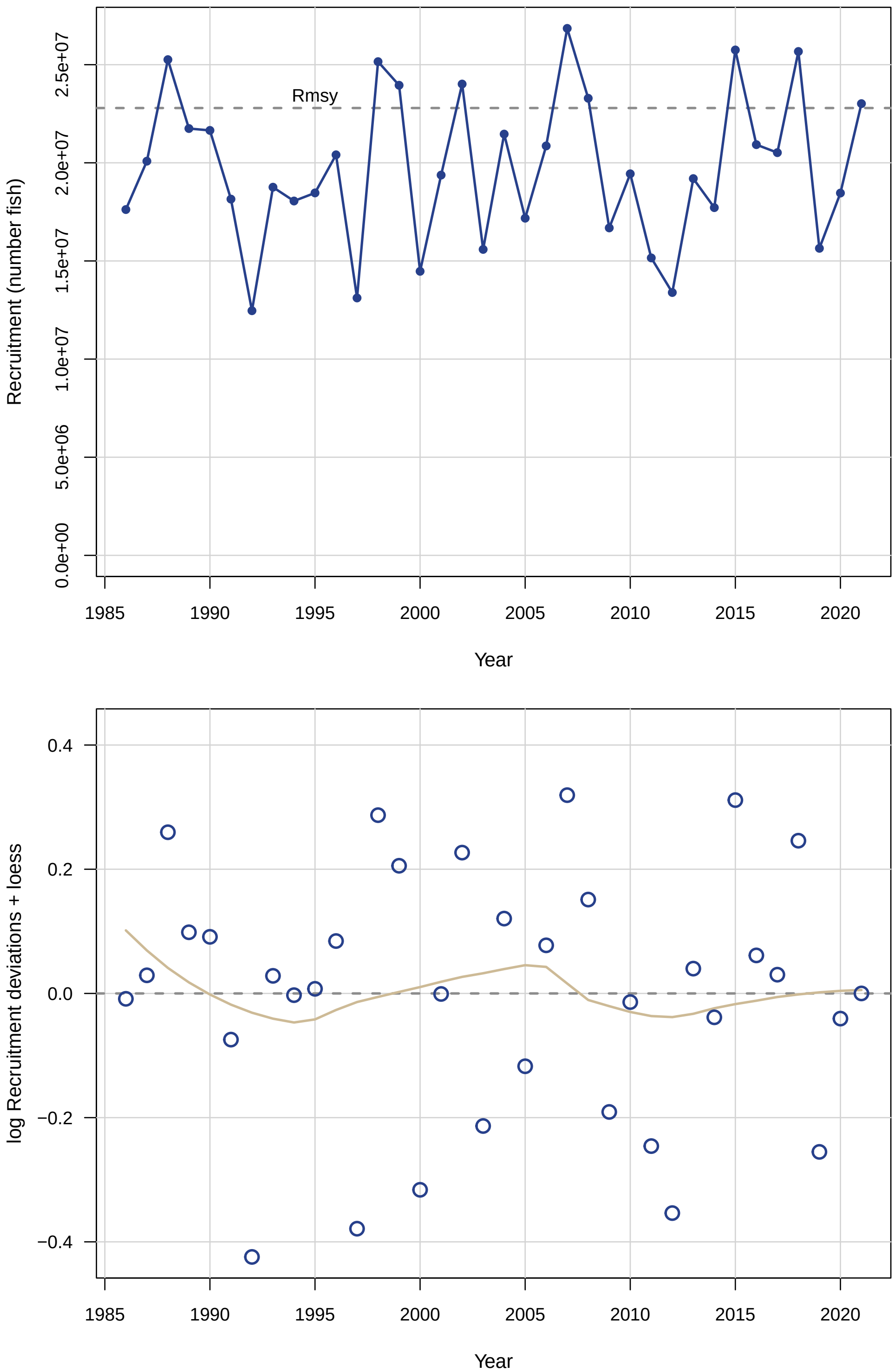


Figure 16. Estimated biomass at age at start of year.

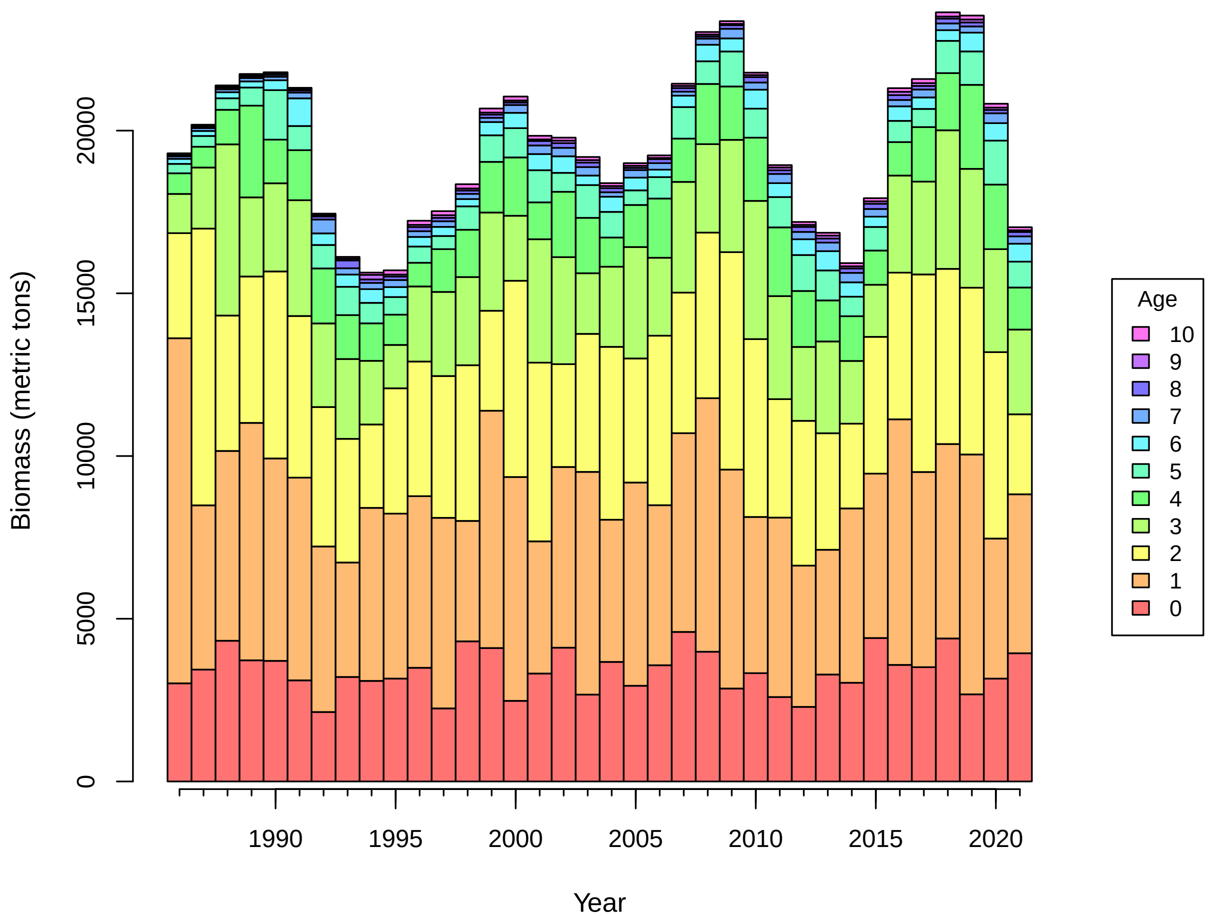


Figure 17. Selectivity of commercial handline fleet for all years in the model. Year indicates start year of the model.

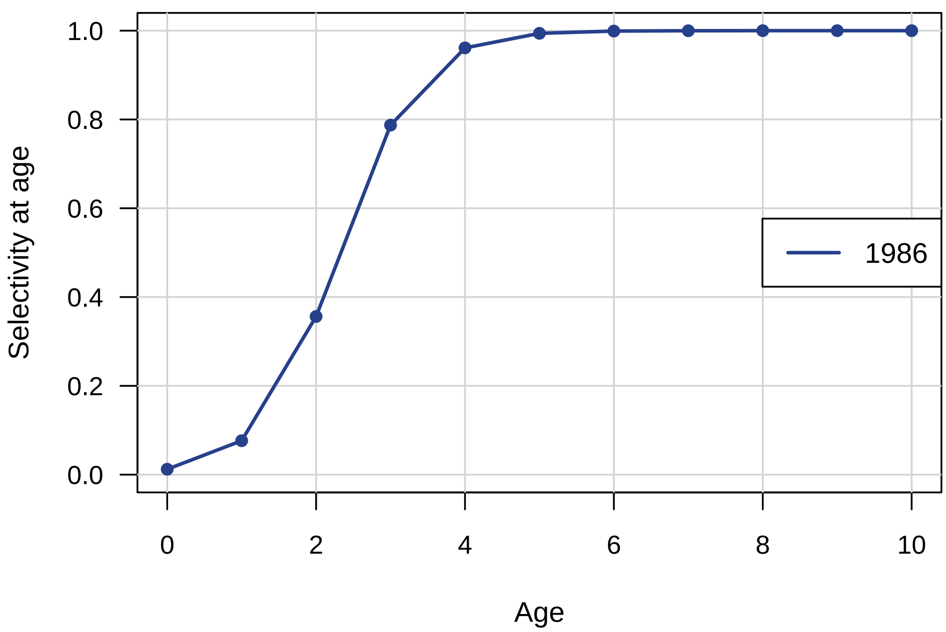


Figure 18. Selectivity of commercial pound net fleet for all years in the model. Year indicates start year of the model.

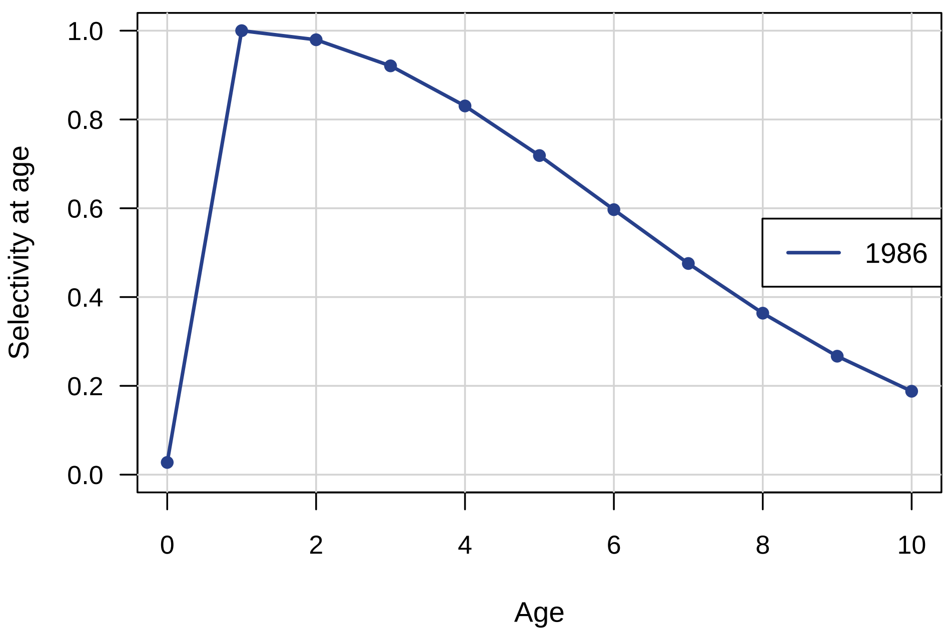


Figure 19. Selectivity of commercial gillnet fleet for all years in the model. Year indicates start year of the model.

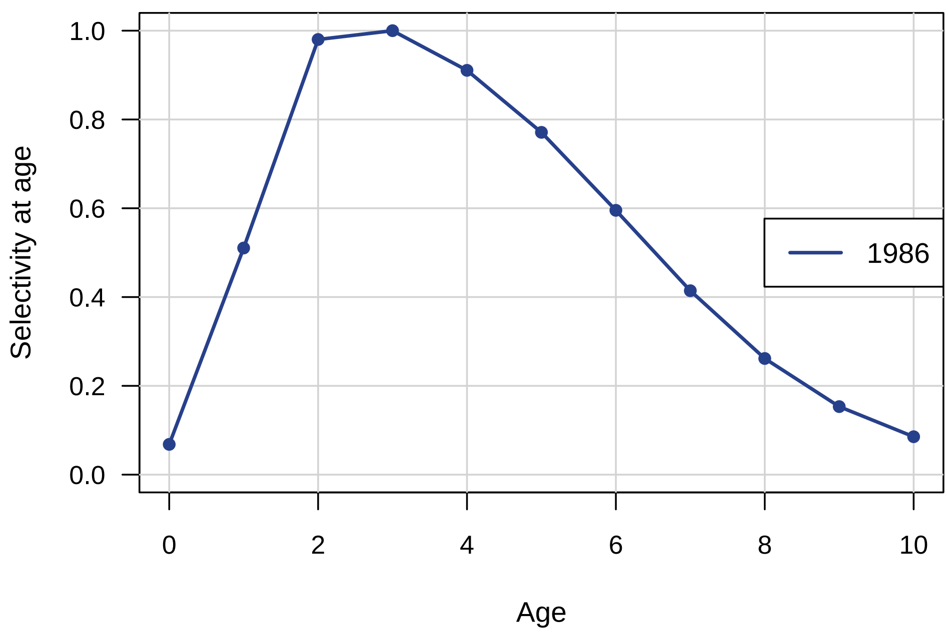


Figure 20. Selectivities of commercial cast net fleet for all years in the model. Year indicates start year of the model.

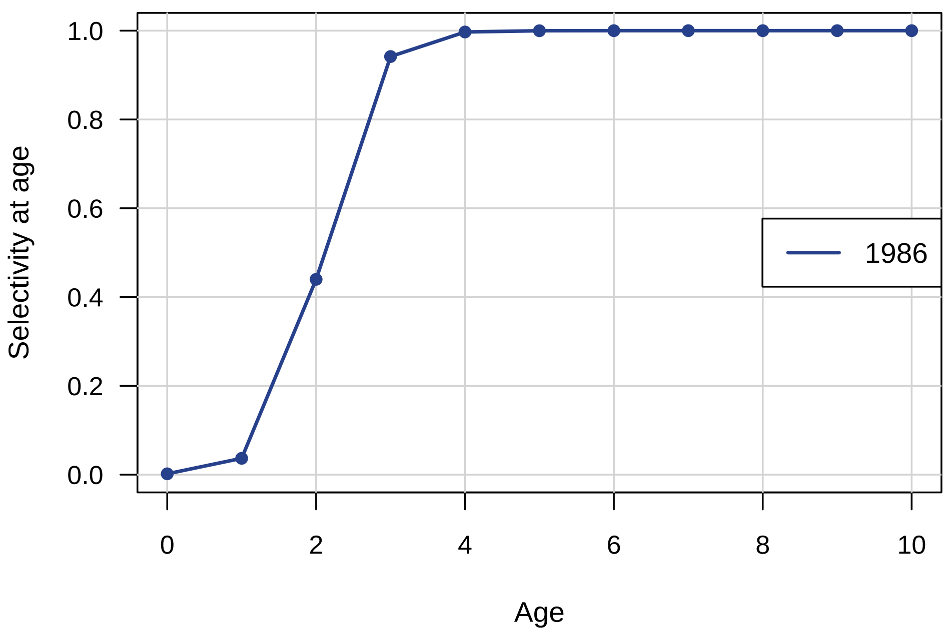


Figure 21. Selectivities of general recreational fishery for all years in the model. Year indicates start year of the model.

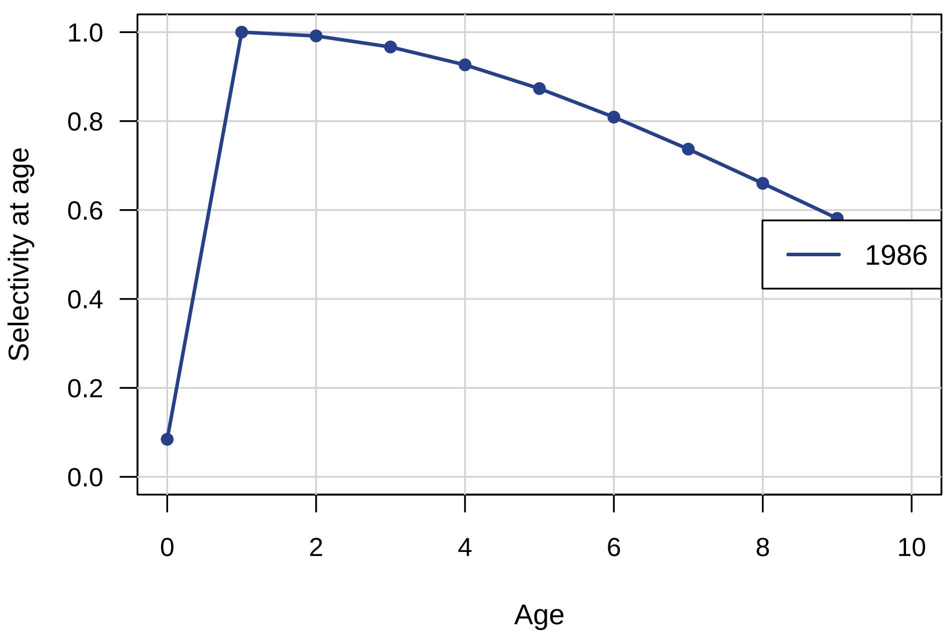


Figure 22. Selectivities of recreational discard for all years in the model. Year indicates start year of the model.

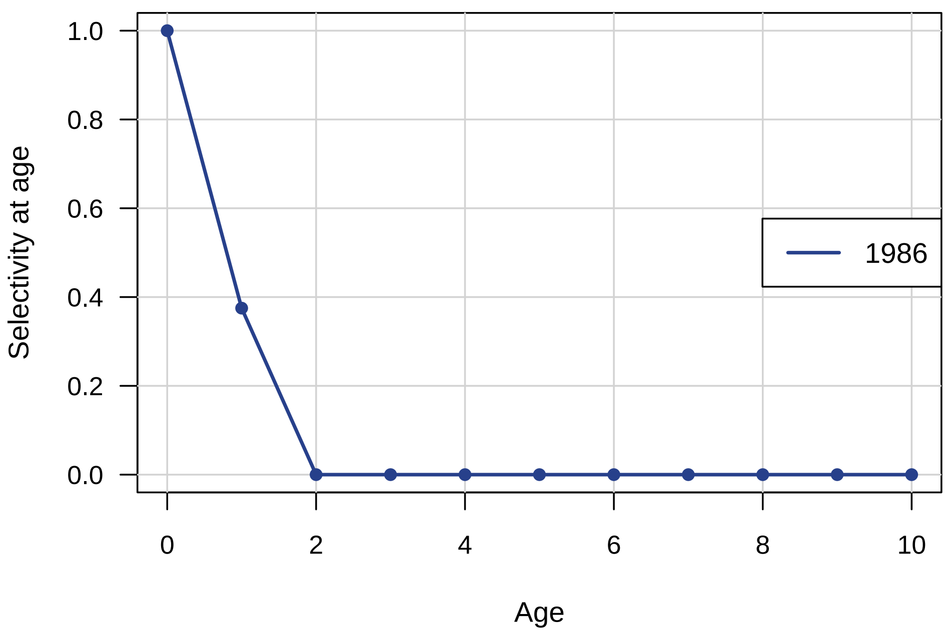


Figure 23. Selectivities of shrimp fishery discard for all years in the model. Year indicates start year of the model.

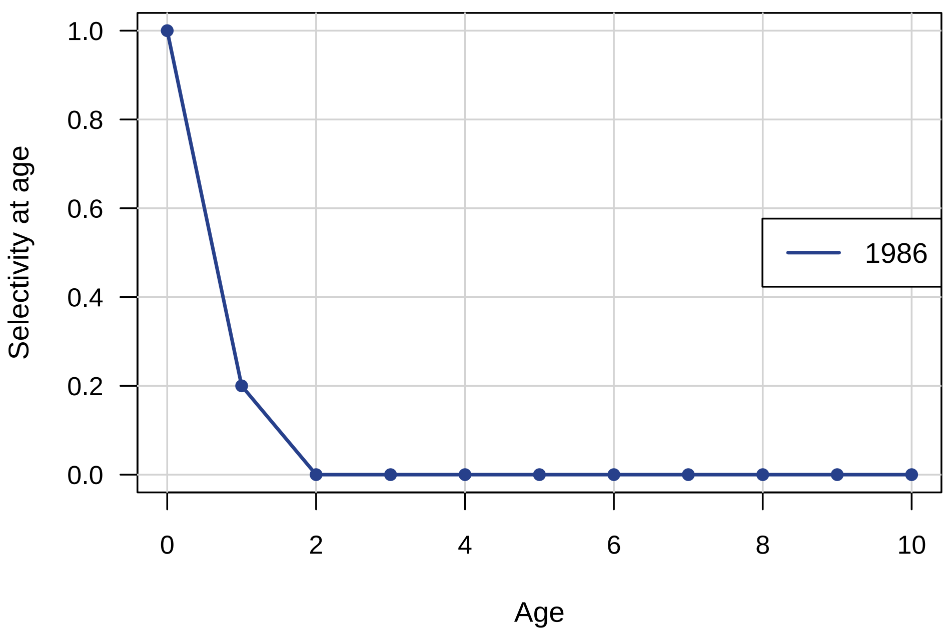


Figure 24. Average selectivity from the terminal assessment year weighted by geometric mean Fs from the last three assessment years for landings (top panel) and discards (bottom panel), and used in computation of benchmarks and central-tendency projections.

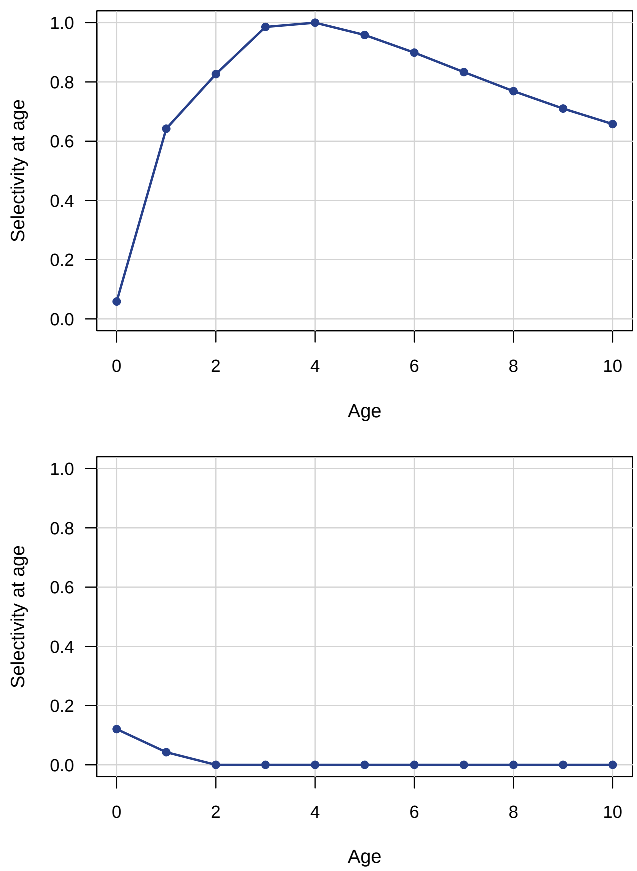


Figure 25. Estimated fully selected fishing mortality rate (per year) by fishery. cH refers to commercial handline, cP to commercial pound net, cG to commercial gill net, cC to commercial cast net, GR for recreational, GR.D for recreational discards, and SB.D for shrimp bycatch. Full F, the maximum F at age summed across fleets, may not equal the sum of fully selected F's because of dome-shaped selectivities.

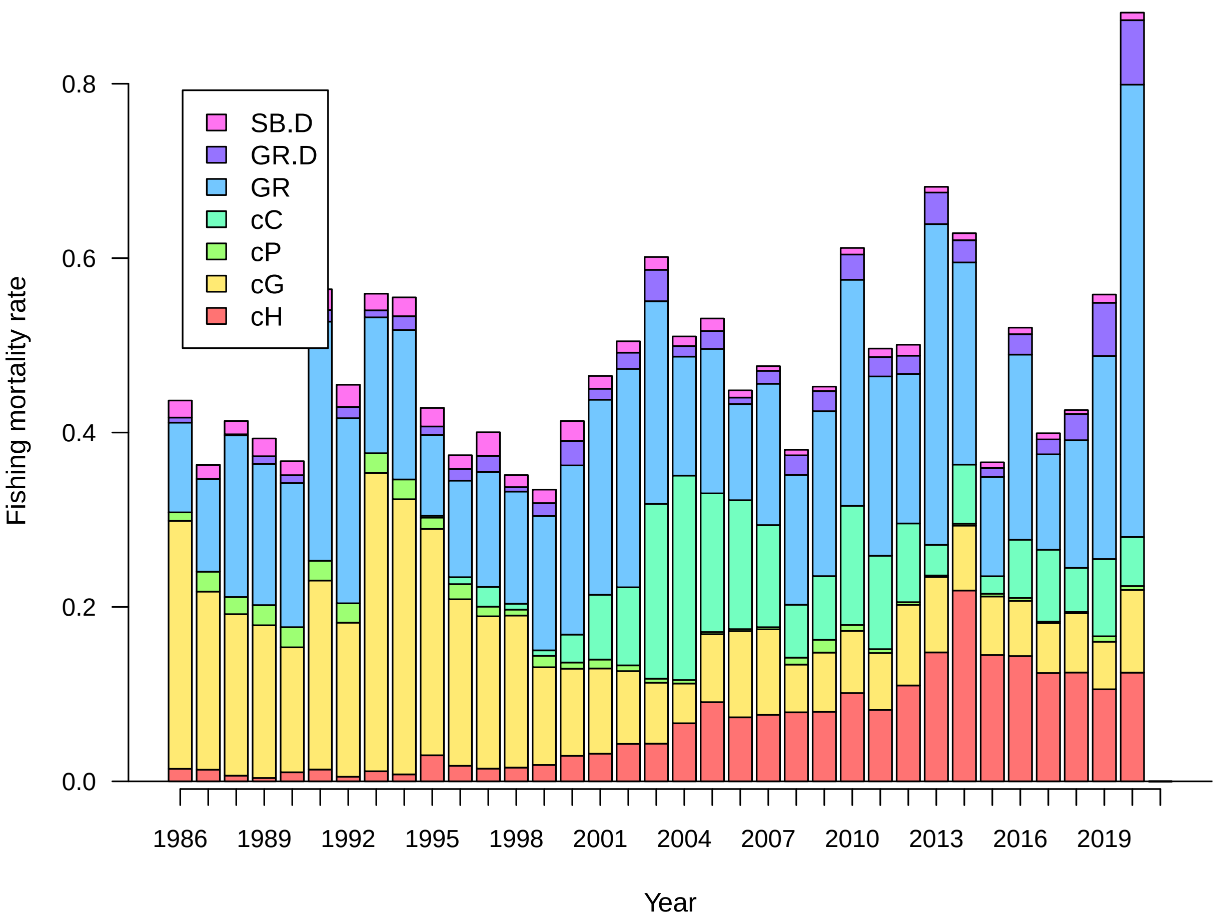


Figure 26. Alternative measures of fishing intensity. Top panel shows equilibrium SPR conditional on annual F, with a reference line at equilibrium MSY*. Bottom panel shows exploitation rate (E) computed as number killed divided total abundance (thick black curve), which can be divided into its components of landings (thin green curve) and dead discards (thin blue curve).*

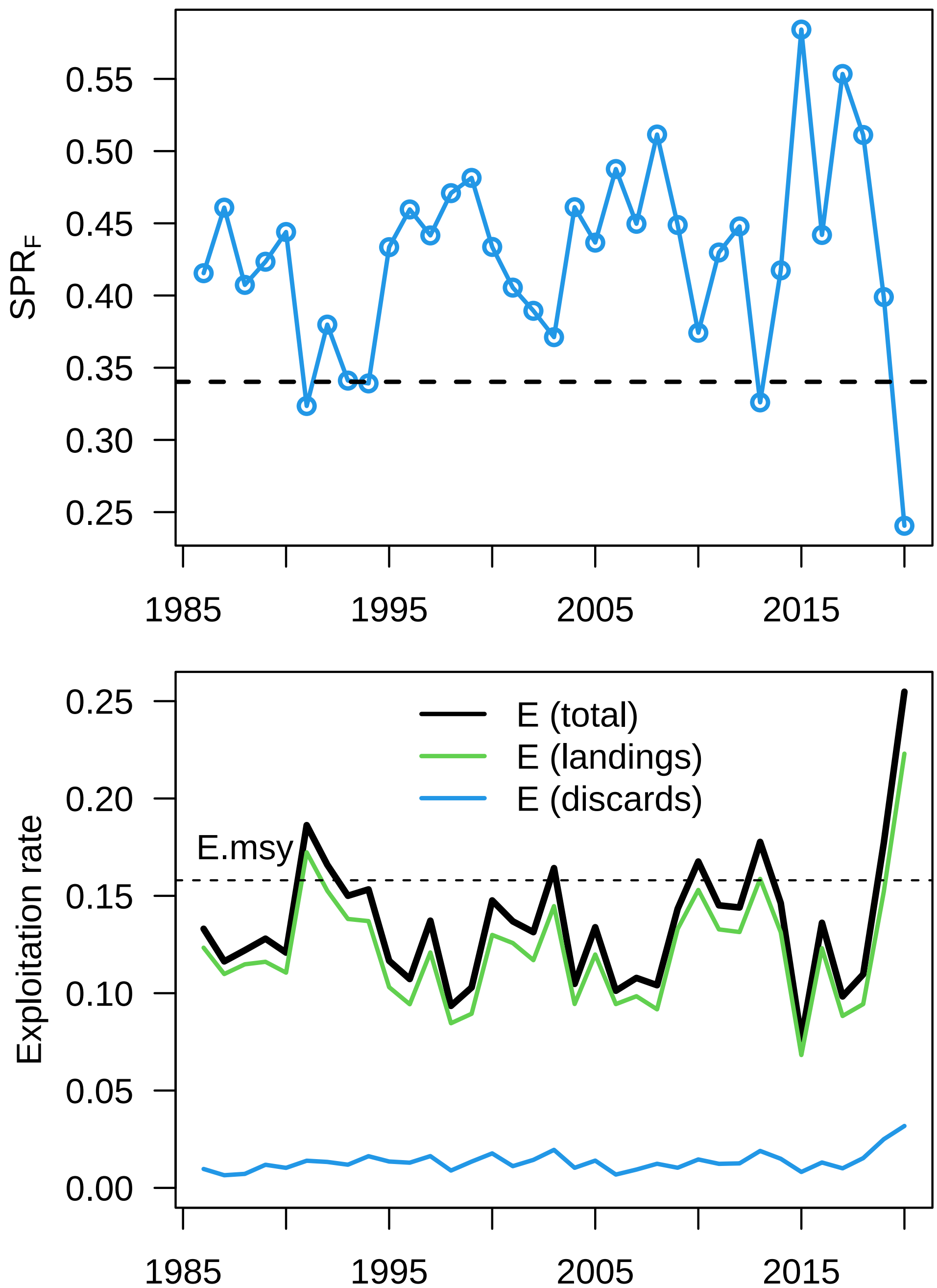


Figure 27. Estimated landings in numbers by fishery from the catch-age model. cH refers to commercial handline, cP to commercial pound net, cG to commercial gill net, cC to commercial cast net, and GR for recreational.

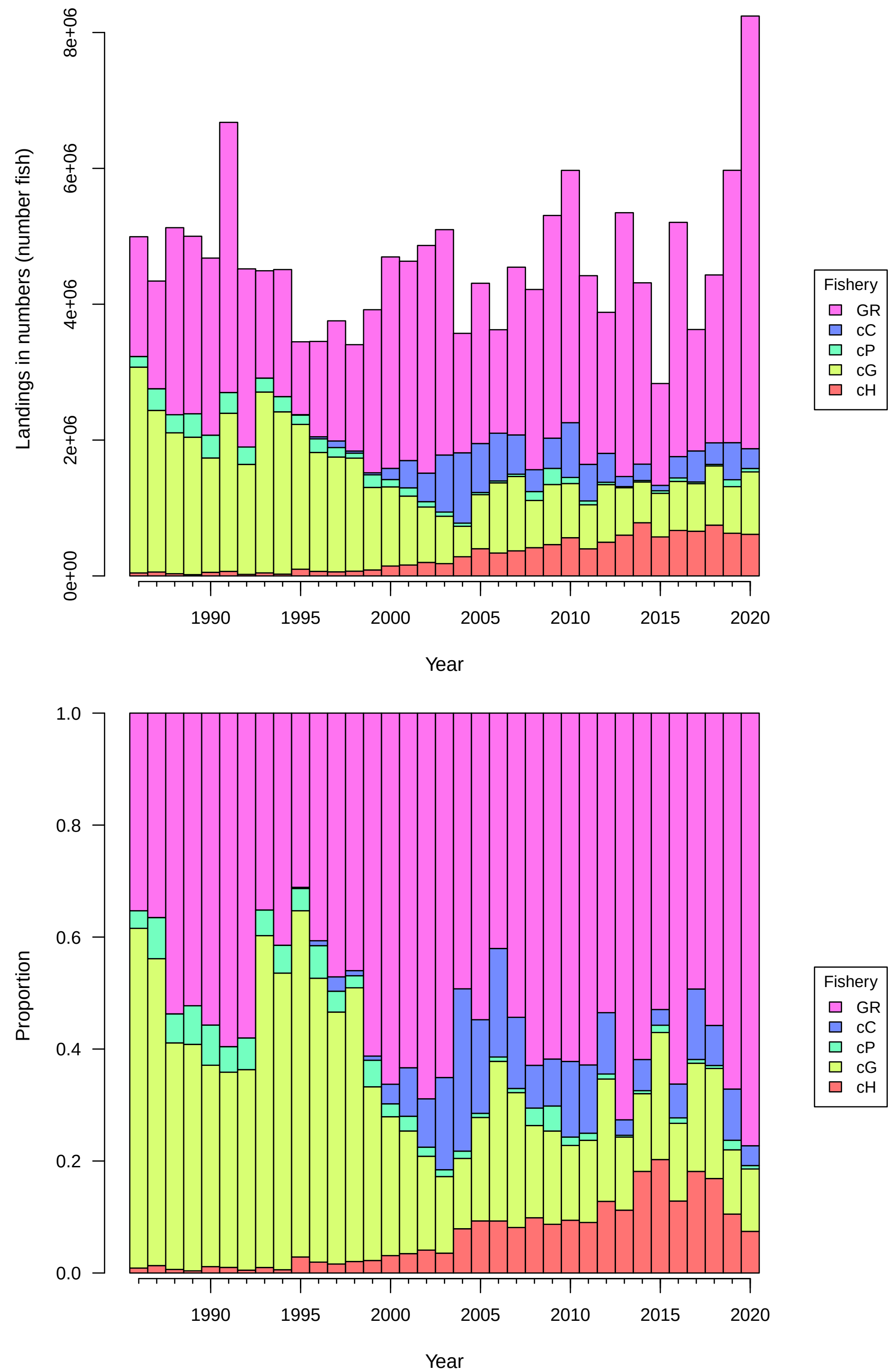


Figure 28. Estimated landings in whole weight by fishery from the catch-age model. cH refers to commercial hand-line, cP to commercial pound net, cG to commercial gill net, cC to commercial cast net, and GR for recreational. Horizontal dashed line in the top panel corresponds to the point estimate of MSY.

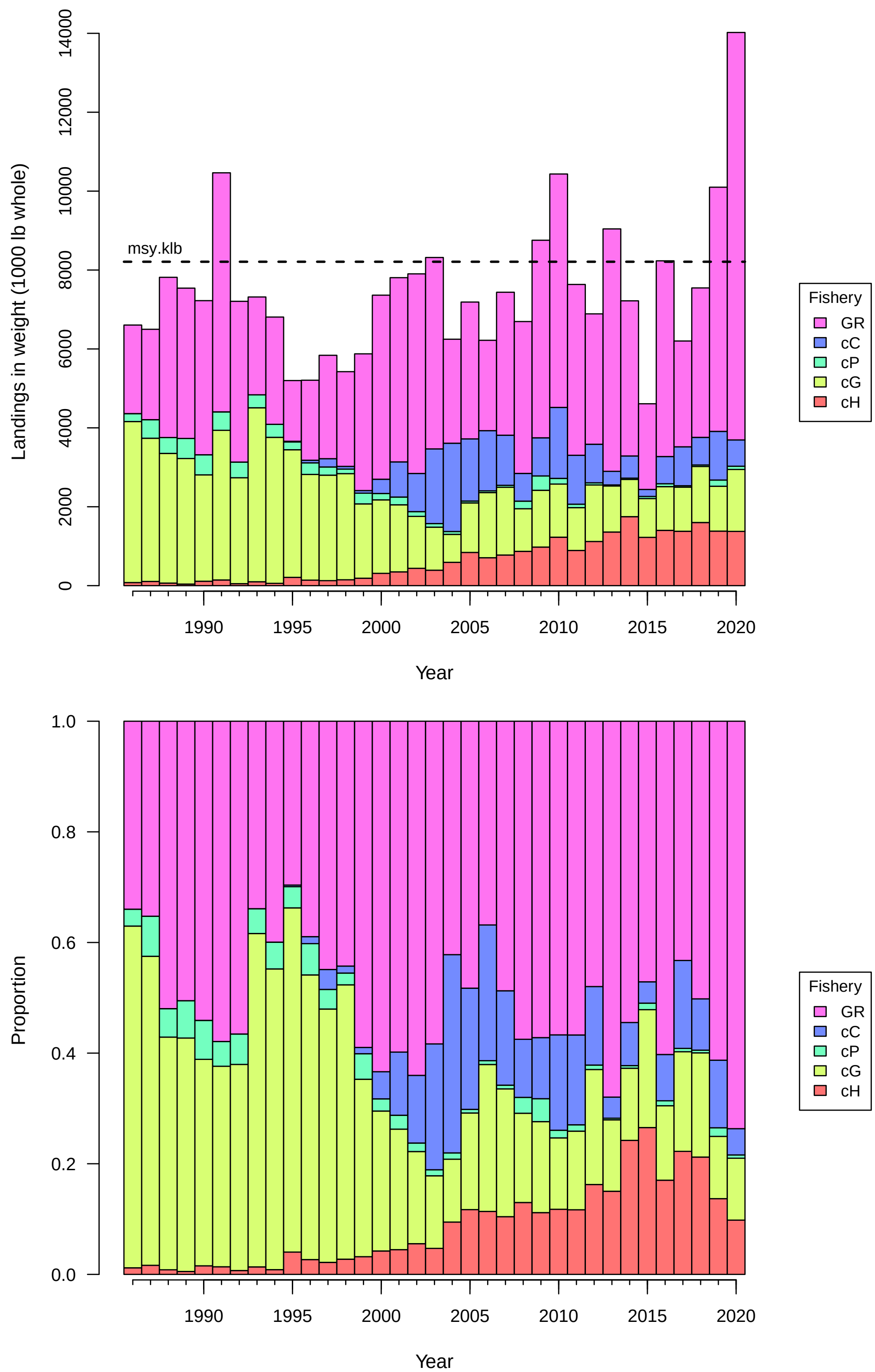
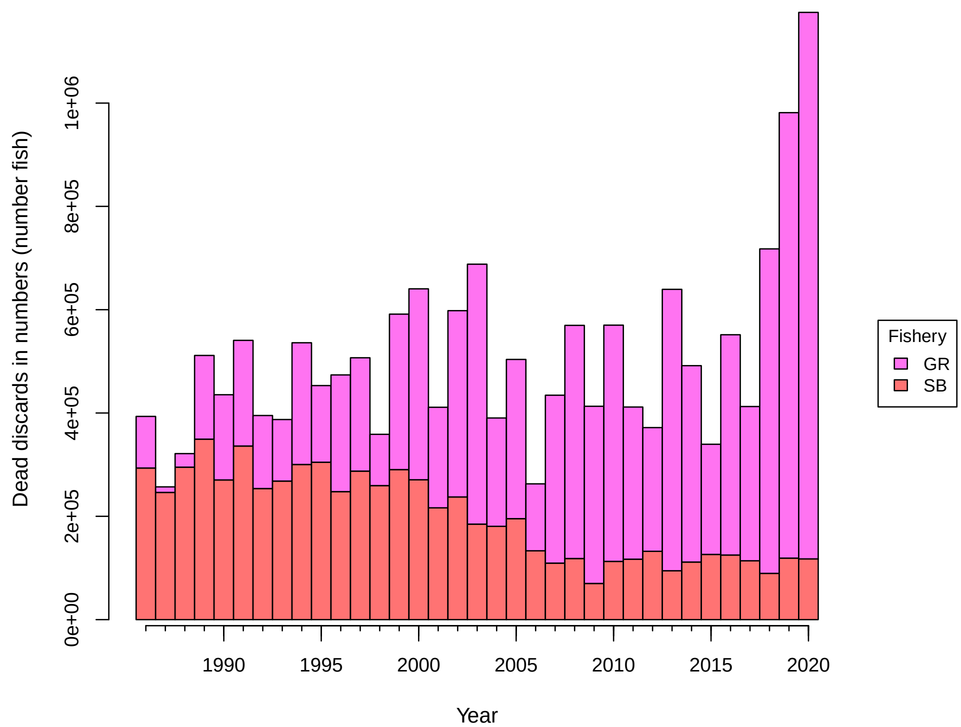


Figure 29. Estimated discards in numbers by fishery from the catch-age model. SB refers to shrimp bycatch, and GR for recreational.



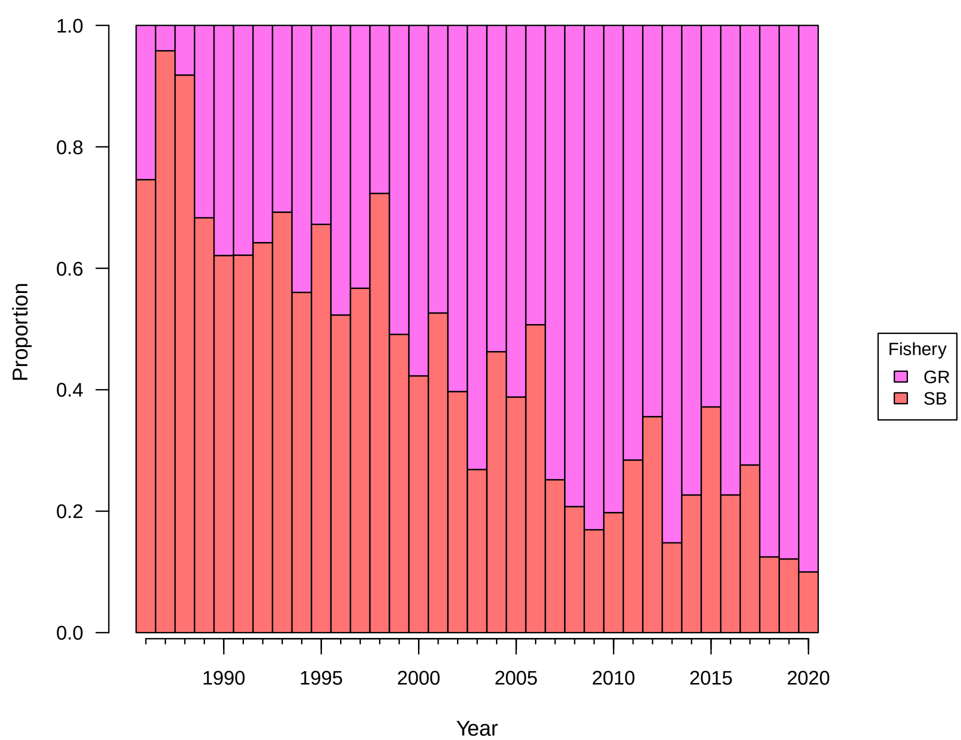


Figure 30. Estimated discards in whole weight by fishery from the catch-age model. SB refers to shrimp bycatch, and GR for recreational.

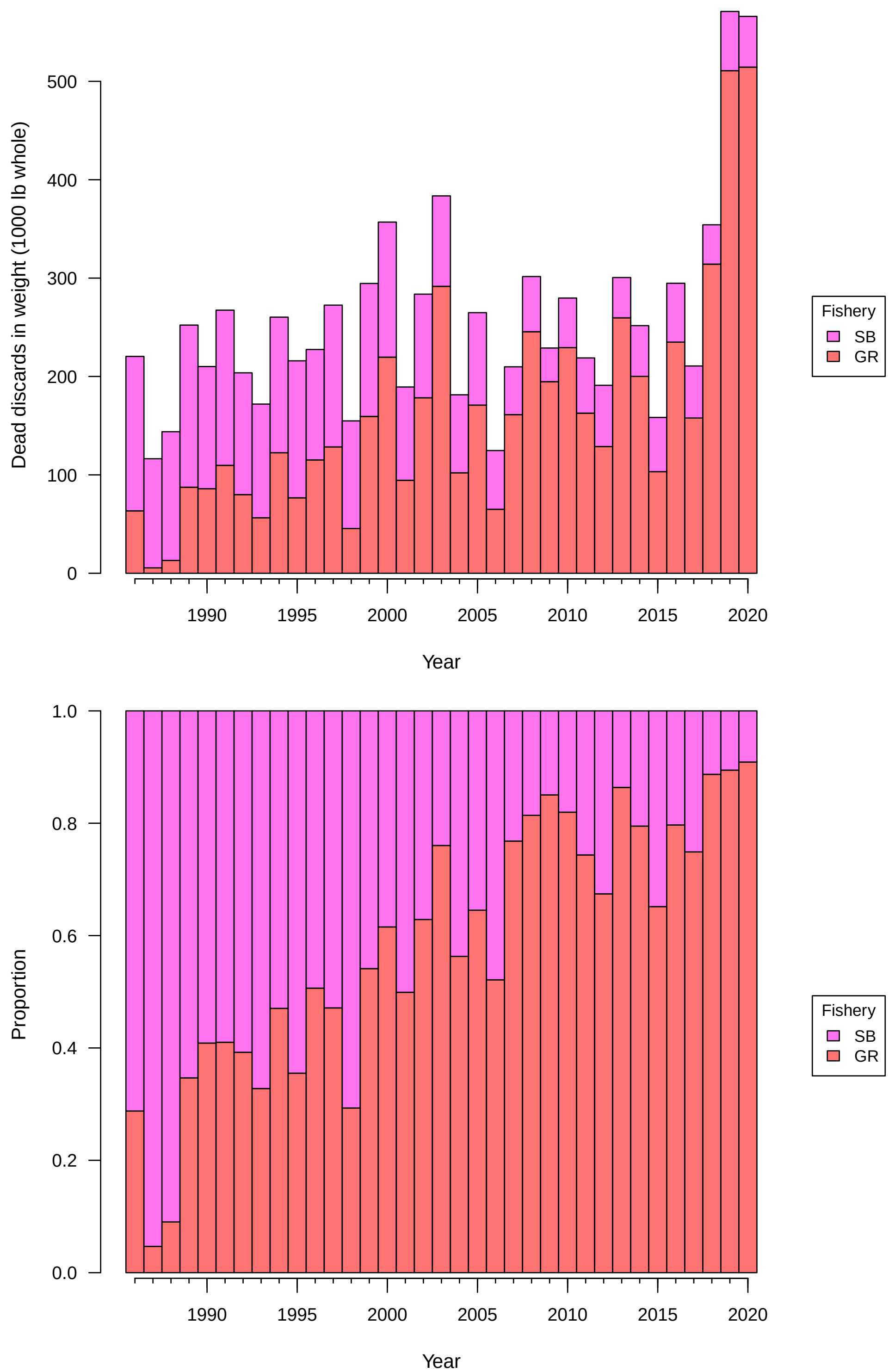


Figure 31. Top panel: Beverton–Holt spawner-recruit curves, with and without lognormal bias correction. The expected (upper) curve was used for computing management benchmarks. Years within panel indicate year of recruitment generated from spawning biomass one year prior. Bottom panel: log of recruits (number age-0 fish) per spawner (mature female gonad weight) as a function of spawners.

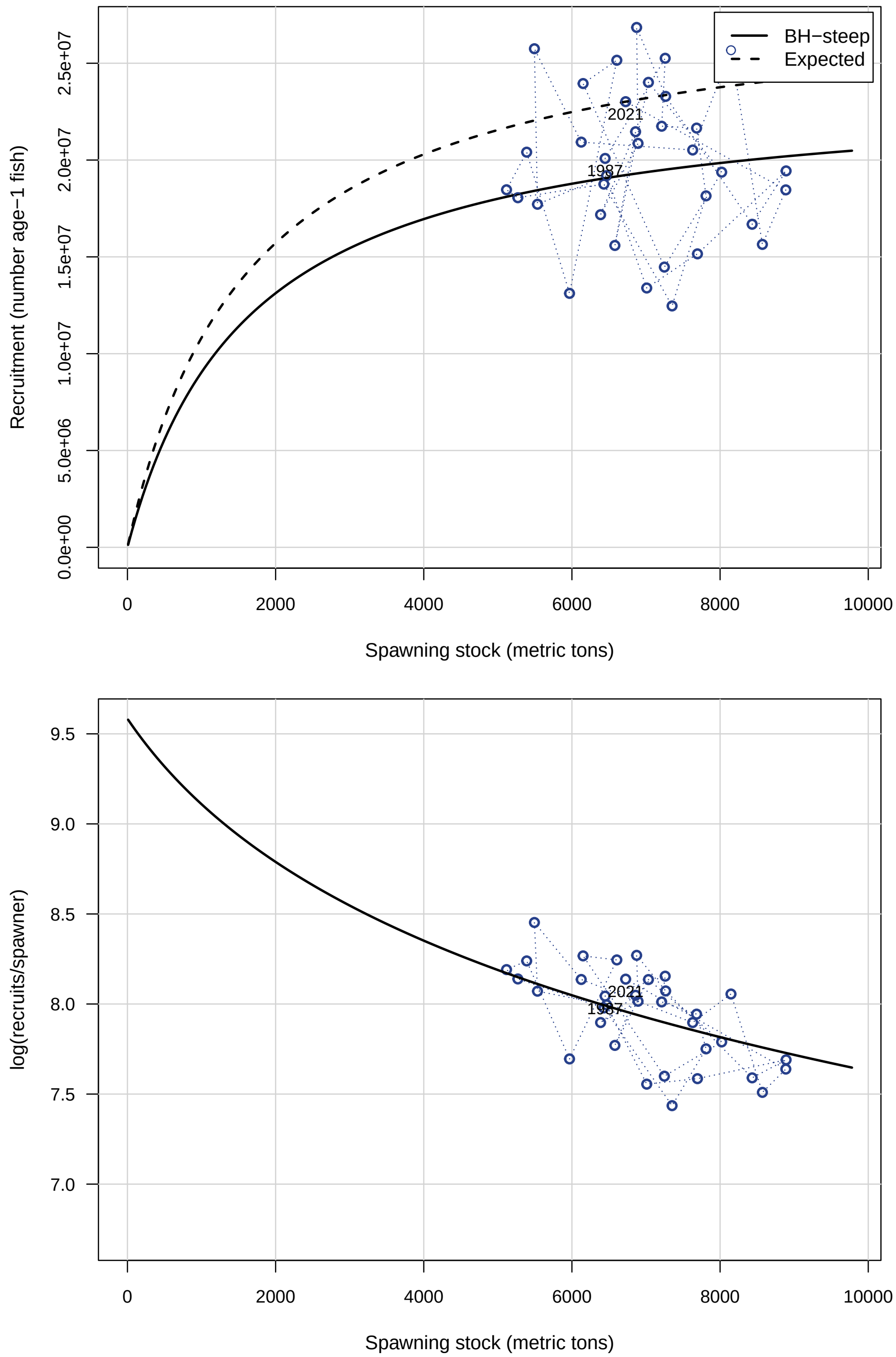


Figure 32. Probability densities of spawner-recruit quantities: Mean recruits (R0, age-0 fish), median recruits, and unfished spawners per recruit. Solid vertical lines represent point estimates or values from the base run of the Beaufort Assessment Model; dashed vertical lines represent medians from the MCBE runs.

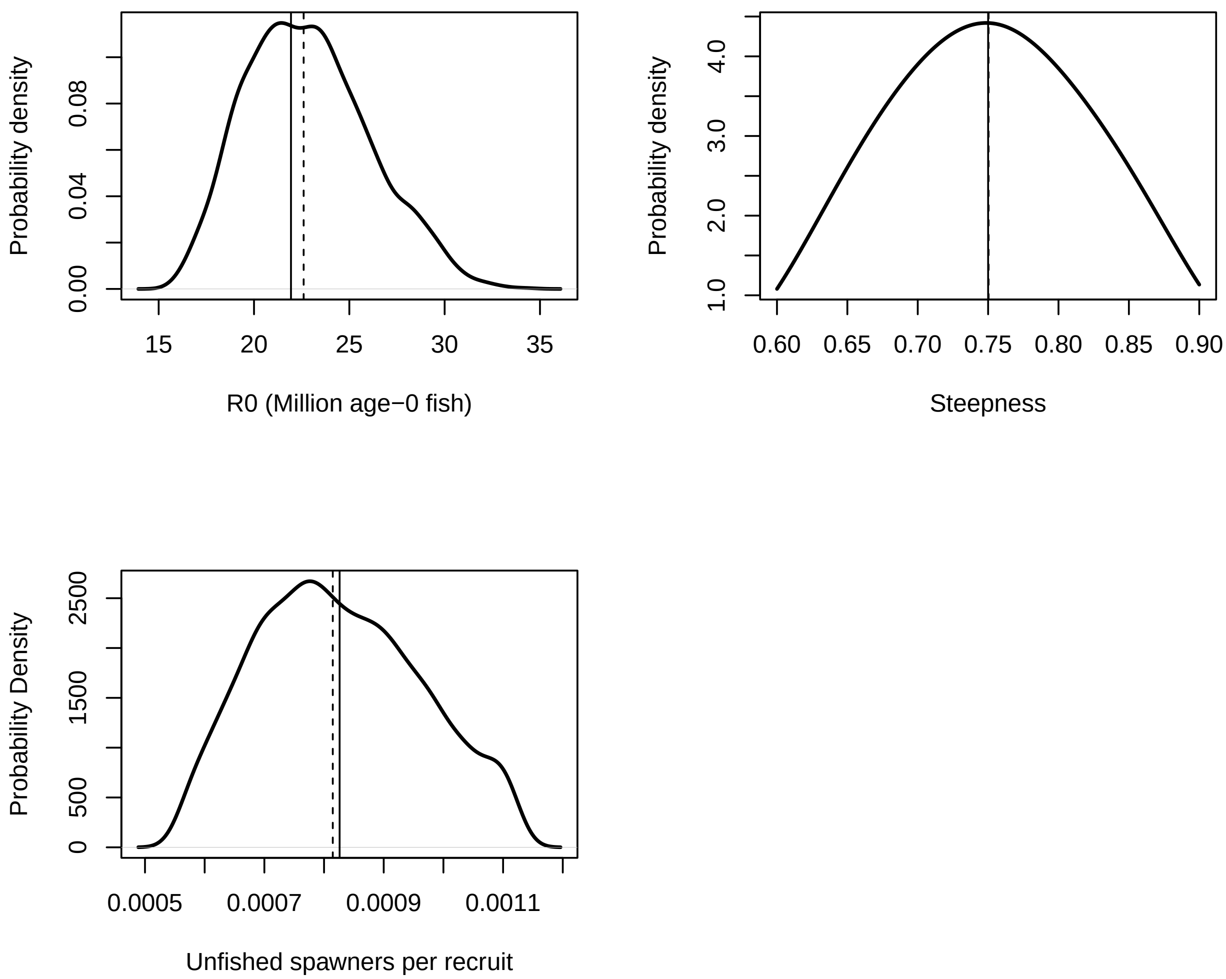


Figure 33. Top panel: yield per recruit. Bottom panel: spawning potential ratio (spawning biomass per recruit relative to that at the unfished level), from which the y% levels provide $F_{y\%}$. Current F (Fcur) is the geometric mean full F from the last 3 years of the assessment. Both curves are based on average selectivity from the end of the assessment period.

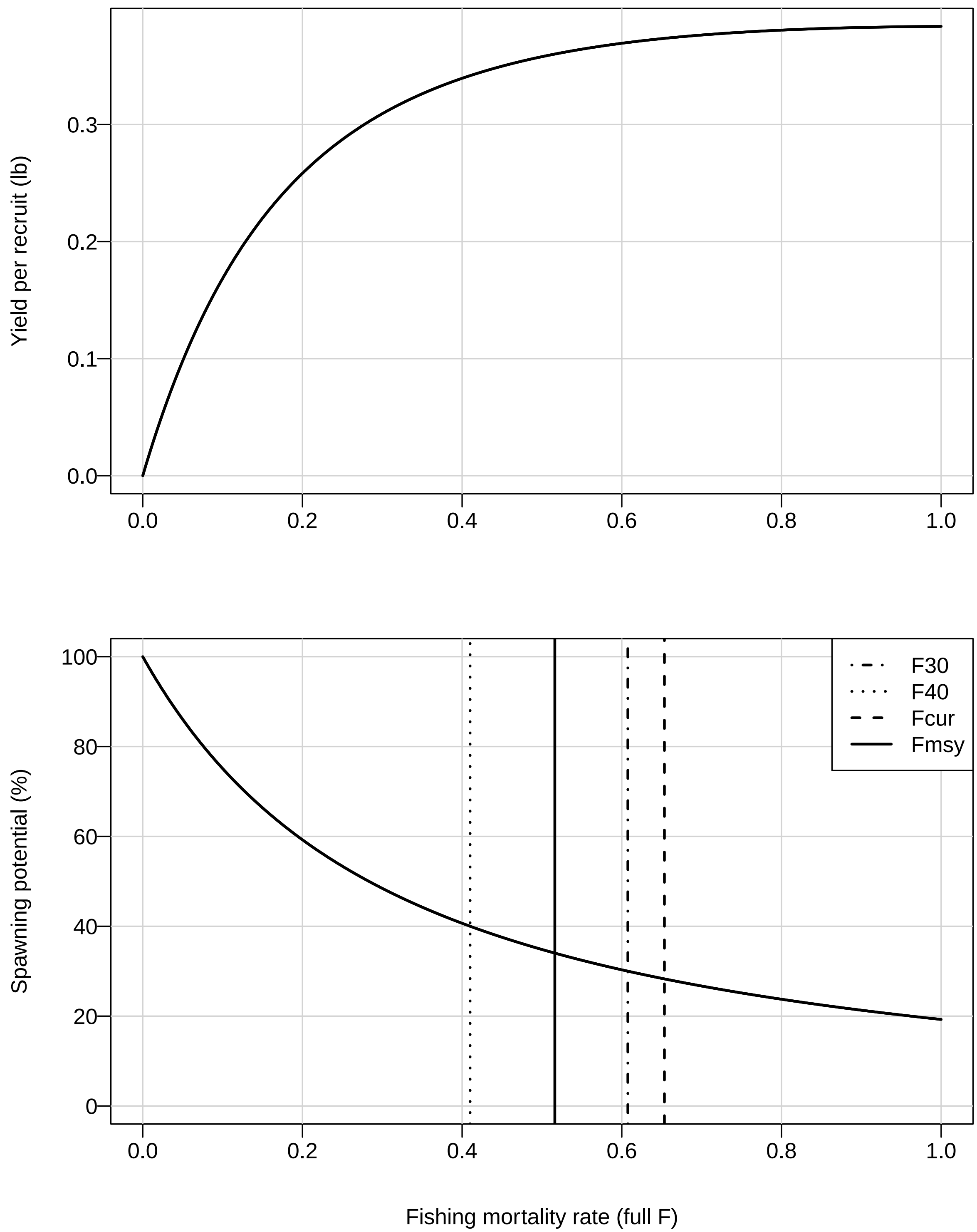


Figure 34. Top panel: equilibrium landings. The peak occurs where fishing rate is $F_{\mathrm{MSY}} = 0.52$ *and equilibrium landings are* MSY = 8210.19 *(1000 lb). Bottom panel: equilibrium spawning biomass. Both curves are based on average selectivity from the end of the assessment period.*

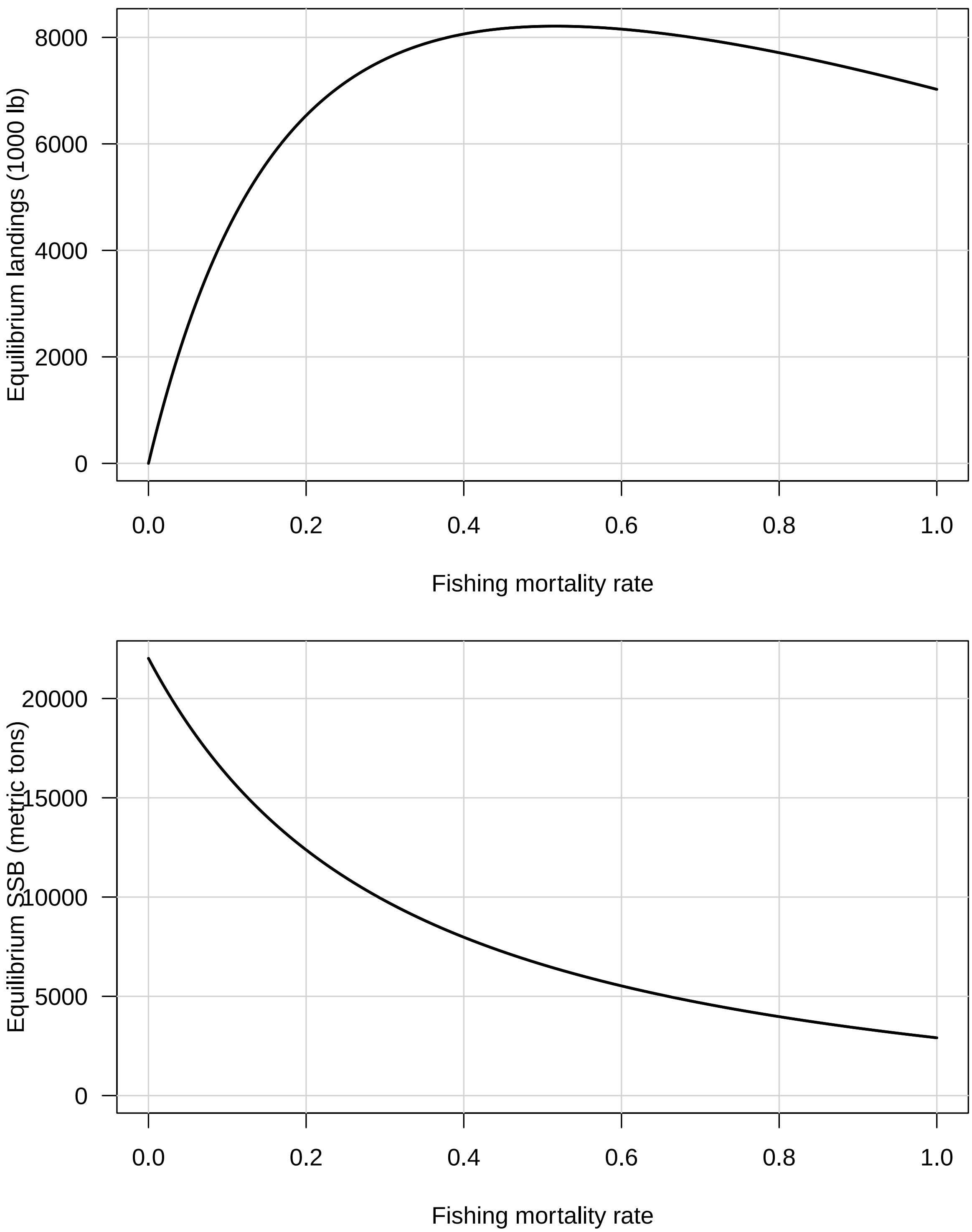


Figure 35. Equilibrium landings as a function of equilibrium biomass, which itself is a function of fishing mortality rate. The peak occurs where equilibrium biomass is $B_{\mathrm{MSY}} = 19588.3$ *mt and equilibrium landings are* $\mathrm{MSY} = 8210.19$ *(1000 lb).*

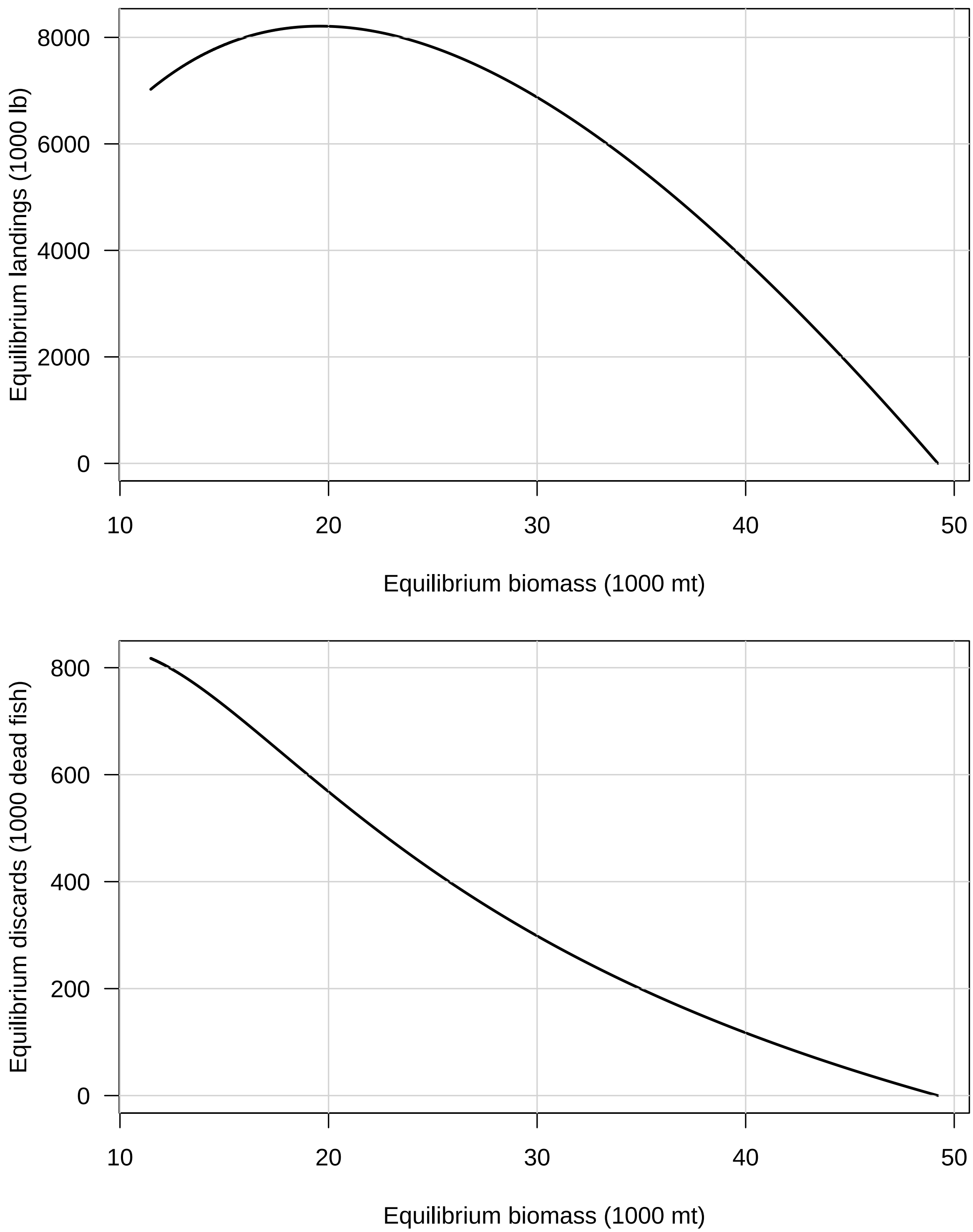


Figure 36. Probability densities of F_{MSY}-related benchmarks from MCB analysis of the Beaufort Assessment Model. Solid vertical line represent point estimates from the base run and the dashed vertical line represent the median of the MCB distribution.

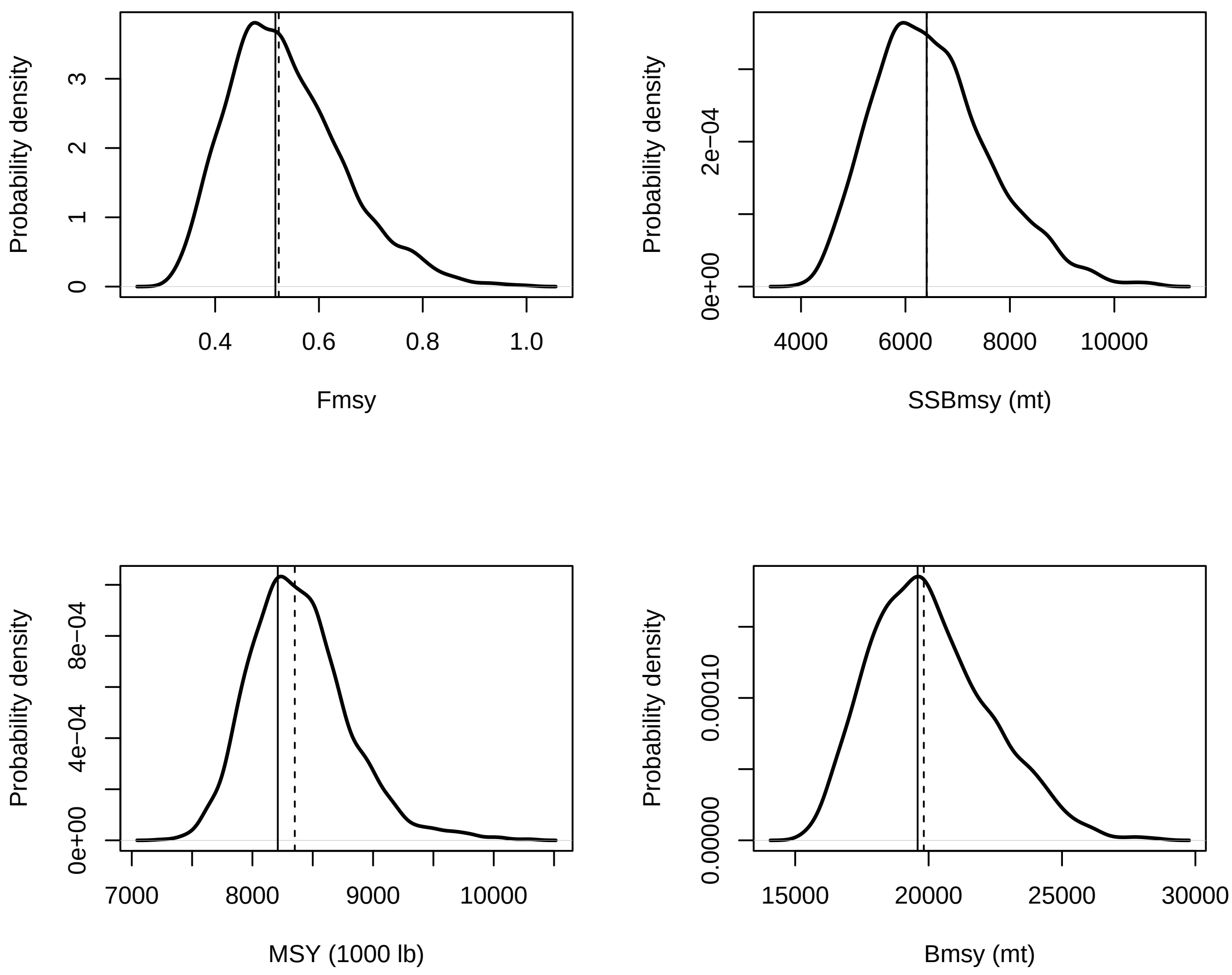


Figure 37. Estimated time series relative to benchmarks. Solid line indicates estimates from base run of the Beaufort Assessment Model; dashed lines indicate the median of the MCB trials; gray error bands indicate 5^{th} *and* 95^{th} *percentiles of the MCB trials. Top panel: spawning biomass relative to the spawning stock biomass at* MSY. *Bottom panel: F relative to* F_{MSY}.

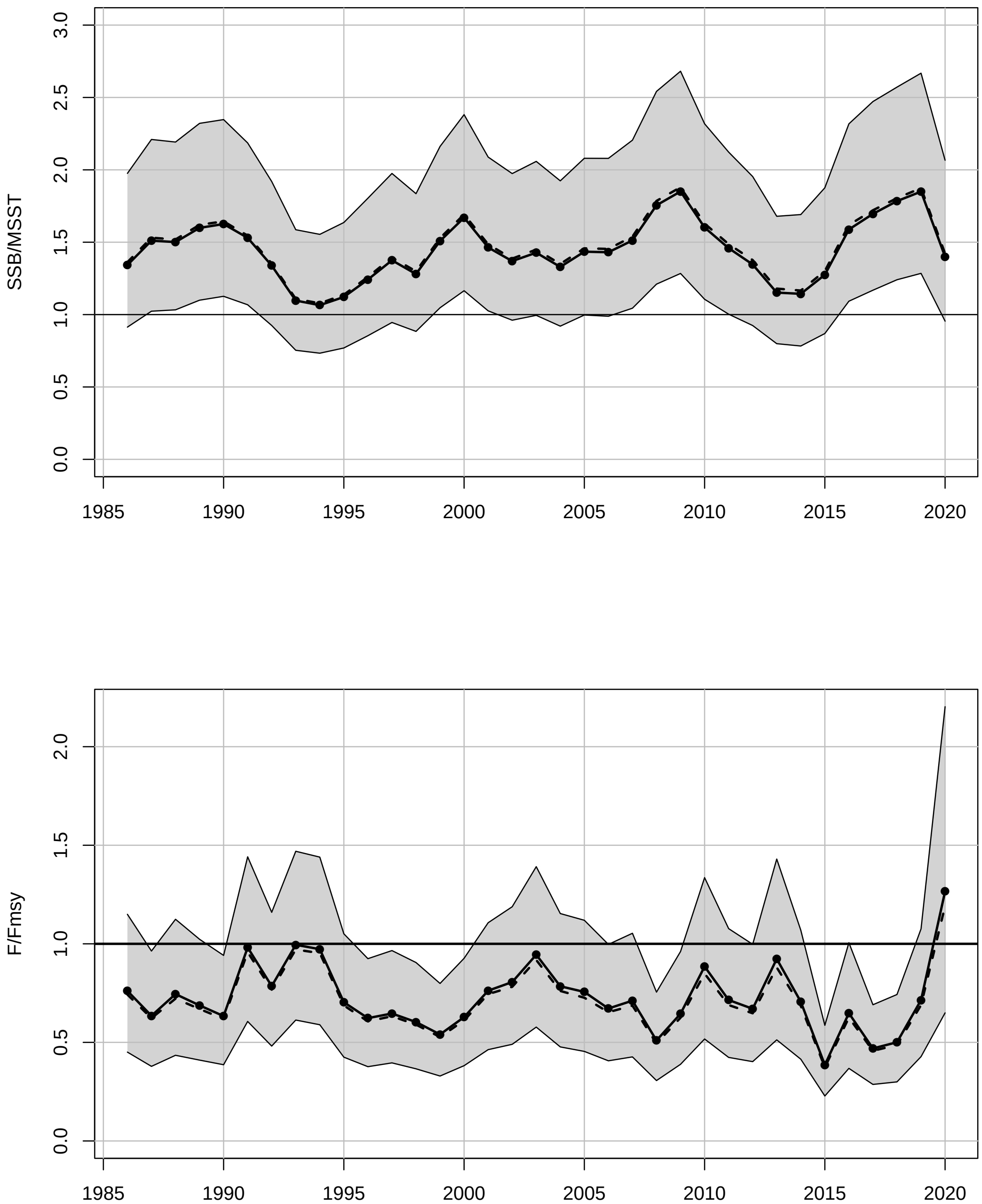


Figure 38. Phase plot of terminal status estimates from MCB analysis of the Beaufort Assessment Model. The intersection of crosshairs indicates estimates from the base run; lengths of crosshairs defined by 5^{th} and 95^{th} percentiles.

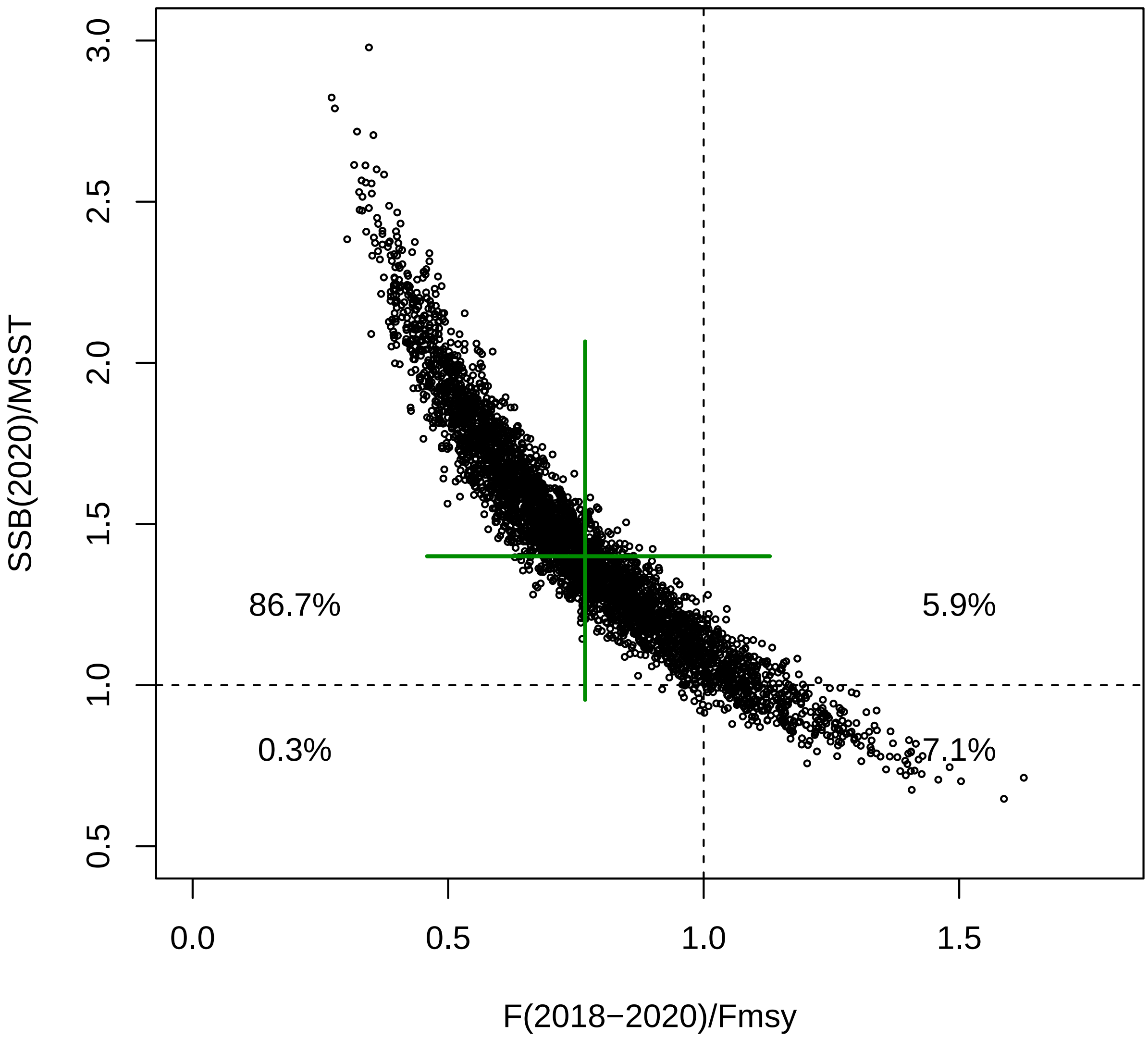


Figure 39. Phase plot of terminal status estimates from MCB analysis of the Beaufort Assessment Model. The intersection of crosshairs indicates estimates from the base run; lengths of crosshairs defined by 5^{th} and 95^{th} percentiles.

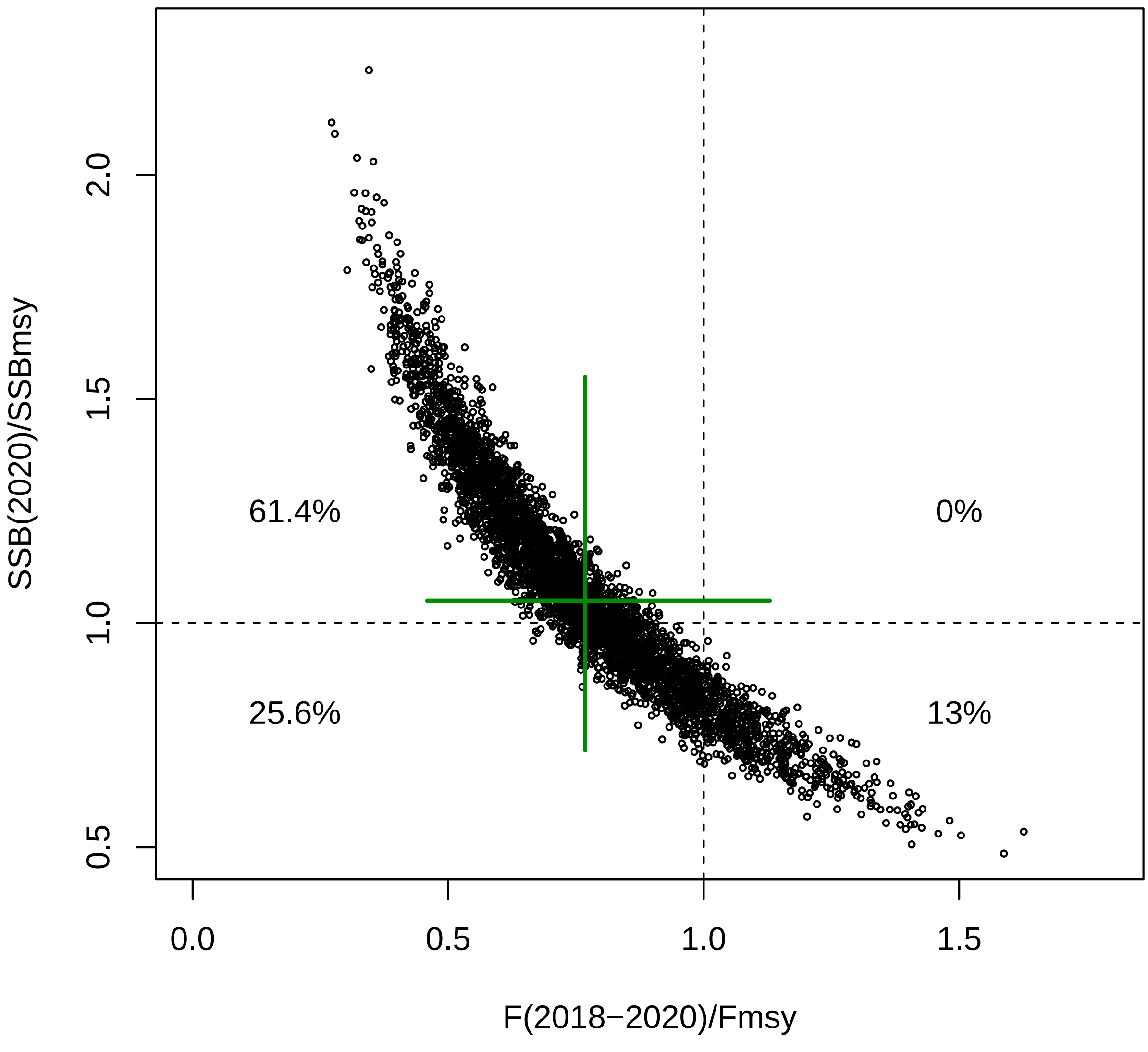


Figure 40. Probability densities of terminal status estimates from MCB analysis of the Beaufort Assessment Model. Solid vertical lines represent point estimates from the base run and dashed vertical lines indicated the median of MCB trials.

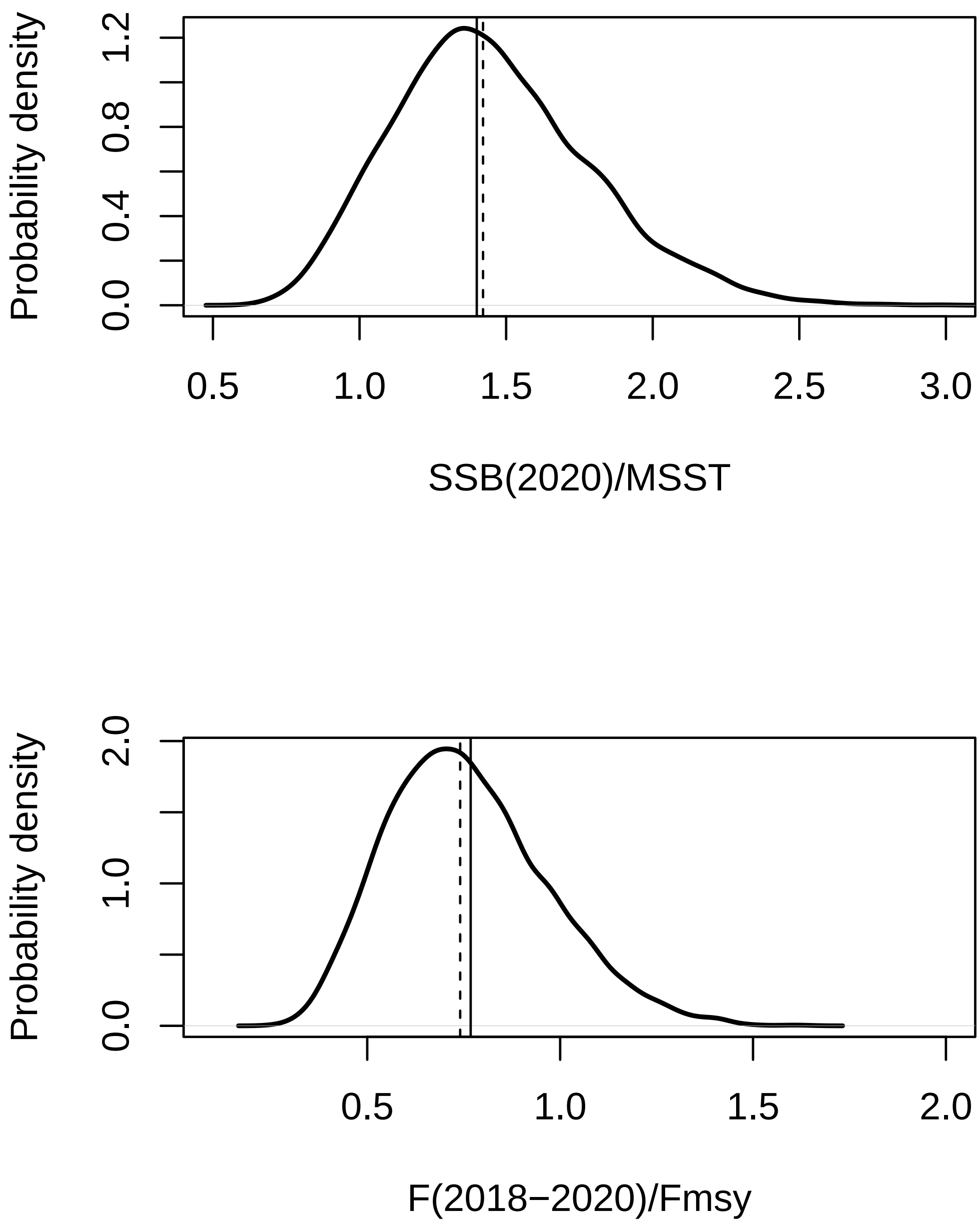


Figure 41. Comparison between SEDAR-28 and SEDAR-78 status indicators. Top panel: Apical F relative to F_{MSY}*. Bottom panel: spawning biomass relative to* MSST*.*

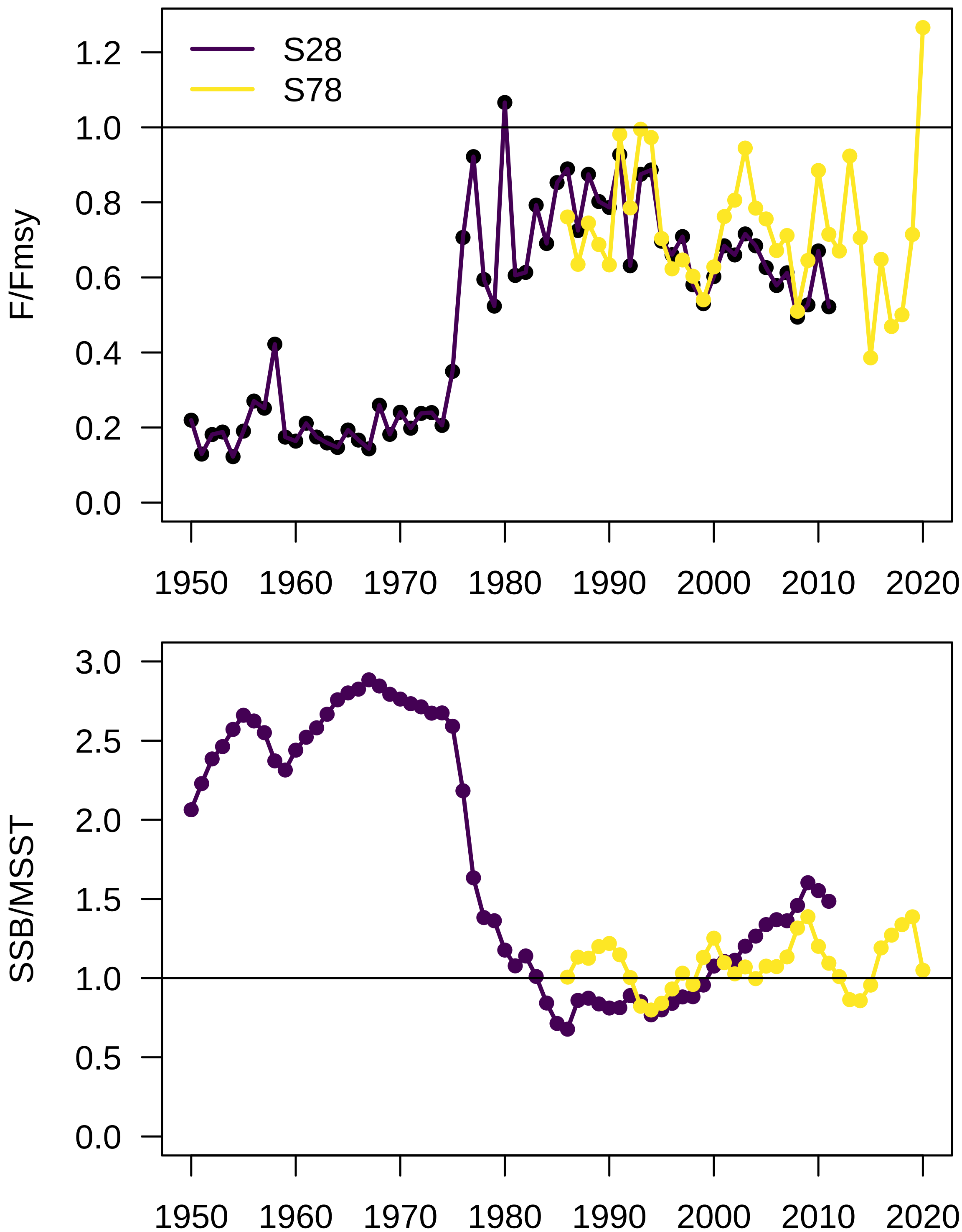


Figure 42. Spanish mackerel: Sensitivity of results to dropping the commercial handline (cH) index. (sensitivity run S1). Top panel – Ratio of F to F_{MSY}. Bottom panel – Ratio of SSB to $\mathrm{SSB}_{\mathrm{MSY}}$.

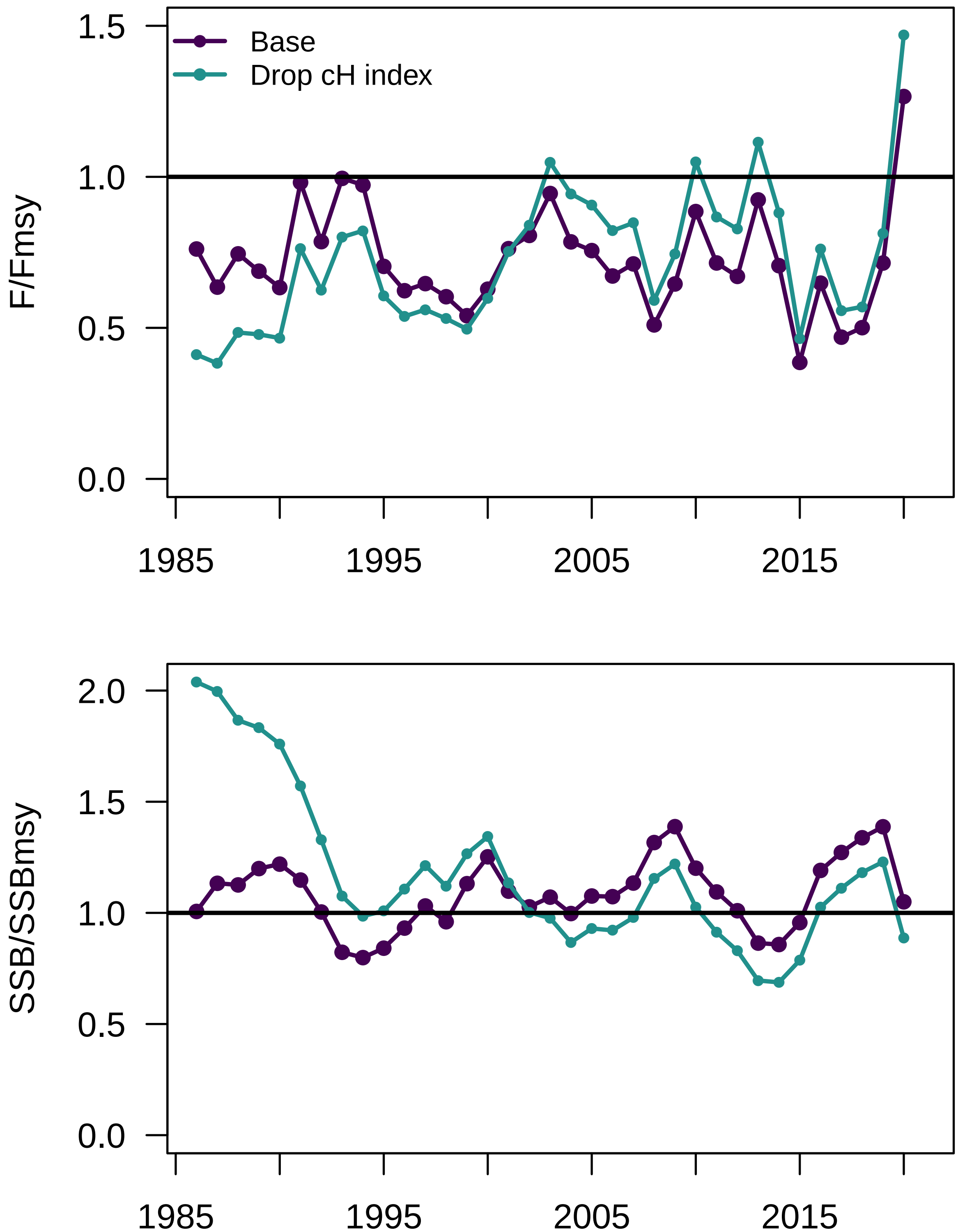


Figure 43. Spanish mackerel: Sensitivity of results to estimates of natural mortality M. (sensitivity runs S2 and S3). Top panel – Ratio of F to F_{MSY}*. Bottom panel – Ratio of* SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$*.*

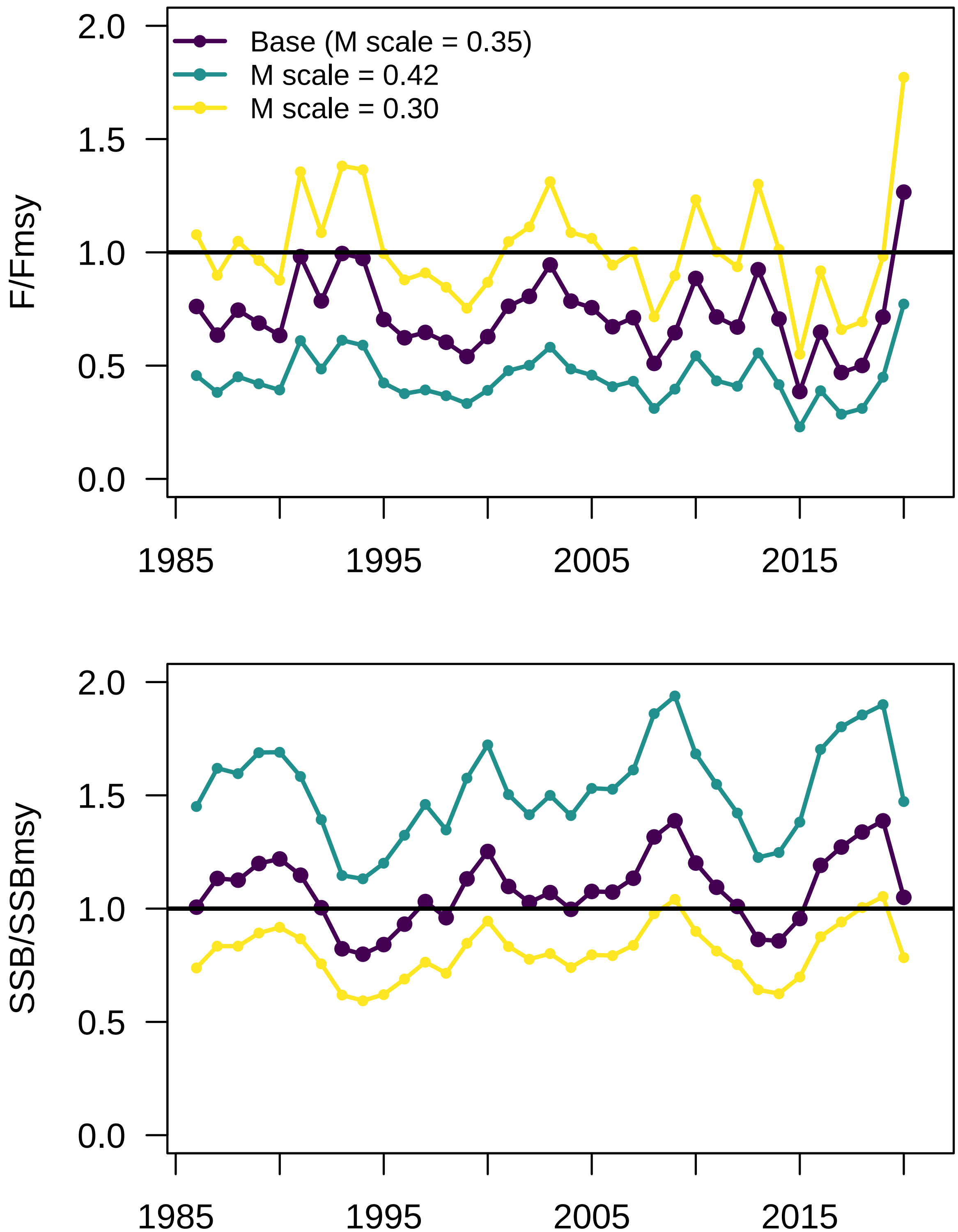


Figure 44. Spanish mackerel: Sensitivity of results to fixed values of steepness (sensitivity runs S4 and S5). Top panel – Ratio of F to F_{MSY}. Bottom panel – Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$.

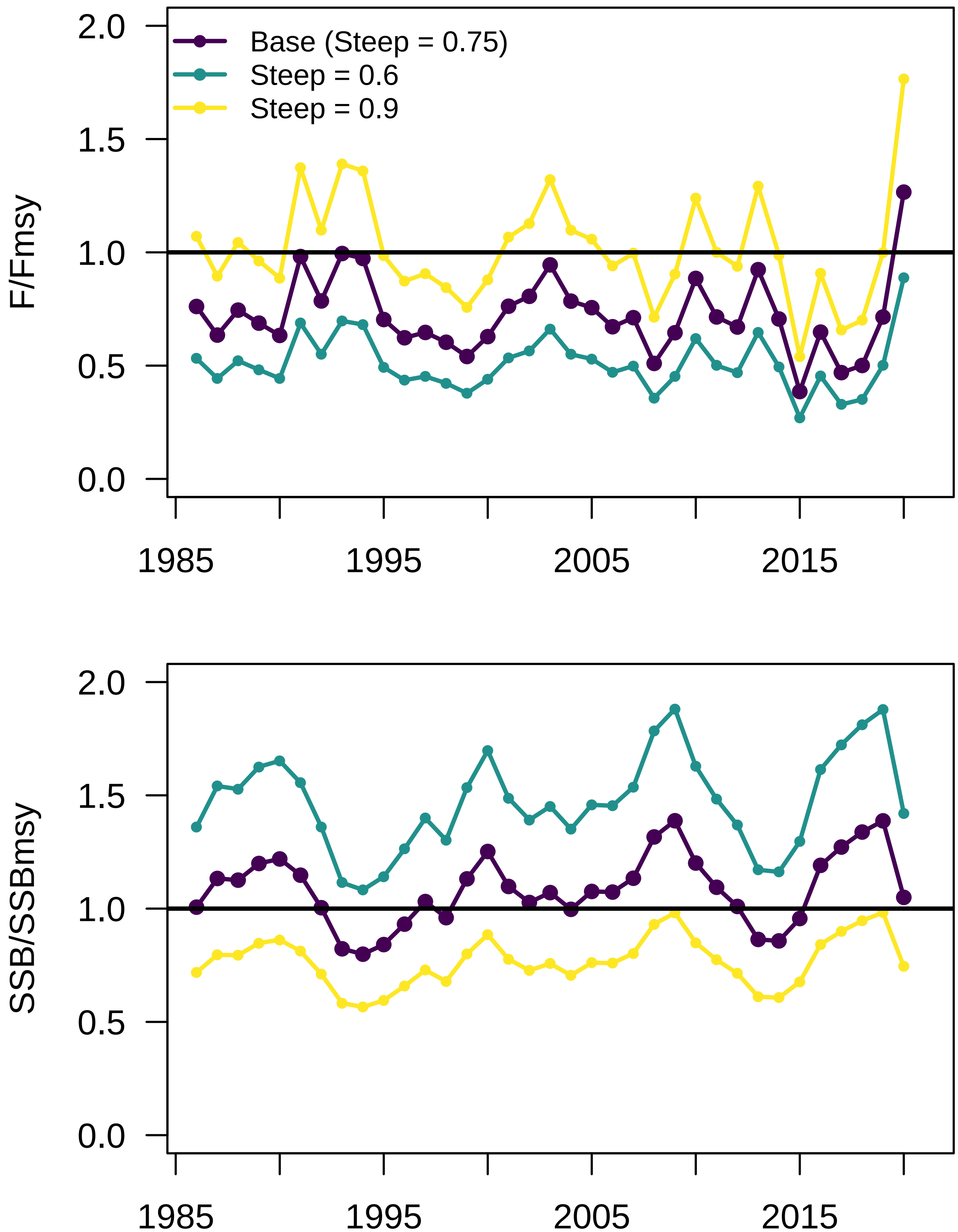


Figure 45. Spanish mackerel: Sensitivity of results to fixed values of general recreational (GR) discard mortality rate. (sensitivity runs S6 and S7). Top panel – Ratio of F to F_{MSY}*. Bottom panel – Ratio of* SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$*.*

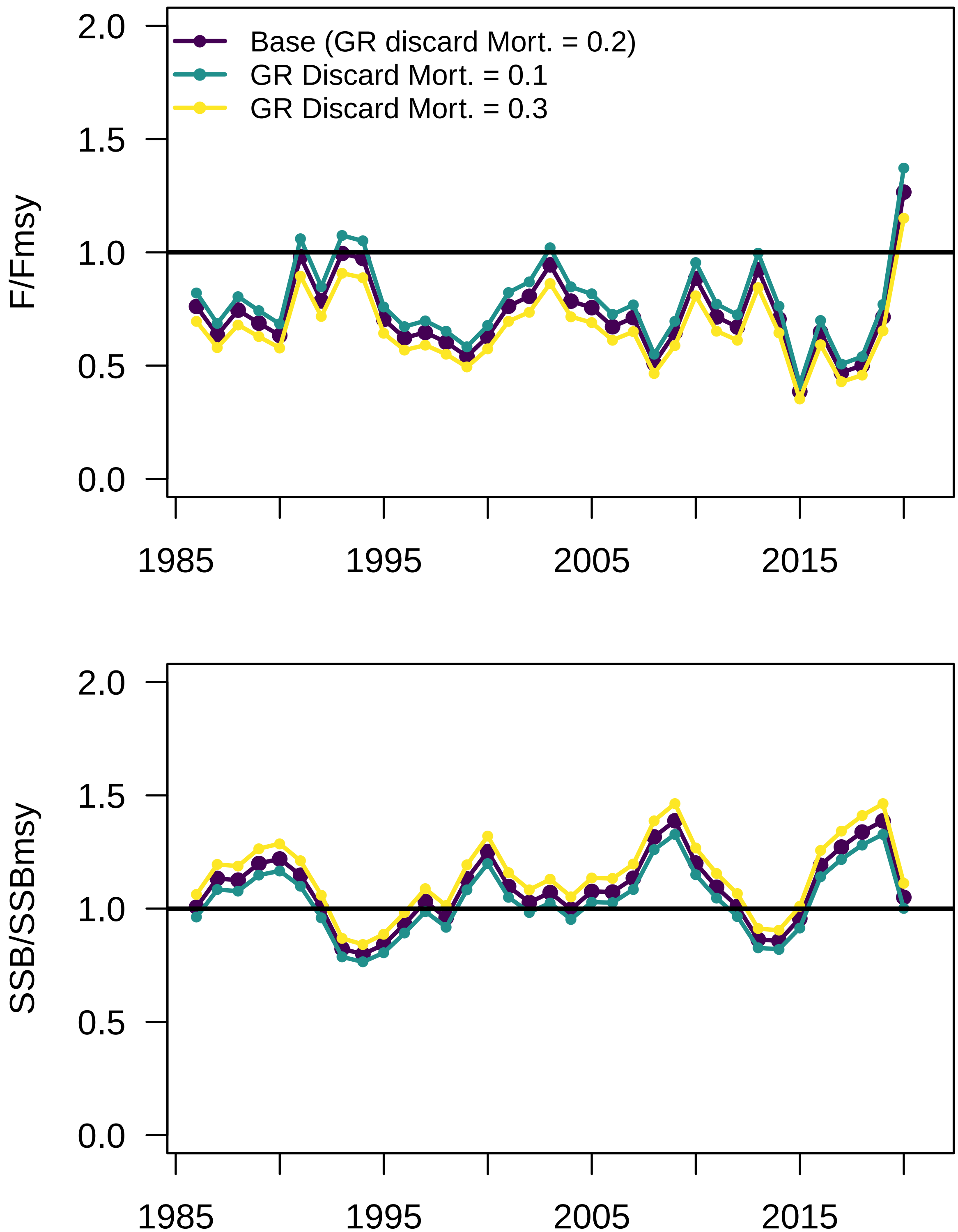


Figure 46. Retrospective analyses. Sensitivity to terminal year of data (sensitivity runs Retro 1–5). Top Panel: Fishing mortality rate, where solid circles show geometric mean of terminal three years, as used to compute fishing status. Middle Panel: Recruitment time series. Bottom Panel: Spawning stock biomass time series.

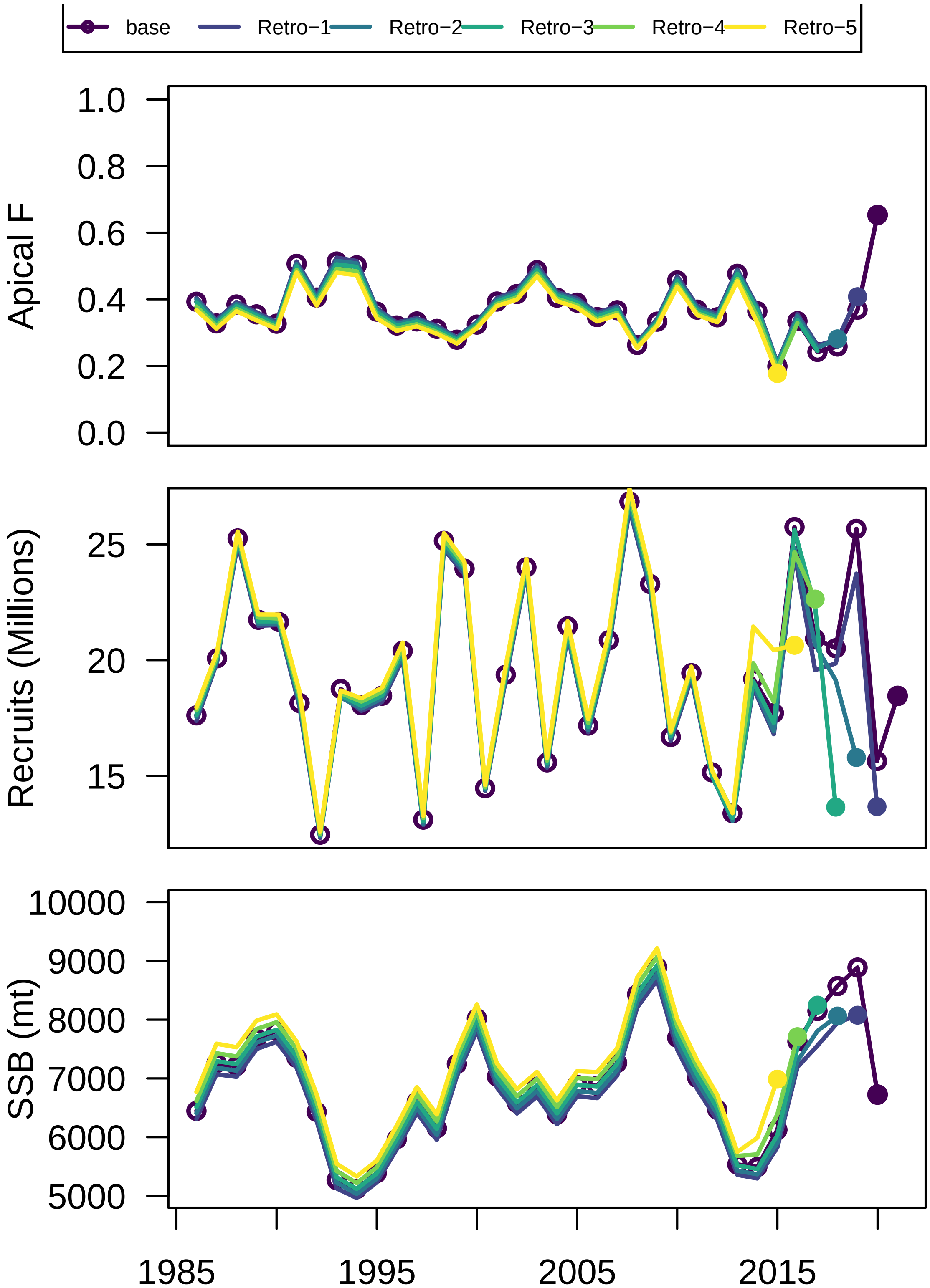


Figure 47. Retrospective analyses. Sensitivity to terminal year of data (sensitivity runs Retro 1–5). Top panel:Relative fishing mortality rate time series. Bottom panel: Relative spawning stock biomass time series.

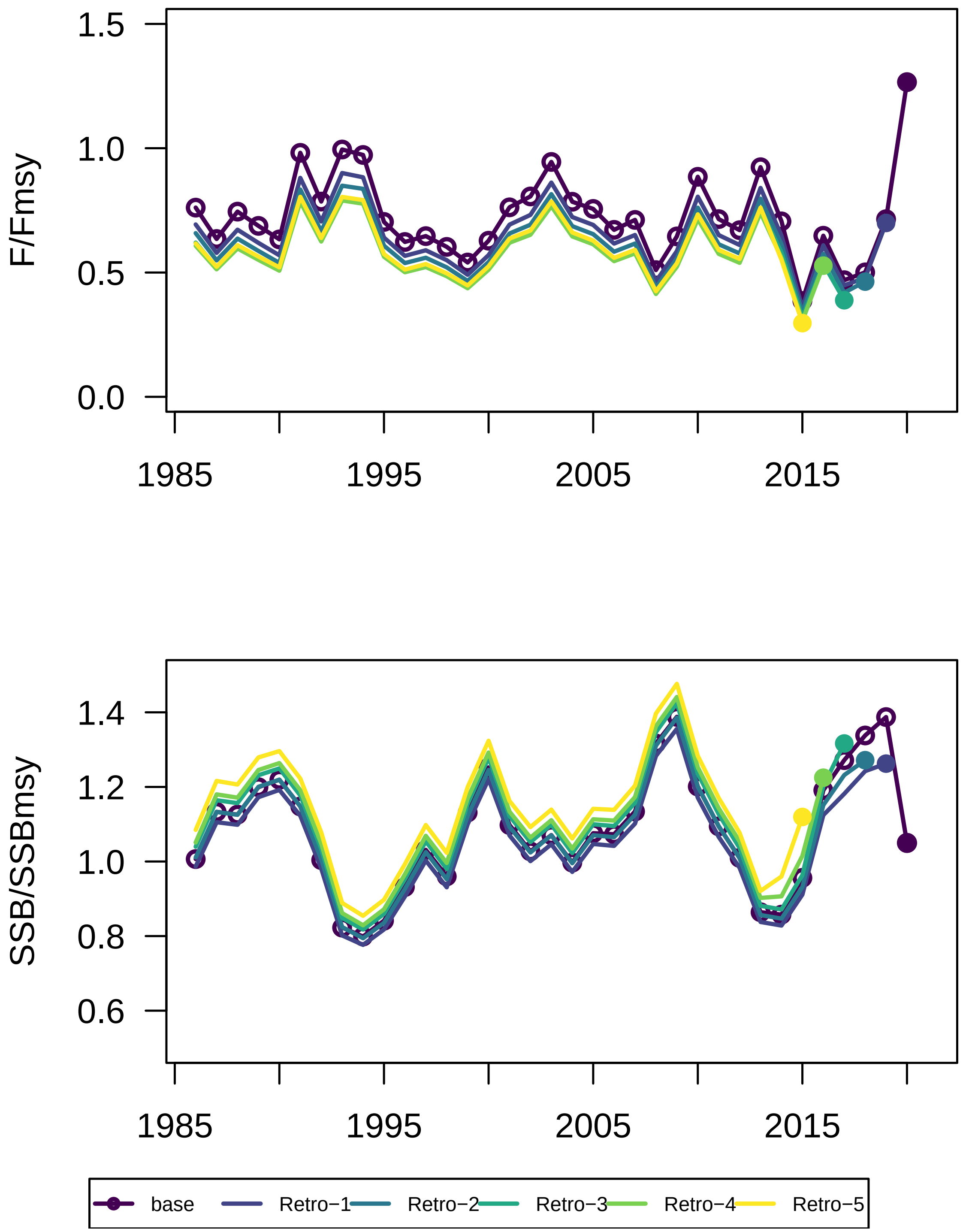


Figure 48. Projection results under scenario 1— $F = F_{\text{current}}$. Interim years (2021-2022) assume current landings based on average of the last 3 years of the assessment. Expected values (base run) represented by solid lines with solid circles, medians represented dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock (SSB) is at time of peak spawning.*

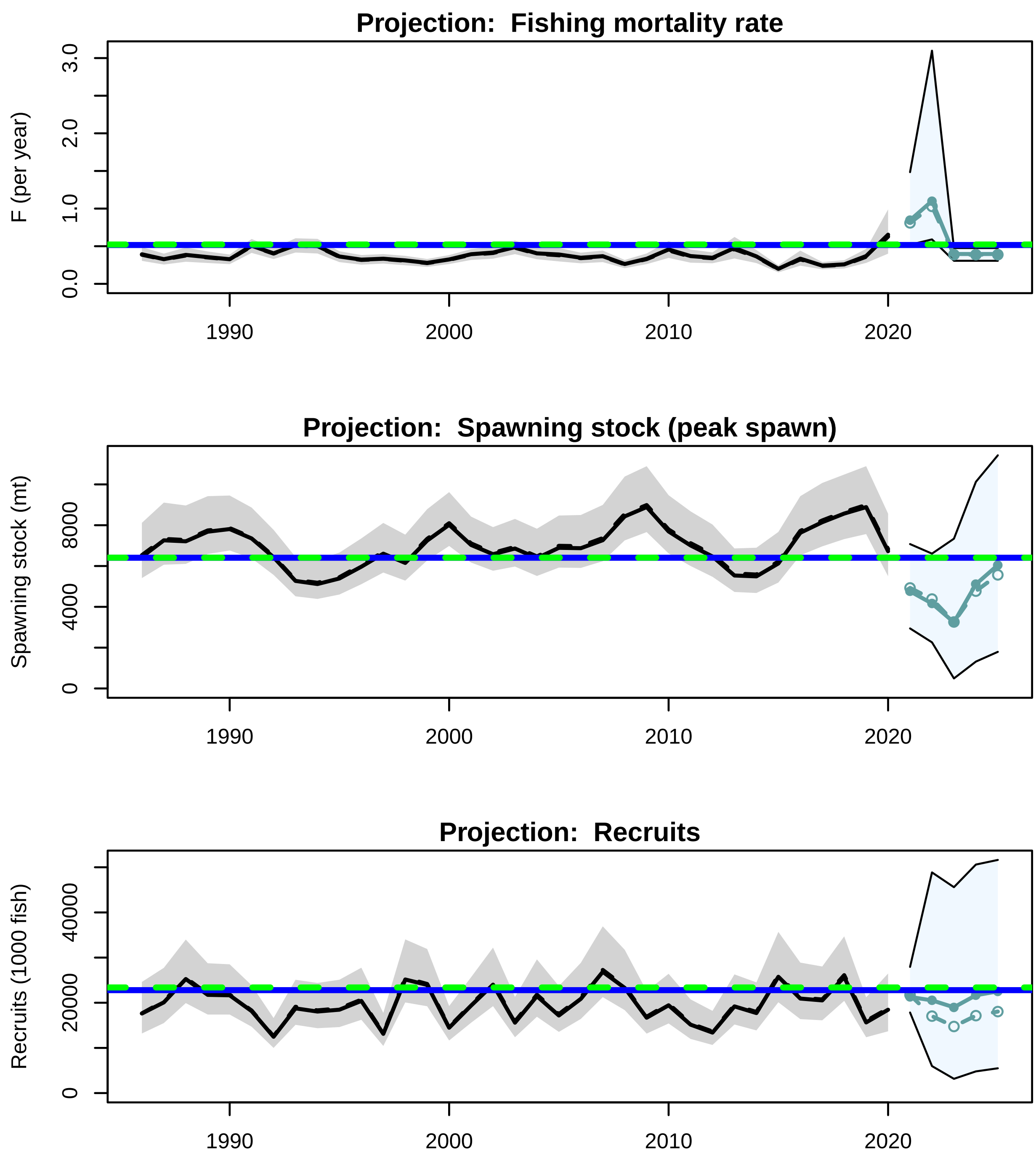


Figure 49. Projection results under scenario 2—fishing mortality rate fixed at $F = F_{\mathrm{MSY}}$. Interim years (2021-2022) assume current landings based on average of the last 3 years of the assessment. Expected values (base run) represented by solid lines with solid circles, medians represented dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock (SSB) is at time of peak spawning.*

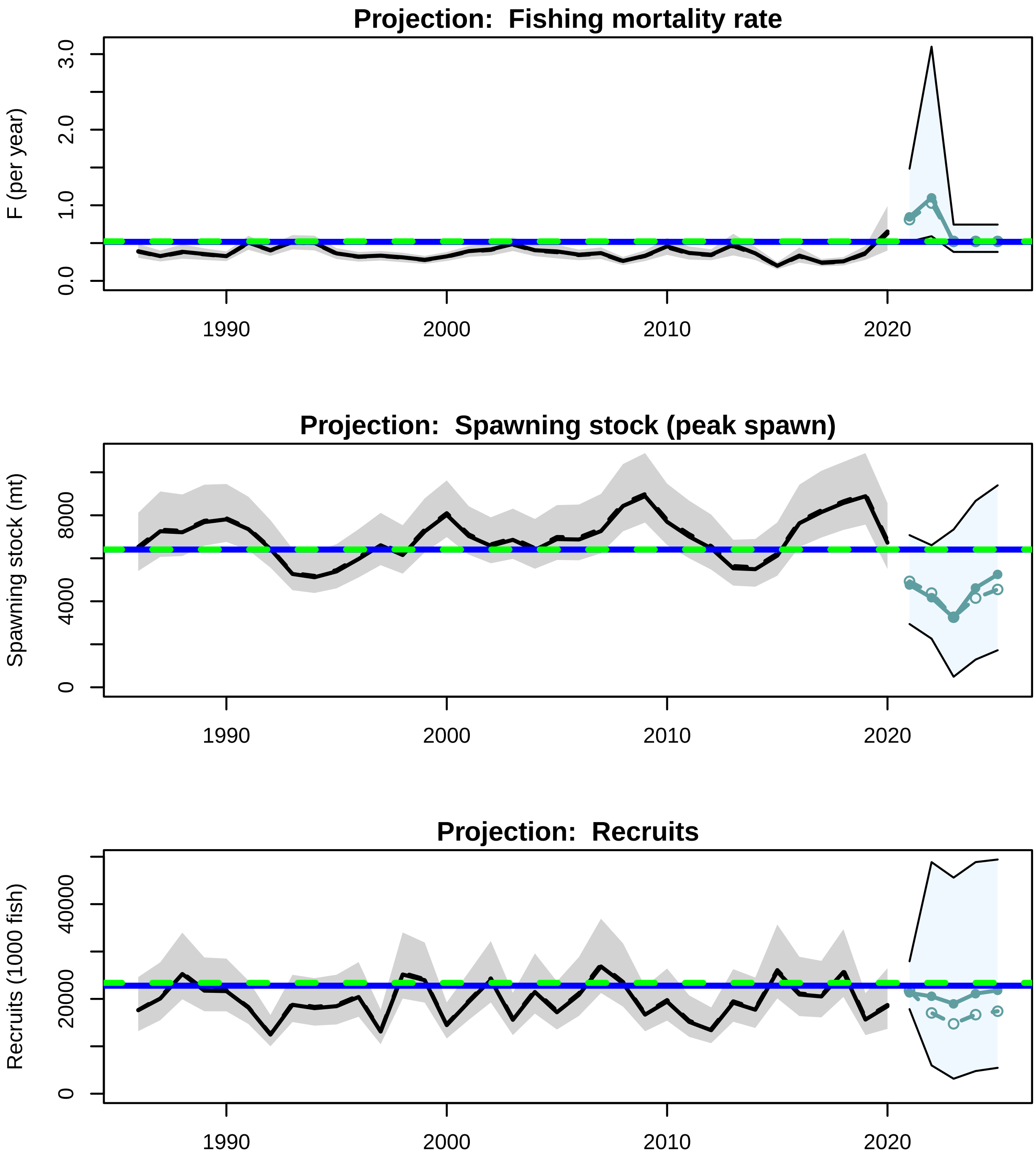
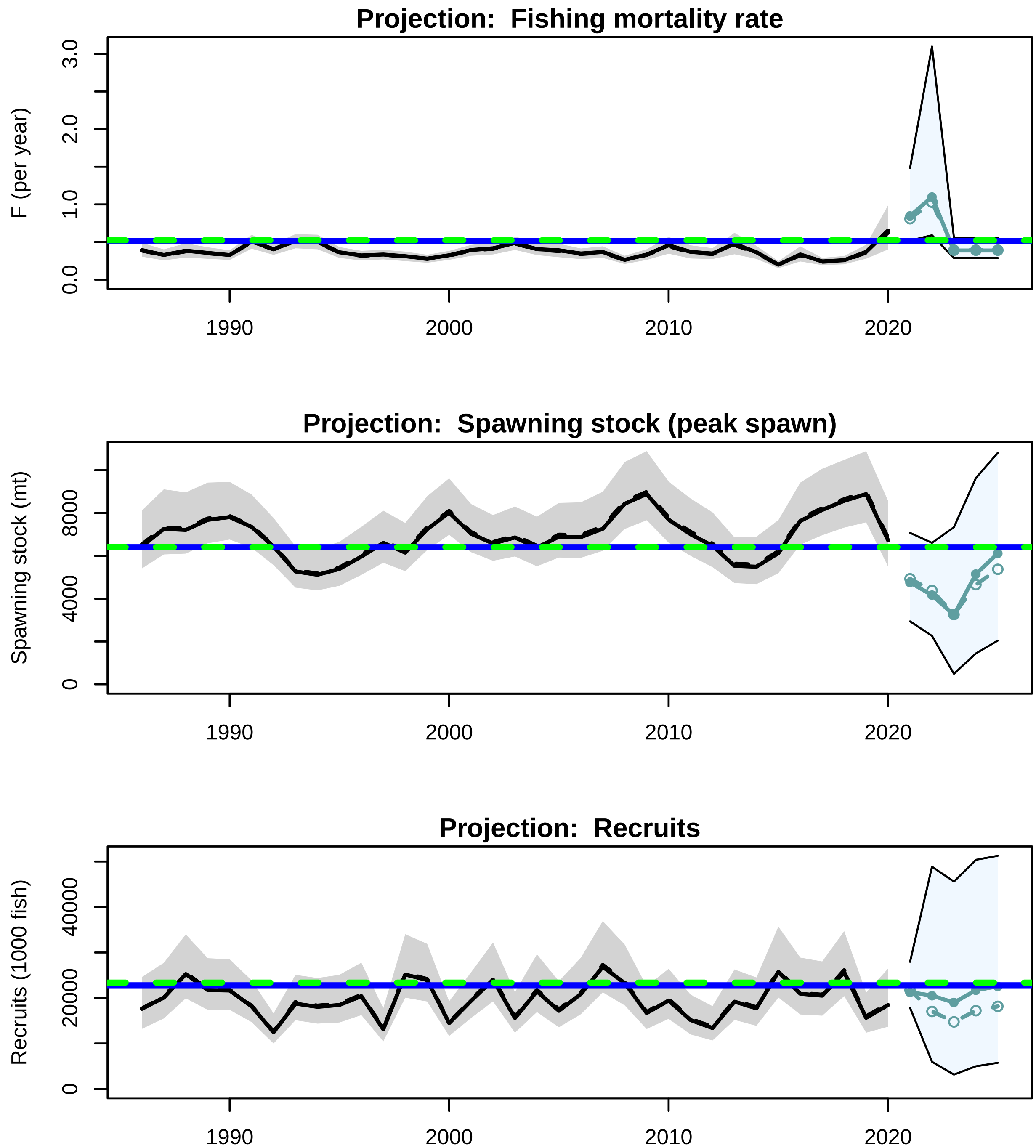


Figure 50. Projection results under scenario 3—fishing mortality rate fixed at $F = 75\% F_{\mathrm{MSY}}$. Interim years (2021-2022) assume current landings based on average of the last 3 years of the assessment. Expected values (base run) represented by solid lines with solid circles, medians represented dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock (SSB) is at time of peak spawning.*



Appendix A Abbreviations and symbols

Table 27. Acronyms and abbreviations used in this report

Symbol	Meaning
ABC	Acceptable Biological Catch
AW	Assessment Workshop (here, for Spanish mackerel)
ASY	Average Sustainable Yield
B	Total biomass of stock, conventionally on January 1r
BAM	Beaufort Assessment Model (a statistical catch-age formulation)
cC	Commercial cast net fleet
cG	Commercial gillnet fleet
cH	Commercial handline fleet
cP	Commercial pound net fleet
CPUE	Catch per unit effort; used after adjustment as an index of abundance
CV	Coefficient of variation
DW	Data Workshop (here, for Spanish mackerel)
F	Instantaneous rate of fishing mortality
F_{MSY}	Fishing mortality rate at which MSY can be attained
FL	Fork length
GLM	Generalized linear model
GR	General recreational fleet (all MRIP modes and headboat)
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
MCBE	Monte Carlo/Boostrap Ensemble, 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 Spanish mackerel as $75\%\mathrm{SSB}_{\mathrm{MSY}}$.
MSY	Maximum sustainable yield (per year)
mt	Metric ton(s). One mt is 1000 kg, or about 2205 lb.
N	Number of fish in a stock, conventionally on January 1
NC	State of North Carolina
NMFS	National Marine Fisheries Service, same as “NOAA Fisheries Service”
NOAA	National Oceanic and Atmospheric Administration; parent agency of NMFS
OY	Optimum yield; SFA specifies that OY $\leq$ MSY.
PSE	Proportional standard error
R	Recruitment
SAFMC	South Atlantic Fishery Management Council (also, Council)
SC	State of South Carolina
SCDNR	Department of Natural Resources of SC
SDNR	Standard deviation of normalized residuals
SEDAR	SouthEast Data Assessment and Review process
SFA	Sustainable Fisheries Act; the Magnuson–Stevens Act, as amended
SL	Standard length (of a fish)
SPR	Spawning potential ratio
SSB	Spawning stock biomass; mature biomass of males and females
$\mathrm{SSB}_{\mathrm{MSY}}$	Level of SSB at which MSY can be attained
TIP	Trip Interview Program, a fishery-dependent biodata collection program of NMFS
TL	Total length (of a fish), as opposed to FL (fork length) or SL (standard length)
VPA	Virtual population analysis, an age-structured assessment
WW	Whole weight, as opposed to GW (gutted weight)
YOY	Young of the year index developed from SEAMAP Coastal Trawl Survey
yr	Year(s)

Appendix B Parameter estimates from the Beaufort Assessment Model

```
# Number of parameters = 310 Objective function value = 2973.77904752711  Maximum gradient component = 0.000879228531802875
# Linf:
582.500000000
# K:
0.598000000000
# t0:
-0.500000000000
# len_cv_val:
0.120000000000
# Linf_L:
680.400000000
# K_L:
0.197000000000
# t0_L:
-2.77000000000
# len_cv_val_L:
0.120000000000
# Linf_f:
610.100000000
# K_f:
0.620000000000
# t0_f:
-0.500000000000
# len_cv_val_f:
0.120000000000
# log_Nage_dev:
 0.721044526056 -0.110720190214 -0.378695642073 -0.205830278289 -0.170537940725 -0.0143846309871 -0.00817447823725 -0.00507612228893 -0.00335125397867 -
 0.00562194911400
# log_R0:
16.9037823420
# steep:
0.750000000000
# rec_sigma:
0.600000000000
# R_autocorr:
0.00000000000
# log_rec_dev:
 -0.00865809003187 0.0291714769012 0.259564750534 0.0984919110203 0.0911762777692 -0.0743548899332 -0.424271401592 0.0283279495895 -0.00276351040706
 0.00743450739733 0.0843884860589 -0.378822030089 0.287079791266 0.205578507604 -0.316200835935 -0.000856680058175 0.226766295547 -0.213472035205
 0.120534518918 -0.117264753350 0.0774584294481 0.319300940206 0.151152100071 -0.190832446791 -0.0139316912979 -0.245812192405 -0.353712113320 0.0399669977688
 -0.0384604000077 0.311324618744 0.0612312440525 0.0302147722828 0.245941233356 -0.255148909990 -0.0405428281204
# log_dm_cH_ac:
0.616417221901
# log_dm_cG_ac:
3.13136906789
# log_dm_cP_ac:
2.72105272183
# log_dm_cC_ac:
0.863234858634
# log_dm_GR_ac:
3.14243380487
# selpar_A50_cH1:
2.31133913893
# selpar_slope_cH1:
1.90059331861
# selpar_A50_cG1:
1.05395387063
# selpar_slope_cG1:
2.59234728990
# selpar_A502_cG1:
5.09439416195
# selpar_slope2_cG1:
0.651526163974
# selpar_szero_cP1:
-3.56604220457
# selpar_Afull_cP1:
1.00000000000
# selpar_sigma_cP1:
6.95993417226
# selpar_A50_cC1:
2.07989501732
# selpar_slope_cC1:
3.02430762852
# selpar_szero_GR1:
-2.38388295999
# selpar_Afull_GR1:
1.00000000000
# selpar_sigma_GR1:
10.8603118299
# log_q_cH:
-9.20278871724
# log_q_GR:
-16.4734884449
# log_q_YOY:
-16.8794517784
# q_RW_log_dev_cH:
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 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000
 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000
```

```
 0.00000000000
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 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000
 0.00000000000
# M_constant:
0.350000000000
# log_avg_F_cH:
-3.25353281733
# log_F_dev_cH:
 -0.989767128558 -1.06354182479 -1.77971475555 -2.29855555584 -1.31339313645 -1.04648442641 -1.99538769584 -1.20608596824 -1.57603216000 -0.256652903454
 -0.773849512885 -0.975754357605 -0.895806835335 -0.719737649762 -0.278521273967 -0.199274607475 0.105975420020 0.110909913118 0.544656493736 0.855079192784
 0.642194544210 0.679447586647 0.717632565187 0.723502562643 0.963665601595 0.750893877869 1.04614414051 1.34211046379 1.73420885451 1.32168041957
 1.31336156275 1.16792219245 1.17261835781 1.00524958721 1.17130645576
# log_avg_F_cG:
-2.20315112118
# log_F_dev_cG:
 0.945846321843 0.614899245944 0.516864570805 0.460835547062 0.260351133232 0.674086135818 0.469883414810 1.13017244035 1.04961058579 0.854635228434
 0.547488921483 0.458418456112 0.456817447025 0.0141966049119 -0.100614022982 -0.121564482772 -0.280002259119 -0.458013179595 -0.884508140192 -0.348619945221
 -0.110568909399 -0.118468620458 -0.702268230072 -0.485179257363 -0.439640853711 -0.525982421966 -0.178913691374 -0.244733759126 -0.394255993274
 -0.497921952432 -0.558085635417 -0.657402104734 -0.486841447261 -0.707390810147 -0.153130336999
# log_avg_F_cP:
-4.95469365339
# log_F_dev_cP:
 0.314030344335 1.17894177827 1.02483958907 1.18682594335 1.18718589624 1.17253886163 1.14784160152 1.16997694262 1.16876427311 0.610722594186 0.902120995838
 0.454474886078 -0.0393270164520 0.613618267125 0.0166548999743 0.369765944888 -0.0707619700597 -0.416244741886 -0.571324503409 -1.07745510660 -1.15384522798
 -1.06753881020 0.121413245719 0.728598138859 -0.0315470724435 -0.452569052196 -0.818828271694 -1.39130044472 -1.17466665517 -0.812115320171 -0.736026445238
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# log_avg_F_cC:
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# log_F_dev_cC:
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 1.15150715377 1.07851506501 0.845153219692 0.187823628744 0.373618639996 1.00063686522 0.756531853588 0.585259692070 -0.357573105301 0.298743790186
 -0.919602561587 0.285082490450 0.496290058620 0.00587857441665 0.565823500209 0.111663142169
# log_avg_F_GR:
-1.75166100459
# log_F_dev_GR:
 -0.521561863948 -0.493976721994 0.0659331500494 -0.0683762975068 -0.0488296391892 0.457532546418 0.201700698379 -0.107623854518 -0.0117851998593
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 -0.0456774712490 -0.453691859610 -0.0675269305795 -0.152672018435 0.0863718599759 0.401430923411 0.169597059723 -0.0113350033823 0.751370017276
 0.289561502603 -0.419893677696 0.201681712723 -0.461524257693 -0.169774643047 0.294857012434 1.09539249298
# log_avg_F_GR_D:
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# log_F_dev_GR_D:
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 -0.398119102519 -0.0719811459720 0.249684850194 -1.04499631792 0.0294114383125 0.662666416546 -0.138161952401 0.255055050997 0.917902110163 -0.174298611039
 0.355051739618 -0.648577990851 0.0299420045855 0.441850783971 0.471326601580 0.697762872342 0.437493705108 0.373292599054 0.922392565273 0.572066115831
 -0.339390208524 0.486359797023 0.172015612123 0.733097580474 1.44345230452 1.63664349164
# log_avg_F_SB_D:
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# log_F_dev_SB_D:
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 0.266275849831 0.806973563402 0.134248494258 0.250424332840 0.643307972386 0.200352755145 0.0748201997507 0.200265020569 -0.0905045472839 0.169350014858
 -0.379057143616 -0.820779106061 -0.633301718105 -0.841234367678 -0.461965577620 -0.217163264828 0.0403529067424 -0.600358892446 -0.400317289917
 -0.632159724408 -0.472340557051 -0.536201497722 -0.975235503768 -0.245682364194 -0.327492884571
# F_init_mult:
0.595961359447
```