S E D A R

Southeast Data, Assessment, and Review

==

SEDAR 17

Stock Assessment Report

South Atlantic Spanish Mackerel

November 18, 2008

SEDAR is a Cooperative Initiative of:

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

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

Stock Assessment Report

Table of Contents

Pages of each Section are numbered separately.

Section I. Introduction

Contents

1. SEDAR Overview

SEDAR (Southeast Data, Assessment and Review) was initially developed by the Southeast Fisheries Science Center and the South Atlantic Fishery Management Council to improve the quality and reliability of stock assessments and to ensure a robust and independent peer review of stock assessment products. SEDAR was expanded in 2003 to address the assessment needs of all three Fishery Management Council in the Southeast Region (South Atlantic, Gulf of Mexico, and Caribbean) and to provide a platform for reviewing assessments developed through the Atlantic and Gulf States Marine Fisheries Commissions and state agencies within the southeast.

SEDAR strives to improve the quality of assessment advice provided for managing fisheries resources in the Southeast US by increasing and expanding participation in the assessment process, ensuring the assessment process is transparent and open, and providing a robust and independent review of assessment products. SEDAR is overseen by a Steering Committee composed of NOAA Fisheries representatives: Southeast Fisheries Science Center Director and the Southeast Regional Administrator; Regional Council representatives: the Executive Directors and Chairs of the South Atlantic, Gulf of Mexico, and Caribbean Fishery Management Councils; and Interstate Commissions: the Executive Directors of the Atlantic States and Gulf States Marine Fisheries Commissions.

SEDAR is organized around three workshops. First is the Data Workshop, during which fisheries, monitoring, and life history data are reviewed and compiled. Second is the Assessment workshop, during which assessment models are developed and population parameters are estimated using the information provided from the Data Workshop. Third and final is the Review Workshop, during which independent experts review the input data, assessment methods, and assessment products.

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

SEDAR Review Workshop Panels consist of a chair, a reviewer appointed by the Council, and 3 reviewers appointed by the Center for Independent Experts (CIE), an independent organization that provides independent, expert reviews of stock assessments and related work. The Review Workshop Chair is appointed by the SEFSC director and is usually selected from a NOAA Fisheries regional science center. Participating councils may appoint representatives of their SSC, Advisory, and other panels as observers to the review workshop.

SEDAR 17 was charged with assessing Spanish mackerel and vermilion snapper in the US South Atlantic. This task was accomplished through workshops held between May and October 2008.

2. Management Review

Table 1. General Management Information

Species	Spanish Mackerel (*Scomberomorus maculatus*)
Management Unit	Southeastern US
Management Unit Definition	The management unit for the Atlantic migratory group of Spanish mackerel extends from 25°20.4' N. lat., which is a line directly east from the Miami-Dade/Monroe County, FL, boundary to the outer limit of the EEZ[1] to the Mid-Atlantic Council Boundaries[2].
Management Entity	South Atlantic Fishery Management Council
Management Contacts SERO / Council	Steve Branstetter, Jack McGovern/ Gregg Waugh
Current stock exploitation status	Not Overfishing
Current stock biomass status	Not Overfished

*Electronic Code of Federal Regulations

1. § 622.2 Spanish mackerel. The boundary separating the Gulf and Atlantic migratory groups of Spanish mackerel is 25°20.4' N. lat., which is a line directly east from the Miami-Dade/Monroe County, FL, boundary to the outer limit of the EEZ.

§ 600.105 (a) New England and Mid-Atlantic Councils. The boundary begins at the intersection point of Connecticut, Rhode Island, and New York at 41°18'16.249" N. lat. and 71°54'28.477" W. long. and proceeds south 37°22'32.75" East to the point of intersection with the outward boundary of the EEZ as specified in the Magnuson-Stevens Act.

Table 2. Specific Management Criteria

The SEDAR 17 Review Panel did not accept the base assessment model as appropriate for making biomass determinations and did not accept estimates of stock abundance, biomass, and exploitation rates, due to concerns about robustness of the assessment to uncertainty in inputs and model assumptions. Results from SEDAR 17 about biomass benchmarks are largely uncertain and should be viewed with extreme caution.

Criteria	Current **		Results from SEDAR 17	
	Definition	Value	Definition	Value ***
MSST	MSST = [(1-M) or 0.7 whichever is greater]*B_{MSY}	8.5 to 11.1	MSST = [(1-M) or 0.7 whichever is greater]*B_{MSY}	8085 mt***
MFMT	MFMT = F_{MSY} where F_{MSY} = $F_{30\%SPR}$	0.42 (0.38 – 0.48)	F_{MSY}	0.371
MSY	Yield at F_{MSY}	5.242 (4.372 – 6.392) mp	Yield at F_{MSY}	11,461,000 pounds***
F_{MSY}	F_{MAX}	0.42 (0.38 – 0.48)	F_{MAX}	0.371***
OY	Yield at F_{OY}	Not specified	Yield at F_{OY}	Not specified
F_{OY}	$F_{40\%SPR}$	0.30 (0.27 – 0.34)	F_{OY} = 65% F_{MSY} 75% F_{MSY} 85% F_{MSY}	pounds*** 10,608,000 11,051,000 11,320,000
M	n/a	0.30	M	0.35

** Stock Assessment on Spanish and King Mackerel Stocks; 2003 Report of the Mackerel Stock Assessment Panel; SFD 2003.

*** Results from SEDAR 17 about biomass benchmarks are largely uncertain and should be viewed with extreme caution.

Table 3. Stock Rebuilding Information

Spanish mackerel is not overfished; no rebuilding plan required.

Table 4. Stock projection information

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

Requested Information	Value
First Year of Management	2009
Projection Criteria during interim years should be based on (e.g., exploitation or harvest)	Fixed Exploitation; Modified Exploitation; Fixed Harvest*
Projection criteria values for interim years should be determined from (e.g., terminal year, avg of X years)	Average of previous 3 years

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

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

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

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

Table 5. Quota Calculation Details

Quota Detail	Value
Current Quota Value	Commercial quota set at 3.87 mp. Recreational allocation set at 3.17 mp.
Next Scheduled Quota Change	None scheduled
Annual or averaged quota ?	annual
If averaged, number of years to average	n/a

How is the quota calculated - conditioned upon exploitation or average landings?
A 2000 seasonal adjustment of harvest levels established a TAC of 7.04 million pounds for Atlantic group Spanish mackerel. This value is based on framework procedures, which specify the Council may not set TAC to exceed the best point estimate of MSY by more than 10 percent. The estimate of MSY from the 1999 Assessment Panel Report is 6.4 million pounds with a range of 5.7 to 7.5 million pounds. With a 7.04 million pound TAC, the commercial allocation is 3.87 million pounds (55%) and the recreational allocation is 3.17 million pounds.

Does the quota include bycatch/discard estimates?
The quota is not adjusted for bycatch estimates.

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

Table 6. Federal Regulatory and FMP History

Description of Action	FMP/Amendment	Effective Date
Established TAC of 27 MP; limited purse seine harvest to 300,000 lbs in Atlantic and 300,000 lbs in Gulf; minimum size limit for Rec/Comm 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
Final Rule for Amendment 1. Provided framework procedure for pre-season adjustment of TAC. TAC of 27 mp for Atlantic, purse seine harvest to 300,000 lbs in Atlantic and 300,000 lbs in Gulf and a minimum size limit for the commercial and recreational sectors are 12 inches FL or 14 inches TL.	50 FR 34846 Amendment 1 (SAFMC 1985)	August 28, 1985
Emergency rule beginning January 1, 1987 through March 31, 1987 would divide 3.716 mp quota into three areas with 1.869 mp going to the Atlantic. The Atlantic boundary was bounded by the NC/VA border and a line directly east of the Dade/Monroe County, Florida boundary to the seaward boundary of the EEZ. The emergency action also established a bag limit of 4 Spanish mackerel per trip and allowed sale of recreationally caught Spanish mackerel under the bag limit.	52 FR 290	January 5, 1987
Spanish mackerel commercial fishery was closed January 14, 1987 to March 31, 1987 because 1.869 mo quota was met.	52 FR 2113	January 20,1987
90 day extension of January 1, 1987 to March 31, 1987 emergency rule for Spanish mackerel.	52 FR 10762	April 3, 1987
Revised MSY, recognized two migratory groups, set TAC at 2.9 mp, established commercial (2.2 mp, 76%) and recreational (0.7 mp, 24%) allocations for TAC, established April 1 to March 31 fishing year, established Dade/Monroe county line as the migratory group boundary, and set commercial quotas and bag limits. A bag limit of 4 fish in FL and 10 in NC, SC, and GA. Charterboat permits were required and it was clarified TAC must be set below the upper range of the ABC.	52 FR 23836 Amendment 2 (SAFMC 1987)	June 25,1987
Framework action – commercial allocation is 2.36 mp and recreational allocation is 0.74 mp, bag limits is 4 fish from FL and 10 fish north of FL.	52 FR 25012	July 2, 1987
Bag limit for Atlantic Spanish mackerel set to 0 for remainder of year because 0.74 mp recreational allocation was reached.	52 FR 35720	September 23, 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
Commercial fishery for Atlantic Spanish mackerel closed December 29, 1987 because 2.36 mp quota met.	52 FR 49415	December 31, 1987
Framework action changed TAC to 4.0 mp for Atlantic Spanish mackerel with 0.96 mp allocated to the recreational sector and 3.04 mp allocated to the commercial sector.	53 FR 25611	July 8, 1988
Bag limit for Atlantic Spanish mackerel reduced to 0 on October 3, 1988 for remainder of year because recreational allocation of 0.96 mp was reached.	53 FR 39097	October 5, 1988
Commercial fishery for Atlantic Spanish mackerel closed December 29, 1988 because the 3.04 mp quota was reached.	54 FR 153	January 4, 1989
Effective April 1, 1989, TAC for Atlantic Spanish mackerel was increased to 6 mp with 1.44 mp allocated to the recreational sector and 4.56 mp allocated to the commercial	54 FR 24920	June 12, 1989

sector.		
Prohibited drift gill nest for coastal pelagics and purse seines for the overfished group of mackerels.	54 FR 29561 Amendment 3 (SAFMC 1989)	July 13, 1989
Reallocated Atlantic group Spanish mackerel equally between recreational and commercial fishermen. TAC = 6.0 mp.	54 FR 38526 Amendment 4 (SAFMC 1989)	September 19, 1989
Framework action changed TAC for Atlantic Spanish mackerel to 5.0 mp, 3.14 mp allocated to the commercial sector and 1.86 mp allocated to the recreational sector.	55 FR 25986	June 26, 1990
Extended the management area for the Atlantic groups of mackerels through the MAFMCs area of jurisdiction, revised the definition of overfishing, redefined recreational bag limits as daily limits, and deleted a 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 from area off FL and 10 fish north of FL.	55 FR 29370 Amendment 5 (SAFMC 1990)	July 19, 1990
Closed commercial fishery for Atlantic Spanish mackerel on January 25, 1991 because 3.14 mp commercial quota was met.	56 FR 3422	January 30, 1991
TAC for Atlantic Spanish mackerel increased to 7.0 mp with 3.5 mp allocated to commercial sector and 3.5 mp 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
Closed commercial fishery for Atlantic Spanish mackerel on December 17, 1991 because 3.5 commercial quota was reached.	56 FR 66001	December 20, 1991
Proposed Rule to increase bag limit in FL for Atlantic Spanish mackerel to that adopted by the state of FL but not to exceed 10 fish.	57 FR 33924	July 31, 1992
Specified rebuilding periods for overfished mackerel stocks, provided for commercial Atlantic Spanish mackerel possession limits, 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, and changed all size limits to fork length only. Minimum size limit is 12 inches FL. In northern zone, boats are restricted to possession limits of 3,500 pounds. In southern zone trip limit are 1,500 pounds per vessel per day during 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. Adjusted quota for Spanish mackerel is 3.25 mp.	57 FR 58151 Amendment 6 (SAFMC 1992)	December 9, 1992
Trip limit reduced to 1,000 pounds per day in Southern zone on January 7, 1993 because 80% of the quota had been reached.	58 FR 4093	January 13, 1993
Trip limit reduced to 500 pounds per day in Southern zone on February 20, 1993 because 100% of the adjusted commercial allocation was reached.	58 FR 11198	February 24, 1993
Commercial TAC for Atlantic Spanish mackerel increased to 9 mp with 4.5 mp commercial and 4.5 mp 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

Trip limit reduced to 1,000 pounds per day on December 22, 1993 because 75% of the quota had been met.	58 FR 68327	December 23, 1993
Trip limit reduced to 500 pounds per day on February 18, 1994.	59 FR 8868	February 24, 1994
Effective April 1, 1994, TAC for Atlantic Spanish mackerel is increased to 9.2 mp (4.6 mp commercial and 4.6 mp recreational).	59 FR 40509	August 9, 1994
Trip limit reduced to 1,000 pounds per day on January 29, 195 because 75% of the quota had been met.	60 FR 4866	January 25, 1995
Effective April 1, 1995, TAC for Atlantic Spanish mackerel increased to 9.4 mp (4.7 mp commercial and 4.7 mp recreational).	60 FR 39698	August 3, 1995
Reduce TAC for Atlantic Spanish mackerel to 7.0 mp (3.5 mp commercial and 3.5 mp 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
Effective with the fishing year that began April 1, 1997, increase the TAC for Atlantic Spanish mackerel to 8.0 mp (4.0 mp commercial, 4.0 mp recreational).	62 FR 53278	October 14, 1997
Reduce trip limit to 1,500 pounds per day on December 16, 1997.	62 FR 66304	December 18, 1997
Modified requirements for a king or Spanish mackerel permit, set the OY target to 40% static SPR for the Atlantic, and modified the seasonal framework adjustment measures.	63 FR 10561 Amendment 8 (SAFMC 1994)	March 4, 1998
Reduce trip limit to 1,500 pounds per day on February 10, 1999.	64 FR 7556	February 16, 1999
Decrease the TAC for Atlantic Spanish mackerel from 8.0 mp to 6.6 mp and change the allocation from 50/50 to 55% commercial (3.63 mp) and 45% recreational (2.97 mp).	64 FR 45457	August 20, 1999
Allowed the retention and sale of damaged, legal sized king and Spanish mackerel within established trip limits.	64 FR 16336 Amendment 9 (SAFMC 1998)	March 28, 2000
Increase TAC from 6.06 mp to 7.04 mp for Atlantic Spanish mackerel with 3.87 mp commercial and 3.17 mp 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 15 fish per person per day. MSY = 5.7-7.5 mp, Bmsy = 12.2-15.8, MSST = 8.5-11.1, MFMT = 0.38-0.48. Effective June 12, 2000.	65 FR 41015	July 3, 2000
Addressed Sustainable Fishery Act definitions.	Amendment 11 (SAFMC 1999)	December 1999
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
Changed the fishing year for Atlantic group Spanish mackerel to March 1 through February 28/29.	70 FR 39187 Amendment 15 SAFMC (2004)	July 7, 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. Effective March 12, 2008.	73FR439	January 3, 2008

Table 7a. 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
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	NC	3/1/96

captain and mate		
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 7b. 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 7c. 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
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; 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.

In 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.

Table 8. Annual Regulatory Summary

Commercial Fishery Regulations			Recreational Fishery Regulations	
Effective Date	Size Limit	Quota	Size Limit	Possession Limit
See Table 6 for annual regulatory summary of Federal regulatory history.				

References

Stock Assessment on Spanish and King Mackerel Stocks; 2003 Report of the Mackerel Stock Assessment Panel; SFD 2003.

Fishery Management Plan for Spanish Mackerel, Fishery Management Report No. 18, Atlantic States Marine Fisheries Commission, November 1990.

3. Assessment History

Full stock assessments of the Atlantic group Spanish mackerel were conducted by Powers et al. (1996), Legault et al. (1998) and Sustainable Fisheries Division (2003). 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 Atlantic group Spanish mackerel was conducted 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 has increased since 1995 and was found to be at a high for the analysis period. Stock biomass increased from about 19 million to 24 million fish. 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 Atlantic group Spanish mackerel were not overfished and overfishing did not occur in 2002/2003. Although all measures of stock status are well within desirable ranges, the median estimate of MSY dropped from 6.4 million pounds in the last full assessment in 1998 to 5.2 million pounds in the 2003 assessment. Much of the decline is believed to be due to the lower estimates of recruitment between the most recent assessment (2003) and the previous stock assessment (Legault et al. 1998). The MSAP recommended an Acceptable Biological Catch (ABC) as the median estimate of catch at F 40% SPR, which was 6.7 million pounds (20th – 80th percentile range = 5.2-8.4 million pounds).

Natural mortality (M) was assumed to be 0.3 as selected by the MSAP based upon longevity and growth rates. A stochastic analysis was conducted allowing M to vary between 0.25 and 0.35. Spawning stock biomass was used to represent age specific fecundity of Atlantic Spanish mackerel, estimated as the biomass of females times the probability of maturity by age times 0.5. Although it is not clearly stated, presumably commercial and recreational landings are divided into Atlantic and Gulf groups according to Amendment 2 (1987) to the Coastal Migratory (Mackerel) FMP. Consideration has been given to including shrimp trawl bycatch estimates for Atlantic Spanish mackerel beginning with Powers et al. (1996). Several Atlantic Spanish mackerel indices of abundance were considered for the 2003 assessment, including: (1) Florida Fish and Wildlife Conservation Commission (FWC) Marine Fisheries Trip Ticket Program, (2) MRFSS Recreational, (3) NMFS Beaufort Laboratory Headboat Survey, (4) North Carolina Division of Marine Fisheries Pamlico Sound Survey, (5) North Carolina Division of Marine Fisheries (NCDENR) Trip Ticket Program, and (6) Southeast Area Monitoring and Assessment South Atlantic (SEAMAP-SA). These data are summarized in Table 12 (Sustainable Fisheries Division 2003). See Figure 13 in this report for a comparison of these indices with the indices used in the previous assessment by Legault et al. (1998). All three stock assessments referenced below were based on the tuned VPA (FADAPT) method (Powers and Restrepo 1992, Restrepo 1996) to obtain statistical estimates of population parameters.

References Cited:

Legault, C.M., N. Cummings and P. Phares. 1998. Stock assessment analyses on Atlantic migratory group king mackerel, Gulf of Mexico migratory group king mackerel, Atlantic migratory group Spanish mackerel, and Gulf of Mexico migratory group Spanish mackerel. NMFS SEFSC Miami Sustainable Fisheries Division Contribution MIA-97/98-15.

Powers, J.E., N. Cummings, and P. Phares. 1996. Stock assessment analyses on Gulf of Mexico migratory group Spanish mackerel, and Atlantic migratory group Spanish mackerel. NMFS SEFSC Miami Sustainable Fisheries Division Contribution MIA-95/96-11.

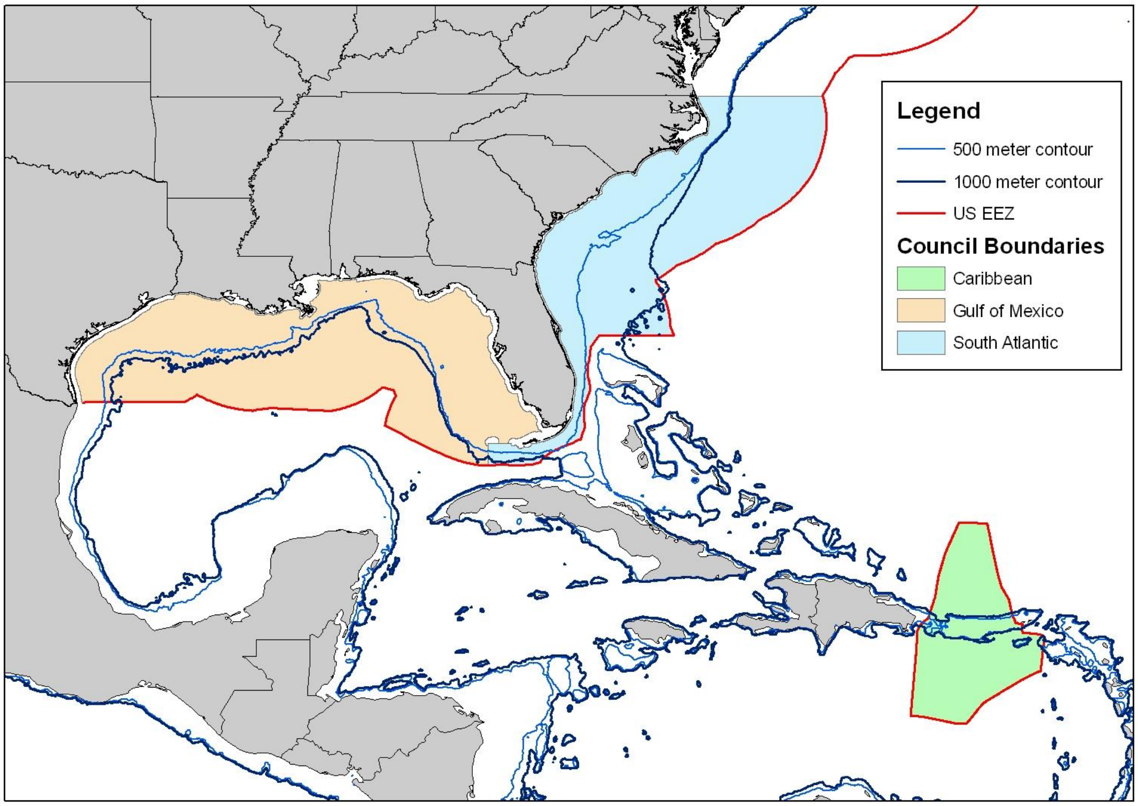
Powers, J.E. and V.R. Restrepo. 1992. Additional options for age-sequenced analysis. ICCAT Coll. Vol. Sci. Pap. 39:540-553.

Restrepo, V.R. 1996. FADAPT 3.0 A Guide. University of Miami, Cooperative Unit for Fisheries Research and Education (CUFER), Miami, FL.

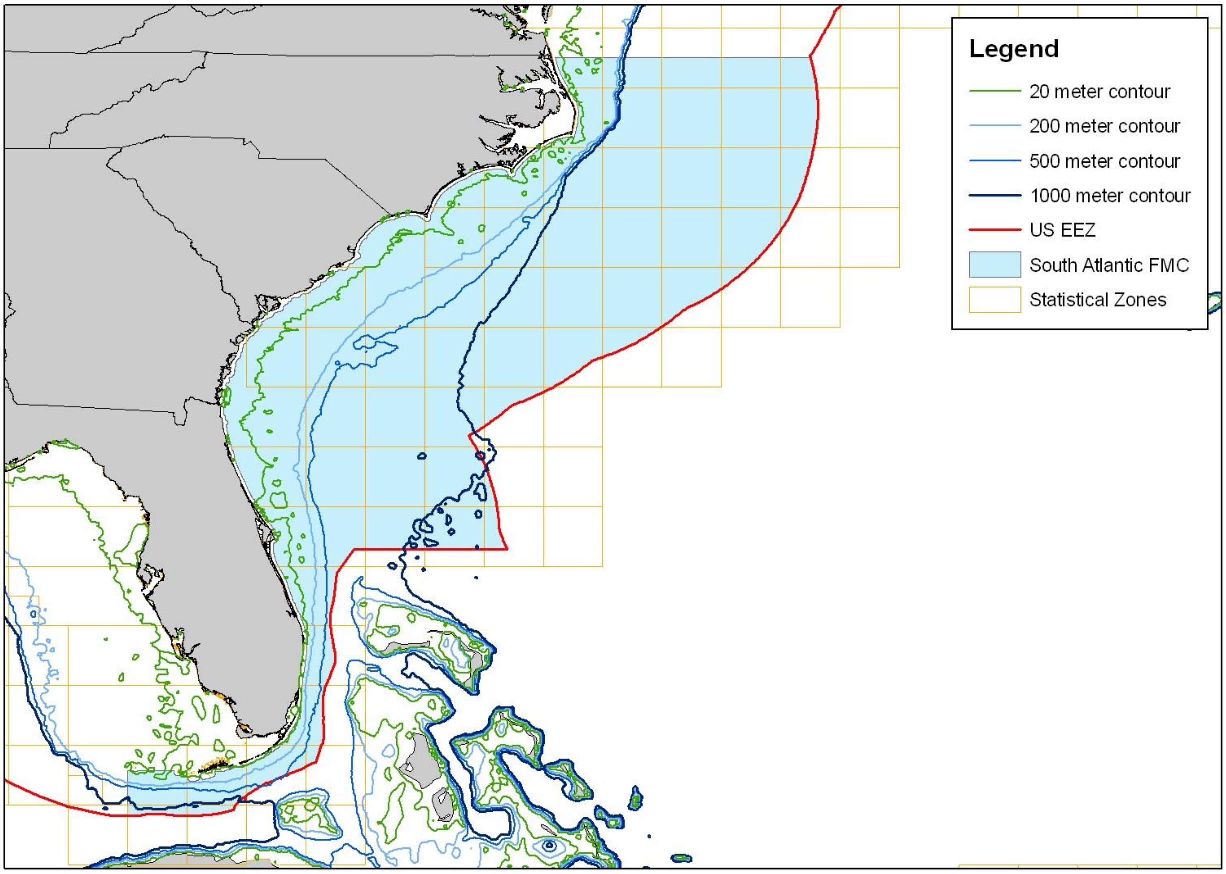
Sustainable Fisheries Division. 2003. Stock assessment analyses on Spanish and king mackerel stocks. NMFS SEFSC Miami Sustainable Fisheries Division Contribution SFD-2003-0008, 147 pp.

4. Southeast Region Maps

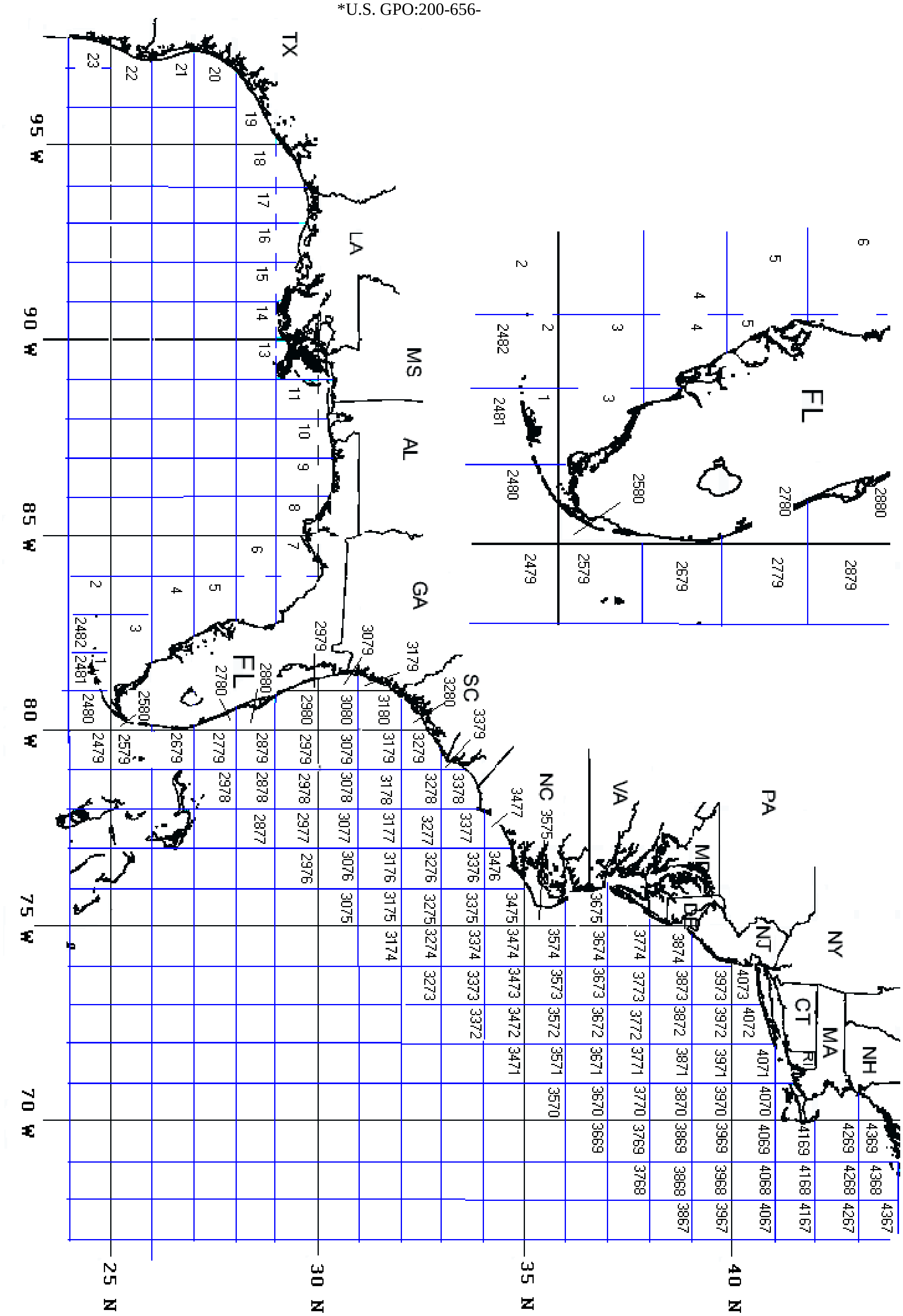
Southeast Region including Council and EEZ Boundaries



South Atlantic Council Boundaries, including contours, EEZ, and statistical area grid



*U.S. GPO:200-656-



140

Statistical Grids and Codes

5. Summary Report

The Summary Report provides a broad but concise view of the salient aspects of the stock assessment. It recapitulates: (a) the information available to and prepared by the Data Workshop (DW); (b) the application of those data, development and execution of one or more assessment models, and identification of the most reliable model configuration as the base run by the Assessment Workshop (AW); and (c) the findings and advice determined during the Review Workshop (RW). All contents of the Summary Report are also elsewhere in the Stock Assessment Report (SAR), including the post-RW Addendum (SAR Section VI).

It is important to note that although a functional base run was put forward by the AW, the RW did not regard the base model as appropriate for addressing biomass benchmarks or computing projections.

5.1. Stock Distribution and Identification

Spanish mackerel are distributed throughout the US Atlantic coast and Gulf of Mexico. The majority of the population exists in Florida waters, and they are targeted by both the recreational and commercial fishing sectors throughout their range. The management unit for the Atlantic migratory group of Spanish mackerel extends from a line directly east from the Miami-Dade/Monroe County, FL, boundary to the outer limit of the EEZ, to the South Atlantic/Mid-Atlantic Councils boundary at the NC-VA state boundary. The boundary was accepted as a practical unit boundary for this assessment, because both recreational and commercial catch data collection efforts for the Gulf and Atlantic have used this boundary. Use of this boundary maintains consistency with Amendment 2 of the Fishery Management Plan for the Coastal Migratory Pelagic Resources.

5.2. Status of the Stock and Fishery

Based on the 2003 Stock Assessment on Spanish and King Mackerel Stocks by the Mackerel Stock Assessment Panel, the stock exploitation status was Not Overfishing. The stock biomass status was Not Overfished.

The SEDAR 17 Review Panel did not accept the base assessment model of the current assessment as appropriate for making biomass determinations. It did concluded, though, from trends in fishery-dependent data that there is an increasing biomass trend, however the last four years have seen a decline. The panel noted that current fishing mortality does not seem to be inhibiting stock growth.

By the current catch at age model base run, the stock exploitation status in 2007 was estimated by the Assessment Workshop to be:

$$F_{2007}/F_{MSY} = 0.872,$$

which indicates that overfishing did not occur in 2007. See Addendum Table 1.16 in **Status Determination Criteria** below.

The SEDAR 17 Review Panel determined:

- The stock assessment as presented by the Assessment Workshop was partially accepted.
- It was concluded that overfishing is not occurring.
- No annual estimates of fishing mortality were accepted due to model uncertainty.
- Stock projections were not accepted due to model uncertainty.
- Overfished status could not be determined from the assessment due to model uncertainty/sensitivity.

5.3. Assessment Methods

Three different model structures were applied: a statistical catch-at-age model (SCA), a stochastic stock reduction analysis, and a surplus production model. A catch curve analysis was performed to provide independent estimates of mortality. The primary model was a statistical catch-at-age model implemented with the AD Model Builder software. The stochastic stock reduction analysis was employed to provide results using an assessment model of intermediate complexity between the fully age-structured catch-at-age model and fully age-aggregated surplus production model. A logistic surplus production model, implemented in ASPIC was used to estimate stock status. While primary assessment of the stock was performed via the age-structured model, the surplus production approach was intended as a complement and for additional verification that the age-structured approach was providing reasonable results.

After considering the results of several requested sensitivity runs, the Review Panel concluded that the SCA model was not adequate to fully address all Assessment Workshop Terms of Reference. The RP concluded that the SCA model could only be used to determine the over-fishing status, but not annual estimates of F, biomass, or if the stock is overfished. The rationale for this conclusion was based on the degree of uncertainty in the input data, (i.e. historic recreational catch and by-catch in shrimp fisheries), sensitivity to model assumptions (e.g. uncertainty about how to weight different sources of information), and lack of fishery-independent indices of adult population size. The panel also concluded, in agreement with the Assessment Panel, that neither the ASPIC model nor the stock reduction model was adequate or appropriate as a standalone stock assessment model.

5.4 . Assessment Data Sources

The catch-at-age model was fit to data from the sources shown in Table 1 through Table 3.

Table 1. Fishery Dependent Assessment Data

Fishery, Index, or Survey	Period	Estimated Discards	Length Composition	Age Composition
Commercial gillnet	1950-2007	1986-2007	1984-2007	1988-2007
Commercial poundnet	1950-2007	--	1982-2007	1992, 1995, 1998, 1999, 2001
Commercial castnet	1995-2007	--	1996, 1999-2007	1996, 2000, 2004-2006
Commercial handlines*	1958-2007	1986-2007	1986-1987, 1990-2006	1989, 1990, 1992, 1995-2002, 2006, 2007
Commercial trawl bycatch	1998-2004, 2006	1950-2007	--	--
MRFS survey	1981-2007	1950-2007	1981-2007	1988-2007
Pre-MRFSS surveys 1960, 1965, 1970	1950-1980		--	--
Headboat survey	1981-2007	1981-2007	--	--
Combined abundance index	See Table 2	See Table 2	--	--

* Commercial handlines include: hook and line, trolling, and electric reels

Table 2. Data Sources Contributing to the Combined Fishery Dependent Abundance Index

Data Source	Form	Period
Florida gillnet preceding the net ban	trip tickets	1985-1994
Florida gillnet after the net ban	trip tickets	1996-2007
Florida cast net	trip tickets	1999-2007
Florida handlines	trip tickets	1985-2007
MRFSS CPUE	survey	1987-2007
Gillnet north of Florida	logbook	1998-2007
Handline north of Florida	logbook	1998-2007

Table 3. Fishery Independent Assessment Data

Survey	Index	Period
SEAMAP Summer trawl	Age zero recruitment	1989-2007
SEAMAP Spring trawl	Age one recruitment	1990-2007

The DW provided information on gear types, discards, and size and age compositions. Appropriate estimates of natural mortality, maturation, and growth rates were also provided by the Data Workshop (DW).

Following the AW a correction in species composition was made involving data used from the three pre-MRFSS recreational angler surveys, resulting in modification to the assessment base run and issuance of an assessment addendum (SAR Section VI). Results of the amended base run were made available during the RW.

The RW concluded the catch data were appropriate for the assessment; however, not all data were adequate. In particular, by-catch statistics from shrimp fisheries were not available for most years, and only three estimates of recreational catch were available for the 31 year period, 1950-1980. The missing catch information was inferred, contributing a major source of uncertainty.

5.5. Catch Trends

Figure 3.8 of the Data Workshop Report depicts landings by commercial gear during 1950-2007.

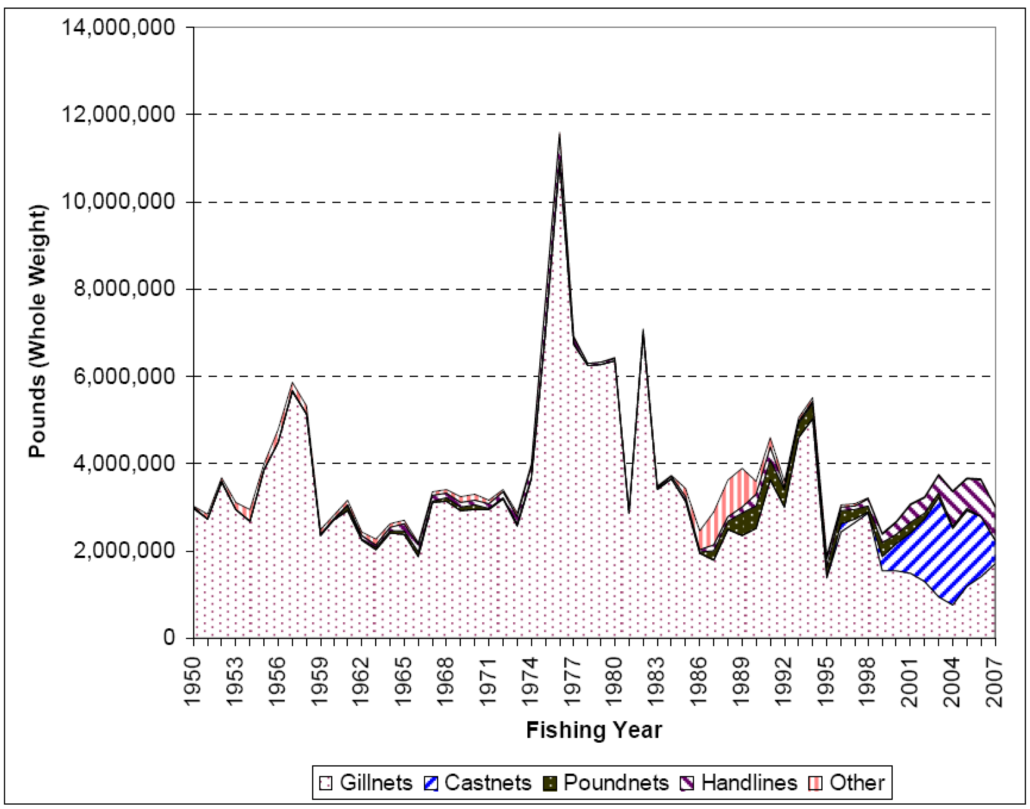


Figure 3.8. Spanish mackerel landings in pounds (whole weight) by gear from the US Atlantic coast, 1950-2007. (see text for data sources by state and temporal duration).

Addendum Table 1.14 presents estimated annual commercial landings by gear and estimated recreational landings during 1950 through 2007. Gillnet landings (L.GN) includes landings reported as by "other" commercial gear.

Table 1.14. Spanish mackerel: Estimated time series of landings (1000 lb) for commercial handlinse (L.HL), commercial gillnet (L.GN), commercial poundnet (L.PN), commercial castnet (L.CN), and general recreational (L.rec).

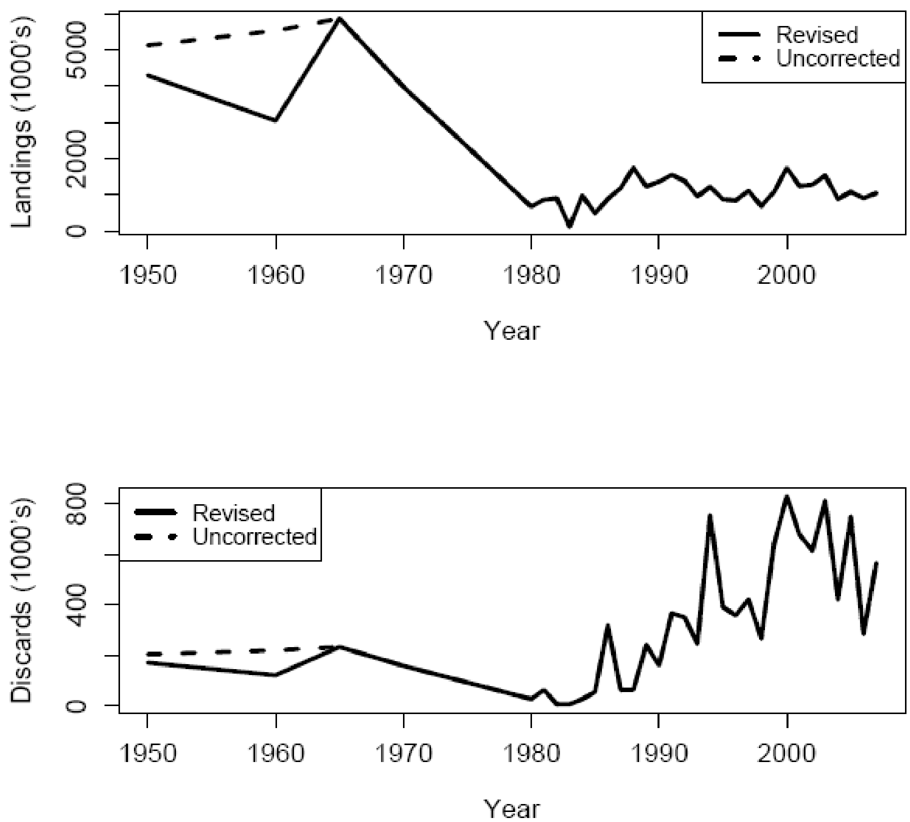
Year	L.HL	L.GN	L.PN	L.CN	L.rec	Total
1950	.	3008.00	13.00	.	5938.14	8959.14
1951	.	2837.00	6.00	.	6468.83	9311.83
1952	.	3674.00	3.00	.	6004.60	9681.60
1953	.	3115.00	1.00	.	5618.95	8734.95
1954	.	2940.00	4.00	.	5667.33	8611.33
1955	.	4004.00	6.00	.	5317.59	9327.59
1956	.	4765.00	16.00	.	5023.19	9804.19
1957	.	5861.00	15.00	.	4576.22	10452.22
1958	10.00	5297.00	6.00	.	4447.52	9760.52
1959	9.00	2471.00	17.00	.	3960.70	6457.70
1960	25.00	2774.00	21.00	.	4011.91	6831.91
1961	20.00	3017.00	122.00	.	5043.21	8202.21
1962	76.00	2349.00	14.00	.	5126.56	7565.56
1963	54.00	2160.00	65.00	.	6209.67	8488.67
1964	103.00	2478.00	32.00	.	6482.72	9095.72
1965	153.00	2467.00	90.00	.	7196.01	9906.01
1966	173.00	1910.00	111.00	.	7175.43	9369.43
1967	142.00	3181.00	23.00	.	6248.68	9594.68
1968	123.00	3211.00	73.00	.	5738.50	9145.50
1969	103.00	3056.00	84.00	.	5539.40	8782.40
1970	127.00	3059.00	104.00	.	5253.39	8543.39
1971	119.00	3019.00	26.00	.	4456.86	7620.86
1972	134.00	3250.00	23.00	.	4575.80	7982.80
1973	162.00	2641.00	51.00	.	3862.86	6716.86
1974	283.00	3686.00	25.00	.	3378.53	7372.53
1975	623.00	7045.00	62.00	.	2986.27	10716.27
1976	582.00	10926.00	77.00	.	2354.13	13939.13
1977	125.00	6753.00	29.00	.	1919.49	8826.49
1978	44.00	6250.00	2.00	.	1400.58	7696.58
1979	50.00	6267.99	1.00	.	1055.70	7374.70
1980	50.00	6372.99	4.00	.	719.44	7146.43
1981	37.00	2868.00	2.00	.	1025.53	3932.53
1982	91.00	6981.00	11.00	.	965.60	8048.60
1983	30.00	3430.01	13.00	.	154.47	3627.48
1984	50.00	3674.01	14.00	.	1275.21	5013.22
1985	59.00	3348.98	33.00	.	502.91	3943.89
1986	56.00	2356.98	39.00	.	925.76	3377.74
1987	116.00	2528.88	235.00	.	1284.15	4164.02
1988	104.00	3327.57	183.00	.	2094.85	5709.41
1989	142.00	3245.82	505.00	.	1548.04	5440.85
1990	250.00	2845.20	509.01	.	1731.14	5335.35
1991	285.00	3853.67	468.01	.	1772.83	6379.51
1992	73.00	3131.23	397.00	.	1489.16	5090.39
1993	61.00	4656.38	328.00	.	1102.33	6147.71
1994	69.00	5106.01	345.00	.	1467.97	6987.97
1995	200.00	1449.03	207.00	34.00	1018.52	2908.55
1996	83.00	2470.05	302.00	197.00	1005.89	4057.93
1997	93.00	2709.68	208.00	76.00	1360.23	4446.90
1998	176.00	2898.95	118.00	33.00	988.06	4214.01
1999	202.00	1556.65	301.99	344.99	1341.59	3747.21
2000	277.99	1575.73	206.00	621.97	2170.36	4852.05
2001	419.00	1514.93	222.00	933.97	1484.32	4574.22
2002	362.01	1318.14	136.00	1420.09	1508.13	4744.37
2003	416.02	951.11	111.00	2270.50	1908.91	5657.53
2004	761.06	788.07	72.00	1745.34	1241.73	4608.20
2005	698.06	1209.15	50.00	1716.34	1467.22	5140.77
2006	839.09	1417.25	10.00	1380.25	1136.11	4782.71
2007	753.05	1705.17	14.00	549.04	1226.36	4247.62

Addendum Table 1.1 and the solid line in Addendum Figure 1.1 present estimates and trends of recreational landings and discards used in the catch-at-age assessment model. They incorporate a 0.75 multiplier on early USFWS and NMFS saltwater angler records to account for angler recall bias.

Table 1.1. Spanish mackerel: Estimates of recreational landings and discards used in the revised catch-age assessment model. All values are in 1000s and incorporate a 0.75 multiplier on early USFWS and NMFS saltwater angler records to account for recall bias.

Year	Rec Landings	Rec Discards
1950	4297	170
1951	4172	165
1952	4047	160
1953	3922	155
1954	3796	150
1955	3671	145
1956	3546	140
1957	3421	135
1958	3296	130
1959	3171	126
1960	3046	121
1961	3611	143
1962	4175	165
1963	4740	188
1964	5305	210
1965	5870	232
1966	5493	217
1967	5117	203
1968	4740	188
1969	4364	173
1970	3988	158
1971	3657	145
1972	3326	131
1973	2995	118
1974	2664	105
1975	2333	92
1976	2002	79
1977	1671	66
1978	1341	53
1979	1010	40
1980	679	26
1981	888	62
1982	904	7
1983	127	5
1984	971	26
1985	487	55
1986	889	318
1987	1185	62
1988	1744	64
1989	1227	240
1990	1359	161
1991	1548	365
1992	1382	350
1993	955	245
1994	1220	752
1995	876	391
1996	841	357
1997	1113	420
1998	688	267
1999	1087	641
2000	1737	827
2001	1243	676
2002	1280	614
2003	1532	812
2004	883	420
2005	1088	748
2006	907	283
2007	1051	565

Figure 1.1. Spanish mackerel: A comparison of revised recreational landings and discards to those originally proposed by the SEDAR 17 DW. The former correct for king mackerel landings that were grouped together with Spanish mackerel landings in a 1960 USFWS saltwater angling report.



Modified Data Workshop Table 4.8.2 shows total weight of Spanish mackerel taken by headboats during 1981 through 2007.

Table 4.8.2 (modified). *Total weight (pounds) of Spanish mackerel caught aboard headboats for fishing years 1981-2007 (March-February) in south Atlantic states.*

Year	Grand Total
1981	73805
1982	14362
1983	4040
1984	2160
1985	2048
1986	9037
1987	4150
1988	932
1989	1474
1990	1915
1991	3948
1992	2199
1993	1428
1994	6472
1995	1571
1996	1937
1997	4131
1998	6290
1999	9312
2000	4025
2001	10963
2002	5603
2003	2620
2004	15728
2005	10897
2006	4575
2007	6432

5.6. Fishing Mortality Trends

The estimated time series of fishing mortality rate (F) shows a peak in the late 1970s and early 1980s when average fishing mortality rates were close to 1.0, with a secondary peak in the early 1990s (Addendum Table 1.8 and Addendum Figure 1.29). Following implementation of the gillnet ban in Florida state waters in 1995, mortality rates of commercial and recreational fisheries declined. Since 2000, the model suggests that fishing mortality rates have been between 0.3 and 0.5.

Historically, the majority of the full F was dominated by gillnet and recreational fisheries, with a shift in the most recent years to include a larger percentage of mortality attributable to the commercial castnet and handlines fisheries.

Throughout most of the assessment period, estimated landings and discard mortalities in number of fish have been dominated by commercial gillnet and recreational sectors. Addendum Table 1.11 shows total landings at age in numbers. Total landings and discards by year and sector are presented in thousands of pounds for landings (Addendum Table 1.14 in **Catch Trends**) and in number for discards and shrimp bycatch (Addendum Table 1.15).

Table 1.8. Spanish mackerel: Estimated time series of fishing mortality rate for commercial handlines (F.HL), commercial gillnet (F.GN), commercial poundnet (F.PN), commercial castnet (F.CN), general recreational (F.rec),commercial handline discards(F.HL.D), commercial gillnet discards(F.GN.D), general recreational discards(F.rec.D), shrimp bycatch (F.shrimp), and full F (F.full).

Year	F.HL	F.GN	F.PN	F.CN	F.rec	F.HL.D	F.GN.D	F.rec.D	F.shrimp	F.full
1950	0.000	0.062	0.000	0.000	0.148	0	0.000	0.006	0.543	0.760
1951	0.000	0.058	0.000	0.000	0.186	0	0.000	0.005	0.354	0.604
1952	0.000	0.084	0.000	0.000	0.182	0	0.000	0.005	0.266	0.537
1953	0.000	0.077	0.000	0.000	0.174	0	0.000	0.005	0.529	0.785
1954	0.000	0.076	0.000	0.000	0.194	0	0.000	0.005	0.433	0.708
1955	0.000	0.115	0.000	0.000	0.196	0	0.000	0.005	0.451	0.767
1956	0.000	0.153	0.000	0.000	0.202	0	0.000	0.005	0.307	0.667
1957	0.000	0.215	0.000	0.000	0.194	0	0.000	0.005	0.493	0.907
1958	0.000	0.217	0.000	0.000	0.214	0	0.000	0.005	0.144	0.580
1959	0.000	0.107	0.000	0.000	0.179	0	0.000	0.005	0.361	0.652
1960	0.001	0.112	0.001	0.000	0.183	0	0.000	0.005	0.660	0.962
1961	0.001	0.124	0.004	0.000	0.262	0	0.000	0.005	0.035	0.431
1962	0.003	0.105	0.000	0.000	0.234	0	0.000	0.006	0.377	0.726
1963	0.002	0.093	0.002	0.000	0.301	0	0.000	0.007	0.035	0.440
1964	0.004	0.110	0.001	0.000	0.294	0	0.000	0.007	0.035	0.451
1965	0.006	0.107	0.003	0.000	0.313	0	0.000	0.009	0.364	0.801
1966	0.007	0.082	0.003	0.000	0.349	0	0.000	0.008	0.059	0.508
1967	0.006	0.145	0.001	0.000	0.291	0	0.000	0.007	0.035	0.485
1968	0.005	0.144	0.002	0.000	0.254	0	0.000	0.007	0.246	0.659
1969	0.004	0.131	0.002	0.000	0.256	0	0.000	0.007	0.439	0.840
1970	0.005	0.134	0.003	0.000	0.267	0	0.000	0.006	0.042	0.457
1971	0.005	0.137	0.001	0.000	0.204	0	0.000	0.006	0.682	1.036
1972	0.006	0.142	0.001	0.000	0.243	0	0.000	0.006	0.340	0.738
1973	0.007	0.125	0.002	0.000	0.206	0	0.000	0.005	0.292	0.636
1974	0.013	0.178	0.001	0.000	0.175	0	0.000	0.005	0.464	0.835
1975	0.032	0.374	0.002	0.000	0.174	0	0.000	0.004	0.338	0.924
1976	0.042	0.820	0.004	0.000	0.167	0	0.000	0.004	0.511	1.548
1977	0.013	0.704	0.002	0.000	0.182	0	0.000	0.004	0.055	0.959
1978	0.005	0.813	0.000	0.000	0.131	0	0.000	0.003	0.058	1.011
1979	0.006	0.823	0.000	0.000	0.098	0	0.000	0.002	0.121	1.051
1980	0.006	0.824	0.000	0.000	0.069	0	0.000	0.002	0.539	1.440
1981	0.004	0.326	0.000	0.000	0.109	0	0.000	0.004	0.059	0.501
1982	0.011	0.877	0.001	0.000	0.093	0	0.000	0.001	0.769	1.751
1983	0.004	0.413	0.001	0.000	0.018	0	0.000	0.001	1.068	1.505
1984	0.007	0.488	0.001	0.000	0.206	0	0.000	0.002	0.077	0.781
1985	0.010	0.591	0.003	0.000	0.066	0	0.000	0.003	0.536	1.209
1986	0.007	0.329	0.003	0.000	0.092	0	0.001	0.015	0.365	0.813
1987	0.011	0.253	0.013	0.000	0.101	0	0.001	0.004	0.367	0.749
1988	0.008	0.267	0.010	0.000	0.167	0	0.001	0.004	0.548	1.005
1989	0.011	0.261	0.028	0.000	0.138	0	0.000	0.015	0.899	1.352
1990	0.022	0.252	0.031	0.000	0.174	0	0.001	0.008	0.725	1.213
1991	0.029	0.408	0.030	0.000	0.177	0	0.001	0.015	0.580	1.240
1992	0.008	0.339	0.023	0.000	0.125	0	0.001	0.018	0.507	1.020
1993	0.006	0.439	0.019	0.000	0.093	0	0.002	0.018	0.242	0.819
1994	0.007	0.505	0.022	0.000	0.146	0	0.002	0.055	0.062	0.799
1995	0.019	0.131	0.013	0.003	0.097	0	0.000	0.021	0.550	0.835
1996	0.007	0.201	0.017	0.017	0.086	0	0.001	0.022	0.043	0.393
1997	0.007	0.206	0.011	0.006	0.106	0	0.002	0.040	0.503	0.881
1998	0.013	0.235	0.007	0.002	0.096	0	0.001	0.020	0.038	0.412
1999	0.016	0.137	0.016	0.028	0.116	0	0.001	0.036	0.516	0.866
2000	0.021	0.133	0.011	0.048	0.181	0	0.001	0.041	0.405	0.841
2001	0.032	0.121	0.011	0.072	0.113	0	0.001	0.033	0.092	0.474
2002	0.025	0.090	0.006	0.097	0.099	0	0.001	0.033	0.020	0.372
2003	0.025	0.058	0.005	0.136	0.122	0	0.001	0.069	0.048	0.465
2004	0.045	0.050	0.003	0.100	0.093	0	0.001	0.035	0.014	0.341
2005	0.045	0.088	0.002	0.111	0.116	0	0.001	0.049	0.039	0.451
2006	0.058	0.108	0.000	0.096	0.085	0	0.000	0.013	0.007	0.369
2007	0.048	0.112	0.001	0.036	0.075	0	0.000	0.025	0.027	0.323
2008	.	.	.	.	.	.	.	.	.	.

Figure 1.29. Spanish mackerel: Estimated instantaneous fishing mortality rate (per year) by fishery. HL refers to commercial handlines, GN to commerical gillnets, PN to commercial poundnets, CN to commercial castnets, MRFSS to general recreational, HL.D to commercial handline discard mortalities, GN.D to commercial gillnet discards, MRFSS.D to recreational discards, and shrimp.B to bycatch in the shrimp fishery.

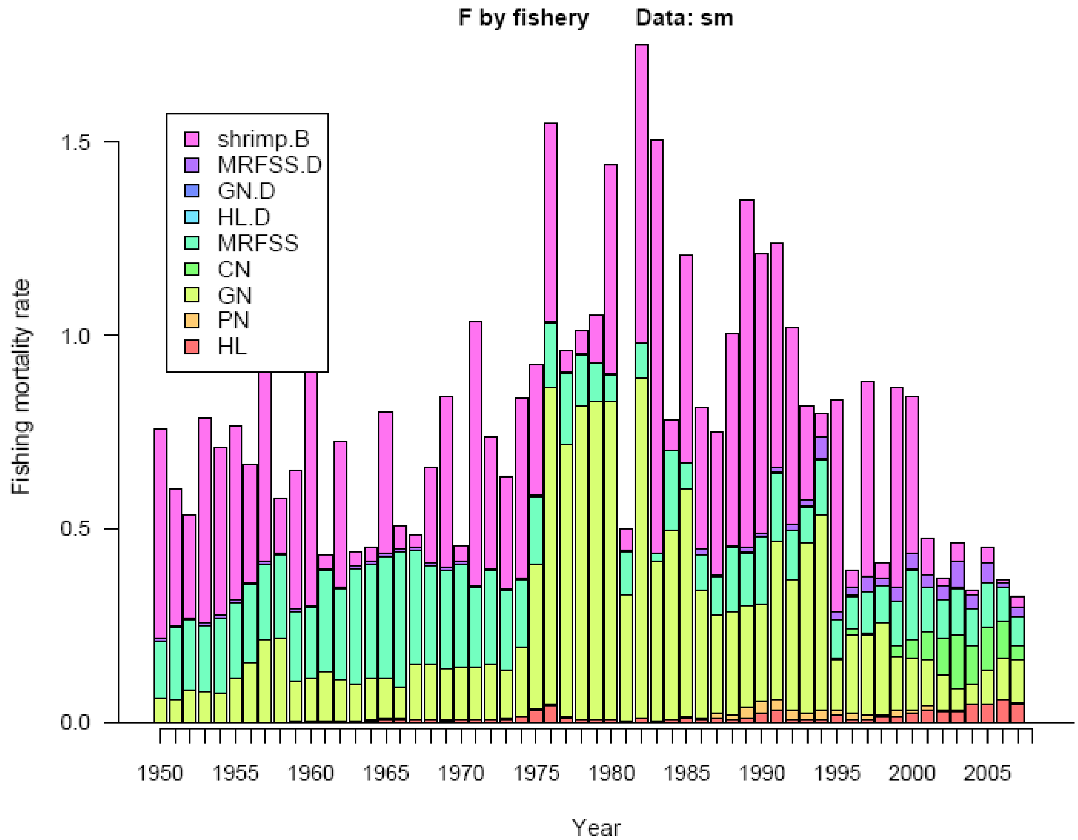


Table 1.11. Spanish mackerel: Estimated total landings at age (1000 fish)

Year	0	1	2	3	4	5	6	7	8	9	10+
1950	99.7	2387.1	1396.3	747.7	445.8	269.0	163.9	100.4	61.5	37.9	61.5
1951	139.0	1679.9	1489.7	865.6	522.0	314.8	191.8	117.5	72.0	44.3	71.9
1952	142.1	2146.8	914.7	910.4	617.5	376.9	229.5	140.6	86.1	53.0	86.1
1953	118.6	2192.4	1104.5	471.3	523.8	359.3	221.5	135.6	83.1	51.1	83.0
1954	133.7	1825.1	1273.1	642.1	307.1	345.2	239.1	148.2	90.7	55.8	90.6
1955	134.9	2020.7	1088.1	823.7	473.2	229.0	259.9	181.0	112.2	69.0	112.0
1956	148.3	2020.5	1321.8	693.7	569.2	330.4	161.5	184.3	128.3	79.9	129.6
1957	134.5	2252.7	1431.8	851.5	468.1	387.9	227.4	111.7	127.5	89.2	146.4
1958	159.8	1948.8	1657.4	793.0	469.6	260.5	218.0	128.5	63.1	72.4	134.5
1959	116.3	2131.9	885.2	559.6	269.7	161.2	90.3	76.0	44.8	22.1	72.8
1960	106.7	1768.0	1291.9	507.9	346.8	168.9	101.9	57.4	48.3	28.6	61.0
1961	208.3	1807.7	1323.8	882.1	372.8	257.2	126.5	76.8	43.2	36.5	68.1
1962	145.0	2914.3	808.0	589.2	437.2	186.8	130.2	64.4	39.1	22.1	53.8
1963	218.1	2587.8	1691.1	456.1	371.7	278.8	120.3	84.3	41.7	25.4	49.6
1964	211.4	3539.3	1178.9	859.4	272.0	224.3	169.9	73.7	51.7	25.7	46.4
1965	206.4	3793.8	1715.0	596.7	498.0	159.4	132.7	101.1	43.9	30.9	43.3
1966	255.3	2989.1	1723.2	808.2	324.8	274.3	88.7	74.2	56.5	24.6	41.9
1967	210.3	3468.8	1241.7	872.6	493.2	200.7	171.1	55.6	46.6	35.6	42.2
1968	181.5	3204.6	1614.3	574.4	445.9	254.7	104.7	89.7	29.2	24.5	41.2
1969	168.1	2635.0	1666.9	787.2	303.7	238.2	137.4	56.8	48.7	15.9	36.0
1970	207.8	2251.6	1417.1	874.3	454.0	177.0	140.2	81.3	33.6	28.9	31.0
1971	117.6	2606.2	1006.1	639.4	435.0	228.3	89.9	71.6	41.5	17.2	30.9
1972	153.2	1627.4	1725.3	591.5	398.0	273.5	145.0	57.4	45.7	26.6	31.1
1973	138.2	1926.5	789.4	788.6	291.9	198.4	137.7	73.4	29.1	23.3	29.5
1974	114.5	1814.0	1224.1	490.0	524.7	196.2	134.7	94.0	50.1	19.9	36.4
1975	145.0	1741.4	1977.5	1086.5	434.6	469.4	177.2	122.3	85.4	45.7	51.6
1976	155.6	2265.6	2523.4	1541.6	767.9	309.1	337.0	128.0	88.3	61.9	71.0
1977	140.7	1582.6	2299.2	790.0	394.4	197.3	80.2	87.9	33.4	23.1	35.0
1978	114.3	1818.7	1742.6	942.4	272.9	136.9	69.1	28.3	31.0	11.8	20.7
1979	99.0	1528.8	2336.7	648.4	284.1	82.6	41.8	21.2	8.7	9.6	10.1
1980	73.6	1251.4	2250.9	882.7	195.4	85.9	25.2	12.9	6.5	2.7	6.1
1981	67.4	697.5	1208.4	481.2	148.9	33.1	14.7	4.3	2.2	1.1	1.5
1982	74.3	1536.7	1551.7	1304.4	461.7	143.8	32.2	14.4	4.3	2.2	2.6
1983	23.5	271.0	1267.9	318.9	212.3	75.4	23.7	5.4	2.4	0.7	0.8
1984	93.7	572.7	958.4	970.9	198.8	133.0	47.7	15.1	3.4	1.5	1.0
1985	99.1	841.1	505.9	448.0	407.8	84.0	56.8	20.5	6.5	1.5	1.1
1986	94.9	939.2	991.4	162.1	117.4	107.4	22.4	15.2	5.5	1.7	0.7
1987	111.9	1199.0	1058.8	488.4	70.2	51.2	47.3	9.9	6.7	2.4	1.1
1988	111.3	1251.3	1454.2	678.0	284.8	41.2	30.4	28.2	5.9	4.0	2.1
1989	185.9	967.1	1018.7	774.4	342.8	145.2	21.2	15.7	14.6	3.1	3.2
1990	262.2	997.1	892.1	577.9	411.3	183.5	78.5	11.5	8.5	8.0	3.5
1991	339.9	1496.1	967.5	606.1	376.2	269.9	121.6	52.3	7.7	5.7	7.7
1992	196.0	1533.8	1051.8	367.7	208.5	130.4	94.5	42.8	18.4	2.7	4.8
1993	114.8	1091.2	1708.4	631.7	199.2	113.8	71.8	52.3	23.7	10.2	4.2
1994	151.5	1135.0	1612.3	997.0	316.9	100.5	58.0	36.8	26.8	12.2	7.5
1995	194.5	995.9	571.0	303.5	145.6	39.1	10.3	5.1	2.9	2.0	1.5
1996	208.3	1231.2	878.3	379.3	200.2	90.6	23.5	6.2	3.2	1.9	2.4
1997	109.8	1441.7	942.4	428.7	182.3	92.7	42.0	11.6	3.4	1.9	2.7
1998	176.8	624.3	1064.9	487.4	219.7	89.0	44.5	21.1	6.3	2.0	2.9
1999	208.3	1239.2	400.4	441.7	207.4	98.6	45.9	28.8	17.2	6.1	5.4
2000	240.7	1451.4	1031.4	233.6	270.8	130.3	66.5	34.5	23.8	15.2	10.7
2001	198.3	1348.6	845.1	464.0	113.2	132.5	66.6	36.5	20.2	14.5	16.3
2002	123.3	1319.7	1039.1	388.6	222.5	55.6	69.1	37.7	22.1	12.8	20.2
2003	61.6	1220.4	1345.3	560.7	222.7	132.9	35.6	47.9	27.6	16.8	25.8
2004	61.3	557.7	1009.4	583.4	259.2	104.1	63.7	17.6	24.2	14.2	22.3
2005	100.8	896.3	709.5	645.7	381.6	167.6	67.4	41.8	11.7	16.3	24.9
2006	134.7	988.0	840.3	351.8	328.1	192.2	85.3	35.3	22.5	6.4	23.0
2007	136.7	1328.4	844.8	334.7	136.9	123.3	71.1	32.0	13.5	8.8	11.7

Table 1.15. Spanish mackerel: Estimated time series of discard and bycatch mortalities (1000 fish) for commercial handlines (D.HL), gillnet (D.GN), general recreational (D.rec), and bycatch in the shrimp fishery (Bycatch).

Year	D.HL	D.GN	D.rec	Total D	Bycatch
1950	.	.	149.60	11122.00	11271.60
1951	.	.	145.20	8316.00	8461.20
1952	.	.	140.80	6343.00	6483.80
1953	.	.	136.40	11122.00	11258.40
1954	.	.	132.00	9231.00	9363.00
1955	.	.	127.60	9267.00	9394.60
1956	.	.	123.20	6448.00	6571.20
1957	.	.	118.80	9223.00	9341.80
1958	.	.	114.40	2969.00	3083.40
1959	.	.	110.88	6818.00	6928.88
1960	.	.	106.48	11122.00	11228.48
1961	.	.	125.84	752.00	877.84
1962	.	.	145.20	7003.00	7148.20
1963	.	.	165.44	752.00	917.44
1964	.	.	184.80	752.00	936.80
1965	.	.	204.16	6879.00	7083.16
1966	.	.	190.96	1241.00	1431.96
1967	.	.	178.64	752.00	930.64
1968	.	.	165.44	4850.00	5015.44
1969	.	.	152.24	7951.00	8103.24
1970	.	.	139.04	872.00	1011.04
1971	.	.	127.60	11122.00	11249.60
1972	.	.	115.28	6184.00	6299.28
1973	.	.	103.84	5360.00	5463.84
1974	.	.	92.40	7924.00	8016.40
1975	.	.	80.96	5749.00	5829.96
1976	.	.	69.52	6895.00	6964.52
1977	.	.	58.08	752.00	810.08
1978	.	.	46.64	752.00	798.64
1979	.	.	35.20	1515.00	1550.20
1980	.	.	22.88	5614.03	5636.91
1981	.	.	54.56	752.00	806.56
1982	.	.	6.16	6863.00	6869.16
1983	.	.	4.40	7430.00	7434.40
1984	.	.	22.88	752.00	774.88
1985	.	.	48.40	8149.00	8197.40
1986	0.35	12	279.84	6101.99	6394.19
1987	0.70	12	54.56	4605.98	4673.24
1988	0.88	14	56.32	6205.03	6276.23
1989	1.23	7	211.20	11120.84	11340.27
1990	1.94	12	141.68	11099.03	11254.65
1991	2.55	14	321.20	11126.85	11464.61
1992	0.44	14	308.00	7387.60	7710.04
1993	0.62	23	215.60	2376.81	2616.03
1994	0.44	26	661.75	631.00	1319.19
1995	2.90	8	344.08	7983.06	8338.05
1996	0.18	15	314.16	510.99	840.32
1997	0.70	18	369.57	3379.44	3767.72
1998	3.52	9	234.95	416.98	664.45
1999	3.08	14	564.05	7000.72	7581.85
2000	3.26	10	727.75	6341.01	7082.02
2001	3.43	11	594.91	1416.20	2025.54
2002	3.96	12	540.35	266.01	822.31
2003	3.52	9	714.59	363.00	1090.12
2004	2.38	7	369.60	130.00	508.98
2005	2.29	8	658.28	451.02	1119.58
2006	2.64	7	249.04	116.00	374.68
2007	2.73	6	497.20	451.00	956.93

5.7. Stock Abundance and Biomass Trends

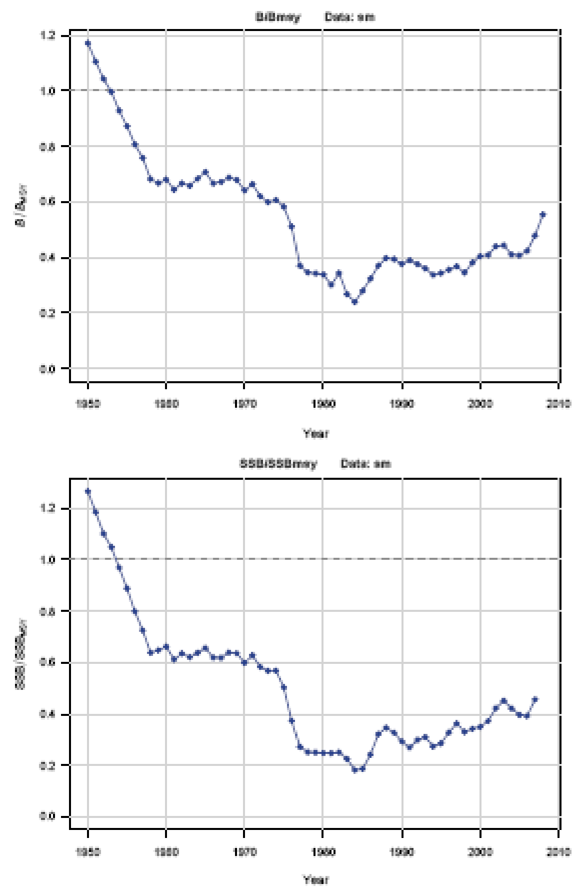
Estimated abundance at age shows truncation of the oldest ages during the 1970s through the mid 1980s (Addendum Table 1.2); however, the stock appears to have rebounded to numbers last seen in the early-mid 1970s. Annual numbers of recruits is shown in the age-0 column of Addendum Table 1.2. Recruitment in recent years was estimated to be below average.

Table 1.2. Spanish mackerel: Estimated abundance at age (1000 fish) at start of year

Year	0	1	2	3	4	5	6	7	8	9	10+
1950	33137.7	19899.0	11949.3	6825.5	4017.5	2412.5	1463.3	896.4	549.2	336.4	546.1
1951	35079.8	11555.8	11259.2	7181.8	4278.3	2567.8	1557.4	954.1	584.5	358.1	581.2
1952	34332.0	14761.0	6304.9	6624.0	4435.6	2694.4	1633.3	1000.6	613.0	375.5	609.6
1953	33812.1	15790.4	8054.2	3643.1	3997.4	2728.9	1674.3	1025.2	628.0	384.7	624.5
1954	32964.7	11949.4	8697.8	4706.5	2223.1	2486.9	1714.8	1062.7	650.7	398.6	647.0
1955	32006.0	12820.7	6449.7	5016.6	2844.2	1369.7	1547.6	1077.8	667.9	409.0	663.8
1956	30798.1	12220.5	6870.4	3601.9	2915.4	1684.6	819.4	935.2	651.3	403.6	654.8
1957	29676.1	13581.6	6474.4	3703.6	2008.0	1655.9	966.5	474.8	541.9	377.4	619.4
1958	28154.0	10860.6	7189.0	3338.2	1950.0	1076.6	896.7	528.6	259.7	296.4	550.7
1959	28332.4	14603.8	5632.7	3651.7	1736.5	1032.9	576.0	484.6	285.7	140.3	462.4
1960	28600.5	11851.9	7962.7	3198.9	2155.5	1044.8	627.7	353.5	297.4	175.3	373.6
1961	27635.1	8860.2	6430.9	4488.9	1873.5	1286.7	629.9	382.2	215.3	181.1	337.7
1962	28089.4	15935.9	4421.6	3396.0	2488.0	1058.2	734.0	363.0	220.3	124.1	301.9
1963	27806.3	11526.6	8216.2	2418.4	1947.2	1454.0	624.6	437.6	216.4	131.3	256.5
1964	28137.9	16008.0	5562.0	4339.0	1356.3	1113.1	839.6	364.3	255.2	126.2	228.5
1965	28484.6	16206.9	7766.4	2909.5	2399.2	764.3	633.6	482.7	209.4	146.7	206.0
1966	27783.7	11775.0	7691.2	4006.4	1591.9	1337.9	430.5	360.4	274.6	119.1	202.7
1967	27772.0	15574.1	5407.0	3947.4	2203.1	892.4	757.5	246.2	206.1	157.0	185.9
1968	28162.7	15989.5	7536.2	2750.5	2107.4	1198.3	490.2	420.3	136.6	114.4	192.2
1969	28102.7	13141.9	8019.6	3928.3	1496.2	1168.1	670.9	277.2	237.7	77.2	175.1
1970	27377.5	10807.3	6590.1	4221.9	2164.5	840.1	662.4	384.3	158.8	136.1	146.0
1971	27945.0	15681.1	5355.1	3430.7	2302.8	1203.1	471.6	375.6	217.9	90.0	161.6
1972	27050.8	8453.6	8293.1	2906.6	1930.3	1320.3	696.6	275.8	219.7	127.4	148.6
1973	26725.9	11515.8	4295.2	4364.6	1594.0	1078.6	745.1	397.1	157.2	125.2	159.0
1974	26745.8	11957.9	6083.7	2345.6	2476.4	921.7	629.9	439.5	234.2	92.8	169.3
1975	25248.5	10087.9	6466.4	3235.7	1275.9	1372.0	515.7	356.0	248.4	132.4	149.6
1976	21597.7	10783.6	5288.2	2890.2	1421.4	569.8	618.8	234.9	162.2	113.2	129.7
1977	17862.8	7738.4	5332.3	1642.5	809.2	403.0	163.1	178.9	67.9	46.9	70.9
1978	16994.2	10109.6	3861.5	1849.2	528.4	263.9	132.7	54.3	59.5	22.6	39.6
1979	16922.7	9612.2	5243.8	1278.0	552.5	159.9	80.7	41.0	16.8	18.4	19.4
1980	16800.8	9004.7	5146.6	1758.8	384.1	168.2	49.2	25.1	12.7	5.2	11.8
1981	16779.9	5890.1	4966.5	1759.8	536.4	118.7	52.5	15.5	7.9	4.0	5.4
1982	15813.2	9510.7	3342.6	2471.2	863.2	267.7	59.8	26.7	7.9	4.0	4.9
1983	13799.2	4407.3	5076.9	1072.1	702.7	248.5	77.8	17.6	7.8	2.3	2.6
1984	12981.0	2864.5	2705.7	2499.6	504.7	336.3	120.1	38.0	8.6	3.8	2.4
1985	24497.4	7207.7	1440.7	1104.1	990.7	203.2	136.7	49.3	15.6	3.5	2.6
1986	25176.8	8609.8	4102.0	591.4	422.1	384.3	79.6	54.1	19.5	6.2	2.4
1987	18870.0	10376.6	4927.6	2046.4	289.8	210.4	193.5	40.5	27.5	9.9	4.4
1988	18392.2	7824.2	5911.1	2565.9	1062.6	153.2	112.3	104.3	21.8	14.8	7.8
1989	23258.5	6353.2	4178.5	2928.2	1278.1	538.7	78.4	58.1	53.9	11.3	11.8
1990	26847.5	5571.4	3417.4	2077.5	1458.0	647.7	275.7	40.5	30.0	27.9	12.1
1991	31793.0	7685.3	2886.2	1651.2	1010.9	722.1	324.0	139.3	20.5	15.2	20.4
1992	23420.1	10436.0	3874.7	1221.8	683.1	425.1	306.6	139.0	59.7	8.8	15.4
1993	14079.8	8285.5	5650.3	1839.5	571.6	325.1	204.3	148.9	67.5	29.0	11.9
1994	13840.7	6493.9	4584.3	2541.3	796.6	251.6	144.5	91.7	66.8	30.3	18.5
1995	23794.7	7345.4	3318.2	1879.9	999.1	318.1	101.5	58.9	37.4	27.2	20.1
1996	15774.7	8044.9	4038.5	1843.9	1096.8	609.2	202.3	67.1	39.7	25.5	32.8
1997	10912.9	8802.3	4308.4	2094.3	1007.9	634.7	374.0	131.2	44.9	27.0	40.3
1998	14441.7	3776.0	4602.1	2229.9	1146.5	584.7	391.0	243.7	88.2	30.6	46.9
1999	22071.4	8129.5	1987.5	2334.4	1195.0	654.7	357.2	254.4	164.2	60.5	54.4
2000	24397.4	7583.7	4333.3	1056.6	1308.0	700.6	400.9	227.8	165.6	108.1	76.9
2001	20757.6	9325.0	3801.0	2174.7	564.1	730.0	407.9	242.9	140.8	103.5	117.4
2002	17209.6	10954.0	5033.8	1956.1	1174.9	317.8	427.8	248.1	150.4	88.1	140.3
2003	10149.0	9793.3	6122.3	2655.9	1080.7	673.1	188.0	260.8	153.3	93.6	144.1
2004	11908.4	5422.2	5361.7	3163.8	1439.8	604.0	385.4	110.1	154.1	91.0	143.0
2005	15200.6	6826.9	3105.0	2908.4	1785.4	836.2	358.6	233.8	67.3	94.6	145.4
2006	20709.9	8356.8	3733.0	1582.3	1550.3	986.3	476.7	210.6	139.1	40.3	145.8
2007	21886.1	12194.9	4724.1	1912.7	843.0	859.2	566.9	283.5	127.3	84.8	115.3
2008	24166.8	12501.0	6953.6	2599.0	1094.3	502.1	531.3	363.1	184.7	83.7	133.5

Estimated biomass at age follows a similar pattern of truncation as did abundance. Total biomass and spawning biomass show nearly identical trends---sharp decline immediately following model initialization, with another decline in the 1970s and early 1980's ostensibly due to a high volume of landings in the commercial gillnet fishery. The stock was estimated to be at it's lowest point in the early-mid 1980s, and since has added substantial biomass (Addendum Figure 1.41). In light of the RW findings, conclusions about biomass benchmarks are largely uncertain, and point estimates should be viewed with extreme caution.

Figure 1.41. Spanish mackerel: Estimated time series of biomass relative to MSY *benchmarks. Top panel – B relative to B_{MSY}. Bottom panel –* SSB *relative to* $\mathrm{SSB}_{\mathrm{MSY}}$.



5.8. Status Determination Criteria

The maximum fishing mortality threshold (MFMT) is defined by the South Atlantic Fishery Management Council as F_{MSY}, and the minimum stock size threshold (MSST) as (1 − M) X SSB_{MSY} with constant M defined here as 0.35. SSB refers to Spawning Stock Biomass, and SSB_{MSY} is the level of SSB when the fishery is operating at maximum sustainable yield.

With F representing total fishing mortality, overfishing is defined as occurring whenever F > MFMT, and a stock is overfished when SSB < MSST. Current status of the stock and fishery are represented by the latest assessment year (2007).

In addition to the MSY-related benchmarks, proxies were computed based on per recruit analyses. These proxies include F_{max}, $F_{30\%}$, and $F_{40\%}$, along with their associated yields. The value of F_{max} is defined as the F that maximizes yield per recruit; the values of $F_{30\%}$ and $F4_{0\%}$ as those Fs corresponding to 30 % and 40 % spawning potential ratio (i.e., spawners per recruit relative to that at the unfished level). These quantities may serve as proxies for F_{MSY}, if the spawner-recruit relationship cannot be estimated reliably.

SFA and management criteria recommendations and values as determined by the model base run are shown in Addendum Table 1.16. The Review Panel did not accept the base assessment model as appropriate for making biomass determinations and did not accept estimates of stock abundance, biomass, and exploitation rates, due to concerns about robustness of the assessment to uncertainty in inputs and model assumptions. Conclusions about biomass benchmarks are largely uncertain and should be viewed with extreme caution.

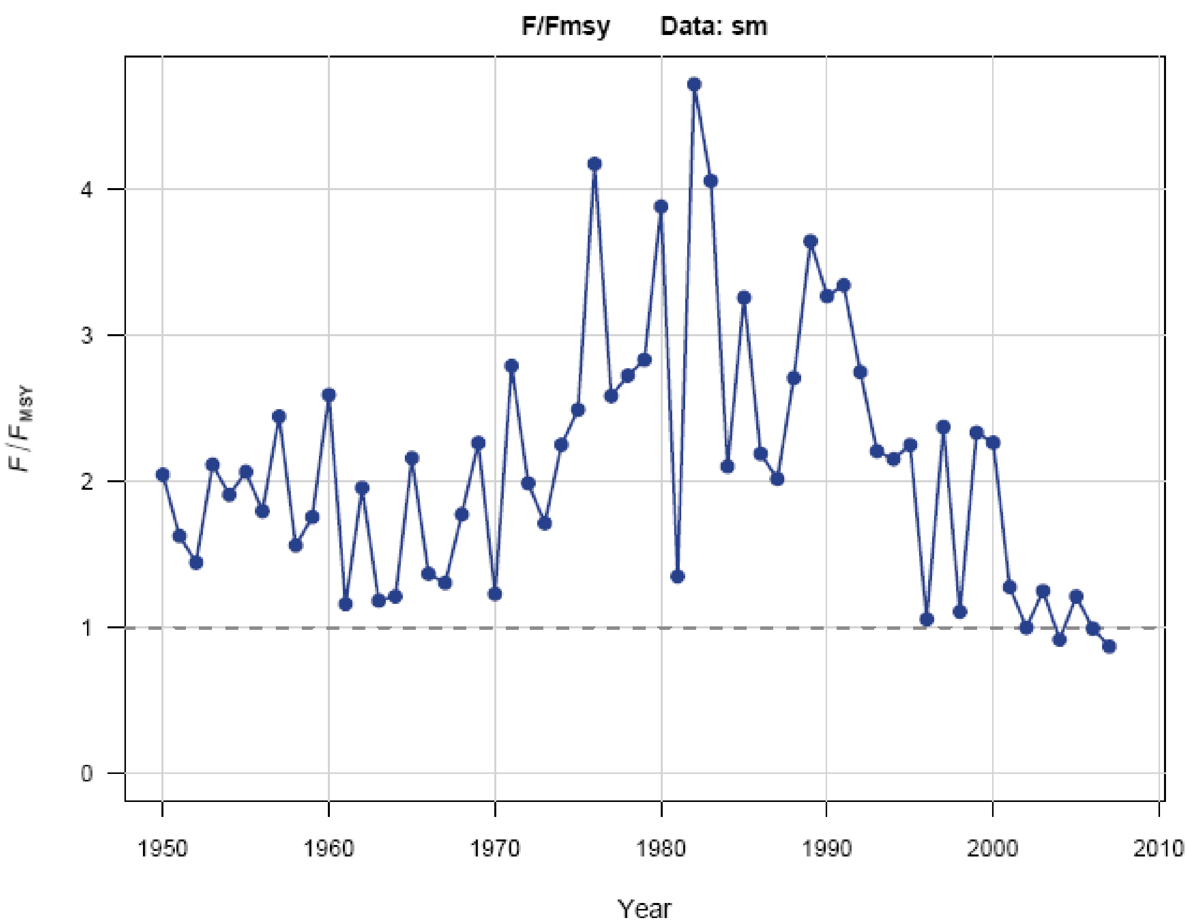
Table 1.16. Spanish mackerel: Revised base run: Estimated status indicators, benchmarks, and related quantities from the catch-at-age model, conditional on estimated current selectivities averaged across fisheries. Precision is represented by 10^{th} and 90^{th} percentiles from bootstrap analysis of the spawner-recruit curve. Estimates of yield do not include discards and shrimp bycatch; D_{MSY} represents discard and bycatch mortalities expected when fishing at F_{MSY}. Rate estimates (F) are in units of per year; status indicators are dimensionless; and biomass estimates are in units of mt or pounds, as indicated. Symbols, abbreviations, and acronyms are listed in Appendix A.

Quantity	Units	Estimate	10^{th} Percentile	90^{th} Percentile
F_{MSY}	y^{-1}	0.371	0.306	0.451
$85\%F_{MSY}$	y^{-1}	0.315	–	–
$75\%F_{MSY}$	y^{-1}	0.278	–	–
$65\%F_{MSY}$	y^{-1}	0.241	–	–
$F_{30\%}$	y^{-1}	0.54	–	–
$F_{40\%}$	y^{-1}	0.38	–	–
F_{max}	y^{-1}	0.84	–	–
B_{MSY}	mt	33743	29016	64016
SSB_{MSY}	mt	12438	9132	21392
MSST	mt	8085	5936	13905
MSY	1000 lb	11461	10819	19665
D_{MSY}	1000 fish	1342	1118	1925
R_{MSY}	1000 fish	33311	26814	52341
Y at $85\%F_{MSY}$	1000 lb	11320	–	–
Y at $75\%F_{MSY}$	1000 lb	11051	–	–
Y at $65\%F_{MSY}$	1000 lb	10608	–	–
Y at $F_{30\%}$	1000 lb	10565	–	–
Y at $F_{40\%}$	1000 lb	11458	–	–
Y at F_{max}	1000 lb	6598	–	–
F_{2007}/F_{MSY}	–	0.872	0.718	1.055
SSB_{2007}/SSB_{MSY}	–	0.456	0.265	0.621
$SSB_{2007}/MSST$	–	0.701	0.408	0.955

The estimated time series of F/F_{msy} shows a generally increasing trend from the 1950s through the late 1970s/early 1980s, peaking at about five times F_{MSY}. This number has declined substantially in recent years, alternation between slight overfishing and no overfishing since 2000 (Addendum Figure 1.42).

The RP focused on analytical requests related to the sensitivity of the assessment model. The results of thirteen sensitivity runs show that, while the estimates of F_{2007}/F_{max} were sensitive, in no case was a different conclusion reached with respect to overfishing.

Figure 1.42. Spanish mackerel: Estimated time series of F relative to F_{MSY}.



5.9. Projections

Projections were run to predict stock status in years after the assessment, 2008 through 2027, and are reported in the Addendum for completeness, however, the RW did not regard the base model as appropriate for computing projections.

In order to examine the probability of rebuilding occurring within the requisite time frame, different values of F were considered that would yield 50%, 60%, 70%, 75%, 80% and 90% probabilities of successful rebuilding by 2019 (assuming a 10 year rebuilding period starting in

2009). For these analyses, the only source of uncertainty was variation in recruitment. Results are reported in the Addendum; however, the RW did not regard the base model as appropriate for computing projections.

5.10. Allowable Biological Catch (ABC) range

An ABC control rule was not available to the AW and RW, thus no ABC range was determined.

5.11. Uncertainty

The effects of uncertainty in model structure was examined by applying the three assessment models with quite different mechanistic structure. For each model, uncertainty in data or assumptions was examined through sensitivity runs. Precision of benchmarks was computed by parametric bootstrap.

Uncertainty in results of the base assessment model was evaluated through sensitivity and retrospective analyses. Plotted in the AW report are time series of F/Fmsy and SSB/SSBmsy for sensitivity to the method of shrimp bycatch extrapolation, influence of early recreational angling records, pre-assessment fishing mortality, differences in data sources from previous assessments, choice of index, autocorrelation in recruitment deviations, factorial combinations of shrimp bycatch and early recreational landings, magnitude of total removals, ending year of the assessment model, and natural mortality.

Retrospective analyses did not show any concerning trends, and in general, results of sensitivity analyses were similar to those in the base model run. In particular, most runs (19/23) indicated that the stock was overfished (two of the exceptions had steepness estimated at the upper bound). There was less agreement among sensitivity runs regarding overfishing status, with 16/23 runs indicating that overfishing was not occurring in the terminal year.

The RW concluded that methods to account for uncertainty were neither well developed nor adequate. Details are provided in the RW Consensus Report (SAR Section V, Chapter 2). It also recommended that managers specify exactly what measures of uncertainty they require and for which parameters or management variables.

5.12. Special Comments

In light of the uncertainty in the assessment results, the Review Panel suggests that the Spanish mackerel assessment be re-evaluated within a timeframe which allows for necessary management advice. The focus of the re-evaluation should be revised input data, principally catch estimates and fishery independent indices, as well as changes in the assessment method as suggested in the RW Consensus Report (SAR Section V, Chapter 2).

5.13. Sources of Information

All sources of Summary Report information are within the SEDAR 17 Spanish Mackerel Stock Assessment Report (SAR). Text is generally from the AW Report (SAR Section III), the RW Report (SAR Section V), and the Addendum (SAR Section VI). Sources of tables and figures are identified throughout the Summary Report.

6. SAIP Form (To be completed following the Review Workshop)

Stock Assessment Improvement Program
Assessment Summary Form

This form must be completed for each stock assessment once it has passed review or been rejected without anticipated revisions in the near future (<1 year). Please fill out all information to the best of your ability.

FMP Common Name   Spanish Mackerel
Stock   South Atlantic
Level of Input Data for
Abundance   1___________
0 = none; 1 = fishery CPUE or imprecise survey with size composition; 2 = precise, frequent survey with age composition; 3 = survey with estimates of q; 4 = habitat-specific survey
Catch   1,2,4________
0 = none; 1 = landed catch; 2 = catch size composition; 3 = spatial patterns (logbooks); 4 = catch age composition; 5 = total catch by sector (observers)
Life History   2___________
0 = none; 1 = size; 2 = basic demographic parameters; 3 = seasonal or spatial information (mixing, migration); 4 = food habits data

Assessment Details
Area   Atlantic
e.g., Gulf of Mexico, South Atlantic, Caribbean, Atlantic.
Level   3,4__________
0 = none; 1 = index only (commercial or research CPUE); 2 = simple life history equilibrium models; 3 = aggregated production models; 4 = size/age/stage-structured models; 5 = add ecosystem (multispecies, environment), spatial & seasonal analyses
Frequency   1___________
0 = never; 1 = infrequent; 2 = frequent or recent (2-3 years); 3 = annual or more
Year Reviewed   2008________
Last Year of Data   2007________
Used in the assessment
Source: SEDAR 17 Assessment workshop report, http://www.sefsc.noaa.gov/sedar
Citation
Review Result   Partially accepted
Accept, Reject, Remand, or Not reviewed
Assessment Type   Benchmark___
New, Benchmark, Update, or Carryover
Notes: Assessment new for Beaufort lab; modern statistical catch-age modeling with increased attention to historical data; many sources of uncertainty in fishery removals (early recreational landings, shrimp bycatch) made determination of benchmarks difficult and imparted a large amount of uncertainty. Review suggested that the modeling was sufficient to conclude overfishing was not occurring in 2007, but that point estimates and overfished status could not be determined.

Stock Status
F/F_{target} N/A_________
F/F_{limit} N/A_________
B/B_{MSY} N/A_________
B/B_{limit} N/A_________
Overfished?   N/A_________
Overfishing?   No overfishing

Basis for:
F_{target} e.g., F_{OY} ________________________________
F_{limit} e.g., F_{MSY} ________________________________
B_{MSY} ________________________________
B_{limit} e.g., MSST ________________________________

Next Scheduled Assessment
Year   Month

7. SEDAR Abbreviations

ABC	Allowable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
ADMB	AD Model Builder software program
ALS	Accumulated Landings System; SEFSC fisheries data collection program
ASMFC	Atlantic States Marine Fisheries Commission
B	stock biomass level
BAC	SAFMC SSC Bioassessment sub-Committee
B_{MSY}	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
GMFMC	Gulf of Mexico Fishery Management Council
F	fishing mortality (instantaneous)
FSAP	GMFMC Finfish Assessment Panel
F_{MSY}	fishing mortality to produce MSY under equilibrium conditions
F_{OY}	fishing mortality rate to produce Optimum Yield under equilibrium
F_{XX}% SPR	fishing mortality rate that will result in retaining XX% of the maximum spawning production under equilibrium conditions
F_{MAX}	fishing mortality that maximizes the average weight yield per fish recruited to the fishery
F_0,	a fishing mortality close to, but slightly less than, Fmax
FWRI	(State of) Florida Fisheries and Wildlife Research Institute
GLM	general linear model
GSMFC	Gulf States Marine Fisheries Commission
GULF FIN	GSMFC Fisheries Information Network
Lbar	mean length
M	natural mortality (instantaneous)
MFMT	maximum fishing mortality threshold, a value off 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
MSST	minimum stock size threshold, a value of B below which the stock is deemed to be overfished
MSY	maximum sustainable yield
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
OY	optimum yield
RVC	Reef Visual Census—a diver-operated survey of reef-fish numbers
SAFMC	South Atlantic Fishery Management Council
SAS	Statistical Analysis Software, SAS corporation.
SEDAR	Southeast Data, Assessment and Review
SEFSC	NOAA Fisheries Southeast Fisheries Science Center
SERO	NOAA Fisheries Southeast Regional Office
SFA	Sustainable Fisheries Act of 1996
SPR	spawning potential ratio, stock biomass relative to an unfished state of the stock

SEDAR Abbreviations – continued

SSB	Spawning Stock Biomass
SSC	Science and Statistics Committee
TIP	Trip Incident Program; biological data collection program of the SEFSC and Southeast States.
Z	total mortality, the sum of M and F

Section II. Data Workshop Report

Contents

1. Introduction

1.1 Workshop Time and Place

The SEDAR 17 Data Workshop was held May 19-23, 2008, in Charleston, SC.

1.2 Terms of Reference

1. Characterize stock structure and develop a unit stock definition. Provide a map of species and stock distribution.

2. Tabulate available life history information (e.g., age, growth, natural mortality, reproductive characteristics, discard mortality rates); provide appropriate models to describe growth, maturation, and fecundity by age, sex, or length as applicable. Evaluate the adequacy of available life-history information for conducting stock assessments and recommend life history information for use in population modeling.

3. Consider relevant fishery dependent and independent data sources to develop measures of population abundance. Document all programs used to develop indices; address program objectives, methods, coverage, sampling intensity, and other relevant characteristics. Provide maps of survey coverage. Develop values by appropriate strata (e.g., age, size, area, and fishery); provide measures of precision. Evaluate the degree to which available indices represent fishery and population conditions. Recommend which data sources should be considered in assessment modeling.

4. Characterize commercial and recreational catch, including both landings and discard removals, in pounds and number. Discuss the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector. Provide length and age distributions of the catch. Provide maps of fishery effort and harvest.

5. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Recommend sampling intensity by sector (fleet), area, and season.

6. Develop a spreadsheet of assessment model input data that incorporates the decisions and recommendations of the Data Workshop. Review and approve the contents of the input spreadsheet within 6 weeks prior to the Assessment Workshop.

7. Prepare complete documentation of workshop actions and decisions (Section II. of the SEDAR assessment report); prepare a list of tasks to be completed following the workshop, including deadlines and personnel assignments.

1.3 Participants

Appointee	Function	Affiliation
Coordination		
Dale Theiling	Chair and Chief Editor	SEDAR
Rachael Lindsay	Administrative Support	SEDAR
Data Management		
Rob Cheshire	Data Compiler	SEFSC
Commercial Statistics Workgroup		
Doug Vaughan	Leader and Editor	SEFSC
Kate Andrews	Data Provider and Rapporteur	SEFSC
Alan Bianchi	Data Provider	NC DMF
Steve Brown	Data Provider	FL FWC
Julie Califf	Data Provider	GA DNR
Jack Holland	Data Provider	NC DMF
Robert Wiggers	Data Provider	SC DNR
Geoff White	Data Provider	ACCSP
Dave Gloeckner	Data Provider	SEFSC/TIP
Kevin J. McCarthy	Data Provider	SEFSC/Logbooks
Recreational Statistics Workgroup		
Erik Williams	Leader, Rapporteur, and Editor	SEFSC
Doug Mumford	Data Provider	NC DMF
Robert Wiggers	Data Provider	SC DNR
Beverly Sauls	Data Provider	FL FWC
Tom Sminkey	Data Provider	MRFSS (MRIP)
Ken Brennan	Data Provider	SEFSC/Headboats
Life History Workgroup		
Jennifer Potts	Leader and Editor	SEFSC
Daniel Carr	Rapporteur	SEFSC
David Wyanski	Data Provider	SC DNR
Marcel Reichert	Data Provider	SC DNR
Doug DeVries	Data Provider	SEFSC
Chris Palmer	Data Provider	SEFSC
Stephanie McInerny	Data Provider	SEFSC
Indices Workgroup		
Kyle Shertzer	Leader and Editor	SEFSC
Helen Takade	Data Provider and Rapporteur	NC DMF
Rob Cheshire	Data Compiler	SEFSC
Elizabeth Wenner	Data Provider	SEAMAP
Pat Harris	Data Provider	MARMAP
Paul Conn	Data Provider	SEFSC
Geoff White	Data Provider	ACCSP
Kate Andrews	Data Provider	SEFSC

Analytical Team Representation

Kyle Shertzer	Vermilion Snapper Lead Analyst	SEFSC
Paul Conn	Spanish Mackerel Lead Analyst	SEFSC

Council Representation

Brian Chevront	Council Member	SAFMC
David Cupka	Council Member	SAFMC
Rick DeVictor	Vermilion Snapper Council Lead	SAFMC
Gregg Waugh	Spanish Mackerel Council Lead	SAFMC

Advisory Panel Representation

Ben Hartig	SAFMC AP Chair	FLA Commercial

Observers and Associates

Jeanne Boylan (SEAMAP)
Myra Brower (SAFMC)
Julie Defilippi (ACCSP)
Kim Iverson (SAFMC)
Bob Mahood (SAFMC)
Paulette Mikell (MARMAP)
Ernest Muhammad (SC DNR)
David Player (SC DNR)
Andi Stephens (SAFMC)
Jessica Stephen (MARMAP)
Elizabeth Vernon (SC DNR)

Acronyms
SEDAR 17 DW Attendance List

ACCSP	Atlantic Coastal Cooperative Statistics Program
AP	Advisory Panel
ASMFC	Atlantic States Marine Fisheries Commission
CCA	Coastal Conservation Association
CIE	Center for Independent Experts
FL FWC	Florida Fish and Wildlife Commission
FMP	Fishery Management Plan
GA DNR	Georgia Department of Natural Resources
MRFSS	Marine Recreational Fisheries Statistics System
MRIP	Marine Recreational Information Program
NC DMF	North Carolina Division of Marine Fisheries
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
SAFMC	South Atlantic Fishery Management Council
SEFSC	Southeast Fisheries Science Center, National Marine Fisheries Service
SC DNR	South Carolina Department of Natural Resources
SEDAR	Southeast Data, Assessment, and Review
SSC	Science & Statistics Committee, South Atlantic Fishery Management Council
TIP	Trip Interview Program, National Marine Fisheries Service

1.4 Workshop Documents

SEDAR 17

South Atlantic Vermilion Snapper and South Atlantic Spanish Mackerel

Data Workshop Document List

Document #	Title	Authors
Documents Prepared for the Data Workshop		
SEDAR17-DW01	South Atlantic Vermilion Snapper Management Information Worksheet	J. McGovern (SERO) R. DeVictor (SAFMC)
SEDAR17-DW02	South Atlantic Spanish Mackerel Management Information Worksheet	J. McGovern (SERO) R. DeVictor (SAFMC)
SEDAR17-DW03	South Atlantic Vermilion Snapper Assessment History	D. Vaughan (SEFSC)
SEDAR17-DW04	South Atlantic Spanish Mackerel Assessment History	D. Vaughan (SEFSC)
SEDAR17-DW05	South Atlantic Vermilion Snapper Commercial Chapter	D. Vaughan (SEFSC)
SEDAR17-DW06	South Atlantic Spanish Mackerel Commercial Chapter	D. Vaughan (SEFSC)
SEDAR17-DW07	A review of Spanish mackerel (*Scomberomorus maculatus)* age data, 1987-2007, Atlantic collections only, from the Panama City Laboratory, SEFSC, NOAA Fisheries Service	C. Palmer, D. DeVries, C. Fioramonti and L. Lombardi-Carlson (SEFSC)
SEDAR17-DW08	Vermilion Snapper Length Frequencies and Condition of Released Fish from At-Sea Headboat Observer Surveys in the South Atlantic, 2004 to 2007	B. Sauls, C. Wilson, D. Mumford, and K. Brennan (SEFSC)
SEDAR17-DW09	Development of Conversion Factors for Different Trap Types used by MARMAP since 1978.	P. Harris (MARMAP)
SEDAR17-DW10	Discards of Spanish Mackerel and Vermilion Snapper Calculated for Commercial Vessels with Federal Fishing Permits in the US South Atlantic	K. McCarthy (SEFSC)
SEDAR17-DW11	Standardized catch rates of vermilion snapper from the headboat sector: Sensitivity analysis of the 10-fish-per-angler bag limit	Sustainable Fisheries Branch (SEFSC)
SEDAR17-DW12	Estimation of Spanish mackerel and vermilion snapper bycatch in the shrimp trawl fishery in the South Atlantic (SA)	K. Andrews (SEFSC)
Documents Prepared for the Assessment Workshop		
SEDAR17-AW01	SEDAR 17 South Atlantic Vermilion Snapper Stock Assessment Model	To be prepared by SEDAR 17
SEDAR17-AW02	SEDAR 17 South Atlantic Spanish Mackerel Stock Assessment Model	To be prepared by SEDAR 17
Documents Prepared for the Review Workshop		

SEDAR17-RW01	SEDAR 17 South Atlantic Vermilion Snapper Document for Peer Review	To be prepared by SEDAR 17
SEDAR17-RW02	SEDAR 17 South Atlantic Spanish Mackerel Document for Peer Review	To be prepared by SEDAR 17
Final Assessment Reports		
SEDAR17-AR01	Assessment of the Vermilion Snapper Stock in the US South Atlantic	To be prepared by SEDAR 17
SEDAR17-AR02	Assessment of the Spanish Mackerel Stock in the US South Atlantic	To be prepared by SEDAR 17
Reference Documents		
SEDAR17-RD01	South Atlantic Vermilion Snapper Stock Assessment Report, SEDAR 2, 2003	SEDAR 2
SEDAR17-RD02	Update of the SEDAR 2 South Atlantic Vermilion Snapper Stock Assessment, 2007	SEDAR
SEDAR17-RD03	Fishery Management Plan for Spanish Mackerel, Atlantic States Marine Fisheries Commission, 1990	L. P. Mercer L. R. Phalen J. R. Maiolo
SEDAR17-RD04	Mitochondrial and nuclear DNA analysis of population subdivision among young-of-the-year Spanish mackerel (*Scomberomorus maculatus*) from the western Atlantic and Gulf of Mexico	V. P. Buonaccorsi E. Starkey J. E. Graves
SEDAR17-RD05	George Fishes MD TAFS 28 1-49	W. A. George
SEDAR17-RD06	Excerpt – Goode 1878 stats 7-1-99	Goode
SEDAR17-RD07	Excerpt – Henshall Comparative Excellence TAF 13 1-115	Henshall
SEDAR17-RD08	Stock Assessment Analyses on Spanish and King Mackerel Stocks, April 2003	Sustainable Fisheries Div, SEFSC
SEDAR17-RD09	Hooking Mortality of Reef Fishes in the Snapper-Grouper Commercial Fishery of the Southeastern United States	D.V. Guccione Jr.
SEDAR17-RD10	Effects of cryptic mortality and the hidden costs of using length limits in fishery management Lewis G Coggins Jr	L. G. Coggins Jr. and others
SEDAR17-RD11	Discard composition and release fate in the snapper and grouper commercial hook-and-line fishery in North Carolina, USA	P. J. Rudershausen and J. A. Buckel
SEDAR17-RD12	A multispecies approach to subsetting logbook data for purposes of estimating CPUE	A. Stephens and A. MacCall

SEDAR17-RD13	The 1960 Salt-Water Angling Survey, USFWS Circular 153	Clark, J. R.
SEDAR17-RD14	The 1965 Salt-Water Angling Survey, USFWS Resource Publication 67	Deuel, D. G. and J. R. Clark
SEDAR17-RD15	1970 Salt-Water Angling Survey, NMFS Current Fisheries Statistics Number 6200	Deuel, D. G.
SEDAR17-RD16	User's Guide: Delta-GLM function for the R Language /environment (Version 1.7.2, revised 07-06-2006)	Dick, E. J. SWFSC/NMFS
SEDAR17-RD17	Reproductive biology of Spanish mackerel, *Scomberomorus maculatus*, in the lower Chesapeake Bay. M.A. Thesis, Virginia Institute of Marine Science. (Selective pages)	Cooksey, C. L. 1996

2. Life History – Reply to TOR 1, 2, and 5. [Life History Workgroup]

2. 1 Overview - group membership, leader, and issues

Overview

The life history working group (LHG) reviewed information on stock structure, natural mortality, age, growth, movements, and reproduction of Atlantic stock Spanish mackerel: and age sampling, size and age composition, and discard mortality in the fisheries for this stock.

Group Membership

Jennifer Potts (Leader)…NMFS-Beaufort

Dan Carr………………..NMFS-Beaufort

Chip Collier……………..NC DMF

Doug DeVries…………..NMFS-Panama City

Stephanie McInerny…..…NMFS-Beaufort

Paulette Mikell………….SC DNR

Chris Palmer……………NMFS-Panama City

Marcel Reichart…………SC DNR

Jessica Stephen………….SC DNR

David Wyanski………….SC DNR

Issues

Some key issues discussed by the LHG included stock composition and possible mixing in the Florida Keys and the necessity of either constraining the von Bertalanffy parameter t_0 or increasing sample size of small age 0 individuals to more accurately model population growth parameters.

2. 2 Stock Definition and Description

Spanish mackerel are distributed throughout the US Atlantic coast and Gulf of Mexico (GoM) (Collette and Russo 1979, 1984). The majority of the population exists in Florida waters and they are targeted by both the recreational and commercial fishing sectors throughout their range (Trent and Anthony 1978). Amendment 2 to the Coastal Pelagics FMP delineated two groups of Spanish mackerel based on evidence from electrophoresis studies, distributional patterns, spawning areas, and the history of exploitation (Skow and Chittenden 1981; GMFMC and SAFMC 1987). The Dade/Monroe County, Florida boundary was accepted as a practical boundary, because both recreational and commercial catch data for the Gulf and Atlantic have used this boundary.

This species has been investigated for evidence of stock structure by multiple researchers with conflicting results. Early studies of morphometrics and meristics (Collette and Russo, 1984), a single allozyme study (Skow and Chittenden, 1981), and an electrophoresis study using 44 muscle enzyme loci (Nakamura, 1987) noted differences between Spanish mackerel in the Atlantic and GoM. More recent work using mitochondrial and nuclear DNA (Buonaccorsi et al., 2001) did not detect a difference between the Atlantic and GoM Spanish mackerel. Given the highly migratory nature of this species, possible mixing of pelagic eggs, and low number of individuals needed to homogenize the genetic signal, it is not surprising that mitochondrial and nuclear DNA differences were not detected; and the authors themselves noted that "From an ecological and fisheries management perspective, even a sensitive genetic analysis is not sufficient to determine that there is no difference among putative stocks. Migration on the order of tens of individuals per generation is sufficient to homogenize allele frequencies among genetic stocks for both markers." In the report of the life history workgroup from the recent data workshop on the closely related king mackerel (SEDAR 16), a discussion on stock structure noted that "a lack of a significant genetic difference in selectively neutral markers, such as mtDNA or nuclear DNA microsatellites, is not definitive evidence that interregional population structure does not exist (Nolan et al. 1991; Pruett et al. 2005)".

Additionally, the differences observed in morphometrics, meristics (Collette and Russo, 1984), and electrophoretic analyses (Nakamura, 1987) indicate separate stocks between the Atlantic and GoM Spanish mackerel. These stocks may have different demographic parameters (eg. length weight relationship, size at age, and fecundity), which will influence inputs and parameters for a stock assessment model. In the co-occurring king mackerel, for which there is ample evidence of movements and mixing between the Atlantic and GoM (Sutter et al. 1991), DeVries et al. (1997) reported significant differences in growth and size at age estimates between fish sampled in Atlantic waters off the SE U.S. and the eastern GoM. More recent studies of otolith shape and elemental composition (Clardy et al. 2008, Patterson and Shepard 2008) strongly supported the existence of separate Atlantic and eastern GoM stocks.

The consensus of the LHG was that the management units should remain distinct between the Atlantic and Gulf to remain consistent with Amendment 2 of the Fishery Mangement Plan for the Coastal Migratory Pelagic Resources (Mackerels) (GMFMC and SAFMC, 1987).

<u>Recommendations for the AW</u>:

1) Keep the status quo, i.e., one south Atlantic stock with a southern boundary at the Dade/Monroe County, Florida boundary.

2. 3 Natural Mortality

Consistent with the recommendations of previous SEDAR panels for other species, including king mackerel *Scomberomorus cavalla* in SEDAR 16, the group recommends modeling the natural mortality rate of Spanish mackerel as a declining 'Lorenzen' function of size (translated to age by use of a growth curve) (Lorenzen 1996). The Lorenzen curve should be scaled such that the average value of M over the range of fully-selected ages (in this case age 2 up to the maximum age) is the same as the point estimate from Hoenig's (1983) regression.

Application of that regression, based on fish data only, to the maximum age estimate of 12 yr from Nobel et al. (1992) suggests an average M value of 0.35 yr^{-1}, and the LHG recommends a sensitivity range of 0.32-0.38 to encompass the Hoenig estimate based on the maximum age of 11 reported in SEDAR 17-DW-07 and in Schmidt et al.(1993). Preliminary calculations of M based on the growth information available at the data workshop are shown in Figure 2.15.1.

Recommendations for the AW:

1) Model the natural mortality rate of Spanish mackerel as a declining Lorenzen function of size.

2) The Lorenzen function should be scaled to an M of 0.35 - the Hoenig estimate of M based on a maximum age of 12 yr from Noble (1992), with sensitivity runs between 0.32 and 0.38.

2. 4 Discard Mortality

Spanish mackerel are harvested by several gears, which have varying discard mortality rates. Currently, few data sets are published on discard mortality of Spanish mackerel (Harrington et al. 2005). Recently, the NOAA Southeast Fisheries Science Center commercial logbook program has provided discard rates for Spanish mackerel from 2002-2007. This program randomly samples 20% of commercial vessels operating in the South Atlantic and Gulf of Mexico. From the commercial logbooks, discard mortality rates can be estimated for gillnets, hook and line, and trolling (SEDAR17-DW10). The gillnet fisheries, including set gillnets, run around gillnets, and cast nets, should have a low number of releases due to gear selectivity for legal sized fish, but any under sized fish would have a high release mortality rate, most likely 100 % (Ben Hartig, personal communication). A discard mortality rate for Spanish mackerel in gillnets was estimated to be 93.4% (Hueter and Manire 1994). This estimate was based on a fishery independent study conducted in Florida for gillnets soaked one hour. The commercial logbooks estimated a gillnet discard mortality for Spanish mackerel at 100% (SEDAR17-DW10). Hook and line fisheries, which would include both recreational and commercial fisheries, were suggested to have a discard mortality of 25% or less (Ben Hartig, personal communication) and this estimate shows consistency with the king mackerel data workshop (SEDAR 16). However, estimates for Spanish mackerel from the commercial logbooks show a discard mortality of 80% for hook and line (SEDAR17-DW10). The MRFSS at-sea headboat observer survey noted very few Spanish mackerel releases (5 fish on >100 trips) and therefore no estimates were developed from this survey. Additionally, the headboats were recorded as drift fishing, which is not a typical manner used to harvest Spanish mackerel. Most recreational fishermen targeting Spanish mackerel troll (Mercer et al. 1990). Trolling appears to have high discard mortality rates similar to gillnets and resulted in 98% discard mortality based on commercial logbook data (SEDAR17-DW10). Since commercial landings for trolling and hook and line will be combined for use in the Spanish mackerel stock assessment, a combined discard mortality was calculated as a mean mortality rate weighted by the percent of discards by gear. So the discard mortality rate for trolls and hook and line combined was estimated to be 88%.

A final component of discard mortality for Spanish mackerel would result from the shrimp trawl fishery. Sufficient data are not available to estimate the number of Spanish mackerel discarded in this fishery but any discarded would most likely have a high discard mortality rate around 100% (Pat Harris, personal communication). Observed shrimps trawl trips off South Carolina captured Spanish mackerel on 41% of the tows (Harris and Dean 1998). However, estimates of discards in shrimp trawls have been considered unreliable and, therefore, were not included in SEDAR 5 (SEDAR5-AW8). Since SEDAR 5, we are not aware of any new studies documenting bycatch in shrimp trawls.

Recommendations for the AW:

1) Use the following commercial and recreational discard mortality rates for the assessment of Spanish mackerel: gillnets 100%, shrimp trawls 100%, trolling 98%, hook and line 80%, and trolling/hook and line combined 88%.

2. 5 Age

The Panama City NMFS Laboratory initially provided age and length data on 13,405 Spanish mackerel collected in Atlantic waters north of Monroe County, Florida during 1987-2007 (Figure 2.15.2). Based on the disproportionate number of outliers in the 1987 (one of the earliest year's collections aged at the Panama City lab) size at age plot compared to that in the pooled data from all subsequent years (Figures 2.15.3 and 2.15.4), the LHG agreed that age data from that year (258 observations) should be excluded from any analyses for SEDAR 17. A description of the methods, information on quality control, and the distribution of age samples by year, sex, geographical location, gear, fishery, and collecting agency or program are detailed in SEDAR 17-DW-07. The large number of aged samples in 2002 was from a cooperative ageing study with the Virginia Institute of Marine Science.

SCDNR provided age and length data on 745 Spanish mackerel collected during 1986 – 1991 for use in SEDAR 17. Because only 2% of the fish in the NMFS data set were collected in South Carolina, the LHG agreed it was important to include as much of the SCDNR data as possible in the assessment. Although no reader comparison data between the SCDNR and NMFS labs were available, size at age plots were compared at the workshop and the results suggested the two groups aged fish similarly. The SCDNR data, however, only included annulus counts, not ages which could link a given fish with the correct year class (i.e., ages were not advanced for fish collected at the beginning of the calendar year before they had formed or completed forming a new annulus for the year). There were marginal increment measurements for some fish, but not all, and there was no way to ascertain if the measurement represented a large, small, or intermediate increment. Based on the marginal increment patterns observed in the much larger NMFS age data set, the LHG agreed the age of all SCDNR fish collected January – March would be calculated as the annulus count + one; for all fish collected July – December, age would equal the annulus count, i.e., they would not be advanced; and those collected April – June (the months when most fish complete annulus formation) would be excluded because there was no way to confidently determine if the age should be advanced. Deleting the April-June collections left 596 observations, which were merged with the Panama City NMFS data set. Table 2.14.1 presents annual sample sizes of Spanish mackerel age data by state, and within Florida, by subregion.

Two other studies examined the age and growth in Spanish mackerel, one in North Carolina (Noble 1992) and the other in Chesapeake Bay (Gaichas 1997), but the raw data were not available to the LHG. The group did decide to utilize the maximum age from the Noble (1992) study for estimating M.

Recommendations for the AW:

1) Use the combined Panama City NMFS and SCDNR data set for ageing the catch.

2. 6 Growth

Issues discussed by the LHG regarding growth included whether to calculate unweighted or weighted von Bertalanffy curves, whether to constrain t_0, and whether to use sex-specific growth curves.

A comparison of the weighted versus the unweighted von Bertalanffy growth curves (Figure 2.15.5) showed very little difference in the two, so the consensus of the group was to use the unweighted.

Growth in Spanish mackerel, as it is in king mackerel *S. cavalla* (DeVries and Grimes 1997), is clearly sexually dimorphic, with females averaging larger than males at age and reaching larger maximum sizes (Figure 2.15.6) (Noble 1992, Schmidt et al. 1993). The group agreed that whenever possible and appropriate, sex-specific curves should be used in the assessment.

A comparison of growth parameters derived from fishery independent, fishery dependent commercial, and fishery dependent recreational samples showed some obvious differences, likely reflecting different selectivities in each (Figure 2.15.7). Not surprisingly, recreational samples tended to be larger at age, especially among the older ages.

There was considerable discussion within the group and during plenary sessions regarding the von Bertalanffy parameter t_0 – how the lack of small, young fish in the age/length data set results in more negative values, whether it is appropriate to constrain the parameter to 0 or -1, whether the purpose of the von Bertalanffy parameters is to describe the growth of the fish in the samples or the true growth of the population, and the effects changing t_0 can have on the strongly and negatively correlated K and L_∞ . The consensus of the workshop participants at the plenary session was that small, age 0 Spanish mackerel collected in the SEAMAP trawl survey should be incorporated in the age/length data base and used to calculate von Bertalanffy parameters, and that this would better anchor the curve and eliminate the need to constrain t_0. There was general agreement that given the clear modes in the seasonal length frequency data (Figure 2.15.8), age 0 individuals could be readily, confidently identified.

Because the SCDNR SEAMAP trawl survey Spanish mackerel data set contained almost 27,000 observations, only a random subsample of 250 assumed age 0 fish was incorporated in the age/length data set. Age 0 modal groups were most easily discerned in the spring and summer cruise length frequency distributions (Fig. 2.15.8), so random subsamples of 50 individuals 3-12 cm FL from the spring collections and 200 fish 3-26 cm FL from the summer cruises were drawn in proportion to the distribution of their sizes (Figure 2.15.9).

Von Bertalanffy parameters were estimated using nonlinear least squares regression, specifically, SAS's NLIN procedure (Marquardt method). Starting parameter values used for the overall and by sex estimates were $t_0 = -0.5$, $K = 0.5563$, and $L_\infty = 515$; while those used for the estimates by sample source (fishery independent, fishery dependent recreational, and fishery dependent commercial) were $t_0 = -0.5$, $K = 0.4$, and $L_\infty = 1000$. The unweighted von Bertalanffy parameters and 95% confidence limits (overall, by sex, and by source) are given in Table 2.14.2. The age 0 fish from the SEAMAP survey were included in the data sets used to calculate both the male and female parameters, as there was no way to assign sex to those observations, and sex-specific growth at that size and age is likely to be insignificant if it exists at all.

<u>Recommendations for the AW</u>:

1) Unweighted von Bertalanffy parameters should be used to model growth.
2) Represent growth in the Spanish mackerel population by sex where possible.

2. 7 Reproduction

The dataset from Schmidt et al. (1993), a life history study conducted by MARMAP, represents the most recent age-based information on the reproductive biology of Spanish mackerel along the Atlantic coast of the southeastern United States. These specimens were collected from 1983-1992, primarily with trawls (n = 1077; 94% fishery-independent) and gillnets (n = 507; 84% fishery-dependent; Table 14.2.3). Eighty-one percent of the trawl-caught specimens were collected by the SEAMAP program at S. Carolina Dept. of Natural Resources. Information below on spawning seasonality, sexual maturity, and sex ratio is based on the most accurate technique (histology) utilized to assess reproductive condition in fishes. Spanish mackerel do not change sex during their lifetime (gonochorism).

2.7.1. Spawning Seasonality

The spawning season of Spanish mackerel is progressively longer from north to south, primarily due to water temperature. In lower Chesapeake Bay, Cooksey (1996) found partially spent, gravid, and running ripe females from June through August. Off the Carolinas and Georgia, females spawn from May through August (Finucane and Collins 1986; Schmidt et al. 1993), perhaps as late as September based on the presence of larvae (Collins and Stender 1987). Off the Atlantic coast of Florida, spawning females have been collected during April through September (Beaumariage 1970; Powell 1975; Finucane and Collins 1986), and as late as October in some years (Klima 1959).

The gonadosomatic index of females is at a maximum during June in the lower Chesapeake (Cooksey 1996) and off southeast Florida (Finucane and Collins 1986).

Spawning appears to take place on the inner continental shelf, as females with "maturing" (hydrated) oocytes have been collected with gillnets near inlets and shoals along Florida's east coast (Powell 1975) and ripe females have been collected at depths of ca. 9 m from

Onslow Bay (North Carolina) through Georgia (Schmidt et al. 1993). The spatial distribution of Spanish mackerel larvae also indicates that spawning takes place on the inner shelf (Collins and Stender 1987).

2.7.2. Sexual Maturity

Maturity ogives in tabular format are available in the Data Workshop summary spreadsheet. This dataset was provided by MARMAP and represents a minor update of the data in Tables 3 and 4 in Schmidt et al. (1993); the numbers of females and males were increased by 32 and 20, respectively. The smallest mature male was 209 mm FL and the youngest was age 0; the size at 50% maturity was 239 mm FL (Logistic; 95% CI = 232-245). All males were mature at 351-375 mm FL and age 1. The smallest mature female was 288 mm FL, and the youngest was age 0; the size at 50% maturity was 353 mm FL (Normal; 95% CI = 349-358). All females were mature by 451-475 mm FL and age 2. Age at 50% maturity for females was 0.54 yr (Normal; 95% CI = 0.45-0.64) (Figure 2.15.10). No estimate of A_{50} could be calculated for males owing to the low number of immature specimens. Mature gonads were present in 85% of the males at age 0, and 100% at ages $\geq$1.

These results are in general agreement with other studies of sexual maturation. Using a histological method, Powell (1975) found vitellogenic and/or mature oocytes in >50% (vs. 94% in MARMAP data) of age-1 female Spanish mackerel sampled in Florida (Atlantic and Gulf coasts) during April through September. This percentage is conservative given that mature females may not be reproductively active throughout the entire spawning season; some may have become reproductively inactive (resting state). Klima (1959), using a macroscopic method, reported that females and males mature at ages 1-2; however, Powell (1975) concluded that the age data of Klima (1959) should be reduced by one year.

2.7.3. Sex ratio

The presence of strong sexual dimorphism in Spanish mackerel (females larger than males at ages 1-5; see Powell 1975; Fable et al. 1987; Schmidt et al. 1993) may result in skewed adult sex ratios when data are analyzed by gear type. In the MARMAP dataset, the percentage of females in samples from a 75 ft falcon trawl without a turtle excluder device was 28 % (n = 396) versus 62% (n = 373) in samples collected with gillnets. Each gear type exhibits evidence of size selectivity, the trawl for smaller specimens (mean FL=318 mm; predominantly males at FL $\leq$375 mm) and gillnets for larger specimens (mean FL=443 mm; predominantly females at FL >400 mm). The low percentage of females in the trawl data reflects the faster growth rate of females vs. males at younger ages and the resulting later sexual maturation of females (3% mature at age 0 vs. 85% for males). A highly skewed sex ratio (80% female, immature included) was also noted by Klima (1959) in recreational hook-and-line catches off southeast Florida. Klima speculated that the high percentage of females reflects their more aggressive feeding behavior, not the lack of males in the areas fished. A similar high percentage of females was noted in gillnet (67%; n = 495) samples of the MARMAP dataset if immature specimens were included.

In the MARMAP dataset, the subsample of specimens from gillnet samples that was assigned an age also revealed an adult sex ratio skewed toward females. The percentage of females in the subsample was 64% (n = 280), similar to the 62% value overall (specimens aged and specimens not aged), but the percentage by age class was noticeably lower at age 0, the result of only 3% of females being mature at age 0 (Fig. 2.15.11). At the youngest ages represented by 100% maturity (ages 2-4), the percentage of females ranged from 64-73%. The percentage dropped to 38-50% at ages 5-7, but sample sizes were small (<40 per age class). Similar trends were noted in samples collected with trawls, even though the sample size was small (n = 77).

2.7.4. Spawning Frequency

No estimate of spawning frequency is available. Cooksey (1996) attempted to collect specimens over a 24-h period to determine the age of postovulatory follicles (POFs), but too few specimens were collected. She suggested that "almost-daily spawns" may be possible, as fresh POFs were observed in ovaries in which final oocyte maturation had begun.

2.7.5. Batch Fecundity

Batch fecundity (BF) vs. fork length (FL) and ovary-free weight (SW) were estimated for narrow ranges of length and weight by Cooksey (1996), but no estimate of batch fecundity vs. age is available.

BF = 610.17*FL – 159,198 (n = 13, r^2 = 0.59, FL = 335-439 mm)
BF = 160.33*SW – 8211 (n = 13, r^2 = 0.69, SW = 336-845 g)

Recommendations for the AW:

1) Consider using age-based sex ratio data in the model, given the uncertainty of the overall sex ratio in the population (consensus of the data workshop panel during plenary session 5/23/08).

2. 8 Movements and Migrations

The following is quoted from section 3.1 of the Atlantic States Marine Fisheries Commission's fishery management plan for Spanish mackerel (Mercer et al. 1990): "Spanish mackerel make seasonal migrations along the Atlantic coast and appear to be much more abundant in Florida during the winter. They move northward each spring to occur off the Carolinas by April or May, off Chesapeake Bay by May or June, and some years, as far north as Narragansett Bay by July (Berrien and Finan 1977)." In a tagging study in North Carolina, 1986-1990, by the NC Division of Marine Fisheries, fish were recaptured as far south as Sebastian Inlet, FL and as far north as the York River in Virginia (Noble 1992). The few fish recaptured in Florida were caught in winter and spring, confirming a southern movement during the fall, while those recaptured in Virginia were caught in summer and fall, supporting a northerly movement during that time of year (Phalen 1989, Noble 1992).

Recommendations for the AW:

None

2. 9 Meristics and Conversion Factors

Equations to make length-length and weight-length conversions were determined using the simple linear regression model and the power function, respectively (Tables 2.14.4 and 2.14.5). All weights are shown in grams and all lengths in millimeters. Coefficients of determination (r^2) ranged from 0.952 to 0.998 for these linear (length) and nonlinear (weight) regressions.

Recommendations for the AW:

1) Use the equations based on combined sources.

2.10 Adequacy of Data for Assessment Analyses

Included in individual sections above

2.11 Life History Research Recommendations

1) Ages provided for future assessments should be advanced when appropriate (i.e., during months when annuli are being formed) so fish can be assigned to the correct year class. If advanced ages cannot be provided, data should include assessment of otolith edge type. Classification schemes for edge type and quality of the otolith/section have been developed by the MARMAP program at SCDNR and are currently used by MARMAP and NMFS Beaufort.

2) Conduct inter-lab comparisons of age readings from test sets of otoliths in preparation for any future stock assessments.

3) Obtain adequate data to determine gutted to whole weight relationships.

4) Investigate the discard mortality of Spanish mackerel in the commercial and recreational trolling fishery, commercial gillnet fishery, and the shrimp trawl fishery.

6) To ensure more accurate estimates of $t_{0,}$ increase efforts to collect age 0 specimens for use in estimating von Bertalanffy (VB) growth parameters.

2.12 Tasks for Completion following Data Workshop (Itemize and include completion dates and responsible parties.)

2.13 Literature Cited

Beaumariage, D. 1970. Current status of biological investigations of Florida's mackerel fisheries. Proc. Gulf Caribb. Fish. Inst. 22:79-86.

Berrien, P., and D. Finan. 1977. Biological and fisheries data on Spanish mackerel, *Scomberomorus maculatus* (Mitchill). NMFS, Sandy Hook Laboratory, Highlands, NJ, Tech. Serv. Rep. No. 9. 52 p.

Buonaccorsi, V. P., E. Starkey, and J. E. Graves. 2001. Mitochondrial and nuclear DNA analysis of population subdivision among young-of-the-year Spanish mackerel (*Scomberomorus maculatus*) from the western Atlantic and Gulf of Mexico. Marine Biology 138:37-45.

Clardy, T.R., W.F. Patterson III, D.A. DeVries, and C.L. Palmer. 2008. Spatial and temporal variability in the relative contribution of U.S. king mackerel (*Scomberomorous cavalla*) stocks to winter mixed fisheries off south Florida. Fish. Bull. 106:152-160.

Collette, B. B., and J. L. Russo. 1979. An introduction to the Spanish mackerels, genus *Scomberomorus,* p. 3-16, In: Nakamura and Bullis (eds.), Proceedings: Colloquium on the Spanish and king mackerel resources of the Gulf of Mexico. Gulf States Marine Fisheries Commission, No. 4, Gulf States Marine Fisheries Commission, Ocean Springs, MS.

Collette, B. B., and J. L. Russo. 1984. Morphology, systematics, and biology of the Spanish mackerels (*Scomberomorus*, Scombridae). Fish. Bull., U.S. 82(4):545-692.

Collins, M.R., and B.W. Stender. 1987. Larval king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*S. maculatus*), and bluefish (*Pomatomus saltatrix*) off the southeast coast of the United States, 1973-1980. Bull. Mar. Sci. 41:822-834.

Cooksey, C.L. 1996. Reproductive biology of Spanish mackerel, *Scomberomorus maculatus*, in the lower Chesapeake Bay. M.A. Thesis, Virginia Institute of Marine Science, 68 p.

DeVries, D. A., and C. B. Grimes. 1997. Spatial and temporal variation in age and growth of king mackerel, *Scomberomorus cavalla*, from the southeastern United States. Fishery Bulletin. 81:97-106.

Fable, W.A., Jr., A.G. Johnson, and L.E. Barger. 1987. Age and growth of Spanish mackerel, *Scomberomorus maculatus*, from Florida and the Gulf of Mexico. Fish. Bull., U.S. 85:777-783.

Finucane, J.H., and L.A. Collins. 1986. Reproduction of Spanish mackerel, *Scomberomorus maculatus*, from the southeastern United States. Northeast Gulf Sci. 8:97-106.

Gaichas, S.K. 1997. Age and growth of Spanish mackerel, *Scomberomorus maculatus*, in the Chesapeake Bay region. M.S. Thesis, Virginia Institute of Marine Science, 111 p.

Gulf of Mexico Fishery Management Council and South Atlantic Fishery Management Council (GMFMC and SAFMC). 1987. Revised amendment 2 to the fishery management plan for the coastal migratory pelagic resources (mackerels) of the Gulf of Mexico and the south Atlantic. GMFMC, Tampa, FL and SAMFC, Charleston, SC. 54pp. plus addendums.

Harrington, J.M., R.A. Myers, and A. A. Rosenberg. 2005. Wasted fishery resources: discarded by-catch in the USA. Fish and Fisheries 6: 350–361.

Harris, P. and J.M. Dean. 1998. The potential impact of juvenile king mackerel (*Scomberomorus cavalla*) and Spanish mackerel (*S. maculatus*) shrimp trawl bycatch mortality on southeast Atlantic adult populations. Appendix L. Stock assessment and fishery evaluation report for king mackerel, Spanish mackerel and cobia. Fishery Management Plan for Coastal Migratory Pelagics, Vol. 1.

Hoenig, J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. 82:898-903.

Hueter, R.E., and C.A. Manire. 1994. Bycatch and catch-release mortality of small sharks in the Gulf coast nursery grounds of Tampa Bay and Charlotte Harbor. Mote Marine Technical Report No. 368. (Final Report to NOAA/NMFS, MARFIN Project NA17FF078-01.

Klima, E.F. 1959. Aspects of the biology and the fishery for *Scomberomorus maculatus* (Mitchill), of southern Florida. Fla. Board Conserv., Mar. Res. Lab. Tech. Ser. No. 27, 39 p.

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystems and aquaculture. Journal of Fish Biology 49: 627-647.

Mercer, L. P., L. R .Phalen, and J. R Maiolo. 1990. Fishery management plan for Spanish mackerel. Atlantic States Marine Fisheries Commission, Fisheries management report No. 18, 78 p.

Nakamura, E.L. 1987. Mexus-Gulf coastal pelagic fish research, 1977-1984. Marine Fisheries Review 49: 36-38.

Nobel, Elizabeth, B. 1992. Migration, age and growth of Spanish mackerel (*Scomberomorus maculatus*) in North Carolina. Study 2 in Completion Report for Project –F/29. N. C. Dept. Env. Health and Nat. Res., Div. Mar. Fish. 51 pp.

Nolan, K. J. Gossfield, I Wirgin. 1991. Discriminating among Atlantic coast populations of American shad (*Alosa sapidissima*) using mitochondrial DNA. Canadian Journal of Fisheries and Aquatic Sciences. 48:1724-1734.

Patterson, W.F., III, and K.E. Shepard. 2008. Estimation of the stock composition of winter king mackerel fisheries off south Florida with natural tags based on otolith stable isotope chemistry. SEDAR16-DW-26.

Phalen, L.R. 1989. Spanish mackerel. p. 8-12, In: Marine Fisheries Research, N.C. Div. Mar. Fish. Ann. Prog. Rep. F-29-3.

Powell, D. 1975. Age, growth, and reproduction in Florida stocks of Spanish mackerel, *Scomberomorus maculatus*. Fla. Dep. Nat. Resour., Fla. Mar. Res. Publ. No. 5, 21 p.

Pruett, C.L., E. Saillant, and J.R. Gold. 2005. Historical population demography of red snapper (*Lutjanus campechanus*) from the northern Gulf of Mexico based on analysis of sequences of mitochondrial DNA. Marine Biology 147: 593–602.

Schmidt, D.J., M.R. Collins, and D.M. Wyanski. 1993. Age, growth, maturity, and spawning of Spanish mackerel, *Scomberomorus maculatus* (Mitchill), from the Atlantic Coast of the southeastern United States. Fish. Bull., U.S. 91:526-533.

Skow, L.C., and M.E. Chittenden. 1981. Differences in hemoglobin phenotypes among Spanish mackerel, *Scomberomorus maculatus*. Northeast Gulf Sci. 5(1):67-70.

Sutter, F.C., R.O. Williams, and M.F. Godcharles.1991. Movement patterns and stock affinities of king mackerel in the southeastern United States. U.S. Fish. Bull. 89:315-324.

Trent, L. and A. Anthony. 1978. Commercial and recreational fisheries for Spanish mackerel, *Scomberomorus maculatus*. *In* E. L. Nakamura and H. R. Bullis, Jr. (editors), Proceedings of the Mackerel Colloquim, p. 17-32. Gulf States Marine Fisheries Commission. No. 4.

Williams, R.O., M.D. Murphy, and R.G. Muller. 1985. A stock assessment of the Spanish mackerel (*Scomberomorus maculatus*) in Florida. Florida Mar. Fish. Comm., Florida Dept. Nat. Resour.

2.14 Tables

Table 2.14.1. Annual numbers of Spanish mackerel from the Atlantic, 1986-2007, by state, and within Florida, by sub-region, aged by NMFS Panama City and SC DNR and included in final SEDAR 17 dataset. NEF = northeast Florida, EF = east Florida, SEF = southeast Florida, SF = south Florida.

Year	MA	VA	NC	SC	GA	NEF	EF	SEF	SF	Total
1986				26						
1987			67	50	59		104			258
1988			91	221	25		6			184
1989			7	185	171					208
1990	21		412	234	72		42			575
1991	40		328	39	210		60			649
1992	37		553	93	36		85			804
1993			268	31			164			463
1994			182				22			204
1995			171				165			336
1996			114				450			564
1997			403				280			683
1998			418				331			749
1999			273				459			732
2000		104	458				468			1,030
2001			485				315			800
2002		853	333			2	395			1,583
2003			318				328			646
2004			280				512	2		794
(blank)										
2005			285				413			698
2006			277				496	4		777
2007			295				368	4	1	668
Total	98	957	6018	879	573	2	5463	10	1	14001
% of Total	0.70	6.84	42.98	6.28	4.09	0.01	39.02	0.07	0.01	100

Table 2.14.2. Unweighted von Bertalanffy parameters for Spanish mackerel (Atlantic stock). Age 0 fish from the SEAMAP survey were used to estimate both the male and female parameters. Lengths (Lmax) are in millimeters fork length.

	N			Std. Error	Lower 95% CL	Upper 95% CL
All	14015	Lmax	606.6	3.7209	599.4	613.9
		K	0.3289	0.00735	0.3145	0.3433
		T_0	-1.6677	0.036	-1.7383	-1.5971
Males	5806	Lmax	520.5	3.1043	514.4	526.6
		K	0.4727	0.0123	0.4487	0.4967
		T_0	-1.2308	0.035	-1.2994	-1.1623
Females	8519	Lmax	628.7	4.165	620.5	636.8
		K	0.3599	0.00839	0.3434	0.3763
		T_0	-1.355	0.0325	-1.4186	-1.2913
FI includes age0 unk	790	Lmax	493	7.2415	478.8	507.2
		K	1.121	0.0626	0.9981	1.2439
		T_0	-0.3835	0.0227	-0.428	-0.339
FD Comm	8867	Lmax	597.8	5.0365	587.9	607.7
		K	0.3096	0.0104	0.2893	0.33
		T_0	-2.0329	0.0645	-2.1594	-1.9064
FD Rec	4068	Lmax	864.5	29.79	806.1	922.9
		K	0.129	0.00961	0.1102	0.1479
		T_0	-3.0332	0.1273	-3.2828	-2.7836

Table 2.14.3. Number of specimens of Spanish mackerel from Schmidt et al. (1993) for which sex and reproductive state were assessed histologically. Specimens were collected during 1983-92. HnL = hook and line

	Source		
Gear	**Fishery-dependent**	**Fishery-independent**	**Total**
Trawl	58	1012	1070
Gillnet	425	77	502
HnL	127	3	130
Stopnet		11	11
Trammel net		1	1
Unknown	104	9	113
Total	714	1113	1827

Table 2.14.4. Simple linear regressions (y = ax + b) to convert lengths of Spanish mackerel. MARMAP = Marine Resources Monitoring Assessment and Prediction Program at S.C. Dept. of Natural Resources, Charleston, SC; **SA** = South Atlantic headboat data from National Marine Fisheries Service. State FL = Florida.

Data Source	Dep. Variable	Ind. Variable	a	b	r^2	n	a SE	b SE	Ind. Range	Units
SA Headboat & State FL	TL	FL	1.0805	33.4862	0.9898	875	0.0037	1.7507	200-780	mm
	FL	TL	0.916	-25.9812	0.9898	875	0.0032	1.707	263-882	mm
	TL	SL	1.1116	43.0491	0.9888	128	0.0106	4.3925	212-730	mm
	FL	SL	1.0378	12.766	0.9907	142	0.0085	3.5645	212-730	mm
	SL	FL	0.9546	-8.3722	0.9907	142	0.0078	3.5011	232-767	mm
MARMAP	TL	FL	1.193	-1.873	0.9984	5009	0.0007	0.1752	47-730	mm
	FL	TL	0.8369	1.944	0.9984	5009	0.0005	0.1467	50-850	mm
	TL	SL	1.3222	-2.9617	0.9956	776	0.0032	0.6672	73-475	mm
	FL	SL	1.086	1.5427	0.9979	785	0.0018	0.3705	73-475	mm
	SL	FL	0.9186	-1.004	0.9979	785	0.0015	0.3426	82-513	mm
Combined	TL	FL	1.1574	5.2853	0.9969	5884	0.0008	0.2516	47-780	mm
	FL	TL	0.8614	-3.7294	0.9969	5884	0.0006	0.2197	50-882	mm
	TL	SL	1.1913	21.5975	0.9910	904	0.0038	0.9465	73-730	mm
	FL	SL	1.0569	7.0274	0.9979	927	0.0016	0.407	73-730	mm
	SL	FL	0.9441	-6.139	0.9979	927	0.0014	0.3936	82-767	mm

Table 2.14.5. Power function (Weight = a*(length)^b) to convert length of Spanish mackerel to weight. MARMAP = Marine Resources Monitoring Assessment and Prediction Program at S.C. Dept. of Natural Resources, Charleston, SC; Panama City = data from various sources provided by Panama City lab of National Marine Fisheries Service; **SA** = South Atlantic headboat data from National Marine Fisheries Service. State FL = Florida.

Data Source	Dep. Variable	Ind. Variable	a	b	r^2	n	Len SE	Wt SE	Length Range	Units
SA Headboat & State FL	Whole Weight	FL	1.935 e-5	2.869	0.9276	871	3.690 e-6	2.989 e-2	200-780	mm g
	Whole Weight	TL	4.851 e-6	3.0262	0.9156	880	1.093 e-6	3.432 e-2	263-882	mm g
Panama City (TIP, MRFSS, NCDMF, RECFIN)	Whole Weight	FL	1.305 e-5	2.9352	0.8992	2603	1.539 e-6	1.860 e-2	145-810	mm g
MARMAP	Whole Weight	FL	1.353 e-5	2.928	0.9835	4947	3.334 e-7	2.750 e-3	47-730	mm g
	Whole Weight	TL	3.590 e-6	3.061	0.9844	4853	1.414 e-7	6.210 e-3	50-850	mm g
Combined	Whole Weight	FL	1.523 e-5	2.909	0.9515	8421	8.176 e-7	8.517 e-3	47-810	mm g
	Whole Weight	TL	2.753 e-6	3.11	0.9657	5734	1.756 e-7	9.797 e-3	50-882	mm g

2.15 Figures

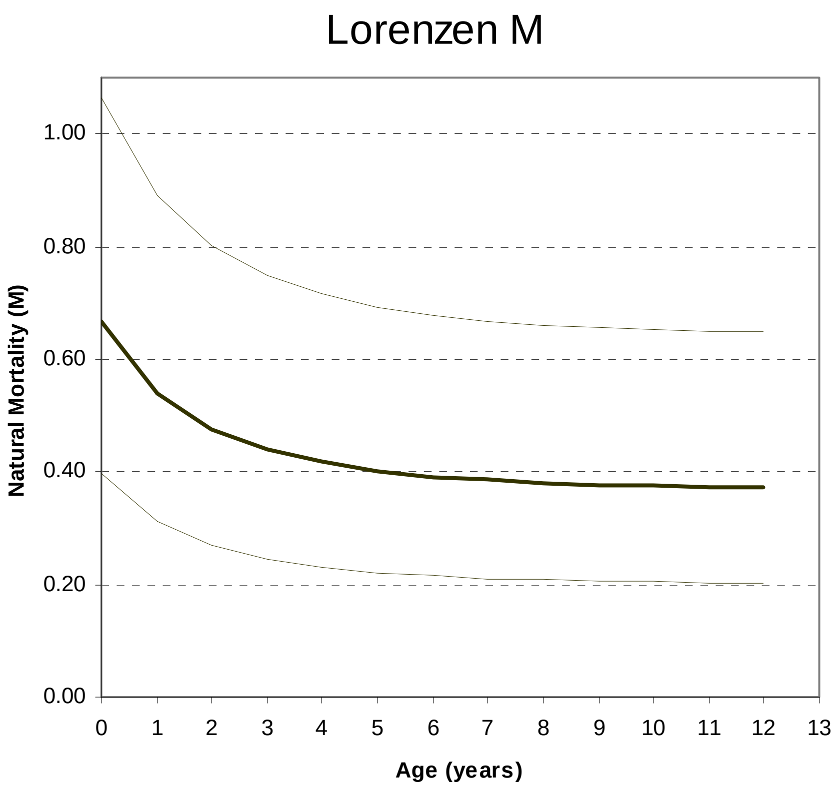


Figure 2.15.1. Unscaled age-varying instantaneous natural mortality (M) for Atlantic stock Spanish mackerel using the Lorenzen approach (Lorenzen 1996).

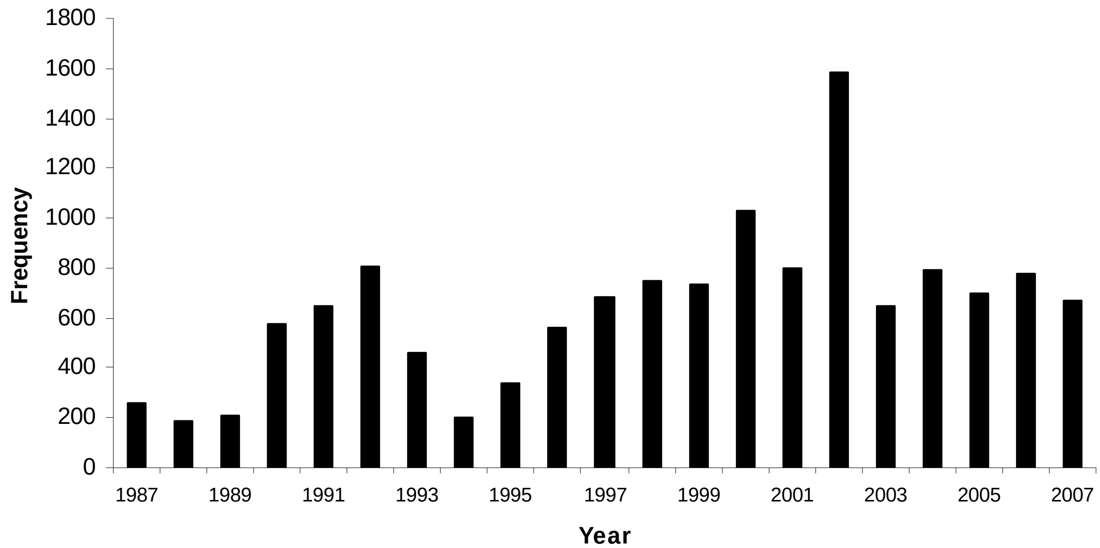


Figure 2.15.2. Annual numbers of Spanish mackerel (Atlantic stock) aged by the Panama City Laboratory of the Southeast Fisheries Science Center, NOAA Fisheries Service, 1987-2007.

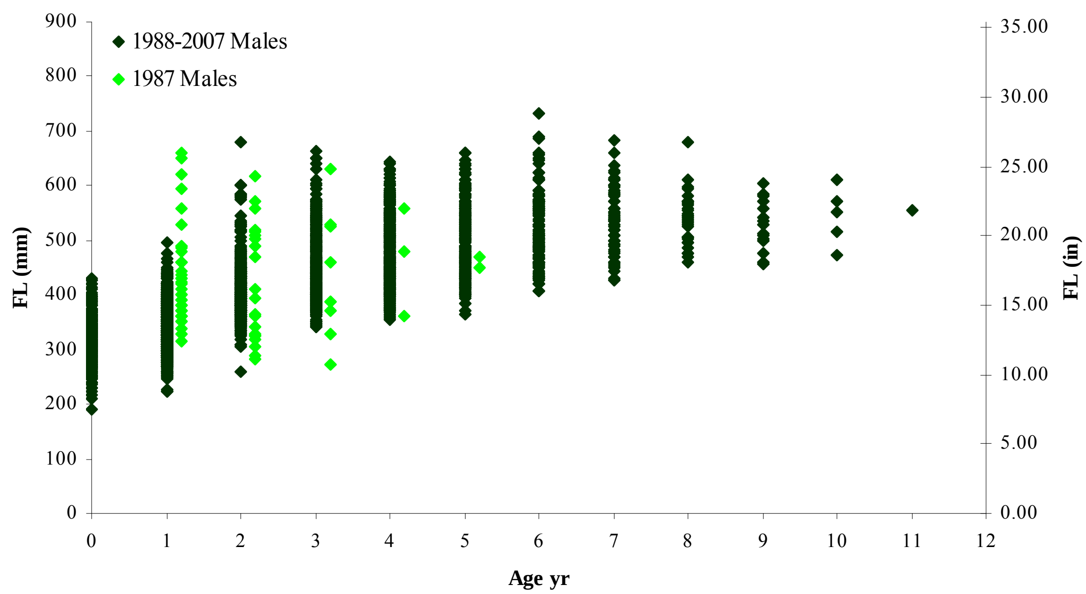


Figure 2.15.3. Length at age distributions of 1987 and 1988-2007 male Spanish mackerel from Atlantic waters aged by NMFS Panama City.

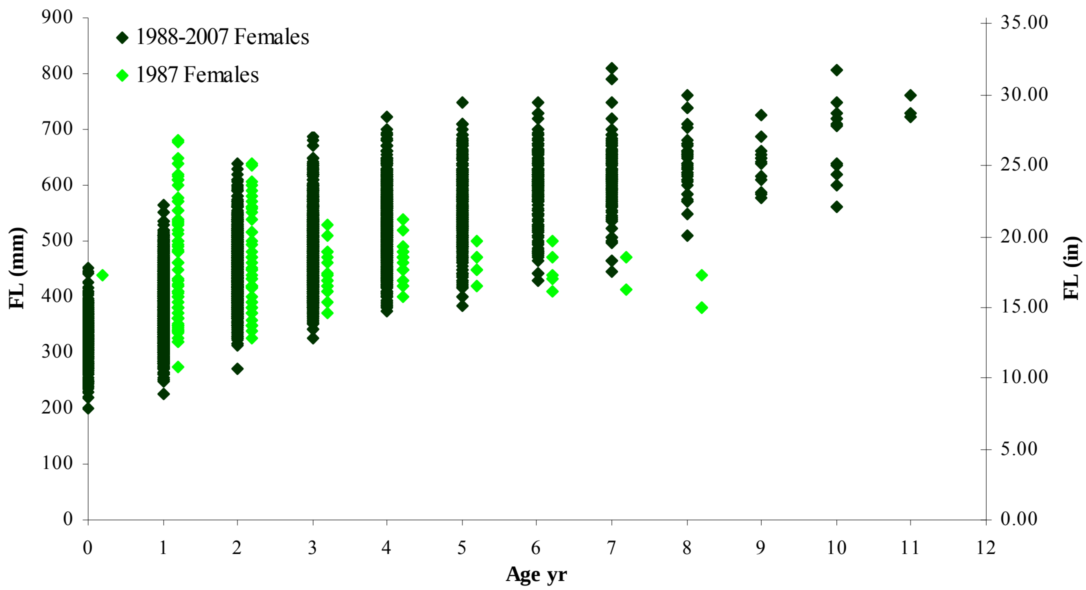


Figure 2.15.4. Length at age distributions of 1987 and 1988-2007 female Spanish mackerel from Atlantic waters aged by NMFS Panama City.

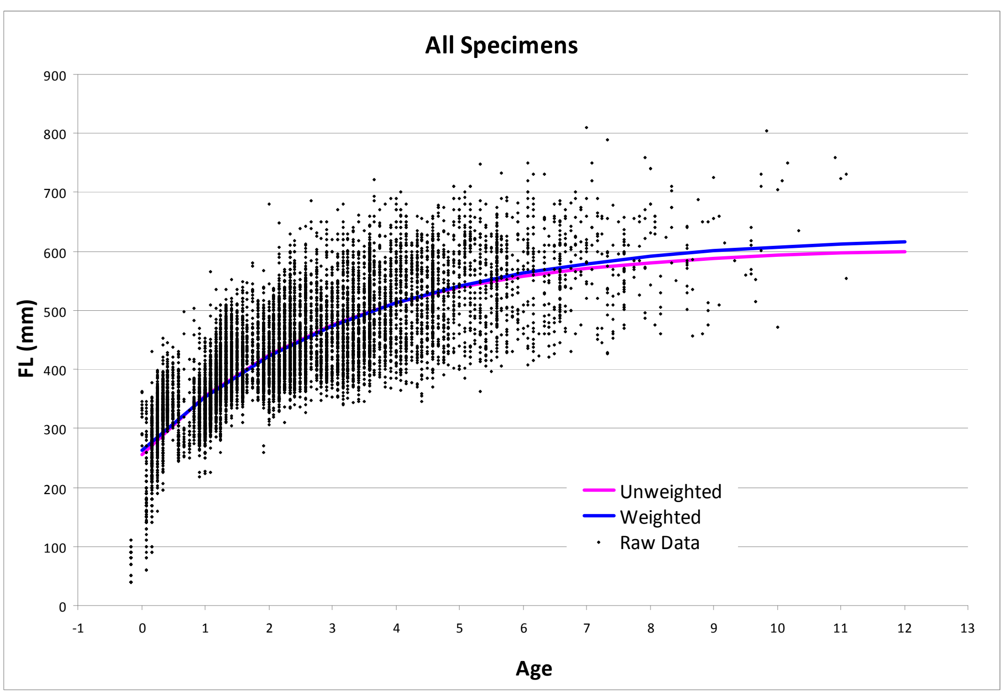


Figure 2.15.5. Overall weighted and unweighted von Bertalanffy growth curves and raw data from 1986-2007 for Atlantic stock Spanish mackerel.

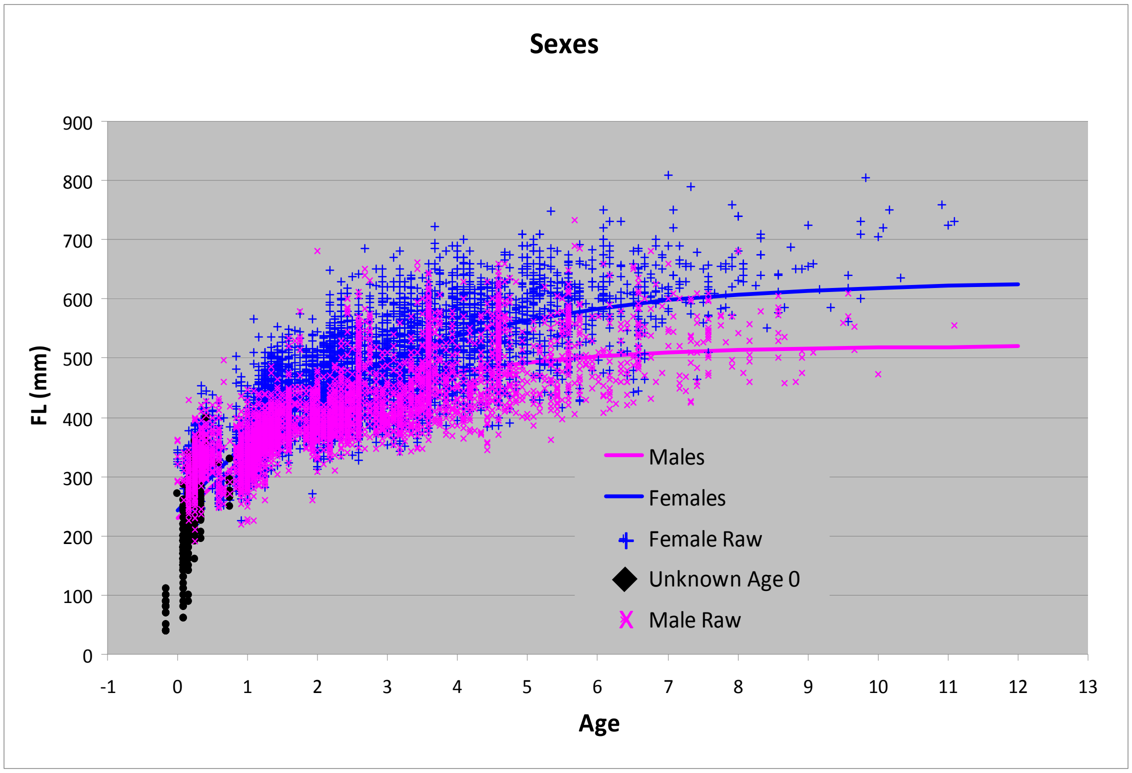


Figure 2.15.6. Unweighted von Bertalanffy growth curves and raw data from 1986-2007 for Atlantic stock Spanish mackerel by sex.

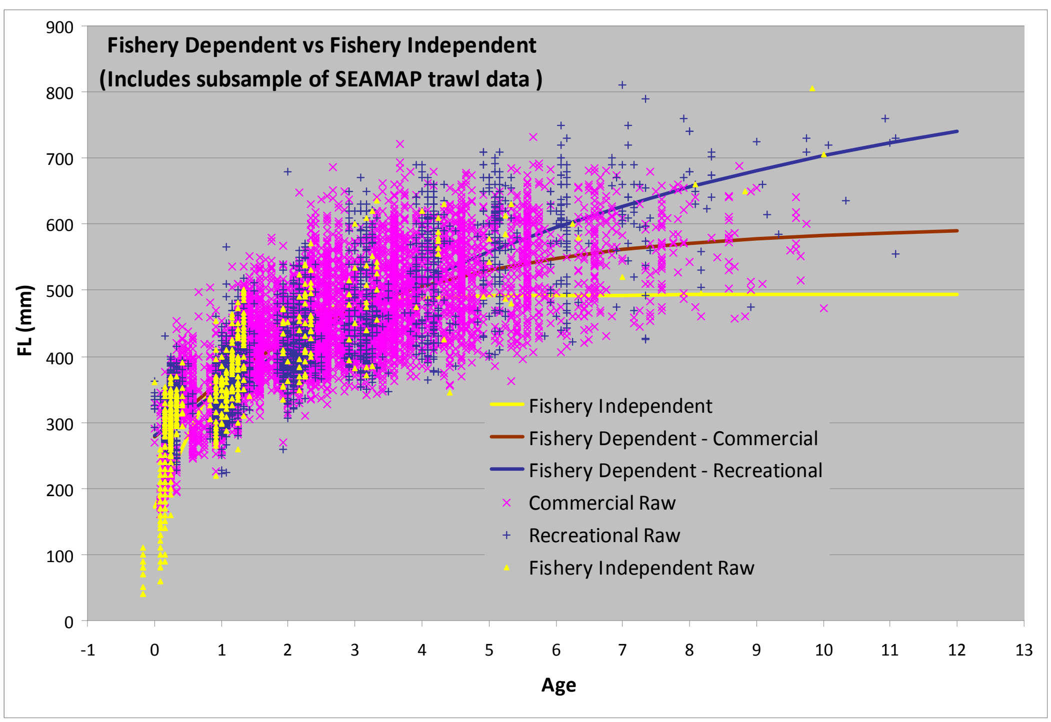


Figure 2.15.7. Von Bertalanffy growth curves and raw data for Atlantic stock Spanish mackerel from fishery independent, fishery dependent commercial, and fishery dependent recreational samples.

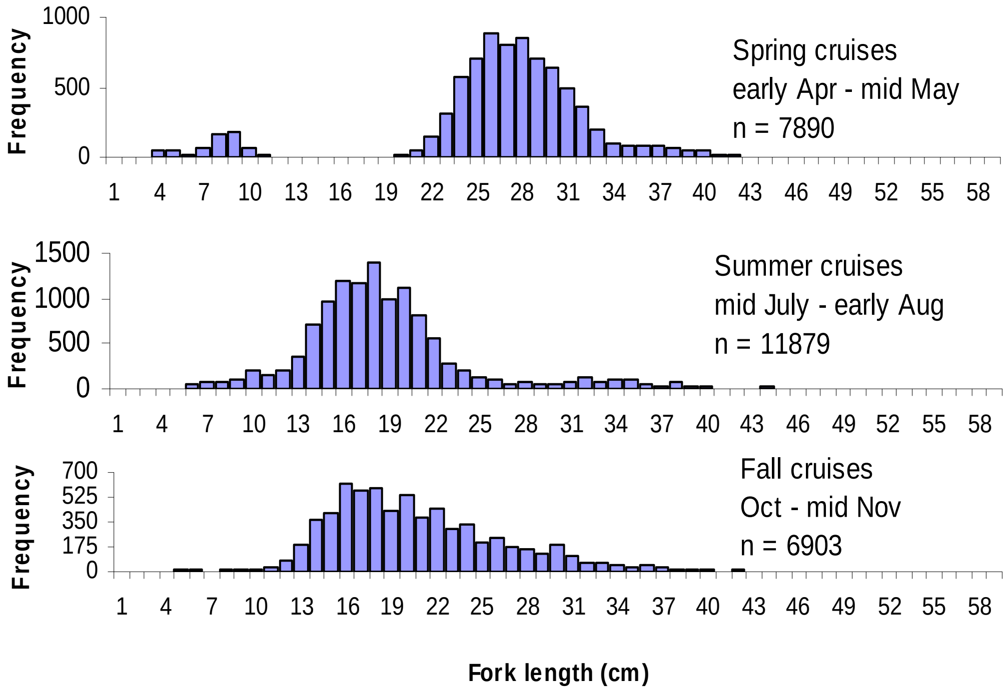


Figure 2.15.8. Size distributions of Spanish mackerel in SEAMAP trawl surveys, 1989-2007.

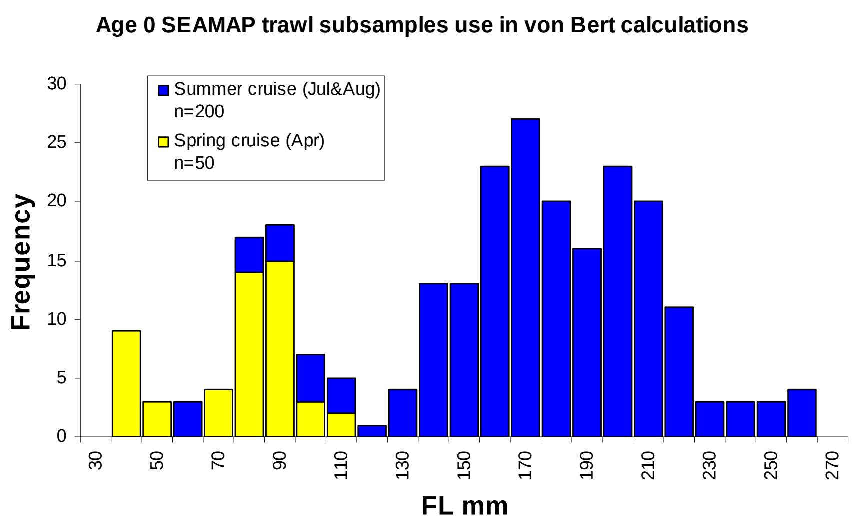


Figure 2.15.9. Size distribution of assumed age 0 Spanish mackerel subsampled from SEAMAP trawl data included in calculations of von Bertalanffy parameters.

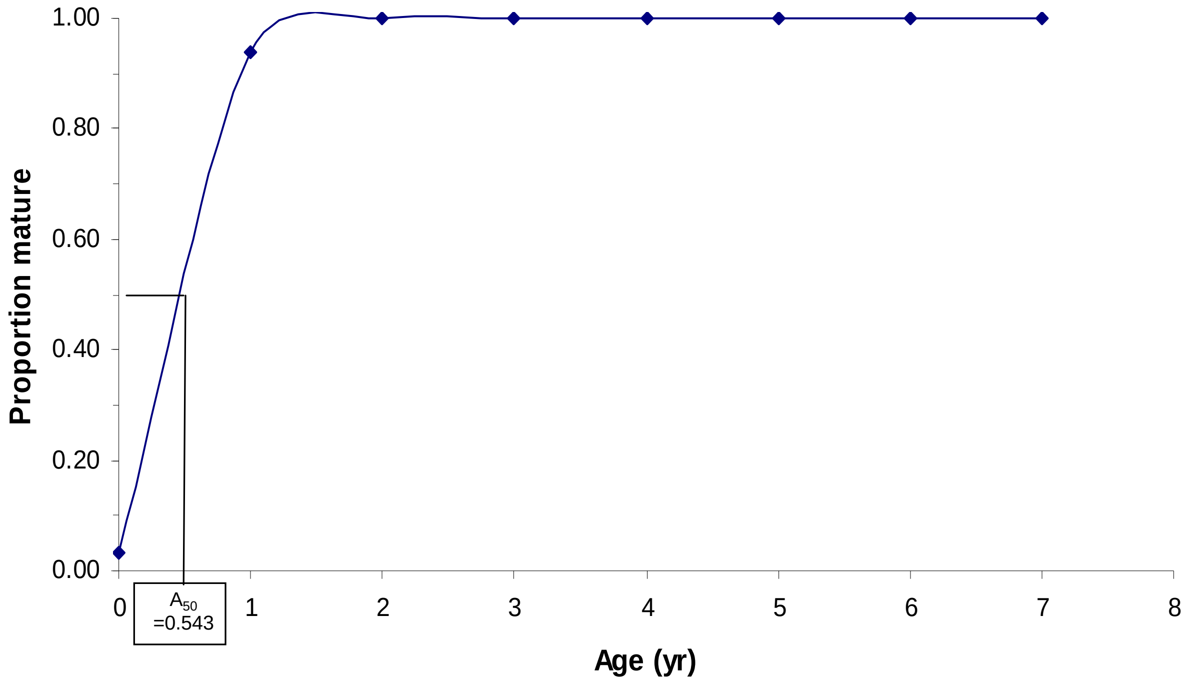


Figure 2.15.10. Proportions of mature female Spanish mackerel at age. A_{50} = age at 50% maturity. Data from Schmidt et al. (1993) plus 32 additional observations from subsequent MARMAP collections.

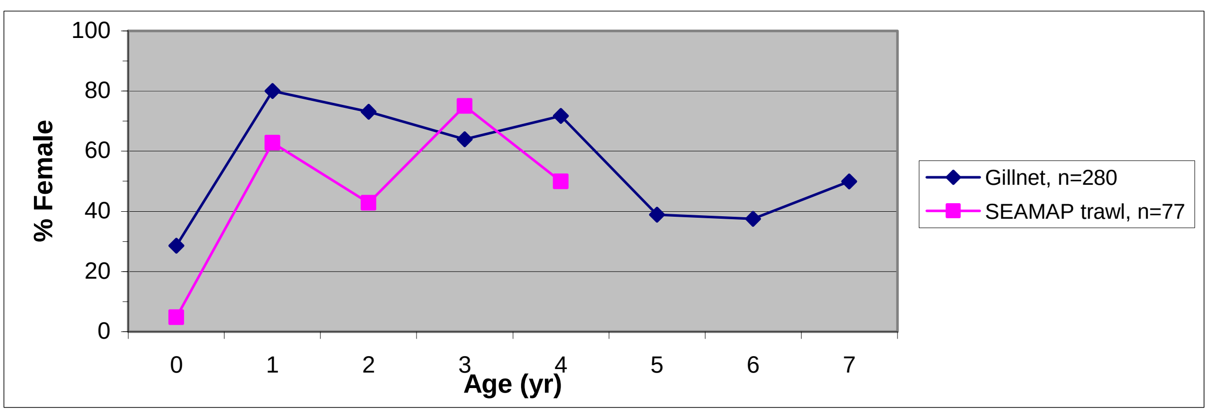


Figure 2.15.11. Percentage of adult female Spanish mackerel by age class in samples caught with gillnets and trawls (SEAMAP-SA program at S.C. Dept. of Natural Resources). Dataset is from life history study conducted by MARMAP.

3 Commercial Fishery

Chair: Douglas Vaughan (NMFS Beaufort); Rapporteur: Kate Andrews (NMFS Panama City); Members: Alan Bianchi (NC DMF), Jack Holland (NC DMF), Robert Wiggers (SC DNR), Julie Califf (GA DNR), Steve Brown (FL FWI), Dave Gloeckner (NMFS Beaufort), Kevin McCarthy (NMFS Miami), and Ben Hartig (FL Commercial Fisherman).

3.1 Overview

Historical commercial landings data for Spanish mackerel were explored to address several issues. These issues included: (1) geographic stock boundaries, (2) historical perspective of landings data (duration of data for stock assessment), (3) grouping of commercial gears for pooling landings, (4) mis-identification of species or need to expand unclassified mackerel landings (this species category does not exist), (5) final presentation of landings by gear in pounds (whole weight) and in numbers based on state and federal data, (6) estimates of discards in numbers from commercial logbooks and from shrimp trawls, (7) length and age compositions sampled from commercial fisheries, and (8) research needs.

3.2 Commercial Landings

3.2.1 NMFS Website for Commercial Landings

The NMFS website for commercial landings:

http://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html

was queried for all Spanish mackerel landings along the Atlantic coast by state. This query produced annual landings by state and gear from 1950-2006 for Florida (east coast) to Maine. Commercial landings data from the NMFS website were split for Florida into the Florida East Coast (Atlantic) and Florida West Coast (Gulf of Mexico) based on county landed. Landings from the Atlantic coast counties from Dade and north were considered as Atlantic Florida.

Additionally, we queried the Standard Atlantic Fisheries Information System (SAFIS, Internet based data entry system developed by the ACCSP) for commercial landings of Spanish mackerel for Virginia and north. Estimates by month and state were obtained for 1980-2007. This latter data was used to replace data downloaded from the NMFS website for those states and years.

Decision 1. Because Spanish mackerel landings were reported as far north as Maine, the Workgroup recommended using commercial landings from along the entire US Atlantic coast to represent landings from the Atlantic Spanish mackerel stock.

Commercial landings data from the northern states (Virginia through Maine) were summarized by gear, to determine which gears are most important for landing Spanish mackerel from this region. Pound nets were found to be most important (69% of landings by weight), followed by gillnets (22.6%), and smaller amounts by haul seines (3.3%), trawls (3.0%) and other gears (2.3%).

Coastwide landings by state and gear for Spanish mackerel were reported consistently back to 1950 on the NMFS Website. These data prior to the ALS (1962) were believed to be valid, although with greater uncertainty associated with them. An expansion factor for Virginia and north was calculated by comparing landings for GA-NC to VA north for 1950-1969 (from the downloaded NMFS website data). Data gaps of varying duration occur prior to 1950, and minimal data is available prior to 1927. Also, landings were only reported for Florida (Atlantic) and North Carolina, and none for Georgia and South Carolina (presumed zero). No historical landings were available for Virginia and north prior to 1950.

Prior to 1950, landings were only reported for Florida (Atlantic) and North Carolina, and none for Georgia and South Carolina (presumed zero). No historical landings were available for Virginia and north prior to 1950. Because of differences in the seasonal distributional of commercial landings in Florida (Atlantic) and North Carolina, linear interpolations for missing years were applied separately by state. The workgroup then discussed application of an approach similar to that applied to red snapper (SEDAR 15) to develop historical landings for 1900-1949, and results are provided in this report for consideration by the Assessment Workshop. As with the red snapper assessment (SEDAR 15), the committee notes that historical data is reported fairly consistently back to 1927, with major gaps for World War II (1941-44) and post World War II (1946-1949). During SEDAR 15 (red snapper) discussions, it was suggested that the landings for 1941-44 were zero, but that a linear interpolation should be applied for 1946-49, using landings reported for 1945 and 1950. Other missing years occurred in 1933 and 1935, which were replaced with the average of the preceding and following years. Although there were occasional landings reported prior to 1927, these were few and far between (1923, 1918, 1908, 1902, and 1897). The approach chosen to fill in these early years was again similar to that applied to red snapper (SEDAR 15). For the years from 1901-1926, landings were linearly interpolated between assumed landings of zero in 1900, and the mean landings for 1927-29 used for “1927”.

Decision 2. With reasonably consistent data back to 1950, the Workgroup recommended that estimates of commercial landings be extended back to 1950.

3.2.2 Accumulated Landings System (ALS)

Historical commercial landings (1962 to present) for the US South Atlantic are maintained in the Accumulated Landings System (ALS) at the SEFSC. For detailed description of the Accumulated Landing System (ALS), see addendum to this section. These data were made available by Josh Bennett (NMFS Miami), and include landings from North Carolina through the Gulf of Mexico. The boundary of the Atlantic stock with the Gulf of Mexico stock is defined [Amendment 2 to the Coastal Migratory Pelagic Resources (Mackerels) FMP] as "*The Dade/Monroe county line (25^o 20.4' N. latitude in south Florida is to be the migratory group boundary for Spanish mackerel. Commercial fishery landings … have historically included Monroe County landings with the Gulf. There are few commercial landings of Dade and Palm Beach Counties and few ports available north of Marathon in Monroe County. Thus, there is a broad area of low catch on either side of this line which will facilitate enforcement.*" Rationale given in Amendment 2 was: "*While the stock identification for Spanish mackerel is not well defined, there is some evidence of Gulf and South Atlantic subpopulations with a mixing zone off south Florida, Williams, Murphy, and Muller (1985). The Councils' Stock Assessment Panel basing its recommendation on evidence from the electrophoresis studies, distributional patterns, spawning areas, and the history of exploitation suggested the Dade/Monroe County, Florida boundary as being a practical boundary because both recreational and commercial catch data for the Gulf and Atlantic have used this boundary. Dade County is the Miami area; while Monroe County includes the Florida Keys.*" This demarcation was implemented in the ALS database by using only landings, rather than catches, associated with the Atlantic coast of Florida (i.e., ALSSTATE = 10). See maps showing shrimp statistical areas for the Gulf of Mexico and U.S. Atlantic coasts (Figure 3.1) and Florida statistical areas (Figure 3.2).

Decision 3. The Workgroup recommends using the southern boundary in Amendment 2 to the Coastal Pelagics (Mackerels) FMP.

Florida's commercial fishery dominates the Atlantic coastal stock of Spanish mackerel, with 77.3% of the landings for the recent period 1997-2006 (their landings represented even higher percentages historically). The remaining south Atlantic states (Georgia-North Carolina) accounted for 17.4% (same time period), and more northern states (Virginia-Maine) accounted for the remaining 5.4%

The ALS database was then used to determine the importance of the different commercial gears to the Spanish mackerel landings from the US south Atlantic (Florida-North Carolina) for 1962-2007. About 88% of Florida's commercial landings were by gillnets (mostly gear code 475, "Runaround Drift Gillnets"), with lesser amounts from handlines (5.2%) and more recently castnets (6.8%). This latter category (code 735) shows up starting in 1995, with landings similar, or even exceeding, gillnets since 2003. This gear was apparently in response to Florida's net ban. For Georgia – North Carolina (mostly North Carolina), gillnets (dominated by gear 425, "Other Gillnets" – typically fixed or anchored) representing over 74% of the landings from this region, with significant landings by pound nets (11.4%), haul seines (8.2%), and handlines (4.3%).

Set gill net vs. runaround gillnet: When combining gear, it was suggested that we should not combine runaround gill net with set gill net as the selectivity may differ. We looked at the mean size of Spanish mackerel caught in each gear and found that set gill net had a mean length of 44 cm FL (SD = 8 cm FL), while runaround gill net had a mean length of 45 cm FL (SD = 7 cm FL). These lengths are not considered different and it was decided to combine the set gill net lengths with runaround gill net lengths (Figure 3.3).

Decision 4. The Workgroup recommends that landings by fishing gear be reduced to four categories, gillnets, castnets, pound nets and handlines. The small percentage from miscellaneous other gears can be pooled with gillnets.

Because Atlantic Spanish mackerel management currently prescribes a fishing year from March 1 through February 28 [Amendment 15 to the Coastal Pelagic (Mackerel) FMP], the ALS database was used to investigate landings by month for the US South Atlantic. We considered monthly landings separately from Florida (monthly data available since 1977) and from the other southern states (Georgia-North Carolina; monthly data available since 1972) using the ALS database. Data for the northern states downloaded from the SAFIS were available by month since 1980.

Florida's commercial fishery is prosecuted primarily during the winter months, with few Spanish mackerel landed between May and September (Figure 3.4). Hence landings for Florida will be adjusted from calendar to fishing year. Data is available for Florida by month in the ALS since 1977. But with no monthly data prior to 1977, adjustments will be based on an average proportion caught in Jan-Feb versus Mar-Dec from subsequent years when monthly data is available (i.e., 1977-1985).

The fisheries to the north, both Georgia-North Carolina and Virginia-Maine, are prosecuted principally during the summer and early fall, with only trivial landings made during January and February (Figures 3.5 and 3.6). Although any adjustment in landings to fishing year from calendar year would be minuscule, such adjustments were made for Georgia-North Carolina based on monthly data from 1972-1980, and for Virginia and north from 1980-2007. For clarification, t*he fishing year runs from March 1 through the end of February the following year, but the fishing year denoted in this report refers to that portion of the year that includes March – December. For example, the fishing year running from March 1, 2005 through February 28, 2006, is denoted as fishing year 2005.*

Decision 5. The Workgroup recommended that commercial landings be aligned to the current fishing year definition, principally affecting landings from Atlantic Florida; and that fishing year runs from March 1 through February 28.

Although Spanish mackerel were landed in gutted form historically, they are now typically landed whole. It is also important to avoid confusion between reporting some landings in whole weight (typically recreational) and other landings in gutted weight (typically commercial). For Spanish mackerel, there appears to be no reason to report landings in gutted weight.

Decision 6. The Workgroup recommended reporting commercial landings in whole weight.

There was discussion about whether small king mackerel are mis-identified as Spanish mackerel, and vice versa. This was not thought to be an issue. The recent king mackerel assessment made a similar judgment in SEDAR 16 data workshop. There does not exist a landings category for unclassified mackerels. Further, Spanish mackerels have been identified as such historically back to the 1800s.

Decision 7. The Workgroup recommended no adjustments be made for either mis-identification or unclassified mackerels.

3.2.3 Commercial Landings Developed from State Databases

Commercial landings in whole weight were developed based on classified Spanish mackerel by the Working Group from each state by gear for fishing years 1950-2007 from state-specific data as augmented by NMFS data described above. Landings from 1962 up to the beginning of state specific landings were obtained from the ALS described above or from the NMFS website/SAFIS for Virginia and north. The NMFS website data was used for landings back to 1950.

Florida – Edited data from 1986-2007 were extracted and summarized by fishing year (March-February), county landed, gear, and fishery (species groups associated with Spanish mackerel trips) with whole pounds, gutted pounds, and number of trips from the Florida trip ticket database. Gears selected for summary were gill nets, cast nets, lines (rod & reel, long line, and electric reel combined) and other. Since gear was not on the trip ticket until late 1991, to fill in for missing gears from 1986-1991, we assigned gear to trips based on gears listed on the commercial fishers' annual license application. A hierarchy of these gear types, based on usage in later years, was used in combination with species composition on the trips to assign the most appropriate gear. Data were then summarized by fishing year and gear for Florida south Atlantic waters from Nassau to Miami-Dade counties from 1985-86 through 2007-08. It was decided that south Atlantic harvest could be adequately calculated using the Florida trip ticket data. In addition, to better estimate harvest from March-December of 1985 (since 1986 is the first official year for trip tickets), and January-February of 2008 (incomplete data), data for all years from 1985-2008 were summarized by each fishing year period (March-December and January-February). An average proportion for each period will then be applied to the appropriate periods from 1985 and 2008 to complete the landings. Finally, size/market data by fishing year were supplied to estimate length by size/market category from the biostatistical (TIP) data.

Georgia – Georgia had no reported Spanish mackerel landings for 1989 – 2007 fishing years.

South Carolina – South Carolina commercial landings data were reported by coastal dealers starting in 1972 through mandatory monthly landings reports required from all SC licensed wholesale dealers. These reports were summaries which collected species, pounds landed, catch disposition (gutted or whole), ex-vessel price and area fished. In September 2003, South Carolina began collecting trip level information through mandatory trip tickets, which captures detailed effort information along with fisherman and vessel identifiers. The majority of commercial landings for Spanish mackerel are reported in whole weight, and in cases where they were reported as gutted weight, a conversion factor of 0.9 was used to determine whole weight. Landings were separated out by gear (hand lines, pound nets, gill nets and other) and by fishing year (1 March thru February 29). Spanish mackerel landings, as reported through monthly SC dealer summaries and trip tickets were documented starting in 1972. Overall, annual commercial landings are minimal, and the majority of landings can be attributed to bycatch from shrimp trawls and have been documented in the "Other" gear type category.

North Carolina – The National Marine Fisheries Service prior to 1978 collected commercial landings data for North Carolina. Port agents would conduct monthly surveys of the state's major commercial seafood dealers to determine the commercial landings for the state. Starting in 1978, the North Carolina Division of Marine Fisheries entered into a cooperative program with the National Marine Fisheries Service to maintain the monthly surveys of North Carolina's major commercial seafood dealers and to obtain data from more dealers. The North Carolina Division of Marine Fisheries Trip Ticket Program (NCTTP) began on 1 January 1994. The NCTTP was initiated due to a decrease in cooperation in reporting under the voluntary NMFS/North Carolina Cooperative Statistics Program in place prior to 1994, as well as an increase in demand for complete and accurate trip-level commercial harvest statistics by fisheries managers. The detailed data obtained through the NCTTP allows for the calculation of effort (i.e. trips, licenses, participants, vessels) in a given fishery that was not available prior to 1994 and provides a much more detailed record of North Carolina's seafood harvest. Annual landings of Spanish Mackerel were calculated for the SEDAR 17 Data Workshop for North Carolina. The annual landings are reported by fishing year, which runs from March to February. Data used to calculate the landings for North Carolina include the North Carolina Trip Ticket Program (1994 to 2008), landings from the ALS (1962 to 1993), and landings from historical data (prior to 1961). Prior to 1972, monthly landings were not recorded for North Carolina. Therefore, the proportion of landings of Spanish Mackerel from March to December and January to February by gear type were calculated across the years of 1972 to 2008. These proportions were then applied to the data that runs from 1950 to 1971 by gear type to determine the landings of Spanish Mackerel by fishing season.

Coastwide Landings in Pounds Commercial landings in pounds (whole weight) are summarized by region (Table 3.1 and Figure 3.7) and gear (Table 3.2 and Figure 3.8). Landings provided by the states were used preferentially to ALS (and in most cases was identical). As noted earlier based on the ALS data, landings are predominantly from Florida, followed by Georgia-North Carolina (mostly North Carolina), and Virginia-Maine. The dominant gear was gillnets, in turn dominated by runaround gillnets in Florida. Both gillnets and poundnets were important in North Carolina and further north. Handlines contribute landings up and down the coast (although mostly in Florida), while castnets have become very important in Florida since about 1995. Other than some peak landings in the latter half of the 1970s and early 1980s, Spanish mackerel commercial landings have been relatively flat, averaging 3.9 million pounds (whole weight) between 1950 and 2007. This average declines to about 3.4 million pounds, by excluding the peak years 1975-1982.

Combined Landings in Numbers – Conversion of commercial landings in weight to numbers is based on mean weights obtained from TIP length sampling by state (as augmented by additional data provided by NC DMF, particularly for pound nets), gear and year. First sampled lengths are converted to weight using the weight length relation given in the Life History Section. When TIP length samples were inadequate (N<20) or non-existent, a weighted average of available weight was obtained by averaging across years, either prior to 1986 or 1986 and later (Table 3.3). The 1986 was selected because of the implementation of a minimum size limit the previous August 1985. Landings in numbers are summarized by region (Table 3.4 and Figure 3.9) and by gear (Table 3.5 and Figure 3.10). Where there were insufficient or no samples available prior to 1986, average weight from post-1986 was used.

Uncertainty in Commercial Landings - The Workgroup discussed the uncertainty that may be associated with the estimates of commercial landings. In past assessments this discussion was framed about coefficients of variation (CV = standard deviation/mean) and how CVs may have varied over time. The CV was thought to have been high in the early years prior to the start of the ALS in 1962. Meanwhile, the CV was thought to be relatively low in recent years, subsequent to North Carolina's trip ticket program in 1994. During the discussion, it was suggested that further improvements were associated with the transfer of responsibility for collection and processing to the SEFSC in 1978 and beginning of state-federal co-operation. Between the late 1970s and 1994, a series of improvements occurred, such as the Florida trip ticket in 1985/1986. Hence, a low CV of 10% was chosen for the recent period (1994-present), high CV of 40% for pre-ALS data, 30% for the early years of the ALS, and a linear interpolation from 30% to 10% form 1978-1994 (Figure 3.11). The Workgroup suggests that these CVs may serve as the basis for developing alternate landings streams for sensitivity model runs.

3.3. Commercial Price

Price per pound was estimated for Spanish mackerel sold in the South Atlantic states from the ALS database (Atlantic Florida – North Carolina) for the years 1962 through 2007. The Producer Price Index (PPI) for "*prepared fresh fish and other seafood*" was obtained from the U.S. Bureau of Labor Statistics website (data.bls.gov), and this index is available starting in 1965. The PPI, like the CPI, is an index that reflects inflation. But the difference here is that the PPI reflects the inflation in costs associated with bringing the product to market. In other words, this PPI reflects more closely the change in costs to fishermen and processors such as trip costs. Using the initial year available (1965) as base year (divide annual index value by the 1965 index value), observed price per pound was adjusted to obtain inflation-adjusted values for the price per pound. Unadjusted and adjusted price per pound are compared in Figures 3.12. The observed price the fishermen received noted a general upwards trend from approximately $0.10 on average in 1965 to

$0.82 per pound in 2007. These values were adjusted by dividing them by the PPI index, such that PPI-adjusted values ranges from $0.10 in 1965 to $0.06 in 2007. Over time, the PPI-adjusted values initially declined to a minimum of about $0.04 in 1987 and then increased gradually since then.

3.4. Commercial Discards

3.4.1 Discards in the Commercial Fishery from Logbooks

The report titled '***Discards of Spanish Mackerel and Vermilion Snapper Calculated for Commercial Vessels with Federal Fishing Permits in the US South Atlantic***' was prepared by Kevin McCarthy (**SEDAR 17-DW10**). A brief summary of the results and discussion for Spanish mackerel follows:

Calculated total discards for each year are provided in Table 3.6 for Spanish mackerel discarded from gillnet, handline and trolling vessels, respectively. Prior to 1998, vessels landing Spanish mackerel were not required to report to the coastal logbook program and the level of reporting and, therefore, effort was unknown. Discards of Spanish mackerel could not be reliably calculated for the years prior to 1998. Because landings by trolling are included in the landing category 'handline', discard estimates of handline and trolling are combined.

Relatively few Spanish mackerel were reported as discarded. For handline and trolling gear, fewer than 2,300 fish were discarded each year. Less than 14,000 Spanish mackerel were discarded annually from the gillnet fishery. Often the number of discards of the species was less than 10,000. The number of trips upon which the calculations were based, however, was very small. These results should be interpreted with caution.

A high percentage of Spanish mackerel were reported as "dead" or "kept" when released regardless of the gear used. The reason reported for discarding Spanish mackerel was most often given as "market conditions" for gillnet trips (95% of individuals) and trolling trips (73%). Regulations were cited in 47% of handline Spanish mackerel discards with another 39% discarded without a reason reported.

The number of trips reporting either Spanish mackerel in the US south Atlantic was very low and the number of individuals of those species reported as discarded was also low. Stratification of the available data was limited because of the small sample sizes and, therefore, likely does not capture much of the variation in numbers of discards within the Spanish mackerel fisheries. How that may affect the number of calculated discards (over or under estimate) is unknown.

The Commercial Workgroup discussed whether these discard estimates could be further extended back in time, possibly based on the average discard to landings ratios in numbers from 1998-2007 as applied to corresponding gillnet and handline landings back to 1986. With Amendment 1 to the Coastal Migratory Pelagic Resources (Mackerels) FMP, a 12" FL (or 14" TL) minimum size limit was implemented in August 1985. Prior to this date, regulatory discarding was unlikely. The average discard to landings ratio was 0.6% for gillnets during 1998-2007 and 1.1% for handlines/trolling for the same time period. These ratios were applied to gillnet and handline landings for Florida – North Carolina for 1986-1997 to obtain estimates of discards from gillnets and handlines for 1986-1997, and are available for consideration by the Assessment Workshop Panel (Figure 3.13 and 3.14). Although uncertainty (as CV) is large for the estimates obtained from the logbooks back to 1998, the uncertainty associated with this additional extrapolation would likely be even larger.

Decision 8. The Workgroup accepted these estimates of Spanish mackerel discards from the gillnet and handline/trolling fisheries for 1998-2007, and offer an extension back to 1986 for use in sensitivity model runs.

3.4.2 Discards from the Shrimp Trawl Fishery

The report titled '***Estimation of Spanish mackerel and vermilion snapper bycatch in the shrimp trawl fishery in the US South Atlantic***' was prepared by Kate I. Andrews (**SEDAR 17-DW12**). A brief summary of the results and discussion for Spanish mackerel follows:

Estimates of Spanish mackerel bycatch in the shrimp trawl fishery was requested for the current SEDAR. Observer data are available, but sparse for the SA region. Effort data are available from representatives of each state (FL, GA, SC, and NC) and from the South Atlantic Shrimping System (SAS). The observer data were fit using a delta GLM model with a lognormal distribution. The resulting index was then scaled to an estimate of the number of fish caught using the average number of nets (from the observer data) and the effort in the SA.

There were historical data available (1972-1997) but there were so few occurrences of Spanish mackerel that the model threw those years out due to the lack of a model constraint (at least two positive tows in one year). The year 1980 had an inordinately large amount of Spanish mackerel caught that year in observed tows (19,000+), but the other years were incredibly small or non-existent. In fact the model threw out all years except 1979-1981 and 1984. The model then produced output too variable to create estimates, so the historical data bore no further investigation. There is no apparent pattern to where the Spanish mackerel were observed. Although there were not two positive tows in 2005 it is unlikely there were no Spanish mackerel caught in the shrimp fishery, but the model was unable to estimate a value for that year. The lognormal model performed better than the gamma model based on AIC scores, so the lognormal model is presented here. Interactions were considered, but no significant interactions were observed. The resulting index and estimates run from 1998-2006, with a missing year at 2005). The expanded estimates are provided for each state by year in the SA (Table 3.7).

Decision 9. The Workgroup considered these estimates of Spanish mackerel bycatch in the US South Atlantic shrimp trawl fishery for 1998-2004 and 2006, and recommended these estimates be carried forward.

3.5 Biological Sampling

3.5.1 Length Distributions

Length samples have been collected by the Trip Interview Program (TIP) and several state agencies since 1980. These samples are collected by port agents at docks where commercial catches are landed throughout the US South Atlantic coasts. Trips are randomly sampled to obtain trip, effort, catch and length frequency information. Occasionally there has been quota sampling to obtain age structures on fish that are rare in the catch (extremely large and small fish). These non-random samples are identified in the data to allow removal from analyses where non-random samples are not appropriate.

Sample data was obtained from the TIP sample data (NMFS/SEFSC), which is a data set from commercial, recreational and research programs. This data was merged with sample data from the inshore Spanish mackerel samples from NCDMF not contained in the data loaded to TIP. The combined dataset was censored to only include commercial samples identified as having no sampling bias, and where year, gear, and state could be assigned (Table 3.8).

Sample data were joined with landings data by year, gear and state. Landings data were also limited to those data that could be assigned a year, gear, and state. Landings and sample data were assigned a state based on landing and sample location.

Years were changed to fishing year by placing January and February in the previous year. Length data were converted to cm fork length and binned by one centimeter group with a floor of 0.5 cm and a ceiling of 0.4 cm. Length was converted to weight (whole weight in kg) using conversions provided by the life history group. The length data and landings data were broken into to two areas FL and NC-GA and five gears; castnet, gillnet, handline, poundnet and others. Length compositions were weighted by expanding the number of lengths in each strata (gear, area, year) by the landings in numbers (relative frequency in stratum x landings in numbers for the stratum).

Market category comparison: It was suggested that we use market category to obtain size trends in landings data. To accomplish this task we would need to allocate landings by size based on market grade. Market grade does vary between states.

Landings are available to varying degrees by market grade for Spanish mackerel for 1994-2007 (Figure 3.19). No landings were from Georgia, only a small amount of landings were from South Carolina and not by market grade, and landings from Virginia and north were not available by market grade. North Carolina landings were available mostly by market grade (about 10% were in the mixed category). Similarly, Florida landings were mostly be market grade (about 9% were 'mixed' or no information provided). Overall, about 62% of Spanish mackerel landings were available by market grade (generally small, medium and large).

However, of the 145,611 length samples obtained for Spanish mackerel, only 28,883 had a market category assigned. It was felt that having only 20% of the samples with market category was inadequate to allocate landings at size by market category.

3.5.2 Age Distributions

A review of the aging data for Spanish mackerel can be found in SEDAR 17 DW07, prepared by Chris Palmer, Doug DeVries, Carrie Fioramonti, and Linda Lombardi-Carlson. Sample size of Spanish mackerel ages from commercial landings in the US Atlantic are summarized by gear for fishing years1986-2007 (Table 3.9). A total of 8,868 aged Spanish mackerel are available for developing age compositions. Age compositions were developed for gillnets (Figure 3.20), castnets (Figure 3.21), handline (Figure 3.22), poundnets (Figure 3.23), and other (Figure 3.24) gear types. Age compositions are plotted for sample size 19 or greater. Weighting was initially by state landings in numbers, and then by length composition as shown in Figures 3.14 -3.18, respectively. This latter weighting is intended to correct for a potential sampling bias of age samples relative to length samples (see Section 3 in SEDAR10 for South Atlantic gag grouper).

3.5.3 Adequacy for characterizing lengths and ages

A total of 145,611 Spanish mackerel lengths were available for use in developing annual length compositions by gear (Table 3.8). Over half of these samples (74,286 fish lengths) were from gillnets collected primarily since 1984 (with the exception of 15 collected in 1982). Of these gillnet fish samples, 83% were collected in Atlantic Florida (compared to 79% of gillnet landings by weight since 1984). The remaining gillnet fish samples (12,514 fish lengths) were from Georgia-North Carolina. Fish samples from castnets, a Florida phenomena in this setting, are only available from Florida and almost entirely since 1996 (13,706 fish lengths, excluding 2 in 1993). Likewise, fish samples from poundnets, no landings from Florida, are only available from Georgia-North Carolina since 1982 (15,518 fish lengths, excluding 9 in 1980). Handline landings are predominantly from Florida (94% by weight), and so are sampled fish lengths (99%). Finally, fish lengths collected from other gears are distributed as 83% from Florida and 17% from Georgia-North Carolina (somewhat reflecting 76% of the landings from Florida). Note that there are no length samples available from Virginia and north (about 7% of the total landings). It is clear from the summary of samples for fish lengths, that there are gear/year combinations for which there may be inadequate samples, even though the overall sample size may appear adequate (Table 3.8). In certain years, post-stratification will be unable to adjust sample weights between Florida and GA-NC. In particular when there were no gillnet samples from GA-NC (1989, 1994, and 1996), or more recently when there were no gillnet samples from Florida (2004 and 2007).

There were two years for which the handline length composition contained a large proportion of fish greater than 70 cm FL, with about 30% in 1994 and over 87% in 1996. The data for these two years were limited to relatively few trips (9 in 1994 and 7 in 1996), and most of the sampled fish came from even fewer trips (2 trips in 1994 and 3 trips in 1996). This situation raises concerns about the representativeness of the handline length compositions for these two years. For other years, the fish lengths were better distributed among many more trips.

A minimum sample size of 20 ages was selected for developing age compositions. The largest sample sizes were associated with gillnets, the dominant gear. Of the 5,443 aged fish from gillnets, 3,847 were from Atlantic Florida, and 1,529 from North Carolina and South Carolina between 1986 and 1990. Ages from Florida gillnets were not available until 1991. All castnet ages were from Florida, while all pound net samples were from North Carolina, as expected. There was a mix of samples for handlines: 759 from Atlantic Florida, 302 from North Carolina and South Carolina. The age composition for handlines in 1990 would be problematic, because all 38 ages were from South Carolina. Less problematic would be that the 130 ages in 1999, 26 ages in 2002, and 25 ages in 2007 are only from Florida. Many of the age samples from "Other" gears were actually from unknown gears (1,052 out of 1,615). In particular, 853 of the 900 aged fish in 2002 were from VIMS (Virginia waters), all from unknown gears.

In general, the Workgroup suggested lumping landings from Other gears with the dominant gear (gillnets), and consequently not using length and age compositions from Other gears.

3.6 Research Recommendations for Spanish mackerel

- Need observer coverage for the fisheries for Spanish mackerel (gillnets, castnets (FL), handlines, poundnets and shrimp trawls for bycatch):
  - 5-10% allocated by strata within states
  - possible to use exemption to bring in everything with no sale
  - get maximum information from fish
- Expand TIP sampling to better cover all statistical strata
  - Predominantly from Florida and by gillnet & castnet gears
  - In that sense, we have decent coverage for lengths
- Trade off with lengths versus ages, need for more ages (i.e., hard parts)
- Need to address issue of fish retained for bait (undersized) or used for food by crew.(how to capture in landings)

==

Addendum to Commercial Landings (Section 3.2):

NMFS SEFIN Accumulated Landings (ALS)

Information on the quantity and value of seafood products caught by fishermen in the U.S. has been collected as early as the late1890s. Fairly serious collection activity began in the 1920s. The data set maintained by the Southeast Fisheries Science Center (SEFSC) in the SEFIN database management system is a continuous data set that begins in 1962.

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

Commercial landings statistics have been collected and processed by various organizations during the 1962-to-present period that the SEFIN data set covers. During the 16 years from 1962 through 1978, these data were collected by port agents employed by the Federal government and stationed at major fishing ports in the southeast. The program was run from the Headquarters Office of the Bureau of Commercial Fisheries in Washington DC. Data collection procedures were established by Headquarters and the data were submitted to Washington for processing and computer storage. In 1978, the responsibility for collection and processing were transferred to the SEFSC.

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

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

1960 - Late 1980s
=================
Although the data processing and database management responsibility were transferred from the Headquarters in Washington DC to the SEFSC during this period, the data collection procedures remained essentially the same. Trained data collection personnel, referred to as fishery reporting specialists or port agents, were stationed at major fishing ports throughout the Southeast Region. The data collection procedures for commercial landings included two parts.

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

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

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

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

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

Cooperative Statistics Program
==============================

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

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

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

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

Florida
=======

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

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

Georgia
=======

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

South Carolina
===========

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

South Carolina began collecting TIP length frequencies in 1983 as part of the Cooperative Statistics Program. Target species and length quotas were supplied by NMFS and sampling targets of 10% of monthly commercial trips by gear were set to collect those species and length frequencies. In 2005, South Carolina began collecting age structures (otoliths) in addition to length frequencies, using ACCSP funding to supplement CSP funding.

North Carolina

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

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

NMFS SEFIN Annual Canvas Data for Florida

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

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

Table 3.1. Spanish mackerel commercial landings (pounds whole weight) by region for the US Atlantic coast. Landings for Florida and Georgia – North Carolina are from the state representatives and augmented as needed with the SEFSC Accumulated Landings System (ALS). Landings for Virginia-Maine were downloaded from SAFIS for 1980-2007 and augmented with earlier data downloaded from the NMFS website. These landings are reported by fishing year (March-February), 1950-2007. Years prior to 1962 are all from NMFS website.

Fishing	US Atlantic Coast			
Year	Florida	Georgia-North Carolina	Virginia and North	Total
1950	2,860,384	147,497	13,457	3,021,338
1951	2,630,016	206,288	6,675	2,842,979
1952	3,499,943	174,268	2,801	3,677,013
1953	2,917,579	195,443	3,003	3,116,024
1954	2,610,245	329,463	3,514	2,943,222
1955	3,838,165	165,443	5,769	4,009,377
1956	4,418,105	346,581	16,647	4,781,333
1957	5,603,620	247,795	23,998	5,875,413
1958	5,088,283	216,285	7,970	5,312,538
1959	2,320,648	156,397	19,006	2,496,051
1960	2,674,347	124,500	20,551	2,819,399
1961	2,898,227	137,577	122,515	3,158,319
1962	2,327,143	96,511	15,008	2,438,662
1963	2,056,484	144,194	79,009	2,279,687
1964	2,498,386	81,310	33,461	2,613,157
1965	2,503,598	130,807	75,028	2,709,433
1966	1,971,607	80,787	141,692	2,194,085
1967	3,239,760	76,690	30,290	3,346,741
1968	3,275,934	70,502	60,704	3,407,139
1969	3,029,951	88,601	124,787	3,243,340
1970	3,026,370	63,727	200,657	3,290,754
1971	3,016,425	95,458	51,918	3,163,801
1972	3,277,349	105,992	23,371	3,406,712
1973	2,729,892	73,060	50,145	2,853,098
1974	3,891,305	77,191	26,065	3,994,561
1975	7,598,290	63,113	67,890	7,729,293
1976	11,466,317	36,896	81,618	11,584,832
1977	6,837,374	48,138	21,376	6,906,888
1978	6,253,326	40,670	1,793	6,295,789
1979	6,302,624	16,072	752	6,319,448
1980	6,343,536	82,566	604	6,426,706
1981	2,854,676	52,210	580	2,907,466
1982	6,891,817	191,043	288	7,083,148
1983	3,426,257	42,042	5,673	3,473,972
1984	3,609,012	128,902	103	3,738,017
1985	3,267,688	174,034	222	3,441,944

Table 3.1. (cont.)

1986	2,206,188	239,907	6,499	2,452,594
1987	2,307,282	505,279	68,170	2,880,731
1988	3,141,359	440,100	34,419	3,615,878
1989	2,877,585	590,865	423,607	3,892,057
1990	2,165,531	839,226	599,992	3,604,749
1991	2,982,448	859,224	765,365	4,607,037
1992	2,464,357	740,351	396,152	3,600,860
1993	4,043,268	590,334	412,715	5,046,317
1994	4,461,090	531,718	528,960	5,521,768
1995	1,260,161	402,709	227,732	1,890,602
1996	2,337,557	402,021	312,964	3,052,542
1997	2,108,989	766,931	211,015	3,086,935
1998	2,667,802	373,020	185,980	3,226,802
1999	1,607,051	459,094	339,902	2,406,047
2000	1,766,569	659,455	255,579	2,681,603
2001	2,193,722	653,176	243,680	3,090,578
2002	2,383,029	698,895	153,638	3,235,562
2003	3,158,137	456,938	133,285	3,748,360
2004	2,812,341	455,703	97,379	3,365,423
2005	3,167,532	445,963	59,157	3,672,652
2006	3,156,517	471,671	17,807	3,645,995
2007	2,508,404	487,200	25,141	3,020,745

Table 3.2. Spanish mackerel commercial landings (pounds whole weight) by gear for the US Atlantic coast. Landings for Florida and Georgia – North Carolina are from the state representatives and augmented as needed with the SEFSC Accumulated Landings System (ALS). Landings for Virginia-Maine were downloaded from SAFIS for 1980-2007 and augmented with earlier data downloaded from the NMFS website. These landings are reported by fishing year (March-February), 1950-2007. Years prior to 1962 are all from NMFS website.

Fishing	US Atlantic Coast					
Year	Gillnets	Castnets	Poundnets	Handlines	Other	Total
1950	2,979,370	0	13,457	0	28,512	3,021,338
1951	2,724,806	0	6,377	0	111,797	2,842,979
1952	3,578,614	0	2,601	0	95,797	3,677,013
1953	2,948,994	0	801	0	166,230	3,116,024
1954	2,666,626	0	3,514	0	273,081	2,943,222
1955	3,864,188	0	5,769	0	139,420	4,009,377
1956	4,481,198	0	15,945	0	284,190	4,781,333
1957	5,655,415	0	14,837	5	205,156	5,875,413
1958	5,132,174	0	5,650	9,999	164,715	5,312,538
1959	2,349,243	0	16,505	8,809	121,494	2,496,051
1960	2,694,147	0	20,551	24,997	79,703	2,819,399
1961	2,918,817	0	121,720	19,989	97,794	3,158,319
1962	2,255,134	0	14,083	75,627	93,818	2,438,662
1963	2,014,934	0	65,260	54,283	145,211	2,279,687
1964	2,415,377	0	32,386	103,222	62,171	2,613,157
1965	2,382,907	0	89,718	152,639	84,168	2,709,433
1966	1,854,689	0	111,249	172,538	55,608	2,194,085
1967	3,102,569	0	23,439	142,450	78,283	3,346,741
1968	3,139,402	0	73,217	123,104	71,416	3,407,139
1969	2,914,553	0	84,228	103,006	141,553	3,243,340
1970	2,938,042	0	104,466	127,184	121,062	3,290,754
1971	2,934,262	0	25,622	119,256	84,661	3,163,801
1972	3,181,305	0	22,975	134,127	68,306	3,406,712
1973	2,572,062	0	50,567	161,977	68,492	2,853,098
1974	3,638,193	0	25,477	283,203	47,688	3,994,561
1975	6,979,294	0	61,606	622,997	65,396	7,729,293
1976	10,891,776	0	76,705	581,893	34,457	11,584,832
1977	6,732,009	0	28,847	125,056	20,975	6,906,888
1978	6,239,821	0	2,396	43,874	9,698	6,295,789
1979	6,263,385	0	771	50,288	5,004	6,319,448
1980	6,356,694	0	4,015	49,685	16,312	6,426,706
1981	2,861,488	0	1,711	37,358	6,909	2,907,466
1982	6,969,239	0	10,825	91,009	12,075	7,083,148
1983	3,415,117	0	13,208	30,281	15,366	3,473,972
1984	3,638,444	0	14,270	50,140	35,163	3,738,017
1985	3,137,390	3,109	32,917	58,927	209,601	3,441,944

Table 3.2. (cont.)

1986	1,941,518	229	39,354	55,923	415,570	2,452,594
1987	1,771,923	759	235,061	115,831	757,157	2,880,731
1988	2,495,669	960	182,884	103,615	832,750	3,615,878
1989	2,354,637	8	504,557	141,772	891,083	3,892,057
1990	2,523,552	1,136	509,415	249,717	320,929	3,604,749
1991	3,625,062	319	468,247	285,484	227,925	4,607,037
1992	3,002,580	44	396,725	72,921	128,590	3,600,860
1993	4,585,016	36	328,326	60,917	72,022	5,046,317
1994	5,025,896	26	345,270	69,470	81,106	5,521,768
1995	1,375,791	34,114	207,390	199,656	73,651	1,890,602
1996	2,428,844	197,449	302,190	83,224	40,835	3,052,542
1997	2,659,955	76,470	207,649	92,925	49,937	3,086,935
1998	2,865,977	33,149	117,742	176,293	33,642	3,226,802
1999	1,532,370	345,491	301,805	201,662	24,720	2,406,047
2000	1,541,415	621,875	206,137	278,029	34,148	2,681,603
2001	1,483,788	934,494	221,644	419,494	31,159	3,090,578
2002	1,309,545	1,420,230	135,683	361,930	8,174	3,235,562
2003	943,902	2,270,236	111,397	416,038	6,786	3,748,360
2004	762,143	1,744,518	72,192	760,911	25,660	3,365,423
2005	1,197,040	1,716,393	49,540	697,521	12,157	3,672,652
2006	1,400,442	1,380,341	9,532	838,653	17,027	3,645,995
2007	1,690,573	548,723	13,614	753,181	14,654	3,020,745

Table 3.3. Spanish mackerel mean weights (in pounds, based on lengths from TIP/states and weight-length relation). Shaded numbers represent averages weighted by sample size across years; and where possible averages are separated prior to and including 1985 and 1986 and later. Mean weights for Georgia – North Carolina applied to landings in weights from Virginia and north.

Fishing	Florida				Georgia - North Carolina			
Year	Gillnets	Castnets	Handlines	Other	Gillnets	Poundnets	Handlines	Other
1950	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1951	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1952	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1953	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1954	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1955	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1956	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1957	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1958	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1959	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1960	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1961	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1962	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1963	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1964	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1965	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1966	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1967	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1968	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1969	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1970	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1971	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1972	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1973	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1974	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1975	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1976	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1977	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1978	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1979	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1980	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1981	2.235	2.002	2.487	1.563	3.799	0.626	4.755	1.019
1982	2.235	2.002	2.487	1.563	3.799	0.849	4.755	1.019
1983	2.235	2.002	2.487	1.563	3.799	0.671	4.755	1.019
1984	2.235	2.002	2.487	1.706	2.277	0.690	4.755	1.019
1985	2.235	2.002	2.487	1.495	5.963	0.403	4.755	0.721

Table 3.3. (cont.)

1986	2.057	2.002	2.487	2.209	1.858	0.736	5.470	0.401
1987	2.099	2.002	2.487	2.209	0.767	0.757	6.261	1.479
1988	2.499	2.002	2.487	2.209	1.023	0.782	4.755	1.539
1989	4.728	2.002	2.487	2.209	1.858	0.544	4.755	1.338
1990	3.343	2.002	2.487	2.209	1.662	0.550	5.287	0.996
1991	3.124	2.002	2.062	2.209	2.791	0.666	4.755	0.778
1992	2.870	2.002	3.674	2.877	1.768	0.807	4.755	1.045
1993	2.507	2.002	1.745	2.156	1.647	1.025	4.755	1.224
1994	2.359	2.002	3.605	2.840	1.858	0.664	4.755	0.884
1995	2.671	2.002	1.461	2.209	1.243	1.199	4.755	1.636
1996	1.961	2.002	11.507	2.209	1.858	1.216	4.755	1.424
1997	1.847	1.453	2.863	2.209	1.636	1.119	4.755	1.850
1998	1.653	2.002	2.661	2.209	2.158	1.271	4.755	1.889
1999	2.090	2.002	2.676	2.209	1.916	0.998	4.755	1.371
2000	1.840	2.182	2.121	2.209	1.931	1.408	4.755	1.204
2001	1.330	1.793	2.516	2.209	1.673	1.223	4.755	1.671
2002	1.376	1.887	2.399	2.209	1.687	1.221	4.755	1.532
2003	1.527	2.213	1.941	2.209	2.008	1.314	4.755	1.168
2004	2.410	2.744	3.460	2.044	2.130	1.331	4.755	2.092
2005	1.393	1.648	1.749	2.183	1.847	0.912	4.755	1.942
2006	1.592	2.067	2.460	2.681	2.006	1.290	4.755	1.636
2007	2.410	1.993	2.487	2.167	1.781	0.894	4.755	1.444

Table 3.4. Commercial landings of Spanish mackerel by region in numbers for fishing years, 1950-2007.

Fishing Year	US Atlantic Coast			
	Florida	Georgia-North Carolina	Virginia and North	Total
1950	1,280,054	59,317	21,493	1,360,864
1951	1,176,961	134,423	10,478	1,321,862
1952	1,566,264	114,568	4,351	1,685,183
1953	1,305,649	169,313	3,441	1,478,403
1954	1,168,114	282,955	5,612	1,456,681
1955	1,717,622	143,734	9,214	1,870,569
1956	1,977,151	294,939	26,156	2,298,247
1957	2,507,683	206,065	32,691	2,746,438
1958	2,277,064	173,097	11,301	2,461,462
1959	1,038,516	126,208	28,816	1,193,541
1960	1,196,800	88,722	32,824	1,318,346
1961	1,296,989	104,857	195,186	1,597,032
1962	1,038,231	91,286	23,401	1,152,919
1963	918,006	131,891	117,730	1,167,626
1964	1,114,016	69,292	47,551	1,230,859
1965	1,114,773	112,997	118,841	1,346,611
1966	876,758	36,010	206,894	1,119,662
1967	1,447,426	57,192	43,301	1,547,919
1968	1,465,599	75,332	88,900	1,629,831
1969	1,354,388	84,461	174,224	1,613,073
1970	1,353,194	57,621	221,709	1,632,525
1971	1,351,758	51,794	54,918	1,458,469
1972	1,467,347	52,146	36,500	1,555,993
1973	1,218,183	55,621	78,986	1,352,790
1974	1,731,622	44,107	40,023	1,815,753
1975	3,377,266	50,206	94,093	3,521,565
1976	5,108,216	23,938	122,402	5,254,557
1977	3,054,198	40,088	31,488	3,125,775
1978	2,796,627	18,365	2,343	2,817,335
1979	2,818,996	5,918	1,135	2,826,049
1980	2,837,528	35,668	880	2,874,076
1981	1,277,016	18,409	622	1,296,048
1982	3,083,676	61,845	316	3,145,837
1983	1,533,857	27,220	6,900	1,567,977
1984	1,617,686	69,224	45	1,686,955
1985	1,503,278	128,306	268	1,631,852

Table 3.4. (cont.)

1986	1,057,477	245,987	7,837	1,311,301
1987	1,079,386	558,072	63,267	1,700,725
1988	1,297,161	449,053	33,617	1,779,831
1989	817,821	548,527	676,278	2,042,625
1990	705,345	571,263	918,693	2,195,302
1991	996,308	504,459	758,321	2,259,089
1992	853,577	573,736	358,127	1,785,440
1993	1,622,336	394,580	340,471	2,357,387
1994	1,878,845	331,260	595,311	2,805,415
1995	538,191	321,827	178,081	1,038,099
1996	1,155,316	230,627	242,865	1,628,807
1997	1,135,303	482,378	168,974	1,786,655
1998	1,569,811	181,628	116,222	1,867,661
1999	755,634	263,684	300,786	1,320,104
2000	887,012	347,600	173,916	1,408,528
2001	1,324,771	391,426	186,899	1,903,096
2002	1,340,454	419,373	116,437	1,876,264
2003	1,549,041	229,160	95,043	1,873,244
2004	984,160	214,446	65,138	1,263,743
2005	1,980,069	241,537	58,162	2,279,768
2006	1,596,854	235,966	11,308	1,844,128
2007	1,079,181	274,353	20,861	1,374,394

Table 3.5. Commercial landings of Spanish mackerel by gear in numbers for fishing years 1950-2007.

Fishing	US Atlantic Coast					
Year	Gillnets	Castnets	Poundnets	Handlines	Other	Total
1950	1,311,378	0	21,493	0	27,993	1,360,864
1951	1,201,916	0	10,184	0	109,762	1,321,862
1952	1,586,974	0	4,154	0	94,054	1,685,183
1953	1,313,919	0	1,279	0	163,205	1,478,403
1954	1,182,957	0	5,612	0	268,112	1,456,681
1955	1,724,473	0	9,214	0	136,883	1,870,569
1956	1,993,761	0	25,467	0	279,018	2,298,247
1957	2,521,318	0	23,697	1	201,422	2,746,438
1958	2,288,618	0	9,023	2,103	161,718	2,461,462
1959	1,046,044	0	26,361	1,852	119,284	1,193,541
1960	1,202,013	0	32,824	5,257	78,252	1,318,346
1961	1,302,409	0	194,405	4,203	96,014	1,597,032
1962	1,008,367	0	22,493	30,354	91,705	1,152,919
1963	899,402	0	104,230	21,655	142,339	1,167,626
1964	1,078,844	0	51,726	39,589	60,700	1,230,859
1965	1,063,926	0	143,294	57,426	81,964	1,346,611
1966	826,308	0	177,683	62,019	53,652	1,119,662
1967	1,383,572	0	37,435	57,282	69,630	1,547,919
1968	1,402,505	0	116,938	49,445	60,943	1,629,831
1969	1,303,833	0	134,526	41,210	133,504	1,613,073
1970	1,304,592	0	166,848	49,977	111,108	1,632,525
1971	1,299,569	0	40,922	47,726	70,252	1,458,469
1972	1,410,583	0	36,694	53,571	55,145	1,555,993
1973	1,146,546	0	80,763	65,135	60,346	1,352,790
1974	1,620,008	0	40,691	113,573	41,480	1,815,753
1975	3,117,903	0	98,395	250,238	55,030	3,521,565
1976	4,870,599	0	122,510	233,194	28,254	5,254,557
1977	3,008,951	0	46,074	50,288	20,463	3,125,775
1978	2,786,729	0	3,827	17,548	9,231	2,817,335
1979	2,801,963	0	1,231	18,693	4,162	2,826,049
1980	2,834,589	0	6,413	17,945	15,129	2,874,076
1981	1,275,969	0	2,733	11,046	6,300	1,296,048
1982	3,097,602	0	12,756	25,382	10,097	3,145,837
1983	1,526,007	0	19,672	9,571	12,727	1,567,977
1984	1,627,658	0	20,691	13,636	24,969	1,686,955
1985	1,376,145	1,553	81,675	19,182	153,298	1,631,852

Table 3.5. (cont.)

1986	951,111	114	53,438	17,912	288,726	1,311,301
1987	992,175	379	310,479	32,401	365,290	1,700,725
1988	1,115,912	480	233,826	38,485	391,129	1,779,831
1989	619,448	4	927,325	54,936	440,912	2,042,625
1990	995,111	567	926,846	87,157	185,619	2,195,302
1991	1,195,102	159	703,409	116,157	244,262	2,259,089
1992	1,191,973	22	491,640	19,434	82,369	1,785,440
1993	1,956,146	18	320,241	30,051	50,931	2,357,387
1994	2,207,248	13	519,864	18,927	59,364	2,805,415
1995	668,828	17,042	173,005	135,808	43,415	1,038,099
1996	1,249,382	98,636	248,591	7,677	24,521	1,628,807
1997	1,490,599	52,635	185,636	31,647	26,138	1,786,655
1998	1,675,541	16,560	92,620	65,523	17,417	1,867,661
1999	753,648	172,591	302,434	74,388	17,044	1,320,104
2000	820,460	285,040	146,359	130,155	26,515	1,408,528
2001	1,018,608	521,271	181,256	163,607	18,355	1,903,096
2002	856,995	752,500	111,095	150,412	5,263	1,876,264
2003	543,997	1,025,831	84,785	213,812	4,820	1,873,244
2004	341,694	635,647	54,253	219,741	12,408	1,263,743
2005	780,529	1,041,278	54,299	397,719	5,943	2,279,768
2006	819,370	667,721	7,389	340,346	9,301	1,844,128
2007	772,475	275,374	15,220	302,125	9,199	1,374,394

Table 3.6a. Calculated yearly total discards of Spanish mackerel by gillnet vessels. Discards are reported in number of fish.

Year	Mean Discards per Square Yard Hour Fished	Discard Standard Deviation	Total Effort (net hours)	Calculated Discards
1998	0.000128	0.001248	68,319,392	8,755
1999	0.000128	0.001248	108,069,010	13,849
2000	0.000128	0.001248	78,265,803	10,030
2001	0.000128	0.001248	83,909,664	10,753
2002	0.000128	0.001248	94,771,378	12,145
2003	0.000128	0.001248	66,592,702	8,534
2004	0.000128	0.001248	51,634,828	6,617
2005	0.000128	0.001248	65,057,690	8,337
2006	0.000128	0.001248	55,474,032	7,109
2007	0.000128	0.001248	49,149,096	6,299

Table 3.6b. Calculated yearly total discards of Spanish mackerel by handline vessels. Discards are reported in number of fish.

Year	Mean Discards per Hook Hour	Discard Standard Deviation	Total Effort (Hook Hours)	Calculated Discards
1998	0.001781	0.048638	1,181,706	2,105
1999	0.001781	0.048638	975,510	1,737
2000	0.001781	0.048638	1,028,259	1,831
2001	0.001781	0.048638	1,081,936	1,927
2002	0.001781	0.048638	1,256,812	2,238
2003	0.001781	0.048638	1,111,641	1,980
2004	0.001781	0.048638	769,984	1,371
2005	0.001781	0.048638	720,595	1,283
2006	0.001781	0.048638	828,102	1,475
2007	0.001781	0.048638	878,993	1,565

Table 3.6c. Calculated yearly total discards of Spanish mackerel by trolling vessels. Discards are reported in number of fish.

Year	Mean Discards per Hook Hour	Discard Standard Deviation	Total Effort (Hook Hours)	Calculated Discards
1998	0.001781	0.048638	1,181,706	2,105
1999	0.001781	0.048638	975,510	1,737
2000	0.001781	0.048638	1,028,259	1,831
2001	0.001781	0.048638	1,081,936	1,927
2002	0.001781	0.048638	1,256,812	2,238
2003	0.001781	0.048638	1,111,641	1,980
2004	0.001781	0.048638	769,984	1,371
2005	0.001781	0.048638	720,595	1,283
2006	0.001781	0.048638	828,102	1,475
2007	0.001781	0.048638	878,993	1,565

Table 3.7. The catch index and estimated number of Spanish mackerel bycatch in the SA shrimp trawl fishery by year.

Year	Index	CV	Estimates
1998	0.176	0.461	417111
1999	2.990	0.284	7004988
2000	3.169	0.214	6340696
2001	0.993	0.507	1415705
2002	0.179	0.372	265600
2003	0.2639	0.414	362660
2004	0.110	0.783	129257
2005			
2006	0.100	0.553	115352
2007			

Table 3.8. Spanish mackerel lengths sampled from the commercial fishery and available in the TIP data base for fishing years 1980-2007. Also includes data provided from inshore fisheries by NC DMF.

	Cast Net		Gill Net		Pound Net		Handline		Other	
Year	FL	NC-GA	FL	NC-GA	FL	NC-GA	FL	NC-GA	FL	NC-GA
1980	0	0	0	0	0	9	0	0	0	2
1981	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	15	0	259	0	0	0	7
1983	0	0	0	0	0	42	0	0	0	4
1984	0	0	900	68	0	56	0	11	695	1
1985	0	0	363	26	0	296	4	3	347	29
1986	0	0	1,469	48	0	181	4	20	0	65
1987	0	0	55	125	0	557	0	45	0	46
1988	0	0	1,232	278	0	666	0	0	0	285
1989	0	0	456	0	0	1,194	0	2	0	240
1990	0	0	3,401	84	0	1,189	9	24	0	948
1991	0	0	6,245	23	0	1,583	142	19	41	396
1992	0	0	9,417	516	0	2,206	162	40	52	299
1993	2	0	7,849	96	0	549	184	7	251	314
1994	0	0	7,536	0	0	510	73	0	0	166
1995	0	0	1,100	11	0	1,203	31	0	0	20
1996	50	0	2,951	0	0	531	102	0	0	155
1997	0	0	1,459	73	0	944	98	0	1	56
1998	4	0	6,293	25	0	827	774	1	9	142
1999	50	0	7,159	255	0	1,152	2,878	1	0	261
2000	3,360	0	2,042	1,681	0	133	2,506	1	11	286
2001	3,683	0	891	480	0	283	4,314	0	26	264
2002	1,967	0	341	600	0	438	3,229	1	22	86
2003	1,686	0	432	423	0	64	762	0	959	67
2004	893	0	0	1,089	0	56	225	0	3,473	21
2005	1,381	0	50	2,051	0	243	468	1	1,722	83
2006	577	0	131	2,495	0	143	84	8	6,127	86
2007	55	0	0	2,052	0	213	5	0	7,610	177

Table 3.9. Spanish mackerel ages sampled from the commercial fishery by gear and available from NMFS Panama City for fishing years 1986-2007.

Fishing Year	Gearname Gillnet	Castnet	Poundnet	Handline	Other	Grand Total
1986	2				4	6
1988	72			9	49	130
1989	135			62	2	199
1990	216		6	38	19	279
1991	175			2	134	311
1992	250		28	79	129	486
1993	90			6	85	181
1994	23				16	39
1995	154		20	25	7	206
1996	417	34		41	34	526
1997	246		4	35	38	323
1998	363		50	84	83	580
1999	528	3	23	130	7	691
2000	539	110		93	58	800
2001	452		60	246	20	778
2002	376			26	900	1302
2003	323					323
2004	336	147	2	2	16	503
2005	249	212		5	12	478
2006	315	50		153	2	520
2007	182			25		207
Grand Total	5443	556	193	1061	1615	8868

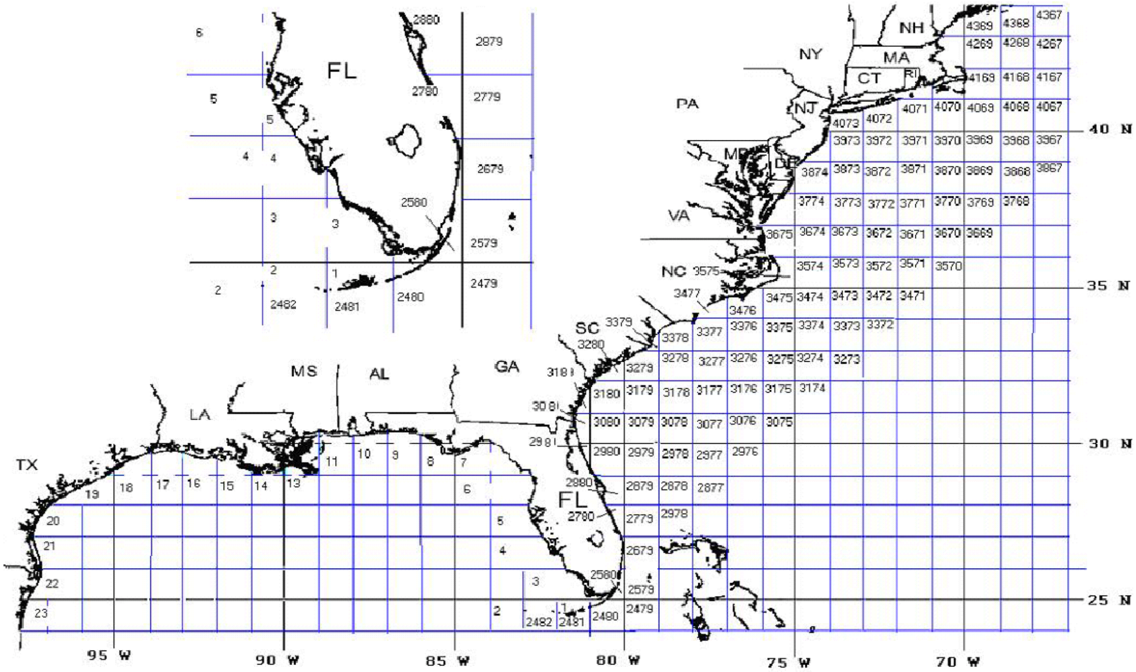


Figure 3.1. Map of U.S. Atlantic and Gulf coast with shrimp area designations.

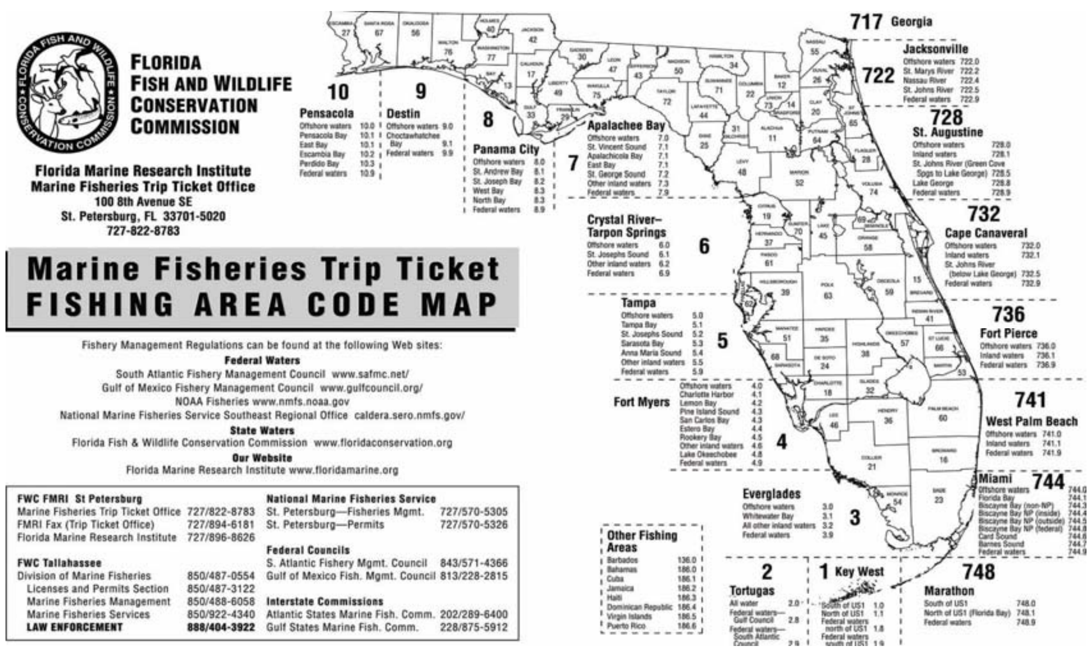


Figure 3.2. Map showing marine fisheries trip ticket fishing area code map for Florida.

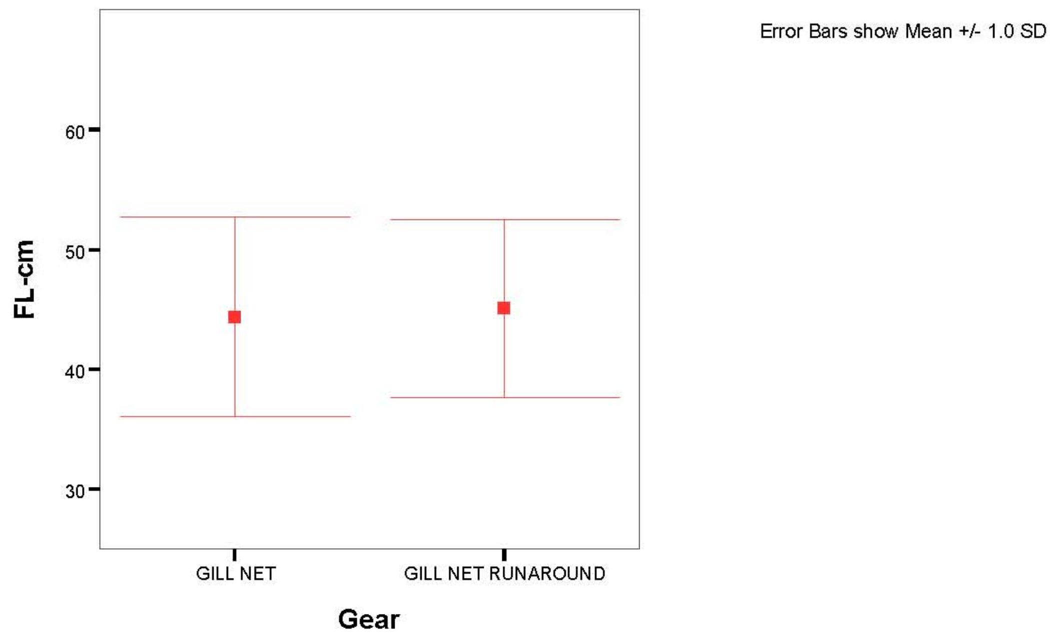


Figure 3.3. Comparison of mean lengths for Spanish mackerel caught with set gill net gear and runaround gill net gear.

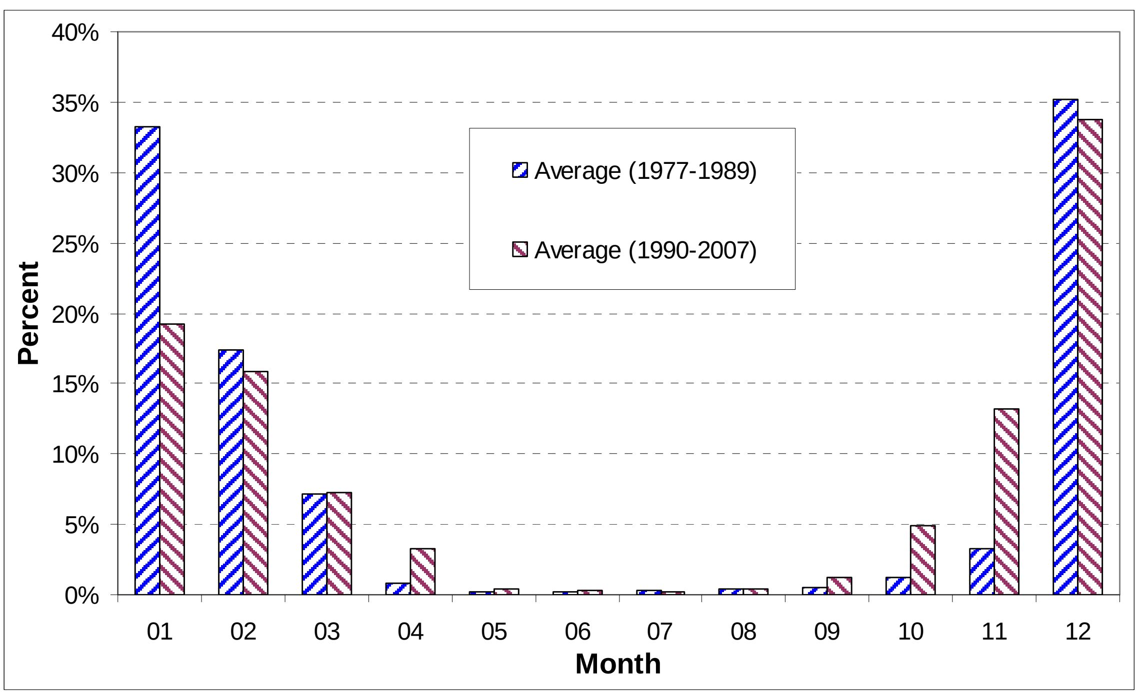


Figure 3.4. Spanish mackerel commercial landings by month from Atlantic Florida from ALS database, 1977-2007.

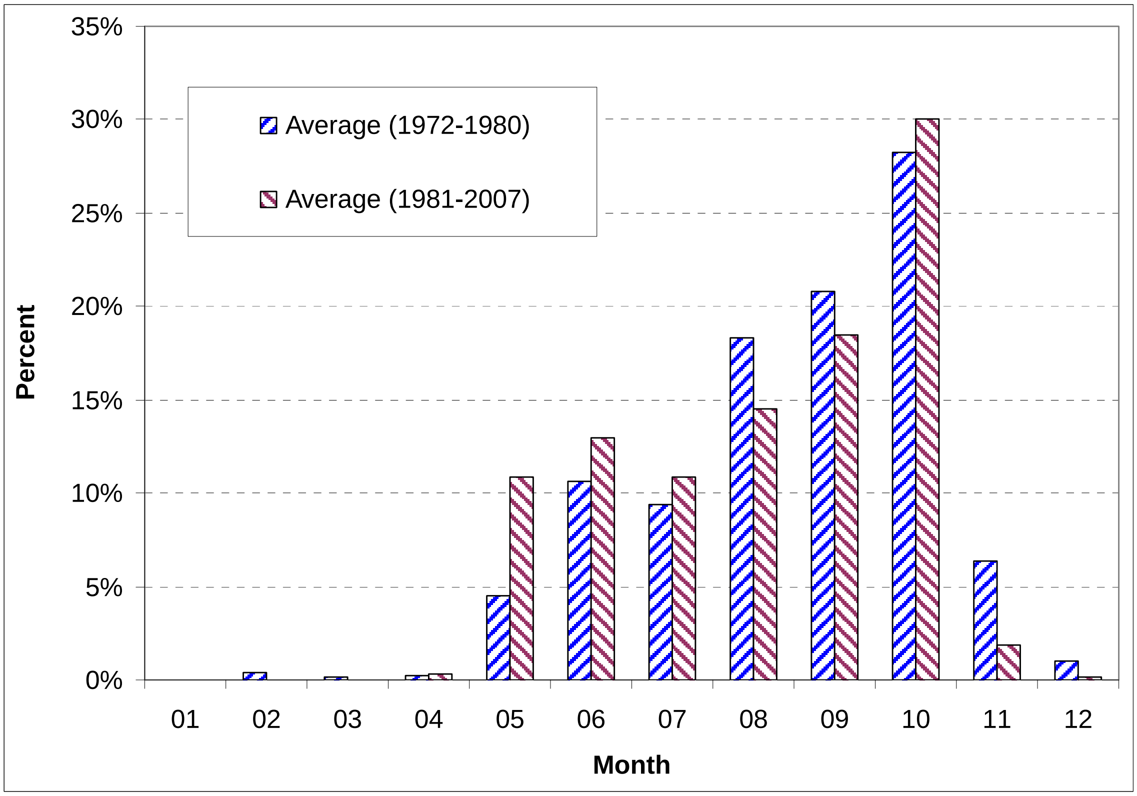


Figure 3.5. Spanish mackerel commercial landings by month from Georgia-North Carolina from ALS database, 1972-2007.

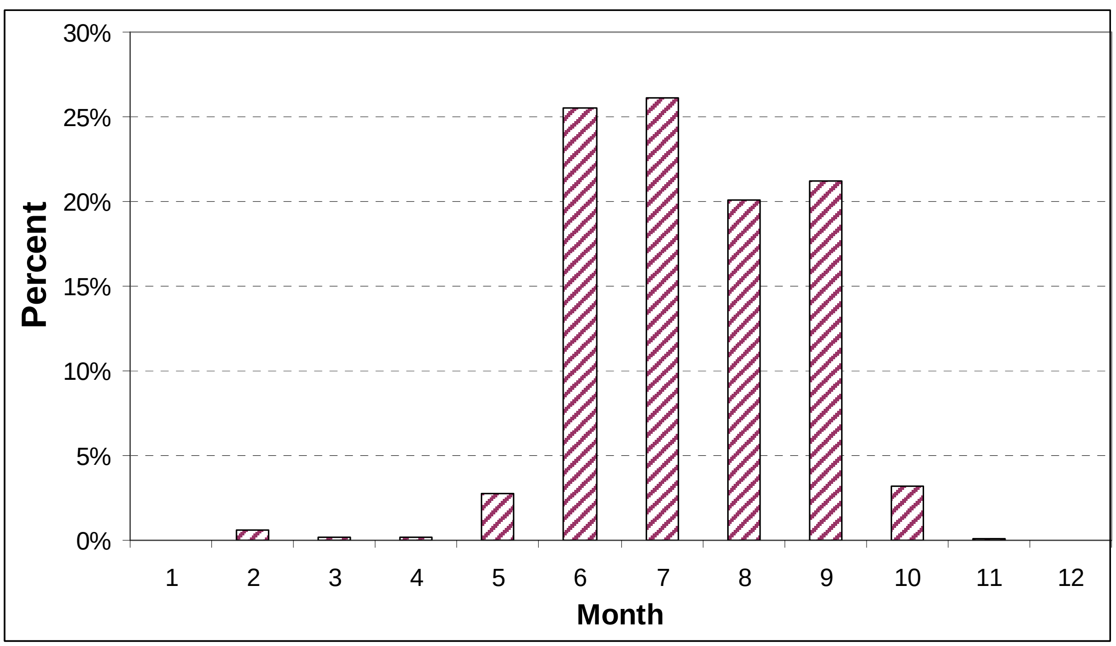


Figure 3.6. Spanish mackerel commercial landings by month from Virginia - Maine from SAFIS database, 1980-2007.

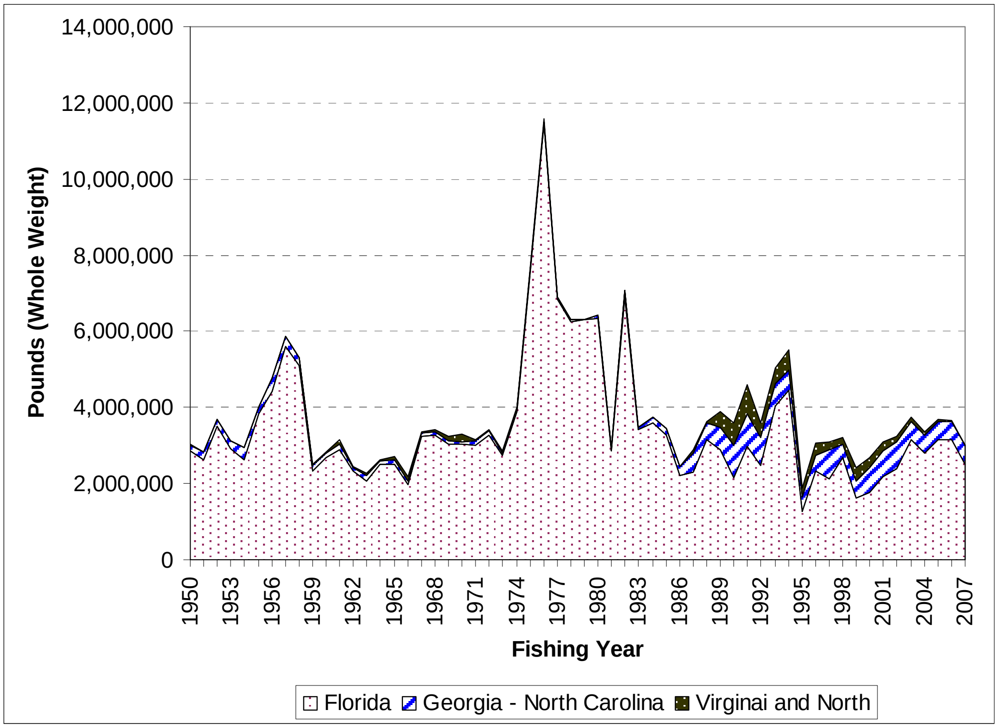


Figure 3.7. Spanish mackerel landings in pounds (whole weight) by region from the U.S. Atlantic coast, 1950-2007. (see text for data sources by state and temporal duration).

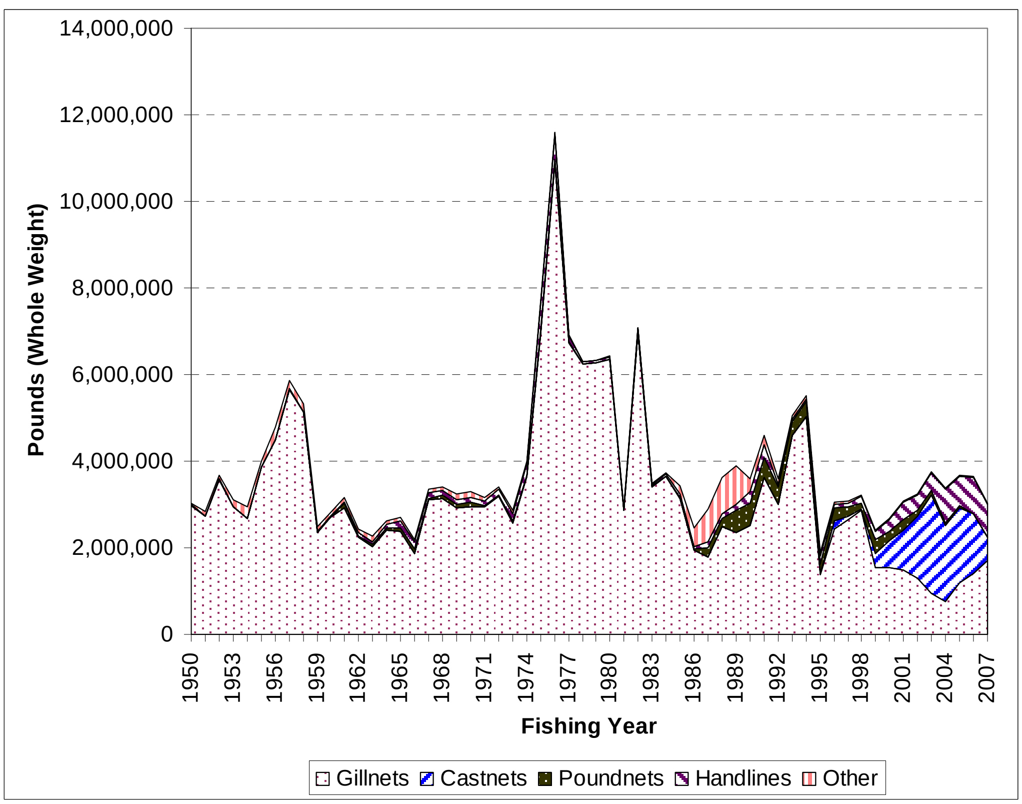


Figure 3.8. Spanish mackerel landings in pounds (whole weight) by gear from the US Atlantic coast, 1950-2007. (see text for data sources by state and temporal duration).

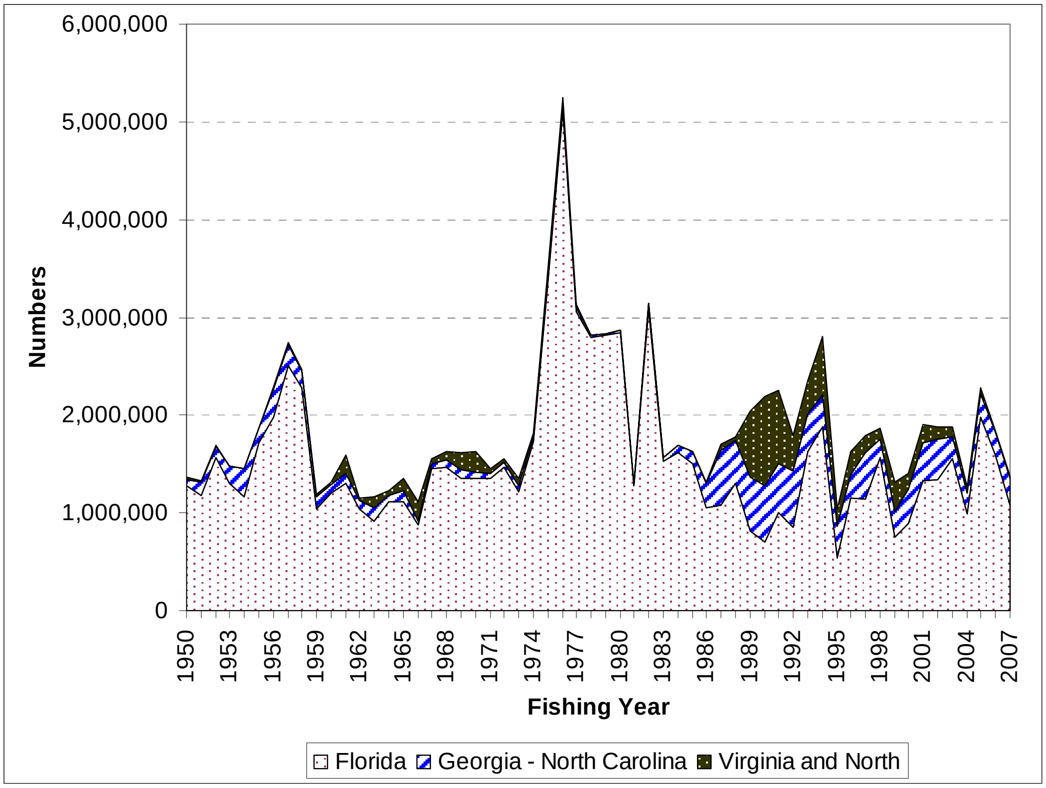


Figure 3.9. Spanish mackerel landings in numbers by region from the U.S. Atlantic coast, 1950-2007. (see text for data sources by state and temporal duration).

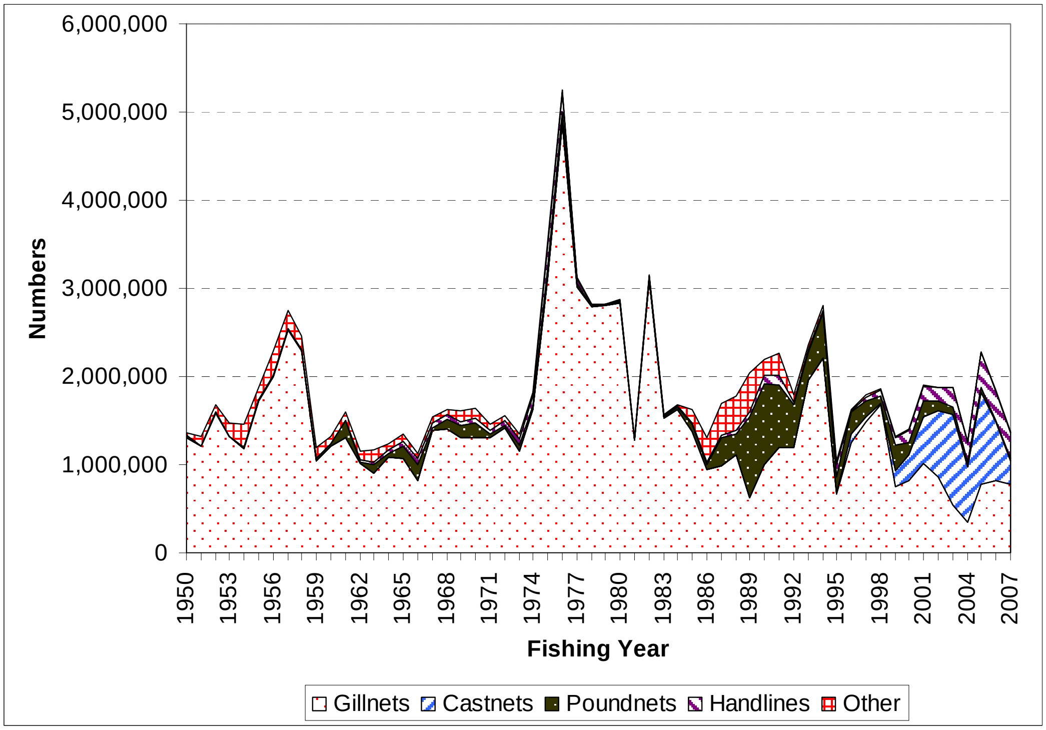


Figure 3.10. Spanish mackerel landings in numbers by gear from the US Atlantic coast, 1950-2007. (see text for data sources by state and temporal duration).

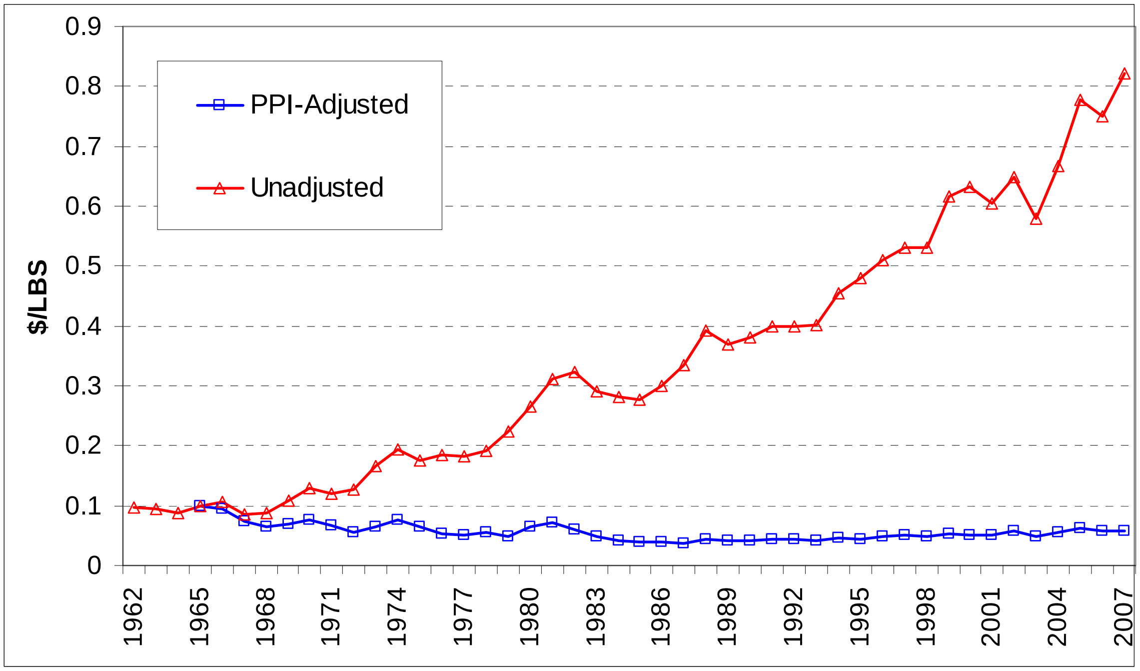


Figure 3.11. US South Atlantic Spanish mackerel, price per pound, unadjusted and adjusted for inflation from the SEFSC ALS database, 1962-2007. Price is adjusted by producer price index (PPI) using 1965 as base year.

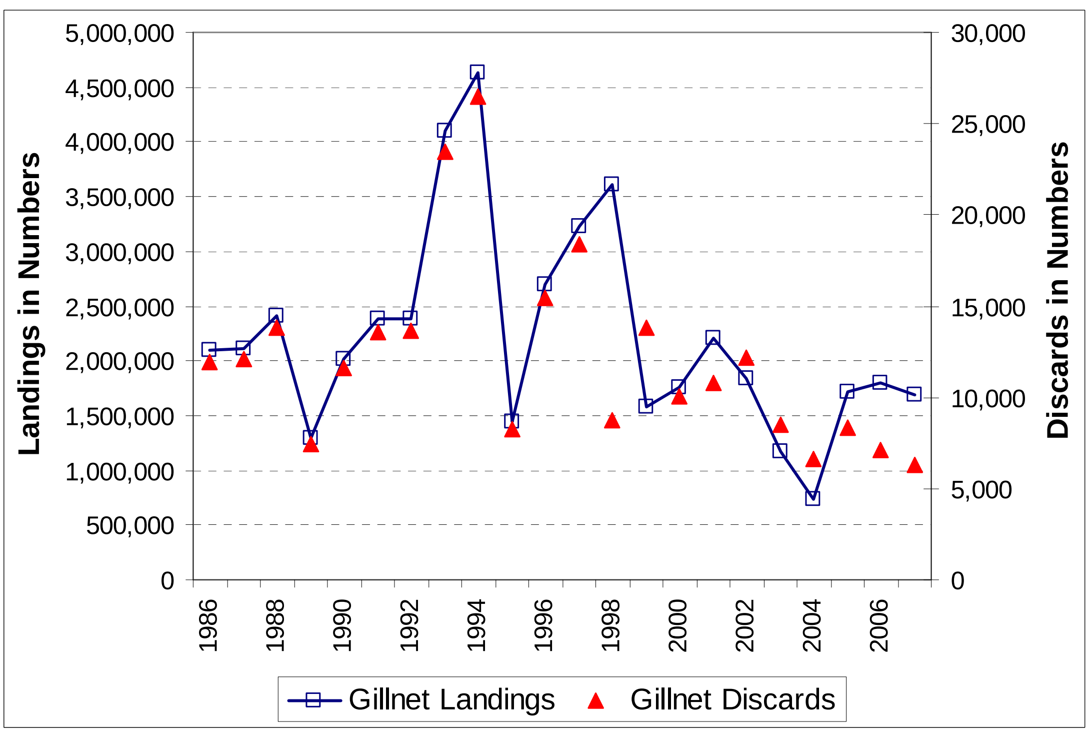


Figure 3.12. Comparison of commercial gillnet landings to discards for US South Atlantic Spanish mackerel (discard values prior to 1998 calculated as proportion of landings in numbers).

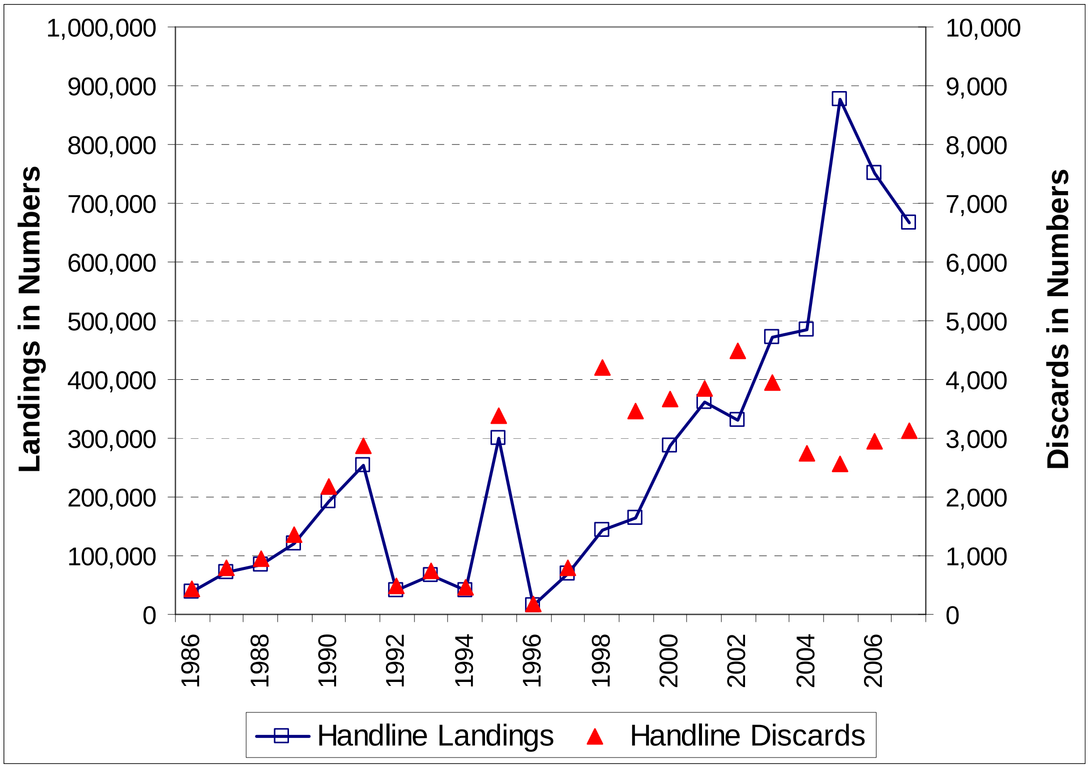


Figure 3.13. Comparison of commercial handline/trolling landings to discards for US South Atlantic Spanish mackerel (discard values prior to 1998 calculated as proportion of landings in numbers) (discard values prior to 1998 calculated as proportion of landings in numbers).

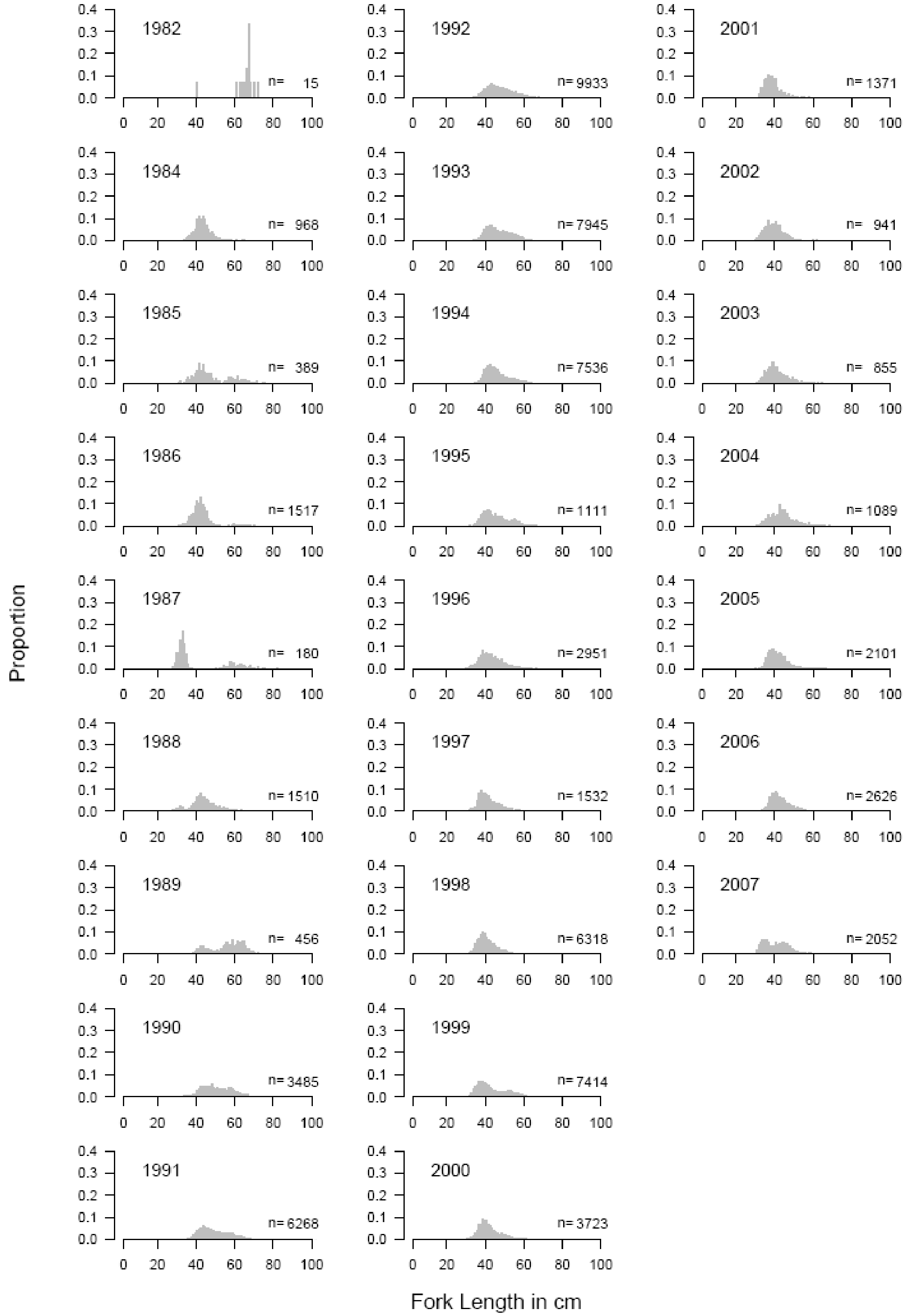


Figure 3.14. Spanish mackerel length composition (number at length, FL-cm) by year for commercial gillnet gear in the US South Atlantic.

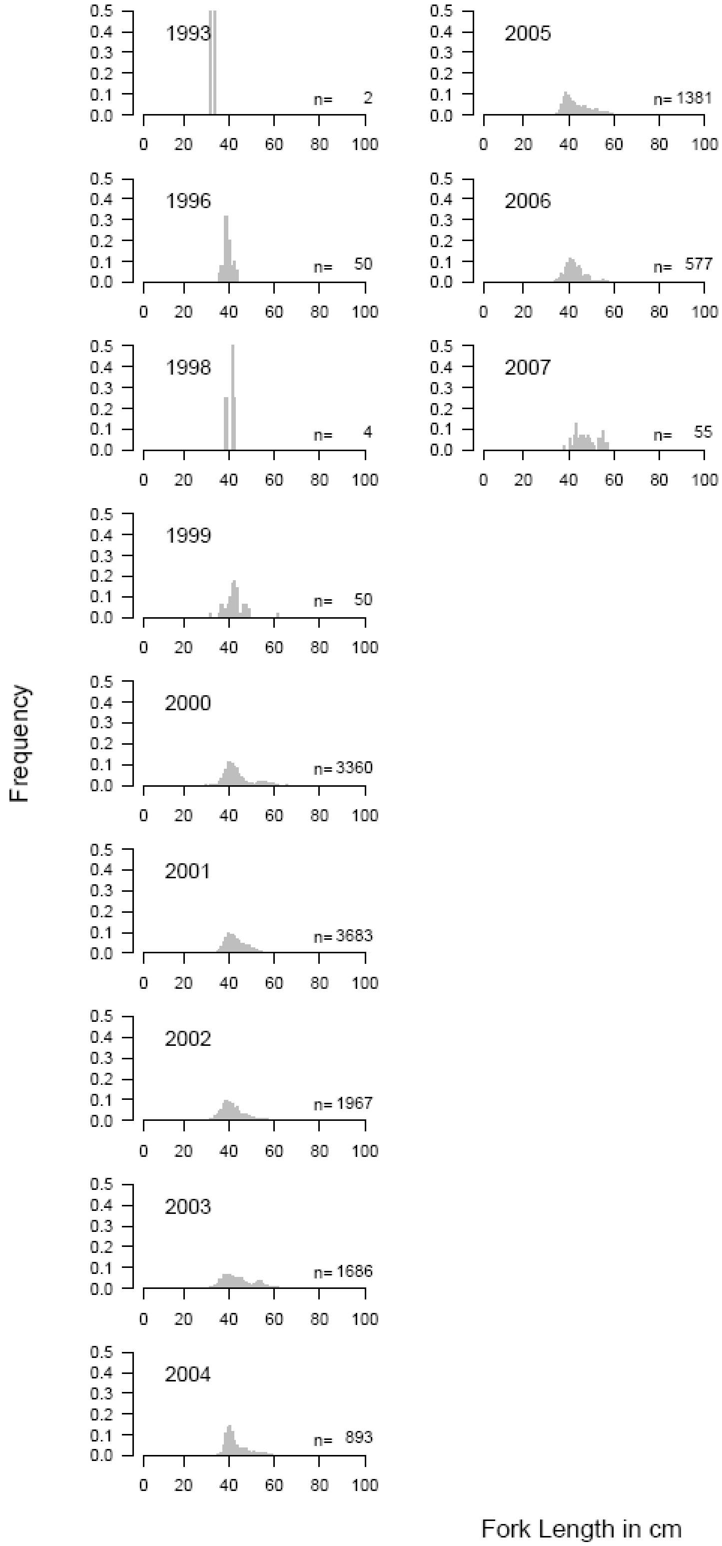


Figure 3.15. Spanish mackerel length composition (number at length, FL-cm) by year for commercial castnet gear in the US South Atlantic.

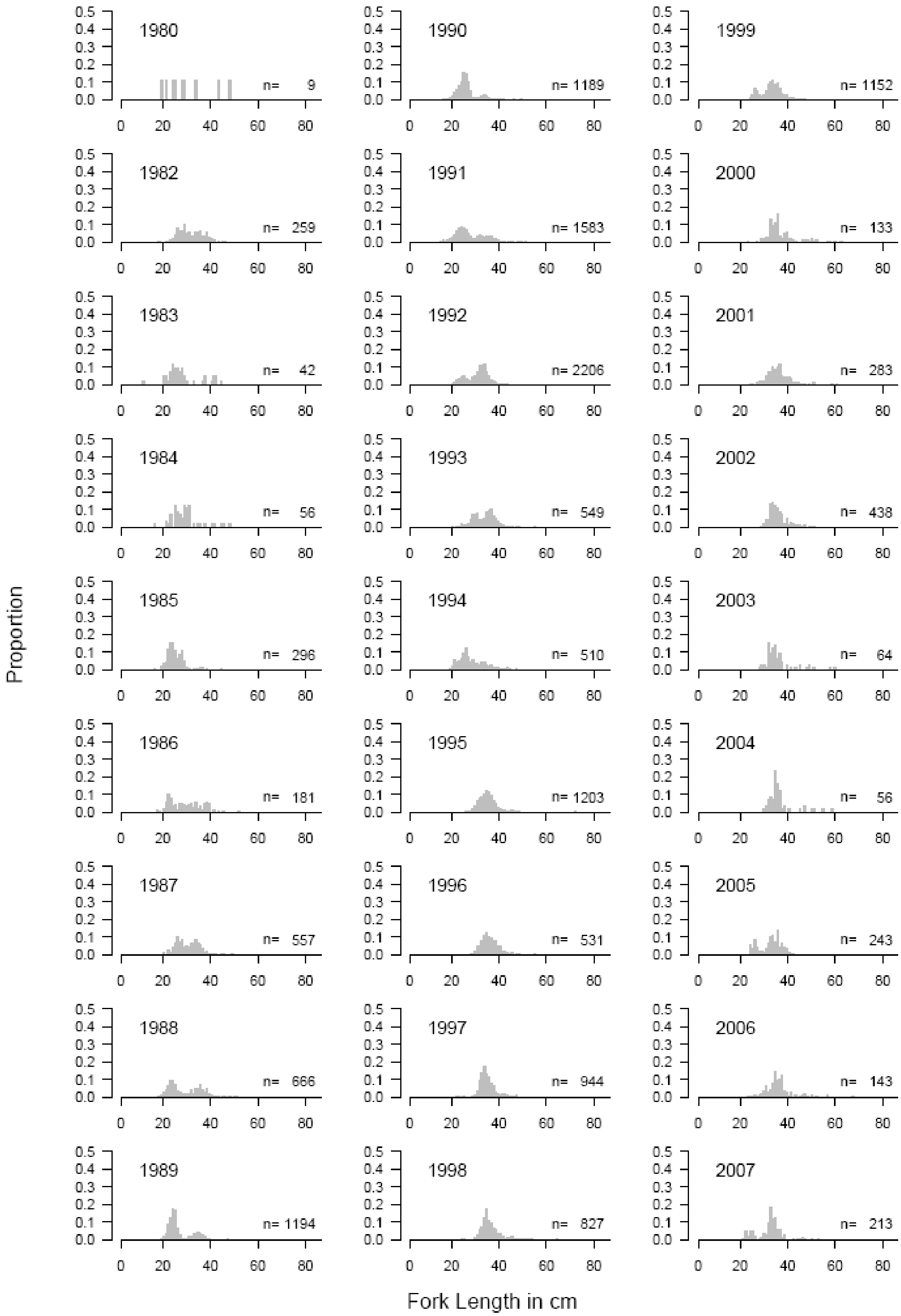


Figure 3.16. Spanish mackerel length composition (number at length, FL-cm) by year for commercial pound net gear in the US South Atlantic.

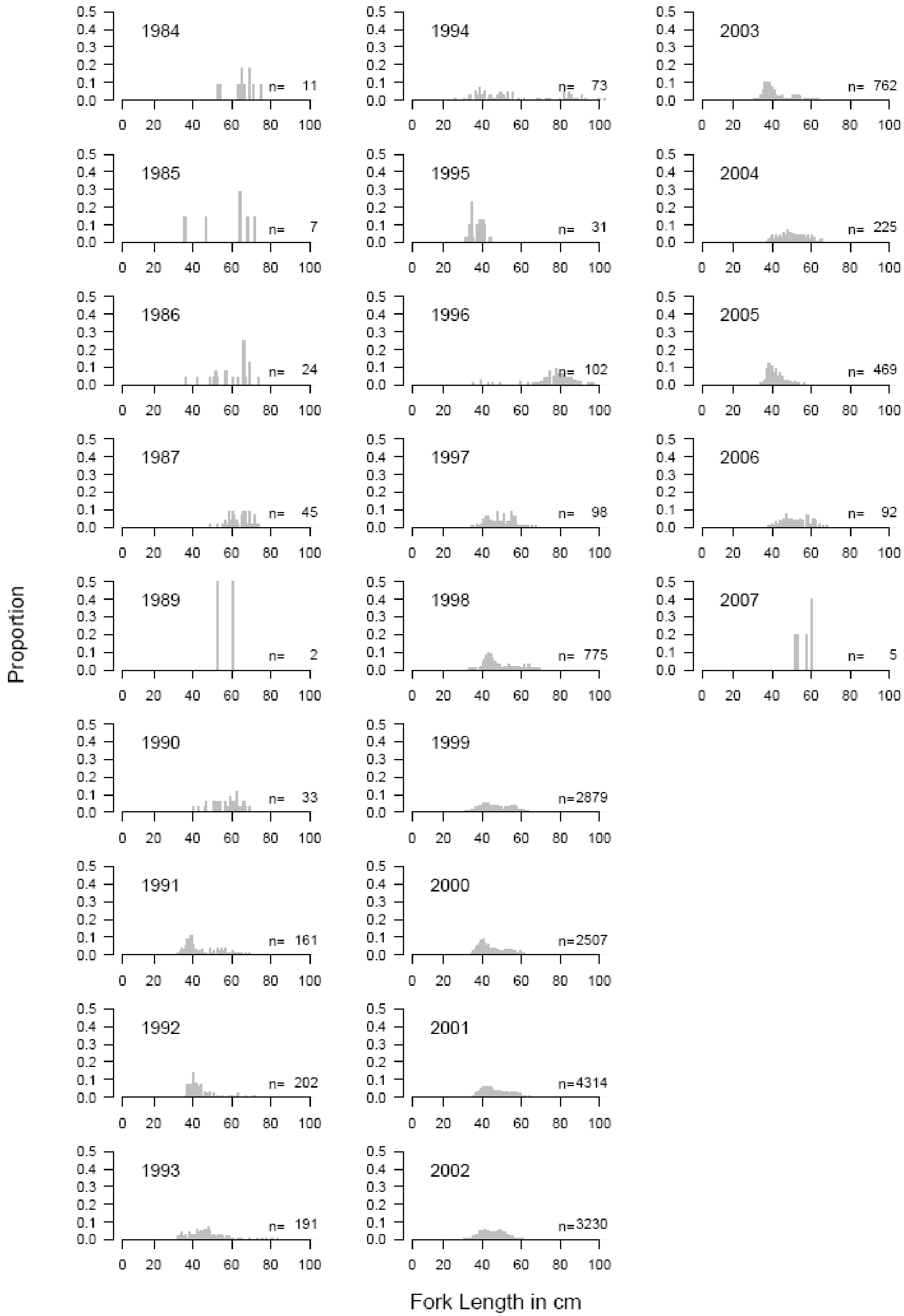


Figure 3.17. Spanish mackerel length composition (number at length, FL-cm) by year for commercial handline gear in the US South Atlantic.

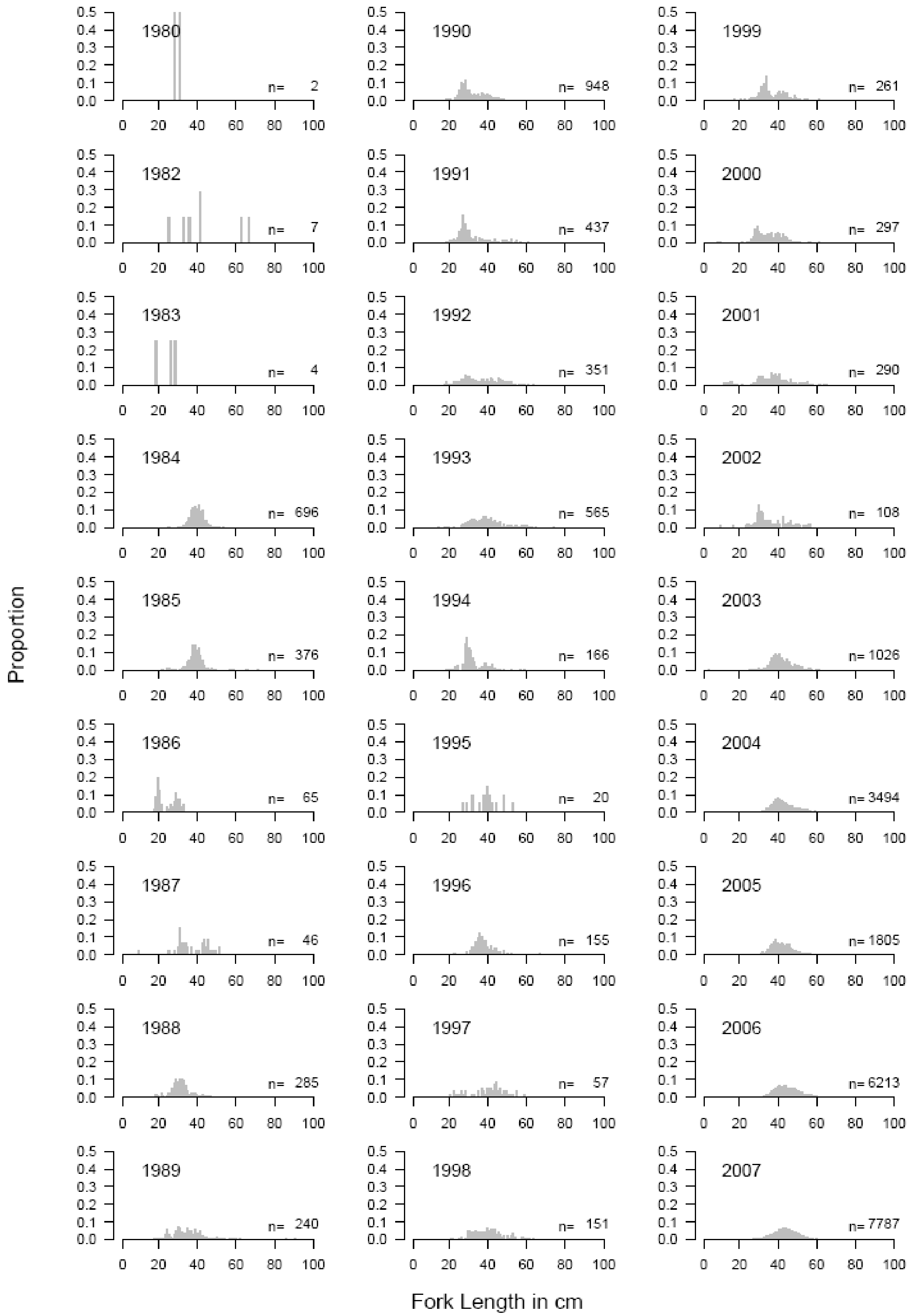


Figure 3.18. Spanish mackerel length composition (number at length, FL-cm) by year for other commercial gears in the US South Atlantic.

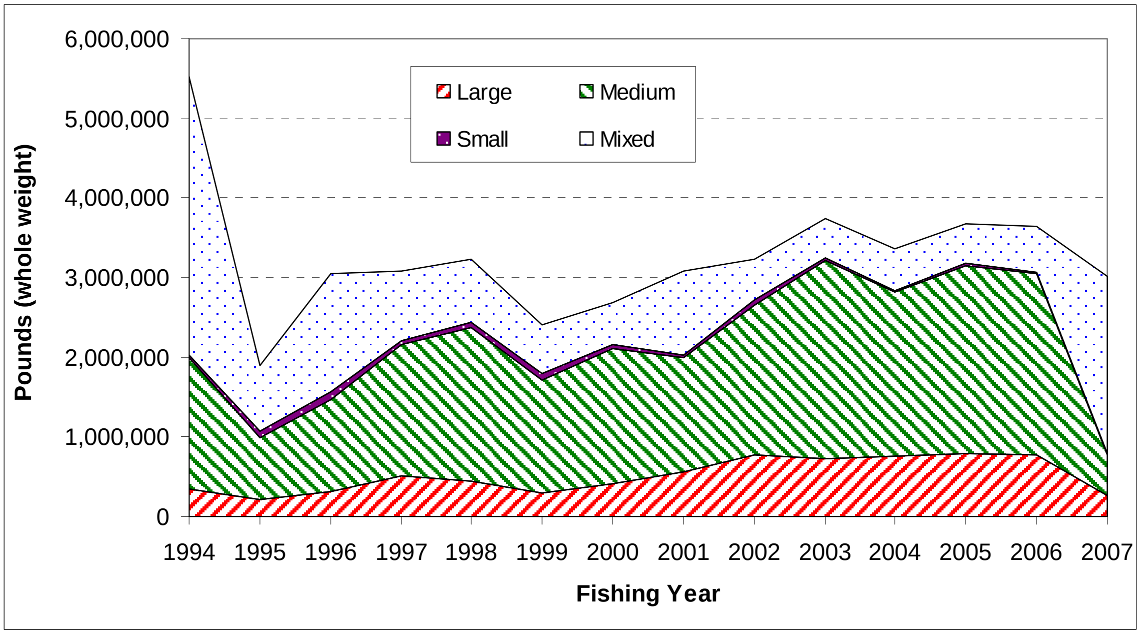


Figure 3.19. Commercial landings of Spanish mackerel by market grade, 1994-2007.

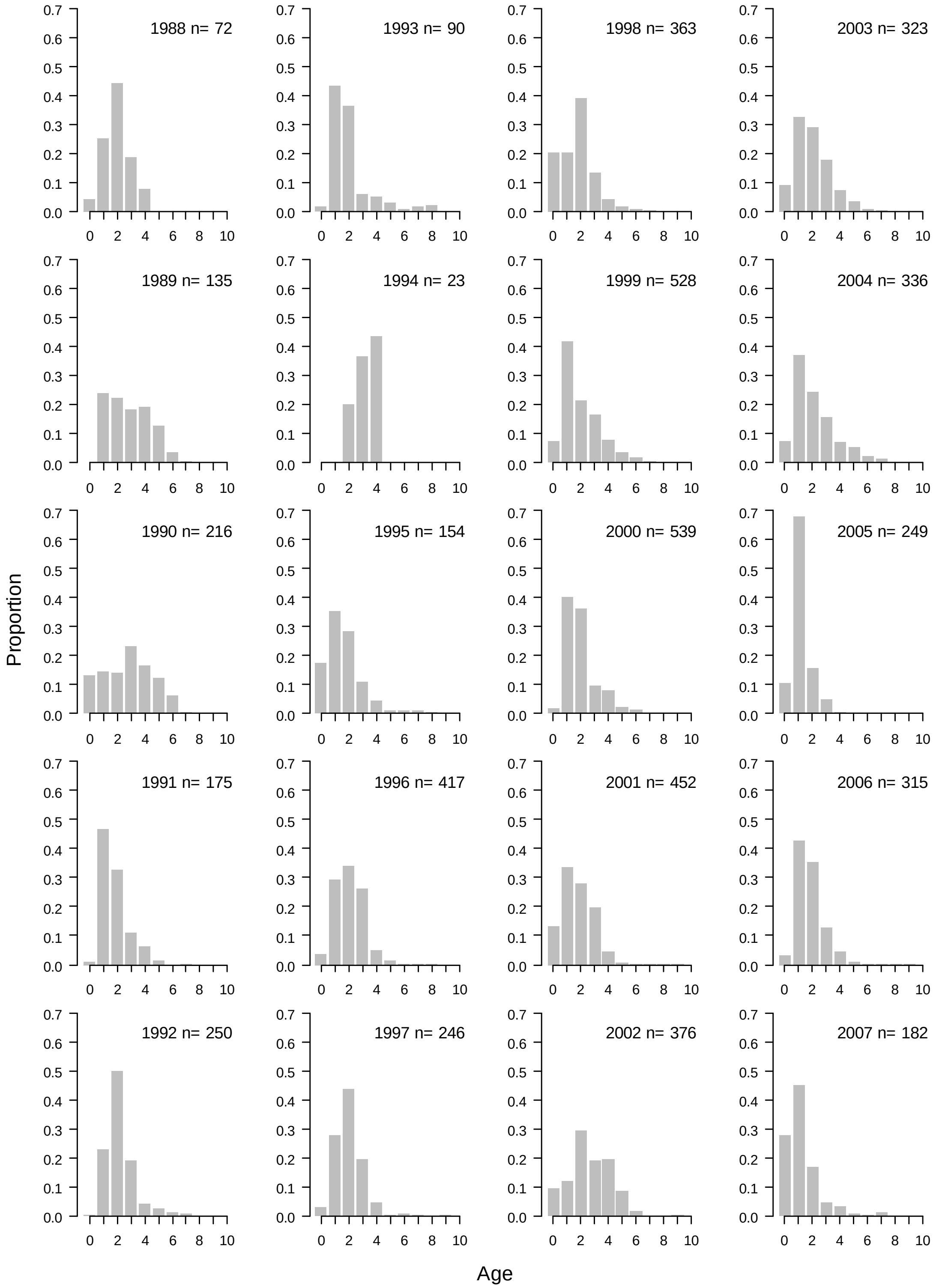


Figure 3.20. Spanish mackerel age frequencies by year for gillnet commercial gears in the US South Atlantic.

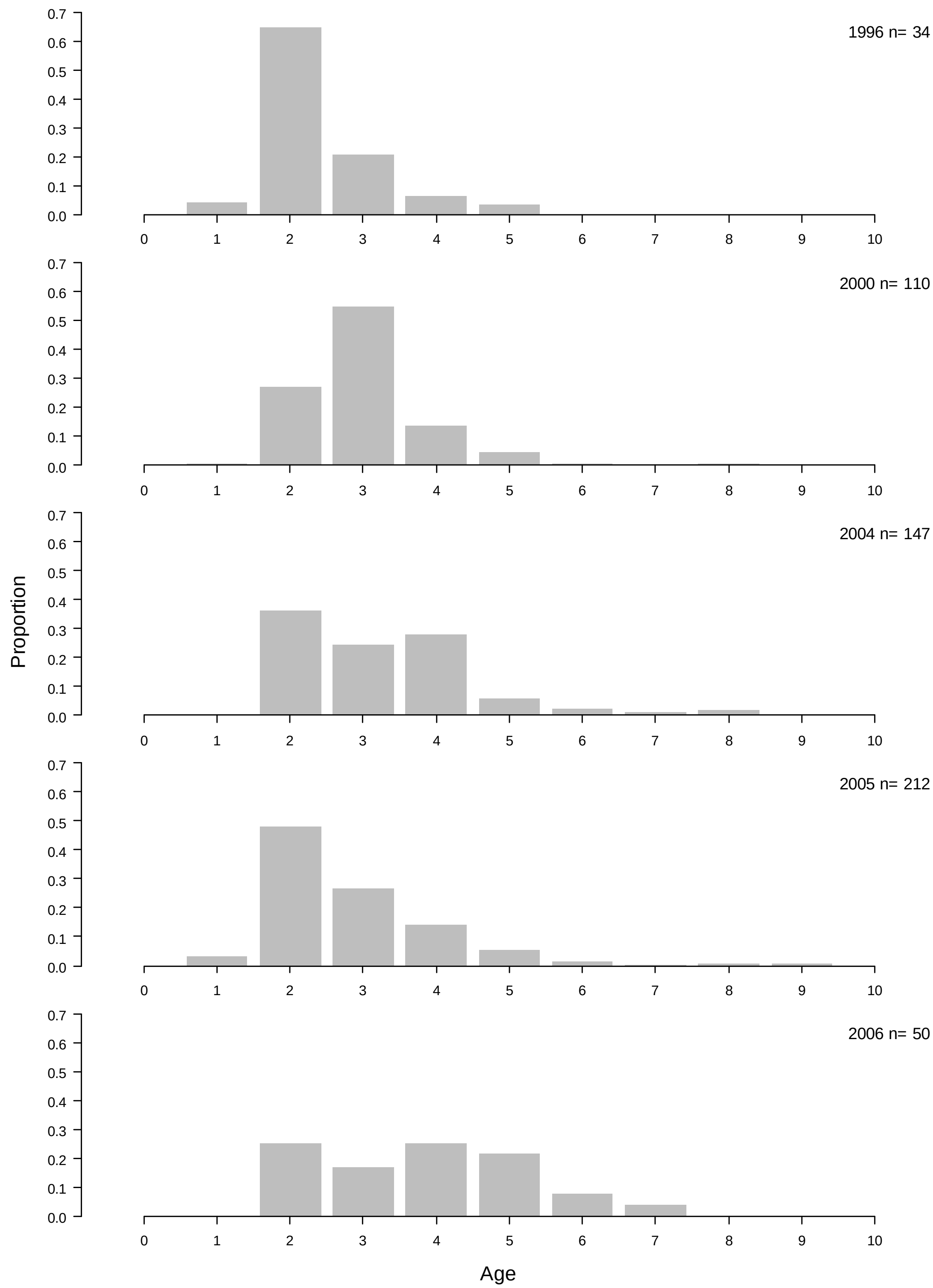


Figure 3.21. Spanish mackerel age frequencies by year for castnet commercial gears in the US South Atlantic.

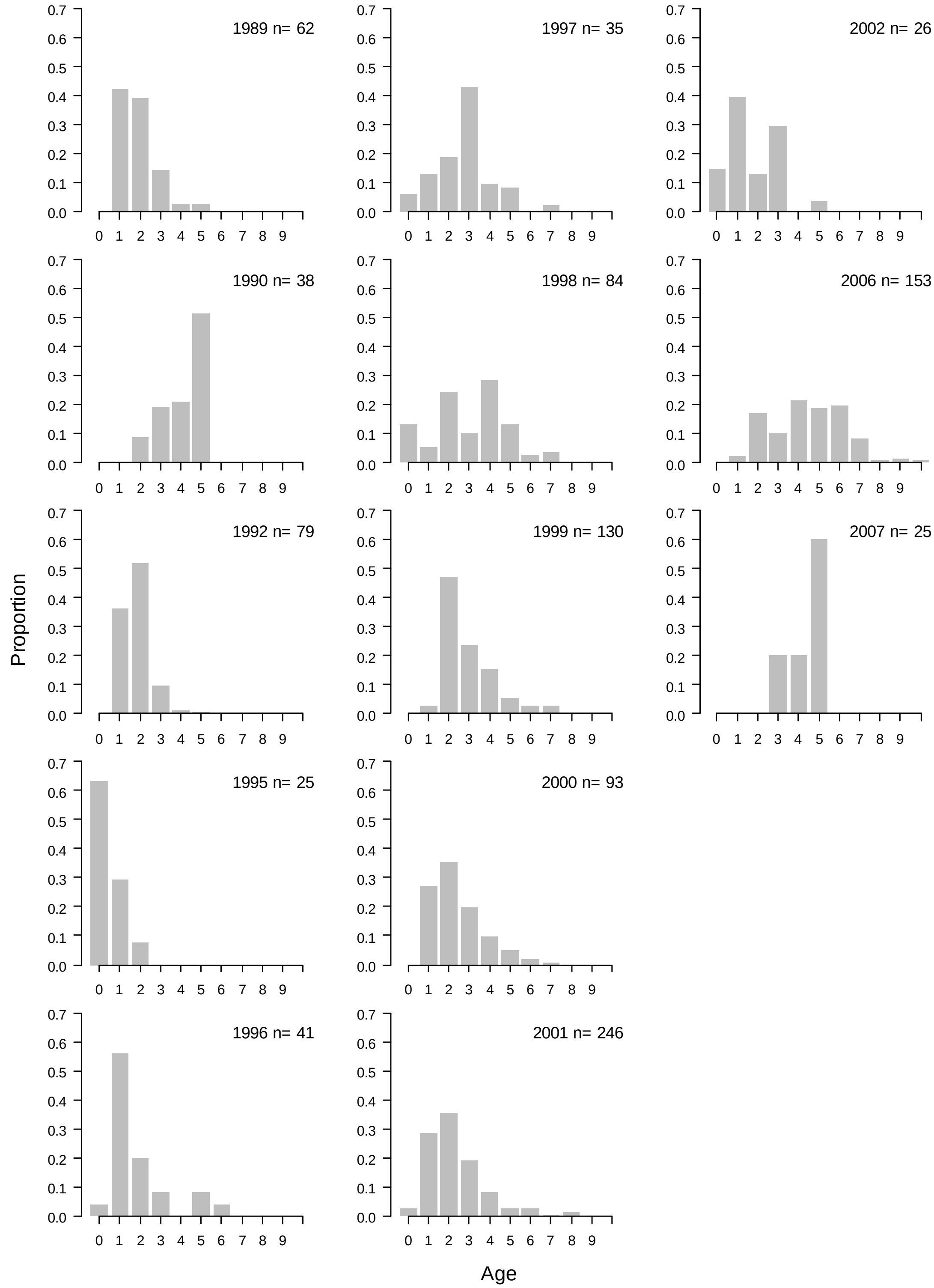


Figure 3.22. Spanish mackerel age frequencies by year for handline commercial gears in the US South Atlantic.

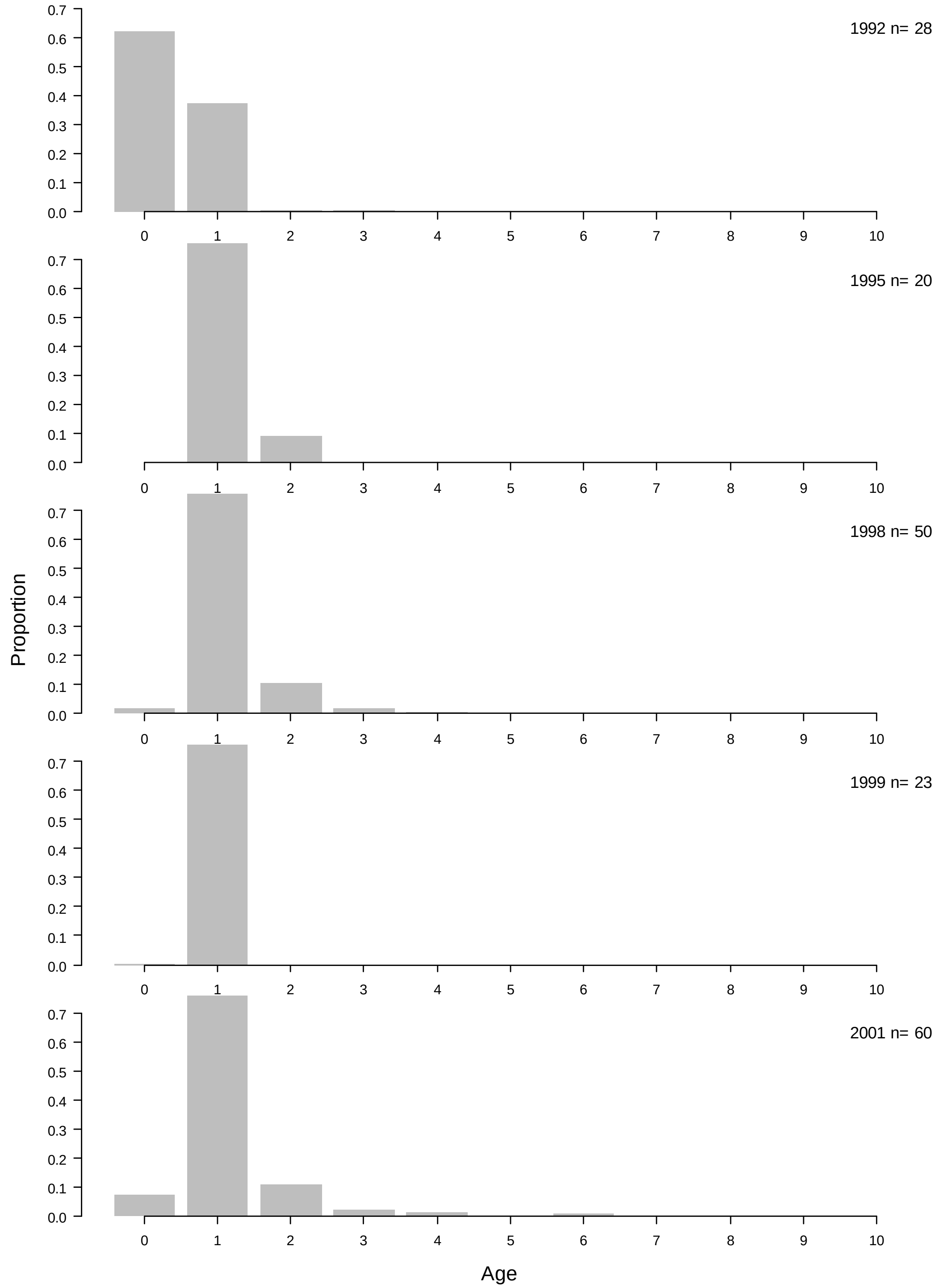


Figure 3.23. Spanish mackerel age frequencies by year for poundnet commercial gears in the US South Atlantic.

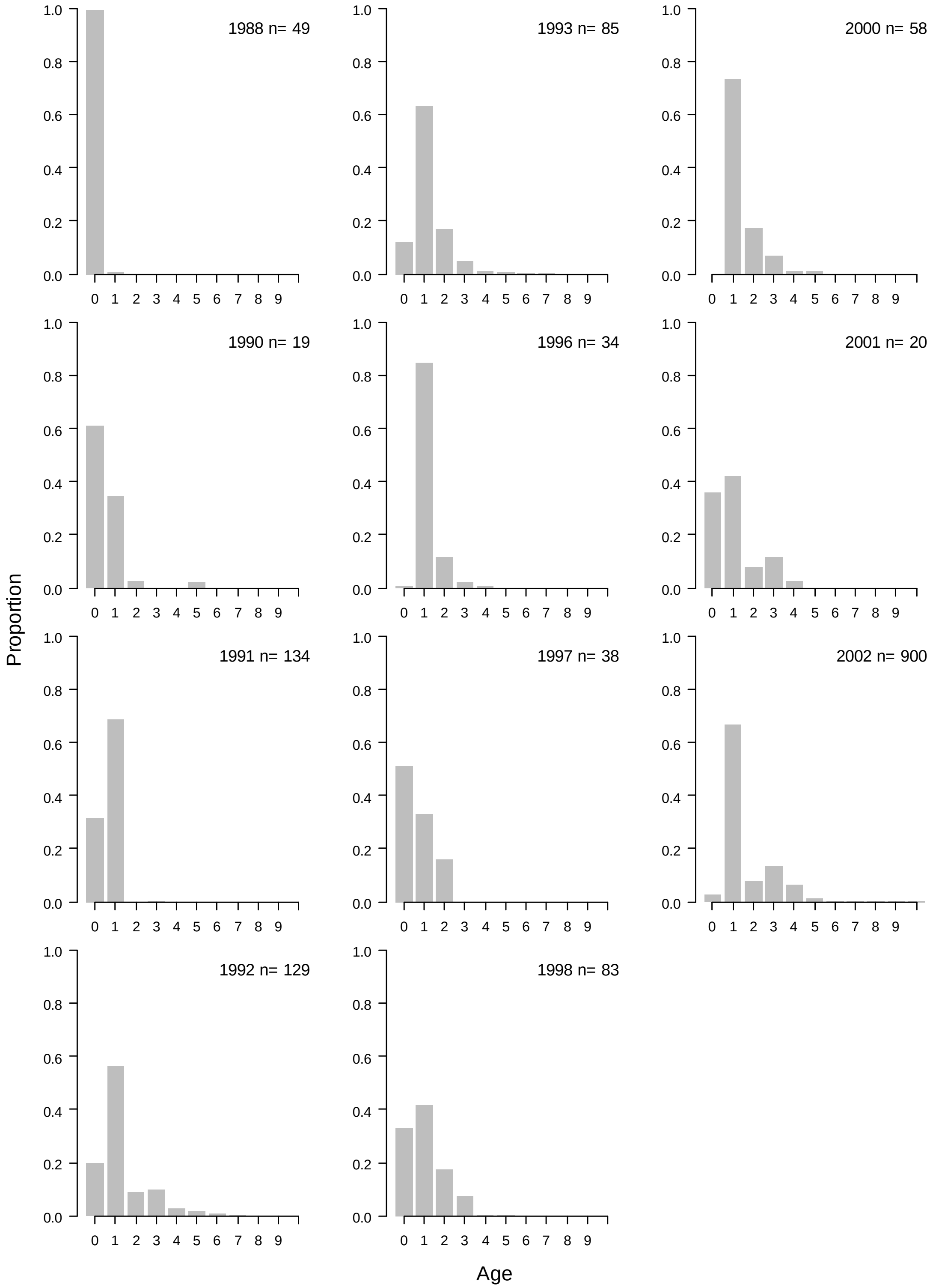


Figure 3.24. Spanish mackerel age frequencies by year for other commercial gears in the US South Atlantic. Note that this category includes a large fraction of unknown gears.

Spanish Mackerel

4. Recreational Fishery Statistics

4.1 Overview - group membership, leader, and issues

Chair: Erik Williams (NMFS Beaufort); Members: Tom Sminkey (NMFS Silver Spring), Ken Brennan (NMFS Beaufort), Rob Cheshire (NMFS Beaufort), Beverly Sauls (FWRC).

Issues:

(1) Only one working paper for the recreational workgroup was submitted, reflecting the relatively small amount of pre-workshop work completed for this workgroup.

(2) At the time of the data workshop the 2007 headboat data had not been through a full set of quality assurance and quality control checks. Key entry was finalized just days prior to the DW.

(3) Historic data, does it accurately reflect catch levels of the species reported?

4.2 Headboat Fishery

Historical accounts of headboat fishing in the South Atlantic for inshore and offshore species date back to the years immediately following World War II. The headboat fishery is a readily identifiable segment of the recreational fishery, and is responsible for a significant percent of the recreational landings for some species. Presently, the number of vessels in the headboat fleet fluctuates slightly from year to year as boats enter or leave the fishery, nonetheless, the relative size of the fleet is known, making it accessible to the Southeast Region Headboat Survey. The Southeast Region Headboat Survey included vessels only in North Carolina and South Carolina during the early part of the survey (1972-1975). The Survey expanded to northeast Florida in 1976, to southeast Florida in 1978, and finally to the Gulf of Mexico in 1986. From 1981-present the Survey included all headboats operating in the southeastern U.S. EEZ, encompassing the areas shown in Figure 4.9.1.

4.2.1 Headboat Landings

Estimated headboat landings from the VA\NC boarder to Key Largo (1981-2007) for Spanish mackerel are based on the fishing year from March to February. Since landings are not available for 2008, a ratio was calculated from the sum of Jan-Feb (03-07) divided by the sum of Mar-Dec (02-06). This ratio was applied to both number and weight of the landings of Mar-Dec 2007 for all areas combined to derive total landings for Jan and Feb 2008. The totals from Mar-Dec 07 and Jan-Feb 08 were combined to give total landings for the 2007 fishing year (Tables 4.8.1 and 4.8.2).

Spanish mackerel are infrequently encountered in the headboat fishery compared to most bottom species that are targeted, which require anchoring the boat and fishing with bottom rigs. This is reflected in the relatively low numbers landed by headboats in the South Atlantic. Some areas such as South Carolina and southeast Florida account for higher percentage of the landings mostly due to the inshore fishery that mixes trolling with bottom fishing during the same trip.

4.2.2 Headboat Discards

The logbook form was modified in 2004 to include a category to collect self-reported discards for each reported trip. This category is described on the form as the number of fish by species released alive and number released dead. Port agents instructed each captain on criteria for determining the condition of discarded fish. A fish is considered “released alive” if it is able to swim away on its own. If the fish floats off or is obviously dead or unable to swim, it is considered “released dead”. This self-reported data is currently unvalidated within the Headboat Survey. The recreational working group compared vermilion snapper discard data from the MRFSS At-Sea Observer program to the Headboat Survey logbook and determined that the logbook discard data was representative of the fishery (See SEDAR17-DW08).

4.2.3 Biological Sampling

Length and weight measurements from fishes taken by anglers on headboats are collected by port agents throughout the coverage area. Also, biological samples (scales, otoliths, spines, stomachs and gonads) are collected routinely. Length-weight data are used to compute average weights for each species and to compute age frequencies and mortality rates. This information combined with logbook data are used to calculate an estimate of total weight (kg) of reef fish landed in the headboat fishery.

4.2.3.1 Sampling Intensity Length/Age/Weight

The headboat sampling for lengths and weight was consistent throughout the time series with the exception of spatial coverage before 1978. The number of fish available to measure was patchy and represents localized effort over relatively small spatial and temporal scales. There are only a few years where the number of samples is high enough to provide information on the length composition of the fishery (See Table 4.8.3). However, even in years with good sample size the spatial differences in effort among years may erroneously indicate changes in the size distribution.

4.2.3.2 Length – Age Distributions

No length composition was generated from the headboat fishery due to the sampling problems discussed in Section 4.2.3.1. Headboat age samples (n=171, from 4 years) were included in the age composition for the general recreational fishery (see Section 4.3.3.2). SEDAR 17 DW participants headboat angling methods for Spanish mackerel were more consistent with charter boat fishing than with typical bottom fishing techniques employed on most headboats.

4.2.3.3 Adequacy for Characterizing Catch

Catch and effort data are reported on logbooks provided to all headboats in the Survey. These forms are completed by the captain or designated crew member after each trip and represent the total number and weight of all the species kept, along with the total number of fish discarded for each species. Each month port agents collect these logbook trip reports and check for accuracy and completeness. Although reporting via the logbooks is mandatory, compliance is low in some areas for recent years, especially South Florida. Landings for these non-reporting vessels were estimated from similar vessels adjusted using port sampler intercept data and estimates of the number of anglers.

4.2.3.4 Alternatives for Characterizing Discards

Based on the comparison of logbook data to the At-Sea Observer data, it was concluded that the logbook discard estimates for Spanish mackerel would be used for the available years back to 2004 for the South Atlantic headboat fishery. For years prior to the addition of the discard category on the logbook form, the recreational workgroup suggests using the average for 2004-2006 to interpolate discards. Further, the group recommends using the charter mode to calculate headboat discards for 1972-1998, since the discard rates from the longer time series of MRFSS reflect historic changes in discard rates. These rates include the impacts from changes in recreational size limits and bag limits for vermilion snapper over time.

4.2.4 Headboat Catch-at-Age/Length

Due to insufficient sample sizes, no length or age compositions were generated from the headboat fishery.

4.2.5 Headboat Effort

Headboat effort has changed only slightly in the past 10 years throughout the South Atlantic (Fig.4.9.2). The number of estimated trips in the headboat fishery has remained relatively constant during this period, with the only noticeable change occurring as effort peaked in GA and FL in 2000.

4.2.6 Comments on Adequacy of Headboat Data for Assessment Analyses

Catch and effort data are reported on logbooks provided to all headboats in the Survey. These forms are completed by the captain or designated crew member after each trip and represent the total number and weight of all the species kept, along with the total number of fish discarded for each species. Each month port agents collect these logbook trip reports and check for accuracy and completeness. Although reporting via the logbooks is mandatory, compliance is low in some areas for recent years, especially South Florida. No other data sources were available to provide information on the headboat fishery sector.

4.3 General Recreational Fishery (aka MRFSS)

4.3.1 General Recreational Landings

The report, **SEDAR16-DW-21: Recreational Survey Data for King Mackerel in the Atlantic and Gulf of Mexico,** was presented at the recent King Mackerel Data Workshop (Feb. 2008) and describes the methodology used to produce the recreational catch estimates based on the traditional MRFSS, the Charter Boat estimates produced by the For-Hire Survey method (FHS) from 2004-2007, and the 'normalization' of the pre-FHS estimates of Charter Boat effort and inclusion in the total annual landings estimates. Correction factors to adjust historical estimates in the Atlantic to those which would have been expected had the new methodology been used were not available prior to that meeting. This computational normalization was only modeled for the southeast states, NC to FL, and followed a similar method used in the Gulf of Mexico by Diaz and Phares (2006). Included in this analyses and time-series of landings were both Spanish

Mackerel and Vermilion Snapper, where they occurred. The recreational fishery for Spanish mackerel, however, also produces significant landings from Virginia, which was not included in the earlier analyses.

For the "old estimation" methodology, the Marine Recreational Fishery Statistics Survey (MRFSS) collected fishing activity data using a telephone survey of households in coastal counties (CHTS) and fishing catch per trip data by interviewing anglers at fishing access sites. This complementary design survey began in 1981 and provides a time series of Spanish mackerel landings from 1981 - 2007 by state on the Atlantic Coast, U.S. To improve the effort estimation procedure for the charterboat mode, MRFSS tested and then implemented a new survey protocol of interviewing the charterboat operators directly (the For Hire Survey, or FHS). This survey became the official estimator of fishing effort for this mode in 2000 for the Gulf of Mexico, 2003 for East Florida, and 2005 for the rest of the Atlantic coast. The shift from one survey method to another in the time series can cause a shift in the trend of landings so it would be advantageous if the earlier effort estimates could be adjusted to more accurate annual numbers based on a relationship that could be modeled between the two surveys' results during the overlapping years. Such conversion (or "correction") factors had been developed for the Gulf of Mexico, where the FHS began earlier. Document **SEDAR16-DW-15** describes the results of this modeling for the South Atlantic.

The MRFSS CHTS pooled 3 years of charterboat trip data to produce an estimate of angler-trips per 2-month 'wave' due to a low frequency of contacts in most coastal zones. These aggregated estimates were more precise than estimates based on unpooled data, which would be highly variable and trends would be hard to recognize. However, to compare the two survey methods' results it was the unpooled estimates that were used in the first attempt at modeling originally presented to the Group. The results were reasonable but the method was questioned because it did not use the official estimates of charterboat angler effort (which were developed by pooling), which is ultimately what would need to be adjusted if a model could be described. The Group stressed that it was important that the methodology used to develop the conversion factors for the Gulf of Mexico be followed. Therefore, the entire GLM model was repeated using the CHTS 3-year pooled effort estimates and the FHS annual estimates of effort, as well as using the entire available time period of FHS data.

From 1981 to 1985, MRFSS considered charterboat and headboat as part of single mode (referred to as "party-charter", or "PC"). Thus, the conversion factors estimated with 2004-2007 charterboat data (used to calibrate 1986-2003 charterboat effort estimates) can not be used to calibrate the 1981-1985 estimates. To calibrate the 1981-1985 combined charterboat and headboat effort estimates, conversion factors will be estimated using 1986-1990 effort estimates instead of 2004-2007 to minimize possible effects of changes in the fishery over time. To do so, headboat (NMFS Headboat Survey) and original (MRFSS) charterboat effort estimates were combined (summed) into one estimate for each year and wave.

Conversion ratios were determined for the significant factors: sub-region (East Florida, North Carolina, or South Carolina & Georgia combined), area fished (Inland vs. Ocean waters), and 2-month wave (Mar.-Dec. north of FL, Jan-Dec for FL). The conversion ratios were then applied to the corresponding cell-level effort estimates (1986-2003) and the adjusted effort estimates were used to produce the adjusted king mackerel landings time series. Similarly, the PC landings estimates of king mackerel from the MRFSS, 1981-1985, were directly adjusted using the headboat + charterboat model ratios. The Group reviewed the modified document and the revised results, and recommended the use of these conversion factors (Table 4.8.4 and 4.8.5).

The final annual landings of Spanish mackerel on the Atlantic coast were adjusted for the fishing year of March 1 to February 28/29. For those landings estimated by MRFSS/FHS surveys north of Florida, no annual adjustments needed to be made because the recreational surveys are not conducted in Jan.-Feb., nor are landings estimated. Therefore, the estimated landings from Feb. - Dec. represent the fishing year. The Florida landings have been adjusted for annual totals by adding the Jan/Feb period landings estimates to the previous calendar-year's March-December landings.

4.3.1.1 Historical Recreational Landings

The workgroup was tasked with collecting any and all recreational landings for years prior to the start of modern data collections. Catch estimates from the MRFSS are not available from pre-1981, and for headboat logbook estimates, vermilion snapper landings are not available pre-1972 from North Carolina to South Carolina, and pre-1980 for Georgia through Florida.

The workgroup considered several historic data sets. The U.S. Fish and Wildlife Service conducted salt-water angling surveys in 1960, 1965, and 1970 (Clark 1962; Deuel and Clark 1968; Deuel 1973). These surveys resulted in estimates of the number of anglers and the number and weight of fish caught by region for all recreational fishing, including headboats. The Mid and South Atlantic regions were used for this assessment. In these surveys Spanish mackerel are reported at the species level (Table 4.8.6 and 4.8.7).

The workgroup noted that the salt-water angling survey estimates for Spanish mackerel are on the order of 6 times those in recent years. This raised some concerns, but after further review of other data sources, there was no evidence to suggest these estimates were incorrect. Old reports of recreational fishing in the state of Florida suggest these estimates may be fairly accurate. For example, according to Rosen and Ellis (1961) in 1958 about 13 percent of all fish kept by recreational anglers were Spanish mackerel. Ellis (1957) estimated that the total number of Spanish mackerel captured by charter boats in Florida was 65,971; this is 9 times higher than the recent Florida charter boat average of about 7,439.

Other data sources examined corroborate the estimates from the 1960, 1965, and 1970 salt-water angling surveys. Older reports from the state of Florida suggest the number of anglers estimated in these salt-water angling surveys is not too different (Ellis et al. 1958). Ellis et al. (1958) estimated 1,247,000 total number of salt and brackish water anglers in Florida in 1955, while the 1960 salt-water angling survey estimated 1,024,000 total anglers for the whole U.S. South

Atlantic. Considering the Ellis et al. (1958) estimate includes the west coast of Florida, while the 1960 survey includes Georgia, South Carolina, and North Carolina, these estimates are not too different.

The percent standard error (PSE) estimates in Table 4.8.7 were derived from a linear interpolation of tabled values provided in the U.S. Fish and Wildlife Service salt-water angling survey reports (Clark 1962; Deuel and Clark 1968; Deuel 1973).

4.3.2 General Recreational Discards

The access-point recreational fisheries surveys (angler intercept) ask anglers about any fish that were not landed or were landed, but not in the whole condition. Those that were not landed and were released alive were designated as discards and the raw reported data were expanded to the estimated totals following the same procedures as the landed fish. No size data were available for this class of catch (except for those headboat-caught fish on trips with an observer/interviewer on board - these are included in the headboat mode section) so catches of discards are reported by number only.

4.3.3 Biological Sampling

The only biological data collected during the routine MRFSS/FHS surveys are length of fish and weight of landed fish. Both are collected opportunistically but field interviewers are instructed to measure and weigh up to fifteen fish of each available species from each angler interviewed. The individual fish are to be selected from the total landed catch at random to avoid any size-bias in the resultant sample. Fish are measured to the nearest mm fork length (center-line total length in non-forked fish) and weighed to the nearest 1/8 or ½ kg, depending on scale precision. Annual sample sizes of fish measured are included on the length-frequency worksheet.

4.3.3.1 Sampling Intensity Length/Age/Weight

See length frequency sample sizes on annual length-frequency worksheet.

4.3.3.2 Length – Age Distributions

The general recreational length composition was created using data from the routine MRFSS/FHS surveys (Figure 4.9.3).

The general recreational age composition was created using data from charter vessels, headboats, and private vessels. The sampling shifts from primarily private vessels to charter vessels (see Table 4.8.8). Tournament vessels were not included because of the potential for bias in selectivity. Three samples removed from the analysis because recreational group members believed they were incorrect since Spanish mackerel were not caught in January in North Carolina in any years other than 2004. Most of the recreational age samples were from North Carolina (Table 4.8.9). All of the Georgia samples were from tournament fishing and were removed.

The recreational ages were weighted by the recreational length composition to overcome potential bias in selecting fish to age and to transfer the weighting given to the length composition based on landings to the age composition. The weighting value for each age record was the proportion from the length composition corresponding to the year and length (1 cm bins) of the aged fish. The weighting values were then summed by age and year to determine the age composition of the fishery. Each value was normalized to sum to 1 across years by dividing each value by the sum for that year. General recreational age composition values were stored in the VS_DW_summary.xls workbook and are plotted in Figure 4.9.4.

4.3.3.3 Adequacy for Characterizing Catch

The samples of length/weight from the MRFSS/FHS surveys are stratified by year, wave, state, mode of fishing, and area fished (= cell) for purposes of estimating mean weight per fish and length frequency (weighted by catch). These cell samples are used to expand the cell catches in number to total kg and pounds landed, then are summed across cells to produce the annual statistics. Similarly, the length frequencies are expanded to counts per length group per cell, then are summed across cells to produce a single annual frequency distribution. If a cell is empty of sample, then a mode or state-level mean is substituted for mean weight. If the length frequency is absent from a cell but a catch number is estimated, then the cell is considered similar to the overall size-frequency distribution.

4.3.3.4 Alternatives for Characterizing Discards

Not addressed.

4.3.4 General Recreational Catch-at-Age/Length

Catch-at-age or length was not computed since age/length composition data is handled separately from catch estimates. For years in which adequate age/length sampling occurs, one could infer catch-at-age/length by multiplying the annual catch estimate by the annual age/length composition.

4.3.5 General Recreational Effort

Not addressed.

4.3.6 Comments on Adequacy of General Recreational Data for Assessment Analyses

Not addressed.

4.4 Recreational Workgroup Research Recommendations

There was insufficient time for this topic to be addressed by the workgroup during the data workshop.

4.5 Tasks for Completion following Data Workshop

Recreational workgroup things to be done post-DW:
(1) MRFSS landings for vermilion and Spanish from 1981-1985 (Tom Sminkey)
(2) Dig through some archives for more information on historic catch rates of Spanish mackerel (Beverly Sauls and Ken Brennan)
(3) Produce PSE's for historic and other landings time series (Erik Williams)
(4) Compute pre-2004 discards in headboat fishery from ratio of charter mode in MRFSS (Ken Brennan)

(5) Compile length composition data from headboat and MRFSS (Rob Cheshire)
(6) Submit all finalized data to Rob by June 13th (All)

4.8 Literature Cited

Clark, J.R. 1962. The 1960 Salt-Water Angling Survey. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, Circular 153, 36 pp.

Deuel, D.G. 1973. The 1970 Salt-Water Angling Survey. U.S. Department of Commerce, National Marine Fisheries Service, Current Fishery Statistics No. 6200, 54 pp.

Deuel, D.G. and J.R. Clark. 1968. The 1965 Salt-Water Angling Survey. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, Resource Publication 67, 51 pp.

Ellis, R.W. 1957. Catches of fish by charter boats on Florida's East Coast. Florida State Board of Conservation, Special Service Bulletin No. 14, 4 pp.

Ellis, R.W., A. Rosen, and A.W. Moffett. 1958. A survey of the number of anglers and of their effort and expenditures in the coastal recreational fishery of Florida. State of Florida, Board of Conservation, Technical Series No. 24, 50 pp.

Rosen, A. and R.W. Ellis. 1961. Catch and fishing effort by anglers in Florida's coastal and offshore waters. Florida State Board of Conservation, Special Service Bulletin No. 18, 9 pp.

4.8 Tables

Table 4.8.1. Total number of Spanish mackerel caught aboard headboats for fishing years 1981-2007 (March-February) by region; North Carolina (NC), South Carolina (SC), Georgia-North Florida (GA/NEFL), and Southeast Florida (SEFL).

Year	NC	SC	GA\NEFL	SEFL	Grand Total
1981	0	0	42	25471	25513
1982	0	0	25	3024	3049
1983	8	1	74	2416	2499
1984	0	134	65	393	592
1985	9	47	73	379	508
1986	33	198	164	2955	3350
1987	5	91	49	1328	1473
1988	83	33	60	324	500
1989	0	181	94	413	688
1990	13	232	231	264	740
1991	14	1099	315	480	1908
1992	38	303	258	442	1041
1993	5	271	85	302	663
1994	2	716	54	1805	2577
1995	5	63	49	484	601
1996	6	466	166	227	865
1997	106	1910	89	375	2480
1998	30	2073	56	231	2390
1999	197	5828	69	642	6736
2000	816	2529	54	363	3762
2001	30	3265	29	407	3731
2002	9	4072	165	397	4643
2003	47	1304	53	343	1747
2004	51	3445	50	1535	5081
2005	28	4707	39	708	5482
2006	11	2562	56	837	3466
2007	2	4637	57	928	5694

Table 4.8.2. Total weight (pounds) of Spanish mackerel caught aboard headboats for fishing years 1981-2007 (March-February) by region; North Carolina (NC), South Carolina (SC), Georgia-North Florida (GA/NEFL), and Southeast Florida (SEFL).

Year	NC	SC	GA\NEFL	SEFL	Grand Total
1981	0	0	115	73690	73805
1982	0	0	109	14254	14362
1983	13	2	119	3907	4040
1984	0	399	206	1555	2160
1985	31	161	269	1587	2048
1986	94	563	490	7891	9037
1987	13	235	127	3775	4150
1988	112	77	133	610	932
1989	0	487	295	692	1474
1990	14	273	771	856	1915
1991	30	1823	792	1304	3948
1992	53	422	630	1094	2199
1993	11	577	185	656	1428
1994	5	1755	135	4577	6472
1995	12	150	88	1321	1571
1996	15	1025	348	549	1937
1997	105	2417	212	1397	4131
1998	75	5180	190	845	6290
1999	202	5987	169	2954	9312
2000	818	1986	145	1077	4025
2001	81	9025	119	1738	10963
2002	8	3678	325	1592	5603
2003	51	1420	136	1014	2620
2004	186	10920	125	4497	15728
2005	65	8530	118	2185	10897
2006	11	2622	104	1838	4575
2007	2	4063	76	2384	6432

Table 4.8.3. Sample size of Spanish mackerel measured for length in the headboat program. NC=North Carolina, SC=South Carolina, NF=North Florida to Cape Canaveral, SF=South Florida from Cape Canaveral through the Florida Keys.

Year	NC	SC	NF	SF	Total	Year	NC	SC	NF	SF	Total
1974		1			1	1991	2	23	9	11	45
1975						1992	1	13	1	12	27
1976						1993		3	4	3	10
1977						1994			2	8	10
1978				4	4	1995		4	3	19	26
1979			2	4	6	1996		1	1	2	4
1980				3	3	1997	28	16	8	22	74
1981			3	11	14	1998	1	13	2	26	42
1982	3			1	4	1999	1	9	10	14	34
1983	2			65	67	2000	22	14	5	15	56
1984			3	17	20	2001	5		1	16	22
1985			3	10	13	2002	5	9	3	18	35
1986		2	5	11	18	2003	32	21	2	45	100
1987	1	4	1	115	121	2004	13	7	1	15	36
1988	2	2	1	13	18	2005	10	8		11	29
1989		2	6	1	9	2006	13	55		17	85
1990	1	30	25	1	57	2007	22	41		19	82

Table 4.8.4. Predicted ratios and standard errors (in parenthesis) between FHS and MRFSS charterboat effort estimates (to be applied to 1986-2003) for the Mid-Atlantic states. Significant factors included state and wave.

	Wave				
	2	3	4	5	6
DE / MD	1.294 (0.52)	1.599 (0.54)	1.930 (0.54)	0.861 (0.52)	1.171 (0.56)
NJ	1.289 (0.36)	1.179 (0.34)	1.644 (0.34)	0.809 (0.34)	1.115 (0.36)
NY	1.187 (0.48)	2.048 (0.54)	2.665 (0.48)	1.210 (0.51)	0.617 (0.48)
VA	0.770 (0.25)	0.680 (0.21)	0.761 (0.21)	0.324 (0.22)	0.313 (0.22)

Table 4.8.5. Party/Charter (PC) mode Ratios for 1981-1985 Vermilion Snapper and Spanish Mackerel estimate adjustment for South Atlantic sub-region (both) and Mid-Atlantic sub-region (Spanish Mackerel only): Headboat (from logbook program: SEHB) plus Charterboat estimates (RDD-CHTS and FHS-GLM Ratio Adjusted) used to produce Party/Charter equivalent landings and adjustment ratios to be applied to the combined PC mode estimates produced by MRFSS using RDD-CHTS derived effort estimates. Significant factors included state and sub-region.

	STATE			
	NC	SC	GA	FL
Vermilion Snapper	1.082 (0.02)	1.082 (0.02)	NA	NA
Spanish Mackerel (south Atlantic)	1.518 (0.09)	2.031 (0.09)	NA	0.710 (0.10)
	ALL MID-ATLANTIC STATES (NY - VA)			
Spanish Mackerel (mid-Atlantic)		1.420 (--)		

Table 4.8.6. Estimates of the number of Spanish mackerel caught (1000s) in the recreational fisheries in the U.S. South and Mid Atlantic areas from the U.S. Fish and Wildlife Service salt-water angling surveys conducted in 1960, 1965, and 1970.

Region	**1960**	**1965**	**1970**
Mid-Atlantic		278	350
South Atlantic	7,380	7,548	4,967
Total	7,380	7,826	5,317

Table 4.8.7. Final estimates of caught Spanish mackerel from recreational anglers.

Year	**Landings (1000s)**	**PSE**
1960	7,380	36%
1965	7,826	46%
1970	5,317	57%

Table 4.8.8. Sample size from unfiltered Spanish mackerel age data from each of the fishing modes (CP=charter, HB=headboat, PR=private, TRN=Tournament). Tournament samples were not included in the age compositon.

Year	CP	HB	PR	TRN	Total
1988	6		109	62	177
1989			35	171	206
1990	66		205	110	381
1991	22		170	211	403
1992	182		16	42	240
1993	13		91	21	125
1994	171				171
1995	70				70
1996	73		5		78
1997	228		88		316
1998	165	31	23		219
1999	40		49	5	94
2000	76		54		130
2001	38		11		49
2002	161		43		204
2003	233		2	86	321
2004	97	135	7	2	241
2005	194	1	9		204
2006	240	4	11		255
2007	182			2	184
Total	2257	171	928	712	4068

Table 4.8.9. Sample size of aged Spanish mackerel by state.

Year	NC	SC	FL	Total
1988	88	14	6	108
1989	4	30	0	34
1990	253	18	0	271
1991	173	8	11	192
1992	161	33	0	194
1993	74	28	0	102
1994	171	0	0	171
1995	67	0	2	69
1996	76	0	1	77
1997	307	0	0	307
1998	214	0	0	214
1999	88	0	0	88
2000	129	0	0	129
2001	46	0	0	46
2002	161	0	42	203
2003	217	0	17	234
2004	220	0	10	230
2005	191	0	13	204
2006	247	0	4	251
2007	181	0	0	181

4.9 Figures

Figure 4.9.1. Reporting areas used in the Southeast Region Headboat Survey.

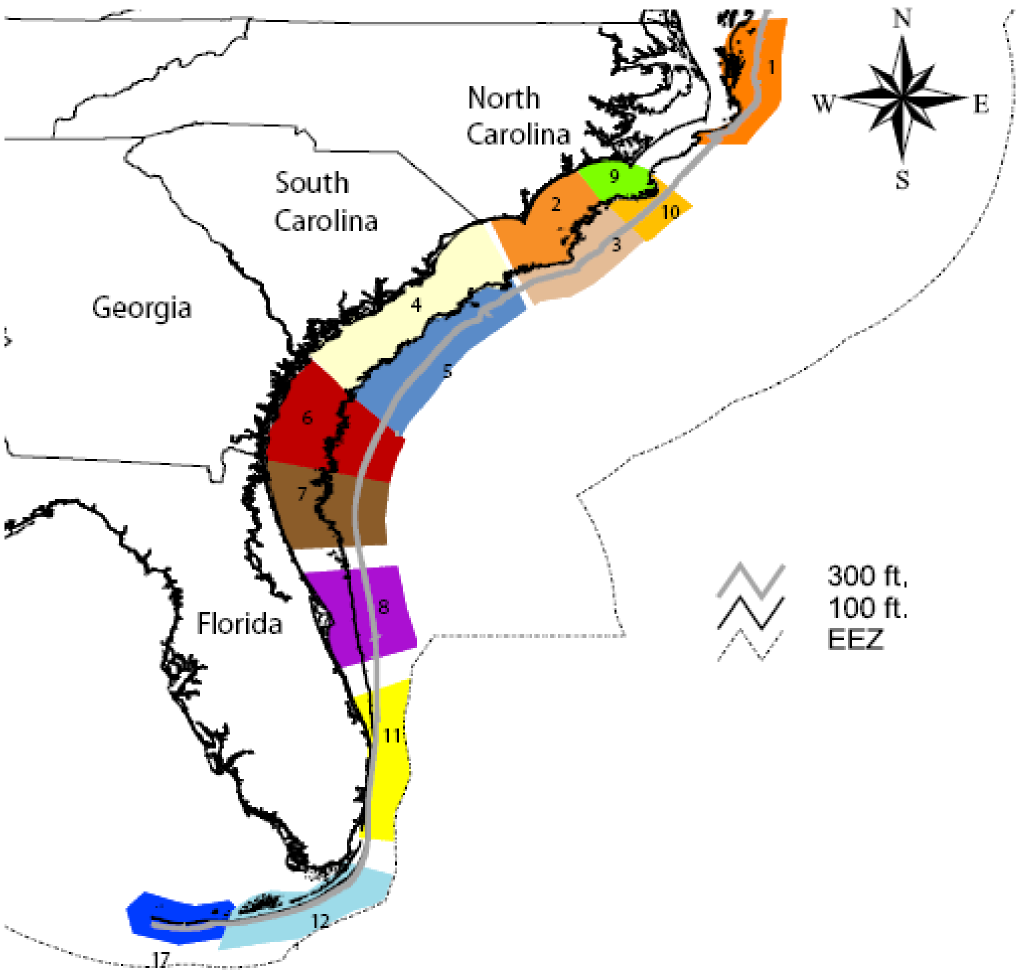


Figure 4.9.2. Number of headboat trips by region in the South Atlantic 1998-2007.

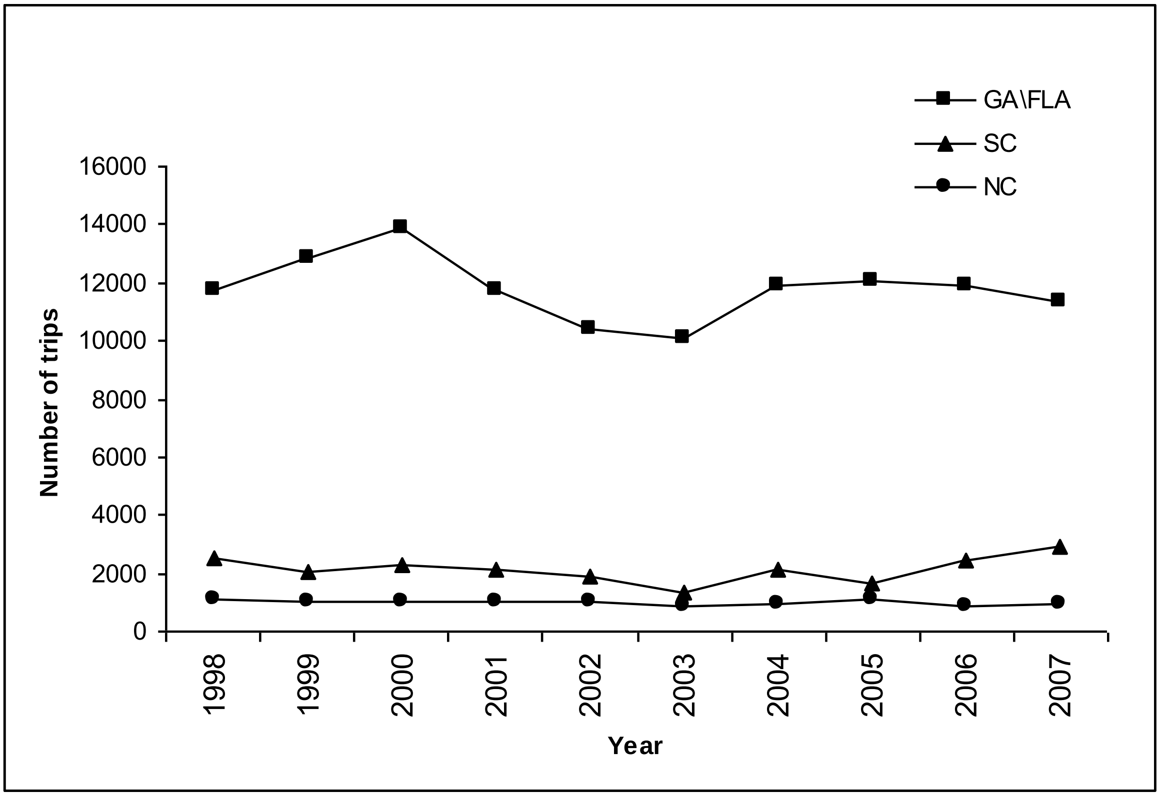


Figure 4.9.3. General recreational length composition from MRFSS data in 1 cm bins.

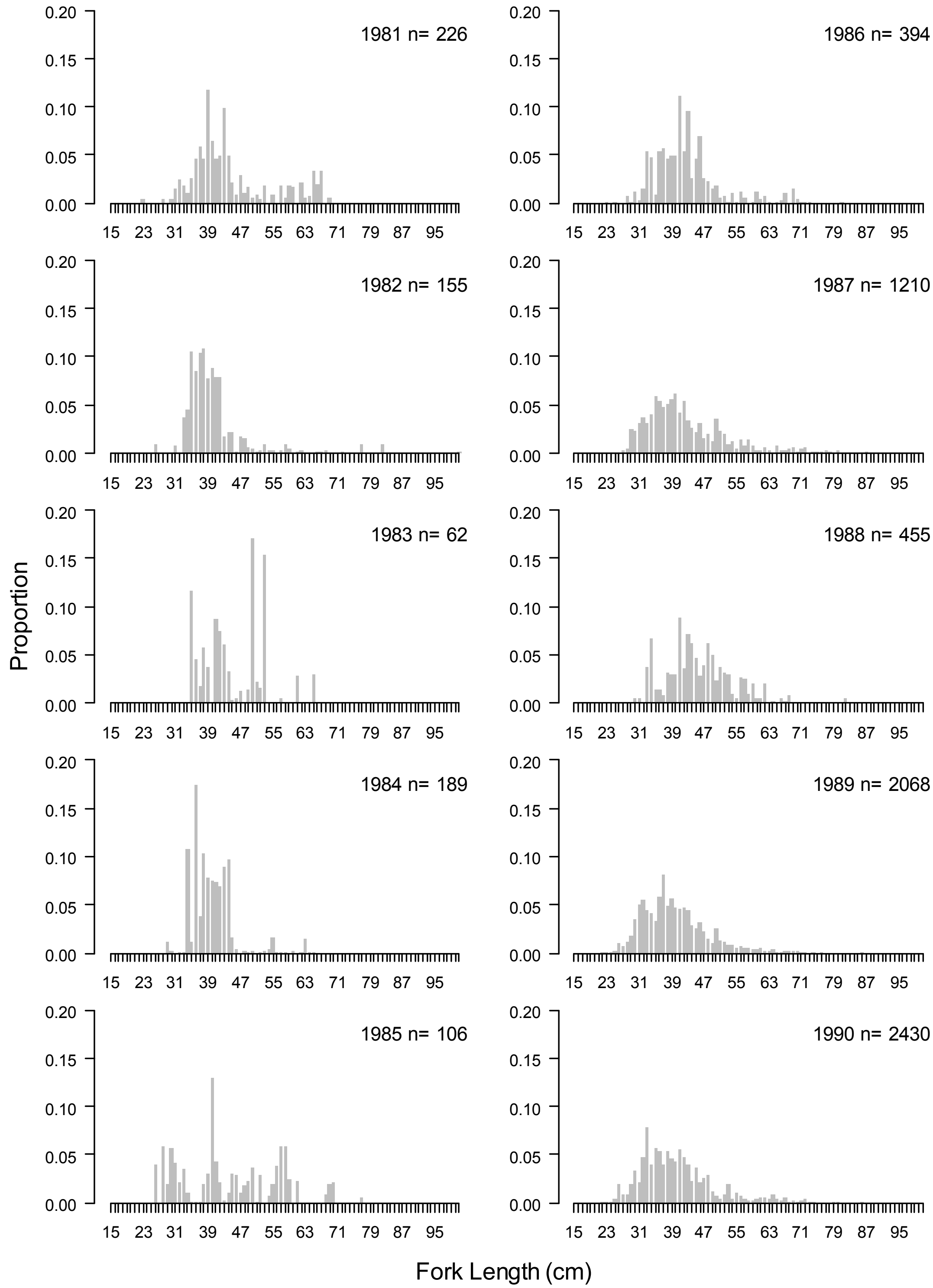


Figure 4.9.3 continued.

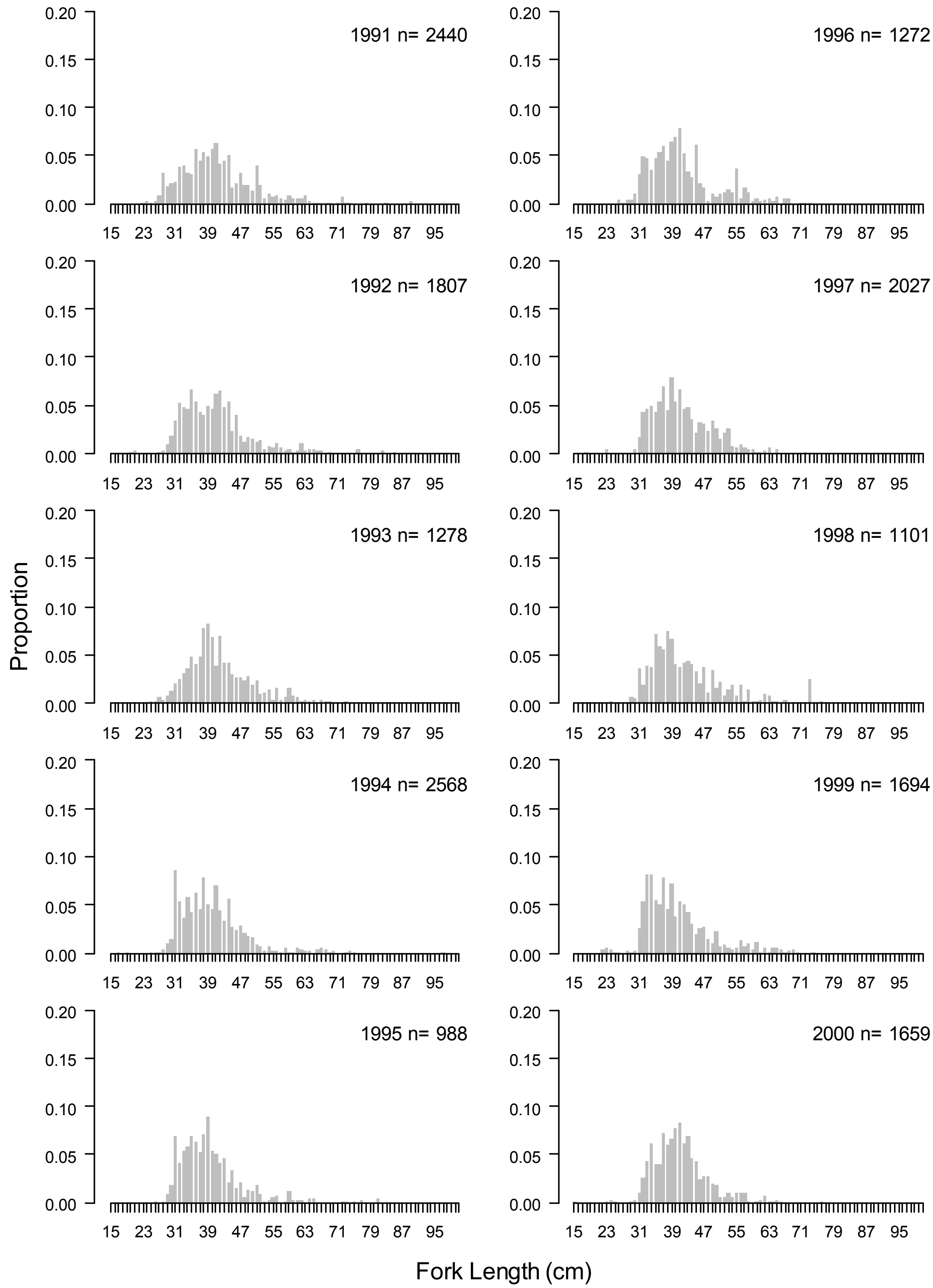


Figure 4.9.3 continued.

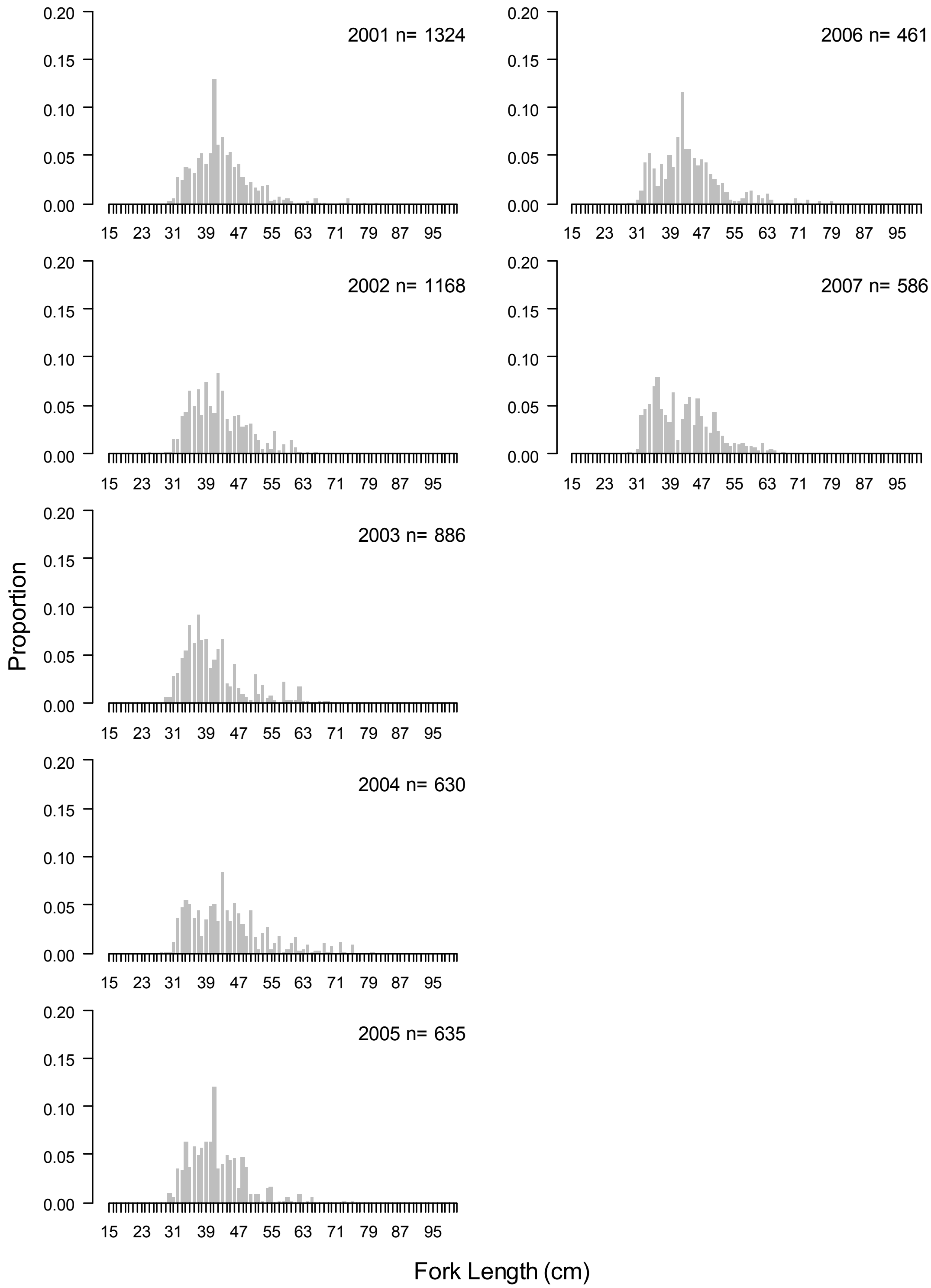
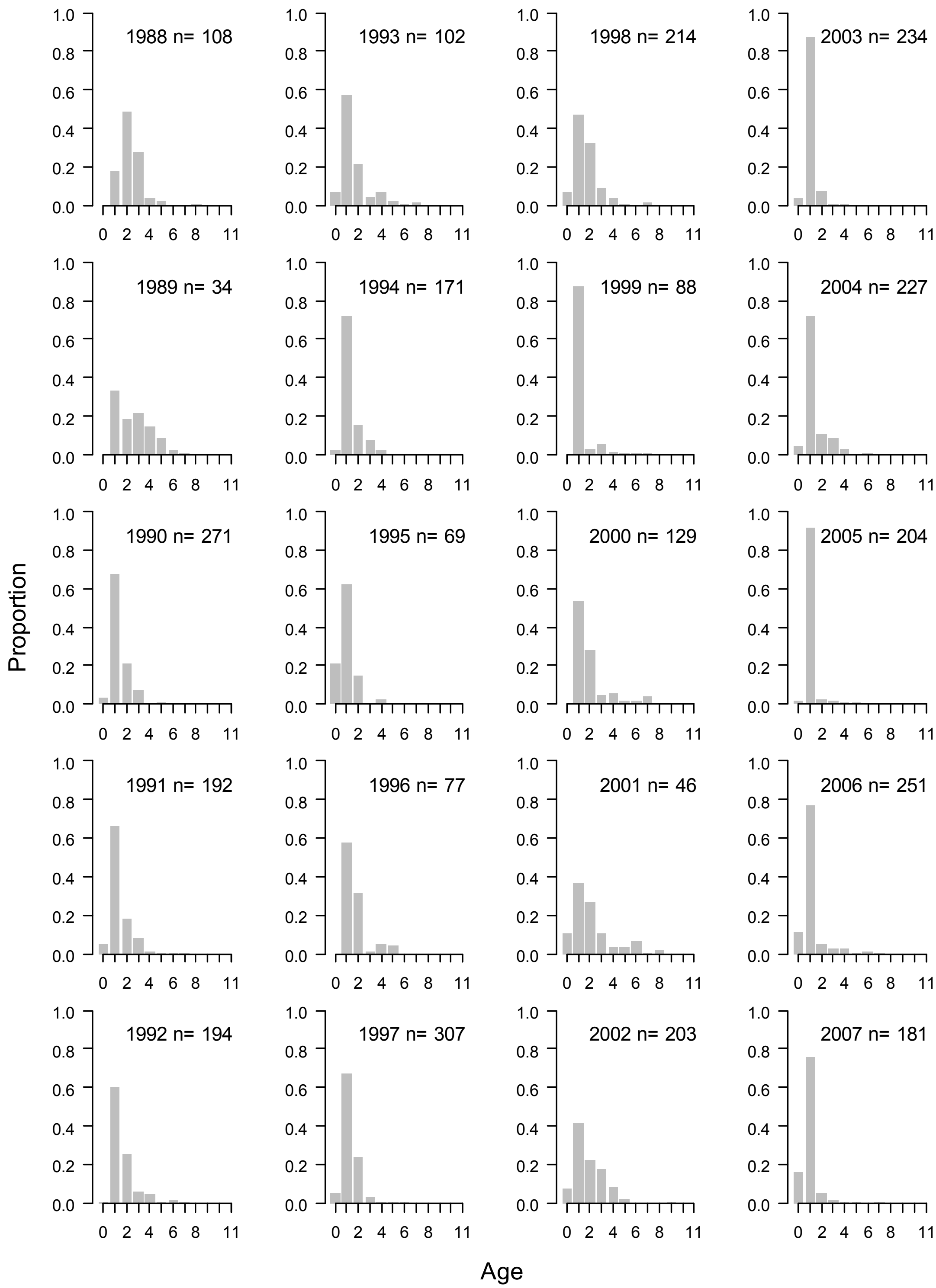


Figure 4.9.4. Age composition of Spanish mackerel from the general recreation fishery. Private, charter, and headboat samples are included. Samples from fishing tournaments were excluded.



5. INDICATORS OF POPULATION ABUNDANCE

5.1 OVERVIEW

Several Spanish mackerel indices of abundance were considered for use in the assessment model. These indices are listed in Table 5.8.1, with pros and cons of each in Table 5.8.2. The possible indices came from fishery dependent and fishery independent data. The DW recommended that six fishery dependent indices be used in the assessment: two from commercial logbook data (for gillnet and handline/trolling fisheries north of Florida), three from commercial trip tickets in Florida (corresponding to handline/trolling, gillnet, and castnet fisheries), and one from general recreational data (MRFSS) (Table 5.8.1, 5.8.2). The three Florida trip ticket indices were conditional on being able to adequately identify and remove records for which a substantial portion of the fishery exceeded trip limits. In addition, the DW recommended use of two fishery independent datasets, both derived from the SEAMAP survey. These included a young-of-year recruitment index derived from summer and fall trawl surveys as well as a one-year-old index from spring trawl surveys.

Membership of this DW working group included Paul Conn, Julie DeFilippi, Pat Harris, Kyle Shertzer (leader), Helen Takade, Elizabeth Wenner, and Geoff White. Ben Hartig (commercial fisherman) provided additional input.

5.2 FISHERY INDEPENDENT INDICES

5.2.1 SEAMAP

5.2.1.1 Background

The SEAMAP survey (Southeast Area Monitoring and Assessment Program) is a fishery independent trawl survey conducted three times a year from Cape Hatteras, NC down to Cape Canaveral, FL according to standardized protocol. This survey recorded a reasonable number of Spanish mackerel for the period 1989-2007; 26,017 fish were caught in a total of 4,872 trawls. In principle, annual changes of catchability should be minimized because the same gear and sample protocols were used throughout. In this regard, indices from SEAMAP are preferable to those from fishery dependent sources.

5.2.1.2 Survey Methods

The SEAMAP program conducts three seasonal trawl surveys each year, with reasonable sample sizes starting in 1989. Samples are taken by trawl from the coastal zone of the South Atlantic Bight (SAB) between Cape Hatteras, North Carolina, and Cape Canaveral, Florida (Figure 5.9.1). Multi-legged cruises are conducted in spring (early April - mid-May), summer (mid-July - early August), and fall (October - mid-November). Stations are randomly selected from a pool of stations within each stratum. The number of stations sampled in each stratum is determined by optimal allocation. A total of 102 stations are sampled each season within twenty four shallow water strata, representing an increase from 78 stations previously sampled in those strata by the trawl survey (1990-2000). Strata are delineated by the 4 m depth contour inshore and the 10 m depth contour offshore. In previous years (1990-2000), stations were sampled in deeper strata with station depths ranging from 10 to 19 m in order to gather data on the reproductive condition of commercial penaeid shrimp. Those strata were abandoned in

2001 in order to intensify sampling in the shallower depth-zone. For purposes of index construction, only shallower depth zones were considered in order to maintain consistency in the survey.

The R/V *Lady Lisa*, a 75-ft (23-m) wooden-hulled, double-rigged, St. Augustine shrimp trawler owned and operated by the South Carolina Department of Natural Resources (SCDNR), is used to tow paired 75-ft (22.9-m) mongoose-type Falcon trawl nets (manufactured by Beaufort Marine Supply; Beaufort, S.C.) without turtle excluder devices. The body of the trawl is constructed of #15 twine with 1.875-in (47.6-mm) stretch mesh. The cod end of the net is constructed of #30 twine with 1.625-in (41.3-mm) stretch mesh and is protected by chafing gear of #84 twine with 4-in (10-cm) stretch "scallop" mesh. A 300 ft (91.4-m) three-lead bridle is attached to each of a pair of wooden chain doors which measured 10 ft x 40 in (3.0-m x 1.0-m), and to a tongue centered on the head-rope. The 86-ft (26.3-m) head-rope, excluding the tongue, had one large (60-cm) Norwegian "polyball" float attached top center of the net between the end of the tongue and the tongue bridle cable and two 9-in (22.3-cm) PVC foam floats located one quarter of the distance from each end of the net webbing. A 1-ft chain drop-back is used to attach the 89-ft foot-rope to the trawl door. A 0.25-in (0.6-cm) tickler chain, which is 3.0-ft (0.9-m) shorter than the combined length of the foot-rope and drop-back, is connected to the door alongside the foot-rope. Trawls are towed for twenty minutes, excluding wire-out and haul-back time, exclusively during daylight hours (1 hour after sunrise to 1 hour before sunset). Sampling during spring of 1989 was conducted at night, and thus was omitted from analysis. Each net is processed separately and assigned a unique collection number (port=odd, starboard=even); however, data from the paired trawls are pooled for analysis to form a standard unit of effort (tow), with the port (odd) collection number assigned to the tow. Contents of each net are sorted separately to species, and total biomass and number of individuals are recorded for all species.

5.2.1.3 Analysis methods

One issue that arises when exploring SEAMAP data is the sizes (and ostensibly ages) that are captured (Figure 5.9.2). In spring trawl surveys, almost all fish appear to be surviving members of the previous year's recruitment class, while summer and fall surveys primarily document young of year (YOY). For example, growth equations derived by Powell (1975) and Schmidt et al. (1993) point to an average size of around 27 inches for YOY, and 35 inches for 1 year olds. However, spawning occurs over a wide range of dates (April/May to August/September; Powell 1975, Schmidt et al. 1993), leading to a wide variety of sizes for a given year class.

For purposes of this stock assessment, we considered one index for young of the year, and one for 1-year-olds. The former appeared to be the primary group that was caught in Summer and Fall trawl surveys, although there were some one-year-olds mixed in. To limit mixing, we eliminated records of fish caught in summer and fall trawl surveys that were greater than 22 cm. An index of young-of year recruitment was then calculated as the average number of fish in this size range caught per summer and fall trawl per year, with sample standard errors used to calculate asymptotic 95% confidence intervals (± 1.96 SE; Figure 5.9.3, Table 5.8.3). Standard errors should be treated with caution. The lengths of fishes in many of the trawls seemed to be correlated (e.g., when fish in a trawl were all of similar size), suggesting that individual trawls did not sample the population randomly.

The correlation between the YOY index and the index of one-year-olds in the following year was -0.26. The DW had hoped that joint modeling of both indices would allow for modeling of winter survival of recruits; however, this may not be possible given that the two do not appear to be related. If one of the indices had to be chosen over the other, the DW recommended using the YOY index because of greater temporal coverage and sample size. In addition, concerns were raised that an unknown proportion of one year olds may be unavailable for sampling due to growth past the selectivity range of the trawling gear. This recommendation was made with some reservation; if there is considerable variability in overwinter mortality of YOY, the one-year-old index may serve as a better recruitment index.

5.2.2 Other fishery independent sources

Other existing data sets (MARMAP survey, NEAMAP survey, N. C. Pamlico Sound trawl survey, Northeast Ground Trawl Survey, and diver reports (e.g., www.reef.com)) were considered for their potential as indices, but they sampled either no Spanish mackerel or insufficient numbers to be useful. The DW thus eliminated them from consideration.

5.3 FISHERY DEPENDENT INDICES

5.3.1 COMMERCIAL LOGBOOK

5.3.1.1 General description

The NMFS collects catch and effort data by trip from commercial fishermen who participate in fisheries managed by the SAFMC. For each fishing trip, data collected include date, gear, fishing area, days at sea, fishing effort, species caught, and weight of the catch (Appendix 5.10.1). The logbook program in the Atlantic started in 1992. In that year, logs were collected from a random sample representing 20% of vessels; starting in 1993, all vessels with snapper-grouper permits were required to submit logs. For Spanish mackerel, mandatory reporting was required in 1998. Using these data, indices of abundance were computed for handline/trolling and gillnet fisheries for 1998–2007 for points north of Florida (Georgia – New York; 31° N ≤ latitude ≤ 40° N). The DW recommended using both indices, which had reasonable sample sizes and CV’s (Table 5.8.5).

5.3.1.2 Issues discussed at the DW

Issue 1: Trip tickets vs. logbook

Option 1: Use trip tickets in NC and FL because they go back further in time (1985 for FL, 1996 for NC), thus increasing sample size. Trip tickets also sample more fishermen because only those with federal permits appear in the logbook survey.

Option 2: Use logbook because more precise information is available on effort and there is better spatial coverage (e.g., Georgia and South Carolina). However, logbook records are only required for Spanish since 1998.
Option 3: Use trip tickets for FL and logbook for the remaining states.
Decision: Option 3, because FL trip ticket gear types better correspond to summarized commercial landings (e.g., cast nets are broken out), which is needed for applying the correct selectivity curve in the assessment model. Records also span the period of apparent low abundance and the net ban. For NC, there is evidence that effort per trip (in terms of net-area-hours) has changed over time, which calls into question the use of NC trip ticket data for developing an index of abundance, because effort it in units of "trip" (Figure 5.9.4).

Issue 2: Gear selection
Option 1: Include separate gillnet and handline/trolling indices
Option 2: Include only gillnets
Decision: Option 1, because sample sizes were reasonable for both groups if all positive trips were included for the handline/trolling index

Issue 3: Defining which trips constitute effort
Option 1: Include only positive trips
Option 2: Use method of Stephens and MacCall (2004) to define effort that could have caught the focal species based on the composition of other species in the catch. This method would include trips with zero catch but positive effort.
Option 3: Include positive trips for the handline/trolling fishery and all trips for the gillnet fishery
Decision: Option 3, because federally licensed vessels are highly selective for Spanish when they are fishing for them. For handline/troll fishery this increases sample size to 1058 records, while applying the method of Stephens and MacCall (2004) to subset trips resulted in a total of 183 positive trips out of 972 trips that were selected as being likely to catch Spanish mackerel. For the gillnet fishery, 70% of trips were positive for Spanish mackerel, so including all of them was thought to be a reasonable indicator for effort.

Issue 4: Defining changes to catchability
Option 1: Include trends in catchability to reflect changes in technology.
Option 2: Do not include changes in catchability
Decision: Option 2, because coastal pelagics are not as susceptible to sonar, GPS, and other technologies that have ostensibly increased catchability in snapper-grouper fisheries.

5.3.1.3 Methods

The CPUE from commercial logbook data was computed in units of total pounds caught per hook-hour for the handline/troll fishery, and total pounds per net-area-hour for the gillnet fishery. The duration of the time series was 1998–2006, and included all records between 31° N and 40° N latitude (Figure 5.9.5; Table 5.8.5). Each record describes weight (total lb) of a single species caught on a single trip, along with descriptive information of the trip, such as effort, date, and area fished (Appendix 5.10.1).

Of trips that caught Spanish mackerel, approximately 85% (6014 records) used gillnets, while most of the remainder used various forms of hook and line (electric reels, gear code E, 48 records; handline, gear code H, 157 records; trolling, gear code, TR, 864 records). Data from 4 positive trawls (gear code T) were deleted for analysis, with the remaining hook and line records combined for calculation of a hook and line index. Excluded were records suspected to be misreported or misrecorded, as in previous SEDAR assessments (e.g., SAFMC, 2006; SAFMC, 2007): The variable "fished" (number of hours fished) was constrained to less than 24 hours; the variable "numgear" (number of lines) to be an integer value; and the variable effort (# hooks/line or number of gillnets used) to be an integer value. All records that were missing *away, effort, fished, numgear, schedule,* or *species* fields were also deleted.

Prior to standardizing CPUE with generalized linear models, a number of outliers were noted, and the top one percent of CPUE records were deleted from both gear types (gillnet & hook-and-line) to remove them from analysis. Standardized catch rates were estimated using generalized linear models assuming either delta-lognormal or delta-gamma error structures (Lo et al., 1992; Dick 2004; Maunder and Punt, 2004), in which the binomial distribution describes positive versus zero CPUE, and the lognormal or gamma distribution describes positive CPUE. Explanatory variables considered, in addition to year (necessarily included), were geographic area, and gear type (handline/electric reels vs. trolling for the hook-and-line index). Geographic areas reported in the logbooks were pooled into two larger areas to provide adequate sample sizes for each level of this factor— GA & SC (31°N ≤ latitude ≤ 33°N), and NC up to NY (34°N ≤ latitude ≤ 40°N). Interactions with year effects were not considered, because there was no *a priori* reason to expect them and because such effects may be inseparable from annual changes in abundance.

Lognormal and gamma models were fitted to both datasets, and the error structure with the lowest AIC was selected (cf., Dick 2004; SEDAR17-RD16). In this case, the lognormal model was resoundingly selected for both indices (ΔAIC = 484.3 for hook & line; ΔAIC = 164.2 for gillnet). To put this in context, Burnham and Anderson (2002, pg 70) suggest that that a ΔAIC score of 10 or greater suggests essentially no support for the lower-ranked model. Delta-lognormal glms appeared to fit the CPUE data reasonably well, with neither normal quantile-quantile plots nor plots of standardized residuals against fitted values showing any serious trends (Appendix Figures 5.10.2.1, 5.10.2.2)

5.3.1.6 Catch Rates and Measures of Precision

Table 5.8.5 shows standardized CPUE series, standard errors (SE), and annual sample sizes (number of positive trips) for gillnet and hook& line fisheries. Figure 5.9.6 shows standardized and nominal CPUE, together with confidence intervals. Logbook indices were weakly (but positively) correlated with $\rho = 0.15$.

5.3.1.7 Comments on Adequacy for Assessment

The logbook index was recommended by the DW for use in the assessment. The DW, however, did express several concerns about this data set (Table 5.2). It was pointed out that there are problems associated with any abundance index and that convincing counter-evidence needs to be presented to not use the logbook data.

Two concerns merit further description. First, the logbook survey only obtains reports from federally permitted commercial fishermen. Since Spanish mackerel are often present in state waters, they can be targeted by commercial fishermen that do not have federal permits. Thus, the survey does not represent total effort for the commercial fishery. This could be problematic if there were partitioning of effort between the two groups such that federally permitted fishermen fished in areas further offshore. In this case, changes in CPUE may reflect changes in migratory pattern in addition to changes in abundance and/or catchability.

Second and probably foremost, the data are obtained from a directed fishery and therefore the index could be subject to problems associated with any fishery dependent index. Overall efficiency may have changed throughout the time series if fishermen of marginal skill have left or joined the fishery at a greater rate than more successful fishermen. Also of concern is whether catch rates in a directed fishery are density-dependent. As fish abundance decreases, fishermen may maintain relatively high catch rates, and as fish abundance increases, catch rates may saturate.

The DW discussed how the assessment might attempt to account for changes in catchability over time. In recent SAFMC assessments of reef fishes (e.g. SAFMC 2006, 2008), base model runs assumed catchability increased over in time in response to changes in technology. However, in the case of Spanish mackerel, the DW decided that the assumption of constant catchability was reasonable because recently developed technologies are not in general useful for locating coastal pelagics.

5.3.2 FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION (FWC) MARINE FISHERIES TRIP TICKET PROGRAM

5.3.2.1 General description

The FWC has recorded fisheries landings and effort data since November 1984. Since then, state law has required that all sales of seafood products from Florida waters be reported via a Marine Fisheries Trip Ticket (cf., http://floridamarine.org/features/view_article.asp?id=23423). Included in the trip ticket database are date of trip, total pounds landed, gear type, county, and areas fished (e.g. inshore, offshore, federal waters). Using these data, indices of abundance were calculated for three gear types: gillnet, castnet, and handline. The DW recommended use of all of these indices, although certain years and trips were to be omitted from analysis.

5.3.2.2 Issues discussed at the DW

Issue 1: What trips should be included given that trip limits changed over time?

Regulations for Spanish mackerel in Florida were changed frequently over the years, with a diverse array of trip limits and closures.

Option 1: Include all trips

Option 2: Only include data from April through October (regulations were reasonably constant during this time period)

Option 3: Include data from trips occurring on days and with gears unlikely to run up against trip limits.

Decision: Option 3, because option 2 eliminates most trips (the primary fishery is in winter), and because option one may lead to problems with interpretability. If trips are constantly hitting up against trip limits, CPUE is unlikely to reflect abundance. In contrast, if we limit analysis to those where the probability of hitting up against a trip limit is relatively low (e.g., 5%), CPUE may better reflect abundance.

Issue 2: What defines effort?

For trip ticket data, the only reasonable proxy for effort is a trip. Examination of the logbook data from 1998-2007 indicated that effort decreased over time for the handline fishery (Figure 5.9.7), which may cast doubt on the utility of a trip as a unit of effort. However, there was some debate as to how primary gear types were assigned in the logbook database (e.g., castnets hardly ever appeared), and whether this decline really represented declining effort or whether it was more of a function of changing gear types. A Florida commercial fisherman present at the DW (Ben Hartig) suggested that due to the directed nature of the commercial fishery in Florida that all fishermen put in about the same amount of effort each time they go out, and that a ‘trip’ is about the best descriptor of effort one could hope for. The DW thus recommended using a ‘trip’ as a measure of effort.

Issue 3: What gears and time series should be considered?

Of the three primary gears used in Florida (castnet, gillnet, and handline), only handline has been consistently similar in method of operation throughout the course of the fishery. The gillnet fishery was largely unregulated until the late 1980’s, with spotter planes being used to locate schools of fish and wrap around nets being used as the primary gear. Following a series of increasingly restrictive federal regulations in the early 1990’s, a gillnet ban was put into effect in Florida state waters in 1995. These events dramatically altered the character of the fishery, with a large castnet fishery arising in the early 2000’s. The DW agreed that if a gillnet index were to be used, it should be broken into two pieces: one prior to the net ban, and one after the net ban. Concerns were raised about anecdotal changes in migratory pattern of Spanish mackerel in recent years (2003-present), whereby Spanish were absent from traditional fishing locations and thus more susceptible to harvest by gillnets than by castnets or handlines. Thus, none of the indices alone would capture true abundance in the last few years prior to the assessment. Nonetheless, the DW agreed to pursue indices for all three gear types, with the thought that a compromise in model fit with all three indices included may best represent abundance in the areas where Spanish mackerel are most frequently landed.

Issue 4: Defining changes to catchability

Option 1: Include trends in catchability to reflect changes in technology.

Option 2: Do not include changes in catchability

Decision: Option 2, because coastal pelagics are not as susceptible to sonar, GPS, and other technologies that have ostensibly increased catchability in snapper-grouper fisheries.

.

5.3.2.3 Methods

As a precursor to analysis, trips were screened to include only those that were unlikely to run up against a trip limit. To do so, a trip limit was assigned to each trip that was positive for Spanish mackerel by associating trip dates with corresponding regulations (some of which changed with day of the week). The percent of trips that met or exceed trip limits were then plotted by time according to gear and trip limit level (Figures 5.9.8-5.9.11). For gillnets and castnets, any trip limits under 3500 lb resulted in a large percent of trips meeting or exceeding trip limits, and so trips occurring on these days were censored from analysis. For the handline fishery, only 500 lb trip limits resulted in a large percentage of trips meeting or exceeding the trip limit; these were likewise omitted from analysis. After applying this approach, the number of trips included in analysis was somewhat reduced but still substantial (Tables 5.8.6-5.8.8). The following time series were considered as having large enough sample sizes for analysis:

- For gillnet, two time series: prior to FL state gillnet ban (1985-1994), after gillnet ban (1996-2007)
- For castnet, one time series (1999-2007)
- For handline, one time series (1985-2007)

For each such series, two generalized linear models (assuming either gamma or normal errors) were used to relate the log of catch/trip to predictor variables. In particular, categorical variables were specified for year, month, and county, and binary variables were assigned for whether other species had been caught. Six such binary variables were assigned, based on whether the other species caught were grouped as one of the following categories by Florida trip ticket personnel: “inshore pelagic,” “offshore pelagic,” “inshore bottom,” “offshore bottom,” “reef fish,” or “other species” (cf., Table 5.8.9). Akaike’s information criterion (AIC) was then used to select among error structures (gamma or normal).

The gamma error structure was selected as the most appropriate for the gillnet fishery prior to the gillnet ban (ΔAIC = 3400), while the normal error structure was selected for the remaining fisheries (ΔAIC = 2621, 7100, and 999, for the 1996-2007 gillnet, the castnet, and the hand lines fisheries, respectively). Standard diagnostic plots (Appendix Figures 5.10.2.3-5.10.2.6) indicated that error assumptions for GLMs were largely reasonable, except perhaps for the castnet fishery. A typical approach in this case would be to inflate the variance of the estimated CPUE trend with a variance inflation factor (cf. McCullough and Nelder 1989). However, the CV associated with trends are typically rescaled prior to assessments in the South Atlantic region, making variance inflation procedures redundant. Instead, one possible suggestion is to decrease the weight on the castnet index during fitting of the assessment model.

5.3.2.4 Sampling Intensity

The numbers of positive trips by year and gear are tabulated in Tables 5.8.6-5.8.8.

5.3.2.5 Size/Age Data

Sizes and ages of fish represented by these indices are the same as those sampled by commercial fisheries using the same gear (see chapter 3 of this DW report).

5.3.2.6 Catch Rates and Measures of Precision

Diagnostic plots of residuals from the GLM model fits are in Appendix 5.10.2. Table 5.8.10 shows nominal CPUE (total lb/trip), standardized CPUE, and coefficients of variation (CV). Figure 5.9.12 shows standardized and nominal CPUE for all Florida trip ticket indices.

5.3.2.7 Comments on Adequacy for Assessment

Trip ticket indices were recommended by the DW for use in the assessment. However, the DW did discuss several concerns (Table 5.2). One concern was that this index may contain problems associated with fishery dependent indices, such as density dependent changes in catchability and/or fish targeting. This was especially relevant given the number and frequency of regulation changes. Although these changes were accounted for in some way by censoring data or were controlled for in GLMs, changes in effort related to the timing of regulations could not be adequately addressed. For instance, if fishermen anticipated that a season would be closed (or if the fishery were opened at the start of a new fishing year), would they increase effort in months of the year where the fishery was not traditionally very active and/or successful? At least one member of the DW thought that these data should be omitted from consideration because of such concerns. However, a commercial fisherman present at the DW (Ben Hartig) provided ancillary information that the trends in the various fisheries were representative of what he was seeing on the water. Data workshop representatives ended by agreeing it was important to attempt to include commercial indices from the state of Florida, which has historically accounted for the vast majority of commercial landings of Spanish mackerel in the south Atlantic.

5.3.3 RECREATIONAL INTERVIEWS

5.3.3.1 General description

The general recreational fishery is sampled by the Marine Recreational Fisheries Statistics Survey (MRFSS). This general fishery includes all recreational fishing from shore, man-made structures, private boats, and charter boats (for-hire vessels that usually accommodate six or fewer anglers). Party boats were removed from this analysis because they are sampled by the headboat survey. Using the MRFSS data from the South Atlantic region, that is Currituck County, North Carolina through Miami-Dade County, Florida (Figure 5.9.13), an index of abundance was computed for 1987–2007.

5.3.3.2 Issues discussed at DW

Issue 1: Trip selection

Option 1: Select angler-trips based on the method of Stephens and MacCall (2004)

Option 2: Use MRFSS data on effective effort to select angler-trips: Apply proportion of intercepted trips that were "directed" [i.e., targeted or caught (A1+B1+B2)] to estimates of total marine recreational angler-trips.

Option 3: Use MRFSS data on effective effort to select angler-trips: Apply proportion of intercepted trips that were "directed" [i.e., targeted or harvested (A1+B1 only)] to estimates of total marine recreational angler-trips.

Decision: Option 2, because it is not clear how to implement the method of Stephens and MacCall (2004) given the MRFSS survey sampling design. Also, inclusion of B2's (discards) are useful for interpretation of CPUE as an index because of the high frequency of MRFSS trips bumping up against bag limits at the beginning of the time series (Figure 5.9.14).

Issue 2: First year of time series
Option 1: Start the time series in 1982, the first year of data collection.
Option 2: Start the time series in 1987, because of small sample sizes in 1982-1986.
Decision: Option 2. The DW decided to start the time series in 1987, when the sampling intensity increased substantially (Table 5.8.11).

Miscellaneous decisions
• A bag limit of 10/person/day was instituted for the recreational fishery in North Carolina, South Carolina and Georgia in 1987. A bag limit of 4/person/day was instituted for the recreational fishery in Florida in 1987. The bag limit in Florida was raised to 5/person/day in 1991 and 10/person/day in 1992. The bag limit for all four states was set at 15/person/day in 2000. The DW examined the occurrence of reaching and exceeding the bag limit and determined that it would not influence an index of abundance derived from recreational fishery data if discard data (B2's) were included in the analysis.
• Estimates of CV of the catch per effort are not obtainable, but instead were represented by proportional standard error (PSE) of total catch.

5.3.3.3 Methods

MRFSS CPUE
The CPUE was computed in units of number fish per angler-trip. The method chosen produced unbiased estimates of "directed" angler trips by applying the proportion of intercepted trips that were "directed" toward Spanish mackerel to estimates of total marine recreational angler trips. Directed trips were defined in two ways. First, directed trips were defined as those trips where Spanish mackerel was listed as targeted (under the variables "prim1" or "prim2") or caught (A1+B1+B2). Type B2 group catches (fish released alive) were assigned angler-trip values based on the leader with additional anglers acting as followers. Second, directed trips were defined as targeted (under the variables "prim1" or "prim2") or harvested (A1+B only). The proportion of directed trips was calculated based on the count of directed trips relative to all samples taken in a year/state/wave/mode/area strata. That proportion was then applied to the effort estimate for the same strata and summed up to the year/region level. The MRFSS data used included those areas ranging from North Carolina to the east coast of Florida excluding Monroe County. The directed trip analysis was obtained from the Atlantic Coastal Cooperative Statistics Program website (ACCSP, 2008).

BAG FREQUENCY DATA
Bag limits are typically analyzed as harvest. ACCSP pre-calculates the data from MRFSS intercept and effort estimate files and stores the output for online user queries. The code produces unbiased estimates of angler trips by catch frequency for harvest of a

species by state/mode/area/wave strata by applying proportion of intercepted trips that caught Spanish mackerel to estimates of total marine recreational angler trips.

5.3.3.4 Sampling Intensity
Sampling intensity (number of intercepted angler-trips) by state is shown in Table 5.8.11.

5.3.3.5 Size/Age Data
Sizes and ages of fish represented by this index are the same as those of the recreational fishery as sampled by the MRFSS (see chapter 4 of this DW report).

5.3.3.6 Catch Rates and Measures of Precision
Table 5.8.11 shows nominal CPUE (number/angler-trip) and estimates of precision, as does Figure 5.9.15.

5.3.4 Other Fishery Dependent Indices

Considerable effort was put towards developing an index from the headboat observer survey program database. However, a small percentage of boats – typically carrying 10 or fewer passengers – caught the majority of Spanish mackerel. Two approaches were considered. In the first, the method of Stephens and MacCall (2004) was used to subset trips by species composition. In the second, trips were subset to only include records from small vessels (≤10 anglers). In practice, both of these approaches resulted in inadequate sample sizes (e.g., 0-160 trips/year). As a result, the DW did not recommend indices developed from the headboat survey.

The Shrimp Fishery Observer Program was also considered, but dismissed by the DW because of low sample sizes (300 trips since the early 1970's) and extreme variability (see SEDAR17-DW12). The NC Citation program and online recreational reports were also considered but dismissed because they were voluntary and likely subject to reporting bias.

5.4 CONSENSUS RECOMMENDATIONS AND SURVEY EVALUATIONS

Two fishery independent indices based on the SEAMAP trawl survey were recommended for analysis, one of which represented young-of-year recruitment, while the other represented one-year-olds. Seven fishery dependent indices were recommended: commercial hook & line north of Florida (logbook), gillnet north of Florida (logbook), gillnet in Florida prior to state net ban (FL trip ticket; 1985-1994), gillnet in Florida after the net ban (FL trip ticket 1996-2007), Florida castnet (FL trip ticket), Florida handline (FL trip ticket), and MRFSS (Tables 5.1, 5.2). These indices are compared in Figure 5.9.17 and their correlations are in Table 5.8.12. It is noted that the correlations between indices are in many cases weak and often negative, indicating that none of the indices alone likely represents abundance well. Nevertheless, by using indices from different sectors of the fishery, one hopes to obtain a more complete picture of stock abundance over time.

5.5 RESEARCH RECOMMENDATIONS

1. Expand existing fishery independent sampling and/or develop new fishery independent sampling of the Spanish mackerel population off the southeastern U.S. Two ideas discussed were the following:
   - Collect age samples from SEAMAP
   - Fishery independent sampling of adults

2. Investigate whether catchability varies as a function of fish density and/or environmental conditions.

3. Investigate how temporal changes in migratory patterns may influence indices of abundance (for fishery dependent and fishery independent indices).

4. Investigate the possibility of using models that allow catchability to follow a random walk.

5.6 ITEMIZED LIST OF TASKS FOR COMPLETION FOLLOWING WORKSHOP

- Perform analysis of Florida trip ticket data
- Analyze logbook hook & line data for positive trips rather than using method of Stephens & MacCall
- Generate tables and figures
- Write chapter of DW report
- Submit data to Data Compiler

5.7 LITERATURE CITED

ACCSP (Atlantic Coastal Cooperative Statistics Program). 2008. Recreational – Advanced Queries; generated by Geoff White; using ACCSP Data Warehouse [online application], Washington, D.C: Available at http://www.accsp.org/ → Data Center → Data Warehouse, accessed May 19, 2008.

Burnham, K. P. and Anderson, D. R. 2002. Model Selection and Multimodel Inference, 2nd Edition. Springer-Verlag, New York, NY, 488 p.

Dick, E. J. 2004. Beyond 'lognormal versus gamma': discrimination among error distributions for generalized linear models. Fisheries Research 70:351-366.

Dunn, P. K. and Smyth, G. K. 1996. Randomized quantile residuals. Journal of Computational and Graphical Statistics 5:236-244.

Lo, N.C., Jacobson, L.D., Squire, J.L. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49:2515-2526.

Maunder, M.N., Punt, A.E. 2004. Standardizing catch and effort data: a review of recent approaches. Fish. Res. 70:141-159.

McCullough, P. and Nelder, J. A. 1989. Generalized linear models, 2nd Edition. New York: Chapman and Hall.

SAFMC. 2006. SEDAR 10 Stock Assessment Report 1: South Atlantic Gag Grouper. (http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=10)

SAFMC. 2008. SEDAR 15 Stock Assessment Report 1: South Atlantic Red Snapper. (http://www.sefsc.noaa.gov/sedar/download/S15%20SAR%201%20Finalfixed.pdf?id=DOCUMENT).

SEDAR17-DW12. Estimation of Spanish mackerel and vermilion snapper bycatch in the shrimp trawl fishery in the South Atlantic. Analysis performed by Kate Andrews, NMFS Southeast Fisheries Science Center.

SEDAR17-RD16. User's Guide: Delta-GLM function for the R language/environment (Version 1.7.1, revised 07-06-2006). Software provided by E.J. Dick of the NMFS Southwest Fisheries Science Center.

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

5.8 Tables

Table 5.8.1. A summary of catch-effort time series available for the SEDAR 17 data workshop.

Fishery Type	Data Source	Area	Years	Units	Standardization Method	Size Range	Issues	Use?
Recreational	Headboat	NC-FL	1976-2007	Number per angler-hr	Stephens and MacCall; delta-GLM	Same as fishery	Fishery dependent; small sample sizes	N
Commercial	Logbook - handline	NC-NY	1998-2007	Pounds per hook-hr	All positive trips	Same as fishery	Fishery dependent	Y
Commercial	Logbook – gillnet	NC-NY	1998-2007	Pounds per net-area-hr	All trips	Same as fishery	Fishery dependent	Y
Commercial	FL Trip Ticket Program - Castnet	FL	1985-2007	Pounds per trip	GLMs on positive trips	Same as fishery	Fishery dependent, only trip-level effort information	Y
Commercial	FL Trip Ticket Program - Gillnet	FL	1985-2007	Pounds per trip	GLMs on positive trips	Same as fishery	Fishery dependent, only trip-level effort information	Y
Commercial	FL Trip Ticket Program – Handline/ Trolling	FL	1985-2007	Pounds per trip	GLMs on positive trips	Same as fishery	Fishery dependent, only trip-level effort information	Y
Commercial	NC Trip Ticket Program	NC	1994-2007	Pounds per trip	—	Same as fishery	Fishery dependent, only trip level information	N
Commercial	Shrimp Fishery Observer Program	NC-FL	1998-2007	Pounds per tow	Delta-GLM (see SEDAR17-DW12)	Primarily young-of-year & 1-year-olds	Fishery dependent, Low sample sizes	N
Recreational	MRFSS	NC-FL	1987-2007	Number per angler-trip	Angler-trips included if species was targeted or caught (A+B1+B2); Nominal	Same as fishery	Fishery dependent	Y
Independent	MARMAP Chevron trap (extended)	NC-FL	1990-2007	Number per trap-hr	Nominal	—	Very low sample sizes	N
Independent	MARMAP Hook and line	NC-FL	1979-1998	Number per hook-hr	Nominal	—	Very low sample sizes	N
Independent	MARMAP Short longline	NC-FL	1980-2007	Number per hook-hr	Nominal	—	Very low sample sizes	N

Fishery Type	Data Source	Area	Years	Units	Standardization Method	Size Range	Issues	Use?
Independent	SEAMAP	NC-FL	1990-2007	Number per hectare	Nominal	see Issues	Only contains ages 0 and 1	Y
Independent	NEAMAP	NY-Cape Hatteras	2006-2007	Number per hectare	Nominal	see Issues	Only contains ages 0 and 1, 2 year time series	N
Independent	NMFS Northeast Groundfish Trawl	ME – Cape Hatteras	1972-2007	Number per hectare	Nominal	—	Very low sample sizes	N
Independent	NC Pamlico Sound Survey	Pamlico Sound, NC	1987-2007	Number per tow	Nominal	—	Very low sample sizes	N
Independent	Diver Reports (Reef.org)	NC-FL	1990-2007	—	—	—	Voluntary reporting	N
Recreational	NC Citation Program	NC	19---2007	—	—	—	Voluntary reporting, variable publicity, target species may not be included in program	N
Recreational	Online recreational trip reporting (myfish.com)	NC-FL	2007	—	—	Same as fishery	Voluntary reporting, currently only on year of data available	N

Table 5.8.2. Issues with each data set considered for CPUE.

<u>Fishery dependent indices</u>

Commercial Logbook –

Gillnet, north of Florida (*Recommended for use*)

Pros: Complete census of federally permitted fishermen
Migrating stock; all individuals ostensibly subject to harvest
Large sample size
Better measures of effort than NC trip tickets

Cons: Fishery dependent
Will not contain all landings and effort (esp. non-federal)
Data are self-reported and largely unverified
Little information on discard rates
Catchability may vary over time and/or abundance

Issues Addressed:
In some cases, self-reported landings have been compared to TIP data, and they appear reliable

Handline & Trolling gears, north of Florida (*Recommended for use*)

Pros: Complete census of federally permitted fishermen
Migrating stock; all individuals ostensibly subject to harvest
Better measures of effort than NC trip tickets

Cons: Fishery dependent
Will not contain all landings and effort (esp. non-federal)
Data are self-reported and largely unverified
Little information on discard rates
Catchability may vary over time and/or abundance

Issues Addressed:
In some cases, self-reported landings have been compared to TIP data, and they appear reliable
Stephens and MacCall method resulted in sample sizes too small to be useful; due to directed nature of fishery, the DW suggested looking at all positive trips instead.

Recreational Headboat (*Not recommended for use*)

Pros: Complete census
Covers entire management area
Longest time series available
Data are verified by port samplers
Consistent sampling

Cons: Fishery dependent
Little information on discard rates
Catchability may vary over time and/or abundance
Spanish mackerel not a target species of many headboats
Low sample sizes

Issues Addressed:
Possible differences between trips carrying 10 or fewer anglers and trips carrying more than 10 anglers

MRFSS (*Recommended for use*)

Pros: Relatively long time series
Nearly complete area coverage (excluded Monroe County)
Only fishery dependent index to include discard information (A+B1+B2)

Cons: Fishery dependent
High uncertainty in MRFSS data
Targeted species (fields prim1 and prim2) are missing for many observations in the data set

Trip Ticket Program

Florida castnet (*Recommended for use*)

Pros: Will contain all landings and all effort
Longer time series than commercial logbook
Castnets can be broken out from gillnets, which is not possible in commercial logbooks
Nominal castnet trends reflect anecdotal reports

Cons: Fishery dependent
Effort only to the trip level
Subject to multiple changes in regulations, particularly trip limits

Issues Addressed: Changes in effort over time, with high variability but no trend in effort.

Florida gillnet (*Recommended for use*)

Pros: Will contain all landings and all effort
Longer time series than commercial logbook

Cons: Fishery dependent
Effort only to the trip level
Subject to multiple changes in regulations, particularly trip limits

Issues Addressed: Changes in effort over time, with high variability but no trend in effort. Need to break up index into two pieces to account for net ban in state waters that went into effect in 1995.

Florida handline/trolling (*Recommended for use*)

Pros: Will contain all landings and all effort
Longer time series than commercial logbook

Cons: Fishery dependent
Effort only to the trip level
Subject to multiple changes in regulations, particularly trip limits

Issues Addressed: Changes in effort over time, with a decreasing trend over time (as investigated with logbook data). Concern that logbook measures of effort misleading, with primary gear types poorly summarized. A trip in this case may be the best level of effort.

North Carolina gillnet (*Not recommended for use*)
Pros: Will contain all landings and all effort
Slightly longer time series than commercial logbook
Cons: Fishery dependent
Effort only to the trip level
Issues Addressed: Changes in effort over time, with a positive trend over time

North Carolina Citation Program (*Not recommended for use*)
Pros: May correlate with changes in size over time
Cons: No measure of effort
Fishery dependent
Limited geographic coverage
Not designed to provide information on abundance
Dependent on fishermen to call in and report citations

Online Recreational Reporting (*Not recommended for use*)
Pros: May contain more detailed trip-level information
Cons: Only contains one year of data
Program is completely voluntary

Shrimp boat observer program (*Not recommended for use*)
Pros: Reasonably long time series (1998-present)
Reasonable spatial coverage
Cons: Fishery dependent
Non-random observer placement
Bycatch estimates highly variable, do not correlate to SEAMAP

Fishery independent

MARMAP

Chevron Trap Index (*Not recommended for use*)

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

Cons: Low sample sizes.

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

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

Cons: Low sample sizes.

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

Pros: Fishery independent

Cons: Low sample sizes.

Trawl Index (*Not recommended for use*)

Pros: Fishery independent

Cons: Low numbers of samples

NEAMAP (*Not recommended for use*)

Pros: Stratified random sample design
Fishery independent

Cons: Spanish mackerel only sampled if at northern end of their range
Only the last 1-2 years have adequate sample size

SEAMAP Trawl Survey (*Recommended for use*)

Pros: Stratified random sample design
Adequate regional coverage
Standardized sampling techniques

Cons: Limited depth coverage (shallow water survey)
Not all ages are represented in the survey

North Carolina Pamlico Sound Survey (*Not recommended for use*)

Pros: Stratified random sample design
Standardized sampling techniques

Cons: Not all ages are represented in the survey
Limited geographic coverage (Pamlico Sound only)
Low sample sizes

NE Groundfish Trawl Survey (*Not Recommended for use*)

Pros: Stratified random sample design

Standardized sampling techniques
Cons: Low sample sizes

Online Diver Reports (*Not recommended for use*)
Pros: May be able to separate observations by highly skilled divers
Cons: Low sample size
Voluntary reporting

Table 5.8.3. Numerical values, standard errors, and sample sizes (number of tows) associated with the SEAMAP summer/fall recruitment index. The index is scaled to it's mean.

Year	Index	SE	*N*
1989	1.04	0.39	106
1990	1.45	0.33	153
1991	1.94	0.41	155
1992	1.14	0.39	156
1993	0.69	0.11	156
1994	0.68	0.15	156
1995	1.21	0.21	156
1996	0.73	0.16	156
1997	0.26	0.08	156
1998	0.59	0.11	156
1999	0.79	0.19	156
2000	1.26	0.30	156
2001	1.86	0.56	204
2002	1.05	0.21	204
2003	0.54	0.13	204
2004	0.62	0.10	204
2005	0.91	0.18	204
2006	1.15	0.21	204
2007	1.11	0.18	204

Table 5.8.4. Numerical values, standard errors, and sample sizes (number of tows) associated with the SEAMAP spring index of one-year-olds. The index is scaled to it's mean.

Year	Index	SE	*N*
1990	0.93	0.29	78
1991	0.69	0.18	78
1992	1.78	0.27	78
1993	0.55	0.24	78
1994	1.16	0.20	78
1995	0.55	0.16	78
1996	1.02	0.30	78
1997	0.74	0.33	78
1998	2.39	1.52	78
1999	1.69	0.54	78
2000	1.83	0.43	78
2001	0.82	0.26	102
2002	0.60	0.15	102
2003	0.62	0.18	102
2004	0.86	0.25	102
2005	0.61	0.29	102
2006	1.14	0.35	102
2007	0.71	0.15	102

Table 5.8.5. Point estimates, jackknife standard errors (SE), and sample sizes (*N*; number of positive trips) associated with the gillnet and handline/trolling (H/T) logbook indices north of Florida. Both indices are scaled to their mean.

Year	Gillnet Index	Gillnet SE	Gillnet *N*	H/T Index	H/T SE	H/T *N*
1998	0.59	0.11	419	0.87	0.12	124
1999	0.79	0.19	509	1.12	0.17	146
2000	1.26	0.30	603	0.88	0.14	125
2001	1.86	0.56	556	0.97	0.15	99
2002	1.05	0.21	721	1.19	0.22	88
2003	0.54	0.13	680	0.93	0.18	75
2004	0.62	0.10	640	1.00	0.21	74
2005	0.91	0.18	578	0.86	0.12	135
2006	1.15	0.21	677	1.16	0.22	80
2007	1.11	0.18	631	0.80	0.12	112

Table 5.8.6 Number of Spanish mackerel trips reported in Florida trip ticket database by fishing year (April-March for 1984-2005; March-April 2006-2007) and trip limit type for the gillnet fishery. Darkly shaded cells were omitted from analysis because >5% of such trips met or exceeded trip limits, while lightly shaded cells were omitted because of possible irregularities at the beginning of the trip ticket program or because of implementation of the Florida state gillnet ban (1995). Total sample size used for analysis, *N*, is obtained by summing white entries across columns.

	Trip Limit					
Fishing Year	500 lb.	1000 lb	1500 lb	3500 lb	Unlimited	*N*
1984	0	0	0	0	272	
1985	0	0	0	0	3088	3088
1986	0	0	0	0	2916	2916
1987	0	0	0	0	3092	3092
1988	0	0	0	0	2663	2663
1989	0	0	0	0	3780	3780
1990	0	0	0	0	4357	4357
1991	0	0	0	0	6135	6135
1992	1335	1020	144	0	3262	3262
1993	1431	1756	3006	0	275	275
1994	105	2287	2668	0	611	611
1995	60	0	1230	0	226	
1996	65	0	771	0	275	275
1997	0	0	2085	0	68	68
1998	0	0	1798	0	346	346
1999	0	0	1262	0	263	263
2000	0	0	258	644	136	780
2001	0	0	68	717	255	972
2002	0	0	15	563	71	634
2003	0	0	16	379	19	398
2004	0	0	83	395	44	439
2005	0	0	51	786	86	872
2006	0	0	121	930	57	987
2007	0	0	20	985	224	1209

Table 5.8.7 Number of Spanish mackerel trips reported in Florida trip ticket database by year and trip limit type for the castnet fishery. Shaded cells were omitted from analysis because >5% of such trips often met or exceeded trip limits (dark gray) or because sample sizes were too low (light gray). Total sample size used for analysis, *N*, is obtained by summing white entries across columns.

	Trip Limit					
Fishing Year	500 lb.	1000 lb	1500 lb	3500 lb	Unlimited	*N*
1984	0	0	0	0	1	
1985	0	0	0	0	33	
1986	0	0	0	0	10	
1987	0	0	0	0	8	
1988	0	0	0	0	10	
1989	0	0	0	0	4	
1990	0	0	0	0	14	
1991	0	0	0	0	26	
1992	0	1	0	0	6	
1993	2	5	4	0	0	
1994	0	2	3	0	0	
1995	24	0	65	0	72	
1996	70	0	193	0	183	
1997	0	0	247	0	14	
1998	0	0	151	0	65	
1999	0	0	353	0	295	295
2000	0	0	193	95	674	769
2001	0	0	268	196	922	1118
2002	0	0	270	293	1393	1686
2003	0	0	640	486	1514	2000
2004	0	0	1412	402	636	1038
2005	0	0	291	155	1314	1469
2006	0	0	871	441	734	1175
2007	0	0	202	419	636	1055

Table 5.8.8 Number of Spanish mackerel trips reported in Florida trip ticket database by year and trip limit type for the hand line fishery. Shaded cells were omitted from analysis because >5% of such trips often met or exceeded trip limits (dark gray) or because sample sizes were too low (light gray). Total sample size used for analysis, *N*, is obtained by summing white entries across columns.

	Trip Limit					
Fishing Year	500 lb.	1000 lb	1500 lb	3500 lb	Unlimited	*N*
1984	0	0	0	0	22	
1985	0	0	0	0	644	644
1986	0	0	0	0	793	793
1987	0	0	0	0	817	817
1988	0	0	0	0	657	657
1989	0	0	0	0	825	825
1990	0	0	0	0	1128	1128
1991	0	0	0	0	1671	1671
1992	66	154	30	0	828	1012
1993	79	143	672	0	36	851
1994	33	134	605	0	87	826
1995	182	0	678	0	371	1049
1996	96	0	549	0	228	777
1997	0	0	1452	0	67	1519
1998	0	0	967	0	345	1312
1999	0	0	378	768	822	1968
2000	0	0	244	896	757	1897
2001	0	0	268	196	922	1386
2002	0	0	216	1074	844	2134
2003	0	0	307	854	568	1729
2004	0	0	930	1006	421	2357
2005	0	0	235	761	914	1910
2006	0	0	597	1544	747	2888
2007	0	0	438	1591	1353	3382

Table 5.8.9 A list of Florida Wildlife & Conservation Commission codes given to indicate whether species belong to "inshore bottom" (IB), "inshore pelagic" (IP), "offshore bottom" (OB), "offshore pelagic" (OP), or "reef fish" (RF) groups. If species other than those listed here were caught in the same trips as Spanish mackerel, they were given a code of "other species" (OS).

CODE	*SPECIES*
IB	CATFISH
IB	CROAKER
IB	CROAKER (NUMBERS)
IB	GOATFISHES
IB	GRUNTS
IB	GRUNTS (NUMBERS)
IB	LIZARDFISH (SNAKEFISH)
IB	MOJARRA
IB	MOJARRA, IRISH POMPANO
IB	MULLET, BLACK (LISA)
IB	MULLET, BLACK, (RED ROE)
IB	MULLET, BLACK, (WHITE ROE)
IB	MULLET, FINGERLING (NUMBERS)
IB	MULLET, FINGERLING (POUNDS)
IB	MULLET, ROE ONLY (W/R)
IB	MULLET, SILVER
IB	MULLET, SILVER (NUMBERS)
IB	PORGY, GRASS
IB	RAYS
IB	SAND PERCH (NUMBERS)
IB	SAND PERCH (SERRANIDAE)
IB	SEAROBINS
IB	SEATROUT, GREY (WEAKFISH, EAST COAST)
IB	SEATROUT, SAND
IB	SEATROUT, SILVER
IB	SEATROUT, SPOTTED
IB	SHEEPSHEAD
IB	SPADEFISH
IB	SPOT
IB	SPOT (NUMBERS)
IB	TILAPIA (NILE PERCH)
IB	WHITING
IP	BLUE RUNNER
IP	BLUE RUNNER (NUMBERS)
IP	BLUEFISH
IP	COBIA
IP	JACK, ATLANTIC BUMPER
IP	JACK, ATLANTIC MOONFISH
IP	JACK, BAR
IP	JACK, BAR (NUMBERS)
IP	JACK, CREVALLE
IP	JACK, HORSE-EYE
IP	JACK, LOOKDOWN

IP	JACK, MIXED
IP	JACK, OTHER
IP	JACK, YELLOW
IP	LADYFISH (HEADED & GUTTED)
IP	LADYFISH (SKIPJACK)
IP	MACKEREL, CERO
IP	MACKEREL, SPANISH
IP	MACKEREL, SPANISH (NUMBERS)
IP	PERMIT
IP	POMFRET (BIG SCALE)
IP	POMFRET (OTHER)
IP	POMPANO
IP	POMPANO, AFRICAN
IP	SHARK, BLACKNOSE
IP	SHARK, BONNETHEAD
IP	SHARK, FINETOOTH
IP	STURGEON
OB	BASS, LONGTAIL
OB	BROTULA ("HAKE")
OB	DRUM, BLACK
OB	EEL, CONGER
OB	EEL, CUSK
OB	FLOUNDER, GULF
OB	FLOUNDER, SOUTHERN
OB	FLOUNDER, SUMMER
OB	FLOUNDERS
OB	HAKE (SOUTHERN,GULF,SPOTTED)
OB	SHARK, ANGEL
OB	SHARK, SAND TIGER
OB	SHARK, SANDBAR
OB	TILEFISH (GOLDEN)
OB	TILEFISH, ANCHOR
OB	TILEFISH, BLACKLINE
OB	TILEFISH, BLUELINE (GRAY)
OB	TILEFISH, GOLDFACE
OB	TILEFISH, SAND
OB	WRECKFISH
OB	WRECKFISH ROE
OP	BARRELFISH
OP	BUTTERFISH
OP	CUTLASSFISH
OP	CUTLASSFISH (NUMBERS)
OP	DOLPHIN
OP	ESCOLAR
OP	HARVESTFISH
OP	MACKEREL, CHUB
OP	MACKEREL, KING (KINGFISH)
OP	MARLIN, BLUE
OP	MARLIN, WHITE
OP	OIL FISH

OP	OPAH
OP	RUDDERFISH, BANDED (AMBERINA)
OP	RUDDERFISH, BANDED (AMBERINA; CORES)
OP	SHARK
OP	SHARK FINS
OP	SHARK, ATLANTIC SHARPNOSE
OP	SHARK, BLACKTIP
OP	SHARK, BULL
OP	SHARK, DUSKY
OP	SHARK, GREAT WHITE
OP	SHARK, HAMMERHEAD
OP	SHARK, LEMON
OP	SHARK, MIXED (LARGE COASTALS)
OP	SHARK, MIXED (SMALL COASTALS)
OP	SHARK, OTHER
OP	SHARK, SHORTFIN MAKO
OP	SHARK, SILKY
OP	SHARK, SPINNER
OP	SHARK, THRESHER
OP	SHARK, TIGER
OP	SHARK,BIGNOSE
OP	SPEARFISH, LONGBILL
OP	SWORDFISH
OP	TRIPLETAIL
OP	TUNA, ALBACORE
OP	TUNA, BIGEYE
OP	TUNA, BLACKFIN
OP	TUNA, BLUEFIN
OP	TUNA, MIXED
OP	TUNA, SKIPJACK
OP	TUNA, YELLOWFIN
OP	TUNNY, LITTLE (BONITO)
OP	TUNNY, LITTLE (BONITO; NUMBERS)
OP	WAHOO
RF	AMBERJACK
RF	AMBERJACK, GREATER (CORES)
RF	AMBERJACK, LESSER
RF	AMBERJACK, LESSER (CORES)
RF	ANGELFISH
RF	BARRACUDA
RF	BIGEYE (TORO SNAPPER)
RF	EEL, MORAY
RF	GROUPER, BLACK (CARBERITA)
RF	GROUPER, CONEY
RF	GROUPER, GAG
RF	GROUPER, GOLIATH
RF	GROUPER, GRAYSBY
RF	GROUPER, HIND, ROCK
RF	GROUPER, MARBLED
RF	GROUPER, MISTY

RF	GROUPER, MIXED
RF	GROUPER, NASSAU
RF	GROUPER, OTHER
RF	GROUPER, RED
RF	GROUPER, RED HIND
RF	GROUPER, SCAMP
RF	GROUPER, SNOWY
RF	GROUPER, SPECKLED HIND (KITTY MITCHELL)
RF	GROUPER, TIGER
RF	GROUPER, WARSAW
RF	GROUPER, YELLOWEDGE
RF	GROUPER, YELLOWFIN
RF	GROUPER, YELLOWMOUTH
RF	HOGFISH (HOG SNAPPER)
RF	JACK, ALMACO
RF	JACK, ALMACO (CORES)
RF	MARGATES
RF	PARROTFISH
RF	PORGIES, UNCL.
RF	PORGY, JOLTHEAD
RF	PORGY, KNOBBED
RF	PORGY, LITTLEHEAD
RF	PORGY, LONGSPINE
RF	PORGY, RED
RF	PUFFERS
RF	ROSEFISH, BLACK BELLY
RF	SCORPIONFISH
RF	SEA BASS, BANK
RF	SEA BASS, BLACK
RF	SEA BASS, ROCK
RF	SEA BASS, UNCL.
RF	SNAPPER, BLACK
RF	SNAPPER, BLACKFIN (HAMBONE)
RF	SNAPPER, CARIBBEAN RED
RF	SNAPPER, CUBERA
RF	SNAPPER, DOG
RF	SNAPPER, GRAY (MANGROVE)
RF	SNAPPER, LANE
RF	SNAPPER, MAHOGONY
RF	SNAPPER, MIXED
RF	SNAPPER, MUTTON
RF	SNAPPER, OTHER
RF	SNAPPER, QUEEN (BALLBAT)
RF	SNAPPER, RED
RF	SNAPPER, SCHOOLMASTER
RF	SNAPPER, SILK (YELLOWEYE)
RF	SNAPPER, VERMILION (B-LINER)
RF	SNAPPER, WENCHMAN
RF	SNAPPER, YELLOWTAIL
RF	SQUIRRELFISH

RF	SURGEONFISH
RF	TRIGGERFISH

Table 5.8.10. Nominal and GLM-based CPUE (total lb/trip) as estimated from Florida trip ticket data, together with a bootstrap-based coefficient of variation (CV). The suffixed number represents a particular index (1-gillnet prior to net ban; 2-gillnet after net ban; 3-castnet; 4-hook & line). Sample sizes are given in Tables 5.8.6-5.8.8.

Year	GLM1	CV1	Nom1	GLM2	CV2	Nom2	GLM3	CV3	Nom3	GLM4	CV4	Nom4
1985	0.46	0.07	0.71							0.69	0.08	0.38
1986	0.59	0.07	0.32							0.94	0.08	0.26
1987	0.83	0.07	0.34							1.03	0.08	0.43
1988	0.64	0.07	0.49							1.21	0.08	0.65
1989	0.93	0.07	0.38							1.16	0.07	1.13
1990	0.79	0.06	0.26							1.12	0.07	1.03
1991	0.65	0.06	0.32							0.87	0.06	0.84
1992	0.63	0.07	0.25							0.85	0.07	0.38
1993	2.10	0.19	4.78							0.87	0.08	0.36
1994	2.40	0.12	2.13							0.68	0.07	0.47
1995										0.69	0.07	1.11
1996				1.25	0.17	2.40				0.63	0.08	0.56
1997				0.77	0.34	2.68				0.67	0.07	0.46
1998				1.05	0.17	1.74				0.95	0.06	0.81
1999				1.05	0.17	1.07	0.77	0.15	0.86	0.82	0.07	0.74
2000				1.09	0.14	0.65	0.77	0.13	0.95	0.92	0.06	1.04
2001				0.88	0.14	0.47	0.83	0.13	0.97	1.40	0.07	1.46
2002				0.85	0.15	0.49	0.95	0.12	1.08	0.85	0.06	1.10
2003				0.94	0.15	0.58	1.39	0.12	1.35	1.22	0.07	1.72
2004				0.62	0.15	0.35	1.48	0.13	1.15	1.52	0.06	2.49
2005				1.11	0.14	0.46	1.17	0.12	1.16	1.22	0.07	2.03
2006				1.17	0.14	0.52	0.86	0.13	0.88	1.46	0.06	2.00
2007				1.21	0.13	0.59	0.78	0.13	0.59	1.22	0.06	1.53

Table 5.8.11 Nominal CPUE (number/angler-trip) and estimates of precision for two methods of summarizing CPUE. The first, 'Total Catch', uses estimates of discards (B2's) while the second (Harvest) does not. The DW selected the former as the most appropriate to use in this assessment, selecting 1987-2007 as having reasonable sample sizes.

Year	TotCatch CPUE	Total Catch PSE	Directed TotCatch Interviews	Harvest CPUE	Harvest PSE	Directed Harvest Interviews
1982	2.72	29.2	195	2.72	29.4	192
1983	0.57	24.1	156	0.56	25.0	152
1984	2.83	31.1	256	2.80	32.0	253
1985	1.67	19.7	232	1.59	21.1	221
1986	4.33	15.7	543	3.25	12.9	522
1987	1.68	7.3	1776	1.64	7.5	1740
1988	2.35	6.4	1895	2.32	6.5	1868
1989	2.01	7.6	2353	1.68	7.1	2327
1990	1.81	6.2	2664	1.65	6.7	2627
1991	1.55	5.4	2991	1.29	5.9	2922
1992	1.67	4.3	2508	1.36	4.8	2435
1993	1.33	5.6	1687	1.12	6.3	1647
1994	2.03	5.9	2567	1.31	5.4	2436
1995	1.63	7.8	1600	1.13	10.0	1531
1996	2.13	6.7	1804	1.62	8.5	1700
1997	2.18	5.8	2141	1.71	7.0	2023
1998	1.86	7.1	1435	1.55	8.8	1322
1999	2.33	5.7	1981	1.74	6.9	1796
2000	2.14	6.0	2011	1.51	7.5	1850
2001	2.26	6.6	1837	1.76	7.1	1730
2002	2.72	7.3	2070	1.91	8.2	1886
2003	2.39	7.7	1735	1.51	7.6	1594
2004	1.98	7.3	1419	1.49	8.8	1316
2005	2.58	7.1	1249	1.82	8.3	1121
2006	1.65	7.1	1152	1.29	8.7	1048
2007	1.76	6.3	1493	1.31	8.2	1366

Table 5.8.12 A correlation matrix for all indices recommended for use in the SEDAR 17 assessment of Spanish mackerel. Included are the 1985-1994 FL trip ticket gillnet index (GN_FL1), the 1996-2007 FL trip ticket gillnet index (GN_FL2), the FL trip ticket castnet index (CN_FL), the FL trip ticket hook & line index (HL_FL), the MRFSS index, the logbook survey gillnet index north of FL (GN_LB), the logbook survey handline index north of FL (HL_LB), the SEAMAP young-of-year index (SMAP_YOYa), a one year lagged version of the young-of-year index (SMAP_YOYb), and the SEAMAP 1-year-old index (SMAP_1YR). The lagged version of the YOY index, SMAP_YOYb, was not recommended for use but is included in this table for correlation comparison.

	GN_FL1	GN_FL2	CN_FL	HL_FL	MRFSS	GN_LB	HL_LB	SMAP_YOYa	SMAP_YOYb	SMAP_1YR
GN_FL1	1.00	NA	NA	-0.37	-0.16	NA	NA	-0.79	-0.73	-0.12
GN_FL2	NA	1.00	-0.63	-0.19	-0.28	-0.64	-0.29	0.22	0.03	0.27
CN_FL	NA	-0.63	1.00	0.44	0.19	0.28	-0.11	-0.67	-0.25	-0.51
HL_FL	-0.37	-0.19	0.44	1.00	0.08	0.27	-0.08	0.22	-0.10	-0.18
MRFSS	-0.16	-0.28	0.19	0.08	1.00	0.14	0.21	-0.22	-0.03	-0.06
GN_LB	NA	-0.64	0.28	0.27	0.14	1.00	0.15	0.19	0.68	-0.55
HL_LB	NA	-0.29	-0.11	-0.08	0.21	0.15	1.00	0.06	0.38	-0.11
SMAP_YOYa	-0.79	0.22	-0.67	0.22	-0.22	0.19	0.06	1.00	0.44	-0.11
SMAP_YOYb	-0.73	0.03	-0.25	-0.10	-0.03	0.68	0.38	0.44	1.00	-0.26
SMAP_1YR	-0.12	0.27	-0.51	-0.18	-0.06	-0.55	-0.11	-0.11	-0.26	1.00

5.9 FIGURES

Figure 5.9.1. Strata sampled by the SEAMAP Coastal Survey.

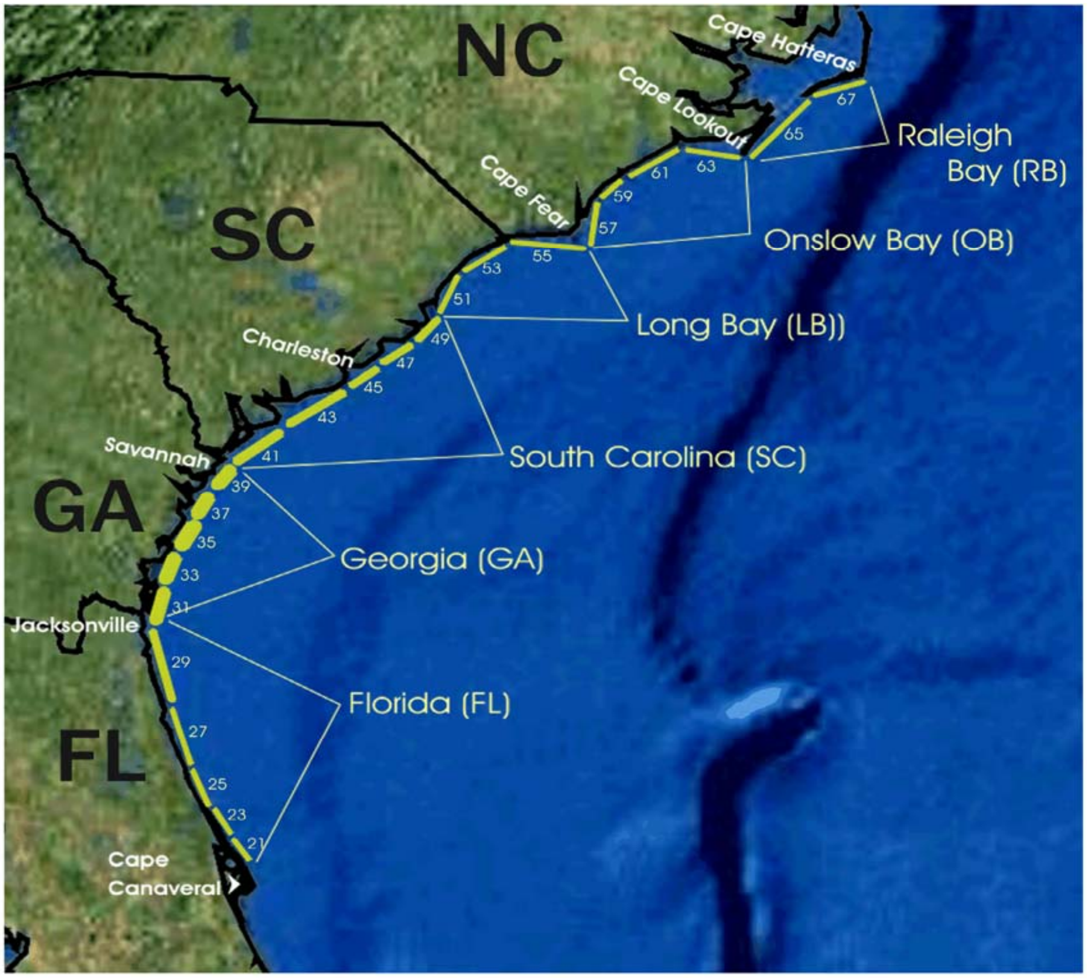


Figure 5.9.2 Length compositions of Spanish mackerel in SEAMAP trawls, 1989-present by season.

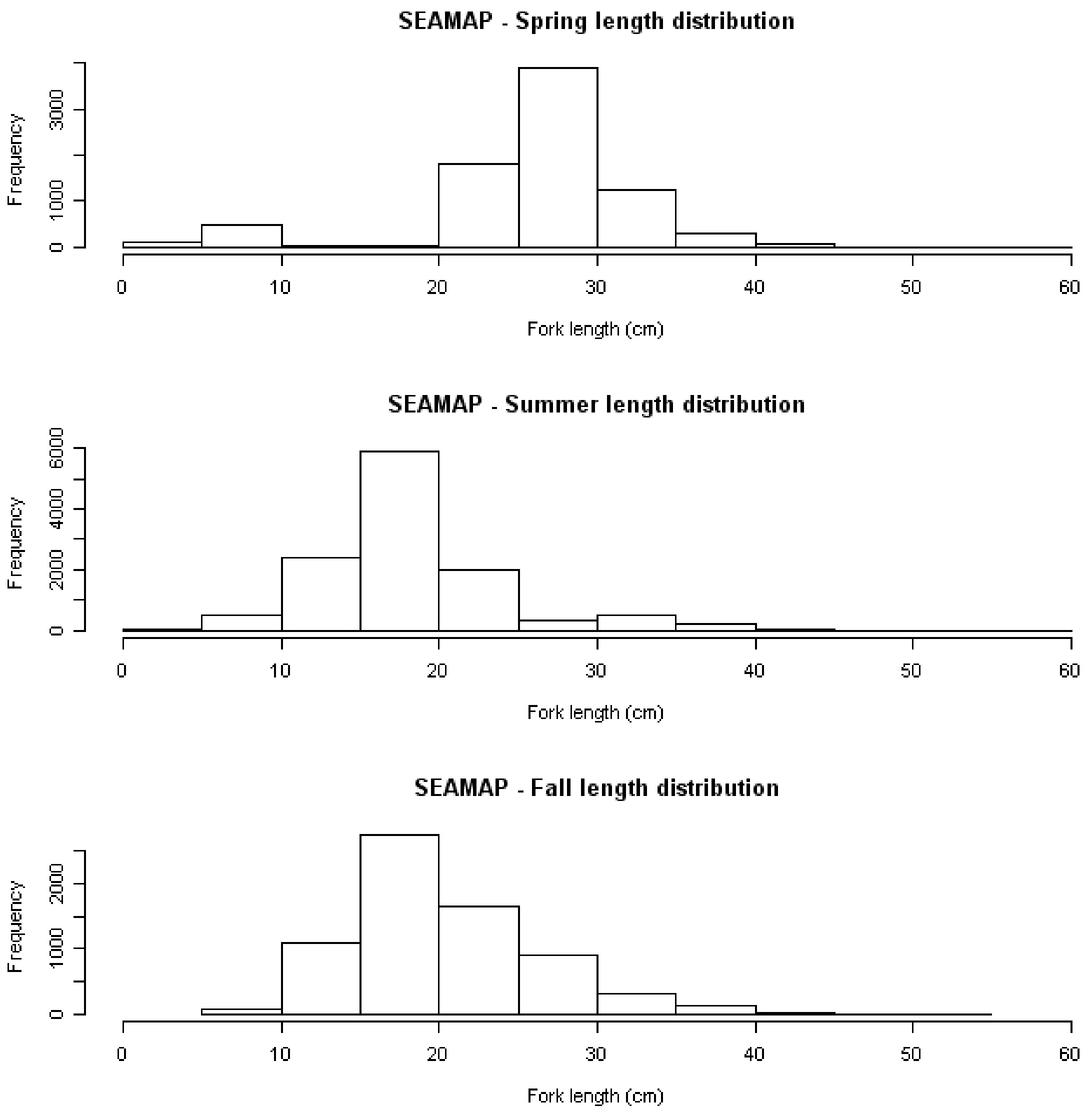
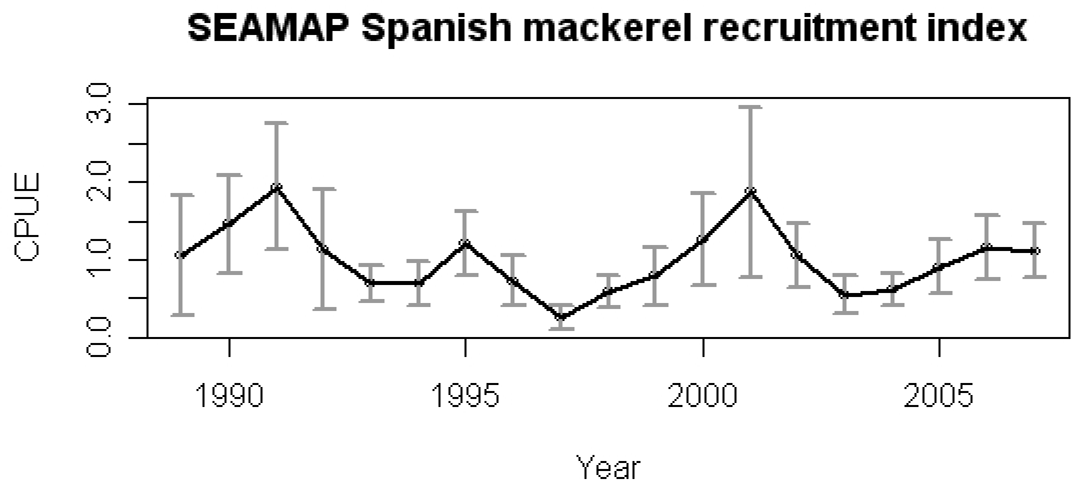


Figure 5.9.3 Indices of young-of-year and one year old south Atlantic Spanish mackerel (U.S.) derived from summer/fall and spring SEAMAP trawl surveys, respectively. Error bars represent 95% asymptotic confidence intervals. Indices are scaled to their mean.



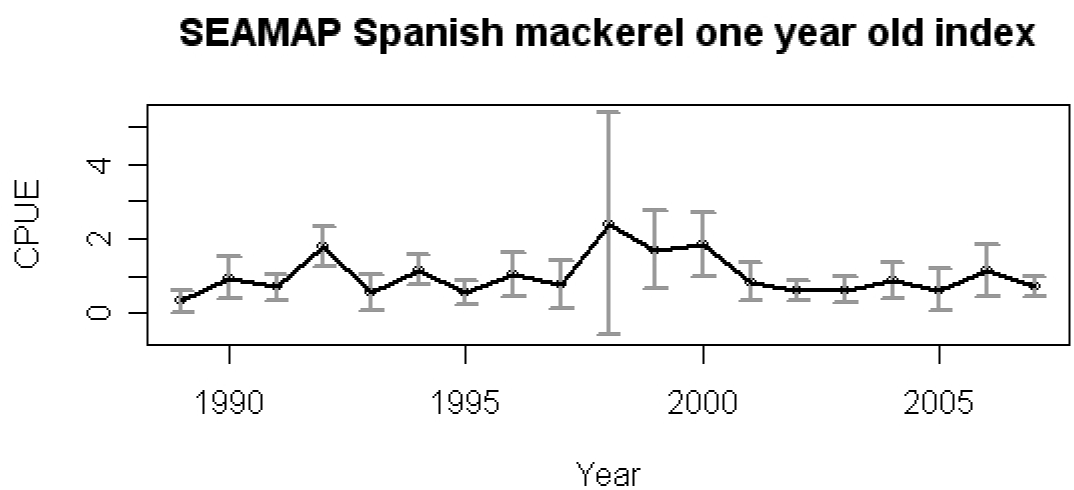


Figure 5.9.4 Net area-hours for the gillnet fishery as calculated from logbook data north of Florida as a function of year. The amount of effort per trip appears to be increasing over time, a feature which may call into question the utility of a 'trip' as a reasonable proxy for effort.

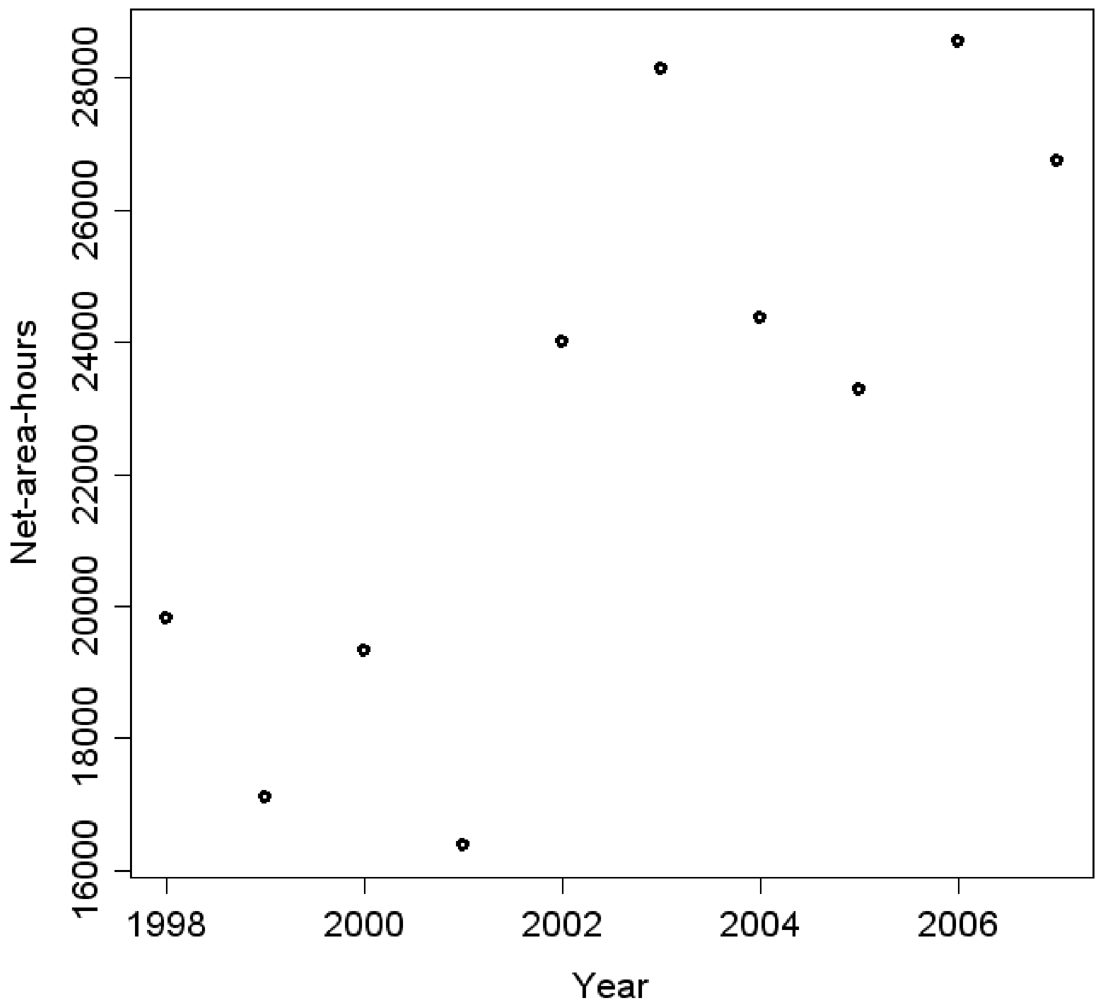


Figure 5.9.5. Areas reported in commercial logbooks. First two digits signify degrees latitude, second two degrees longitude. Areas were excluded from the analysis if south of 31 degree latitude.

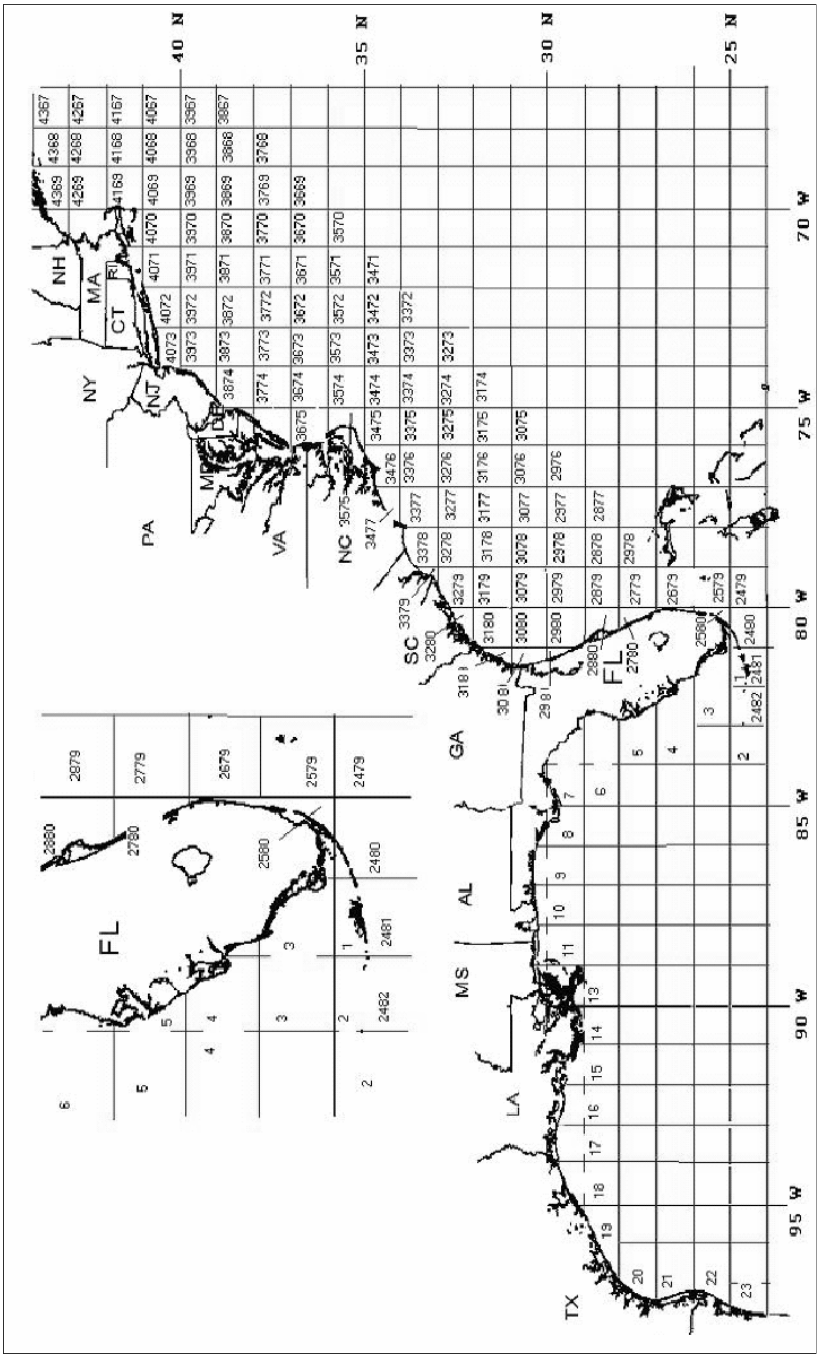
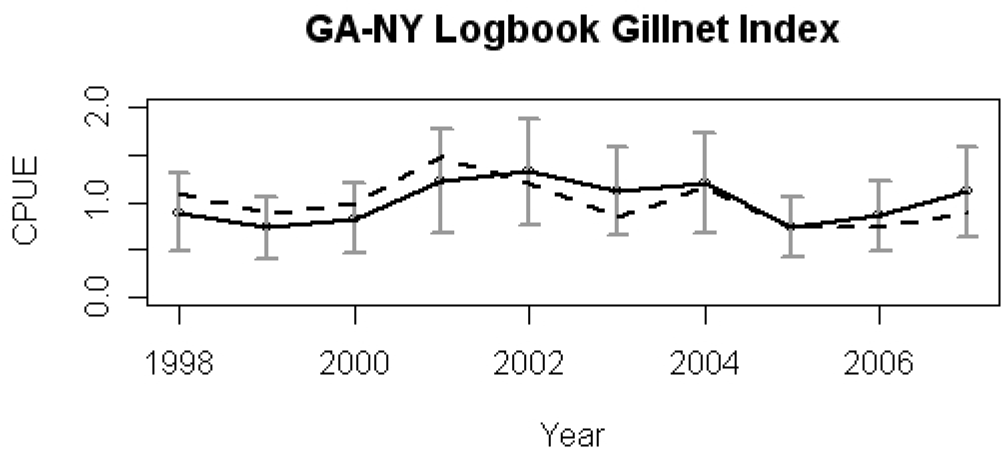


Figure 5.9.6 Standardized (solid line) and nominal (dashed line) catch per unit effort over time for the logbook survey. Error bars give 95% asymptotic confidence intervals.



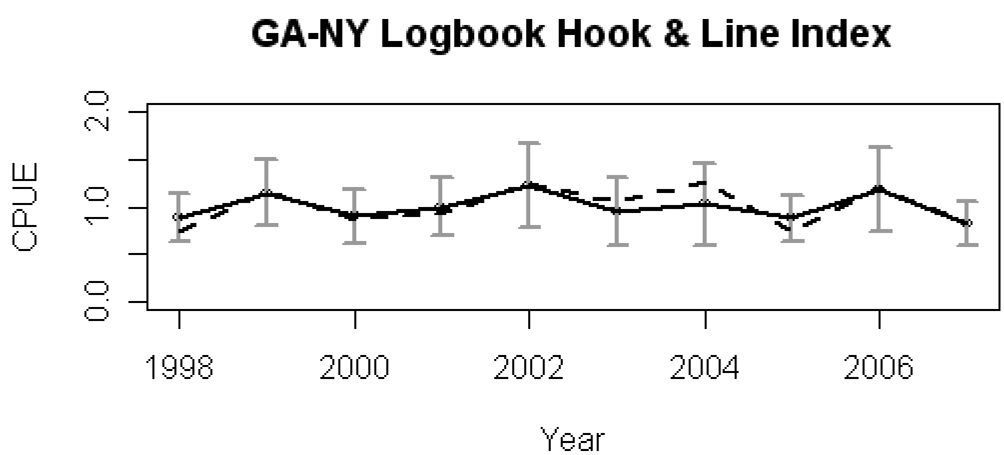


Figure 5.9.7 A plot of the average number of hook-hrs per trip for Florida trips that were classified with gear code 'H' (hand lines) in the commercial logbook survey database. A decrease in average number of hook-hrs over time casts some doubt on the utility of using a 'trip' as a unit of effort.

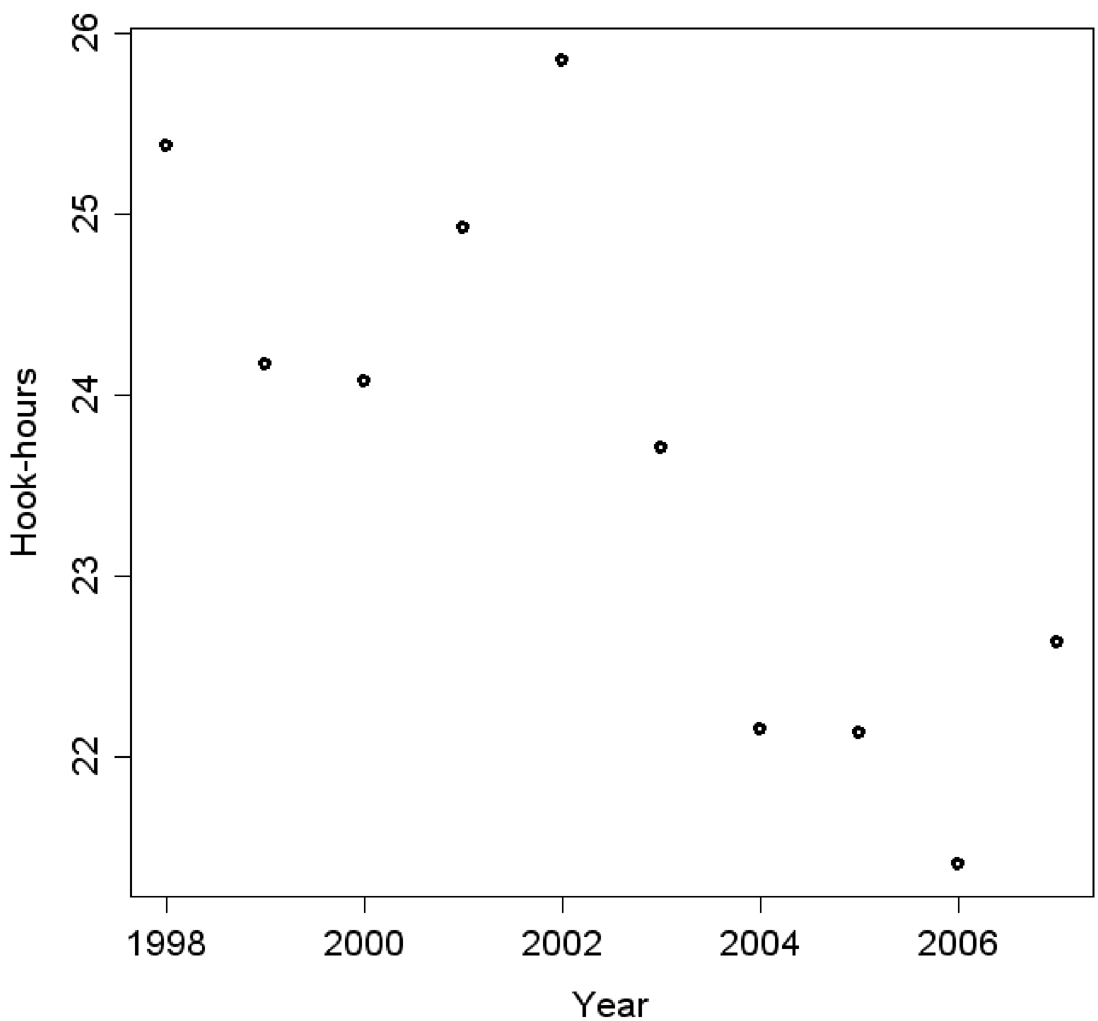


Figure 5.9.8 Percent of Spanish mackerel trips meeting or exceeding the trip limit when the trip limit was 500 lb. When trip limits were exceeded more that 5% of the time (dashed line), the relationship between CPUE and abundance was thought to be questionable. Trips occurring on days where the trip limit was 500 lb were thus censored from analysis.

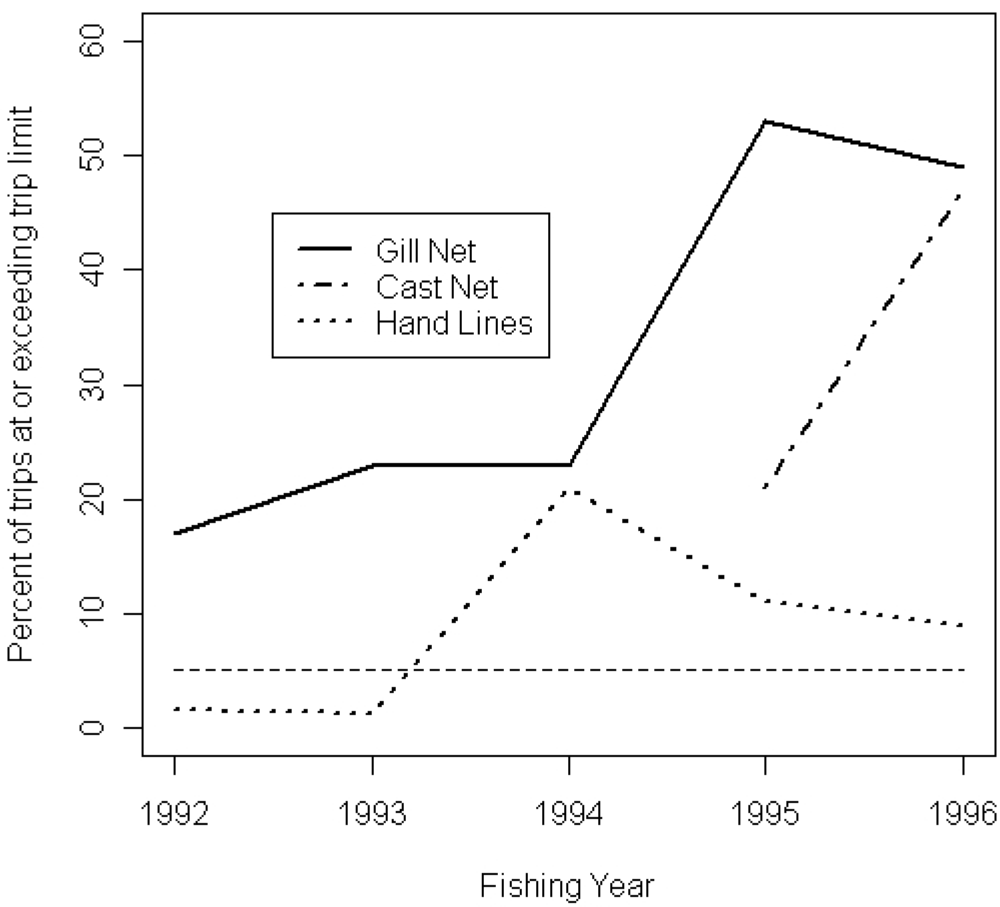


Figure 5.9.9 Percent of Spanish mackerel trips meeting or exceeding the trip limit when the trip limit was 1000 lb. When trip limits were exceeded more that 5% of the time (dashed line), the relationship between CPUE and abundance was thought to be questionable. Trips occurring on days where the trip limit was 1000 lb in the gillnet fishery were thus censored from analysis. Such trips were also eliminated for the cast net fishery because of small sample sizes.

Figure 5.9.10 Percent of Spanish mackerel trips meeting or exceeding the trip limit when the trip limit was 1500 lb. When trip limits were exceeded more that 5% of the time (dashed line), the relationship between CPUE and abundance was thought to be questionable. Trips occurring on days where the trip limit was 1500 lb in the gill net and cast net fisheries were thus censored from analysis, but retained for hand line fisheries.

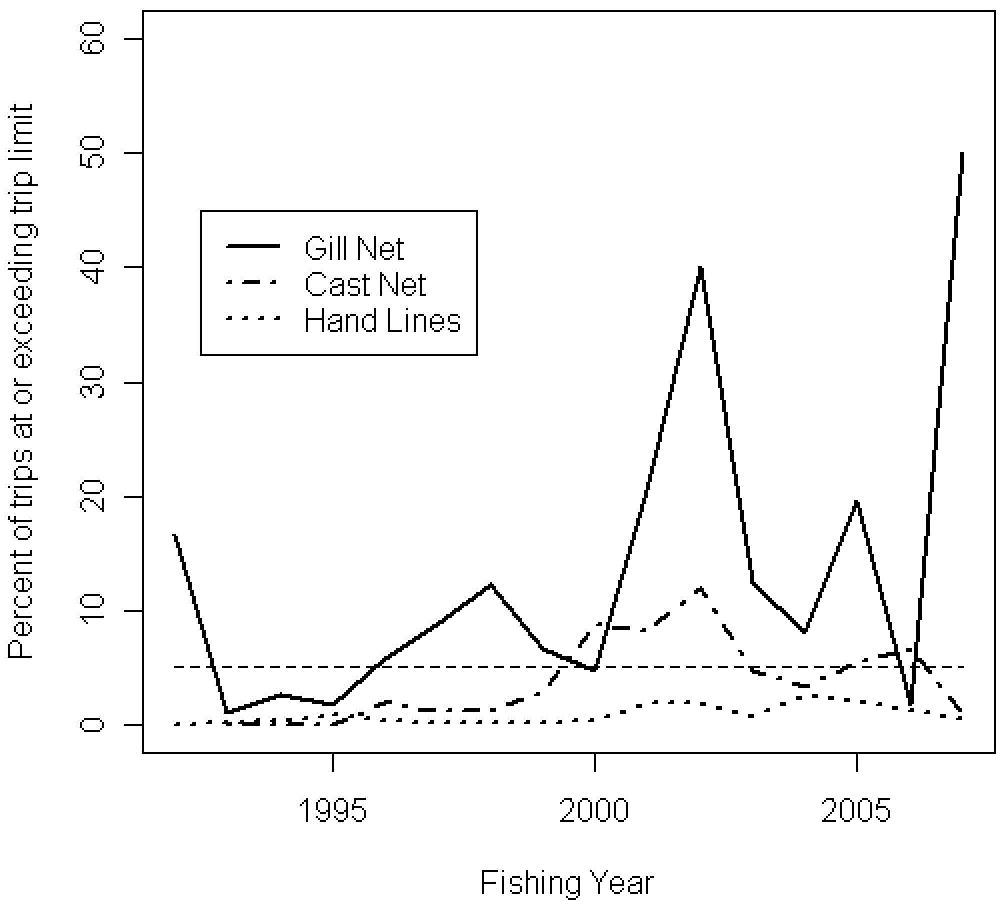
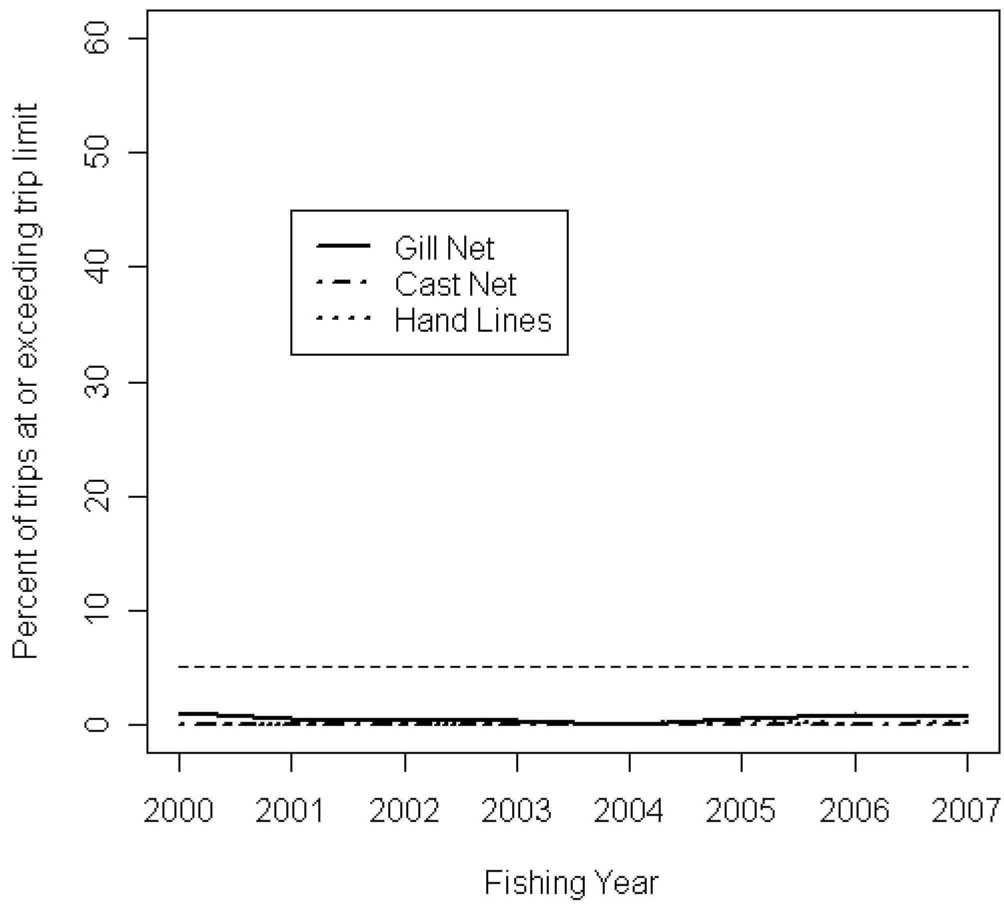


Figure 5.9.11 Percent of Spanish mackerel trips meeting or exceeding the trip limit when the trip limit was 3500 lb. When trip limits were exceeded more that 5% of the time (dashed line), the relationship between CPUE and abundance was thought to be questionable. This threshold was never exceeded so all such trips were retained for analysis.



5.9.12 Estimated CPUE indices of total catch for Florida trip ticket data. The two upper panels give standardized CPUE for the gillnet fishery pre- and post-Florida gillnet bans, as output from GLMs and as calculated directly from data ("Nominal"). The bottom panels give estimated CPUE for castnet and hand line fisheries. Large differences in nominal and GLM CPUE's result mainly from fishery closures.

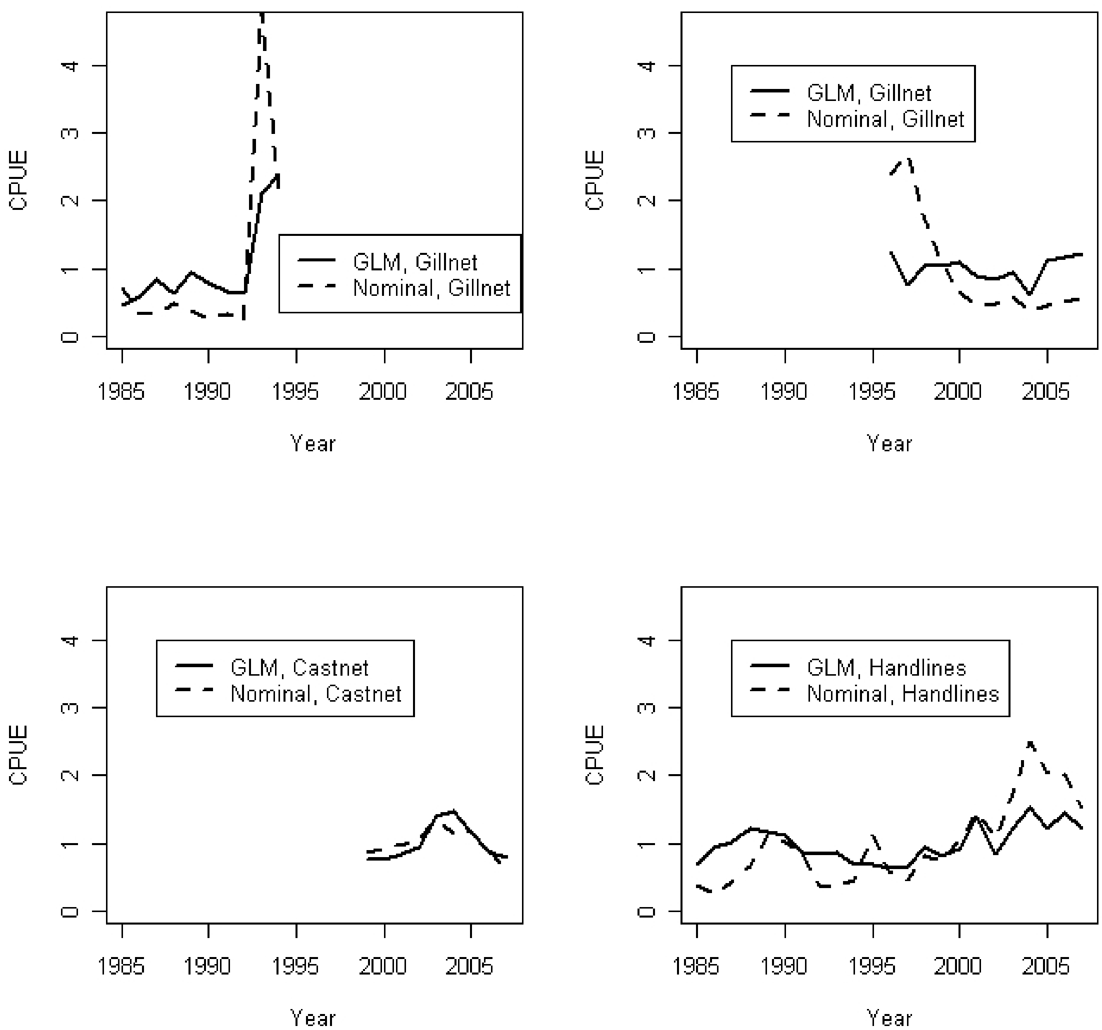


Figure 5.9.13 Counties sampled by the MRFSS, as used to compute the index of abundance, included those along the coast from Currituck County, NC through Miami-Dade County, FL.

Figure 5.9.14 The ratio of MRFSS trips that met or exceeded the bag limit to the total number of trips by year. The blue line (diamonds) gives the ratio including discards (A+B1+B2), while the pink line (squares) gives the ratio with respect to number harvested (A+B1).

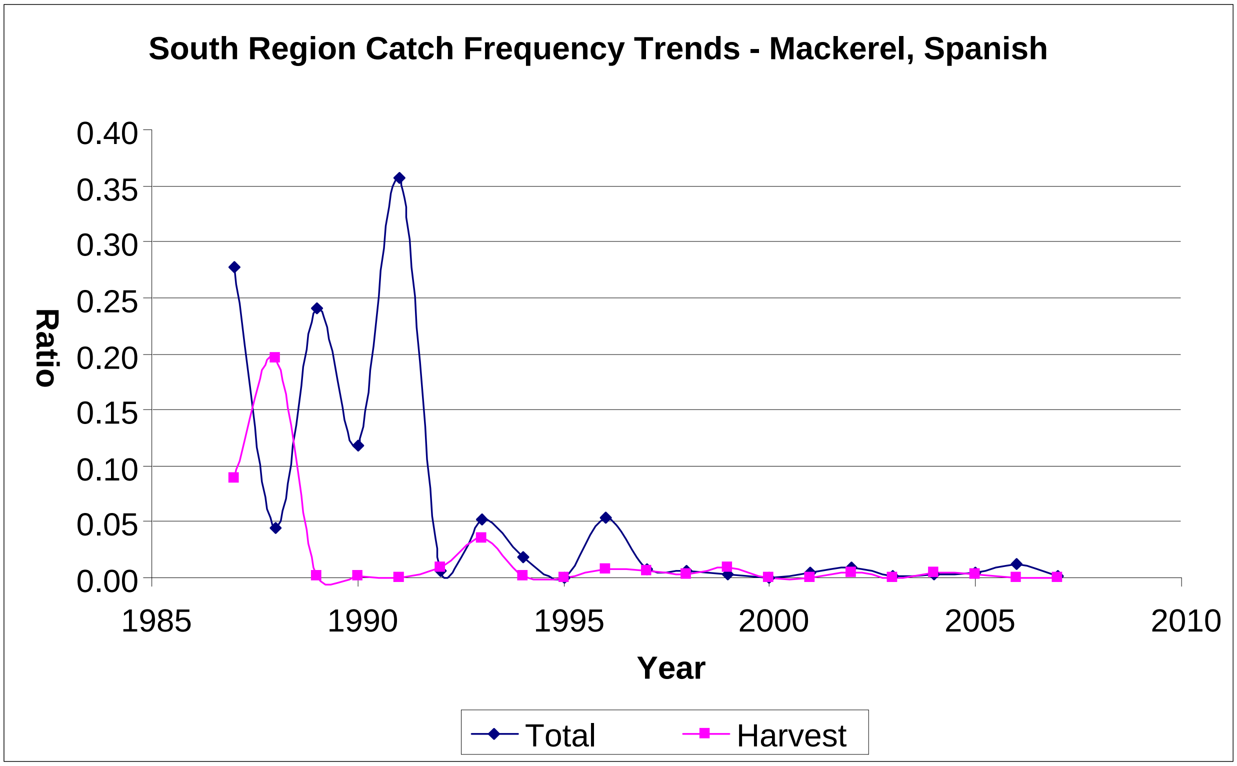


Figure 5.9.15. Spanish mackerel CPUE from the MRFSS survey. The blue line (diamonds) gives the ratio including discards (A+B1+B2), while the pink line (squares) gives the ratio with respect to number harvested (A+B1). The DW selected the former (blue line) as most appropriate for use in the assessment, specifying that the time series begin in 1987 to provide adequate sample sizes.

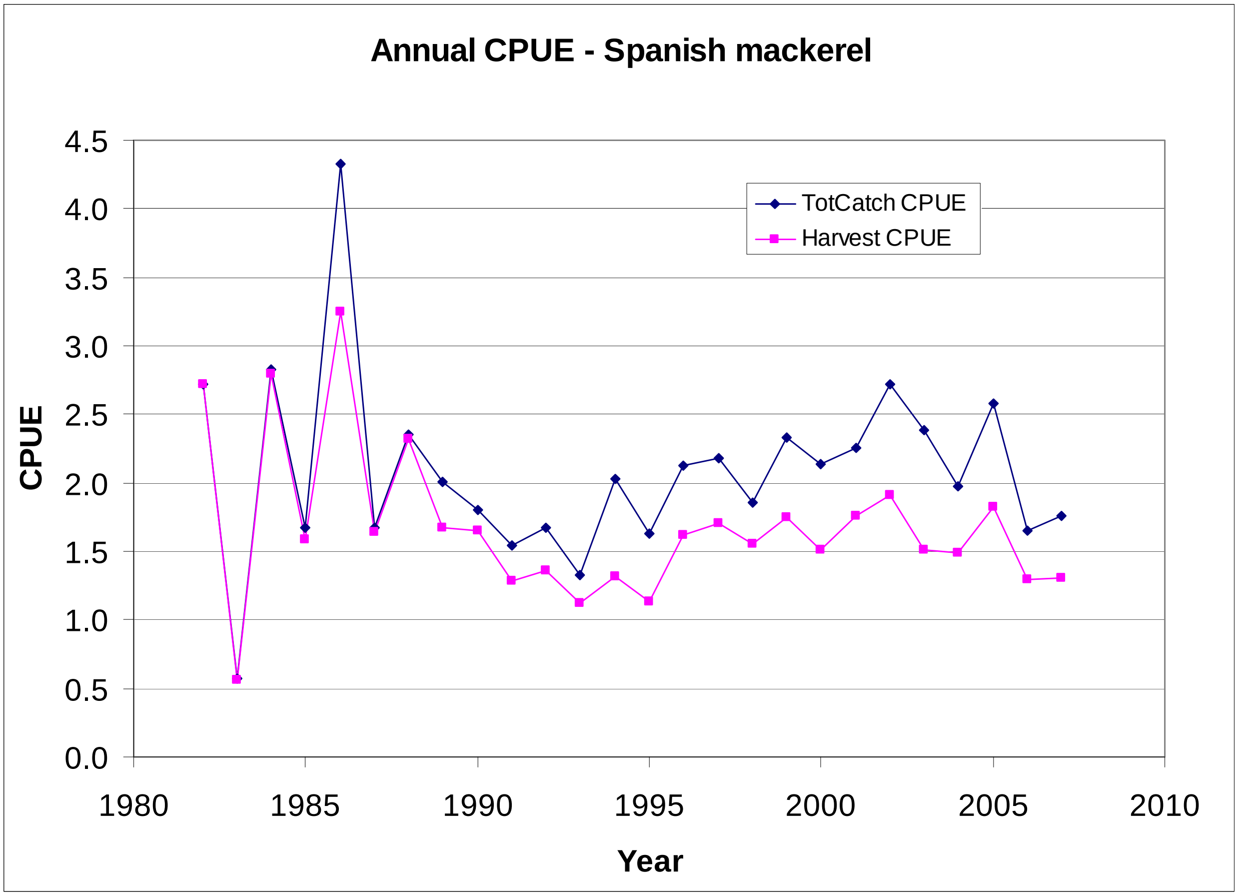
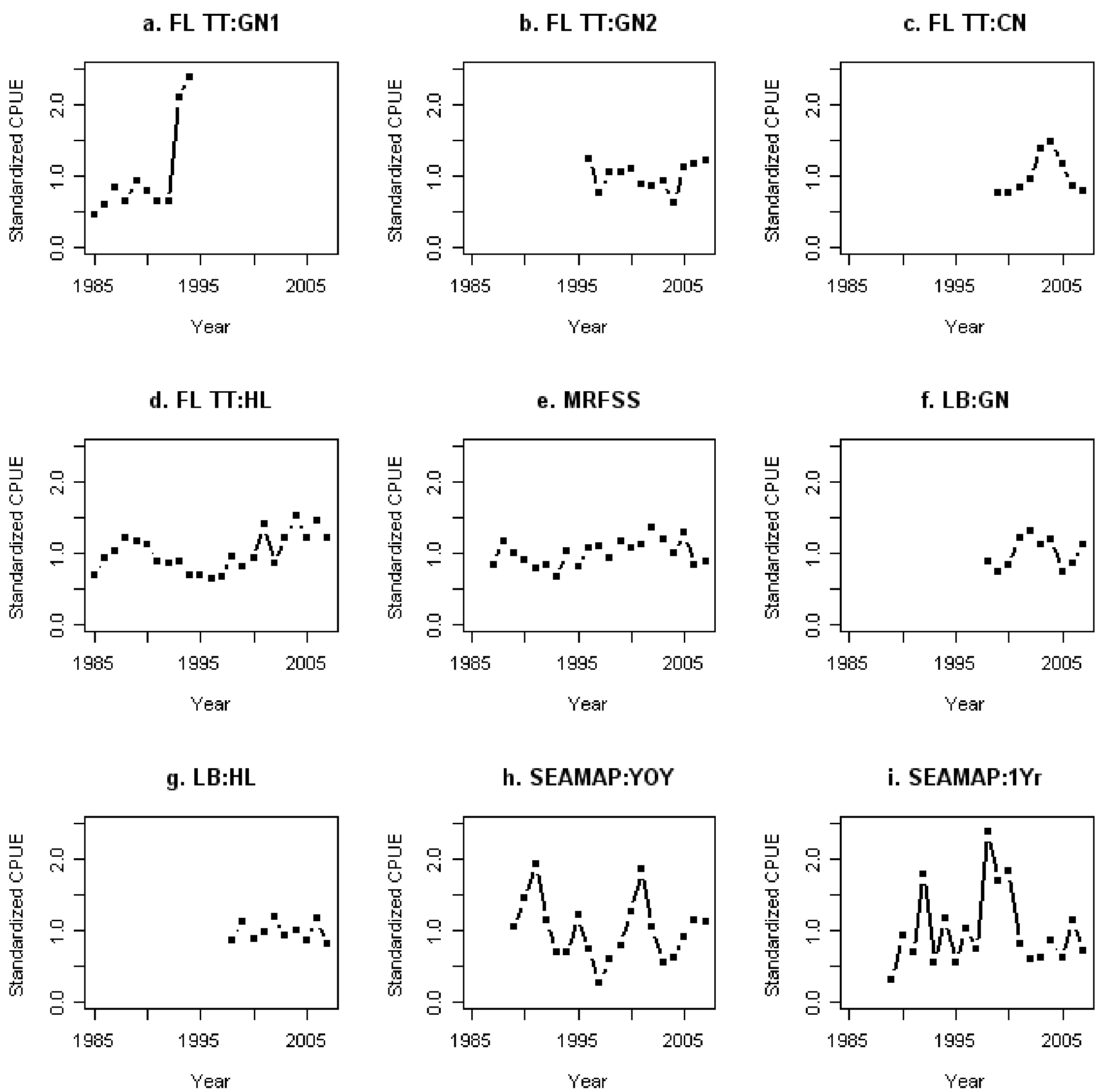


Figure 5.9.16. A plot of all indices recommended for use in the SEDAR 17 assessment of Spanish mackerel. Those included are a) a Florida trip ticket gillnet index prior to the FL state gillnet ban ("FL TT:GN1"), b) a FL trip ticket gillnet index after the FL state gillnet ban ("FL TT:GN2"), c) a Florida trip ticket castnet index ("FL TT:CN"), d) a Florida trip ticket hook & line index ("FL TT:HL"), e) the MRFSS index, f) a gillnet index using logbook survey data north of Florida ("LB:GN"), g) a hook & line index using logbook data north of Florida ("LB:HL"), h) a young-of-year index using summer and fall SEAMAP trawls (SEAMAP:YOY), and i) an index of one-year-olds from SEAMAP spring trawls ("SEAMAP-1Yr"). Each index is scaled to it's mean.



5.10 APPENDICES

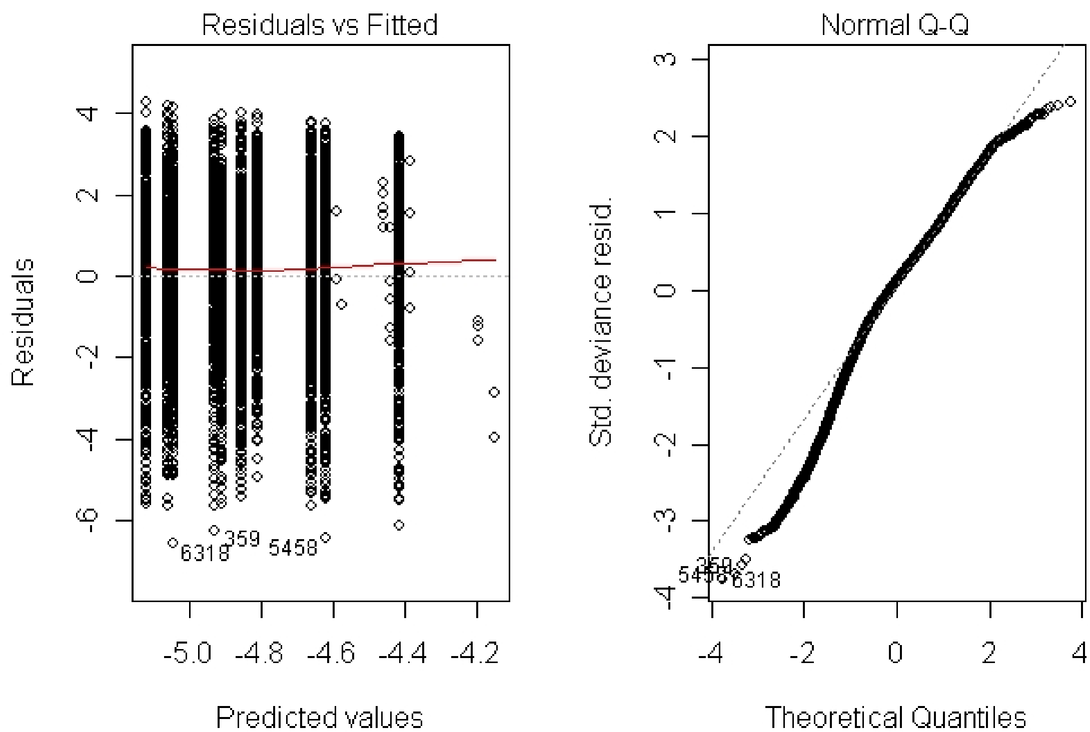
Appendix 5.10.1 Information contained in the commercial logbook data set (all variables are numeric unless otherwise noted):

schedule: this is a unique identifier for each fishing trip and is a character variable
species: a character variable to define the species
gear: a character variable, the gear type, multiple gear types may be used in a single trip, L = longline, H = handline, E = electric reels, B = bouy gear, GN = gill net, P = diver using power head gear, S = diver using spear gun, T = trap, TR = trolling
area: area fished, in the south Atlantic these codes have four digits- the first two are degrees of latitude and the second two are the degrees of longitude
conversion: conversion factor for calculating total pounds (totlbs) from gutted weight
gutted: gutted weight of catch for a particular species, trip, gear, and area
whole: whole weight of catch for a particular species, trip, gear, and area
totlbs: a derived variable that sums the gutted (with conversion factor) and whole weights, this is the total weight in pounds of the catch for a particular species, trip, gear, and area
length: length of longline (in miles) or gill net (in yards)
mesh1 – mesh4: mesh size of traps or nets
numgear: the amount of a gear used, number of lines (handlines, electric reels), number of sets (longlines), number of divers, number of traps, number of gill nets
fished: hours fished on a trip, this is problematic for longline data as discussed later
effort: like numgear, the data contained in this field depends upon gear type; number of hooks/line for handlines, electric reels, and trolling; number of hooks per longline for longlines; number of traps pulled for traps; depth of the net for gill nets, this field is blank for divers
source: a character variable, this identifies the database that the record was extracted from, sg = snapper grouper, grf = gulf reef fish, all records should have this source code
tif_no: a character variable, trip identifier, not all records will have a tif_no
vesid: a character variable, a unique identifier for each vessel
started: numeric (mmddyy8) variable, date the trip started
landed: numeric (mmddyy8) variable, date the vessel returned to port
unload: numeric (mmddyy8) variable, date the catch was unloaded
received: numeric (mmddyy8) variable, date the logbook form was received from the fisherman
opened: numeric (mmddyy8) variable, date the logbook form was opened and given a schedule number
away: number of days at sea, this value should equal (landed-started+1)
crew: number of crew members, including the captain

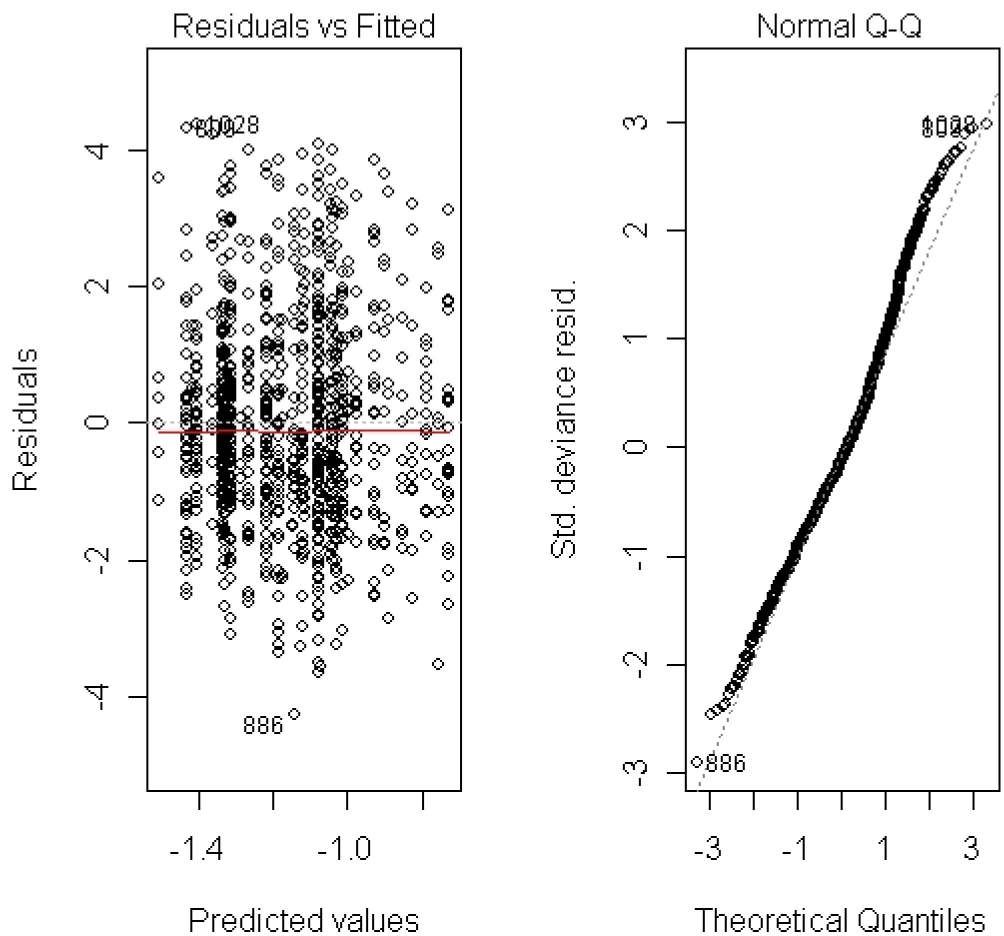
dealer: character variable, identifier for the dealer who bought the catch, in some cases there may be multiple dealers for a trip
state: character variable, the state in which the catch was sold
county: character variable, the county in which the catch was sold
area1 – area3: areas fished, if the trip included catch from multiple areas, those areas will be listed here
trip_ticket: character variable, trip ticket number, a unique identifier for each trip not all trips have this identifier

Appendix 5.10.2 Diagnostic plots for generalized linear models used to construct indices.

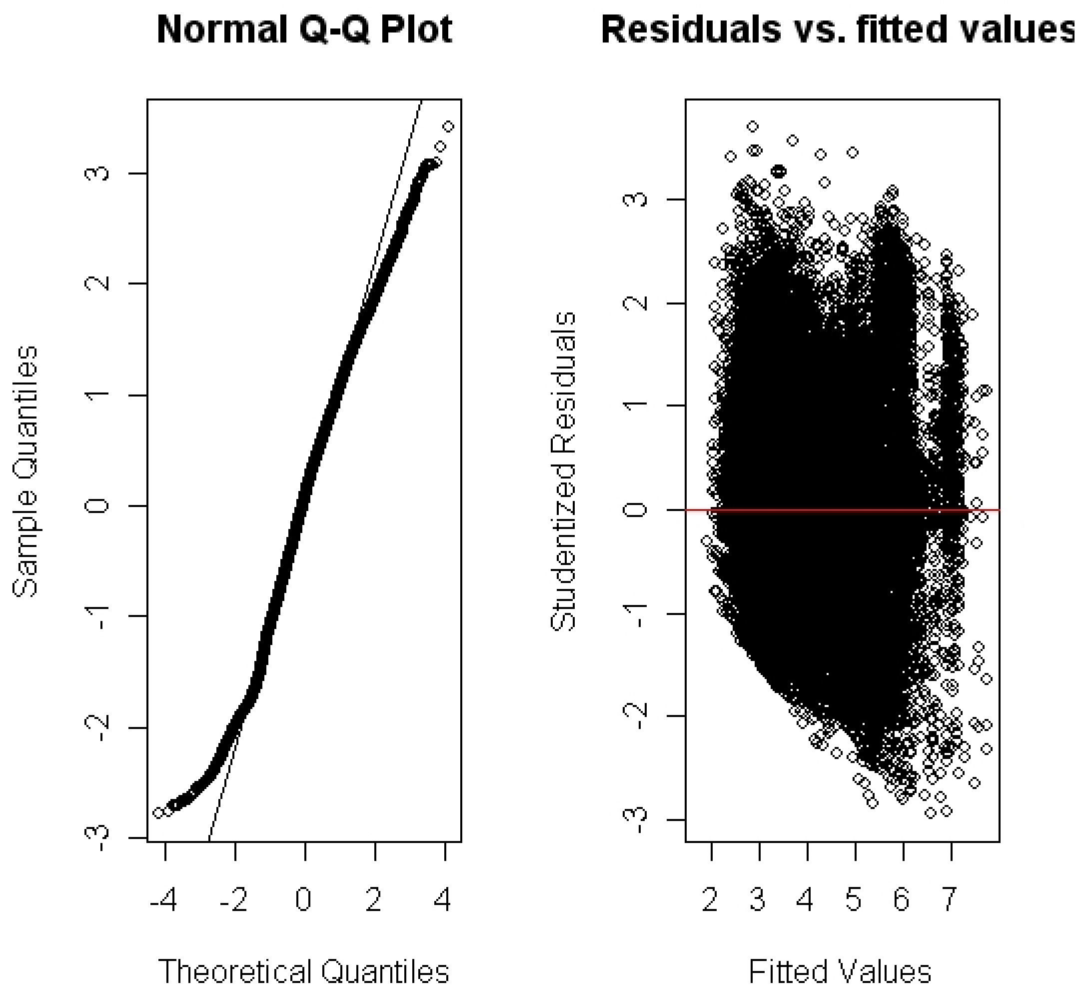
Appendix Figure 5.10.2.1. Regression diagnostics for the lognormal part of the delta-lognormal model for gillnet CPUE data from the logbook survey. The first panel gives a plot of fitted values against studentized residuals, indicating that residual variance is roughly constant across the range of fitted values. The second panel gives a normal quantile-quantile plot, where quantiles of residuals are close to being normally distributed (i.e., falling on the dotted line), with slight over-dispersion apparent in large CPUE observations and slight under-dispersion in small values of CPUE.



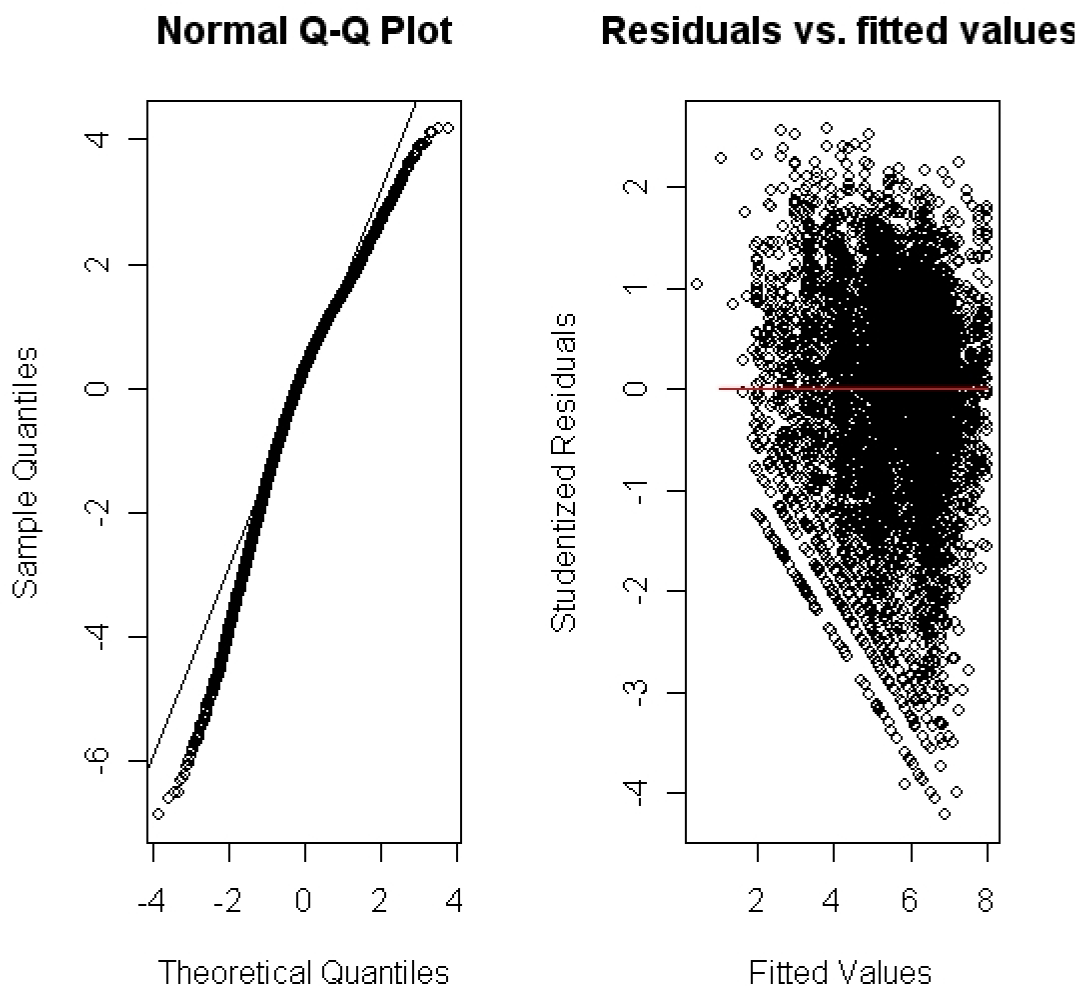
Appendix Figure 5.10.2.2 Regression diagnostics for the lognormal part of the delta-lognormal model for hook&line CPUE data from the logbook survey. The first panel gives a plot of fitted values against studentized residuals, indicating that residual variance is roughly constant across the range of fitted values. The second panel gives a normal quantile-quantile plot, where quantiles of residuals are close to being normally distributed (i.e., falling on the dotted line).



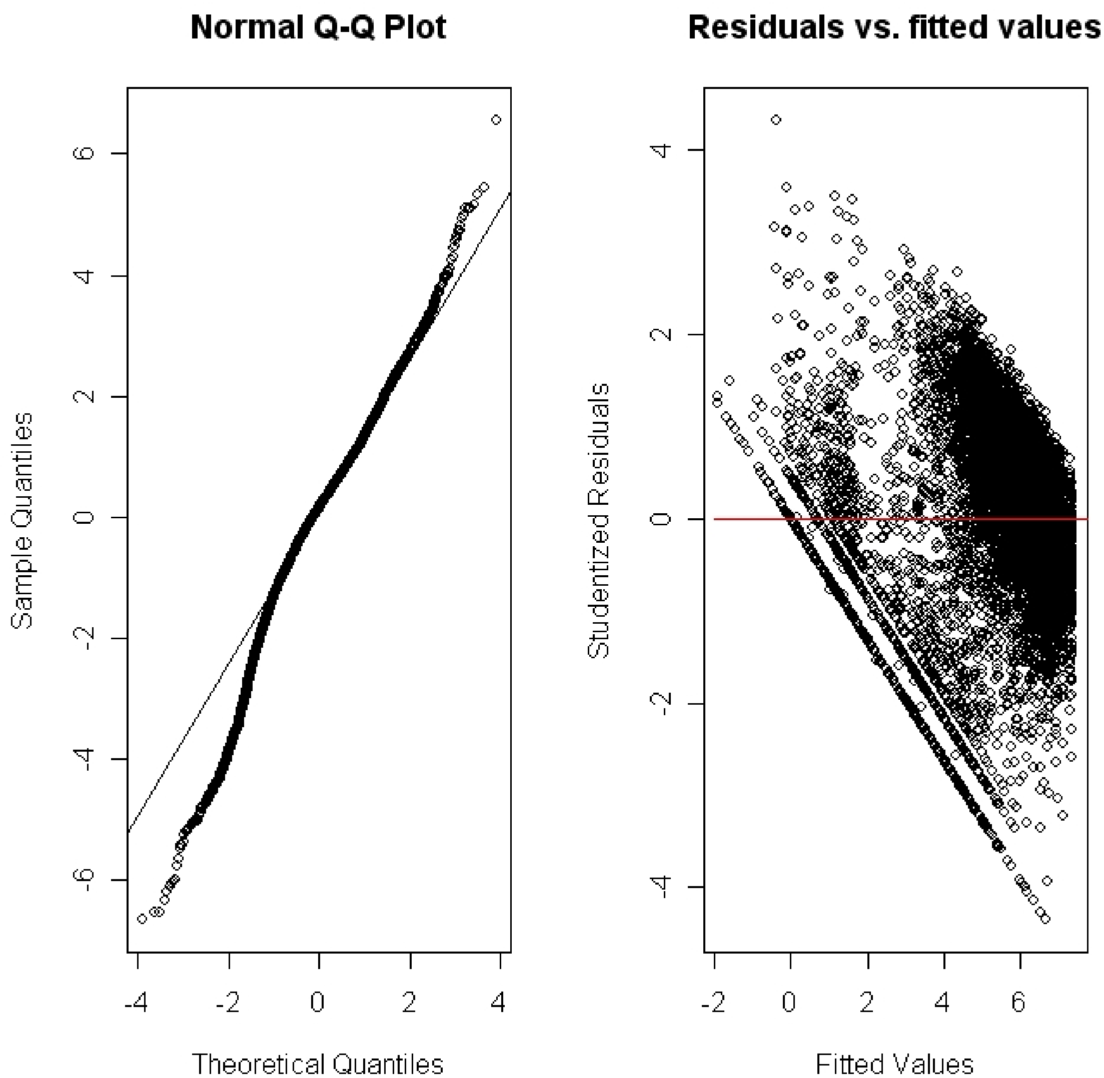
Appendix Figure 5.10.2.3. A normal quantile plot of randomized quantile residuals (cf. Dunn and Smyth 1995), together with a plot of studentized randomized quantile residuals vs. fitted values for the generalized linear model fit to 1985-1994 Florida trip ticket gillnet CPUE data. The normal quantile-quantile plot reveals that the fitted model has residuals that are somewhat underdispersed in comparison to the fitted gamma model. Residual variance appears roughly constant across the range of fitted values.



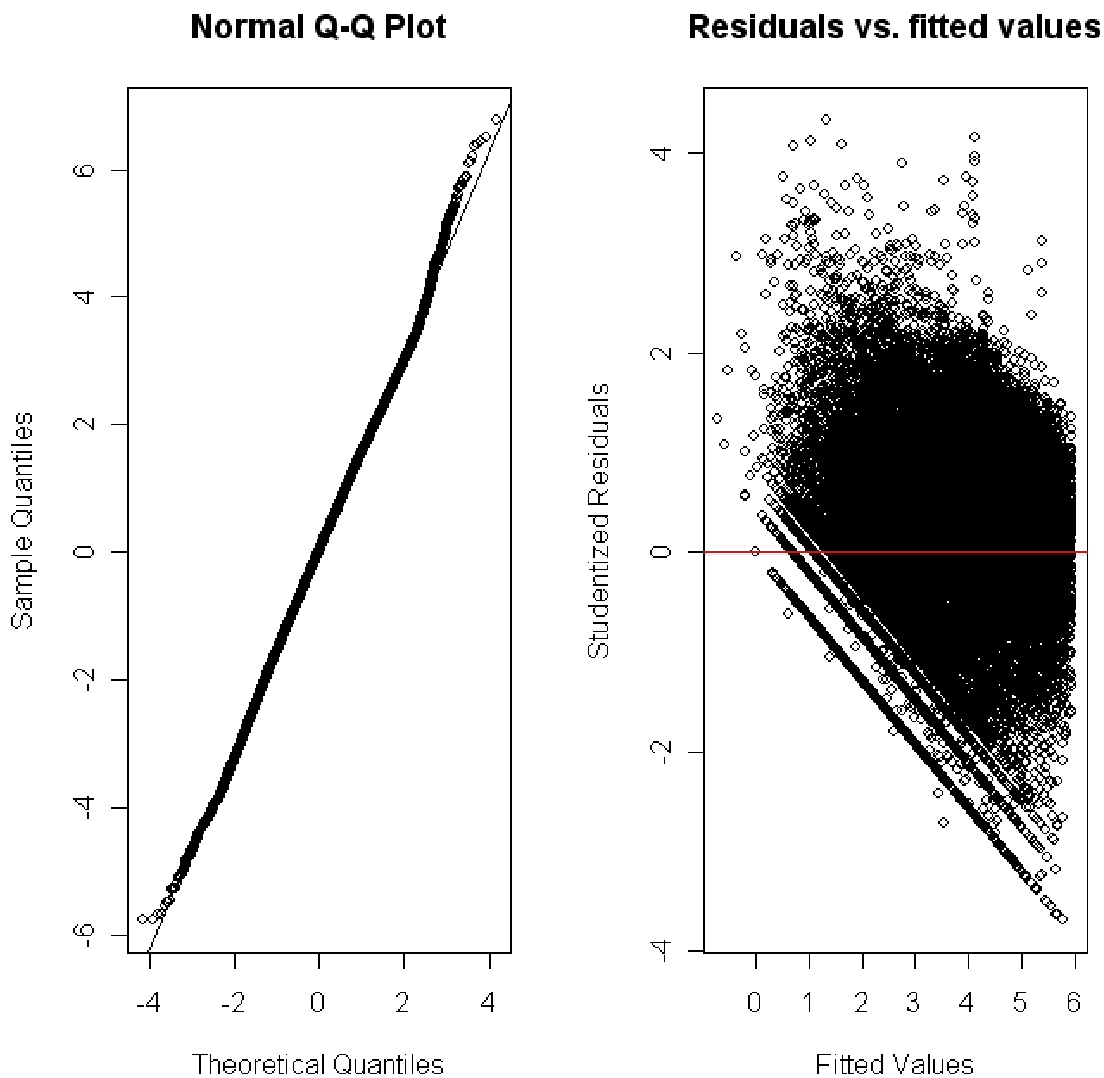
Appendix Figure 5.10.2.4. A normal quantile plot of residuals, together with a plot of studentized residuals vs. fitted values for the generalized linear model fit to 1996-2007 Florida trip ticket gillnet CPUE data. The normal quantile-quantile plot reveals that CPUE is overdispersed in comparison to the normal model at lower values, but somewhat underdispersed at higher values. Residual variance appears roughly constant across the range of fitted values. The absence of values in the lower left quadrant is related to the lower boundary of observations (1 lb).



Appendix Figure 5.10.2.5. A normal quantile plot of residuals, together with a plot of studentized residuals vs. fitted values for the generalized linear model fit to 1999-2007 Florida trip ticket castnet CPUE data. The normal quantile-quantile plot reveals extreme overdispersion in relation to the normal model, while the second panel reveals that residual variance decreases as the fitted value increases. The absence of values in the lower left quadrant is related to the lower boundary of observations (1 lb).



Appendix Figure 5.10.2.6. A normal quantile plot of residuals, together with a plot of studentized residuals vs. fitted values for the generalized linear model fit to 1985-2007 Florida trip ticket hook & line CPUE data. The normal quantile-quantile plot reveals that residuals are roughly normally distributed, while panel 2 indicates that residual variance is roughly constant across the range of fitted values. The absence of values in the lower left quadrant is related to the lower boundary of observations (1 lb).



6. Submitted Comments

None were received.

Section III. Assessment Workshop Report

Contents

1. Workshop Proceeding

1.1 Introduction

1.1.1 Workshop Time and Place

The SEDAR 17 Assessment Workshop was held August 25-29, 2008 in Beaufort, NC.

1.1.2 Terms of Reference

1. Review any changes in data following the data workshop, any analyses suggested by the data workshop, and provide estimated values for any required data in DW TOR 4 that are not available from observations. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.
2. Develop population assessment models that are compatible with available data and recommend which model and configuration is deemed most reliable or useful for providing advice. Document all input data, assumptions, and equations. Document model code in an AW working paper.
3. Provide estimates of stock population parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, discard removals, etc) by age and other relevant categorizations (i.e., fleet or sector); include representative measures of precision for parameter estimates.
4. Characterize uncertainty in the assessment and estimated values, considering components such as input data sources, data assumptions, modeling approach, and model configuration. Provide appropriate measures of model performance, reliability, and 'goodness of fit'.
5. Provide yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations, including figures and tables of complete parameters.
6. Provide estimates for SFA criteria consistent with applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and MSA National Standards. This may include: evaluating existing SFA benchmarks, estimating alternative SFA benchmarks, and recommending proxy values.
7. Provide declarations of stock status relative to SFA benchmarks; recommend alternative SFA benchmarks if necessary.
8. Project future stock conditions. Provide estimates of exploitation, stock abundance and yield (discards and directed harvest) in pounds and numbers for a minimum of 10 years into the future. Fully document all projection assumptions (e.g., recruitment, selectivity, discard mortality). Develop rebuilding schedules if warranted; include estimated generation time. Stock projections shall be developed in accordance with the following:
   - A) If stock is overfished:
     - F=0, F=current, F=Fmsy, Ftarget (OY),
     - F=Frebuild (max that rebuild in allowed time)
   - B) If stock is overfishing
     - F=Fcurrent, F=Fmsy, F= Ftarget (OY)
   - C) If stock is neither overfished nor overfishing
     - F=Fcurrent, F=Fmsy, F=Ftarget (OY)

9. Evaluate the impacts of past and current management actions on the stock, with emphasis on determining progress toward stated management goals and identifying possible unintended fishery or population effects.
10. Consider the data workshop research recommendations. Provide additional recommendations for future research and data collection (field and assessment); be as specific in describing sampling design and sampling intensity.
11. Prepare an accessible, documented, labeled, and formatted spreadsheet containing all model parameter estimates and all relevant population information resulting from model estimates and any projection and simulation exercises. Include all data included in assessment report tables, all data that support assessment workshop figures, and those tables required for the summary report.
12. Complete the Assessment Workshop Report (Section III of the SEDAR Stock Assessment Report), prepare a first draft of the Advisory Report, and develop a list of tasks to be completed following the workshop.
13. Perform a probabilistic analysis of proposed reference points and provide the probability of overfishing at various harvest or exploitation levels. (Added 7-2-08)

1.1.3 Participants

Appointee	Function	Affiliation
Coordination		
Dale Theiling	Chair	SEDAR
Rachael Lindsay	Administrative Support	SEDAR
Science and Statistics Committee Representation		
Marcel Reichert	Stock Leader & Proceedings Editor - Vermilion Snapper	SC DNR/MARMAP
Scott Crosson	Stock Leader & Proceedings Editor - Spanish Mackerel	NC DMF
Rapporteur		
Rick DeVictor	Rapporteur	SAFMC
Analytical Team		
Kyle Shertzer	Lead Analyst and Model Editor - Vermilion Snapper	SEFSC Beaufort
Paul Conn	Lead Analyst and Model Editor - Spanish Mackerel	SEFSC Beaufort
Doug Vaughan	Analyst	SEFSC Beaufort
Erik Williams	Analyst	SEFSC Beaufort
Rob Cheshire	Team Member	SEFSC Beaufort
Data Workgroup Leaders		
Doug Vaughan	Commercial Data Presenter	SEFSC Beaufort
Erik Williams	Recreational Data Presenter	SEFSC Beaufort
Jennifer Potts	Life History Data Presenter	SEFSC Beaufort
Kyle Shertzer	Indices Data Presenter	SEFSC Beaufort

Council Representation

Brian Cheuvront	Council Member	NC DMF
Rick DeVictor	Council Staff – Stocks Lead	SAFMC
Andi Stephens	Council Staff - Fishery Biologist	SAFMC

Advisory Panel Representation

Ben Hartig	Mackerel AP Chair	Florida Commercial

Appointed Observers

Jessica Stephen	Observer	SC DNR/MARMAP
Jack McGovern	Observer	SERO

Observers

Jim Waters	Observer	SEFSC Beaufort
Jim Thorson	Observer	Virginia Tech

1.1.4 Workshop Documents

Documents prepared for and by the SEDAR 17 data and assessment workshops:

Document #	Title	Authors
Documents Prepared for the Data Workshop		
SEDAR17-DW01	South Atlantic Vermilion Snapper Management Information Worksheet	J. McGovern (SERO) R. DeVictor (SAFMC)
SEDAR17-DW02	South Atlantic Spanish Mackerel Management Information Worksheet	J. McGovern (SERO) R. DeVictor (SAFMC)
SEDAR17-DW03	South Atlantic Vermilion Snapper Assessment History	D. Vaughan (SEFSC)
SEDAR17-DW04	South Atlantic Spanish Mackerel Assessment History	D. Vaughan (SEFSC)
SEDAR17-DW05	South Atlantic Vermilion Snapper Commercial Chapter	D. Vaughan (SEFSC)
SEDAR17-DW06	South Atlantic Spanish Mackerel Commercial Chapter	D. Vaughan (SEFSC)
SEDAR17-DW07	A review of Spanish mackerel (*Scomberomorus maculatus)* age data, 1987-2007, Atlantic collections only, from the Panama City Laboratory, SEFSC, NOAA Fisheries Service	C. Palmer, D. DeVries, C. Fioramonti and L. Lombardi-Carlson (SEFSC)
SEDAR17-DW08	Vermilion Snapper Length Frequencies and Condition of Released Fish from At-Sea Headboat Observer Surveys in the South Atlantic, 2004 to 2007	B. Sauls, C. Wilson, D. Mumford, and K. Brennan (SEFSC)
SEDAR17-DW09	Development of Conversion Factors for Different Trap Types used by MARMAP since 1978.	P. Harris (MARMAP)
SEDAR17-DW10	Discards of Spanish Mackerel and Vermilion Snapper Calculated for Commercial Vessels with Federal Fishing Permits in the US South Atlantic	K. McCarthy (SEFSC)
SEDAR17-DW11	Standardized catch rates of vermilion snapper from the headboat sector: Sensitivity analysis of the 10-fish-per-angler bag limit	Sustainable Fisheries Branch (SEFSC)
SEDAR17-DW12	Estimation of Spanish mackerel and vermilion snapper	K. Andrews (SEFSC)

	bycatch in the shrimp trawl fishery in the South Atlantic (SA)	
	Documents Prepared for the Assessment Workshop	
SEDAR17-AW01	SEDAR 17 South Atlantic Vermilion Snapper Stock Assessment Model	To be prepared by SEDAR 17
SEDAR17-AW02	SEDAR 17 South Atlantic Spanish Mackerel Stock Assessment Model	To be prepared by SEDAR 17
SEDAR17-AW03	Development of an aging error matrix for the vermilion snapper catch-at-age stock assessment model	E. Williams (SEFSC)
SEDAR17-AW04	Catch curve analysis of age composition data for Spanish mackerel	E. Williams (SEFSC)
SEDAR17-AW05	Catch curve analysis of age composition data for vermilion snapper	E. Williams (SEFSC)
SEDAR17-AW06	Methods for combining multiple indices into one, with application to south Atlantic (U.S.) Spanish mackerel	P. Conn (SEFSC)
SEDAR17-AW07	Extrapolation of Spanish mackerel bycatch by commercial shrimp trawl fisheries	P. Conn (SEFSC)
SEDAR17-AW08	A Bayesian approach to stochastic stock reduction analysis, with application to south Atlantic Spanish mackerel	P. Conn (SEFSC)
SEDAR17-AW09	Surplus–production Model Results of Vermilion Snapper off the Southeastern United States	R. Cheshire (SEFSC)
SEDAR17-AW10	Surplus–production Model Results of Spanish Mackerel off the Southeastern United States	R. Cheshire (SEFSC)
SEDAR17-AW11	AD Model Builder code to implement catch-age assessment model of vermilion snapper	K. Shertzer (SEFSC)
SEDAR17-AW12	AD Model Builder code to implement catch-age assessment model of Spanish mackerel	P. Conn (SEFSC)
SEDAR17-AW13	ASCII file populated by results of VS base catch-age model	K. Shertzer (SEFSC)
	Documents Prepared for the Review Workshop	
SEDAR17-RW01	SEDAR 17 South Atlantic Vermilion Snapper Document for Peer Review	To be prepared by SEDAR 17
SEDAR17-RW02	SEDAR 17 South Atlantic Spanish Mackerel Document for Peer Review	To be prepared by SEDAR 17
	Final Assessment Reports	
SEDAR17-AR01	Assessment of the Vermilion Snapper Stock in the US South Atlantic	To be prepared by SEDAR 17
SEDAR17-AR02	Assessment of the Spanish Mackerel Stock in the US	To be prepared by

	South Atlantic	SEDAR 17
Reference Documents		
SEDAR17-RD01	South Atlantic Vermilion Snapper Stock Assessment Report, SEDAR 2, 2003	SEDAR 2
SEDAR17-RD02	Update of the SEDAR 2 South Atlantic Vermilion Snapper Stock Assessment, 2007	SEDAR
SEDAR17-RD03	Fishery Management Plan for Spanish Mackerel, Atlantic States Marine Fisheries Commission, 1990	L. P. Mercer L. R. Phalen J. R. Maiolo
SEDAR17-RD04	Mitochondrial and nuclear DNA analysis of population subdivision among young-of-the-year Spanish mackerel (*Scomberomorus maculatus*) from the western Atlantic and Gulf of Mexico	V. P. Buonaccorsi E. Starkey J. E. Graves
SEDAR17-RD05	George Fishes MD TAFS 28 1-49	W. A. George
SEDAR17-RD06	Excerpt – Goode 1878 stats 7-1-99	Goode
SEDAR17-RD07	Excerpt – Henshall Comparative Excellence TAF 13 1-115	Henshall
SEDAR17-RD08	Stock Assessment Analyses on Spanish and King Mackerel Stocks, April 2003	Sustainable Fisheries Div, SEFSC
SEDAR17-RD09	Hooking Mortality of Reef Fishes in the Snapper-Grouper Commercial Fishery of the Southeastern United States	D.V. Guccione Jr.
SEDAR17-RD10	Effects of cryptic mortality and the hidden costs of using length limits in fishery management Lewis G Coggins Jr	L. G. Coggins Jr. and others
SEDAR17-RD11	Discard composition and release fate in the snapper and grouper commercial hook-and-line fishery in North Carolina, USA	P. J. Rudershausen and J. A. Buckel
SEDAR17-RD12	A multispecies approach to subsetting logbook data for purposes of estimating CPUE	A. Stephens and A. MacCall
SEDAR17-RD13	The 1960 Salt-Water Angling Survey, USFWS Circular 153	J. R. Clark
SEDAR17-RD14	The 1965 Salt-Water Angling Survey, USFWS Resource Publication 67	D. G. Deuel and J. R. Clark
SEDAR17-RD15	1970 Salt-Water Angling Survey, NMFS Current Fisheries Statistics Number 6200	D. G. Deuel
SEDAR17-RD16	User's Guide: Delta-GLM function for the R Language /environment (Version 1.7.2, revised 07-06-2006)	E. J. Dick (SWFSC/NMFS)
SEDAR17-RD17	Reproductive biology of Spanish mackerel, *Scomberomorus maculatus*, in the lower Chesapeake Bay. M.A. Thesis, Virginia Institute of Marine Science. (Selective pages)	C. L. Cooksey
SEDAR17-RD18	The summer flounder chronicles: Science, politics, and litigation, 1975–2000	M. Terceiro
SEDAR17-RD19	Use of Angler Diaries to Examine Biases Associated	N. Connelly and T.

	with 12-Month Recall on Mail Questionnaires	Brown
SEDAR17-RD20	Comparing 1994 Angler Catch and Harvest Rates from On-Site and Mail Surveys on Selected Maine Lakes	B. Roach
SEDAR17-RD21	Response Errors in Canadian Waterfowl Surveys	A. Sen
SEDAR17-RD22	Exaggeration of Walleye Catches by Alberta Anglers	M. Sullivan
SEDAR17-RD23	Effects of Recall Bias and Non-response Bias on Self-Report Estimates of Angling Participation	M. A. Tarrant and M. J. Manfredo
SEDAR17-RD24	Influence of Survey Method on Estimates of Statewide Fishing Activity	T. Thompson
SEDAR 17-RD25	Final Amendment 6 to the Fishery Management Plan for the Shrimp Fishery of the South Atlantic Region	SAFMC, 2004

1.2 Panel Recommendations and Comments

The following consensus comments and recommendations were made by the assessment panel in response to the Assessment Workshop Terms of Reference. Specifics of those terms reported by the analysts and accepted by the panel are discussed in detail in Chapters 2 and Chapter 3. Those earning panel discussion follow.

1. Review any changes in data following the data workshop, any analyses suggested by the data workshop, and provide estimated values for any required data in DW TOR 4 that are not available from observations. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.

The original assessment only used data back to the early 80s, when MRFSS was getting established. This run goes back to 1950, which is as far back as we have reliable commercial data. However, we only have limited recreational data pre-1981. There are Fish and Wildlife and National Marine Fisheries Service Saltwater Angler Surveys for years 1960, 1965, and 1970 only (RD13, RDW14, and RD15). All three of those data points yield harvests far larger than modern, up to 5x bigger. Modelers chose to extrapolate that data for pre-MRFSS recreational landings, adding imputed data points on a straight linear basis pre-1960. The starting year 1950 was assumed to have landings equal to the mean of the three existing years and a line was drawn from 1950 to 1960 to account for 1950s-era landings.

There was general agreement that angler effort was heavier in the post-WWII era; converted surplus military vessels were used as headboats and the fish schooled in ways that made them easier to catch. Ben Hartig agreed that recreational effort was much heavier then, but was not sure if it was 5x heavier. Discards would have been lower without bag and size limits. Identification errors seem unlikely for FWS and NMFS angler surveys on this particular species; pictures were shown to people. Brian Cheuvront pointed out that “telescoping bias” has been shown in many fish and wildlife studies to cause overestimates averaging 100% of catch rates.

The telescoping bias issue was discussed at length during the week and it was noted that changes in using this data for the Spanish mackerel assessment would seem to demand changes in the same for vermillion and all future assessments, not including species identification errors. Pre-MRFSS data is always higher than MRFSS data, often by several degrees of magnitude. The citations seemed clear enough that the committee chose to use a base run with pre-MRFSS landings at .75 of the early FWS and NMMS survey and imputed data points, with additional sensitivity runs at .5, 1 and 1.25. Human behavior is normally distributed so testing at regular increments is logical. Failure to adjust the pre-MRFSS recreational data yields earlier population estimates far higher than present, especially the pre-1970 estimates.

The committee also discussed the proper methods for estimating bycatch from shrimp trawling. Initial assumptions of very high levels of mortality of Spanish mackerel from shrimp trawling, but not all shrimping trips were using the same trawling gears or done in the same areas (inshore ocean, sounds, etc) and records are incomplete. The trawling survey indicated substantial Spanish mackerel bycatch in 1999 and 2000, while the other six years of survey data were an order of magnitude smaller. The revised shrimp landings only include trawl type gears and use a “hockey stick” type bycatch model, assuming bycatch maxes out before landings do. The introduction of BRDs in the mid-90 was assumed to reduce bycatch 40%.

2. Develop population assessment models that are compatible with available data and recommend which model and configuration is deemed most reliable or useful for providing advice. Document all input data, assumptions, and equations. Document model code in an AW working paper.

The primary model was a statistical catch-at-age model, with catch-curve analysis, a surplus production model, and a stochastic stock reduction model used in support; data is from commercial landings and MRFSS data with pre-MRFSS recreational data adjusted as noted above. Shrimp bycatch is based on hockey stick model. See Chapter 3.

10. Consider the data workshop research recommendations. Provide additional recommendations for future research and data collection (field and assessment); be as specific in describing sampling design and sampling intensity.

Recommendations of the Assessment Panel

Comprehensive Data and Assessment Archive: A goal of the SEDAR process, as stated in several workshop Terms of Reference, is to properly document all aspects of the data employed in the assessments, the assessments themselves, and the peer review of assessment details and results. While the various workshop reports and data workbooks compile much of the information, concern has been expressed that a full compilation of data manipulations, and programs used to generate the final data used in the assessment is not available following a SEDAR cycle. The concept of a SEDAR Comprehensive Data and Assessment Workshops Archive was proposed by the SEDAR 17 Data Compiler during preparations for the DW. Though the idea was not advanced from the DW as a formal recommendation it was generally taken favorably. An archive could serve as: a single reference for anyone wishing to dig deeper into how data were processed, a reference for future assessments, a backup of final data processing programs or spreadsheets for those who develop them, and continuity in cases of personnel changes for future assessments and updates. When discussed at the AW it was recognized implementation of an archive could have benefits and costs, but that it would require more attention than SEDAR 17 AW participants could give it, and all SEDAR cooperators were not present. The AW recommends that a SEDAR-wide workgroup be convened to identify the pros and cons of a Comprehensive Data and Assessment Archive for each future SEDAR.

Independent Expert on Assessment Panel: The assessment panel recommends that for future SEDAR assessment workshops, a scientist experienced in assessment methods and modeling (such as a CIE reviewer, or a NMFS or state person from outside the region) be provided as a workshop panelist. An independent expert can participate in discussing technical details of the methods used for SEDAR assessments, and assist in decisions related to model configuration during the workshop. In particular, the analysts believe that an independent analyst could contribute fresh information to improve the assessments.

Review and Qualification of Historic Recreational Angler Survey Reports: Pre-MRFSS catch and related effort data from south Atlantic recreational fisheries are very scarce, but are considered valuable to stock assessments, where available. Two reports of the U. S. Fish and Wildlife Service (SEDAR 17-RD13 and SEDAR 17-RD14) and one of the NMFS (SEDAR 17-RD15) characterize south Atlantic salt-water angling effort and success based on recall surveys conducted in 1960, 1965, and 1970, respectively. These references have been viewed in various ways in previous stock assessments performed through the SEDAR process. In SEDAR 2 for South Atlantic black sea bass, these data were not used explicitly in the age-structured modeling, however, with assumptions, were used to extend the time frame for application of the production modeling approach. In SEDAR 15 for South Atlantic red snapper these data were employed by the assessment panel at face value for the three survey years and to interpolate recreational landings before, between, and after survey years. In SEDAR 15 for South Atlantic greater amberjack the review panel agreed with the assessment panel that the survey estimates of recreational landings of “jacks” not be included in the assessment due in part to species identification concerns. For the present assessment the assessment panel has employed the survey data for both stocks under assessment, but considers recall bias on the part of persons surveyed to be a significant factor. Thus they chose to reduce the weight of the estimates in its base runs and explore the effect on the model through sensitivity runs.

A guiding principal of the SEDAR process is consistency in the identification and utilization of data that characterize fishery stocks under assessment and the fisheries that affect the stocks. Because the three pre-MRFSS saltwater angling survey reports have proven of value, and likely will be referenced in future stock assessments, the AW recommends they be reviewed by a group of fishery professionals. The group should include persons knowledgeable in survey design, data collection, and application of survey data to fishery stock assessments. The group’s function would be to qualify the three surveys, and others which the group may identify, and provide guidelines that further consistency in their utilization in future stock assessment conducted under the SEDAR process. The review of these reports could be coupled with a review and qualification of commercial and other data to standardize their use in stock assessments, as recommended in the SEDAR 17 data workshop reports.

Avoid Brief Workshop Interims: The panel made a recommendation against scheduling abbreviated SEDAR stock assessments. AW participants felt that an abbreviated schedule could compromise the quality of the assessment.

2 Data Input and Changes

Processing of data for the assessment is described in the SEDAR 17 Spanish mackerel Data Workshop Report. This section describes additional manipulations to the data output for use in the ADMB age structured model.

2.1 *Life History (Growth, Maturity, and Mortality)*

During the data workshop, it was decided that a two sex model was to be preferred for Spanish mackerel because of sex-specific differences in growth schedules. When implementing such a model, one needs to specify a sex ratio for recruits to the population (young-of-year in the case of Spanish). There were very few data on young-of-year sex ratio (a total of seven samples consisting of two females and five males). We found these to be insufficient for estimating a population-level sex ratio, instead preferring to make the assumption of a 50/50 sex ratio at the time of recruitment for all models employing multiple sexes (i.e., statistical catch-at-age, stochastic SRA).

Estimates of scaled Lorenzen natural mortality were not included in the SEDAR 17 Spanish mackerel data workshop report, and are now presented here for completeness. These resulted from rescaling the Lorenzen curve to produce an average M equivalent to the estimate of Hoenig. Age specific values were as follows:

Age 0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9+
0.50	0.41	0.36	0.33	0.31	0.30	0.29	0.29	0.29	0.28

Generation time (G) was estimated from Eq. 3.4 in Gotelli (1998, p. 57):

$$G = \Sigma\, l_x b_x x / \Sigma\, l_x b_x,$$

where summation was over ages x = 1 through 100 (by which age the numerator and denominator were both essentially zero), l_x is the number of fish at age starting with 1 fish at age 1 and decrementing based on natural mortality only, and b_x is per capita birth rate of females at age. Because female biomass is used as a proxy for female reproduction in our model, we substitute the product of $m_x w_x$ for b_x in this equation, where m_x is proportion of females mature at age and w_x is expected weight (of females) at age. This weighted average of age for mature female biomass yields an estimate of 4.4 yrs.

2.2 *Commercial Fishery*

2.2.1 Commercial Landings

For the statistical catch-at-age model, the decision was made to fit landings exactly when possible; in an effort to do so, a common coefficient of variation of 0.05 was assigned to all landings time series. This was following suggestions by the SEDAR 15 Review workshop, where it was argued that possible deviations from observed landings be considered in sensitivity analysis by running the model with alternative landings time series. Commercial landings were modeled in units of 1000 lb whole weight (Table 2.7.1).

2.2.2 Commercial Length and Age Compositions

Commercial length compositions were changed to have a minimum limit at 10cm and a maximum limit of 70cm for input into the assessment model, with 1cm bins. Age compositions were changed to have an age 10+ group.

2.2.3 Commercial Discards

Estimates of commercial discards for Spanish mackerel can be found in SEDAR 17-DW10 for the period 1998-2007 (Table 2.7.2). Extensions of these discard estimates from commercial gillnets and handline (including trolling) fisheries for 1986-2007 were developed during the data workshop with discussion and recommendation (Decision 8) included in SEDAR 17 DW commercial section (§3.4.1).

Without samples of commercial discards, historical TIP length frequency data prior to 1986 were investigated for commercial gillnet and handline fisheries. The 1986 was used as the cutoff because a 12” FL minimum size limit was instituted in August of 1985. Unfortunately, data was limited for these years and few fish were landed below the subsequent minimum size limit. For gillnet gear (SEDAR 17 DW, Figure 3.14) only a few 30cm FL fish were landed in 1985, otherwise all TIP-sampled Spanish mackerel would have been legal. For handline gear, all TIP-sampled Spanish mackerel prior to 1986 would have been legal. There were a variety of fish sampled by TIP below the minimum size limit after 1985. For the gillnet fishery, Spanish mackerel as small as 13” FL were landed in 1988, but in general the smallest landed were 25cm - 26cm FL. For handline gear, the smallest Spanish mackerel landed were about 24cm – 25cm FL.

Bycatch estimates of Spanish mackerel in commercial fisheries were extrapolated back in time based on an estimated “hockey stick” relationship between bycatch and annual shrimp landings. An additional assumption was that bycatch reduction devices (BRDs) had reduced bycatch by 40% in recent years (for details, see SEDAR-17-AW-07). Using this approach, estimates of bycatch were obtained for the period 1950-2007 (Figure 2.8.1).

Age-specific selectivities for discards were needed as inputs for model runs because there was no information on age or size structure of discards. In order to calculate discard selectivity, we assumed that fish were discarded because they were lower than the size limit. Out of 6,248 age-sampled fish that were age 2 or higher, none were less than the 12 inch size limit for Spanish. We thus assumed that only age 0 and age 1 fish were discarded. Assuming a normal distribution for length at age, discard selectivities for each gear and age were calculated by

$$s_a = \frac{\int_{L0}^{\lim} Normal(x;\mu_a,\sigma_a)}{\max\left(\int_{L0}^{\lim} Normal(x;\mu_a,\sigma_a)\right)},$$

where s_a gives selectivity at age, *L0* gives the smallest size that is represented in a given fishery's length composition sample, *lim* gives the minimum size limit, μ_a gives the mean length at age (as calculated by the von Bertalanffy growth equation, for instance), and σ_a gives the standard deviation of length at age. Using this approach, we estimated age 0 and age 1 selectivities for gillnet and handline fisheries (Table 2.7.2).

2.3 *Recreational Fishery*

2.3.1 Recreational Landings

The 1960,1965, and 1970 general recreational estimates (Clark, 1962; Deuel and Clark, 1968; Deuel, 1973) in number included headboat landings and the typical MRFSS fishing modes (shore, private vessel, charter vessel). Appropriate use of these values received considerable discussion during the SEDAR 17 AW. In particular, the AW panel was concerned about the potential for recall bias, as the salt-water angling survey was based on a 1-year recall. In general, such a long recall is likely to lead to overestimates of landings and effort (Roach et al. 1999, Tarrant et al. 1993). At least one author has suggested that landings reported in these salt-water angling surveys could be biased high by as much as 100% (Terceiro, 2002). The AW panel had no information to estimate the amount of bias for SEDAR 17 species, but acknowledged that landings reported in the angling survey were likely biased high, and recommended reducing the 1960, 1965, and 1970 estimates to between 50% and 100% of the reported values. Thus, these estimates were reduced to 75% of the reported values for the base run of the assessment model (Table 2.7.3). For sensitivity runs, values of 50%, 100%, and 125% were used.

Headboat landings were linearly interpolated from the average annual headboat landings from 1981-84 back to 0 in 1946, the year in which it was estimated as the start of the headboat fishing sector. The estimated headboat landings were subtracted from the salt-water angling survey estimates to give the MRFSS portion of the landings.

The assessment model starting year, 1950, was assigned the value of the average salt-water angling survey estimates (all of which were reduced by 25%) for 1960, 1965, and 1970. The remaining missing years of landings were linearly interpolated between available data points to generate the final series of landings in number. Headboat landings were minimal and the two series of recreational landings were combined for input into the assessment model as on recreational landings series in thousands of fish. The CV's were assumed to be 0.05 for all years in order to fit landings exactly within the assessment model (uncertainty in landings were to be investigated via sensitivity runs with alternate landings streams).

2.3.2 Recreational Length and Age Compositions

The lower limit of the recreational length bins were expanded from 15cm to 10 cm with 0 values. The length bins over 70cm were pooled into the 70-plus cm bin. The age-11 bin was lumped into the age-10 bin to create a 10-plus group.

2.3.3 Recreational Discards

Discard ratios (number of discarded fish/number of landed fish) were computed where discard and landings estimates were available (2003-2007 headboat, 1981-2007 MRFSS). The MRFSS discard ratio prior to 1981 was calculated to be the average discard ratio of the MRFSS years prior to the 1983 size regulation (1981-82). Headboat discard ratios for 1981-2003 were computed as the average annual headboat discard ratio from 2004-2006. Headboat discards were assumed to be 0 prior to 1981.

Annual discards in numbers (1000) were estimated as the annual landings in number multiplied by the corresponding annual discard ratio for each fishery. Headboat and MRFSS discard estimates were combined to create one recreational time series of discards with CV’s set to 0.05 for all years. The method presented in section 2.2.3 was applied to generate discard selectivities for the recreational fishery (Table 2.7.4).

2.4 *Indices*

Because of the large number of indices and uncertainty about which ones best represented population trends, a Bayesian hierarchical model was used to estimate a single index of relative abundance from seven of the original indices (Figure 2.8.2; SEDAR-17-AW-Combining-Indices). This combined index was thought to be useful in that analysts anticipated numerical difficulties in model fitting due to conflicting information.

2.5 *Total removals*

Although the catch-age assessment modeled landings and discards by fishery, the surplus production model and stock reduction analysis utilized a single time series of total removals. This single time series combined landings and discards in pounds of whole weight (Table 2.7.4).

2.6 *References*

Clark, J. 1962. The 1960 Salt-Water Angling Survey. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, *Circular* 153, 36 pp.

Deuel, D. G. 1973. 1970 Salt-Water Angling Survey. U.S. Department of Commerce, NOAA, *Current Fishery Statistics* No. 6200, 54 p.

Deuel, D. G., and J. R. Clark. 1968. The 1965 Salt-Water Angling Survey. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, *Resource Publication* 67, 51 p.

Gotelli, Nicholas J. 1998. A Primer of Ecology, 2nd Edition. Sinauer Associates, Inc., Sunderland, MA, 236 p.

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystems and aquaculture. Fish. Biol. 49:627-647.

Roach, B., J. Trial, and K. Boyle. 1999. Comparing 1994 angler catch and harvest rates from on-site and mail surveys on selected lakes. North American Journal of Fisheries Management 19:203-208.

SEDAR-17-AW-06. Methods for combining multiple indices into one, with application to south Atlantic (U.S.) Spanish mackerel

SEDAR-17-AW-07. 2008. Extrapolation of Spanish mackerel bycatch by commercial shrimp trawl fisheries

SEDAR 17-DW10. 2008. Discards of Spanish Mackerel and Vermilion Snapper Calculated for Commercial Vessels with Federal Fishing Permits in the US South Atlantic.

Tarrant, M. A., M. J. Manfredo, P. B. Bayley, and R. Hess. 1993. Effects of recall bias and nonresponse bias on self-report estimates of angling participation. North American Journal of Fisheries Management 13:217-222.

Teceiro, M. 2002. The summer flounder chronicles: Science, politics, and litigation, 1975-2000. Reviews in Fish Biology and Fisheries 11: 125-168.

2.7 *Tables*

Table 2.7.1 Commercial landings used in the catch-age assessment model with all values in total weight (1000's of pounds).

Year	Gillnet	Castnet	Poundnet	Handline	CV
1950	3008	0	13	0	0.05
1951	2837	0	6	0	0.05
1952	3674	0	3	0	0.05
1953	3115	0	1	0	0.05
1954	2940	0	4	0	0.05
1955	4004	0	6	0	0.05
1956	4765	0	16	0	0.05
1957	5861	0	15	0	0.05
1958	5297	0	6	10	0.05
1959	2471	0	17	9	0.05
1960	2774	0	21	25	0.05
1961	3017	0	122	20	0.05
1962	2349	0	14	76	0.05
1963	2160	0	65	54	0.05
1964	2478	0	32	103	0.05
1965	2467	0	90	153	0.05
1966	1910	0	111	173	0.05
1967	3181	0	23	142	0.05
1968	3211	0	73	123	0.05
1969	3056	0	84	103	0.05
1970	3059	0	104	127	0.05
1971	3019	0	26	119	0.05
1972	3250	0	23	134	0.05
1973	2641	0	51	162	0.05
1974	3686	0	25	283	0.05
1975	7045	0	62	623	0.05
1976	10926	0	77	582	0.05
1977	6753	0	29	125	0.05
1978	6250	0	2	44	0.05
1979	6268	0	1	50	0.05
1980	6373	0	4	50	0.05
1981	2868	0	2	37	0.05
1982	6981	0	11	91	0.05
1983	3430	0	13	30	0.05
1984	3674	0	14	50	0.05
1985	3347	3	33	59	0.05
1986	2357	0	39	56	0.05
1987	2529	1	235	116	0.05
1988	3328	1	183	104	0.05
1989	3246	0	505	142	0.05
1990	2844	1	509	250	0.05
1991	3853	0	468	285	0.05
1992	3131	0	397	73	0.05

1993	4657	0	328	61	0.05
1994	5107	0	345	69	0.05
1995	1449	34	207	200	0.05
1996	2470	197	302	83	0.05
1997	2710	76	208	93	0.05
1998	2900	33	118	176	0.05
1999	1557	345	302	202	0.05
2000	1576	622	206	278	0.05
2001	1515	934	222	419	0.05
2002	1318	1420	136	362	0.05
2003	951	2270	111	416	0.05
2004	788	1745	72	761	0.05
2005	1209	1716	50	698	0.05
2006	1417	1380	10	839	0.05
2007	1705	549	14	753	0.05

Table 2.7.2. Estimates of Spanish mackerel commercial discards form gillnets and handlines estimated from logbook (1998-2007; SEDAR17 DW-10) and as ratio with commercial landings for 1986-1997. Ratio based on years 1998-2007 and estimated as 0.013 for gillnets and 0.025 for handlines. All values are in numbers of fish.

	Florida-North Carolina		Discards FL-NC	
Fishing Year	Gillnet	Handline	Gillnet	Handline
1986	949,265	17,912	11,968	447
1987	960,898	32,276	12,115	806
1988	1,094,315	38,471	13,797	960
1989	589,966	54,393	7,438	1,358
1990	917,507	86,811	11,568	2,167
1991	1,079,472	115,548	13,610	2,884
1992	1,084,220	19,163	13,670	478
1993	1,857,747	29,669	23,423	741
1994	2,098,626	18,589	26,460	464
1995	653,726	135,788	8,242	3,389
1996	1,225,196	7,481	15,447	187
1997	1,461,803	31,474	18,431	786
1998	1,640,647	65,122	8,755	4,210
1999	715,852	74,016	13,849	3,474
2000	794,383	130,024	10,030	3,662
2001	1,000,068	163,450	10,753	3,854
2002	835,367	150,321	12,145	4,476
2003	532,239	213,643	8,534	3,960
2004	334,009	219,700	6,617	2,742
2005	776,207	397,698	8,337	2,566
2006	816,737	340,300	7,109	2,950
2007	768,904	302,106	6,299	3,130

Table 2.7.3 Estimates of recreational landings and discards used in the catch-age assessment model. All values are in number and incorporate a 0.75 multiplier on early USFWS saltwater angling records to account for recall bias.

	Number (1000)			
Year	Landings	CV's	Discards	CV's
1950	5126.313	0.05	203.088	0.05
1951	5167.181	0.05	204.696	0.05
1952	5208.050	0.05	206.304	0.05
1953	5248.919	0.05	207.912	0.05
1954	5289.788	0.05	209.519	0.05
1955	5330.656	0.05	211.127	0.05
1956	5371.525	0.05	212.735	0.05
1957	5412.394	0.05	214.343	0.05
1958	5453.263	0.05	215.950	0.05
1959	5494.131	0.05	217.558	0.05
1960	5535.000	0.05	219.166	0.05
1961	5601.900	0.05	221.805	0.05
1962	5668.800	0.05	224.444	0.05
1963	5735.700	0.05	227.084	0.05
1964	5802.600	0.05	229.723	0.05
1965	5869.500	0.05	232.362	0.05
1966	5493.150	0.05	217.437	0.05
1967	5116.800	0.05	202.512	0.05
1968	4740.450	0.05	187.587	0.05
1969	4364.100	0.05	172.662	0.05
1970	3987.750	0.05	157.737	0.05
1971	3656.846	0.05	144.613	0.05
1972	3325.941	0.05	131.489	0.05
1973	2995.037	0.05	118.365	0.05
1974	2664.133	0.05	105.241	0.05
1975	2333.228	0.05	92.117	0.05
1976	2002.324	0.05	78.992	0.05
1977	1671.420	0.05	65.868	0.05
1978	1340.515	0.05	52.744	0.05
1979	1009.611	0.05	39.620	0.05
1980	678.707	0.05	26.496	0.05
1981	887.572	0.05	62.150	0.05
1982	903.658	0.05	6.744	0.05
1983	126.613	0.05	5.475	0.05
1984	970.959	0.05	26.055	0.05
1985	486.603	0.05	55.105	0.05
1986	888.669	0.05	318.282	0.05
1987	1184.722	0.05	61.851	0.05
1988	1743.737	0.05	63.669	0.05
1989	1226.580	0.05	239.940	0.05
1990	1359.381	0.05	160.519	0.05
1991	1548.321	0.05	365.198	0.05
1992	1381.943	0.05	349.769	0.05

1993	955.035	0.05	244.734	0.05
1994	1219.750	0.05	752.475	0.05
1995	875.801	0.05	390.739	0.05
1996	840.958	0.05	356.791	0.05
1997	1112.855	0.05	420.087	0.05
1998	688.367	0.05	267.322	0.05
1999	1086.753	0.05	640.558	0.05
2000	1736.803	0.05	827.136	0.05
2001	1242.552	0.05	676.133	0.05
2002	1280.433	0.05	613.806	0.05
2003	1532.491	0.05	811.847	0.05
2004	883.212	0.05	420.079	0.05
2005	1087.623	0.05	748.129	0.05
2006	906.936	0.05	283.212	0.05
2007	1050.894	0.05	565.322	0.05

Table 2.7.4 Estimates of discard selectivity for age zero and age one Spanish mackerel for different fisheries and sexes. Discard selectivities of older age classes were assumed to be zero.

Gear	Sex	Age 0 selectivity	Age 1 selectivity
Comm Handline	M	1.00	0.64
Comm Handline	F	1.00	0.48
Comm Gillnet	M	1.00	0.40
Comm Gillnet	F	1.00	0.33
Recreational	M	1.00	0.41
Recreational	F	1.00	0.34

Table 2.7.5. Total removals in whole weight, as used in surplus production model and stock reduction analysis. For the stock reduction analysis, landings were linearly interpolated from 1950 to 0 in 1900 as an initialization period. In contrast, the surplus reduction analysis was started in 1950.

year	Landings (lbs)
1900	0
1901	354084
1902	708167
1903	1062251
1904	1416335
1905	1770418
1906	2124502
1907	2478585
1908	2832669
1909	3186753
1910	3540836
1911	3894920
1912	4249004
1913	4603087
1914	4957171
1915	5311255
1916	5665338
1917	6019422
1918	6373506
1919	6727589
1920	7081673
1921	7435756
1922	7789840
1923	8143924
1924	8498007
1925	8852091
1926	9206175
1927	9560258
1928	9914342
1929	10268426
1930	10622509
1931	10976593
1932	11330677
1933	11684760
1934	12038844
1935	12392927
1936	12747011
1937	13101095
1938	13455178
1939	13809262
1940	14163346
1941	14517429

1942	14871513
1943	15225597
1944	15579680
1945	15933764
1946	16287847
1947	16641931
1948	16996015
1949	17350098
1950	17704182
1951	16657594
1952	16906741
1953	18059891
1954	17330371
1955	18495798
1956	18394872
1957	20520712
1958	17915472
1959	16496511
1960	18372318
1961	15322997
1962	16874248
1963	14729469
1964	15205490
1965	17530441
1966	14296247
1967	14483135
1968	15139724
1969	15232312
1970	12070427
1971	14783014
1972	12694429
1973	11210000
1974	12574252
1975	14918165
1976	18513681
1977	11093885
1978	9832549
1979	9465985
1980	10318444
1981	4553348
1982	10780607
1983	6246590
1984	5442073
1985	6983003
1986	5630095
1987	6178058
1988	8376070
1989	8995048
1990	8896181
1991	10569830

1992	8154481
1993	7165638
1994	7100815
1995	5632044
1996	3962407
1997	5692704
1998	4434035
1999	5996160
2000	7289560
2001	5710694
2002	5024619
2003	5912290
2004	4864170
2005	5734790
2006	5427640
2007	4884373

2.8 *Figures*

Figure 2.8.1. Shrimp trawl bycatch (numers of fish) as extrapolated by an estimated hockey stick relationship between shrimp landings and observed bycatch. The extrapolation procedure also assumed a 40% reduction in bycatch after full implementation of BRDs in 1997.

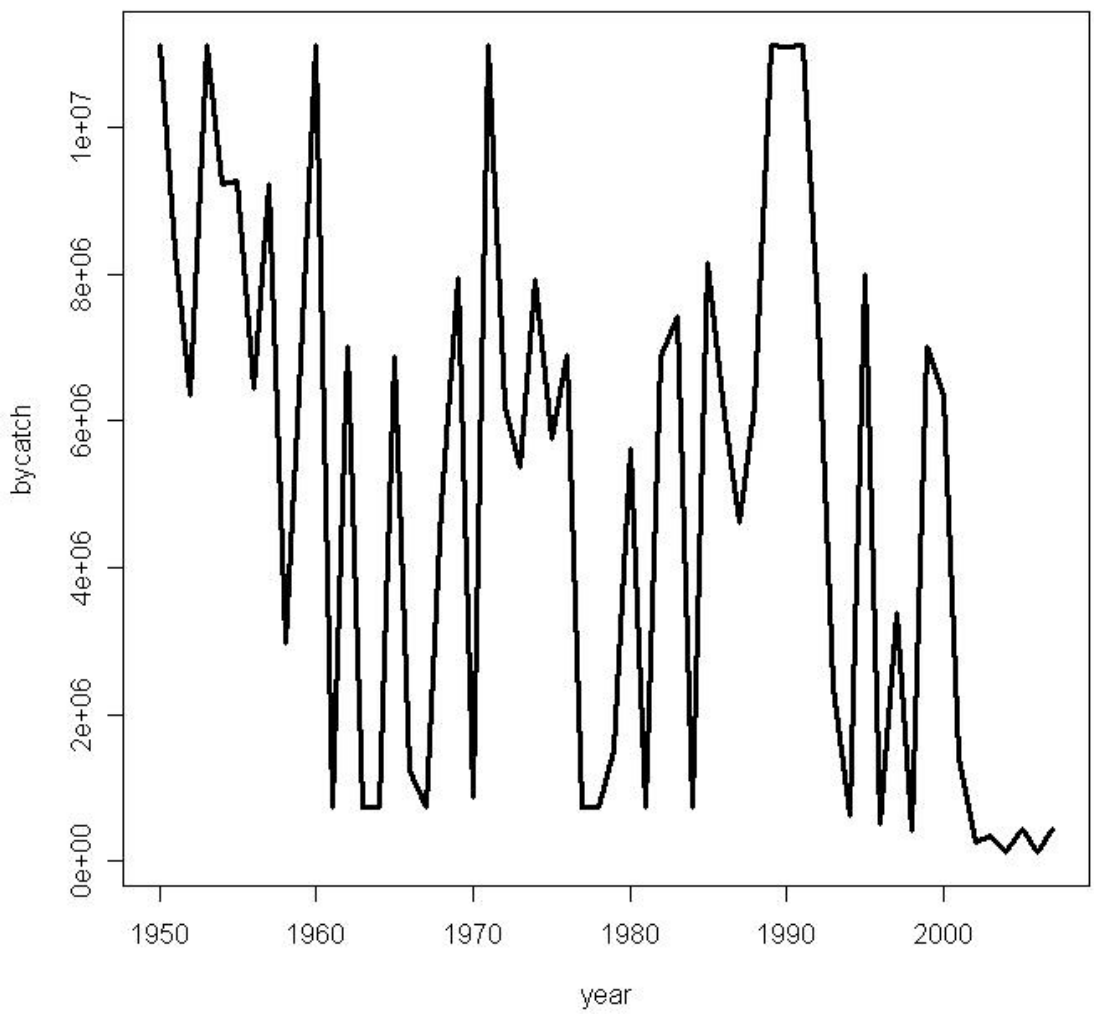
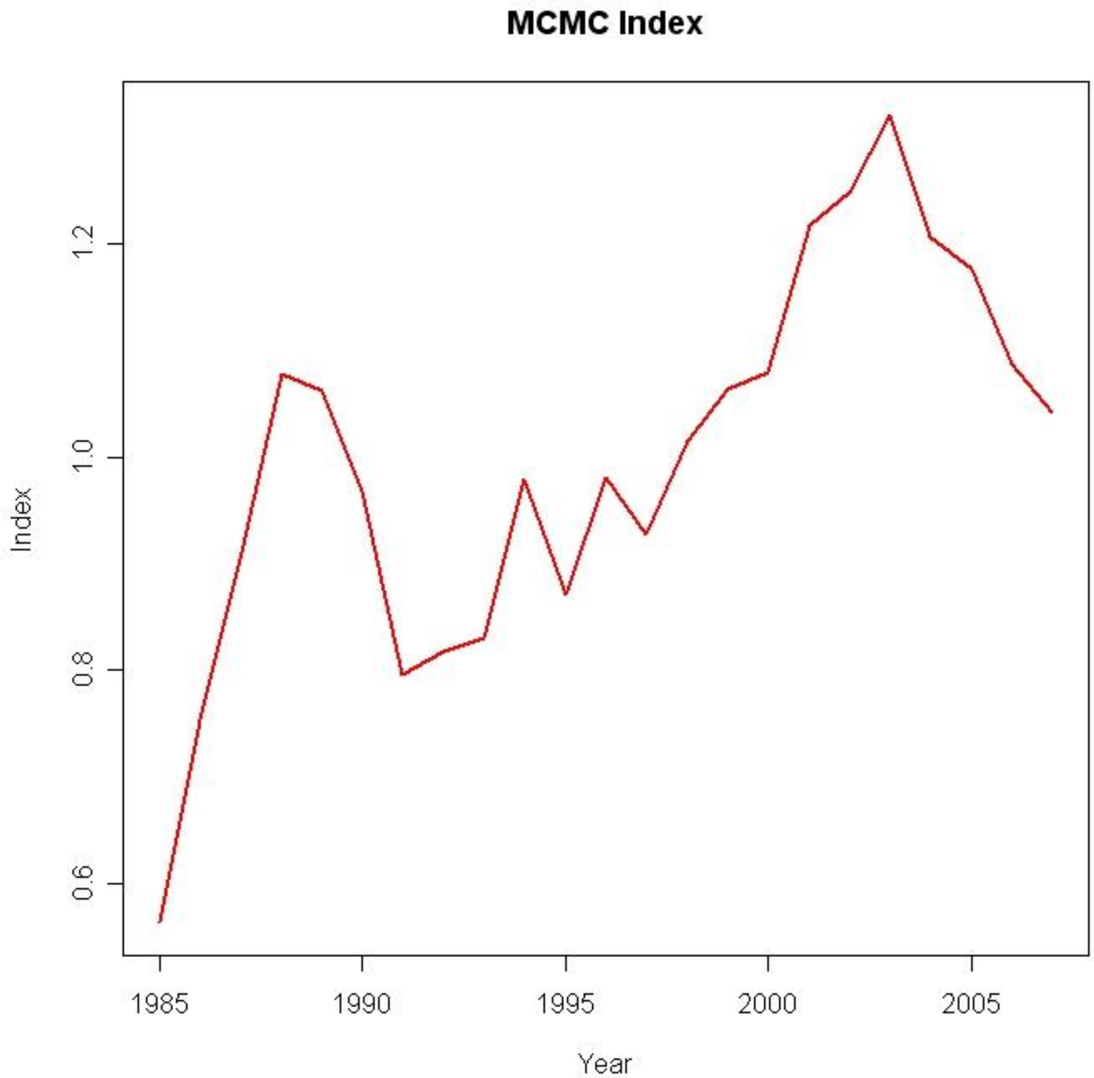


Figure 2.8.2. Estimates of a single combined relative abundance index for Spanish mackerel based on Bayesian hierarchical analysis (solid line).



3 Stock Assessment Models and Results

Three different model structures were applied in this assessment of Spanish mackerel: a statistical catch-at-age model, a stochastic stock reduction analysis, and a surplus production model. In addition, a catch curve analysis was performed to provide independent estimates of mortality. The catch-at-age model was considered to be the primary assessment model. Abbreviations used in this report are defined in Appendix A.

3.1 Model 1: Catch-at-age model

3.1.1 Model 1 Methods

3.1.1.1 **Overview** The primary model in this assessment was a statistical catch-at-age model (Quinn and Deriso 1999), implemented with the AD Model Builder software (Otter Research 2004). In essence, a statistical catch-at-age model simulates a population forward in time while including fishing processes. Quantities to be estimated are systematically varied until characteristics of the simulated populations match available data on the real population. Statistical catch-at-age models share many attributes with ADAPT-style tuned and untuned VPAs.

The method of forward projection has a long history in fishery models. It was introduced by Pella and Tomlinson (1969) for fitting production models and then used by Fournier and Archibald (1982), Deriso et al. (1985) in their CAGEAN model, and Methot (1989) in his stock-synthesis model. The catch-at-age model of this assessment is similar in structure to the CAGEAN and stock-synthesis models. Versions of this assessment model have been used in previous SEDAR assessments of red porgy, black sea bass, tilefish, snowy grouper, gag grouper, greater amberjack, and red snapper.

3.1.1.2 **Data Sources** The catch-at-age model was fit to data from two fishery independent indices, to extrapolated estimates of bycatch in the shrimp fishery, and to data from each of the five primary fisheries on southeastern U.S. Spanish mackerel: commercial gillnet, commercial poundnet, commercial castnet, 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 discard mortalities by fishery (excluding poundnet and gillnet), annual length composition of landings by fishery, annual age composition of landings by fishery, seven fishery dependent indices of abundance, and two fishery independent indices (from SEAMAP trawl surveys). These data are tabulated in §2 of this report. The general recreational fishery has been sampled since 1981 by the MRFSS, but for previous years, landings values were obtained by linearly interpolating data reported in three saltwater angling surveys conducted in 1960, 1965, and 1970. (Clark 1962; Deuel and Clark 1968; Deuel 1973). Following discussion at the AW about possible recall bias with this survey (e.g., Roach et al. 1999; Tarrant et al. 1993; Teceiro 2002), these data were multiplied by 0.75 prior to analysis. Recreational landings in year 1 of the assessment model (1950) were set equal to the average of these three data points with linear interpolation up to 1960. Data on annual discard mortalities, as fit by the model, were computed by multiplying total discards (tabulated in §2) by the fishery-specific release mortality rates (1.0 deaths per released fish in the commercial gillnet fishery and 0.88 for commercial handlines and recreational fisheries). Extrapolation of shrimp bycatch was based on a hockey stick model relating bycatch to shrimp landings, as described in SEDAR 2008e.

3.1.1.3 **Model Configuration and Equations** Model equations are detailed in Table 3.1 and AD Model Builder code for implementation in SEDAR 2008g. A general description of the assessment model follows:

Natural mortality rate The natural mortality rate (M) was assumed constant over time, but decreasing with age. The form of M as a function of age was based on Lorenzen (1996). The Lorenzen (1996) approach inversely relates the natural mortality at age to mean weight at age W_a by the power function $M_a = \alpha W_a^{\beta}$, where α is a scale parameter and β is a shape parameter. Lorenzen (1996) provided point estimates of α and β for oceanic fishes, which were used for this assessment. As in previous SEDAR assessments, the Lorenzen estimates of M_a were rescaled by a scalar multiple to provide a fraction (1.5%) of survivors at the oldest age consistent with the findings of Hoenig (1983) and discussed in Hewitt and Hoenig (2005).

Stock dynamics In the assessment model, new biomass was acquired through growth and recruitment, while abundance of existing cohorts experienced exponential decay from fishing and natural mortality, where the force of fishing mortality was assumed constant throughout annual intervals. The population was assumed closed to immigration and emigration. The oldest age class 10+ allowed for the accumulation of fish (i.e., plus group). The initial stock biomass was assumed to be less than the unfished (virgin) level, because moderate commercial landings had been documented and because of anecdotal reports of substantial recreational landings back into the 1800s. Indeed, historical records indicated exploitation had been occurring for centuries prior to year 1 of the assessment model. Initial biomass and abundance were set assuming an equilibrium age structure (cf., Caswell 2001) at a constant level of assumed fishing mortality.

Growth and maturity Mean size at age (total length) was modeled with the von Bertalanffy equation, and weight at age (whole weight) as a function of length. As suggested by the DW, separate growth curves were estimated from males and females since females grow at a faster rate and grow to a larger size on average. Maturity at age of females was modeled with a logistic equation. Parameters of growth, length-weight conversion, and maturity were estimated by the DW and were treated as input to the assessment model. For fitting size composition data, the distribution of size at age was assumed normal with CV estimated by the assessment model.

Sex ratio A 50 : 50 sex ratio was assumed at the time of recruitment to the fishery (age 0). Differential selectivities then allowed sex ratio to change throughout time.

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 at the midpoint of the year.

Recruitment Recruitment was predicted from spawning biomass using a Beverton–Holt spawner-recruit model. In years when composition data could provide information on year-class strength (1982–2007), estimated recruitment was conditioned on the Beverton–Holt model with autocorrelated residuals. In years prior, recruitment followed the Beverton–Holt model precisely (similar to an age-structured production model).

Landings Time series of landing from five fisheries were modeled: commercial handlines, commercial gillnet, commercial poundnet, commercial castnet, and general recreational (MRFSS + 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 recreational fishery.

Discards Starting in 1986 with the implementation of size-limit regulations, time series of discard mortalities (in units of 1000 fish) were modeled for commercial handline and gillnet fisheries. Recreational angler survey data indicated non-ignorable discards prior to establishment of the size limit. Data from these years were used to calculate a ratio of discards to landings, which was used to extrapolate recreational discards back to year 1 of the assessment model. 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.

Bycatch A study of eight years of shrimp fishery observer data indicated highly variable but substantial catch of Spanish mackerel in the commercial shrimp fishery. A loose relationship between bycatch estimates and shrimp landings was used to extrapolate bycatch to all years of the assessment model where observer data was missing (SEDAR 2008e). Bycatch was modeled via the Baranov catch equation (Baranov 1918), assuming that only age 0 fish were selected.

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.

Selectivities Selectivities were predominantly estimated using a parametric approach. Initial exploration of selectivity assumed a logistic function for all landings. However, lack of fit was detected in recreational and gillnet fisheries. In particular, it appeared that recreational fisheries predominantly targeted age one fish, perhaps because of mismatches between the availability of fish by age and the spatial distribution of recreational effort. As such, selectivity for age one fish was set to one, with separate parameters estimated for age 0, age 2, and age 3+. For the gillnet fishery, there appeared to be a shift in selectivity following a gillnet ban in Florida in 1995. This was confirmed anecdotally by testimony of a Florida commercial fisherman (B. Hartig), who indicated that the majority of landings prior to 1995 came from run-around gillnets targeting dense schools of fish on wintering grounds. Following the net ban, gillnet landings were primarily obtained via set nets; there was also a spatial shift in the fishery where younger fish were more vulnerable. We thus assumed a logistic selectivity prior to 1995, with a double-logistic (dome-shaped) model for the period 1995-2007. We assumed a logistic selectivity function for all other landings sources. This parametric approach reduces the number of estimated parameters and imposes theoretical structure on the estimates. Critical to estimating selectivity parameters are age and size composition data.

In addition to standard selectivities, we attempted to account for differential selectivities between males and females. These were thought to result from differential growth rates. In order to do so, we calculated a delay constant, c, which minimized the squared difference in the von Bertalanffy growth equation between males and females:

$$\left[l_\infty^F(1-\exp(-K^F(a-a_0^F)))-l_\infty^M(1-\exp(-K^M(a+c-a_0^M)))\right]^2$$

Using this approach, c was estimated as 0.20, and was substituted into logistic selectivity equations. The result is that the selectivity of an age a male is equivalent to that of an age $a-0.2$ female. This approach did not work well for dome-shaped selectivities, so selectivities for the recreational fishery and the gillnet fishery after the gillnet ban were set constant across sex.

Selectivities of discards could not be estimated directly, because composition data (both age and length) of discards were lacking. Instead, selectivities of discards were computed using the following approach. First, all discards were assumed to occur because of size of the fish in relation to the 12 inch FL size limit. Records of fish with both age and length compositions available were examined, indicating that fish below this size were either zero- or one-year-olds. Second, we determined $l_g^{\min}$ the minimum length ever recorded for a given gear type, using this length as a proxy for the length at which fish become vulnerable to a given gear. Third, the proportion of fish of a given age and sex that were greater than this size but less than the size limit was then calculated as

$$p_{g,a,s}=\int_{l_g^{\min}}^{l^{\text{limit}}}\text{Normal}(l_{a,s};\sigma_{a,s}),$$

where g denotes gear, a denotes age, s denotes sex, and l^{limit} gives the minimum size limit. Finally, the $p_{g,a,s}$ were rescaled to have a maximum of 1.0 for each gear and sex (see Table 3.1).

Indices of abundance A total of nine indices of abundance (two fishery independent and seven fishery dependent) were recommended for use by the DW. However, initial model runs using all indices were somewhat unstable.

One possible contributing factor was that many of these indices were negatively correlated. In response, the AW recommended using two indices of abundance in the base run. The first was an index of age zero (young-of-year) recruitment derived from a fishery independent (SEAMAP) trawl survey. The second was a “combined" index resulting from a hierarchical analysis of all seven fishery dependent indices (SEDAR 2008d). This index assumed that all seven fishery dependent indices were attempting to measure the same quantity (relative abundance), but that each was subject to sampling and process errors. Predicted indices were computed from number at age at the midpoint of the year and associated selectivity vectors. Unlike previous assessments, the DW and AW agreed that catchability increases due to technology creep was unlikely to be an issue for Spanish mackerel. Thus, catchability was assumed constant over time for each index.

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, as described in §3.1.1.7. Computed benchmarks included MSY, fishing mortality rate at MSY (F_{MSY}), and total mature biomass at MSY ($\mathrm{SSB}_{\mathrm{MSY}}$). These benchmarks are conditional on the estimated selectivity functions. The selectivity pattern used here was the effort-weighted selectivities at age, with effort from each fishery (including discard and bycatch mortalities) estimated as the full F averaged over the last three years of the assessment.

Fitting criterion The fitting criterion was a tuned maximum likelihood approach in which the log likelihood for each data component (e.g. landings, age compositions, etc.) was given a different weight. Landings, discards, bycatch, and index data were fit using a lognormal likelihood. Composition data were fit using a multinomial likelihood. The total likelihood also included penalty terms to discourage (1) fully selected F greater than 3.0 in any year and (2) large deviation from zero in recruitment residuals during the last three assessment years. In addition, a least-squares penalty term was applied to log deviations of annual recruitment (allowing for autocorrelation), permitting estimation of the Beverton–Holt spawner-recruit parameters internal to the assessment model.

Likelihood component weights In general, our weighting strategy was to fit landings, discard, and bycatch streams as closely as possible. This strategy was suggested to us in the SEDAR 15 review workshop, and was implemented by setting likelihood weights at 1000 for each of these data components. Alternate removal time series could then be evaluated via sensitivity analysis. Determination of likelihood weights for indices, length compositions, and age compositions was then made using the following procedure:

1. initialize likelihood weights for age compositions, length compositions, and indices to 1.0
2. systematically change the weight on length compositions from 0.001 to 1.0 to explore tradeoffs between length and age compositions
3. select a value for w_{lc} that provides the maximum increase of fit to length compositions without compromising fit to age compositions (the latter were trusted more)
4. using the value of w_{lc} from (3) and keeping the weight on age compositions at 1.0, systematically alter the likelihood weight for indices from 1.0 to 500.0, with the goal of finding a weight where the fit to indices plateaus while still fitting age compositions reasonably well.

An objective determination of these weights is largely an unsolved problem in statistical catch-at-age modeling; however, this procedure helped reduce subjectivity in weightings. For purposes of this assessment, we visually examined a relative likelihood plot (Fig. 3.1), to set $w_{\mathrm{lc}} = 0.05$ in step 3. The same approach was used in step 4 to set $w_{\mathrm{index}} = 100$ (Figs. 3.2 & 3.3). For the latter case, trade offs between indices and age compositions are more pronounced than tradeoffs between indices and cumulative compositions (age + length).

Configuration of base run and sensitivity analyses A base model run was configured as described above and in Table 3.1. Sensitivity of results to the base configuration was examined through sensitivity and retrospective analyses. These runs vary from the base run as follows:

- S1: Use mean shrimp bycatch for all years data were missing
- S2: Use 0.5 multiplier on USFWS saltwater angling records, with reinterpolation
- S3: Use 1.0 multiplier on USFWS saltwater angling records, with reinterpolation
- S4: Use 1.25 multiplier on USFWS saltwater angling records, with reinterpolation
- S5: Pre-assessment fishing mortality set to 0.1
- S6: Pre-assessment fishing mortality set to 0.3
- S7: "Continuity" run with shrimp bycatch and historical recreational landings multiplied by 0.01
- S8: All nine indices were used
- S9: Autocorrelation in recruitment residuals set to zero
- S10: Shrimp bycatch and historical recreational landings both given a multiplier of 4.0
- S11: Shrimp bycatch given a multiplier of 0.25, historical recreational landings given a multiplier of 4.0
- S12: Shrimp bycatch given a multiplier of 4.0, historical recreational landings given a multiplier of 0.25
- S13: Shrimp bycatch and historical recreational landings both given a multiplier of 0.25
- S14: Shrimp bycatch and historical recreational landings both given a multiplier of 0.25, pre-assessment fishing mortality set at 0.1
- S15: Shrimp bycatch and historical recreational landings both given a multiplier of 4.0, pre-assessment fishing mortality set at 0.3
- S16: One standard error subtracted from all removals (SE obtained from DW)
- S17: One standard error added to all removals (SE obtained from DW)
- S18: Retrospective analysis with terminal year of 2006
- S19: Retrospective analysis with terminal year of 2005
- S20: Retrospective analysis with terminal year of 2004
- S21: Retrospective analysis with terminal year of 2003
- S22: Low M at age, computing by rescaling the Lorenzen estimates to provide cumulative survival to the upper bound (5%) of Hoenig (1983)
- S23: High M at age, computing by rescaling the Lorenzen estimates to provide cumulative survival to the lower bound (1%) of Hoenig (1983)

Model testing To ensure that the assessment model produced viable estimates (i.e., that all model parameters are identifiable), test data were generated with known parameter values and then analyzed with the assessment model. For simplicity, a stripped down version of the model (Table 3.1) was considered, but this version nevertheless retained all essential components. In particular, a two-sex simulation model was used to generate data from one fishery and included likelihood contributions of landings, CPUE, and age composition. Selectivity at age remained the same over time, and all likelihood weights were set equal to one. The simulation model was written in R (R Development Core Team 2007) and was programmed independently of the assessment model.

Parameter identification was determined using the "analytical-numeric" approach of Burnham et al. (1987). Expected value data were generated deterministically from input parameter values, without any process or sampling error. These data were then analyzed via the assessment model in attempt to obtain the exact parameters that generated the data.

In this test, all model parameters were estimated exactly. This result provides evidence that all parameters could be properly identified. It further suggests that the assessment model is implemented correctly and can provide an accurate assessment. As an additional measure of quality control, all code and input files were reviewed for accuracy by multiple analysts.

3.1.1.4 **Parameters Estimated** The model estimated annual fishing mortality rates of each fishery, selectivity parameters for each fishery, Beverton–Holt parameters including autocorrelation, annual recruitment deviations, catchability coefficients associated with abundance indices, and CV of size at age. Estimated parameters are identified in Table 3.1.

3.1.1.5 **Catch curve analysis** Catch curve analysis was conducted to provide estimates of total mortality ($Z = F + M$) from age composition data. These analyses are detailed in SEDAR (2008c). In short, catch curves were analyzed by linear regression of the log-transformed proportions at age. Proportions at age were represented by both true and synthetic cohorts. For both true and synthetic cohorts, catch curve analysis requires the assumptions that mortality and catchability remain constant with age. An additional assumption for synthetic cohorts is constant recruitment. These assumptions are rarely met, if ever, by fish populations. Thus, the application of catch curve analysis here is for diagnostic purposes, primarily to ensure that catch-age estimates of mortality were within a reasonable range.

3.1.1.6 **Per Recruit and Equilibrium Analyses** Static spawning potential ratio (static SPR) of each year was computed as the asymptotic spawners per recruit given that year's fishery-specific Fs and selectivities, divided by spawners per recruit that would be obtained in an unexploited stock. In this form, static SPR ranges between zero and one, and represents SPR that would be achieved under an equilibrium age structure at the current F (hence the term *static*).

Yield per recruit and spawning potential ratio were computed as functions of F, as were equilibrium landings and spawning biomass. Equilibrium landings and discards were also computed as functions of biomass B, which itself is a function of F. As in computation of MSY-related benchmarks (described in §3.1.1.7), per recruit and equilibrium analyses applied the most recent selectivity patterns averaged across fisheries, weighted by F from the last three years (2005–2007).

3.1.1.7 **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 identified from the spawner-recruit curve and parameters describing growth, natural mortality, maturity, and selectivity.

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 estimated variance (σ^2) of recruitment deviation: $\varsigma = \exp(\sigma^2/2)$. Then, equilibrium recruitment (R_{eq}) associated with any F is,

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

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

Estimates of MSY and related benchmarks are conditional on selectivity pattern. The selectivity pattern used here was the effort-weighted selectivities at age estimated over the last three years (2005–2007), a period of unchanged regulations.

The maximum fishing mortality threshold (MFMT) is defined by the SAFMC as F_{MSY}, and the minimum stock size threshold (MSST) as $(1 - M) \times \text{SSB}_{\text{MSY}}$ (Restrepo et al. 1998), with constant M defined here as 0.35. Overfishing is defined as $F >$ MFMT and overfished as SSB $<$ MSST. Current status of the stock and fishery are represented by the latest assessment year (2007).

In addition to the MSY-related benchmarks, proxies were computed based on per recruit analyses. These proxies include $F_{\max}$, $F_{30\%}$, and $F_{40\%}$, along with their associated yields. The value of $F_{\max}$ is defined as the F that maximizes yield per recruit; the values of $F_{30\%}$ and $F_{40\%}$ as those Fs corresponding to 30% and 40% spawning potential ratio (i.e., spawners per recruit relative to that at the unfished level). These quantities may serve as proxies for F_{MSY}, if the spawner-recruit relationship cannot be estimated reliably. Mace (1994) recommended $F_{40\%}$ as a proxy; however, later studies have found that $F_{40\%}$ is too high across many life-history strategies (Williams and Shertzer 2003) and can lead to undesirably low levels of biomass and recruitment (Clark 2002).

3.1.1.8 **Uncertainty and Measures of Precision** The effects of uncertainty in model structure was examined by applying three assessment models—the catch-at-age model, a stochastic stock reduction analysis, and a surplus-production model—with quite different mechanistic structure. For each model, uncertainty in data or assumptions was examined through sensitivity runs.

Precision of benchmarks was computed by parametric bootstrap. The bootstrap procedure generated lognormal recruitment deviations, with variance and autocorrelation as estimated by the assessment model. It then re-estimated the Beverton–Holt spawner-recruit curve and its associated MSY benchmarks. The procedure was iterated $n = 10000$ times, and the 10^{th} and 90^{th} percentiles of each benchmark were used to indicate uncertainty.

Uncertainty in the projections was computed through Monte Carlo simulations, with time series of future recruitments determined by random lognormal deviation (described in §3.1.1.9). The variance of this distribution was that estimated in the assessment, as was the autocorrelation of residuals. The 10^{th} and 90^{th} percentiles from $n = 2000$ projection replicates were used to quantify uncertainty in future time series.

3.1.1.9 **Projection methods** Projections were run to predict stock status in years after the assessment, 2008–2028. In contrast, a time frame of 10 years reflects the maximum allowable rebuilding time for a stock whocan rebuild in 10 years or less at $F = 0$. The structure of the projection model was the same as that of the assessment model, and parameter estimates were those from the assessment base run. Time-varying quantities, such as fishery selectivity curves, were fixed to the most recent values of the assessment period. Fully selected F was apportioned between landings, discard, and bycatch mortalities according to the selectivity curves averaged across fisheries, using geometric mean F from the last three years of the assessment period.

Initialization of projections In projections, any change in fishing effort was assumed to start in 2009, which is the earliest year management regulations could be implemented. Because the assessment period ended in 2007, the projections required a one year initialization period (2008). The initial abundance at age in the projection (start of 2008), other than at age 0, was taken to be the 2007 estimates from the assessment, discounted by 2007 natural and fishing mortalities. The initial abundance at age 0 was computed using the estimated spawner-recruit model and the 2007 estimate of SSB. The fully selected fishing mortality rate in the initialization period was taken to be the geometric mean of fully selected F during 2005–2007.

Annual predictions of SSB (mid-year), F, recruits, landings, and discards were represented by deterministic projections. These projections were built on the estimated spawner-recruit relationship with bias correction, and were thus consistent with estimated benchmarks in the sense that long-term fishing at F_{MSY} would yield MSY from a stock size at $\mathrm{SSB}_{\mathrm{MSY}}$. Uncertainty in future time series was quantified through Monte Carlo simulations.

Stochasticity of projections Projections used a Monte Carlo procedure to generate stochasticity in the spawner-recruit relationship. The Beverton–Holt model (without bias correction), fit by the assessment, was used to compute expected annual recruitment values ($\bar{R}_y$). Variability was added to the expected values by choosing multiplicative deviations at random from a lognormal distribution with first-order autocorrelation,

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

Here ϵ_y was drawn from a normal distribution with mean $\hat{\varrho}\epsilon_{y-1}$ and standard deviation $\hat{\sigma}$, where $\hat{\varrho}$ and $\hat{\sigma}$ are estimates of autocorrelation and standard deviation from the assessment model (Table 3.1).

The Monte Carlo procedure generated 2000 replicate projections, each with a different stream of stochastic recruitments, and each with a different annual estimate of SSB, F, recruitment, landings, and discards. Precision of projections was represented by the 10^{th} and 90^{th} percentiles of the 2000 stochastic projections.

Projection scenarios Several constant-F projection scenarios were considered:

- Scenario 1: $F = 0$
- Scenario 2: $F = F_{\mathrm{current}}$, defined as the geometric mean F of 2005–2007
- Scenario 3: $F = F_{\mathrm{MSY}}$
- Scenario 4: $F = 65\% F_{\mathrm{MSY}}$
- Scenario 5: $F = 75\% F_{\mathrm{MSY}}$
- Scenario 6: $F = 85\% F_{\mathrm{MSY}}$
- Scenario 7: $F = F_{\mathrm{rebuild}}$, defined as the maximum F that allows rebuilding by the recovery time horizon

3.1.1.10 **Probabilistic analysis** In order to examine the probability of rebuilding occurring within the requisite time frame, we examined additional projections. In particular, different values of F were considered that would yield 50%, 60%, 70%, 80% and 90% probabilities of successful rebuilding by 2019 (assuming a 10 year rebuilding period starting in 2009). For these analyses, the only source of uncertainty was variation in recruitment.

3.1.2 Model 1 Results

3.1.2.1 **Measures of Overall Model Fit** Overall, the catch-at-age model fit well to the available data. Annual fits to length compositions from each fishery were reasonable in most years, as were fits to age compositions (Figure 3.4). Residuals of these fits, by year and fishery, are summarized with bubble plots; differences between annual observed and predicted vectors are summarized with angular deviation (Figure 3.5–3.14). Angular deviation is defined as the arc cosine of the dot product of two vectors.

The model was configured to fit observed commercial and recreational landings closely (Figures 3.15–3.19). In addition, it fit well to observed discards (Figures 3.20–3.22) and to "observed" shrimp bycatch (3.23).

Fits to indices of abundance were reasonable (Figures 3.24 & 3.25). The combined index shows a generally increasing trend from the early 1980's to present, mirroring anecdotal reports by commercial fishermen. The SEAMAP index suggests highly variable recruitment from year to year; however, mismatches between trawl surveys and the timing of migration are an alternative explanation.

3.1.2.2 **Parameter Estimates** Estimates of all parameters from the catch-at-age model are shown in Appendix B. The estimated coefficient of variation of length at age was $\widehat{\mathrm{CV}} = 9.7\%$ (Figures 3.26, 3.27).

3.1.2.3 **Stock Abundance and Recruitment** Estimated abundance at age shows truncation of the oldest ages during the 1970s through the mid 1980s (Table 3.2); however, the stock appears to have rebounded to numbers last seen in the early-mid 1970s. Annual number of recruits is shown in Table 3.2 (age-0 column) and in Figure 3.28. Recruitment in recent years was estimated to be below average.

3.1.2.4 **Stock Biomass (total and spawning stock)** Estimated biomass at age follows a similar pattern of truncation as did abundance (Tables 3.3 & 3.4, Figures 3.29 & 3.30). Total biomass and spawning biomass show nearly identical trends—sharp decline immediately following model initialization, with another decline in the 1970s and early 1980's ostensibly due to a high volume of landings in the commercial gillnet fishery. The stock was estimated to be at it's lowest point in the early-mid 1980s, and since has added substantial biomass (Table **??**).

3.1.2.5 **Fishery Selectivity** Estimated selectivities of landings from recent years indicate that full selection occurs at an early age (age 3 for handlines, age 2 for gillnets and castnets, and age 1 for poundnets). For poundnets, castnets, and handlines, females reached full selectivity faster because of how we modeled selectivity as a function of growth. Average selectivities of landings, discard mortalities, and all fishing-related mortalities combined were computed from F-weighted selectivities in the most recent period of regulations. These average selectivities were used to compute benchmarks and in projections. All selectivities from the most recent period, including average selectivities, are presented in Tables 3.6 & 3.7.

3.1.2.6 **Fishing Mortality** The estimated time series of fishing mortality rate (F) shows a peak in the late 1970s and early 1980s when average fishing mortality rates were close to 1.0, with a secondary peak in the early 1990s (Figure 3.31). Following implementation of the gillnet ban in Florida state waters in 1995, mortality rates of commercial and recreational fisheries declined. Since 2000, our model suggests that fishing mortality rates have been between 0.3 and 0.5.

Historically, the majority of the full F was dominated by gillnet and recreational fisheries, with a shift in the most recent years to include a larger percentage of mortality attributable to the commercial castnet and handlines fisheries (Figure 3.31, Table 3.8).

Full F at age is shown in Tables 3.9 & 3.10 for males and females, respectively. In any given year, the maximum F at age may be less than that year's fully selected F. 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 (commercial gillnet after 1995, recreational) have dome-shaped selectivity.

Results from the catch curve analysis (SEDAR 2008c) suggest total mortality rates from 1985 to present ranged from Z = 0.15 up to Z = 1.0, and provide some evidence that total mortality rates have decreased over time. The bulk of the estimates seem to be between Z = 0.3 and Z = 0.8. If we use a constant natural mortality (M) estimate of 0.35, which corresponds to the Hoenig estimate, it suggests fully selected fishing mortality rates are on the order of F = 0 and F = 0.45. The number of estimates of Z which fall below the perceived natural mortality estimate of 0.35 provides some indication that that exploitation on this species may be overestimated in the assessment model or that there are some issues with nonrepresentative aging samples and/or natural mortality estimates.

Throughout most of the assessment period, estimated landings and discard mortalities in number of fish have been dominated by commercial gillnet and recreational sectors (Figures 3.32, 3.33). Table 3.11 shows total landings at age in numbers, Table 3.12 in metric tons, and Table 3.13 in 1000 lb. Total landings and discards by year and sector are presented in 1000 lb. for landings (Table 3.14) and in number for discards and shrimp bycatch (Table 3.15).

3.1.2.7 **Stock-Recruitment Parameters** The estimated Beverton–Holt spawner-recruit curve is shown in Figure 3.34. 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 3.35). Estimated parameters were as follows: steepness $\hat{h} = 0.62$, $\widehat{R_0} = 46.4$ million, first-order autocorrelation $\hat{\varrho} = 0.57$, and bias correction $\hat{\varsigma} = 1.1$. A profile likelihood plot (Fig. 3.36) revealed a well defined minimum for steepness, suggesting that it was an identifiable parameter. Uncertainty in these parameters was estimated through bootstrap analysis of the spawner-recruit curve (Figure 3.37).

3.1.2.8 **Per Recruit and Equilibrium Analyses** Static spawning potential ratio (static SPR) was variable but showed a decreasing trend from 1950 to a minimum in the 1980s. Since then, static SPR has steadily increased to a new high (Figure 3.38, Table **??**). This increase is likely attributable to a variety of factors, possibly including (a) decreases in bycatch mortality due to BRDs in the shrimp fishery, (b) changing selectivity in the gillnet fishery after the Florida gillnet ban in 1995, (c) increased prominence of the commercial handlines sector which typically select older fish, and (d) reduced fishing mortality.

Yield per recruit and spawning potential ratio were computed as functions of F (Figure 3.39), as were equilibrium landings and spawning biomass (Figures 3.40). Equilibrium landings and discards were also computed as functions of biomass B, which itself is a function of F (Figure 3.41). As in computation of MSY-related benchmarks, per recruit analyses applied the most recent selectivity patterns averaged across fisheries, weighted by F from the last three years (2005–2007). Per-recruit estimates were $F_{\max} = 0.84$, $F_{30\%} = 0.54$, and $F_{40\%} = 0.38$ (Figure 3.39, Table 3.16). For this stock of Spanish mackerel, F_{MSY} corresponded to an F that provided 42% SPR (i.e., $F_{42\%}$), but of course, a proxy is unnecessary if F_{MSY} is estimated directly.

3.1.2.9 **Benchmarks / Reference Points / ABC values** As described in §3.1.1.7, biological reference points (benchmarks) were derived analytically assuming equilibrium dynamics, corresponding to the estimated spawner-recruit curve with bias correction (Figure 3.34). This approach is consistent with methods used in rebuilding projections (i.e., fishing at F_{MSY} yields MSY from a stock size of SSB_{MSY}). Reference points estimated were F_{MSY}, MSY, B_{MSY} and SSB_{MSY}. Based on F_{MSY}, three possible values of F at optimum yield (OY) were considered—$F_{\text{OY}} = 65\% F_{\text{MSY}}$, $F_{\text{OY}} = 75\% F_{\text{MSY}}$, and $F_{\text{OY}} = 85\% F_{\text{MSY}}$—and for each, the corresponding yield was computed. Uncertainty of benchmarks was computed through bootstrap analysis of the spawner-recruit curve, as described in §3.1.1.8.

Estimates of benchmarks are summarized in Table 3.16. Point estimates of MSY-related quantities were $F_{\text{MSY}} = 0.352$/yr, MSY $= 13{,}098{,}920$ lb, $B_{\text{MSY}} = 40{,}288$ mt, and $\text{SSB}_{\text{MSY}} = 15{,}026{,}730$ mt. Distributions of these benchmarks are shown in Figure 3.42.

3.1.2.10 **Status of the Stock and Fishery** Estimated time series of B/B_{MSY} and $\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$ show similar patterns: stock status quickly declines below the MSY benchmark after model initialization in 1950, reaching it's nadir in the mid-1980s. Since then, stock biomass has climbed to higher values, but is still substantially below MSY levels (Figures 3.43 & 3.30, Table ??). Current stock status was estimated to be $\mathrm{SSB}_{2007}/\mathrm{SSB}_{\mathrm{MSY}} = 0.377$ and $\mathrm{SSB}_{2007}/\mathrm{MSST} = 0.581$, indicating that the stock is overfished (Table 3.16).

The estimated time series of F/F_{MSY} shows a generally increasing trend from the 1950s through the late 1970s/early 1980s, peaking at about five times F_{MSY}. This number has declined substantially in recent years, alternating between slight overfishing and no overfishing since 2000 (Figure 3.44, Table ??). The most recent estimate ($F_{2007}/F_{\mathrm{MSY}} = 0.919$) indicates that overfishing did not occur in 2007 (Table 3.16).

3.1.2.11 **Evaluation of Uncertainty** Uncertainty in results of the base assessment model was evaluated through sensitivity and retrospective analyses, as described in §3.1.1.3. Plotted are time series of F/F_{MSY} and $\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$ for sensitivity to the method of shrimp bycatch extrapolation (Figure 3.45), influence of early recreational angling records (Figure 3.46), pre-assessment fishing mortality (Figure 3.47), differences in data sources from previous assessments (Figure 3.48), choice of index (Figure 3.49), autocorrelation in recruitment deviations (Figure 3.50), factorial combinations of shrimp bycatch and early recreational landings (Figures 3.51 & 3.52), magnitude of total removals (Figures 3.53), ending year of the assessment model (Figure 3.54), and natural mortality (Figure 3.55). Retrospective analyses did not show any concerning trends, and in general, results of sensitivity analyses were similar to those in the base model run. (Table 3.17). In particular, most runs (19/23) indicated that the stock was overfished (two of the exceptions had steepness estimated at the upper bound). There was less agreement among sensitivity runs regarding overfishing status with 16/23 runs indicating that overfishing was not occurring in the terminal year.

3.1.2.12 **Projections** Projection scenario 1, in which $F = 0$, predicted the stock to recover to the level of $\mathrm{SSB}_{\mathrm{MSY}}$ with probability 0.5 in 2012 (Figure 3.56, Table 3.18). Since this value is less than ten years, the allotted rebuilding time specified under the MSRA is ten years. However, for visual clarity, projections were run for 20 years.

Projection scenario 2, in which $F = F_{\mathrm{current}}$, predicted the stock to increase over time (Figure 3.57, Table 3.19); however the proportion of projections for which rebuilding occurs in the requisite time frame was just 0.28. If F is reduced to F_{MSY}, as in scenario 3, the stock was predicted to begin recovery, but not to the level of $\mathrm{SSB}_{\mathrm{MSY}}$ within the rebuilding time frame (Figure 3.58, Table 3.20). If F is reduced to 65% or 75% of F_{MSY}, as in scenarios 4 & 5, the stock was predicted to recover in time (Figures 3.59 & 3.60, Tables 3.21 & 3.27). About 49% of projections recovered in time for the case where F was reduced to 85% of F_{MSY} (Figure 3.60, Table 3.23). The maximum F that allowed rebuilding within the time frame was $F_{\mathrm{rebuild}} = 0.285$, or about 81 % of F_{MSY} (Figure 3.62, Table 3.24).

3.1.2.13 **Probabilistic analysis** Levels of fishing mortality for which 50%, 60%, 70%, 75%, 80%, and 90% of stochastic stock trajectories had recovered by 2019 were given by $F = 0.285$, $F = 0.248$, $F = 0.215$, $F = 0.199$, $F = 0.182$, and $F = 0.136$ (Figure 3.63, Tables 3.25-3.29.

3.2 Model 2: Stock reduction analysis

3.2.1 Model 2 Methods

3.2.1.1 **Overview** Stochastic stock reduction analysis (SRA), as applied in this assessment, models an age-structured population by fitting to age-aggregated data. Its purpose here was to provide results using an assessment model of intermediate complexity between the fully age-structured catch-at-age model and fully age-aggregated surplus production model. The SRA approach works by initializing a stock at a range of values for biomass and productivity, and projecting the stock forward under stochastic recruitment (Walters et al. 2006). The method then examines the likelihood of each of the stock trajectories, given the history of exploitation and fits to observed data. In this manner, one can estimate plausible values of virgin recruitment (R_0) and steepness (h) of the spawner-recruit curve, along with management quantities.

3.2.1.2 Data Sources

The SRA model was fit using a single time series of removals (1950–2007) and a single index of abundance (1985–2007). Total removals, including landings and dead discards, were linearly interpolated back to zero in 1900 as an "initialization period."

Landings The SEDAR-17 DW provided estimates of commercial landings in pounds (whole weight) and recreational landings in numbers of fish. For use in SRA, all landings were combined into a single time series in units of pounds. Thus, headboat and recreational landings were converted to pounds, which was accomplished by multiplying landings in numbers by the average annual mean weight from the recreational fishery prior to implementation of a 12 inch FL minimum size limit in 1983 (see SEDAR 2008g).

Dead Discards & Bycatch Estimates of bycatch and total discards (alive and dead) were provided in numbers for commercial and recreational data sources. These estimates were converted to numbers of dead discards by applying the discard mortality rates suggested by the DW. These values were then converted to units of pounds, as described in SEDAR (2008g). The dead discards in weight were combined with the total landings for input to the SRA model (Table 2.7.5 of §III(2)).

Index of abundance Estimates of relative abundance were provided by the SEDAR-17 DW using data from Florida trip tickets, commercial logbooks, and MRFSS. These seven indices were combined into one index of catch per effort as described in §III(2), following the methods described in SEDAR (2008d). Indices derived from SEAMAP trawl surveys were excluded as they were highly variable and only represented one age class (and thus not representative of population trend).

Rather than fitting to values of the index (I_t), inference was based on gradient matching (Ellner et al. 2002), that is, based on fitting $\lambda_t = I_{t+1}/I_t$, the finite rate of population change. The quantity λ_t is dimensionless, which removes the need to estimate a catchability parameter q (SEDAR 2008f).

3.2.1.3 Model Configuration and Equations

Model equations and estimation procedures are described in (SEDAR 2008f). This section provides a synposis of the methods and describes specifics of this application to Spanish mackerel.

In stochastic SRA, uncertainty in population dynamics of each stock trajectory is described by the parameter vector $\boldsymbol{\theta}$,

$$\boldsymbol{\theta} = \{R_0, h, \sigma_R, \epsilon_1, \epsilon_2, \ldots, \epsilon_Y\} \tag{2}$$

where R_0 is average recruitment of an unexploited population, h is steepness, σ_R is the standard deviation of recruitment deviations around the spawner-recruit function, and ϵ_t is the annual recruitment deviation in year t, generated here for 1982–2007. The inclusion of uncertainty in the ϵ_t parameters is the fundamental difference between deterministic and stochastic SRA, and it is considered essential for adequately assessing population viability of a stock over the history of exploitation (McAllister et al. 1994).

In addition to the estimated parameters of the stochastic SRA, the model requires additional information to define the stock. This model input is assumed to be without error. For Spanish mackerel, it is summarized by $\boldsymbol{\phi}$,

$$\boldsymbol{\phi} = \{\boldsymbol{M}, \boldsymbol{m}, \boldsymbol{w}, \boldsymbol{s}\} \tag{3}$$

which represents age-specific vectors of natural mortality, maturity of females, weight, and combined selectivity of the fishing gears, respectively. Here, life-history vectors were the same as those provided by the DW and used in the catch-at-age model (note, a 50/50 sex ratio was also assumed at the time of recruitment). Selectivity was assumed to be given by the age- and sex-specific vectors

$$\mathbf{s_M} = [0.1, 0.4, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0], \text{and}$$

$$\mathbf{s_F} = [0.1, 0.7, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0].$$

These selectivity vectors were reasonable approximations of the selectivity vectors obtained by the catch-age model.

Because of the large number of latent recruitment deviations in stochastic SRAs, classical maximum likelihood inference is problematic. An alternative, used here, is Bayesian inference. In this application, prior distributions on parameters R_0, h, and σ_R were specified as uniform:

$$[R_0] : \text{Uniform}(20000000, 70000000)$$

$$[h] : \text{Uniform}(0.25, 0.95)$$

$$[\sigma_R] : \text{Uniform}(0.35, 0.80).$$

In addition, lower and upper bounds on F were implemented to avoid stock abundance from becoming unrealistically low or high. The bounds were based loosely on estimates from catch curve analysis (SEDAR 2008c). In particular, we specified a Uniform(0.15, 1.05) range restriction on F_t for the period 1982 to 2007. For the period 1950-1980, we knew less about F_t because no age samples were available; for this period we admitted more uncertainty by assuming that $F_t \sim \text{Uniform}(0.05, 2.0)$ was reasonable. For the initialization period (1901-1949), we imposed an even less informative prior of Uniform(0.00,2.0). However, we set recruitment deviations for the initialization period to zero to prevent lower values of R_0 from being removed prematurely from the population of particles.

Posterior inference was based on sequential importance sampling (SIS), which has history in Bayesian fishery applications (e.g. McAllister et al. 1994; McAllister and Ianelli 1997; Newman and Lindley 2006). SIS involves sampling the initial state vector $\boldsymbol{\theta}$ a large number of times (say n_p) from assumed prior distributions of parameters. Each sample, termed a “particle," is passed through the population model. The probability of retaining a particle then depends on the fit to data, and those particles surviving this process contribute to inference about the parameters.

Many algorithms exist for performing SIS, ranging in levels of complexity. The one used here, known as the bootstrap particle filter (Gordon et al. 1993), is of moderate complexity. This algorithm, adapted for stochastic SRA (SEDAR 2008f), proceeds as follows:

1. Randomly sample n_p values from prior distributions for R_0, h, and σ_R. The ith draw from each distribution is associated with particle i.

2. Initialize population vector (number at age) of each particle in year $t = 1$.

3. For each particle, generate a recruitment deviation $\epsilon_t \sim \text{lognormal}(0, \sigma_R)$. Propagate the population forward one time step.

4. Assign a weight w_p to each particle. Weight $w_p = 0$ if landings exceed abundance or if any $F_t \notin [F_L, F_U]$, and $w_p = \text{L}(\lambda_t|\boldsymbol{\theta})$ otherwise. $\text{L}(\lambda_t|\boldsymbol{\theta})$ gives the likelihood for the observed values of population change.

5. Resample the particles with replacement, where the probability of selecting particle p is given by $w_p / \sum_p w_p$. Increment year, $t = t + 1$

6. Repeat steps 3 to 5 until the end of the study.

The collection of particles in the final sample then provides an approximation to the posterior distributions of model parameters and management quantities.

For the above procedure, one must specify a likelihood function for the observed values of population change (λ_t). Here, a normal likelihood was applied. To define that likelihood, the standard deviation of population growth was assumed to be constant through time at $\sigma_\lambda = 0.05$; initial fits with empirically estimated values led to substantial particle depletion.

3.2.2 Model 2 Results

3.2.2.1 Model Fit In stochastic SRA, thousands of particles were fit to the population growth rate (λ_t). Several representative fits from the base run are shown in Figure 3.64, along with corresponding trajectories of spawning biomass. The algorithm resulted in a fair amount of particle depletion, whereby only a few initial particles were represented in the final solution.

3.2.2.2 Parameter Estimates and Uncertainty Posterior distributions of parameter estimates are shown in Figure 3.65. When interpreting these estimates, one should bear in mind that stochastic SRA is likely to impart some bias on estimated parameters (SEDAR 2008f). Bias occurs because one possible outcome of a stochastic stock trajectory is extinction, which is more probable for low values of $R0$ and h, and high values of σ_R. Thus, surviving particles available to be sampled for the posterior distributions would tend to have parameter values that minimized the random chance of extinction, potentially imparting bias on estimates (high for $R0$ and h, low for σ_R).

3.2.2.3 Status of the Stock and Fishery The posterior distribution of current F/F_{MSY} from the base run of SRA indicated a high probability that overfishing is occurring (Figure 3.66). The posterior distribution of current SSB/MSST indicated that the stock was overfished (Figure 3.66).

3.3 Model 3: Surplus production model

3.3.1 Model 3 Methods

3.3.1.1 Overview Assessments based on age or length structure are often favored because they incorporate more data on the structure of the population. However, these approaches typically involve fitting a large number of parameters to the data, decomposing population change into a number of processes including growth, mortality, and recruitment. A simplified approach, which may sacrifice some bias in favor of precision, is to aggregate data across age or length classes, and to summarize the relationship between complex population processes by using a simple mathematical model such as a logistic population model.

A logistic surplus production model, implemented in ASPIC (Prager 2005), was used to estimate stock status of Spanish mackerel off the southeastern U.S. While primary assessment of the stock was performed via the age-structured model, the surplus production approach was intended as a complement, and for additional verification that the age-structured approach was providing reasonable results.

3.3.1.2 **Data Sources**

The surplus-production model was fit using a single time series of removals, which included landings and dead discards, and the single "combined" index of abundance which was available from 1985–2007.

Landings The SEDAR-17 DW provided estimates of commercial landings in pounds (whole weight) and recreational landings in numbers of fish. For use in the production model, all landings were combined into a single time series in units of pounds. Thus, headboat and recreational landings were converted to pounds, which was accomplished by multiplying landings in numbers by the average annual mean weight from the MRFSS prior to implementation of the 12 inch FL size limit in 1983 (SEDAR 2008g).

Dead Discards Estimates of total discards (alive and dead) were provided in numbers for commercial and recreational data sources. These estimates were converted to numbers of dead discards by applying the discard mortality rates suggested by the DW. These values were then converted to units of pounds, as described in SEDAR (2008g). The dead discards in weight were combined with the total landings for input to the ASPIC model (Table 2.7.5 of §III(2)).

Index of abundance Estimates of relative abundance were provided by the SEDAR-17 DW using data from Florida trip tickets, commercial logbooks, and MRFSS. These seven indices were combined into one index of catch per effort as described in §III(2), following the methods described in SEDAR (2008d).

The data input file of the base production model run is provided in Appendix C.

3.3.1.3 **Model Configuration and Equations**

Production modeling used the model formulation and ASPIC software of Prager (1994; 2005). This is an observation-error estimator of the continuous-time form of the Schaefer (logistic) production model (Schaefer 1954; 1957). Modeling was conditioned on catch.

The logistic model for population growth is the simplest form of a differential equation which satisfies a number of ecologically realistic constraints, such as a carrying capacity (a consequence of limited resources). When written in terms of stock biomass, this model specifies that

$$\frac{dB_t}{dt} = rB_t - \frac{r}{K}B_t^2, \tag{4}$$

where B_t is biomass in year t, r is the intrinsic rate of increase in absence of density dependence, and K is carrying capacity (Schaefer 1954; 1957). This equation may be rewritten to account for the effects of fishing by introducing an instantaneous fishing mortality term, F_t:

$$\frac{dB_t}{dt} = (r - F_t)B_t - \frac{r}{K}B_t^2. \tag{5}$$

By writing the term F_t as a function of catchability coefficients and effort expended by fishermen in different fisheries, Prager (1994) showed how to estimate model parameters from time series of yield and effort. Nonparametric confidence intervals on parameters were estimated through bootstrap.

The base run was structured to allow B_1/K to be estimated with the objective function set to least absolute value (LAV) to minimize the influence of outliers in the combined index. Additional runs were made to examine model sensitivity to B_1/K values and selection of the objective function.

3.3.2 **Model 3 Results**

3.3.2.1 **Model Fit**

Fits to indices from the base and sensitivity runs of the surplus production model are shown in Figure 3.67. In general, fits to overall index trend was adequate, but missed a lot of year to year variation.

The base run estimated B_1/K at 0.76 in 1950, which falls within the range of values expected. Combining the indices allowed the model to fit the data without the added difficulty of resolving conflicts among the indices.

3.3.2.2 **Parameter Estimates and Uncertainty** Parameter estimates and MSY benchmarks from the base surplus production model run are tabulated in Appendix D, along with estimates of bias and precision.

3.3.2.3 **Status of the Stock and Fishery** Estimates of annual biomass from the base production model have been above MSST throughout the time series, while estimates of F indicate overfishing between 1950 and 1980. Since then, the base model suggests no overfishing from 1983-2007 (Figure 3.68). The estimate of $F_{2007}/F_{\mathrm{MSY}}$ indicates no overfishing in the terminal year. In general, the surplus production model produced a similar history of exploitation when compared to the age-structured model; however conclusions regarding stock status are quite different. Unlike the age-structured model, ASPIC indicates the stock was not overfished in 2007, nor was overfishing occurring (Figure 3.69).

Sensitivity analyses of the production model provided qualitatively similar results as the base run (Table 3.30).

3.4 Discussion

3.4.1 Comments on Assessment Results

Estimated benchmarks play a central role in this assessment. Values of $\mathrm{SSB}_{\mathrm{MSY}}$ and F_{MSY} are used to gauge status of the stock and fishery. In rebuilding projections, SSB reaching $\mathrm{SSB}_{\mathrm{MSY}}$ is the criterion that defines a successfully rebuilt stock. Computation of benchmarks is conditional on selectivity. If selectivity patterns change in the future, for example as a result of new management regulations or quota reallocations among fishery sectors, estimates of benchmarks would likely change as well.

The base run of the age-structured assessment model indicated that the stock is overfished ($\mathrm{SSB}_{2007}/\mathrm{SSB}_{\mathrm{MSY}} = 0.377$) but that overfishing is not occurring ($F_{2007}/F_{\mathrm{MSY}} = 0.919$). Certain sensitivity analyses yielded different results, but 19 out of 23 sensitivity runs agreed with the base run that the stock was overfished and 16 out of 23 sensitivity runs agreed with the base run that overfishing was not occurring in the terminal year. Conclusions about stock status were the most sensitive to different combinations of shrimp bycatch and recreational landings prior to implementation of standardized surveys, which also happened to be two of the largest sources of uncertainty.

In addition to sensitivity runs, there are some disagreements in qualitative findings between the catch-age model and the other two structural models fit to the available data. In particular, the SRA largely agreed with estimates of stock status from the catch-age model, while the age-aggregated surplus production model and its various sensitivity runs came to a different conclusion about stock status. However, the former two models account for age structure and thus must be considered more realistic.

3.4.2 Comments on Projections

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

- Initial abundance at age of the projections were based on estimates from the assessment. If those estimates are inaccurate, rebuilding will likely be affected.
- 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 rebuilding.

- The projections assumed levels of shrimp bycatch similar to those in the last three years (which were projected to be low). Years of high bycatch in the shrimp fishery would likely affect rebuilding.
- The projections assumed that the estimated spawner-recruit relationship applies in the future and that past residuals represent future uncertainty in recruitment. The assessment results suggest that recruitment may be characterized by runs of high or low values, possibly due in part to environmental conditions. If so, rebuilding may be affected.
- The projections assumed that the only source of uncertainty was from annual variation in recruitment. Thus, confidence intervals and rebuilding trajectories should be treated with caution as there are many other sources of uncertainty that were difficult to quantify.

3.5 References

References

Baranov, F. I. 1918. On the question of the biological basis of fisheries. Nauchnye Issledovaniya Ikhtiologicheskii Instituta Izvestiya **1**:81–128.

Burnham, K. P., D. R. Anderson, G. C. White, C. Brownie, and K. H. Pollock. 1987. Design and analysis methods for fish survival experiments based on release-recapture. American Fisheries Society Monograph **5**:1–437.

Caswell, H. 2001. Matrix Population Models, 2nd Edition. Sinauer, Sunderland, MA.

Clark, J. R., 1962. The 1960 Salt-Water Angling Survey. U.S. Department of the Interior, Bureau of Sport Fisheries & Wildlife, Circular 153, Washington, D. C.

Clark, W. G. 2002. $F_{35\%}$ revisited ten years later. North American Journal of Fisheries Management **22**:251–257.

Deriso, R. B., T. J. I. Quinn, and P. R. Neal. 1985. Catch-age analysis with auxiliary information. Canadian Journal of Fisheries and Aquatic Sciences **42**:815–824.

Deuel, D. G., 1973. The 1970 Salt-Water Angling Survey. U. S. Department of Commerce Current Fishery Statistics Number 6200, Washington, D. C.

Deuel, D. G., and J. R. Clark, 1968. The 1965 Salt-Water Angling Survey. Bureau of Sport Fisheries & Wildlife Resource Publication 67, Washington, D. C.

Ellner, S. P., Y. Seifu, and R. H. Smith. 2002. Fitting population dynamic models to time-series data by gradient matching. Ecology **83**:2256–2270.

Fournier, D., and C. P. Archibald. 1982. A general theory for analyzing catch at age data. Canadian Journal of Fisheries and Aquatic Sciences **39**:1195–1207.

Gordon, N., J. Salmond, and A. Smith. 1993. A novel approach to non-linear/non-Gaussian Bayesian state estimation. IEEE Proceedings on Radar and Signal Processing **140**:107–113.

Hewitt, D. A., and J. M. Hoenig. 2005. Comparison of two approaches for estimating natural mortality based on longevity. Fishery Bulletin **103**:433–437.

Hoenig, J. M. 1983. Empirical use of longevity data to estimate mortality rates. Fishery Bulletin **81**:898–903.

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystems and aquaculture. Journal of Fish Biology **49**:627–642.

Ltd, O. R., 2004. An Introduction to AD Model Builder version 7.1.1. Box 2040, Sidney, British Columbia.

Mace, P. M. 1994. Relationships between common biological reference points used as thresholds and targets of fisheries management strategies. Canadian Journal of Fisheries and Aquatic Sciences **51**:110–122.

McAllister, M. K., and J. N. Ianelli. 1997. Bayesian stock assessment using catch-age data and the sampling-resampling importance algorithm. Canadian Journal of Fisheries and Aquatic Sciences **54**:284–300.

McAllister, M. K., E. K. Pikitch, A. I. Punt, and R. Hilborn. 1994. A Bayesian approach to stock assessment and harvest decisions using the sampling/importance resampling algorithm. Canadian Journal of Aquatic Sciences **51**:2673–2687.

Methot, R. D. 1989. Synthetic estimates of historical abundance and mortality for northern anchovy. American Fisheries Society Symposium **6**:66–82.

Newman, K. B., and S. T. Lindley. 2006. Accounting for demographic and environmental stochasticity, observation error, and parameter uncertainty in fish population dynamics models. North American Journal of Fisheries Management **26**:685–701.

Pella, J. J., and P. K. Tomlinson. 1969. A generalized stock production model. Bulletin of the Inter-American Tropical Tuna Commission **13**:419–496.

Prager, M. H. 1994. A suite of extensions to a nonequilibrium surplus-production model. Fisheries Bulletin **92**:374–389.

Prager, M. H., 2005. User's Manual for ASPIC: A Stock-Production Model Incorporating Covariates (ver. 5) And Auxiliary Programs. National Marine Fishery Service, Beaufort Laboratory Document BL-2004-01, Beaufort, NC.

Quinn, T. J. I., and R. B. Deriso. 1999. Quantitative Fish Dynamics. Oxford University Press, New York.

R Development Core Team, 2007. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org.

Restrepo, V. R., G. G. Thompson, P. M. Mace, L. L. Gabriel, L. L. Wow, A. D. MacCall, R. D. Methot, J. E. Powers, B. L. Taylor, P. R. Wade, and J. F. Witzig, 1998. Technical guidance on the use of precautionary approahces to implementing Natinoal Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act. NOAA Technical Memorandum-F/SPO-31.

Roach, B., J. Trial, and K. Boyle. 1999. Comparing 1994 angler catch and harvest rates from on-site and mail surveys on selected laskes. North American Journal of Fisheries Management **19**:203–208.

Schaefer, M. B. 1954. Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. Bulletin of the Inter-American Tropical Tuna Commission **1**:27–56.

Schaefer, M. B. 1957. A study of the dynamics of the fishery for yellowfin tuna in the eastern tropical Pacific Ocean. Bulletin of the Inter-American Tropical Tuna Commission **2**:247–268.

SEDAR, 2008c. SEDAR-17-AW-04: Catch curve analysis of age composition data for Spanish mackerel.

SEDAR, 2008d. SEDAR-17-AW-06: Methods for combining multiple indices into one, with application to south Atlantic (U.S.) Spanish mackerel.

SEDAR, 2008e. SEDAR-17-AW-07: Extrapolation of Spanish mackerel bycatch by commercial shrimp trawl fisheries.

SEDAR, 2008f. SEDAR-17-AW-08: A Bayesian approach to stochstic stock redution analysis, with application to South Atlantic Spanish mackerel.

SEDAR, 2008g. SEDAR-17-AW-10: Preliminary surplus production model results of Spanish mackerel off the southeastern United States.

Shepherd, J. G. 1982. A versatile new stock-recruitment relationship for fisheries, and the construction of sustainable yield curves. Journal du Conseil pour l'Exploration de la Mer **40**:67–75.

Tarrant, M. A., M. J. Manfredo, P. B. Bayley, and R. Hess. 1993. Effects of recall bias and nonresponse bias on self-report estimates of angling participation. North American Journal of Fisheries Management **13**:217–222.

Teceiro, M. 2002. The summer flounder chronicles: Science, politics, and litigation. Reviews in Fish Biology and Fisheries **11**:125–168.

Walters, C. J., S. J. D. Martell, and J. Korman. 2006. A stochastic approach to stock reduction analysis. Canadian Journal of Fisheries and Aquatic Sciences **63**:212–223.

Williams, E. H., and K. W. Shertzer. 2003. Implications of life-history invariants for biological reference points used in fishery management. Canadian Journal of Fisheries and Aquatic Science **60**:710–720.

3.5.1 Tables

Table 3.1. General definitions, input data, population model, and negative log-likelihood components of the statistical catch-at-age model. Hat notation ($\hat{*}$) indicates parameters estimated by the assessment model, and breve notation ($\breve{*}$) indicates estimated quantities whose fit to data forms the objective function.

Quantity	Symbol	Description or definition
General Definitions		
Index of years	y	$y \in \{1950 \ldots 2007\}$
Index of ages	a	$a \in \{0 \ldots A\}$, where $A = 10^+$
Index of length bins	l	$l \in \{1 \ldots 61\}$
Length bins	l'	$l' \in \{10, 11, \ldots, 70\}$, with values as midpoints and bin size of 1 cm
Index of fisheries	f	$f \in \{1 \ldots 5\}$ where 1=commercial gillnet, 2=commercial poundnet, 3=commercial handlines, 4=commercial castnet, and 5=general recreational (MRFSS)
Index of CPUE	u	$u \in \{1 \ldots 10\}$ where 1 = combined index, 2 = SEAMAP YOY, 3 = SEAMAP 1YR, 4 = Florida gillnet prior to net ban, 5 = Florida gillnet after net ban, 6 = Florida handlines index, 7 = Florida castnet index, 8 = Georgia-New York hand lines index, 9 = Georgia-New York gillnet index, and 10 = MRFSS
Input Data		
Proportion female at age	$\rho_{a,y}$	0.5 for $a = 0$; $N^F_{a,y}/N_{a,y}$ otherwise
Proportion females mature at age	m_a	Estimated by logistic regression
Observed length compositions	$p^{\lambda}_{f,l,y}$	Proportional contribution of length bin l in year y to fishery f
Observed age compositions	$p^{\alpha}_{f,a,y}$	Proportional contribution of age class a in year y to fishery f
Length comp. sample sizes	$n^{\lambda}_{f,y}$	Number of length samples collected in year y from fishery f
Age comp. sample sizes	$n^{\alpha}_{f,y}$	Number of age samples collected in year y from fishery f
Observed fishery landings	$L_{f,y}$	Reported landings in year y from fishery f (in numbers for recreational, whole weight for all others)
SDs of landings	$c^L_{f,y}$	Set to 0.05 for all landings since the goal was to fit landings exactly. Annual values estimated for MRFSS were used in sensitivity runs, as were SDs for other fisheries. In the latter case they were set based on understanding of historical accuracy of data

Table 3.1. (continued)

Quantity	Symbol	Description or definition
Observed abundance indices	$U_{u,y}$	$u = 1$, combined index, $y \in \{1985 \dots 2007\}$ $u = 2$, SEAMAP YOY, $y \in \{1989 \dots 2007\}$ $u = 3$, SEAMAP 1YR, $y \in \{1990 \dots 2007\}$ $u = 4$, FL Gillnet 1, $y \in \{1985 \dots 1994\}$ $u = 5$, FL Gillnet 2, $y \in \{1996 \dots 2007\}$ $u = 6$, FL handlines, $y \in \{1985 \dots 2007\}$ $u = 7$, FL castnet, $y \in \{1999 \dots 2007\}$ $u = 8$, GA-NY Handlines, $y \in \{1998 \dots 2007\}$ $u = 9$, GA-NY Gillnet, $y \in \{1998 \dots 2007\}$ $u = 10$, MRFSS, $y \in \{1987 \dots 2007\}$
SDs of abundance indices	$c^U_{u,y}$	$u = \{1 \dots 10\}$ as above. Annual values estimated from delta-lognormal GLM for commercial, from PSEs for MRFSS, and from sample design for SEAMAP. Each time series rescaled to a maximum of 0.3. For the combined index, all SDs were set at 0.15
Natural mortality rate	M_a	Function of combined-sex weight at age (w_a): $M_a = \alpha w_a^\beta$, with estimates of α and β from Lorenzen (1996). Lorenzen M_a then rescaled based on Hoenig estimate.
Observed total discards	$D'_{f,y}$	Discards (Numbers of fish) in year y from fishery $f = 1, 3, 5$.
Discard mortality rate	δ_f	Proportion discards by fishery f that die. Values from the DW were 1.0 for commercial gillnet, and 0.88 for recreational and commercial handline fisheries.
Observed discard mortalities	$D_{f,y}$	$D_{f,y} = \delta_f D'_{f,y}$ for $f = 1, 3, 5$
SDs of dead discards	$c^D_{f,y}$	Set at 0.05 for model fitting, with estimated/assumed values used to generate alternative landings streams in sensitivity runs
Discard selectivity	$s'_{f,a,s}$	Selectivity at age vectors for different fisheries (subscript f) and sexes (1 = females, 2 = males) $f = 1$, $s = 1$: [1.00, 0.33, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0] $f = 1$, $s = 2$: [1.00, 0.40, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0] $f = 3$, $s = 1$: [1.00, 0.48, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0] $f = 3$, $s = 2$: [1.00, 0.64, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0] $f = 5$, $s = 1$: [1.00, 0.34, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0] $f = 5$, $s = 2$: [1.00, 0.41, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0]
Bycatch	K_y	Spanish mackerel bycatch in the shrimp fishery in year y (Numbers of fish); all bycatch assumed to be age 0.
SDs of bycatch	c^B_y	Set at 0.05 for model fitting with estimated/assumed values used to generate alternative landings streams in sensitivity runs
pre-assessment fishing mortality	F_{hist}	Fishing mortality used to initialize population model in first year of the model. Set at 0.2 for the base run, varied in sensitivity runs
pre-assessmental selectivity	s_{hist}	Selectivity applied to females to set initial equilibrium population size and structure. Set at [0.05, 0.5, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0]
Male selectivity lag	a_s	Year increment by which males lag behind females in terms of growth. The estimate of 0.2 was applied in all cases.

Table 3.1. (continued)

Quantity	Symbol	Description or definition
Aging error matrix	$\mathcal{E}$	Elements $\mathcal{E}_{ij}$ give the probability of aging an age i fish as age j; no aging error data were available so $\mathcal{E}$ was set to the identity matrix
Population Model		
Mean length at age	$l_{a,s}$	Total length at age by sex; $l_{a,s} = L^s_\infty(1 - \exp[-K^s(a - t^s_0)])$ where K^s, L^s_∞, and t^s_0 are parameters estimated by the DW (note: s superscript denotes sex, not exponentiation).
CV of $l_{a,s}$	$\widehat{c}^\lambda_a$	Estimated variation of growth, assumed constant across ages and sexes.
Age–length conversion	$\psi_{a,l,s}$	$\psi_{a,l,s} = \frac{1}{\sqrt{2\pi}(\widehat{c}^\lambda_a l_{a,s})} \frac{\exp\left[-\left(l'_{a,s} - l_{a,s}\right)^2\right]}{\left(2(\widehat{c}^\lambda_a l_{a,s})^2\right)}$, the Gaussian density function. Matrices of the $\psi_{a,l,s}$ are rescaled to sum to one across ages.
Individual weight at age	$w_{a,s}$	Computed from length at age by $w_{a,s} = \theta_1 l^{\theta_2}_{a,s}$ where θ_1 and θ_2 are parameters estimated by the DW
Fishery selectivity	$s_{f,a,s,y}$	$= \begin{cases} \frac{1}{1+\exp[-\widehat{\eta}_{1,f,y}(b-\widehat{\alpha}_{1,f,y})]} & : \text{for } f = 2,3,4 \\ \frac{1}{1+\exp[-\widehat{\eta}_{1,f,y}(b-\widehat{\alpha}_{1,f,y})]} & : \text{for } f = 1, y < 1995 \\ \left(\frac{1}{\max s_{f,a,s,y}}\right)\left(\frac{1}{1+\exp[-\widehat{\eta}_{1,f,y}(b-\widehat{\alpha}_{1,f,y})]}\right) \left(1 - \frac{1}{1+\exp[-\widehat{\eta}_{2,f,y}(b-[\widehat{\alpha}_{1,f,y}+\widehat{\alpha}_{2,f,y}])]}\right) & : \text{for } f = 1, y \geq 1995 \end{cases}$ where $\widehat{\eta}_{1,f,y}$, $\widehat{\eta}_{2,f,y}$, $\widehat{\alpha}_{1,f,y}$, and $\widehat{\alpha}_{2,f,y}$ are fishery-specific parameters, and $b = a$ for females and $b = a - a_s$ for males. Note that all parameters were assumed constant over time with the exception of commercial gillnet; a different parameter was estimated prior to 1995 and after 1995 in this case. For the recreational fishery, $s_{f,1,s,y}$ was set to 1.0, while $s_{f,0,s,y}$, $s_{f,2,s,y}$, $s_{f,3+,s,y}$ were estimated as free parameters. Curves were rescaled, if necessary, to have a maximum of one.
Fishing mortality rate of landings	$F_{f,a,s,y}$	$F_{f,a,s,y} = s_{f,a,s,y}\widehat{F}_{f,y}$ where $\widehat{F}_{f,y}$ is an estimated fully selected fishing mortality rate by fishery
Fishing mortality rate of discards	$F^D_{f,a,s,y}$	$F^D_{f,a,s,y} = s'_{f,a,s}\widehat{F}^D_{f,y}$ where $\widehat{F}^D_{f,y}$ is an estimated fully selected fishing mortality rate of discards by fishery
Fishing mortality rate of bycatch	$\widehat{F}^B_y$	Fishing mortality rate of age 0 fish in year y associated with shrimp fishery
Total fishing mortality rate	F_y	$F_y = \sum_f \left(\widehat{F}_{f,y} + \widehat{F}^D_{f,y}\right) + \widehat{F}^B_y$

Table 3.1. (continued)

Quantity	Symbol	Description or definition
Total mortality rate	$Z_{a,y,s}$	$Z_{a,y,s} = \begin{cases} M_a + \sum_{f=1}^{5} F_{f,a,s,y} + \sum_{f=1,3,5} F^D_{f,a,s,y} + \widehat{F}^B_y & \text{: for } a=0 \\ M_a + \sum_{f=1}^{5} F_{f,a,s,y} + \sum_{f=1,3,5} F^D_{f,a,s,y} & \text{otherwise} \end{cases}$
Abundance at age, sex	$N_{a,y}$, $N_{a,y,s}$	Represent pooled sex and sex-specific abundance, respectively. $N_{0,1950} = \max\left(1, \frac{4\widehat{R}_0\widehat{h}\phi_{\text{hist}} - \phi_0(1-\widehat{h})}{(5\widehat{h}-1.0)\phi_{\text{hist}}}\varsigma\right)$ $N_{0,1950,s} = [(2-s)\rho_{a,y} - (1-s)(1-\rho_{a,y})]\, N_{0,1950}$ $N_{a+1,1950,s} = N_{a,1950,s}\exp(-M_a) \quad \forall a \in (0 \ldots A-1)$ $N_{A,1950,s} = N_{A-1,1950,s}\frac{\exp(-M_{A-1})}{1-\exp(-M_A)}$ $N_{0,y+1} = \begin{cases} \frac{0.8\widehat{R}_0\widehat{h}S_y}{0.2\phi_0\widehat{R}_0(1-\widehat{h})+(\widehat{h}-0.2)S_y}\varsigma & \text{for } y+1 < 1982 \\ \frac{0.8\widehat{R}_0\widehat{h}S_y}{0.2\phi_0\widehat{R}_0(1-\widehat{h})+(\widehat{h}-0.2)S_y}\exp(\widehat{R}_{y+1}) & \text{for } y+1 \geq 1982 \end{cases}$ $N_{0,y+1,s} = [(2-s)\rho_{a,y} - (1-s)(1-\rho_{a,y})]\, N_{0,y+1}$ $N_{a+1,y+1,s} = N_{a,y,s}\exp(-Z_{a,y,s}) \quad \forall a \in (0 \ldots A-1)$ $N_{A,y,s} = N_{A-1,y-1,s}\frac{\exp(-Z_{A-1,y-1,s})}{1-\exp(-Z_{A,y-1,s})}$ where 1950 is the initialization year and ϕ_{hist} gives spawning stock biomass per recruit at the assumed pre-assessment fishing level. Parameters $\widehat{R}_0$ (unfished recruitment) and $\widehat{h}$ (steepness) are estimated parameters of the spawner-recruit curve, and $\widehat{R}_y$ are estimated annual recruitment deviations in log space for $y \geq 1982$ and are zero otherwise. The bias correction is $\varsigma = \exp(\sigma^2/2)$, where σ^2 is the variance of recruitment deviations during 1982–2004. Quantities ϕ_0 and S_y are described below.
Abundance at age (mid-year)	$N'_{a,y}$	Used to match indices of abundance $N'_{a,y,s} = N_{a,y,s}\exp(-Z_{a,y,s}/2)$
Abundance at age at time of spawning	$N''_{a,y}$	Assumed mid-year $N''_{a,y,s} = N'_{a,y,s}$
Unfished abundance at age per recruit at time of spawning	NPR_a	$NPR_1 = \exp(-M_0/2)$ $NPR_{a+1} = NPR_a\exp[-(M_a+M_{a+1})/2] \quad \forall a \in (0 \ldots A-1)$ $NPR_A = \frac{NPR_{A-1}\exp[-(M_{A-1}+M_A)/2]}{1-\exp(-M_A)}$
Unfished mature biomass per recruit	ϕ_0	$\phi_0 = \sum_a NPR_a w_{a,1}\rho_{a,y}m_a$
Mature biomass	S_y	$S_y = \sum_a N''_{a,y}w_a\rho_{a,y}m_a$ Also referred to as spawning stock biomass (SSB)
Population biomass	B_y	$B_y = \sum_a\sum_s N_{a,y,s}w_{a,s}$
Landed catch at age, sex	$C_{f,a,y,s}$	$C_{f,a,y,s} = \frac{F_{f,a,y,s}}{Z_{a,y,s}}N_{a,y,s}[1-\exp(-Z_{a,y,s})]$
Discard mortalities at age, sex	$C^D_{f,a,y,s}$	$C^D_{f,a,y,s} = \frac{F^D_{f,a,y,s}}{Z_{a,y,s}}N_{a,y,s}[1-\exp(-Z_{a,y,s})]$
Bycatch at age, sex	$C^B_{y,s}$	$C^B_{y,s} = \frac{F^B_{y,s}}{Z_{0,y,s}}N_{0,y,s}[1-\exp(-Z_{0,y,s})]$

Table 3.1. (continued)

Quantity	Symbol	Description or definition
Predicted landings in wgt	$\breve{L}_{f,y}$	$\breve{L}_{f,y} = \sum_a \sum_s C_{f,a,y,s} w_{a,s}$ for $f = 1,2,3,4$
Predicted landings in #	$\breve{L}_{f,y}$	$\breve{L}_{f,y} = \sum_a \sum_s C_{f,a,y,s}$ for $f = 5$
Predicted discard mortalities	$\breve{D}_{f,y}$	$\breve{D}_{f,y} = \sum_a \sum_s C^D_{f,a,y_s}$
Predicted shrimp bycatch	$\breve{K}_y$	$\breve{K}_y = \sum_s C^B_{y,s}$
Predicted length compositions	$\breve{p}^\lambda_{f,l,y}$	$\breve{p}^\lambda_{f,l,y} = \frac{\sum_a \sum_s \psi_{a,l} C_{f,a,y,s}}{\sum_a \sum_s C_{f,a,y,s}}$
Predicted age compositions	$\breve{p}^\alpha_{f,a,y}$	$\breve{p}^\alpha_{f,a,y} = \frac{\sum_s \sum_i C_{f,i,y,s} \mathcal{E}_{i,a}}{\sum_a \sum_s C_{f,a,y,s}}$
Predicted CPUE	$\breve{U}_{u,y}$	$\breve{U}_{u,y} = \begin{cases} \widehat{q}_u \sum_a \sum_s N'_{a,y,s} s_{u,a,y,s} & \text{for } u = 2,3,10 \\ \widehat{q}_u \sum_a \sum_s N'_{a,y,s} s_{u,a,y,s} w_{a,s} & \text{for } u = 1,4,5,6,7,8,9 \end{cases}$ where $\widehat{q}_u$ is the estimated catchability coefficient of index u and $s_{u,a,y}$ is the selectivity of the relevant fishery. For SEAMAP trawl survey, the YOY index is assumed to have $s_{u,a,y} = 1$ for $a = 0$ and $s_{u,a,y} = 0$ otherwise; the 1YR index is assumed to have $s_{u,a,y} = 1$ for $a = 1$ and $s_{u,a,y} = 0$ otherwise.
Objective Function		
Multinomial length compositions	Λ_1	$\Lambda_1 = -\omega_1 \sum_f \sum_y \left[n^\lambda_{f,y} \sum_l (p^\lambda_{f,l,y} + x) \log \left(\frac{(\breve{p}^\lambda_{f,l,y}+x)}{(p^\lambda_{f,l,y}+x)} \right) \right]$ where $\omega_1 = 0.05$ is a preset weight and $x =$1e-5 is an arbitrary value to avoid log zero. The denominator of the log is a scaling term. Bins are 1 cm wide.
Multinomial age compositions	Λ_2	$\Lambda_2 = -\omega_2 \sum_f \sum_y \left[n^\alpha_{f,y} \sum_a (p^\alpha_{f,a,y} + x) \log \left(\frac{(\breve{p}^\alpha_{f,a,y}+x)}{(p^\alpha_{f,a,y}+x)} \right) \right]$ where $\omega_2 = 1$ is a preset weight and $x =$1e-5 is an arbitrary value to avoid log zero. The denominator of the log is a scaling term.
Lognormal landings	Λ_3	$\Lambda_3 = \omega_3 \sum_f \sum_y \frac{\left[\log\left((L_{f,y}+x)/(\breve{L}_{f,y}+x)\right)\right]^2}{2(c^L_{f,y})^2}$ where $\omega_3 = 1000$ is a preset weight and $x =$1e-5 is an arbitrary value to avoid log zero or division by zero
Lognormal discard mortalities	Λ_4	$\Lambda_4 = \omega_4 \sum_f \sum_y \frac{\left[\log\left((\delta_f D_{f,y}+x)/(\breve{D}_{f,y}+x)\right)\right]^2}{2(c^D_{f,y})^2}$ for $f = 1,3,5$ where $\omega_4 = 1000$ is a preset weight and $x =$1e-5 is an arbitrary value to avoid log zero or division by zero
Lognormal Bycatch	Λ_5	$\Lambda_4 = \omega_4 \sum_f \sum_y \frac{\left[\log\left((K_y+x)/(\breve{K}_y+x)\right)\right]^2}{2(c^B_y)^2}$ where $\omega_5 = 1000$ is a preset weight and $x =$1e-5 is an arbitrary value to avoid log zero or division by zero

Table 3.1. (continued)

Quantity	Symbol	Description or definition
Lognormal CPUE	Λ_6	$\Lambda_6 = \sum_{u=1}^{2} \omega_6 \sum_y \frac{\left[\log\left((U_{u,y}+x)/(\breve{U}_{u,y}+x)\right)\right]^2}{2(c^U_{u,y})^2}$ where $\omega_6 = 100$ is a preset weight and x =1e-5 is an arbitrary value to avoid log zero or division by zero. Only the first two indices (combined, SEAMAP YOY) were fit in the base run.
Constraint on recruitment deviations	Λ_7	$\Lambda_7 = \omega_7 \left[R_{1982}^2 + \sum_{y>1982} (R_y - \widehat{\varrho} R_{y-1})^2\right]$ where R_y are recruitment deviations in log space, $\omega_6 = 1.0$ is a preset weight and $\widehat{\varrho}$ is the estimated first-order autocorrelation
Additional constraint on recruitment deviations	Λ_8	$\Lambda_8 = \omega_8 \left(\sum_{y \geq 2005} R_y^2\right)$ where $\omega_8 = 1$ is a preset weight
Constraint on F_y	Λ_9	$\Lambda_9 = \omega_9 \sum_y I_y (F_y - \Psi)^2$ where $\omega_9 = 1$ is a preset weight, $\Psi = 3.0$ is the max unconstrained F_y, and $I_y = \begin{cases} 1 & \text{: if } F_y > \Psi \\ 0 & \text{: otherwise} \end{cases}$
Total objective function	Λ	$\Lambda = \sum_{i=1}^{9} \Lambda_i$ Objective function minimized by the assessment model

Table 3.2. Spanish mackerel: Estimated abundance at age (1000 fish) at start of year

Year	0	1	2	3	4	5	6	7	8	9	10+
1950	38010.9	22825.4	13706.5	7829.3	4608.4	2767.3	1678.5	1028.3	629.9	385.9	626.4
1951	40494.5	14447.2	12854.0	8260.0	4932.6	2960.6	1795.7	1100.1	673.9	412.9	670.2
1952	39701.0	17984.8	7827.5	7569.5	5120.4	3118.1	1890.3	1158.1	709.5	434.6	705.5
1953	39116.5	18986.6	9693.3	4525.4	4590.8	3166.2	1947.4	1192.5	730.5	447.5	726.5
1954	38123.0	15078.4	10248.6	5636.4	2763.3	2858.3	1991.1	1237.0	757.5	464.0	753.2
1955	36941.9	15860.9	7912.3	5851.1	3394.7	1697.0	1772.9	1247.4	775.0	474.5	770.3
1956	35409.0	15117.3	8180.0	4363.8	3390.8	2005.4	1012.5	1068.4	751.8	467.0	757.7
1957	33851.7	16281.5	7610.3	4336.2	2423.3	1918.9	1146.2	584.6	616.8	434.0	714.2
1958	31684.1	13280.5	8074.7	3845.1	2275.1	1295.1	1035.8	624.9	318.7	336.3	632.3
1959	31177.8	16630.7	6292.8	3940.6	1960.2	1181.4	679.2	548.7	331.0	168.8	518.2
1960	30562.3	13459.9	8157.6	3355.8	2225.0	1128.2	686.8	398.8	322.2	194.4	407.5
1961	28314.3	9916.8	6365.3	4207.8	1838.3	1242.4	636.3	391.2	227.2	183.5	346.3
1962	28081.3	16221.9	4261.4	3028.9	2148.1	956.4	652.8	337.7	207.6	120.6	284.0
1963	27073.0	11447.1	7533.7	2154.1	1626.9	1175.9	528.8	364.5	188.6	115.9	228.2
1964	27192.9	15494.9	4989.2	3675.2	1130.0	869.8	635.0	288.4	198.8	102.9	189.6
1965	27678.5	15595.4	7045.2	2456.8	1922.7	602.4	468.3	345.3	156.8	108.1	160.6
1966	26865.0	11277.7	7151.3	3491.7	1291.9	1030.3	326.0	256.0	188.8	85.7	148.4
1967	27016.8	15002.7	4984.5	3533.9	1853.1	698.8	562.9	179.9	141.3	104.2	130.5
1968	27726.7	15520.5	7051.1	2436.3	1810.2	966.9	368.3	299.6	95.8	75.2	126.2
1969	27845.8	12868.7	7612.6	3555.1	1279.6	968.5	522.5	201.0	163.5	52.3	111.0
1970	27100.4	10644.7	6329.2	3899.3	1903.7	698.1	533.7	290.8	111.9	91.0	91.8
1971	28082.5	15503.9	5179.9	3212.3	2071.4	1030.3	381.6	294.7	160.6	61.8	101.9
1972	27177.0	8530.2	8113.7	2758.5	1770.1	1162.9	584.2	218.6	168.8	92.0	94.7
1973	27032.8	11586.9	4293.5	4201.2	1486.3	971.6	644.7	327.2	122.4	94.5	105.6
1974	27329.7	12139.1	6090.0	2319.4	2354.9	848.9	560.5	375.7	190.6	71.3	117.8
1975	25793.6	10435.2	6549.3	3208.6	1247.4	1289.8	469.6	313.2	209.9	106.5	106.7
1976	21811.3	11109.2	5469.0	2894.0	1388.9	548.9	573.2	210.8	140.6	94.2	96.7
1977	17849.5	7865.0	5497.6	1678.6	797.7	387.6	154.7	163.1	60.0	40.0	54.9
1978	16961.4	10102.9	3938.4	1914.6	542.3	261.3	128.2	51.7	54.5	20.0	32.0
1979	16871.7	9593.6	5255.6	1320.0	580.9	166.7	81.1	40.2	16.2	17.1	16.5
1980	16707.6	8974.9	5148.7	1783.9	402.6	179.5	52.0	25.6	12.7	5.1	10.7
1981	16629.8	5835.2	4958.3	1776.8	550.3	125.8	56.6	16.6	8.1	4.0	5.1
1982	15904.1	9420.2	3311.2	2471.8	873.7	275.3	63.6	28.9	8.5	4.2	4.7
1983	13813.0	4460.5	5026.1	1062.8	703.6	251.8	80.1	18.7	8.5	2.5	2.6
1984	12985.0	2872.5	2737.8	2470.6	499.3	336.0	121.5	39.0	9.1	4.1	2.5
1985	24494.9	7210.1	1445.1	1116.5	978.3	200.9	136.5	49.8	16.0	3.7	2.8
1986	25177.7	8608.3	4103.3	593.1	426.7	379.4	78.7	54.0	19.7	6.3	2.6
1987	18871.6	10377.2	4926.8	2047.1	290.6	212.7	191.0	40.0	27.5	10.0	4.6
1988	18392.5	7825.2	5911.5	2565.5	1063.0	153.6	113.5	103.0	21.6	14.8	8.0
1989	23258.8	6353.4	4179.1	2928.5	1277.9	538.9	78.7	58.7	53.3	11.2	11.9
1990	26848.0	5571.6	3417.6	2077.8	1458.2	647.7	275.9	40.7	30.4	27.5	12.0
1991	31793.4	7685.7	2886.3	1651.3	1011.1	722.2	324.0	139.4	20.5	15.3	20.2
1992	23420.2	10436.3	3875.0	1221.9	683.2	425.2	306.7	139.0	59.8	8.8	15.4
1993	14080.4	8285.5	5650.5	1839.7	571.7	325.2	204.4	148.9	67.5	29.0	11.9
1994	13841.4	6494.4	4584.4	2541.5	796.7	251.6	144.5	91.8	66.9	30.3	18.5
1995	23795.5	7345.8	3318.5	1880.1	999.3	318.2	101.5	58.9	37.4	27.2	20.1
1996	15775.3	8045.4	4038.8	1844.1	1096.9	609.3	202.3	67.1	39.7	25.5	32.8
1997	10913.4	8802.7	4308.7	2094.5	1008.0	634.8	374.0	131.2	44.9	27.0	40.3
1998	14442.3	3776.3	4602.4	2230.1	1146.6	584.8	391.1	243.8	88.2	30.7	46.9
1999	22072.1	8129.9	1987.7	2334.6	1195.2	654.8	357.2	254.5	164.3	60.6	54.4
2000	24398.3	7584.1	4333.5	1056.8	1308.2	700.7	400.9	227.9	165.7	108.1	76.9
2001	20758.6	9325.5	3801.2	2174.9	564.2	730.1	408.0	243.0	140.9	103.5	117.4
2002	17210.4	10954.6	5034.2	1956.3	1175.0	317.9	427.9	248.2	150.5	88.1	140.3
2003	10149.6	9793.8	6122.8	2656.2	1080.8	673.2	188.0	260.9	153.4	93.7	144.2
2004	11909.0	5422.5	5362.0	3164.1	1440.0	604.1	385.5	110.2	154.2	91.1	143.0
2005	15201.6	6827.3	3105.2	2908.7	1785.6	836.4	358.7	233.8	67.3	94.6	145.4
2006	20711.1	8357.4	3733.2	1582.5	1550.5	986.5	476.8	210.7	139.1	40.3	145.9
2007	21887.8	12195.6	4724.4	1912.9	843.1	859.3	567.0	283.6	127.4	84.8	115.3
2008	25049.5	12502.1	6954.1	2599.2	1094.5	502.2	531.4	363.2	184.8	83.7	133.6

Table 3.3. Spanish mackerel: Estimated biomass at age (mt) at start of year

Year	0	1	2	3	4	5	6	7	8	9	10+
1950	4661.0	8745.8	9259.6	7321.2	5260.0	3586.3	2363.0	1529.3	971.9	610.3	1007.5
1951	4965.6	5535.5	8681.8	7720.9	5629.9	3836.8	2528.1	1636.1	1039.8	653.0	1077.8
1952	4868.3	6891.0	5286.8	7073.7	5841.5	4040.8	2661.3	1722.3	1094.6	687.4	1134.6
1953	4796.6	7274.9	6546.4	4228.3	5235.7	4100.9	2741.6	1773.5	1127.1	707.8	1168.3
1954	4674.8	5777.4	6921.6	5266.0	3150.9	3700.8	2801.5	1839.6	1168.6	733.9	1211.4
1955	4529.9	6077.2	5343.8	5466.8	3870.6	2196.8	2493.5	1854.0	1195.6	750.5	1238.8
1956	4342.0	5792.3	5523.8	4076.2	3866.2	2595.7	1423.7	1587.3	1159.1	738.6	1218.6
1957	4151.0	6238.2	5138.3	4048.8	2762.3	2483.9	1611.6	868.2	950.6	685.9	1148.6
1958	3885.2	5088.4	5450.4	3588.1	2592.0	1675.9	1456.4	928.1	491.0	531.3	1016.6
1959	3823.1	6372.0	4247.5	3675.8	2231.6	1527.7	954.7	814.9	510.0	266.6	833.0
1960	3747.7	5157.2	5508.5	3132.3	2532.1	1457.9	964.6	592.1	496.3	306.9	654.8
1961	3472.0	3799.6	4298.0	3929.3	2093.6	1604.6	892.9	580.4	349.9	289.8	556.3
1962	3443.4	6214.9	2877.1	2827.8	2447.7	1236.3	915.7	500.5	319.5	190.3	456.2
1963	3319.8	4385.9	5086.1	2010.9	1853.3	1520.9	742.4	540.0	289.9	182.9	366.5
1964	3334.5	5936.6	3368.8	3430.9	1287.1	1124.7	892.1	427.7	305.5	162.1	304.3
1965	3394.0	5975.3	4756.2	2293.5	2190.1	778.9	657.7	512.4	241.2	170.3	257.7
1966	3294.3	4320.8	4828.0	3259.0	1471.5	1332.0	457.8	379.8	290.6	135.2	237.9
1967	3312.9	5747.8	3365.4	3299.3	2110.3	903.5	790.4	266.8	217.4	164.3	209.2
1968	3400.0	5946.5	4759.0	2273.5	2062.1	1249.8	517.2	444.4	147.3	118.6	202.3
1969	3414.6	4930.4	5138.5	3316.2	1456.8	1252.3	733.5	298.1	251.6	82.4	178.0
1970	3323.1	4078.3	4272.4	3638.3	2166.4	902.1	749.5	431.2	172.1	143.5	147.2
1971	3443.6	5939.8	3496.5	2997.3	2358.0	1330.7	535.6	437.1	246.9	97.4	163.5
1972	3332.5	3268.3	5476.7	2573.8	2015.1	1502.5	819.4	324.0	259.7	145.0	151.9
1973	3314.9	4439.5	2898.3	3919.6	1691.9	1255.4	904.7	484.6	188.2	149.0	169.3
1974	3351.3	4650.9	4111.4	2164.5	2680.5	1096.8	786.5	556.7	292.9	112.4	188.8
1975	3162.9	3998.1	4420.1	2993.4	1420.2	1666.4	658.9	464.2	322.6	167.7	171.0
1976	2674.6	4256.1	3687.5	2694.5	1580.6	709.3	804.2	312.4	216.1	148.4	154.9
1977	2188.8	3012.9	3698.8	1555.7	905.4	500.6	217.1	241.7	92.2	63.0	87.9
1978	2079.9	3870.4	2651.4	1771.6	612.2	336.5	179.8	76.6	83.8	31.6	51.3
1979	2068.9	3675.4	3537.1	1221.6	654.6	213.4	113.4	59.5	24.9	26.9	26.4
1980	2048.7	3438.4	3465.1	1650.1	453.7	229.3	72.2	37.7	19.5	8.0	17.1
1981	2039.2	2235.5	3336.9	1643.5	619.8	160.7	78.5	24.3	12.5	6.4	8.1
1982	1950.2	3609.2	2233.3	2294.6	984.3	351.4	88.1	42.3	12.9	6.5	7.5
1983	1693.8	1708.8	3381.8	985.3	795.8	321.5	110.9	27.3	12.9	3.9	4.2
1984	1592.3	1100.5	1845.7	2291.4	564.0	431.0	168.2	57.0	13.8	6.4	4.0
1985	3003.7	2762.3	974.0	1037.5	1105.5	257.2	190.0	72.8	24.3	5.8	4.4
1986	3087.4	3297.8	2764.2	550.5	483.2	486.2	109.3	79.4	29.9	9.8	4.1
1987	2314.1	3975.6	3322.8	1902.7	328.8	273.2	265.6	58.7	41.8	15.6	7.2
1988	2255.4	2997.2	3988.3	2389.2	1204.4	197.1	158.3	151.2	32.8	23.1	12.6
1989	2852.1	2433.7	2818.4	2728.2	1451.4	692.6	109.5	86.4	81.1	17.4	18.8
1990	3292.2	2133.2	2305.2	1934.9	1656.8	834.6	384.8	59.8	46.3	42.9	19.1
1991	3898.6	2942.4	1945.6	1538.1	1148.2	931.1	453.3	205.3	31.3	24.0	32.0
1992	2871.9	3995.5	2609.9	1135.7	776.0	547.8	429.4	205.3	91.3	13.8	24.4
1993	1726.6	3172.7	3807.5	1709.3	647.8	419.1	285.9	220.1	103.4	45.4	18.8
1994	1697.3	2487.0	3088.5	2361.0	902.3	323.4	202.3	135.5	102.5	47.6	29.5
1995	2917.9	2812.8	2235.6	1745.2	1131.5	408.7	141.6	87.0	57.3	42.8	32.0
1996	1934.4	3081.7	2726.0	1718.1	1241.2	782.5	282.1	98.9	60.9	40.0	52.3
1997	1338.2	3371.4	2909.5	1956.2	1145.5	814.6	521.4	193.2	68.5	42.4	64.4
1998	1771.0	1446.5	3107.8	2084.1	1306.9	754.1	544.8	358.7	134.6	48.0	74.9
1999	2706.6	3114.5	1342.3	2181.6	1363.1	847.2	500.2	374.1	250.7	94.7	86.7
2000	2991.8	2904.7	2926.7	987.6	1491.9	907.3	563.5	336.9	252.6	169.1	122.4
2001	2545.5	3572.2	2566.2	2032.7	643.5	945.3	573.9	360.7	216.0	161.7	186.8
2002	2110.4	4196.2	3398.5	1827.3	1340.4	411.6	601.8	368.7	231.7	138.4	223.0
2003	1244.6	3752.0	4133.1	2481.2	1232.0	871.9	264.5	387.6	236.4	147.8	229.7
2004	1460.3	2077.4	3620.1	2955.3	1641.5	781.7	542.3	163.7	237.6	143.9	228.5
2005	1864.1	2615.7	2096.3	2716.9	2035.2	1082.3	504.2	347.5	103.8	149.5	232.8
2006	2539.7	3202.0	2520.4	1478.1	1767.4	1276.4	670.2	312.7	214.5	63.7	233.8
2007	2684.0	4672.8	3189.3	1786.7	961.0	1112.0	796.9	421.1	196.1	134.1	184.9
2008	3071.7	4790.2	4696.3	2427.5	1247.5	649.8	746.9	539.2	284.5	132.1	214.4

Table 3.4. Spanish mackerel: Estimated biomass at age (1000 lb) at start of year

Year	0	1	2	3	4	5	6	7	8	9	10+
1950	10275.8	19281.2	20414.0	16140.4	11596.3	7906.4	5209.5	3371.4	2142.7	1345.6	2221.1
1951	10947.2	12203.8	19140.1	17021.6	12411.8	8458.8	5573.4	3606.9	2292.3	1439.5	2376.2
1952	10732.7	15192.1	11655.4	15594.7	12878.2	8908.5	5867.2	3797.0	2413.1	1515.4	2501.4
1953	10574.7	16038.3	14432.3	9321.8	11542.7	9041.0	6044.2	3909.9	2484.8	1560.4	2575.7
1954	10306.1	12737.0	15259.6	11609.5	6946.6	8158.9	6176.1	4055.6	2576.4	1617.9	2670.6
1955	9986.8	13397.9	11781.1	12052.2	8533.1	4843.0	5497.3	4087.4	2635.9	1654.6	2731.1
1956	9572.4	12769.7	12177.8	8986.5	8523.5	5722.5	3138.8	3499.5	2555.3	1628.3	2686.6
1957	9151.4	13753.0	11328.0	8926.0	6089.8	5476.1	3553.0	1914.1	2095.8	1512.2	2532.3
1958	8565.5	11217.9	12016.2	7910.4	5714.3	3694.7	3210.8	2046.1	1082.6	1171.2	2241.3
1959	8428.6	14047.9	9364.2	8103.8	4919.9	3368.1	2104.7	1796.5	1124.3	587.8	1836.4
1960	8262.2	11369.6	12144.2	6905.4	5582.4	3214.1	2126.7	1305.3	1094.2	676.7	1443.6
1961	7654.4	8376.7	9475.6	8662.6	4615.7	3537.6	1968.6	1279.5	771.3	638.9	1226.5
1962	7591.5	13701.5	6343.0	6234.2	5396.2	2725.6	2018.7	1103.5	704.4	419.6	1005.7
1963	7318.9	9669.3	11212.9	4433.4	4085.8	3353.1	1636.7	1190.6	639.1	403.2	807.9
1964	7351.3	13088.0	7427.0	7563.9	2837.6	2479.6	1966.7	942.8	673.5	357.3	671.0
1965	7482.6	13173.2	10485.7	5056.3	4828.3	1717.1	1450.1	1129.7	531.9	375.4	568.1
1966	7262.7	9525.7	10644.0	7184.8	3244.2	2936.7	1009.3	837.2	640.6	298.0	524.5
1967	7303.7	12671.7	7419.5	7273.7	4652.4	1991.9	1742.6	588.3	479.2	362.3	461.2
1968	7495.6	13109.9	10491.8	5012.3	4546.2	2755.4	1140.2	979.7	324.8	261.5	446.1
1969	7527.8	10869.6	11328.6	7310.9	3211.7	2760.9	1617.1	657.3	554.6	181.7	392.5
1970	7326.3	8991.0	9419.1	8021.0	4776.1	1988.9	1652.4	950.6	379.5	316.4	324.5
1971	7591.8	13095.0	7708.6	6608.0	5198.4	2933.7	1180.7	963.6	544.4	214.7	360.4
1972	7347.0	7205.4	12074.0	5674.3	4442.5	3312.4	1806.6	714.2	572.4	319.6	334.8
1973	7308.0	9787.3	6389.7	8641.3	3729.9	2767.8	1994.4	1068.4	414.8	328.6	373.2
1974	7388.3	10253.5	9064.0	4771.9	5909.5	2418.0	1734.0	1227.4	645.7	247.7	416.2
1975	6973.0	8814.4	9744.7	6599.2	3131.1	3673.7	1452.7	1023.3	711.3	369.8	377.1
1976	5896.4	9383.0	8129.5	5940.4	3484.6	1563.8	1772.9	688.6	476.4	327.2	341.4
1977	4825.4	6642.2	8154.5	3429.7	1996.1	1103.7	478.6	533.0	203.3	139.0	193.8
1978	4585.3	8532.8	5845.3	3905.7	1349.6	741.8	396.4	168.9	184.7	69.6	113.1
1979	4561.1	8102.9	7798.0	2693.1	1443.1	470.4	250.0	131.3	54.9	59.3	58.2
1980	4516.7	7580.3	7639.3	3637.8	1000.3	505.4	159.3	83.2	42.9	17.7	37.7
1981	4495.7	4928.4	7356.6	3623.3	1366.4	354.3	173.0	53.6	27.5	14.0	18.0
1982	4299.5	7957.0	4923.6	5058.7	2170.0	774.8	194.2	93.2	28.3	14.4	16.6
1983	3734.2	3767.3	7455.6	2172.2	1754.4	708.8	244.6	60.2	28.4	8.5	9.3
1984	3510.4	2426.2	4069.1	5051.6	1243.4	950.2	370.9	125.7	30.4	14.2	8.8
1985	6621.9	6089.9	2147.2	2287.3	2437.2	567.1	419.0	160.6	53.5	12.8	9.6
1986	6806.5	7270.5	6094.1	1213.7	1065.3	1071.9	241.0	175.0	65.9	21.7	9.0
1987	5101.7	8764.8	7325.5	4194.7	724.8	602.3	585.6	129.4	92.2	34.3	16.0
1988	4972.2	6607.7	8792.7	5267.4	2655.3	434.5	349.0	333.3	72.3	51.0	27.7
1989	6287.7	5365.4	6213.6	6014.8	3199.8	1527.0	241.4	190.6	178.7	38.3	41.5
1990	7258.1	4702.9	5082.1	4265.7	3652.7	1840.1	848.4	131.8	102.2	94.7	42.0
1991	8595.0	6486.9	4289.3	3390.8	2531.4	2052.8	999.4	452.6	69.0	52.9	70.5
1992	6331.4	8808.6	5753.9	2503.9	1710.8	1207.8	946.6	452.7	201.3	30.3	53.9
1993	3806.5	6994.5	8394.0	3768.4	1428.2	923.9	630.3	485.3	227.9	100.1	41.5
1994	3741.9	5482.9	6808.9	5205.2	1989.2	713.0	445.9	298.8	226.0	104.9	65.0
1995	6432.9	6201.2	4928.7	3847.6	2494.5	901.1	312.2	191.8	126.3	94.3	70.6
1996	4264.7	6793.9	6009.8	3787.8	2736.4	1725.0	621.9	218.0	134.2	88.2	115.3
1997	2950.3	7432.7	6414.3	4312.7	2525.4	1795.9	1149.5	425.9	151.1	93.4	141.9
1998	3904.3	3189.1	6851.4	4594.6	2881.3	1662.5	1201.0	790.8	296.8	105.8	165.0
1999	5967.0	6866.4	2959.3	4809.7	3005.2	1867.7	1102.8	824.8	552.6	208.8	191.1
2000	6595.8	6403.8	6452.3	2177.3	3289.1	2000.2	1242.2	742.8	556.8	372.7	269.9
2001	5611.9	7875.3	5657.4	4481.4	1418.6	2084.0	1265.2	795.1	476.2	356.4	411.8
2002	4652.7	9251.0	7492.4	4028.5	2955.0	907.5	1326.8	812.9	510.9	305.2	491.7
2003	2743.8	8271.8	9111.9	5470.0	2716.1	1922.1	583.1	854.5	521.1	325.9	506.3
2004	3219.5	4580.0	7981.0	6515.3	3618.9	1723.3	1195.5	360.9	523.9	317.1	503.7
2005	4109.6	5766.6	4621.7	5989.8	4486.9	2386.1	1111.6	766.0	228.8	329.5	513.3
2006	5599.0	7059.2	5556.6	3258.6	3896.5	2814.0	1477.5	689.5	472.8	140.5	515.5
2007	5917.1	10301.7	7031.2	3939.0	2118.7	2451.6	1756.9	928.4	432.4	295.5	407.7
2008	6771.9	10560.5	10353.6	5351.7	2750.3	1432.7	1646.7	1188.7	627.3	291.3	472.6

Table 3.5. Spanish mackerel: Estimated time series and status indicators. Fishing mortality rate is full F, which includes discard and bycatch mortalities. Total biomass (B) is at the start of the year, and spawning biomass (SSB) at the midpoint; B and SSB are in units mt. SPR is static spawning potential ratio, and MSST is the minimum spawning stock threshold.

Year	F	F/F_{MSY}	B	B/B_{unfished}	SSB	$\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$	SSB/MSST	SPR
1950	0.671	1.906	45316	0.4921	18087	1.204	1.852	0.3479
1951	0.550	1.562	43305	0.4703	17124	1.140	1.754	0.3752
1952	0.499	1.417	41302	0.4486	16105	1.072	1.649	0.3823
1953	0.707	2.009	39701	0.4312	15405	1.025	1.578	0.3134
1954	0.658	1.869	37246	0.4045	14305	0.952	1.465	0.3186
1955	0.719	2.042	35017	0.3803	13126	0.874	1.344	0.2844
1956	0.654	1.858	32323	0.3510	11769	0.783	1.205	0.2882
1957	0.873	2.480	30087	0.3268	10560	0.703	1.081	0.2209
1958	0.632	1.794	26703	0.2900	9104	0.606	0.932	0.2708
1959	0.714	2.029	25257	0.2743	8797	0.586	0.901	0.2715
1960	1.046	2.970	24550	0.2666	8438	0.562	0.864	0.1866
1961	0.588	1.671	21866	0.2375	7248	0.482	0.742	0.2690
1962	0.845	2.400	21429	0.2327	7134	0.475	0.731	0.2229
1963	0.558	1.585	20299	0.2205	6662	0.443	0.682	0.2834
1964	0.538	1.529	20574	0.2234	6716	0.447	0.688	0.2949
1965	0.870	2.470	21227	0.2305	6942	0.462	0.711	0.2128
1966	0.564	1.601	20007	0.2173	6568	0.437	0.673	0.2852
1967	0.540	1.534	20387	0.2214	6636	0.442	0.680	0.2960
1968	0.708	2.010	21121	0.2294	6965	0.464	0.713	0.2587
1969	0.882	2.505	21052	0.2286	7021	0.467	0.719	0.2202
1970	0.491	1.395	20024	0.2175	6674	0.444	0.684	0.3218
1971	1.056	2.999	21046	0.2286	7135	0.475	0.731	0.1954
1972	0.758	2.151	19869	0.2158	6709	0.447	0.687	0.2539
1973	0.647	1.836	19415	0.2109	6644	0.442	0.680	0.2988
1974	0.835	2.371	19993	0.2171	6779	0.451	0.694	0.2431
1975	0.930	2.641	19446	0.2112	6104	0.406	0.625	0.2004
1976	1.556	4.419	17238	0.1872	4611	0.307	0.472	0.1133
1977	0.954	2.708	12564	0.1365	3412	0.227	0.349	0.1978
1978	0.995	2.827	11745	0.1276	3174	0.211	0.325	0.1963
1979	1.036	2.944	11622	0.1262	3150	0.210	0.323	0.1903
1980	1.432	4.068	11440	0.1242	3108	0.207	0.318	0.1290
1981	0.500	1.419	10165	0.1104	3088	0.206	0.316	0.3319
1982	1.744	4.952	11580	0.1258	3112	0.207	0.319	0.0957
1983	1.505	4.275	9046	0.0982	2803	0.187	0.287	0.1239
1984	0.781	2.219	8074	0.0877	2263	0.151	0.232	0.2281
1985	1.209	3.434	9437	0.1025	2320	0.154	0.238	0.1566
1986	0.813	2.308	10902	0.1184	3009	0.200	0.308	0.2424
1987	0.749	2.127	12506	0.1358	3997	0.266	0.409	0.2630
1988	1.005	2.854	13410	0.1456	4307	0.287	0.441	0.1936
1989	1.352	3.839	13290	0.1443	4072	0.271	0.417	0.1347
1990	1.212	3.444	12710	0.1380	3644	0.243	0.373	0.1502
1991	1.240	3.522	13150	0.1428	3353	0.223	0.343	0.1399
1992	1.020	2.897	12701	0.1379	3716	0.247	0.381	0.1848
1993	0.819	2.326	12157	0.1320	3855	0.257	0.395	0.2254
1994	0.799	2.269	11377	0.1236	3407	0.227	0.349	0.2194
1995	0.835	2.371	11613	0.1261	3554	0.237	0.364	0.2719
1996	0.393	1.115	12018	0.1305	4081	0.272	0.418	0.3917
1997	0.881	2.501	12425	0.1349	4514	0.301	0.462	0.2394
1998	0.412	1.170	11631	0.1263	4109	0.274	0.421	0.3807
1999	0.866	2.461	12862	0.1397	4259	0.283	0.436	0.2446
2000	0.841	2.387	13655	0.1483	4350	0.290	0.445	0.2319
2001	0.474	1.347	13804	0.1499	4629	0.308	0.474	0.3501
2002	0.372	1.055	14848	0.1613	5257	0.350	0.538	0.4027
2003	0.464	1.319	14981	0.1627	5616	0.374	0.575	0.3533
2004	0.341	0.968	13852	0.1504	5251	0.350	0.538	0.4267
2005	0.451	1.280	13748	0.1493	4935	0.328	0.505	0.3564
2006	0.369	1.049	14279	0.1551	4882	0.325	0.500	0.3967
2007	0.323	0.918	16139	0.1753	5672	0.378	0.581	0.4509
2008	.	.	18800	0.2042	.	.	.	.

Table 3.6. Spanish mackerel: Selectivity at age by fishery for males, 1996-2007

Age	Length(mm)	Length(in)	HL	GN	PN	CN	Rec	Avg L	Avg D	Total
0	229.6	9.0	0.0084	0.0461	0.0299	0.0000	0.0299	0.0217	0.1262	0.1479
1	339.2	13.4	0.1444	0.5052	1.0000	0.0015	1.0000	0.4152	0.0295	0.4447
2	407.5	16.0	0.7713	1.0000	1.0000	1.0000	0.6642	0.7582	0.0000	0.7582
3	450.1	17.7	0.9854	0.9489	1.0000	1.0000	0.5057	0.7339	0.0000	0.7339
4	476.6	18.8	0.9993	0.7637	1.0000	1.0000	0.5057	0.6835	0.0000	0.6835
5	493.1	19.4	1.0000	0.5195	1.0000	1.0000	0.5057	0.6145	0.0000	0.6145
6	503.4	19.8	1.0000	0.2948	1.0000	1.0000	0.5057	0.5510	0.0000	0.5510
7	509.9	20.1	1.0000	0.1452	1.0000	1.0000	0.5057	0.5088	0.0000	0.5088
8	513.9	20.2	1.0000	0.0657	1.0000	1.0000	0.5057	0.4863	0.0000	0.4863
9	516.4	20.3	1.0000	0.0285	1.0000	1.0000	0.5057	0.4758	0.0000	0.4758
10+	517.9	20.4	1.0000	0.0122	1.0000	1.0000	0.5057	0.4712	0.0000	0.4712

Table 3.7. Spanish mackerel: Selectivity at age by fishery for females, 1996-2007

Age	Length(mm)	Length(in)	HL	GN	PN	CN	Rec	Avg L	Avg D	Total
0	242.6	9.5528	0.0151	0.0461	0.6276	0.0000	0.0299	0.0241	0.1262	0.1503035
1	359.3	14.1468	0.2350	0.5052	1.0000	0.0743	1.0000	0.4423	0.0244	0.4667622
2	440.7	17.3522	0.8599	1.0000	1.0000	1.0000	0.6642	0.7705	0.0000	0.7705180
3	497.6	19.5888	0.9919	0.9489	1.0000	1.0000	0.5057	0.7348	0.0000	0.7347807
4	537.2	21.1494	0.9996	0.7637	1.0000	1.0000	0.5057	0.6835	0.0000	0.6835210
5	564.9	22.2383	1.0000	0.5195	1.0000	1.0000	0.5057	0.6145	0.0000	0.6145390
6	584.2	22.9980	1.0000	0.2948	1.0000	1.0000	0.5057	0.5510	0.0000	0.5510471
7	597.6	23.5281	1.0000	0.1452	1.0000	1.0000	0.5057	0.5088	0.0000	0.5087701
8	607.0	23.8980	1.0000	0.0657	1.0000	1.0000	0.5057	0.4863	0.0000	0.4863134
9	613.6	24.1561	1.0000	0.0285	1.0000	1.0000	0.5057	0.4758	0.0000	0.4758004
10+	618.1	24.3362	1.0000	0.0122	1.0000	1.0000	0.5057	0.4712	0.0000	0.4711706

Table 3.8. Spanish mackerel: Estimated time series of fishing mortality rate for commercial handlines (F.HL), commercial gillnet (F.GN), commercial poundnet (F.PN), commercial castnet (F.CN), general recreational (F.rec),commercial handline discards(F.HL.D), commercial gillnet discards(F.GN.D), general recreational discards(F.rec.D), shrimp bycatch (F.shrimp), and full F (F.full).

Year	F.HL	F.GN	F.PN	F.CN	F.rec	F.HL.D	F.GN.D	F.rec.D	F.shrimp	F.full
1950	0.000	0.054	0.000	0.000	0.154	0.000	0.000	0.006	0.457	0.671
1951	0.000	0.051	0.000	0.000	0.194	0.000	0.000	0.006	0.300	0.550
1952	0.000	0.072	0.000	0.000	0.196	0.000	0.000	0.005	0.226	0.499
1953	0.000	0.065	0.000	0.000	0.195	0.000	0.000	0.006	0.441	0.707
1954	0.000	0.065	0.000	0.000	0.223	0.000	0.000	0.006	0.364	0.658
1955	0.000	0.097	0.000	0.000	0.236	0.000	0.000	0.006	0.379	0.719
1956	0.000	0.130	0.000	0.000	0.255	0.000	0.000	0.007	0.262	0.654
1957	0.000	0.183	0.000	0.000	0.263	0.000	0.000	0.007	0.420	0.873
1958	0.000	0.189	0.000	0.000	0.308	0.000	0.000	0.007	0.127	0.632
1959	0.000	0.097	0.000	0.000	0.285	0.000	0.000	0.008	0.323	0.714
1960	0.001	0.110	0.001	0.000	0.319	0.000	0.000	0.009	0.606	1.046
1961	0.001	0.132	0.004	0.000	0.409	0.000	0.000	0.008	0.035	0.588
1962	0.004	0.118	0.000	0.000	0.336	0.000	0.000	0.009	0.378	0.845
1963	0.003	0.109	0.002	0.000	0.399	0.000	0.000	0.008	0.036	0.558
1964	0.005	0.133	0.001	0.000	0.354	0.000	0.000	0.008	0.036	0.538
1965	0.008	0.129	0.003	0.000	0.344	0.000	0.000	0.009	0.377	0.870
1966	0.009	0.098	0.004	0.000	0.384	0.000	0.000	0.008	0.061	0.564
1967	0.007	0.172	0.001	0.000	0.316	0.000	0.000	0.007	0.036	0.540
1968	0.006	0.169	0.002	0.000	0.273	0.000	0.000	0.007	0.251	0.708
1969	0.005	0.151	0.003	0.000	0.272	0.000	0.000	0.007	0.444	0.882
1970	0.006	0.152	0.004	0.000	0.282	0.000	0.000	0.006	0.042	0.491
1971	0.006	0.153	0.001	0.000	0.212	0.000	0.000	0.006	0.678	1.056
1972	0.006	0.156	0.001	0.000	0.251	0.000	0.000	0.006	0.338	0.758
1973	0.008	0.134	0.002	0.000	0.209	0.000	0.000	0.005	0.288	0.647
1974	0.014	0.188	0.001	0.000	0.176	0.000	0.000	0.004	0.452	0.835
1975	0.034	0.388	0.002	0.000	0.172	0.000	0.000	0.004	0.330	0.930
1976	0.043	0.837	0.004	0.000	0.164	0.000	0.000	0.004	0.504	1.556
1977	0.013	0.702	0.002	0.000	0.179	0.000	0.000	0.004	0.055	0.954
1978	0.005	0.798	0.000	0.000	0.130	0.000	0.000	0.003	0.058	0.995
1979	0.006	0.809	0.000	0.000	0.098	0.000	0.000	0.002	0.121	1.036
1980	0.006	0.812	0.000	0.000	0.068	0.000	0.000	0.002	0.543	1.432
1981	0.004	0.323	0.000	0.000	0.109	0.000	0.000	0.004	0.059	0.500
1982	0.011	0.875	0.001	0.000	0.094	0.000	0.000	0.001	0.762	1.744
1983	0.004	0.415	0.001	0.000	0.018	0.000	0.000	0.001	1.067	1.505
1984	0.007	0.489	0.001	0.000	0.206	0.000	0.000	0.002	0.077	0.781
1985	0.010	0.591	0.003	0.000	0.066	0.000	0.000	0.003	0.536	1.209
1986	0.007	0.329	0.003	0.000	0.092	< 0.001	0.001	0.015	0.365	0.813
1987	0.011	0.253	0.013	0.000	0.101	< 0.001	0.001	0.004	0.367	0.749
1988	0.008	0.267	0.010	0.000	0.167	< 0.001	0.001	0.004	0.548	1.005
1989	0.011	0.261	0.028	0.000	0.138	< 0.001	0.000	0.015	0.898	1.352
1990	0.022	0.252	0.031	0.000	0.174	< 0.001	0.001	0.008	0.725	1.212
1991	0.029	0.408	0.030	0.000	0.177	< 0.001	0.001	0.015	0.580	1.240
1992	0.008	0.339	0.023	0.000	0.125	< 0.001	0.001	0.018	0.507	1.020
1993	0.006	0.439	0.019	0.000	0.093	< 0.001	0.002	0.018	0.242	0.819
1994	0.007	0.505	0.022	0.000	0.146	< 0.001	0.002	0.055	0.062	0.799
1995	0.019	0.131	0.013	0.003	0.097	< 0.001	0.000	0.021	0.550	0.835
1996	0.007	0.201	0.017	0.017	0.086	< 0.001	0.001	0.022	0.043	0.393
1997	0.007	0.206	0.011	0.006	0.106	< 0.001	0.002	0.040	0.503	0.881
1998	0.013	0.235	0.007	0.002	0.096	< 0.001	0.001	0.020	0.038	0.412
1999	0.016	0.137	0.016	0.028	0.115	< 0.001	0.001	0.036	0.516	0.866
2000	0.021	0.133	0.011	0.048	0.181	< 0.001	0.001	0.041	0.405	0.841
2001	0.032	0.121	0.011	0.072	0.113	< 0.001	0.001	0.033	0.092	0.474
2002	0.025	0.090	0.006	0.097	0.099	< 0.001	0.001	0.033	0.020	0.372
2003	0.025	0.058	0.005	0.136	0.122	< 0.001	0.001	0.069	0.048	0.464
2004	0.045	0.050	0.003	0.100	0.093	< 0.001	0.001	0.035	0.014	0.341
2005	0.045	0.088	0.002	0.111	0.116	< 0.001	0.001	0.049	0.039	0.451
2006	0.058	0.108	0.000	0.096	0.085	< 0.001	0.000	0.013	0.007	0.369
2007	0.048	0.112	0.001	0.036	0.075	< 0.001	0.000	0.025	0.027	0.323

Table 3.9. Spanish mackerel: Estimated instantaneous fishing mortality rate (per yr) at age for males, including discard mortality

Year	0	1	2	3	4	5	6	7	8	9	10+
1950	0.467	0.162	0.144	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132
1951	0.312	0.201	0.167	0.148	0.149	0.149	0.149	0.149	0.149	0.149	0.149
1952	0.237	0.206	0.184	0.170	0.171	0.171	0.171	0.171	0.171	0.171	0.171
1953	0.453	0.204	0.179	0.163	0.164	0.164	0.164	0.164	0.164	0.164	0.164
1954	0.377	0.233	0.197	0.177	0.178	0.178	0.178	0.178	0.178	0.178	0.178
1955	0.393	0.249	0.230	0.215	0.216	0.216	0.216	0.216	0.216	0.216	0.216
1956	0.277	0.272	0.268	0.258	0.259	0.259	0.259	0.259	0.259	0.259	0.259
1957	0.435	0.284	0.313	0.314	0.317	0.317	0.317	0.317	0.317	0.317	0.317
1958	0.144	0.330	0.348	0.343	0.345	0.345	0.345	0.345	0.345	0.345	0.345
1959	0.340	0.299	0.264	0.241	0.242	0.242	0.242	0.242	0.242	0.242	0.242
1960	0.625	0.335	0.296	0.272	0.273	0.273	0.273	0.273	0.273	0.273	0.273
1961	0.056	0.430	0.376	0.342	0.343	0.344	0.344	0.344	0.344	0.344	0.344
1962	0.397	0.353	0.316	0.291	0.293	0.293	0.293	0.293	0.293	0.293	0.293
1963	0.057	0.416	0.352	0.315	0.316	0.316	0.316	0.316	0.316	0.316	0.316
1964	0.055	0.373	0.341	0.317	0.319	0.319	0.319	0.319	0.319	0.319	0.319
1965	0.397	0.365	0.335	0.312	0.314	0.314	0.314	0.314	0.314	0.314	0.314
1966	0.081	0.403	0.340	0.303	0.304	0.304	0.304	0.304	0.304	0.304	0.304
1967	0.054	0.338	0.347	0.338	0.340	0.341	0.341	0.341	0.341	0.341	0.341
1968	0.267	0.296	0.316	0.313	0.315	0.316	0.316	0.316	0.316	0.316	0.316
1969	0.460	0.294	0.301	0.294	0.296	0.296	0.296	0.296	0.296	0.296	0.296
1970	0.057	0.304	0.310	0.302	0.304	0.304	0.304	0.304	0.304	0.304	0.304
1971	0.691	0.232	0.262	0.266	0.267	0.267	0.267	0.267	0.267	0.267	0.267
1972	0.352	0.270	0.290	0.288	0.290	0.290	0.290	0.290	0.290	0.290	0.290
1973	0.300	0.228	0.249	0.248	0.250	0.250	0.250	0.250	0.250	0.250	0.250
1974	0.462	0.199	0.271	0.290	0.292	0.292	0.292	0.292	0.292	0.292	0.292
1975	0.341	0.220	0.436	0.506	0.511	0.511	0.511	0.511	0.511	0.511	0.511
1976	0.517	0.260	0.778	0.956	0.966	0.967	0.967	0.967	0.967	0.967	0.967
1977	0.067	0.254	0.661	0.798	0.806	0.806	0.806	0.806	0.806	0.806	0.806
1978	0.068	0.213	0.694	0.861	0.869	0.870	0.870	0.870	0.870	0.870	0.870
1979	0.130	0.181	0.681	0.855	0.864	0.865	0.865	0.865	0.865	0.865	0.865
1980	0.550	0.152	0.665	0.844	0.853	0.853	0.853	0.853	0.853	0.853	0.853
1981	0.068	0.144	0.320	0.379	0.383	0.383	0.383	0.383	0.383	0.383	0.383
1982	0.769	0.184	0.733	0.924	0.934	0.934	0.934	0.934	0.934	0.934	0.934
1983	1.069	0.062	0.330	0.424	0.429	0.429	0.429	0.429	0.429	0.429	0.429
1984	0.087	0.258	0.513	0.595	0.601	0.601	0.601	0.601	0.601	0.601	0.601
1985	0.544	0.131	0.501	0.630	0.637	0.637	0.637	0.637	0.637	0.637	0.637
1986	0.385	0.136	0.319	0.382	0.386	0.386	0.386	0.386	0.386	0.386	0.386
1987	0.376	0.143	0.280	0.325	0.328	0.328	0.328	0.328	0.328	0.328	0.328
1988	0.560	0.207	0.329	0.366	0.369	0.369	0.369	0.369	0.369	0.369	0.369
1989	0.920	0.200	0.325	0.367	0.370	0.370	0.370	0.370	0.370	0.370	0.370
1990	0.741	0.237	0.354	0.390	0.393	0.393	0.393	0.393	0.393	0.393	0.393
1991	0.604	0.258	0.478	0.551	0.556	0.556	0.556	0.556	0.556	0.556	0.556
1992	0.531	0.191	0.368	0.429	0.432	0.433	0.433	0.433	0.433	0.433	0.433
1993	0.267	0.165	0.417	0.506	0.511	0.511	0.511	0.511	0.511	0.511	0.511
1994	0.126	0.244	0.506	0.602	0.608	0.608	0.608	0.608	0.608	0.608	0.608
1995	0.581	0.188	0.227	0.209	0.185	0.153	0.123	0.104	0.093	0.089	0.086
1996	0.078	0.214	0.296	0.274	0.237	0.188	0.143	0.113	0.097	0.089	0.086
1997	0.558	0.239	0.298	0.272	0.234	0.184	0.138	0.107	0.091	0.083	0.080
1998	0.073	0.232	0.318	0.294	0.250	0.193	0.140	0.105	0.086	0.077	0.073
1999	0.563	0.219	0.271	0.249	0.224	0.190	0.160	0.139	0.128	0.123	0.121
2000	0.458	0.279	0.328	0.298	0.273	0.241	0.211	0.191	0.180	0.175	0.173
2001	0.136	0.204	0.303	0.286	0.264	0.234	0.207	0.189	0.179	0.175	0.173
2002	0.062	0.168	0.278	0.263	0.247	0.225	0.205	0.191	0.184	0.181	0.179
2003	0.125	0.189	0.299	0.282	0.272	0.258	0.245	0.236	0.231	0.229	0.228
2004	0.055	0.143	0.250	0.242	0.233	0.221	0.210	0.202	0.198	0.197	0.196
2005	0.097	0.189	0.312	0.299	0.283	0.262	0.242	0.229	0.222	0.219	0.218
2006	0.029	0.155	0.306	0.299	0.280	0.254	0.229	0.213	0.205	0.201	0.199
2007	0.060	0.149	0.235	0.228	0.208	0.181	0.155	0.139	0.130	0.126	0.124

Table 3.10. Spanish mackerel: Estimated instantaneous fishing mortality rate (per yr) at age for females, including discard mortality

Year	0	1	2	3	4	5	6	7	8	9	10+
1950	0.468	0.166	0.149	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132
1951	0.312	0.205	0.172	0.148	0.149	0.149	0.149	0.149	0.149	0.149	0.149
1952	0.238	0.211	0.192	0.170	0.171	0.171	0.171	0.171	0.171	0.171	0.171
1953	0.453	0.209	0.186	0.163	0.164	0.164	0.164	0.164	0.164	0.164	0.164
1954	0.377	0.237	0.204	0.177	0.178	0.178	0.178	0.178	0.178	0.178	0.178
1955	0.394	0.256	0.240	0.216	0.216	0.216	0.216	0.216	0.216	0.216	0.216
1956	0.277	0.281	0.281	0.259	0.259	0.259	0.259	0.259	0.259	0.259	0.259
1957	0.436	0.298	0.332	0.315	0.317	0.317	0.317	0.317	0.317	0.317	0.317
1958	0.145	0.344	0.367	0.344	0.345	0.345	0.345	0.345	0.345	0.345	0.345
1959	0.340	0.306	0.274	0.242	0.242	0.242	0.242	0.242	0.242	0.242	0.242
1960	0.626	0.343	0.308	0.272	0.273	0.273	0.273	0.273	0.273	0.273	0.273
1961	0.058	0.440	0.389	0.343	0.343	0.344	0.344	0.344	0.344	0.344	0.344
1962	0.398	0.361	0.328	0.292	0.293	0.293	0.293	0.293	0.293	0.293	0.293
1963	0.059	0.425	0.364	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316
1964	0.057	0.383	0.355	0.318	0.319	0.319	0.319	0.319	0.319	0.319	0.319
1965	0.399	0.375	0.349	0.313	0.314	0.314	0.314	0.314	0.314	0.314	0.314
1966	0.084	0.410	0.350	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
1967	0.055	0.352	0.365	0.339	0.341	0.341	0.341	0.341	0.341	0.341	0.341
1968	0.269	0.309	0.334	0.314	0.315	0.316	0.316	0.316	0.316	0.316	0.316
1969	0.463	0.305	0.317	0.295	0.296	0.296	0.296	0.296	0.296	0.296	0.296
1970	0.060	0.316	0.326	0.303	0.304	0.304	0.304	0.304	0.304	0.304	0.304
1971	0.692	0.244	0.278	0.266	0.267	0.267	0.267	0.267	0.267	0.267	0.267
1972	0.353	0.283	0.306	0.289	0.290	0.290	0.290	0.290	0.290	0.290	0.290
1973	0.301	0.239	0.263	0.249	0.250	0.250	0.250	0.250	0.250	0.250	0.250
1974	0.463	0.215	0.291	0.291	0.292	0.292	0.292	0.292	0.292	0.292	0.292
1975	0.344	0.253	0.478	0.509	0.511	0.511	0.511	0.511	0.511	0.511	0.511
1976	0.523	0.329	0.867	0.961	0.966	0.967	0.967	0.967	0.967	0.967	0.967
1977	0.071	0.310	0.733	0.802	0.806	0.806	0.806	0.806	0.806	0.806	0.806
1978	0.071	0.275	0.776	0.865	0.870	0.870	0.870	0.870	0.870	0.870	0.870
1979	0.133	0.245	0.764	0.860	0.864	0.865	0.865	0.865	0.865	0.865	0.865
1980	0.554	0.216	0.748	0.849	0.853	0.853	0.853	0.853	0.853	0.853	0.853
1981	0.069	0.169	0.353	0.381	0.383	0.383	0.383	0.383	0.383	0.383	0.383
1982	0.773	0.253	0.823	0.929	0.934	0.934	0.934	0.934	0.934	0.934	0.934
1983	1.072	0.095	0.372	0.427	0.429	0.429	0.429	0.429	0.429	0.429	0.429
1984	0.090	0.296	0.563	0.598	0.601	0.601	0.601	0.601	0.601	0.601	0.601
1985	0.548	0.177	0.562	0.634	0.637	0.637	0.637	0.637	0.637	0.637	0.637
1986	0.388	0.161	0.353	0.384	0.386	0.386	0.386	0.386	0.386	0.386	0.386
1987	0.385	0.163	0.306	0.326	0.328	0.328	0.328	0.328	0.328	0.328	0.328
1988	0.566	0.228	0.357	0.368	0.369	0.369	0.369	0.369	0.369	0.369	0.369
1989	0.938	0.220	0.353	0.368	0.370	0.370	0.370	0.370	0.370	0.370	0.370
1990	0.761	0.258	0.381	0.391	0.393	0.393	0.393	0.393	0.393	0.393	0.393
1991	0.624	0.292	0.522	0.554	0.556	0.556	0.556	0.556	0.556	0.556	0.556
1992	0.547	0.217	0.403	0.431	0.433	0.433	0.433	0.433	0.433	0.433	0.433
1993	0.280	0.199	0.462	0.508	0.511	0.511	0.511	0.511	0.511	0.511	0.511
1994	0.141	0.280	0.558	0.605	0.608	0.608	0.608	0.608	0.608	0.608	0.608
1995	0.588	0.188	0.228	0.209	0.185	0.153	0.123	0.104	0.093	0.089	0.086
1996	0.088	0.215	0.297	0.274	0.237	0.188	0.143	0.113	0.097	0.089	0.086
1997	0.565	0.238	0.299	0.272	0.235	0.184	0.138	0.107	0.091	0.083	0.080
1998	0.077	0.232	0.319	0.294	0.250	0.193	0.140	0.105	0.086	0.077	0.073
1999	0.573	0.220	0.272	0.249	0.224	0.190	0.160	0.139	0.128	0.123	0.121
2000	0.465	0.282	0.330	0.298	0.273	0.241	0.211	0.191	0.180	0.175	0.173
2001	0.143	0.209	0.306	0.286	0.264	0.234	0.207	0.189	0.179	0.175	0.173
2002	0.066	0.175	0.280	0.263	0.247	0.225	0.205	0.191	0.184	0.181	0.179
2003	0.128	0.196	0.301	0.282	0.272	0.258	0.245	0.236	0.231	0.229	0.228
2004	0.058	0.152	0.254	0.242	0.233	0.221	0.210	0.202	0.198	0.197	0.196
2005	0.099	0.198	0.316	0.299	0.283	0.262	0.242	0.229	0.222	0.219	0.218
2006	0.030	0.166	0.311	0.300	0.280	0.254	0.229	0.213	0.205	0.201	0.199
2007	0.060	0.154	0.240	0.228	0.208	0.181	0.155	0.139	0.130	0.126	0.124

Table 3.11. Spanish mackerel: Estimated total landings at age (1000 fish)

Year	0	1	2	3	4	5	6	7	8	9	10+
1950	121.5	2814.0	1574.9	827.7	493.3	297.6	181.4	111.1	68.1	41.9	68.0
1951	169.4	2168.2	1691.8	973.0	588.0	354.6	216.1	132.4	81.1	49.9	81.0
1952	176.7	2764.0	1132.6	1013.1	693.9	424.6	258.6	158.4	97.0	59.7	97.0
1953	156.9	2895.8	1363.2	583.2	599.0	415.1	256.5	157.1	96.2	59.2	96.1
1954	179.6	2583.7	1573.2	782.7	388.4	403.6	282.4	175.5	107.4	66.1	107.3
1955	187.1	2897.0	1401.9	972.2	571.1	286.8	301.1	211.8	131.6	81.0	131.4
1956	209.3	2995.8	1663.6	851.8	670.4	398.3	202.0	213.2	150.0	93.6	151.9
1957	198.7	3377.5	1779.7	1006.6	570.0	453.4	272.1	138.8	146.4	103.5	170.3
1958	241.9	3127.0	2059.6	961.7	576.4	329.6	264.8	159.8	81.5	86.4	162.4
1959	195.1	3562.5	1255.4	725.1	365.1	221.0	127.7	103.1	62.2	31.9	97.9
1960	190.6	3179.0	1801.9	685.4	459.9	234.3	143.3	83.2	67.2	40.7	85.4
1961	310.4	2889.9	1719.1	1048.7	463.6	314.7	161.9	99.5	57.8	46.9	88.5
1962	202.6	4007.0	995.3	657.6	472.1	211.1	144.8	74.9	46.0	26.9	63.3
1963	276.8	3245.0	1923.3	500.3	382.2	277.6	125.4	86.4	44.7	27.6	54.3
1964	246.0	4021.4	1245.5	859.8	267.6	206.9	151.7	68.9	47.5	24.7	45.5
1965	221.1	3966.6	1731.1	566.8	449.1	141.3	110.4	81.4	37.0	25.6	38.0
1966	273.5	3109.3	1769.9	785.1	293.9	235.4	74.8	58.8	43.3	19.8	34.2
1967	224.1	3605.3	1266.7	873.4	463.8	175.7	142.2	45.4	35.7	26.4	33.1
1968	193.6	3327.2	1658.1	564.0	424.5	227.8	87.2	70.9	22.7	17.9	30.0
1969	178.7	2736.5	1715.1	778.9	284.0	215.9	117.0	45.0	36.6	11.8	25.0
1970	219.6	2337.3	1462.4	874.4	432.4	159.3	122.3	66.7	25.6	21.0	21.1
1971	124.4	2684.6	1038.0	643.6	420.6	210.2	78.2	60.4	32.9	12.7	21.0
1972	159.9	1693.5	1772.5	593.3	385.8	254.6	128.5	48.1	37.1	20.3	20.9
1973	143.8	1977.9	820.0	793.7	284.6	186.9	124.6	63.2	23.7	18.3	20.5
1974	119.4	1860.8	1262.6	501.6	516.6	187.1	124.1	83.2	42.2	15.9	26.2
1975	149.6	1803.2	2044.1	1102.5	434.8	451.6	165.1	110.1	73.8	37.6	37.7
1976	157.8	2328.8	2635.3	1559.5	758.1	300.8	315.4	116.0	77.4	52.0	53.4
1977	139.1	1591.3	2360.4	804.5	387.4	189.1	75.8	79.9	29.4	19.7	27.0
1978	112.6	1798.2	1756.2	964.6	276.9	134.0	66.0	26.6	28.1	10.4	16.6
1979	97.5	1510.7	2315.2	662.4	295.5	85.1	41.6	20.6	8.3	8.8	8.5
1980	72.3	1236.9	2231.1	887.4	203.0	90.9	26.4	13.0	6.4	2.6	5.5
1981	66.8	691.2	1200.7	483.2	151.9	34.9	15.8	4.6	2.3	1.1	1.4
1982	75.1	1525.2	1536.3	1303.8	467.0	147.7	34.3	15.6	4.6	2.2	2.5
1983	23.6	275.1	1260.1	317.3	213.4	76.7	24.5	5.7	2.6	0.8	0.8
1984	93.7	573.9	970.6	960.7	196.9	133.1	48.3	15.5	3.6	1.7	1.0
1985	99.1	841.4	507.6	453.2	402.8	83.1	56.7	20.7	6.7	1.6	1.2
1986	94.9	939.0	991.7	162.5	118.7	106.1	22.1	15.2	5.5	1.8	0.7
1987	111.9	1199.0	1058.6	488.6	70.4	51.8	46.7	9.8	6.7	2.5	1.1
1988	111.3	1251.4	1454.2	677.9	284.9	41.4	30.7	27.9	5.8	4.0	2.2
1989	185.9	967.1	1018.7	774.4	342.8	145.2	21.3	15.9	14.4	3.0	3.2
1990	262.2	997.1	892.0	578.0	411.3	183.5	78.5	11.6	8.6	7.9	3.4
1991	339.8	1496.0	967.4	606.1	376.3	270.0	121.6	52.3	7.7	5.8	7.6
1992	195.9	1533.7	1051.7	367.7	208.6	130.4	94.5	42.8	18.4	2.7	4.8
1993	114.8	1091.1	1708.3	631.7	199.2	113.8	71.8	52.3	23.7	10.2	4.2
1994	151.5	1135.0	1612.1	997.0	316.9	100.5	58.0	36.8	26.8	12.2	7.5
1995	194.5	995.9	571.0	303.5	145.7	39.1	10.3	5.1	2.9	2.0	1.5
1996	208.3	1231.2	878.3	379.3	200.2	90.6	23.5	6.2	3.2	1.9	2.4
1997	109.8	1441.7	942.4	428.7	182.3	92.7	42.0	11.6	3.4	1.9	2.7
1998	176.8	624.3	1064.9	487.4	219.7	89.0	44.5	21.1	6.3	2.0	2.9
1999	208.3	1239.2	400.4	441.7	207.4	98.6	45.9	28.8	17.2	6.1	5.4
2000	240.7	1451.4	1031.4	233.6	270.8	130.3	66.5	34.5	23.8	15.2	10.7
2001	198.3	1348.6	845.1	464.0	113.2	132.5	66.6	36.5	20.2	14.6	16.3
2002	123.3	1319.7	1039.0	388.6	222.5	55.6	69.1	37.7	22.1	12.8	20.2
2003	61.6	1220.4	1345.2	560.7	222.7	132.9	35.6	47.9	27.6	16.8	25.8
2004	61.3	557.7	1009.4	583.3	259.2	104.1	63.7	17.6	24.2	14.2	22.3
2005	100.8	896.3	709.5	645.7	381.6	167.6	67.4	41.8	11.7	16.3	24.9
2006	134.7	988.0	840.2	351.8	328.1	192.2	85.3	35.3	22.5	6.4	23.0
2007	136.8	1328.4	844.8	334.7	136.9	123.3	71.1	32.0	13.5	8.8	11.7

Table 3.12. Spanish mackerel: Estimated total landings at age (mt)

Year	0	1	2	3	4	5	6	7	8	9	10+
1950	14.9	1079.3	1066.1	774.1	563.1	385.7	255.3	165.2	105.0	66.3	109.4
1951	20.8	831.4	1144.5	909.6	671.2	459.6	304.2	196.9	125.1	78.9	130.3
1952	21.7	1060.2	766.5	946.9	791.6	550.2	364.0	235.6	149.7	94.5	155.9
1953	19.3	1110.6	922.4	545.0	683.1	537.6	361.1	233.6	148.4	93.7	154.6
1954	22.1	990.8	1064.3	731.4	442.8	522.6	397.4	261.0	165.8	104.6	172.6
1955	23.0	1111.3	948.8	908.5	651.2	371.3	423.4	314.8	203.0	128.0	211.3
1956	25.8	1149.4	1126.1	795.8	764.4	515.6	284.1	316.7	231.3	148.1	244.3
1957	24.5	1296.5	1205.0	940.0	649.7	586.9	382.5	206.1	225.6	163.5	273.9
1958	29.8	1200.0	1393.8	897.6	656.7	426.5	372.3	237.3	125.5	136.4	261.1
1959	24.0	1366.2	848.9	676.5	415.6	285.9	179.4	153.2	95.9	50.3	157.3
1960	23.4	1219.2	1219.0	639.8	523.4	302.8	201.2	123.5	103.5	64.3	137.2
1961	38.4	1108.2	1162.7	979.5	527.9	406.5	227.2	147.7	89.0	74.1	142.2
1962	24.9	1536.6	673.3	614.1	537.9	272.9	203.1	111.0	70.9	42.4	101.6
1963	34.1	1244.2	1300.4	467.1	435.4	359.0	176.0	128.0	68.7	43.6	87.3
1964	30.3	1542.3	842.6	802.8	304.8	267.6	213.2	102.2	73.0	38.9	73.1
1965	27.3	1521.4	1171.0	529.3	511.5	182.7	155.0	120.8	56.9	40.3	61.0
1966	33.8	1192.1	1196.7	732.9	334.7	304.4	105.1	87.2	66.7	31.2	54.9
1967	27.6	1383.3	857.4	815.5	528.2	227.2	199.7	67.4	54.9	41.7	53.1
1968	23.9	1276.9	1122.1	526.4	483.6	294.5	122.4	105.2	34.9	28.2	48.1
1969	22.1	1050.0	1160.6	726.6	323.3	279.2	164.3	66.8	56.3	18.5	40.1
1970	27.2	896.8	989.6	816.0	492.0	205.8	171.8	98.8	39.5	33.0	33.9
1971	15.3	1030.6	702.7	600.6	478.9	271.5	109.8	89.6	50.6	20.1	33.7
1972	19.7	650.0	1199.7	553.7	439.2	329.0	180.2	71.3	57.1	32.0	33.6
1973	17.8	759.2	555.1	740.7	324.0	241.5	174.8	93.7	36.4	28.9	32.9
1974	14.8	715.1	855.5	468.3	588.0	241.7	174.1	123.3	64.8	25.0	42.0
1975	18.6	694.6	1385.4	1028.8	495.0	583.4	231.7	163.2	113.5	59.2	60.4
1976	19.7	899.9	1784.2	1452.4	862.7	388.8	442.5	171.9	118.9	82.0	85.6
1977	17.3	614.0	1594.8	745.8	439.8	244.2	106.3	118.4	45.2	31.0	43.2
1978	14.0	695.6	1187.5	892.8	312.6	172.5	92.6	39.4	43.1	16.3	26.5
1979	12.1	585.4	1565.3	613.2	332.9	109.0	58.2	30.5	12.8	13.9	13.6
1980	9.0	480.3	1508.7	821.1	228.8	116.1	36.7	19.2	9.9	4.1	8.7
1981	8.3	266.5	811.9	447.1	171.1	44.6	21.9	6.8	3.5	1.8	2.3
1982	9.4	591.4	1040.9	1210.7	526.1	188.6	47.5	22.8	6.9	3.5	4.1
1983	3.0	107.2	852.8	294.3	241.3	98.0	33.9	8.4	3.9	1.2	1.3
1984	11.6	221.0	657.0	891.2	222.4	170.7	66.9	22.7	5.5	2.6	1.6
1985	12.4	326.2	343.8	421.2	455.2	106.4	78.9	30.3	10.1	2.4	1.8
1986	11.9	362.4	671.3	150.9	134.4	135.9	30.7	22.3	8.4	2.8	1.2
1987	14.3	461.8	717.2	454.2	79.6	66.5	64.9	14.3	10.2	3.8	1.8
1988	14.0	481.1	985.0	631.5	322.8	53.1	42.8	40.9	8.9	6.3	3.4
1989	23.9	371.9	689.7	721.7	389.3	186.6	29.6	23.4	21.9	4.7	5.1
1990	33.6	383.0	603.8	538.3	467.3	236.5	109.5	17.0	13.2	12.3	5.4
1991	43.5	575.5	654.7	564.7	427.3	348.1	170.2	77.1	11.8	9.0	12.1
1992	25.1	590.3	711.4	341.8	236.9	168.0	132.3	63.2	28.1	4.3	7.6
1993	14.7	421.0	1156.5	587.1	225.7	146.7	100.5	77.4	36.3	16.0	6.7
1994	19.3	437.4	1090.8	926.4	358.9	129.2	81.2	54.4	41.1	19.2	11.9
1995	24.4	381.5	384.8	281.7	164.9	50.2	14.3	7.5	4.4	3.2	2.3
1996	26.1	471.8	592.9	353.4	226.5	116.4	32.7	9.2	4.9	3.0	3.8
1997	13.7	552.3	636.4	400.4	207.1	119.0	58.6	17.1	5.2	3.0	4.3
1998	21.9	239.2	719.2	455.5	250.5	114.8	61.9	31.0	9.6	3.1	4.6
1999	26.2	475.1	270.5	412.7	236.6	127.5	64.3	42.3	26.3	9.6	8.6
2000	30.0	556.4	696.8	218.3	308.9	168.7	93.5	51.1	36.3	23.8	17.1
2001	24.8	517.4	570.8	433.6	129.1	171.5	93.7	54.2	30.9	22.7	26.0
2002	15.4	506.7	701.7	363.0	253.8	72.1	97.2	56.0	34.0	20.1	32.1
2003	7.7	468.9	908.4	523.7	253.9	172.2	50.1	71.1	42.6	26.5	41.1
2004	7.6	214.4	682.0	544.9	295.5	134.7	89.6	26.2	37.3	22.5	35.6
2005	12.5	344.3	479.3	603.2	435.0	216.9	94.7	62.1	18.1	25.8	39.9
2006	16.6	379.7	567.7	328.6	374.0	248.7	119.9	52.4	34.6	10.2	36.9
2007	16.8	510.0	570.8	312.6	156.1	159.5	100.0	47.5	20.8	13.8	18.8

Table 3.13. Spanish mackerel: Estimated total landings at age (1000 lb)

Year	0	1	2	3	4	5	6	7	8	9	10+
1950	32.9	2379.5	2350.3	1706.6	1241.3	850.4	562.9	364.3	231.5	146.1	241.1
1951	45.9	1832.9	2523.2	2005.4	1479.6	1013.2	670.7	434.0	275.8	174.0	287.3
1952	47.9	2337.2	1689.9	2087.6	1745.2	1213.0	802.6	519.4	330.1	208.3	343.8
1953	42.5	2448.5	2033.5	1201.6	1506.1	1185.2	796.0	514.9	327.3	206.5	340.8
1954	48.6	2184.3	2346.3	1612.4	976.3	1152.1	876.1	575.3	365.5	230.6	380.6
1955	50.7	2449.9	2091.7	2002.8	1435.6	818.6	933.5	694.1	447.6	282.3	465.9
1956	56.8	2534.0	2482.5	1754.5	1685.2	1136.7	626.3	698.3	509.9	326.4	538.5
1957	53.9	2858.2	2656.5	2072.4	1432.3	1294.0	843.3	454.3	497.5	360.6	603.8
1958	65.6	2645.5	3072.8	1978.9	1447.7	940.4	820.9	523.1	276.8	300.8	575.6
1959	52.9	3012.0	1871.6	1491.3	916.3	630.2	395.6	337.7	211.3	111.0	346.8
1960	51.7	2687.8	2687.4	1410.5	1153.9	667.5	443.6	272.3	228.3	141.8	302.5
1961	84.6	2443.1	2563.4	2159.3	1163.9	896.2	500.9	325.6	196.3	163.3	313.5
1962	54.9	3387.7	1484.3	1353.8	1185.9	601.7	447.7	244.7	156.2	93.5	224.1
1963	75.2	2743.0	2866.9	1029.8	960.0	791.5	388.0	282.3	151.5	96.0	192.4
1964	66.8	3400.2	1857.7	1769.8	672.0	589.9	470.0	225.3	161.0	85.8	161.1
1965	60.2	3354.1	2581.5	1166.8	1127.7	402.9	341.8	266.3	125.4	88.9	134.5
1966	74.5	2628.2	2638.3	1615.7	737.9	671.1	231.7	192.2	147.0	68.7	120.9
1967	60.8	3049.6	1890.2	1797.9	1164.5	500.9	440.2	148.6	121.0	91.9	117.0
1968	52.8	2815.2	2473.8	1160.5	1066.2	649.2	269.9	231.9	76.9	62.2	106.0
1969	48.7	2314.8	2558.7	1602.0	712.7	615.5	362.2	147.2	124.2	40.9	88.3
1970	60.0	1977.1	2181.7	1798.9	1084.8	453.8	378.7	217.9	87.0	72.9	74.7
1971	33.8	2272.0	1549.3	1324.2	1055.7	598.6	242.0	197.5	111.6	44.2	74.2
1972	43.4	1432.9	2644.9	1220.8	968.2	725.3	397.4	157.1	125.9	70.6	74.0
1973	39.2	1673.8	1223.8	1632.9	714.2	532.5	385.4	206.5	80.2	63.8	72.4
1974	32.5	1576.4	1886.0	1032.3	1296.4	532.9	383.9	271.7	143.0	55.1	92.6
1975	41.0	1531.3	3054.3	2268.1	1091.3	1286.2	510.8	359.8	250.1	130.6	133.2
1976	43.5	1983.9	3933.4	3201.9	1902.0	857.1	975.6	378.9	262.1	180.8	188.6
1977	38.2	1353.7	3515.8	1644.1	969.5	538.3	234.4	261.0	99.6	68.3	95.3
1978	30.9	1533.5	2618.1	1968.3	689.1	380.3	204.1	86.9	95.1	36.0	58.5
1979	26.8	1290.5	3451.0	1351.8	734.0	240.2	128.2	67.3	28.2	30.6	30.0
1980	19.9	1058.8	3326.1	1810.2	504.4	256.0	81.0	42.3	21.8	9.1	19.3
1981	18.2	587.5	1790.0	985.6	377.2	98.3	48.2	14.9	7.7	3.9	5.0
1982	20.7	1303.8	2294.7	2669.0	1159.8	415.8	104.6	50.2	15.3	7.8	9.0
1983	6.5	236.3	1880.2	648.7	532.0	215.9	74.8	18.4	8.7	2.6	2.8
1984	25.6	487.2	1448.5	1964.9	490.2	376.3	147.5	50.0	12.1	5.7	3.5
1985	27.4	719.2	758.0	928.6	1003.6	234.6	174.0	66.7	22.2	5.3	4.0
1986	26.2	798.9	1480.0	332.7	296.4	299.6	67.7	49.1	18.5	6.1	2.5
1987	31.5	1018.2	1581.1	1001.4	175.6	146.6	143.2	31.6	22.6	8.4	3.9
1988	30.9	1060.7	2171.5	1392.2	711.7	117.0	94.4	90.1	19.6	13.8	7.5
1989	52.6	819.9	1520.6	1591.0	858.2	411.5	65.3	51.6	48.4	10.4	11.3
1990	74.1	844.4	1331.3	1186.8	1030.2	521.4	241.5	37.5	29.1	27.1	12.0
1991	95.9	1268.7	1443.3	1244.9	942.0	767.3	375.2	169.9	25.9	19.9	26.6
1992	55.4	1301.4	1568.4	753.6	522.2	370.4	291.6	139.4	62.0	9.4	16.7
1993	32.4	928.2	2549.7	1294.3	497.5	323.3	221.6	170.6	80.1	35.4	14.7
1994	42.6	964.3	2404.7	2042.4	791.2	284.9	178.9	119.9	90.7	42.3	26.2
1995	53.8	841.1	848.3	621.1	363.6	110.7	31.6	16.5	9.8	7.0	5.1
1996	57.6	1040.1	1307.1	779.1	499.4	256.5	72.1	20.2	10.8	6.6	8.3
1997	30.2	1217.6	1403.1	882.7	456.7	262.4	129.2	37.7	11.4	6.5	9.5
1998	48.3	527.4	1585.6	1004.2	552.2	253.1	136.6	68.4	21.3	6.9	10.2
1999	57.8	1047.3	596.3	909.9	521.5	281.2	141.8	93.3	57.9	21.2	19.0
2000	66.2	1226.5	1536.1	481.3	680.9	372.0	206.1	112.6	80.1	52.5	37.6
2001	54.7	1140.8	1258.3	956.0	284.7	378.2	206.5	119.5	68.2	50.1	57.3
2002	33.9	1117.1	1547.0	800.2	559.6	158.9	214.4	123.5	74.9	44.2	70.7
2003	16.9	1033.8	2002.7	1154.7	559.7	379.6	110.5	156.8	93.9	58.5	90.6
2004	16.8	472.6	1503.6	1201.3	651.5	297.0	197.5	57.7	82.2	49.6	78.5
2005	27.5	759.1	1056.7	1329.8	959.0	478.3	208.9	137.0	39.8	56.8	88.0
2006	36.5	837.1	1251.6	724.5	824.6	548.3	264.4	115.5	76.3	22.4	81.4
2007	37.1	1124.3	1258.5	689.3	344.0	351.6	220.4	104.7	45.8	30.5	41.5

Table 3.14. Spanish mackerel: Estimated time series of landings (1000 lb) for commercial handlinse (L.HL), commercial gillnet (L.GN), commercial poundnet (L.PN), commercial castnet (L.CN), and general recreational (L.rec).

Year	L.HL	L.GN	L.PN	L.CN	L.rec	Total
1950	.	3008.00	13.00	.	7085.95	10106.95
1951	.	2837.00	6.00	.	7898.97	10741.97
1952	.	3674.00	3.00	.	7647.76	11324.76
1953	.	3115.00	1.00	.	7486.94	10602.94
1954	.	2940.00	4.00	.	7803.96	10747.96
1955	.	4004.00	6.00	.	7662.73	11672.73
1956	.	4765.00	16.00	.	7567.99	12348.99
1957	.	5861.00	15.00	.	7250.81	13126.81
1958	10.00	5297.00	6.00	.	7334.93	12647.93
1959	9.00	2471.00	17.00	.	6879.73	9376.73
1960	25.00	2774.00	21.00	.	7227.34	10047.34
1961	20.00	3017.00	122.00	.	7650.95	10809.95
1962	76.00	2349.00	14.00	.	6795.41	9234.41
1963	54.00	2160.00	65.00	.	7297.73	9576.73
1964	103.00	2478.00	32.00	.	6846.50	9459.50
1965	153.00	2467.00	90.00	.	6939.92	9649.92
1966	173.00	1910.00	111.00	.	6932.22	9126.22
1967	142.00	3181.00	23.00	.	6036.76	9382.76
1968	123.00	3211.00	73.00	.	5557.43	8964.43
1969	103.00	3056.00	84.00	.	5372.27	8615.27
1970	127.00	3059.00	104.00	.	5097.40	8387.40
1971	119.00	3019.00	26.00	.	4339.05	7503.05
1972	134.00	3250.00	23.00	.	4453.55	7860.55
1973	162.00	2641.00	51.00	.	3770.69	6624.69
1974	283.00	3686.00	25.00	.	3308.93	7302.93
1975	623.00	7045.00	62.00	.	2926.71	10656.71
1976	582.00	10926.00	77.00	.	2322.84	13907.84
1977	125.00	6753.00	29.00	.	1911.32	8818.32
1978	44.00	6249.99	2.00	.	1404.70	7700.70
1979	50.00	6267.99	1.00	.	1059.45	7378.45
1980	50.00	6372.99	4.00	.	721.89	7148.88
1981	37.00	2868.00	2.00	.	1029.59	3936.59
1982	91.00	6981.00	11.00	.	967.63	8050.63
1983	30.00	3430.00	13.00	.	154.09	3627.09
1984	50.00	3674.00	14.00	.	1273.53	5011.54
1985	59.00	3348.98	33.00	.	502.78	3943.76
1986	56.00	2356.99	39.00	.	925.75	3377.73
1987	116.00	2528.88	235.00	.	1284.12	4163.99
1988	104.00	3327.57	183.00	.	2094.80	5709.36
1989	142.00	3245.82	505.00	.	1548.03	5440.85
1990	250.00	2845.20	509.01	.	1731.15	5335.35
1991	285.00	3853.67	468.01	.	1772.84	6379.53
1992	73.00	3131.23	397.00	.	1489.18	5090.41
1993	61.00	4656.38	328.00	.	1102.35	6147.73
1994	69.00	5106.01	345.00	.	1467.98	6987.98
1995	200.00	1449.03	207.00	34.00	1018.53	2908.56
1996	83.00	2470.05	302.00	197.00	1005.89	4057.94
1997	93.00	2709.68	208.00	76.00	1360.24	4446.91
1998	176.00	2898.95	118.00	33.00	988.06	4214.01
1999	202.00	1556.65	301.99	344.99	1341.59	3747.22
2000	277.99	1575.73	206.00	621.97	2170.37	4852.06
2001	419.00	1514.93	222.00	933.97	1484.32	4574.22
2002	362.01	1318.14	136.00	1420.09	1508.14	4744.38
2003	416.02	951.11	111.00	2270.50	1908.92	5657.54
2004	761.06	788.07	72.00	1745.34	1241.73	4608.20
2005	698.06	1209.15	50.00	1716.34	1467.23	5140.78
2006	839.09	1417.25	10.00	1380.25	1136.12	4782.71
2007	753.05	1705.17	14.00	549.04	1226.37	4247.63

Table 3.15. Spanish mackerel: Estimated time series of discard and bycatch mortalities (1000 fish) for commercial handlines (D.HL), gillnet (D.GN), general recreational (D.rec), and bycatch in the shrimp fishery (Bycatch).

Year	D.HL	D.GN	D.rec	Bycatch	Total
1950	.	.	178.64	11122.00	11300.64
1951	.	.	180.40	8316.00	8496.40
1952	.	.	181.28	6343.00	6524.28
1953	.	.	183.04	11122.00	11305.04
1954	.	.	184.80	9231.00	9415.80
1955	.	.	185.68	9267.00	9452.68
1956	.	.	187.44	6448.00	6635.44
1957	.	.	188.32	9223.00	9411.32
1958	.	.	190.08	2969.00	3159.08
1959	.	.	191.84	6818.00	7009.84
1960	.	.	192.72	11122.00	11314.72
1961	.	.	195.36	752.00	947.36
1962	.	.	197.12	7003.00	7200.12
1963	.	.	199.76	752.00	951.76
1964	.	.	202.40	752.00	954.40
1965	.	.	204.16	6879.00	7083.16
1966	.	.	190.96	1241.00	1431.96
1967	.	.	178.64	752.00	930.64
1968	.	.	165.44	4850.00	5015.44
1969	.	.	152.24	7951.00	8103.24
1970	.	.	139.04	872.00	1011.04
1971	.	.	127.60	11122.00	11249.60
1972	.	.	115.28	6184.00	6299.28
1973	.	.	103.84	5360.00	5463.84
1974	.	.	92.40	7924.00	8016.40
1975	.	.	80.96	5749.00	5829.96
1976	.	.	69.52	6895.00	6964.52
1977	.	.	58.08	752.00	810.08
1978	.	.	46.64	752.00	798.64
1979	.	.	35.20	1515.00	1550.20
1980	.	.	22.88	5614.03	5636.91
1981	.	.	54.56	752.00	806.56
1982	.	.	6.16	6863.00	6869.16
1983	.	.	4.40	7430.00	7434.40
1984	.	.	22.88	752.00	774.88
1985	.	.	48.40	8149.00	8197.40
1986	0.35	12	279.84	6102.00	6394.19
1987	0.70	12	54.56	4605.98	4673.24
1988	0.88	14	56.32	6205.03	6276.23
1989	1.23	7	211.20	11120.84	11340.27
1990	1.94	12	141.68	11099.03	11254.65
1991	2.55	14	321.20	11126.86	11464.62
1992	0.44	14	308.00	7387.60	7710.04
1993	0.62	23	215.60	2376.81	2616.03
1994	0.44	26	661.75	631.00	1319.19
1995	2.90	8	344.08	7983.07	8338.05
1996	0.18	15	314.16	510.99	840.32
1997	0.70	18	369.57	3379.44	3767.72
1998	3.52	9	234.95	416.98	664.45
1999	3.08	14	564.05	7000.72	7581.85
2000	3.26	10	727.75	6341.02	7082.02
2001	3.43	11	594.91	1416.20	2025.54
2002	3.96	12	540.35	266.01	822.31
2003	3.52	9	714.59	363.00	1090.12
2004	2.38	7	369.60	130.00	508.98
2005	2.29	8	658.28	451.02	1119.58
2006	2.64	7	249.04	116.00	374.68
2007	2.73	6	497.20	451.00	956.93

Table 3.16. Spanish mackerel: Base run: Estimated status indicators, benchmarks, and related quantities from the catch-at-age model, conditional on estimated current selectivities averaged across fisheries. Precision is represented by 10^{th} and 90^{th} percentiles from bootstrap analysis of the spawner-recruit curve. Estimates of yield do not include discards and shrimp bycatch; D_{MSY} represents discard and bycatch mortalities expected when fishing at F_{MSY}. Rate estimates (F) are in units of per year; status indicators are dimensionless; and biomass estimates are in units of mt or pounds, as indicated. Symbols, abbreviations, and acronyms are listed in Appendix A.

Quantity	Units	Estimate	10^{th} Percentile	90^{th} Percentile
F_{MSY}	y^{-1}	0.352	0.274	0.467
$85\%F_{MSY}$	y^{-1}	0.299	–	–
$75\%F_{MSY}$	y^{-1}	0.264	–	–
$65\%F_{MSY}$	y^{-1}	0.229	–	–
$F_{30\%}$	y^{-1}	0.540	–	–
$F_{40\%}$	y^{-1}	0.376	–	–
F_{max}	y^{-1}	0.838	–	–
B_{MSY}	mt	40288	31362	90938
SSB_{MSY}	mt	15027	9876	30728
MSST	mt	9767	6420	19973
MSY	1000 lb	13099	11614	26585
D_{MSY}	1000 fish	1485	1205	2476
R_{MSY}	1000 fish	38786	28891	72307
Y at $85\%F_{MSY}$	1000 lb	12938	–	–
Y at $75\%F_{MSY}$	1000 lb	12622	–	–
Y at $65\%F_{MSY}$	1000 lb	12105	–	–
Y at $F_{30\%}$	1000 lb	11669	–	–
Y at $F_{40\%}$	1000 lb	13070	–	–
Y at F_{max}	1000 lb	6348	–	–
F_{2007}/F_{MSY}	–	0.919	0.734	1.122
SSB_{2007}/SSB_{MSY}	–	0.377	0.185	0.574
$SSB_{2007}/MSST$	–	0.581	0.284	0.884

Table 3.17. Spanish mackerel: Results from sensitivity runs of catch-at-age model.

Run	Description	Fmsy	SSBmsy(mt)	MSY(1000 lb)	F(2007)/Fmsy	SSB(2007)/SSBmsy	SSB(2007)/MSST	steep	R0(1000)
Base	—	0.352	15022	13099	0.92	0.38	0.58	0.62	46395
S1	Mean bycatch	0.349	13194	10874	1.48	0.34	0.52	0.61	40065
S2	Early rec 0.5	0.382	11406	10836	0.85	0.5	0.77	0.65	36764
S3	Early rec 1.0	0.336	18491	15356	0.96	0.31	0.47	0.6	55742
S4	Early rec 0.75	0.325	21974	17602	0.99	0.26	0.4	0.58	65041
S5	Initial F=0.1	0.361	13659	12228	0.9	0.42	0.64	0.63	42722
S6	Initial F=0.3	0.342	17069	14434	0.95	0.33	0.51	0.6	51965
S7	Continuity	0.664	2828	5009	0.67	1.31	2.01	0.9	12400
S8	All indices	0.355	13481	13416	1.15	0.29	0.45	0.66	43187
S9	No recruit autocorr	0.352	15028	13100	0.92	0.38	0.58	0.62	46406
S10	4.0 / 4.0 / 0.2	0.364	63356	39325	0.47	0.28	0.42	0.55	163987
S11	4.0 / 0.25 / 0.2	0.26	46981	32614	1.63	0.08	0.13	0.51	131250
S12	0.25 / 4.0 / 0.2	0.729	12065	15285	0.2	1.83	2.82	0.9	44626
S13	0.25 / 0.25 / 0.2	0.496	4411	5863	0.85	0.89	1.38	0.78	16671
S14	0.25 / 0.25 / 0.1	0.501	4353	5844	0.85	0.91	1.4	0.79	16537
S15	4.0 / 4.0 / 0.3	0.355	77944	47051	0.48	0.22	0.34	0.53	198073
S16	Landings -1SD	0.2	17215	8637	1.49	0.29	0.45	0.51	5714
S17	Landings +1SD	0.351	26555	20405	0.72	0.35	0.55	0.59	76862
S18	Retro 2006	0.359	14419	13302	0.99	0.35	0.54	0.63	45366
S19	Retro 2005	0.357	14577	12665	1.17	0.34	0.53	0.64	45175
S20	Retro 2004	0.344	15016	12800	0.88	0.38	0.59	0.63	46904
S21	Retro 2003	0.363	14142	12677	1.12	0.44	0.67	0.65	45078
S22	Low M	0.37	16622	14334	1.03	0.3	0.47	0.76	30197
S23	High M	0.343	14786	12814	0.9	0.39	0.61	0.57	53497

Table 3.18. Spanish mackerel: Projection results under scenario R1—fishing mortality rate fixed at $F = 0$. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{\mathrm{MSY}}}$, SSB = mid-year spawning stock biomass (mt), R = recruits (1000 fish), L = landings (1000 lb whole weight), Sum L = cumulative landings (1000 lb), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,888	5070	5070	894
2009	0	0	6308	24,431	0	5070	0
2010	0	0.03	9644	26,274	0	5070	0
2011	0	0.22	12,273	32,530	0	5070	0
2012	0	0.5	15,276	36,003	0	5070	0
2013	0	0.73	18,458	39,005	0	5070	0
2014	0	0.85	21,676	41,439	0	5070	0
2015	0	0.93	24,813	43,369	0	5070	0
2016	0	0.96	27,777	44,885	0	5070	0
2017	0	0.99	30,504	46,072	0	5070	0
2018	0	0.99	32,957	47,002	0	5070	0
2019	0	1	35,125	47,733	0	5070	0
2020	0	1	37,012	48,310	0	5070	0
2021	0	1	38,637	48,766	0	5070	0
2022	0	1	40,021	49,130	0	5070	0
2023	0	1	41,191	49,420	0	5070	0
2024	0	1	42,172	49,652	0	5070	0
2025	0	1	42,992	49,839	0	5070	0
2026	0	1	43,673	49,989	0	5070	0
2027	0	1	44,238	50,110	0	5070	0

Table 3.19. Spanish mackerel: Projection results under scenario R2—fishing mortality rate fixed at $F_{current}$. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{\mathrm{MSY}}}$, SSB = mid-year spawning stock biomass (mt), R = recruits (1000 fish), L = landings (1000 lb whole weight), Sum L = cumulative landings (1000 lb), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,888	5070	5070	894
2009	0.378	0	6308	24,431	5940	11,010	990
2010	0.378	0	7101	26,274	6735	17,745	1068
2011	0.378	0.02	7879	28,012	7510	25,255	1140
2012	0.378	0.04	8622	29,550	8223	33,478	1204
2013	0.378	0.09	9316	30,882	8878	42,355	1259
2014	0.378	0.13	9953	32,023	9473	51,828	1307
2015	0.378	0.15	10,527	32,991	10,005	61,832	1347
2016	0.378	0.19	11,037	33,807	10,474	72,307	1381
2017	0.378	0.22	11,485	34,490	10,883	83,190	1410
2018	0.378	0.25	11,872	35,060	11,236	94,425	1434
2019	0.378	0.28	12,205	35,532	11,537	105,963	1453
2020	0.378	0.31	12,489	35,924	11,793	117,756	1470
2021	0.378	0.32	12,729	36,248	12,009	129,764	1483
2022	0.378	0.33	12,932	36,515	12,190	141,954	1495
2023	0.378	0.34	13,102	36,735	12,341	154,295	1504
2024	0.378	0.34	13,243	36,917	12,467	166,762	1511
2025	0.378	0.35	13,362	37,066	12,572	179,334	1518
2026	0.378	0.36	13,460	37,189	12,659	191,992	1523
2027	0.378	0.36	13,541	37,290	12,730	204,723	1527

Table 3.20. Spanish mackerel: Projection results under scenario R3—fishing mortality rate fixed at F_{MSY}. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{\text{MSY}}}$, SSB = mid-year spawning stock biomass (mt), R = recruits (1000 fish), L = landings (1000 lb whole weight), Sum L = cumulative landings (1000 lb), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,888	5070	5070	894
2009	0.352	0	6308	24,431	5581	10,652	925
2010	0.352	0	7246	26,274	6410	17,062	999
2011	0.352	0.02	8107	28,311	7208	24,270	1076
2012	0.352	0.06	8945	29,972	7949	32,219	1141
2013	0.352	0.1	9736	31,425	8643	40,862	1198
2014	0.352	0.15	10,464	32,668	9276	50,138	1246
2015	0.352	0.19	11,124	33,720	9844	59,983	1287
2016	0.352	0.23	11,712	34,603	10,347	70,329	1322
2017	0.352	0.28	12,228	35,339	10,785	81,114	1351
2018	0.352	0.31	12,675	35,950	11,163	92,277	1374
2019	0.352	0.34	13,060	36,455	11,485	103,762	1394
2020	0.352	0.36	13,387	36,872	11,758	115,521	1411
2021	0.352	0.38	13,665	37,215	11,988	127,509	1424
2022	0.352	0.4	13,898	37,498	12,181	139,690	1435
2023	0.352	0.41	14,093	37,729	12,341	152,031	1444
2024	0.352	0.41	14,255	37,920	12,475	164,506	1452
2025	0.352	0.42	14,390	38,076	12,586	177,092	1458
2026	0.352	0.43	14,502	38,203	12,677	189,769	1463
2027	0.352	0.44	14,595	38,308	12,752	202,521	1467

Table 3.21. Spanish mackerel: Projection results under scenario R4—fishing mortality rate fixed at $0.65F_{\mathrm{MSY}}$*. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching* $SSB_{F_{\mathrm{MSY}}}$*, SSB = mid-year spawning stock biomass* (mt)*, R = recruits (1000 fish), L = landings (1000* lb *whole weight), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.*

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,888	5070	5070	894
2009	0.229	0	6308	24,431	3762	8833	607
2010	0.229	0.01	8000	26,274	4601	13,434	657
2011	0.229	0.05	9336	29,774	5399	18,832	741
2012	0.229	0.14	10,730	32,054	6169	25,002	801
2013	0.229	0.24	12,101	34,083	6942	31,944	853
2014	0.229	0.35	13,401	35,802	7666	39,610	898
2015	0.229	0.45	14,605	37,230	8329	47,939	934
2016	0.229	0.52	15,694	38,403	8921	56,860	965
2017	0.229	0.57	16,660	39,362	9440	66,300	989
2018	0.229	0.62	17,504	40,141	9888	76,188	1010
2019	0.229	0.66	18,231	40,774	10,270	86,457	1026
2020	0.229	0.69	18,851	41,286	10,592	97,049	1039
2021	0.229	0.72	19,374	41,700	10,861	107,910	1050
2022	0.229	0.76	19,813	42,036	11,086	118,996	1059
2023	0.229	0.76	20,179	42,307	11,271	130,267	1066
2024	0.229	0.77	20,482	42,526	11,424	141,691	1071
2025	0.229	0.78	20,731	42,704	11,550	153,241	1076
2026	0.229	0.8	20,937	42,848	11,653	164,894	1080
2027	0.229	0.81	21,106	42,964	11,737	176,631	1083

Table 3.22. Spanish mackerel: Projection results under scenario R5—fishing mortality rate fixed at $0.75F_{\mathrm{MSY}}$*. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching* $SSB_{F_{\mathrm{MSY}}}$*, SSB = mid-year spawning stock biomass* (mt)*, R = recruits (1000 fish), L = landings (1000* lb *whole weight), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.*

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,888	5070	5070	894
2009	0.264	0	6308	24,431	4296	9366	699
2010	0.264	0.01	7776	26,274	5160	14,526	755
2011	0.264	0.04	8963	29,354	5979	20,505	841
2012	0.264	0.11	10,181	31,454	6763	27,268	905
2013	0.264	0.2	11,364	33,321	7535	34,803	960
2014	0.264	0.28	12,477	34,909	8253	43,057	1007
2015	0.264	0.36	13,501	36,235	8907	51,963	1046
2016	0.264	0.43	14,422	37,331	9489	61,452	1078
2017	0.264	0.48	15,236	38,233	9998	71,450	1105
2018	0.264	0.52	15,946	38,970	10,437	81,886	1127
2019	0.264	0.56	16,557	39,571	10,811	92,697	1145
2020	0.264	0.61	17,077	40,061	11,127	103,824	1159
2021	0.264	0.62	17,516	40,459	11,391	115,215	1171
2022	0.264	0.64	17,884	40,782	11,612	126,827	1181
2023	0.264	0.66	18,191	41,045	11,794	138,621	1189
2024	0.264	0.67	18,445	41,258	11,945	150,567	1195
2025	0.264	0.69	18,655	41,431	12,069	162,636	1200
2026	0.264	0.7	18,828	41,571	12,171	174,807	1204
2027	0.264	0.71	18,971	41,685	12,255	187,062	1208

Table 3.23. Spanish mackerel: Projection results under scenario R6—fishing mortality rate fixed at $0.85F_{\mathrm{MSY}}$. F = *fishing mortality rate (per year), Pr(recover) = proportion of cases reaching* $SSB_{F_{\mathrm{MSY}}}$, SSB = *mid-year spawning stock biomass* (mt), R = *recruits (1000 fish),* L = *landings (1000* lb *whole weight), Sum* L = *cumulative landings (1000* lb), *and* D = *discard mortalities (1000 fish). Horizontal lines give relevant quantities at* MSY *levels.*

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,888	5070	5070	894
2009	0.299	0	6308	24,431	4818	9889	790
2010	0.299	0	7559	26,274	5684	15,573	853
2011	0.299	0.03	8608	28,935	6507	22,080	937
2012	0.299	0.08	9664	30,858	7285	29,365	1003
2013	0.299	0.15	10,678	32,560	8038	37,403	1060
2014	0.299	0.22	11,624	34,013	8732	46,135	1108
2015	0.299	0.28	12,488	35,232	9361	55,496	1149
2016	0.299	0.34	13,263	36,247	9919	65,415	1183
2017	0.299	0.39	13,946	37,086	10,406	75,821	1211
2018	0.299	0.43	14,539	37,776	10,826	86,647	1234
2019	0.299	0.47	15,049	38,342	11,184	97,831	1253
2020	0.299	0.5	15,484	38,805	11,487	109,318	1268
2021	0.299	0.53	15,851	39,184	11,741	121,059	1281
2022	0.299	0.55	16,158	39,493	11,953	133,012	1291
2023	0.299	0.56	16,415	39,745	12,129	145,141	1300
2024	0.299	0.57	16,629	39,950	12,275	157,416	1307
2025	0.299	0.58	16,805	40,117	12,395	169,811	1312
2026	0.299	0.59	16,951	40,253	12,494	182,304	1317
2027	0.299	0.6	17,071	40,364	12,575	194,879	1321

Table 3.24. Spanish mackerel: Projection results under scenario R7—fishing mortality rate fixed at $F_{rebuild} = 0.285$. *F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching* $SSB_{F_{\mathrm{MSY}}}$, *SSB = mid-year spawning stock biomass* (mt)*, R = recruits (1000 fish), L = landings (1000* lb *whole weight), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at* MSY *levels.*

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,888	5070	5070	894
2009	0.285	0	6308	24,431	4608	9678	753
2010	0.285	0.01	7646	26,274	5475	15,153	814
2011	0.285	0.03	8750	29,105	6299	21,453	899
2012	0.285	0.09	9870	31,099	7081	28,534	964
2013	0.285	0.17	10,951	32,868	7844	36,378	1020
2014	0.285	0.24	11,962	34,377	8550	44,928	1068
2015	0.285	0.32	12,888	35,640	9190	54,119	1108
2016	0.285	0.37	13,720	36,688	9760	63,878	1141
2017	0.285	0.42	14,454	37,553	10,257	74,135	1169
2018	0.285	0.46	15,093	38,263	10,686	84,821	1192
2019	0.285	0.5	15,642	38,844	11,051	95,872	1210
2020	0.285	0.54	16,109	39,318	11,360	107,232	1226
2021	0.285	0.56	16,504	39,705	11,619	118,851	1238
2022	0.285	0.58	16,836	40,020	11,835	130,686	1248
2023	0.285	0.6	17,112	40,276	12,014	142,700	1256
2024	0.285	0.62	17,341	40,485	12,162	154,862	1263
2025	0.285	0.63	17,531	40,655	12,284	167,146	1268
2026	0.285	0.63	17,687	40,793	12,384	179,530	1273
2027	0.285	0.64	17,815	40,905	12,467	191,997	1276

Table 3.25. Spanish mackerel: Projection results under F = 0.248, the fishing mortality needed to make Pr(rebuilding)=0.6 within the recovery time frame. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{\mathrm{MSY}}}$, SSB = mid-year spawning stock biomass (mt), R = recruits (1000 fish), L = landings (1000 lb whole weight), Sum L = cumulative landings (1000 lb), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,888	5070	5070	894
2009	0.248	0	6308	24,431	4054	9124	657
2010	0.248	0.01	7877	26,274	4909	14,033	711
2011	0.248	0.04	9131	29,545	5721	19,754	795
2012	0.248	0.12	10,427	31,728	6501	26,255	858
2013	0.248	0.22	11,694	33,669	7276	33,531	912
2014	0.248	0.3	12,890	35,317	7999	41,531	958
2015	0.248	0.39	13,993	36,690	8659	50,190	996
2016	0.248	0.48	14,988	37,822	9248	59,438	1028
2017	0.248	0.52	15,869	38,751	9763	69,201	1054
2018	0.248	0.56	16,637	39,508	10,207	79,409	1075
2019	0.248	0.6	17,299	40,124	10,586	89,995	1092
2020	0.248	0.65	17,863	40,624	10,906	100,901	1106
2021	0.248	0.67	18,339	41,030	11,174	112,074	1117
2022	0.248	0.69	18,738	41,359	11,396	123,471	1126
2023	0.248	0.71	19,070	41,626	11,581	135,052	1134
2024	0.248	0.72	19,346	41,842	11,733	146,785	1140
2025	0.248	0.72	19,573	42,017	11,858	158,643	1145
2026	0.248	0.75	19,760	42,160	11,961	170,604	1149
2027	0.248	0.76	19,914	42,275	12,045	182,649	1152

Table 3.26. Spanish mackerel: Projection results under $F = 0.215$, the fishing mortality needed to make Pr(rebuilding)=0.7 within the recovery time frame. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{\mathrm{MSY}}}$, SSB = mid-year spawning stock biomass (mt)*, R = recruits (1000 fish), L = landings (1000* lb *whole weight), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.*

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,888	5070	5070	894
2009	0.215	0	6308	24,431	3549	8619	571
2010	0.215	0.01	8090	26,274	4371	12,991	618
2011	0.215	0.05	9488	29,940	5155	18,145	700
2012	0.215	0.15	10,956	32,291	5914	24,060	759
2013	0.215	0.26	12,405	34,384	6681	30,741	810
2014	0.215	0.39	13,786	36,153	7402	38,143	853
2015	0.215	0.48	15,067	37,619	8063	46,206	888
2016	0.215	0.56	16,228	38,821	8655	54,861	917
2017	0.215	0.61	17,260	39,801	9174	64,035	941
2018	0.215	0.66	18,163	40,596	9622	73,658	960
2019	0.215	0.7	18,941	41,239	10,004	83,662	976
2020	0.215	0.74	19,605	41,759	10,326	93,988	989
2021	0.215	0.76	20,165	42,179	10,596	104,584	999
2022	0.215	0.78	20,635	42,519	10,820	115,404	1007
2023	0.215	0.8	21,027	42,793	11,006	126,410	1014
2024	0.215	0.81	21,351	43,015	11,159	137,569	1019
2025	0.215	0.82	21,619	43,194	11,284	148,854	1024
2026	0.215	0.83	21,839	43,339	11,387	160,241	1027
2027	0.215	0.84	22,019	43,456	11,471	171,712	1030

Table 3.27. Spanish mackerel: Projection results under $F = 0.199$. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{\text{MSY}}}$, SSB = mid-year spawning stock biomass (mt), R = recruits (1000 fish), L = landings (1000 lb whole weight), Sum L = cumulative landings (1000 lb), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,888	5070	5070	894
2009	0.199	0	6308	24,431	3300	8371	529
2010	0.199	0.01	8195	26,274	4099	12,470	573
2011	0.199	0.06	9667	30,131	4862	17,332	653
2012	0.199	0.17	11,223	32,565	5605	22,936	710
2013	0.199	0.29	12,768	34,730	6360	29,296	758
2014	0.199	0.42	14,246	36,557	7072	36,368	799
2015	0.199	0.53	15,621	38,066	7728	44,096	833
2016	0.199	0.6	16,870	39,300	8316	52,412	861
2017	0.199	0.65	17,983	40,303	8831	61,243	883
2018	0.199	0.71	18,958	41,114	9277	70,520	902
2019	0.199	0.75	19,799	41,770	9657	80,177	917
2020	0.199	0.78	20,516	42,298	9978	90,155	928
2021	0.199	0.8	21,123	42,724	10,246	100,401	938
2022	0.199	0.82	21,632	43,068	10,469	110,870	946
2023	0.199	0.84	22,055	43,346	10,654	121,523	952
2024	0.199	0.85	22,407	43,570	10,805	132,329	957
2025	0.199	0.86	22,696	43,750	10,930	143,259	961
2026	0.199	0.87	22,934	43,896	11,032	154,291	965
2027	0.199	0.88	23,129	44,014	11,116	165,407	967

Table 3.28. Spanish mackerel: Projection results under $F = 0.182$, the fishing mortality needed to make Pr(rebuilding)=0.6 within the recovery time frame. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{\mathrm{MSY}}}$, SSB = mid-year spawning stock biomass (mt), R = recruits (1000 fish), L = landings (1000 lb whole weight), Sum L = cumulative landings (1000 lb), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,888	5070	5070	894
2009	0.182	0	6308	24,431	3034	8104	485
2010	0.182	0.01	8309	26,274	3801	11,906	525
2011	0.182	0.07	9862	30,335	4536	16,442	602
2012	0.182	0.19	11,516	32,857	5256	21,698	656
2013	0.182	0.33	13,167	35,099	5993	27,691	702
2014	0.182	0.46	14,753	36,985	6691	34,382	741
2015	0.182	0.58	16,234	38,539	7335	41,718	773
2016	0.182	0.65	17,584	39,806	7914	49,632	799
2017	0.182	0.7	18,789	40,831	8422	58,054	820
2018	0.182	0.76	19,845	41,659	8862	66,916	837
2019	0.182	0.8	20,758	42,326	9237	76,153	851
2020	0.182	0.82	21,537	42,863	9553	85,706	862
2021	0.182	0.84	22,197	43,295	9818	95,524	871
2022	0.182	0.86	22,750	43,643	10,038	105,563	878
2023	0.182	0.88	23,211	43,923	10,220	115,783	884
2024	0.182	0.89	23,593	44,149	10,370	126,153	889
2025	0.182	0.9	23,908	44,331	10,493	136,647	892
2026	0.182	0.9	24,167	44,478	10,594	147,240	895
2027	0.182	0.91	24,379	44,597	10,676	157,916	898

Table 3.29. Spanish mackerel: Projection results under $F = 0.136$, the fishing mortality needed to make Pr(rebuilding)=0.9 within the recovery time frame. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{\mathrm{MSY}}}$, SSB = mid-year spawning stock biomass (mt)*, R = recruits (1000 fish), L = landings (1000* lb *whole weight), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.*

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,888	5070	5070	894
2009	0.136	0	6308	24,431	2299	7369	364
2010	0.136	0.01	8626	26,274	2949	10,319	394
2011	0.136	0.09	10,414	30,888	3580	13,899	459
2012	0.136	0.25	12,353	33,650	4207	18,106	504
2013	0.136	0.42	14,319	36,094	4859	22,964	541
2014	0.136	0.58	16,231	38,136	5484	28,448	573
2015	0.136	0.68	18,034	39,803	6066	34,514	599
2016	0.136	0.77	19,690	41,150	6591	41,106	620
2017	0.136	0.83	21,177	42,232	7055	48,161	637
2018	0.136	0.87	22,488	43,098	7457	55,617	650
2019	0.136	0.9	23,625	43,792	7800	63,417	661
2020	0.136	0.92	24,599	44,346	8090	71,507	670
2021	0.136	0.93	25,426	44,791	8333	79,839	676
2022	0.136	0.94	26,120	45,148	8535	88,374	682
2023	0.136	0.95	26,700	45,434	8702	97,076	686
2024	0.136	0.95	27,181	45,664	8840	105,916	690
2025	0.136	0.95	27,578	45,849	8953	114,868	693
2026	0.136	0.96	27,904	45,998	9045	123,913	695
2027	0.136	0.96	28,172	46,119	9121	133,034	697

Table 3.30. Parameter, benchmark, and status estimates from base and sensitivity runs of the surplus production model applied to spanish mackerel. Runs are defined by the objective function (LS=Least Squares, LAV=Least Absolute Values) and by B_1/K fixed or estimated.

Run	Obj. Fcn.	B_1/K	K (lb)	r	MSY (lb)	F_{MSY}	B_{MSY} (lb)	B/MSST	F/F_{MSY}
LAV.B1K.5	LAV	0.50 (fixed)	4.32E+08	0.13	1.44E+07	0.07	2.16E+08	2.46	0.21
base	LAV	0.76 (est.)	3.02E+08	0.16	1.24E+07	0.08	1.51E+08	2.47	0.25
SSE.B1K.5	LS	0.50 (fixed)	2.06E+08	0.31	1.57E+07	0.16	1.03E+08	2.77	0.17
SSE.B1K.est	LS	0.73 (est.)	8.50E+07	0.76	1.60E+07	0.38	4.25E+07	2.80	0.17

3.5.2 Figures

Figure 3.1. Spanish mackerel: Likelihood tradeoff between length compositions and age compositions. A decreasing likelihood indicates a better fit, while an increasing likelihood indicates a worse fit.

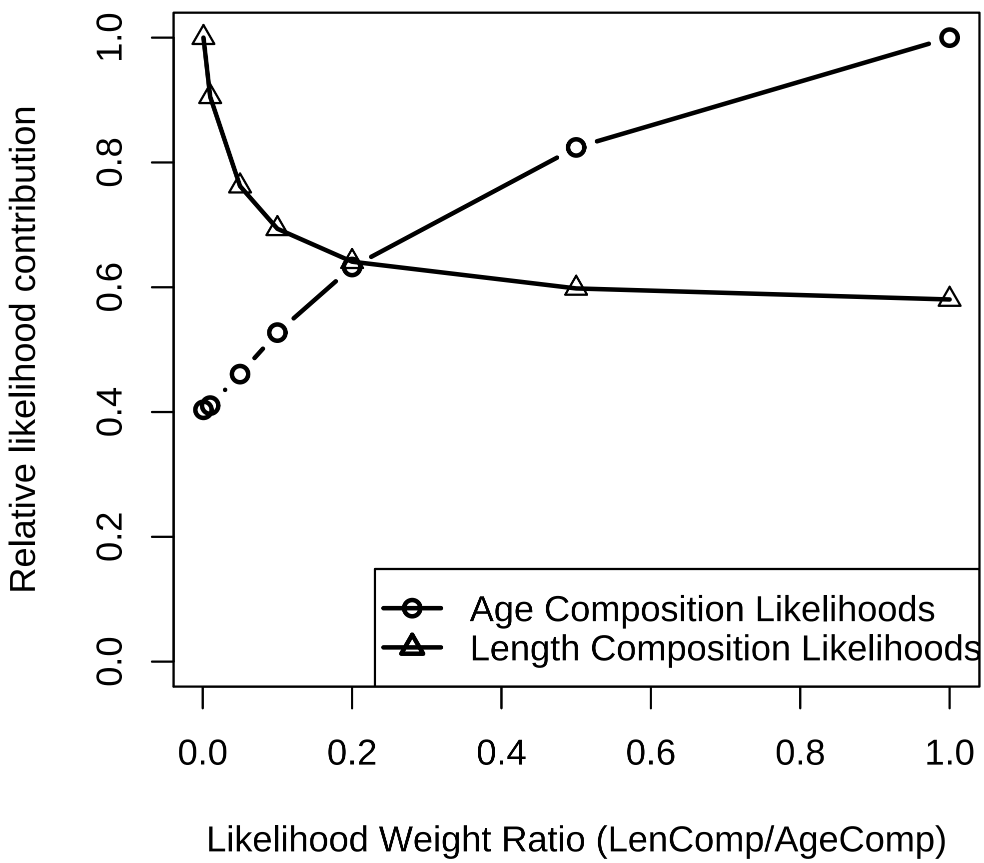


Figure 3.2. Spanish mackerel: Likelihood tradeoff between relative abundance indices and age/length compositions. A decreasing likelihood indicates a better fit, while an increasing likelihood indicates a worse fit.

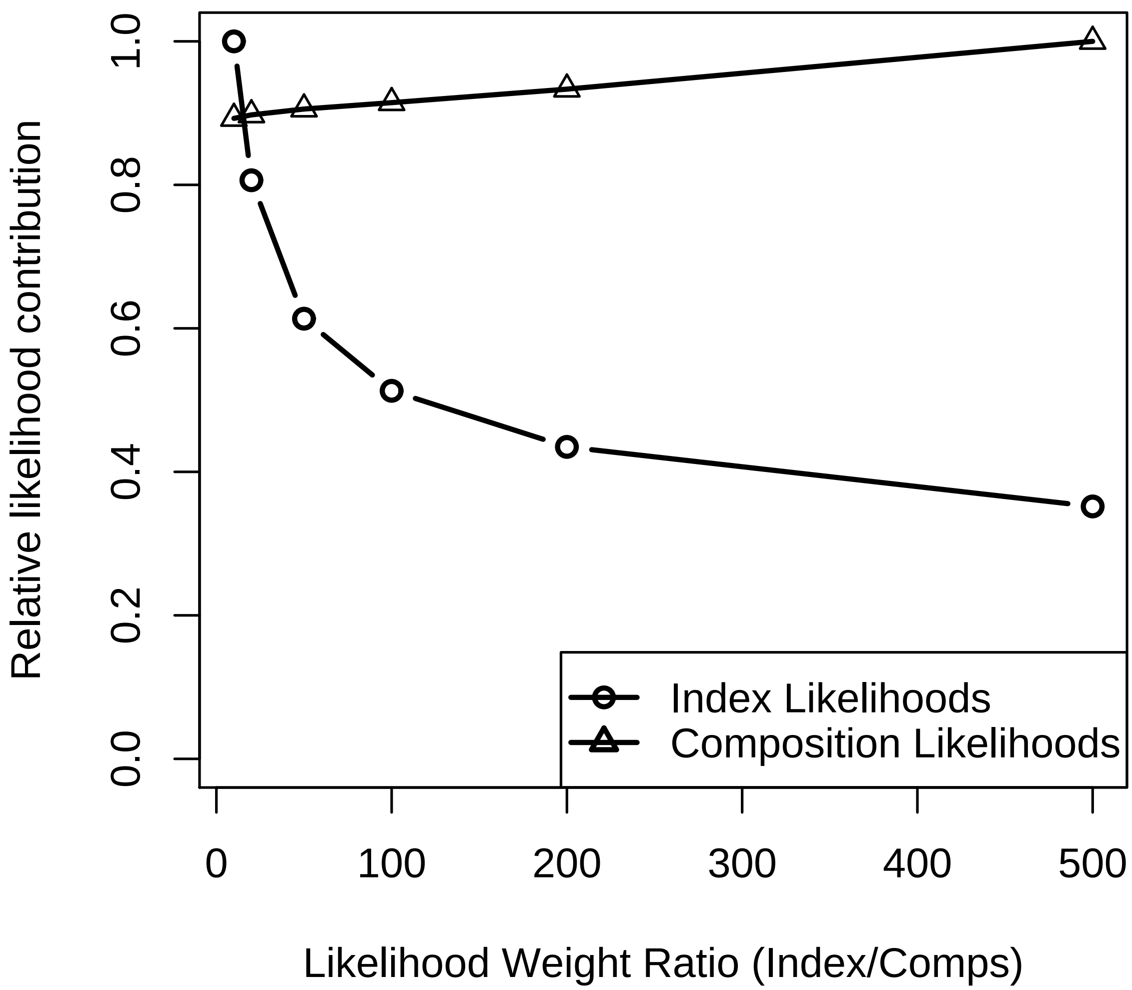


Figure 3.3. Spanish mackerel: Likelihood tradeoff between relative abundance indices and age compositions. A decreasing likelihood indicates a better fit, while an increasing likelihood indicates a worse fit.

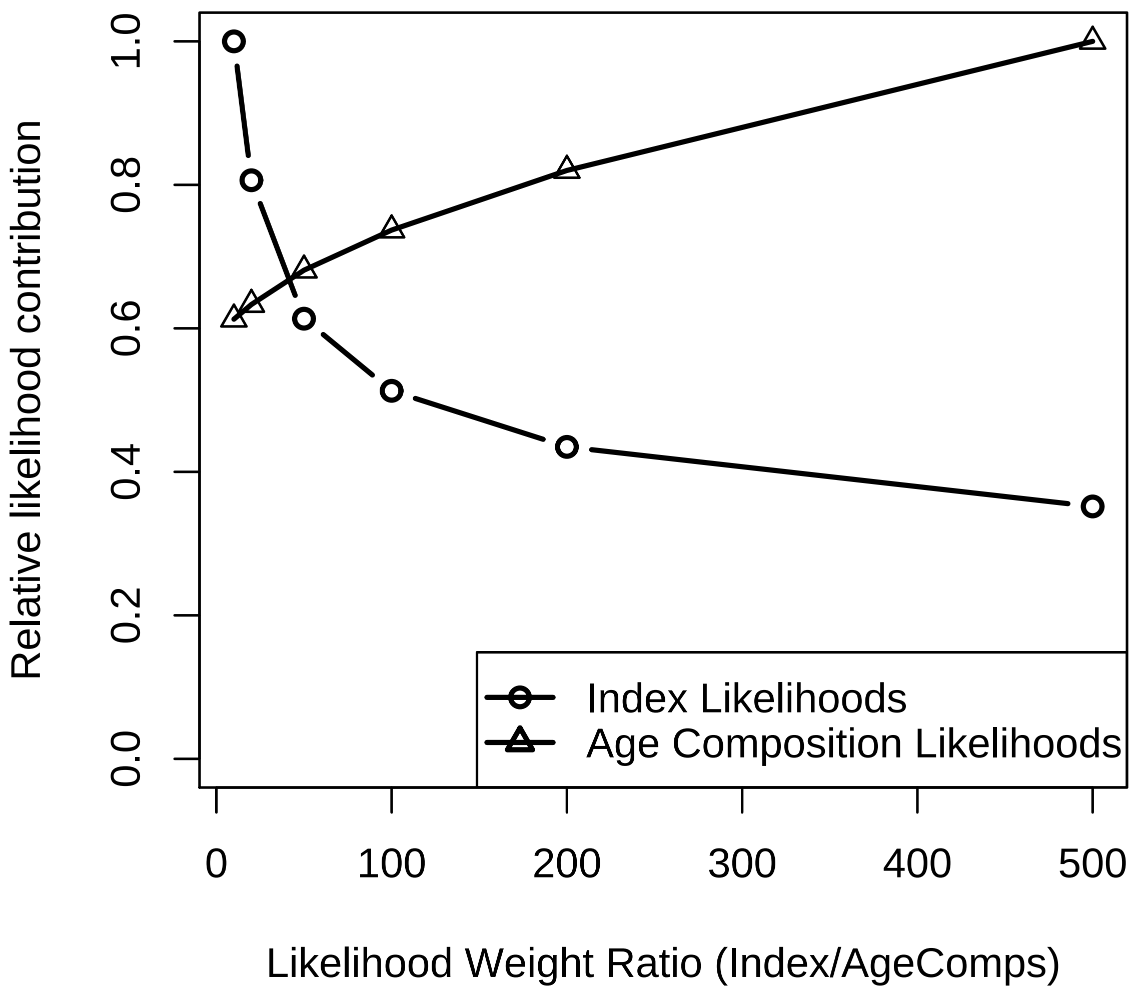


Figure 3.4. Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery. In panels indicating the data set, lcomp refers to length compositions, acomp to age compositions, HL to commercial handlines, GN to commercial gillnet, CN to commercial castnet, PN to commercial poundnet, and MRFSS to general recreational.

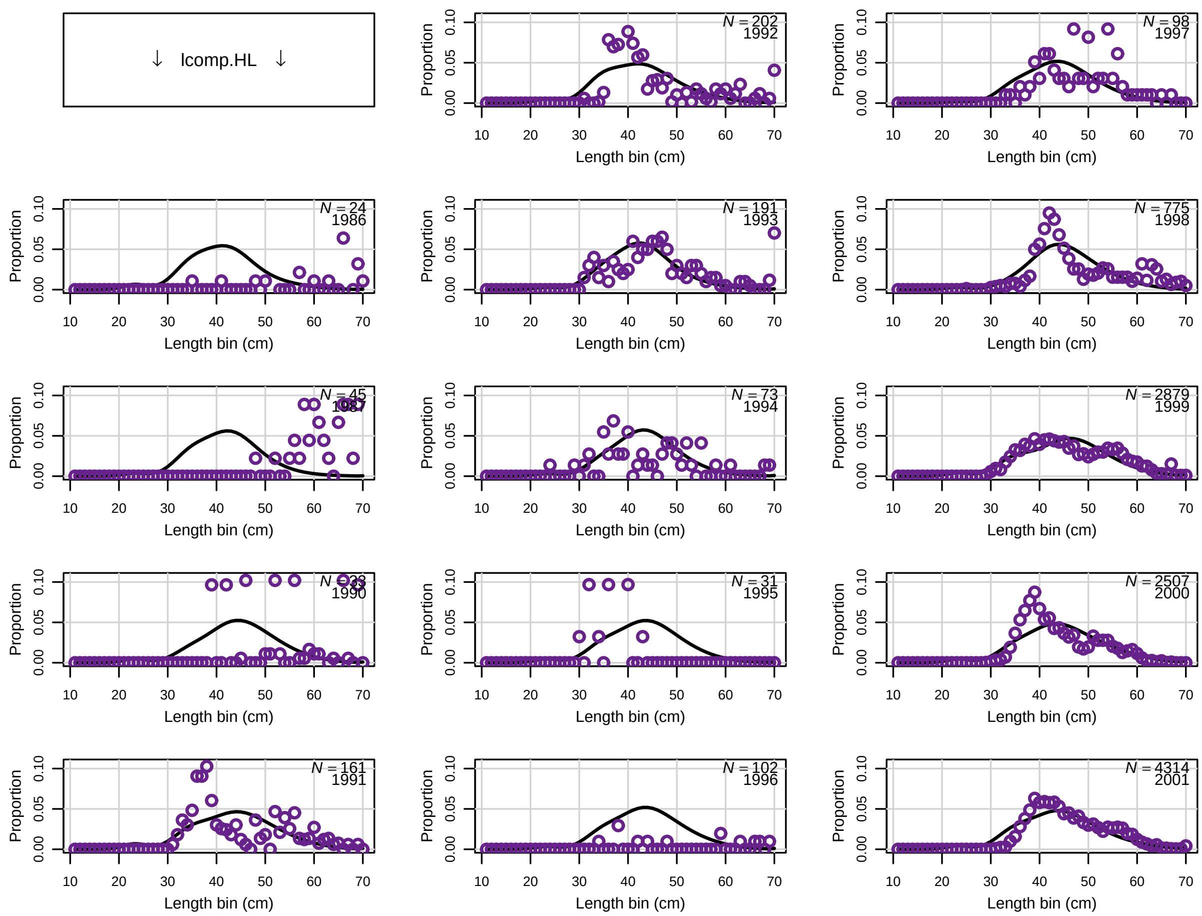


Figure 3.4. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

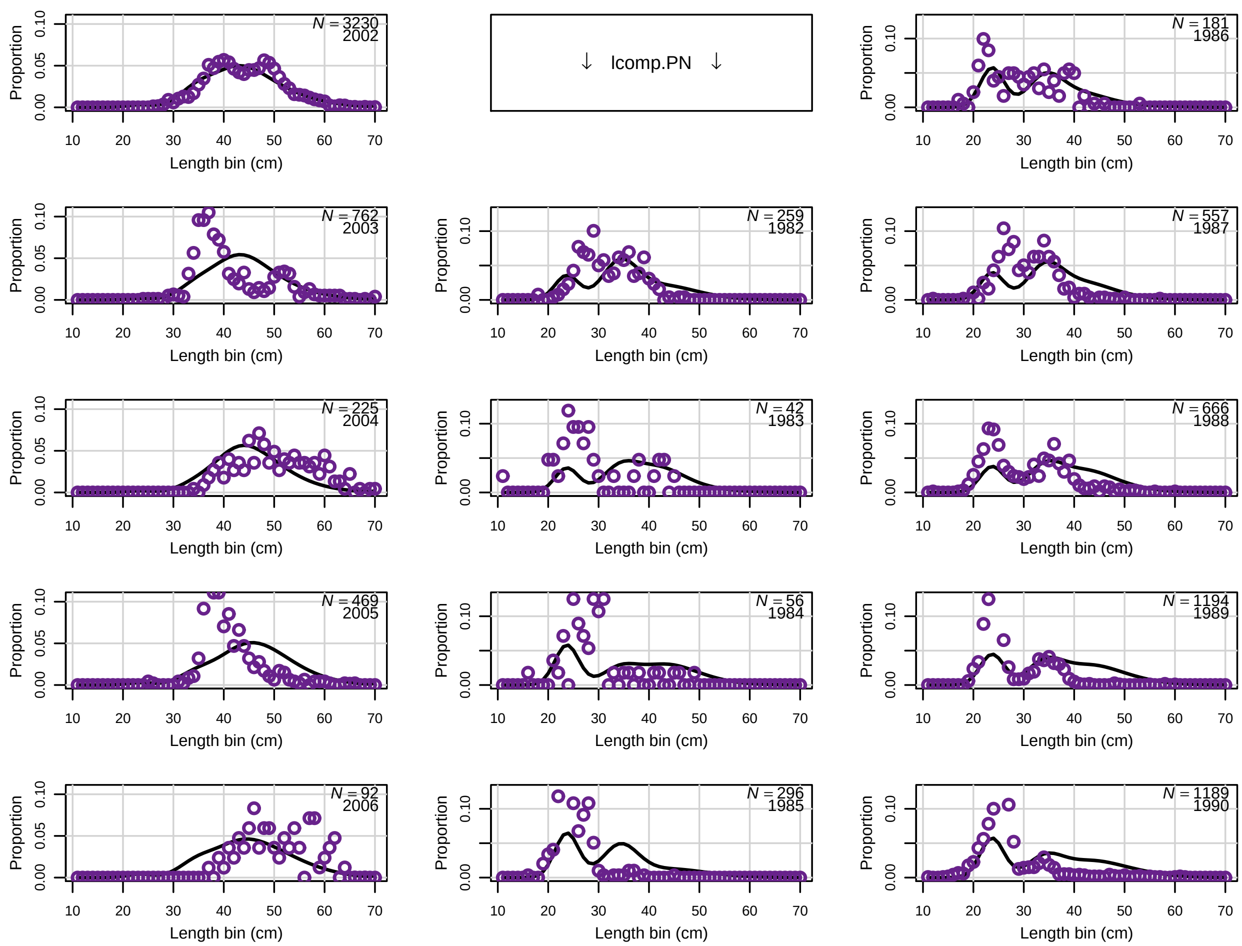


Figure 3.4. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

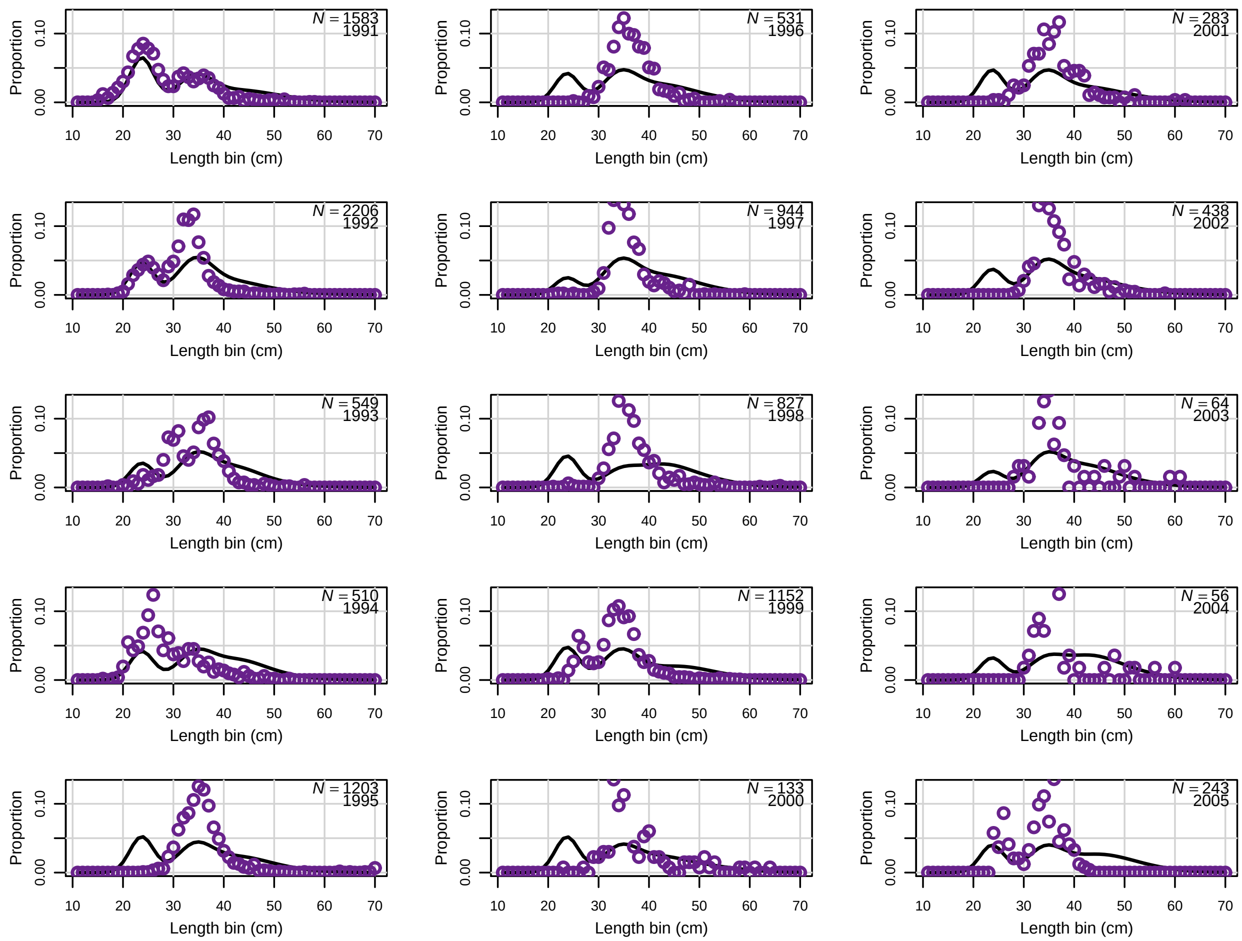


Figure 3.4. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

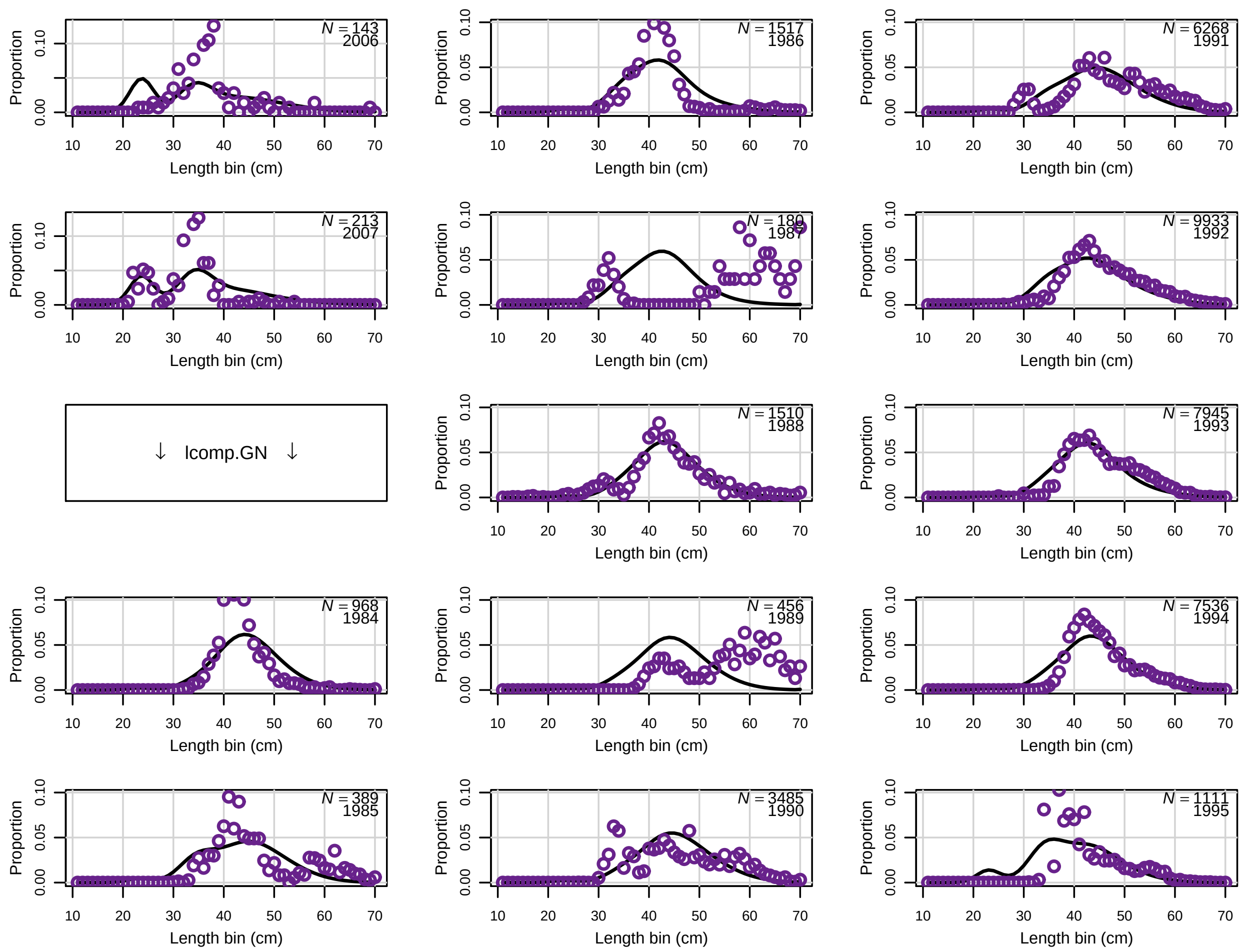


Figure 3.4. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

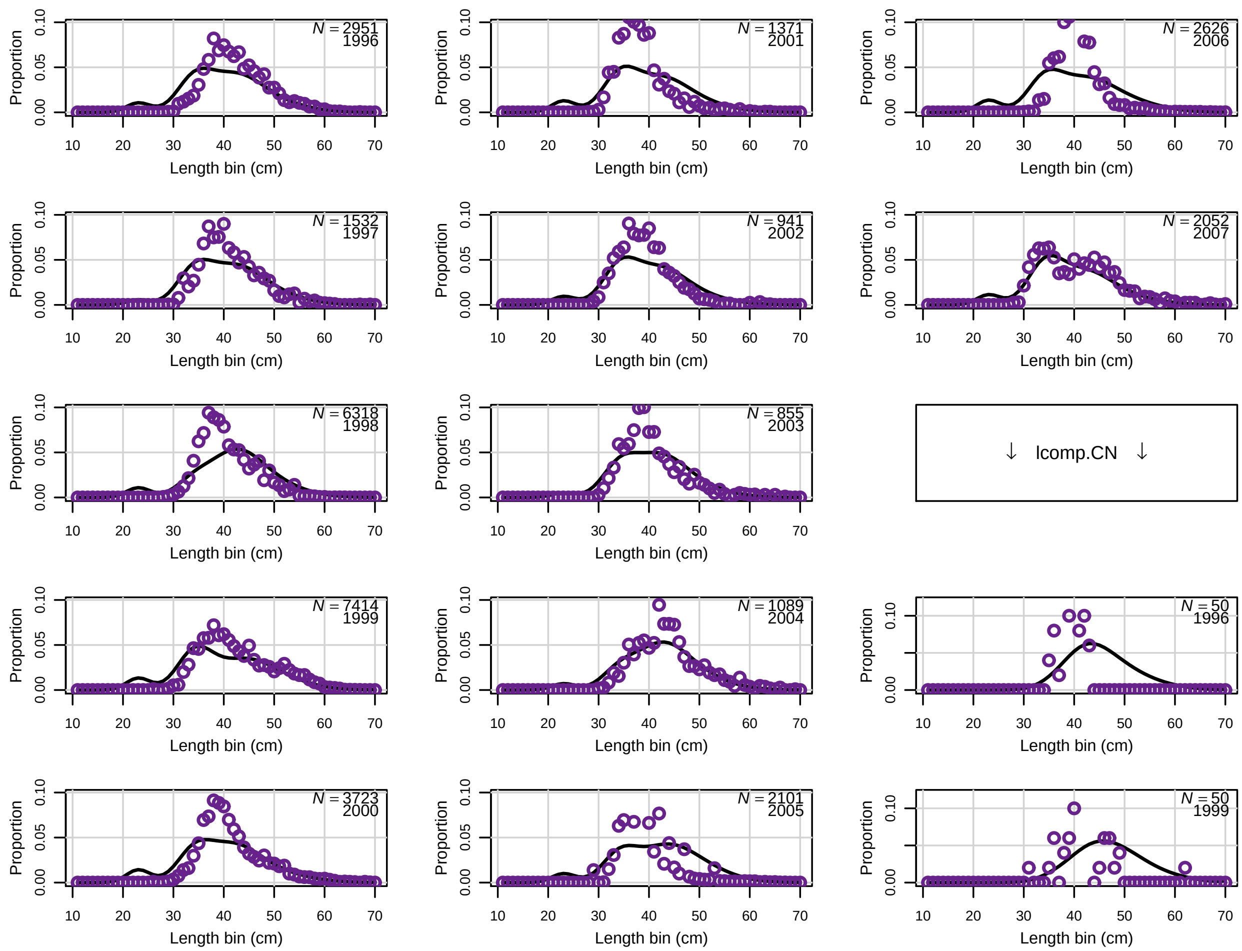


Figure 3.4. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

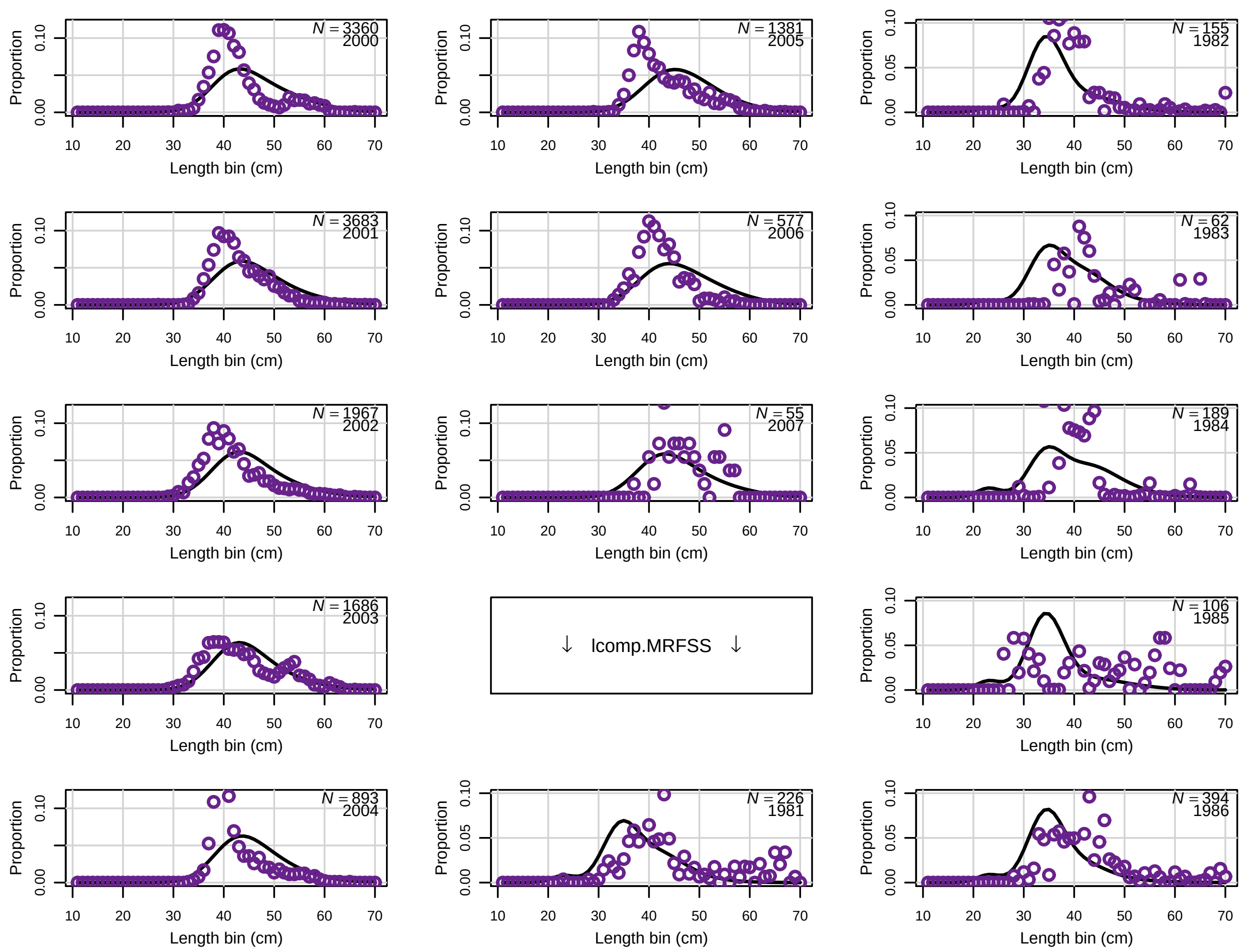


Figure 3.4. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

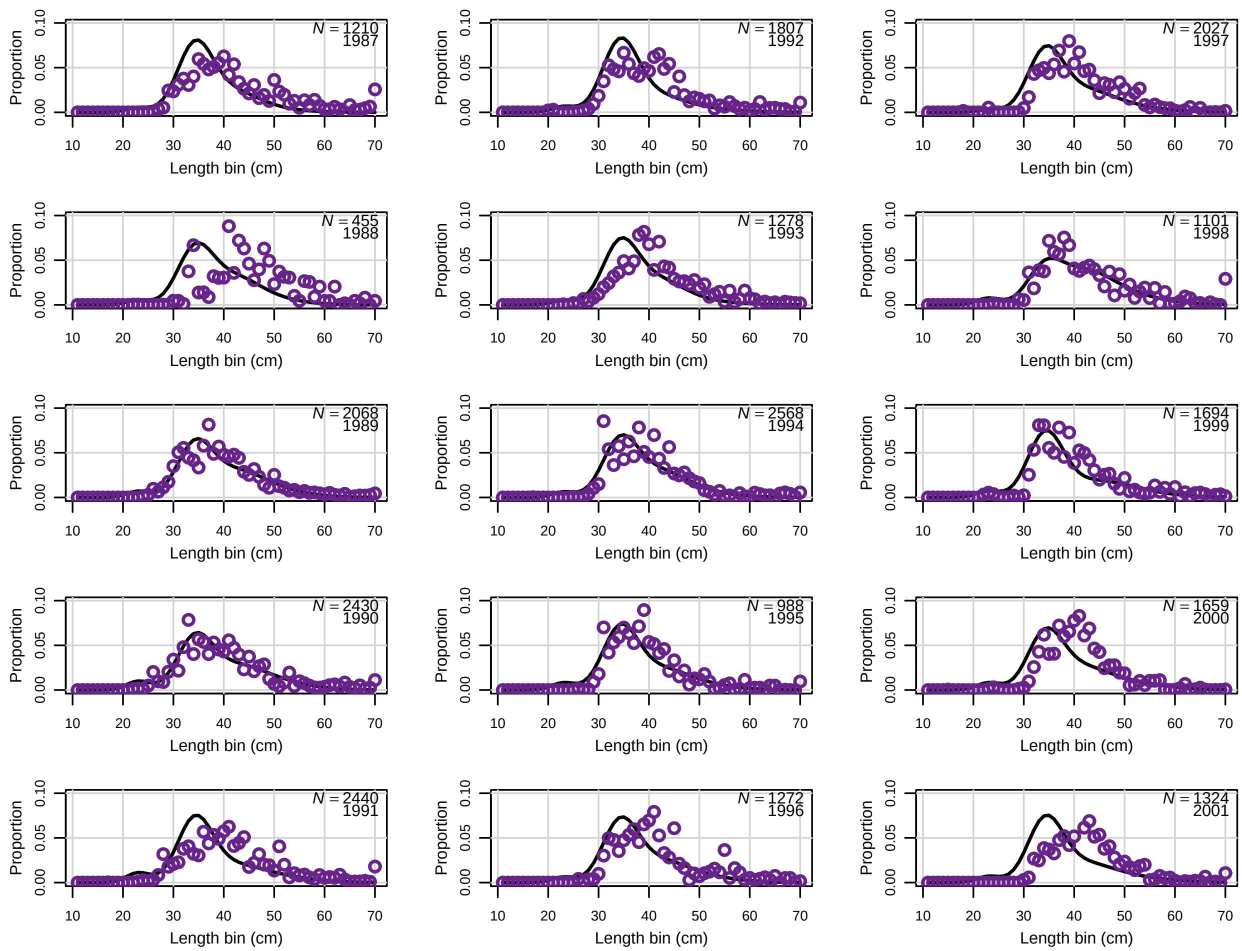


Figure 3.4. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

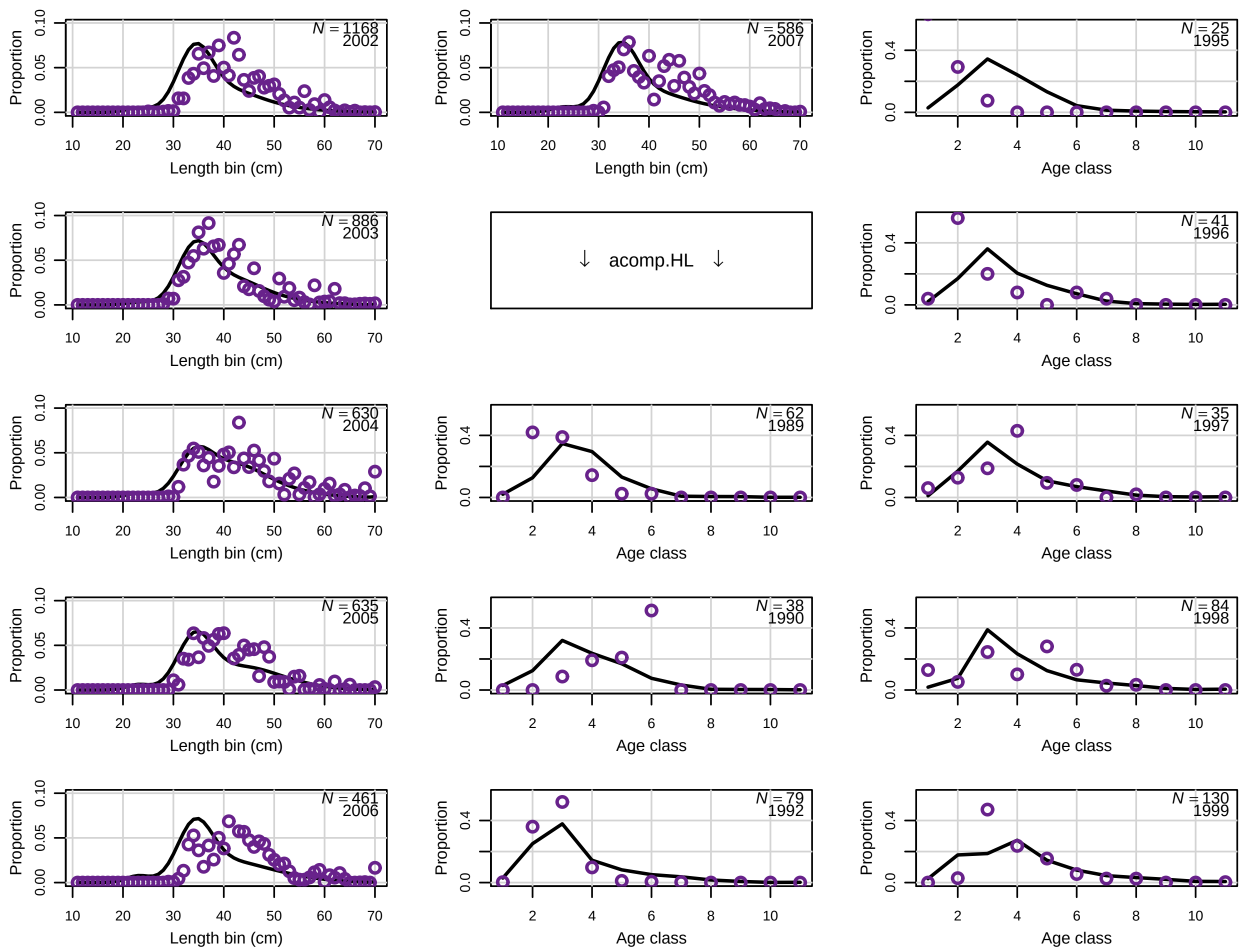


Figure 3.4. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

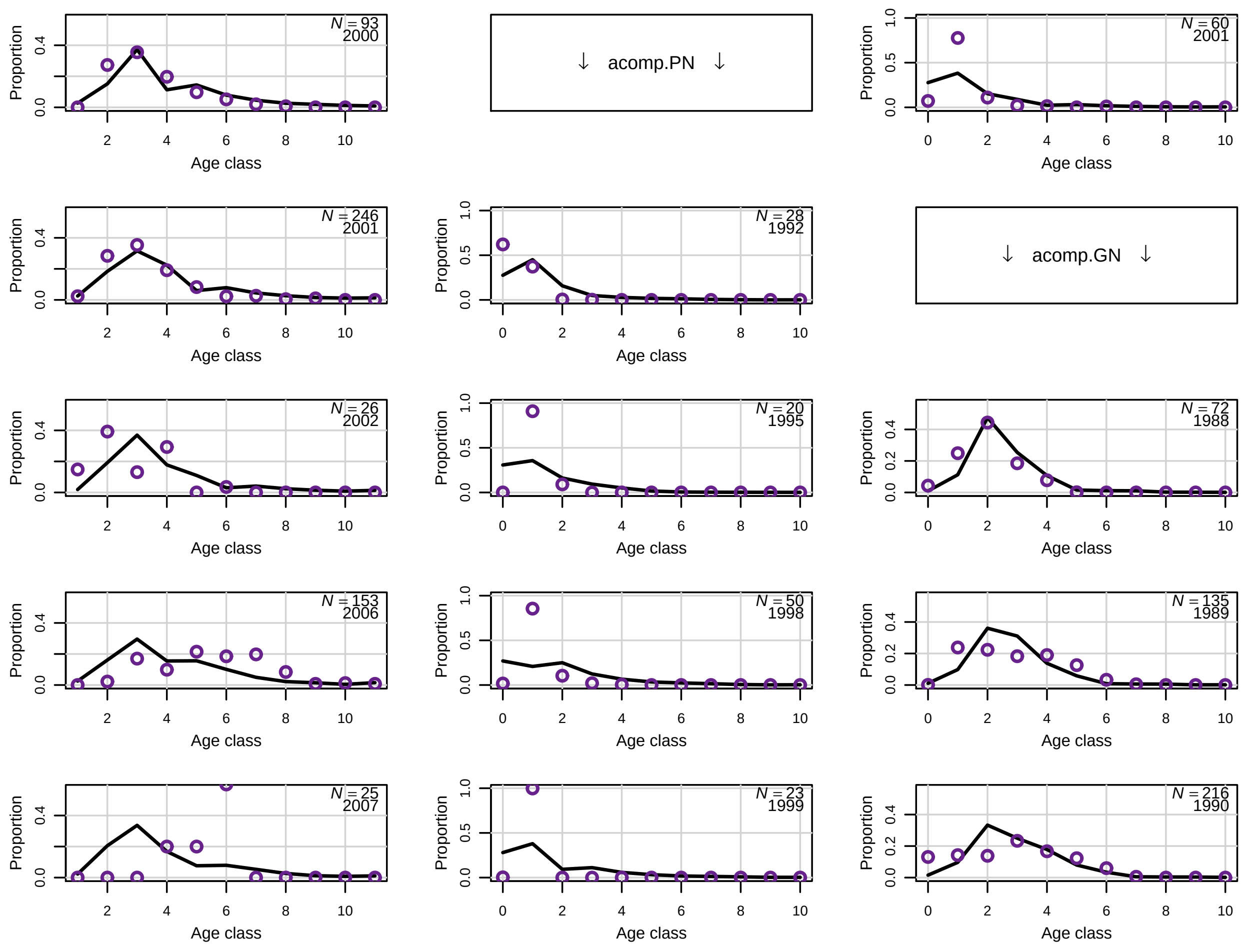


Figure 3.4. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

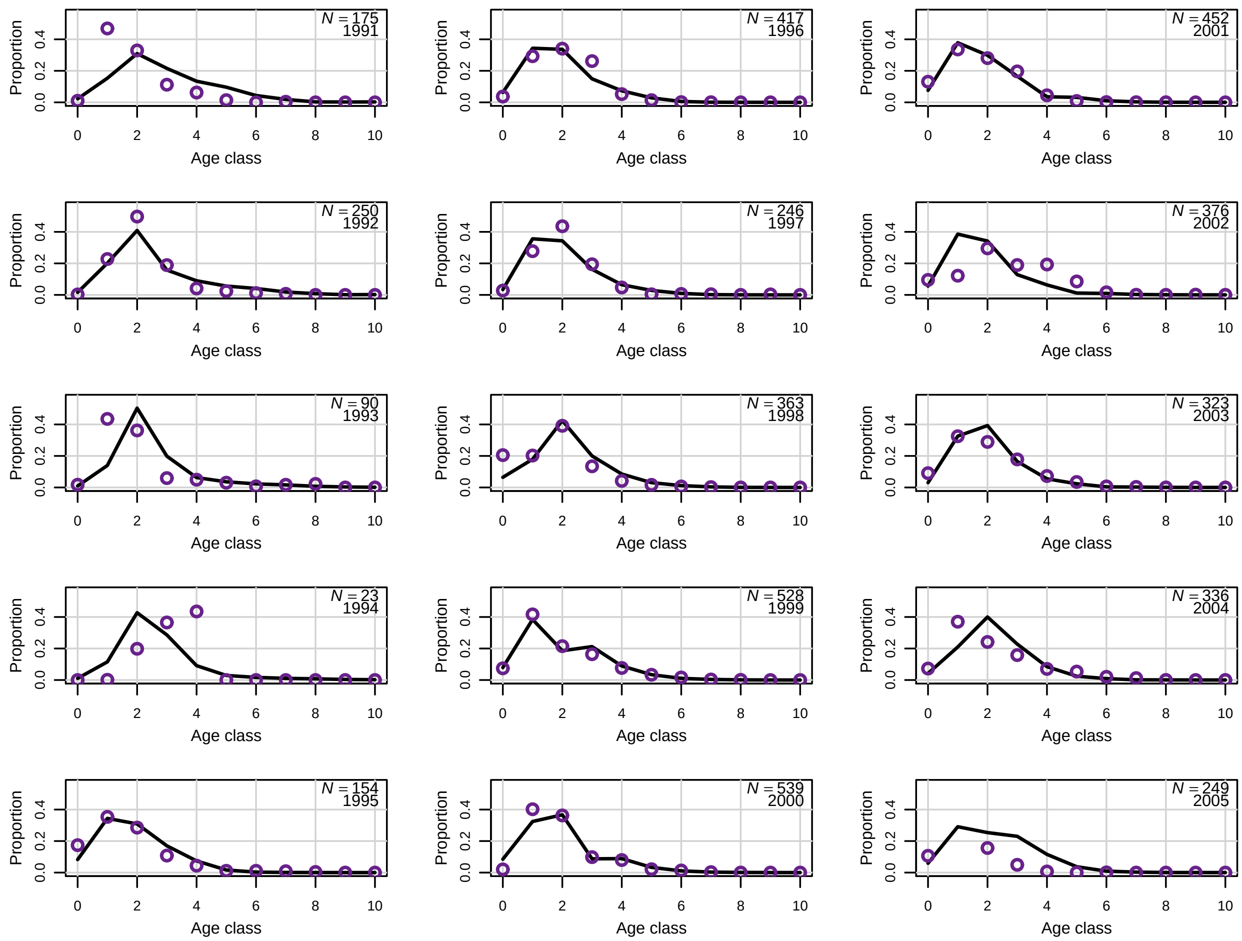


Figure 3.4. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

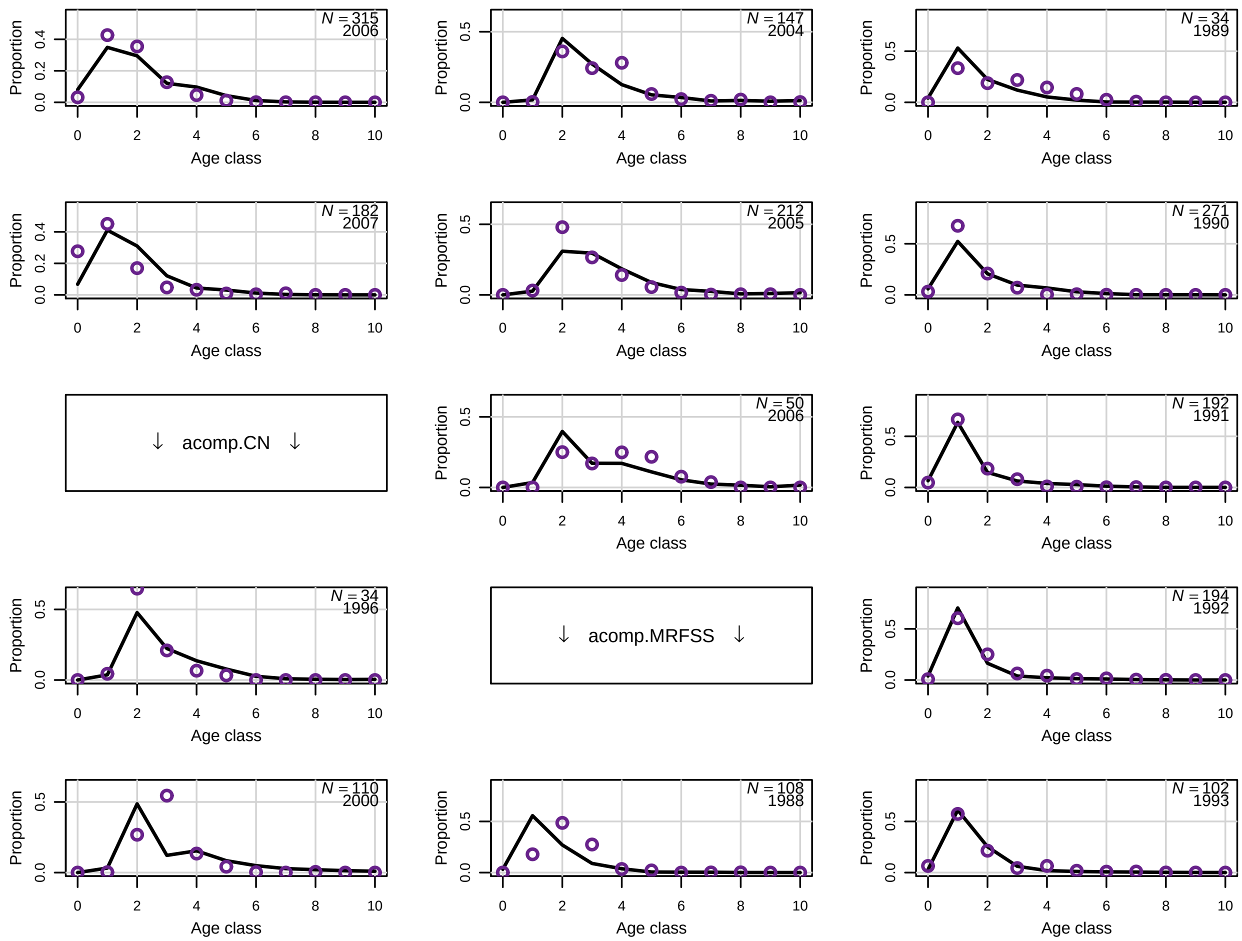


Figure 3.4. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

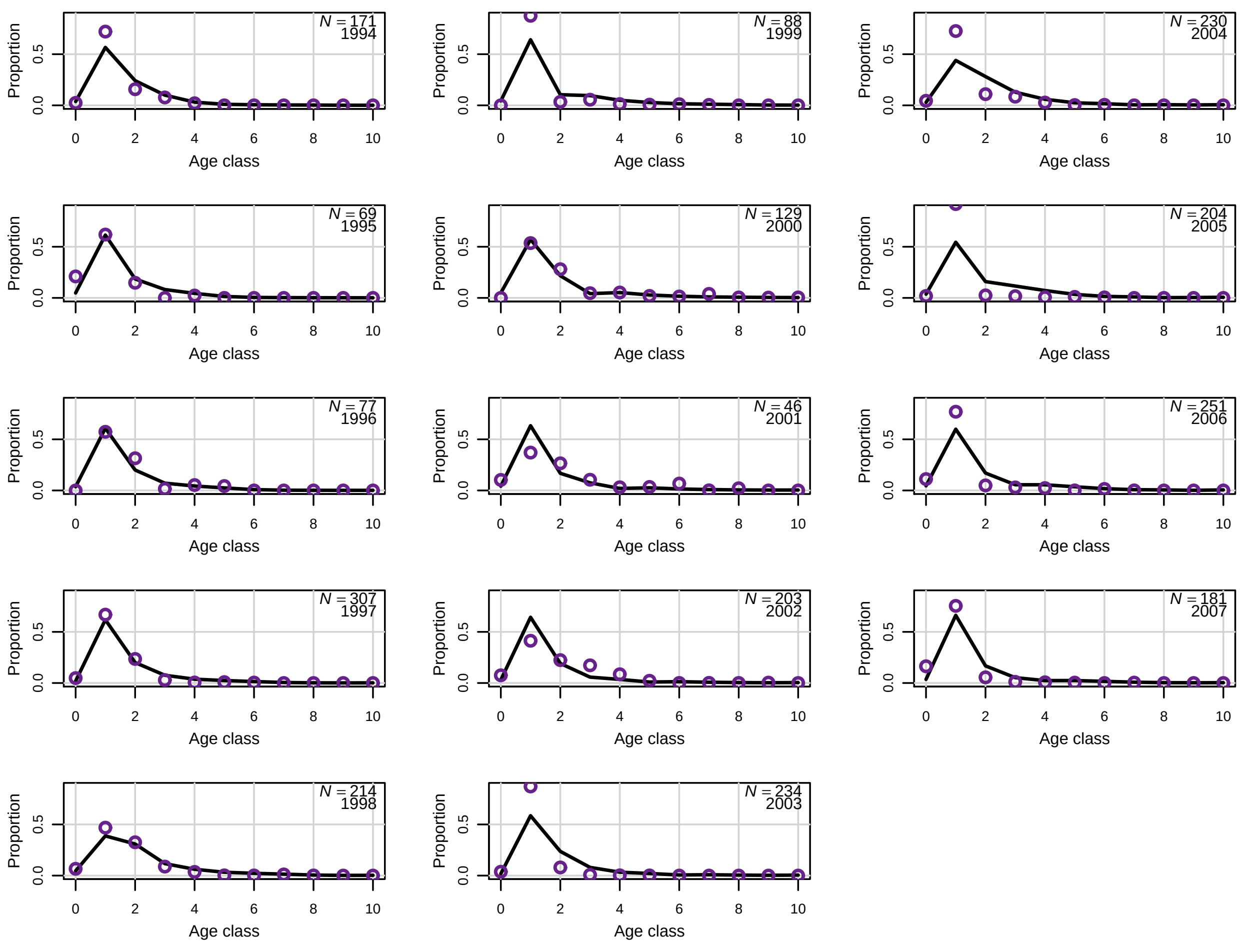


Figure 3.5. Spanish mackerel: Top panel is a bubble plot of length composition residuals from the commercial handline fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

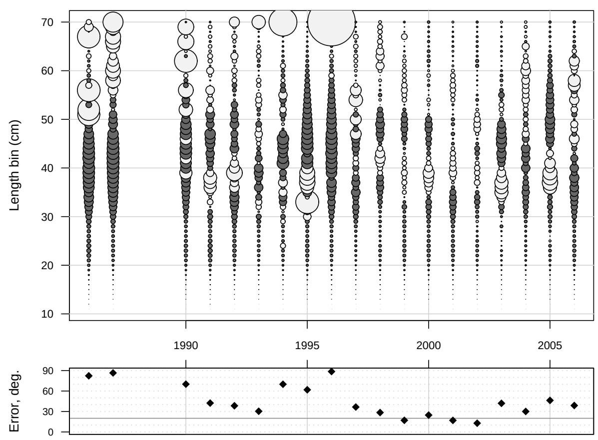


Figure 3.6. Spanish mackerel: Top panel is a bubble plot of length composition residuals from the commercial gillnet fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

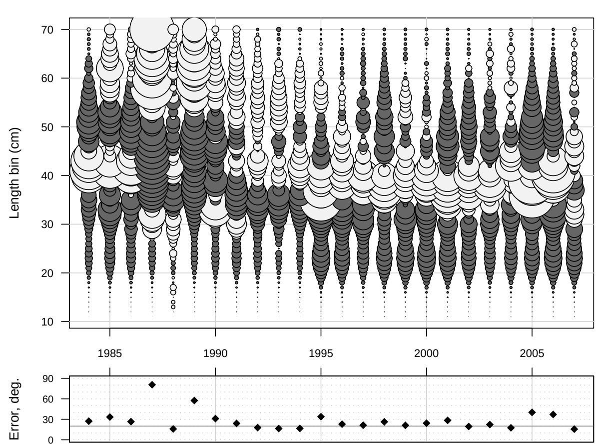


Figure 3.7. Spanish mackerel: Top panel is a bubble plot of length composition residuals from the commercial poundnet fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

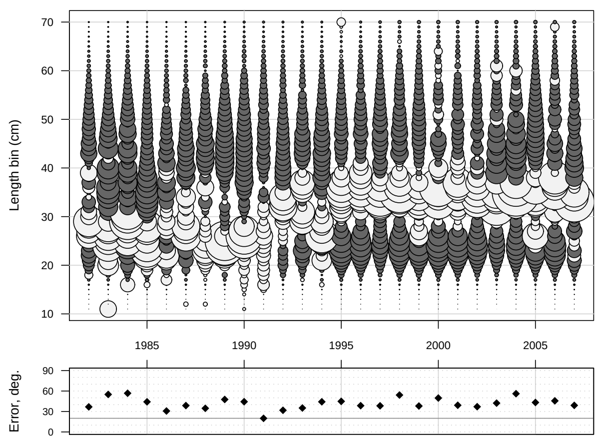


Figure 3.8. Spanish mackerel: Top panel is a bubble plot of length composition residuals from the commercial castnet fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

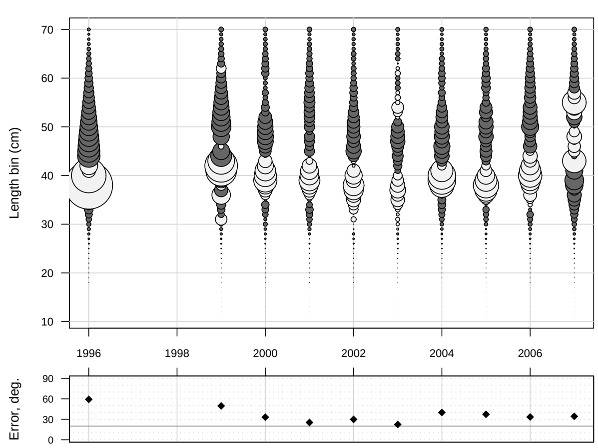


Figure 3.9. Spanish mackerel: Top panel is a bubble plot of length composition residuals from the recreational fishery (MRFSS); Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

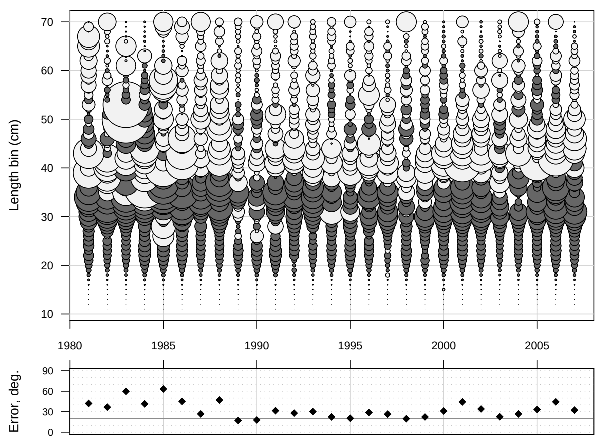


Figure 3.10. Spanish mackerel: Top panel is a bubble plot of age composition residuals from the commercial handlines fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

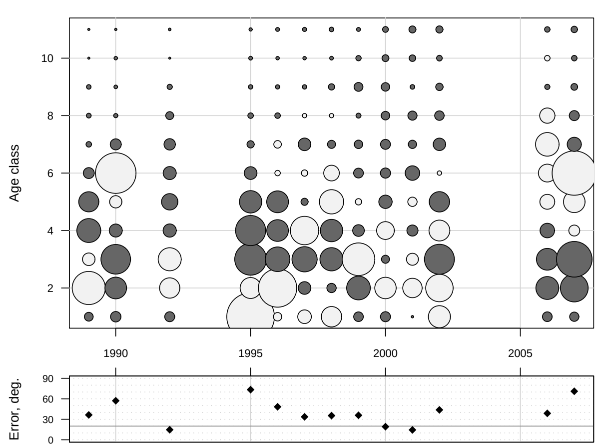


Figure 3.11. Spanish mackerel: Top panel is a bubble plot of age composition residuals from the commercial gillnet fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

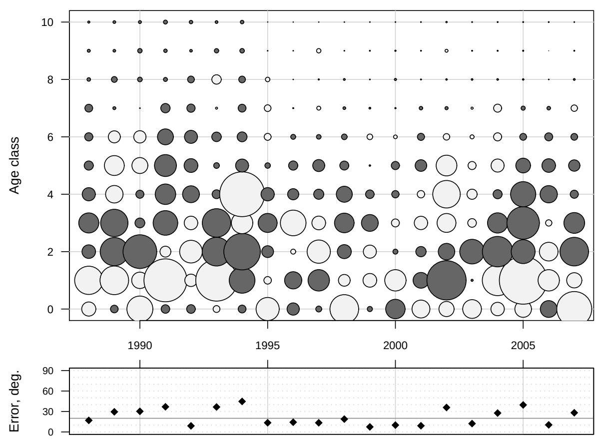


Figure 3.12. Spanish mackerel: Top panel is a bubble plot of age composition residuals from the poundnet fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

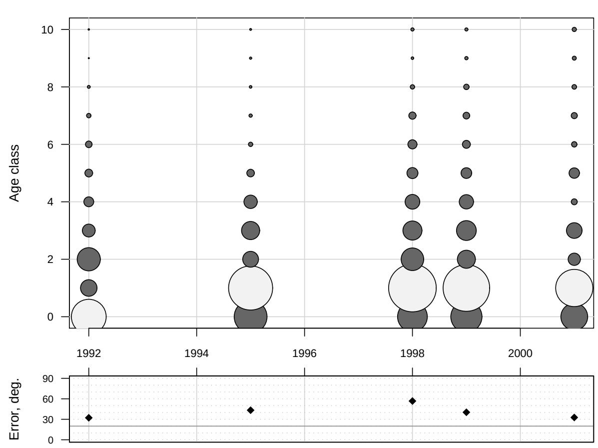


Figure 3.13. Spanish mackerel: Top panel is a bubble plot of age composition residuals from the castnet fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

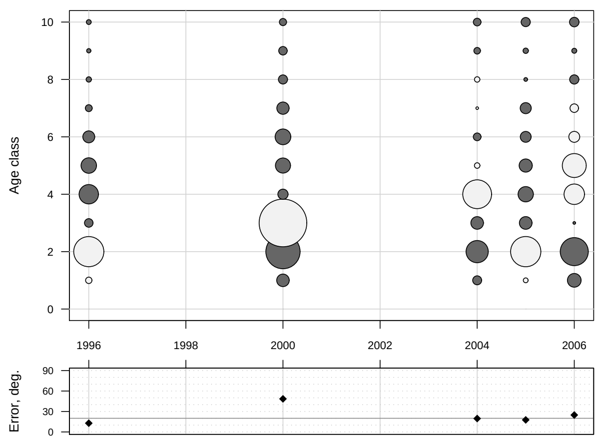


Figure 3.14. Spanish mackerel: Top panel is a bubble plot of age composition residuals from the recreational fishery (MRFSS); Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

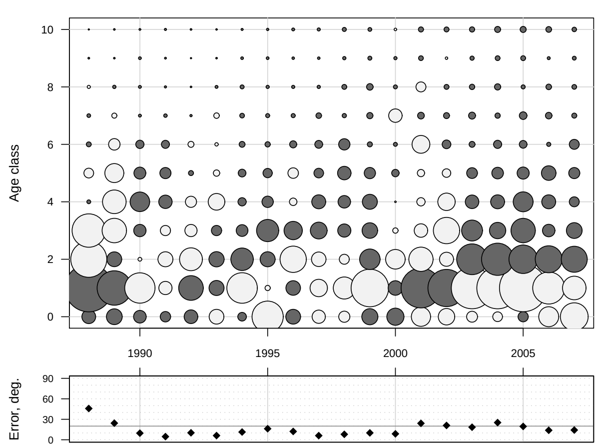


Figure 3.15. Spanish mackerel: Observed (open circles) and estimated (solid line, circles) commercial handlines landings (whole weight). Open and closed circles are indistinguishable.

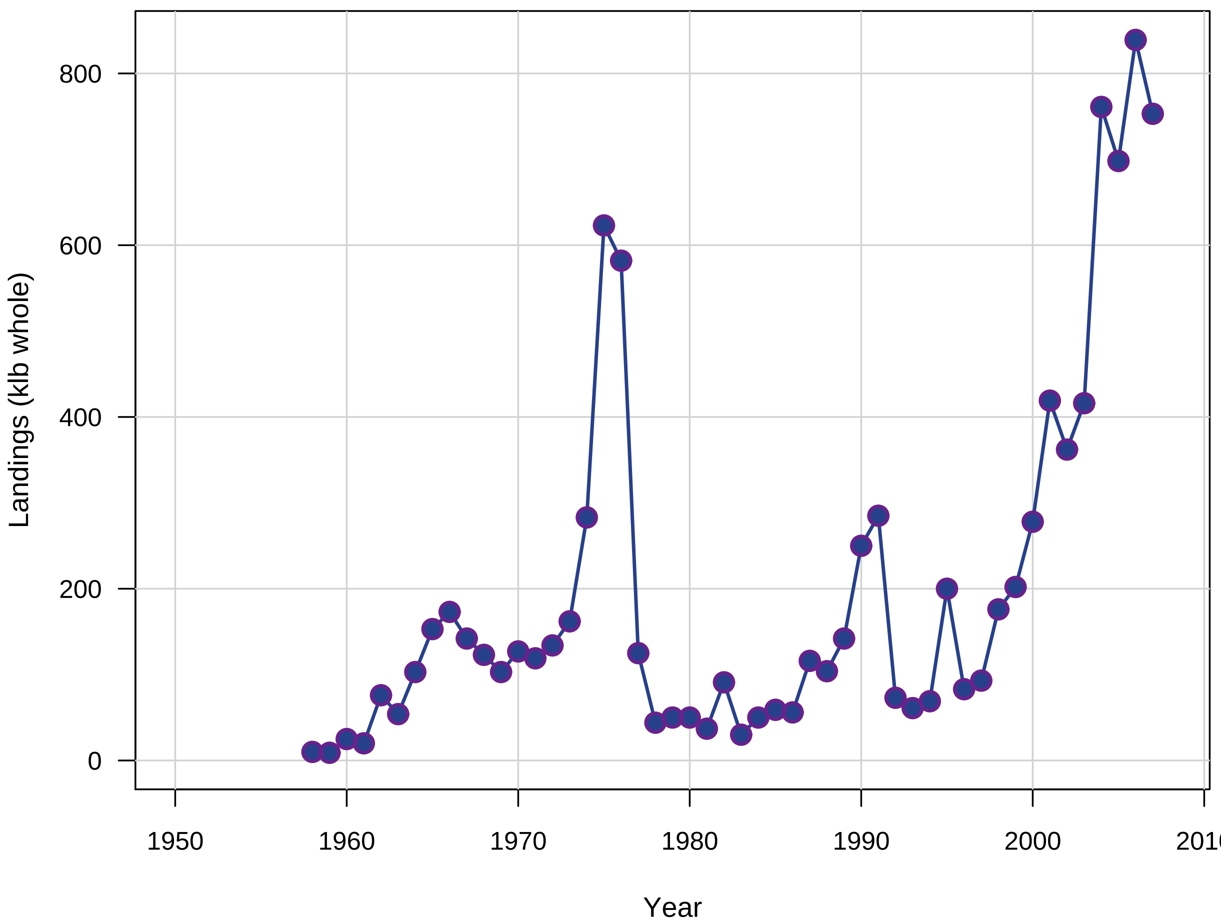


Figure 3.16. Spanish mackerel: Observed (open circles) and estimated (solid line, circles) commercial gillnet landings (whole weight). Open and closed circles are indistinguishable.

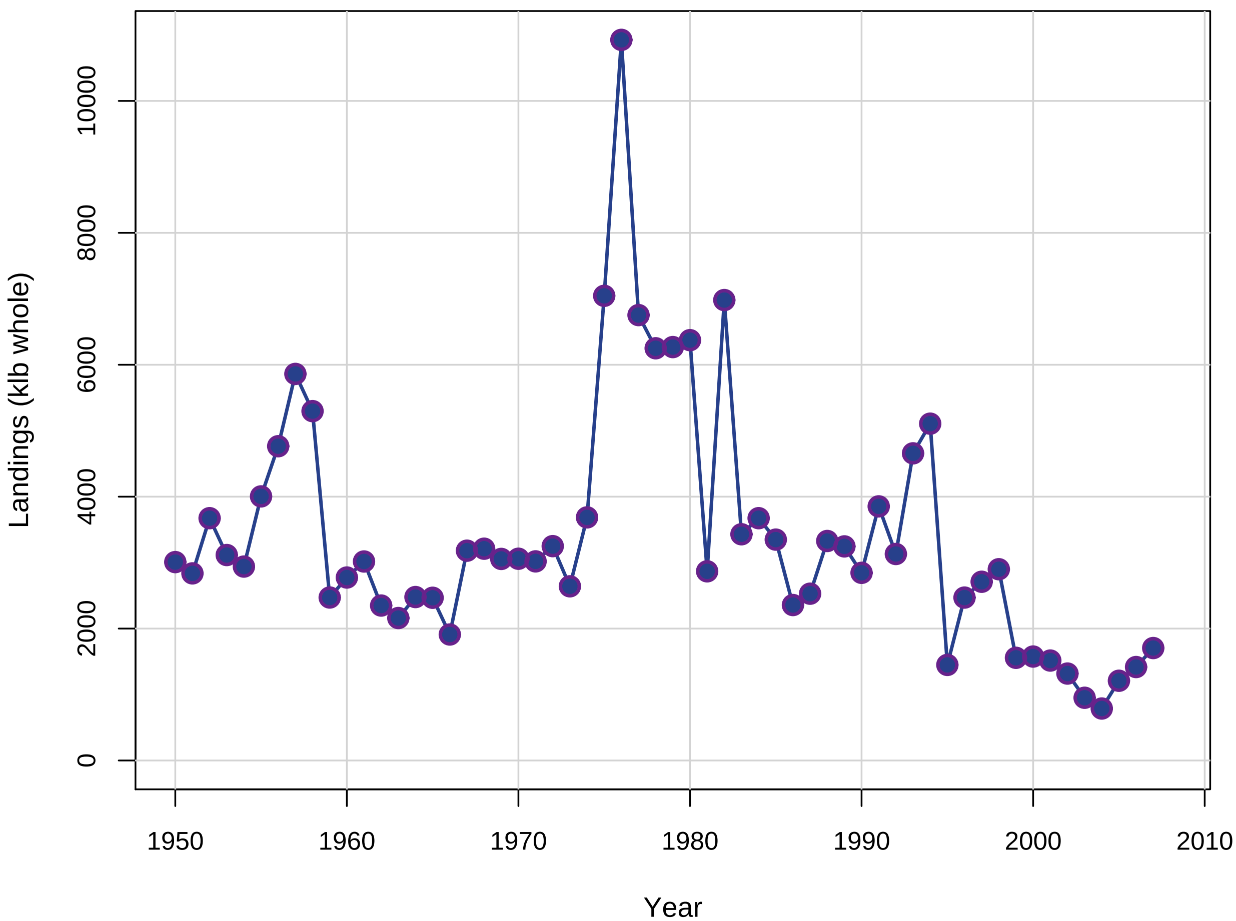


Figure 3.17. Spanish mackerel: Observed (open circles) and estimated (solid line, circles) commercial poundnet landings (whole weight). Open and closed circles are indistinguishable.

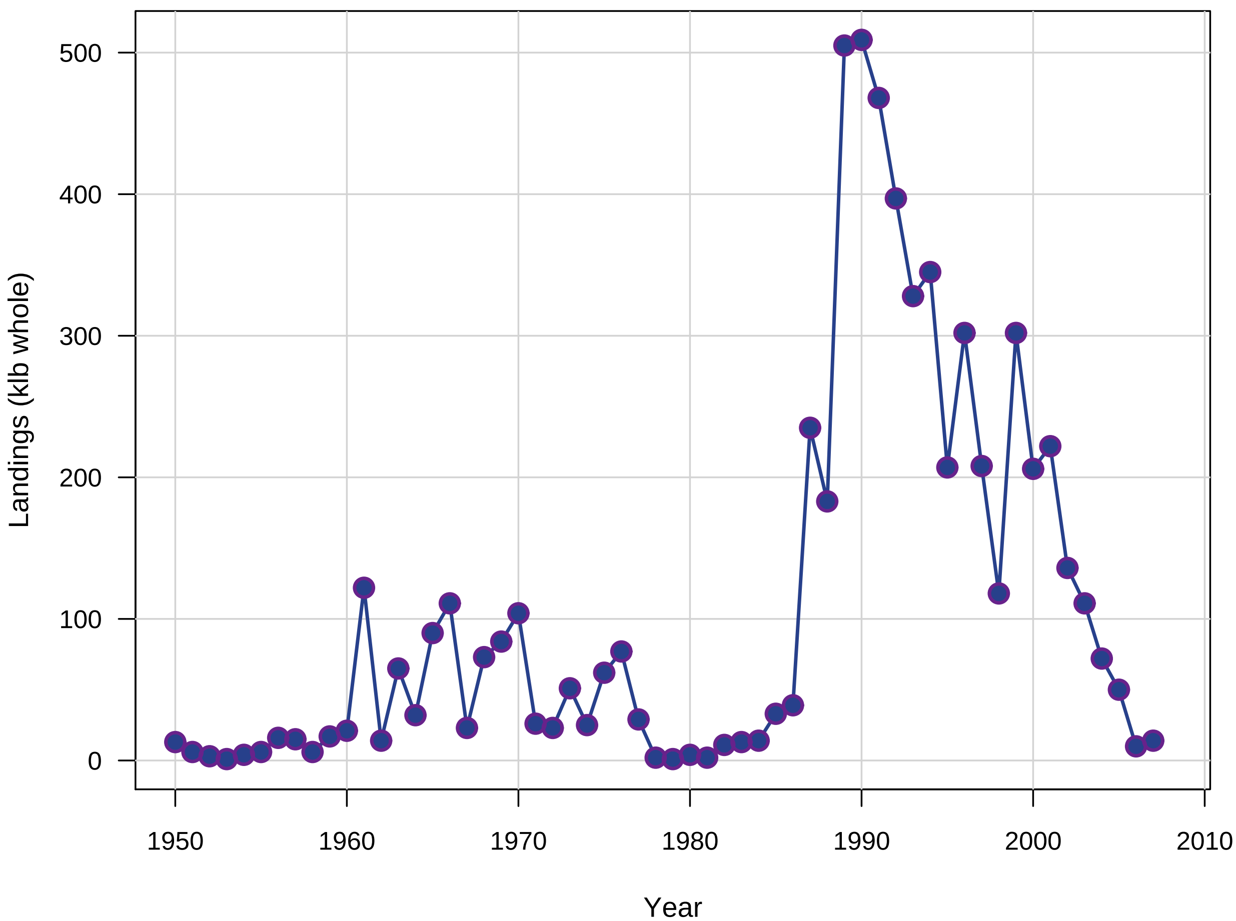


Figure 3.18. Spanish mackerel: Observed (open circles) and estimated (solid line, circles) commercial castnet landings (whole weight). Open and closed circles are indistinguishable.

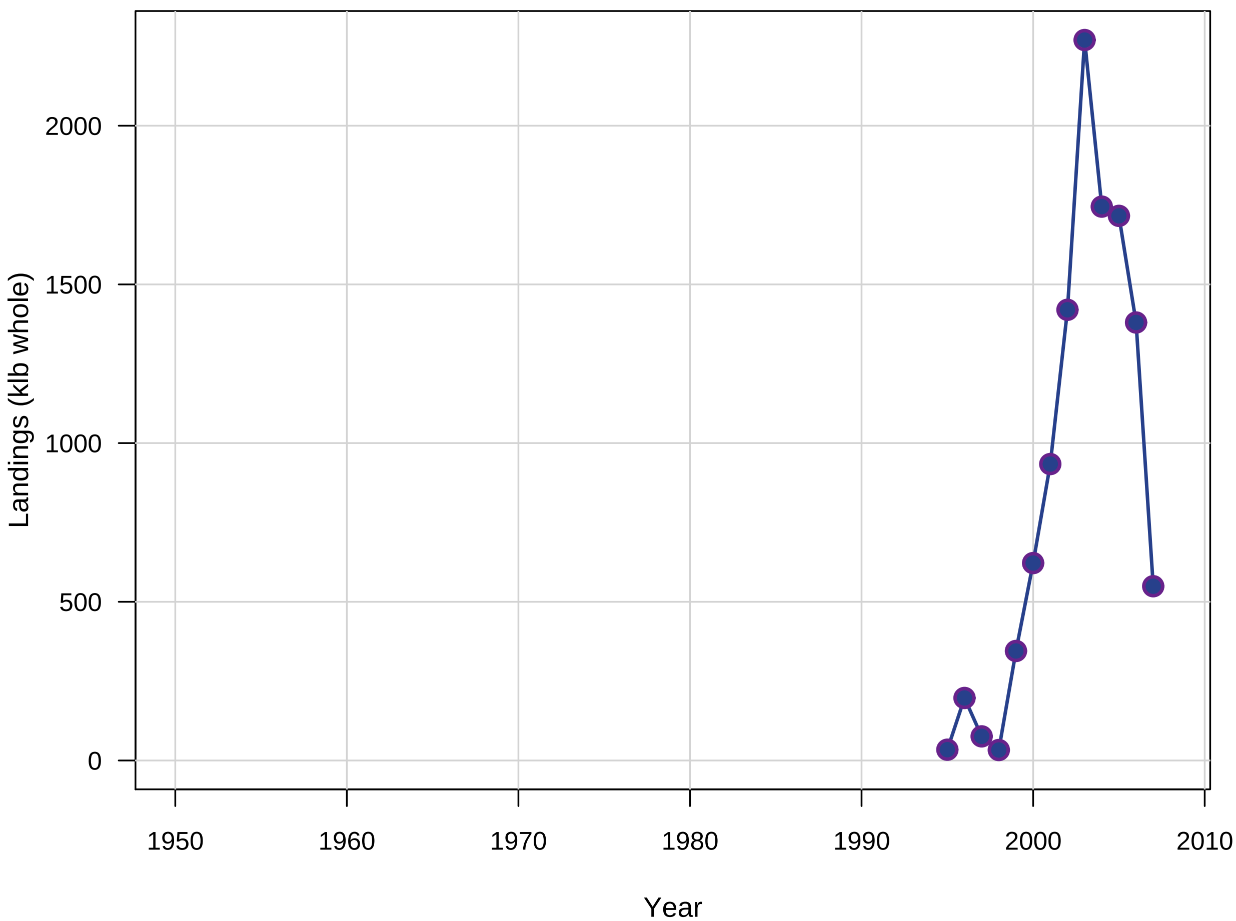


Figure 3.19. Spanish mackerel: Observed (open circles) and estimated (solid line, circles) general recreational landings (whole weight). Open and closed circles are indistinguishable.

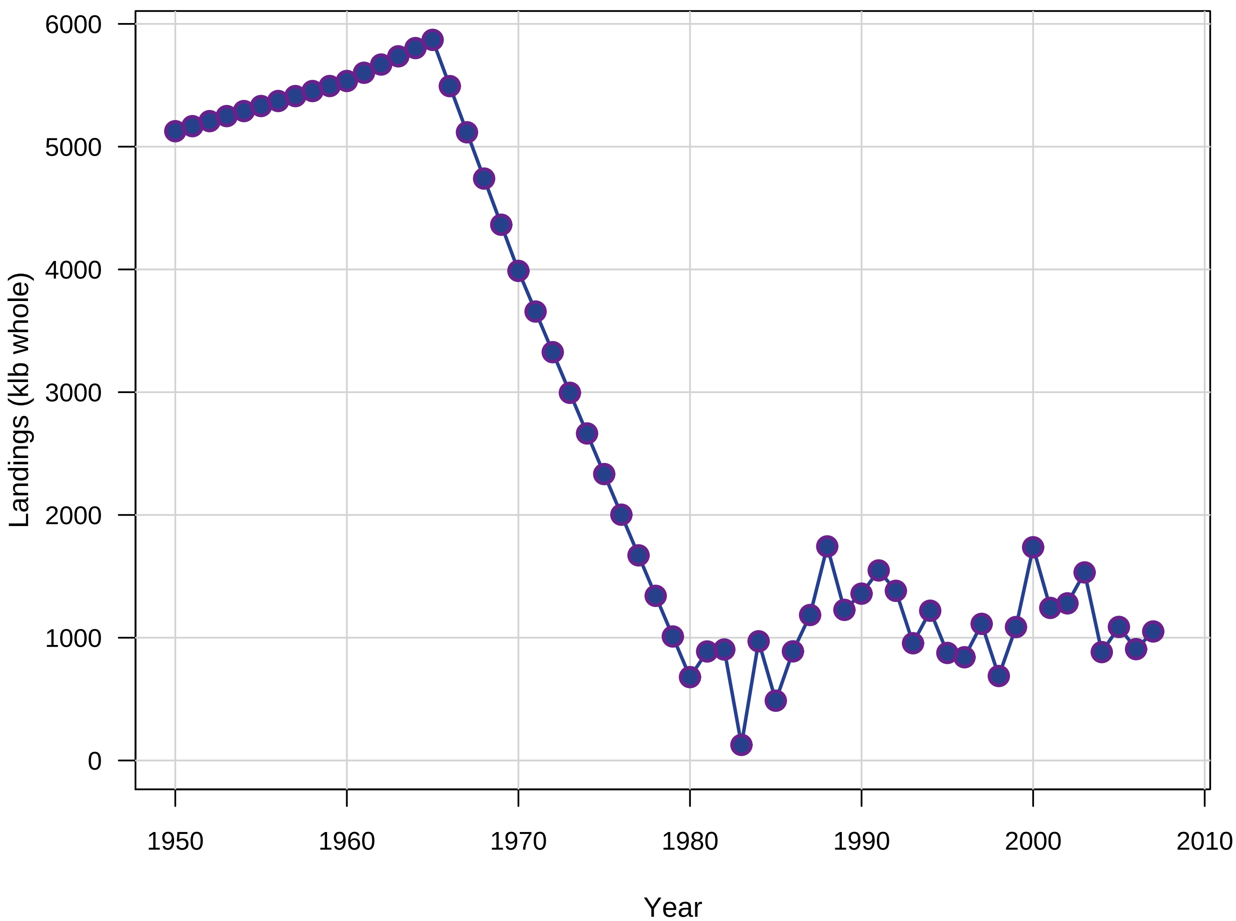


Figure 3.20. Spanish mackerel: Observed (open circles) and estimated (solid line, circles) commercial handline discard mortalities. Open and closed circles are indistinguishable.

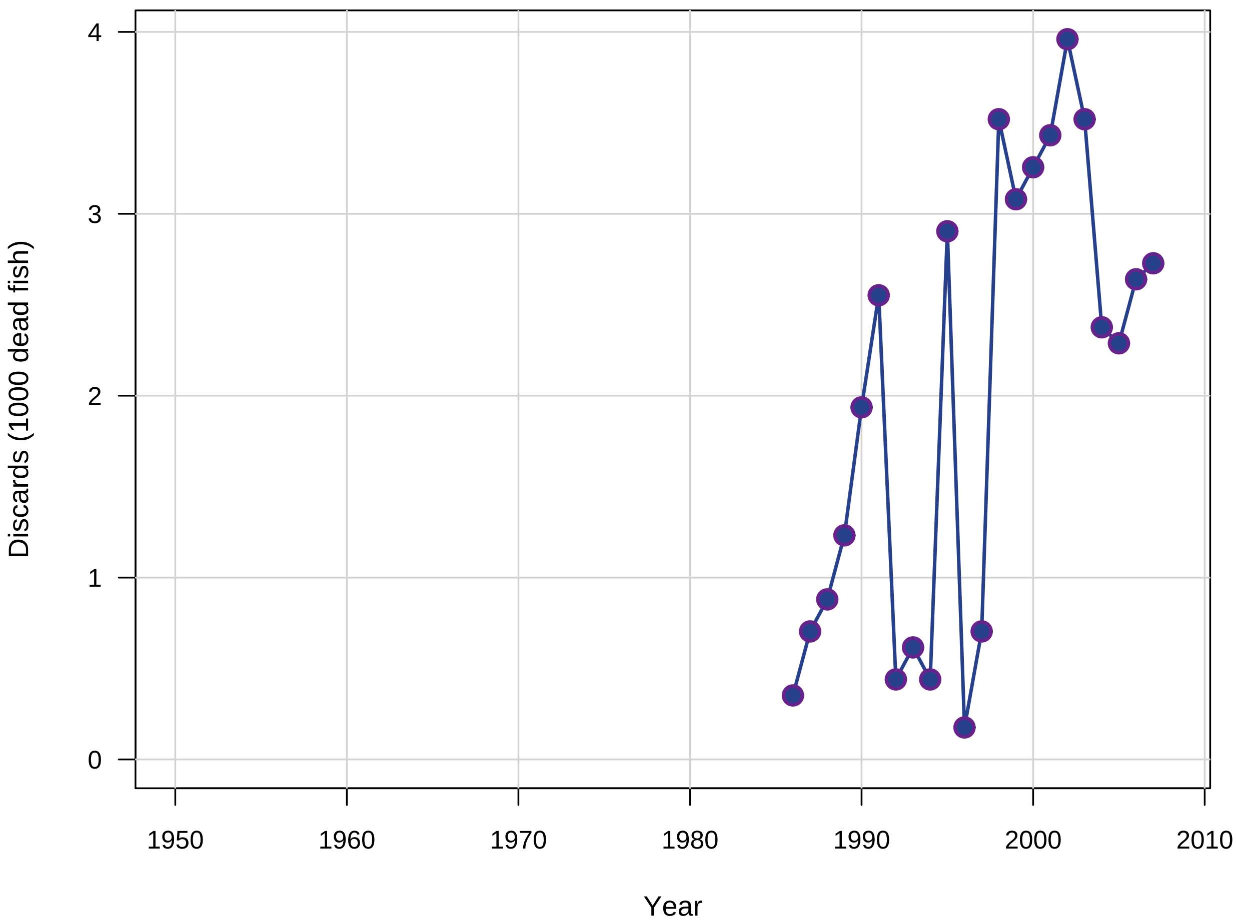


Figure 3.21. Spanish mackerel: Observed (open circles) and estimated (solid line, circles) commercial gillnet discard mortalities. Open and closed circles are indistinguishable.

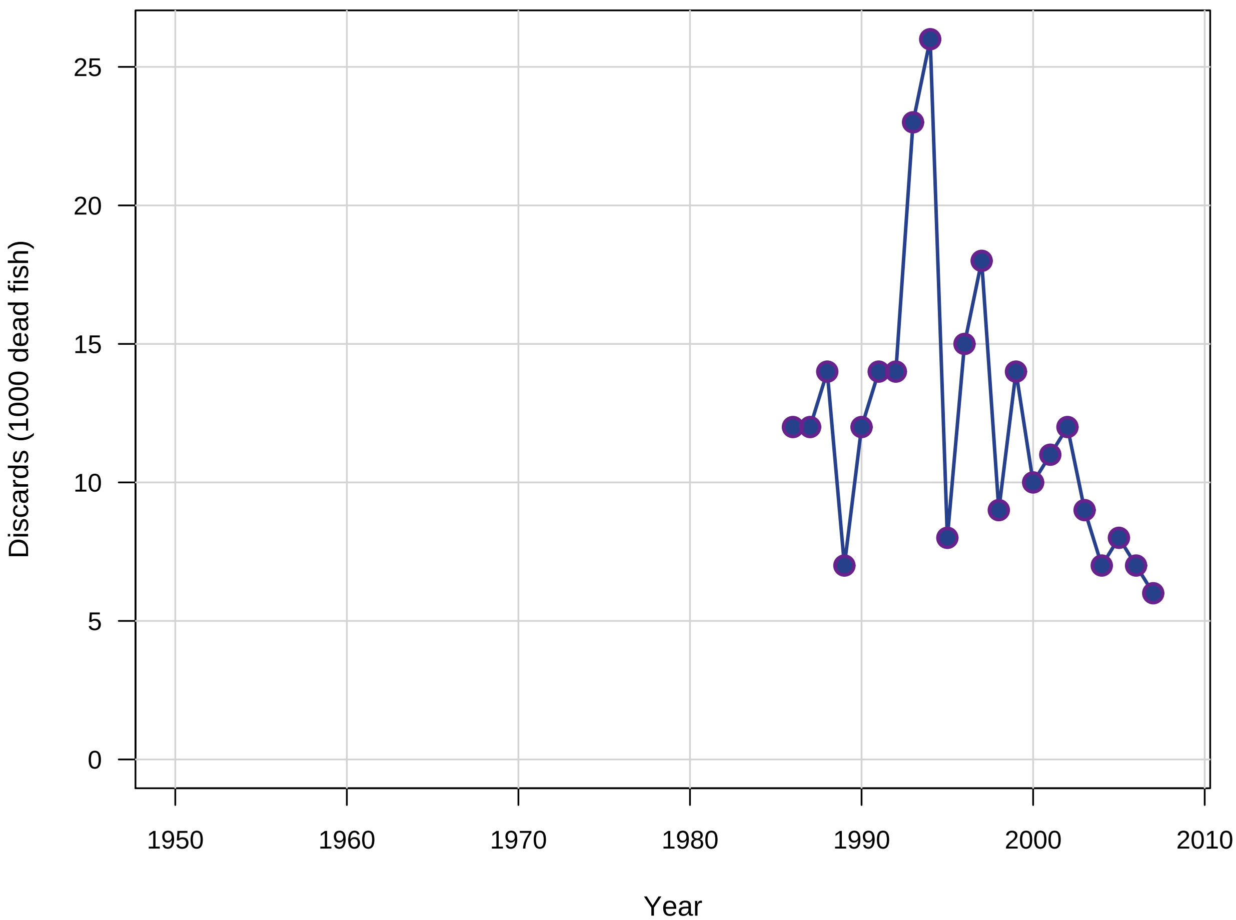


Figure 3.22. Spanish mackerel: Observed (open circles) and estimated (solid line, circles) general recreational discard mortalities. Open and closed circles are indistinguishable.

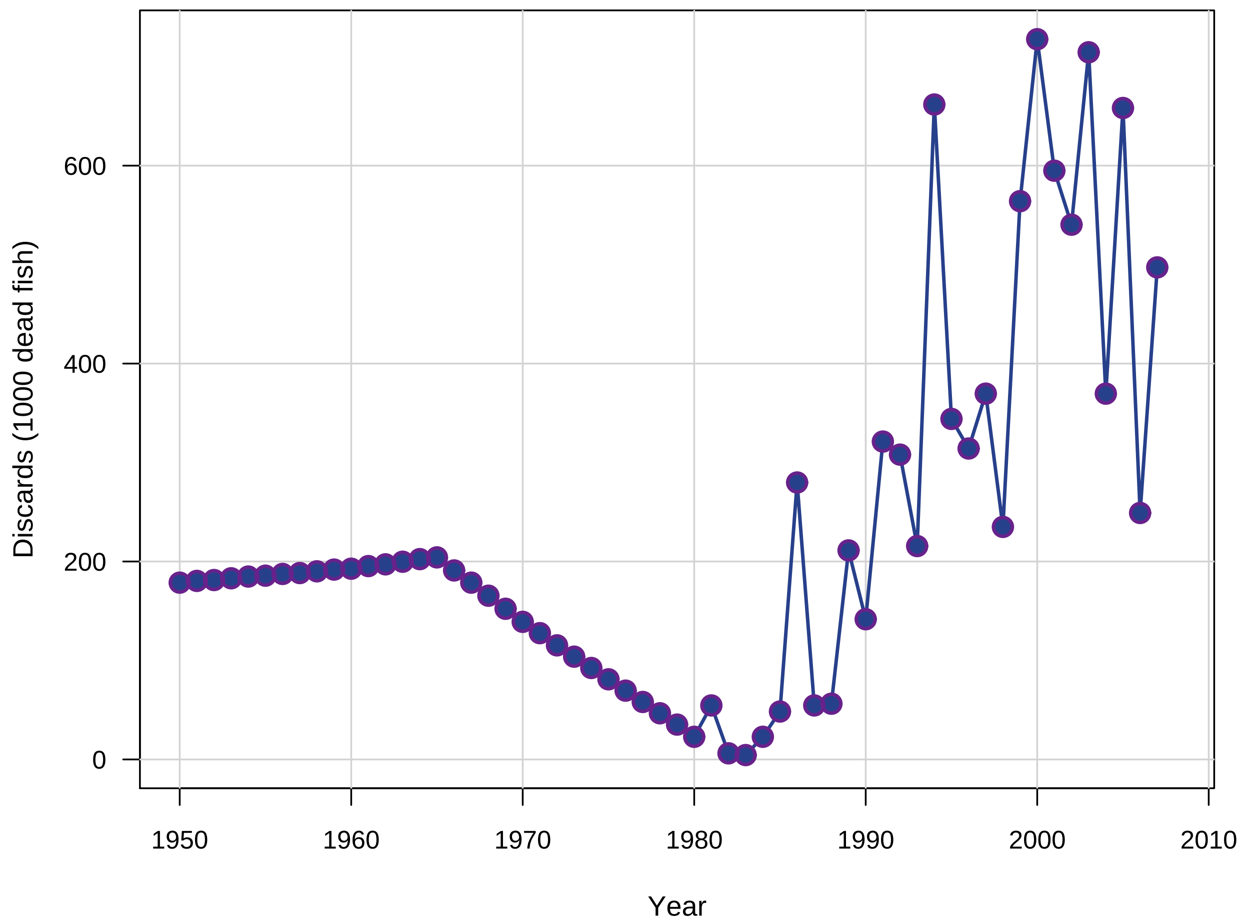


Figure 3.23. Spanish mackerel: Observed (open circles) and estimated (solid line, circles) bycatch mortalities in the shrimp fishery. Open and closed circles are indistinguishable.

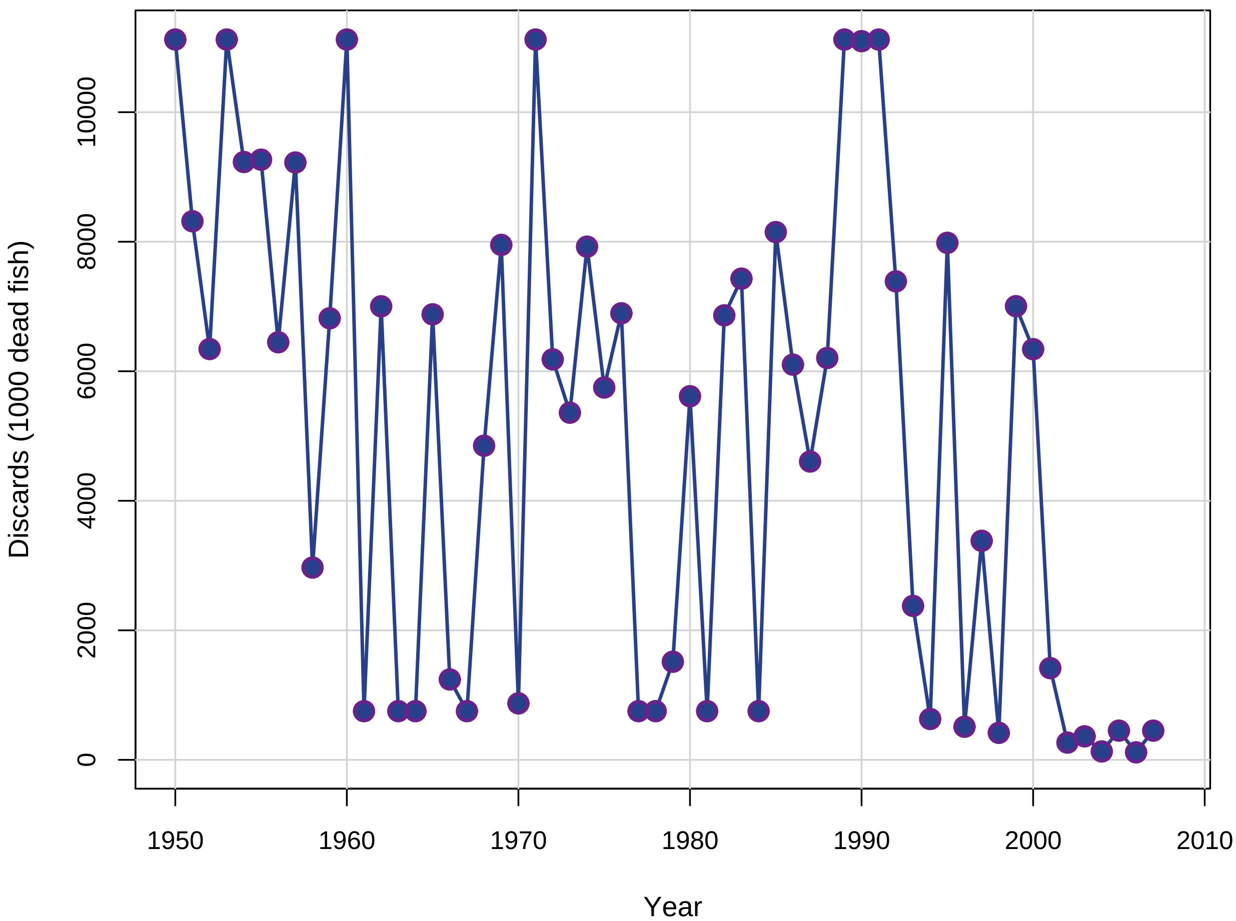


Figure 3.24. Spanish mackerel: Fit to the combined CPUE index of abundance; Observed (open circles) and estimated (solid line, circles).

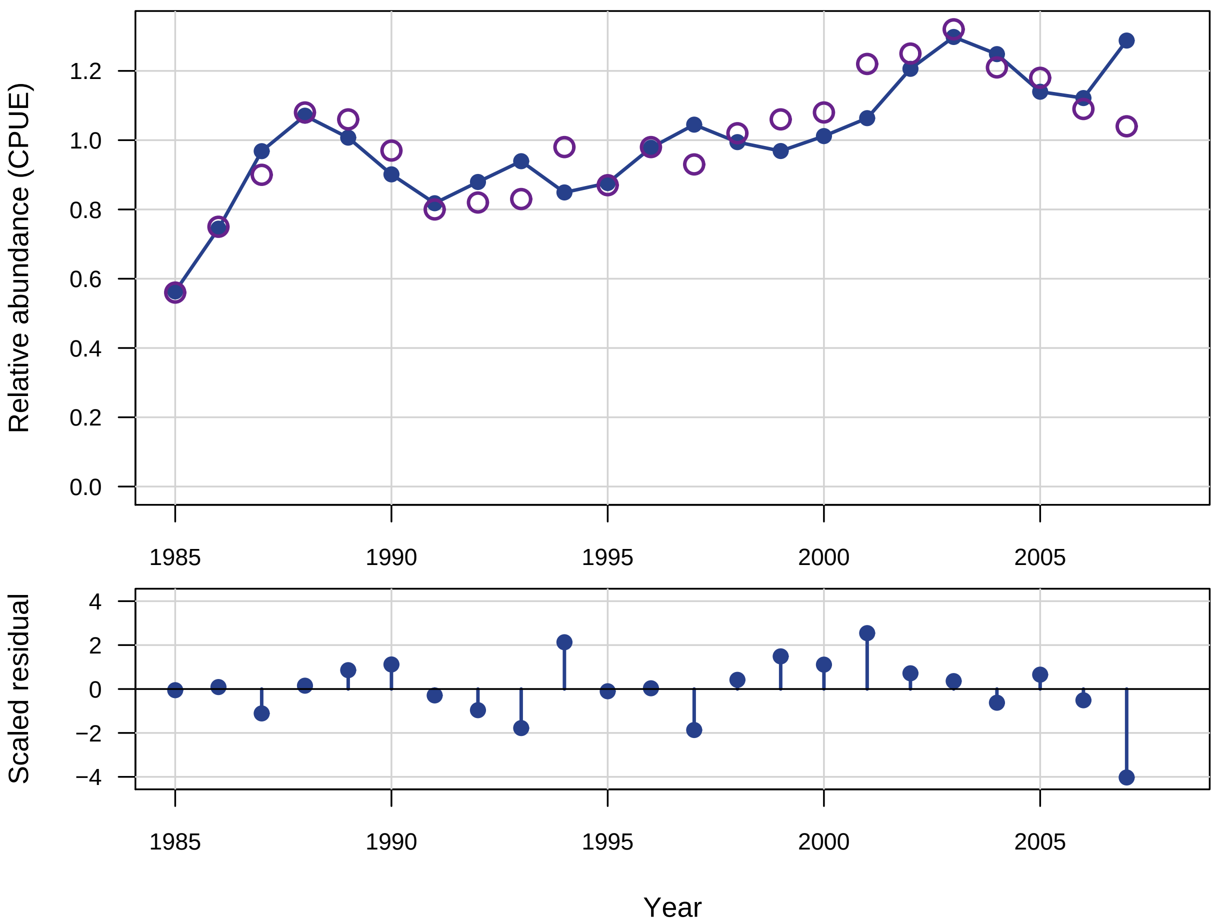


Figure 3.25. Spanish mackerel: Fit of index of abundance from the SEAMAP young-of-year trawl survey; Observed (open circles) and estimated (solid line, circles).

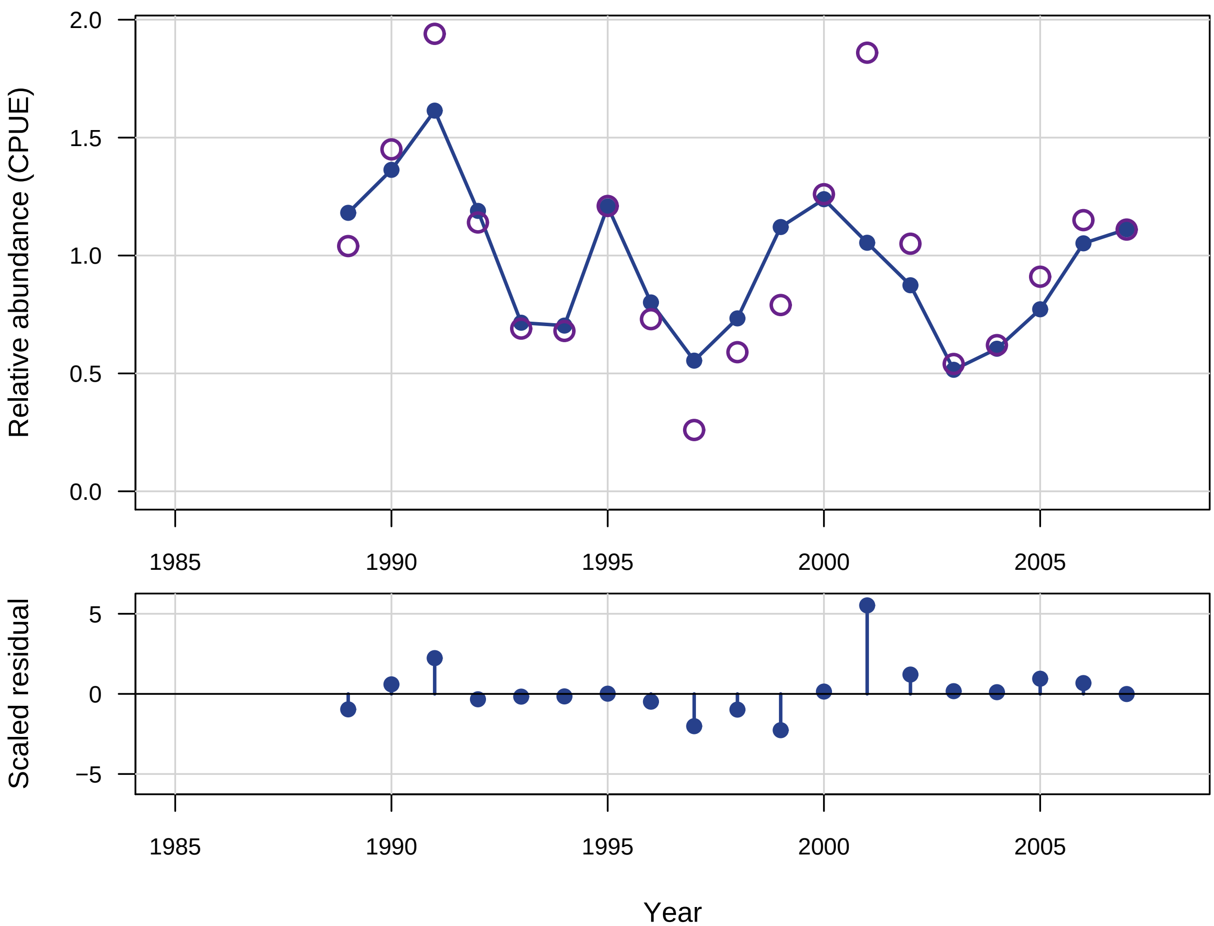


Figure 3.26. Spanish mackerel: Mean length at age (mm) and estimated 95% confidence interval for male Spanish mackerel.

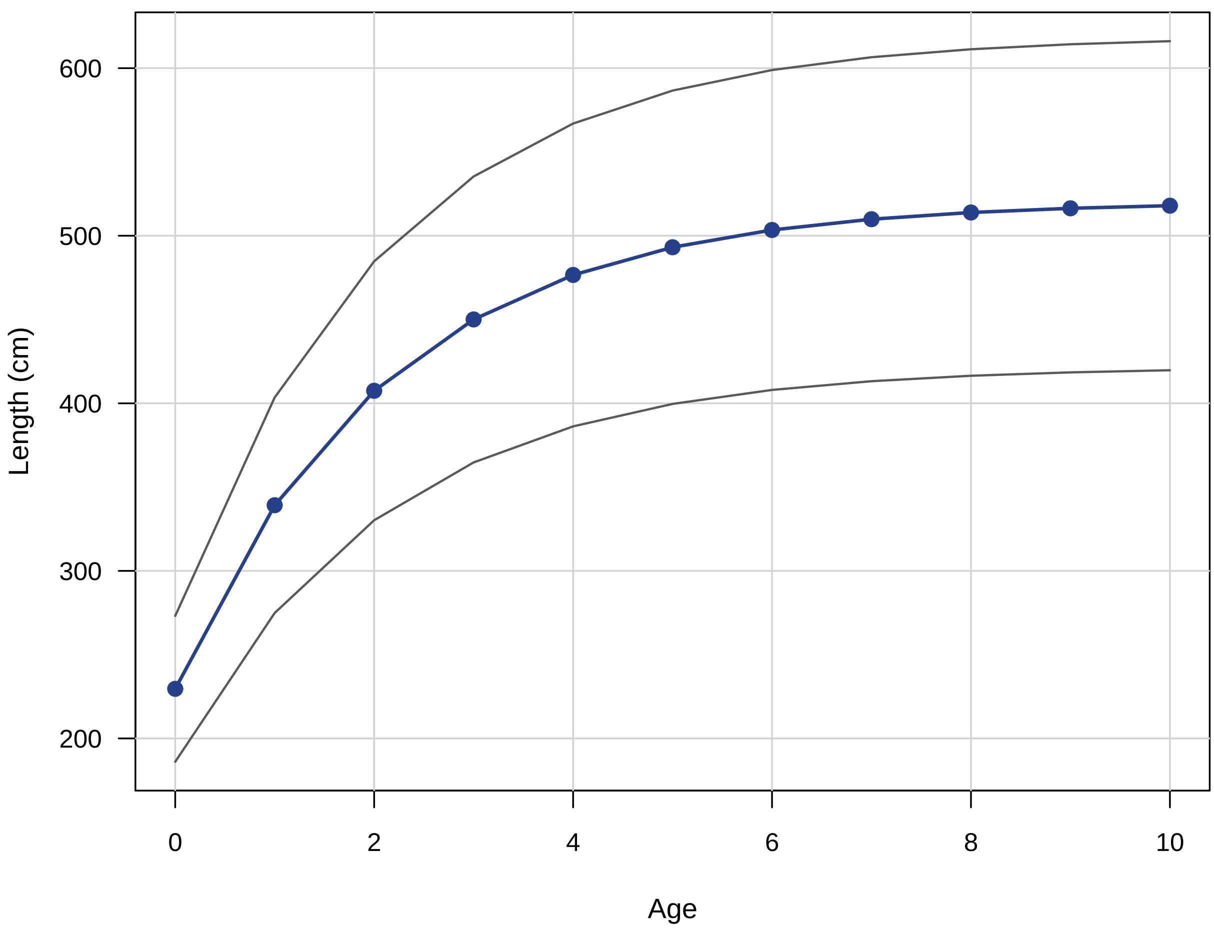


Figure 3.27. Spanish mackerel: Mean length at age (mm) and estimated 95% confidence interval for female Spanish mackerel.

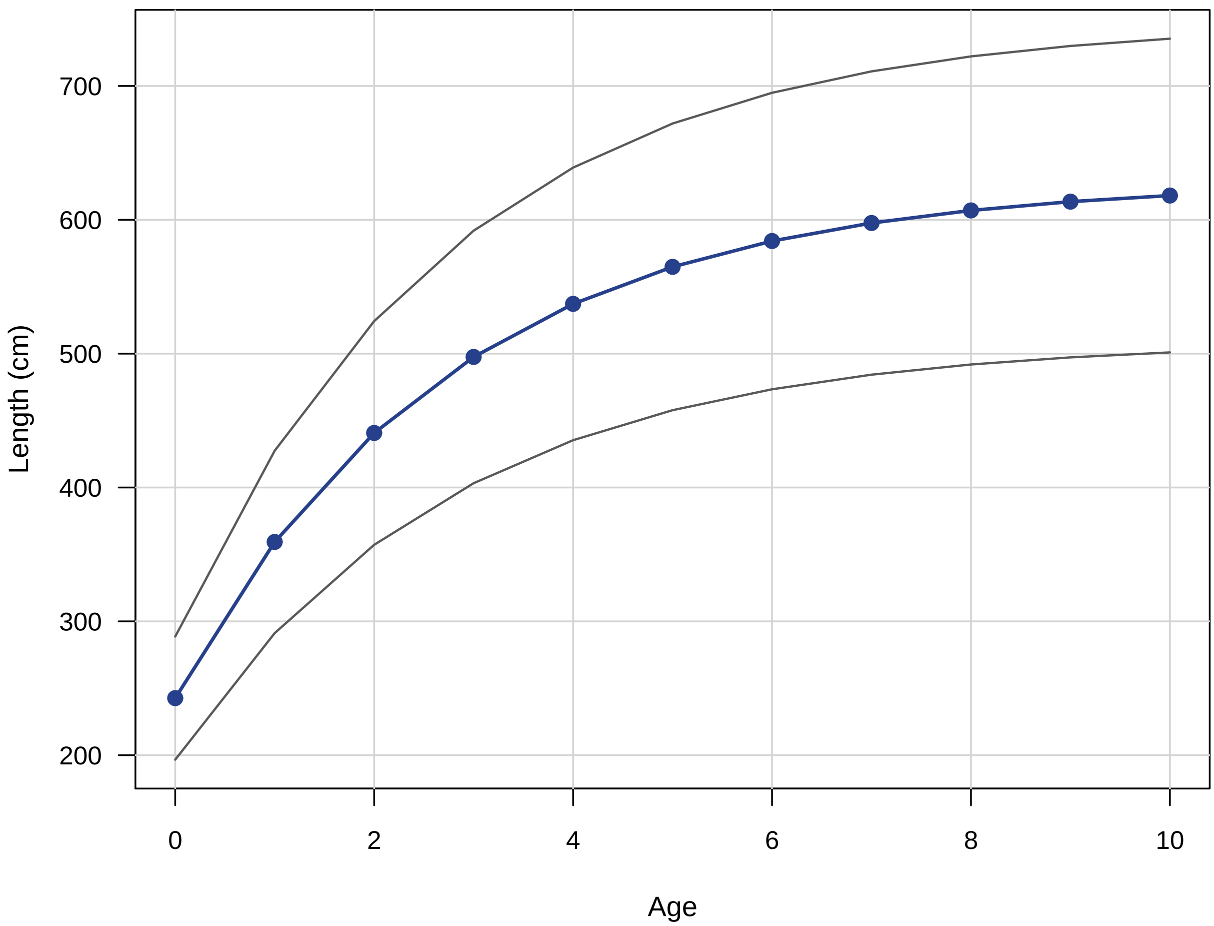


Figure 3.28. Spanish mackerel: Top panel – Estimated recruitment of age-1 fish. Bottom panel – log recruitment residuals.

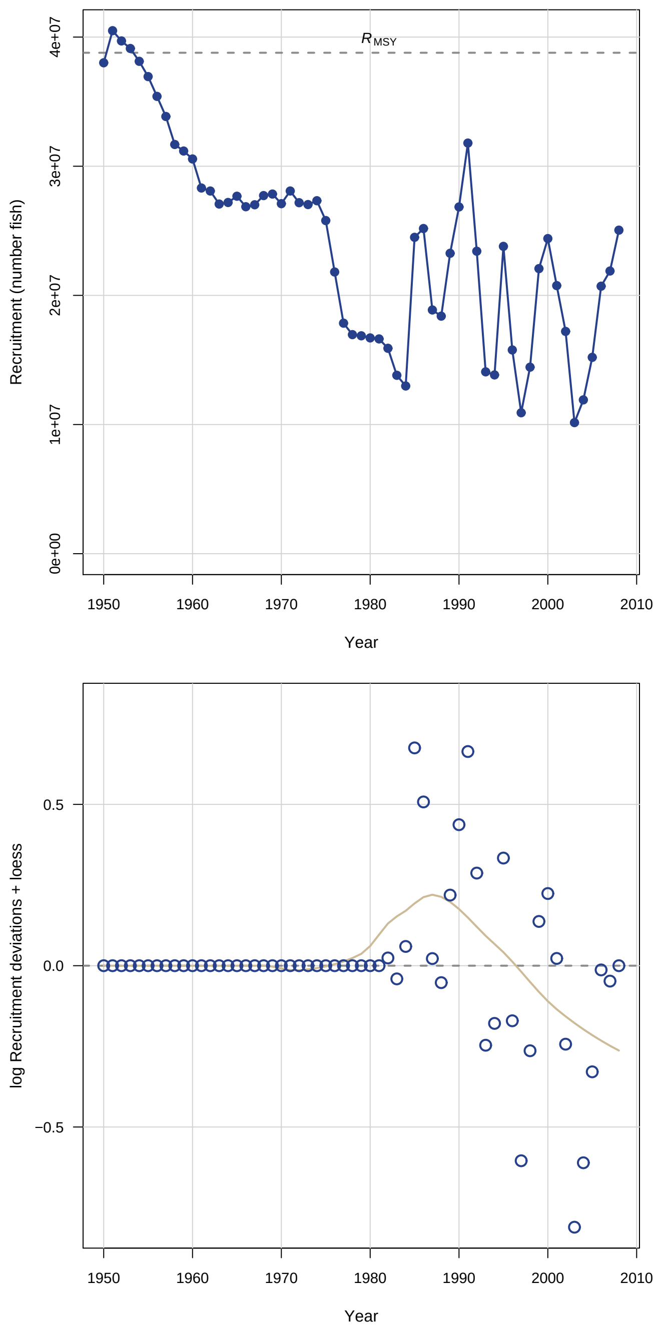


Figure 3.29. Spanish mackerel: Estimated spawning biomass (metric tons) at midpoint of each year by age class.

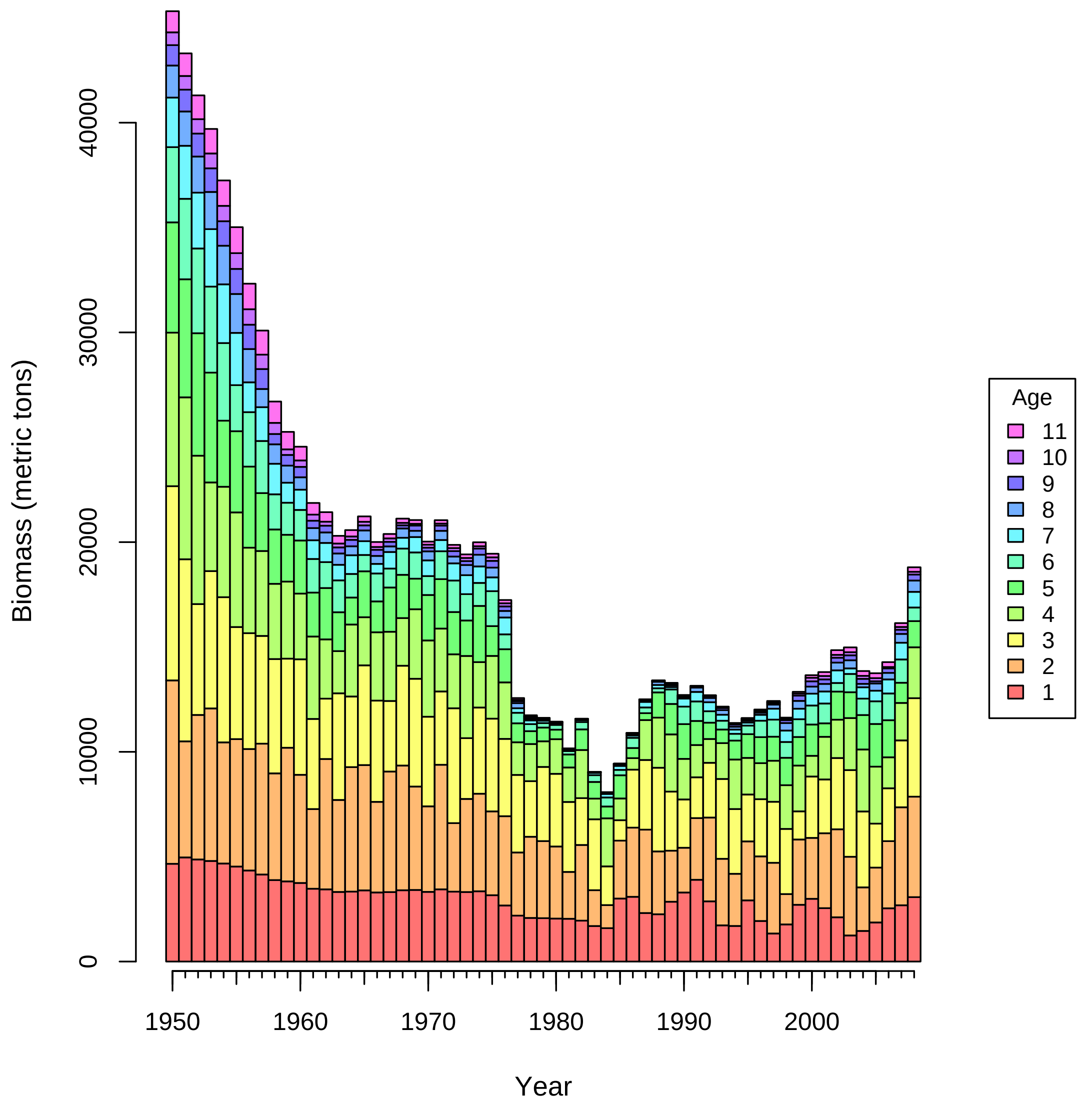


Figure 3.30. Spanish mackerel: Estimated spawning biomass (metric tons) at midpoint of year in relation to management benchmarks.

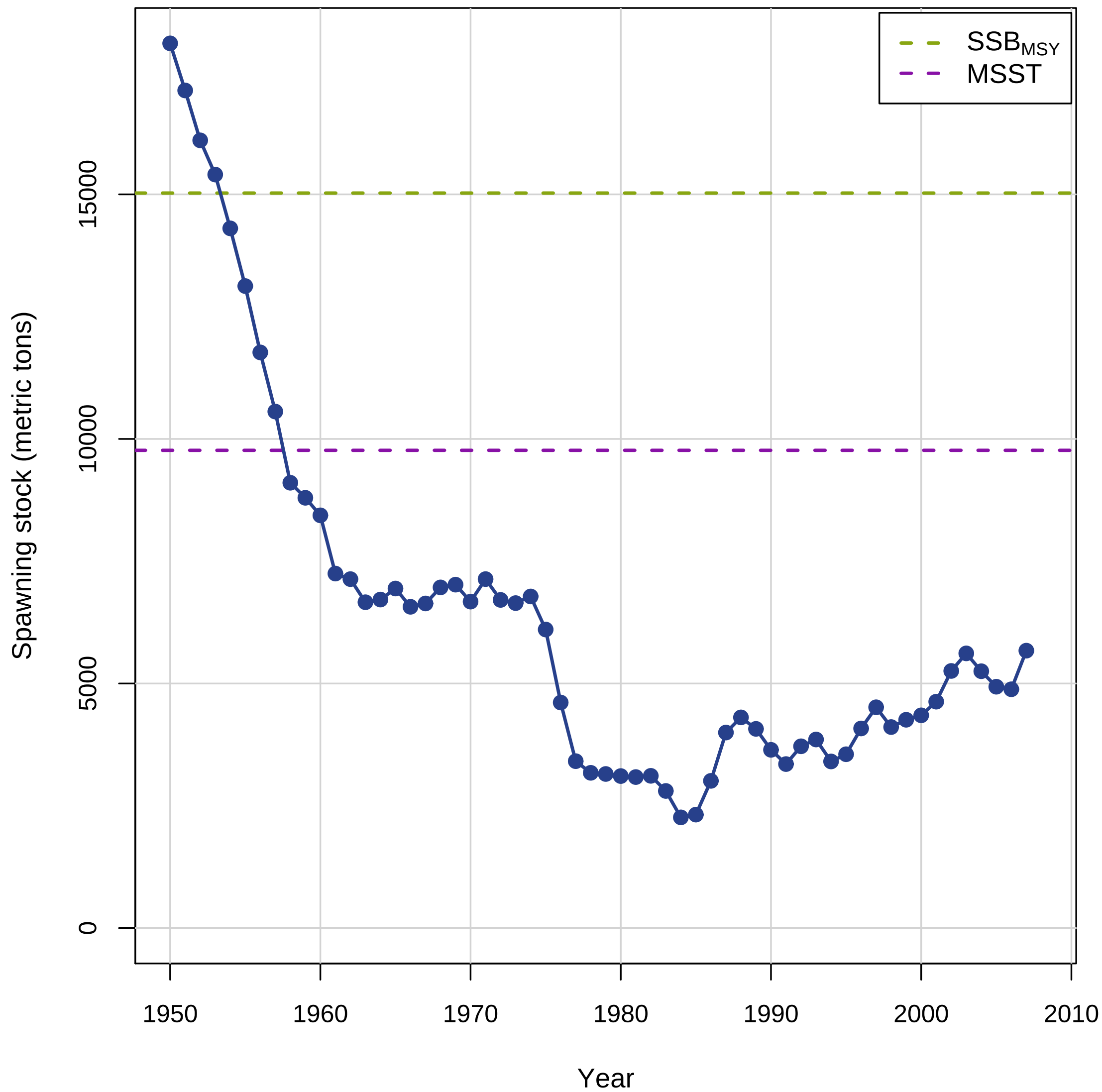


Figure 3.31. Spanish mackerel: Estimated instantaneous fishing mortality rate (per year) by fishery. HL refers to commercial handlines, GN to commerical gillnets, PN to commercial poundnets, CN to commercial castnets, MRFSS to general recreational, HL.D to commercial handline discard mortalities, GN.D to commercial gillnet discards, MRFSS.D to recreational discards, and shrimp.B to bycatch in the shrimp fishery.

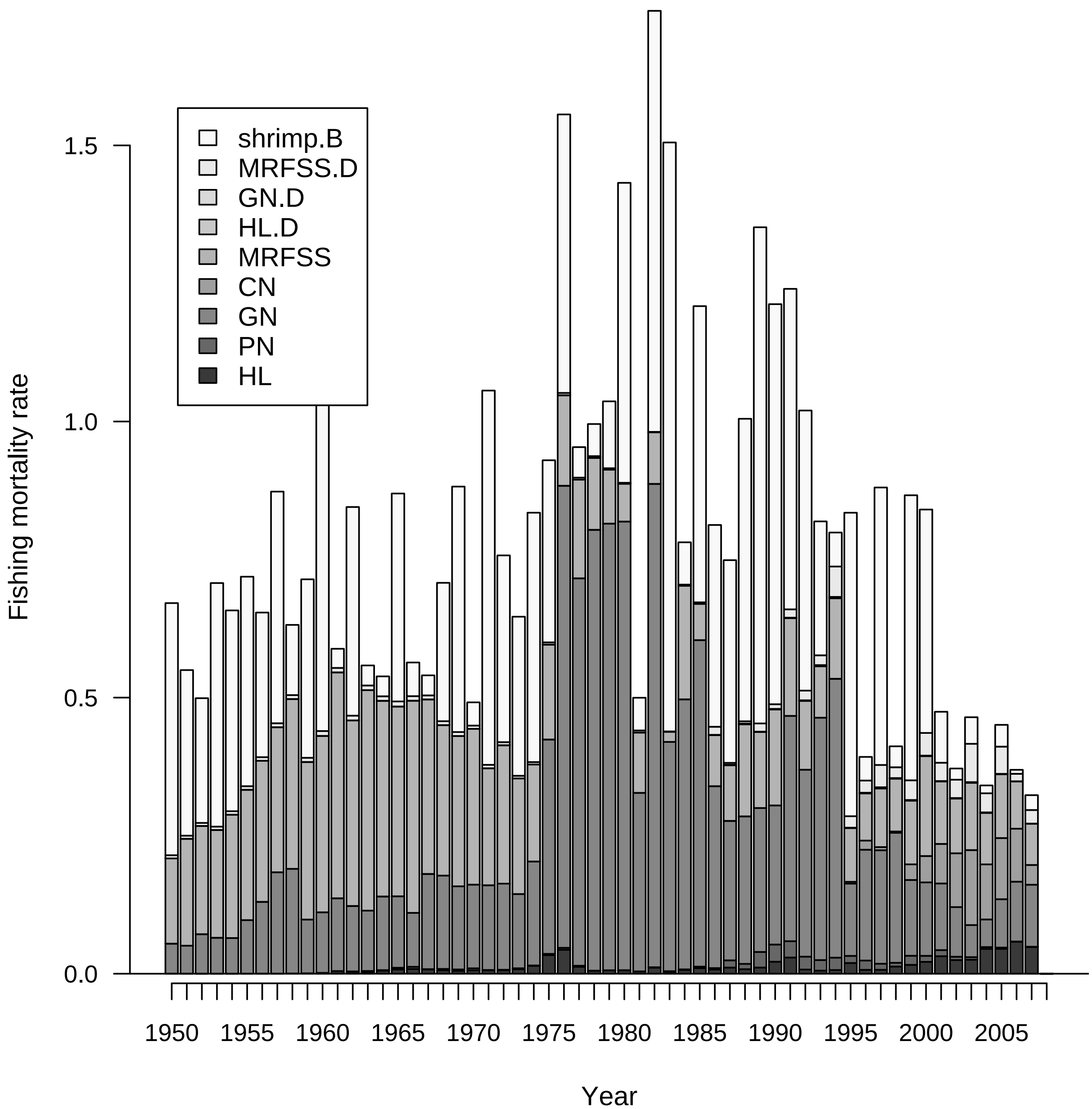


Figure 3.32. Spanish mackerel: Estimated landings by fishery from the catch-at-age model. HL refers to commercial handlines, GN to commerical gillnets, PN to commercial poundnets, CN to commercial castnets, and MRFSS to general recreational.

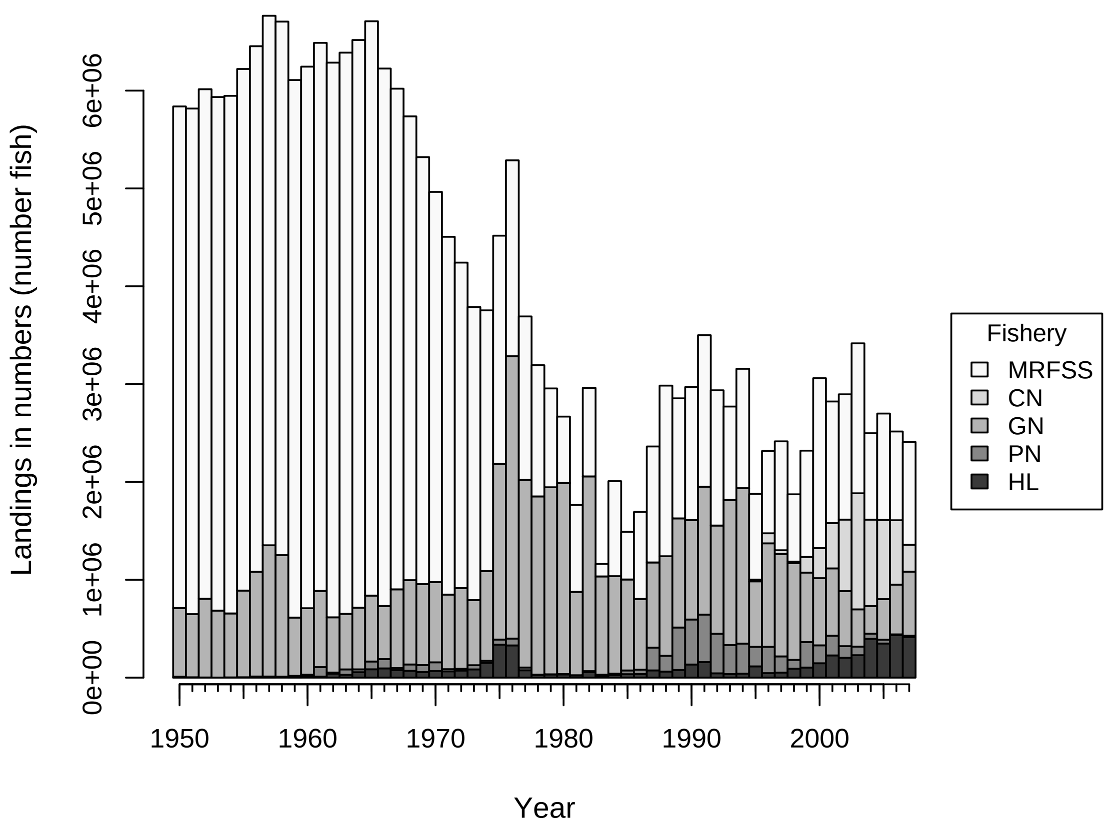


Figure 3.33. Spanish mackerel: Estimated discard and bycatch mortalities by fishery from the catch-at-age model. HL refers to commercial handline discard mortalities, GN to commercial gillnet discards, MRFSS to recreational discards, and shrimp to bycatch in the shrimp fishery.

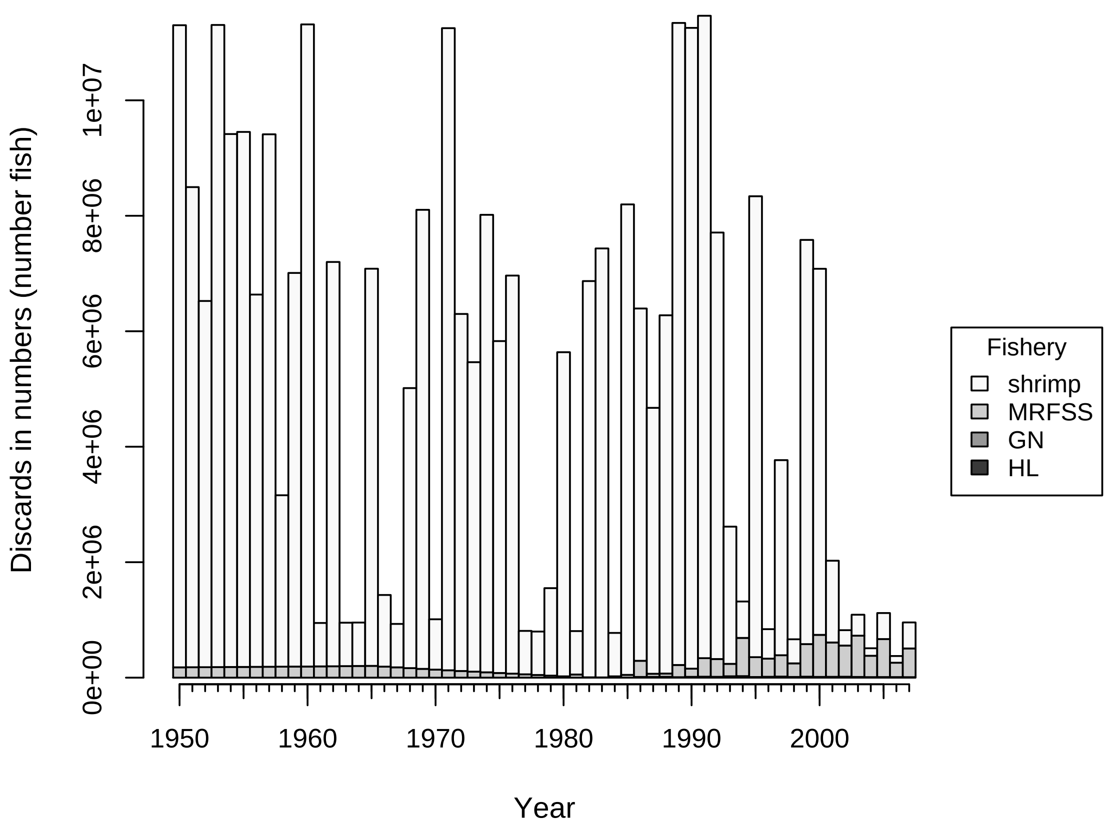


Figure 3.34. Spanish mackerel: Estimated Beverton–Holt spawner-recruit curves, with and without lognormal bias correction.

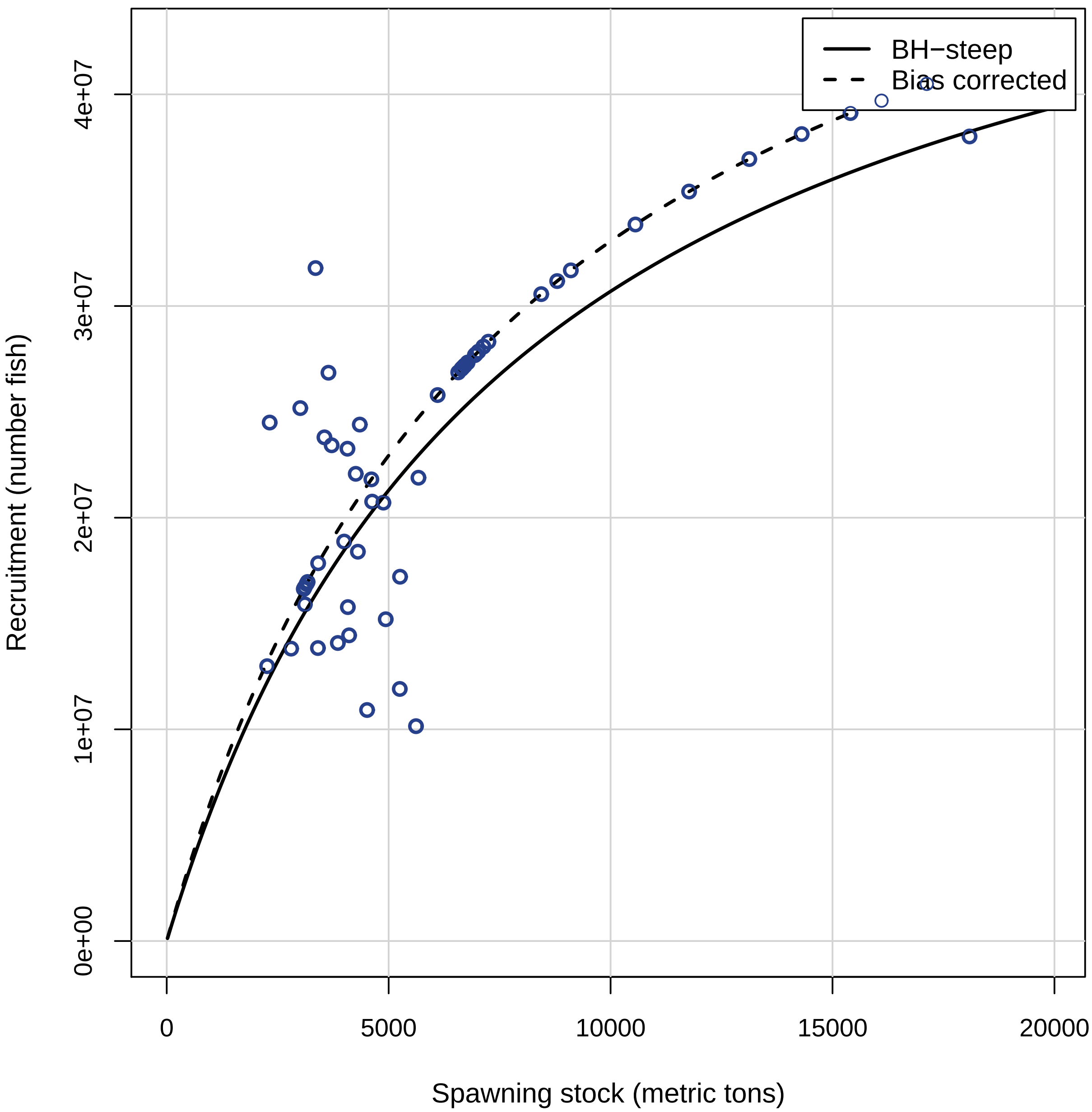


Figure 3.35. Spanish mackerel: Recruits per spawner as a function of the number of spawners (log scale).

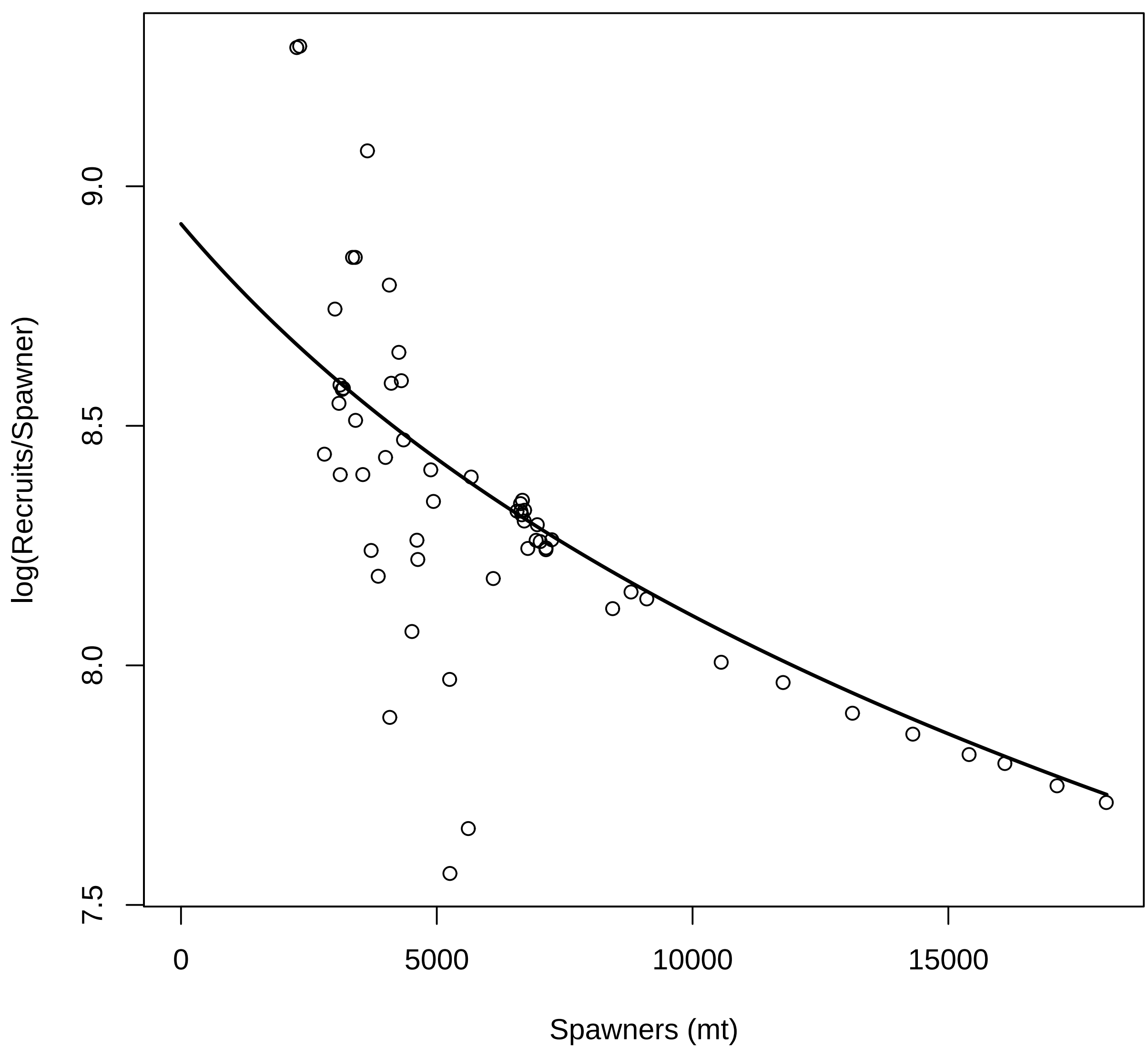


Figure 3.36. Spanish mackerel: Profile likelihood plot for steepness; a well defined minima exists near $h = 0.62$.

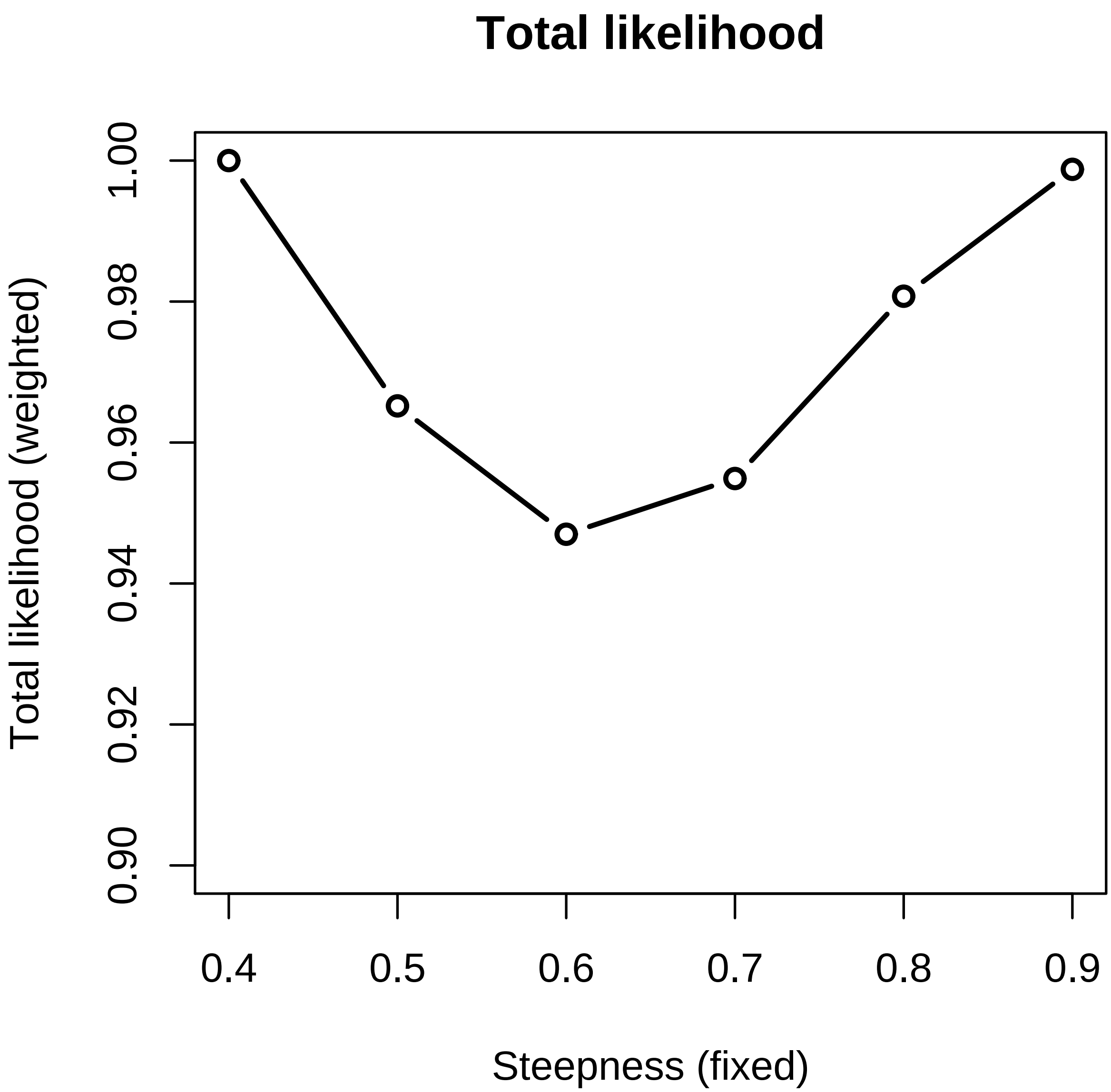


Figure 3.37. Spanish mackerel: Uncertainty in stock-recruit parameters generated by bootstrapping stock-recruit residuals. Vertical lines represent estimates from the assessment model

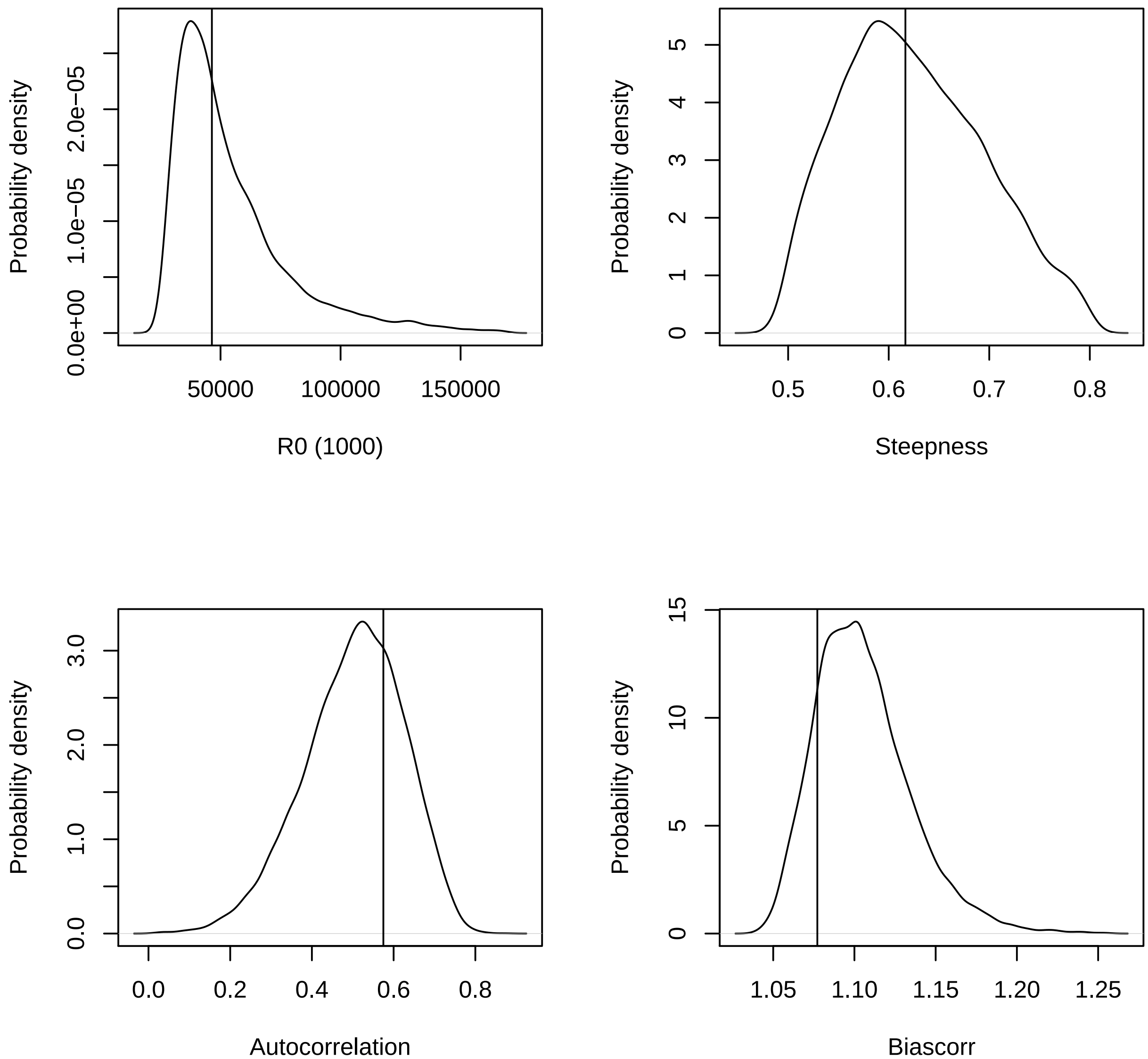


Figure 3.38. Spanish mackerel: Estimated time series of static spawning potential ratio, the annual equilibrium spawners per recruit relative to that at the unfished level.

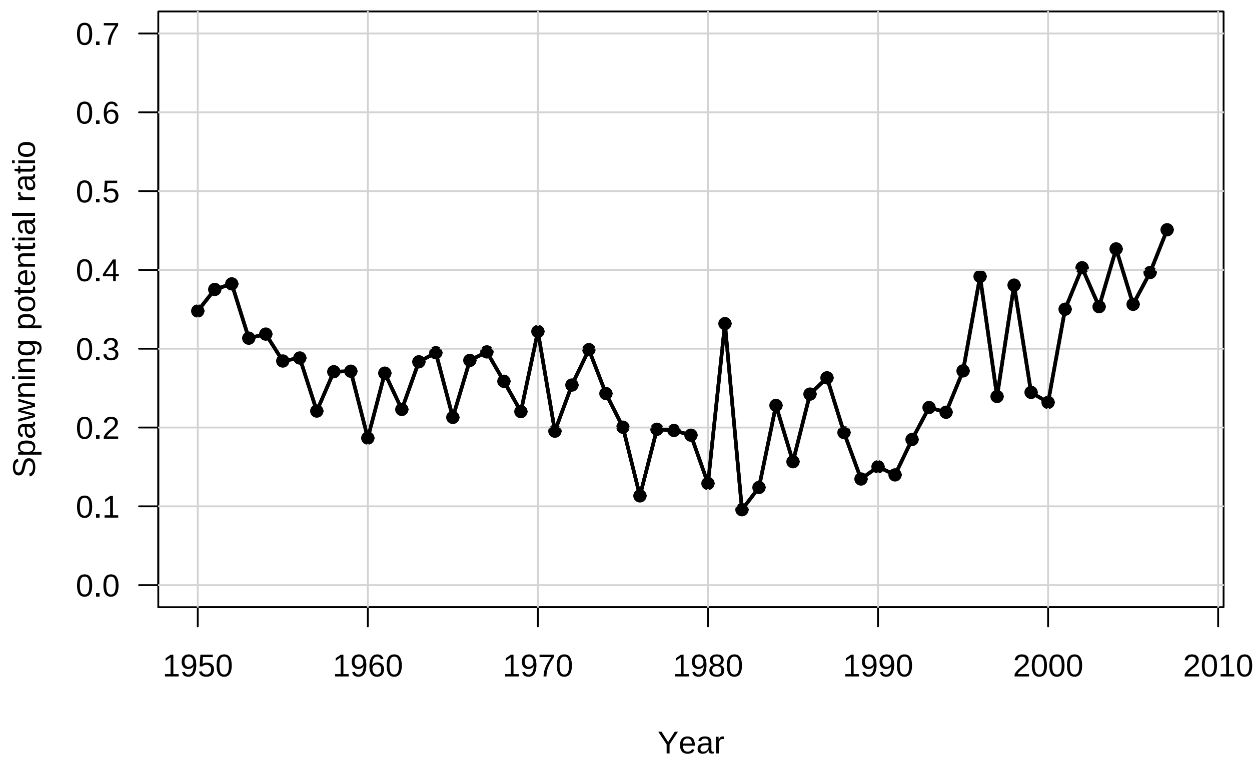


Figure 3.39. Spanish mackerel: Top panel – Yield per recruit, from which the maximum provides $F_{\max}$. Bottom panel – Spawning potential ratio (spawners per recruit relative to that at the unfished level), from which the 30% and 40% levels provide $F_{30\%}$ and $F_{40\%}$. Both curves are based on average selectivity from the end of the assessment period.

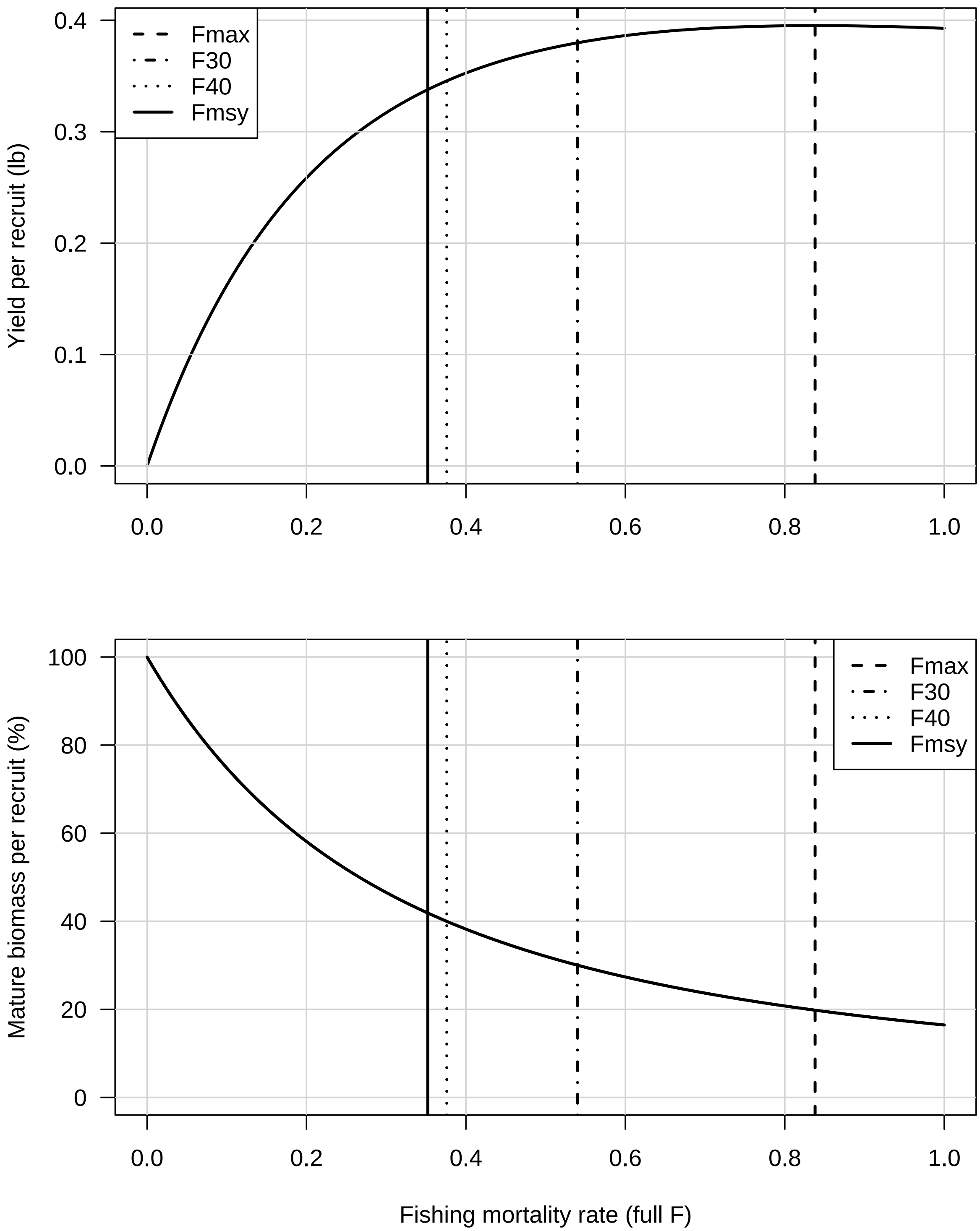


Figure 3.40. Spanish mackerel: Top panel – Equilibrium landings. Bottom panel – Equilibrium spawning biomass. Both curves are based on average selectivity from the end of the assessment period.

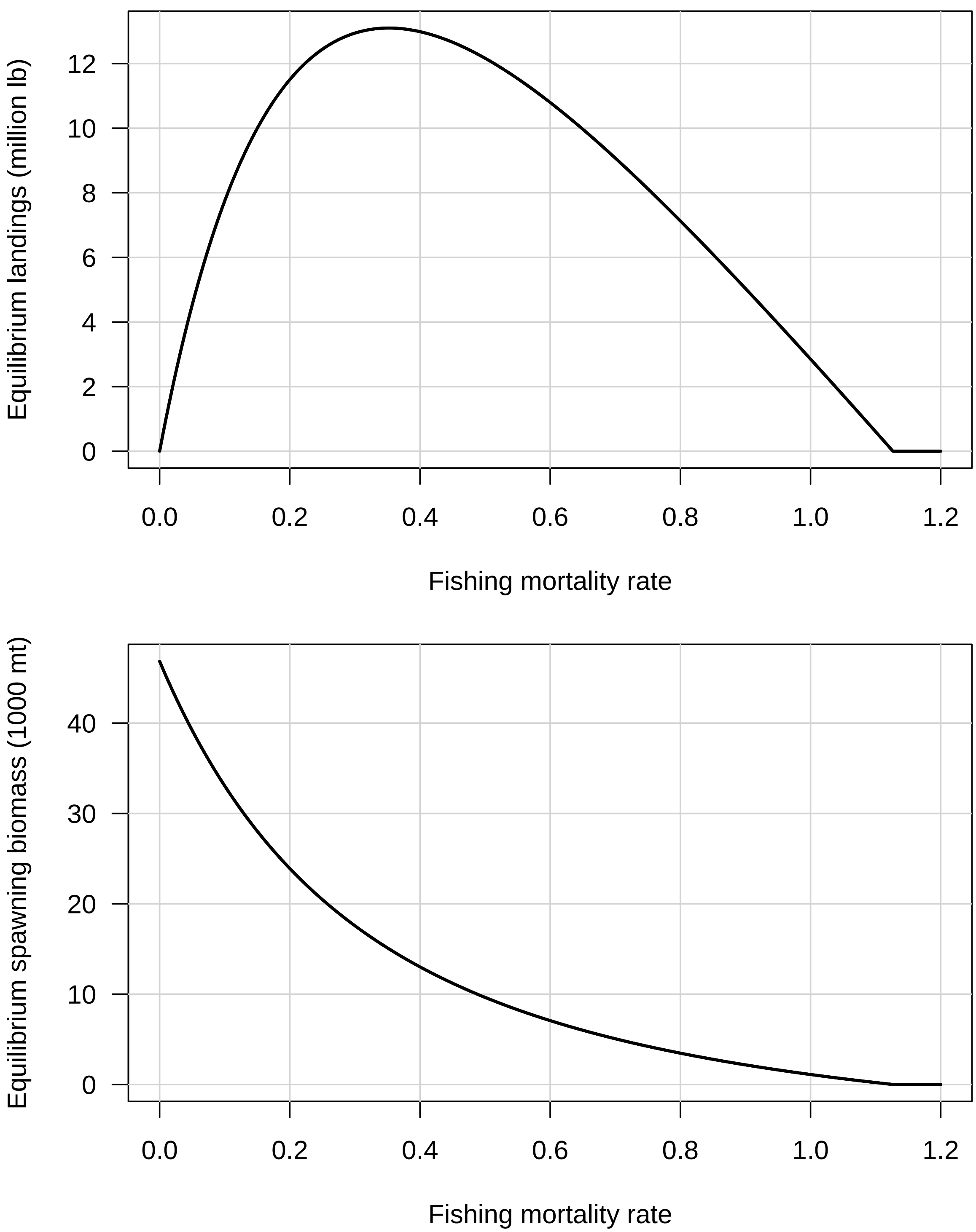


Figure 3.41. Spanish mackerel: Top panel – Equilibrium landings as a function of equilibrium biomass, which itself is a function of fishing mortality rate. The peak occurs where equilibrium biomass is $B_{\mathrm{MSY}} = 40.3$ *1000 mt and equilibrium landings are* $\mathrm{MSY} = 13.1$ *million lb. Bottom panel – Equilibrium discard and bycatch mortality as a function of equilibrium biomass.*

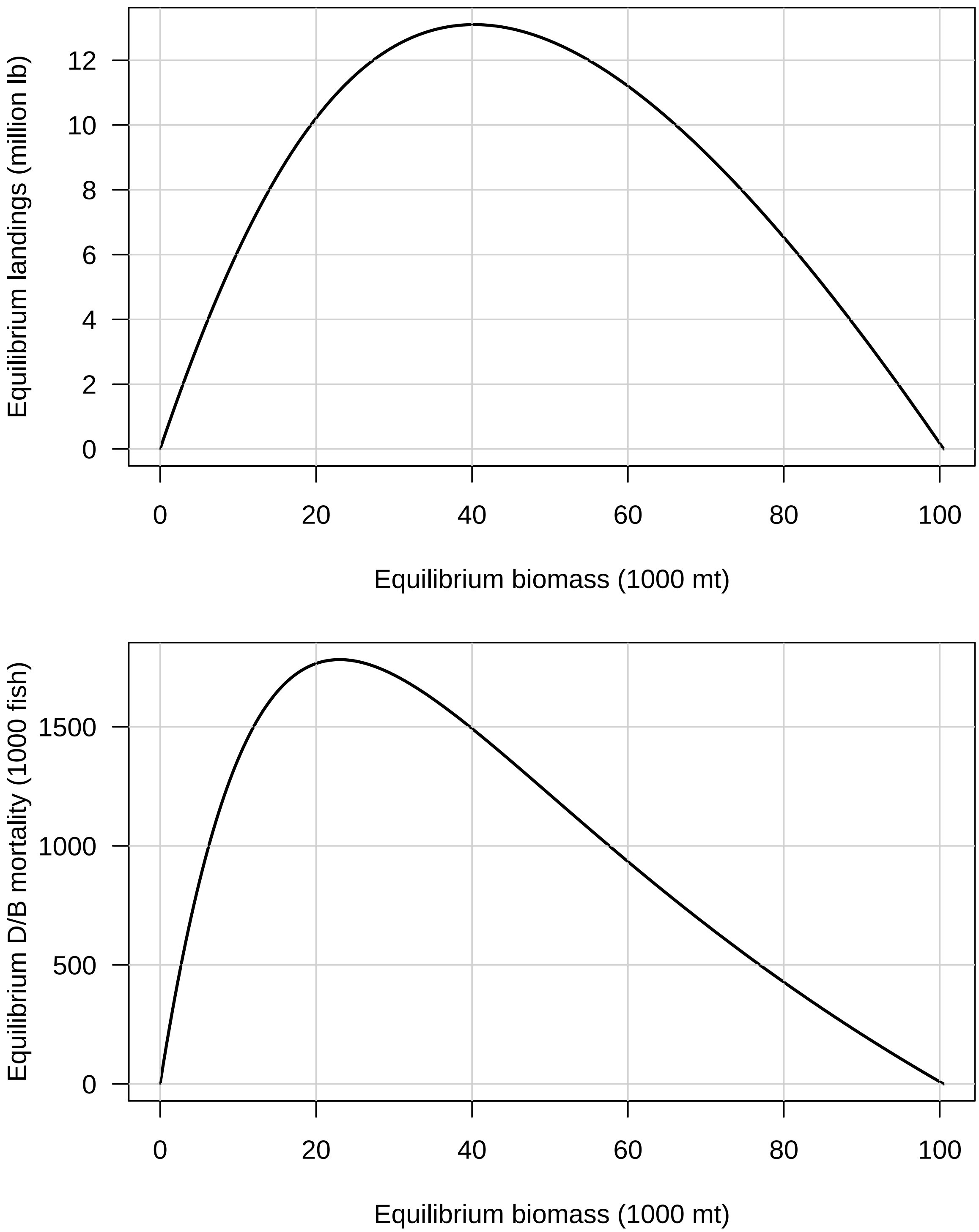


Figure 3.42. Spanish mackerel: Probability densities of MSY*-related benchmarks. Vertical lines represent point estimates.*

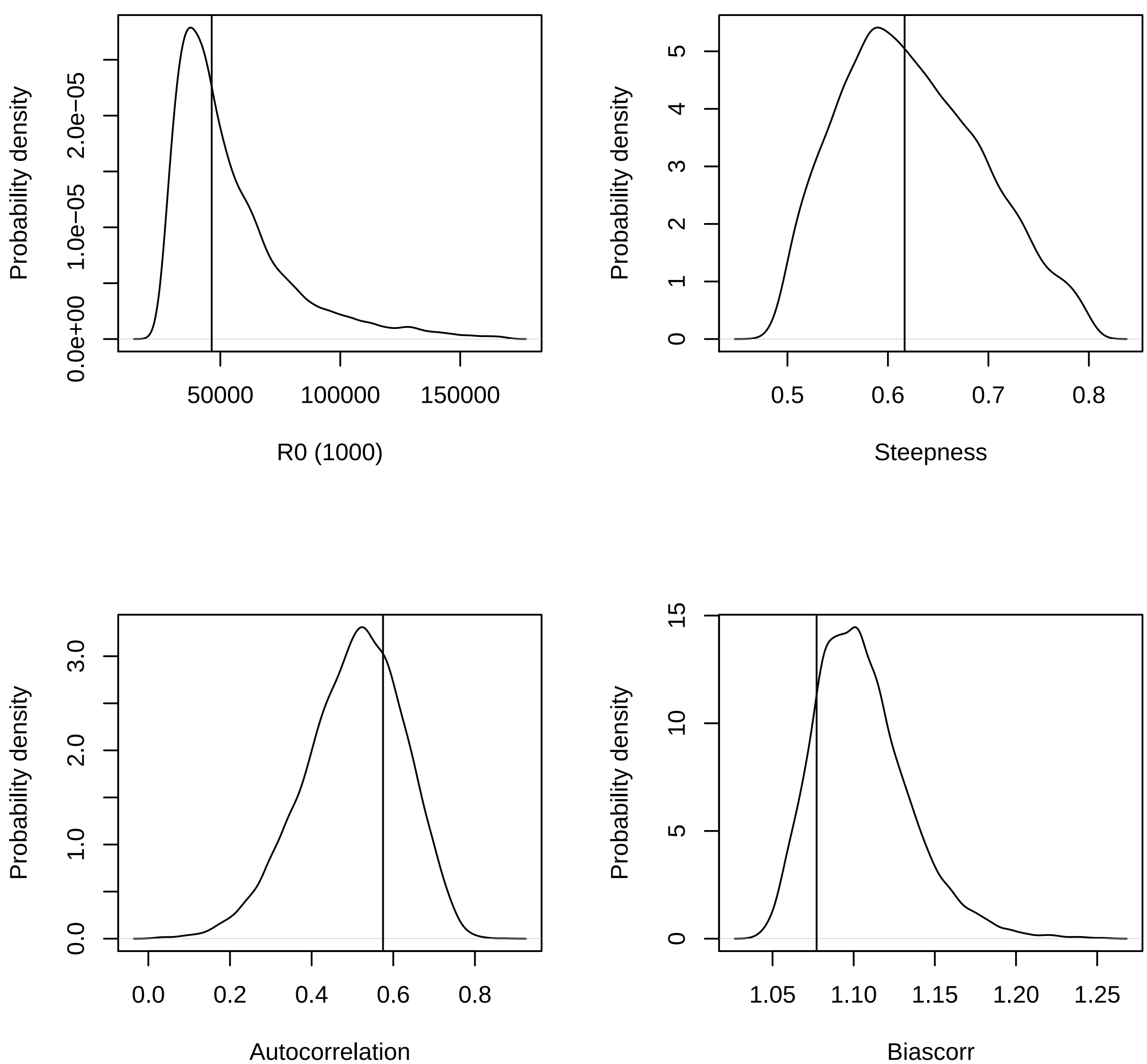
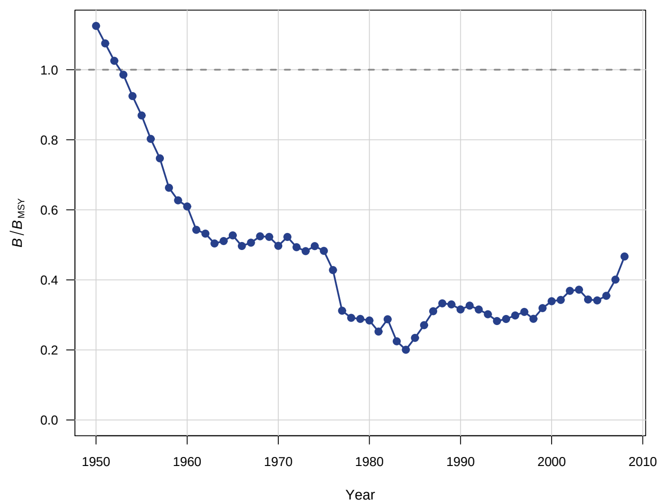


Figure 3.43. Spanish mackerel: Estimated time series of biomass relative to MSY *benchmarks. Top panel – B relative to B_{MSY}. Bottom panel –* SSB *relative to* $\mathrm{SSB}_{\mathrm{MSY}}$.



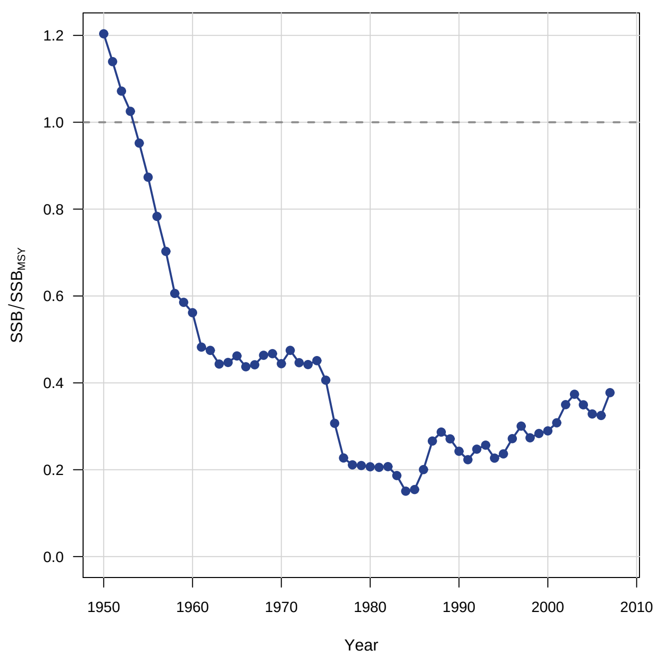


Figure 3.44. Spanish mackerel: Estimated time series of F relative to F_{MSY}.

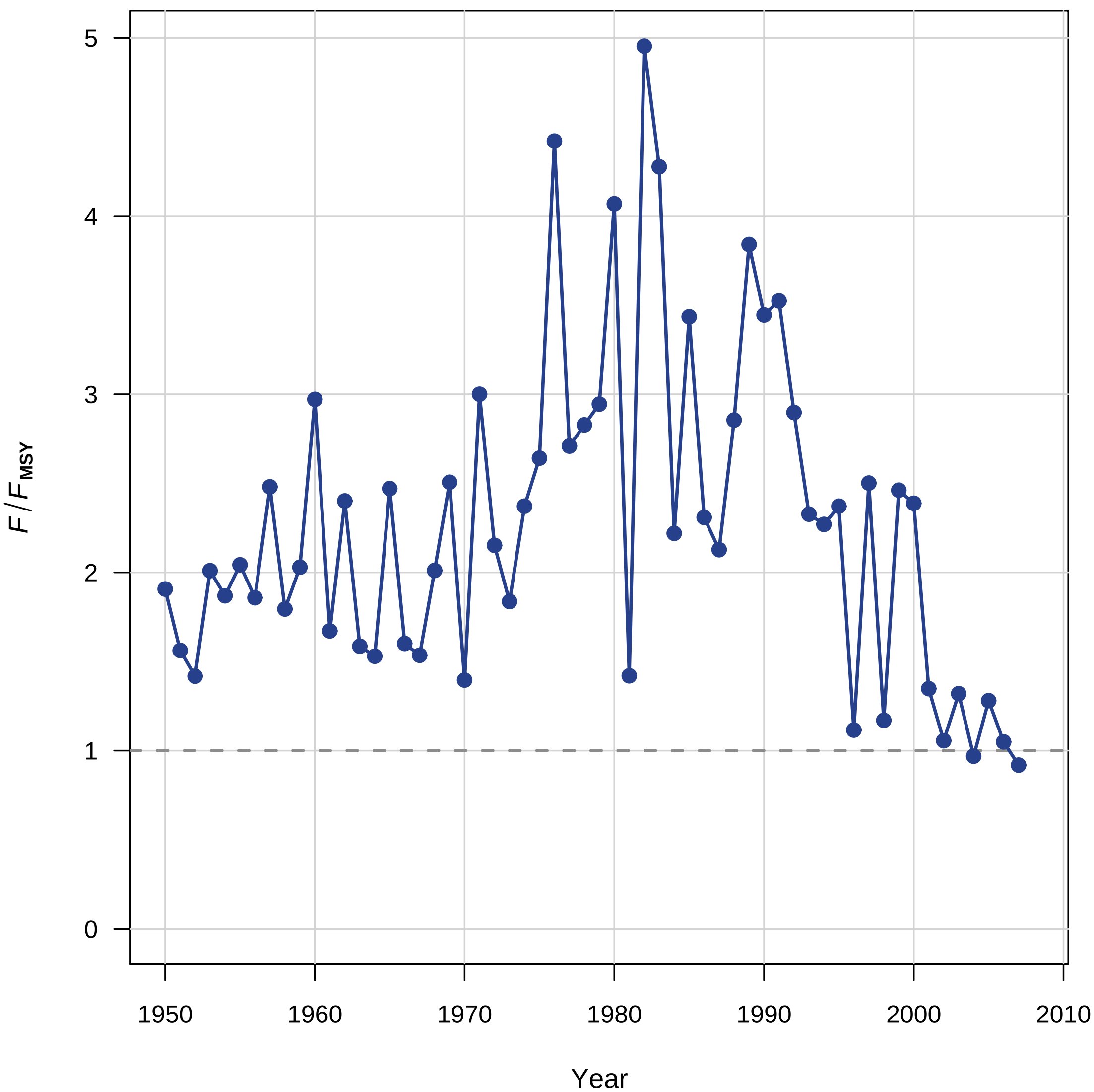


Figure 3.45. Spanish mackerel: Sensitivity of results to using the "hockey stick" model for extrapolating shrimp bycatch (Base run) to using mean bycatch for all years observer data was not available (sensitivity run S1). Top panel – Ratio of F to F_{MSY}. Bottom panel – Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$.

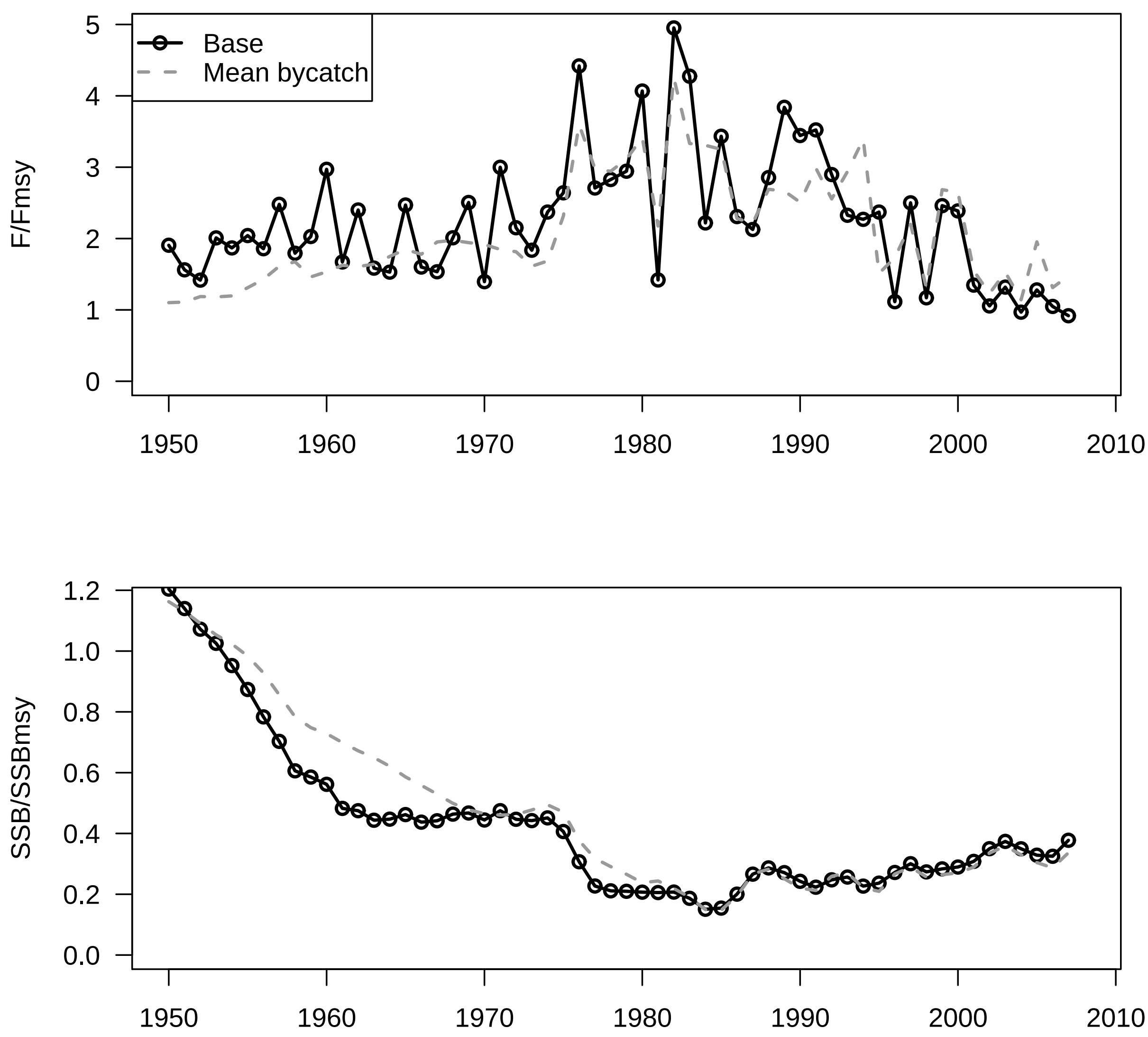


Figure 3.46. Spanish mackerel: Sensitivity of results to multiplier on early recreational saltwater angling survey records (sensitivity runs S2 - S4). Top panel – Ratio of F to F_{MSY}. Bottom panel – Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$.

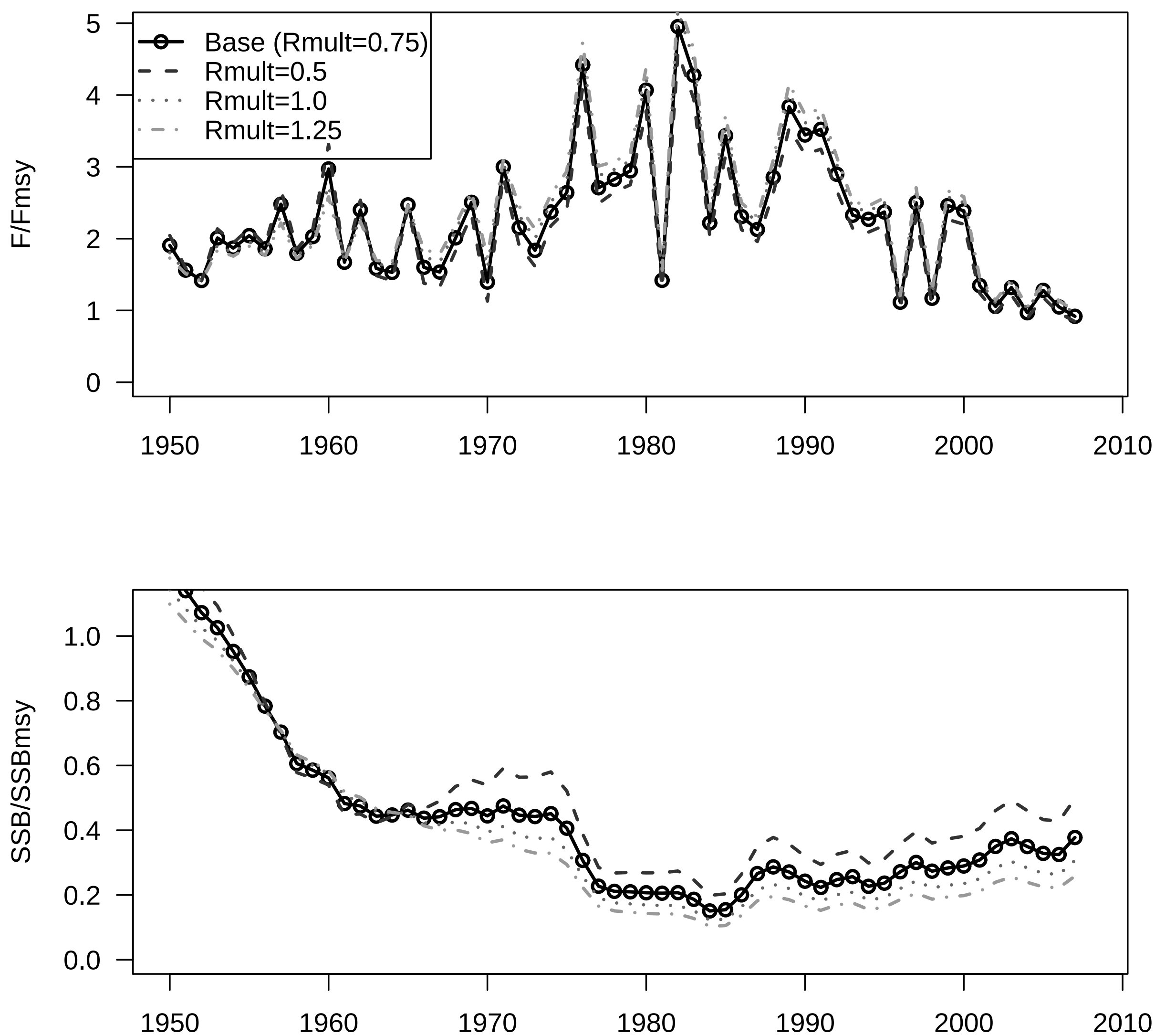


Figure 3.47. Spanish mackerel: Sensitivity of results to the fishing mortality rate used to set initial population size and structure in the first year of the assessment model (sensitivity runs S5 and S6). Top panel – Ratio of F to F_{MSY}. Bottom panel – Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$.

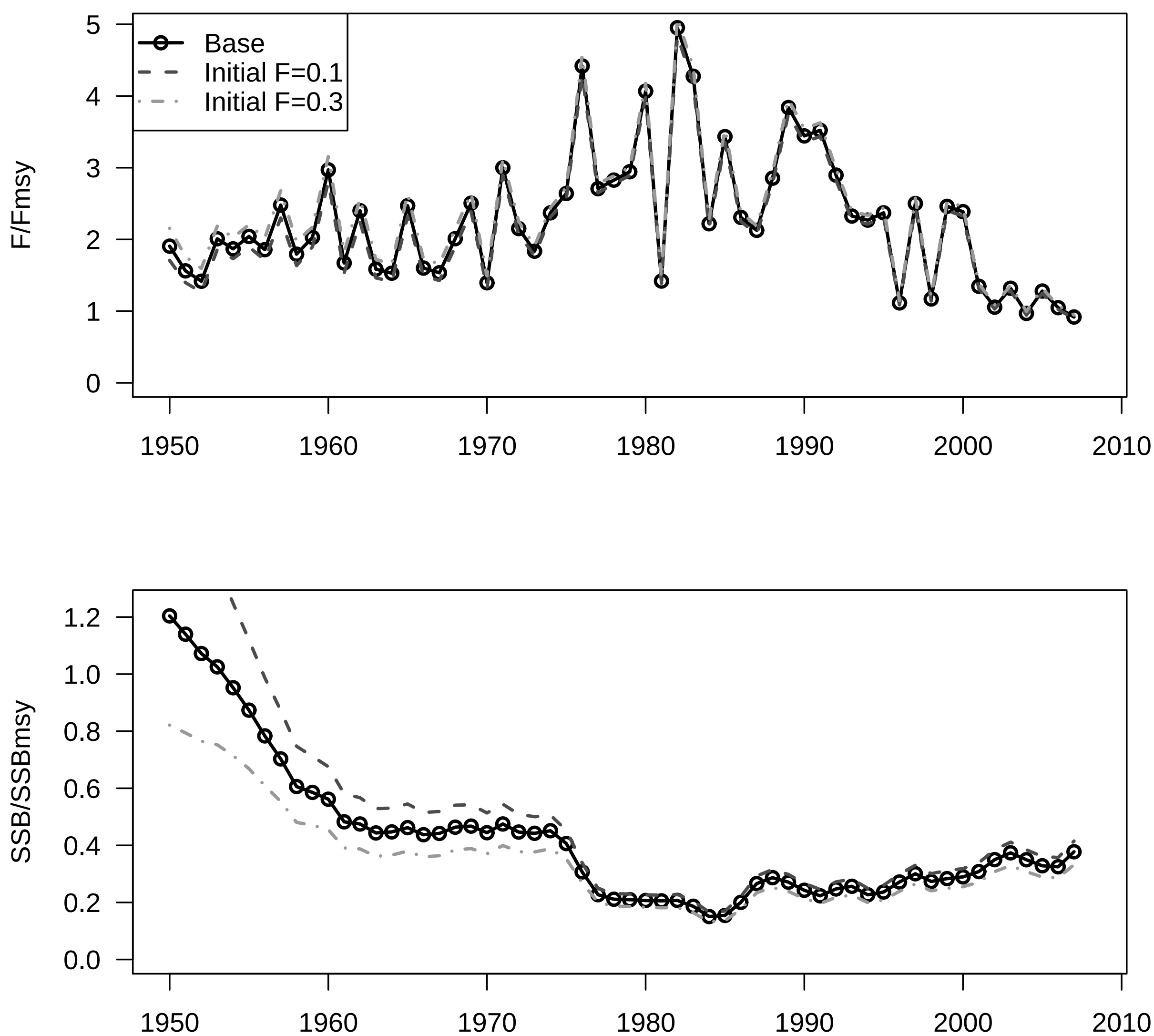


Figure 3.48. Spanish mackerel: A comparison of the base run to a "continuity" run assuming minimal shrimp bycatch and minimal early recreational landings (both were given a multiplier of 0.01; sensitivity run S7). Top panel – Ratio of F to F_{MSY}. Bottom panel – Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$.

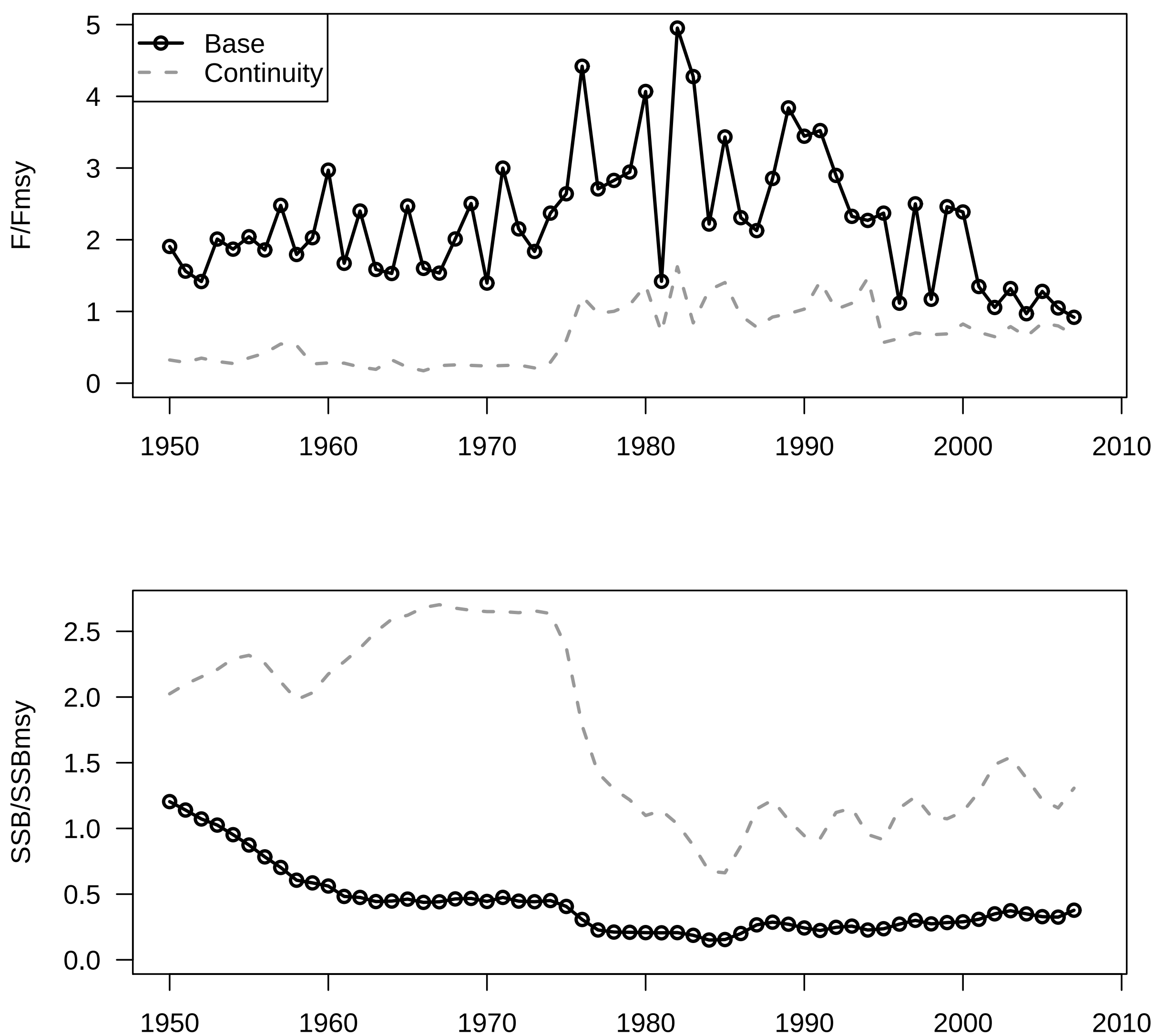


Figure 3.49. Spanish mackerel: Sensitivity of results to choice of index (sensitivity runs S8). Top panel – Ratio of F to F_{MSY}. Bottom panel – Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$.

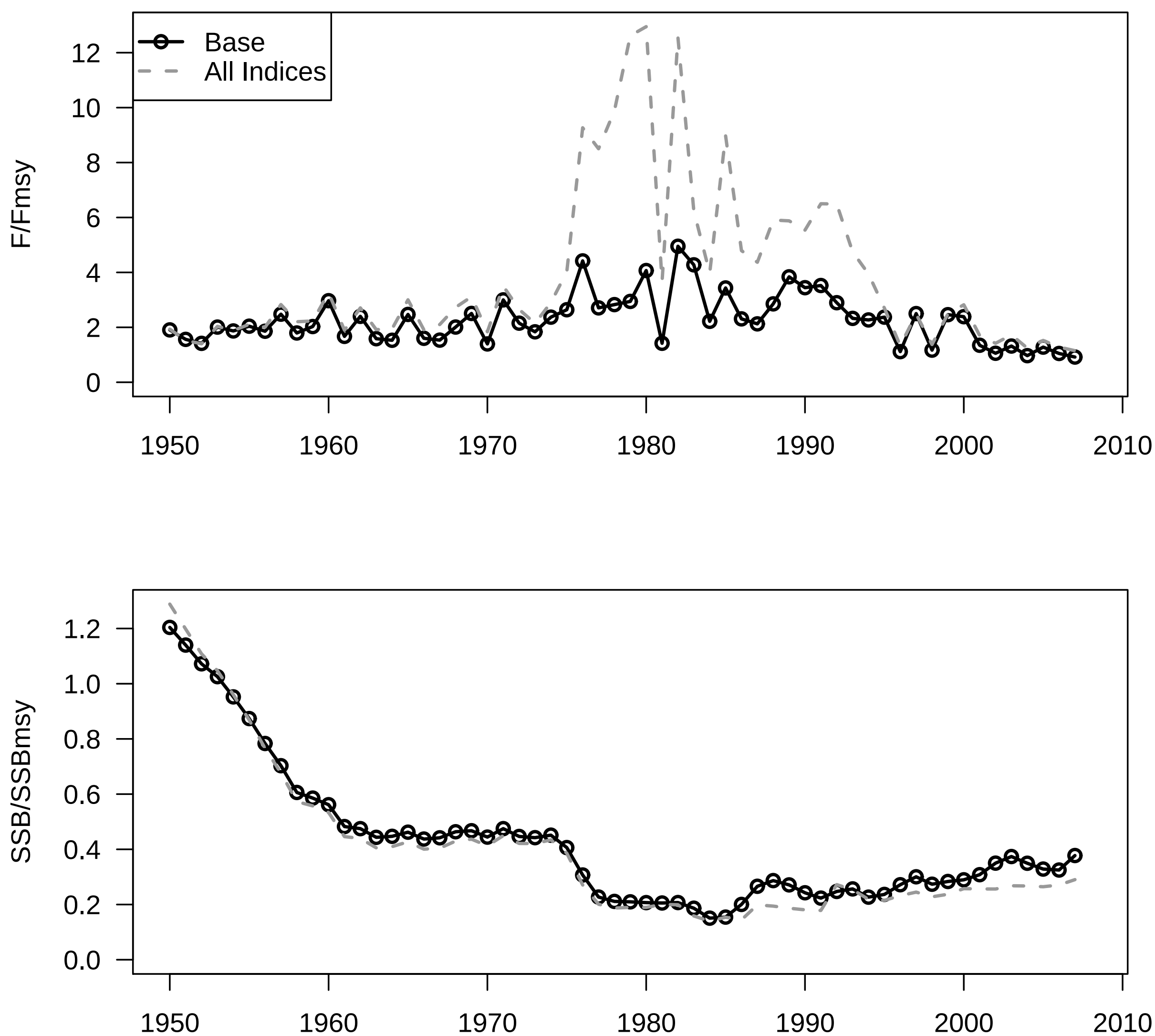


Figure 3.50. Spanish mackerel: Sensitivity of results to autocorrelated recruitment residuals (sensitivity run S9). Top panel – Ratio of F to F_{MSY}. Bottom panel – Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$.

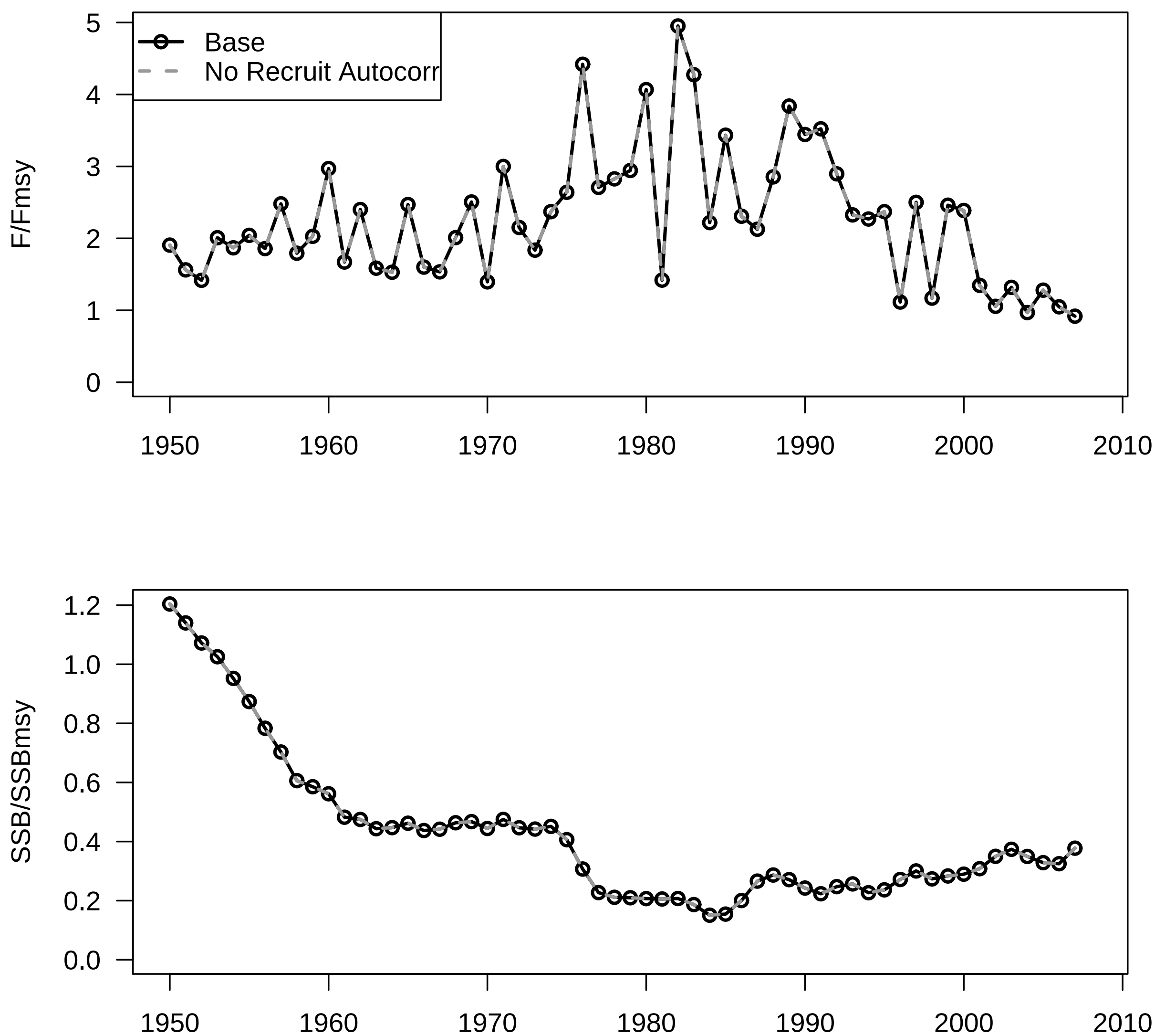


Figure 3.51. Spanish mackerel: Sensitivity of results to factorial combinations of early recreational landings and shrimp bycatch (sensitivity runs S10 - S15). Displayed is the ratio of F to F_{MSY} for a/b/c where a gives historical recreational multipler, b gives shrimp landings multiplier, and c gives pre-assessment fishing mortality rate.

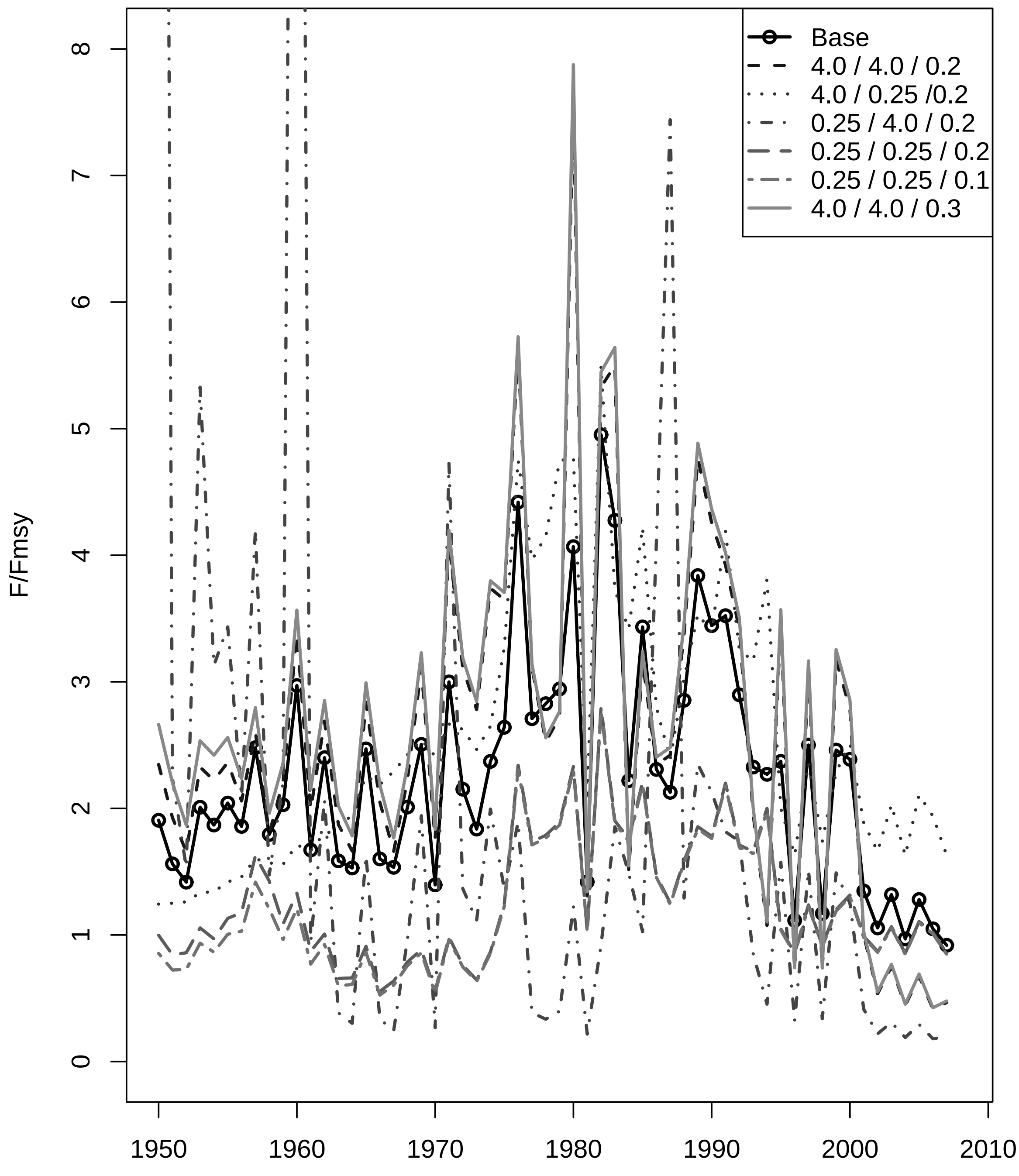


Figure 3.52. Spanish mackerel: Sensitivity of results to factorial combinations of early recreational landings and shrimp bycatch (sensitivity runs S10 - S15). Displayed is the ratio of SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$ *for a/b/c where a gives historical recreational multipler, b gives shrimp landings multiplier, and c gives pre-assessment fishing mortality rate.*

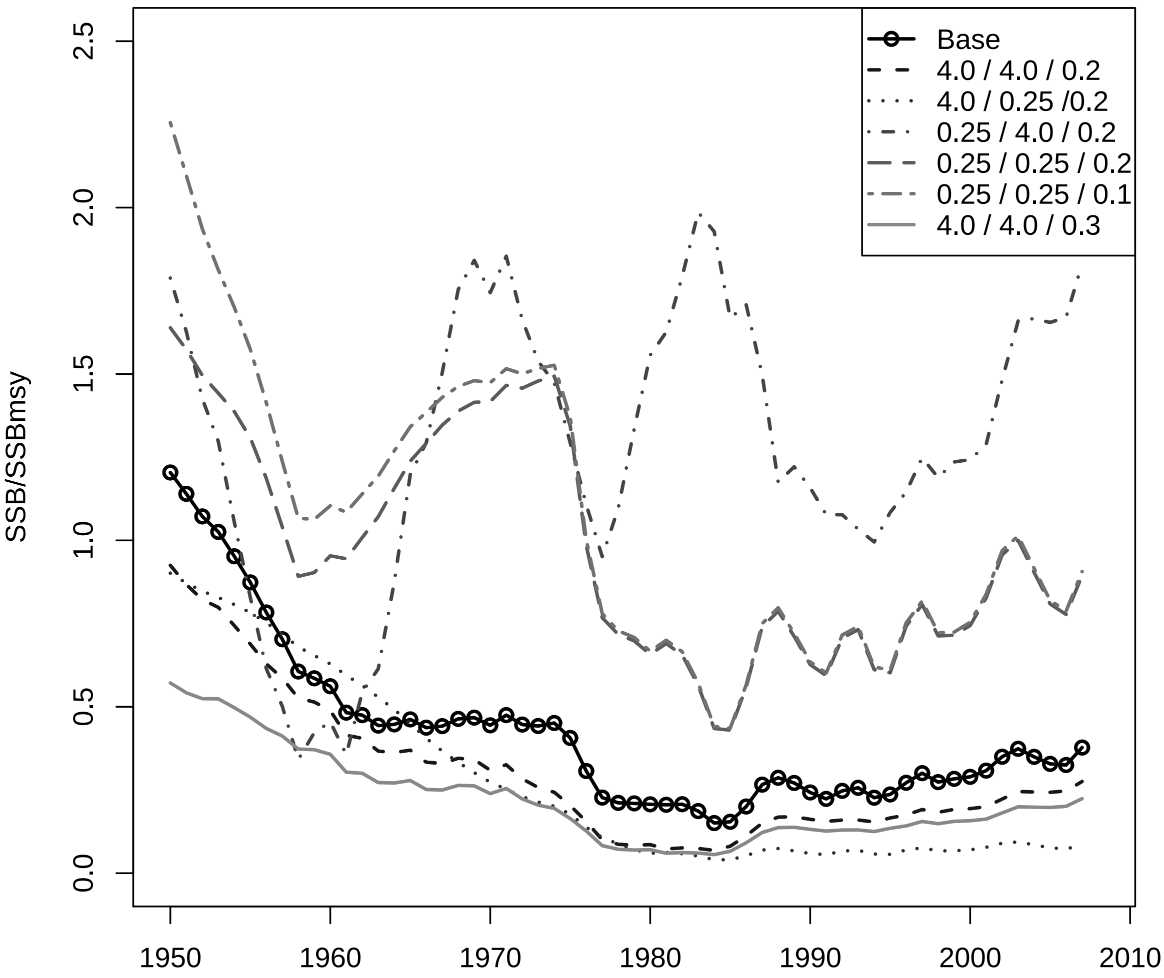


Figure 3.53. Spanish mackerel: Sensitivity of results to total landings (sensitivity runs S16 - S17). Top panel – Ratio of F to F_{MSY}. Bottom panel – Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$.

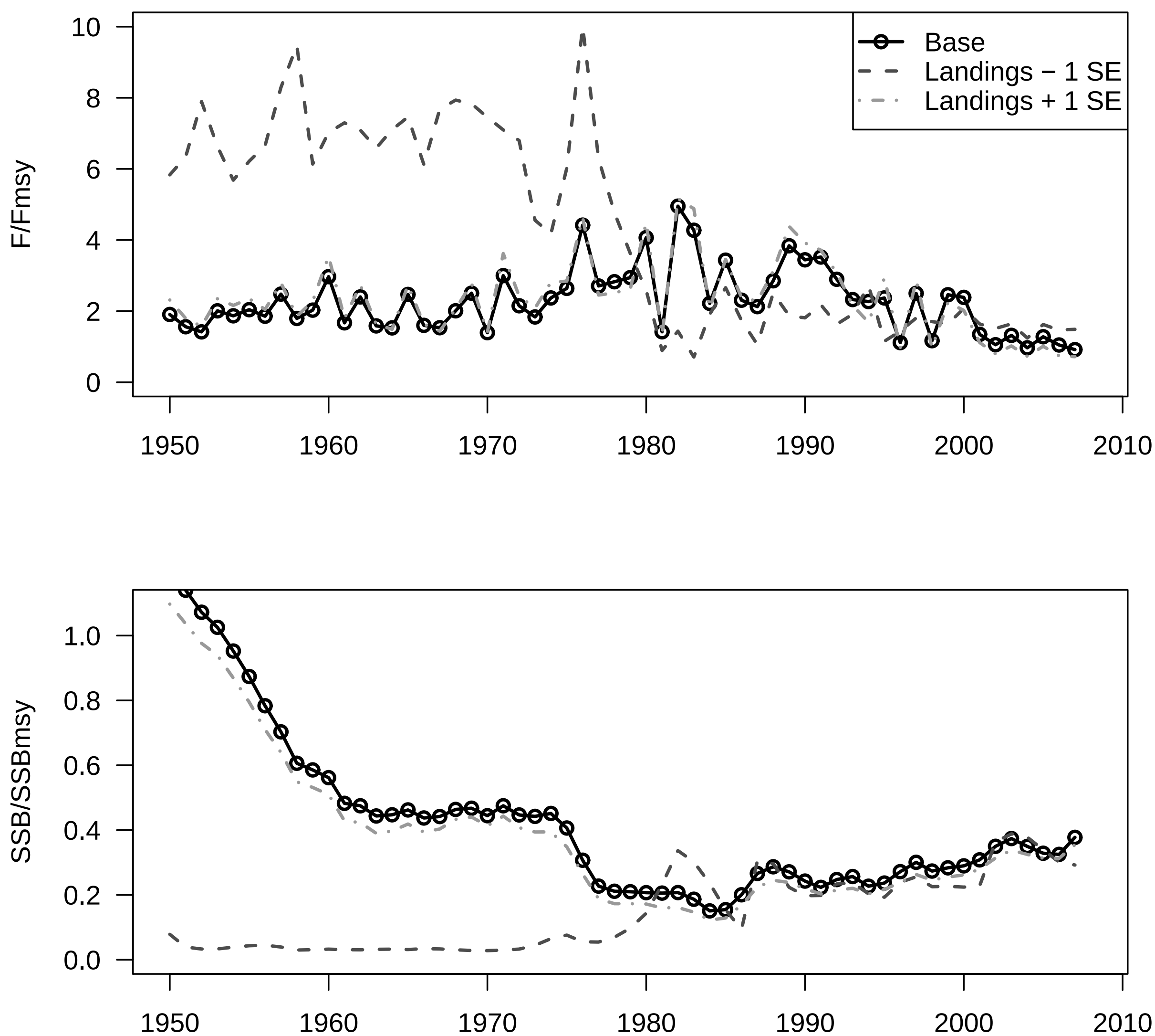


Figure 3.54. Spanish mackerel: Retrospective analysis. Sensitivity of results to terminal year of data (sensitivity runs S18–S21). Top panel – Ratio of F to F_{MSY}. Bottom panel – Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$.

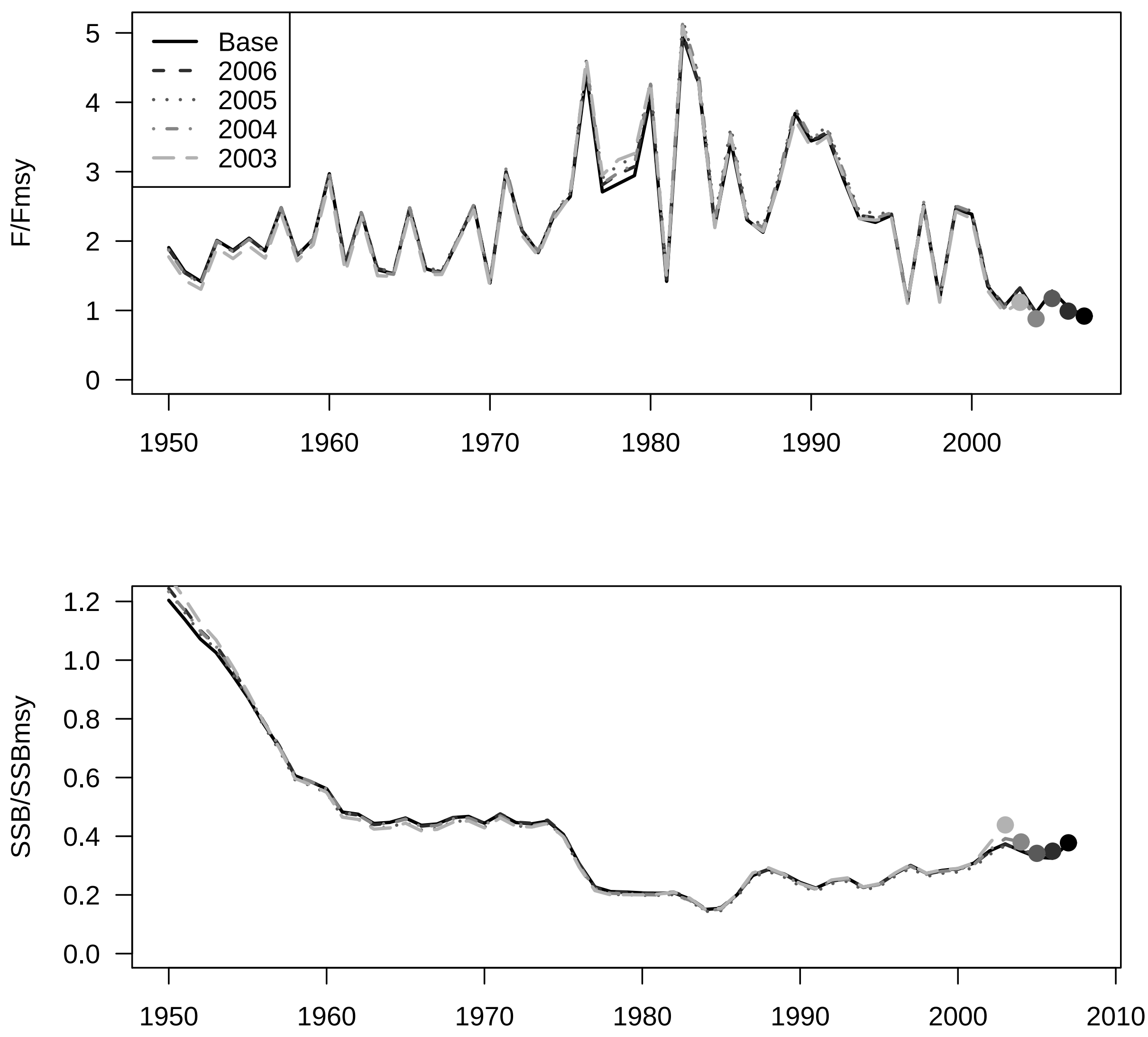


Figure 3.55. Spanish mackerel: Sensitivity of results to natural mortality (sensitivity runs S22–S23). Top panel – Ratio of F to F_{MSY}. Bottom panel – Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{MSY}}$.

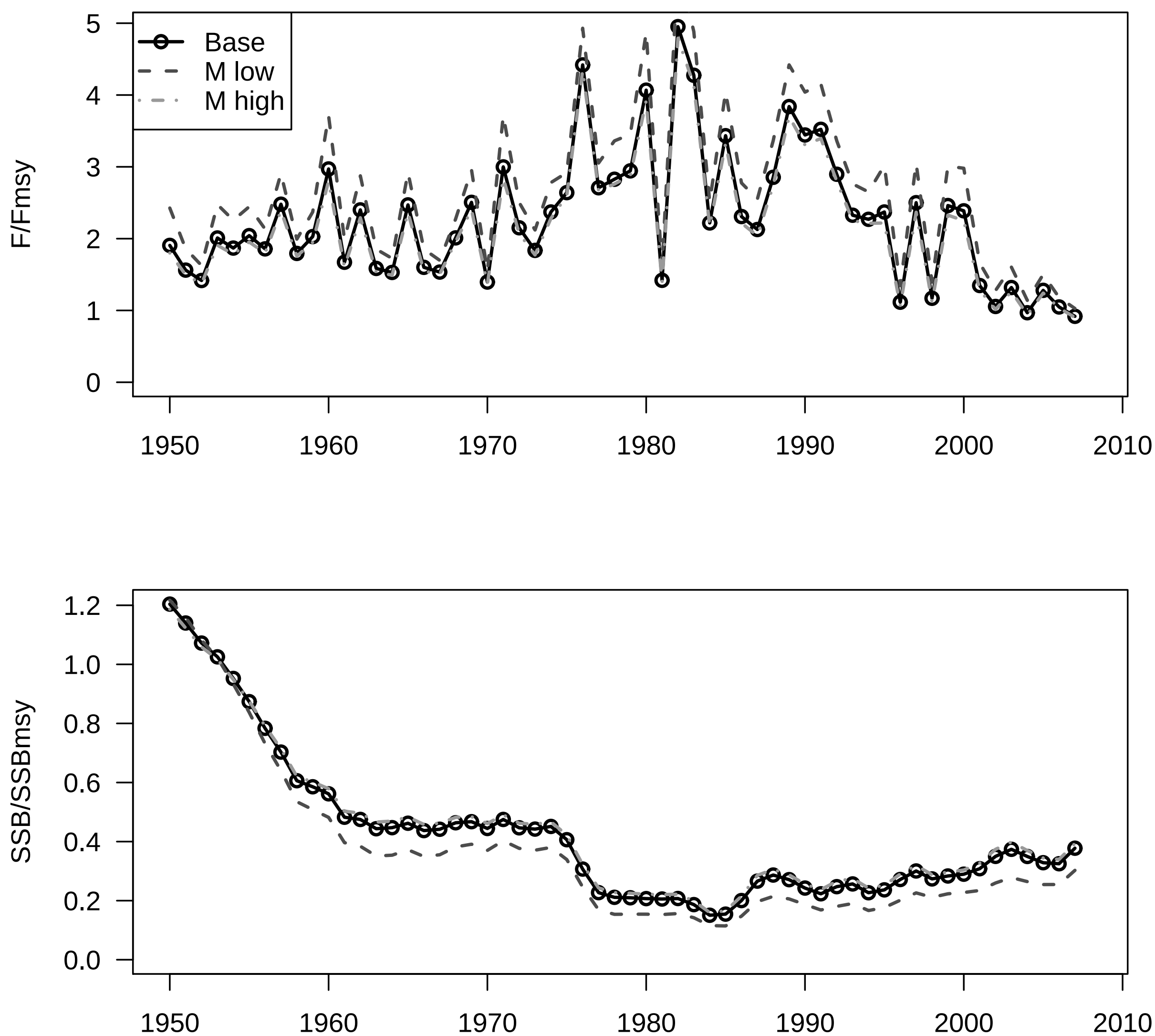


Figure 3.56. Spanish mackerel: Projection results under scenario 1—fishing mortality rate fixed at $F = 0$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10^{th} and 90^{th} percentiles of 1000 replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock biomass (SSB) is at mid-year.*

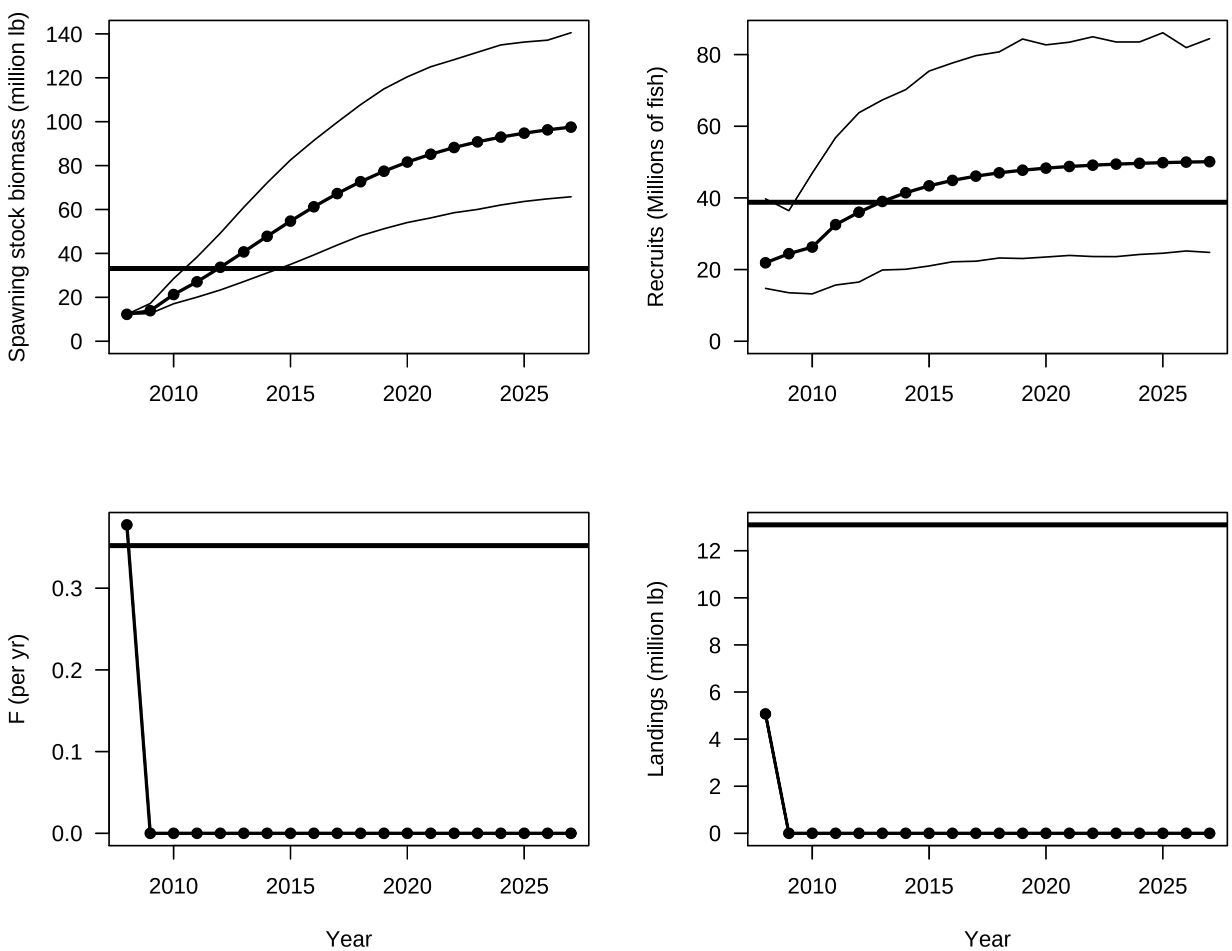


Figure 3.57. Spanish mackerel: Projection results under scenario 2—fishing mortality rate fixed at $F = F_{\text{current}}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10^{th} and 90^{th} percentiles of 1000 replicate projections. Horizontal lines mark MSY-related quantities. Spawning stock biomass (SSB) is at mid-year.

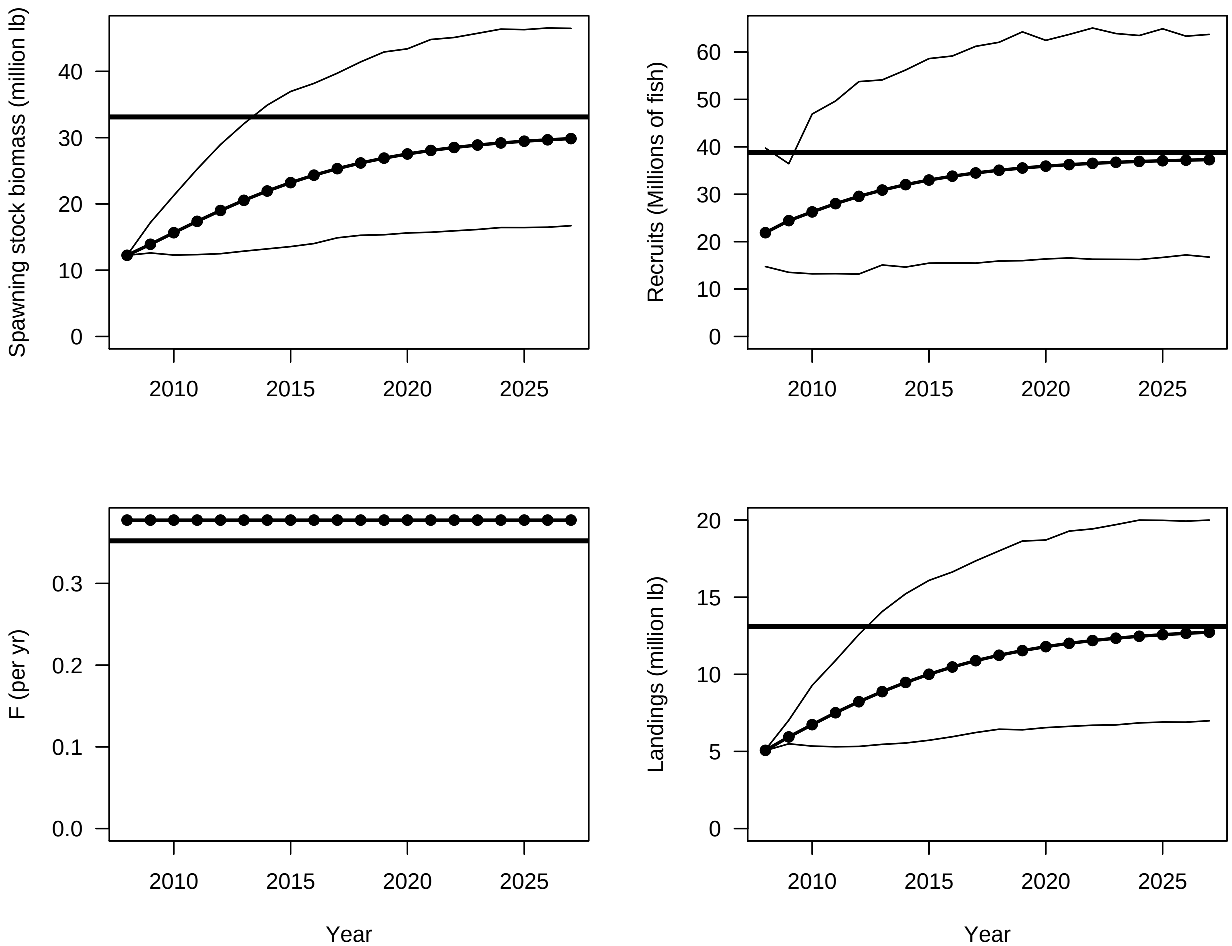


Figure 3.58. Spanish mackerel: Projection results under scenario 3—fishing mortality rate fixed at $F = F_{\mathrm{MSY}}$*. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to* 10^{th} *and* 90^{th} *percentiles of 1000 replicate projections. Horizontal lines mark* MSY*-related quantities. Spawning stock biomass (SSB) is at mid-year.*

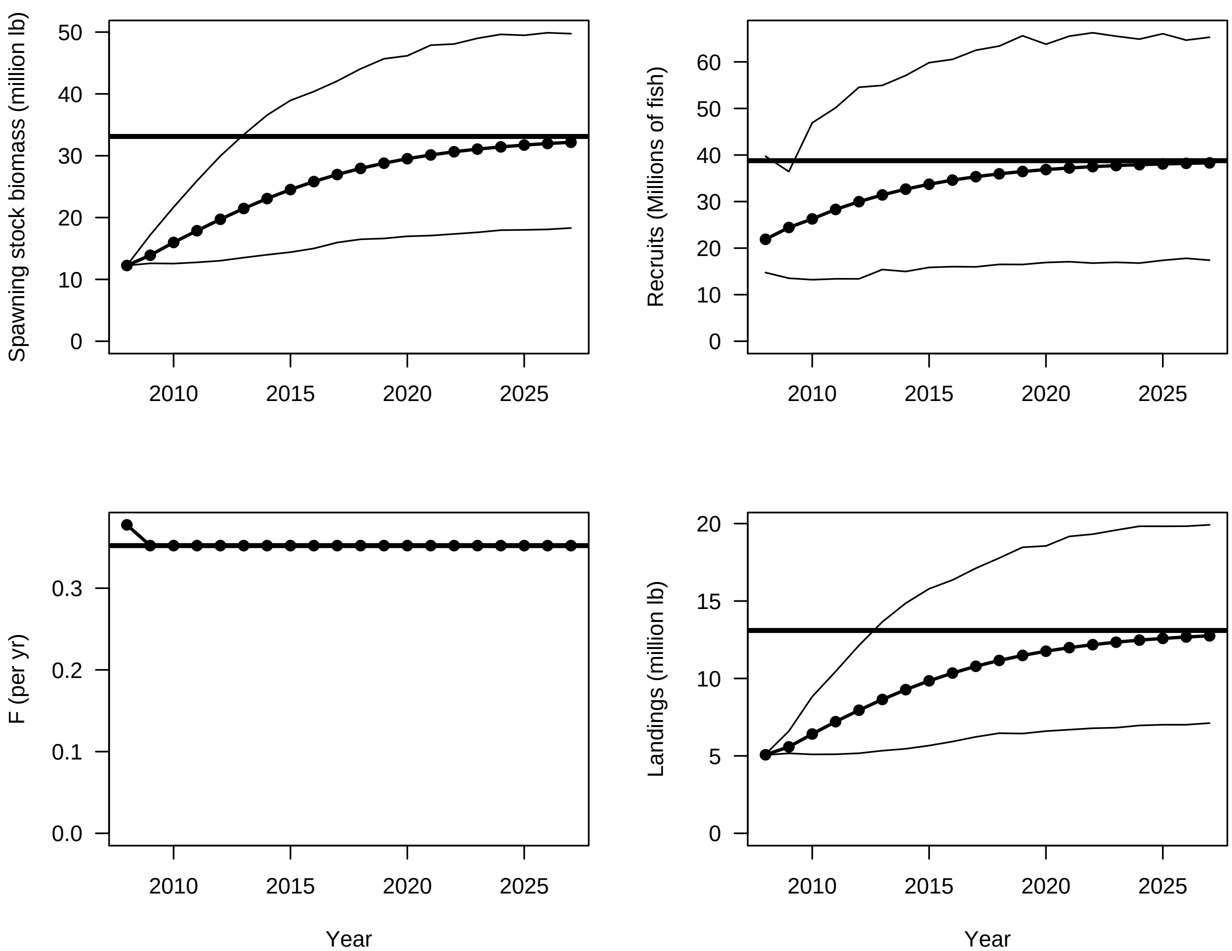


Figure 3.59. Spanish mackerel: Projection results under scenario 4—fishing mortality rate fixed at $F = 65\%F_{\mathrm{MSY}}$*. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to* 10^{th} *and* 90^{th} *percentiles of 1000 replicate projections. Horizontal lines mark* MSY*-related quantities. Spawning stock biomass (SSB) is at mid-year.*

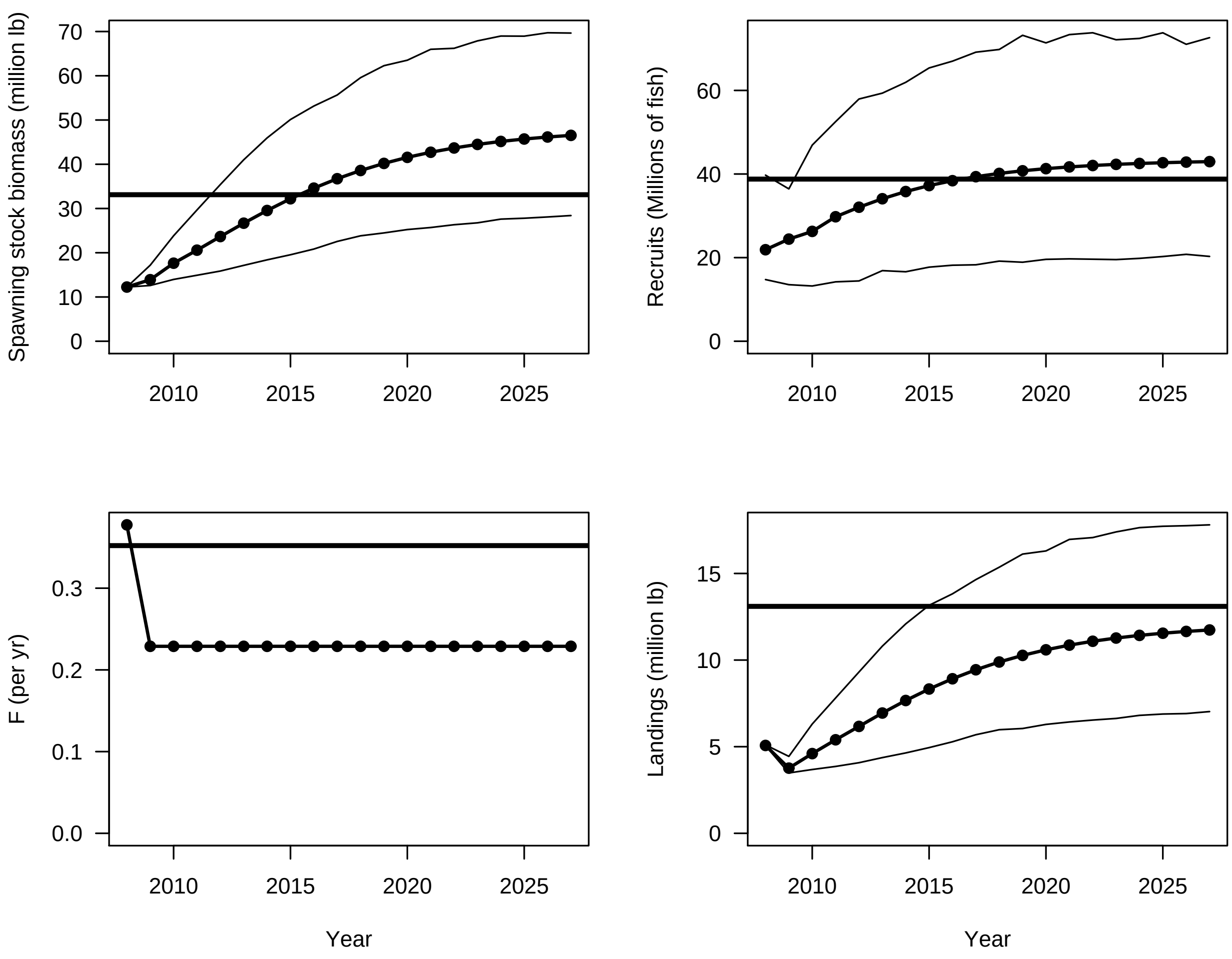


Figure 3.60. Spanish mackerel: Projection results under scenario 5—fishing mortality rate fixed at $F = 75\% F_{\mathrm{MSY}}$*. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to* 10^{th} *and* 90^{th} *percentiles of 1000 replicate projections. Horizontal lines mark* MSY*-related quantities. Spawning stock biomass (SSB) is at mid-year.*

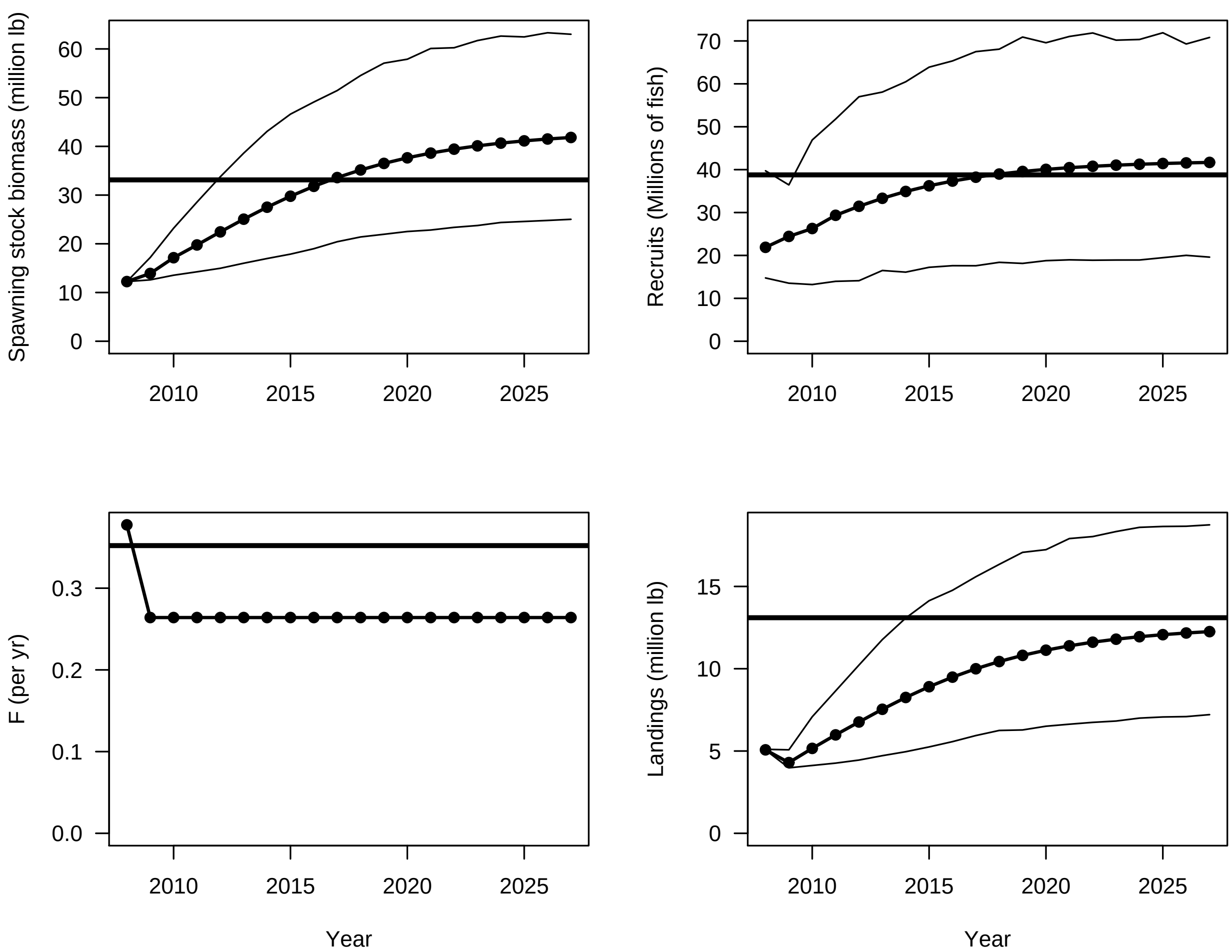


Figure 3.61. Spanish mackerel: Projection results under scenario 6—fishing mortality rate fixed at $F = 85\%F_{\mathrm{MSY}}$*. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to* 10^{th} *and* 90^{th} *percentiles of 1000 replicate projections. Horizontal lines mark* MSY*-related quantities. Spawning stock biomass (SSB) is at mid-year.*

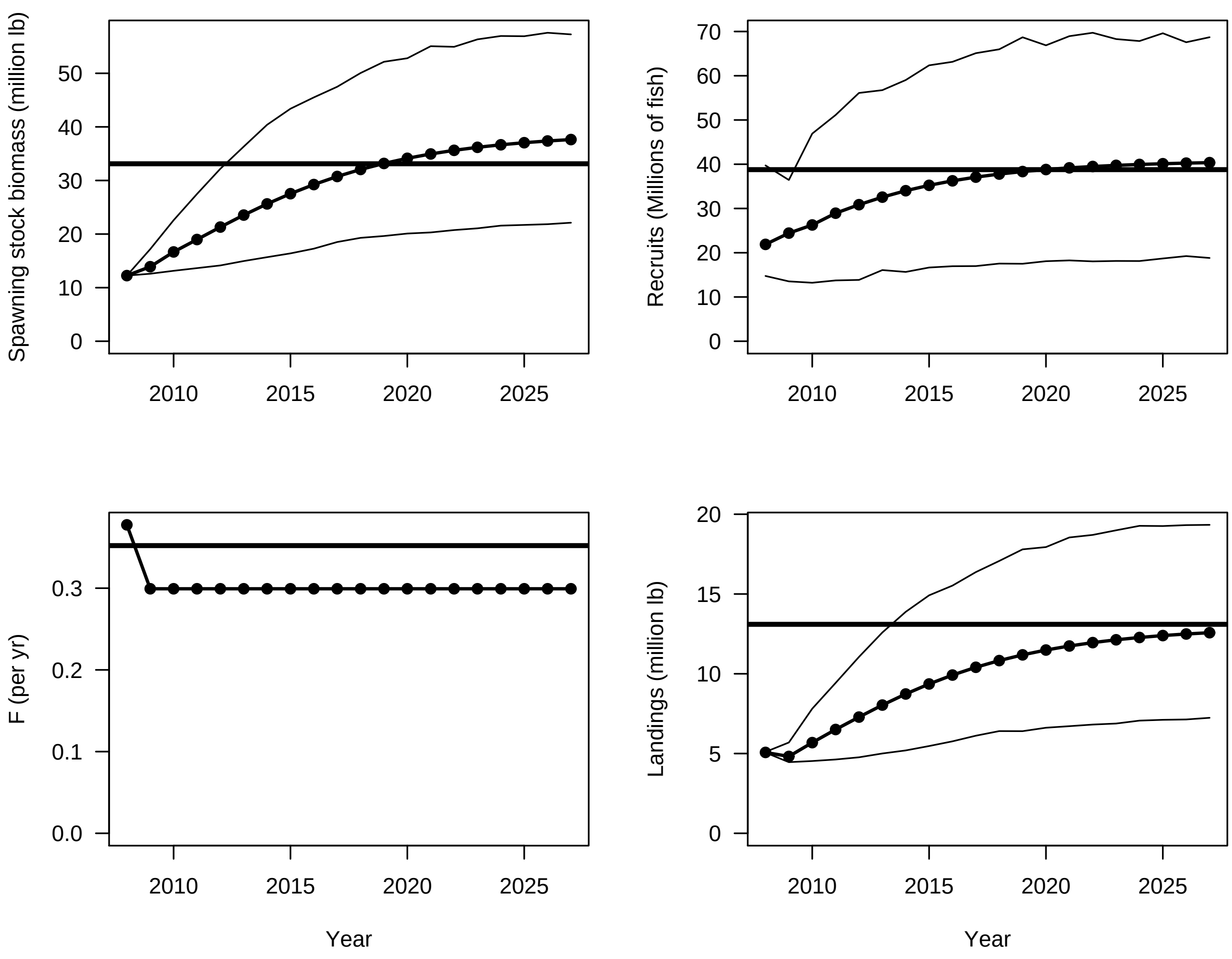


Figure 3.62. Spanish mackerel: Projection results under scenario 7—fishing mortality rate fixed at $F = F_{\mathrm{rebuild}} = 0.285$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10^{th} and 90^{th} percentiles of 1000 replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock biomass (SSB) is at mid-year.*

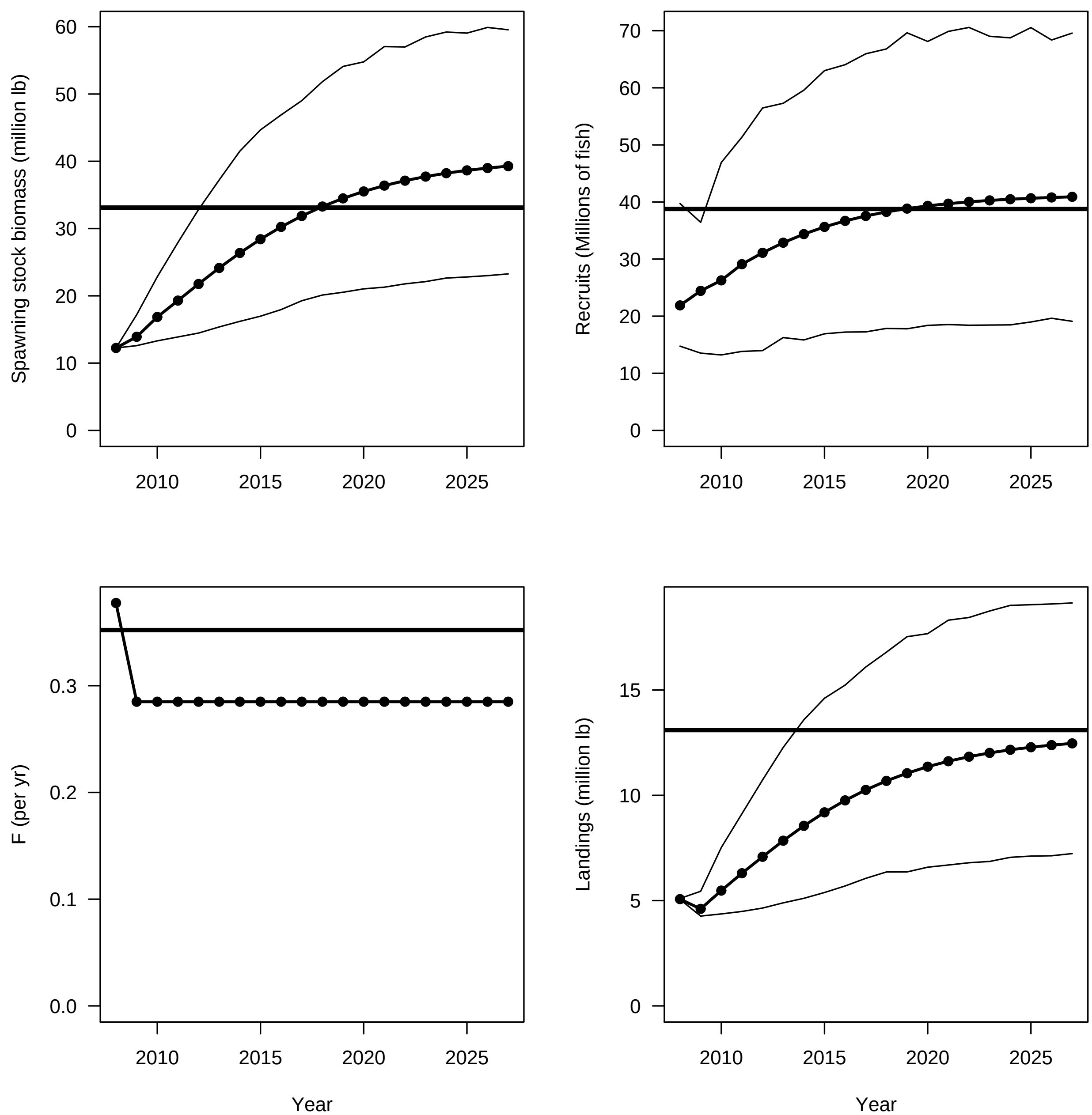


Figure 3.63. Spanish mackerel: Results of probabilistic analysis showing the probability of stock recovery to $\mathrm{SSB}_{\mathrm{MSY}}$ *as a function of year. The vertical line corresponds to 2019, the maximum rebuilding time frame under the MSRA.*

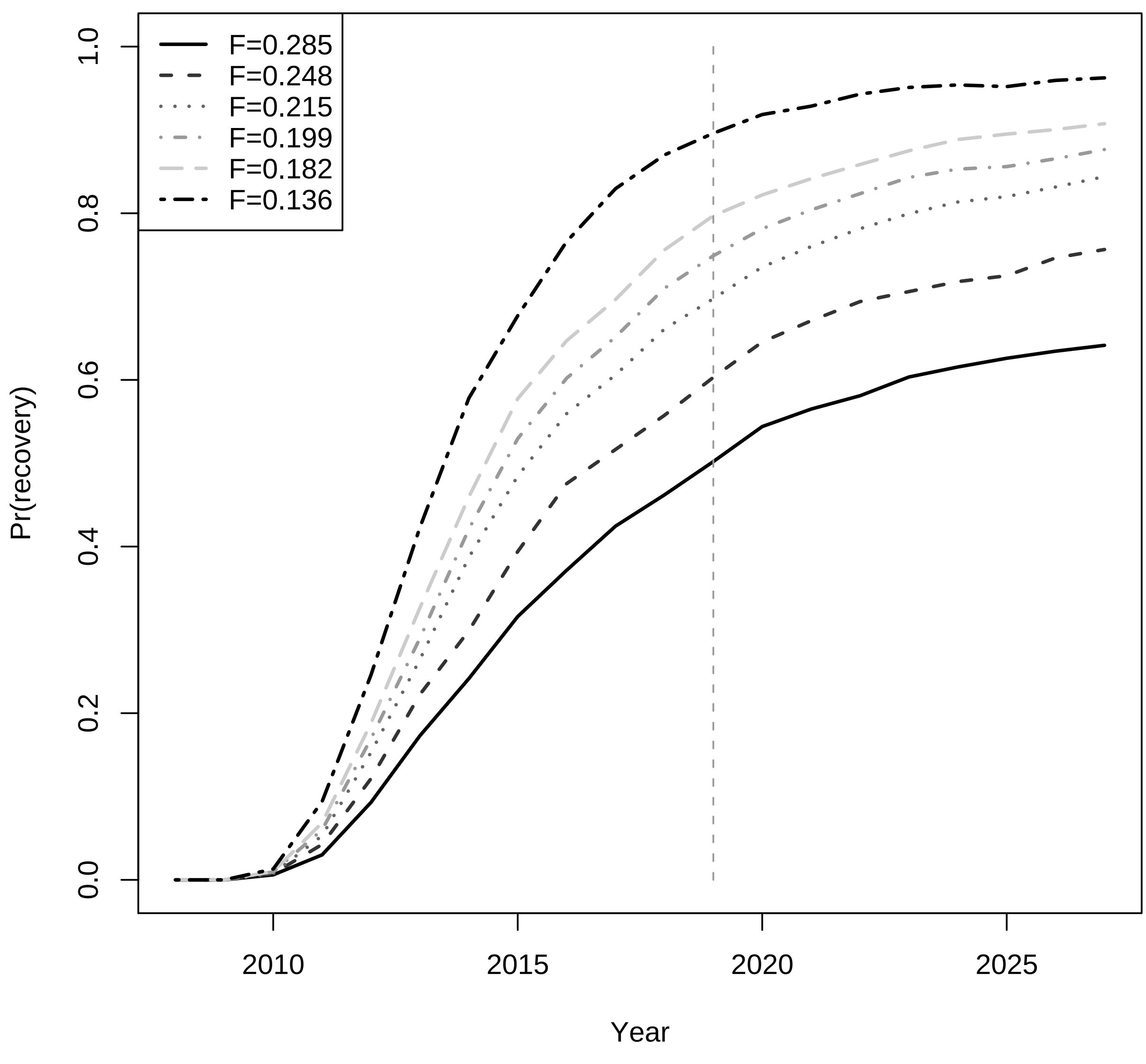
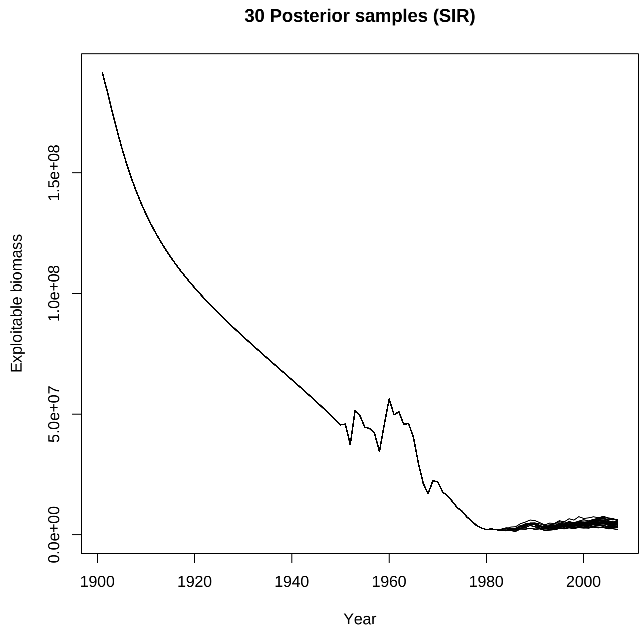


Figure 3.64. Stock reduction analysis time series (30 randomly selected "particles"). Top panel: spawning biomass relative to the unfished level. Bottom panel: observed (open circles) and predicted (lines) population growth rates.



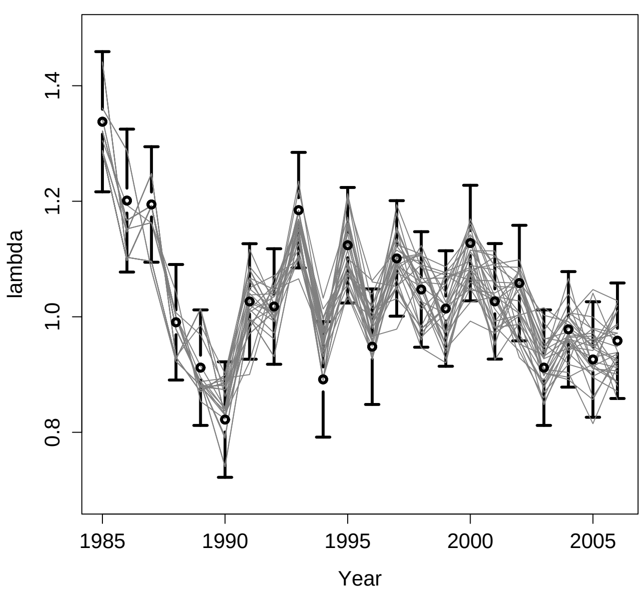


Figure 3.65. Posterior distributions of parameters estimated by stock reduction analysis.

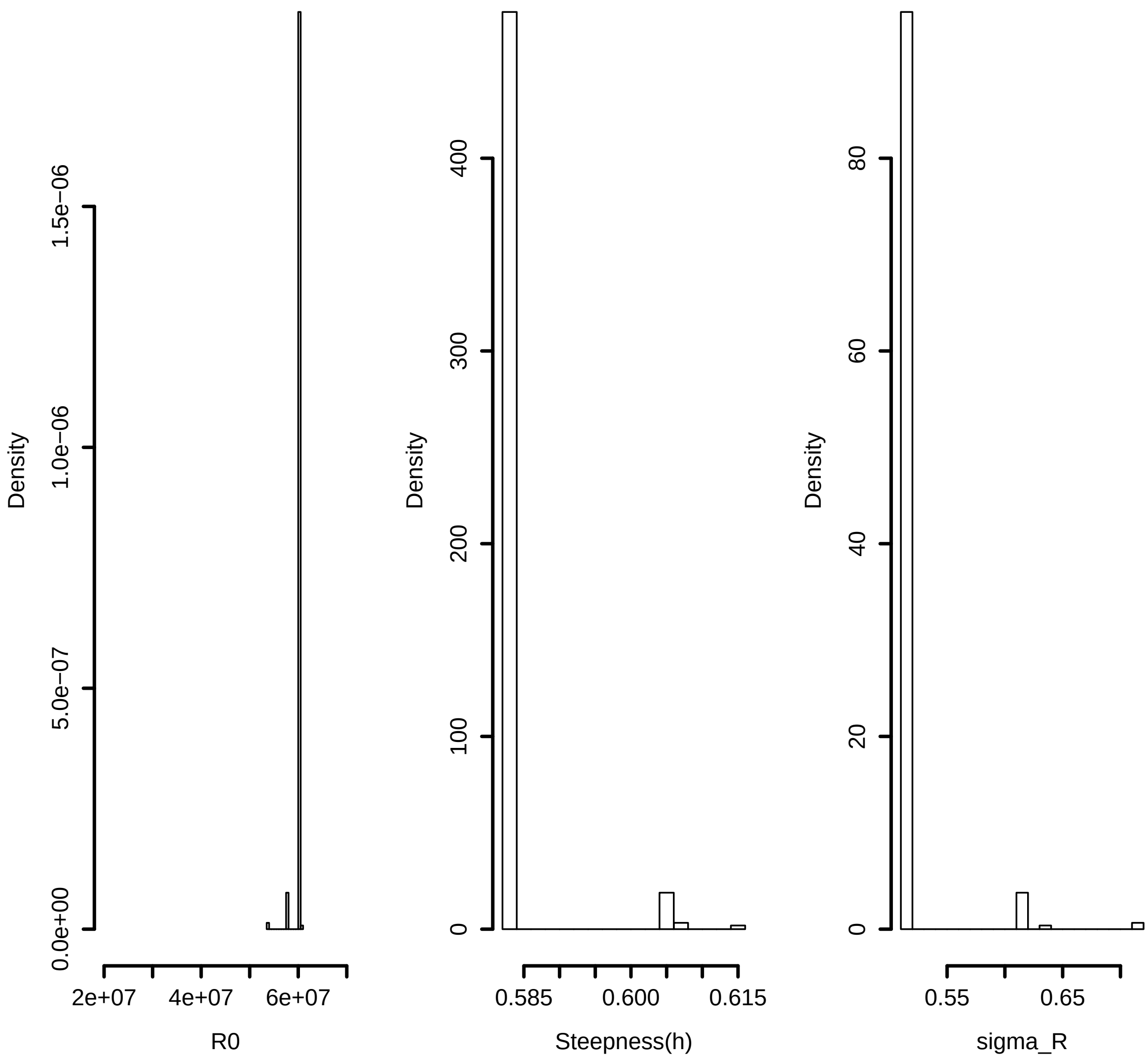
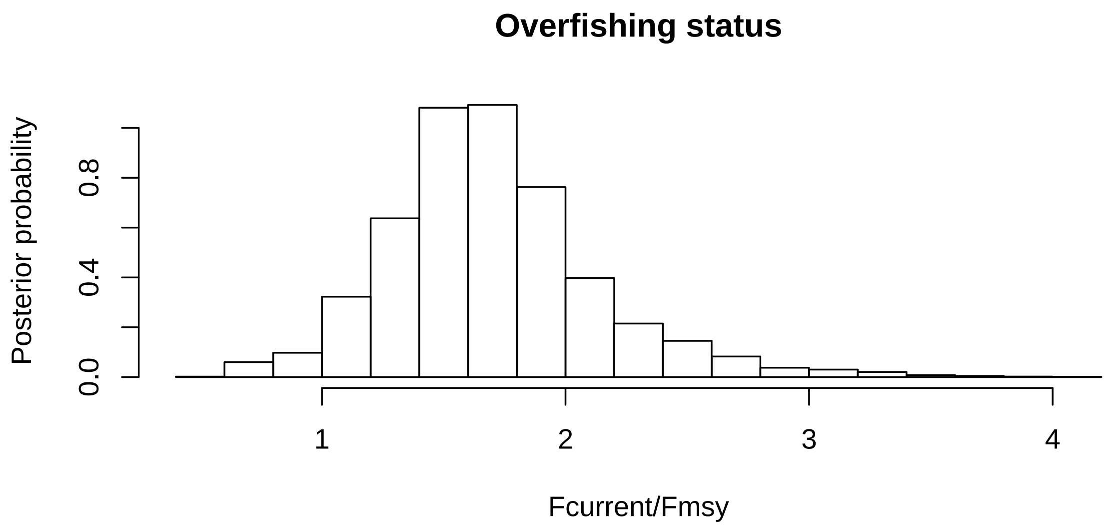


Figure 3.66. Posterior distributions of current (2007) fishery status and stock status from the stock reduction analysis.



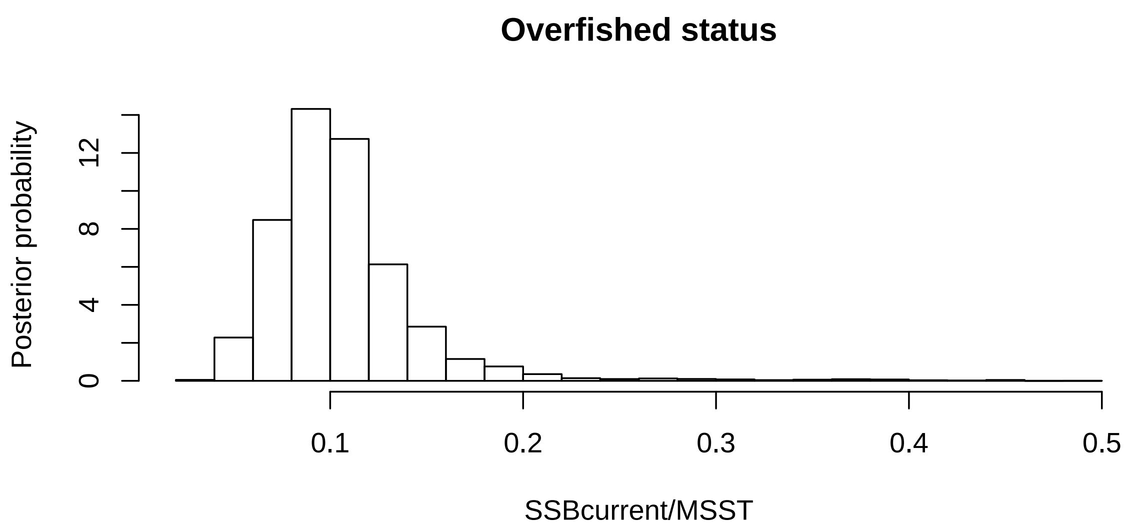


Figure 3.67. Surplus production model fits to the combined index: Observed (solid circles) and predicted CPUE (lines).

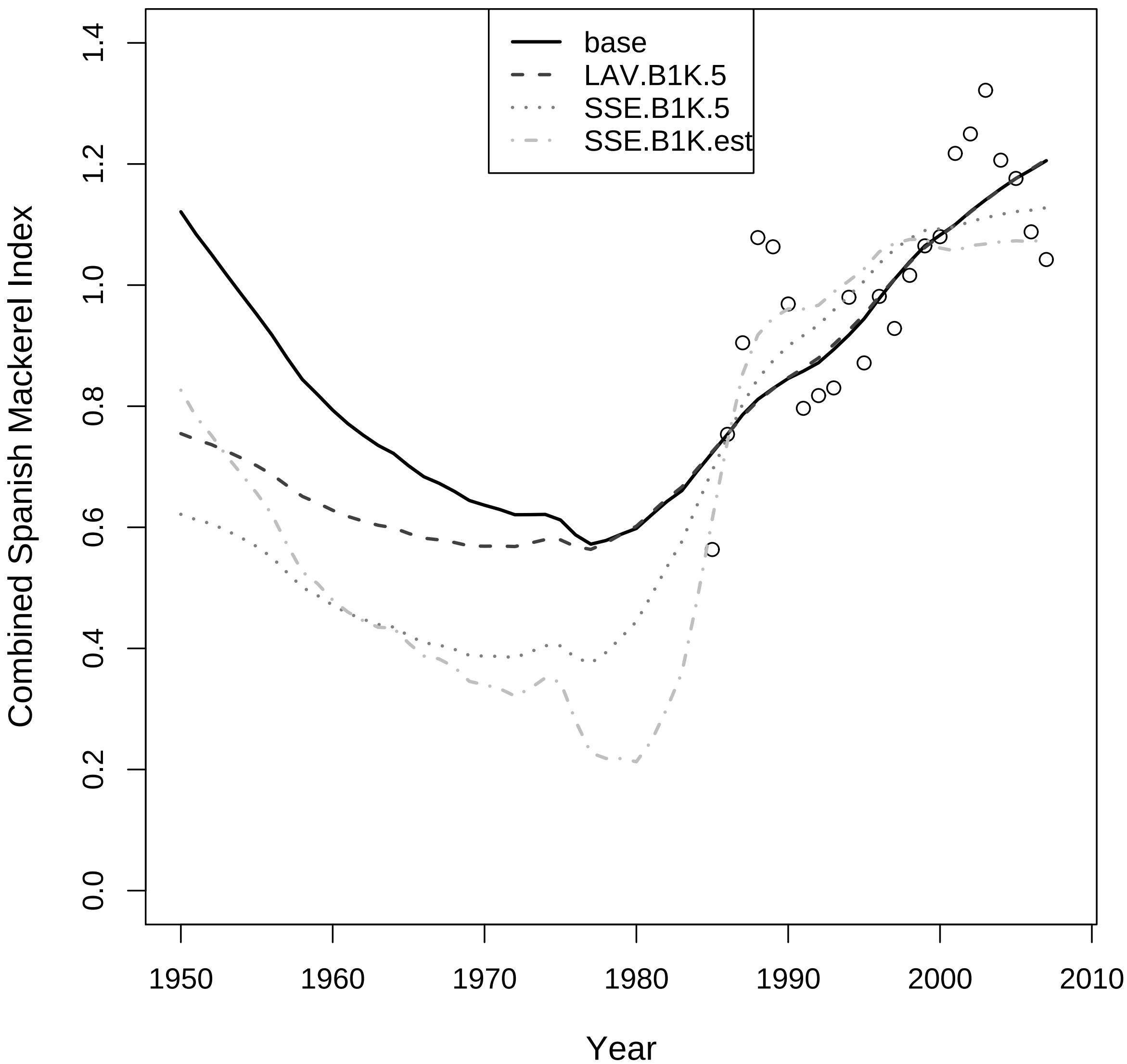


Figure 3.68. Base surplus production model estimates of biomass and fishing mortality rate relative to their thresholds. Dotted lines represent 80% approximate confidence limits from bootstrap analysis.

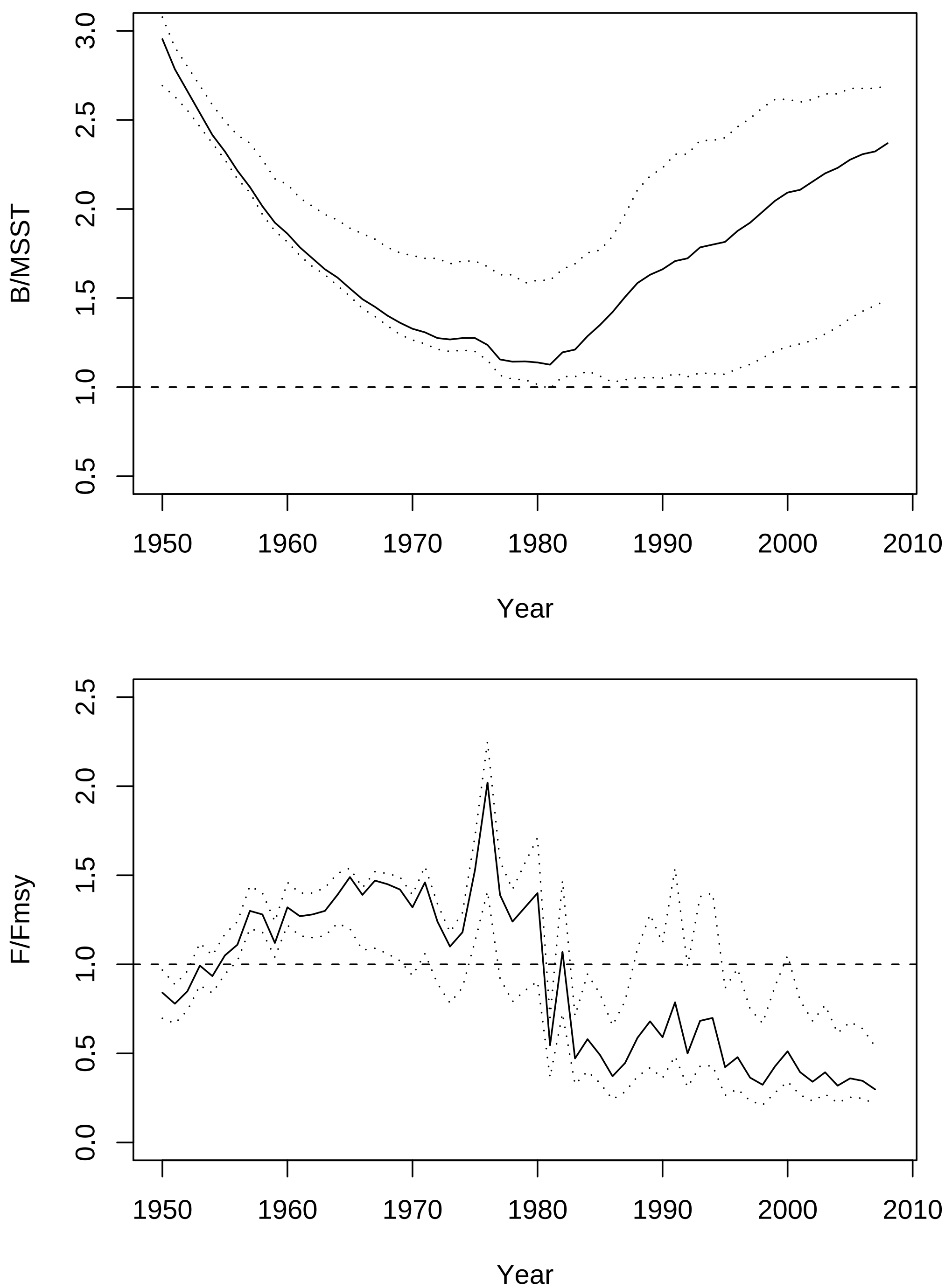
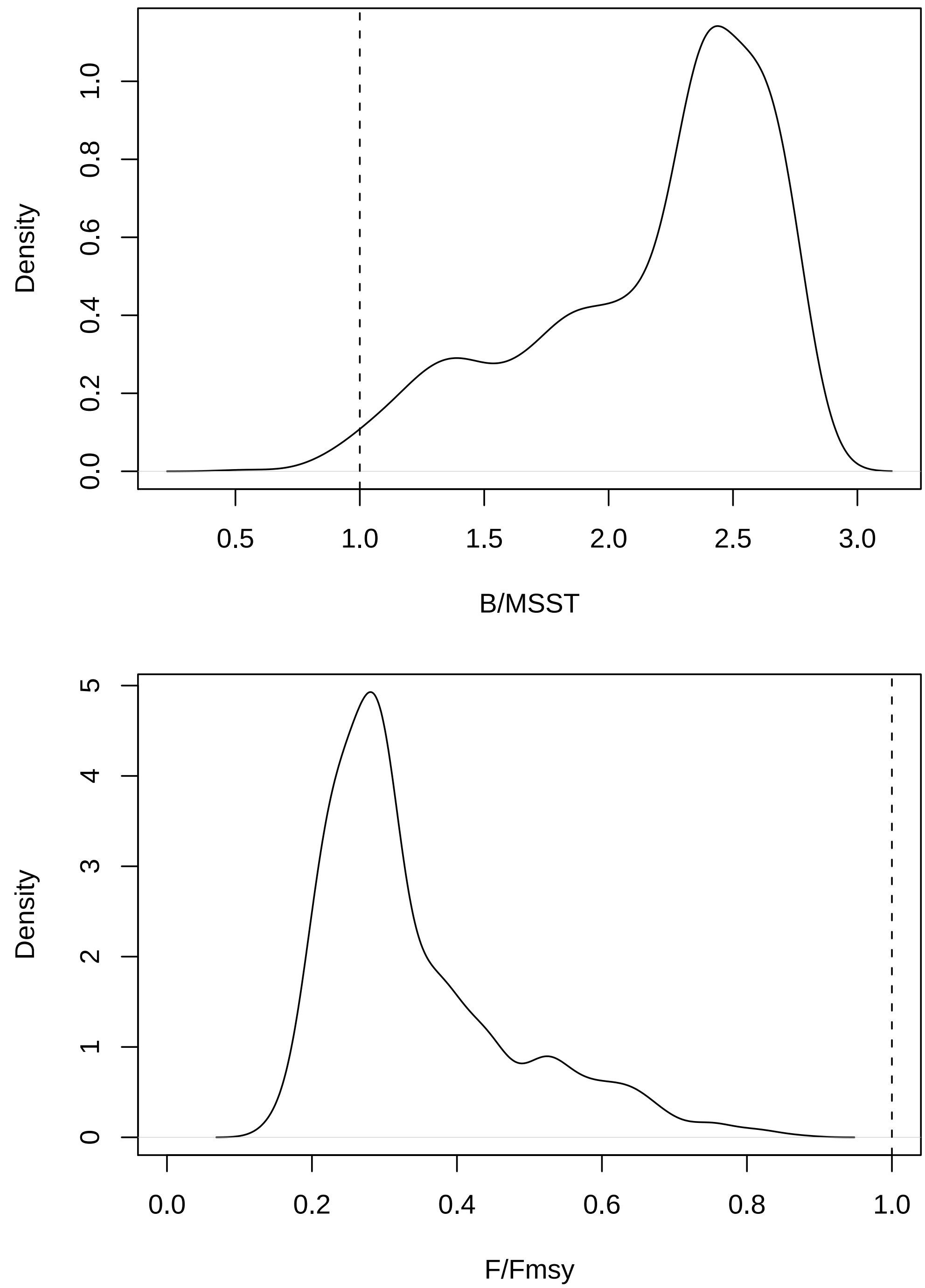


Figure 3.69. Bootstrap distributions of current (2007) fishery status and stock status from the base surplus production model.



Appendix A Abbreviations and symbols

Table A.1. Acronyms, abbreviations, and mathematical symbols used in this report

Symbol	Meaning
AW	Assessment Workshop (here, for Spanish mackerel)
ASY	Average Sustainable Yield
B	Total biomass of stock, conventionally on January 1r
CPUE	Catch per unit effort; used after adjustment as an index of abundance
CV	Coefficient of variation
DW	Data Workshop (here, for Spanish mackerel)
E	Exploitation rate; fraction of the biomass taken by fishing per year
E_{MSY}	Exploitation rate at which MSY can be attained
F	Instantaneous rate of fishing mortality
F_{MSY}	Fishing mortality rate at which MSY can be attained
FL	State of Florida
GA	State of Georgia
GLM	Generalized linear model
K	Average size of stock when not exploited by man; carrying capacity
kg	Kilogram(s); 1 kg is about 2.2 lb.
klb	Thousand pounds; thousands of pounds
lb	Pound(s); 1 lb is about 0.454 kg
m	Meter(s); 1 m is about 3.28 feet.
M	Instantaneous rate of natural (non-fishing) mortality
MFMT	Maximum fishing-mortality threshold; a limit reference point used in U.S. fishery management; often based on F_{MSY}
mm	Millimeter(s); 1 inch = 25.4 mm
MRFSS	Marine Recreational Fisheries Statistics Survey, a data-collection program of NMFS
MSST	Minimum stock-size threshold; a limit reference point used in U.S. fishery management. The SAFMC has defined MSST for Spanish mackerel as $(1-M)\mathrm{SSB}_{\mathrm{MSY}} = 0.7\mathrm{SSB}_{\mathrm{MSY}}$.
MSY	Maximum sustainable yield (per year)
mt	Metric ton(s). One mt is 1000 kg, or about 2205 lb.
N	Number of fish in a stock, conventionally on January 1
NC	State of North Carolina
NMFS	National Marine Fisheries Service, same as "NOAA Fisheries Service"
NOAA	National Oceanic and Atmospheric Administration; parent agency of NMFS
NY	State of New York
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
SD	Standard deviation
SE	Standard error
SEAMAP	Southeast Area Monitoring and Assessment Program, a fishery-independent data collection program of SCDNR
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
SSRA	Stochastic stock reduction analysis
SW	Scoping workshop; first of 3 workshops in SEDAR updates
TIP	Trip Interview Program, a fishery-dependent biodata collection program of NMFS
TL	Total length (of a fish), as opposed to FL (fork length) or SL (standard length)
VPA	Virtual population analysis, an age-structured assessment model characterized by computations backward in time; may use abundance indices to influence the estimates
yr	Year(s)

Appendix B Parameter estimates from AD Model Builder implementation of catch-at-age assessment model

```
# Number of parameters = 453  Objective function value = 4941.23  Maximum gradient component = 0.00161336
# log_len_cv:
-2.33579949587
# log_R0:
17.6527120881
# steep:
0.616615279231
# log_dev_N_rec:
 0.0240023979955 -0.0408233626894 0.0596390560920 0.675098029527
  0.507597484830 0.0220981202484 -0.0525214542236 0.218843641142
  0.437056062997 0.663823580431 0.287077356170 -0.246539479003
  -0.178872379909 0.333615714596 -0.170768105718 -0.604637536677
  -0.263643066957 0.137187351954 0.223695326560 0.0225142115596
   -0.243269974774 -0.810531568069 -0.610864281066 -0.328932587934
   -0.0130633274712 -0.0477812096118
# R_autocorr:
0.574887985110
# selpar_slope_HL:
2.99504795438
# selpar_L50_HL_keep:
1.39411168675
# selpar_slope_PN:
19.9999997264
# selpar_L50_PN:
-0.0260928987317
# selpar_slope_GN:
3.32166221219
# selpar_L50_GN_keep:
1.45956034296
# selpar_slope_GN2:
2.97735564106
# selpar_L50_GN2:
1.06348345667
# selpar_slope2_GN2:
0.867993134259
# selpar_L502_GN2:
3.69863851901
# selpar_slope_CN:
19.9999966986
# selpar_L50_CN:
1.12614529114
# selpar_age0_MRFSS:
0.0298645349595
# selpar_age2_MRFSS:
0.664171872737
# selpar_age3_MRFSS:
0.505711827519
# log_q_comb:
-9.32297732877
# log_q_SMAP_YOY:
-16.7958633834
# log_avg_F_HL:
-4.75488438513
# log_F_dev_HL:
 -3.19899584654 -3.21294350794 -2.18392313846 -2.30330863287
 -0.835932654797 -1.16855455615 -0.467761923074 -0.0987391125826
  0.00587131471564 -0.139529758766 -0.314153175572 -0.551973793291
   -0.333329585170 -0.380343600328 -0.308646716218 -0.0645400945555
    0.494806643984 1.36151619011 1.61458138041 0.380320068847
     -0.471517074080 -0.333874587544 -0.342991976964 -0.752367926627
      0.241159312407 -0.887448903766 -0.273205187760 0.144339084414
       -0.142116844059 0.258078667005 -0.0551002520754 0.261577777241
        0.925112638242 1.22434331837 -0.127684295314 -0.433760273931
         -0.256502221585 0.813956424770 -0.208804390735 -0.194205199677
          0.409386904382 0.622979684358 0.915008634627 1.30431648364
```

```
          1.05421122985 1.07759953102 1.65217362741 1.65207881392
           1.90543447072 1.72340302999
# log_avg_F_PN:
-6.42901321788
# log_F_dev_PN:
 -2.20956399096 -2.92567369547 -3.56206483344 -4.61610816812
  -3.15718475907 -2.67139930215 -1.59146442500 -1.55693781350
   -2.34015322866 -1.26571698975 -1.00617038595 0.888762188270
    -1.26288429028 0.333108613537 -0.391978120803 0.617492698732
     0.879723333456 -0.712557919338 0.400173159630 0.542684582813
      0.799631452889 -0.641273541864 -0.700779445410 0.101914261592
       -0.629620047016 0.366251281158 0.818689765601 0.117159561435
        -2.50025590314 -3.18719263916 -1.77487147224 -2.44658260358
        -0.752172453415 -0.438973391299 -0.188415197014 0.587912657877
         0.522351187845 2.09204993122 1.78922556988 2.86030292051
         2.95738013065 2.90822691723 2.66986405307 2.47143486537
         2.63221860051 2.07508629168 2.34811807202 1.91286281459
         1.43455069887 2.32060142867 1.90677733683 1.92132904235
         1.31821841766 1.07812300120 0.718758309039 0.401301511997
         -1.22417481494 -1.03811522660
# log_avg_F_GN:
-1.67536474936
# log_F_dev_GN:
 -1.23827945102 -1.30712629286 -0.962190290734 -1.05666211533
 -1.06513904074 -0.658703618878 -0.366239319614 -0.0207911702032
 0.0112363966399 -0.654612090336 -0.534973151186 -0.350978103398
 -0.457613399990 -0.538045033536 -0.339152109426 -0.369822420903
 -0.651311147405 -0.0825177805863 -0.102583538706 -0.218184521460
 -0.211680866387 -0.198849421707 -0.182745670180 -0.331744877883
 0.00536604415416 0.729289257570 1.49713622801 1.32102157898 1.45019326004
 1.46328798914 1.46763384424 0.546157696213 1.54221982208 0.796367277036
 0.959891289727 1.14983248948 0.564963365085 0.299262688563 0.355438765663
 0.331034937866 0.296825448781 0.778919599463 0.592320617704
 0.851907461462 0.992167771482 -0.358507302162 0.0692174694218
 0.0931562392006 0.229062722935 -0.310635194756 -0.342044025946
 -0.439368123261 -0.733750755510 -1.17144397833 -1.31981362799
 -0.759912106034 -0.547371212438 -0.511118502036
# log_avg_F_CN:
-3.44365058185
# log_F_dev_CN:
 -2.26413517153 -0.656901007668 -1.70912714829 -2.61459112664
 -0.121791945072 0.401396808473 0.807367738555 1.11551532066
 1.44699471410
 1.13824077775 1.24326785860 1.09998883348 0.113774347578
# log_avg_F_MRFSS:
-1.83032899944
# log_F_dev_MRFSS:
 -0.0385325812683 0.188255716409 0.200793248207 0.196845119468
 0.331651552199 0.386918313763 0.465638033942 0.493641483200
 0.651412083376 0.576445884293 0.689277702590 0.936624457381
 0.739829182655 0.912244718573 0.792993840850 0.762489273046
 0.873914351029 0.678638381343 0.530456968532 0.529272999993
 0.565137107624 0.278544148348 0.446729879995 0.266801745701
 0.0910667388963 0.0692114711643 0.0218979533465 0.107882233650
 -0.206795237591 -0.493180820848 -0.851207171299 -0.383945772231
 -0.537866169521 -2.16285528899 0.248537601722 -0.893009603026
 -0.551980478509 -0.465089999170 0.0399229907005 -0.152800634444
 0.0817436947398 0.0991878784667 -0.250291618204 -0.541205779850
 -0.0933085132101 -0.498664200284 -0.628351639526 -0.411539638156
 -0.515590307363 -0.328209370940 0.121615175459 -0.349570701950
 -0.481368125121 -0.274123573864 -0.541599221184 -0.327958614516
 -0.630740722431 -0.765836147168
# log_avg_F_HL_D:
-9.30557633864
# log_F_dev_HL_D:
 -1.66167995729 -0.786150024881 -0.410040201524 -0.103698682675
 0.189958260106 0.230308407772 -1.36459390569 -0.675383100512
 -0.980943819059 0.594669985308 -2.06761458685 -0.290606393550
 1.12680550063 0.692934394646 0.647586441010 0.674053322302
 0.894304427925
 1.19989630339 0.824142375907 0.564410994603 0.390636568657
```

```
 0.311003689775
# log_avg_F_GN_D:
-7.17649335150
# log_F_dev_GN_D:
 -0.196464299771 0.0162564362603 0.308844548028 -0.432001330372
 -0.0684302096350 -0.146499883250 0.0503751926986 0.911956919317
 1.04344933403 -0.457822197911 0.328002670075 0.951887019848
 -0.0192001261147 0.149995538096 -0.300662952526 -0.217030119704
 -0.0306578059481 0.140946049630 -0.151048700116 -0.240460826288
 -0.697963018006 -0.943472238342
# log_avg_F_MRFSS_D:
-4.77952000965
# log_F_dev_MRFSS_D:
 -0.372676945229 -0.392037494194 -0.428118662728 -0.337275385087
 -0.295156691635 -0.263763859466 -0.252428103650 -0.162498001477
 -0.171575607121 -0.112388233540 0.0466910620360 -0.0406176831761
 0.0294334509969 0.00488480478182 -0.0320938481933 0.0847577557528
 -0.0225744858777 -0.149305151352 -0.177508901741 -0.163577182986
 -0.355204012957 -0.309022875181 -0.406286433804 -0.567672212887
 -0.644043213406 -0.745746727280 -0.700146417467 -0.822780508950
 -1.04038154904 -1.28800027899 -1.55344545926 -0.793169342205
 -2.76357917457 -2.76182281439 -1.35843837814 -1.09717359439
 0.552427159521 -0.871447217396 -0.700448972829 0.574568867196
 0.000837339728942 0.586924937744 0.739976064085 0.747747928524
 1.87933275512 0.903300888762 0.968646971305 1.56979660214 0.843664368047
 1.44528558502 1.58664494514 1.37262625792 1.37455801406 2.11129055735
 1.41460620469 1.76890635562 0.473324104653 1.07217244041
# log_avg_F_shrimp:
-1.70164783605
# log_F_dev_shrimp:
 0.917693669854 0.497183409795 0.213874042060 0.883087267935
 0.690036592211 0.732468968632 0.361894918350 0.832989673185
 -0.360912237639 0.572276085470 1.20133764619 -1.66113004611
 0.728236737983 -1.61583562626 -1.62118297915 0.725014965907
 -1.09606364010 -1.61544916212 0.317597735054 0.890834262104
 -1.46859919919 1.31272050670 0.617390339526 0.457305906731
 0.906636634074
 0.592330707021 1.01703821741 -1.19422985684 -1.14288474080
 -0.409514482976 1.09134156414 -1.12381737707 1.43041260155 1.76605547293
 -0.867393626605 1.07879007599 0.694957033238 0.699419779143 1.09989838575
 1.59461220689 1.37937686180 1.15756438125 1.02281081323 0.284722898258
 -1.08637155868 1.10315015463 -1.45065152622 1.01349838888 -1.56965036974
 1.04037387167 0.796807604089 -0.680702384647 -2.19942834730
 -1.33201372524 -2.55054392680 -1.53173989792 -3.23004150085
 -1.91358416735
```

Appendix C ASPIC Input: Computer input file to run base production model.

```
BOT                        Run Mode
'SAFMC Spansish Mackerel SEDAR 17 (2007) Landings and Combined Indices(with CV)'
LOGISTIC YLD LAV       Modeltype, conditioning, loss fn
112                        Verbosity
1000                        N Bootstraps
0  100000                   Monte Carlo
1d-8                       Conv (fit)
3d-8  6                    Conv (restart), N restarts
1d-4  20                    Conv (F), steps/yr for generalized
8d0                         Max F allowed
1d0                         Weight for B1>K
1                          Number of series
1.0d0  1.0d0               Series weights
0.50d0                      B1/K guess
2.0e6                      MSY guess
2.0e7                      K guess
5d-8                       q guess
1 1 1 1                  Estimate flags
2e4  2e7                   MSY bounds
1e6  1e9                   K bounds
82184571                   Random seed
58                       Number of years
"Combined Index (1950-2006), Total Ldgs whole pounds"
"CC"

1950 -1              17704182
1951 -1              16657594
1952 -1              16906741
1953 -1              18059891
1954 -1              17330371
1955 -1              18495798
1956 -1              18394872
1957 -1              20520712
1958 -1              17915472
1959 -1              16496511
1960 -1              18372318
1961 -1              15322997
1962 -1              16874248
1963 -1              14729469
1964 -1              15205490
1965 -1              17530441
1966 -1              14296247
1967 -1              14483135
1968 -1              15139724
1969 -1              15232312
1970 -1              12070427
1971 -1              14783014
1972 -1              12694429
1973 -1              11210000
1974 -1              12574252
1975 -1              14918165
1976 -1              18513681
1977 -1              11093885
1978 -1              9832549
1979 -1              9465985
1980 -1              10318444
1981 -1              4553348
1982 -1              10780607
1983 -1              6246590
1984 -1              5442073
1985 0.5633219       6983003
1986 0.7535533       5630095
1987 0.9047252       6178058
1988 1.078462        8376070
1989 1.063249        8995048
1990 0.9688326       8896181
```

```
1991 0.7965118      10569830
1992 0.817554       8154481
1993 0.8302015      7165638
1994 0.9799069      7100815
1995 0.8714802      5632044
1996 0.9813545      3962407
1997 0.9283988      5692704
1998 1.016071       4434035
1999 1.064815       5996160
2000 1.079967       7289560
2001 1.217526       5710694
2002 1.24964        5024619
2003 1.321729       5912290
2004 1.206303       4864170
2005 1.176162       5734790
2006 1.087976       5427640
2007 1.042259       4884373


Note: Source of data is file "SM_AW_input.xls" dated 14 aug 2008, prepared by RTC
This input file prepared by RTC, 14 AUG 2008 using the combined index per Paul Conn
```

Appendix D ASPIC Output: Base production model.

```
SAFMC Spansish Mackerel SEDAR 17 (2007) Landings and Combined Indices(with CV)                                     Page 1
                                                                                  Wednesday, 27 Aug 2008 at 17:28:36
ASPIC -- A Surplus-Production Model Including Covariates (Ver. 5.30)
                                                                                                      BOT program mode
Author:     Michael H. Prager; NOAA Center for Coastal Fisheries and Habitat Research            LOGISTIC model mode
            101 Pivers Island Road; Beaufort, North Carolina  28516  USA                           YLD conditioning
            Mike.Prager@noaa.gov                                                                   LAV optimization

Reference:  Prager, M. H. 1994. A suite of extensions to a nonequilibrium            ASPIC User's Manual is available
            surplus-production model.  Fishery Bulletin 92: 374-389.                           gratis from the author.

CONTROL PARAMETERS (FROM INPUT FILE)           Input file: e:\...17-sm-aspic\run75pctrec\sm2008_1950_b1k_est_lavbot.inp
------------------------------------------------------------------------------------------------------------------------
Operation of ASPIC:  Fit logistic (Schaefer) model by direct optimization with bootstrap.
Number of years analyzed:                       58            Number of bootstrap trials:                        1000
Number of data series:                           1            Bounds on MSY (min, max):       2.000E+04     2.000E+07
Objective function:           Least absolute values            Bounds on K (min, max):         1.000E+06     1.000E+09
Relative conv. criterion (simplex):       1.000E-08            Monte Carlo search mode, trials:        0        100000
Relative conv. criterion (restart):       3.000E-08            Random number seed:                             82184571
Relative conv. criterion (effort):        1.000E-04            Identical convergences required in fitting:            8
Maximum F allowed in fitting:                 8.000


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


GOODNESS-OF-FIT AND WEIGHTING (NON-BOOTSTRAPPED ANALYSIS)
------------------------------------------------------------------------------------------------------------------------
                                                     Weighted            Weighted      Current     Inv. var.    R-squared
Loss component number and title                           LAV     N          MSE        weight        weight      in CPUE

Loss(-1)  LAV in yield                              0.000E+00
Loss(0)   Penalty for B1 > K                        0.000E+00     1          N/A     1.000E+00          N/A
Loss(1)   Combined Index (1950-2006), Total Ldgs    2.162E+00    23          N/A     1.000E+00          N/A        0.560
..............................................................
TOTAL OBJECTIVE FUNCTION:                      2.16205547E+00
Estimated contrast index (ideal = 1.0):            0.4246          C* = (Bmax-Bmin)/K
Estimated nearness index (ideal = 1.0):            1.0000          N* = 1 - |min(B-Bmsy)|/K


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

B1/K      Starting relative biomass (in 1950)       7.549E-01          5.000E-01    4.000E-01            1            1
MSY       Maximum sustainable yield                 1.237E+07          2.000E+06    9.508E+06            1            1
K         Maximum population size                   3.016E+08          2.000E+07    5.705E+07            1            1
phi       Shape of production curve (Bmsy/K)        0.5000             0.5000            ----            0            1

--------- Catchability Coefficients by Data Series ---------------
q(1)      Combined Index (1950-2006), Total Ldgs    5.017E-09          5.000E-08    4.750E-06            1            1


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

MSY       Maximum sustainable yield                 1.237E+07                          ----                     ----
Bmsy      Stock biomass giving MSY                  1.508E+08                           K/2         K*n**(1/(1-n))
Fmsy      Fishing mortality rate at MSY             8.204E-02                      MSY/Bmsy                 MSY/Bmsy

n         Exponent in production function           2.0000                             ----                     ----
g         Fletcher's gamma                          4.000E+00                          ----      [n**(n/(n-1))]/[n-1]
```

B./Bmsy	Ratio: B(2008)/Bmsy	1.604E+00	----	----
F./Fmsy	Ratio: F(2007)/Fmsy	2.478E-01	----	----
Fmsy/F.	Ratio: Fmsy/F(2007)	4.036E+00	----	----
Y.(Fmsy)	Approx. yield available at Fmsy in 2008	1.984E+07	MSY*B./Bmsy	MSY*B./Bmsy
	...as proportion of MSY	1.604E+00	----	----
Ye.	Equilibrium yield available in 2008	7.862E+06	4*MSY*(B/K-(B/K)**2)	g*MSY*(B/K-(B/K)**n)
	...as proportion of MSY	6.356E-01	----	----

--------- Fishing effort rate at MSY in units of each CE or CC series ---------

fmsy(1)	Combined Index (1950-2006), Total Ldgs	1.635E+07	Fmsy/q(1)	Fmsy/q(1)

SAFMC Spansish Mackerel SEDAR 17 (2007) Landings and Combined Indices(with CV) Page 2

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1950	0.079	2.277E+08	2.234E+08	1.770E+07	1.770E+07	9.494E+06	9.658E-01	1.510E+00
2	1951	0.077	2.195E+08	2.161E+08	1.666E+07	1.666E+07	1.005E+07	9.398E-01	1.455E+00
3	1952	0.081	2.128E+08	2.096E+08	1.691E+07	1.691E+07	1.049E+07	9.834E-01	1.412E+00
4	1953	0.089	2.064E+08	2.028E+08	1.806E+07	1.806E+07	1.090E+07	1.086E+00	1.369E+00
5	1954	0.088	1.993E+08	1.962E+08	1.733E+07	1.733E+07	1.125E+07	1.077E+00	1.322E+00
6	1955	0.098	1.932E+08	1.896E+08	1.850E+07	1.850E+07	1.155E+07	1.189E+00	1.281E+00
7	1956	0.101	1.862E+08	1.829E+08	1.839E+07	1.839E+07	1.181E+07	1.226E+00	1.235E+00
8	1957	0.117	1.796E+08	1.753E+08	2.052E+07	2.052E+07	1.204E+07	1.427E+00	1.191E+00
9	1958	0.106	1.712E+08	1.682E+08	1.792E+07	1.792E+07	1.220E+07	1.298E+00	1.135E+00
10	1959	0.101	1.655E+08	1.633E+08	1.650E+07	1.650E+07	1.228E+07	1.231E+00	1.097E+00
11	1960	0.116	1.612E+08	1.582E+08	1.837E+07	1.837E+07	1.234E+07	1.416E+00	1.069E+00
12	1961	0.100	1.552E+08	1.537E+08	1.532E+07	1.532E+07	1.236E+07	1.215E+00	1.029E+00
13	1962	0.113	1.522E+08	1.500E+08	1.687E+07	1.687E+07	1.237E+07	1.372E+00	1.010E+00
14	1963	0.101	1.477E+08	1.465E+08	1.473E+07	1.473E+07	1.236E+07	1.225E+00	9.798E-01
15	1964	0.106	1.454E+08	1.439E+08	1.521E+07	1.521E+07	1.234E+07	1.288E+00	9.641E-01
16	1965	0.125	1.425E+08	1.398E+08	1.753E+07	1.753E+07	1.230E+07	1.528E+00	9.451E-01
17	1966	0.105	1.373E+08	1.362E+08	1.430E+07	1.430E+07	1.225E+07	1.279E+00	9.105E-01
18	1967	0.108	1.352E+08	1.341E+08	1.448E+07	1.448E+07	1.222E+07	1.317E+00	8.969E-01
19	1968	0.115	1.330E+08	1.315E+08	1.514E+07	1.514E+07	1.217E+07	1.404E+00	8.819E-01
20	1969	0.119	1.300E+08	1.284E+08	1.523E+07	1.523E+07	1.210E+07	1.446E+00	8.622E-01
21	1970	0.095	1.269E+08	1.269E+08	1.207E+07	1.207E+07	1.206E+07	1.160E+00	8.414E-01
22	1971	0.118	1.269E+08	1.255E+08	1.478E+07	1.478E+07	1.202E+07	1.436E+00	8.413E-01
23	1972	0.103	1.241E+08	1.237E+08	1.269E+07	1.269E+07	1.197E+07	1.251E+00	8.230E-01
24	1973	0.091	1.234E+08	1.238E+08	1.121E+07	1.121E+07	1.197E+07	1.104E+00	8.182E-01
25	1974	0.102	1.241E+08	1.238E+08	1.257E+07	1.257E+07	1.197E+07	1.238E+00	8.232E-01
26	1975	0.122	1.235E+08	1.220E+08	1.492E+07	1.492E+07	1.192E+07	1.490E+00	8.192E-01
27	1976	0.158	1.205E+08	1.171E+08	1.851E+07	1.851E+07	1.175E+07	1.928E+00	7.994E-01
28	1977	0.097	1.138E+08	1.140E+08	1.109E+07	1.109E+07	1.164E+07	1.186E+00	7.545E-01
29	1978	0.085	1.143E+08	1.152E+08	9.833E+06	9.833E+06	1.168E+07	1.040E+00	7.581E-01
30	1979	0.081	1.162E+08	1.173E+08	9.466E+06	9.466E+06	1.176E+07	9.836E-01	7.704E-01
31	1980	0.087	1.185E+08	1.192E+08	1.032E+07	1.032E+07	1.183E+07	1.055E+00	7.856E-01
32	1981	0.037	1.200E+08	1.237E+08	4.553E+06	4.553E+06	1.197E+07	4.488E-01	7.956E-01
33	1982	0.084	1.274E+08	1.280E+08	1.078E+07	1.078E+07	1.209E+07	1.026E+00	8.447E-01
34	1983	0.047	1.287E+08	1.317E+08	6.247E+06	6.247E+06	1.217E+07	5.784E-01	8.534E-01
35	1984	0.039	1.346E+08	1.380E+08	5.442E+06	5.442E+06	1.228E+07	4.806E-01	8.927E-01
36	1985	0.048	1.414E+08	1.441E+08	6.983E+06	6.983E+06	1.234E+07	5.905E-01	9.380E-01
37	1986	0.037	1.468E+08	1.502E+08	5.630E+06	5.630E+06	1.237E+07	4.569E-01	9.736E-01
38	1987	0.039	1.535E+08	1.566E+08	6.178E+06	6.178E+06	1.235E+07	4.808E-01	1.018E+00
39	1988	0.052	1.597E+08	1.617E+08	8.376E+06	8.376E+06	1.230E+07	6.315E-01	1.059E+00
40	1989	0.054	1.636E+08	1.653E+08	8.995E+06	8.995E+06	1.225E+07	6.634E-01	1.085E+00
41	1990	0.053	1.669E+08	1.686E+08	8.896E+06	8.896E+06	1.220E+07	6.433E-01	1.107E+00
42	1991	0.062	1.702E+08	1.710E+08	1.057E+07	1.057E+07	1.215E+07	7.535E-01	1.129E+00
43	1992	0.047	1.718E+08	1.738E+08	8.154E+06	8.154E+06	1.208E+07	5.720E-01	1.139E+00
44	1993	0.040	1.757E+08	1.781E+08	7.166E+06	7.166E+06	1.196E+07	4.904E-01	1.165E+00
45	1994	0.039	1.805E+08	1.829E+08	7.101E+06	7.101E+06	1.181E+07	4.733E-01	1.197E+00
46	1995	0.030	1.852E+08	1.882E+08	5.632E+06	5.632E+06	1.161E+07	3.647E-01	1.228E+00
47	1996	0.020	1.912E+08	1.949E+08	3.962E+06	3.962E+06	1.131E+07	2.478E-01	1.268E+00
48	1997	0.028	1.985E+08	2.012E+08	5.693E+06	5.693E+06	1.099E+07	3.449E-01	1.317E+00
49	1998	0.021	2.038E+08	2.070E+08	4.434E+06	4.434E+06	1.065E+07	2.611E-01	1.352E+00
50	1999	0.028	2.100E+08	2.122E+08	5.996E+06	5.996E+06	1.031E+07	3.444E-01	1.393E+00

51	2000	0.034	2.144E+08	2.158E+08	7.290E+06	7.290E+06	1.007E+07	4.118E-01	1.422E+00
52	2001	0.026	2.171E+08	2.192E+08	5.711E+06	5.711E+06	9.820E+06	3.175E-01	1.440E+00
53	2002	0.022	2.212E+08	2.235E+08	5.025E+06	5.025E+06	9.491E+06	2.740E-01	1.467E+00
54	2003	0.026	2.257E+08	2.274E+08	5.912E+06	5.912E+06	9.178E+06	3.170E-01	1.497E+00
55	2004	0.021	2.290E+08	2.310E+08	4.864E+06	4.864E+06	8.867E+06	2.567E-01	1.519E+00
56	2005	0.024	2.330E+08	2.344E+08	5.735E+06	5.735E+06	8.563E+06	2.982E-01	1.545E+00
57	2006	0.023	2.358E+08	2.373E+08	5.428E+06	5.428E+06	8.300E+06	2.788E-01	1.564E+00
58	2007	0.020	2.387E+08	2.403E+08	4.884E+06	4.884E+06	8.012E+06	2.478E-01	1.583E+00
59	2008		2.418E+08						1.604E+00

SAFMC Spanish Mackerel SEDAR 17 (2007) Landings and Combined Indices(with CV) Page 3

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) Combined Index (1950-2006), Total Ldgs w

----

Data type CC: CPUE-catch series Series weight: 1.000

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale	Statist weight
1	1950	*	1.121E+00	0.0792	1.770E+07	1.770E+07	0.00000	1.000E+00
2	1951	*	1.084E+00	0.0771	1.666E+07	1.666E+07	0.00000	1.000E+00
3	1952	*	1.051E+00	0.0807	1.691E+07	1.691E+07	0.00000	1.000E+00
4	1953	*	1.017E+00	0.0891	1.806E+07	1.806E+07	0.00000	1.000E+00
5	1954	*	9.842E-01	0.0884	1.733E+07	1.733E+07	0.00000	1.000E+00
6	1955	*	9.514E-01	0.0975	1.850E+07	1.850E+07	0.00000	1.000E+00
7	1956	*	9.175E-01	0.1006	1.839E+07	1.839E+07	0.00000	1.000E+00
8	1957	*	8.796E-01	0.1171	2.052E+07	2.052E+07	0.00000	1.000E+00
9	1958	*	8.442E-01	0.1065	1.792E+07	1.792E+07	0.00000	1.000E+00
10	1959	*	8.193E-01	0.1010	1.650E+07	1.650E+07	0.00000	1.000E+00
11	1960	*	7.935E-01	0.1162	1.837E+07	1.837E+07	0.00000	1.000E+00
12	1961	*	7.712E-01	0.0997	1.532E+07	1.532E+07	0.00000	1.000E+00
13	1962	*	7.524E-01	0.1125	1.687E+07	1.687E+07	0.00000	1.000E+00
14	1963	*	7.352E-01	0.1005	1.473E+07	1.473E+07	0.00000	1.000E+00
15	1964	*	7.221E-01	0.1057	1.521E+07	1.521E+07	0.00000	1.000E+00
16	1965	*	7.016E-01	0.1254	1.753E+07	1.753E+07	0.00000	1.000E+00
17	1966	*	6.836E-01	0.1049	1.430E+07	1.430E+07	0.00000	1.000E+00
18	1967	*	6.728E-01	0.1080	1.448E+07	1.448E+07	0.00000	1.000E+00
19	1968	*	6.596E-01	0.1152	1.514E+07	1.514E+07	0.00000	1.000E+00
20	1969	*	6.443E-01	0.1186	1.523E+07	1.523E+07	0.00000	1.000E+00
21	1970	*	6.365E-01	0.0951	1.207E+07	1.207E+07	0.00000	1.000E+00
22	1971	*	6.294E-01	0.1178	1.478E+07	1.478E+07	0.00000	1.000E+00
23	1972	*	6.208E-01	0.1026	1.269E+07	1.269E+07	0.00000	1.000E+00
24	1973	*	6.209E-01	0.0906	1.121E+07	1.121E+07	0.00000	1.000E+00
25	1974	*	6.213E-01	0.1015	1.257E+07	1.257E+07	0.00000	1.000E+00
26	1975	*	6.121E-01	0.1223	1.492E+07	1.492E+07	0.00000	1.000E+00
27	1976	*	5.874E-01	0.1581	1.851E+07	1.851E+07	0.00000	1.000E+00
28	1977	*	5.722E-01	0.0973	1.109E+07	1.109E+07	0.00000	1.000E+00
29	1978	*	5.782E-01	0.0853	9.833E+06	9.833E+06	0.00000	1.000E+00
30	1979	*	5.886E-01	0.0807	9.466E+06	9.466E+06	0.00000	1.000E+00
31	1980	*	5.981E-01	0.0866	1.032E+07	1.032E+07	0.00000	1.000E+00
32	1981	*	6.205E-01	0.0368	4.553E+06	4.553E+06	0.00000	1.000E+00
33	1982	*	6.424E-01	0.0842	1.078E+07	1.078E+07	0.00000	1.000E+00
34	1983	*	6.606E-01	0.0474	6.247E+06	6.247E+06	0.00000	1.000E+00
35	1984	*	6.926E-01	0.0394	5.442E+06	5.442E+06	0.00000	1.000E+00
36	1985	5.633E-01	7.232E-01	0.0484	6.983E+06	6.983E+06	0.24982	1.000E+00
37	1986	7.536E-01	7.536E-01	0.0375	5.630E+06	5.630E+06	0.00000	1.000E+00
38	1987	9.047E-01	7.860E-01	0.0394	6.178E+06	6.178E+06	-0.14074	1.000E+00
39	1988	1.078E+00	8.113E-01	0.0518	8.376E+06	8.376E+06	-0.28469	1.000E+00
40	1989	1.063E+00	8.293E-01	0.0544	8.995E+06	8.995E+06	-0.24851	1.000E+00
41	1990	9.688E-01	8.458E-01	0.0528	8.896E+06	8.896E+06	-0.13586	1.000E+00
42	1991	7.965E-01	8.580E-01	0.0618	1.057E+07	1.057E+07	0.07430	1.000E+00
43	1992	8.176E-01	8.718E-01	0.0469	8.154E+06	8.154E+06	0.06427	1.000E+00
44	1993	8.302E-01	8.937E-01	0.0402	7.166E+06	7.166E+06	0.07373	1.000E+00
45	1994	9.799E-01	9.176E-01	0.0388	7.101E+06	7.101E+06	-0.06572	1.000E+00
46	1995	8.715E-01	9.444E-01	0.0299	5.632E+06	5.632E+06	0.08036	1.000E+00
47	1996	9.814E-01	9.778E-01	0.0203	3.962E+06	3.962E+06	-0.00358	1.000E+00
48	1997	9.284E-01	1.010E+00	0.0283	5.693E+06	5.693E+06	0.08378	1.000E+00
49	1998	1.016E+00	1.038E+00	0.0214	4.434E+06	4.434E+06	0.02177	1.000E+00
50	1999	1.065E+00	1.065E+00	0.0283	5.996E+06	5.996E+06	0.00000	1.000E+00
51	2000	1.080E+00	1.083E+00	0.0338	7.290E+06	7.290E+06	0.00241	1.000E+00
52	2001	1.218E+00	1.100E+00	0.0260	5.711E+06	5.711E+06	-0.10158	1.000E+00

53	2002	1.250E+00	1.121E+00	0.0225	5.025E+06	5.025E+06	-0.10823	1.000E+00
54	2003	1.322E+00	1.141E+00	0.0260	5.912E+06	5.912E+06	-0.14721	1.000E+00
55	2004	1.206E+00	1.159E+00	0.0211	4.864E+06	4.864E+06	-0.03994	1.000E+00
56	2005	1.176E+00	1.176E+00	0.0245	5.735E+06	5.735E+06	0.00000	1.000E+00
57	2006	1.088E+00	1.190E+00	0.0229	5.428E+06	5.428E+06	0.09003	1.000E+00
58	2007	1.042E+00	1.206E+00	0.0203	4.884E+06	4.884E+06	0.14553	1.000E+00

* Asterisk indicates missing value(s).

SAFMC Spansish Mackerel SEDAR 17 (2007) Landings and Combined Indices(with CV) Page 4

ESTIMATES FROM BOOTSTRAPPED ANALYSIS

Param name	Point estimate	Estimated bias in pt estimate	Estimated relative bias	Bias-corrected approximate confidence limits 80% lower	80% upper	50% lower	50% upper	Inter-quartile range	Relative IQ range
B1/K	7.549E-01	-1.770E-02	-2.34%	6.089E-01	9.339E-01	7.097E-01	8.167E-01	1.070E-01	0.142
K	3.016E+08	1.331E+07	4.41%	1.830E+08	4.423E+08	2.451E+08	3.553E+08	1.101E+08	0.365
q(1)	5.017E-09	1.110E-09	22.12%	2.220E-09	5.749E-09	2.882E-09	5.020E-09	2.138E-09	0.426
MSY	1.237E+07	1.748E+05	1.41%	1.063E+07	1.418E+07	1.137E+07	1.319E+07	1.819E+06	0.147
Ye(2008)	7.862E+06	4.981E+05	6.34%	5.606E+06	1.071E+07	6.226E+06	9.573E+06	3.346E+06	0.426
Y.@Fmsy	1.984E+07	-1.055E+06	-5.32%	1.104E+07	2.517E+07	1.539E+07	2.282E+07	7.436E+06	0.375
Bmsy	1.508E+08	6.655E+06	4.41%	9.148E+07	2.211E+08	1.226E+08	1.776E+08	5.507E+07	0.365
Fmsy	8.204E-02	1.123E-02	13.69%	5.310E-02	1.573E-01	6.668E-02	1.127E-01	4.603E-02	0.561
fmsy(1)	1.635E+07	-8.999E+05	-5.50%	8.563E+06	2.254E+07	1.268E+07	1.995E+07	7.269E+06	0.445
B./Bmsy	1.604E+00	-1.292E-01	-8.06%	1.034E+00	1.773E+00	1.365E+00	1.725E+00	3.601E-01	0.225
F./Fmsy	2.478E-01	4.416E-02	17.82%	1.940E-01	4.478E-01	2.145E-01	3.195E-01	1.050E-01	0.424
Ye./MSY	6.356E-01	4.964E-02	7.81%	4.026E-01	9.813E-01	4.744E-01	8.632E-01	3.888E-01	0.612

INFORMATION FOR REPAST (Prager, Porch, Shertzer, & Caddy. 2003. NAJFM 23: 349-361)

Unitless limit reference point in F (Fmsy/F.): 4.036
CV of above (from bootstrap distribution): 0.2734

NOTES ON BOOTSTRAPPED ESTIMATES:

- Bootstrap results were computed from 1000 trials.
- Results are conditional on bounds set on MSY and K in the input file.
- All bootstrapped intervals are approximate. The statistical literature recommends using at least 1000 trials for accurate 95% intervals. The default 80% intervals used by ASPIC should require fewer trials for equivalent accuracy. Using at least 500 trials is recommended.
- Bias estimates are typically of high variance and therefore may be misleading.

Trials replaced for lack of convergence: 0 Trials replaced for MSY out of bounds: 15
Trials replaced for q out-of-bounds: 0
Trials replaced for K out-of-bounds: 8 Residual-adjustment factor: 1.1002

Elapsed time: 0 hours, 10 minutes, 49 seconds.

4 Submitted Comments

4.1 The following comments on the Spanish Mackerel stock assessment were offered during the routine post-AW conference call on September 29, 2008, by Ben C. Hartig, Chairman of the SAFMC Mackerel Advisory Panel and attendee at the SEDAR 17 Data and Assessment Workshops.

I've thought alot about what transpired at the AW and in my opinion there has to be some sense of reality when contemplating the results of the Spanish Mackerel assessment. In my opinion, the current assessment bears little resemblance to the current status of the stock.

The wholesale dismissal of the results of previous assessments is a troubling aspect of this document. Over the past 20 years a number of assessments were completed that have indicated a steady rebuilding of the stock to biomass levels not seen since the mid 1970's. In the 1999 assessment MSY was 6.4 million pounds. The value was 5.2 million pounds in the 2003 assessment and in the current assessment MSY is 13.2 million pounds, which is 2.5 times higher than the 2003 result.

The problem with the current MSY is that not only is it wrong but dangerously high. It was at this level of harvest that the fishery became severely overfished during the mid 1970's thru the early 1980's (fig. 3.16). Harvest levels of this magnitude were only possible with significant increases in the size of commercial vessels, the introduction of gill nets which fished much deeper in the water column and the utilization of spotter aircraft to locate schools of Spanish Mackerel.

The three recreational surveys in the 1960, 1965 and 1970, conducted by the FWC and NMFS, and used to project recreational landings back in 1950, bear little relationship to reality. For one thing, if a stock was as large as historical reconstruction indicates commercial catch would have been significantly larger, due to the increased availability of fish. The average commercial catch during the 1960-70 time period was only 2.63 million pounds while the average reconstructed recreational landing for the same period were 8.81 million pounds.

In stark contrast, the average recreational landings since the MRFSS survey was implemented in 1981 was 1.33 million pounds, which is approximately 6.6 times lower than the reconstructed historical average. Recently the MRFSS adjusted it's magnitude of landings. This adjustment was toward lower recreational landings not higher.

Over the past 5 seasons, commercial production of Spanish Mackerel has produced approximately 3.5 million pounds. The historical commercial average, excluding the significantly higher harvest levels during 1975-82, was 3.4 million pounds, indicating we have rebuilt the commercial fishery at least to long term historical levels.

Two aspects of Spanish Mackerel biology, fast growth and 100% maturity at just over age 1, makes this species very resilient to fishing pressure. Figure 3.19 illustrates the reconstructed historical recreational landings from 1950 to 1980. Figure 3.29 depicts the estimated spawning biomass over time. Both show precipitous declines on about the same time scale but in different years. The question I asked in the AW was what caused the significant stock decline? The answer given by one of the analysts was that Recreational fishing effort was the primary reason for the decline. There is no way that recreational fishermen, fishing with the most inefficient gear (fishing poles) overfished a coastal pelagic species that grows quickly, is short lived, and is 100% mature at just over age one. It did not happen!

The overarching problem I have with this current assessment is that it grossly overestimates the productivity of the stock, causing an unrealistically high MSY. In my opinion this is the most important question that the Review Panel needs to address in October.

Sincerely,

Ben C. Hartig
Chairman Mackerel Advisory Panel

Section II. Research Recommendations

Contents

1. Data Workshop

1.1 Recommendations of the Life History Work Group

1. Ages provided for future assessments should be advanced when appropriate (i.e., during months when annuli are being formed) so fish can be assigned to the correct year class. If advanced ages cannot be provided, data should include assessment of otolith edge type. Classification schemes for edge type and quality of the otolith/section have been developed by the MARMAP program at SCDNR and are currently used by MARMAP and NMFS Beaufort.

2. Conduct inter-lab comparisons of age readings from test sets of otoliths in preparation for any future stock assessments.

3. Obtain adequate data to determine gutted to whole weight relationships.

4. Investigate the discard mortality of Spanish mackerel in the commercial and recreational trolling fishery, commercial gillnet fishery, and the shrimp trawl fishery.

5. To ensure more accurate estimates of t0, increase efforts to collect age 0 specimens for use in estimating von Bertalanffy (VB) growth parameters.

1.2 Recommendations of the Commercial Work Group

1. Need observer coverage for the fisheries for Spanish mackerel (gillnets, castnets
2. (FL), handlines, poundnets and shrimp trawls for bycatch):
   - 5-10% allocated by strata within states
   - possible to use exemption to bring in everything with no sale
   - get maximum information from fish

3. Expand TIP sampling to better cover all statistical strata
   - Predominantly from Florida and by gillnet & castnet gears
   - In that sense, we have decent coverage for lengths

4. Trade off with lengths versus ages, need for more ages (i.e.,hard parts)

5. Need to address issue of fish retained for bait (undersized) or used for food by crew.(how to capture in landings)

1.3 Recommendations of the Recreational Work Group

There was insufficient time for this topic to be addressed by the workgroup during the data workshop.

1.4 Recommendations of the Indices Work Group

1. Expand existing fishery independent sampling and/or develop new fishery independent sampling of the Spanish mackerel population off the southeastern U.S.
   Two ideas discussed were the following:
   - Collect age samples from SEAMAP
   - Fishery independent sampling of adults

2. Investigate whether catchability varies as a function of fish density and/or environmental conditions.

3. Investigate how temporal changes in migratory patterns may influence indices of abundance (for fishery dependent and fishery independent indices).

4. Investigate the possibility of using models that allow catchability to follow a random walk.

2. Assessment Workshop

2.1 Recommendations of the Assessment Panel

Comprehensive Data and Assessment Archive: A goal of the SEDAR process, as stated in several workshop Terms of Reference, is to properly document all aspects of the data employed in the assessments, the assessments themselves, and the peer review of assessment details and results. While the various workshop reports and data workbooks compile much of the information, concern has been expressed that a full compilation of data manipulations, and programs used to generate the final data used in the assessment is not available following a SEDAR cycle. The concept of a SEDAR Comprehensive Data and Assessment Workshops Archive was proposed by the SEDAR 17 Data Compiler during preparations for the DW. Though the idea was not advanced from the DW as a formal recommendation it was generally taken favorably. An archive could serve as: a single reference for anyone wishing to dig deeper into how data were processed, a reference for future assessments, a backup of final data processing programs or spreadsheets for those who develop them, and continuity in cases of personnel changes for future assessments and updates. When discussed at the AW it was recognized implementation of an archive could have benefits and costs, but that it would require more attention than SEDAR 17 AW participants could give it, and all SEDAR cooperators were not present. The AW recommends that a SEDAR-wide workgroup be convened to identify the pros and cons of a Comprehensive Data and Assessment Archive for each future SEDAR.

Independent Expert on Assessment Panel: The assessment panel recommends that for future SEDAR assessment workshops, a scientist experienced in assessment methods and modeling (such as a CIE reviewer, or a NMFS or state person from outside the region) be provided as a workshop panelist. An independent expert can participate in discussing technical details of the methods used for SEDAR assessments, and assist in decisions related to model configuration during the workshop. In particular, the analysts believe that an independent analyst could contribute fresh information to improve the assessments.

Review and Qualification of Historic Recreational Angler Survey Reports: Pre-MRFSS catch and related effort data from south Atlantic recreational fisheries are very scarce, but are considered valuable to stock assessments, where available. Two reports of the U. S. Fish and Wildlife Service (SEDAR 17-RD13 and SEDAR 17-RD14) and one of the NMFS (SEDAR 17-RD15) characterize south Atlantic salt-water angling effort and success based on recall surveys conducted in 1960, 1965, and 1970, respectively. These references have been viewed in various ways in previous stock assessments performed through the SEDAR process. In SEDAR 2 for South Atlantic black sea bass, these data were not used explicitly in the age-structured modeling, however, with assumptions, were used to extend the time frame for application of the production modeling approach. In SEDAR 15 for South Atlantic red snapper these data were employed by the assessment panel at face value for the three survey years and to interpolate recreational landings before, between, and after survey years. In SEDAR 15 for South Atlantic greater amberjack the review panel agreed with the assessment panel that the survey estimates of recreational landings of "jacks" not be included in the assessment due in part to species identification concerns. For the present assessment the assessment panel has employed the survey data for both stocks under assessment, but considers recall bias on the part of persons surveyed to be a significant factor. Thus they chose to reduce the weight of the estimates in its base runs and explore the effect on the model through sensitivity runs.

A guiding principal of the SEDAR process is consistency in the identification and utilization of data that characterize fishery stocks under assessment and the fisheries that affect the stocks. Because the three pre-MRFSS saltwater angling survey reports have proven of value, and likely will be referenced in future stock assessments, the AW recommends they be reviewed by a group of fishery professionals. The group should include persons knowledgeable in survey design, data collection, and application of survey data to fishery stock assessments. The group's function would be to qualify the three surveys, and others which the group may identify, and provide guidelines that further consistency in their utilization in future stock assessment conducted under the SEDAR process. The review of these reports could be coupled with a review and qualification of commercial and other data to standardize their use in stock assessments, as recommended in the SEDAR 17 data workshop reports.

Avoid Brief Workshop Interims: The panel made a recommendation against scheduling abbreviated SEDAR stock assessments. AW participants felt that an abbreviated schedule could compromise the quality of the assessment.

3. Review Workshop

3.1 Research Recommendations of the Review Panel

In its review of DW research recommendations the RW noted the recommendation to increase samples should be accompanied by information on the methodology to determine adequate sample sizes for both length frequency and age samples. Some recommendations for future research related to indicators of population abundance were outlined; however, for those to be useful, a clear statement of the problem, research objectives, methodology and identification of groups and/or projects that could undertake such research should be specified. The RW noted that the DW provided useful recommendations regarding life history, commercial, and indices. However, some of these recommendations need to be more specific and deadlines and personnel assignments identified. The need of a fishery independent index of the adult population was mentioned but ways forward were not spelled clearly enough.

In its review of pre-AW changes in data, the RW noted estimation of shrimp bycatch data resulted in a highly variable time-series, which was not fully justified. Lack of consistency with historical data requires clarification. Better documentation of the shrimp bycatch estimation procedure would be useful. Pre-MRFSS catch estimates are not available, and data for the period 1950 – 1980 was extrapolated from 3 data points, which raised some concern. Research into estimating historical recreational catch should continue.

As to estimation of uncertainty in the SCA model, the RW states research into better methods to include the uncertainty in landings history is recommended.

Section V. Review Workshop Report

Contents

1. Introduction

1.1. Workshop Time and Place

The SEDAR 17 Review Workshop was held at the Hampton Inn in Savannah, Georgia on October 20 through October 24, 2008.

1.2. Terms of Reference

1. Evaluate the adequacy, appropriateness, and application of data used in the assessment*.
2. Evaluate the adequacy, appropriateness, and application of methods used to assess the stock*.
3. Recommend appropriate estimates of stock abundance, biomass, and exploitation*.
4. Evaluate the methods used to estimate population benchmarks and management parameters (*e.g., MSY, Fmsy, Bmsy, MSST, MFMT, or their proxies*); provide estimated values for management benchmarks, a range of ABC, and declarations of stock status*.
5. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; recommend appropriate estimates of future stock condition* (e.g., exploitation, abundance, biomass).
6. Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters*. Ensure that the implications of uncertainty in technical conclusions are clearly stated.
7. Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and Advisory Report and that reported results are consistent with Review Panel recommendations**.
8. Evaluate the SEDAR Process. Identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops; identify any additional information or assistance which will improve Review Workshops; suggest improvements or identify aspects requiring clarification.
9. Review the research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted. Clearly indicate the research and monitoring needs that may appreciably improve the reliability of future assessments. Recommend an appropriate interval for the next assessment.
10. Prepare a Peer Review Consensus Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks to be completed following the workshop. Complete and submit the Consensus Report within 3 weeks of workshop conclusion.

* The review panel may request additional sensitivity analyses, evaluation of alternative assumptions, and correction of errors identified in the assessments provided by the assessment workshop panel; the review panel may not request a new assessment. Additional details regarding the latitude given the review panel to deviate from assessments provided by the assessment workshop panel are provided in the *SEDAR Guidelines* and the *SEDAR Review Panel Overview and Instructions*.

** The panel shall ensure that corrected estimates are provided by addenda to the assessment report in the event corrections are made in the assessment, alternative model configurations are recommended, or additional analyses are prepared as a result of review panel findings regarding the TORs above.

1.3. List of Participants

SEDAR 17

Stock Assessment Peer Review Workshop
October 20-24, 2008
Savannah, GA

Appointee	Function	Affiliation
Independent Review Panel		
Mr. Gary Shepherd	Chair and Reviewer	NOAA/NMFS
Dr. Noel Cadigan	Reviewer	CIE
Mr. Patrick Cordue	Reviewer	CIE
Dr. Beatriz Roel	Reviewer	CIE
Rapporteur		
Dr. Andi Stephens	Rapporteur - Vermilion Snapper	SEDAR
Presenters and Analytical Team		
Dr. Kyle Shertzer	Lead Analyst and Data Presenter - Vermilion Snapper	SEFSC
Dr. Paul Conn	Lead Analyst and Data Presenter - Spanish Mackerel	SEFSC
Appointed Observers		
Duane Harris	Council Chairman	SAFMC
George Geiger	Council Member	SAFMC
Rick DeVictor	Council Staff Lead – Vermilion Snapper	SAFMC
Gregg Waugh	Council Staff Lead - Spanish Mackerel	SAFMC
Dr. Marcel Reichert	Stock Leader – Vermilion Snapper	SAFMC SSC
Dr. Andi Stephens	Fishery Biologist	SAFMC
Dr. Scott Crosson	Stock Leader – Spanish Mackerel	SAFMC SSC
Ben Hartig	Mackerel AP Chair	Florida Commercial
Coordination		
Dale Theiling	Coordinator	SEDAR
Rachael Lindsay	Administrative Support	SEDAR
Tyree Davis	Information Technology Support	SEFSC

Acronyms

AP	Advisory Panel
CIE	Center for Independent Experts
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
SAFMC	South Atlantic Fishery Management Council
SEDAR	Southeast Data, Assessment, and Review
SEFSC	Southeast Fisheries Science Center
SERO	Southeast Regional Office
SSC	Scientific and Statistical Committee

1.4. List of Review Workshop Working Papers & Documents

SEDAR 17
South Atlantic Vermilion Snapper and South Atlantic Spanish Mackerel
Workshop Document List

Document #	Title	Authors
Documents Prepared for the Data Workshop		
SEDAR17-DW01	South Atlantic Vermilion Snapper Management Information Worksheet	J. McGovern (SERO) R. DeVictor (SAFMC)
SEDAR17-DW02	South Atlantic Spanish Mackerel Management Information Worksheet	J. McGovern (SERO) R. DeVictor (SAFMC)
SEDAR17-DW03	South Atlantic Vermilion Snapper Assessment History	D. Vaughan (SEFSC)
SEDAR17-DW04	South Atlantic Spanish Mackerel Assessment History	D. Vaughan (SEFSC)
SEDAR17-DW05	South Atlantic Vermilion Snapper Commercial Chapter	D. Vaughan (SEFSC)
SEDAR17-DW06	South Atlantic Spanish Mackerel Commercial Chapter	D. Vaughan (SEFSC)
SEDAR17-DW07	A review of Spanish mackerel (*Scomberomorus maculatus)* age data, 1987-2007, Atlantic collections only, from the Panama City Laboratory, SEFSC, NOAA Fisheries Service	C. Palmer, D. DeVries, C. Fioramonti and L. Lombardi-Carlson (SEFSC)
SEDAR17-DW08	Vermilion Snapper Length Frequencies and Condition of Released Fish from At-Sea Headboat Observer Surveys in the South Atlantic, 2004 to	B. Sauls, C. Wilson, D. Mumford, and K. Brennan (SEFSC)

	2007	
SEDAR17-DW09	Development of Conversion Factors for Different Trap Types used by MARMAP since 1978.	P. Harris (MARMAP)
SEDAR17-DW10	Discards of Spanish Mackerel and Vermilion Snapper Calculated for Commercial Vessels with Federal Fishing Permits in the US South Atlantic	K. McCarthy (SEFSC)
SEDAR17-DW11	Standardized catch rates of vermilion snapper from the headboat sector: Sensitivity analysis of the 10-fish-per-angler bag limit	Sustainable Fisheries Branch (SEFSC)
SEDAR17-DW12	Estimation of Spanish mackerel and vermilion snapper bycatch in the shrimp trawl fishery in the South Atlantic (SA)	K. Andrews (SEFSC)
Documents Prepared for the Assessment Workshop		
SEDAR17-AW01	SEDAR 17 South Atlantic Vermilion Snapper Stock Assessment Model	SEDAR 17
SEDAR17-AW02	SEDAR 17 South Atlantic Spanish Mackerel Stock Assessment Model	SEDAR 17
SEDAR17-AW03	Development of an aging error matrix for the vermilion snapper catch-at-age stock assessment model	E. Williams (SEFSC)
SEDAR17-AW04	Catch curve analysis of age composition data for Spanish mackerel	E. Williams (SEFSC)
SEDAR17-AW05	Catch curve analysis of age composition data for vermilion snapper	E. Williams (SEFSC)
SEDAR17-AW06	Methods for combining multiple indices into one, with application to south Atlantic (U.S.) Spanish mackerel	P. Conn (SEFSC)
SEDAR17-AW07	Extrapolation of Spanish mackerel bycatch by commercial shrimp trawl fisheries	P. Conn (SEFSC)
SEDAR17-AW08	A Bayesian approach to stochastic stock reduction analysis, with application to south Atlantic Spanish mackerel	P. Conn (SEFSC)
SEDAR17-AW09	Preliminary Surplus–production Model Results of Vermilion Snapper off the Southeastern United States	R. Cheshire (SEFSC)
SEDAR17-AW10	Preliminary Surplus–production Model Results of Spanish Mackerel off the Southeastern United States	R. Cheshire (SEFSC)
SEDAR17-AW11	AD Model Builder code to implement catch-age assessment model of vermilion snapper	K. Shertzer (SEFSC)
SEDAR17-AW12	AD Model Builder code to implement catch-age assessment model of Spanish mackerel	P. Conn (SEFSC)
SEDAR17-AW13	ASCII file populated by results of VS base catch-age model	K. Shertzer (SEFSC)

Documents Prepared for the Review Workshop		
SEDAR17-RW01	SEDAR 17 South Atlantic Vermilion Snapper Document for Peer Review	SEDAR 17
SEDAR17-RW02	SEDAR 17 South Atlantic Spanish Mackerel Document for Peer Review	SEDAR 17
Final Assessment Reports		
SEDAR17-AR01	Assessment of the Vermilion Snapper Stock in the US South Atlantic	SEDAR 17
SEDAR17-AR02	Assessment of the Spanish Mackerel Stock in the US South Atlantic	SEDAR 17
Reference Documents		
SEDAR17-RD01	South Atlantic Vermilion Snapper Stock Assessment Report, SEDAR 2, 2003	SEDAR 2
SEDAR17-RD02	Update of the SEDAR 2 South Atlantic Vermilion Snapper Stock Assessment, 2007	SEDAR
SEDAR17-RD03	Fishery Management Plan for Spanish Mackerel, Atlantic States Marine Fisheries Commission, 1990	L. P. Mercer L. R. Phalen J. R. Maiolo
SEDAR17-RD04	Mitochondrial and nuclear DNA analysis of population subdivision among young-of-the-year Spanish mackerel (*Scomberomorus maculatus*) from the western Atlantic and Gulf of Mexico	V. P. Buonaccorsi E. Starkey J. E. Graves
SEDAR17-RD05	George Fishes MD TAFS 28 1-49	W. A. George
SEDAR17-RD06	Excerpt – Goode 1878 stats 7-1-99	Goode
SEDAR17-RD07	Excerpt – Henshall Comparative Excellence TAF 13 1-115	Henshall
SEDAR17-RD08	Stock Assessment Analyses on Spanish and King Mackerel Stocks, April 2003	Sustainable Fisheries Div, SEFSC
SEDAR17-RD09	Hooking Mortality of Reef Fishes in the Snapper-Grouper Commercial Fishery of the Southeastern United States	D.V. Guccione Jr.
SEDAR17-RD10	Effects of cryptic mortality and the hidden costs of using length limits in fishery management Lewis G Coggins Jr	L. G. Coggins Jr. and others
SEDAR17-RD11	Discard composition and release fate in the snapper and grouper commercial hook-and-line fishery in North Carolina, USA	P. J. Rudershausen and J. A. Buckel
SEDAR17-RD12	A multispecies approach to subsetting logbook data for purposes of estimating CPUE	A. Stephens and A. MacCall

SEDAR17-RD13	The 1960 Salt-Water Angling Survey, USFWS Circular 153	J. R. Clark
SEDAR17-RD14	The 1965 Salt-Water Angling Survey, USFWS Resource Publication 67	D. G. Deuel and J. R. Clark. 1968
SEDAR17-RD15	1970 Salt-Water Angling Survey, NMFS Current Fisheries Statistics Number 6200	D. G. Deuel. 1973
SEDAR17-RD16	User's Guide: Delta-GLM function for the R Language /environment (Version 1.7.2, revised 07-06-2006)	E. J. Dick (SWFSC/NMFS). 2006
SEDAR17-RD17	Reproductive biology of Spanish mackerel, *Scomberomorus maculatus*, in the lower Chesapeake Bay. M.A. Thesis, Virginia Institute of Marine Science. (Selective pages)	C. L. Cooksey. 1996
SEDAR17-RD18	The summer flounder chronicles: Science, politics, and litigation, 1975–2000	M. Terceiro. 2002
SEDAR17-RD19	Use of Angler Diaries to Examine Biases Associated with 12-Month Recall on Mail Questionnaires	N. Connelly and T. Brown. 1995
SEDAR17-RD20	Comparing 1994 Angler Catch and Harvest Rates from On-Site and Mail Surveys on Selected Maine Lakes	B. Roach. 1999
SEDAR17-RD21	Response Errors in Canadian Waterfowl Surveys	A. Sen. 1973
SEDAR17-RD22	Exaggeration of Walleye Catches by Alberta Anglers	M. Sullivan. 2003
SEDAR17-RD23	Effects of Recall Bias and Non-response Bias on Self-Report Estimates of Angling Participation	M. A. Tarrant and M. J. Manfredo. 1993
SEDAR17-RD24	Influence of Survey Method on Estimates of Statewide Fishing Activity	T. Thompson. 1990
SEDAR 17-RD25	Final Amendment 6 to the Fishery Management Plan for the Shrimp Fishery of the South Atlantic Region	SAFMC. 2004
SEDAR 17-RD26	SEDAR 17-RD26 SA Gag Stock Assessment Report SEDAR 10 updated	SEDAR. 2006
SEDAR 17-RD27	Effect of Some Variations in Sampling Practices on Len Freq Dist of Gag	CHING-PING CHIH. 2006
SEDAR 17-RD28	Fluctuations in Abundance of Spanish Mackerel in Chesapeake Bay and the Mid-Atlantic Region. North Am. J. Fisheries Management. 12:450-458.	M. E. Chittenden, Jr, L. R. Barbieri and C. M. Jones. 1993.
SEDAR 17-RD29	Returns from 1965 Schlitz Tagging Program w Cumulative Analysis of Previous Results	D. Beaumariage. 1969
SEDAR 17-RD30	Spatial and temporal occurrence of Spanish Mackerel in Chesapeake Bay, Fishery Bulletin	Chittenden, M.E. Jr, L. R. Barbieri and C. M. Jones. 1993.

2. Consensus Report

Summary

- The stock assessment as presented by the Assessment Workshop (AW) was partially accepted.
- It was concluded that overfishing is not occurring.
- No annual estimates of fishing mortality were accepted due to model uncertainty.
- Stock projections were not accepted due to model uncertainty.
- Overfished status could not be determined from the assessment due to model uncertainty/sensitivity.

2.1 *Terms of Reference*

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

The assessment included commercial catch statistics for 1950-2007, with information on gear types, discards, and size and age compositions. Recreational catch statistics were also available for 1981-2007, and three estimates of recreational catch were available for 1960, 1965, and 1970. By-catch estimates of Spanish mackerel taken in shrimp fisheries were made for 1998-2004, and 2006. Seven fishery-dependent and two fishery-independent indices of stock size were used. In addition, appropriate estimates of natural mortality, maturation, and growth rates were provided by the Data Workshop (DW).

The catch data were appropriate for the assessment; however, not all data were adequate. In particular, by-catch statistics from shrimp fisheries were not available for most years, and only three estimates of recreational catch were available for the 31 year period, 1950-1980. The missing catch information was inferred from the small amount of data available to the assessment, and this is a major source of uncertainty in this assessment. Suggested improvements to the data are covered under section 2.1.8 <u>Additional information or assistance to improve Review Workshops.</u>

The application of the data in the assessment was clear and reasonable in many instances, although improvements were possible, as usual (see section 2.1.8).

<u>Summary of Panel Discussions</u>

The effects of changes in gear compositions and other fishery regulations were described by the assessment team (AT) and discussed by the Review Panel (RP). It was agreed that such changes need to be incorporated in the assessment model. The sampling for length and ages compositions was discussed. It was noted that the number of trips sampled is a better indicator of sampling precision than the annual number of length measurements.

The age 0 birthdate was questioned, along with the resulting growth curve fits. If samples are mid-year, with the beginning of the year equivalent to July 1, age-0s vulnerable to sampling are actually age 0.25 or age-0.5. It was agreed that this should be considered when estimating the growth model for future assessments. It was also suggested to look for evidence that growth rates have changed over time.

Summary plots of total fishery removals (in numbers and/or weights) were not presented in the report, however, these were provided later in the meeting.

MRFSS catch rates were converted to account for a change in survey methodology. The conversions were somewhat complicated, and it would be useful to have a plot of converted and unconverted catch rates to understand the effect of the conversion. This information was considered in some detail at the DW, but not available for the RP.

CPUE's of commercial logbooks from handline/trolling fisheries were based only on positive trips. This will be a source of bias if there are a significant number of zero's in directed trips, and the proportion of such trips changes over time. The AT's response was that in trips directed at Spanish mackerel there should not be too many zeros, so this issue may not be important. Florida trip ticket indices excluded many days and gears when trips limits likely affected catch rates. If the proportion of sets affected by trip limits changed over time then excluding this information could bias an index. This issue requires further consideration (see section 2.1.8). Changes in catchability of CPUE indices was considered, especially related to the use of spotter planes for gillnet fisheries. The AT felt that spotter planes would not affect catchability within the time frame of the indices. The RP also pointed out that hyperstability (i.e. the ability to maintain catch rates even when stock size declines) of fishery-dependent CPUE indices is common. The conclusion was to include CPUE indices in the assessment assuming catchability has not changed over time.

Negative correlations among some of the stock size indices were considered. The AT responded that there were no good reasons to exclude any of the indices. The RP felt that additional screening of indices prior to inclusion in the assessment would be useful, including examination of cohort effects in length frequencies.

The RP noted that the estimated relationship between shrimp landings and Spanish mackerel by-catch estimates in shrimp fisheries were heavily influenced by two data points which occurred at the two highest years of shrimp landings. The AT indicated that the CV for these data points was high but not large enough to suggest the data points were anomalous. While there were limited data, the AT felt they could not ignore those two points. The RP noted that shrimp boats could not be selected randomly for by-catch information which creates difficulties in raising the sampled by-catches to the whole fleet, or using the by-catch rate per shrimp landings to infer by-catches in other years where observer data is poor or not available. One of the documents available to the meeting (DW12) indicated historical (1972-1997) data, except in 1980, suggested few Spanish mackerel were caught in shrimp fisheries in those years. This is not consistent with the extrapolated by-catches used in the assessment, and needs clarification. However, a participant suggested that, while the historic by-catches are uncertain, they were probably much larger than recent values. The RP concluded that the estimation of by-catch was poorly documented, uncertain, and estimates were difficult to use in the assessment.

Historic recreational fishery landings (1950-1980) inferred from three salt-water surveys in 1960, 1965, and 1970 were quite uncertain and problematical to use in an assessment. Sensitivity adjustments for recall bias were described although it was pointed out that non-response bias may also be important. In the 1960 salt-water survey, King and Spanish mackerels were reported under a single category of Spanish mackerels. This was corrected by the AT and a revision of the 1960 estimate was provided. The RP asked if the recreational CPUE based on recent effort would be realistic for the historic landing estimates. The AT replied that something similar was done, and the implied catch rates were realistic, approximately 30 fish per angler trip. Also, why were the commercial catches so small relative to the recreational catches? The AT replied that there were other more valuable commercial species available at that time, so that there was not much commercial interest in Spanish mackerel; however, a meeting participant felt that the ratio of recreational to commercial catch should have been more proportional to recent levels. Research should continue to improve this information.

The RP felt it would be useful for the DW to provide recommendations about appropriate values for steepness in the stock-recruitment relationship. Species experts may have insight on this topic based on their knowledge of the species biology and if not, possibly supply values for similar stocks/species.

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

The AT presented results from four assessment methods. The primary assessment method used a statistical catch-at-age model (SCA), and the supporting methods were: a stock reduction model (SRA); a non-equilibrium production model (ASPIC); and catch curve analysis (as a diagnostic for the SCA).

After considering the results of several requested sensitivity runs, the RP concluded that the SCA model was not adequate to fully address all ToR's. The RP concluded that the SCA model could only be used to determine the over-fishing status, but not annual estimates of F, biomass or if the stock is over-fished. The rationale for this conclusion was based on the degree of uncertainty in the input data, (i.e. historic recreational catch and by-catch in shrimp fisheries), sensitivity to model assumptions (e.g. uncertainty about how to weight different sources of information), and lack of fishery-independent indices of adult population size. Further rational and suggested improvements to the assessment methods are covered under section 2.1.8.

The ASPIC model was not adequate as a standalone stock assessment model because the combined tuning index generally followed a "one-way trip", which in this type of model is known to produce poor results. In addition, because the ASPIC model did not use available age or length data, it was not appropriate for a "best-practice" stock assessment. The SRA was of intermediate complexity between the ASPIC and SCA models and was presented as a check of the SCA model; therefore, on its own the SRA was neither adequate nor appropriate for the stock assessment. Catch curves were highly variable and difficult to interpret in direct comparison to the SCA results.

Summary of Panel Discussions

The main issues discussed related to the SCA method: fitting the early (and uncertain) catch history exactly, the assumed stock-recruitment relationship, the relative weights applied to likelihood components (catch, length frequencies, age frequencies, abundance indices), and the method of calculating a total F across fisheries. The assessment sensitivity to values for natural mortality was also considered. Several requests for analyses with regards to these issues were completed (*see* Section 2.2).

A set of sensitivity runs was requested to explore the robustness of the model in the determination of over-fished and over-fishing stock status. The dimensions of uncertainties were: steepness in the stock-recruit relationship, landings history, likelihood weighting, and natural mortality. Because of a high degree of sensitivity in the MSY benchmarks to the specified value of steepness, the results of the sensitivity runs were also considered relative to $F_{40\%}$ and the MSST associated with $B_{40\%}$ (*see* Section 2.2). The results suggested that the model was robust to the conclusion that over-fishing did not occur in 2007, but were inconclusive about over-fished status.

There was concern from the RP that the catch histories were being fitted exactly even though much of the early recreational catch and by-catch estimates/extrapolations were very uncertain. The RP agreed that there was inadequate information in the data supplied to the model to reliably estimate early catches. The main concern was that the uncertainty in catches was not being propagated through to the final assessment results (*see* recommendations under section 2.1.8). The AT noted that a decision from a previous SEDAR was to fit these data exactly, and incorporate uncertainty by doing scenario modeling. However, the RP suggested that this is a poor way to account for uncertainty. The RP recommended that a bootstrap approach be explored for the next assessment to account for uncertainty in model inputs.

The steepness of the assumed Beverton-Holt stock-recruitment relationship was estimated in the model at 0.64 although the RP felt that there was no evidence of a stock-recruit relationship from the model estimates. It was agreed that, in the absence of a complete assessment of estimation uncertainty, a range of steepness values should be used in sensitivity runs (*see* Section 2.2).

The SCA application utilized subjective likelihood weighting, which was considered to be inappropriate. An alternative approach is to “estimate” the “process error” of each component through an iterative approach, in which each data component’s total variance is adjusted so that the variance of the standardized residuals is approximately equal to one. The RP suggested that this is a more objective approach to weighting of likelihoods. However, it was noted that the experience with VPAs is that iterative re-weighting of data can lead to undesirable outcomes in some situations, by placing too much weight on some data. Some subjective judgment of the appropriateness of data sources may still be required.

The option of starting the model is 1980 was discussed. The RP felt that it was unclear if this would improve the assessment, however, it would constitute a new assessment which would exceed the meeting ToRs.

The lack of model fit to the length compositions was noted by the RP. The lack of fit indicated a mis-match with the age compositions. It was suggested that this might be related to changes in growth rates.

The combined index values were used as an index of biomass in the SCA model. This combined index was not considered to be appropriate for the following reasons: 1) it does not allow re-weighting of real indices to examine their sensitivity in the stock assessment, 2) it is unclear how to quantify the uncertainty in the index, and 3) selectivity of the combined index is ill-defined (i.e. a mixture of gear types that can change over time) and may not be constant over time.

Relative profile likelihoods for R0 were requested by the RP, including runs with steepness fixed as well as estimated within the model. The profiles appeared to indicate that the biomass estimates were being driven by length and age frequencies. The RP concluded that there were four dimensions of uncertainties: 1) steepness, 2) recreational catch and by-catch in shrimp fisheries, 3) natural mortality, and 4) weightings of the likelihood components. Although the model suggested evidence for a particular value of steepness, the RP was concerned that this could be still poorly estimated.

Calculation of the total *F* across fisheries was discussed. The AT summed the fully selected *F'*s for each fishery to derive the fully recruited *F* over all fisheries. In the terminal year this was done in conjunction with an *F*-averaged selectivity that was not re-scaled to have maximum of 1. This approach allowed valid comparisons of the total *F* with the calculated F_{MSY} but made comparisons with catch-curve estimates of *F* problematic. The RP requested that fully recruited *F*s be computed from age based F's summed across fisheries for comparison to catch curve estimates.

The methods used in the assessment to calculate Z's from catch curves were discussed. The RP was not sure if the methods used were appropriate (*see* section 2.1.8), and some found it difficult to interpret what the implied mortalities meant. They seemed to indicate some average cumulative mortality experience by a group of cohorts, rather than year-specific mortality. The RP suggested that the Z's provided from catch curve analysis should be calculated such that they are comparable with Z's from the SCA.

There was discussion about the pros and cons of using existing packages for the assessment, rather than creating "in-house" software. No conclusion was reached, but the AT preferred to use their own computer code developed in AD model builder.

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

The RP did not accept estimates of stock abundance, biomass, and exploitation rates, due to concerns about robustness of the assessment to uncertainty in inputs and model assumptions.

2.1.4. Evaluate the methods used to estimate population benchmarks and management parameters (*e.g., MSY, Fmsy, Bmsy, MSST, MFMT, or their proxies*); provide estimated values for management benchmarks, a range of ABC, and declarations of stock status.

Due to concerns about the robustness of estimates of population benchmarks and management parameters (see Summary Discussion below), these estimates were not accepted. However, the RP did accept that over-fishing is not occurring. In sensitivity analyses this conclusion, based on F2007/Fmsy, was robust even though estimates of F and Fmsy were not robust.

The RP concluded from trends in fishery-dependent data that there is an increasing biomass trend, however the last four years have seen a decline.

Summary of Panel Discussions

The method of Shepherd (1982) was used to determine F_{MSY} as well as associated benchmarks and management thresholds. The approach used is reputable and commonly used in stock assessments. However, the results from the method depend on biological and fishery parameters which may be poorly determined. Particularly in this stock assessment, the value of steepness is highly uncertain and, as a consequence, so are the estimated benchmarks. In these circumstances it may be more prudent to use proxies for F_{MSY} and B_{MSY} rather than values calculated from an assumed level of steepness. However, B_{MSY} and its proxies are both sensitive to uncertainty in landings.

The RP noted that current fishing mortality does not seem to be inhibiting stock growth. No indices are decreasing at alarming rates.

The use of F_{MSY} as a *limit* reference point was questioned by a RP member. A discussion followed on the choice of benchmarks and the process to follow for setting the ABC.

2.1.5. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; recommend appropriate estimates of future stock condition (e.g., exploitation, abundance, biomass).

The projection method uses estimated numbers at age as a starting point and projects forward using stochastic recruitment. However, the average projection trajectory is defined to be deterministic (to ensure that the average trajectory is consistent with the deterministic benchmarks). This is an adequate approach for short term projections (1-3 years).

Due to concerns (see above) about the robustness of the stock assessment results, the AW projections were not accepted.

Summary of Panel Discussions

Projections need to better account for uncertainty, including process error in all state equations and not just recruitment.

2.1.6. Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters. Ensure that the implications of uncertainty in technical conclusions are clearly stated.

The RP concluded that methods to account for uncertainty were neither well developed nor adequate. The main approach was to examine the variations in point estimates based on sensitivity runs. In addition, the SCA model estimates were compared with those from simpler models (SRA and ASPIC). A partial bootstrap was used for projections, in which recruitments were sampled from the stock-recruit curve including model predicted deviations. Sensitivity analyses were also used to evaluate uncertainty/robustness in the conclusion regarding over-fishing and over-fished status.

Summary of Panel Discussions

The RP noted that standard errors were not provided for model results. Sensitivity runs are a subjective quantification of uncertainty which depend on the choice of various inputs to vary or modify for the sensitivity analysis. The results do not provide a probabilistic characterization of uncertainty. Also, sensitivity analyses are made with respect to the base run which may be biased; therefore the sensitivity runs could be poorly centered. The RP concluded that the sensitivity analyses conducted by the AW did not explore the full uncertainty about over-fishing status.

Only considering stochastic recruitment in the projections ignores important components of uncertainty; for example, 2007 stock size uncertainty, and other parameter uncertainty.

2.1.7. Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and Advisory Report and that reported results are consistent with Review Panel recommendations.

Do remotely after meeting.

2.1.8. Evaluate the SEDAR Process. Identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops; identify any additional information or assistance which will improve Review Workshops; suggest improvements or identify aspects requiring clarification.

Comments from the Review Panel are provided after each Workshop ToR.

I. Terms of Reference of Data Workshop

1. Characterize stock structure and develop a unit stock definition. Provide a map of species and stock distribution.

Maps of the region where the stocks are distributed were provided. Charts indicating the distribution of the catch would be useful. If available, charts showing the stock distribution and relative abundance based on survey results would also be of interest.

2. Tabulate available life history information (e.g., age, growth, natural mortality, reproductive characteristics, discard mortality rates); provide appropriate models to describe growth, maturation, and fecundity by age, sex, or length as applicable. Evaluate the adequacy of available life-history information for conducting stock assessments and recommend life history information for use in population modeling.

Life history information required for stock assessment is clearly provided without going into unnecessary detail. Guidance on steepness, the fraction of virgin recruitment expected at $0.2B_0$, would be helpful.

Estimation of the von Bertalanffy growth parameters within the assessment model may allow better estimation of fishery selectivities. The possibility of change in growth over time was not considered for Spanish mackerel.

There was some confusion over the inclusion of age 0 fish in the modelling of growth and maturity. It was unclear how the true age of the fish coincided with the fishing year criteria used in the assessment. It was suggested that the actual age of the fish (age 0.5, etc.) be considered when modelling growth.

3. Consider relevant fishery dependent and independent data sources to develop measures of population abundance. Document all programs used to develop indices; address program objectives, methods, coverage, sampling intensity, and other relevant characteristics. Provide maps of survey coverage. Develop values by appropriate strata (e.g., age, size, area, and fishery); provide measures of precision. Evaluate the degree to which available indices represent fishery and population conditions. Recommend which data sources should be considered in assessment modeling.

Sample sizes used to estimate length composition need to be characterized by the number of trips sampled rather than number of fish measured.

The Data Workshop presented the indicators of population abundance available and made recommendations for use in stock assessment. The Workshop preferences for particular indices (ranking) based on pros and cons presented could be helpful.

GLMs were used to construct the CPUEs but results and diagnostics were not fully documented. ANOVA tables should be provided to evaluate conclusions reached in the modelling. In addition, a step-wise regression should be considered to provide justification for the selection of explanatory variables. Factors associated with vessel type are often influential on CPUE but do not seem to have been evaluated in the GLM analysis.

4. Characterize commercial and recreational catch, including both landings and discard removals, in pounds and number. Discuss the adequacy of available data for accurately *characterizing harvest and discard by species and fishery sector. Provide length and age distributions of the catch. Provide maps of fishery effort and harvest.*

The DW provided the best available commercial and recreational catch data. Graphs representing the time-series of all removals in pounds and numbers by gear, including both recreational and commercial bycatch and discards were not presented. Bycatch data from the shrimp fisheries was inferred from a small amount of available data. A more defensible statistical model to estimate missing points should be considered.
Linear interpolation of missing catch in the recreational fishery was also identified as a problem (*see* comments in section 2.1.8.2 below, (ToR 1)).
Maps of fishery effort and harvest would have helped visualisation of the fishery but were not presented.

5. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Recommend sampling intensity by sector (fleet), area, and season.

Sampling recommendations were generally to increase sample sizes. Information on the methodology followed to determine adequate sample sizes for both length frequency and age samples would be useful.
Some recommendations for future research related to indicators of population abundance were outlined. However, for those to be useful, a clear statement of the problem, research objectives, methodology and identification of groups and/or projects that could undertake such research should be specified.

6. Develop a spreadsheet of assessment model input data that incorporates the decisions and recommendations of the Data Workshop. Review and approve the contents of the input spreadsheet within 6 weeks prior to the Assessment Workshop.

Completed as required.

7. Prepare complete documentation of workshop actions and decisions (Section II. of the SEDAR assessment report); prepare a list of tasks to be completed following the workshop, including deadlines and personnel assignments.

Adequately addressed. The list of pending tasks were itemised for the indicators of population abundance but no deadlines and personnel assignments were identified. In cases where no tasks were identified (i.e. commercial fishery) a statement saying so should be placed in the corresponding section of the report.

II. Terms of Reference of the Assessment Workshop

1. Review any changes in data following the data workshop, any analyses suggested by the data workshop, and provide estimated values for any required data in DW TOR 4 that are not available from observations. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.

Since estimates of shrimp bycatch data for the early period of the fishery were unavailable, missing data were estimated. . The function implemented resulted in a highly variable time-series which was not fully justified. Lack of consistency with historical data (1972 – 1997, document DW12) requires clarification. Better documentation of the shrimp bycatch estimation procedure would be useful.

Catch estimates from the MRFSS are not available from pre-1981. Data for the period 1950 – 1980 was extrapolated from 3 data points (from 1960,1965 and 1970). Although the estimates were on the order of 6 times those in recent years which raised some concern, published material in the 1950s suggests large recreational catches of that same order or larger. Research into estimating historical recreational catch should continue.

2. Develop population assessment models that are compatible with available data and recommend which model and configuration is deemed most reliable or useful for providing advice. Document all input data, assumptions, and equations. Document model code in an AW working paper.

Population assessment models compatible with the data available were developed, input data, assumptions and equations provided. The equations in the AW report corresponding to the objective function need to specify the years across which summations were performed. The Statistical Catch at Age (SCA) model configurations were specified and justified although the implications of those choices were not fully explored (i. e. weight in the likelihood terms). The use of specified multipliers for each likelihood component in the SCA model undermines the statistical nature of the model. Standardized residuals cannot be calculated when the multipliers are not equal to 1. Therefore, the internal statistical consistency of the model cannot be verified – and data weightings are subjective. It is recommended that base models use multipliers of 1 (and weights be adjusted, if necessary, using effective sample sizes and CVs). However, it was noted that the experience with VPA’s is that iterative re-weighting of data can lead to undesirable outcomes in some situations, placing too much weight on some data. Some subjective judgment of the “value” of data sources may still be required.

3. Provide estimates of stock population parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, discard removals, etc) by age and other relevant categorizations (i.e., fleet or sector); include representative measures of precision for parameter estimates.

Provided as required.

4. Characterize uncertainty in the assessment and estimated values, considering components such as input data sources, data assumptions, modeling approach, and model configuration. Provide appropriate measures of model performance, reliability, and ‘goodness of fit’.

Uncertainty was estimated in the SCA model by parametric bootstrap. It is not clear which parameters and their uncertainties were taken into account. Variances in parameter estimates do not reflect uncertainty in the catch data or structural uncertainty. Although sensitivity to key assumptions was explored through sensitivity tests, this approach does not provide information on precision of estimated parameters. Research into better methods to include the uncertainty in landings history is recommended.

It is also recommended that managers specify exactly what measures of uncertainty they require and for which parameters or management variables.

5. Provide yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations, including figures and tables of complete parameters.

Provided as required.

6. Provide estimates for SFA criteria consistent with applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and MSA National Standards. This may include: evaluating existing SFA benchmarks, estimating alternative SFA benchmarks, and recommending proxy values.

Existing benchmarks were evaluated. It was recognised that benchmarks would be sensitive to modelling assumptions. The implications for stock assessment were not fully explored (i. e. sensitivity to steepness). Proxy values were not recommended.

7. Provide declarations of stock status relative to SFA benchmarks; recommend alternative SFA benchmarks if necessary.

Provided as required.

8. Project future stock conditions. Provide estimates of exploitation, stock abundance and yield (discards and directed harvest) in pounds and numbers for a minimum of 10 years into the future. Fully document all projection assumptions (e.g., recruitment, selectivity, discard mortality). Develop rebuilding schedules if warranted; include estimated generation time. Stock projections shall be developed in accordance with the following:

A) If stock is overfished: F=0, F=current, F=Fmsy, Ftarget (OY), F=Frebuild (max that rebuild in allowed time) B) If stock is overfishing F=Fcurrent, F=Fmsy, F= Ftarget (OY) C) If stock is neither overfished nor overfishing F=Fcurrent, F=Fmsy, F=Ftarget (OY)

Performed as required. Projections were performed under the assumed functional form for stock and recruitment. The results were conditioned on the assessment.

9. Evaluate the impacts of past and current management actions on the stock, with emphasis on determining progress toward stated management goals and identifying possible unintended fishery or population effects.

The impact of past and current management actions was not evaluated.

10. Consider the data workshop research recommendations. Provide additional recommendations for future research and data collection (field and assessment); be as specific in describing sampling design and sampling intensity.

Recommendations from the DW were considered. In cases where the AW could not address those recommendations, i.e. creation of a Comprehensive Data and Assessment Archive, an alternative forum was identified.

11. Prepare an accessible, documented, labelled, and formatted spreadsheet containing all model parameter estimates and all relevant population information resulting from model estimates and any projection and simulation exercises. Include all data included in assessment report tables, all data that support assessment workshop figures, and those tables required for the summary report.

Prepared as requested.

12. Complete the Assessment Workshop Report (Section III of the SEDAR Stock Assessment Report), prepare a first draft of the Advisory Report, and develop a list of tasks to be completed following the workshop.

Completed as requested.

13. Perform a probabilistic analysis of proposed reference points and provide the probability of overfishing at various harvest or exploitation levels. (Added 7-2-08)

The probability of stock recovery to the SSB reference points by year was evaluated for a range of harvest levels.

<u>Additional information or assistance to improve Review Workshops</u>

The standardization of fishery catch data to derive CPUE was poorly described. Stock size indices should play an important role in stock assessment, and it is necessary to have more information available on how indices were derived to evaluate if they are included appropriately in the assessment model. This information should include summary statistics from the standardization (e.g. ANOVA-type tables), and a description of covariates excluded from the standardization (e.g. vessels, vessel class). Information on the annual geographic distribution of the various fisheries may provide information on changes in index catchability. Trends in fishery catch rates may depend on factors other than trends in population size. This problem was recognized by the assessment team.

Historic recreational fishery landings (1950-1980) were quite uncertain and difficult to use in the assessment. The three salt-water surveys should be examined in detail by recreational fishery survey experts to examine the potential magnitude of recall and non-response bias. Effort information would be quite valuable to extrapolate estimates to other years and for comparison with more recent estimates of recreational catch.

Spanish mackerel by-catch estimates in shrimp fisheries were poorly documented, uncertain, and difficult to use in the assessment. In a previous assessment (SEDAR 5) estimates of discards in shrimp trawls were considered too unreliable to include in the assessment. Shrimp boats could not be selected randomly for by-catch information; therefore, it is necessary to compare basic statistics on sampled trips (i.e. vessel tonnage, length, horsepower, number nets, etc.) with fleet-wide information in order to assess if the raising of sampled by-catch rates to the fleet, and to other years, is appropriate. A working paper (DW12) indicated historical (1972-1997) data, except in 1980, suggested few Spanish mackerel were caught in shrimp fisheries in those years. This is not consistent with the extrapolated by-catches used in the assessment, and needs clarification. The model used to extrapolate by-catches to unsampled years suggested a sharp increase in by-catches when shrimp landings increased from 20 000 to 30 000 lbs. This model over-estimated by-catch in 5 of 8 years, and under-estimated by-catch in only 2 of 8 years. A better fitting segmented regression model has the potential of greatly reducing the interpolated by-catches.

The assessment would benefit from simulation testing of the proposed assessment model or as a preferred alternative, on realistic operating models

The stock assessment could benefit from additional simple data explorations and stock assessment models. Better plots of changes in age and length distributions, better calculations of Z from catch curves (e.g. Chapman-Robson), and simple age-based methods (separable catch at age) or other methods (CSA – catch survey analysis) may provide additional insights and better justification for the SCA approach.

2.1.9. Review the research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted. Clearly indicate the research and monitoring needs that may appreciably improve the reliability of future assessments. Recommend an appropriate interval for the next assessment.

The DW provided useful recommendations regarding Life History, commercial and indices. However, some of these recommendations need to be more specific and deadlines and personnel assignments identified. The need of a fishery independent index of the adult population was mentioned but ways forward were not spelled clearly enough. No research recommendations were provided by the Recreational Workgroup.

In light of the uncertainty in the assessment results, it is suggested that the Spanish mackerel assessment be re-evaluated within a timeframe which allows for necessary management advice. The focus of the re-evaluation should be revised input data, principally catch estimates and fishery independent indices, as well as changes in the assessment method as suggested by reviewers.

2.1.10. Prepare a Peer Review Consensus Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks to be completed following the workshop. Complete and submit the Consensus Report within 3 weeks of workshop conclusion.

Completed as required.

2.2. *Further Analyses and Evaluations*

The review panel focused on analytical requests related to the sensitivity of the AW assessment model. These are summarized in Figure 2.2.1 and Figure 2.2.2. The results are also presented in Table 2.2.1. The results show that, while the estimates of F2007/Fmax were sensitive, in no case was a different conclusion reached with respect to "over-fishing".

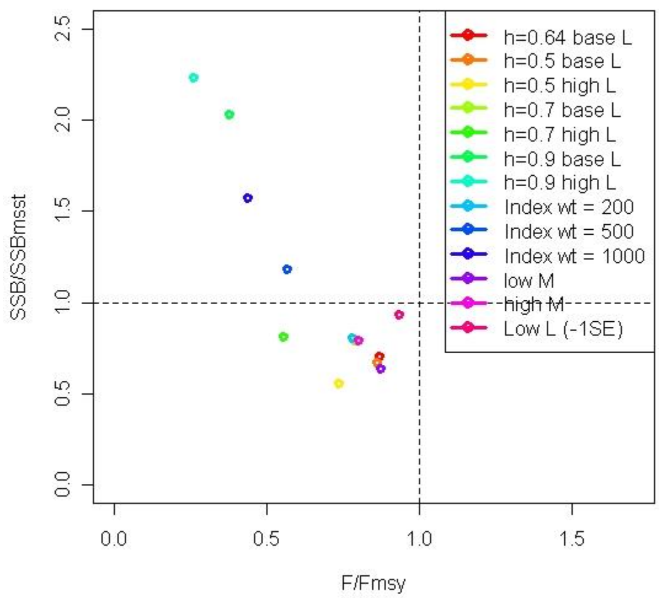


Figure 2.2.1. Results of requested sensitivity runs. Sensitivity was assessed on over-fished (y axis) and over-fishing (x-axis) assessment results.

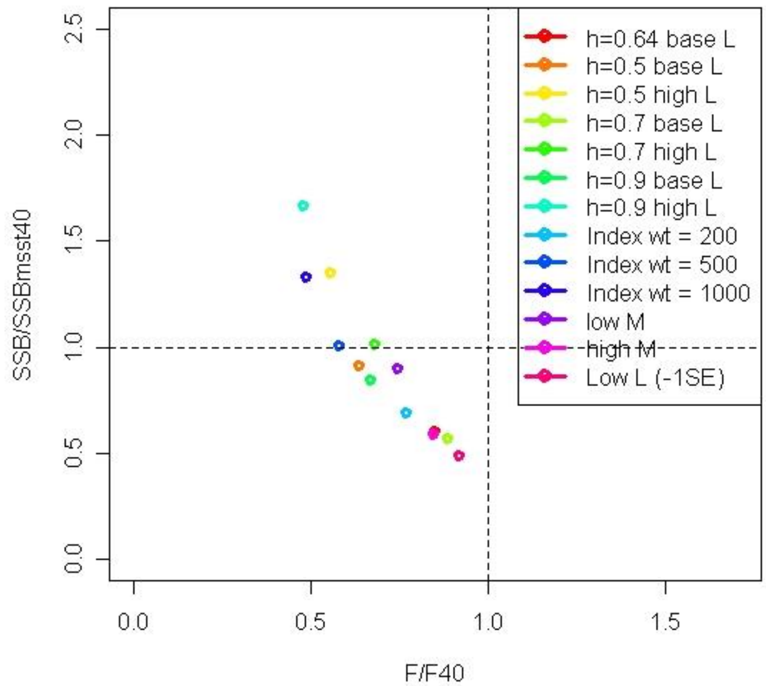


Figure 2.2.2. Results of requested sensitivity runs. Sensitivity was assessed on over-fished (y axis) and over-fishing (x-axis) assessment results, relative to proxy reference points.

Table 2.2.1. Results of requested sensitivity runs.

Run	description	Fmsy	SSBmsy	MSY	F.Fmsy	SSB.SSBmsy	SSB.MSST	h	R0(1000)	F.2007
1	h=0.64 base Landings	0.371	12438.15	5199	0.87	0.46	0.7	0.64	39452	0.25
2	h=0.5 base Landings	0.281	19831.7	5560	0.86	0.44	0.67	0.5	52840	0.18
3	h=0.5 high Landings	0.287	35493.33	9513	0.74	0.36	0.56	0.5	95232	0.15
4	h=0.7 base Landings	0.425	10494.99	5112	0.79	0.51	0.79	0.7	34769	0.26
5	h=0.7 high Landings	0.463	18234.71	8796	0.56	0.52	0.81	0.7	54356	0.19
6	h=0.9 base Landings	0.672	6032.41	4476	0.38	1.32	2.03	0.9	24245	0.19
7	h=0.9 high Landings	0.694	10880.59	7565	0.26	1.45	2.23	0.9	40031	0.13
8	Index wgt = 200	0.375	12414.23	5148	0.78	0.52	0.8	0.64	38935	0.22
9	Index wgt = 500	0.387	12392.09	5067	0.57	0.77	1.18	0.64	36966	0.15
10	Index wgt = 1000	0.42	12339.78	5077	0.44	1.02	1.57	0.64	34305	0.12
11	M low	0.323	20692.8	5751	0.87	0.41	0.63	0.64	32774	0.20
12	M high	0.401	10781.19	5025	0.8	0.51	0.79	0.64	41546	0.25
13	Low landings (-1SE)	0.374	7591.89	3273	0.93	0.61	0.93	0.64	23547	0.27

2.3. *Additional Comments*

No additional comments.

2.4. *Recommendations for Future Workshops*

The panel felt that additional documentation from the DW and AW would be beneficial. This is described in previous sections (2.1.8). However, they are somewhat lacking in what is required to review a stock assessment. There appears to be no requirement for executive summaries to be produced for any aspect of the data preparation or assessment. The DW and AW reports could have been greatly improved with the inclusion of executive summaries aimed at reviewers who may be unfamiliar with the particular fisheries and data sets. The panel also felt that the review would benefit if more DW participants attended the review.

2.5. *Reviewer Statements*

Gary Shepherd - Review Panel Chair: The SEDAR 17 review was based on assessment results provided by the Data Workshop and Assessment Workshop. Although the Review Panel has made recommendations for additional information in future reports, the extensive data and analyzes in the documents represented a tremendous effort by the two groups, which was appreciated. In addition, I would like to acknowledge the professionalism and patience by the assessment team in providing additional analyzes as requested by the Review Panel. The conclusions of the review panel as presented in the summary report accurately represent my own conclusion regarding the assessment of Spanish mackerel.

Beatriz Roel - CIE Reviewer. The SEDAR 17 review process was undertaken on the basis of the documentation made available to the Panel and the presentations made by the Assessment Team. The documentation was comprehensive and the AT presentations were of high standard. The interaction between the Review Panel, the Assessment Team and other participants was facilitated by a relaxed atmosphere and I would like to thank participants and organizers for a productive and pleasant meeting.
The contents of the Consensus Report provide an accurate and complete summary of my views on the issues covered in the review.

Noel Cadigan - CIE Reviewer. I agree that the content of this summary report reflects the consensus of the SEDAR 17 Review Workshop.

Patrick Cordue - CIE Reviewer: The content of this report represents the consensus view of the four Panel members. A full summary of my individual views is contained in my CIE report. My general conclusions and views are consistent with those in the consensus report. However, my CIE report contains technical criticisms and recommendations which are not included in the consensus report.

3. Submitted Comments

3.1 Written comments submitted by Chairman of the Mackerel Advisory Panel, Ben Hartig

As Chairman of the Mackerel advisory Panel, I attended SEDAR 16 (King Mackerel) and SEDAR 17 (Spanish Mackerel and Vermilion Snapper). I served as a panel member in both DW's and AW's (missed king mackerel AW) and as an appointed observer for the RW's. I will try to keep my comments specific to SEDAR 17, however, some comments will be applicable to both assessments.

My overall evaluation of the RW was a very positive experience. The depth and rigor which the data and models were subjected to by the RW panel was beyond what I had experienced in past assessments. There were extensive discussions documenting the various positive or negative aspects of the data and modeling. These discussions fostered increased understanding of the data and modeling processes.

Both of the Beaufort analysts did excellent jobs responding to the RW panel requests for additional model runs and other data needs in a timely fashion.

There is additional constructive criticism offered below, although, not in a prioritized sequence:

1) In both assessments I asked the same question. What was the sampling protocol and was it met? I never did get a satisfactory answer in either assessment. You will not find this in either assessment. The SEFSC needs to develop sampling protocols for all species assessed as soon as possible. And include the results in the DW report. For Spanish Mackerel Dr. Conn did an excellent job in breaking down the fishery into its harvesting components. Additionally, these components need to have their corresponding harvest levels sampled adequately, based on the sampling protocol, in both space and time.

2) The overall number of length and age samples for Spanish Mackerel has been declining in recent years. With Magnuson's new responsibility squarely on the shoulders of the analysts and the SSC, the data has to be better not worse if the intent of the new re-authorization is to succeed.

3) If the goal of SEDAR is to have commercial fishermen involved, then the process needs to be more fishermen friendly. It may not be reasonable to expect that fishermen are able to react in real time to all of the computer runs generated in the AW. As an example, in the week after the AW I offered an additional sensitivity run based on a new recreational landings stream. I was told that the computer run could not be accommodated without approval from the SEFSC in Miami. Instead of pursuing the Miami route, I was content to have my request reviewed by the RW and let them make the determination as to its validity. It would be helpful for fishermen to have an additional week to digest the RW and ask for other sensitivity runs if needed.

4) The relationship between the Beaufort and Miami stock assessment analysts needs to change immediately! Currently, the two labs do not have the level of professionalism needed to work with each other on common assessment problems, therefore, the SEDAR process suffers.

5) In the Spanish Mackerel assessment it would have been extremely helpful to have a Miami analyst, familiar with the previous assessment, participate in the AW and RW. More importantly, it would have been instructive for a Miami analyst to complete a "continuity run"

based on the previous assessment using the new data. This could have given some perspective to the new model.

6) A council appointed reviewer was missing from the SEDAR 17. In SEDAR 16 this position was filled and the assessment was a better product with their involvement. This position also allows some access to additional runs by appointed observers.

7) There were a number of sensitivity runs completed in the AW which were not included in the peer review document. All sensitivity runs from the AW should be available in the RW document.

I have one final comment on the Addendum that Dr. Conn completed in Section VI of the SAR. I sincerely appreciate the considerable extra work that was accomplished in an effort to produce a functional assessment. However, both the shrimp by-catch and the historical recreational landings stream have required significant mathematical gyrations to be of use in the assessment.

The historical recreational landings have now been mathematically altered due to recall bias and species identification. At what point do you abandon the effort to use this data? In my mind, you are already past this point.

The other stock assessment scientists that have tried to work with the shrimp by-catch data, found that it was too imprecise and would introduce too much uncertainty into the assessment. They framed their management advice as "conditional" on shrimp by-catch. And the Council should keep this in mind when setting TAC.

The new MSY from this additional analysis is 11.5 million pounds. This is lower than the original base run of 13 million. The commercial allocation, based on the way in which TACs have been set previously, would be 6.3 million pounds. This is about 1 million pounds higher than any year from the historical data set excluding the extreme landings (1974-1980). And from my perspective, it is still too high!

Sincerely,
Ben Hartig

Section VI. Addendum

Contents

1 Addendum: Revised catch-at-age analysis

1.1 Revised landings time series

Following the assessment workshop, a review of publications documenting early recreational landings from the U.S. Fish & Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) saltwater angler reports (Clark 1962; Deuel and Clark 1968; Deuel 1973) revealed that the 'Mackerel, Spanish' category in these reports included estimated landings for cero, Spanish, and king mackerel in 1960 and cero and Spanish mackerel in 1965 and 1970. This was thought to be a problem because at the data workshop all landings from the "Mackerel, Spanish" category were included as part of the Spanish mackerel recreational landings. Inspection of current landings of cero mackerel revealed that they were likely negligible (<1% of recent mackerel landings), so that the 1965 and 1970 estimates of landings were reasonable. However, king mackerel landings in 1965 and 1970 reports were substantial, which indicated that the data point used for 1960 in the base assessment run was too high. In an attempt to account for this problem, we computed the percentage of king mackerel in the total south Atlantic mackerel catch from the 1965 and 1970 reports, which was shown to make up 46% and 44% of the total catch, respectively. As such, the RW suggested that the recreational landings in 1960 should be reduced by 45% to account for contamination of king mackerel. As suggested by the AW, both time series were multiplied by 0.75, in an attempt to adjust for suspected recall bias. Comparisons of initial and revised recreational landings streams are shown in Figure 1.1 & Table 1.1. Recreational landings at the time of model initialization (1950) were set to the average of 1960, 1965, and 1970, with linear interpolation used to impute missing data points (the same approach used in SEDAR (2008a)). The assessment results reviewed at the review workshop included the revised landings time series.

1.2 Analysis methods

The same statistical catch-age model in an identical configuration to the AW base run (SEDAR 2008a) was used to estimate fishery parameters and management quantities, with the only difference being the change in early recreational landings and discards. Measures of uncertainty and projections were also obtained using the same approaches outlined in SEDAR (2008a).

1.3 Results

Measures of Overall Model Fit Overall, the catch-at-age model fit well to the available data. Annual fits to length compositions from each fishery were reasonable in most years, as were fits to age compositions (Figure 1.2). Residuals of these fits, by year and fishery, are summarized with bubble plots; differences between annual observed and predicted vectors are summarized with angular deviation (Figure 1.3–1.12). Angular deviation is defined as the arc cosine of the dot product of two vectors.

The model was configured to fit observed commercial and recreational landings closely (Figures 1.13–1.17). In addition, it fit well to observed discards (Figures 1.18–1.20) and to "observed" shrimp bycatch (1.21).

Fits to indices of abundance were reasonable (Figures 1.22 & 1.23). The combined index shows a generally increasing trend from the early 1980's to present, mirroring anecdotal reports by commercial fishermen. The SEAMAP index suggests highly variable recruitment from year to year; however, mismatches between trawl surveys and the timing of migration are an alternative explanation.

Parameter Estimates Estimates of all parameters from the catch-at-age model are shown in Appendix B. The estimated coefficient of variation of length at age was $\widehat{\mathrm{CV}} = 9.7\%$ (Figures 1.24, 1.25).

Stock Abundance and Recruitment Estimated abundance at age shows truncation of the oldest ages during the 1970s through the mid 1980s (Table 1.2); however, the stock appears to have rebounded to numbers last seen in the early-mid 1970s. Annual number of recruits is shown in Table 1.2 (age-0 column) and in Figure 1.26. Recruitment in recent years was estimated to be below average.

Stock Biomass (total and spawning stock) Estimated biomass at age follows a similar pattern of truncation as did abundance (Tables 1.3 & 1.4, Figures 1.27 & 1.28). Total biomass and spawning biomass show nearly identical trends—sharp decline immediately following model initialization, with another decline in the 1970s and early 1980's ostensibly due to a high volume of landings in the commercial gillnet fishery. The stock was estimated to be at it's lowest point in the early-mid 1980s, and since has added substantial biomass (Table 1.5).

Fishery Selectivity Estimated selectivities of landings from recent years indicate that full selection occurs at an early age (age 3 for handlines, age 2 for gillnets and castnets, and age 1 for poundnets). For poundnets, castnets, and handlines, females reached full selectivity faster because of how we modeled selectivity as a function of growth. Average selectivities of landings, discard mortalities, and all fishing-related mortalities combined were computed from F-weighted selectivities in the most recent period of regulations. These average selectivities were used to compute benchmarks and in projections. All selectivities from the most recent period, including average selectivities, are presented in Tables 1.6 & 1.7.

Fishing Mortality The estimated time series of fishing mortality rate (F) shows a peak in the late 1970s and early 1980s when average fishing mortality rates were close to 1.0, with a secondary peak in the early 1990s (Figure 1.29). Following implementation of the gillnet ban in Florida state waters in 1995, mortality rates of commercial and recreational fisheries declined. Since 2000, our model suggests that fishing mortality rates have been between 0.3 and 0.5.

Historically, the majority of the full F was dominated by gillnet and recreational fisheries, with a shift in the most recent years to include a larger percentage of mortality attributable to the commercial castnet and handlines fisheries (Figure 1.29, Table 1.8).

Full F at age is shown in Tables 1.9 & 1.10 for males and females, respectively. In any given year, the maximum F at age may be less than that year's fully selected F. 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 (commercial gillnet after 1995, recreational) have dome-shaped selectivity.

A comparison of catch curve estimates of full F SEDAR (2008c) to those calculated from the assessment model (Figure 1.30) indicated that the range of F was similar for the two approaches. As suggested by the RW, catch curve estimates of Z were restricted to those calculated with age proportions across years, with zero values omitted; F was then calculated by subtracting out a constant natural mortality rate of $M = 0.35$. To aid in comparison, catch-age estimates of full F were adjusted so that full selectivity had a maximum of 1.0.

Throughout most of the assessment period, estimated landings and discard mortalities in number of fish have been dominated by commercial gillnet and recreational sectors (Figures 1.31, 1.32). Table 1.11 shows total landings at age in numbers, Table 1.12 in metric tons, and Table 1.13 in 1000 lb. Total landings and discards by year and sector are presented in 1000 lb. for landings (Table 1.14) and in number for discards and shrimp bycatch (Table 1.15).

Stock-Recruitment Parameters The estimated Beverton–Holt spawner-recruit curve is shown in Figure 1.33. 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 1.34). Estimated parameters were as follows: steepness $\hat{h} = 0.64$, $\widehat{R_0} = 39.4$ million, and first-order autocorrelation $\hat{\varrho} = 0.56$. Uncertainty in these parameters was estimated through bootstrap analysis of the spawner-recruit curve (Figure 1.35).

Per Recruit and Equilibrium Analyses Static spawning potential ratio (static SPR) was variable but showed a decreasing trend from 1950 to a minimum in the 1980s. Since then, static SPR has steadily increased to a new high (Figure 1.36, Table 1.5). This increase is likely attributable to a variety of factors, possibly including (a) decreases in bycatch mortality due to BRDs in the shrimp fishery, (b) changing selectivity in the gillnet fishery after the Florida gillnet ban in 1995, (c) increased prominence of the commercial handlines sector which typically select older fish, and (d) reduced fishing mortality.

Yield per recruit and spawning potential ratio were computed as functions of F (Figure 1.37), as were equilibrium landings and spawning biomass (Figures 1.38). Equilibrium landings and discards were also computed as functions of biomass B, which itself is a function of F (Figure 1.39). As in computation of MSY-related benchmarks, per recruit analyses applied the most recent selectivity patterns averaged across fisheries, weighted by F from the last three years (2005–2007). Per-recruit estimates were $F_{\max} = 0.84$, $F_{30\%} = 0.54$, and $F_{40\%} = 0.38$ (Figure 1.37, Table 1.16). For this stock of Spanish mackerel, F_{MSY} corresponded to an F that provided 40.5% SPR (i.e., $F_{40.5\%}$), but of course, a proxy is unnecessary if F_{MSY} is estimated directly.

Benchmarks / Reference Points / ABC values Biological reference points (benchmarks) were derived analytically assuming equilibrium dynamics, corresponding to the estimated spawner-recruit curve with bias correction (Figure 1.33). This approach is consistent with methods used in rebuilding projections (i.e., fishing at F_{MSY} yields MSY from a stock size of $\mathrm{SSB}_{\mathrm{MSY}}$). Reference points estimated were F_{MSY}, MSY, B_{MSY} and $\mathrm{SSB}_{\mathrm{MSY}}$. Based on F_{MSY}, three possible values of F at optimum yield (OY) were considered—$F_{\mathrm{OY}} = 65\% F_{\mathrm{MSY}}$, $F_{\mathrm{OY}} = 75\% F_{\mathrm{MSY}}$, and $F_{\mathrm{OY}} = 85\% F_{\mathrm{MSY}}$—and for each, the corresponding yield was computed. Uncertainty of benchmarks was computed through bootstrap analysis of the spawner-recruit curve.

Estimates of benchmarks are summarized in Table 1.16. Point estimates of MSY-related quantities were $F_{\mathrm{MSY}} = 0.371$/yr, $\mathrm{MSY} = 11,460,960$ lb, $B_{\mathrm{MSY}} = 33,743$ mt, and $\mathrm{SSB}_{\mathrm{MSY}} = 12,438$ mt. Distributions of these benchmarks are shown in Figure 1.40.

Status of the Stock and Fishery Estimated time series of B/B_{MSY} and $\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$ show similar patterns: stock status quickly declines below the MSY benchmark after model initialization in 1950, reaching it's nadir in the mid-1980s. Since then, stock biomass has climbed to higher values, but is still substantially below MSY levels (Figures 1.41 & 1.28, Table 1.5). Current stock status was estimated to be $\mathrm{SSB}_{2007}/\mathrm{SSB}_{\mathrm{MSY}} = 0.456$ and $\mathrm{SSB}_{2007}/\mathrm{MSST} = 0.701$, indicating that the stock is overfished (Table 1.16). However, the the SEDAR 17 RW did not accept the base assessment model as appropriate for making biomass determinations. Conclusions about biomass benchmarks are largely uncertain, and point estimates should be viewed with extreme caution.

The estimated time series of F/F_{MSY} shows a generally increasing trend from the 1950s through the late 1970s/early 1980s, peaking at about five times F_{MSY}. This number has declined substantially in recent years, alternating between slight overfishing and no overfishing since 2000 (Figure 1.42, Table 1.5). The most recent estimate ($F_{2007}/F_{\mathrm{MSY}} = 0.872$) indicates that overfishing did not occur in 2007 (Table 1.16). A variety of sensitivity runs were requested at the review workshop; conclusions were relatively robust to choice of sensitivity run, and the RW concluded that overfishing was likely not occurring in 2007.

Evaluation of Uncertainty Uncertainty was addressed within several sensitivity runs at the RW (SEDAR 2008b), and through bootstrap analysis of the spawner recruit curve (Figures 1.35 & 1.40).

Projections The review workshop did not regard the base model as appropriate for addressing biomass benchmarks or computing projections. Nevertheless, the same suite of projections as in SEDAR (2008a) are presented here for completeness.

Projection scenario 1, in which $F = 0$, predicted the stock to recover to the level of $\mathrm{SSB}_{\mathrm{MSY}}$ with probability 0.5 in 2012 (Figure 1.43, Table 1.17). Since this value is less than ten years, the allotted rebuilding time specified under the MSRA is ten years. However, for visual clarity, projections were run for 20 years.

Projection scenario 2, in which $F = F_{\mathrm{current}}$, predicted the stock to increase over time (Figure 1.44, Table 1.18); however the proportion of projections for which rebuilding occurs in the requisite time frame was just 0.36. If F is reduced to F_{MSY}, as in scenario 3, the stock was predicted to begin recovery, but not to the level of $\mathrm{SSB}_{\mathrm{MSY}}$ within the rebuilding time frame (Figure 1.45, Table 1.19). If F is reduced to 65%, 75%, or 85% of F_{MSY}, as in scenarios 4, 5, & 6, the stock was predicted to recover in time (Figures 1.46, 1.47 & 1.48, Tables 1.20, 1.21 & 1.22). The maximum F that allowed rebuilding within the time frame was $F_{\mathrm{rebuild}} = 0.325$, or about 88 % of F_{MSY} (Figure 1.49, Table 1.23).

Probabilistic analysis Levels of fishing mortality for which 50%, 60%, 70%, 80%, and 90% of stochastic stock trajectories had recovered by 2019 were given by $F = 0.325$, $F = 0.288$, $F = 0.252$, $F = 0.218$, and $F = 0.175$ (Figure 1.50, Tables 1.23-1.27).

1.4 References

References

Clark, J. R., 1962. The 1960 Salt-Water Angling Survey. U.S. Department of the Interior, Bureau of Sport Fisheries & Wildlife, Circular 153, Washington, D. C.

Deuel, D. G., 1973. The 1970 Salt-Water Angling Survey. U. S. Department of Commerce Current Fishery Statistics Number 6200, Washington, D. C.

Deuel, D. G., and J. R. Clark, 1968. The 1965 Salt-Water Angling Survey. Bureau of Sport Fisheries & Wildlife Resource Publication 67, Washington, D. C.

SEDAR, 2008a. SEDAR 17 Assessment Workshop Report.

SEDAR, 2008b. SEDAR 17 Review Workshop Report.

SEDAR, 2008c. SEDAR-17-AW-04: Catch curve analysis of age composition data for Spanish mackerel.

1.4.1 Tables

Table 1.1. Spanish mackerel: Estimates of recreational landings and discards used in the revised catch-age assessment model. All values are in 1000s and incorporate a 0.75 multiplier on early USFWS and NMFS saltwater angler records to account for recall bias.

Year	Rec Landings	Rec Discards
1950	4297	170
1951	4172	165
1952	4047	160
1953	3922	155
1954	3796	150
1955	3671	145
1956	3546	140
1957	3421	135
1958	3296	130
1959	3171	126
1960	3046	121
1961	3611	143
1962	4175	165
1963	4740	188
1964	5305	210
1965	5870	232
1966	5493	217
1967	5117	203
1968	4740	188
1969	4364	173
1970	3988	158
1971	3657	145
1972	3326	131
1973	2995	118
1974	2664	105
1975	2333	92
1976	2002	79
1977	1671	66
1978	1341	53
1979	1010	40
1980	679	26
1981	888	62
1982	904	7
1983	127	5
1984	971	26
1985	487	55
1986	889	318
1987	1185	62
1988	1744	64
1989	1227	240
1990	1359	161
1991	1548	365
1992	1382	350
1993	955	245
1994	1220	752
1995	876	391
1996	841	357
1997	1113	420
1998	688	267
1999	1087	641
2000	1737	827
2001	1243	676
2002	1280	614
2003	1532	812
2004	883	420
2005	1088	748
2006	907	283
2007	1051	565

Table 1.2. Spanish mackerel: Estimated abundance at age (1000 fish) at start of year

Year	0	1	2	3	4	5	6	7	8	9	10+
1950	33137.7	19899.0	11949.3	6825.5	4017.5	2412.5	1463.3	896.4	549.2	336.4	546.1
1951	35079.8	11555.8	11259.2	7181.8	4278.3	2567.8	1557.4	954.1	584.5	358.1	581.2
1952	34332.0	14761.0	6304.9	6624.0	4435.6	2694.4	1633.3	1000.6	613.0	375.5	609.6
1953	33812.1	15790.4	8054.2	3643.1	3997.4	2728.9	1674.3	1025.2	628.0	384.7	624.5
1954	32964.7	11949.4	8697.8	4706.5	2223.1	2486.9	1714.8	1062.7	650.7	398.6	647.0
1955	32006.0	12820.7	6449.7	5016.6	2844.2	1369.7	1547.6	1077.8	667.9	409.0	663.8
1956	30798.1	12220.5	6870.4	3601.9	2915.4	1684.6	819.4	935.2	651.3	403.6	654.8
1957	29676.1	13581.6	6474.4	3703.6	2008.0	1655.9	966.5	474.8	541.9	377.4	619.4
1958	28154.0	10860.6	7189.0	3338.2	1950.0	1076.6	896.7	528.6	259.7	296.4	550.7
1959	28332.4	14603.8	5632.7	3651.7	1736.5	1032.9	576.0	484.6	285.7	140.3	462.4
1960	28600.5	11851.9	7962.7	3198.9	2155.5	1044.8	627.7	353.5	297.4	175.3	373.6
1961	27635.1	8860.2	6430.9	4488.9	1873.5	1286.7	629.9	382.2	215.3	181.1	337.7
1962	28089.4	15935.9	4421.6	3396.0	2488.0	1058.2	734.0	363.0	220.3	124.1	301.9
1963	27806.3	11526.6	8216.2	2418.4	1947.2	1454.0	624.6	437.6	216.4	131.3	256.5
1964	28137.9	16008.0	5562.0	4339.0	1356.3	1113.1	839.6	364.3	255.2	126.2	228.5
1965	28484.6	16206.9	7766.4	2909.5	2399.2	764.3	633.6	482.7	209.4	146.7	206.0
1966	27783.7	11775.0	7691.2	4006.4	1591.9	1337.9	430.5	360.4	274.6	119.1	202.7
1967	27772.0	15574.1	5407.0	3947.4	2203.1	892.4	757.5	246.2	206.1	157.0	185.9
1968	28162.7	15989.5	7536.2	2750.5	2107.4	1198.3	490.2	420.3	136.6	114.4	192.2
1969	28102.7	13141.9	8019.6	3928.3	1496.2	1168.1	670.9	277.2	237.7	77.2	175.1
1970	27377.5	10807.3	6590.1	4221.9	2164.5	840.1	662.4	384.3	158.8	136.1	146.0
1971	27945.0	15681.1	5355.1	3430.7	2302.8	1203.1	471.6	375.6	217.9	90.0	161.6
1972	27050.8	8453.6	8293.1	2906.6	1930.3	1320.3	696.6	275.8	219.7	127.4	148.6
1973	26725.9	11515.8	4295.2	4364.6	1594.0	1078.6	745.1	397.1	157.2	125.2	159.0
1974	26745.8	11957.9	6083.7	2345.6	2476.4	921.7	629.9	439.5	234.2	92.8	169.3
1975	25248.5	10087.9	6466.4	3235.7	1275.9	1372.0	515.7	356.0	248.4	132.4	149.6
1976	21597.7	10783.6	5288.2	2890.2	1421.4	569.8	618.8	234.9	162.2	113.2	129.7
1977	17862.8	7738.4	5332.3	1642.5	809.2	403.0	163.1	178.9	67.9	46.9	70.9
1978	16994.2	10109.6	3861.5	1849.2	528.4	263.9	132.7	54.3	59.5	22.6	39.6
1979	16922.7	9612.2	5243.8	1278.0	552.5	159.9	80.7	41.0	16.8	18.4	19.4
1980	16800.8	9004.7	5146.6	1758.8	384.1	168.2	49.2	25.1	12.7	5.2	11.8
1981	16779.9	5890.1	4966.5	1759.8	536.4	118.7	52.5	15.5	7.9	4.0	5.4
1982	15813.2	9510.7	3342.6	2471.2	863.2	267.7	59.8	26.7	7.9	4.0	4.9
1983	13799.2	4407.3	5076.9	1072.1	702.7	248.5	77.8	17.6	7.8	2.3	2.6
1984	12981.0	2864.5	2705.7	2499.6	504.7	336.3	120.1	38.0	8.6	3.8	2.4
1985	24497.4	7207.7	1440.7	1104.1	990.7	203.2	136.7	49.3	15.6	3.5	2.6
1986	25176.8	8609.8	4102.0	591.4	422.1	384.3	79.6	54.1	19.5	6.2	2.4
1987	18870.0	10376.6	4927.6	2046.4	289.8	210.4	193.5	40.5	27.5	9.9	4.4
1988	18392.2	7824.2	5911.1	2565.9	1062.6	153.2	112.3	104.3	21.8	14.8	7.8
1989	23258.5	6353.2	4178.5	2928.2	1278.1	538.7	78.4	58.1	53.9	11.3	11.8
1990	26847.5	5571.4	3417.4	2077.5	1458.0	647.7	275.7	40.5	30.0	27.9	12.1
1991	31793.0	7685.3	2886.2	1651.2	1010.9	722.1	324.0	139.3	20.5	15.2	20.4
1992	23420.1	10436.0	3874.7	1221.8	683.1	425.1	306.6	139.0	59.7	8.8	15.4
1993	14079.8	8285.5	5650.3	1839.5	571.6	325.1	204.3	148.9	67.5	29.0	11.9
1994	13840.7	6493.9	4584.3	2541.3	796.6	251.6	144.5	91.7	66.8	30.3	18.5
1995	23794.7	7345.4	3318.2	1879.9	999.1	318.1	101.5	58.9	37.4	27.2	20.1
1996	15774.7	8044.9	4038.5	1843.9	1096.8	609.2	202.3	67.1	39.7	25.5	32.8
1997	10912.9	8802.3	4308.4	2094.3	1007.9	634.7	374.0	131.2	44.9	27.0	40.3
1998	14441.7	3776.0	4602.1	2229.9	1146.5	584.7	391.0	243.7	88.2	30.6	46.9
1999	22071.4	8129.5	1987.5	2334.4	1195.0	654.7	357.2	254.4	164.2	60.5	54.4
2000	24397.4	7583.7	4333.3	1056.6	1308.0	700.6	400.9	227.8	165.6	108.1	76.9
2001	20757.6	9325.0	3801.0	2174.7	564.1	730.0	407.9	242.9	140.8	103.5	117.4
2002	17209.6	10954.0	5033.8	1956.1	1174.9	317.8	427.8	248.1	150.4	88.1	140.3
2003	10149.0	9793.3	6122.3	2655.9	1080.7	673.1	188.0	260.8	153.3	93.6	144.1
2004	11908.4	5422.2	5361.7	3163.8	1439.8	604.0	385.4	110.1	154.1	91.0	143.0
2005	15200.6	6826.9	3105.0	2908.4	1785.4	836.2	358.6	233.8	67.3	94.6	145.4
2006	20709.9	8356.8	3733.0	1582.3	1550.3	986.3	476.7	210.6	139.1	40.3	145.8
2007	21886.1	12194.9	4724.1	1912.7	843.0	859.2	566.9	283.5	127.3	84.8	115.3
2008	24166.8	12501.0	6953.6	2599.0	1094.3	502.1	531.3	363.1	184.7	83.7	133.5

Table 1.3. Spanish mackerel: Estimated biomass at age (mt) at start of year

Year	0	1	2	3	4	5	6	7	8	9	10+
1950	4063.5	7624.5	8072.5	6382.6	4585.6	3126.5	2060.1	1333.2	847.3	532.1	878.3
1951	4301.6	4427.7	7604.4	6712.7	4883.1	3327.7	2192.6	1419.0	901.8	566.3	934.8
1952	4209.9	5655.8	4258.2	6189.4	5059.9	3491.7	2299.5	1488.1	945.8	593.9	980.4
1953	4146.2	6050.2	5439.1	3403.5	4558.3	3534.2	2357.0	1524.6	968.9	608.5	1004.4
1954	4042.3	4578.5	5873.9	4396.5	2534.5	3219.5	2412.5	1580.4	1003.9	630.4	1040.6
1955	3924.7	4912.3	4355.7	4686.3	3242.3	1772.8	2176.3	1601.8	1030.5	646.8	1067.6
1956	3776.6	4682.3	4639.0	3363.8	3323.5	2180.1	1152.0	1389.1	1004.0	638.3	1053.0
1957	3639.0	5203.8	4370.8	3457.1	2288.3	2143.0	1358.5	705.1	835.0	596.4	996.2
1958	3452.3	4161.2	4851.9	3113.9	2220.8	1392.7	1260.5	784.9	400.0	468.1	885.4
1959	3474.2	5595.4	3801.4	3405.0	1976.0	1335.3	809.3	719.5	439.9	221.6	743.1
1960	3507.1	4541.1	5376.6	2985.1	2451.8	1349.3	881.3	524.7	458.1	276.8	600.4
1961	3388.7	3394.8	4342.2	4191.4	2133.0	1661.0	883.5	566.8	331.4	285.9	542.4
1962	3444.4	6105.3	2985.3	3170.6	2834.6	1367.5	1029.0	537.6	338.8	195.8	484.9
1963	3409.7	4416.4	5547.2	2258.0	2218.2	1880.5	876.7	647.9	332.5	207.0	411.9
1964	3450.4	6133.3	3755.9	4051.4	1545.1	1439.4	1179.3	540.0	391.9	198.7	366.6
1965	3492.9	6209.6	5243.7	2716.9	2733.4	988.4	889.9	716.1	322.0	230.9	330.2
1966	3406.9	4511.4	5193.1	3740.6	1813.9	1730.2	604.7	534.7	422.6	187.8	324.7
1967	3405.5	5966.8	3651.0	3686.4	2509.9	1154.2	1064.0	365.2	317.2	247.7	297.8
1968	3453.4	6126.3	5087.2	2567.6	2401.4	1549.7	688.7	623.6	210.2	180.4	308.1
1969	3446.1	5035.1	5414.0	3665.7	1704.2	1510.9	942.3	411.3	365.8	121.8	280.7
1970	3357.1	4140.6	4449.0	3940.5	2464.3	1086.2	930.7	570.1	244.4	214.7	234.1
1971	3426.7	6007.8	3615.2	3202.0	2622.4	1554.6	662.2	557.4	335.3	142.0	259.1
1972	3317.1	3239.0	5598.3	2712.6	2198.2	1706.6	977.7	409.1	338.2	201.0	238.4
1973	3277.2	4412.2	2899.7	4073.0	1815.1	1394.2	1046.0	588.6	241.9	197.6	255.0
1974	3279.7	4581.5	4107.3	2189.3	2819.6	1191.2	884.3	651.7	360.1	146.2	271.6
1975	3096.1	3865.1	4364.4	3019.0	1453.0	1773.0	723.9	527.9	382.0	208.6	239.9
1976	2648.4	4131.3	3565.8	2691.5	1617.8	736.5	868.5	348.3	249.4	178.4	208.0
1977	2190.4	2964.4	3587.9	1522.5	918.7	520.6	229.0	265.2	104.5	73.9	113.7
1978	2083.9	3873.0	2599.6	1711.2	596.6	340.0	186.2	80.5	91.5	35.6	63.5
1979	2075.1	3682.5	3528.9	1182.5	622.6	204.8	112.8	60.7	25.8	29.0	31.1
1980	2060.2	3449.8	3463.5	1626.6	432.8	214.9	68.3	37.0	19.6	8.2	19.0
1981	2057.6	2256.5	3342.3	1627.5	604.0	151.6	72.7	22.7	12.1	6.3	8.7
1982	1939.1	3643.9	2254.4	2293.9	972.3	341.6	82.9	39.1	12.0	6.3	7.8
1983	1692.1	1688.4	3416.0	993.9	794.7	317.3	107.7	25.7	11.9	3.6	4.2
1984	1591.8	1097.5	1824.1	2318.3	570.1	431.3	166.3	55.5	13.0	5.9	3.9
1985	3004.0	2761.4	971.1	1026.0	1119.5	260.3	190.3	72.1	23.6	5.5	4.1
1986	3087.3	3298.4	2763.3	549.0	478.0	492.5	110.6	79.5	29.6	9.6	3.9
1987	2313.9	3975.4	3323.4	1902.0	327.8	270.2	269.0	59.4	41.9	15.4	7.0
1988	2255.3	2996.8	3988.1	2389.6	1204.0	196.5	156.6	153.1	33.2	23.2	12.3
1989	2852.0	2433.6	2818.0	2728.0	1451.6	692.3	109.2	85.5	82.1	17.6	18.7
1990	3292.1	2133.1	2305.1	1934.5	1656.6	834.7	384.7	59.6	45.8	43.5	19.1
1991	3898.6	2942.3	1945.5	1537.9	1148.0	931.0	453.3	205.2	31.2	23.7	32.3
1992	2871.9	3995.4	2609.7	1135.6	775.9	547.7	429.3	205.3	91.2	13.7	24.4
1993	1726.5	3172.6	3807.3	1709.1	647.7	419.0	285.8	220.1	103.4	45.4	18.8
1994	1697.2	2486.9	3088.4	2360.8	902.1	323.3	202.2	135.5	102.5	47.6	29.5
1995	2917.8	2812.7	2235.4	1745.1	1131.3	408.6	141.6	87.0	57.2	42.8	32.0
1996	1934.3	3081.5	2725.8	1717.9	1241.0	782.3	282.0	98.8	60.8	40.0	52.3
1997	1338.2	3371.3	2909.3	1956.0	1145.3	814.5	521.3	193.1	68.5	42.3	64.3
1998	1770.9	1446.4	3107.6	2083.9	1306.7	753.9	544.6	358.6	134.6	48.0	74.8
1999	2706.5	3114.4	1342.2	2181.4	1363.0	847.0	500.1	374.0	250.6	94.7	86.7
2000	2991.7	2904.6	2926.6	987.5	1491.8	907.1	563.4	336.9	252.5	169.0	122.4
2001	2545.4	3572.0	2566.0	2032.5	643.4	945.1	573.8	360.6	216.0	161.6	186.7
2002	2110.3	4195.9	3398.3	1827.1	1340.2	411.5	601.7	368.7	231.7	138.4	222.9
2003	1244.5	3751.8	4132.8	2480.9	1231.8	871.7	264.4	387.5	236.3	147.8	229.6
2004	1460.3	2077.3	3619.9	2955.0	1641.3	781.5	542.2	163.7	237.6	143.8	228.4
2005	1864.0	2615.6	2096.2	2716.7	2035.0	1082.1	504.1	347.4	103.8	149.4	232.7
2006	2539.5	3201.8	2520.3	1477.9	1767.2	1276.2	670.0	312.7	214.4	63.7	233.7
2007	2683.8	4672.5	3189.0	1786.5	960.9	1111.8	796.7	421.0	196.1	134.0	184.9
2008	2963.4	4789.8	4696.0	2427.2	1247.3	649.7	746.7	539.0	284.5	132.1	214.3

Table 1.4. Spanish mackerel: Estimated biomass at age (1000 lb) at start of year

Year	0	1	2	3	4	5	6	7	8	9	10+
1950	8958.4	16809.2	17796.8	14071.1	10109.6	6892.8	4541.7	2939.2	1868.0	1173.1	1936.3
1951	9483.4	9761.3	16764.8	14798.9	10765.4	7336.3	4833.8	3128.3	1988.1	1248.5	2060.9
1952	9281.3	12468.8	9387.8	13645.3	11155.2	7697.9	5069.5	3280.8	2085.0	1309.4	2161.3
1953	9140.7	13338.4	11991.2	7503.3	10049.4	7791.6	5196.4	3361.2	2136.1	1341.5	2214.3
1954	8911.6	10093.9	12949.7	9692.6	5587.7	7097.9	5318.6	3484.1	2213.1	1389.8	2294.1
1955	8652.5	10829.8	9602.8	10331.6	7148.0	3908.2	4797.9	3531.3	2271.8	1426.0	2353.7
1956	8325.9	10322.8	10227.3	7416.0	7327.0	4806.3	2539.6	3062.4	2213.5	1407.2	2321.6
1957	8022.6	11472.3	9636.0	7621.5	5044.8	4724.5	2995.0	1554.4	1840.8	1314.8	2196.3
1958	7611.1	9173.8	10696.6	6864.9	4896.0	3070.5	2779.0	1730.3	881.9	1032.0	1952.0
1959	7659.4	12335.7	8380.7	7506.6	4356.3	2943.8	1784.2	1586.2	969.9	488.5	1638.2
1960	7731.8	10011.3	11853.3	6581.0	5405.4	2974.7	1942.9	1156.7	1009.9	610.2	1323.6
1961	7470.8	7484.2	9573.0	9240.5	4702.5	3661.8	1947.7	1249.6	730.7	630.4	1195.8
1962	7593.7	13459.9	6581.5	6989.9	6249.3	3014.9	2268.6	1185.3	746.9	431.6	1069.1
1963	7517.1	9736.5	12229.4	4978.0	4890.3	4145.7	1932.7	1428.4	733.0	456.4	908.1
1964	7606.8	13521.5	8280.3	8931.8	3406.4	3173.4	2599.9	1190.5	864.0	438.1	808.3
1965	7700.5	13689.8	11560.4	5989.8	6026.2	2179.1	1961.9	1578.8	709.9	509.1	728.1
1966	7511.0	9945.8	11448.9	8246.5	3998.9	3814.5	1333.0	1178.8	931.6	413.9	715.8
1967	7507.9	13154.5	8049.1	8127.1	5533.3	2544.6	2345.8	805.2	699.3	546.1	656.6
1968	7613.5	13506.2	11215.3	5660.5	5294.2	3416.5	1518.4	1374.9	463.5	397.7	679.2
1969	7597.3	11100.4	11935.8	8081.4	3757.1	3331.0	2077.3	906.8	806.4	268.6	618.9
1970	7401.2	9128.4	9808.4	8687.3	5432.8	2394.6	2051.8	1256.8	538.8	473.4	516.1
1971	7554.6	13244.9	7970.1	7059.3	5781.5	3427.3	1460.0	1228.8	739.2	313.1	571.3
1972	7312.9	7140.7	12342.1	5980.3	4846.2	3762.3	2155.4	901.9	745.5	443.1	525.6
1973	7225.1	9727.3	6392.7	8979.3	4001.5	3073.7	2306.1	1297.7	533.3	435.6	562.1
1974	7230.4	10100.5	9055.2	4826.6	6216.0	2626.1	1949.5	1436.7	794.0	322.4	598.8
1975	6825.7	8521.0	9621.9	6655.8	3203.2	3908.8	1595.9	1163.7	842.2	459.9	529.0
1976	5838.7	9108.0	7861.2	5933.7	3566.6	1623.7	1914.6	767.9	549.9	393.2	458.6
1977	4829.0	6535.3	7909.9	3356.6	2025.4	1147.7	504.9	584.7	230.3	163.0	250.7
1978	4594.2	8538.4	5731.1	3772.6	1315.4	749.5	410.5	177.4	201.8	78.5	139.9
1979	4574.9	8118.6	7779.9	2607.0	1372.7	451.4	248.7	133.9	56.8	63.8	68.5
1980	4541.9	7605.5	7635.7	3586.0	954.3	473.7	150.6	81.6	43.1	18.1	41.9
1981	4536.3	4974.8	7368.5	3588.0	1331.6	334.1	160.3	50.1	26.7	13.9	19.2
1982	4274.9	8033.5	4970.1	5057.2	2143.5	753.1	182.7	86.1	26.4	13.9	17.1
1983	3730.5	3722.3	7531.0	2191.3	1752.1	699.4	237.5	56.6	26.2	8.0	9.3
1984	3509.3	2419.5	4021.5	5110.9	1256.9	950.9	366.7	122.3	28.6	13.1	8.6
1985	6622.6	6087.9	2140.8	2262.0	2468.0	573.8	419.6	158.9	52.1	12.1	9.1
1986	6806.3	7271.7	6092.1	1210.3	1053.8	1085.7	243.9	175.3	65.2	21.1	8.5
1987	5101.3	8764.3	7326.7	4193.2	722.8	595.8	593.1	130.9	92.4	34.0	15.4
1988	4972.1	6606.9	8792.2	5268.2	2654.3	433.2	345.2	337.5	73.2	51.0	27.2
1989	6287.7	5365.2	6212.7	6014.2	3200.1	1526.4	240.7	188.5	181.0	38.8	41.3
1990	7257.9	4702.8	5081.9	4264.9	3652.2	1840.2	848.1	131.4	101.0	95.9	42.2
1991	8594.9	6486.6	4289.1	3390.5	2530.8	2052.4	999.4	452.3	68.8	52.3	71.2
1992	6331.4	8808.4	5753.4	2503.6	1710.5	1207.4	946.3	452.6	201.2	30.2	53.9
1993	3806.3	6994.5	8393.7	3768.0	1427.9	923.7	630.1	485.1	227.9	100.1	41.5
1994	3741.7	5482.6	6808.8	5204.6	1988.8	712.8	445.8	298.7	225.9	104.8	65.0
1995	6432.6	6200.9	4928.3	3847.3	2494.0	900.9	312.1	191.7	126.2	94.3	70.6
1996	4264.5	6793.5	6009.3	3787.3	2736.0	1724.7	621.7	217.9	134.1	88.1	115.2
1997	2950.2	7432.4	6413.8	4312.3	2525.0	1795.6	1149.2	425.7	151.0	93.3	141.8
1998	3904.1	3188.8	6851.0	4594.1	2880.9	1662.2	1200.7	790.6	296.7	105.7	164.9
1999	5966.8	6866.0	2959.0	4809.2	3004.8	1867.4	1102.6	824.6	552.4	208.7	191.0
2000	6595.6	6403.5	6452.0	2177.1	3288.7	1999.9	1242.0	742.6	556.6	372.6	269.7
2001	5611.6	7874.8	5657.0	4481.0	1418.4	2083.6	1264.9	795.0	476.1	356.3	411.6
2002	4652.4	9250.4	7491.9	4028.1	2954.6	907.3	1326.5	812.7	510.7	305.1	491.5
2003	2743.7	8271.3	9111.3	5469.5	2715.7	1921.8	583.0	854.3	521.0	325.8	506.1
2004	3219.3	4579.7	7980.5	6514.7	3618.4	1723.0	1195.2	360.8	523.7	317.0	503.6
2005	4109.3	5766.3	4621.3	5989.3	4486.3	2385.7	1111.3	765.8	228.7	329.4	513.1
2006	5598.7	7058.7	5556.3	3258.2	3896.0	2813.5	1477.2	689.3	472.7	140.5	515.3
2007	5916.7	10301.0	7030.6	3938.6	2118.4	2451.1	1756.5	928.1	432.3	295.4	407.6
2008	6533.2	10559.7	10352.9	5351.1	2749.9	1432.4	1646.3	1188.4	627.1	291.2	472.5

Table 1.5. Spanish mackerel: Estimated time series and status indicators. Fishing mortality rate is full F, which includes discard and bycatch mortalities. Total biomass (B) is at the start of the year, and spawning biomass (SSB) at the midpoint; B and SSB are in units mt. SPR is static spawning potential ratio, and MSST is the minimum spawning stock threshold.

Year	F	F/F_{MSY}	B	B/B_{unfished}	SSB	$\mathrm{SSB}/\mathrm{SSB}_{\mathrm{MSY}}$	SSB/MSST	SPR
1950	0.760	2.048	39506	0.505	15745	1.266	1.947	0.309
1951	0.604	1.628	37272	0.476	14734	1.185	1.822	0.348
1952	0.537	1.446	35173	0.449	13697	1.101	1.694	0.362
1953	0.785	2.116	33595	0.429	13035	1.048	1.612	0.288
1954	0.708	1.909	31313	0.400	12047	0.969	1.490	0.304
1955	0.767	2.067	29417	0.376	11046	0.888	1.366	0.274
1956	0.667	1.798	27202	0.347	9933	0.799	1.229	0.291
1957	0.907	2.445	25593	0.327	9022	0.725	1.116	0.220
1958	0.580	1.564	22992	0.294	7942	0.638	0.982	0.300
1959	0.652	1.758	22521	0.288	8060	0.648	0.997	0.315
1960	0.962	2.593	22952	0.293	8242	0.663	1.019	0.229
1961	0.431	1.163	21721	0.277	7608	0.612	0.941	0.354
1962	0.726	1.957	22494	0.287	7899	0.635	0.977	0.277
1963	0.440	1.186	22206	0.284	7716	0.620	0.954	0.349
1964	0.451	1.214	23052	0.294	7931	0.638	0.981	0.343
1965	0.801	2.160	23874	0.305	8163	0.656	1.010	0.237
1966	0.508	1.370	22470	0.287	7702	0.619	0.953	0.313
1967	0.485	1.308	22666	0.289	7695	0.619	0.952	0.323
1968	0.659	1.776	23197	0.296	7947	0.639	0.983	0.280
1969	0.840	2.264	22898	0.292	7908	0.636	0.978	0.235
1970	0.457	1.231	21632	0.276	7448	0.599	0.921	0.340
1971	1.036	2.791	22385	0.286	7805	0.628	0.965	0.202
1972	0.738	1.989	20936	0.267	7251	0.583	0.897	0.262
1973	0.636	1.715	20200	0.258	7061	0.568	0.873	0.303
1974	0.835	2.252	20483	0.262	7072	0.569	0.875	0.244
1975	0.924	2.492	19653	0.251	6260	0.503	0.774	0.202
1976	1.548	4.173	17244	0.220	4647	0.374	0.575	0.113
1977	0.959	2.586	12491	0.160	3386	0.272	0.419	0.197
1978	1.011	2.726	11662	0.149	3135	0.252	0.388	0.194
1979	1.051	2.833	11556	0.148	3115	0.250	0.385	0.188
1980	1.440	3.881	11400	0.146	3081	0.248	0.381	0.128
1981	0.501	1.352	10162	0.130	3075	0.247	0.380	0.330
1982	1.751	4.719	11593	0.148	3120	0.251	0.386	0.095
1983	1.505	4.057	9056	0.116	2808	0.226	0.347	0.124
1984	0.781	2.104	8078	0.103	2265	0.182	0.280	0.228
1985	1.209	3.258	9438	0.121	2320	0.187	0.287	0.157
1986	0.813	2.190	10902	0.139	3009	0.242	0.372	0.242
1987	0.749	2.019	12506	0.160	3997	0.321	0.494	0.262
1988	1.005	2.709	13409	0.171	4307	0.346	0.533	0.193
1989	1.352	3.644	13289	0.170	4072	0.327	0.504	0.134
1990	1.213	3.268	12709	0.162	3644	0.293	0.451	0.150
1991	1.240	3.343	13149	0.168	3352	0.270	0.415	0.140
1992	1.020	2.749	12700	0.162	3716	0.299	0.460	0.185
1993	0.819	2.208	12156	0.155	3855	0.310	0.477	0.225
1994	0.799	2.154	11376	0.145	3406	0.274	0.421	0.219
1995	0.835	2.250	11611	0.148	3553	0.286	0.439	0.264
1996	0.393	1.058	12017	0.153	4080	0.328	0.505	0.381
1997	0.881	2.373	12424	0.159	4514	0.363	0.558	0.233
1998	0.412	1.110	11630	0.149	4109	0.330	0.508	0.370
1999	0.866	2.335	12861	0.164	4258	0.342	0.527	0.239
2000	0.841	2.266	13653	0.174	4349	0.350	0.538	0.229
2001	0.474	1.279	13803	0.176	4628	0.372	0.572	0.346
2002	0.372	1.002	14847	0.190	5256	0.423	0.650	0.398
2003	0.465	1.252	14979	0.191	5615	0.451	0.695	0.350
2004	0.341	0.919	13851	0.177	5251	0.422	0.649	0.422
2005	0.451	1.215	13747	0.176	4934	0.397	0.610	0.353
2006	0.369	0.995	14277	0.182	4881	0.392	0.604	0.393
2007	0.323	0.872	16137	0.206	5671	0.456	0.701	0.441
2008	.	.	18690	0.239	.	.	.	.

Table 1.6. Spanish mackerel: Selectivity at age (males)

Age	Length(mm)	Length(in)	HL	GN	PN	CN	Rec	Avg L	Avg D	Total
0	229.6	9.0	0.0084	0.0461	0.0299	0.0000	0.0299	0.0217	0.1262	0.1479
1	339.2	13.4	0.1444	0.5052	1.0000	0.0015	1.0000	0.4152	0.0295	0.4446
2	407.5	16.0	0.7712	1.0000	1.0000	1.0000	0.6642	0.7582	0.0000	0.7582
3	450.1	17.7	0.9854	0.9489	1.0000	1.0000	0.5058	0.7339	0.0000	0.7339
4	476.6	18.8	0.9993	0.7638	1.0000	1.0000	0.5058	0.6835	0.0000	0.6835
5	493.1	19.4	1.0000	0.5195	1.0000	1.0000	0.5058	0.6146	0.0000	0.6146
6	503.4	19.8	1.0000	0.2948	1.0000	1.0000	0.5058	0.5511	0.0000	0.5511
7	509.9	20.1	1.0000	0.1452	1.0000	1.0000	0.5058	0.5088	0.0000	0.5088
8	513.9	20.2	1.0000	0.0657	1.0000	1.0000	0.5058	0.4863	0.0000	0.4863
9	516.4	20.3	1.0000	0.0285	1.0000	1.0000	0.5058	0.4758	0.0000	0.4758
10	517.9	20.4	1.0000	0.0122	1.0000	1.0000	0.5058	0.4712	0.0000	0.4712

Table 1.7. Spanish mackerel: Selectivity at age (females)

Age	Length(mm)	Length(in)	HL	GN	PN	CN	Rec	Avg L	Avg D	Total
0	242.6	9.5528	0.0151	0.0461	0.6276	0.0000	0.0299	0.0241	0.1262	0.1502974
1	359.3	14.1468	0.2349	0.5052	1.0000	0.0742	1.0000	0.4423	0.0244	0.4667373
2	440.7	17.3522	0.8599	1.0000	1.0000	1.0000	0.6642	0.7705	0.0000	0.7705225
3	497.6	19.5888	0.9919	0.9489	1.0000	1.0000	0.5058	0.7348	0.0000	0.7348139
4	537.2	21.1494	0.9996	0.7638	1.0000	1.0000	0.5058	0.6836	0.0000	0.6835632
5	564.9	22.2383	1.0000	0.5195	1.0000	1.0000	0.5058	0.6146	0.0000	0.6145822
6	584.2	22.9980	1.0000	0.2948	1.0000	1.0000	0.5058	0.5511	0.0000	0.5510844
7	597.6	23.5281	1.0000	0.1452	1.0000	1.0000	0.5058	0.5088	0.0000	0.5088019
8	607.0	23.8980	1.0000	0.0657	1.0000	1.0000	0.5058	0.4863	0.0000	0.4863428
9	613.6	24.1561	1.0000	0.0285	1.0000	1.0000	0.5058	0.4758	0.0000	0.4758292
10	618.1	24.3362	1.0000	0.0122	1.0000	1.0000	0.5058	0.4712	0.0000	0.4711995

Table 1.8. Spanish mackerel: Estimated time series of fishing mortality rate for commercial handlines (F.HL), commercial gillnet (F.GN), commercial poundnet (F.PN), commercial castnet (F.CN), general recreational (F.rec),commercial handline discards(F.HL.D), commercial gillnet discards(F.GN.D), general recreational discards(F.rec.D), shrimp bycatch (F.shrimp), and full F (F.full).

Year	F.HL	F.GN	F.PN	F.CN	F.rec	F.HL.D	F.GN.D	F.rec.D	F.shrimp	F.full
1950	0.000	0.062	0.000	0.000	0.148	0	0.000	0.006	0.543	0.760
1951	0.000	0.058	0.000	0.000	0.186	0	0.000	0.005	0.354	0.604
1952	0.000	0.084	0.000	0.000	0.182	0	0.000	0.005	0.266	0.537
1953	0.000	0.077	0.000	0.000	0.174	0	0.000	0.005	0.529	0.785
1954	0.000	0.076	0.000	0.000	0.194	0	0.000	0.005	0.433	0.708
1955	0.000	0.115	0.000	0.000	0.196	0	0.000	0.005	0.451	0.767
1956	0.000	0.153	0.000	0.000	0.202	0	0.000	0.005	0.307	0.667
1957	0.000	0.215	0.000	0.000	0.194	0	0.000	0.005	0.493	0.907
1958	0.000	0.217	0.000	0.000	0.214	0	0.000	0.005	0.144	0.580
1959	0.000	0.107	0.000	0.000	0.179	0	0.000	0.005	0.361	0.652
1960	0.001	0.112	0.001	0.000	0.183	0	0.000	0.005	0.660	0.962
1961	0.001	0.124	0.004	0.000	0.262	0	0.000	0.005	0.035	0.431
1962	0.003	0.105	0.000	0.000	0.234	0	0.000	0.006	0.377	0.726
1963	0.002	0.093	0.002	0.000	0.301	0	0.000	0.007	0.035	0.440
1964	0.004	0.110	0.001	0.000	0.294	0	0.000	0.007	0.035	0.451
1965	0.006	0.107	0.003	0.000	0.313	0	0.000	0.009	0.364	0.801
1966	0.007	0.082	0.003	0.000	0.349	0	0.000	0.008	0.059	0.508
1967	0.006	0.145	0.001	0.000	0.291	0	0.000	0.007	0.035	0.485
1968	0.005	0.144	0.002	0.000	0.254	0	0.000	0.007	0.246	0.659
1969	0.004	0.131	0.002	0.000	0.256	0	0.000	0.007	0.439	0.840
1970	0.005	0.134	0.003	0.000	0.267	0	0.000	0.006	0.042	0.457
1971	0.005	0.137	0.001	0.000	0.204	0	0.000	0.006	0.682	1.036
1972	0.006	0.142	0.001	0.000	0.243	0	0.000	0.006	0.340	0.738
1973	0.007	0.125	0.002	0.000	0.206	0	0.000	0.005	0.292	0.636
1974	0.013	0.178	0.001	0.000	0.175	0	0.000	0.005	0.464	0.835
1975	0.032	0.374	0.002	0.000	0.174	0	0.000	0.004	0.338	0.924
1976	0.042	0.820	0.004	0.000	0.167	0	0.000	0.004	0.511	1.548
1977	0.013	0.704	0.002	0.000	0.182	0	0.000	0.004	0.055	0.959
1978	0.005	0.813	0.000	0.000	0.131	0	0.000	0.003	0.058	1.011
1979	0.006	0.823	0.000	0.000	0.098	0	0.000	0.002	0.121	1.051
1980	0.006	0.824	0.000	0.000	0.069	0	0.000	0.002	0.539	1.440
1981	0.004	0.326	0.000	0.000	0.109	0	0.000	0.004	0.059	0.501
1982	0.011	0.877	0.001	0.000	0.093	0	0.000	0.001	0.769	1.751
1983	0.004	0.413	0.001	0.000	0.018	0	0.000	0.001	1.068	1.505
1984	0.007	0.488	0.001	0.000	0.206	0	0.000	0.002	0.077	0.781
1985	0.010	0.591	0.003	0.000	0.066	0	0.000	0.003	0.536	1.209
1986	0.007	0.329	0.003	0.000	0.092	0	0.001	0.015	0.365	0.813
1987	0.011	0.253	0.013	0.000	0.101	0	0.001	0.004	0.367	0.749
1988	0.008	0.267	0.010	0.000	0.167	0	0.001	0.004	0.548	1.005
1989	0.011	0.261	0.028	0.000	0.138	0	0.000	0.015	0.899	1.352
1990	0.022	0.252	0.031	0.000	0.174	0	0.001	0.008	0.725	1.213
1991	0.029	0.408	0.030	0.000	0.177	0	0.001	0.015	0.580	1.240
1992	0.008	0.339	0.023	0.000	0.125	0	0.001	0.018	0.507	1.020
1993	0.006	0.439	0.019	0.000	0.093	0	0.002	0.018	0.242	0.819
1994	0.007	0.505	0.022	0.000	0.146	0	0.002	0.055	0.062	0.799
1995	0.019	0.131	0.013	0.003	0.097	0	0.000	0.021	0.550	0.835
1996	0.007	0.201	0.017	0.017	0.086	0	0.001	0.022	0.043	0.393
1997	0.007	0.206	0.011	0.006	0.106	0	0.002	0.040	0.503	0.881
1998	0.013	0.235	0.007	0.002	0.096	0	0.001	0.020	0.038	0.412
1999	0.016	0.137	0.016	0.028	0.116	0	0.001	0.036	0.516	0.866
2000	0.021	0.133	0.011	0.048	0.181	0	0.001	0.041	0.405	0.841
2001	0.032	0.121	0.011	0.072	0.113	0	0.001	0.033	0.092	0.474
2002	0.025	0.090	0.006	0.097	0.099	0	0.001	0.033	0.020	0.372
2003	0.025	0.058	0.005	0.136	0.122	0	0.001	0.069	0.048	0.465
2004	0.045	0.050	0.003	0.100	0.093	0	0.001	0.035	0.014	0.341
2005	0.045	0.088	0.002	0.111	0.116	0	0.001	0.049	0.039	0.451
2006	0.058	0.108	0.000	0.096	0.085	0	0.000	0.013	0.007	0.369
2007	0.048	0.112	0.001	0.036	0.075	0	0.000	0.025	0.027	0.323
2008	.	.	.	.	.	.	.	.	.	.

Table 1.9. Spanish mackerel: Estimated instantaneous fishing mortality rate (per yr) at age for males, including discard mortality

Year	0	1	2	3	4	5	6	7	8	9	10+
1950	0.553	0.157	0.146	0.137	0.138	0.138	0.138	0.138	0.138	0.138	0.138
1951	0.365	0.194	0.168	0.152	0.152	0.152	0.152	0.152	0.152	0.152	0.152
1952	0.277	0.193	0.184	0.175	0.176	0.176	0.176	0.176	0.176	0.176	0.176
1953	0.540	0.184	0.173	0.164	0.165	0.165	0.165	0.165	0.165	0.165	0.165
1954	0.444	0.204	0.186	0.173	0.174	0.174	0.174	0.174	0.174	0.174	0.174
1955	0.463	0.210	0.217	0.212	0.214	0.214	0.214	0.214	0.214	0.214	0.214
1956	0.318	0.219	0.250	0.254	0.256	0.256	0.256	0.256	0.256	0.256	0.256
1957	0.505	0.218	0.292	0.311	0.313	0.313	0.313	0.313	0.313	0.313	0.313
1958	0.156	0.238	0.307	0.323	0.325	0.325	0.325	0.325	0.325	0.325	0.325
1959	0.371	0.193	0.200	0.197	0.198	0.198	0.198	0.198	0.198	0.198	0.198
1960	0.671	0.197	0.207	0.205	0.206	0.206	0.206	0.206	0.206	0.206	0.206
1961	0.049	0.280	0.272	0.260	0.261	0.261	0.261	0.261	0.261	0.261	0.261
1962	0.390	0.248	0.238	0.226	0.227	0.227	0.227	0.227	0.227	0.227	0.227
1963	0.051	0.315	0.274	0.248	0.249	0.249	0.249	0.249	0.249	0.249	0.249
1964	0.051	0.309	0.282	0.262	0.263	0.264	0.264	0.264	0.264	0.264	0.264
1965	0.382	0.331	0.296	0.273	0.274	0.274	0.274	0.274	0.274	0.274	0.274
1966	0.078	0.365	0.303	0.268	0.269	0.269	0.269	0.269	0.269	0.269	0.269
1967	0.052	0.310	0.308	0.297	0.299	0.299	0.299	0.299	0.299	0.299	0.299
1968	0.261	0.274	0.284	0.278	0.280	0.280	0.280	0.280	0.280	0.280	0.280
1969	0.455	0.275	0.275	0.266	0.267	0.267	0.267	0.267	0.267	0.267	0.267
1970	0.056	0.287	0.286	0.276	0.277	0.277	0.277	0.277	0.277	0.277	0.277
1971	0.695	0.222	0.244	0.245	0.246	0.246	0.246	0.246	0.246	0.246	0.246
1972	0.353	0.261	0.274	0.270	0.272	0.272	0.272	0.272	0.272	0.272	0.272
1973	0.303	0.223	0.238	0.236	0.238	0.238	0.238	0.238	0.238	0.238	0.238
1974	0.474	0.197	0.262	0.278	0.281	0.281	0.281	0.281	0.281	0.281	0.281
1975	0.349	0.220	0.425	0.492	0.496	0.496	0.496	0.496	0.496	0.496	0.496
1976	0.524	0.261	0.767	0.941	0.950	0.951	0.951	0.951	0.951	0.951	0.951
1977	0.067	0.258	0.665	0.802	0.810	0.811	0.811	0.811	0.811	0.811	0.811
1978	0.068	0.215	0.706	0.876	0.885	0.885	0.885	0.885	0.885	0.885	0.885
1979	0.129	0.183	0.693	0.870	0.879	0.879	0.879	0.879	0.879	0.879	0.879
1980	0.547	0.153	0.673	0.855	0.865	0.865	0.865	0.865	0.865	0.865	0.865
1981	0.067	0.144	0.322	0.381	0.385	0.385	0.385	0.385	0.385	0.385	0.385
1982	0.776	0.184	0.734	0.925	0.935	0.935	0.935	0.935	0.935	0.935	0.935
1983	1.071	0.062	0.328	0.422	0.427	0.427	0.427	0.427	0.427	0.427	0.427
1984	0.087	0.258	0.512	0.594	0.600	0.600	0.600	0.600	0.600	0.600	0.600
1985	0.544	0.131	0.501	0.630	0.637	0.637	0.637	0.637	0.637	0.637	0.637
1986	0.385	0.136	0.319	0.382	0.386	0.386	0.386	0.386	0.386	0.386	0.386
1987	0.376	0.143	0.280	0.325	0.328	0.328	0.328	0.328	0.328	0.328	0.328
1988	0.560	0.207	0.329	0.366	0.369	0.369	0.369	0.369	0.369	0.369	0.369
1989	0.920	0.200	0.325	0.367	0.370	0.370	0.370	0.370	0.370	0.370	0.370
1990	0.741	0.237	0.354	0.390	0.393	0.393	0.393	0.393	0.393	0.393	0.393
1991	0.604	0.258	0.478	0.551	0.556	0.557	0.557	0.557	0.557	0.557	0.557
1992	0.531	0.191	0.368	0.429	0.433	0.433	0.433	0.433	0.433	0.433	0.433
1993	0.267	0.165	0.417	0.506	0.511	0.511	0.511	0.511	0.511	0.511	0.511
1994	0.126	0.244	0.506	0.602	0.608	0.608	0.608	0.608	0.608	0.608	0.608
1995	0.581	0.188	0.227	0.209	0.185	0.153	0.123	0.104	0.093	0.089	0.086
1996	0.078	0.214	0.296	0.274	0.237	0.188	0.143	0.113	0.097	0.089	0.086
1997	0.558	0.239	0.298	0.272	0.235	0.184	0.138	0.107	0.091	0.083	0.080
1998	0.073	0.232	0.318	0.294	0.250	0.193	0.140	0.105	0.086	0.077	0.073
1999	0.563	0.219	0.271	0.249	0.224	0.191	0.160	0.139	0.128	0.123	0.121
2000	0.458	0.280	0.328	0.298	0.273	0.241	0.211	0.191	0.180	0.175	0.173
2001	0.136	0.204	0.303	0.286	0.264	0.234	0.207	0.189	0.180	0.175	0.173
2002	0.062	0.168	0.278	0.263	0.247	0.225	0.205	0.191	0.184	0.181	0.179
2003	0.125	0.189	0.299	0.282	0.272	0.258	0.245	0.236	0.231	0.229	0.228
2004	0.055	0.143	0.250	0.242	0.233	0.221	0.210	0.202	0.198	0.197	0.196
2005	0.097	0.189	0.312	0.299	0.283	0.262	0.242	0.229	0.222	0.219	0.218
2006	0.029	0.155	0.306	0.299	0.280	0.254	0.229	0.213	0.205	0.201	0.199
2007	0.060	0.149	0.235	0.228	0.208	0.181	0.155	0.139	0.130	0.126	0.124

Table 1.10. Spanish mackerel: Estimated instantaneous fishing mortality rate (per yr) at age for females, including discard mortality

Year	0	1	2	3	4	5	6	7	8	9	10+
1950	0.554	0.162	0.152	0.137	0.138	0.138	0.138	0.138	0.138	0.138	0.138
1951	0.366	0.198	0.173	0.152	0.152	0.152	0.152	0.152	0.152	0.152	0.152
1952	0.277	0.199	0.193	0.175	0.176	0.176	0.176	0.176	0.176	0.176	0.176
1953	0.540	0.189	0.181	0.164	0.165	0.165	0.165	0.165	0.165	0.165	0.165
1954	0.445	0.209	0.194	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174
1955	0.463	0.218	0.228	0.213	0.214	0.214	0.214	0.214	0.214	0.214	0.214
1956	0.319	0.231	0.266	0.255	0.256	0.256	0.256	0.256	0.256	0.256	0.256
1957	0.506	0.234	0.313	0.312	0.313	0.313	0.313	0.313	0.313	0.313	0.313
1958	0.157	0.255	0.329	0.324	0.325	0.325	0.325	0.325	0.325	0.325	0.325
1959	0.372	0.201	0.211	0.197	0.198	0.198	0.198	0.198	0.198	0.198	0.198
1960	0.672	0.206	0.219	0.205	0.206	0.206	0.206	0.206	0.206	0.206	0.206
1961	0.052	0.290	0.285	0.261	0.261	0.261	0.261	0.261	0.261	0.261	0.261
1962	0.391	0.256	0.249	0.227	0.227	0.227	0.227	0.227	0.227	0.227	0.227
1963	0.053	0.322	0.283	0.249	0.249	0.249	0.249	0.249	0.249	0.249	0.249
1964	0.052	0.318	0.294	0.263	0.264	0.264	0.264	0.264	0.264	0.264	0.264
1965	0.384	0.340	0.308	0.273	0.274	0.274	0.274	0.274	0.274	0.274	0.274
1966	0.080	0.372	0.312	0.268	0.269	0.269	0.269	0.269	0.269	0.269	0.269
1967	0.053	0.322	0.324	0.298	0.299	0.299	0.299	0.299	0.299	0.299	0.299
1968	0.263	0.286	0.299	0.279	0.280	0.280	0.280	0.280	0.280	0.280	0.280
1969	0.457	0.285	0.289	0.266	0.267	0.267	0.267	0.267	0.267	0.267	0.267
1970	0.059	0.297	0.300	0.277	0.277	0.277	0.277	0.277	0.277	0.277	0.277
1971	0.696	0.232	0.258	0.245	0.246	0.246	0.246	0.246	0.246	0.246	0.246
1972	0.355	0.273	0.289	0.271	0.272	0.272	0.272	0.272	0.272	0.272	0.272
1973	0.305	0.233	0.252	0.237	0.238	0.238	0.238	0.238	0.238	0.238	0.238
1974	0.476	0.212	0.281	0.279	0.281	0.281	0.281	0.281	0.281	0.281	0.281
1975	0.352	0.252	0.466	0.494	0.496	0.496	0.496	0.496	0.496	0.496	0.496
1976	0.529	0.329	0.854	0.946	0.951	0.951	0.951	0.951	0.951	0.951	0.951
1977	0.071	0.313	0.737	0.806	0.810	0.811	0.811	0.811	0.811	0.811	0.811
1978	0.071	0.279	0.789	0.880	0.885	0.885	0.885	0.885	0.885	0.885	0.885
1979	0.133	0.248	0.777	0.874	0.879	0.879	0.879	0.879	0.879	0.879	0.879
1980	0.550	0.218	0.758	0.860	0.865	0.865	0.865	0.865	0.865	0.865	0.865
1981	0.068	0.169	0.355	0.383	0.385	0.385	0.385	0.385	0.385	0.385	0.385
1982	0.780	0.253	0.824	0.930	0.935	0.935	0.935	0.935	0.935	0.935	0.935
1983	1.073	0.094	0.371	0.425	0.427	0.427	0.427	0.427	0.427	0.427	0.427
1984	0.090	0.297	0.562	0.597	0.600	0.600	0.600	0.600	0.600	0.600	0.600
1985	0.548	0.177	0.562	0.633	0.637	0.637	0.637	0.637	0.637	0.637	0.637
1986	0.388	0.161	0.353	0.384	0.386	0.386	0.386	0.386	0.386	0.386	0.386
1987	0.385	0.163	0.306	0.326	0.328	0.328	0.328	0.328	0.328	0.328	0.328
1988	0.566	0.228	0.357	0.368	0.369	0.369	0.369	0.369	0.369	0.369	0.369
1989	0.938	0.220	0.353	0.368	0.370	0.370	0.370	0.370	0.370	0.370	0.370
1990	0.761	0.258	0.381	0.391	0.393	0.393	0.393	0.393	0.393	0.393	0.393
1991	0.624	0.292	0.522	0.554	0.556	0.557	0.557	0.557	0.557	0.557	0.557
1992	0.547	0.217	0.403	0.431	0.433	0.433	0.433	0.433	0.433	0.433	0.433
1993	0.280	0.199	0.462	0.508	0.511	0.511	0.511	0.511	0.511	0.511	0.511
1994	0.141	0.280	0.558	0.605	0.608	0.608	0.608	0.608	0.608	0.608	0.608
1995	0.588	0.188	0.228	0.209	0.185	0.153	0.123	0.104	0.093	0.089	0.086
1996	0.088	0.215	0.297	0.274	0.237	0.188	0.143	0.113	0.097	0.089	0.086
1997	0.565	0.238	0.299	0.273	0.235	0.184	0.138	0.107	0.091	0.083	0.080
1998	0.077	0.232	0.319	0.294	0.250	0.193	0.140	0.105	0.086	0.077	0.073
1999	0.573	0.220	0.272	0.249	0.224	0.191	0.160	0.139	0.128	0.123	0.121
2000	0.465	0.282	0.330	0.298	0.273	0.241	0.211	0.191	0.180	0.175	0.173
2001	0.143	0.209	0.306	0.286	0.264	0.234	0.207	0.189	0.180	0.175	0.173
2002	0.066	0.175	0.280	0.263	0.247	0.225	0.205	0.191	0.184	0.181	0.179
2003	0.128	0.196	0.301	0.282	0.272	0.258	0.245	0.236	0.231	0.229	0.228
2004	0.058	0.152	0.254	0.242	0.233	0.221	0.210	0.202	0.198	0.197	0.196
2005	0.099	0.198	0.316	0.299	0.283	0.262	0.242	0.229	0.222	0.219	0.218
2006	0.030	0.166	0.311	0.300	0.280	0.254	0.229	0.213	0.205	0.201	0.199
2007	0.060	0.154	0.240	0.229	0.208	0.181	0.155	0.139	0.130	0.126	0.124

Table 1.11. Spanish mackerel: Estimated total landings at age (1000 fish)

Year	0	1	2	3	4	5	6	7	8	9	10+
1950	99.7	2387.1	1396.3	747.7	445.8	269.0	163.9	100.4	61.5	37.9	61.5
1951	139.0	1679.9	1489.7	865.6	522.0	314.8	191.8	117.5	72.0	44.3	71.9
1952	142.1	2146.8	914.7	910.4	617.5	376.9	229.5	140.6	86.1	53.0	86.1
1953	118.6	2192.4	1104.5	471.3	523.8	359.3	221.5	135.6	83.1	51.1	83.0
1954	133.7	1825.1	1273.1	642.1	307.1	345.2	239.1	148.2	90.7	55.8	90.6
1955	134.9	2020.7	1088.1	823.7	473.2	229.0	259.9	181.0	112.2	69.0	112.0
1956	148.3	2020.5	1321.8	693.7	569.2	330.4	161.5	184.3	128.3	79.9	129.6
1957	134.5	2252.7	1431.8	851.5	468.1	387.9	227.4	111.7	127.5	89.2	146.4
1958	159.8	1948.8	1657.4	793.0	469.6	260.5	218.0	128.5	63.1	72.4	134.5
1959	116.3	2131.9	885.2	559.6	269.7	161.2	90.3	76.0	44.8	22.1	72.8
1960	106.7	1768.0	1291.9	507.9	346.8	168.9	101.9	57.4	48.3	28.6	61.0
1961	208.3	1807.7	1323.8	882.1	372.8	257.2	126.5	76.8	43.2	36.5	68.1
1962	145.0	2914.3	808.0	589.2	437.2	186.8	130.2	64.4	39.1	22.1	53.8
1963	218.1	2587.8	1691.1	456.1	371.7	278.8	120.3	84.3	41.7	25.4	49.6
1964	211.4	3539.3	1178.9	859.4	272.0	224.3	169.9	73.7	51.7	25.7	46.4
1965	206.4	3793.8	1715.0	596.7	498.0	159.4	132.7	101.1	43.9	30.9	43.3
1966	255.3	2989.1	1723.2	808.2	324.8	274.3	88.7	74.2	56.5	24.6	41.9
1967	210.3	3468.8	1241.7	872.6	493.2	200.7	171.1	55.6	46.6	35.6	42.2
1968	181.5	3204.6	1614.3	574.4	445.9	254.7	104.7	89.7	29.2	24.5	41.2
1969	168.1	2635.0	1666.9	787.2	303.7	238.2	137.4	56.8	48.7	15.9	36.0
1970	207.8	2251.6	1417.1	874.3	454.0	177.0	140.2	81.3	33.6	28.9	31.0
1971	117.6	2606.2	1006.1	639.4	435.0	228.3	89.9	71.6	41.5	17.2	30.9
1972	153.2	1627.4	1725.3	591.5	398.0	273.5	145.0	57.4	45.7	26.6	31.1
1973	138.2	1926.5	789.4	788.6	291.9	198.4	137.7	73.4	29.1	23.3	29.5
1974	114.5	1814.0	1224.1	490.0	524.7	196.2	134.7	94.0	50.1	19.9	36.4
1975	145.0	1741.4	1977.5	1086.5	434.6	469.4	177.2	122.3	85.4	45.7	51.6
1976	155.6	2265.6	2523.4	1541.6	767.9	309.1	337.0	128.0	88.3	61.9	71.0
1977	140.7	1582.6	2299.2	790.0	394.4	197.3	80.2	87.9	33.4	23.1	35.0
1978	114.3	1818.7	1742.6	942.4	272.9	136.9	69.1	28.3	31.0	11.8	20.7
1979	99.0	1528.8	2336.7	648.4	284.1	82.6	41.8	21.2	8.7	9.6	10.1
1980	73.6	1251.4	2250.9	882.7	195.4	85.9	25.2	12.9	6.5	2.7	6.1
1981	67.4	697.5	1208.4	481.2	148.9	33.1	14.7	4.3	2.2	1.1	1.5
1982	74.3	1536.7	1551.7	1304.4	461.7	143.8	32.2	14.4	4.3	2.2	2.6
1983	23.5	271.0	1267.9	318.9	212.3	75.4	23.7	5.4	2.4	0.7	0.8
1984	93.7	572.7	958.4	970.9	198.8	133.0	47.7	15.1	3.4	1.5	1.0
1985	99.1	841.1	505.9	448.0	407.8	84.0	56.8	20.5	6.5	1.5	1.1
1986	94.9	939.2	991.4	162.1	117.4	107.4	22.4	15.2	5.5	1.7	0.7
1987	111.9	1199.0	1058.8	488.4	70.2	51.2	47.3	9.9	6.7	2.4	1.1
1988	111.3	1251.3	1454.2	678.0	284.8	41.2	30.4	28.2	5.9	4.0	2.1
1989	185.9	967.1	1018.7	774.4	342.8	145.2	21.2	15.7	14.6	3.1	3.2
1990	262.2	997.1	892.1	577.9	411.3	183.5	78.5	11.5	8.5	8.0	3.5
1991	339.9	1496.1	967.5	606.1	376.2	269.9	121.6	52.3	7.7	5.7	7.7
1992	196.0	1533.8	1051.8	367.7	208.5	130.4	94.5	42.8	18.4	2.7	4.8
1993	114.8	1091.2	1708.4	631.7	199.2	113.8	71.8	52.3	23.7	10.2	4.2
1994	151.5	1135.0	1612.3	997.0	316.9	100.5	58.0	36.8	26.8	12.2	7.5
1995	194.5	995.9	571.0	303.5	145.6	39.1	10.3	5.1	2.9	2.0	1.5
1996	208.3	1231.2	878.3	379.3	200.2	90.6	23.5	6.2	3.2	1.9	2.4
1997	109.8	1441.7	942.4	428.7	182.3	92.7	42.0	11.6	3.4	1.9	2.7
1998	176.8	624.3	1064.9	487.4	219.7	89.0	44.5	21.1	6.3	2.0	2.9
1999	208.3	1239.2	400.4	441.7	207.4	98.6	45.9	28.8	17.2	6.1	5.4
2000	240.7	1451.4	1031.4	233.6	270.8	130.3	66.5	34.5	23.8	15.2	10.7
2001	198.3	1348.6	845.1	464.0	113.2	132.5	66.6	36.5	20.2	14.5	16.3
2002	123.3	1319.7	1039.1	388.6	222.5	55.6	69.1	37.7	22.1	12.8	20.2
2003	61.6	1220.4	1345.3	560.7	222.7	132.9	35.6	47.9	27.6	16.8	25.8
2004	61.3	557.7	1009.4	583.4	259.2	104.1	63.7	17.6	24.2	14.2	22.3
2005	100.8	896.3	709.5	645.7	381.6	167.6	67.4	41.8	11.7	16.3	24.9
2006	134.7	988.0	840.3	351.8	328.1	192.2	85.3	35.3	22.5	6.4	23.0
2007	136.7	1328.4	844.8	334.7	136.9	123.3	71.1	32.0	13.5	8.8	11.7

Table 1.12. Spanish mackerel: Estimated total landings at age (mt)

Year	0	1	2	3	4	5	6	7	8	9	10+
1950	12.3	915.7	945.4	699.3	508.8	348.6	230.7	149.3	94.9	59.9	98.8
1951	17.1	644.2	1008.0	809.2	595.8	407.9	270.0	174.8	111.1	70.1	115.7
1952	17.5	823.6	619.2	850.8	704.5	488.4	323.2	209.1	132.9	83.9	138.4
1953	14.6	841.1	747.6	440.4	597.3	465.3	311.8	201.7	128.2	80.9	133.5
1954	16.4	700.1	861.6	599.9	350.2	446.9	336.4	220.4	140.0	88.3	145.8
1955	16.6	775.5	736.8	769.6	539.4	296.3	365.5	269.0	173.0	109.1	180.1
1956	18.3	775.7	895.2	648.0	648.9	427.6	227.0	273.7	197.8	126.3	208.4
1957	16.6	865.6	970.0	795.0	533.5	502.0	319.6	165.9	196.5	141.0	235.5
1958	19.7	748.6	1122.4	739.9	534.9	337.0	306.4	190.8	97.2	114.3	216.2
1959	14.3	818.2	599.0	521.9	306.9	208.3	126.9	112.8	69.0	34.9	117.0
1960	13.2	678.6	874.7	474.0	394.5	218.1	143.1	85.2	74.4	45.2	98.0
1961	25.8	693.5	895.9	823.8	424.5	332.1	177.4	113.8	66.6	57.7	109.4
1962	17.8	1118.0	546.8	550.2	498.1	241.5	182.5	95.4	60.1	34.9	86.4
1963	26.9	992.4	1143.7	425.9	423.4	360.6	168.9	124.8	64.0	40.1	79.7
1964	26.0	1357.5	797.6	802.6	309.8	290.0	238.7	109.3	79.3	40.4	74.5
1965	25.5	1455.0	1160.1	557.2	567.4	206.1	186.4	150.0	67.5	48.6	69.5
1966	31.5	1146.0	1165.1	754.7	370.2	354.7	124.5	110.1	87.0	38.8	67.2
1967	25.9	1330.8	840.4	815.0	561.9	259.6	240.4	82.5	71.7	56.2	67.6
1968	22.4	1229.8	1092.5	536.3	508.1	329.4	147.1	133.2	44.9	38.7	66.1
1969	20.8	1011.0	1128.0	734.7	345.9	308.1	193.0	84.3	74.9	25.1	57.8
1970	25.7	863.9	958.9	816.1	516.9	228.9	197.0	120.7	51.7	45.7	49.8
1971	14.5	1000.4	681.2	596.9	495.4	295.1	126.3	106.3	63.9	27.2	49.6
1972	18.9	624.5	1167.7	552.2	453.3	353.5	203.5	85.1	70.4	42.0	49.8
1973	17.1	739.4	534.4	736.1	332.4	256.5	193.3	108.8	44.7	36.7	47.3
1974	14.1	697.0	829.4	457.4	597.4	253.6	189.1	139.4	77.0	31.4	58.3
1975	18.0	670.6	1340.3	1014.0	494.9	606.7	248.8	181.4	131.3	72.0	82.8
1976	19.5	875.3	1708.5	1435.9	874.0	399.6	473.0	189.7	135.9	97.5	113.7
1977	17.5	610.7	1553.6	732.4	447.8	254.8	112.6	130.4	51.3	36.5	56.1
1978	14.2	703.5	1178.3	872.3	308.1	176.3	97.0	41.9	47.7	18.6	33.2
1979	12.3	592.4	1579.7	600.1	320.2	105.7	58.5	31.5	13.4	15.1	16.2
1980	9.2	485.9	1521.9	816.5	220.2	109.8	35.0	19.0	10.0	4.2	9.8
1981	8.4	269.0	817.1	445.1	167.7	42.3	20.4	6.4	3.4	1.8	2.4
1982	9.3	595.9	1051.3	1211.1	520.0	183.5	44.7	21.1	6.5	3.4	4.2
1983	3.0	105.6	858.1	295.7	240.1	96.3	32.8	7.8	3.6	1.1	1.3
1984	11.6	220.6	648.7	900.7	224.5	170.6	66.1	22.0	5.2	2.4	1.5
1985	12.4	326.1	342.7	416.4	460.8	107.6	79.0	29.9	9.8	2.3	1.7
1986	11.9	362.4	671.2	150.5	133.0	137.7	31.1	22.3	8.3	2.7	1.1
1987	14.3	461.8	717.3	454.1	79.4	65.8	65.8	14.5	10.2	3.8	1.7
1988	14.0	481.1	985.0	631.6	322.7	52.9	42.4	41.4	9.0	6.3	3.3
1989	23.9	371.9	689.7	721.7	389.4	186.6	29.6	23.1	22.2	4.8	5.1
1990	33.6	383.0	603.9	538.3	467.3	236.5	109.5	17.0	13.0	12.4	5.5
1991	43.5	575.5	654.7	564.7	427.2	348.0	170.2	77.0	11.7	8.9	12.2
1992	25.1	590.3	711.4	341.8	236.9	168.0	132.2	63.2	28.1	4.2	7.6
1993	14.7	421.1	1156.6	587.1	225.7	146.6	100.5	77.4	36.3	16.0	6.6
1994	19.3	437.4	1090.9	926.4	358.9	129.2	81.1	54.4	41.1	19.2	11.9
1995	24.4	381.5	384.8	281.7	164.9	50.2	14.3	7.5	4.4	3.2	2.3
1996	26.1	471.8	592.9	353.4	226.5	116.4	32.7	9.2	4.9	3.0	3.8
1997	13.7	552.3	636.4	400.4	207.1	119.0	58.6	17.1	5.2	3.0	4.3
1998	21.9	239.2	719.2	455.5	250.5	114.8	61.9	31.0	9.6	3.1	4.6
1999	26.2	475.1	270.5	412.7	236.6	127.5	64.3	42.3	26.3	9.6	8.6
2000	30.0	556.3	696.8	218.3	308.9	168.7	93.5	51.1	36.3	23.8	17.1
2001	24.8	517.4	570.8	433.7	129.1	171.5	93.7	54.2	30.9	22.7	26.0
2002	15.4	506.7	701.7	363.0	253.8	72.1	97.2	56.0	34.0	20.1	32.1
2003	7.7	468.9	908.4	523.8	253.9	172.2	50.1	71.1	42.6	26.5	41.1
2004	7.6	214.4	682.1	544.9	295.5	134.7	89.6	26.2	37.3	22.5	35.6
2005	12.5	344.3	479.3	603.2	435.0	216.9	94.7	62.1	18.0	25.8	39.9
2006	16.6	379.7	567.8	328.6	374.0	248.7	119.9	52.4	34.6	10.1	36.9
2007	16.8	510.0	570.8	312.7	156.1	159.5	99.9	47.5	20.8	13.8	18.8

Table 1.13. Spanish mackerel: Estimated total landings at age (1000 lb)

Year	0	1	2	3	4	5	6	7	8	9	10+
1950	27.0	2018.9	2084.3	1541.7	1121.8	768.5	508.7	329.2	209.2	132.0	217.9
1951	37.6	1420.3	2222.2	1783.9	1313.5	899.3	595.3	385.3	244.9	154.5	255.0
1952	38.5	1815.8	1365.2	1875.8	1553.1	1076.8	712.4	461.1	293.0	184.9	305.1
1953	32.1	1854.2	1648.1	970.8	1316.8	1025.8	687.3	444.6	282.5	178.3	294.2
1954	36.2	1543.4	1899.4	1322.6	772.0	985.3	741.7	485.9	308.6	194.7	321.4
1955	36.6	1709.7	1624.3	1696.7	1189.2	653.3	805.7	593.0	381.5	240.6	397.1
1956	40.3	1710.2	1973.7	1428.7	1430.5	942.8	500.4	603.4	436.2	278.5	459.5
1957	36.6	1908.3	2138.5	1752.7	1176.2	1106.6	704.7	365.7	433.1	310.7	519.1
1958	43.4	1650.4	2474.4	1631.2	1179.2	743.0	675.5	420.6	214.4	252.0	476.6
1959	31.6	1803.8	1320.7	1150.6	676.5	459.3	279.7	248.6	152.0	76.9	258.0
1960	29.0	1496.0	1928.4	1045.0	869.7	480.9	315.5	187.9	164.0	99.6	215.9
1961	56.9	1528.9	1975.1	1816.1	935.8	732.1	391.2	251.0	146.7	127.2	241.3
1962	39.3	2464.7	1205.5	1213.0	1098.2	532.3	402.4	210.2	132.5	76.9	190.5
1963	59.3	2187.8	2521.4	939.0	933.4	795.0	372.3	275.2	141.2	88.3	175.7
1964	57.4	2992.7	1758.5	1769.4	683.1	639.3	526.2	240.9	174.9	89.1	164.3
1965	56.2	3207.7	2557.6	1228.5	1250.9	454.4	411.0	330.7	148.7	107.1	153.2
1966	69.6	2526.5	2568.7	1663.7	816.0	782.0	274.5	242.8	191.9	85.6	148.1
1967	57.1	2933.9	1852.8	1796.8	1238.8	572.4	530.0	181.9	158.0	123.9	149.0
1968	49.5	2711.1	2408.6	1182.3	1120.1	726.2	324.2	293.6	99.0	85.3	145.7
1969	45.8	2228.8	2486.9	1619.8	762.6	679.3	425.6	185.8	165.2	55.3	127.4
1970	56.7	1904.5	2114.1	1799.2	1139.5	504.6	434.3	266.0	114.1	100.7	109.7
1971	32.0	2205.5	1501.7	1316.0	1092.2	650.5	278.4	234.3	140.9	60.0	109.4
1972	41.6	1376.9	2574.4	1217.3	999.3	779.4	448.6	187.7	155.1	92.6	109.9
1973	37.7	1630.1	1178.2	1622.8	732.8	565.5	426.2	239.8	98.6	80.9	104.4
1974	31.2	1536.6	1828.5	1008.5	1317.0	559.0	416.9	307.2	169.8	69.3	128.6
1975	39.8	1478.5	2954.9	2235.6	1091.1	1337.4	548.5	399.9	289.4	158.7	182.6
1976	42.9	1929.8	3766.7	3165.6	1926.9	880.9	1042.9	418.2	299.5	215.1	250.8
1977	38.6	1346.3	3425.0	1614.8	987.2	561.8	248.1	287.4	113.2	80.4	123.7
1978	31.4	1551.0	2597.7	1923.2	679.3	388.7	213.8	92.4	105.1	41.1	73.2
1979	27.2	1306.0	3482.7	1323.1	705.9	233.1	129.0	69.4	29.5	33.2	35.7
1980	20.3	1071.2	3355.3	1800.2	485.4	242.0	77.3	41.8	22.1	9.3	21.6
1981	18.4	593.0	1801.4	981.3	369.6	93.2	44.9	14.0	7.5	3.9	5.4
1982	20.5	1313.6	2317.7	2670.0	1146.4	404.5	98.5	46.4	14.3	7.5	9.3
1983	6.5	232.7	1891.8	651.9	529.3	212.3	72.4	17.3	8.0	2.4	2.8
1984	25.6	486.2	1430.2	1985.7	495.0	376.1	145.7	48.6	11.4	5.2	3.4
1985	27.4	718.9	755.5	918.1	1016.0	237.2	174.2	66.0	21.6	5.0	3.8
1986	26.2	799.0	1479.7	331.8	293.2	303.5	68.5	49.2	18.3	6.0	2.4
1987	31.5	1018.1	1581.4	1001.1	175.1	145.0	145.0	32.0	22.6	8.3	3.8
1988	30.9	1060.6	2171.5	1392.5	711.5	116.7	93.4	91.3	19.8	13.9	7.4
1989	52.6	820.0	1520.5	1591.0	858.4	411.3	65.2	51.0	49.0	10.5	11.2
1990	74.1	844.4	1331.3	1186.8	1030.2	521.5	241.4	37.4	28.8	27.4	12.1
1991	95.9	1268.7	1443.4	1244.9	941.9	767.3	375.2	169.8	25.8	19.7	26.9
1992	55.4	1301.4	1568.5	753.6	522.2	370.3	291.5	139.4	62.0	9.4	16.7
1993	32.4	928.3	2549.8	1294.3	497.5	323.3	221.5	170.5	80.1	35.3	14.7
1994	42.6	964.3	2404.9	2042.4	791.1	284.8	178.9	119.9	90.6	42.2	26.2
1995	53.8	841.1	848.3	621.1	363.6	110.7	31.6	16.5	9.8	7.0	5.1
1996	57.6	1040.1	1307.1	779.1	499.4	256.5	72.1	20.2	10.8	6.6	8.3
1997	30.2	1217.6	1403.1	882.7	456.7	262.4	129.1	37.7	11.4	6.5	9.5
1998	48.3	527.4	1585.6	1004.2	552.2	253.1	136.6	68.4	21.3	6.9	10.2
1999	57.8	1047.4	596.3	909.9	521.5	281.2	141.8	93.3	57.9	21.1	19.0
2000	66.2	1226.5	1536.2	481.3	681.0	372.0	206.1	112.6	80.1	52.5	37.6
2001	54.7	1140.8	1258.3	956.1	284.7	378.2	206.5	119.4	68.2	50.1	57.3
2002	33.9	1117.1	1547.1	800.2	559.6	158.9	214.4	123.5	74.9	44.2	70.7
2003	16.9	1033.8	2002.8	1154.7	559.7	379.6	110.5	156.7	93.9	58.5	90.6
2004	16.8	472.6	1503.7	1201.3	651.5	297.0	197.5	57.7	82.2	49.6	78.4
2005	27.5	759.1	1056.7	1329.9	959.0	478.3	208.9	137.0	39.8	56.8	88.0
2006	36.5	837.1	1251.7	724.5	824.6	548.3	264.4	115.5	76.3	22.4	81.4
2007	37.1	1124.3	1258.5	689.3	344.1	351.6	220.3	104.7	45.8	30.5	41.5

Table 1.14. Spanish mackerel: Estimated time series of landings (1000 lb) for commercial handlinse (L.HL), commercial gillnet (L.GN), commercial poundnet (L.PN), commercial castnet (L.CN), and general recreational (L.rec).

Year	L.HL	L.GN	L.PN	L.CN	L.rec	Total
1950	.	3008.00	13.00	.	5938.14	8959.14
1951	.	2837.00	6.00	.	6468.83	9311.83
1952	.	3674.00	3.00	.	6004.60	9681.60
1953	.	3115.00	1.00	.	5618.95	8734.95
1954	.	2940.00	4.00	.	5667.33	8611.33
1955	.	4004.00	6.00	.	5317.59	9327.59
1956	.	4765.00	16.00	.	5023.19	9804.19
1957	.	5861.00	15.00	.	4576.22	10452.22
1958	10.00	5297.00	6.00	.	4447.52	9760.52
1959	9.00	2471.00	17.00	.	3960.70	6457.70
1960	25.00	2774.00	21.00	.	4011.91	6831.91
1961	20.00	3017.00	122.00	.	5043.21	8202.21
1962	76.00	2349.00	14.00	.	5126.56	7565.56
1963	54.00	2160.00	65.00	.	6209.67	8488.67
1964	103.00	2478.00	32.00	.	6482.72	9095.72
1965	153.00	2467.00	90.00	.	7196.01	9906.01
1966	173.00	1910.00	111.00	.	7175.43	9369.43
1967	142.00	3181.00	23.00	.	6248.68	9594.68
1968	123.00	3211.00	73.00	.	5738.50	9145.50
1969	103.00	3056.00	84.00	.	5539.40	8782.40
1970	127.00	3059.00	104.00	.	5253.39	8543.39
1971	119.00	3019.00	26.00	.	4456.86	7620.86
1972	134.00	3250.00	23.00	.	4575.80	7982.80
1973	162.00	2641.00	51.00	.	3862.86	6716.86
1974	283.00	3686.00	25.00	.	3378.53	7372.53
1975	623.00	7045.00	62.00	.	2986.27	10716.27
1976	582.00	10926.00	77.00	.	2354.13	13939.13
1977	125.00	6753.00	29.00	.	1919.49	8826.49
1978	44.00	6250.00	2.00	.	1400.58	7696.58
1979	50.00	6267.99	1.00	.	1055.70	7374.70
1980	50.00	6372.99	4.00	.	719.44	7146.43
1981	37.00	2868.00	2.00	.	1025.53	3932.53
1982	91.00	6981.00	11.00	.	965.60	8048.60
1983	30.00	3430.01	13.00	.	154.47	3627.48
1984	50.00	3674.01	14.00	.	1275.21	5013.22
1985	59.00	3348.98	33.00	.	502.91	3943.89
1986	56.00	2356.98	39.00	.	925.76	3377.74
1987	116.00	2528.88	235.00	.	1284.15	4164.02
1988	104.00	3327.57	183.00	.	2094.85	5709.41
1989	142.00	3245.82	505.00	.	1548.04	5440.85
1990	250.00	2845.20	509.01	.	1731.14	5335.35
1991	285.00	3853.67	468.01	.	1772.83	6379.51
1992	73.00	3131.23	397.00	.	1489.16	5090.39
1993	61.00	4656.38	328.00	.	1102.33	6147.71
1994	69.00	5106.01	345.00	.	1467.97	6987.97
1995	200.00	1449.03	207.00	34.00	1018.52	2908.55
1996	83.00	2470.05	302.00	197.00	1005.89	4057.93
1997	93.00	2709.68	208.00	76.00	1360.23	4446.90
1998	176.00	2898.95	118.00	33.00	988.06	4214.01
1999	202.00	1556.65	301.99	344.99	1341.59	3747.21
2000	277.99	1575.73	206.00	621.97	2170.36	4852.05
2001	419.00	1514.93	222.00	933.97	1484.32	4574.22
2002	362.01	1318.14	136.00	1420.09	1508.13	4744.37
2003	416.02	951.11	111.00	2270.50	1908.91	5657.53
2004	761.06	788.07	72.00	1745.34	1241.73	4608.20
2005	698.06	1209.15	50.00	1716.34	1467.22	5140.77
2006	839.09	1417.25	10.00	1380.25	1136.11	4782.71
2007	753.05	1705.17	14.00	549.04	1226.36	4247.62

Table 1.15. Spanish mackerel: Estimated time series of discard and bycatch mortalities (1000 fish) for commercial handlines (D.HL), gillnet (D.GN), general recreational (D.rec), and bycatch in the shrimp fishery (Bycatch).

Year	D.HL	D.GN	D.rec	Total D	Bycatch
1950	.	.	149.60	11122.00	11271.60
1951	.	.	145.20	8316.00	8461.20
1952	.	.	140.80	6343.00	6483.80
1953	.	.	136.40	11122.00	11258.40
1954	.	.	132.00	9231.00	9363.00
1955	.	.	127.60	9267.00	9394.60
1956	.	.	123.20	6448.00	6571.20
1957	.	.	118.80	9223.00	9341.80
1958	.	.	114.40	2969.00	3083.40
1959	.	.	110.88	6818.00	6928.88
1960	.	.	106.48	11122.00	11228.48
1961	.	.	125.84	752.00	877.84
1962	.	.	145.20	7003.00	7148.20
1963	.	.	165.44	752.00	917.44
1964	.	.	184.80	752.00	936.80
1965	.	.	204.16	6879.00	7083.16
1966	.	.	190.96	1241.00	1431.96
1967	.	.	178.64	752.00	930.64
1968	.	.	165.44	4850.00	5015.44
1969	.	.	152.24	7951.00	8103.24
1970	.	.	139.04	872.00	1011.04
1971	.	.	127.60	11122.00	11249.60
1972	.	.	115.28	6184.00	6299.28
1973	.	.	103.84	5360.00	5463.84
1974	.	.	92.40	7924.00	8016.40
1975	.	.	80.96	5749.00	5829.96
1976	.	.	69.52	6895.00	6964.52
1977	.	.	58.08	752.00	810.08
1978	.	.	46.64	752.00	798.64
1979	.	.	35.20	1515.00	1550.20
1980	.	.	22.88	5614.03	5636.91
1981	.	.	54.56	752.00	806.56
1982	.	.	6.16	6863.00	6869.16
1983	.	.	4.40	7430.00	7434.40
1984	.	.	22.88	752.00	774.88
1985	.	.	48.40	8149.00	8197.40
1986	0.35	12	279.84	6101.99	6394.19
1987	0.70	12	54.56	4605.98	4673.24
1988	0.88	14	56.32	6205.03	6276.23
1989	1.23	7	211.20	11120.84	11340.27
1990	1.94	12	141.68	11099.03	11254.65
1991	2.55	14	321.20	11126.85	11464.61
1992	0.44	14	308.00	7387.60	7710.04
1993	0.62	23	215.60	2376.81	2616.03
1994	0.44	26	661.75	631.00	1319.19
1995	2.90	8	344.08	7983.06	8338.05
1996	0.18	15	314.16	510.99	840.32
1997	0.70	18	369.57	3379.44	3767.72
1998	3.52	9	234.95	416.98	664.45
1999	3.08	14	564.05	7000.72	7581.85
2000	3.26	10	727.75	6341.01	7082.02
2001	3.43	11	594.91	1416.20	2025.54
2002	3.96	12	540.35	266.01	822.31
2003	3.52	9	714.59	363.00	1090.12
2004	2.38	7	369.60	130.00	508.98
2005	2.29	8	658.28	451.02	1119.58
2006	2.64	7	249.04	116.00	374.68
2007	2.73	6	497.20	451.00	956.93

Table 1.16. Spanish mackerel: Revised base run: Estimated status indicators, benchmarks, and related quantities from the catch-at-age model, conditional on estimated current selectivities averaged across fisheries. Precision is represented by 10^{th} and 90^{th} percentiles from bootstrap analysis of the spawner-recruit curve. Estimates of yield do not include discards and shrimp bycatch; D_{MSY} represents discard and bycatch mortalities expected when fishing at F_{MSY}. Rate estimates (F) are in units of per year; status indicators are dimensionless; and biomass estimates are in units of mt or pounds, as indicated. Symbols, abbreviations, and acronyms are listed in Appendix A.

Quantity	Units	Estimate	10^{th} Percentile	90^{th} Percentile
F_{MSY}	y^{-1}	0.371	0.306	0.451
$85\%F_{\mathrm{MSY}}$	y^{-1}	0.315	–	–
$75\%F_{\mathrm{MSY}}$	y^{-1}	0.278	–	–
$65\%F_{\mathrm{MSY}}$	y^{-1}	0.241	–	–
$F_{30\%}$	y^{-1}	0.54	–	–
$F_{40\%}$	y^{-1}	0.38	–	–
$F_{\max}$	y^{-1}	0.84	–	–
B_{MSY}	mt	33743	29016	64016
$\mathrm{SSB}_{\mathrm{MSY}}$	mt	12438	9132	21392
MSST	mt	8085	5936	13905
MSY	1000 lb	11461	10819	19665
$\mathrm{D}_{\mathrm{MSY}}$	1000 fish	1342	1118	1925
R_{MSY}	1000 fish	33311	26814	52341
Y at $85\%F_{\mathrm{MSY}}$	1000 lb	11320	–	–
Y at $75\%F_{\mathrm{MSY}}$	1000 lb	11051	–	–
Y at $65\%F_{\mathrm{MSY}}$	1000 lb	10608	–	–
Y at $F_{30\%}$	1000 lb	10565	–	–
Y at $F_{40\%}$	1000 lb	11458	–	–
Y at $F_{\max}$	1000 lb	6598	–	–
$F_{2007}/F_{\mathrm{MSY}}$	–	0.872	0.718	1.055
$\mathrm{SSB}_{2007}/\mathrm{SSB}_{\mathrm{MSY}}$	–	0.456	0.265	0.621
$\mathrm{SSB}_{2007}/\mathrm{MSST}$	–	0.701	0.408	0.955

Table 1.17. Spanish mackerel: Projection results under scenario R1—fishing mortality rate fixed at $F = 0$. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{40\%}}$, SSB = mid-year spawning stock biomass (mt)*, R = recruits (1000 fish), L = landings (1000* lb *whole weight), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.*

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,886	5070	5070	894
2009	0	0	6307	23,776	0	5070	0
2010	0	0.12	9580	25,342	0	5070	0
2011	0	0.45	12,100	30,379	0	5070	0
2012	0	0.74	14,867	33,013	0	5070	0
2013	0	0.88	17,702	35,170	0	5070	0
2014	0	0.95	20,481	36,857	0	5070	0
2015	0	0.98	23,112	38,159	0	5070	0
2016	0	0.99	25,531	39,163	0	5070	0
2017	0	1	27,703	39,937	0	5070	0
2018	0	1	29,615	40,538	0	5070	0
2019	0	1	31,272	41,006	0	5070	0
2020	0	1	32,689	41,372	0	5070	0
2021	0	1	33,890	41,661	0	5070	0
2022	0	1	34,899	41,890	0	5070	0
2023	0	1	35,740	42,071	0	5070	0
2024	0	1	36,438	42,216	0	5070	0
2025	0	1	37,014	42,332	0	5070	0
2026	0	1	37,489	42,424	0	5070	0
2027	0	1	37,879	42,499	0	5070	0

Table 1.18. Spanish mackerel: Projection results under scenario R2—fishing mortality rate fixed at $F_{current}$. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{MSY}}$, SSB = mid-year spawning stock biomass (mt)*, R = recruits (1000 fish), L = landings (1000* lb *whole weight), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.*

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,886	5070	5070	894
2009	0.378	0	6307	23,776	5938	11,009	966
2010	0.378	0.01	7045	25,342	6695	17,704	1031
2011	0.378	0.05	7744	26,699	7386	25,089	1088
2012	0.378	0.11	8388	27,850	8000	33,089	1136
2013	0.378	0.16	8969	28,810	8544	41,633	1176
2014	0.378	0.2	9484	29,606	9019	50,653	1209
2015	0.378	0.24	9933	30,261	9430	60,083	1237
2016	0.378	0.28	10,319	30,798	9781	69,864	1259
2017	0.378	0.31	10,647	31,235	10,078	79,942	1278
2018	0.378	0.34	10,923	31,592	10,326	90,267	1293
2019	0.378	0.36	11,154	31,881	10,532	100,799	1305
2020	0.378	0.37	11,346	32,115	10,702	111,502	1315
2021	0.378	0.4	11,505	32,306	10,843	122,345	1323
2022	0.378	0.41	11,636	32,459	10,958	133,303	1329
2023	0.378	0.42	11,743	32,584	11,052	144,355	1334
2024	0.378	0.41	11,830	32,685	11,129	155,484	1339
2025	0.378	0.42	11,902	32,766	11,191	166,675	1342
2026	0.378	0.43	11,960	32,832	11,242	177,917	1345
2027	0.378	0.43	12,007	32,886	11,284	189,201	1347

Table 1.19. Spanish mackerel: Projection results under scenario R3—fishing mortality rate fixed at $F_{\rm MSY}$. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{\rm MSY}}$, SSB = mid-year spawning stock biomass (mt)*, R = recruits (1000 fish), L = landings (1000* lb *whole weight), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.*

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,886	5070	5070	894
2009	0.371	0	6307	23,776	5847	10,917	949
2010	0.371	0.01	7082	25,342	6613	17,530	1014
2011	0.371	0.05	7802	26,763	7312	24,842	1072
2012	0.371	0.11	8468	27,939	7934	32,776	1120
2013	0.371	0.17	9070	28,923	8488	41,263	1161
2014	0.371	0.21	9604	29,738	8973	50,236	1194
2015	0.371	0.25	10,071	30,409	9392	59,628	1222
2016	0.371	0.29	10,473	30,957	9750	69,378	1245
2017	0.371	0.33	10,814	31,404	10,053	79,430	1263
2018	0.371	0.35	11,102	31,768	10,306	89,736	1278
2019	0.371	0.37	11,342	32,063	10,516	100,253	1290
2020	0.371	0.39	11,542	32,302	10,690	110,943	1300
2021	0.371	0.41	11,707	32,495	10,834	121,777	1308
2022	0.371	0.43	11,843	32,652	10,951	132,728	1315
2023	0.371	0.44	11,954	32,778	11,047	143,775	1320
2024	0.371	0.44	12,045	32,881	11,125	154,900	1324
2025	0.371	0.44	12,120	32,963	11,189	166,089	1328
2026	0.371	0.45	12,180	33,030	11,241	177,330	1330
2027	0.371	0.45	12,229	33,084	11,283	188,612	1332

Table 1.20. Spanish mackerel: Projection results under scenario R4—fishing mortality rate fixed at $0.65F_{\mathrm{MSY}}$. F = *fishing mortality rate (per year), Pr(recover) = proportion of cases reaching* $SSB_{F_{\mathrm{MSY}}}$, SSB = *mid-year spawning stock biomass* (mt), R = *recruits (1000 fish),* L = *landings (1000* lb *whole weight), Sum* L = *cumulative landings (1000* lb*), and* D = *discard mortalities (1000 fish). Horizontal lines give relevant quantities at* MSY *levels.*

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,886	5070	5070	894
2009	0.241	0	6307	23,776	3948	9019	624
2010	0.241	0.02	7862	25,342	4772	13,791	668
2011	0.241	0.12	9057	28,033	5520	19,311	736
2012	0.241	0.25	10,247	29,721	6212	25,523	783
2013	0.241	0.38	11,373	31,156	6874	32,398	822
2014	0.241	0.49	12,402	32,331	7471	39,869	854
2015	0.241	0.57	13,322	33,280	7998	47,867	880
2016	0.241	0.62	14,127	34,042	8453	56,320	901
2017	0.241	0.66	14,821	34,652	8839	65,159	917
2018	0.241	0.71	15,409	35,139	9163	74,323	931
2019	0.241	0.73	15,904	35,527	9433	83,756	941
2020	0.241	0.76	16,315	35,838	9655	93,411	950
2021	0.241	0.78	16,656	36,086	9837	103,248	956
2022	0.241	0.8	16,935	36,284	9986	113,234	962
2023	0.241	0.81	17,163	36,442	10,107	123,341	966
2024	0.241	0.82	17,349	36,568	10,205	133,546	970
2025	0.241	0.82	17,500	36,669	10,284	143,830	972
2026	0.241	0.83	17,622	36,750	10,348	154,178	975
2027	0.241	0.84	17,721	36,815	10,400	164,578	976

Table 1.21. Spanish mackerel: Projection results under scenario R5—fishing mortality rate fixed at $0.75F_{\mathrm{MSY}}$*. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching* $SSB_{F_{\mathrm{MSY}}}$*, SSB = mid-year spawning stock biomass* (mt)*, R = recruits (1000 fish), L = landings (1000* lb *whole weight), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.*

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,886	5070	5070	894
2009	0.278	0	6307	23,776	4506	9576	717
2010	0.278	0.02	7630	25,342	5344	14,920	767
2011	0.278	0.1	8674	27,670	6100	21,020	836
2012	0.278	0.2	9697	29,211	6792	27,811	885
2013	0.278	0.3	10,652	30,520	7443	35,255	926
2014	0.278	0.39	11,518	31,597	8025	43,280	960
2015	0.278	0.47	12,285	32,472	8535	51,815	987
2016	0.278	0.52	12,954	33,178	8974	60,789	1009
2017	0.278	0.56	13,527	33,746	9347	70,136	1027
2018	0.278	0.59	14,012	34,202	9659	79,794	1041
2019	0.278	0.62	14,419	34,567	9918	89,712	1053
2020	0.278	0.65	14,757	34,860	10,131	99,843	1062
2021	0.278	0.68	15,036	35,095	10,307	110,150	1069
2022	0.278	0.69	15,265	35,283	10,450	120,600	1075
2023	0.278	0.7	15,452	35,434	10,566	131,166	1080
2024	0.278	0.71	15,605	35,555	10,660	141,826	1084
2025	0.278	0.71	15,729	35,652	10,737	152,563	1087
2026	0.278	0.73	15,829	35,730	10,799	163,361	1089
2027	0.278	0.74	15,910	35,792	10,848	174,210	1091

Table 1.22. Spanish mackerel: Projection results under scenario R6—fishing mortality rate fixed at $0.85F_{\text{MSY}}$. *F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching* $SSB_{F_{\text{MSY}}}$, *SSB = mid-year spawning stock biomass* (mt)*, R = recruits (1000 fish), L = landings (1000* lb *whole weight), Sum L = cumulative landings (1000* lb*), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.*

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,886	5070	5070	894
2009	0.315	0	6307	23,776	5051	10,122	811
2010	0.315	0.02	7405	25,342	5878	15,999	867
2011	0.315	0.07	8312	27,307	6623	22,622	933
2012	0.315	0.16	9181	28,701	7298	29,920	983
2013	0.315	0.24	9984	29,882	7921	37,840	1024
2014	0.315	0.3	10,705	30,857	8472	46,313	1059
2015	0.315	0.37	11,339	31,653	8953	55,266	1087
2016	0.315	0.43	11,890	32,299	9366	64,632	1110
2017	0.315	0.46	12,360	32,821	9715	74,347	1128
2018	0.315	0.49	12,756	33,243	10,008	84,355	1143
2019	0.315	0.52	13,089	33,582	10,250	94,605	1155
2020	0.315	0.56	13,364	33,855	10,451	105,056	1165
2021	0.315	0.57	13,592	34,075	10,615	115,672	1172
2022	0.315	0.58	13,779	34,252	10,750	126,421	1179
2023	0.315	0.59	13,932	34,394	10,859	137,281	1184
2024	0.315	0.6	14,057	34,508	10,948	148,229	1188
2025	0.315	0.61	14,158	34,600	11,021	159,250	1191
2026	0.315	0.62	14,241	34,674	11,079	170,329	1194
2027	0.315	0.63	14,307	34,733	11,126	181,455	1196

Table 1.23. Spanish mackerel: Projection results under scenario R7—fishing mortality rate fixed at $F_{rebuild} = 0.325$. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{\mathrm{MSY}}}$, SSB = mid-year spawning stock biomass (mt), R = recruits (1000 fish), L = landings (1000 lb whole weight), Sum L = cumulative landings (1000 lb), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,886	5070	5070	894
2009	0.325	0	6307	23,776	5191	10,262	835
2010	0.325	0.02	7348	25,342	6011	16,272	892
2011	0.325	0.07	8220	27,213	6750	23,022	957
2012	0.325	0.15	9053	28,569	7418	30,440	1007
2013	0.325	0.23	9818	29,716	8031	38,472	1049
2014	0.325	0.28	10,504	30,664	8573	47,044	1083
2015	0.325	0.35	11,107	31,438	9045	56,089	1111
2016	0.325	0.4	11,629	32,068	9449	65,538	1134
2017	0.325	0.43	12,075	32,578	9791	75,329	1153
2018	0.325	0.46	12,451	32,990	10,077	85,406	1168
2019	0.325	0.5	12,766	33,322	10,315	95,722	1180
2020	0.325	0.53	13,027	33,590	10,512	106,233	1190
2021	0.325	0.54	13,243	33,805	10,673	116,906	1198
2022	0.325	0.55	13,420	33,979	10,805	127,710	1204
2023	0.325	0.57	13,565	34,119	10,912	138,622	1209
2024	0.325	0.57	13,683	34,231	10,999	149,622	1213
2025	0.325	0.58	13,779	34,321	11,070	160,692	1216
2026	0.325	0.59	13,857	34,394	11,128	171,820	1219
2027	0.325	0.6	13,921	34,453	11,174	182,994	1221

Table 1.24. Spanish mackerel: Projection results under $F = 0.288$, the fishing mortality rate needed to achieve a probability of recovery of 0.6 by 2019. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{\mathrm{MSY}}}$, SSB = mid-year spawning stock biomass (mt), R = recruits (1000 fish), L = landings (1000 lb whole weight), Sum L = cumulative landings (1000 lb), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,886	5070	5070	894
2009	0.288	0	6307	23,776	4651	9721	742
2010	0.288	0.02	7570	25,342	5487	15,208	794
2011	0.288	0.09	8577	27,575	6242	21,451	862
2012	0.288	0.18	9558	29,077	6932	28,382	912
2013	0.288	0.28	10,472	30,352	7577	35,959	953
2014	0.288	0.37	11,297	31,403	8152	44,112	986
2015	0.288	0.45	12,028	32,257	8656	52,768	1014
2016	0.288	0.5	12,664	32,948	9089	61,857	1036
2017	0.288	0.53	13,209	33,505	9456	71,313	1054
2018	0.288	0.56	13,669	33,952	9763	81,076	1069
2019	0.288	0.6	14,055	34,311	10,019	91,095	1081
2020	0.288	0.63	14,376	34,599	10,229	101,324	1090
2021	0.288	0.65	14,641	34,830	10,402	111,726	1097
2022	0.288	0.66	14,858	35,015	10,543	122,270	1103
2023	0.288	0.67	15,036	35,164	10,658	132,928	1108
2024	0.288	0.68	15,180	35,283	10,751	143,679	1112
2025	0.288	0.69	15,298	35,379	10,827	154,505	1115
2026	0.288	0.7	15,393	35,455	10,888	165,393	1118
2027	0.288	0.71	15,470	35,517	10,937	176,329	1120

Table 1.25. Spanish mackerel: Projection results under $F = 0.252$, the fishing mortality needed to achive a probability of recovery of 0.70 by 2019. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{\text{MSY}}}$, SSB = mid-year spawning stock biomass (mt), R = recruits (1000 fish), L = landings (1000 lb whole weight), Sum L = cumulative landings (1000 lb), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,886	5070	5070	894
2009	0.252	0	6307	23,776	4113	9183	651
2010	0.252	0.02	7794	25,342	4943	14,127	697
2011	0.252	0.11	8943	27,927	5696	19,822	765
2012	0.252	0.23	10,082	29,572	6390	26,212	814
2013	0.252	0.35	11,156	30,970	7051	33,263	853
2014	0.252	0.46	12,136	32,117	7645	40,908	886
2015	0.252	0.54	13,009	33,045	8169	49,077	912
2016	0.252	0.6	13,772	33,791	8620	57,697	933
2017	0.252	0.63	14,428	34,389	9003	66,700	950
2018	0.252	0.67	14,985	34,867	9325	76,025	964
2019	0.252	0.7	15,452	35,249	9592	85,617	975
2020	0.252	0.73	15,841	35,555	9812	95,429	983
2021	0.252	0.75	16,162	35,799	9993	105,422	990
2022	0.252	0.77	16,426	35,994	10,140	115,562	996
2023	0.252	0.78	16,642	36,151	10,260	125,822	1000
2024	0.252	0.78	16,817	36,276	10,357	136,179	1004
2025	0.252	0.79	16,960	36,376	10,436	146,615	1007
2026	0.252	0.8	17,075	36,456	10,499	157,115	1009
2027	0.252	0.81	17,168	36,520	10,550	167,665	1011

Table 1.26. Spanish mackerel: Projection results under $F = 0.218$, the fishing mortality rate needed to achieve a probability of recovery of 0.80 by 2019. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{\mathrm{MSY}}}$, SSB = mid-year spawning stock biomass (mt), R = recruits (1000 fish), L = landings (1000 lb whole weight), Sum L = cumulative landings (1000 lb), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,886	5070	5070	894
2009	0.218	0	6307	23,776	3594	8665	565
2010	0.218	0.03	8011	25,342	4396	13,061	605
2011	0.218	0.14	9305	28,259	5128	18,189	671
2012	0.218	0.28	10,609	30,039	5809	23,998	717
2013	0.218	0.42	11,851	31,551	6468	30,466	754
2014	0.218	0.55	12,994	32,786	7065	37,531	785
2015	0.218	0.63	14,019	33,778	7594	45,126	809
2016	0.218	0.68	14,921	34,573	8052	53,178	829
2017	0.218	0.72	15,699	35,206	8442	61,619	844
2018	0.218	0.77	16,361	35,711	8769	70,388	857
2019	0.218	0.8	16,918	36,113	9041	79,429	867
2020	0.218	0.82	17,383	36,433	9266	88,695	875
2021	0.218	0.83	17,767	36,687	9450	98,145	881
2022	0.218	0.85	18,083	36,891	9600	107,745	886
2023	0.218	0.86	18,341	37,053	9722	117,467	890
2024	0.218	0.87	18,551	37,183	9821	127,288	893
2025	0.218	0.87	18,722	37,286	9901	137,190	896
2026	0.218	0.88	18,860	37,369	9966	147,155	898
2027	0.218	0.89	18,972	37,435	10,018	157,173	900

Table 1.27. Spanish mackerel: Projection results under $F = 0.175$, the fishing mortality rate needed to achieve a probability of recovery of 0.90 by 2019. F = fishing mortality rate (per year), Pr(recover) = proportion of cases reaching $SSB_{F_{\mathrm{MSY}}}$, SSB = mid-year spawning stock biomass (mt), R = recruits (1000 fish), L = landings (1000 lb whole weight), Sum L = cumulative landings (1000 lb), and D = discard mortalities (1000 fish). Horizontal lines give relevant quantities at MSY levels.

Year	F(per yr)	Pr(recover)	SSB(mt)	R(1000)	L(1000 lb)	Sum L(1000 lb)	D(1000)
2008	0.378	0	5554	21,886	5070	5070	894
2009	0.175	0	6307	23,776	2922	7993	455
2010	0.175	0.05	8297	25,342	3655	11,648	488
2011	0.175	0.19	9790	28,679	4332	15,980	548
2012	0.175	0.36	11,322	30,630	4969	20,949	589
2013	0.175	0.52	12,802	32,281	5597	26,546	622
2014	0.175	0.64	14,180	33,620	6171	32,717	649
2015	0.175	0.73	15,428	34,690	6684	39,401	670
2016	0.175	0.79	16,533	35,540	7130	46,531	687
2017	0.175	0.85	17,493	36,213	7511	54,043	700
2018	0.175	0.88	18,314	36,746	7832	61,875	711
2019	0.175	0.9	19,007	37,169	8100	69,975	719
2020	0.175	0.91	19,586	37,504	8321	78,295	726
2021	0.175	0.92	20,066	37,771	8502	86,797	731
2022	0.175	0.93	20,462	37,983	8650	95,447	736
2023	0.175	0.94	20,786	38,151	8771	104,218	739
2024	0.175	0.94	21,051	38,286	8868	113,086	742
2025	0.175	0.94	21,265	38,393	8947	122,034	744
2026	0.175	0.95	21,439	38,479	9011	131,045	745
2027	0.175	0.95	21,580	38,547	9063	140,108	747

1.4.2 Figures

Figure 1.1. Spanish mackerel: A comparison of revised recreational landings and discards to those originally proposed by the SEDAR 17 DW. The former correct for king mackerel landings that were grouped together with Spanish mackerel landings in a 1960 USFWS saltwater angling report.

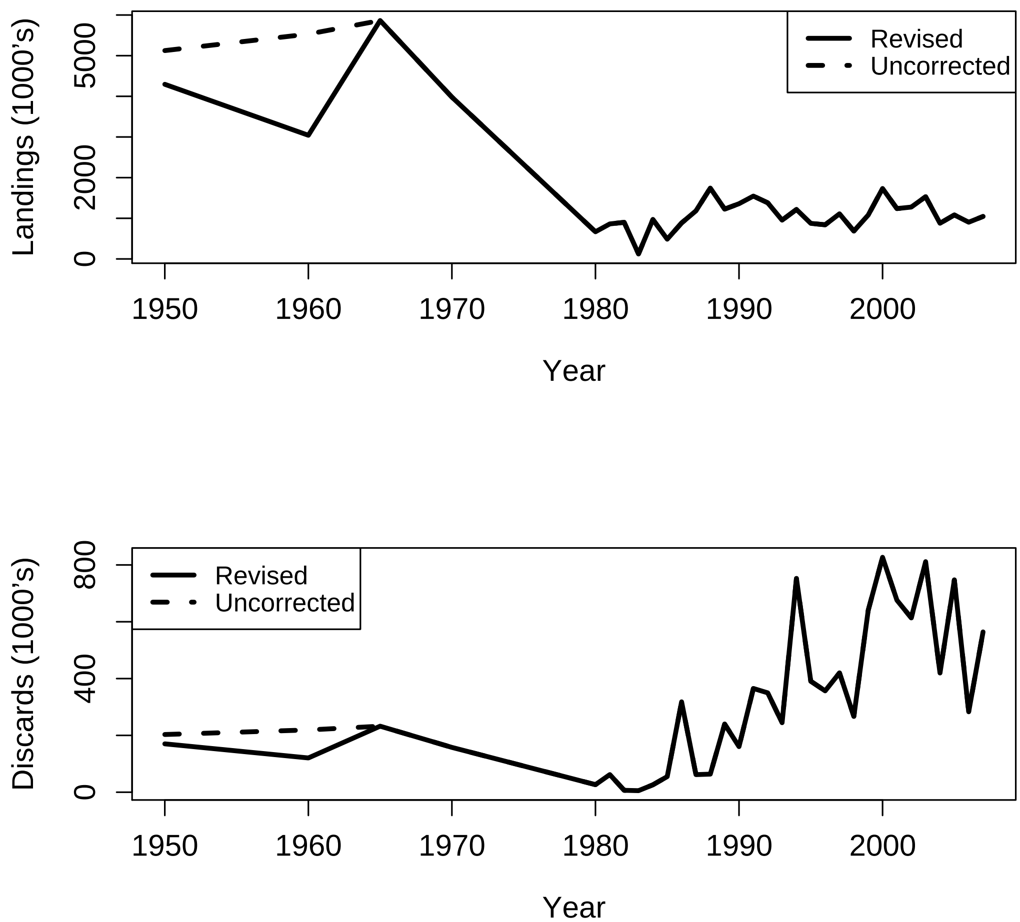


Figure 1.2. Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery. In panels indicating the data set, lcomp refers to length compositions, acomp to age compositions, HL to commercial handlines, GN to commercial gillnet, CN to commercial castnet, PN to commercial poundnet, and MRFSS to general recreational.

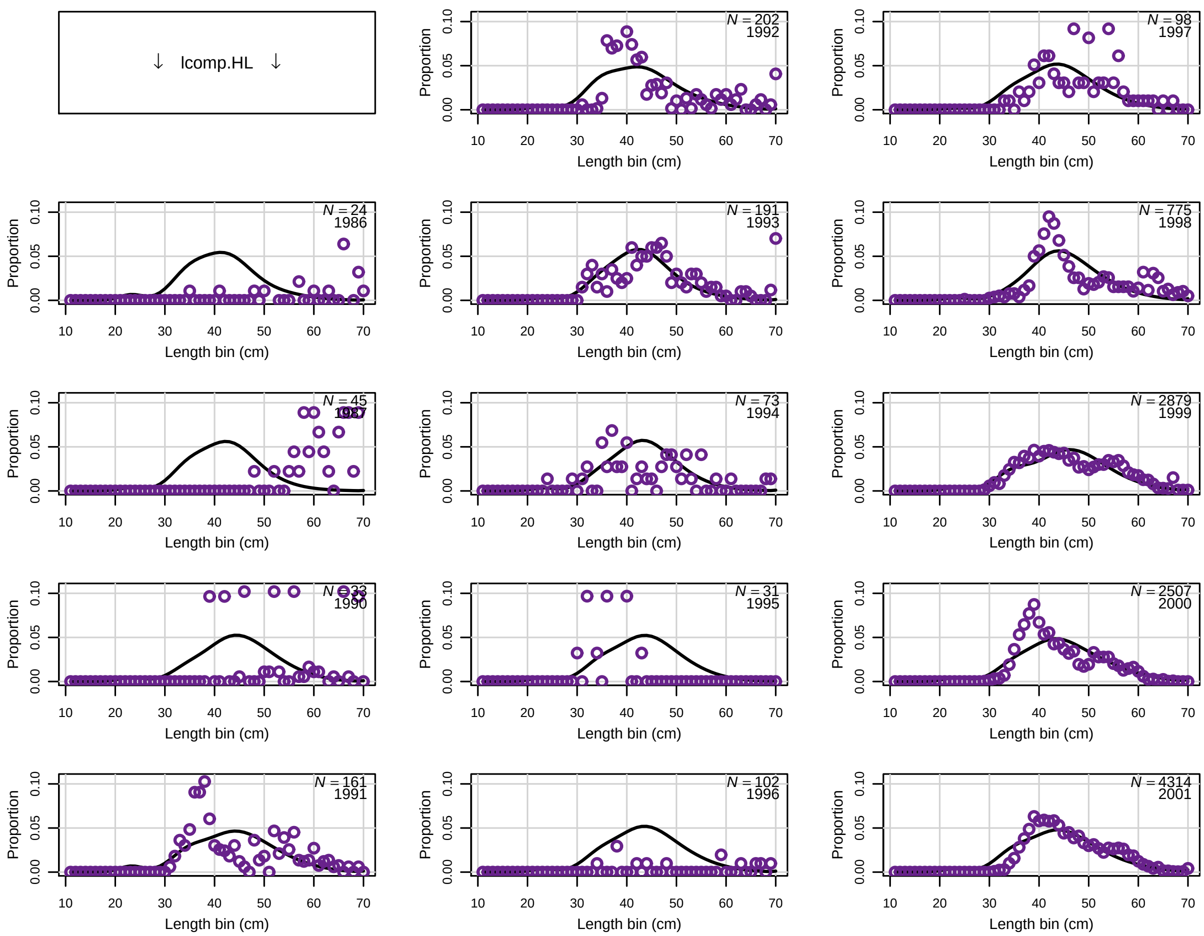


Figure 1.2. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

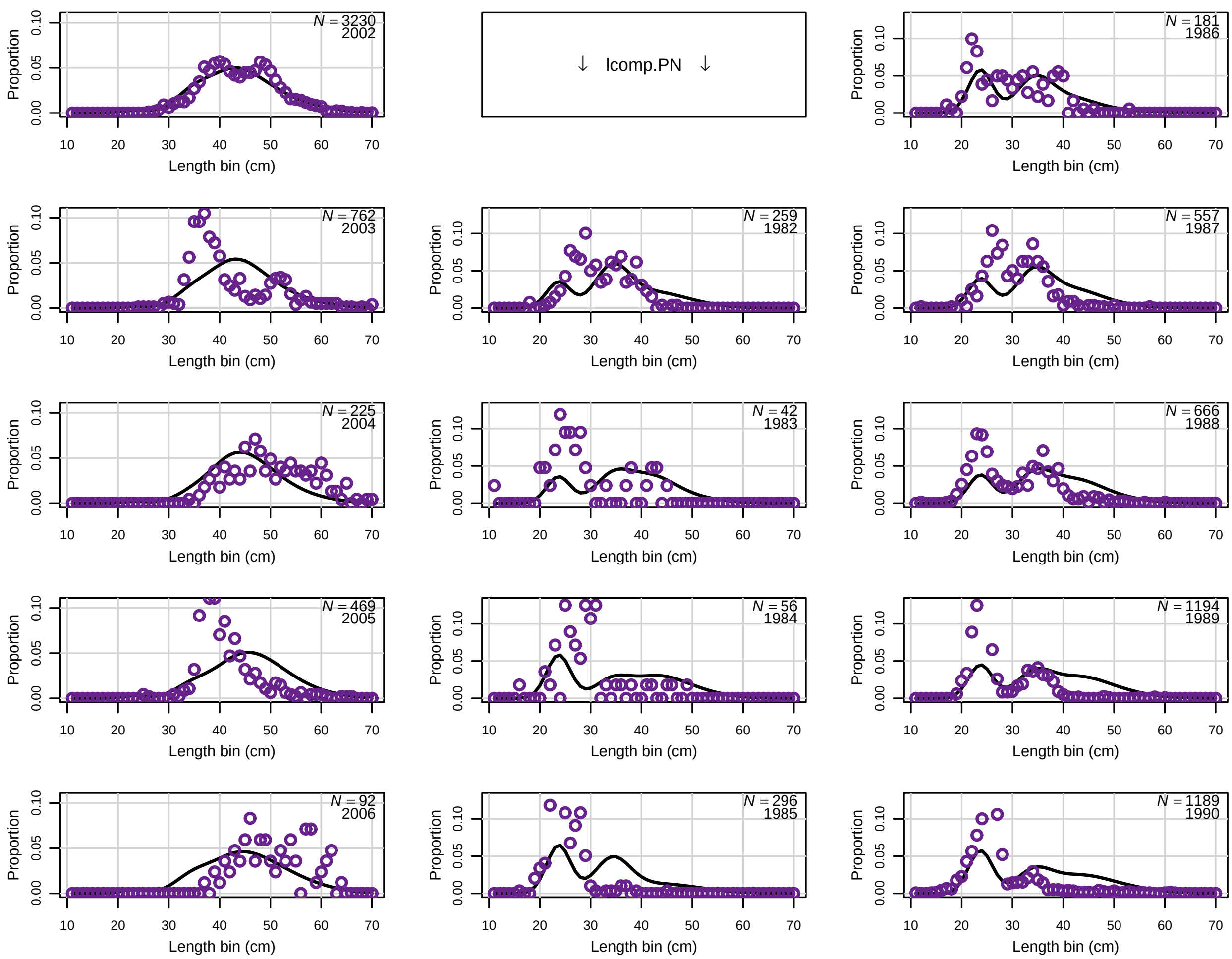


Figure 1.2. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

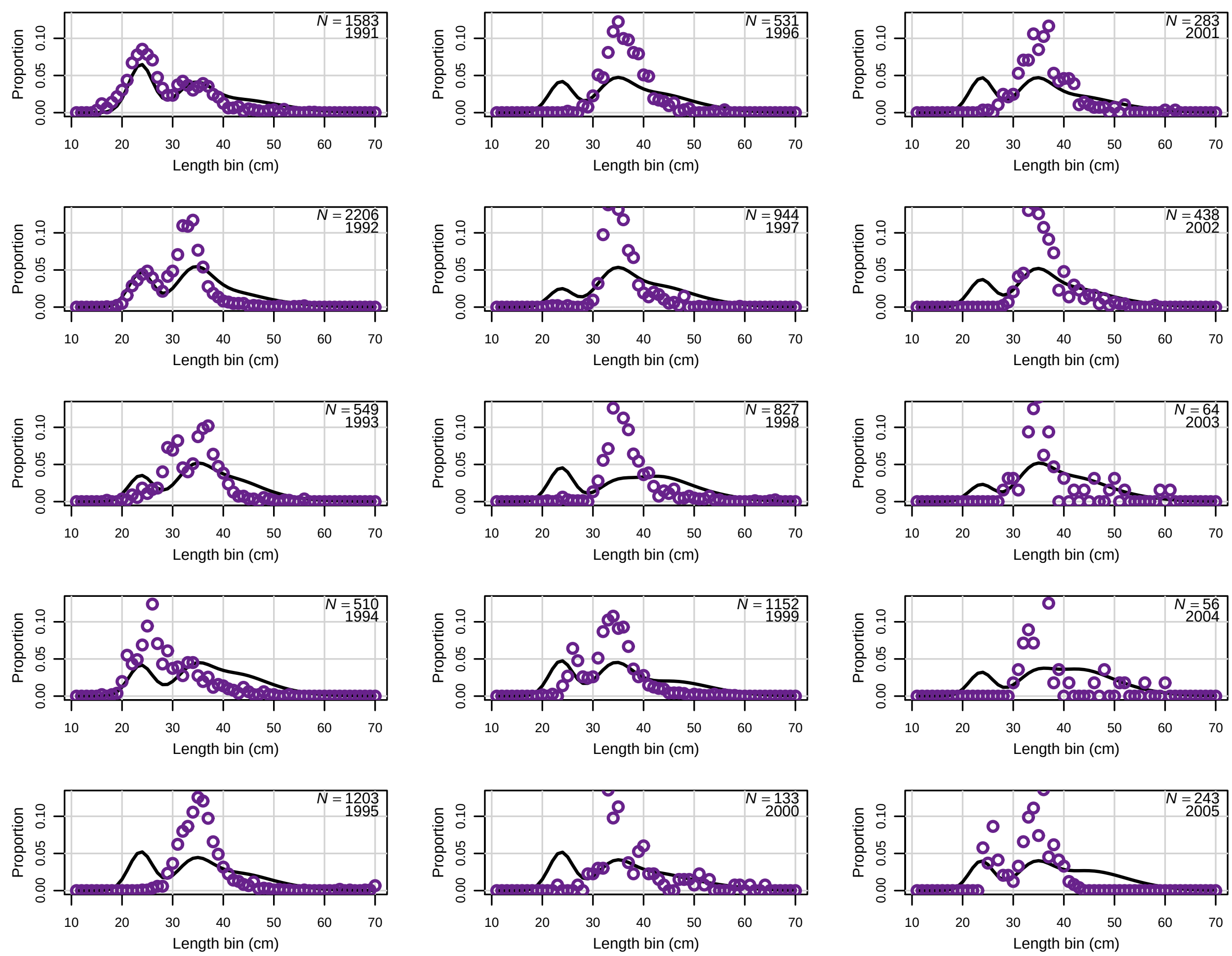


Figure 1.2. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

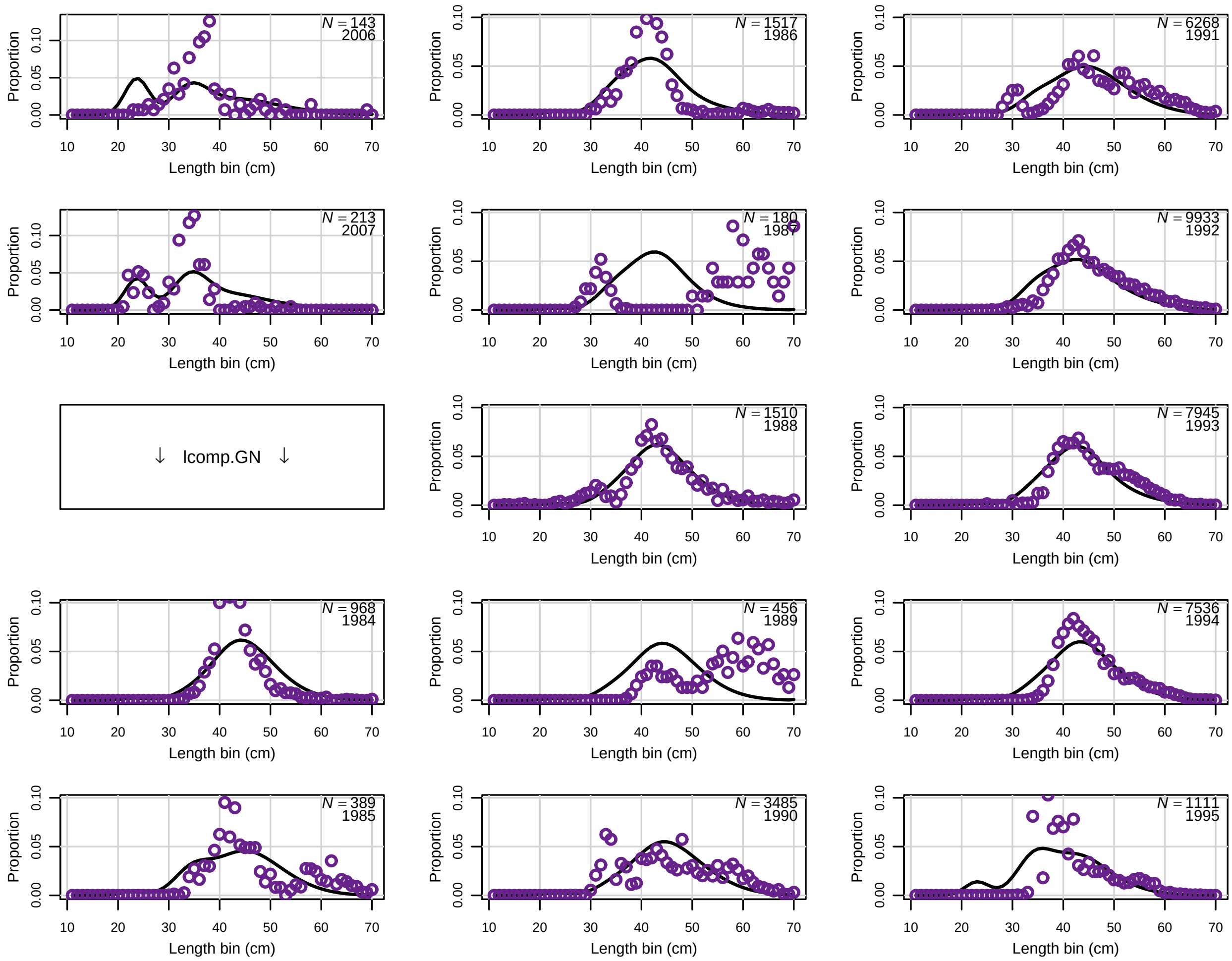


Figure 1.2. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

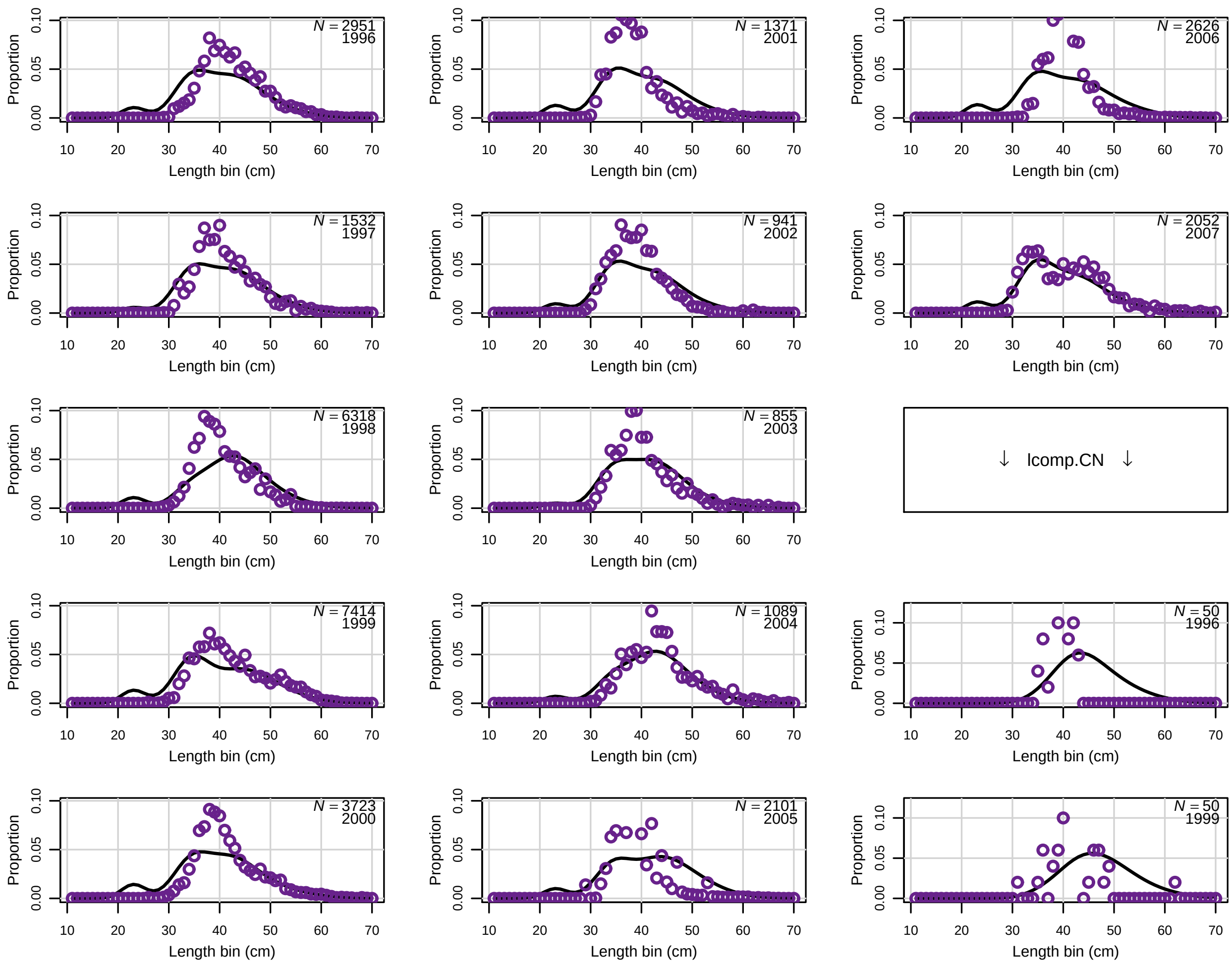


Figure 1.2. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

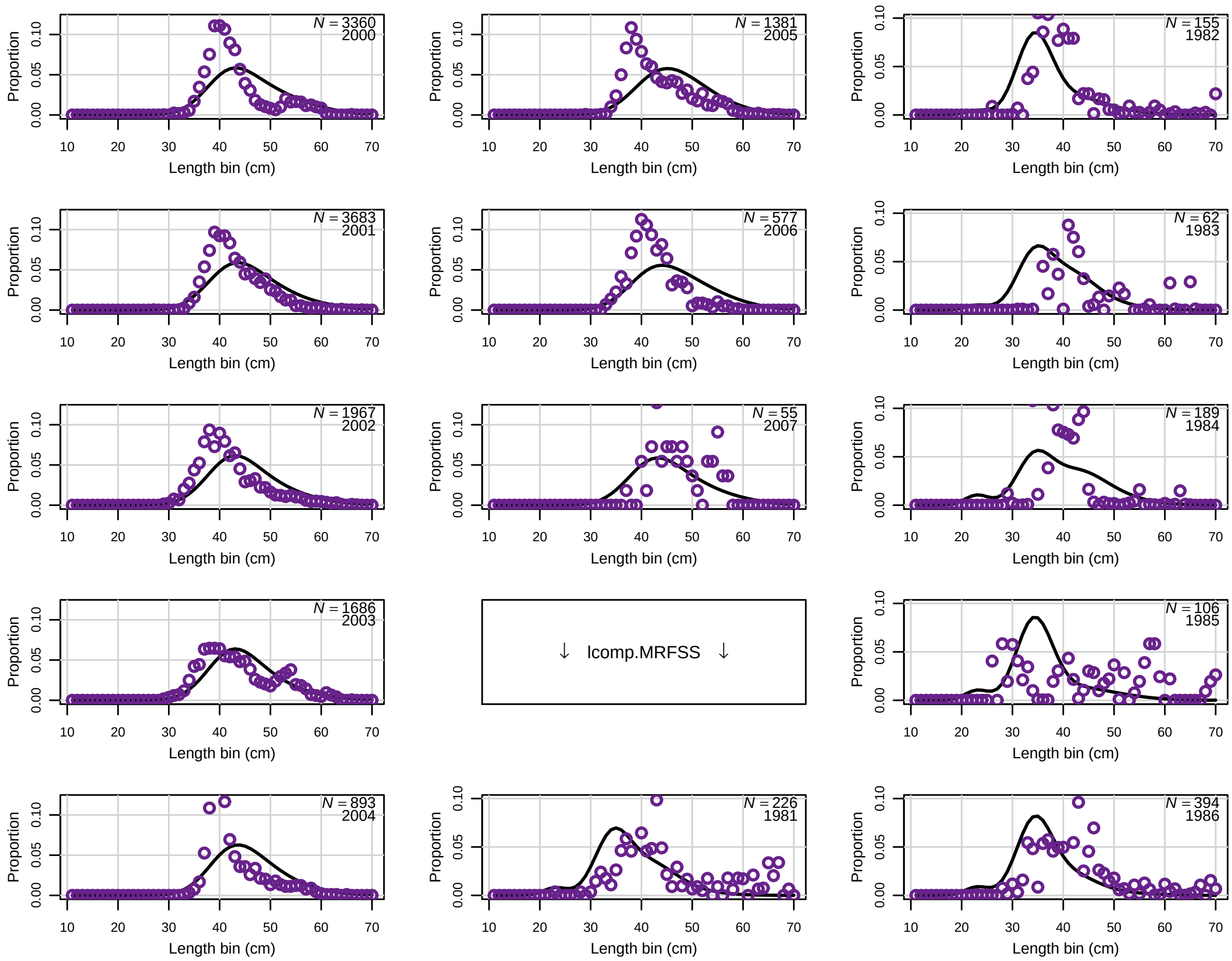


Figure 1.2. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

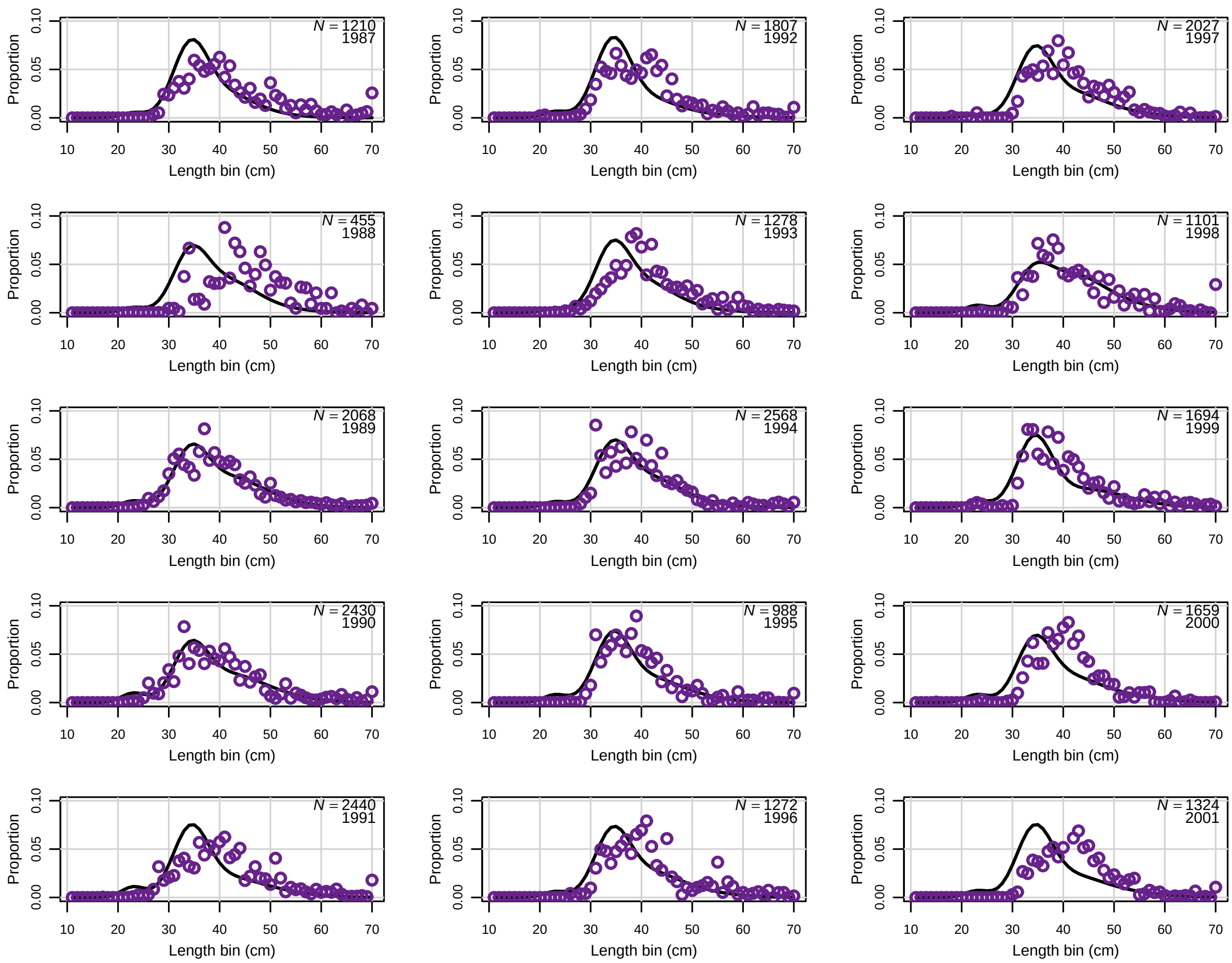


Figure 1.2. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

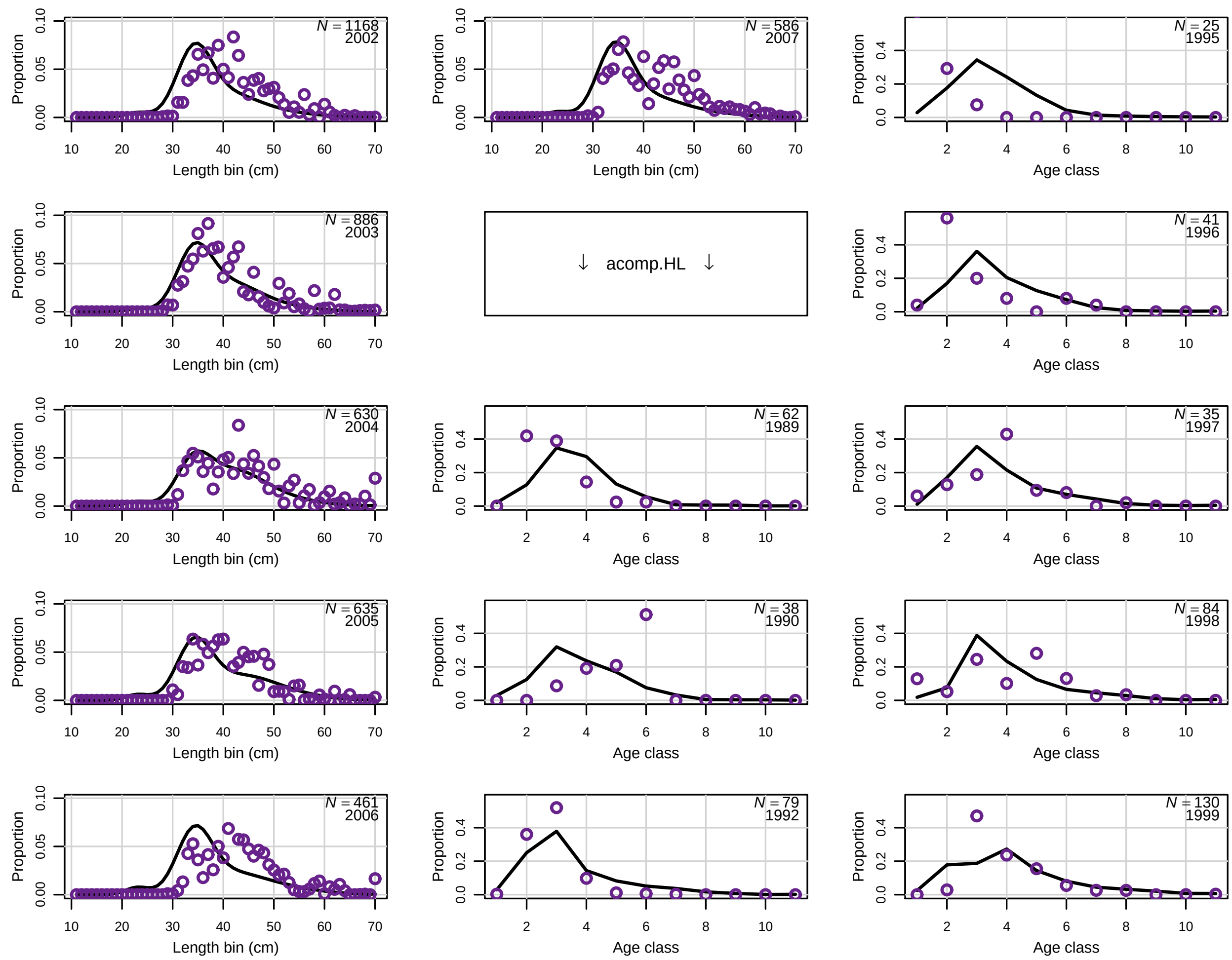


Figure 1.2. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

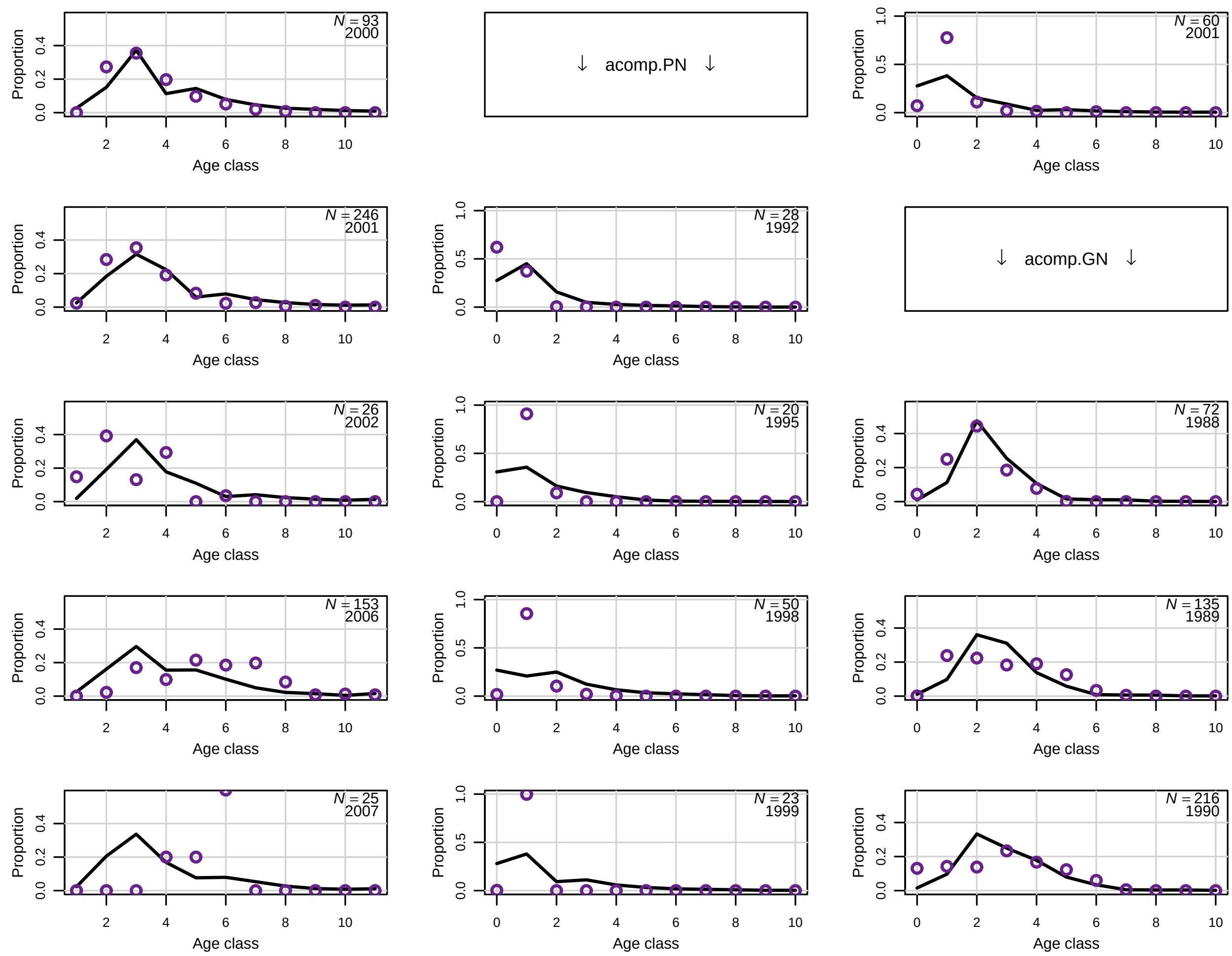


Figure 1.2. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

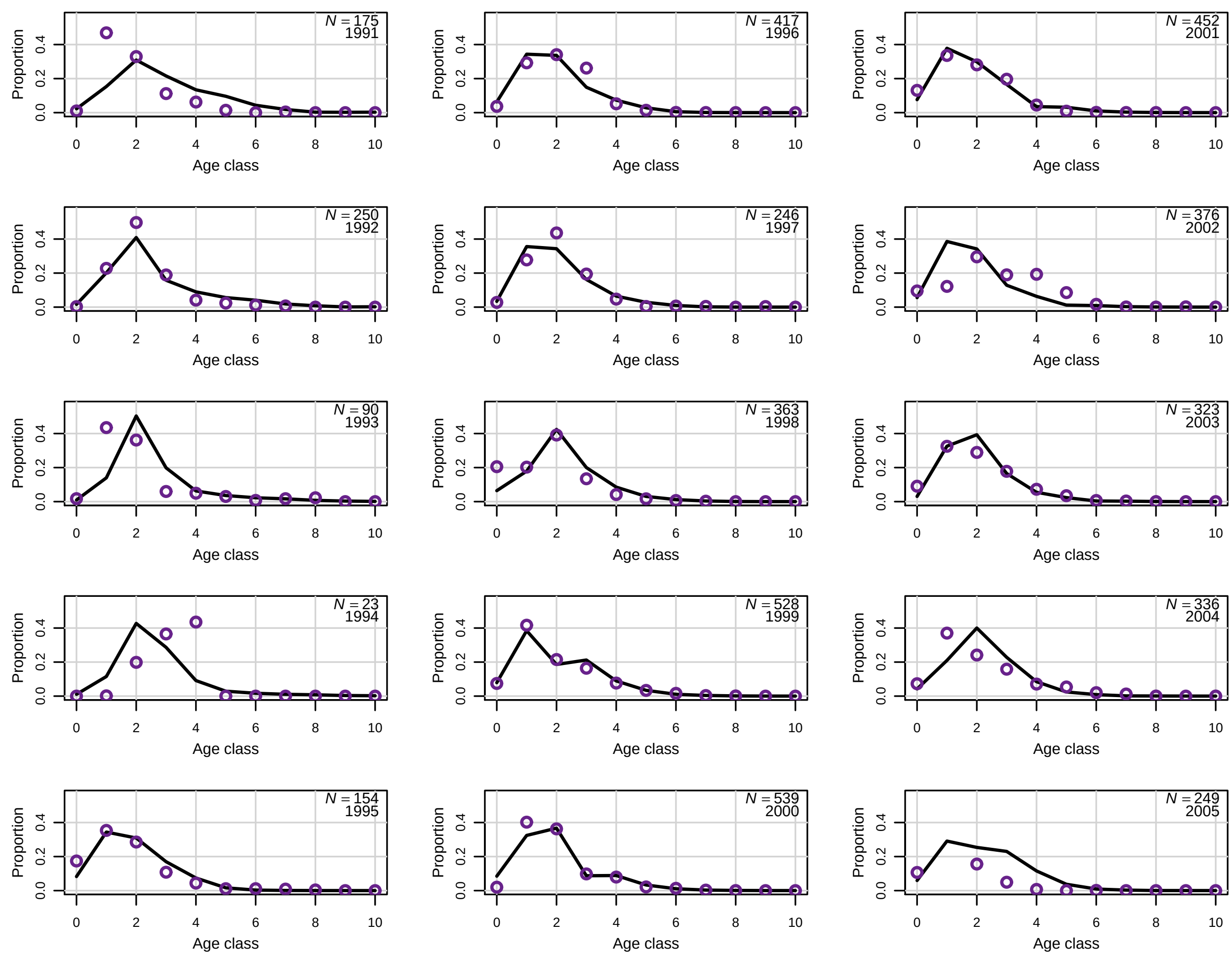


Figure 1.2. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

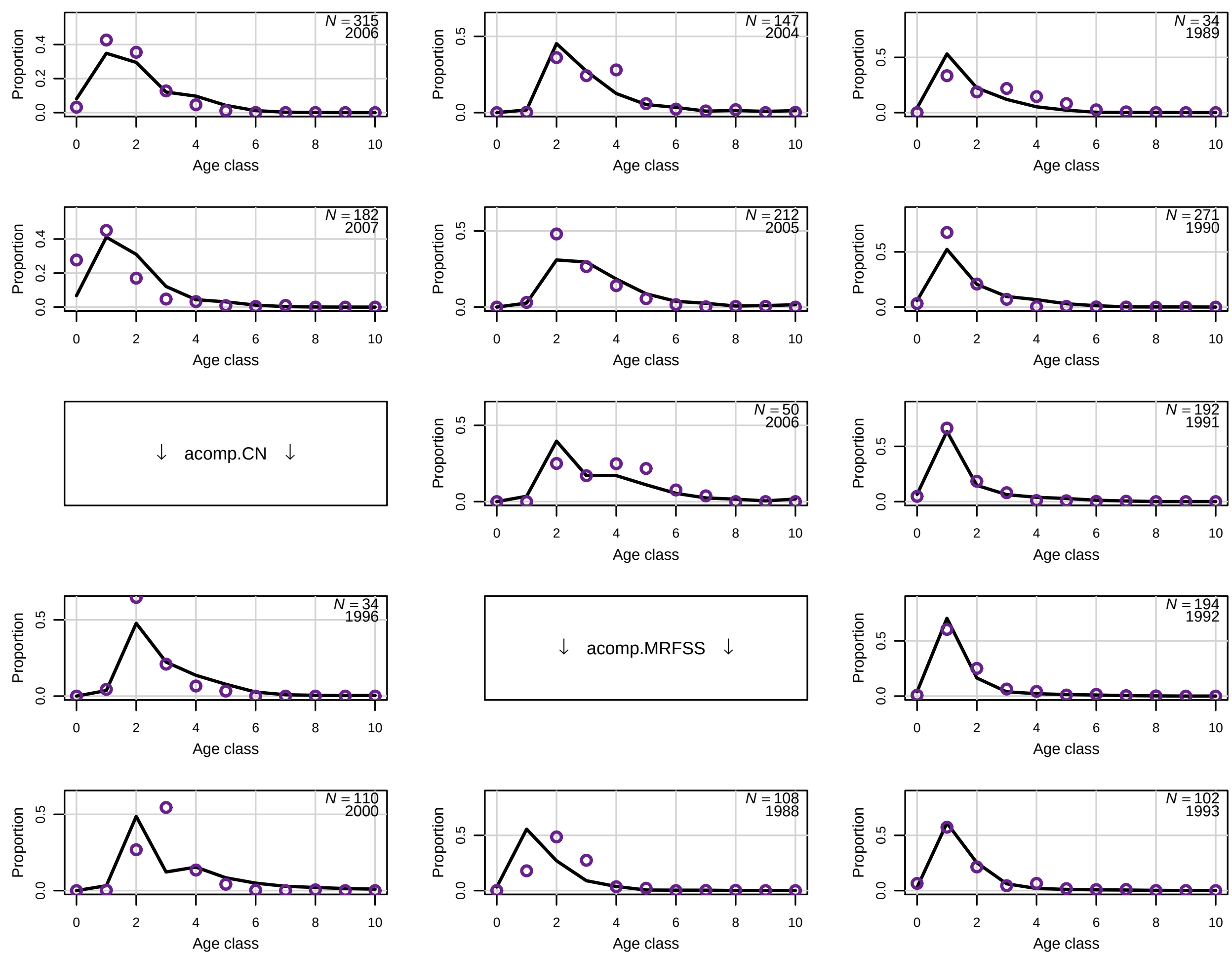


Figure 1.2. (cont.) Spanish mackerel: Observed (open circles) and estimated (solid line) annual length and age compositions by fishery.

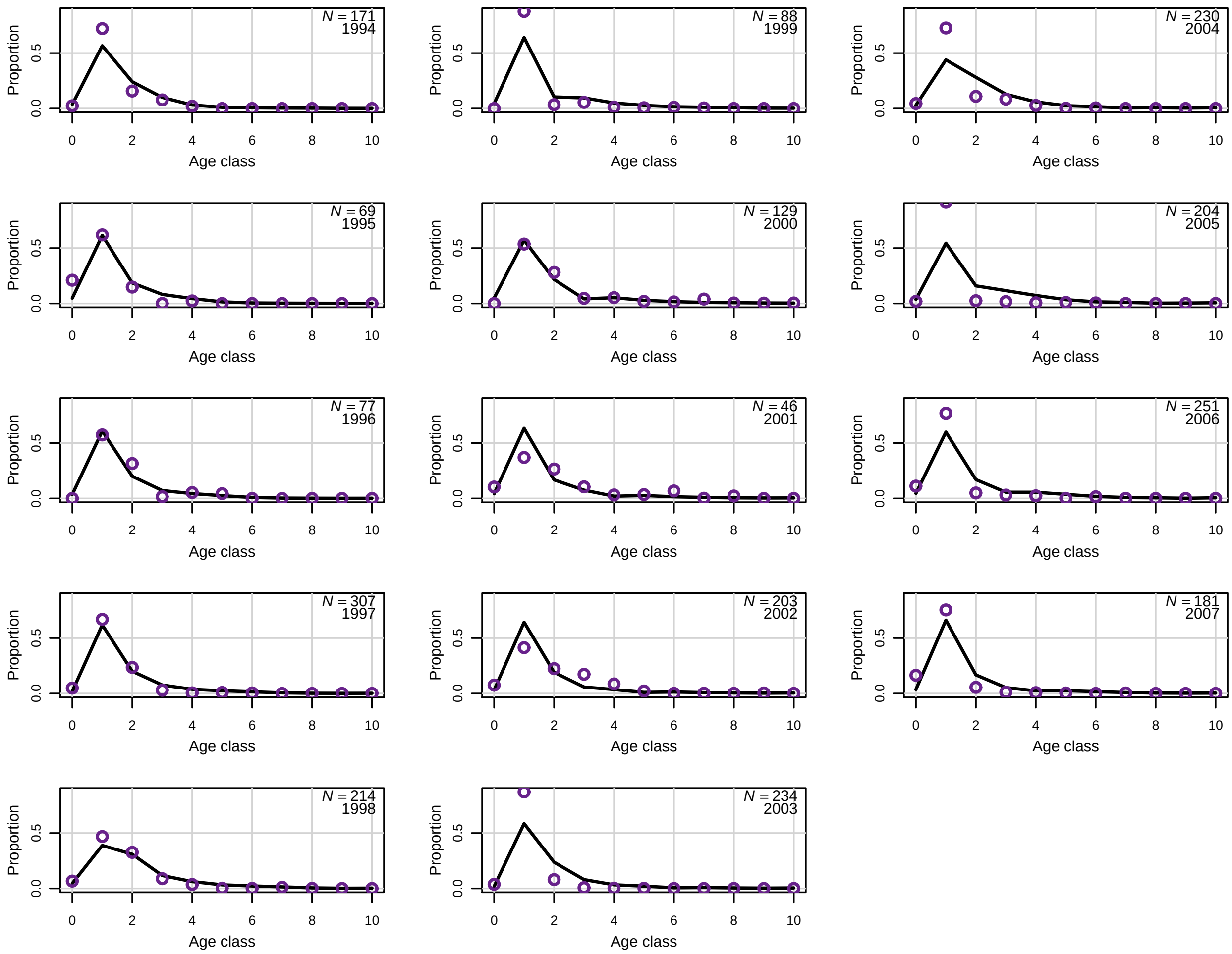


Figure 1.3. Spanish mackerel: Top panel is a bubble plot of length composition residuals from the commercial handline fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

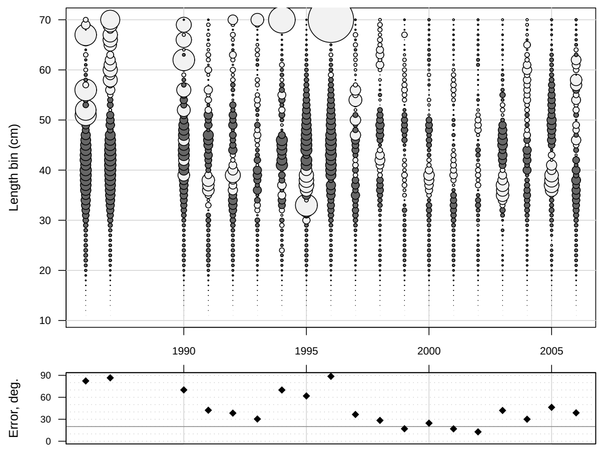


Figure 1.4. Spanish mackerel: Top panel is a bubble plot of length composition residuals from the commercial gillnet fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

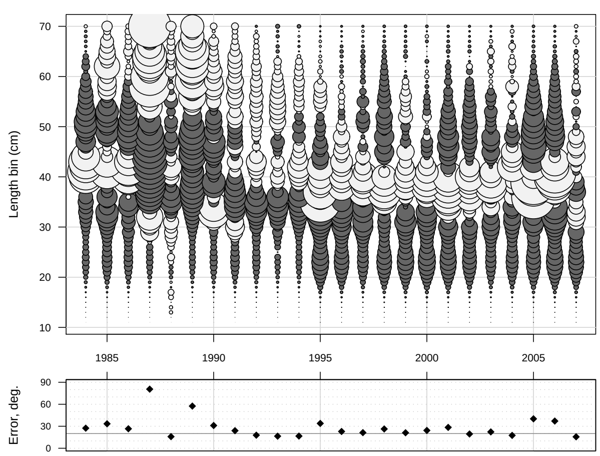


Figure 1.5. Spanish mackerel: Top panel is a bubble plot of length composition residuals from the commercial poundnet fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

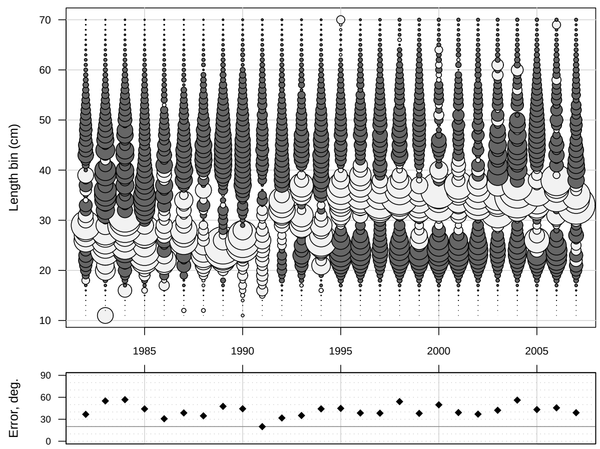


Figure 1.6. Spanish mackerel: Top panel is a bubble plot of length composition residuals from the commercial castnet fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

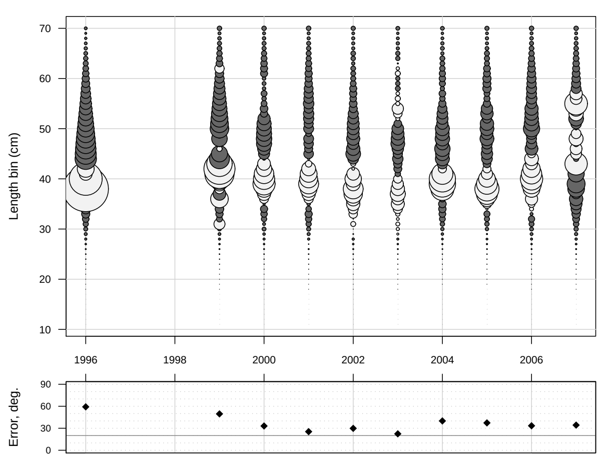


Figure 1.7. Spanish mackerel: Top panel is a bubble plot of length composition residuals from the recreational fishery (MRFSS); Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

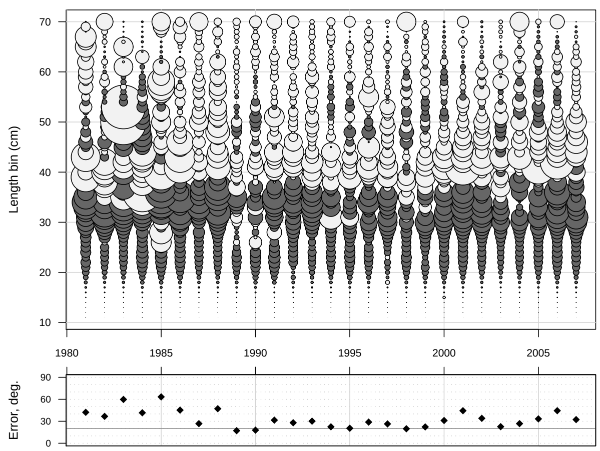


Figure 1.8. Spanish mackerel: Top panel is a bubble plot of age composition residuals from the commercial handlines fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

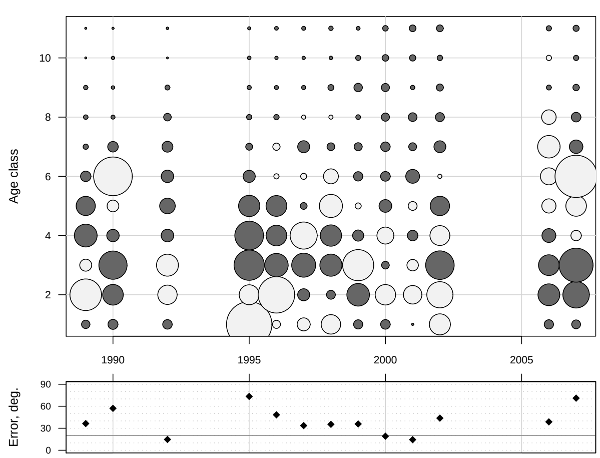


Figure 1.9. Spanish mackerel: Top panel is a bubble plot of age composition residuals from the commercial gillnet fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

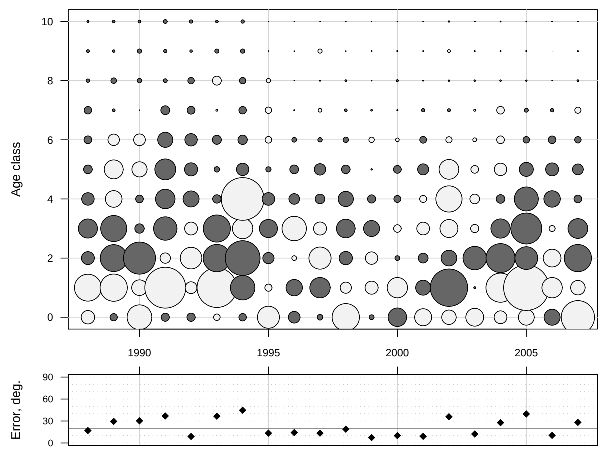


Figure 1.10. Spanish mackerel: Top panel is a bubble plot of age composition residuals from the poundnet fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

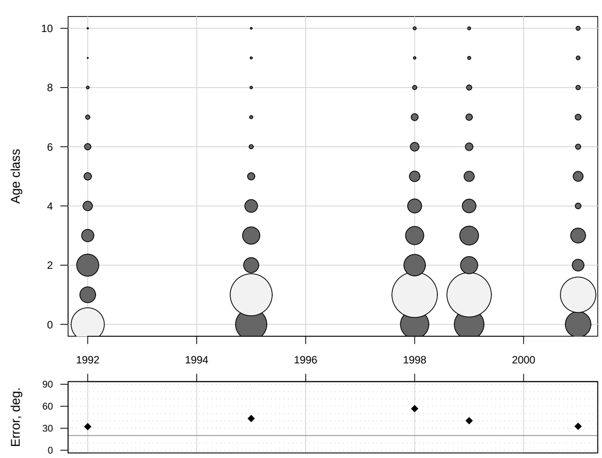


Figure 1.11. Spanish mackerel: Top panel is a bubble plot of age composition residuals from the castnet fishery; Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

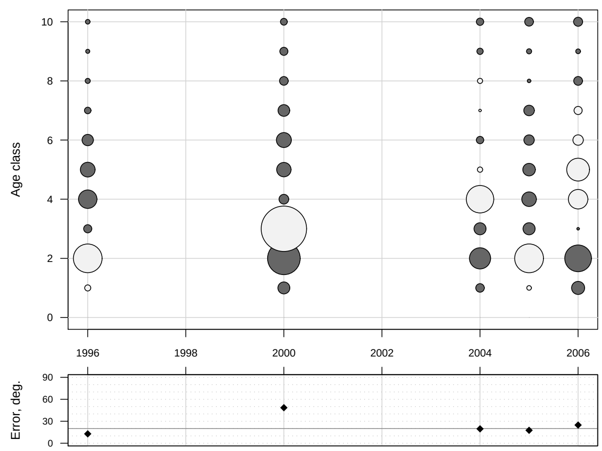


Figure 1.12. Spanish mackerel: Top panel is a bubble plot of age composition residuals from the recreational fishery (MRFSS); Dark represents overestimates and light underestimates. Bottom panel shows the angle (in degrees) between vectors of observations and estimates, with a reference line at 20 degrees. Error is bounded between 0 and 90 degrees, with 0 indicating a perfect fit.

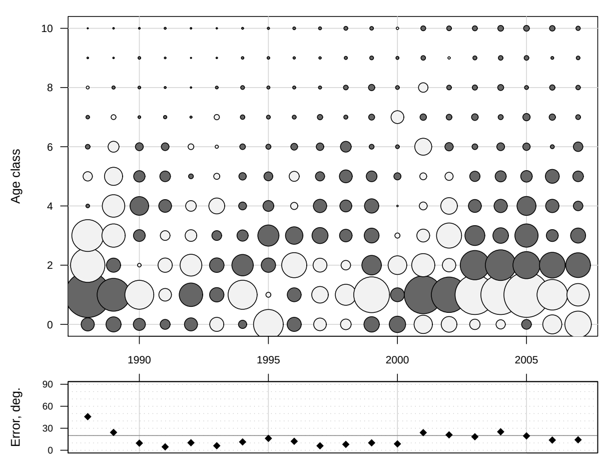


Figure 1.13. Spanish mackerel: Observed (open circles) and estimated (solid line, circles) commercial handlines landings (whole weight). Open and closed circles are indistinguishable.

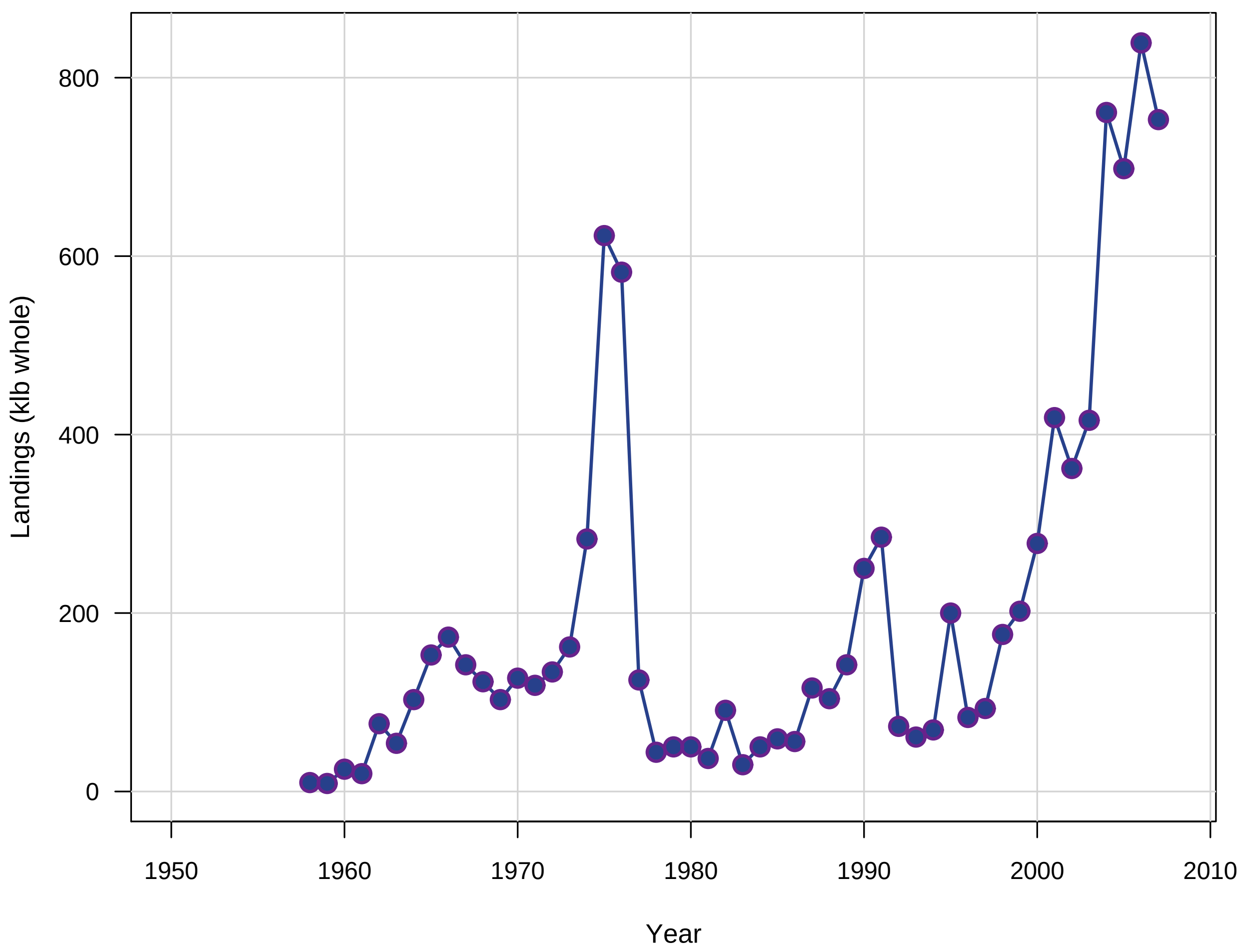


Figure 1.14. Spanish mackerel: Observed (open circles) and estimated (solid line, circles) commercial gillnet landings (whole weight). Open and closed circles are indistinguishable.

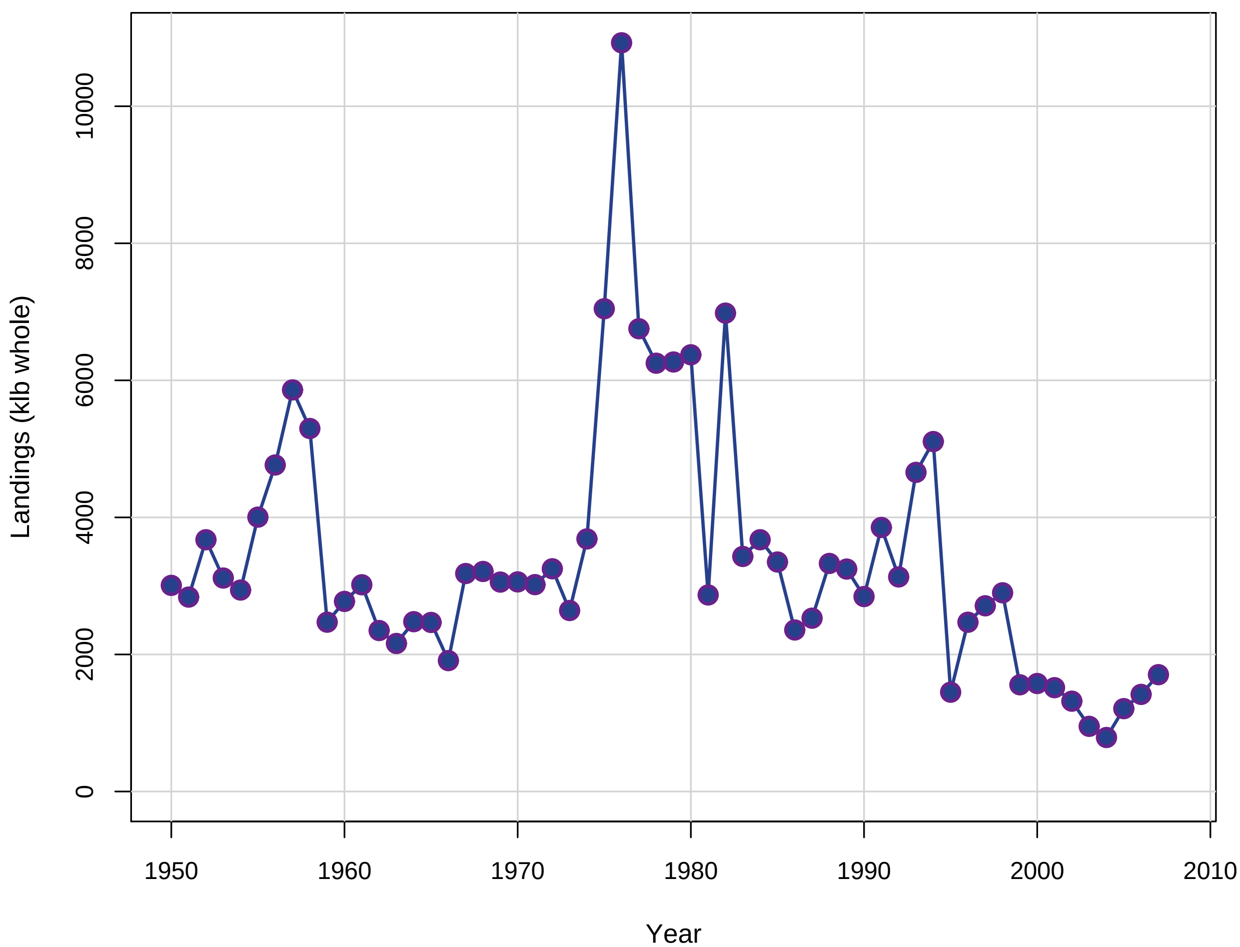


Figure 1.15. Spanish mackerel: Observed (open circles) and estimated (solid line, circles) commercial poundnet landings (whole weight). Open and closed circles are indistinguishable.

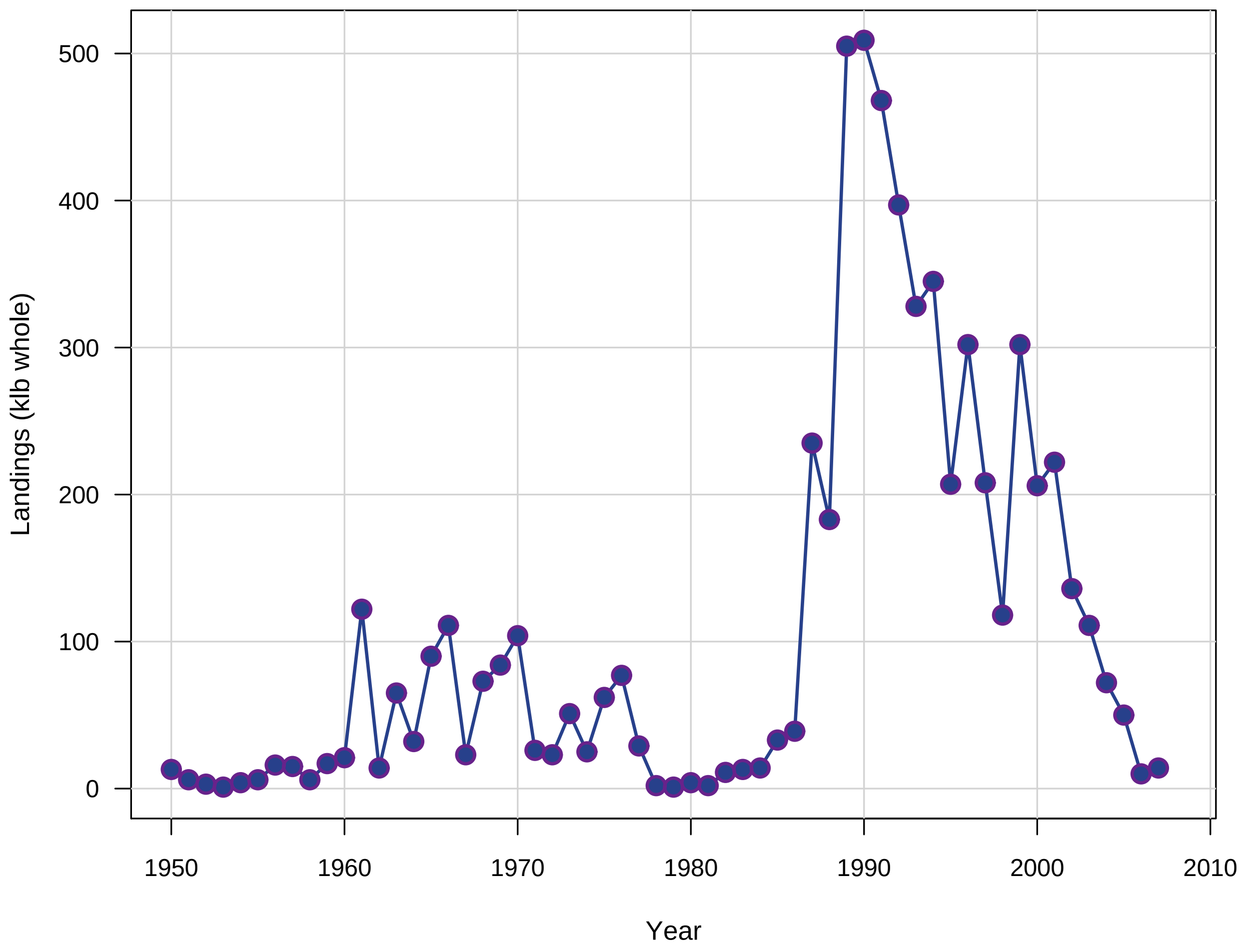


Figure 1.16. Spanish mackerel: Observed (open circles) and estimated (solid line, circles) commercial castnet landings (whole weight). Open and closed circles are indistinguishable.

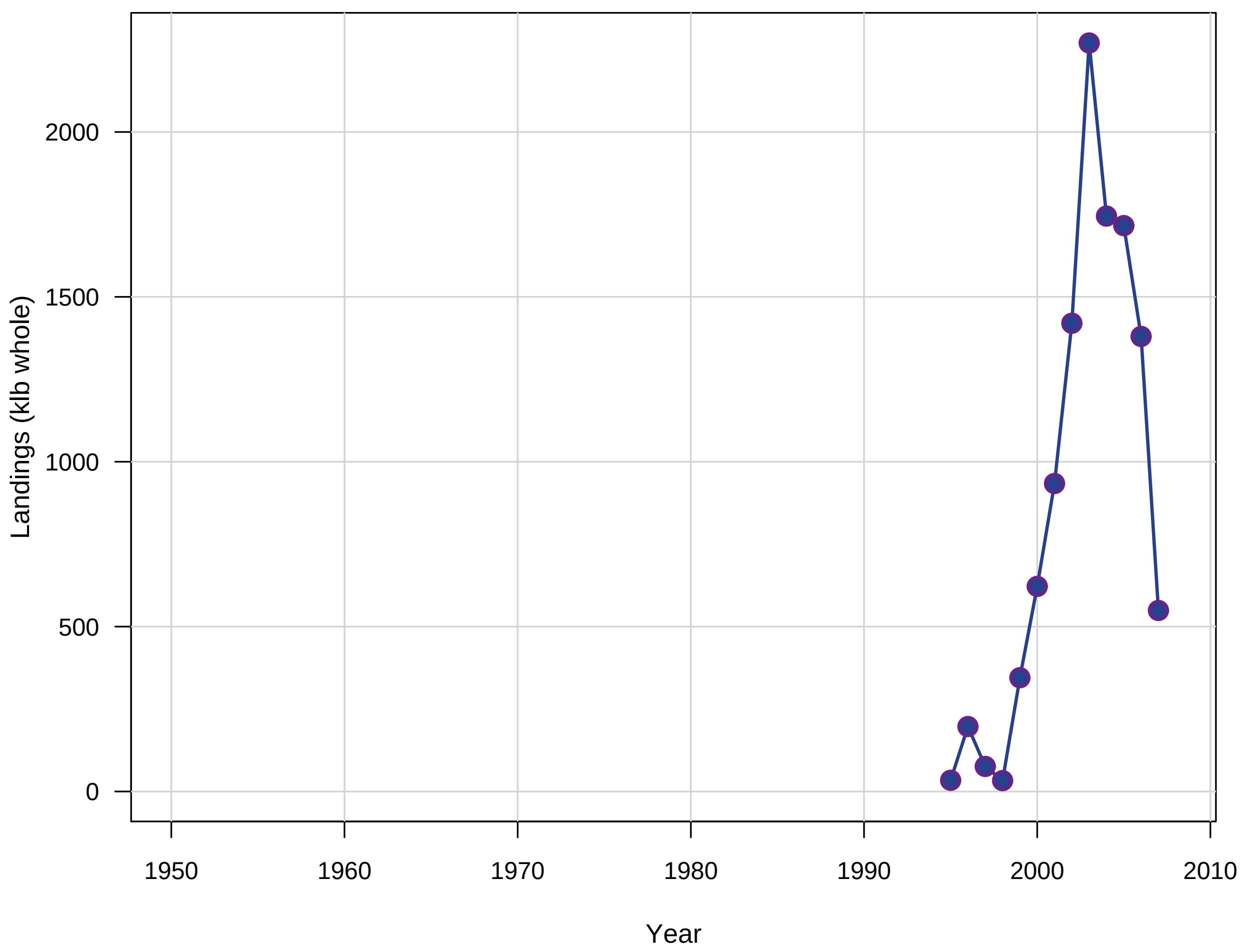


Figure 1.17. Spanish mackerel: Observed (open circles) and estimated (solid line, circles) general recreational landings (whole weight). Open and closed circles are indistinguishable.

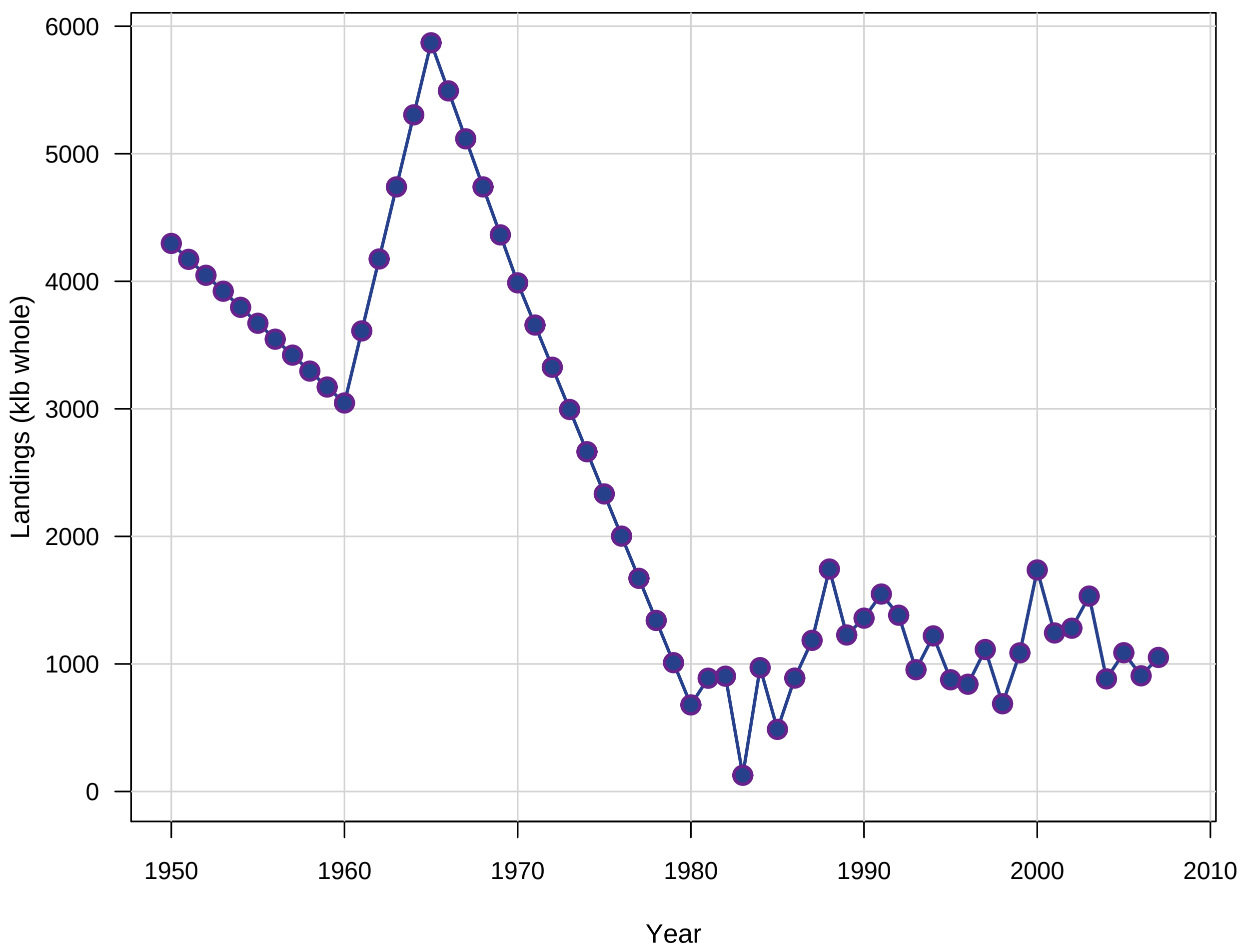


Figure 1.18. Spanish mackerel: Observed (open circles) and estimated (solid line, circles) commercial handline discard mortalities. Open and closed circles are indistinguishable.

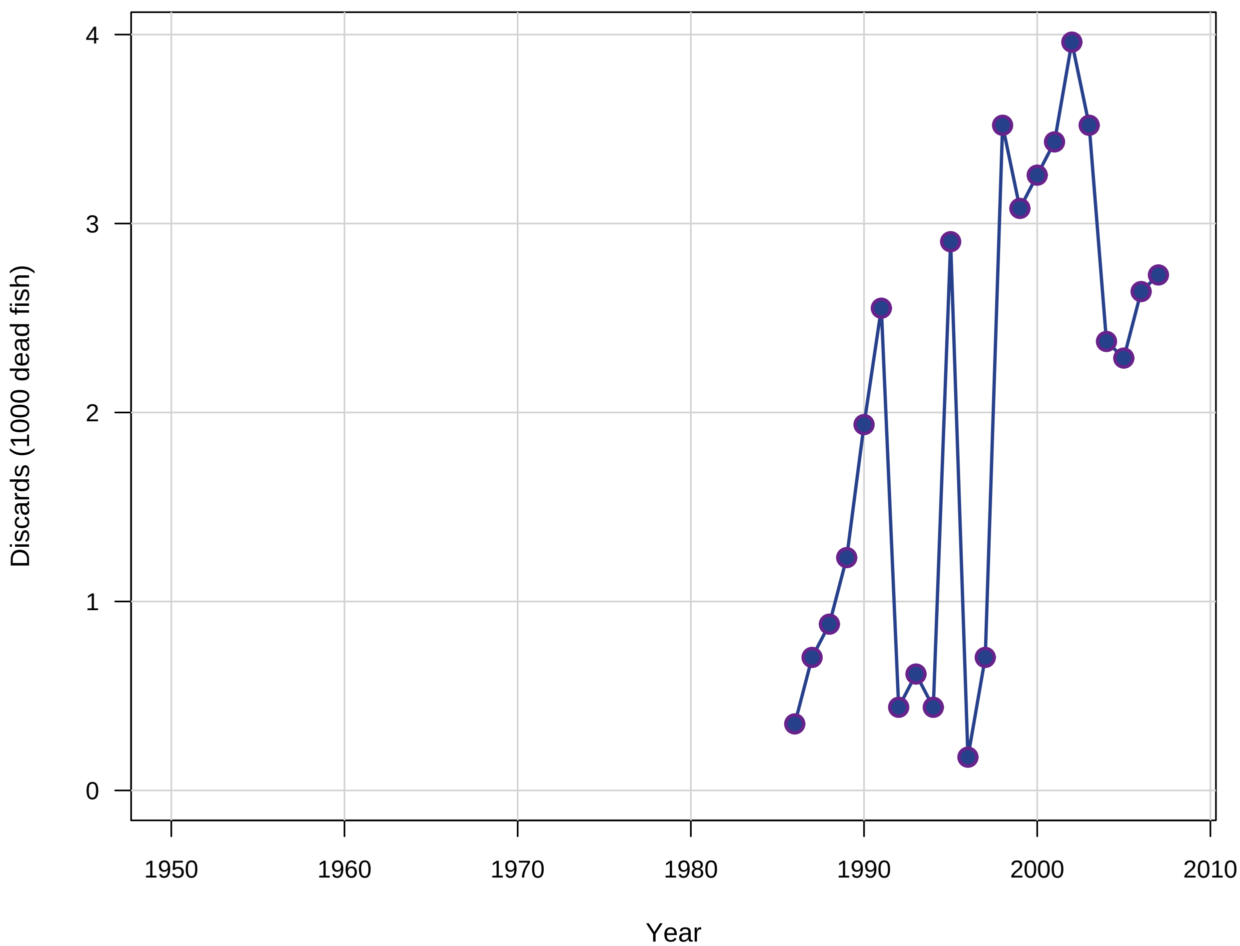


Figure 1.19. Spanish mackerel: Observed (open circles) and estimated (solid line, circles) commercial gillnet discard mortalities. Open and closed circles are indistinguishable.

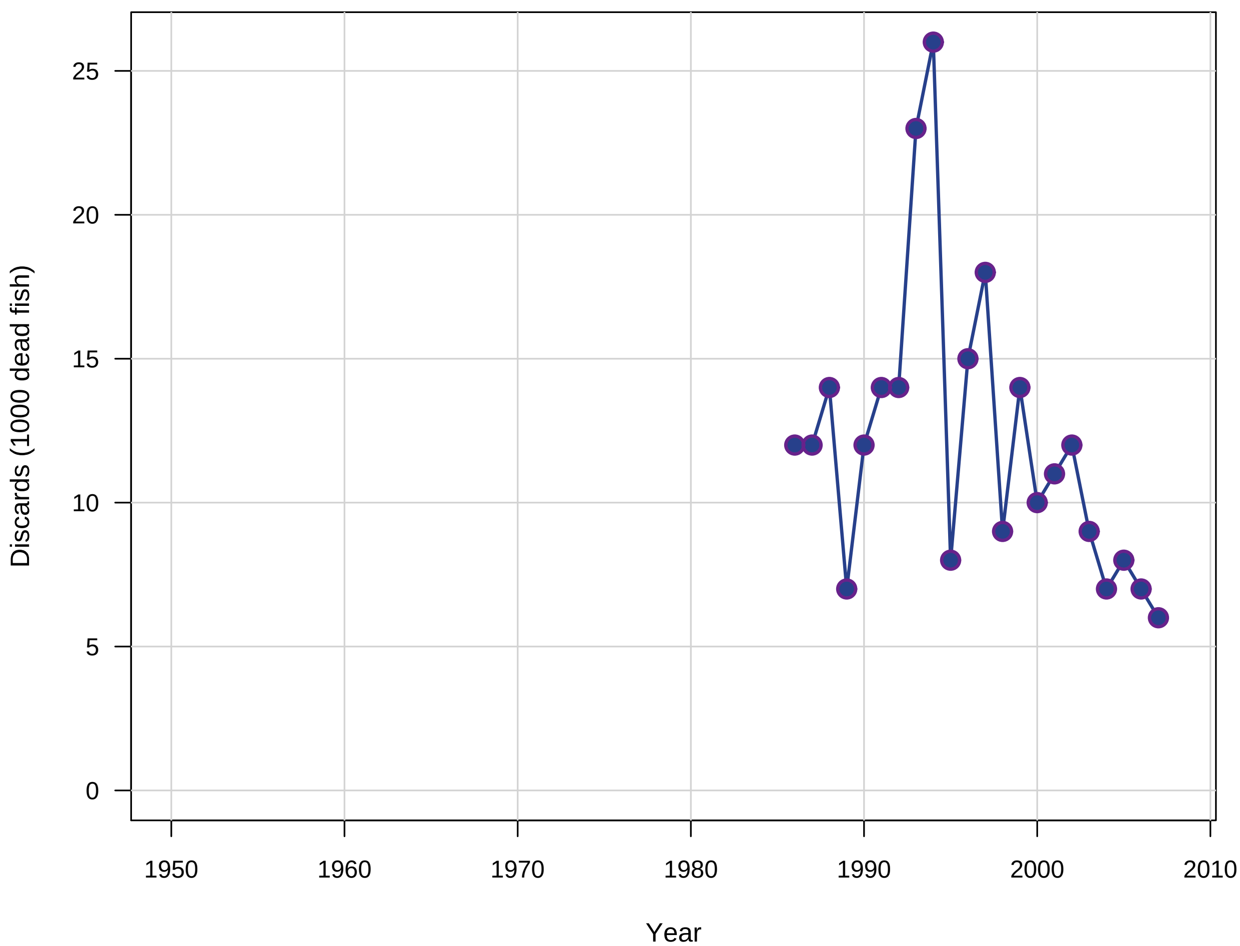


Figure 1.20. Spanish mackerel: Observed (open circles) and estimated (solid line, circles) general recreational discard mortalities. Open and closed circles are indistinguishable.

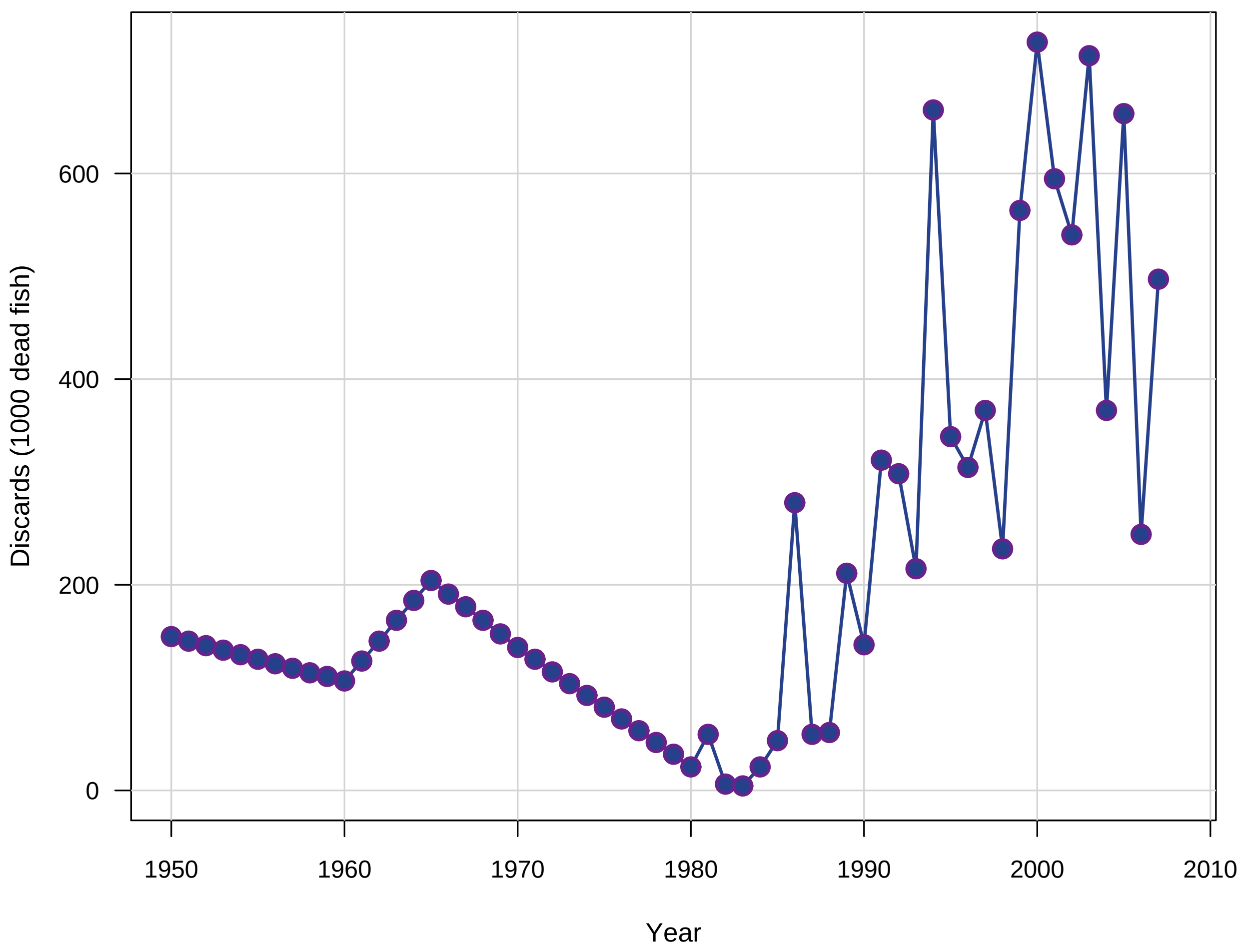


Figure 1.21. Spanish mackerel: Observed (open circles) and estimated (solid line, circles) bycatch mortalities in the shrimp fishery. Open and closed circles are indistinguishable.

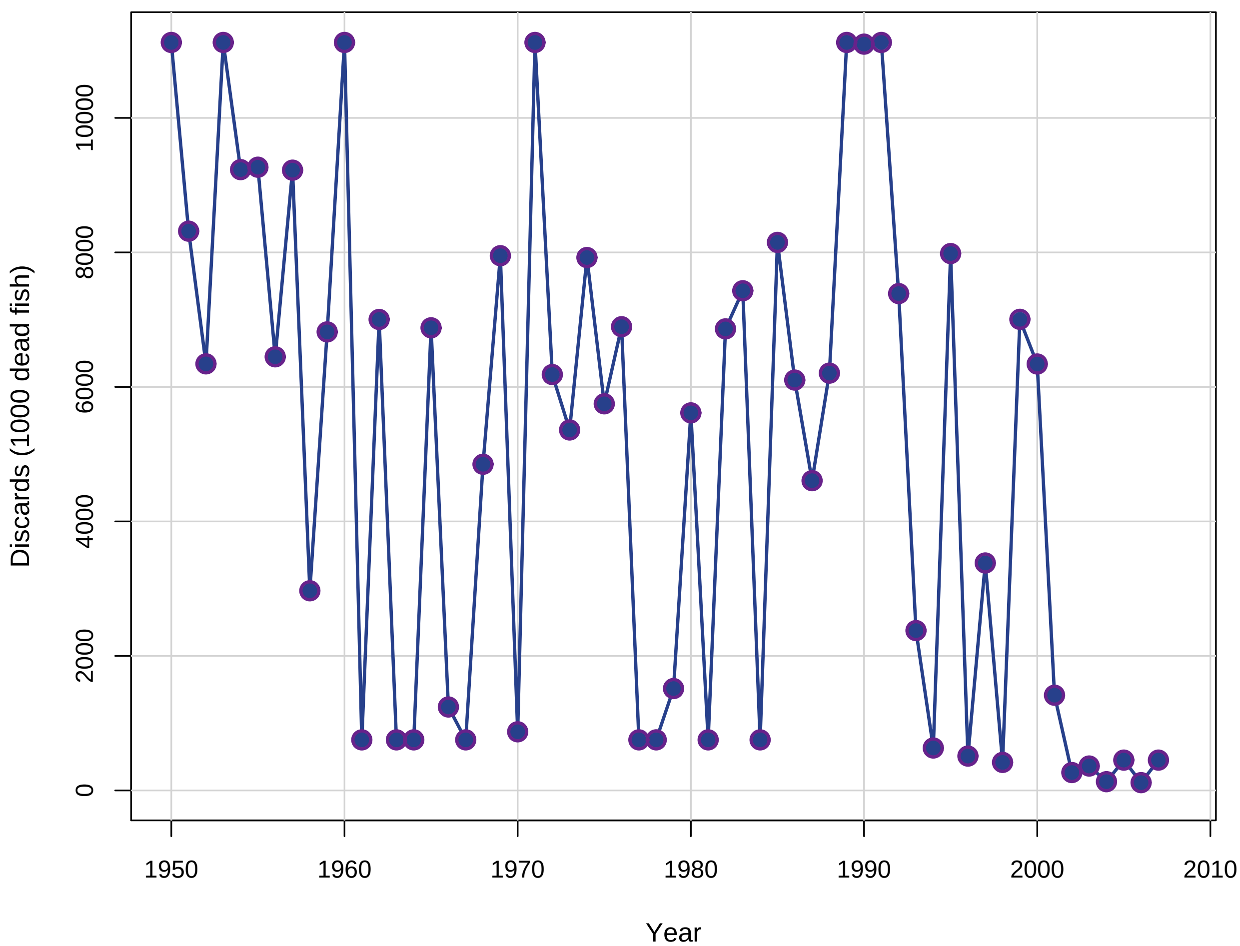


Figure 1.22. Spanish mackerel: Fit to the combined CPUE index of abundance; Observed (open circles) and estimated (solid line, circles).

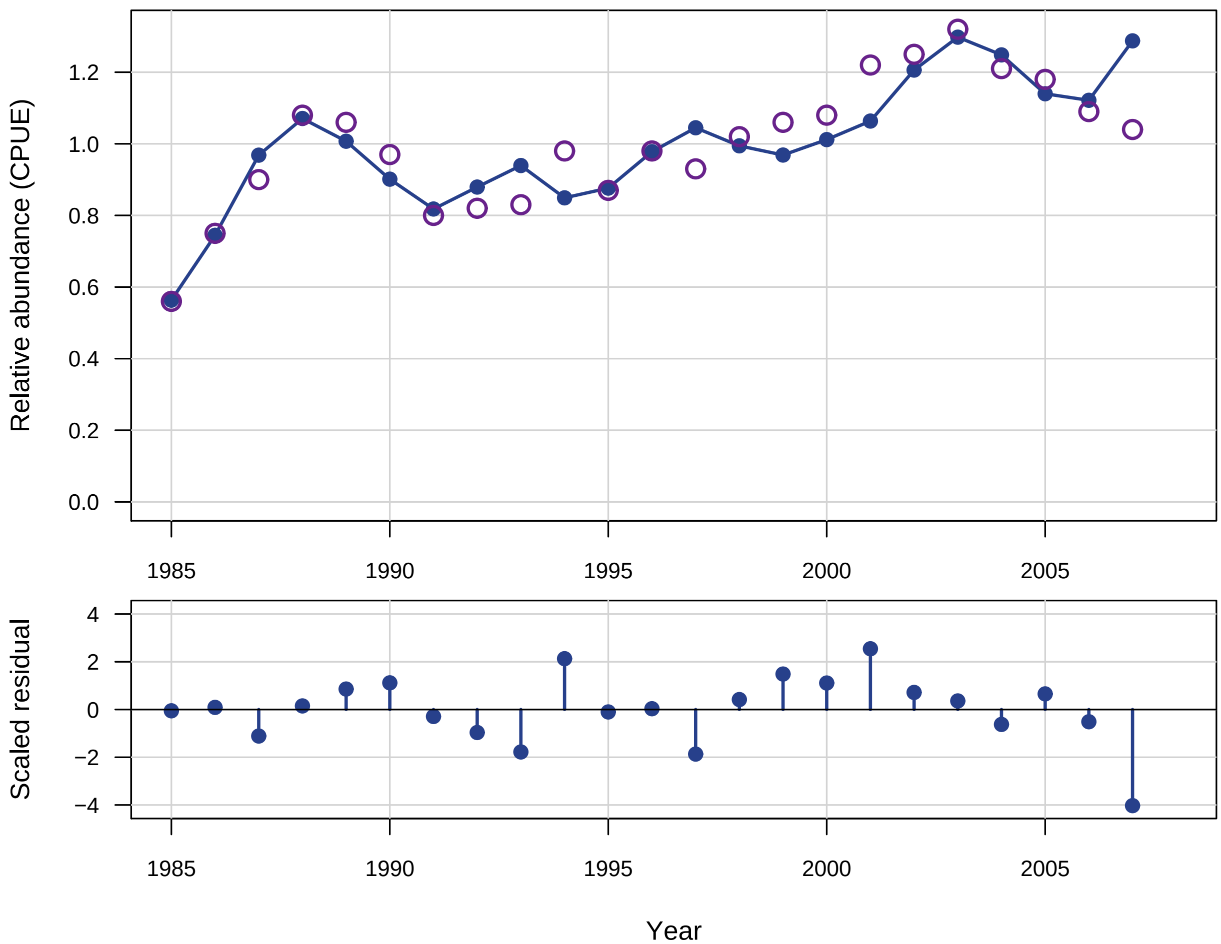


Figure 1.23. Spanish mackerel: Fit of index of abundance from the SEAMAP young-of-year trawl survey; Observed (open circles) and estimated (solid line, circles).

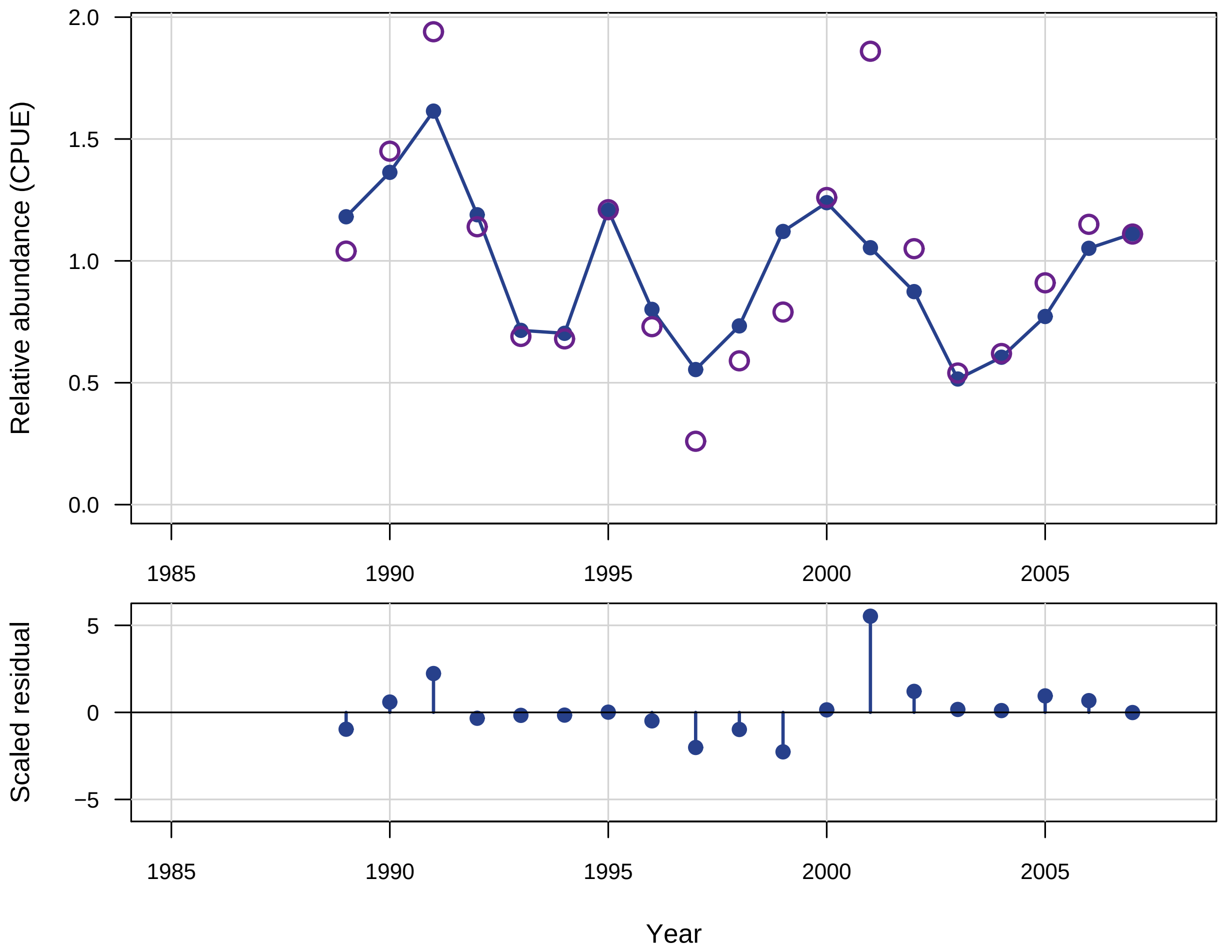


Figure 1.24. Spanish mackerel: Mean length at age (mm) and estimated 95% confidence interval for male Spanish mackerel.

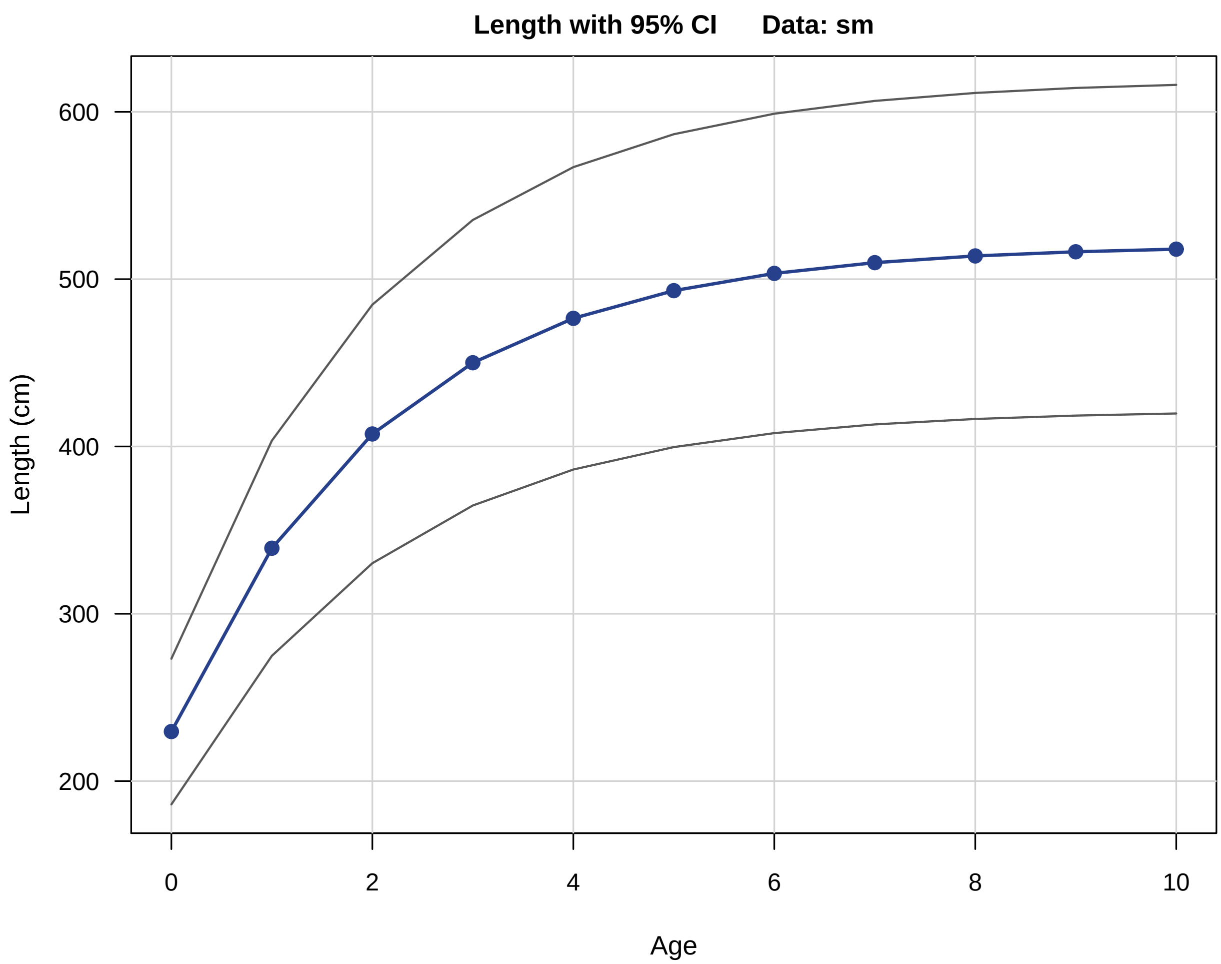


Figure 1.25. Spanish mackerel: Mean length at age (mm) and estimated 95% confidence interval for female Spanish mackerel.

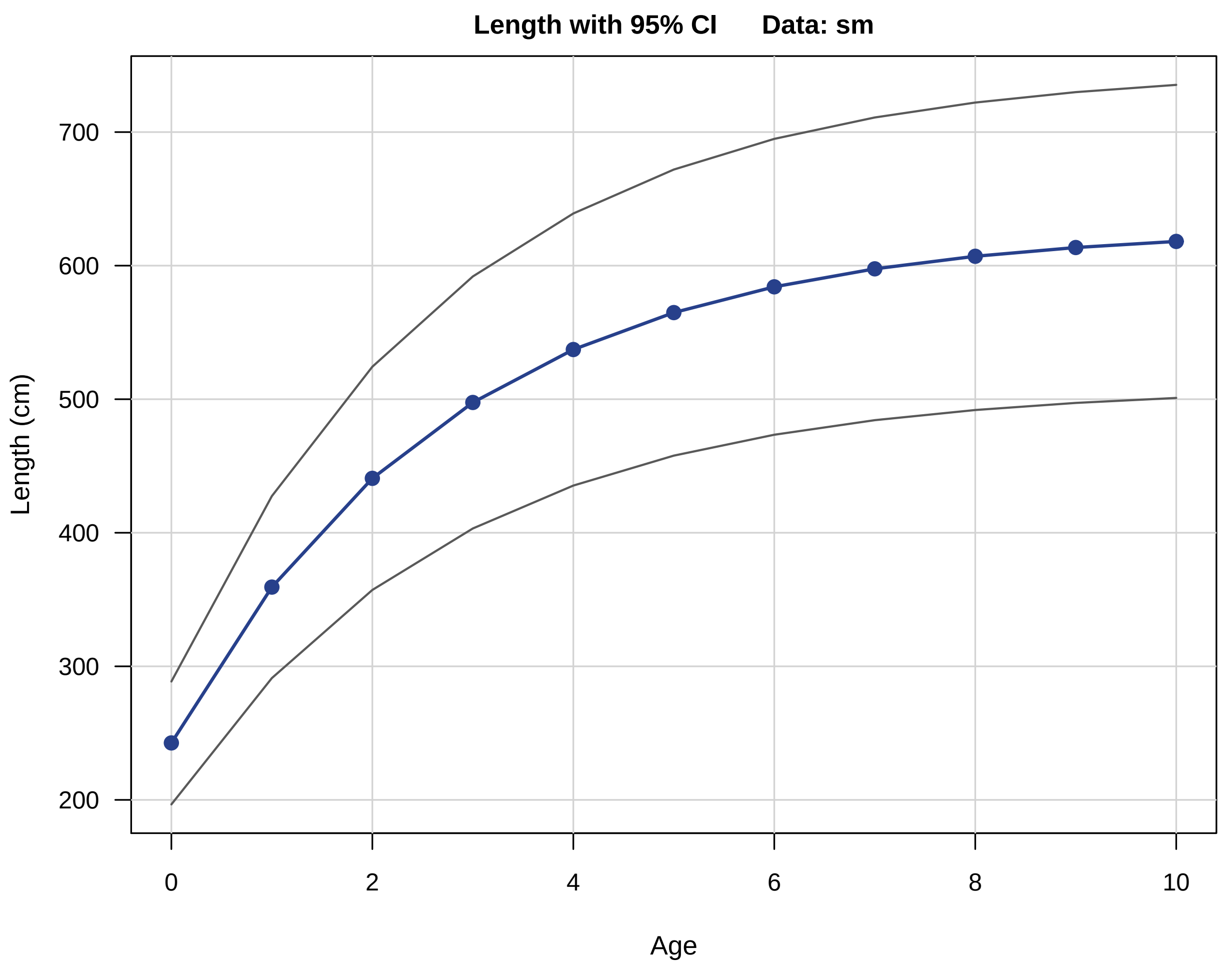


Figure 1.26. Spanish mackerel: Top panel – Estimated recruitment of age-1 fish. Bottom panel – log recruitment residuals.

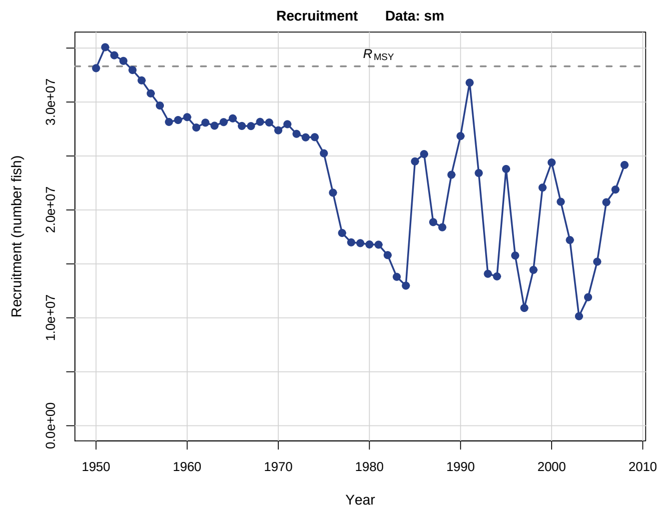


Figure 1.27. Spanish mackerel: Estimated spawning biomass (metric tons) at midpoint of each year by age class.

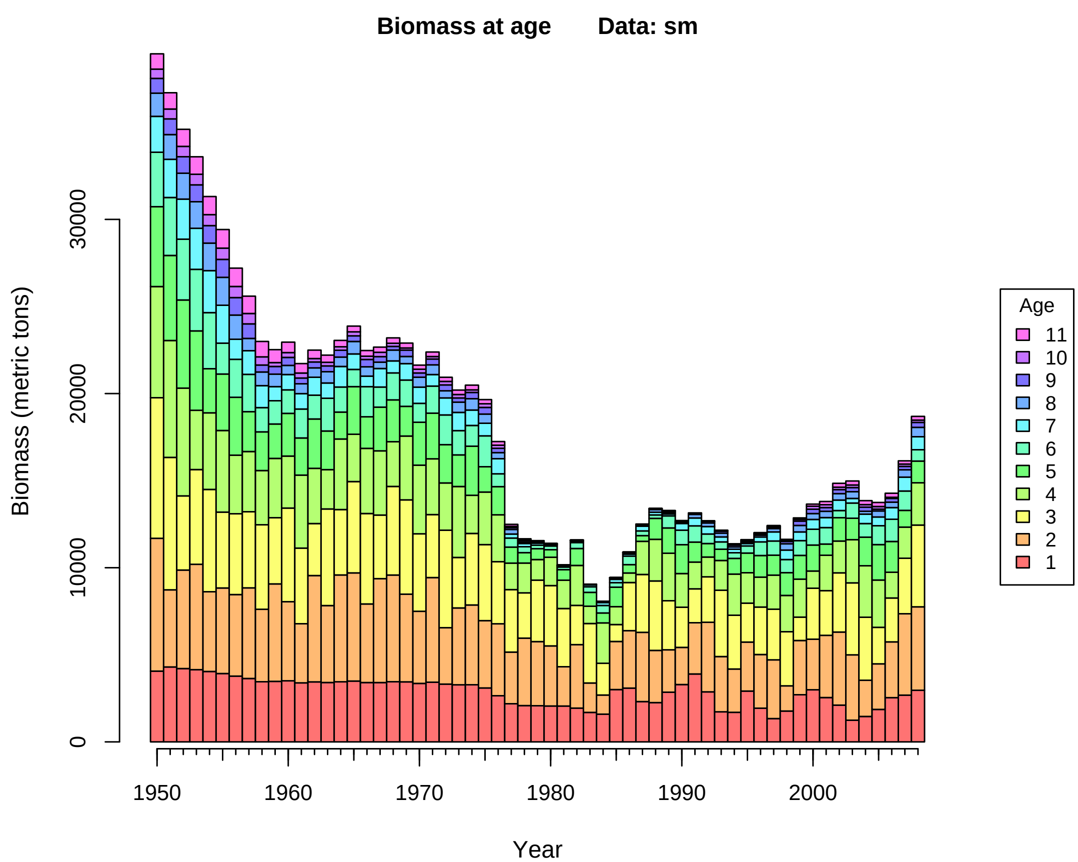


Figure 1.28. Spanish mackerel: Estimated spawning biomass (metric tons) at midpoint of year in relation to management benchmarks.

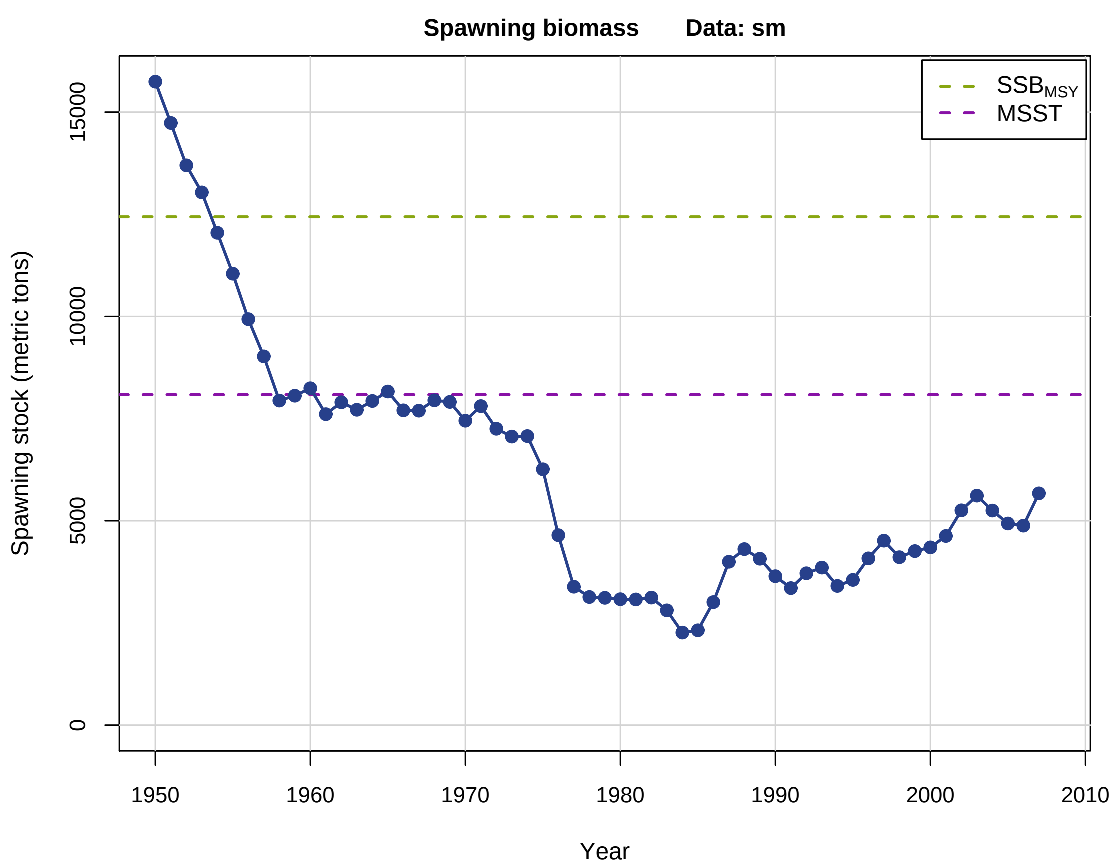


Figure 1.29. Spanish mackerel: Estimated instantaneous fishing mortality rate (per year) by fishery. HL refers to commercial handlines, GN to commerical gillnets, PN to commercial poundnets, CN to commercial castnets, MRFSS to general recreational, HL.D to commercial handline discard mortalities, GN.D to commercial gillnet discards, MRFSS.D to recreational discards, and shrimp.B to bycatch in the shrimp fishery.

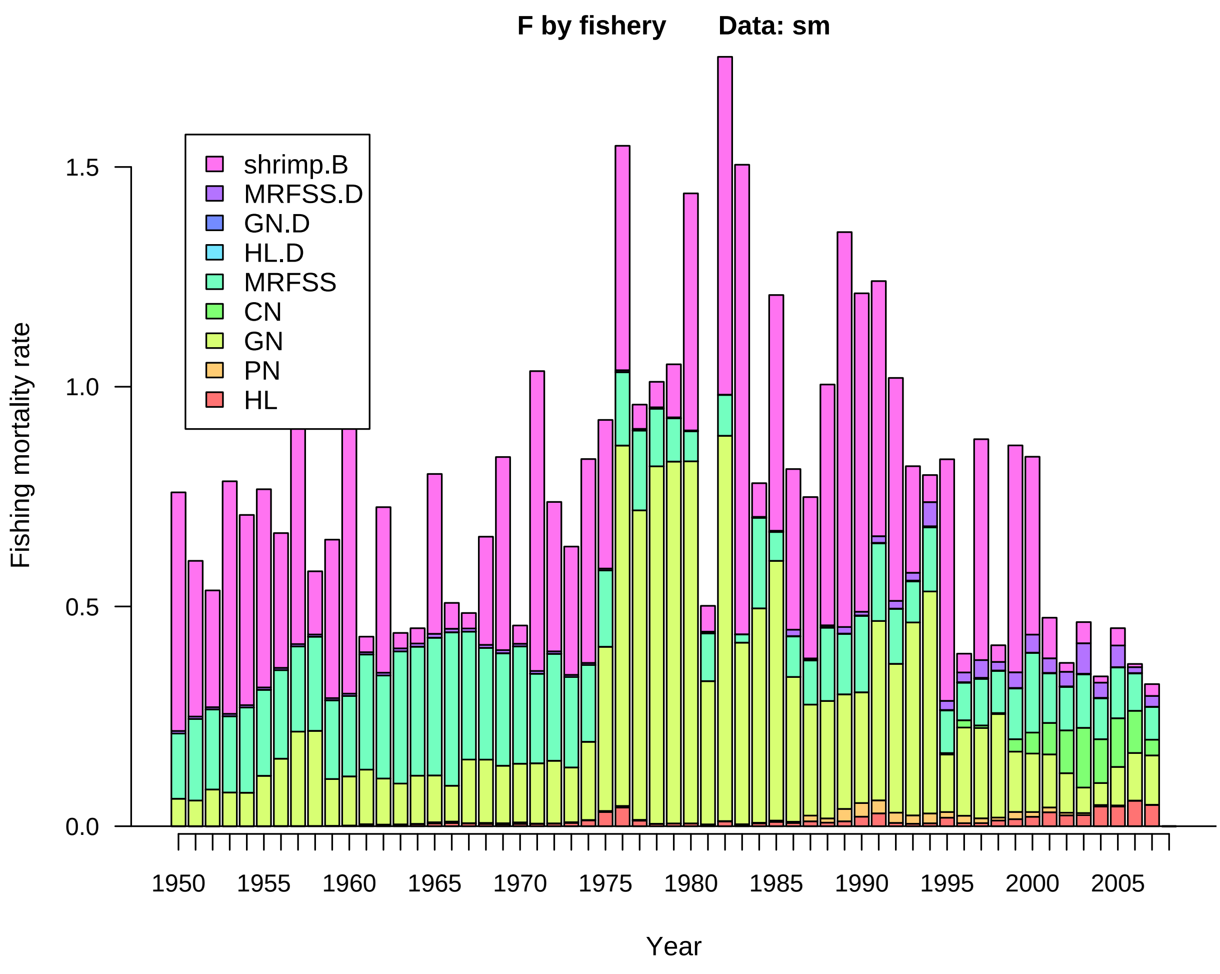


Figure 1.30. Spanish mackerel: A comparison of catch curve estimates of full F (colored circles; obtained by subtracting out a constant natural mortality rate of 0.35) to full F values obtained form the catch-age model (black line and circles). The latter was adjusted so that the selectivity at full F had a maximum of 1.0 (this was not the case in the assessment model).

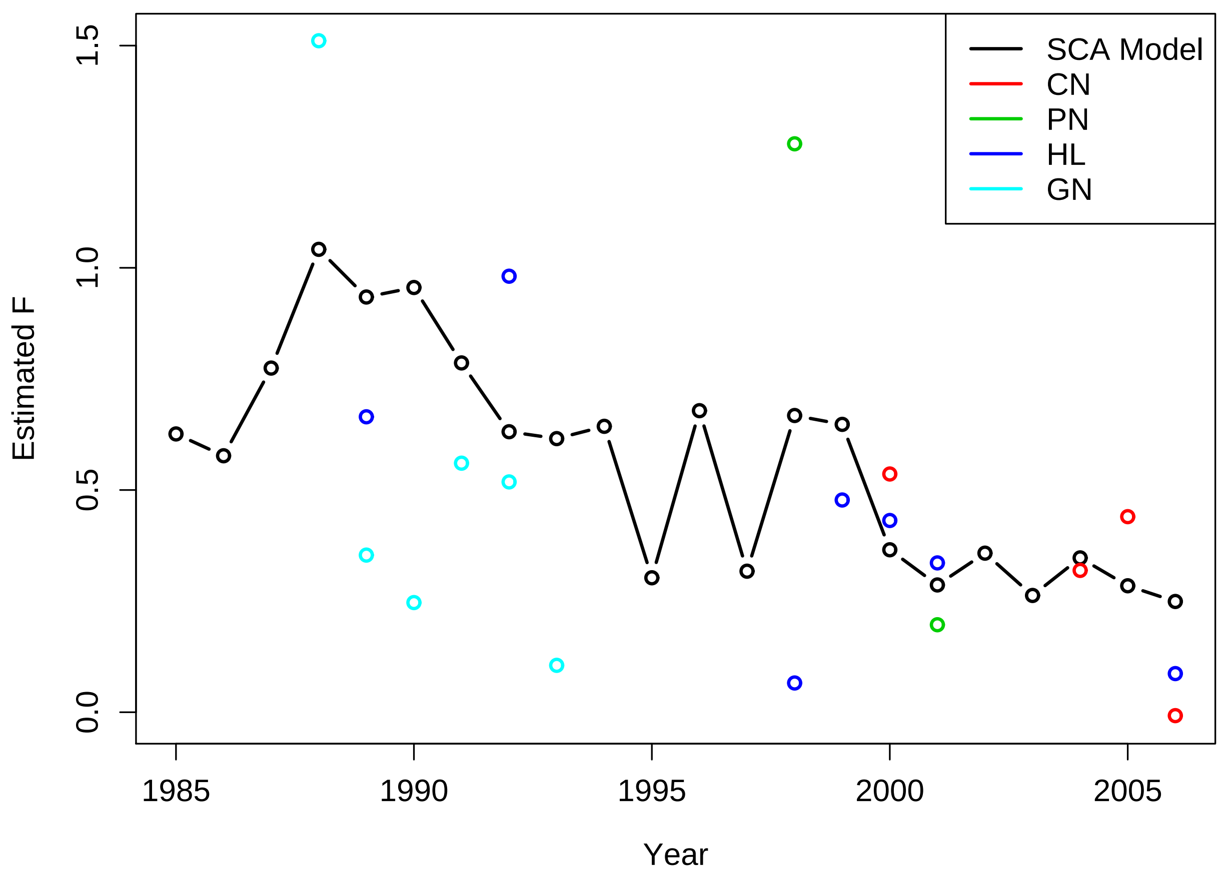


Figure 1.31. Spanish mackerel: Estimated landings by fishery from the catch-at-age model. HL refers to commercial handlines, GN to commerical gillnets, PN to commercial poundnets, CN to commercial castnets, and MRFSS to general recreational.

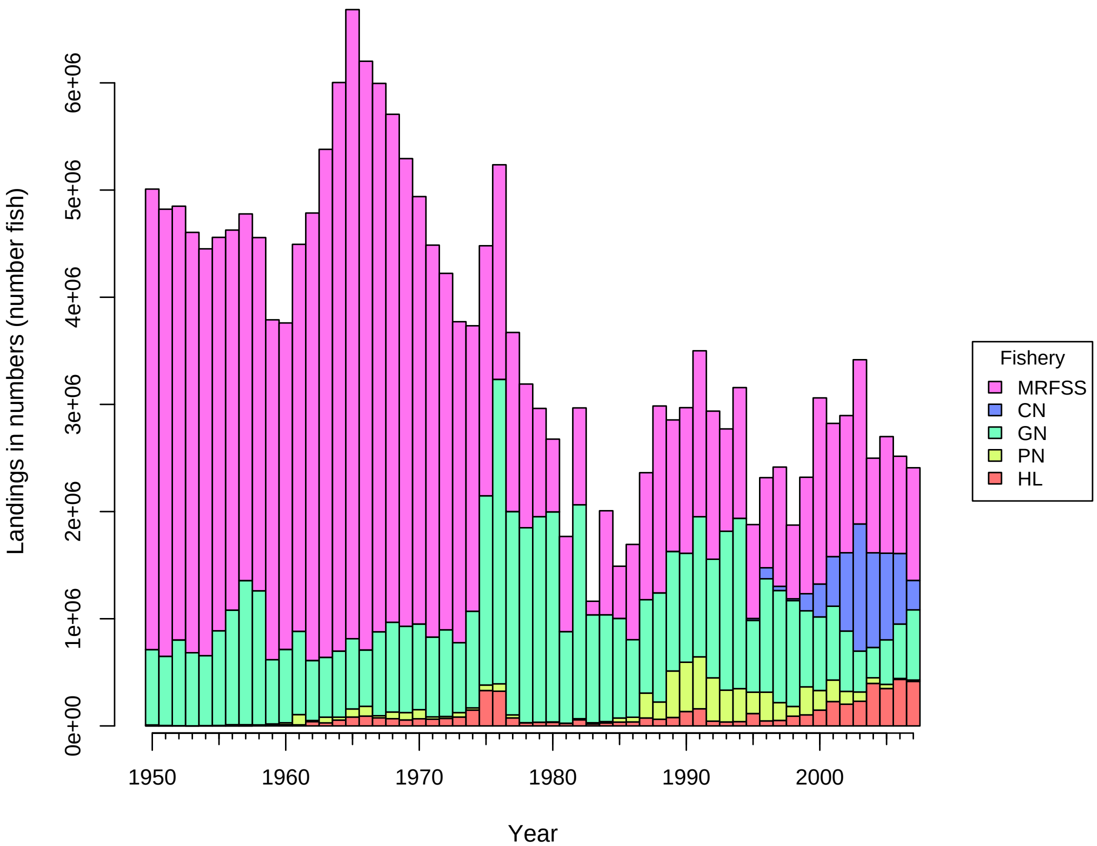


Figure 1.32. Spanish mackerel: Estimated discard and bycatch mortalities by fishery from the catch-at-age model. HL refers to commercial handline discard mortalities, GN to commercial gillnet discards, MRFSS to recreational discards, and shrimp to bycatch in the shrimp fishery.

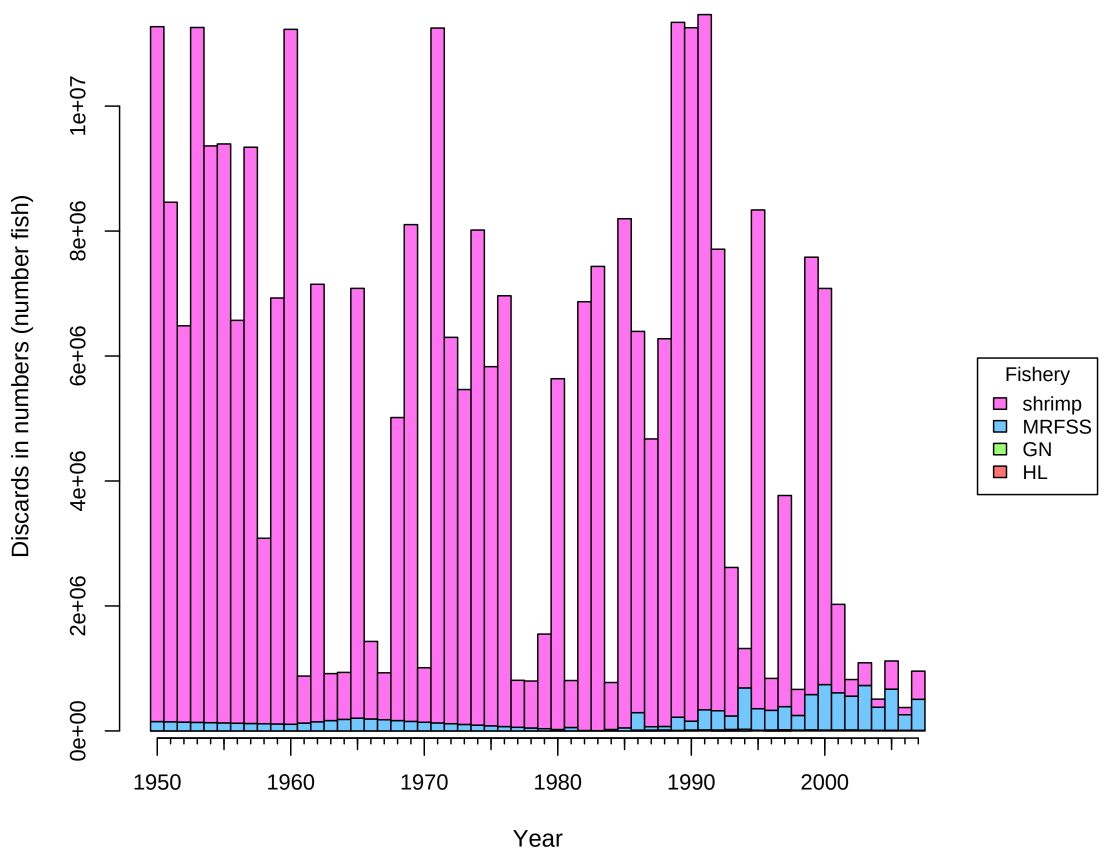


Figure 1.33. Spanish mackerel: Estimated Beverton–Holt spawner-recruit curves, with and without lognormal bias correction.

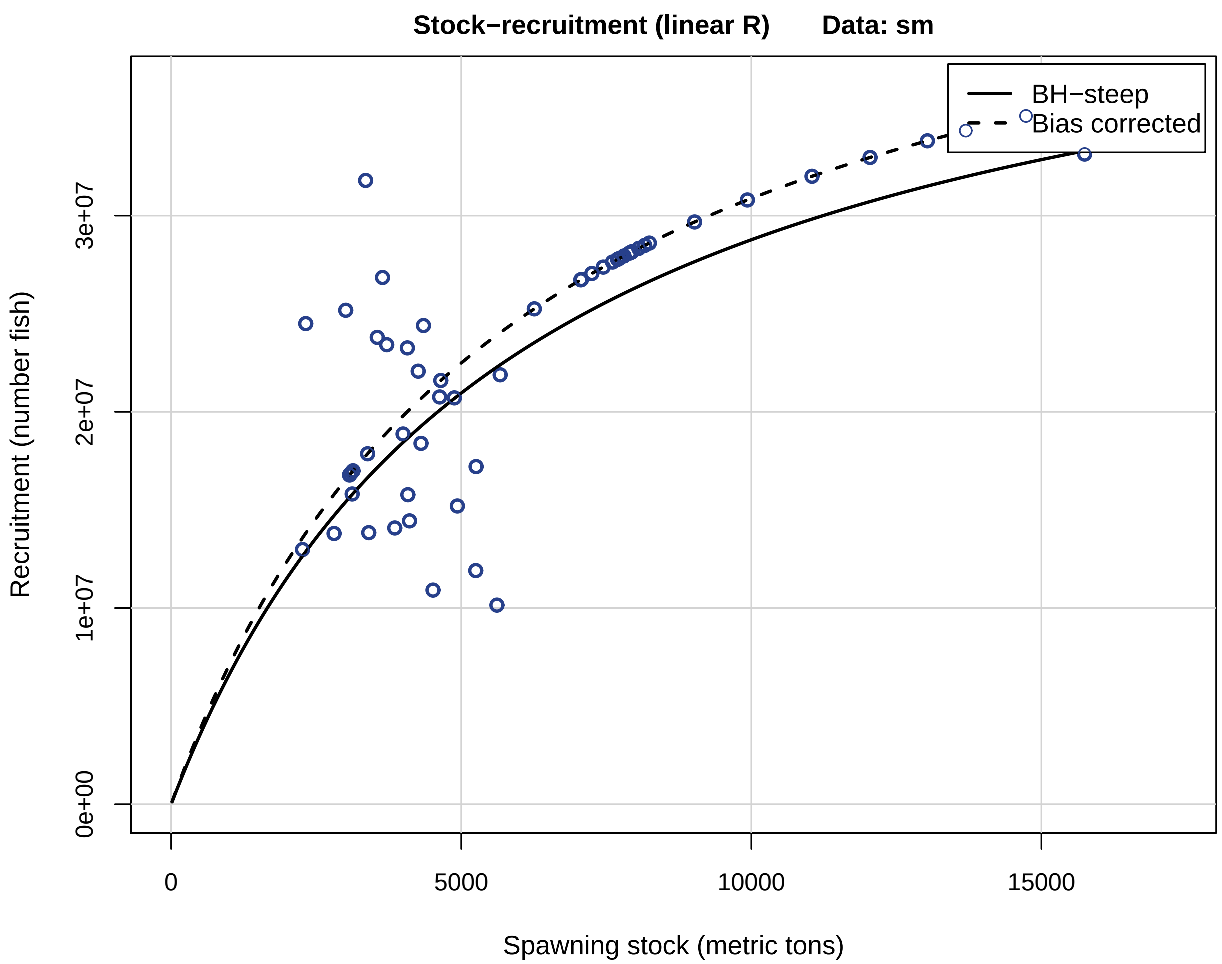


Figure 1.34. Spanish mackerel: Recruits per spawner as a function of the number of spawners (log scale).

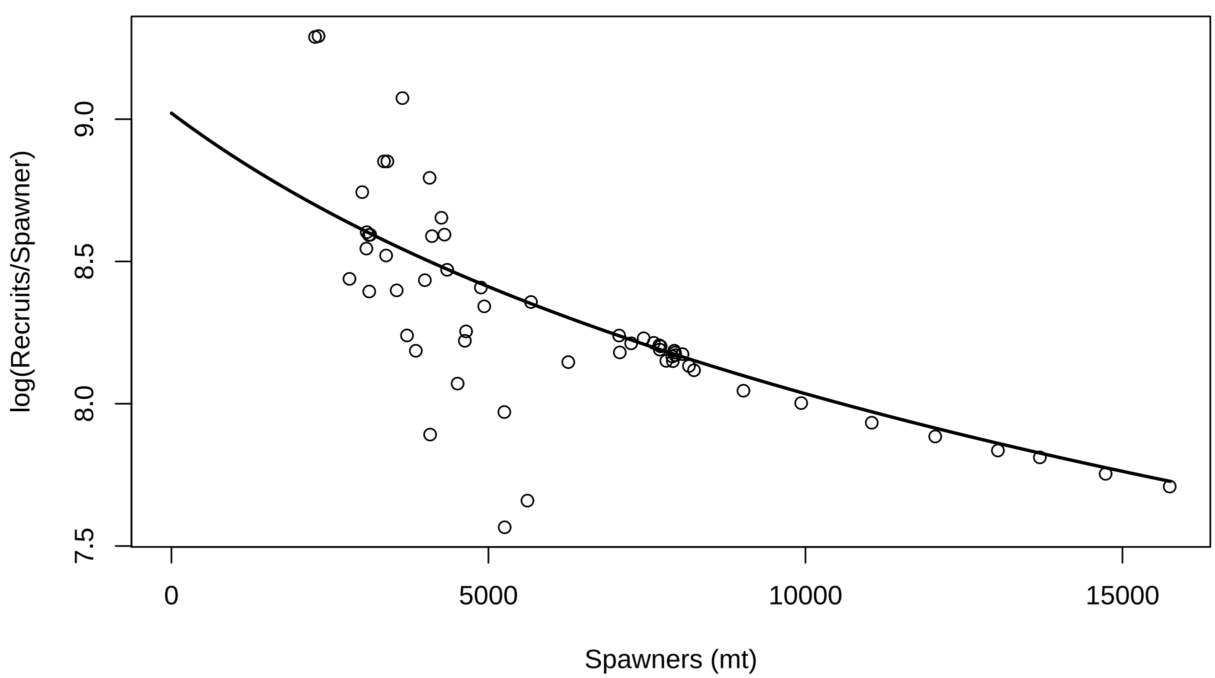


Figure 1.35. Spanish mackerel: Uncertainty in stock-recruit parameters generated by bootstrapping stock-recruit residuals. Vertical lines represent estimates from the assessment model

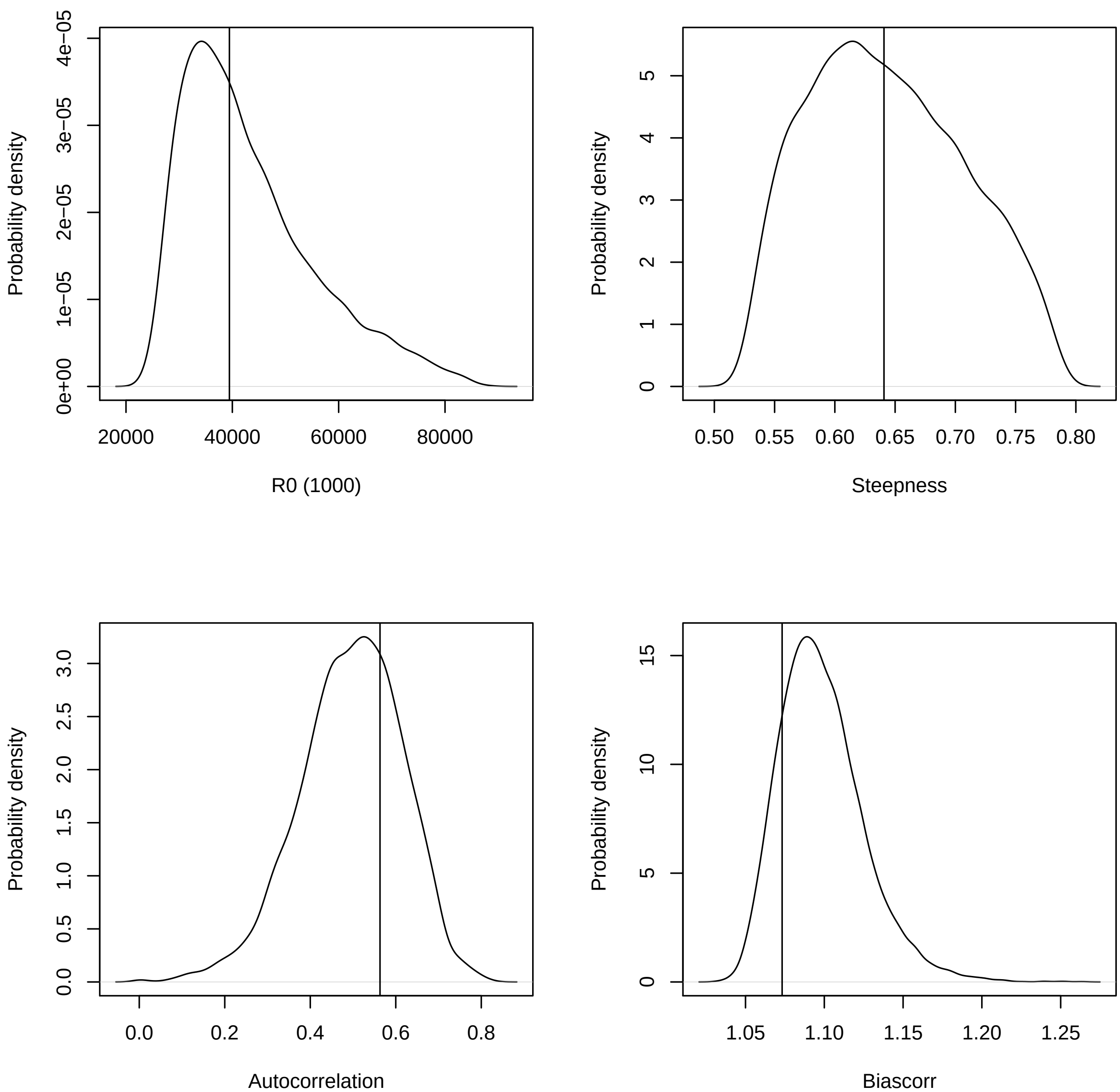


Figure 1.36. Spanish mackerel: Estimated time series of static spawning potential ratio, the annual equilibrium spawners per recruit relative to that at the unfished level.

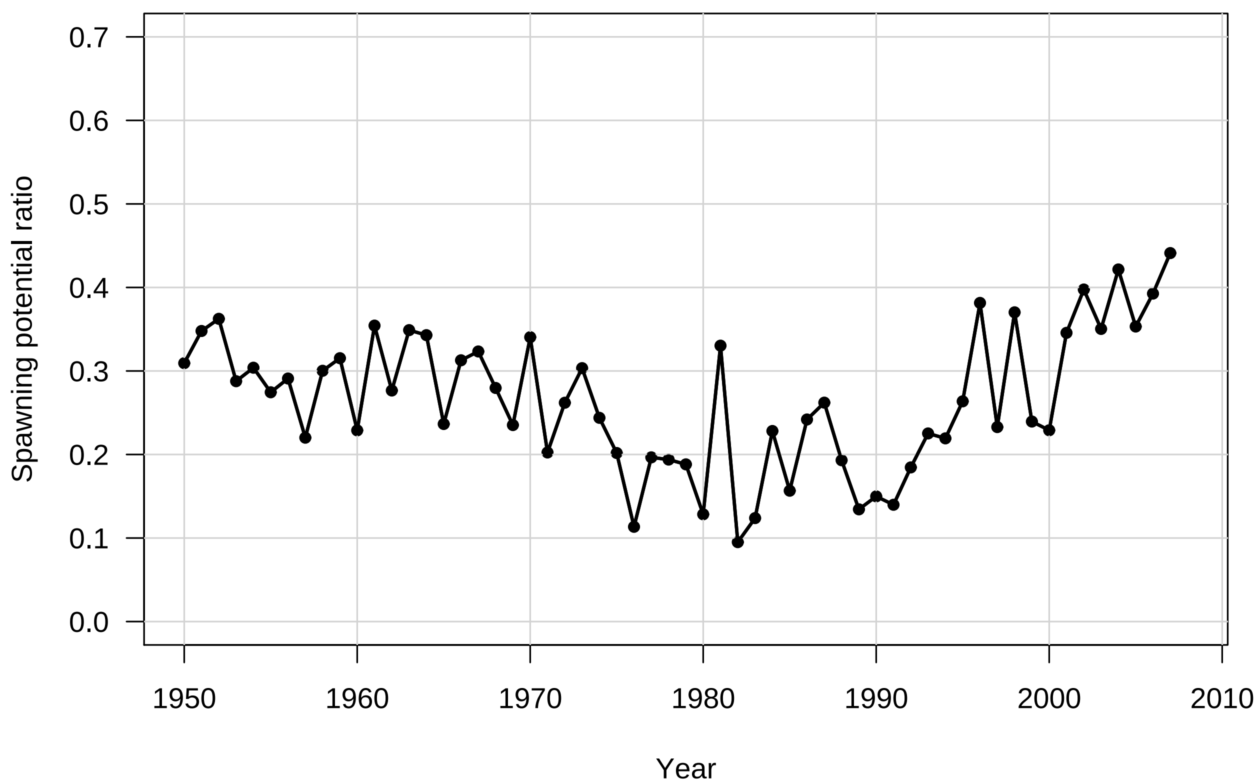


Figure 1.37. Spanish mackerel: Top panel – Yield per recruit, from which the maximum provides $F_{\max}$. Bottom panel – Spawning potential ratio (spawners per recruit relative to that at the unfished level), from which the 30% and 40% levels provide $F_{30\%}$ and $F_{40\%}$. Both curves are based on average selectivity from the end of the assessment period.

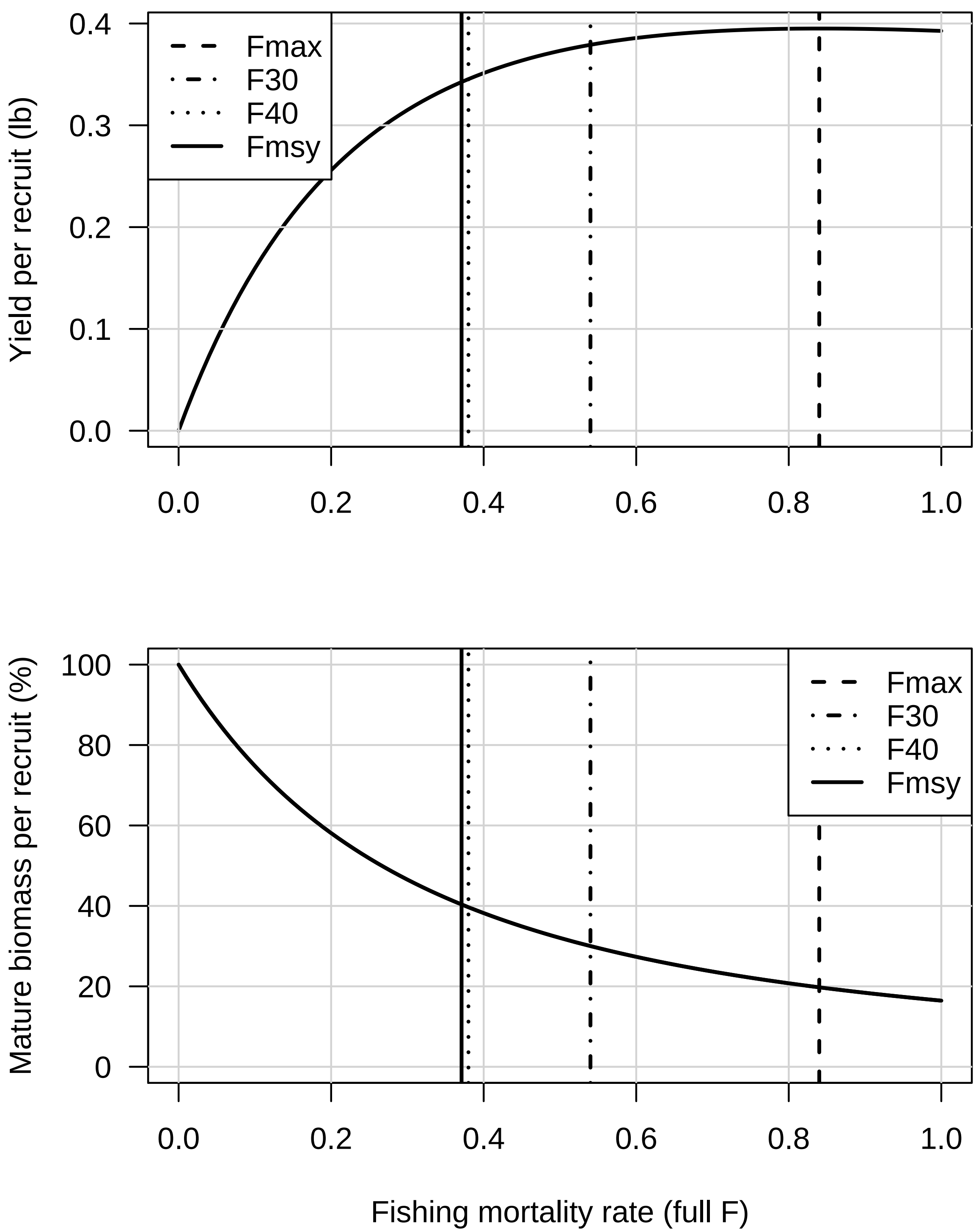


Figure 1.38. Spanish mackerel: Top panel – Equilibrium landings. Bottom panel – Equilibrium spawning biomass. Both curves are based on average selectivity from the end of the assessment period.

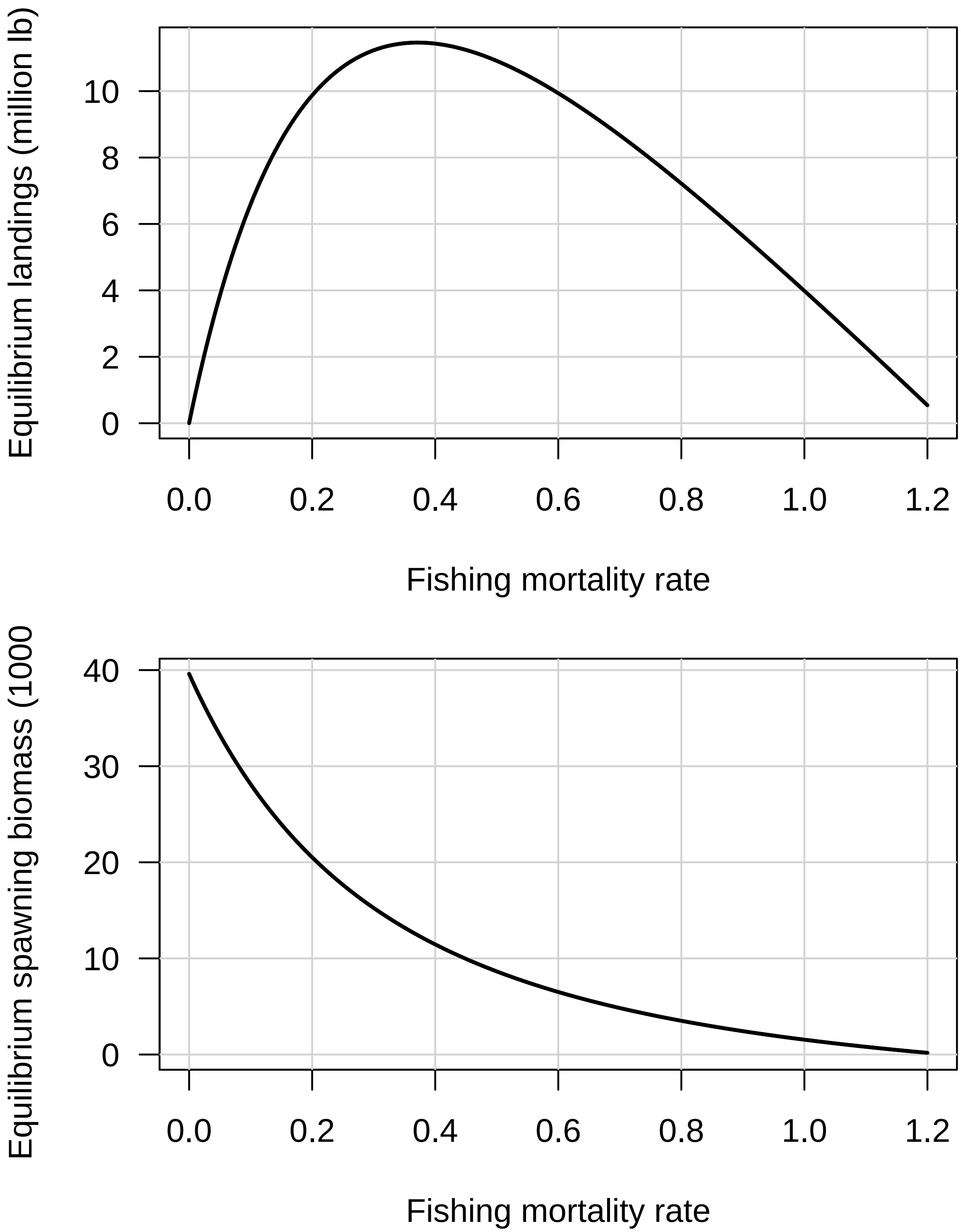


Figure 1.39. Spanish mackerel: Top panel – Equilibrium landings as a function of equilibrium biomass, which itself is a function of fishing mortality rate. The peak occurs where equilibrium biomass is $B_{\mathrm{MSY}} = 40.3$ *1000 mt and equilibrium landings are* MSY $= 13.1$ *million lb. Bottom panel – Equilibrium discard and bycatch mortality as a function of equilibrium biomass.*

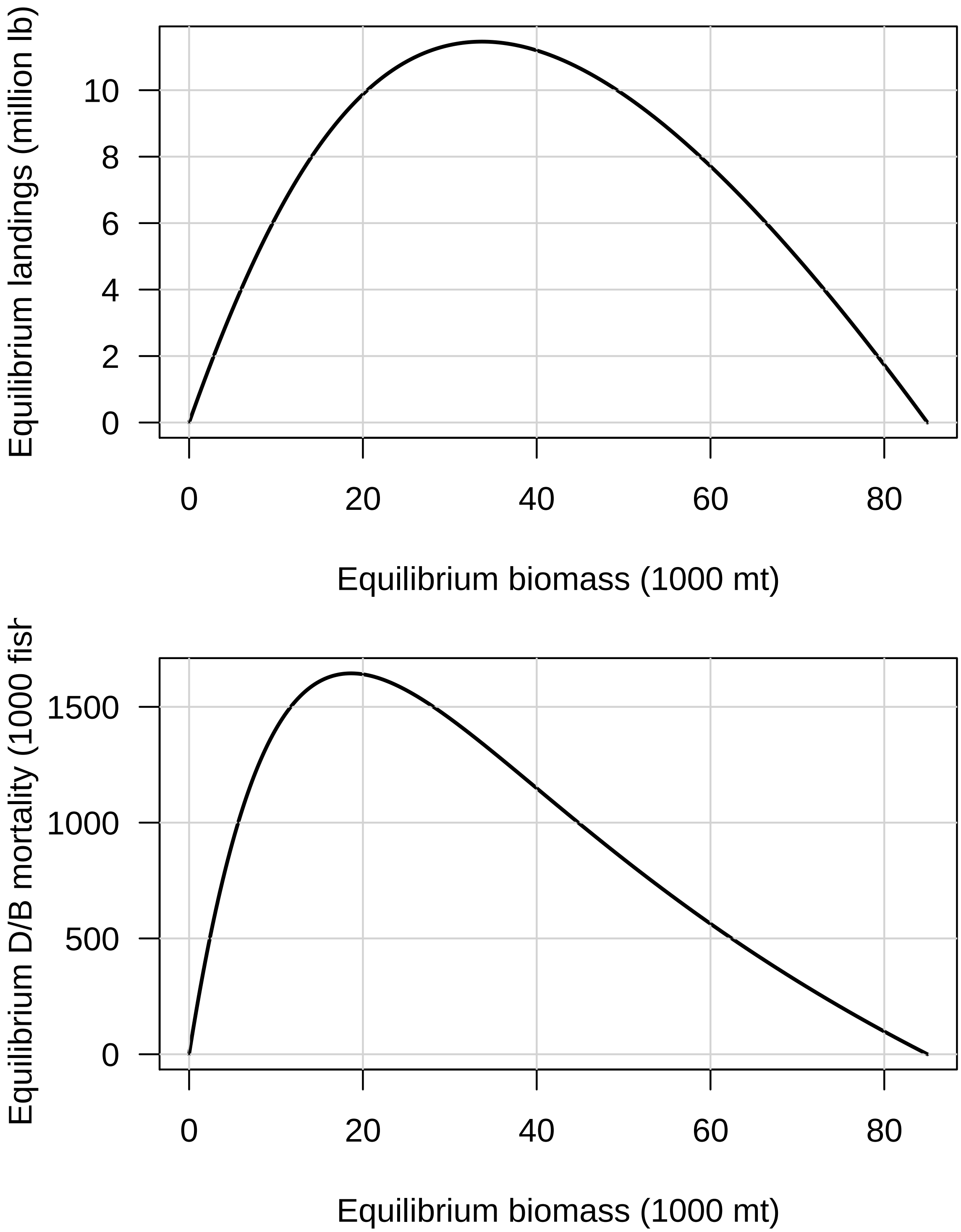


Figure 1.40. Spanish mackerel: Probability densities of MSY*-related benchmarks. Vertical lines represent point estimates.*

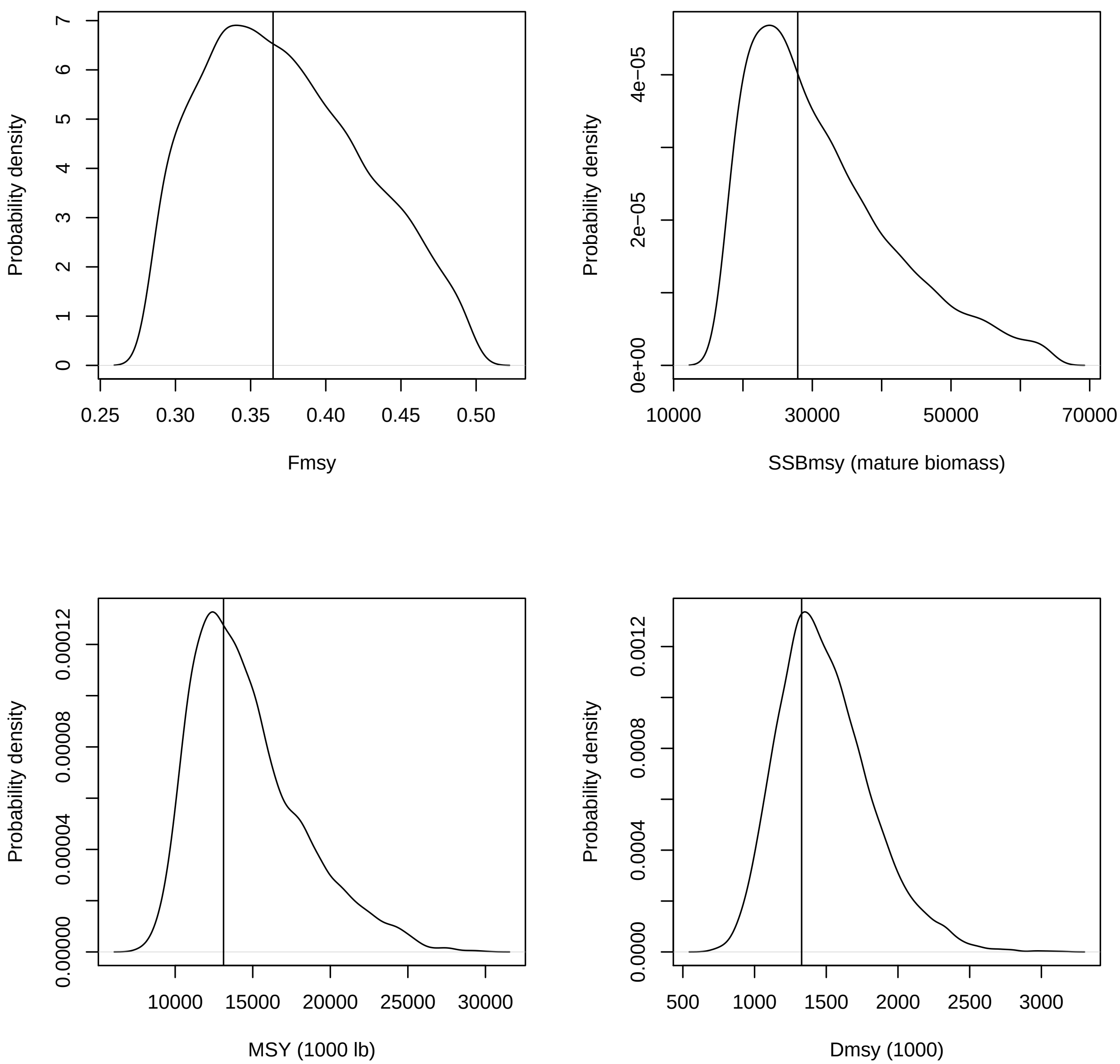


Figure 1.41. Spanish mackerel: Estimated time series of biomass relative to MSY *benchmarks. Top panel – B relative to B_{MSY}. Bottom panel –* SSB *relative to* $\mathrm{SSB}_{\mathrm{MSY}}$.

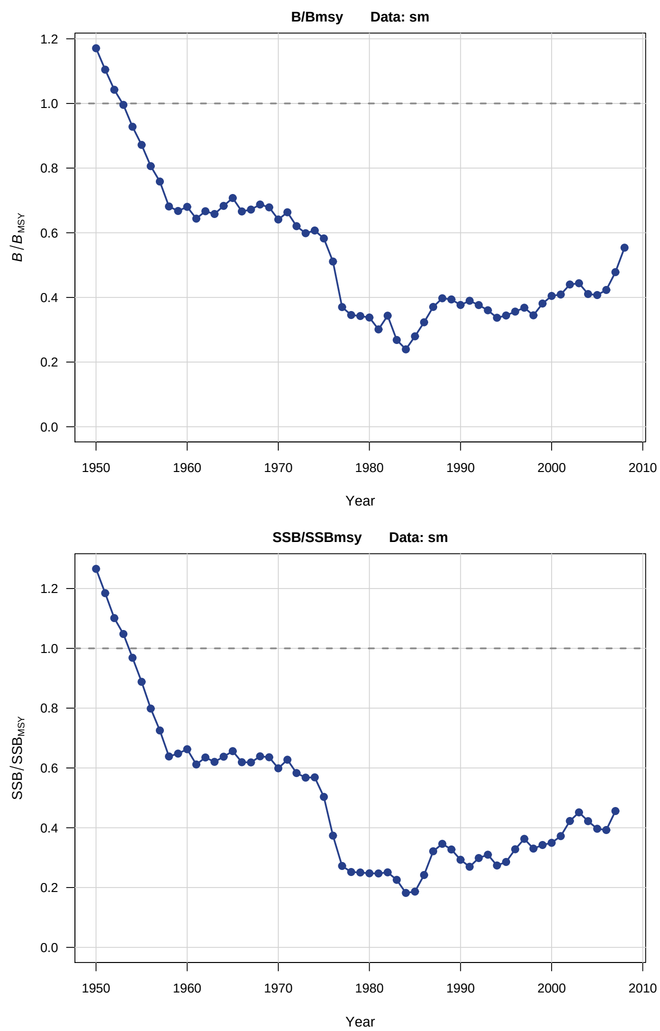


Figure 1.42. Spanish mackerel: Estimated time series of F relative to F_{MSY}.

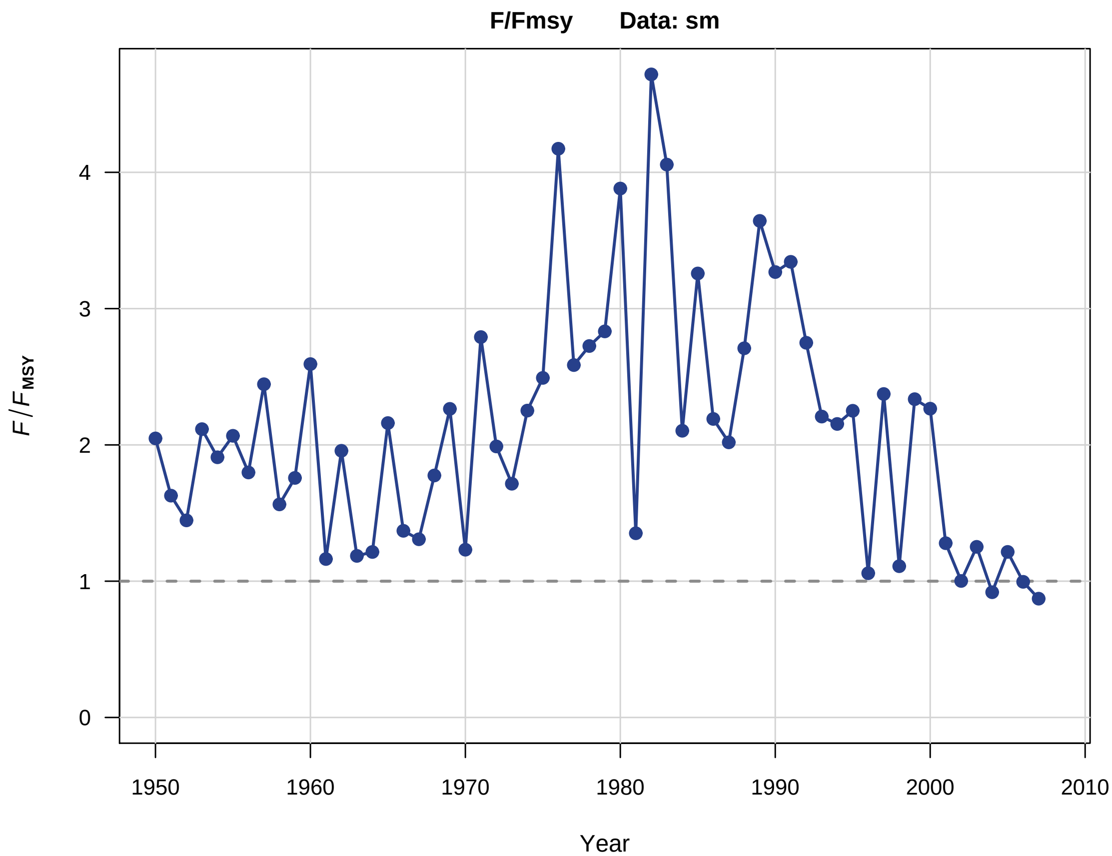


Figure 1.43. Spanish mackerel: Projection results under scenario 1—fishing mortality rate fixed at $F = 0$. *Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to* 10^{th} *and* 90^{th} *percentiles of 1000 replicate projections. Horizontal lines mark* MSY*-related quantities. Spawning stock biomass (SSB) is at mid-year.*

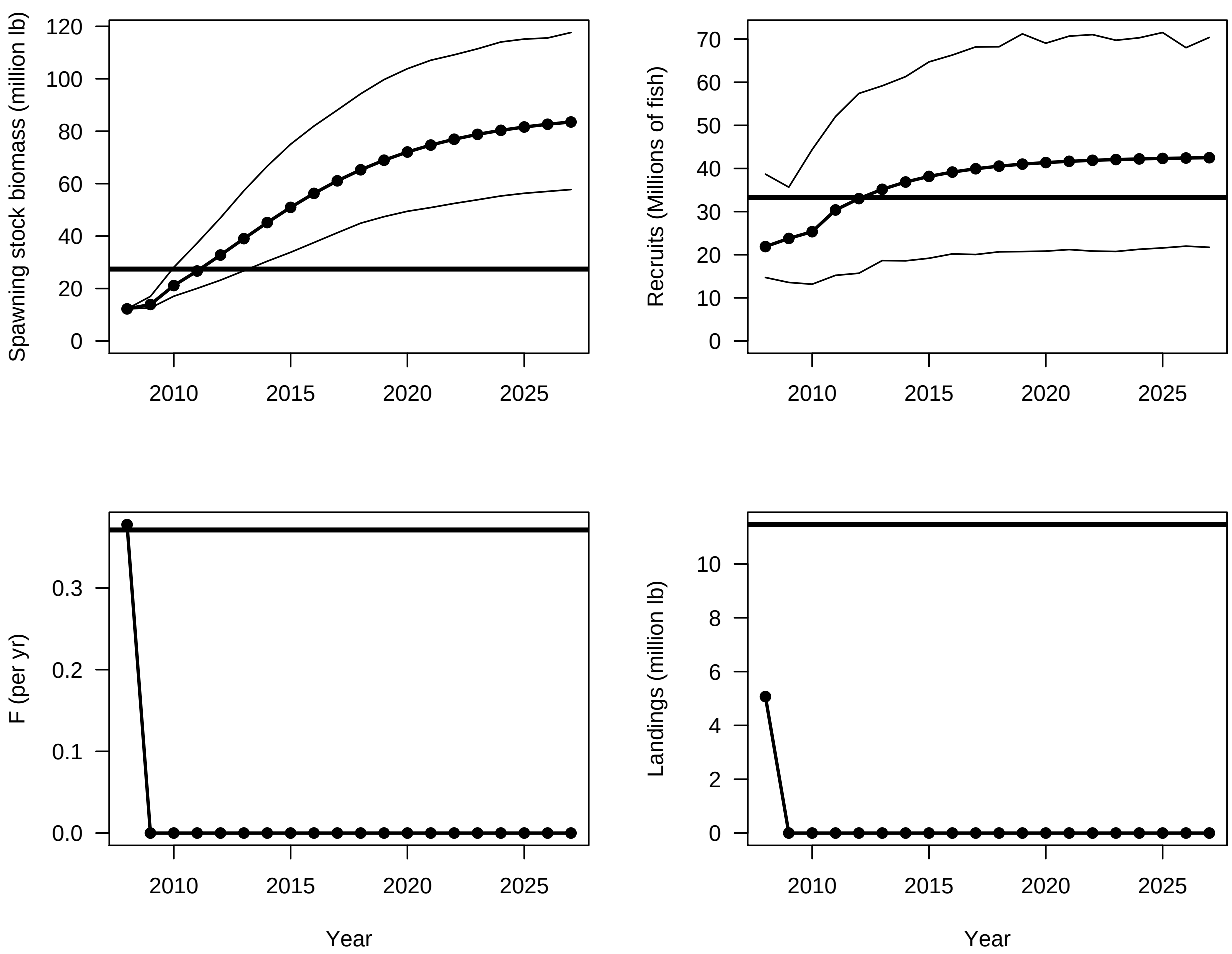


Figure 1.44. Spanish mackerel: Projection results under scenario 2—fishing mortality rate fixed at $F = F_{\text{current}}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10^{th} and 90^{th} percentiles of 1000 replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock biomass (SSB) is at mid-year.*

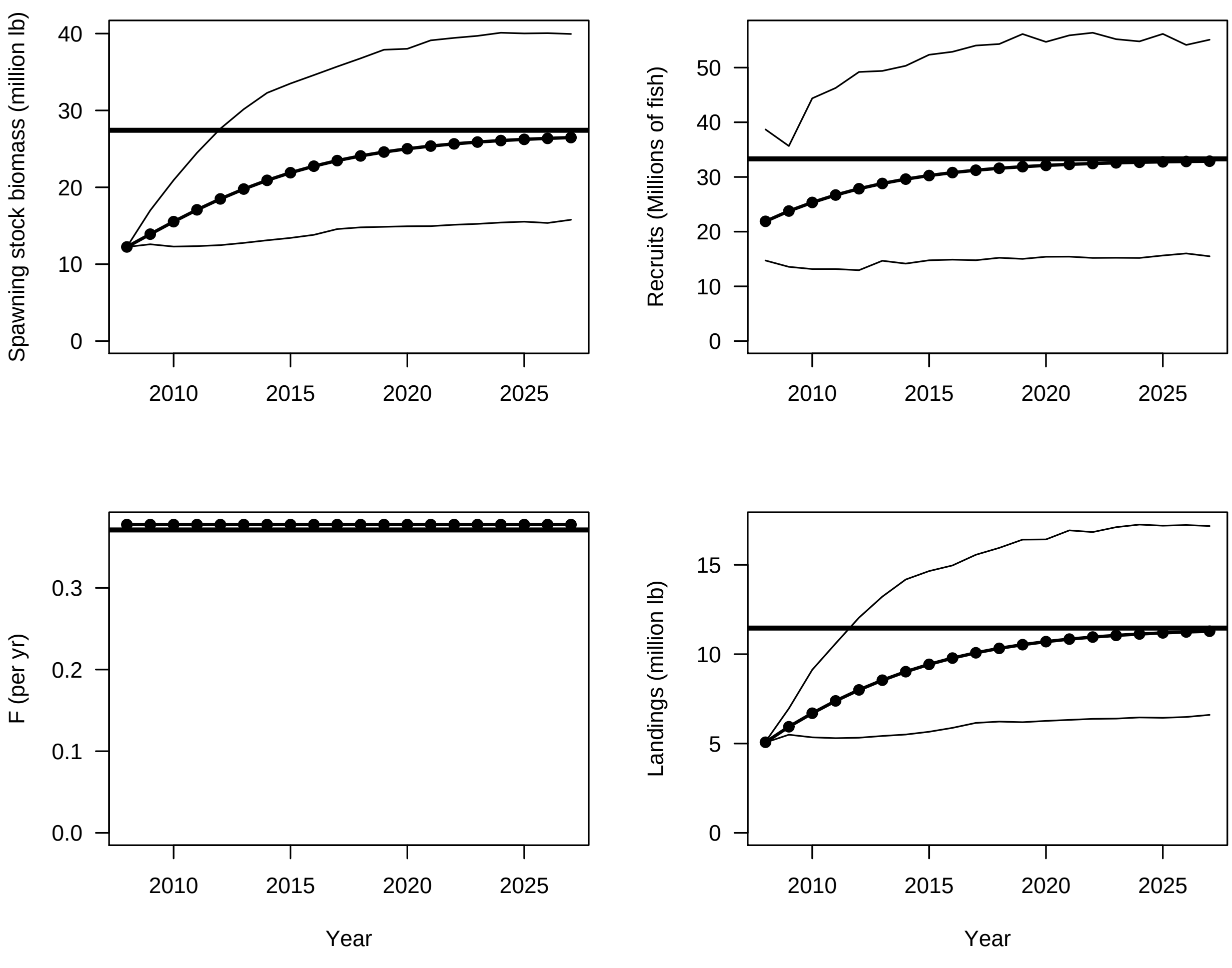


Figure 1.45. Spanish mackerel: Projection results under scenario 3—fishing mortality rate fixed at $F = F_{\mathrm{MSY}}$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10^{th} and 90^{th} percentiles of 1000 replicate projections. Horizontal lines mark MSY*-related quantities. Spawning stock biomass (SSB) is at mid-year.*

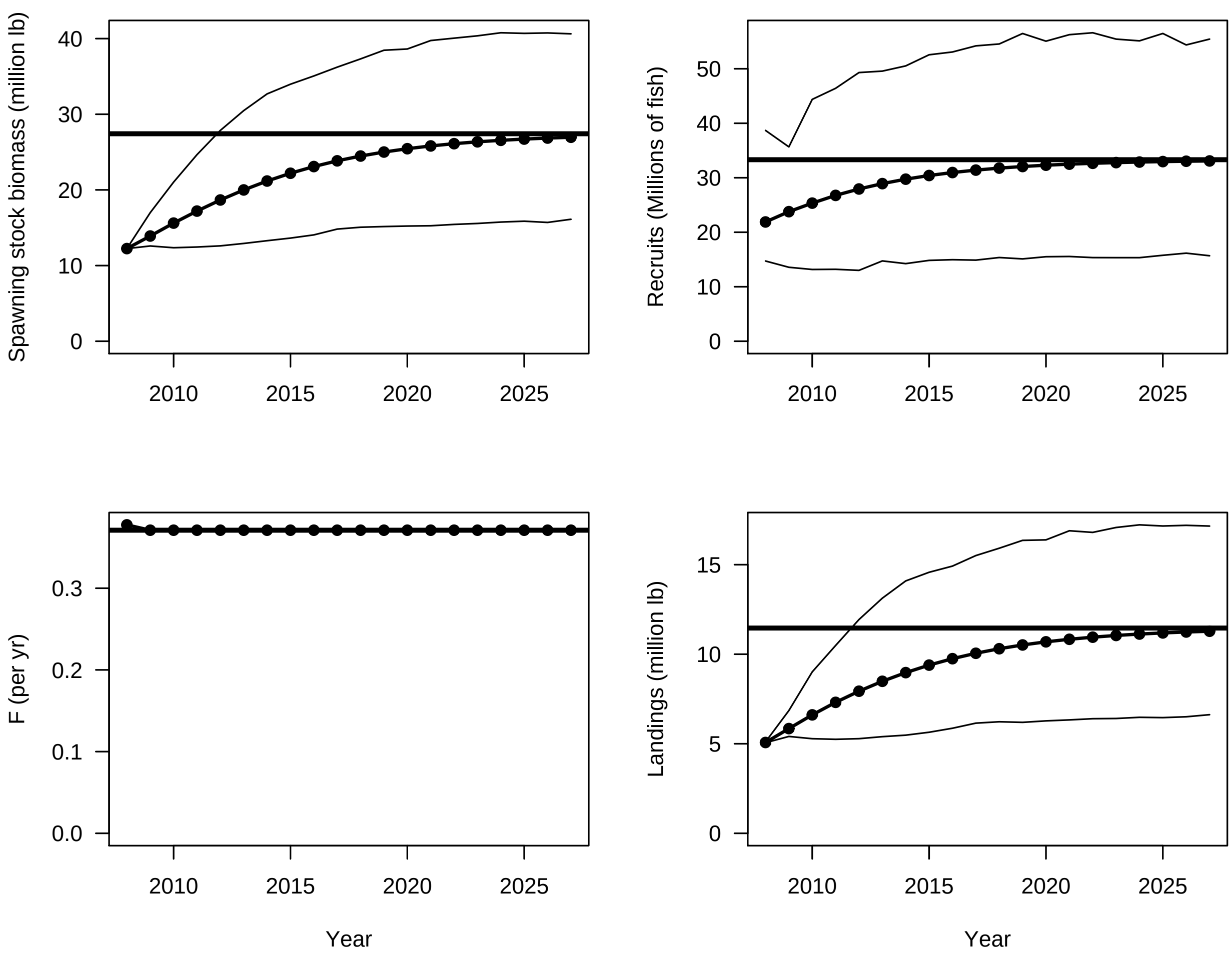


Figure 1.46. Spanish mackerel: Projection results under scenario 4—fishing mortality rate fixed at $F = 65\%F_{\mathrm{MSY}}$*. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to* 10^{th} *and* 90^{th} *percentiles of 1000 replicate projections. Horizontal lines mark* MSY*-related quantities. Spawning stock biomass (SSB) is at mid-year.*

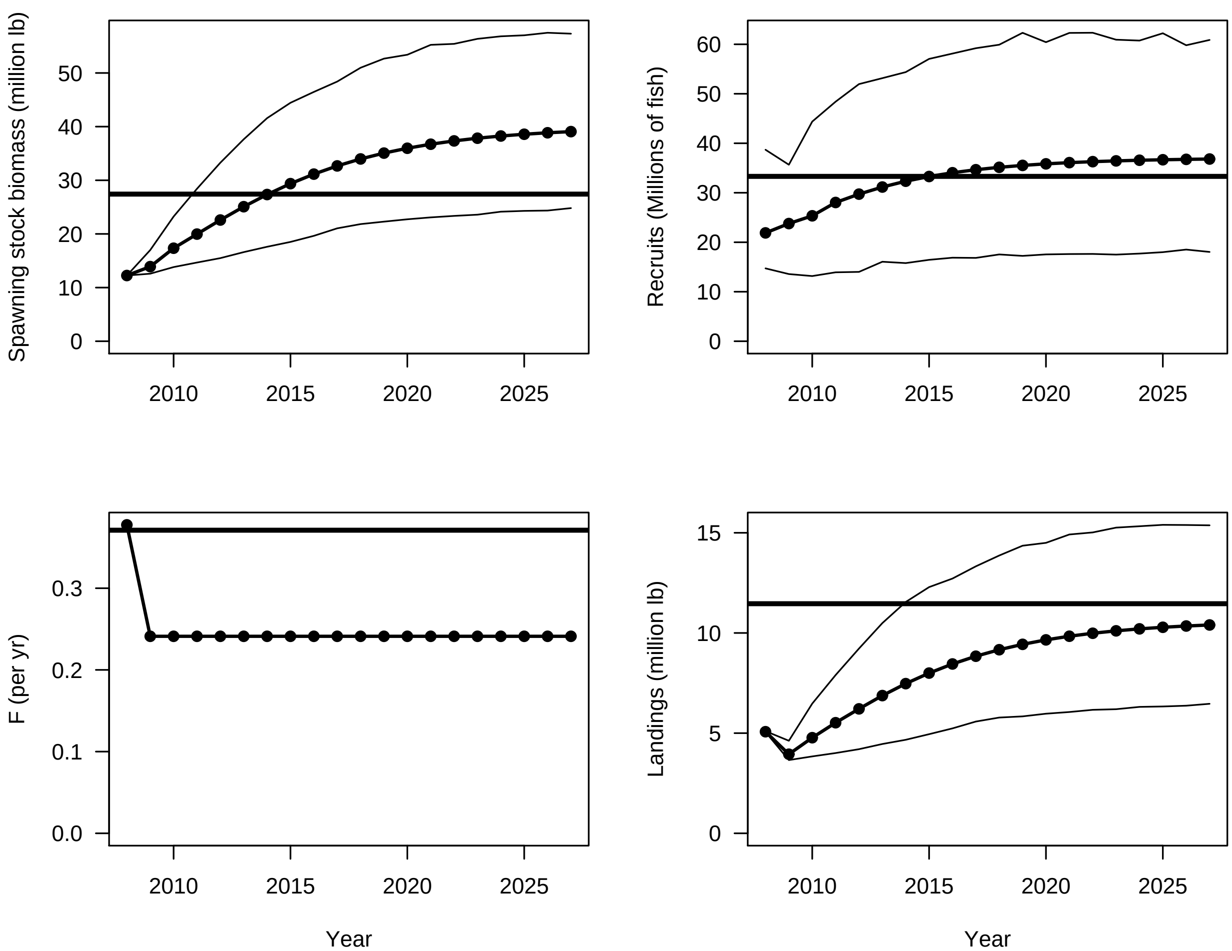


Figure 1.47. Spanish mackerel: Projection results under scenario 5—fishing mortality rate fixed at $F = 75\% F_{\mathrm{MSY}}$. *Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to* 10^{th} *and* 90^{th} *percentiles of 1000 replicate projections. Horizontal lines mark* MSY*-related quantities. Spawning stock biomass (SSB) is at mid-year.*

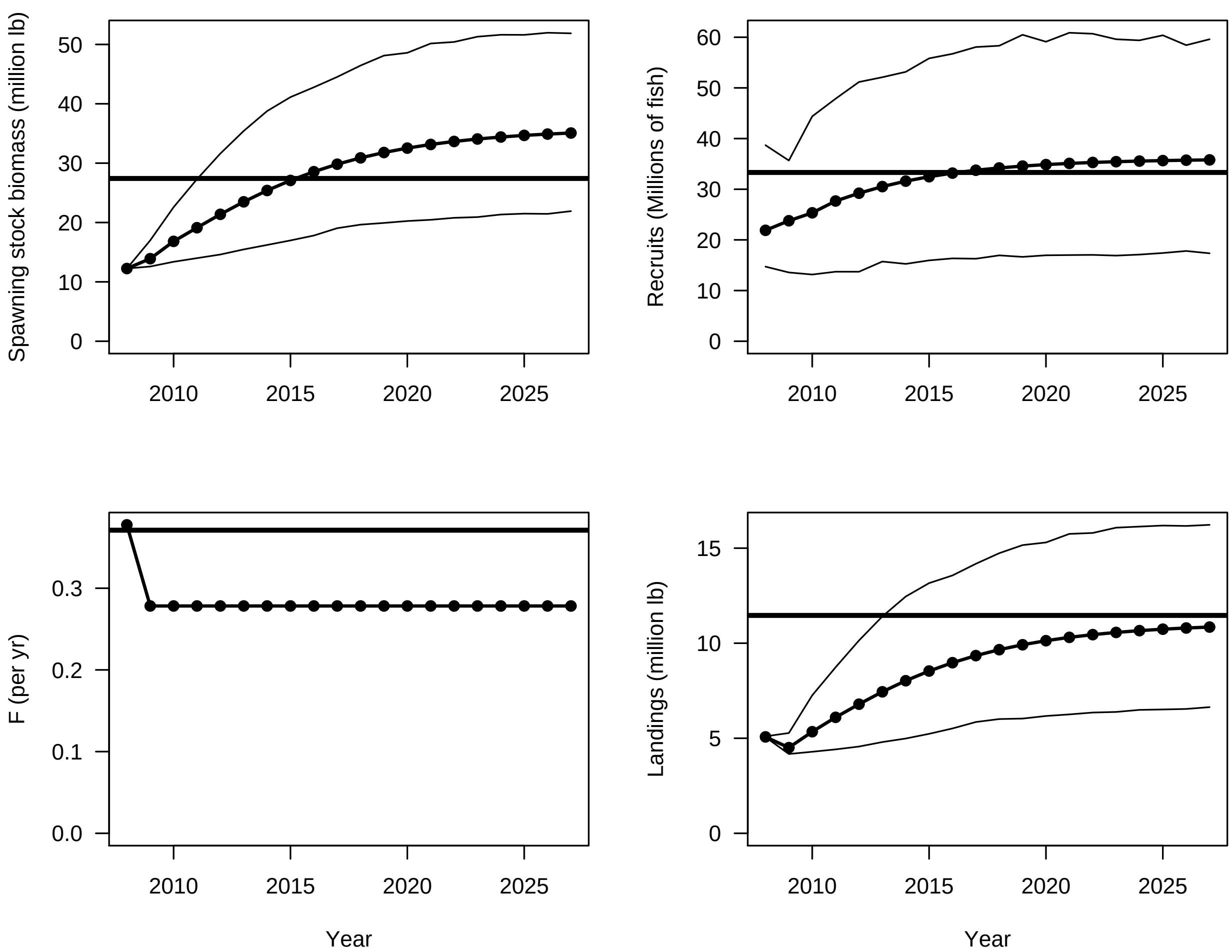


Figure 1.48. Spanish mackerel: Projection results under scenario 6—fishing mortality rate fixed at $F = 85\% F_{\mathrm{MSY}}$. *Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to* 10^{th} *and* 90^{th} *percentiles of 1000 replicate projections. Horizontal lines mark* MSY*-related quantities. Spawning stock biomass (SSB) is at mid-year.*

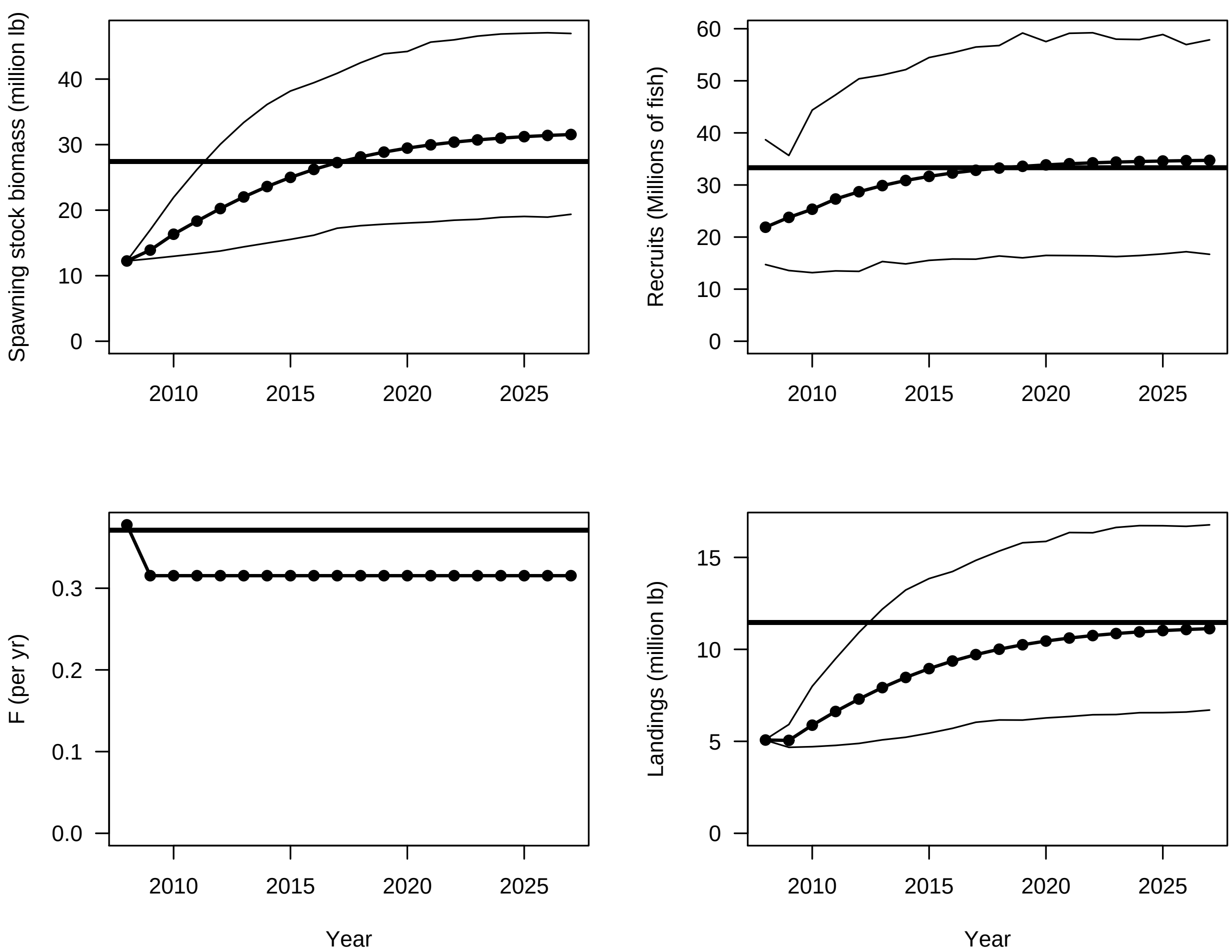


Figure 1.49. Spanish mackerel: Projection results under scenario 7—fishing mortality rate fixed at $F = F_{\mathrm{rebuild}} = 0.325$. Expected values represented by dotted solid lines, and uncertainty represented by thin lines corresponding to 10^{th} and 90^{th} percentiles of 1000 replicate projections. Horizontal lines mark MSY-related quantities. Spawning stock biomass (SSB) is at mid-year.

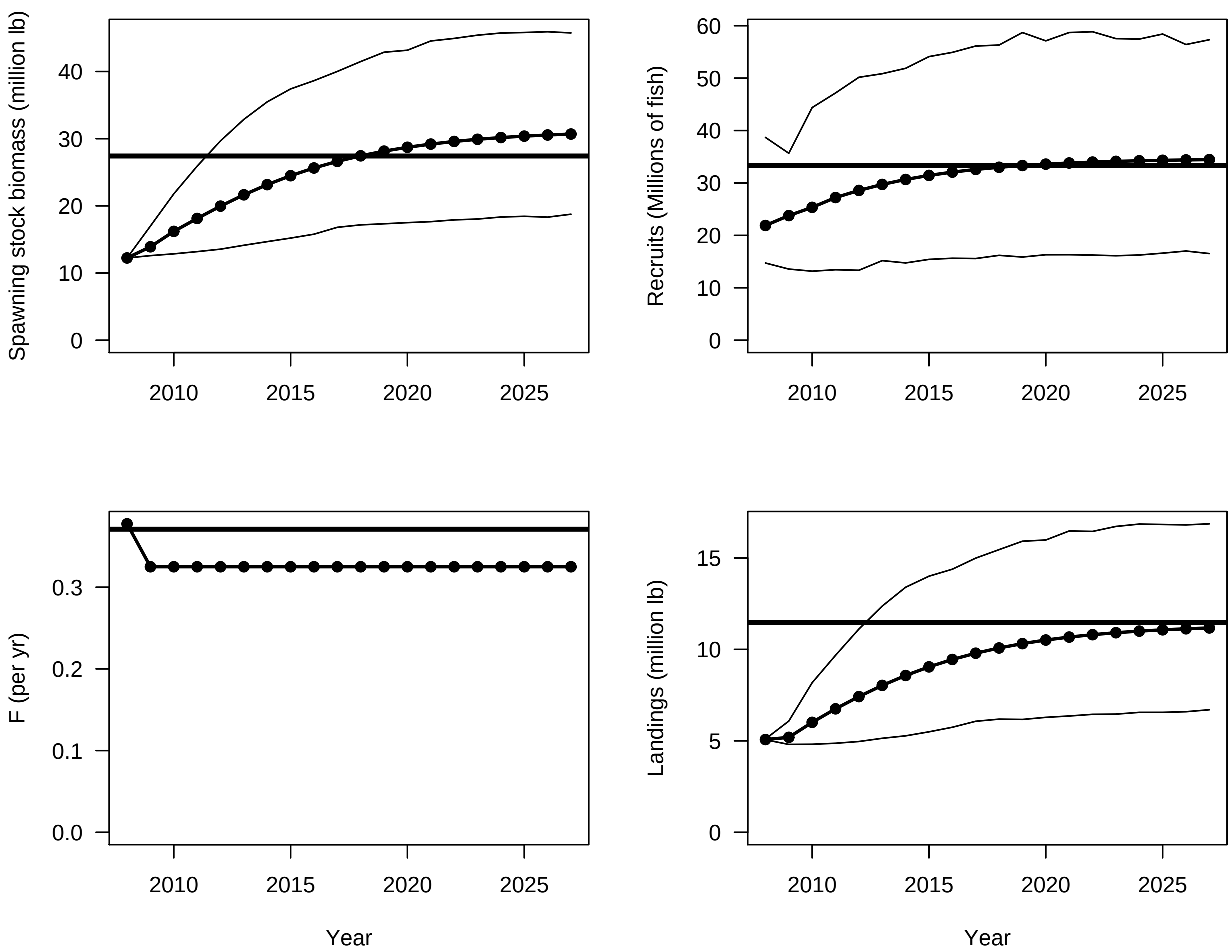
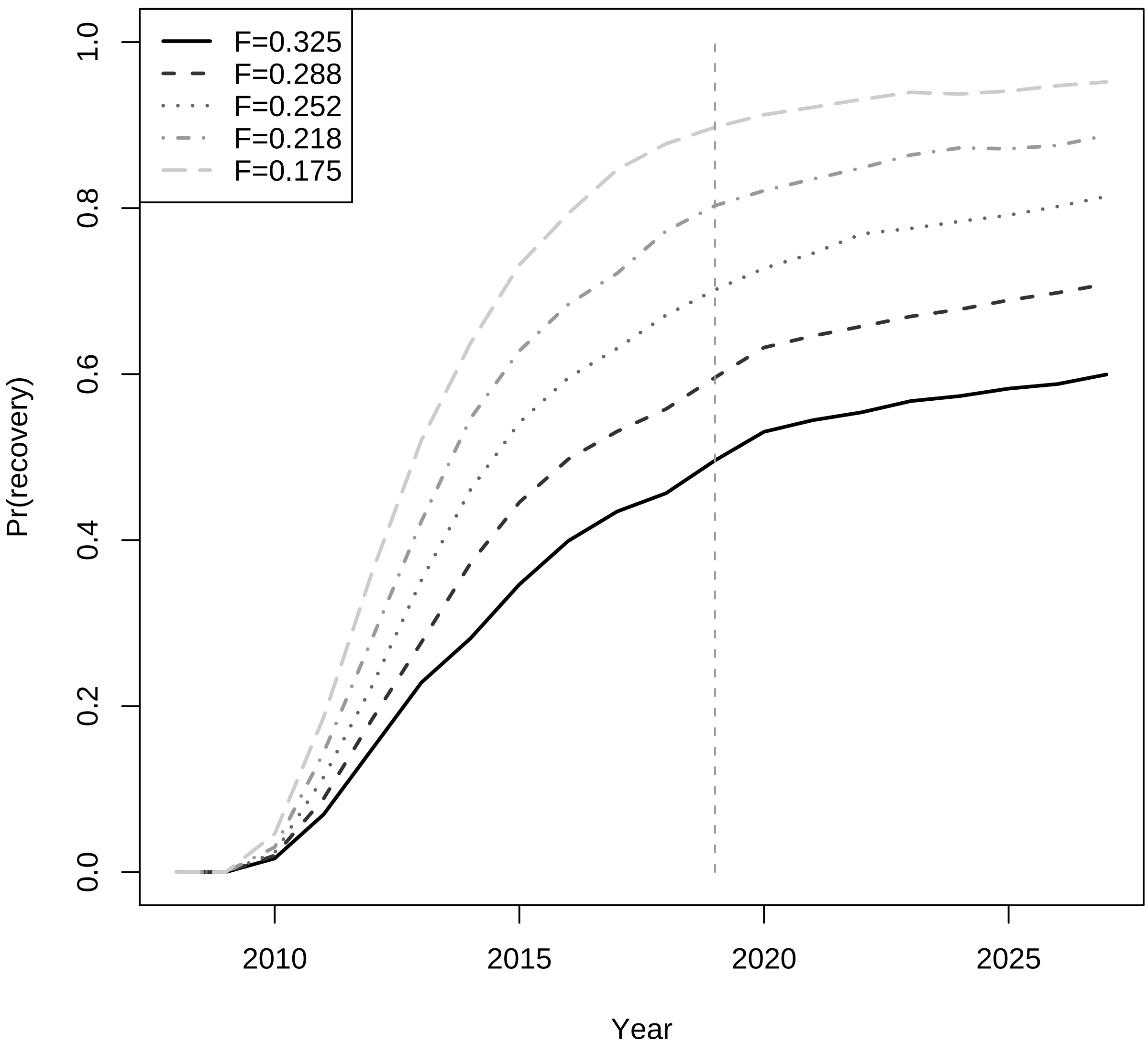


Figure 1.50. Spanish mackerel: Results of probabilistic analysis showing the probability of stock recovery to $\mathrm{SSB}_{\mathrm{MSY}}$ *as a function of year. The vertical line corresponds to 2019, the maximum rebuilding time frame under the MSRA.*



Appendix A Abbreviations and symbols

Table A.1. Acronyms, abbreviations, and mathematical symbols used in this report

Symbol	Meaning
AW	Assessment Workshop (here, for Spanish mackerel)
ASY	Average Sustainable Yield
B	Total biomass of stock, conventionally on January 1r
CPUE	Catch per unit effort; used after adjustment as an index of abundance
CV	Coefficient of variation
DW	Data Workshop (here, for Spanish mackerel)
E	Exploitation rate; fraction of the biomass taken by fishing per year
E_{MSY}	Exploitation rate at which MSY can be attained
F	Instantaneous rate of fishing mortality
F_{MSY}	Fishing mortality rate at which MSY can be attained
FL	State of Florida
GA	State of Georgia
GLM	Generalized linear model
K	Average size of stock when not exploited by man; carrying capacity
kg	Kilogram(s); 1 kg is about 2.2 lb.
klb	Thousand pounds; thousands of pounds
lb	Pound(s); 1 lb is about 0.454 kg
m	Meter(s); 1 m is about 3.28 feet.
M	Instantaneous rate of natural (non-fishing) mortality
MFMT	Maximum fishing-mortality threshold; a limit reference point used in U.S. fishery management; often based on F_{MSY}
mm	Millimeter(s); 1 inch = 25.4 mm
MRFSS	Marine Recreational Fisheries Statistics Survey, a data-collection program of NMFS
MSST	Minimum stock-size threshold; a limit reference point used in U.S. fishery management. The SAFMC has defined MSST for Spanish mackerel as $(1 - M)\mathrm{SSB}_{\mathrm{MSY}} = 0.7\mathrm{SSB}_{\mathrm{MSY}}$.
MSY	Maximum sustainable yield (per year)
mt	Metric ton(s). One mt is 1000 kg, or about 2205 lb.
N	Number of fish in a stock, conventionally on January 1
NC	State of North Carolina
NMFS	National Marine Fisheries Service, same as "NOAA Fisheries Service"
NOAA	National Oceanic and Atmospheric Administration; parent agency of NMFS
NY	State of New York
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
SD	Standard deviation
SE	Standard error
SEAMAP	Southeast Area Monitoring and Assessment Program, a fishery-independent data collection program of SCDNR
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
SSRA	Stochastic stock reduction analysis
SW	Scoping workshop; first of 3 workshops in SEDAR updates
TIP	Trip Interview Program, a fishery-dependent biodata collection program of NMFS
TL	Total length (of a fish), as opposed to FL (fork length) or SL (standard length)
VPA	Virtual population analysis, an age-structured assessment model characterized by computations backward in time; may use abundance indices to influence the estimates
yr	Year(s)

Appendix B Parameter estimates from AD Model Builder implementation of catch-at-age assessment model

```
# Number of parameters = 453  Objective function value = 4941.29  Maximum gradient component = 0.000205979
# log_len_cv:
-2.33572557889
# log_R0:
17.4905976433
# steep:
0.640772671814
# log_dev_N_rec:
 0.00168002749203 -0.0641687001809 0.0257235732008 0.643408130086
  0.490637440704 0.0230332887602 -0.0465314754456 0.221118854523
   0.432085150720 0.653601864551 0.283388775613 -0.247901676804
    -0.188141999092 0.327037237243 -0.168371520376 -0.595482708603
     -0.260784785480 0.142432213795 0.230352797324 0.0333615795012
      -0.223664064338 -0.786318373471 -0.591325027799 -0.313709857812
       0.00143297237263 -0.0228937164865
# R_autocorr:
0.563133433244
# selpar_slope_HL:
2.99492949386
# selpar_L50_HL_keep:
1.39419003961
# selpar_slope_PN:
19.9999997263
# selpar_L50_PN:
-0.0260965811173
# selpar_slope_GN:
3.32165702228
# selpar_L50_GN_keep:
1.45954905282
# selpar_slope_GN2:
2.97734677515
# selpar_L50_GN2:
1.06349063219
# selpar_slope2_GN2:
0.868062336980
# selpar_L502_GN2:
3.69896637056
# selpar_slope_CN:
19.9999966964
# selpar_L50_CN:
1.12616410928
# selpar_age0_MRFSS:
0.0298640185843
# selpar_age2_MRFSS:
0.664181573780
# selpar_age3_MRFSS:
0.505767721655
# log_q_LB_HL:
-12.5000000000
# log_q_FL_gill1:
-11.0000000000
# log_q_FL_gill2:
-11.0000000000
# log_q_LB_gill:
-11.0000000000
# log_q_FL_HL:
-9.32287304732
# log_q_CN:
-12.5000000000
# log_q_MRFSS:
-11.0000000000
# log_q_SMAP_YOY:
-16.7958172553
# log_q_SMAP_1YR:
-12.5000000000
```

```
# log_avg_F_HL:
-4.78623963206
# log_F_dev_HL:
 -3.03330029532 -3.09078931762 -2.13219974364 -2.32972776485
  -0.924109990158 -1.29865064855 -0.628641284094 -0.257723321933
  -0.139860060213 -0.280230769580 -0.439213925301 -0.658048262661
  -0.426013267396 -0.458494311963 -0.366366088517 -0.107141966975
  0.471487018780 1.35603412167 1.62728564073 0.415837516268
  -0.422294694433 -0.285536687107 -0.298358506091 -0.713247152751
  0.273650447217 -0.860635265313 -0.243955363343 0.175304540923
  -0.110625592427 0.289533901381 -0.0236365264495 0.293078191477
  0.956631015823 1.25588598473 -0.0961301951771 -0.402228098236
  -0.224972978569 0.845495847634 -0.177274206017 -0.162680495509
  0.440904953509 0.654504598115 0.946535533480 1.33584532782 1.08573858599
  1.10912169723 1.68369158869 1.68360437806 1.93697293294 1.75494295773
# log_avg_F_PN:
-6.42583143253
# log_F_dev_PN:
 -2.07326999460 -2.77711611202 -3.40249217475 -4.45114031466
 -2.98729236324 -2.50115861840 -1.42484361395 -1.40272287410
 -2.20670975154 -1.17924684605 -0.979507843669 0.847475062065
 -1.35591785860 0.198179998959 -0.544629543176 0.467589236808
 0.733131265850 -0.847509730991 0.279696942942 0.433714534374
 0.700002594325 -0.723159040034 -0.771141723708 0.0473554854868
 -0.666718626596 0.345410329372 0.813005965543 0.122630146666
 -2.49262089198 -3.18133822481 -1.77167996327 -2.44765368546
 -0.757827870969 -0.443754936822 -0.192251408138 0.584680112906
 0.519184501137 2.08891568038 1.78612576418 2.85721968563 2.95430637897
 2.90515878797 2.66678575217 2.46835116238 2.62915383080 2.07202383938
 2.34505273462 1.90979518767 1.43149251805 2.31753706439 1.90371176727
 1.91826346740 1.31514962385 1.07505637068 0.715700076110 0.398248076666
 -1.22722575183 -1.04117418163
# log_avg_F_GN:
-1.68127494949
# log_F_dev_GN:
 -1.09319677005 -1.15840011016 -0.800595597506 -0.885492290667
 -0.893614545277 -0.484761131228 -0.193957738390 0.143869761457
 0.151189328737 -0.557797131864 -0.509411134810 -0.404264221091
 -0.573660880613 -0.695704469132 -0.528925285107 -0.557842579169
 -0.824854253897 -0.251864645807 -0.256312801234 -0.352105059810
 -0.331724837363 -0.304966006214 -0.267388882823 -0.401440331235
 -0.0449751106731 0.696889598062 1.48293869792 1.33060909100 1.47466611247
 1.48694992967 1.48745094953 0.560246864388 1.54965183853 0.797417877464
 0.963554037562 1.15528099448 0.570966000100 0.305226396561 0.361418171452
 0.337062447085 0.302874258356 0.784988709317 0.598390880683
 0.857955502293 0.998218300818 -0.352496858279 0.0752184979143
 0.0991510955568 0.235053916832 -0.304643679080 -0.336052593487
 -0.433371273529 -0.727752996561 -1.16544752193 -1.31381916834
 -0.753916319784 -0.541368785993 -0.505114247122
# log_avg_F_CN:
-3.44349672332
# log_F_dev_CN:
 -2.26412492501 -0.656901337636 -1.70913160492 -2.61460433214
 -0.121785596333 0.401393761930 0.807369363155 1.11551198676 1.44698470166
 1.13822864834 1.24327158729 1.10000133798 0.113786408942
# log_avg_F_MRFSS:
-1.90440824287
# log_F_dev_MRFSS:
 -0.00320443627836 0.220101131838 0.201759644471 0.153410643893
 0.264182596194 0.273418190866 0.302968630661 0.263615636817
 0.364078493342 0.185572020025 0.206155549252 0.564309653486
 0.453796762096 0.703100061123 0.678653260811 0.744121570362
 0.852286945892 0.670681922132 0.534829380270 0.541967896758
 0.584142870925 0.313839936316 0.490830891495 0.323601314971
 0.160925890423 0.155044252119 0.115434166053 0.199079982212
 -0.126438462594 -0.415919953339 -0.776176337556 -0.313654896104
 -0.471120738827 -2.08657806957 0.324490701251 -0.818527382387
 -0.477926038601 -0.390978871256 0.114086792219 -0.0786669915292
 0.155871070688 0.173328605374 -0.176164741458 -0.467091726061
 -0.0191614378776 -0.424516441628 -0.554207108464 -0.337404246061
 -0.441445473187 -0.254074961153 0.195757311118 -0.275427119125
```

```
 -0.407224585614 -0.199982982009 -0.467456897645 -0.253819565334
 -0.556587136867 -0.691687174928
# log_avg_F_HL_D:
-9.30552814093
# log_F_dev_HL_D:
 -1.66172330935 -0.786108360305 -0.410040495995 -0.103724577944
 0.189942383969 0.230283344393 -1.36463137262 -0.675386462761
 -0.980933788344 0.594668425411 -2.06761533957 -0.290599856057
 1.12680743772 0.692929896514 0.647586716997 0.674061351849 0.894311659460
 1.19990937160 0.824149152353 0.564429055619 0.390651004732
 0.311033762333
# log_avg_F_GN_D:
-7.17644520959
# log_F_dev_GN_D:
 -0.196495592932 0.0163014703311 0.308837236446 -0.432028261106
 -0.0684462875745 -0.146526638499 0.0503358880356 0.911956828623
 1.04345803692 -0.457824832212 0.328000585460 0.951894119859
 -0.0191995480359 0.149990386474 -0.300663481940 -0.217022597642
 -0.0306512866041 0.140959434674 -0.151043028439 -0.240442051699
 -0.697949469359 -0.943440910779
# log_avg_F_MRFSS_D:
-4.84271852931
# log_F_dev_MRFSS_D:
 -0.321914087271 -0.372451393715 -0.450802599320 -0.387331486973
 -0.388042148635 -0.399480359803 -0.446669866506 -0.400570491784
 -0.487856768203 -0.492826123435 -0.401331811146 -0.393250056185
 -0.220925528502 -0.152527729806 -0.100033961669 0.109684381106
 0.00223959999977 -0.118156726798 -0.136137270327 -0.114987040363
 -0.304220744509 -0.243975134100 -0.337838421725 -0.492830764085
 -0.556170889770 -0.656332666063 -0.621300962090 -0.757807149864
 -0.978667040252 -1.22755843152 -1.49648415673 -0.739234553289
 -2.69625702290 -2.69533565468 -1.29473194088 -1.03405171918
 0.615641872724 -0.808155707543 -0.637209231891 0.637788655154
 0.0640679361423 0.650144934683 0.803183523432 0.810994319250
 1.94258819315 0.966544974410 1.03189162116 1.63305032770 0.906911680147
 1.50852712531 1.64989111559 1.43588046986 1.43781123651 2.17455058653
 1.47785860079 1.83217175747 0.536584366830 1.13545036357
# log_avg_F_shrimp:
-1.67476624037
# log_F_dev_shrimp:
 1.06393951588 0.637111345047 0.349368849751 1.03826074333 0.837197942691
 0.878375149717 0.492676761776 0.966971016809 -0.264381944748
 0.654634123298 1.25961778408 -1.66667980410 0.698237621963 -1.67210103480
 -1.68417994742 0.663261169026 -1.15826586425 -1.67090247181
 0.272752965643 0.852254683357 -1.50619422457 1.29240283084 0.595807141457
 0.443410453287 0.906504379679 0.590419078901 1.00265853746 -1.22181947375
 -1.17170129211 -0.439547728280 1.05732698661 -1.15994611168 1.41175063044
 1.74083292133 -0.893954445441 1.05177591469 0.668119655998 0.672639677673
 1.07304049637 1.56774917808 1.35252659415 1.13070018875 0.995933279560
 0.257897413005 -1.11319961696 1.07631138864 -1.47749040729 0.986673385455
 -1.59648627941 1.01353349828 0.769971618004 -0.707529647535
 -2.22625723145 -1.35883302763 -2.57737443061 -1.55855303125
 -3.25686355897 -1.94038334698
```

2. Added Documentation of Final Review Model Configuration

None