SEDAR

Southeast Data, Assessment, and Review

SEDAR 22

Stock Assessment Report

Gulf of Mexico Yellowedge Grouper

August 2011

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

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY

Table of Contents

Section 1. Introduction
Section 2. Data Workshop Report
Section 3. Assessment Workshop Report
Section 4. Research Recommendations
Section 5. Review Workshop Reports
Section 6. Addenda and Post-Review Updates

THIS PAGE HAS BEEN LEFT BLANK INTENTIONALLY

SEDAR

Southeast Data, Assessment, and Review

SEDAR 22

Gulf of Mexico Yellowedge Grouper

SECTION I: Introduction

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

1. SEDAR PROCESS DESCRIPTION

SouthEast Data, Assessment, and Review (**SEDAR**) is a cooperative Fishery Management Council process initiated in 2002 to improve the quality and reliability of fishery stock assessments in the South Atlantic, Gulf of Mexico, and US Caribbean. SEDAR seeks improvements in the scientific quality of stock assessments and the relevance of information available to address fishery management issues. SEDAR emphasizes constituent and stakeholder participation in assessment development, transparency in the assessment process, and a rigorous and independent scientific review of completed stock assessments.

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

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

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

SEDAR Review Workshop Panels consist of a chair, 3 reviewers appointed by the Center for Independent Experts (CIE), and three reviewers appointed from the SSC of the Council having jurisdiction over the stocks being assessed. The Review Workshop Chair is appointed by the Council from their SSC. Participating councils may appoint additional representatives of their SSC, Advisory, and other panels as observers.

2. MANAGEMENT OVERVIEW

2.1 *FISHERY MANAGEMENT PLAN AND AMENDMENTS*

The following summary describes only those management actions that likely affect yellowedge grouper fisheries and harvest

Original GMFMC FMP

The Fishery Management Plan (FMP) for the reef fish fishery of the Gulf of Mexico was implemented in November 8, 1984. This plan is for the management of reef fish resources under authority of the Gulf of Mexico Fishery Management Council Management Council. The plan considers reef fish resources throughout its range from Florida through Texas. The area which will be regulated by the federal government under this plan is confined to the waters of the fishery conservation zone (FCZ). The FCZ estimated area is 6.82×10^5 km ^{2} (263,525 square miles) and of that 12.4% of it is estimated as part of the continental shelf that is encompassed within the FCZ. Yellowedge grouper is one of the many species included in the fishery management unit. The four objectives of the FMP were: (1) to rebuild the declining reef fish stocks wherever they occur within the fishery, (2) establish a fishery reporting system for monitoring the reef fish fishery, (3) conserve reef fish habitats and increase reef fish habitats in appropriate areas and to provide protection for juveniles while protecting existing new habitats, (4) to minimize conflicts between user groupers of the resource and conflicts for space.

Measures in the original FMP that would have affected yellowedge grouper are maximum sustainable yield (MSY) and optimum yield (OY) estimates for all grouper and snapper species in aggregate, permits and gear specifications for fish traps along with a limit on the number of fish traps allowed per vessel, establishment of a stressed area within which the use of fish traps, roller trawls, and powerheads for the taking of reef fish was prohibited, and a prohibition on the use of poison or explosives for taking reef fish.

GMFMC FMP Amendments affecting yellowedge grouper

Description of Action	FMP/Amendment	Effective Date
Placed in the management unit/no regulations/Optimum Yield aggregate for groupers and snappers =45 mp.	Original FMP	1981

(1) Created deep-water and shallow-water aggregates (2) Set 1.8 mp (whole weight) deep-water grouper commercial quota (3) Allowed 2 day possession for charterboat/headboat (4) Established 20-50 fathom buoy/longline gear boundary (5) Established a commercial reef fish vessel permit (6) Established fish trap permits, 100 traps per person (7) Established fishing season January 1-December 31 (8)Established a framework for setting total allowable catch (9)Established a 5 grouper aggregate recreational bag limit	Amendment 1 (GMFMC 1990)	2/21/90
Changed TAC specification from April to August Set 1.8 mp (gutted weight) as the deep-water commercial quota. Scamp is shallow-water until closed then deep-water grouper -Set a three-year moratorium on issuance of new commercial reef fish permits	Amendment 4 (GMFMC 1992)	5/8/92
Grouper quotas were expressed in whole weight by multiplying the gutted weight by 1.18. This conversion factor was modified to 1.05 for deep-water and shallow-water groupers.	Supplemental Rule	5/22/92
Established reef fish dealer permitting and record keeping requirements, allowed transfer of fish trap permits, and endorsements between immediate family members during the fish trap moratorium, and allowed transfer of other reef fish permits or endorsements in the event of death or disability of the person who was the qualifier for the permit or endorsement.	Amendment 7 (GMFMC 1994)	2/7/94
(1) Limit sale of Gulf reef fish by permitted vessels to permitted reef fish dealers,(2) require that permitted reef fish dealers purchase reef fish caught in Gulf federal waters only from permitted vessels, (3) allow transfer of reef fish permits and fish trap endorsements in the event of death of disability, (4) implement a new reef fish permit moratorium for no more than 5 years or until 12/31/00, (5) allow permit transfers to other persons with vessels by vessel owners (not operators)	Amendment 11 (GMFMC 1996)	1/1/96

who qualified for their reef fish permit, and (6) allow a onetime transfer of existing fish trap endorsements to permitted reef fish vessels whose owners have landed reef fish from fish traps in federal waters, as reported on logbooks received by the science and research director of NMFS from 11/20/92 through 2/6/94.		
Ten year phase-out for the fish trap fishery in the EEZ; allowed transfer of fish trap endorsements for the first two years and thereafter only upon death or disability of the endorsement holder, to another vessel owned by the same entity, or to any of the 56 individuals who were fishing traps after 11/19/92 and were excluded by the moratorium; and prohibited the use of fish traps west of Cape San Blas, Florida.	Amendment 14 (GMFMC 1997)	4/24/97
Prohibit harvest of reef fish from traps other than permitted reef fish traps.	Amendment 15 (GMFMC 1998)	1/29/98
Prohibits the possession of reef fish exhibiting the condition of trap rash on board any vessel in the Gulf EEZ and that does not have a valid fish trap endorsement and requires fish trap owners or operators to provide trip initiation and termination reports and to comply with a vessel/gear inspection requirement.	Amendment 16A (GMFMC 2000)	1/10/00
Extended the commercial reef fish permit moratorium until December 31, 2005	Amendment 17 (GMFMC 2000)	8/2/00
1) Prohibits vessels from retaining reef fish caught under recreational bag/possession limits when commercial quantities of Gulf reef fish are aboard, (2) adjusts maximum crew size on charter vessels that also have a commercial reef fish permit, and (3) prohibits the use of reef fish for bait except for sand or dwarf sand perch.	Amendment 18A (GMFMC 2007)	5/6/07
Establish 3-year moratorium on issuance of charter and headboat permits for-hire reef fish	Amendment 20 (GMFMC 2001)	7/1/03

Continues the Steamboat Lumps and Madison-Swanson reserves for an additional six years, until June 2010.	Amendment 21 (GMFMC 2003)	6/3/04
Implemented specific bycatch reporting methodologies for logbooks and a mandatory commercial and for-hire (charter vessel/headboat) observer program for the reef fish fishery.	Amendment 22 (GMFMC 2004)	7/5/05
Replaced the commercial reef fish permit moratorium with a permanent limited access system	Amendment 24 (GMFMC 2005)	8/17/05
Replaced reef fish for-hire moratorium with limited access system	Amendment 25 (GMFMC 2005)	6/15/06
Requires the use of non-stainless steel circle hooks when using natural baits to fish for Gulf reef fish and the use of venting tools and dehooking devices when participating in the commercial or recreational reef fish fisheries.	Amendment 27 (GMFMC 2007)	6/1/08
Management of shallow water grouper (SWG) to achieve OY. (1) Establishes ACLs and AMs for the commercial and aggregate SWG fishery, (2) adjusts recreational grouper bag limits to 4 grouper/person/day and seasonal closures to all SWG closed 2/1 – 3/31 (3) adjusts commercial grouper season to “No Closed Season”, instead a four month seasonal area closure at the Edges, (4) eliminates the end date for the Madison-Swanson and Steamboat Lumps marine reserves, and (5) requires that vessels with federal commercial or charter reef fish permits comply with the more restrictive of state or federal reef fish regulations when fishing in state waters	Amendment 30B (GMFMC 2008)	4/16/09
Proposes to rationalize effort and reduce overcapacity in the commercial grouper and tilefish fisheries in order to achieve and maintain OY. Several management alternatives including Individual Fishing Quota (IFQ) programs are developed to achieve these	Amendment 29 (GMFMC 2009)	1/1/10

objectives.		
Created season area closures for longline gear April through August from 35 fathoms shoreward, would establish an endorsement to use bottom longline gear to fish for reef fish in the eastern Gulf of Mexico greatly limiting the fishery, and created a gear limitation:1,000 hooks of which no more than 750 hooks are rigged for fishing or fished. Under this alternative all options for number of hooks per vessel are lower than the average number of hooks used by most commercial reef fish fishers in the bottom longline component of the fishery.	Amendment 31 (GMFMC 2009)	**IN NOAA REVIEW – REGULATIONS NOT ESTABLISHED**

*Yellowedge grouper stock assessment was conducted in 2002, but determined inconclusive. However it did extend the maximum age of yellowedge grouper from 35 to 85 years

Gulf Council Regulatory Amendments

An October 2005 regulatory amendment, implemented January 1, 2006, established a 6,000 pound GW aggregate deep-water (DWG) and shallow-water grouper (SWG) trip limit for the commercial grouper fishery, replacing the 10,000/7,500/5,500 step-down trip limit that had been implemented by emergency rule [70 FR 77057].

2.2. Emergency and Interim Rules

An emergency rule of February 17, 2005 that established trip limits for the commercial shallow-water and deep-water grouper fisheries in the Gulf of Mexico (EEZ) is in effect from March 3, 2005 through August 16, 2005 and was extended an additional 180 days by NMFS through February 12, 2006. The trip limit was initially set at 10,000 pounds gutted-weight (GW) for deep-water and shallow-water grouper combined. If on or before August 1 the fishery is estimated to have landed more than 50% of either the shallow-water grouper or the red grouper quota, then a 7,500 pound GW trip limit takes effect; and if on or before October 1 the fishery is estimated to have landed more than 75% of either the shallow-water grouper or red grouper quota, then a 5,500 pound GW trip limit takes effect [70 FR 8037].

An interim rule, published July 25, 2005, proposed for the period August 9, 2005 through January 23, 2006, a temporary reduction in the aggregate grouper bag limit from five to three grouper

per day, and a closure of the recreational fishery, from November-December 2005, for all grouper species. The closed season was applied to all grouper in order to prevent effort shifting from red grouper to other grouper species. This rule was challenged by organizations representing recreational fishing interests and on October 31, 2005 a U.S. District Court judge ruled that an interim rule could only be applied to the species undergoing overfishing. This resulted in the aggregate grouper bag limit and closed season for all grouper to be overturned [70 FR 42510].

An emergency rule effective May 18, 2009 moved the buoy/longline gear boundary line to 50 fathoms. That rule was replaced on October 16, 2009 by a rule under the Endangered Species Act moving the boundary to 35 fathoms and implementing 1,000 hooks of which no more than 750 hooks are rigged for fishing or fished.

2.3. Secretarial Amendments

Secretarial Amendment 1, implemented July 15, 2004, reduced the commercial quota from (1.6 mp whole weight) for deep-water grouper quota and reinstated gutted weight. The quota was reduced for deep-water grouper from 1.35 MP gutted weight to 1.02 mp gutted weight.

2.4. Control Date Notices

Notice of Control Date 11/1/89 54 FR 46755:

-Anyone entering the commercial reef fish fishery in the Gulf of Mexico after 11/1/89 may be assured of future access to the reef fish resource of a management regime is developed and implemented that limits the number of participants in the fishery.

Notice of Control Date 11/18/98 63 FR 64031:

-The Council considered whether there was a need to impose additional management measures limiting entry into the recreational-for-hire (i.e., charter vessel and headboat) fisheries for reef fish in the EEZ of the Gulf of Mexico and if needed what management measures should be imposed. Possible measures include the establishment of a limited entry program to control participation or effort in the recreational-for-hire fisheries for reef fish in the EEZ. In Amendment 20 to the Reef Fish FMP, a qualifying date of March 29, 2001 was adopted.

Notice of Control Date 7/12/00 65 FR 42978:

-The Council considered whether there was a need to limit participation by gear type in the commercial reef fish fisheries in the Gulf EEZ and if so what management measures should be imposed. Possible measures include modifications to the existing limited entry program to control fishery participation or effort, based on gear type, such as a requirement for gear endorsement on the commercial reef fish vessel permit for the appropriate gear. Gear types that may be included are longlines, buoy gear, handlines, rod-and-reel, bandit gear, spear fishing gear, and powerheads used with spears.

Notice of Control Date 10/15/04 69 FR 67106:

-The Council is considered the establishment of an IFQ to control participation or effort in the commercial grouper fishery of the Gulf of Mexico. The control data above would determine eligibility of catch histories in the commercial grouper fishery.

2.5. Management Program Specifications

Table 2.5.1. General Management Information

Species	Yellowedge grouper (*Epinephelus flavolimbatus*)
Management Unit	Gulf of Mexico
Management Unit Definition	All waters within the Gulf of Mexico Fishery Management Council boundaries. Defined as the economic zone (EEZ), 200 miles from state boundary line.
Management Entity	Gulf of Mexico Fishery Management Council
Management Contacts SERO / Council	/ Carrie Simmons
Current stock exploitation status	Not yet determined
Current stock biomass status	Not yet determined

Table 2.5.2. Specific Management Criteria

Criteria	Gulf of Mexico – Current		Gulf of Mexico - Alternative	
	Definition	Value	Definition	Value
MSST	undefined*	To Be	MSST = [(1-M) or 0.5	SEDAR 22

		Determined (TBD)	whichever is greater]*B_{MSY}	
MFMT	F30%SPR	TBD	F_{MSY}	SEDAR 22
MSY	undefined**	TBD	Yield at F_{MSY}	SEDAR 22
F_{MSY}	no proxy defined	TBD	F_{MSY}	SEDAR 22
OY	undefined**	TBD	Yield at F_{OY}	SEDAR 22
F_{OY}	undefined***	TBD	F_{OY} =65%, 75%, 85% F_{MSY}	SEDAR 22
M	--	TBD	Instantaneous natural mortality	SEDAR 22
Probability value for evaluating status	50% Fcurr> MFMT = overfishing		Annual yield @ F_{MFMT}	

The Generic SFA Amendment (1999) states that MSST will be implemented by framework amendment for each stock as estimates of B_{MSY} and MSST are developed by NMFS, the Reef Fish Stock Assessment Panel, and Council. Thus, MSST is undefined until established following a stock assessment in which B_{MSY} or a proxy is determined. However, the Council has generally adopted (1-M)SSB_{MSY} as the MSST for stocks with stock assessments.

**Proposed SPR based proxies of MSY and OY in the Generic SFA Amendment were rejected by NMFS on the basis that such proxies must be biomass based.

*** The Council has typically used 75% of F_{MSY} (or F_{MSY} proxy) as its definition of F_{OY}. However, no generic definition of F_{OY} has been set, and it is therefore undefined for stocks without prior assessments.

Yields (MSY and OY) are in terms of pounds landed under prevailing selectivity's and after estimating and accounting for discards in the stock assessment.

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

Stock Rebuilding Information

The current stock biomass is unknown; therefore, no rebuilding plan is required at this time.

Table 2.5.3. Stock projection information.

Requested Information	Value
First Year of Management	2013
Projection Criteria during interim years should be based on (e.g., exploitation or harvest)	Fixed exploitation at F_{OY} or Frebuilding as appropriate.
Projection criteria values for interim years should be determined from (e.g., terminal year, avg of X years)	Average of previous 3 years

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

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

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

Table 2.5.4. Quota Calculation Details

There is currently not a quota specified for this stock, only a deep-water grouper quota = 1.02 mp gutted weight. The deep-water grouper includes scamp after the shallow-water grouper quota is filled. If a yellowedge grouper quota is established, the other remaining species would need to be considered: misty, snowy, and warsaw.

Current Quota Value	1.02 mp gutted weight
Next Scheduled Quota Change	None at this time
Annual or averaged quota ?	Annual

If averaged, number of years to average	
Does the quota include bycatch/discard?	Bycatch/discards incorporated into assessment

Commercial sector

The commercial deep-water grouper quota is 1.02 MP gutted weight and includes scamp after the shallow-water grouper quota is filled. This quota was implemented July 15, 2004 in Secretarial Amendment 1. An aggregate deep-water and shallow-water grouper trip limit of 6,000 pounds gutted weight was implemented on January 1, 2006. The deep-water quota is typically caught by June.

If a total allowable catch is established for yellowedge grouper, it will be necessary to establish commercial and recreational allocations so that the commercial shallow-water quota can be adjusted accordingly. There is currently no formal guidance for allocating grouper species other than red grouper and gag. If total allowable catch was developed for yellowedge grouper then it would be deducted from deep-water grouper quota.

Recreational Sector

The Amendment 30B proposed rule would establish new grouper bag limits and extend the Gulf grouper recreational closed season. These recreational measures are projected to reduce gag landings by 26% and increase red grouper landings by 17%. The aggregate grouper bag limit would be reduced from 5 fish to 4 fish per person per day. Within this aggregate bag limit, there is a 2 fish gag bag limit and a 2 fish red grouper bag limit per person per day. Lowering the aggregate grouper bag limit is intended to slow or prevent a shift in effort from gag to other shallow-water and deep-water grouper species as a result of actions to constrain the harvest of gag. Although deep-water grouper and shallow-water grouper species other than gag and red grouper represent a small portion of the recreational harvest, they could be significantly affected by shifts in fishing effort resulting from changes to gag and red grouper regulations [73 FR 68390].

If a yellowedge grouper total allowable catch and recreational allocation are established, it may be necessary to revise the recreational grouper harvest regulations to keep the recreational sector within its allocation. The determination of appropriate regulatory alternatives is beyond the scope of the SEDAR assessment.

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

Discard mortality estimates are to be estimated and incorporated into the assessment in order to estimate quotas and allocations in terms of landed catches that take into account discard mortality. Appropriate values for current levels of discards and discard mortality rates are to be determined and calculated as part of the Data and Assessment workshops using available data, research, and observations (both observer and anecdotal) to determine values that represent the best available scientific information.

In the recreational sector aggregate bag limits that pertain to all groupers except goliath grouper and Nassau grouper. No more than 2 gag grouper per person (counts as part of the 4 grouper aggregate bag limit), and no more than 2 red grouper per person (counts as part of the 4 grouper aggregate bag limit). Yellow-edge grouper are likely not landed frequently by recreational anglers. However, the reduction in the aggregate grouper bag limit may increase yellowedge grouper bycatch.

There is currently not a quota specified for this stock, only a deep-water grouper quota. If a yellowedge grouper quota is established, it will be taken from the other deep-water grouper allowance.

2.6. Management and Regulatory Timeline

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

Table 2.6.1. Annual Commercial Yellowedge Grouper Regulatory Summary

Year	Fishing Year	Size Limit	Possession Limit
1983	Calendar Year	None	--
1984	Calendar Year	None	--
1985	Calendar Year	None	--
1986	Calendar Year	None	--
1987	Calendar Year	None	--
1988	Calendar Year	None	--
1989	Calendar Year	None	--
1990	Calendar Year	None	--
1991	Calendar Year	None	--
1992	Calendar Year	None	--
1993	Calendar Year	None	
1994	Calendar Year	None	
1995	Calendar Year	None	
1996	Calendar Year	None	
1997	Calendar Year	None	
1998	Calendar Year	None	"
1999	Calendar Year	None	"
2000	Calendar Year	None	
2001	Calendar Year	None	"
2002	Calendar Year	None	"
2003	Calendar Year	None	"
2004	Calendar Year	None	Commercial Fishery Closure for DWG June 23, 2005
2005	Calendar Year	None	The trip limit was initially set at 10,000 pounds gutted-weight (GW). If on or before 10/1 the fishery is estimated to have landed more than 75% of either SWG or red grouper quota then a 5,500 pound GW trip limit takes effect." Commercial Fishery Closure for DWG June 23, 2005
2006	Calendar Year		Established a 6,000 pound GW aggregate DWG and SWG trip limit Commercial Fishery Closure for DWG June 27, 2006
2007	Calendar Year		Commercial Fishery Closure for DWG June 2, 2007
2008	Calendar Year		Commercial Fishery Closure for DWG May 10,2008 The Commercial Fishery re-opened for DWG November 1-10, 2008
2009	Calendar Year		Commercial Fishery Closures for DWG June 27, 2009

Table 2.6.2. Annual Recreational Yellowedge Grouper Regulatory Summary

Year	Fishing Year	Size Limit	Bag Limit
1983[1]	Calendar Year	None	--
1984[1]	Calendar Year	None	--
1985[2]	Calendar Year	None	--
1986	Calendar Year	None	
1987	Calendar Year	None	
1988	Calendar Year	None	
1989	Calendar Year	None	
1990[3]	Calendar Year	None	5 grouper aggregate[1]/person/day
1991	Calendar Year	None	
1992	Calendar Year	None	
1993	Calendar Year	None	
1994	Calendar Year	None	
1995	Calendar Year	None	
1996	Calendar Year	None	
1997	Calendar Year	None	
1998	Calendar Year	None	
1999	Calendar Year	None	
2000	Calendar Year	None	
2001	Calendar Year	None	
2002	Calendar Year	None	
2003	Calendar Year	None	
2004	Calendar Year	None	
2005	Calendar Year	None	Published 7/05-Limited aggregate grouper bag limit from 5 to 3 grouper per day but, was overturned by 12/05
2006	Calendar Year	None	5 grouper aggregate[1]/person/day
2007	Calendar Year	None	
2008	Calendar Year	None	
2009	Calendar Year	None	4 grouper aggregate[1]/person/day

[1] The following species are included in the Gulf of Mexico grouper aggregate. The shallow-water grouper are defined as the following species: black grouper, gag (no more than 2 per person), red grouper (no more than 2 per person), yellowfin grouper, yellowmouth grouper, rock hind, red hind, speckled hind (1 per vessel), and scamp. Deep-water grouper are defined as misty grouper, snowy grouper, yellowedge grouper, warsaw grouper (1 per vessel), and scamp once the shallow-water grouper quota is filled. Recreational aggregate grouper bag limits apply to all groupers in aggregate.

2009-2010: For-hire captain and crew prohibited from retaining bag limits for any grouper while under charter. Federally permitted for-hire reef fish vessel must comply with the more restrictive of federal or state reef fish regulations when fishing for reef fish in state waters.

2.7 State Regulatory History

Florida:

Alabama: Recreational regulations

December 12, 1995-Established a grouper aggregate bag limit in Alabama waters of 5 fish per person for recreational fishermen

August 27, 2009 -Reduced the grouper aggregate bag limit to 4 fish for recreational fishermen

There are no regulations for commercial fishing for these species.

* Alabama Marine Resources is proposing regulations this year to the Conservation Advisory Board that will close Alabama waters at any time adjacent federal waters are closed to the taking of a specific reef fish species. These would include both the recreational fisheries and the commercial fisheries. We hope to have these regulations in place by May 2010.

Mississippi:

Historically Mississippi has followed the regulations set forth by the Gulf Council; however, we have not changed our regulations to reflect the regulations put into effect by the Gulf Council on July 29, 2009. We are still currently at a recreational five fish aggregate for the groupers.

Louisiana:

For Louisiana the only significant differences for these two species between federal and state management occurred in 2009, when modifications to include IFQ rules were not adopted, and rules on having charter vessels comply with more restrictive rules were also not adopted.

Texas: They do not have matching rules in Texas waters, but enforce federal rules under Joint Enforcement Agreements.

References

GMFMC (Gulf of Mexico Fishery Management Council). 1981. Fishery management plan for the reef fish fishery of the Gulf of Mexico and environmental impact statement. Gulf of Mexico Fishery Management Council, Tampa, Florida. 155 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 1989. Amendment 1 to the reef fish fishery management plan. Gulf of Mexico Fishery Management Council, Tampa, Florida. 356 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 1991. Amendment 4 to the reef fish fishery management plan. Gulf of Mexico Fishery Management Council, Tampa, Florida. 42 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 1993. Amendment 5 to the reef fish fishery management plan. Gulf of Mexico Fishery Management Council, Tampa, Florida. 450 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 1993. Amendment 7 to the reef fish fishery management plan for the reef fish resources of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, Florida. 30 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 1993. Amendment 11 to the reef fish fishery management plan for the reef fish resources of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, Florida. 92 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 1996. Amendment 14 to the reef fish fishery management plan for the reef fish fishery of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, Florida. 89 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 1997. Amendment 15 to the reef fish fishery management plan for the reef fish fishery of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, Florida. 114 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 1998. Amendment 16A to the reef fish fishery management plan for the reef fish fishery of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, Florida. 49 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 1998. August 1998 report of the Reef Fish Stock Assessment Panel. Gulf of Mexico Fishery Management Council, Tampa, Florida. 19 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 1999. Amendment 17 to the reef fish fishery management plan for the reef fish resources of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, Florida. 28 pp

GMFMC (Gulf of Mexico Fishery Management Council). 1999. Regulatory amendment to the reef fish fishery management plan to set 1999 gag/black grouper management measures (revised). Gulf of Mexico Fishery Management Council, Tampa, Florida. 84 pp.

GMFMC (Gulf of Mexico Fishery Management Council) 2001. Generic Amendment Addressing the Establishment of the Tortugas Marine Reserves in the Following Fishery Management Plans of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, Florida. 194 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 2003. Amendment 21 to the reef fish fishery management plan. Gulf of Mexico Fishery Management Council, Tampa, Florida. 143 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 2004. Final Environmental Impact Statement for the Generic Essential Fish Habitat Amendment to the following fishery management plans of the Gulf of Mexico: Shrimp Fishery of the Gulf of Mexico, Red Drum Fishery of the Gulf of Mexico, Reef Fish Fishery of the Gulf of Mexico, Stone Crab Fishery of the Gulf of Mexico, Coral and Coral Reef Fishery of the Gulf of Mexico, Spiny Lobster Fishery of the Gulf of Mexico and South Atlantic, Coastal Migratory Pelagic Resources of the Gulf of Mexico and South Atlantic. Gulf of Mexico Fishery Management Council, Tampa, Florida. 118 pp.

GMFMC (Gulf of Mexico Fishery Management Council). Corrected Amendment 20 for a Charter Vessel/Headboat Permit Moratorium Amending the FMPs for reef fish and Amendment 14 for Coastal Migratory Pelagics. 2003. Gulf of Mexico Fishery Management Council, Tampa, Florida. 165 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 2004. Amendment 22 to the reef fish fishery management plan to set red snapper sustainable fisheries act targets and thresholds, set a rebuilding plan, and establish bycatch reporting methodologies for the reef fish fishery. Gulf of Mexico Fishery Management Council, Tampa, Florida 33607 350 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 2005. Amendment 18a to the Reef Fish FMP for resolving enforcement of regulations, for updating the framework procedure for setting total allowable catch, and to reduce bycatch mortality of incidentally caught endangered sea turtles and smalltooth sawfish. Gulf of Mexico Fishery Management Council, 2203 North Lois Avenue, Suite 1100, Tampa, Florida 33607. 192 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 2005. Amendment 25 to the Reef Fish FMP and Amendment 17 for the Coastal Migratory Pelagics to for extend the charter vessel/headboat permit moratorium. Gulf of Mexico Fishery Management Council, 2203 North Lois Avenue, Suite 1100, Tampa, Florida 33607. 80 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 2005. Final Regulatory Amendment to the Reef Fish Fishery Management Plan to Set Recreational Management Measures for Grouper Starting in 2006. Gulf of Mexico Fishery Management Council, Tampa, Florida. 124 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 2007. Amendment 27 to the Reef Fish FMP and Amendment 14 to the Shrimp FMP to end overfishing and rebuild the red snapper stock. Gulf of Mexico Fishery Management Council, 2203 North Lois Avenue, Suite 1100, Tampa, Florida 33607. 490 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 2008. Amendment 30B to the Reef Fish FMP: Gag – End Overfishing and Set Management Thresholds and Targets, Red Grouper – Set Optimum Yield TAC and Management Measures, Time/Area Closures, and Federal Regulatory Compliance. Gulf of Mexico Fishery Management Council, 2203 North Lois Avenue, Suite 1100, Tampa, Florida 33607. 462 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 2009. Amendment 29 to the reef fish fishery management plan. Effort Management in the Commercial Grouper and Tilefish Fisheries. Gulf of Mexico Fishery Management Council, Tampa, Florida 33607. 300 pp.

GMFMC (Gulf of Mexico Fishery Management Council). 2009. Amendment 31 to the Fishery Management Plan for Reef Fish Resources in the Gulf of Mexico. Addresses bycatch of sea turtles in the bottom longline component of the Gulf of Mexico Reef Fish Fishery. Gulf of Mexico Fishery Management Council, Tampa, Florida 33607. 260 pp.

3. ASSESSMENT HISTORY AND REVIEW

The first assessment of yellowedge grouper was completed in 2002 (Cass-Calay and Bahnick 2002) but was inconclusive regarding the status of the stock. Estimates of initial spawning stock biomass were quite variable and extremely sensitive to initial inputs. Consequently any estimates of current stock status or MSY were also poorly determined. At the time it was felt that there was insufficient data to effectively model the population. In response to the absence of definitive stock status or quota advice, the reef fish stock assessment panel (GMFMC, 2002) recommended an allowable biological catch of 0.84 million lbs gutted weight (381) metric tons, commensurate with the historical average landings.

The 2002 assessment used an age-structured production model Porch (2002). The model included landings from 1986 to 2001 and standardized CPUE time series from the commercial handline and longline logbook program from 1993-2001 split into East and Western Gulf of Mexico. A species association statistic was used to subset the total logbook trips to identify trips targeting yellowedge grouper. The model used Bayesian priors on many of the key inputs (Table 22 in Cass-Calay and Bahnick 2002) and estimated M, R_0 (virgin recruitment), catchability and selectivity parameters. Of importance for the current assessment, the previous model used an initial estimate of M as 0.0533 based upon the maximum age of 85, logistic selectivity functions for the longline fishery and gamma functions for the handline fishery. Sensitivity analyses were conducted with ranges of steepness values of 0.7, 0.65 and 0.6 and with the removal of the 1990 and 1991 index values from one handline index.

In the interim between the 2002 assessment there have been a number of critical improvements in the information content for yellowedge grouper. These include substantial increases in the numbers of length and age composition samples from the fishery, the continuation of the NMFS bottom longline survey such that it now represents a 10 year time series of CPUE and age composition and, most notably, a massive effort to obtain and age archival otolith samples collected by Lew Bullock from the start of the fishery in the late 1970s. This set of initial age and length composition samples represents an unparalleled view of the size and age structure of the population in the first years of the fishery and may give substantial new insights. These additional sources of information coupled with substantial efforts to extend the time series of landings back to the 1970s give hope that the current assessment model will have much more informative data.

Cass-Calay, S.L., and M. Bahnick. 2002. Status of the yellowedge grouper fishery in the Gulf of Mexico. Sustainable Fisheries Division Contribution No. SFD-02/03-172. NMFS, Southeast Fisheries Science Center, Miami, FL.

4. REGIONAL MAPS

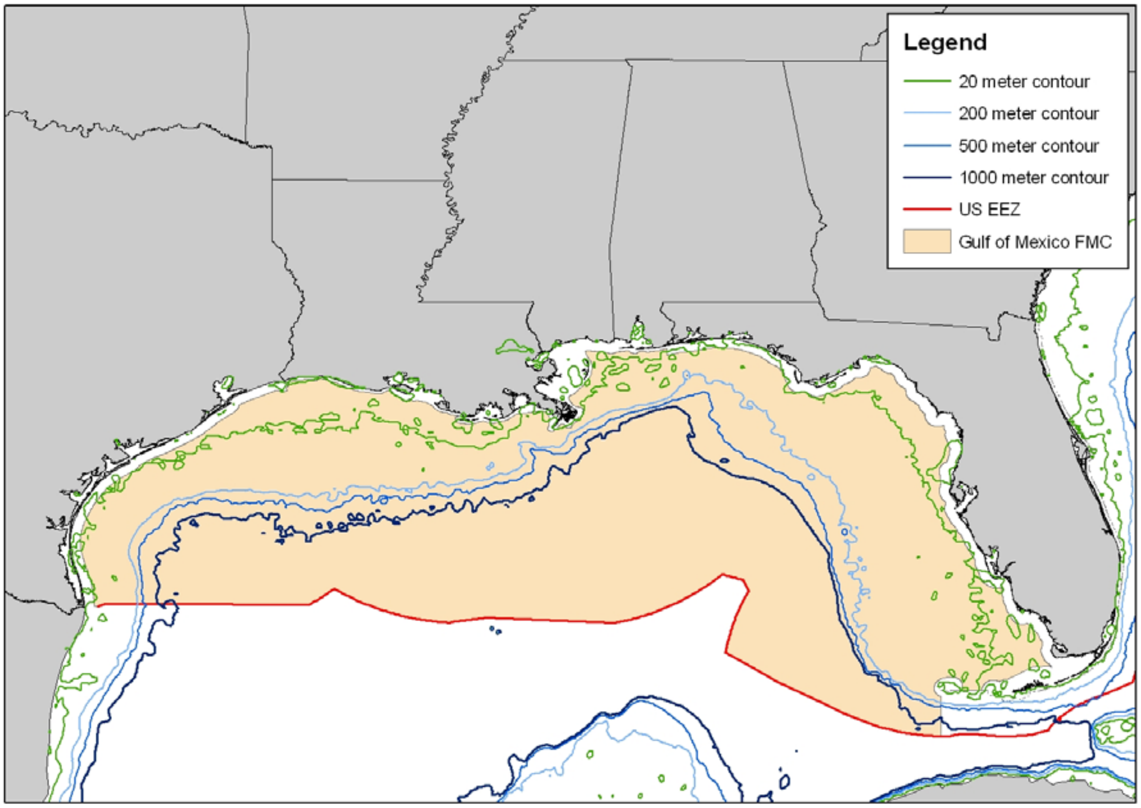


Figure 4.1. Gulf of Mexico management region including Council and EEZ Boundaries

5. **ASSESSMENT SUMMARY**

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; (b) the application of those data, development and execution of one or more assessment models, and (c) the findings and advice determined during the Review Workshop.

Stock Status and Determination Criteria

It proved difficult for the Review Panel (RP) to choose a single model realization that stood out as being 'best'. For pragmatic reasons the SS3 central run was suggested as the run to use for estimates of abundance, biomass and exploitation in order to visualize trends. It is very important to appreciate that the base run is only one of many equally plausible runs and it was suggested mainly because it makes use of the best expert knowledge in configuring the model. However, other runs with different model configurations or model parameters can give stock trajectories that suggest different trends and may be equally valid.

The base run with the $SPR_{30\%}$ benchmark implies that yellowedge grouper is not overfished and overfishing is not occurring in 2009. Sensitivity runs show this classification to be near the definition boundaries.

Table 1. Summary of stock status determination criteria.

The Review Panel chose three runs for stochastic projections which they felt represented realistic levels of between-model-uncertainty for the assessment and cover the likely levels of stock productivity and alternative states of nature: Run 1, which is the base run, Run 11 (low M), which represents a plausible level of low productivity of the stock, and Run 15, increased weighting of indices which provides an equally likely alternative interpretation of the available information to the central run. The Review Panel recommends that MSY proxies ($SPR_{30\%}$ or $SPR_{40\%}$) be used but did not recommend which SPR proxy was most appropriate. The values below are presented for $SPR_{30\%}$. Values represent means of MCMC posterior distributions. Spawning biomass units and yield units are million pounds gutted weight.

Criteria	Recommended Values from SEDAR 22			
	Definition	Run 1 (Base)	Run 11 (LowM)	Run 15 (Fit Indices)
M (Instantaneous natural mortality; per year)	Mean of M values from DW	0.073	0.055	0.073
$F_{current}$ (per year)	Average F 2007 - 2009	1.0	1.0	1.0
F_{MSY} (per year)	$F_{SPR30\%}$	1.06	0.778	1.301
$SSB_{current}$ (mil. lbs)	Spawning stock biomass in 2009	9.533	7.711	11.222
$SSB_{SPR30\%}$ (mil.lbs)	Equilibrium SSB @ $F_{SPR30\%}$	8.621	8.70	8.92
MSST (mil.lbs)	(1-M)*$SSB_{SPR30\%}$	7.992	8.065	8.269
MFMT (per year)	$F_{SPR30\%}$	1.06	0.778	1.301
MSY (1000 pounds)	Equilibrium Yield at $F_{SPR30\%}$	0.788	0.724	0.854
OY (1000 pounds)	Equilibrium Yield at F_{OY}	NA	NA	NA
F_{OY} (per year)	75% of $F_{SPR30\%}$	0.795	0.584	0.976
Biomass Status	$SSB_{current}$/MSST	1.193	0.956	1.357
Exploitation Status	$F_{current}$/MFMT	0.949	1.292	0.774

Stock Identification and Management Unit

- The common name for *Epinephelus flavolimbatus* is yellowedge grouper however, commercially they are also commonly called and marketed as yellowfin grouper.
- Gulf of Mexico (GOM) yellowedge grouper are classified as a single stock. Cass-Calay and Bahnick assumed a single GOM stock for the 2002 yellowedge grouper assessment.

Due to limited information on stock structure the LH DW recommends the assumption of a unit stock for the GOM.

Species Distribution:

- Yellowedge grouper are found in the western Atlantic from North Carolina to southern Florida, the entire Gulf of Mexico, Cuba, the West Indies, off the coasts of Central America, and the northern coast of South America to Brazil.
- Yellowedge grouper are primarily distributed between the 50 to 300 m depth contours throughout the GOM. Smaller yellowedge grouper (<400 mm TL) were found in shallower depths between 35-125 m while larger fish were found in up to 300 m depths.
- Adult yellowedge grouper prefer mostly soft substrate throughout the western and central GOM, but have also been found at the shelf edge on mud, sand, sand-shell and hard bottom areas.

Stock Life History

- The Life History Working Group (LH WG) reviewed estimates of total (Z) and natural mortality (M) from catch curves and proxy equations to develop a table of estimated M values as informative priors for the assessment. Plausible natural mortality (M) estimates ranged from <0.003 to 0.3 based on a suite of life history proxies.
- The LH WG recommended that catch curves constructed from the Bullock samples collected during 1977-1980 represent the best estimates for the true value of M; that is, the total mortality during this beginning period of the fishery was Z=0.078 (SE=0.009, 95% CI=0.060-0.096).
- The LH WG recommended that the assessment incorporate a range of M estimates for sensitivity runs from 0.01 to 0.09 for yellowedge grouper.
- Female yellowedge grouper from the northern GOM exhibited a spawning season extending from February to November with peak development in March through September.
- Mature females ranged in size from 510 to 1,000 mm TL and ages 6-36. Based on logistic regression, size and age at 50% maturity for females in the GOM were 547 mm TL and age 8 years, respectively.
- Yellowedge grouper are protogynous hermaphrodites. The size and age at 50% sexual transition for GOM yellowedge grouper was 815 mm TL and 22 years.
- Ontogenetic habitat shifts have been observed for yellowedge grouper. Radiocarbon age validation of yellowedge grouper noted different ^{14}C signals throughout the life of a fish indicating that juvenile fish are found in shallower depths and move out to deeper water as they age.

Assessment Methods

Stock Synthesis 3.20 (SS3, SS-V3.20e) was used as the principal assessment method. It is an age-structured population assessment tool and is a well-established approach. It is an integrated statistical catch at age model that can simultaneously estimate selectivities, fishing mortalities, abundance as well as biological parameters such as growth rates. Data are input in relatively unprocessed form and hence a wide variety of data can be included. SS3 can tolerate missing values for most types of data. It is well designed to deal with the data available for the yellowedge grouper assessment, but does require the analyst to make a number of choices in the configuration of the model.

The base run of the model assumed two geographical areas (Eastern and Western Gulf) that allowed for differences in growth and natural mortality. Asymptotic selectivity was assumed for longline gears, but dome shaped for the trawl and handline gears.

Exploratory analysis was also performed using Stock Reduction Analysis (SRA). While a much simpler approach, SRA is based on a very similar age structured population model that uses an historical catch stream to estimate a stock biomass trajectory. The principal limitation of the method is that it does not use data on age and length within the model.

As well as the more complex assessment tools, the AW also carried out a simple catch curve analysis for two time periods. An early time period (1977-1980) corresponds to low fishing activity where the estimated total mortality (Z) gives an indication of natural mortality while the more recent period (2000s) give estimates of Z when the fishery was larger. The Z estimates suggest values for M and F in recent years that are consistent with the base run assessment which provides additional support for the SS3 estimates.

Assessment Data

- Input data comprised catches, length and age compositions, abundance indices and life history data.
- Landings data were available for the years 1975 onwards and were split into two areas (Eastern and Western Gulf). Landings data prior to 1991 were derived using several methods for varying time frames and are described in detail in the Data Workshop Report. Discards and recreational catches were small and were added to the total landings.
- A fixed vector of maturity at age, and a fixed length-weight relationship was used for weight at age and fecundity at age for both males and females.
- Age and length composition data were available from both fishery dependent and independent sources. The information was stratified by region, gear, and sex.
- One commercial and one fishery independent survey were available which had been standardized using a delta-lognormal model. These are partitioned into two assessment areas. The commercial longline CPUE is a longer and continuous series since 1991 while the NMFS Bottom Longline (BLL) CPUE series begins in 2000 and was interrupted in 2005in the west due to a hurricane event.

- Overall the data summarized above were considered by the Review Panel to be adequate for the purpose of assessment, but noted that the quantity of data was low and there are concerns over some aspects of its quality.

Release Mortality

There is no information available regarding yellowedge grouper discard mortality. However, given the depths fished and common information regarding the condition of captured fish, the assumption is that discard mortality is equal to 100%.

Catch Trends

- Substantial landings for yellowedge grouper began to occur in the early 1980s, with a peak in 1982 of 4,395,875 gutted pounds.
- The landings decreased rapidly after the 1982 peak, generally leveling off from around 1993 forward.
- These landings generally match the rapid expansion of the deep-water longline fishery in the early 1980's and its rapid movement inshore to target red grouper.

Fishing Mortality Trends

Stock Synthesis does produce region and fishery-specific estimates of instantaneous fishing mortality rates. In a multi-area, multi-fishery model, it is impossible to produce an overall instantaneous fishing mortality rate. Therefore, a proxy must be used to get estimates of Gulfwide fishing mortality. The Assessment Panel decided to use F relative to F current to determine stock status, as was done in the SEDAR 7 Gulf of Mexico red snapper assessment and in the 2009 Gulf of Mexico red snapper assessment update.

Fleet-specific patterns of instantaneous Fishing mortality represent relative trends in fishing mortality by fleet and area. The East fishing mortality spiked in the early 1980s, then declined and now appears to be slightly increasing since the mid-1990s. Fishing mortality in the West has been on a slight decline over the last 20 years after peaking between 1983-1995. Current fishing mortality rates in the East appear to be twice that of the West which largely reflects the fact that landings in the East have been much higher than that of the West.

Given the selectivity patterns estimated in the model and the dominance of the longline fishery, the fishing mortality at age is concentrated on the older fish and is relatively constant for ages 20-40+.

Stock Abundance and Biomass Trends

The general biomass trend is a steep decline starting in the early 1980s, commensurate with a dramatic increase in F, then a leveling off since around 1993. This generally matches the rapid expansion of the deep-water longline fishery in the early 1980's and its rapid movement inshore to target red grouper. It is likely that there would have been an extremely strong decline in CPUE during this time, but unfortunately we do not have any indices from before 1995. The time period covered by the indices is largely after most of the major population changes predicted by the model.

The estimated Beverton-Holt stock recruitment relationship appears quite poorly estimated. There are very few observations at lower stock sizes and very little evidence of a stock-recruitment relationship. This could largely be a function of the spawning stock being estimated to have been constant for the past 15 years, while estimated recruitment has fluctuated.

The partitioning of recruits by area was relatively 2:1 which matches the allocation of habitat area with the East being approximately twice the area of inhabitable habitat for YEG of that of the West

Projections

The RP selected three model runs for full Markov chain Monte Carlo (MCMC) development to quantify uncertainty in parameter estimates and derived quantities (Base model, LowM and the model with increased weighting on the indices).

The Base model was overfished only at SPR40% and the low M model was overfished at both SPR30% and SPR40%. At no SPR levels was the increased weight on the indices model overfished. Overfishing ($\mathbf{F}_{CURRENT}$/MFMT**)** was occurring in these same models and also in the increased fit to the indices model at SPR40%. Note that the Fcurrent values of '1' are due to the use of relative F as the measure of fishing mortality. Hence MFMT and other fishing mortality proxies are shown relative to the current F, so that $\mathbf{F}_{CURRENT}$>MFMTindicates overfishing.

For the model runs which indicate overfished status (SSB_{2009}<MSST) the time to rebuild was determined by projection the population forward in time with no fishing mortality. In all cases Tmax was 10 years and Tmin ranged from 1 (rebuilt in 2010) to 6 years. This time was counted as the number of years since 2009 that it took for the MCMC posterior mean SSB/MSST to be greater than 1.

Scientific Uncertainty

- Uncertainty in parameter estimates was quantified by computing asymptotic standard errors for each parameter. Asymptotic standard errors provide a minimum estimate of uncertainty in parameter values. In addition, uncertainty in parameter estimates and key derived quantities was estimated using MCMC methods for the three runs selected by the Review Panel.
- Uncertainty in data inputs and model configuration was examined through a sensitivity analysis. Fourteen alternative runs were included in the assessment report. Four additional sensitivity analyses were run at the request of the Review Panel.

- Of the 18 sensitivity runs examined, six were identified as representing the range of uncertainty (see Table 1 of the Review Workshop Report). The central run (Run 1), Low M (Run 11) and the increased weight on indices (Run 15) were chosen by the Review Panel to represent the uncertainty using MCMC stochastic simulations. The Low M seems to represent a plausible level of low productivity for the stock, and the increased indices weight allowed for a balanced contribution of indices to age and length composition data.

Significant Assessment Modifications

- The stock assessment team found it necessary to make several changes to the Gulf of Mexico yellowedge grouper assessment to better respond to the requests of the review panel. Since the assessment workshop the critical changes include: 1) use of 'F relative' as the fishing mortality proxy, 2) addition of a model run (Increased weight on the indices) , 3) slight modification to the bottom longline standard error and 4) Markov chain Monte Carlo runs for three model runs (BASE, LowM and Increased weight on the indices). The latter model run was requested by the RP to attempt to fit the increasing trend in the indices by increasing the weighting on the indices.
- After the RW, SS3 version 3.20e, which has some enhanced projection capabilities necessary for management advice, became available. It was desired to transition to the new version. The BASE model was re-run with the SS3 version 3.20e which resulted in a less than 0.5% difference in almost all estimated quantities.

Summary Comments

Overall substantial progress has been made in the assessment of yellowedge grouper relative to the last assessment in 2002. Three critical pieces of information now exist that substantially improve our ability to assess the stock: 1) 10-year time series of survey index and size and age composition from the NMFS bottom longline survey;2) reclamation of a vast archive of historic age and length composition data from the beginning of the fishery; and 3) ability to push the landings history back to approximately the start of the fishery in 1975. These additions should make the determination of stock status, productivity and consequent management advice much better determined than in 2002.

Notwithstanding these changes, several key uncertainties and issues remain:

- Magnitude of the historic landings of yellowedge from within the mass of unclassified groupers during the 1980-1986 time period at the initiation of the deepwater longline fishery.
- Uncertainty in the natural mortality rates
- Discrepancy between the input and the estimated probability of transition to male.
- Uncertainties regarding the stock-recruitment relationship exist.

What we can have confidence in this assessment is that the landings have been more or less stable for the past 20 years and that this stability appears to be due to harvests close to only slightly higher than yields at SPR30% and close to the yields at MSY. Our confidence in this statement comes largely from two pieces of evidence. One, the early and late age composition provides strong information on natural mortality and a good ability to evaluate the effects of this harvest history on the current age composition. Second, the extremely high landings in 1981-1985, regardless of the high or low scenarios, give substantial insight into the inherent productivity of the stock, even if we do not know the nature of the stock recruitment relationship.

Sources of Information

All information was copied directly or generated from the information available in the final Stock Assessment Report for SEDAR 22: Gulf of Mexico Yellowedge Grouper.

Table 2: Commercial landings (gutted lbs) for Gulf of Mexico yellowedge grouper. Landings are separated into four fisheries: commercial hand line east (CM HL E), commercial hand line west (CM HL W), commercial long line east (CM LL E), and commercial long line west (CM LL W). Recreational landings and discards (assumed 100% dead) in gutted lbs were added to handline landings and MRFSS landings were split evenly between East and West regions. (*Extracted from Table 2.1 and 2.3 of the Assessment report*)

	Western Gulf				Eastern Gulf			
Year	CM HL W	CM LL W	Comm. Discards	Rec W	CM HL E	CM LL E	Comm. Discards	Rec E
1975	113,454				351,630			
1976	74,084				296,289			
1977	60,985				255,015			
1978	67,082				231,954			
1979	75,112	36,031			343,702			
1980	44,176	46,681			333,638	446,729		
1981	230,857	682,027			301,678	1,515,422		
1982	225,393	680,796		65,285	264,745	3,224,942		65285
1983	117,510	646,674			235,083	2,476,207		
1984	197,754	612,551		209	232,890	1,727,472		
1985	210,188	578,428			294,541	978,737		
1986	98,119	544,306		666	544,942	230,002		229
1987	63,191	437,827		552	345,548	337,222		552
1988	281,401	606,346		1,089	269,219	489,354		1,089
1989	49,078	351,233		8,652	66,533	273,663		8,652
1990	39,015	345,943	613	822	117,818	373,245		822
1991	40,159	317,054	1960	666	78,977	334,785		666
1992	77,802	386,692	2173	245	66,276	511,134		245
1993	76,642	319,263	854	1,712	32,506	348,000		1,712
1994	42,398	277,888	1000	212	50,969	698,474		212
1995	30,945	372,383	1198	303	23,332	415,288		303
1996	19,477	155,994	1072	90	21,838	332,554		90
1997	18,681	124,475	1644	798	15,384	561,599		798
1998	25,478	215,034	1574	3,964	22,040	420,914		3,964
1999	37,094	274,224	1795	339	28,134	633,502		339
2000	42,735	295,164	1733	19	21,200	732,240		19
2001	22,893	197,259	1730	712	15,031	541,818		712
2002	26,455	301,981		1,919	22,141	434,577		1,919
2003	33,021	363,051		195	24,735	682,769		195
2004	27,950	296,015	1193	606	20,520	580,862	11656	606
2005	23,365	268,662	2498	28,301	16,138	479,251		28,301
2006	16,426	226,984	1733	1,388	21,337	480,590		1,388
2007	27,529	137,744	12418	226	10,514	692,691		226
2008	24,168	158,430	552	408	8,676	627,767		408
2009	43,453	210,874	59	2,472	20,399	553,821		2,472

Table 3: Fishing mortality (exploitation rate) estimates, stock abundance, biomass, spawning stock biomass age-0 recruits (thousand fish) for Gulf of Mexico YEG from the base model, asymptotic standard deviations based on inverting the hessian matrix are given in parentheses.

year	Overall exploitation rate	Total biomass (gutted MT)	Total number (1000s)	Spawning biomass (gutted MT, males & females)	Recruits (1000s)
1975	0.011 (0.0002)	33667	5338.6	30319 (465)	855 (185.1)
1976	0.01 (0.0001)	33100	5312.4	29811 (459)	835.5 (178.4)
1977	0.009 (0.0001)	32641	5314.3	29362 (452)	852.9 (181.3)
1978	0.014 (0.0002)	32250	5329	28944 (444)	867 (183.4)
1979	0.028 (0.0004)	31893	5372.7	28535 (436)	902.3 (188.1)
1980	0.09 (0.0013)	31397	5335	27989 (426)	849.4 (175.5)
1981	0.163 (0.0024)	30523	5305	27075 (416)	873.1 (176.1)
1982	0.148 (0.0026)	27874	5075.1	24470 (404)	802.8 (158.3)
1983	0.136 (0.0027)	23565	4722.3	20287 (392)	774.4 (152.4)
1984	0.115 (0.0025)	20401	4537.1	17190 (380)	834.9 (173.3)
1985	0.087 (0.0021)	18016	4668	14840 (369)	1108 (227.7)
1986	0.078 (0.0019)	16387	4597.5	13222 (359)	952.2 (200.5)
1987	0.112 (0.0029)	15452	4392.5	12258 (351)	756.4 (145.9)
1988	0.056 (0.0016)	14788	4264.2	11546 (345)	743.9 (139.2)
1989	0.065 (0.0018)	13740	4168.3	10493 (339)	780.5 (144.7)
1990	0.058 (0.0017)	13574	4089.7	10250 (337)	714.9 (137.9)
1991	0.079 (0.0024)	13344	4253.2	9967 (335)	941.9 (191.2)
1992	0.06 (0.0019)	13234	4416.9	9819 (335)	1001.1 (240.2)
1993	0.084 (0.0027)	12912	5001.9	9490 (337)	1495.2 (326.7)
1994	0.067 (0.0023)	12868	4897.8	9429 (341)	981 (233)
1995	0.043 (0.0015)	12600	4623.6	9149 (346)	750.9 (153.7)
1996	0.056 (0.002)	12584	4598.8	9062 (353)	872 (184.4)
1997	0.053 (0.0019)	12888	4873.7	9245 (363)	1143.6 (239.1)
1998	0.074 (0.0028)	13034	4784.1	9285 (373)	887.7 (190.5)
1999	0.083 (0.0033)	13236	4686.8	9374 (385)	825.6 (156.1)
2000	0.06 (0.0025)	13172	4431.8	9261 (399)	656 (113.1)
2001	0.06 (0.0026)	13002	4422.7	9097 (417)	833.9 (21.6)
2002	0.088 (0.004)	13117	4420.3	9236 (438)	834.5 (21.4)
2003	0.073 (0.0035)	13215	4412.8	9388 (461)	835.1 (21.2)
2004	0.061 (0.0031)	12952	4366.2	9237 (484)	834.5 (21.6)
2005	0.058 (0.003)	12884	4344.9	9256 (510)	834.6 (21.6)
2006	0.068 (0.0036)	12945	4340.1	9389 (537)	835.1 (21.5)
2007	0.063 (0.0035)	13038	4340.1	9541 (564)	835.7 (21.4)
2008	0.064 (0.0036)	12994	4326.3	9556 (590)	835.7 (21.4)
2009	0.064 (0.0035)	13004	4320.9	9593 (615)	835.9 (21.5)

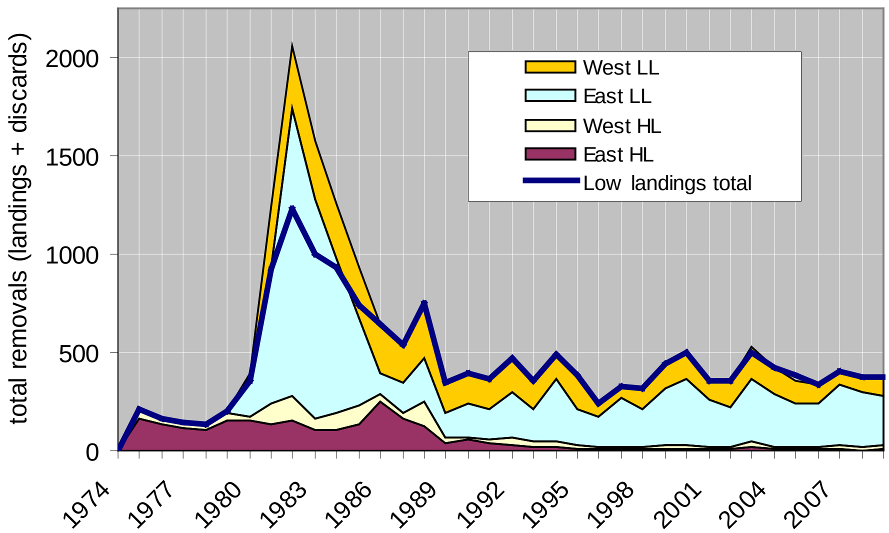


Figure 1: Landings by fishery sector
Low and Base landings scenarios. Removals by fleet are shown for the high scenario where unclassified longline caught grouper in stat areas 6 and 7 are assumed 96% YEG. Only the total removals are shown for the low landings scenario where unclassified longline caught grouper in stat area 6 are assumed to be 23% YEG. The differences only apply to the longline fishery and only over the years 1980-1985. (*Figure 2.3 from the Assessment Workshop Report*)

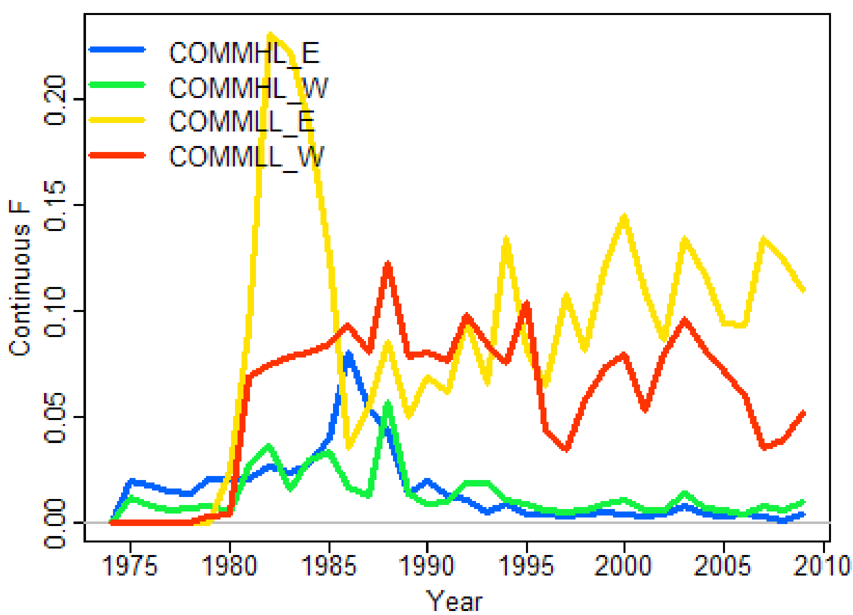


Figure 2: Fishing Mortality
Base model estimated fleet specific fishing mortality rates.

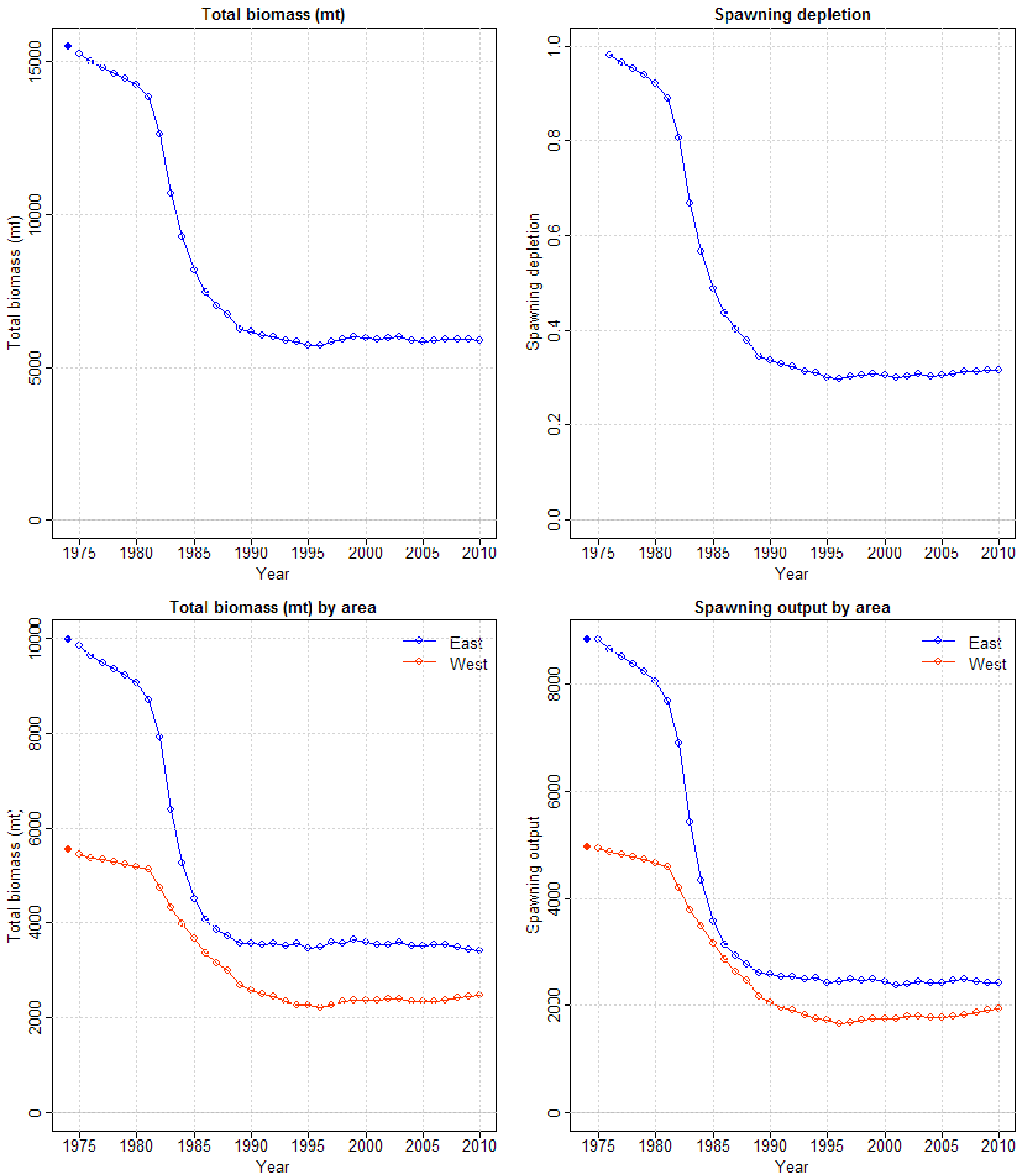


Figure 3: Stock Biomass

Total biomass, spawning depletion (relative to virgin SSB), total biomass by area and spawning stock biomass by area for the Base model

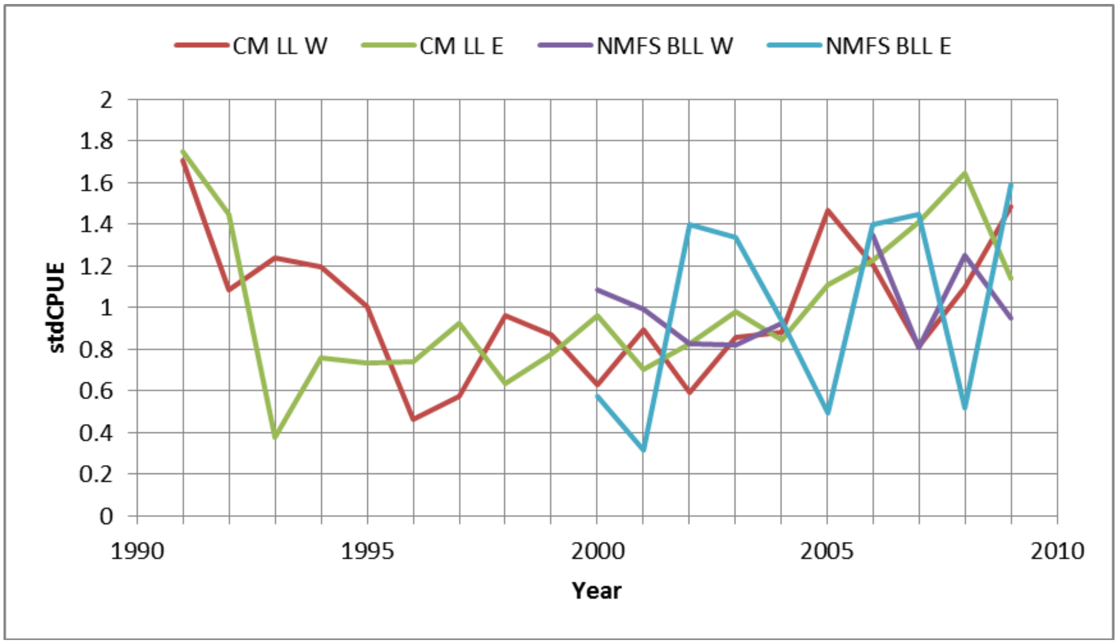


Figure 4: Abundance Indices
Standardized indices of relative abundance for Gulf of Mexico yellowedge grouper. The indices are from the commercial long line east (CM LL E), commercial long line west (CM LL W), NMFS bottom long line survey east (NMFS BLL E), and NMFS bottom long line survey west (NMFS BLL W). (*Figure 2.15 from the Assessment Workshop Report*)

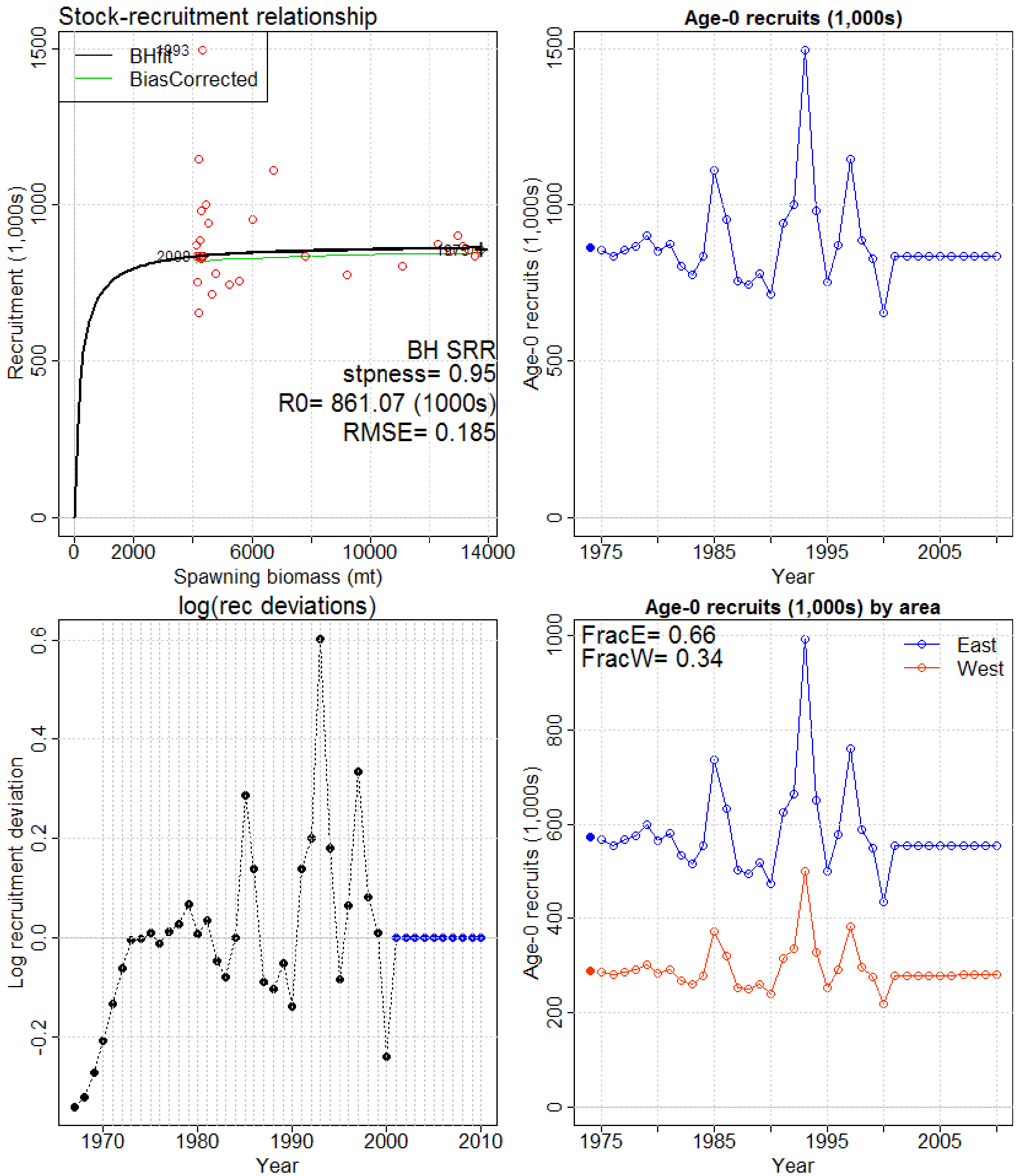


Figure 5: Stock-Recruitment
Base model stock recruit relationship, recruits, recruitment deviations and recruits by region.

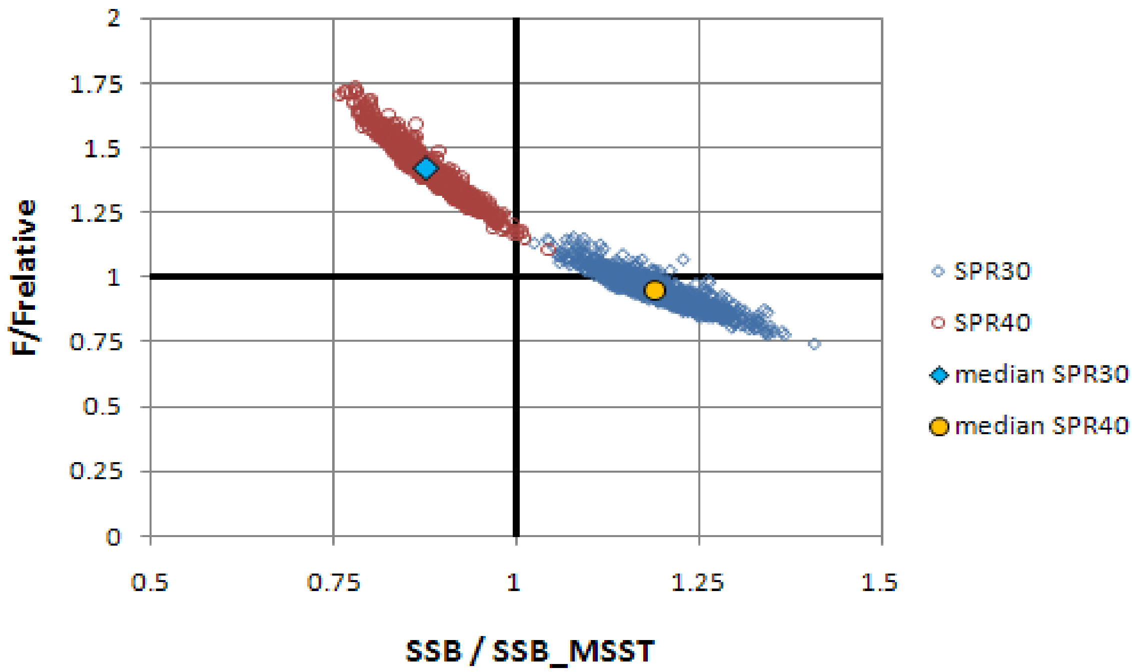


Figure 6: Stock Status and Control Rule
Base model uncertainty in stock status from sampled MCMC runs (495 sampled from 100000). Fishing mortality rate is calculated is the deterministic F2009/$F_{SPR30\%}$ or $F_{SPR40\%}$. SSB status is calculated as the deterministic SSB2009/SSB_MSST where SSB_MSST is (1-M)*$SSB_{SPR30\%}$ or $SSB_{SPR40\%}$ and M=0.073.

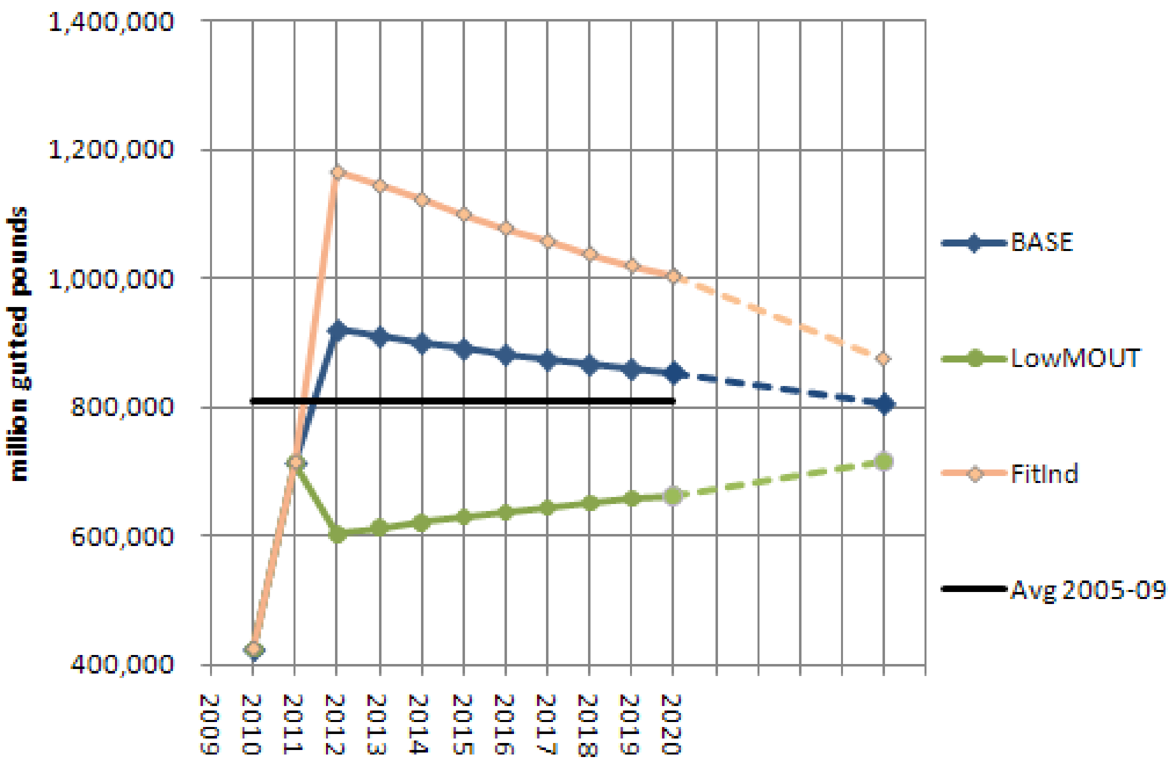


Figure 7: Projections

Short-term deterministic yield projections at FSPR30% for the Base, Low M and increased fit to the indices model. The equilibrium yields at FSPR30% are plotted as points on the far right. The black line is the average landings from 2005-2009 for reference. (*Figure 19 in the Addendum*)**.**

6. SEDAR ABBREVIATIONS

ABC	Allowable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
ADMB	AD Model Builder software program
ALS	Accumulated Landings System; SEFSC fisheries data collection program
ASMFC	Atlantic States Marine Fisheries Commission
B	stock biomass level
BMSY	value of B capable of producing MSY on a continuing basis
CFMC	Caribbean Fishery Management Council
CIE	Center for Independent Experts
CPUE	catch per unit of effort
F	fishing mortality (instantaneous)
F_{MAX}	fishing mortality that maximizes the average weight yield per fish recruited to the fishery
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_0	a fishing mortality close to, but slightly less than, Fmax
FL FWCC	Florida Fish and Wildlife Conservation Commission
FWRI	(State of) Florida Fisheries and Wildlife Research Institute
GA DNR	Georgia Department of Natural Resources
GLM	general linear model
GMFMC	Gulf of Mexico Fishery Management Council
GSMFC	Gulf States Marine Fisheries Commission
GULF FIN	GSMFC Fisheries Information Network
M	natural mortality (instantaneous)
MARMAP	Marine Resources Monitoring, Assessment, and Prediction
MFMT	maximum fishing mortality threshold, a value of F above which overfishing is deemed to be occurring
MRFSS	Marine Recreational Fisheries Statistics Survey; combines a telephone survey of households to estimate number of trips with creel surveys to estimate catch and effort per trip
MRIP	Marine Recreational Information Program

MSST	minimum stock size threshold, a value of B below which the stock is deemed to be overfished
MSY	maximum sustainable yield
NC DMF	North Carolina Division of Marine Fisheries
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
OY	optimum yield
SAFMC	South Atlantic Fishery Management Council
SAS	Statistical Analysis Software, SAS Corporation
SC DNR	South Carolina Department of Natural Resources
SEDAR	Southeast Data, Assessment and Review
SEFSC	Fisheries Southeast Fisheries Science Center, National Marine Fisheries Service
SERO	Fisheries Southeast Regional Office, National Marine Fisheries Service
SPR	spawning potential ratio, stock biomass relative to an unfished state of the stock
SSB	Spawning Stock Biomass
SSC	Science and Statistics Committee
TIP	Trip Incident Program; biological data collection program of the SEFSC and Southeast States.
Z	total mortality, the sum of M and F

SEDAR

Southeast Data, Assessment, and Review

SEDAR 22

Gulf of Mexico Yellowedge Grouper

SECTION II: Data Workshop Report

August 2010

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

Table of Contents

1. INTRODUCTION 5
   1.1. WORKSHOP TIME AND PLACE 5
   1.2. TERMS OF REFERNCE 5
   1.3. LIST OF PARTICIPANTS 6
   1.4. LIST OF DATA WORKSHOP WORKING PAPERS AND REFERNCE DOCUMENTS 7
2. LIFE HISTORY 10
   2.1. OVERVIEW 10
      2.1.1. Life History Data Working group membership 10
      2.1.2. Issues 10
   2.2. REVIEW OF WORKING PAPERS 10
   2.3. STOCK DEFINITION AND DESCRIPTION 11
      2.3.1 Stock structure and definition 11
      2.3.2 Population genetics 11
      2.3.3 Tagging 11
      2.3.4 Larval transport and connectivity 12
      2.3.5 Distribution 12
   2.4. NATURAL MORTALITY 12
   2.5. DISCARD MORTALITY 14
   2.6. AGE 15
   2.7. GROWTH 17
   2.8. REPRODUCTION 18
   2.9. MOVEMENTS AND MIGRATIONS 18
   2.10. MORPHOMETRICS AND CONVERSION FACTORS 19
   2.11. COMMETNS ON ADEQUACY OF DATA FOR ASSESSMENT ANALYSES 19
   2.12. ITEMIZED LIST OF TASKS FOR COMPLETION FOLLOWING WORKSHOP 20
   2.13. LITERATURE CITED 20
   2.14. TABLES 23
   2.15. FIGURES 31
3. COMMERCIAL FISHERY STATISTICS 42
   3.1. OVERVIEW 42

3.1.1. Group membership 42
3.1.2. Issues 42
3.2. REVIEW OF WORKING PAPERS (Author and Presenter) 43
3.3. COMMERCIAL LANDINGS 44
3.3.1. Historical Catch Area 44
3.3.2. Discussion of Methods to Calculate Historical Landings of Yellowedge Grouper 45
3.3.4 Mis-Identification 50
3.4. COMMERCIAL DISCARDS 52
3.5. COMMERCIAL EFFORT 53
3.6. BIOLOGICAL SAMPLING: SIZE COMPOSITION BY GEAR TYPE 54
3.7. COMPARISION BETWEEN TIP AND AGE & GROWTH LENGTH FREQUENCIES 54
3.8. COMMENTS ON ADEQUACY OF DATA FOR ASSESSMENT ANALYSES 55
3.9. TABLES 55
3.10. FIGURES 69
4. RECREATIONAL FISHERY STATISTICS 79
4.1. OVERVIEW 79
4.1.1. Group membership 79
4.2. REVIEW OF WORKING PAPERS 79
4.3. RECREATIONAL LANDINGS 79
4.4. RECREATIONAL DISCARDS 80
4.5. BIOLOGICAL SAMPLING 80
4.6. RECREATIONAL CATCH-AT-AGE/LENGTH 80
4.7. RECREATIONAL EFFORT 81
4.8. COMMENTS ON THE ADEQUACY OF DATA FOR ASSESSMENT ANALYSES 81
4.9. LITERATURE CITED 81
4.10. TABLES 81
5. MEASURES OF POPULATION ABUNDANCE 83
5.1. OVERVIEW 83
5.1.1. Group Membership 83
5.2. REVIEW OF WORKING PAPERS 83
5.3. FISHERY INDEPENDENT INDICES 84

5.3.1. NOAA Fisheries SEAMAP Groundfish Survey (SEDAR22-DW-06)........................ 84
5.3.2 NOAA Fisheries Bottom Longline Survey (SEDAR22-DW-07)................................ 86
5.4. FISHERY DEPENDENT INDICES.. 88
5.4.1 Commercial Logbook (Longline) (SEDAR22-DW-02) 88
5.5. CONSENSUS RECOMMENDATIONS AND SURVEY EVALUATIONS.................... 90
5.6. ITEMIZED LIST OF TASKS FOR COMPLETION FOLLOWING WORKSHOP......... 90
5.7. LITERATURE CITED 91
5.8. TABLES... 92
5.9. FIGURES 97
6. ANALYTIC APPROACH.. 103
6.1. SUGGESTED ANALYTIC APPROACH GIVEN THE DATA 103
6.2. REFERENCES.. 104
APPENDIX 1: INDICES WORKSHEETS…………………………………………………..105

1. INTRODUCTION

1.1. *WORKSHOP TIME AND PLACE*

The SEDAR 22 Data Workshop was held March 15 - 19, 2010 in Tampa, Florida.

1.2. *TERMS OF REFERNCE*

1. Characterize stock structure and develop a unit stock definition. Provide maps of species and stock distribution.
2. Review, discuss and tabulate available life history information (e.g., age, growth, natural mortality, reproductive characteristics); provide appropriate models to describe growth, maturation, and fecundity by age, sex, or length as applicable. Evaluate the adequacy of available life-history information for conducting stock assessments and recommend life history information for use in population modeling.
3. Provide measures of population abundance that are appropriate for stock assessment. Consider and discuss all available and relevant fishery dependent and independent data sources. Document all programs evaluated, addressing program objectives, methods, coverage, sampling intensity, and other relevant characteristics. Provide maps of survey coverage. Develop CPUE and index values by appropriate strata (e.g., age, size, area, and fishery); provide measures of precision and accuracy. Evaluate the degree to which available indices adequately represent fishery and population conditions. Recommend which data sources are considered adequate and reliable for use in assessment modeling.
4. Characterize commercial and recreational catch, including both landings and discard, in pounds and number. Provide estimates of discard mortality rates by fishery and other strata as appropriate or feasible. Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector. Provide length and age distributions if feasible. Provide maps of fishery effort and harvest.
5. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Include specific guidance on sampling intensity (number of samples including age and length structures) and appropriate strata and coverage.
6. Develop a spreadsheet of assessment model input data that reflects the decisions and recommendations of the Data Workshop. Review and approve the contents of the input spreadsheet by June 1.

7. Prepare the Data Workshop report providing complete documentation of workshop actions and decisions (Section II. of the SEDAR assessment report). Develop a list of tasks to be completed following the workshop.

1.3. *LIST OF PARTICIPANTS*

Workshop Panel

Adam Pollack .... NMFS Pascagoula
Bob Spaeth .... GMFMC AP
Brad Kenyon .... GMFMC AP
Brian Linton .... NMFS Miami
Charlie Bergmann .... NMFS Pascagoula
Debbie Fable .... NMFS Panama City
Elbert Whorton .... GMFMC SSC
Gary Fitzhugh .... NMFS Panama City
Harry Blanchet .... GMFMC SSC/LADWLF
Hope Lyon .... NMFS Panama City
John Quinlan .... NMFS Miami
John Walter .... NMFS Miami
Kevin McCarthy .... NMFS Miami
Linda Lombardi .... NMFS Panama City
Martin Fisher .... GMFMC AP
Melissa Cook .... NMFS Panama City
Neil Baertlein .... NMFS Miami
Refik Orhun .... NMFS Miami
Richard Fulford .... GMFMC SSC/Univ of S. MS
Steve Turner .... NMFS Miami
Walter Ingram .... NMFS Pascagoula

CIE Reviewer

Yong Chen .... Univ. of Maine

Council Representation

Bob Shipp .... GMFMC

Observers

Greg Abrams ....

Staff

Carrie Simmons .... GMFMC Staff
Julie Neer .... SEDAR
Tina O’Hern .... GMFMC Staff

Patrick Gilles..NMFS Miami

1.4. *LIST OF DATA WORKSHOP WORKING PAPERS AND REFERNCE DOCUMENTS*

Document #	Title	Authors	Working Group
Documents Prepared for the Data Workshop			
SEDAR22-DW-01	Golden tilefish (*Lopholatilus chamaeleonticeps*) age, growth, and reproduction from the northeastern Gulf of Mexico: 1985,1997-2009	Linda Lombardi, Gary Fitzhugh, Hope Lyon	Life History
SEDAR22-DW-02	Commercial longline vessel standardized catch rates of yellowedge grouper in the Gulf of Mexico	Neil Baertlein and Kevin McCarthy	Indices
SEDAR22-DW-03	Golden tilefish and blueline tilefish standardized catch rates from commercial longline vessels in the Gulf of Mexico	Kevin McCarthy	Indices
SEDAR22-DW-04	Discards of yellowedge grouper, golden tilefish, and blueline tilefish from commercial fishing vessels in the Gulf of Mexico	Kevin McCarthy	Catch Statistics
SEDAR22-DW-05	Explorations of habitat associations of yellowedge grouper and golden tilefish	John F Walter, Melissa Cook, Brian Linton, Linda Lombardi, and John A. Quinlan	Life History
SEDAR22-DW-06	Abundance Indices of subadult Yellowedge Grouper, *Epinephelus flavolimbatus*, Collected in Summer and Fall Groundfish Surveys in the northern Gulf of Mexico	Adam G. Pollack and G. Walter Ingram, Jr.	Indices

SEDAR22-DW-07	Abundance Indices of Yellowedge Grouper and Golden Tilefish Collected in NMFS Bottom Longline Surveys in the northern Gulf of Mexico	G. Walter Ingram, Jr. and Adam G. Pollack	Indices
SEDAR22-DW-08	Yellowedge grouper (Epinephelus flavolimbatus) age, growth and reproduction from the northern Gulf of Mexico	Melissa Cook and Michael Hendon	Life History
SEDAR22-DW-09	Observed Length frequency distributions and otolith sampling issues for yellowedge groupers caught in the Gulf of Mexico from 1984 to 2009.	Ching-Ping Chih	Life History/ Catch Statistics
SEDAR22-DW-10	Observed Length frequency distributions and otolith sampling issues for tile fish caught in the Gulf of Mexico from 1984 to 2009	Ching-Ping Chih	Life History/ Catch Statistics
SEDAR22-DW-11	Length frequency distributions for blue line tile fish caught in the Gulf of Mexico from 1984 to 2009	Ching-Ping Chih	Life History/ Catch Statistics
SEDAR22-DW-12	Estimation of species misidentification in the commercial landing data of tile fish in the Gulf of Mexico from 1984 to 2009	Ching-Ping Chih	Catch Statistics
SEDAR22-DW-13	Estimation of species misidentification in the commercial landing data of yellowedge groupers in the Gulf of Mexico from 1984 to 2009	Ching-Ping Chih	Catch Statistics
SEDAR22-DW-14	Evidence of hermaphroditism in Golden Tilefish (*Lopholatilus chamaeleonticeps*) in the Gulf of Mexico	Hope Lyon	Life History
SEDAR22-DW-15	Recreational Survey Data for Yellowedge Grouper, Tilefish (golden), and Blueline Tilefish in the Gulf of Mexico	Vivian M. Matter	Catch Statistics
SEDAR22-DW-16	Estimated Recreational Catch in Weight: Method for Filling in	Vivian M. Matter	Catch

	Missing Weight Estimates from the Recreational Surveys		Statistics
SEDAR22-DW-17	Commercial Landings of Yellowedge Grouper, Golden Tilefish, and Blueline Tilefish from the Gulf of Mexico region	Refik Orhun	Catch Statistics

Reference Documents

SEDAR22-RD01	Lead-radium dating of golden tilefish (*Lopholatilus chamaeleonticeps*)	Allen Andrew
SEDAR22-RD02	Status of the yellowedge grouper fishery in the Gulf of Mexico	Shannon L. Cass-Calay and Melissa Bahnick
SEDAR22-RD03	Yellowedge grouper (*Epinephelus flavolimbatus*) and golden tilefish (*Lopholatilus chamaeleonticeps*) distributions, habitat preferences and available biological samples	Melissa Cook and Linda Lombardi-Carlson
SEDAR22-RD04	Validation of yellowedge grouper, *Epinephelus flavolimbatus*, age using nuclear bomb-produced radiocarbon	Melissa Cook & Gary R. Fitzhugh & James S. Franks
SEDAR22-RD05	Population dynamics structure, and per –recruit analyses of yellowedge grouper, *Epinephelus flavolimbatus* from the northern Gulf of Mexico	Melissa Cook
SEDAR22-RD06	Reproduction of yellowedge grouper *Epinephelus flavolimbatus*, from the eastern Gulf of Mexico	Bullock, L. H., M. F. Godcharles and R. E. Crabtree
SEDAR22-RD07	Burrow utilization by yellowedge grouper, *Epinephelus flavolimbatus*, in the northwestern Gulf of Mexico	Jones, R. S., E. J. Gutherz, W. R. Nelson and G. C. Matlock
SEDAR22-RD08	Age and growth of the yellowedge grouper, *Epinephelus flavolimbatus*, and the yellowmouth grouper, *Mycteroperca interstitialis*, off	Manickchand-Heileman, S. C. and D. A. T. Phillip

	Trinidad and Tobago	
SEDAR22-RD09	A descriptive survey of the bottom longline fishery in the Gulf of Mexico	Prytherch, H. F.

2. LIFE HISTORY

2.1. *OVERVIEW*

2.1.1. Life History Data Working group membership

Melissa Cook	SEFSC Panama City, DW leader and editor
Gary Fitzhugh	SEFSC, Panama City
Linda Lombardi-Carlson	SEFSC Panama City
Hope Lyon	SEFSC Panama City
Harry Blanchet	LDWF, GMFMC SSC
Brian Linton	SEFSC, Miami
Carrie Simmons	GMFMC, Staff lead

2.1.2. Issues

Issues discussed in the Life History Data Working Group (LH DW) for yellowedge grouper included the distribution (locations, depths) of catch, stock definition and population genetic analyses, identification of yellowedge grouper in the historical catch information, criteria used for age determinations, use of otolith weight-fish age relationship to estimate fish age, age and size at maturity, age and size at sex transition, construction of growth curves, movement and meristics (length-length and length-weight relationships). Estimates of natural mortality and discard mortality were discussed. The availability of aged fish collected at the beginning of commercial fishing provided estimates for the true value of natural mortality. Issues remaining at the end of the Data Workshop were related to the use of otolith weight to assign age for those fish that were not aged, primarily fish collected during 1982-1983 (the Johnson samples).

2.2. *REVIEW OF WORKING PAPERS*

Working papers were reviewed that were pertinent to the life history group. A central paper was SEDAR22-DW-08 which presented the age, growth and reproduction results for Gulf of Mexico

(GOM) yellowedge grouper, *Epinephelus flavolimbatus.* Working document SEDAR22-DW-05 presented Gulf habitat associations of tilefish and yellowedge grouper. Also reviewed was SEDAR22-DW-09 which presented comparisons of length data collected by the Trip Interview Program and reported hard part collection by port agents.

2.3. *STOCK DEFINITION AND DESCRIPTION*

Kingdom: Animalia (animals)

Phylum: Chordata (organisms with a notochord)

Subphylum: Vertebrata (animals with a backbone)

Class: Actinopterygii (ray-finned fishes)

Order: Perciformes

Family: Serranidae (sea basses and groupers)

Genus: Epinphelus

Species: flavolimbatus (Poey, 1865)

The common name for *Epinephelus flavolimbatus* is yellowedge grouper, however, commercially they are also commonly called and marketed as yellowfin grouper.

2.3.1 Stock structure and definition

Currently Gulf of Mexico (GOM) yellowedge grouper are classified as a single stock. Cass-Calay and Bahick (2002) assumed a single GOM stock for the 2002 yellowedge grouper assessment. Due to limited information on stock structure the LH DW recommends the assumption of a unit stock for the GOM.

2.3.2 Population genetics

Currently, there is no published information on the genetics of yellowedge grouper from the GOM. Preliminary genetic research noted a considerable amount of diversity within the 23 samples assayed. Samples were collected from the eastern and western GOM, Bay of Campeche and Atlantic. Certain haplotypes were unique to particular regions and there was a trend suggesting some measure of population differentiation (Joe Quattro, personal communication).

2.3.3 Tagging

Due to depths inhabited by yellowedge grouper no known tagging studies have been conducted.

2.3.4 Larval transport and connectivity

Eggs and larvae are pelagic and cannot be distinguished from larval snowy grouper, *Epinephelus niveatus,* therefore, no larval transport information is known for yellowedge grouper (Richards, 1999).

2.3.5 Distribution

Yellowedge grouper are found in the western Atlantic from North Carolina (Huntsman, 1976) to southern Florida, the entire Gulf of Mexico (GOM), Cuba (Smith, 1971), the West Indies, off the coasts of Central America, and the northern coast of South America to Brazil (Carpenter and Nelson, 1971; Smith, 1971; Heemstra and Randall, 1993; Carpenter, 2002) (Figure 1). Yellowedge grouper are primarily distributed between the 50 to 300 m depth contours throughout the GOM (Cook, 2007) (Figure 2). Smaller yellowedge grouper (<400 mm TL) were found in shallower depths between 35-125 m while larger fish were found in up to 300 m depths (Cook, 2007). Unlike most grouper, which are associated with reefs and structure, yellowedge grouper can be found in a variety of habitats. Adult yellowedge grouper prefer mostly soft substrate throughout the western and central GOM (Cook, 2007) and were observed in three distinct types of burrows, similar to those associated with tilefish, cut into cohesive mud-clay sediment in the western GOM (Jones et al., 1989). They have also been found at the shelf edge on mud, sand or sand-shell bottom (Jones et al., 1989; Heemstra and Randall, 1993). In the central GOM yellowedge grouper are associated with soft substrate near the Mississippi-Alabama pinnacles and also with patch reef areas within the pinnacles (Cook, 2007). The highest densities of yellowedge grouper collected on NMFS bottom longline surveys, from 1999-2004, were within a 45 km radius of the Naples sinkhole along the 100 Fathom Break (Cook, 2007). The area is composed of hard bottom, small cobble and rock outcrops < 1 meter high, and the surrounding substrate is flat with silty sand and rock talus (Reed et al., 2005).

2.4. *NATURAL MORTALITY*

The LH DW reviewed estimates of total (Z) and natural mortality (M) from catch curves and various equations (Table 1). The LH DW developed a table of estimated M values as informative priors for the assessment (Table 2). Natural mortality (M) estimates ranged from <0.0 to >0.3 based on maximum observed ages ranging from 46-85 depending on data set (Figure 3).

The base model to be used for analysis of yellowedge grouper in SEDAR 22 will be Stock Synthesis (Methot 2010). This model has the capacity to accept a distribution of informative priors, and estimate M within the model. That capacity reduces some of the need to specify a single estimate for M. However, other analytic methods that are intended to be run in the assessment process do require a specified value of M, or have difficulty in resolving M in some circumstances. Therefore, providing a good estimate of M for those cases will help evaluate the relative performance of the various models.

Several data sources, (1) Panama City Lab and (2) Bullock (see section 2.6 Age for further description of the data source), were utilized in order to develop the estimates presented here. A variety of data were required for the published methods to estimate M. Average water temperatures were obtained from NMFS longline cruise data where yellowedge grouper were collected. Age at maturity was derived from available literature on the species (Cook, 2007) and from SEDAR22 DW-08. Values for k, L_{inf} and t_{max} were obtained from fish aged using sectioned otoliths (SEDAR22 DW-08). The otoliths were aged by the same readers, using the same methodology. Details of the ageing process and methods of validation of otolith ageing are presented in SEDAR22-DW-08 and Cook (2007).

Disappearance rates were obtained through catch curve analysis, using data from different datasets, or from subsets of the data. Since protogyny is also present, one subset of the data was to consider females only, through those ages between full recruitment to longline gear and significant transition to males. Another case considered was to use all sexed fish, irrelevant of sex. Thirdly, all aged fish were considered. This last case increases the sample size significantly. In each case, the t_{max} associated with that dataset or subset was utilized for calculation of M.

The true value of Z should be considered as an upper limit of M, since with no fishing Z=M. Under fished conditions, Z=M+F, so some value of M below Z is reasonable. However negative estimates of M are not, since this would only be possible if there were contributions to the stock from some additional area. Catch curve analyses conducted by the LH DW showed negative slopes (positive M), so negative values for M should be discounted.

One of the caveats that should be mentioned here is that the species being assessed in SEDAR 22 are lower continental shelf / shelf break / continental slope species, while most of the published literature considers species that occur in more coastal zones. This may be pertinent to many aspects of the life history, since these deeper waters may be more constant in temperature and salinity than the coastal waters, and those factors may contribute to development of successful life history strategies.

The true value of M is rarely determined because it should be calculated from an unfished population, which requires sampling a population before the onset of fishing. The Bullock data set is comprised of yellowedge grouper harvested by the commercial longline and hand line fisheries during 1977-1984 which coincided with the beginning of the commercial fishery for yellowedge grouper. The LH DW divided the Bullock data into two subsets (1) 1977-1980 (majority of samples collected) and (2) 1977-1980 grids 4 and 5 only (to allow for comparison with recent Panama City Lab samples) and catch curves were constructed for each subset.

The LH WG recommended that catch curves constructed from the Bullock samples collected during 1977-1980 represent the best estimates for the true value of M; that is, the total mortality during this beginning period of the fishery was Z=0.078 (SE=0.009, 95% CI=0.060-0.096) (Figure 4). The bulk of commercially harvested yellowedge grouper continues to be harvested in statistical grids 4 and 5 (32% during 1999-2009). A comparison of the Bullock aged fish collected during 1977-1980 and Panama City Lab aged fish from 1998-2009 from grids 4 and 5 were used to compare calculations of M (Figure 5). Bullock catch curves (1977-1980, grids 4-5) estimated total mortality (Z) to be Z=0.068 (SE=0.018, 95% CI=0.032-0.105). In comparison, Panama City Lab (1998-2009, grids 4-5) current estimates of Z were Z=0.134 (SE=0.008, 95% CI=0.150-0.118).

The yellowedge grouper distribution of the functions of M includes estimates that are higher than current estimates of Z from catch curve calculations. We suggest that those estimates be discounted in development of any prior distributions of F. Table 2 and Figure 3 represent 140 estimates of M using different functions and sets of data. The LH WG recommends that the assessment incorporate a range of M estimates for sensitivity runs from 0.01 to 0.09 for yellowedge grouper. Choices of M based on catch curves constructed from the Bullock historical data for base runs is 0.068 and 0.078.

2.5. *DISCARD MORTALITY*

The Life History group noted that there was no information available regarding yellowedge grouper discard mortality. However, given the depths fished and common information regarding the condition of captured fish, the assumption is that discard mortality is equal to 100%.

2.6. *AGE*

Yellowedge grouper length and age data was available from three different data sources: (1) Panama City Lab – samples collected from 1979-2009, (2) Bullock – samples collected from 1977-1984, (3) Johnson – samples collected 1982-1983 (Table 3). A description of each data set is presented below.

(1) The Panama City Lab archive had a total of 10,417 yellowedge grouper collected and sampled from 1979-2009. A subsample of 8,197 otoliths was selected for ageing and 7,394 yellowedge grouper were successfully aged (SEDAR22 DW-08). Although yellowedge grouper were collected over a thirty year time period, sampling effort was not evenly distributed temporally, and varied considerably by sector and gear which made comparable comparisons over time difficult. Ninety-four percent of the yellowedge grouper otoliths were collected during the more recent years (1998-2009). The majority of samples came from the west coast of Florida (63%), followed by Louisiana (20%), Texas (15%), Mississippi (<1%) and Alabama (<1%). The bulk of samples were obtained from the trip interview program (TIP; 83%), fishery independent surveys (7%), cooperative research programs (5%) and scientific observer programs (4%). Yellowedge grouper otoliths were mainly collected from fish harvested in the commercial longline (76%) and hand line fisheries (16%), and scientific longline (6%) and trawl surveys (1%) (SEDAR22-DW-08).

Sectioned yellowedge grouper otoliths are difficult to interpret and age. Cook et al. (2009) used bomb-produced ^{14}C to validate observed ages. Yellowedge grouper otoliths were aged by two individual readers, a primary reader and a secondary reader aged at least 20% of otoliths aged by the primary reader. Indices of precision were calculated from otoliths aged by both readers (n = 2,108) with an overall average percent error of 9.07%, with percent agreement of 16.8% increasing to 91.9% ±5 years (S22-DW-08). The LH DW noted that these are reasonable results given the deeper water depth and generally slow growth of species with similar habitats affiliations and life history.

Yellowedge grouper ranged from 100-1,228 mm TL (mean=656, SE=1.82) (Figure 6 A) and ages 0-85 years (mean=14.9, SE=0.10) (Figure 6 B). The majority of the fish were 90-929 mm in length

(95%) and age 0-30 years (95%). A summary of descriptive statistics by time period): 1) 1979-1989, 2) 1991-1994 and 3) 1998-2009), sector and gear is presented in Table 4. Yellowedge grouper harvested using hand lines were slightly larger and older during 1991-94 (mean=684 mm TL, mean=18 years) than during 1998-2009 (mean=636 mm TL, mean=13 years) (SEDAR22 DW-08). Commercial longline gear captured larger and older fish (mean=661 mm TL, mean=15 years) than commercial hand line gear (mean=636 mm TL, mean=13 years) (SEDAR22 DW-08).

Some regional differences in demographics were noted; i.e., larger and older yellowedge grouper were sampled from the western GOM (Cook, 2007; S22-DW-08). Since commercial longline gear comprises the majority of the harvest, age and length data were evaluated by region (grids 1-11 were the eastern GOM, grids 12-21 were the western GOM, 1998-2009 data only). Mean lengths were significantly different between regions (ANOVA, $F_{(1,5288)} = 296.0$, $p < 0.0001$), yellowedge grouper from the western GOM (mean=721, SE=4.2) than from the eastern GOM (mean=642, SE=2.2). Mean ages were also significantly different between regions (ANOVA, $F_{(1,5288)} = 36.6$, $p < 0.0001$), with fish collected in the western GOM older (mean=16.6, SE=0.2) than in the eastern GOM (mean=14.7, SE=0.1).

(2) The Bullock data set is comprised of otoliths collected from commercial longline and hand lines sectors during 1977-1984 (the majority of otoliths were collected in 1977-1980). The objective was to describe yellowedge grouper life history. A description of yellowedge grouper reproduction was published by Bullock et al. (1996). However, the authors reported that the otoliths were difficult to age and no ages were reported. The otoliths were viewed again in early 2010 and ages were determined for 452 yellowedge grouper from the west Florida coast. The average size and age of yellowedge grouper collected during 1977-1984 was greater than observed during recent years. Yellowedge grouper ranged from 341-1,083 mm TL (mean=753.4, SE=2.07) (Figure 7 A) and ages 3-56 years (mean=18.9, SE=0.45) (Figure 7 B). The majority of the fish were 340-939 mm in length (95%) and age 3-37 (95%). Length data was collected for an additional 3,214 fish (Figure 8). The data set did not include gear information for individual fish; therefore, summaries could not be made by gear type.

(3) The Johnson data set is comprised of length data and otoliths obtained from 886 commercially harvested yellowedge grouper sampled in Treasure Island, FL (Pinellas County) from 1982-1983 by port sampler Lucius Johnson. There had been uncertainty about the source of these samples but recent discussions between SEFSC personnel recalled Johnson was collecting samples for the Prytherch study on the early long-line fishery and was recognized in the resulting report for his efforts (Prytherch 1983, submitted to SEDAR as reference document S22_RD09_TM_SEFC_122.pdf). It was noted by the LH WG that while the report refers to "yellowfin" grouper, the Johnson otoliths are distinct and identifiable as coming from yellowedge grouper and the (Beaufort SEFSC) codes Johnson used identified yellowedge grouper. Otoliths were not aged due to time constraints, however, the LH DW noted that the strong relationship observed between otolith weight and fish age (Cook et al. 2009) could be used to provide estimated ages for those fish. The estimated ages (as well as prediction error) will be used as inputs into SS3 to provide additional age and length data for the model since little data is available from the early 1980s. They will not be used to construct any additional growth curves or modify existing curves.

Differences in the relationship were observed over time; therefore the LH DW recommended a subsample of otoliths from this data set be used to construct the otolith weight – fish age equation used to assign predicted ages of the remaining samples. A subsample of 47 otoliths was used to construct the curve (Predicted age=8.8883*otolith weight+7.8178, SE=0.477, R^2=0.89, Figure 9). Predicted ages (n=807) ranged from 10-54 years which are reasonable based on previous age and growth research (Cook, 2007).

2.7. *GROWTH*

Yellowedge grouper ages and total lengths from the entire Panama City Lab time series (1979-2009) and subsamples of that time series were fit to von Bertalanfy growth functions (VBGF) (SEDAR22 DW-08). For all data: L_∞ = 1,004.5 mm, k = 0.059, t_o = -4.75 (Table 5). VBGF fits were also made by sex. The VBGF predicted the females to grow faster but obtain a smaller asymptotic size (male: L_∞ = 1043.2 mm, k = 0.054, t_o = -5.531; female: L_∞ = 843.0 mm, k = 0.095, t_o = -3.051). The smaller predicted asymptotic sizes for females is most likely because yellowedge grouper are protogynous hermaphrodites and few females are observed in the larger size classes and the maximum observed age of females was 36 years verses a maximum age of 70 years for males. An additional VBGF was conducted for the entire Bullock data set (1977-1984). Growth was predicted to be slower L_∞ = 1,042.5 mm, k = 0.048, t_o = -6.543 (Figure 10).

The LH DW noted data distribution issues that typically affect VBGF fits. In particular, the low number of samples of very young fish resulted in unrealistic fits of t_o. It was discussed that an iterative fitting process, allowing for sample size weighting by sex and region would be conducted within the assessment (e.g., by Stock Synthesis 3 model) and would correct this effect. However, the LH DW provided unconstrained estimates of VBGF as well as VGBF fits constrained to t_o = zero, needed to complete mortality equations and develop "prior values" to enter into the model (Table 2). It should be noted that in all unconstrained cases t_o was always less than zero. When t_o was constrained to equal zero, the growth coefficient increased.

2.8. *REPRODUCTION*

Female yellowedge grouper from the northern GOM exhibited a spawning season extending from February to November with peak development in March through September (SEDAR22-DW 08). Immature females ranged in size 141-650 mm TL and age 0-16 years old. Mature females ranged in size from 510 to 1,000 mm TL and age 6-36 (SEDAR22-DW-08). Based on logistic regression, size and age at 50% maturity for females in the GOM were 547 mm TL and age 8 years, respectively (Figure 11, 12). Yellowedge grouper are protogynous hermaphrodites. The size and age at 50% sexual transition for GOM yellowedge grouper was 815 mm TL and 22 years (Figures 13, 14). The overall sex ratio for yellowedge grouper sampled was 1:3.2 (male:female).

Based upon histologically sexed yellowedge grouper, 265 females were available to estimate average somatic weight at age (SEDAR22-DW-08, Figure 15). Active and spawning yellowedge grouper females ranged in age from 6-36 years old, the majority (87%) were twenty years old and younger. The relationships between hydrated and vitellogenic ovary weight and somatic weight were fairly proportional when graphically compared, these data (extrapolated to spawning stock biomass total, SSB) may be selected as the proxy for fecundity (Figure 16).

2.9. *MOVEMENTS AND MIGRATIONS*

Ontogenetic shifts have been observed for yellowedge grouper. Radiocarbon age validation of yellowedge grouper noted different ^{14}C signals throughout the life of a fish indicating that juvenile fish are found in shallower depths and move out to deeper water as they age (Cook et al. 2009). Cook (2007) noted that smaller, younger yellowedge grouper were found in shallower depths between 35-125 m while larger fish were found in up to 300 m depths. A large amount of variability was observed between length and depth, indicating that once a fish reached >400 mm TL they could be found at any depth between 125-300 m.

2.10. *MORPHOMETRICS AND CONVERSION FACTORS*

Conversions for length and weight were presented to the data workshop. Measurements of yellowedge grouper have been reported in terms of total length (TL), fork length (FL) and standard length (SL), whole weight (WW) and gutted weight (GW). Each metric is strongly correlated with the others and can easily be converted to another (Table 6).

2.11. *COMMETNS ON ADEQUACY OF DATA FOR ASSESSMENT ANALYSES*

Aging: Difficulties determining ages from otolith sections were discussed. Validation studies usingbomb-produced ^{14}C were conducted and progress was noted over earlier studies. But there was less ageing precision than observed in some SEDARs for shallow water species. The LH DW noted that these are reasonable results given the deeper water depth and generally slow growth of species with similar habitats affiliations and life history. The LH DW noted that all yellowedge grouper otoliths, including the Bullock samples and subset of Johnson samples, were viewed by the same two readers which is beneficial because this eliminates the possibility of reader ageing differences over time. The LH DW recommended the strong relationship observed between otolith weight and fish age be used to provide estimated ages for un-aged Johnson fish from 1982-1983. The estimated ages (as well as prediction error) will be used as inputs into SS3 to provide additional age and length data for the model.

Biological sampling: The LH DW noted that age sampling levels from recent years were in general informative for assessment purposes. But there were sample size concerns (S22-DW-09); the LH WG recommends minimum otolith sampling levels (i.e., >= 500 per year per major strata) based upon GulfFIN guidelines. An increase in otolith sampling level is particularly needed for the western GOM.

Reproduction Parameters: Given that yellowedge grouper are protogynous, the LH DW recommends the use of SSB-total as the preferred form of reproductive potential following Brooks et al. (2008).

Natural Mortality: The LH DW panel recommends model sensitivity runs using M as an age-fixed value and as an age-variable value (Lorenzen M). As in earlier SEDARs, the panel believes an age-variable approach is more realistic and thus the preferred approach.

2.12. *ITEMIZED LIST OF TASKS FOR COMPLETION FOLLOWING WORKSHOP*

Complete age composition for use in auxiliary model runs (VPA, SRA). (John Walter, John Quinlan)

Investigate the use of otolith weight to age relationship to see if otolith weight can be used to assign ages for those fish that were not aged. (Melissa Cook).

2.13. *LITERATURE CITED*

Alagaraja, K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. Indian J. Fish. 31: 177-208.

Alverson, D.L. and M.J. Carney 1975. A graphic review of the growth and decay of population cohorts. J. Cons. int. Explor. Mer. 36: 133-143.

Beverton, R.J.H. and S.J. Holt 1956. A review of methods for estimating mortality rates in exploited fish populations, with special reference to sources of bias in catch sampling. Rapp. Proc.-Verb. Réun. Cons. int. Explor. Mer. 140: 67–83.

Brooks, E.N., Shertzer, K.W., Gedamke, T. and D.S. Vaughan. 2008. Stock assessment of protogynous fish: evaluating measures of spawning biomass used to estimate biological reference points. Fish. Bull. 106:12-23.

Bullock, L.H., M. Godcharles, and R.E. Crabtree 1996. Reproduction of the yellowedge grouper, *Epinephelus flavolimbatus*, from the eastern Gulf of Mexico. Bull. Mar. Sci. 59(1):216-224.

Carpenter, K. E. [ed.] 2002. The living marine resources of the Western Central Atlantic. Volume 2: Bony fishes part 1 (Acipenseridae to Grammatidae). FAO species identification guide for fishery purposes and American Society of Ichthyologists and Herpetologists special pub. No. 5, FAO, Rome, p. 1308-1369.

Carpenter, J. S. and W. R. Nelson. 1971. Fishery potential for snapper and grouper in the Caribbean area and the Guianas. Pages 21-26 *in* Symposium on investigations and resources of the Caribbean Sea and adjacent regions. FAO Fish. Rept. No. 71.2, 149p.

Cass-Calay, S. L., and M. Bahnick. 2002. Status of the yellowedge grouper fishery in the Gulf of Mexico. Sustainable Fisheries Division Contribution No. SFD-02/03-172. National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, FL.

Cook, M. 2007. Population dynamics, structure and per-recruit analysis of yellowedge grouper, *Epinephelus flavolimbatus*, from the northern Gulf of Mexico. Doctoral dissertation, University of Southern Mississippi, Hattiesburg, MS, 172p.

Cook, M., Gary R. Fitzhugh, and James S. Franks. 2009. Validation of yellowedge grouper, *Epinephelus flavolimbatus*, age using nuclear bomb-produced radiocarbon. Environ. Biol. Fish. 86:461-472.

Heemstra, P. C. and J. E. Randall. 1993. FAO species catalogue. Groupers of the world. (Family Serranidae, Subfamily Epinephelinae). An annotated and illustrated catalogue of the grouper, rockcod, hind, coral grouper and lyretail species known to date. FAO Fish. Synops. No. 125, Vol. 16, p. 155-156.

Hewitt, D.A. and J.M. Hoenig 2005. Comparison of two approaches for estimating natural mortality based on longevity. Fish. Bull. 103: 433-437.

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

Huntsman, G. R. 1976. Offshore bottom fisheries of the United States south Atlantic coast. Pages 192-221 *in* H. R. Bullis, Jr. and A. C. Jones [eds.] Proceedings: Colloquium on snapper-grouper fishery resources of the western central Atlantic Ocean. FL Sea Grant Rep. 17, 333p.

Huntsman, G. R., J. Potts, R. W. Mays and D. Vaughan. 1999. Groupers (Serranidae, Epinephelinae): Endangered apex predators of reef communities. Pages 217-231 *in* J. A. Musick [ed.] Life in the slow lane, ecology and conservation of long-lived marine animals. Am. Fish. Soc. Symp. 23.

Jensen, A.L. 1996. Beverton and Holt life history invariants result from optimal tradeoff of reproduction and survival. Can. J. Fish. Aquat. Sci. 53: 820-822.

Jones, R. S., E. J. Gutherz, W. R. Nelson and G. C. Matlock. 1989. Burrow utilization by yellowedge grouper, *Epinephelus flavolimbatus*, in the northwestern Gulf of Mexico. Environ. Biol. Fish. 26:277-284.

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.

Lorenzen, K. 2005. Population dynamics and potential of fisheries stock enhancement: practical theory of assessment and policy analysis. Philosophical Transactions of the Royal Society of London B 360: 171-189.

Methot, R. D. 2010. User manual for stock synthesis, model version 3.10b. Seattle, Washington.

Nelson, W.R. and J.S. Carpenter. 1968. Bottom longline explorations in the Gulf of Mexico. Com. Fish. Rev. 30:57-62.

Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. J. Cons. int. Explor. Mer. 39: 175-192.

Pauly, D. and C. Binohlan 1996. FishBase and AUXIM as tools for comparing the life history patterns, growth and natural mortality of fish: applications to snappers and groupers. pp. 218-243 In: F. Arreguín-Sánchez, J.L. Munro, M.C. Balgos & D. Pauly (eds.) Biology, Fisheries and Culture of Tropical Groupers and Snappers. ICLARM Conf. Proc. 48: 449p.

Quinn, T. J., and R. B. Deriso. 1999. Quantitative Fish Dynamics. Oxford University Press, Inc., New York.

Ralston, S. 1987. Mortality rates of snappers and groupers. pp. 375-404. In: J.J. Polovina & S. Ralston (eds.) Tropical Snappers and Groupers: Biology and fisheries management. Westview Press, Boulder.

Reed, J. K., S. A. Pomponi, D. Weaver, C. K. Paull and A. E. Wright. 2005. Deep-water sinkholes and bioherms of south Florida and the Pourtales Terrace-habitat and fauna. Bull. Mar. Sci. 77(2):267-296.

Richards, W. J. 1999. Preliminary guide to the identification of the early life history stages of serranid fishes of the western central Atlantic. NOAA Tech. Memo. NMFS-SEFSC-419, 105 p.

SEDAR22-DW-05. Walter, J. F., M. Cook, B. Linton, L. Lombardi and J. A. Quinlan. 2010. Explorations of habitat associations of yellowedge grouper and golden tilefish. National Oceanic Atmospheric Administration, National Marine Fisheries Service, Southeast Fishery Science Center.

SEDAR22-DW-08. Cook, M and M. Hendon. 2010. Yellowedge grouper (*Epinephelus flavolimbatus*) age, growth and reproduction from the northern Gulf of Mexico. National Oceanic Atmospheric Administration, National Marine Fisheries Service, Panama City Laboratory Contribution 10-06.

SEDAR22-DW-09. Chih, C. 2010. Observed Length frequency distributions and otolith sampling issues for tile fish caught in the Gulf of Mexico from 1984 to 2009. National Oceanic Atmospheric Administration, National Marine Fisheries Service, Southeast Fishery Science Center.

Smith, C. L. 1971. A revision of the American groupers: *Epinephelus* and allied genera. Bull. Am. Mus. Nat. Hist. 146(2):67-242.

2.14. *TABLES*

Table 1. Equations for estimating natural mortality (M).

Method	Parameters	Authors & Parameter Explanations	Equation
Alverson & Carney	k, tmax	Quinn & Deriso (1999):	M = 3k/(exp(0.38*tmax*k)-1)
Beverton & Holt	k, am	Beverton and Holt (1956; a_m = age at 50% maturity)	M = 3k/(exp(a_m*k)-1)
$Hoenig_f$	tmax	Hoenig (1983; for fish)	M=exp(1.46 - 1.01*ln(tmax))
$Hoenig_c$	tmax	Hoenig (1983; fish plus other taxa)	M=exp(1.44-0.982*ln(tmax))
Pauly	Linf, k, T	Quinn & Deriso (1999):	M=exp(-0.0152+0.6543*ln(k)-0.279*ln(Linf, cm)+0.4634*lnT(°C))
		Pauly (1980):	M = 10^(-0.0066-0.279*(log(Linf))+0.6543*log(K)+0.4634*Log(T))
Pauly Method II (snappers and groupers)	Linf, k, T	Pauly and Binohlan (1996)	M=10^(-0.0636-0.279*(log(Linf)+0.6543*log(k)+0.4634*log(T))
			T=Average annual Sea Temperature at depth
Ralston	k	Ralston (1987)	M=0.0189 + 2.06*k
Ralston (geometric mean)	k	Ralston (1987)	M=-0.0666+2.52*k
Ralston Method II	k	Pauly and Binohlan (1996)	M=-0.1778+3.1687*k
Lorenzen Age-Specific	W at age	Lorenzen (1996; ocean)	M=3.69*W^(-0.305)
Jensen	k	Jensen (1996)	M = 1.5*K

Alagaraja	tmax, survivorship to tmax	Alagaraja (1984)	M=-ln[S(tmax)]/tmax; derived from S(tmax)=exp(-M*tmax)
Rule of thumb	tmax	Hewitt and Hoenig (2005)	M = 2.996/tmax

Table 2. Yellowedge Grouper Natural Mortality- shaded values are above estimated Z for combined information (sexes combined + unsexed) of 0.068 to 0.078 or Z<0.

Data Source	Observed Max Age (years)	Number of Fish Aged	Von Bert* Linf (mm)	Von Bert* k	Water Temp. (°C)	Age.50Maturity	Alverson & Carney	Beverton & Holt	Hoenig$_f$	Hoenig$_c$	Pauly	Pauly (snappers and groupers)	Ralston	Ralston (geometric mean)	Ralston Method II	Jensen	Rule of thumb	Alagaraja 0.01	Alagaraja 0.02	Alagaraja 0.05
1999-2009 Female Age data without fixed T_0	36	712	843.03	0.10	16	8.2	0.107	0.242	0.115	0.125	0.222	0.194	0.215	0.173	0.124	0.143	0.083	0.128	0.109	0.083
1999-2009 Female age data WITH fixed T_0	36	712	762.55	0.16	16	8.2	0.059	0.174	0.115	0.125	0.324	0.284	0.355	0.344	0.339	0.245	0.083	0.128	0.109	0.083
1999-2009 Combined Sex Age data without fixed T_0 - UNCENSORED	70	933	1043.28	0.05	16	8.2	0.050	0.290	0.059	0.065	0.145	0.127	0.131	0.071	-0.005	0.082	0.043	0.066	0.056	0.043
1999-2009 Combined Sex age data WITH fixed T_0 - UNCENSORED	70	933	880.93	0.12	16	8.2	0.017	0.220	0.059	0.065	0.248	0.217	0.256	0.223	0.187	0.173	0.043	0.066	0.056	0.043
1999-2009 Combined Sex Age data without fixed T_0 – CENSORED	46	930	1043.28	0.05	16	8.2	0.103	0.290	0.090	0.098	0.145	0.127	0.131	0.071	-0.005	0.082	0.065	0.100	0.085	0.065
1999-2009 Combined Sex age data WITH fixed T_0 - CENSORED	46	930	880.93	0.12	16	8.2	0.053	0.220	0.090	0.098	0.248	0.217	0.256	0.223	0.187	0.173	0.065	0.100	0.085	0.065
1998-2009 Sexed + Unsexed Age data without fixed T_0	85	6942	1017.70	0.06	16	8.2	0.032	0.286	0.048	0.054	0.152	0.133	0.138	0.080	0.006	0.087	0.035	0.054	0.046	0.035

1998-2009 Sexed + Unsexed age data WITH fixed T_0	85	6942	883.29	0.11	16	8.2	0.010	0.229	0.048	0.054	0.236	0.207	0.239	0.203	0.161	0.161	0.035	0.054	0.046	0.035
Bullock 1977-1980 data, without T0 correction, Unsexed	56	437	1042.52	0.05	16	8.2	0.081	0.299	0.074	0.081	0.133	0.117	0.118	0.054	-0.026	0.072	0.054	0.082	0.070	0.053
Bullock 1977-1980 data, with T0 correction, unsexed	56	437	894.15	0.10	16	8.2	0.041	0.236	0.074	0.081	0.225	0.198	0.225	0.185	0.139	0.150	0.054	0.082	0.070	0.053

Censored data have excluded the oldest 3 fish (ages 50, 56, 70) in the sexed dataset, and only includes the data to 46 (last continuous age)

In the overall dataset (6942 samples) a single age of 85 was found in addition to one more fish of age 70. No other fish were over 56 years old.

H2O temps - 18.5 ^{o}C from NMFS surveys - all historical incl. LL & groundfish, that caught YE grouper. 15.4 ^{o}C from BLL historic & current (2005) NMFS data. Source: Cook (2007)

Table 3. Summary of the number of yellowedge grouper otoliths aged by data source: Panama City Lab, Bullock and Johnson. Johnson otoliths were not aged but ages may be estimated using the otolith weight-age relationship. Years with zero samples are excluded from table.

Year	PC Lab aged fish	Bullock aged fish	Johnson available otoliths
1977		3	
1978		116	
1979	6	186	
1980		132	
1982	13	11	711
1983	25		175
1984	29	4	
1985	8		
1986	25		
1987	3		
1988	9		
1989	5		
1991	249		
1992	69		
1993	9		
1994	2		
1998	5		
1999	97		
2000	138		
2001	439		
2002	238		
2003	814		
2004	581		
2005	681		
2006	478		
2007	867		
2008	1274		
2009	1330		
Total	7394	452	886

Table 4. Summary of life history statistics for yellowedge grouper otoliths from the Panama City Lab archive. Yellowedge grouper were collected in 1979-1989 (*n*=123), 1991-1994 (*n*=327) and 1998-2009 (*n*=6,934) by head boat (HB), scientific survey (SS), commercial (CM) and charter party (CP) sectors using hand line (HL), bottom longline (LL), and trawl (TRW) gear types. Results include the sample size (*n*), range (minimum-maximum), mean, standard deviation and standard error for each parameter: total length (mm) and age (years).

Time Period	Mode Gear	Parameter	*n*	Range (Min-Max)	Mean	Standard Deviation	Standard Error
1979-1989	HB HL	Total Length	42	335-710	493.55	87.14	13.45
		Age	42	4-11	5.60	1.75	0.27
	SS LL	Total Length	81	488-1050	735.33	136.94	15.22
		Age	81	5-81	25.59	16.14	1.79
1991-1994	CM HL	Total Length	251	290-1110	684.47	162.61	10.26
		Age	251	2-70	17.86	13.76	0.87
	CM LL	Total Length	53	460-1100	706.81	138.09	18.97
		Age	53	3-50	14.83	8.19	1.13
	CP HL	Total Length	23	425-1160	789.57	173.86	36.25
		Age	23	5-77	22.96	20.55	4.28
1998-2009	CM HL	Total Length	963	262-1092	635.50	141.49	4.56
		Age	963	2-52	13.21	6.53	0.21
	CM LL	Total Length	5538	211-1178	660.72	147.74	1.99
		Age	5538	1-85	15.13	7.88	0.11
	SS LL	Total Length	350	322-1228	703.84	165.79	8.86
		Age	350	2-70	15.90	9.09	0.49
	SS TRW	Total Length	83	100-1075	219.54	157.47	17.28
		Age	83	0-38	2.70	6.03	0.66

Table 5. Results of yellowedge grouper von Bertalanffy growth curves from fish from the Panama City Lab archive (1979-2009, SEDAR 22-DW-08) and Bullock (1977-1984). Source refers to the data used in the analysis, predicted TL is total length, n is the number of samples, L_∞ is the maximum theoretical length, K is the growth coefficient, t_0 is the theoretical age at length zero, R^2 is the coefficient of determination.

Source	Size Range Examined (TL mm)	Age Range Examined (Years)	n	L_∞	K	t_0	R^2
All years	100-1,228	0-85	7394	1,004.5	0.059	-4.75	0.68
1979-1989	335-1,050	4-81	123	966.9	0.042	-11.87	0.67
1991-1994	290-1,160	2-77	329	969.8	0.059	-7.452	0.72
1998-2009	100-1,228	0-85	6942	1,017.7	0.058	-4.576	0.68
1977-1984	347-1,030	3-56	452	1,042.5	0.048	-6.543	0.81

Table 6. Equations used to convert various length and weight measurements of yellowedge grouper collected in the northern Gulf of Mexico. TL is total length (mm), FL is fork length (mm), SL is standard length (mm), WW is whole weight, GW is gutted weight (kg), R^2 is the coefficient of determination for the reported linear regression and N is the number of observations.

Equation	R^2	Size Range Examined	N
SL = 0.849*FL – 13.033	0.996	285-855 mm SL	1,331
SL = 0.791*TL + 1.295	0.993	285-855 mm SL	1,451
FL = 1.174*SL + 18.285	0.996	350-1033 mm FL	1,331
FL = 0.935*TL + 15.874	0.997	99-1174 mm FL	1,593
TL = 1.257*SL + 3.401	0.993	360-1083 mm TL	1,451
TL = 1.067*FL – 15.065	0.997	99-1174 mm TL	1,593
WW = 2.691 x 10^{-08} * ($TL^{\wedge 2.870}$)	0.979	99-1,228 mm TL 0.012-24.00 kg WW	1,722
GW = 2.106 x 10^{-08} * ($TL^{\wedge 2.910}$)	0.969	250-1,178 mm TL 0.22-22.40 kg GW	2,916
WW = 1.728 x 10-08 * (FL^2.956)	0.979	99-1,228 mm FL 0.012-24.00 kg WW	1,722
GW = 1.470 x 10-08 * (FL^2.984)	0.969	250-1,178 mm TL 0.22-22.40 kg GW	2,916

2.15. *FIGURES*

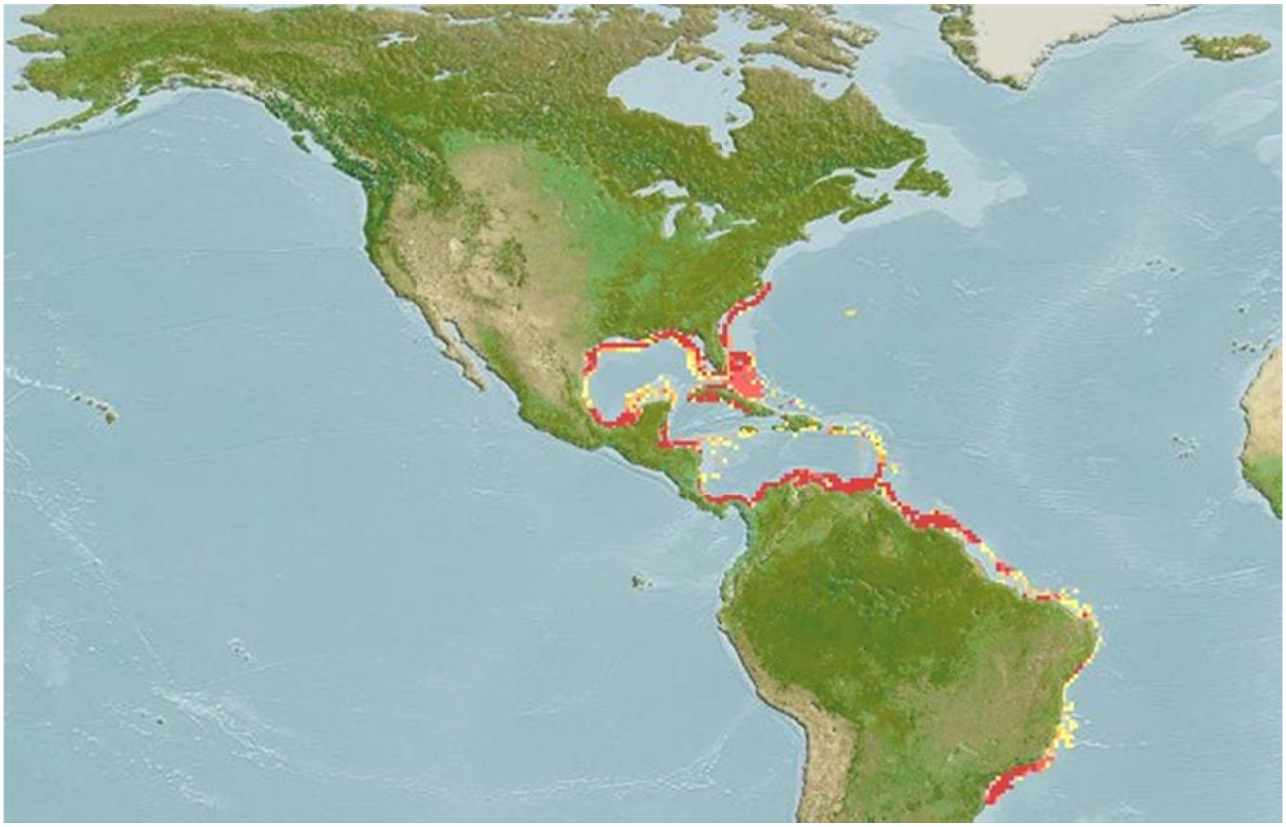


Figure 1. Estimated worldwide distribution for yellowedge grouper (Heemstra and Randall , 1993) and www.fishbase.org).

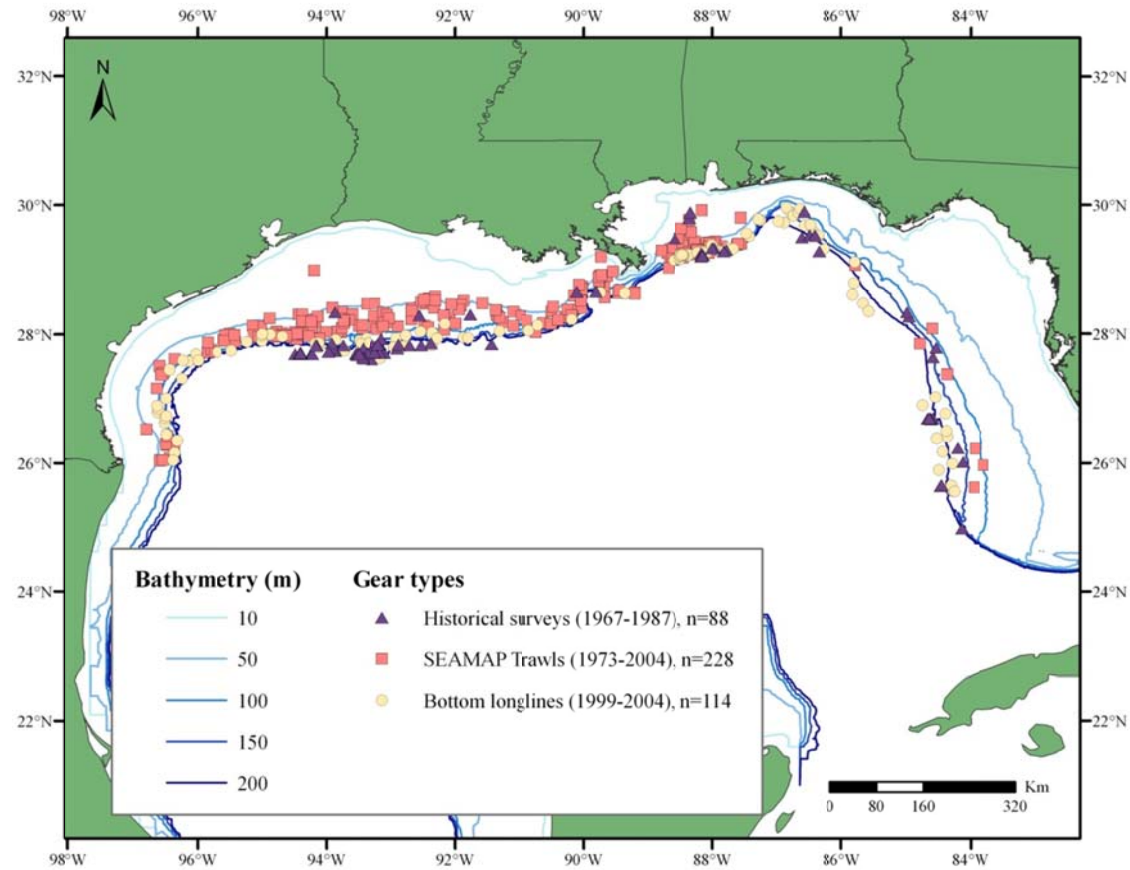


Figure 2. Locations of yellowedge grouper collected in the northern Gulf of Mexico on fishery independent surveys from 1967-2004. Gear types used include trawls (shrimp, fish, high opening bottom and mongoose), longlines (vertical, off-bottom and bottom) and fish traps. Data points indicate location of catch not number of fish collected. Figure reprinted from Cook (2007).

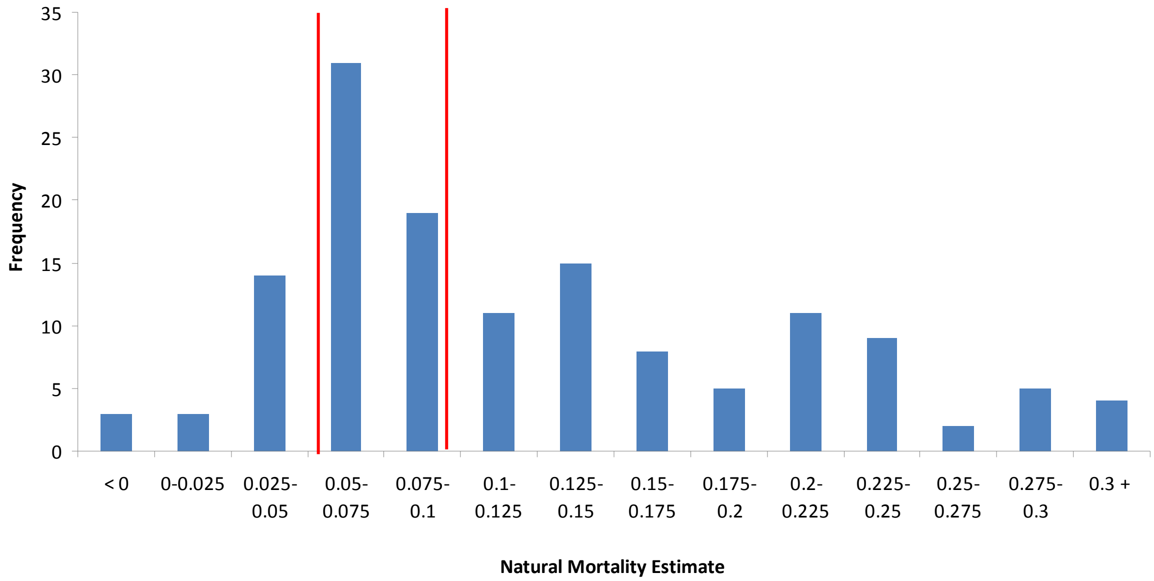


Figure 3. Distribution of estimates of natural mortality (M) for yellowedge grouper. Estimates of M (*n*=140) were based on various equations with varying input parameters (Table 1). Red lines indicate approximate minimum and maximum possible values of M, based on estimates of total mortality (Z) estimates (Z=0.068-0.078) from catch curve analysis.

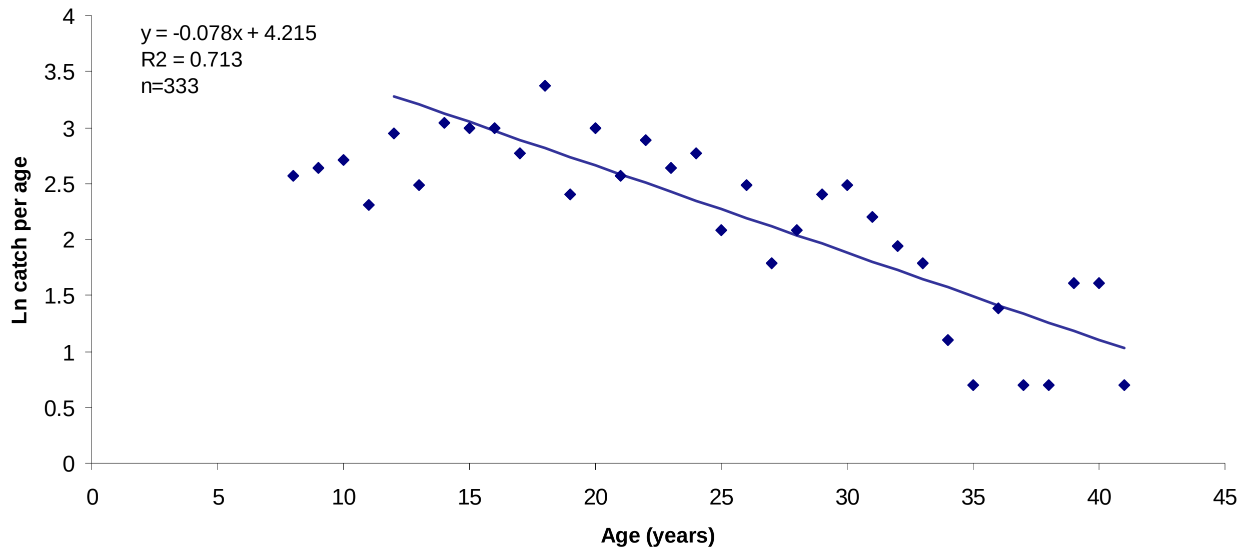


Figure 4. Estimate of total mortality (Z=0.078) for yellowedge grouper harvested during 1977-1980 by commercial longlines and hand lines (Bullock data set). Ages 12-41 years were used to construct the catch curve.

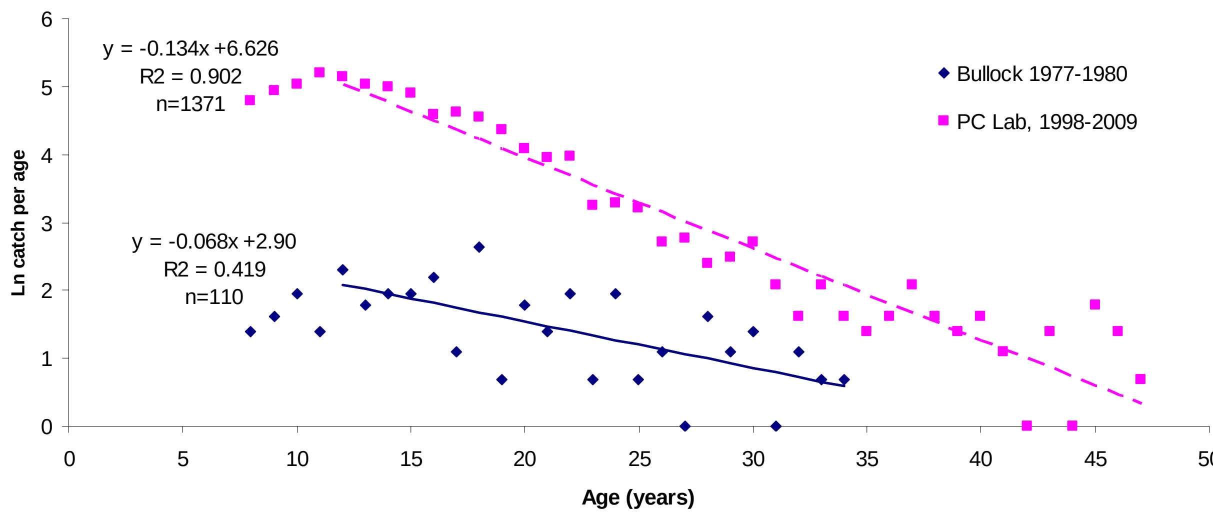
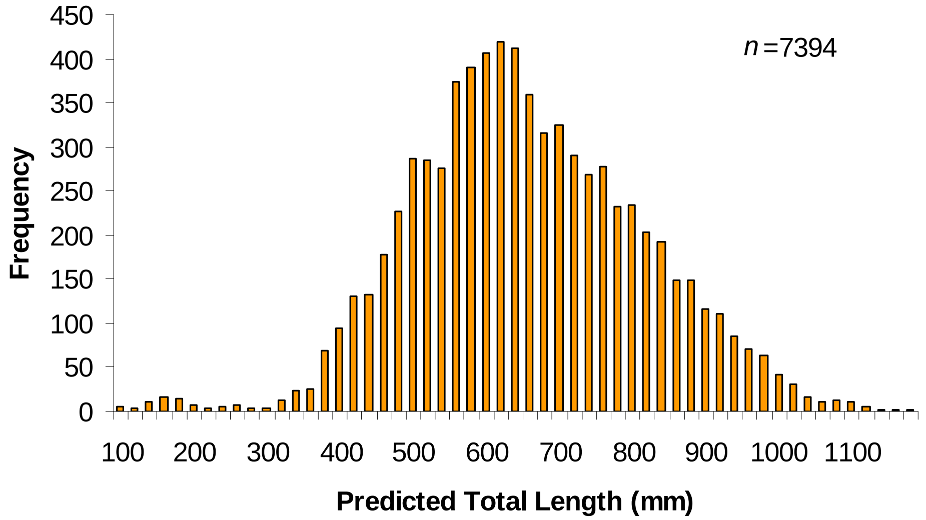


Figure 5. Estimates of total mortality (Z) for yellowedge grouper collected in statistical grids 4 and 5. Data were collected by Bullock (1977-1980) in western Florida and the Panama City Lab (1998-2009). Estimates of total mortality (Z) are (1977-80: Z=0.068, 1999-2009: Z=0.134). Ages 12-34 years (Bullock 1977-80) and 12-41 years (SEDAR 22 DW-08) were used to construct the catch curves.



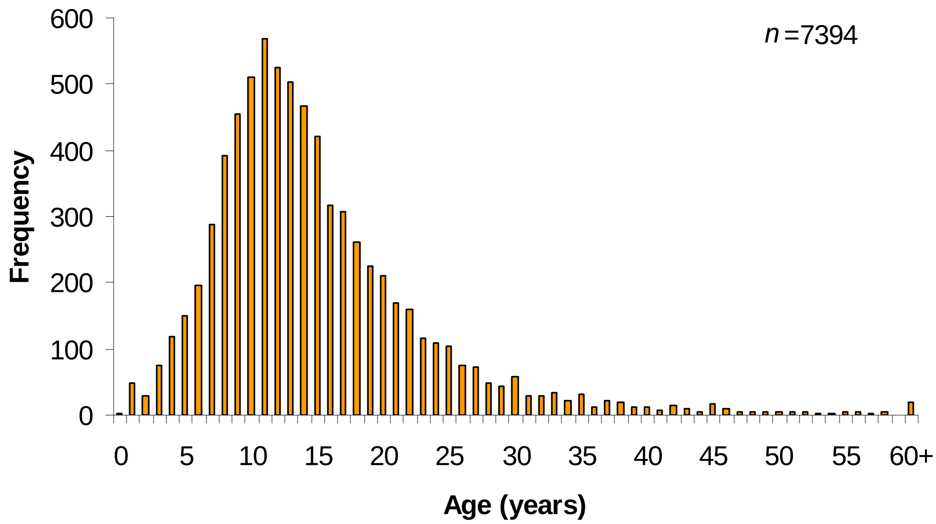
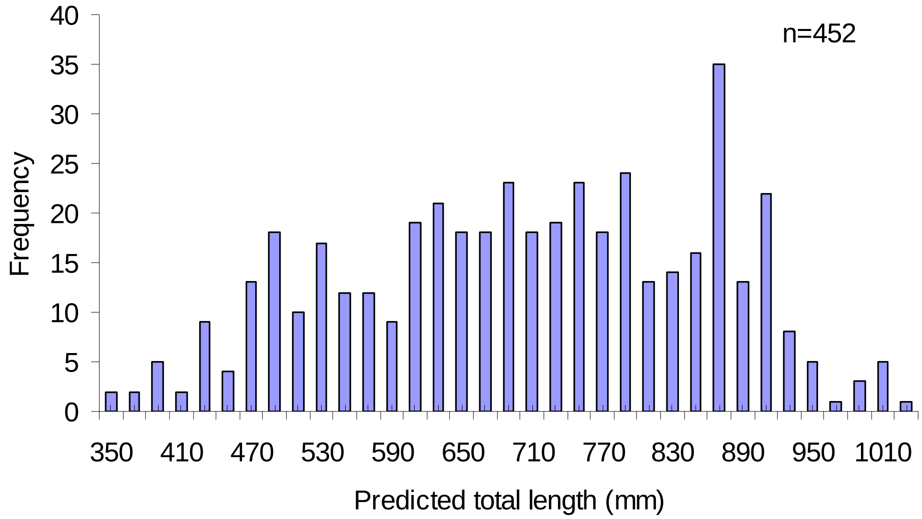


Figure 6. A) Length and B) age frequency distributions of yellowedge grouper collected during 1979-2009 by fishery dependent and independent sources using various gear types (bottom longline, hand line, trawls) in the northern Gulf of Mexico.



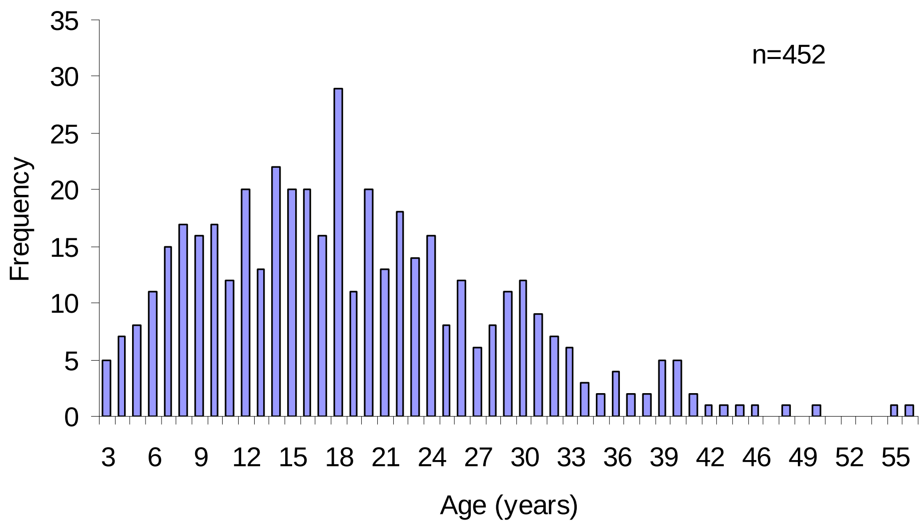


Figure 7. A) Length and B) age frequency distributions of aged yellowedge grouper collected during 1977-1984 (Bullock data set). Fish were collected from the commercial longline and hand line fisheries off the Florida west coast.

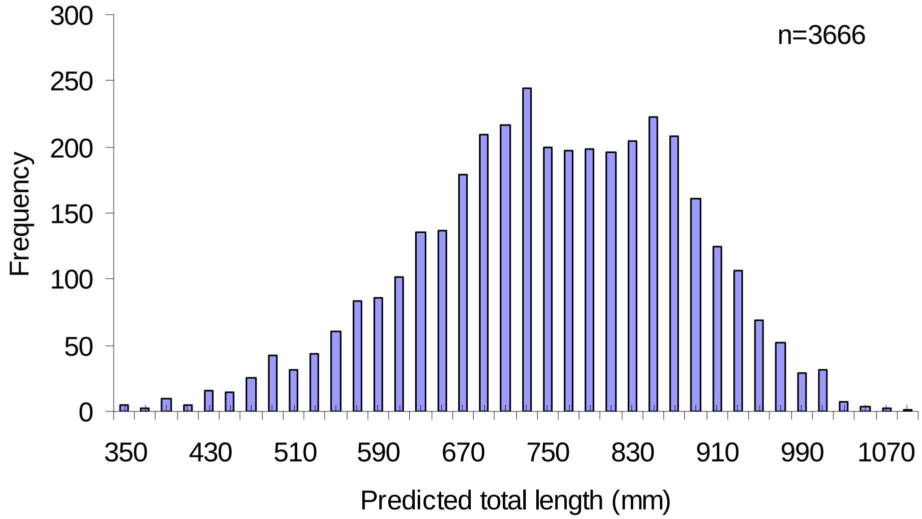


Figure 8. A) Length frequency distribution of yellowedge grouper collected during 1977-1984 (Bullock data set). Fish were collected from the commercial longline and hand line fisheries off the Florida west coast. Aged fish lengths (*n*=452) and length data only (*n*=3,214) combined.

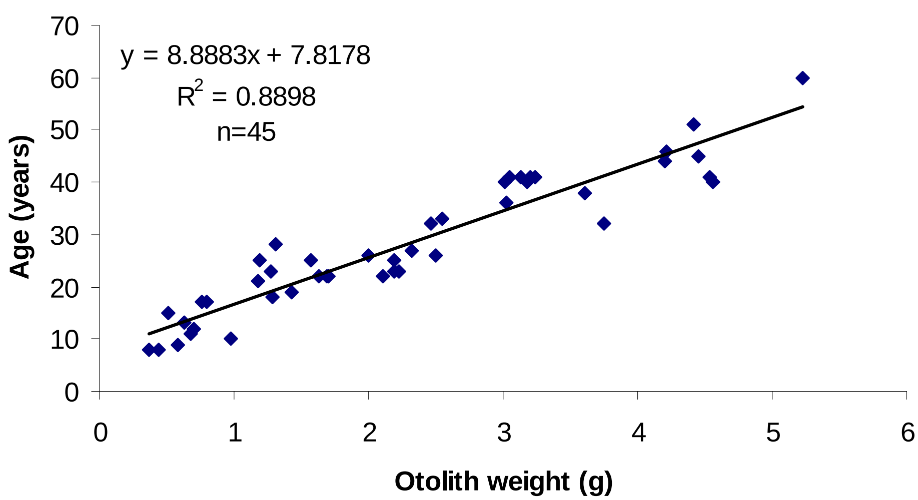


Figure 9. Otolith weight – age relationship of Johnson subsampled otoliths.

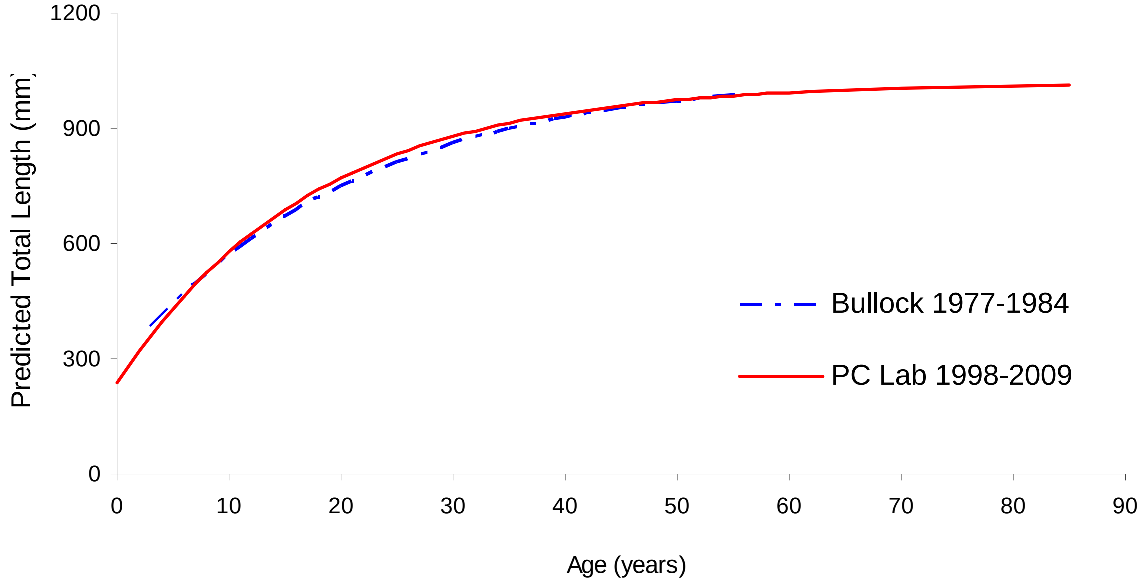


Figure 10. Results of von Bertalanffy growth curves for yellowedge grouper collected by the Panama City Lab during 1998-2009 (L_∞ = 1,017.7 mm, k = 0.058, t_o = -4.576) and by Bullock during 1977-1984 (L_∞ = 1042.5 mm, k = 0.048, t_o = -6.543).

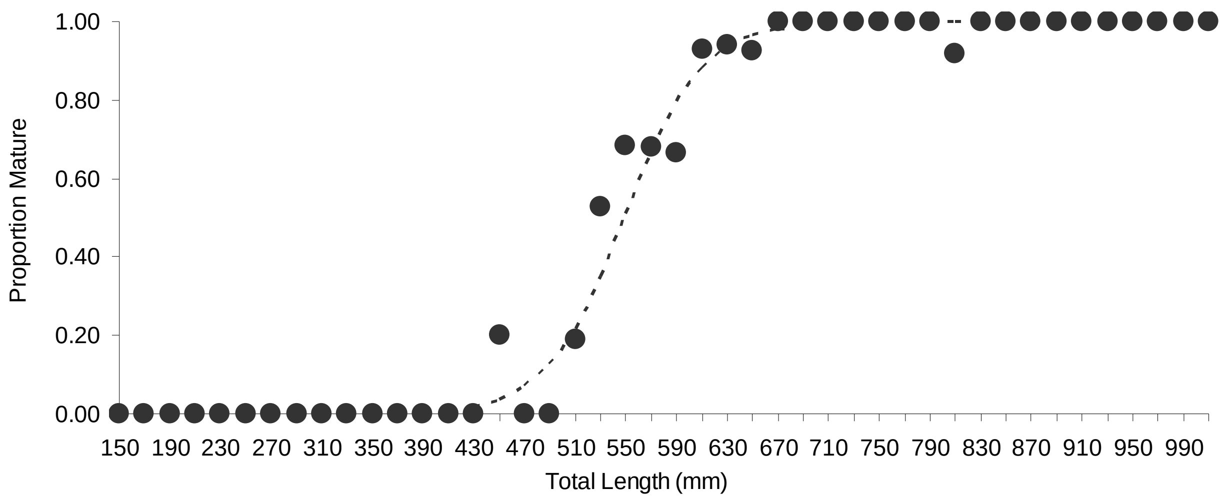


Figure 11. Length at maturity based on mature and immature female yellowedge grouper during all months of the year. Logistic regression function:

Proportion = 1/(1+EXP(-(-18.11 + 0.033*Length))), n=608, L50 maturity = 549 mm TL.

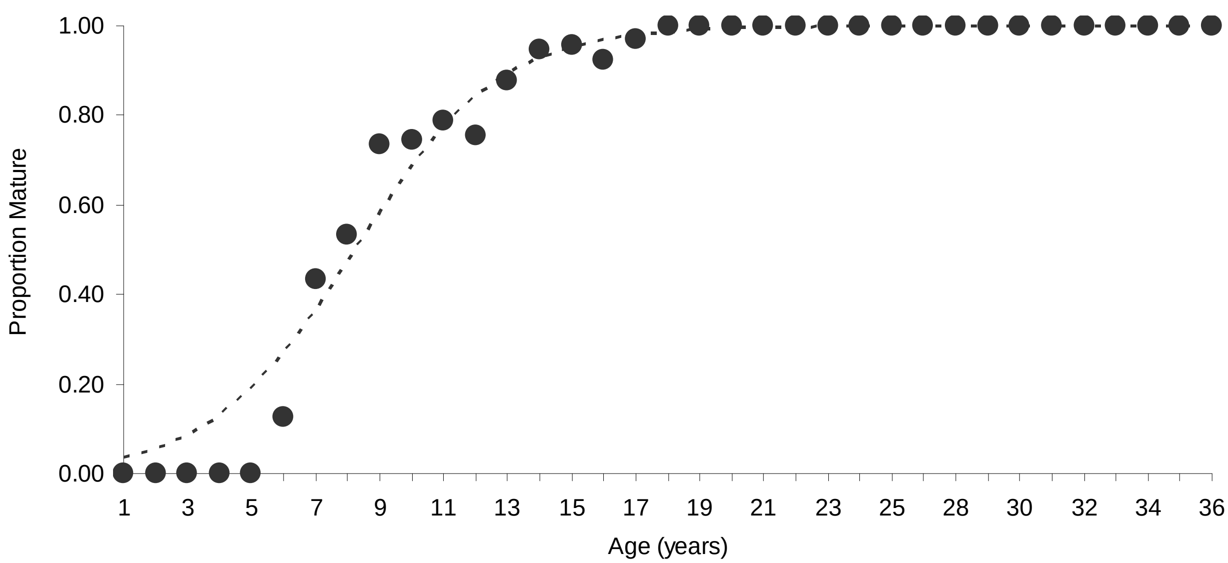


Figure 12. Age at maturity based on mature and immature female yellowedge grouper during all months of the year. Logistic regression function:

Proportion = 1/(1+EXP(-(-3.718 + 0.451*Age))), n=608, A50 maturity = 8.2 years.

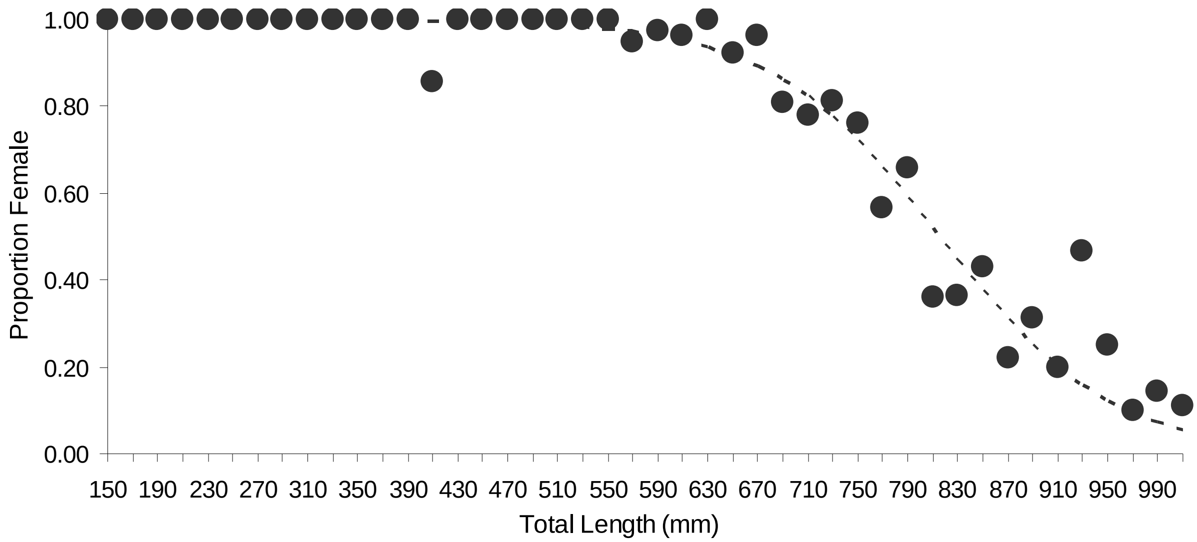


Figure 13. Proportion female by size, assessed histologically. Logistic regression function: Proportion = 1/(1+EXP(-(-11.894 + 0.015*Length))), n=933, L50 transition = 815 mm TL.

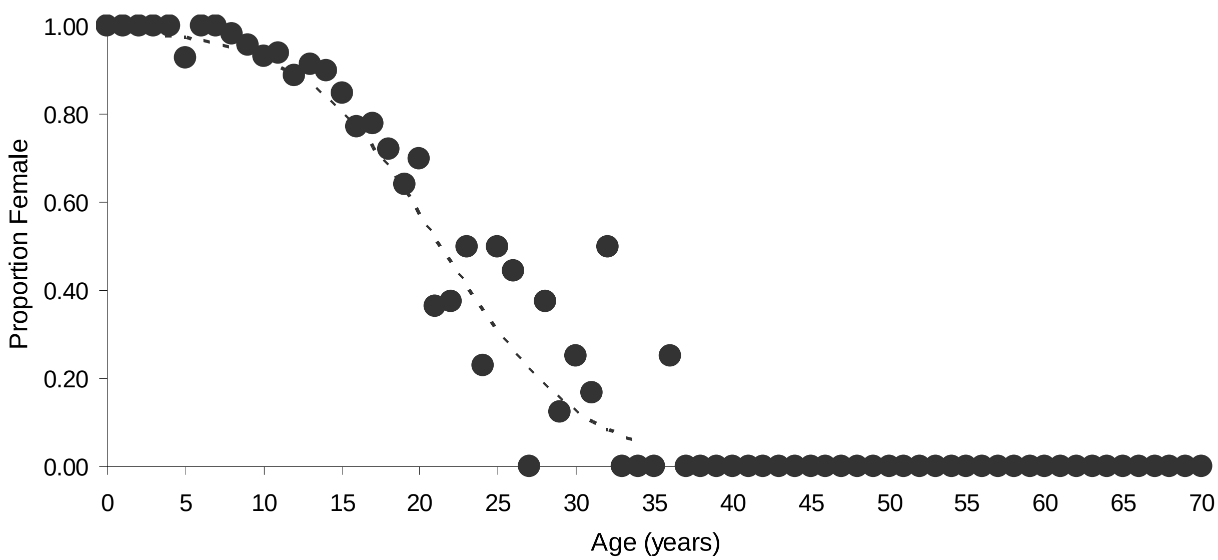


Figure 14. Proportion female by age, assessed histologically. Logistic regression function: Proportion = 1/(1+EXP(-(-4.970 + 0.223*Age))), n=933, A50 transition = 22.3 years.

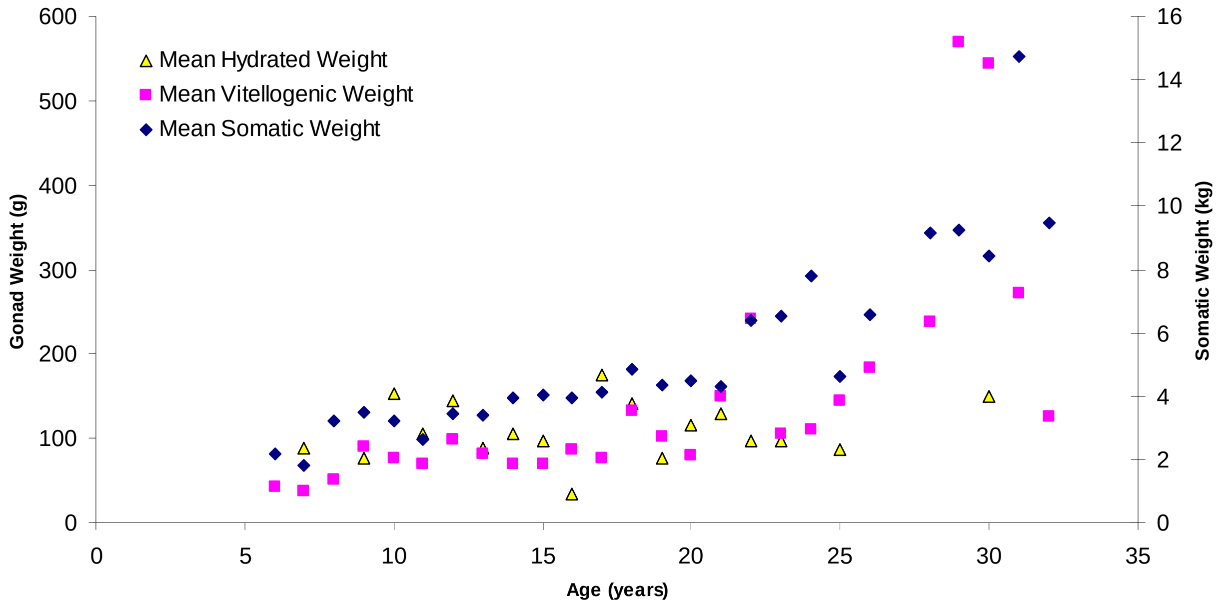


Figure 15. Mean gonad weight at age of yellowedge grouper females with vitellogenic or hydrated ova and mean somatic weight at age.

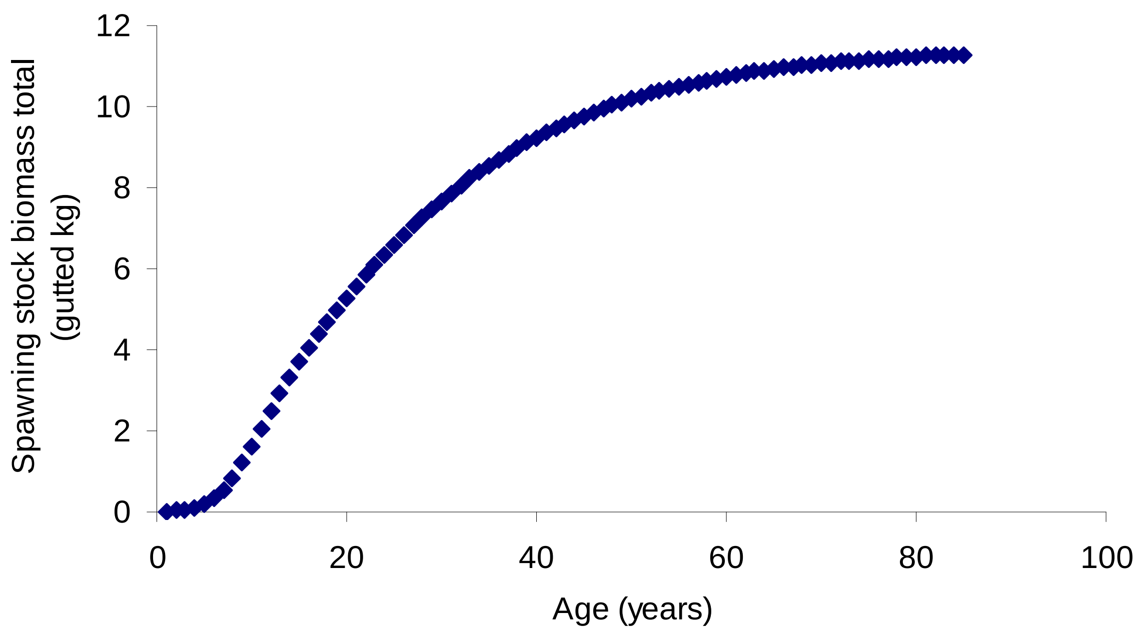


Figure 16. Spawning stock biomass total as the proxy for fecundity for yellowedge grouper.

3. COMMERCIAL FISHERY STATISTICS

3.1. *OVERVIEW*

The deepwater grouper-complex consists of eight species of fishes from 3 families of fishes, groupers (5 species), tilefishes (2 species) and a snapper species. The primary three species of importance and considered in the SEDAR 22 data workshop for stock assessment are the yellowedge grouper *Epinephelus flavolimbatus*; tilefish (often imprecisely called golden tilefish) *Lopholatilus chamaeleonticeps;* and blueline tilefish *Caulolatilus microps*. The other five secondary species also in the deep water grouper complex are warsaw grouper *Epinephelus nigritus*; snowy grouper *Epinephelus niveatus*; misty grouper, *Epinephelus mystacinus;* speckled hind *Epinephelus drummondhayi*; and queen snapper *Etelis oculatus*. These five secondary species were not considered in the data workshop, although commercial landings were presented.

3.1.1. Group membership

Refik Orhun (Group Leader) ....NMFS-Miami
Steve Turner...NMFS-Miami
Kevin McCarthy..NMFS-Miami
John Quinlan ....NMFS-Miami
Bob Spaeth ....
Commercial Fisheries
Martin Fisher... Commercial Fisheries
Brad Kenyon ....Recreational Fisheries
Linda Lombardi ....NMFS-Panama City
Gary Fitzhugh ....NMFS-Panama City
Debbie Fable .... NMFS-Pascagoula
Charlie Bergmann .... NMFS-Pascagoula
Melissa Cook .... NMFS-Pascagoula
Richard Fulford...SSC - Univ. of Mississippi
Harry Blanchet ....Louisiana Sea Grant
Yong Chen……………...... ....CIE Reviewer - Univ. of Maine

3.1.2. Issues

Commercial landings of yellowedge grouper were explored to address a variety of issues (listed below). Some are evident from the list of working papers presented and discussed (section 3.3).

Other issues included the historical onset and composition of the deep water grouper complex long line (LL) and vertical line (VL = hand and bandit or electric line) fisheries, with special attention given to identification of yellowedge grouper (YEG) from unclassified groupers:

(1) Commercial landings

(2) Discards

(3) Length Frequency Distribution of samples by gear

(4) Mis-identification

  a. Mis-identification or mis-labeling of yellowedge grouper as yellowfin grouper 1975-1990 Gulf of Mexico wide

(5) Onset of the LL fishery in the Gulf of Mexico as a pure deep water fishery targeting yellowedge grouper the fishery

(6) Partial switch of LL fishery to shallow water groupers and LL fishery mixed from 1982 onwards w/ a shallow water and a deep-water grouper complex fishery

(7) Proportion of unclassified groupers in the long line fishery to be attributed yellowedge grouper from the onset of LL fishery to the partial switch of the LL fishery to shallow water groupers until 1986 when grouper landings classification by species becomes regulation

(8) Year of onset of VL fishery and proportion of landings to be assigned to yellowedge grouper from unclassified groupers landings prior to 1986 when grouper landings classification by species becomes regulation

(9) Proportion of unclassified grouper landings (both LL and VL) to be attributed yellowedge grouper from 1986-2009

3.2. *REVIEW OF WORKING PAPERS (Author and Presenter)*

All SEDAR 22 Data Workshop (DW) working papers relevant to the commercial fisheries group were presented, reviewed, and discussed during the data workshop. The recommendations resulting from the discussion will be presented in each the relevant chapter, e.g. size distribution of landings samples by gear, misidentification, discards, effort, etc. Below is the list of the papers reviewed in the group

SEDAR **-22 DW-17:** Commercial Landings of Yellowedge Grouper, Golden Tilefish, and Blueline Tilefish from the Gulf of Mexico region (Refik Orhun)

SEDAR **-22-DW-15:** Recreational Survey Data for Yellowedge Grouper, Tilefish (Golden), and Blueline Tilefish in the Gulf of Mexico (Vivian Matter, Author; Richard Fulford, Presenter)

SEDAR **-22-DW-04:** Discards of Yellowedge Grouper, Golden Tilefish, and Blueline Tilefish from commercial fishing vessels in the Gulf of Mexico (Kevin McCarthy)

SEDAR**-22-DW-09:** Observed Length frequency distributions and otolith sampling issues for yellowedge groupers caught in the Gulf of Mexico from 1984 to 2009 (Ching-Ping Chih, author; John Quinlan, presenter)

SEDAR**-22-DW-13:** Estimation of species misidentification in the commercial landing data of yellowedge groupers in the Gulf of Mexico from 1984 to 2009 (Ching-Ping Chih, author; John Quinlan, presenter)

3.3. *COMMERCIAL LANDINGS*

3.3.1. Historical Catch Area

Prytherch (1983) divided the fishing grounds of the bottom longline fishery into three regions; Southern Gulf (SE), Northeastern Gulf (NE) and Western Gulf (W) (Figure 3.1.1). On the basis of similar landings species composition we propose a similar stratification of the 21 Gulf of Mexico 'shrimp grid' or '**statareas**' extending from statistical area 1 at the Southeastern edge of the Gulf of Mexico in Monroe county, North of the US 1 Line, to the West to statistical area 21 ending at the Texas US/Mexican Border (Figure 3.1.2) into three fishing regions. This classification differs from Prytherch only in that the Western Gulf region includes statistical areas 13-21 and the Northeastern Gulf encompasses stat areas 6-12. These regions also generally reflect similarities in the species composition of bottom longline trips from each of the three areas. These spatial classifications will be used in the assessment modeling as well. The general goal of these classifications is to partition the assessment into areas which have received fairly similar levels of overall fishing mortality over time, while maintaining enough aggregation of the data so that there are few missing cells for age composition, CPUE or landings.

Decision: Commercial landings for yellowedge grouper will be grouped by gear type into three geographical fishing areas based upon combining statistical areas as follows:

Southeastern Gulf SE statistical areas 1-5

Northeastern Gulf NE statistical areas 6-12

Western Gulf W statistical areas 13-21

3.3.2. Discussion of Methods to Calculate Historical Landings of Yellowedge Grouper

Landings of yellowedge grouper become available in 1986 with the onset of the grouper identification or classification requirement. Although classification of groupers began in 1986, unclassified groupers continued to be reported after 1985; a proportion of those unclassified groupers calculated to be yellowedge grouper (see below). These unclassified grouper landings 1986 and later were handled in the same way as had been done for gag and black grouper in the SEDAR 12 and 19, respectively. Prior to 1986 almost all grouper landings except warsaw grouper, Nassau grouper and goliath grouper (formerly jewfish) were recorded as unclassified grouper.

For the development of the historical landings record prior to 1986, commercial fishermen and dealers who had fished during that period from the mid-70's onward, Bob Spaeth, Martin Fisher, Gregg Abrams and others were asked to recollect the early fishery on yellowedge grouper and deepwater-complex fishery, e.g. snowy grouper, speckled hind, tilefish and blueline tilefish. Several fish houses were contacted by phone during the working group sessions and their comments were incorporated in the discussion and recommendations of the group.

The working group concluded that substantial landings of deep water groupers began in about 1975 and that they consisted primarily of yellowedge grouper as well as some snowy grouper and a few other deepwater species. It was noted that during the early part of the deep water fishery yellowedge was commonly referred to as yellowfin grouper even by some fisheries biologists (see below) until at least 1990. The commercial landings of the LL and VL fishery of unclassified groupers were substantial; the VL landings records date back to 1963 and the LL landings began in 1979. When the amount of pre-1986 unclassified groupers that might have been yellowedge was calculated, the two gear types (LL and VL) were treated separately. Both

LL and VL landings of unclassified groupers and the species composition of the respective fisheries are discussed below.

<u>Yellowfin Grouper Landings</u>. Historically, yellowedge groupers may have been reported as yellowfin grouper, *Mycteroperca venenosa,* from the onset of the fishery to about 1990. In fact, Prytherch (1983) makes no reference to yellowedge grouper in his report but rather refers to the dominant deepwater grouper species in the landings as yellowfin, demonstrating that the appellation 'yellowfin' was in widespread usage.

Yellowfin grouper inhabit shallower coral reef and hard bottom habitats than yellowedge grouper and are rarely caught in the current yellowedge fishery. During 1991 concerted efforts were made to have dealers report grouper landings by species (from 1986 to1990 distinguishing the only five primary species of groupers had been emphasized). Bob Spaeth suggested that those efforts coincided with concern about ciguatera toxin in some grouper species, including yellowfin grouper, which provided further incentive to properly distinguish the species.

The 1986-1990 yellowfin landings averaged 114,178 lbs per year with a peak of 358,654 lbs reported in 1986 (Tables 3.3.1.a and b., and Figure 3.3.1). In the five period after that (1991-1995) average landings were 8,818 lbs per year or only 7.7% of the landings from 1986-1990 (Table 3.3.1.b). Average landings per year of yellowfin grouper from 1996-2009 were 5,676 lbs. The working group concluded that landings well below 10,000 lbs per year probably more truly reflected the normal yellowfin landings in the Gulf and that the 1986-1990 landings reflected substantial mis-reporting of yellowedge as yellowfin.

The average percent of yellowfin grouper of the combined landings of yellowedge and yellowfin are about 9.6% in the years 1986-1990, whereas the average for 1991-2009 is 0.77% (Table 3.3.1.b), indicating a much higher level of misidentification in years prior to 1991. As a first approach the average yellowfin landings 1991-1995 were determined and compared relative to the average landings 1986-1990, the years with erroneous reporting. The landings 1991-1995 were on average only 7.7% of the landings 1986-1990, and following the logic, it was assumed that only 7.7% of yellowfin grouper landings 1986-1990 were actually yellowfin grouper landings and yellowfin grouper landings assigned to yellowedge grouper for 1986-1990 are shown in Table 3.3.1.c. After 1990, it was assumed that yellowfin grouper were properly identified in the ALS landings.

Decision: The majority of yellowfin grouper landings will be assumed as yellowedge grouper landings1986-1990. As a correction, 92.3% of yellowfin groupers landings will be assigned to yellowedge groupers in those years.

Historical Gulf of Mexico Long Line (LL) Fishery of Unclassified Groupers:

The grouper LL fishery begins in the ALS landing records in 1979 as unclassified groupers (Table 3.3.2 and Figure 3.3.2.a and b.). It was reported to the group by commercial fishermen representatives, is that the LL gear was introduced to the Gulf of Mexico by a group of fishermen from New England.

It was further reported that the LL fishery in the Gulf of Mexico began as a purely deep water fishery targeting yellowedge groupers from 1979 to 1981. The initial increase in landings coincides with the adoption of LL gear and is corroborated by notes from fish house interviews during the time. On August 10, 1981, Spence fish Co, Niceville, FL reported to have produced 800,000lbs of deepwater grouper from March-August of that year of which 90% were yellowedge grouper compared to only 50,000lbs in 1980 (Lew Bullock, 2010, field notes). Further, it was noted by several LL vessels that they fished off of Louisiana waters and landed in ports on the West Coast of Florida (Cortez).

In 1982, LL fishermen began shifting to inshore waters and targeting shallow water groupers with the newly acquired LL gear skills. By 1982, reportedly about more than half of the LL fishery in West Florida had shifted to shallow water grouper consisting mostly of red grouper (Prytherch 1983). Analysis of LL fishery grouper species composition by fishing region according to the Prytherch (1983) survey is shown in Tables 3.3.3.a.-c. Application of presumed yellowedge grouper proportion of unclassified groupers landings and calculated yellowedge LL landings 1979-1982 is shown Table 3.3.4.

Decision: Deepwater LL fishery began in 1979 in the Gulf of Mexico primarily targeting yellowedge grouper as reported in the ALS database. The proportion of unclassified grouper LL fishery assigned to yellowedge grouper will be classified according to the species composition of a Gulf wide LL grouper fishery survey report 1982 by Prytherch (1983).

The unclassified grouper landings will be grouped by three separate fishing areas of the Southeast (SE), Northeast (NE), and Western (West) Gulf. The proportion of yellowfin grouper LL landings (actually yellowedge grouper landings called yellowfin) will be applied to the years of unclassified grouper LL landings in 1979, 1980, 1981, and 1982 to calculate the landings for yellowedge grouper in those years.

Decision: LL fishery began targeting/shifting to shallow water groupers in1982 and remained a mixed fishery thereafter with both shallow water and deepwater components.

Decision: Information on assignment of unclassified grouper landings from 1983-1985 was not available, and the most sensible approach based on opinions of scientists and fishermen was to use region-specific linear interpolation to estimate annual landings between the estimated level of yellowedge grouper landings in 1982 and the calculated landings in 1986. This linear interpolation captures the shift in targeting from deepwater to shallow water groupers by the longline fishery.

Historical Gulf of Mexico Vertical Line (VL) Fishery of Unclassified Groupers:

Based upon two interviews with fishermen (Lew Bullock pers comm.), the VL species composition of the catch in 1986-1989 was reported to be similar to the species compostion in 1975-1985, or at least it did not undergo the same offshore/inshore shift as the longline fishery. Therefore the working group considered it reasonable to use the 1986-1989 VL species composition to calculate the amount of yellowedge grouper in the unclassified groupers vertical line landings from 1975-1985.

The reported average grouper species composition commercial landings of the VL fishery 1986-1989 was analyzed and calculated for the three fishing region (Table 3.3.5 and Figure 3.3.4.).

The combined proportion of yellowedge and yellowfin in the VL landings 1986-1989 was used to assign yellowedge grouper VL line proportions from unclassified grouper VL landings 1975 to 1985 by geographical fishing region.

Initial discussions regarding the yellowedge grouper landings with vertical line gear centered on the unusually high landings of 400,000-500,000 in 1986-1988, which some thought were too high with regards to long line landings in the same years as well as vertical line landings 1990-1994, which were 4-5 times less than the 1986-1988 landings. With the extension of the time series of VL landings back to 1975, these landings did not appear to be incongruously high, and further discussions with vertical line fishermen and dealers active in those years indicated that these landings levels were realistic.

From discussions conducted in the working group and from investigations done after the workshop, the yellowedge fishery began as a vertical line fishery and then transitioned rapidly after 1979 into a longline fishery. Some fishermen recalled landing a few yellowedge in the late 1960's and others not until the mid 1970's (Lew Bullock pers comm.). In either case, landings of yellowedge prior to 1975 appear to have been extremely low such that the fishery could be reasonably considered to have started in 1975.

Decisions Regarding Distribution of Unclassified Grouper Landings with vertical line gear

Decision: Vertical line landings of yellowedge will be assumed to have started in 1975 (zero landings in 1974).

Decision: Since VL fishery did not go through drastic changes as the LL fishery in the 1980’s, it was deemed reasonable to use yellowedge grouper species composition of VL landings from 1986-1989 to assign landings to Yellowedge from the unclassified grouper landings in the VL fishery for years prior to 1986 and back to 1975.

Calculated Yellowedge Grouper Landings:

Yellowedge grouper landing from 1986-2009 were compiled using methods similar to those used for red, gag and black grouper since 2005 (SEDAR 10). Proportions of a grouper species in the classified groupers, in this case yellowedge grouper, are calculated and applied to assign a proportion of unclassified groupers landings to the yellowedge landings by year, state, gear and statistical area (Figures 3.3.3 and 3.3.4).

The sum of reported yellowedge grouper and yellowedge grouper calculated from yellowfin grouper landings (1986-1990) and yellowedge grouper calculated from unclassified groupers from VL (1975-2009) and LL fishery (1979-2009) will be referred to as calculated yellowedge grouper landings. Estimated commercial landings of calculated yellowedge grouper by gear type and geographical fishing area, West, NE and SE Gulf, including a proportion of unclassified groupers from 1986 onwards are shown in Table 3.3.6 and Figure 3.3.5. These landings estimates were made using best available knowledge of scientists and differ from the estimated landings compiled for the previous yellowedge grouper stock assessment in 2002. Differences are attributable the current inclusion and assignment of yellowedge grouper landings from a proportion of unclassified groupers landings and a proportion of yellowfin grouper landings not considered in 2002 (Table 3.3.7.). In 2002, no yellowedge grouper landings were assigned from unclassified groupers or yellowfin grouper.

3.3.4 Mis-Identification

The working group reviewed two documents on mis-identification of yellowedge grouper and golden tilefish (see below). Members of the group had extensive discussions both during the workshop and after on ways of calculating quantities of mis-identified fish eventually concluding that with adequate sample size the two proposed methods yielded identical results (see below).

The group also concluded that in the years when sample sizes were adequate, the amounts of the total landings of yellowedge and golden tilefish which had been classified as other species (bony fish, unclassified grouper, …) was sufficiently low compared to the calculated total landings of yellowedge and golden tilefish, that it could be neglected.

***Mis-identification Sampling and Calculation*:**

The misidentification and improper allocation of fishes into (other species recorded as yellowedge) and out of (yellowedge recorded as other species) the yellowedge grouper landings estimates is discussed in SEDAR 22- DW-13. (Note: The same issue holds for tilefish as described in SEDAR 22 – DW 12.) The Data Workshop requested a secondary analysis of yellowedge misidentified as general grouper, bony fishes, and black grouper. The focus of this analysis was to examine the occurrence of misidentified yellowedge in those three landings categories. Rather than base this estimate on the number of yellowedge sampled as described in SEDAR 22 – DW 13, the Workshop recommended basing the calculations on the number of the general grouper, bony fishes, and black grouper sampled. This issue was thoroughly reviewed algebraically and through an examination of sampling protocols.

Algebraically, the DW-13 method simplifies to consideration of the reported landings and sampling data. The sampling data is used to generate estimates of the proportion of yellowedge grouper reported by dealers as some other species (bony fish, for instance). The sampling data also provides the total number of yellowedge grouper identified by the port agents. Note that these estimates are based on sampling of individual trips and the reports submitted by dealers. The ratio of these two estimates multiplied by the reported landings returns the number or weight of yellowedge grouper that must be added to the reported landings to estimate the true landings. If sample sizes are adequate, this method does correctly estimate the misidentified landings.

An examination of TIP sampling protocols indicates that implementing the methods suggested by the Data Workshop would greatly increase the uncertainties in the estimation of a misidentification rate. This is because dealers often categorize landings such as bony fish or unclassified grouper after TIP agents have already done their dock-site sampling. As a result, it is not feasible to conduct random sampling of fish that belong to bony fish or unclassified grouper landings. Consequently, estimation of species compositions for bony fish or unclassified grouper can be biased. Also, sampling for the dominant misidentification categories (bony fish, unclassified grouper, and black grouper) is inconsistent and of low intensity especially in the early years of the sampling program. Low intensity sampling in combination with low misidentification rates, can create biases which will exacerbate uncertainty issues.

Decision: Although the method suggested by the Data Workshop is mathematically valid, and perhaps conceptually cleaner, the sampling protocols of the TIP program were not structured to allow accurate estimation of misidentification rates by this method. The method suggested by the Data Workshop introduces an additional source of uncertainty because the exact landing categories often cannot be determined at the time of dock site sampling, and because the low sampling intensity common to general categories such as bony fish or unclassified grouper can result in biased estimates of misidentified landings for a target species.

Further, review of the methods specified in SEDAR 22 – DW 12 and SEDAR 22 – DW 13 indicates that, when sampling intensity is sufficient, they produce fully adequate, unbiased estimates of the number of fish misidentified and true landings. Given this, no change in the approach taken in documents SEDAR 22 – DW 12 and SEDAR 22 – DW 13 is recommended.

3.4. *COMMERCIAL DISCARDS*

Data from the SEFSC coastal fisheries self-reported logbook program were used to calculate the number and yellowedge grouper discarded during the period January 1, 1990 through December 31, 2009.A detailed description of the available data and methods used for calculating discards are available in SEDAR22-DW-04.

Due to the small number of trips reporting yellowedge grouper discards, the calculation of discards was limited to simple ratio estimation. For the years 2002-2009 when discard data were reported, all available data were pooled by gear (vertical line and logline only) and the mean discard rate for each year and deep-water grouper season (open or closed) was calculated. Mean discard rates were then applied to the yearly gear-specific effort for each deep-water grouper season. Effort for logline was defined as total hooks fished per year. Vertical line effort was total hook hours fished. Discards were calculated for years prior to 2002 by applying gear-specific mean discard rates calculated for deep-water grouper open season (there were no deep-water grouper closed seasons prior to 2004) for all years (2002-2009) to the year/deep-water grouper open season effort for each gear. Yearly yellowedge grouper discard totals for each gear are included in Table 3.4.1. Long line discards could not be calculated prior to 2002 because no open season discards were reported by logline vessels. Zero calculated discards appear in the table during years in which vessels submitted discard logbooks, but no yellowedge grouper discards were reported.

The release condition of reported discarded yellowedge grouper is provided in Table 3.4.2 for vertical line data reported yearly and for logline with all years combined due to small sample size. The majority (>87%) of vertical line discards and all logline discards were reported as due to regulatory restrictions (Table 3.4.3).Beginning in 2008, the discard reason categories were expanded to include “not legal size” and “out of season”. During both 2008 and 2009 over 90% of vertical line discards were reported as out of season.

The number of trips reporting yellowedge grouper and tilefish discards in the Gulf of Mexico was low. This was particularly true of the tilefish species and the deep-water grouper open season yellowedge grouper data. Given that the observed discard observations were so few, the discard rate of yellowedge grouper may be poorly characterized. Even with the limited available data, it does appear likely that the majority of yellowedge grouper discards occur during closed seasons and that yellowedge grouper discards are likely to be few. An additional concern associated with these data is the high percentage of trips that report “no discards”. Vessels selected to report discards must submit discard logbooks or report no discards to remain in permit compliance. The percentage of logline trips reporting no discards for a trip has ranged from 20 to 42 percent. Such high rates of “no discards” reports seem unlikely, suggesting that discards have been underreported in general. The calculated discards provided here should be used with caution, given the limitations and uncertainties of the available data.

3.5. *COMMERCIAL EFFORT*

Total effort reported to the coastal logbook program from the commercial golden tilefish, blueline tilefish, and yellowedge grouper fisheries is provided in Table 3.5.1. Effort of all trips reporting landings of one pound or more of those species was summed by year. Effort totals are provided for logline and vertical line (hand line and electric reel/bandit rig) vessels only. Very few landings of golden tilefish, blueline tilefish, or yellowedge grouper were reported from vessels fishing other gears. Total yearly logline and vertical line effort in the Gulf of Mexico is provided in Table 3.5.2 for comparison.

3.6. *BIOLOGICAL SAMPLING: SIZE COMPOSITION BY GEAR TYPE*

Length Composition Data from Trip Intercept Program:

Length measurements for individual Yellowedge grouper sampled in the Trip Intercept Program were examined to see if the length distributions from the handline and longline fisheries differed. Figure 3.6.1. shows the length frequency distributions for these two yellowedge grouper fisheries. Handline length frequency distributions were skewed to the left (smaller fish predominated). Longline length frequency distributions were more normal. To test whether or not the two fisheries produced the same length frequency distributions, a quantile-quantile plot was produced (Figure 3.6.2). This plot indicates that the two distributions differ from one another throughout most of the range of observations. The distribution-free two-sample Kolmogorov-Smirnov analysis was used to test whether or not the two data sets were drawn from the same distribution. This test indicated that the longline and handline length measurements were not drawn from the same distribution (p-value << 0.05).

Decision: Handline and longline fisheries for yellowedge grouper do not produce identical length frequency distributions. This can arise through differences in selectivity or through an interaction between the locations of the fisheries and the spatial distribution of the population of yellowedge grouper. Given these observations, handline and longline fisheries should be treated as different fleets in the assessment.

3.7. *COMPARISION BETWEEN TIP AND AGE & GROWTH LENGTH FREQUENCIES*

Two SEDAR 22 Data Workshop reports (S22-DW-09 and S22-DW–10) indicated that there were differences between the length frequencies derived from the length and otolith samples from the Trip Interview Program. The Data Workshop recommended a review of the issue. Subsequent review indicates that the length frequencies distributions of the two sample types are different in some years, particularly in the early years of the sampling programs (Figure 3.6.3). The length frequency distributions of the two sample types are reasonably similar in the more recent years of the sampling period. It is recommended that the assessment team adjust (reweight) the data used for determining the catch-at-age and growth relationships in the assessment model on a year-by-year basis. This will ensure that proper corrections are made when required, and that all the data will be handled in a consistent manner.

3.8. *COMMENTS ON ADEQUACY OF DATA FOR ASSESSMENT ANALYSES*

The commercial landings working group considered the yellowedge grouper landings data from 1986 to present to be relatively accurate. The group emphasizes that the 1975-1985 data are substantially more uncertain.

3.9. *TABLES*

Table 3.3.1.a. Total Gulf of Mexico yellowfin grouper landings 1986-2009 (in lbs gutted wt) for three geographical fishing areas SE=Southeastern Gulf Stat areas 1-5; NE=Northeastern Gulf (stat areas 6-12); W=Western Gulf (stat areas 13-21). LL = longline; VL = vertical line.

Year	W Gulf VL	W Gulf LL	NE Gulf VL	NE Gulf LL	SE Gulf VL	SE Gulf LL	Grand Total
1986	19,636		117,823	10,421	137,752	42,147	358,654
1987	3,775	186	15,636	1,679	397	3,002	27,386
1988	2,253	13,579	9,208	23	1,761	1,338	30,521
1989	15,453	70,599	486	472	43	291	120,592
1990	16,679	9,231	3,015	1,574	103	764	33,734
1991	312	478	421	799	2,894	168	7,223
1992	151	10	1,120	464	257	610	3,195
1993	846	170	551	60	1,767	42	3,729
1994	15,075	4,001	693	428	1,520	83	21,938
1995	2,786	719	3,250	488	589	58	8,004
1996	881	340	7,142	420	1,829	344	11,548
1997	1,313	556	1,908	81	175	94	4,540
1998	527	252	200	5	63	17	1,126
1999	3,506	1,218	421	53	6	2	5,290
2000	2,483	349	2,978	2,002	65	9	10,373
2001	550	773	8,197	1,396	83	122	11,210
2002	2,770	3,053	1,681	105	83	4	9,334
2003	848	1,705	1,511	107	25	3	4,311
2004		1,131	2,794	633	76	277	5,506
2005		2,461	1,011	15	1,992	12	5,813
2006		175	144	74	296	46	834
2007	1,154	4,146	550	73	56		6,031
2008	256	965	1	3		11	2,151
2009		1,264	56	11		4	1,402

Table 3.3.1.b. Total yellowfin and yellowedge grouper landings 1986-2009 from the Gulf of Mexico, percent of yellowfin grouper landings of combined yellowedge grouper and yellowfin grouper landings, average yellowfin grouper landings 1986-1990, 1991-1995 and 1996-2009.

YEAR	Yellowedge Grouper	Yellowfin Grouper	% Yellowfin/ Yellowfin+ Yellowedge	Average Landings	Comments
1986	1,114,903	358,654	24.3%		
1987	1,161,020	27,386	2.3%		
1988	1,620,333	30,521	1.8%		
1989	659,908	120,592	15.5%		
1990	847,079	33,734	3.8%	114,178 (100%)	1986-1990
1991	770,975	7,223	0.9%		
1992	1,041,905	3,195	0.3%		
1993	776,410	3,729	0.5%		
1994	1,069,729	21,938	2.0%		
1995	841,948	8,004	0.9%	8,818 (7.7%)	1991-1995
1996	529,862	11,548	2.1%		
1997	720,139	4,540	0.6%		
1998	683,466	1,126	0.2%		
1999	972,954	5,290	0.5%		
2000	1,091,339	10,373	0.9%		
2001	777,001	11,210	1.4%		
2002	785,154	9,334	1.2%		
2003	1,103,576	4,311	0.4%		
2004	925,347	5,506	0.6%		
2005	787,416	5,813	0.7%		
2006	745,337	834	0.1%		
2007	868,478	6,031	0.7%		
2008	819,040	2,151	0.3%		
2009	828,547	1,402	0.2%	5,676	1996-2009

Average percent yellowfin/(yellowfin + yellowedge) 1986-1990= 9.55 %
Average percent yellowfin/(Yellowfin + yellowedge) 1991-2009= 0.77%
Percentage of 1991-1995 yellowfin landings relative to 1986-1990 landings: 8,818/114,178= 7.7%

Table 3.3.1.c. 1986-1990 Yellowfin groupers landings (92. 3% of total landing estimated from comparison with landing from 1991-1995, see table 3.3.1.b.) from the Gulf of Mexico to be assigned as yellowedge grouper landings by gear and geographical fishing area. LL = longline; VL = vertical line.

YEAR	VL	LL	VL	LL	VL	LL	Grand Total
1986	18,120	-	108,724	9,616	127,114	38,893	330,956
1987	3,484	171	14,428	1,549	366	2,770	25,271
1988	2,079	12,530	8,497	21	1,625	1,235	28,164
1989	14,260	65,147	448	436	40	268	111,279
1990	15,391	8,518	2,782	1,452	95	705	31,129

Table 3.3.2. Total Gulf of Mexico unclassified grouper landings (in lbs gutted wt) 1962-2009 by gear for the three geographical fishing areas SE=Southeastern Gulf Stat areas 1-5; NE=Northeastern Gulf (stat areas 6-12); W=Western Gulf (sta tareas 13-21). LL = longline; VL = vertical line

Year	W Gulf VL	W Gulf LL	NE Gulf VL	NE Gulf LL	SE Gulf VL	SE Gulf LL	Grand Total
1963	550,868		1,406,955		4,075,622		6,033,444
1964	689,007		2,285,822		4,130,917		7,105,747
1965	708,995		2,464,618		4,626,236		7,799,850
1966	342,481		1,830,972		4,801,843		6,975,296
1967	355,184		1,278,364		4,150,710		5,784,258
1968	449,662		1,410,811		4,420,249		6,280,722
1969	356,194		1,438,688		5,333,632		7,128,514
1970	460,559		997,802		5,593,944		7,052,306
1971	548,815		2,287,056		3,684,350		6,520,221
1972	556,508		2,617,899		3,399,400		6,573,807
1973	398,694		1,919,237		2,967,498		5,285,429
1974	288,828		2,168,537		3,505,897		5,963,263
1975	300,480		2,766,810		4,083,071		7,150,361
1976	199,527		2,262,104		3,960,167		6,421,798
1977	157,758		1,777,216		3,054,883		4,989,858
1978	173,532		1,534,794		2,936,928		4,645,254
1979	194,303	46,031	2,704,454		3,518,285		6,463,073
1980	114,276	59,636	2,608,324	398,128	3,448,101	278,961	6,907,427
1981	597,194	871,308	2,443,510	1,208,488	2,953,030	1,549,005	9,622,535
1982	583,058	869,735	2,046,880	2,630,798	2,780,362	3,045,949	11,956,782
1983	303,982	414,480	1,652,489	1,593,880	2,788,655	2,558,046	9,311,532
1984	511,561	520,156	1,545,733	581,788	2,939,605	2,722,879	8,821,722
1985	543,726	966,810	2,018,635	844,243	3,594,329	1,988,387	9,956,130
1986	107,505	213,325	59,565	62,423	59,548	49,583	551,950
1987	120,153	245,869	61,411	45,606	96,718	71,237	640,993
1988	205,611	170,213	73,321	37,871	124,835	90,349	702,198
1989	195,445	172,651	75,308	5,943	28,871	17,138	495,355
1990	54,124	73,841	49,415	13,107	43,363	24,973	258,823
1991	39,260	49,717	29,121	38,112	8,393	19,251	183,855
1992	67,085	35,431	14,273	39,658	13,764	13,339	183,551
1993	30,182	69,362	10,620	28,053	5,258	26,780	170,255
1994	9,246	24,795	6,112	9,611	3,405	10,805	63,975
1995	8,268	39,338	3,829	8,017	2,174	5,892	67,518
1996	7,944	31,965	1,037	4,914	589	1,600	48,048
1997	11,244	33,424	1,240	17,186	440	2,990	66,523
1998	22,533	69,342	2,391	3,845	788	2,654	101,553
1999	6,607	52,614	3,061	7,016	1,025	3,840	74,163
2000	7,200	18,383	3,382	15,800	631	1,706	47,103
2001	8,871	36,999	4,068	11,915	239	708	62,801

2002	6,966	34,168	1,289	2,394	352	1,183	46,353
2003	2,713	20,653	951	1,397	257	1,034	27,005
2004	4,023	23,156	2,522	2,161	651	2,889	35,403
2005	5,677	13,631	1,552	1,085	60	180	22,186
2006	4,851	15,672	496	417	50	248	21,734
2007	90	189	390	314	16	76	1,074
2008	513	1,517	312	45	10	45	2,442
2009	470	1,177	292	69	1	1	2,011

Table 3.3.3. Species composition and landings of groupers sampled in 1982 during a long line survey of the commercial long line fishery in the Gulf Mexico conducted in three different geographical fishing grounds (after Prytherch 1983).

a. Long Line caught groupers - Western Grounds 1982

NMFS code	Species	% comp	(lbs)
1426	Yellowfin Grouper	**78.3%**	32,559
4740	Warsaw Grouper	18.3%	7,626
1411	Speckled Hind	0.9%	375
1424	Scamp Grouper	0.2%	67
1422	Black Grouper	0.8%	328
1416	Goliath Grouper	1.5%	640
1414	Snowy Grouper	0.0%	-

Total 41,595 lbs

Percent deep water species landings 1,035/41.595 = 97.5 %

b. Long Line caught groupers - Northern Grounds 1982

NMFS code	Species	% comp	(lbs)
1426	Yellowfin Grouper	**96.3%**	90,339
4740	Warsaw Grouper	3.2%	2,964
1411	Speckled Hind	0.4%	375
1424	Scamp Grouper	0.1%	67
1422	Black Grouper	0.1%	63
1416	Red Grouper	0.0%	-
1414	Snowy Grouper	0.0%	-

Total 93,808 lbs

Percent deep water species landings 93,678/93,808 = 99.9 %

c. Long Line caught groupers - Southern Grounds 1982

NMFS code	Species	% comp	(lbs)
1416	Red Grouper	34.9%	33,612
1414	Snowy	30.0%	28,860
1426	Yellowfin	**22.7%**	21,874
1422	Black	10.6%	10,191
4740	Warsaw	0.9%	883
1424	Scamp	0.4%	419
1411	Speckled	0.4%	375

Total 96,214 lbs

Percent deep water species landings 51,992/96,214 = 54.0 %

Table 3.3.4. Species composition and landings of unclassified groupers sampled in 1982 during a long line survey of the commercial Long Line fishery in the Gulf Mexico conducted in three different geographical fishing grounds (after Prytherch 1983). Note the Yellowfin in the original Prytherch (1983) report as evidence of wide spread mis-identification of yellowedge as Yellowfin.

Year	Deep water LL Landings	% Yellowfin West Gulf	% Yellowfin NE Gulf	% Yellowfin SE Gulf	LL Lands. Yellowedge West Gulf	LL Lands. Yellowedge NE Gulf	LL Lands. Yellowedge SE Gulf	LL Lands. Yellowedge Gulf Total
1979	46,031	78.3%	96.3%	22.7%	36,966	-	-	36,966
1980	736,725	78.3%	96.3%	22.7%	47,892	383,781	117,267	548,940
1981	3,628,801	78.3%	96.3%	22.7%	699,727	1,164,939	651,156	2,515,822
1982	6,546,482	78.3%	96.3%	22.7%	681,003	2,533,458	691,430	3,905,891

Table 3.3.5. Gulf Mexico of grouper species composition of the Vertical Line landings 1986-1989 by geographical fishing areas.

SE Gulf, Stat areas 1-5	**%**	**NE Gulf, Stat areas 6-12**	**%**	**West, Stat areas 13-21**	**%**
Red Grouper	73.2%	Red Grouper	55.3%	Yellowedge Grouper	27.4%
Black Grouper	8.9%	Black Grouper	18.5%	Warsaw Grouper	25.0%
Gag Grouper	8.8%	Gag Grouper	11.3%	Scamp	21.3%
Yellowedge Grouper	3.4%	Yellowedge Grouper	7.5%	Yellowfin Grouper	11.2%
Snowy Grouper	1.8%	Scamp	5.2%	Gag Grouper	5.8%
Scamp	1.7%	Warsaw Grouper	1.3%	Black Grouper	5.5%
Jewfish	1.2%	Snowy Grouper	0.5%	Snowy Grouper	2.1%
Yellowfin Grouper	0.5%	Jewfish	0.3%	Marbled Grouper	0.6%
Warsaw Grouper	0.4%	Yellowfin Grouper	0.2%	Jewfish	0.4%
Nassau Grouper	0.0%	Nassau Grouper	0.0%	Speckled Hind	0.3%
Speckled Hind	0.0%	Grand Total	100.0%	Red Grouper	0.2%
Grand Total	100.0%			Red Hind	0.0%
				Rock Hind	0.0%
				Yellowmouth Grouper	0.0%
				Graysby	0.0%
				Nassau Grouper	0.0%
				Misty Grouper	0.0%
				Grand Total	100.0%
Yellowedge+yellowfin	**3.9%**	Yellowedge+yellowfin	**7.6%**	Yellowedge+yellowfin	**38.7%**

Table 3.3.6. Calculated total Gulf of Mexico Yellowedge grouper landings 1974-2009 (in lbs gutted wt) for the three geographical fishing areas including mislabeled Yellowfin landing 1986-1990 and the unclassified grouper landings from 1975 onwards for vertical line (VL) and 1979 onwards for long line (LL) fisheries based grouper species composition found the Prytherch (1983) LL survey in 1982. SE=Southeastern Gulf Stat areas 1-5; NE=Northeastern Gulf (stat areas 6-12); W=Western Gulf (stat areas 13-21) based on the recommendations from the SEDAR 22 data workshop.

Year	W Gulf VL	W Gulf LL	NE Gulf VL	NE Gulf LL	SE Gulf VL	SE Gulf LL	Grand Total
1974	-		-		-		-
1975	116,156		210,370		160,238		486,764
1976	77,131		171,995		155,414		404,541
1977	60,985		135,128		119,887		315,999
1978	67,082		116,696		115,258		299,036
1979	75,112	36,031	205,629	-	138,073	-	454,845
1980	44,176	46,681	198,320	383,405	135,319	63,324	871,224
1981	230,857	682,027	185,788	1,163,798	115,890	351,624	2,729,985
1982	225,393	680,796	155,631	2,533,511	109,114	691,430	4,395,875
1983	117,510	646,674	125,644	1,928,289	109,439	547,917	3,475,474
1984	*	*	117,527	1,323,067	115,363	404,405	2,770,667
1985	*	*	153,484	717,845	141,057	260,892	2,061,894
1986	98,119	544,306	*	*	256,727	117,379	1,417,369
1987	63,191	437,827	257,166	212,141	88,382	125,081	1,183,788
1988	281,401	606,346	177,597	348,345	91,623	141,009	1,646,320
1989	49,078	351,233	*	*	18,278	22,137	740,507
1990	39,015	345,943	*	*	41,696	110,509	876,022
1991	*	*	28,930	175,356	50,047	159,430	770,975
1992	77,802	386,692	*	*	59,633	293,125	1,041,905
1993	*	*	21,096	171,418	11,410	176,582	776,410
1994	*	277,888	*	*	28,603	428,013	1,069,729
1995	*	372,383	*	180,655	8,984	234,634	841,948
1996	*	155,994	*	213,253	4,218	119,300	529,862
1997	*	*	6,097	230,134	9,286	331,465	720,139
1998	*	*	13,448	135,100	8,592	285,815	683,466
1999	37,094	274,224	18,581	196,148	9,553	437,354	972,954
2000	42,735	295,164	12,920	321,990	8,280	410,250	1,091,339
2001	22,893	197,259	9,338	241,112	5,693	300,705	777,001
2002	26,455	301,981	12,055	232,587	10,086	201,990	785,154
2003	33,021	363,051	14,611	340,073	10,124	342,695	1,103,576
2004	27,950	296,015	7,814	164,879	12,706	415,983	925,347
2005	23,365	268,662	12,184	133,541	3,953	345,710	787,416
2006	16,426	226,984	15,530	203,502	5,806	277,089	745,337
2007	27,529	137,744	6,550	277,070	3,964	415,622	868,478
2008	24,168	158,430	6,515	283,959	2,162	343,808	819,040
2009	43,453	210,874	11,989	201,355	8,410	352,466	828,547

Table 3.3.7. Calculated commercial landings of Gulf of Mexico yellowedge grouper 1986-2009 in lbs gutted wt and landings 1986-2001 used for 2002 stock assessment. Column on the far right shows the total difference between the 2010 and 2002 landings estimates. LL = longline; VL = vertical line

YEAR	Sedar 22 2010 LL	Sedar 22 2010 VL	Sedar 22 Total 2010	2002 LL	2002 VL	Total 2002	Difference 2010-2002 Total
1974			-				
1975	-	486,764	486,764				486,764
1976	-	404,541	404,541				404,541
1977	-	315,999	315,999				315,999
1978	-	299,036	299,036				299,036
1979	36,031	418,813	454,845				454,845
1980	493,410	377,814	871,224				871,224
1981	2,197,449	532,535	2,729,985				2,729,985
1982	3,905,738	490,137	4,395,875				4,395,875
1983	3,122,880	352,594	3,475,474				3,475,474
1984	2,340,023	430,645	2,770,667				2,770,667
1985	1,557,165	504,729	2,061,894				2,061,894
1986	774,308	643,061	1,417,369	579,094	334,705	913,799	526,362
1987	775,049	408,739	1,183,788	563,584	335,814	899,398	286,106
1988	1,095,699	550,621	1,646,320	881,810	419,475	1,301,285	346,993
1989	624,896	115,611	740,507	402,468	85,803	488,271	258,309
1990	719,189	156,833	876,022	612,863	129,621	742,484	135,719
1991	651,840	119,136	770,975	573,885	96,843	670,728	100,248
1992	897,826	144,078	1,041,905	669,869	124,944	794,813	247,091
1993	667,262	109,147	776,410	538,837	124,989	663,826	112,584
1994	976,362	93,367	1,069,729	935,979	55,620	991,598	78,131
1995	787,671	54,277	841,948	667,213	43,413	710,627	131,322
1996	488,547	41,315	529,862	435,372	41,919	477,291	52,571
1997	686,074	34,065	720,139	600,756	37,876	638,632	81,507
1998	635,949	47,517	683,466	524,021	35,161	559,182	124,284
1999	907,726	65,228	972,954	801,071	44,734	845,805	127,149
2000	1,027,404	63,935	1,091,339	909,811	53,883	963,693	127,646
2001	739,076	37,925	777,001	636,115	40,937	677,053	99,948
2002	736,558	48,595	785,154				
2003	1,045,820	57,756	1,103,576				
2004	876,877	48,470	925,347				
2005	747,913	39,503	787,416				
2006	707,574	37,763	745,337				
2007	830,435	38,043	868,478				
2008	786,197	32,844	819,040				
2009	764,695	63,852	828,547				

Table 3.4.1. Calculated yearly commercial vertical line and logline vessel yellowedge grouper discards by year. Discards are reported in number of fish.

Year	Vertical Line Discards	Logline Discards
1990	219	#
1991	700	#
1992	776	#
1993	305	#
1994	357	#
1995	428	#
1996	383	#
1997	587	#
1998	562	#
1999	641	#
2000	619	#
2001	618	#
2002	0	0
2003	*	0
2004	426	4,163
2005	892	0
2006	619	0
2007	4,435	*
2008	197	0
2009	21	0

#could not be calculated

*confidential data, but very few discards

Table 3.4.2. Percent of reported yellowedge grouper discards by estimated condition at release from commercial vessels.

Region	Year	All Dead	Majority Dead	All Alive	Majority Alive	Kept	Unknown	Unreported	N Fish
Vertical Line	2002	No discards reported							
	2003	Confidential data							
	2004	80.8%	15.3%	1.5%	0.6%	1.2%	0.6%	0.0%	339
	2005	83.9%	12.9%	0.7%	0.0%	2.6%	0.0%	0.0%	155
	2006	88.3%	10.1%	1.6%	0.0%	0.0%	0.0%	0.0%	248
	2007	44.2%	11.6%	9.1%	30.7%	0.2%	1.1%	3.2%	473
	2008	47.0%	12.9%	39.0%	1.1%	0.0%	0.0%	0.0%	549
	2009	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	137
	N Fish	1,227	223	267	153	10	7	15	1,902
Longline		0.0%	98.53%	0.0%	0.92%	0.0%	0.55%	0.0%	545

Table 3.4.3. Percent of reported yellowedge grouper discards by reason for discard from commercial vessels.

Region	Year	Not legal size	Out of season	Other regulations	Market conditions	Unreported	N Fish
Vertical Line	2002	No discards reported					
	2003	Confidential data not shown					
	2004	0.0%	0.0%	100.0%	0.0%	0.0%	339
	2005	0.0%	0.0%	94.8%	5.2%	0.0%	155
	2006	0.0%	0.0%	87.5%	0.0%	12.5%	248
	2007	0.0%	0.0%	100.0%	0.0%	0.0%	473
	2008	3.5%	92.5%	4.0%	0.0%	0.0%	549
	2009	0.0%	91.2%	2.9%	5.8%	0.0%	137
	N Fish	19	633	1,202	16	32	1,901
Longline		0.0%	0.0%	100.0%	0.0%	0.0%	545

Table 3.5.1. Reported golden tilefish, blueline tilefish, and yellowedge grouper total commercial fishing effort by year and gear fished in the Gulf of Mexico. Effort is defined as: logline – hooks fished and vertical line – hook hours fished. No trips reported blueline tilefish landings prior to 1993.

Year	Golden Tilefish		Blueline Tilefish		Yellowedge Grouper	
	Logline	Vertical line	Logline	Vertical line	Long line	Vertical line
1990	20,650	1,040			791,035	99,370
1991	108,500	5,400			2,522,020	441,027
1992	1,075,000	64,866			2,098,220	482,698
1993	2,594,250	135,590	2,005,250	567,496	4,571,870	956,650
1994	6,932,075	162,965	4,693,875	898,625	9,424,561	1,307,637
1995	6,236,350	123,126	3,490,965	969,045	9,089,235	1,277,702
1996	4,110,850	116,560	1,517,430	852,144	6,006,520	1,103,339
1997	5,888,940	542,766	4,538,250	1,242,228	10,807,900	2,050,354
1998	4,916,652	237,388	3,943,072	1,027,750	8,833,422	1,726,876
1999	5,673,450	430,605	3,006,200	843,317	10,646,450	1,898,750
2000	7,456,880	259,038	4,576,300	1,313,126	11,349,830	2,022,895
2001	5,922,225	164,764	3,551,050	1,028,506	9,779,535	1,918,324
2002	4,629,702	265,156	2,278,300	867,862	6,907,956	2,235,470
2003	6,613,000	312,199	3,536,280	771,210	11,584,630	2,177,766
2004	5,711,598	354,598	3,059,200	524,475	8,210,618	1,215,133
2005	4,583,876	285,094	1,903,716	417,132	6,177,386	945,872
2006	3,504,900	81,999	2,748,150	407,758	6,688,896	650,908
2007	3,339,650	191,992	2,076,950	347,626	6,977,050	784,539
2008	3,484,770	204,106	2,253,800	308,538	5,175,470	554,300
2009	2,866,200	173,140	1,854,650	299,472	5,202,350	804,327

Table 3.5.2. Total effort by year in the Gulf of Mexico reported to the coastal logbook program. Effort is defined as: logline – hooks fished and vertical line – hook hours fished.

Year	Long line	Vertical line
1990	2,860,561	523,538
1991	7,540,045	1,672,538
1992	6,534,972	1,854,139
1993	20,672,475	3,647,862
1994	25,182,372	4,264,703
1995	23,207,479	5,120,010
1996	19,824,375	4,578,622
1997	29,199,055	7,011,492
1998	27,203,196	6,717,985
1999	33,491,739	7,658,254
2000	28,375,357	7,396,677
2001	27,302,818	7,388,187
2002	22,980,633	7,606,856
2003	28,149,288	7,865,746
2004	26,832,283	6,536,835
2005	21,676,581	5,587,754
2006	24,766,701	5,262,599
2007	19,868,725	5,745,021
2008	17,834,960	5,008,894
2009	9,294,394	5,839,076

3.10. *FIGURES*

Figure 3.1.1. Historical Major Long line Fishing Grounds (Prytherch 1982).

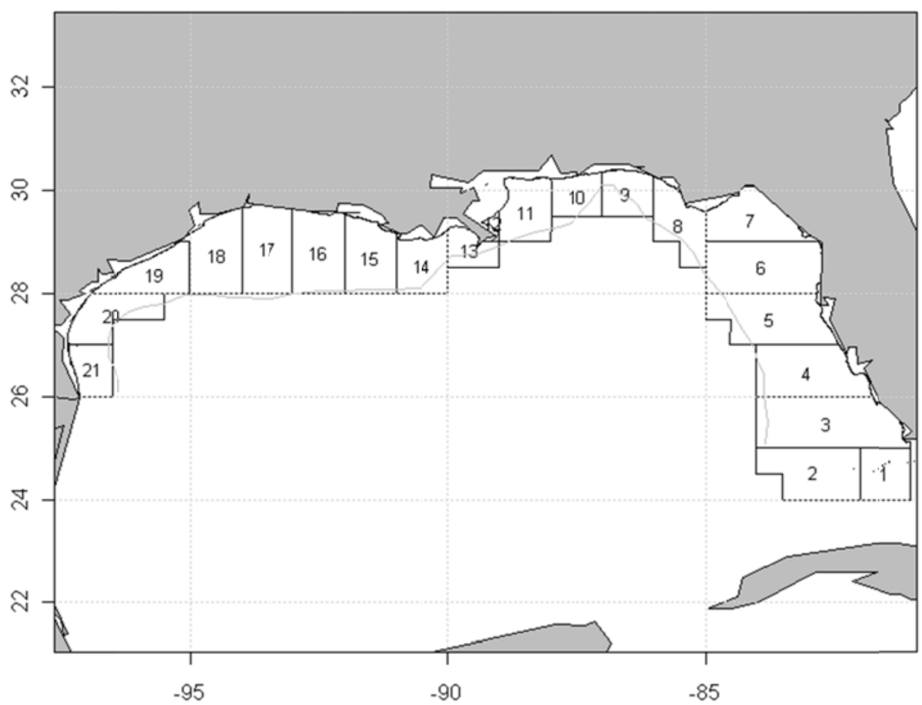


Figure 3.1.2. Statistical fishing or 'statareas' 1-21 in the Gulf of Mexico ranging from about Key West, FL in the Southeast to the Texas US/Mexican border in the Western Gulf.

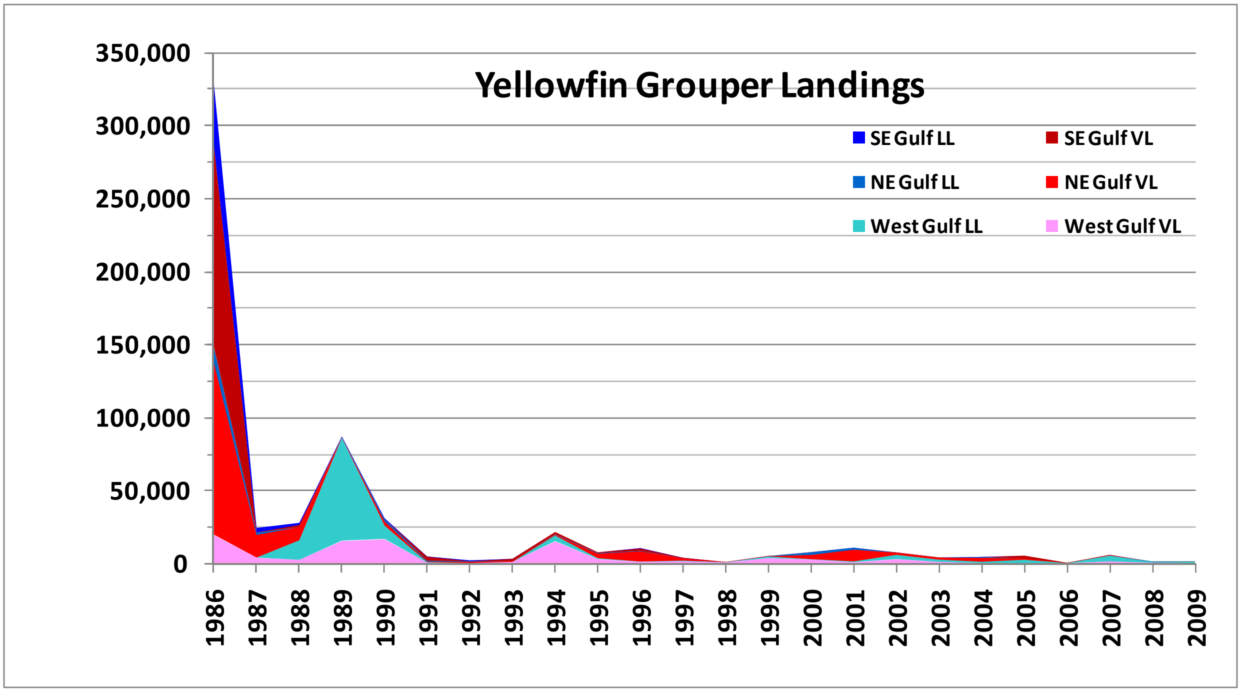
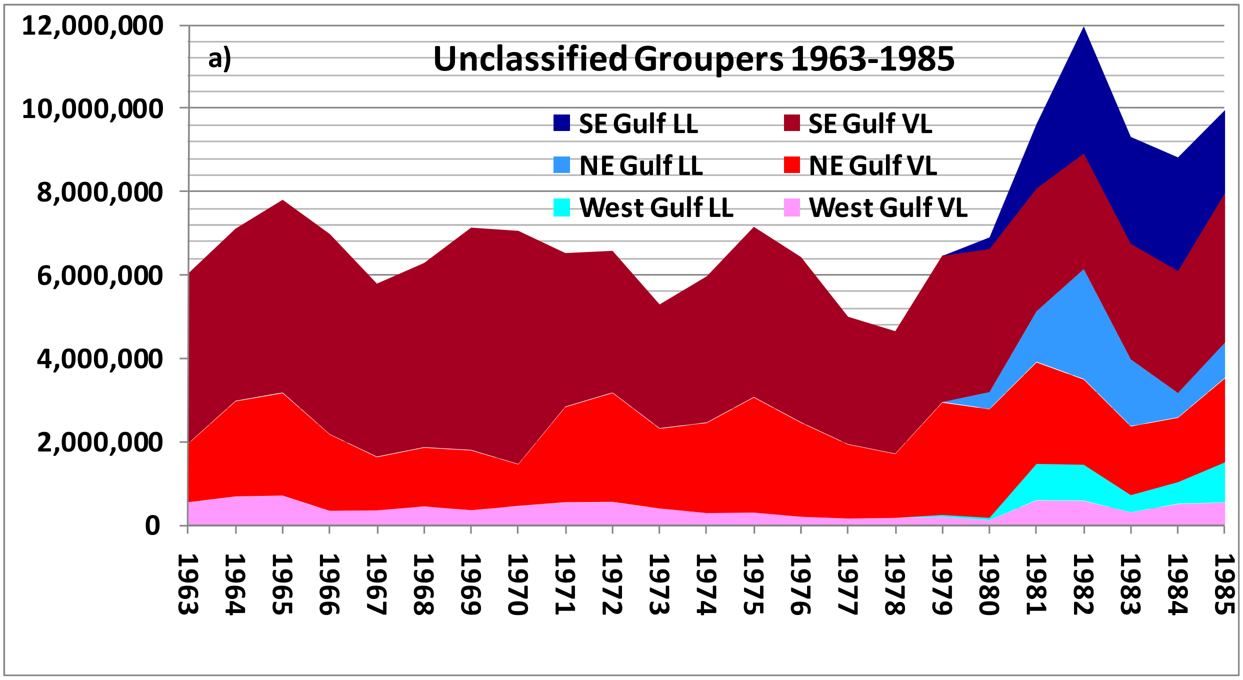


Figure 3.3.1. Preliminary commercial landings of Yellowfin grouper from the Gulf of Mexico management regions by geographical fishing area and gear type.SE=Southeastern Gulf Statareas 1-5; NE=Northeastern Gulf (statareas 6-12); W=Western Gulf (statareas 13-21).



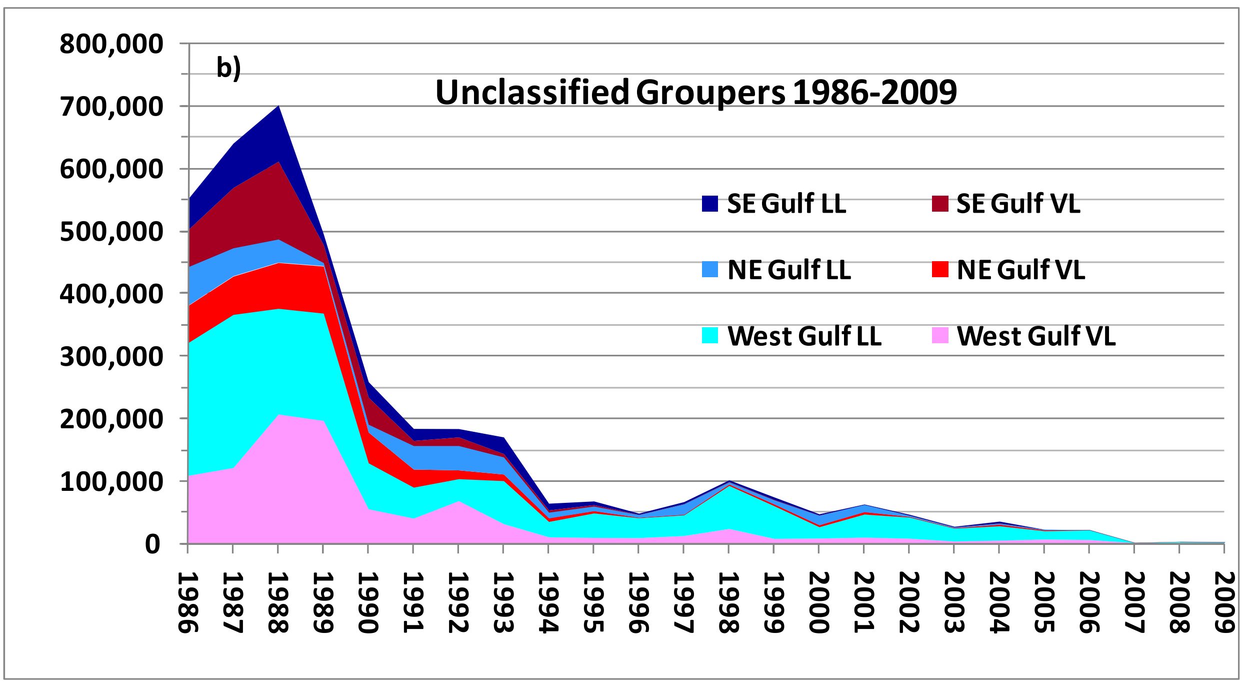


Figure 3.3.2. Commercial landings of unclassified groupers from the Gulf of Mexico management region by geographical fishing area and gear type.

a) 1963 – 1985 before the grouper classification requirement comes in effect in 1986
b) 1986 - 2009 after the grouper classification requirement comes in effect in 1986

SE=Southeastern Gulf Statareas 1-5; NE=Northeastern Gulf (statareas 6-12); W=Western Gulf (statareas 13-21) LL = long line, and VL = Vertical Line (hand and electric or bandit combined)

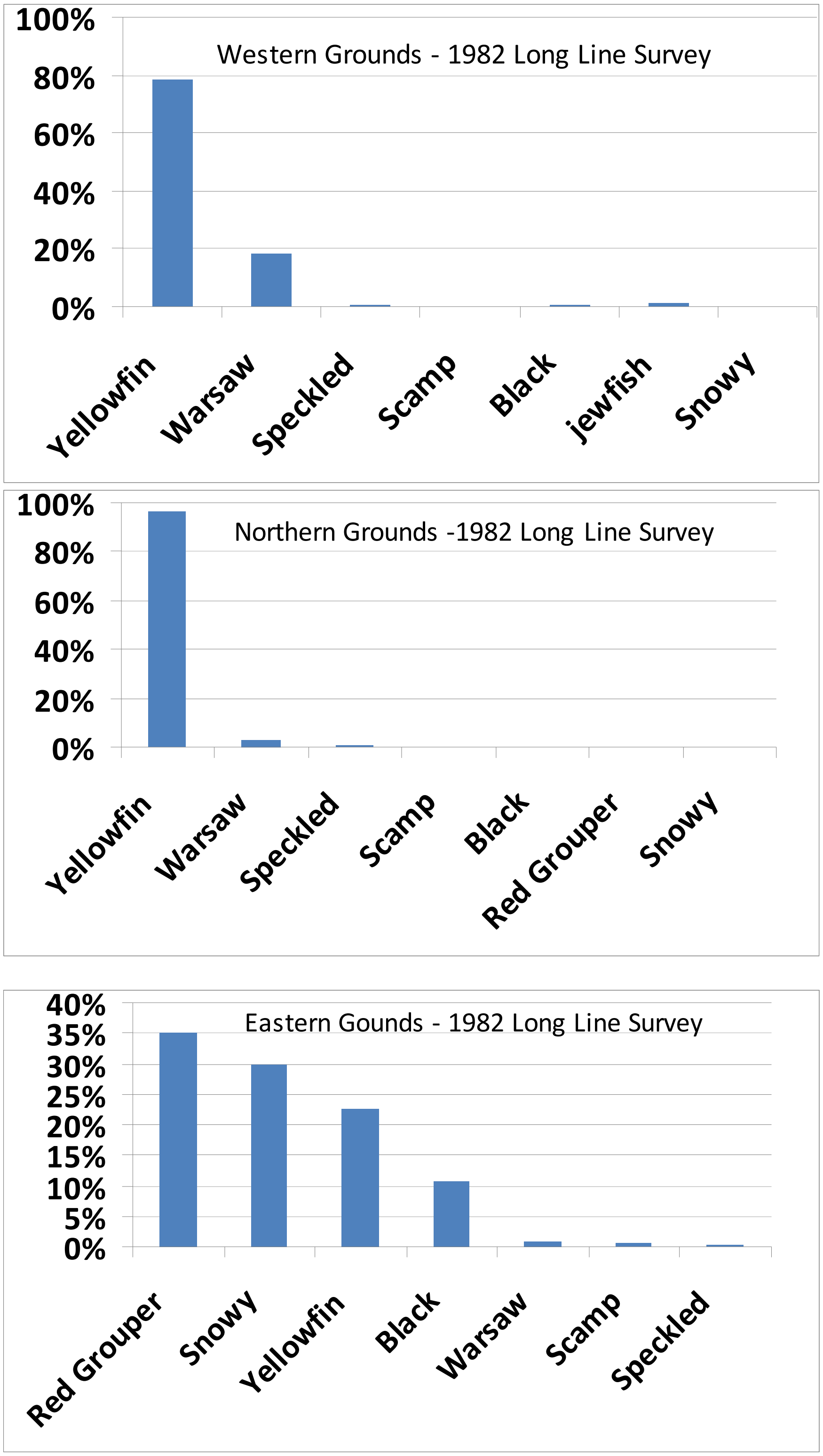


Figure 3.3.3. Percent species composition of grouper commercial long line fishery landings in 1982 for three different geographical fishing areas in the Gulf of Mexico after report by Prytherch (1983), see areas in Figure 3.3.1

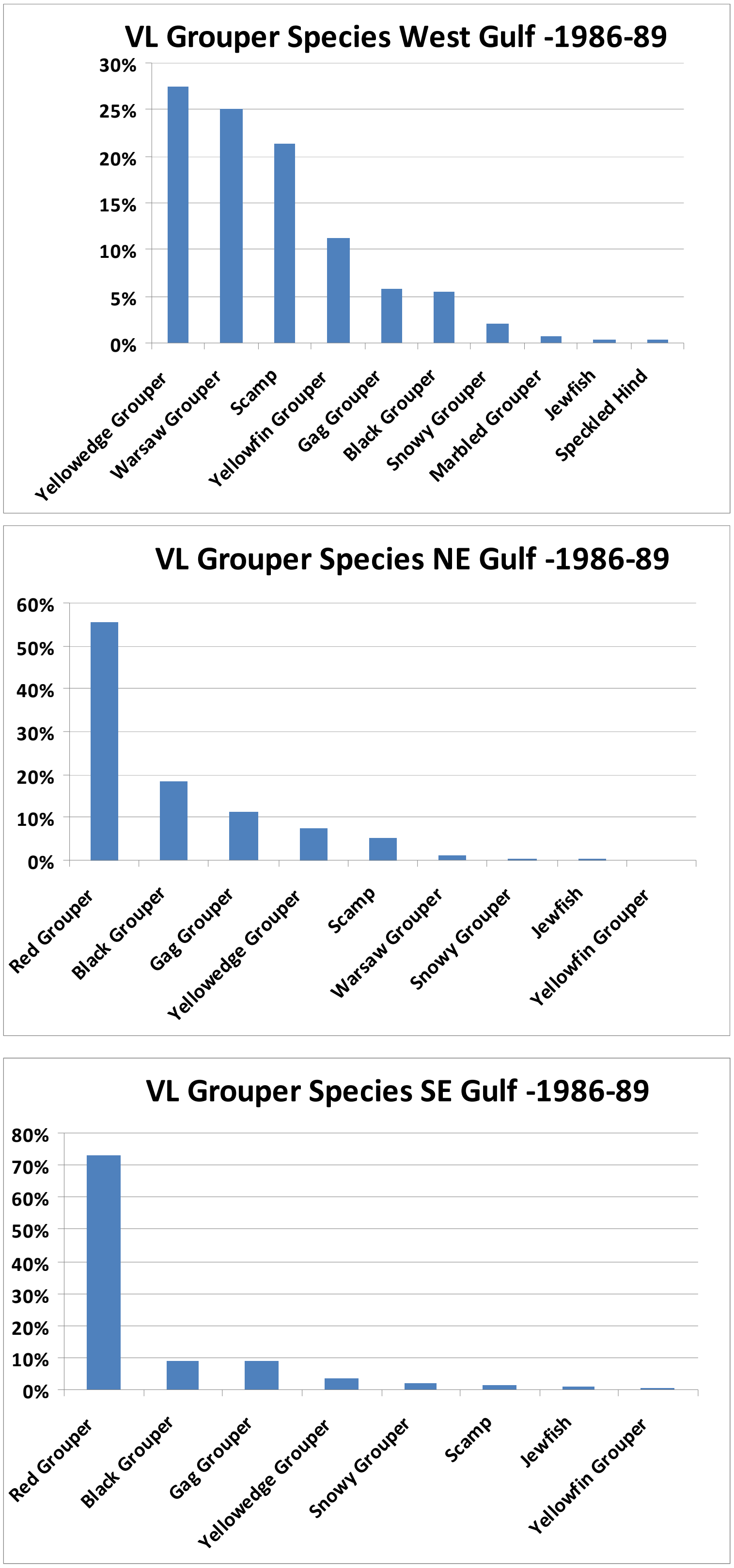


Figure 3.3.4. Percent species composition of grouper commercial vertical line landings from 1986 to 1989 for three different geographical fishing areas in the Gulf of Mexico. Note different axes between panels.

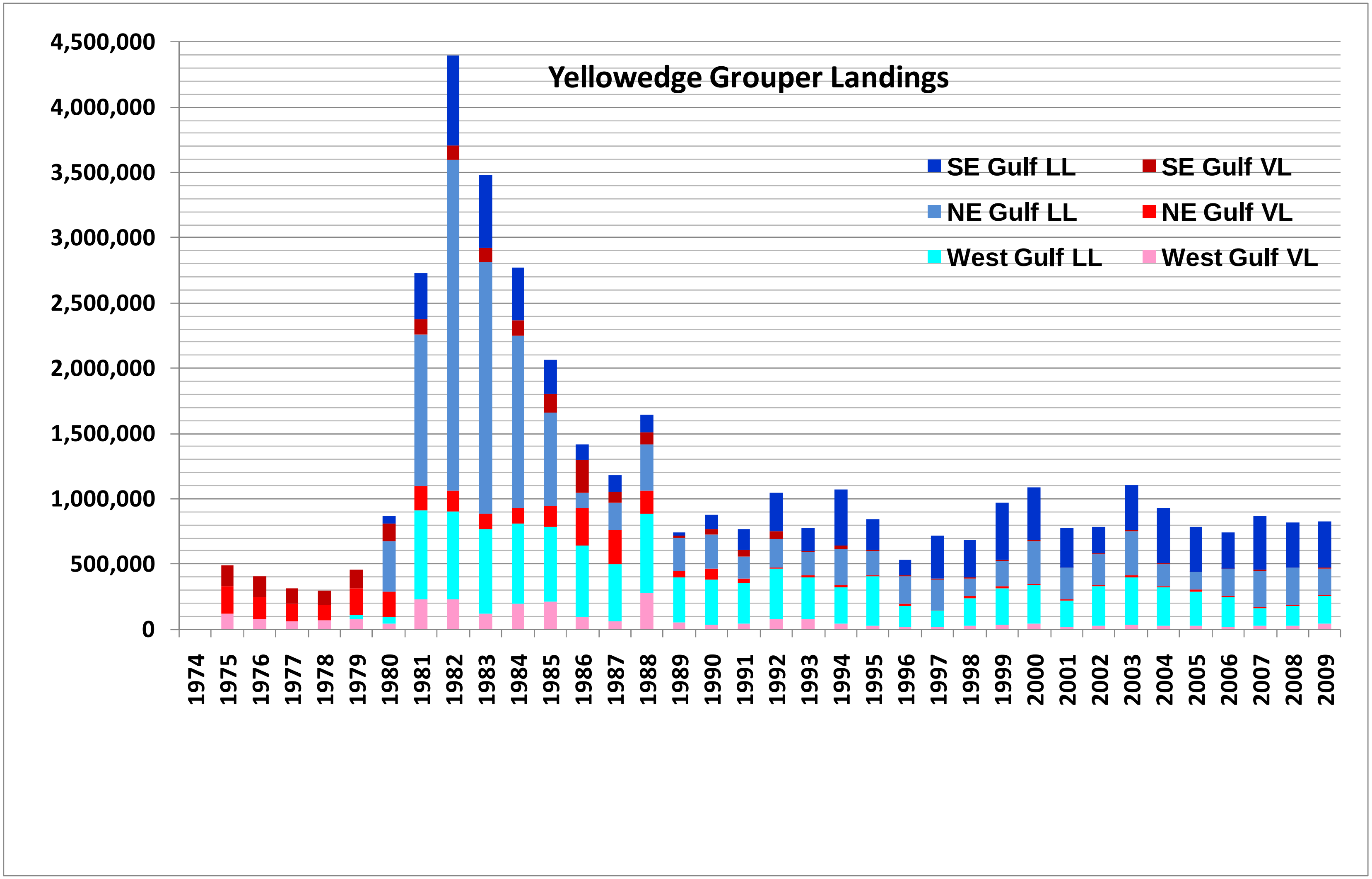


Figure 3.3.5. Updated calculated yellowedge grouper landings 1974-2009 (in lbs gutted wt) for three geographical fishing areas, including mislabeled Yellowfin landing 1975-1990 and unclassified grouper landings from 1979 onwards for the LL fishery and 1975 onwards for VL fishery. Analysis of grouper species compositions prior to 1986 for the LL fishery are shown in Table 3.3.3. and Figure 3.3.3 and for the VL fishery in Table 3.3.5. and Figure3.3.4.

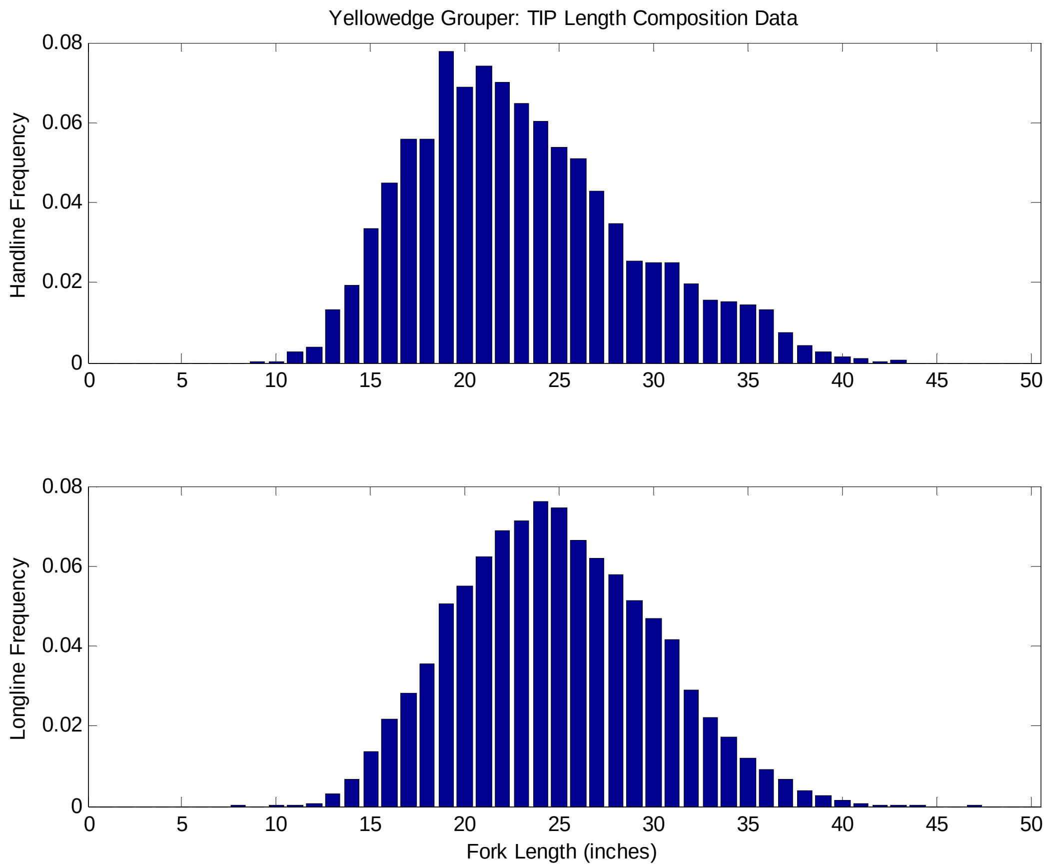


Figure 3.6.1. – Length frequency distributions for the yellowedge grouper handline (top panel) and longline (bottom panel) Trip Intercept Program data. There were 8,101 length observations from the handline fishery and 44,063 observations from the longline fishery.

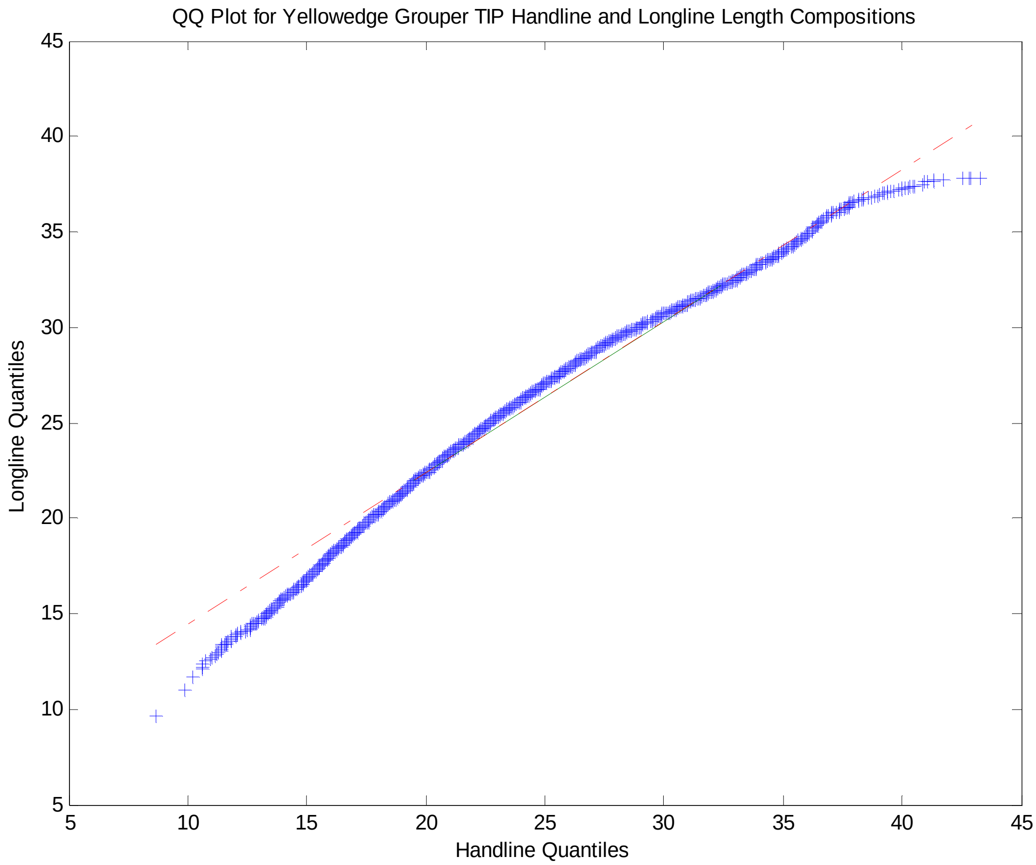


Figure 3.6.2. – Quantile-Quantile plot for the yellowedge grouper handline and long line length data measured by the Trip Intercept Program. This plot demonstrates deviations between the handline and longline length frequency distributions. Data drawn from identical distributions would fall along the red dotted line.

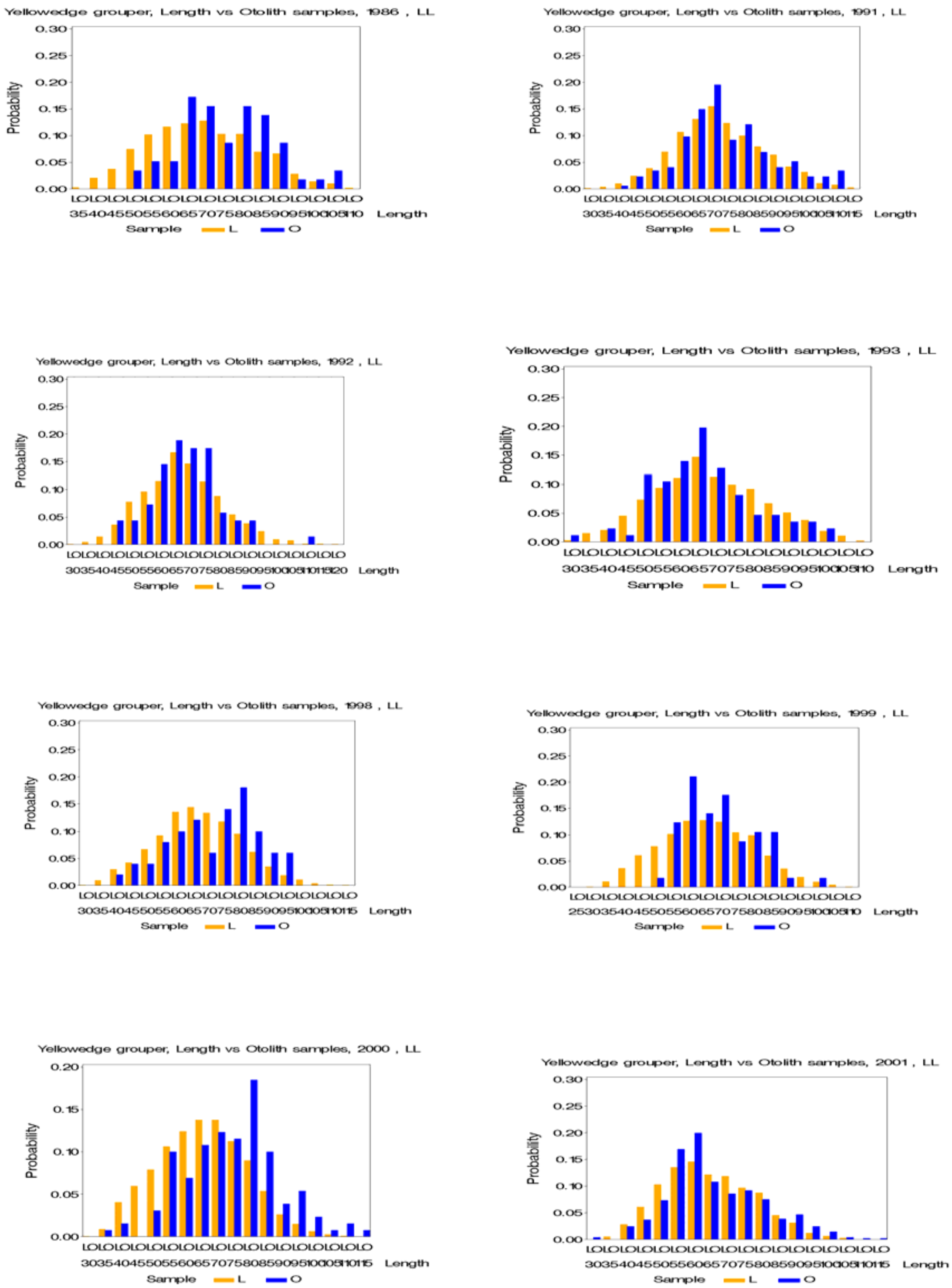


Figure 3.6.3. - Comparisons of yellowedge grouper length frequency distributions from TIP length and otolith samples from 1986- 2009. Orange bars indicate data derived from length samples, blue bars indicate data derived from otolith samples. Lengths (x-axis) are given in centimeters (cont’d next page.)

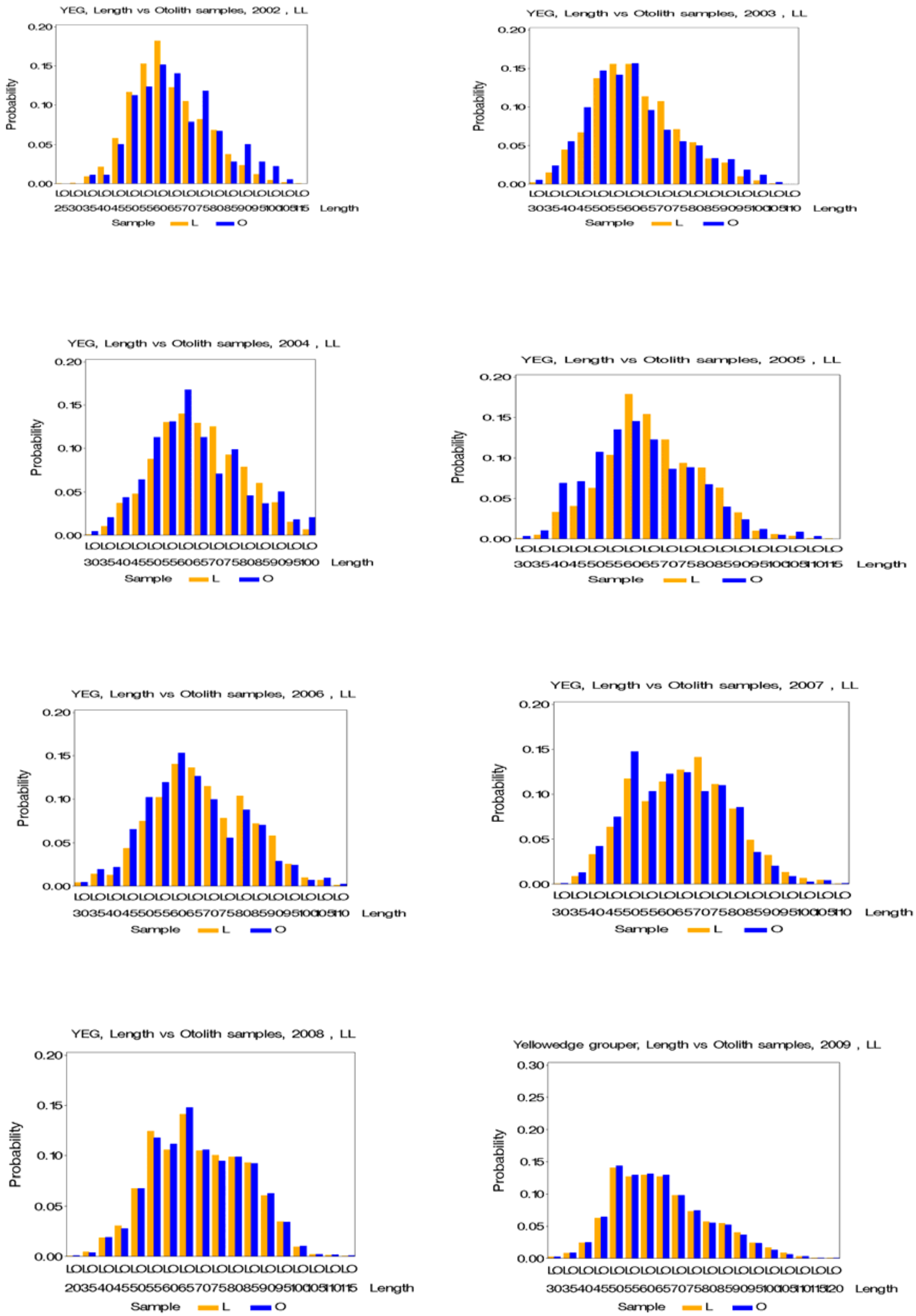


Figure 3.6.3. – Cont'd

4. RECREATIONAL FISHERY STATISTICS

4.1. *OVERVIEW*

The recreational landings for Yellowedge grouper in the Gulf of Mexico are small in comparison to landings in the commercial sector and for this reason the recreational and commercial landings groups were merged. The group membership is given in section 3.1.The primary issue with estimates of recreational landings of Yellowedge grouper are the validity of data for several years in which landings were abnormally high. This will be addressed below.

4.1.1. Group membership

Refik Orhun (Group Leader) ....NMFS-Miami
Steve Turner..NMFS-Miami
Kevin McCarthy..NMFS-Miami
John Quinlan ....NMFS-Miami
Bob Spaeth .... Commercial Fisheries
Martin Fisher.. Commercial Fisheries
Brad Kenyon ....Recreational Fisheries
Linda Lombardi ....NMFS-Panama City
Gary Fitzhugh ....NMFS-Panama City
Debbie Fable .... NMFS-Pascagoula
Charlie Bergmann .... NMFS-Pascagoula
Melissa Cook .... NMFS-Pascagoula
Richard Fulford...SSC - Univ. of Mississippi
Harry Blanchet...Louisiana Sea Grant
Yong Chen…………….... ....CIE Reviewer - Univ. of Maine

4.2. *REVIEW OF WORKING PAPERS*

Two working papers were provided to the working group (DW-15 and 16).The first summarized estimates of recreational landings since 1982 based on three surveys: The MRFSS survey, the NMFS Headboat survey (HBT), and the Texas Parks and Wildlife Department recreational harvest survey. Data were given as number of fish landed per year estimated for each region or sector. The second working paper summarized an approach for filling in missing weight data when it was not provided as a part of the catch estimates.

4.3. *RECREATIONAL LANDINGS*

Recreational landings of were sporadic and low as reported in the three recreational surveys; typically less than 5,000 lbs in all years except 1982 and 2005.The data as originally presented in DW-15 reported landings of over 16,000 fish in 1982 and over 5,000 fish in 2005.It was the consensus of the data workshop panel, particularly members from the fishing community that estimates for these years were overestimates most likely due to misallocation of catch from the Atlantic side of Florida that was landed in Monroe Co. The group recommended that the recreational catch data be recalculated after all intercept and effort data for Monroe Co., Fl was removed. Recalculated, recreational landings in number of fish and weight are shown in Tables 4.3.1.

4.4. *RECREATIONAL DISCARDS*

Recreational discards were reported only for the MRFSS survey and were given by year in DW-15.It was the consensus of the Data workshop panel that these data be recalculated as described in section 4.3. Recreational discards for yellowedge grouper from 1982 to 2009 are shown in Table 4.3.2.

4.5. *BIOLOGICAL SAMPLING*

Due to very low amount of recreational landings and its accordingly very low impact on the stock assessment process, biological sampling was not considered in the data workshop.

4.6. *RECREATIONAL CATCH-AT-AGE/LENGTH*

Due to very low amount of recreational landings and its accordingly very low impact on the stock assessment process, sampling of recreational catch-at-age/length was not considered in the data workshop.

Directed and discard –.The removal of data for Monroe Co., FL did not completely eliminate the anomalous landings data for 1982 and 1987.Discussion regarding the overall validity of existing surveys (particularly MRFSS) for providing estimates of recreational catch led the group to recommend that estimates of recreational landings by year be based on …….

4.7. *RECREATIONAL EFFORT*

Estimates of recreational effort were not provided to the working group but they were included in the conversion of recreational survey data to total catch. There were some questions regard the effort data used to make this conversion as Yellowedge grouper are not a commonly targeted species for recreational anglers due to depth and distance from shore. No recommendations were made by the working group regarding the estimation of recreational effort for Yellowedge grouper.

4.8. *COMMENTS ON THE ADEQUACY OF DATA FOR ASSESSMENT ANALYSES*

Members of the working group expressed concern regarding the validity of the estimates for 1982 and 2005.The overall reliability of the recreational data is not known as the nature of the effort calculation was not described. The consensus of the group was that recreational landings for yellowedge grouper are small in comparison to commercial landings and should not therefore overly influence the assessment. For this reason, summary estimates of landings across years are being considered for generating a final estimate of total landings for the assessment model. Given that the total commercial landings in 1982 (~4 million lbs) appear to be far greater than the recreational landings, it is likely that including these numbers will have little effect upon the assessment.

4.9. *LITERATURE CITED*

Prytherch, H.F. (1983). A descriptive survey of the bottom long line fishery in the Gulf of Mexico. NOAA Technical Memorandum NMFS-SEFSC-122. 33p.

4.10. *TABLES*

Table 4.3.1. Recreational Landings of yellowedge grouper from 1982 to 2009 collected by three data sampling survey sources, Headboat, MRFSS and Texas Parks and Wildlife (TPWD). Landings exclude Monroe County and are in numbers of fish and lbs gutted weight.

Year	Headboat (#)	MRFSS (#)	TWPD (#)	Headboat (lb)	MRFSS (lb)	TWPD (lb)
1982		13,146			130,570	
1984			21			209
1986	121		44	457		437
1987	497			1,103		
1988	949			2,178		

1989	325	1,668		734	16,570	
1990	599			1,643		
1991	364	0		1,331	0	
1992	130			489		
1993	84	311		333	3,090	
1994	57	0		423	0	
1995	101			605		
1996	26	0		180	0	
1997	73	92		369	1,226	
1998	63	346		445	7,483	
1999	6	125		53	624	
2000	6			37		
2001	6	222		50	1,373	
2002	4	415		29	3,808	
2003	11	32		91	299	
2004	10	126		69	1,143	
2005	32	6,160		142	56,460	
2006	21	223		207	2,568	
2007	43	25		202	250	
2008	43	62		202	613	
2009		567			4,944	

Table 4.3.2. Recreational discards of yellowedge grouper from 1982 to 2009 collected by three data sampling survey sources, Headboat, MRFSS, and Texas Parks and Wildlife (TPWD). Landings exclude Monroe County and are in numbers of fish.

Year	Headboat (#)	MRFSS (#)	TWPD (#)
1982		0	
1984			
1986			
1987			
1988			
1989		0	
1990			
1991		11,139	
1992			
1993		0	
1994		322	
1995			
1996		876	
1997		1,144	
1998		0	

1999		219	
2000			
2001		0	
2002		0	
2003		0	
2004		0	
2005		0	
2006		0	
2007		0	
2008		0	
2009		0	

5. MEASURES OF POPULATION ABUNDANCE

5.1. *OVERVIEW*

Several indices of abundance were considered for use in the assessment model. These indices came from both fishery independent and dependent data sources. The DW recommended the use of three fishery independent indices (two from NOAA Fisheries SEAMAP groundfish survey and NOAA Fisheries bottom longline survey) and one fishery dependent indices (commercial logbook data).

5.1.1. Group Membership

Membership of this DW working group included Neil Baertlein, Walter Ingram (leader), Kevin McCarthy, Adam Pollack, John Walter and Elbert Whorton, with assistance from Melissa Cook and Linda Lombardi.

5.2. *REVIEW OF WORKING PAPERS*

The working group reviewed a three working papers and reference documents describing index construction, including:

SEDAR22-DW-02 (Commercial logbook)
SEDAR22-DW-06 (NOAA Fisheries groundfish)
SEDAR22-DW-07 (NOAA Fisheries bottom longline)

Several improvements to analyses were identified. In some cases these modifications are described in appendices to original working documents; otherwise, they are reported here. We refer the reader to the original working documents for further details on exploratory data analysis, technical analysis, and diagnostics.

5.3. *FISHERY INDEPENDENT INDICES*

5.3.1. NOAA Fisheries SEAMAP Groundfish Survey (SEDAR22-DW-06)

5.3.1.1 General Description

The National Oceanic and Atmospheric Administration (NOAA) Fisheries has been conducting groundfish surveys in the northern Gulf of Mexico since fall, 1972 (Nichols and Pellegrin 1989). Initially the survey (Fall Groundfish Survey) was centered in the north-central Gulf of Mexico (Atchafalaya Bay, Louisiana to Mobile Bay, Alabama) and was designed to address a decline in finfish stocks that supported the pet food industry. Starting in 1981, a Summer Groundfish Survey was added to investigate brown shrimp stocks in the northern Gulf of Mexico. Even though the two surveys employed the same gear, a 40 foot shrimp trawl, they employed slightly differing sampling protocols in order to address specific requirements for their respective study. Beginning in 1987, a standardized SEAMAP protocol was used for both surveys to ensure compatibility of the data. This survey was conducted as a component of the Southeast Area Monitoring and Assessment Program (SEAMAP) (Rester *et al.* 2002).

5.3.1.2. Issues Discussed at the DW

Issue 1: Years to Include in Final Model

The groundfish survey has not always covered the current sampling area of Brownsville, TX to Mobile Bay, AL. During the early years of the groundfish survey (1972-1980), sampling was concentrated in the north central Gulf of Mexico (shrimp statistical zones 11-15). It was not until later years (1982-present) that the survey was expanded to cover most of the northern Gulf of Mexico (shrimp statistical zones 11-21). During the early years of the expanded survey, coverage was spotty (see SEDAR22-DW-06 Appendix). In 1987, a change in survey design was implemented and coverage became more consistent between shrimp statistical zones. The problem was there were large gaps in data for the early years forcing the models to try to fill in these gaps.

Option 1: Use data from 1972-2008 to model abundance for entire coverage area
Option 2: Use data from 1987-2008 to model abundance for entire coverage area
Option 3: Use data from 1972-2008, but only from shrimp statistical zones 11-15
Option 4: Use data from 1982-2008, but only from shrimp statistical zones 16-21

Decision: Both Option 2 and Option 3 because this survey represents an index value that is heavily centered on subadult yellowedge grouper. Option 3 allows for use of an index that may be representative of a virgin stock (major fishery started in the late 1970s) and has full coverage of the given area throughout the time series. Option 2 because it represents a subadult index that covers most of the northern Gulf of Mexico.

Miscellaneous Decisions

- The DW acknowledged that based on the length frequency distribution and age distribution (see SEDAR22-DW-06) that these indices do represent the subadult yellowedge grouper.
- The DW acknowledged that there may be some underlying cause that is behind the erratic changes in abundance in the early years when compared to later years of the survey.

5.3.1.3. Analysis Methods

Available catch per unit effort (CPUE) data from NOAA Fisheries SEAMAP groundfish survey from 1972-2008 was used to develop indices of abundance for subadult yellowedge grouper. Standardized indices of abundance were constructed using a delta lognormal modeling approach (Lo *et al.* 1992). Seven factors were considered for inclusion in the binomial submodel that models the proportion of stations where a yellowedge grouper were captured. These factors were year, depth zone, shrimp statistical zone, season, bottom type, time of day and fish time. All factors, except fish time, were included in the positive catch submodel which modeled effects on the number of yellowedge captured. A complete description of the methodology and results are presented in SEDAR22-DW-06.

5.3.1.4. Sampling Intensity

A map of survey coverage is provided in Figure 5.9.1. For annual maps of survey coverage, see SEDAR22-DW-06.

5.3.1.5. Size/Age Data

Length data for yellowedge grouper captured in NOAA Fisheries groundfish trawls are available from 1985-2008. This data indicates that most fish captured are subadults (>600 mm total length), with only a 4 individuals out of the 138 measured being larger than 600 mm. Age data is available for yellowedge grouper captured from 2000-2008 with most fish at age 1 and the majority falling between ages 1 and 4.

5.3.1.6. Catch Rates and Measures of Precision

Catch rates (CPUE) are presented in number of fish per trawl-hour and have been standardized as aforementioned in Analysis Methods. Measures of precision are presented as coefficients of variation (CV). The standardized and nominal CPUE as well as the CV are presented in Tables 5.8.1 and 5.8.2.

5.3.1.7 Comments on Adequacy for Assessment

The DW recommended using the two models for the assessment. The short time series (1987-2008) should be used as a base run and the longer (1972-2008) centralized model should be used as a sensitivity run. These decisions will allow for the use of the full time series and account for some of the survey design changes implemented throughout the time frame of the groundfish survey.

5.3.2 NOAA Fisheries Bottom Longline Survey (SEDAR22-DW-07)

5.3.2.1 General Description

The Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories has conducted standardized bottom longline surveys in the Gulf of Mexico, Caribbean, and Western North Atlantic since 1995. The objective of these surveys is to provide fisheries independent data for stock assessment purposes for as many species as possible. These surveys are conducted annually in U.S. waters of the Gulf of Mexico (GOM) and/or the Atlantic Ocean, and they provide an important source of fisheries independent information on large coastal sharks, snappers and groupers from the GOM and Atlantic.

5.3.2.2 Analysis Methods & Issues Discussed at the DW

For the SEDAR 22, we used the time series of data between 2000 and 2009 to develop abundance indices for yellowedge grouper. Due to the effects of Hurricane Katrina on the distribution of effort, the 2005 survey was dropped. Only data from stations within the depth range of capture for yellowedge grouper (i.e. 70 – 365 m) were used in development of annual indices for this species. Standardized indices of abundance, based on CPUE (number of yellowedge grouper per 100 hook hours) were constructed using a delta lognormal modeling approach (Lo *et al.* 1992). Initially, three factors were considered for inclusion in the binomial and lognormal submodels: water depth, survey area (three demarcations in the GOM: Eastern Gulf (east of 88^o west longitude); Central Gulf (between 88^o and 93^o west longitude); and Western Gulf (west of 93^o west longitude) and year. A backward selection procedure was used to determine which variables were to be included into each submodel based on type 3 analyses with a level of significance for inclusion of $\alpha = 0.05$. If year was not significant then it was forced into each submodel in order to estimate least-squares means for each year. The findings of this initial model run are described in SEDAR22-DW-07.

During the workshop I was asked to incorporate sediment data into the delta-lognormal model. This data is summarized by Rester (2009). The variables included for testing, along with those listed above, were the amounts of mud, clay, and carbonate in core samples taken nearest to the station location and the linear critical sheer stress and sorting factor of the sediment in said core sample. Modeling methods were conducted as described above. The findings of this second model run are described in Addendum 1 of SEDAR22-DW-07.

Finally, during the data workshop, I was also asked by the stock assessment scientist to develop indices for three areas of the Gulf. These areas were based on the NMFS shrimp statistical zones, employed in many fishery independent survey designs: southwest Florida (SWFLA), zones 2-5;

northwest Florida (NWFLA), zones 6-11; and the western Gulf (WEST), zones 13-21. This area variable and a variable denoting the interaction of this area and year were forced into the models developed for each species in Addendum 1 of SEDAR22-DW-07. The Table 5.8.3 and Figure 5.9.3 summarize these area-specific abundance indices and summaries of Type 3 tests for model inclusion.

5.3.2.3. Sampling Intensity

The positions of all stations, within the depth range yellowedge grouper were collected (i.e. 70 – 365 m), and positions of stations where yellowedge grouper were captured were plotted for all survey years combined (Figure 5.9.4). Survey coverage area varied during the time series due to weather or mechanical problems. For annual maps of survey coverage, see SEDAR22-DW-07.

5.3.2.4 Size/Age Data

Length data was collected on specimens throughout the time series whenever possible. Yellowedge grouper range from 300 to 1250 mm total length, with an average total length of 707 mm.

5.3.2.5 Catch Rates and Measures of Precision

Catch rates (CPUE) are presented as number of yellowedge grouper per 100 hook hours and have been standardized as aforementioned in Analysis Methods. Measures of precision are presented as coefficients of variation (CV). The standardized and nominal CPUE as well as the CV are presented in Table 5.8.3.

5.3.2.6 Comments on Adequacy for Assessment

The workshop group recommends using this index for the assessment.

5.4. *FISHERY DEPENDENT INDICES*

5.4.1 Commercial Logbook (Longline) (SEDAR22-DW-02)

5.4.1.1 General Description & Issues Discussed at the DW

Using the Southeast Fisheries Science Center's Coastal Fisheries Logbook Program (CFLP) available commercial longline data, an index of abundance was created for yellowedge grouper in the Gulf of Mexico. An initial index of abundance was created (SEDAR22-DW-02), however during the data workshop it was recommended that the unusually high amount of yellowfin grouper (*Mycteroperca venenosa)* landings be reclassified as yellowedge grouper. That decision was based upon consultation with the panel's fishermen and other members. The results below are from the yellowedge-yellowfin landing adjustment dataset and are fully described in the SEDAR22-DW-02 Addendum.

5.4.1.2 Analysis Methods & Sampling Intensity

For each fishing trip, the CFLP database included a unique trip identifier, the landing date, fishing gear deployed, areas fished, number of days at sea, number of crew, gear specific fishing effort, species caught and weight of the landings. Fishing effort data available for longline included number of sets and number of hooks fished per set. Clear outliers in the data, i.e. effort values falling outside the 99.5 percentile of the data, were also excluded from the analyses. Data were further restricted to include only those trips with landings and effort data received by the CFLP within 45 days of the completion of the trip.

Yellowedge grouper trips were identified using a data subsetting technique (modified from Stephens and MacCall, 2004) intended to restrict the data set to trips with fishing effort in yellowedge grouper habitat. Targeted trips were identified independently for the eastern Gulf of Mexico (statistical areas 2-7) and the western Gulf (statistical areas 8-21). Figure 5.9.5A and 5.9.5B provide species-specific regression coefficients. The magnitude of the coefficients indicates the predictive impact of each species.

CPUE was defined as gutted pounds of yellowedge grouper per hook. The effects of area, days at sea, distance between hooks, number of crew, season, total hooks fished, and longline length were tested. The delta lognormal model approach (Lo et al. 1992) was used to construct a standardized index of abundance. This method combines separate general linear model (GLM) analyses of the proportion of successful trips (trips that landed yellowedge grouper) and the catch rates on successful trips to construct a single standardized CPUE index. Parameterization of each model was accomplished using a GLM procedure (GENMOD; Version 8.02 of the SAS System for Windows © 2000. SAS Institute Inc., Cary, NC, USA).

The final delta-lognormal model was fit using a SAS macro, GLIMMIX (Russ Wolfinger, SAS Institute). All factors were modeled as fixed effects except two-way interaction terms containing

YEAR which were modeled as random effects. To facilitate visual comparison, a relative index and relative nominal CPUE series were calculated by dividing each value in the series by the mean value of the series.

5.4.1.3 Results & Discussion

The final models for the binomial on proportion positive trips (PPT) and the lognormal on CPUE of successful trips were:

PPT = Area + Days at sea + Year

LOG(CPUE) = Area + Distance between Hooks + Year + Year*Area

The linear regression statistics and analysis of the mixed model formulations of the final models are summarized in the addendum to SEDAR22-DW-02. Plots of annual trends for proportion positive trips and nominal CPUE, as well as diagnostic plots for the binomial and lognormal components of the analyses, can also be found in the SEDAR22-DW-02 addendum.

Relative nominal CPUE, number of trips, proportion positive trips, and relative abundance indices are provided in Table 5.8.4 for the vertical line model. The delta-lognormal abundance index developed, with 95% confidence intervals, is shown in Figure 5.9.6

5.4.1.4 Comments on Adequacy for Assessment

The workshop group recommends using this index for the assessment.

5.5. *CONSENSUS RECOMMENDATIONS AND SURVEY EVALUATIONS*

The workshop group recommends using the indices described above as inputs into the assessment model. Figure 1.5 illustrates linear coverage of specific abundance indices along the coast of the Gulf of Mexico.

5.6. *ITEMIZED LIST OF TASKS FOR COMPLETION FOLLOWING WORKSHOP*

The group was tasked with developing an extended time series for yellowedge grouper, which included data from historic exploratory fishing surveys conducted by NMFS, the current NOAA

Fisheries bottom longline (SEDAR22-DW-07), and current observer data from the commercial bottom longline fishery.

The tasks to be completed for all fisheries dependent bottom longline indices are as follows:
1.) Define all yellowfin grouper landings as yellowedge grouper except for when both species were reported on a trip.
2.) Rerun Stevens-McCall data subsetting procedure after completion #1.

3.) Construct 3 separate indices for yellowedge grouper for three regions in the Gulf of Mexico (areas 2-5, 6-11, & 13-21).

The results of these tasks will be submitted as documents for the upcoming Assessment Workshop.

5.7. *LITERATURE CITED*

Lo, N.C.H., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. *Canadian Journal of Fisheries and Aquatic Science* 49:2515-2526.

Nichols S. and G.J. Pellegrin, Jr. 1989. Trends in catch per unit effort for 157 taxa caught in the Gulf of Mexico fall groundfish survey 1972 to 1988. National Marine Fisheries Service, Southeast Fisheries Center, Pascagoula, Mississippi.

Rester, J. 2009. Distribution of bottom habitat information in the Gulf of Mexico. Gulf States Marine Fisheries Commission NA05NMF4331073.

Rester, J.K., D. Hanisko, N. Sanders, Jr. and B. Pellegrin. 2002. SEAMAP Environmental and Biological Atlas of the Gulf of Mexico, 2000. Gulf States Marine Fisheries Commission. Ocean Springs, MS. Number 101. 264pp.

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

5.8. *TABLES*

Table 5.8.1: Indices of yellowedge grouper developed using the delta-lognormal model for 1987-2008. The nominal CPUE, nominal frequency of occurrence, the number of samples (*N*), the DL Index (number per trawl-hour), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

Survey Year	Nominal CPUE	Frequency	N	DL Index	Scaled Index	CV	LCL	UCL
1987	0.00000	0.00000	76	0.00000	0.00000			
1988	0.01854	0.02041	98	0.01613	0.28347	2.37249	0.01811	4.43667
1989	0.00439	0.01149	87	0.01029	0.18089	4.01535	0.00622	5.26367
1990	0.08619	0.04000	100	0.07165	1.25953	0.96890	0.24744	6.41133
1991	0.06488	0.03636	110	0.05424	0.95344	1.11989	0.15712	5.78579
1992	0.07283	0.03670	109	0.03806	0.66896	1.20086	0.10108	4.42722
1993	0.03750	0.04902	102	0.03718	0.65360	1.12655	0.10692	3.99541
1994	0.07402	0.03636	110	0.06173	1.08509	1.02027	0.20037	5.87635
1995	0.02923	0.02041	98	0.03386	0.59525	1.75882	0.05540	6.39541
1996	0.27642	0.09615	104	0.11453	2.01325	0.58552	0.67969	5.96330
1997	0.09401	0.04082	98	0.04334	0.76190	1.17310	0.11853	4.89735
1998	0.04287	0.01923	104	0.02201	0.38698	2.10338	0.02872	5.21363
1999	0.02171	0.02752	109	0.01140	0.20037	2.28525	0.01341	2.99402
2000	0.09021	0.06186	97	0.04937	0.86788	0.96439	0.17145	4.39333
2001	0.07693	0.05952	84	0.03451	0.60668	1.17456	0.09424	3.90568
2002	0.11284	0.08491	106	0.11324	1.99055	0.59606	0.66078	5.99641
2003	0.11381	0.09474	95	0.09128	1.60458	0.65687	0.48434	5.31592
2004	0.12907	0.10753	93	0.08996	1.58142	0.62053	0.50502	4.95203
2005	0.15433	0.08537	82	0.07370	1.29548	0.76691	0.33242	5.04872
2006	0.21166	0.07368	95	0.10546	1.85382	0.67683	0.54282	6.33103
2007	0.12122	0.06250	80	0.05903	1.03761	0.95042	0.20855	5.16238
2008	0.12627	0.06024	166	0.06367	1.11925	0.68497	0.32373	3.86963

Table 5.8.2: Indices of yellowedge grouper developed using a binomial model for 1972-2008. The nominal CPUE, nominal frequency of occurrence, the number of samples (*N*), the Index (frequency of occurrence), the indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV) are listed.

Survey Year	Nominal CPUE	Frequency	N	Index	Scaled Index	CV
1972	0.00000	0.00000	71	0.00000	0.00000	
1973	0.00000	0.00000	82	0.00000	0.00000	
1974	0.00971	0.00485	206	0.00621	0.20357	1.02076
1975	0.01667	0.00833	120	0.01255	0.41125	1.01737
1976	0.25600	0.04800	125	0.06727	2.20433	0.42036
1977	0.18182	0.03030	99	0.03658	1.19879	0.59099
1978	0.08602	0.01075	93	0.01430	0.46865	1.02146
1979	0.00000	0.00000	89	0.00000	0.00000	
1980	0.18182	0.05194	77	0.08534	2.79652	0.50322
1981	0.16071	0.06250	64	0.08521	2.79206	0.50076
1982	0.03571	0.01785	112	0.02642	0.86569	0.72286
1983	0.00000	0.00000	70	0.00000	0.00000	
1984	0.00000	0.00000	84	0.00000	0.00000	
1985	0.12155	0.03947	76	0.04383	1.43625	0.61785
1986	0.00000	0.00000	39	0.00000	0.00000	
1987	0.00000	0.00000	31	0.00000	0.00000	
1988	0.00000	0.00000	33	0.00000	0.00000	
1989	0.00000	0.00000	34	0.00000	0.00000	
1990	0.07908	0.02127	47	0.00836	0.27396	1.07260
1991	0.00000	0.00000	44	0.00000	0.00000	
1992	0.00000	0.00000	45	0.00000	0.00000	
1993	0.00906	0.02325	43	0.00919	0.30141	1.11295
1994	0.05050	0.02272	44	0.00934	0.30630	1.07189
1995	0.00000	0.00000	37	0.00000	0.00000	
1996	0.37330	0.09756	41	0.05472	1.79304	0.56820

1997	0.04762	0.02777	36	0.00816	0.26743	1.12227
1998	0.00000	0.00000	38	0.00000	0.00000	
1999	0.00000	0.00000	40	0.00000	0.00000	
2000	0.00000	0.00000	37	0.00000	0.00000	
2001	0.02052	0.02941	34	0.01203	0.39427	1.10039
2002	0.00000	0.00000	41	0.00000	0.00000	
2003	0.14694	0.09090	33	0.04573	1.49860	0.66044
2004	0.03563	0.02777	36	0.01173	0.38454	1.07021
2005	0.00000	0.00000	31	0.00000	0.00000	
2006	0.09183	0.02777	36	0.01229	0.40299	1.08513
2007	0.00000	0.00000	23	0.00000	0.00000	
2008	0.00000	0.00000	70	0.00000	0.00000	

Table 5.8.3: Area-specific abundance indices and summaries of Type 3 tests for model inclusion.

Table 5.8.3.a: *Type 3 Tests of Fixed Effects for the Binomial Submodel for Yellowedge Grouper*

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
YEAR	8	579	6.67	0.83	0.5724	0.5729
Area	2	579	0.44	0.22	0.8015	0.8016
sta_dpth	1	579	4.49	4.49	0.0340	0.0344
Carbonate	1	579	1.50	1.50	0.2204	0.2209
lCritShStrs	1	579	5.22	5.22	0.0223	0.0227
*YEAR*Area*	13	579	6.24	0.48	0.9371	0.9361

Table 5.8.3.b: *Type 3 Tests of Fixed Effects for the Lognormal Submodel for Yellowedge Grouper*

Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
YEAR	8	121	1.25	0.2745
Area	2	121	0.75	0.4734
*YEAR*Area*	13	121	0.96	0.4976

Table 5.8.3.c: *Abundance Indices and Variability*

Survey Year	*Area*	*Nominal Frequency*	*N*	*Index*	*Scaled Index*	*CV*	*LCL*	*UCL*
2000	NWFLA	0.28571	7	0.24922	0.51119	0.86261	0.11502	2.27188
2001	NWFLA	0.17241	29	0.22536	0.46225	0.56739	0.16070	1.32966
2002	NWFLA	0.33333	15	0.42259	0.86681	0.51609	0.32798	2.29090
2003	NWFLA	0.25000	28	0.50848	1.04299	0.45763	0.43604	2.49477
2004	NWFLA	0.19048	20	0.39862	0.81763	0.61117	0.26498	2.52286
2006	NWFLA	0.42857	7	1.15009	2.35903	0.64875	0.72100	7.71846
2007	NWFLA	0.21429	14	0.45707	0.93752	0.72390	0.25595	3.43401
2008	NWFLA	0.10000	10	0.21671	0.44451	1.24105	0.06445	3.06569
2009	NWFLA	0.37500	16	0.75411	1.54680	0.45852	0.64567	3.70562
2001	SWFLA	0.00000	19	0.00000	0.00000	.	.	.
2003	SWFLA	0.21875	32	0.76688	1.57299	0.46283	0.65172	3.79657
2004	SWFLA	0.16667	30	0.46950	0.96302	0.55196	0.34333	2.70126
2006	SWFLA	0.26316	19	0.41394	0.84906	0.54312	0.30713	2.34717
2007	SWFLA	0.31579	19	0.80989	1.66122	0.51044	0.63455	4.34896
2008	SWFLA	0.09091	11	0.30008	0.61551	1.24194	0.08917	4.24889
2009	SWFLA	0.25000	20	0.70607	1.44827	0.52878	0.53649	3.90965
2000	WEST	0.24242	66	0.42160	0.86478	0.30227	0.47871	1.56219
2001	WEST	0.26087	46	0.43616	0.89463	0.35504	0.44912	1.78207
2002	WEST	0.26471	68	0.45864	0.94076	0.28859	0.53433	1.65633
2003	WEST	0.25000	32	0.36234	0.74323	0.42124	0.33119	1.66790
2004	WEST	0.21875	32	0.39667	0.81364	0.49316	0.32001	2.06871
2006	WEST	0.27586	29	0.59795	1.22650	0.42760	0.54043	2.78354
2007	WEST	0.09091	22	0.31664	0.64949	0.90307	0.13861	3.04331
2008	WEST	0.20000	10	0.42392	0.86953	0.89709	0.18701	4.04301
2009	WEST	0.20588	34	0.43811	0.89865	0.46790	0.36908	2.18808

Table 5.8.4. Longline relative nominal CPUE, number of trips, proportion positive trips, and relative abundance index for yellowedge grouper (1992-2009) in the Gulf of Mexico.

YEAR	Relative Nominal CPUE	Trips	Proportion Successful Trips	Relative Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1991	2.763221	116	0.922414	1.516128	0.984288	2.335337	0.218542
1992	1.562496	123	0.918699	1.449104	0.937928	2.238874	0.220112
1993	0.804279	174	0.867816	0.621648	0.389431	0.992335	0.237077
1994	0.812022	326	0.868098	0.912207	0.642000	1.296140	0.177003
1995	1.189826	344	0.848837	0.814693	0.563764	1.177309	0.185658
1996	0.701543	204	0.872549	0.668300	0.439352	1.016554	0.212045
1997	0.733037	367	0.901907	0.868919	0.625398	1.207265	0.165549
1998	0.630989	331	0.851964	0.747721	0.518602	1.078065	0.184488
1999	0.862710	389	0.858612	0.823427	0.576316	1.176493	0.179838
2000	0.868600	429	0.892774	0.835222	0.597652	1.167228	0.168523
2001	0.823798	408	0.906863	0.805724	0.577871	1.123420	0.167350
2002	0.740617	354	0.875706	0.783833	0.549460	1.118179	0.179041
2003	0.726188	440	0.925000	0.921541	0.670646	1.266299	0.159912
2004	0.706083	306	0.908497	0.854458	0.603201	1.210375	0.175437
2005	0.847371	279	0.892473	1.136052	0.806778	1.599713	0.172393
2006	0.863297	267	0.928839	1.220332	0.881659	1.689099	0.163616
2007	1.067990	258	0.980620	1.289692	0.947675	1.755143	0.154992
2008	1.248652	229	0.930131	1.485238	1.068224	2.065045	0.165914
2009	1.047280	223	0.946188	1.245760	0.889774	1.744171	0.169465

5.9. *FIGURES*

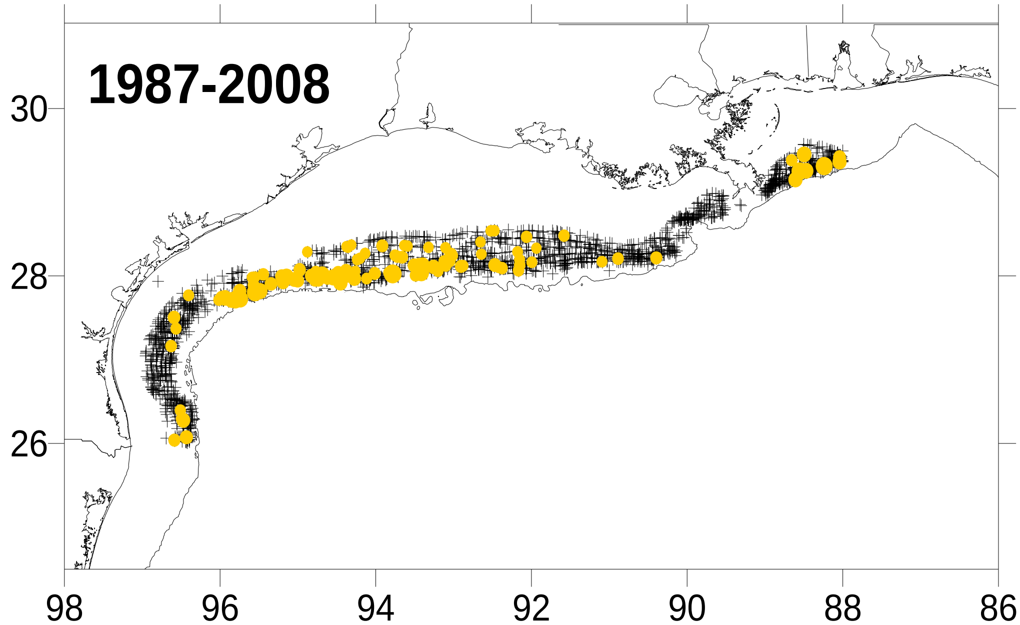


Figure 5.9.1: Overview of locations of groundfish survey trawls in the northern Gulf of Mexico conducted between 1987 and 2008. Each + indicates the starting point of a trawl station and the circle represents where yellowedge grouper were captured and the CPUE. The smallest circle represents a CPUE of 0.25 fish per hour, while the largest circle represents a CPUE of 6 fish per hour.

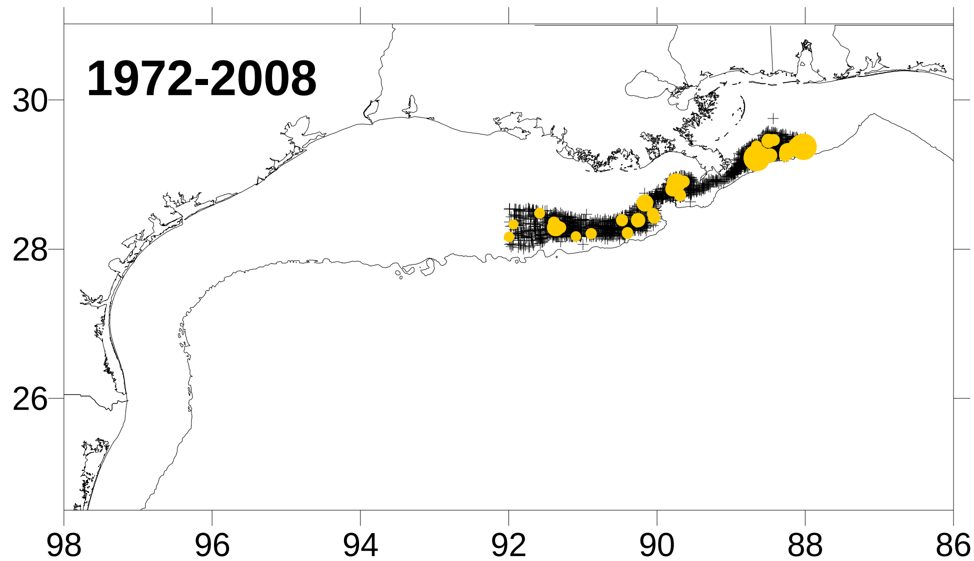


Figure 5.9.2: Overview of locations of groundfish survey trawls in the northern Gulf of Mexico conducted between 1972 and 2008. Each + indicates the starting point of a trawl station and the circle represents where yellowedge grouper were captured and the CPUE. The smallest circle represents a CPUE of 0.38 fish per hour, while the largest circle represents a CPUE of 14 fish per hour.

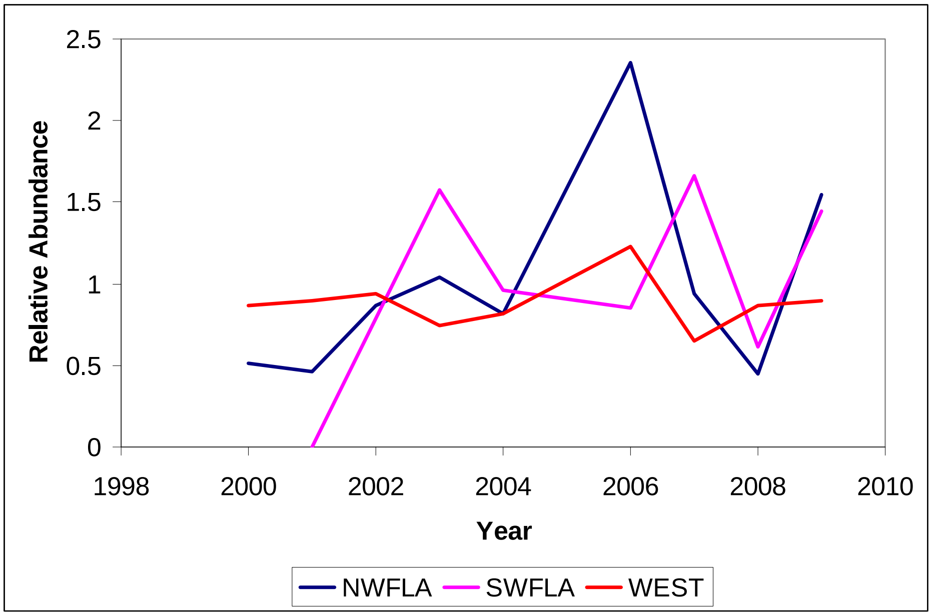


Figure 5.9.3: Area-specific abundance indices for yellowedge grouper

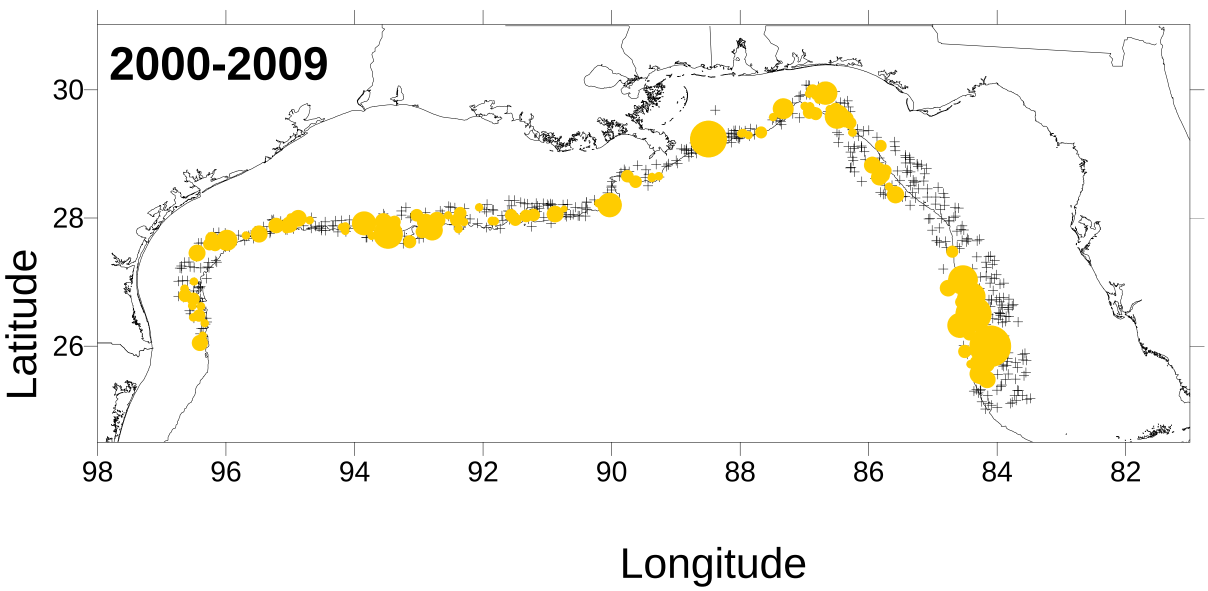
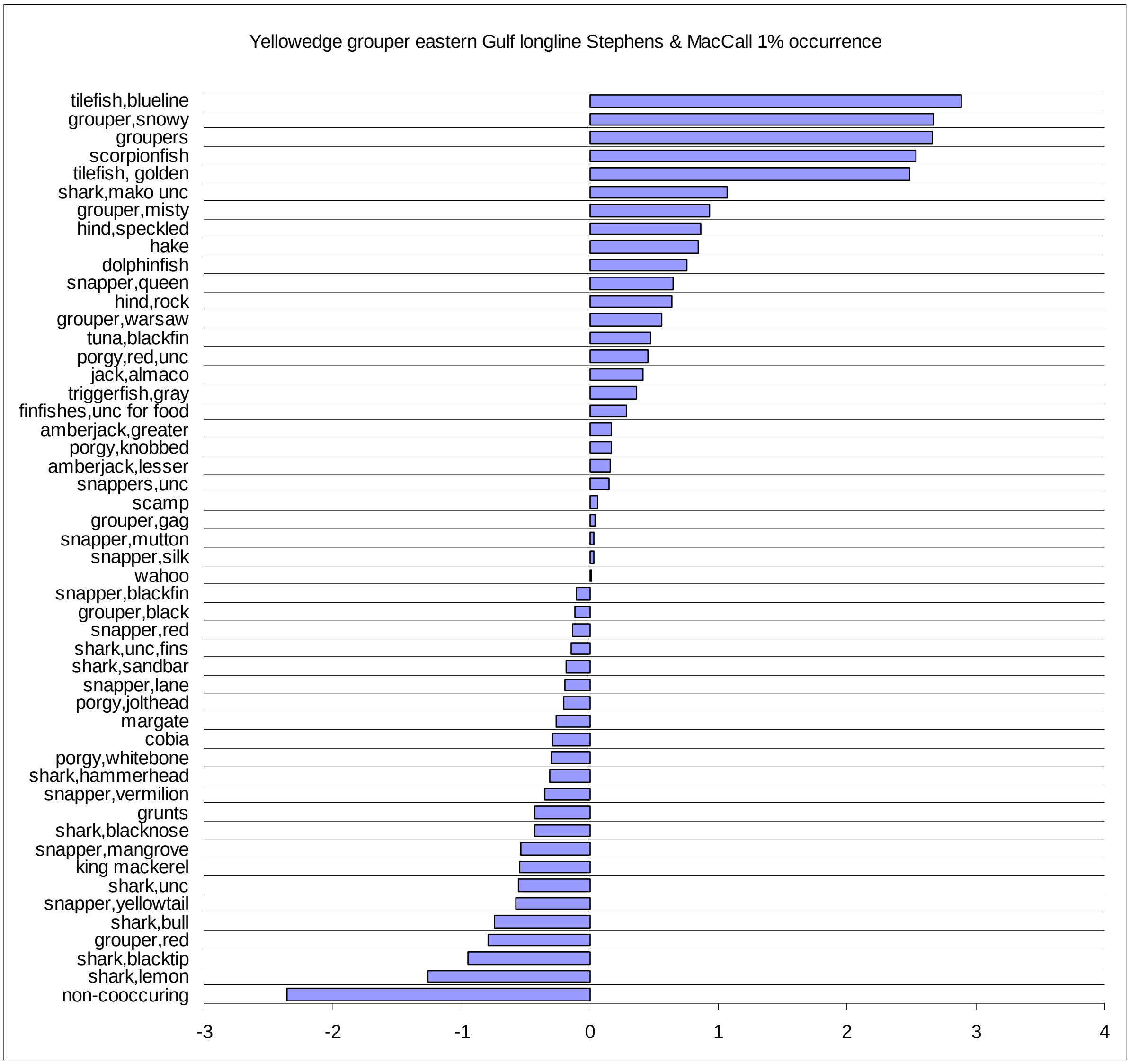
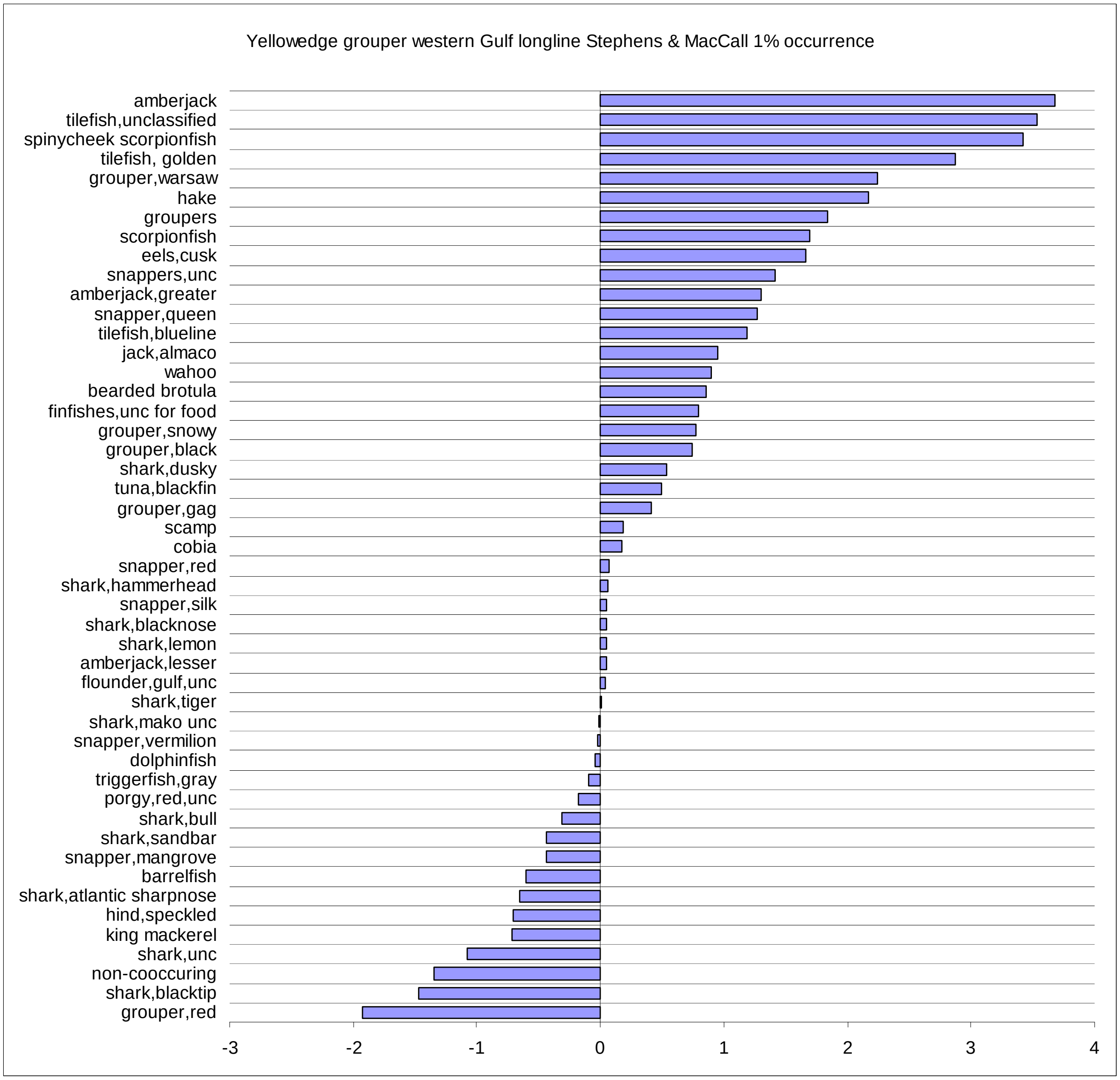


Figure 5.9.4: Survey effort included in analyses and CPUE of yellowedge grouper from 2000 through 2009 in the Gulf of Mexico. Crosses indicate effort with no catch. The size of yellow circles is linearly related to positive CPUE (range: 0.4 – 9 yellowedge grouper per 100 hook hours).

Figure 5.9.5: Regression coefficients from the Stephens & MacCall analyses. Positive coefficients signify species that had positive associations with the target species. The magnitude of the coefficients indicates the predictive impact of each species. The value for "non-coocurring" is the regression intercept and denotes the probability a trip was fishing in the target species' habitat, but did not report any of the listed species. Species included were reported on at least one percent of longline trips in the eastern or western Gulf of Mexico.



5.9.5.A. Yellowedge grouper eastern Gulf of Mexico longline



5.9.5.B. Yellowedge grouper western Gulf of Mexico longline

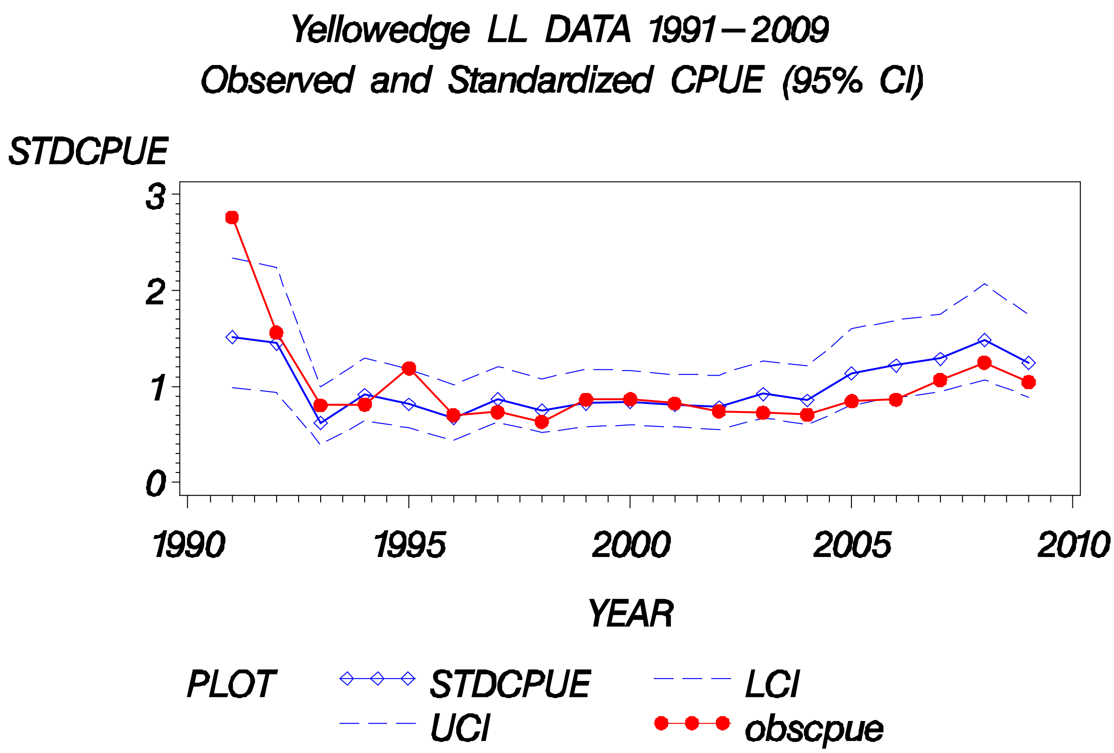


Figure 5.9.6: Yellowedge grouper nominal CPUE (solid circles), standardized CPUE (open diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dashed lines) for vessels fishing longline gear in the Gulf of Mexico.

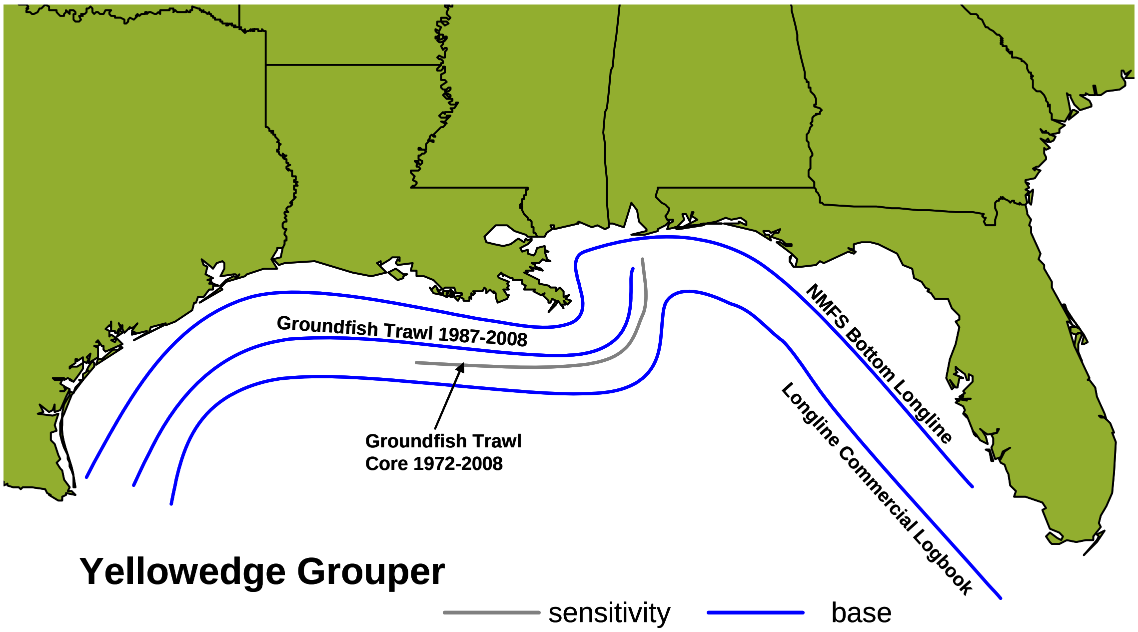


Figure 5.9.7: Linear coverage of specific abundance indices along the coast of the Gulf of Mexico.

6. ANALYTIC APPROACH

6.1. *SUGGESTED ANALYTIC APPROACH GIVEN THE DATA*

Stock Synthesis III (SSIII, Methot 2000) will be the first assessment modeling approach for both yellowedge grouper (YEG) and tilefish. SSIII is an integrated statistical catch-at-age model which is widely used for stock assessments in the United States and throughout the world. SSIII takes relatively unprocessed input data and incorporates many of the important processes (mortality, selectivity, growth, etc) that operate in conjunction to produce observed catch, size and age composition and CPUE indices. In addition, SSIII can incorporate time series of environmental data. Because many of these inputs are correlated, the concept behind SSIII is that they should be modeled together, which helps to ensure that uncertainties in the input data are properly accounted for in the assessment. SSIII has the ability to incorporate an early, data poor time period for which only catch data are available and a more recent, data-rich time period for which indices and length and age observations are available. Such a situation exists for both YEG and tilefish, however both fisheries are rather short (~40 years) and for YEG we have the benefit of substantial age composition data from fairly early in the fishery. However, in either case, there is evidence of substantial landings prior to the routine collection of age composition data from throughout the spatial distribution of the stock.

As a second assessment modeling approach, stochastic stock reduction analysis (SRA, Walters et al. 2005) will also be applied to both species. SRA is a less data-intensive method which can help to determine how large the stock needed to be to have produced the time series of observed landings. This will provide a necessary check on the SSIII results and may be very useful in determining stock status relative to the initial population size. SRA has been applied to several other Gulf of Mexico species including gag and red grouper and red snapper.

For both species, there are sources of uncertainty which will have to be incorporated within the modeling framework or through sensitivity analyses. Uncertainties in assigned ages created by aging error, changing growth rates and unknown M can be incorporated within the SSIII framework. Given the complex reproductive biology of YEG and tilefish, the most effective proxy for spawning stock biomass is another source of uncertainty and will have to be considered in some manner as well. Unfortunately, the greatest uncertainties in either of these two assessments are in the actual landings levels themselves, because of a lack of historical identification of groupers and tilefishes to species. Very few modeling approaches can deal with large uncertainties in total catch, so these may have to be considered through sensitivity runs with both SRA and SSIII.

6.2. *REFERENCES*

Walters, C. J., S. J.D. Martell, and J. Korman 2006. A stochastic approach to stock reduction analysis. Can. J. Fish. Aquat. Sci. 63: 212–223.

Methot, R.D. 2000. Technical description of the stock synthesis assessment program. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-43, 4

Appendix 1: Indices Worksheets

Evaluation of Abundance Indices of Yellowedge Grouper: Commercial Logbook (Longline) (SEDAR22-DW-02)

Working Group Comments: No minimum size regulation, but size/age range unknown.

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.	✓			
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)	✓			
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)	✓			
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).	✓			
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).	✓			
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.	✓			

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).				✓
B. Describe any changes to reporting requirements, variables reported, etc.	✓			
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.		✓		

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				✓
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?				✓

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).			✓	
B. Describe the effects (if any) of management regulations on CPUE		✓		
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.		✓		

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.		✓		
B. Include tables and/or figures of number of positive observations by factors and interaction terms.		✓		
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.		✓		
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.		✓		
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).		✓		
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.				✓
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				✓
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.		✓		

Working Group Comments:

-Data from closed seasons were excluded. Effects for trip limits were examined and appeared to have little effect. Results were not included in the document. There is no minimum size in the regulations.

Number of observations by factors and interaction terms were examined, but were not included in the document due to confidentiality concerns.

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

	Not Applicable	Absent	Incomplete	Complete
1. Binomial Component				
A. Include plots of the chi-square residuals by factor.				✓
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)		✓		
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).		✓		
2. Lognormal/Gamma Component				
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.		✓		
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.		✓		
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.		✓		
F. Include plots of the residuals by factor				✓
3. Poisson Component				
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	✓			
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	✓			
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			
4. Zero-inflated model				
A. Include ROC curve to quantify goodness of fit.	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).	✓			
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.	✓			

Working Group Comments:

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

	Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).				✓

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance	✓			
2. Table of model statistics (e.g. AIC criteria)	✓			

	Date Received	*Workshop Recommendation*	*Revision Deadline* ***	*Author and Rapporteur Signatures*
First Submission	3/17/10	Accept with revisions		
Revision	4/9/10 (Addendum)			

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Workshop recommendations:
-Yellowfin grouper should be assumed to be yellowedge grouper except in the case where both species were reported on a trip. The yellowfin/yellowedge adjustment affected the Stevens-McCall trip selection, but change to the index was was minimal.

Working group recommendations:
-Following the workshop, it was recommended by the assessment biologists and indices work group that separate indices be created for Gulf of Mexico areas 2-5, 6-11, and 13-21. Results of these analyses will be disseminated in a working paper prior to the assessment workshop/webinar (by 5/10/10).

Evaluation of Abundance Indices of Yellowedge Grouper: SEAMAP Groundfish Survey (SEDAR22-DW-06)

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

Item	Not Applicable	Absent	Incomplete	Complete
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✓
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✓
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✓
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✓
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓

2. Fishery Dependent Indices

Item	Not Applicable	Absent	Incomplete	Complete
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).	✓			
B. Describe any changes to reporting requirements, variables reported, etc.	✓			
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).	✓			
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.	✓			

METHODS

1. Data Reduction and Exclusions

Item	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				✓
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?		✓		

Working Group Comments:

Working Group Comments:

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	✓			
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	✓			

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.		✓		
B. Include tables and/or figures of number of positive observations by factors and interaction terms.		✓		
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.		✓		
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.				✓
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				✓
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.			✓	
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?		✓		
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.		✓		

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

Item	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
1. Binomial Component					
A. Include plots of the chi-square residuals by factor.		✓			
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)		✓			
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓	
2. Lognormal/Gamma Component					
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓	
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				✓	
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓	
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.		✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.		✓			
F. Include plots of the residuals by factor			✓		
3. Poisson Component					
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	✓				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	✓				
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	✓				
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓				
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓				***The feasibility of this diagnostic is still under review.***
4. Zero-inflated model					
A. Include ROC curve to quantify goodness of fit.	✓				
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).	✓				
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.	✓				

MODEL DIAGNOSTICS (CONT.)

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).			✓	

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance	✓			
2. Table of model statistics (e.g. AIC criteria)	✓			

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	3/15/10	Accept with revisions		
Revision	4/12/10 (Addendum)	Accept		

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Revisions described in Section 1.3.1.2

Evaluation of Abundance Indices Yellowedge Grouper: NOAA Fisheries Bottom Longline Survey (SEDAR22-DW-07)

DESCRIPTION OF THE DATA SOURCE

	Not Applicable	Absent	Incomplete	Complete
1. Fishery Independent Indices				
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.				✓
B. Describe sampling methodology (e.g. gear, vessel, soak time etc.)				✓
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design etc.)				✓
D. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).				✓
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic).				✓
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.				✓
2. Fishery Dependent Indices				
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line etc.).	✓			
B. Describe any changes to reporting requirements, variables reported, etc.	✓			
C. Describe the variables reported in the data set (e.g. location, time, temperature, catch, effort etc.).	✓			
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.	✓			

METHODS

	Not Applicable	Absent	Incomplete	Complete
1. Data Reduction and Exclusions				
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas etc.). Report the number of records removed and justify removal.				✓
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage etc).				✓
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?		✓		

Working Group Comments:

Working Group Comments:

2. Management Regulations (for FD Indices)

	Not Applicable	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures etc.).	✓			
B. Describe the effects (if any) of management regulations on CPUE	✓			
C. Discuss methods used (if any) to minimize the effects of management measures on the CPUE series.	✓			

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.		✓		
B. Include tables and/or figures of number of positive observations by factors and interaction terms.		✓		
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.		✓		
D. Include tables and/or figures of average (unstandardized) CPUE by factors and interaction terms.				✓
E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				✓
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				✓
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds).				✓

4. Model Standardization

	Not Applicable	Absent	Incomplete	Complete
A. Describe model structure (e.g. delta-lognormal)				✓
B. Describe construction of GLM components (e.g. forward selection from null etc.)				✓
C. Describe inclusion criteria for factors and interactions terms.			✓	
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?		✓		
E. Provide a table summarizing the construction of the GLM components.				✓
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC etc.)				✓
G. Report convergence statistics.		✓		

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the CPUE indices working group.

1. Binomial Component

	Not Applicable	Absent	Incomplete	Complete
A. Include plots of the chi-square residuals by factor.		✓		
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)		✓		
C. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).				✓

2. Lognormal/Gamma Component

	Not Applicable	Absent	Incomplete	Complete
A. Include histogram of log(CPUE) or a histogram of the residuals of the model on CPUE. Overlay the expected distribution.				✓
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.				✓
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.				✓
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.		✓		
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.		✓		
F. Include plots of the residuals by factor			✓	

3. Poisson Component

	Not Applicable	Absent	Incomplete	Complete
A. Report overdispersion parameter and other fit statistics (e.g. chi-square / degrees of freedom).	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.	✓			
C. Include QQ-plot – (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.	✓			
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			

4. Zero-inflated model

	Not Applicable	Absent	Incomplete	Complete
A. Include ROC curve to quantify goodness of fit.	✓			
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).	✓			
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.	✓			

Working Group Comments:

The feasibility of this diagnostic is still under review.

MODEL DIAGNOSTICS (CONT.)

Not Applicable	Absent	Incomplete	Complete

Working Group Comments:

D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.	✓			
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.	✓			

MODEL RESULTS

A. Tables of Nominal CPUE, Standardized CPUE, Observations, Positive Observations, Proportion Positive Observations and Coefficients of Variation (CVs). Other statistics may also be appropriate to report				✓
B. Figure of Nominal and Standardized Indices with measure of variance (i.e. CVs).			✓	

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

1. Plot of resulting indices and estimates of variance	✓			
2. Table of model statistics (e.g. AIC criteria)	✓			

	Date Received	*Workshop Recommendation*	*Revision Deadline ****	*Author and Rapporteur Signatures*
First Submission	3/15/10	Accept with revisions		
Revision	4/12/10 (Addendum)	Accept		

The revision deadline is negotiated by the author, the SEDAR coordinator and the CPUE rapporteur. The author ***DOES NOT*** *commit to any* ***LEGAL OBLIGATION*** *by agreeing to submit a manuscript before this deadline. The maximum penalty for failure to submit a revised document prior to the submission deadline is rejection of the CPUE series.*

Justification of Working Group Recommendation

Revisions described in Section 1.3.2.2

SEDAR

Southeast Data, Assessment, and Review

SEDAR 22

Gulf of Mexico Yellowedge Grouper

SECTION III: Assessment Process Report

January 2011

NOTE: Modifications to the model results reported in this report were made during the Review Workshop held 14-17 February 2011. For complete results reflecting those changes, please see the Addendum of this Stock Assessment Report (Section VI).

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

Table of Contents

1. WORKSHOP PROCEEDINGS 4
1.1. INTRODUCTION 4
1.1.1. Workshop time and Place 4
1.1.2. Terms of Reference 4
1.1.3. List of Participants 5
1.1.4. List of Assessment Process Working and Reference Papers 6
1.2. PANEL RECOMMENDATIONS AND COMMENT 7
1.2.1. Term of Reference 1 7
1.2.2. Term of Reference 2 7
1.2.3. Term of Reference 3 7
1.2.4. Term of Reference 4 8
1.2.5. Term of Reference 5 8
1.2.6. Term of Reference 6 8
1.2.7. Term of Reference 7 8
1.2.8. Term of Reference 8 8
1.2.9. Term of Reference 9 8
1.2.10. Term of Reference 10 8
1.2.11. Term of Reference 11 8
2. DATA REVIEW AND UPDATE 8
2.1. COMMERCIAL LANDINGS DATA 9
2.2. RECREATIONAL LANDINGS AND DISCARDS 11
2.3. COMMERCIAL DISCARDS 12
2.4. AGE COMPOSITION DATA 12
2.4.1. Aging error 12
2.5. LENGTH COMPOSITION DATA 13
2.6. INDICES 13
2.7. LIFE HISTORY 14
2.8. TABLES 14
2.9. FIGURES 25
3. STOCK ASSESSMENT MODELS AND RESULTS 39

3.1. MODEL 1: STOCHASTIC STOCK REDUCTION ANALYSIS 39
3.1.1. Model 1 Methods 39
3.1.2. Model 1 Results 42
3.1.3. References 45
3.2. MODEL 2: STOCK SYNTHESIS 46
3.2.1. Model 2: Methods 46
3.2.2. Model 2 Results 52
3.2.3. Discussion 64
3.2.4. References 66
3.3. COMPARISON OF SRA AND SS3 68
3.4. TABLES 70
3.5. FIGURES 96

1. WORKSHOP PROCEEDINGS

1.1. *INTRODUCTION*

1.1.1. Workshop time and Place

The SEDAR 22 Assessment Process was held via a series of webinars between May and September 2010.

1.1.2. Terms of Reference

1. Review any changes in data following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.
2. Develop 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.
3. Provide estimates of stock population parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, etc); include appropriate and representative measures of precision for parameter estimates.
4. Characterize uncertainty in the assessment and estimated values, considering components such as input data, 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 National Standards. This may include: evaluating existing SFA benchmarks, estimating alternative SFA benchmarks; and recommending proxy values. **In addition, specify OFL, and recommend a range of ABC for review by the SSC in compliance with ACL guidelines.**
7. Provide declarations of stock status relative to SFA benchmarks.
8. Perform a probabilistic analysis of proposed reference points and provide the probability of overfishing at various harvest or exploitation levels.
9. Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules if warranted; include estimated generation time. Stock projections shall be developed in accordance with the following:
    - A) If stock is overfished:
        - F=0, F=current, F=Fmsy, Ftarget (OY),
        - F=Frebuild (max that rebuild in allowed time)
    - B) If stock is overfishing
        - F=Fcurrent, F=Fmsy, F= Ftarget (OY)
    - C) If stock is neither overfished nor overfishing
        - F=Fcurrent, F=Fmsy, F=Ftarget (OY)
10. Evaluate the results of past management actions and, if appropriate, probable impacts of current management actions with emphasis on determining progress toward stated management goals.

11. Provide recommendations for future research and data collection (field and assessment); be as specific as practicable in describing sampling design and sampling intensity and emphasize items which will improve future assessment capabilities and reliability.
12. Prepare an accessible, documented, labeled, and formatted spreadsheet containing all model parameter estimates and all relevant population information resulting from model estimates and any projection and simulation exercises. Include all data included in assessment report tables and all data that support assessment workshop figures.
13. Complete the Assessment Workshop Report (Section III of the SEDAR Stock Assessment Report).

1.1.3. List of Participants

SEDAR 22: Gulf of Mexico Yellowedge Grouper and Tilefish

SEDAR 22 ASSESSMENT WEBINARS ATTENDANCE REPORT

x = present

First	Last	Web1 13-May	Web2 1-Jul	Web3 21-Jul	Web4 12-Aug	Web4 cont 13-Aug	Web5 23-Aug	Web6 1-Sep	Web7 4-Oct	Web8 3-Nov	Web9 12-Jan-11
PANELISTS											
Brian	Linton	x	x	x	x	x	x	x	x	x	x
John	Walter	x	x	x	x	x	x	x	x	x	x
John	Quinlan	x		x	x		x		x		
Linda	Lombardi	x	x	x	x	x	x	x	x	x	x
Harry	Blanchet	x	x	x	x		x	x	x		x
Shannon	Cass-Calay		x	x	x	x	x	x	x	x	x
Richard	Fulford		x	x	x	x	x			x	
Joe	Powers										
Will	Patterson	x	x	x				x	x		x
Robert	Allman	x	x	x			x	x			
Irby	Basco										
Bob	Spaeth										
Martin	Fischer										
TJ	Tate										
Neil	Baertlein										
COUNCIL REPRESENTATION											
Bob	Shipp				x		x			x	
STAFF											
Julie	Neer	x	x	x	x	x	x	x	x	x	x
Carrie	Simmons		x	x	x	x	x	x	x		
John	Froeschke	x									x
Kari	Fenske				x						
John	Carmichael				x						

OBSERVERS

Clay	Porch	x					x	x			
Nancy	Cummings	x	x	x				x			
Nick	Farmer				x	x	x	x	x	x	x
Rich	Malinowski							X			x
Todd	Gedamke		x								x

1.1.4. List of Assessment Process Working and Reference Papers

Documents Prepared for the Assessment Workshop		
SEDAR22-AW-01	United States Commercial Longline Vessel Standardized Catch Rates of Golden and Blueline Tilefish in the Gulf of Mexico, 1992-2009: Revised	Kevin McCarthy
SEDAR22-AW-02	United States Commercial Longline Vessel Standardized Catch Rates of Yellowedge Grouper (*Epinephelus flavolimbatus*) for Three Regions in the Gulf of Mexico, 1991-2009	Neil Baertlein and Kevin McCarthy
Reference Documents		
SEDAR22-RD10	Comparison of Two Techniques for Estimating Tilefish, Yellowedge Grouper, and Other Deepwater Fish Populations	Matlock, Gary C., Walter R. Nelson, Robert S. Jones, Albert W. Green, Terry J. Cody, Elmer Gutherz, and Jeff Doerzbacher
SEDAR22-RD11	Deep-water sinkholes and biotherms of South Florida and the Pourtales Terrace – Habitat and Fauna	John K. Reed, Shirley A. Pomponi, Doug Weaver, Charles K. Paul, and Amy E. Wright
SEDAR22-RD12	Tilefishes of the genus *Caulolatilus* construct burrows in the sea floor	K.W. Able, D.C. Twichell, C.B. Grimes, and R.S. Jones
SEDAR22-RD13	Spawning Locations for Atlantic Reef Fishes off the Southeastern U.S.	GEORGE R. SEDBERRY, O. PASHUK, D.M. WYANSKI, J.A. STEPHEN, and P. WEINBACH
SEDAR22-RD14	Trends in tilefish distribution and relative abundance off South Carolina and Georgia	Charles A. Barnes and Bruce W. Stender

SEDAR22-RD15	Age, growth, and reproductive biology of blueline tilefish along the Southeastern coast of the United States, 1982-1999	Patrick J. Harris, David M. Wyanski, and Paulette T. Powers Mikell
SEDAR22-RD16	Temporal and spatial variation in habitat characteristics of tilefish (Lopholatilus chamaeleonticeps) off the east coast of Florida	Kenneth W. Able, Churchill B. Grimes, Robert S. Jones and David C. Twichell
SEDAR22-RD17	The Complex Life History of Tilefish *Lopholatilus chamaeleonticeps* and Vulnerability to Exploitation	Churchill B. Grimes and Stephen C. Turner
SEDAR22-RD18	The fishery for tilefish, *Lopholatilus chamaeleonticeps*, off South Carolina and Georgia	Bob Low, Glenn Ulrich, and Frank Blum
SEDAR22-RD19	Tilefish off South Carolina and Georgia	R.A. Low, Jr., G.F. Ulrich, and F. Blum
SEDAR22-RD20	Spawner-recruit relationships of demersal marine fishes: Prior distribution of steepness for possible use in SEDAR stock assessments	SEDAR 24−AW−06 - Sustainable Fisheries Branch

1.2. *PANEL RECOMMENDATIONS AND COMMENT*

1.2.1. Term of Reference 1

Review any changes in data following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.

1.2.2. Term of Reference 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.

1.2.3. Term of Reference 3

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

1.2.4. Term of Reference 4

Characterize uncertainty in the assessment and estimated values, considering components such as input data, modeling approach, and model configuration. Provide appropriate measures of model performance, reliability, and 'goodness of fit'.

1.2.5. Term of Reference 5

Provide yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations, including figures and tables of complete parameters.

1.2.6. Term of Reference 6

Provide estimates for SFA criteria consistent with applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards. This may include: evaluating existing SFA benchmarks, estimating alternative SFA benchmarks; and recommending proxy values. In addition, specify OFL, and recommend a range of ABC for review by the SSC in compliance with ACL guidelines.

1.2.7. Term of Reference 7

Provide declarations of stock status relative to SFA benchmarks.

1.2.8. Term of Reference 8

Perform a probabilistic analysis of proposed reference points and provide the probability of overfishing at various harvest or exploitation levels.

1.2.9. Term of Reference 9

Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules if warranted; include estimated generation time.

1.2.10. Term of Reference 10

Evaluate the results of past management actions and, if appropriate, probable impacts of current management actions with emphasis on determining progress toward stated management goals.

1.2.11. Term of Reference 11

Provide recommendations for future research and data collection (field and assessment); be as specific as practicable in describing sampling design and sampling intensity and emphasize items which will improve future assessment capabilities and reliability.

2. DATA REVIEW AND UPDATE

Early in the SEDAR process for yellowedge grouper there was an effort to partition the assessment model into three regions (West – statistical grids 13 to 21; Northeast – statistical grids 6 to 12; and Southeast – statistical grids 1 to 5). These divisions would provide more appropriate treatment of the various habitat types across the Gulf of Mexico, but are also supported by the work of Prytherch (1983) who identified three primary fishing areas (West, middle, Southeast) of relevance to this assessment. This three region approach was initially adopted by the assessment workshop panel (AWP).

However this spatial partitioning appeared to present some modeling problems most likely due to the fact that the deepwater fishery for YEG in the northeastern Gulf of Mexico between stat areas 5 and 8 was not well differentiated. Prytherch (1983) states that vessels fishing from St. Petersberg, FL could see the lights of the vessels from Panama City, indicating that, at least on the fishing grounds, there was little separation between fish landed by vessels from the South and fish landed by vessels from the Central region, as the three area partition originally separated them.

On this basis the model was condensed into two regions; East (statistical grids 1 to 12) and West (grids 13 to 21). Subdivision beyond this, which was desirable as this long-lived species could be vulnerable to serial local depletion, simply could not be supported by the available data.

2.1. *COMMERCIAL LANDINGS DATA*

The commercial landings shown in Table 2.1 were reconstructed back to 1975 via the reconciliation of several lines of evidence which are discussed below. The color coding in Table 2.1 will assist with interpretation of the following paragraphs.

The unshaded landings from 1991 onward (Table 2.1) were compiled directly from the SEFSC Accumulated Landings System (ALS) (Orhun 2010). The data prior to 1991 required several corrections.

First, identification of grouper landings to species before 1986 was not required except for warsaw and goliath groupers. This resulted in a significant ALS record, extending from 1975 to 1985, of ‘unclassified grouper’, some of which were yellowedge grouper. These landings were accounted for in this assessment. The vertical line landings from 1975 to 1985 (purple shading in

Table 2.1) were estimated by multiplying the fishing area-specific unclassified grouper landings by the fraction of known yellowedge and yellowfin vertical line landings from 1986 to 1989 (blue shading in Table 2.1). This action requires an assumption here that the ratio of yellowedge and yellowfin to other groupers was constant from 1975 to 1989. Yellowfin were included because there is clear evidence that yellowedge were misclassified as yellowfin in early reporting.

In the original data, there existed a sharp transition between high landings of 1981-1982 and the relatively lower landings of 1986 on. This transition was viewed by the SEDAR Data Workshop as unrealistic. To correct this, the longline landings between 1983 and 1985 (green shading in Table 2.1) were estimated by linearly interpolation, by fishing area, between the 1982 and 1986 landings.

The misclassification of yellowedge as yellowfin, which was more common in the western Gulf than in the East, also needed to be addressed. To correct this, the data collected by Prytherch (1983) was reanalyzed and compared with existing ALS data. Area-specific corrections were developed that reclassified a fraction of the yellowfin landings from 1986 to 1990 as yellowedge (blue shading in Table 2.1).

The last major data decision required partitioning the unclassified groupers landing by longlines between 1979 and 1982 (orange shading). These unclassified grouper were partitioned according to the fraction of yellowedge to total groupers recorded by Prytherch (1983) from the deepwater longline fishery during 1982. In the original three-area partitioning, 26% of unclassified grouper in the South region (stat areas 1-5) assigned as yellowedge. For the Central (6-12) region 96% were assigned to be YEG, on the basis of the Prytherch study.

Condensing of the model into two areas initiated a re-evaluation of some of the decisions regarding the spatial allocation of historical landings of YEG. The key re-evaluation was the large quantity of unclassified groupers captured on longlines in statistical areas 6 and 7 which were over 2 million pounds in 1982. These stat areas are largely, if not entirely, in shallower water than where YEG are found and are substantial areas for red grouper (Figure 2.2). Thus it is highly likely that many or all of the fish in stat area 7 were red grouper in these early years. It also might be likely that the composition of unclassified groupers in stat area 6 would have been similar to that of stat area 5, which would mean that they would be less than 96% YEG.

To construct an alternative landings history which could be considered the 'low' or perhaps the lower bound on the historical landings, all unclassified groupers in stat area 7 were removed and the percentage of YEG in stat area 6 was changed from 23% to 96%. Given the high landings of unclassified grouper in stat area 6, this resulted in a reduction in total YEG landings in the years 1980-1985 (Table 2.2, Figure 2.3). The following short table shows this reallocation:

Year	Low: Stat area 6 is 23%, none in 7	High: Stat area 6/7 are 96% YEG	Difference
1980	792,909	871,224	78,316
1981	2,043,982	2,729,985	686,003
1982	2,713,687	4,395,875	1,682,188
1983	2,213,833	3,475,474	1,261,641
1984	1,929,573	2,770,667	841,094
1985	1,641,347	2,061,894	420,547

This resulted in a substantial reduction of YEG landings in 1980-1985.

To obtain total removals, commercial discards were added to the appropriate fleet landings, assuming that all discards were dead. A weight of 2.8 lbs (1/2 the average weight of landed yellowedge grouper from the headboat fishery) was used to multiply the discards in numbers to obtain discards in weight. Commercial discards were split evenly between the east and west region.

2.2. ***RECREATIONAL LANDINGS AND DISCARDS***

The recreation landings were considered to be too minor to necessitate treatment as a separate fishing fleet (Table 2.3) and were added to the vertical line commercial landings. Landings in pounds (Matter 2010) and discards in number, converted to pounds with an average weight of

2.8 pounds (1/2 the average weight of landed yellowedge grouper from the headboat fishery), under the assumption that all discarded YEG died were summed. Then all recreational landings and discards were added to the commercial handline fisheries in equal proportions East and West, though all of Texas Parks and Wildlife (TPWD) landings were allocated to the West handline.

2.3. ***COMMERCIAL DISCARDS***

Commercial discards were determined by the SEDAR Data Workshop (SEDAR22-DW-04, McCarthy 2010) to be very small, though possibly underreported. Yellowedge longline discards could be calculated for only one year. Similar to the recreational discards, commercial discards were assumed to weigh 2.8 pounds (1/2 the average weight of landed yellowedge grouper from the headboat fishery and added to the appropriate fishery, split evenly East and West. Both commercial discards and recreational landings usually were less than 1% of the total landings almost every year so any alternative treatment of this set of data would be unlikely to substantively alter model results and advice.

2.4. ***AGE COMPOSITION DATA***

Age composition data comes from four sources (Table 2.4, Figures 2.4-2.10):

1) Aged fish obtained from fishery dependent sampling and aged by otolith readings (1984-2009).

2) Pre-TIP age composition sampling conducted by the State of Florida collected by Lew Bullock, Mark Godcharles and Lucious Johnson. For some fish obtained in 1982-1983, otoliths were weighed and ages obtained from an otolith age-otolith weight regression. These fish were not used in the final analysis, however.

3) NFMS bottom longline survey, fish aged by otoliths

4) SEAMAP bottom trawl survey, fish aged by otoliths. These length and age composition samples are quite important for growth modeling as they represent the only age 0 and most of the age 1 and 2 fish in assessment.

2.4.1. Aging error

Two aging error matrices were used, one from the otolith weight-otolith age relationship derived for fish collected from the commercial fishery in 1982-1983 and one from the standard Panama City Lab aging precision error (Table 2.6). Originally both sets of age composition data were considered however, in subsequent assessment iterations the otolith weight-otolith age data provided anomalous fits to the age composition data and were removed from consideration.

2.5. ***LENGTH COMPOSITION DATA***

Length composition data comes from four sources (Table 2.5 , Figures 2.11-2.14):

1) TIP measured lengths (1984-2009)

2) Pre-TIP length and age composition sampling conducted by the State of Florida collected by Lew Bullock, Mark Godcharles and Lucious Johnson. (1977-1983)

3) NFMS bottom longline survey, all fish measured.

4) NMFS bottom trawl survey, all fish measured.

For all length composition the absolute sample size input to SS3 was capped at a maximum of 200.

2.6. ***INDICES***

Two commercial longline (SEDAR22-DW-02) indices and two NMFS bottom longline survey indices were used (Table 2.7, Figure 2.15). Juvenile abundance indices from the NMFS trawl survey (SEDAR22-DW-06) were considered for inclusion but, given the extremely low numbers of fish caught, were not used. Indices were constructed after the DW workshop specifically for the East (stat areas 1-12) and the West (stat areas 13-21). For the three-area model indices were constructed for the South (grids 1-5), Central (grids (6-12) and West (13-21) (Table 2.8) but these were only used in one run presented in this document.

The coefficient of variation (CV) associated with the standardized indices were converted to log-scale standard errors by:

$$\log(SE) = \sqrt{\log_e\left(1 + CV^2\right)},$$

for input into SS3.

2.7. *LIFE HISTORY*

Inputs for many life history parameters are discussed below in *Model configuration*. A fixed vector of maturity at age, and a fixed length-weight relationship was used for weight at age and fecundity at age for both males and females (Table 2.9). Figure 2.16 depicts the derivation of the input hermaphroditism parameters and will be discussed in section 3.

2.8. *TABLES*

Table 2.1. Commercial landings in gutted pounds.

	Western Gulf		Eastern Gulf		
Year	Vertical Line	Longline	Vertical Line	Longline	Total
1974	-	-	-	-	-
1975	113,454	-	351,630	-	465,083
1976	74,084	-	296,289	-	370,374
1977	60,985	-	255,015	-	315,999
1978	67,082	-	231,954	-	299,036
1979	75,112	36,031	343,702	-	454,845
1980	44,176	46,681	333,638	446,729	871,224
1981	230,857	682,027	301,678	1,515,422	2,729,985
1982	225,393	680,796	264,745	3,224,942	4,395,875
1983	117,510	646,674	235,083	2,476,207	3,475,474
1984	197,754	612,551	232,890	1,727,472	2,770,667
1985	210,188	578,428	294,541	978,737	2,061,894
1986	98,119	544,306	544,942	230,002	1,417,369
1987	63,191	437,827	345,548	337,222	1,183,788
1988	281,401	606,346	269,219	489,354	1,646,320
1989	49,078	351,233	66,533	273,663	740,507
1990	39,015	345,943	117,818	373,245	876,022
1991	40,159	317,054	78,977	334,785	770,975
1992	77,802	386,692	66,276	511,134	1,041,905
1993	76,642	319,263	32,506	348,000	776,410
1994	42,398	277,888	50,969	698,474	1,069,729
1995	30,945	372,383	23,332	415,288	841,948
1996	19,477	155,994	21,838	332,554	529,862
1997	18,681	124,475	15,384	561,599	720,139
1998	25,478	215,034	22,040	420,914	683,466
1999	37,094	274,224	28,134	633,502	972,954
2000	42,735	295,164	21,200	732,240	1,091,339
2001	22,893	197,259	15,031	541,818	777,001
2002	26,455	301,981	22,141	434,577	785,154
2003	33,021	363,051	24,735	682,769	1,103,576
2004	27,950	296,015	20,520	580,862	925,347
2005	23,365	268,662	16,138	479,251	787,416
2006	16,426	226,984	21,337	480,590	745,337
2007	27,529	137,744	10,514	692,691	868,478
2008	24,168	158,430	8,676	627,767	819,040
2009	43,453	210,874	20,399	553,821	828,547

Table 2.2. Table of high and low landings scenarios. Landings are in metric tons as input to SS3, except for the totals in pounds.

High landings							Low Landings					
East HL+rec landings and discards	West HL+rec landings and discards	East LL+ discards	West LL+ discards	Total	Total lbs (1000s)	Year	East HL+rec landings and discards	West HL+rec landings and discards	East LL+ discards	West LL+ discards	total	total lbs (1000s)
0	0	0	0	0	0.00	1974	0	0	0	0	0	0.00
159.5	51.46	0	0	210.96	465.09	1975	159.5	51.46	0	0	210.96	465.09
134.39	33.6	0	0	168	370.38	1976	134.39	33.6	0	0	168	370.38
115.67	27.66	0	0	143.33	315.99	1977	115.67	27.66	0	0	143.33	315.99
105.21	30.43	0	0	135.64	299.04	1978	105.21	30.43	0	0	135.64	299.04
155.9	34.07	0	16.34	206.31	454.84	1979	155.9	34.07	0	16.34	206.31	454.84
151.34	20.04	202.63	21.17	395.18	871.22	1980	151.34	20.04	167.11	21.17	359.66	792.91
136.84	104.72	687.38	309.36	1238.3	2729.98	1981	136.84	104.72	376.22	309.36	927.13	2043.97
149.7	131.85	1462.81	308.8	2053.16	4526.44	1982	120.09	102.24	699.78	308.8	1230.91	2713.69
106.63	53.56	1123.19	293.33	1576.71	3476.05	1983	106.63	53.3	550.92	293.33	1004.18	2213.84
105.66	90.27	783.57	277.85	1257.35	2771.98	1984	135.25	119.31	402.05	277.85	934.47	2060.15
133.71	95.45	443.95	262.37	935.48	2062.38	1985	133.6	95.6	253.19	262.37	744.76	1641.91
247.4	44.72	104.33	246.89	643.34	1418.32	1986	247.21	45.08	104.33	246.89	643.51	1418.70
160.57	32.49	152.96	198.59	544.62	1200.68	1987	156.85	28.78	152.96	198.59	537.18	1184.28
122.25	127.78	221.97	275.03	747.03	1646.92	1988	122.33	127.86	221.97	275.03	747.19	1647.27
37.21	29.3	124.13	159.32	349.96	771.53	1989	34.01	26.09	124.13	159.32	343.55	757.40
53.61	17.87	169.3	156.92	397.69	876.76	1990	53.72	17.97	169.3	156.92	397.91	877.24
36.99	19.38	151.86	143.81	352.04	776.12	1991	43.3	25.7	151.86	143.81	364.67	803.96
30.77	36	231.85	175.4	474.01	1045.01	1992	30.58	35.81	231.85	175.4	473.64	1044.20
14.96	34.98	157.85	144.82	352.61	777.37	1993	15.66	35.68	157.85	144.82	354	780.44
23.9	20.01	316.82	126.05	486.78	1073.17	1994	23.56	19.67	316.82	126.05	486.1	1071.67
11.86	15.32	188.37	168.91	384.46	847.59	1995	10.88	14.33	188.37	168.91	382.49	843.25
11.86	10.79	150.84	70.76	244.25	538.48	1996	10.7	9.63	150.84	70.76	241.93	533.36
7.63	9.13	254.74	56.46	327.95	723.01	1997	8.36	9.86	254.74	56.46	329.41	726.22
10.36	11.91	190.92	97.54	310.73	685.04	1998	12.07	13.62	190.92	97.54	314.15	692.58
13.48	17.55	287.35	124.39	442.76	976.12	1999	13.45	17.51	287.35	124.39	442.7	975.99
10.87	20.64	332.14	133.88	497.54	1096.89	2000	10.01	19.78	332.14	133.88	495.81	1093.07
7.28	10.85	245.76	89.48	353.37	779.05	2001	7.52	11.09	245.76	89.48	353.85	780.11
10.3	12.26	197.12	136.98	356.66	786.30	2002	10.91	12.86	197.12	136.98	357.87	788.97
24.03	27.79	309.7	164.68	526.2	1160.07	2003	11.29	15.05	309.7	164.68	500.71	1103.88
10.17	13.54	266.12	136.91	426.73	940.78	2004	9.84	13.21	266.12	136.91	426.08	939.35
7.95	11.23	217.38	121.86	358.43	790.20	2005	20.7	23.98	217.38	121.86	383.92	846.40
10.22	7.99	217.99	102.96	339.16	747.72	2006	10.66	8.43	217.99	102.96	340.04	749.66
8.71	16.42	314.2	62.48	401.81	885.84	2007	7.65	15.37	314.2	62.48	399.7	881.19
4.21	11.24	284.75	71.86	372.06	820.25	2008	4.21	11.24	284.75	71.86	372.06	820.25
10.39	20.84	251.21	95.65	378.09	833.55	2009	10.39	20.84	251.21	95.65	378.09	833.55

Table 2.3 Recreational landings in gutted lbs.

Year	Recreational Landings		
	Headboat	**MRFSS**	**TPWD**
1982		130,570	
1984			209
1986	457		437
1987	1,103		
1988	2,178		
1989	734	16,570	
1990	1,643		
1991	1,331	0	
1992	489		
1993	333	3,090	
1994	423	0	
1995	605		
1996	180	0	
1997	369	1,226	
1998	445	7,483	
1999	53	624	
2000	37		
2001	50	1,373	
2002	29	3,808	
2003	91	299	
2004	69	1,143	
2005	142	56,460	
2006	207	2,568	
2007	202	250	
2008	202	613	
2009		4,944	

Table 2.4. Age composition sample sizes.

	East														West													total
	F				M				U					F				M				U					
YEAR	HL	LL	**SSLL**	SS TRW	HL	LL	SSLL	SS TRW	HL	LL	SSLL	SS TRW	E Total	HL	LL	SSLL	SS TRW	HL	LL	SSLL	SS TRW	HL	LL	SSLL	SS TRW	W Total	
1977	1				3								4														4
1978	88				17				2				107	7												7	114
1979	118	1			44	1			19		6		189									2				2	191
1980	40	44			26	17			1	2			130														130
1981																											
1982										683	13		696														696
1983										169			169											50		50	219
1984										4			4											58		58	62
1985											8		8														8
1986									4				4									21				21	25
1987																						3				3	3
1988																						9				9	9
1989																						5				5	5
1990																											
1991																						237	12			249	249
1992										11			11									31	27			58	69
1993																						6	3			9	9
1994																						2				2	2
1995																											
1996																											
1997																											
1998										5			5														5
1999			34				6		1	55	1		97														97
2000			8				1		13	85			107			30				8			5	2	6	51	158
2001	4		6		1		1		31	350		3	396			22				18		16		2	5	63	459

2002			12	4			5		20	150	1	1	193			34				8		19	2	2	1	66	259
2003		140	34			39	6		37	513	4	2	775			18	5			4		10	11			48	823
2004	3	76	18			26	4		19	350			497			18	3			6		19	41	6	6	99	596
2005		44	6			18	3		7	460			538			2						71	49		11	133	671
2006			8				6		8	277	3	1	303			24				10		46	99		13	192	495
2007		21	17			9	4		21	454	3	1	530			8				6		95	230			339	869
2008		138	2			46	1		50	413	2		652			6				2		193	412		7	620	1272
2009		14	19			2	4		6	519			564			18				8		275	475		3	779	1343
total	254	478	164	4	91	158	41	1	239	4500	41	8	5979	7		180	8	0	0	70	0	1060	1366	120	52	2863	8842

Table 2.5. Length composition sample sizes.

	East														West													total
	Female				Male				Unknown				Total	Female				Male				Unknown				W Total	
YEAR	HL	LL	SSLL	TRW	HL	LL	SSLL	TRW	HL	LL	SSLL	TRW		HL	LL	SSLL	TRW	HL	LL	SSLL	TRW	HL	LL	SSLL	TRW		
1977					3								3														3
1978	88				17				2				107	7												7	114
1979	118	1			44	1			19		6		189									2				2	191
1980	40	44			26	17			1	2			130														130
1982										683	13		696														696
1983										169			169											25		25	194
1984									71	552			623	40	26			1				54	493	29		643	1266
1985									19	469	8		496	83	84			1				494	1441			2103	2599
1986									4	598			602									370	509			879	1481
1987									39	617			656									62	197			259	915
1988									25	192			217									114	31			145	362
1989									4	214			218									86	28			114	332
1990									37	658			695									364	263			627	1322
1991	5	1							26	757			789	25	46			3	17			716	662			1469	2258
1992	28								59	896			983	1	14			1	1			837	680			1534	2517
1993	2	27			1	2			129	436			597									176	530			706	1303
1994	15	15			4				296	1347			1677	1	3							366	327			697	2374
1995	27					9			316	1420			1772		1							180	157			338	2110
1996									506	608			1114	1	2							96	115			214	1328
1997	12	9							231	1378			1630									169	20			189	1819
1998						26			227	2667			2920									56	101			157	3077
1999			34				6		188	3088	1		3317									49	162			211	3528
2000	17		8				1		96	5271			5393			15				4		2	335	1	6	363	5756
2001			6			25	1		67	2746		3	2848			11				9		20	24	1	5	70	2918
2002	20		12	4	2		5		41	1554	1	1	1640			17				4		31	3	1	1	57	1697

2003			34			36	6		50	2476	4	2	2608			9	5			2		24	18			58	2666
2004	3		18				4	1	60	2007			2093			9	3			3		24	43	3	6	91	2184
2005	7	11	6				3		48	1623			1698			1						84	60		11	156	1854
2006			8				6		64	576	3	1	658			12				5		53	115		13	198	856
2007	9	4	17				4		16	1468	3	1	1522			4				3		112	273			392	1914
2008	4	5	2				1		99	755	2		868			3				1		190	483		7	684	1552
2009	3	1	19				4		21	1343			1391	1		9				4		316	567		3	900	2291
total	398	118	164	4	97	116	41	1	2761	36570	41	8	40319	159	176	90	8	6	18	35		5047	7637	60	52	13288	53607

Table 2.6. Aging error vectors.

Mean age	otolith reading standard error	otolith weight/otolith age prediction standard error	Mean age	otolith reading standard error	otolith weight/otolith age prediction standard error
0.5	1.1	4.5	21.5	3.7	4.3
1.5	1.0	4.5	22.5	3.9	4.3
2.5	1.2	4.5	23.5	4.1	4.3
3.5	1.3	4.5	24.5	4.3	4.3
4.5	1.8	4.5	25.5	4.4	4.3
5.5	1.9	4.5	26.5	4.6	4.3
6.5	2.6	4.5	27.5	4.8	4.3
7.5	2.2	4.4	28.5	5.0	4.3
8.5	2.5	4.4	29.5	5.2	4.3
9.5	2.6	4.4	30.5	5.4	4.3
10.5	2.6	4.4	31.5	5.6	4.3
11.5	2.7	4.4	32.5	5.7	4.3
12.5	2.3	4.4	33.5	5.9	4.3
13.5	3.1	4.4	34.5	6.1	4.3
14.5	3.2	4.4	35.5	6.3	4.3
15.5	2.8	4.4	36.5	6.5	4.3
16.5	2.5	4.3	37.5	6.7	4.3
17.5	3.2	4.3	38.5	6.9	4.3
18.5	3.0	4.3	39.5	7.1	4.4
19.5	3.3	4.3	40.5	7.2	4.4

Table 2.7 Indices used in two-area SS3 model

	CM LL E		CM LL W		NMFS BLL E		NMFS BLL W	
	std index	log SE	std index	log SE	std index	log SE	std index	log SE
1991	1.749	0.281	1.706	0.18	-	-	-	-
1992	1.45	0.292	1.086	0.27	-	-	-	-
1993	0.375	0.234	1.238	0.23	-	-	-	-
1994	0.76	0.175	1.192	0.23	-	-	-	-
1995	0.735	0.185	1.006	0.27	-	-	-	-
1996	0.742	0.199	0.462	0.53	-	-	-	-
1997	0.927	0.162	0.573	0.44	-	-	-	-
1998	0.636	0.174	0.961	0.28	-	-	-	-
1999	0.775	0.178	0.868	0.3	-	-	-	-
2000	0.963	0.166	0.627	0.4	0.574	0.526	1.086	0.328
2001	0.703	0.166	0.894	0.3	0.312	0.54	0.989	0.355
2002	0.828	0.171	0.593	0.43	1.399	0.334	0.825	0.349
2003	0.98	0.161	0.856	0.32	1.336	0.314	0.819	0.421
2004	0.846	0.173	0.878	0.32	0.934	0.39	0.921	0.486
2005	1.109	0.176	1.463	0.21	0.492	0.668	-	-
2006	1.225	0.17	1.206	0.25	1.397	0.394	1.35	0.425
2007	1.413	0.163	0.816	0.37	1.448	0.387	0.809	0.801
2008	1.643	0.177	1.094	0.27	0.519	0.839	1.253	0.777
2009	1.141	0.175	1.482	0.21	1.589	0.333	0.949	0.469

Table 2.8. Indices used in three-area SS3 model

	CM LL Central		CM LL South		CM LL W		NMFS BLL Central		NMFS BLL South		NMFS BLL West	
	std index	log SE	std index	log SE	std index	log SE	std index	log SE	std index	log SE	std index	log SE
1991	1.5718	0.21	1.784	0.21	1.706	0.18	-	-	-	-	-	-
1992	1.4906	0.19	1.3356	0.32	1.086	0.27	-	-	-	-	-	-
1993	0.4888	0.46	0.2793	0.88	1.238	0.23	-	-	-	-	-	-
1994	0.9426	0.23	0.6014	0.41	1.192	0.23	-	-	-	-	-	-
1995	0.8243	0.26	0.5919	0.45	1.006	0.27	-	-	-	-	-	-
1996	0.9664	0.23	0.4618	0.6	0.462	0.53	-	-	-	-	-	-
1997	1.038	0.21	0.8105	0.31	0.573	0.44	-	-	-	-	-	-
1998	0.6348	0.32	0.6191	0.41	0.961	0.28	-	-	-	-	-	-
1999	0.866	0.25	0.6746	0.38	0.868	0.3	-	-	-	-	-	-
2000	1.0625	0.2	0.8053	0.33	0.627	0.4	0.511	0.9	-	-	-	-
2001	0.6946	0.3	0.7193	0.35	0.894	0.3	0.462	0.76	-	-	0.8648	0.29
2002	0.8188	0.25	0.8989	0.31	0.593	0.43	0.867	0.45	-	-	0.8946	0.33
2003	1.0891	0.19	0.8608	0.3	0.856	0.32	1.043	0.35	1.573	0.25	0.9408	0.26
2004	0.8815	0.24	0.8057	0.33	0.878	0.32	0.818	0.52	0.963	0.43	0.7432	0.43
2005	0.9729	0.23	1.2435	0.22	1.463	0.21	-	-	-	-	0.8136	0.45
2006	1.1739	0.19	1.2832	0.21	1.206	0.25	2.359	0.22	0.849	0.47	1.2265	0.29
2007	1.2397	0.18	1.7197	0.16	0.816	0.37	0.938	0.53	1.661	0.25	0.6495	0.78
2008	1.4818	0.16	1.8122	0.15	1.094	0.27	0.445	1.15	0.616	0.94	0.8695	0.63
2009	0.7618	0.29	1.6932	0.16	1.482	0.21	1.547	0.25	1.448	0.29	0.8987	0.4

Table 2.9. Maturity, weight and fecundity input.

	Proportion Mature at Length mat=1/(1 + exp(slope*(<size @ inflection)))	**Weight at length (kg) GW = 2.106 x 10-08 * (TL^2.910)**
	size at inflection = 54.9	a = 0.00002106
	slope = -0.33	b = 2.91
length (cm TL)	Maturity	Weight (kg, gutted)
9	0.0000	0.013
13	0.0000	0.037
17	0.0000	0.080
21	0.0000	0.148
25	0.0001	0.246
29	0.0002	0.379
33	0.0007	0.553
37	0.0027	0.771
41	0.0101	1.039
45	0.0367	1.362
49	0.1249	1.746
53	0.3482	2.193
57	0.6666	2.711
61	0.8822	3.302
65	0.9655	3.972
69	0.9906	4.726
73	0.9975	5.568
77	0.9993	6.503
81	0.9998	7.536
85	1	8.671
89	1	9.913
93	1	11.265
97	1	12.734
101	1	14.323
105	1	16.037
109	1	17.880
113	1	19.857
117	1	21.972
121	1	24.231
125	1	26.636
129	1	29.193

2.9. ***FIGURES***

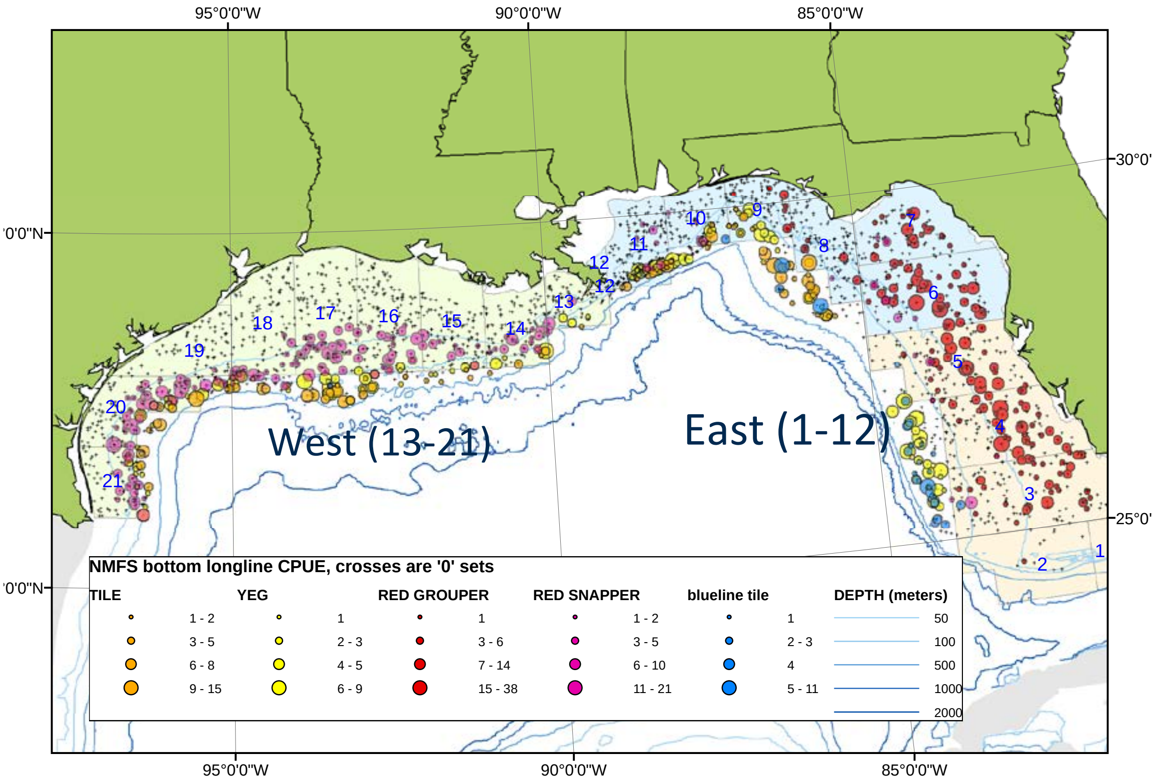


Figure 2.1. Spatial partitioning of YEG assessment model into East and West regions. Data represents NMFS bottom longline catch rates for five predominant teleosts. Dots are locations with no catch of any of the 5 species.

Figure 2.2. Spatial representation of fishing locations for the early (1982-1983) deepwater longline fleet (Prytherch 1983). A key point is the lack of separation between the "Northern" and "Eastern" grounds.

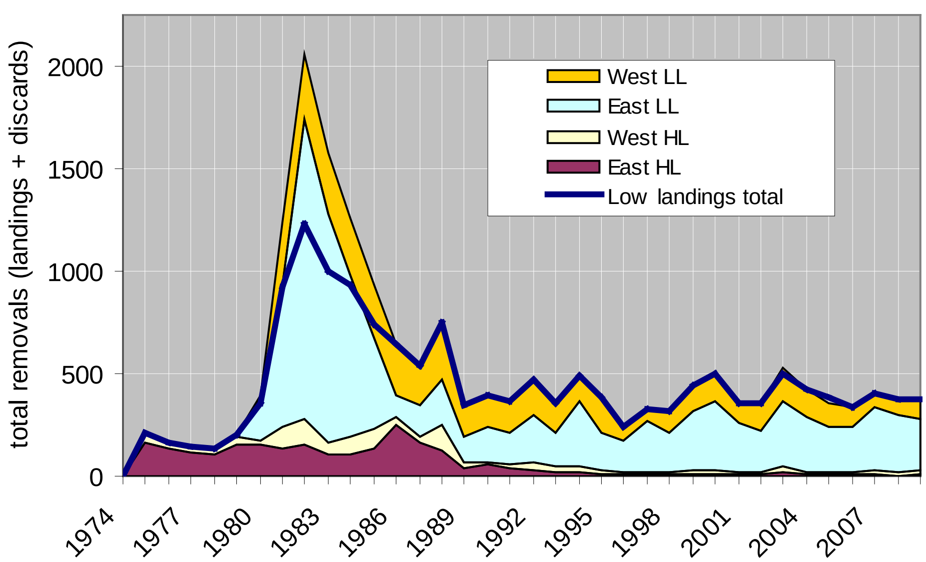


Figure 2.3. "Low" and "High" landings scenarios. Removals by fleet are shown for the high scenario where unclassified longline caught grouper in stat areas 6 and 7 are assumed 96% YEG. Only the total removals are shown for the low landings scenario where unclassified longline caught grouper in stat area 6 are assumed to be 23% YEG. The differences only apply to the longline fishery and only over the years 1980-1985.

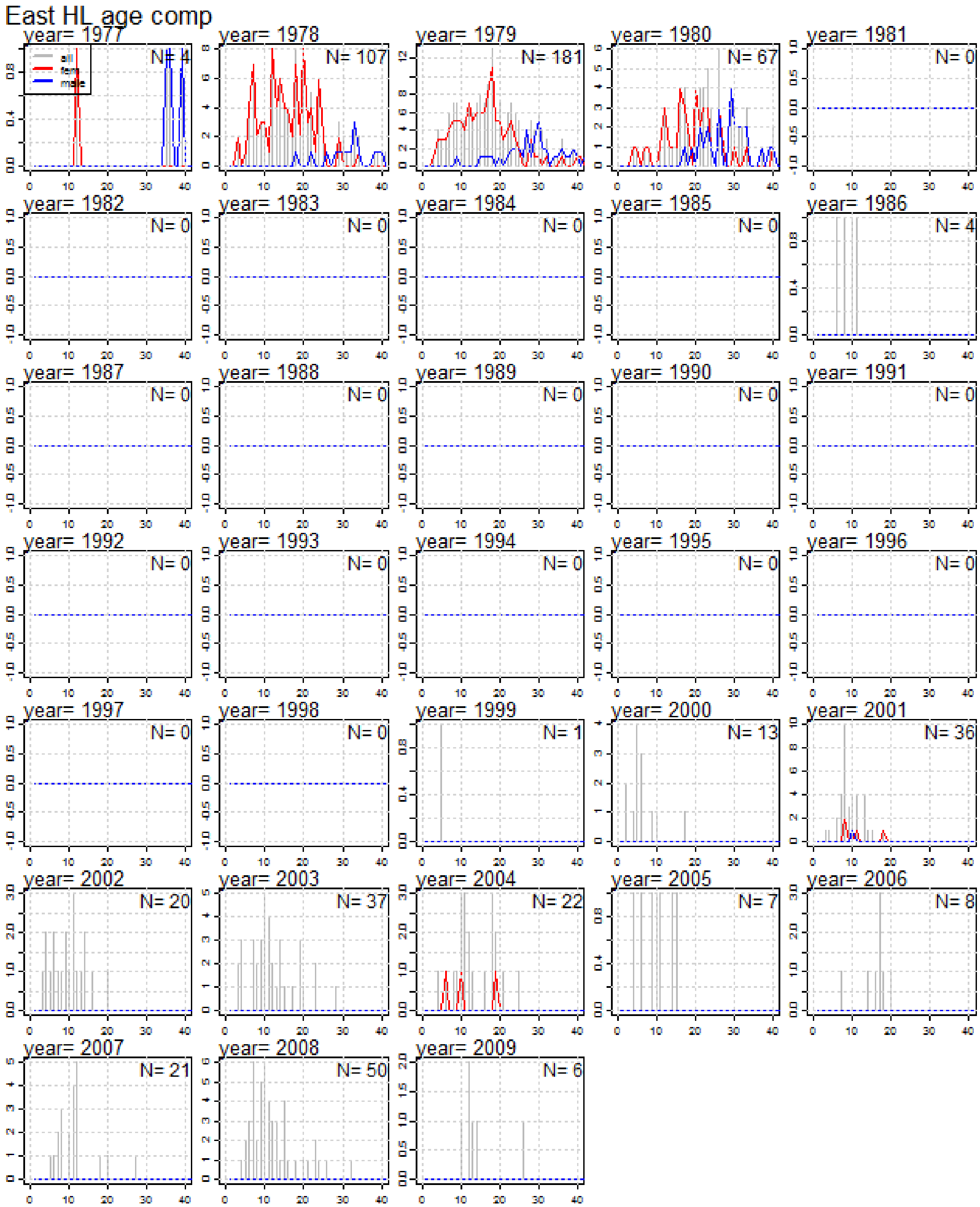


Figure 2.4. Commercial handline East age composition. Red lines are females, blue are males. Shaded bars are both or unknown sex.

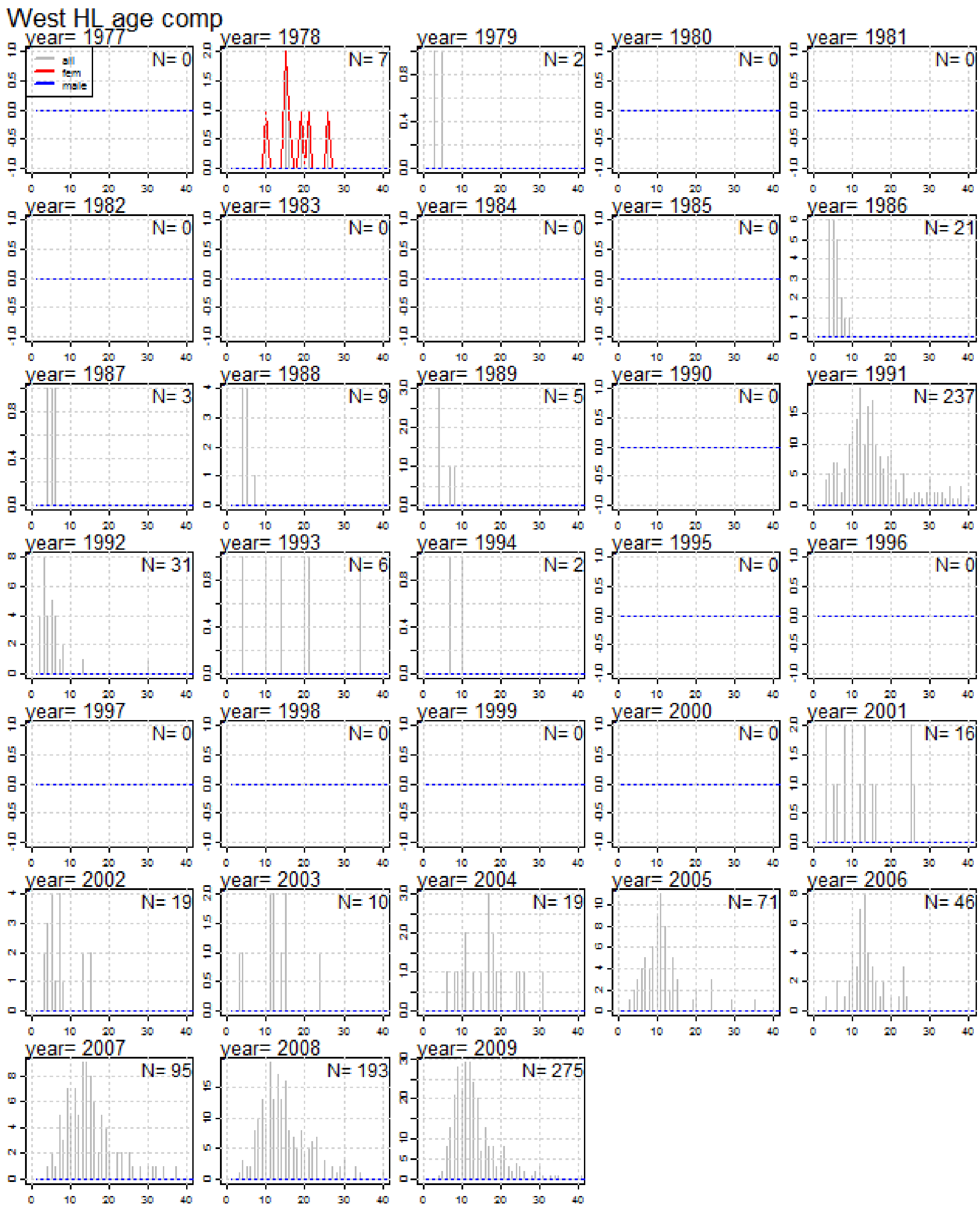


Figure 2.5. Commercial handline West age composition. Red lines are females, blue are males.

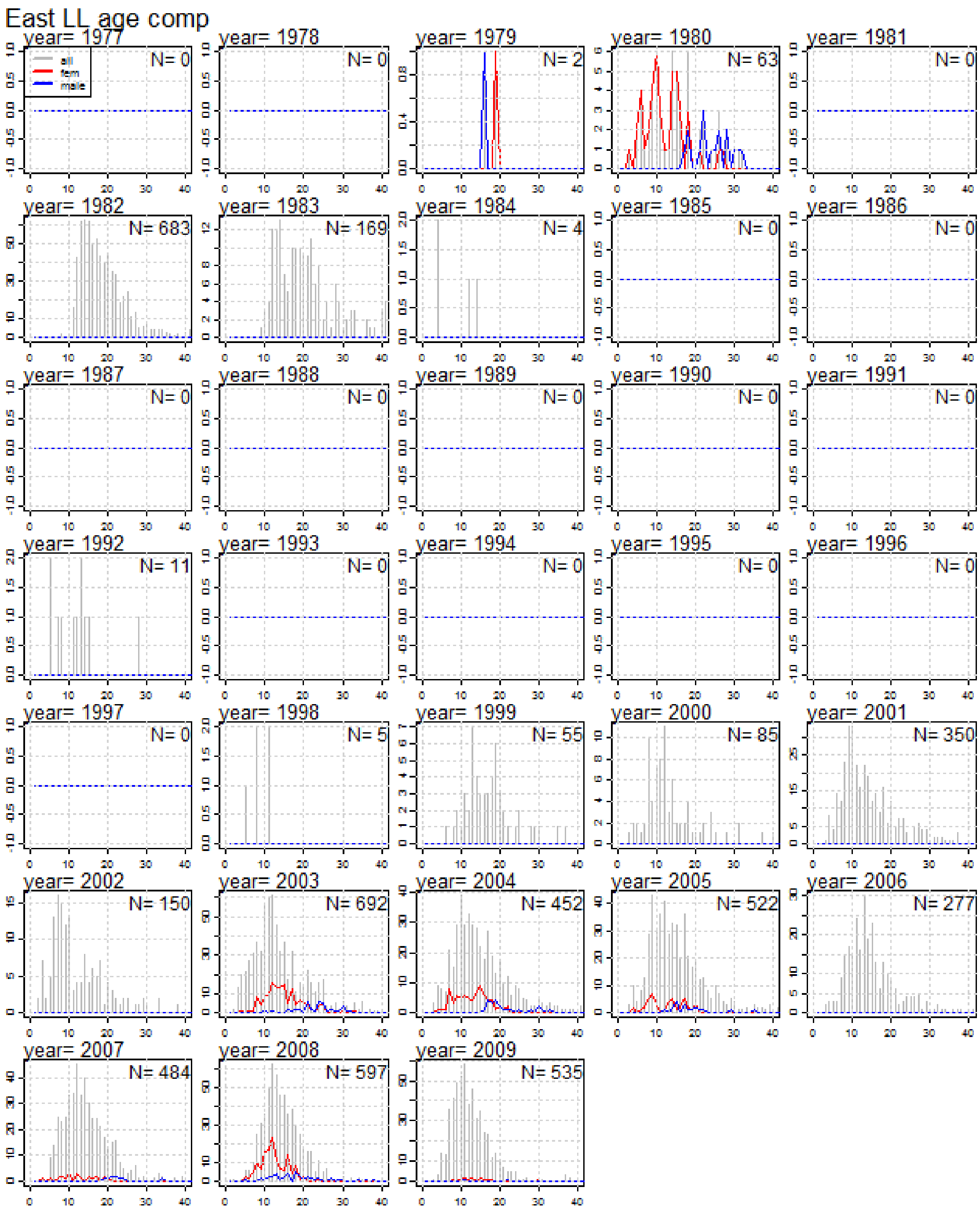


Figure 2.6. Commercial longline East age composition. Red lines are females, blue are males.

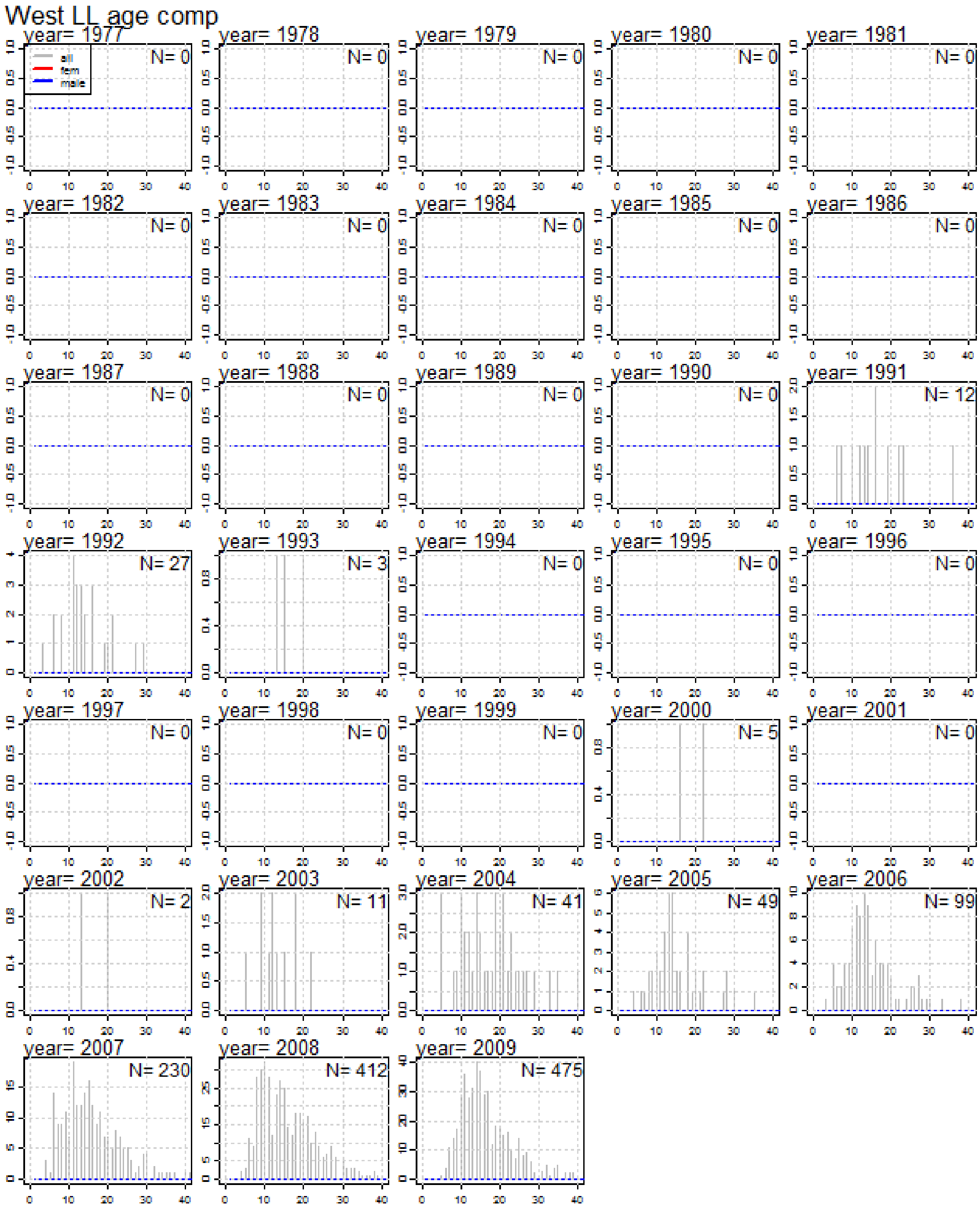


Figure 2.7. Commercial longline West age composition. Red lines are females, blue are males.

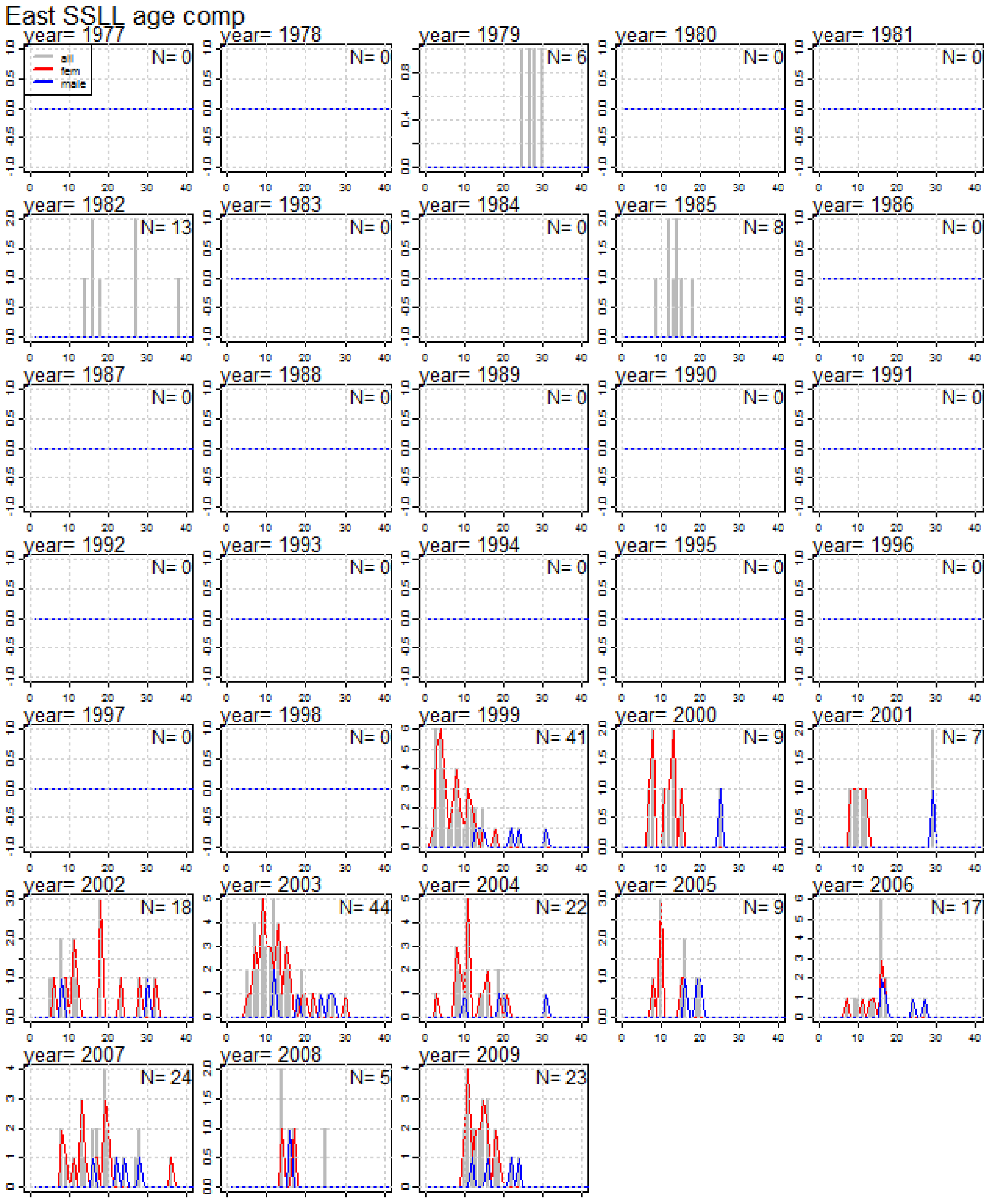


Figure 2.8. NMFS bottom longline East age composition. Red lines are females, blue are males.

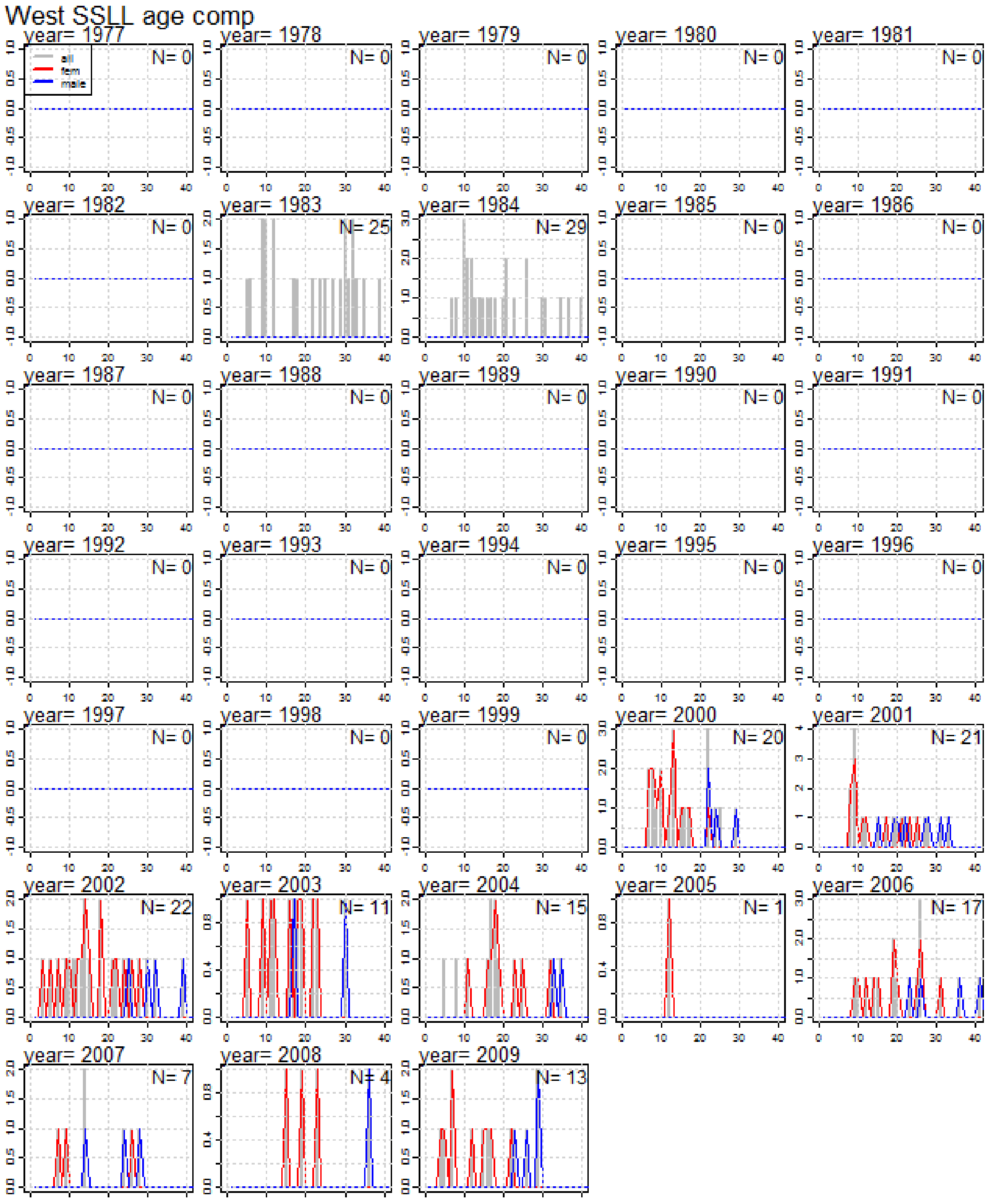


Figure 2.9. NMFS bottom longline West age composition. Red lines are females, blue are males.

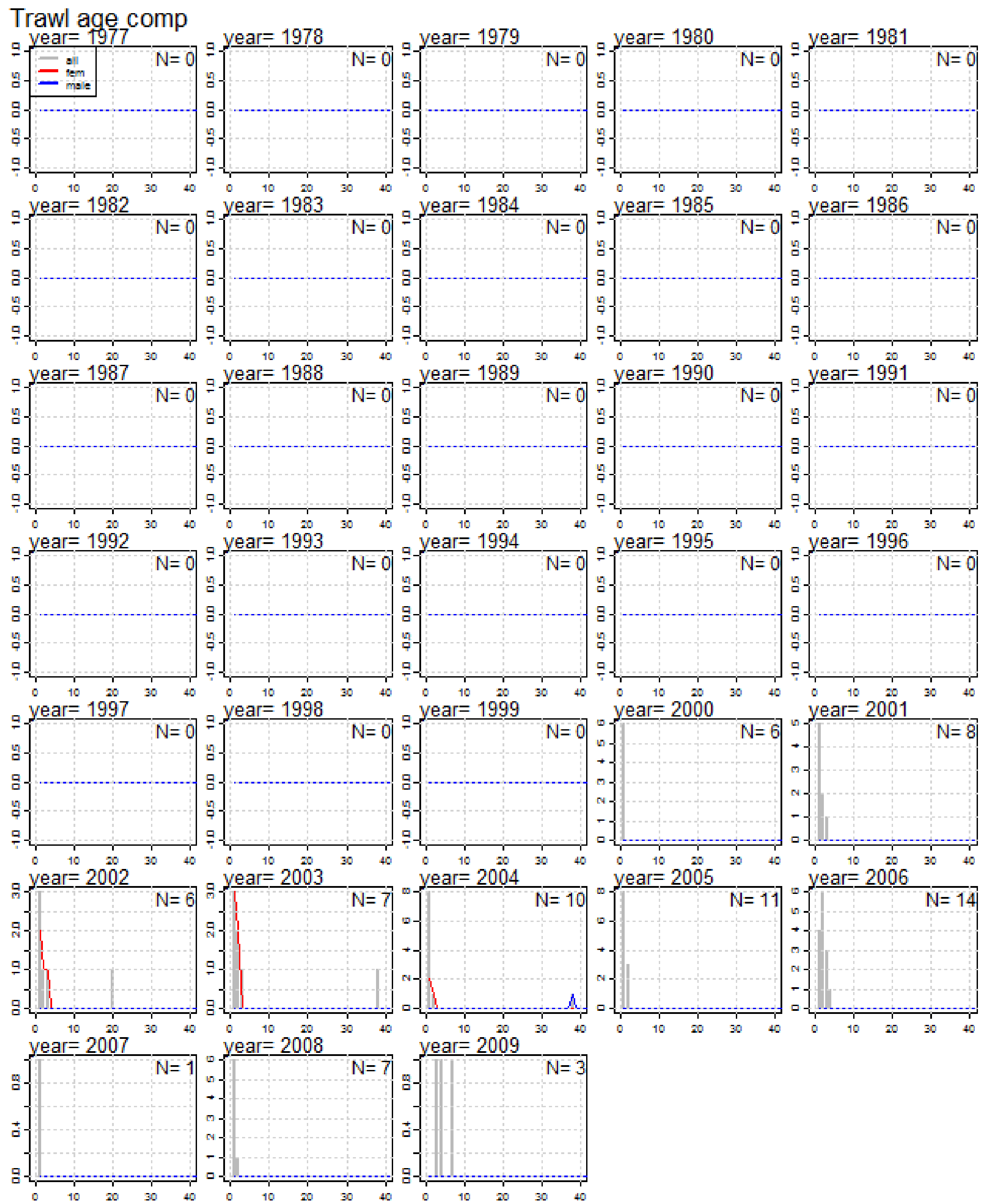


Figure 2.10. SEAMAP trawl East and West age composition. Red lines are females, blue are males.

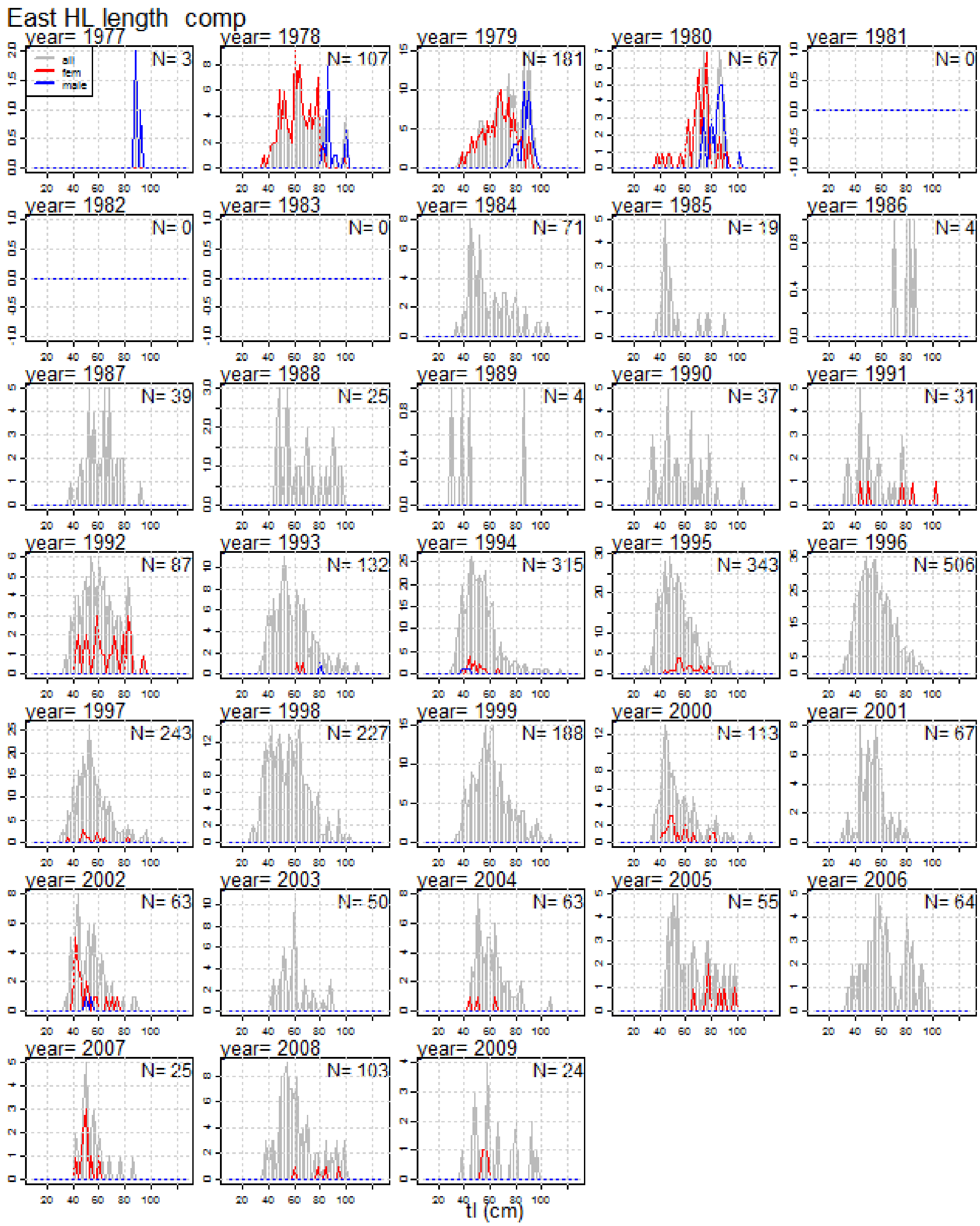


Figure 2.11.Commercial handline East length composition. Red lines are females, blue are males. Shaded bars are both or unknown sex.

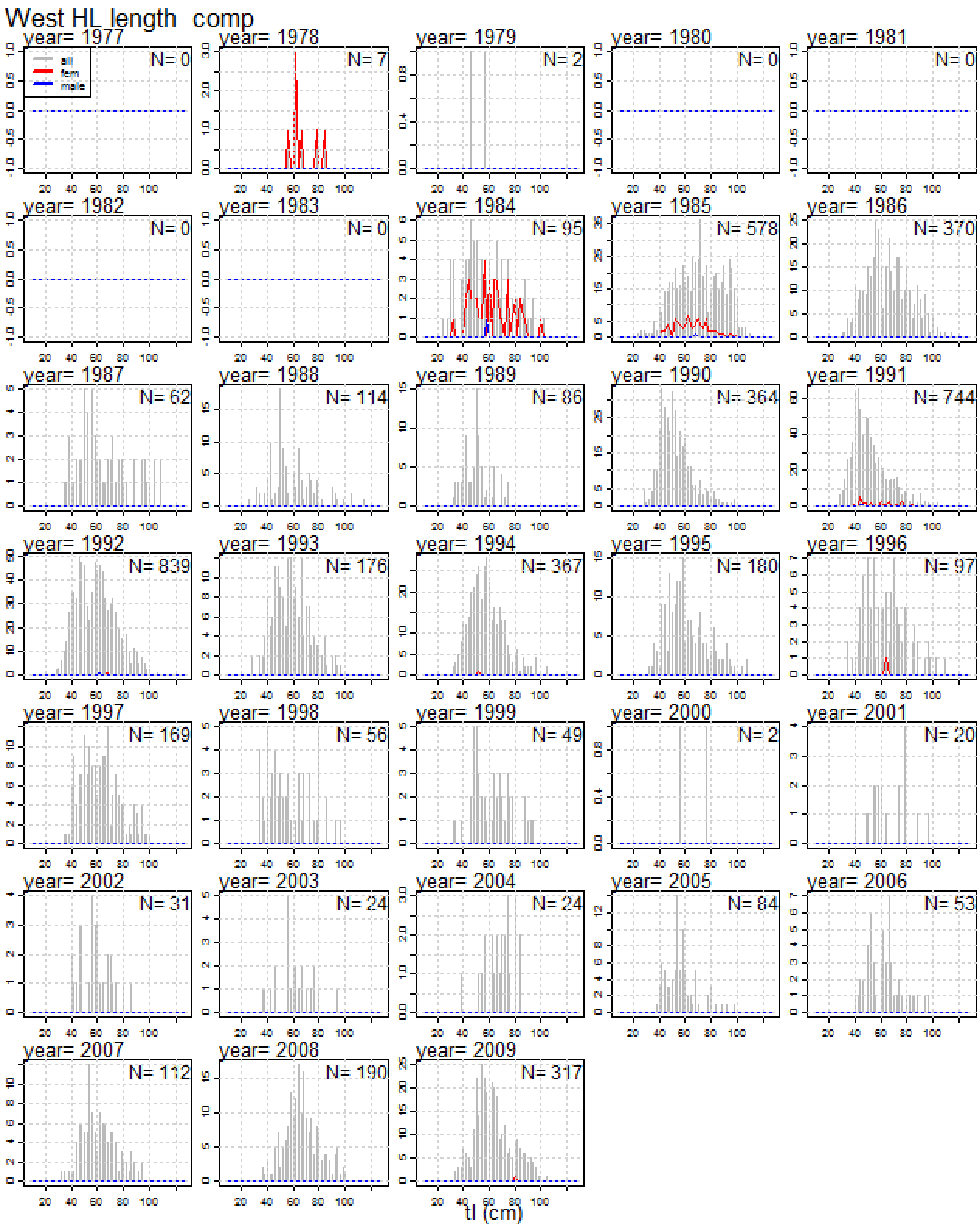


Figure 2.12.Commercial handline West length composition. Red lines are females, blue are males. Shaded bars are both or unknown sex.

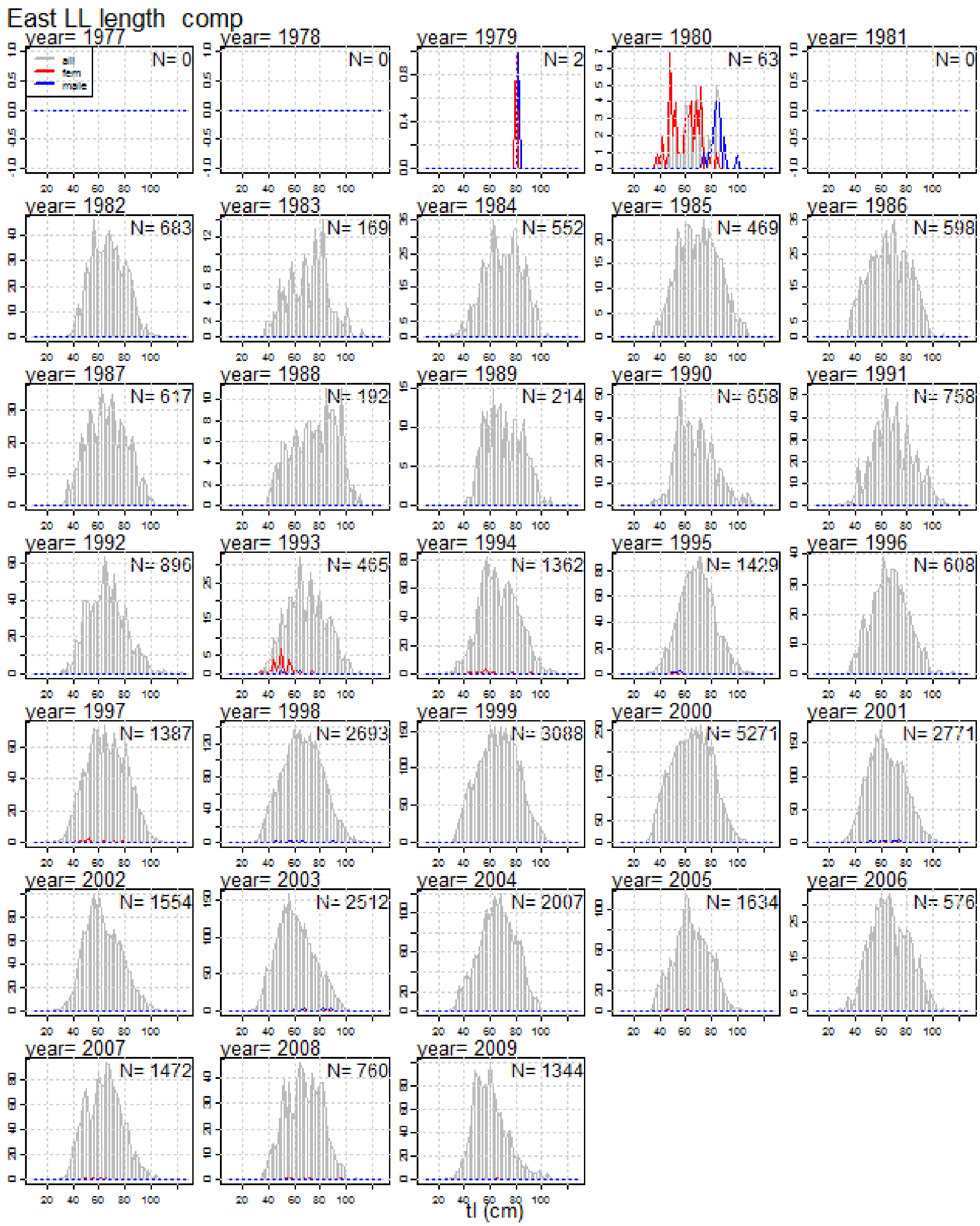


Figure 2.13.Commercial longline East length composition. Red lines are females, blue are males. Shaded bars are both or unknown sex.

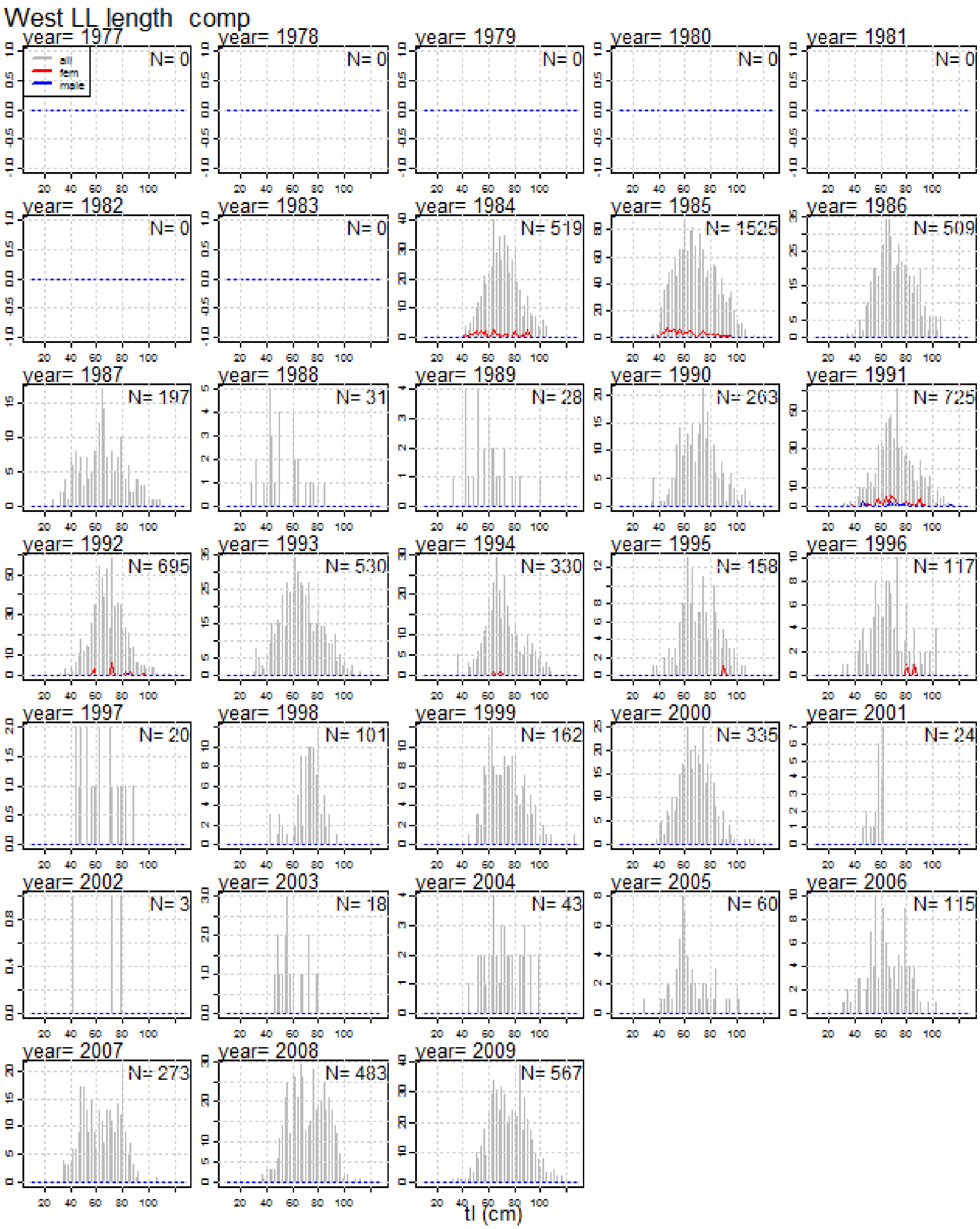


Figure 2.14.Commercial longline West length composition. Red lines are females, blue are males. Shaded bars are both or unknown sex.

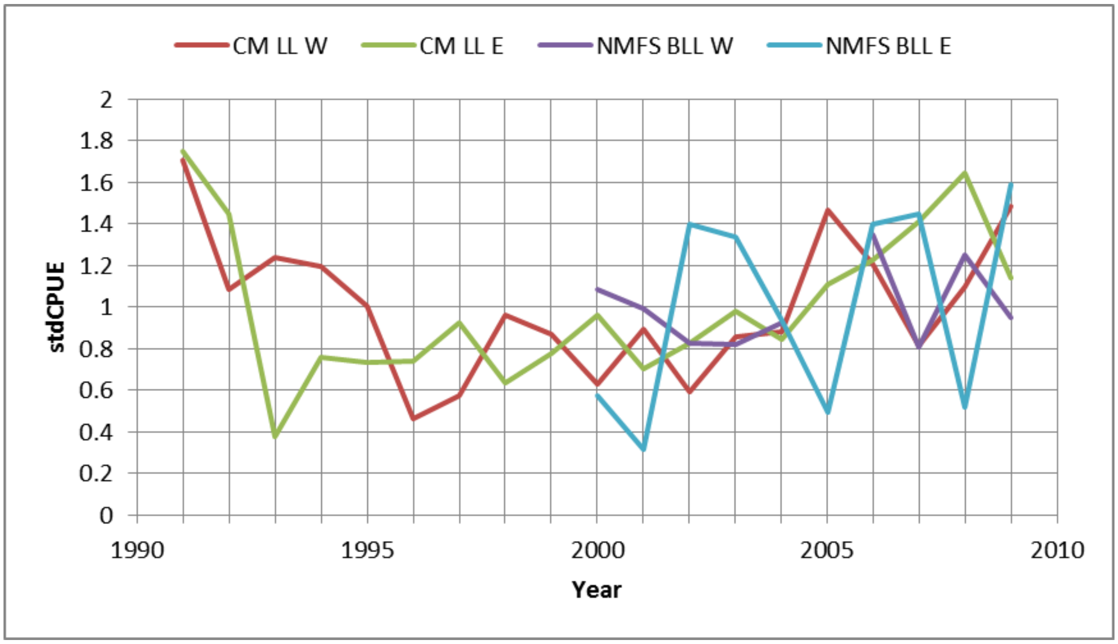


Figure 2.15. Indices used in YEG assessment.

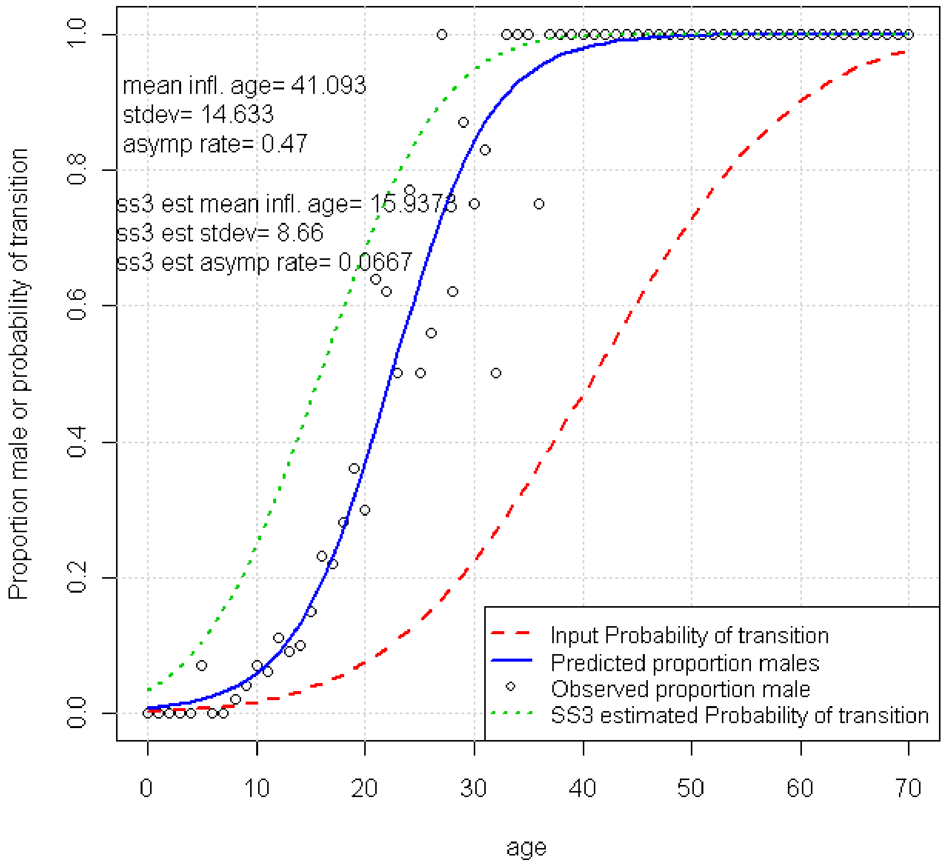


Figure 2.16. Hermaphrodite transition probability. The red dashed line is the input probability of transitioning to male at age, which increases up to an asymptotic rate. Parameter input to SSIII is as three parameters of a cumulative normal curve defining the probability of transitioning to male at age. Black points are observed proportion male at age and the blue line is a logistic model fit. The green line is the SS3 estimated transition parameters.

3. STOCK ASSESSMENT MODELS AND RESULTS

3.1. *MODEL 1: STOCHASTIC STOCK REDUCTION ANALYSIS*

3.1.1. Model 1 Methods

3.1.1.1. Overview

Stochastic stock reduction analysis (SRA) was applied to yellowedge grouper (*Epinephelus flavolimbatus*) from the Gulf of Mexico. Stochastic SRA (Walters et al. 2006) is a deterministic age structured population model with Beverton-Holt stock-recruitment function that estimates forward in time. SRA uses maximum sustainable yield (MSY) and exploitation at MSY (Umsy) as leading parameters, and given these parameters the model simulates changes in biomass by subtracting estimates of mortality and adding recruits. A single trajectory of biomass over time is produced, as well as, estimates of MSY, Umsy, Ucurrent, Goodyear's Compensation Ratio (recK), and stock status. SRA is a less data-intensive method which can help to determine how large the stock needed to be to have produced the time series of observed landings. SRA should not be a replacement for more computational complex assessment models (such as stock synthesis, referred to as SS) but used more as a tool to make possible conclusions of stock status based on historical catches and recent abundances. SRA has been applied to several Gulf of Mexico species including red snapper (*Lutjanus campechanus*, SEDAR 2005), gag (*Mycteroperca microlepis*, SEDAR 2006a), and red grouper *(Epinephelus morio*, SEDAR 2006b).

3.1.1.2. Data Sources

Stochastic SRA inputs were obtained through SEDAR 22 Data Workshop documents:

Document Reference	Parameter(s)
S22_yellowedge_DW_Final.pdf, Chapter 2 Life History	Growth parameters*
	Natural mortality
	Length at Maturity
	Weight at 100 cm
S22_yellowedge_DW_Final.pdf, Chapter 3 Commercial Statistics	Catch histories
S22_yellowedge_DW_Final.pdf, Chapter 5 Measures of Population Abundance	Indices of Abundance*

*East region designation was established after these reports were written, therefore growth parameters and indices for this region appear first in the assessment report.

3.1.1.3. Model Configuration and Equations

Stochastic SRA (Walters et al. 2006) is an age structured population model with Beverton-Holt stock-recruitment function that simulates biomass forward in time from the start of the fishery, with exploitation rates calculated each year from observed catch divided by modeled vulnerable population (sum of vulnerabilities at age multiplied by modeled numbers at age). In Stochastic SRA, recruitment is assumed to have had lognormally distributed annual anomalies (with variance estimated from VPA estimates of recent recruitment variability), and to account for the effects of these a very large number of simulation runs is made with anomaly sequences chosen from normal prior distributions (with or without autocorrelation). The resulting sample of possible historical stock trajectories is sampled using Markov Chain Monte Carlo integration (MCMC). Summing frequencies of occurrence of different values of leading population parameters over this sample amounts to solving the full state space estimation problem for the leading parameters (i.e. find marginal probability distribution for the leading population parameters integrated over the probability distribution of historical state trajectories implied by recruitment process errors and by the likelihood of observed population trend indices).

The stochastic SRA is parameterized by taking Umsy (annual exploitation rate producing MSY at equilibrium) and MSY as leading parameters, then calculating the Beverton-Holt stock-recruit parameters from these parameters and from per-recruit fished and unfished eggs and vulnerable biomasses (Forrest et al. 2008). Under this parameterization, we effectively assume a uniform Bayes prior for Umsy and MSY, rather than a uniform prior for the stock-recruitment parameters. This is an age-structured version of the stock-recruitment parameterization in terms of policy parameters suggested by Schnute and Kronlund (1996).

Natural mortality rate was treated as age-independent, and was sampled for each simulation trial from a uniform prior distribution with M ranging from 0.08-0.10.
Vulnerabilities at age were provided from SS from logistic functions of age selectivities given size selectivities and size-at-age data (SS, Asel2). Fecundity was assumed to be proportional to the differences between age-specific body weight and weight at maturity calculated from input parameters.

SRA provides probability distributions of leading parameters (Umsy, MSY) and other population parameters (vulnerable biomass, catch, exploitation), as well as the probability of the population being overfished or undergoing overfishing based on the ratio of current biomass/biomass at MSY less than 1 and the ratio of current exploitation/exploitation at MSY greater than 1.. Each of these parameters is reported with a level of uncertainty determined through MCMC resampling.

3.1.1.4. Uncertainty and Measures of Precision

Stochastic SRA uses a Monte Carlo approach, as well as Bayesian and likelihood approaches for estimating leading parameters.

3.1.1.5. Benchmark / Reference points methods

Stochastic SRA estimates benchmark for probability of overfished as the ratio of Biomass current/Biomass at MSY less than 40% and the benchmark for probability of overfishing as the ratio of Exploitation current/Exploitation MSY greater than 1.

3.1.1.6. Projection methods

Future vulnerable biomasses were projected with an amount of landings equivalent to the average landings per year per region for the past five years (2005-2009: all areas combined, commercial landings = 770,000 gutted lbs; east, commercial landings = 550,000 gutted lbs; west, commercial landings = 220,000 gutted lbs). These projections will assess future biomass trajectories under the assumption of no changes to current regulations. Stochastic SRA obtains probability distributions for future stock status using Markov Chain Monte Carlo methods.

3.1.2. Model 1 Results

Stochastic SRA model was applied to yellowedge grouper life history parameters (Table 3.1) and commercial catch history (Table 3.2) by region (East and West of Mississippi River) in the Gulf of Mexico. Vulnerabilities at age were provided from SS from logistic functions of age selectivities given size selectivities and size-at-age data (SS, Asel2) and were the same in both regions (Table 3.3). Commercial longline indices by region were used with varying degrees of uncertainty (index standard error) and the default value for recruitment anomalies was used (1.0)(Table 3.4). An increase in the uncertainty (1.96 * CV for all years) was necessary in the commercial longline index for all data combined for a satisfactory number of model iterations. Each model was manually ceased after several million MCMC iterations (all data, 2.3 x 10^6; east, 2.3 x 10^6; west, 2.4 10^6).

3.1.2.1. Measures of Overall Model Fit

Stochastic SRA does not provide measures of overall model fit.

3.1.2.2. Parameter estimates & associated measures of uncertainty

Stochastic SRA model provided estimates of population parameters such as vulnerable biomass, maximum sustainable yield, exploitation (current and at maximum sustainable yield), and Goodyear's compensation ratio for each MCMC iteration. Summary statistics were calculated for these parameters given combinations of Umsy and MSY that yielded positive Goodyear's compensation ratio (recK) values. Some of the MCMC samples result in implausible and negative recK parameter estimates and it was necessary to remove these values prior to summarizing. Parameter estimates for the overall Gulf of Mexico SRA run are shown in Table 3.6. Median values for MSY are 356 mt with ranges between the 1^{st} and 3^{rd} quartile between 332 and 380 mt.

Regional results

- The eastern region of the Gulf of Mexico yielded a higher carrying capacity of yellowedge grouper compared to the western region given the historical catches (Figure 3.1, Tables 3.5-6). Historical exploitation levels were higher in the east during the earliest years of the fishery and the west region was predicted to have higher exploitation since the mid-1980s (Figure 3.2).
- SRA model estimated maximum sustainable yield (MSY) to be higher in the east region with median MSY at 227 gutted MT compared to 122 mt gutted MT in the west (Figure 3.3).
- Median exploitation at MSY was predicted to higher in the western region (0.07 ± 0.01 and 0.10 ± 0.1, east and west respectively) (Figure 3.4, Table 3.6).
- The central tendencies of current exploitation were higher in the western region ($U_{current}$ 0.07 ± 0.02 and 0.09 ± 0.02, east and west respectively).
- The eastern region has a tighter distribution of MSY values but a similar distribution of U_{msy} values as the west (Figure 3.5). Given the sample distribution of MSY and U_{msy}, there is a high probability that recent catches have been at MSY in the west and below MSY in the east.

3.1.2.3. Stock Abundance and Recruitment

Stochastic SRA provides a time series of vulnerable biomass as a measure of stock abundance (Figure 3.1). Recruitment for yellowedge grouper from each region was modeled using the default value of 0.5 for the standard deviation of recruitment without autocorrelation. Normally distributed recruitment anomalies were predicted for each region, with both regions having similar recruitment anomalies throughout the time series (Figure 3.6).

3.1.2.4. Stock Biomass (total and spawning stock)

Stochastic SRA does not provide measures of spawning stock biomass. Total egg production was calculated as a proxy for stock biomass.

3.1.2.5. Fishery Selectivity

Stochastic SRA does not provide measures of fishery selectivity.

3.1.2.6. Fishing Mortality

Stochastic SRA does not provide measures of fishing mortality.

3.1.2.7. Stock-Recruitment Parameters

Stochastic SRA does provide measures of Goodyear's Recruitment Compensation Ratio (recK) which directly translates to the steepness of the stock-recruitment curve. Overall recK median values were 91.10 and 81.02 and 104.80 for the East and West, respectively. These translate to steepness values of 0.96, 0.95 and 0.963, respectively.

3.1.2.8. Evaluation of Uncertainty

Stochastic SRA does not provide other evaluations of uncertainty than those presented in 3.1.2.2.

3.1.2.9. Benchmarks / Reference Points / ABC values

The default benchmark for overfishing and overfished status in the SRA program employs the Pacific Fisheries Management Council 40:10 rule and is not directly comparable to the benchmarks employed by the Gulf of Mexico Fisheries Management Council. However, new model outputs (January 2011) provided vectors of total biomass for the final year of data, spawning stock biomass for the final year of data, and spawning stock biomass at maximum sustainable yield for each MCMC iteration. The probability of being in an overfished condition shown in the figures and calculated here come from the number of MCMC iterations with the ratio of $SSB_{current}/SSB_{msy}$ less than one and the probability of overfishing comes from the ratio of $U_{current}/U_{msy}$ greater than one. Under this rule, SRA results predicts yellowedge grouper in the Gulf of Mexico to be overfished ($P(SSB_{current}/SSB_{msy)}$<1)=99.9) but not experiencing overfishing ($P(U_{current}/U_{msy})$>1)=45.8% (Table 3.7). Summary statistics for estimated parameters and benchmarks are shown in Table 3.7. Regional model runs indicate that YEG is overfished in both regions (prob. overfished: east 99.75%, west 100%) but only experiencing overfishing in the East (prob. overfishing: East 55%, West 42%, Figure 3.7,Table 3.7).

3.1.2.10. Projections

Stochastic SRA projections were run by designating future landings as the average yellowedge grouper landings for the entire Gulf of Mexico and per region, respectively. In each of these scenarios, most of the MCMC runs increased in biomass (Figure 3.8), though the east region showed a slower rate of increase.

3.1.3. References

Forrest, R., Martell, S. Melnychuk, M. and C. Walters. 2008. Age-structure model with leading management parameters, incorporating age-specific selectivity and maturity. Can. J. Fish. Aquat. Sci. 65: 286-296.

Schnute, J.T. and A.R. Kronlund. 1996. A management oriented approach to stock recruitment analysis. Can. J. Fish. Aquat. Sci. 53:1281-1293.

Southeast Data, Assessment and Review (SEDAR). 2005. Stock Assessment Report of SEDAR07, Gulf of Mexico Red Snapper. Report 1. SEDAR, One Southpark Circle #306, Charleston, SC 29414.

SEDAR. 2006a. Stock Assessment Report of SEDAR10, Gulf of Mexico Gag Grouper. Report 2. SEDAR, One Southpark Circle #306, Charleston, SC 29414.

SEDAR. 2006b. Stock Assessment Report of SEDAR12, Gulf of Mexico Red Grouper. Report 1. SEDAR, One Southpark Circle #306, Charleston, SC 29414.

Walters, C.J., S.J.D. Martell, and J. Korman. 2006. A stochastic approach to stock reduction analysis. Can. J. Fish. Aquat. Sci. 63: 212-223.

3.2. ***MODEL 2: STOCK SYNTHESIS***

3.2.1. Model 2: Methods

Stock Synthesis III (SSIII, Methot 2000) is an integrated statistical catch-at-age model which is widely used for stock assessments in the United States and throughout the world. SSIII takes relatively unprocessed input data and incorporates many of the important processes (mortality, selectivity, growth, etc.) that operate in conjunction to produce observed catch, size and age composition and CPUE indices. In addition, SSIII can incorporate time series of environmental data. Because many of these inputs are correlated, the concept behind SSIII is that they should be modeled together, which helps to ensure that uncertainties in the input data are properly accounted for in the assessment. SSIII has the ability to incorporate an early, data poor time period for which only catch data are available and a more recent, data-rich time period for which indices and length and age observations are available. For YEG we have the benefit of substantial age composition data from fairly early on in the fishery.

3.2.1.1. Data sources

Data sources are described above in section 2.

3.2.1.2. Model configuration and equations

Specific equations can be found in the technical description of stock synthesis (Methot 2000) and are not reproduced here.

Initial fishing mortality

Substantial work was conducted to track landings of YEG back to the beginning of the deep-water fishery. Based on discussions at the DW and subsequent discussions and interviews with fishermen, it appears that the deep-water fishery generally began in the mid to late 1970's. Based on this input an initial equilibrium F of zero was assumed for all fleets, under the assumption that the population started in 1974 under close to virgin fishing conditions.

Temporal domain

The model begins in 1974 under the assumption of an unfished condition. The first year of catch and data is 1975 and the modeling time period extends until 2009. Model projections were run to 2029.

Spatial resolution

Yellowedge grouper are not believed to exhibit high movement rates. This low probability of movement, coupled with their longevity and low population growth rates increases the potential that highly concentrated fishing effort can serially deplete different local concentrations, while overall catch rates and age composition fail to reflect overall population declines. To ward against such serial depletion we desired to incorporate as much spatial resolution as possible while maintaining adequate sample sizes and balance.

Furthermore there are substantial differences in habitat type between the Eastern and Western Gulf of Mexico. The Eastern gulf is dominated more by hard bottom habitats while the Western gulf has less hard structure. Yellowedge grouper utilize both rocky hard-bottom habitats as well as soft-sediment habitats and, in particular, sediments with tilefish burrows (Jones et al. 1989, Cook 2007).

Originally the model was set up to include three spatial regions (shaded areas in Figure 2.1), however, difficulties related to the assignation of age composition data and landings to the correct NMFS shrimp grid necessitated the condensing the spatial domain into Eastern (shrimp grids 1-12) and a Western (shrimp grids 13-21) regions (Figure 2.1). The three-region model also exhibited extremely poor fits to the CPUE time series as well as anomalous recruitment deviations, likely caused by the substantial mismatch between the early age composition data, much of which was believed to come from shrimp grids 4 and 5 and the historical landings which largely came from shrimp grids 5 and 6. This mismatch may have been caused by forcing the partitioning of landings between the South and a Central region when it may not be simple to partition these landings spatially given that the historical fishing grounds actually cover both locations (Figure 2.2). The most expedient solution was to combine the two areas into one.

Plus group decisions

The plus group was set at 40 for the purpose of the assessment as age and length composition information was relatively sparse with only 186 out of 8655 or 2.1% of all aged fish between 40-85 years old, growth was generally linear and size at age appears to approach the asymptotic L_{max} near age 40. Furthermore, there was little evidence of changes in selectivities from ages 39 to 40 and above.

Natural mortality

Natural mortality was initially fixed within the model to a value of 0.073 commensurate with the mean value of the most likely ranges of M based upon catch curves, maximum age- mortality regressions and other life-history-based proxies for M (SEDAR22 DW report). Within SS3, a Lorenzen scaling function was used with a reference age (the age where the input value of 0.073 was assumed to apply) was set at 15. This Lorenzen function scales M according to the growth curve, so the actual scaling of M varies between males and females and according to the growth rates in the different regions.

Growth modeling

Growth rates were estimated separately for each region and for each sex. Growth was modeled with a three parameter (L_{min}, L_{max} and K) Von Bertalannfy function. The highly variable estimation of Lmin due to very few age 0 and 1 fish caused this parameter to vary greatly which had an undesirable consequence of creating great disparity in estimated values for age 0 and 1 natural mortality due to the Lorenzen scaling according to the growth curve. For this reason the AW panel agreed that Lmin should be fixed at the mean value estimated from the separately estimated 3-parameter growth curves. This size (5 cm) was then used for all growth modeling, thus reducing the number of parameters to two (L_{max} and K) and the moderating the wild fluctuations in M for ages 0 and 1. For both sexes and for all growth curves fixed CVs of 0.1626 and 0.1165 were used for young (age<= 0) and old (age>= age at L_{max}) which generally corresponded to the CV of length at age for young and old fish. For intermediate ages a linear interpolation of the CV on mean size-at-age is used.

Maturity, fecundity and length-weight relationships

For both males and females a fixed length-weight relationship was used to obtain biomass and fecundity (Table 2.9). Fecundity was assumed to be proportional to male and female biomass. Maturity was input as fixed slope and size of inflection parameters of a logistic function of length where maturity = 1/(1 + exp(slope*(inflection))). Length weight relationships and maturity at size relationships were developed by the DW.

Recruitment partitioning, stock recruitment and recruitment deviations

A Beverton-Holt stock recruitment relationship was fit within SS3. Spawning stock was assumed to be the total spawners in all regions and a single parameter defining the fractional allocation of age 0 recruits was estimated. Recruits were then allocated to both regions based upon this estimated fraction. In the three region model, two parameters were estimated.

Two parameters of the stock recruitment relationship were estimated; R_0 or the virgin recruitment level and steepness. A third parameter, sigmaR or the standard deviation in recruitment was input as a fixed value for reasons that will be described below. Rarely is sigmaR directly estimable from the given data and hence it is often necessary to input it as a fixed parameter.

Recruitment deviations were estimated starting in 1967 and ending in 2000, as this is the last year that reliable age or length composition would give information on recruitment deviations. I began the early recruitment deviations prior to the start of the model because the initial age and length samples contain signals of recruitment several years prior. A ramp in recruitment bias adjustment was initiated in 1967 ramped to the full bias adjustment of 1 in 1977, kept at 1 until 1999 and ramped down to zero in 2000. No forecast recruitment deviations were estimated.

In theory the SEAMAP trawl survey length composition samples should provide some recruitment signal, however the very small samples sizes gave very odd, and, likely spurious, recruitment patterns. It was deemed not prudent to allow one or two fish to constitute all of the evidence for or against a recruitment deviation. This logic is similar to the logic that led the DW panel not to recommend using the trawl survey index in the model due to low numbers of fish and low likelihood that the survey adequately captures a recruitment signal.

Modeling conditional age at length

SS3 provides the option to model the age composition as a set of conditional ages at length. This modeling framework operates similarly to an age length key where a distribution of ages is input for a given length bin. This modeling approach is recommended (Methot 2010) and avoids double use of fish for both age and size information because the age information is considered conditional on the length information, contains more detailed information on the variance of size-at-age and provides better ability to estimate growth parameters and the age composition need not be selected completely at random. Thus data collected in a length-stratified program can be incorporated, provided there is no bias for a particular age within a length bin (such as might occur if fish only are captured when they mature). This was particularly useful due to the potential for biased sampling of larger fish for otolith aging identified in SEDAR22-DW-09. The age composition data was input in this manner with ages assigned to 2 cm length bins with the length bins ranging from 8 to 128 cm and the ages from 1-40 where 40 represents a plus group age.

Selectivity modeling

For all fleets, only length based selectivity was estimated and selectivities within a fleet or survey for both areas were mirrored. This means that a single selectivity was estimated for the handline fishery for both East and West regions. The handline fishery and the NMFS trawl survey selectivity were modeled with 6 parameter double normal functions (option 24 in SS3), which allow for either asymptotic or dome-shaped selectivity. A dome-shape could be possible for the handline which could be limited by maximum depth but the double-normal function does not necessarily pre-suppose a dome-shape to be the case. A dome-shape is most likely the case for the trawl survey which fishes at the shallowest depths inhabited by YEG and rarely captures large fish either due to gear avoidance, depth or movement of YEG into untrawlable habitat. For the handline fishery the initial selectivity parameter (selectivity at the smallest length) was fixed to a very low value as fish below 30 cm were never captured. This reduced the number of estimated selectivity parameters for this fleet to 5.

For the commercial longline fishery and the NMFS bottom longline fishery selectivity was modeled with a two parameter logistic function. No parametric prior distributions were used for the selectivity modeling other than for the time block estimates. Only likely min and maximum values were given for other parameters.

The longline fishery selectivity was modeled with two time blocks: 1975-1985 and 1986-2009. These time blocks were designed to account for the beginnings of the longline fishery when vessels often carried both longline and handline gear (Prytherch 1983) and used both interchangeably and a later period reflecting the more recent specialized deep-water longline fishery. During that early time period the length composition of the longline caught fish closely resembled those caught on handlines (Figure 32 in Bullock and Smith 1991). One sensitivity run examined the impact of using a single selectivity for the commercial longline.

Age-based selectivities were not estimated. The ‘realized’ selectivity for a fish of a given age was then assumed to be only a function of its size. As the apparent selectivity is the vector product of age and size selectivity, we assumed that the modeled size of the animal already incorporated all age-based factors. We feel that there is no clear rationale for modeling age-based selectivity in addition to length-based selectivity. This is consistent with the assumption that most of the factors that affect selectivity (hook size, fishing location, fishing method) operate largely upon size or length rather on fish age.

<u>*Hermaphroditism*</u>

Within SS3, sex change is modeled with 3 parameters (inflection age, standard deviation and an asymptotic rate) that define a cumulative normal distribution for the probability of transition of females to males as a function of age. Initially the three input parameters were estimated externally from the observed sex ratios (Figure 2.16) but then were allowed to be estimated within the assessment model from sex-specific age and length composition data.

3.2.1.3. Parameters estimated and prior distributions

A total of 73 parameters were estimated for the ‘base’ model (Table 3.8, Figure 3.9, though the recruitment deviations are not shown on the plot) with specific sensitivity runs adding or removing other parameters. Table 3.8 provides a table of parameters and their estimates from the base model run, starting values, minimum and maximum values as well as asymptotic standard deviations.

Steepness and the selectivity block multipliers for the commercial longline selectivity were the only parameters given prior distributions. Steepness was given a symmetric beta distribution with a min and max between 0.4 and 0.99, a central tendency of 0.7 and a standard deviation of 2. The symmetric beta distribution penalizes departures from central tendency with a penalty proportional to the standard deviation (Figure 3.9). In this case the prior distribution for steepness is relatively non-constraining except at the boundaries of the distribution. For the selectivity block multipliers a standard deviation of 0.2 was used which represents a very diffuse prior on the estimated change in selectivity. The selectivity change parameter is estimated as an offset from the initial baseparm where the selectivity parameter = baseparm * exp(blockparm).

3.2.1.4. Uncertainty and measures of precision

Uncertainty of parameter estimates was evaluated in two ways, first by obtaining the asymptotic estimates of variance by inverting the information matrix (hessian or the matrix of second derivatives) and second through Markov Chain Monte-Carlo (MCMC) estimation within the SS3 model. For derived parameters such as spawning stock biomass the variance is calculated through the delta method.

3.2.1.5. Benchmark and reference point methods

Benchmarks were calculated at Fmsy, F at 40% spawning potential ratio (F_{SPR40}), F at 30% spawning potential ratio (F_{SPR30}),and F at 40% of virgin biomass ($F_{40virgin}$). Fishing mortality was calculated as the exploitation rate in biomass. This value represents a useful proxy for an instantaneous fishing mortality rate when there are multiple areas, and multiple fisheries with different selectivity patterns. As the above reference points are all calculated with respect to this F proxy, they scale appropriately. For spawning stock biomass, both males and females are included according to recommendations in Brooks et al. (2007) that when the potential for decreased fertilization is moderate or unknown spawning stock biomass of both males and females should be used. For determination of current status F and SSB in 2009 are both used rather than some average over several years.

3.2.2. Model 2 Results

3.2.2.1. Sensitivity analyses on inputs (scoping and profiling for stp, sigmaR and reference age for M)

<u>*General description*</u>

The basic modeling strategy presented here begins with a series of scoping or ranging model runs to define the range and sensitivity to some basic inputs. The model runs are organized in Table 3.9. The first model results presented are a series of ‘scoping’ runs or sensitivity runs that are critical for determining appropriate input parameters as well as determining the estimability of several critical inputs. The first series of runs evaluate the value of sigma R, or the standard deviation of recruitment. Methot and Taylor (unpublished ms) advise testing the sensitivity of the root mean square error (RMSE) of the recruitment deviations to a range of values of sigma R with the goal of achieving an RMSE that is slightly less than the input value of sigmaR. Rarely is sigma R directly estimable from the data, so it is rather critical to specify an appropriate value of sigma R.

The second run involved exploring the likelihood to various levels of reference age for the Lorenzen natural mortality scaling. As this reference age is chosen so that the 'target' M corresponds to the chosen age, this choice could be perceived as arbitrary, and the resulting choice could drive the assessment outcome. Setting the target age to a young age effectively drives down the natural mortality, setting it to an old age drives up the overall M. Thus exploring the sensitivity of the likelihood can help to determine the most appropriate age.

The third scoping run is to determine the estimability of the steepness parameter. Often without strong contrast in spawning stock and clear recruitment signals, it may be difficult to estimate steepness. Overall likelihoods for models with different levels of steepness will have similar values resulting in a shallow or smooth likelihood profile. In these situations, it may be necessary to input a tighter Bayesian prior on steepness, to fix a value of steepness to some desired level or, ultimately, to abandon the hope of estimating an appropriate steepness and to employ proxies for MSY when the stock-recruitment relationship is poorly determined (Restrepo et al 1998). Thus the main goal here is to determine whether we can properly estimate the stock-recruitment relationship, or if our input values wholly determine the outcome.

Scoping on sigma R

Values of sigma R above 0.3 all lead to estimated RMSE > sigma R (Table 3.10). In these cases, the input value of sigma R creates recruitment variability not necessarily observed in the data. It appears that there is rather little information in the data on recruitment variability as when estimated sigmaR is 0. When estimated, the value of sigmaR tended to hit the minimum bound, either 0 or 0.01, in both cases (Table 3.10). Given the recommendations of Methot and Taylor (unpublished ms) to choose a sigmaR >= RMSE, or, conversely, to explore a range of sigmaR until it meets the above condition, the recommended value is 0.2. Derived and estimated benchmarks for different values of sigmaR clearly show that settings for this value can have a substantial impact upon the assessment (Table 3.11). But if we assume that values of sigmaR for which sigmaR < RMSE represent situations where the input value is creating spurious recruitments we can rule out these runs. In addition we can likely use the lowest value of sigmaR as some indicator of stock results in the absence of recruitment deviations, which, in this case, appear to be a worst case scenario over all values of sigmaR.

Profile for reference age (5,15,20, 25) for natural mortality scaling

The choice of a reference age for the natural mortality scaling is, unfortunately, not a neutral decision and it may not be possible to rely solely upon the data to determine the appropriate age. As the reference age increases we obtain a lower likelihood and better fit (Table 3.12) , however the practical result is that of increasing the total mortality experienced, in the same manner as actually increasing or decreasing the reference M (Figure 3.10). To choose the reference age I derived the Lorenzen curve with initial estimated of the growth curves from SS3 and a target M of 0.073. On the basis of the function, the age which corresponded to M=0.073 was 15 and this was the input value to for SS3. However, this decision represents an assessment uncertainty. Given the direct scaling of M which occurs with different reference ages, this uncertainty in the reference age will likely be very similar to the sensitivity runs that scale the actual value of M.

Scoping on steepness

These runs evaluate the likelihood components for various input values of steepness to determine the direction that the model estimates steepness (Table 3.13). Without substantial contrast in stock size and/or clearer evidence of recruitments, it may be unlikely that steepness can be well estimated. It appears that the model tends to estimate very high values of steepness, but there is very little contrast between values of 0.7 and 0.99. Because of this the AW panel recommended employing proxy benchmarks which avoid the explicitly modeling or choosing of a value for steepness. These proxy benchmarks will be discussed in a following section.

3.2.2.2 Base model results

General description

This set of model results is the 'Base' or most likely model formulation based upon the previous scoping runs and decisions made by the AW panel. Key characteristics of the model are as follows:

- 2 areas, East and West
- Separate sexes, with estimated sex transition from female to male
- 4 estimated growth rates (male, female, East and West)
- single input mortality rate, scaled with the Lorenzen function
- 4 fleets: Commercial Longline, E and W Commercial handline, E and W
- 4 indices: Commercial Longline, E and W and NMFS bottom longline, E and W
- 2 Surveys: NMFS bottom longline, SEAMAP trawl survey
- 4 Estimated selectivities: Commercial Longline: Logistic
    - Commercial Handline: double normal
    - NMFS bottom Longline: Logistic
    - SEAMAP trawl: double normal
- 73 estimate parameters

Measures of overall model fit

Overall the model fit to the CPUE indices is rather poor. The model fails to fit the increases in the commercial longline index in the East but does at least fit the West index somewhat. The CVs on all indices were quite high so the model is not terribly restricted to fit the indices. Furthermore the indices only contribute a small amount to the total likelihood (-23.7) indicating that they are not terribly influential on the overall results (Table 3.14). Note that the negative value indicates that fitting the index improves the likelihood (subtracts from the overall likelihood). In contrast, the likelihood components for the age (9317) and length composition (4170) indicate that these components have the greatest influence on the model.

The fits to the length composition are relative good, for the cell (year, region, fleet, sex) combinations that have adequate data (Figures 3.12-3.35). Fits to the length composition data can also be evaluated by plots of the Pearson residuals (Figures 3.36-3.54). The residual are plotted as with solid circles as positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed). There are few strong patterns in the residuals other than what appear to be small clumps of missing or higher than predicted numbers of fish in certain lengths. These may be a function of the patchy distribution of the fish and the fact that length composition samples might be more of a cluster sample than actually independent samples.

Fits to the conditional age at length can be evaluated by looking at the Pearson residuals to the age at length fits (Figures 3.55-3.76). Generally, where there are sufficient samples, the plots should represent random variability around the population growth curve. As an example of a poor and highly problematic fit, I have included the residuals around the fits to the ages obtained from the 1982-83 otolith weight-otolith age regression (Figure 3.77). Clearly these did not fit the population growth curve and the result of including these data points was that the model created entirely spurious early recruitment deviations to fit them. Growth curve fits and the Lorenzen M scaling are shown in Figure 3.78. The growth curve fits reflect documented spatial variation in growth rates with fish in the East, or at least in the South, being smaller at age than in the West. The growth curves differ substantially at young ages from growth curves brought to the data workshop because of the strong influence of the estimated selectivities upon the observed sizes at ages. It is likely that these growth curves better represent the population, to the extent that the estimated selectivities provides a scaling factor between the observed size at age and the population size at age.

The fraction of males at length and age obtained by the estimated probability of transition are shown in Figure 3.79. The fraction of males-at-length indicate a higher fraction of males at length between 60 and 80 cm and a lower fraction of males between 80 and 120 cm than in the observed input data. In addition the fraction of males-at-age are lower than the observed data. These differences are most likely attributable to the joint estimation of growth and selectivity and to the different data sets used to empirically estimate the sex ratios versus the data in the assessment. The observed data comes from 712 female and 221 male fish obtained from 1999-2009 whereas the sex composition data in the assessment includes the fish from prior to 1999 as well as the fish measured and sexed in the TIP program. As the actual sex ratios are a source of uncertainty, one of the sensitivity runs uses just the input probabilities rather than estimating them.

Parameter estimates and asymptotic standard errors for are given in Table 3.8. The standard errors appear quite low on all parameters, except they are very high for the recruitment deviations, indicating that the recruit deviations are quite poorly estimated. This is likely due to an absence of clear and identifiable cohorts in either the age or length composition, with the exception of the 1993 year class which might actually appear as a cohort in the age comp (Figures 2.6 and 2.7).

Stock abundance, stock biomass (total and spawning stock)

Predicted total biomass (mt), spawning biomass (mt), age-0 recruits (thousand fish), and fishing mortality for are given in Table 3.15. Total biomass, spawning depletion (relative to virgin biomass and region-specific total and spawning biomass are plotted in Figure 3.80. The general biomass trend is a steep decline starting in the early 1980s, commensurate with a dramatic increase in F, then a leveling off since around 1993 (Figure 3.81). This generally matches the rapid expansion of the deep-water longline fishery in the early 1980's and its rapid movement inshore to target red grouper. It is likely that there would have been an extremely strong decline in CPUE during this time, but unfortunately we do not have any indices from before 1995. The time period covered by the indices is largely after most of the major population changes predicted by the model.

These population changes can be seen in the plots of the numbers at age by year for both sexes in the East and West (Table 3.16 and Figure 3.82). The estimated strong cohorts are also clearly visible on this plot.

Spawning stock and recruitment, stock-recruitment parameters

The estimated Beverton-Holt stock recruitment relationship appears quite poorly estimated (Figure 3.83). There are very few observations at lower stock sizes and very little evidence of a stock-recruitment relationship. This could largely be a function of the spawning stock being estimated to have been constant for the past 15 years, while estimated recruitment has fluctuated.

Steepness is estimated to be 0.95, virgin recruitment 824,700 age 0 recruits and the RMSE on recruitment deviations 0.189. The recruitment deviations show some rather strange behavior in the early years, 1967-1973. I do not know what is creating these deviations and they may have some influence upon future abundance because of the delayed entry of recruits into the fishery (fish generally do not recruit to the fishery until ~ age 10).

The partitioning of recruits by area was relatively 2:1 which matches the allocation of habitat area with the East being approximately twice the area of inhabitable habitat for YEG of that of the West (Walter et al. 2010).

Fishery Selectivity

Fishery and survey selectivity patterns for the commercial handline East and West (HLE, HLE) and SEAMAP trawl surveys East and West (TRWE, TRWW) were both modeled with a double normal selectivity pattern (Figure 3.84) which allows both logistic or dome-shaped selectivities. For the handline fishery, the estimated selectivity was nearly asymptotic with a sharp falling off at the largest size bins. This strange pattern could result from very few large fish to estimate selectivity at these lengths.

Early (1975-1985) and late (1986-2009) selectivity vectors were modeled separately for the commercial longline. Early selectivity (solid lines) appears clearly shifted towards smaller fish which likely reflects the mixed handline and longline nature of the early longline fishery. The more recent selectivity vector (dotted lines) indicates a shifting towards larger fish.

The NMFS bottom longline survey shows a selectivity pattern that is focused very much on large fish, and larger fish than the commercial longline. The SEAMAP trawl survey shows as selectivity pattern strongly focused on extremely small fish, which reflects both the shallower location of these tows in areas separated from the distribution of larger fish and the potential that larger fish avoid the trawl.

Fishing Mortality

Fleet-specific patterns of instantaneous F show different trends from the overall pattern (Figure 3.85). The East fishing mortality spiked in the early 1980s, then declined and now appears to be slightly increasing since the mid-1990s. Fishing mortality in the West has been on a slight decline over the last 20 years after peaking between 1983-1995. Current fishing mortality rates in the East appear to be twice that of the West (Table 3.17) which largely reflects the fact that landings in the East have been much higher than that of the West.

Given the selectivity patterns estimated above and the dominance of the longline fishery, the fishing mortality at age is concentrated on the older fish and is relatively constant for ages 20-40+ (Table 3.16).

Evaluation of Uncertainty

Standard deviations of the estimated parameters are given in Table 3.6. These provide some measure of the uncertainty around a particular estimate but do not necessarily capture all of the sources of uncertainty. For this reason MCMC runs were performed on the base model. At the present time only 100,000 MCMC runs have been completed so these results are preliminary and may be further updated with MCMC results from other model constructions. For these preliminary runs, the 100,000 runs were thinned twice, once at every 100th run, then the first 10 of these was removed as a burn in and then every other of these runs were saved to give 495 total retained MCMC runs. Plots of the individual points and cumulative means (Figure 3.86) appear that most estimated or derived parameters reached convergence, though the parameters that depend upon the stock recruitment relationship (MSY-related parameters) do show some tendency for trend. This might necessitate a greater number of MCMC runs, but, in general these runs appear to capture the range of uncertainty that can be obtained with the MCMC approach.

3.2.2.3 Sensitivity analyses (Alternate model runs or configurations)

General description

This set of model results describes several sensitivity results run on various model scenarios. The first is a run designed to mimic the 2002 assessment run by using only data from 1986-2009. The second run includes no recruitment deviations, such that recruitment comes strictly off of the stock recruitment relationship. The third model is the three-area model, exactly the same as the base model, above but with three areas; South, Central and West. The fourth model has no selectivity time-blocks implemented for the commercial longline fishery. The fifth model allows M to be estimated and the last model uses a fixed value of 0.7 for steepness which contrasts with the high values (~0.94) generally estimated in all other models. The last model did not estimate the 3 parameters defining the transition rate from females to males. Likelihood fits for sensitivity runs are given in Table 3.14, parameter estimates in Table 3.19 and derived quantities and benchmarks in Table 3.20. Overall SSB, recruits and F trajectories for the sensitivity runs are shown in Figures 3.87 and 3.88.

Update 2002 model (1986-2009), assume zero equilibrium catch, and assume five year average equilibrium catch

These models mimic strict updates to the 2002 assessment and largely reach the same conclusion: current stock status depends upon the assumed level of fishing prior to the start of the model since there is no contrast in the data during the 1986-2009 time period.

Model with no recruitment deviations (Null deviation model)

This model is instructive as it appears to represent the most 'pessimistic' version of the base model. If the recruitment deviations are entirely spurious and not to be trusted, then not estimating them could be considered prudent and it appears that, if this causes a bias, the bias is in the direction of a more pessimistic stock status.

Three-area model

This model displays a highly divergent fit to the longline CPUE index in the south (Figure 3.89) which indicates that, despite the index increasing, the stock is plummeting over the 1986-2009 time period. Time series of biomass indicate that the South region has been declining continuously while F goes extremely high due to recent increases in landings (Figure 3.90). Such an extreme increase in F does not appear in the age composition. I believe that these trends are caused by simple mismatch of the landings with the age composition caused by an imprecise allocation of substantial early landings to the central region. Most of the early age composition comes from the South, yet most of the landings from the same time period were put in the central region (Figure 3.90). The end result of this mismatch is a) high recruitment deviations, b) the model has to give the South a very low amount of total recruitment, and say that it is a much smaller initial population than the central and west and b) given the recent increases in landings in South, these are having a drastic negative impact upon this region. As long as we can generally rule out the possibility that the population is collapsing (we should see a severe truncation of the age structure), then it is more likely that these patterns are spurious and a simple solution was to combine the South and the Central regions.

No selectivity time-blocks

This modification has very little effect other than to somewhat ameliorate the early erratic recruitment deviations.

Estimate M

This model estimates two separate M values, East= 0.088 and West = 0.110. It has substantially improved fits to the indices (Figure 3.91) and a much more optimistic stock status commensurate with increasing natural mortality. The estimated M values are, however, substantially higher than those estimated by the catch curves at the data workshop for the early time period, and the estimate of M for the West is among the higher of those calculated at the DW. Because there is a direct tradeoff between natural mortality and fishing mortality, allowing M to be estimated higher will reduce the apparent F.

Low value of steepness (0.7)

This run was requested to determine benchmarks and stock status for a fixed steepness of 0.7. The greatest impact would be to bring Fmsy between the two proxies of FSPR30 and FSPR40, indicating that the two proxies would likely serve as relatively similar proxies for Fmsy if the true steepness is close to 0.7.

Hermaphroditism parameters not estimated

Originally the hermaphroditism parameters were input as fixed values. However just as selectivity can bias estimation of growth rates, it may also influence the observed sex ratio at size and hence one may want to estimate these parameters in the integrated model. When estimated, the parameters diverge substantially from the input values and the modeled sex ratio has a lower proportion of male fish at age than the input data (Figure 3.92). These differences and the adequacy of the age and length composition data to estimate the herm parms should be further explored but they actually make little difference to the current assessment (Table 3.20) as spawning stock biomass is calculated as both males and females. If SSB was taken to be just females, then this could have a larger impact.

3.2.2.4. Sensitivity analyses around true uncertainty in base model

General description

These model runs represent a range of uncertainties around the base model. For the purposes of characterizing uncertainty they could be considered runs that bound the ranges of plausibility for natural mortality (M varied from 0.055-0.9) or on historical landings (high or low landings scenario).

1. Alternative partitioning of landings in statistical area 6

This represents one of the greatest uncertainties and has a very direct impact upon the assessment in that it scales the population size and downwards as SSB benchmarks and the potential yield. It basically says that if these landings had not been taken, the stock has always been smaller and MSY and proxies for it scale downward. This partitioning of landings may be the more realistic partitioning given that the difference between the high and low landings scenario hinged upon the partitioning of unclassified grouper in stat area 6. If 96% of these early grouper were YEG, then the high landings scenario is most plausible. If 23% is a more likely percentage for stat area 6 in 1982, then the low scenario is most plausible.

The fits to the CPUE indices do, however degrade substantially in moving to the low landings scenario and there may be some other inconsistency in the model causing this (Figure 3.93).

2. Low M (0.055) and High M (0.099)

Both of these have the anticipated effect of scaling estimated parameters and stock status up and down with M. They bracket a 25% increase and a 25% decrease in natural mortality from the base value of 0.073.

3.2.2.5. Sensitivity analyses (retrospectives on Base model)

General description

These model runs are 5-year retrospective analyses of the base model, i.e., run the same model but remove 1, 2, etc.,… years of data to see whether there is a pattern in the terminal year estimates of SSB, fishing mortality rate and other parameters. Severe biases (as opposed to random fluctuations) represent problematic retrospective patterns.

Five-year retrospective patterns

Retrospective patterns were explored by peeling 10 years of data from the base model (Figure 3.94). The retrospective patterns for biomass and for recruitment are shown and do not appear to produce a particularly problematic pattern.

3.2.2.6. Projections

Projections were run according to two fishing mortality scenarios, $F_{SPR30\ and}$ F_{SPR40} from 2010 to 2029. The final year partitioning of relative F was used to allocate F among the four fleets.

Stock status and outlook

Table 3.22 provides the required SFA and MSRA evaluations using SPR 40% and SPR 30% reference points for Gulf of Mexico yellowedge grouper BASE, low M, high M and low landings runs. Depending upon the proxy for MSY (SPR 40% or SPR 30%), the stock status using the base run ranges from overfished and overfishing to not overfished, slightly overfishing (Figure 3.95). This does not incorporate uncertainties related to landings histories or any other uncertainty explored in the sensitivity runs.

Projected yields in 2011 at the $F_{40\%SPR}$ range from 310-1100 thousand pounds of YEG. Yields at $F_{30\%SPR}$ range from 460-1550 thousand pounds of YEG (Figure 3.97). Recent catches in the past five years have averaged ~860,000lbs which is 50,000lbs higher that than the OFL for 2011 at $F_{30\%SPR}$. Spawning stock biomass would be projected to increase under most $F_{SPR40\%}$ projections but would be actually need to reduced to reach the desired target level under high mortality scenario for both F targets (Figure 3.96).

Short term projected yields under the high M scenario would be substantially (F30%SPR) or moderately (FSPR40%) higher than actual landings from 1986-2009. In contrast, under the base model yields at F30%SPR would be almost the same as the landings from the last several years (Figure 3.97).

Projections with decremented recruitment

To evaluate the potential impact of the reductions in recruitment due to the Deepwater Horizon oil spill in 2010 on the population and on projected yields I decremented 2010 recruitment by 25%, 50%, 75% and 100% (total failure). Projections under these scenarios were performed for the base model with F at $F_{SPR30\%}$. Spawning stock biomass shows a very slight impact of the recruitment declines and then only 7-8 years into the future (Figures 3.98 and 3.99). The long-term impact appears to be approximately a 5% reduction in SSB in year 2029 for a recruitment failure in 2010. This result is not surprising given that the stock recruitment relationship does not have a high correlation between stock and recruitment (Steepness=0.95). Further, the YEG population is maintained by high spawning stock biomass, rather than supported solely by annual recruitments as would be the case for a species with a much shorter lifespan and greater reliance on annual recruitments. The greater danger for this stock is that the spawning stock could be damaged, which, given the low natural mortality rates, even a small reduction in spawning stock could have substantial population level consequences.

As alteration of the fishing mortality rate is the only management action that can be taken in the face of an episodic mortality event, it is necessary to see whether reductions in TAC would be warranted, given a reduction in 2010 recruitment. Projected yields at $F_{SPR30\%}$ indicate that any reductions in TAC would not be warranted until 2015, and even then the most severe reductions would be on the order of 5% (Figure 3.100). So, again, a single year reduction in recruitment would have minimal impact and there would be minimal management response under the current management scenario. However, direct impacts on the spawning stock are unknown and unquantified. The AW considered impacts on the spawning stock but was not comfortable modeling these at the present time.

3.2.3. Discussion

Overall substantial progress has been made in the assessment of yellowedge grouper relative to the last assessment in 2002. Three critical pieces of information now exist that substantially improve our ability to assess the stock. First we now have a 10-year time series of survey index and size and age composition from the NMFS bottom longline survey. Second, we have reclaimed a vast archive of historic age and length composition data from the beginning of the fishery. Third we have been able to push the landings history back to approximately the start of the fishery in 1975. These additions should make the determination of stock status, productivity and consequent management advice much better determined than in 2002.

Notwithstanding these changes, several key uncertainties and issues remain. The primary uncertainty is in the magnitude of the historic landings of yellowedge from within the mass of unclassified groupers during the 1980-1986 time period at the initiation of the deepwater longline fishery. The high and low landings trajectories give, not surprisingly, high and low yields at all benchmarks. The two landings time series span two likely ranges of the landings and could be considered jointly. It may be likely that landings from stat area 6 were more likely to be red grouper in the early longline fishery but it could also be likely that landings from stat area 5 in this early fishery were higher than 26% yellowedge. However this uncertainty is far less than the uncertainty of either not considering landings prior to 1986 or having to estimate some level of landings prior to 1986.

A second source of uncertainty is in the natural mortality rates, which, again, have direct impact upon the benchmarks. It is informative, in this regard, to consider the catch curves derived from the early (1977-1980) age composition and the current catch curves (Figures 3.101 and 3.102). If we assume constant recruitment, which actually the SS3 model could not refute, when allowed to estimated sigma R (it estimated a value of 0, or constant recruitment) then the total mortality estimates from these early catch curves are 0.075 -0.0943 for females and males in the South region (stat areas 1-5) for 1977-1980. Similar values were estimated in the DW with slightly different partitioning of the data. Recent values are between 0.13-0.15 indicating a potential doubling, likely commensurate fishing. These catch curves give us a fairly strong basis for the assumed M~0.073, at least in the South or East region. When estimated, M in the East was 0.088 and in the West 0.11. Unfortunately we do not have age composition from the beginning of the fishery in the West to document such a large difference in natural mortality rates. Furthermore, we might want there to be a fairly strong biological basis for such a large difference in M because, within the integrated modeling approach, many factors interact and fitting a higher M in the West might be due to an interaction with growth rates or recruitment. So, in conclusion, there is some evidence from catch curves that M might be slightly greater than 0.073, at least for males but we have little evidence to say that it is substantially higher in the West versus the East.

Another unresolved issue is the discrepancy between the input and the estimated probability of transition to male. The estimated transition rate of females to males gives a different sex ratio at age than that of the input data. This is odd but the estimated stock benchmarks, stock status and projected yields (Table 3.20 and Figure 3.95) are virtually indistinguishable between the base model that estimated these parameters and the sensitivity run that used fixed values. This is likely because of using both males and females in SSB. If further explorations of model runs with different metrics for SSB are to be considered, then the issue of sex transition probabilities and the adequacy of the data to estimate these would need to be explored. But for the purposes of providing advice with the current metric for SSB, this discrepancy is inconsequential.

Lastly, uncertainties regarding the stock-recruitment relationship exist. When estimated, the SRR shows a tendency towards high values of steepness. These values appear very high for a fish with such a long lifespan and low maturity but higher values may actually have some biological realism. Demersal fish tend to show fairly high levels of Goodyear's (Goodyear 1993) compensation ratio (Goodwin 2006) which correspond to relatively high levels of steepness. This is generally thought to occur whereby recruitment is largely habitat limited and strong density dependence in early life history occurs. As the stock is fished, number of available niches opens allowing for a substantial increase in juvenile survival as the stock gets fished down, resulting in high compensation ratios and high steepness in the SRR. Such a situation could exist for YEG.

Nevertheless, we can have very little confidence in the estimated stock recruitment relationship and hence it is recommended to use a proxy for MSY such as and SPR-based value.

What we can have confidence in this assessment is that the landings have been more or less stable for the past 20 years and that this stability appears to be due to harvests close to only slightly higher than yields at SPR30% and close to the yields at MSY. Our confidence in this statement comes largely from two pieces of evidence. One, the early and late age composition provides strong information on natural mortality and a good ability to evaluate the effects of this harvest history on the current age composition. Second, the extremely high landings in 1981-1985, regardless of the high or low scenarios, give substantial insight into the inherent productivity of the stock, even if we do not know the nature of the stock recruitment relationship.

3.2.4. References

Brooks, E. N., K. W. Shertzer, T. Gedamke, and D. S. Vaughan. 2007. Stock assessment of protogynous fish: evaluating measures of spawning biomass used to estimate biological reference points. Fishery Bulletin 106:12:23.

Bullock, L.H. and Gregory B. Smith. 1991. Seabasses (Pisces: Serranidae). Memoirs of the Hourglass Cruises 8, 1-243.

Bullock, L. H., M. F. Godcharles and R. E. Crabtree. 1996. Reproduction of yellowedge grouper *Epinephelus flavolimbatus*, from the eastern Gulf of Mexico. Bull. Mar. Sci. 59(1):216-224.

Cass-Calay, S.L., and M. Bahnick. 2002. Status of the yellowedge grouper fishery in the Gulf of Mexico. Sustainable Fisheries Division Contribution No. SFD-02/03-172. NMFS, Southeast Fisheries Science Center, Miami, FL.

Cook, M. D. 2007. Population dynamics, structure and per-recruit analysis of yellowedge grouper, *EPINEPHELUS FLAVOLIMBATUS*, from the northern Gulf of Mexico. PhD. dissertation. University of Southern Mississippi.

Goodyear, C. P. 1993. Spawning stock biomass per recruit in fisheries management: foundation and current use. In S. J. Smith, J. J. Hunt and D. Rivard (ed.) Rish evaluation and biological reference points for fisheries management. Can. Spec. Publ. Fish. Aquat. Sci. 120: 67-81.

Goodwin, N. B. A. Grant, A. L. Perry, N. K. Dulvy, and J. D. Reynolds. 2006. Life history correlates of density-dependent recruitment in marine fishes. 2006. Can. J. Fish. Aquat. Sci. 63: 494–509.

GMFMC. 2002. Report of the reef fish stock assessment panel. Reef Fish Stock Assessment Panel. September 17-19, 2002 Meeting NMFS, SEFSC, Miami, FL. http://www.gulfcouncil.org/news_resources/stock_assessments_sedar_reports.php

Jones, R. S., E. J. Gutherz, W. R. Nelson and G. C. Matlock. 1989. Burrow utilization by yellowedge grouper, *Epinephelus flavolimbatus*, in the northwestern Gulf of Mexico. Environ. Biol. Fish. 26:277-284.

Matter, V.M. and Turner, S (2010). Estimated Recreational Catch in Weight: Method for Filling in Missing Weight Estimates from the Recreational Surveys with Application to Yellowedge Grouper, Tilefish (golden), and Blueline Tilefish. SEDAR 22 Working Report S22-DW-16. 8p.

McCarthy, K. (2010). Discards of yellowedge grouper, golden tilefish, and blueline tilefish from commercial fishing vessels in the Gulf of Mexico. SEDAR 22 Working Report S16-DW-04. 5p.

Methot, R.D. 2000. Technical description of the stock synthesis assessment program. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-43, 46 p.

Methot R. 2010. User Manual for the Stock Synthesis Model Version 3.10b Feb 26, 2010. NOAA Fisheries Service Seattle, WA.

Methot R. and Taylor, I. 2010. Modeling the variability of recruitment in fishery assessment models. *unpublished MS*.

Orhun, M.R. (2010). Commercial Fishery Landings of Yellowedge Grouper, Golder Tilefish, and Blueline Tilefish for the Gulf of Mexico. SEDAR 22 Working Report S22-DW-17. 10p.

Prytherch, H. F. 1983. A descriptive survey of the bottom longline fishery in the Gulf of Mexico. NOAA technical memorandum. NMFS-SEFC-122.

Restrepo, V. R. G. G. Thompson, P. M. Mace,W. L. Gabriel, L. L. Low,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 approaches to implementing national atandard 1 of the Magnuson-Stevens Fishery Conservation and Management Act. NOAA Technical Memorandum NMFS-F/SPO.

Walter, J. F. M. Cook, B. Linton, L. Lombardi, and J.A. Quinlan 2010. Explorations of habitat associations of yellowedge grouper and golden tilefish. SEDAR22-DW-05.

3.3. ***COMPARISON OF SRA AND SS3***

Comparison of SRA and SS3 models provides analyses from two different assessment models; one with a high level of inputs and model complexity (SS3) and another with very low level of complexity (SRA).

The two models have very similar trajectories of biomass and fishing mortality over time (Figures 3.103 -3.105; Table 3.23). For SRA exploited biomass is plotted, while for SS3 the total biomass is shown which will tend to lead to slightly higher plotted values for SS3 versus SRA, though the general patterns should be comparable. For overall biomass, SRA and SS3 have very similar trajectories (Figure 3.103); the main difference is that the biomass estimated by SRA in the West is much lower than for SS3 (Figure 3.104) leading to lower total biomass.

Furthermore, trajectories of fishing mortality (here quantified as exploitation rates) are quite similar, and show the exact same pattern but with only slight scaling differences. These scaling differences in exploitation level are likely due to the signal that SS3 gets from age and length composition which suggests a slightly lower level of exploitation. In response, the SS3 model likely matches this lower level of exploitation through recruitment deviations. When recruitment deviations were turned off in SS3, the absolute levels for current exploitation rate come very close to the SRA estimates (green line in Figure 3.105).

When the SRA probability of overfishing is calculated as the proportion of MCMC runs in which U_{2009}/U_{MSY} is greater than 1.0, then the Gulf-wide probability of overfishing is 45.79% with the median value approximately 1 (Table 3.23). When the SRA probability of being overfished is calculated as the proportion of MCMC runs in which SSB_{2009}/SSB_{msy} is less than 1.0, then the Gulf-wide probability of being overfished is 99.96% with a median value of 0.48 (Table 3.23). Thus SRA results indicate that the stock is overfished but there is less than a 50% likelihood that the stock is undergoing overfishing. This result contrasts with the SS3 base model stock status as based upon SSB_{msy} which would indicate that the stock is not overfished but agrees with the SS3 fishing status which would suggest that overfishing is not occurring. However the AW panel decided not to use the estimated MSY-based proxies for fishing and biomass status so these comparisons are not particularly useful. A more useful comparison between the two models is for stock status at SSB 40% of virgin (or vulnerable biomass at 40% of virgin for SRA). In this case the relative stock status is in fairly close agreement $SSB/SSB_{40\%virgin}$ for SS3= 0.75 versus $VulnB2009/Vuln_{40\%virgin}$ =0.789 for SRA (Table 3.23).

Benchmark levels are fairly similar between the two models. SRA does not calculate the same $SPR_{30\%}$ or $SPR_{40\%}$ metrics, and so we compare metrics related to SSB_{msy}. Estimated values for MSY are also fairly similar between the two models though SS3 estimates higher MSY (SRA MSY = 356 MT; SS3 MSY = 375 MT). Exploitation at MSY is higher for SS3 (0.098) than for SRA (0.084) which could lead to the differences in estimated MSY values and to a rather substantial difference in the F/Fmsy. Since AW panel has chosen to use proxy benchmarks rather than MSY-related benchmarks for fishing status, the differences in F_{MSY} are not a substantial issue.

There are several differences in the basic inputs between SRA and SS3. SRA also only uses a single index for each model, whereas SS3 uses four separate indices. These differences in index trend would clearly lead to some differences in model results.

In conclusion, while there are some differences in benchmarks and in some of the basic inputs, the models still have quite similar results and appear to generally corroborate each other, or at least share the same biases.

3.4. ***TABLES***

Table 3.1. Life history parameter input values for the Stochastic SRA model for yellowedge grouper from the Gulf of Mexico.

Parameter	Definition	All	East	West
# ages	Number of age classes	85	85	85
Bhat 2009	Biomass in the last year	6.0E+06	6.0E+06	6.0E+06
SD Bhat	Standard Deviation Bhat	1.0E+08	1.0E+08	1.0E+08
Uhat 2009	Exploitation for the last year	0.10	0.10	0.10
SD Uhat	Standard Deviation of Uhat	0.02	0.02	0.02
SD rec	Standard Deviation of RecK	0.50	0.50	0.50
Rec rho	Recruitment Residuals	0	0	0
Future Catch	Amount of future landings (gutted lbs)	350,000	250,000	100,000
Ufuture	Future exploitation	NA	NA	NA
growth von B K	von Bertalanffy growth coefficient	0.06	0.04	0.08
growth Linfinity (cm)	von Bertalanffy asymptotic length	100.5	109.3	95.7
CV length age	Variation of length at age	0.08	0.08	0.08
length maturity (cm)	Length at maturity	55	55	55
wt (kg) at 100 cm	Size (weight) of fish at 100 cm	11	11	11
growth tzero	Size (length, cm) at time zero			
MSY min (gutted lbs)	Maximum Sustainable Yield Minimum	20,000	20,000	20,000
MSY max (gutted lbs)	Maximum Sustainable Yield Maximum	2,200,000	2,200,000	660,000
Umsy min	Minimum Exploitation at MSY	0.01	0.01	0.01
Umsy max	Maximum Exploitation at MSY	0.20	0.20	0.20
S min	Minimum Survivalship (S-0.02)	0.90	0.90	0.90
S max	Maximum Survivalship (S+0.02)	0.94	0.94	0.94

Table 3.2. Commercial catch histories (gutted pounds) for yellowedge grouper by region (East and West of Mississippi River) in the Gulf of Mexico.

Year	All	East	West
1975	465,084	351,630	113,454
1976	370,373	296,289	74,084
1977	316,000	255,015	60,985
1978	299,036	231,954	67,082
1979	454,845	343,702	111,143
1980	871,224	780,367	90,857
1981	2,729,984	1,817,100	912,884
1982	4,395,876	3,489,687	906,189
1983	3,475,474	2,711,290	764,184
1984	2,770,667	1,960,362	810,305
1985	2,061,894	1,273,278	788,616
1986	1,417,369	774,944	642,425
1987	1,183,788	682,770	501,018
1988	1,646,320	758,573	887,747
1989	740,507	340,196	400,311
1990	876,021	491,063	384,958
1991	770,975	413,762	357,213
1992	1,041,904	577,410	464,494
1993	776,411	380,506	395,905
1994	1,069,729	749,443	320,286
1995	841,948	438,620	403,328
1996	529,863	354,392	175,471
1997	720,139	576,983	143,156
1998	683,466	442,954	240,512
1999	972,954	661,636	311,318
2000	1,091,339	753,440	337,899
2001	777,001	556,849	220,152
2002	785,154	456,718	328,436
2003	1,103,576	707,504	396,072
2004	925,347	601,382	323,965
2005	787,416	495,389	292,027
2006	745,337	501,927	243,410
2007	868,478	703,205	165,273
2008	819,041	636,443	182,598
2009	828,547	574,220	254,327

Table 3.3. Yellowedge grouper vulnerabilities at age were provided from SS3 from logistic functions of age selectivities given size selectivities and size-at-age data (SS, Asel2). The same age vulnerabilities were used for all data combined and for each region. Vulnerabilities for age 41-85 were 0.9999.

Age	Vulnerability	Age	Vulnerability
1	0.01043	21	0.99942
2	0.02636	22	0.99951
3	0.06494	23	0.99964
4	0.15088	24	0.99971
5	0.31163	25	0.99978
6	0.47628	26	0.99982
7	0.64679	27	0.99986
8	0.78939	28	0.99989
9	0.88165	29	0.99991
10	0.93920	30	0.99995
11	0.96119	31	0.99997
12	0.97543	32	0.99998
13	0.98454	33	0.99990
14	0.99030	34	0.99990
15	0.99393	35	0.99990
16	0.99620	36	0.99990
17	0.99763	37	0.99990
18	0.99832	38	0.99990
19	0.99852	39	0.99990
20	0.99908	40	0.99990

Table 3.4. Commercial longline indices and coefficient of variation (CV) for yellowedge grouper. An increase in the uncertainty (1.96 * CV for all years) was necessary in the commercial longline index for all data combined for a satisfactory number of model iterations.

Year	All Index	All CV	East Index	East CV	West Index	West CV
1991	1.5161	0.22	1.7492	0.28	1.7058	0.18
1992	1.4491	0.22	1.4498	0.29	1.0857	0.27
1993	0.6216	0.24	0.3746	0.23	1.2382	0.23
1994	0.9122	0.18	0.7595	0.17	1.1920	0.23
1995	0.8147	0.19	0.7353	0.18	1.0055	0.27
1996	0.6683	0.21	0.7424	0.20	0.4616	0.53
1997	0.8689	0.17	0.9267	0.16	0.5727	0.44
1998	0.7477	0.19	0.6363	0.17	0.9614	0.28
1999	0.8234	0.18	0.7754	0.18	0.8682	0.3
2000	0.8352	0.17	0.9626	0.17	0.6273	0.4
2001	0.8057	0.17	0.7028	0.17	0.8941	0.3
2002	0.7838	0.18	0.8277	0.17	0.5931	0.43
2003	0.9215	0.16	0.9796	0.16	0.8562	0.32
2004	0.8545	0.18	0.8465	0.17	0.8778	0.32
2005	1.1361	0.17	1.1089	0.18	1.4626	0.21
2006	1.2203	0.16	1.2253	0.17	1.2059	0.25
2007	1.2897	0.16	1.4135	0.16	0.8155	0.37
2008	1.4852	0.17	1.6429	0.18	1.0943	0.27
2009	1.2458	0.17	1.1410	0.18	1.4820	0.21

Table 3.5. Vulnerable biomass (gutted pounds) trajectories by region for yellowedge grouper.

Year	All	East	West
1975	30,669,554	21,226,482	9,603,418
1976	30,131,491	20,608,235	9,105,831
1977	29,772,783	20,402,153	9,205,349
1978	29,414,075	19,783,906	9,105,831
1979	29,055,367	19,577,823	9,006,314
1980	28,517,304	19,577,823	8,857,038
1981	27,620,534	18,959,576	8,807,279
1982	24,571,514	17,104,835	7,911,624
1983	20,805,077	13,601,435	7,015,968
1984	16,679,933	11,128,447	6,269,589
1985	14,348,329	9,067,623	5,572,968
1986	12,913,496	8,449,376	4,876,347
1987	11,478,663	7,831,129	4,378,760
1988	11,119,955	6,800,718	3,980,691
1989	9,864,476	6,388,553	3,284,070
1990	9,326,414	6,388,553	2,985,518
1991	8,967,706	6,388,553	2,736,725
1992	8,608,998	6,182,471	2,587,449
1993	8,250,289	5,976,388	2,239,139
1994	8,070,935	6,182,471	2,089,863
1995	7,532,873	5,770,306	1,890,828
1996	7,353,519	5,770,306	1,691,794
1997	7,532,873	5,976,388	1,741,552
1998	7,891,581	5,976,388	1,791,311
1999	8,070,935	6,182,471	1,841,070
2000	7,532,873	6,182,471	1,741,552
2001	7,532,873	6,182,471	1,841,070
2002	7,891,581	6,388,553	2,040,104
2003	8,250,289	6,594,635	2,040,104
2004	8,070,935	6,388,553	1,990,346
2005	8,788,352	6,388,553	2,089,863
2006	8,967,706	6,800,718	2,139,622
2007	9,326,414	7,418,965	2,189,380
2008	9,505,768	7,006,800	2,338,656
2009	9,685,122	7,006,800	2,388,415

Table 3.6. Summarization of parameter estimates and benchmark values from SRA model runs. Reck values less than 0 have been removed.

		Min.	1st	Median	Mean	3rd	max
GOM	MSY (mt)	110	332	356	357	380	703
	Umsy	0.01	0.07	0.08	0.08	0.09	0.11
	Ucurrent	0.02	0.07	0.08	0.08	0.09	0.17
	U.2009.Umsy	0.24	0.83	0.98	0.99	1.14	3.49
	RecK	1.64	44.04	91.10	1662.00	218.70	785800000
	Btotal.2009 (mt)	2533	4478	5139	5413	6024	23350
	SSB.2009 (mt)	2026	3955	4598	4864	5459	21800
	SSBmsy (mt)	6431	8799	9521	9731	10420	26440
	SSB/SSBmsy	0.23	0.43	0.48	0.50	0.56	1.29
East	MSY (mt)	87	212	227	230	244	592
	Umsy	0.01	0.06	0.07	0.07	0.08	0.09
	Ucurrent	0.01	0.06	0.07	0.07	0.09	0.17
	U.2009.Umsy	0.17	0.85	1.04	1.05	1.23	3.61
	RecK	1.77	38.54	81.02	1041.00	204.20	347500000
	Btotal.2009 (mt)	1712	3289	3875	4211	4735	21910
	SSB.2009 (mt)	1495	3011	3587	3915	4428	21050
	SSBmsy (mt)	4976	6620	7198	7444	7974	24810
	SSB/SSBmsy	0.22	0.43	0.50	0.52	0.58	1.39
West	MSY (mt)	52	114	122	122	129	254
	Umsy	0.02	0.09	0.10	0.10	0.11	0.13
	Ucurrent	0.01	0.08	0.09	0.09	0.11	0.18
	U.2009.Umsy	0.18	0.83	0.96	0.98	1.10	3.14
	RecK	1.58	51.82	104.80	947.00	242.20	85530000
	Btotal.2009 (mt)	733	1262	1413	1466	1605	12150
	SSB.2009 (mt)	544	1034	1176	1227	1357	10930
	SSBmsy (mt)	1932	2559	2748	2798	2981	10320
	SSB/SSBmsy	0.20	0.38	0.43	0.44	0.49	1.39

Table 3.7. SRA probability of overfishing occurring and probability of being overfished based on the percentage of MCMC samples which meet the criteria. Note that these criteria are relative to the estimated MSY-based biomass and exploitation rates and may not be comparable to similar status results based on proxies for MSY.

	Overfishing	Overfished
	P(Ucurrent/Umsy)>1	P(SSBcurrent/SSBmsy)<1)=
GOM, overall	45.79%	99.96%
East	55.08%	99.75%
West	41.98%	99.99%

Table 3.8 List of the parameters (72) estimated in SS3 YEG model runs, initial guess estimates, low and upper bounds, and phase of estimation.

Num	Label	Value	phase of est	Min	Max	Init	Prior	PR type	Pr SD	Parm St Dev
1	NatM_p_1_Fem_GP_1	0.073	_	0.02	0.15	0.073	0.073	_	0.2	_
2	L_at_Amin_Fem_GP_1	5	_	0	40	5	5	_	0.8	_
3	L_at_Amax_Fem_GP_1	90.3104	3	70	120	84.3	84.3	_	0.8	1.02148
4	VonBert_K_Fem_GP_1	0.0781804	3	0.02	0.15	0.059	0.059	_	0.8	0.00175
5	CV_young_Fem_GP_1	0.1626	_	0.05	0.5	0.1626	0.1626	_	0.1	_
6	CV_old_Fem_GP_1	0.1165	_	0.05	0.5	0.1165	0.1165	_	0.1	_
7	NatM_p_1_Fem_GP_2	0.073	_	0.02	0.15	0.073	0.073	_	0.2	_
8	L_at_Amin_Fem_GP_2	5	_	0	40	5	5	_	0.8	_
9	L_at_Amax_Fem_GP_2	90.0159	3	70	120	84.3	84.3	_	0.8	1.35745
10	VonBert_K_Fem_GP_2	0.088926	3	0.02	0.15	0.059	0.059	_	0.8	0.00281
11	CV_young_Fem_GP_2	0.1626	_	0.05	0.5	0.1626	0.1626	_	0.1	_
12	CV_old_Fem_GP_2	0.1165	_	0.05	0.5	0.1165	0.1165	_	0.1	_
13	NatM_p_1_Mal_GP_1	0.073	_	0.02	0.15	0.073	0.073	_	0.2	_
14	L_at_Amin_Mal_GP_1	5	_	0	40	5	5	_	0.8	_
15	L_at_Amax_Mal_GP_1	91.5031	3	70	130	100.45	100.45	_	0.8	0.67957
16	VonBert_K_Mal_GP_1	0.091565	3	0.02	0.15	0.059	0.059	_	0.8	0.00308
17	CV_young_Mal_GP_1	0.1626	_	0.05	0.5	0.1626	0.1626	_	0.1	_
18	CV_old_Mal_GP_1	0.1165	_	0.05	0.5	0.1165	0.1165	_	0.1	_
19	NatM_p_1_Mal_GP_2	0.073	_	0.02	0.15	0.073	0.073	_	0.2	_
20	L_at_Amin_Mal_GP_2	5	_	0	40	5	5	_	0.8	_
21	L_at_Amax_Mal_GP_2	90.2071	3	70	130	100.45	100.45	_	0.8	0.87666
22	VonBert_K_Mal_GP_2	0.103095	3	0.02	0.15	0.059	0.059	_	0.8	0.00527
23	CV_young_Mal_GP_2	0.1626	_	0.05	0.5	0.1626	0.1626	_	0.1	_
24	CV_old_Mal_GP_2	0.1165	_	0.05	0.5	0.1165	0.1165	_	0.1	_
25	Wtlen_1_Fem	2.11E-05	_	1.8E-05	3.0E-05	2.1E-05	2.1E-05	_	0.2	_
26	Wtlen_2_Fem	2.91	_	2.5	3.8	2.91	2.91	_	0.2	_
27	Mat50%_Fem	55	_	54.2738	61.3098	55	55	_	0.8	_
28	Mat_slope_Fem	-0.33	_	-0.35	-0.15	-0.33	-0.33	_	0.8	_
29	Eggs_scalar_Fem	2.11E-05	_	1.8E-05	3.0E-05	2.1E-05	2.1E-05	_	0.2	_
30	Eggs_exp_len_Fem	2.91	_	2.5	3.8	2.91	2.91	_	0.2	_
31	Wtlen_1_Mal	2.11E-05	_	1.8E-05	3.0E-05	2.1E-05	2.1E-05	_	0.2	_
32	Wtlen_2_Mal	2.91	_	2.5	3.8	2.91	2.91	_	0.2	_
33	Herm_Infl_age	14.7895	4	12	70	41	41	_	0.0	2.51934
34	Herm_stdev	8.13726	4	5	20	14.63	14.63	_	0.0	2.13958
35	Herm_asymptote	0.0593376	4	0.04	0.8	0.470231	0.470231	_	0.0	0.01277
36	RecrDist_GP_1	0	_	-4	4	0	0	_	99.0	_
37	RecrDist_GP_2	0	_	-4	4	0	0	_	99.0	_
38	RecrDist_Area_1	1.70597	2	-5	4	1	1	_	0.0	0.0224
39	RecrDist_Area_2	1	_	-5	4	1	1	_	0.0	_
40	RecrDist_Seas_1	1	_	-4	4	1	1	_	0.0	_
41	CohortGrowDev	1	_	1	1	1	1	_	0.0	_
42	SR_R0	6.7221	1	4.5	16.5	8.5	8.5	_	0.8	0.01502
43	SR_steep	0.953466	1	0.4	0.99	0.6	0.8	sym beta	2.0	0.02474
44	SR_sigmaR	0.2	_	0	2	0.2	0.2	_	50.0	_
45	SR_envlink	0	_	-5	5	0	0	_	50.0	_
46	SR_R1_offset	0	_	-5	5	0	0	_	50.0	_
47	SR_autocorr	0	_	0	0.5	0	0	_	50.0	_
48	Main_InitAge_8	-0.361037	_	_	_	_	_	_	_	0.18686
49	Main_InitAge_7	-0.334663	_	_	_	_	_	_	_	0.19009
50	Main_InitAge_6	-0.280285	_	_	_	_	_	_	_	0.19519

51	Main_InitAge_5	-0.209984	_	_	_	_	_	_	_	0.20142
52	Main_InitAge_4	-0.135174	_	_	_	_	_	_	_	0.20751
53	Main_InitAge_3	-0.069856	_	_	_	_	_	_	_	0.21428
54	Main_InitAge_2	-0.017798	_	_	_	_	_	_	_	0.21919
55	Main_InitAge_1	-0.015861	_	_	_	_	_	_	_	0.22028
56	Main_RecrDev_1975	0.0043554	_	_	_	_	_	_	_	0.22123
57	Main_RecrDev_1976	-0.005954	_	_	_	_	_	_	_	0.21936
58	Main_RecrDev_1977	0.0275768	_	_	_	_	_	_	_	0.21986
59	Main_RecrDev_1978	0.0466933	_	_	_	_	_	_	_	0.21942
60	Main_RecrDev_1979	0.0822629	_	_	_	_	_	_	_	0.21555
61	Main_RecrDev_1980	0.0071192	_	_	_	_	_	_	_	0.21199
62	Main_RecrDev_1981	0.0391472	_	_	_	_	_	_	_	0.20674
63	Main_RecrDev_1982	-0.038168	_	_	_	_	_	_	_	0.20192
64	Main_RecrDev_1983	-0.064913	_	_	_	_	_	_	_	0.20155
65	Main_RecrDev_1984	0.0084711	_	_	_	_	_	_	_	0.2138
66	Main_RecrDev_1985	0.309394	_	_	_	_	_	_	_	0.21294
67	Main_RecrDev_1986	0.144204	_	_	_	_	_	_	_	0.21777
68	Main_RecrDev_1987	-0.090458	_	_	_	_	_	_	_	0.19578
69	Main_RecrDev_1988	-0.106895	_	_	_	_	_	_	_	0.18928
70	Main_RecrDev_1989	-0.058009	_	_	_	_	_	_	_	0.1871
71	Main_RecrDev_1990	-0.147741	_	_	_	_	_	_	_	0.19434
72	Main_RecrDev_1991	0.137369	_	_	_	_	_	_	_	0.20512
73	Main_RecrDev_1992	0.182089	_	_	_	_	_	_	_	0.24452
74	Main_RecrDev_1993	0.613172	_	_	_	_	_	_	_	0.22188
75	Main_RecrDev_1994	0.168829	_	_	_	_	_	_	_	0.242
76	Main_RecrDev_1995	-0.094834	_	_	_	_	_	_	_	0.20504
77	Main_RecrDev_1996	0.0591926	_	_	_	_	_	_	_	0.21422
78	Main_RecrDev_1997	0.351558	_	_	_	_	_	_	_	0.2128
79	Main_RecrDev_1998	0.0846531	_	_	_	_	_	_	_	0.21832
80	Main_RecrDev_1999	0.0107934	_	_	_	_	_	_	_	0.18892
81	Main_RecrDev_2000	-0.245251	_	_	_	_	_	_	_	0.16967
91	InitF_1COMMHL_E	0	_	0	1	0	0.01	_	99.0	_
92	InitF_2COMMHL_W	0	_	0	1	0	0.01	_	99.0	_
93	InitF_3COMMLL_E	0	_	0	1	0	0.01	_	99.0	_
94	InitF_4COMMLL_W	0	_	0	1	0	0.01	_	99.0	_
95	Q_base_1_COMMHL_E	-8.59974	1	-50	50	-8.6	-8.6	_	10.0	343094
96	Q_base_2_COMMHL_W	-8.59974	1	-50	50	-8.6	-8.6	_	10.0	343094
97	Q_base_3_COMMLL_E	-7.73004	1	-50	50	-8.6	-8.6	_	10.0	0.06575
98	Q_base_4_COMMLL_W	-7.23648	1	-50	50	-8.6	-8.6	_	10.0	0.08285
99	Q_base_5_NMFSBLL_E	-5.71696	1	-50	50	-8.6	-8.6	_	10.0	0.17863
100	Q_base_6_NMFSBLL_W	-5.44824	1	-50	50	-8.6	-8.6	_	10.0	0.18902
101	Q_base_7_NMFSTRW_E	-8.59974	1	-50	50	-8.6	-8.6	_	10.0	343094
102	Q_base_8_NMFSTRW_W	-8.59974	1	-50	50	-8.6	-8.6	_	10.0	343094
103	SizeSel_1P_1_COMMHL_E	51.1004	2	30.3	119.79	49.5	49.5	_	0.1	0.57439
104	SizeSel_1P_2_COMMHL_E	1.63588	2	-5	3	-1	-1	_	0.1	0.74686
105	SizeSel_1P_3_COMMHL_E	4.84476	2	-4	12	7.2	7.2	_	0.1	0.074
106	SizeSel_1P_4_COMMHL_E	-1.3684	2	-2	6	5.9	5.9	_	0.1	12.6528
107	SizeSel_1P_5_COMMHL_E	-6.6	_	-15	5	-6.6	-6.6	_	0.1	_
108	SizeSel_1P_6_COMMHL_E	-5.78729	2	-6	5	-0.9	-0.9	_	0.1	6.01217
109	SizeSel_2P_1_COMMHL_W	1	_	1	80	1	1	_	0.1	_
110	SizeSel_2P_2_COMMHL_W	-1	_	-1	80	-1	-1	_	0.1	_
111	SizeSel_3P_1_COMMLL_E	40	_	30	80	40	40	_	40.0	_
112	SizeSel_3P_2_COMMLL_E	20	_	10	30	20	20	_	20.0	_
113	SizeSel_4P_1_COMMLL_W	1	_	1	80	1	1	_	0.1	_
114	SizeSel_4P_2_COMMLL_W	-1	_	-1	80	-1	-1	_	0.1	_
115	SizeSel_5P_1_NMFSBLL_E	63.615	2	30	100	47.7058	47.7058	_	5.0	2.39521
116	SizeSel_5P_2_NMFSBLL_E	21.9002	2	10	50	10.5888	10.5888	_	5.0	2.10364

117	SizeSel_6P_1_NMFSBLL_W	1	_	1	80	1	1	_	0.1	_
118	SizeSel_6P_2_NMFSBLL_W	-1	_	-1	80	-1	-1	_	0.1	_
119	SizeSel_7P_1_NMFSTRW_E	14.7904	2	11	50	15	15	_	0.1	1.72637
120	SizeSel_7P_2_NMFSTRW_E	-9.60198	2	-10	3	-3.25	-3.25	_	0.1	10.6897
121	SizeSel_7P_3_NMFSTRW_E	3.14353	2	-7	12	2.5	2.5	_	0.1	1.73029
122	SizeSel_7P_4_NMFSTRW_E	4.40572	2	-3	8	5	5	_	0.1	0.42333
123	SizeSel_7P_5_NMFSTRW_E	-3.71177	2	-15	5	-3	-3	_	0.1	1.03631
124	SizeSel_7P_6_NMFSTRW_E	-3.77637	2	-10	1	-8	-8	_	0.1	0.6194
125	SizeSel_8P_1_NMFSTRW_W	1	_	1	80	1	1	_	0.1	_
126	SizeSel_8P_2_NMFSTRW_W	-1	_	-1	80	-1	-1	_	0.1	_
127	AgeSel_1P_1_COMMHL_E	0	_	0	40	0	5	_	99.0	_
128	AgeSel_1P_2_COMMHL_E	40	_	0	40	40	6	_	99.0	_
129	AgeSel_2P_1_COMMHL_W	0	_	0	40	0	5	_	99.0	_
130	AgeSel_2P_2_COMMHL_W	40	_	0	40	40	6	_	99.0	_
131	AgeSel_3P_1_COMMLL_E	0	_	0	40	0	5	_	99.0	_
132	AgeSel_3P_2_COMMLL_E	40	_	0	40	40	6	_	99.0	_
133	AgeSel_4P_1_COMMLL_W	0	_	0	40	0	5	_	99.0	_
134	AgeSel_4P_2_COMMLL_W	40	_	0	40	40	6	_	99.0	_
135	AgeSel_5P_1_NMFSBLL_E	0	_	0	40	0	5	_	99.0	_
136	AgeSel_5P_2_NMFSBLL_E	40	_	0	40	40	6	_	99.0	_
137	AgeSel_6P_1_NMFSBLL_W	0	_	0	40	0	5	_	99.0	_
138	AgeSel_6P_2_NMFSBLL_W	40	_	0	40	40	6	_	99.0	_
139	AgeSel_7P_1_NMFSTRW_E	0	_	0	40	0	5	_	99.0	_
140	AgeSel_7P_2_NMFSTRW_E	40	_	0	40	40	6	_	99.0	_
141	AgeSel_8P_1_NMFSTRW_W	0	_	0	40	0	5	_	99.0	_
142	AgeSel_8P_2_NMFSTRW_W	40	_	0	40	40	6	_	99.0	_
143	SizeSel_3P_1_COMMLL_ E BLK1mult_1975	0.222452	3	-15	1	0.1	0.1	sym beta	0.2	0.0135
144	SizeSel_3P_1_COMMLL_E BLK1mult_1986	0.351569	3	-15	1	0.1	0.1	sym beta	0.2	0.00802
145	SizeSel_3P_2_COMMLL_E BLK1mult_1975	-0.634473	3	-15	1	0.1	0.1	sym beta	0.2	0.08078
146	SizeSel_3P_2_COMMLL_E BLK1mult_1986	-0.140539	3	-15	1	0.1	0.1	sym beta	0.2	0.02413

Table 3.9. Description of model runs.

Type	number	RUN	Key characteristics	Key Result
scoping runs	1	Scoping sigma R	8 fixed values of sigma R (0.1-0.9), one free estimation	sigma R input should be ~0.2
	2	Profile on ref. age	4 fixed value for reference age (5,15, 20, 25) for Lorenzen M scaling	Reference age is sensitive; same as scaling M
	3	Scoping steepness	8 fixed values of steepness (0.3-0.99)	Model estimates steepness >0.9
Base and sensitivity runs	4	Base model results	4 growth curves, 4 fleets, 4 surveys, 2 sexes, 2 areas	presented in detail
	5	Update 2002 model	(1986-2009), assume zero equilibrium catch.	Results depend upon initial F
	6	Update 2002 model	(1986-2009), assume five year average equilibrium catch.	Results depend upon initial F
	7	no recruitment devs		Poorer fit due to no rec devs
	8	Three-area model	Originial three area, 6 growth curve model	Poor fit to CPUE, F is extremely high in South
	9	No sel.time-blocks	Single selectivity for comm LL	Poorer fit to model
	10	Estimate M	Estimate M for East and West	Better fit, model estimates M of 0.087 in East, 0.11 in West
	11	Low steepness (0.7)	input fixed steepness of 0.7	More pessimistic stock status
	12	no est. herm. parms	Fixed input herm parms	Poor model fit
sensitivity around base model	14	Low landings	Alternative partitioning of 1981-1985 landings in statistical area 6 and 7	Lower overall MSY, and other yields
	15	Low M	M=0.055	Poorer model fit, Lower MSY
	16	High M	M=0.099	Better model fit, Higher MSY

Table 3.10. Root mean square error versus input sigma R. The recommendation is to choose an input value of sigma R >= RMSE, hence the shaded region is the recommended value. When allowed to freely estimate sigmaR, the model tended towards the minimum value or either 0 or 0.01.

Input sigma R	Estimated Root Mean Square Error (RMSE) of recruitment deviations	RMSE / sigmaR	Likelihood
EstSigR, min 0, hits bound	0	0	13532.1*
EstSigR, min 0.01, hits bound	0.00156	0.0243	13433
0.1	0.082	0.677	13477.6
0.2	0.186	0.867	13484.2
0.3	0.344	1.312	13477.2
0.4	0.547	1.868	13470.9
0.5	0.779	2.429	13479.3
0.6	0.893	2.217	13465.6
0.8	1.189	2.21	13467.9
0.9	1.189	2.21	13469

*model estimating sigma r with a minimum value of 0, hit the min bound, had an exceptionally high gradient value and likely did not converge

Table 3.11. Derived quantities for sigmaR scoping runs.

	Est	sigr.1	sigr.2	sigr.3	sigr.4	sigr.5	sigr.6	sigr.8	sigr.9
TotBio_Unfished	13615	14644	14872	15207	15019	13965	14239	13351	13552
SPB_Virgin	12140	13029	13231	13547	13389	12452	12708	11932	12105
Recr_Virgin	847	829	840	864	855	781	805	740	758
SSB_B40%virgin	4856	5211	5292	5419	5356	4981	5083	4773	4842
SSB_SPR40%	4817	5136	5201	5294	5183	4795	4829	4474	4468
MSST	4465	4761	4821	4907	4805	4445	4476	4147	4142
SSB_MSY	1695	2290	2389	2576	2713	2589	2814	2765	2940
SPB_2009	1880	3522	3836	4400	4945	4980	5517	5654	6028
SSB/B40%virgin	0.387	0.676	0.725	0.812	0.923	1.000	1.085	1.185	1.245
SSB/SPR40%	0.390	0.686	0.737	0.831	0.954	1.039	1.142	1.264	1.349

SSB/MSST	0.421	0.740	0.796	0.897	1.029	1.120	1.232	1.363	1.455
SSB/MSY	1.109	1.538	1.606	1.708	1.823	1.923	1.960	2.045	2.050
Fstd_B40%virgin	0.041	0.047	0.047	0.047	0.046	0.046	0.045	0.044	0.043
Fstd_SPR40%	0.041	0.048	0.048	0.048	0.048	0.048	0.048	0.047	0.048
Fstd_MSY	0.108	0.102	0.099	0.094	0.088	0.086	0.080	0.075	0.071
F_2009	0.123	0.077	0.072	0.064	0.058	0.058	0.053	0.052	0.049
Yield B40%virgin	255	318	322	325	316	290	290	264	264
Yield_SPR40%	256	320	324	328	321	295	296	270	272
Yield_MSY	309	369	372	372	358	327	323	291	288

Table 3.12. Likelihood components for reference age for Lorenzen M scaling.

likelihood component	BaseRefAge5	BaseRefAge15	BaseRefAge20	BaseRefAge25
TOTAL	13846.8	13484.7	13436.5	13416.4
Catch	0	0	0	0
Equil_catch	0	0	0	0
Survey	-0.01	-22.63	-27.21	-29.21
Length_comp	4316.39	4223.96	4195.55	4181.48
Age_comp	9440.79	9308.43	9297.09	9293.67
Recruitment	83.28	-29.79	-32.9	-33.1
Forecast_Recruitment	0	0	0	0
Parm_priors	6.37	4.7	3.98	3.52
Parm_softbounds	0.01	0.01	0.01	0.01
Parm_devs	0	0	0	0
Crash_Pen	0	0	0	0

Table 3.13. Likelihood components for input values of steepness.

likelihood	Stp0.3	Stp0.4	Stp0.5	Stp0.6	Stp0.7	Stp0.8	Stp0.9	Stp0.99
TOTAL	13609.3	13562.2	13521.3	13494.7	13482.3	13474	13481.4	13479.5
Catch	0	0	0	0	0	0	0	0
Equil_catch	0	0	0	0	0	0	0	0
Survey	30.87	14.64	3.01	-7.49	-14.2	-18.86	-20.61	-24.14
Length_comp	4181.65	4186.01	4199.5	4194.03	4196.46	4197.63	4222.6	4201.41
Age_comp	9355.17	9341.17	9326.8	9326.98	9323.69	9321.47	9305.02	9317.05
Recruitment	38.33	4.11	-10.82	-20.68	-25.32	-28.11	-28.62	-31.06
Forecast_Rec	0	0	0	0	0	0	0	0
Parm_priors	3.25	16.22	2.78	1.85	1.63	1.9	2.97	16.23
Parm_softbounds	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Parm_devs	0	0	0	0	0	0	0	0
Crash_Pen	0	0	0	0	0	0	0	0

Table 3.14. Likelihood components for base and sensitivity runs.

component	YEG BASE Oct20	Update 86_09	Update 86_09 zeroeq	No Rec Devs	Three Area	No Sel Blocks	Est. M	Low Stp 0.7	No Est Herm Parms	BASE low Landing	LowM	HighM
TOTAL	13439	11582	11913	13507	15182	13471	13353	13442	13485	13445	13634	13375
Catch	0	0	0	0	0	0	0	0	0	0	0	0
Equil_catch	0	1.44	0	0	0	0	0	0	0	0	0	0
Survey	-23.7	-22.2	25.86	-14	-9.79	-21.7	-29.3	-15.5	-22.6	-7.01	-6.24	-30.4
Length_comp	4170	3399	3488	4172	4800	4197	4110	4150	4224	4146	4242	4133
Age_comp	9317	8196	8333	9344	10375	9319	9300	9330	9308	9318	9378	9300
Recruitment	-28.9	1.37	63.78	0	10.87	-26.9	-29.8	-24.4	-29.8	-17.6	14.85	-30.6
Forecast Rec.	0	0	0	0	0	0	0	0	0	0	0	0
Parm_priors	4.57	5.45	1.67	5.42	5.52	3.42	2.44	1.64	4.7	4.92	6.16	3.01
Parm bounds	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Parm_devs	0	0	0	0	0	0	0	0	0	0	0	0
Crash_Pen	0	0	0	0	0	0	0	0	0	0	0	0

Table 3.15. Predicted total biomass (mt), spawning biomass (mt), age-0 recruits (thousand fish), and fishing mortality for Gulf of Mexico YEG from the base model, asymptotic standard deviations based on inverting the hessian matrix are given in parentheses.

year	Total abundance (gutted MT)	Spawning biomass (gutted MT, males and females)	Recruitment (1000s)	Overall F
1975	15003	13288 (169.58)	814.99 (179.778)	0.014 (0.0002)
1976	15003	13058 (167.18)	804.93 (176.219)	0.012 (0.0001)
1977	14764	12856 (164.29)	830.37 (182.149)	0.01 (0.0001)
1978	14508	12669 (161.04)	845.97 (185.155)	0.01 (0.0001)
1979	14302	12486 (157.47)	876.22 (188.354)	0.015 (0.0002)
1980	14126	12242 (153.5)	812.65 (172.159)	0.029 (0.0003)
1981	13967	11831 (149.11)	838.33 (173.065)	0.093 (0.001)
1982	13746	10653 (144.11)	774.96 (156.48)	0.164 (0.002)
1983	13355	8815 (138.66)	752.44 (151.862)	0.154 (0.0021)
1984	12160	7416 (133.39)	807.13 (172.981)	0.142 (0.0022)
1985	10273	6356 (128.58)	1084.86 (230.374)	0.121 (0.0021)
1986	8844	5629 (124.53)	916.99 (199.478)	0.092 (0.0017)
1987	7770	5197 (121.36)	723.63 (142.016)	0.081 (0.0016)
1988	7038	4887 (119)	710 (134.706)	0.118 (0.0025)
1989	6621	4416 (117.04)	742.38 (139.234)	0.057 (0.0013)
1990	6334	4323 (116.27)	678.54 (132.355)	0.069 (0.0016)
1991	5866	4200 (115.98)	900.98 (185.271)	0.061 (0.0015)
1992	5808	4139 (116.47)	943.25 (231.291)	0.084 (0.0021)
1993	5707	3995 (117.57)	1441.31 (319.096)	0.064 (0.0017)
1994	5660	3969 (119.65)	928.71 (225.462)	0.089 (0.0024)
1995	5516	3845 (122.24)	712.43 (147.402)	0.071 (0.002)
1996	5494	3807 (125.6)	830.32 (179.063)	0.045 (0.0013)
1997	5372	3891 (129.62)	1111.61 (237.607)	0.06 (0.0018)
1998	5362	3906 (134.03)	854.06 (188.006)	0.056 (0.0018)
1999	5497	3942 (139.18)	793.92 (152.307)	0.078 (0.0026)
2000	5557	3886 (145.31)	627.24 (108.941)	0.088 (0.0031)
2001	5641	3806 (152.77)	799.4 (18.2768)	0.064 (0.0024)
2002	5606	3860 (161.59)	799.87 (18.1457)	0.064 (0.0025)
2003	5524	3919 (171.26)	800.37 (18.0088)	0.089 (0.0036)
2004	5569	3862 (181.46)	799.89 (18.2821)	0.076 (0.0033)
2005	5605	3868 (192.47)	799.94 (18.3403)	0.065 (0.003)
2006	5504	3922 (204.12)	800.39 (18.236)	0.062 (0.0029)
2007	5472	3984 (216.00)	800.9 (18.1072)	0.071 (0.0035)
2008	5494	3991 (227.56)	800.95 (18.1708)	0.068 (0.0034)
2009	5530	4002 (238.53)	801.05 (18.214)	0.068 (0.0036)

Table 3.16. Estimated numbers at age and sex by region, in thousands.

Region	sex	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
East	Fem.	1975	549.6	350.1	264.4	203.2	160.1	127.9	104.4	87.5	76.0	97.7	87.8	79.2	71.5	64.6	58.3	52.7	47.5	42.9	38.6	34.7	31.1	27.9	25.0	22.3	19.9	17.8	15.8	14.1	12.6	11.2	9.9	8.8	7.9	7.0	6.2	5.5	4.9	4.4	3.9	3.5	28.0
East	Fem.	1976	542.8	356.5	264.4	213.6	170.5	137.4	111.4	91.6	77.1	67.2	86.5	77.9	70.3	63.5	57.3	51.8	46.7	42.1	37.9	34.1	30.6	27.4	24.5	21.9	19.6	17.5	15.6	13.9	12.3	11.0	9.8	8.7	7.7	6.9	6.1	5.4	4.8	4.3	3.8	3.4	29.2
East	Fem.	1977	560.1	352.1	269.2	213.6	179.3	146.4	119.7	97.8	80.8	68.3	59.7	76.9	69.3	62.6	56.5	51.0	46.0	41.5	37.3	33.6	30.1	27.0	24.2	21.6	19.3	17.2	15.3	13.7	12.2	10.8	9.6	8.6	7.6	6.8	6.0	5.3	4.8	4.2	3.8	3.3	30.4
East	Fem.	1978	570.8	363.3	265.9	217.5	179.3	153.9	127.6	105.2	86.4	71.7	60.7	53.1	68.6	61.9	55.8	50.4	45.4	41.0	36.9	33.1	29.7	26.7	23.9	21.3	19.0	17.0	15.1	13.5	12.0	10.7	9.5	8.4	7.5	6.7	5.9	5.3	4.7	4.2	3.7	3.3	31.5
East	Fem.	1979	591.3	370.2	274.4	214.8	182.5	153.9	134.1	112.2	93.0	76.7	63.8	54.1	47.4	61.3	55.2	49.8	44.9	40.5	36.4	32.7	29.4	26.3	23.6	21.1	18.8	16.8	15.0	13.3	11.9	10.5	9.4	8.3	7.4	6.6	5.9	5.2	4.6	4.1	3.7	3.3	32.6
East	Fem.	1980	548.4	383.5	279.6	221.7	180.3	156.7	134.0	117.7	98.8	82.2	67.9	56.6	48.0	42.1	54.4	49.0	44.1	39.7	35.8	32.1	28.8	25.9	23.1	20.7	18.5	16.5	14.7	13.1	11.6	10.4	9.2	8.2	7.3	6.5	5.8	5.1	4.6	4.1	3.6	3.2	33.3
East	Fem.	1981	566.0	355.7	289.7	225.9	186.0	154.7	136.3	117.2	103.1	86.5	71.8	59.3	49.3	41.8	36.5	47.1	42.4	38.1	34.3	30.8	27.6	24.8	22.2	19.8	17.7	15.8	14.0	12.5	11.1	9.9	8.8	7.8	7.0	6.2	5.5	4.9	4.4	3.9	3.4	3.1	33.0
East	Fem.	1982	523.1	367.1	268.6	234.0	189.5	159.5	134.2	118.5	101.3	88.2	73.2	60.1	49.2	40.6	34.2	29.8	38.3	34.4	30.8	27.6	24.8	22.2	19.8	17.7	15.8	14.1	12.6	11.2	10.0	8.9	7.9	7.0	6.2	5.5	4.9	4.4	3.9	3.5	3.1	2.7	30.5
East	Fem.	1983	507.6	339.3	277.2	217.0	196.3	162.3	137.6	114.8	99.1	82.2	69.2	55.8	44.8	36.0	29.3	24.4	21.1	27.0	24.1	21.5	19.2	17.2	15.4	13.7	12.2	10.9	9.7	8.6	7.7	6.8	6.1	5.4	4.8	4.3	3.8	3.4	3.0	2.7	2.4	2.1	24.3
East	Fem.	1984	544.4	329.3	256.2	224.0	182.0	168.1	140.1	117.9	96.3	80.7	64.8	53.1	41.8	33.0	26.2	21.1	17.5	15.0	19.1	17.0	15.1	13.5	12.0	10.7	9.5	8.5	7.6	6.7	6.0	5.3	4.7	4.2	3.7	3.3	3.0	2.6	2.3	2.1	1.8	1.6	19.4
East	Fem.	1985	732.9	353.1	248.7	207.0	187.8	155.9	145.1	120.2	99.3	79.1	64.4	50.6	40.6	31.5	24.6	19.3	15.5	12.7	10.9	13.8	12.2	10.9	9.7	8.6	7.7	6.8	6.1	5.4	4.8	4.3	3.8	3.4	3.0	2.7	2.4	2.1	1.9	1.7	1.5	1.3	15.9
East	Fem.	1986	619.3	475.4	266.7	200.9	173.6	160.9	134.6	124.8	102.0	82.7	64.6	51.8	40.1	31.9	24.6	19.0	14.9	11.9	9.8	8.3	10.5	9.3	8.2	7.3	6.5	5.8	5.1	4.6	4.1	3.6	3.2	2.8	2.5	2.2	2.0	1.8	1.6	1.4	1.3	1.1	13.8
East	Fem.	1987	488.6	401.6	359.0	215.4	168.4	148.4	138.3	115.3	106.1	85.9	69.2	53.7	42.9	33.1	26.2	20.1	15.5	12.1	9.6	7.9	6.7	8.5	7.5	6.6	5.9	5.2	4.6	4.1	3.6	3.2	2.9	2.6	2.3	2.0	1.8	1.6	1.4	1.3	1.1	1.0	12.6
East	Fem.	1988	479.7	316.9	303.3	290.0	180.6	144.1	128.1	119.4	99.1	90.5	72.8	58.3	45.0	35.7	27.4	21.6	16.5	12.7	9.9	7.8	6.4	5.4	6.8	6.0	5.3	4.7	4.2	3.7	3.3	2.9	2.6	2.3	2.0	1.8	1.6	1.4	1.3	1.1	1.0	0.9	11.6
East	Fem.	1989	502.0	311.1	239.3	245.0	243.1	154.6	124.5	110.8	102.8	84.6	76.7	61.2	48.5	37.2	29.3	22.3	17.5	13.3	10.2	7.9	6.2	5.1	4.3	5.4	4.7	4.2	3.7	3.3	2.9	2.6	2.3	2.0	1.8	1.6	1.4	1.3	1.1	1.0	0.9	0.8	10.3
East	Fem.	1990	458.5	325.6	235.0	193.3	205.5	208.6	134.5	109.1	97.3	90.2	74.2	67.0	53.2	42.1	32.1	25.2	19.1	15.0	11.3	8.7	6.7	5.3	4.3	3.6	4.5	4.0	3.5	3.1	2.7	2.4	2.1	1.9	1.7	1.5	1.3	1.2	1.0	0.9	0.8	0.7	9.9
East	Fem.	1991	609.2	297.4	245.9	189.8	162.1	176.2	181.1	117.4	95.3	84.8	78.3	64.0	57.4	45.4	35.7	27.1	21.1	16.0	12.4	9.4	7.2	5.5	4.3	3.5	3.0	3.7	3.2	2.8	2.5	2.2	2.0	1.7	1.5	1.4	1.2	1.1	1.0	0.9	0.8	0.7	9.2
East	Fem.	1992	636.7	395.1	224.6	198.7	159.2	139.1	153.2	158.5	102.9	83.4	74.0	68.0	55.3	49.4	38.8	30.4	23.0	17.9	13.5	10.4	7.9	6.0	4.6	3.6	2.9	2.4	3.1	2.7	2.3	2.1	1.8	1.6	1.4	1.3	1.1	1.0	0.9	0.8	0.7	0.6	8.6
East	Fem.	1993	978.4	413.0	298.4	181.4	166.6	136.5	120.8	133.9	138.6	89.7	72.2	63.6	58.0	46.7	41.4	32.3	25.1	18.9	14.6	11.0	8.5	6.4	4.8	3.7	2.9	2.3	2.0	2.4	2.1	1.9	1.6	1.5	1.3	1.1	1.0	0.9	0.8	0.7	0.6	0.6	7.8
East	Fem.	1994	627.3	634.6	311.9	241.1	152.2	143.0	118.9	106.0	117.9	121.9	78.7	63.1	55.3	50.1	40.2	35.5	27.6	21.3	16.0	12.3	9.2	7.1	5.3	4.0	3.1	2.4	1.9	1.6	2.0	1.8	1.5	1.4	1.2	1.1	0.9	0.8	0.7	0.7	0.6	0.5	7.3
East	Fem.	1995	481.3	406.9	479.3	251.9	202.1	130.5	124.1	103.7	92.4	102.0	104.5	66.7	52.9	45.7	41.0	32.6	28.5	22.0	16.9	12.6	9.7	7.2	5.5	4.1	3.1	2.4	1.8	1.5	1.2	1.5	1.4	1.2	1.0	0.9	0.8	0.7	0.6	0.6	0.5	0.4	6.4
East	Fem.	1996	561.2	312.2	307.3	387.2	211.3	173.4	113.5	108.8	91.1	81.1	89.2	90.8	57.6	45.3	39.0	34.8	27.5	23.9	18.4	14.1	10.4	8.0	5.9	4.5	3.4	2.5	1.9	1.5	1.2	1.0	1.3	1.1	1.0	0.8	0.7	0.7	0.6	0.5	0.5	0.4	5.9
East	Fem.	1997	752.4	364.0	235.8	248.2	324.8	181.4	151.0	99.7	95.9	80.3	71.2	78.0	79.1	49.9	39.1	33.4	29.7	23.4	20.2	15.5	11.8	8.7	6.7	4.9	3.8	2.8	2.1	1.6	1.2	1.0	0.8	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.4	5.5
East	Fem.	1998	576.3	488.1	274.9	190.4	208.2	278.6	157.7	132.2	87.4	83.8	69.7	61.3	66.6	66.9	41.8	32.5	27.6	24.4	19.1	16.4	12.5	9.5	7.0	5.3	4.0	3.0	2.2	1.7	1.3	1.0	0.8	0.7	0.8	0.7	0.6	0.6	0.5	0.4	0.4	0.3	5.0
East	Fem.	1999	535.5	373.8	368.6	222.1	159.7	178.7	242.5	138.3	116.3	76.7	73.3	60.6	53.0	57.1	57.0	35.4	27.4	23.2	20.4	15.9	13.6	10.4	7.9	5.8	4.4	3.2	2.5	1.8	1.4	1.0	0.8	0.6	0.5	0.7	0.6	0.5	0.5	0.4	0.4	0.3	4.6
East	Fem.	2000	422.6	347.3	282.3	297.7	186.2	137.0	155.2	212.0	120.9	101.2	66.2	62.6	51.2	44.3	47.3	46.8	28.9	22.2	18.6	16.3	12.6	10.8	8.2	6.2	4.5	3.4	2.5	1.9	1.4	1.1	0.8	0.6	0.5	0.4	0.5	0.5	0.4	0.4	0.3	0.3	4.1
East	Fem.	2001	539.7	274.1	262.3	228.0	249.6	159.6	119.0	135.5	184.8	104.8	86.8	56.1	52.4	42.3	36.2	38.3	37.5	22.9	17.5	14.6	12.7	9.8	8.4	6.3	4.8	3.5	2.6	1.9	1.5	1.1	0.8	0.6	0.5	0.4	0.3	0.4	0.3	0.3	0.3	0.2	3.5
East	Fem.	2002	540.0	350.0	207.0	211.9	191.2	214.1	138.8	104.2	118.8	161.5	90.9	74.7	47.9	44.3	35.5	30.1	31.6	30.8	18.7	14.2	11.8	10.2	7.9	6.7	5.0	3.8	2.8	2.1	1.5	1.2	0.9	0.6	0.5	0.4	0.3	0.3	0.3	0.3	0.2	0.2	3.1
East	Fem.	2003	540.3	350.3	264.3	167.2	177.7	164.1	186.3	121.7	91.5	104.2	141.0	78.9	64.4	40.9	37.6	29.9	25.3	26.4	25.6	15.5	11.7	9.7	8.4	6.4	5.5	4.1	3.1	2.3	1.7	1.2	0.9	0.7	0.5	0.4	0.3	0.2	0.2	0.3	0.2	0.2	2.9
East	Fem.	2004	539.9	350.5	264.5	213.5	140.2	152.3	142.4	162.5	106.0	79.2	89.3	119.5	66.1	53.2	33.5	30.5	24.1	20.1	20.9	20.1	12.1	9.1	7.6	6.5	5.0	4.2	3.2	2.4	1.7	1.3	1.0	0.7	0.5	0.4	0.3	0.2	0.2	0.2	0.2	0.2	2.5
East	Fem.	2005	539.9	350.2	264.7	213.7	179.0	120.3	132.4	124.6	142.2	92.4	68.5	76.5	101.3	55.5	44.3	27.6	25.0	19.6	16.3	16.8	16.1	9.7	7.3	6.0	5.1	3.9	3.3	2.5	1.9	1.4	1.0	0.7	0.6	0.4	0.3	0.2	0.2	0.1	0.1	0.2	2.2
East	Fem.	2006	540.2	350.2	264.5	213.8	179.2	153.6	104.6	116.0	109.4	124.6	80.5	59.3	65.7	86.3	46.9	37.2	23.1	20.7	16.2	13.4	13.8	13.2	7.9	5.9	4.8	4.2	3.2	2.7	2.0	1.5	1.1	0.8	0.6	0.5	0.3	0.2	0.2	0.1	0.1	0.1	2.0
East	Fem.	2007	540.6	350.4	264.5	213.6	179.3	153.7	133.7	91.7	101.9	95.8	108.6	69.6	50.9	56.0	73.0	39.4	31.0	19.1	17.1	13.3	11.0	11.2	10.7	6.4	4.8	3.9	3.3	2.6	2.2	1.6	1.2	0.9	0.7	0.5	0.4	0.3	0.2	0.2	0.1	0.1	1.8
East	Fem.	2008	540.6	350.6	264.6	213.6	179.1	153.8	133.6	116.8	80.1	88.5	82.5	92.4	58.6	42.3	46.0	59.4	31.8	24.9	15.2	13.5	10.5	8.6	8.8	8.3	5.0	3.7	3.0	2.6	2.0	1.7	1.2	0.9	0.7	0.5	0.4	0.3	0.2	0.2	0.1	0.1	1.6
East	Fem.	2009	540.7	350.6	264.8	213.8	179.1	153.6	133.7	116.9	102.2	69.8	76.5	70.6	78.2	49.1	35.1	37.8	48.5	25.7	20.0	12.2	10.8	8.3	6.8	6.9	6.6	3.9	2.9	2.4	2.0	1.5	1.3	1.0	0.7	0.5	0.4	0.3	0.2	0.2	0.1	0.1	1.4
East	Male	1975	540.7	350.7	264.8	213.9	179.2	153.7	133.6	117.0	102.3	89.2	60.5	65.7	60.0	65.9	41.0	29.1	31.1	39.6	20.9	16.2	9.8	8.6	6.6	5.4	5.5	5.2	3.1	2.3	1.9	1.6	1.2	1.0	0.8	0.6	0.4	0.3	0.2	0.2	0.1	0.1	1.2
East	Male	1976	541.2	350.7	264.8	213.9	179.4	153.9	133.8	117.3	103.1	90.1	78.3	52.9	57.1	51.9	56.7	35.0	24.7	26.4	33.4	17.6	13.6	8.2	7.2	5.5	4.5	4.6	4.3	2.5	1.9	1.5	1.3	1.0	0.8	0.6	0.5	0.3	0.3	0.2	0.1	0.1	1.1
East	Male	1977	541.7	351.0	264.8	214.0	179.4	154.0	134.0	117.5	103.3	90.8	79.2	68.5	45.9	49.4	44.6	48.4	29.8	21.0	22.2	28.1	14.7	11.3	6.8	6.0	4.6	3.7	3.8	3.6	2.1	1.6	1.3	1.1	0.8	0.7	0.5	0.4	0.3	0.2	0.2	0.1	1.1
East	Male	1978	542.1	351.3	265.1	214.0	179.5	154.0	134.1	117.7	103.5	91.0	79.7	69.2	59.5	39.7	42.4	38.1	41.2	25.3	17.7	18.7	23.5	12.3	9.4	5.7	5.0	3.8	3.1	3.1	2.9	1.7	1.3	1.0	0.9	0.7	0.6	0.4	0.3	0.2	0.2	0.1	1.1
East	Male	1979	542.5	351.6	265.3	214.2	179.5	154.1	134.1	117.8	103.7	91.2	79.9	69.7	60.2	51.4	34.1	36.3	32.4	34.9	21.3	14.9	15.7	19.7	10.3	7.8	4.7	4.1	3.1	2.5	2.6	2.4	1.4	1.1	0.9	0.7	0.6	0.5	0.3	0.3	0.2	0.1	1.0
East	Male	1980	542.9	351.9	265.6	214.4	179.7	154.1	134.2	117.8	103.8	91.3	80.1	69.9	60.6	52.0	44.2	29.2	30.9	27.5	29.5	17.9	12.4	13.1	16.4	8.5	6.5	3.9	3.4	2.6	2.1	2.1	2.0	1.2	0.9	0.7	0.6	0.5	0.4	0.3	0.2	0.2	1.0
East	Male	1981	543.2	352.1	265.7	214.5	179.8	154.2	134.2	117.8	103.8	91.4	80.2	70.0	60.7	52.4	44.7	37.8	24.8	26.1	23.2	24.8	15.0	10.4	10.9	13.6	7.1	5.4	3.2	2.8	2.1	1.7	1.7	1.6	1.0	0.7	0.6	0.5	0.4	0.3	0.2	0.2	1.0
East	Male	1982	543.5	352.3	265.9	214.7	180.0	154.4	134.3	117.8	103.8	91.4	80.3	70.1	60.9	52.5	45.0	38.2	32.2	21.0	22.1	19.5	20.7	12.5	8.7	9.1	11.3	5.9	4.5	2.7	2.3	1.8	1.4	1.4	1.4	0.8	0.6	0.5	0.4	0.3	0.3	0.2	1.1
East	Male	1983	543.7	352.5	266.1	214.8	180.1	154.5	134.4	117.9	103.8	91.4	80.3	70.2	60.9	52.6	45.1	38.5	32.5	27.2	17.7	18.5	16.3	17.3	10.4	7.2	7.5	9.4	4.8	3.7	2.2	1.9	1.5	1.2	1.2	1.1	0.7	0.5	0.4	0.3	0.3	0.2	1.1
East	Male	1984	544.0	352.7	266.2	215.0	180.2	154.6	134.5	118.0	103.9	91.4	80.3	70.2	61.0	52.7	45.2	38.6	32.7	27.5	23.0	14.9	15.5	13.6	14.4	8.7	6.0	6.2	7.7	4.0	3.0	1.8	1.6	1.2	1.0	1.0	0.9	0.5	0.4	0.3	0.3	0.2	1.2
East	Male	1985	544.2	352.8	266.3	215.1	180.3	154.7	134.6	118.1	104.0	91.5	80.3	70.2	61.0	52.7	45.3	38.7	32.8	27.7	23.2	19.3	12.5	13.0	11.4	12.0	7.2	4.9	5.1	6.4	3.3	2.5	1.5	1.3	1.0	0.8	0.8	0.8	0.4	0.3	0.3	0.2	1.2
East	Male	1986	544.4	353.0	266.5	215.2	180.4	154.8	134.7	118.2	104.1	91.6	80.4	70.2	61.0	52.7	45.3	38.7	32.9	27.8	23.4	19.5	16.2	10.4	10.8	9.4	10.0	6.0	4.1	4.3	5.3	2.7	2.1	1.2	1.1	0.8	0.7	0.7	0.6	0.4	0.3	0.2	1.2
East	Male	1987	544.5	353.1	266.6	215.3	180.5	154.9	134.8	118.3	104.2	91.7	80.4	70.3	61.0	52.7	45.3	38.7	32.9	27.9	23.5	19.7	16.4	13.5	8.7	9.0	7.8	8.2	4.9	3.4	3.5	4.3	2.2	1.7	1.0	0.9	0.7	0.5	0.5	0.5	0.3	0.2	1.3
East	Male	1988	544.7	353.2	266.7	215.4	180.6	154.9	134.9	118.4	104.2	91.7	80.5	70.3	61.1	52.7	45.3	38.7	33.0	27.9	23.5	19.7	16.5	13.7	11.3	7.2	7.5	6.5	6.8	4.1	2.8	2.9	3.6	1.8	1.4	0.8	0.7	0.5	0.4	0.4	0.4	0.2	1.3
East	Male	1989	544.8	353.3	266.7	215.4	180.6	155.0	134.9	118.4	104.3	91.8	80.6	70.4	61.1	52.8	45.3	38.8	33.0	27.9	23.5	19.8	16.5	13.8	11.4	9.4	6.0	6.2	5.4	5.6	3.4	2.3	2.4	3.0	1.5	1.2	0.7	0.6	0.5	0.4	0.4	0.3	1.4
East	Male	1990	545.0	353.4	266.8	215.5	180.7	155.1	135.0	118.5	104.3	91.9	80.6	70.4	61.2	52.8	45.4	38.8	33.0	27.9	23.6	19.8	16.5	13.8	11.5	9.5	7.8	5.0	5.1	4.4	4.6	2.8	1.9	2.0	2.4	1.3	0.9	0.6	0.5	0.4	0.3	0.3	1.5
East	Male	1991	545.1	353.5	266.9	215.6	180.8	155.1	135.0	118.5	104.4	91.9	80.7	70.5	61.2	52.9	45.4	38.8	33.0	27.9	23.6	19.8	16.6	13.8	11.5	9.5	7.8	6.4	4.1	4.2	3.7	3.8	2.3	1.6	1.6	2.0	1.0	0.8	0.5	0.4	0.3	0.2	1.6
East	Male	1992	545.2	353.5	266.9	215.6	180.8	155.2	135.1	118.6	104.4	91.9	80.7	70.5	61.3	52.9	45.4	38.8	33.0	27.9	23.6	19.8	16.6	13.8	11.5	9.6	7.9	6.5	5.3	3.4	3.5	3.0	3.2	1.9	1.3	1.3	1.6	0.8	0.6	0.4	0.3	0.3	1.6
East	Male	1993	545.3	353.6	267.0	215.7	180.9	155.2	135.1	118.6	104.5	92.0	80.7	70.5	61.3	53.0	45.5	38.9	33.0	28.0	23.6	19.8	16.6	13.9	11.5	9.6	7.9	6.5	5.4	4.4	2.8	2.9	2.5	2.6	1.5	1.1	1.1	1.4	0.7	0.5	0.3	0.3	1.6
East	Male	1994	545.3	353.7	267.0	215.7	180.9	155.3	135.2	118.7	104.5	92.0	80.8	70.6	61.3	53.0	45.5	38.9	33.1	28.0	23.6	19.8	16.6	13.9	11.5	9.6	7.9	6.6	5.4	4.4	3.6	2.3	2.4	2.0	2.1	1.3	0.9	0.9	1.1	0.6	0.4	0.3	1.7
East	Male	1995	0.0	0.0	0.2	0.4	0.7	1.0	1.4	1.7	2.2	3.8	4.6	5.4	6.3	7.1	8.0	8.8	9.6	10.4	11.1	11.8	12.3	12.8	13.2	13.5	13.7	13.8	13.9	13.8	13.7	13.6	13.4	13.2	12.9	12.6	12.2	11.9	11.5	11.1	10.7	10.3	202.9
East	Male	1996	0.0	0.0	0.2	0.4	0.8	1.1	1.5	1.8	2.2	2.6	4.5	5.3	6.2	7.0	7.9	8.7	9.5	10.2	10.9	11.6	12.1	12.6	13.0	13.2	13.5	13.6	13.6	13.6	13.5	13.4	13.2	12.9	12.6	12.3	12.0	11.7	11.3	10.9	10.5	10.1	197.7
East	Male	1997	0.0	0.0	0.2	0.4	0.8	1.2	1.6	1.9	2.3	2.7	3.1	5.3	6.1	6.9	7.7	8.6	9.3	10.1	10.8	11.4	11.9	12.4	12.8	13.0	13.3	13.4	13.4	13.4	13.3	13.2	13.0	12.7	12.5	12.2	11.8	11.5	11.1	10.7	10.4	10.0	193.2
East	Male	1998	0.0	0.0	0.2	0.5	0.8	1.3	1.7	2.1	2.4	2.8	3.2	3.6	6.0	6.8	7.6	8.4	9.2	9.9	10.6	11.2	11.8	12.2	12.6	12.9	13.1	13.2	13.2	13.2	13.1	13.0	12.8	12.6	12.3	12.0	11.7	11.3	11.0	10.6	10.2	9.9	189.1
East	Male	1999	0.0	0.0	0.2	0.5	0.8	1.3	1.8	2.2	2.6	3.0	3.3	3.7	4.2	6.8	7.6	8.3	9.1	9.8	10.5	11.1	11.6	12.1	12.4	12.7	12.9	13.0	13.1	13.1	13.0	12.8	12.6	12.4	12.1	11.8	11.5	11.2	10.8	10.5	10.1	9.7	185.5

East	Male	2000	0.0	0.0	0.2	0.5	0.8	1.3	1.8	2.3	2.8	3.2	3.5	3.9	4.2	4.6	7.4	8.2	9.0	9.7	10.3	10.9	11.4	11.9	12.2	12.5	12.7	12.8	12.8	12.8	12.7	12.6	12.4	12.2	11.9	11.6	11.3	11.0	10.6	10.3	9.9	9.6	180.8
East	Male	2001	0.0	0.0	0.2	0.5	0.8	1.3	1.8	2.3	2.9	3.4	3.7	4.0	4.3	4.6	5.0	7.9	8.6	9.3	9.9	10.4	10.9	11.3	11.7	12.0	12.1	12.3	12.3	12.3	12.2	12.1	11.9	11.7	11.4	11.1	10.8	10.5	10.2	9.8	9.5	9.2	171.9
East	Male	2002	0.0	0.0	0.2	0.5	0.9	1.3	1.8	2.3	2.8	3.4	3.7	4.0	4.2	4.4	4.6	5.0	7.7	8.3	8.9	9.3	9.8	10.2	10.5	10.7	10.9	11.0	11.0	11.0	10.9	10.8	10.6	10.4	10.2	10.0	9.7	9.4	9.1	8.8	8.5	8.2	152.7
East	Male	2003	0.0	0.0	0.2	0.5	0.9	1.3	1.8	2.2	2.7	3.0	3.4	3.6	3.8	3.8	3.9	4.0	4.2	6.5	6.9	7.2	7.6	7.8	8.1	8.3	8.4	8.5	8.5	8.5	8.4	8.3	8.2	8.0	7.9	7.7	7.5	7.2	7.0	6.8	6.5	6.3	117.0
East	Male	2004	0.0	0.0	0.2	0.5	0.8	1.4	1.8	2.3	2.6	2.9	3.1	3.4	3.4	3.4	3.4	3.4	3.4	3.6	5.4	5.7	5.9	6.1	6.3	6.4	6.5	6.6	6.6	6.6	6.5	6.5	6.4	6.3	6.1	6.0	5.8	5.6	5.5	5.3	5.1	4.9	90.4
East	Male	2005	0.0	0.0	0.2	0.4	0.9	1.3	1.9	2.3	2.7	2.9	3.1	3.2	3.3	3.2	3.2	3.1	3.0	3.0	3.1	4.6	4.8	4.9	5.1	5.2	5.2	5.3	5.3	5.3	5.2	5.2	5.1	5.0	4.9	4.8	4.6	4.5	4.4	4.2	4.1	3.9	71.9
East	Male	2006	0.0	0.0	0.2	0.4	0.8	1.3	1.7	2.4	2.8	3.0	3.1	3.2	3.2	3.2	3.1	3.0	2.9	2.8	2.7	2.8	4.1	4.2	4.3	4.4	4.4	4.5	4.5	4.5	4.4	4.4	4.3	4.2	4.1	4.0	3.9	3.8	3.7	3.6	3.4	3.3	60.5
East	Male	2007	0.0	0.0	0.2	0.5	0.8	1.2	1.8	2.2	2.9	3.2	3.4	3.4	3.5	3.4	3.3	3.2	3.0	2.8	2.7	2.6	2.6	3.8	3.9	3.9	4.0	4.0	4.0	4.0	4.0	3.9	3.9	3.8	3.7	3.6	3.5	3.4	3.3	3.2	3.1	3.0	53.9
East	Male	2008	0.0	0.0	0.2	0.6	0.8	1.2	1.7	2.3	2.7	3.4	3.6	3.8	3.7	3.7	3.5	3.4	3.2	2.9	2.7	2.6	2.5	2.4	3.5	3.6	3.6	3.6	3.6	3.6	3.6	3.5	3.5	3.4	3.3	3.2	3.2	3.1	3.0	2.9	2.8	2.7	48.1
East	Male	2009	0.0	0.0	0.2	0.5	1.1	1.3	1.6	2.2	2.8	3.2	3.9	4.0	4.0	3.8	3.7	3.5	3.3	3.0	2.8	2.6	2.4	2.3	2.2	3.2	3.2	3.2	3.2	3.2	3.1	3.1	3.0	3.0	2.9	2.8	2.8	2.7	2.6	2.5	2.4	2.3	42.0
West	Fem.	1975	0.0	0.0	0.2	0.4	0.9	1.7	1.8	2.1	2.7	3.4	3.8	4.4	4.5	4.4	4.1	4.0	3.6	3.4	3.1	2.8	2.5	2.3	2.2	2.1	3.0	3.0	3.0	3.0	3.0	2.9	2.9	2.8	2.7	2.7	2.6	2.5	2.4	2.4	2.3	2.2	39.2
West	Fem.	1976	0.0	0.0	0.2	0.4	0.7	1.4	2.4	2.3	2.7	3.2	4.0	4.2	4.8	4.8	4.6	4.3	4.0	3.7	3.4	3.0	2.7	2.4	2.2	2.1	2.0	2.8	2.8	2.8	2.7	2.7	2.6	2.6	2.5	2.4	2.4	2.3	2.2	2.2	2.1	2.0	35.6
West	Fem.	1977	0.0	0.0	0.1	0.4	0.7	1.1	2.0	3.1	2.9	3.2	3.8	4.5	4.7	5.2	5.1	4.8	4.4	4.1	3.7	3.3	3.0	2.6	2.3	2.1	1.9	1.9	2.6	2.6	2.5	2.5	2.4	2.4	2.3	2.3	2.2	2.1	2.1	2.0	1.9	1.8	32.8
West	Fem.	1978	0.0	0.0	0.2	0.4	0.8	1.1	1.6	2.6	3.9	3.4	3.7	4.2	4.9	4.9	5.4	5.1	4.8	4.3	4.0	3.5	3.2	2.8	2.4	2.1	1.9	1.8	1.7	2.3	2.3	2.2	2.2	2.1	2.1	2.0	2.0	1.9	1.8	1.8	1.7	1.7	29.2
West	Fem.	1979	0.0	0.0	0.2	0.5	0.7	1.2	1.6	2.1	3.3	4.7	4.0	4.2	4.7	5.3	5.3	5.7	5.3	4.9	4.4	3.9	3.4	3.1	2.7	2.3	2.0	1.8	1.6	1.5	2.2	2.1	2.0	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.6	1.5	26.9
West	Fem.	1980	0.0	0.0	0.3	0.5	0.9	1.1	1.6	2.0	2.6	3.9	5.3	4.4	4.4	4.8	5.3	5.2	5.5	5.1	4.6	4.0	3.6	3.1	2.8	2.4	2.0	1.8	1.6	1.4	1.3	1.8	1.8	1.7	1.7	1.6	1.6	1.5	1.5	1.4	1.4	1.3	23.1
West	Fem.	1981	0.0	0.0	0.2	0.8	1.0	1.4	1.5	2.1	2.6	3.1	4.5	6.0	4.8	4.8	5.1	5.5	5.3	5.5	5.0	4.5	3.9	3.5	3.0	2.6	2.2	1.9	1.6	1.4	1.3	1.2	1.7	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.2	21.0
West	Fem.	1982	0.0	0.0	0.2	0.5	1.5	1.5	2.0	2.0	2.7	3.1	3.6	5.2	6.7	5.3	5.1	5.3	5.7	5.4	5.5	5.0	4.4	3.8	3.3	2.8	2.5	2.1	1.8	1.5	1.3	1.2	1.1	1.5	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.1	19.5
West	Fem.	1983	0.0	0.0	0.2	0.4	0.9	2.3	2.1	2.6	2.4	3.2	3.5	4.1	5.6	7.0	5.4	5.2	5.3	5.6	5.2	5.3	4.7	4.1	3.5	3.1	2.6	2.2	1.9	1.6	1.3	1.2	1.0	1.0	1.3	1.3	1.2	1.2	1.1	1.1	1.0	1.0	17.3
West	Fem.	1984	0.0	0.0	0.2	0.5	0.7	1.5	3.2	2.7	3.3	2.9	3.7	4.0	4.5	6.0	7.4	5.6	5.3	5.3	5.6	5.1	5.1	4.5	3.9	3.3	2.9	2.4	2.1	1.7	1.4	1.2	1.0	0.9	0.9	1.2	1.1	1.1	1.0	1.0	1.0	0.9	15.7
West	Fem.	1985	0.0	0.0	0.2	0.6	0.8	1.1	2.0	4.2	3.4	3.9	3.4	4.1	4.3	4.7	6.1	7.4	5.5	5.1	5.1	5.2	4.7	4.7	4.1	3.5	3.0	2.5	2.1	1.8	1.5	1.2	1.0	0.9	0.8	0.7	1.0	1.0	0.9	0.9	0.8	0.8	13.7
West	Fem.	1986	0.0	0.0	0.2	0.5	1.1	1.3	1.6	2.7	5.2	4.0	4.4	3.7	4.4	4.4	4.7	6.0	7.1	5.2	4.7	4.7	4.7	4.3	4.2	3.6	3.1	2.6	2.2	1.8	1.5	1.3	1.0	0.9	0.8	0.7	0.6	0.8	0.8	0.8	0.7	0.7	11.7
West	Fem.	1987	0.0	0.0	0.1	0.4	0.9	1.7	1.8	2.0	3.3	6.2	4.6	4.9	4.0	4.6	4.6	4.7	6.0	7.0	5.1	4.5	4.4	4.4	3.9	3.8	3.3	2.8	2.3	1.9	1.6	1.4	1.1	0.9	0.8	0.7	0.6	0.5	0.7	0.7	0.6	0.6	10.3
West	Fem.	1988	0.0	0.0	0.2	0.4	0.8	1.3	2.4	2.4	2.6	4.0	7.2	5.2	5.4	4.3	4.9	4.7	4.8	6.0	6.9	4.9	4.4	4.2	4.2	3.7	3.6	3.0	2.6	2.1	1.8	1.4	1.2	1.0	0.8	0.7	0.6	0.5	0.5	0.6	0.6	0.6	9.4
West	Fem.	1989	0.0	0.0	0.2	0.4	0.6	1.2	1.9	3.2	3.0	3.0	4.5	7.8	5.5	5.5	4.3	4.8	4.6	4.6	5.6	6.4	4.5	3.9	3.8	3.7	3.2	3.1	2.6	2.2	1.8	1.5	1.2	1.0	0.8	0.7	0.6	0.5	0.4	0.4	0.5	0.5	8.1
West	Fem.	1990	0.0	0.0	0.2	0.4	0.8	1.0	1.7	2.4	4.0	3.5	3.5	5.0	8.4	5.8	5.7	4.3	4.7	4.4	4.4	5.3	6.0	4.2	3.6	3.4	3.3	2.9	2.8	2.3	1.9	1.6	1.3	1.1	0.9	0.7	0.6	0.5	0.4	0.4	0.3	0.4	7.1
West	Fem.	1991	0.0	0.0	0.2	0.4	0.8	1.2	1.4	2.3	3.1	4.8	4.1	3.9	5.5	9.0	6.0	5.8	4.4	4.7	4.4	4.3	5.1	5.7	3.9	3.4	3.1	3.1	2.6	2.5	2.1	1.7	1.4	1.2	0.9	0.8	0.6	0.5	0.4	0.4	0.3	0.3	6.4
West	Fem.	1992	0.0	0.0	0.2	0.4	0.8	1.3	1.8	1.8	2.9	3.7	5.5	4.6	4.3	5.9	9.4	6.2	5.9	4.4	4.6	4.2	4.1	4.8	5.3	3.6	3.1	2.9	2.8	2.4	2.2	1.9	1.5	1.2	1.0	0.8	0.7	0.6	0.4	0.4	0.3	0.3	5.7
West	Fem.	1993	0.0	0.0	0.2	0.4	0.8	1.3	1.8	2.3	2.2	3.4	4.2	6.1	4.9	4.4	5.9	9.3	6.0	5.6	4.1	4.3	3.9	3.7	4.3	4.7	3.2	2.7	2.5	2.4	2.0	1.9	1.6	1.3	1.0	0.9	0.7	0.6	0.5	0.4	0.3	0.3	4.8
West	Fem.	1994	0.0	0.0	0.2	0.4	0.8	1.2	1.8	2.3	2.9	2.7	3.9	4.6	6.5	5.1	4.5	5.9	9.2	5.8	5.4	3.9	4.0	3.6	3.4	3.9	4.2	2.9	2.4	2.2	2.1	1.8	1.7	1.4	1.1	0.9	0.7	0.6	0.5	0.4	0.3	0.3	4.2
West	Fem.	1995	0.0	0.0	0.2	0.4	0.8	1.2	1.8	2.3	2.9	3.4	3.1	4.3	5.0	6.9	5.3	4.6	5.9	9.0	5.6	5.1	3.6	3.7	3.3	3.1	3.6	3.8	2.6	2.1	1.9	1.8	1.5	1.4	1.2	1.0	0.8	0.6	0.5	0.4	0.3	0.3	3.7
West	Fem.	1996	0.0	0.0	0.2	0.4	0.8	1.3	1.8	2.3	2.9	3.5	4.0	3.5	4.8	5.4	7.3	5.5	4.7	6.0	9.0	5.6	5.0	3.5	3.6	3.1	2.9	3.3	3.6	2.4	2.0	1.8	1.7	1.4	1.3	1.1	0.9	0.7	0.6	0.5	0.4	0.3	3.5
West	Fem.	1997	0.0	0.0	0.2	0.4	0.8	1.3	1.8	2.3	2.9	3.5	4.0	4.5	3.9	5.2	5.8	7.7	5.7	4.8	6.0	8.9	5.5	4.9	3.4	3.4	3.0	2.7	3.1	3.3	2.2	1.8	1.6	1.5	1.3	1.2	1.0	0.8	0.6	0.5	0.4	0.3	3.3
West	Fem.	1998	0.0	0.0	0.2	0.4	0.8	1.3	1.8	2.3	2.9	3.5	4.1	4.6	5.0	4.2	5.5	6.1	7.9	5.8	4.8	6.0	8.8	5.3	4.7	3.2	3.2	2.8	2.5	2.9	3.0	2.0	1.6	1.5	1.4	1.2	1.1	0.9	0.7	0.6	0.5	0.4	3.2
West	Fem.	1999	0.0	0.0	0.2	0.4	0.8	1.3	1.8	2.3	2.9	3.5	4.1	4.6	5.1	5.5	4.5	5.8	6.2	8.0	5.8	4.8	5.9	8.5	5.1	4.5	3.1	3.0	2.6	2.4	2.7	2.8	1.8	1.5	1.3	1.3	1.0	1.0	0.8	0.6	0.5	0.4	3.1
West	Fem.	2000	0.0	0.0	0.2	0.4	0.8	1.3	1.8	2.3	2.9	3.5	4.1	4.7	5.1	5.5	5.8	4.7	6.0	6.3	8.1	5.8	4.7	5.7	8.2	4.9	4.2	2.9	2.8	2.4	2.2	2.4	2.6	1.7	1.4	1.2	1.1	0.9	0.9	0.7	0.6	0.4	3.0
West	Fem.	2001	0.0	0.0	0.2	0.4	0.8	1.3	1.8	2.3	2.9	3.5	4.1	4.7	5.2	5.6	5.9	6.1	4.8	6.0	6.4	8.0	5.6	4.5	5.5	7.8	4.6	4.0	2.7	2.6	2.2	2.0	2.2	2.3	1.5	1.2	1.1	1.0	0.8	0.8	0.6	0.5	3.0
West	Fem.	2002	0.0	0.0	0.2	0.5	0.8	1.3	1.8	2.3	2.9	3.5	4.1	4.7	5.2	5.6	5.9	6.1	6.2	4.9	6.1	6.3	7.8	5.5	4.3	5.2	7.4	4.3	3.7	2.5	2.4	2.0	1.8	2.0	2.1	1.4	1.1	1.0	0.9	0.8	0.7	0.6	3.1
West	Fem.	2003	0.0	0.0	0.2	0.5	0.8	1.3	1.8	2.3	2.9	3.5	4.1	4.7	5.2	5.6	5.9	6.2	6.3	6.3	4.9	6.0	6.2	7.6	5.2	4.1	4.9	6.9	4.0	3.4	2.3	2.2	1.9	1.7	1.8	1.9	1.2	1.0	0.9	0.8	0.7	0.6	3.2
West	Fem.	2004	0.0	0.0	0.2	0.5	0.8	1.3	1.8	2.3	2.9	3.5	4.1	4.7	5.2	5.6	6.0	6.2	6.4	6.4	6.3	4.8	5.9	6.0	7.3	5.0	3.9	4.6	6.4	3.7	3.2	2.1	2.0	1.7	1.5	1.7	1.7	1.1	0.9	0.8	0.7	0.6	3.3
West	Fem.	2005	0.0	0.0	0.2	0.5	0.8	1.3	1.8	2.3	2.9	3.5	4.1	4.7	5.2	5.6	6.0	6.2	6.4	6.5	6.4	6.3	4.7	5.7	5.7	6.9	4.7	3.7	4.3	6.0	3.4	2.9	1.9	1.8	1.5	1.4	1.5	1.5	1.0	0.8	0.7	0.7	3.4
West	Fem.	2006	0.0	0.0	0.2	0.5	0.8	1.3	1.8	2.3	2.9	3.5	4.1	4.7	5.2	5.6	6.0	6.2	6.4	6.5	6.5	6.3	6.1	4.6	5.5	5.5	6.5	4.4	3.4	4.0	5.5	3.2	2.7	1.7	1.7	1.4	1.2	1.4	1.4	0.9	0.7	0.6	3.5
West	Fem.	2007	0.0	0.0	0.2	0.5	0.8	1.3	1.8	2.3	2.9	3.5	4.1	4.7	5.2	5.6	6.0	6.2	6.4	6.5	6.5	6.4	6.2	5.9	4.4	5.2	5.2	6.1	4.1	3.2	3.7	5.1	2.9	2.4	1.6	1.5	1.3	1.1	1.2	1.2	0.8	0.6	3.6
West	Fem.	2008	0.0	0.0	0.2	0.5	0.8	1.3	1.8	2.3	2.9	3.5	4.1	4.7	5.2	5.6	6.0	6.2	6.4	6.5	6.5	6.4	6.2	6.0	5.7	4.2	4.9	4.8	5.7	3.8	2.9	3.4	4.6	2.6	2.2	1.4	1.4	1.1	1.0	1.1	1.1	0.7	3.7
West	Fem.	2009	0.0	0.0	0.2	0.5	0.8	1.3	1.8	2.3	2.9	3.5	4.1	4.7	5.2	5.6	6.0	6.2	6.4	6.5	6.5	6.4	6.3	6.0	5.8	5.4	4.0	4.6	4.5	5.3	3.5	2.7	3.1	4.2	2.4	2.0	1.3	1.2	1.0	0.9	1.0	1.0	3.9
West	Male	1975	0.0	0.0	0.2	0.5	0.8	1.3	1.8	2.3	2.9	3.5	4.1	4.7	5.2	5.6	6.0	6.2	6.4	6.5	6.5	6.4	6.3	6.1	5.8	5.5	5.1	3.7	4.3	4.2	4.9	3.2	2.4	2.8	3.8	2.2	1.8	1.2	1.1	0.9	0.8	0.9	4.2
West	Male	1976	0.0	0.0	0.2	0.5	0.8	1.3	1.8	2.3	2.9	3.5	4.1	4.7	5.2	5.6	6.0	6.2	6.4	6.5	6.5	6.4	6.3	6.1	5.8	5.5	5.2	4.8	3.5	4.0	3.8	4.5	3.0	2.2	2.5	3.4	1.9	1.6	1.0	1.0	0.8	0.7	4.4
West	Male	1977	0.0	0.0	0.2	0.5	0.8	1.3	1.8	2.3	2.9	3.5	4.1	4.7	5.2	5.6	6.0	6.2	6.4	6.5	6.5	6.4	6.3	6.1	5.8	5.5	5.2	4.9	4.5	3.2	3.7	3.5	4.1	2.7	2.0	2.3	3.1	1.7	1.4	0.9	0.9	0.7	4.5
West	Male	1978	0.0	0.0	0.2	0.5	0.8	1.3	1.8	2.3	2.9	3.5	4.1	4.7	5.2	5.6	6.0	6.3	6.4	6.5	6.5	6.4	6.3	6.1	5.8	5.6	5.2	4.9	4.5	4.1	2.9	3.4	3.2	3.7	2.4	1.8	2.1	2.8	1.6	1.3	0.8	0.8	4.5
West	Male	1979	0.0	0.0	0.2	0.5	0.8	1.3	1.8	2.3	2.9	3.5	4.1	4.7	5.2	5.6	6.0	6.3	6.4	6.5	6.5	6.4	6.3	6.1	5.8	5.6	5.2	4.9	4.6	4.2	3.8	2.7	3.1	2.9	3.4	2.2	1.6	1.9	2.5	1.4	1.2	0.7	4.6
West	Male	1980	271.3	173.8	132.3	102.4	81.1	65.1	53.3	44.8	39.1	50.3	45.3	40.9	36.9	33.4	30.2	27.3	24.6	22.2	20.0	17.9	16.1	14.4	12.9	11.5	10.3	9.1	8.1	7.2	6.4	5.7	5.1	4.5	4.0	3.5	3.1	2.8	2.5	2.2	1.9	1.7	13.7
West	Male	1981	267.9	176.9	132.3	107.6	86.4	69.9	56.9	47.0	39.7	34.7	44.9	40.5	36.6	33.1	29.9	27.0	24.4	22.0	19.8	17.7	15.9	14.3	12.7	11.4	10.2	9.0	8.0	7.2	6.4	5.6	5.0	4.5	4.0	3.5	3.1	2.8	2.4	2.2	1.9	1.7	14.4
West	Male	1982	276.5	174.7	134.7	107.6	90.8	74.5	61.2	50.2	41.7	35.4	31.1	40.2	36.3	32.8	29.7	26.8	24.2	21.8	19.6	17.6	15.8	14.2	12.7	11.3	10.1	9.0	8.0	7.1	6.3	5.6	5.0	4.4	3.9	3.5	3.1	2.7	2.4	2.2	1.9	1.7	15.1
West	Male	1983	281.7	180.3	133.0	109.6	90.8	78.4	65.2	54.0	44.7	37.3	31.8	27.9	36.2	32.7	29.5	26.7	24.1	21.7	19.5	17.5	15.7	14.1	12.6	11.2	10.0	8.9	7.9	7.1	6.3	5.6	5.0	4.4	3.9	3.5	3.1	2.7	2.4	2.1	1.9	1.7	15.8
West	Male	1984	291.9	183.7	137.3	108.2	92.5	78.4	68.6	57.6	48.0	39.9	33.4	28.5	25.1	32.5	29.3	26.5	23.9	21.5	19.4	17.4	15.6	14.0	12.5	11.2	10.0	8.9	7.9	7.0	6.2	5.5	4.9	4.4	3.9	3.4	3.1	2.7	2.4	2.1	1.9	1.7	16.4
West	Male	1985	270.7	190.4	139.9	111.7	91.3	79.8	68.5	60.5	51.1	42.8	35.6	29.8	25.5	22.4	29.1	26.2	23.7	21.3	19.2	17.2	15.5	13.8	12.4	11.1	9.9	8.8	7.8	6.9	6.2	5.5	4.9	4.3	3.8	3.4	3.0	2.7	2.4	2.1	1.9	1.7	16.9
West	Male	1986	279.4	176.5	144.9	113.8	94.2	78.8	69.8	60.5	53.7	45.6	38.2	31.9	26.7	22.9	20.1	26.0	23.5	21.1	19.0	17.1	15.3	13.7	12.3	11.0	9.8	8.7	7.7	6.9	6.1	5.4	4.8	4.3	3.8	3.4	3.0	2.7	2.4	2.1	1.9	1.6	17.3
West	Male	1987	258.2	182.2	134.4	117.9	96.0	81.0	68.2	60.3	51.8	45.6	38.4	32.0	26.6	22.2	18.9	16.6	21.4	19.3	17.3	15.6	14.0	12.5	11.2	10.0	8.9	7.9	7.1	6.3	5.6	4.9	4.4	3.9	3.5	3.1	2.7	2.4	2.1	1.9	1.7	1.5	16.3
West	Male	1988	250.6	168.4	138.7	109.3	99.4	82.4	69.9	58.5	51.2	43.5	37.9	31.7	26.3	21.7	18.1	15.4	13.5	17.3	15.6	14.0	12.5	11.2	10.0	8.9	8.0	7.1	6.3	5.6	5.0	4.4	3.9	3.5	3.1	2.8	2.4	2.2	1.9	1.7	1.5	1.3	15.1
West	Male	1989	268.7	163.4	128.2	112.8	92.2	85.5	71.4	60.5	50.2	43.5	36.7	31.7	26.4	21.8	17.9	14.9	12.6	11.1	14.2	12.7	11.4	10.2	9.1	8.1	7.2	6.5	5.7	5.1	4.5	4.0	3.6	3.2	2.8	2.5	2.2	2.0	1.7	1.5	1.4	1.2	14.1
West	Male	1990	361.8	175.3	124.4	104.3	95.1	79.2	73.8	61.4	51.4	42.2	36.2	30.3	26.1	21.6	17.8	14.6	12.1	10.2	8.9	11.4	10.2	9.1	8.2	7.3	6.5	5.8	5.1	4.6	4.1	3.6	3.2	2.8	2.5	2.2	2.0	1.8	1.6	1.4	1.2	1.1	12.9
West	Male	1991	305.7	235.9	133.4	101.2	87.9	81.6	68.3	63.3	52.0	43.0	34.9	29.7	24.7	21.1	17.4	14.3	11.7	9.7	8.2	7.1	9.1	8.1	7.3	6.5	5.8	5.1	4.6	4.1	3.6	3.2	2.8	2.5	2.2	2.0	1.8	1.6	1.4	1.2	1.1	1.0	11.7
West	Male	1992	241.2	199.4	179.6	108.5	85.3	75.6	70.8	59.3	54.8	44.7	36.7	29.6	24.9	20.6	17.5	14.4	11.7	9.6	7.9	6.6	5.7	7.3	6.5	5.8	5.2	4.6	4.1	3.6	3.2	2.9	2.5	2.3	2.0	1.8	1.6	1.4	1.2	1.1	1.0	0.9	10.7
West	Male	1993	236.8	157.3	151.8	146.1	91.5	73.4	65.7	61.8	51.6	47.5	38.5	31.4	25.1	21.0	17.3	14.6	11.9	9.7	7.9	6.5	5.4	4.7	6.0	5.3	4.7	4.2	3.7	3.3	2.9	2.6	2.3	2.0	1.8	1.6	1.4	1.3	1.1	1.0	0.9	0.8	9.9
West	Male	1994	247.8	154.4	119.7	123.4	122.9	78.2	62.8	55.7	51.7	42.6	38.6	30.9	24.9	19.7	16.4	13.4	11.2	9.1	7.4	6.0	4.9	4.1	3.5	4.5	4.0	3.5	3.1	2.8	2.4	2.2	1.9	1.7	1.5	1.3	1.2	1.1	0.9	0.8	0.7	0.7	8.4

West	Male	1995	226.3	161.6	117.5	97.4	104.0	105.7	67.9	54.7	48.5	44.8	36.7	33.0	26.3	21.0	16.6	13.7	11.1	9.3	7.5	6.1	4.9	4.0	3.3	2.9	3.6	3.2	2.8	2.5	2.2	2.0	1.8	1.6	1.4	1.2	1.1	1.0	0.9	0.8	0.7	0.6	7.7
West	Male	1996	300.7	147.6	123.0	95.6	82.1	89.5	92.0	59.3	47.7	42.1	38.7	31.5	28.1	22.2	17.7	13.9	11.4	9.2	7.7	6.2	5.0	4.0	3.3	2.7	2.3	2.9	2.6	2.3	2.0	1.8	1.6	1.4	1.3	1.1	1.0	0.9	0.8	0.7	0.6	0.5	7.2
West	Male	1997	314.3	196.1	112.4	100.1	80.6	70.7	77.9	80.4	51.8	41.5	36.4	33.2	26.8	23.8	18.7	14.8	11.6	9.5	7.6	6.3	5.1	4.1	3.3	2.7	2.2	1.9	2.4	2.1	1.9	1.7	1.5	1.3	1.1	1.0	0.9	0.8	0.7	0.6	0.6	0.5	6.6
West	Male	1998	483.0	205.0	149.3	91.4	84.3	69.3	61.2	67.5	69.4	44.4	35.2	30.6	27.7	22.2	19.6	15.3	12.0	9.4	7.6	6.1	5.1	4.1	3.2	2.6	2.1	1.7	1.5	1.9	1.7	1.5	1.3	1.1	1.0	0.9	0.8	0.7	0.6	0.6	0.5	0.4	5.9
West	Male	1999	309.6	315.0	156.0	121.4	77.0	72.5	60.1	53.2	58.5	59.7	37.9	29.8	25.7	23.1	18.4	16.2	12.6	9.9	7.6	6.2	5.0	4.1	3.3	2.6	2.1	1.7	1.4	1.2	1.5	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.6	0.5	0.4	0.4	5.4
West	Male	2000	237.6	201.9	239.8	126.9	102.3	66.3	63.0	52.4	46.4	50.7	51.5	32.5	25.4	21.8	19.5	15.4	13.5	10.4	8.2	6.3	5.1	4.1	3.3	2.7	2.1	1.7	1.4	1.1	1.0	1.2	1.1	0.9	0.8	0.7	0.7	0.6	0.5	0.5	0.4	0.4	5.0
West	Male	2001	277.0	154.9	153.7	195.0	107.0	88.0	57.6	54.9	45.5	39.9	43.3	43.5	27.2	21.1	18.0	15.9	12.6	10.9	8.4	6.6	5.0	4.1	3.2	2.7	2.1	1.7	1.3	1.1	0.9	0.8	1.0	0.8	0.7	0.7	0.6	0.5	0.5	0.4	0.4	0.3	4.4
West	Male	2002	371.4	180.7	117.9	125.0	164.5	92.2	76.8	50.6	48.3	40.1	35.1	38.0	38.0	23.7	18.3	15.5	13.7	10.8	9.4	7.2	5.6	4.3	3.5	2.7	2.3	1.8	1.4	1.1	0.9	0.8	0.6	0.8	0.7	0.6	0.6	0.5	0.4	0.4	0.3	0.3	4.3
West	Male	2003	284.5	242.2	137.5	95.9	105.5	141.8	80.5	67.6	44.7	42.7	35.4	30.9	33.4	33.4	20.7	16.0	13.5	11.9	9.4	8.1	6.2	4.8	3.7	3.0	2.3	1.9	1.5	1.2	1.0	0.8	0.6	0.5	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	4.1
West	Male	2004	264.3	185.5	184.4	111.9	80.9	90.9	123.6	70.6	59.4	39.1	37.3	30.7	26.8	28.7	28.6	17.7	13.6	11.5	10.1	7.9	6.8	5.2	4.0	3.1	2.5	2.0	1.6	1.3	1.0	0.8	0.6	0.5	0.5	0.6	0.5	0.4	0.4	0.3	0.3	0.3	3.9
West	Male	2005	208.6	172.4	141.2	150.0	94.3	69.6	79.1	108.0	61.6	51.6	33.8	32.0	26.2	22.7	24.3	24.0	14.8	11.3	9.5	8.3	6.5	5.6	4.3	3.3	2.5	2.0	1.6	1.3	1.0	0.8	0.6	0.5	0.4	0.4	0.5	0.4	0.4	0.3	0.3	0.2	3.6
West	Male	2006	266.4	136.1	131.2	114.9	126.4	81.2	60.6	69.0	94.1	53.4	44.4	28.9	27.2	22.1	19.1	20.3	20.0	12.2	9.3	7.8	6.8	5.3	4.6	3.5	2.7	2.0	1.6	1.3	1.1	0.8	0.7	0.5	0.4	0.3	0.3	0.4	0.3	0.3	0.3	0.2	3.3
West	Male	2007	266.6	173.7	103.6	106.7	96.9	108.9	70.8	53.2	60.7	82.6	46.8	38.8	25.1	23.5	19.1	16.4	17.3	17.0	10.4	7.9	6.6	5.8	4.5	3.8	2.9	2.2	1.7	1.4	1.1	0.9	0.7	0.5	0.4	0.4	0.3	0.2	0.3	0.3	0.2	0.2	3.1
West	Male	2008	266.7	173.8	132.2	84.2	90.0	83.4	94.9	61.9	46.4	52.8	71.4	40.2	33.1	21.3	19.8	16.0	13.6	14.4	14.1	8.6	6.5	5.4	4.7	3.7	3.1	2.4	1.8	1.4	1.1	0.9	0.7	0.6	0.4	0.4	0.3	0.2	0.2	0.3	0.2	0.2	2.8
West	Male	2009	266.5	173.9	132.3	107.6	71.0	77.4	72.4	82.4	53.6	39.9	45.0	60.3	33.6	27.4	17.6	16.3	13.0	11.1	11.6	11.3	6.9	5.2	4.3	3.8	2.9	2.5	1.9	1.4	1.1	0.9	0.7	0.6	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	2.5

Table 3.17. Fleet specific instantaneous fishing mortality rates. Fishing mortality rates are the apical instantaneous fishing mortality rate. For the longline fishery, and for the most recent years where the fishery is mostly longlines, apical F is generally the F on ages 20-40+ due to the logistic selectivity.

Year	F Comm HLE	F Comm HLW	F Comm LLE	F Comm LLW	Apical F East (~sum of HL and LL)	Apical F West (~sum of HL and LL)
1975	0.018	0.010	0.000	0.000	0.018	0.010
1976	0.015	0.007	0.000	0.000	0.015	0.007
1977	0.013	0.006	0.000	0.000	0.013	0.006
1978	0.012	0.006	0.000	0.000	0.012	0.006
1979	0.018	0.007	0.000	0.004	0.018	0.011
1980	0.019	0.004	0.026	0.005	0.044	0.009
1981	0.018	0.023	0.095	0.072	0.112	0.095
1982	0.019	0.025	0.239	0.079	0.257	0.104
1983	0.021	0.014	0.232	0.083	0.252	0.097
1984	0.025	0.026	0.200	0.086	0.224	0.112
1985	0.037	0.031	0.133	0.090	0.169	0.120
1986	0.074	0.016	0.038	0.101	0.111	0.115
1987	0.049	0.011	0.060	0.088	0.108	0.097
1988	0.040	0.053	0.094	0.135	0.132	0.185
1989	0.010	0.010	0.054	0.087	0.064	0.095
1990	0.018	0.008	0.075	0.090	0.092	0.096
1991	0.012	0.009	0.068	0.086	0.079	0.093
1992	0.010	0.018	0.105	0.109	0.114	0.125
1993	0.005	0.018	0.072	0.095	0.076	0.111
1994	0.008	0.010	0.147	0.085	0.153	0.094
1995	0.004	0.008	0.089	0.118	0.091	0.123
1996	0.003	0.005	0.070	0.050	0.073	0.054
1997	0.002	0.005	0.118	0.039	0.119	0.043
1998	0.003	0.006	0.089	0.066	0.091	0.071
1999	0.004	0.009	0.134	0.084	0.136	0.091
2000	0.003	0.010	0.159	0.091	0.160	0.099
2001	0.002	0.005	0.120	0.060	0.120	0.064
2002	0.003	0.006	0.095	0.091	0.097	0.095
2003	0.004	0.008	0.149	0.110	0.150	0.116
2004	0.003	0.006	0.128	0.090	0.129	0.095
2005	0.003	0.005	0.104	0.082	0.105	0.086
2006	0.003	0.004	0.103	0.068	0.104	0.071
2007	0.002	0.006	0.149	0.040	0.148	0.046
2008	0.001	0.005	0.137	0.045	0.136	0.050
2009	0.003	0.010	0.122	0.059	0.123	0.067

Table 3.18. Age specific instantaneous fishing mortality rates, East and West.

Region	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	avg 20-40	Apical
East	1975	0.000	0.000	0.000	0.000	0.001	0.003	0.007	0.010	0.013	0.015	0.016	0.017	0.017	0.017	0.017	0.017	0.018	0.018	0.018	0.018	0.018	0.018
East	1976	0.000	0.000	0.000	0.000	0.001	0.003	0.006	0.009	0.011	0.013	0.014	0.014	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
East	1977	0.000	0.000	0.000	0.000	0.001	0.003	0.005	0.008	0.010	0.011	0.012	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
East	1978	0.000	0.000	0.000	0.000	0.001	0.002	0.005	0.007	0.009	0.010	0.011	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
East	1979	0.000	0.000	0.000	0.000	0.001	0.004	0.007	0.011	0.014	0.016	0.017	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
East	1980	0.000	0.000	0.000	0.000	0.002	0.005	0.010	0.016	0.023	0.028	0.033	0.036	0.039	0.040	0.042	0.042	0.043	0.043	0.044	0.044	0.044	0.044
East	1981	0.000	0.000	0.000	0.000	0.002	0.007	0.016	0.030	0.047	0.062	0.075	0.086	0.093	0.099	0.103	0.106	0.107	0.109	0.110	0.110	0.112	0.112
East	1982	0.000	0.000	0.000	0.001	0.003	0.012	0.031	0.061	0.098	0.135	0.166	0.191	0.210	0.224	0.233	0.240	0.245	0.248	0.251	0.252	0.257	0.257
East	1983	0.000	0.000	0.000	0.001	0.004	0.012	0.031	0.061	0.097	0.133	0.164	0.188	0.207	0.220	0.229	0.236	0.240	0.244	0.246	0.248	0.252	0.252
East	1984	0.000	0.000	0.000	0.001	0.004	0.012	0.029	0.057	0.089	0.120	0.147	0.169	0.185	0.196	0.204	0.210	0.214	0.217	0.219	0.220	0.224	0.224
East	1985	0.000	0.000	0.000	0.001	0.004	0.012	0.027	0.049	0.074	0.097	0.116	0.131	0.142	0.150	0.156	0.159	0.162	0.164	0.165	0.166	0.169	0.169
East	1986	0.000	0.000	0.000	0.001	0.006	0.016	0.031	0.047	0.062	0.073	0.082	0.088	0.093	0.097	0.100	0.102	0.104	0.105	0.106	0.107	0.110	0.110
East	1987	0.000	0.000	0.000	0.001	0.004	0.012	0.023	0.036	0.048	0.059	0.068	0.075	0.081	0.086	0.091	0.094	0.097	0.099	0.101	0.102	0.107	0.107
East	1988	0.000	0.000	0.000	0.001	0.004	0.011	0.022	0.035	0.048	0.061	0.072	0.082	0.091	0.099	0.105	0.110	0.114	0.117	0.120	0.122	0.130	0.130
East	1989	0.000	0.000	0.000	0.000	0.001	0.004	0.008	0.013	0.018	0.024	0.030	0.035	0.040	0.044	0.048	0.051	0.053	0.055	0.057	0.058	0.062	0.062
East	1990	0.000	0.000	0.000	0.001	0.002	0.006	0.012	0.020	0.028	0.037	0.045	0.052	0.059	0.065	0.070	0.074	0.077	0.080	0.082	0.084	0.090	0.090
East	1991	0.000	0.000	0.000	0.001	0.002	0.005	0.009	0.015	0.022	0.030	0.037	0.044	0.050	0.055	0.059	0.063	0.066	0.068	0.070	0.072	0.077	0.077
East	1992	0.000	0.000	0.000	0.001	0.002	0.005	0.011	0.019	0.028	0.039	0.049	0.059	0.068	0.076	0.083	0.089	0.093	0.097	0.100	0.103	0.111	0.111
East	1993	0.000	0.000	0.000	0.001	0.001	0.003	0.007	0.012	0.018	0.025	0.032	0.039	0.045	0.050	0.055	0.059	0.062	0.065	0.067	0.068	0.074	0.074
East	1994	0.000	0.000	0.000	0.001	0.003	0.006	0.013	0.022	0.035	0.049	0.063	0.077	0.090	0.101	0.110	0.118	0.124	0.129	0.134	0.137	0.149	0.149
East	1995	0.000	0.000	0.000	0.001	0.002	0.004	0.007	0.013	0.020	0.028	0.037	0.046	0.053	0.060	0.066	0.070	0.074	0.077	0.080	0.082	0.089	0.089
East	1996	0.000	0.000	0.000	0.000	0.001	0.003	0.006	0.011	0.016	0.023	0.030	0.036	0.042	0.048	0.052	0.056	0.059	0.061	0.063	0.065	0.071	0.071
East	1997	0.000	0.000	0.000	0.001	0.002	0.004	0.009	0.016	0.025	0.036	0.047	0.058	0.068	0.077	0.084	0.091	0.096	0.100	0.103	0.106	0.116	0.116
East	1998	0.000	0.000	0.000	0.001	0.002	0.004	0.007	0.013	0.020	0.028	0.037	0.045	0.053	0.059	0.065	0.070	0.073	0.077	0.079	0.081	0.088	0.088
East	1999	0.000	0.000	0.000	0.001	0.002	0.005	0.011	0.019	0.029	0.042	0.055	0.067	0.079	0.089	0.097	0.104	0.110	0.115	0.119	0.122	0.133	0.133
East	2000	0.000	0.000	0.000	0.001	0.003	0.006	0.012	0.021	0.034	0.048	0.063	0.078	0.092	0.104	0.114	0.122	0.129	0.135	0.139	0.143	0.156	0.156
East	2001	0.000	0.000	0.000	0.001	0.002	0.004	0.009	0.016	0.025	0.036	0.047	0.059	0.069	0.078	0.085	0.092	0.097	0.101	0.105	0.107	0.117	0.117
East	2002	0.000	0.000	0.000	0.001	0.002	0.004	0.008	0.013	0.021	0.030	0.039	0.048	0.056	0.063	0.069	0.074	0.078	0.082	0.084	0.087	0.094	0.094
East	2003	0.000	0.000	0.000	0.001	0.002	0.006	0.011	0.020	0.032	0.045	0.060	0.074	0.086	0.097	0.107	0.115	0.121	0.126	0.131	0.134	0.146	0.146
East	2004	0.000	0.000	0.000	0.001	0.002	0.005	0.010	0.017	0.027	0.039	0.051	0.063	0.074	0.084	0.092	0.098	0.104	0.108	0.112	0.115	0.125	0.125
East	2005	0.000	0.000	0.000	0.001	0.002	0.004	0.008	0.014	0.022	0.032	0.042	0.051	0.060	0.068	0.075	0.080	0.085	0.089	0.092	0.094	0.102	0.102
East	2006	0.000	0.000	0.000	0.001	0.002	0.004	0.008	0.014	0.023	0.032	0.042	0.052	0.060	0.068	0.075	0.080	0.085	0.088	0.091	0.094	0.102	0.102
East	2007	0.000	0.000	0.000	0.001	0.002	0.005	0.011	0.019	0.030	0.044	0.058	0.072	0.084	0.095	0.105	0.113	0.119	0.124	0.129	0.132	0.144	0.144
East	2008	0.000	0.000	0.000	0.001	0.002	0.005	0.010	0.017	0.028	0.040	0.053	0.066	0.077	0.088	0.096	0.104	0.110	0.114	0.118	0.122	0.133	0.133
East	2009	0.000	0.000	0.000	0.001	0.002	0.005	0.009	0.017	0.026	0.037	0.049	0.061	0.071	0.080	0.088	0.094	0.100	0.104	0.107	0.110	0.120	0.120
West	1975	0.000	0.000	0.000	0.000	0.001	0.003	0.006	0.008	0.009	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
West	1976	0.000	0.000	0.000	0.000	0.001	0.002	0.004	0.005	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
West	1977	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
West	1978	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
West	1979	0.000	0.000	0.000	0.000	0.001	0.003	0.005	0.007	0.008	0.009	0.010	0.010	0.010	0.010	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
West	1980	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.005	0.006	0.007	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
West	1981	0.000	0.000	0.000	0.001	0.005	0.013	0.027	0.042	0.057	0.068	0.077	0.083	0.087	0.090	0.091	0.093	0.093	0.094	0.094	0.095	0.095	0.095
West	1982	0.000	0.000	0.000	0.001	0.005	0.014	0.029	0.046	0.062	0.075	0.084	0.090	0.095	0.098	0.100	0.101	0.102	0.103	0.103	0.103	0.104	0.104
West	1983	0.000	0.000	0.000	0.001	0.004	0.011	0.024	0.039	0.054	0.067	0.076	0.083	0.087	0.090	0.092	0.094	0.094	0.095	0.096	0.096	0.097	0.097
West	1984	0.000	0.000	0.000	0.001	0.005	0.015	0.031	0.049	0.066	0.080	0.090	0.097	0.102	0.105	0.107	0.109	0.110	0.110	0.111	0.111	0.112	0.112
West	1985	0.000	0.000	0.000	0.001	0.006	0.017	0.034	0.054	0.072	0.087	0.097	0.105	0.110	0.113	0.115	0.117	0.118	0.118	0.119	0.119	0.120	0.120
West	1986	0.000	0.000	0.000	0.001	0.005	0.011	0.020	0.031	0.043	0.055	0.065	0.075	0.083	0.089	0.094	0.098	0.102	0.104	0.106	0.108	0.113	0.113
West	1987	0.000	0.000	0.000	0.001	0.004	0.008	0.016	0.025	0.035	0.045	0.054	0.062	0.069	0.075	0.079	0.083	0.086	0.088	0.090	0.091	0.096	0.096
West	1988	0.000	0.000	0.001	0.003	0.010	0.025	0.044	0.065	0.085	0.102	0.118	0.131	0.142	0.151	0.158	0.163	0.168	0.171	0.174	0.176	0.183	0.183
West	1989	0.000	0.000	0.000	0.001	0.003	0.008	0.015	0.024	0.034	0.044	0.053	0.061	0.067	0.073	0.077	0.081	0.084	0.086	0.087	0.089	0.094	0.094
West	1990	0.000	0.000	0.000	0.001	0.003	0.008	0.015	0.023	0.033	0.043	0.053	0.061	0.068	0.073	0.078	0.082	0.084	0.087	0.088	0.090	0.095	0.095
West	1991	0.000	0.000	0.000	0.001	0.003	0.008	0.014	0.023	0.032	0.042	0.051	0.059	0.066	0.071	0.075	0.079	0.081	0.084	0.085	0.087	0.091	0.091
West	1992	0.000	0.000	0.000	0.002	0.005	0.012	0.022	0.034	0.047	0.060	0.071	0.082	0.090	0.097	0.103	0.107	0.111	0.113	0.115	0.117	0.123	0.123
West	1993	0.000	0.000	0.000	0.001	0.005	0.011	0.020	0.032	0.043	0.054	0.065	0.073	0.081	0.087	0.092	0.096	0.099	0.101	0.103	0.104	0.110	0.110
West	1994	0.000	0.000	0.000	0.001	0.003	0.008	0.015	0.024	0.034	0.043	0.052	0.060	0.067	0.072	0.076	0.080	0.083	0.085	0.086	0.088	0.092	0.092
West	1995	0.000	0.000	0.000	0.001	0.004	0.009	0.017	0.028	0.041	0.054	0.066	0.077	0.086	0.093	0.099	0.104	0.108	0.111	0.113	0.115	0.121	0.121
West	1996	0.000	0.000	0.000	0.001	0.002	0.004	0.008	0.013	0.019	0.024	0.030	0.034	0.038	0.041	0.044	0.046	0.047	0.049	0.050	0.050	0.053	0.053
West	1997	0.000	0.000	0.000	0.001	0.002	0.004	0.007	0.011	0.015	0.020	0.024	0.027	0.030	0.033	0.035	0.036	0.038	0.039	0.039	0.040	0.042	0.042
West	1998	0.000	0.000	0.000	0.001	0.002	0.006	0.011	0.017	0.024	0.032	0.039	0.045	0.050	0.054	0.057	0.060	0.062	0.064	0.065	0.066	0.070	0.070
West	1999	0.000	0.000	0.000	0.001	0.003	0.007	0.014	0.023	0.032	0.041	0.050	0.058	0.064	0.070	0.074	0.077	0.080	0.082	0.084	0.085	0.090	0.090
West	2000	0.000	0.000	0.000	0.001	0.004	0.008	0.016	0.025	0.035	0.045	0.055	0.063	0.070	0.076	0.081	0.084	0.087	0.089	0.091	0.093	0.098	0.098
West	2001	0.000	0.000	0.000	0.001	0.002	0.005	0.010	0.015	0.022	0.029	0.035	0.041	0.045	0.049	0.052	0.054	0.056	0.058	0.059	0.060	0.063	0.063
West	2002	0.000	0.000	0.000	0.001	0.003	0.007	0.013	0.022	0.032	0.042	0.051	0.059	0.066	0.072	0.077	0.080	0.083	0.086	0.087	0.089	0.094	0.094
West	2003	0.000	0.000	0.000	0.001	0.004	0.009	0.016	0.027	0.039	0.051	0.062	0.072	0.081	0.088	0.093	0.098	0.101	0.104	0.106	0.108	0.114	0.114
West	2004	0.000	0.000	0.000	0.001	0.003	0.007	0.014	0.022	0.032	0.042	0.051	0.060	0.066	0.072	0.077	0.080	0.083	0.086	0.087	0.089	0.094	0.094
West	2005	0.000	0.000	0.000	0.001	0.003	0.006	0.012	0.020	0.028	0.037	0.046	0.053	0.060	0.065	0.069	0.072	0.075	0.077	0.079	0.080	0.084	0.084
West	2006	0.000	0.000	0.000	0.001	0.002	0.005	0.010	0.016	0.023	0.031	0.038	0.044	0.049	0.053	0.057	0.060	0.062	0.063	0.065	0.066	0.070	0.070
West	2007	0.000	0.000	0.000	0.001	0.002	0.004	0.008	0.012	0.017	0.022	0.026	0.030	0.033	0.036	0.038	0.039	0.041	0.042	0.042	0.043	0.045	0.045
West	2008	0.000	0.000	0.000	0.001	0.002	0.004	0.008	0.013	0.018	0.023	0.028	0.032	0.035	0.038	0.040	0.042	0.044	0.045	0.046	0.046	0.049	0.049
West	2009	0.000	0.000	0.000	0.001	0.003	0.006	0.012	0.018	0.025	0.032	0.039	0.044	0.049	0.052	0.055	0.058	0.060	0.061	0.062	0.063	0.066	0.066

Table 3.19. Input and estimated parameters for sensitivity runs.

num	parameter	YEG BASE	Update 86_09	No Rec Devs	No Sel Blocks	Est. M	Low Stp 0.7	No Est Herm Parms	BASE low Land.	LowM	HighM
1	NatM_p_1_Fem_GP_1	0.073	0.073	0.073	0.073	0.088	0.073	0.073	0.073	0.055	0.090
2	L_at_Amin_Fem_GP_1	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
3	L_at_Amax_Fem_GP_1	90.310	99.088	92.320	91.209	92.554	91.213	93.295	89.100	87.349	93.323
4	VonBert_K_Fem_GP_1	0.078	0.067	0.075	0.077	0.074	0.077	0.074	0.080	0.084	0.073
5	CV_young_Fem_GP_1	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163
6	CV_old_Fem_GP_1	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117
7	NatM_p_1_Fem_GP_2	0.073	0.073	0.073	0.073	0.110	0.073	0.073	0.073	0.055	0.090
8	L_at_Amin_Fem_GP_2	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
9	L_at_Amax_Fem_GP_2	90.016	98.114	92.427	90.590	95.200	91.457	93.806	90.278	86.268	93.730
10	VonBert_K_Fem_GP_2	0.089	0.077	0.085	0.088	0.080	0.087	0.083	0.089	0.097	0.083
11	CV_young_Fem_GP_2	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163
12	CV_old_Fem_GP_2	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117
13	NatM_p_1_Mal_GP_1	0.073	0.073	0.073	0.073	0.000	0.073	0.073	0.073	0.055	0.090
14	L_at_Amin_Mal_GP_1	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
15	L_at_Amax_Mal_GP_1	91.503	98.368	90.956	91.894	92.311	90.701	90.820	90.741	90.084	92.280
16	VonBert_K_Mal_GP_1	0.092	0.074	0.094	0.091	0.089	0.095	0.092	0.095	0.098	0.089
17	CV_young_Mal_GP_1	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163
18	CV_old_Mal_GP_1	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117
19	NatM_p_1_Mal_GP_2	0.073	0.073	0.073	0.073	0.000	0.073	0.073	0.073	0.055	0.090
20	L_at_Amin_Mal_GP_2	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
21	L_at_Amax_Mal_GP_2	90.207	99.721	89.345	90.911	93.573	89.232	89.437	91.234	89.605	91.188
22	VonBert_K_Mal_GP_2	0.103	0.073	0.108	0.102	0.087	0.108	0.103	0.100	0.113	0.097
23	CV_young_Mal_GP_2	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163
24	CV_old_Mal_GP_2	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117
25	Wtlen_1_Fem	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
26	Wtlen_2_Fem	2.910	2.910	2.910	2.910	2.910	2.910	2.910	2.910	2.910	2.910
27	Mat50%_Fem	55.000	55.000	55.000	55.000	55.000	55.000	55.000	55.000	55.000	55.000
28	Mat_slope_Fem	-0.330	-0.330	-0.330	-0.330	-0.330	-0.330	-0.330	-0.330	-0.330	-0.330
29	Eggs_scalar_Fem	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	Eggs_exp_len_Fem	2.910	2.910	2.910	2.910	2.910	2.910	2.910	2.910	2.910	2.910
31	Wtlen_1_Mal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
32	Wtlen_2_Mal	2.910	2.910	2.910	2.910	2.910	2.910	2.910	2.910	2.910	2.910
33	Herm_Infl_age	14.790	50.859	16.618	15.669	21.040	15.966	41.000	14.574	12.000	19.560
34	Herm_stdev	8.137	20.000	8.666	8.677	10.630	8.797	14.630	8.310	7.225	9.957
35	Herm_asymptote	0.059	0.382	0.072	0.065	0.105	0.067	0.470	0.057	0.042	0.095
36	RecrDist_Area_1	1.706	1.237	1.687	1.703	0.568	1.689	1.702	1.494	1.727	1.675
37	RecrDist_Area_2	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
38	SR_R0	6.722	7.111	6.720	6.714	7.934	6.767	6.726	6.574	5.869	7.544
39	SR_steep	0.953	0.978	0.967	0.954	0.862	0.700	0.956	0.960	0.974	0.902
40	SR_sigmaR	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
41	Main_InitAge_8	-0.361	-0.254	0.000	-0.411	-0.144	-0.396	-0.334	-0.527	-0.643	-0.194
42	Main_InitAge_7	-0.335	-0.178	0.000	-0.377	-0.179	-0.372	-0.311	-0.483	-0.571	-0.218

43	Main_InitAge_6	-0.280	-0.081	0.000	-0.312	-0.182	-0.320	-0.259	-0.412	-0.465	-0.213
44	Main_InitAge_5	-0.210	-0.276	0.000	-0.229	-0.166	-0.250	-0.189	-0.323	-0.332	-0.190
45	Main_InitAge_4	-0.135	0.096	0.000	-0.134	-0.141	-0.172	-0.111	-0.230	-0.188	-0.156
46	Main_InitAge_3	-0.070	-0.114	0.000	-0.041	-0.117	-0.100	-0.040	-0.146	-0.065	-0.121
47	Main_InitAge_2	-0.018	0.863	0.000	0.050	-0.108	-0.038	0.019	-0.072	0.032	-0.095
48	Main_InitAge_1	-0.016	-0.112	0.000	0.086	-0.144	-0.030	0.014	-0.040	0.064	-0.112
49	Main_RecrDev_1975	0.004	-0.253	0.000	0.126	-0.163	-0.014	0.026	0.016	0.249	-0.115
50	Main_RecrDev_1976	-0.006	-0.114	0.000	0.087	-0.178	-0.038	0.010	0.025	0.146	-0.125
51	Main_RecrDev_1977	0.028	0.692	0.000	0.066	-0.150	-0.020	0.041	0.078	0.199	-0.096
52	Main_RecrDev_1978	0.047	-0.139	0.000	0.014	-0.121	-0.008	0.051	0.100	0.108	-0.071
53	Main_RecrDev_1979	0.082	0.173	0.000	0.008	-0.081	0.031	0.083	0.146	0.457	-0.035
54	Main_RecrDev_1980	0.007	-0.302	0.000	-0.051	-0.102	-0.031	0.015	0.060	-0.023	-0.069
55	Main_RecrDev_1981	0.039	0.000	0.000	0.030	-0.066	0.006	0.052	0.147	0.300	-0.045
56	Main_RecrDev_1982	-0.038	0.000	0.000	-0.019	-0.101	-0.069	-0.031	0.049	0.058	-0.096
57	Main_RecrDev_1983	-0.065	0.000	0.000	-0.047	-0.105	-0.096	-0.064	-0.012	-0.098	-0.104
58	Main_RecrDev_1984	0.008	0.000	0.000	0.015	-0.009	-0.013	0.029	0.019	-0.251	-0.008
59	Main_RecrDev_1985	0.309	0.000	0.000	0.336	0.185	0.323	0.337	0.458	0.930	0.206
60	Main_RecrDev_1986	0.144	0.000	0.000	0.153	0.088	0.182	0.117	0.212	-0.059	0.097
61	Main_RecrDev_1987	-0.090	0.000	0.000	-0.086	-0.078	-0.051	-0.108	-0.043	-0.071	-0.084
62	Main_RecrDev_1988	-0.107	0.000	0.000	-0.099	-0.097	-0.051	-0.114	-0.045	-0.005	-0.101
63	Main_RecrDev_1989	-0.058	0.000	0.000	-0.049	-0.052	0.013	-0.062	0.018	0.148	-0.055
64	Main_RecrDev_1990	-0.148	0.000	0.000	-0.152	-0.102	-0.090	-0.168	-0.118	-0.134	-0.111
65	Main_RecrDev_1991	0.137	0.000	-8.595	0.136	0.170	0.201	0.132	0.186	0.146	0.158
66	Main_RecrDev_1992	0.182	0.000	-8.595	0.163	0.293	0.206	0.175	0.115	-0.229	0.274
67	Main_RecrDev_1993	0.613	0.000	-7.690	0.628	0.552	0.744	0.586	0.772	1.126	0.556
68	Main_RecrDev_1994	0.169	0.000	-7.247	0.146	0.279	0.189	0.132	0.085	-0.232	0.264
69	Main_RecrDev_1995	-0.095	0.000	-5.697	-0.117	0.041	-0.069	-0.131	-0.145	-0.307	0.018
70	Main_RecrDev_1996	0.059	0.000	-5.480	0.037	0.181	0.089	0.029	0.022	-0.164	0.158
71	Main_RecrDev_1997	0.352	0.000	-8.595	0.338	0.394	0.402	0.336	0.396	0.649	0.376
72	Main_RecrDev_1998	0.085	0.000	-8.595	0.042	0.225	0.090	0.049	0.035	-0.164	0.194
73	Main_RecrDev_1999	0.011	0.000	51.966	-0.039	0.186	0.011	-0.018	-0.034	-0.155	0.153
74	Main_RecrDev_2000	-0.245	0.000	-1.525	-0.300	-0.006	-0.258	-0.293	-0.311	-0.454	-0.044

Table 3.20. Derived quantities for base and sensitivity runs. Reference points and benchmarks from sensitivity runs for Gulf of Mexico tilefish. Benchmarks are reported for four reference points : 1) SPR40%. 2) SPR30%, 3) SSB at MSST which (1-M)*$SSB_{SPR40\%}$ and 4) SSB_{MSY}.

estimate/ benchmark	YEG BASE	Update 86_09	Update 86_09 zeroeq	No Rec Devs	Three Area	No Sel Blocks	Est. M	Low Stp0.7	NoEst Herm Parms	low Land-ing	LowM	HighM
TotBio_Unfished	15120	23851	9935	14821	15599	15082	18583	15673	14749	13165	14288	17103
SPB_Virgin	13423	21636	8839	13176	13978	13417	15470	13923	13122	11686	13172	14541
Recr_Virgin	831	1226	559	829	881	824	2791	869	834	716	354	1889
SSB_B40%virgin	5369	8654	3536	5270	5591	5367	6188	5569	5249	4674	5269	5817
SSB_SPR40%	5270	8579	3371	5202	5494	5268	5801	4567	5157	4600	5216	5573
SSB_SPR30%	3911	6403	2460	3873	4080	3910	4190	3007	3863	3449	4013	4113
MSST_SPR40%	4885	7953	3125	4822	5093	4884	5378	4233	4780	4264	4835	5166
SSB_MSY	2401	3552	1926	2247	2513	2396	3127	4072	2371	2012	2377	2853
SPB_2009	4026	8090	3496	3489	6105	3982	7883	3606	3812	3486	2562	6710
SSB/B40%virgin	0.750	0.935	0.989	0.662	1.092	0.742	1.274	0.647	0.726	0.746	0.486	1.154
SSB/SPR40%	0.764	0.943	1.037	0.671	1.111	0.756	1.359	0.790	0.739	0.758	0.491	1.204
SSB/SPR30%	1.030	1.263	1.421	0.901	1.496	1.018	1.881	1.199	0.987	1.011	0.638	1.632
SSB/MSST_SPR40%	0.824	1.017	1.119	0.724	1.199	0.815	1.466	0.852	0.797	0.817	0.530	1.299
SSB/MSY	1.677	2.278	1.815	1.553	2.430	1.662	2.521	0.885	1.608	1.733	1.078	2.352
Fstd_B40%virgin	0.047	0.043	0.045	0.047	0.047	0.046	0.049	0.039	0.047	0.046	0.040	0.051
Fstd_SPR40%	0.048	0.043	0.047	0.048	0.048	0.047	0.053	0.048	0.048	0.047	0.040	0.053
Fstd_SPR30%	0.066	0.060	0.065	0.066	0.067	0.065	0.073	0.066	0.067	0.066	0.057	0.073
Fstd_MSY	0.099	0.099	0.080	0.103	0.101	0.098	0.091	0.053	0.099	0.102	0.087	0.097
F_2009	0.068	0.037	0.086	0.077	0.049	0.070	0.035	0.078	0.072	0.079	0.108	0.041
F_2009/Fstd_40%virgin	1.466	0.870	1.932	1.634	1.056	1.515	0.713	2.010	1.516	1.700	2.738	0.807
F_2009/Fstd_SPR40%	1.432	0.860	1.824	1.607	1.032	1.480	0.661	1.633	1.482	1.666	2.702	0.767
F_2009/Fstd_SPR30%	1.032	0.618	1.317	1.159	0.737	1.066	0.480	1.177	1.071	1.201	1.910	0.559
F_2009/Fstd_MSY	0.691	0.375	1.073	0.742	0.487	0.712	0.383	1.474	0.722	0.774	1.244	0.424
Yield B40%virgin	323	457	200	318	328	317	436	271	319	279	249	413
Yield_SPR40%	326	459	204	320	331	319	448	282	322	281	250	421
Yield_SPR30%	358	504	219	353	365	351	448	275	356	312	285	463
Yield_MSY	375	532	222	371	382	367	498	283	369	325	288	472

Table 3.21. Uncertainty in management benchmarks with the base model. Maximum likelihood estimates and asymptotic standard deviations are and median and standard deviations from the MCMC runs are shown.

estimate/ benchmark	MLE	asymptotic stdev	MCMC median	StDev MCMC
SPB_Virgin	13423.00	173.33	13209.90	192.84
Recr_Virgin	831.00	12.47	820.72	13.23
SSB_SPR40%	5270.00	86.31	5148.85	100.91
SSB_MSY	2401.00	233.03	2476.74	227.39
SPB_2009	4026.00	239.89	3955.53	261.86
Fstd_SPR40%	0.0480	0.0004	0.0478	0.0003
Fstd_MSY	0.0990	0.0088	0.0948	0.0082
F_2009	0.0680	0.0036	0.0692	0.0041
SSB/SPR40%	0.764	0.000	0.768	0.039
SSB/MSY	1.677	0.036	1.597	0.191
Fstd/F_SPR40%	1.42	0.01	1.45	0.09
Fstd/Fstd_MSY	0.69	0.01	0.73	0.09
Yield B40%virgin	323.00	6.80	315.18	7.63
Yield_SPR40%	326.00	5.93	318.45	6.61
Yield_MSY	375.00	12.94	363.21	13.70

Table 3.22. Required SFA and MSRA evaluations using SPR 40% and SPR 30% reference points for Gulf of Mexico yellowedge grouper BASE, low M, high M and low landings runs. Biomass units are 1000lbs, gutted weight (SSB, MSST, and MSY).

		40%SPR				30%SPR			
Criteria	Definition	BASE	Low M	High M	Low Land	BASE	Low M	High M	Low Land
	Mortality Rate Criteria								
$F_{MSY\ or\ proxy}$	$F_{SPRtgt\%}$	0.048	0.040	0.053	0.000	0.066	0.057	0.073	0.066
MFMT	$F_{SPR40\%}$	0.048	0.040	0.053	0.047	0.066	0.057	0.073	0.066
F_{OY}	75% of $F_{SPRtgt\%}$	0.036	0.030	0.040	0.035	0.050	0.042	0.055	0.049
$F_{CURRENT}$	F_{2009}	0.068	0.108	0.041	0.079	0.068	0.108	0.041	0.079
$F_{CURRENT}$/MFMT	F_{2009}	1.432	2.702	0.767	1.666	1.032	1.910	0.559	1.201
Base M	**Biomass Criteria**								
SSB_{MSY} (1000lbs)	Equilibrium SSB @ $F_{SPRtgt\%}$	11614.3	11496.4	12282.6	10139.1	8619.4	8843.8	9064.8	7600.9
MSST (1000lbs)	(1-M)*$SSB_{SPRtgt\%}$ M=0.073 or 0.055 or 0.09 for low and high	10766.5	10864.1	11177.1	9399.0	3625.3	3791.9	3742.7	3196.9
$SSB_{CURRENT}$	SSB_{2009}	8873.7	5646.3	14789.3	7683.2	4026.2	2561.8	6710.2	3486.0
$SS_{CURRENT}$/MSST	SSB_{2009}	0.824	0.520	1.323	0.817	1.111	0.676	1.793	1.090
Equilibrium MSY	Equilibrium Yield @ $F_{SPRtgt\%}$	717.77	551.56	926.78	619.74	789.32	628.22	1019.45	687.47
Equilibrium OY	Equilibrium Yield @ F_{OY}	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
OFL (1000lbs)	Annual Yield @ FMFMT								
	OFL 2010	552.37	296.30	1142.37	475.61	820.44	437.39	1694.79	718.76
	OFL 2011	565.74	309.93	1131.74	486.15	818.75	448.32	1625.15	712.17
	OFL 2012	578.21	323.75	1119.34	496.35	816.47	459.37	1558.60	706.37
	OFL 2013	589.87	337.66	1105.90	506.24	813.93	470.49	1496.23	701.47
	OFL 2014	600.76	351.52	1092.04	515.78	811.35	481.55	1438.82	697.49
	OFL 2015	610.93	365.22	1078.26	524.92	808.86	492.42	1386.81	694.33
Annual OY (ACT)	Annual Yield @ F_{OY}								
	OY 2010	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	OY 2011	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	OY 2012	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	OY 2013	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	OY 2014	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	OY 2015	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	Annual Yield (2011) @ 65% FMFMT	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Alternative ACT:	Annual Yield (2011) @ 75% FMFMT	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	Annual Yield (2011) @ 85% FMFMT	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Generation									

Time									
Rebuild Time	(if B_{2009}<MSST)	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Tmin	@ F=0	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Midpoint	mid of Tmin, Tmax	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	if Tmin>10y, Tmin + 1								
Tmax	Gen	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
ABC	Recommend Range	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD

Table 3.23. Comparison of estimated quantities and benchmarks between SRA and SS3. SRA values are the median of the MCMC values after runs with recK values that are negative are removed. For SS3 the values are the maximum likelihood estimates. To calculate the current vulnerable biomass we use the SRA mean of the MCMC runs for 2009 and for virgin biomass, we use the first year of the model, 1975.

estimate/ benchmark	YEG BASE	SRA ALL	SRA EAST	SRA WEST
TotBio_Unfished	15120	NA	NA	NA
Vulnerable biomass, unfished	NA	13915	9631	4357
Vulnerable biomass @40%virgin	NA	5566	3852	1743
SSB at 40%virgin	5369	NA	NA	NA
SSB_2009	4026	4598	3700	1211
VulnB_2009	NA	4394	3179	1084
SSB/SSB40%virgin	0.7499	NA	NA	NA
VulnB_2009/VulnB@B40%virgin	NA	0.789	0.825	0.622
SSB/SSBmsy	1.677	0.485	0.500	0.428
Yield_MSY (MT)	374.60	355.50	226.90	121.80
exploitation rate (U) at MSY	0.099	0.084	0.071	0.100
U_2009	0.068	0.080	0.072	0.094
U2009/Umsy	0.691	0.976	1.036	0.959

3.5. ***FIGURES***

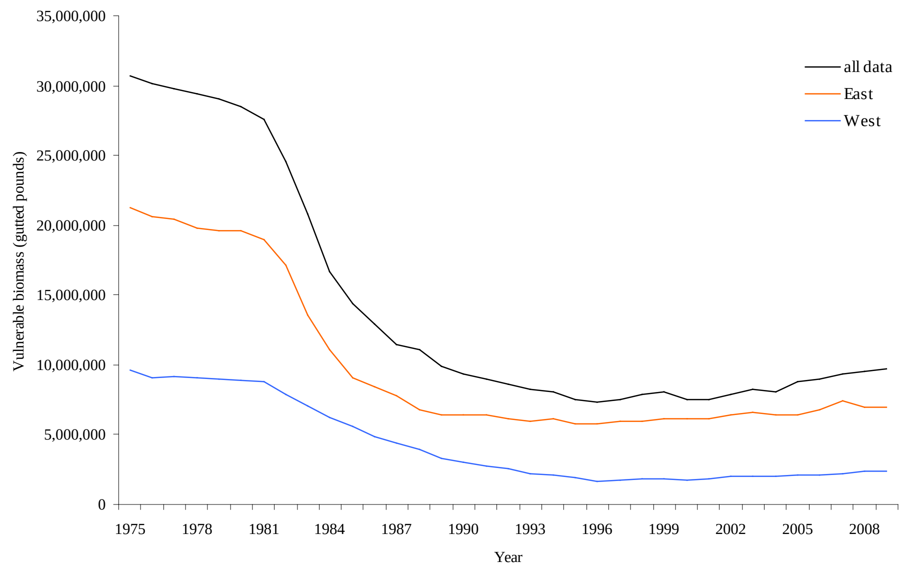


Figure 3.1. Estimates of vulnerable biomass for yellowedge grouper by region (east and west of the Mississippi River) and all data combined in the Gulf of Mexico for the time period catch histories exist. Note that the 'all data' model is an independent model and not the sum of the East and West biomass.

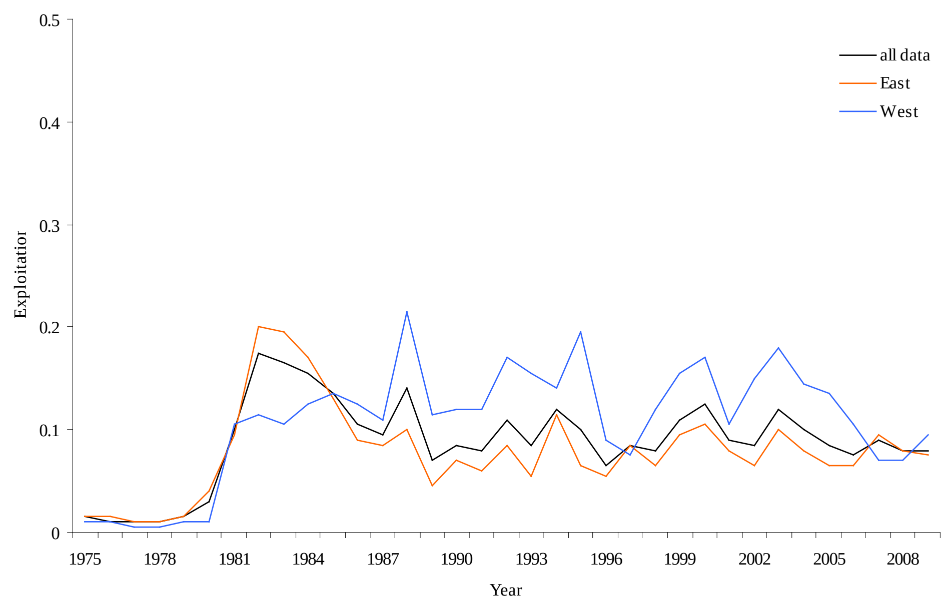


Figure 3.2. Estimates of exploitation for yellowedge grouper by region (east and west of the Mississippi River) and all data combined in the Gulf of Mexico for the time period catch histories exist.

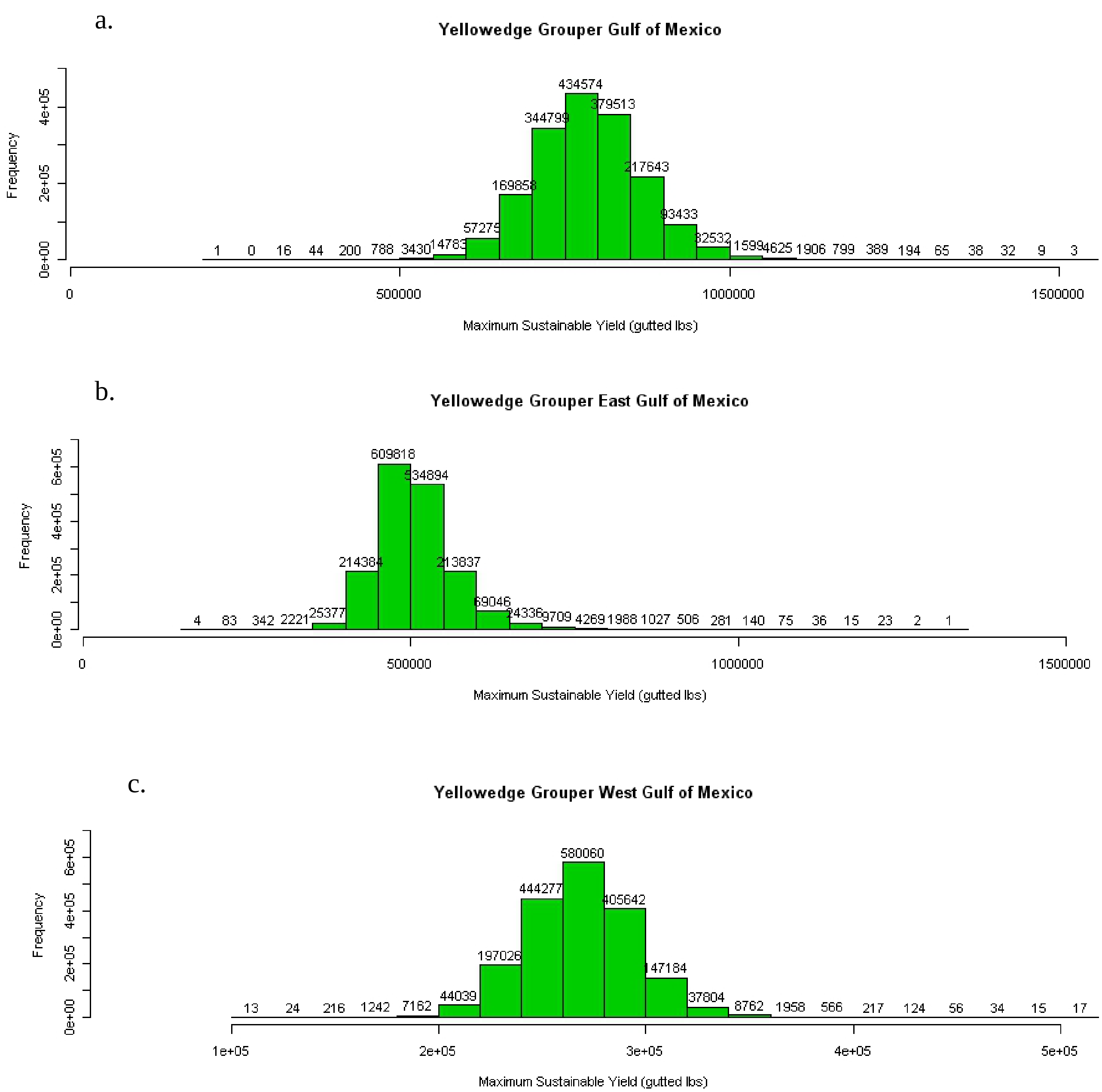


Figure 3.3. Distribution of maximum sustainable yield values for (a) all data combined, (b) East Gulf of Mexico and (c) West Gulf of Mexico for yellowedge grouper. Sample sizes per size bin are above each respective column. Note, figures not drawn on the same x-axis or y-axis.

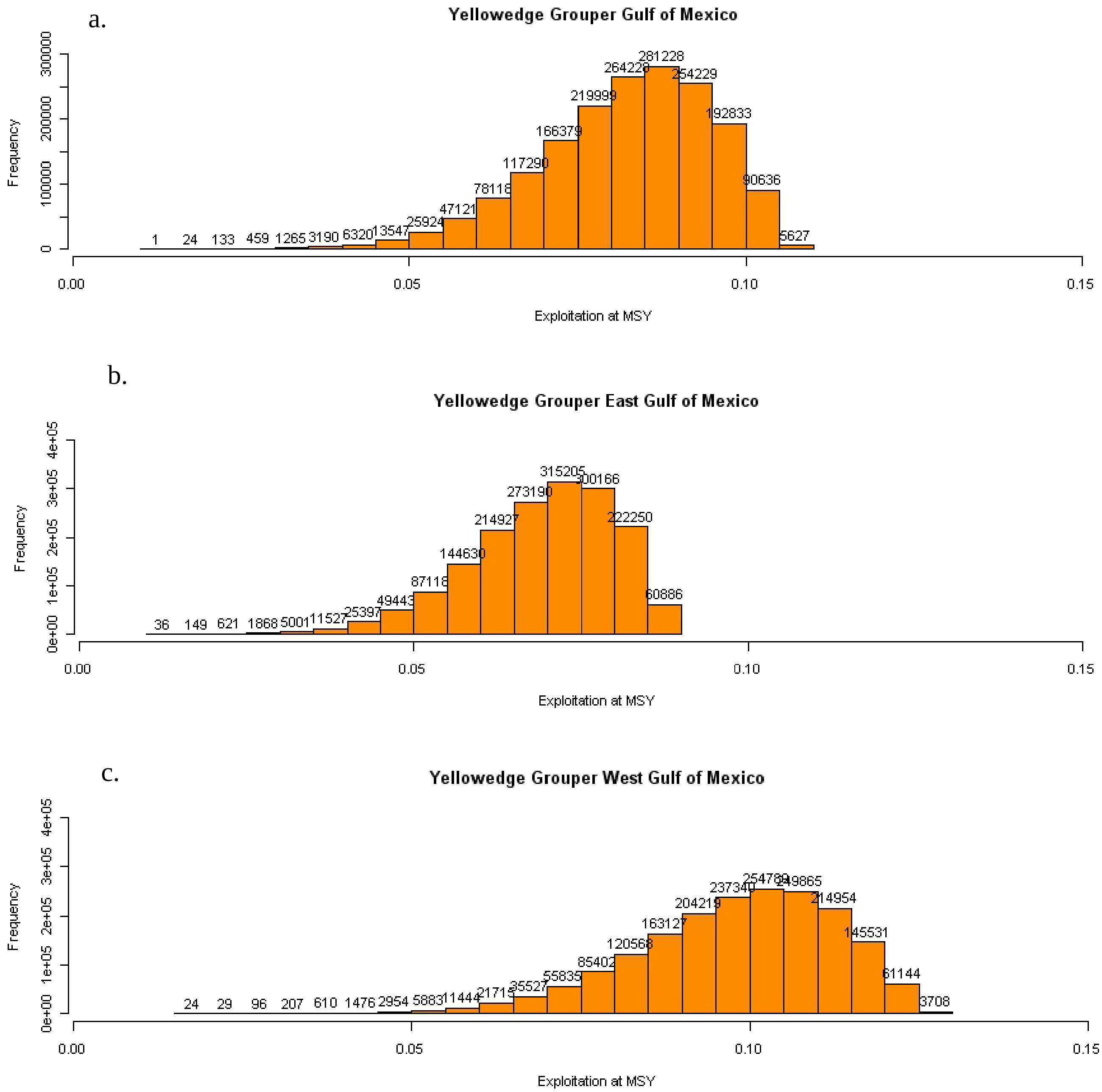


Figure 3.4. Distribution of exploitation at maximum sustainable yield (MSY) values (a) all data combined, (b) East Gulf of Mexico and (c) West Gulf of Mexico for yellowedge grouper. Sample sizes per size bin are above each respective column. Note, figures not drawn on the same y-axis.

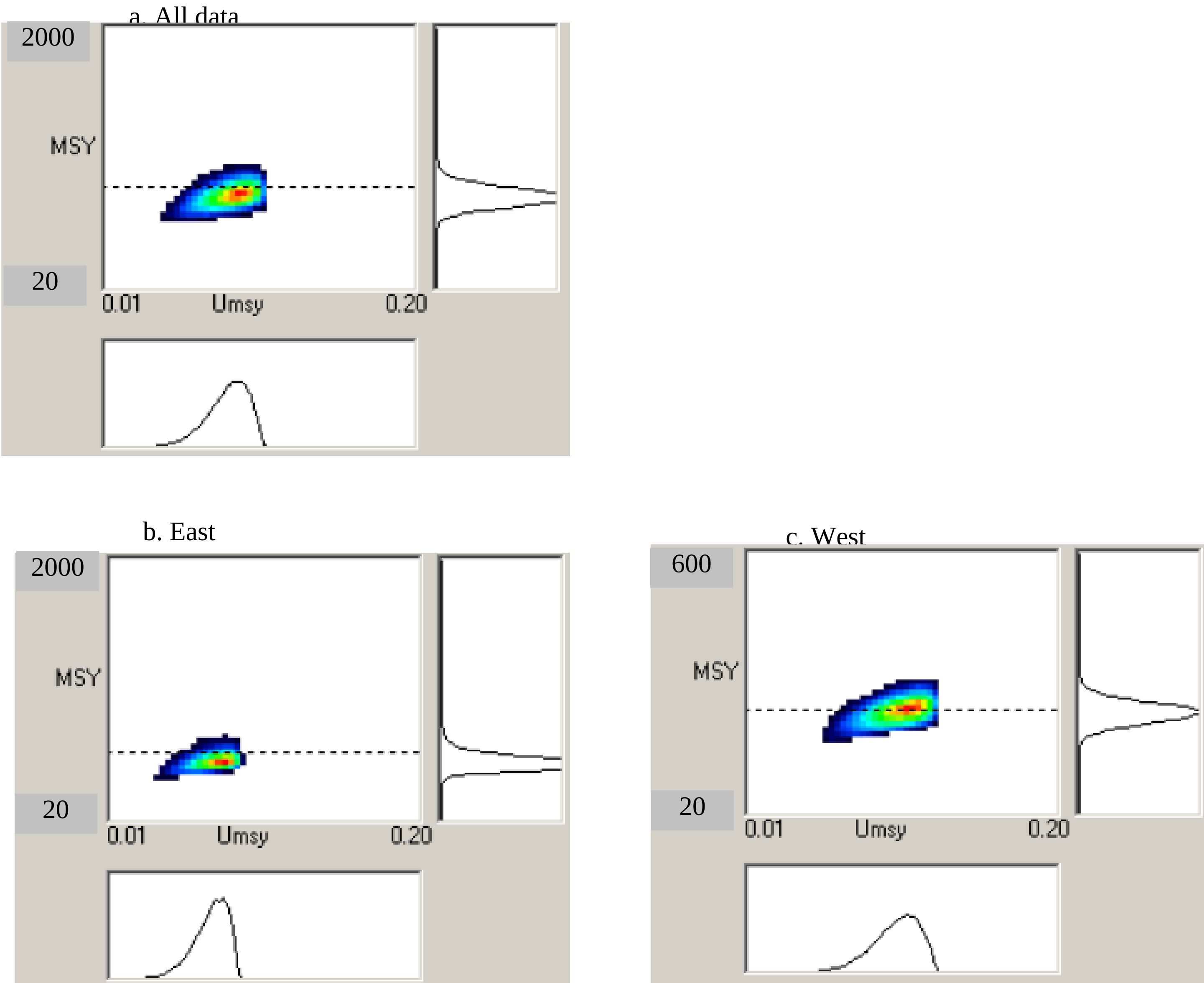
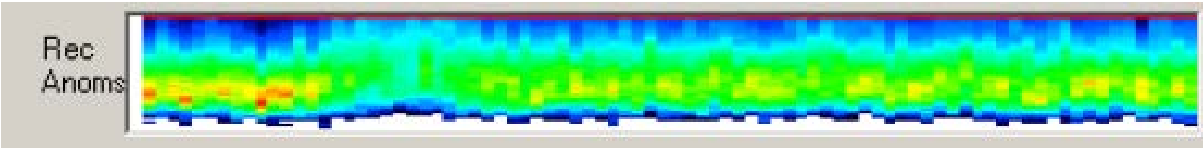
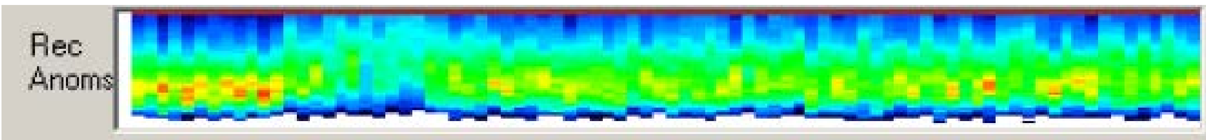


Figure 3.5. Sample distributions of maximum sustainable yield (MSY) given the sample distribution of exploitation at maximum sustainable yield (Umsy) for (a) all data combined, (b) East Gulf of Mexico and (c) West Gulf of Mexico for yellowedge grouper. Dotted line indicate the average catch for the given time series for either region. Note: range of MSY and Umsy differ for figure c.

a. All data



b. East



c. West

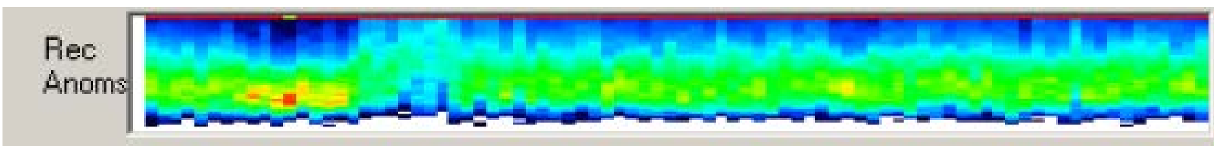
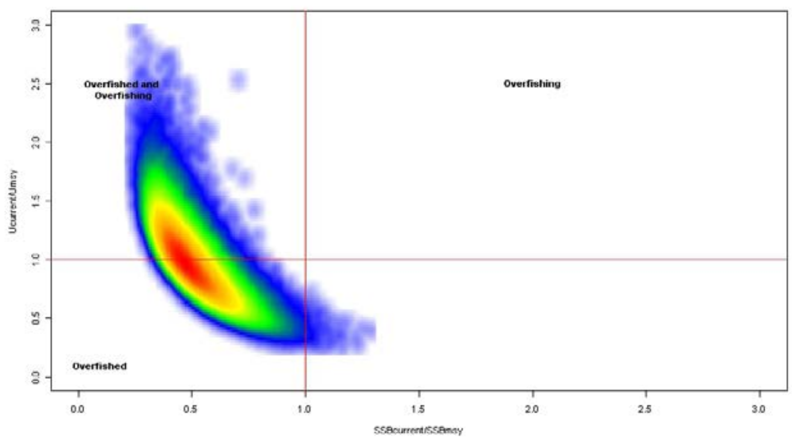
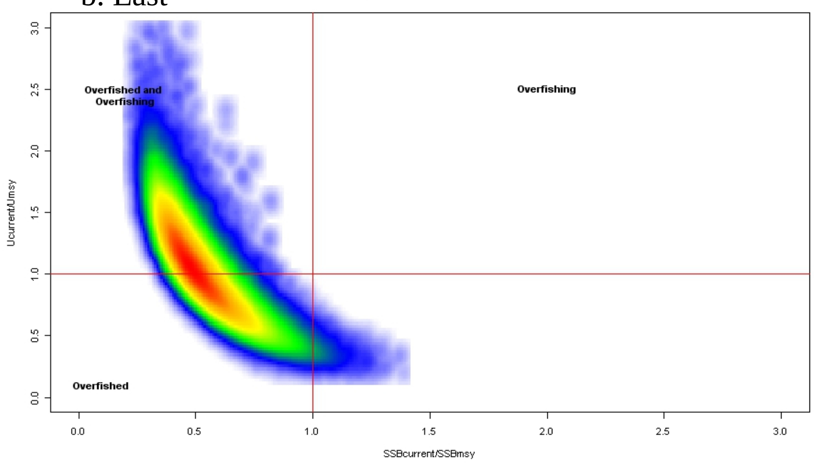


Figure 3.6. Recruitment anomalies for the historical and future projection time periods for yellowedge grouper for (a) all data combined, (b) East Gulf of Mexico and (c) West Gulf of Mexico.

a. All data



b. East



c. West

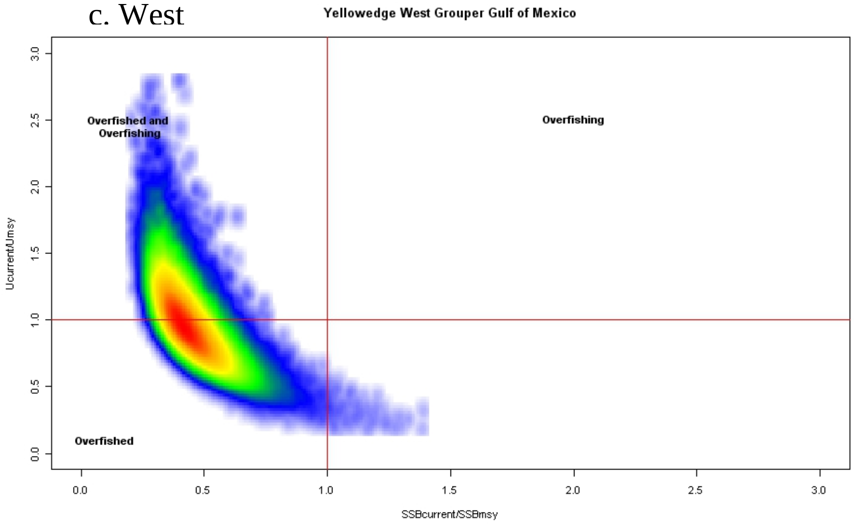


Figure 3.7. Current stock status and harvest rate for yellowedge grouper for (a) all data combined, (b) East Gulf of Mexico and (c) West Gulf of Mexico. Smooth Scatter plot (R Developing Core Team) color symbolizes density of points (red highest density).

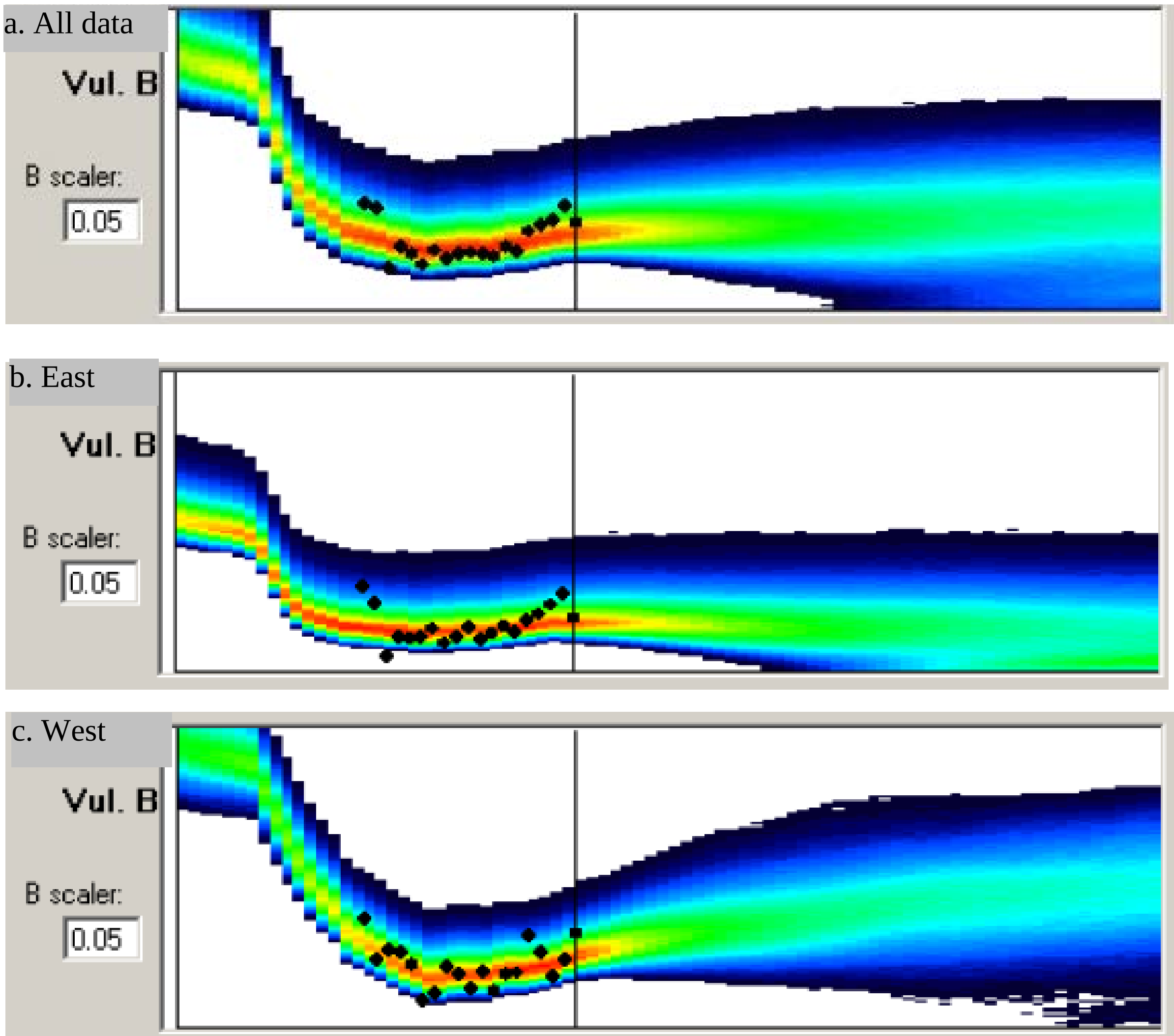


Figure 3.8. Future vulnerable biomasses were projected with an amount of landings equivalent to the average landings per year per region for the past five years (2005-2009) (a) all data combined, 770,000 gutted lbs; (b) East Gulf of Mexico, 550,000 gutted lbs; (c) West Gulf of Mexico, 220,000 gutted lbs. The vertical line indicates the last year of data, 2009, timeline of figures 1975 - 2059. Black dots represent the respectively commercial longline index.

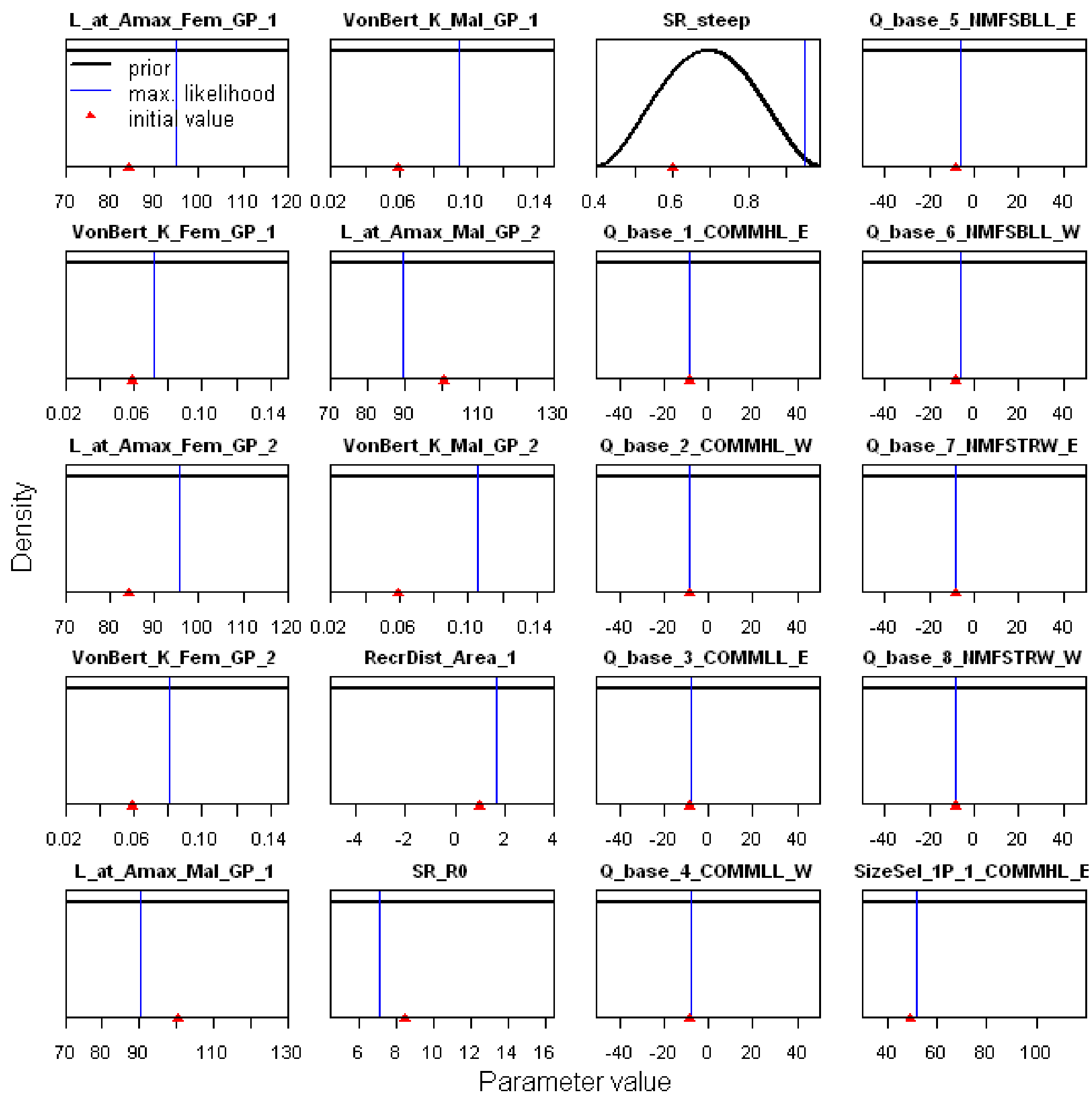


Figure 3.9. Input parameters, priors, maximum likelihood and starting values.

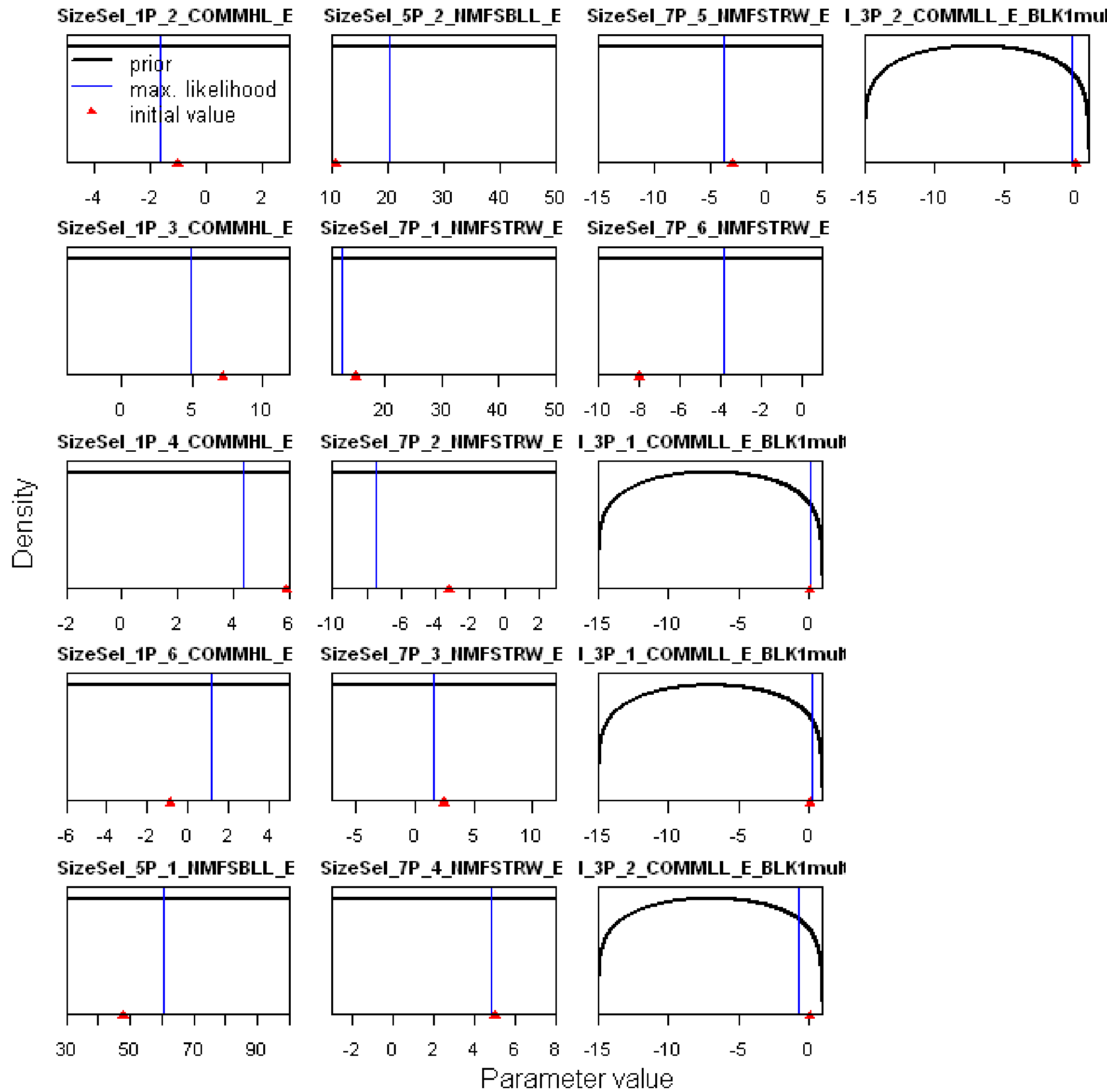


Figure 3.9. continued.

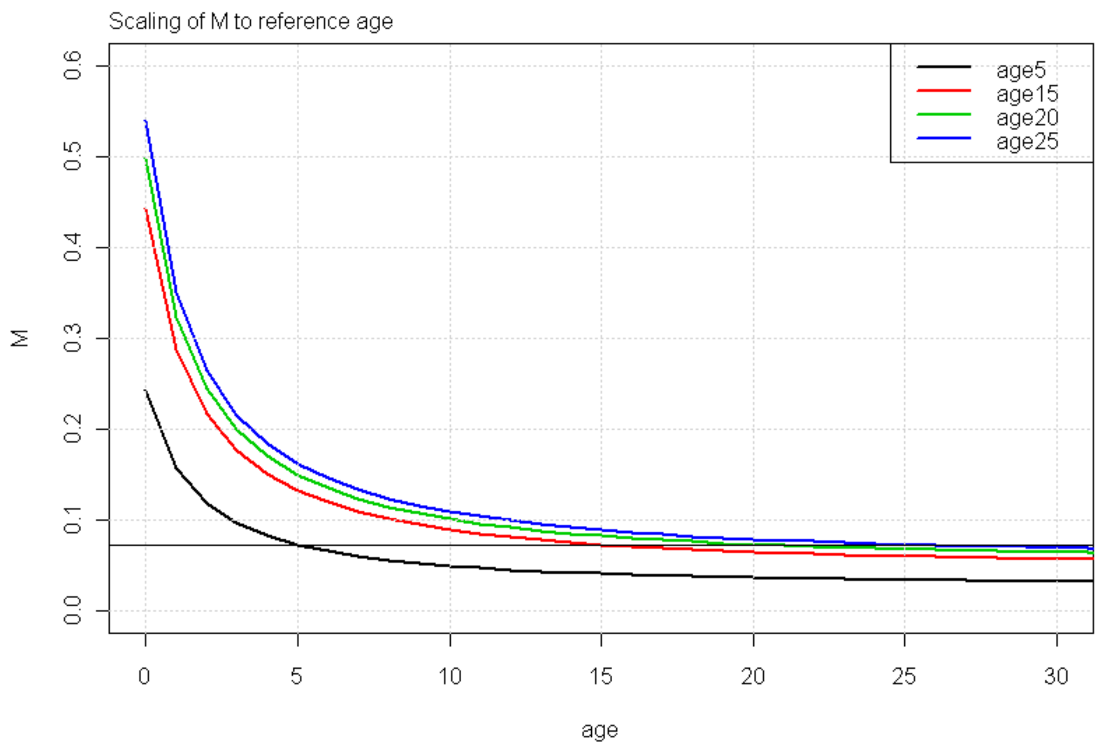


Figure 3.10. Scaling of mortality at age according to the reference age. Only mortality for females of growth morph 1 (East) are shown. Not the increase in total mortality that occurs with an increase in the reference age. The solid line is the target M of 0.073.

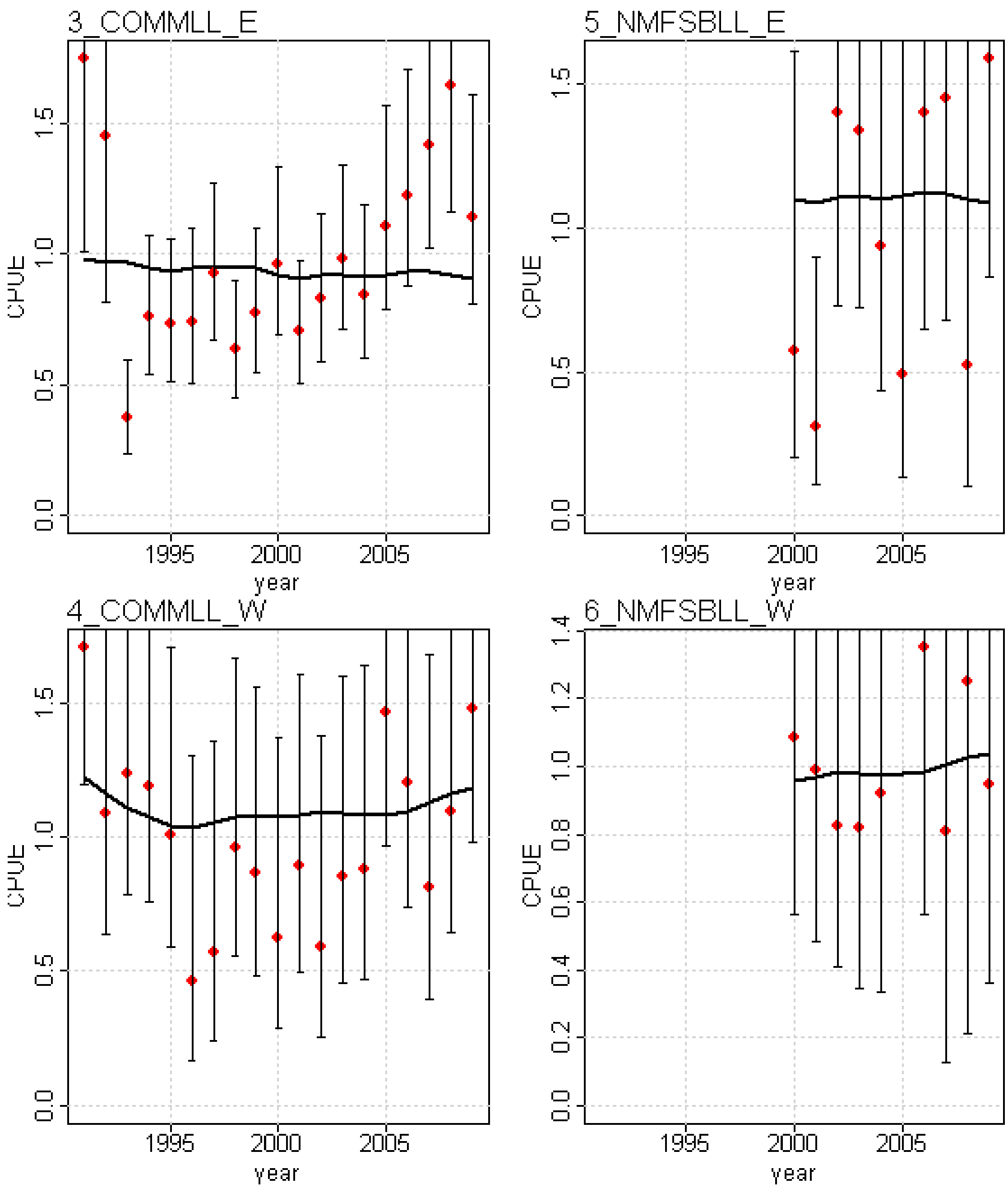


Figure 3.11. Base model fits to the CPUE indices.

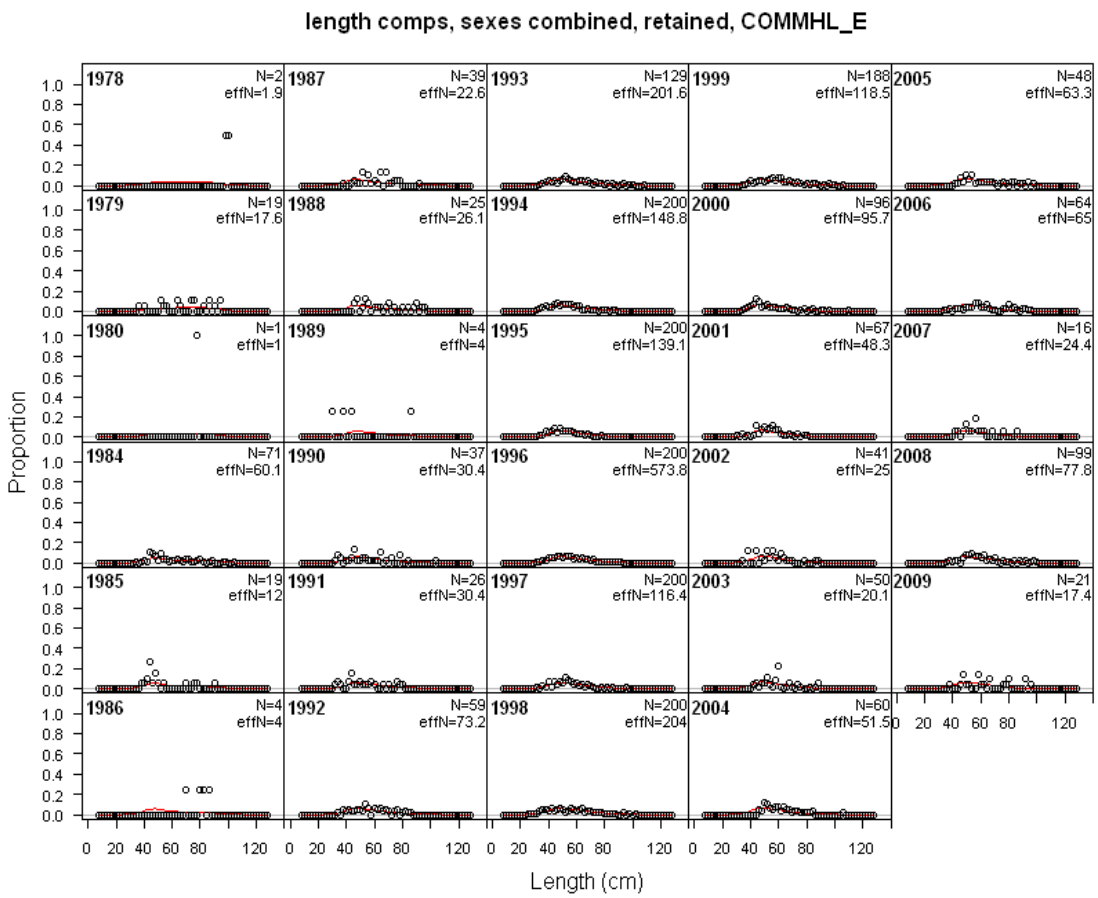


Figure 3.12. Length composition fits, commercial handline East, both sexes not differentiated.

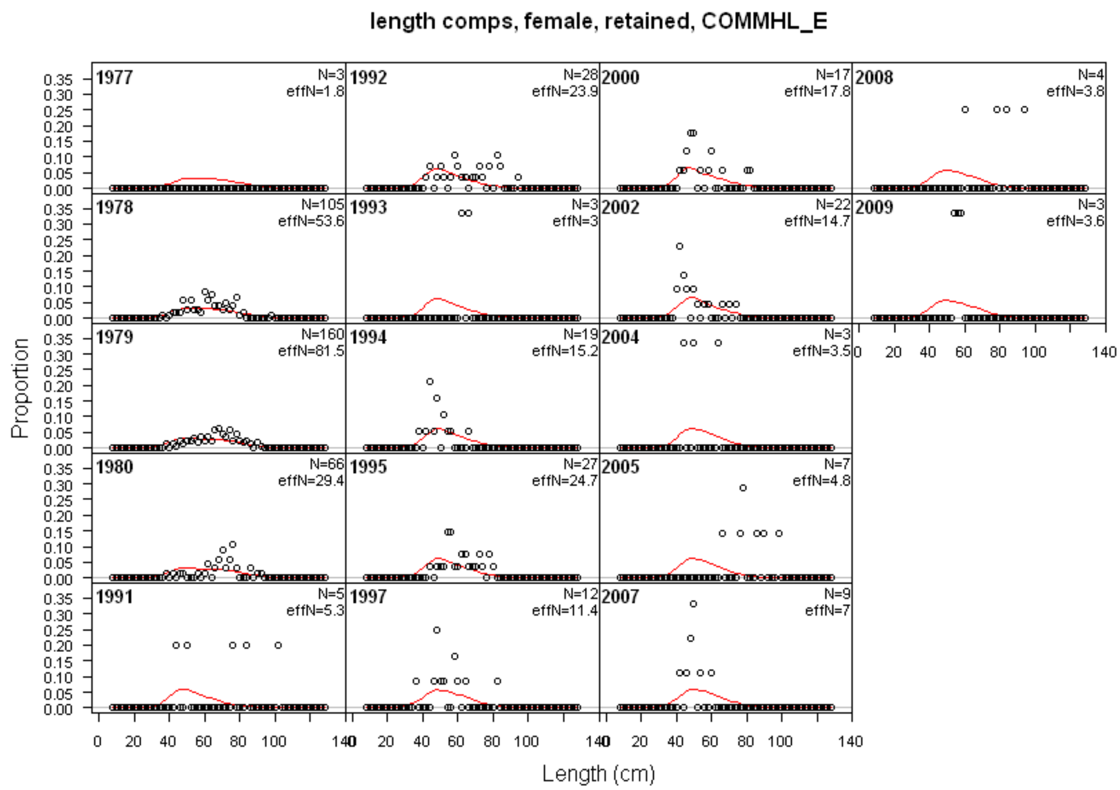


Figure 3.13. Length composition fits, commercial handline East, female

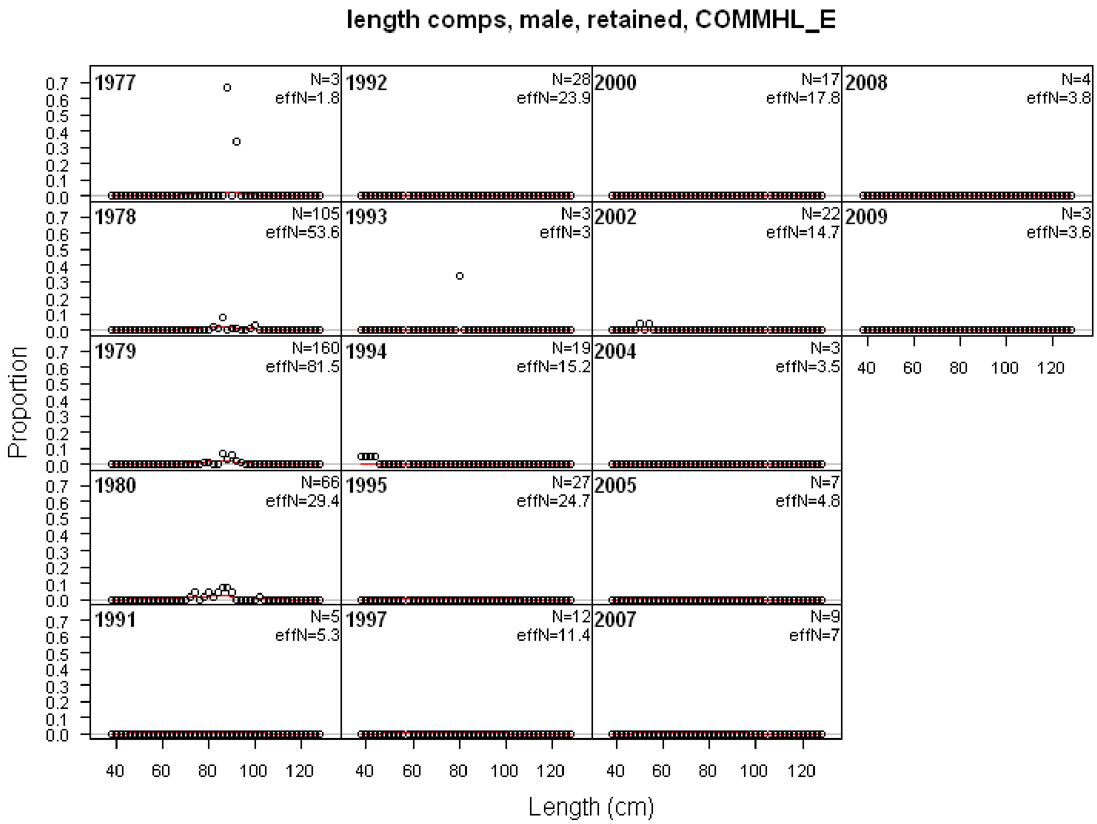


Figure 3.14. Length composition fits, commercial handline East, male.

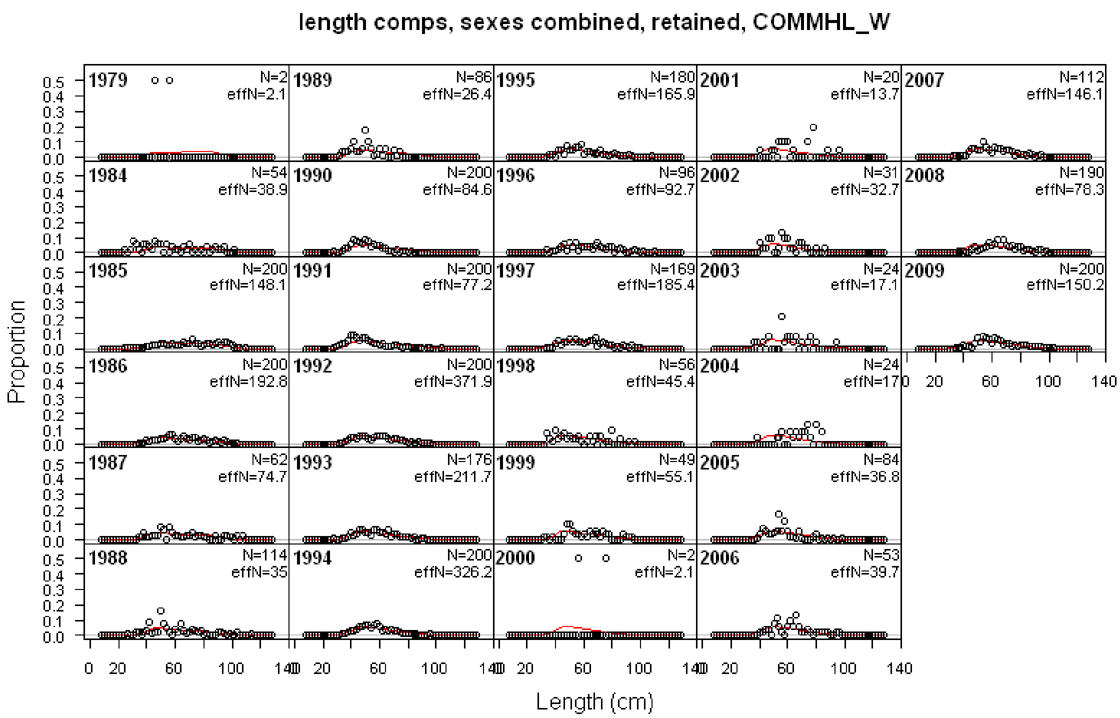


Figure 3.15. Length composition fits, commercial handline West, both sexes combined.

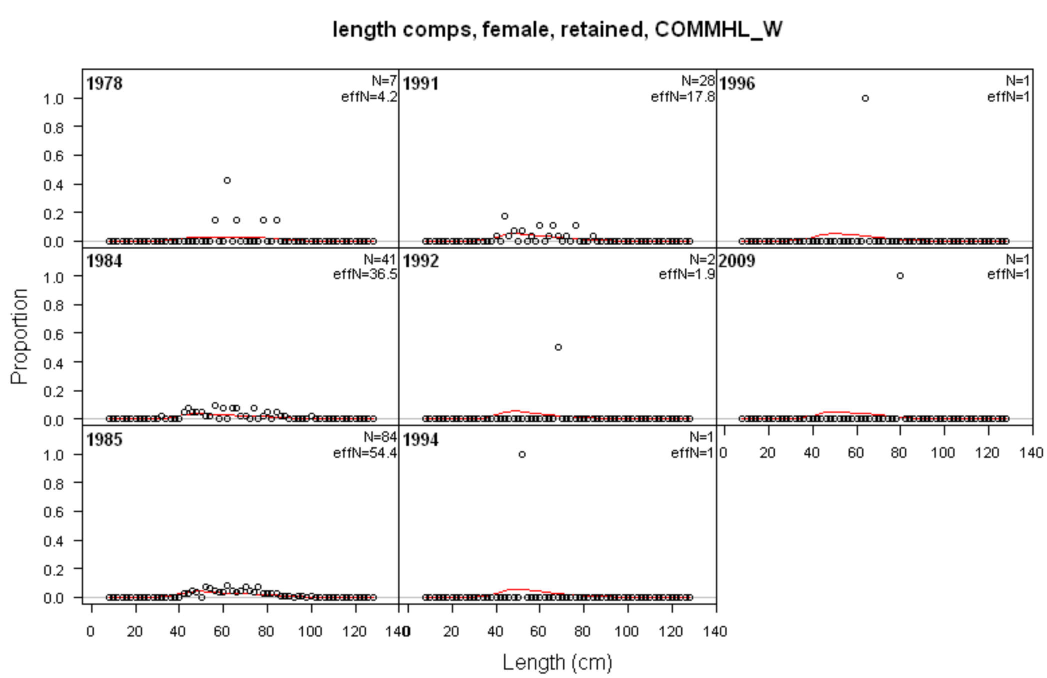


Figure 3.16. Length composition fits, commercial handline West,females.

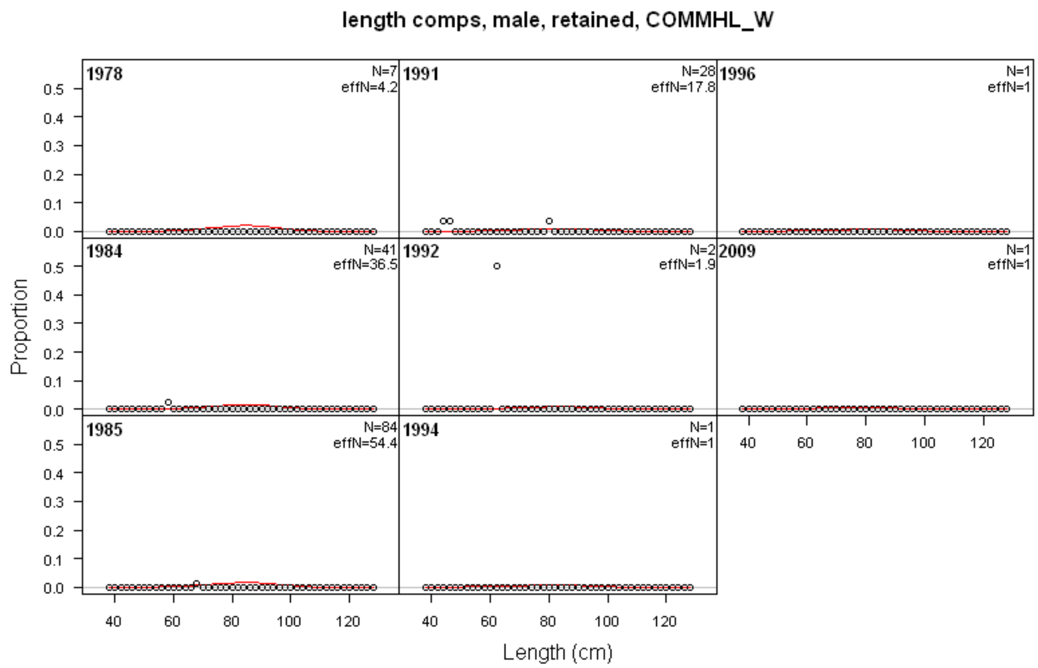


Figure 3.17. Length composition fits, commercial handline West, males.

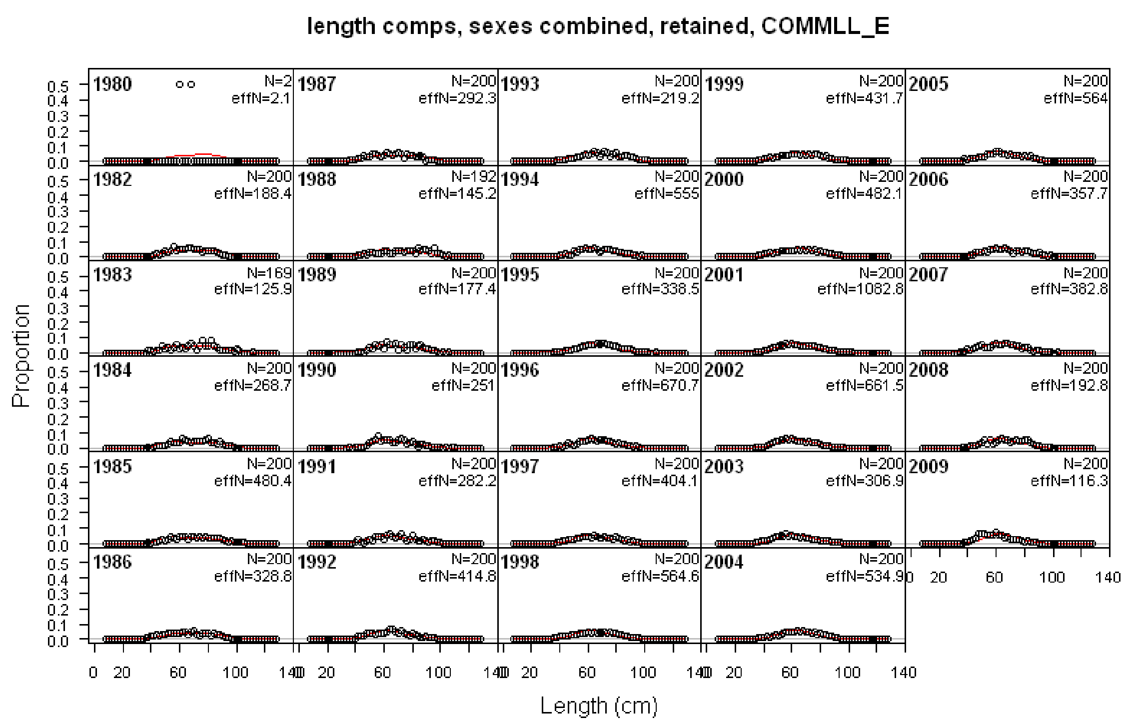


Figure 3.18. Length composition fits, commercial longline East, sexes not differentiated

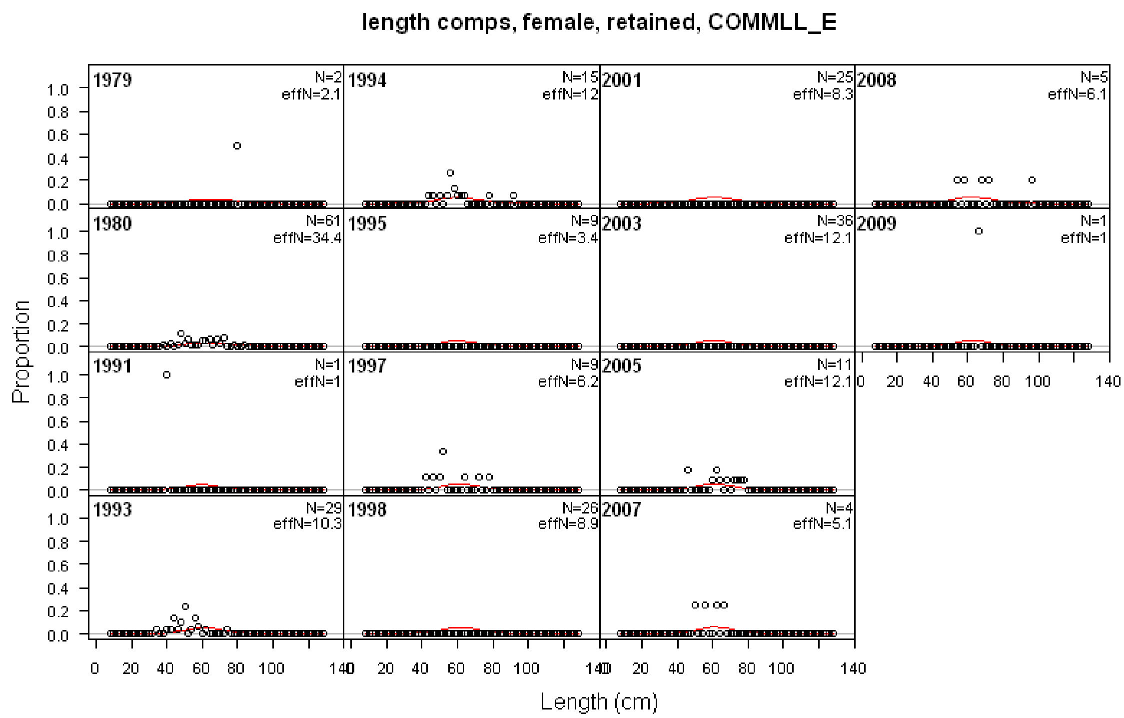


Figure 3.19. Length composition fits, commercial longline East, females.

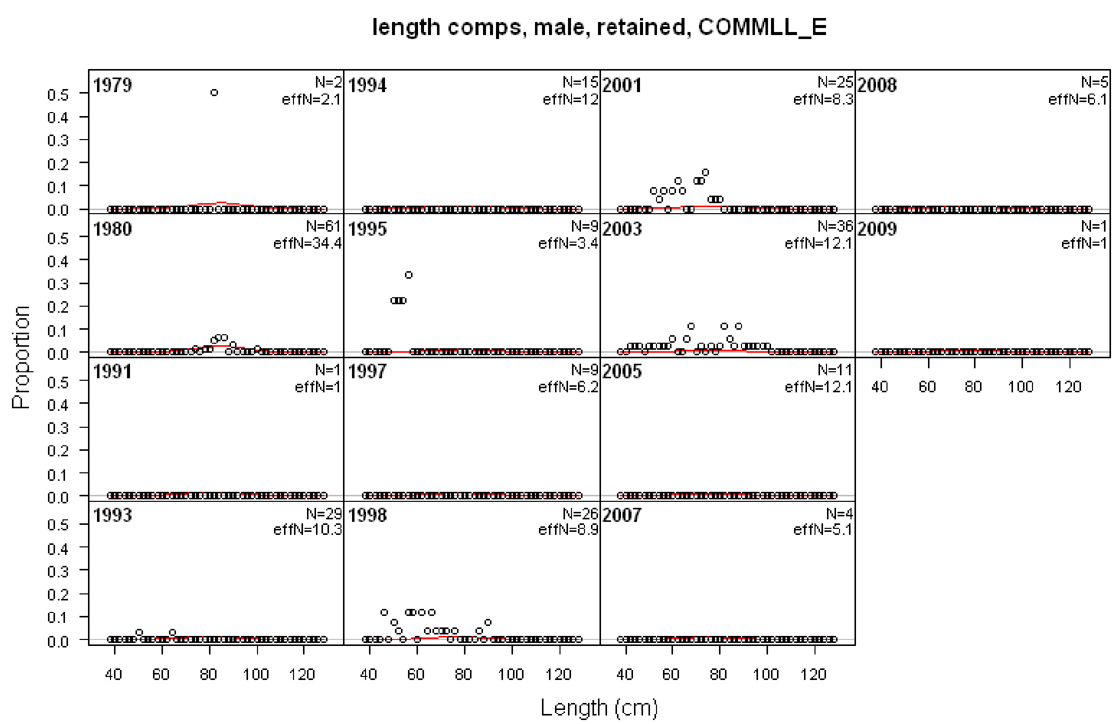


Figure 3.20. Length composition fits, commercial longline East, males.

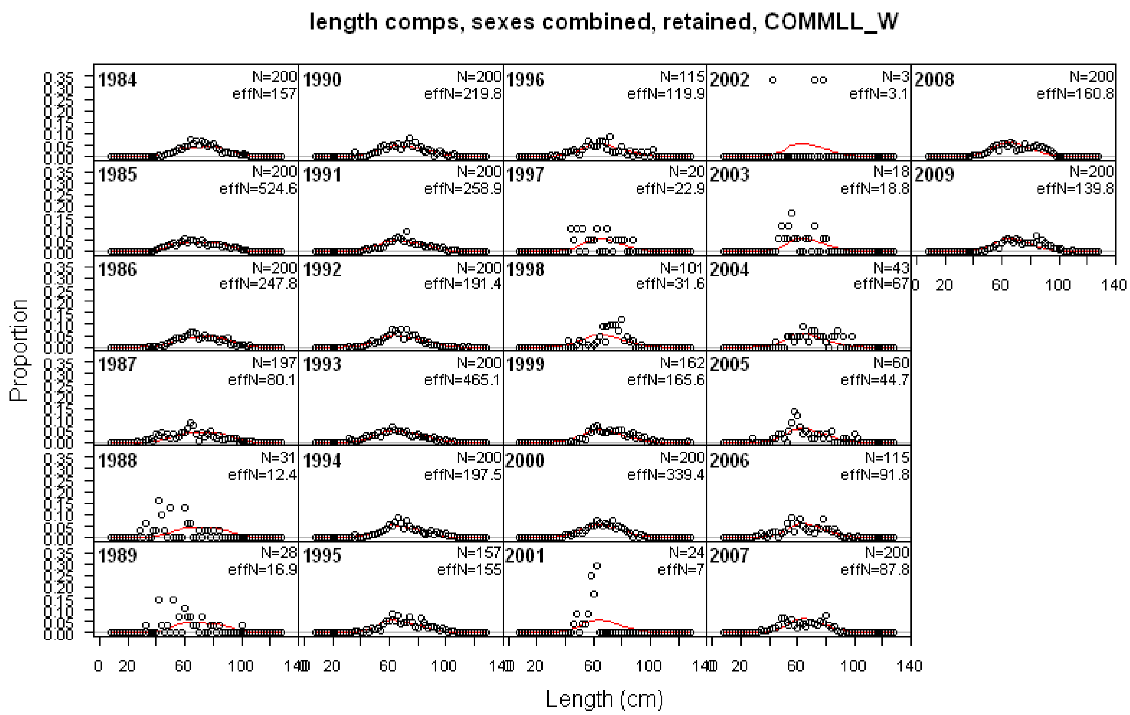


Figure 3.21. Length composition fits, commercial longline West, sexes not differentiated.

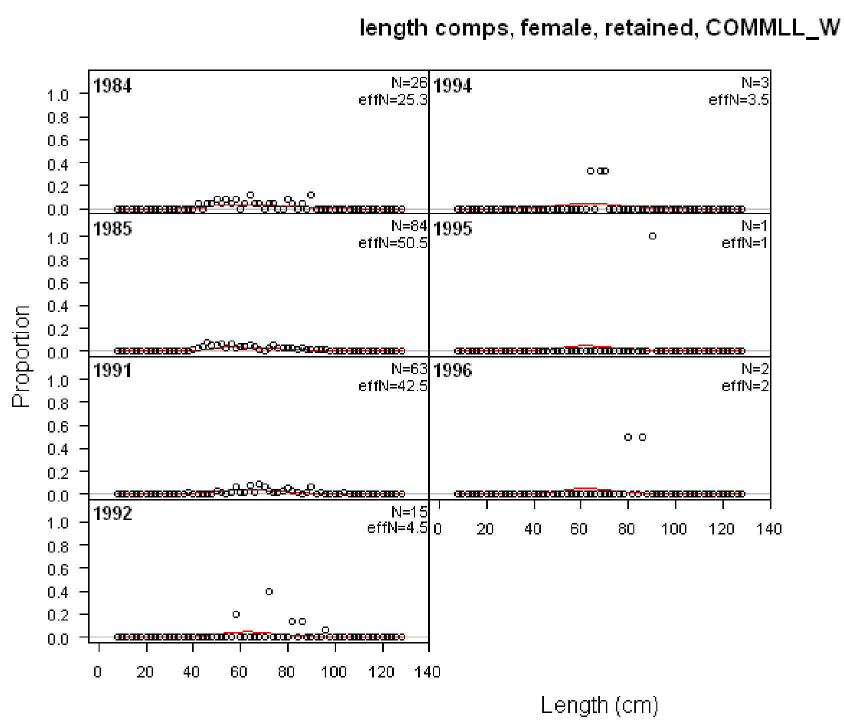


Figure 3.22. Length composition fits, commercial longline West, females.

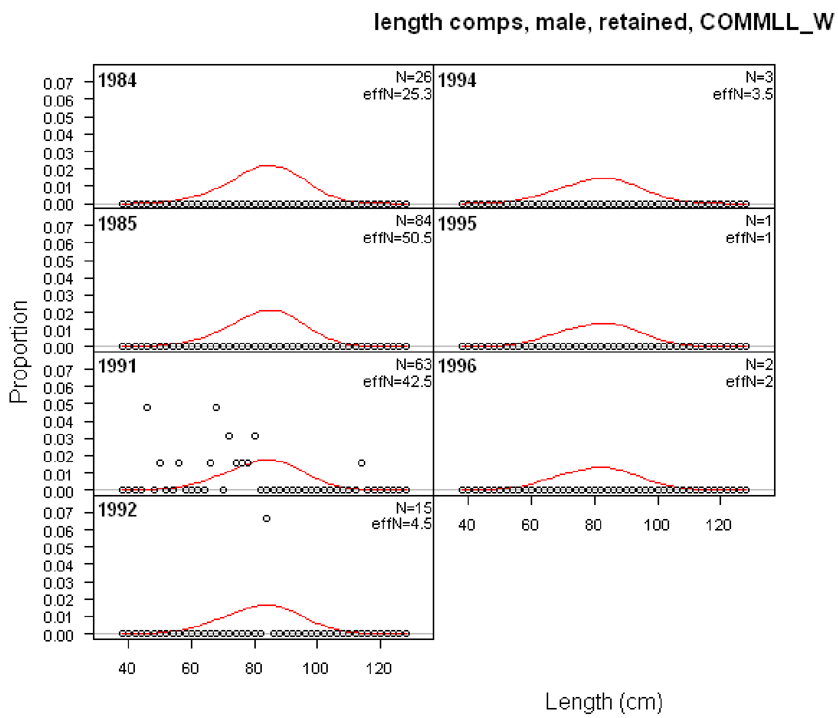


Figure 3.23. Length composition fits, commercial longline West, males.

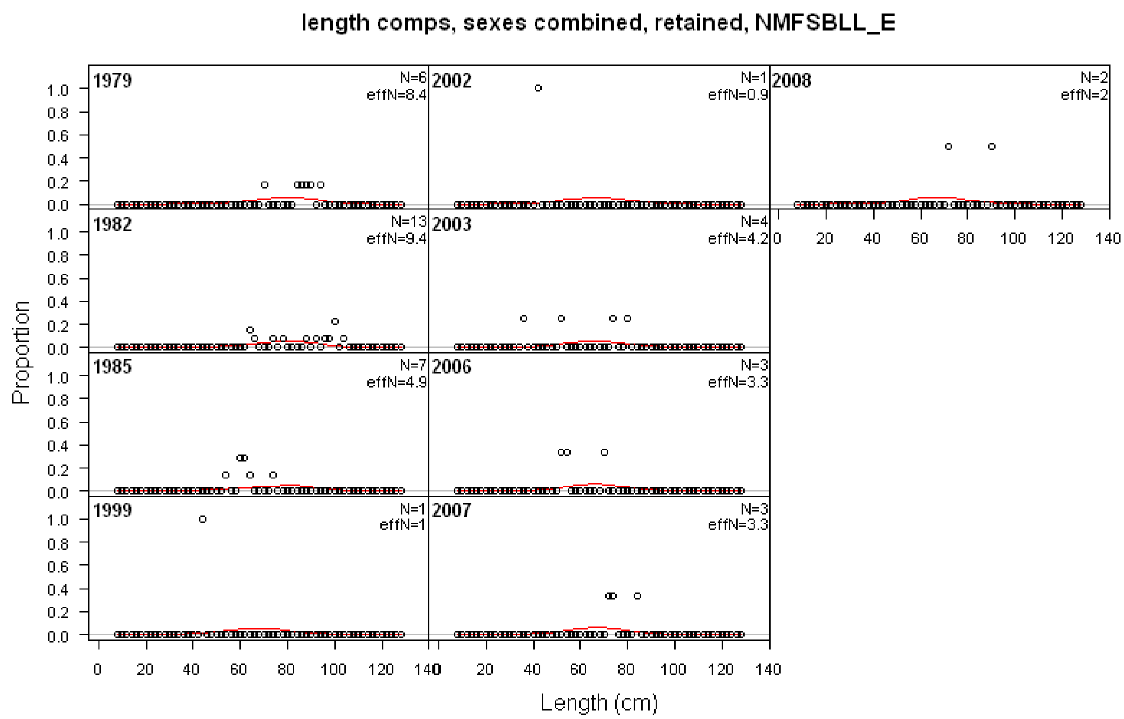


Figure 3.24. Length composition fits, NMFS bottom longline East, sexes not differentiated.

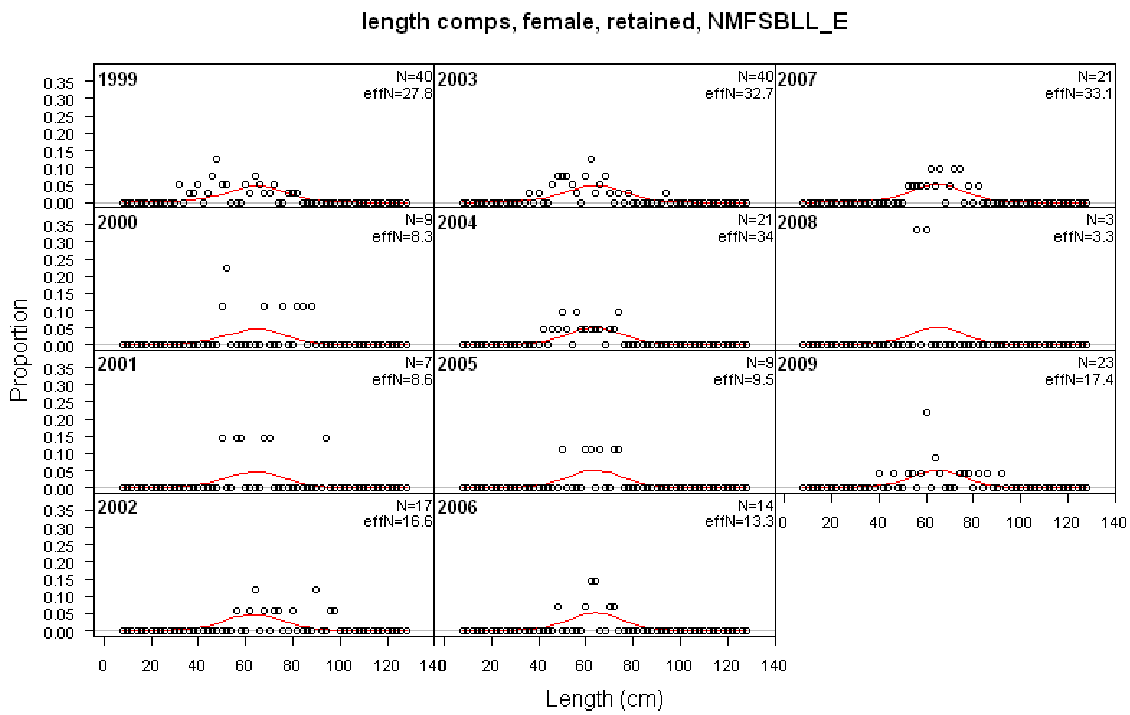


Figure 3.25. Length composition fits, NMFS bottom longline East, females.

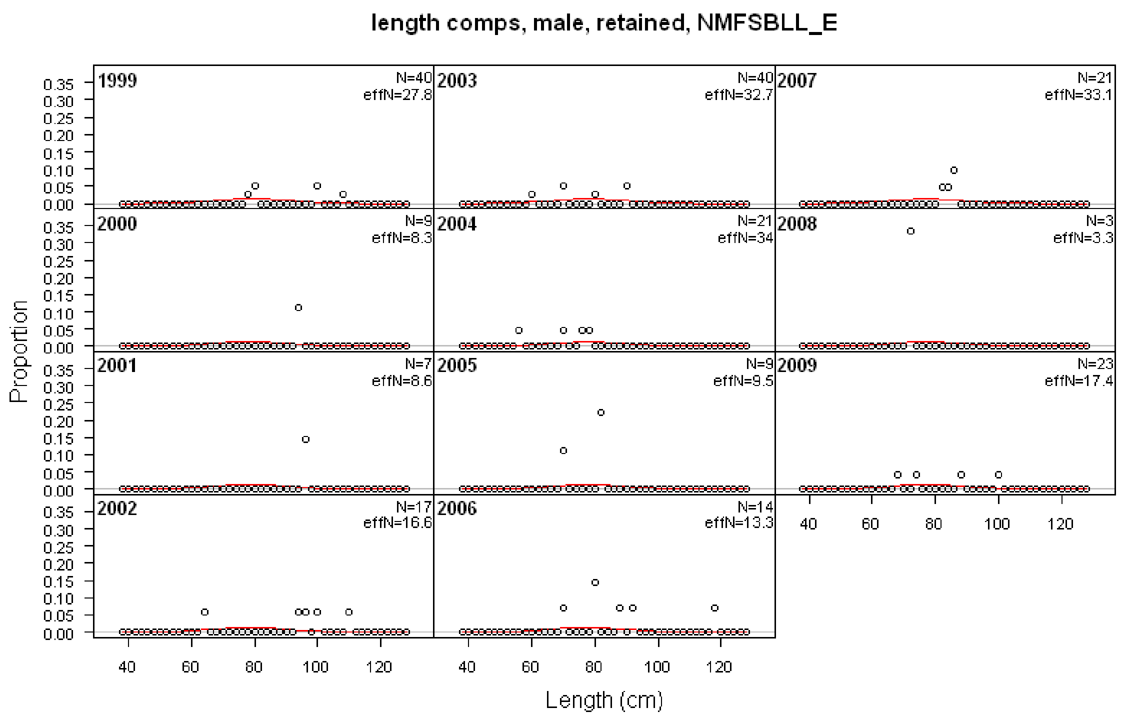


Figure 3.26. Length composition fits, NMFS bottom longline East, males.

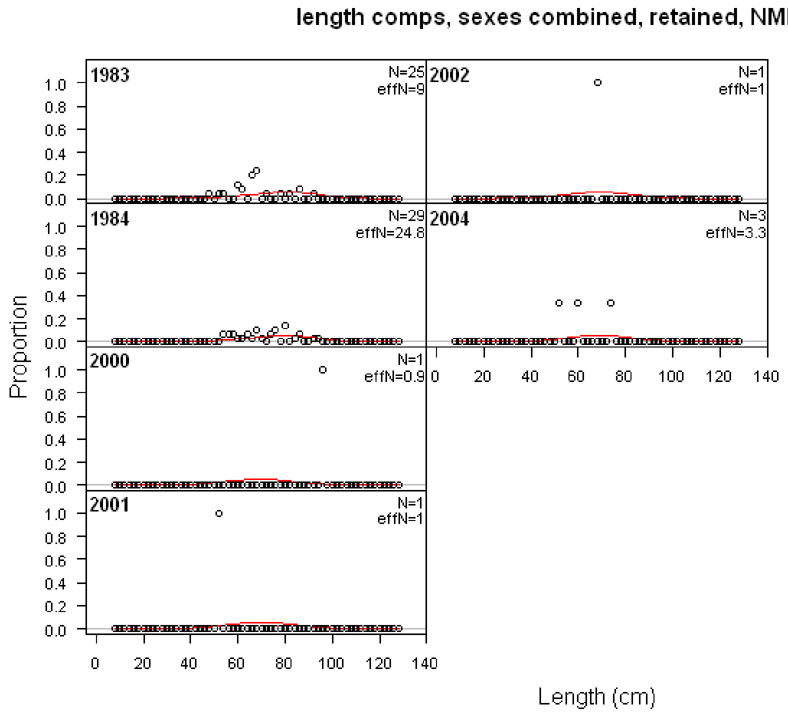


Figure 3.27. Length composition fits, NMFS bottom longline West, sexes not differentiated.

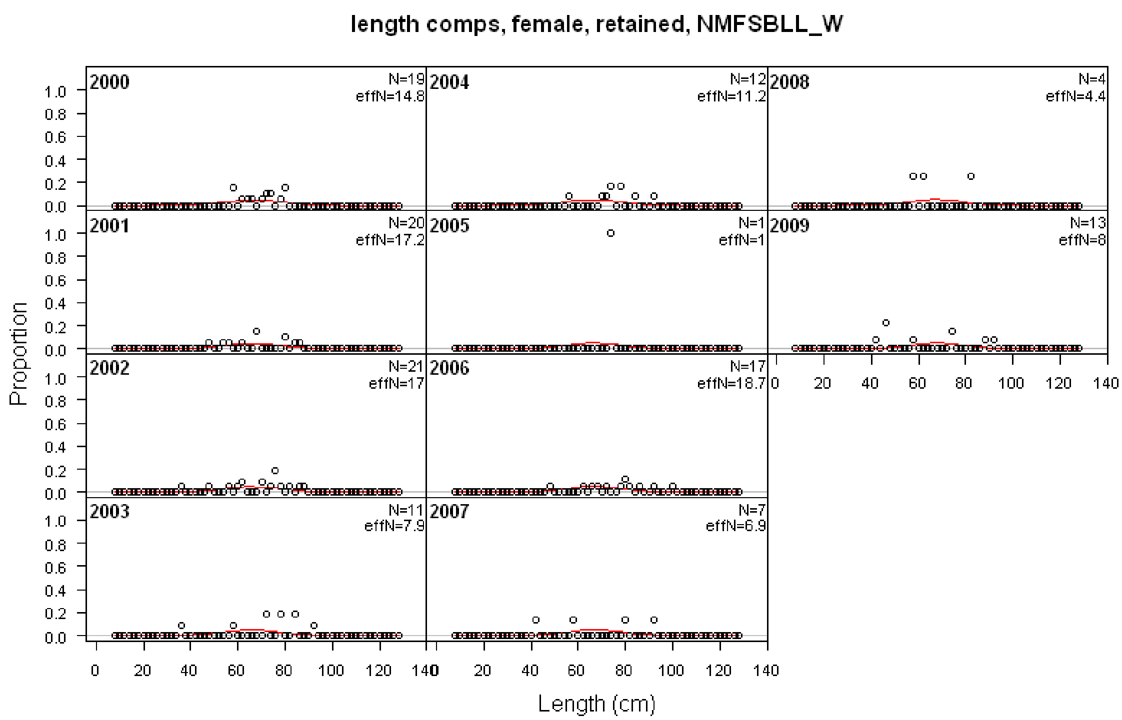


Figure 3.28. Length composition fits, NMFS bottom longline West, females.

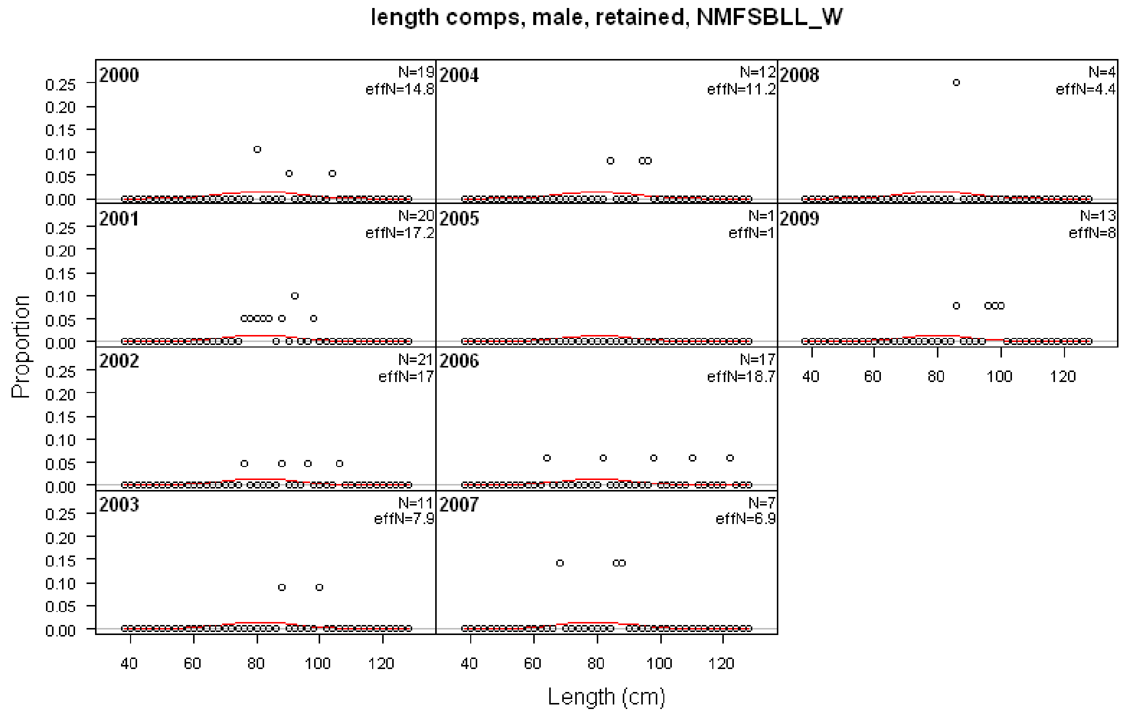


Figure 3.29. Length composition fits, NMFS bottom longline West, males.

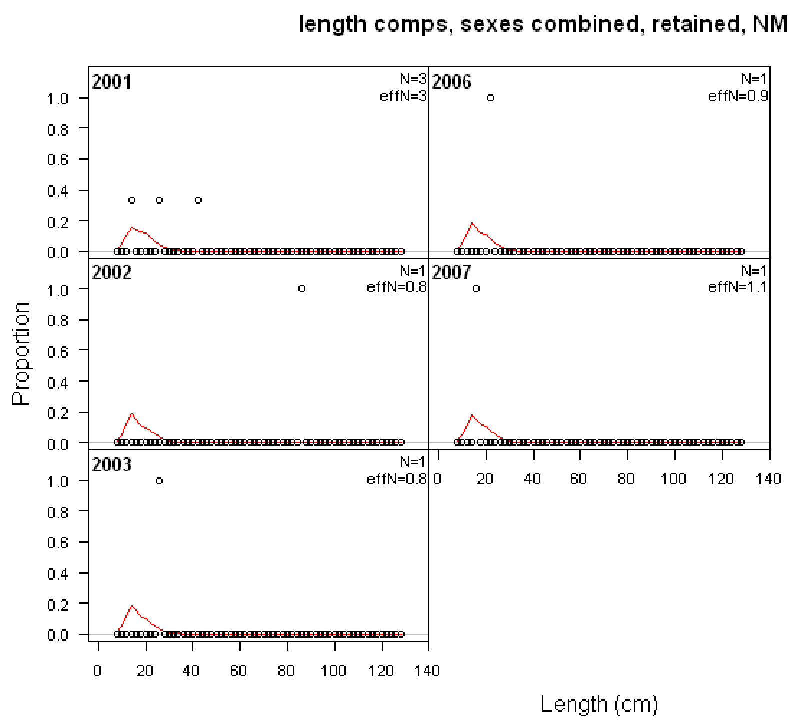


Figure 3.30. Length composition fits, SEAMAP trawl East, sexes not differentiated.

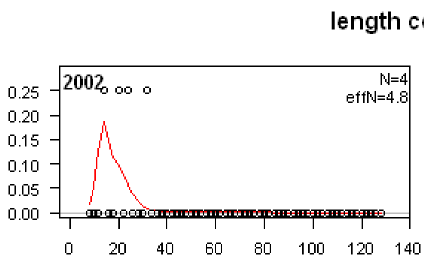


Figure 3.31. Length composition fits, SEAMAP trawl East, females.

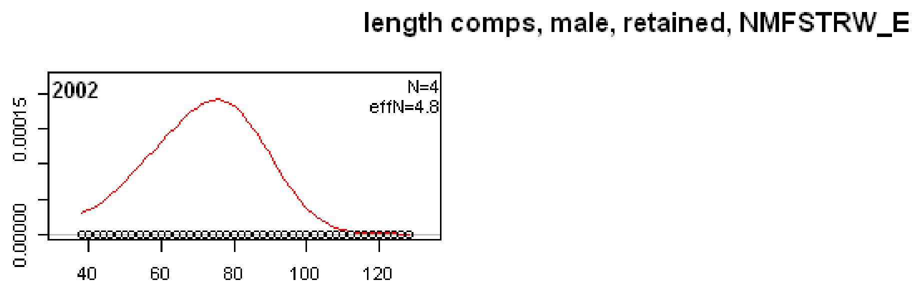


Figure 3.32. Length composition fits, SEAMAP trawl East, males.

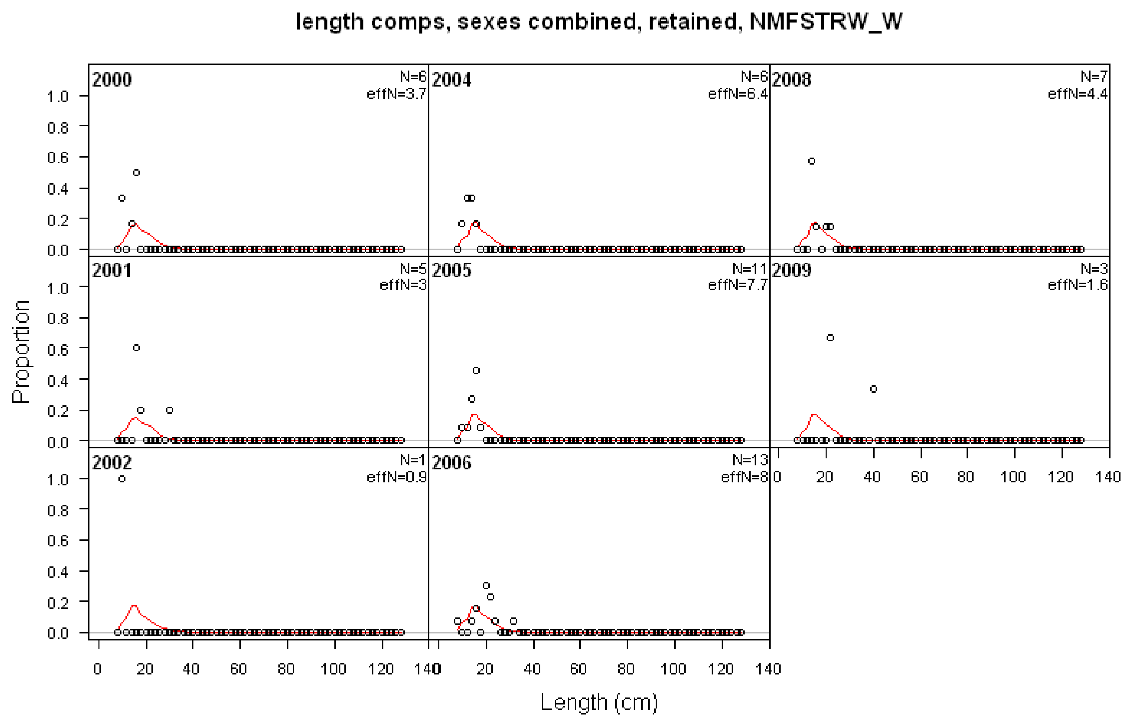


Figure 3.33. Length composition fits, SEAMAP trawl West, sexes not differentiated.

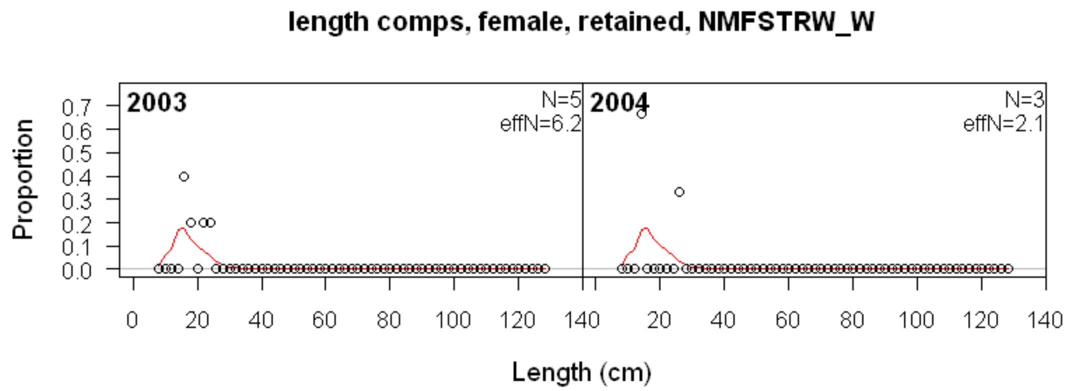


Figure 3.34. Length composition fits, SEAMAP trawl West, females.

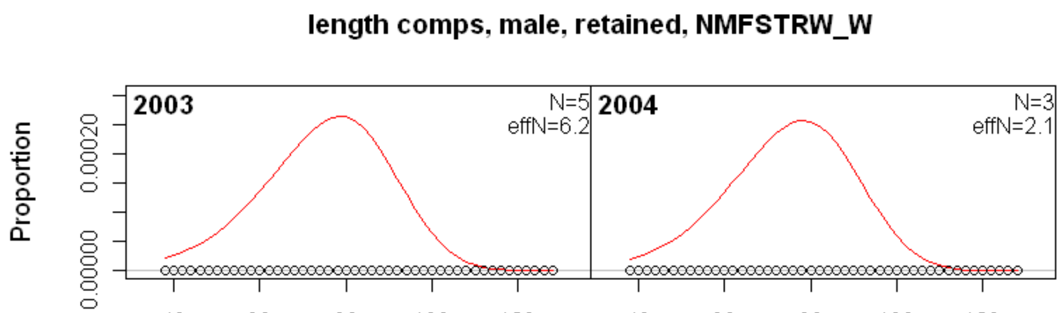


Figure 3.35. Length composition fits, SEAMAP trawl West, males.

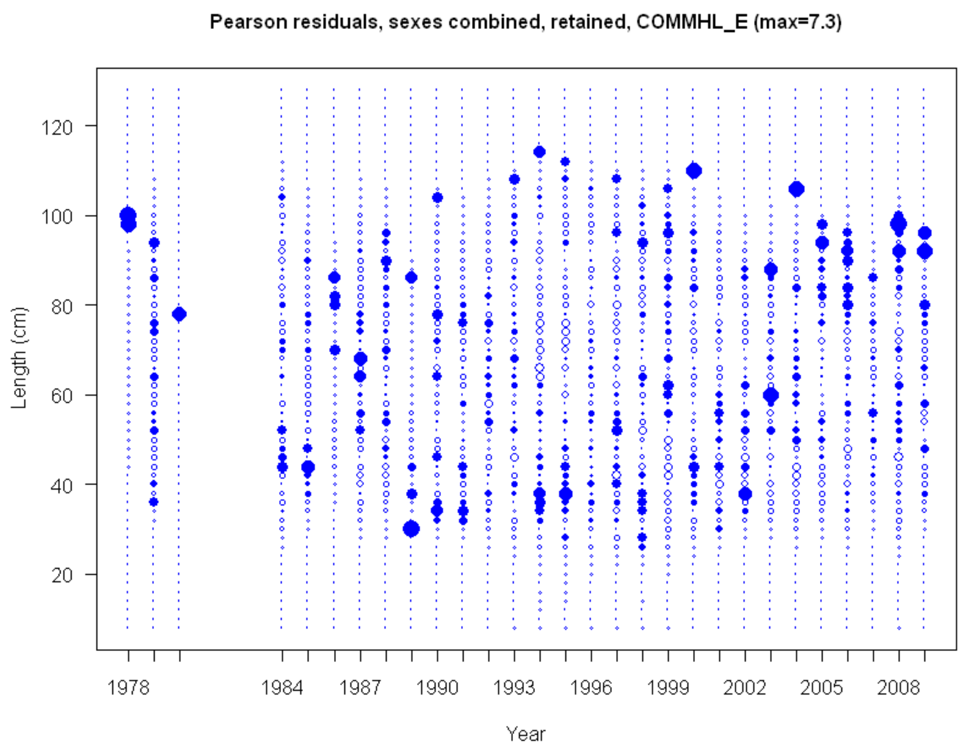


Figure 3.36. Pearson residuals commercial handline East, sexes not differentiated. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

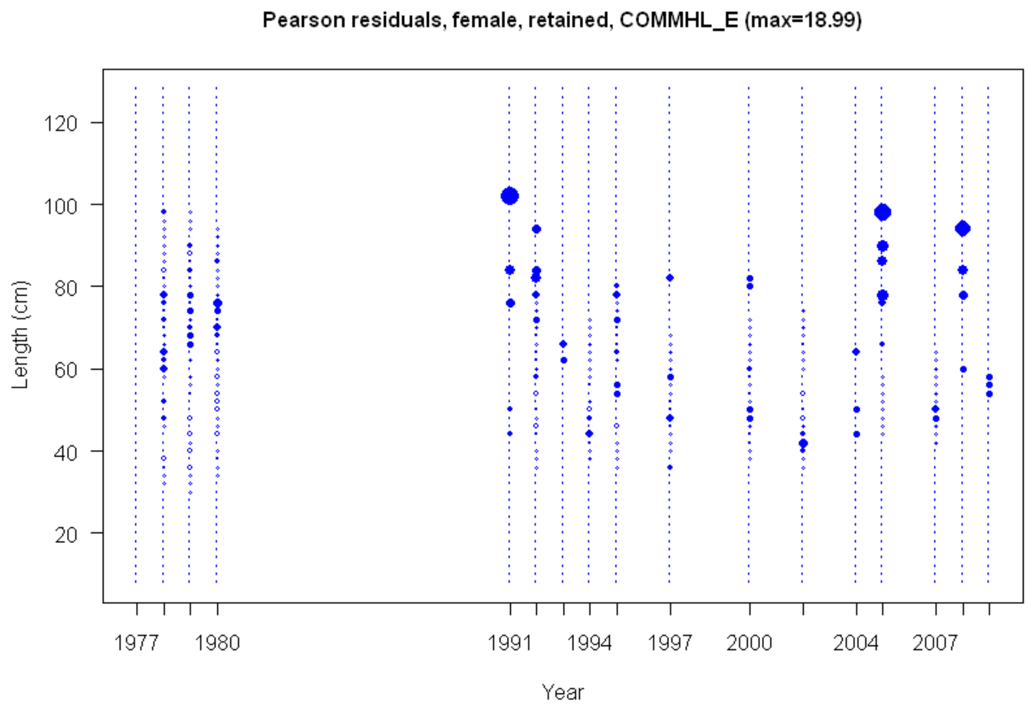


Figure 3.37. Pearson residuals commercial handline East, females.

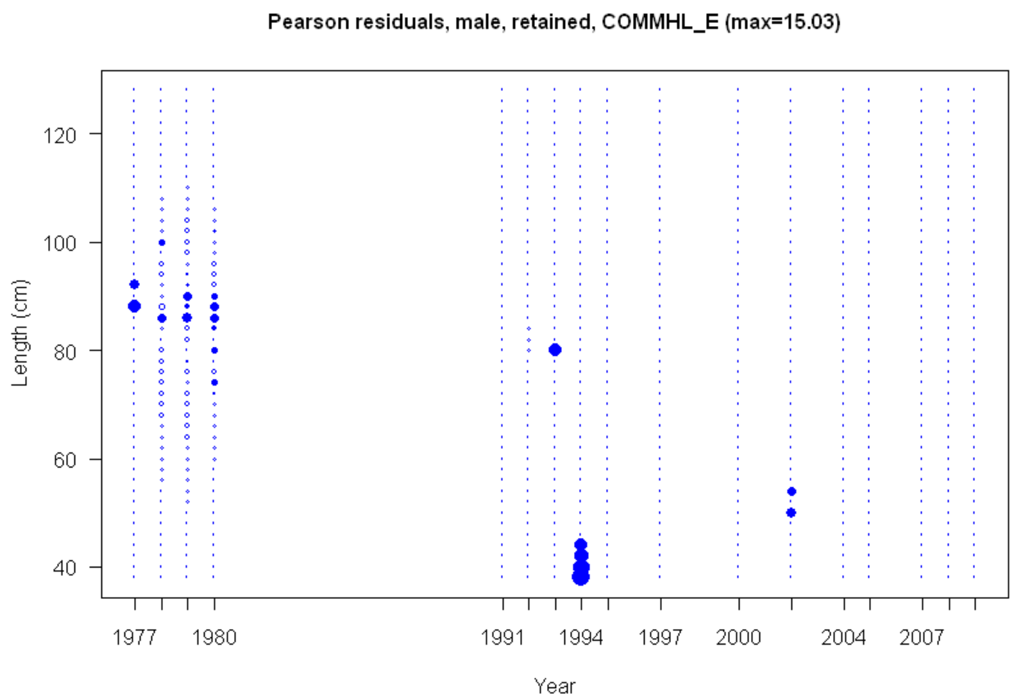


Figure 3.38. Pearson residuals commercial handline East, males.

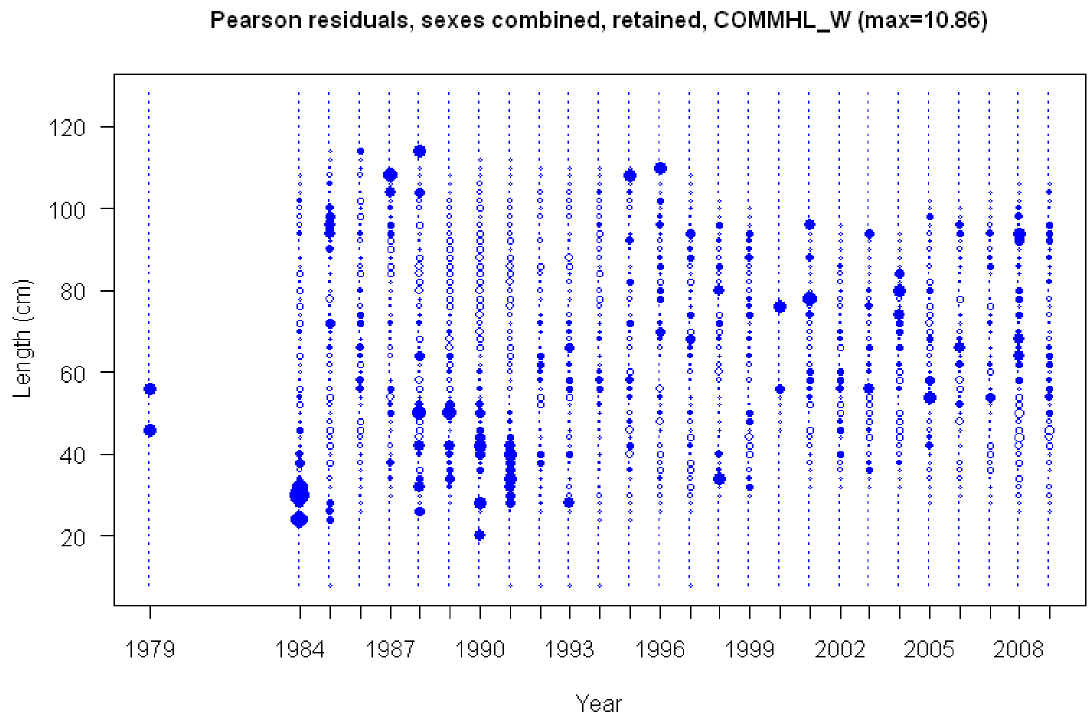


Figure 3.39. Pearson residuals commercial handline West, sexes not differentiated.

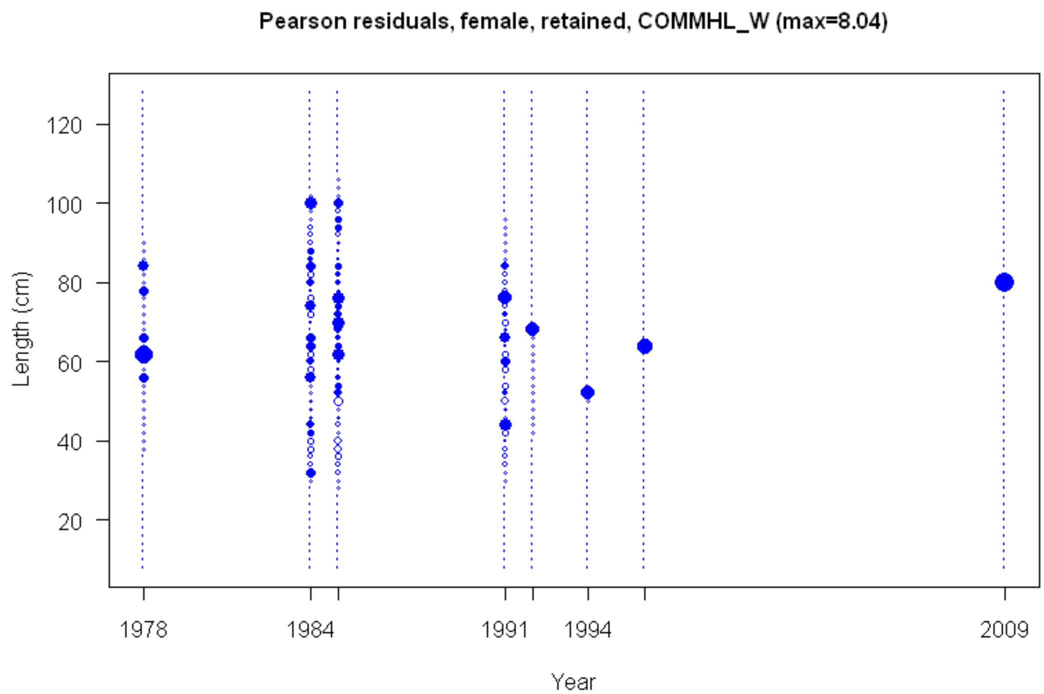


Figure 3.40. Pearson residuals commercial handline West, females.

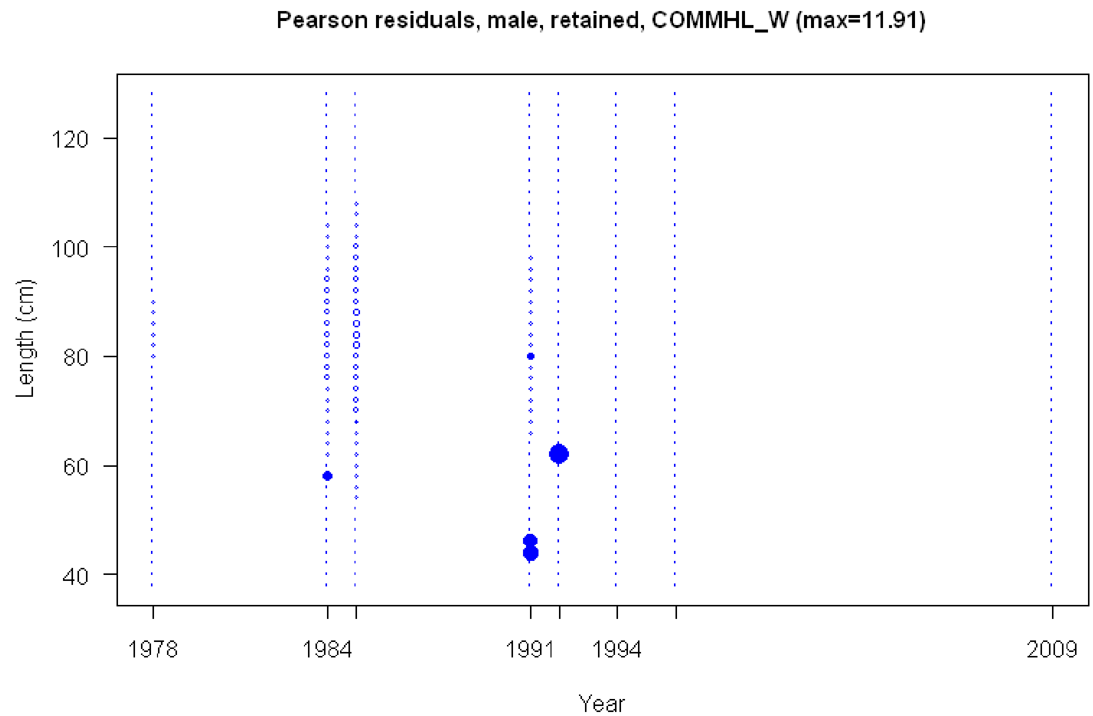


Figure 3.41. Pearson residuals commercial handline West, males.

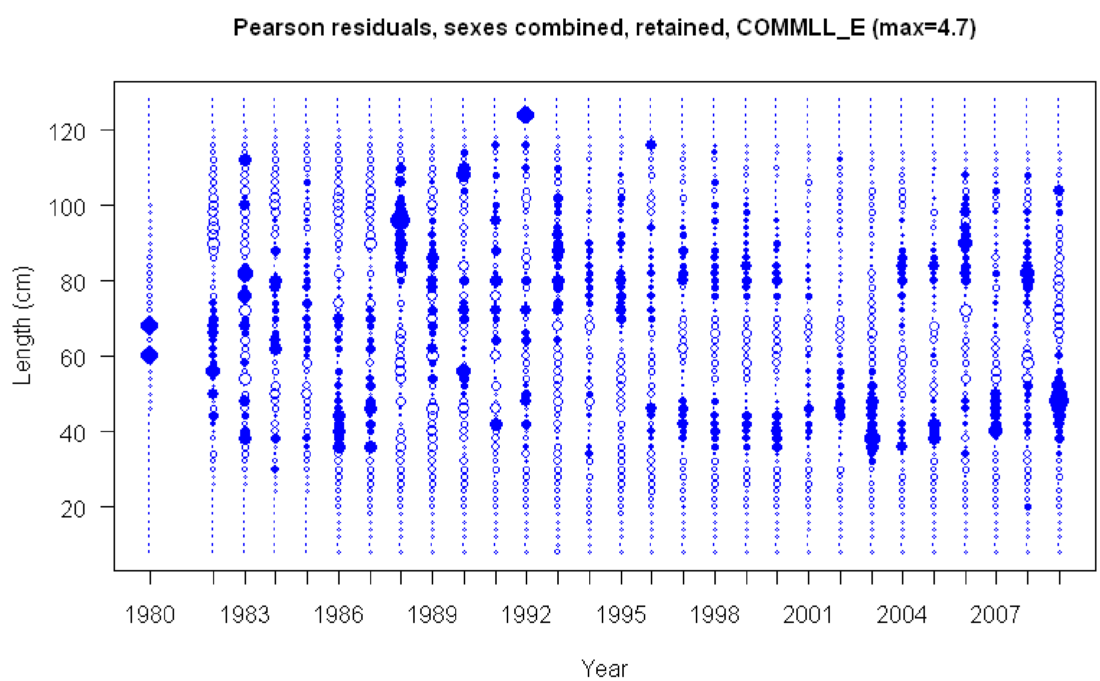


Figure 3.42. Pearson residuals commercial longline East, sexes not differentiated.

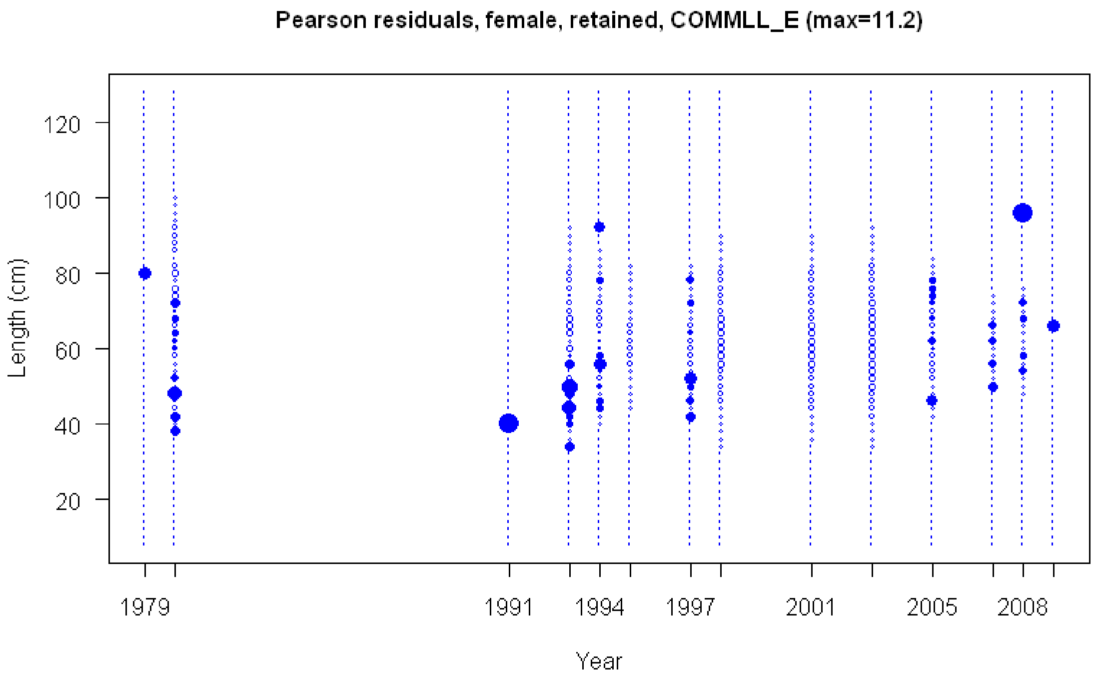


Figure 3.43. Pearson residuals commercial longline East, females.

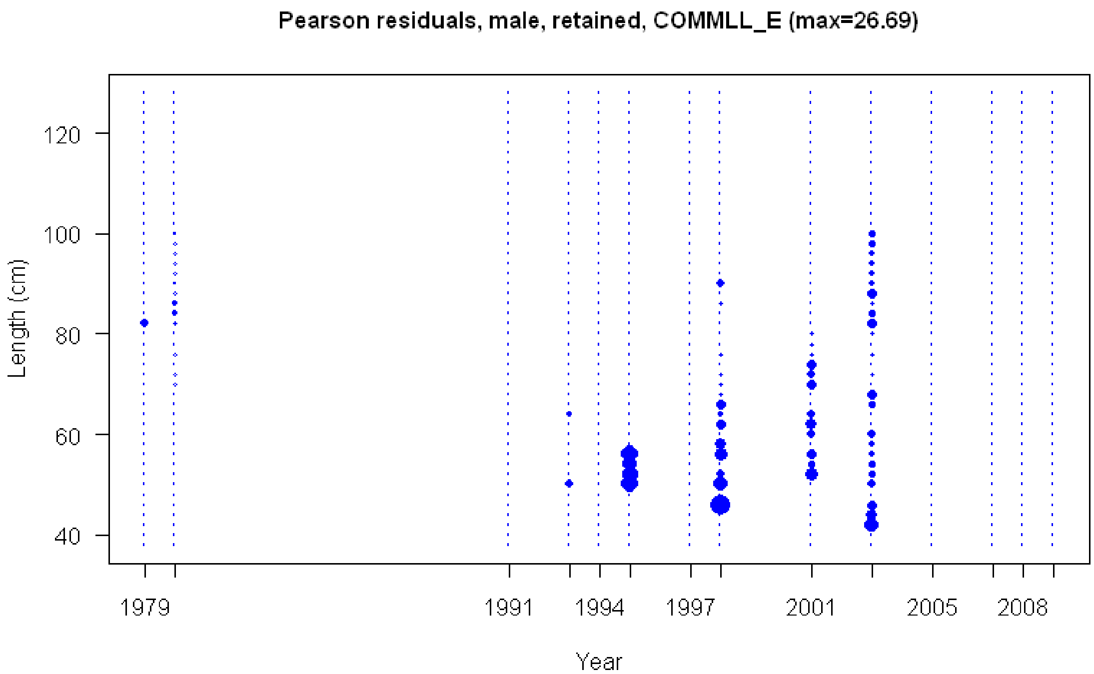


Figure 3.44. Pearson residuals commercial longline East, males.

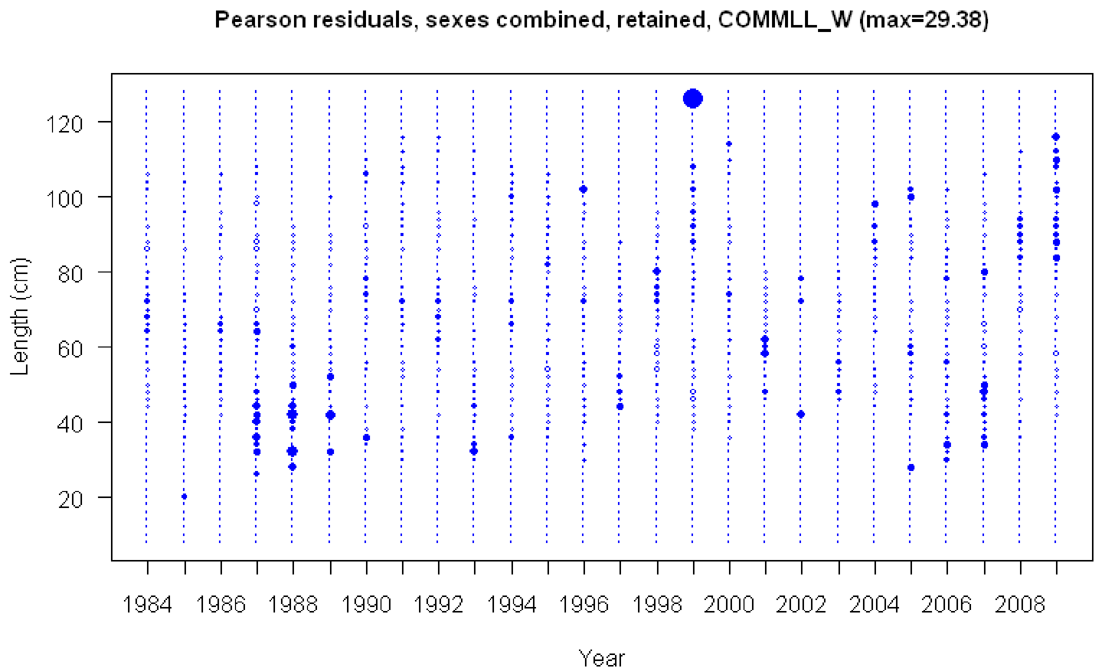


Figure 3.45. Pearson residuals commercial longline West, sexes not differentiated.

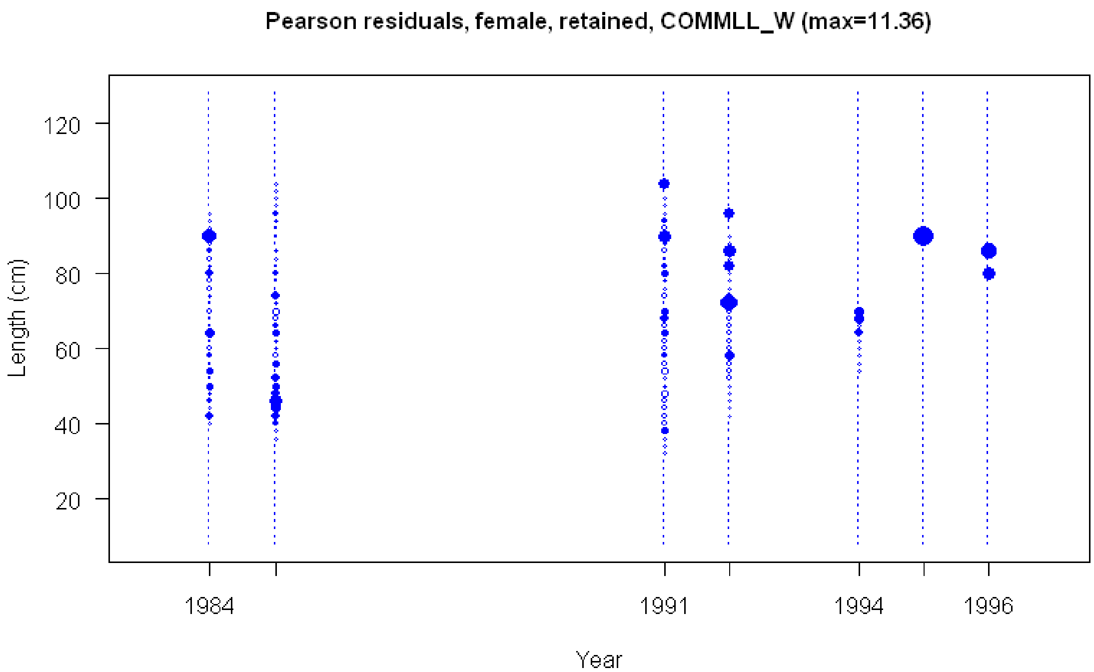


Figure 3.46. Pearson residuals commercial longline West, females.

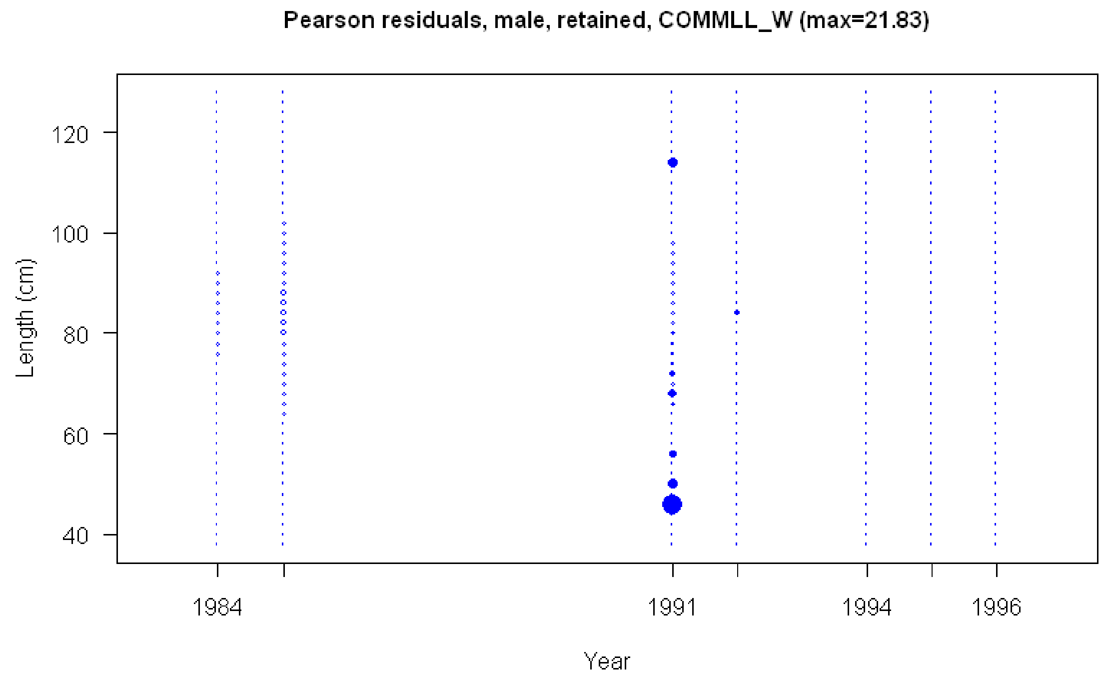


Figure 3.47. Pearson residuals commercial longline West, males.

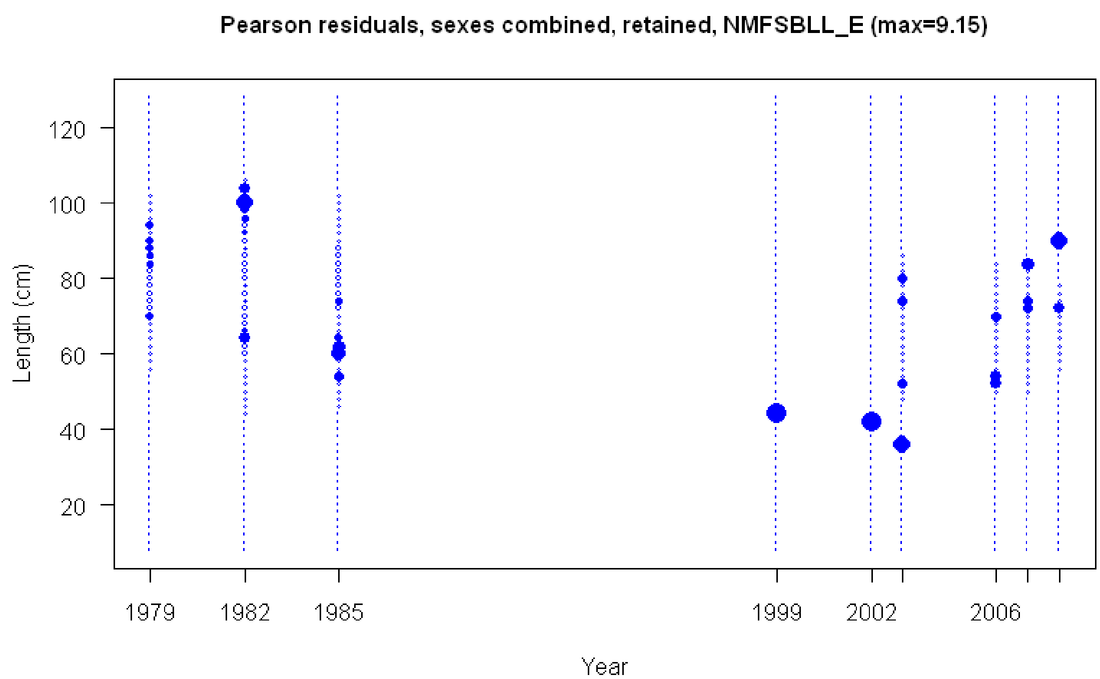


Figure 3.48. Pearson residuals NMFS bottom longline East, sexes not differentiated.

Figure 3.49. Pearson residuals NMFS bottom longline East, females.

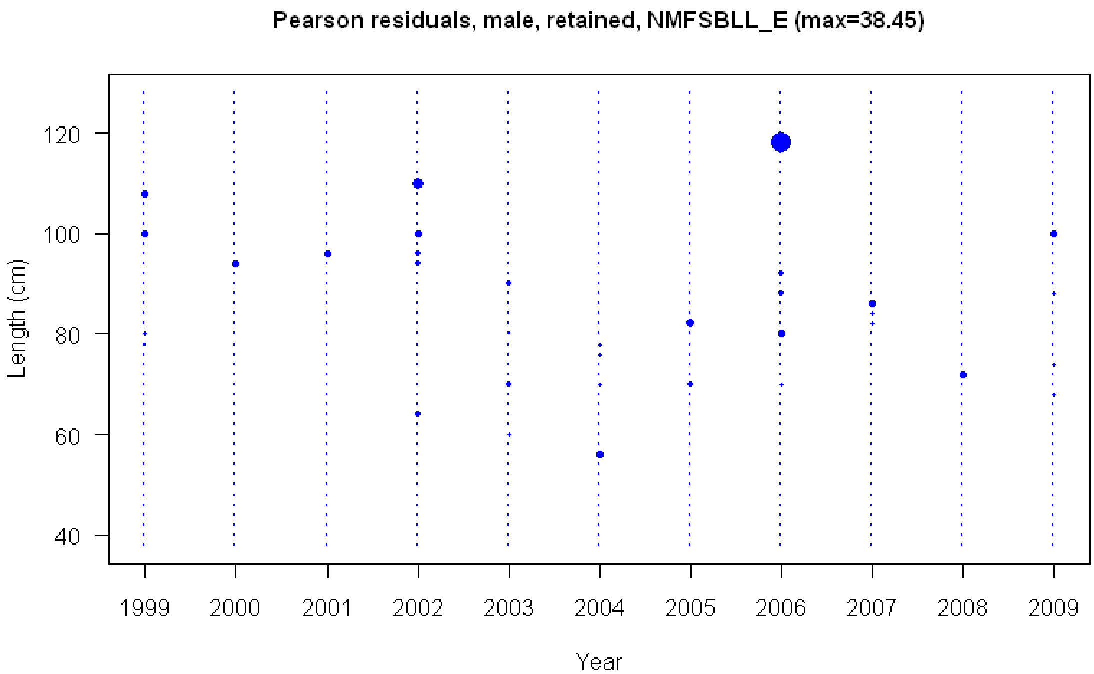


Figure 3.50. Pearson residuals NMFS bottom longline East, males.

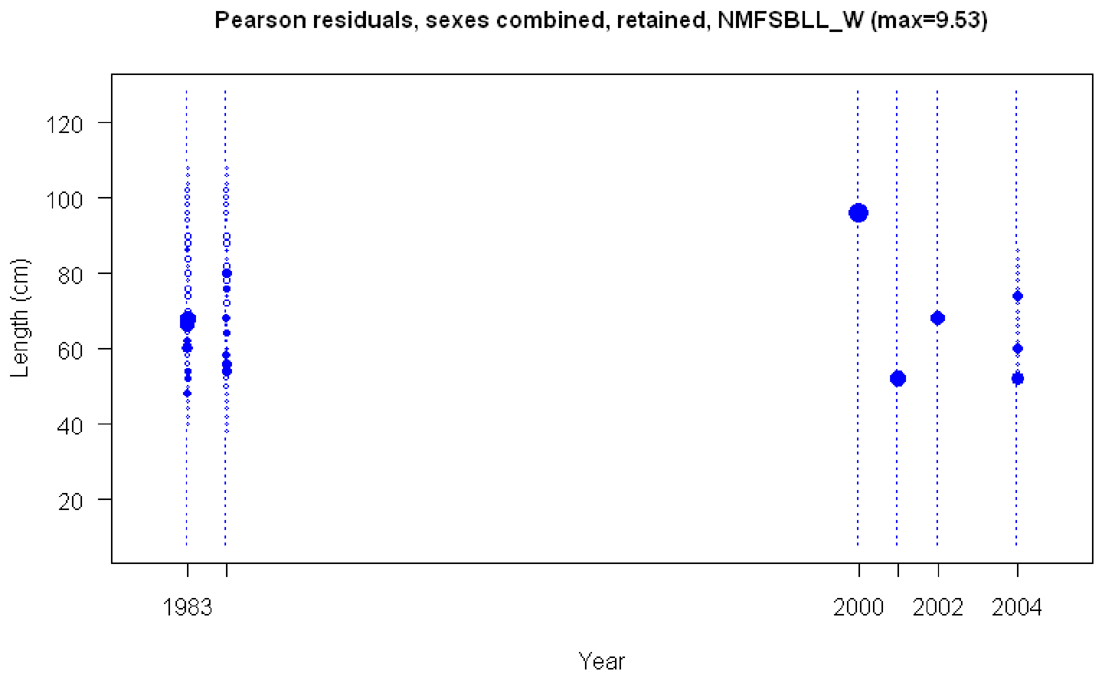


Figure 3.51. Pearson residuals NMFS bottom longline West, males.

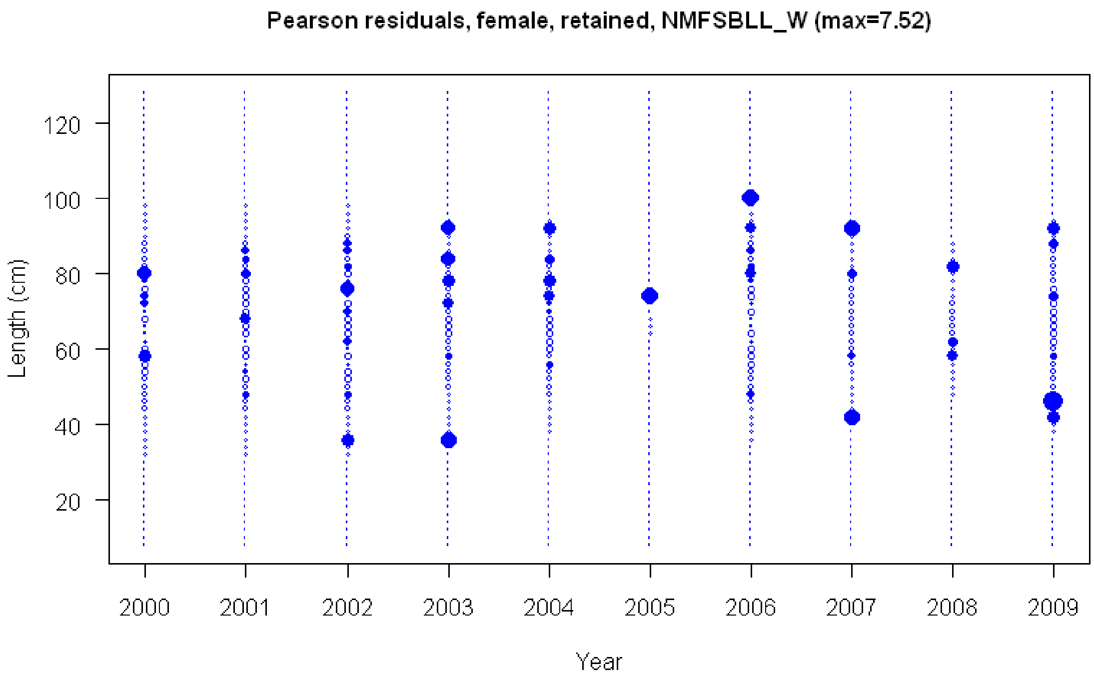


Figure 3.52. Pearson residuals NMFS bottom longline West, females.

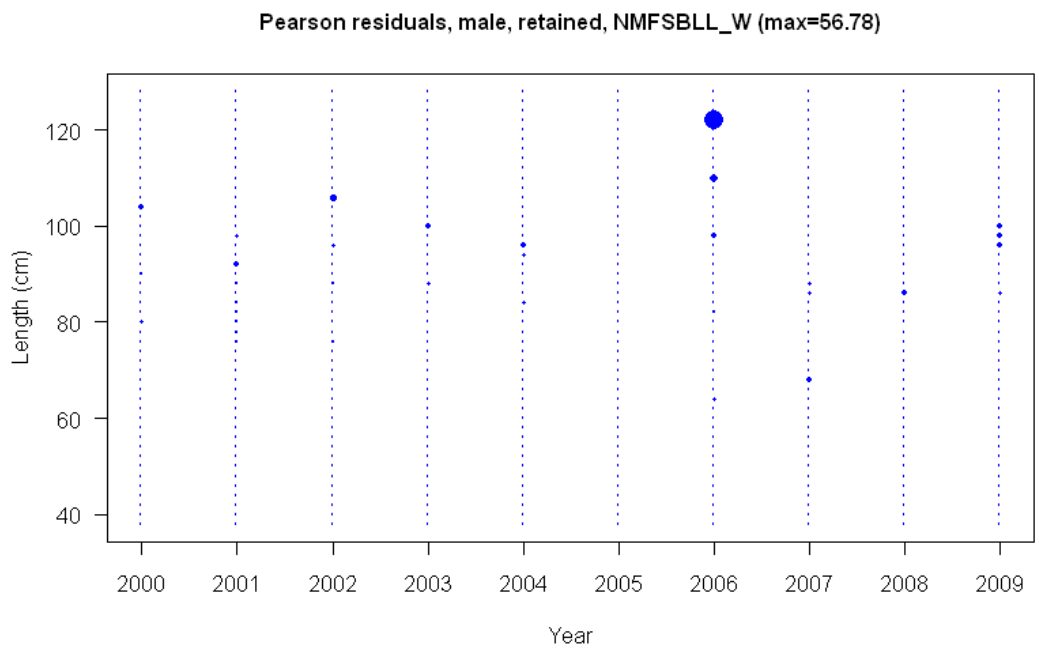


Figure 3.53. Pearson residuals NMFS bottom longline West, males.

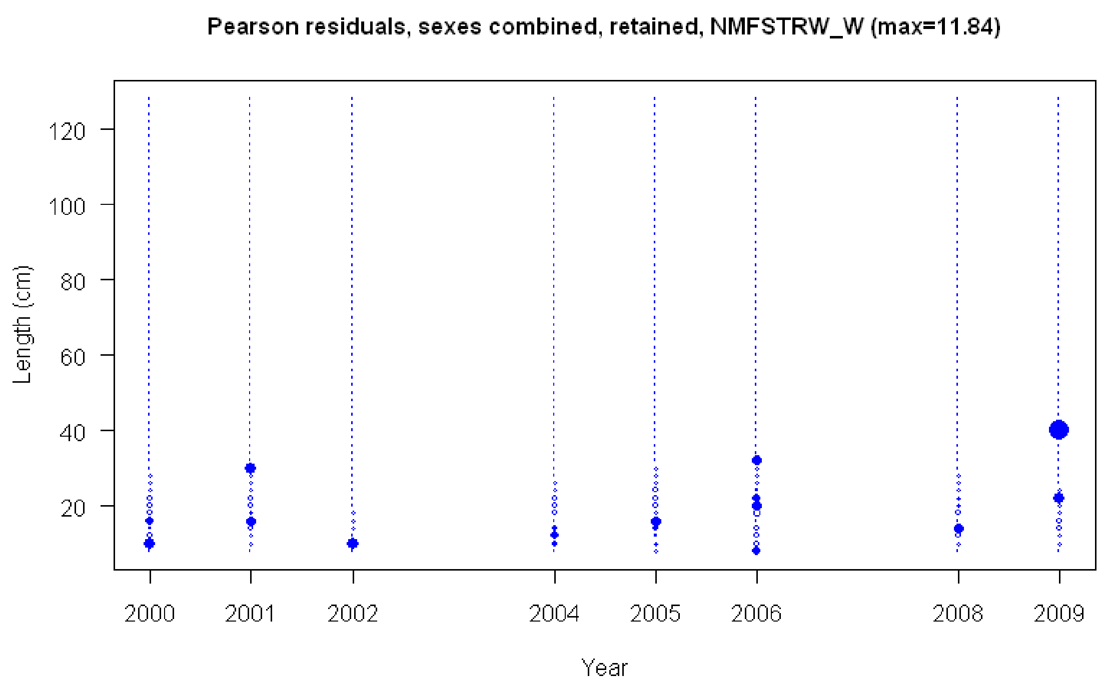


Figure 3.54. Pearson residuals SEAMAP trawl West, sexes not differentiated. All other Pearson residual plots for the males, females and for the East are uninformative as they have only a few fish.

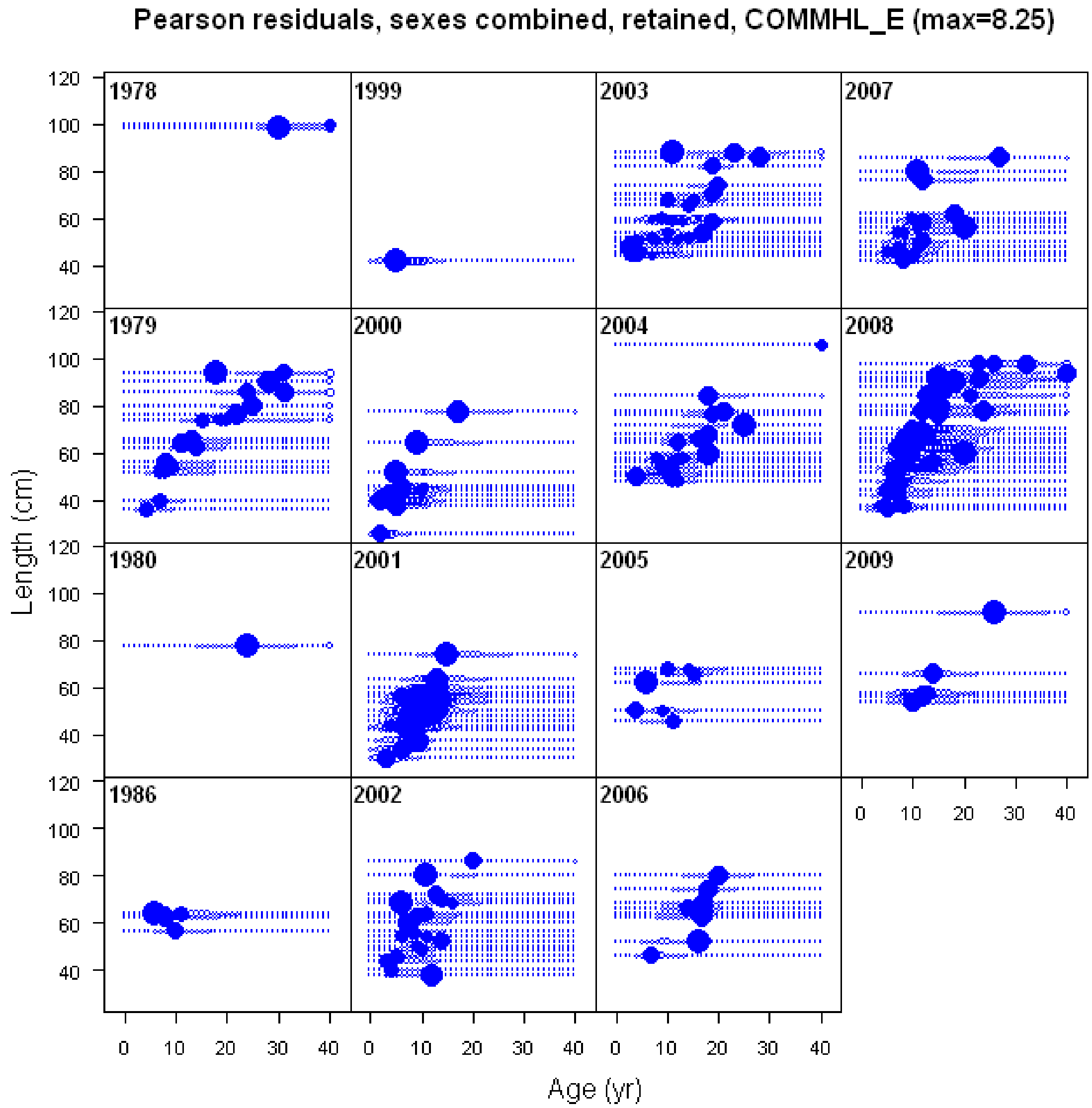


Figure 3.55. Pearson residuals for fits to conditional age at length, commercial handline East, both sexes combined.

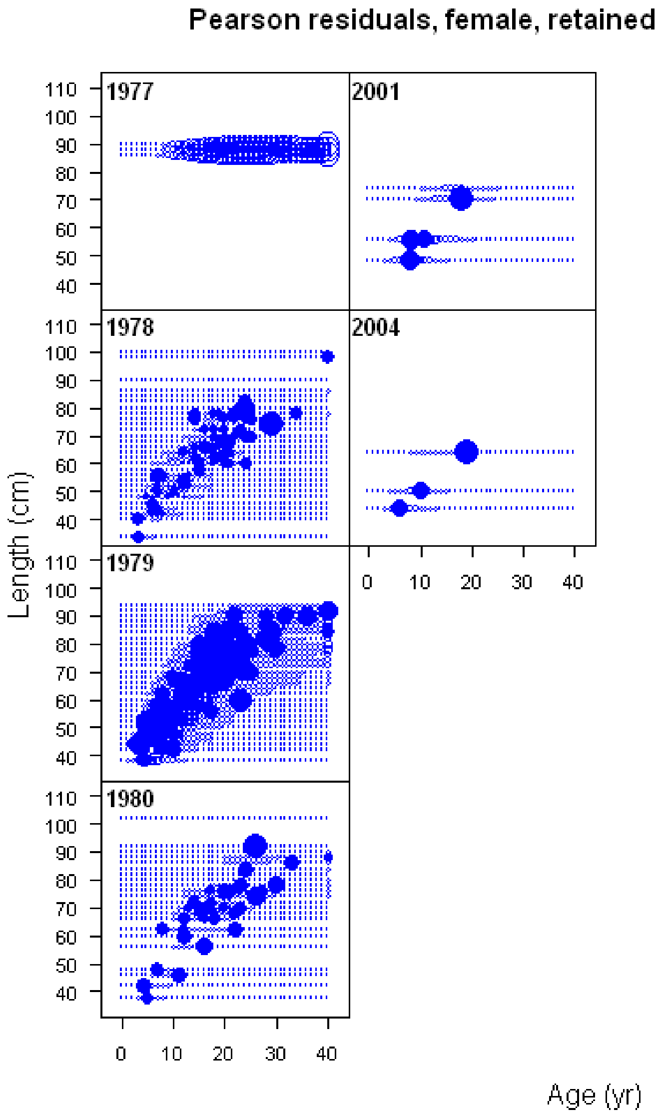


Figure 3.56. Pearson residuals for fits to conditional age at length,commercial handline East, females

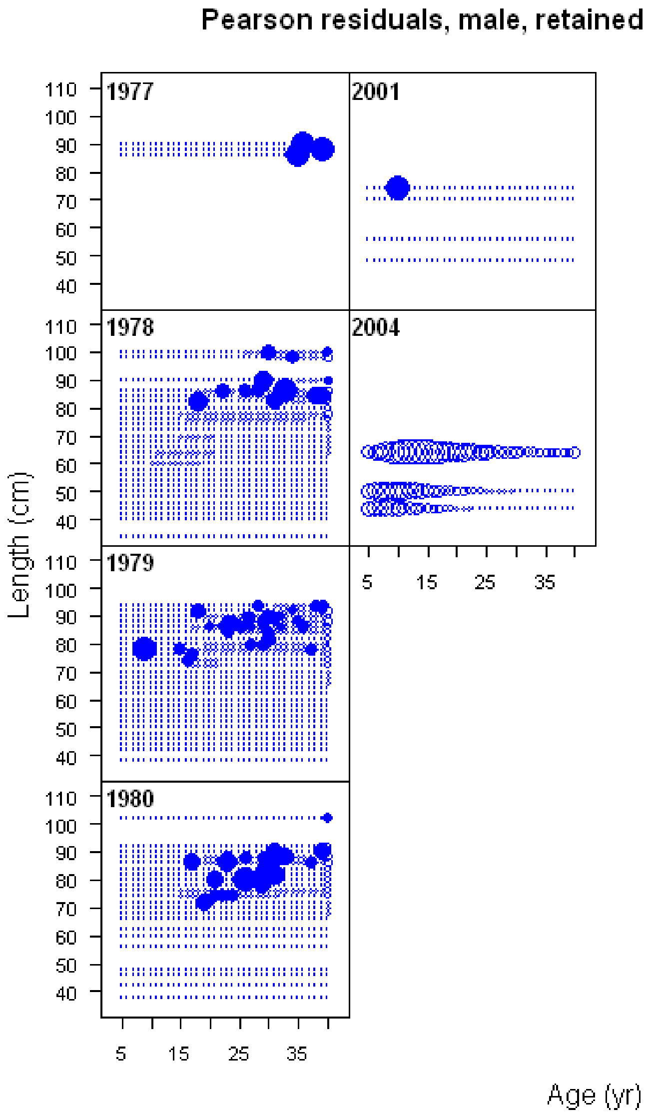


Figure 3.57. Pearson residuals for fits to conditional age at length, commercial handline East, males

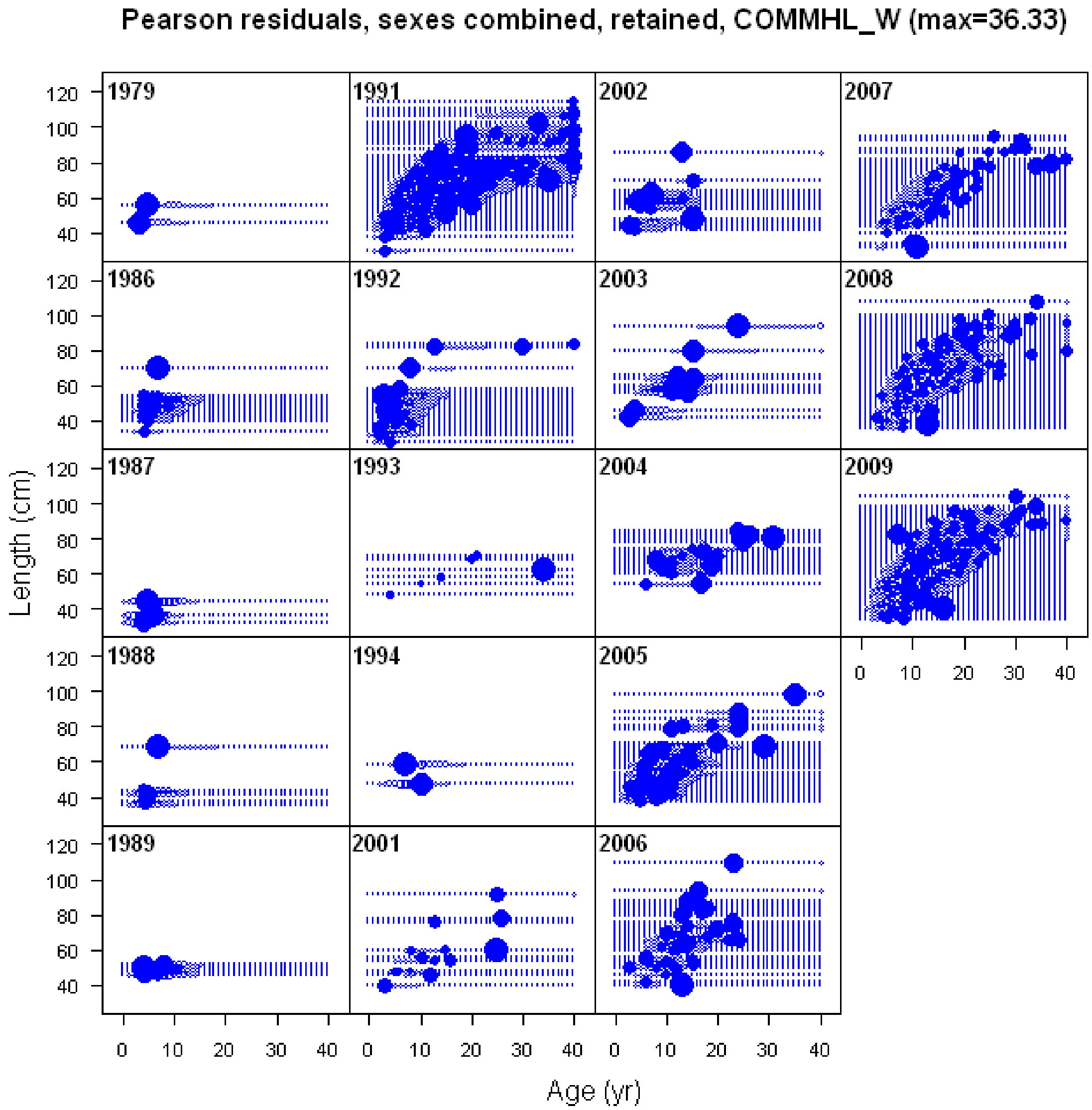


Figure 3.58. Pearson residuals for fits to conditional age at length, commercial handline West, both sexes.

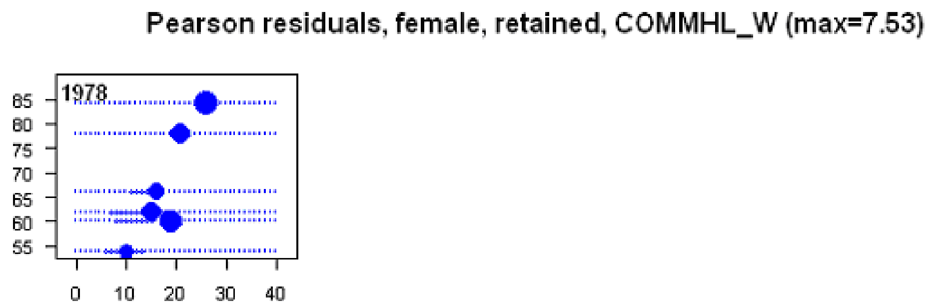


Figure 3.59. Pearson residuals for fits to conditional age at length, commercial handline West, females.

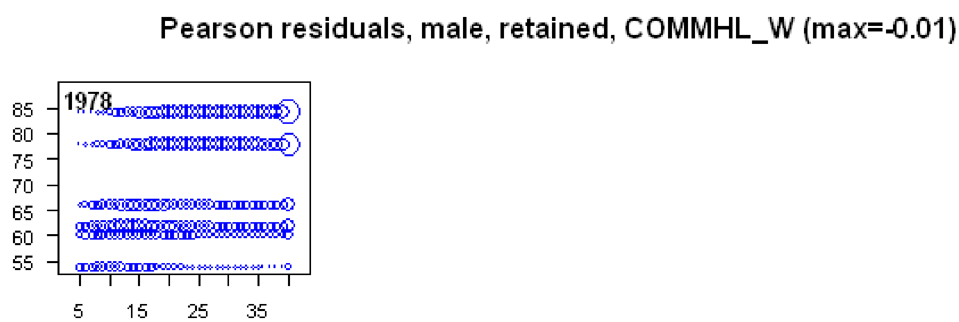


Figure 3.60. Pearson residuals for fits to conditional age at length, commercial handline West, males.

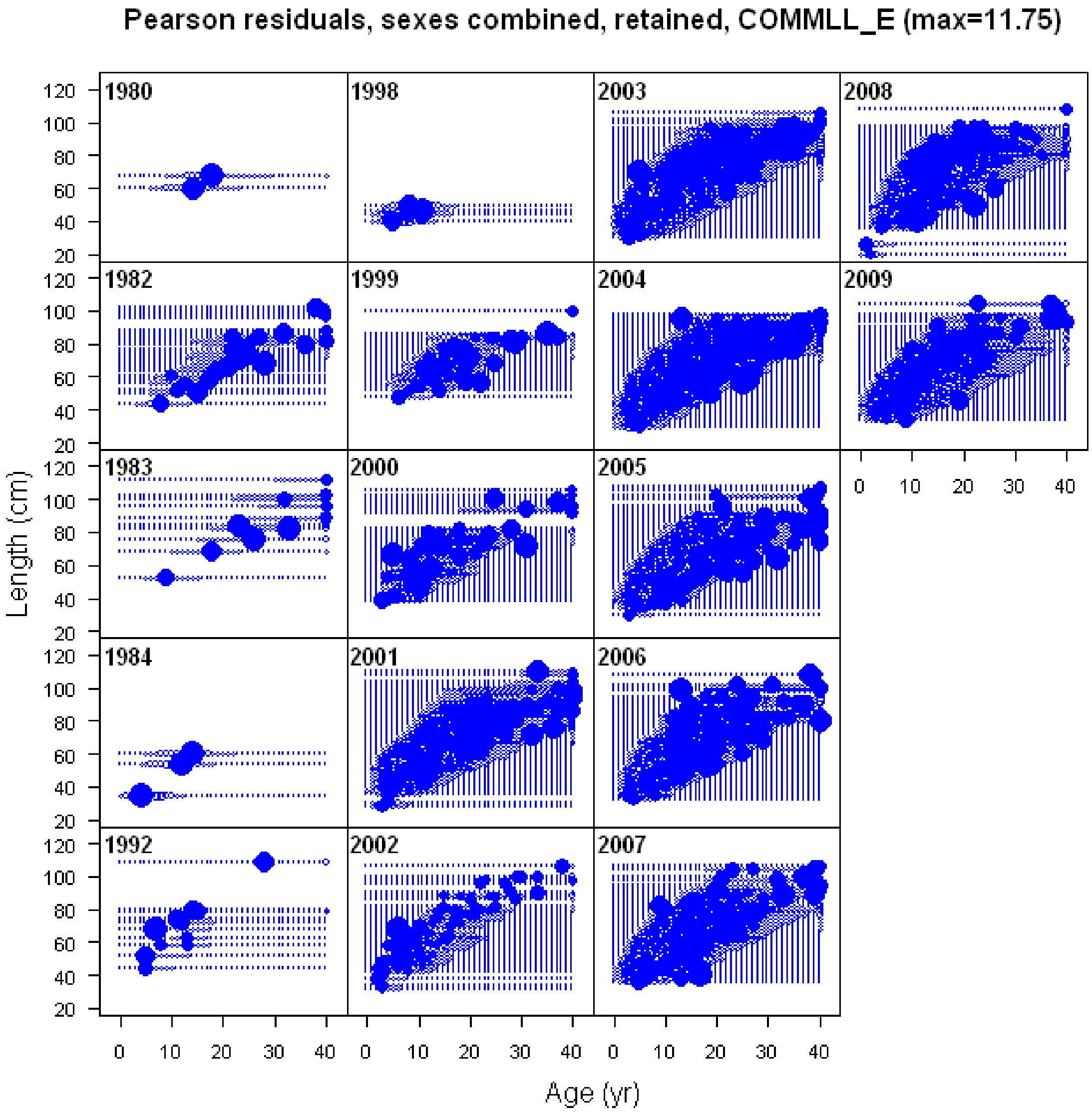


Figure 3.61. Pearson residuals for fits to conditional age at length, commercial longline East, sexes combined.

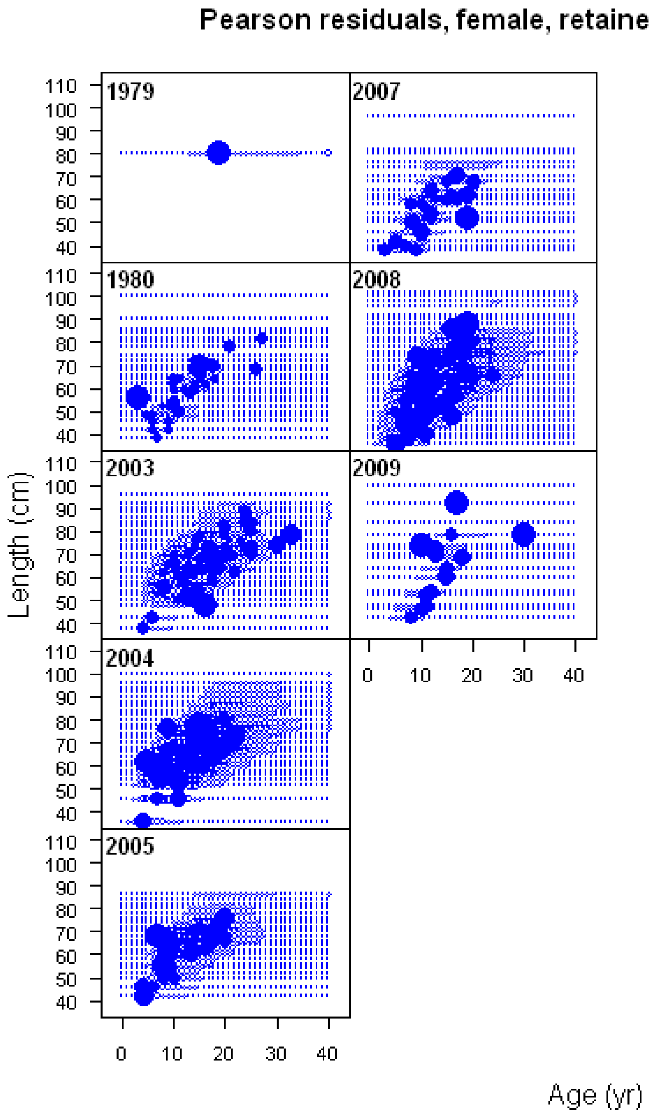


Figure 3.62. Pearson residuals for fits to conditional age at length, commercial longline East, females.

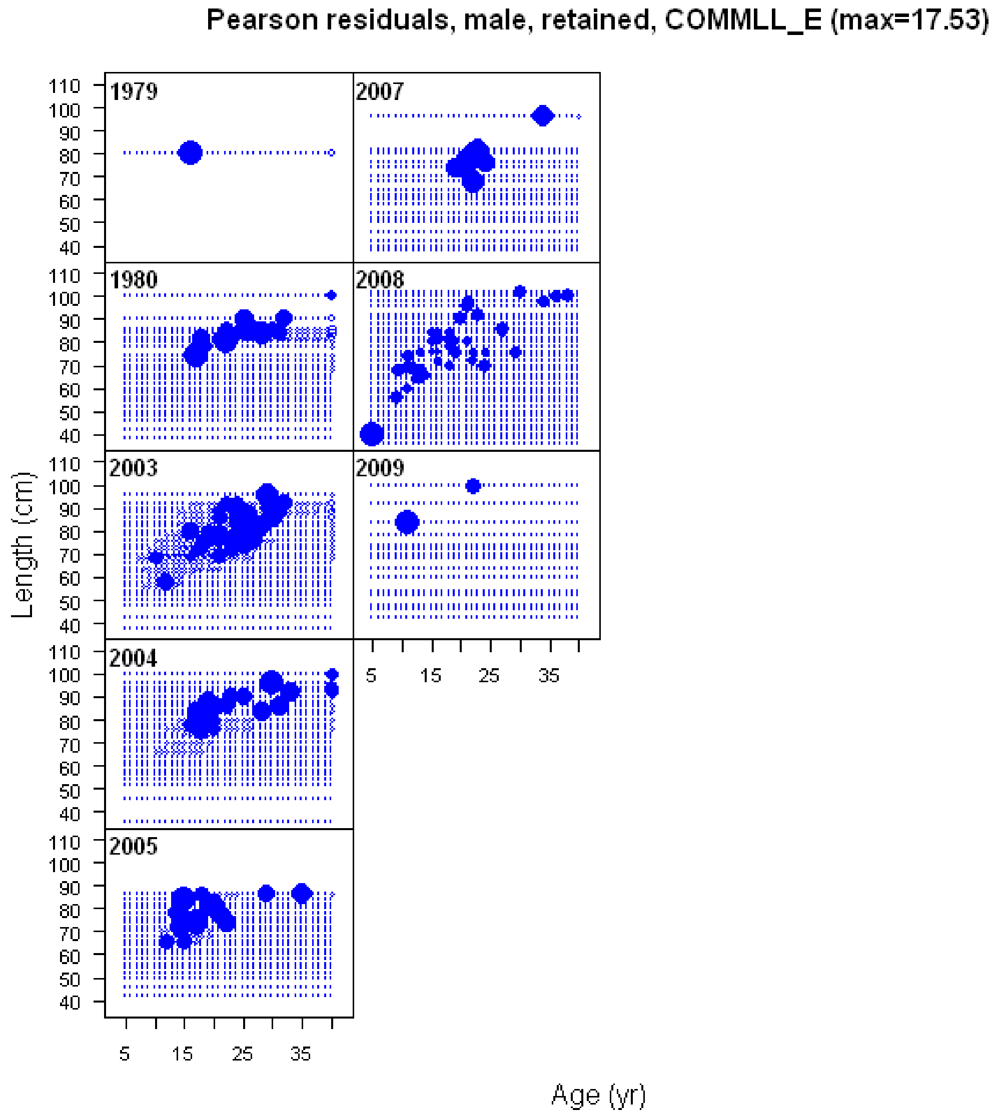


Figure 3.63. Pearson residuals for fits to conditional age at length, commercial longline East, males.

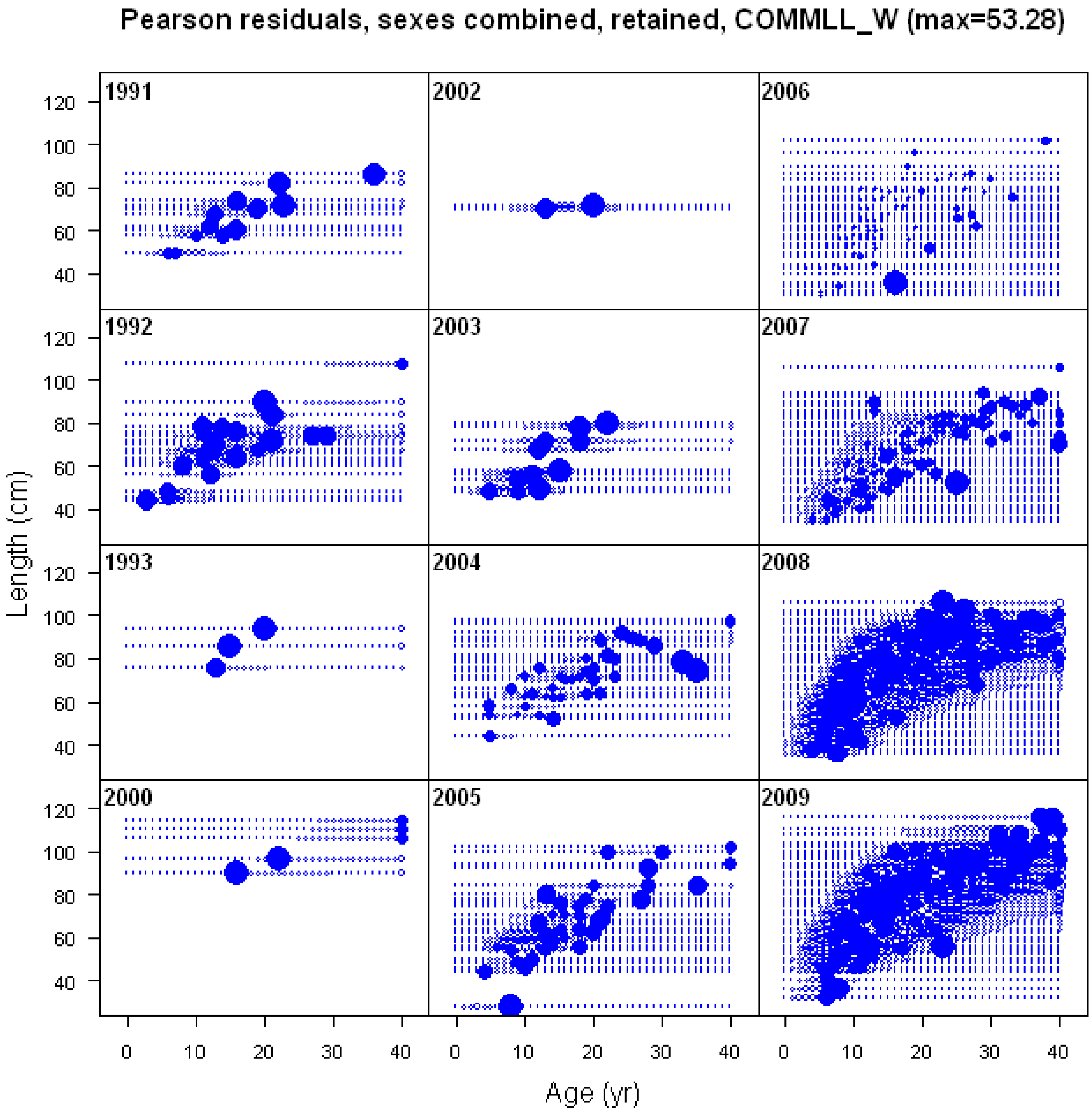


Figure 3.64. Pearson residuals for fits to conditional age at length, commercial longline West, sexes combined. No similar plot exists for males or females separately.

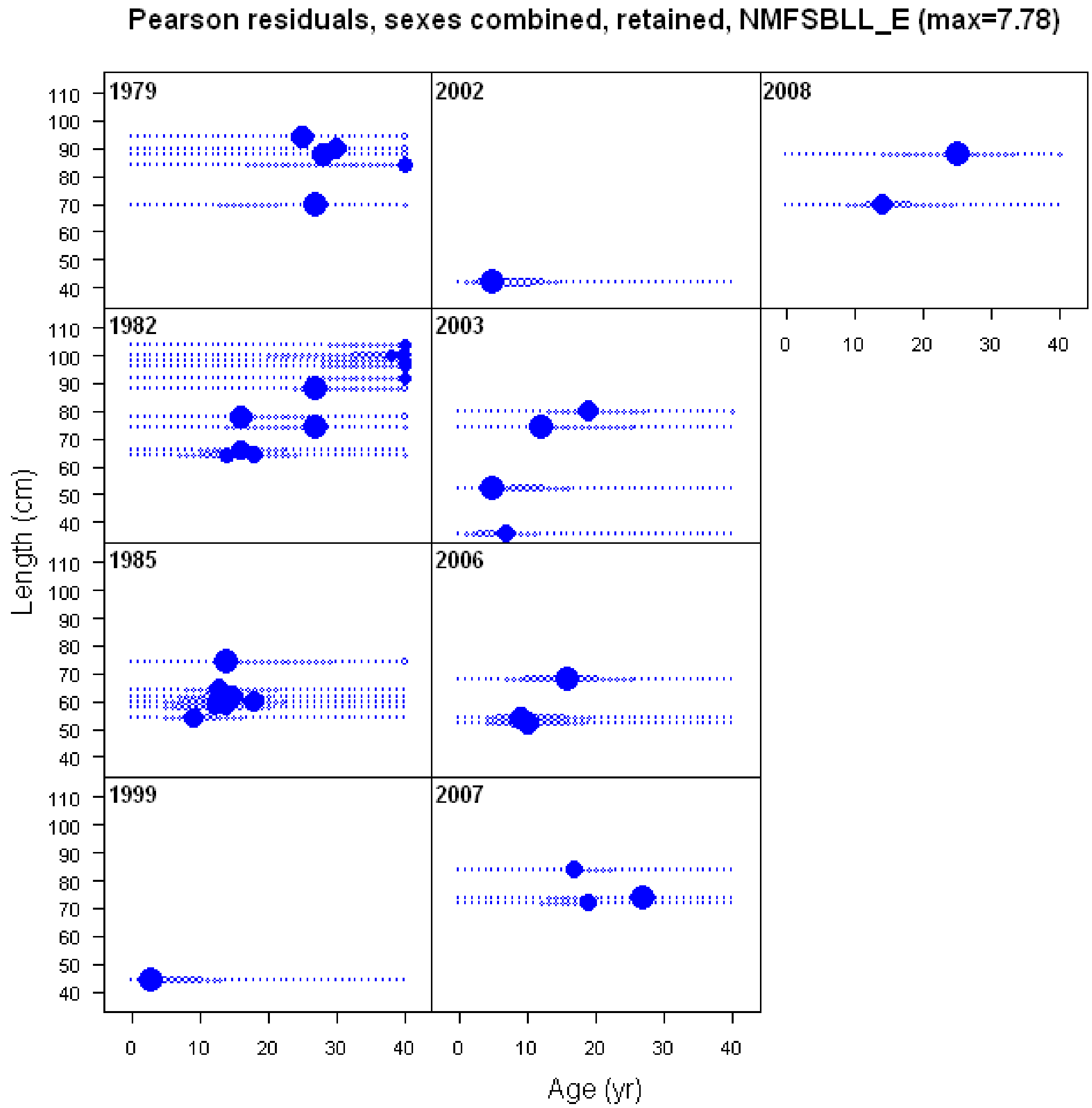


Figure 3.65. Pearson residuals for fits to conditional age at length, NMFS BLL West, both sexes.

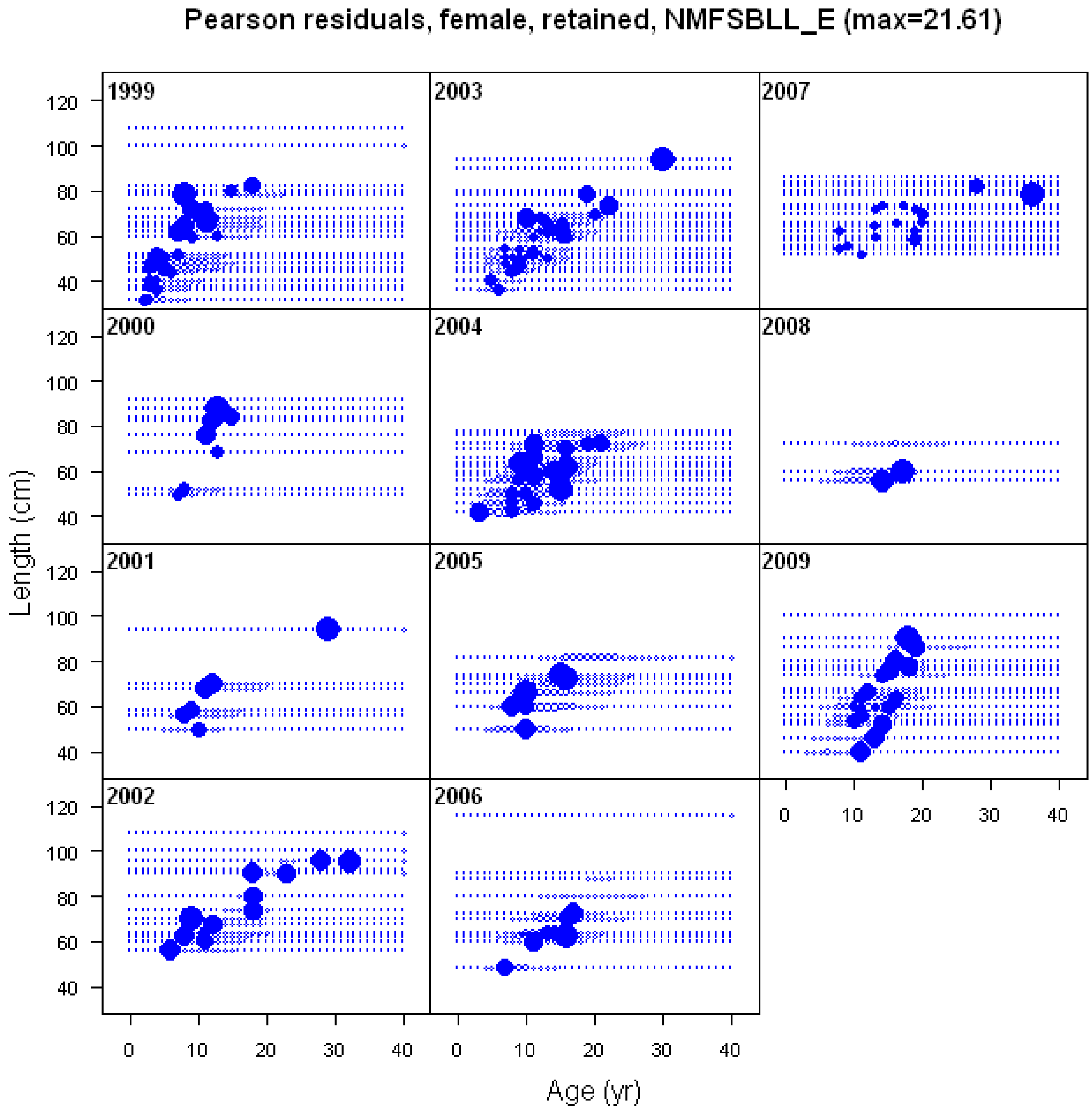


Figure 3.66. Pearson residuals for fits to conditional age at length, NMFS BLL West, females.

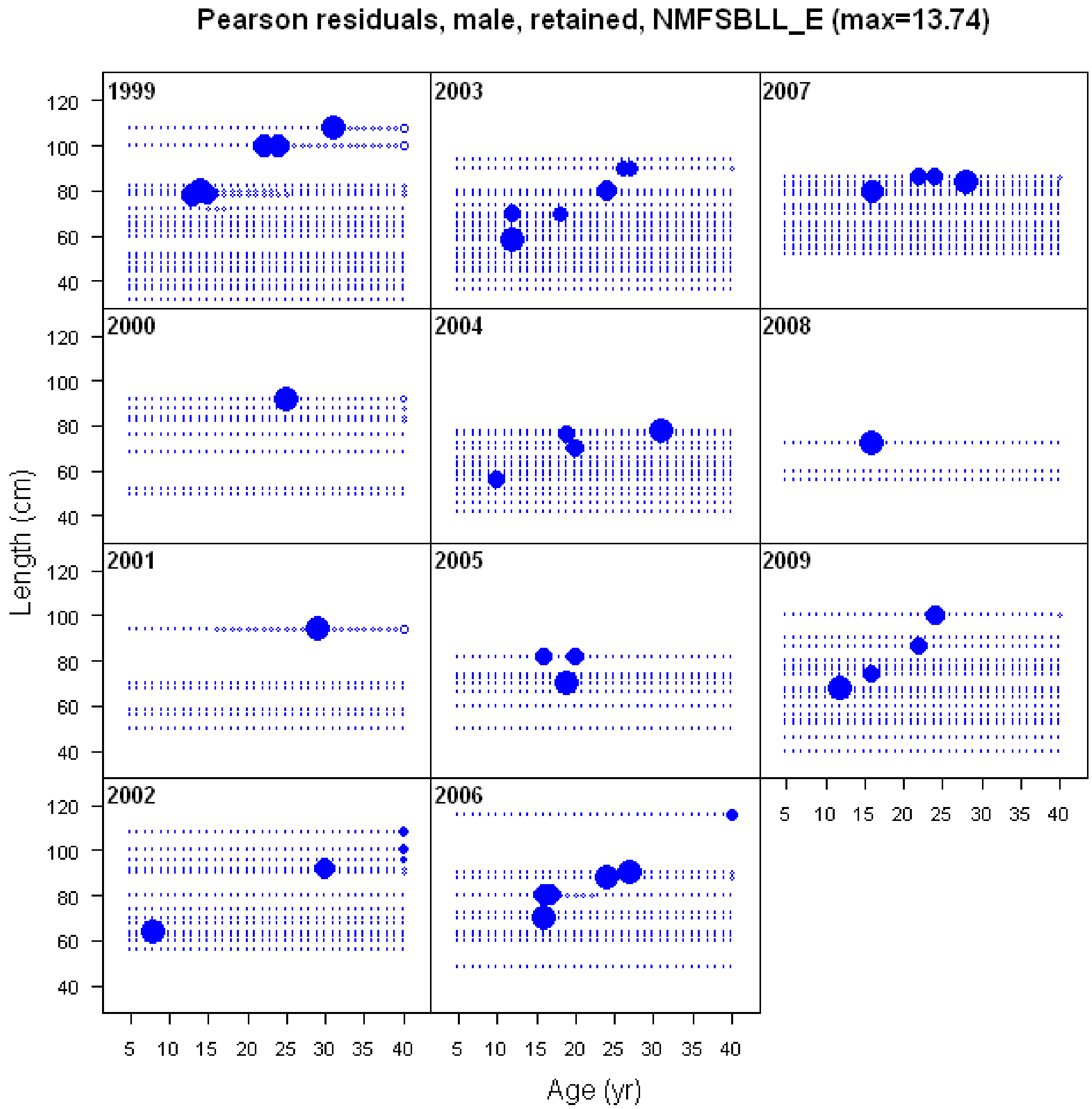


Figure 3.67. Pearson residuals for fits to conditional age at length, NMFS BLL East, males.

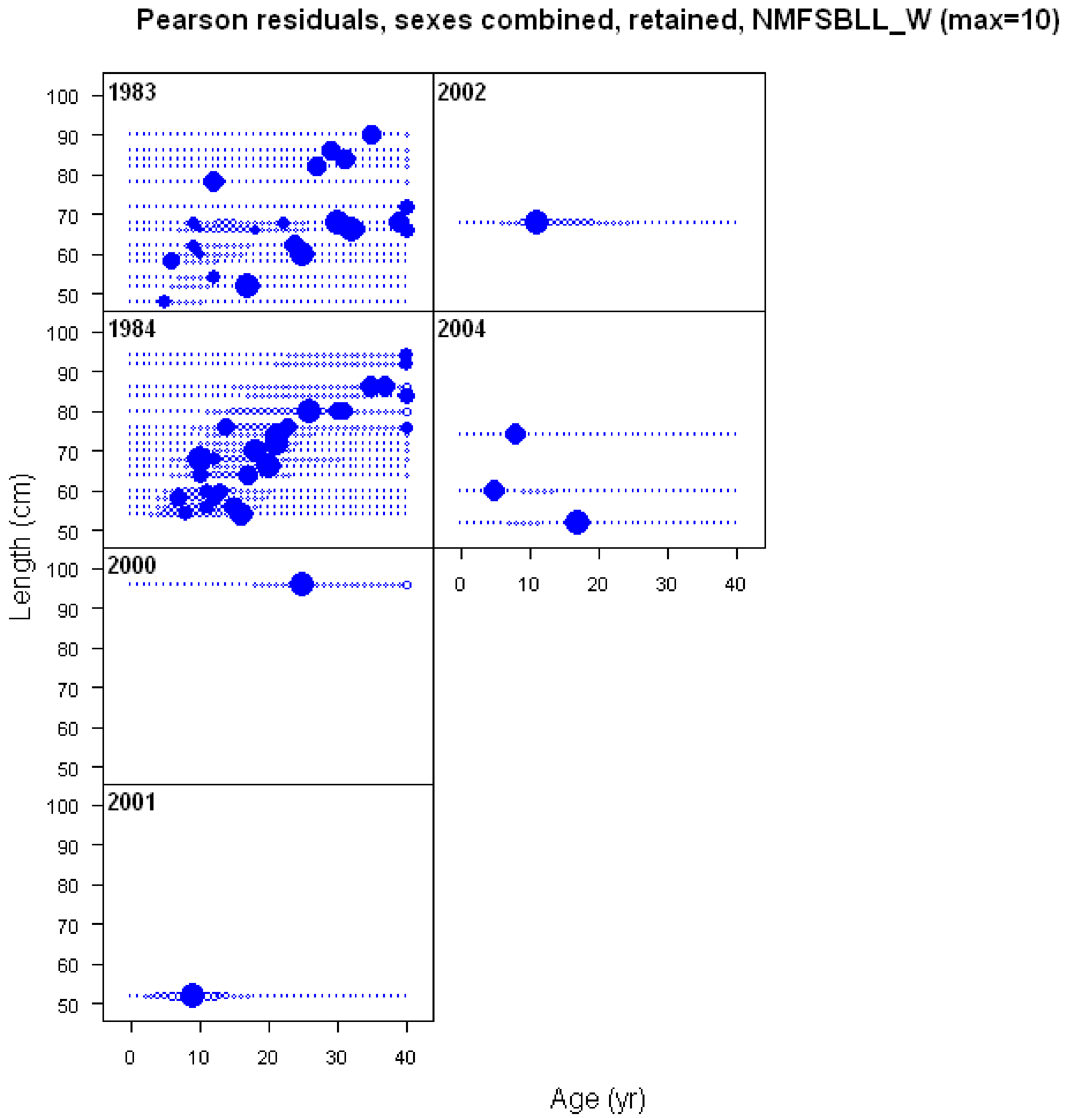


Figure 3.68. Pearson residuals for fits to conditional age at length, NMFS BLL West, both sexes.

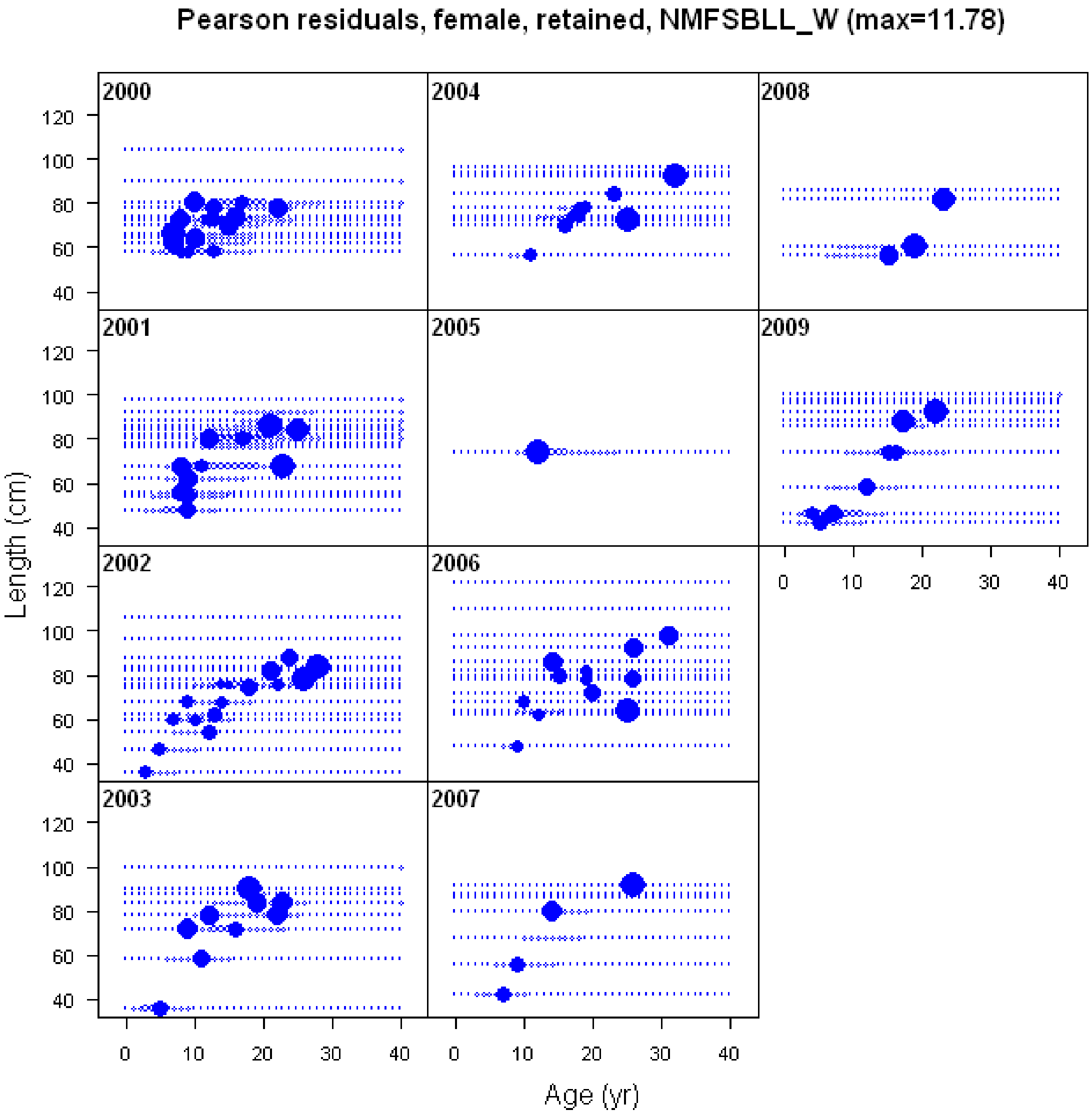


Figure 3.69. Pearson residuals for fits to conditional age at length, NMFS BLL East, females.

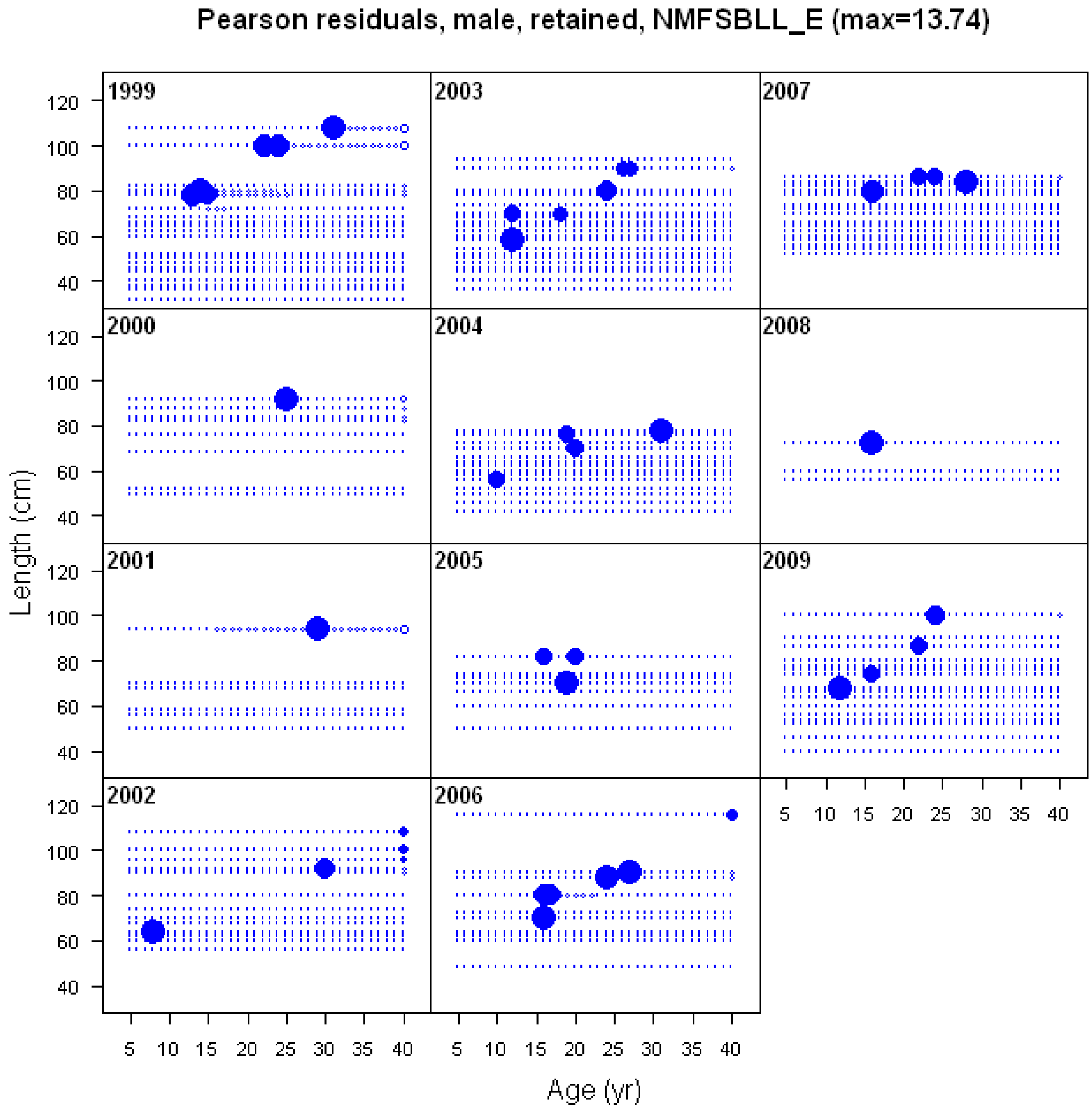


Figure 3.70. Pearson residuals for fits to conditional age at length, NMFS BLL East, males.

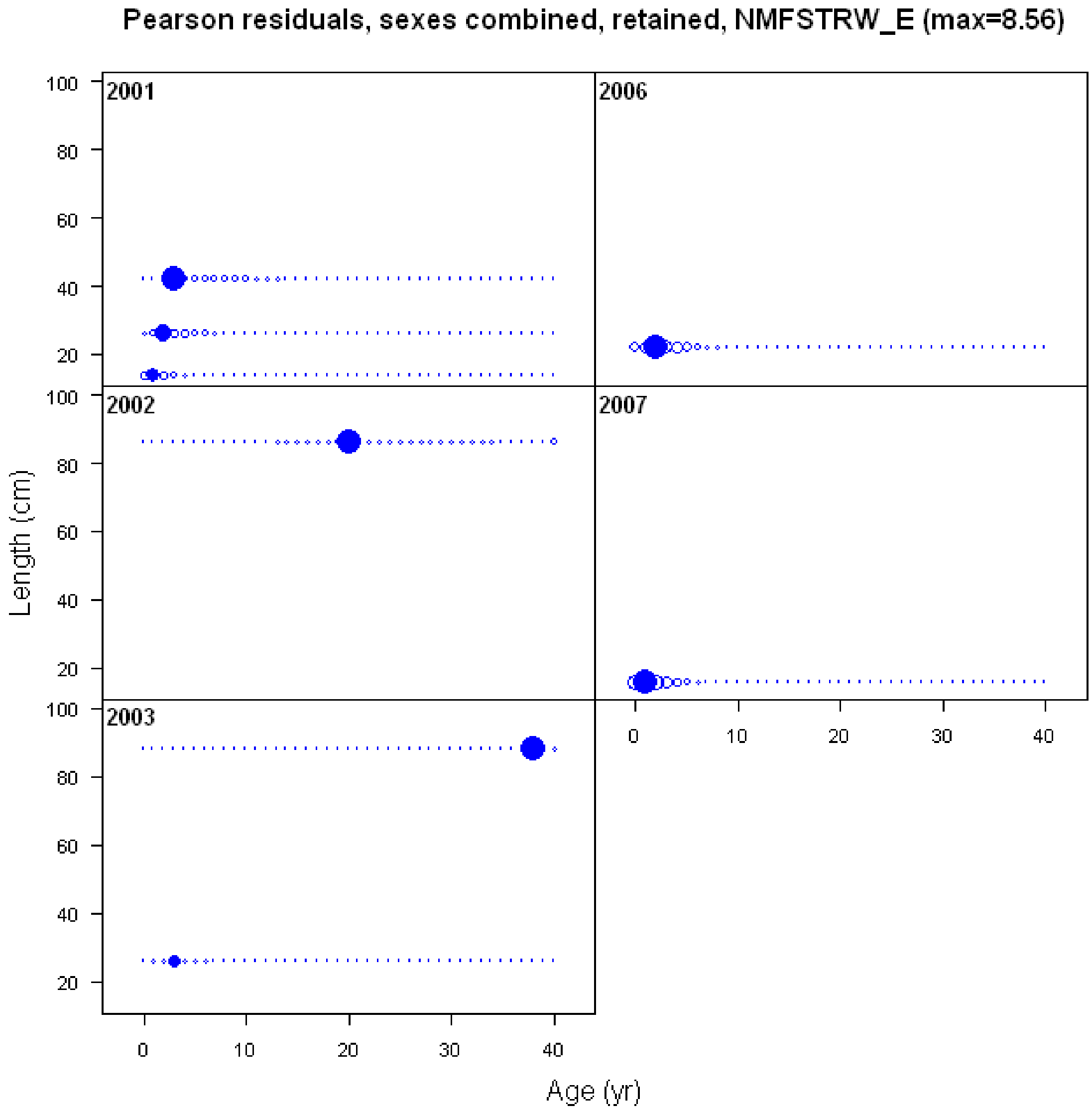


Figure 3.71. Pearson residuals for fits to conditional age at length, NMFS BLL East, both sexes.

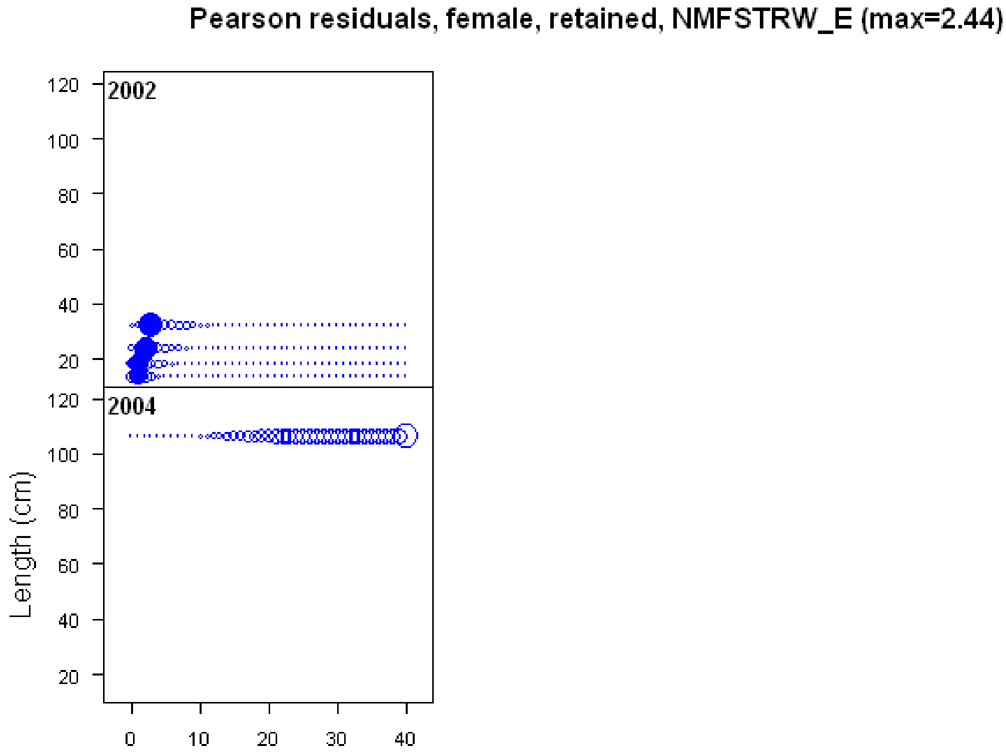


Figure 3.72. Pearson residuals for fits to conditional age at length, NMFS BLL East, females.

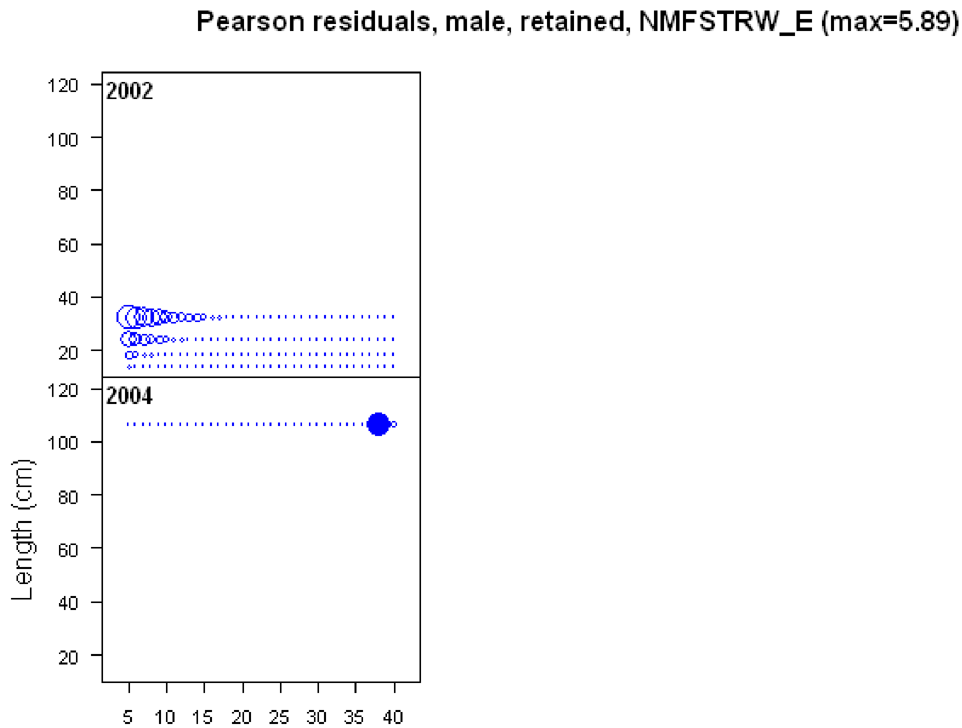


Figure 3.73. Pearson residuals for fits to conditional age at length, NMFS BLL East, males.

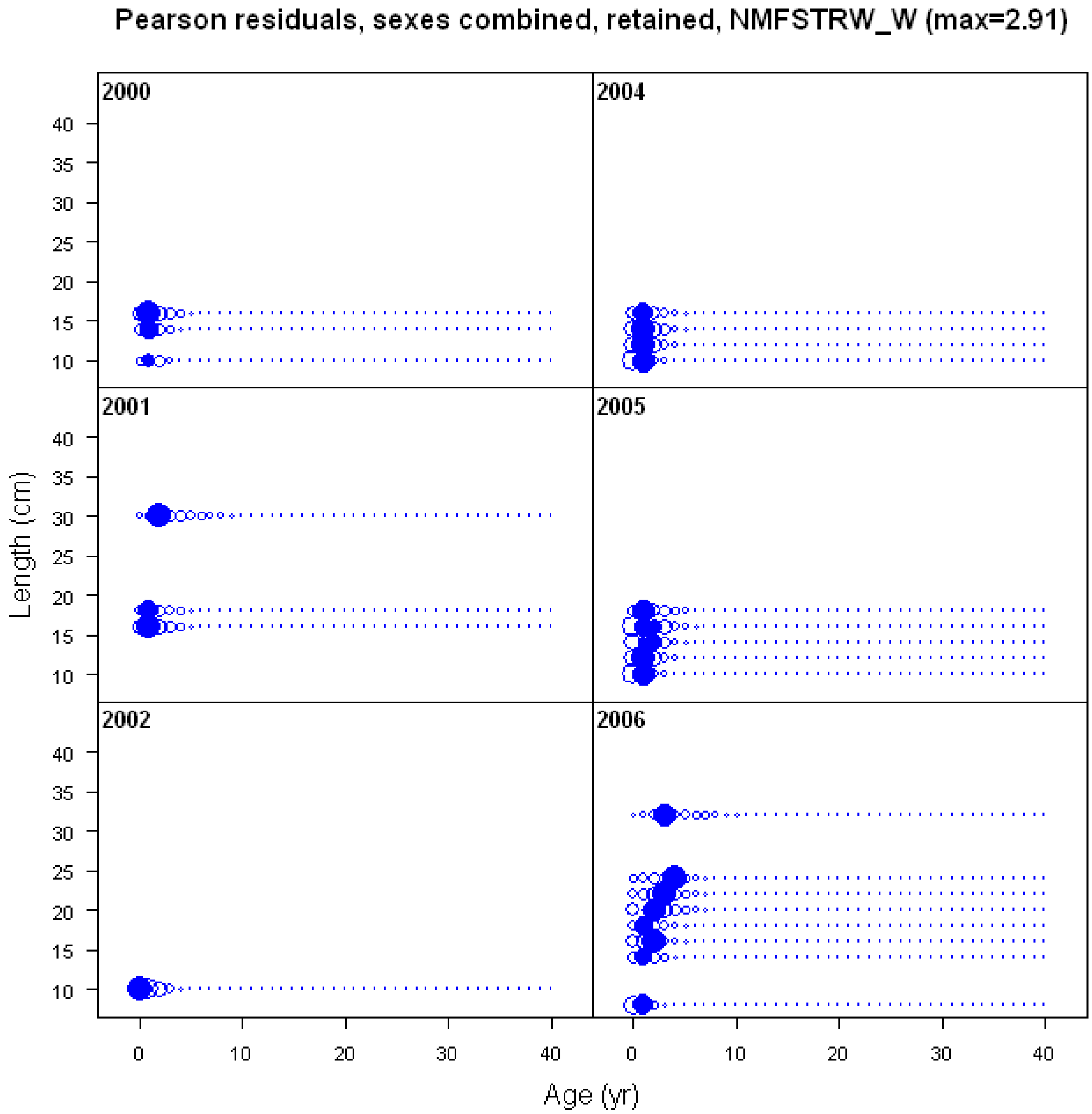


Figure 3.74. Pearson residuals for fits to conditional age at length, NMFS BLL West, both sexes.

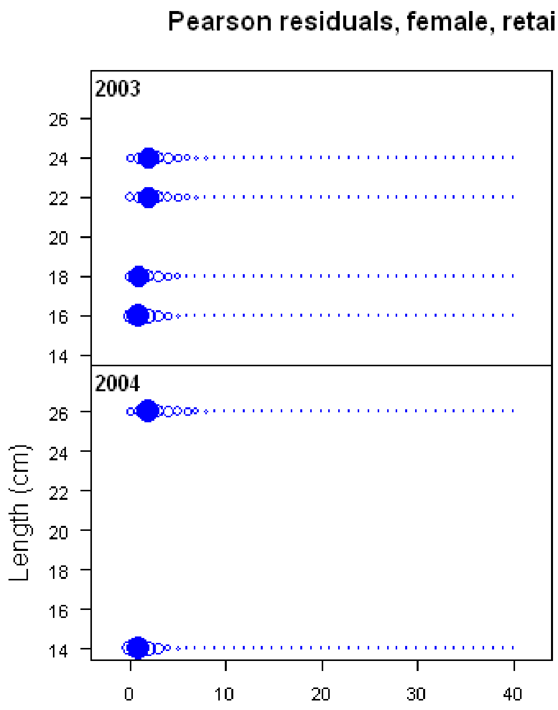


Figure 3.75. Pearson residuals for fits to conditional age at length, NMFS BLL West, females.

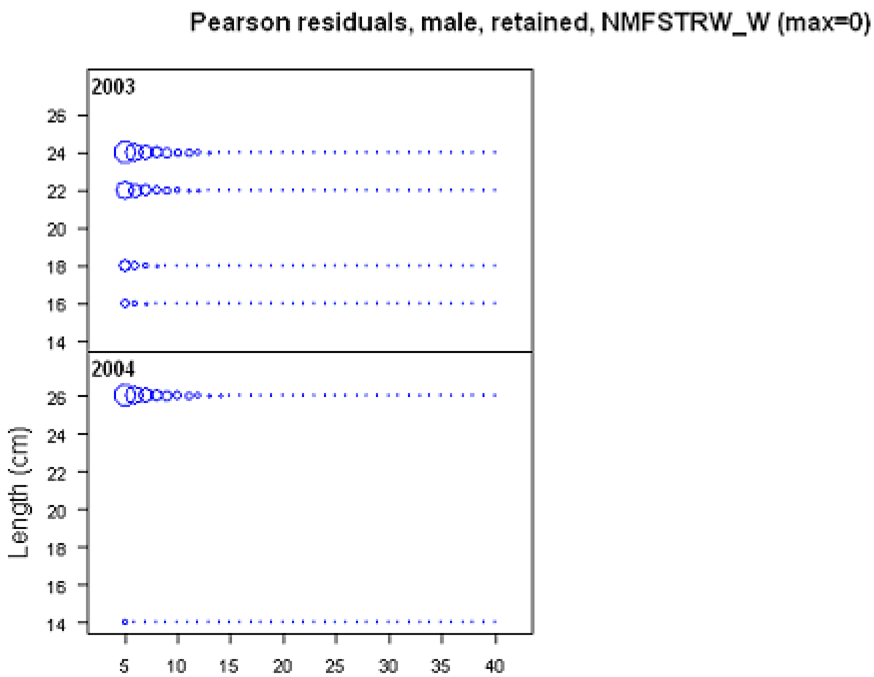


Figure 3.76. Pearson residuals for fits to conditional age at length, NMFS BLL West, males. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

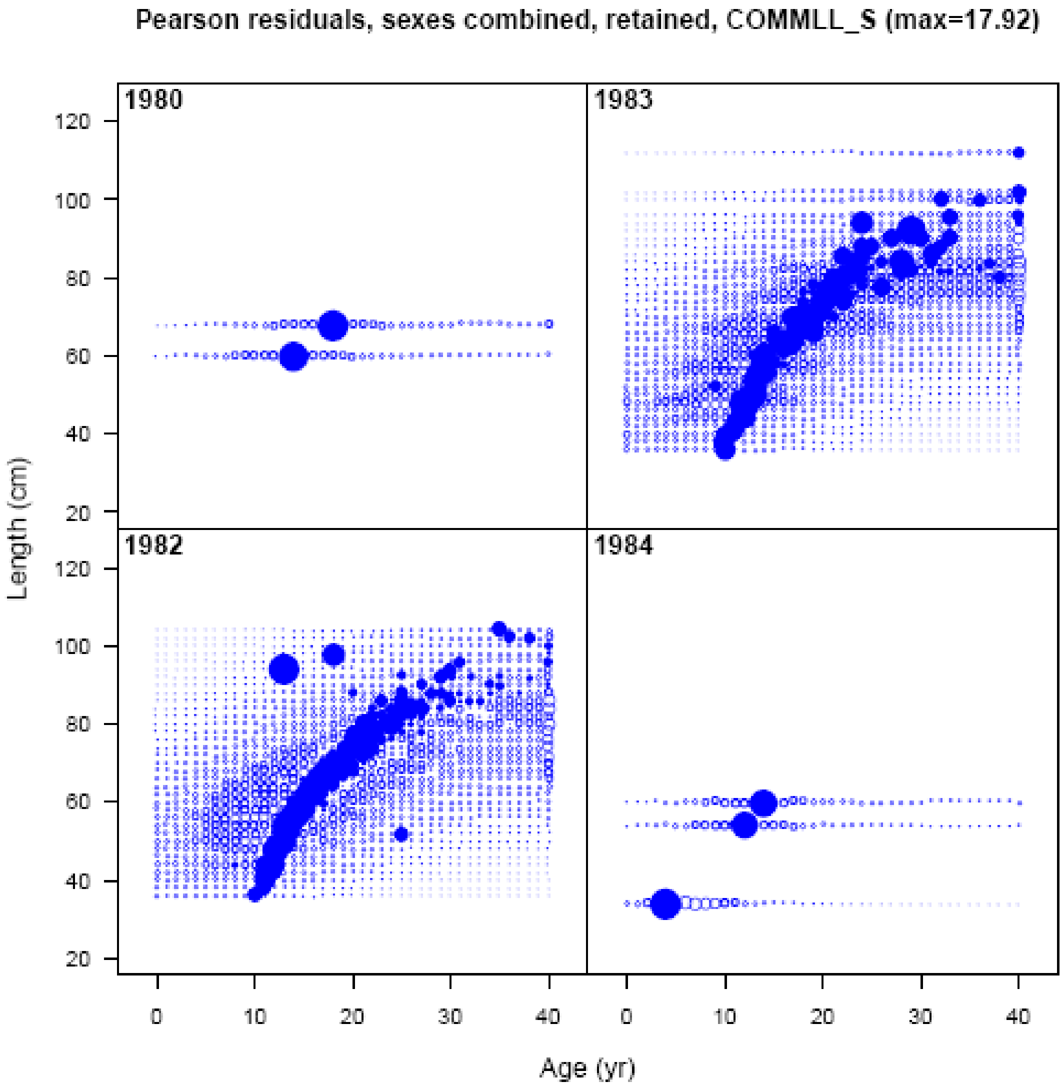


Figure 3.77. Pearson residuals to fits to 1982-83 otolith weight – otolith age regression predicted ages indicated an extremely biased fit.

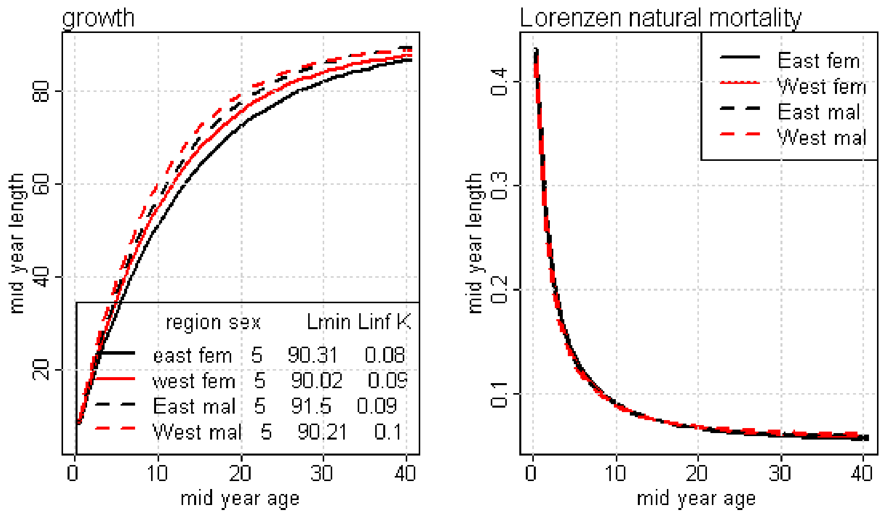


Figure 3.78. Base model estimated growth curves and Lorenzen M curves.

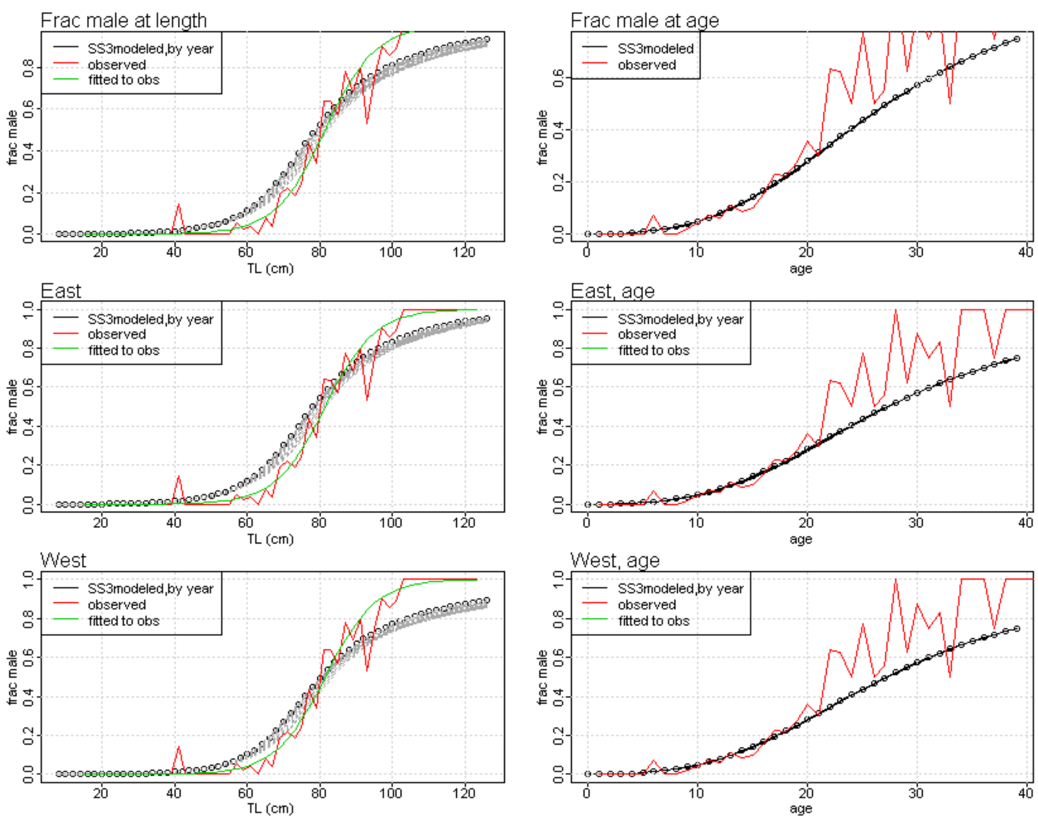


Figure 3.79. Empirically observed fraction male at length and age (Red) and SS3 estimated fraction (gray). The green lines is a fit conducted to the observed fraction male at length but not used in SS3 modeling. The transition probabilities are only estimated as a function of age within SS3. The top row is the combined data.

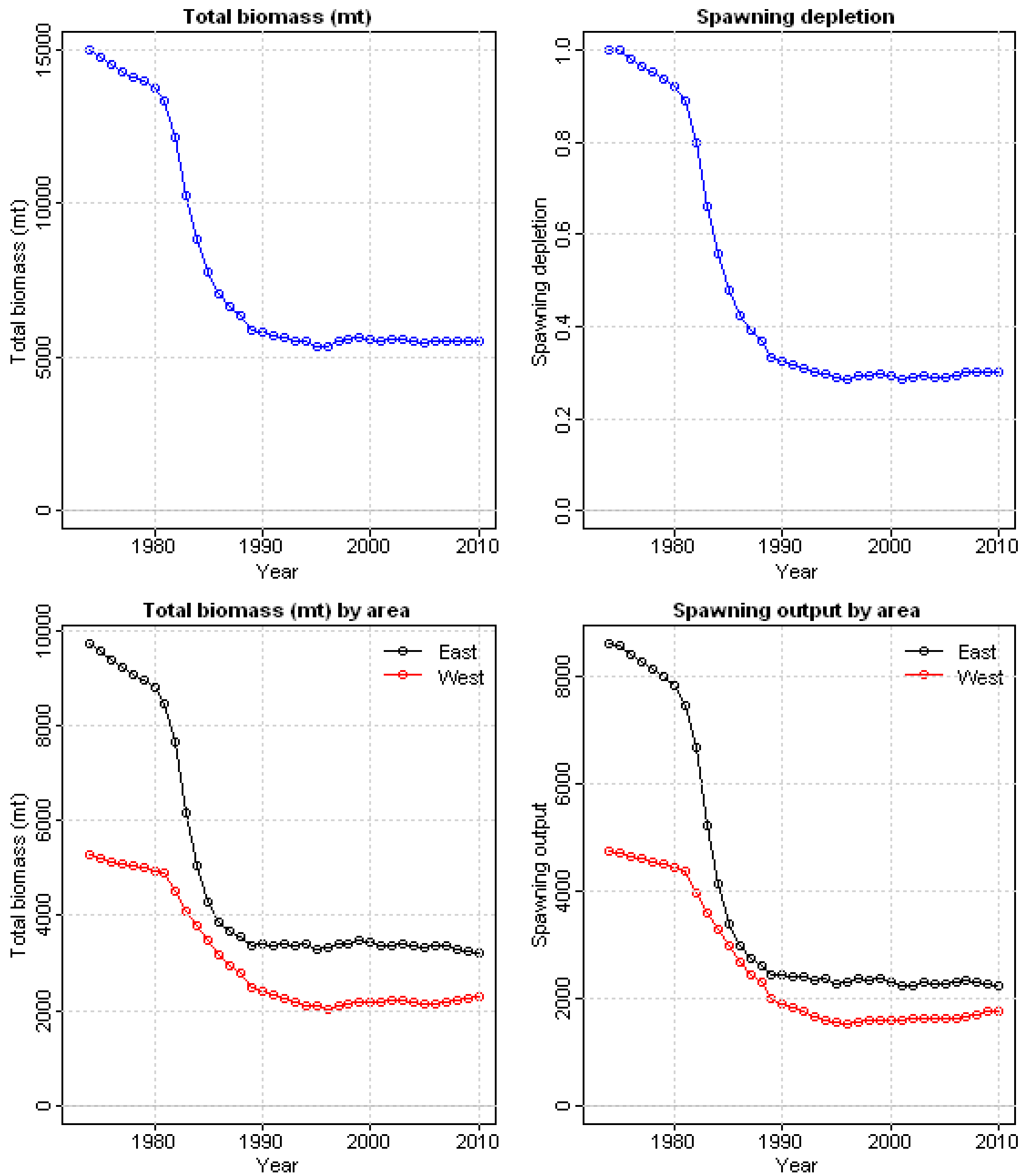


Figure 3.80. Stock Biomass (total and spawning stock).

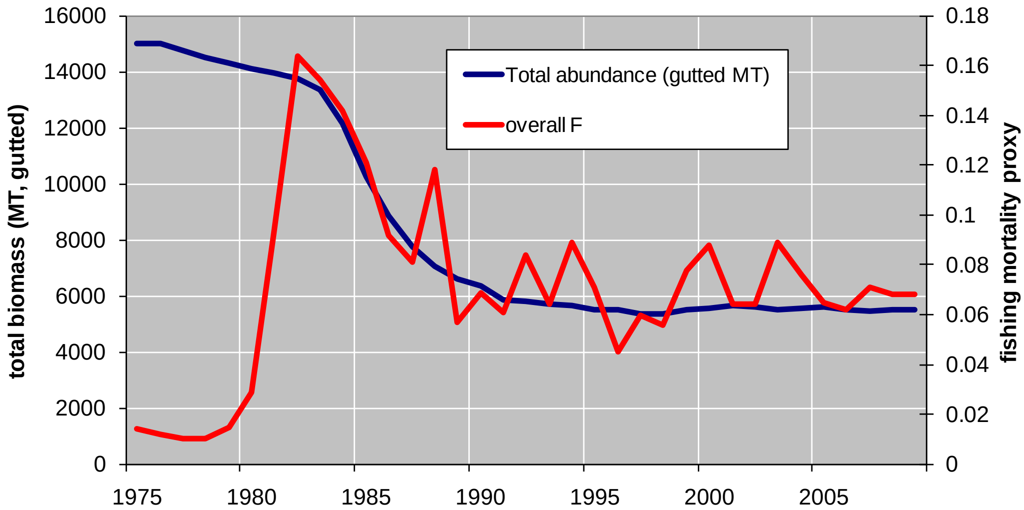


Figure 3.81. Total estimated biomass and fishing mortality, YEG base model.

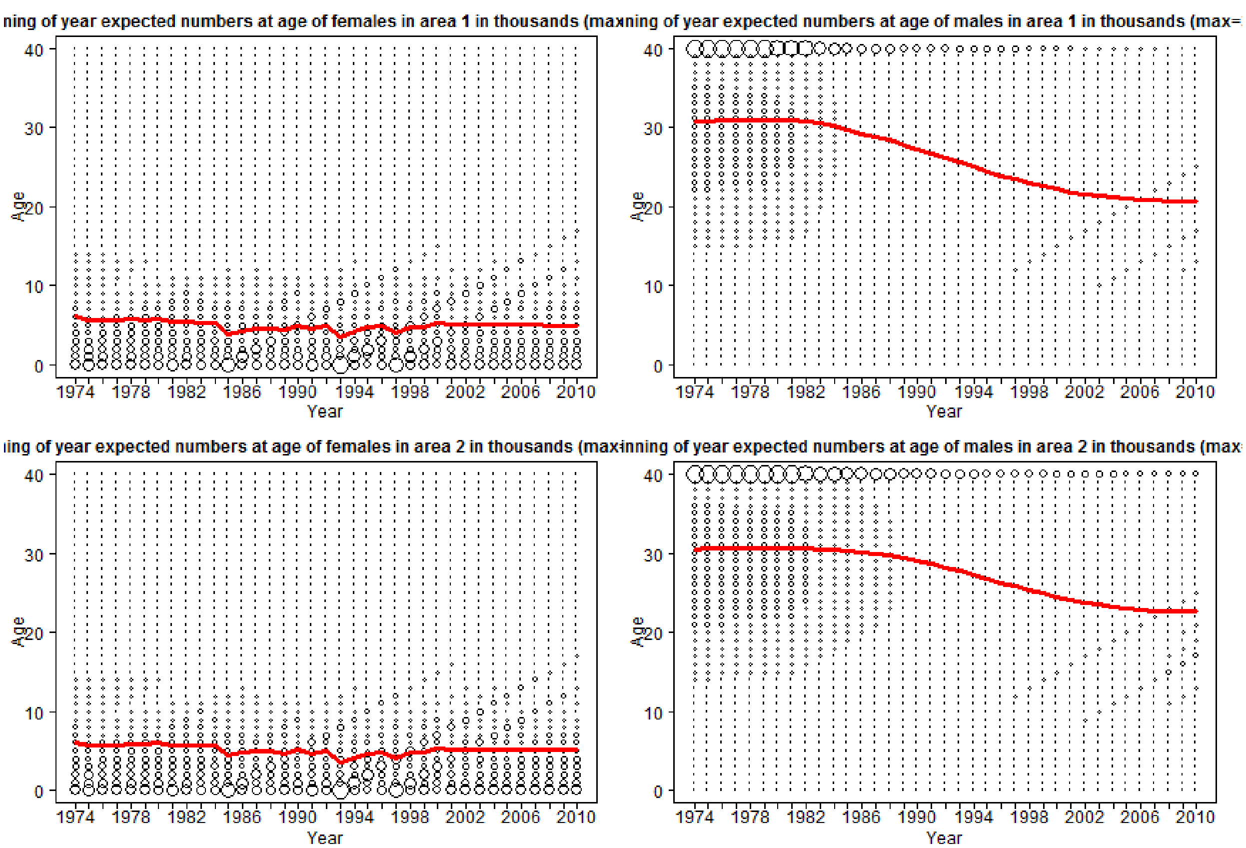


Figure 3.82. Numbers by year and age for females (left) and males (right) and for East (top) and West (bottom). Red line is the mean age. Note that this is from a previous version of the base model and the absolute numbers may be different but the pattern is largely the same.

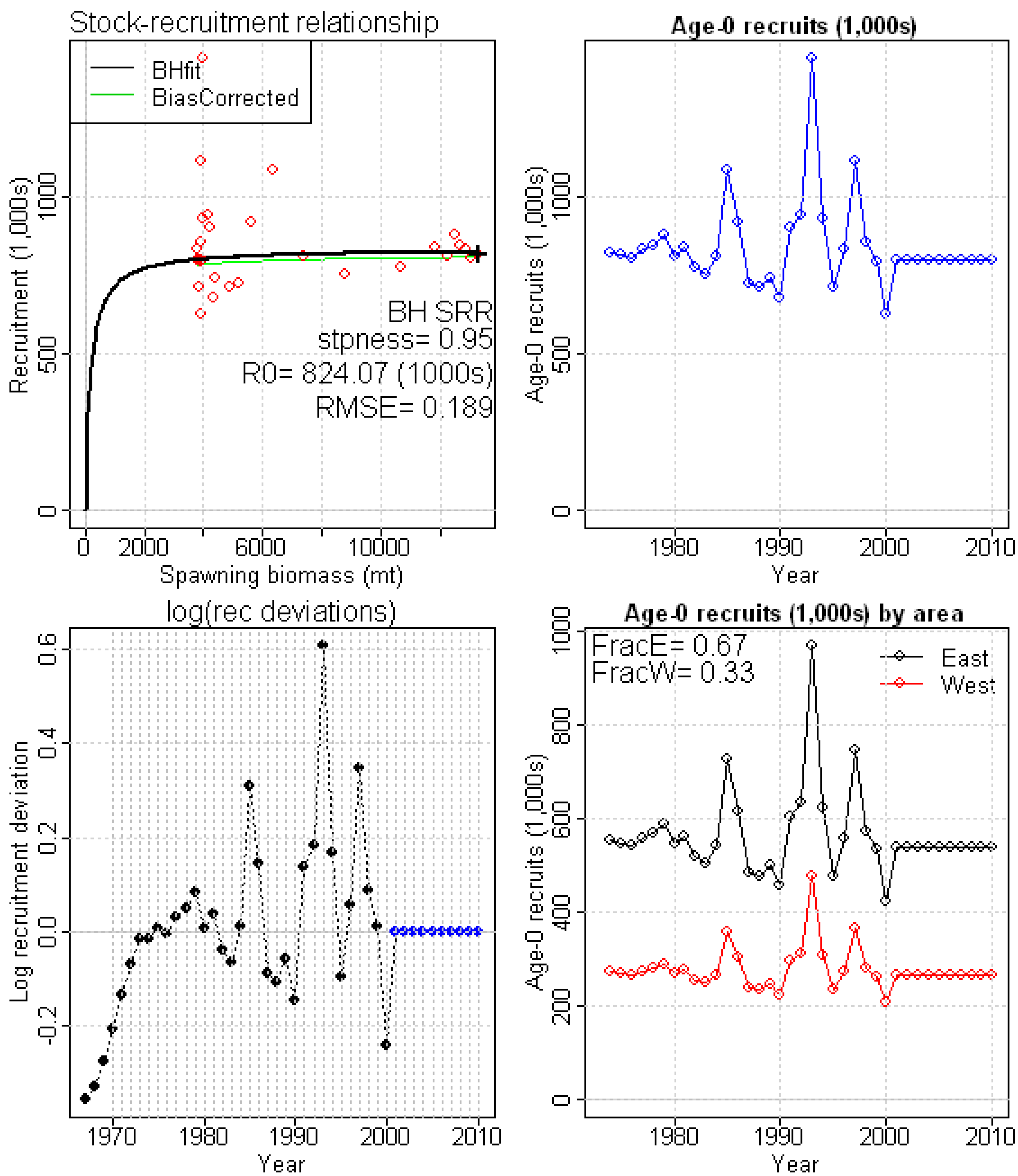


Figure 3.83. Base model stock recruit relationship, recruits, recruitment deviations and recruits by region.

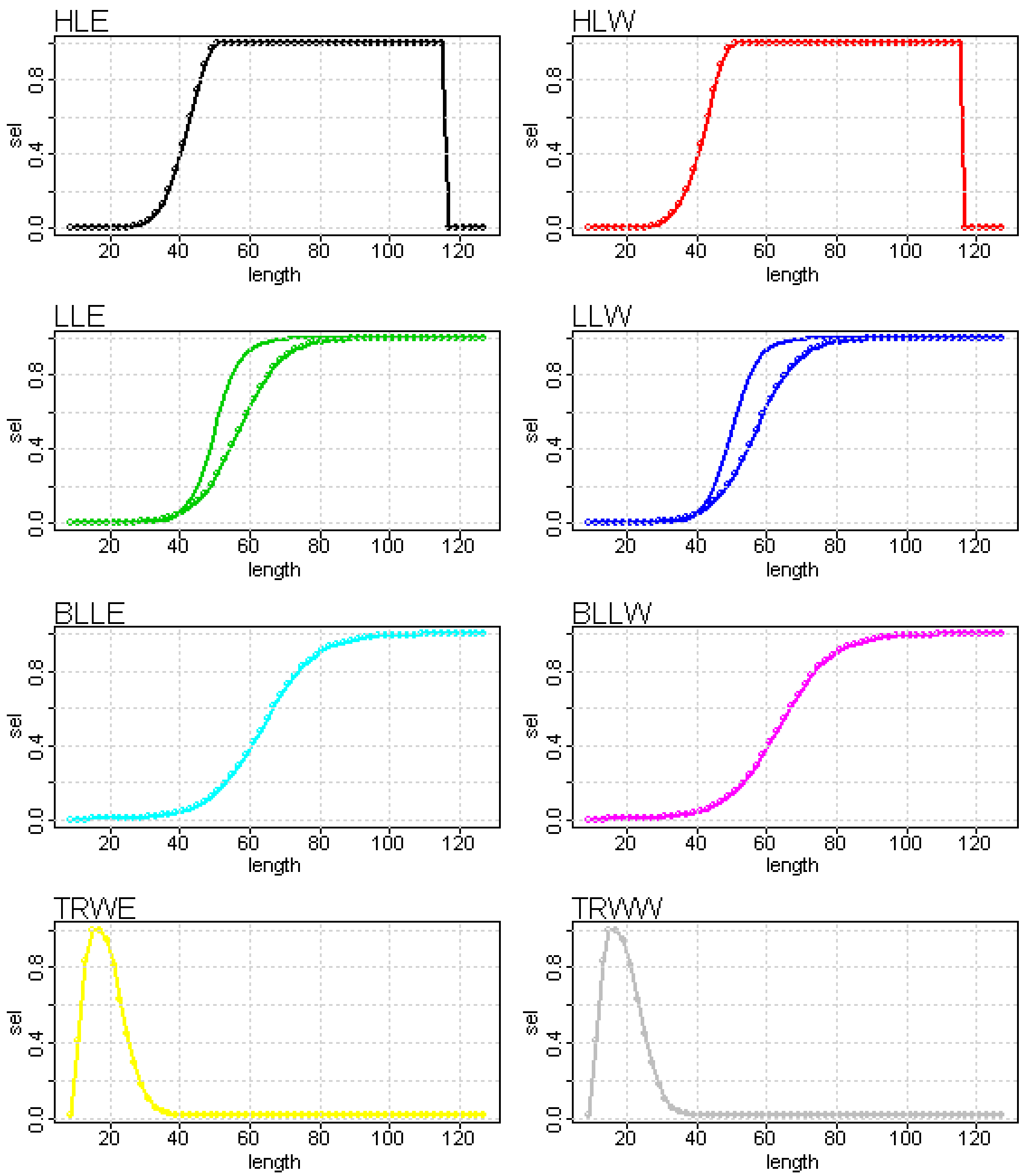


Figure 3.84. Fishery and survey selectivity patterns. Commercial handline East and West (HLE, HLE) and SEAMAP trawl surveys East and West (TRWE, TRWW) were both modeled with a double normal selectivity pattern. Commercial longline East and West, NMFS bottom longline East and West were both modeled with logistic functions. For each fleet or survey selectivity patterns were mirrored so they were jointly estimated. For the commercial longline indices, the solid lines are the 1975-2005 vectors and the dotted lines are the 1986-2009 vectors.

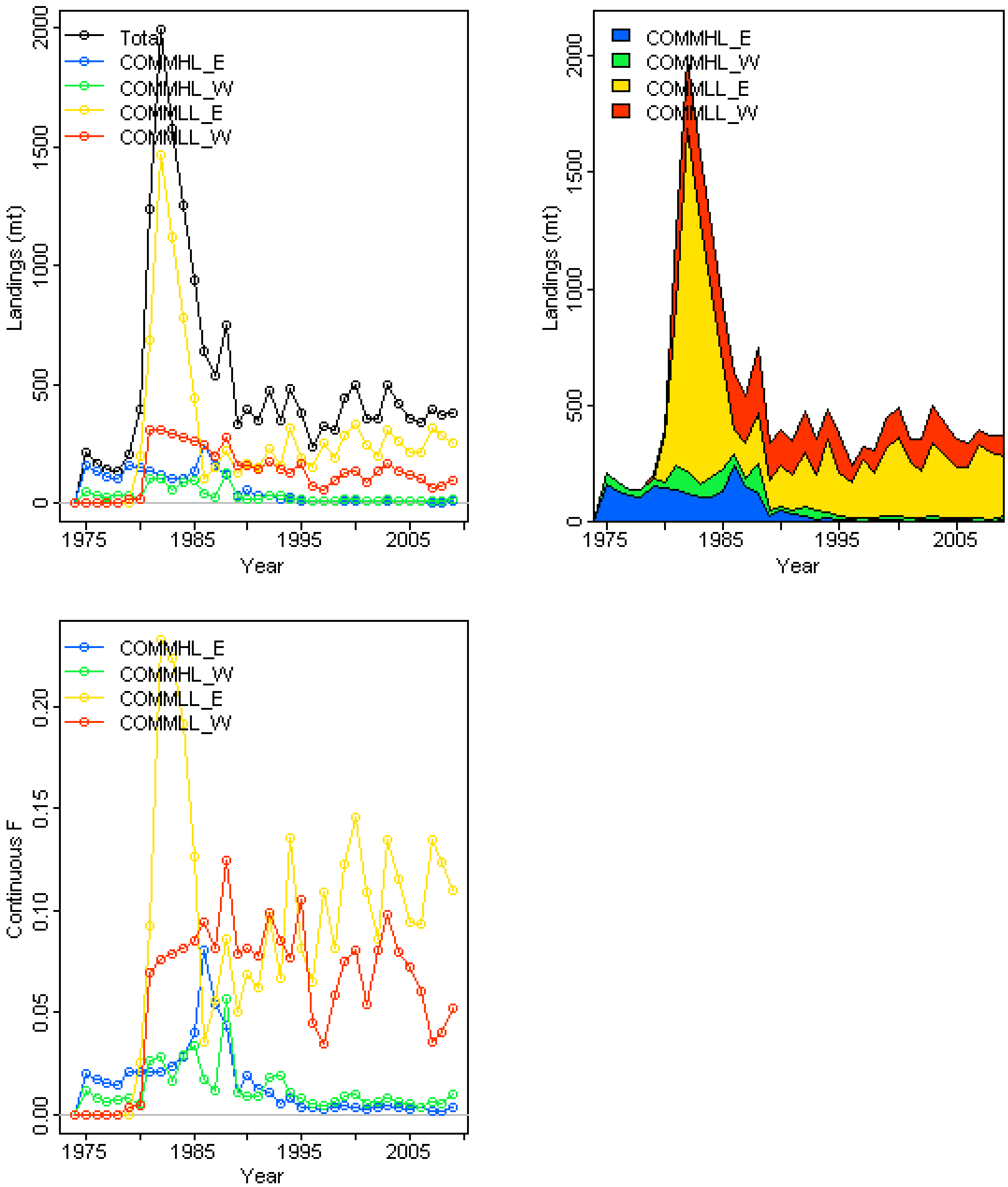


Figure 3.85. Base model landings and estimated fleet specific fishing mortality rates.

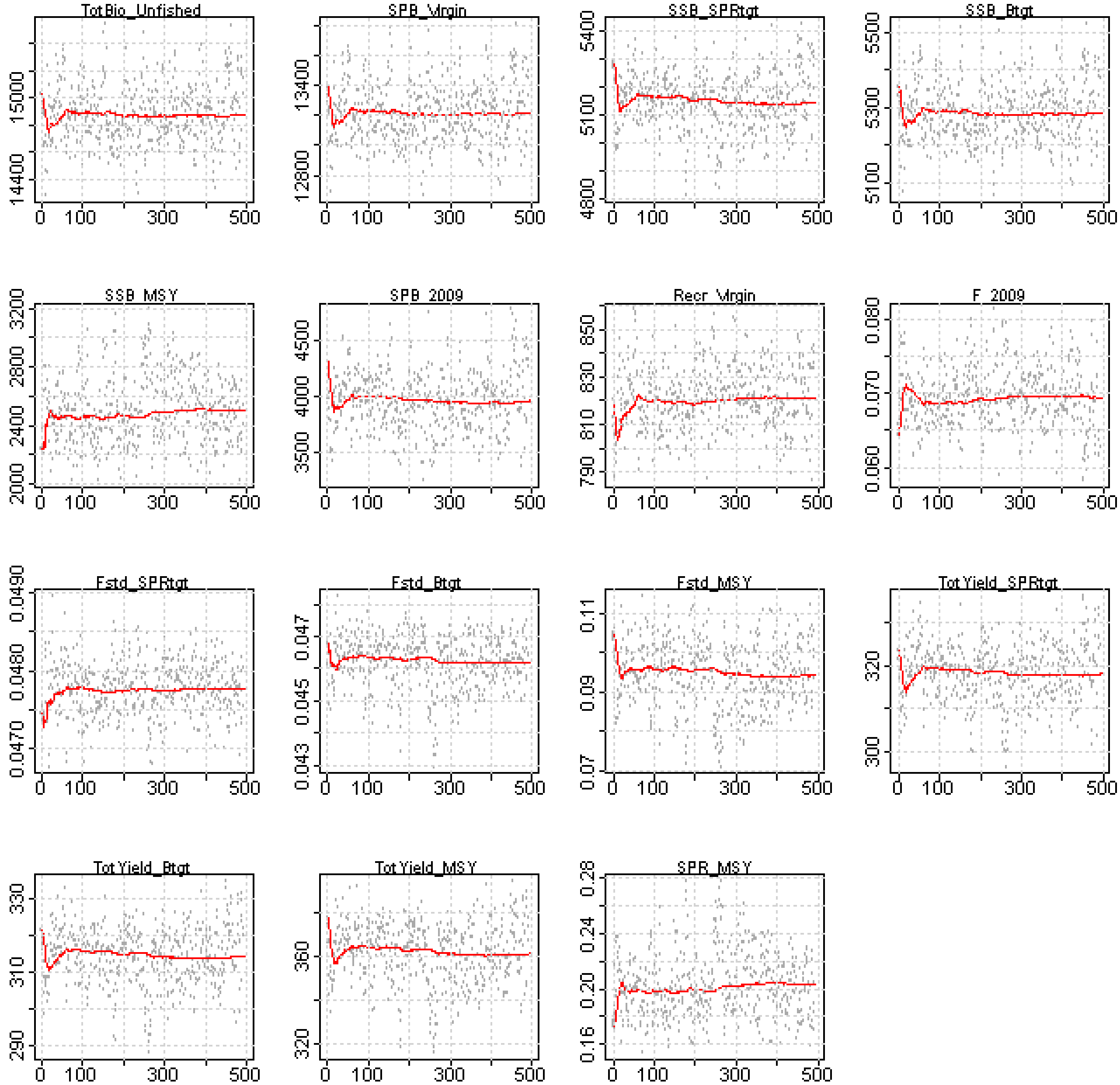


Figure 3.86. Individual points and cumulative means from MCMC runs for the BASE model. The SPR40% is the SPR reference for these runs.

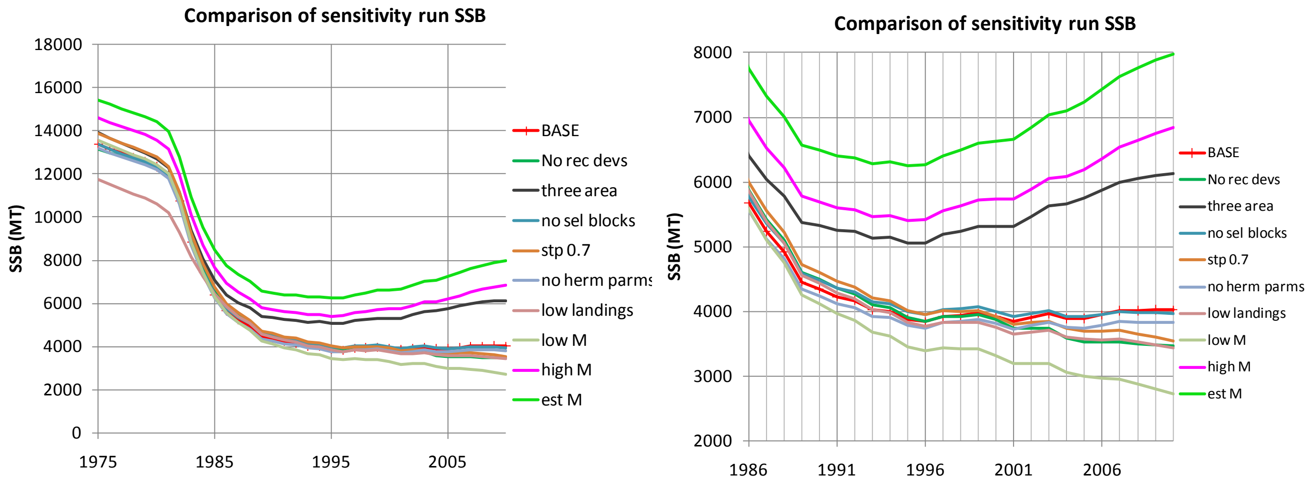


Figure 3.87. Comparison of SSB trajectories for 9 sensitivity runs.

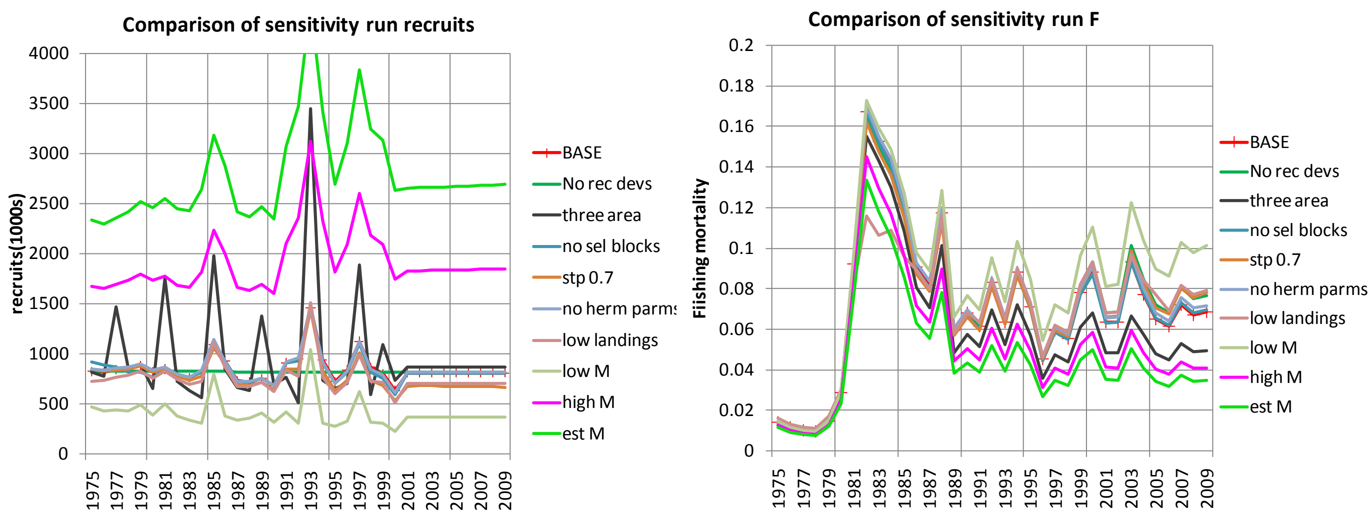


Figure 3.88. Comparison of recruitments and F trajectories for 9 sensitivity runs.

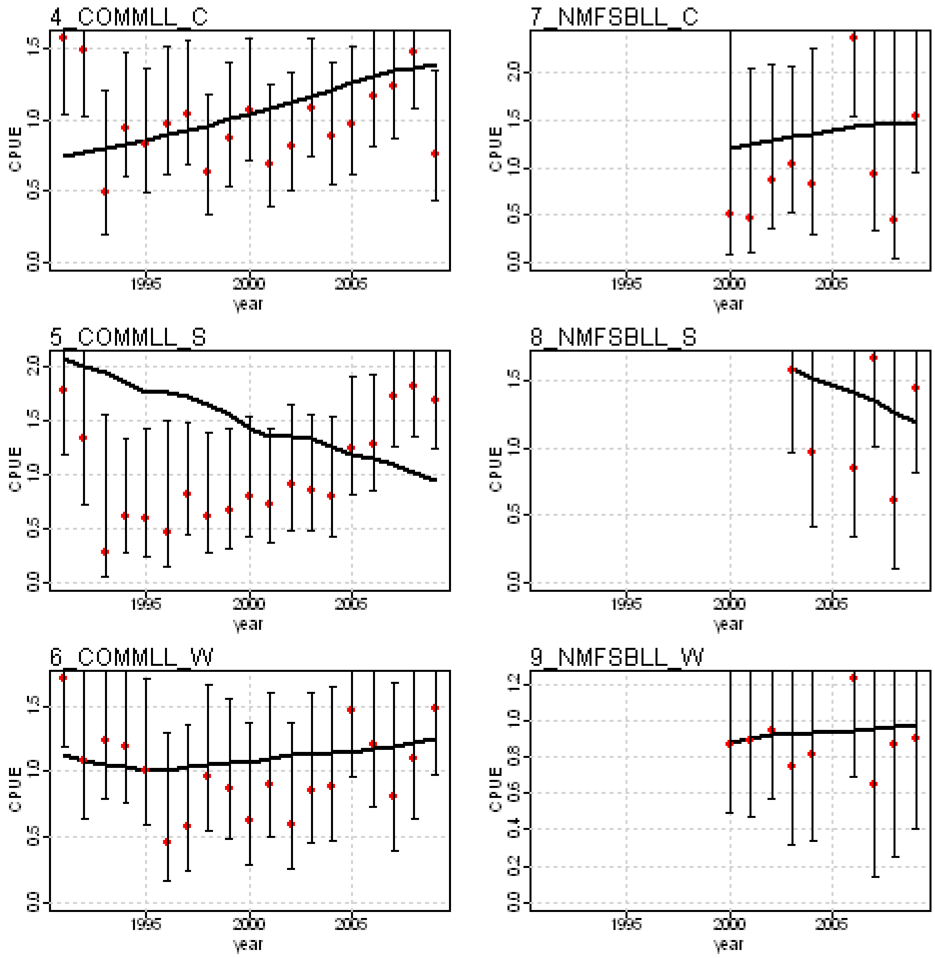


Figure 3.89. Fits to CPUE indices for the three area sensitivity run.

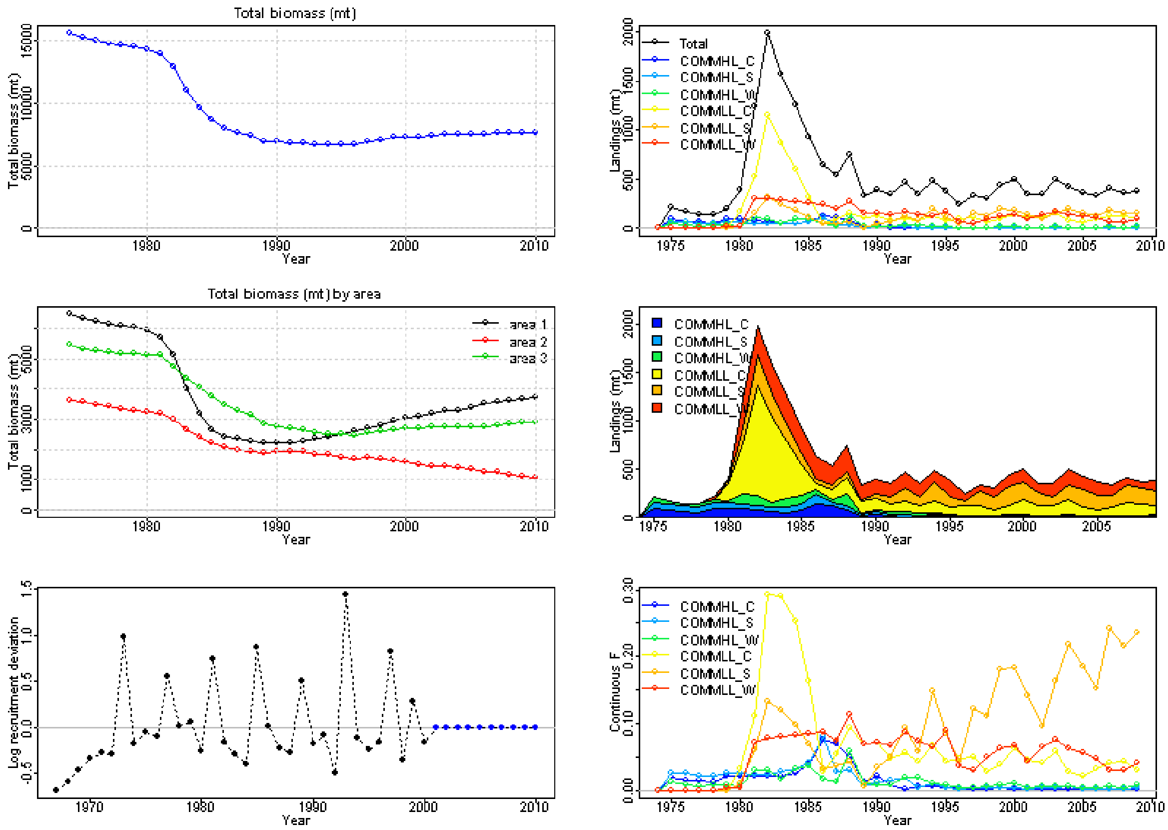


Figure 3.90. Total biomass, biomass by area, recruitment deviations, landings and instantaneous F for the three-area model.

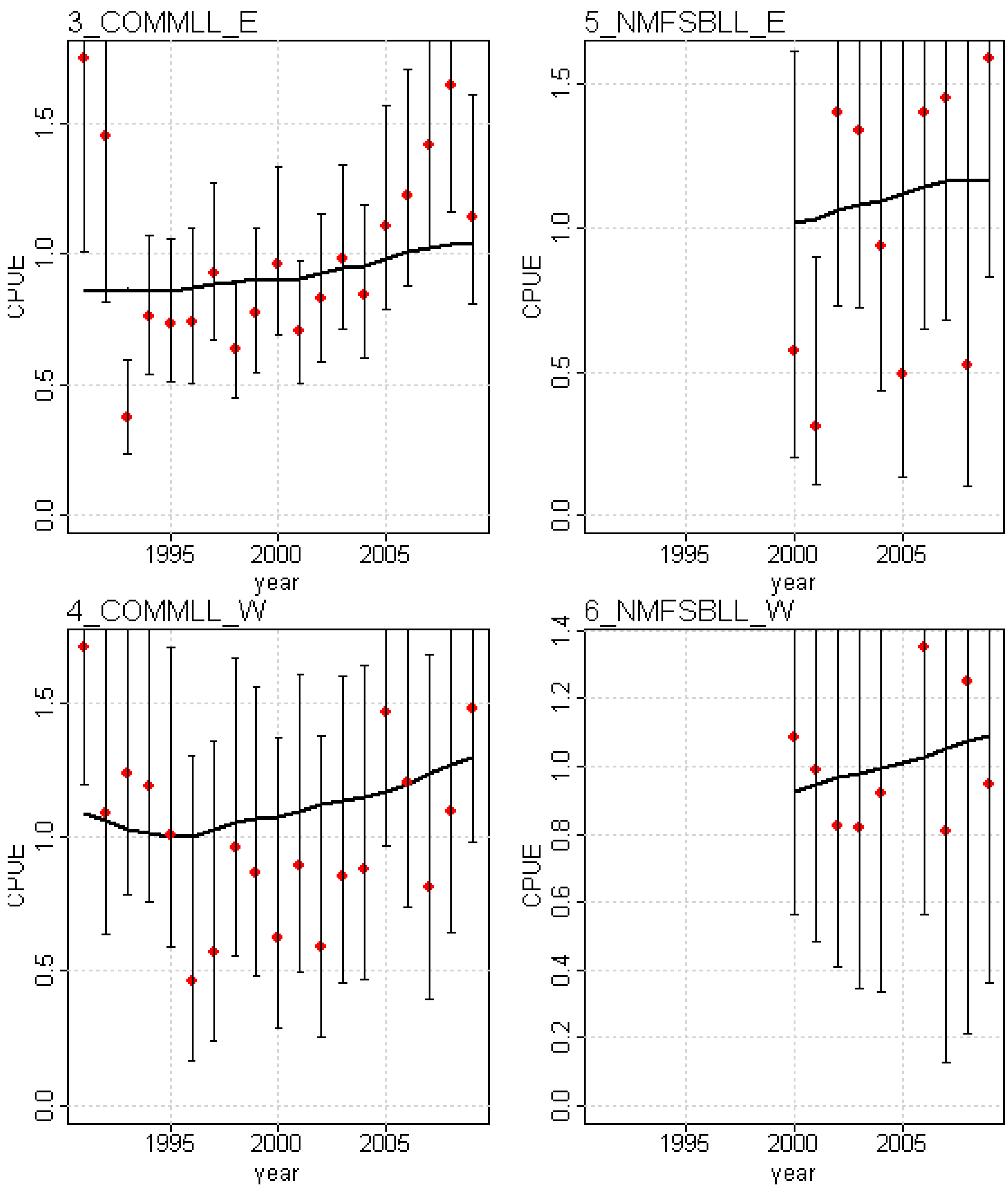


Figure 3.91. Fits to CPUE indices for the estimate M sensitivity run.

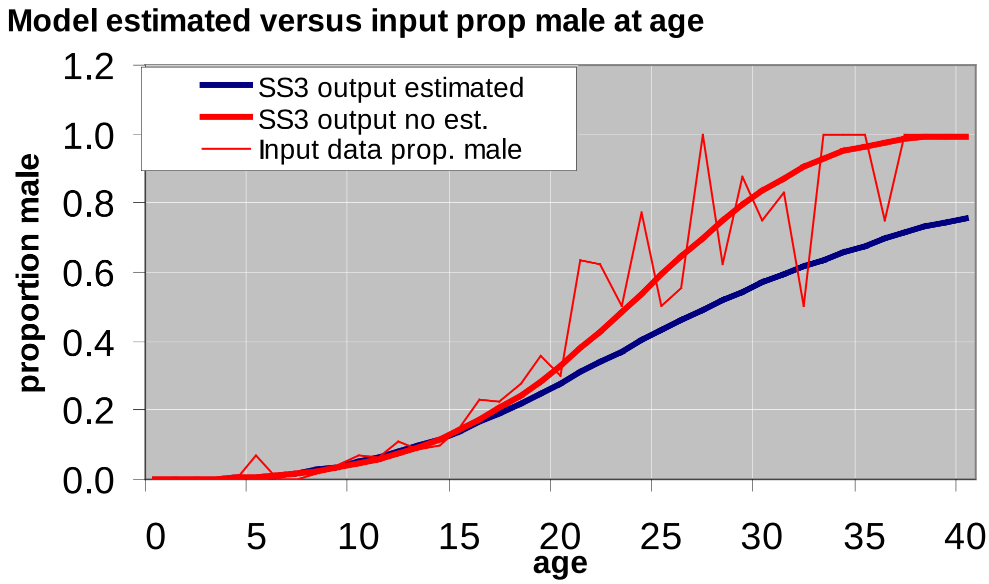


Figure 3.92. SS3 model estimated proportion of males at age (blue) versus the proportion estimated at the data workshop as initial input.

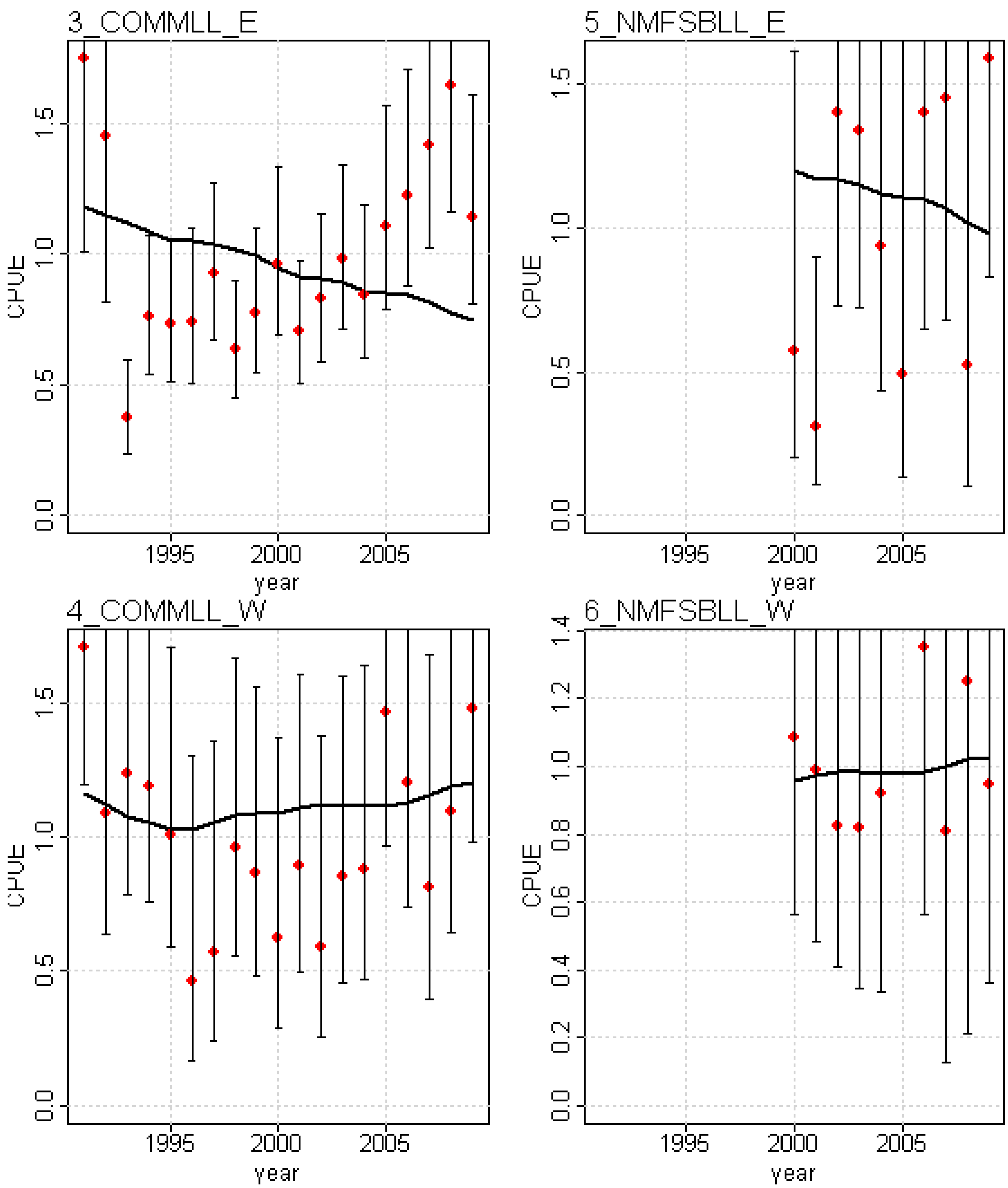


Figure 3.93. CPUE fits for sensitivity run incorporating low landings history.

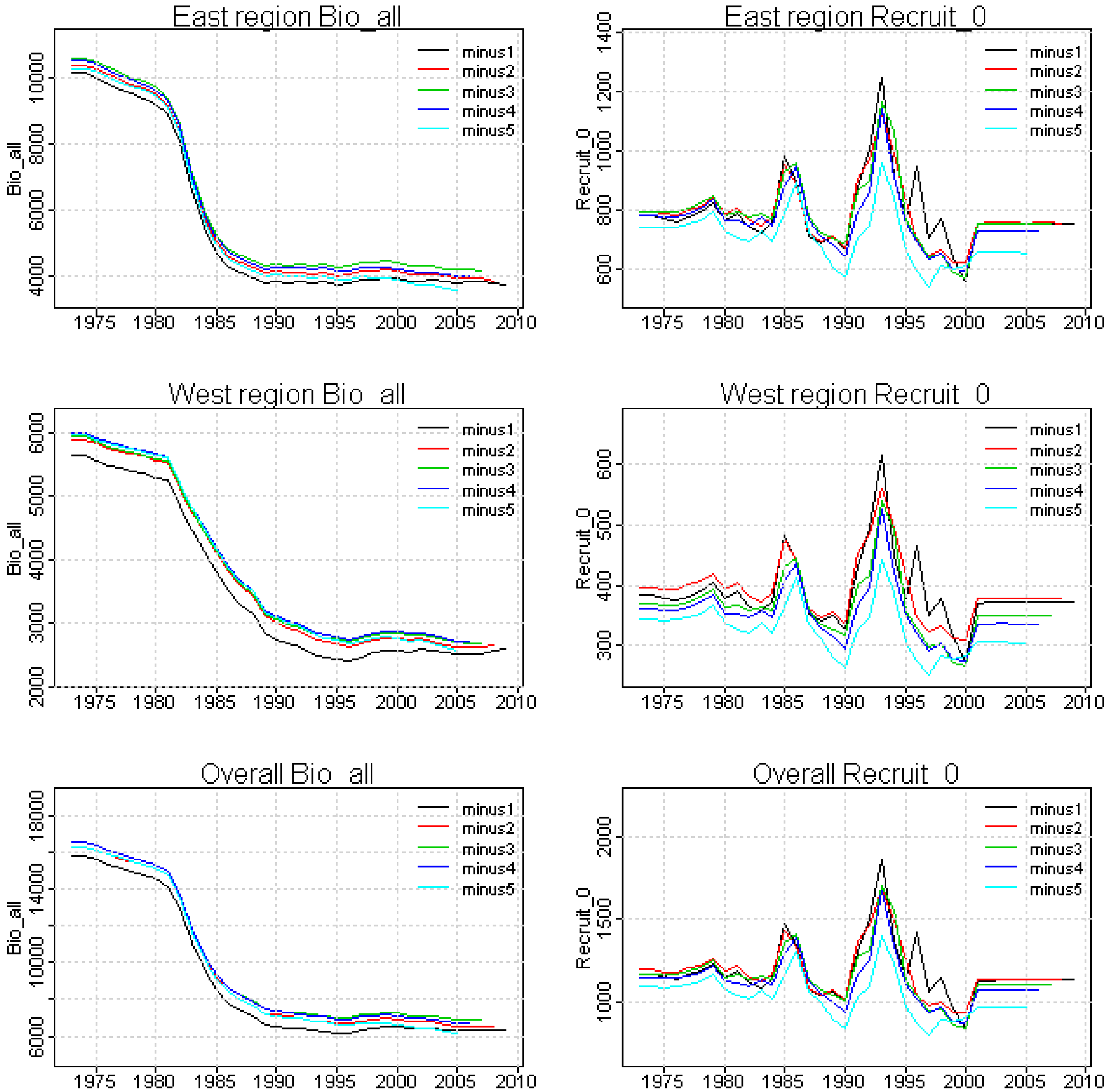


Figure 3.94. Retrospective patterns for total biomass and estimated recruits for the base model.

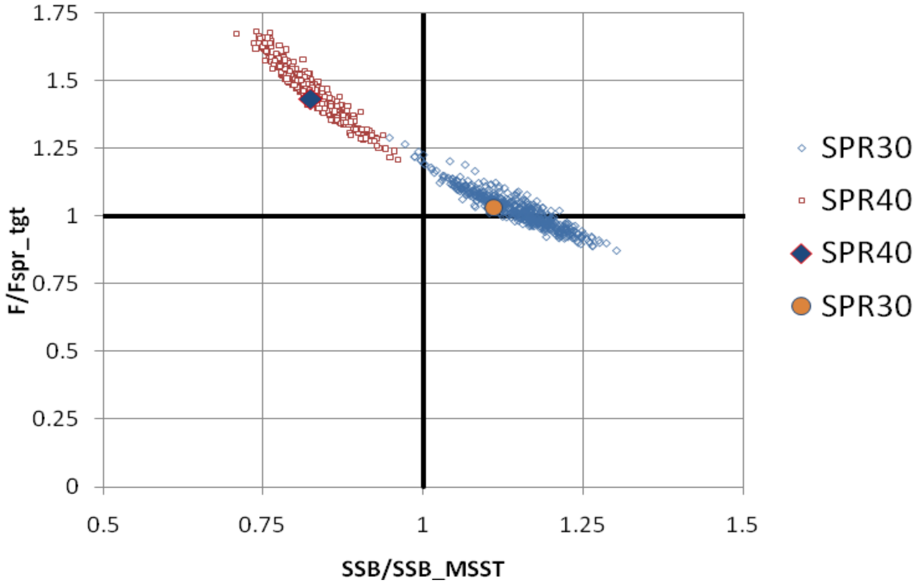


Figure 3.95. Base model uncertainty in stock status from sampled MCMC runs (495 sampled from 100000). Fishing mortality rate is calculated is the deterministic F2009/$F_{SPR30\%}$ or $F_{SPR40\%}$. SSB status is calculated as the deterministic SSB2009/SSB_MSST where SSB_MSST is (1-M)*$SSB_{SPR30\%}$ or $SSB_{SPR40\%}$ and M=0.073.

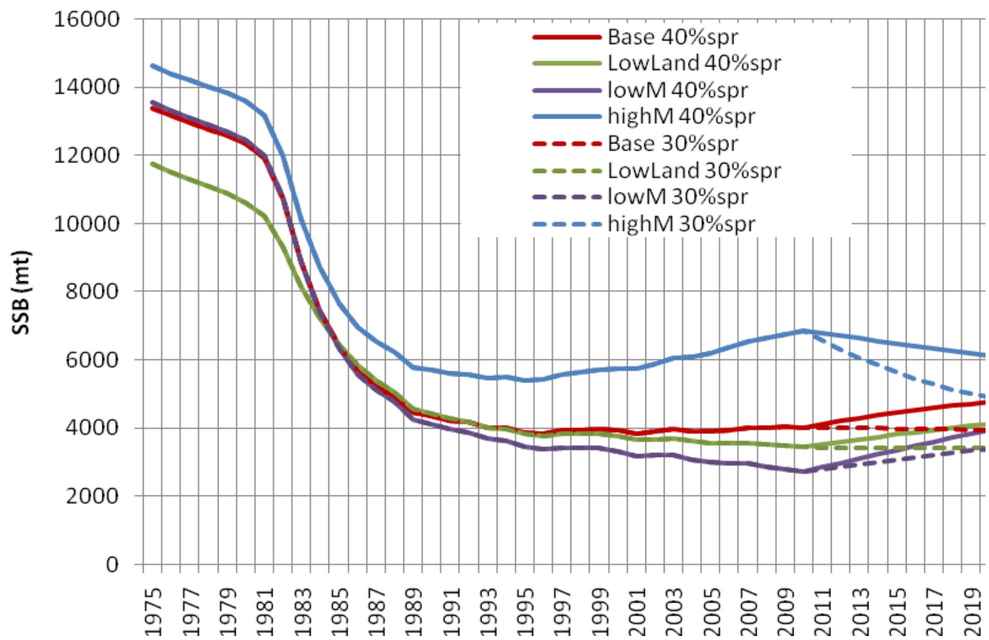


Figure 3.96. Historic and projected spawning stock biomass under for four model configurations under FSPR30 and FSPR40%. Models shown are the base model, the low landings model and the high and low M models.

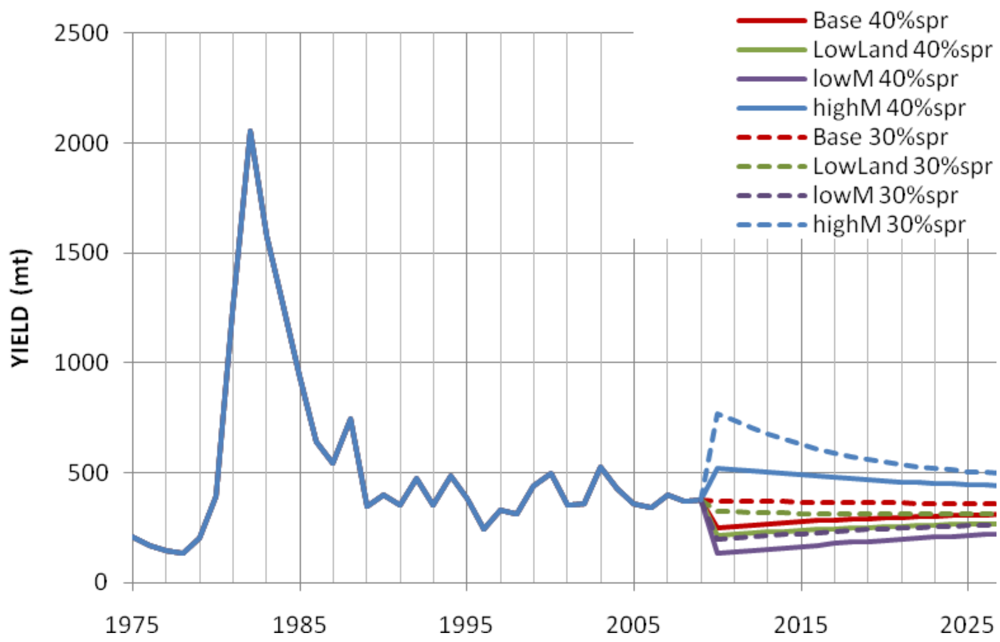


Figure 3.97. 1970-2029 historic and projected yield for four model configurations under $F_{SPR30\%}$ and $F_{SPR40\%}$. Models shown are the base model, the low landings model and the high and low M models.

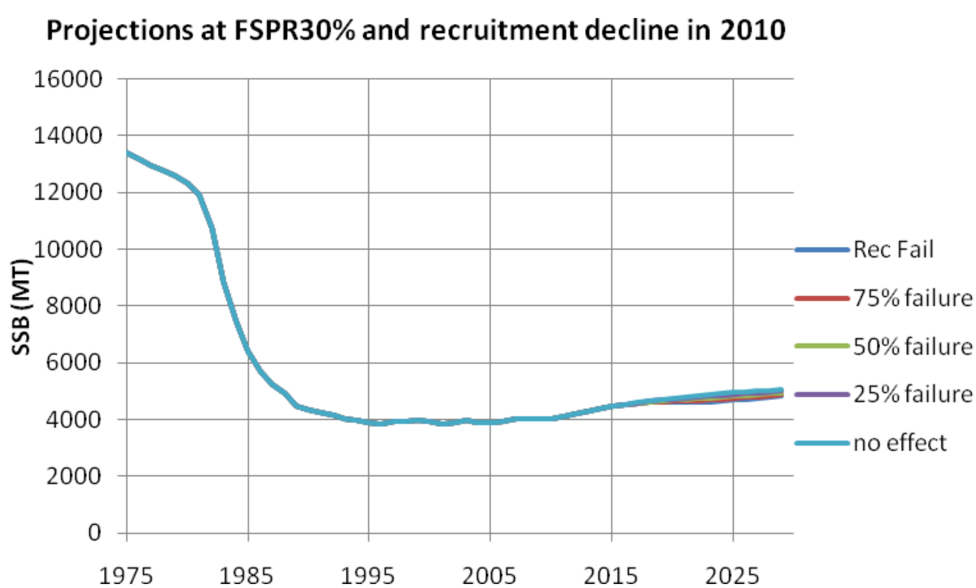


Figure 3.98. Base model projections of SSB when fished at Fspr30% and the base model under recruitment decline in 2010 scenarios.

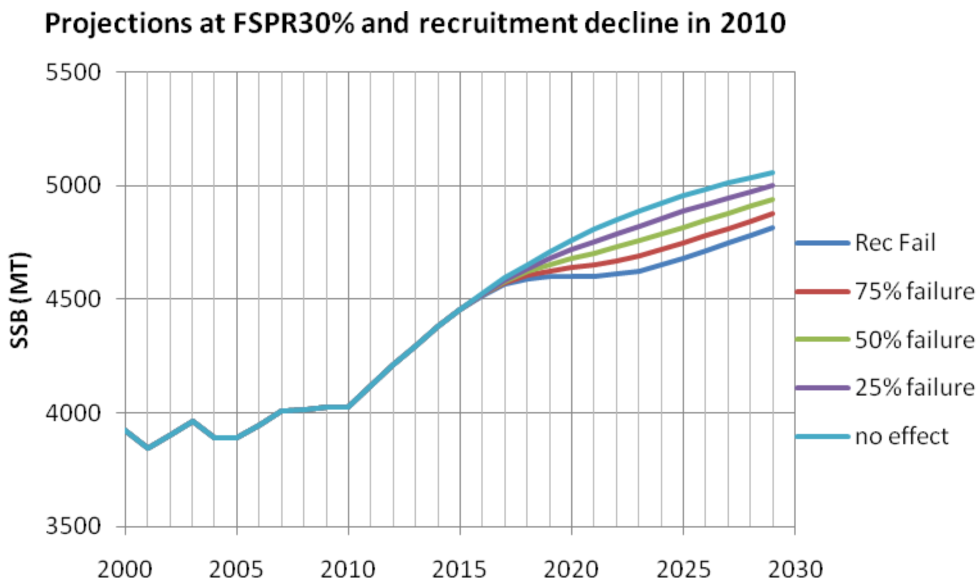


Figure 3.99. Base model projections of SSB when fished at Fspr30% under recruitment decline in 2010 scenarios, years expanded.

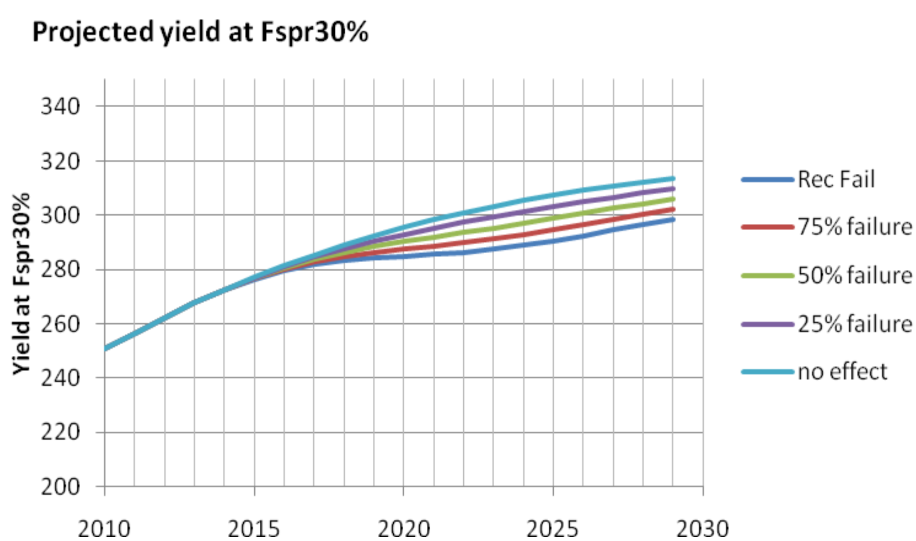


Figure 3.100. Base model projected yield at Fspr30% and the base model under recruitment decline in 2010 scenarios, years expanded.

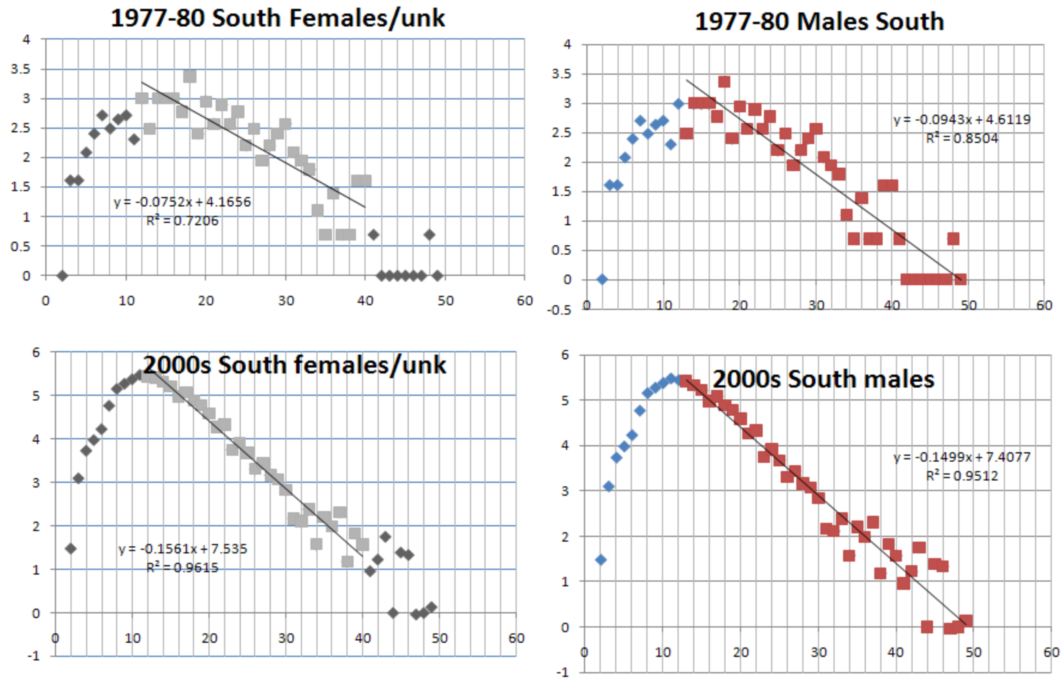


Figure 3.101. Cross-sectional catch curves for early (1977-1980) and recent (2000s) yellowedge grouper for the South region YEG for South females and unknown sex 1977-1980

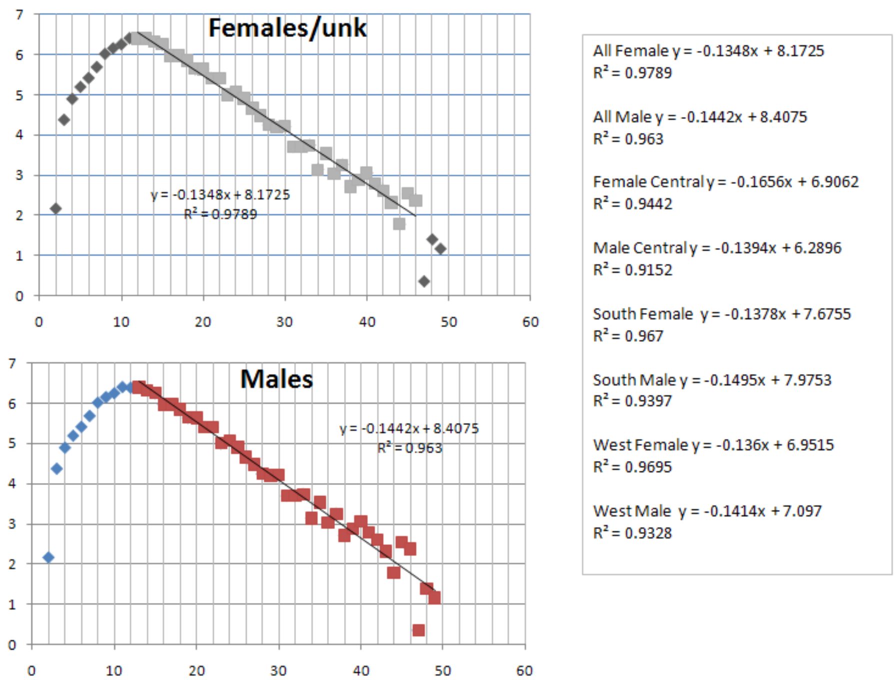


Figure 3.102. Cross-sectional catch curves for early (1977-1980) and recent (2000s) yellowedge grouper for the South region YEG for South females and unknown sex 1977-1980 Recent (2000s) catch curves

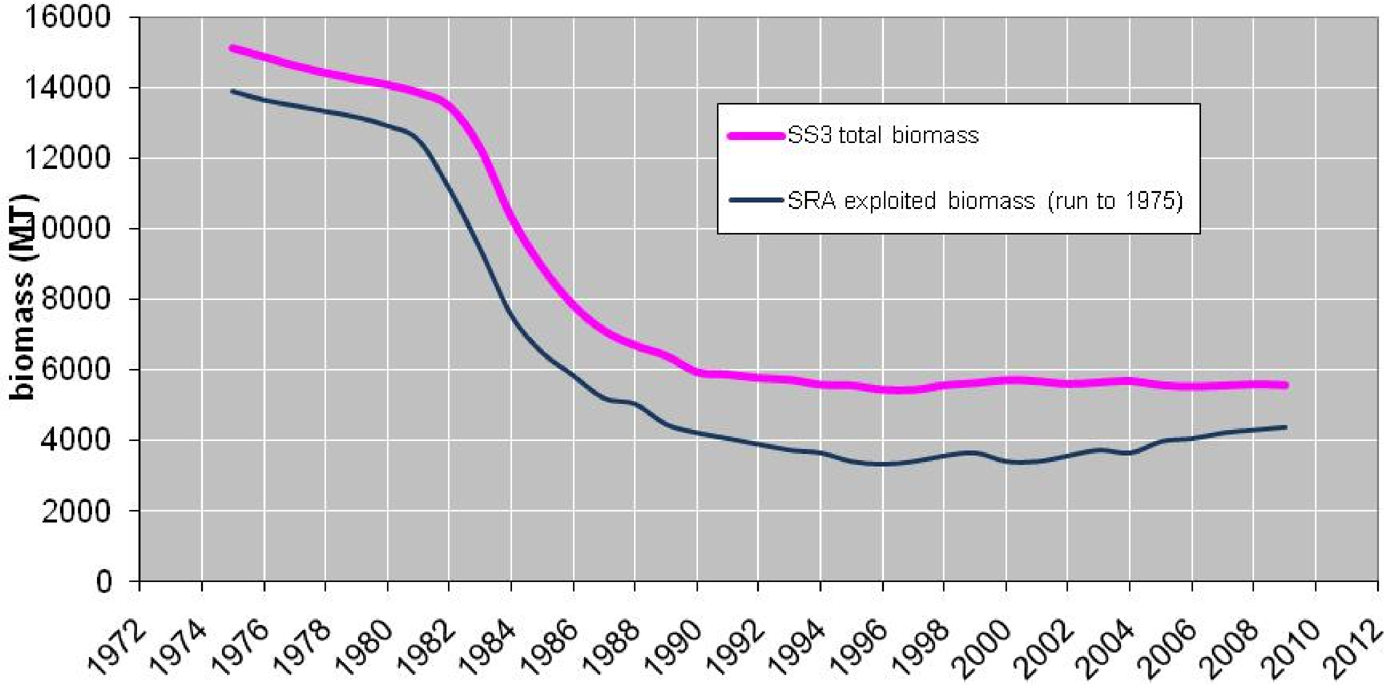


Figure 3.103. Comparison of biomass trajectories.

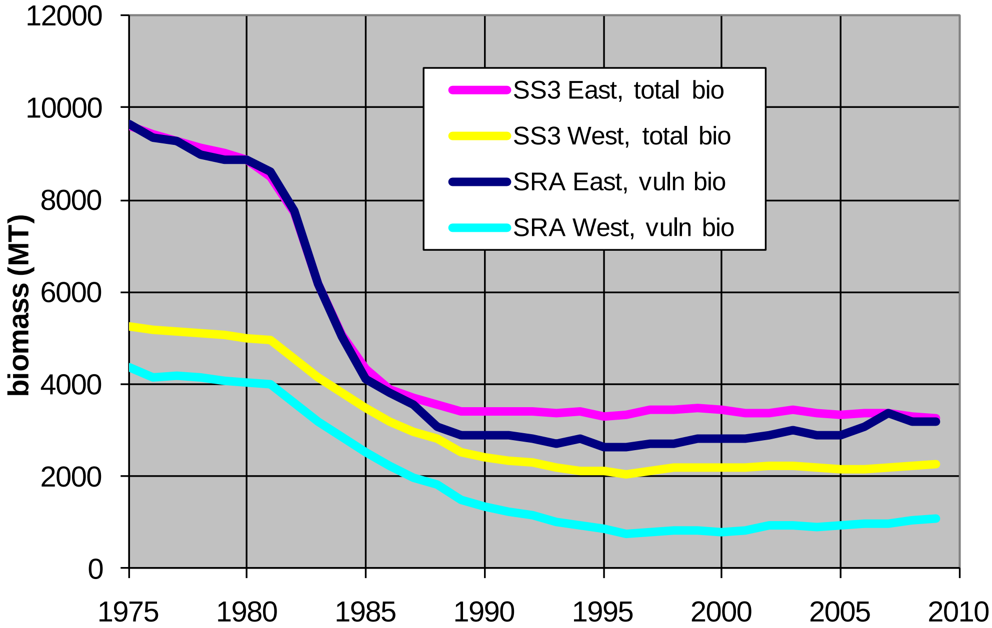


Figure 3.104. Comparison of biomass trajectories by region.

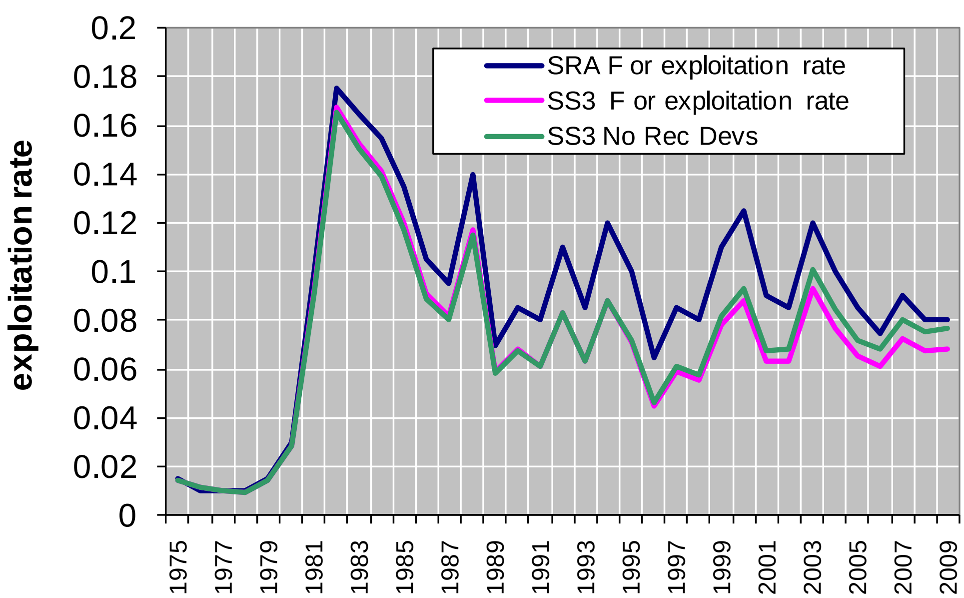


Figure 3.105. Estimated overall exploitation rates for SRA (all area model) and SS3 (combined across both areas).

SEDAR

Southeast Data, Assessment, and Review

SEDAR 22

Gulf of Mexico Yellowedge Grouper

SECTION IV: Research Recommendations

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

1. DATA WORKSHOP RESEARCH RECOMMENDATIONS

1.1 LIFE HISTORY WORKING GROUP

- The LH DW recommends directed studies for better estimation of onset of maturity, batch fecundity by age, spawning frequency by age, and spawning duration by age.
- Recommend the fishery-independent longline survey enhance collection of sediment/habitat data to allow post-stratification. Increased resolution of spatial population structure is important given the demographic differences (east and western GOM) noted. There is the potential for over-exploitation of sub-populations within the larger GOM stock.
- Monitor for possibility of increased discards/high-grading as ITQs (catch shares) is undertaken as management approach.
- Since preliminary genetic research and demographic comparisons by Cook (2007) found differences between regions in the GOM the LH DW recommends additional genetic research on population genetics throughout the GOM be conducted.
- Improve information on stock structure/rates of possible exchange between Gulf and Atlantic, including pathways for larval transport.
- Age Johnson historical otoliths collected off Florida during 1982-1983. Use otolith age results to support ages determined using otolith weight to predict age.

1.2 COMMERCIAL STATISTICS WORKING GROUP

No recommendations were provided.

1.3 RECREATIONAL STATISTICS WORKING GROUP

No recommendations were provided.

1.4 INDICES OF ABUNDANCE WORKING GROUP

In both the fishery-independent surveys presented above, precision in abundance indices could be improved by increasing the number of samples at least two- to three-fold.

<u>Research recommendations for fishery dependent data:</u>

1.) Expand observer coverage to provide a subsample adequate to construct indices of abundance (Pelagic Longline Observer Progam has 5-8% coverage). Observer data provides finer spacial resolution and a more accurate measure of CPUE. It also provides size frequency and discard information that is currently unavailable in the self-reported dataset. Current observer coverage is inadequate for the construction of indices of abundance.

2.) Self logbook data should be restructured to collect data on a per set basis rather than per trip. This would allow for a more accurate calculation of CPUE. Data subsetting (determining targeting) would be vastly improved with set-based data.

2. CIE REVIEWER RECOMMENDATIONS - DATA WORKSHOP

Conclusions and recommendations

I would like to commend the great efforts of all the participating scientists, managers and fishermen in the SEDAR 22 DW in the identification, evaluation and compilation of the information on life history, fishery-dependent and fishery-independent abundance indices, and landings in the commercial and recreational fisheries for YG, tilefish (i.e., golden tilefish), and blueline tilefish in the GOM. I was impressed by the breadth of expertise and experience of the panelists, openness of discussion for considering alternative approaches/suggestions, and constructive dialogs in each working group and at the plenary meetings throughout the workshop. All the comments, whether they were from scientists, managers, or fishermen, were fully considered and discussed. In particular, I commend the inclusion in the Data Workshop of fishermen, who provided insights on the quality of the fishery data, in particular for historical fisheries data. I observed on many occasions constructive interactions and dialogs between scientists/mangers and representatives of the industry in the Workshop.

In general, I consider the information identified and compiled in the DW represents the best efforts given all the limitations associated with data quality and quantity. I consider the approaches used in developing life history parameters, fisheries landings, and abundance indices sound.

Having said that, I believe that there are large uncertainties associated with data identified and compiled in the DW, and that there is room for further improvement. I have made the following general comments and specific recommendations.

General comments

Although the SoW states that all the working papers and reference/background information for the workshop will be available two weeks before the workshop, only a few working papers (less than 25% of all the working papers promised) were available before the start of the workshop (not mention two weeks before the start of the workshop). Many working papers were still not ready in the middle of the workshop, which made my work difficult. The three separate working groups worked concurrently every day, making it impossible for me, as the only CIE reviewer, to be fully involved in each group's discussions.

I was told at the DW that Stock Synthesis 3 (SS3) will be used for the assessment of YG and tilefish. This choice of stock assessment model has direct impacts on the quality and quantity of the data that need to be evaluated and compiled in the Workshop. However, I observed that most DW panelists did not know exactly the data requirements, key assumptions, and options of the SS3 program. I recommend that future data workshop start with the introduction of the stock assessment model that will be used in the assessment so that data workshop participants understand the information needs of the stock assessment model.

I noticed that the time period that the SEDAR 22 assessment covers had not been defined prior to the DW. I suggest that a stock assessment time period be defined prior to the DW so that working groups can focus on the defined time period, and not waste time discussing data falling outside the target stock assessment. The DW may also be a good place to discuss and make a decision about the time period the stock assessment should cover.

There is a need to include scientific names for all species covered in the TORs and SoW. The tilefish is the official name of golden tilefish in the American Fisheries Society list of fish species. However, both golden tilefish and blueline tilefish were discussed at the Workshop. This creates some confusion. It is clear from all the discussions at this Workshop that the information for blueline tilefish is not sufficient for a formal stock assessment using an assessment model like SS3.

Specific recommendations

Although I have provided detailed comments and recommendations under each TOR, I re-iterate the following recommendations.

- Possible existence of local stocks for both species needs to be evaluated;

- More comparative studies need to be done to evaluate differences in data collected from different monitoring programs;
- More comparative studies need to be done to evaluate differences in parameters estimated using different methods to improve our understanding of the degree of uncertainty associated with these parameters;
- More comparative studies need to be done to evaluate spatial and temporal variability in key life history parameters, abundance indices and landings;
- More habitat variables need to be included in CPUE and abundance index standardization;
- General additive models need to be considered in standardizing abundance index and CPUE;
- Instead of using a point estimate as a bias correction factor in correcting potential biases in landings data, a range of correction factors can be used so that large uncertainty in landings data can be incorporated into the stock assessment;
- The quality of catch data (landings, catch size/age composition, catch sex ratio etc.) is probably the most questionable of the data available to the stock assessment for both fish species, and the stock assessment model should have an ability to incorporate uncertainty in catch data;
- A critical evaluation of fishery-independent monitoring programs should be done to identify problems associated with the current program design in quantifying population dynamics;
- A systematic mail survey/interview of fishermen who have been involved in the GOM YG and tilefish needs to be done to have a better understanding of the degree of misreporting/underreporting and to identify if there is spatial and temporal variability in underreporting;
- It appears that outliers may exist in the assessment and given the data quality concerns, I suggest that robust estimation methods be used in the assessment (although this may be the choice of the modelers, but I believe that the Data Workshop is a place to make the recommendation because this is the place to deal with data quality issues);
- Uncertainty should be considered in all life history modeling, and confidence intervals should be estimated for the key life history parameters for the GOM YG and tilefish;

- Because of the extremely small YG catch in the SEAMAP bottom trawl survey, caution should be used in applying the derived abundance index, and the change in survey protocol in 1987 calls for a separate analysis of the two time periods and two different catchabilities in population modeling;
- Different measures for SSB should be considered for both tilefish and YG in stock assessment modeling; and
- I recommend conducting a systematic evaluation of current sampling programs for quantifying size composition and age composition of commercial catch. Factors such as adequate spatial and temporal coverage and sampling intensity to have high effective sample sizes should be considered. I recommend developing alternative sampling designs, developing a simulated fishery that mimics temporal and spatial variability in size and age compositions in commercial landings, applying current and alternative sampling programs to the simulated fishery, comparing the performance of the sampling programs with respect to their replications of built-in size and age compositions in the simulated fishery, and identifying a cost-effective port sampling program for quantifying size and age compositions of commercial landings.

Finally, I strongly concur with the recommendations made by the LHG in their draft DW report regarding life history work for the GOM YG and tilefish, and I think all the issues raised in the report are critical to improve the life history data quality. The draft reports of the other two groups (IG and LDG) were not available when I prepared this report so I cannot make any comments regarding the recommendations they will list in the DW reports.

3. ASSESSMENT WORKSHOP RESEARCH RECOMMENDATIONS

No specific research recommendations were provided.

4. CIE REVIEW RECOMMENDATIONS – ASSESSMENT PROCESS

The research recommendations in the yellowedge grouper assessment report were all identifying appropriate areas for further investigation but a number of them were rather short on proposed investigative methodologies.

One proposal was to look at genetics. The application of genetics to fisheries management has had mixed success but here is a need to address stock structure and a regional genetics program may be able to address this issue, not only for this species but for others in the same position.

The fishery dependent research recommendations were both good but it is probably worth defining how much observer coverage would be required to provide adequate data from which to construct alternative indices. The additional fishery information obtained from an expanded observer program (on such things as discards) would, however, also be very welcome.

Direct aging of the Johnson otoliths from 1982 and 1983 is a low cost and worthwhile study that will directly feed into future assessments and specifically help to correct the paucity of data in the earlier years of the fishery.

Additional research recommendations have been identified by the reviewer and are presented below in priority order.

Reviewer Recommendations

• In a fishery with multiple data deficiencies, one of the objects of modeling is to identify those data sets that, by their inadequacy or absence, have a disproportionate impact on the outcome of the assessment. This then provides an independent assessment of the prioritization of future research effort aimed at improving the assessment most effectively. More could probably be made of this in defining immediate future research focus.

• Analyze existing data, or collect and analyze new data to confirm that the yellowedge grouper is composed of only a single stock. This could focus on a genetics program aimed at a number of species in the region, as this appears to be a shared problem amongst a number of species.

• Selection bias has occurred in yellowedge grouper age samples, with many more samples in recent years and more from some fishery areas than others (e.g. Florida). Some attempts to obtain a balance of samples from the different areas of (i) the fishery and (ii) the wider stock distribution should be developed and implemented

• While the recreational landings represent a small proportion of the landings it could be worth reviewing the biological data available as recreational fisheries often either target or catch different age or length components of the stock compared to other fisheries. This can be seen in differences between the handline and longline fisheries here. If this is the case then this small part of the fishery may contain useful information about length or age. A basic analysis of length and possibly otolith weight (as a proxy for age) would advise whether this merits further consideration.

• The core input data are in imperial units (lbs) while model processed data (e.g. weight at length or age) are presented in metric units. More importantly the landings/catch data are in lbs and model outputs are in kgs making comparison somewhat difficult. Input and output data should be presented in consistent units.

5. REVIEW PANEL RESEARCH RECOMMENDATIONS

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

Based on the observations made during the review, the RP suggested priority might be determined for the following research topics:

1. Research to improve abundance indices and their development from fishery-dependent and fishery-independent data sources would appear to have relatively high priority as they would have a great impact on the assessment. Topics could include, but not be limited to:

    - Improve precision in fishery-independent survey abundance indices by increasing the number of samples, including expansion into deeper water.

    - Improve precision in fishery-independent survey abundance indices by expanding observer coverage to at least 5% of the area to provide additional accurate information adequate to construct indices of abundance. Observer data should provide finer spatial resolution, a more accurate measure of CPUE, size frequency and discard information that is currently unavailable in the self-reported dataset. Current observer coverage is inadequate for this purpose.

- Improve fishery-independent survey abundance indices by using logbooks to collect data on a set-by-set basis rather than per trip. This would allow for a much more accurate calculation of CPUE.
- Re-examination of the standardization of CPUE indices, both the models and the covariates (habitat, sediment, depth etc.).

2. For yellowedge grouper, ageing could be improved. There are historical otoliths collected off Florida during 1982-1983 which could be used if partitioned between species (e.g. using discriminant analysis). More age data might become available if the relationship between age and otolith weight could be developed. This could have a significant impact the stock assessment.
3. Research to improve stock definition and structure. For the stock assessment, the biggest impact of this sort of research is on the way data are broken down into areas to try to improve coherence within sub-sets of data. This suggests that priority for this sort of research should depend upon demonstrating that the data can support alternative stock structures and that there would be greater coherence within these subsets of data. There were no apparent cohorts identifiable in the age composition data from the two areas used in this assessment, but insufficient data to support break down into three areas. Improving the basic data through, for example, re-examination of the sampling design for size and age composition from the commercial fishery might have higher priority.
4. Research on life history is high priority, but should first and foremost be reflected in data collection before assessment model structure. While model structure might be seen as improved in representing real biological processes, such as protogynous hermaphroditism, unless there is sufficient monitoring and other data, the model will effectively be unable to incorporate the process in the assessment. One of the research recommendations which could prove important is to determine a more appropriate way to model spawning stock size for protogynous species.

In addition to research identified in the DW and AW, the RP recommends further work on the stock assessment modelling. The RP found results depended on how different sources of information were weighted, and alternative weighting schemes could be considered in developing future stock assessments. The age and length composition likelihood models appear appropriate, so research may be more focused on the abundance index standardization and ensuring their likelihood model and scale parameters are compatible with the age and length composition likelihood.

The RP also suggested some additional methods which would improve the absolute stock size estimate. These methods would help determine the shape of the selection curve, the value of M, and therefore would improve the MSY estimation. Even though M has been reasonably well estimated, the assessment is still very uncertain, because F and M are low, so further improvements in the estimate of M would be beneficial. Absolute stock estimates might be obtained from 1) underwater video surveys to count fish burrows; 2) deep water tagging, as done for redfish in the Irminger Sea; or 3) depletion fishing experiments within a small area (e.g. 1 x 1 km) combined with NMFS survey type long line fishing to estimate survey catchability, like that done in the REX project for cod and other species in the north-eastern North Sea.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 22

Gulf of Mexico Yellowedge Grouper

SECTION V: Review Workshop Report

April 2011

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

Table of Contents

Table of Contents 2
1. INTRODUCTION 2
1.1 WORKSHOP TIME AND PLACE 2
1.2 TERMS OF REFERENCE 2
1.3 LIST OF PARTICIPANTS 3
2. REVIEW PANEL REPORT 4

1. INTRODUCTION

1.1 WORKSHOP TIME AND PLACE

The SEDAR 22 Review Workshop was held February 14-17, 2011 in Tampa, Florida.

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, OFL, Fmsy, Bmsy, MSST, MFMT, or their proxies*); recommend appropriate management benchmarks and 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 that reported results are consistent with Review Panel recommendations.
8. Evaluate the SEDAR Process as applied to the reviewed assessments and identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops.

9. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted. Clearly denote research and monitoring needs that could improve the reliability of future assessments. Recommend an appropriate interval for the next assessment, and whether a benchmark or update assessment is warranted.
10. Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks to be completed following the workshop.

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

Workshop Panel

Doug Gregory, Chair .... GMFMC SSC
Henrik Sparholt .... CIE Reviewer
Paul Medley .... CIE Reviewer
Robin Cook .... CIE Reviewer
Stephen Szedlmayer .... GMFMC SSC

Analytic Representation

Brian Linton .... NMFS SEFSC Miami
Linda Lombardi .... NMFS SEFSC Panama City
John Walter .... NMFS SEFSC Miami

Council Representation

John Greene .... GMFMC

Official Observers

Martin Fisher .... GMFMC AP

Other Observers

Michael Larkin .... SERO
Nick Framer .... SERO

Todd Gedamke..NMFS Miami

Staff

Carrie Simmons ....GMFMC Staff
Charlotte Schiaffo ....GMFMC Staff
John Froeschke..GMFMC Staff
Julie Neer .... SEDAR
Ryan Rindone.. SEDAR
Tyree Davis...NMFS Miami

2. REVIEW PANEL REPORT

SEDAR 22 Benchmark Review Consensus Report

Gulf of Mexico Yellowedge Grouper (*Epinephelus flavolimbatus*)

1. Summary

The base run with the $SPR_{30\%}$ benchmark places the stock in the 'not overfishing was occurring and not overfished' category for 2009. However, sensitivity runs show this stock to be effectively on the definition boundaries. All terms of reference were adequately addressed by the Data Workshop (DW) and Assessment Workshop (AW), although some AW ToRs awaited decisions from the Review Panel (RP), which are set out below. The stock assessment presented by the Assessment Workshop (AW) was accepted after minor modifications made during the review meeting. The Review Panel (RP) thanked all the members of the DW and AW for their diligence in preparing their reports and willingness to respond to questions from the RP.

2. Terms of Reference

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

Input data comprised catches, length and age compositions, abundance indices and life history data based mainly on proposals from the Data Workshop.

Landings data were available for the years 1975 onwards and were split into two areas (Eastern and Western Gulf). A number of corrections had to be made to the landings data before 1991 to account for non species-specific records and likely mis-classification of species. The corrections made have been reviewed and are considered reasonable, but which must lead to uncertainty in the precision of the estimates as well as possible bias. In order to consider the latter, the AW constructed a 'low catch' dataset which attempts to correct for possible over-estimation of yellowedge grouper in shallow areas where red grouper are more likely to have predominated. This appears to be a reasonable approach.

Discards and recreational catches are small and were added to the total landings. Due to their very low levels, the effect of uncertainty in these catch estimates are believed to be negligible.

Length composition data are available for much of the time period and were stratified by gear and region (Eastern and Western Gulf). Some samples were further stratified by gender, but comprise quite small sample sizes.

Age compositions are also available for much of the time period and are similarly stratified for gear, region and gender, though there are many years in the Eastern area with no samples. Age determination error is large, but has been verified with C_{14} analysis.

One commercial and one fishery independent survey were chosen which had been standardized using a delta-lognormal model. These are partitioned into two assessment areas. The commercial CPUE is a longer and continuous series since 1992 while the NMFS Bottom Longline (BLL) CPUE series begins in 2000 and was interrupted in 2005 due to a hurricane event. The

Coefficients of Variation (CVs) on the survey estimates are large in relation to the apparent signal in the point estimates.

Overall the data summarized above were considered by the Review Panel (RP) to be adequate for the purpose of assessment, but noted that the quantity of data was low and there are concerns over some aspects of its quality as outlined above.

Life history data were provided by the DW and were considered adequate for the assessment as they are based on a thorough review of existing information pertaining to this or related species. The work on ageing and the efforts to reconstruct pre-trip ticket catch composition since the first yellowedge stock assessment in 2002 is commendable.

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

Stock Synthesis 3.2 (SS3) was used as the principal assessment method. It is an age-structured population assessment tool and is a well established approach. It includes a population simulation model to calculate the abundance and mortality of a harvested population, an observation model to link to observable data variables, and a statistical model to adjust parameters of the population model and observation model to achieve the best fit to all the data. Data are presented to the model in its most natural form and hence a wide variety of data can be included. SS3 can tolerate missing values for most types of data. It is well designed to deal with the data available for the yellowedge grouper assessment, but does require the analyst to make a number of choices in the configuration of the model.

The RP supported the choices made by the AW and considered them adequate for characterizing the fishery and stock, given the limitations of the data available. The central run of the model assumed two geographical areas (Eastern and Western Gulf) that allowed for differences in growth and natural mortality. Asymptotic selectivity was assumed for longline gears, but dome shaped for the trawl and handline gears.

Selectivities were assumed the same in both areas. Recruitment was assumed to follow a Beverton-Holt relationship applicable to the combined area, but total recruitment was partitioned between the two areas. It did not prove possible to estimate a satisfactory standard deviation parameter (Sigma) for recruitment variability based on maximum likelihood, so this was set to 0.3 which satisfies the guideline that the Sigma should be greater than the estimated RMSE (Root Mean Square Error) from the model.

Exploratory analysis was also performed using Stock Reduction Analysis (SRA). While a much simpler approach, SRA is based on a very similar age structured population model that uses an historical catch stream to estimate a stock biomass trajectory. In the implementation used by the AW, SRA uses the CPUE data series with prior estimates of MSY and U_{MSY} (exploitation rate at MSY) to construct the biomass trajectory over time. Extensions of the model allow a full MCMC (Monte Carlo-Markov Chain) simulation to estimate the probability distribution of quantities of interest. The principal limitation of the method is that it does not use data on age and length within the model, although these data can be used externally to define the age-dependent vulnerabilities of the stock. The RP felt that SRA was a useful additional analysis and assisted in interpreting the behavior of the SS3 runs, particularly in understanding the influence of the age and length data on the assessment. The SRA model estimated a positive development of stock biomass in recent years reflecting the CPUE series more closely, which contrasts with the SS3 base run where the influence of the age and length data resulted in a more-or-less flat recent stock trajectory.

Both SRA and SS3 assessments treated the total catches as exact values, which means that any errors or biases in these values will be translated directly into the estimated quantities and are most likely to appear in the annual fishing mortality/exploitation rate estimates. Given the limited quantity and quality of data available, treating the catches as exact is probably necessary in SS3 (it is unavoidable for SRA) in order to obtain a satisfactory fit, but it is not a requirement of the model. It does mean, however, that the stock trajectory, especially for the earlier years when catches are much less certain should be treated with caution.

As well as the more complex assessment tools, the AW also carried out a simple catch curve analysis for two time periods. An early time period (1977-1980) corresponds to low fishing activity where the estimated total mortality (Z) gives an indication of natural mortality while the more recent period (2000s) give estimates of Z when the fishery was larger. The Z estimates suggest values for M and F in recent years that are consistent with the base run assessment which provides additional support for the SS3 estimates.

It was noted that one of the best possible estimates of M is available for yellowedge grouper. It is rare for assessments to have an estimate of mortality from when a stock was very lightly exploited. In this case, the RP believed that the natural mortality estimate was relatively reliable, although the assessment results were still sensitive to small changes in this parameter.

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

It proved difficult to choose a single model run that stood out as being 'best'. For pragmatic reasons the SS3 base run is suggested as the run to use for estimates of abundance, biomass and exploitation in order to visualize trends. It is very important to appreciate that the base run is only one of many equally plausible runs and it is suggested mainly because it makes use of the best expert knowledge in configuring the model. However, other runs with different model configurations or model parameters can give stock trajectories that suggest different trends and may be equally valid. Six different runs were chosen to encompass the range of possible "states of nature" of the yellowedge grouper in the Gulf of Mexico (see Table 1).

The way output is generated from SS3 can give the impression that the values in the whole time series of population estimates are all equally accurate. In practice the early year values are predicated on assumptions of historical constancy in the fishery and the stock. Hence it may be unwise to interpret the stock trajectory in the early years as representing what actually occurred.

Table 1. Yellowedge Grouper spawning stock biomass and fishing mortality rates for six likely scenarios depicting status of the stock relative to the SPR30% reference point. Note: SSB & Yield are in gutted metric tons.

Run #	Name	SSB_{2009}	$SSB_{SPR30\%}$	SSB_{2009}/ $SSB_{SPR30\%}$	F_{2009}	$F_{SPR30\%}$	F_{2009}/ $F_{SPR30\%}$
1	Base	4351.42	3998.95	1.088	0.0642	0.0662	0.97
8	Steepness=0.7	3610.01	3007.49	1.200	0.0778	0.0662	1.176
10	Low landings	3757.36	3508.51	1.071	0.0743	0.0659	1.128
11	Low M (0.055)	3160.18	3892.36	0.812	0.0886	0.0643	1.379
12	High M (0.099)	6663.98	4094.6	1.628	0.0415	0.0734	0.566
15	Equal weighting	5183.62	4159.55	1.246	0.0543	0.0684	0.794

2.4. Evaluate the methods used to estimate population benchmarks and management parameters (e.g., MSY, OFL, Fmsy, Bmsy, MSST, MFMT, or their proxies); recommend appropriate management benchmarks and provide estimated values for management benchmarks, a range of ABC, and declarations of stock status.

The MSY benchmarks were calculated using a Beverton-Holt recruitment curve estimated from within the model. The Beverton-Holt curve has a number of computationally convenient attributes that make it the curve of choice for many assessments. Unfortunately most stock-recruitment curves cannot be estimated with any precision and this assessment is no exception. Consequently there is a question mark about the reliability of the MSY values, not the least because the estimated recruitment curve has few values to define the asymptote and steepness proved problematic to estimate. However, MSY benchmarks are provided in Table 2 for comparison purposes.

Table 2. Yellowedge Grouper maximum sustainable yield and fishing mortality estimates for six likely scenarios depicting status of the stock relative to the MSY reference point. Note: SSB & Yield are in gutted metric tons. Natural mortality=0.073. MSST = (1-0.073)*MSY

Run #	Name	SSB_{2009}	MSY	SSB_{2009}/ MSY	F_{2009}	F_{MSY}	F_{2009}/ F_{MSY}	MSST
1	Base	4351.42	380.4	11.439	0.0642	0.0964	0.6660	352.63
8	Steepness=0.7	3610.01	283.2	12.747	0.0778	0.0529	1.4707	262.53
10	Low landings	3757.36	334.1	11.246	0.0743	0.1003	0.7408	309.71
11	Low M (0.055)	3160.18	336.2	9.400	0.0886	0.092	0.9630	311.66
12	High M (0.099)	6663.98	473.5	14.074	0.0415	0.0969	0.4283	438.93
15	Equal weighting	5183.62	417	12.431	0.0543	0.1044	0.5201	386.56

Fourteen different runs were presented to the review workshop. A fifteenth run was requested by the RP representing a more balanced weighting between the main sources of information (length and age compositions and abundance indices). These different runs were presented to the review workshop as the possible interpretations of the stock development. The RP identified six of these sensitivity runs to represent the range of likely scenarios which apply to this stock. These runs were chosen as follows:

Run	Name	Description	Used	Justification
1	**Base**	**The "base case" developed by the Assessment Workshop from which the sensitivities are developed.**	**Yes**	**The central run is used as the most likely scenario for comparison with the other runs.**
2	Update 86_09	These were based on the previous 2002 assessment updated with 2009 data in two configurations defining the initial conditions.	No	These sensitivities were only run to compare the new model with the previous assessment. The current model was considered an improvement, so no further reference was made to the 2002 assessment.
3	Update 86_09 zero eq catch		No	
4	No Rec Devs	The recruitments were determined by the fitted stock recruitment relationship with no error.	No	The lack of recruitment variation was thought to be unrealistic.
5	Three Area	A trial configuration for the model with three instead of two regions.	No	It was found that the data were unable to support three areas, and the resulting model provided a poor fit to the data.
6	No Selectivity Blocks	Selectivity was set to remain constant over time.	No	Suspected changes in the selectivity over time were not accounted for, resulting in a poorer fit of the model.
7	Est. M	Natural was estimated from the data within the model.	No	The maximum likelihood estimate was unrealistically high, suggesting that this parameter could not be estimated within the model.
8	**Steepness= 0.7**	**The alternative steepness was lower than the fitted value and possibly more appropriate for a long-lived slow-growing species.**	**Yes**	**This is proposed as an alternative stock recruitment relationship and should produce different benchmarks.**
9	No Estimated Hermaph. Parameters	The parameters governing the sex transition were fixed from an alternative analysis rather than being estimated within the model.	No	Unless the SSB was calculated from a single sex (females), the results were insensitive to the transition from females to males (see Run 14).
10	**Low landings**	**The configuration of the model was the same as Run 1, but alternative assumptions on how to allocate historical undifferentiated grouper landings led to an alternative lower catch time series.**	**Yes**	**Lower past catches, which could apply, had a significant impact on the perceived past biomass (SSB0).**
11	**LowM**	**A low natural mortality set towards the lower end of the possible range identified by the Data Workshop.**	**Yes**	**The assessment is highly sensitive to natural mortality, so a realistic range was included in management advice.**

12	HighM	A higher natural mortality set towards the higher end of the possible range identified by the Data Workshop.	No	
13	Production	The model was configured to emulate an age structured production model, ignoring the available age and length compositions.	No	The production model ignored some of the available information (length and age), and no reason to exclude these data.
14	No males in SSB	An alternative landings time series was developed making alternative assumptions on the designation of undifferentiated tilefish between tilefish species.	No	It was not possible to ensure that female biomass could be accurately estimated (see Run 9).
15	**Increased weight to survey data**	**The abundance indices received a higher weight (*10), leading to a more balanced weighting between the indices and compositions.**	**Yes**	**This balanced the high contribution to the likelihood of the age and length data which the RP felt could give more credence to the survey data.**

From the six runs identified as representing the range of uncertainty, the Base run (1), Low M (11) and the equal weighting (15) were chosen to represent the estimate of uncertainty using MCMC stochastic simulations. The Low M seems to represent a plausible level of low productivity for the stock, and the equal weighting provides an equally likely alternative interpretation of the available information to the central run.

The RP recommends that proxies ($SPR_{30\%}$ or $SPR_{40\%}$) are used. Proxies are more robust rather than relying on estimates of MSY where information is lacking. The RP does not believe that steepness can be reliably estimated for this stock, so MSY benchmarks cannot be estimated reliably.

The RP noted that if species interactions are taken into account $SPR_{10\%}$ or $SPR_{20\%}$ may be better proxies for MSY than the $SRP_{30\%}$ and $SPR_{40\%}$ which are more widely accepted internationally as appropriate precautionary management targets. This argument is based on accumulated experience from some data rich stocks and from multispecies and ecosystem research results from the recent decades especially in the North Atlantic area (see the individual CIE report of Henrik Sparholt).

The base run with the $SPR_{30\%}$ benchmark implies that yellowedge grouper is not overfished, and overfishing is not occurring in 2009. Sensitivity runs show this classification to be near the definition boundaries.

Acceptable Biological Catch and associated probabilities of overfishing were still worked on by the assessment analysts when the RP finalised this report: Therefore Table 3, below, was not completed.

Table 3. Estimates of ABC and P* for the six equally valid "states of nature" for the yellowedge grouper population in the Gulf of Mexico.

		ABC (P*=Probability of Overfishing)						
Run	Name	15%	20%	25%	30%	35%	40%	45%
1	Base							
8	Steepness= 0.7							
10	Low landings							
11	LowM							
12	HighM							
15	Equal Weighting							

2.5 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 methods applied for projecting population status were appropriate. All projections are carried out in SS3. Projections were made from 2010 to 2020 using a standard age-structured forward catch equation method applying a fixed fishing mortality.

Of the 15 sensitivity runs presented to the RP, six (Runs, 1, 8, 10, 11, 12, and 15) were selected as more appropriate for prediction due to their degree of realism to the actual stock population dynamic. The start year for catches affected by future management actions was 2011. Deterministic projections were carried out for all main six sensitivities.

The RP also requested that stochastic projections (MCMC) should be carried out for the Central (Run 1), Low M (Run 11) and Equal Weighting (Run 15) runs only. These were selected to cover the likely levels of stock productivity and alternative states of nature. Although more sensitivity runs could legitimately be used to cover more uncertainty, there is a limit on the number which can be treated in this way. The RP believes that the selected runs are sufficient to cover uncertainty for use in the harvest control rule.

Uncertainty in initial stock abundance was modelled in the projection by using replicate MCMC fits as starting points where appropriate. Additional uncertainty was introduced in projections by stochastic selection of annual recruitment values from the fitted stock-recruitment relationship. The RP agreed with this standard approach. The RP also agreed that projections correctly modelled the time series of future F and biomass values required for evaluation of the various management options examined.

For yellowedge grouper, final year F estimates were used for the current fishing mortality projections. Fishing mortality showed little variation in the final three years, so using the geometric mean of the last three years would make little difference.

The RP recommended that a harvest control rule, similar to the 40:10 harvest control rule used by the Pacific Fisheries Management Council, be developed for these fisheries. The rule would automatically reduce fishing mortality if the stock fell below the trigger level (biomass target proxy i.e. $B_{SPR30\%}$) in projections. This would increase safety for the stock between assessment periods.

The projections tables (for $F_{SPR30\%}$) with stock status contain the ratio SSB/$SSB_{SPR30\%}$ and yield for the six runs and from 2010 through 2020(Table 4).

Table 4. Stock status and Yields from 2010 through 2020 for the six "states of nature" scenarios for yeallowedge grouper in the Gulf of Mexico.

		Stock Status (SSB / $SSB_{SPR30\%}$)										
Run	Name	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	Base	1.09	1.13	1.14	1.13	1.11	1.10	1.09	1.09	1.08	1.07	1.06
8	Steepness= 0.7	1.18	1.21	1.20	1.19	1.18	1.17	1.16	1.15	1.14	1.13	1.13
10	Low landings	1.06	1.09	1.09	1.08	1.07	1.06	1.05	1.05	1.04	1.04	1.03
11	LowM	0.80	0.83	0.83	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.92
12	HighM	1.65	1.70	1.72	1.65	1.57	1.50	1.44	1.39	1.34	1.30	1.26
15	Equal Weighting	1.26	1.32	1.34	1.31	1.29	1.26	1.24	1.22	1.19	1.17	1.15

		Yield ($F_{SPR30\%}$)										
Run	Name	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	Base	192	324	417	413	408	404	400	396	393	390	387
8	Steepness= 0.7	192	324	331	327	324	321	318	315	313	310	308
10	Low landings	192	324	359	353	349	345	341	338	335	333	331
11	LowM	192	324	274	278	282	285	289	292	296	298	301
12	HighM	192	324	791	754	719	688	659	634	611	592	574
15	Equal Weighting	192	324	528	519	509	499	489	479	471	463	455

2.6 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 use of the SRA model seems appropriate in order to understand the dynamics of the stock and as an indicator of model uncertainty. However, SS3 meets the requirements for management advice and makes better use of all the available data (i.e. includes the length and age data).

Uncertainty in the assessment was characterised in two ways. Major sources of uncertainty, particularly errors associated with model structure and fixed parameters, were assessed through sensitivity analyses. Within model errors (observation and process errors) were estimated using MCMC over the likelihood function.

The SS3 model was run with more than 15 different configurations, including scoping runs for key parameters. This gave a good overview of the uncertainties in the data, population dynamic parameters and the various values being estimated. The RP requested an additional run (Run 15) where the CPUE indices got a higher weight and the age and length data a lower weight in order to balance the importance of these input data or observations in the model.

Three other run configurations were requested by the RP to improve understanding of the model and determine the reliability of the model fit. These were alternate removals of the age and length data from the Eastern and Western areas, and fitting an alternative Ricker stock-recruitment relationship. While the results are of interest, they are not recommended by the RP to use for management advice.

In the Base model, a ‘natural’ weighting was applied between the different sources of information. This natural weight arises from standard likelihoods used for the data. Justification for the alternative weighting sensitivity runs rests on the potential incompatibility between the likelihoods used for the length and age composition data, and the abundance indices. The likelihoods for the compositions are based on the multinomial, whereas a lognormal is used for the abundance indices, where the scale parameter for the lognormal are obtained from the observations through the standardisation. Standardisation is carried out using generalised linear models, which also have an assumed likelihood. It is possible that the scaling factor for this likelihood, represented by the standard errors on the (log) abundance indices, is not consistent with the effective variance used in the length and age likelihoods.

The RP recommended three sensitivity runs be taken forward for MCMC analysis which would characterise the broad range of uncertainty in estimated values. Further MCMC runs can be added to this analysis. The RP identified a further three candidate runs which would extend this range of uncertainty if required. The RP agreed that these gave the most appropriate representation of the stock dynamics and its uncertainties.

MCMC convergence for the relevant variables of interest was obtained, showing that simulation converged for the base model, but the Low M and Alternative Weighting fits both failed some tests on some output variables. This indicates that the MCMC simulations should be run for longer, although slow convergence may also suggest the models do not fit the data so well, and therefore the likelihood shape is difficult for the MCMC procedure to map. However, given that the majority of variables pass the diagnostic tests, the model output is probably adequate for characterizing the uncertainty for management advice, even if quantitative estimates of uncertainty (e.g. confidence intervals, variance) might still be improved.

It was unclear how a number of sensitivity model MCMC runs could be combined into a single assessment. There is no standard way to combine uncertainty over models. It can be assumed, however, that MCMC are random independent draws from separate underlying probability density functions which represent the uncertainty for each model (i.e. sensitivity run). These MCMC sets can be combined if each model is assumed equally likely and mutually exclusive. This should be assumed by default. If some sensitivity runs are considered more likely, a weight can be applied to each MCMC set in proportion to this probability. In this case, if the MCMC are to be combined to calculate the decision rule, the RP agreed that the three models proposed should be considered equally likely.

2.7 Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations.

The RP found that stock assessment results were clearly presented in the stock assessment report and that reported results are consistent with the RP recommendations. This includes the RP recommendations for the stochastic projections which should form the basis for the harvest control rules. The input for the ABC(P*) table was still worked on by the assessment analysts when the RP finalised the present report so the RP has not seen this table.

2.8 *Evaluate the SEDAR Process as applied to the reviewed assessments and identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops.*

The SEDAR benchmark process was applied to yellowedge grouper and the process was adequately followed. The major difficulties in the process centered around two basic problems. First, this is a data-poor assessment and second, the model used was the relatively complex Stock Synthesis Model. This was the first application of the Stock Synthesis Model to a Gulf of Mexico population and the combination of data limitations and model complexity made model output interpretations difficult.

The Data Workshop addressed all the terms of reference appropriately. This species is limited to deep water with little indication of upstream populations. It was also assumed the Gulf populations were independent of those found on the Atlantic east coast of the US.

The abundance indices available were thoroughly evaluated through the modeling processes. The combined availability of fishery dependent and fishery independent indices was good. However, one point of concern is how to balance the relative influences of the CPUE indices and the age/length compositions when they apparently impart differing or contradicting signals. It would be useful for the DW ToR to include providing specific guidance on data quality to help the assessment and review workshops decide among conflicting information sources.

The Assessment Workshop addressed all the terms of reference appropriately, including adjustments recommended by the RP. The OFL yield streams and recommended ABCs were not provided to the workshop (AW ToR 6), but required decisions from the RP to be completed. Also, past management actions were only partially evaluated (AW ToR 10), because full management objectives have not been formulated. ToR 11 required research recommendations, but none were added to the Data Workshop recommendations. This should be made clear in the AW report.

A major element of the assessment relating to projections had not been undertaken at the time of the Review Workshop. This partly reflects the need to review the estimates of historical stock size and trends before conducting the projections. However, it became clear after the review workshop that the method used for projections had not been fully developed and tested. The assessment analysts encountered difficulties in running the MCMC analyses and the Review Panel was not able to subject the results to thorough review by correspondence over a month beyond the actual Review Workshop. In the future consideration should be given to ensuring that even if final projection runs cannot be anticipated before the Review Workshop, the relevant methodology and software is fully tested with illustrative exploratory runs so that the Review Panel is better placed to review the final results.

2.9 *Consider the research recommendations provided by the Data and Assessment Workshops and make any additional recommendations or prioritizations warranted. Clearly denote research and monitoring needs that could improve the reliability of future assessments. Recommend an*

appropriate interval for the next assessment, and whether a benchmark or update assessment is warranted.

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

Based on the observations made during the review, the RP suggested priority might be determined for the following research topics:

1. Research to improve abundance indices and their development from fishery-dependent and fishery-independent data sources would appear to have relatively high priority as they would have a great impact on the assessment. Topics could include, but not be limited to:
   - Improve precision in fishery-independent survey abundance indices by increasing the number of samples, including expansion into deeper water.
   - Improve precision in fishery-independent survey abundance indices by expanding observer coverage to at least 5% of the area to provide additional accurate information adequate to construct indices of abundance. Observer data should provide finer spatial resolution, a more accurate measure of CPUE, size frequency and discard information that is currently unavailable in the self-reported dataset. Current observer coverage is inadequate for this purpose.
   - Improve fishery-independent survey abundance indices by using logbooks to collect data on a set-by-set basis rather than per trip. This would allow for a much more accurate calculation of CPUE.
   - Re-examination of the standardisation of CPUE indices, both the models and the covariates (habitat, sediment, depth etc.).
2. For yellowedge grouper, ageing could be improved. There are historical otoliths collected off Florida during 1982-1983 which could be used if partitioned between species (e.g. using discriminant anaysis). More age data might become available if the relationship between age and otolith weight could be developed. This could have a significant impact the stock assessment.
3. Research to improve stock definition and structure. For the stock assessment, the biggest impact of this sort of research is on the way data are broken down into areas to try to improve coherence within sub-sets of data. This suggests that priority for this sort of research should depend upon demonstrating that the data can support alternative stock structures and that there would be greater coherence within these subsets of data. There were no apparent cohorts identifiable in the age composition data from the two areas used in this assessment, but insufficient data to support break down into three areas. Improving the basic data through, for example, re-examination of the sampling design for size and age composition from the commercial fishery might have higher priority.

4. Research on life history is high priority, but should first and foremost be reflected in data collection before assessment model structure. While model structure might be seen as improved in representing real biological processes, such as protogynous hermaphroditism, unless there is sufficient monitoring and other data, the model will effectively be unable to incorporate the process in the assessment. One of the research recommendations which could prove important is to determine a more appropriate way to model spawning stock size for protogynous species.

In addition to research identified in the DW and AW, the RP recommends further work on the stock assessment modelling. The RP found results depended on how different sources of information were weighted, and alternative weighting schemes could be considered in developing future stock assessments. The age and length composition likelihood models appear appropriate, so research may be more focused on the abundance index standardisation and ensuring their likelihood model and scale parameters are compatible with the age and length composition likelihood.

The RP also suggested some additional methods which would improve the absolute stock size estimate. These methods would help determine the shape of the selection curve, the value of M, and therefore would improve the MSY estimation. Even though M has been reasonably well estimated, the assessment is still very uncertain, because F and M are low, so further improvements in the estimate of M would be beneficial. Absolute stock estimates might be obtained from 1) underwater video surveys to count fish burrows; 2) deep water tagging, as done for redfish in the Irminger Sea; or 3) depletion fishing experiments within a small area (e.g. 1 x 1 km) combined with NMFS survey type long line fishing to estimate survey catchability, like that done in the REX project for cod and other species in the north-eastern North Sea.

The next assessment should be conducted within 2 years. Given the problems with the assessment and methods for this stock which were not available for full review, the next assessment should be a benchmark assessment.

2.10 Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks to be completed following the workshop.

This report is the peer review summary.

The following tasks were required on completion of the review panel workshop, the results of which are reflected in this report. These tasks complete the assessment panel's terms of reference:

1. Conduct deterministic projections of biomass, stock status and estimate benchmarks and management parameters for 6 runs identified in this report. This was completed.
2. Conduct MCMC analyses for three runs identified in this report. These can be used for probabilistic projections and benchmarks, and the ABC based on the overfishing probability harvest control rule (P*). Due to problems and time consuming nature of the MCMC simulations, this was not completed before the RP completed its report.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 22

Gulf of Mexico Yellowedge Grouper

Section VI: Addenda and Post-Review Updates

May 2011

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

SEDAR 22 Yellowedge grouper Review Workshop Addendum

May 10, 2011

Addendum executive summary

This addendum documents the additional model runs, analyses and the MCMC projections used to obtain probability distributions around the overfishing limit (OFL). Since the assessment workshop the critical changes include: 1) use of 'F relative' as the fishing mortality proxy, 2) addition of a model run (Increased weight on the indices) , 3) slight modification to the bottom longline standard error and 4) Markov chain Monte Carlo runs for three model runs (BASE, LowM and Increased weight on the indices). The latter model run was requested by the RP to attempt to fit the increasing trend in the indices by increasing the weighting on the indices.

Regarding the overall assessment, several key pieces of information lend credibility to this assessment and several limit some our level of inference. The key information is the large body of age composition data from the late-1970s during the initiation of the fishery which give us an unprecedented view of a near-virgin age composition and natural mortality based upon early catch curves. The second key piece of information is the extremely high reconstructed landings from the early 1980s. Neither of these were available at the time of the 2002 stock assessment and their addition give us a much better view of the response of the population to the high levels of removals in the early 1980s. Nonetheless there is limited evidence of recruitment signals in the age and length composition, a very poor fit to the CPUE indices and no information on recent recruitment from either indices or age and length composition as the fish do not enter the fishery until age 8 or later. Thus we have limited information to determine a stock-recruitment relationship and will have uncertainty in current stock status as the model sees little data on recruitments within the past 10 years.

The most critical assumptions to the assessment are: 1) the early landings time series, of which an alternative (and lower) time series was constructed but not chosen for MCMC evaluation by the RP and 2) the proxy for spawning stock biomass (SSB is currently both males and females combined). The two landings time series produce very similar stock status projections but scale the absolute level of landings and hence the absolute level of OFL. Considering a proxy that includes only female biomass would result in a more optimistic stock status because of a lower absolute SSB, but is problematic because of the poorly estimated hermaphroditic transition parameters.

While there appears to be substantial uncertainty in the actual stock status there is much less model uncertainty in the long-term productivity of the stock (Figure 19). The uncertainty in stock status between the three models recommended by the RP (Base SSB/MSST=1.2, LowM SSB/MSST=0.95 and Fit Ind SSB/MSST=1.4, Tables 16-18) results in short term yield recommendations that vary by plus or minus 25% around the Base model, depending on whether SSB needs to be built up or reduced (Tables 13-15, Figure 19). However, the three models all converge to long-term yields at $F_{SPR30\%}$ that are plus or minus 8% of the BASE model (Figure 19).

1. Post-review workshop changes

1.1. Change to NMFS bottom longline standard error.

After the RW, it was determined that the standard errors input for the NMFS bottom longline index were initially input as the CV on the normal scale, rather than the log scale standard error (log scale SE= sqrt(log_e(1+CV^2)). Some of the resulting SEs were slightly lower than the input CVs but otherwise showed very little difference. The BASE model was re-run and showed less than a 1% difference in all resulting estimated quantities. All post RW model runs, projections and MCMC results use the corrected log scale SE. Changing from SS version 3.10 to 3.20 had very little impact (green and blue lines, Figures 1.11 A-C) upon the resulting estimated quantities. Estimated parameters, likelihoods and derived quantities for models ran with SS3 version 3.20e and with the change to the NMFS bottom longline standard error are shown in tables 1.1-1.3.

1.2. Change to version SS3 3.20e
After the RW, SS3 version 3.20e, which has some enhanced projection capabilities necessary for management advice, became available. It was desired to transition to the new version. The BASE model was re-run with the SS3 version 3.20e which resulted in a less than 0.5% difference in almost all estimated quantities (red and blue lines on Figures 11 A-C). Subsequently an additional version of SS was recompiled on 4.22.11 to output the necessary relative fishing mortality rates.

However, the dual change to version 3.20e and changing the standard error on the NMFS bottom longline index did have a detectable change resulting in higher estimates of SSB, recruitment and lower exploitation rate with concomitant changes in benchmark quantities (purple line on Figures 11 A-C). These changes are likely due to improvements made to the software between SS version 3.10 and 3.20. All post-RW model runs, projections and MCMC results use SS3 version 3.20e and the important model runs and additional requested model runs were re-run with version 3.20e and with the corrected CV on the NMFS bottom longline. The major result of this change is that F_2009/Fstd_SPR30% for the BASE model changes from 1.03 to 0.970 indicating a change in fishing status (Table 3).

1.3. Change to relative F
To be consistent with the SEDAR 22 tilefish assessment, it was decided to use a reference F relative to Fcurrent as a proxy for the Gulfwide fishing mortality. This relative F reference point is calculated from the F multiplier that SS estimates to obtain the reference F (e.g., Fspr30%). The CATCHEM model used in the SEDAR 7 Gulf of

Mexico red snapper assessment and in the 2009 Gulf of Mexico red snapper assessment update estimates a similar F multiplier for reference point calculations. NOTE that F relative > 1 means that overfishing is NOT occurring and that current F can be increased to reach F_{MSY}.

2. Additional Model Runs

2.1. Review workshop model runs. During the review workshop several additional model runs were requested by the RP. These model runs were as follows:

a) Eastern age and length composition removed
b) Western age and length composition removed
c) Model run with Ricker stock recruitment relationship
d) Increased weighting on indices and reduced weighting on the age composition

a,b) Model runs with Eastern age and length composition removed and then Western removed.

These model runs had the Eastern region age and length composition inputs removed by adding a negative value to the year in the data input. This removes the influence of the corresponding age or length observations for the year. The purpose of this was to determine whether the regions were giving conflicting signals of recruitment. For recruitment deviations, removing the West resulted in less change from the BASE model than removing the East age composition (Figure 1.1). With only the West age and length composition, the recruitment deviations showed a single time period of high recruitment in the mid-1980s, and no evidence of the high 1993 year class. Absolute recruitment levels and virgin biomass levels were also substantially higher for the model with the East age composition removed (Figure 1.2,1.3). Removing the East age composition removed much of the early age composition which provided the contrast between early and recent age structure. Without this contrast in age structure, the model estimates a much higher total biomass and estimates that the population is extremely lightly fished, even with the high early landings. Removing the West had less of an impact but did result in some divergent deviation estimates from the BASE model, notably in 1988 and again in 1997 where the BASE model and the Remove West model diverge substantially. This is indicative of some conflicting signals in the East and West age composition data. In summary, it appears that removing the age and length composition from the East produced very divergent results, whereas removing the West had far less strange results.

c) Model run with Ricker stock recruitment relationship. This model run was the same as the BASE model but with a Ricker stock recruitment relationship estimated. This model run produced poorer fits to the CPUE indices (Figure 1.6) and decreasing trends in recruitment over the entire time series (Figure 1.7).

d) The final set of additional model runs involved increasing the weighting on the indices and decreasing the weight on the age and length composition. This was done by reducing the weight (lambdas) on the age and length composition likelihoods by a factor of 0.5 and increasing the lambda on the indices by 2. This did not substantively change the fits to the indices so the lambdas were changed to 0.2 and 5, resulting in a 10-fold relative increase in the weight of the indices over the age and length composition data. Results for this final weighting scheme are presented and show a better fit to the CPUE indices with all fits showing a substantial increase in recent years (Figure 1.8). The estimated recruitment relationship shows an unrealistic trend with positive deviations only observed for the years 1989-1999 with a strong peak of recruits during the years 1991-1997 (Figure 1.9). Trends in spawning stock biomass (Figure 1.10) differ from the BASE model in that they show an increase in recent years commensurate with the fits to the indices.

3. Projections

3.1. Projection Methods

Six model runs were chosen for deterministic projections at Fcurrent, FMSY, FSPR20%, FSPR30%, Fspr40%, 75% of FSPR30% and 75% of FSPR40%. Originally these projections were run at the review workshop. With the change in the NMFS bottom longline standard error and the change to SS3 version 3.20e these projection results were re-run and are shown in this document. Future recruitment levels are estimated as random deviations from the spawner recruit curve. Projections begin in 2010 and run through 2029.

F current was the average F between 2007 and 2009 to be consistent with decisions made for Gulf of Mexico tilefish. Future selectivities were taken to be the average selectivity for the latest three years. Projections at 75% of FSPR values were conducted by changing the control rule buffer in the Forecast.ss file to 0.75. For years 2010 and 2011 landings were obtained from the Quota Monitoring System at the Southeast Regional Office (http://sero.nmfs.noaa.gov/quotas/quotas.htm). For 2010, landings of deepwater groupers 59.4% or 605,880 lbs of the total quota of 1.02 million gutted pounds had been caught as of 12/31/10. Of the deepwater grouper complex, yellowedge were assumed to represent 70% of the deepwater grouper complex so it was assumed that 424,116 lbs of YEG were caught in 2010. These were split according to a three year average allocation of landings between the fleets and regions. For 2011, it was assumed that the total quota would be caught representing 70% (714,000 lbs) of the 1.02 mp deepwater grouper complex. These were partitioned by fleet East and West (Tables 1.1 and 1.2) for both the high and low landings scenarios. The difference between these scenarios was only that for the low scenarios, YEG in stat area 7 were removed.

3.2. Projection Results

Deterministic projection results are shown in Figure 13 and Tables 5-7.

4. Uncertainty Estimates

The RP selected three model runs for full Markov chain Monte Carlo (MCMC) development to quantify uncertainty in parameter estimates and derived quantities (Base model, LowM and the model with increased weighting on the indices).

4.1. MCMC Methods

One million MCMC runs were conducted for each model. The runs were initially subsampled at a rate of 1/500, then the first 10 were removed as a burn-in and then further subsampled at a rate of ½. This gave 995 MCMC runs which were subjected to a further burn-off of 95 of these runs, giving a total burn-in of the first 100,000 runs and a total of 900 remaining MCMCs. This burn-in period was determined based upon visual inspection of the chains with only 5000 samples burned off and by use of the diagnostic tests described below.

For the increased fit to the indices run, it was necessary to reduce the minimum value for the commercial longline selectivity parameter 2 from 10 to 8 as the MCMCs tended to hit a minimum bound which substantially degraded performance.

MCMC runs were visually examined by inspecting the plots of the chains and the cumulative means of the posterior values for all estimated parameters and derived quantities. Only selected management benchmarks and key estimated parameters are shown in figures 1.15-1.17 for the three runs. Two diagnostic tests for convergence were performed with the *CODA* library for R. The first tests the equality of means of two subsets of the MCMC runs (Geweke 1992) taking into account autocorrelation in the estimate of the standard errors. We used the CODA default first 10% and the last 50% of the chain. A rejection of the null hypothesis indicates that the two means are different and hence the chain is unlikely to have converged on a stable estimate. A p-value less than 0.025 indicates rejection of the null hypothesis as this is a two-sided test.

The second diagnostic tests whether enough samples have been taken to estimate the mean with a certain level of precision (Heidelberger and Welch 1981, 1983). The test proceeds in two parts; the first part tests the null hypothesis that the sampled values come from a stationary distribution using the Cramer-von-Mises statistic. The test is applied to the whole chain, and, if the null hypothesis is rejected then to subsets of the data obtained by successively discarding the first 10%, 20% and up to 50% of the chain. If, at this point, the null hypothesis is still rejected, the chain is deemed to have failed the test and is likely to be non-stationary. For this test we use a p-value for rejection of the null hypothesis of 0.05. The second part examines whether the mean has been estimated to a certain level of precision. It proceeds by calculating a 95% confidence interval for the mean, using the subset of the chain which passed the previous stationarity test. Half the width of this interval is then compared with the estimate of the mean. If the ratio of the half-width divided by the mean is lower than a chosen value of precision (here we used the default value of 0.1) the half-width test is passed. If the test fails then the chain length may not be sufficient to estimate the mean with desired level of precision. The effective sample size is also shown on the plots.

4.2. MCMC Diagnostics

Plots of the MCMC chains and cumulative means for 20 key estimated or derived quantities are shown in figures 13-15 and appendices A-C. MCMC plots for all estimated parameters and derived quantities are shown in appendix figures A1-C5. Maximum likelihood estimates of parameters are shown as blue lines on the figures and the cumulative MCMC mean is shown as a red line. The MLE and the cumulative mean of the MCMCs are provided as well as output from each diagnostic test.

The Base model passed all MCMC diagnostic tests for the (Table 10). Significant values ($p<0.025$) for Geweke's statistic indicate that for the Low M run the MCMCs failed the test for SSBmsy (Table 11). For the increased fit to the indices run SPB_2009, SSBmsy, forecasted Catch in 2012 and 2013 all failed the Geweke test which indicated a significant difference between the mean of the first 10% and the last 50% (Table 12). For the Low M model, all three hermaphroditism parameters failed the Heidelberger and Welch tests for stationarity and for precision of the mean (Table 11).

Overall, the hermaphroditism parameters appeared very poorly estimated which was reflected both in the poor convergence statistics, low effective sample size and divergence between the MLE and the mean of the MCMCs. As spawning stock biomass of both males and females is used as the SSB proxy, these parameters have very little bearing on assessment results.

5. Projection results and management advice

Summary statistics for key quantities obtained from the MCMC posterior values are shown in Tables 13-15 and histograms are shown in Figures 16-18. For these figures and tables, biomass values have been converted into gutted pounds. For comparison the maximum likelihood estimates (MLE) and standard deviations are also shown in the tables. The MCMC means and medians were quite similar so the means are presented. In most situations the MCMC standard deviations are higher than those based upon asymptotic theory by inverting the Hessian matrix. In general the MCMC mean and the MLE estimates show some divergence. Also the MCMC means are

SFA and MSRA Management tables

SFA and MSRA evaluations using SPR 20%, SPR 30% and SPR 40% reference points for Gulf of Mexico yellowedge grouper base, low M and increased weight on the indices models are shown in tables 16-18. Values in the model represent means of MCMC posterior distributions. For all management tables 2010 and 2011 landings are input as known quantities so that all projections are conditional on these values. Spawning biomass units and yield units are million pounds gutted weight.

The Base model was overfished only in at SPR40% and the low M model was overfished at both SPR30% and SPR40%. At no SPR levels was the increase weight on the indices model overfished. Overfishing ($F_{CURRENT}$/MFMT) was occurring in these same models and also in the increased fit to the indices model at SPR40%. Note that the Fcurrent values of '1' are due to the use of the relative F as the measure of fishing mortality. Hence MFMT and other fishing mortality proxies are shown relative to the current F, so that($F_{CURRENT}$/MFMT) <=1 indicates not overfishing.

For the model runs which indicate overfished status (SSB_{2009}<MSST) the time to rebuild was determined by projection the population forward in time with no fishing mortality. In all cases Tmax was 10 years and Tmin ranged from 1 (rebuilt in 2010) to 6 years. This time was counted as the number of years since 2009 that it took for the MCMC posterior mean SSB/MSST > 1.

Probability tables for management advice

To construct probability tables which give probabilities that a given TAC will produce $F<F_{MSY}$ (or the proxy which is the fishing mortality rate that gives a *to be determined* level of SPR) each of three SS3 assessment models were projected at three proxies for F_{MSY} ($F_{SPR20\%}$, $F_{SPR30\%,}$ and $F_{SPR40\%}$). The TAC values were tabulated and the cumulative frequency of TAC levels gives a probability distribution around the overfishing limit (OFL) (Tables 19-21). This approach is similar to the P-star approach of Shertzer et al. (2008) except that the catch associated with a given probability of exceeding OFL is based on the assumption that fishing at the given F_{SPR} level occurred in the previous years. For short term projections, the differences in catches produced by the two approaches should be slight.

Literature cited

Geweke, J. 1992. Evaluating the accuracy of sampling-based approaches to calculating posterior moments. *In* Bayesian Statistics 4 (ed JM Bernado, JO Berger, AP Dawid and AFM Smith). Clarendon Press, Oxford, UK.

Heidelberger P and Welch PD. 1981. A spectral method for confidence interval generation and run length control in simulations. Comm. ACM. 24, 233-245.

Heidelberger P and Welch PD. 1983. Simulation run length control in the presence of an initial transient. Operation Research., 31, 1109-44.

Shertzer, K., M. Prager, and E. Williams. 2008. A probability-based approach to setting annual catch levels. Fish. Bull. 106: 225-232.

Table 1. Input and estimated parameters for re-run base model and sensitivity runs as well as additional model runs from RW.

Lab	Base YEG	LowM	IndFit	LowStp0 .7	HighM	Low Land	Ricker SRR	Rem_ E	Rem_ W
NatM_p_1_Fem_GP_1	0.073	0.055	0.073	0.073	0.09	0.073	0.073	0.073	0.073
L_at_Amin_Fem_GP_1	5	5	5	5	5	5	5	5	5
L_at_Amax_Fem_GP_1	91.416	89.2978	90.2902	91.1727	93.4036	90.0554	90.6717	120	88.4648
VonBert_K_Fem_GP_1	0.0768	0.08033	0.07845	0.077265	0.07331	0.07859	0.07847	0.02988	0.084045
CV_young_Fem_GP_1	0.1626	0.1626	0.1626	0.1626	0.1626	0.1626	0.1626	0.1626	0.1626
CV_old_Fem_GP_1	0.1165	0.1165	0.1165	0.1165	0.1165	0.1165	0.1165	0.1165	0.1165
NatM_p_1_Fem_GP_2	0.073	0.055	0.073	0.073	0.090	0.073	0.073	0.073	0.073
L_at_Amin_Fem_GP_2	5	5	5	5	5	5	5	5	5
L_at_Amax_Fem_GP_2	91.884	89.001	91.831	91.550	94.249	91.841	90.687	82.581	83.213
VonBert_K_Fem_GP_2	0.086	0.091	0.085	0.087	0.082	0.087	0.089	0.122	0.150
CV_young_Fem_GP_2	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163
CV_old_Fem_GP_2	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117
NatM_p_1_Mal_GP_1	0.073	0.073	0.073	0.073	0.090	0.073	0.073	0.073	0.073
L_at_Amin_Mal_GP_1	5	5	5	5	5	5	5	5	5
L_at_Amax_Mal_GP_1	90.728	90.458	87.695	90.501	92.054	89.776	90.281	70.000	107.389
VonBert_K_Mal_GP_1	0.095	0.095	0.113	0.096	0.090	0.099	0.097	0.150	0.065
CV_young_Mal_GP_1	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163
CV_old_Mal_GP_1	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117
NatM_p_1_Mal_GP_2	0.073	0.073	0.073	0.073	0.090	0.073	0.073	0.073	0.073
L_at_Amin_Mal_GP_2	5	5	5	5	5	5	5	5	5
L_at_Amax_Mal_GP_2	89.236	89.145	90.203	89.080	90.922	89.461	89.077	93.510	90.969
VonBert_K_Mal_GP_2	0.108	0.109	0.100	0.109	0.097	0.107	0.110	0.094	0.101
CV_young_Mal_GP_2	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163
CV_old_Mal_GP_2	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117
Wtlen_1_Fem	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wtlen_2_Fem	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91
Mat50%_Fem	55	55	55	55	55	55	55	55	55
Mat_slope_Fem	-0.33	-0.33	-0.33	-0.33	-0.33	-0.33	-0.33	-0.33	-0.33
Eggs_scalar_Fem	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Eggs_exp_len_Fem	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91
Wtlen_1_Mal	2.1E-05	2.1E-05	2.1E-05	2.11E-05	2.11E-05	2.11E-05	2.11E-05	2.11E-05	2.11E-05
Wtlen_2_Mal	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91
Herm_Infl_age	16.182	17.569	18.404	16.219	20.115	16.112	16.202	23.422	20.560
Herm_stdev	8.779	9.095	9.727	8.912	10.154	8.918	9.253	20.000	7.507
Herm_asymptote	0.068	0.088	0.081	0.068	0.099	0.067	0.067	0.040	0.123
RecrDist_Area_1	1.685	1.702	1.732	1.688	1.666	1.466	1.697	4.000	1.850
RecrDist_Area_2	1	1	1	1	1	1	1	1	1
SR_R0	6.758	6.064	6.813	6.768	7.550	6.618	6.785	8.981	6.687
SR_steep	0.947	0.968	0.964	0.700	0.903	0.956	0.990	0.753	0.927
SR_sigmaR	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Main_InitAge_8	-0.341	-0.504	-0.265	-0.396	-0.186	-0.505	-0.465	-0.268	-0.358
Main_InitAge_7	-0.322	-0.449	-0.259	-0.372	-0.211	-0.467	-0.437	-0.256	-0.325
Main_InitAge_6	-0.273	-0.363	-0.245	-0.320	-0.206	-0.401	-0.381	-0.233	-0.267

Main_InitAge_5	-0.208	-0.259	-0.226	-0.250	-0.184	-0.318	-0.307	-0.200	-0.195
Main_InitAge_4	-0.133	-0.149	-0.203	-0.173	-0.151	-0.227	-0.227	-0.158	-0.121
Main_InitAge_3	-0.063	-0.058	-0.182	-0.100	-0.116	-0.142	-0.154	-0.097	-0.082
Main_InitAge_2	-0.004	0.015	-0.163	-0.038	-0.090	-0.063	-0.088	-0.037	-0.070
Main_InitAge_1	-0.002	0.033	-0.153	-0.030	-0.108	-0.031	-0.068	0.001	-0.066
Main_RecrDev_1975	0.009	0.086	-0.141	-0.014	-0.112	0.018	-0.041	0.026	-0.021
Main_RecrDev_1976	-0.012	0.073	-0.130	-0.038	-0.122	0.019	-0.071	-0.011	0.000
Main_RecrDev_1977	0.011	0.113	-0.112	-0.020	-0.094	0.059	-0.065	-0.057	0.009
Main_RecrDev_1978	0.028	0.118	-0.094	-0.008	-0.070	0.078	-0.066	-0.074	-0.031
Main_RecrDev_1979	0.068	0.164	-0.079	0.030	-0.034	0.128	-0.037	-0.029	-0.088
Main_RecrDev_1980	0.008	0.044	-0.086	-0.031	-0.066	0.061	-0.107	-0.055	-0.108
Main_RecrDev_1981	0.036	0.111	-0.092	0.006	-0.042	0.137	-0.059	0.021	-0.120
Main_RecrDev_1982	-0.047	0.002	-0.110	-0.069	-0.095	0.036	-0.122	0.129	-0.096
Main_RecrDev_1983	-0.079	-0.049	-0.105	-0.097	-0.104	-0.025	-0.143	0.352	0.110
Main_RecrDev_1984	0.000	-0.012	-0.061	-0.013	-0.005	0.021	-0.066	0.218	0.513
Main_RecrDev_1985	0.287	0.461	0.005	0.323	0.205	0.422	0.341	0.231	0.151
Main_RecrDev_1986	0.138	0.156	0.002	0.181	0.093	0.211	0.242	0.405	0.219
Main_RecrDev_1987	-0.089	-0.096	-0.038	-0.052	-0.086	-0.045	-0.002	0.263	0.175
Main_RecrDev_1988	-0.104	-0.092	-0.035	-0.051	-0.101	-0.047	0.031	0.083	0.305
Main_RecrDev_1989	-0.052	-0.020	0.005	0.014	-0.055	0.018	0.126	-0.074	0.085
Main_RecrDev_1990	-0.139	-0.158	0.052	-0.089	-0.111	-0.111	-0.006	-0.104	-0.177
Main_RecrDev_1991	0.138	0.149	0.200	0.201	0.157	0.183	0.287	-0.075	0.174
Main_RecrDev_1992	0.199	0.051	0.340	0.206	0.274	0.147	0.098	-0.071	0.151
Main_RecrDev_1993	0.602	0.776	0.508	0.744	0.552	0.743	1.093	-0.034	0.246
Main_RecrDev_1994	0.181	0.045	0.442	0.189	0.266	0.112	0.106	-0.050	0.122
Main_RecrDev_1995	-0.085	-0.175	0.306	-0.069	0.017	-0.131	-0.057	-0.024	-0.033
Main_RecrDev_1996	0.065	-0.008	0.310	0.089	0.148	0.033	0.112	-0.009	-0.060
Main_RecrDev_1997	0.335	0.415	0.313	0.406	0.343	0.377	0.612	0.052	-0.154
Main_RecrDev_1998	0.082	0.010	0.201	0.084	0.181	0.040	0.087	0.066	-0.005
Main_RecrDev_1999	0.009	-0.066	0.105	0.009	0.171	-0.030	0.055	0.039	0.036
Main_RecrDev_2000	-0.241	-0.366	-0.011	-0.254	-0.059	-0.302	-0.223	0.028	0.077

Table 2. Negative log likelihood components and weighting factors (λ) for re-run base, sensitivity and RW runs. (Lower values equal better fit). Higher values for λ indicated increased weighting in the likelihood and vice-versa.

	label	TOTAL	Catch	Survey	Length comp	Age comp	Recruitment	Parm priors	Parm soft bounds
	value	13428.4	0	-24.56	4155	9323.2	-29.77	4.27	0
BaseYEG	λ	1	1	1	1	1	1	1	1
	value	13509.4	0	-17.3	4214.2	9325.7	-19.07	5.51	0
LowM	λ	1	1	1	1	1	1	1	1
	value	2517.3	0	-170.5	843.07	1865.7	-26.33	5.17	0
IndFit	λ	1	1	5	0.2	0.2	1	1	1
	value	13441.6	0	-15.76	4151.1	9328.8	-24.35	1.64	0
LowStp0.7	λ	1	1	1	1	1	1	1	1
	value	13394.1	0	-30.45	4153.1	9299.4	-31.2	3.02	0
HighM	λ	1	1	1	1	1	1	1	1
	value	13444	0	-8.66	4140.4	9326.8	-19.55	4.71	0
LowLand	λ	1	1	1	1	1	1	1	1
	value	13474.2	0	4.27	4133.8	9344.5	-9.96	1.63	0.01
RickerRun	λ	1	1	1	1	1	1	1	1
	value	2786.66	0	-24.65	1895.2	948.67	-34.21	1.64	0.02
Rem_E	λ	1	1	1	1	1	1	1	1
	value	5817.59	0	-17.01	1976.9	3884.9	-30.63	3.45	0.01
Rem_W	λ	1	1	1	1	1	1	1	1

Table 3. Derived quantities and benchmarks for base and sensitivity runs. Original models presented at the review workshop are provided for reference. Re-run models use SS3 V3.20E and correct SE for NMFS longline. SSReference points and benchmarks from sensitivity runs for Gulf of Mexico tilefish. Benchmarks are reported for four reference points : 1) SPR40%. 2) SPR30%, 3) SSB at MSST which (1-M)*$SSB_{SPR40\%}$ and 4) SSB_{MSY}.

	Original models					Re-run models, with SS3 V3.20E and correct SE for NMFS longline				
estimate/ benchmark	YEG BASE	LowM (DW report values incorrect)	HighM	Low Stp0.7	low Land-ing	YEG BASE	LowM	HighM	Low Stp0.7	low Land-ing
TotBio_Unfished	15120	14748	17235	15673	13165	15510.6	14541	17161.3	15674.3	13539.3
SPB_Virgin	13423	13606	14653	13923	11686	13783.4	13232.7	14591.9	13923.6	12017.8
Recr_Virgin	831	374	1903	869	716	861.061	430.032	1901.44	869.217	748.652
SSB_B40%virgin	5369	5442	5861	5569	4674	5513.35	5293.07	5836.75	5569.43	4807.13
SSB_SPR40%	5270	not run	not run	4567	4600	5396.72	5226.69	5594.22	4566.93	4724.12
SSB_SPR30%	3911	4013	4113	3007	3449	3998.95	3892.36	4094.6	3007.49	3508.51
SSB_SPR20%						2601.17	2558.03	2594.99	1448.05	2292.89
MSST_SPR30%	3625	3720	3813	2788	3197	3707.03	3608.22	3795.69	2787.94	3252.39
SSB_MSY	2401	2507	2868	4072	2012	2535.97	2563.17	2859.45	4069.86	2110.77
SPB_2009	4026	2806	6755	3606	3486	4351.42	3160.18	6663.98	3610.01	3757.36
SSB/B40%virgin	0.750	0.516	1.152	0.647	0.746	0.7893	0.5970	1.1417	0.6482	0.7816
SSB/SPR40%	0.764	not run	not run	0.790	0.758	0.806	0.605	1.191	0.790	0.795
SSB/SPR30%	1.030	0.699	1.642	1.199	1.011	1.088	0.812	1.628	1.200	1.071
SSB/SPR20%	not run	not run	not run	not run	not run	1.673	1.235	2.568	2.493	1.639
SSB/MSST_SPR30%	1.111	0.754	1.772	1.293	1.090	1.174	0.876	1.756	1.295	1.155
SSB/MSY	1.677	1.119	2.355	0.885	1.733	1.716	1.233	2.331	0.887	1.780
Fstd_40%virgin	0.0466	0.0398	0.0508	0.0388	0.0463	0.046	0.046	0.051	0.039	0.046
Fstd_SPR40%	0.0477	not run	not run	0.0477	0.0472	0.048	0.046	0.053	0.048	0.048
Fstd_SPR30%	0.0662	0.0566	0.0734	0.0662	0.0656	0.0662	0.0643	0.0734	0.0662	0.0659
Fstd_SPR20%	not run	not run	not run	not run	not run	0.0947	0.0921	0.1033	0.0947	0.0945
Fstd_MSY	0.0988	0.0859	0.0970	0.0529	0.1016	0.0964	0.0920	0.0969	0.0529	0.1003
F_2009	0.0683	0.1012	0.0410	0.0779	0.0787	0.0642	0.0886	0.0415	0.0778	0.0743
F_2009/Fstd_40%virgin	1.4664	2.5447	0.8067	2.0098	1.6997	1.382	1.945	0.817	2.008	1.599
F_2009/Fstd_SPR40%	1.4322	NA	NA	1.6333	1.6658	1.345	1.914	0.777	1.632	1.564
F_2009/Fstd_SPR30%	1.0323	1.7868	0.5589	1.1775	1.2006	0.970	1.379	0.566	1.176	1.128
F_2009/Fstd_SPR20%	not run	not run	not run	not run	not run	0.678	0.962	0.402	0.822	0.786
F_2009/Fstd_MSY	0.6912	1.1778	0.4226	1.4743	0.7744	0.666	0.964	0.428	1.472	0.741
Frelative	NA	NA	NA	NA	NA	0.938	1.430	0.492	1.141	1.048
Yield B40%virgin	323	258	416	271	279	330	296	414	271	288
Yield_SPR40%	326	NA	NA	282	281	333	298	422	282	290
Yield_SPR30%	358	285	463	275	312	365	325	460	275	319
Yield_SPR20%	not run	not run	not run	not run	not run	380.3	336.2	472.7	211.7	333.8
Yield_MSY	375	297	476	283	325	380.4	336.2	473.5	283.2	334.1

Table 4. Derived quantities and benchmarks for review workshop requested model runs. Models use SS3 V3.20E and correct SE for NMFS longline. SSReference points and benchmarks from sensitivity runs for Gulf of Mexico tilefish. Benchmarks are reported for four reference points : 1) SPR40%. 2) SPR30%, 3) SSB at MSST which (1-M)*$SSB_{SPR40\%}$ and 4) SSB_{MSY}.

	RW requested models			
estimate/ benchmark	FitInd	Ricker SRR	Remove East age and length	Remove West age and length
TotBio_Unfished	16025.3	16048.3	73452.4	19898
SPB_Virgin	14178.7	14249.6	60914.4	18092.3
Recr_Virgin	909.832	884.556	7951.35	802.165
SSB_B40%virgin	5671.46	5699.84	24365.8	7236.92
SSB_SPR40%	5590.85	not run	not run	not run
SSB_SPR30%	4159.55	1060.94	21107.4	7017.67
SSB_SPR20%	2728.25	1060.94	21107.4	7017.67
MSST_SPR30%	3855.90	983.49	19566.56	6505.38
SSB_MSY	2471.47	6470.37	16690.20	3372.19
SPB_2009	5183.62	2789.68	56042.70	7601.14
SSB/B40%virgin	0.9140	0.4894	2.3001	1.0503
SSB/SPR40%	0.927	not run	not run	not run
SSB/SPR30%	1.246	2.629	2.655	1.083
SSB/SPR20%	1.900	2.629	2.655	1.083
SSB/MSST_SPR30%	1.344	2.837	2.864	1.168
SSB/MSY	2.097	0.431	3.358	2.254
Fstd_40%virgin	0.049	0.029	0.037	0.040
Fstd_SPR40%	0.049	NA	NA	NA
Fstd_SPR30%	0.0684	0.0476	0.0424	0.0414
Fstd_SPR20%	0.0974	0.0476	0.0424	0.0414
Fstd_MSY	0.1044	0.0260	0.0519	0.0848
F_2009	0.0543	0.1037	0.0055	0.0409
F_2009/Fstd_40%virgin	1.118	3.585	0.152	1.028
F_2009/Fstd_SPR40%	1.098	not run	not run	not run
F_2009/Fstd_SPR30%	0.794	2.176	0.131	0.988
F_2009/Fstd_SPR20%	0.558	2.176	0.131	0.988
F_2009/Fstd_MSY	0.520	3.985	0.107	0.483
Frelative	0.757	4.033	0.116	1.000
Yield B40%virgin	358	201	1265	353
Yield_SPR40%	360	not run	not run	not run
Yield_SPR30%	397	65	1313	358
Yield_SPR20%	416	not run	not run	not run
Yield_MSY	417	203	1341	405

Table 5. High landings scenario. Estimated and assumed YEG landings (in gutted mt) by fleet and area. QMS is SERO quota monitoring system data.

Year	HLE	HLW	LLE	LLW	assume 70% YEG	QMS (MT)	QMS (lbs)	Quota (lbs)
2007	7.652	15.370	314.2	62.480				
2008	4.209	11.236	284.75	71.863				
2009	10.388	20.844	251.2	95.651				
3yr avg %	0.019	0.041	0.739	0.200				
2010	3.7	7.9	142.3	38.5	192.5	275.0	606223	
2011	6.3	13.4	239.5	64.8	323.9	462.7		1020000

Table 6. Low landings scenario. Estimated and assumed YEG landings (in gutted mt) by fleet and area. QMS is SERO quota monitoring system data.

year	HLE	HLW	LLE	LLW	QMS (YEG MT), assume 70% YEG	QMS (MT)	QMS landings (lbs)	Quota
2007	8.707	16.424	314.20	62.480				
2008	4.209	11.236	284.75	71.863				
2009	10.388	20.844	251.21	95.651				
3yr avg. %	0.020	0.042	0.738	0.200				
2010	3.9	8.1	142.1	38.4	192.5	275.0	606,223	1020000
2011	6.6	13.6	239.0	64.7	323.9	462.7		1020000

Table 7. Deterministic projected yields (in gutted mt) under various harvest scenarios for 6 runs. Catch for 2010 and 2011 was fixed to estimated values.

RUN	rule	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
BASE	SPR20	192	324	657	620	586	557	531	509	490	474	460
BASE	SPR30	192	324	417	413	408	404	400	396	393	390	387
BASE	SPR40	192	324	282	287	291	295	298	301	304	307	309
BASE	SPR30_75	192	324	316	319	321	324	326	328	329	331	332
BASE	SPR40_75	193	324	213	219	225	231	236	241	246	251	255
BASE	MSY	192	324	673	633	597	565	538	515	495	477	463
BASE	FCURR	192	324	319	320	322	323	325	326	327	328	328
LowStp	SPR20	192	324	520	491	465	442	422	405	390	377	366
LowStp	SPR30	192	324	331	327	324	321	318	315	313	310	308
LowStp	SPR40	192	324	224	227	231	234	237	239	242	244	246
LowStp	SPR30_75	192	324	250	253	255	257	259	260	262	263	264
LowStp	SPR40_75	193	324	169	174	179	183	188	192	196	199	203
LowStp	MSY	192	324	252	255	257	259	260	262	263	264	265
LowStp	FCURR	192	324	252	253	255	256	257	258	259	260	261
LowMOUT	SPR20	192	324	428	417	406	397	389	382	376	370	365
LowMOUT	SPR30	192	324	274	278	282	285	289	292	296	298	301
LowMOUT	SPR40	192	324	186	193	200	207	214	221	227	232	238
LowMOUT	SPR30_75	192	324	207	214	221	227	233	239	245	250	255
LowMOUT	SPR40_75	192	324	141	148	155	162	169	176	182	188	194
LowMOUT	MSY	192	324	427	416	406	397	389	381	375	370	365
LowMOUT	FCURR	192	324	208	214	220	227	232	238	243	248	253
HighM	SPR20	192	324	1,251	1,122	1,012	919	842	778	726	683	649
HighM	SPR30	192	324	791	754	719	688	659	634	611	592	574
HighM	SPR40	192	324	533	525	517	509	501	493	486	480	474
HighM	SPR30_75	192	324	601	587	573	560	547	535	524	515	506
HighM	SPR40_75	193	324	403	404	404	403	402	401	400	399	398
HighM	MSY	192	324	1,145	1,042	952	875	810	755	709	671	640
HighM	FCURR	192	324	607	590	574	558	543	530	518	507	498
lowLand	SPR20	192	324	575	534	501	472	449	429	413	400	390
lowLand	SPR30	192	324	359	353	349	345	341	338	335	333	331
lowLand	SPR40	192	324	238	242	246	250	253	256	259	262	265
lowLand	SPR30_75	192	324	272	274	276	278	280	282	284	285	287
lowLand	SPR40_75	192	324	180	186	191	197	202	207	212	216	220
lowLand	MSY	192	324	623	572	529	495	466	443	424	409	396
lowLand	FCURR	192	324	266	268	269	270	272	273	275	276	277
FitInd	SPR20	192	324	828	775	726	682	643	609	580	554	533
FitInd	SPR30	192	324	528	519	509	499	489	479	471	463	455
FitInd	SPR40	192	324	359	362	364	366	367	367	367	367	367
FitInd	SPR30_75	192	324	400	401	401	400	399	397	396	394	392
FitInd	SPR40_75	193	324	271	277	283	287	291	295	298	301	304
FitInd	MSY	192	324	909	839	777	721	673	632	597	567	542
FitInd	FCURR	192	324	409	408	407	405	402	399	397	394	392

Table 8. Deterministic projected SSB (in gutted mt) under various harvest scenarios for 6 runs. Catch for 2010 and 2011 was fixed to estimated values.

LAB	rule	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
BASE	SPR20	4352.2	4504.1	4544.3	4297.5	4075.1	3876.9	3701.7	3548.4	3415.3	3300.7	3202.5
BASE	SPR30	4352.2	4504.1	4544.3	4501.3	4458.4	4416.7	4376.9	4339.4	4304.5	4272.5	4243.3
BASE	SPR40	4352.2	4504.1	4544.3	4616.3	4683.4	4746.0	4803.9	4857.4	4906.6	4951.6	4992.8
BASE	SPR30_75	4352.2	4504.1	4544.3	4587.5	4626.6	4661.9	4693.8	4722.6	4748.5	4771.8	4792.6
BASE	SPR40_75	4352.2	4504.1	4544.3	4675.3	4801.4	4922.2	5037.0	5145.7	5247.9	5343.7	5433.0
BASE	MSY	4352.2	4504.1	4544.3	4284.0	4050.4	3842.9	3660.3	3501.1	3363.4	3245.2	3144.2
BASE	FCURR	4352.2	4504.1	4544.3	4586.1	4624.5	4660.0	4692.8	4723.0	4750.9	4776.6	4800.4
LowStp	SPR20	3548.8	3638.0	3614.8	3420.9	3246.6	3091.5	2954.4	2834.2	2729.4	2638.5	2559.9
LowStp	SPR30	3548.8	3638.0	3614.8	3581.8	3549.4	3518.2	3488.5	3460.3	3433.9	3409.2	3386.4
LowStp	SPR40	3548.8	3638.0	3614.8	3672.7	3727.4	3778.8	3826.7	3871.0	3911.5	3948.4	3982.0
LowStp	SPR30_75	3548.8	3638.0	3614.8	3650.0	3682.4	3712.3	3739.5	3764.1	3786.0	3805.5	3822.9
LowStp	SPR40_75	3548.8	3638.0	3614.7	3719.4	3820.8	3918.3	4011.4	4099.4	4182.2	4259.5	4331.6
LowStp	MSY	3548.8	3638.0	3614.8	3648.3	3679.1	3707.3	3733.0	3756.2	3776.8	3795.1	3811.2
LowStp	FCURR	3548.9	3638.0	3614.8	3649.7	3682.4	3713.0	3741.5	3767.7	3791.6	3813.4	3833.2
LowMOUT	SPR20	3122.9	3238.9	3248.0	3168.1	3095.3	3029.6	2970.6	2918.1	2871.6	2830.7	2794.9
LowMOUT	SPR30	3122.9	3238.9	3248.1	3298.8	3348.1	3395.5	3440.6	3482.9	3522.4	3558.8	3592.2
LowMOUT	SPR40	3122.9	3238.9	3248.1	3373.1	3496.8	3618.1	3735.7	3848.8	3956.6	4058.6	4154.5
LowMOUT	SPR30_75	3122.9	3238.9	3248.1	3355.4	3460.9	3563.8	3663.2	3758.1	3848.1	3932.7	4011.8
LowMOUT	SPR40_75	3122.9	3238.9	3248.0	3411.9	3576.1	3738.8	3898.8	4054.4	4204.8	4348.9	4486.3
LowMOUT	MSY	3122.9	3238.9	3248.0	3168.8	3096.6	3031.5	2973.0	2920.9	2874.7	2834.2	2798.6
LowMOUT	FCURR	3122.9	3238.9	3248.1	3355.2	3461.0	3564.4	3664.4	3760.4	3851.7	3937.8	4018.6
HighM	SPR20	6743.3	6961.2	7054.2	6346.2	5736.3	5216.9	4779.3	4414.1	4112.1	3864.3	3662.1
HighM	SPR30	6743.3	6961.2	7054.2	6736.3	6437.8	6162.1	5911.3	5686.0	5485.9	5309.7	5155.9
HighM	SPR40	6743.3	6961.2	7054.2	6955.3	6851.6	6747.2	6645.0	6547.1	6455.1	6369.7	6291.3
HighM	SPR30_75	6743.3	6961.2	7054.2	6898.1	6742.1	6590.4	6445.9	6310.8	6186.2	6072.5	5969.8
HighM	SPR40_75	6743.3	6961.2	7054.2	7066.0	7066.5	7058.8	7045.5	7028.5	7009.5	6989.4	6969.2
HighM	MSY	6743.3	6961.2	7054.2	6436.1	5893.9	5424.0	5021.5	4680.2	4393.4	4154.4	3956.4
HighM	FCURR	6743.3	6961.2	7054.2	6893.3	6735.2	6583.7	6441.6	6310.3	6190.8	6083.1	5987.1
lowLand	SPR20	3710.9	3815.9	3812.9	3597.5	3411.2	3250.9	3113.6	2996.5	2897.0	2812.7	2741.5
lowLand	SPR30	3710.9	3815.9	3812.9	3777.9	3746.5	3718.4	3693.5	3671.4	3651.9	3634.8	3619.8
lowLand	SPR40	3710.9	3815.9	3812.9	3879.3	3943.8	4005.9	4065.2	4121.1	4173.4	4222.0	4266.9
lowLand	SPR30_75	3710.9	3815.9	3812.9	3850.6	3887.3	3922.7	3956.4	3988.2	4017.8	4045.1	4070.3
lowLand	SPR40_75	3710.9	3815.9	3812.9	3928.2	4041.4	4151.6	4257.8	4359.3	4455.4	4545.9	4630.5
lowLand	MSY	3710.9	3815.9	3812.9	3557.4	3339.5	3154.4	2997.7	2865.6	2754.5	2661.4	2583.5
lowLand	FCURR	3710.9	3815.9	3812.9	3856.4	3899.6	3942.0	3983.2	4022.7	4060.3	4095.7	4128.9
FitInd	SPR20	5258.4	5472.8	5563.6	5208.4	4881.2	4584.8	4320.3	4087.3	3884.3	3709.2	3559.4
FitInd	SPR30	5258.4	5472.8	5563.6	5465.5	5361.9	5257.0	5154.0	5055.1	4962.0	4875.7	4796.4
FitInd	SPR40	5258.4	5472.8	5563.7	5610.8	5644.5	5667.7	5682.7	5691.5	5695.6	5696.2	5694.3
FitInd	SPR30_75	5258.4	5472.8	5563.6	5575.6	5575.3	5566.1	5550.6	5530.9	5508.7	5485.3	5461.5
FitInd	SPR40_75	5258.4	5472.8	5563.6	5686.5	5795.1	5891.1	5976.3	6051.8	6119.0	6178.7	6231.8
FitInd	MSY	5258.4	5472.8	5563.6	5138.9	4755.4	4414.5	4115.7	3856.8	3635.0	3446.7	3288.1
FitInd	FCURR	5258.4	5472.8	5563.7	5568.5	5562.4	5548.7	5529.9	5508.3	5485.1	5461.7	5438.7

Table 9. Deterministic projected exploitation rates under various harvest scenarios for 6 runs. Catch for 2010 and 2011 was fixed to estimated values.

LAB	rule	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
BASE	SPR20	0.064	0.033	0.054	0.108	0.107	0.105	0.104	0.103	0.102	0.101	0.100	0.099
BASE	SPR30	0.064	0.033	0.054	0.069	0.068	0.068	0.068	0.068	0.068	0.067	0.067	0.067
BASE	SPR40	0.064	0.033	0.054	0.046	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047
BASE	SPR30_75	0.064	0.033	0.054	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052
BASE	SPR40_75	0.064	0.033	0.054	0.035	0.035	0.035	0.036	0.036	0.036	0.036	0.036	0.036
BASE	MSY	0.064	0.033	0.054	0.110	0.109	0.108	0.106	0.105	0.104	0.103	0.102	0.101
BASE	FCURR	0.064	0.033	0.054	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052
LowStp	SPR20	0.078	0.040	0.066	0.107	0.106	0.105	0.103	0.102	0.101	0.100	0.100	0.099
LowStp	SPR30	0.078	0.040	0.066	0.068	0.068	0.068	0.068	0.067	0.067	0.067	0.067	0.067
LowStp	SPR40	0.078	0.040	0.066	0.046	0.046	0.046	0.047	0.047	0.047	0.047	0.047	0.047
LowStp	SPR30_75	0.078	0.040	0.066	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052
LowStp	SPR40_75	0.078	0.040	0.066	0.035	0.035	0.035	0.035	0.036	0.036	0.036	0.036	0.036
LowStp	MSY	0.078	0.040	0.066	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.053
LowStp	FCURR	0.078	0.040	0.066	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.051	0.051
LowMOUT	SPR20	0.089	0.046	0.074	0.098	0.097	0.097	0.096	0.095	0.095	0.094	0.094	0.094
LowMOUT	SPR30	0.089	0.046	0.074	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
LowMOUT	SPR40	0.089	0.046	0.074	0.043	0.043	0.043	0.043	0.044	0.044	0.044	0.044	0.045
LowMOUT	SPR30_75	0.089	0.046	0.074	0.047	0.048	0.048	0.048	0.048	0.049	0.049	0.049	0.049
LowMOUT	SPR40_75	0.089	0.046	0.074	0.032	0.032	0.033	0.033	0.033	0.033	0.034	0.034	0.034
LowMOUT	MSY	0.089	0.046	0.074	0.098	0.097	0.096	0.096	0.095	0.095	0.094	0.094	0.094
LowMOUT	FCURR	0.089	0.046	0.074	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.049	0.049
HighM	SPR20	0.042	0.021	0.035	0.132	0.130	0.127	0.124	0.121	0.118	0.116	0.114	0.112
HighM	SPR30	0.042	0.021	0.035	0.084	0.083	0.082	0.081	0.080	0.080	0.079	0.078	0.077
HighM	SPR40	0.042	0.021	0.035	0.056	0.056	0.056	0.056	0.056	0.056	0.055	0.055	0.055
HighM	SPR30_75	0.042	0.021	0.035	0.064	0.063	0.063	0.063	0.062	0.062	0.062	0.061	0.061
HighM	SPR40_75	0.042	0.021	0.035	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
HighM	MSY	0.042	0.021	0.035	0.121	0.119	0.117	0.114	0.112	0.110	0.108	0.106	0.104
HighM	FCURR	0.042	0.021	0.035	0.064	0.064	0.063	0.063	0.062	0.061	0.061	0.060	0.060
lowLand	SPR20	0.074	0.038	0.063	0.111	0.109	0.106	0.104	0.102	0.101	0.099	0.098	0.097
lowLand	SPR30	0.074	0.038	0.063	0.070	0.069	0.069	0.068	0.068	0.067	0.067	0.067	0.067
lowLand	SPR40	0.074	0.038	0.063	0.046	0.046	0.046	0.046	0.047	0.047	0.047	0.047	0.047
lowLand	SPR30_75	0.074	0.038	0.063	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053
lowLand	SPR40_75	0.074	0.038	0.063	0.035	0.035	0.035	0.036	0.036	0.036	0.036	0.036	0.037
lowLand	MSY	0.074	0.038	0.063	0.121	0.117	0.114	0.112	0.109	0.107	0.106	0.104	0.103
lowLand	FCURR	0.074	0.038	0.063	0.052	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.050
FitInd	SPR20	0.054	0.027	0.045	0.114	0.112	0.111	0.110	0.108	0.107	0.106	0.105	0.104
FitInd	SPR30	0.054	0.027	0.045	0.072	0.072	0.072	0.072	0.072	0.071	0.071	0.071	0.071
FitInd	SPR40	0.054	0.027	0.045	0.049	0.049	0.050	0.050	0.050	0.050	0.050	0.050	0.050
FitInd	SPR30_75	0.054	0.027	0.045	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055
FitInd	SPR40_75	0.054	0.027	0.045	0.037	0.037	0.038	0.038	0.038	0.038	0.038	0.038	0.038
FitInd	MSY	0.054	0.027	0.045	0.125	0.123	0.121	0.120	0.118	0.116	0.115	0.113	0.112
FitInd	FCURR	0.054	0.027	0.045	0.056	0.056	0.056	0.056	0.056	0.055	0.055	0.055	0.055

Table 10. Convergence statistics for MCMC runs for the BASE model. Key quantities include the negative log likelihood value (Objective_function), virgin spawning biomass (SPB_Virgin, in 1000lbs), 2009 spawning biomass (SPB_2009, in 1000lbs), spawning biomass at SPR 30% (SSB_SPRtgt), yield at SPR 30% (TotYield_SPRtgt), forecasted catches for 2010-2015 (ForeCatch_20XX, in 1000lbs), Fspr30% / Fcurrent (relative_Fref), and recruitment and herm. parms. Diagnostics include effective sample size (EffSS), Geweke's test (GWE_conv), Heidelberger and Welch's test stages I (HeidelStat) and II (HeidelWidth), the MLE value, and the cumulative mean of the MCMC chain in the last cycle (cumMean).

	EffSS	GWE conv	Heidel Stat	Heidel Width	MLE	cumMean
Objective_function	900	pass	pass	pass	13434.4	13452.521
SPB_Virgin	876.2	pass	pass	pass	29782.37	30138.157
SPB_2009	884.9	pass	pass	pass	8906.52	9527.626
SSB_SPRtgt	809.1	pass	pass	pass	8676.828	8616.112
TotYield_SPRtgt	806.7	pass	pass	pass	787.874	787.043
ForeCatch_2012	805.8	pass	pass	pass	849.839	912.556
ForeCatch_2013	804.4	pass	pass	pass	845.123	902.285
ForeCatch_2014	802.8	pass	pass	pass	840.253	892.082
ForeCatch_2015	801	pass	pass	pass	835.414	882.198
relative_Fref	806.7	pass	pass	pass	1.248	1.06
RecrDist_Area_1	559.9	pass	pass	pass	1.71	1.687
SR_steep	900	pass	pass	pass	0.953	0.928
SR_R0	892.4	pass	pass	pass	6.722	6.752
Herm_Infl_age	50.7	pass	pass	pass	14.82	25.149
Herm_stdev	61.2	pass	pass	pass	8.213	14.648
Herm_asymptote	99.4	pass	pass	pass	0.059	0.101
F_2009	794.9	pass	pass	pass	0.068	0.065
Fstd_SPRtgt	811	pass	pass	pass	0.066	0.066
Fstd_MSY	900	pass	pass	pass	0.098	0.092

Table 11. Convergence statistics for MCMC runs for the low M model. Key quantities include the negative log likelihood value (Objective_function), virgin spawning biomass (SPB_Virgin, in 1000lbs), 2009 spawning biomass (SPB_2009, in 1000lbs), spawning biomass at SPR 30% (SSB_SPRtgt), yield at SPR 30% (TotYield_SPRtgt), forecasted catches for 2010-2015 (ForeCatch_20XX, in 1000lbs), Fspr30% / Fcurrent (relative_Fref), and recruitment and herm. parms. Diagnostics include effective sample size (EffSS), Geweke's test (GWE_conv), Heidelberger and Welch's test stages I (HeidelStat) and II (HeidelWidth), the MLE value, and the cumulative mean of the MCMC chain in the last cycle (cumMean).

	EffSS	GWE conv	Heidel Stat	Heidel Width	MLE	cumMean
Objective_function	98.6	pass	pass	pass	13509.1	13504.869
SPB_Virgin	80.4	pass	pass	pass	29146.916	29899.744
SPB_2009	97.6	pass	pass	pass	6960.749	7706.558
SSB_SPRtgt	108.7	pass	pass	pass	8573.48	8695.008
TotYield_SPRtgt	99.6	pass	pass	pass	715.311	723.621
ForeCatch_2012	99.3	pass	pass	pass	602.822	668.438
ForeCatch_2013	100.2	pass	pass	pass	611.813	673.158
ForeCatch_2014	100.9	pass	pass	pass	620.465	677.601
ForeCatch_2015	101.4	pass	pass	pass	628.751	681.777
relative_Fref	95.7	pass	pass	pass	0.89	0.778
RecrDist_Area_1	154.4	pass	pass	pass	1.702	1.68
SR_steep	105.2	pass	pass	pass	0.968	0.951
SR_R0	49	pass	pass	pass	6.064	6.104
Herm_Infl_age	6.9	pass	fail	fail	17.569	31.017
Herm_stdev	2.9	pass	fail	fail	9.095	15.978
Herm_asymptote	22.2	pass	fail	fail	0.088	0.149
F_2009	108.4	pass	pass	pass	0.089	0.082
Fstd_SPRtgt	141.8	pass	pass	pass	0.064	0.064
Fstd_MSY	118.7	pass	pass	pass	0.092	0.087

Table 12. Convergence statistics for MCMC runs for the increased weight on indices model. Key quantities include the negative log likelihood value (Objective_function), virgin spawning biomass (SPB_Virgin, in 1000lbs), 2009 spawning biomass (SPB_2009, in 1000lbs), spawning biomass at SPR 30% (SSB_SPRtgt), yield at SPR 30% (TotYield_SPRtgt), forecasted catches for 2010-2015 (ForeCatch_20XX, in 1000lbs), Fspr30% / Fcurrent (relative_Fref), and recruitment and herm. parms. Diagnostics include effective sample size (EffSS), Geweke's test (GWE_conv), Heidelberger and Welch's test stages I (HeidelStat) and II (HeidelWidth), the MLE value, and the cumulative mean of the MCMC chain in the last cycle (cumMean).

	EffSS	GWE conv	Heidel Stat	Heidel Width	MLE	cumMean
Objective_function	352.5	pass	pass	pass	2518.65	2543.048
SPB_Virgin	224.5	fail	pass	pass	31228.634	30656.986
SPB_2009	265.7	fail	pass	pass	11411.762	11214.815
SSB_SPR30%	390.4	pass	pass	pass	9161.057	8914.369
TotYield_SPR30%	233.9	pass	pass	pass	873.742	853.882
ForeCatch_2012	257.8	fail	pass	pass	1162.806	1147.304
ForeCatch_2013	260.1	fail	pass	pass	1141.72	1126.625
ForeCatch_2014	262.1	fail	pass	pass	1119.751	1104.837
ForeCatch_2015	263.7	fail	pass	pass	1097.683	1082.783
relative_Fref	252.3	fail	pass	pass	1.675	1.301
RecrDist_Area_1	477	pass	pass	pass	1.732	1.744
SR_steep	900	pass	pass	pass	0.964	0.951
SR_R0	114.9	pass	pass	pass	6.813	6.792
Herm_Infl_age	109.3	pass	pass	pass	18.395	29.723
Herm_stdev	325.9	pass	pass	pass	9.725	15.37
Herm_asymptote	178.1	pass	pass	pass	0.081	0.138
F_2009	287	pass	pass	pass	0.054	0.055
Fstd_SPRtgt	614.4	pass	pass	pass	0.068	0.069
Fstd_MSY	900	pass	pass	pass	0.104	0.101

Table 13. Summary of marginal posterior distributions for key parameters and derived quantities from Gulf of Mexico YEG BASE model. Spawning biomass (SPB and SBB) and Catch/Yield is in thousand pounds gutted weight.

base	Lower10th	Mean	Upper90th	MCMC STD	MLE	MLE_STD
Objective_function	13445.89	13452.5	13459.61	5.65	13434.4	<NA>
SPB_Virgin	29552.51	30138.2	30772.42	484.25	29782.38	178.33
SPB_2009	8736.357	9527.6	10332.86	647.91	8906.52	241.79
SSB_SPRtgt	8291.905	8616.11	8904.315	245.98	8676.828	82.34
TotYield_SPRtgt	757.146	787.043	815.156	23.22	787.874	7.95
ForeCatch_2012	830.678	912.56	995.781	66.49	849.839	25.19
ForeCatch_2013	824.394	902.29	981.057	62.56	845.123	23.77
ForeCatch_2014	820.065	892.08	966.786	58.7	840.253	22.35
ForeCatch_2015	813.939	882.198	952.032	54.98	835.414	20.95
relative_Fref	0.968	1.06	1.154	0.08	1.248	<NA>
RecrDist_Area_1	1.656	1.687	1.719	0.02	1.71	0.02
SR_steep	0.884	0.928	0.965	0.03	0.953	0.02
SR_R0	6.729	6.752	6.775	0.02	6.722	0.02
Herm_Infl_age	16.51	25.149	34	6.57	14.82	2.57
Herm_stdev	9.597	14.648	19.121	3.49	8.213	2.19
Herm_asymptote	0.068	0.101	0.136	0.03	0.059	0.01
F_2009	0.06	0.065	0.07	0	0.068	0.00
Fstd_SPRtgt	0.066	0.066	0.067	0	0.066	0.00
Fstd_MSY	0.08	0.092	0.103	0.01	0.098	0.01

Table 14. Summary of marginal posterior distributions for key parameters and derived quantities from Gulf of Mexico YEG Low natural mortality run. Spawning biomass (SPB and SBB) and Catch/Yield is in thousand pounds gutted weight.

LowM	Lower10th	Mean	Upper90th	MCMC_STD	MLE	MLE_STD
Objective_function	13497	13504.87	13513.1	6.39	13509.1	<NA>
SPB_Virgin	29355.88	29899.74	30483.44	424.54	29146.92	138.78
SPB_2009	7035.837	7706.558	8403.535	526.02	6960.749	181.85
SSB_SPRtgt	8493.61	8695.008	8890.537	161.47	8573.48	54.44
TotYield_SPRtgt	703.037	723.621	742.759	15.45	715.311	5.27
ForeCatch_2012	603.59	668.438	737.348	50.81	602.822	17.90
ForeCatch_2013	611.336	673.158	738.787	48.34	611.813	17.14
ForeCatch_2014	619.132	677.601	740.336	45.81	620.465	16.32
ForeCatch_2015	627.081	681.777	740.685	43.29	628.751	15.48
relative_Fref	0.706	0.778	0.854	0.06	0.89	<NA>
RecrDist_Area_1	1.653	1.68	1.707	0.02	1.702	0.02
SR_steep	0.925	0.951	0.975	0.02	0.968	0.02
SR_R0	6.08	6.104	6.13	0.02	6.064	0.01
Herm_Infl_age	19.951	31.017	40.224	7.71	17.569	3.24
Herm_stdev	10.411	15.978	19.581	3.43	9.095	2.33
Herm_asymptote	0.101	0.149	0.193	0.03	0.088	0.02
F_2009	0.076	0.082	0.089	0	0.089	0.00
Fstd_SPRtgt	0.064	0.064	0.065	0	0.064	0.00

Table 15. Summary of marginal posterior distributions for key parameters and derived quantities from Gulf of Mexico YEG increase weight on indices model. Spawning biomass (SPB and SBB) is female gonad weight in pounds. Catch/Yield is in thousand pounds gutted weight.

base	Lower10th	Mean	Upper90th	MCMC STD	MLE	MLE_STD
Objective_function	2535.91	2543.05	2551.1	5.97	2518.65	<NA>
SPB_Virgin	29703.15	30656.99	31684.38	789.28	31228.63	371.94
SPB_2009	10137.95	11214.82	12387.81	890.08	11411.76	403.43
SSB_SPRtgt	8621.93	8914.37	9217.81	236.03	9161.06	112.68
TotYield_SPRtgt	826.61	853.88	882.26	22.71	873.74	10.51
ForeCatch_2012	1035.47	1147.3	1262.97	91.15	1162.81	40.58
ForeCatch_2013	1022.21	1126.63	1235	84.47	1141.72	37.71
ForeCatch_2014	1008.07	1104.84	1205.31	78.1	1119.75	34.96
ForeCatch_2015	993.47	1082.78	1175.82	72.11	1097.68	32.37
relative_Fref	1.17	1.3	1.44	0.11	1.68	<NA>
RecrDist_Area_1	1.68	1.74	1.81	0.05	1.73	0.05
SR_steep	0.92	0.95	0.97	0.02	0.96	0.02
SR_R0	6.75	6.79	6.84	0.03	6.81	0.03
Herm_Infl_age	15.91	29.72	45.54	11.32	18.4	10.10
Herm_stdev	10.02	15.37	19.43	3.5	9.72	6.51
Herm_asymptote	0.06	0.14	0.24	0.08	0.08	0.06
F_2009	0.05	0.06	0.06	0	0.05	0.00
Fstd_SPRtgt	0.07	0.07	0.07	0	0.07	0.00
Fstd_MSY	0.09	0.1	0.11	0.01	0.1	0.01

Table 13. SFA and MSRA evaluations using SPR 20% reference points for Gulf of Mexico yellowedge grouper models. Values represent means of MCMC posterior distributions. Spawning biomass units and yield units are million pounds gutted weight.

Criteria	Definition	SPR20% BASE	SPR20% LowM	SPR20% Fit Indices
	Mortality Rate Criteria			
$F_{MSY\ or\ proxy}$	$F_{SPRxx\%}$	1.71	1.23	2.103
MFMT	$F_{SPRxx\%}$	1.71	1.23	2.103
F_{OY}	75% of $F_{SPRxx\%}$	1.282	0.922	1.577
$F_{CURRENT}$	Avg. F 2007-2009	1	1	1
$F_{CURRENT}$/MFMT	**$F_{CURRENT}$**/MFMT	0.588	0.817	0.479
Base M	**Base M**	0.073	0.073	0.073
	Biomass Criteria			
$SSB_{MSY\ or\ proxy}$	Equilibrium SSB @ $F_{SPRxx\%}$	5.545	5.669	5.812
MSST	(1-M)*$SSB_{SPRxx\%}$ M=0.13	5.140	5.255	5.388
$SSB_{CURRENT}$	SSB_{2009}	9.533	7.711	11.222
$SS_{CURRENT}$/MSST	SSB_{2009}	1.855	1.467	2.083
Equilibrium MSY	Equilibrium Yield (mil. lbs) @ $F_{SPRxx\%}$	0.811	0.742	0.890
Equilibrium OY	Equilibrium Yield @ F_{OY}	NA	NA	NA
OFL	Annual Yield @ FMFMT			
	Actual 2010 landings	0.424	0.424	0.424
	Est. 2011 landings	0.714	0.714	0.714
	OFL 2012	1.438	1.035	1.809
	OFL 2013	1.355	1.000	1.691
	OFL 2014	1.282	0.968	1.583
	OFL 2015	1.217	0.940	1.485
Annual OY (ACT)	Annual Yield @ F_{OY}			
	Actual 2010 landings	0.424	0.424	0.424
	Est. 2011 landings	0.714	0.714	0.714
	OY 2012	1.096	0.787	1.379
	OY 2013	1.066	0.783	1.332
	OY 2014	1.038	0.778	1.285
	OY 2015	1.012	0.774	1.240
Generation Time				
Rebuild Time	(if B_{2009}<MSST)	NA	NA	NA
Tmin	@ F=0			
Midpoint	mid of Tmin, Tmax			
Tmax	if Tmin>10y, Tmin + 1 Gen			
ABC	Recommend Range	TBD	TBD	TBD

Table 14. SFA and MSRA evaluations using SPR 30% reference points for Gulf of Mexico yellowedge grouper model. Values represent means of MCMC posterior distributions. Spawning biomass units and yield units are million pounds gutted weight.

Criteria	Definition	SPR20% BASE	SPR30% LowM	SPR40% Fit Indices
	Mortality Rate Criteria			
$F_{MSY\ or\ proxy}$	$F_{SPRxx\%}$	1.06	0.778	1.301
MFMT	$F_{SPRxx\%}$	1.06	0.778	1.301
F_{OY}	75% of $F_{SPRxx\%}$	0.795	0.584	0.976
$F_{CURRENT}$	Avg. F 2007-2009	1	1	1
$F_{CURRENT}$/MFMT	$F_{CURRENT}$/MFMT	0.949	1.292	0.774
Base M	Base M	0.073	0.073	0.073
	Biomass Criteria			
$SSB_{MSY\ or\ proxy}$	Equilibrium SSB @ $F_{SPRxx\%}$	8.621	8.700	8.920
MSST	(1-M)*$SSB_{SPRxx\%}$ M=0.13	7.992	8.065	8.269
$SSB_{CURRENT}$	SSB_{2009}	9.533	7.711	11.222
$SS_{CURRENT}$/MSST	SSB_{2009}	1.193	0.956	1.357
Equilibrium MSY	Equilibrium Yield @ $F_{SPRxx\%}$	0.788	0.724	0.854
Equilibrium OY	Equilibrium Yield @ F_{OY}	NA	NA	NA
OFL	Annual Yield @ FMFMT			
	Actual 2010 landings	0.424	0.424	0.424
	Est. 2011 landings	0.714	0.714	0.714
	OFL 2012	0.913	0.669	1.148
	OFL 2013	0.903	0.674	1.127
	OFL 2014	0.893	0.678	1.106
	OFL 2015	0.883	0.682	1.083
Annual OY (ACT)	Annual Yield @ F_{OY}			
	Actual 2010 landings	0.424	0.424	0.424
	Est. 2011 landings	0.714	0.714	0.714
	OY 2012	0.692	0.506	0.870
	OY 2013	0.698	0.519	0.872
	OY 2014	0.703	0.531	0.871
	OY 2015	0.707	0.543	0.870
Generation Time				
Rebuild Time	(if B_{2009}<MSST)	NA		NA
Tmin	@ F=0		1	
Midpoint	mid of Tmin, Tmax		5.5	
Tmax	if Tmin>10y, Tmin + 1 Gen		10	
ABC	Recommend Range	TBD	TBD	TBD

Table 15. SFA and MSRA evaluations using SPR 40% reference points for Gulf of Mexico yellowedge grouper models. Values represent means of MCMC posterior distributions. Spawning biomass units and yield units are million pounds gutted weight.

Criteria	Definition	SPR20% Fit Indices	SPR30% Fit Indices	SPR40% Fit Indices
	Mortality Rate Criteria			
$F_{MSY\ or\ proxy}$	$F_{SPRxx\%}$	0.707	0.527	0.87
MFMT	$F_{SPRxx\%}$	0.707	0.527	0.87
F_{OY}	75% of $F_{SPRxx\%}$	0.531	0.395	0.652
$F_{CURRENT}$	Avg. F 2007-2009	1	1	1
$F_{CURRENT}$/MFMT	**$F_{CURRENT}$/MFMT**	1.421	1.909	1.158
Base M	Base M	0.073	0.073	0.073
	Biomass Criteria			
$SSB_{MSY\ or\ proxy}$	Equilibrium SSB @ $F_{SPRxx\%}$	11.698	11.731	12.028
MSST	(1-M)*$SSB_{SPRxx\%}$ M=0.13	10.844	10.875	11.150
$SSB_{CURRENT}$	SSB_{2009}	9.533	7.711	11.222
$SS_{CURRENT}$/MSST	SSB_{2009}	0.879	0.709	1.006
Equilibrium MSY	Equilibrium Yield @ $F_{SPRxx\%}$	0.722	0.668	0.778
Equilibrium OY	Equilibrium Yield @ F_{OY}	NA	NA	NA
OFL	Annual Yield @ FMFMT			
	Actual 2010 landings	0.424	0.424	0.424
	Est. 2011 landings	0.714	0.714	0.714
	OFL 2012	0.618	0.458	0.778
	OFL 2013	0.627	0.472	0.785
	OFL 2014	0.636	0.486	0.789
	OFL 2015	0.643	0.499	0.793
Annual OY (ACT)	Annual Yield @ F_{OY}			
	Actual 2010 landings	0.424	0.424	0.424
	Est. 2011 landings	0.714	0.714	0.714
	OY 2012	0.467	0.346	0.587
	OY 2013	0.480	0.361	0.601
	OY 2014	0.492	0.376	0.612
	OY 2015	0.504	0.390	0.622
Generation Time				
Rebuild Time	(if B_{2009}<MSST)			NA
Tmin	@ F=0	2	6	
Midpoint	mid of Tmin, Tmax	6	8	
Tmax	if Tmin>10y, Tmin + 1 Gen	10	10	
ABC	Recommend Range	TBD	TBD	TBD

Table 16. Probabilities of exceeding OFL for Gulf of Mexico YEG at SPR 20% reference point. Probabilities calculated from marginal posterior distribution of yield at Fspr20%. Catches are reported in thousand pounds gutted weight. Note that 2005-2009 landings average ~800,000 lbs gutted weight.

		BASE					Fit Indices					Low M				
MT	pounds	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
300	661,200	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
310	683,240	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
320	705,280	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
330	727,320	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
340	749,360	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
350	771,400	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
360	793,440	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	3%
370	815,480	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	4%	8%
380	837,520	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	4%	8%	16%
390	859,560	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	5%	9%	17%	29%
400	881,600	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	9%	17%	29%	45%
410	903,640	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	8%	16%	28%	44%	60%
420	925,680	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	14%	25%	41%	57%	74%
430	947,720	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	21%	37%	54%	71%	85%
440	969,760	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	32%	49%	66%	81%	93%
450	991,800	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	43%	60%	76%	90%	98%
460	1,013,840	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	54%	71%	85%	96%	100%
470	1,035,880	0%	0%	0%	2%	5%	0%	0%	0%	0%	0%	64%	79%	92%	98%	100%
480	1,057,920	0%	0%	0%	3%	11%	0%	0%	0%	0%	0%	73%	87%	96%	100%	100%
490	1,079,960	0%	0%	1%	5%	19%	0%	0%	0%	0%	0%	81%	92%	98%	100%	100%
500	1,102,000	0%	0%	2%	10%	30%	0%	0%	0%	0%	0%	87%	96%	100%	100%	100%
510	1,124,040	0%	1%	4%	17%	43%	0%	0%	0%	0%	0%	92%	98%	100%	100%	100%
520	1,146,080	0%	2%	8%	26%	58%	0%	0%	0%	0%	0%	96%	100%	100%	100%	100%
530	1,168,120	1%	3%	13%	36%	69%	0%	0%	0%	0%	0%	98%	100%	100%	100%	100%
540	1,190,160	1%	5%	21%	50%	79%	0%	0%	0%	0%	0%	99%	100%	100%	100%	100%
550	1,212,200	2%	8%	29%	61%	87%	0%	0%	0%	0%	2%	100%	100%	100%	100%	100%
560	1,234,240	3%	15%	38%	71%	92%	0%	0%	0%	0%	4%	100%	100%	100%	100%	100%
570	1,256,280	5%	21%	51%	80%	97%	0%	0%	0%	0%	7%	100%	100%	100%	100%	100%
580	1,278,320	8%	28%	61%	87%	98%	0%	0%	0%	2%	12%	100%	100%	100%	100%	100%
590	1,300,360	14%	36%	69%	92%	99%	0%	0%	0%	3%	18%	100%	100%	100%	100%	100%
600	1,322,400	19%	48%	77%	96%	100%	0%	0%	0%	7%	28%	100%	100%	100%	100%	100%
610	1,344,440	25%	58%	85%	98%	100%	0%	0%	1%	10%	37%	100%	100%	100%	100%	100%
620	1,366,480	32%	65%	90%	98%	100%	0%	0%	3%	15%	48%	100%	100%	100%	100%	100%
630	1,388,520	41%	72%	94%	99%	100%	0%	0%	4%	23%	58%	100%	100%	100%	100%	100%
640	1,410,560	51%	80%	97%	100%	100%	0%	1%	8%	31%	68%	100%	100%	100%	100%	100%
650	1,432,600	59%	86%	98%	100%	100%	0%	2%	12%	39%	75%	100%	100%	100%	100%	100%
660	1,454,640	66%	91%	99%	100%	100%	0%	3%	16%	50%	84%	100%	100%	100%	100%	100%
670	1,476,680	72%	93%	99%	100%	100%	0%	5%	23%	58%	89%	100%	100%	100%	100%	100%
680	1,498,720	79%	97%	100%	100%	100%	1%	8%	31%	67%	93%	100%	100%	100%	100%	100%
690	1,520,760	85%	98%	100%	100%	100%	2%	11%	37%	74%	95%	100%	100%	100%	100%	100%

700	1,542,800	89%	98%	100%	100%	100%	3%	16%	46%	80%	97%	100%	100%	100%	100%	100%
710	1,564,840	92%	99%	100%	100%	100%	5%	22%	54%	87%	98%	100%	100%	100%	100%	100%
720	1,586,880	95%	99%	100%	100%	100%	8%	28%	62%	90%	99%	100%	100%	100%	100%	100%
730	1,608,920	97%	100%	100%	100%	100%	11%	34%	69%	94%	99%	100%	100%	100%	100%	100%
740	1,630,960	98%	100%	100%	100%	100%	15%	41%	75%	96%	100%	100%	100%	100%	100%	100%
750	1,653,000	99%	100%	100%	100%	100%	20%	49%	81%	97%	100%	100%	100%	100%	100%	100%
760	1,675,040	99%	100%	100%	100%	100%	26%	55%	87%	98%	100%	100%	100%	100%	100%	100%
770	1,697,080	99%	100%	100%	100%	100%	32%	62%	90%	99%	100%	100%	100%	100%	100%	100%
780	1,719,120	100%	100%	100%	100%	100%	38%	69%	93%	99%	100%	100%	100%	100%	100%	100%
790	1,741,160	100%	100%	100%	100%	100%	44%	74%	95%	99%	100%	100%	100%	100%	100%	100%
800	1,763,200	100%	100%	100%	100%	100%	52%	80%	96%	100%	100%	100%	100%	100%	100%	100%
810	1,785,240	100%	100%	100%	100%	100%	58%	85%	98%	100%	100%	100%	100%	100%	100%	100%
820	1,807,280	100%	100%	100%	100%	100%	66%	89%	99%	100%	100%	100%	100%	100%	100%	100%
830	1,829,320	100%	100%	100%	100%	100%	72%	92%	99%	100%	100%	100%	100%	100%	100%	100%
840	1,851,360	100%	100%	100%	100%	100%	79%	94%	100%	100%	100%	100%	100%	100%	100%	100%
850	1,873,400	100%	100%	100%	100%	100%	83%	96%	100%	100%	100%	100%	100%	100%	100%	100%
860	1,895,440	100%	100%	100%	100%	100%	90%	97%	100%	100%	100%	100%	100%	100%	100%	100%

Table 17. Probabilities of exceeding OFL for Gulf of Mexico YEG at SPR 30% reference point. Probabilities calculated from marginal posterior distribution of yield at Fspr30%. Catches are reported in thousand pounds gutted weight. Note that 2005-2009 landings average ~800,000 lbs gutted weight.

		BASE					Fit Indices					Low M				
MT	gutted pounds	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
100	220,400	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
110	242,440	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
120	264,480	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
130	286,520	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
140	308,560	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
150	330,600	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
160	352,640	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
170	374,680	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
180	396,720	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
190	418,760	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
200	440,800	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
210	462,840	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
220	484,880	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
230	506,920	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
240	528,960	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%
250	551,000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	2%	1%	0%	0%
260	573,040	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	7%	5%	4%	3%	1%
270	595,080	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	17%	13%	10%	7%	5%
280	617,120	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	32%	26%	21%	17%	14%
290	639,160	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	48%	44%	39%	36%	30%
300	661,200	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	65%	61%	57%	54%	50%
310	683,240	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	77%	75%	73%	72%	70%
320	705,280	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	87%	87%	86%	85%	84%
330	727,320	0%	0%	1%	1%	1%	0%	0%	0%	0%	0%	94%	94%	94%	94%	94%
340	749,360	2%	2%	2%	2%	2%	0%	0%	0%	0%	0%	98%	98%	98%	98%	99%
350	771,400	3%	3%	4%	4%	6%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%
360	793,440	6%	7%	9%	11%	13%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%
370	815,480	13%	15%	18%	21%	24%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%
380	837,520	22%	25%	30%	34%	40%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%
390	859,560	32%	37%	44%	51%	59%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%
400	881,600	47%	53%	60%	66%	73%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%
410	903,640	60%	66%	72%	78%	85%	0%	0%	0%	0%	1%	100%	100%	100%	100%	100%
420	925,680	70%	75%	83%	88%	93%	0%	0%	0%	2%	3%	100%	100%	100%	100%	100%
430	947,720	80%	86%	91%	94%	97%	0%	1%	2%	4%	8%	100%	100%	100%	100%	100%
440	969,760	88%	92%	95%	98%	98%	1%	3%	5%	9%	14%	100%	100%	100%	100%	100%
450	991,800	93%	96%	98%	99%	99%	4%	6%	10%	15%	24%	100%	100%	100%	100%	100%
460	1,013,840	97%	98%	99%	99%	100%	7%	10%	15%	24%	36%	100%	100%	100%	100%	100%
470	1,035,880	98%	99%	99%	100%	100%	11%	15%	24%	35%	49%	100%	100%	100%	100%	100%
480	1,057,920	99%	99%	100%	100%	100%	16%	24%	34%	47%	63%	100%	100%	100%	100%	100%
490	1,079,960	100%	100%	100%	100%	100%	25%	33%	45%	60%	73%	100%	100%	100%	100%	100%
500	1,102,000	100%	100%	100%	100%	100%	33%	43%	56%	70%	83%	100%	100%	100%	100%	100%
510	1,124,040	100%	100%	100%	100%	100%	41%	54%	67%	79%	90%	100%	100%	100%	100%	100%

520	1,146,080	100%	100%	100%	100%	100%	52%	63%	75%	87%	94%	100%	100%	100%	100%	100%
530	1,168,120	100%	100%	100%	100%	100%	60%	72%	83%	91%	96%	100%	100%	100%	100%	100%
540	1,190,160	100%	100%	100%	100%	100%	69%	80%	90%	95%	98%	100%	100%	100%	100%	100%
550	1,212,200	100%	100%	100%	100%	100%	77%	86%	93%	97%	99%	100%	100%	100%	100%	100%
560	1,234,240	100%	100%	100%	100%	100%	83%	90%	96%	98%	99%	100%	100%	100%	100%	100%
570	1,256,280	100%	100%	100%	100%	100%	88%	93%	98%	99%	100%	100%	100%	100%	100%	100%
580	1,278,320	100%	100%	100%	100%	100%	92%	96%	99%	99%	100%	100%	100%	100%	100%	100%
590	1,300,360	100%	100%	100%	100%	100%	94%	98%	99%	100%	100%	100%	100%	100%	100%	100%
600	1,322,400	100%	100%	100%	100%	100%	97%	99%	99%	100%	100%	100%	100%	100%	100%	100%
610	1,344,440	100%	100%	100%	100%	100%	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%
620	1,366,480	100%	100%	100%	100%	100%	99%	99%	100%	100%	100%	100%	100%	100%	100%	100%
630	1,388,520	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
640	1,410,560	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
650	1,432,600	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 18. Probabilities of exceeding OFL for Gulf of Mexico YEG at SPR 40% reference point. Probabilities calculated from marginal posterior distribution of yield at Fspr40%. Catches are reported in thousand pounds gutted weight. Note that 2005-2009 landings average ~800,000 lbs gutted weight.

		BASE					Fit Indices					Low M				
MT	gutted pounds	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
100	220,400	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
110	264,480	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
120	286,520	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
130	308,560	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
140	330,600	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
150	352,640	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
160	374,680	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%
170	396,720	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	1%	0%	0%	0%
180	418,760	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	15%	6%	3%	1%	0%
190	440,800	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	35%	19%	10%	4%	1%
200	462,840	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	58%	43%	27%	15%	6%
210	484,880	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	78%	67%	52%	37%	21%
220	506,920	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	91%	84%	74%	62%	46%
230	528,960	2%	1%	0%	0%	0%	0%	0%	0%	0%	0%	98%	95%	89%	82%	72%
240	551,000	6%	3%	2%	1%	0%	0%	0%	0%	0%	0%	100%	99%	98%	95%	89%
250	573,040	16%	11%	6%	4%	2%	0%	0%	0%	0%	0%	100%	100%	100%	99%	98%
260	595,080	32%	24%	18%	12%	8%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%
270	617,120	52%	42%	34%	27%	21%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%
280	639,160	69%	63%	57%	48%	39%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%
290	661,200	83%	77%	72%	67%	63%	2%	1%	0%	0%	0%	100%	100%	100%	100%	100%
300	683,240	92%	90%	87%	84%	79%	6%	4%	2%	1%	1%	100%	100%	100%	100%	100%
310	705,280	97%	96%	95%	93%	92%	12%	9%	7%	5%	4%	100%	100%	100%	100%	100%
320	727,320	99%	98%	98%	98%	97%	24%	18%	14%	12%	10%	100%	100%	100%	100%	100%
330	749,360	99%	99%	99%	99%	99%	35%	31%	27%	23%	20%	100%	100%	100%	100%	100%
340	771,400	100%	100%	100%	100%	100%	49%	44%	40%	37%	35%	100%	100%	100%	100%	100%
350	793,440	100%	100%	100%	100%	100%	63%	59%	56%	53%	52%	100%	100%	100%	100%	100%
360	815,480	100%	100%	100%	100%	100%	75%	71%	70%	69%	68%	100%	100%	100%	100%	100%
370	837,520	100%	100%	100%	100%	100%	84%	82%	81%	80%	81%	100%	100%	100%	100%	100%
380	859,560	100%	100%	100%	100%	100%	90%	90%	89%	90%	90%	100%	100%	100%	100%	100%
390	881,600	100%	100%	100%	100%	100%	94%	93%	94%	94%	94%	100%	100%	100%	100%	100%
400	903,640	100%	100%	100%	100%	100%	97%	97%	97%	97%	98%	100%	100%	100%	100%	100%
410	925,680	100%	100%	100%	100%	100%	99%	98%	99%	99%	99%	100%	100%	100%	100%	100%
420	947,720	100%	100%	100%	100%	100%	99%	99%	99%	99%	99%	100%	100%	100%	100%	100%
430	969,760	100%	100%	100%	100%	100%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%
440	991,800	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
450	1,013,840	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
460	1,035,880	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
470	1,057,920	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
480	1,079,960	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Figures

Figure 1. Recruitment deviations estimated when either the East or West age and length composition data are removed.

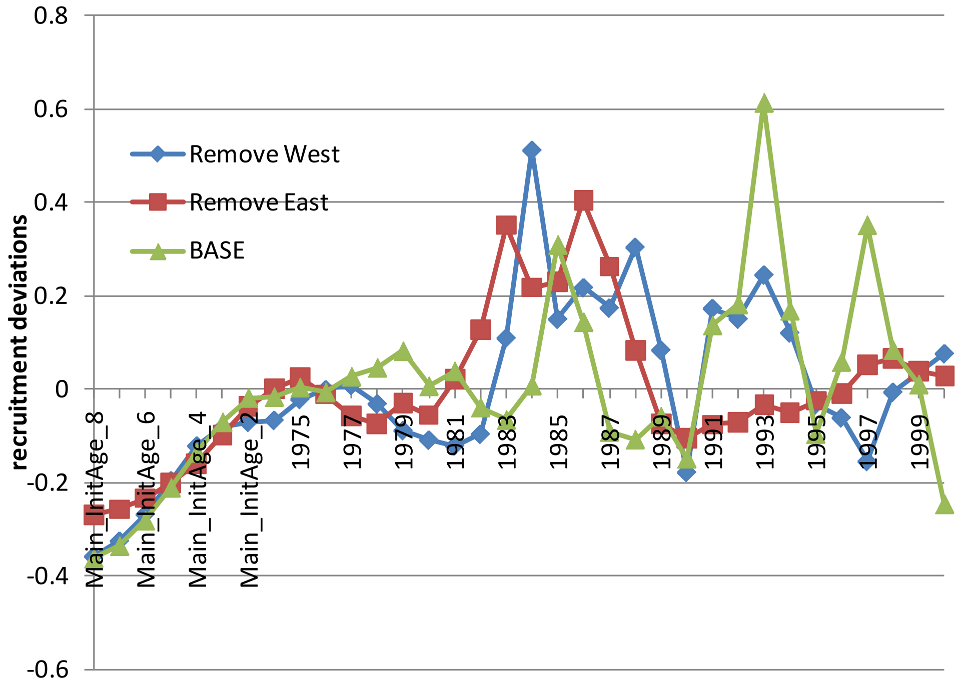


Figure 2. Absolute recruitment levels when either the East or West age and length composition data are removed.

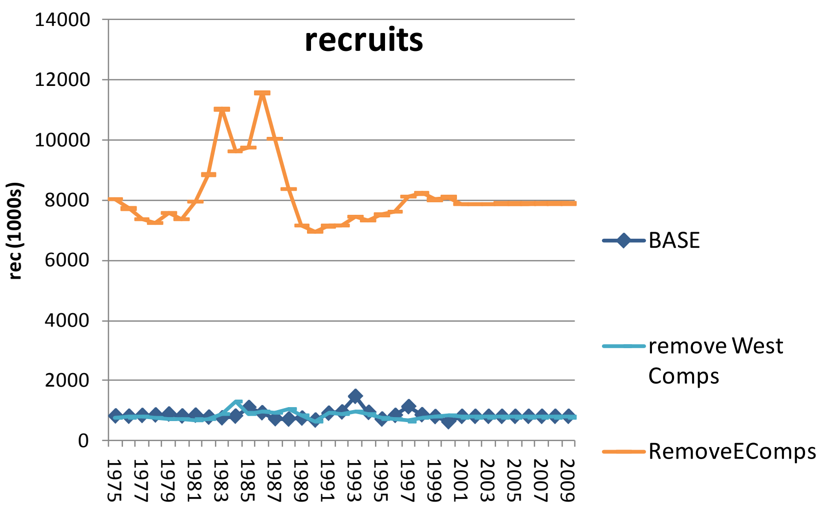


Figure 3. Spawning stock biomass levels when either the East or West age and length composition data are removed.

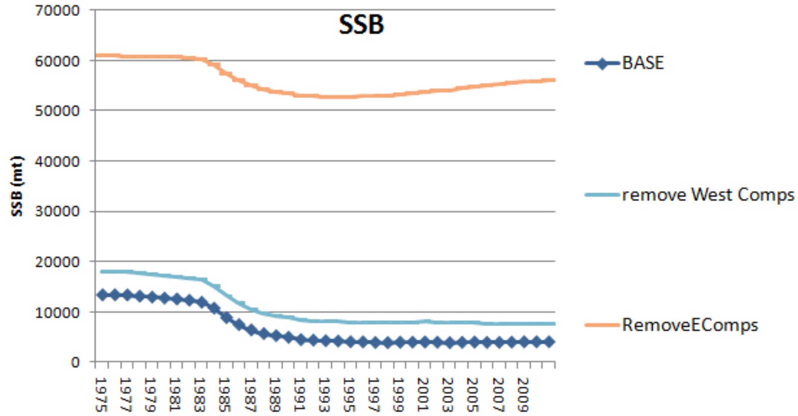


Figure 4. CPUE index fits to the model with the East age composition removed.

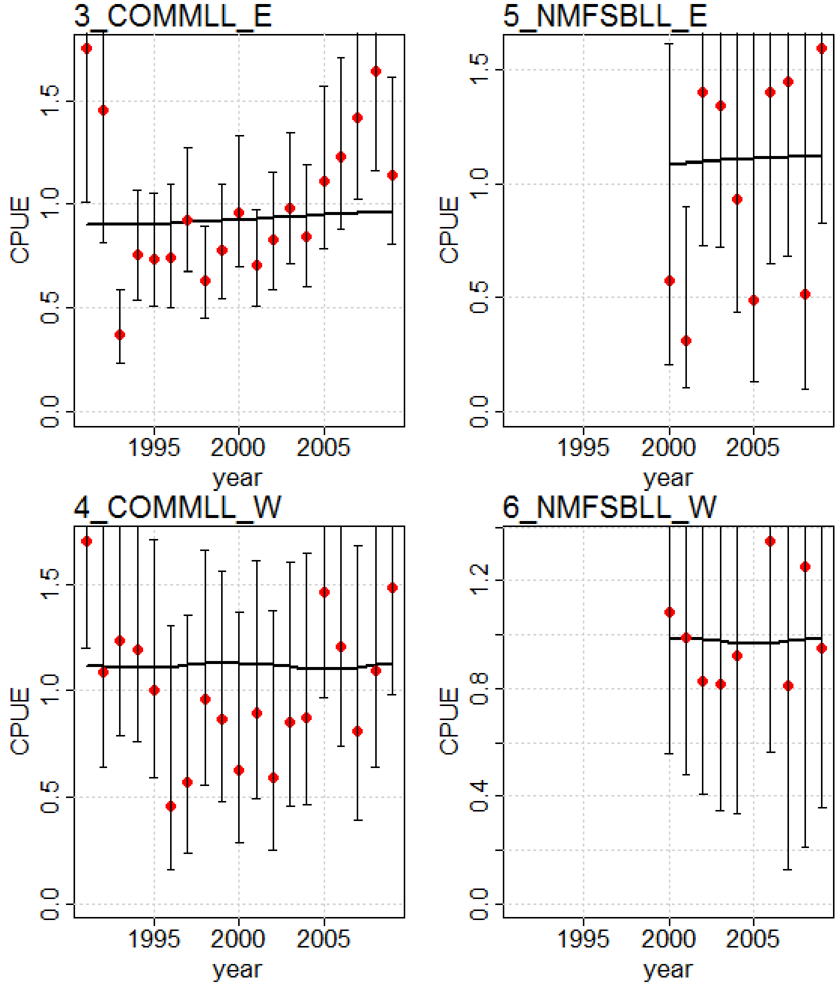


Figure 5. CPUE index fits to the model with the West age composition removed.

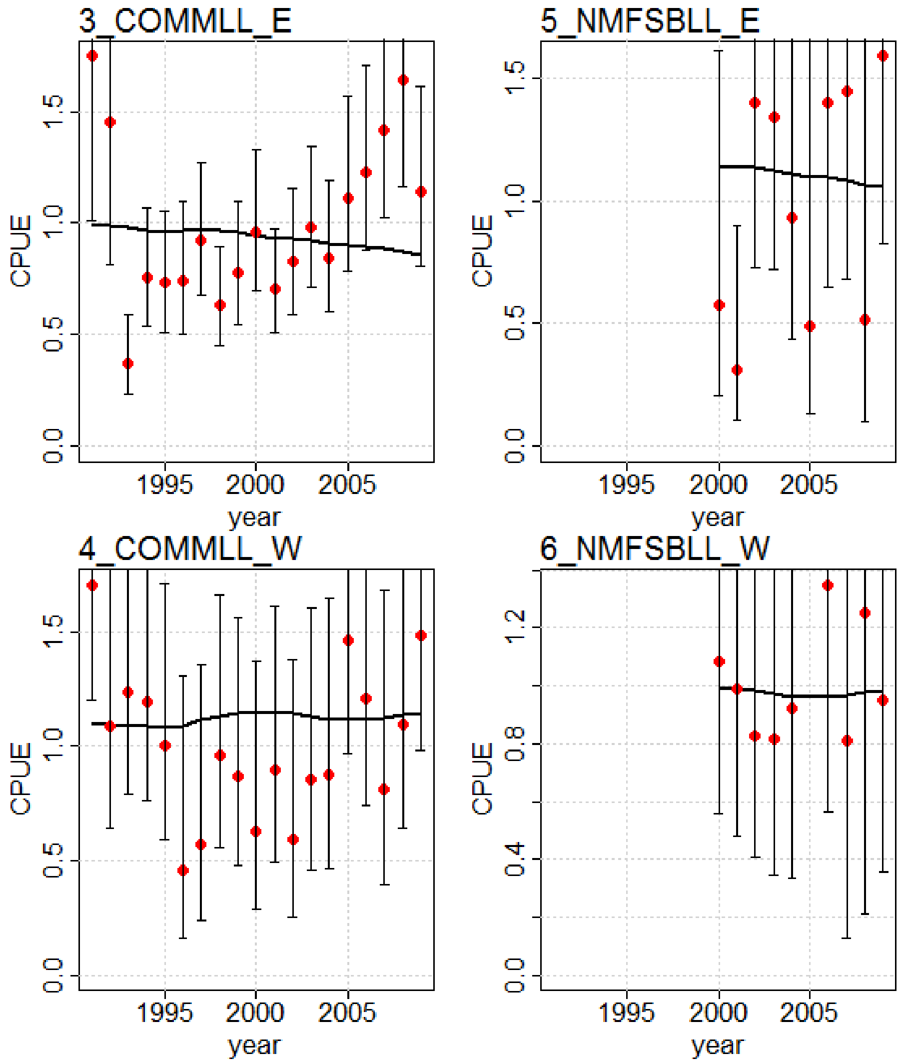


Figure 6. CPUE index fits with Ricker stock recruitment run.

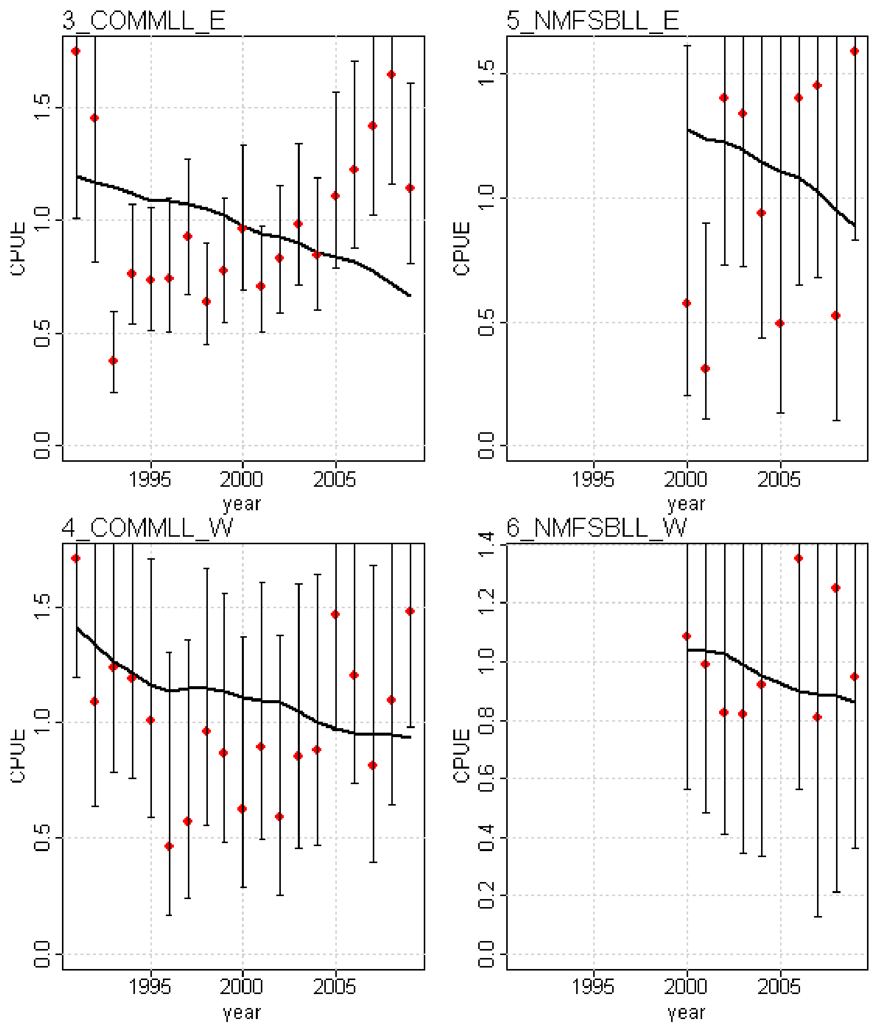


Figure 7. Stock recruitment relationship and recruitments from Ricker SRR run.

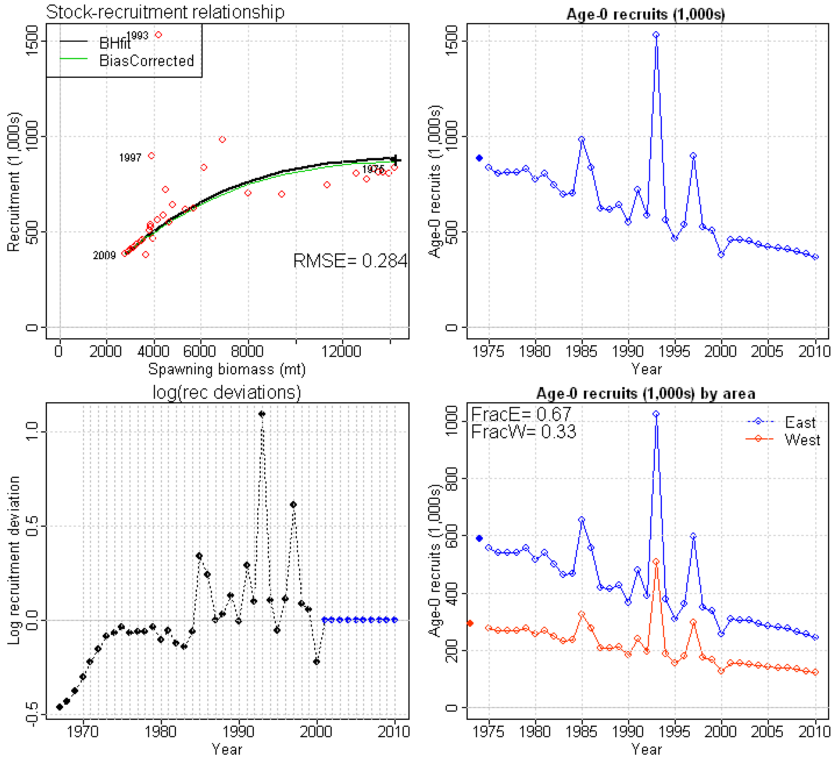


Figure 8. CPUE index fits with increased weighting on the indices

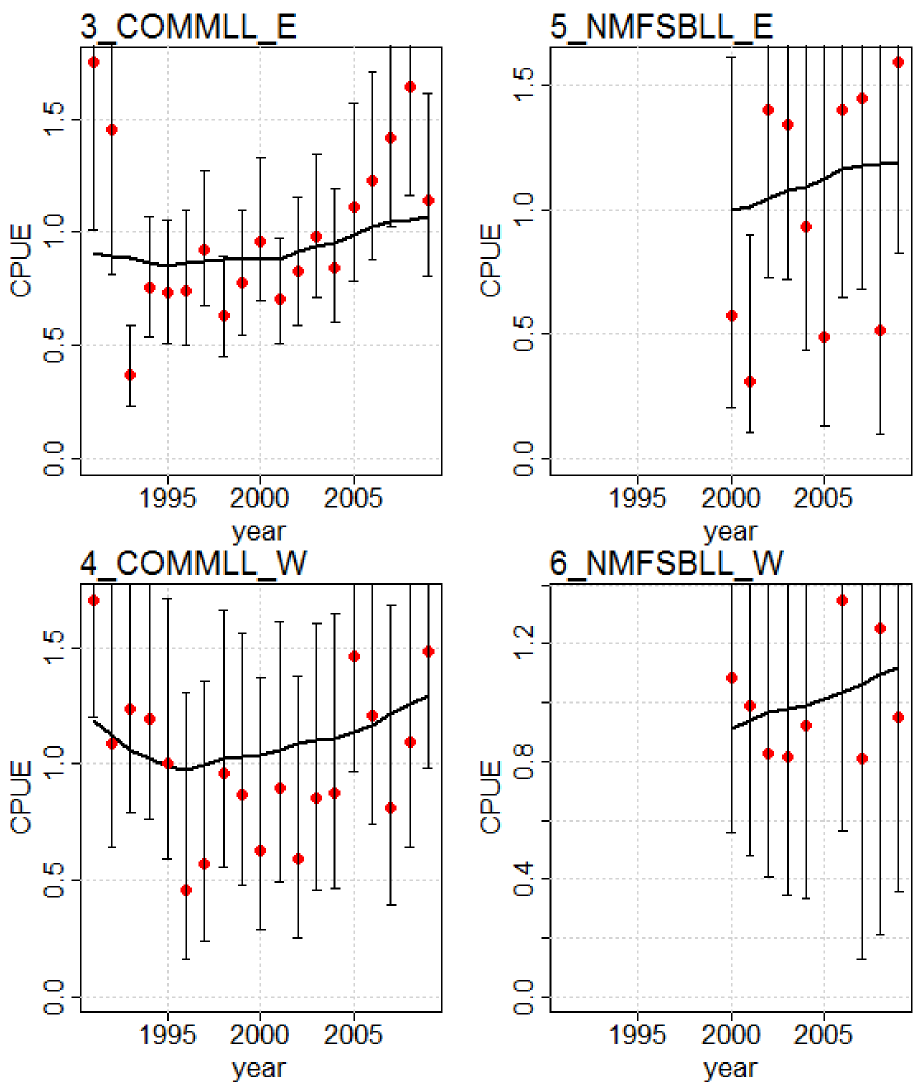


Figure 9. Stock-recruitment relationship with increased weighting on the indices.

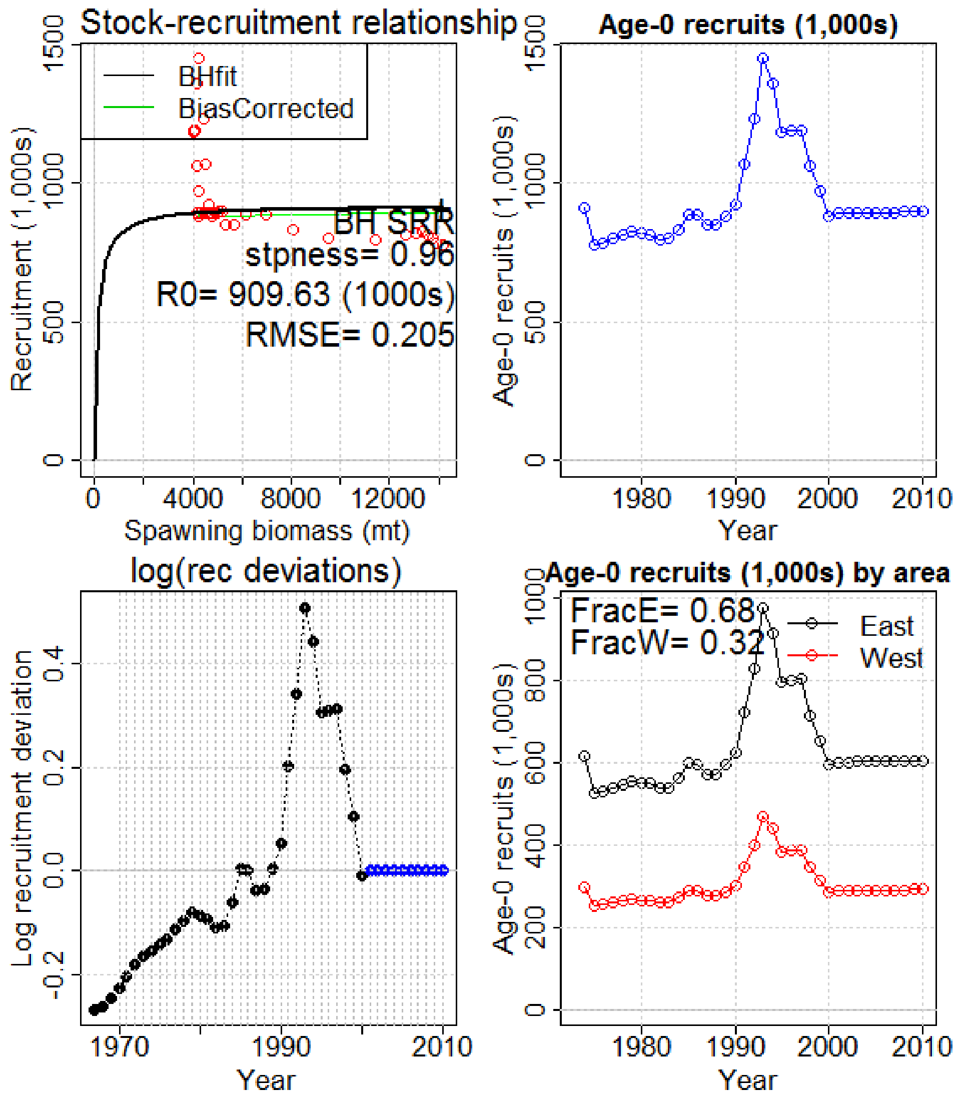


Figure 10. Total biomass, spawning depletion (relative to virgin SSB), total biomass by area and spawning stock biomass by area with increased weighting on the indices.

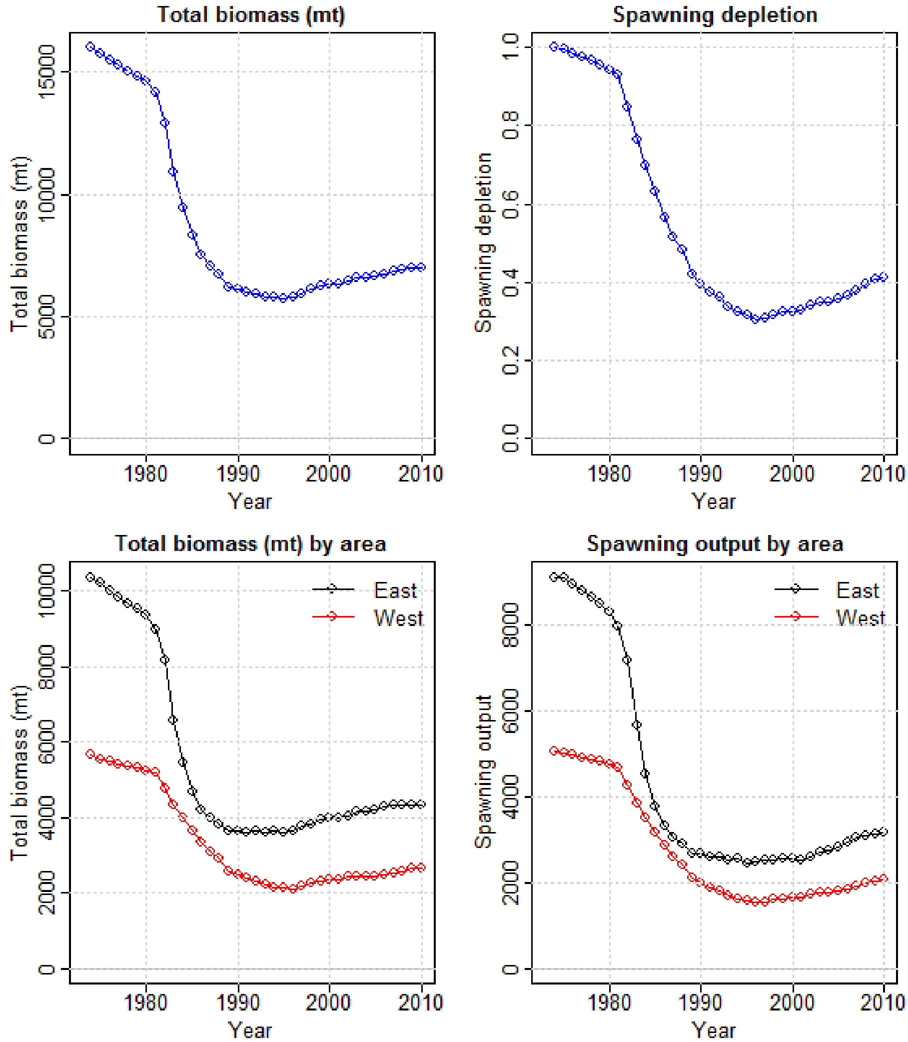


Figure 11. Comparison of the changing the model from SS3 3.10 to 3.20 and to correcting the CV on the NMFS bottom longline survey, exploitation rates (A), SSB (B) and recruitment (C). Changing from SS version 3.10 to 3.20 had very little impact and changing the CV alone had little impact, however the dual change did result in higher estimates of SSB, recruitment and lower exploitation rate with concomitant changes in benchmark quantities.

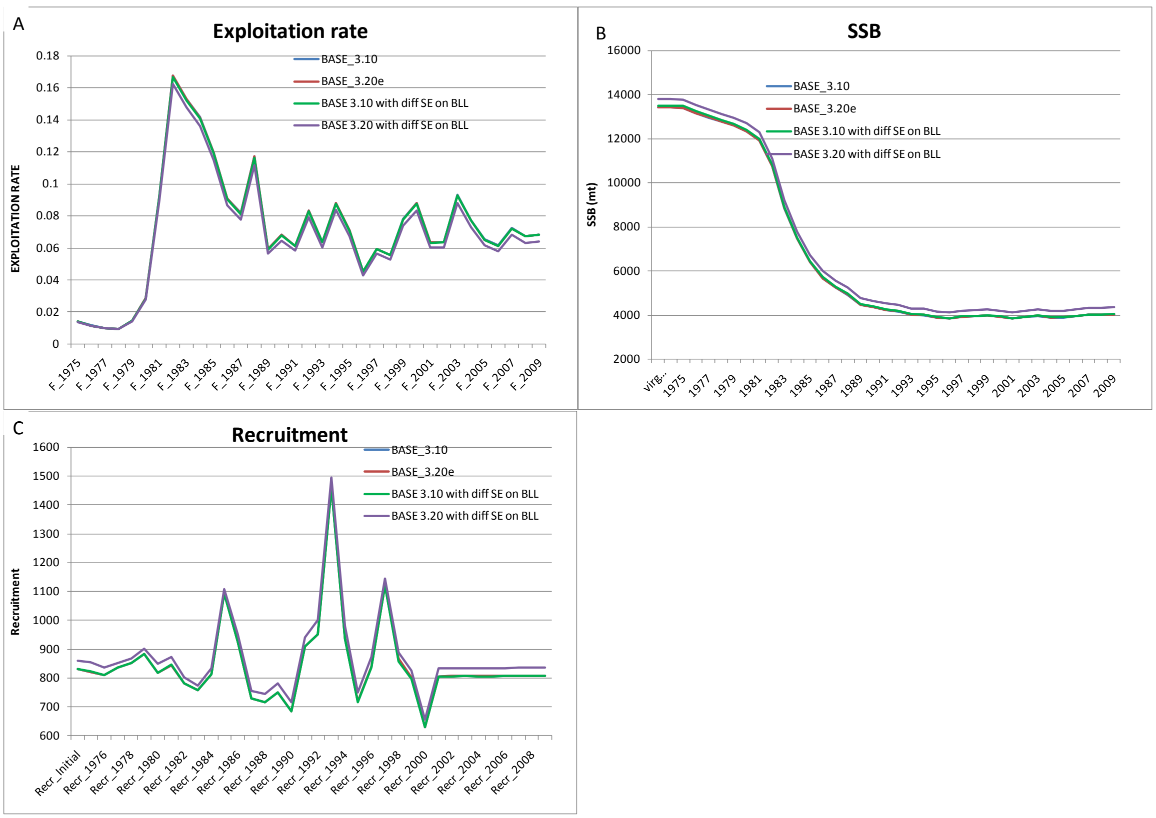


Figure 12. Deterministic projections of SSB, exploitation rate and yields for six model runs at $F_{SPR20\%}$, $F_{SPR30\%}$, $F_{SPR40\%}$, 75% of $F_{SPR30\%}$, 75% of $F_{SPR40\%}$ F_{MSY} and Fcurrent which is exploitation rate in 2009.

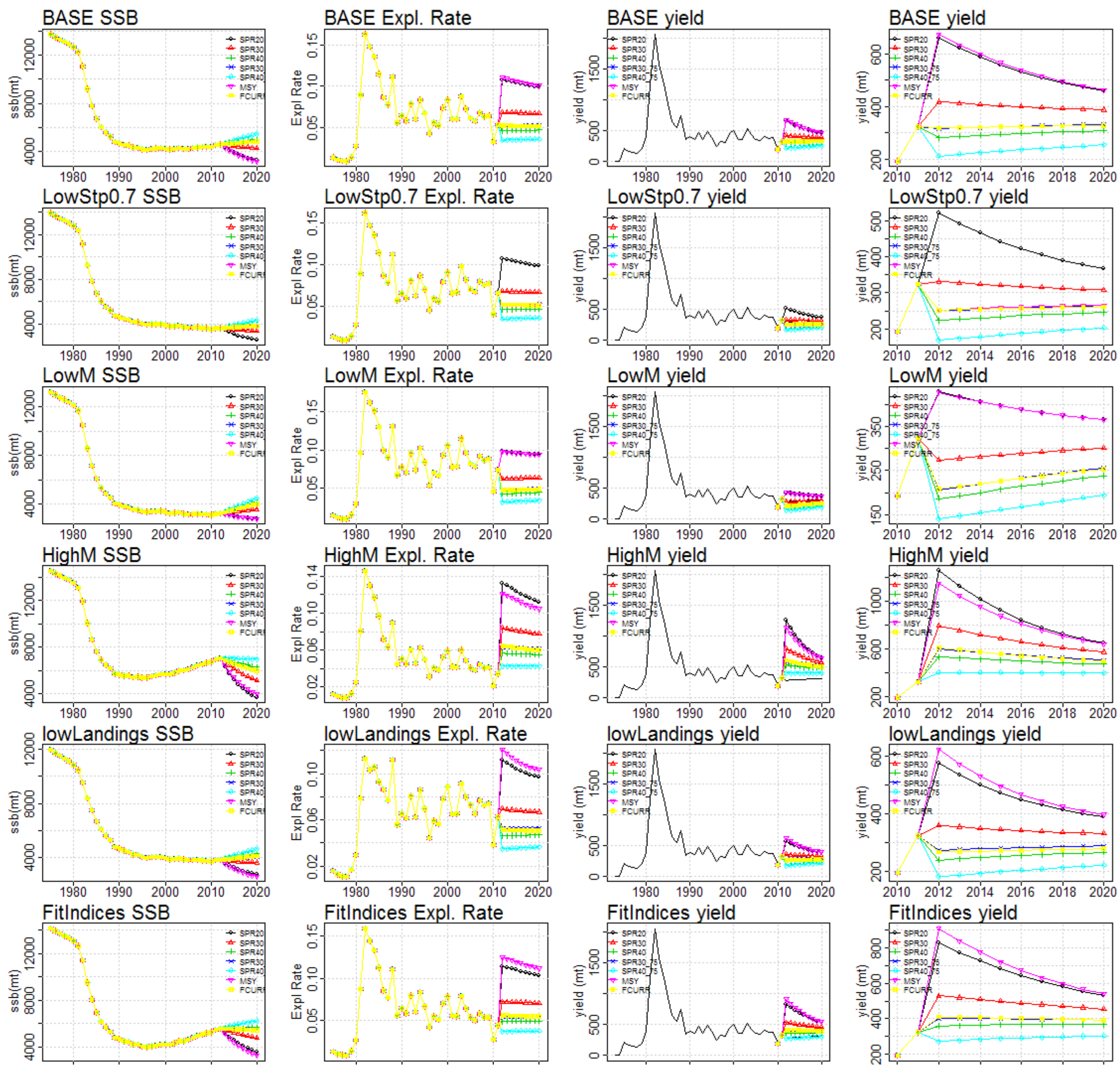


Figure 13. MCMC chains for key estimated and derived quantities for the BASE model. SPRtgt is SPR30%.

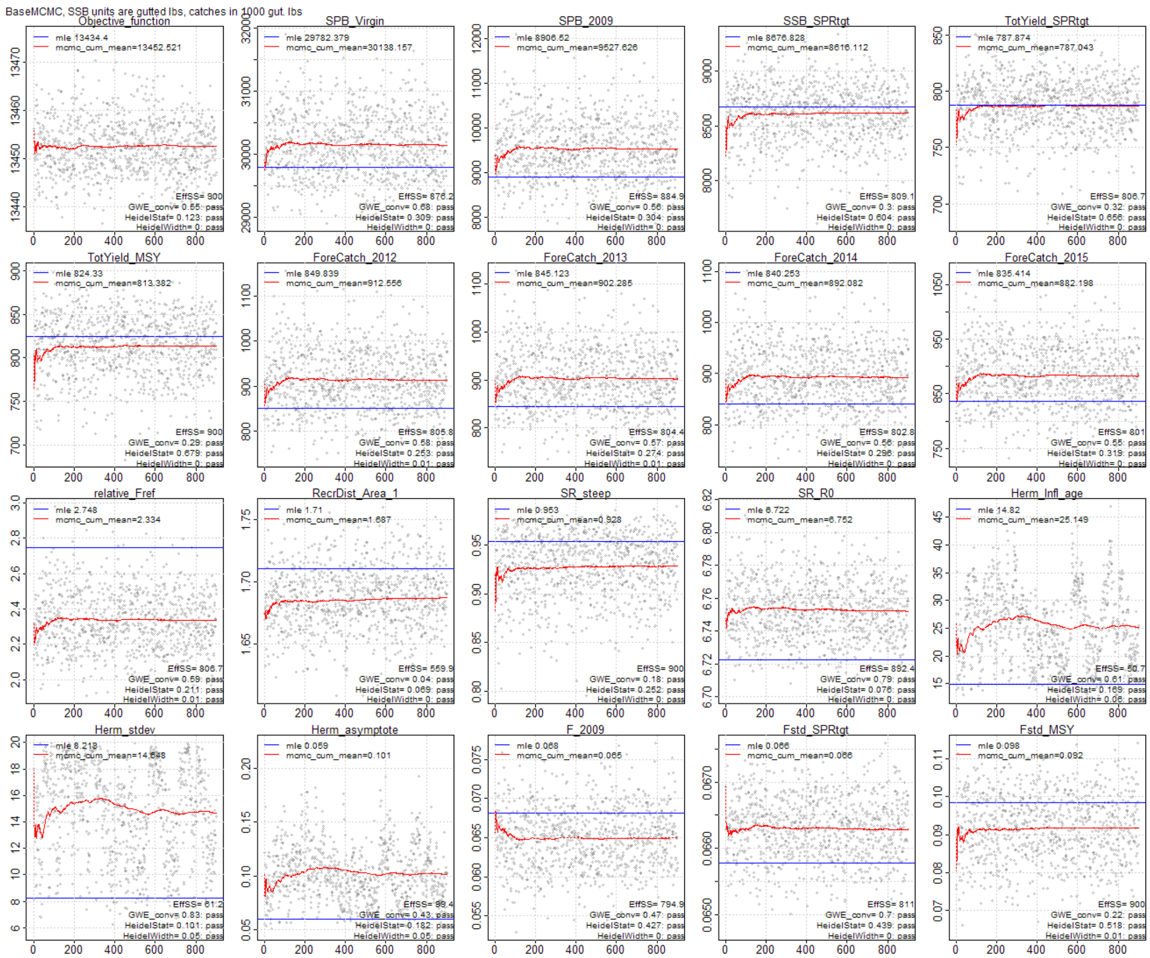


Figure 14. MCMC chains for key estimated and derived quantities for the low M model. SPRtgt is SPR30%.

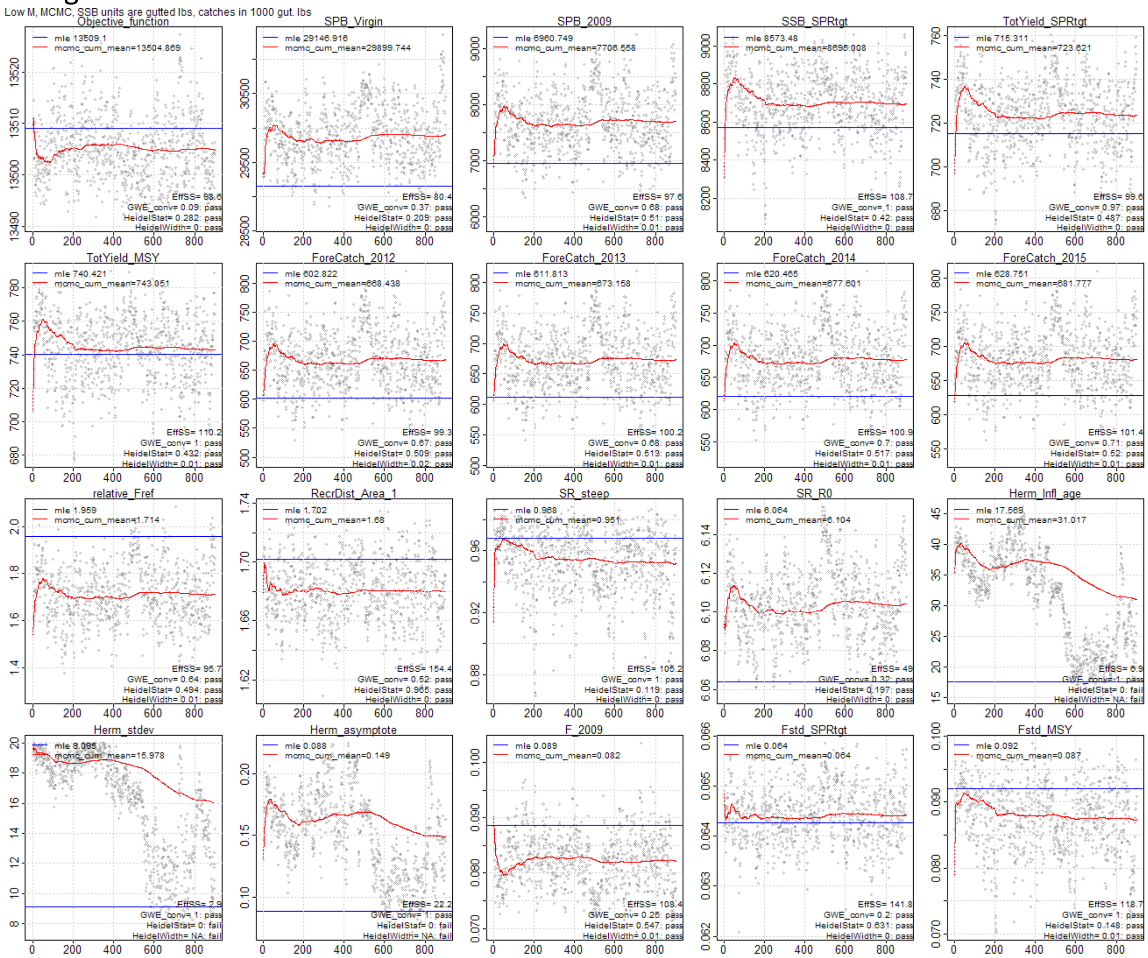


Figure 15. MCMC chains for key estimated and derived quantities for the increased weight on indices model. SPRtgt is SPR30%.

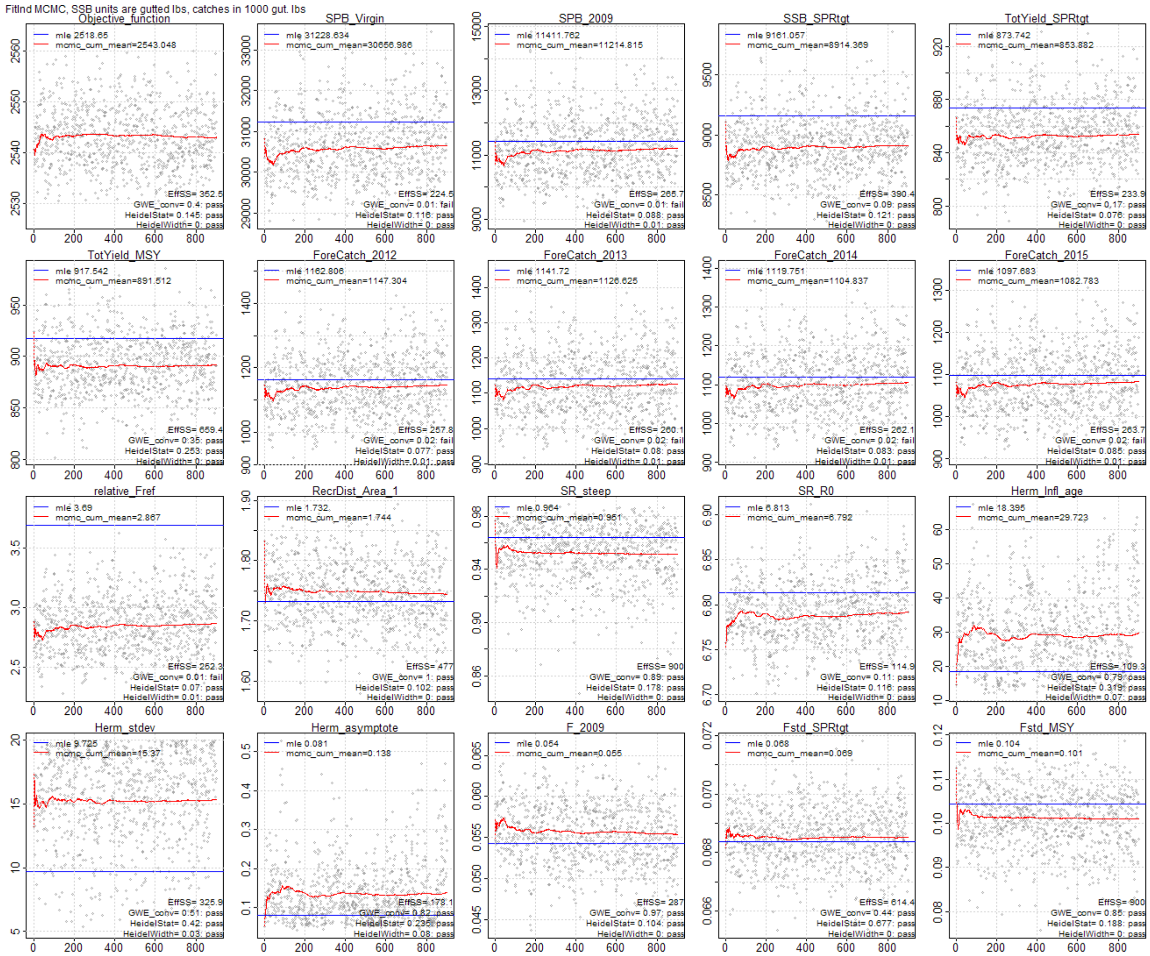


Figure 16. Histograms of MCMC values for key estimated and derived quantities for the BASE model. SPRtgt is SPR30%. The red line is the MCMC mean and the blue line is the MLE. Yields and biomass are in thousand gutted lbs.

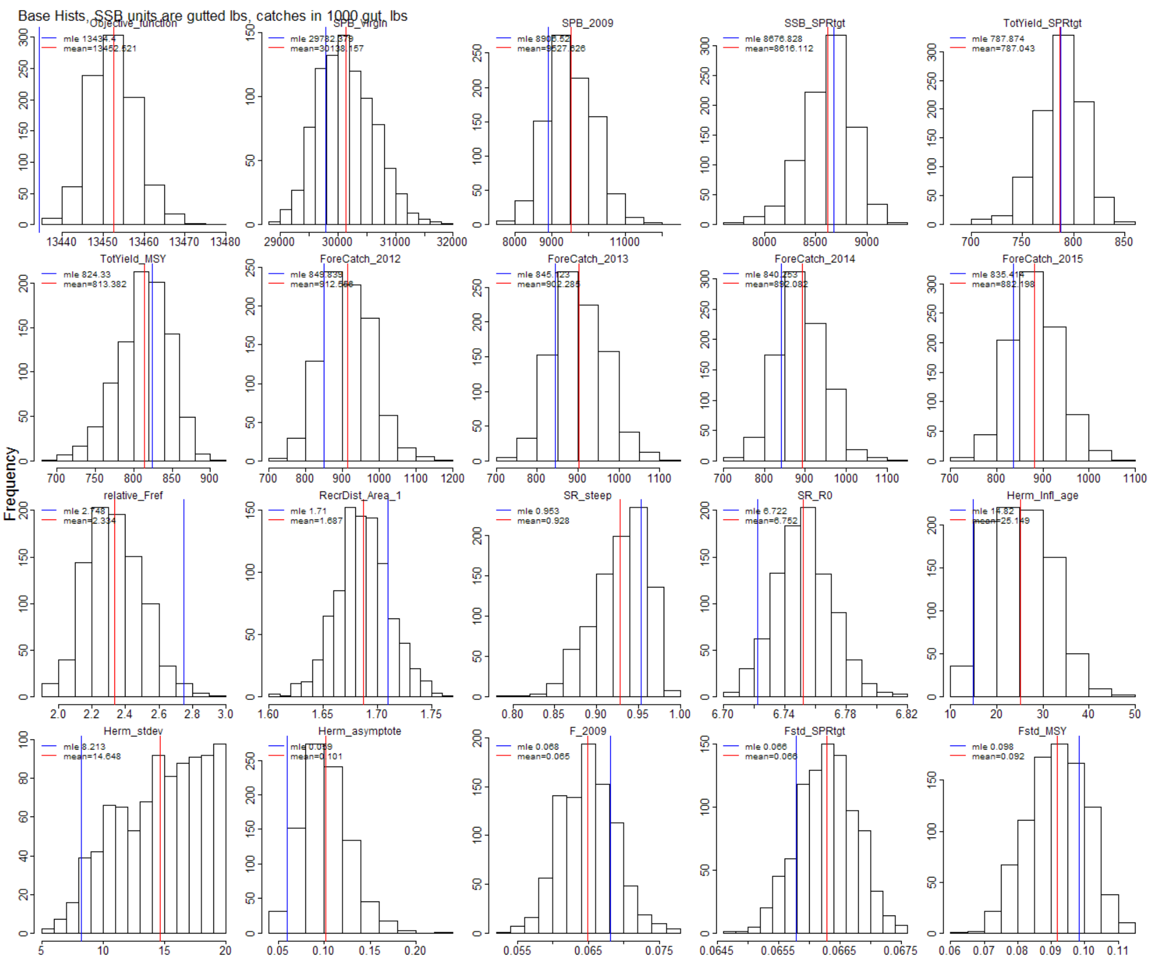


Figure 17. Histograms of MCMC values for key estimated and derived quantities for the Low M model. SPRtgt is SPR30%. The red line is the MCMC mean and the blue line is the MLE.

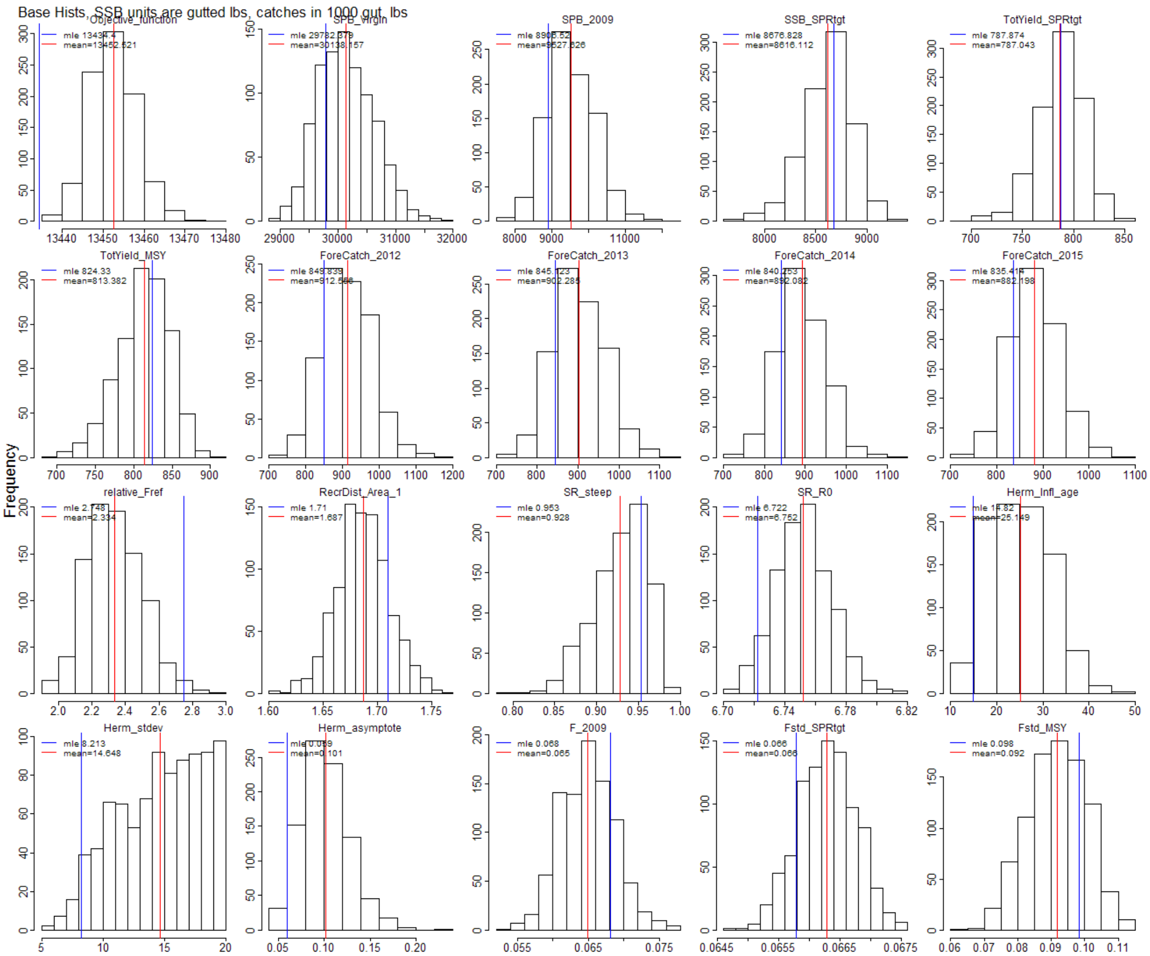


Figure 18. Histograms of MCMC values for key estimated and derived quantities for the increased weight on indices model. SPRtgt is SPR30%. The red line is the MCMC mean and the blue line is the MLE.

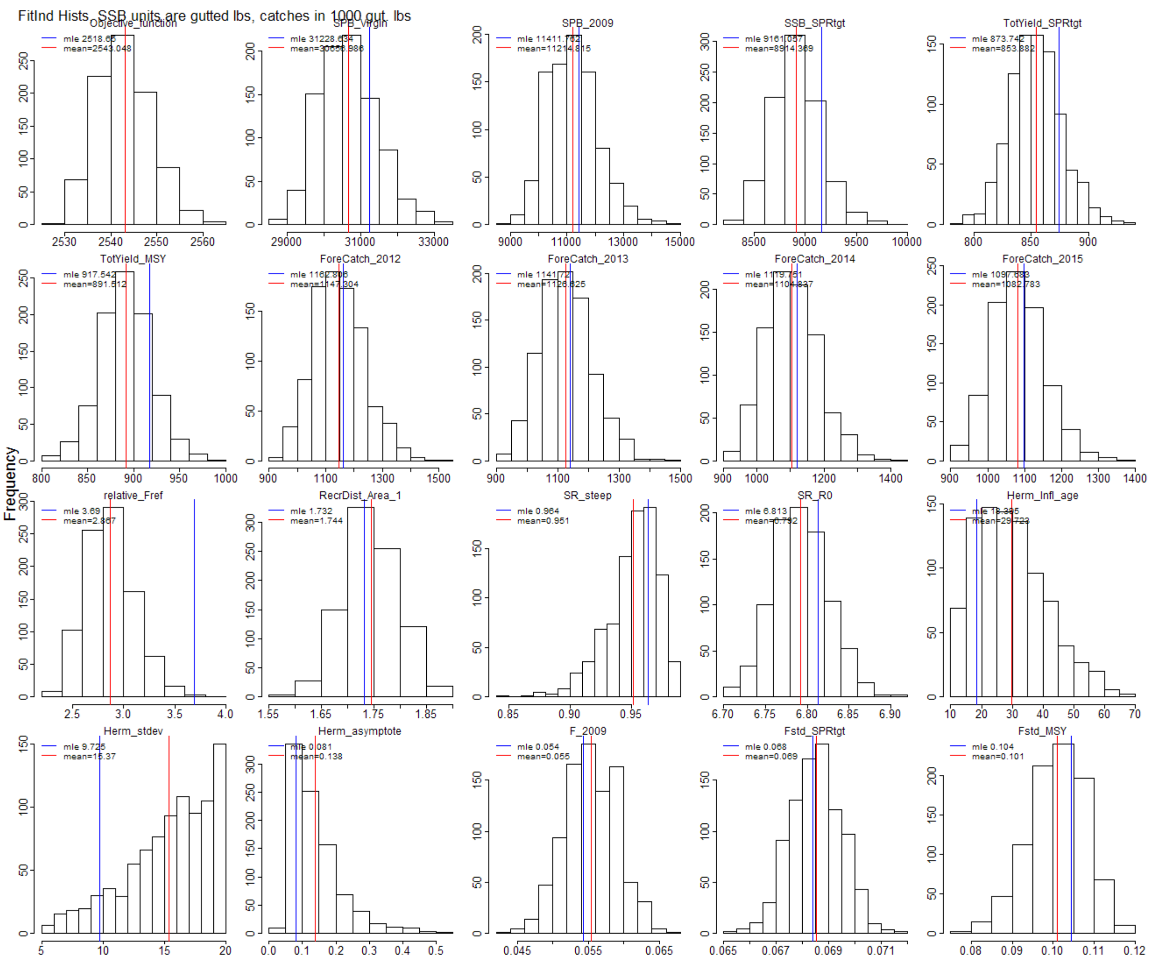
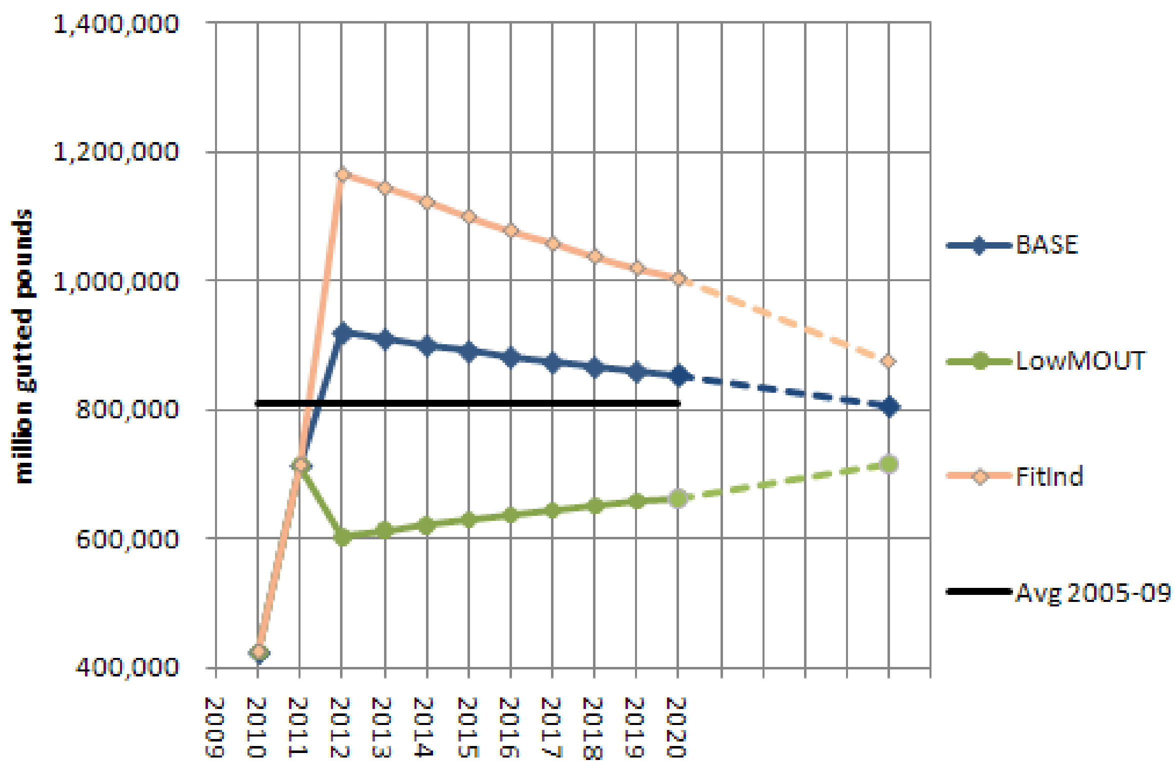


Figure 19. Short-term deterministic yield projections at FSPR30% for the Base, Low M and increased fit to the indices model. The equilibrium yields at FSPR30% are plotted as points on the far right. The black line is the average landings from 2005-2009 for reference.



Appendix. 1

Figure A.1. BASE model MCMC plots for all estimated parameters.

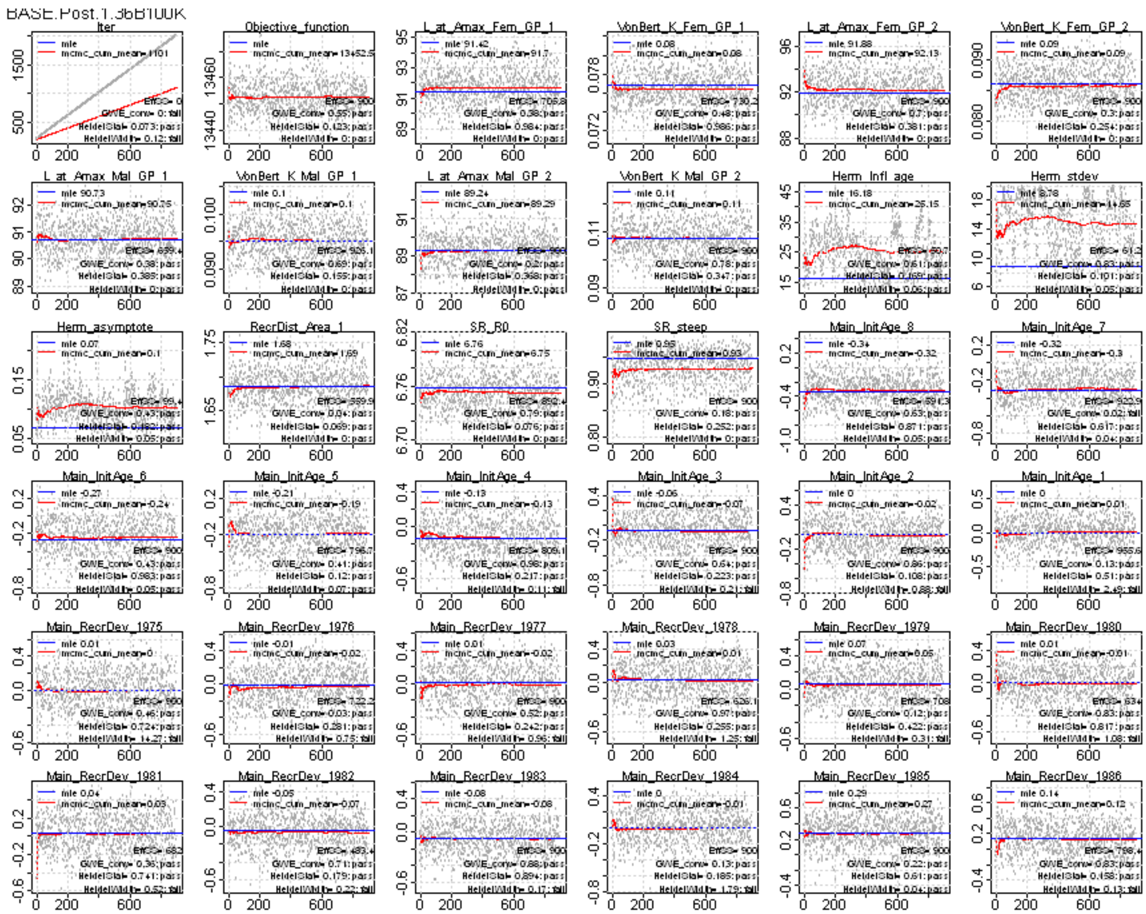


Figure A.1, cont. BASE model MCMC plots for all estimated parameters.

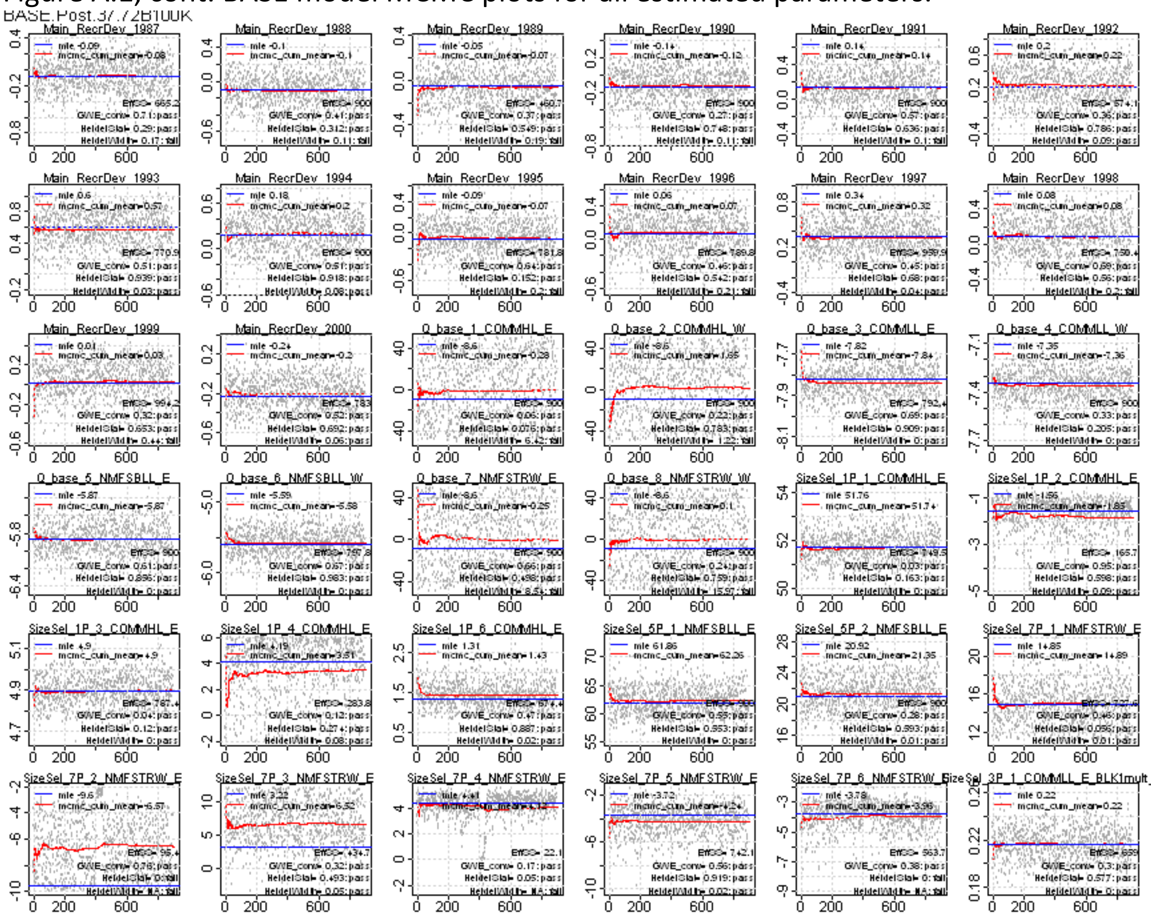


Figure A.1, cont.. BASE model MCMC plots for all estimated parameters.

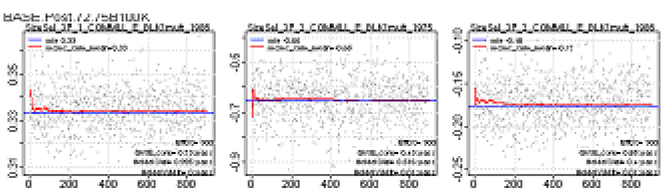


Figure A.2. BASE model MCMC plots for all derived spawning stock biomass.

Figure A.3. BASE model MCMC plots for derived recruitments.

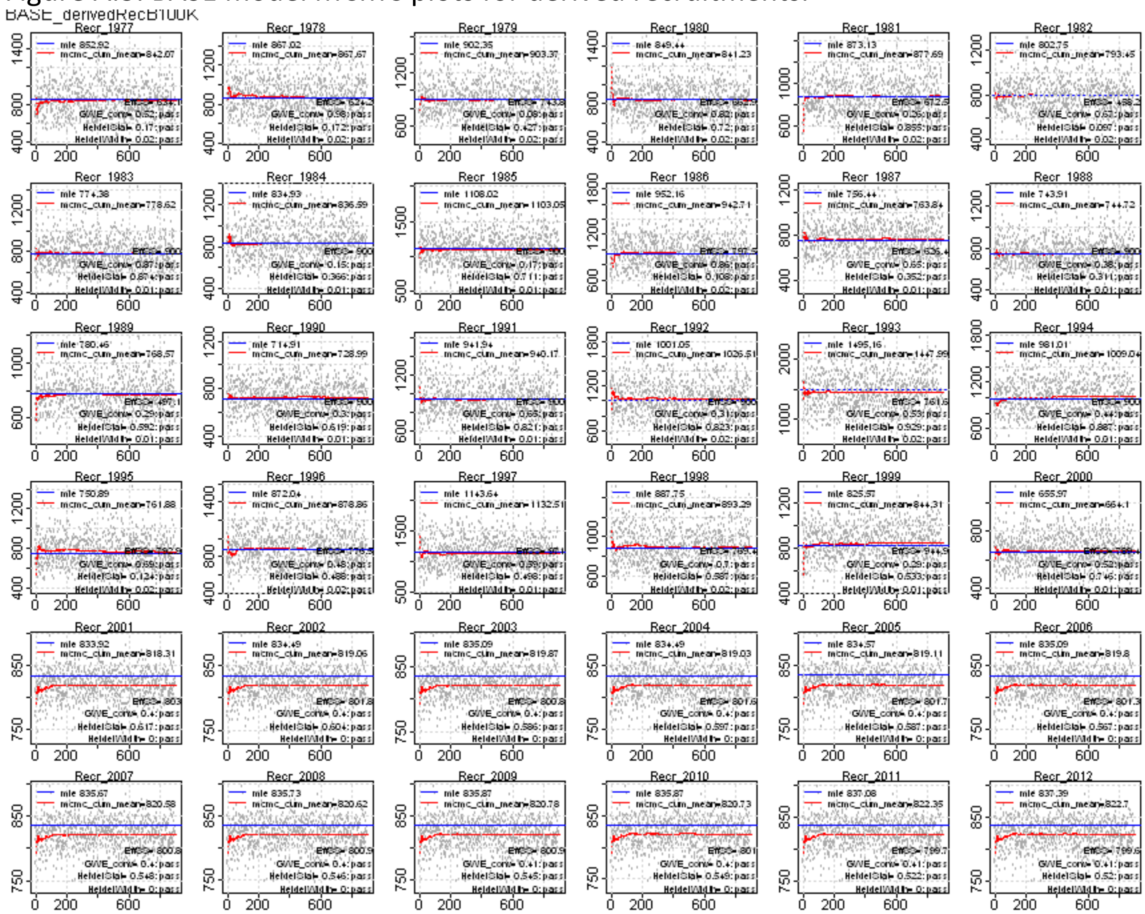


Figure A.4. BASE model MCMC plots for derived fishing mortality (exploitation rate).

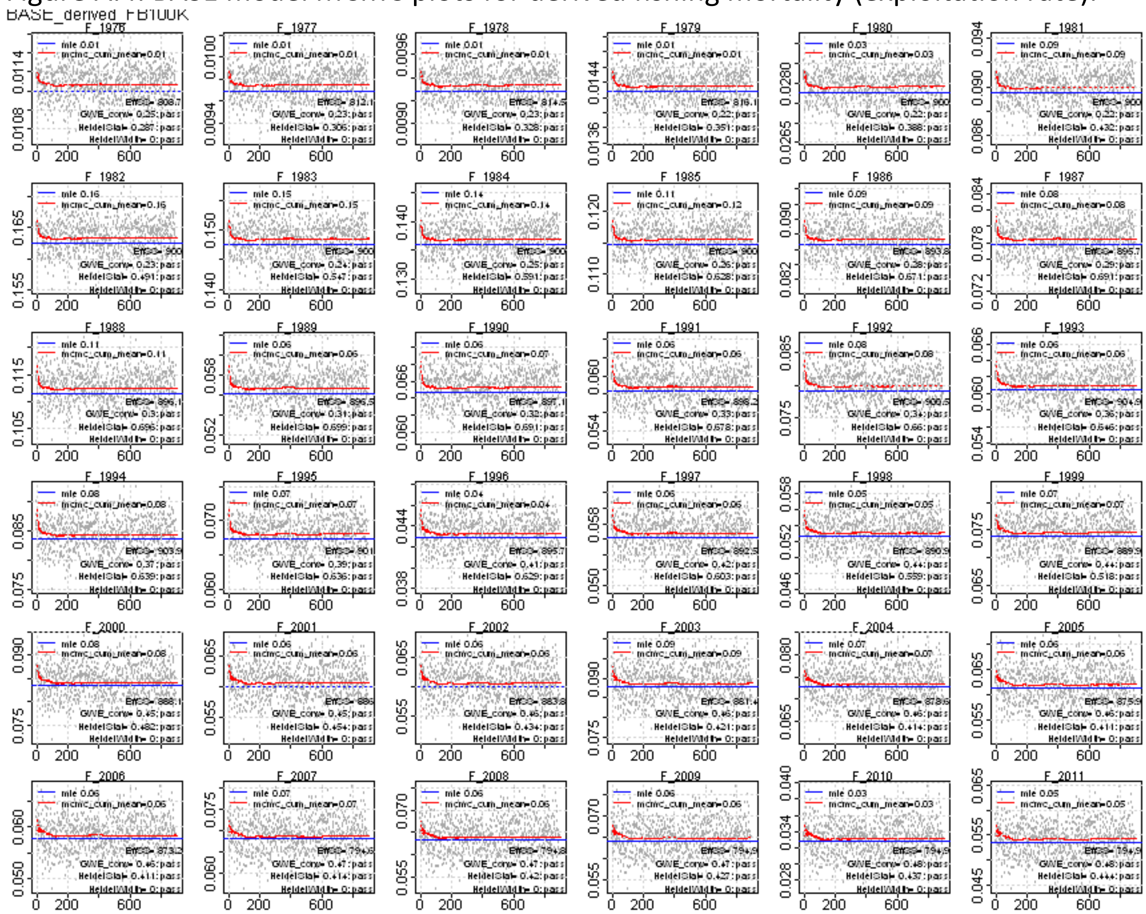


Figure A.5. BASE model MCMC plots for benchmarks and forecast catches.

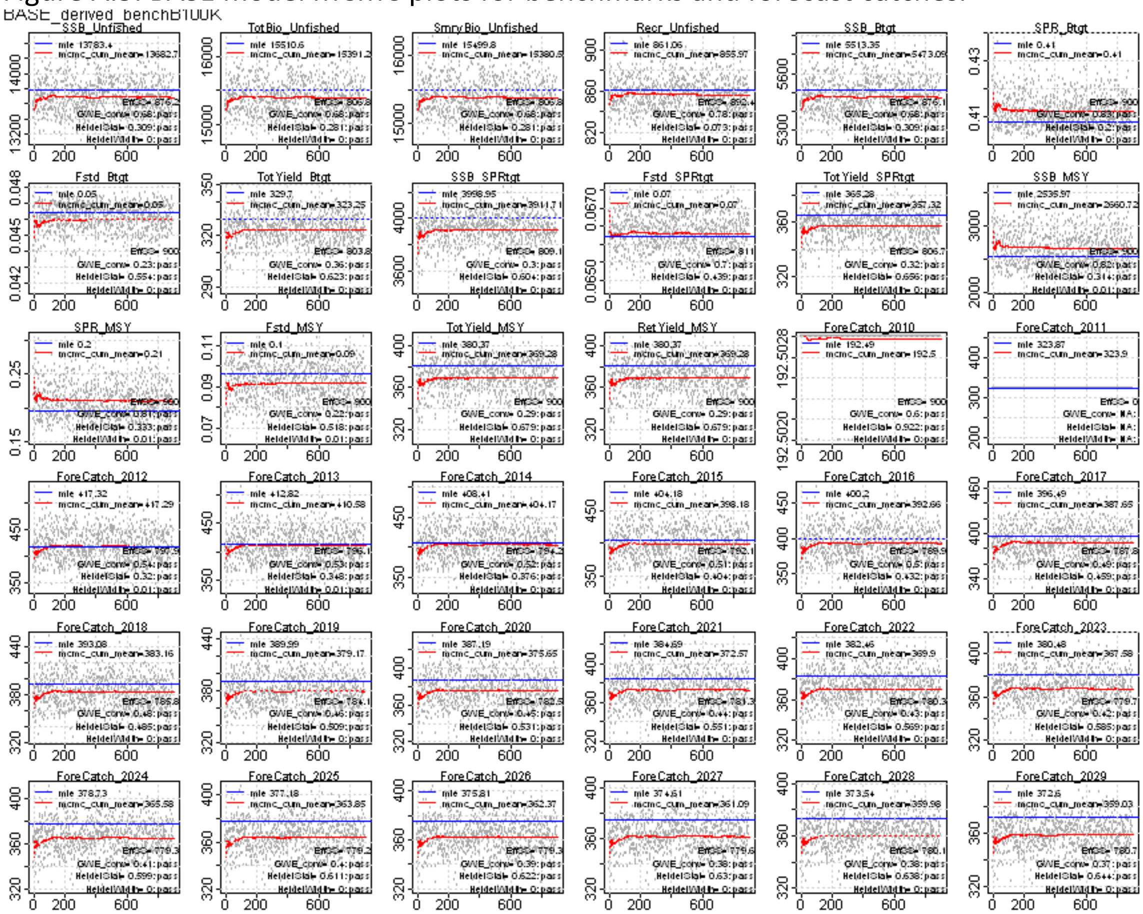


Figure B.1. Low M model MCMC plots for all estimated parameters.

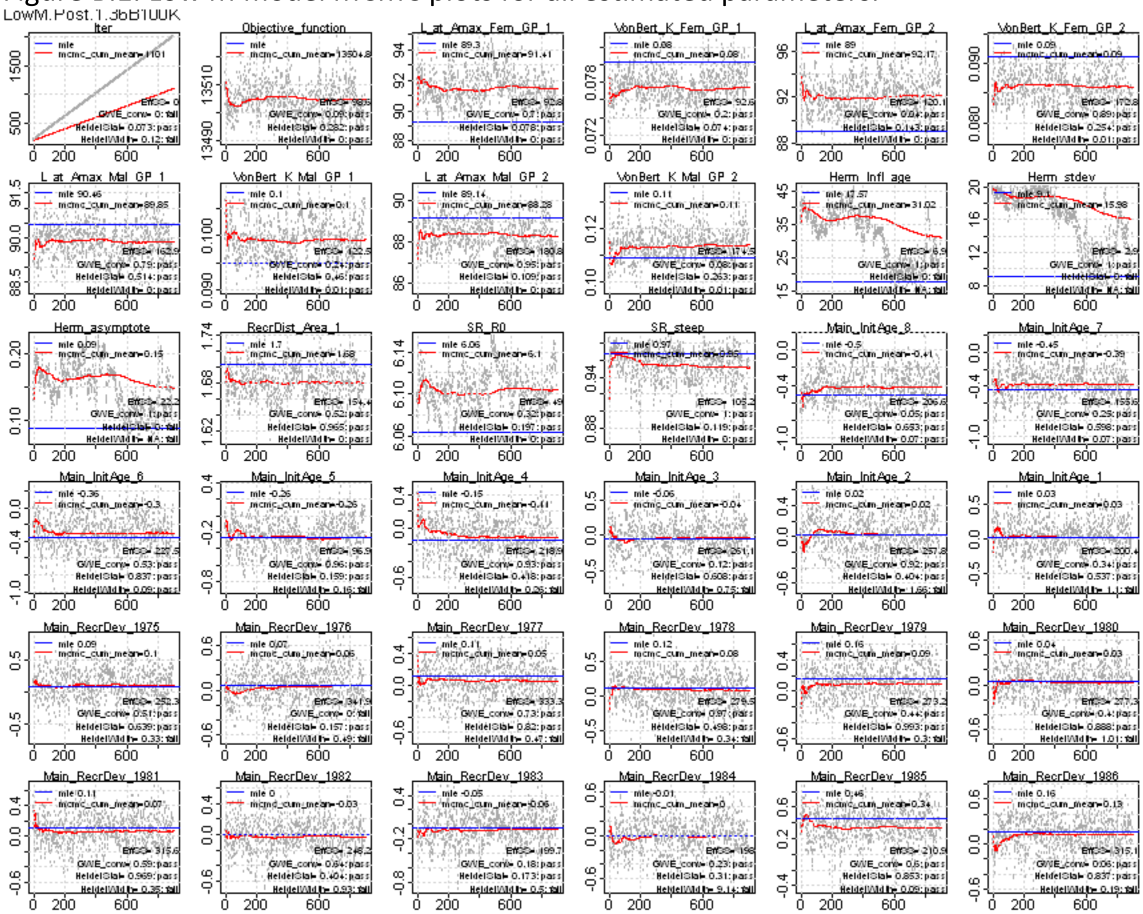


Figure B.1., cont. Low M model MCMC plots for all estimated parameters.

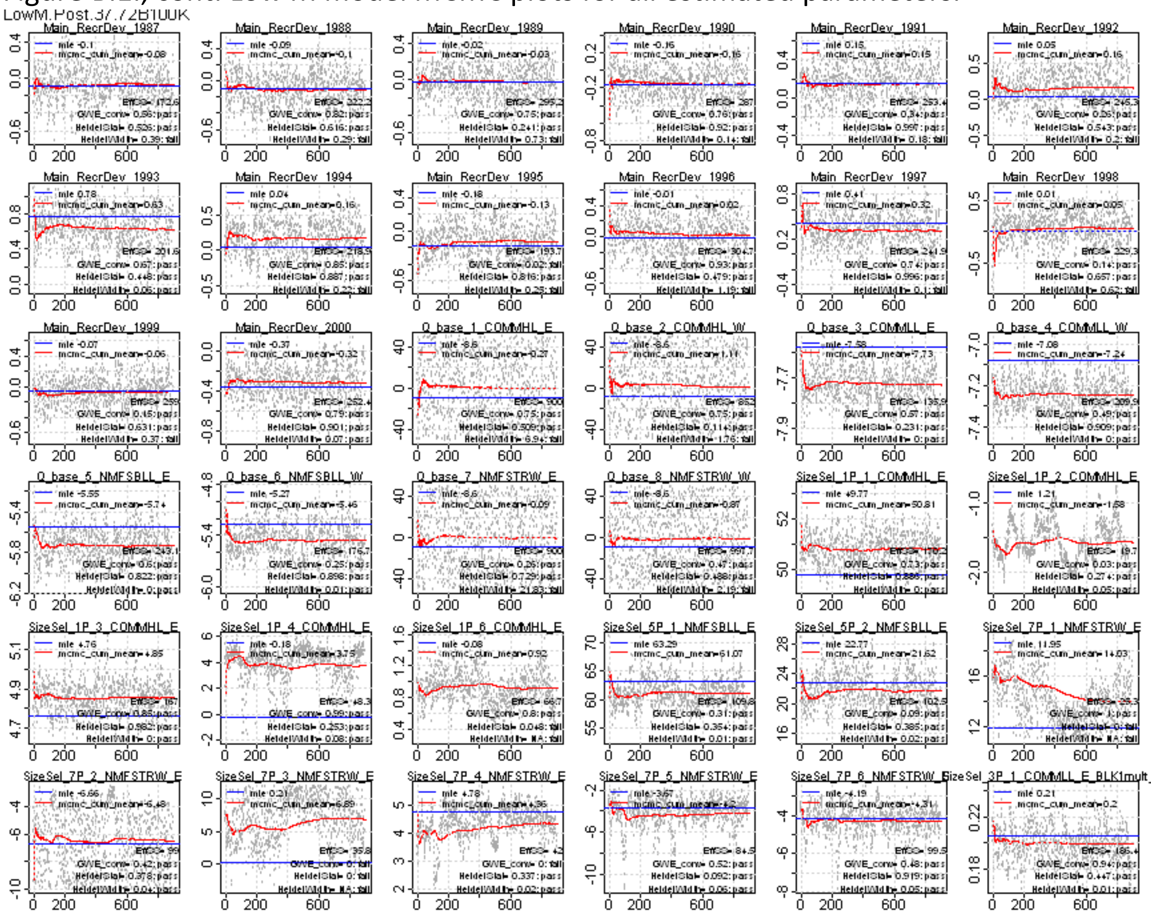


Figure B.1., cont. Low M model MCMC plots for all estimated parameters.

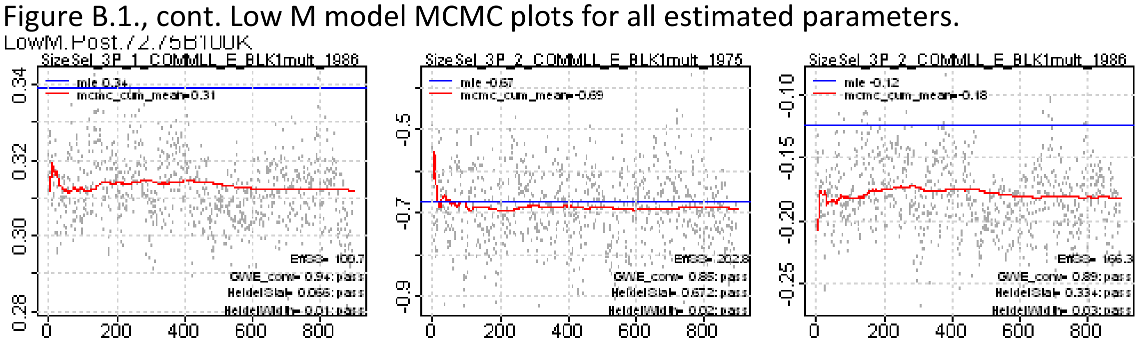


Figure B.2. Low M model MCMC plots for derived spawning stock biomass.

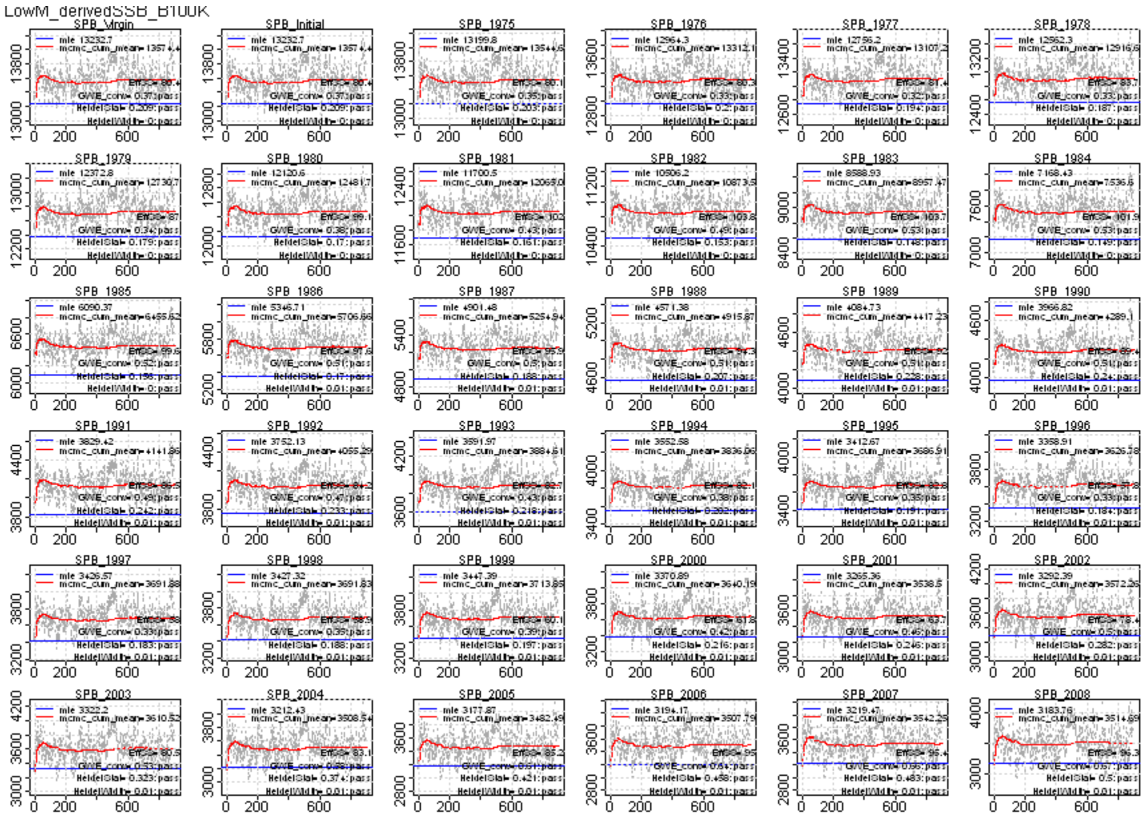


Figure B.3. Low M model MCMC plots for derived recruitments.

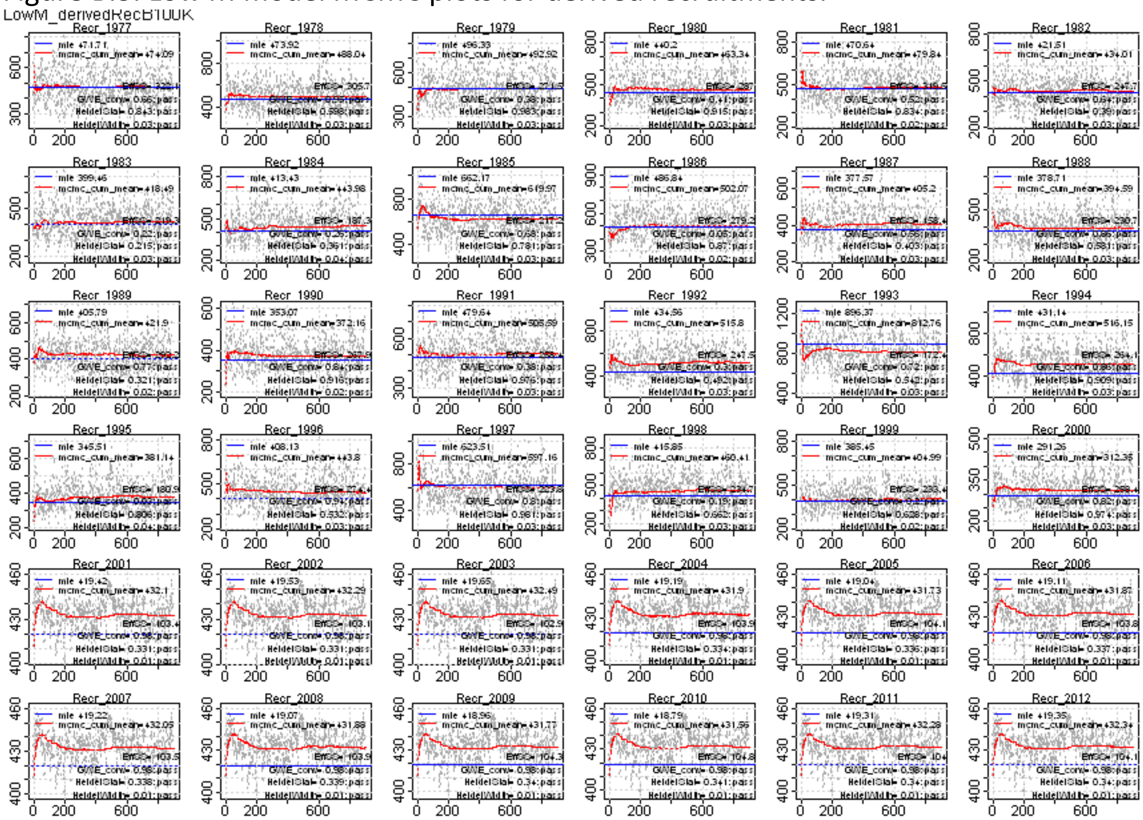


Figure B.4. Low M model MCMC plots for derived fishing mortality (exploitation rate).

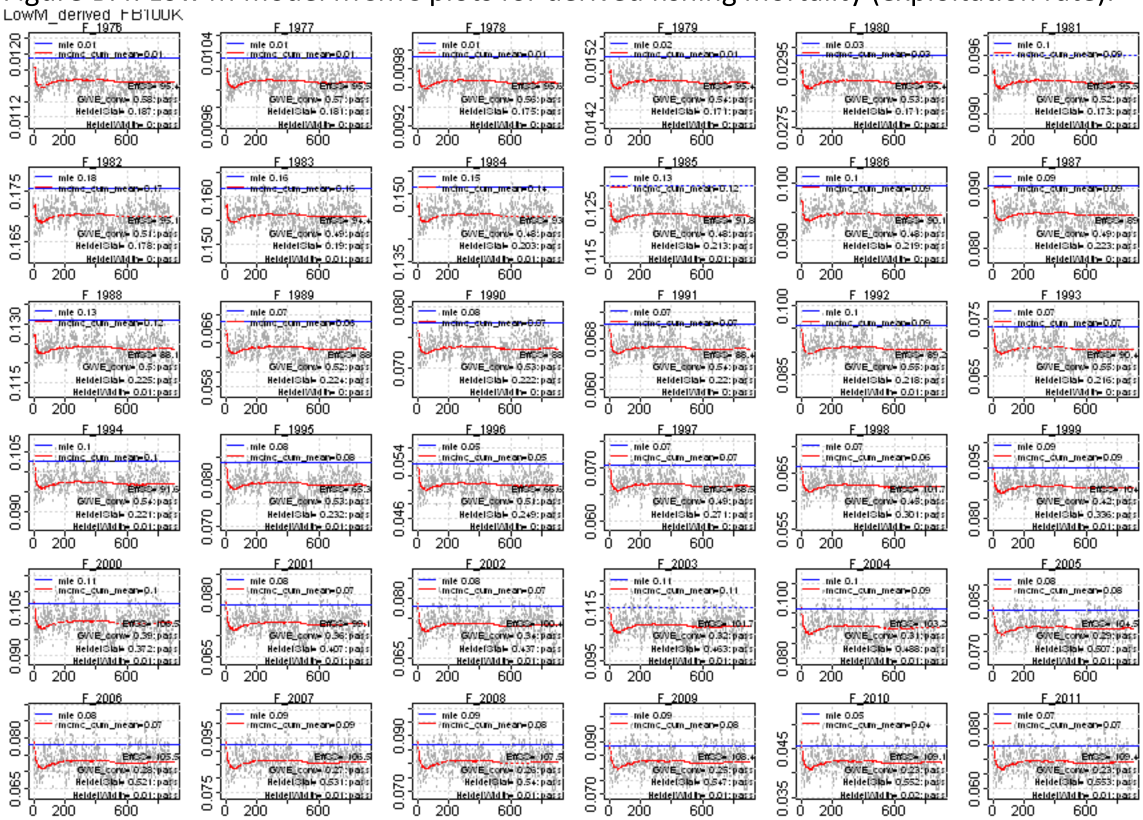


Figure B.5. Low M model MCMC plots for benchmarks and forecast catches.

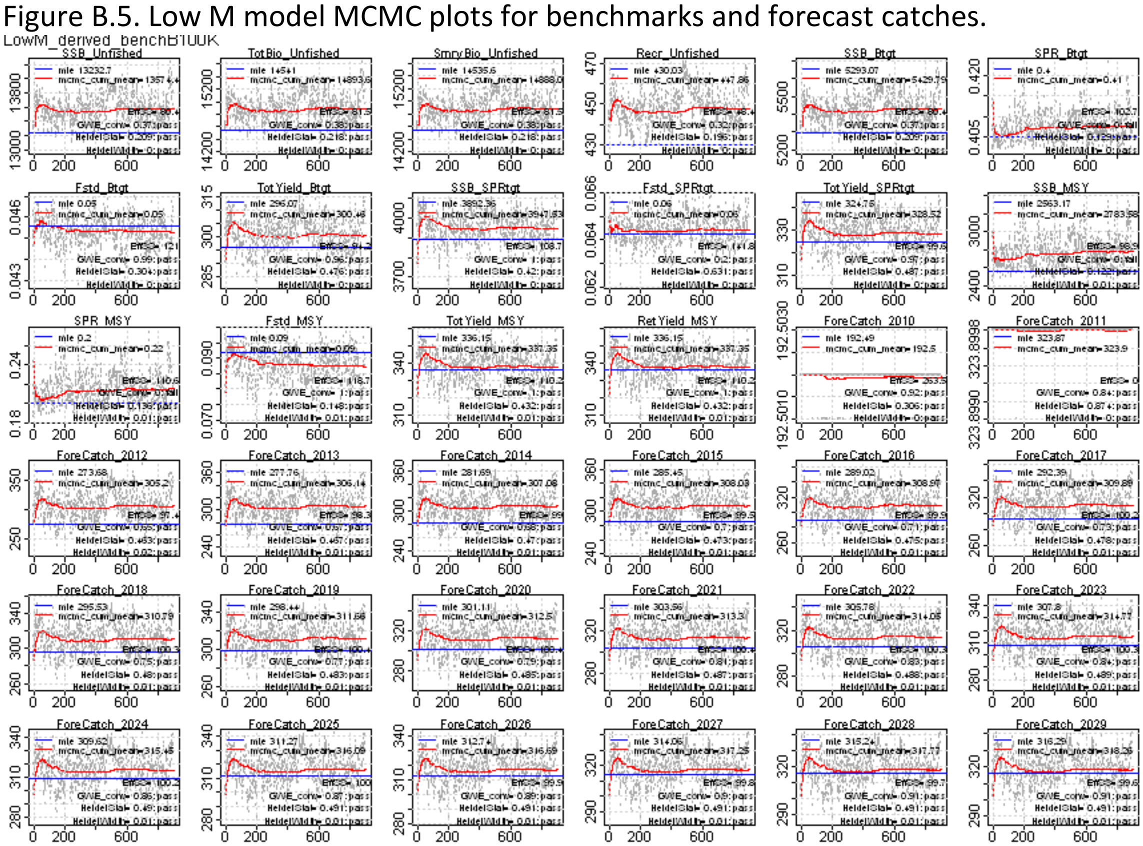


Figure C.1. Fit indices model MCMC plots for all estimated parameters.

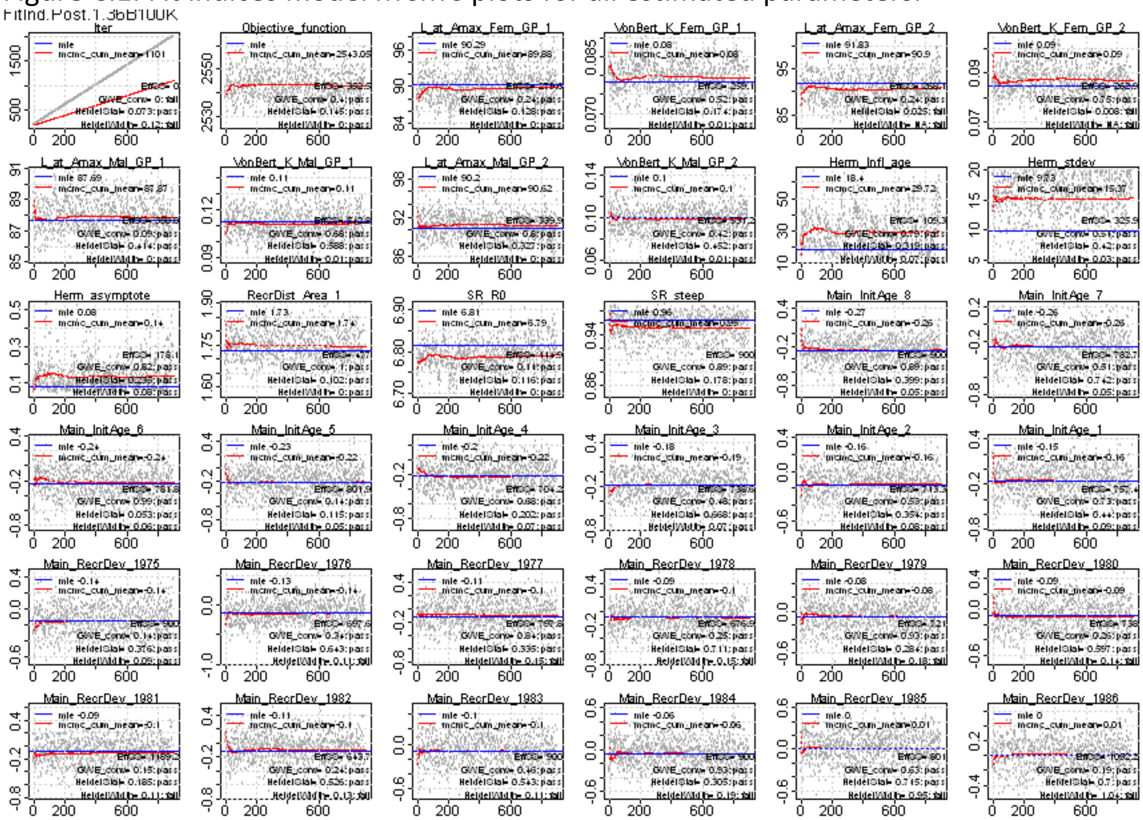


Figure C.1., cont. Fit indices model MCMC plots for all estimated parameters.

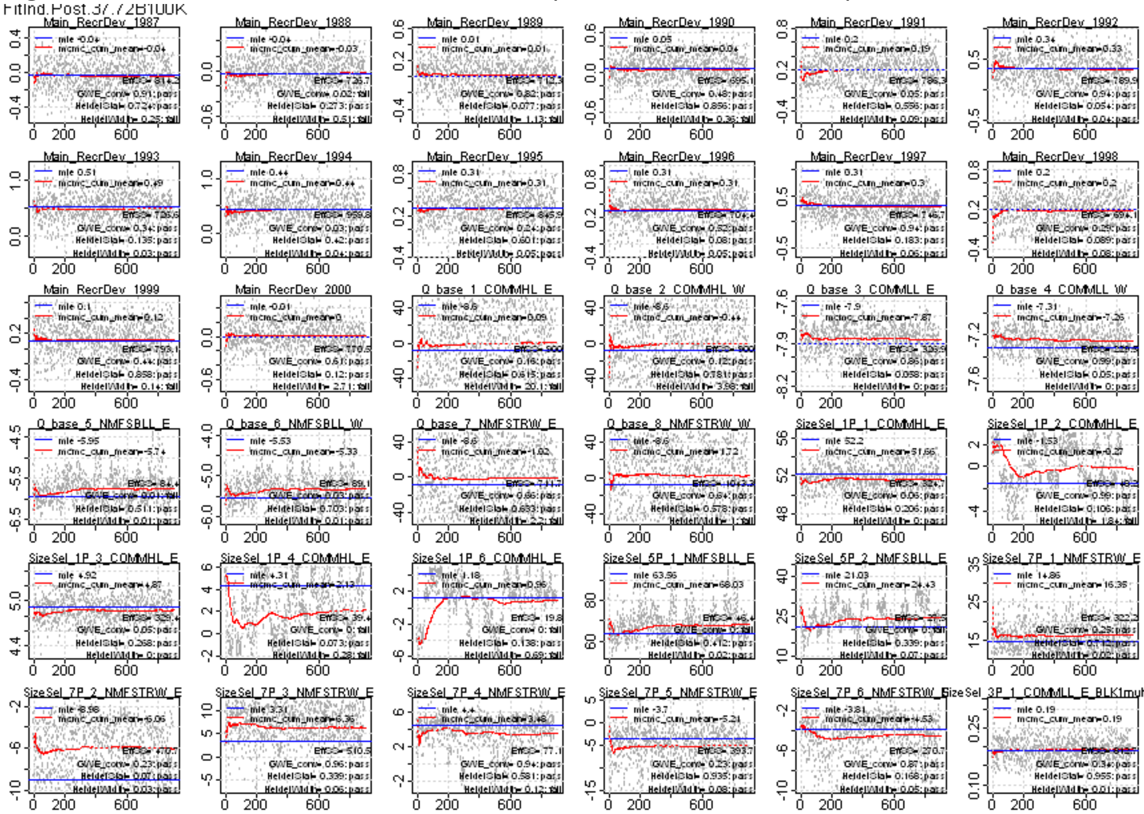


Figure C.1., cont. Fit indices model MCMC plots for all estimated parameters.

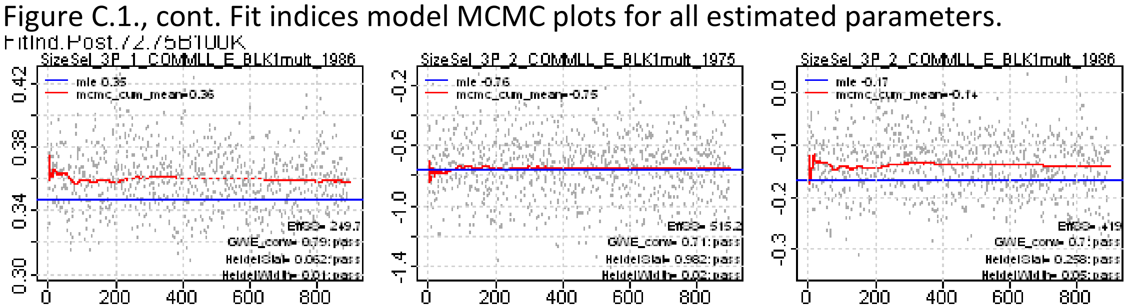


Figure C.2. Fit indices model MCMC plots for derived spawning stock biomass.

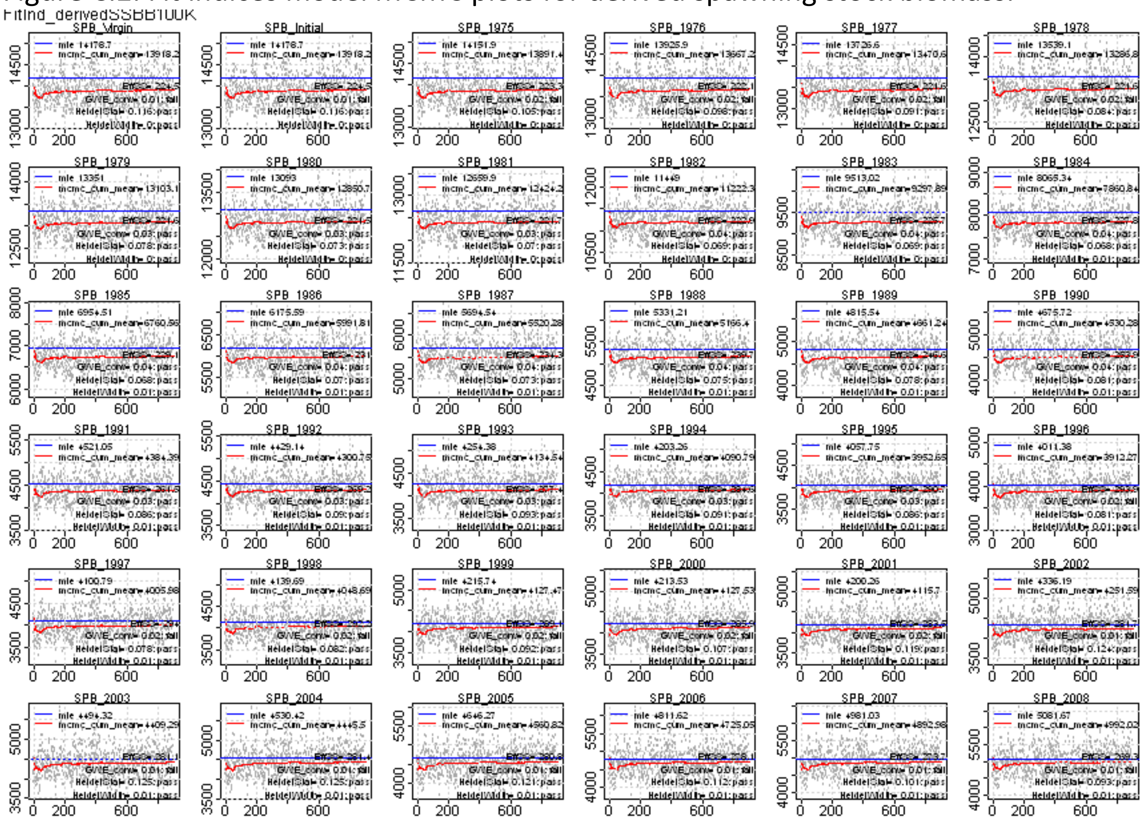


Figure C.3. Fit indices model MCMC plots for derived recruitments.

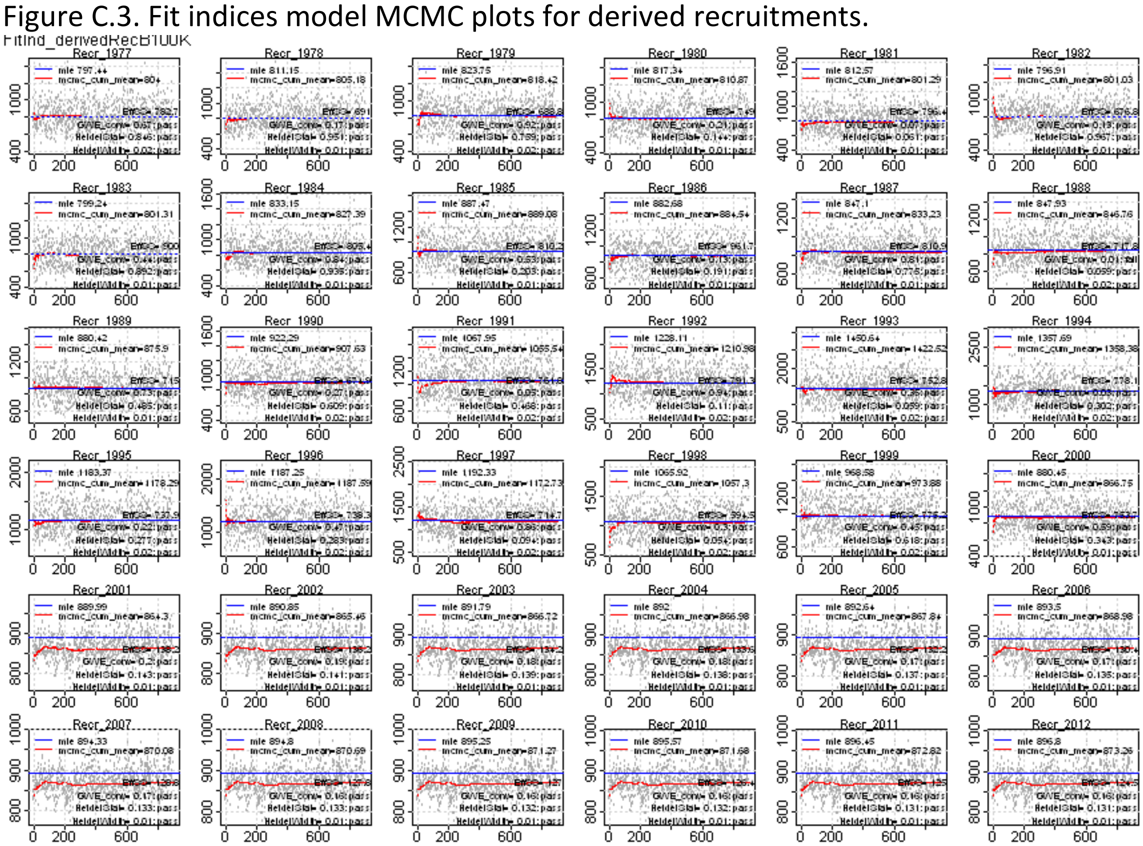


Figure C.4. Fit indices MCMC plots for derived fishing mortality (exploitation rate).

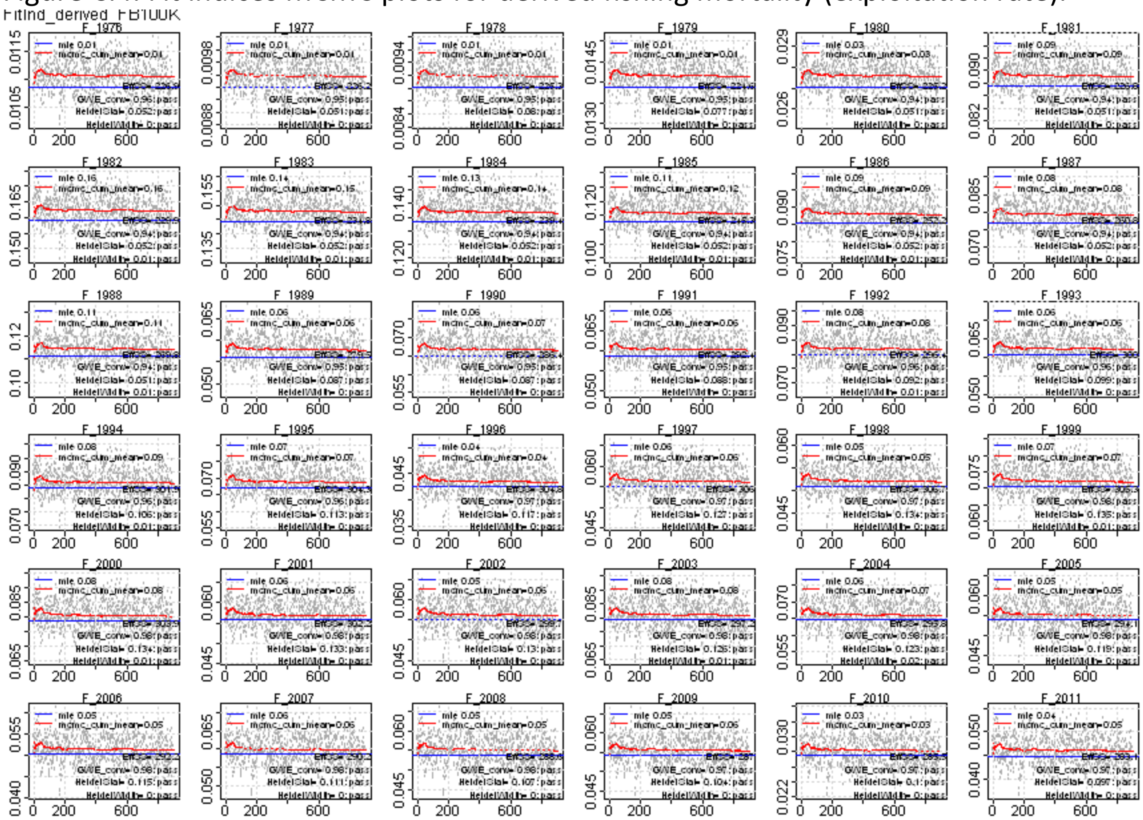


Figure C.5. Fit indices model MCMC plots for benchmarks and forecast catches.