SEDAR

Southeast Data, Assessment, and Review

SEDAR 19
Stock Assessment Report

Gulf of Mexico and South Atlantic Black Grouper

March 2010

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

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SECTION I: Introduction

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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 three workshops. First is the Data Workshop, during which fisheries, monitoring, and life history data are reviewed and compiled. Second is the Assessment workshop, during which assessment models are developed and population parameters are estimated using the information provided from the Data Workshop. Third and final is the Review Workshop, during which independent experts review the input data, assessment methods, and assessment products. 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 one reviewer appointed by each council having jurisdiction over the stocks assessed. The Review Workshop Chair is appointed by the SEFSC director and is usually selected from a NOAA Fisheries regional science center. Participating councils may appoint representatives of their SSC, Advisory, and other panels as observers.

2. MANAGEMENT OVERVIEW

2.1 *FISHERY MANAGEMENT PLAN AND AMENDMENTS*

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

Oiginal SAMFC FMP

The Fishery Management Plan (FMP), Regulatory Impact Review, and Final Environmental Impact Statement for the Snapper-Grouper Fishery of the South Atlantic Region, approved in 1983 and implemented in August of 1983, establishes a management regime for the fishery for snappers, groupers and related demersal species of the Continental Shelf of the southeastern United States in the fishery conservation zone (FCZ) under the area of authority of the South Atlantic Fishery Management Council and the territorial seas of the states, extending from the North Carolina/Virginia border through the Atlantic side of the Florida Keys to 83o W longitude. In the case of the sea basses, the management regime applies only to south of Cape Hatteras, North Carolina. Regulations apply only to Federal waters.

Measures in the original FMP that would have affected black grouper included the 4" trawl mesh size regulation.

SAFMC FMP Amendments affecting black grouper

Description of Action	FMP/Amendment	Effective Date
Prohibit trawls	Amendment 1 (SAFMC 1988)	1/12/89
Prohibit fish traps, entanglement nets & longlines within 50 fathoms; Aggregate bag limit of 5 groupers per person per day excluding Nassau and goliath grouper[1]; Black grouper 20" TL commercial and recreational minimum size limit	Amendment 4 (SAFMC 1991)	1/1/92

Oculina Experimental Closed Area	Amendment 6 (SAFMC 1993)	6/27/94
Limited entry program: transferable permits and 225-lb non-transferable permits	Amendment 8 (SAFMC 1997)	12/98
Black grouper 24" TL commercial and recreational minimum size limit; During March and April of each year, no black grouper harvest or possession greater than the bag limit and no purchase or sale; Within the 5 fish aggregate grouper bag limit, no more than 2 fish may be gag or black grouper (individually or in combination); Vessels with longlines may only possess deepwater species	Amendment 9 (SAFMC 1998a)	2/24/99
MSY proxy for black grouper is 30% static SPR; OY proxy is 45% static SPR	Amendment 11 (SAFMC 1998b)	12/2/99
Establish eight deepwater Type II marine protected areas to protect a portion of the population and habitat of long-lived deepwater snapper grouper species	Amendment 14 (SAFMC 2007)	2/12/09
Reduce the 5 aggregate grouper bag limit to 3; Reduce the 2 gag/black bag (individually or in combination) bag limit from 2 to 1; when gag quota met, prohibit harvest of, possession, and retention of shallow water groupers (which includes black grouper)	Amendment 16 (SAFMC 2008)	**IN NOAA REVIEW – REGULATIONS NOT ESTABLISHED**

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. Black 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 black 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.

The FMP also list Florida's management history, documenting a minimum size limit for black grouper of 12 inches fork length (FL) in the early 1980s.

GMFMC FMP Amendments affecting black grouper

Description of Action	FMP/Amendment	Effective Date
Set a 20-inch total length minimum size limit on black grouper Commercial grouper quota was set at 11.0 mp, broken down into SWG which includes black grouper set at 9.2 mp. A recreational bag limit of 5 grouper in aggregate was established, with a 2-day bag limit allowed for fishers on qualified for0hire vessels that were out over 24 hours. The stressed area was expanded, and a longline/buoy gear boundary was established. The number of fish traps allowed per vessel was reduced from 200 to 100. Reef fish permits were required for commercial reef fish vessels. Commercial harvest of reef fish using trawls or entangling nets was prohibited. Reporting requirements established for commercial and for-hire recreational vessels	Amendment 1 (GMFMC 1990)	2/21/90
Established a moratorium on the issuance of new commercial reef fish permits for three years. TAC was specified from April to August	Amendment 4 (GMFMC 1992)	5/8/92
Established additional restrictions on the use of fish traps and closed the region of Riley's Hump (near Dry Tortugas, Florida) to all fishing during May and June.	Amendment 5 (GMFMC 1994)	2/7/94
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) 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.	Amendment 11 (GMFMC 1996)	1/1/96
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 for another five years, from its	Amendment 17	8/2/00

previous expiration date of December 31, 2000 to December 31, 2005, unless replaced sooner by a comprehensive controlled access system.	(GMFMC 2000)	
(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
Establishes two marine reserves off the Dry Tortugas prohibiting fishing for any species and anchoring by fishing vessels.	Amendment 19 (GMFMC 2002)	8/19/02
Established a three year moratorium on the issuance of charter and headboat vessel permits in the recreational for-hire reef fish fisheries in the Gulf EEZ.	Amendment 20 (GMFMC 2001)	7/29/02
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 reef fish for-hire permit moratorium that expired in June 2006 with a permanent 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
Proposes to rationalize effort and reduce overcapacity in the commercial grouper and tilefish fisheries in order to achieve and maintain	Amendment 29	**IN NOAA REVIEW – REGULATIONS**

OY. Several management alternatives including Individual Fishing Quota (IFQ) programs are developed to achieve these objectives.	(GMFMC 2009)	**NOT ESTABLISHED**
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 six 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)	Final rule under review

Gulf of Mexico Council Regulatory Amendments

A July 1991 regulatory amendment was implemented in November 12, 1991, which provided a one-time increase in 1991 quota for shallow-water groupers (SWG) from 9.2 million pounds (mp) to 9.9 mp. This action provides the commercial fishery an opportunity to harvest 0.7 mp that were not harvested in 1990 due to an early closure of the fishery in1990. NMFS projected the 9.2 million pound quota to be reached on November 7, 1990, but subsequent data showed that the actual harvest was 8.5 mp [56 FR 58188].

An August 1999 regulatory amendment, implemented June 19, 2000, increased the commercial and recreational minimum size limits for gag and black grouper, prohibited commercial sale of black grouper each year from February 15 to March 15, and established two marine reserves (Steamboat Lumps and Madison-Swanson) that are closed year-round to commercial and recreational fishing for all species under the Council's jurisdiction [65 FR 31827].

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].

A March 2006 regulatory amendment, implemented July 15, 2006, established a recreational red grouper bag limit of one fish per person per day as part of the five grouper per person aggregate bag limit, and prohibited for-hire vessel captains and crews from retaining bag limits of any grouper while under charter [71 FR 34534]. An additional provision established a recreational closed season for black grouper, gag, and red grouper from February 15 to March 15 each year (matching a previously established commercial closed season) beginning with the 2007 season [71 FR 66878].

2.2 EMERGENCY AND INTERIM RULES (IF ANY)

Gulf of Mexico

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 and an increased bycatch morality of incidentally caught red grouper. 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].

The Council requested an interim rule starting January 1, 2009 through May 31, 2009 because the process for Amendment 30B rules could take until late 2009. This rule established a recreational grouper aggregate bag limit of 5 fish, closed recreational season for black grouper remained from 2/15 through 3/15. This rule also required operators of federally permitted Gulf of Mexico commercial and for-hire reef fish vessels fishing in state waters to comply with the more restrictive of federal or state reef fish regulations [73 FR 73219].

2.3 SECRETARIAL AMENDMENTS

Gulf of Mexico

Secretarial Amendment 1, implemented July 15, 2004, reduced the commercial quota for shallow-water grouper from 9.35 to 8.8 mp (GW) and reduced the commercial quota for deep-water grouper from 1.35 to 1.02 mp (GW). In this amendment bottom longlines were considered for movement out to 50 fathoms which also had been considered under Reef Fish Amendment 18 [54 FR 214].

2.4 CONTROL DATE NOTICES

South Atlantic

Notice of Control Date 07/30/91 56 FR 36052:

-Anyone entering federal snapper grouper fishery (other than for wreckfish) in the EEZ off S. Atlantic states after 07/30/91 was not assured of future access if limited entry program developed.

Notice of Control Date 10/14/05 70 FR 60058:

-The Council is considering management measures to further limit participation or effort in the commercial fishery for snapper grouper species (excluding Wreckfish).

Notice of Control Date 3/8/07 72 FR 60794:

-The Council may consider measures to limit participation in the snapper grouper for-hire fishery

Gulf of Mexico

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

South Atlantic

Species	Black Grouper (*Mycteroperca bonaci*)
Management Unit	Southeastern US
Management Unit Definition	All waters within South Atlantic Fishery Management Council Boundaries
Management Entity	South Atlantic Fishery Management Council
Management Contacts SERO / Council staff	Jack McGovern/Rick DeVictor
Current stock exploitation status	Overfishing
Current stock biomass status	Unknown

Gulf of Mexico

Species	Black Grouper (*Mycteroperca bonaci*)
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 staff	Andy Strelcheck/Carrie Simmons
Current stock exploitation status	Not yet determined
Current stock biomass status	Not yet determined
Special note	Due to regional nomenclature gag were often landed as black grouper. Thus, black grouper reported landings include a proportion of gag.

Table 2.5.2. Specific Management Criteria

South Atlantic

Criteria	South Atlantic - Current		South Atlantic - Proposed	
	Definition	Value	Definition	Value
MSST	MSST = [(1-M) or 0.5 whichever is greater]*B_{MSY}	Unknown	MSST = [(1-M) or 0.5 whichever is greater]*B_{MSY}	SEDAR 19
MFMT	F_{MSY}	0.18[1]	F_{MSY}	SEDAR 19
MSY	Yield at F_{MSY}	Not Specified	Yield at F_{MSY}	SEDAR 19
F_{MSY}	$F_{30\%SPR}$	0.18[1]	F_{MAX}	SEDAR 19
OY	Yield at F_{OY}	Not Specified	Yield at F_{OY}	SEDAR 19
F_{OY}	$F_{45\%SPR}$	Not specified[2]	F_{OY} = 65%,75%, 85% F_{MSY}	SEDAR 19
M	n/a	0.15[1]	M	SEDAR 19

[1]Potts and Brennan (2001)

Gulf of Mexico

Criteria	Gulf of Mexico – Current		Gulf of Mexico - Alternative	
	Definition	Value	Definition	Value
MSST	undefined*	To Be Determined (TBD)	MSST = [(1-M) or 0.5 whichever is greater]*B_{MSY}	SEDAR 19
MFMT	F30%SPR	TBD	F_{MSY}	SEDAR 19
MSY	undefined**	TBD	Yield at F_{MSY}	SEDAR 19
F_{MSY}	no proxy defined	TBD	F_{MSY}	SEDAR 19
OY	undefined**	TBD	Yield at F_{OY}	SEDAR 19
F_{OY}	undefined***	TBD	F_{OY} =65%, 75%, 85% F_{MSY}	SEDAR 19
M	--	TBD	Instantaneous natural mortality	SEDAR 19
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 are 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 selectivities, 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.

Table 2.5.3. Stock Rebuilding Information

South Atlantic

The current stock biomass status is unknown; no rebuilding plan required.

Gulf of Mexico

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

Table 2.5.4. Stock projection information.

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

South Atlantic

Requested Information	Value
First Year of Management	2011
Projection Criteria during interim years should be based on (e.g., exploitation or harvest)	Fixed Exploitation; Modified Exploitation; Fixed Harvest*
Projection criteria values for interim years should be determined from (e.g., terminal year, avg of X years)	Average of previous 3 years

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

Gulf of Mexico

Requested Information	Value
First Year of Management	2011
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 2.5.5. Quota Calculation Details

If the stock is managed by quota, please provide the following information

South Atlantic

There is currently not a quota specified for this stock.

Gulf of Mexico

There is currently not a quota specified for this stock, only a SWG quota. The SWG quota is the sum of the red grouper quota, gag quota, plus a 0.41 mp allowance for other shallow-water grouper. If a black grouper quota is established, it will be taken from the other grouper allowance, and the SWG quota will become the sum of the three species quotas plus the remaining other grouper allowance.

Current Quota Value	
Next Scheduled Quota Change	
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 Shallow Water Grouper (SWG) quota will, upon implementation of the proposed rule for Amendment 30B, consist of three parts, a red grouper quota, a gag quota, and an allowance for other shallow-water grouper in aggregate including black grouper. The process for calculating the commercial quota is established in Amendment 30B as follows: Set the commercial gag and red grouper quotas by multiplying the TAC for each year by each species' commercial allocation. The allowance for the commercial other shallow water grouper will be 0.41 mp which is the average landings for the baseline years of 2001-2004. The aggregate commercial shallow-water grouper quota for each year is the sum of the gag and red grouper quotas, plus the other shallow-water grouper allowance. Other shallow-water grouper consists of black grouper, yellowfin grouper, rock hind, red hind, yellowmouth grouper, and scamp before the SWG quota is reached at which time scamp is considered a DWG [73 FR 68390].

Based on annual TACs specified in Amendment 30B for red grouper and gag, and interim commercial:recreational allocations of 39:61 for gag and 76:24 for red grouper, the commercial gag quota would be set at 1.32 million lb (598,742 kg) in 2009, 1.41 million lb (639,565 kg) in 2010, and 1.49 million lb (675,853 kg) in 2011. The red grouper quota would be set at 5.75 million lb (2.61 million kg) for all three years.

If a TAC is established for black grouper, it will be necessary to establish commercial and recreational allocations so that the commercial SWG quota can be adjusted accordingly. There is currently no formal guidance for allocating grouper species other than red grouper and gag. Pending guidance from the Council, the same methodology used in Amendment 30B to establish gag and red grouper allocations will be applied to black grouper. An interim allocation of black grouper will be based on the proportion of commercial to recreational landings during the years 1986 –through 2005. The commercial allocation will be applied to the TAC to determine the black grouper quota. That quota will be deducted from the other shallow water grouper allowance. The shallow-water grouper aggregate quota will then be the sum of the red grouper, gag, and black grouper quotas, plus the remaining other grouper allowance.

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 SWG and deep-water grouper species as a result of actions to constrain the harvest of gag. Although DWG and SWG 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 black grouper TAC 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.

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.

For the commercial sector, to prevent an early season closure of the SWG fishery, this proposed rule would authorize the NOAA Assistant Administrator for Fisheries, to file a notification with the Office of the *Federal Register* to implement an incidental bycatch allowance trip limit when 80% of the gag or red grouper quota is reached or projected to be reached. Harvest of the remaining shallow-water species would continue with an incidental harvest allowance on the closed species of 200 lb until either the gag, red grouper, or SWG quota is reached or projected to be reached, upon which the entire SWG fishery would close [73 FR 68390].

In the recreational sector seasonal closures that pertain to the entire recreational SWG fishery are proposed to minimize bycatch and prevent effort shifting [73 FR 68390].

The catch data for both commercial and recreational fisheries included a conversion of a portion of black grouper landings to gag to reflect misidentification of gag as black grouper, particularly during the 1980s and in the northern Gulf. In addition, most commercial grouper landings were not identified to species prior to 1986. Therefore a portion of the unclassified grouper landings were converted to gag landings based on the proportion of gag in years when classified landings were available (GMFMC 2008).

2.6. Federal Management and Regulatory Timeline

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

Table 2.6.1. Annual Commercial Black Grouper Regulatory Summary for Federal Waters

	Fishing Year		Size Limit		Possession Limit	
Year	Atlantic	Gulf	Atlantic	Gulf	Atlantic	Gulf
1983	Calendar Year	Calendar year	None		--	--
1984	"	"	None		--	--
1985	"	"	None		--	--
1986	"	"	None		--	--
1987	"	"	None		--	--
1988	"	"	None		--	--
1989	"	"	None		--	--
1990	"	"	None	20 in TL	--	--
1991	"	"	None	"	--	--
1992	"	"	20 in FL	"	--	--
1993	"	"	20 in FL	"	--	--
1994	"	"	20 in FL	"	--	--
1995	"	"	20 in FL	"	--	--
1996	"	"	20 in FL	"	--	--
1997	"	"	20 in FL	"	--	--
1998	"	"	20 in FL	"	--	--
1999	"	"	24 in FL	"	During March and April of each year, no black grouper harvest or possession greater than the bag limit and no purchase or sale	--
2000	"	"	24 in FL	24 in TL	"	Prohibited sale of black grouper each year from 2/15 to 3/15
2001		"	24 in FL	"	"	"
2002		"	24 in FL	"	"	"
2003		"	24 in FL	"	"	"
2004		"	24 in FL	"	"	"
2005	"	"	24 in FL	"	"	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.
2006	"	"	24 in FL	"	"	Established a 6,000 pound GW aggregate DWG and SWG trip limit
2007	"	"	24 in FL	"	"	
2008	"	"	24 in FL	"	"	"

Table 2.6.2. Annual Recreational Black Grouper Regulatory Summary for Federal Waters

	Fishing Year		Size Limit		Bag Limit	
Year	Atlantic	Gulf	Atlantic	Gulf	Atlantic	Gulf
1983[1]	Calendar Year	Calendar Year	--		--	--
1984[1]	"	"	--		--	--
1985[2]	"	"	--		--	--
1986	"	"	--		--	--
1987	"	"	--		--	--
1988	"	"	--		--	--
1989	"	"	--		--	--
1990[3]	"	"	--	20 in TL	--	5 grouper aggregate[2]/person/day
1991	"	"	--		--	
1992	"	"	20 in TL		5 grouper aggregate[1/]person/day	
1993	"	"	20 in TL		"	
1994	"	"	20 in TL		"	
1995	"	"	20 in TL		"	
1996	"	"	20 in TL		"	
1997	"	"	20 in TL		"	
1998	"	"	20 in TL		"	
1999	"	"	24 in TL		Within the aggregate, not more than 2 fish may be gag or black (individually or in combination)	
2000	"	"	24 in TL	22 in TL	"	
2001	"	"	24 in TL		"	
2002	"	"	24 in TL		"	
2003	"	"	24 in TL		"	
2004	"	"	24 in TL		"	
2005	"	"	24 in TL		"	Published 7/05-Limited aggregate grouper bag limit from 5 to 3 grouper per day but, was overturned by 12/05
2006	"	"	24 in TL		"	5 grouper aggregate[2]/person/day

2007	"	"	24 in TL		"	Recreational closed season established each year from 2/15 to 3/15
2008	"	"	24 in TL	22 in TL		"

[1]The following species are included in the South Atlantic grouper aggregate: snowy grouper, gag, black grouper, golden tilefish, misty grouper, red grouper, scamp, tiger grouper, yellowedge grouper, yellowfin grouper, yellowmouth grouper, blueline tilefish, sand tilefish, coney, graysby, red hind, and rock hind.

[2]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, red grouper (no more than 1 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.

2.7. State Management and Regulatory Timeline

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

Table 2.7.1. State Regulatory History of Annual Commercial Black Grouper Regulatory Summary - Florida

	Fishing Year		Minimum Size Limit State Waters		Possession Limit	
Year	Atlantic	Gulf	Atlantic	Gulf	Atlantic	Gulf
1983	Calendar Year	Calendar year	**12 in FL[a]**	**12 in FL[a]**	**No more than 10% of individuals may be undersize (FL Statutes Chapter 370.11, effective ~7/1/1977)**	**No more than 10% of individuals may be undersize (FL Statutes Chapter 370.11, effective ~7/1/1977)**
1984	"	"	**12 in FL**	**12 in FL**	"	"
1985	"	"	**18 in FL**	**18 in FL**	**(effective 7/29/1985)**	**(effective 7/29/1985)**
1986	"	"	**18 in FL**	**18 in FL**	"	"
1987	"	"	**18 in FL**	**18 in FL**	**Use of longline gear for reef fish in state waters by commercial fishermen prohibited; bycatch allowance of 5% is permitted harvesters of other species using this gear; use of stab nets (or sink nets) to take snapper or grouper is prohibited in Atlantic waters of Monroe County; 5% of snapper and grouper in possession of harvester may be smaller than the minimum size limit; must be landed in whole condition (head and tail intact) (effective 12/11/1986)**	**Use of longline gear for reef fish in state waters by commercial fishermen prohibited; bycatch allowance of 5% is permitted harvesters of other species using this gear; 5% of snapper and grouper in possession of harvester may be smaller than the minimum size limit; must be landed in whole condition (head and tail intact) (effective 12/11/1986)**
1988	"	"	**18 in FL**	**18 in FL**	"	"
1989	"	"	**18 in FL**	**18 in FL**	"	"
1990	"	"	**20 in TL[b]**	**20 in TL[b]**	**Minimum size 20 in TL; All snapper and grouper designated as "restricted species"; Allowable gear for snappers and groupers are hook and line, black sea bass traps, spears, gigs, or lance (except powerheads, bangsticks, or explosive**	**Minimum size 20 in TL; All snapper and grouper designated as "restricted species"; Allowable gear for snappers and groupers are hook and line, black sea bass traps, spears, gigs, or lance (except powerheads, bangsticks, or**

					devices); all commercial harvest of any species of snapper, grouper, and sea bass is prohibited in state waters whenever harvest of that species is prohibited in adjacent federal waters; snapper and grouper must be landed in whole condition (2/1/1990)	**explosive devices); all commercial harvest of any species of snapper, grouper, and sea bass is prohibited in state waters whenever harvest of that species is prohibited in adjacent federal waters; snapper and grouper must be landed in whole condition (2/1/1990)**
1991	"	"	**20 in TL**	**20 in TL**	"	"
1992	"	"	**20 in TL**	**20 in TL**	"	**Requires that a harvester have the appropriate federal permit in order to exceed snapper/grouper bag limits and to purchase or sell snapper/grouper on the state's Gulf Coast (12/31/1992)**
1993	"	"	**20 in TL**	**20 in TL**	**Use of longline gear in state waters prohibited (1/1/1993); Persons who possess either a Gulf of Mexico or South Atlantic federal reef fish permit to commercially harvest snappers and grouper (except red snapper) in all state waters until July 1, 1995. (10/18/1993)**	**Use of longline gear in state waters prohibited (1/1/1993); Persons who possess either a Gulf of Mexico or South Atlantic federal reef fish permit to commercially harvest snappers and grouper (except red snapper) in all state waters until July 1, 1995. (10/18/1993)--**
1994	"	"	**20 in TL**	**20 in TL**	**Rule language modified to provide the same state and federal definitions of Gulf of Mexico and Atlantic Ocean regions (3/1/1994)**	**Rule language modified to provide the same state and federal definitions of Gulf of Mexico and Atlantic Ocean regions (3/1/1994)**
1995	"	"	**20 in TL**	**20 in TL**	**Continues the allowance of persons to possess either the proper South Atlantic or Gulf permit to harvest reef fish for commercial purposes through 12/31/1995. (7/1/1995)**	**Continues the allowance of persons to possess either the proper South Atlantic or Gulf permit to harvest reef fish for commercial purposes through 12/31/1995. (7/1/1995)**
1996	"	"	**20 in TL**	**20 in TL**	**Continues the allowance of persons to possess either the proper South Atlantic or Gulf permit to harvest reef fish for commercial purposes through**	**Continues the allowance of persons to possess either the proper South Atlantic or Gulf permit to harvest reef fish for commercial purposes through**

					12/31/1996. (1/1/1996)	**12/31/1996. (1/1/1996)**
1997	"	"	**20 in TL**	**20 in TL**	**Continues the allowance of persons to possess either the proper South Atlantic or Gulf permit to harvest reef fish for commercial purposes through 12/31/1997. (11/271996)**	**Continues the allowance of persons to possess either the proper South Atlantic or Gulf permit to harvest reef fish for commercial purposes through 12/31/1997. (11/271996)**
1998	"	"	**20 in TL**	**20 in TL**	"	"
1999	"	"	**24 in TL**	**20 in TL; Monroe County state waters 24 in TL**	**Minimum size limit 24 in TL in Atlantic Ocean state waters only; No black grouper or gag harvest or possession greater than the bag limit (2 fish daily within the 5 fish daily aggregate limit for all groupers) and no purchase or sale during March and April (12/31/1998); state waters of Monroe County: minimum size limit 24 in TL, 2-fish daily recreational bag limit for black grouper and gag, prohibits the harvest, possession, or landing of black grouper and gag in excess of the recreational bag limit and the purchase, sale, or exchange of black grouper and gag during March and April (3/1/1999)**	**State waters of Monroe County: minimum size limit 24 in TL, 2-fish daily recreational bag limit for black grouper or gag, prohibits the harvest, possession, or landing of black grouper or gag in excess of the recreational bag limit and the purchase, sale, or exchange of black grouper and gag during March and April (3/1/1999)**
2000	"	"	**24 in TL**	**20 in TL; Monroe County state waters 24 in TL**	**Eliminates the 5-day commercial season closure extension in the reef fish rule, restores documentation requirement for reef fish species possessed during a closure period (Chapter 68B-14, F.A.C.) (1/1/2000)**	**Eliminates the 5-day commercial season closure extension in the reef fish rule, restores documentation requirement for reef fish species possessed during a closure period (Chapter 68B-14, F.A.C.) (1/1/2000)**
2001	"	"	**24 in TL**	**24 in TL**	“	**Raised minimum size limit of Gulf of Mexico gag and black grouper to 24 in TL for commercial harvesters. Feb. 15-Mar 15 closed season for the commercial harvest of Gulf gag, black, and red grouper (1/1/2001)**

2002	"	"	**24 in TL**	**24 in TL**	"	"
2003	"	"	**24 in TL**	**24 in TL**	**Imported reef fishes must comply with Florida's legal minimum size limits, includes minimum size limits for 19 reef fish species (1/1/2003)**	**Imported reef fishes must comply with Florida's legal minimum size limits, includes minimum size limits for 19 reef fish species (1/1/2003)**
2004	"	"	**24 in TL**	**24 in TL**	"	"
2005	"	"	**24 in TL**	**24 in TL**	"	**Grouper (includes all grouper species listed in Chap. 68B-14.001(2)(b), F.A.C., except bank sea bass and black sea bass) vessel trip limit for commercial harvesters in state waters of 10,000 pounds until the National Marine Fisheries Service reduces the vessel trip limit in adjacent federal waters. The grouper vessel trip limit shall be restored in state waters to 10,000 pounds on January 1 of the following year (5/20/2005).**
2006	"	"	**24 in TL**	**24 in TL**	**Specifies total length (TL) measurement means the straight line distance from the most forward point of the head with the mouth closed, to the farthest tip of the tail with the tail compressed or squeezed, while the fish is lying on its side (7/1/2006)**	**Specifies total length (TL) measurement means the straight line distance from the most forward point of the head with the mouth closed, to the farthest tip of the tail with the tail compressed or squeezed, while the fish is lying on its side (7/1/2006).**
2007	"	"	**24 in TL**	**24 in TL**	**Commercial trip limits in the Atlantic are set to the same trip limits in federal waters (7/1/2007)**	**Commercial fishermen prohibited from harvesting or possessing the recreational bag limit of reef fish species on commercial trips (7/1/2007)**
2008	"	"	**24 in TL**	**24 in TL**	"	**Requires all commercial fishermen fishing for reef fish species to use circle hooks, dehooking devices, and venting tools beginning 6/1/2008. (4/1/2008)**
2009	"	"	**24 in TL**	**24 in TL**	"	"

[a]Measurement specified as "from the tip of the nose to the rear center edge of the tail (i.e., a fork length)." [b]Measurement is a total length.

Table 2.7.2. State Regulatory History of Annual Recreational Black Grouper Regulatory Summary – Florida

	Fishing Year		Size Limit		Bag Limit	
Year	Atlantic	Gulf	Atlantic	Gulf	Atlantic	Gulf
1983[1]	Calendar Year	Calendar Year	**12 in FL[a]**	**12 in FL[a]**	**No more than 10% of individuals may be undersize (effective ~7/1/1977)**	**No more than 10% of individuals may be undersize (effective ~7/1/1977)**
1984[1]	"	"	**12 in FL**	**12 in FL**	**No more than 10% of individuals may be undersize**	**No more than 10% of individuals may be undersize**
1985[2]	"	"	**18 in FL**	**18 in FL**	**(effective 7/29/1985)**	**(effective 7/29/1985)**
1986	"	"	**18 in FL**	**18 in FL**	**Grouper aggregate bag limit of 5 per recreational angler daily, with off-the-water possession limit of 10 per recreational angler, for any combination of groupers, excluding rock hind and red hind, 5% of grouper in possession may be smaller than minimum size limit (12/11/1986)**	**Grouper aggregate bag limit of 5 per recreational angler daily, with off-the-water possession limit of 10 per recreational angler, for any combination of groupers, excluding rock hind and red hind, 5% of grouper in possession may be smaller than minimum size limit (12/11/1986)**
1987	"	"	**18 in FL**	**18 in FL**	"	"
1988	"	"	**18 in FL**	**18 in FL**	"	"
1989	"	"	**18 in FL**	**18 in FL**	"	"
1990[3]	"	"	**20 in TL[b]**	**20 in TL[b]**	**Allowable gear: hook and line, spear, gig, or lance (except powerheads, bangsticks, or explosive devices), grouper must be landed in whole condition (2/1/1990)**	**Allowable gear: hook and line, spear, gig, or lance (except powerheads, bangsticks, or explosive devices), grouper must be landed in whole condition (2/1/1990) (Federal: 5 grouper aggregate[2]/person/day)**
1991	"	"	**20 in TL**	**20 in TL**	"	"
1992	"	"	**20 in TL**	**20 in TL**	**(Federal: 5 grouper aggregate[1/]person/day)**	"

1993	"	"	**20 in TL**	**20 in TL**	"	"
1994	"	"	**20 in TL**	**20 in TL**	**Allows a two-day possession limit for reef fish statewide for persons aboard charter and head boats on trips exceeding 24 hours provided that the vessel is equipped with a permanent berth for each passenger aboard, and each passenger has a receipt verifying the trip length. Modifies rule language to provide the same state and federal definitions of Gulf of Mexico and Atlantic Ocean regions (3/1/1994)**	**Allows a two-day possession limit for reef fish statewide for persons aboard charter and head boats on trips exceeding 24 hours provided that the vessel is equipped with a permanent berth for each passenger aboard, and each passenger has a receipt verifying the trip length. Modifies rule language to provide the same state and federal definitions of Gulf of Mexico and Atlantic Ocean regions (3/1/1994)**
1995	"	"	**20 in TL**	**20 in TL**	"	"
1996	"	"	**20 in TL**	**20 in TL**	"	"
1997	"	"	**20 in TL**	**20 in TL**	"	"
1998	"	"	**20 in TL**	**20 in TL**	"	"
1999	"	"	**24 in TL**	**20 in TL;** **Monroe County state waters 24 in TL**	**Black grouper and gag management modified in Atlantic Ocean state waters to a 2 fish daily recreational bag limit (within the federal 5 fish daily aggregate limit for all groupers), harvest and possession prohibited in excess of the bag limit, and purchase and sale of black grouper and gag during March and April (12/31/1998)** **[Federal: Within the aggregate, not more than 2 fish may be gag or black (individually or in combination)]**	**Harvest and possession prohibited in excess of the bag limit, and purchase and sale of black grouper and gag during March and April (12/31/1998); Monroe County state waters: a 2 fish daily recreational bag limit (within the 5 fish daily aggregate limit for all groupers) for black and gag grouper. Harvest, possession, or landing of black grouper and gag in excess of the recreational bag limit and the purchase, sale, or exchange of black grouper and gag during March and April are prohibited (3/1/1999)**
2000	"	"	**24 in TL**	**20 in TL; Monroe County state waters**	"	"

				24 in TL		
2001	"	"	**24 in TL**	**22 in TL; Monroe County state waters 24 in TL**	"	**Minimum size limit for gag and black grouper increased to 22 inches total length for recreational anglers in Gulf of Mexico state waters (1/1/2001)**
2002	"	"	**24 in TL**	**22 in TL; Monroe County state waters 24 in TL**	"	"
2003	"	"	**24 in TL**	**22 in TL; Monroe County state waters 24 in TL**	"	"
2004	"	"	**24 in TL**	**22 in TL; Monroe County state waters 24 in TL**	"	"
2005	"	"	**24 in TL**	**22 in TL; Monroe County state waters 24 in TL**	"	" **[Federal: Published 7/05-Limited aggregate grouper bag limit from 5 to 3 grouper per day but, was overturned by 12/05]**
2006	"	"	**24 in TL**	**22 in TL; Monroe County state waters 24 in TL**	**Specifies total length (TL) measurement means the straight line distance from the most forward point of the head with the mouth closed, to the farthest tip of the tail with the tail compressed or squeezed, while the fish is lying on its side (7/1/2006)**	**Specifies total length (TL) measurement means the straight line distance from the most forward point of the head with the mouth closed, to the farthest tip of the tail with the tail compressed or squeezed, while the fish is lying on its side (7/1/2006). [Federal: 5 grouper**

						aggregate[2]/person/day]
2007	"	"	**24 in TL**	**22 in TL; Monroe County state waters 24 in TL**	**Commercial fishermen prohibited from harvesting or possessing the recreational bag limit of reef fish species on commercial trips (7/1/2007)**	**Zero bag limit for Gulf gag, red and black grouper for captains and crew on for-hire vessels, commercial fishermen prohibited from harvesting or possessing the recreational bag limit of reef fish species on commercial trips (7/1/2007)**
2008	"	"	**24 in TL**	**22 in TL; Monroe County state waters 24 in TL**	"	**Requires all commercial and recreational anglers fishing for any Gulf reef fish species to use circle hooks, dehooking devices and venting tools (4/1/2008)**
2009	"	"	**24 in TL**	**22 in TL; Monroe County state waters 24 in TL**	"	"

[a]Measurement specified as "from the tip of the nose to the rear center edge of the tail (i.e., a fork length)."
[b]Measurement is a total length.

No other states provided state regulatory tables, as the state regulations did not differ significantly from the federal regulations.

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3. ASSESSMENT HISTORY AND REVIEW

Black grouper are included in the Snapper-Grouper Fishery Management Plan but black grouper only comprise a regional fishery as they are caught primarily in south Florida. The stock assessment history for black grouper in the southeast U.S. waters is brief. Black grouper have not had a formal stock assessment where all of the data and the model have undergone an outside review.

Huntsman and Mason (1987) examined the ages of 303 fish collected in the headboat fishery from south Florida and they estimated von Bertalanffy growth parameters and total mortality of black grouper with two catch curves including different ages. The first catch curve used fish aged seven and older and obtained a total mortality estimate of 0.53 per year and the second used fish of ages 5 and older and obtained a total mortality estimate of 0.49 per year. The oldest fish that they observed in their samples was 14 years old although they speculated that the maximum age of black grouper could be three to five years older. They also noted that the yield per recruit could be increased by increasing effort and lowering the minimum size.

Huntsman et al. (1994) did a similar analysis with fish that were collected in 1988 from both commercial and recreational fisheries and estimated fishing mortality at 0.32 per year and a spawning stock ratio (spawning potential ratio) of 37% and concluded that the stock was not overfished. This exercise was repeated using data from 1990 (Huntsman et al. 1991) and the fishing mortality was 0.20 per year and the SPR was 43%. They also noted that yield per recruit could be increased by increasing effort and raising the minimum size to 26 inches.

Ault et al (1998) used the estimated lengths from the National Marine Fishery Service-University of Miami's Reef Visual Census to determine total mortality for black grouper and SPR value. Their estimate of SPR was approximately 6%. However, their samples came from diver observations on the coral reefs in the Florida Keys and they did not have access to all ages of fish and, consequently, the SPR was biased.

Potts and Brennan (2001) presented a summary of the status of snapper-grouper species for the South Atlantic Fishery Management Council using commercial as well as recreational fishery data and they found the black grouper stock to be overfished (SPR = 10%, range 0.58-15%) with a fully recruited fishing mortality estimate of 0.60 per year and a natural mortality of 0.15 per year. Unfortunately, they did not provide details on how the landings were aged, the number of fish at age, nor which ages were included in their catch curve.

Accounting for selectivity is very important in determining the condition of black grouper as illustrated by the Manooch and Mason and the Ault et al studies. Unfortunately, regulations reduced the longline fishery for reef fish in the South Atlantic in 1992 to beyond 50 fathoms and eliminated it for reef fish other than deep water species in 1999. Without the larger fish from the longline fishery, the sizes and ages of black groupers in these studies were truncated and produced biased estimates of total mortality because the mortality estimates included the loss of fish from nearshore waters as they moved further offshore to deeper waters. When data from longlines were included in black grouper catch curves, the estimates of total mortality declined (Muller 2009, SEDAR19-AW-06).

Given the marked difference between the conclusions from these early analyses, and given the advances in the life history information over the past two decades, it is prudent to move from yield per recruit, catch curves, and mean length models to more complex models that integrate more sources of information.

3.1. Literature Cited

Ault, J. S., J. A. Bohnsack, G. A. Meester. 1998. A retrospective (1979-1996) multispecies assessment of coral reef fish stocks in the Florida Keys. Fishery Bulletin 96: 395-414.

Huntsman, G. R., J. Potts, R. Mays, R. L. Dixon, P. W. Willis, M. Burton, and Beverly W. Harvey. 1991. A stock assessment of the Snapper-Grouper comples in the U.S. South Atlantic based on fish caught in 1990. Beaufort Laboratory. Southeast Fisheries Science Center. National Marine Fisheries Service.

Huntsman, G. R., J. Potts, and R. W. Mays. 1994. A preliminary assessment of the populations of seven species of grouper (Serranidae, Epinepheliniae) in the western Atlantic ocean from Cape Hatteras, North Carolina to the Dry Tortugas, Florida. Proceedings. 43rd Gulf and Caribbean Fisheries Institute 193-213.

Manooch, C. S. III and D. L. Mason. 1987. Age and growth of the Warsaw grouper and black grouper from the southeast region of the United States. Northeast Gulf Science 9:65-75.

Muller, R.G. 2009. Catch curves from two periods in the black grouper fishery. SEDAR19-AW-06.

Potts, J. C. and K. Brennan. 2001. Trends in catch data and estimated static SPR values for fifteen species of reef fish landed along the southeastern United States. National Oceanic and Atmospheric Administration. Center for Coastal Fisheries and Habitat Research. Beaufort Laboratory.

4. REGIONAL MAPS

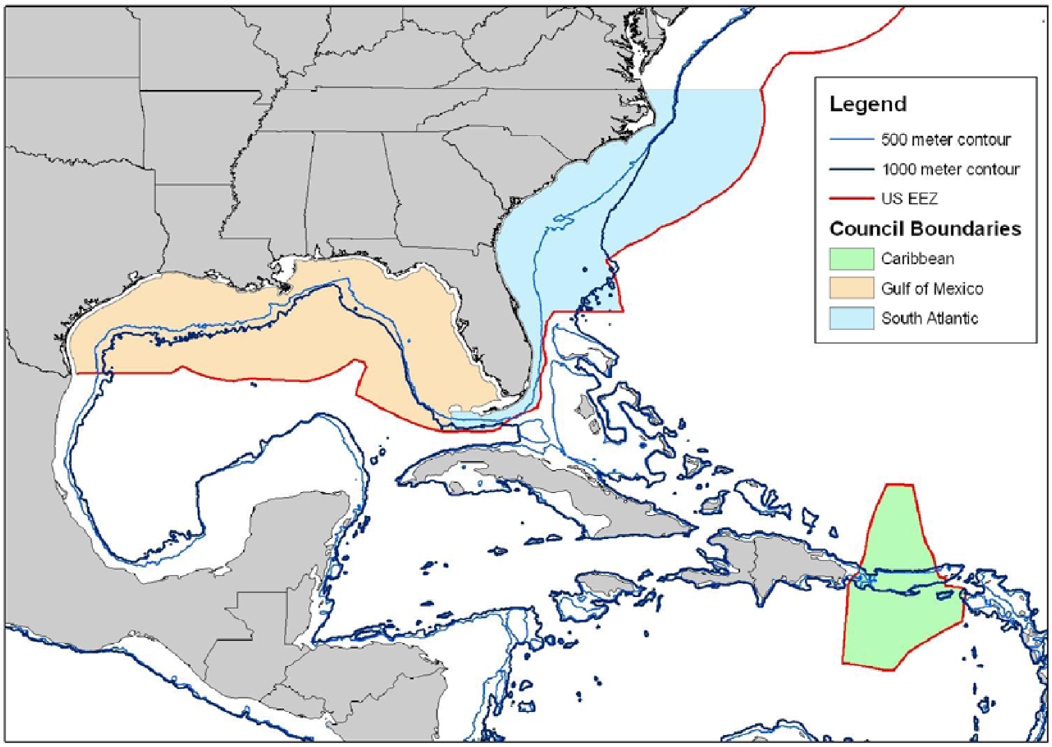


Figure 4.1. Southeast Region including Council and EEZ Boundaries

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 identification of the most reliable model configuration as the base run by the Assessment Workshop (AW); and (c) the findings and advice determined during the Review Workshop.

Stock Status and Determination Criteria

The U.S. southeast stock of black grouper is not currently overfished, nor is it experiencing overfishing.

Table 1. Summary of stock status determination criteria.

Criteria	Recommended Values from SEDAR 19	
	Definition	Value
M (Instantaneous natural mortality; per year)	Average of Lorenzen M (if used)	0.136
F_{2008} (per year)	Fishing mortality in 2008	0.108
$F_{current}$ (per year)	Geometric mean of the directed fishing mortality rates on fully selected ages from 2006 - 2008	0.096
F_{MSY} proxy (per year; if used)	$F_{30\%SPR}$	0.216
SSB_{2008} (million pounds)	Spawning stock biomass in 2008	8.29
$SSB_{MSY\ (or\ proxy)}$ (million pounds)	$SSB_{F30\%SPR}$	5.92
MSST (million pounds)	(1-M)*SSB $_{F30\%SPR}$	5.12
MFMT (per year)	$F_{30\%SPR}$	0.216
MSY (million pounds)	Yield at 30%SPR	0.520
OY (million pounds in 2011)	Yield at F_{OY}	OY (65% $F_{30SPR)}$= 0.461 OY (75% $F_{30SPR)}$= 0.530 OY (85% $F_{30SPR)}$= 0.596
F_{OY} (per year)	F_{OY} = 65%,75%, 85% $F_{F30\%SPR}$	65% F_{30SPR}= 0.141 75% F_{30SPR}= 0.162 85% F_{30SPR}= 0.185
Biomass Status	$SSB_{2008}/SSB_{F30\%SPR}$	1.40
Exploitation Status	$F_{current}$/MFMT	0.50

***All weights are whole weight in pounds.

Stock Identification and Management Unit

The black grouper (*Mycteroperca bonaci*) fishery has been managed in the US as separate Atlantic and Gulf of Mexico stock units with the boundary essentially being U.S. Highway 1 in the Florida Keys west to the Dry Tortugas. The SEDAR19 Life History Data Working Group (LH WG) for the South Atlantic (SA) and Gulf of Mexico (GOM) reviewed the available stock structure information and concluded there is no evidence that suggests different stock management units need to be considered at this time. Also, given that black grouper in the southeastern U.S. appear to belong to a single population and that catches of black grouper in the southeastern U.S. are primarily in south Florida, particularly in the Florida Keys, the assessment should treat the stock as a single unit rather than provide separate assessments for each of the two management units.

Species Distribution

Black grouper (*M. bonaci*) in the southeastern United States (the northern most part of their range) are found chiefly in southern Florida and the Florida Keys, although specimens have been recorded from Massachusetts to Texas. The range of black grouper extends to southeastern Brazil and east to Bermuda. They are often found associated with rocky ledges and coral reefs from 10-100 m. In the northern hemisphere, black grouper are more often caught in the southeastern Gulf of Mexico, southern Gulf of Mexico, and the Caribbean, spawning aggregations off the coast of Belize. In the southeastern US, black grouper are caught more commonly in the Florida Keys along the reef tract, and are caught along high relief areas in deeper waters off of the west coast of Florida to the Florida Middle Grounds and off of the east coast of Florida. Generally, larger and older individuals are caught more often in deeper waters.

Stock Life History

- There are species identification issues between black grouper and gag
- Limited tagging data suggests black groupers only move short distances
- Natural mortality is thought to vary by age so an age-specific Lorenzen mortality curve was used, with an average M of 0.136 per year and that value was determined through the Hoenig method, using a maximum observed age of 33 years.
- The LH WG recommended using an overall von Bertalanffy growth curve with L_∞ = 1334 (mm), $k = 0.1432 \cdot year^{-1}$, and $t_0 = -0.9028 \cdot year$ in the assessment model. These values were obtained using the most appropriate treatment of the data: all available age data with the Diaz et al. (2004) correction applied for fishery dependent samples.

- Black grouper are protogynous hermaphrodites and age and length of transition were determined.
- The peak spawning season of black grouper based on back-calculated hatching dates of post-larval fish from February through April

Assessment Methods

Three models were developed for black grouper ranging from catch curves to provide a reasonable scale for natural mortality, a non-equilibrium surplus production to investigate whether the landings and indices contained useful information, and the main (base) assessment model, a statistical catch-at-age model (ASAP2), to estimate population sizes, spawning biomass trends, benchmarks, stock status, and projections.

Assessment Data

The base run was configured with four fleets (headboat, general recreational (MRFSS), commercial hook-and-line which includes landings from traps and spears, and commercial longlines) and five indices of abundance (four fishery-dependent indices and the FWC Visual Survey Age-1 index) for the period of 1986 through 2008. Because of changes in minimum size limits, a separate selectivity block for each regulatory period (1986-1991, 1992-1998, and 1999-2009) was used to estimate the age composition for each fleet except for the longline fleet which did not have age samples from the first period (1986-1991). Discards were linked to their fleets.

Release Mortality

- The commercial workgroup recommended using 20% as the point estimate for hook and line release mortality for black grouper with a sensitivity range of 10-30% and a point estimate of 30% for long line release mortality for black grouper with a sensitivity range of 25-35%.
- The Recreational workgroup recommended a discard mortality of 20%, fishery-wide, with sensitivity analyses run for from 10-30%.
- The Assessment Workshop decided to support the point estimates and range of values recommended by the Data Workshop: 20% (range of 10-30%) for hook-and-line and 30% (range of 25-35%) for longline.
- The Review Panel was concerned with the lack of empirical data to support the discard mortality estimate of 20%. Sensitivity runs were performed that varied this estimate from 10 – 90%. These results support the high impact of this parameter. In the absence of any substantive empirical data the panel did not see a strong basis to change the value from 20%, however, attempts should be made to obtain a more accurate estimate of both acute and chronic discard mortality.

Catch Trends

Headboat and commercial longline catches remained relatively low and stable over the assessment period when compared to general recreational and commercial handline, which showed a steady decline over the time series. Commercial handline peaked in 1987 with 64,461 fish, and declined to similar landings as commercial longline and headboat from about 1998 onward.

Fishing Mortality Trends

- The instantaneous total catch rates (F-multipliers) for commercial hook-and-line and for MRFSS in the beginning of the time series were approximately 0.17 per year but then the commercial hook-and-line catch rate declined while the total catch rate for MRFSS was variable but remained at the higher level and the total catch rate in 2008 (0.28 per year) was the highest of the time series.
- Prior to 1991, the commercial hook-and-line fleet accounted for much of the directed fishing mortality with MRFSS being the next highest. However, the fishing mortality from the commercial hook-and-line fleet has declined since 1987 to a low of 0.010 per year in 2008 while the fishing mortality rate for MRFSS increased from 1990 to 1998 and then has declined from a peak in 1997 to a low in 2003. The directed fishing mortality on age-5 (fully selected) fish for MRFSS was 0.091 per year in 2008. The other fleets, headboats and longlines, accounted for only a small portion of the fishing mortality.
- The combined (directed and discards) fishing mortality rate on age-5 fish, the fully selected age, has declined from values exceeding 0.25 per year in the beginning of the time series to less than half that level in recent years even with the upturn in 2008. The combined fishing mortality rate in 2008 was 0.108 per year.

Stock Abundance and Biomass Trends

- The number of fish in the population decreased until 1990 and then increased until 2000 and has declined afterwards. Over the whole time series, the total number per year has increased.
- Recruitment, expressed as the number of age-1 fish, has been variable but decreased after 1994. Early in the time series, recruitment comprised approximately 30-35% of the stock by number but more recently, 2002-2008, the percentage has been lower at 23-27%. In numbers of fish, the plus group of age-20 and older fish was approximately 2% of the annual total number in the early part of the time series and then declined to 1.4% in 1994-1997 and has returned to 2%in 2008.

- The total biomass was stable at 6.0 million pounds until 1993 when it began to increase and has continued to increase such that the highest total biomass was in 2008 (11 million pounds). The spawning biomass, including both males and females, had a similar pattern and was stable at 3.5 million pounds until 1993 when it began to increase. In 2008, the spawning biomass was 8.3 million pounds. The plus group has decreased from 19% to 9% of the total biomass and was 10% in 2008.

Projections

Eight stochastic projections were run using F = 0, $F_{current}$, $F_{30\%SPR}$ (both councils' overfishing limit), 0.65*$F_{30\%SPR}$, 0.75*$F_{30\%SPR}$, 0.85*$F_{30\%SPR}$, $F_{40\%SPR}$, and $F_{45\%SPR}$ (the SAFMC's optimum yield measure). The stochastic projections encompassed a wider range of fishing mortality rates and the projections include more variability than did the P* estimates because they used the number of fish in 2008 and the fishing mortality rates for 2006-2008 from the 2.5 million MCMC results to provide variability in the starting number of fish in the population in addition to the variability in the overfishing limit. The overfishing limit, $F_{30\%SPR}$ had the highest fishing mortality rate (0.217 per year on fully selected ages) followed by 0.85*$F_{30\%SPR}$ (F= 0.185 per year on fully selected ages), $F_{40\%SPR}$ and 0.75*$F_{30\%SPR}$ had similar rates (0.165 and 0.163 per year on fully selected ages respectively) and 0.65*$F_{30\%SPR}$ and $F_{45\%SPR}$ also had similar rates at (F = 0.141 and 0.144 per year on fully selected ages, respectively). Recruitment was inverse to fishing mortality, i.e. the lowest fishing mortality rates, F = 0 or F = $F_{current}$, had higher recruitment. The spawning biomass increased with $F_{45\%SPR}$ or lower fishing mortality rates and declined under higher fishing mortality rates. Because we assume that the fishery for reef species will continue to operate on suitable bottom habitat, when the directed fishery closes, i.e., F = 0, the discards were projected to increase because the directed fishery was converted to discards and those were in addition to the existing level of discard of undersized fish.

Scientific Uncertainty

ASAP2 estimates uncertainty with a covariance matrix of the estimated parameters and through Markov Chain Monte Carlo (MCMC) simulations. The distributions of MCMC outcomes for the fishing mortality per year on fully selected ages in 2008 and the spawning biomass in 2008 can be found in the addendum. The profiles were similar to their normal approximations but the F_{2008} point estimate was higher than the mode of the MCMC estimates.

ASAP2 has retrospective analysis (Mohn 1999) as an option and we found little the retrospective bias in the black grouper estimates assessment model when using terminal years of 2004 through 2008.

To gain further understanding of the model and the data, the reviewers suggested additional sensitivity runs and we re-ran the original sensitivity runs identified at the Data workshop. The additional sensitivity runs requested by the reviewers were reinstating the longline age compositions, removing the years 1994-1997 from the NMFS-UM RVC indices, removing the years 2006-2008 from the longline index because of trip limits, weighting the longline index by 10, weighting all of the indices by 10, using a single hook-and-line selectivity block and a single longline selectivity block for all years, excluding the 1986-1990 from of the time series in the analysis, repeating these runs with the shortened time series, and a run with the FWC Visual Survey age-1index but excluding the RVC indices and FWC Visual Survey. This exercise led to making additional runs using just the RVC indices, the RVC multi-age index, the RVC age-1 index, the FWC VS indices, the FWC VS multi-age index, the FWC VS age-1 index, keeping the RVC and the FWC multi-age indices after removing the age-1 indices. The original sensitivity runs included two alternative natural mortality rates, 0.10 per year and 0.20 per year; alternative release mortality rates of 0.10, 0.20, 0.30, 0.50, 0.75, and 0.90 for hook-and-line fleets including the recreational fleets coupled to longline release mortality rates of 0.25, 0.30, 0.35, 0.50, 0.75, 0.90; and setting steepness values at 0.60 to 0.95 plus free in 0.05 increments and then running that range again but allowing the steepness to vary with CV=0.10 There were 75 sensitivity runs.

Significant Assessment Modifications

The methods for the Statistical Catch-at-Age model (ASAP2) did not change from what was done at the assessment workshop. However, additional runs were conducted to explore the influence of different data inputs such as indices or years to include in the analyses. These exploratory runs ultimately led the reviewers to select a new base run. The differences in configuration between the original base run and the new base run were 1) to reinstate the longline age compositions in the model which had been removed at the recommendation of the AW, 2) exclude the NMFS-UM Reef Census Survey (RVC) and the RVC age-1 index, and 3) exclude the FWC Visual Survey. In reviewing the data inputs for the final configuration after the review workshop, we found that the longline discard weight had been calculated with the average hook-and-line weight at age instead of the longline average weight-at-age (revised longline discard weights are provided in Table A2.1.2) and that the initial effective sample sizes used the lesser of the number of lengths in the fleet or the number of ages in the von Bertalanffy growth curve i.e. by period instead of the number of ages by year. Those additional corrections were incorporated into the new base run, sensitivity runs, and projections.

Sources of Information

All information was copied directly or generated from the information available in the final Stock Assessment Report for SEDAR 19: South Atlantic and Gulf of Mexico Black Grouper.

Tables

- Table 1: Summary of stock status and determination criteria (above)
- Table 2: Summary of life history parameters by age
- Table 3: Catch and discards by fishery sector
- Table 4: Fishing mortality estimates
- Table 5: Stock abundance and biomass
- Table 6: Spawning stock biomass and Recruitment

Figures

- Figure 1: Landings by fishery sector
- Figure 2: Discards by fishery sector
- Figure 3: Fishing Mortality
- Figure 4: Stock Biomass
- Figure 5: Abundance Indices
- Figure 6: Stock-Recruitment
- Figure 7: Yield per Recruit
- Figure 8: Stock Status and Control Rule
- Figure 9: Projections

Table 2: Summary of life history characteristics.

Age (year)	TL (mm) (mid-year)	M (y^{-1})	Proportion mature		Proportion	
			Female	Male	Female	Male
0	243	0.495	0.00	0.00	1.00	0.00
1	388	0.343	0.00	0.01	1.00	0.00
2	515	0.271	0.00	0.01	1.00	0.00
3	624	0.230	0.00	0.01	1.00	0.00
4	719	0.203	0.02	0.01	1.00	0.00
5	801	0.185	0.08	0.02	1.00	0.00
6	872	0.171	0.31	0.03	0.97	0.03
7	934	0.161	0.70	0.04	0.96	0.04
8	987	0.153	0.93	0.06	0.94	0.06
9	1033	0.147	0.99	0.08	0.92	0.08
10	1074	0.141	1.00	0.11	0.89	0.11
11	1108	0.137	1.00	0.15	0.85	0.15
12	1138	0.134	1.00	0.20	0.80	0.20
13	1165	0.131	1.00	0.26	0.74	0.26
14	1187	0.129	1.00	0.33	0.67	0.33
15	1207	0.127	1.00	0.41	0.59	0.41
16	1224	0.125	1.00	0.50	0.50	0.50
17	1239	0.124	1.00	0.58	0.42	0.58
18	1251	0.123	1.00	0.67	0.33	0.67
19	1262	0.122	1.00	0.74	0.26	0.74
20	1272	0.121	1.00	0.80	0.20	0.80
21	1280	0.120	1.00	0.85	0.15	0.85
22	1287	0.120	1.00	0.89	0.11	0.89
23	1294	0.119	1.00	0.92	0.08	0.92
24	1299	0.119	1.00	0.94	0.06	0.94
25	1304	0.118	1.00	0.96	0.04	0.96
26	1308	0.118	1.00	0.97	0.03	0.97
27	1311	0.118	1.00	0.98	0.02	0.98
28	1314	0.117	1.00	0.99	0.01	0.99
29	1317	0.117	1.00	0.99	0.01	0.99
30	1319	0.117	1.00	0.99	0.01	0.99
31	1321	0.117	1.00	0.99	0.01	0.99
32	1323	0.117	1.00	1.00	0.00	1.00
33	1325	0.117	1.00	1.00	0.00	1.00

Table 3: (Table A2.1.2.) Landings and discards in numbers and pounds by fleet and year.

	Landings (numbers)				Landings (pounds)				
Year	Headboat	MRFSS	Comm HL	Comm LL	Headboat	MRFSS	Comm HL	Comm LL	Total
1986	4,803	62,293	34,185	7,492	19,976	447,266	426,270	129,457	1,022,970
1987	3,231	55,769	64,461	11,337	39,603	382,021	567,539	125,101	1,114,264
1988	3,056	29,269	25,835	5,144	24,288	188,198	365,587	83,995	662,067
1989	2,084	28,002	35,478	4,998	19,806	181,452	384,267	82,395	667,920
1990	1,921	21,959	25,711	6,765	17,764	74,441	299,700	109,944	501,850
1991	1,703	32,959	13,817	2,594	15,378	398,475	163,451	53,681	630,985
1992	2,546	34,094	14,018	1,546	20,965	281,616	218,010	58,787	579,378
1993	2,128	26,831	12,070	982	25,129	140,596	165,666	35,670	367,061
1994	2,474	21,996	8,518	643	24,053	166,073	139,558	25,401	355,084
1995	4,525	25,993	7,546	571	31,760	236,796	115,303	24,975	408,834
1996	2,911	37,155	9,105	788	36,613	316,559	120,418	29,915	503,505
1997	3,763	43,409	6,215	828	48,274	450,156	89,464	34,644	622,538
1998	6,122	30,635	6,133	1,066	84,984	389,372	88,334	41,778	604,468
1999	1,873	15,280	3,625	1,418	25,267	169,613	79,719	51,646	326,245
2000	1,065	8,763	4,362	1,304	15,118	112,952	92,434	50,077	270,581
2001	2,073	10,350	4,731	1,390	31,013	136,623	100,951	55,020	323,607
2002	1,120	11,663	4,265	1,498	15,271	139,377	89,052	53,496	297,196
2003	1,270	16,914	6,135	1,856	11,940	262,670	97,394	77,142	449,147
2004	1,613	15,585	4,280	2,113	18,414	139,018	91,732	73,385	322,549
2005	2,000	12,943	3,358	1,563	25,733	135,772	73,266	45,734	280,505
2006	1,130	7,732	3,373	1,792	17,862	92,165	72,223	61,444	243,695
2007	1,282	14,614	2,431	1,300	17,828	156,224	54,849	43,457	272,357
2008	339	14,671	1,451	536	3,930	162,408	33,236	17,843	217,417

	Discards (numbers)				Discards (pounds)				
Year	Headboat	MRFSS	Comm HL	Comm LL	Headboat	MRFSS	Comm HL	Comm LL	Total
1986	5,018	6,694			8,014	10,691			18,705
1987	3,376	31,074			5,391	49,626			55,017
1988	3,193	3,192			5,099	5,097			10,196
1989	2,177	4,118			3,477	6,576			10,053
1990	2,007	3,509			3,205	5,604			8,809
1991	1,779	15,025			2,842	23,995			26,837
1992	2,660	17,345			13,767	83,614			97,380
1993	2,223	10,488	1,114	40	11,506	50,558	6,517	121	68,702
1994	2,585	15,158	1,357	49	13,377	73,074	7,934	147	94,532
1995	4,728	6,564	1,225	44	22,505	29,113	6,587	131	58,336
1996	3,041	17,646	1,330	46	14,478	78,264	7,152	120	100,014
1997	3,932	14,565	1,407	50	18,715	64,599	7,566	131	91,011
1998	6,396	11,943	1,301	48	30,448	52,970	6,995	124	90,538
1999	1,957	11,035	1,459	53	8,628	82,449	11,586	419	103,082
2000	1,113	8,805	1,443	49	4,906	65,786	11,457	384	82,533
2001	2,166	7,026	1,249	46	9,550	52,493	9,915	360	72,318
2002	1,170	9,173	1,315	42	3,788	63,012	8,339	297	75,436
2003	1,327	10,590	1,665	48	4,296	24,531	10,555	349	39,730
2004	1,685	10,592	940	44	7,273	79,234	7,483	276	94,266
2005	2,090	4,124	1,880	33	8,959	23,541	11,452	186	44,138
2006	1,181	6,315	231	39	3,362	36,501	1,424	216	41,502
2007	1,339	8,884	1,777	35	4,181	58,075	12,385	219	74,860
2008	354	10,686	259	31	1,514	82,197	2,123	217	86,051

Table 4: (Table A3.3.4.11.) Fishing mortality per year for directed (a), dead discards (b), and combined (c) for black grouper by year and age.

a. Directed fishing mortality per year.

	Ages																			
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	0.066	0.265	0.346	0.305	0.254	0.203	0.156	0.117	0.089	0.070	0.058	0.050	0.045	0.042	0.040	0.039	0.038	0.037	0.036	0.036
1987	0.015	0.268	0.403	0.354	0.293	0.232	0.175	0.128	0.094	0.071	0.057	0.048	0.042	0.039	0.036	0.035	0.034	0.033	0.032	0.032
1988	0.039	0.228	0.321	0.284	0.237	0.188	0.141	0.102	0.074	0.056	0.045	0.038	0.033	0.031	0.029	0.028	0.027	0.027	0.026	0.026
1989	0.009	0.206	0.281	0.249	0.209	0.166	0.124	0.090	0.066	0.050	0.040	0.034	0.030	0.028	0.027	0.026	0.025	0.024	0.024	0.024
1990	0.005	0.090	0.234	0.206	0.172	0.137	0.104	0.077	0.058	0.045	0.037	0.032	0.028	0.026	0.025	0.024	0.024	0.023	0.023	0.023
1991	0.005	0.145	0.248	0.215	0.177	0.140	0.106	0.079	0.059	0.045	0.036	0.030	0.026	0.023	0.021	0.020	0.019	0.018	0.018	0.017
1992	0.014	0.092	0.156	0.176	0.197	0.155	0.106	0.073	0.052	0.038	0.030	0.024	0.020	0.018	0.017	0.016	0.015	0.015	0.015	0.014
1993	0.016	0.059	0.122	0.154	0.165	0.134	0.091	0.062	0.043	0.032	0.024	0.019	0.016	0.014	0.013	0.012	0.012	0.011	0.011	0.011
1994	0.003	0.017	0.067	0.133	0.168	0.128	0.085	0.056	0.038	0.028	0.021	0.017	0.014	0.012	0.011	0.011	0.010	0.010	0.010	0.010
1995	0.017	0.044	0.093	0.134	0.152	0.112	0.074	0.049	0.033	0.024	0.018	0.015	0.012	0.011	0.010	0.010	0.009	0.009	0.009	0.009
1996	0.006	0.039	0.102	0.143	0.179	0.133	0.085	0.054	0.035	0.025	0.018	0.015	0.012	0.011	0.010	0.010	0.009	0.009	0.009	0.009
1997	0.000	0.038	0.102	0.175	0.198	0.141	0.088	0.055	0.035	0.024	0.018	0.015	0.012	0.011	0.010	0.010	0.010	0.009	0.009	0.009
1998	0.000	0.020	0.080	0.156	0.195	0.141	0.088	0.055	0.035	0.024	0.018	0.015	0.013	0.011	0.011	0.010	0.010	0.010	0.009	0.009
1999	0.004	0.022	0.042	0.074	0.120	0.097	0.067	0.048	0.035	0.027	0.021	0.018	0.015	0.014	0.012	0.012	0.011	0.010	0.010	0.010
2000	0.000	0.016	0.030	0.054	0.095	0.081	0.058	0.042	0.031	0.024	0.020	0.017	0.014	0.013	0.012	0.011	0.010	0.010	0.009	0.009
2001	0.001	0.015	0.036	0.064	0.094	0.076	0.054	0.040	0.030	0.023	0.019	0.016	0.014	0.013	0.011	0.011	0.010	0.010	0.009	0.009
2002	0.001	0.007	0.029	0.069	0.097	0.076	0.054	0.039	0.029	0.023	0.018	0.015	0.013	0.012	0.011	0.010	0.010	0.009	0.009	0.009
2003	0.000	0.002	0.018	0.058	0.084	0.065	0.048	0.036	0.027	0.022	0.018	0.016	0.014	0.012	0.011	0.011	0.010	0.010	0.009	0.009
2004	0.000	0.014	0.041	0.076	0.105	0.082	0.056	0.040	0.029	0.022	0.018	0.015	0.013	0.011	0.010	0.010	0.009	0.009	0.008	0.008
2005	0.000	0.002	0.023	0.071	0.086	0.063	0.045	0.032	0.024	0.019	0.015	0.013	0.011	0.010	0.009	0.008	0.008	0.008	0.007	0.007
2006	0.000	0.002	0.018	0.055	0.076	0.059	0.041	0.029	0.021	0.016	0.013	0.011	0.010	0.009	0.008	0.008	0.008	0.007	0.007	0.007
2007	0.000	0.003	0.028	0.071	0.096	0.071	0.048	0.032	0.023	0.017	0.013	0.011	0.009	0.008	0.007	0.007	0.006	0.006	0.006	0.006
2008	0.000	0.022	0.050	0.073	0.105	0.081	0.051	0.033	0.022	0.015	0.011	0.008	0.007	0.006	0.005	0.005	0.005	0.004	0.004	0.004

Table 4: (Table A3.3.4.11) (continued). Fishing mortality per year for directed (a), dead discards (b), and combined (c) for black grouper by year and age.

b. Dead discard fishing mortality per year.

	Ages																			
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	0.025	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1987	0.041	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.022	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1989	0.024	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1990	0.022	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.034	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.036	0.036	0.031	0.021	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.031	0.036	0.030	0.018	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.034	0.044	0.040	0.021	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.029	0.034	0.029	0.016	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.040	0.046	0.038	0.023	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.045	0.051	0.043	0.021	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.046	0.055	0.048	0.025	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.021	0.058	0.044	0.025	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.016	0.046	0.036	0.021	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.017	0.043	0.032	0.017	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.015	0.045	0.034	0.016	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.012	0.036	0.028	0.013	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.017	0.049	0.036	0.018	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.016	0.039	0.029	0.011	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.013	0.038	0.028	0.013	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.015	0.048	0.035	0.016	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.016	0.055	0.039	0.021	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 4: (Table A3.3.4.11) (continued). Fishing mortality per year for directed (a), dead discards (b), and combined (c) for black grouper by year and age.

c. Combined fishing mortality per year.

	Ages																			
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	0.091	0.274	0.346	0.305	0.254	0.203	0.156	0.117	0.089	0.070	0.058	0.050	0.045	0.042	0.040	0.039	0.038	0.037	0.036	0.036
1987	0.056	0.287	0.403	0.354	0.293	0.232	0.175	0.128	0.094	0.071	0.057	0.048	0.042	0.039	0.036	0.035	0.034	0.033	0.032	0.032
1988	0.061	0.237	0.321	0.284	0.237	0.188	0.141	0.102	0.074	0.056	0.045	0.038	0.033	0.031	0.029	0.028	0.027	0.027	0.026	0.026
1989	0.033	0.213	0.281	0.249	0.209	0.166	0.124	0.090	0.066	0.050	0.040	0.034	0.030	0.028	0.027	0.026	0.025	0.024	0.024	0.024
1990	0.028	0.113	0.234	0.206	0.172	0.137	0.104	0.077	0.058	0.045	0.037	0.032	0.028	0.026	0.025	0.024	0.024	0.023	0.023	0.023
1991	0.039	0.164	0.248	0.215	0.177	0.140	0.106	0.079	0.059	0.045	0.036	0.030	0.026	0.023	0.021	0.020	0.019	0.018	0.018	0.017
1992	0.050	0.128	0.186	0.197	0.201	0.155	0.106	0.073	0.052	0.038	0.030	0.024	0.020	0.018	0.017	0.016	0.015	0.015	0.015	0.014
1993	0.047	0.095	0.152	0.172	0.170	0.134	0.091	0.062	0.043	0.032	0.024	0.019	0.016	0.014	0.013	0.012	0.012	0.011	0.011	0.011
1994	0.037	0.062	0.107	0.154	0.171	0.128	0.085	0.056	0.038	0.028	0.021	0.017	0.014	0.012	0.011	0.011	0.010	0.010	0.010	0.010
1995	0.045	0.079	0.122	0.149	0.154	0.112	0.074	0.049	0.033	0.024	0.018	0.015	0.012	0.011	0.010	0.010	0.009	0.009	0.009	0.009
1996	0.045	0.084	0.140	0.166	0.182	0.133	0.085	0.054	0.035	0.025	0.018	0.015	0.012	0.011	0.010	0.010	0.009	0.009	0.009	0.009
1997	0.045	0.089	0.144	0.196	0.200	0.141	0.088	0.055	0.035	0.024	0.018	0.015	0.012	0.011	0.010	0.010	0.010	0.009	0.009	0.009
1998	0.046	0.076	0.128	0.181	0.198	0.141	0.088	0.055	0.035	0.024	0.018	0.015	0.013	0.011	0.011	0.010	0.010	0.010	0.009	0.009
1999	0.025	0.080	0.086	0.099	0.124	0.097	0.067	0.048	0.035	0.027	0.021	0.018	0.015	0.014	0.012	0.012	0.011	0.010	0.010	0.010
2000	0.016	0.061	0.066	0.075	0.099	0.081	0.058	0.042	0.031	0.024	0.020	0.017	0.014	0.013	0.012	0.011	0.010	0.010	0.009	0.009
2001	0.018	0.058	0.068	0.081	0.097	0.076	0.054	0.040	0.030	0.023	0.019	0.016	0.014	0.013	0.011	0.011	0.010	0.010	0.009	0.009
2002	0.016	0.052	0.063	0.085	0.099	0.076	0.054	0.039	0.029	0.023	0.018	0.015	0.013	0.012	0.011	0.010	0.010	0.009	0.009	0.009
2003	0.012	0.039	0.046	0.071	0.085	0.065	0.048	0.036	0.027	0.022	0.018	0.016	0.014	0.012	0.011	0.011	0.010	0.010	0.009	0.009
2004	0.017	0.063	0.076	0.094	0.108	0.082	0.056	0.040	0.029	0.022	0.018	0.015	0.013	0.011	0.010	0.010	0.009	0.009	0.008	0.008
2005	0.016	0.041	0.052	0.082	0.087	0.063	0.045	0.032	0.024	0.019	0.015	0.013	0.011	0.010	0.009	0.008	0.008	0.008	0.007	0.007
2006	0.013	0.040	0.046	0.068	0.078	0.059	0.041	0.029	0.021	0.016	0.013	0.011	0.010	0.009	0.008	0.008	0.008	0.007	0.007	0.007
2007	0.016	0.051	0.063	0.087	0.098	0.071	0.048	0.032	0.023	0.017	0.013	0.011	0.009	0.008	0.007	0.007	0.006	0.006	0.006	0.006
2008	0.016	0.077	0.089	0.095	0.108	0.081	0.051	0.033	0.022	0.015	0.011	0.008	0.007	0.006	0.005	0.005	0.005	0.004	0.004	0.004

Table 5: (Table A3.3.4.9.) Estimated annual population numbers-at-age (a) and stock biomass (lb, b) at the beginning of the year.

a. Population abundance.

	Ages																			
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	276,734	201,534	59,614	39,803	29,717	23,213	16,833	12,171	8,842	6,788	5,221	3,922	3,065	2,489	2,037	1,675	1,400	1,175	993	14,692
1987	230,281	170,049	113,811	33,049	23,746	19,060	15,919	12,237	9,282	6,986	5,498	4,297	3,266	2,572	2,099	1,726	1,424	1,192	1,003	13,467
1988	206,163	146,521	94,864	59,603	18,774	14,652	12,706	11,359	9,234	7,297	5,650	4,528	3,585	2,749	2,177	1,785	1,473	1,218	1,022	12,477
1989	184,453	130,538	85,906	53,943	36,295	12,250	10,205	9,379	8,796	7,404	5,994	4,712	3,818	3,045	2,345	1,865	1,533	1,267	1,051	11,707
1990	200,271	120,104	78,411	50,838	34,013	24,365	8,723	7,656	7,346	7,110	6,118	5,021	3,987	3,252	2,605	2,013	1,606	1,323	1,096	11,087
1991	210,105	131,083	79,716	48,640	33,456	23,674	17,847	6,677	6,076	5,987	5,905	5,142	4,259	3,403	2,787	2,239	1,736	1,386	1,145	10,599
1992	209,365	136,005	82,678	48,748	31,752	23,189	17,299	13,631	5,288	4,945	4,970	4,968	4,370	3,646	2,927	2,406	1,940	1,506	1,206	10,273
1993	230,107	134,038	88,882	53,759	32,393	21,466	16,682	13,220	10,866	4,336	4,134	4,208	4,246	3,760	3,150	2,537	2,092	1,689	1,315	10,072
1994	260,137	147,733	90,567	59,835	36,623	22,594	15,776	12,943	10,655	8,984	3,648	3,519	3,613	3,668	3,261	2,741	2,214	1,828	1,480	10,023
1995	245,559	168,746	103,200	63,771	41,485	25,525	16,709	12,316	10,491	8,852	7,590	3,116	3,030	3,129	3,188	2,843	2,396	1,938	1,604	10,140
1996	234,841	157,915	115,910	71,573	44,432	29,397	19,167	13,185	10,058	8,761	7,507	6,499	2,688	2,628	2,723	2,782	2,487	2,099	1,702	10,361
1997	233,863	151,058	107,838	78,963	49,024	30,616	21,622	14,960	10,711	8,381	7,423	6,426	5,607	2,331	2,287	2,376	2,434	2,179	1,843	10,641
1998	236,399	150,410	102,682	73,127	52,520	33,177	22,349	16,822	12,142	8,925	7,102	6,356	5,544	4,863	2,029	1,995	2,078	2,132	1,913	11,009
1999	235,117	151,885	103,626	70,793	49,367	35,627	24,217	17,391	13,655	10,118	7,564	6,081	5,483	4,808	4,230	1,770	1,745	1,820	1,871	11,392
2000	233,464	154,389	104,171	74,502	51,869	36,058	27,167	19,234	14,216	11,385	8,556	6,456	5,229	4,741	4,172	3,683	1,545	1,526	1,596	11,687
2001	210,197	154,639	107,913	76,429	55,930	38,866	27,943	21,790	15,815	11,895	9,649	7,314	5,559	4,526	4,118	3,636	3,219	1,352	1,339	11,715
2002	205,130	138,961	108,471	78,994	57,001	41,973	30,265	22,485	17,955	13,252	10,091	8,254	6,300	4,813	3,932	3,589	3,177	2,818	1,187	11,514
2003	192,852	135,893	97,985	79,821	58,687	42,676	32,677	24,364	18,541	15,057	11,252	8,639	7,116	5,459	4,184	3,429	3,138	2,783	2,473	11,208
2004	182,592	128,277	97,152	73,307	60,164	44,585	33,597	26,469	20,156	15,573	12,792	9,634	7,446	6,163	4,743	3,647	2,997	2,747	2,442	12,063
2005	181,721	120,790	89,462	70,523	53,999	44,681	34,529	26,978	21,807	16,902	13,227	10,958	8,310	6,455	5,361	4,139	3,190	2,626	2,413	12,802
2006	188,252	120,399	86,119	66,555	52,562	40,934	35,237	28,049	22,392	18,377	14,406	11,360	9,471	7,216	5,623	4,684	3,625	2,799	2,309	13,444
2007	188,386	125,012	85,958	64,416	50,326	40,202	32,437	28,748	23,366	18,928	15,702	12,396	9,833	8,234	6,292	4,916	4,105	3,182	2,462	13,921
2008	168,761	124,801	88,242	63,229	47,782	37,733	31,458	26,274	23,861	19,719	16,165	13,515	10,738	8,558	7,188	5,508	4,315	3,607	2,803	14,500

Table 5: (Table A3.3.4.9) (continued). Estimated annual population numbers-at-age (a) and stock biomass (lb, b) at the beginning of the year.

b. Stock biomass.

	Ages																			
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	247,677	558,652	344,094	387,404	428,253	453,776	419,358	368,918	314,780	276,038	237,226	195,592	165,338	143,487	124,303	107,278	93,421	81,223	70,741	1,172,459
1987	206,101	471,376	656,917	321,663	342,199	372,593	396,598	370,925	330,445	284,081	249,799	214,290	176,164	148,305	128,090	110,496	95,019	82,419	71,487	1,074,717
1988	184,516	406,156	547,554	580,115	270,551	286,408	316,545	344,317	328,719	296,734	256,729	225,838	193,422	158,482	132,846	114,289	98,255	84,169	72,841	995,682
1989	165,085	361,851	495,848	525,029	523,053	239,455	254,245	284,284	313,128	301,089	272,346	235,009	205,963	175,558	143,081	119,382	102,306	87,586	74,841	934,234
1990	179,243	332,928	452,588	494,805	490,156	476,291	217,315	232,077	261,516	289,126	277,958	250,416	215,100	187,517	158,934	128,906	107,122	91,409	78,054	884,781
1991	188,044	363,362	460,118	473,413	482,127	462,779	444,630	202,384	216,314	243,473	268,311	256,461	229,766	196,207	170,026	143,386	115,814	95,825	81,554	845,837
1992	187,382	377,006	477,216	474,468	457,571	453,293	430,963	413,192	188,243	201,082	225,839	247,751	235,770	210,197	178,563	154,049	129,429	104,120	85,941	819,798
1993	205,946	371,553	513,026	523,234	466,820	419,608	415,606	400,725	386,829	176,301	187,827	209,849	229,050	216,786	192,174	162,458	139,586	116,771	93,690	803,726
1994	232,823	409,516	522,752	582,373	527,775	441,658	393,037	392,340	379,304	365,310	165,762	175,474	194,912	211,482	198,956	175,474	147,718	126,362	105,425	799,816
1995	219,775	467,764	595,670	620,680	597,843	498,961	416,264	373,332	373,473	359,952	344,867	155,380	163,440	180,395	194,502	182,019	159,841	133,954	114,274	809,200
1996	210,183	437,740	669,033	696,617	640,305	574,651	477,498	399,664	358,037	356,270	341,066	324,131	145,012	151,500	166,116	178,130	165,956	145,070	121,236	826,805
1997	209,307	418,733	622,441	768,546	706,486	598,472	538,676	453,477	381,315	340,786	337,288	320,471	302,490	134,422	139,513	152,138	162,412	150,620	131,295	849,181
1998	211,577	416,937	592,681	711,746	756,860	648,544	556,791	509,915	432,232	362,927	322,699	316,982	299,097	280,385	123,768	127,745	138,674	147,357	136,271	878,508
1999	210,430	421,025	598,129	689,023	711,424	696,427	603,321	527,144	486,104	411,426	343,669	303,252	295,805	277,196	258,114	113,303	116,414	125,791	133,287	909,064
2000	208,950	427,966	601,275	725,131	747,481	704,860	676,804	583,009	506,065	462,939	388,733	321,960	282,107	273,372	254,569	235,833	103,097	105,475	113,682	932,662
2001	188,126	428,659	622,874	743,883	806,006	759,747	696,151	660,483	563,012	483,690	438,415	364,754	299,865	260,963	251,268	232,775	214,746	93,477	95,389	934,841
2002	183,591	385,200	626,095	768,844	821,434	820,482	753,992	681,550	639,162	538,863	458,499	411,648	339,890	277,495	239,935	229,813	212,005	194,742	84,550	918,872
2003	172,603	376,695	565,567	776,901	845,734	834,230	814,070	738,509	660,055	612,282	511,241	430,850	383,860	314,732	255,276	219,555	209,399	192,333	176,211	894,405
2004	163,420	355,584	560,762	713,501	867,025	871,548	837,002	802,337	717,533	633,252	581,222	480,438	401,683	355,328	289,415	233,492	199,964	189,885	173,955	962,652
2005	162,640	334,830	516,372	686,398	778,184	873,426	860,209	817,742	776,300	687,299	601,000	546,466	448,281	372,184	327,075	264,988	212,871	181,507	171,906	1,021,585
2006	168,486	333,746	497,077	647,783	757,467	800,174	877,864	850,212	797,140	747,290	654,565	566,525	510,937	416,074	343,109	299,880	241,893	193,457	164,513	1,072,818
2007	168,605	346,533	496,151	626,958	725,242	785,865	808,100	871,412	831,817	769,668	713,432	618,206	530,487	474,777	383,906	314,787	273,877	219,910	175,388	1,110,956
2008	151,041	345,948	509,331	615,405	688,592	737,603	783,721	796,430	849,410	801,841	734,487	674,007	579,304	493,433	438,580	352,664	287,876	249,333	199,654	1,157,105

Table 6: (Table A3.3.4.10.) Spawning biomass offset to the spawning season (mid-March) and recruitment of age-1 fish by year.

Year	Spawning biomass (lb)	Recruitment Number of age-1 fish
1986	3,706,670	276,734
1987	3,644,680	230,281
1988	3,541,110	206,163
1989	3,457,730	184,453
1990	3,424,660	200,271
1991	3,486,200	210,105
1992	3,587,180	209,365
1993	3,691,590	230,107
1994	3,811,990	260,137
1995	3,961,100	245,559
1996	4,160,390	234,841
1997	4,385,590	233,863
1998	4,630,100	236,399
1999	4,896,800	235,117
2000	5,213,420	233,464
2001	5,570,170	210,197
2002	5,958,520	205,130
2003	6,371,550	192,852
2004	6,809,070	182,592
2005	7,225,420	181,721
2006	7,636,630	188,252
2007	8,000,670	188,386
2008	8,291,540	168,761

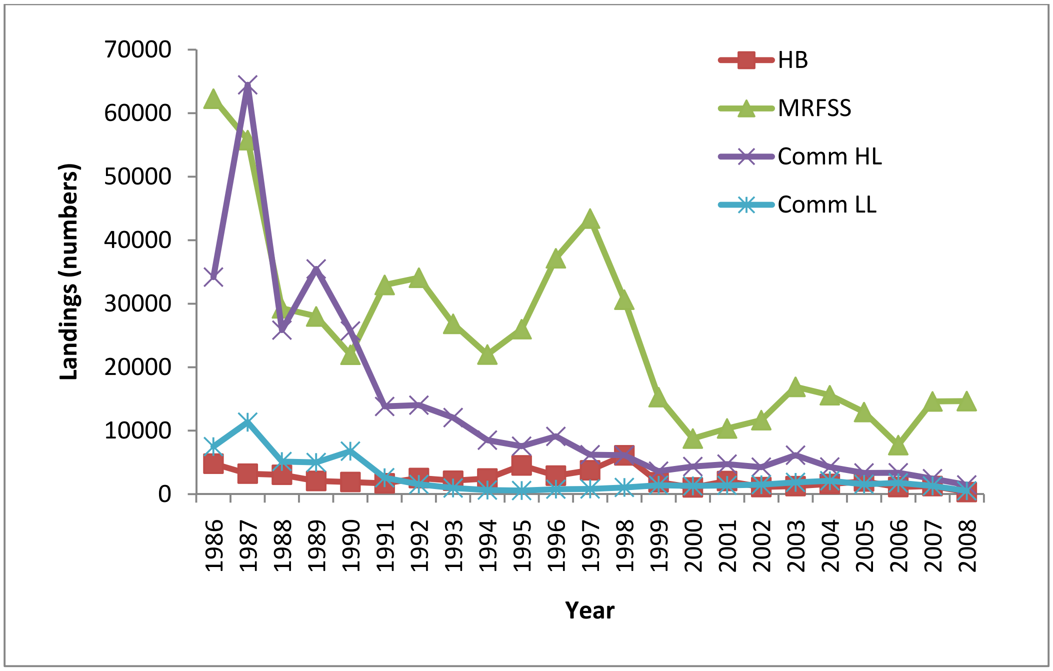


Figure 1: Landings (in numbers) by fleet.

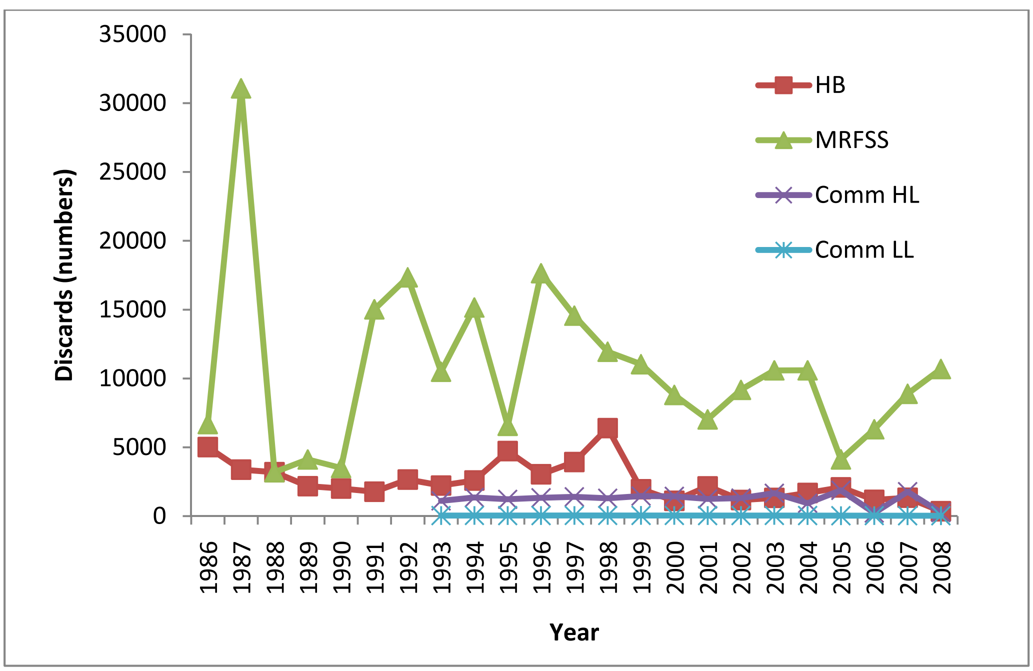
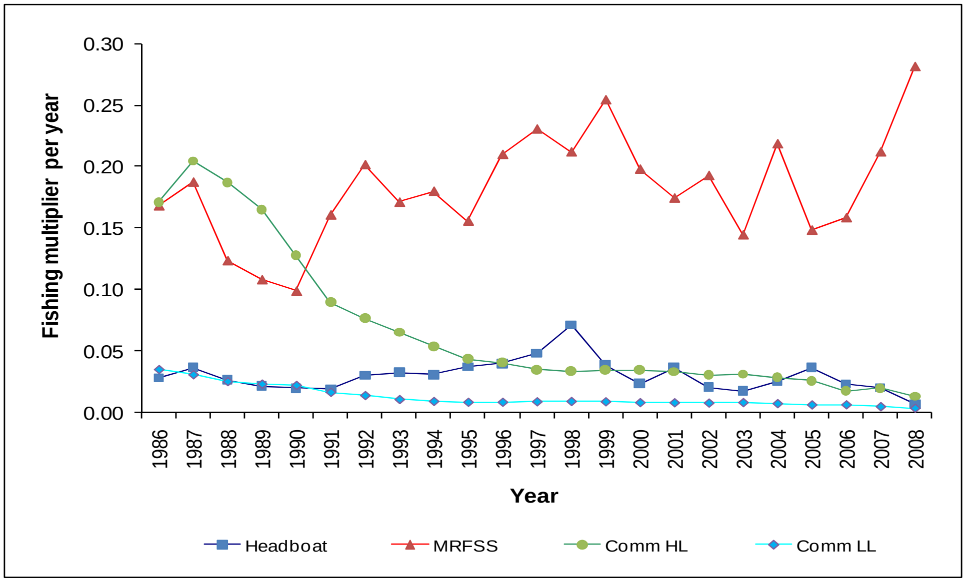


Figure 2: Discards (in numbers) by fleet.

a.



b.

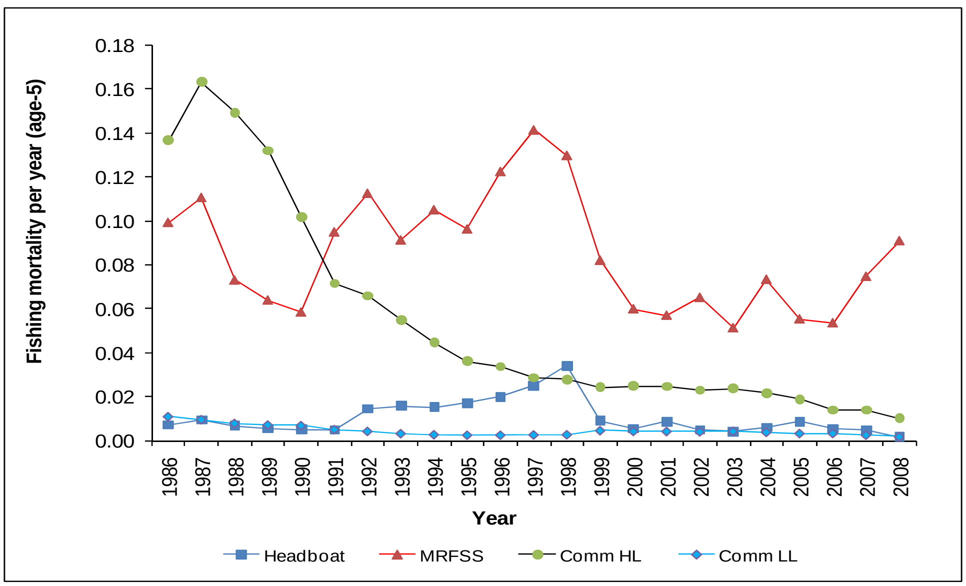


Figure 3: (Figure A3.3.5.10.) Fishing multiplier (directed and discards, a) and the directed fishing mortality rate (b) by fleet and year.

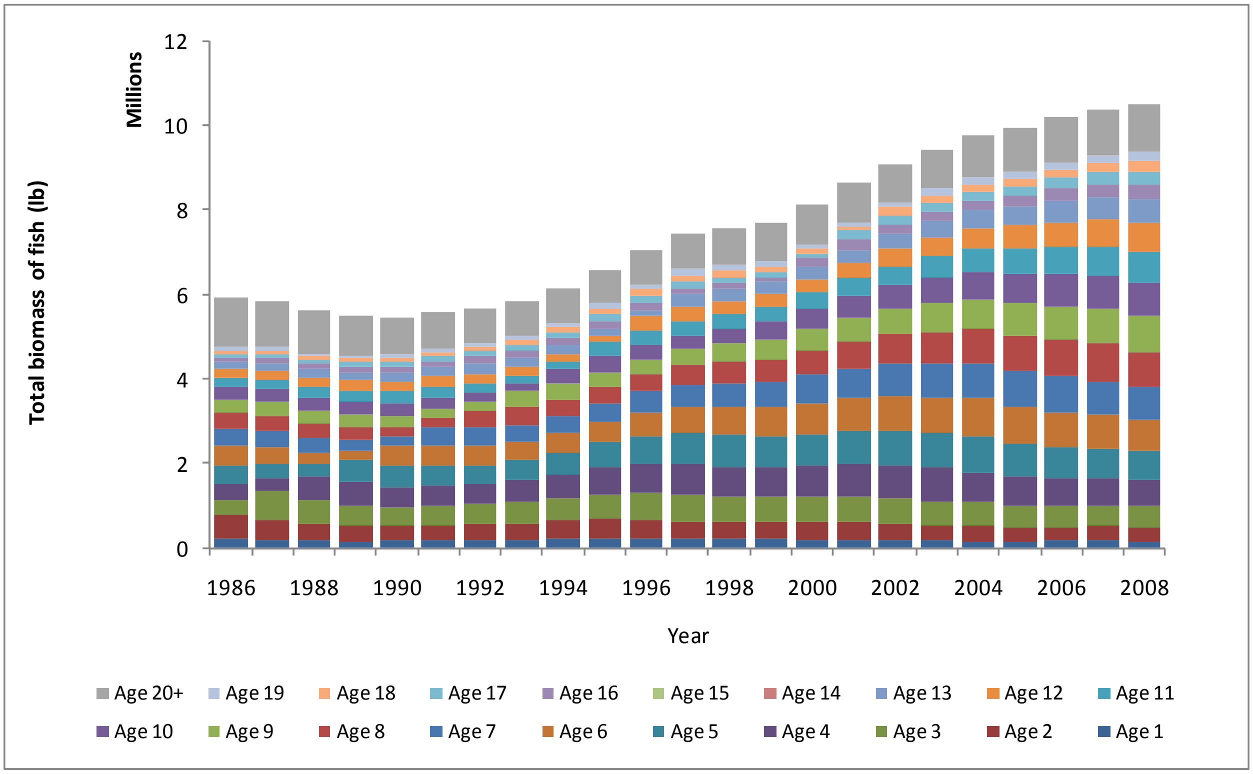


Figure 4: (Figure A3.3.5.8.) Total biomass in pounds by year and age.

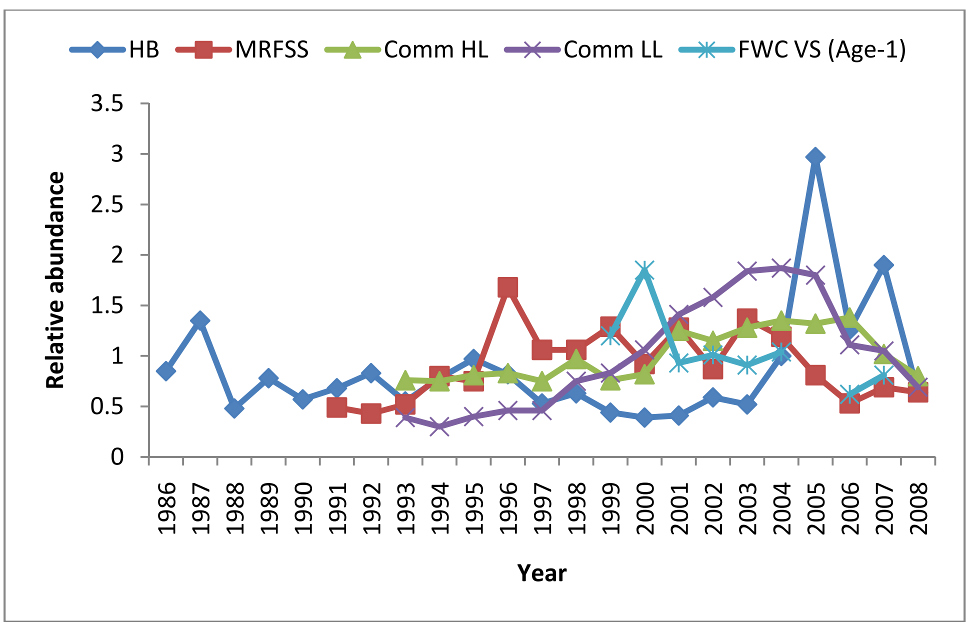


Figure 5. Indices of abundance included in final base model.

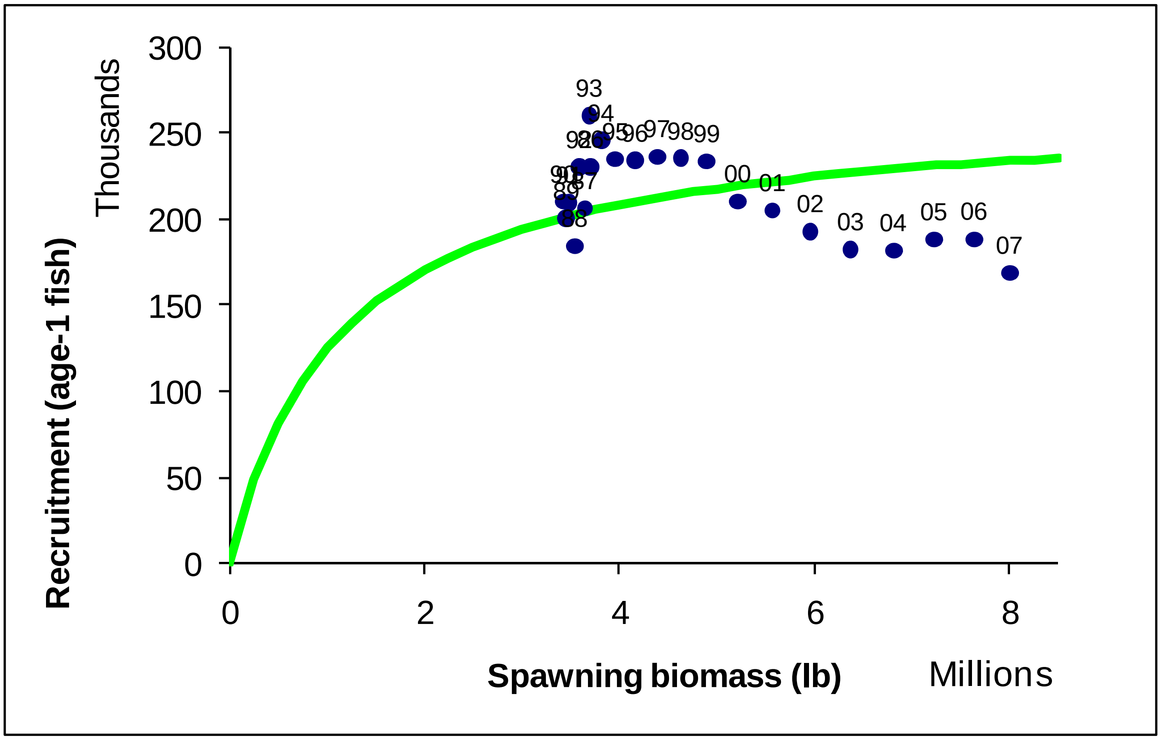


Figure 6: (Figure A3.3.5.14.) The estimated Beverton-Holt stock-recruitment relationship for black grouper. The point estimate for steepness was 0.84 and 22.4 million lb for the spawning biomass at F= 0. The equivalent figure in the original report was Figure 3.3.5.13.

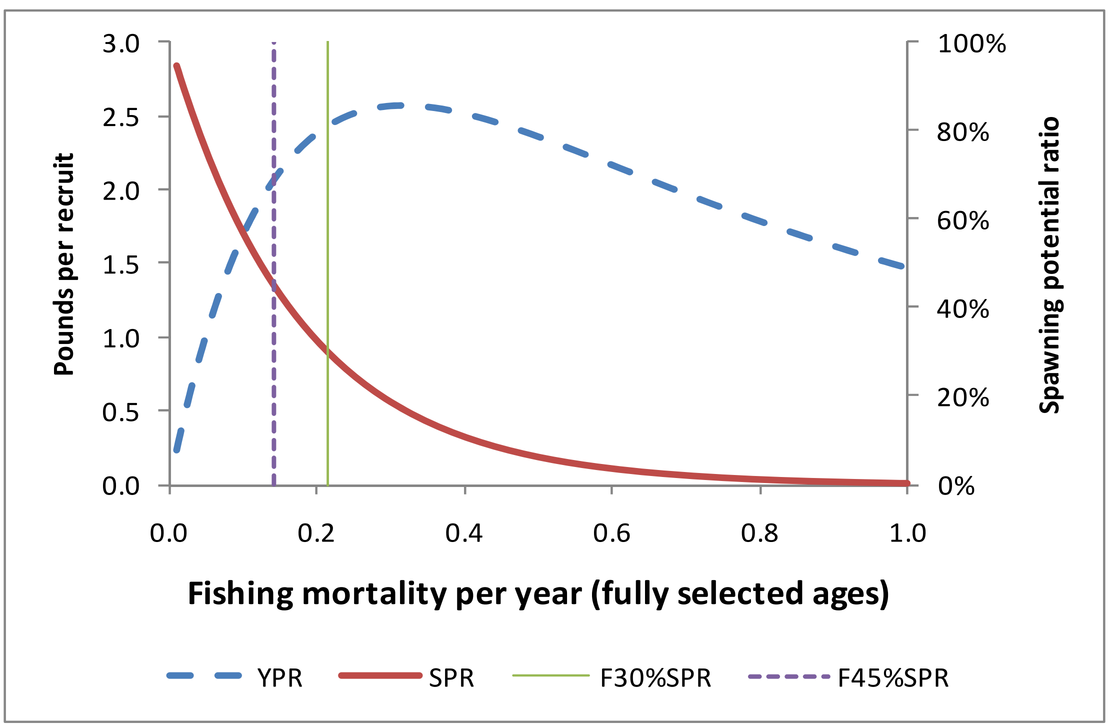


Figure 7: **(Figure A3.3.5.12.)** Yield-per-recruit and static spawning potential ratio for black grouper.

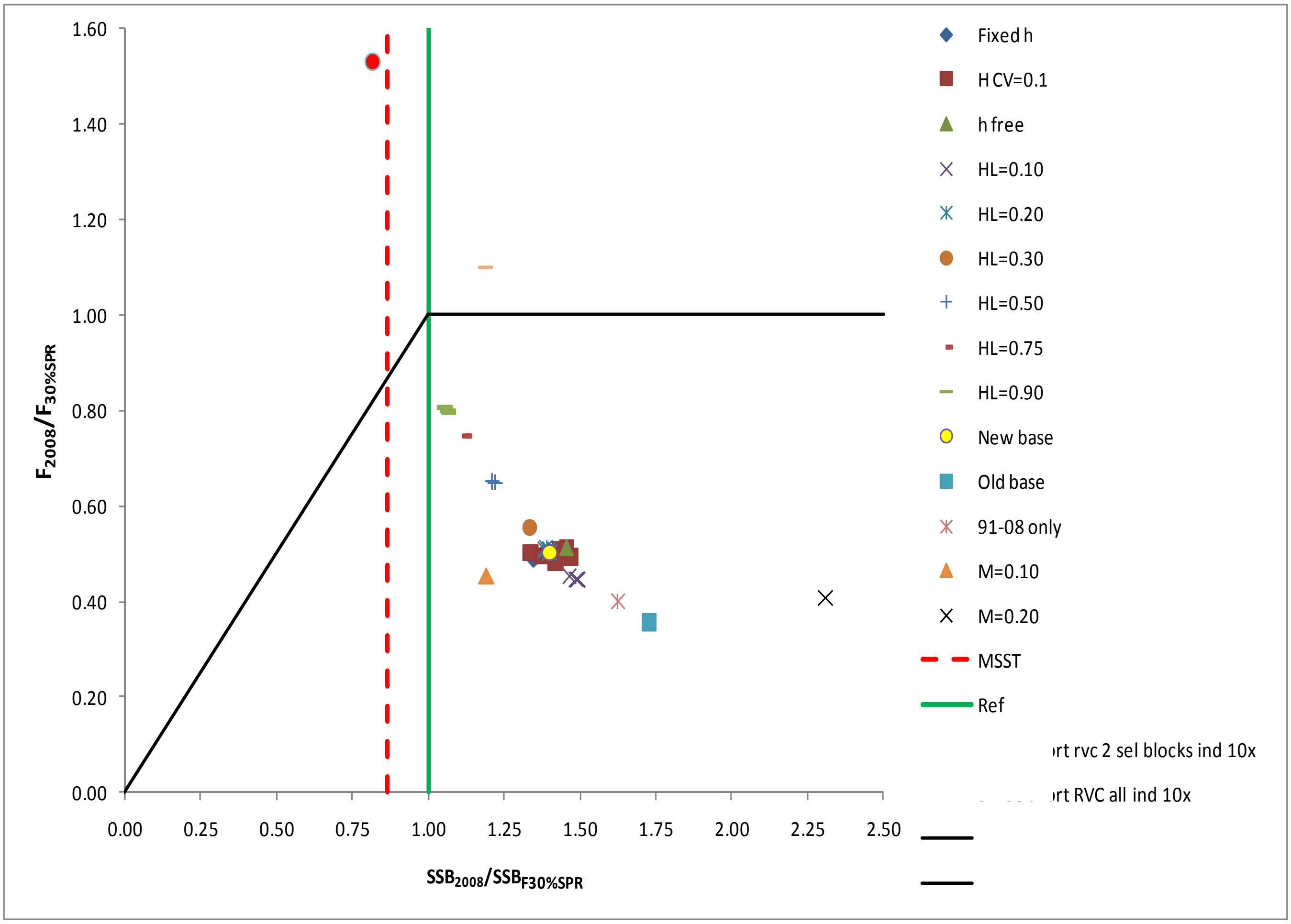
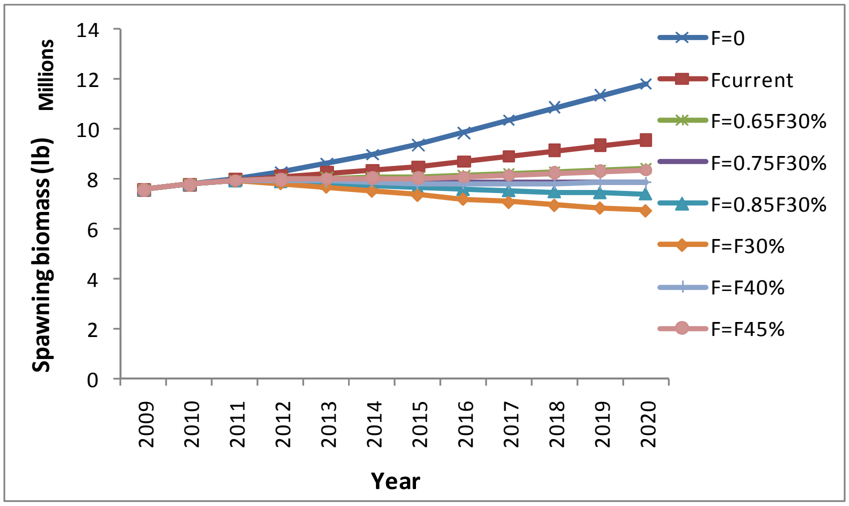
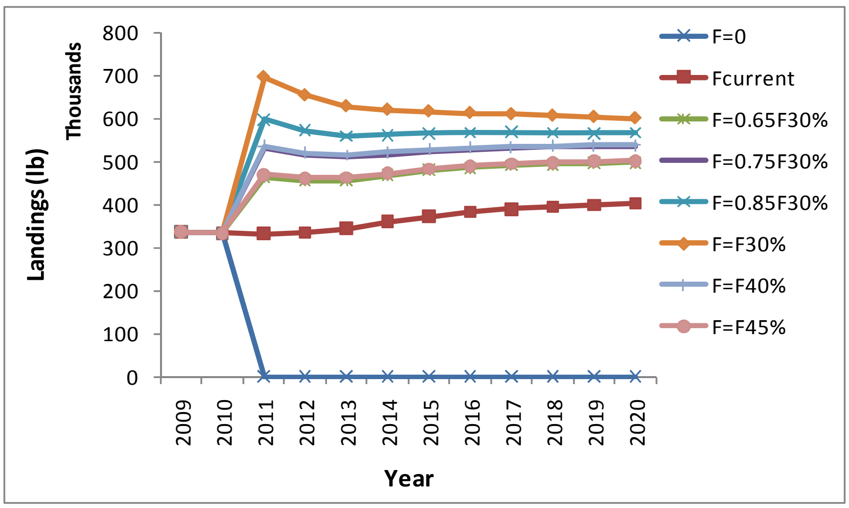


Figure 8: (Figure A3.3.5.22.) Fishing mortality ratios ($F_{2008}/F_{30\%SPR}$) and spawning biomass ratios ($SSB_{2008}/SSB_{F30\%SPR}$) for the exploratory and sensitivity runs.

a.



b.



c.

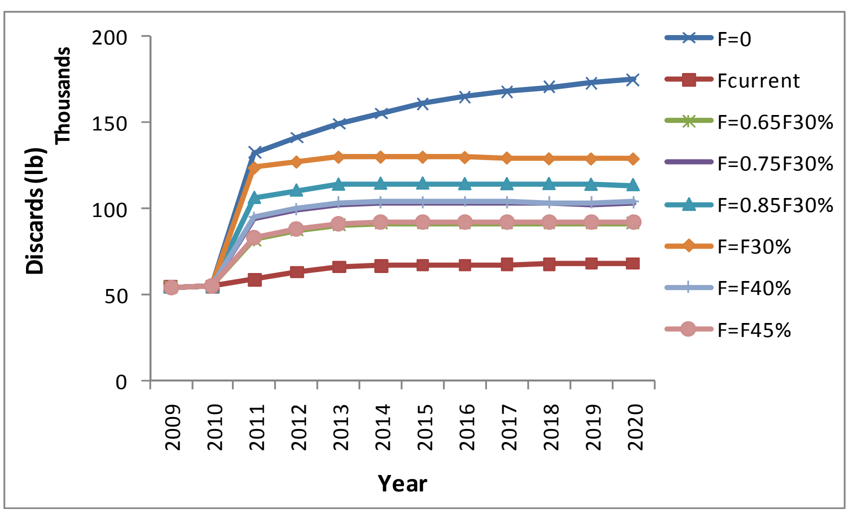


Figure 9: (Figure A3.3.5.26.) Comparison of projections for spawning biomass (a), landings (b) and discards across alternative fishing mortality rates. The equivalent figure in the original report was Figure 3.3.5.23.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 19

South Atlantic and Gulf of Mexico Black Grouper

SECTION II: Data Workshop Report

September 2009

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

Table of Contents

INTRODUCTION

1.1. *WORKSHOP TIME AND PLACE*

The SEDAR 19 Data Workshop was held June 22 - 26, 2009 in Charleston, South Carolina.

1.2. *TERMS OF REFERNCE*

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

2. 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 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. Evaluate 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 within 6 weeks prior to the Assessment Workshop.

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

Anne Lange .... SAFMC SSC
Beverly Sauls .... FWC FWRI
Bill Tucker .... GMFMC AP
Bill Lindberg .... GMFMC SSC
Bob Speath .... GMFMC AP
Byron White .... SC DNR
Chip Collier .... SAFMC SSC/NC DMF
Chris Hayes .... ACCSP
Daniel Carr .... NMFS/SEFSC
Dave Gloeckner .... NMFS/SEFSC
David Player .... SC DNR
David Wyanski .... SC DNR
Dennis O'Hern .... GMFMC AP
Don DeMaria .... SAFMC AP
Douglas Gregory .... GMFMC SSC
Jack McGovern .... SERO
Jennifer Potts .... NMFS/SEFSC
Jessica Stephen .... SC DNR
Joe O'Hop .... FWC FWRI
Julie DeFlippi .... ACCSP
Ken Brennan .... NMFS/SEFSC
Kevin McCarthy .... NMFS/SEFSC
Kyle Shertzer .... NMFS/SEFSC
Marcel Reichert .... SAFMC SSC/ SC DNR
Paul Conn .... NMFS/SEFSC
Richard Stiglitz .... SAFMC AP
Rob Cheshire .... NMFS/SEFSC
Robert Muller .... FWC FWRI
Russell Hudson .... DSF
Stephanie McInerny .... NC DMF
Steve Brown .... FWC FWRI
Thomas Sminkey .... NMFS/HQ
Walter Ingram .... NMFS/SEFSC
Walter Keithly .... GMFMC SSC

Council Representation

Brian Cheuvront .... SAFMC/NC DMF
George Geiger .... SAFMC
Mark Robison .... SAFMC/ FL FWRI
Kay Williams .... GMFMC

Observers

Claudia Friess.. Ocean Conservancy
Chad Hanson..PEW
Chris Robbins.. Ocean Conservancy
David Hoke..NOAA
Jerry Ault.. University of Miami
Mark Millikin.. NMFS/HQ
Richard Hall..NOAA

Staff

Carrie Simmons..GMFMC
Gregg Waugh..SAFMC
John Carmichael..SAFMC
Julie Neer.. SEDAR
Rachael Lindsay.. SEDAR
Rick DeVictor..SAFMC
Tyree Davis..NMFS Miami

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

Document #	Title	Authors	Working Group
Documents Prepared for the Data Workshop			
SEDAR19-DW-01	Black grouper, *Mycteroperca bonaci*, standardized catch rates from the Marine Recreational Fisheries Statistics Survey in south Florida,1991-2008	Robert G. Muller	Indices
SEDAR19-DW-02	A fishery independent index for black grouper, *Mycteroperca bonaci*, from Florida Fish and Wildlife Research Institute's visual survey in the Florida Keys, 1999-2007	Robert G. Muller and Alejandro Acosta	Indices
SEDAR19-DW-03	Construction of a headboat index for south Atlantic red grouper	Paul Conn	Indices

SEDAR19-DW-04	Construction of a headboat index for black grouper	Paul Conn	Indices
SEDAR19-DW-05	Evaluation of the 1960, 1965, and 1970 U.S. Fish and Wildlife Service salt-water angling survey data for use in the stock assessment of red grouper (Southeast US Atlantic) and black grouper (Southeast US Atlantic and Gulf of Mexico)	Rob Cheshire and Joe O'Hop	Recreational Statistics
SEDAR19-DW-06	Steepness of spawner-recruit relationships in reef fishes of the southeastern U.S.: A prior distribution for possible use in stock assessment	Sustainable Fisheries Branch	Life History
SEDAR19-DW-07	South Atlantic Region Recreational Fishery Catches of Red and Black Grouper, 1981 - 2008 and Gulf of Mexico Landings of Black Grouper.	Tom Sminkey	Recreational Statistics
SEDAR19-DW-08	Length Frequencies and Condition of Released Red Grouper and Black Grouper from At-Sea Headboat Observer Surveys in the Gulf of Mexico and Atlantic Ocean, 2005 to 2007.	Beverly Sauls	Recreational Statistics
SEDAR19-DW-09	Age, growth, and maturity of black grouper (*Mycteroperca bonaci*) – Crabtree and Bullock (1998) revisited	Joe O'hop and Rick Beaver	Life History
SEDAR19-DW-10	Ault-Smith Notes on Reef-fish Visual Census (RVC) Population Statistics Estimation for Black Grouper (*Mycteroperca bonaci*) and Red Grouper (*Epinephelus mori*) in the Florida Keys and Dry Tortugas Regions	Jerald S. Ault and Steven G. Smith	Indices/Life History
SEDAR19-DW-11	Patterns of annual abundance of black and red grouper in the Florida Keys and Dry Tortugas based on	G. Walter Ingram, Jr. and Douglas E. Harper	Indices

	reef fish visual census conducted by NOAA NMFS.		
SEDAR19-DW-12	A fishery independent index for red grouper, *Epinephelus morio*, from Florida Fish and Wildlife Research Institute's visual survey in the Florida Keys, 1999-2007	Robert G. Muller and Alejandro Acosta	Indices
SEDAR19-DW-13	United States Commercial Vertical Line and Longline Vessel Standardized Catch Rates of Black Grouper the Gulf of Mexico and South Atlantic, 1993-2008	Kevin McCarthy	Indices
SEDAR19-DW-14	United States Commercial Vertical Line Vessel Standardized Catch Rates of Red Grouper in the US South Atlantic, 1993-2008	Kevin McCarthy	Indices
SEDAR19-DW-15	Calculated discards of black grouper from commercial vertical line and longline fishing vessels in the Gulf of Mexico and US South Atlantic	Kevin McCarthy	Commercial Statistics
SEDAR19-DW-16	Calculated discards of red grouper from commercial vertical line fishing vessels in the US South Atlantic	Kevin McCarthy	Commercial Statistics
SEDAR19-DW-17	Patterns of annual abundance of red grouper observed in chevron traps set during the MARMAP Survey (1990 – 2008) in the U.S. South Atlantic.	G. Walter Ingram, Jr. and Jessica Stephen	Indices
SEDAR19-DW-18	Standardized catch rates of Atlantic red grouper (*Epinephelus morio*) from the North Carolina Commercial Fisheries Trip Ticket Program.	Walter Ingram, Stephanie McInerny, and Alan Bianchi	Indices

SEDAR19-DW-19	Red grouper standardized catch rates from the Marine Recreational Fisheries Statistics Survey for the southeastern U.S. Atlantic Ocean, 1991-2008	Chris Hayes and Robert G. Muller	Indices
SEDAR19-DW-20	Standardized catch rates of black grouper. *Mycteroperca bonaci*, and red grouper, *Epinephelus morio*, from Florida's commercial trip tickets, 1991-2008	Robert G. Muller	Indices
SEDAR19-DW-21	Estimated Landings and Discards of Red Grouper in the South Atlantic and Black Grouper in the South Atlantic and Gulf of Mexico Headboat Fishery, 2004-2008.	Ken Brennan	Recreational Statistics
Reference Documents			
SEDAR19-RD01	Reproduction in the protogynous black grouper (*Mycteroperca bonaci* (Poey) from the southern Gulf of Mexico	Thierry Brulé, Ximena Renán, Teresa Colás-Marrufo, Yazmin Hauyon, and Armin N. Tuz-Sulub	
SEDAR19-RD02	Life history of red grouper (*Epinephelus morio*) off the coasts of North Carolina and South Carolina	Julian M. Burgos, George R. Sedberry, David M. Wyanski, and Patrick J. Harris	
SEDAR19-RD03	Trends in catch data and estimated static SPR values for fifteen species of reef fish landed along the southeastern United States	Jennifer C. Potts and Ken Brennan	
SEDAR19-RD04	Density, species and size distribution of groupers (Serranidae) in three habitats at Elbow Reef, Florida Keys	Robert Sluka, Mark Chiappone, Kathleen M. Sullivan, Thomas A. Potts, Jose M. Levy, Emily F. Schmitt and Geoff Meester	
SEDAR19-RD05	Population genetic analysis of red grouper, *Epinephelus morio*, and	M. S. Zatcoff, A. O. Ball and G. R. Sedberry	

	scamp, *Mycteroperca phenax*, from the southeastern U.S. Atlantic and Gulf of Mexico	
SEDAR19-RD06	The 1960 Salt-Water Angling Survey, USFWS Circular 153	J. R. Clark
SEDAR19-RD07	The 1965 Salt-Water Angling Survey, USFWS Resource Publication 67	D. G. Deuel and J. R. Clark
SEDAR19-RD08	1970 Salt-Water Angling Survey, NMFS Current Fisheries Statistics Number 6200	D. G. Deuel
SEDAR19-RD09	Age, growth, and reproduction of black grouper, *Mycteroperca bonaci*, in Florida waters	Roy E. Crabtree and Lewis H. Bullock
SEDAR19-RD10	Age and growth of the warsaw grouper and black grouper from the southeast region of the United States	Charles S. Manooch, III and Diane L. Mason
SEDAR19-RD11	The influence of spear fishing on species composition and size of groupers on patch reefs in the upper Florida Keys	Robert D. Sulka and Kathleen M. Sullivan
SEDAR19-RD12	Aspects of fishing and reproduction of the black grouper *Mycteroperca bonaci* (Poey, 1860) (Serranidae: Epinephelinae) in the Northeastern Brazil	Simone Ferreira Teixeira, Beatrice Padovani Ferreira and Isaíras Pereira Padovan**
SEDAR19-RD13	Diet composition of juvenile black grouper (*Mycteroperca bonaci)* from coastal nursery areas of the Yucatan Peninsula, Mexico	Thierry Brulé, Enrique Puerto-Novelo, Esperanza Pérez-Díaz, and Ximena Renán-Galindo
SEDAR19-RD14	Life history of the red grouper *(Epinephelus morio)* off the North Carolina and South Carolina coast	Julian M. Burgos
SEDAR19-RD15	Mean Size at Age: An Evaluation of Sampling Strategies with Simulated	C. Phillip Goodyear

	Red Grouper Data	
SEDAR19-RD16	Evaluation of average length as an estimator of exploitation status for the Florida coral reef fish community.	Ault, J.S., S.G. Smith, and J.A. Bohnsack
SEDAR19-RD17	A retrospective (1979-1996) multispecies assessment of coral reef fish stocks in the Florida Keys	Ault, J.S., J.A. Bohnsack, and G.A. Meester
SEDAR19-RD18	Building sustainable fisheries in Florida's coral reef ecosystem: positive signs in the Dry Tortugas.	Ault, J.S., S.G. Smith, J.A. Bohnsack, J. Luo, D.E. Harper, and D.B. McClellan
SEDAR19-RD19	Are the coral reef finfish fisheries of south Florida sustainable?	Ault, J.S., S.G. Smith and J.T. Tilmant
SEDAR19-RD20	Fishery management analyses for reef fish in Biscayne National Park: bag & size limits	Ault, J.S., S.G. Smith, and J.T. Tilmant
SEDAR19-RD21	Site characterization for Biscayne National Park: assessment of fisheries resources and habitats	Ault, J.S., S.G. Smith, G.A. Meester, J. Luo, and J.A. Bohnsack
SEDAR19-RD22	Baseline Multispecies Coral Reef Fish Stock Assessment for the Dry Tortugas	Jerald S. Ault, Steven G. Smith, Geoffrey A. Meester, Jiangang Luo, James A. Bohnsack, and Steven L. Miller
SEDAR19-RD23	Movement of yellowtail snapper (*Ocyurus chrysurus* Block 1790) and black grouper (*Mycteroperca bonaci* Poey 1860) in the northern Florida Keys National Marine Sanctuary as determined by acoustic telemetry	James Lindholm, Les Kaufman, Steven Miller, Adam Wagschal and Melinda Newville
SEDAR19-RD24	Coral reef fish response to FKNMS management zones: the first ten years (1997-2007)	James A. Bohnsack, Douglas E. Harper, David B. McClellan, and G. Todd Kellison and Jerald S. Ault, Steven G. Smith, Natalia Zurcher
SEDAR19-RD25	Reef fish movements and marine designs	Nick Farmer
SEDAR19-RD26	A Cooperative Multi-agency Reef Fish Monitoring Protocol for the Florida Keys Coral Reef Ecosystem	Marilyn E. Brandt, Natalia Zurcher, Alejandro Acosta, Jerald S. Ault, James A. Bohnsack, Michael W. Feeley, Doug E. Harper, John Hunt, Todd Kellison, David B. McClellan,

		Matt E. Patterson, Steven G. Smith1
SEDAR19-RD27	The Natural Mortality Rate of Gag Grouper: A Review of Estimators for Data-Limited Fisheries	Trevor J. Kenchington
SEDAR19-RD28	Population Assessment of the Scamp, *Mycteroperca phenax,* from the Southeastern United States	Charles S.Manooch, III, Jennifer C. Potts, Michael L. Burton, and Patrick J. Harris
SEDAR19-RD29	A Review for Estimating Natural Mortality in Fish Populations	Kate. I. Siegfried & Bruno Sansó

2. LIFE HISTORY

2.1. *OVERVIEW*

2.1.1. Group membership

Marcel Reichert	SC-DNR-MARMAP, WG leader and editor, SAFMC SSC
Jennifer Potts	SEFSC Beaufort, Data compiler red grouper
Byron White	SC-DNR-MARMAP, Data provider
Dave Wyanski	SC-DNR-MARMAP, Data provider
Joe O'Hop	FWRI, Data compiler and editor for black grouper
Doug Gregory	FL Sea Grant, GMFMC SSC
Bill Lindberg	University of Florida, GMFMC SSC
Carrie Simmons	GMFMC Staff lead
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2.1.2. Issues

Issues discussed in the Life History Working Group for black grouper included the distribution (locations, depths) of catch, stock definition and population genetic analyses, identification of black grouper (and gag) in the historical catch information, criteria used for age determinations, maturity definitions (including the restriction of data to specimens collected just prior to the onset of spawning versus no temporal restrictions), age and size at sex transition, construction of growth curves, estimates of natural mortality, discard mortality estimation, movement and migration data sources, stock-recruitment (steepness) recommendations, and meristics (length-length and length-weight relationships). Issues remaining at the end of the Data Workshop were related to the write-up of natural mortality and discard mortality estimation, comments on stock-recruitment, and movements and migration of black grouper.

2.2. *REVIEW OF WORKING PAPERS*

Crabtree and Bullock (1998) studied the life history, morphometrics, age and growth, reproduction, and maturity of black grouper [*Mycteroperca bonaci* (Poey 1860)] in the southeastern United States, and confirmed the findings of Garcia-Cagide and Garcia (1996) that this species was a protogynous hermaphrodite [i.e., individuals are born as females, and may transform to males at some time later in life (Sadovy and Shapiro 1987)]. Previously, Manooch and Mason (1987) had provided length-weight, age and growth, and some estimates of total mortality using catch curves for this species caught by anglers on head boats. More recently, Rénan et al. (2001), Brulé et al. (2003), and Brulé et al. (2005) provided details on life history, reproductive strategies, and composition of the diet of juvenile black groupers in the southern Gulf of Mexico. Zatcoff (2001) discussed aspects of the genetic stock structure of black grouper in the southeastern United States. This document uses data from specimens collected by Crabtree and Bullock (1998) and Lew Bullock (personal communication) as well as more recent data (Table 2.2) collected by biological surveys in the southeastern United States [National Marine Fisheries Service (NMFS) Southeast Fisheries Science Center (SEFSC) Trip Interview Program, SEFSC Head Boat Survey, NMFS Marine Recreational Fishery Statistics Survey (MRFSS), Gulf States Marine Fisheries Commission (GSMFC) Fisheries Information Network (FIN) Biological Sampling Program, Florida Fish and Wildlife Conservation Commission's (FWC) Fish and Wildlife Research Institute (FWRI) Fisheries Independent Monitoring Program (FIM) and Biological Sampling, and some additional information from the NMFS Cooperative Research Program (CRP), NMFS Southeast Bottom Longline Observer Program, and a small number of additional specimens from a variety of other sources]. The analyses provided in this report are intended to update the relationships described in Crabtree and Bullock (1998), to provide some alternatives to the age, growth and maturity relationships based upon the aging of specimens (otoliths) adjusted for the time of year of annulus deposition in black grouper, and document issues and recommendations from the Life History Working Group and Data Workshop attendees.

2.3. *STOCK STRUCTURE/DEFINITION AND IDENTIFICATION*

Nelson et al. (2004) present the taxonomy of black grouper as follows:

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: *Mycteroperca*
            - Species: *bonaci* (Poey, 1860)
              - common name: black grouper (English)
              - cherna negrillo (Spanish)

2.3.1 Stock structure/definition

The black grouper (*Mycteroperca bonaci*) fishery has been managed in the US as separate Atlantic and Gulf of Mexico stock units with the boundary essentially being U.S. Highway 1 in the Florida Keys west to the Dry Tortugas. The SEDAR19 Life History Data Working Group (LH WG) for the South Atlantic (SA) and Gulf of Mexico (GOM) reviewed the available stock structure information and concluded there is no evidence that suggests different stock management units need to be considered at this time. Also, given that black grouper in the southeastern U.S. appear to belong to a single population (see section 2.3.2) and that catches of black grouper (*M. bonaci*) in the southeastern U.S. are primarily in south Florida, particularly in the Florida Keys, the assessment should treat the stock as a single unit rather than provide separate assessments for each of the two management units.

2.3.2 Population genetics

Zatcoff (2001) examined the population genetics of black grouper (*M. bonaci*) in the southeastern U.S. and Caribbean using microsatellite DNA from specimens collected in the Florida Keys (116 specimens), Campeche Banks (Mexico, 75 specimens), Belize (51 specimens), and Bermuda (52 specimens). The conclusions were that there was genetic homogeneity among samples from the Florida Keys, Mexico, and Belize indicating that these specimens belonged to single stock of black grouper. The specimens from Bermuda were differentiated from the other areas, and represent a separate stock of black grouper in the west central Atlantic (Zatcoff 2001). Currently, there is no other published information on the genetics of black grouper available from the southeastern US, Caribbean, or southern Atlantic Ocean.

2.3.3 Tagging

Some published information is available on tagging of black grouper from the US South Atlantic and Gulf of Mexico. Tagging information from the Florida Keys (Lindholm et al. 2005, Farmer 2009) and GOM suggest that black grouper only move short distances, which could contribute to future stock separation given enough time. Both of those studies tagged few black grouper which, based upon their sizes, were probably sexually immature, so only limited conclusions about the movements of black grouper can be drawn from these studies. If future research reveals a more complex subpopulation structure that may not be genetically distinct but which has functionally independent units [e.g. red snapper (Fischer et al. 2004)], then it may be possible to partition the population into meaningful subunits. But at this point, the black grouper of the South Atlantic and Gulf of Mexico should be treated as a single population.

2.3.4 Larval transport and connectivity

Keener et al. (1988) found small numbers of *M. bonaci* postlarvae during a study of larval transport into and out of tidal inlets in South Carolina. Postlarvae were aged using daily increments accumulated in the lapillus (the anterior-most located and often the smallest of the three pairs of otoliths in fish). *M. bonaci* postlarvae averaged 15 mm SL in their collections and were from 31 to 57 days old (Keener et al. 1988). Postlarvae were found mostly in surface collections during flood tides in mid-April to early May. Similar in timing to *M. bonaci*, gag (*M.*

microlepis) were more common in their collections. Back-calculated fertilization dates in both species (Keener et al. 1988) were calculated to occur from mid-February to early March, with *M. bonaci* (black grouper) fertilization occuring a little later than *M. microlepis* (gag).

2.3.5 Distribution

Black grouper (*M. bonaci*; Figure 2.15.1) in the southeastern United States (the northern most part of their range) are found chiefly in southern Florida and the Florida Keys, although specimens are recorded from Massachusetts to Texas (Bullock and Smith, 1991). The range of black grouper (*M. bonaci*) extends to southeastern Brazil and east to Bermuda (Figure 2.15.2; Kaschner et al. 2008).

Black grouper are often found associated with rocky ledges and coral reefs from 10-100 m [Bullock and Smith 1991, Brulé et al. 2003, O'Hop and Beaver 2009 (SEDAR19-DW-09)]. In the northern hemisphere, black grouper are more often caught in the southeastern Gulf of Mexico (Figure 2.15.1), southern Gulf of Mexico [e.g, Campeche Banks (Brulé et al., 2003)], and the Caribbean [e.g., spawning aggregations off the coast of Belize (Sala et al. 2001, Paz and Sedberry, unpublished manuscript)]. In the southeastern US (Figure 2.15.1), black grouper are caught more commonly in the Florida Keys along the reef tract, and are caught along high relief areas in deeper waters off of the west coast of Florida to the Florida Middle Grounds and off of the east coast of Florida. Generally, larger and older individuals are caught more often in deeper waters [Figure 2.15.3; O'Hop and Beaver 2009 (SEDAR19-DW-09), see also Brulé et al. 2003].

2.3.6 Identification issues

Gag (*Mycteroperca microlepis*), a species of grouper similar in appearance to *M. bonaci* (Figure 2.15.4), is sometimes referred to as "black grouper[1]" by both recreational and commercial fishers. Except in the Florida Keys, gag (*M. microlepis*) is more frequently caught off of Florida's west coast north of the Florida Keys than *M. bonaci*. There is confusion in the identification of these species by some fishers and outdoors writers [O'Hop and Beaver 2009

[1] The conventions in this document are that black grouper will refer only to *M. bonaci*, gag will refer only to *M. microlepis*, and "black grouper" (in quotes) will refer to uncertain identifications of groupers in catches from commercial and recreational fisheries that may or may not have included specimens of *M. bonaci*.

(SEDAR19-DW-09)]. In addition, the recreational landings recorded in the NMFS Marine Recreational Fishery Statistics Survey (MRFSS) appear to have different percentages of "black grouper" and gag in the earlier portion of the time series than in the later years [e.g, 1981-1987 Florida east coast, and 1981-1989 Florida west coast; O'Hop and Beaver 2009 (SEDAR19-DW-09)], and it is probable that some of the interviewers did not distinguish between these two species particularly during those early years. The NMFS Head Boat Survey does not appear to have these issues, although there are occasional instances of black grouper reported from some areas that appear questionable but which are possible. Potential methods to adjust the reported recreational catches of black grouper and gag in the U.S. portion of the Gulf of Mexico were discussed during SEDAR 10 (see Phares et al., 2006).

Prior to 1986, groupers landed and sold commercially were not reported separately by species. Beginning in 1986, several species of groupers were reported separately (including "black grouper" and gag). However, there is also confusion in the time series of commercial catches of "black grouper" (referring to black grouper or gag, and possibly other species of grouper) by seafood dealers in the early portion of this time series, and methods to adjust the reported commercial catches of black grouper and gag in the U.S. Gulf of Mexico using dockside samples from the Trip Interview Program were discussed during SEDAR 10 (see Chih and Turner, 2006).

The unadjusted time series of reported landings (commercial and recreational) for black grouper (and gag) are uncertain and inaccurate. Therefore, inferring the distribution of the stock of black grouper (*M. bonaci*) from the reported commercial and recreational fisheries landings alone without a rigorous analysis of the underlying data is unwise and not recommended.

2.4. *NATURAL MORALITY*

Quinn and Deriso (1999), at the end of their chapter discussing methods for estimating natural mortality (M), noted that there were a variety of methods for its calculation and none that were without some drawbacks. Their best advice was to calculate a range for M using a variety of appropriate methods rather than rely on a single point estimate of M. The LH WG evaluated natural mortality (M) estimates for black grouper (*M. bonaci*) using the following methods:

Alagaraja 1984, Alverson & Carney [1975, as presented in Quinn & Deriso (1999)], Beverton and Holt (1956), Hoenig (for fish and for all taxa, 1983), Pauly (1980; intercept modified for use of natural logarithms as presented in Quinn & Deriso, 1999), Pauly and Binohlan (1996; intercept modified for use of natural logarithms), Ralston (1987), Lorenzen (1996; 2005), Jensen (1996), and the "Rule of thumb". The formulas are listed in Table 2.14.2 and the estimated M values are provided in Table 2.14.3. Because the estimates for the Von Bertalanffy growth curve parameters *k* and L_∞ did not vary much (Table 2.14.3; see growth curves in Table 2.14.5), the variability in the M estimates that were based on these *k* and L_∞ do not vary much either. To provide context for evaluating these estimates, a catch curve (Robson and Chapman 1961) using specimens aged from the 2000-08 long line fishery (see O'Hop and Beaver 2009) produced estimates of total mortality (Z) of $0.23 \cdot y^{-1}$ (ages 9-33) or $0.15 \cdot y^{-1}$ (ages 15-33) which indicate that the estimates of M above $0.15 \cdot y^{-1}$ are too high.

The LH WG recommends using the observed maximum age ($T_{\mathbf{max}}$) of 33 years for black grouper (*M. bonaci*; see section 2.6.3). For the Beverton-Holt estimate of M, the range of the 95% confidence interval for the age at 50% ♀ maturity was 6.2-6.8 years. Using a *k* value of 0.1432 (from the size-limit corrected Von Bertalannfy growth curve) resulted in M values between 0.26 to $0.30 \cdot y^{-1}$. We also estimated M based on the Pauly (1980) and Pauly and Binohlan (1996) equations using 20.9°C (average bottom temperature in the region based on MARMAP data). Estimates of M using this method for 15°C, 25°C, and 30°C are provided in Table 2.4.b to evaluate the effect of the temperature choice on M estimates. Other natural mortality estimates using models based on growth parameters [Alverson & Carney (1975), Ralston (1987), Jensen (1966)] were variable, ranging from 0.09 to $0.31 \cdot y^{-1}$ and those based upon maximum age [Hoenig (1983), Alagaraja (1984), "rule-of-thumb") fell in the lower part of that range.

At the Data Workshop, the LH WG recommended that the assessment incorporate a range of M estimates for sensitivity runs from 0.10 to $0.29 \cdot y^{-1}$ for black grouper. A choice of M calculated from Hoenig's equations (Hoenig 1983) for a base run was $0.126\text{-}0.136 \cdot y^{-1}$, with $0.136 \cdot y^{-1}$ recommended for the base run following the recommendations of Hewitt and Hoenig (2005). Based upon the catch curve calculated from long line catches (Robson and Chapman 1961), M estimates for sensitivity runs above $0.15 \cdot y^{-1}$ (catch curve estimate of Z for ages 15-33) would be excessive. As a result, the LH WG recommendation for M in sensitivity runs should be modified to 0.10 to $0.15 \cdot y^{-1}$.

It is unlikely that there is a constant natural mortality rate ($M \cdot y^{-1}$) across all sizes and ages of individuals in a population; more plausibly, natural mortality rates vary by size and age in populations. Alternative approaches to constant mortality rates were discussed by Caddy (1996) and Lorenzen (1996). Caddy (1996) developed methods to divide the life span of short-lived species into time intervals of increasing duration (reciprocal time intervals) or by defining time intervals corresponding to the duration of life history stages (e.g., eggs, planktonic stages, post-settlement larvae, juveniles, pre-adults, adults) of species. Non-fishing mortality rates can be assigned to these intervals over which mortality rates may be relatively constant, and an overall mortality rate estimated from catch curves or indirect methods (e.g., Table 2.14.2) is used to scale mortality rates over each time interval based upon average lifetime fecundity and population replacement rate assuming a stable age distribution (Caddy 1996). Giménez-Hurtado et al. (2009) adapted Caddy's method for estimating natural mortality rates for life history stages of red grouper on the Campeche Banks. At present, fecundity estimates for *M . bonaci* (black grouper) have not been made so Caddy's approach to estimating a varying M over the lifespan of this species would be precluded.

Another method for estimating non-fishing (=natural) mortality rates by size was developed by Lorenzen (1996). He used a meta-analysis of non-fishing mortality rates and body size from published studies of several species in natural and aquaculture systems and found a exponential relationship between body size and M. Lorenzen (2005) notes that "Natural mortality rates within natural fish populations are strongly size-dependent…" and that "….natural mortality is approximately inversely proportional to length…". Body weight and natural mortality rates were shown to be related (Lorenzen 1996), and length and growth parameters can be used to generate similar mortality rate estimates (Lorenzen 2005). Using the approach detailed in Lorenzen (2005), age-specific mortality rates are calculated from the parameters from the Von Bertalannfy growth curve (L_∞, k, and t_0), age, the ages over which the survivorship curve is scaled (fully recruited age to last ages in the catch), and an estimate of natural mortality as a "target" rate.

The observations in natural populations that support these adjustments to age-specific survival rates are that non-fishing (= natural) mortality rates of younger and smaller fish are high, that older and larger fish are subject to lower non-fishing mortality rates, and that a simple exponential decline in numbers over the entire lifespan of a species (i.e., a fixed $M \cdot y^{-1}$ for the non-fishing mortality rate) may underestimate these age-specific rates in younger, smaller fish and overestimate these rates in older, larger fish. Scaling these non-fishing age-specific mortality rates using the Lorenzen (1996; 2005) approach estimates slightly higher non-fishing mortality rates (i.e., survival rates are slightly lower) in younger and smaller fish and slightly lower rates (i.e., survival rates are slightly higher) in older and larger fish compared to those estimated using a fixed $M \cdot y^{-1}$. Using a fixed non-fishing mortality rate and using age-specific mortality rates are two different yet similar models for population non-fishing mortality rates. The Lorenzen approach considers non-fishing mortality rates to be variable over the life span of the individuals in the population. Predation rates comprise a larger share of the non-fishing mortality rate for individuals of smaller sizes compared to larger individuals. The Lorenzen approach adjusts the simple exponential non-fishing mortality rate such that the age-specific rates vary inversely with size.

The DW recommended the Lorenzen (2005) age-specific model for estimates of natural mortality in black grouper (*M. bonaci*) for Ages 1+ (or Age 0+ if desired), as was done in several of the SEDAR assessments [e.g., SEDAR 4 (Snowy Grouper and Tilefish), SEDAR 10 (South Atlantic and Gulf of Mexico Gag Grouper), SEDAR12 (GOM red grouper) and SEDAR15A (mutton snapper)]. The LH WG recommends that the Hoenig estimate for M ($0.136 \cdot y^{-1}$) be used as the "target" M estimate for the Lorenzen age-specific approach and scaled over ages 3-33 for black grouper following the general recommendations for generating age-specific M in the SEDAR 12 Review Workshop Review Panel Consensus Summary using a spreadsheet supplied by one of the CIE reviewers (Dr. Paul Medley). These age-specific M estimates (Table 2.14.4) are recommended for use in the initial base run of the model(s) for black grouper, with sensitivity analyses using age-specific M estimates scaled over ages 3-33 years and with "target" M values from 0.10 and $0.15 \cdot y^{-1}$ (see discussion above).

2.5. *DISCARD MORTALITY*

There are no experimental studies of discard mortality (i.e., mortality after catch was released) for *M. bonaci* (black grouper) available. Wilson and Burns (1996), Overton and Zabawski (2003), McGovern et al. (2005), and Ruderhausen et al. (2007), studied aspects of discard mortality in the closely related species *M. microlepis* (gag). Hook placement, depth of capture, and venting of the swim bladder were important factors in the survival of released gag. McGovern et al. (2005) found a distinct relationship between depth of capture and mortality of released gag. Dead discards in the 2001 gag assessment (Ortiz 2006) were estimated using two different methods. The first method used a fixed proportion of the total discards for consistency with a previous assessment of gag (Turner et al. 2001) and some previous reef fish assessments. Discard mortality in recreational fisheries was assigned by Turner et al. (2001) and Ortiz (2006) as 20% of discards, and commercial discard mortality was assigned as 30% of discards. The second method used in the gag assessment (Ortiz 2006) assigned discard mortality on the basis of an estimated depth of capture assumed in recreational and commercial fisheries. Lacking any information specifically for black grouper (*M. bonaci*), discard mortality estimates may have to be inferred from similar species such as gag and use similar values such as used in the recent assessments of gag in the southeastern U.S. The Data Workshop participants recommended that the estimation of discard mortality of black grouper from catches in recreational and commercial fisheries assume values of 20% and 30%, respectively.

2.6. *AGE*

2.6.1 Available age data

Age data for black grouper (*M. bonaci*) were available from the Crabtree and Bullock (1998) study (their otolith sections and spreadsheet from fishery dependent and special collections were re-located) and additional material from Bullock (FWRI, personal communication), FWRI biological sampling programs (fishery dependent and a few fishery independent specimens), NMFS SEFSC laboratories at Panama City, FL and Beaufort, NC (fishery dependent and a few fishery independent specimens). Otolith sections from the Crabtree and Bullock (1988) study were re-examined by personnel from FWRI's Age and Growth Laboratory, providing counts of annuli and an evaluation of the edge type for the marginal increment analysis to compare with average annuli counts from Crabtree and Bullock (1998). FWRI's Age and Growth Laboratory sectioned otoliths from the other *M. bonaci* specimens provided by the various labs for SEDAR 19. A series of tables with the number of age samples by fishery, gear, collection program, and year (Table 2.14.1) were available from O'Hop and Beaver [2009, (SEDAR19-DW-09)].

2.6.2. Age procedures, error matrix, and conversion criteria.

Sectioned or whole otoliths were used to estimate ages of black grouper (*M. bonaci*) by several studies (e.g., Manooch and Mason, 1987, Crabtree and Bullock 1998), and ages were validated by marginal increment (translucent zone on the edge of an otolith) analysis. Annulus formation in this species is typically in March-April, and one ring is formed each year (Crabtree and Bullock 1998). Manooch and Mason (1987) reported ages as annuli counts, and Crabtree and Bullock (1998) used the average of six annuli counts [three reads each by two readers, with the calculation of a coefficient of variation (CV)] to estimate the age of black grouper. Crabtree and Bullock (1998) rejected the otolith if the CV of the annuli counts exceeded 12%.

Otolith sections used in the Crabtree and Bullock (1998) study were re-examined and re-aged with the new criteria to compare with their published results (growth curve, size and age at maturity analysis, and size and age in the proportion of females in the samples of the population (an estimate of the size of transition for protogynous species). All but seven of the 1,060 slides used in the Crabtree and Bullock (1998) study were relocated and re-aged [O'Hop and Beaver 2009 (SEDAR19-DW-09)]. Otolith sections which were rejected (133 slides) by Crabtree and Bullock (1998) based on the CV exceeding 12% were also re-examined and an age was determined if the section was considered readable. The agreement (Average Percent Error (APE)) between the Crabtree and Bullock (1998) annuli counts and the re-counts for SEDAR 19 was 3.5% (J. Tunnell, FWRI Fish Biology Section, Age and Growth Lab, personal communication). Unfortunately, the Manooch and Mason (1987) otolith slides could not be located for use in SEDAR 19 and were not included in this analysis. A spreadsheet with the total lengths, annuli counts, and month and year of collection from Manooch and Mason (1987) was available; however, information on the marginal increment on these otoliths was not available so it was not possible to apply the same criteria for aging as was used for SEDAR 19.

Black grouper (*M. bonaci*) otoliths from collection sources (e.g., projects listed in Table 2.14.1) other than from Crabtree and Bullock (1998) were obtained from the NMFS Panama City and

Beaufort Laboratories and FWRI. Whole black grouper otoliths were embedded in Araldite two-part epoxy and cut using a Buehler Isomet low-speed saw. Four diamond wafering blades each separated by a 0.4 mm aluminum spacer were used to yield three sections that were mounted on a microscope slide and covered with Flo-Texx mounting media. Otolith sections were viewed under a stereomicroscope with either transmitted or reflected light. Counts of annuli and edge type were recorded for each readable otolith. Three different categories for edge type were used: otoliths with an annulus on the margin of the section are classified as edge type 2, otoliths with an edge type 4 have a translucent marginal zone up to 2/3 complete, otoliths with an edge type 6 have a translucent marginal zone greater than 2/3 complete. Each otolith was read twice with each read independent, and discrepancies in annuli counts and edge types were resolved. A subsample of 20% of the otoliths [excluding otoliths from Crabtree and Bullock (1998) which were analyzed separately] was read by all readers for precision and quality control (Campana 2001), and the APE for this subsample was 4.78% - acceptably under the 5% level for otoliths which are considered not difficult to read.

Because one annulus is formed each year in black grouper, the number of annuli is usually the age of the specimen. The formation of an annulus in black grouper frequently occurs in March-April (Crabtree and Bullock 1998), so specimens caught early in the year often show a relatively large translucent zone (i.e., marginal increment) at the edge of their otoliths. The interpretation for these specimens is that these fish were caught before the next annulus was formed. Annuli counts for specimens with marginal increments that are 2/3 or more complete during the time of year around annulus formation can be adjusted to a biological age by adding one to the number of counted annuli (e.g., Campana 2001), and many of the SEDARs have used this technique in their age determinations [e.g., SEDAR 19 (red grouper; Reichert et al. 2009), SEDAR 15A (mutton snapper; Tunnell et al. 2007), SEDAR 10 (gag; Reichert et al. 2005)].

Annulus count, edge type and capture date were used to estimate the age of a fish based on a January 1st birth date. The age of a fish with an edge type 2 or 4 was equal to the number of annuli. The age of a fish caught prior to June 1st with an edge type 6 (a large translucent zone) is equal to the number of annuli plus one. The age of a fish with edge type 6 caught on or after June 1st, is equal to the number of annuli.

Ages were determined for a total of 2,288 otoliths, including the 1,055 re-aged from the Crabtree and Bullock (1998) study. The maximum observed age for *M. bonaci* specimens was 33 years, and two of the four specimens (the third specimen had no information available for the gear used but was from a commercial fishing boat that used long line gear on another occasion, and the fourth specimen had no information on the gear used or mode of fishing) of this age were obtained from commercial long line fishermen. Of the 18 specimens aged 29 years or older, 11 were from long lines (of the other seven, six were from unspecified commercial gears and one had no gear or mode of fishing information). Of the 222 specimens aged 15 years and older, 93% of the specimens came from the commercial fishery (69% from long lines, 19% from unspecified fishing gears, 2% from hook and line), 4% from the recreational fishery (2% from head boats, 1% from charter boats, 1% from tournaments), and 3% were from unspecified gears and modes of fishing. It is possible that older specimens could be harvested by gears other than long lines and commercial fishing, but there was more emphasis on sampling in the long line catches than in other modes and gears. However, there has been sampling of fish for length measurements and otoliths in other modes and gears by commercial and recreational samplers, and if older black grouper were being landed frequently in other modes and by other gears they should have been sampled. So, it is very likely that long lines are deployed in deeper habitats where larger and older black grouper are more frequently encountered and that other gears and modes of fishing do not fish those areas as frequently. Brulé et al. (2003) also noted smaller (and presumably younger) *M. bonaci* in shallower waters (4-20 m) taken by spearfishers and hook-and-line fishermen compared with larger specimens from deeper waters (40-210 m) taken by long line fishermen off the Campeche Banks.

2.6.3. Maximum age

The maximum age of black grouper (M. bonaci) in the samples (n= 2,288) is 33 years (Crabtree and Bullock 1998). Four fish of this age (two from the long line fishery, and one from unidentified commercial gear but which we suspect were probably from a long line catch, and one from unspecified fishing gear and mode of fishing) were represented in catches from 1978-2008 [O'Hop and Beaver 2009 (SEDAR19-DW-09)]. The LH WG recommends using 33 years as the maximum age for black grouper since this was the age actually observed from catches over several years in the deeper habitats where the larger and older specimens have been found, and collections of M. bonaci in catches from long lines has been more frequent than from other types of fishing gears.

2.7. *GROWTH*

Using the data combined from all sources (commercial fisheries, recreational fisheries, fishery independent, and special collections) of otoliths, a series of Von Bertalanffy (VB) growth parameters were estimated (Table 2.14.5) for black grouper (*M. bonaci*). The LH WG recommends using $L_\infty = 1334$ (mm), $k = 0.1432 \cdot year^{-1}$, and $t_0 = -0.9028 \cdot year$ for use in the assessment model. These values were obtained using the most appropriate treatment of the data: all available age data with the Diaz et al. (2004) correction applied for fishery dependent samples. The LH WG feels that the selected values are robust, since there was very little variability between the VB parameter estimates between the various regressions [Table 2.14.5; see also other regressions in O'Hop and Beaver 2009 (SEDAR19-DW-09)].

2.8. *REPRODUCTION*

Black grouper (*M. bonaci*) are protogynous hermaphrodites (Garcia-Cagide and Garcia 1996, Crabtree and Bullock 1998, Rénan et al., 2001, Brulé et al. 2003). The LH WG recommends that information provided in Crabtree and Bullock (1998) be used for spawning seasonality, and that other parameters (age-at-maturity for females, age-at-sex transition, and sex ratio at age if needed) that depend upon age determinations use the ages adjusted for marginal increment type and time of year [O'Hop and Beaver 2009 (SEDAR19-DW-09)]. Size-at-maturity and age-at-maturity were estimated originally by Crabtree and Bullock (1998) from histological examinations of specimens caught in all months of the year rather than restricting these analyses to months just prior to the onset of the spawning season (Hunter and Macewicz 2003). The LH WG recommends that size-at-maturity and age-at-maturity estimates for black grouper (*M. bonaci*) be restricted to January-March (beginning in the month just prior to spawning to the peak of the spawning season) as was done in O'Hop and Beaver [2009 (SEDAR19-DW-09)] to provide the best estimates for these parameters (Table 2.14.6).

2.8.1 Spawning season

The peak spawning season of black grouper (*M. bonaci*) is assumed to occur from February through April. Keener et al. (1988) suggested that the postlarvae of black grouper (*M. bonaci*) that they captured entering tidal inlets in South Carolina were fertilized by early April (using back-calculated ages from daily growth rings in the otoliths of the postlarvae). Claro and Lindeman (2003), in a study on spawning sites on the Cuban shelf which involved interviews with experienced fishermen, list the months when spawning occurs in black grouper as December or January-March. Fishermen noted that the peak spawning months occurred in February-March associated with a full moon. Claro and Lindeman (2003) also noted that the habitats where spawning aggregations were found were in rocky areas with coral heads in 14-40 m of water, and that fishermen felt that the number of individuals in those aggregations had declined over time. The data from aggregations of black grouper in other areas (Eklund et al. 2000; Heyman 2001, Heyman and Requena 2002, Paz and Sedberry (unpublished manuscript), presumably for spawning but possibly also for feeding (Teixeira et al. 2004), occurs along rocky high relief areas in waters 30 m and deeper. One aggregation at which spawning activity was confirmed (Sala et al., 2001) occurred in such an area between 30-50 m in water depth.

2.8.2 Fecundity

No estimates of annual fecundity at age are available for black grouper (*M. bonaci*) along the Atlantic coast and Gulf of Mexico of the southeastern U.S. Some observations of females with hydrated oocytes were noted in Crabtree and Bullock (1998). Given the limitations of the equations and the lack of adequate gonad weight data, the consensus of DW was to recommend the use of total mature biomass (male and female combined) as a proxy for fecundity. In the absence of other fecundity estimates, gonad weight has served as a proxy for fecundity at age for protogynous hermaphrodites in other SEDARs (e.g., SEDAR12).

2.8.3 Age and size at maturity

Black grouper (*M. bonaci*) is a protogynous hermaphrodite (i.e., the gonads function first as ovaries and then transform into testes) (Garcia-Cagide and Garcia 1996, Crabtree and Bullock 1998, Brulé et al. 2003, Teixeira et al. 2004). The timing of peak gonad development in the southeastern U.S. and the Campeche Banks (Mexico, southern Gulf of Mexico) is during

December-March, though females with vitellogenic oocytes occur in all months of the year (Crabtree and Bullock 1998, Brulé et al. 2003). Garcia-Cagide and Garcia (1996) note that spawning of black grouper in Cuban waters takes place from November to May with peaks in November and February. In the southern hemisphere in waters off northeastern Brazil, spawning may occur from April to September (Teixeira et al. 2004).

The length- and age-at-maturity of females and proportion of females at length and age (Table 2.14.6, Figure 2.15.6) were estimated from data originally presented in Crabtree and Bullock (1998). The data were fit using a logistic regression (Proc NLIN, SAS ver. 9.2) for the proportion of mature females at length using

$$\text{Proportion (mature ♀)} = 1 / (1+(e^{-r*(TL-L_{50})})) ,$$

where TL is the total length of the specimen in millimeters and Proportion (mature ♀) is either a 0 (immature) or 1 (mature) based upon Crabtree and Bullock's (1998) histological analyses of specimens. The regression estimates the slope of the relationship (r) and the length estimate (L_{50}) at 50% maturity. Similarly, the proportion of mature females at age were fit to the logistic regression

$$\text{Proportion (mature ♀)} = 1 / (1+(e^{-r*(Age-A_{50})})) ,$$

where Age is either the average annuli counts from Crabtree and Bullock (1998) or the ages adjusted for the marginal increment type and time of year (SEDAR 19), and Proportion (mature ♀) is either a 0 (immature) or 1 (mature) based upon Crabtree and Bullock's (1998) histological analyses of specimens. The proportion of females at length or age (a measure of the length- and age-at-transition from female to male in protogynous species was modeled similarly, where specimens were coded as a 1 (female) or 0 (male) based on histological analyses. The logistic regressions solved for the slope (r) and either the length (L_{50}) or age (A_{50}) at which the proportion of females was estimated to be 50% of the sample population. The parameters and other statistics from these regressions are presented in Table 2.8.3.

The smallest mature female was 508 mm TL (Figure 2.15.6), and the youngest was age 3 (Figure 2.15.6); age at 50% ♀ maturity was 6.5 yr (95% CI = 6.2-6.8) and length at 50% ♀ maturity was 856 mm TL (95% CI = 840-871). The largest immature female was 938 mm TL and the oldest was age 7 (Figure 2.15.6).

In SEDAR19 red grouper LH WG report, the classical definition of maturity was utilized, such that inactive mature females have been included in the numerator and denominator of the proportion mature calculation and the data set has not been temporally restricted. This is a methodological difference between the black grouper and red grouper LH WG recommendations. The black grouper LH WG chose to restrict the data set to those months (January-March) just prior to the peak spawning following the recommendations of Hunter and Macewicz (2003).

2.8.4 Age and size at sex transition.

Only two black grouper (M. bonaci) specimens were found in transition from female to male. The smallest transitional specimen (considered male for this analysis) was 947 mm TL, and it was 6 years old. The other specimen was 980 mm TL and it was not aged (otolith not taken). The proportion of females to males by age collected for the Crabtree and Bullock (1998) study was used to estimate the age-at-transition using a logistic regression (see section 2.8.3 for description of the equations). The length at which 50% of the specimens were female (L_{50}) was 1214 mm (95% CI = 1203-1225; Figure 2.17.7) and the age (adjusted age) at which 50% of the specimens were female (A_{50}) was 16.0 years (95% CI = 15.3-16.8; Figure 2.17.7). The largest female was 1310 mm TL and the oldest female was 21 years old. The LH WG recommends the use of the age-at-sex transition (using the adjusted ages for specimens) and length-at-sex transition listed for black grouper (*M. bonaci*) in Table 2.14.6.

2.8.5 Sex ratio

Few of the specimens (38 of the 888, 4.3%) examined histologically for the Crabtree and Bullock (1998) study were males. Only 2 of the 38 were transitional specimens [for classification system see Moe (1963)]. It is believed that the time to complete transition from females to males is relatively quick (Crabtree and Bullock 1998), so it is not surprising that only a few transitional specimens were seen. Given the low number of specimens that were male available for this analysis, it is recommended to use the logistic regressions to model the sex ratio by length and age.

2.8.6 Life history parameters and steepness

The LH WG did not have an opportunity to discuss steepness issues related to life history parameters. The LH WG recommends this topic should be addressed in a separate meeting, possibly in conjunction with a future SEDAR DW. The meeting should involve a broad range of individuals with expertise in steepness-related life history aspects and include members of the assessment teams.

An average steepness value of 0.70 has been suggested for fish which are periodic strategists (Rose et al. 2001) and could be used for a base model run. Rose et al. (2001) described periodic strategists as “larger, highly fecund fishes with long life spans” which delay maturation to attain a body size sufficient to produce a large clutch. Red snapper was one of the species that they suggested as fitting into this group, and reef fish such as black grouper (*M. bonaci*) also fit the description of periodic strategists. A range of steepness values fixed from 0.60-0.90 in 0.10 increments could be useful for examining the sensitivity of the assessment model to this parameter, along with allowing the model to solve for steepness without fixing its value explicitly.

2.9. *MOVEMENTS AND MIGRATION*

There are some studies and anecdotal reports on movements and aggregations of *M. bonaci* (presumably related to spawning in most accounts) in the Florida Keys (Eklund et al. 2000, DeMaria 1996), Belize [Sala et al. 2001 (with an account of spawning activity just after sunset), Paz and Sedberry unpublished manuscript, Heyman 2001, Heyman and Requena 2002], Cuba (Claro and Lindeman 2003), and northeastern Brazil (Teixeira et al. 2004, possibly feeding aggregations).

Empirical information about movement characteristics of black grouper (*M. bonaci*) comes from relatively few fish. Lindholm et al. (2005) acoustically tagged 5 fish [380-740 mm SL (= 469-888 mm TL using equation in Table 2.10)] and recorded their locations for 8 months along a linear array of 5 single-channel, omnidirectional receivers (Vemco model VR2) in the northern Florida Keys National Marine Sanctuary [Conch Reef and Davis Reef areas (seaward of Key Largo and Tavernier in the upper Keys)]. The time at-liberty ranged from approximately 1 month to more than 5 months, with >90% of signal detections at the station where the fish were caught and released. Four of the 5 fish moved briefly (i.e. < 24 hrs roundtrip) between that receiver station and another also located on Conch Reef. One fish visited an adjacent reef 4 km away and returned within 24 hours. These results coarsely indicate high site fidelity while resident at a given reef site.

Farmer (2009) acoustically tagged 2 black grouper (in addition to 45 red grouper plus other species) and recorded their locations for approximately 4 months within a grid array of 25 VR2 receivers in the Dry Tortugas Marine Reserve. These two tagged specimens were 570 and 749mm TL. Home range sizes were estimated as minimum convex polygons that averaged 1.13 km2 (± 0.86 S.E.). Most signal detections were within the reception radius (~ 300m) of one or two receivers; movement frequency was < 1% and movement distances averaged 210.71 ± 0.35 m. Lunar effects on transmission receptions were not significant; diurnal and crepuscular detections were greater than nocturnal detections, and activity around dawn was greatest. Distances moved by day were greater than at other times. These fish mostly occupied isolated low-relief reef habitat within their home ranges, with continuous low-relief habitat utilized less than its proportional representation.

By comparison, gag (*M. microlepis*), a congener ecologically similar to black grouper, has similarly sized home ranges with a capacity for homing (Kiel 2004), and residence times (avg. = 9.8 months) significantly affected by reef habitat patchiness (Lindberg et al. 2006). Gag also show ontogenetic habitat shifts (e.g. Koenig and Coleman 1998, Collins et al. 1998), revisit reefs after leaving (Lindberg et al. 2006), and move long distances (Lindberg et al. 2006, McGovern et al. 2005). Given the limited spatial-temporal scales of existing black grouper studies, it would be inappropriate to assume that black grouper do or do not have analogous movement characteristics.

The specimens tagged by Lindholm et al. (2005) and Farmer (2009) were probably females and probably not sexually mature (i.e., below the L_{50} of 856 mm TL; Table 2.14.6). There was no significant relationship between daily movements of *M. bonaci* and lunar phase detected in the acoustic telemetry studies (Farmer 2009), though there may be some relationship between aggregation activity (presumably sexually mature individuals) prior to and after sunset, lunar phase (days after a full moon) and spawning aggregations in *M. bonaci* (Eklund et al. 2001, Sala et al. 2001) with actual spawning observed on one occasion after sunset (Sala et al. 2001) near the full moon.

There is information from the north coast of the Yucatan peninsula on the habitat of juvenile *M. bonaci* (105-455 mm TL) in shallow waters (1-10 m) characterized as irregular hard bottom of limestone outcrops or rocks surrounded by sandy areas (Brulé et al. 2005). Sites at which juvenile black grouper were found were shallow rocky reef habitats which had either high vertical relief with crevices, caves, or small dispersed rocks. FWRI's Fishery Independent Program (FIM) collected a few small black grouper specimens (Table 2.14.1, chiefly in the lower Indian River area (Figure 2.15.1). The gears (seines, otter trawls) used by the FIM for typical collections would not be appropriate for sampling in rocky reef habitats and therefore it is unsurprising that so few specimens were recorded by this program. Data from sampling in shallow waters (1-34 m) of the Florida Keys by the FWC Reef-fish Visual Survey (Muller and Acosta 2009) indicate that there is some trend for juveniles to be smaller in shallower waters and larger in deeper locations, but the trend is not particularly strong in juvenile black grouper (Figure 2.15.8). Catch information from fisheries (data from Crabtree and Bullock 1998, Brulé et al. 2003) indicate that specimens of black grouper from shallow reef habitats (4-20 m) are typically smaller than those caught in deeper waters (40-210 m) generally (fig. 2.3.5.c-d). Generally, it can be inferred from these studies that black grouper move from shallower to deeper habitats as they increase in length and age.

2.10. *MERISTICS AND CONVERSION FACTORS*

The LH WG recommends the conversions in Table 2.14.7 for length-length and length-weight transformations where needed. Total lengths were measured by squeezing the tail (following Hubbs and Lagler, 1964). The LH WG feels that the conversions are robust since they were established using relatively large data with appropriate size ranges. Additional conversions, if needed, are contained in O'Hop and Beaver [2009 (SEDAR19-DW-09)].

2.11. *COMMENTS ON THE ADEQUACY OF DATA FOR ASSESSMENT PURPOSES*

2.11.1 Adequacy of data

The following data and information for black grouper (*M. bonaci*) was deemed adequate for use in the assessment: stock definition and genetic structure, range of natural mortality estimates and age-specific mortality vector, operational definition of discard mortality (i.e., 20% mortality of recreational discards, 30% mortality of commercial discards), aging criteria (adjusted ages) and quality assurance on age determinations, growth parameters for the combined data (sampling sizes by year and gear/fishery are inadequate for construction of annual age compositions and other analyses), reproductive parameters (using adjusted ages for the Crabtree and Bullock 1998 study, but additional research should be conducted on sex ratios, maturity, and fecundity by habitat/area fished), and meristics and conversion factors. Data are limited on movements and migrations in black grouper, but there are on-going studies using acoustic telemetry in the Florida Keys that may, in the future, shed some light on some aspects of movements in this species.

2.11.2 Research recommendations.

- The DW LH WG recognized the value of continuing the otolith workshops and exchange of otoliths in preparation for SEDAR data workshops. These workshops are especially important for species that have been recognized as relatively difficult to age.

- The DW LH WG also recognizes the value of similar workshops to discuss the interpretation of reproductive samples, and the possible exchange of histological sections between labs in preparation for SEDAR Data Workshops. This will be especially important for species that have been recognized as relatively difficult to stage.

- Because little or no fecundity information is available for *M. bonaci* (black grouper) from the South Atlantic or the Gulf of Mexico, the DW LH WG recommends initiating a study to further identify aggregations and spawning locations, movements relating to aggregations and spawning, and to estimate fecundity for female age classes in both the GOM and Atlantic populations.

- The data on catch distributions of black grouper (*M. bonaci*) presented at the DW suggest that there are habitat and depth characteristics in the Florida Keys and the shelf areas of the South Atlantic and west Florida that are influencing the movements of this species. The DW LH WG recommends a study to further investigate movements of this species, especially individuals that are mature females and males, by use of genetic tagging, external tagging, or other relevant techniques.

- There is a need for improved collection and collection strategy for hard parts, in particular from the recreational sector. Samplers' encounter rate with anglers that have caught black grouper (*M. bonaci*) are low, particularly in recreational fisheries where bag limits restrict the number of available specimens. Some ingenuity in sampling design will probably be required.

- Increase of fishery independent data to include the entire area of black grouper (*M. bonaci*) distribution in the Atlantic and Gulf of Mexico in the southeastern U.S. Although the SEAMAP video surveys covers general areas (e.g., Florida Middle Grounds, West Florida shelf, Pulley Ridge, etc.) where black grouper are caught, few black grouper have been seen in this survey. Perhaps either some additional research on habitat preferences may aid in locating this species in these areas, or some other type of fishery independent sampling might be more successful in encountering black grouper and generating estimates of abundance in areas outside of the Florida Keys.

- Virtually no information on the life history and distribution of young juveniles (age 0-1) black grouper (*M. bonaci*) is available. The DW LH WG recommends a study to gather information on these early ages. These studies should include sampling for postlarvae in the months (March-June) after spawning is presumed to occur, location of habitats in Florida (particularly in the Florida Keys) where these fish occur (presumably rocky habitats not presently sampled by the fishery independent program in Florida), and diet composition, growth, and movements of juveniles.

2.11.3 Procedural recommendation:

- The DW recommends that the report of the natural mortality workshop organized by NMFS (Seattle, WA, August 2009) be made available to the DW LH WG before the next SEDAR as a guide in the discussions concerning natural mortality.

2.11.4 Special acknowledgements:

These analyses would not have been possible without the help of many state and federal biologists and concerned fishermen in the southeastern region. Lew Bullock (FWC) located otolith slides and supplied field and laboratory notes from 1978-1997 showing the sampling locations, modes of fishing, and fishing gears for specimens analyzed in the Crabtree and Bullock (1998) study. The otolith slides and data sheets from their study helped to provide consistency in the aging information and extended the information available on where (locations and depths) and how (fishing modes and gears) black grouper were caught. Don and Karen DeMaria, besides helping to obtain the specimens, provided some sampling location information absent from Lew's notes, clarified how specimens collected by commercial spearfishers in the Keys for the Crabtree and Bullock (1998) study were obtained, and explained potential biases (undersized fish collected under special permits, selection of specimens, etc.) in the collection process. Biologists participating in the NMFS Trip Interview Program, NMFS Head Boat Survey, FWRI and FIN biological sampling programs collected the lion's share of the otoliths since the Crabtree and Bullock (1998) study, and in several cases clarified information that they collected. David Gloeckner and Ken Brennan (NMFS, Beaufort Laboratory) provided the TIP and Head Boat data bases, respectively, which were essential to linking the otolith collections

with sampling information (depth, location, gear, dates, etc.). Tim MacDonald provided information for specimens (while few in number, they were important to the younger side of the growth curve) collected in the FWRI Fisheries Independent Monitoring Program. Linda Lombardi-Carlson (NMFS, Panama City Laboratory), Dr. Jennifer Potts (NMFS, Beaufort Laboratory), and Kelley Kowal (FWC) provided otoliths, sampling and measurement information from archived material, and Janet Tunnell, Alison Amick, and Jessica Carroll of the FWRI Age and Growth Lab processed the otoliths, provided annuli counts (including the re-examinations of the Crabtree and Bullock (1998) slides), marginal increment, and quality assurance data. Dr. Jennifer Potts (NMFS Beaufort Laboratory) provided a spreadsheet to the LH WG which was very helpful in deriving the estimates for natural mortality for this report. Dr. Walter Ingram (NMFS Pascagoula Laboratory) shared the SAS code in Proc Model for the size-truncated Von Bertalannfy growth curve which was used to generate the growth curve parameters for black grouper in this report. Dr. Robert Muller provided valuable comments and editorial revisions for this report.

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

1. Complete draft of SEDAR19-DW-09. Assigned to J. O'Hop. Anticipated completion date: July 13, 2009. Completed by July 31, 2009.
2. Compile from literature sources information on population movements and migrations in black grouper. Assigned to: W. Lindberg, D. Gregory, and J. O'Hop. Anticipated completion date: July 13, 2009. Completed July 13, 2009.
3. Complete section on natural mortality estimation. Assigned to J. O'Hop. Anticipated completion date: July 20, 2009. Completed: July 31, 2009.
4. Compile information and complete life history work group report for black grouper. Assigned to: J. O'Hop. Anticipated completion date: July 20, 2009. Completed: August 6, 2009. Final draft incorporating comments received to date completed: August 20, 2009.

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2.14. *TABLES*

Table 2.14.1. Number of *M. bonaci* (black grouper) otoliths aged from biological surveys in the southeastern US by project name, mode of fishing, and gear. Coast assignment based upon latitude/ longitude, descriptions of locations, or area fished (NMFS Shrimp Grid or Head Boat Area Fished) on data collection records.

PROJECT	<missing>	Atlantic Ocean	Gulf of Mexico	Total
Crabtree and Bullock (1998)	218	595	242	1,055
FWRI FIM	.	15	4	19
FWRI (FIN-BIOSTAT)	.	18	3	21
NMFS HEAD BOAT SURVEY	.	25	2	27
FWRI (HEAD BOAT)	.	7	.	7
FWRI (Biological Sampling)	.	3	1	4
NMFS MRFSS (FWRI)	.	6	.	6
NC DEHNR	.	7	.	7
NMFS TIP	7	155	977	1,139
FWRI TOURNAMENT	.	.	3	3
Total	225	831	1,232	2,288

Mode of fishing	<missing>	Atlantic Ocean	Gulf of Mexico	Total
<missing>	13	7	3	23
CM (Commercial)	175	165	1,139	1,479
FI (Fishery-Independent)	.	15	4	19
HB (Head Boat)	3	37	28	68
PC (Party/Charter)	.	43	4	47
PR (Private/Rental Boat)	1	8	.	9
RC (other Recreational)	1	3	1	5
SC (Special Collections)	31	553	36	620
SS (Surveys)	1	.	.	1
TR (Tournaments)	.	.	17	17
Total	225	831	1,232	2,288

Gear	<missing>	Atlantic Ocean	Gulf of Mexico	Total
<missing>	97	24	50	171
BANDIT RIG	.	29	27	56
COLD KILL	.	1	.	1
HOOK AND LINE GEARS	14	168	64	246
LONG LINE	78	19	1,031	1,128
FIM SEINES	.	14	2	16
FIM OTTER TRAWLS	1	1	2	4
SPEARFISHING	33	574	56	663
TRAPS	2	1	.	3
Total	225	831	1,232	2,288

Table 2.14.2. Various published methods and formulae for estimating natural mortality (M).

Reference sources	Parameters	Sources and notes	Formulae
Alagaraja	t_{max}, survivorship to t_{max}	Alagaraja (1984) S = survivorship	$M = -\ln[S(t_{max})]/t_{max}$; derived from $S(t_{max}) = \exp(-M*t_{max})$
Alverson & Carney	k, t_{max}	Alverson and Carney (1975) From Quinn and Deriso (1999):	$M = 3k/(\exp(0.38*t_{max}*k)-1)$
Beverton & Holt	k, a_m	Beverton and Holt (1956) (a_m = age at 50% ? maturity)	$M = 3k/(\exp(a_m*k)-1)$
$Hoenig_f$	t_{max}	Hoenig (1983) (for fish)	$M=\exp(1.46 - 1.01*\ln(t_{max}))$
$Hoenig_c$	t_{max}	Hoenig (1983) (fish, other taxa)	$M=\exp(1.44 - 0.982*\ln(t_{max}))$
Jensen	k	Jensen (1996)	$M = 1.5*k$
Pauly	L_∞, k, T	Pauly (1980) From Quinn and Deriso (1999):	$M=\exp(-0.0152 + 0.6543*\ln(k) - 0.279*\ln(L_\infty, cm) + 0.4634*\ln T(°C))$
Pauly Method II	L_∞, k, T	Pauly and Binohlan (1996)	$M=\exp(-0.1464 + 0.6543(k)- 0.279*\ln(L_\infty, cm)+ 0.4634*\ln T(°C))$
Ralston	k	Ralston (1987)	$M=0.0189 + 2.06*k$
"Rule of thumb"	t_{max}	2.996 ≈ survivorship of 0.05 Hewitt and Hoenig (2005)	$M = 2.996/t_{max}$
Age-specific natural mortality			
Lorenzen	W at age, N at age	Lorenzen (1996), Lorenzen (2005) a_1- a_t : first and last ages for scaling M-at-age to M_{target} – a target natural mortality estimate from one of the other methods in this table (spreadsheet by Paul Medley, pers. comm. for SEDAR 12)	$M=3.69*W\char`^(-0.305)$ (Lorenzen 1996) Survival = $\exp(-M*t_{a1})$ $= \exp(\ln((L_{at}/(L_{at}+L_\infty (\exp(k*a_1)-1))) * (M_1/(L_\infty*k)))$ $M_1 = (a_t-a_1)*(L_\infty*k*M_{target}) / \ln(L_{at}/(L_{at}+L_\infty*(\exp(k*(a_t-a_1))-1)))$ $M_{age} = -\ln(L_{at}/(L_{at}+L_\infty*(\exp(k*(a_t-a_{t-1}))-1))) * (M_1/(L_\infty*k))$

Table 2.14.3. Range of natural mortality estimates (y^{-1}) based on a variety of published methods and subsets of the available data.

Data Source	Obs. Max Age	Von Bert*		Water Temp , (°C)	Age-at-50% maturity (a_m) (95%CI)	Alverson & Carney	Beverton	$Hoenig_f$ ------- $Hoenig_c$	Pauly	Pauly Method II (snappers and groupers)	Ralston	Jensen	"Rule of thumb"	Alagaraja[1]		
		L_{inf} (mm)	k											0.01	0.02	0.05
All age data with size limit correction	33	1334	0.1432	20.9	6.5 (6.2-6.8)	0.086	0.28 (0.26-0.30)	0.126 0.136	0.288	0.253	0.314	0.215	0.091	0.140	0.119	0.091
All age data without correction	33	1364	0.1348	20.9	6.5 (6.2-6.8)	0.091	0.29 (0.27-0.31)	0.126 0.136	0.275	0.242	0.297	0.202	0.091	0.140	0.119	0.091
varying temp.	33	1334	0.1432	15					0.247	0.217						
varying temp.	33	1334	0.1432	25					0.313	0.275						
varying temp.	33	1334	0.1432	30					0.341	0.299						

[1] Note: values in italics under Alagaraja are population survivorship proportions.

Table 2.14.4. Lorenzen age specific natural mortality (M) estimates scaled to Hoenig's estimate (0.136) over ages 3-33 using parameters from growth curves uncorrected and corrected for size limits.

Age (years)	Growth curve (VonBertalannfy) with no size limit correction [L_∞ = 1364.7, *k* = 0.1348, t_0 = -1.0125] O'Hop and Beaver [2009 (SEDAR19-DW-09)]		Growth curve (VonBertalannfy) with size limit correction (Diaz et al. 2004) [L_∞ = 1334.2, *k* = 0.1432, t_0 = -0.9028] **SEDAR19 LH WG recommendation**	
	TL (mm) (mid-year)	M (y^{-1})	TL (mm) (mid-year)	M (y^{-1})
0	252	0.489	243	0.495
1	392	0.344	388	0.343
2	515	0.274	515	0.271
3	622	0.233	624	0.230
4	716	0.206	719	0.203
5	797	0.187	801	0.185
6	869	0.173	872	0.171
7	931	0.162	934	0.161
8	986	0.154	987	0.153
9	1034	0.148	1033	0.147
10	1076	0.142	1074	0.141

11	1112	0.138	1108	0.137
12	1144	0.134	1138	0.134
13	1172	0.131	1165	0.131
14	1196	0.129	1187	0.129
15	1217	0.127	1207	0.127
16	1236	0.125	1224	0.125
17	1252	0.124	1239	0.124
18	1266	0.122	1251	0.123
19	1279	0.121	1262	0.122
20	1290	0.120	1272	0.121
21	1299	0.119	1280	0.120
22	1307	0.119	1287	0.120
23	1315	0.118	1294	0.119
24	1321	0.118	1299	0.119
25	1326	0.117	1304	0.118
26	1331	0.117	1308	0.118
27	1335	0.116	1311	0.118
28	1339	0.116	1314	0.117
29	1342	0.116	1317	0.117
30	1345	0.116	1319	0.117
31	1348	0.115	1321	0.117
32	1350	0.115	1323	0.117
33	1352	0.115	1325	0.117

Table 2.14.5 Estimates of Von Bertalanffy (VB) growth parameters using various subsets of the available age data based on non-linear regression analysis. L_∞= VB asymptotic TL in mm, *k*=VB growth coefficient, t_0=VB theoretical age at length=0 in years, n = sample size, and MSE is the mean square error for the non-linear regression. The standard errors for the parameter estimates are in parentheses.

Black Grouper (*M. bonaci*) VB Growth Parameters

Data Source	Parameters					Number of model parameters
	L_∞ (mm)	k (y^{-1})	t_0 (y)	n	MSE	
All available age data, corrected for minimum size limits (Diaz et al. 2004), and recreational and commercial specimens below existing minimum size limits excluded from analysis **(SEDAR19 LH WG recommendation)**	1334.2 (9.56)	0.1432 (0.0023)	-0.9028 (0.0272)	2,271	6003.0	4[1]
All available age data, without correction for minimum size limits, and recreational and commercial specimens below existing minimum size limits excluded from analysis [O'Hop and Beaver 2009 (SEDAR19-DW-09)]	1364.7 (7.94)	0.1348 (0.0025)	-1.0125 (0.0648)	2,271	5958.6	3
All available age data, without correction for minimum size limits [O'Hop and Beaver 2009 (SEDAR19-DW-09)]	1365.8 (7.98)	0.1343 (0.0025)	-1.0281 (0.0646)	2,288	5972.6	3

[1] This model solves for an extra term representing the coefficient of variation (CV) in total length at each age. The model solution (Proc Model, SAS ver. 9.2), obtained using maximum likelihood methods, provides the optimal solutions by minimizing the standard deviations around the average lengths at age (Walter Ingram, NMFS Pascagoula Laboratory, pers. comm.). The estimate for the CV parameter was 0.0989 (SE = 0.0015).

Table 2.14.6. Results of logistic regressions for length-at-maturity, age-at-maturity, and length-at-transition or age-at-transition of females to males for *M. bonaci* in the southeastern U.S. Length is measured as total length in millimeters.

Length -at-Maturity or Proportion Females-at-Length regressions	n	P	MSE	R	SE	L_{50} (mm)	SE
Length-at-maturity (all months)[a]	783	< 0.05	0.0785	0.0198	0.00174	825.3	4.6538
Length-at-maturity (January-March)[b] **SEDAR 19 LH WG recommendation**	236	< 0.05	0.0698	0.0258	0.00400	855.6	7.7537

Length-at-transition (50% males) (all months)[a] ***SEDAR 19 LH WG recommendation***	890	< 0.05	0.0228	- 0.0158	0.00124	1213.7	5.4577

Age-at-Maturity or Age-at-Transition (50% Females) regressions	n	p	MSE	R	se	A_{50} (years)	se
Age-at-maturity (all months, avg. annuli counts)[a]	617	< 0.05	0.0876	1.3724	0.1340	5.202	0.0779
Age-at-maturity (all months, adjusted ages)[b]	617	< 0.05	0.0922	1.1754	0.1144	5.741	0.0938

Age-at-maturity (January-March, avg. annuli counts)	236	< 0.05	0.0815	1.3873	0.2525	5.6909	0.1611
Age-at-maturity (January-March, adjusted ages)[b] **SEDAR 19 LH WG recommendation**	236	< 0.05	0.0770	1.6809	0.3262	6.4828	0.1465

Age-at-transition (50% females) (all months, avg. annuli counts)[a]	696	< 0.05	0.0245	- 0.3518	0.0279	15.4693	0.3898

Age-at-transition (50% females) (all months, adjusted ages) [b] **SEDAR 19 LH WG recommendation**	696	< 0.05	0.0244	-0.3498	0.0278	16.0297	0.3885

[a] re-analyzed data from Crabtree and Bullock (1998)
[b] Italicized regressions are analyses performed for SEDAR 19 Black Grouper incorporating any revisions to lengths and using samples from a subset of months and/or ages derived from annuli counts adjusted for the marginal increment type and time of year. **Results in boldface are recommendations for use in SEDAR 19 for black grouper.**

Table 2.14.7. Conversions for black grouper (*M. bonaci*). Lengths (total length=TL, fork length=FL, standard length=SL) in mm, and weights (WW=total wet weight, GW=gutted wet weight) in kilograms.

Dependent/ independent variables	Conversion equation	r^2	n	Independent variable	Dependent variable range and units
TL/SL	TL = 26.96 + 1.1630*SL	0.999	1,338	SL	51.2-1325 mm
TL/FL	TL = -1.44 + 1.0276*FL	0.999	1,339	FL	238-1495 mm
SL/FL	SL = -23.85 + 0.8827*FL	0.999	1,320	FL	238-1495 mm
WW/TL[1]	WW = 4.28391*10-9*TL$^{3.1863}$	0.992	904	TL	77.5-1525 mm
WW/FL[2]	WW = 8.74748*10-9*FL$^{3.0843}$	0.972	2,552	FL	206-1495 mm
WW/GW	WW=1.061*GW (no intercept model)	---	636	GW	0.47-61.59 kg

[1] for bias adjustment, WW/TL (ln transformed WW and TL) regression MSE was 0.0097.
[2] for bias adjustment, WW/FL (ln transformed WW and FL) regression MSE was 0.0266.

2.15. *FIGURES*

Figure 2.15.1. Map of Southeastern US region showing catch locations for *M. bonaci*.

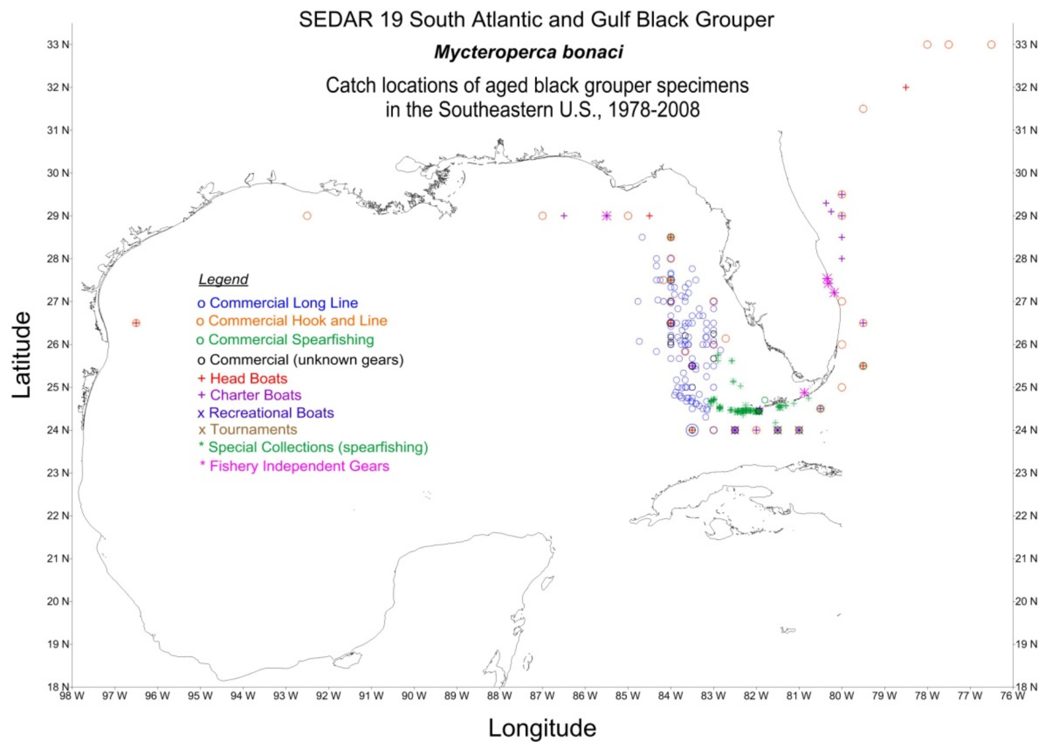


Figure 2.15.2. Estimated worldwide distribution for black grouper (Kaschner et al., 2008 and www.fishbase.org).

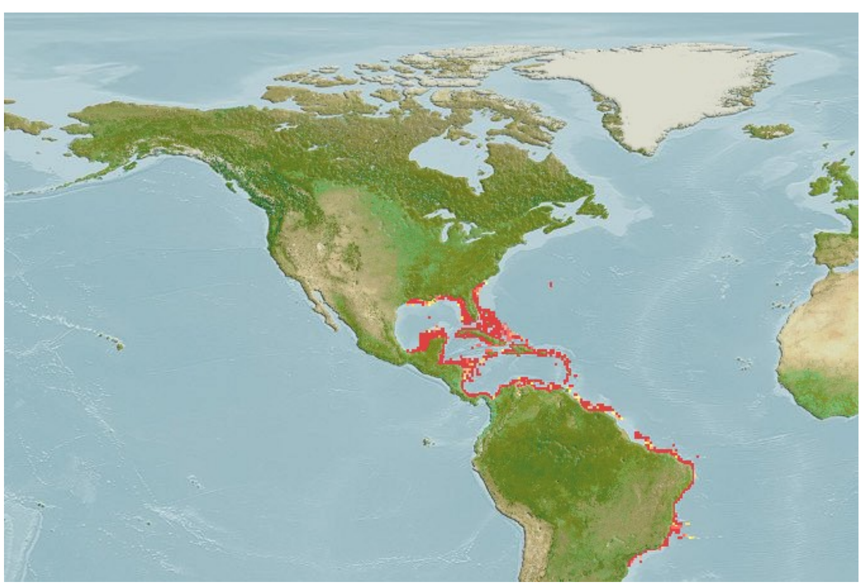


Figure 2.15.3. Black grouper (*M. bonaci*) specimens by length and age and depth of catch, 1978-2008. [Data sources: Bullock (personal communication), NMFS Trip Interview Program, Florida FWC/GSMFC FIN biological sampling, otolith data.]

Black grouper specimens by length and depth

Black grouper specimens by age and depth

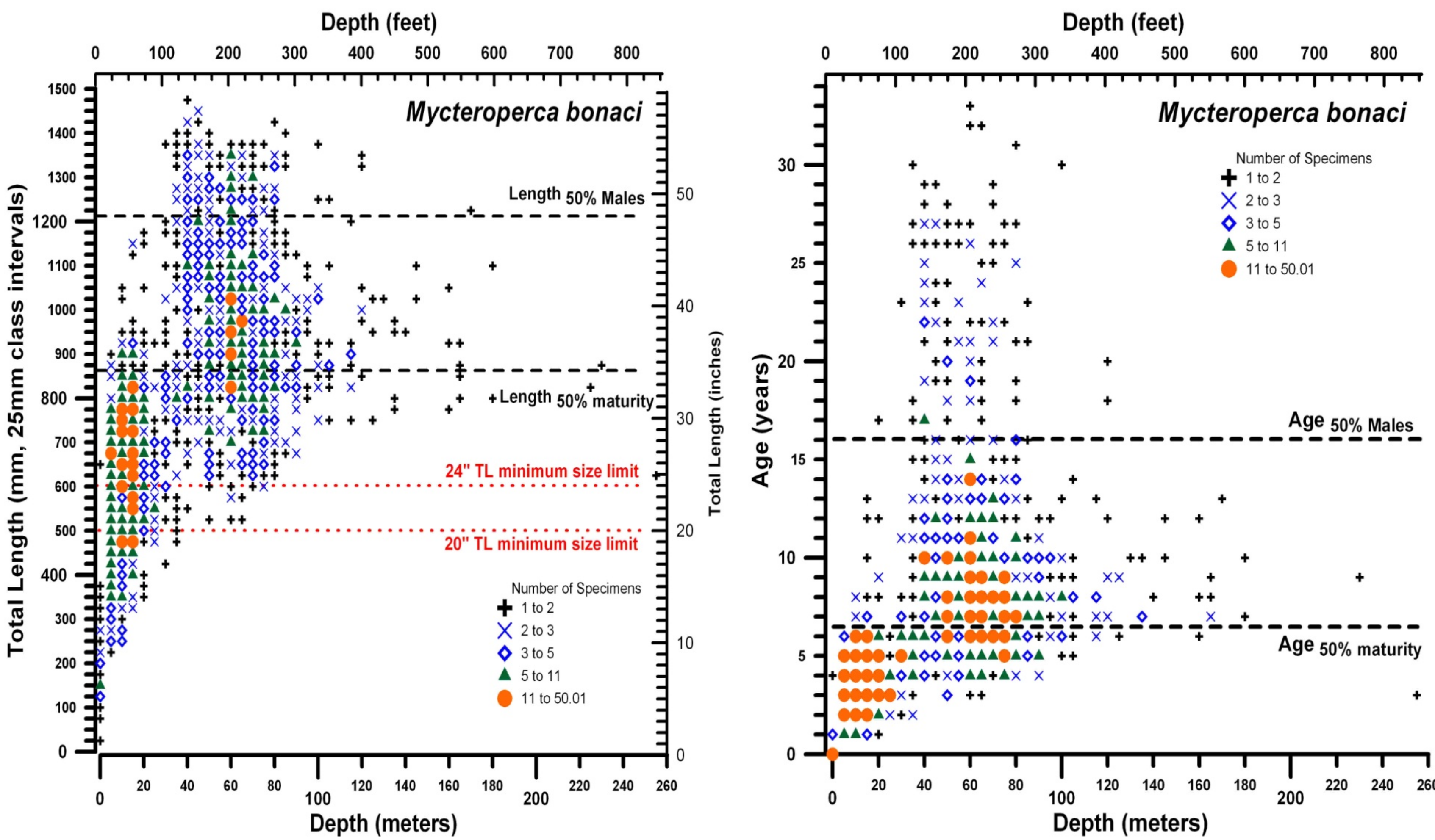


Figure 2.15.4. (a) Black grouper (*M. bonaci*); and (b) gag (*M. microlepis*), the species similar in appearance; (c) close-up of brassy spots on the body of *M. bonaci* (black grouper).

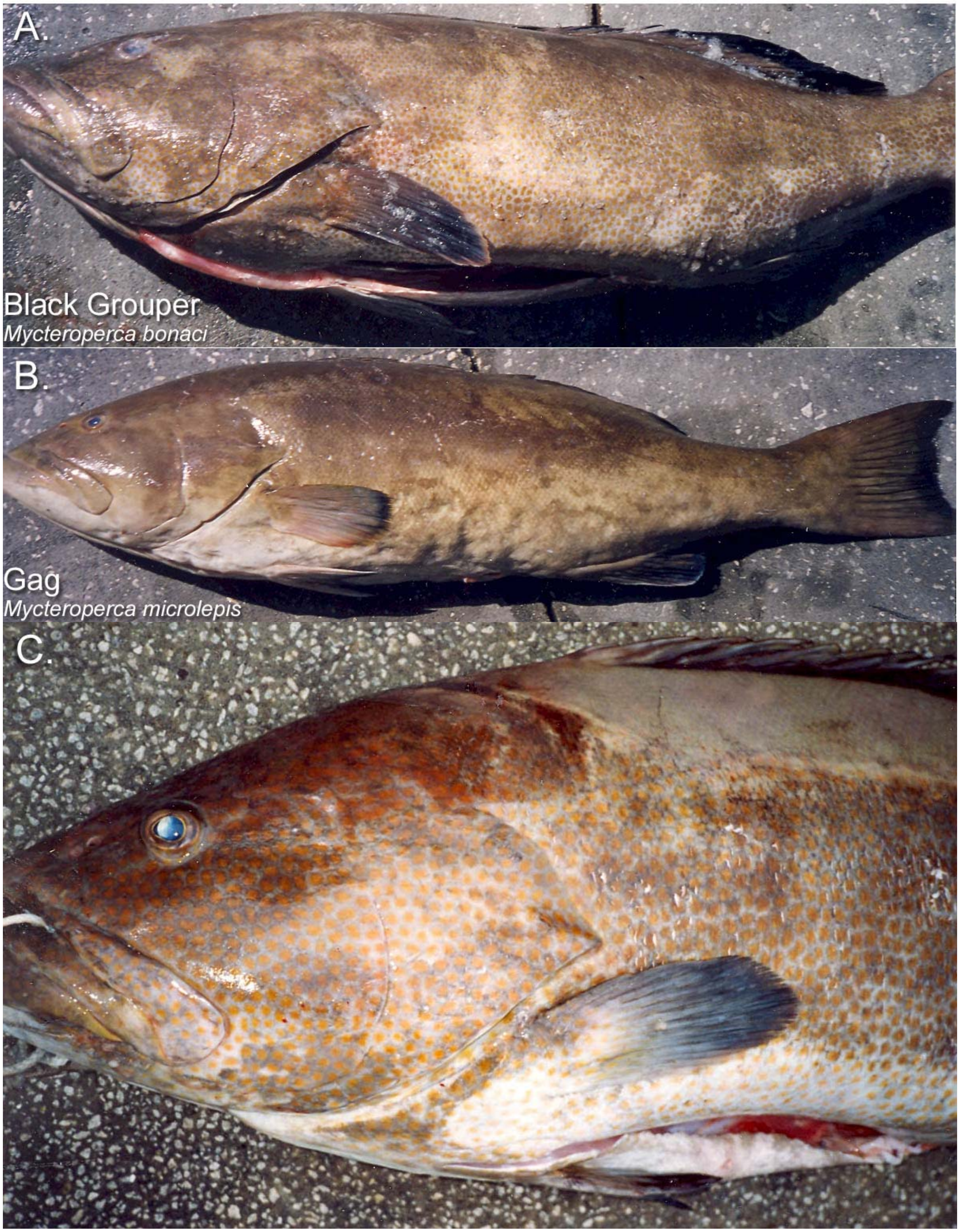


Figure 2.15.5. Black grouper (*M. bonaci*) total length (TL) versus age relationship in the southeastern US using an age-truncated Von Bertalannfy growth curve (Diaz et al. 2004). Undersized specimens measured from recreational and commercial catches were omitted from the regression.

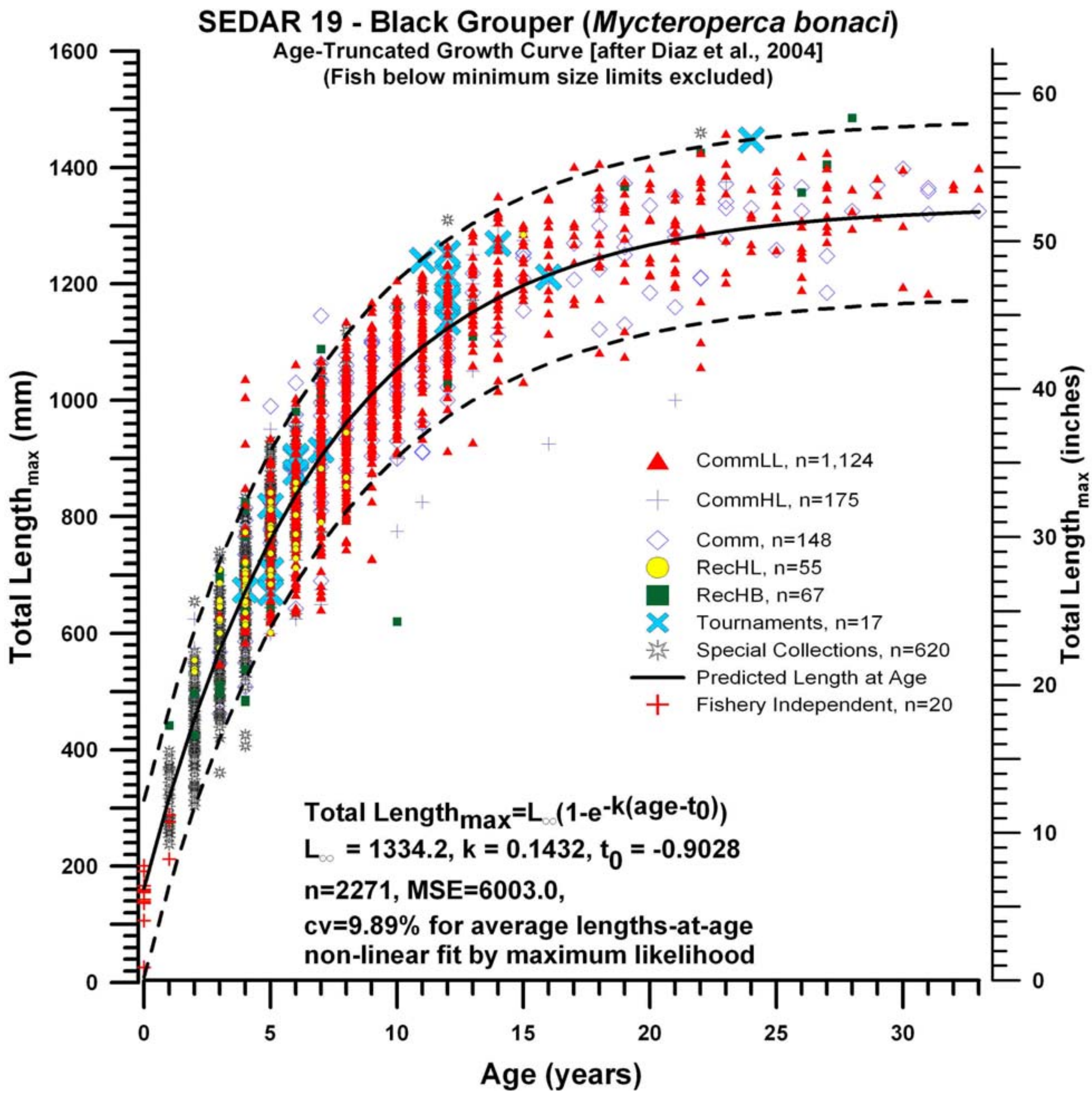
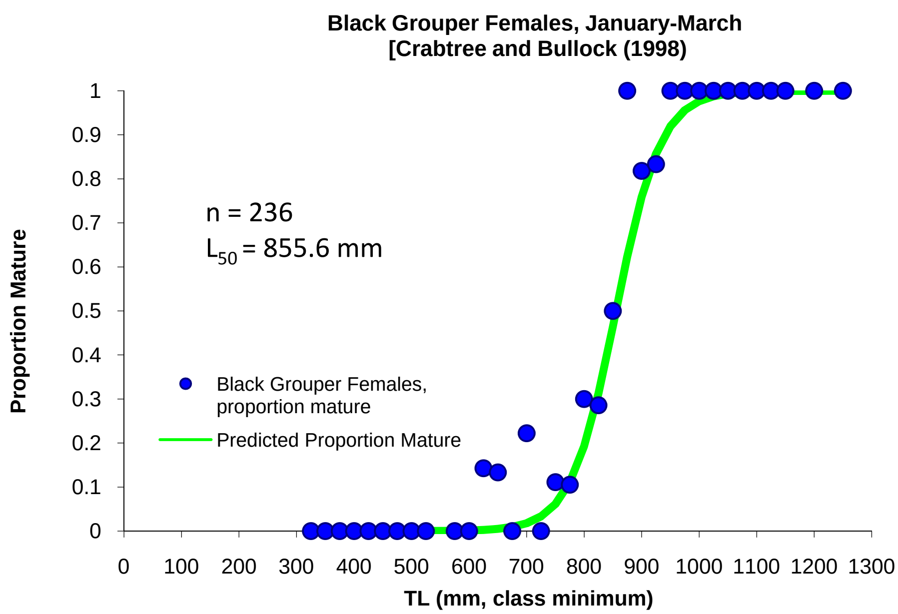


Figure. 2.15.6. Logistic regressions of maturity by length and age of black grouper (*M. bonaci*) specimens collected by Crabtree and Bullock (1998) restricted to the months just prior to the onset of spawning (January-March).

Length-at-maturity



Age-at-maturity

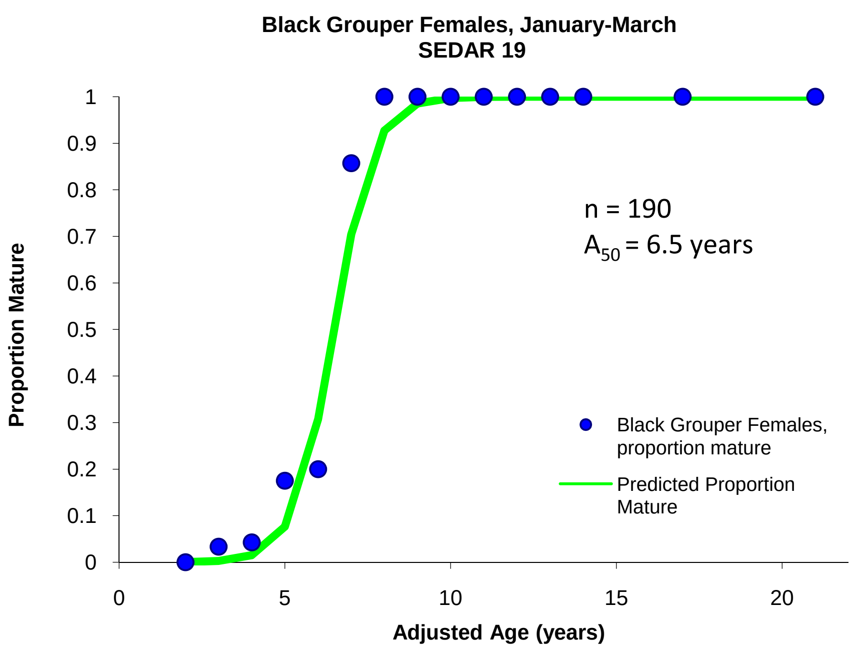
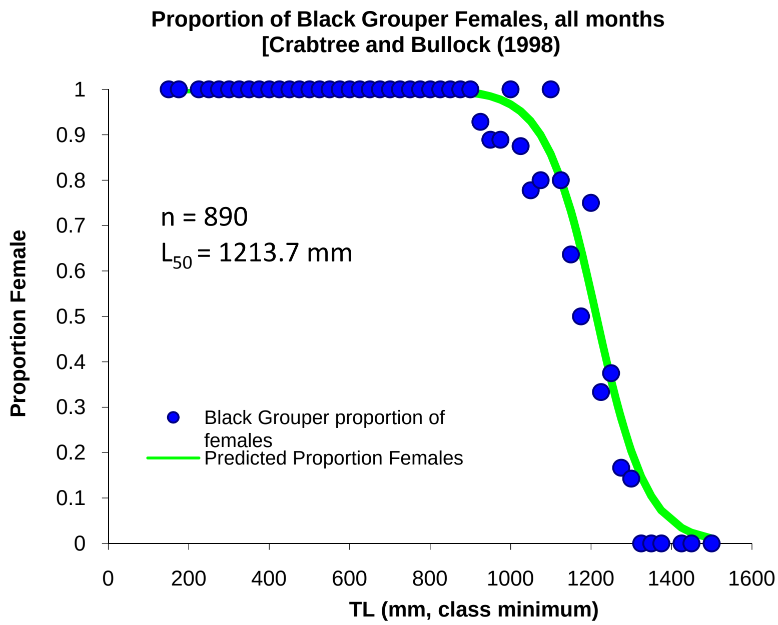


Figure 2.15.7. Logistic regressions of proportion of females at length and age of black grouper (*Mycteroperca bonaci*) specimens collected by Crabtree and Bullock (1998).

Proportion of females at length



Proportion of females at age

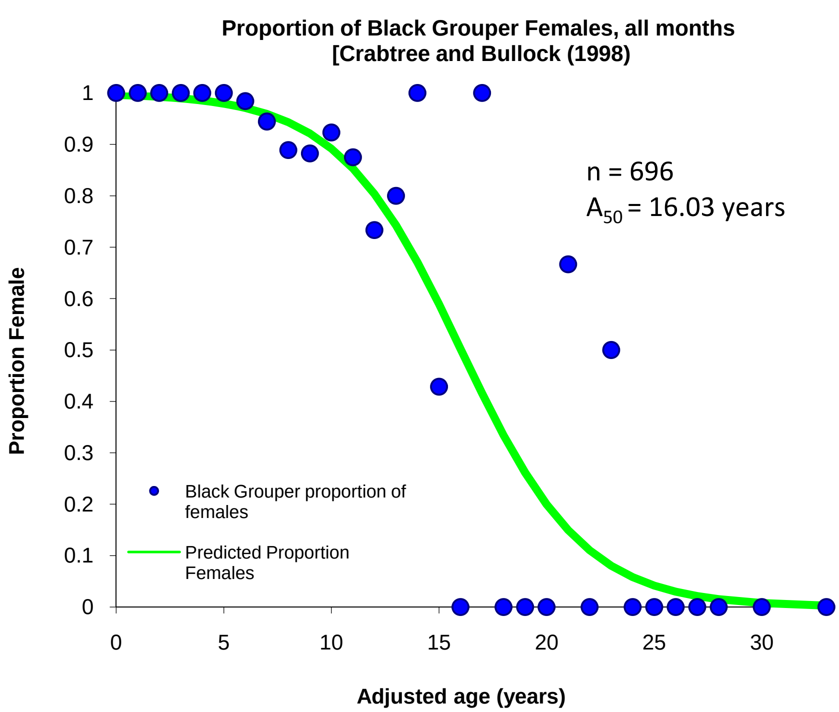
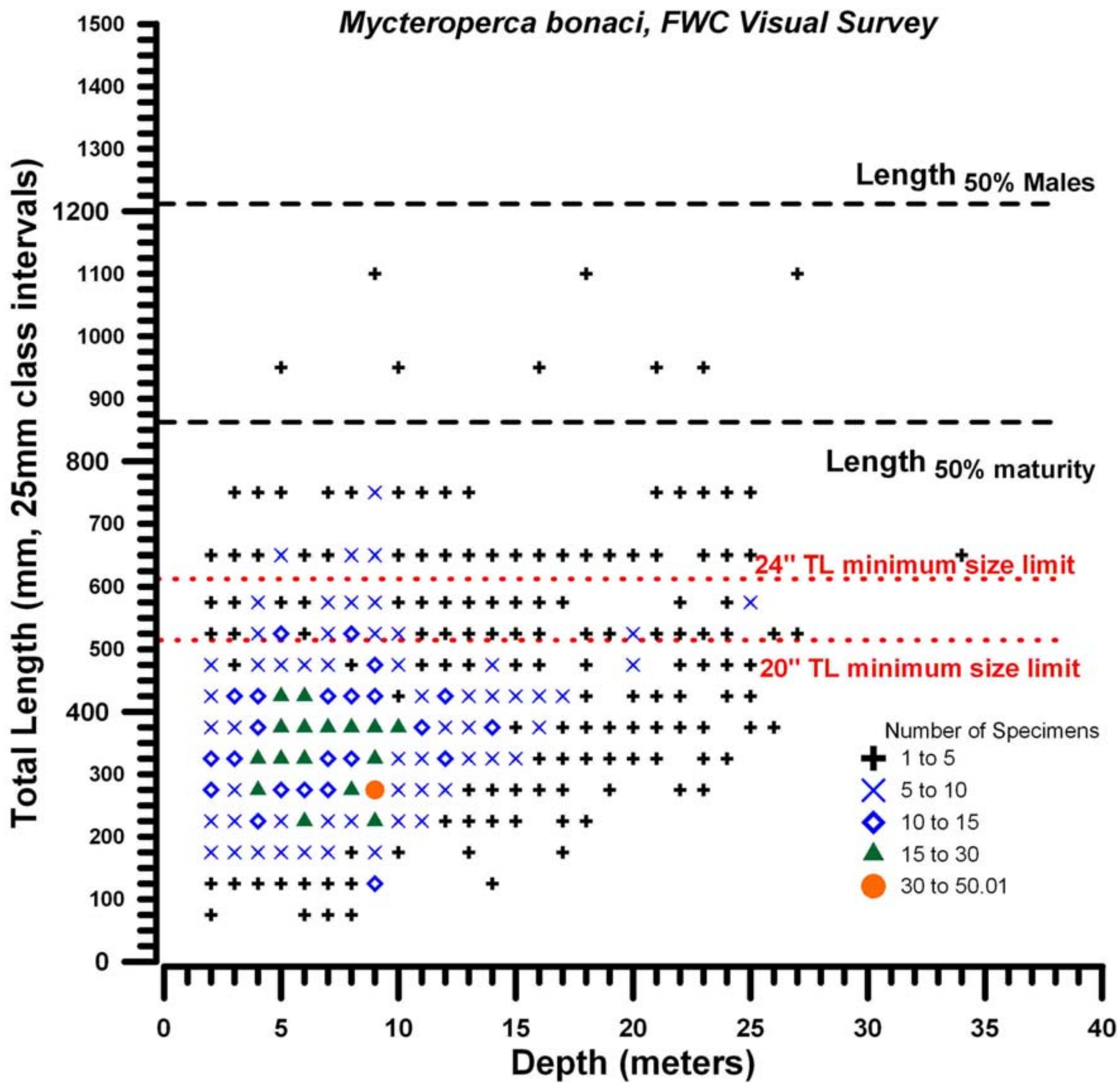


Figure 2.15.8. Estimated total length (mm) of black grouper observed in the FWC Visual Survey by depth.



3. COMMERCIAL FISHERY STATISTICS

3.1. *OVERVIEW*

3.1.1. Group membership

Chair: Dave Gloeckner (SEFSC), Steve Brown (FWC), Stephanie McInerny (NCDMF), David Player (SCDNR), Julie Defilippi (ACCSP), Chris Hayes (ACCSP), Chris Robbins (Ocean Conservancy), Don DeMaria (Fisherman – Keys/SG), Richard Stiglitz (Fisherman – Keys/SG), Bill Tucker (Fisherman – Florida), Bob Spaeth (Fisherman – West Central Florida), Walter Keithly (LSU, GMFMC – SSC).

3.1.2. Issues

Historical commercial landings data for black grouper were explored to address several issues. These issues included: (1) duration of data for the stock assessment, (2) northern boundary of landings for stock assessment (3) methodology for proportioning Florida landings into Atlantic and Gulf, (4) methodology for proportioning landings by gear and area, (5) methodology for proportioning all state ‘unclassified’ landings, (6) correction for misidentified black grouper, (7) commercial discards, (8) discard mortality, and (9) research needs.

3.2. *REVIEW OF WORKING PAPERS*

Title: Calculated discards of black grouper from commercial vertical line and long line fishing vessels in the Gulf of Mexico and US South Atlantic

Author: Kevin McCarthy

Abstract: In August 2001, the Southeast Fisheries Science Center (SEFSC) initiated a program to collect commercial fishing vessel discard data from Gulf of Mexico and US South Atlantic fisheries. A reporting form was developed that supplements the existing vessel coastal logbook forms that are currently mandatory for those fisheries (Poffenberger and McCarthy 2004). Discard data from the SEFSC coastal fisheries logbook program were used to calculate the number of black grouper that were discarded during the period January 1, 2002 through December 31, 2008.

Data collection for the discard logbook program involves, each year, a 20% random sample of the vessels with South Atlantic snapper-grouper, Gulf of Mexico reef-fish, king mackerel, Spanish mackerel, or shark permits are selected to report the number of animals discarded by species. To assure that the sample was representative of vessels with those Federal permits, the universe of permitted vessels was stratified by region and gear fished. A random sample was selected, without replacement, from each stratum. Region was defined as the Gulf of Mexico (Gulf-side of the Florida Keys-Dry Tortugas to the Texas-Mexico border) and the South Atlantic (which extends from the North Carolina-Virginia border to the southern/eastern side of the Florida Keys-Dry Tortugas). Fishing gear strata included hand line, electric reel (bandit rig), trolling, long line, trap, gillnet, and diving. The selected fishers were instructed to complete a supplemental discard form for every fishing trip that they made. Trips with no discards were reported as such.

Reported data included the numbers of discards by species, estimated condition of the fish when released, reason for release (due to regulations or unmarketable/unwanted), and the fishing area where the animal was discarded. There are six options for the condition of released fish: all animals are dead, majority of the animals are dead, all animals are alive when released, majority of animals are alive, the fish are kept but not sold, and the condition of the animals is unknown. To calculate species specific discard rates, discard data were matched to the landings and effort data reported (for the appropriate trip) to the coastal logbook program.

3.3. *COMMERCIAL LANDINGS*

3.3.1. Preliminary landings and discussion on methods

Initially, the Accumulated Landings System (ALS) was queried on 20 May 2009 for all grouper landings along the South Atlantic and Gulf of Mexico coast by state from 1962-2008. This query produced annual landings by grouper species and for unclassified groupers (available by gear) from 1962-2008 for Florida, Georgia, South Carolina, North Carolina, Mississippi, Alabama, Louisiana and Texas. Prior to 1986, individual grouper species, other than goliath or Warsaw, were not identified, so landings were for unclassified groupers. Additionally, we queried the Standard Atlantic Fisheries Information System for commercial landings of unclassified grouper from 1950-1961. To obtain any landings from north of North Carolina, we queried the Commercial Fisheries Database at the NEFSC for any records containing black grouper.

The historical data from ACCSP (originally collected by NMFS and DOI) showed no landings for black grouper, but had grouper unclassified landings, which were assumed to include black grouper. The only grouper species identified in the historical data were Warsaw and goliath groupers. The annual data on commercial landings begins in 1950, while previous to that year, data collection was inconsistent, but collected by federal agencies starting in 1880. Prior to 1950, there were gaps of up to 10 years between the collection of landings statistics in some states and even the landings in these years may not be complete. The use of interpolation to fill in years where data were not collected has been discouraged because of the annual variations in landings, which could lead to erroneous or misleading estimates (Chestnut & Davis, 1975). Additionally, black grouper were not classified before 1986, so proportioning of unclassified landings would be necessary. Given that black grouper were often reported as gag and vice versa, any estimates would be suspect. Given the low landings of black grouper, any error could drastically affect the reliability of the landings estimates.

Decision 1. Because grouper landings were inconsistently collected prior to 1950, and proportioning of unclassified grouper landings would be required prior to 1986, the group recommended that landings would not extend further back than 1986.

No pounds identified as black grouper in the Commercial Fisheries Database at NEFSC were reported as landed north of North Carolina.

Decision 2. Because no black grouper landings were reported north of North Carolina, the Workgroup recommended using the VA/NC line as the northern boundary for the South Atlantic black grouper stock.

The Commercial Working Group also discussed the separation of stock boundary between U.S. South Atlantic and Gulf of Mexico waters. The Working Group decided to use the

SAFMC-GMFMC boundary by using water body code designations found along the Florida Keys (Monroe County) (Figure 3.1), which was the method applied in SEDAR 10. Essentially, Florida Bay and waters north and west of the Florida Keys are designated in the Gulf of Mexico, while waters south and east of the Keys are designated in the South Atlantic. For historical landings data (1986-1992) from the Florida Atlantic (east) Coast, the water bodies are identified as 0010, 0019, 0029, 7200-7510, 7994, 7996, and also 0000, 9999 when the state was identified as code 10. Florida Gulf (west) Coast water bodies, specifically for the Florida Keys, are identified as 0011, 0018, 0020 and 0028 and a general Gulf of Mexico code of 5000.

Decision 3. The Workgroup decided to apply the same approach for dividing black grouper into South Atlantic and Gulf of Mexico as was used in SEDAR 10.

The group also discussed the assignment of gear and area.

Florida

As there is uncertainty in gear and area assignment by dealers in the trip ticket data, it was decided that trip ticket should be allocated to gear and area based on General Canvass or logbook data. The data source for the water body and gear allocations for Florida comes from the Florida General Canvass for the years 1986-1992. See maps showing shrimp statistical areas for the Gulf of Mexico and U.S. Atlantic coasts (Figure 3.2) and Florida statistical areas (Figure 3.1). For the years 1993-2008 water body and gear allocations are based on water body ratios as reported in the Fishery Logbook data and applied to the total landings reported in the ALS data set for the state of Florida. The group consensus was data reported directly by fishermen in the logbook program versus data reported third person by dealers and associated staff submitted to the ALS would be more precise in assigning area of capture to catch.

North Carolina-Georgia

For NC-GA the group felt that since the landings are small and few logbook records exist early in the logbook program, no adjustment to gear or area based on logbook data was necessary.

Alabama-Texas

The group decided to use the methods in SEDAR 10 for AL-TX. For Gulf states other than FL, statistical area and gear were recorded by dealers for most states in most years. They were not recorded in the monthly data for Louisiana from 1990 through 1999 and for Texas, gear was not recorded after 1992. Gear and area were recorded in relatively sparse logbook data starting in 1990 and more extensive logbook data in 1993 and later. The group consensus was data on gear and fishing area reported directly by fishermen through the logbook program was probably more accurate than the data reported by dealers and associated staff to the landings program (Accumulated Landings System, ALS).

Decision 4. The group decided to use the methods described in SEDAR 10. For annual data for Florida, Florida General Canvass data was used to assign gear and area to the monthly data for 1986- 1992, while logbook data was used for 1993-2008. They also decided to use the logbook data to assign gear and area for the other Gulf states for 1990-2008 where there were sufficient numbers of observations. There were relatively few observations in 1990-1992 for most states and larger numbers of observations for 1993 and later. Despite the relatively lower numbers of observations the log book data were used for Louisiana starting in 1990 because there was no other information available. For the other Gulf states the logs were used to assign gear and area for1993 and later.

The issue of misidentification of gag with black grouper was discussed by the Working Group at length. The discussions were based on the methods used in SEDAR10. The following decisions were made by area.

Atlantic

With minimal landings of black grouper reported for Georgia and South Carolina, no correction to black grouper landings for black grouper misidentification was deemed necessary. In most years North Carolina generally had minimal landings of black grouper. However, as noted in SEDAR10-DW-28, there were major exceptions; i.e., large reported landings of black grouper were found for 1981-1985 and 1992-1993. These were deemed anomalous by the SEDAR 10 Commercial Working Group and all black grouper landings for these years in North Carolina were assigned to gag grouper landings. As noted in SEDAR 10 the misidentification of gag and black showed no defined trend over time, so the group decided to use the conclusions of SEDAR 10. The decision was made not to make any additional adjustments to black grouper landings for misidentification in the South Atlantic (except for NC), especially as regards Florida Atlantic Coast.

Gulf

It was reported in SEDAR10-DW-24 that port agents from Texas through Alabama confirmed that while black grouper did occasionally occur in the landings, gag accounted for nearly all of the landings of those two species. The group recommended that the complements of the proportion of gag [1 - gag/(gag+black)] by statistical area (Figure 1) from SEDAR10-DW-24 be used to calculate the total black landings. The proportions from statistical areas 7-21 were similar (generally 0.97 and above) and many of the areas, especially off Texas to Mississippi, had low sample sizes; therefore the data for areas 7 and above were combined. Proportions in number were used rather than proportions in weight. There are differences in average weights of commercially landed gag and black grouper when the species are accurately identified. If most of the reported black grouper are gag, then using a proportion based on number of fish observed in the sampled landings would be more accurate that a proportion based on weight observed in the sampled landings.

Decision 5. The group decided to use the methods described in SEDAR 10 to proportion black and gag grouper landings into black grouper. The only change to South Atlantic data was that all black grouper before 1994 in NC were considered gag, while Gulf landings used the complements of the proportion of gag to gag+black by statistical area as calculated in SEDAR 10.

The decision was made to present all landings in gutted weight. The standard conversion of groupers for Georgia -Texas from whole weight to gutted weight is by dividing whole weight by 1.18. South Carolina uses a conversion of 1.11, while North Carolina uses a conversion of 1.25. With landings data inputted to model in gutted weight, any conversions from gutted back to whole weight will be based on conversions supplied by the life history group.

Decision 6. The group decided that since there are differences in conversion factors for gutted to whole weight among states, the data will be presented in gutted weight and the biological conversion can be applied in the model.

The group examined the landings by gear before the workshop. It was decided to use hand lines, long lines, diving, trap, and other gears as the gear groupings.

Decision 7. The group decided to use hand lines, long lines, diving, trap, and other gears as the gear groupings.

The group also discussed proportioning unclassified groupers into black grouper.

NC-FL east coast

A proportion of the unclassified grouper landings (1410) were converted to black grouper. NCDMF believes that black grouper landings are adequately reviewed by trip ticket staff and are not recorded as unclassified, so no unclassified grouper landings were added to black grouper landings for NC. With the exception of NC, unclassified groupers were proportioned into black grouper landings. When black and gag grouper are classified in the same year as unclassified grouper, we used that year's ratio of black and gag/total classified grouper landings to separate out the proportion of unclassified which may have been black and gag. Annual proportions or ratios were developed for each year, state, gear, and statistical area. The proportion of black to gag calculated from logbook (1990-2008) or ALS (1986-1989) was then applied to the unclassified considered black or gag. Warsaw and goliath groupers were not included among classified groupers because they were identified historically back to 1962, while other groupers were classified beginning in the mid 1980s. The group decided that black grouper is not included in the unclassified grouper landings after the beginning of trip ticket programs in NC, SC, and GA. Unclassified were proportioned for NC prior to 1994; for SC prior to 2004; and for GA prior to 2000. For FL east coast the unclassified grouper landings were proportioned for 1986-2008.

FL west coast-TX

Starting in 1986 grouper landings began to be identified by species and the amount of unclassified groupers declined sharply. For this reason, a proportion of the unclassified grouper landings were then converted to gag and black grouper. The above methods (NC-GA) were used to calculate black and gag landings from unclassified for 1986-2008. The complement of the proportion of gag misidentified as black from TIP observations by statistical area was then applied to derive the black grouper landings contained in the unclassified grouper landings.

Decision 8. The group decided to proportion unclassified grouper landings into black grouper landings for 1986-2008 for SC-TX, but not for NC.

The areas to be used in the assessment were the MRFSS areas supplied by Bob Muller (Figure 3.3).

Decision 9. As these areas don't correspond to the water bodies used in calculating the landings data, the group decided to assign the area based on the nearest split in water body for FL and state of landing outside of FL.

3.3.2. Final methods used to develop annual commercial landings by state and gear

North Carolina

NCDMF provided landings data from 1986-2008. All landing prior to 1994 were removed, so no adjustments for unclassified grouper landings or gear and area were made.

South Carolina

ALS data for SC was used for 1986-2008. No adjustments for misidentification or gear and area were made. Addition of proportioned unclassified from 1986-2008.

Georgia

ALS data for GA was used for 1986-2008. No adjustments for misidentification or gear and area were made. Addition of proportioned unclassified from 1986-2008.

Florida

ALS data for FL was used for 1986-2008. Area and gear were assigned based on logbook (1993-2008) or General Canvass (1986-1992). Assignment to Atlantic was based on waterbody codes for Gulf or Atlantic described above. Unclassified groupers were proportioned into black grouper. For the Gulf coast, a correction for misidentification was used based on TIP ratios of black/ gag by statistical area. No misidentification correction was applied to the east coast.

Alabama

ALS data for AL was used for 1986-2008. Area and gear were assigned based on logbook (1990-2008) or ALS (1986-1992). Unclassified groupers were proportioned into black grouper. A correction for misidentification was used based on TIP ratios of black/gag by statistical area.

Mississippi

ALS data for MS was used for 1986-2008. Area and gear were assigned based on logbook (1990-2008) or ALS (1986-1992). Unclassified groupers were proportioned into black grouper. A correction for misidentification was used based on TIP ratios of black/gag by statistical area.

Louisiana

ALS data for LA was used for 1986-2008. Area and gear were assigned based on logbook (1990-2008) or ALS (1986-1992). Unclassified groupers were proportioned into black grouper. A correction for misidentification was used based on TIP ratios of black/gag by statistical area.

Texas

ALS data for TX was used for 1986-2008. Area and gear were assigned based on logbook (1990-2008) or ALS (1986-1992). Unclassified groupers were proportioned into black grouper. A correction for misidentification was used based on TIP ratios of black/gag by statistical area.

Final landings estimates in pounds gutted weight are reported in Table 3.1 by year, MRFSS area, and gear. Final landings in numbers (Table 3.2) were calculated with the mean weight derived by TIP data in each strata (year, MRFSS area, gear) (Table 3.3). When mean weights could not be derived because of low sample size (N<20), the mean was calculated within each gear across years. Years were separated before 1992, from 1992 to 1998, and greater than or equal to 1999 because of size regulations implemented in 1992 and 1999. If there were no samples for that gear, then the mean weight was calculated across all gears and years before or after 1992.

Estimates of coefficients of variation for each year's landings were developed by reviewing the estimates of SEDAR10 and modifying them to suit the periods when proportioning unclassified landings, gear and area, and adjustment for misidentification (Table 3.4). The estimate of CV was 0.10 to account for unreported landings. Add 0.10 to the estimate if unclassified grouper landings are proportioned into black grouper landings. Add 0.05 if gear and area proportions are applied from logbook or 0.10 if gear and area are from General Canvass or ALS. Add an additional .10 if landings are adjusted by TIP data for misidentification. To calculate an overall CV the CV for each state and year was multiplied by landings for each state and year. The CVs multiplied by the landings were summed across states by year and then divided by the landings summed across states by year. The result was used as the overall CV for each year's landings.

3.4. *COMMERCIAL DISCARDS*

3.4.1 Logbook discards

Discard calculations for black grouper followed the methods described in SEDAR19 DW-15. hand line and long line discards and effort reported from the logbook program were included in those analyses. Data reported from other gears were insufficient for discards to be calculated. Five factors were examined with GLM analyses for their possible influence on the black grouper discard rate and the proportion of trips with discards. Significant main effects were used to stratify the available discard and total effort data for total discard calculations. Calculated black grouper discards are provided in Table 3.5.

The release condition of discarded black grouper for hand line gear is reported in Table 3.6. In all years except 2004, over 90% of black grouper discards were reported as “alive” or “majority alive” when released. In 2004, 86% of discards were reported as “alive” or “majority alive”. For long line, no breakdown by year could be calculated due to low sample sizes, but 82% were reported as alive.

Fishers were requested to report the reason fish were discarded. “Due to regulatory restrictions” accounted for more than 98% of reported black grouper discards in all years prior to 2008 for hand line trips. Long line trips reported discards due to regulations in 85% of reports. Beginning in 2008, the regulatory restriction reporting category was expanded to differentiate between fish discarded due to size restriction and those discarded due to fishery closures. Approximately 68% black grouper discards were reported as undersized with another 19% discarded due to unspecified regulatory restrictions.

The number of trips reporting black grouper discards in the US South Atlantic and Gulf of Mexico ranged from 37 to 132 hand line trips per year. Only 11 long line trips reported black grouper discards during the period 2002-2008. The number of yearly hand line trips with discard reports ranged from 2,064 to 6,960 each year. The percentage of trips reporting “no discards” has increased since the inception of the discard logbook program; more than doubling from 25% to 55% for hand line trips (combined Gulf of Mexico and South Atlantic). The number of long line Gulf of Mexico reporting trips varied from 100 to 280 trips each year; 24 to 40% of those trips reported “no discards”, however no clear trend in the percentage of those reports was apparent over time. With increasing number of "no discards" hand line reporting trips and the extremely small long line sample, black grouper discards may be both underreported and poorly characterized by the available self-reported discard data.

3.4.2 Observer Data

Limited observer data were available for analysis. An observer program was begun in the Gulf of Mexico in July 2006 and is ongoing. South Atlantic observer trips on hand line vessels began in 2007 (a single 2006 trip had observer coverage). Funding cuts reduced the number of observer trips in both regions during 2008. A total of 219 Gulf of Mexico and South Atlantic hand line trips had observer reports.

Black grouper reported in the observer data set were too few for any analysis. That black grouper discards were rare events suggests that the low discard rate of the species calculated from self reported data may be accurate. Both hand line and long line self reported black grouper discards were low throughout the available time series.

Decision 10: The group decided to accept the logbook estimates, although there seems to be a decreasing trend in discard estimates that may be due to under-reporting. The degree of impact of such reporting, resulting in more "no discard" trips, is unknown. Estimated discards are reported in table 3.4.

3.5. *DISCARD MORTALITY*

Black grouper from the Atlantic and the Gulf of Mexico were considered to be one stock so release mortality for this species will consist of a single point estimate and sensitivity range and will not be broken down by region. Currently, there are no published studies that estimate release mortality for black grouper. This species is in the same genus as gag grouper, therefore estimates of release mortality for gag grouper were used to help estimate mortality for black grouper. In addition, based on input from fishermen, this species was said to be similar to gag in size, habitat of capture, and release behavior so using gag grouper as a species for comparison was reasonable.

SEDAR 10 (Atlantic and Gulf gag grouper) used an estimate of 30% release mortality across all gears in the Gulf and 40% mortality in the Atlantic. The estimate in the Atlantic was higher because it is assumed that, on average, fishermen are fishing deeper in the Atlantic than in the Gulf of Mexico. Estimates of release mortality from the commercial logbooks showed around a 7% mortality for hook and line gear while long lines showed around 18% mortality (SEDAR19-DW15). Gulf of Mexico fishermen attending the SEDAR 12 data workshop reported that for black grouper around 5% or less are released dead or dying. However, they also reported that in most cases, discards of this species were few in number. Since long lines are an important gear for harvesting black grouper as is hook and line, a separate estimate of release mortality was developed for each of these two gears.

The initial estimates of release mortality for black grouper by the commercial workgroup were: 10% for hook and line with a sensitivity range of 5-15% and 30% for long lines with a sensitivity range of 25-35%. The plenary group discussed the depth and range of the species and felt that 10% mortality for hook and line was too low for black grouper because it did not incorporate any delayed mortality. Gag was said (by fishermen) to be heartier than other groupers in most cases and would show greater signs of survival after release. Black grouper are typically caught in areas where gag occur and gag are caught in relatively deeper waters in the Atlantic and in shallower waters in the Gulf of Mexico. Those black grouper caught in the Gulf are from deeper waters than other groupers and are typically larger and would not likely be discarded.

After further discussion, the plenary agreed on 20% release mortality for hook and line with a sensitivity range of 10-30%. Most discards tend to be smaller undersized fish and these fish are typically caught in shallower waters. Those fish caught in deeper waters tend to be bigger and are not usually discarded. So it makes sense for the release mortality rates to be lower than those reported in deeper waters from the estimates modeled by depth. In the McGovern et al. (2005) study, 14% mortality was reported for 15 M. Most black grouper that are of a size to be released are being caught in waters comparable to this depth. Therefore, 20% release mortality for hook and line for this species is not unreasonable. The

20% and 30% mortality rates by gear for black grouper are similar to those used in the gag grouper SEDAR (SEDAR 10). The sensitivity range for hook and line was also widened to include smaller and larger estimates of release mortality. Estimates of discard mortality in numbers and pounds are given for hand line in Table 3.7 and for long line in table 3.8.

Decision 11: The commercial workgroup recommends using 20% as the point estimate for hook and line release mortality for black grouper with a sensitivity range of 10-30% and a point estimate of 30% for long line release mortality for black grouper with a sensitivity range of 25-35%.

3.6. *COMMERCIAL EFFORT*

Commercial effort and CPUE was presented by Kevin McCarthy in SEDAR19 DW13. Black grouper trips were identified using a modified Stevens and MacCall approach. Four factors were examined with GLM analyses for their possible influences on the proportion of trips that landed black grouper and catch rate for black grouper. Significant main effects were used to stratify the available effort data for total catch calculations. Calculated black grouper effort and CPUE are provided in Table 3.9 for hand line and 3.10 for long line.

3.7. *BIOLOGICAL SAMPLING*

Length samples have been collected by the Trip Interview Program (TIP) and several state agencies since 1981. These samples are collected by port agents at docks where commercial catches are landed throughout the southeast US coast. Trips are randomly sampled to obtain trip, effort, catch and length frequency information. Occasionally there has been quota sampling to obtain age structures on fish that are rare in the catch (extremely large and small fish). These non-random samples are identified in the data to allow removal from analyses were non-random samples are not appropriate.

Biological sample data were obtained from the TIP sample data (NMFS/SEFSC), which is a data set of sampling data from commercial, recreational, and fishery independent research programs. A subset of these data were used for analyses, which contained commercial samples that were identified as having no sampling bias. These data were further limited to those that could be assigned a year, gear, and state. Data that had an unknown sampling year, gear, or sampling state were deleted from the file. Biological data were joined with landings data by year, gear, and state. Landings data were also limited to only those data that could be assigned a year, gear, and state. Landings and biological data were assigned a state based on landing and sample location. Where no trip landing data were available, the sample was excluded.

3.7.1. SAMPLING INTENSITY

3.7.1.1 Length samples

The number of trips sampled ranged from a high of 66 for long line gear in 2005 to a low of zero for many strata (Table 3.11). The number of trips sampled was consistently greater than 10 trips for hand line gear from 1990-2008, and long line for 1997-2008. Pots and traps, and diving trips were rarely sampled.

The number of fish sampled had a high of 277 for long line gear in 1999 to lows of zero for many of the strata (Table 3.12). The number of lengths sampled was consistently greater than 100 for long line gear for 1998-2007. Hand line lengths sampled were well below 100 lengths per year for most years. Pots and traps, and diving trips were rarely sampled.

3.7.1.2 Age samples

The number of trips sampled for ages ranged from zero to 26 for hand line and zero to 84 for long line (Table 3.13). Hand line samples were consistently less than 40 samples per year. Long line samples had greater than 100 ages collected for 1995-1996 and 2004-2007.

3.7.2 Length/Age Distributions

3.7.2.1 Length distributions

Length data were converted to cm total length and binned into one centimeter group with a floor of 0.6 cm and a ceiling of 0.5 cm. Length was converted to weight (gutted weight in pounds) using conversions provided by the life history group. The length data and landings data were divided into hand line, long line, traps, diving, and other gears. Length compositions were weighted by the trip landings in numbers and the landings in numbers by strata (MRFSS area, year, gear). Annual length compositions of black grouper are summarized in Figures 3.5 – 3.9.

3.7.2.2 Age Distributions

Sample size and number of trips sampled for black grouper ages by gear were summarized by gear from commercial landings for 1986-2008 (Table 3.13). Age compositions of samples were developed for hand line and long line (1988-2008, Figure 3.10). Ages were then weighted by landings and length composition with the formula:

$$RW_i = \frac{NLi \,/\, TN}{OLi \,/\, TO},$$

where *NLi* was the number of fish measured with length *i*, *TN* was the total number of fish measured in that strata, *OLi* was the number of ages sampled at length *i,* and *TO* was the total number of ages sampled within the strata (Chih, 2009). This weighting corrected for a potential sampling bias of age samples relative to length samples (see Section 3 in SEDAR10 for South Atlantic gag).

3.7.3 Adequacy for characterizing catch

3.7.3.1 Lengths

Length sampling has been inadequate for gears other than hand line and long line. Even within these gears there are many years with less than 50 length samples collected. Sampling fractions are less than 0.05 for many years in the hand line and long line gear categories. Sample size needs to paid particular attention when using the length compositions. Length sampling fractions are displayed in Table 3.14.

3.7.3.2 Ages

Of the 1,350 aged black grouper, 1,112 were from the commercial long line fishery from 1986-2008. Only 238 were from the hand line fishery for the same period. It is doubtful that 238 ages are enough to characterize the age composition of the hand line fishery, but there may be enough for the long line fishery. Once again, the sample sizes are of particular concern. Age sampling fractions are displayed in Table 3.15.

3.7.4 Alternatives for characterizing discard length/age

The group discussed alternatives for characterizing lengths and ages of discards. As this data does not exist in any known database, the group suggests using a regulatory approach. It is suggested that lengths from earlier periods when the smaller sizes were legal are applied to the discards.

3.8. *COMMERCIAL CATCH-AT-AGE/LENGTH ; DIRECTED AND DISCARD*

Catch at age is handled within the assessment model and does not require discussion or presentation here.

3.9. *COMMENTS OD ADEQUECY OF DATA FOR ASSESSMENT ANALYES*

Landings data are reliable since the beginning of trip ticket programs, however: proportioning of unclassified grouper landings to black grouper, proportioning of gear and area, and correcting for misidentification creates error in these estimates of black grouper landings. CVs were allocated based on these adjustments.

3.10. *POST-WORKSHOP TASKS*

- Discard mortality estimates: McInerny: 7/1/09
- Preliminary documentation of discussions and results: Defillippi, 7/6/09
- TIP length samples: Gloeckner, 7/15/09
- TIP sampling fractions: Gloeckner, 7/15
- TIP length frequencies: Gloeckner, 7/15
- Commercial age sampling fractions: Gloeckner, 7/15
- Commercial age frequencies: Gloeckner, 7/15
- Commercial effort: Gloeckner, 7/15
- Final landings in pounds: Gloeckner, 7/15
- Final landings in numbers: Gloeckner, 7/15
- Workshop document: Gloeckner, 7/24

3.11. *RESEARCH RECOMMENDATIONS FOR BLACK GROUPER*

• Still need observer coverage for the snapper-grouper fishery

– 5-10% allocated by strata within states

– get maximum information from fish

• Expand TIP sampling to better cover all statistical strata

• Trade off with lengths versus ages, need for more ages (i.e., hard parts)

• Workshop to resolve historical commercial landings for a suite of snapper-grouper species

– Monroe County (SA-GoM division)

– Historical species identification (mis-identification and unclassified)

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Addendum to Commercial Landings (Section 3.3):

NMFS SEFIN Accumulated Landings (ALS)

Information on the quantity and value of seafood products caught by fishermen in the U.S. has been collected as early as the late 1880s. Fairly serious collection activity began in the 1920s. The data set maintained by the Southeast Fisheries Science Center (SEFSC) in the SEFIN database management system is a continuous data set that began in 1962. In addition to quantity and value, information on the gear used to catch the fish, the area where the fishing occurred, and the distance from shore are also recorded. Because the quantity and value data are collected from seafood dealers, the information on gear and fishing location are estimated and added to the data by data collection specialists. In some states, this ancillary data are not available.

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

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

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

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

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

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

There are two problems with the commercial fishery statistics that were collected from seafood dealers. First, dealers do not always record the specific species that are caught and second, fish or shellfish are not always purchased at the same location where they are unloaded, i.e., landed. Dealers have always recorded fishery products in ways that meet their needs, which sometimes make it ambiguous for scientific uses. Although the port agents can readily identify individual species, they usually were not at the fish house when fish were being unloaded and thus, could not observe and identify the fish.

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

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

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

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

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

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

South Carolina
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Prior to 1972, commercial landings data were collected by various federal fisheries agents based in South Carolina, either U.S. Fish or Wildlife or National Marine Fisheries Service personnel. In 1972, South Carolina began collecting landings data from coastal dealers in cooperation with federal agents. Mandatory monthly landings reports on forms supplied by the Department are required from all licensed wholesale dealers in South Carolina. Until fall of 2003, those reports were summaries collecting species, pounds landed, disposition (gutted or whole) and market category, gear type and area fished; since September 2003, landings have been reported by a mandatory trip ticket system collecting landings by species, disposition and market category, pounds landed, ex-vessel prices with associated effort data to include gear type and amount, time fished, area fished, vessel and fisherman information. South Carolina began collecting TIP length frequencies in 1983 as part of the Cooperative Statistics Program. Target species and length quotas were supplied by NMFS and sampling targets of 10% of monthly commercial trips by gear were set to collect those species and length frequencies. In 2005, South Carolina began collecting age structures (otoliths) in addition to length frequencies, using ACCSP funding to supplement CSP funding.

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

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

Beginning in 1985, mandatory reporting by all seafood dealers was implemented by the State of Florida. The State requires that a report (ticket) be completed and submitted to the State for every trip. Dealers have to report the type of gear as well as the quantity (pounds) purchased for each species. Information on the area of catch can also be provided on the tickets for individual trips. As of 1986 the ALS system relies solely on the Florida trip ticket data to create the ALS landings data for all species other than shrimp.

Alabama
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Data collection in Alabama is voluntary and is conducted by state and federal port agents that visit dealers and docks monthly. Summaries of the total landings (pounds) and value for species or market category are recorded. Port agents provide information on gear and fishing area from their knowledge of the fisheries and interaction with fishermen and dealers. As of mid- 2000, the State of Alabama required fishermen and dealers to report all commercial landings data through a trip ticket system. As of 2001 the ALS system relies solely on the Alabama trip ticket data to create the ALS landings data for Alabama.

Mississippi
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Data collection in Mississippi is voluntary and is conducted by state and federal port agents that visit dealers and docks monthly. Summaries of the total landings (pounds) and value for species or market category are recorded. Port agents provide information on gear and fishing area from their knowledge of the fisheries and interaction with fishermen and dealers.

Louisiana
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Prior to 1993, commercial landings statistics were collected in Louisiana by Federal port agents following the traditional procedures established by the NMFS. Monthly summaries of the quantity and value were collected from each dealer in the state. The information on gear, area and distance from shore were added by the individual port agents.

Beginning in January 1993, the Department of Wildlife and Fisheries, State of Louisiana began to enforce the states' mandatory reporting requirement. Dealers have to be licensed by the State and are required to submit monthly summaries of the purchases that were made for individual species or market categories. With the implementation of the State statute, Federal port agents did not participate in the collection of commercial fishery statistics.

Since the implementation of the State program, information on the gear used, the area of catch and the distance from shore has not been added to the landings statistics (1992-1999). In 1998 the State of Louisiana required fishermen and dealers to report all commercial landings data through a trip ticket system. These data contain detailed landings information by trip including gear, area of capture and vessel information. As of 2000, the ALS system relies solely on the Louisiana trip ticket data to create the ALS landings data for Louisiana.

Texas
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The State has a mandatory reporting requirement for dealers licensed by the State. Dealers are required to submit monthly summaries of the quantities (pounds) and value of the purchases that were made for individual species or market categories.

Information on gear, area and distance from shore are added to the state data by SEFSC personnel. Furthermore, landings of species that are unloaded in Texas, but transported to locations in other states are added to the commercial landings statistics by SEFSC personnel.

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3.13. *TABLES*

Table 3.13.1. Commercial landings by gear and year in pounds gutted weight (thousands). Diving, trap and other gears are aggregated into the "other' gear category in order to maintain confidentiality.

	GEAR		
YEAR	HANDLINE	LONGLINE	OTHER
1986	344.0	122.0	57.8
1987	439.9	117.9	95.0
1988	261.4	79.2	83.1
1989	236.6	77.7	125.6
1990	173.1	103.6	109.4
1991	86.4	50.6	67.7
1992	128.4	55.4	77.1
1993	114.5	33.6	41.6
1994	98.4	23.9	33.1
1995	83.3	23.5	25.4
1996	88.6	28.2	24.9
1997	67.2	32.7	17.1
1998	69.3	39.4	14.0
1999	62.1	48.7	13.1
2000	69.9	47.2	17.2
2001	72.3	51.9	22.8
2002	62.4	50.4	21.5
2003	67.8	72.7	24.0
2004	70.8	69.2	15.7
2005	53.8	43.1	15.3
2006	55.5	57.9	12.5
2007	36.6	41.0	15.0
2008	21.4	16.8	10.0

Table 3.13.2. Commercial landings by gear and year in numbers (thousands). Diving, trap and other gears are aggregated into the "other' gear category in order to maintain confidentiality.

YEAR	GEAR		
	HANDLINE	LONGLINE	OTHER
1986	26.3	7.5	7.9
1987	52.8	11.3	11.6
1988	15.8	5.1	10.0
1989	18.1	5.0	17.4
1990	13.2	6.8	12.5
1991	6.6	2.6	7.2
1992	8.7	1.5	5.3
1993	9.2	1.0	2.9
1994	6.1	0.6	2.4
1995	5.7	0.6	1.9
1996	7.3	0.8	1.8
1997	4.9	0.8	1.3
1998	5.1	1.1	1.0
1999	2.9	1.4	0.7
2000	3.5	1.3	0.8
2001	3.7	1.4	1.0
2002	3.2	1.5	1.1
2003	5.0	1.9	1.1
2004	3.7	2.1	0.6
2005	2.8	1.6	0.6
2006	2.9	1.8	0.5
2007	1.9	1.3	0.5
2008	1.1	0.5	0.4

Table 3.13.3. Mean weights in pounds gutted weight used to derive landings in numbers by year and gear.

	GEAR				
YEAR	DIVING	HANDLINE	LONGLINE	OTHER	TRAP
1986	32.770	6.433	44.851	3.302	6.734
1987	32.770	9.904	25.810	3.302	6.480
1988	32.770	23.555	2.923	3.302	8.106
1989	32.770	13.087	21.548	3.302	6.510
1990	32.770	31.649	14.014	3.302	8.987
1991	32.770	7.222	27.910	3.302	8.024
1992	12.083	15.846	33.415	27.757	21.825
1993	11.759	11.989	32.064	27.757	18.454
1994	11.759	16.383	35.707	27.757	18.454
1995	11.759	26.883	42.899	27.757	18.454
1996	11.759	9.380	33.809	27.757	18.454
1997	11.759	19.771	45.868	27.757	18.454
1998	11.759	15.148	36.214	27.757	18.454
1999	28.098	20.858	34.042	27.757	12.517
2000	28.098	21.754	40.471	27.757	12.517
2001	28.098	13.865	40.387	27.757	12.517
2002	28.098	26.468	33.082	27.757	12.517
2003	28.098	17.468	43.022	27.757	12.517
2004	28.098	15.696	31.100	27.757	12.517
2005	28.098	19.121	28.964	27.757	12.517
2006	28.098	19.362	27.730	27.757	12.517
2007	28.098	15.549	27.337	27.757	12.517
2008	28.098	27.405	28.764	27.757	12.517

Table 3.13.4. Estimated coefficients of variation to be applied to commercial landings.

	STATE								
YEAR	AL	eFL	GA	LA	MS	NC	SC	TX	wFL
1986	0.40	0.35	0.20	0.40	0.40	0.20	0.20	0.40	0.40
1987	0.40	0.35	0.20	0.40	0.40	0.20	0.20	0.40	0.40
1988	0.40	0.35	0.20	0.40	0.40	0.20	0.20	0.40	0.40
1989	0.40	0.35	0.20	0.40	0.40	0.20	0.20	0.40	0.40
1990	0.35	0.35	0.20	0.35	0.35	0.20	0.20	0.35	0.40
1991	0.35	0.35	0.20	0.35	0.35	0.20	0.20	0.35	0.40
1992	0.35	0.30	0.20	0.35	0.35	0.20	0.20	0.35	0.35
1993	0.35	0.30	0.20	0.35	0.35	0.20	0.20	0.35	0.35
1994	0.35	0.30	0.20	0.35	0.35	0.10	0.20	0.35	0.35
1995	0.35	0.30	0.20	0.35	0.35	0.10	0.20	0.35	0.35
1996	0.35	0.30	0.20	0.35	0.35	0.10	0.20	0.35	0.35
1997	0.35	0.30	0.20	0.35	0.35	0.10	0.20	0.35	0.35
1998	0.35	0.30	0.20	0.35	0.35	0.10	0.20	0.35	0.35
1999	0.35	0.30	0.20	0.35	0.35	0.10	0.20	0.35	0.35
2000	0.35	0.30	0.20	0.35	0.35	0.10	0.20	0.35	0.35
2001	0.35	0.30	0.20	0.35	0.35	0.10	0.20	0.35	0.35
2002	0.35	0.30	0.20	0.35	0.35	0.10	0.20	0.35	0.35
2003	0.35	0.30	0.20	0.35	0.35	0.10	0.20	0.35	0.35
2004	0.35	0.30	0.20	0.35	0.35	0.10	0.20	0.35	0.35
2005	0.35	0.30	0.20	0.35	0.35	0.10	0.20	0.35	0.35
2006	0.35	0.30	0.20	0.35	0.35	0.10	0.20	0.35	0.35
2007	0.35	0.30	0.20	0.35	0.35	0.10	0.20	0.35	0.35
2008	0.35	0.30	0.20	0.35	0.35	0.10	0.20	0.35	0.35

Table 3.13.5. Calculated annual commercial hand line and long line black grouper discards by year. Discards are reported in number of fish.

Year	Black Grouper Hand Line Calculated Discards in Numbers	Black Grouper Long Line Calculated Discards in Numbers
1993	5,571	134
1994	6,783	162
1995	6,125	145
1996	6,651	154
1997	7,036	168
1998	6,505	159
1999	7,296	178
2000	7,215	163
2001	6,244	153
2002	6,576	139
2003	8,324	160
2004	4,701	148
2005	9,400	110
2006	1,155	129
2007	8,886	115
2008	1,295	104

Table 3.13.6. Estimated condition at release of black grouper commercial hand line and long line discards. Annual percent of discards reported by release condition category. Also included are the number of logbook reports entered, number of discard reports entered and the number of discard reports that reported at least one discard for any species.

Gear	Year	All Dead	Majority Dead	All Alive	Majority Alive	Kept	Unknown	Unreported	N Fish	N logbook reports	N discard reports	N reporting any discards
Handline	2002	0.75%	1.49%	95.52%	2.24%	0.00%	0.00%	0.00%	134	31,422	3,896	2,967
	2003	0.00%	0.00%	90.09%	5.41%	0.30%	3.90%	0.30%	333	31,707	3,976	2,807
	2004	11.79%	1.89%	85.85%	0.00%	0.47%	0.00%	0.00%	212	30,007	3,718	2,324
	2005	0.00%	0.46%	92.24%	5.48%	0.91%	0.00%	0.91%	219	26,207	3,253	2,103
	2006	0.00%	0.00%	98.25%	0.00%	1.75%	0.00%	0.00%	57	27,203	2,552	1,488
	2007	0.80%	0.00%	94.40%	3.20%	1.60%	0.00%	0.00%	250	25,500	4,153	2,160
	2008	0.00%	0.00%	98.82%	0.78%	0.39%	0.00%	0.00%	255	25,172	8,600	4,045
	N Fish	7	1,356	43	10	13	3	1,460				
Longline		9.10%	0.00%	81.80%	0.00%	9.10%	0.00%	0.00%	151	29,524	1,844	1,158

Table. 3.13.7. Estimated black grouper hand line discards and dead discards in numbers and converted to pounds gutted weight using the TIP hand line mean weights for each year.

Year	Black Grouper Vertical Line Calculated Discards in Numbers	Black Grouper Vertical Line Discards in Pounds	Mortality	Black Grouper Vertical Line Dead Discards in Numbers	Mean Weight	Pounds Gutted
1993	5,571	66,788	0.20	1,114	11.989	13,358
1994	6,783	111,123	0.20	1,357	16.383	22,225
1995	6,125	164,659	0.20	1,225	26.883	32,932
1996	6,651	62,387	0.20	1,330	9.380	12,477
1997	7,036	139,108	0.20	1,407	19.771	27,822
1998	6,505	98,539	0.20	1,301	15.148	19,708
1999	7,296	152,182	0.20	1,459	20.858	30,436
2000	7,215	156,953	0.20	1,443	21.754	31,391
2001	6,244	86,571	0.20	1,249	13.865	17,314
2002	6,576	174,055	0.20	1,315	26.468	34,811
2003	8,324	145,405	0.20	1,665	17.468	29,081
2004	4,701	73,788	0.20	940	15.696	14,758
2005	9,400	179,738	0.20	1,880	19.121	35,948
2006	1,155	22,363	0.20	231	19.362	4,473
2007	8,886	138,167	0.20	1,777	15.549	27,633
2008	1,295	35,490	0.20	259	27.405	7,098

Table. 3.13.8. Estimated long line discards and dead discards in numbers and converted to pounds gutted weight using the TIP long line mean weights for each year.

Year	Black Grouper Long Line Calculated Discards in Numbers	Black Grouper Long Line Discards in Pounds	Mortality	Black Grouper Long Line Dead Discards in Numbers	Mean Weight	Pounds Gutted
1993	134	4,297	0.30	40	32.064	1,289
1994	162	5,785	0.30	49	35.707	1,735
1995	145	6,220	0.30	44	42.899	1,866
1996	154	5,207	0.30	46	33.809	1,562
1997	168	7,706	0.30	50	45.868	2,312
1998	159	5,758	0.30	48	36.214	1,727
1999	178	6,059	0.30	53	34.042	1,818
2000	163	6,597	0.30	49	40.471	1,979
2001	153	6,179	0.30	46	40.387	1,854
2002	139	4,598	0.30	42	33.082	1,380
2003	160	6,883	0.30	48	43.022	2,065
2004	148	4,603	0.30	44	31.100	1,381
2005	110	3,186	0.30	33	28.964	956
2006	129	3,577	0.30	39	27.730	1,073
2007	115	3,144	0.30	35	27.337	943
2008	104	2,991	0.30	31	28.764	897

Table 3.13.9. Hand line relative nominal CPUE, number of trips, proportion positive trips, and relative abundance index for black grouper (1993-2008).

YEAR	Relative Nominal CPUE	Trips	Proportion Successful Trips	Relative Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1993	1.005	1,549	0.706	0.760	0.585	0.989	0.132
1994	0.938	2,175	0.648	0.753	0.588	0.965	0.124
1995	1.037	1,881	0.681	0.808	0.631	1.034	0.124
1996	1.164	1,923	0.742	0.831	0.652	1.058	0.122
1997	0.708	2,647	0.697	0.749	0.586	0.957	0.123
1998	0.780	2,693	0.753	0.971	0.765	1.233	0.120
1999	0.767	2,375	0.784	0.758	0.589	0.974	0.126
2000	0.859	2,337	0.793	0.821	0.640	1.054	0.125
2001	1.002	2,571	0.794	1.250	0.984	1.587	0.120
2002	0.967	2,317	0.765	1.150	0.906	1.461	0.120
2003	1.293	2,224	0.728	1.279	1.003	1.632	0.122
2004	1.304	2,017	0.769	1.348	1.063	1.710	0.119
2005	1.076	1,819	0.779	1.318	1.038	1.674	0.120
2006	1.152	1,393	0.738	1.382	1.077	1.773	0.125
2007	1.239	1,136	0.682	1.018	0.788	1.315	0.129
2008	0.710	1,101	0.642	0.804	0.605	1.069	0.143

Table 3.13.10. Long line relative nominal CPUE, number of trips, proportion positive trips, and relative abundance index for black grouper (1993-2008).

YEAR	Relative Nominal CPUE	Trips	Proportion Successful Trips	Relative Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1993	0.263	382	0.838	0.390	0.063	2.431	1.145
1994	0.293	462	0.727	0.304	0.037	2.494	1.422
1995	0.461	295	0.739	0.403	0.047	3.458	1.476
1996	0.456	403	0.801	0.455	0.083	2.481	1.026
1997	0.884	619	0.740	0.459	0.091	2.313	0.960
1998	1.125	578	0.875	0.754	0.260	2.187	0.573
1999	1.221	596	0.901	0.832	0.315	2.197	0.516
2000	1.483	498	0.902	1.062	0.446	2.525	0.454
2001	1.463	584	0.918	1.406	0.721	2.743	0.344
2002	1.409	517	0.905	1.581	0.826	3.024	0.333
2003	1.059	630	0.908	1.837	1.027	3.286	0.297
2004	1.986	636	0.901	1.869	1.085	3.220	0.277
2005	1.491	591	0.887	1.803	1.039	3.127	0.281
2006	1.046	656	0.829	1.107	0.473	2.591	0.445
2007	0.984	460	0.854	1.049	0.354	3.110	0.586
2008	0.376	498	0.779	0.690	0.178	2.677	0.764

Table 3.13.11. Number of trips sampled by year and gear.

	GEAR				
YEAR	DIVING	HANDLINE	LONGLINE	OTHER	TRAPS
1986	1	13	13	1	4
1987	2	9	9	1	6
1988		10	5		6
1989		5	3		11
1990	1	12	8		14
1991	1	19	9		1
1992	2	24	20		5
1993	2	37	17		2
1994		24	8		1
1995		14	11		2
1996		14	6		
1997	1	20	13		
1998	2	31	48		
1999	1	33	52		
2000	2	43	48		
2001	2	32	53		
2002	5	21	38		2
2003		33	56		4
2004		18	60		
2005	1	22	66		
2006	2	12	62		
2007		26	52		
2008		25	37		

Table 3.13.12. Number of lengths collected by year and gear.

	GEAR				
YEAR	DIVING	HANDLINE	LONGLINE	OTHER	TRAPS
1986	18	26	44	1	32
1987	10	36	52	1	100
1988		61	27		164
1989		11	37		151
1990	1	23	36		246
1991	2	27	47		18
1992	29	89	42		26
1993	14	199	39		2
1994		53	21		6
1995		42	36		18
1996		70	21		
1997	1	28	68		
1998	3	61	252		
1999	1	67	277		
2000	6	68	231		
2001	2	44	156		
2002	7	40	153		4
2003		73	112		9
2004		21	174		
2005	2	28	184		
2006	10	19	195		
2007		33	131		
2008		31	80		

Table 3.13.13. Number of commercial age samples collected and number of trips from which the age samples were collected by gear and year.

	AGES		TRIPS	
YEAR	HANDLINE	LONGLINE	HANDLINE	LONGLINE
1986				
1987				
1988				
1989				
1990	5		5	
1991	6		4	
1992	4		4	
1993	9		7	
1994	11	11	6	4
1995	13	109	10	30
1996	12	105	7	35
1997				
1998	5		5	
1999	10	3	6	2
2000	9	7	7	6
2001	17	34	14	22
2002	10	37	7	24
2003	13	85	11	44
2004	11	114	10	51
2005	18	156	15	73
2006	19	240	14	84
2007	35	136	26	57
2008	31	75	16	40

Table 3.13.14. Commercial length sampling fractions by gear and year.

YEAR	GEAR				
	DIVING	HANDLINE	LONGLINE	OTHER	TRAP
1986	0.14	0.00	0.01	0.00	0.00
1987	0.02	0.00	0.00	0.01	0.01
1988	0.00	0.00	0.01	0.00	0.02
1989	0.00	0.00	0.01	0.00	0.01
1990	0.01	0.00	0.01	0.00	0.02
1991	0.00	0.00	0.02	0.00	0.00
1992	0.01	0.01	0.03	0.00	0.01
1993	0.01	0.02	0.04	0.00	0.00
1994	0.00	0.01	0.03	0.00	0.01
1995	0.00	0.01	0.06	0.00	0.04
1996	0.00	0.01	0.03	0.00	0.00
1997	0.00	0.01	0.08	0.00	0.00
1998	0.00	0.01	0.24	0.00	0.00
1999	0.00	0.02	0.20	0.00	0.00
2000	0.01	0.02	0.18	0.00	0.00
2001	0.00	0.01	0.11	0.00	0.00
2002	0.01	0.01	0.10	0.00	0.01
2003	0.00	0.01	0.06	0.00	0.03
2004	0.00	0.00	0.08	0.00	0.00
2005	0.00	0.01	0.12	0.00	0.00
2006	0.01	0.01	0.11	0.00	0.00
2007	0.00	0.01	0.10	0.00	0.00
2008	0.00	0.02	0.15	0.00	0.00

Table 3.13.15. Commercial age sampling fractions for hand line and long line gear by year.

YEAR	HANDLINE	LONGLINE
1986	0.00	0.00
1987	0.00	0.00
1988	0.00	0.00
1989	0.00	0.00
1990	0.00	0.00
1991	0.00	0.00
1992	0.00	0.00
1993	0.00	0.00
1994	0.00	0.02
1995	0.00	0.18
1996	0.00	0.13
1997	0.00	0.00
1998	0.00	0.00
1999	0.00	0.00
2000	0.00	0.01
2001	0.00	0.02
2002	0.00	0.02
2003	0.00	0.05
2004	0.00	0.05
2005	0.01	0.10
2006	0.01	0.14
2007	0.01	0.11
2008	0.02	0.14

3.14. *FIGURES*

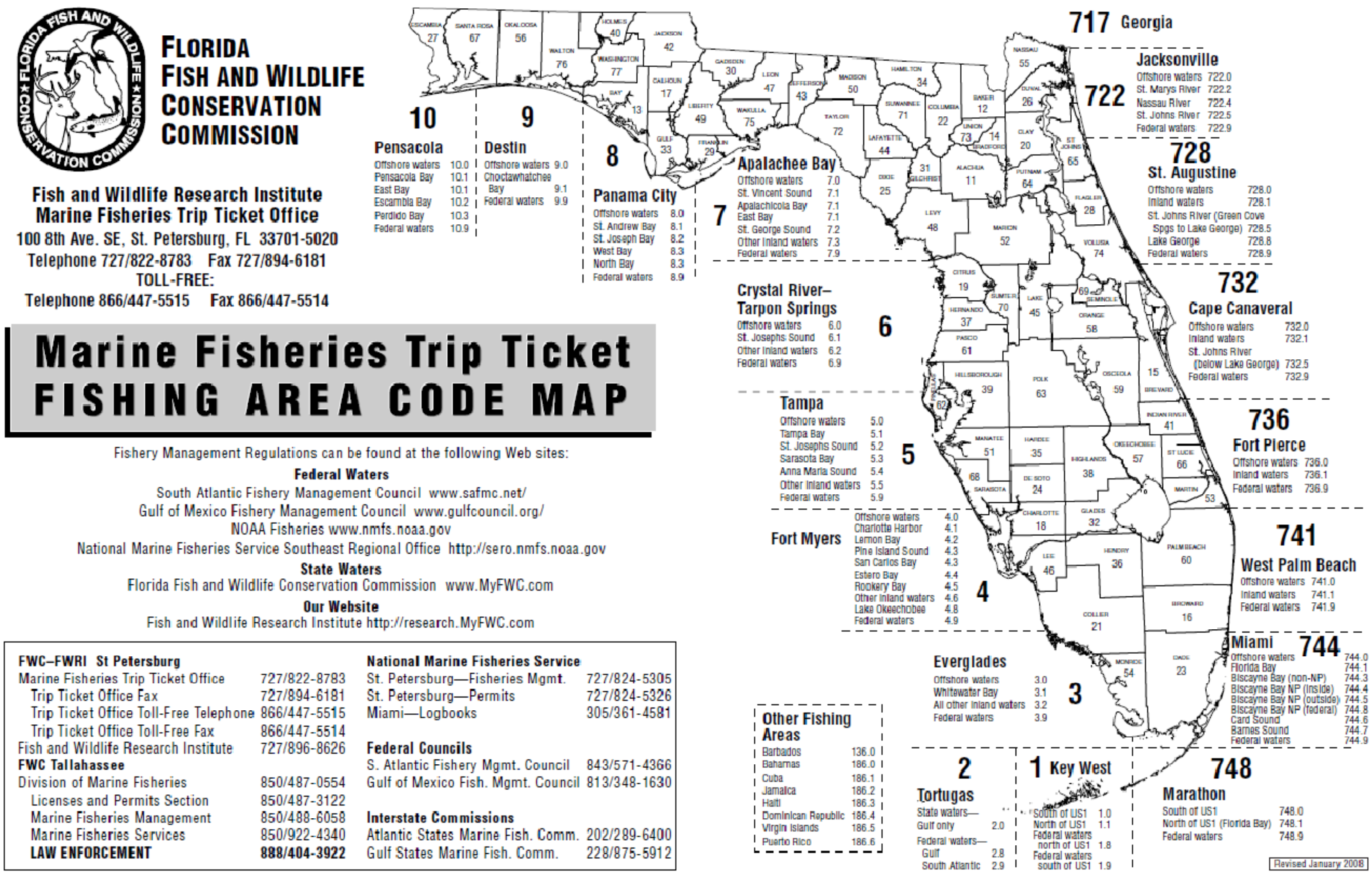
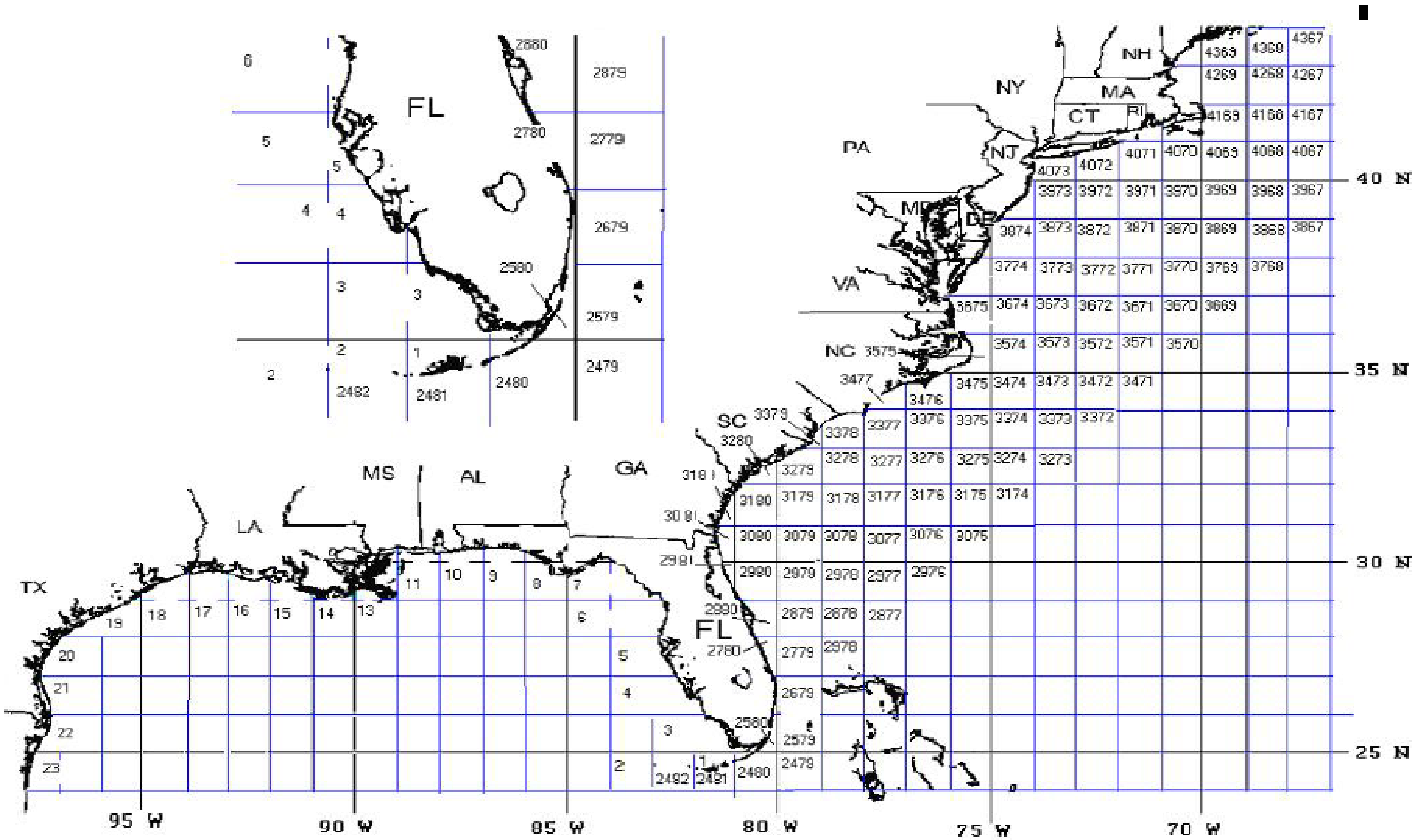


Figure 3.14.1. Map of fishing areas used by the FL trip ticket program.



Area Map:
South Atlantic Statistical Grid Map – Grid Numbers follow lines of longitude and latitude. The first two digits in the four digit grid numbers are latitude degrees and the second two digits are longitude degrees.
Gulf of Mexico Statistical Grid Map – Use the grid number of the area you fished. Note that gulf grid numbers do not follow lines of longitude and latitude.
Florida Close-up (See Inset) - The close-up grid map of south Florida shows the 4 digit codes for the South Atlantic Region and the 1 digit code in the Gulf of Mexico Region.

Figure 3.14.2. Map of fishing area designations used in logbook reports.

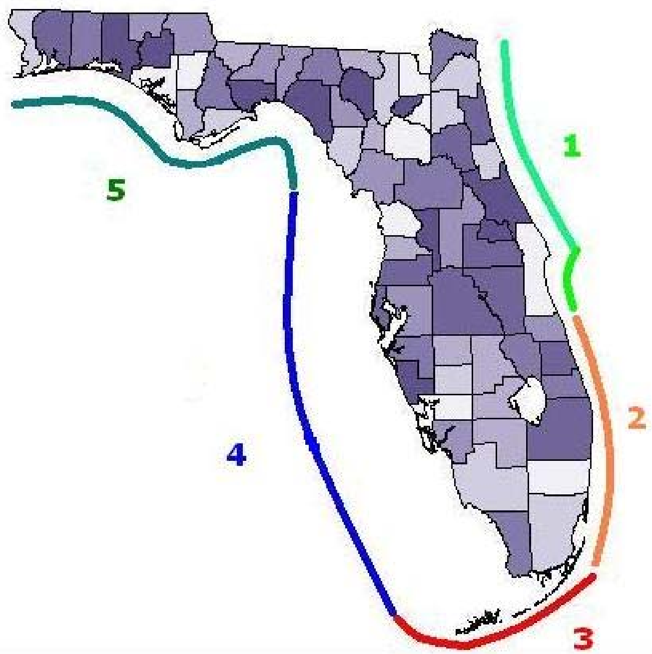


Figure 3.14.3. Map of fishing area designations applied to commercial data for black grouper.

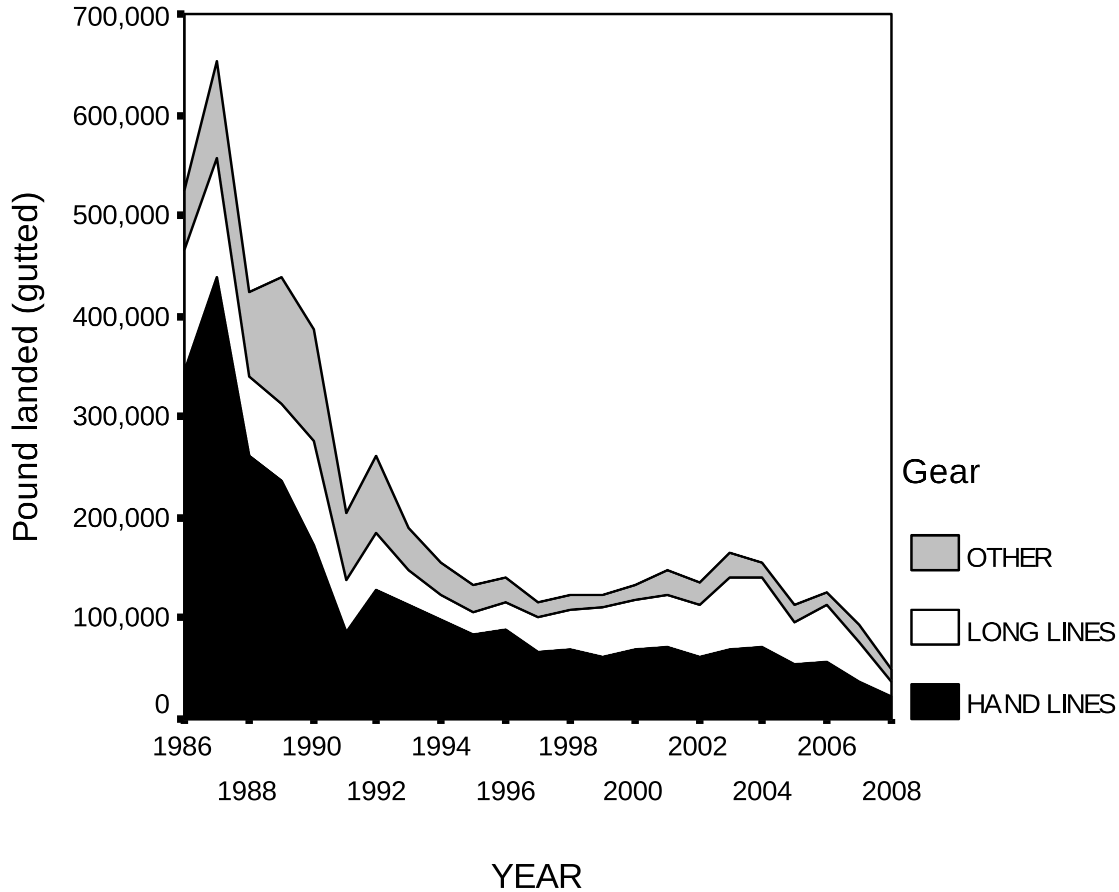


Figure 3.14.4. Adjusted commercial landings in pounds gutted weight. Diving, trap, and other gear have been combined into the "other" category to maintain confidentiality.

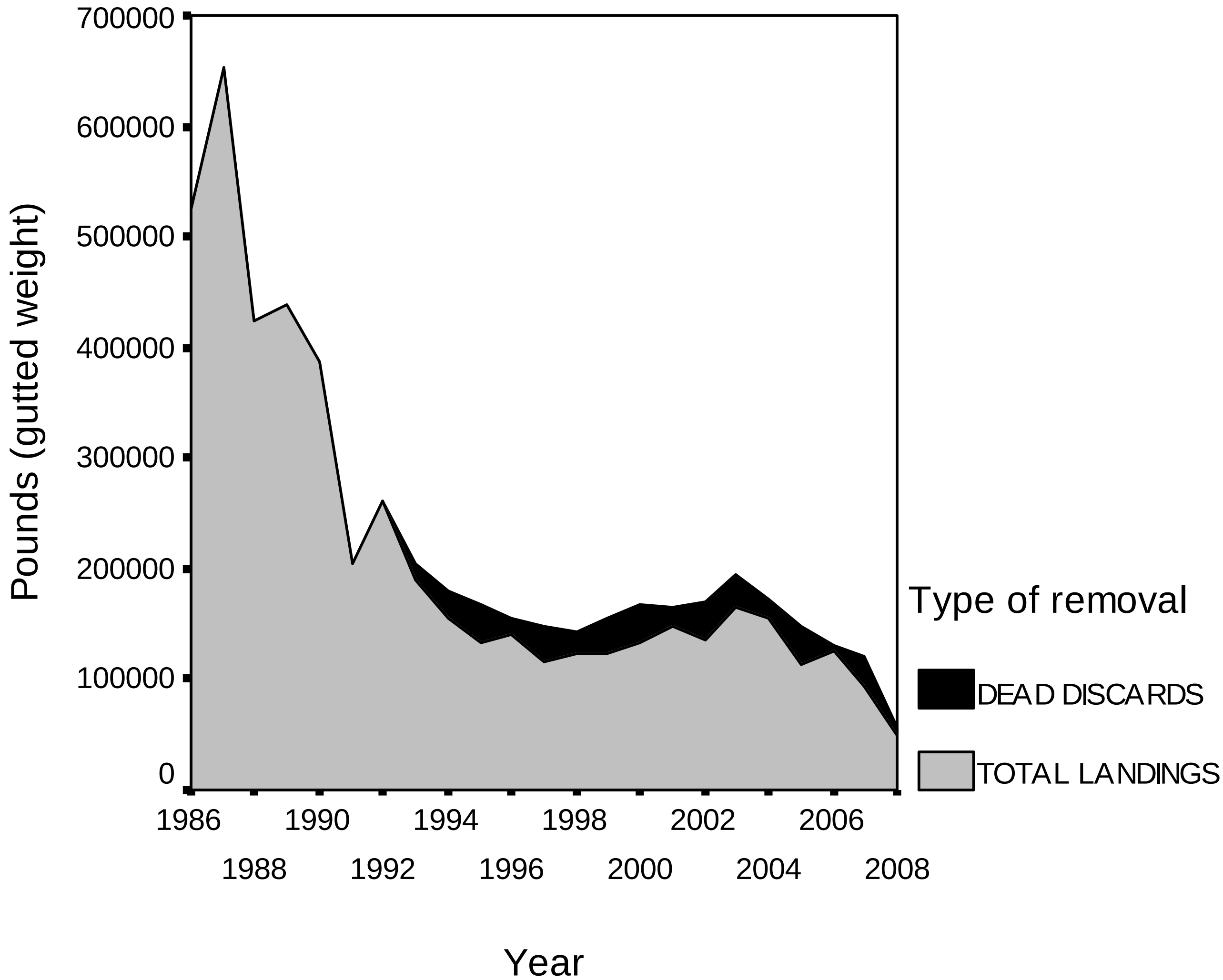


Figure 3.14.5. Adjusted commercial landings and dead discards 1993-2008 in pounds gutted weight.

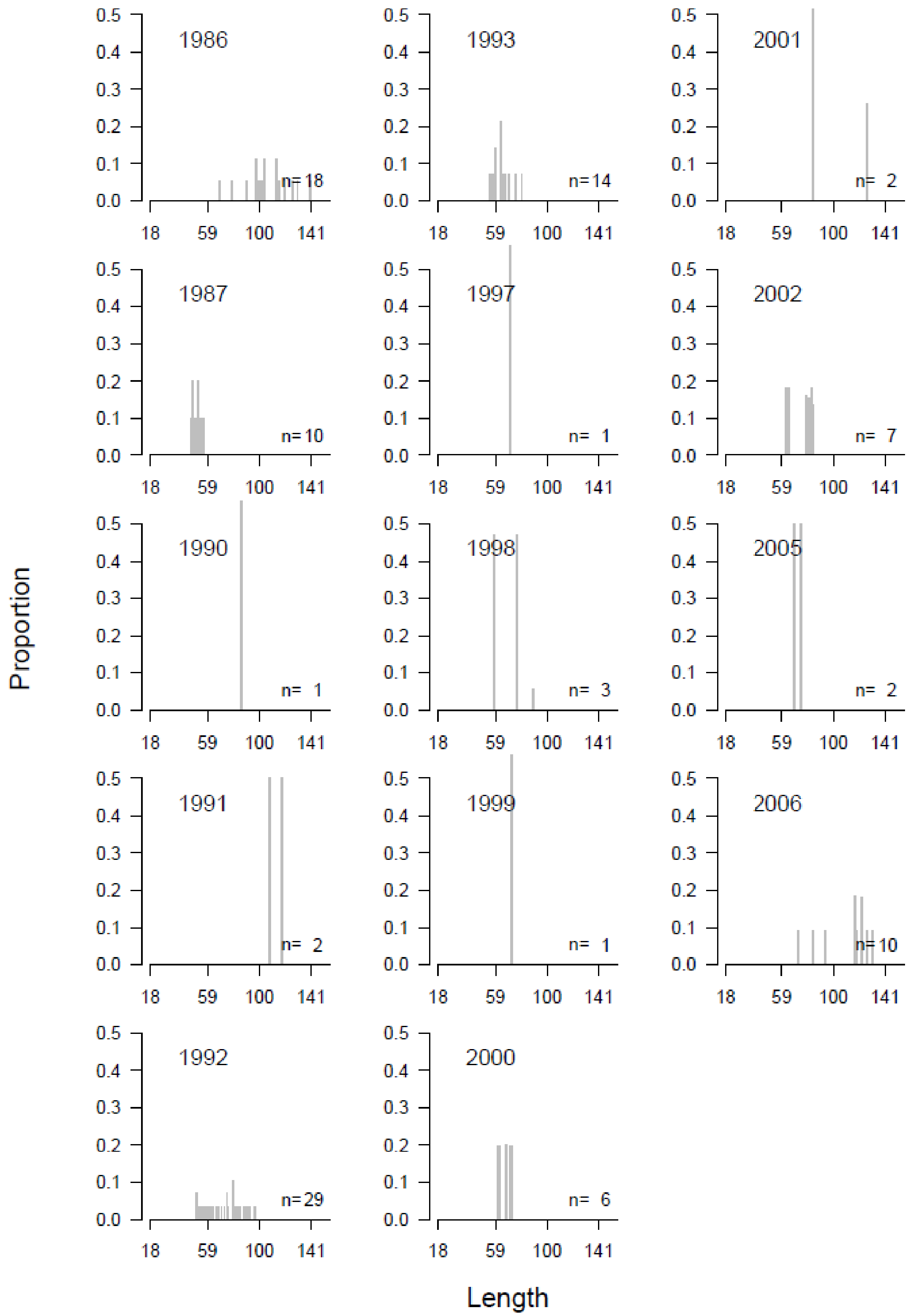


Figure 3.14.6. Relative length composition of commercial length samples by year for diving gear.

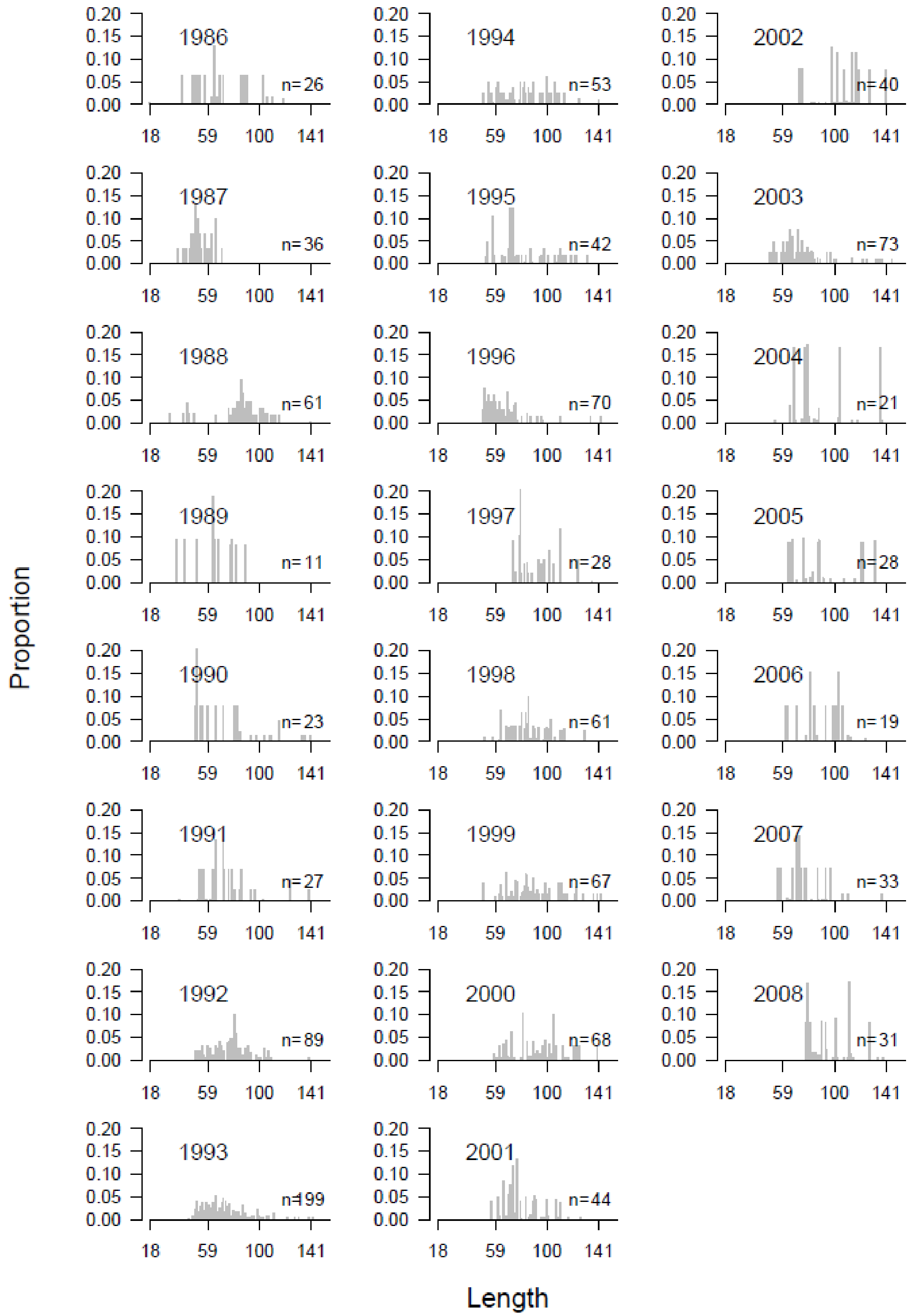


Figure 3.14.7. Relative length composition of commercial length samples by year for hand line gear.

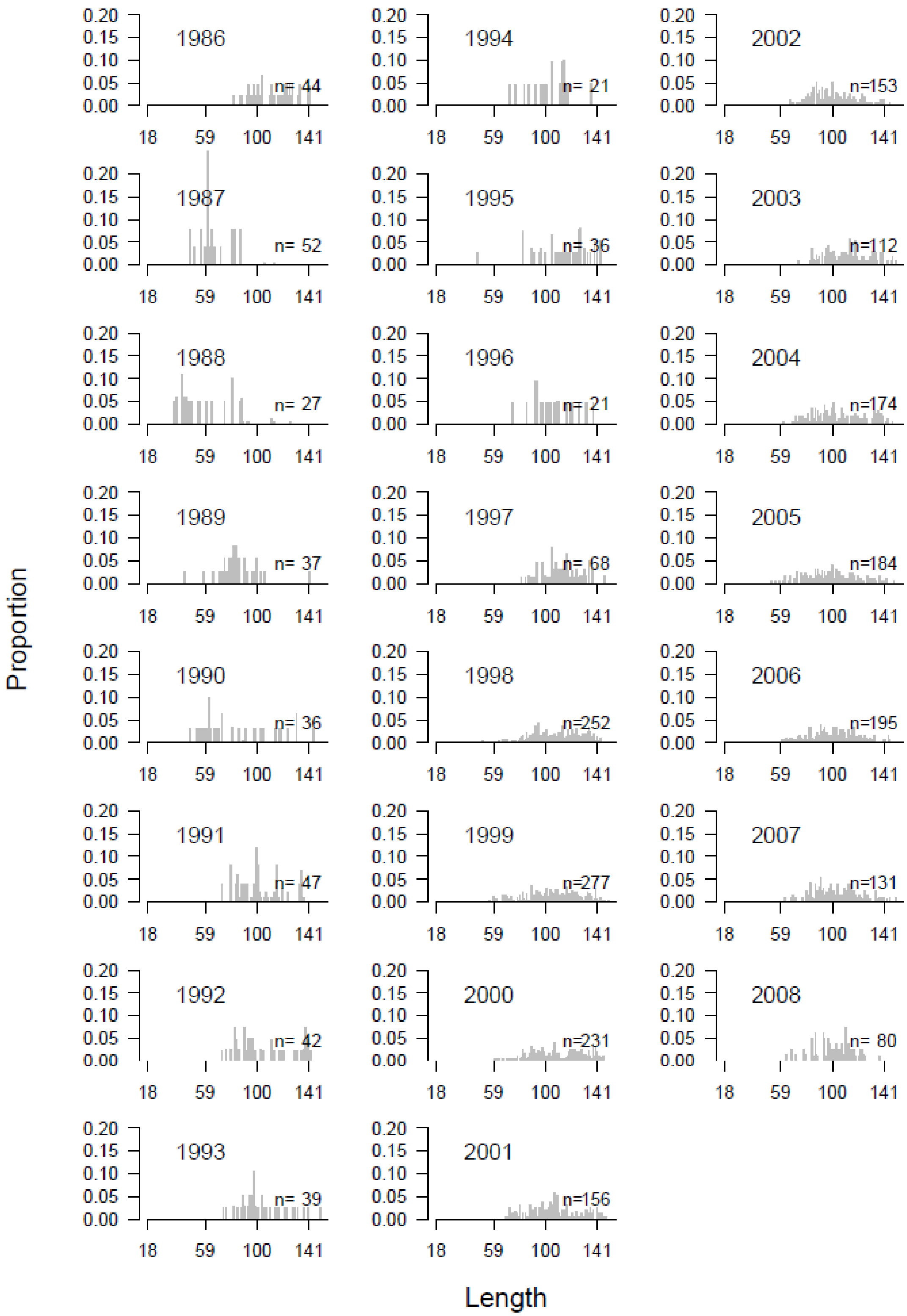


Figure 3.14.8. Relative length composition of commercial length samples by year for long line gear.

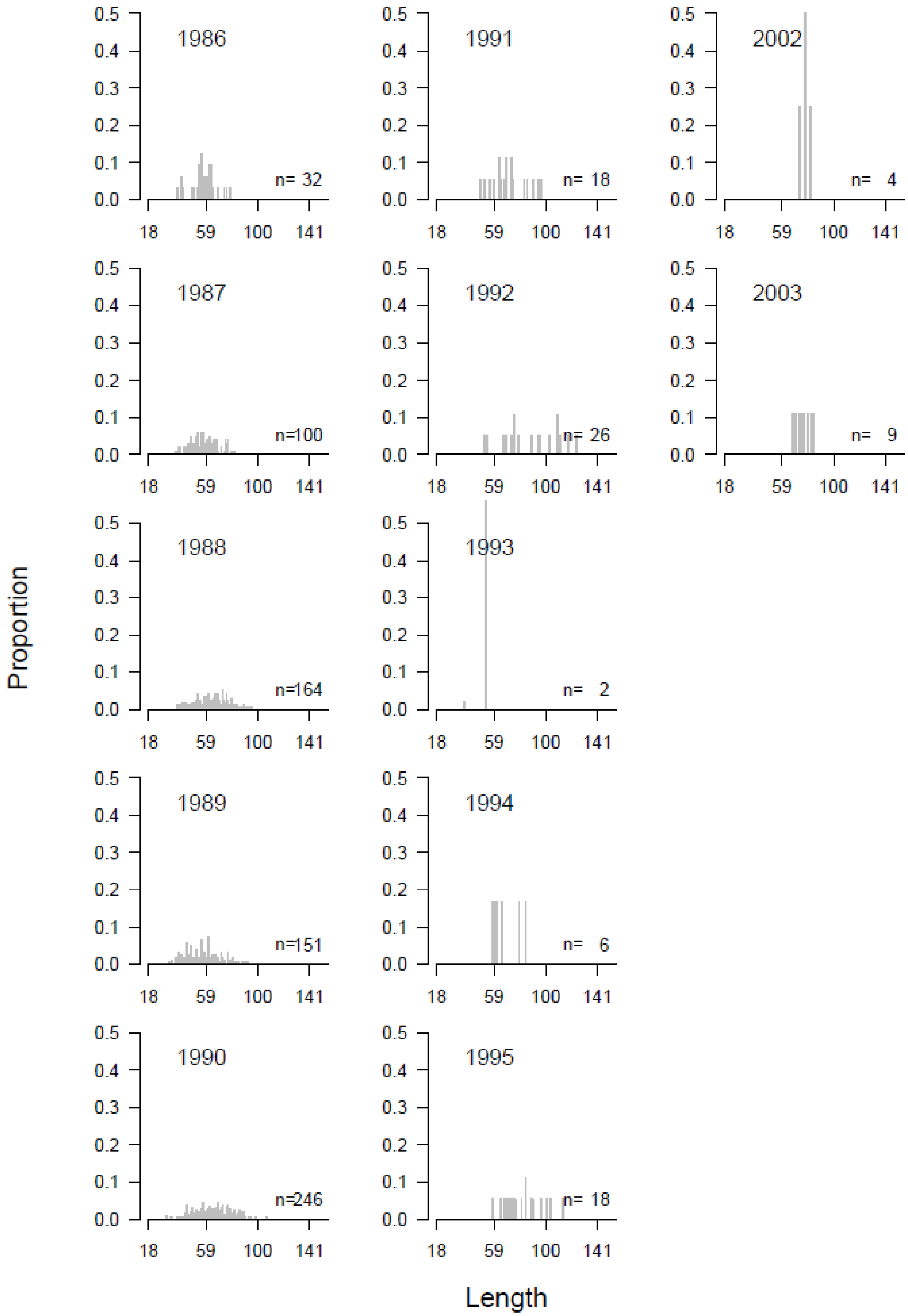


Figure 3.14.9. Relative length composition of commercial length samples by year for pot and trap gear.

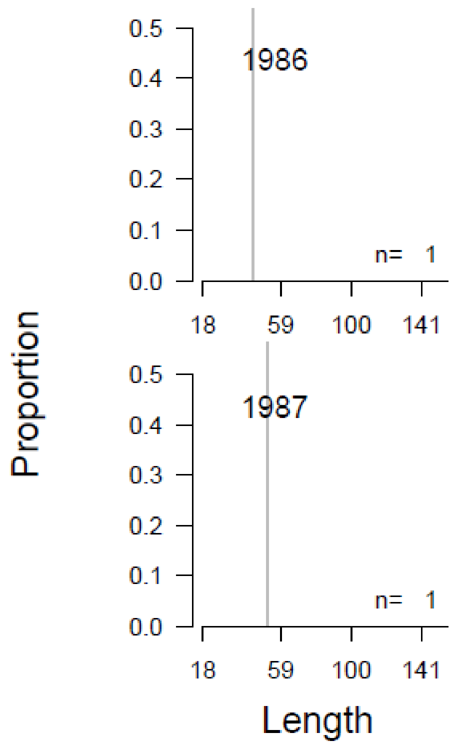


Figure 3.14.10. Relative length composition of commercial length samples by year for other gear.

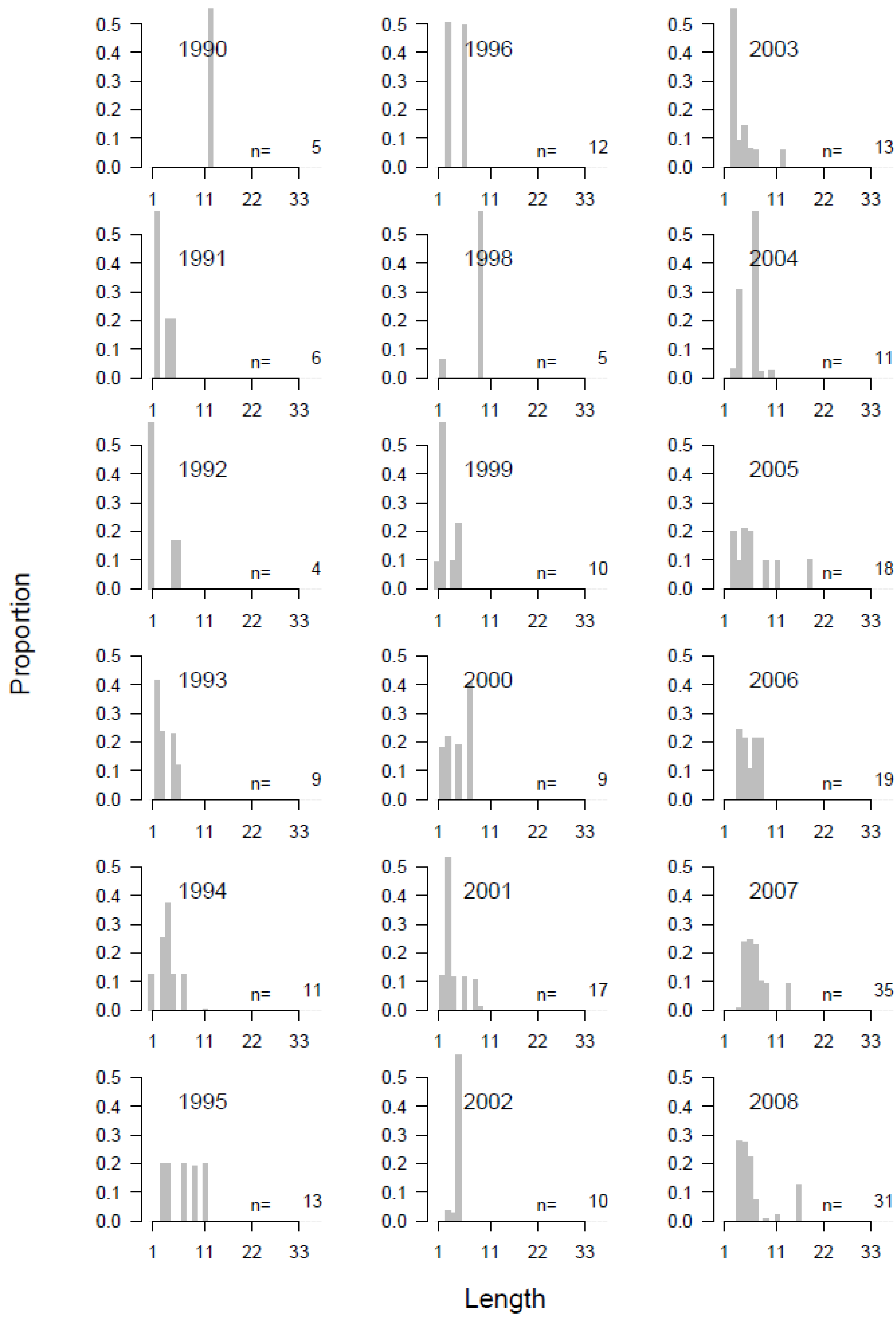


Figure 3.14.11. Relative age composition of age samples by year for hand line.

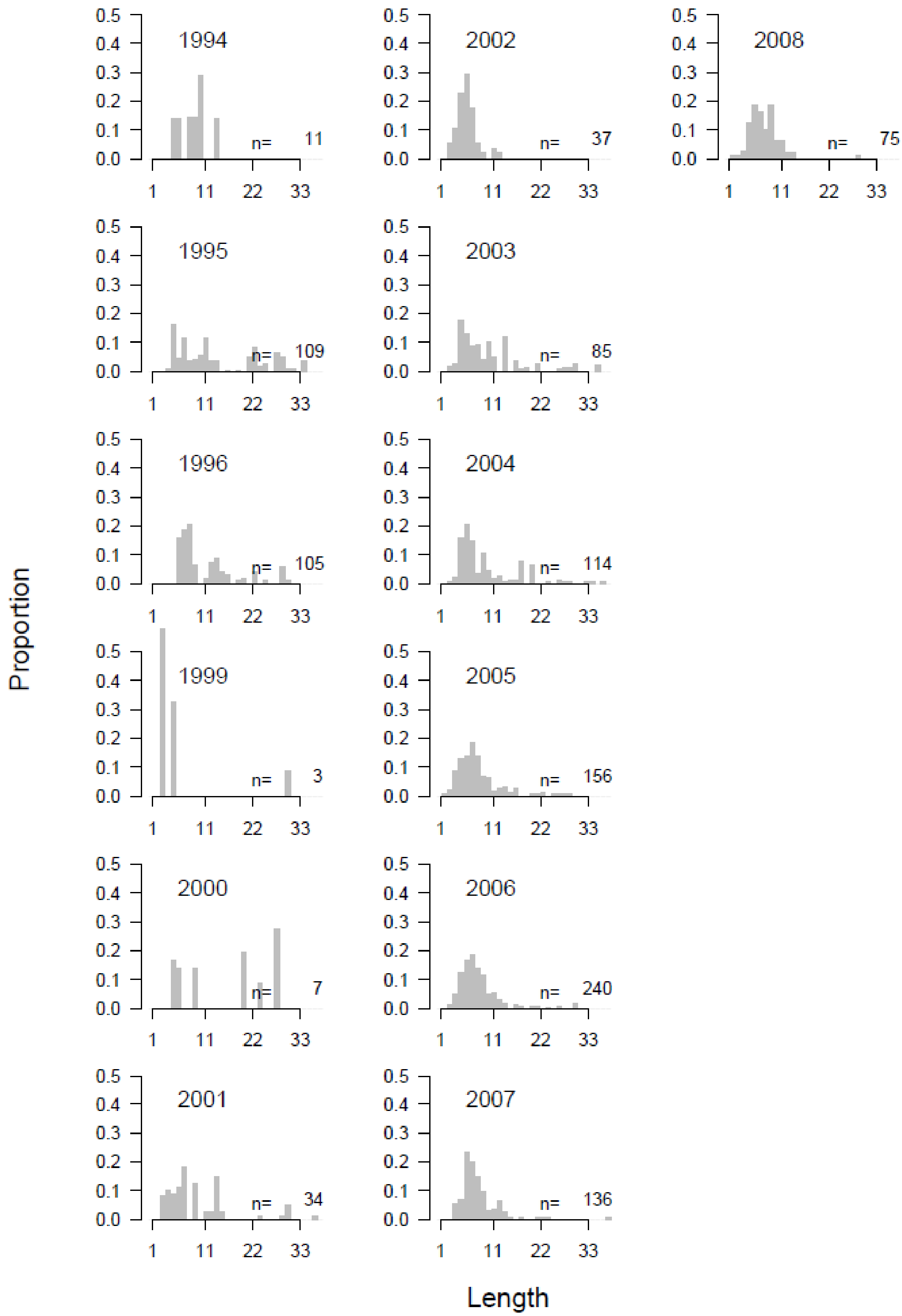


Figure 3.14.12. Relative age composition of age samples by year for long line.

4. RECRATIONAL FISHERY STATISTICS

4.1. *OVERVIEW*

4.1.1 Group membership

Members- Beverly Sauls (FWRC), Tom Sminkey (NMFS Silver Spring), Ken Brennan (NMFS Beaufort), Dennis O'Hern (AP/Fisherman rep), Russell Hudson (Industry rep), Chad Hanson (Observer), Anne Lange (Leader, SAFMC SSC)

4.1.2 Issues:

(1) Black Grouper Charter Boat Landings 1986-2003 & 2004-2008, survey methods changed.

(2) Black Grouper landings – 1980's: apparently include gag and possibly others in mid-peninsula and panhandle region of Gulf coast of FL, but Keys data look reasonable.

(3) How to address 1960, 1965, and 1970 U.S. Fish and Wildlife Service (FWS) survey data.

(4) How far back should estimates be generated for the recreational data.

4.2. *GENERAL RECREATIONAL FISHERY – MRFSS*

4.2.1 Review of Working Papers

SEDAR19-DW-07_Groupers_Rec_Landings.pdf, T. R. Sminkey, NMFS, ST1, Silver Spring, MD. 2009 – This paper describes the general linear model regression analysis of Charter boat effort estimates produced by the MRFSS' Coastal Household Telephone Survey (CHTS) and the For-Hire Survey, and how the model can be used to produce a continuous time series of effort and catches (or landings) of fishes when the survey method has changed during that time series. The regression ratios were then applied to the historical time series of effort prior to the overlapping survey methods to produce adjusted charter boat effort for each earlier year. That 'adjusted effort' was substituted for the originally estimated effort and new catch statistics were generated for black grouper. The regression method treats the South Atlantic region and the Gulf region separately, and ratios are provided for each region. The Gulf region analysis and ratios were produced by Diaz and Phares (2004) and applied here to black grouper catch statistics. The recreational statistics workgroup recommends using these adjusted charter boat landings when producing the overall aggregate landings of black grouper, and have included adjusted landings in Table 4.6.1.

4.2.2 MRFSS RECREATIONAL LANDINGS

Recreational landings of black grouper were generated from the MRFSS surveys of recreational anglers, conducted from 1981 – 2008 along the Atlantic and Gulf coasts. The area included in these landings encompasses North Carolina to Florida in the Atlantic and Louisiana to Florida in the Gulf of Mexico. Texas was not surveyed by the MRFSS so is not included in this section. Because fishing boats departing from and returning to sites in Monroe County, Florida (the Keys) can fish in either the Atlantic or the Gulf waters, this segment of FL is often separated out for reporting landings or fishing effort using post-stratification techniques. For the black grouper recreational fishery, there were issues of identification and ‘lumping’ of gag and black grouper catches being reported as black grouper in the early years of the MRFSS, 1981-1990, particularly in the middle Gulf coast area of FL and the panhandle region of FL. It was decided by the recreational fishery statistics workgroup, with input from NMFS and Florida Fish and Wildlife Conservation Commission (FWC) scientists that these landings could not be separated so it would be best to exclude any catch statistics of black grouper from those two regions of the Gulf from aggregate landings for those years. The post-stratification methods were used to remove all but the Keys region of FL from the Gulf landings of black grouper.

The charter boat survey methods changed during the time series of monitored landings available, so an adjustment was made to produce a uniform time series of landings. This work is detailed in the workshop paper, SEDAR19 DW07, and is discussed above. Weight landings were produced from the adjusted number landed using mean weights by year. There was little mean weight variance within the year.

Total adjusted landings, by numbers and weight (pounds), and live discards are tabulated for the range in Table 4.6.1.

4.2.3. MRFSS Recreational Discards

Live discard information, identification to lowest possible taxon and numbers per angler, are collected during the MRFSS' surveys. These charter boat mode discards are adjusted similar to landings adjustments for the survey method change using relative proportions to total landings (as detailed in SEDAR 19 DW-07), and presented by number for black grouper in Table 4.6.1. We do not have any size or age data available for live discards reported by the MRFSS (all data from angler reports, not observed).

4.2.4. MRFSS Discard Mortality

Given lack of specific studies the recreational WG discussed what would be considered reasonable ranges of discard mortality, based on estimates presented by the commercial and life history WGs. For black grouper the WG recommends a discard mortality of 20%, fishery-wide, with sensitivity analyses run for from 10-30%.

4.2.5. MRFSS Biological Sampling

4.2.5.1. Sampling Intensity Length/Age/Weight

The MRFSS angler-intercept survey collected lengths and weights of subsamples of landed fishes. The black grouper length frequencies are included in the SEDAR19 DW spreadsheet of statistics (BG_DW_summary.xls) and follow the requested standards (1 cm length groups, Total Length converted from measured Fork Length). The annual sample sizes of the measured black groupers are reported beside the annual frequencies.

Weights of individual fish are obtained and used to produce average weights per sampled cell (year/wave/sub-region/state/collapsed mode/collapsed area) which are then applied to the harvested (A+B1 catch) catch in numbers to produce the harvested weight estimates. Substitution of mean weight from higher geographically pooled levels (state, then sub-region) may be used to replace missing values within cells if the number of weighed fish per cell is less than 2. If no weights of fish are obtained within the sub-region for a mode during the entire wave then no average weight is available and no weight of landings will be estimated. This potential ‘gap’ in landings estimates may lead to underestimating total harvest if the missing weights are not accounted for in any analysis or stock assessment. Therefore, landed weights from MRFSS should always be compared to landed numbers of fish to evaluate potential missing weight field data.

4.2.5.2 Length – Age distributions

The WG had no input on this issue.

4.2.5.3. Adequacy for characterizing catch

The WG had no input on this issue.

4.2.5.4 Alternatives for characterizing discards

The WG had no input on this issue

4.2.6. MRFSS Recreational Catch-at-Age/Length; directed and discard

The WG had no input on this issue

4.2.7. MRFSS Recreational Effort

Marine recreational fishing effort throughout the managed range of black grouper (South Atlantic region, Florida Keys, and Gulf of Mexico) is tabulated in Table 4.6.2. Detailed tables of fishing effort by sub-region and mode are provided in the data workshop fishery statistics spreadsheets, RG_DW_summary.xls and BG_DW_summary.xls.

4.3. *HEADBOAT FISHERY*

4.3.1. Review of Working Papers

SEDAR19-DW-21 Estimated Landings and Discards of Red Grouper in the South Atlantic and Black Grouper in the South Atlantic and Gulf of Mexico Headboat Fishery, 2004-2008.pdf, K. J. Brennan, NMFS, Beaufort, NC. This working paper summarizes the estimated landings and discards for both red grouper and black grouper from 2004 to 2008. Prior to 2004 discard information was not collected on the headboat logbook form. Since this self reported data lacks validation the paper recommends continued comparisons to the At-Sea-Observer program.

SEDAR 19-DW-08 Length Frequencies and Condition of Released Red Grouper and Black Grouper from At-Sea Headboat Observer Surveys in the Gulf of Mexico and Atlantic Ocean, 2005 to 2007.pdf, B. Sauls FWC, St. Petersburg, FL. This working paper summarizes information collected on the size, release condition, and final disposition of black and red grouper collected by trained observers during at-sea surveys on board headboats. While this information is specific to the recreational headboat fishery, it provides valuable information on the size of discarded fish from the recreational fishery, which historically has not been collected in other surveys of recreational fishing.

4.3.2. Headboat Landings

The Southeast Region Headboat Survey estimates landings and effort for headboats in the South Atlantic and Gulf of Mexico. To determine black grouper landings for the earliest possible year, the recreational working group first considered when both the South Atlantic and the Gulf of Mexico headboat data could be used together. Although estimated landings in the South Atlantic are available from 1981, the SRHS did not have coverage in the Gulf of Mexico until 1986. It was therefore the recommendation of the WG to use landings and effort estimates starting in 1986. The WG discussed possible species identification problems in the Gulf of Mexico.

Issue 1: The 1986 and 1987 estimated landings for black grouper AL\NEFL were extremely high. After further review and personal communications with the previous SRHS coordinator, it was concluded that this was a species identification problem.

Option 1: Use estimated black grouper landings from AL\NWFL as reported.
Option 2: Adjust 1986 and 1987 estimated landings for AL\NWFL to account for identification issue.
Decision: Option 2. The WG recommended adjusting estimated landings for the years in question. The average estimated landings from 1988-1990 were applied to 1986 and 1987 both numerically and by weight. Results are shown in Tables 4.6.3 and 4.6.4.

4.3.3. Headboat Discards

Prior to 2004 discard information was not collected on the headboat logbook form. The estimated headboat discards for 2004-2008 are summarized in SEDAR19-DW-21. Based on past comparisons to the MRFSS AT-Sea Observer data it was concluded that the logbook data was underreported. The At-Sea Observer discard data for black grouper was limited in sample size (N=76, 2005-2008) and was therefore not used. The MRFSS charterboat discards was used as a proxy for headboat discards because they most closely resembled the type of fishing that occurs on headboats and accounts for regulatory changes that were implemented during the time series.

Headboat At-Sea Observer Survey

An observer survey of the recreational headboat fishery was launched in NC and SC in 2004 and in FL in 2005 to collect more detailed information on recreational headboat catch, particularly for discarded fish. Headboat vessels are randomly selected throughout the year in each state, or each sub-region in Florida. Biologists board selected vessels with permission from the captain and observe anglers as they fish on the recreational trip. Data collected include number and species of fish landed and discarded, size of landed and discarded fish, and the release condition of discarded fish (FL only). Data are also collected on the length of the trip, area fished (inland, state, and federal waters) and, in Florida, the minimum and maximum depth fished. In the Florida Keys (sub-region 3) some vessels that run trips that span more than 24 hours are also sampled to collect information on trips that fish farther offshore and for longer durations, primarily in the vicinities of the Dry Tortugas. Funding for this data collection was discontinued in the Florida Keys and west coast of Florida in 2008. While this data set is a short time series, it provides valuable quantitative information on the size distribution and release condition of fish discarded in the recreational fishery. Data from Florida are summarized in SEDAR19-DW-08.

Length frequencies of discards from the Gulf of Mexico and Atlantic regions of Florida were provided for this assessment. No black grouper were discarded from trips sampled in GA, SC, or NC. Lengths were converted from mid-line length to total length using the length conversion factor provided in the Life History section of this report. Numbers of sampled trips are provided below.

Year	Northwest FL	West FL Peninsula	Florida Keys	Southeast FL	Northeast FL	GA	SC	NC
2005	49	61	34	95	43	6	97	58
2006	45	79	52	71	38	7	88	45
2007	50	62	46	71	49	8	91	52
2008	0	0	0	76	52	3	78	39

4.3.4. Biological Sampling – Headboat Fishery

4.3.4.1. Sampling Intensity Length/Age/Weight

The weighed and measured black grouper sample sizes from the headboat fishery by year and region are given in Table 4.6.7. The number of headboat trips with weighed and measured black grouper by year and region are given in Table 4.6.8. Raw black grouper ages from the headboat fishery, by year, are given in Table 4.6.9.

4.3.5. Headboat Length/Age Distributions

4.3.5.1. Headboat Length Composition

Length compositions from the headboat fishery were generated from 1981-2008. The headboat areas were aggregated to regions of North Carolina through North Florida (ATL), and Southeast Florida (SEF - Florida break at Cape Canaveral), Florida Keys (Key), West Florida (SWF), Florida Panhandle to Texas (GUL). Samples were aggregated across years instead of season due to the small number of samples. The headboat length composition was weighted by the associated landings by year and region for 1981-2008. Two fish were deleted from the composition because of very small lengths. The removed fish were less than 7 cm. Bins at 105,112,116, and 125cm were pooled into a 105+ bin. Length composition values were submitted to Joe O'Hop for inclusion in the black grouper data summary and are plotted in Figure 4.7.2.

4.3.5.2. Headboat Age Composition

There were insufficient headboat ages were to consider weighting by year and region. If ages are to be used in the assessment they will need to be aggregated across years. Raw age distribution data is given in Table 4.6.9.

4.3.5.3. Adequacy for characterizing catch

The WG had no input on this issue

4.4.5.4. Alternatives for characterizing discards

The WG had no input on this issue

4.3.6. Headboat Catch-at-Age/Length; directed and discard

The WG had no input on this issue

4.3.7. Headboat Fishery Effort

Estimated headboat angler days decreased 24% in the South Atlantic and 14% in the Gulf of Mexico from 2007 to 2008 (Tables 4.6.5 and 4.6.6). The most obvious factor which impacted the headboat fishery in both the Atlantic and Gulf of Mexico was the high price of fuel. The Energy Information Administration reported the price per gallon of diesel fuel reached a high of $4.80/gal in July 2008 compared to $2.90/gal in July 2007 (Figure 4.7.1). The timing of the peak prices coincided with historically the busiest time of year for headboats and tourism for most of the regions included in the Survey. Reports from industry staff, captains\owners, and port agents indicated throughout the 2008 season, this was the factor that most affected the amount of trips, number of passengers, and overall fishing effort.

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

Regarding the adequacy of the available recreational data for assessment analyses, the WG discussed the following:

- Landings, as adjusted, appear to be adequate for the time period covered, though they are limited by problems with identification and by the limited time period.
- Size data appear to adequately represent the landed catch on an annual basis, for the time period covered.

4.5. *LITERATURE CITED*

Sminkey, T.R., 2009. SEDAR19-DW-07 - South Atlantic Region Recreational Fishery Catches of Red and Black Grouper, 1981 - 2008 and Gulf of Mexico Landings of Black Grouper. NOAA, NMFS. SEDAR19_DW_07_Groupers_Rec_Landings.pdf

Diaz, G. A. and P. Phares, 2004. SEDAR7-AW-03. Estimated conversion factors for calibrating MRFSS charterboat landings and effort estimates for the Gulf of Mexico in 1981-1997 with For Hire Survey estimates with application to red snapper landings. NOAA, NMFS, SEFSC, 11p.

Brennan, K.J. 2009. SEDAR19-DW-21- Estimated Landings and Discards of Red Grouper in the South Atlantic and Black Grouper in the South Atlantic and Gulf of Mexico Headboat Fishery, 2004-2008. NOAA, NMFS. SEDAR19_DW_21_Headboat_logbook_est.discards.pdf.

Sauls, B. SEDAR 19-DW-08 - Length Frequencies and Condition of Released Red Grouper and Black Grouper from At-Sea Headboat Observer Surveys in the Gulf of Mexico and Atlantic Ocean, 2005 to 2007. FWC. FWRI. 8p. SEDAR19_DW_08_Sauls.pdf.

4.6. *TABLES*

Table 4.6.1. Black Grouper Recreational Fishery Catch Statistics from the Marine Recreational Fisheries Statistics Survey (MRFSS)

Table 4.6.2. Marine Recreational Fishery Information (MRIP, formerly MRFSS), Angler Effort from the Gulf of Mexico Sub-region, excluding the Florida Keys (see Table 2) (does not included any Texas fishing effort); angler-trips by fishing mode

Table 4.6.3. Estimated landings of black grouper in the South Atlantic headboat fishery 1986-2008.

Table 4.6.4. Estimated landings of black grouper in the Gulf of Mexico headboat fishery 1986-2008.

Table 4.6.5. South Atlantic headboat estimated angler days 1981-2008.

Table 4.6.6. Gulf of Mexico headboat estimated angler days 1986-2008.

Table 4.6.7. Number of black grouper included in the headboat length compositions by region. ATL=Atlantic, SEF=Southeast Florida, KEY=Florida Keys, SWF=Southwest Florida, GUL=Florida Panhandle through Texas.

Table 4.6.8. Number of trips catching black grouper included in the headboat length composition by region. ATL=Atlantic, SEF=Southeast Florida, KEY=Florida Keys, SWF=Southwest Florida, GUL=Florida Panhandle through Texas.

Table 4.6.9. Raw black grouper ages from the headboat fishery.

Table 4.6.1. Adjusted Black Grouper Recreational Fishery Catch Statistics from the Marine Recreational Fisheries Statistics Survey (MRFSS)

	Landings (harvest); adjusted				Live Discards	
Year	Number (x1000)	PSE (CV)	Weight (lbs)	PSE (CV)	Number (x1000)	PSE (CV)
1981	48.818	24.7	202,107	27	16.27	16.27
1982	45.698	28.3	254,081	45.9	1.388	1.388
1983	83.299	39.9	278,219	51	0.934	0.934
1984	78.75	45.2	144,900	38.2	43.682	43.682
1985	54.841	50	184,814	38.4	33.449	33.449
1986	62.293	26.4	447,266	15.9	33.471	33.471
1987	55.769	20.3	382,021	43.1	155.368	155.368
1988	29.269	46.2	188,198	28.9	15.958	15.958
1989	28.002	37.3	181,452	19.2	20.588	20.588
1990	21.959	60.2	74,441	35.8	17.544	17.544
1991	32.959	34.9	398,475	42.5	75.124	75.124
1992	34.094	24.2	281,616	46.2	86.724	86.724
1993	26.831	25	140,596	27.9	52.438	52.438
1994	21.996	32.7	166,073	25.4	75.792	75.792
1995	25.993	25.4	236,796	22.3	32.819	32.819
1996	37.155	16.8	316,559	22.4	88.228	88.228
1997	43.409	21.6	450,156	15.6	72.823	72.823
1998	30.635	24.7	389,372	16.4	59.715	59.715
1999	15.28	38.9	169,613	13.7	55.174	55.174
2000	8.763	35.4	112,952	24.2	44.023	44.023
2001	10.35	21.4	136,623	25.1	35.128	35.128
2002	11.663	43.6	139,377	14.7	45.863	45.863
2003	16.914	22.7	262,670	13.6	52.951	52.951
2004	15.585	21.8	139,018	13.3	52.961	52.961
2005	12.943	35.9	135,772	20.9	20.618	20.618
2006	7.732	36.8	92,165	18.4	31.577	31.577
2007	14.614	22.2	156,224	22.6	44.422	44.422
2008	14.671	33.1	162,408	18.9	53.429	53.429

Table 4.6.2. Marine Recreational Fishery Information (MRIP, formerly MRFSS), Angler Effort from the Gulf of Mexico Sub-region, excluding the Florida Keys (see Table 2) (does not included any Texas fishing effort); angler-trips by fishing mode.

YEAR	Shore	PSE	Charter	PSE	Priv/Rent	PSE	All Modes	PSE
1981	4,470,097	9.5	193,051	11.8	4,439,186	10	9,102,334	6.7
1982	6,713,659	8.5	598,159	7.6	4,885,774	6.1	12,197,592	5.3
1983	10,710,328	10.5	488,963	9.4	6,086,649	5.8	17,285,941	6.8
1984	9,689,764	9.5	379,977	9.1	6,315,594	6.2	16,385,335	6.1
1985	7,528,396	10.4	583,626	10.3	6,383,234	6.9	14,495,257	6.2
1986	10,152,934	6.4	431,334	9.1	7,844,565	3.8	18,428,834	3.9
1987	5,867,838	5.9	283,966	13.8	7,874,789	3.2	14,026,592	3.1
1988	8,074,692	4.4	500,105	8.5	10,352,804	2.3	18,927,600	2.3
1989	5,956,222	5.1	455,029	9.5	8,220,154	3.1	14,631,406	2.7
1990	5,180,294	4.7	334,713	8.3	6,648,049	3.1	12,163,056	2.6
1991	7,441,415	4.1	294,003	9.1	8,012,939	3	15,748,358	2.5
1992	7,457,774	2.8	305,657	4.4	8,549,107	1.9	16,312,539	1.6
1993	6,724,099	2.3	515,454	4	8,140,261	1.9	15,379,816	1.4
1994	6,646,636	2.3	621,222	3.8	8,593,115	1.8	15,860,973	1.4
1995	6,268,982	2.3	691,789	2.9	8,896,939	1.7	15,857,708	1.3
1996	5,959,794	2.7	736,609	2.8	8,576,163	1.8	15,272,567	1.4
1997	6,739,975	2.6	775,624	3.6	9,347,284	1.8	16,862,882	1.5
1998	6,389,504	2.9	605,004	3.2	8,530,035	1.9	15,524,545	1.6
1999	5,671,528	2.7	557,002	3.4	8,782,785	1.8	15,011,316	1.5
2000	8,312,747	2.7	666,993	3.4	11,356,650	1.8	20,336,390	1.5
2001	9,394,401	2.3	594,584	2.9	12,068,175	1.8	22,057,161	1.4
2002	7,103,284	2.5	592,349	3	11,455,274	1.7	19,150,906	1.4
2003	7,927,996	2.6	552,771	3.2	13,720,239	1.8	22,201,006	1.5
2004	9,235,491	2.8	643,274	2.9	13,801,505	1.8	23,680,269	1.5
2005	8,412,018	3	593,880	2.9	12,518,049	2.1	21,523,948	1.7
2006	9,161,504	3.1	698,757	2.9	13,635,231	2.2	23,495,492	1.8
2007	8,824,277	3.3	741,160	3.2	14,111,718	2.1	23,677,158	1.8
2008	8,430,206	3.3	700,775	3.3	14,222,225	2.1	23,353,206	1.8

Table 4.6.3. Estimated landings of black grouper in the South Atlantic headboat fishery 1986-2008.

Area	North Carolina		South Carolina		Georgia\NE Florida		SE Florida	
Year	Number	Weight(lbs)	Number	Weight(lbs)	Number	Weight(lbs)	Number	Weight(lbs)
1986	0	0	0	0	3	21	1291	14913
1987	0	0	0	0	0	0	1831	26496
1988	0	0	0	0	14	205	2276	20414
1989	0	0	0	0	3	39	684	5824
1990	0	0	0	0	19	181	373	3231
1991	0	0	14	158	8	90	373	4216
1992	0	0	1	9	17	150	814	8568
1993	0	0	0	0	6	76	1144	12622
1994	0	0	0	0	7	80	1157	10869
1995	0	0	0	0	1	8	1005	7403
1996	0	0	1	20	2	36	945	10493
1997	2	35	0	0	2	35	543	7013
1998	0	0	1	17	1	14	675	8092
1999	0	0	0	0	6	85	648	9158
2000	0	0	0	0	2	37	585	10328
2001	0	0	0	0	0	0	504	7540
2002	0	0	0	0	3	58	532	7516
2003	0	0	0	0	0	0	610	7580
2004	0	0	0	0	10	189	1090	14153
2005	0	0	0	0	2	30	1764	22882
2006	0	0	0	0	0	0	1042	16471
2007	0	0	0	0	1	13	1198	16852
2008	0	0	0	0	1	12	260	3153

Table 4.6.4. Estimated landings of black grouper in the Gulf of Mexico headboat fishery 1986-2008.

Area	SW Florida		Alabama\NE Florida		Louisiana		Texas	
Year	Number	Weight(lbs)	Number	Weight(lbs)	Number	Weight(lbs)	Number	Weight(lbs)
1986	3359	4292	67	647	44	54	39	50
1987	1281	11598	67	647	5	93	47	769
1988	717	2995	24	248	0	0	25	425
1989	1270	12701	104	1012	3	30	20	200
1990	1429	13405	72	682		0	28	265
1991	1245	9925	52	812	4	64	7	112
1992	1679	11591	16	303	9	186	10	159
1993	886	11260	80	1018	6	76	6	76
1994	1290	12826	13	180	1	14	6	83
1995	3506	24262	5	34	4	27	4	27
1996	1855	24870	99	1093	0	0	9	102
1997	3196	40924	5	66	8	108	7	93
1998	5393	76151	42	573	1	13	9	124
1999	622	8066	103	1353	489	6538	5	67
2000	277	2788	25	270	161	1253	15	442
2001	1404	21004	52	778	80	1197	33	494
2002	470	5697	16	272	80	1358	19	371
2003	627	3891	16	155	0	0	17	313
2004	473	3167	16	362	0	0	24	544
2005	140	718	13	78	0	0	81	2025
2006	16	253	4	63	0	0	68	1075
2007	59	718	0	0	1	10	23	235
2008	36	357	4	39	5	49	33	321

Table 4.6.5. South Atlantic headboat estimated angler days 1981-2008.

Year	NC	SC	GA\NE FL	SE FL	Grand Total
1981	19372	59030	72069	226456	376927
1982	26939	67539	66961	226172	387611
1983	23830	65713	83499	194364	367406
1984	28865	67313	95234	193760	385172
1985	31346	66001	94446	186398	378191
1986	31187	67227	113101	203960	415475
1987	35261	78806	114144	218897	447108
1988	42421	76468	109156	192618	420663
1989	38678	62708	102920	213944	418250
1990	43240	57151	98234	224661	423286
1991	40936	67982	85111	194911	388940
1992	41177	61790	90810	173714	367491
1993	42785	64457	74494	162478	344214
1994	36693	63231	65745	177035	342704
1995	40294	61739	59104	142507	303644
1996	35142	54929	47236	152617	289924
1997	37189	60147	52756	120510	270602
1998	37399	61342	51790	103551	254082
1999	31596	55499	56770	107042	250907
2000	31323	40291	59771	122478	253863
2001	31779	49263	55795	107592	244429
2002	27601	42467	48911	102635	221614
2003	22998	36556	52795	92216	204565
2004	27255	50461	50544	123157	251417
2005	31573	34036	47778	123300	236687
2006	25730	56070	48943	126607	257350
2007	28997	60725	53759	103386	246867
2008	17156	47285	52338	71593	188372

Table 4.6.6. Gulf of Mexico headboat estimated angler days 1986-2008.

Year	SW FL	AL\NW FL	LA	TX	Grand Total
1986	138741	101336	5891	56568	302536
1987	140938	76111	6362	63363	286774
1988	128300	67648	7691	70396	274035
1989	151092	57233	2867	63389	274581
1990	153148	60758	6898	58144	278948
1991	111920	62392	6373	59969	240654
1992	118622	66180	9911	76218	270931
1993	134193	73702	11256	80905	300056
1994	135451	69110	12651	100777	317989
1995	114614	67797	10498	90465	283374
1996	90577	64336	10988	91854	257755
1997	83844	65598	9008	82208	240658
1998	118670	66665	7855	77653	270843
1999	115158	60959	8026	58235	242378
2000	102225	57106	4952	58395	222678
2001	101495	55748	6222	55361	218826
2002	86277	55554	6222	66951	215004
2003	81656	62555	6636	52732	203579
2004	94936	63494	0	64990	223420
2005	77436	52797	0	59857	190090
2006	57702	66374	5005	70788	199869
2007	68882	67993	2522	63760	203157
2008	68057	62116	2944	41185	174302

Table 4.6.7. Number of black grouper included in the headboat length compositions by region. ATL=Atlantic, SEF=Southeast Florida, KEY=Florida Keys, SWF=Southwest Florida, GUL=Florida Panhandle through Texas.

Year	ATL	SEF	KEY	SWF	GUL	Total
1981		4	66			70
1982		5	36			41
1983	1	1	32			34
1984	3	5	38			46
1985		6	47			53
1986		8	43	3		54
1987		4	24			28
1988	4	2	11		1	18
1989		3	17	7		27
1990	2		12	9		23
1991			10			10
1992	2	2	7			11
1993	1	5	12			18
1994	4	2	15			21
1995	1		13			14
1996	8		15	1		24
1997	3	2	20		1	26
1998	5	10	14		1	30
1999		4	7	1	1	13
2000		2	5		1	8
2001		5	4		1	10
2002		8	1			9
2003		3	5			8
2004		3	3			6
2005			5		2	7
2006		1	8		1	10
2007		7	3		1	11
2008		2				2

Table 4.6.8. Number of trips catching black grouper included in the headboat length composition by region. ATL=Atlantic, SEF=Southeast Florida, KEY=Florida Keys, SWF=Southwest Florida, GUL=Florida Panhandle through Texas.

Year	ATL	SEF	KEY	SWF	GUL	Total
1981		4	48			52
1982		5	31			36
1983	1	1	28			30
1984	3	5	34			42
1985		6	36			42
1986		7	27	3		37
1987		4	16			20
1988	4	2	9		1	16
1989		3	12	4		19
1990	2		10	2		14
1991			4			4
1992	2	2	7			11
1993	1	3	11			15
1994	3	2	14			19
1995	1		13			14
1996	6		13	1		20
1997	3	2	19		1	25
1998	3	9	13		1	26
1999		4	3	1	1	9
2000		2	3		1	6
2001		5	4		1	10
2002		6	1			7
2003		3	4			7
2004		3	3			6
2005			4		2	6
2006		1	8		1	10
2007		6	2		1	9
2008		2				2

Table 4.6.9. Raw black grouper ages from the headboat fishery.

Headboat	Age																	
Year	1	2	3	4	5	6	7	8	9	10	12	13	19	22	26	27	28	Total
1979						1												1
1980		1	2	5	3	1	2	1	1			1						17
1982				1														1
1984	1						1											2
1985			1															1
1986				1		1									1			3
1990				1	1							1				1	1	5
1991					3	2												5
1992						1	1											2
1993			1			2	1			1								5
1994		1		2	2			1										6
1995				1	1						2			1				5
1996						1							1					2
1997							1											1
2001							1			1								2
2003				1														1
2004				2														2
2005					1		1											2
2006			1															1
2007				2	1		1											4

4.7. *FIGURES*

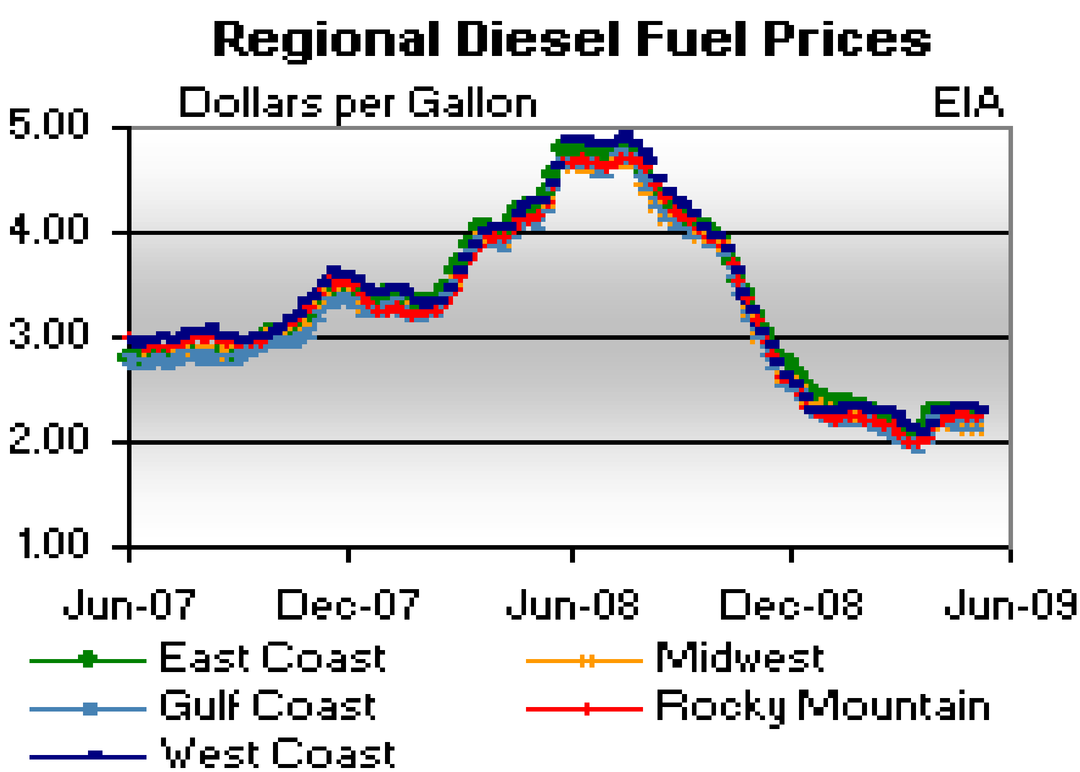


Figure 4.7.1. Regional diesel fuel prices Jun 07-Jun-09.

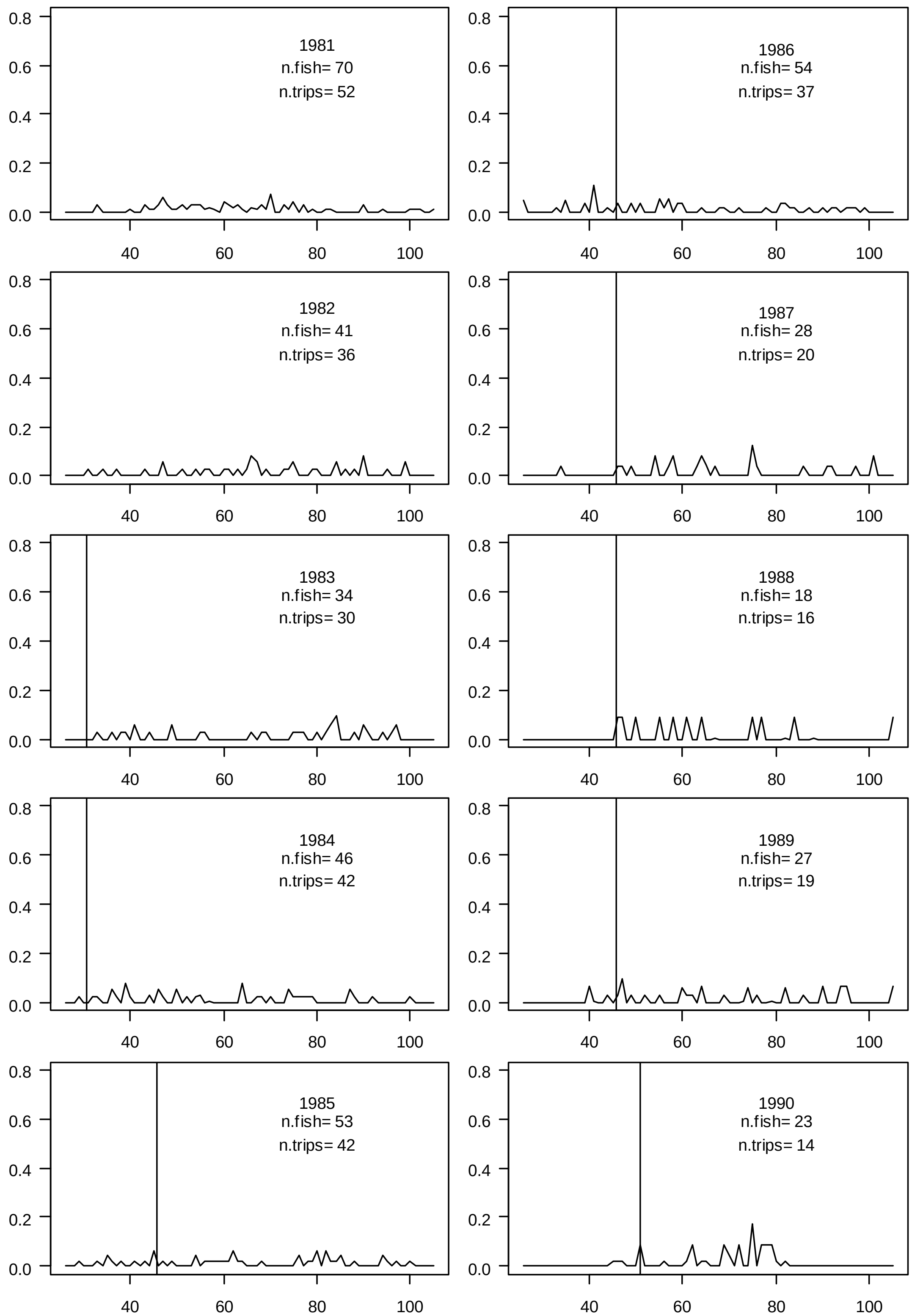


Figure 4.7.2. Black grouper length composition from the headboat fishery. Vertical lines represent minimum size limit regulations

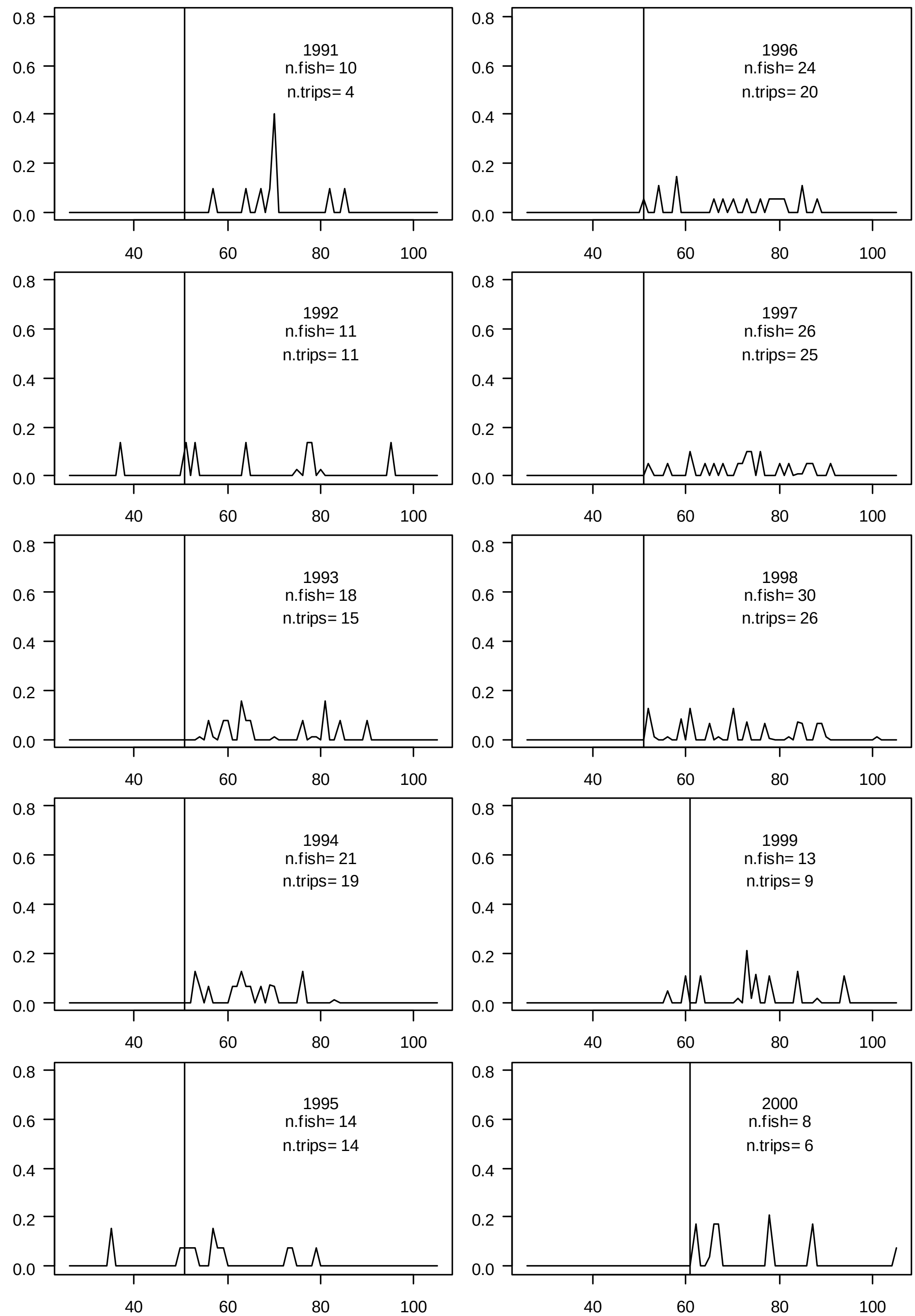


Figure 4.7.2. Continued.

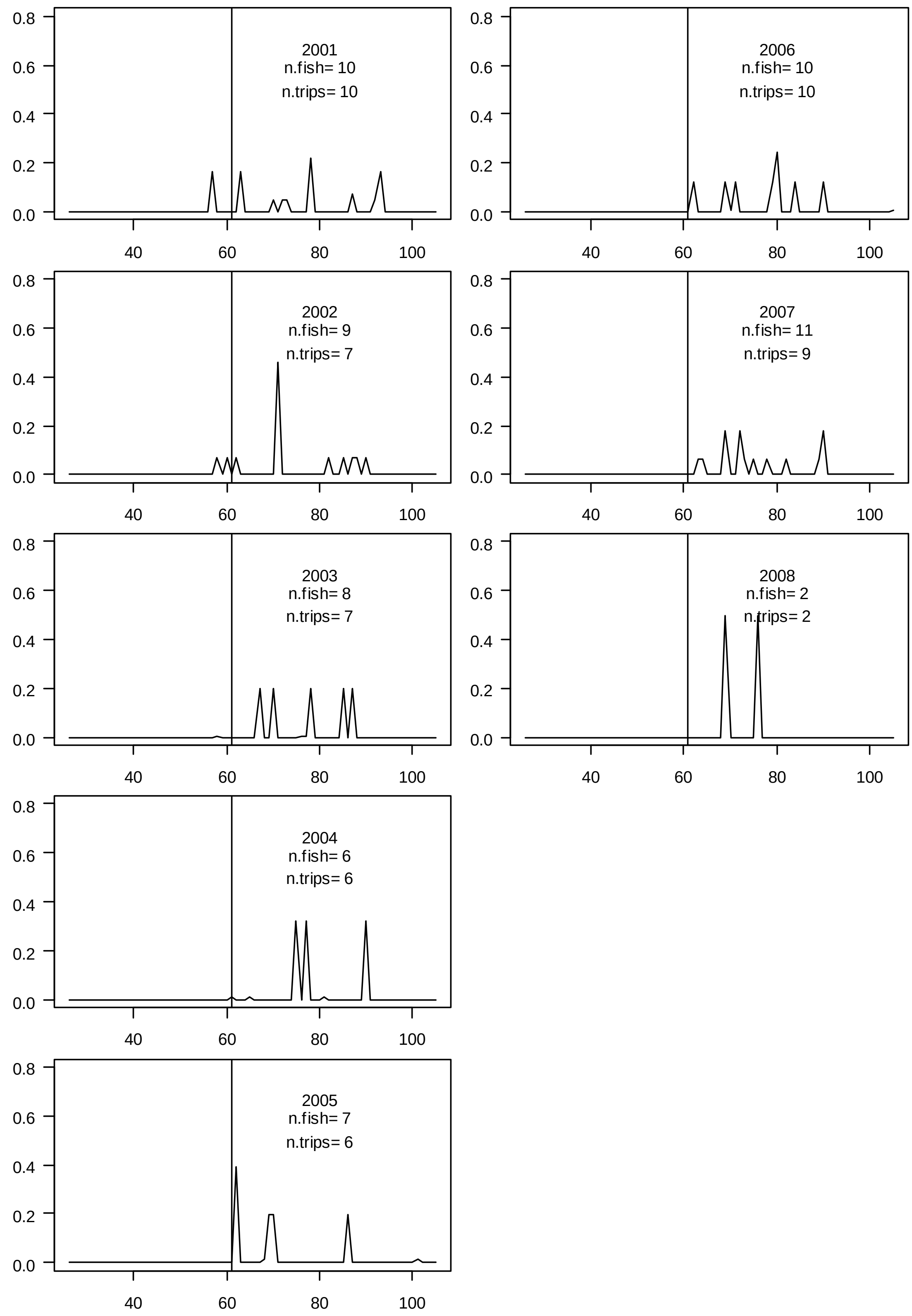


Figure 4.7.2. Continued.

Appendix I: Historical perspective of recreational grouper fisheries

Historical Records of Red and Black Grouper

Anecdotal and reported catches of grouper, including red and black grouper, have occurred since at least the mid 1800s. While much of the reports of actual landings in select areas, primarily regions or counties in Florida, reflect commercial catches, there are some sporadic reports of catch from sportfish, charter, or party boats. These reports provide evidence of directed effort targeting red and black grouper by sport anglers, particularly in Florida, dating back to at least the 1870s. However, it is unclear through historical records the extent and magnitude of angling activity for red and black grouper over the past 100 years.

Since there are very few and incomplete records of red and black grouper annual catches and effort prior to 1981, it is felt that historical records are inadequate to develop recreational historical landings for the purpose of this stock assessment. For the few records that do detail grouper landings for an area or a state (Florida), the grouper species are lumped together and not separated by species. Additionally, there seems to be some confusion with red grouper, red snapper, and gray ("mangrove") snapper in early accounts. Even more significant, several species of grouper appeared to be called black grouper depending on time period and locality. For instance, Hallock (1876) uses the nomenclature *Serranus nigritus* to describe black grouper which seems to refer to warsaw grouper (*Epinephelus nigritius*) but the description of the species is more similar to goliath grouper which he describes as a favorite target of anglers.

Historical reports of encounters with red and black grouper by sport fishermen occur as early as the 1870s ((Hallock 1876). At that time, red grouper were also called red snapper along the east coast of Florida and were coined *Serranus erythrogaster* by DeKay in 1842 (Hallock 1876, Perry et al 1892). *S. erythrogaster* is a synomym for *Epinephelus morio* (http://www.flmnh.ufl.edu/fish/gallery/Descript/RedGrouper/RedGrouper.html). Hallock (1876) reports of catching *S. erythrogaster* in Mosquito Inlet and Indian River Inlet on the east Coast of Florida. Also reported by Hallock (1876) are catches of "black" grouper (*S. nigritus*) which may indeed been goliath groupers. In early reports, black grouper was used to describe jewfish and it was suggested that what is now known as goliath grouper were actually two different species: one that lived inshore weighing up to 150 pounds and one that lived offshore getting to 600+ pounds (Goode 1887).

While red grouper seemed to be abundantly caught along Florida's east coast, it was unclear how far north the species occurred (Perry et al 1892, Smith 1907). Black grouper were predominantly known from the Florida Keys, particularly Key West, but sporadic accounts of this species appeared in Beaufort Harbor and Woods Hole (Smith 1907). Early accounts showed that red grouper were the most abundant grouper in the Keys (Schroeder 1895). In the Palm Beach area, "semi-professional boatmen" would take out "pleasure parties" often from out of state to go fish for grouper among others species (Brice 1897). Several other early accounts similarly describe catching grouper species including red and black grouper, in addition to jewfish, dating back to the late 1800s and early 1900s (Goode 1887, Gregg 1902, Turner 1902, Holder 1903).

By the late 1800's a commercial fishery for grouper and other species had developed with some reported landings by gear type in different localities (Brice 1897). Jarvis (1934) reported several years of grouper landings between 1902 and 1934, and described the habitats and habits of some grouper species in Florida.

The earliest available and known record of actual recreational landings and effort occurs in 1955 from charter boats along the east coast of Florida (Ellis 1957). For instance, in 1955 there were 514 charter boats mainly between Stuart and Key West that caught 67,871 grouper (448,847 pounds) during 270,800 fisherman-trips. Grouper in this study was not separated by species and included "predominantly *Epinephalus*, *Mycteroperca*, *Garrupa*, *Cephalopholis*." Effort from the various fishing modes throughout Florida during that same time period was also estimated by Ellis et al 1958. For example, there was an estimated 381,000 trips made on 762 charter boats, 459,000 trips made on 164 party boats, 836,000 fisherman days from shore, and 10,589,000 trips made on private recreational boats for a total of nearly 20 million fisherman-days fishing in salt and brackish water in 1955 in Florida. Much of this activity occurred in southeast Florida and by visitors to the state. Moe (1963) estimated that 32% of the charter boat effort in Florida during the early 1960s occurred on the bottom which provides evidence that this part of the fishery was not likely primarily targeting grouper. However, about 69% of the effort from the party boat fleet fished on the bottom possibly targeting groupers and snappers. However, there is also probable that the party boats were targeting the smaller reef fish species such as grunts. In contrast, the commercial fishery during this time targeted species on the bottom in 99% of their trips (Moe 1963).

Table 4.A.1. Review of Historic State-Level Surveys of Recreational Fishing Effort and Catch.

Year(s)	Mode and Area	Methods	Effort	Catch	Citation
2/1956-2/1957	Charter, Atlantic coast of Florida, including Keys.	Interviews of 104 charter captains, ~300 interviews of angling parties, 140 charter logbooks.	514 vessels; Estimated 270,820 angler trips	Unclassified grouper species, estimated total catch: 67,871 fish 448,847 pounds	Ellis, R.W. Catches of Fish by Charter Boats on Florida's East Coast. Report to Florida State Board of Conservation. Coral Gables, FL. Special Service Bull. 14.
1955-1957	Private recreational angling, Florida offshore fishing (Gulf and Atlantic)	Mail surveys of 1,100 households, return rate 70%. Monthly panel survey (telephone).	Private boat angling 52% of effort; bridge/pier/jetty angling 27%; charter and party angling 5%.	Grouper was not listed as a target species or any portion of recreational catch.	Rosen, A. and R. Ellis. 1961. Catch and Fishing Effort by Anglers in Florida's Coastal and Offshore Waters. Florida State Board of Conservation, Special Service Bull. 18.
1962	Private recreational boats, charter boats, party boats. Area includes offshore fishing in Florida.	Personal interviews with party/charter vessel operators; post-card survey of 10% (14,000) of private boat owners (33.6% return rate).	Bottom fishing effort (angler days): Party: 100,197 Charter: 24,347	For-Hire: Along Atlantic coast and Keys: Charter vessels primarily surface fishing for dolphin, king mackerel, sailfish, etc.; Party vessels list red grouper and "black grouper" among primary species taken. Private Boats: Gulf and Atlantic combined: Red grouper the fourth most sought fish by private recreational boat fishery. Black grouper a sport fish primarily in Keys, of minor importance.	1963, Moe, M. A Survey of Offshore Fishing in Florida. Florida State Board of Conservation. Professional Paper Series, No. 4.

The possibility of using the Salt-Water Angling Surveys of 1960, 1965, and 1970 (Clark 1962, Deuel and Clark 1968, Deuel 1973) were considered by the Recreational Workgroup for estimating red grouper landings prior
to the 1981 implementation of MRFSS. However, those surveys were not advised for extending time series of recreational landings for SEDAR-19 assessments. For grouper species in the South Atlantic region, a major
caveat regarded the surveys' wording when asking for the "kinds of saltwater fish" caught by the angler. The grouper category included "sea bass, hinds, etc.", and while there was a separate category for black sea bass, given the way the grouper category was annotated, many of the fish recorded in the grouper category were likely to have been sea bass. Thus, black sea bass, a common species in this region, were reported under one of two categories (groupers or black sea bass) in unknown proportions. The high average weight applied to the grouper category in 1960 could also be a gross overestimation if sea bass were included in the grouper category. Changes in survey procedures among the three years for estimating total weight of fish by species are described in Table Y below.

Table Y. Changes in Salt-Water Angling survey procedures for estimating total weight by species.

Year	# Groupers	Lbs. Groupers	Notes on Weight Estimates
1960	2,286,000	34,290,000	Interviewed selected charter captains and marine scientists to get an estimated average weight of 15 pounds per grouper in S. Atlantic.
1965	6,905,000	54,581,000	Asked respondents to record average weight of fish caught.
1970	4,198,000	24,121,000	Manually corrected for respondents that reported estimated total weight rather than average weight for species caught.

Annotated Bibliography: historical recreational catch and effort of red and black grouper.

Compiled: Chad Hanson

Hallock 1876

Charles Hallock. 1876. Camp Life in Florida. A handbook for sportsmen and settlers.

Pg 56-57: [downloaded at www.archive.org]

Serranus erythogaster (red snapper or grouper), called by both in different localities.

- East Florida goes by snapper
- At mosquito inlet, small (one to three pounds),
- Indian River inlet, taken at 10-12 pounds, in gulf twice the size

Black grouper (*S. nigritus*) - ??

- Olive brown, dark mottled lines, resembling tortoise shell
- Taken at mosquito inlet from 2 to 10 pounds
- Favorite target of anglers
- Found under mangroves or in holes in banks
- book also mentions Jewfish later on

Goode 1887, new edition 1908

Game and Food Fishes of North American with especial reference to habits and methods of capture. G. Brown Goode.

[Downloaded from google books, electronic copy, paper copy of pages below]

Red grouper: *E. morio* (pp 47-53)

- Up to 40-50 lbs,
- no record north of Florida
- most abundant southern florida,
- west florida, red snapper more abundant, grouper not in demand by small market value
- DeKay writes in 1842: not unusual for "groper" or "red groper" to show up in NY markets ,coming from reefs of Florida, informed by West Indie fishermen that occasionally but rarely taken from off NY
- Holbrooke: brought into Charleston from Florida Jan-Mar
  - Abundant along whole east coast of florida, florida keys, and gulf of mexico
- Stearns: extremely abundant in GOM, with red snapper, more of a bottom fish than snapper
- S.C. Clarke refers to a fish called "mangrove snapper" or "red grouper"

Black Grouper: *E. nigritus*, called Jew-Fish in Florida and Texas, called Warsaw in Pensacola

- Abundant on east florida and GOM
- Large jew-fish *Promicrops guasa* – adult of black grouper?
- Confusion of which spp black grouper (Pensacola: *M. brunnea, M. microlepis, M*. stomis)

Perry et al 1892

American Game Fishes Their Habits, Habitat, And Peculiarities ; How, When, And Where To Angle For Them. W. A. Perry (" Sillalicum "), A. A. Mosher, W, H. H. Murray,W. D. ToMLiN, A. N. Cheney, Prof. G. Brown Goode, W. N. Haldeman, Francis Endicott, Fred. Mather, S. C. Clarke, Rev. Luther Pardee, Charles Hallock, F. H. Thurston (" Kelpie "), J. Harrington Keene,Prof. David Starr Jordan, William C. Harris, B. C. Milam, G. O. Shields ("Coquina"), J. G. A. Creighton, Dr. J. A. Henshall.

[Downloaded at archive.org, electronic copy]

Red Grouper – E. morio (pg 310) also called *Serranus erythogaster*

- Found on east Florida coast and in abundant and large in West Indies
- Not sure how far north its found
- Found near bottom, in deep holes, near mangrove roots (referring to gray snapper?)
- Image on pg 311 red grouper

Schroeder 1895

William C. Schroeder. 1895. Fisheries of Key West and Clam Industry in Southern Florida

Commercial market in Key West. APPENDIX XII TO THE REPORT OF THE U. S. COMMISSIONER OF FISHERIES FOR 1923. Bureau of Fisheries Document No. 962

[Downloaded at archive.org, electronic copy] pp.3-4, 14-16

- Red grouper – most abundant and best known of Keys groupers, widely distributed, most common during winter but taken throughout year, on rocky, coral, grassy bottoms
  - In shallow water taken 0.5 to 2 lbs, deeper water 2-15 lbs, over 20 lbs not common
  - Ships well alive, transported to Cuba
  - Uncommon north of Florida, rare straggler in North Carolina
- Black grouper (M. bonaci) not sold a lot but highly valued due to size
  - 5-50 lbs, caught deeper than 25 ft , most common Feb-Apr, uncommon over 50lb, average weight 10 lbs, max 100 lbs
- Also mentions, M. microlepis (gag), M. venenosa (yellow-finned grouper, yellow grouper), Promicrops itaiara (jewfish, spotted jewfish), M. falcata phenax (scamp)

Brice 1897

Fish and Fisheries of Coastal Waters of Florida. LETTER FROM THE COMMISSIONER OF FISH AND FISHERIES, TRANSMITTING, IN RESPONSE TO SENATE RESOLUTION OF FEBRUARY 15, 1895, A REPORT ON THE FISH AND FISHERIES OF THE COASTAL WATERS OF FLORIDA. United States Commission ov Fish and Fisheries, Washington, JD. C, January 28, 1897. 54th Congress, 2nd session, document 100.

[downloaded at archive.org, electronic copy] pp.21, 33-36,

- Palm beach, semi-professional boatmen engaged in taking pleasure parties for "grouper"
- "The catch is largely sheepshead, although bluefish, snappers, muttonfish, kingfish, groupers, Spanish mackerel, and other species are also taken in considerable quantities.
- In 1891 this fishery yielded 15,500 pounds, valued at $1,208, and in 1895, 90,852 pounds, worth 62,422."
- "The principal fishes obtained in ocean fishing off Lake Worth are sheepshead, Spanish mackerel, kingfish, red fish, groupers, bluefish, red snapper, and mutton-fish, all of which are comparatively abundant."
  - Biscayne Bay landings (pg 36) 1895:"grouper" = 14,100 pounds
  - Lake worth: table on pp 33-34 of numbers fishermen, landings by gear for 1894 and 1895 ("grouper)"

Gregg 1902

Where, When, and How to Catch Fish on the East Coast of Florida. William H. Gregg.

[downloaded at archive.org, electronic copy]

- Fished in "every State and Territory in the Union but three, and from Siberia and Behring Sea to the Gulfs of California and Mexico, and, all things considered, regard Florida as unequaled in the richness and variety of its attractions for all sorts of sport with rod and reel"
- Snapper Bank furnishes red snapper or red grouper
- Description of species including red grouper, black grouper, jewfish
- Locations and how caught

Turner 1902

Giant Fish of Florida. J. Turner-Turner. 1902.

- Select chapters describing catching tarpon, jewfish, kingfish, etc
- Lots of illustrations

Holder 1903

Charles F. Holder. 1903. Big Game Fishes of the United States

[downloaded at archive.org, electronic copy]

Red grouper: *E. morio* (start pg 211)

- ranging up to 70 lbs (3.5 ft long), largest fish of its kind seen by author,
- caught in 20-100 ft, prefers bases of great coral reefs
- found in abundance in grounds north of Sand, Middle, and East Keys and Tortugas
- chief attraction of sport anglers, caught amongst a wide variety of species
- common of red snapper
- comes inshore in June to spawn, but not migratory

black grouper: *Garrupa nigrita* ---

- the description actually sounds like a jewfish,
- large individuals called jewfish, smaller up to 150 lbs called black grouper
- ranges from Pensacola to mouth of St. Johns River
- attains weight at last 600 pounds

smaller black grouper: *M. bonaci*

- 20-45 pounds

The Florida jewfish – starts at p 298

Smith 1907

<u>The Fishes of North Carolina.</u> Hugh M. Smith. 1907

[downloaded at google books, electronic copy]

Red Grouper: *E. morio* Pp 276

- Biological description
- Abundant Brazil to Florida, regularly extends range up south atlantic coast, occasional straggler up to MA,
- Important food fish in Key West, GOM, and southward,
- attaining 3 ft in length
- NC: does not occur in sufficient abundance or large enough size to have economic value

Black grouper: *M. bonaci* (p.278-9)

- Atlantic coast north of Florida: shows up as straggler from West Indies,
- author reported from Woods Hole, specimens seined in Beaufort Harbor in 1902 and 1904
- attains 50lbs, used for food
- Abundant at key west

Holder 1908

Charles F. Holder. Sportfishing in California and Florida. From BULLETIN OF THE BUREAU OF FISHERIES, Volume XXVIII, 1908 Proceedings of the Fourth International Fishery Congress. Washington, 1908

[downloaded at archive.org, electronic copy]

- Grouper notable food fish: red grouper most valuable, deepwater fish caught on hand line

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Jarvis 1934

No mention of recreational, only commercial, GOM

- Description of landings of "grouper" 1902-1932
- Description of species, habitats, markets
- Report of large number of dead fish off Campeche Bay

Ellis 1957 (Catches of fish by charter boats on Florida's east coast. Robert W. Ellis. 1957. The Marine Laboratory, University of Miami, Marine Fisheries Research, Special Service Bulletin No. 14. Report to the Florida State Board of Conservation).

[Bev Sauls paper copy]

- Estimated charter boat catches off East Florida using charter boat catch records (logbooks) and interviews of anglers fishing on charter boats
- 514 charter boats in industry centered between Stuart and Key West, with some in Daytona Beach area
  - Dade Co = 182
  - Broward = 100
  - Palm Beach = 68
  - Martin = 26
  - Volusia = 17
  - St. Johns = 2
- Records of 443 trips during February 1, 1956 and January 31, 1957
- 104 interviews of charter captains (20% of industry)
- "About 300" interviews made of anglers on charter boats
- 90% anglers were tourists, peak activity in winter
- 140 daily trips with catch data from charter boat captain interviews or log books
- Effort estimated for 1955

Results

- 18 trips out of 443 (4%) recorded no catch
- Average catch per angler per trip = 2.6 fish weighing 21.2 pounds
- Dolphin, bonito, kingfish, and "grouper" most frequently caught
- Survey

o Grouper – caught on 40 trips (9.0%), 393 fish (28.5%), 2599 pounds (7.8%), average 6.6 pounds
- Total estimates for time period
o Grouper = 67,871 fish, 448,847 pounds
o Total effort for all charter trips = 270,820 man trips on Florida's east coast
- Grouper: predominantly Epinephalus, Mycteroperca, Garrupa, Cephalopholis

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Ellis, Rosen and Moffett, 1958

(Robert W. Ellis, Albert Rosen, and Alan W. Moffett. 1958. A Survey of the Number of Anglers and of Their Fishing Effort and Expenditures in the Coastal Recreational Fishery in Florida. The Marine Laboratory, University of Miami, Virginia Key, Miami 49, Florida. State of Florida Board of Conservation Technical Series No. 24.)

[paper copy in Bev Sauls file; digital copy downloaded at FWRI library]

In 1955:

- estimated 34% Florida residents fished in salt/brackish water, ~7% owned at least one boat
- 762 charter boats made 95,000 trips in FL waters; 381,000 fisherman-days
o ~89% took place in southeast Florida
- 164 party boats made boat 33,000 trips; 459,000 fisherman-days
o ~66% represents visitors
o Greater than half in southeast Florida
- 558 fishing camps around state catering salt/brackish anglers
- 1.5 million fisherman-days from anglers rented skiffs (with rented or angler supplied outboard motors)
- 569,000 fisherman-days spent on 23 paid piers around state
- 5.6 million fisherman-days from 226 bridges, free piers, and jetties
o 39% by visitors
o 40% occurred in southeast Florida
- 267,000 fisherman days from daylight shorefishing; no data on night fishing
o 37% by visitors
- 10,589,000 fisherman-days from private boat anglers; 14% from visitors
- Total fisherman-days = 20 million all types of salt/brackish fishing
➔ No mention of catch type

Moe 1963

A Survey of Offshore Fishing in Florida. Martin A. Moe, Jr. January 1963. Professional Papers Series Number Four. Florida State Board of Conservation, Marine Laboratory, St. Petersburg, Florida. 177pp.

[paper copy in Beverly Sauls, available at FWRI online library,] Fishing pressure (pp 66):

- Charter boat: 31.6% of its effort on bottom
- Party boat: 31.3% of effort on surface
- Commercial: 99.3% on bottom
- Descriptions of fishing effort (qualitative) by county and vessel type, and most commonly caught species

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Milon & Thunberg, 1993

J. Walter Milon and Eric M. Thunberg. 1993. <u>A regional analysis of current and future florida resident participation in marine recreational fishing</u>. Sea Grant Report Number 112.

- based on the mrfss during July 1991 to June 1992 (76,549 interviews)
- "grouper" trips = 3,114 total (of 51,016, 6.1%) (table 4.1)
  - party = 113 (3.6%)
  - charter = 99 (3.2%)
  - private/rental = 2719 (87.3%)
  - shore = 183 (5.9%)
- grouper not defined

Holbrook's "Ichthyology of South Carolina,"

5. MEASURES OF POPULATION ABUNDANCE

5.1. *OVERVIEW*

Several indices of abundance were considered for use in the assessment model. These indices are listed in Table 5.1, with pros and cons of each in Table 5.2. The possible indices came from fishery independent and dependent data sources. The DW recommended the use of two fishery independent indices (one from the FWC Visual Survey, and one from the U. Miami/NMFS RVC survey) and four fishery dependent indices (two from commercial logbook data, one from headboat data, and one from general recreational data) (Table 5.1 and 5.2).

5.1.1. Group Membership

Membership of this DW working group included Jerry Ault, Rob Cheshire, Chip Collier, Paul Conn (leader), Claudia Friess, Chris Hayes, Walter Ingram, Kevin McCarthy, Bob Muller, Kyle Shertzer, and Jessica Stephen.

5.2. *REVIEW OF WORKING PAPERS*

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

SEDAR19-DW-01	(Marine recreational fisheries statistics survey [MRFSS])
SEDAR19-DW-02	(FWC visual survey)
SEDAR19-DW-04	(Headboat survey)
SEDAR19-DW-10	(U. Miami/NMFS Reef fish visual census)
SEDAR19-DW-11	(U. Miami/NMFS Reef fish visual census)
SEDAR19-DW-13	(Commercial logbook indices)
SEDAR19-DW-20	(Florida commercial trip tickets)
SEDAR19-RD-26	(Reef monitoring protocols for the RVC survey)

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*

Black grouper have been sampled by several potential diver surveys, which primarily occurred off of the Florida Keys and within Dry Tortugas National Park. These included a Florida Wildlife Commission (FWC) visual census survey, and a joint University of Miami-NMFS Reef Fish Visual Census (RVC). We also considered a number of other fishery independent data sources, such as a volunteer reef fish survey (Reef.com), diver surveys on a smaller spatial scale, and several trap-based surveys.

5.3.1 Florida Wildlife Commission (FWC) visual census survey

5.3.1.1 General description

The description of the Florida Fish and Wildlife Conservation Commission (FWC) visual census and the calculations of the catch rate index are in Muller and Acosta (2009, SEDAR19-DW-02). Briefly, the Florida Keys National Marine Sanctuary (FKNMS) was divided into 6 zones (Figure 5.1) from Key Largo to the Dry Tortugas and the four zones from Key Largo to Key West were sampled monthly from April through October with stationary point counts. A habitat-based, random-stratified site selection procedure, based upon the "Benthic Habitats of the Florida Keys" GIS system, was used to select 39 sample sites each month. Stationary divers recorded the number of individuals for each of the target species that were observed within an imaginary five-meter radius cylinder and assigns fish to length intervals. On each dive, two divers conducted two point-counts that are at least 15 m apart.

5.3.1.2 Issues discussed at the DW

Issue #1: Trip subsetting

In SEDAR19-DW-02, several methods for trip subsetting were considered, including the method of Stephens & MacCall (2004), as well as a cluster analysis approach.

Option 1: Use method of Stephens & MacCall for subsetting

Option 2: Use cluster analysis for subsetting

Option 3: Perform standardization on full dataset (i.e., no subsetting)

Decision: Option 3, because this analysis would be consistent with the sampling design (there being little reason to expect shifts in "targeting" over time given that it is a standardized survey). Also, the first two approaches eliminate a substantial number of trips.

Issue #2: Redundancy with RVC survey

The FWC visual survey (FWC-VS) is similar to the NMFS-UM Reef Visual Census (RVC) in that both methods use point-counts in an imaginary cylinder that extends from the surface to the bottom but the sampling designs differ. Starting in 2008, the VS adopted the same protocols as the RVC which enhances the RVC. Given that the VS has a shorter time series (1999-2007 vs. 1994-2008), DW participants discussed whether or not to use both surveys.

Option 1: Use the RVC survey

Option 2: Use both surveys

Decision: Option 2. While discussing the distribution of the two species, the work group noted that black grouper are primarily found in southern Florida and that the Florida Keys can be considered the center core of their distribution. The work group thought that having both a design-based (RVC) and model-based (VS) index would complement each other in this important region.

5.3.1.3 Analysis methods

Standardization methods followed those articulated in SEDAR19-DW-02, but were repeated using all of the observations (as discussed in section 5.3.1.2). A generalized linear model (GLM) using a binomial distribution with a logit link was used to estimate the annual proportion of dive/habitats that observed black or red grouper. The number of fish per dive/habitat on positive dives was estimated with a second GLM that used a gamma distribution with a log-link. The potential explanatory variables for the GLM were year, month (May-October), zone (A-D), bottom habitat relief, bottom habitat type, percent of biological cover, depth category, secchi distance, and the number of counts for that dive/habitat. Depth was categorized by 4-meter intervals (13.1 ft) with all depths greater than 24 m (78.7 ft) combined. Secchi distance was categorized by two-meter intervals from six or less meters to 26 or more meters (19.7 - 85.3 ft).

Variables to include in the model were chosen in a stepwise manner using the smallest Akaike Information Criterion (AIC) at each level of the number of predictor variables, provided that the variable was significant at the $\alpha = 0.05$ level in the regression based on two times the change in log-likelihood (Tables 5.3, 5.4). The annual index was the product of the proportion positive times the number of fish per dive/habitat from the least-squares means. The variability was estimated with a Monte Carlo technique that used the least-squares means and their standard errors that was repeated the same number of times as there were positive dive/habitats per year.

Seven dive/habitats lacked complete information for standardization, so 2,524 dive/habitats were used in the standardization of the catch rates. The fits of the GLMs for the proportion of positive dive/habitats and for the number of black grouper observed per dive/habitat were reasonable (Figure 5.2). The GLM for the proportion of positive dive/habitats reduced the mean deviance by 7.5% with number of point-count accounting for 2.4%, bottom habitat relief (2.4%), zone (1.7%), bottom habitat type (0.6%), and year (0.3) and the GLM for the number of black grouper per dive/habitat reduced the mean deviance by 10.9% with secchi distance (4.1%, visibility), year (4.1%), depth category (1.9%), and bottom habitat type (0.9%) (Tables 5.3 and 5.4).

5.3.1.4 Sampling Intensity

A map of survey coverage is provided in Figure 5.1. Sample sizes for the survey are given in Table 5.5.

5.3.1.5 Size/Age Data

Because the visual survey only sampled waters that were 30 m (97 ft) deep or less, they under sampled the deeper reef habitats of the Florida Keys and, as a consequence, they probably missed the larger groupers (Table 5.6). Therefore to determine the appropriate ages for this index, the 95% observed length range from the survey was used to calculate corresponding ages. The 95% length range was from 150 mm TL to 800 mm TL and, after rearranging the von Bertalanffy growth equation from Crabtree and Bullock (1998), these lengths correspond to ages 0 through 4.

5.3.1.6 Catch Rates and Measures of Precision

The standardized catch rates, nominal catch rates, and coefficient of variation are provided in Figure 5.3 and Table 5.5. The standardized values were similar (correlation $r = 0.88$, $df = 6$, $P < 0.05$) but smoother than the nominal rates. Standardized CPUE revealed a slightly decreasing trend in the first part of the time series with a slight increase from 2006 to 2007. The catch rates calculated with all of the VS data had more contrast than did the catch rates calculated with the Stephens and MacCall regression (Figure 5.4).

5.3.1.7 Comments on Adequacy for Assessment

The DW suggested using this survey in the assessment of black grouper. The survey has a reasonable sampling design, is fishery independent, and is conducted in the heart of black grouper's range. One panelist questioned whether diver surveys are appropriate for black grouper given they can be skittish in the presence of divers. However, as long as the degree of "skittishness" remains constant over time, the survey should still yield meaningful CPUE indices.

5.3.2 University of Miami / NMFS RVC Diver Survey

5.3.2.1 General Description

The reef-fish visual census (RVC) has been conducted in the Florida reef tract since 1979 to the present in a collaboration between NOAA Fisheries SEFSC and the University of Miami. The RVC utilizes standard, non-destructive, in situ visual monitoring methods by highly trained and experienced divers using open circuit SCUBA. The general statistical approach and sampling survey design methodologies incorporating habitat covariates are fully described in Ault et al. (2002, 2005, 2006). Field methods and sampling protocols are detailed in Brandt et al. (2009). In the 2008 survey year, the Florida Fish & Wildlife Conservation Commission and the National Park Service joined on as survey collaborators. The RVC survey is conducted in two principal regions of the south Florida coral reef ecosystem domain: (1) the Florida Keys (Key Biscayne to west of Key West) with a domain size of 559 km^2; and, (2) the Dry Tortugas region with a domain size of 339 km^2 (Figure 5.5).

Notable milestones for the Florida Keys surveys: (1) 1979-1993: sampling conducted along the Keys reef tract in various reef habitats, but limited in any particular year with respect to geographical coverage and habitats; (2) 1994-2000: sampling coverage expanded to include all geographic regions of the Keys (Biscayne National Park, upper Keys, middle Keys, lower Keys), the full range of reef habitats less than 18 m in depth, and all no-take marine reserves (implemented prior to 1998 survey); (3) 2001-2008: sampling coverage expanded to include forereef habitats ranging from 18-33 m in depth. The survey domain and habitat strata for the Florida Keys surveys are described in Table 5.7. Sample sizes by strata and year are given in Table 5.8. Notable milestones for the Dry Tortugas surveys: (1) 1999-2000, 2004, 2006, 2008: sampling conducted in all reef habitats less than 33 m in depth in two principal areas, Tortugas Bank and Dry Tortugas National Park, including no-take marine reserves. Habitat strata for the Dry Tortugas surveys are described in Table 5.9, and corresponding sample sizes are given in Table 5.10.

5.3.2.2 Issues Discussed at the Data Workshop

Issue 1: Include/exclude design points in the Dry Tortugas

The Dry Tortugas were not included in the sampling frame every year, and also occurred in a marine reserve.

Decision: Exclude, because the portion of the population occupying the reserve may not represent population level abundance. For instance, it may be "buffered" from the effects of fishing and may not accurately reflect population level increases or declines.

Issue 2: Design or model based analysis

The survey was designed to estimate abundance across the entire sampling frame (via two-stage stratified random sampling). However, there were gaps in spatial coverage in early years; model based standardization is thus somewhat attractive.

Option 1: Design-based inference from 1994-present.

Option 2: Model-based inference

Option 3: Design-based inference from 1994-present with model-based inference prior to 1994.

Decision: Option 1 because the survey was designed in a robust fashion and permitted appropriate extrapolation. As such, no assumptions need to be made about functional forms of delta-GLMs, etc. Model based estimates were examined prior to 1994, but were determined to be too imprecise to be useful; further, changes in sampling location made these estimates difficult to interpret.

5.3.2.3 Methods

The census is conducted annually using a two-stage stratified random survey design. Technical descriptions and computational details of this statistical survey design are provided in Ault et al. (2002).

5.3.2.4 Sampling Intensity

A map of survey coverage is provided in Figure 5.5. Sample sizes for the Florida Keys are given in Table 5.8. For annual maps of survey coverage, see SEDAR19-DW-11.

5.3.2.4 Size/Age Data

Since counts of animals were size specific, the design-based estimation approach yielded annual estimates of numbers of individuals in various length bins (Table 5.11). If desired, these numbers could easily be converted to frequencies and sample sizes for use in multinomial models in the assessment. See Figure 5.6 for a visual depiction of these data and for information on annual sample sizes.

5.3.2.5 Catch Rates and Measures of Precision

Catch rates were not computed for this index because survey-wide abundance estimates were available. Instead, key population estimates provided from the RVC for black grouper for the Florida Keys and Dry Tortugas regions are: (1) abundance-at-length by year; (2) total abundance and standard error by year; (see Ault et al. 1998, 2005 & 2008 for computational details). These data are shown in Table 5.11 (population level abundance by year is provided at the bottom of this table). Abundance estimates are provided for the years in which the complete domain was surveyed (1994-2008). For the Florida Keys, the deep forereef stratum (18-33 m) was not surveyed prior to 2001. Analysis of surveys from 2001-2008 showed a consistent relationship in density estimates between deep forereef and mid-depth forereef (6-18 m) strata (both strata are principally low-relief habitats) outside of no-take marine reserves. This relationship was used to estimate abundance in the deeper forereef stratum for the years 1994-2000. Thus, abundance estimates comprise the same survey domain in each year. To compare these data with other indices, total abundance was summed over length classes and standardized to its mean (e.g., Table 5.18).

5.3.2.6 Comments on Adequacy for Assessment

The DW suggested that the RVC survey be used in the assessment of black grouper. The RVC is a well designed, fishery independent survey that covers the heart of the range of black grouper. However, the DW suggested limiting the analysis to the Florida Keys, and to 1994-2008. Several possibilities exist for using it as an index. Perhaps the simplest would be to use the total abundance estimated over all lengths for a given year as an index value (length frequencies could then be used for estimating selectivity for the index). One DW panelist questioned whether diver surveys are appropriate for black grouper given they can be skittish in the presence of divers. However, as long as the degree of “skittishness” remains constant over time, the survey should still yield meaningful CPUE indices. Another DW participant questioned whether the spatial coverage was broad enough.

5.3.3 Other data sources considered

Other sources of fishery independent data were considered for a possible index of abundance, including MARMAP surveys, SEAMAP surveys, diver reports (reef.org), and several diving surveys in the Florida Keys and Dry Tortugas (Table 5.1). The DW determined that these surveys sampled either insufficient numbers of black grouper to be useful as an index of abundance, or the spatial coverage overlapped with similar surveys and/or covered too small of a spatial area to be representative of stock level abundance. An additional factor for diver surveys in and around the Dry Tortugas was that these were conducted in or near a marine protected area.

5.4. *FISHERY DEPENDENT INDICES*

5.4.1 Recreational Headboat

5.4.1.1 General Description

The headboat fishery is sampled separately from other recreational fisheries, and includes an area ranging from North Carolina to Texas (Figure 5.7). The headboat fishery comprises large, for-hire vessels that charge a fee per angler and typically accommodate 6–60 passengers. With simple hook & line gear, passengers on these vessels frequently target hard bottom reefs, sampling many members of the snapper-grouper complex. Headboat records were examined in detail, and catch-per-unit-effort (CPUE) standardization was employed to generate a fishery dependent index from 1986-2008. Analysis was limited to south Florida where black grouper are the most abundant and where misidentification/misreporting of gag and black grouper was hopefully minimized.

5.4.1.2 Issues Discussed at the DW

Miscellaneous decisions

- The DW acknowledged that changes in size limits could be accounted for by the assessment model through estimation of selectivity.
- The DW considered changes in bag limits of groupers in the Gulf and south Atlantic, but found there to be little evidence that these resulted in few trips where anglers met their collective bag limit. Therefore, the DW believed there to be little reason for changes in bag limits to have affected CPUE.

5.4.1.3 Methods

The CPUE was computed in units of number of fish per hook-hour. The duration of the time series was 1986–2008. Spatial coverage included the headboat strata 11, 12, 17, 18, and 21 (Figure 5.7). Methods for analyzing headboat CPUE are presented in detail in SEDAR19-DW-04 and are not reproduced in their entirety here.

Effective effort was based on those trips from areas where black grouper were available to be caught. Without fine-scale geographic information on fishing location, trips to be included in the analysis must be inferred. To do so, the method of Stephens and MacCall (2004) was applied. The method uses multiple logistic regression to estimate a probability for each trip that the focal species was caught, given other species caught on that trip. Model selection (i.e., choice of predictor species) was based on AIC using a backward stepwise algorithm (Venables and Ripley, 2002). The selected model was used to compute for each trip a probability that black grouper was caught, and a trip was then included if its associated probability was higher than a threshold probability. The threshold was defined to be that which results in the same number of predicted and observed positive trips, as in Stephens and MacCall (2004). Application of Stephens and MacCall (2004) resulted in 11,057 trips (4.6% of trips), of which ~20% were positive.

Standardized catch rates were estimated using a delta-GLM error structure (Lo et al., 1992; Stefánsson, 1996; Maunder and Punt, 2004), in which the binomial distribution describes positive versus zero CPUE, and either a lognormal or gamma distribution describes the positive CPUE. Both models resulted in poor fits, and successive trials with different transformation of the dependent variable suggested that GLM assumptions were best met when using $CPUE^{-1.0}$ as the response variable within a Gamma model for positive CPUE. Explanatory variables considered, in addition to year (necessarily included), were month, vessel, trip type (half-day or full-day trips), and a factor variable for number of anglers (defined by sample quartiles). Both model components (binomial and gamma) included main effects only.

Measures of precision were computed by a jackknife routine and summarized by the resulting CV. The jackknife routine iteratively refitted the delta-GLM model N times (N is the total sample size), where each iteration removed a unique record.

5.4.1.4 Sampling Intensity

The numbers of positive trips by year and area are presented in Figure 5.8. The method of Stephens and MacCall (2004) does not necessarily select all positive trips.

5.4.1.5 Size/Age Data

Sizes and ages of fish represented by this index are the same as those sampled by the headboat survey (see chapter 4 of this DW report).

5.4.1.6 Catch Rates and Measures of Precision

Figure 5.8 shows the nominal CPUE and the percent positive trips. Table 5.12 shows nominal CPUE (fish/angler-hr), standardized CPUE, and coefficients of variation (CV). Figure 5.9 shows standardized and nominal CPUE and their standard errors.

5.4.1.7 Comments on Adequacy for Assessment

The headboat index was recommended by the DW for use in the assessment. It had the advantages of wide geographic coverage and reasonable sample sizes, which could mitigate any effect of schooling on CPUE. However, the DW did discuss several concerns (Table 5.2). One concern was that this index may contain problems associated with fishery dependent indices. The DW, however, did note that the headboat fishery is not a directed fishery for black grouper. Rather, it more generally fishes a complex of snapper-grouper species, and does so with only limited search time. Thus, the headboat index may be a more reliable index of abundance than one developed from a fishery that targets black grouper specifically.

5.4.2 Recreational Intercepts (MRFSS)

5.4.2.1 General Description

The Marine Recreational Fisheries Statistics Survey (MRFSS) samples the general recreational fishery. This national survey intercepts anglers fishing from shore, man-made structures, private/rental boats, and charter boats. Headboats are another component of recreational fishing but they are sampled by a separate headboat survey (see section 5.4.1). Being that black groupers are reef fish and unlikely to be caught from shore or man-made structures, only private/rental boats and charter boats were included in calculating the catch rates. As black groupers primarily occur on southern Florida reefs, only MRFSS intercepts from Tampa Bay to Cape Canaveral (Pinellas - Volusia counties; Figure 5.10) were included in calculating catch rates. Although MRFSS intercepts began in 1979, MRFSS changed their sampling protocol in 1991 to link additional interviews from the same trip together, also 1991 was the first full year after the extensive training of samplers had been implemented which reduced the mis-identification of gag, *Mycteroperca microlepis*, as black grouper; therefore, the index of abundance only uses data from 1991 through 2008.

5.4.2.2 Issues Discussed at DW

Issue 1: Trip selection

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

Option 2: Select angler trips using cluster analysis.

Decision: Option 2 preferred. The Stephens and MacCall logistic regression selected very few intercepts that caught black grouper (405 intercepts selected with S&M vs. 1575 intercepts for cluster analysis). The DW noted that this index includes all catches (landings plus discards), and should be applied as such in the assessment model, meaning that the selectivity curve must encompass all of the catch not just landings.

Issue 2: First year of time series

Option 1: Start the time series in 1981, the first year of data collection.

Option 2: Start the time series in 1987, because of increased sampling intensity starting in 1987, reflected in the increase in sample sizes.

Option 3: Start the time series in 1991 because of the ability to link all of the intercepts from the same trip to a single trip instead of treating them as independent observations also the species identifications were more accurate beginning in 1991 with the additional training of samplers.

Decision: Option 3 preferred. The DW decided to start the time series in 1991 when all of the intercepts per trip could aggregated to a single trip. Species identification was a problem with black groupers especially prior to 1991 that was reduced with the additional training of samplers.

Issue 3: Calculating nominal catch rates

Option 1: Use the MRFSS intercepts that caught black grouper to calculate the nominal catch rates as was done in the working paper (SEDAR19-DW-01).

Option 2: Use all of the MRFSS intercepts from southern Florida to calculate the nominal catch rate.

Decision: Option 2 preferred. Using all of the intercepts avoids the bias associated with ignoring those intercepts (97%) that did not catch black grouper. Table 5.14 below has the revised nominal catch rates.

Issue 4: Whether to use MRFSS index in assessment

Decision: Use the MRFSS index with the understanding that the selectivity for the index will have to incorporate both landings and discards.

<u>*Miscellaneous decisions*</u>

Although a bag limit of 5 groupers/person/day was instituted for the recreational fishery in 1990 in the Gulf of Mexico and 1992 in the South Atlantic and in 1999 changed to include no more than 2 black groupers in the bag per day in the South Atlantic, the bag limit was not considered to bias the index. The DW examined the occurrence of trips exceeding the bag limit and noted that two trips out of 6,239 trips exceeded the aggregate bag limit and only one trip in the South Atlantic exceeded the more stringent 2-fish black grouper limit. Also, the effect of the bag limit should be minimal because index included discarded fish.

5.4.2.3 Methods

The CPUE was computed in units of number fish per trip. All of the trips from 1991 through 2008 for the southeast US (MRFSS sub regions 6 and 7) were extracted. Inland or bay trips were excluded as well as trips fishing from shore resulting in 58,469 intercepts. Pair-wise similarities of species were calculated using the Morisita Similarity Index because the response variable, the total catch of black grouper (Type A, B1, and B2), was count data. The similarity values were entered into a hierarchical cluster analysis that used average linkage clustering and the cluster that included black grouper also included yellowtail snapper, mutton snapper, and gray triggerfish. If any of these four species was caught on a trip then that trip was selected. There were 9,631 intercepts selected and black grouper was landed on 1,589 of those trips.

Black grouper catch rates were standardized using two generalized linear models (GLMs): the first model estimated the annual proportion of positive trips using a binomial distribution with a logit-link and the second GLM estimated the annual number of black grouper caught per trip with a gamma distribution with log-link. Potential explanatory variables were year, wave (two-month time period), mode (charterboat or private/rental boat), area (nearshore or offshore), region (southeast -- Volusia-Dade, Florida Keys -- Monroe, southwest -- Collier-Pinellas), avidity (0, 5, 10, 15, 20, 30, 40+ trips per wave), hours fished (0, 2, 4, 6, 8, 10, 12+ hr), and the number of anglers on the trip (1, 2, 3, 4, 5, 6, 7+). Variables were evaluated for inclusion in the GLM through a step-wise process. The variables included in the GLMs were chosen in a stepwise manner using the smallest Akaike Information Criterion (AIC) at each level of the number of predictor variables, provided that the variable was significant at the $\alpha = 0.05$ level in the regression with the significance based on two times the change in log-likelihood (Chi-square distribution).

The annual mean catch per intercept values were calculated with a Monte Carlo method based on the least-squares mean probability of catch a black grouper multiplied by the mean number of black grouper caught per angler in that year. Random variation was added to each outcome by multiplying the standard error of the proportion positive by a random, normal deviate and by multiplying the standard error of the number per intercept by a different random, deviate. After the random deviates were added to the respective least-square means, the terms were back-transformed to their original scales and multiplied together. This process was repeated the same number of times each year as the number of intercepts that caught black grouper in that year and the index was the mean of the outcomes by year

5.4.2.4 Sampling Intensity

Sampling intensity (number of intercepted trips) in southern Florida by region, mode of fishing, area, and year is shown in Table 5.13.

5.4.2.5 Size/Age Data

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

5.4.2.6 Catch Rates and Measures of Precision

Table 5.14 shows nominal and standardized black grouper catch rates (number/trip) and their coefficients of variation. The index group questioned calculating nominal catch rates with just the positive intercepts and recommended calculating the nominal catch rates using all of the 58,469 MRFSS intercepts from southern Florida. The revised nominal catch rates (Table 5.14) are more similar to the standardized catch rates (correlation, $r = 0.83$, $df = 16$, $P < 0.05$) than the catch rates calculated with just the positive intercepts (correlation, $r = 0.61$, $df = 16$, $P < 0.05$). Figure 5.11shows standardized MRFSS catch rates and measures of uncertainty.

5.4.2.7 Comments on Adequacy for Assessment

The DW recommended using the MRFSS index in the assessment. However, the DW did discuss several concerns. Because the survey measures the discards as well as the landings, the group thought that the MRFSS index was less sensitive to regulatory changes.

5.4.3 Commercial Logbook (Longline)

5.4.3.1 General Description

Commercial fishermen who participate in fisheries managed by the SAFMC began to report catch and effort data in the logbook program to the NMFS in 1990 (Gulf of Mexico) and 1992 (South Atlantic). Logbook data reported for each trip include date, gear, fishing area, days at sea, fishing effort, species caught, and weight of the catch. Logs were originally collected from a random sample representing 20% of vessels in Florida with 100% reporting from other states; starting in 1993, all commercial fishermen holding snapper-grouper permits were required to submit logs. An index of abundance for black grouper from the logbook data was computed for 1993–2008.

5.4.3.2 Issues Discussed at the DW

Issue 1: Gear selection

Option 1: Use vertical lines (composed of handline and electric reels) logbooks from South Carolina through Texas and longline logbooks from Florida Keys through Texas. Very few (less than 200) longline trips were reported in the SA.

Issue 2: Year selection

Option 1: Use data starting in 1990

Option 2: Use data starting in 1992

Option 3: Use data starting in 1993

Decision: Option 3, because pre-1993 included only 20% coverage of Florida fishermen, whereas 1993 began 100% coverage.

Issue 3:Defining which trips constitute effort

Option 1: Use method of Stephens and MacCall (2004) to define effort that could have caught the focal species based on the composition of other species in the landings based on geographical regions as defined in SEDAR 19 DW-13. This method would include trips with effort but zero landings of black grouper.

Option 2: Redefining areas was discussed but no specific alternatives were suggested.

Decision: Option 1, use geographical regions as defined in SEDAR 19 DW-13.

Issue 4: Trip tickets versus logbooks

Commercial logbooks and Florida trip tickets (see section 5.4.5.1) both include information on catch rates of commercial fisheries, with the main differences being that (i) trip tickets more accurately reflect catch for fishers that fish in Florida state waters, (ii) trip tickets are filled out by dealers, while logbooks are filled out by fishermen, (iii) logbooks include finer scale effort information, and (iv) logbook data are available over the spatial extent of the stock while trip tickets are available only at the state level.

Option 1: Use Florida trip ticket data to summarize commercial catch rates.

Option 2: Use commercial logbooks.

Decision: Option 2, because it more accurately represented abundance over the entire range of the stock, and because there appeared to be some substantial changes in effort over time when a trip was used to define effort (as opposed to using hook-hours to define effort, for instance).

5.4.3.3 Methods

Available catch per unit effort (CPUE) data reported to the coastal logbook program from 1993 - 2008 was used to develop two abundance indices for black grouper. A complete description of methodology and results are provided in SEDAR19 DW-13. Separate indices were developed for the Gulf of Mexico and South Atlantic vertical line (handline and electric reel) fishery and for the Gulf of Mexico longline fishery.

Data were restricted to include only those trips reporting fishing effort by a single gear and area fished. Only trips with landings and effort data reported within 45 days of the completion of the trip were included in the analyses. Approximately 77 percent of vertical line trips and 66 percent of longline trips were retained.

Analyses were spatially limited by excluding all trips with landings reported from North Carolina. This was necessary due to species misreporting of gag grouper as black grouper (Muller, pers. comm.). Trip Interview Program (TIP) data included very few black grouper observed North Carolina landings, however gag grouper were observed.
Clear outliers in the data, e.g. landings falling outside the 99.5 percentile of the data, were also excluded from the analyses.

Reported vertical line trips made in both the Gulf of Mexico and South Atlantic during the period February 15th through April 30th were excluded from the analysis due to closed seasons. In addition, the shallow water grouper fishery was closed in the Gulf of Mexico beginning November 15, 2004 through December 31, 2004 and again beginning October 10, 2005 through December 31, 2005 due to quota restrictions. All trips reporting landings, in either the Gulf of Mexico or South Atlantic, during those periods were excluded from the analysis. The longline analysis was limited to trips reported from the Gulf of Mexico, therefore data reported from February 15th and March 15th or during the 2004 and 2005 closures due to quota restrictions were excluded from the analysis.

As noted in SEDAR 10, black and gag grouper have often been misreported. Area specific black:gag grouper ratios (available from SEDAR 10) were applied to correct the available data for misreporting. South Atlantic data was assumed to be properly reported, except for landings made in North Carolina. Trips with landings in North Carolina were excluded from the analyses. Final gear specific data sets were constructed using the Stephens and MacCall (2004) data subsetting method.

Five factors were examined using GLM analyses as possible influences on both the proportion of vertical line trips that landed black grouper and the vertical line catch rate of black grouper. Factors included: year, month, area fished, days at sea, and number of crew. Six factors were examined for possible influence on the longline proportion of positive black grouper trips and longline black grouper catch rate. Standardized indices of abundance were constructed for both gears using the delta lognormal model approach of Lo et al. (1992).

5.4.3.4 Sampling Intensity

The numbers of positive trips by year and area are tabulated for vertical line in Table 5.15 and for longline in Table 5.16. The method of Stephens and MacCall (2004) does not necessarily select all positive trips.

5.4.3.5 Size/Age Data

Sizes and ages of fish represented by this index are the same as those of the commercial handline and longline fisheries.

5.4.3.6 Catch Rates and Measures of Precision

Diagnostic plots from the delta-GLM model fit are in SEDAR19-DW-13. Tables 5.15 and 5.16 show nominal CPUE (pounds/hook-hr), standardized CPUE, coefficients of variation (CV), and annual sample sizes (number trips selected by Stephens and MacCall method). Figures 5.12 and 5.13 show standardized and nominal CPUE in the vertical line and longline black grouper fisheries.

5.4.3.7 Comments on Adequacy for Assessment

The logbook indexes for both vertical line and longline were recommended by the DW for use in the assessment. They have the advantages of wide geographic coverage, better estimation of effort than Florida trip ticket data, and very large sample sizes. The DW, however, did express several concerns about this data set. It was pointed out that there are problems associated with any fishery dependent abundance index and that convincing counter-evidence needs to be presented to not use the logbook data.

Three concerns merit further description. First, commercial fishermen may target different species through time. If changes in targeting have occurred, effective effort can be difficult to estimate. However, the DW recognized that the method of Stephens and MacCall (2004), used here to identify trips for the analysis, can accommodate changes in targeting, as long as species assemblages were consistent.

Second, the data are self-reported and largely unverified. Some attempts at verification have found the data to be reliable, but problems likely remain.

> Third and probably foremost, the data are obtained from a directed fishery and therefore the index could contain problems associated with any fishery dependent index. Fishing efficiency of the fleet has likely increased over time due to improved electronics. In addition, overall efficiency may have changed throughout the time series if fishermen of marginal skill have left or entered the fishery at a greater rate than more successful fishermen. Also of concern is whether catch rates in a directed fishery are density-dependent. As fish abundance decreases, fishermen may maintain relatively high catch rates, and as fish abundance increases, catch rates may saturate.

The DW discussed how the assessment might attempt to account for changes in catchability over time. Constant catchability, though commonly assumed, would not be an appropriate assumption in this fishery, as the DW generally believed that catchability has increased with improvements in fishing gear and technology. However, commercial fishers at the DW noted a decrease in experience among captains, suggesting a decrease in catchability over the years covered by the commercial vertical line and longline indices. That may negate or reduce any increase due to technology. See section 5.5 for further discussion about catchability.

5.4.4 Other Data Sources Considered

5.4.4.1 Florida Fish and Wildlife Conservation Commission Marine Resources Information System (Trip Tickets)

The Florida Fish and Wildlife Conservation Commission (FWC) Marine Resources Information System (trip tickets) began in late 1984 and was adopted by the National Marine Fisheries Service as the official source of Florida's landings in 1986. The program requires Florida's commercial fishers to sell their catch to licensed wholesale dealers and each sale is recorded on a trip ticket, a copy of which goes to FWC. Information collected on trip tickets include the fisher's Saltwater Products License number, wholesale dealer's license number, date landed, time fished, area fished, county landed, depth, gear fished, number of sets, number of traps pulled, soak time, species codes, size or market categories, amount of catch, and unit price, with these last fields completed for everything landed. Some fields were phased in; for example, beginning in mid-1991, each trip ticket included a series of boxes so that the fishers could indicate the gear used on the trip. A major advantage over the previous monthly dealer reports was that the trip ticket system had species and size codes such that grouper landings could now be reported by species instead of 'Unclassified groupers' and that species assemblages, i.e., species that are frequently caught together, could be identified.

Standardized commercial catch rates were developed from Florida trip tickets using a delta-GLM approach on trips selected by the method of Stephens and MacCall (2004), and the details are presented in SEDAR19-DW-20. As the DW decided it was more appropriate to use commercial logbook indices, these methods and results are not reproduced here.

The purpose of this exercise was to compare the standardized catch rates derived from FWC's trip ticket program to those derived from NMFS Coastal Fisheries Logbook Program (logbook) (McCarthy and Baertlein 2009, SEDAR19-DW-13,and SEDAR19-DW-14). Are the catch rate patterns similar in the data from two programs? The underlying assumption is that both programs are reporting fishing activity but the logbooks record more detailed effort information. This issue was raised during the SEDAR19 DW planning conference call in April 2009.

A comparison of the FWC trip ticket HL black grouper index values to those from the NMFS Logbook vertical line index showed that, indeed, the patterns were similar (correlation coefficient, $r = 0.86$, $df = 14$, $P < 0.05$) as were the patterns between Florida trip ticket LL black grouper index to the NMFS logbook LL index (correlation coefficient, $r = 0.71$, $df = 14$, $P < 0.05$).

There was good agreement between the two indices with black grouper because the center of that fishery is southern Florida such that both data sources captured the same signal from the fishery because both systems were tracking the same stock. This exercise supports using the logbook catch rates in the stock assessment even though there was little difference between the indices.

5.5. *CATCHABILITY*

Indices of abundance are used in stock assessment to make inference about trends in numbers or biomass of the stock. Typically, models assume that catchability is constant, such that the number or biomass is linearly related to the index. However, this assumption can be faulty, particularly for fishery dependent indices, because of changes in catchability that result from changes in such factors as fish abundance, fishing technology, fishers' behavior, and management (Wilberg et al., In review).

In February of 2009, a SEDAR procedural workshop was held to address time-varying catchability (SEDAR, 2009). The workshop recommended that future SEDAR assessments consider time-varying catchability, both qualitatively through discussion at the data workshop and quantitatively in the stock assessment model, if possible.

Based on recommendations from the SEDAR procedural workshop, the SEDAR-19 indices working group, along with fishermen at the DW, discussed possible changes in catchability over time. The starting point for this discussion was the report of the procedural workshop (SEDAR, 2009), in particular, section three of that report. Section three documented sector-specific timelines of factors that could affect catchability in the recreational, headboat, charter/for hire, and commercial sectors; it was compiled primarily by fishermen.

Most of the SEDAR-19 discussion focused on commercial fisheries. GPS on vessels reduced search time for fishing locations, and was adopted by the fleet over time as the technology became more affordable. The fishermen believed that the technology started to become important in 1993 and its effects were fully saturated by 2003. The longline fleet has continued to benefit by interfacing GPS with onboard personal computers. The recreational sector also increased its catchability through GPS, perhaps more so than the commercial sector.

The fishermen discussed several mechanisms that could have led to decreased catchability over time. For example, it was suggested that the overall skill and experience of commercial fishing crews has declined. Also, with greater numbers of fishermen on the water, particularly recreational fishermen, competition for prime fishing locations has increased; thus, fishing effort across the fleet includes more sub-prime locations.

Time-varying catchability of fishery independent indices was also discussed, as it might relate to environmental factors. For MARMAP indices, the standardization explored bottom temperature as a possible covariate of catch rates. For the Florida Keys surveys, hurricane events might have reduced the number of fish in the survey area.

The SEDAR-19 indices group did not discuss modeling approaches for time-varying catchability, but did note previous reviews on this topic (SEDAR, 2009; Wilberg et al., In review). As stated in the executive summary of SEDAR (2009), "…methods should be flexible because no one method will be best for all cases, and because there have not been enough studies testing the performance of alternative catchability models."

5.6. *CONSENSUS RECOMMENDATIONS AND SURVEY EVALUATIONS*

Two fishery independent indices were recommended for use in the assessment: the FWC visual survey and the U. Miami/NMFS RVC. Four fishery dependent indices were recommended: commercial handline (logbook), commercial longline (logbook), headboat, and MRFSS (Tables 5.1, 5.2). The six indices are compared graphically in Figure 5.14 and their correlations in Table 5.17. A summary of each index and their relative CVs are presented in Table 5.18. A map of the survey area showing the spatial coverage of all indices is also available (Figure 5.15).

Correlations between indices (Table 5.17) varied widely. Commercial logbook indices were highly correlated ($\rho = 0.87$), and fishery independent indices were reasonably correlated as well ($\rho = 0.44$). However, there were a large number of negative or weak (insignificant) correlations, including a negative relationship between the FWC visual survey and commercial logbooks. Weak correlations may be attributable to different selectivities, different trends in catchability, or nonrandom/biased sampling. However, it is difficult to tell on a priori grounds. In addition to previous suggestions for the need to account for time varying changes in catchability, it may be worth considering an approach for estimating an additional component of process error associated with each index, either in the assessment model (Geromont and Butterworth 2001, Wade 2002) or outside of it (Conn, Accepted) to account for this apparent discrepancy.

5.7. *RESEARCH RECOMMENDATIONS*

1. Expand fishery independent sampling to provide indices of abundance. The DW Panel noted that this recommendation has been the first on the list for virtually all previous SEDAR's in the south Atlantic.
2. Examine variability in catchability
    - Environmental effects
    - Changes over time associated with increases in technology and potential changes in fishing practices. This is of particular importance when considering fishery dependent indices.
    - Potential density-dependent changes in catchability. This is of particular importance for schooling fishes.
3. Conduct studies to examine how the behavior of fisherman changes over time and how these changes relate to factors such as gas prices and economic trends
4. Consider optimal sample allocation for species of interest when designing surveys to increase sample sizes.
5. Examine possible temporal changes in species assemblages. Such changes could influence how the Stephens and MacCall method is applied when determining effective effort.
6. Continue to expand fishery dependent at-sea-observer surveys. Such surveys collects discard information, which would provide for a more accurate index of abundance.

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

- Generate any remaining tables and figures
- Finish writing chapter of DW report

- Submit data to Data Compiler

5.9. *LITERATURE CITED*

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5.10. *TABLES*

Table 5.1. Black grouper: A summary of catch-effort time series available for the SEDAR 19 data workshop.

Fishery Type	Data Source	Area	Years	Units	Standardization Method	Size Range	Issues	Use?
Commercial	Logbook - handline	SC-Texas	1993-2008	Pounds per hook-hr	Stephens and MacCall; delta-GLM	Same as fishery	Fishery dependent	Y
Commercial	Logbook - longline	Gulf	1993-2008	Pounds per hook	Stephens and MacCall; delta-GLM	Same as fishery	Fishery dependent	Y
Commercial	FL Trip Tickets	FL	1991-2008	Pounds per trip	Stephens and MacCall; delta-GLM	Same as fishery	Fishery dependent, use logbook instead	N
Recreational	Headboat	South FL	1986-2008	Number per angler-hr	Stephens and MacCall; delta-GLM	Same as fishery	Fishery dependent	Y
Recreational	MRFSS	FL	1987-2008	Number per trip (A+B1+B2).	Cluster analysis; delta-GLM	Same as fishery including discards	Fishery dependent	Y
Independent	FWC Visual Census	FL Keys	1999-2004, 2006, 2007	Number per dive per habitat	delta-GLM	150mm to 800mm TL; Ages 0-4	Limited to relatively small segment of stock range	Y
Independent	U Miami/NMFS RVC survey	FL Keys	1994-2008	Number by length class per survey	Design-based inference	Generally 100mm to 1000mm TL	Limited to relatively small segment of stock range	Y
Independent	U Miami/NMFS RVC survey	FL Keys (forereef only)	1979-1993	Number per survey	delta-GLM	Same as above	Highly variable, low number of locations, sampling locations often change between years	N
Independent	U Miami/NMFS RVC survey	Tortugas	1994-1998, 2004, 2006, 2008	Number per length class per survey	Design-based inference	100mm to 1200mm TL	Few years, high correlation with Keys FWC survey, abundance in MPA may not represent population abundance	N
Independent	MARMAP	NC-FL	1990-2008	Number per trap-hr	—	—	Very low sample sizes	N
Independent	SEAMAP	Gulf	Varying	Varying	—	—	Very low sample sizes	N
Independent	SEAMAP	South Atlantic	1990-2008	Number per trap	—	—	Very low sample sizes	N
Independent	Diver Reports (Reef.org)	NC-FL	1990-2008	—	—	—	Voluntary reporting	N

Fishery Type	Data Source	Area	Years	Units	Standardization Method	Size Range	Issues	Use?
Independent	NMFS Video survey	Gulf	?	—	—	—	1 black grouper	N
Independent	NOS diver surveys	Tortugas	2001-2007	Mean count per survey	—	—	Limited spatial coverage	N
Independent	NMFS-Beaufort	Riley's Hump	2001-2008	Mean count per survey	—	—	Limited spatial coverage	N
Recreational	Online recreational trip reporting (myfish.com)	NC-FL	2007-2008	—	—	—	Voluntary reporting, currently only two years of data available	N

Table 5.2. Issues with each data set considered for CPUE.

Fishery dependent indices

Commercial Logbook – Handline (*Recommended for use*)

Pros: Complete census

Covers entire management area

Continuous, 15-year time series

Large annual sample size

Cons: Fishery dependent (targeting)

Data are self-reported and largely unverified

Little information on discard rates

Catchability may vary over time and/or abundance

Issues Addressed:

Possible shift in species preference [Stephens and MacCall (2004) approach]

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

Increases in catchability over time (e.g., due to advances in technology or knowledge) can be addressed in the assessment model

Recreational Headboat (*Recommended for use*)

Pros: Complete census

Covers entire management area

Longest time series available

Data are verified by port samplers

Consistent sampling

Large annual sample size

Generally non-targeted for focal species

Cons: Fishery dependent

Little information on discard rates

Catchability may vary over time and/or abundance

Issues Addressed:

Increases in catchability over time (e.g., due to advances in technology or knowledge) can be addressed in the assessment model

Starting year 1986 to conform with assessment model and improvements in survey coverage

MRFSS (*Recommended for use*)

Pros: Relatively long time series

Nearly complete area coverage

Only fishery dependent index to include discard information (A+B1+B2)

Cons: Fishery dependent

High uncertainty in MRFSS unobserved catches

Florida Trip Tickets (*Not Recommended for use*)

Pros: Good information on fishermen from state waters

Cons: Very similar data used in logbook index

Less information on effort when compared to logbooks

Fishery independent

FWC Visual Census (*Recommended for use)*

Pros: Fishery independent diver survey

Standardized sampling techniques

Reasonable CVs

Survey occurs in heart of black grouper's range

Cons: High degree of spatial overlap with RVC survey

U. Miami/NMFS RVC Survey

Florida Keys 1994-Present (*Recommended for use*)

Pros: Well designed survey

Fishery independent

Southern Florida in heart of black grouper's range

Cons: Spatial coverage limited to southern Florida

Issues addressed :

Analysis methods (design vs. model-based inference)

Potential of hurricanes to affect CPUE

Florida Keys 1980-1994 (*Not recommended for use*)

Pros: Fishery independent survey

Cons: Range, spatial coverage more limited than later periods

High variability

Tortugas (*Not recommended for use*)

Pros: Well designed survey

Fishery independent

Cons: Survey occurs primarily in marine protected areas

Doubtful that abundance trends in this area (an MPA) will track changes at the population scale

Issues addressed :

Potential of hurricanes to affect CPUE

NOS Diver surveys (*Not recommended for use*)

Pros: Fishery independent

Cons: Spatially limited

Occur primarily in and around a marine protected area

NMFS-Beaufort Riley's Hump diver survey (*Not recommended for use*)

Pros: Fishery independent

Cons: Spatially limited

Occur primarily in and around a marine protected area

MARMAP (*Not Recommended for use*)

Pros: Fishery independent surveys (several gears employed over the years)

Adequate spatial coverage

Standardized sampling techniques

Cons: Little to no black grouper sampled

SEAMAP Trawl Survey (*Not recommended for use*)

Pros: Stratified random sample design

Adequate regional coverage

Standardized sampling techniques

Cons: Limited depth coverage (shallow water survey)

Inadequate sample sizes

Diver Reports (www.reef.org) (*Not recommended for use*)

Pros: Trained divers

Visual account of species present

Cons: Not designed with objective of providing an index of abundance

Sample sizes off the southeastern U.S. (dives documenting black grouper) reported on the website appear to be low

Table 5.3. Step-wise identification of variables to include in the general linearized model (binomial distribution and a logit link) for the proportion of positive dive/habitats in the FWC visual survey based on the lowest Akaike Information Criterion (AIC). The fields include the variables, the degrees of freedom for that variable (df), the deviance of the model with those variables, the mean deviance (deviance/df), the change in mean deviance (Δ mean dev), percent reduction in mean deviance (% mean dev), cumulative reduction in mean deviance, log likelihood, the change in log likelihood from previous run, minus two times the change in log-likelihood, chi-square value, the Chi-square degrees of freedom, the probability of the null hypothesis (Prob Ho), and the AIC.

Variables	df	Deviance	mean dev	Δ mean de	% mean d	Cum %	log like	Δ log like	-2*log like	df X^2	Prob Ho	AIC
Null	2523	2562.2009	1.0155				-1281.101			1		2564.20
Year	2516	2542.9278	1.0107	0.0048	0.47%		-1271.464	-9.6366	19.273	7	0.007373	2558.93
Month	2518	2554.4373	1.0145	0.0010	0.10%		-1277.219	-3.8818	7.764	5	0.169754	2566.44
Zone	2520	2514.7645	0.9979	0.0176	1.73%		-1257.382	-23.7183	47.437	3	2.81E-10	2522.76
BottomHabitatRelief	2521	2525.1226	1.0016	0.0139	1.37%		-1262.561	-18.5392	37.078	2	8.88E-09	2531.12
BottomHabitatType	2521	2527.0634	1.0024	0.0131	1.29%		-1263.532	-17.5688	35.138	2	2.34E-08	2533.06
Biocover	2517	2553.1613	1.0144	0.0011	0.11%		-1276.581	-4.5199	9.040	6	0.171352	2567.16
Dep_cat	2517	2538.0341	1.0084	0.0071	0.70%		-1269.017	-12.0834	24.167	6	0.000487	2552.03
Secchi	2516	2549.1967	1.0132	0.0023	0.23%		-1274.598	-6.5022	13.004	7	0.072001	2565.20
Num counts	2520	2497.3062	0.9910	0.0245	2.41%	2.4%	-1248.653	-32.4474	64.895	3	5.28E-14	2505.31
With num_counts												
Year	2513	2479.0299	0.9865	0.0045	0.44%		-1239.515	-9.138	18.276	7	0.010784	2501.03
Month	2515	2490.1841	0.9901	0.0009	0.09%		-1245.092	-3.561	7.122	5	0.21171	2508.18
Zone	2517	2456.2353	0.9759	0.0151	1.49%		-1228.118	-20.535	41.071	3	6.32E-09	2470.24
BottomHabitatRelief	2518	2433.0991	0.9663	0.0247	2.43%	4.8%	-1216.550	-32.103	64.207	2	1.14E-14	2445.10
BottomHabitatType	2518	2456.0741	0.9754	0.0156	1.54%		-1228.037	-20.616	41.232	2	1.11E-09	2468.07
Biocover	2514	2487.5732	0.9895	0.0015	0.15%		-1243.787	-4.867	9.733	6	0.136356	2507.57
Dep_cat	2514	2473.1889	0.9838	0.0072	0.71%		-1236.595	-12.059	24.117	6	0.000497	2493.19
Secchi	2513	2485.1531	0.9889	0.0021	0.21%		-1242.577	-6.077	12.153	7	0.095632	2507.15
With num_counts and bottom habitat relief												
Year	2511	2409.5644	0.9596	0.0067	0.66%		-1204.782	-11.7674	23.535	7	0.001375	2435.56
Month	2513	2427.0986	0.9658	0.0005	0.05%		-1213.549	-3.0003	6.001	5	0.306161	2449.10
Zone	2515	2386.6298	0.949	0.0173	1.70%	6.5%	-1193.315	-23.2347	46.469	3	4.51E-10	2404.63
BottomHabitatType	2516	2415.2843	0.9600	0.0063	0.62%		-1207.642	-8.9075	17.815	2	0.000135	2431.28
Biocover	2512	2421.2122	0.9639	0.0024	0.24%		-1210.606	-5.9435	11.887	6	0.064538	2445.21
Dep_cat	2512	2422.9643	0.9646	0.0017	0.17%		-1211.482	-5.0675	10.135	6	0.119081	2446.96
Secchi	2511	2423.9193	0.9653	0.0010	0.10%		-1211.960	-4.5900	9.180	7	0.23999	2449.92
With num_counts, bottom habitat relief, and zone												
Year	2508	2364.5750	0.9428	0.0062	0.61%		-1182.288	-11.0274	22.055	7	0.002486	2396.58
Month	2510	2381.0937	0.9486	0.0004	0.04%		-1190.547	-2.7681	5.536	5	0.353993	2409.09
BottomHabitatType	2513	2368.9921	0.9427	0.0063	0.62%	7.2%	-1184.496	-8.8189	17.638	2	0.000148	2390.99
Biocover	2509	2377.9358	0.9478	0.0012	0.12%		-1188.968	-4.3470	8.694	6	0.191533	2407.94
Dep_cat	2509	2382.1649	0.9494	-0.0004	-0.04%		-1191.082	-2.2325	4.465	6	0.614013	2412.16
Secchi	2508	2380.6020	0.9492	-0.0002	-0.02%		-1190.301	-3.0139	6.028	7	0.536507	2412.60
With num_counts, bottom habitat relief, zone, and bottom habitat type												
Year	2506	2354.3624	0.9395	0.0032	0.32%	7.5%	-1177.181	-7.3148	14.630	7	0.041052	2390.36
Month	2508	2362.9160	0.9422	0.0005	0.05%		-1181.458	-3.0380	6.076	5	0.298894	2394.92
Biocover	2507	2362.8196	0.9425	0.0002	0.02%		-1181.410	-3.0862	6.172	6	0.404158	2396.82
Dep_cat	2507	2364.6900	0.9432	-0.0005	-0.05%		-1182.345	-2.1510	4.302	6	0.63588	2398.69
Secchi	2506	2363.6083	0.9432	-0.0005	-0.05%		-1181.804	-2.6919	5.384	7	0.613234	2399.61
With num_counts, bottom habitat relief, zone, and bottom habitat type												
Month	2501	2348.0482	0.9388	0.0007	0.07%		-1174.024	-3.1571	6.314	5	0.276835	2394.05
Biocover	2500	2348.5569	0.9394	0.0001	0.01%		-1174.279	-2.9027	5.805	6	0.445339	2396.56
Dep_cat	2500	2349.5757	0.9398	-0.0003	-0.03%		-1174.788	-2.3933	4.787	6	0.57146	2397.58
Secchi	2499	2348.5882	0.9398	-0.0003	-0.03%		-1174.294	-2.8871	5.774	7	0.566348	2398.59

Table 5.4. Step-wise identification of variables to include in the general linearized model (log-normal distribution and identity link) for the number of black grouper per point-count seen on positive dive/habitats in the FWC visual survey based on the lowest Akaike Information Criterion (AIC). The fields include the variables, the degrees of freedom for that variable (df), the deviance of the model with those variables, the mean deviance (deviance/df), the change in mean deviance (Δ mean dev), percent reduction in mean deviance (% mean dev), cumulative reduction in mean deviance, log likelihood, the change in log likelihood from previous run, minus two times the change in log-likelihood, chi-square value, the Chi-square degrees of freedom, the probability of the null hypothesis (Prob Ho), and the AIC.

Variables	df	Deviance	mean dev	Δ mean de	% mean d	Cum %	log like	Δ log like	-2*log like	df X^2	Prob Ho	AIC
Null	517	243.8022	0.4716				-224.737			2		453.47
Year	510	230.8508	0.4526	0.0190	4.03%		-209.608	-15.1291	30.258	7	8.51E-05	437.22
Month	512	243.3507	0.4753	-0.0037	-0.78%		-224.222	-0.5146	1.029	5	0.960176	462.44
Zone	514	239.7867	0.4665	0.0051	1.08%		-220.128	-4.6082	9.216	3	0.026548	450.26
BottomHabitatRelief	515	243.6846	0.4732	-0.0016	-0.34%		-224.603	-0.1340	0.268	2	0.87459	457.21
BottomHabitatType	515	242.1540	0.4702	0.0014	0.30%		-222.854	-1.8829	3.766	2	0.152148	453.71
Biocover	511	241.4855	0.4726	-0.0010	-0.21%		-222.087	-2.6499	5.300	6	0.505976	460.17
Dep_cat	511	233.7494	0.4574	0.0142	3.01%		-213.062	-11.6751	23.350	6	0.000687	442.12
Secchi	510	230.5668	0.4521	0.0195	4.13%	4.1%	-209.267	-15.4698	30.940	7	6.38E-05	436.53
With secchi distance												
Year	503	217.7651	0.4329	0.0192	4.07%	8.2%	-193.487	-15.7799	31.560	7	4.9E-05	418.97
Month	505	230.1335	0.4557	-0.0036	-0.76%		-208.746	-0.5204	1.041	5	0.959208	445.49
Zone	507	227.4286	0.4486	0.0035	0.74%		-205.477	-3.7903	7.581	3	0.055523	434.95
BottomHabitatRelief	508	230.4348	0.4536	-0.0015	-0.32%		-209.108	-0.1584	0.317	2	0.853508	440.22
BottomHabitatType	508	228.8152	0.4504	0.0017	0.36%		-207.157	-2.1096	4.219	2	0.121286	436.31
Biocover	504	229.4243	0.4552	-0.0031	-0.66%		-207.893	-1.3742	2.748	6	0.839698	445.79
Dep_cat	504	222.6429	0.4418	0.0103	2.18%		-199.600	-9.6666	19.333	6	0.003636	429.20
With secchi distance and year												
Month	498	217.2145	0.4362	-0.0033	-0.70%		-192.789	-0.6981	1.396	5	0.924729	427.58
Zone	500	215.4632	0.4309	0.0020	0.42%		-190.557	-2.9298	5.860	3	0.118644	419.11
BottomHabitatRelief	501	217.7173	0.4346	-0.0017	-0.36%		-193.426	-0.0605	0.121	2	0.941294	422.85
BottomHabitatType	501	215.7549	0.4306	0.0023	0.49%		-190.930	-2.5570	5.114	2	0.077537	417.86
Biocover	497	216.1682	0.4349	-0.0020	-0.42%		-191.458	-2.0294	4.059	6	0.668719	426.92
Dep_cat	497	210.7571	0.4241	0.0088	1.87%	10.1%	-184.474	-9.0132	18.026	6	0.006167	412.95
With secchi distance, year, and depth category												
Month	492	209.5607	0.4259	-0.0018	-0.38%		-182.907	-1.5670	3.134	5	0.679336	419.81
Zone	494	208.6401	0.4223	0.0018	0.38%		-181.695	-2.7784	5.557	3	0.135281	413.39
BottomHabitatRelief	495	210.6173	0.4255	-0.0014	-0.30%		-184.291	-0.1826	0.365	2	0.833101	416.58
BottomHabitatType	495	207.9622	0.4201	0.0040	0.85%	10.9%	-180.800	-3.6739	7.348	2	0.025377	409.60
Biocover	491	209.2978	0.4263	-0.0022	-0.47%		-182.561	-1.9124	3.825	6	0.700372	421.12
With secchi distance, year, depth category, and bottom habitat type												
Month	490	206.9474	0.4223	-0.0022	-0.47%		-179.454	-1.3454	2.691	5	0.747525	416.91
Zone	492	206.2452	0.4192	0.0009	0.19%		-178.520	-2.2802	4.560	3	0.206966	411.04
BottomHabitatRelief	493	207.8736	0.4217	-0.0016	-0.34%		-180.683	-0.1171	0.234	2	0.889496	413.37
Biocover	489	207.0018	0.4233	-0.0032	-0.68%		-179.527	-1.2731	2.546	6	0.863262	419.05

Table 5.5. Summary of catch-effort records from FWC's visual survey. The number of dive/habitats for the standardization is the number that observed black grouper.

	Nominal				Standardized			
Year	Number of Dive/habitats	Mean Number of Fish per Dive/habitat	Coefficient of Variation	Index Scaled to Mean	Number of Dive/habitats	Mean Number of Fish per Dive/habitat	Coefficient of Variation	Index Scaled to Mean
1999	200	0.475	0.196	1.36	47	0.273	0.153	1.54
2000	214	0.393	0.158	1.12	56	0.222	0.164	1.26
2001	322	0.419	0.135	1.20	79	0.185	0.142	1.05
2002	334	0.356	0.118	1.02	79	0.153	0.133	0.87
2003	356	0.303	0.159	0.87	60	0.138	0.161	0.78
2004	326	0.371	0.319	1.06	57	0.188	0.186	1.06
2005								
2006	382	0.254	0.139	0.73	66	0.141	0.171	0.80
2007	397	0.317	0.128	0.91	74	0.151	0.160	0.85
Total	2531				518			

Table 5.6. Total lengths of black grouper from the FWC visual survey, the number of fish lengths estimated, and the number dive/habitats sampled by year.

	Number	Number	Total length (cm, lower bound)															
Year	Fish	Dive/habitats	5	10	15	20	25	30	35	40	45	50	55	60	70	80	90	100+
1999	142	200	0.0070	0.1268	0.0986	0.2113	0.1549	0.1479	0.0775	0.0915	0.0352	0.0352	0.0000	0.0141	0.0000	0.0000	0.0000	0.0000
2000	238	214	0.0042	0.0294	0.0378	0.0546	0.2101	0.1975	0.1807	0.1218	0.0630	0.0168	0.0420	0.0294	0.0084	0.0042	0.0000	0.0000
2001	165	322	0.0000	0.0061	0.0485	0.0667	0.1212	0.1333	0.1697	0.1152	0.0788	0.0788	0.0727	0.0545	0.0424	0.0000	0.0121	0.0000
2002	121	334	0.0000	0.0000	0.0331	0.1570	0.0826	0.1901	0.1901	0.1405	0.0496	0.0496	0.0496	0.0248	0.0083	0.0165	0.0000	0.0083
2003	97	356	0.0103	0.0000	0.0412	0.0103	0.1443	0.1237	0.1443	0.1753	0.0928	0.1031	0.0825	0.0619	0.0103	0.0000	0.0000	0.0000
2004	123	326	0.0000	0.0000	0.0407	0.0650	0.2439	0.1138	0.1220	0.0976	0.0569	0.0488	0.1057	0.0650	0.0163	0.0081	0.0081	0.0081
2005	0	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2006	79	382	0.0127	0.0000	0.0253	0.1139	0.0633	0.1139	0.1772	0.1519	0.0253	0.0886	0.0506	0.1266	0.0506	0.0000	0.0000	0.0000
2007	104	397	0.0000	0.0096	0.0577	0.0577	0.1635	0.1731	0.1635	0.0769	0.1058	0.0769	0.0577	0.0096	0.0385	0.0096	0.0000	0.0000

Table 5.7. Habitat-depth strata for the Florida Keys RVC survey domain (a) prior to implementation of no-take marine reserves, and (b) post-implementation of reserves. Nh is the number of primary sample units (dimensions 200 m by 200 m; 40,000 m^2) comprising a stratum; Wh is the corresponding proportion of the domain contained within a stratum.

(a)

Stratum Code	Description	Nh	Wh
PCHR	Hawk's Channel patch reefs	4914	0.3518
HRRF	High-relief habitat (reefs extend >3 m vertically, mostly occurs in shallow forereef)	345	0.0247
FRSH	Forereef, depth 0-6 m, low-relief (reefs extend <2 m vertically from sand base)	1489	0.1066
FRMD	Forereef, depth 6-18 m, low-relief	5845	0.4184
FRDP	Forereef, depth 18-33 m, low-relief	1376	0.0985
	Total	**13969**	**1**

(b)

Stratum Code	Protected	Nh	Wh
PCHR	0	4751	0.3401
PCHR	1	163	0.0117
HRRF	0	170	0.0122
HRRF	1	175	0.0125
FRSH	0	1374	0.0984
FRSH	1	115	0.0082
FRMD	0	5489	0.3929
FRMD	1	356	0.0255
FRDP	0	1376	0.0985
	Total	**13969**	**1**

Table 5.8. RVC primary unit sample sizes by strata and year for the period 1994-2008 in the Florida Keys survey domain. The period represents the time when full habitat stratification of the survey domain was employed. The actual number of scientific dives in a year is computed by multiplying the Total by 2.

Year	PCHR Open	MPA	HRRF Open	MPA	FRSH Open	MPA	FRMD Open	MPA	FRDP Open	Total
1994	36		43		20		27		0	126
1995	76		106		35		74		0	291
1996	46		65		26		14		0	151
1997	127		117		60		104		0	408
1998	110	59	50	97	48	42	43	12	0	461
1999	62	22	23	88	26	6	168	45	0	440
2000	102	52	22	68	44	20	176	43	0	527
2001	145	28	94	134	93	40	138	45	25	742
2002	107	24	47	50	18	19	281	53	29	628
2003	92	24	53	62	40	21	95	37	24	448
2004	42	6	33	54	30	4	48	14	15	246
2005	123	19	34	55	49	14	110	48	46	498
2006	138	33	43	46	52	42	153	59	42	608
2007	137	24	32	62	50	22	204	41	47	619
2008	186	30	42	43	75	29	219	65	46	735

Table 5.9. Habitat-region strata for the Dry Tortugas RVC survey domain: (a) prior to implementation of no-take marine reserves; and, (b) post-implementation of reserves. Nh is the number of primary sample units (dimensions 200 m by 200 m; 40,000 m^2) comprising a stratum; Wh is the corresponding proportion of the domain contained within a stratum.

(a)

Stratum Code	Location	Habitat	Nh	Wh
BANK_CONT_LR	Tortugas Bank	Contiguous reef, low-relief	2584	0.3172
BANK_CONT_HR	Tortugas Bank	Contiguous reef, high-relief	359	0.0441
BANK_ISOL_LR	Tortugas Bank	Isolated reef structures, low-relief	45	0.0055
BANK_ISOL_MR	Tortugas Bank	Isolated reef structures, medium-relief	422	0.0518
BANK_ISOL_HR	Tortugas Bank	Isolated reef structures, high-relief	20	0.0025
PARK_CONT_LR	Dry Tortugas National Park	Contiguous reef, low-relief	2403	0.2950
PARK_CONT_MR	Dry Tortugas National Park	Contiguous reef, medium-relief	211	0.0259
PARK_CONT_HR	Dry Tortugas National Park	Contiguous reef, high-relief	39	0.0048
PARK_ISOL_LR	Dry Tortugas National Park	Isolated reef structures, low-relief	905	0.1111
PARK_ISOL_MR	Dry Tortugas National Park	Isolated reef structures, medium-relief	736	0.0903
PARK_ISOL_HR	Dry Tortugas National Park	Isolated reef structures, high-relief	21	0.0026
PARK_SPGR_LR	Dry Tortugas National Park	Spur-groove reef, low-relief	283	0.0347
PARK_SPGR_HR	Dry Tortugas National Park	Spur-groove reef, high-relief	119	0.0146
		Total	**8147**	**1**

(b)

Stratum Code	Protected	Nh	Wh
BANK_CONT_LR	0	1120	0.1375
BANK_CONT_LR	1	1464	0.1797
BANK_CONT_HR	0	37	0.0045
BANK_CONT_HR	1	322	0.0395
BANK_ISOL_LR	0	28	0.0034
BANK_ISOL_LR	1	17	0.0021
BANK_ISOL_MR	0	133	0.0163
BANK_ISOL_MR	1	289	0.0355
BANK_ISOL_HR	1	20	0.0025
PARK_CONT_LR	0	2403	0.2950
PARK_CONT_MR	0	211	0.0259
PARK_CONT_HR	0	39	0.0048
PARK_ISOL_LR	0	905	0.1111
PARK_ISOL_MR	0	736	0.0903
PARK_ISOL_HR	0	21	0.0026
PARK_SPGR_LR	0	283	0.0347
PARK_SPGR_HR	0	119	0.0146
	Total	**8147**	**1**

Table 5.10. Primary unit sample sizes by strata and year for the Dry Tortugas RVC survey from 1999-2008.

	BANK_CONT_LR		BANK_CONT_HR		BANK_ISOL_LR		BANK_ISOL_MR		BANK_ISOL_HR		PARK CONT_LR	PARK CONT_MR	PARK CONT_HR	PARK ISOL_LR	PARK ISOL_MR	PARK ISOL_HR	PARK SPGR_LR	PARK SPGR_HR	
Year	**Open**	**MPA**	**Open**	**MPA**	**Open**	**MPA**	**Open**	**MPA**	**Open**	**MPA**	**Open**	**Open**	**Open**	**Open**	**Open**	**Open**	**Open**	**Open**	**Total**
1999	51		61		17		31		16		47	8	10	12	14	6	30	24	327
2000	51		31		40		21		10		64	17	12	45	52	7	9	22	381
2004	41	18	9	32	19	4	19	54		18	146	39	33	44	45	14	26	8	569
2006	43	23	6	32	4	6	15	55		8	117	43	24	14	60	14	18	8	490
2008	56	47	10	18	10	14	22	48		23	108	87	31	56	51	22	36	14	653

Table 5.11. Estimates of length-specific abundance for black grouper in the Florida Keys obtained from the U. Miami/NMFS RVC diver survey.

FLen (cm)		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2		0	0	0	0	0	0	9171	0	0	0	0	0	0	0	0
3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6		0	0	640	0	0	0	0	4464	0	658	0	0	0	0	0
7		0	0	0	0	0	0	0	4464	0	0	0	0	0	0	0
8		0	0	0	0	0	0	0	688	0	5592	0	0	0	0	0
9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10		0	0	0	0	6058	0	844	4464	0	5592	0	0	512	0	0
11		0	0	0	0	0	0	0	4464	0	0	0	0	0	0	0
12		0	0	0	5467	0	0	6463	4464	5577	0	0	0	3887	0	0
13		0	0	0	0	0	0	0	0	0	0	0	9299	4295	0	0
14		0	0	0	0	42010	15047	0	0	0	0	0	0	0	0	0
15		0	0	0	0	12525	0	20028	643	4454	11842	0	0	0	0	5828
16		0	0	0	0	1113	0	0	8928	0	0	12202	4330	0	0	0
17		0	0	0	0	6058	2251	0	0	0	0	0	0	4295	0	2914
18		17138	3893	0	0	54535	24566	0	0	9093	0	0	0	0	0	7871
19		0	0	0	0	0	6410	0	0	5376	0	0	0	4295	0	5639
20		35135	0	13013	8272	7042	70246	35864	23331	32730	0	24968	9587	5697	0	8553
21		0	0	0	10935	408	0	0	0	9619	0	0	0	4544	0	0
22		0	0	0	0	6058	437	24384	9486	3375	658	0	4330	0	6868	0
23		0	0	0	0	42010	6562	59599	0	8626	0	0	0	4295	0	0
24		0	0	0	0	408	0	45432	0	6098	0	0	0	4033	14543	5733
25		0	137621	640	5467	48644	30363	25645	21649	12333	14548	3070	5416	10597	23861	14381
26		17138	0	0	5467	3113	54663	16056	0	10031	1032	0	0	0	4147	0
27		0	0	13013	36861	6058	4840	2195	4464	0	0	0	394	0	6868	3989
28		17138	0	0	0	42010	3033	18658	874	7037	11184	0	805	4786	7492	9676
29		0	0	0	0	408	1126	0	5680	0	0	0	0	0	309	0
30		408277	4006	0	6232	42010	15047	67330	41122	49917	6250	366	9515	15152	20236	43039
31		0	0	0	0	0	3033	1098	0	0	5592	0	6210	0	3433	6437
32		0	0	0	459	4077	2038	0	23903	12987	5920	732	3764	512	3743	12533
33		0	0	0	0	0	0	18612	0	4809	10212	0	11502	0	3838	2819
34		0	0	0	459	90252	12283	6463	6368	3828	7233	0	0	0	309	5639
35		18427	0	426	43093	52350	68254	52478	58903	59577	21466	15560	46232	26741	35983	43818
36		1289	0	640	36861	296	31697	1098	4464	2227	0	0	0	0	0	2504
37		1402	0	0	0	296	0	844	0	2227	165	366	14712	0	565	5733
38		0	0	0	459	0	0	10863	17015	6681	5592	366	12490	4328	8007	5566
39		0	0	0	0	45419	0	0	10144	283	0	0	0	0	0	2819
40		18540	0	1921	12313	47012	1516	23365	98485	57464	7613	732	76180	29494	25000	27431
41		0	0	0	0	0	1601	0	0	7515	1654	0	0	8065	618	2914
42		0	0	0	459	796	24566	3714	6424	7515	5592	0	11502	4033	3433	6814
43		0	684	0	6386	0	1516	0	11847	3755	0	0	0	0	874	1832
44		0	0	640	0	0	0	0	688	11972	1032	0	8421	0	309	609
45		19830	0	8667	43706	46179	28447	87136	47984	20976	11510	11222	77030	23091	11853	29201
46		0	0	0	0	0	0	0	688	2227	0	0	0	0	309	0
47		0	0	0	0	0	291	0	16799	0	0	0	0	649	0	0
48		0	0	0	0	0	0	2343	2110	17710	5980	732	0	0	0	2819
49		0	0	0	459	0	0	0	5840	1915	0	0	0	0	0	461
50		0	0	1921	459	0	2623	19881	46089	38014	46567	24781	65393	18396	29173	35138
51		0	0	0	0	0	0	1098	7104	2227	0	0	0	0	0	0
52		0	0	0	0	0	0	0	186	14422	343	732	842	0	958	2819
53		0	0	0	0	0	0	0	5914	2227	0	0	0	0	0	2819
54		0	0	0	0	0	0	0	279	0	0	0	0	0	0	3380
55		0	0	0	459	888	30096	15969	13837	15848	7639	3972	3764	7149	14946	8190
56		0	0	0	0	0	0	0	0	4454	165	366	0	0	0	609
57		1402	0	0	0	0	0	0	1375	0	0	0	0	0	0	0
58		0	0	0	0	0	0	0	372	6023	0	0	3369	0	759	3374
59		0	0	0	0	0	0	320	0	2510	0	0	0	0	0	0
60		0	684	640	0	296	10022	13443	33479	34725	24432	35421	70659	38916	35011	23138
61		0	0	0	0	0	0	0	172	0	0	0	8332	0	3037	0
62		0	0	0	0	0	0	0	0	0	1316	0	0	0	3037	457
63		0	0	640	0	0	0	1646	0	0	0	366	0	0	309	0
64		0	0	640	0	0	0	0	0	0	0	0	0	0	0	0
65		0	0	640	3264	0	0	2700	15402	18076	5051	43175	25585	10200	5627	12146
66		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67		0	0	0	0	0	0	0	186	0	0	0	0	0	0	0
68		0	0	0	0	0	0	0	186	0	328	565	0	0	309	461
69		0	0	0	0	0	0	0	0	947	0	0	0	0	0	3380
70		0	0	1281	0	0	30533	2059	12688	9915	15933	55458	50576	12067	48818	2139
71		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
72		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73		0	0	0	0	0	0	0	172	0	0	0	0	0	0	0
74		0	0	0	0	0	0	0	0	0	328	565	0	0	0	0
75		0	0	0	0	0	0	0	4471	23833	3737	7774	9759	13197	31247	3841
76		0	0	0	0	0	0	0	0	0	0	0	0	0	3037	0
77		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
79		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80		0	0	0	0	0	0	2059	9102	22506	9250	27452	21920	7775	14120	0
81		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83		0	0	0	0	0	0	0	0	380	328	21470	0	0	0	0
84		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85		0	0	0	0	0	874	0	2813	6098	2391	10856	0	649	0	0
86		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88		0	0	0	0	0	0	0	0	0	0	0	0	0	759	0
89		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90		0	0	0	0	0	3250	0	0	380	1976	32326	1839	491	7088	0
91		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
92		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
94		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95		0	0	0	0	0	0	0	0	6098	9401	366	0	0	0	0
96		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
98		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100		0	0	0	0	0	0	320	12335	15773	1643	42449	1199	0	6074	0
101		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
102		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
103		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
104		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
105		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
106		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
107		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
108		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
109		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110		0	0	0	0	0	0	0	0	0	1314	0	3369	7775	3346	0
111		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
112		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
113		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
114		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
115		0	0	0	0	0	0	0	0	1667	0	0	0	0	0	0
116		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
117		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
118		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
119		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
121		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
122		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
123		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
124		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
125		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	**Population**	**555,718**	**146,888**	**45,364**	**227,540**	**608,335**	**487,232**	**599,178**	**617,011**	**614,058**	**279,060**	**378,412**	**578,326**	**279,913**	**390,255**	**369,463**
	Recruits	**513,254**	**145,520**	**27,734**	**122,714**	**467,151**	**320,198**	**410,320**	**228,360**	**245,467**	**107,779**	**56,898**	**111,383**	**93,639**	**131,631**	**178,869**

Table 5.12. Standardized and nominal CPUE indices for black grouper from the headboat data. A CV was calculated using the leave-one-out jackknife estimator implemented by Dick (2004).

Year	Delta-GLM	CV	Nominal
1978	0.97	0.71	0.26
1979	1.66	0.42	0.60
1980	1.47	0.33	0.87
1981	1.32	0.32	0.83
1982	1.55	0.30	1.61
1983	1.76	0.32	2.72
1984	1.05	0.31	1.16
1985	1.28	0.30	1.17
1986	0.85	0.32	0.62
1987	1.35	0.31	1.52
1988	0.48	0.34	0.53
1989	0.78	0.32	0.92
1990	0.57	0.35	0.45
1991	0.68	0.35	0.52
1992	0.83	0.30	0.58
1993	0.55	0.30	0.55
1994	0.78	0.29	0.83
1995	0.97	0.30	1.55
1996	0.82	0.28	0.84
1997	0.53	0.31	0.68
1998	0.63	0.32	0.88
1999	0.44	0.35	0.69
2000	0.39	0.37	0.49
2001	0.41	0.30	0.75
2002	0.59	0.33	1.01
2003	0.52	0.33	1.64
2004	1.00	0.35	2.08
2005	2.97	0.31	2.24
2006	1.26	0.31	0.97
2007	1.90	0.31	1.00
2008	0.64	0.36	0.43

Table 5.13. The number of MRFSS intercepts in southern Florida from Cape Canaveral to Tampa Bay by region, mode of fishing, area, and year.

			Year																	
Region	Mode	Area	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Southeast	Charterboat	<= 3 mi	163	357	183	79	140	94	129	232	633	550	866	1365	1226	765	1023	735	839	746
		> 3 mi	222	276	176	303	215	274	395	499	758	771	1047	1024	897	1049	779	727	594	384
	Private/Rental	<= 3 mi	628	1176	1070	1099	1216	1041	1132	1183	2080	1619	1438	2072	1952	1986	1749	2170	2223	1772
		> 3 mi	590	1058	743	865	994	1059	943	1212	2674	2072	1810	2210	2059	1782	1396	1941	1725	1416
Florida Keys	Charterboat	<= 10 mi	198	306	189	241	155	103	287	413	390	377	217	323	460	296	239	137	311	515
		> 10 mi	119	238	207	186	248	348	760	1362	2372	2468	2680	2991	2932	2320	2051	1537	1836	2636
	Private/Rental	<= 10 mi	382	606	925	794	526	451	767	488	467	133	145	106	205	197	41	174	203	249
		> 10 mi	149	221	143	193	181	471	70	90	136	130	102	129	258	185	50	227	311	277
Southw est	Charterboat	<= 10 mi	14	25	24	28	55	29	168	412	568	389	271	381	578	588	465	145	158	271
		> 10 mi	4	157	77	75	157	37	265	559	601	458	558	692	1071	1113	781	281	297	409
	Private/Rental	<= 10 mi	584	1389	751	788	428	735	1237	1559	1780	912	1375	1419	1352	1694	1502	1741	783	1742
		> 10 mi	218	788	660	650	466	625	390	696	969	584	818	793	652	1181	874	447	353	444
		Total	3271	6597	5148	5301	4781	5267	6543	8705	13428	10463	11327	13505	13642	13156	10950	10262	9633	10861

Table 5.14. Nominal (both positive and all intercepts) and standardized catch rates for black grouper calculated with MRFSS intercepts selected by cluster analysis, coefficients of variation, and the indices scaled to their means by year.

	Nominal (positive intercepts)				Nominal (all intercepts)				Cluster analysis			
Year	Number of intercepts	Mean catch per trip	Coefficient of variation	Index (scaled to mean)	Number of intercepts	Mean catch per trip	Coefficient of variation	Index (scaled to mean)	Number of intercepts	Mean catch per trip	Coefficient of variation	Index (scaled to mean)
1991	21	2.190	0.264	0.93	1382	0.033	0.341	0.52	21	0.146	0.246	0.49
1992	38	1.789	0.132	0.76	2578	0.026	0.208	0.41	38	0.128	0.241	0.43
1993	34	1.941	0.166	0.83	1986	0.033	0.238	0.52	34	0.156	0.240	0.52
1994	37	2.838	0.208	1.21	2130	0.049	0.264	0.77	37	0.237	0.217	0.80
1995	31	2.323	0.226	0.99	2031	0.035	0.288	0.55	31	0.223	0.229	0.75
1996	53	3.396	0.265	1.44	2262	0.080	0.298	1.25	53	0.499	0.224	1.68
1997	70	2.571	0.114	1.09	2631	0.068	0.164	1.07	69	0.316	0.187	1.06
1998	91	2.231	0.094	0.95	3282	0.062	0.139	0.97	90	0.314	0.149	1.06
1999	138	2.638	0.127	1.12	5224	0.070	0.152	1.09	137	0.385	0.138	1.29
2000	137	2.080	0.094	0.88	4223	0.067	0.126	1.06	136	0.274	0.129	0.92
2001	145	2.241	0.089	0.95	4327	0.075	0.120	1.18	144	0.381	0.122	1.28
2002	128	2.398	0.114	1.02	4621	0.066	0.143	1.04	128	0.258	0.142	0.87
2003	161	2.745	0.094	1.17	4544	0.097	0.122	1.52	159	0.408	0.132	1.37
2004	134	2.694	0.147	1.15	3959	0.091	0.170	1.43	131	0.353	0.149	1.19
2005	102	1.951	0.082	0.83	3406	0.058	0.127	0.91	102	0.242	0.161	0.81
2006	66	1.727	0.091	0.73	3487	0.033	0.152	0.51	65	0.156	0.178	0.53
2007	100	2.020	0.101	0.86	3077	0.066	0.141	1.03	97	0.204	0.149	0.69
2008	103	2.107	0.109	0.90	3319	0.065	0.146	1.02	103	0.190	0.170	0.64
Total	1589				58469				1575			

Table 5.15. Vertical line relative nominal CPUE, number of trips, proportion positive trips, and relative abundance index for black grouper (1993-2008) in the Gulf of Mexico and South Atlantic.

YEAR	Relative Nominal CPUE	Trips	Proportion Successful Trips	Relative Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1993	1.005205	1,549	0.706262	0.760265	0.584593	0.988727	0.131945
1994	0.937506	2,175	0.647816	0.753406	0.588052	0.965257	0.124372
1995	1.03721	1,881	0.681021	0.807998	0.631444	1.033918	0.123745
1996	1.163521	1,923	0.74207	0.830801	0.652144	1.058402	0.121507
1997	0.70797	2,647	0.697015	0.749053	0.586204	0.957143	0.123033
1998	0.779819	2,693	0.752692	0.970882	0.7647	1.232655	0.119787
1999	0.766768	2,375	0.784421	0.75778	0.589364	0.974323	0.126173
2000	0.858588	2,337	0.792897	0.821114	0.639876	1.053686	0.12518
2001	1.002164	2,571	0.793855	1.24974	0.984355	1.586674	0.119779
2002	0.966789	2,317	0.764782	1.150358	0.905669	1.461156	0.120006
2003	1.292723	2,224	0.727518	1.279496	1.003433	1.631509	0.12197
2004	1.304033	2,017	0.76946	1.348231	1.062721	1.710446	0.119403
2005	1.076439	1,819	0.778999	1.317928	1.037823	1.673633	0.119895
2006	1.152239	1,393	0.737976	1.381648	1.076979	1.772506	0.125043
2007	1.239348	1,136	0.682218	1.017537	0.787554	1.314682	0.128632
2008	0.709679	1,101	0.642144	0.803761	0.604597	1.068533	0.143094

Table 5.16. Longline relative nominal CPUE, number of trips, proportion positive trips, and relative abundance index for black grouper (1993-2008) 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)
1993	0.263172	382	0.837696	0.389993	0.06256	2.43118	1.144533
1994	0.293037	462	0.727273	0.304463	0.037176	2.493504	1.42157
1995	0.460769	295	0.738983	0.402581	0.046863	3.458447	1.475914
1996	0.455659	403	0.801489	0.454841	0.0834	2.480589	1.026217
1997	0.884469	619	0.739903	0.459357	0.091212	2.313402	0.960229
1998	1.124559	578	0.875433	0.753783	0.259771	2.18727	0.572764
1999	1.221014	596	0.901007	0.832058	0.315092	2.197198	0.515587
2000	1.483386	498	0.901606	1.061633	0.446348	2.525084	0.454379
2001	1.462713	584	0.917808	1.406196	0.720808	2.743294	0.343682
2002	1.408771	517	0.905222	1.580777	0.826448	3.023607	0.332981
2003	1.059397	630	0.907937	1.836644	1.026655	3.285683	0.297076
2004	1.986202	636	0.900943	1.868794	1.08469	3.219713	0.277109
2005	1.491005	591	0.886633	1.802807	1.039227	3.127432	0.280741
2006	1.046025	656	0.829268	1.106723	0.472748	2.590884	0.445274
2007	0.983704	460	0.854348	1.04919	0.353905	3.110436	0.58606
2008	0.376118	498	0.779116	0.69016	0.177923	2.67711	0.763618

Table 5.17. Pearson correlation coefficients between indices recommended for the SEDAR 19 assessment of black grouper. Values in parentheses are p-values where the null hypothesis is that the specified indices are uncorrelated (calculated using the function "cor.test" in the R statistical programming platform). Note that the FWC and RVC indices were based on all observed fish, not just those in exploitable phases.

	FWC visual	RVC	Headboat	MRFSS	Logbook Vertical Line
RVC	0.44 (0.27)	1			
Headboat	0.01 (0.98)	-0.22 (0.43)	1		
MRFSS	0.41 (0.31)	-0.21 (0.45)	-0.40 (0.10)	1	
Logbook Vertical Line	-0.75 (0.03)	0.17 (0.55)	-0.23 (0.40)	0.06 (0.84)	1
Logbook Longline	-0.50 (0.20)	0.35 (0.20)	-0.20 (0.45)	0.19 (0.48)	0.87 (0.00)

Table 5.18. A summary of all indices recommended for the SEDAR 19 black grouper assessment together with estimated coefficient of variation (CV). All indices have been standardized to their mean.

Year	FWC visual	CV	RVC	CV	Headboat	CV	MRFSS	CV	Logbook Vertical Line	CV	Logbook Longline	CV
1986					0.98	0.32						
1987					1.56	0.31						
1988					0.55	0.34						
1989					0.90	0.32						
1990					0.66	0.35						
1991					0.78	0.35	0.54	0.25				
1992					0.96	0.30	0.47	0.24				
1993					0.63	0.30	0.58	0.24	0.759	0.132	0.390	1.145
1994			1.35	0.16	0.90	0.29	0.88	0.22	0.752	0.124	0.304	1.422
1995			0.36	0.19	1.12	0.30	0.82	0.23	0.808	0.124	0.403	1.476
1996			0.11	0.48	0.95	0.28	1.85	0.22	0.831	0.122	0.455	1.026
1997			0.55	0.17	0.61	0.31	1.17	0.19	0.751	0.123	0.459	0.960
1998			1.48	0.26	0.73	0.32	1.16	0.15	0.970	0.120	0.754	0.573
1999	1.50	0.15	1.18	0.13	0.51	0.35	1.42	0.14	0.757	0.126	0.832	0.516
2000	1.22	0.16	1.46	0.11	0.45	0.37	1.01	0.13	0.819	0.125	1.062	0.454
2001	1.02	0.14	1.50	0.14	0.47	0.30	1.41	0.12	1.248	0.120	1.406	0.344
2002	0.84	0.13	1.49	0.13	0.68	0.33	0.95	0.14	1.149	0.120	1.581	0.333
2003	0.76	0.16	0.68	0.17	0.60	0.33	1.51	0.13	1.280	0.122	1.837	0.297
2004	1.04	0.19	0.92	0.26	1.15	0.35	1.30	0.15	1.351	0.119	1.869	0.277
2005			1.40	0.12	3.43	0.31	0.89	0.16	1.322	0.120	1.803	0.281
2006	0.78	0.17	0.68	0.16	1.45	0.31	0.58	0.18	1.382	0.125	1.107	0.445
2007	0.83	0.16	0.95	0.14	2.19	0.31	0.75	0.15	1.016	0.129	1.049	0.586
2008			0.90	0.11	0.74	0.36	0.70	0.17	0.803	0.143	0.690	0.764
Units	Numbers		Numbers		Numbers		Numbers		Pounds		Pounds	

5.11. *FIGURES*

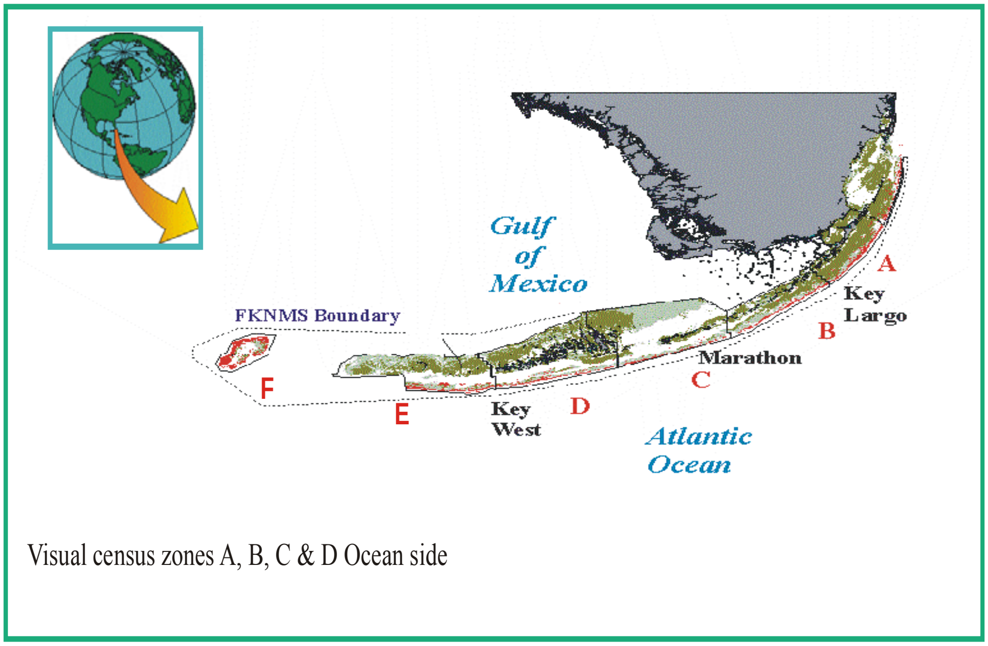

Figure 5.1. Map of FWC visual survey sampling areas in the Florida Keys National Marine Sanctuary (FKNMS).

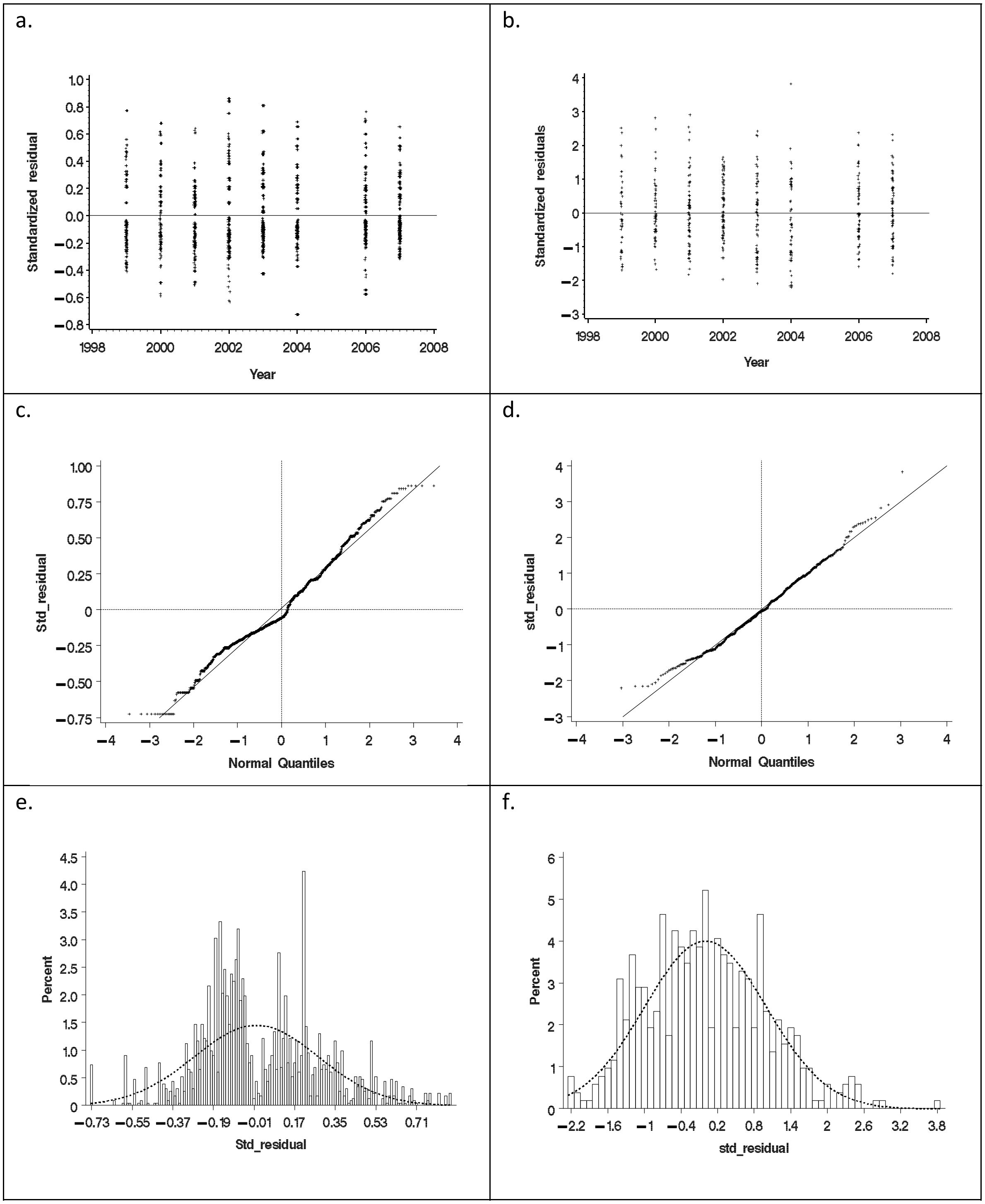

Figure 5.2. Diagnostics for revised FWC visual survey for black grouper. Quantile plot (a) and standardized residuals (b) of the generalized linear model (GLM) using a binomial distribution with a logit link for the proportion of positive black grouper intercepts and a quantile plot (c) and standardized residuals (d) of the GLM using a log-normal distribution with an identity link for the number of black grouper observed per point-count on positive dive/habitats from dive/habitat point-counts.

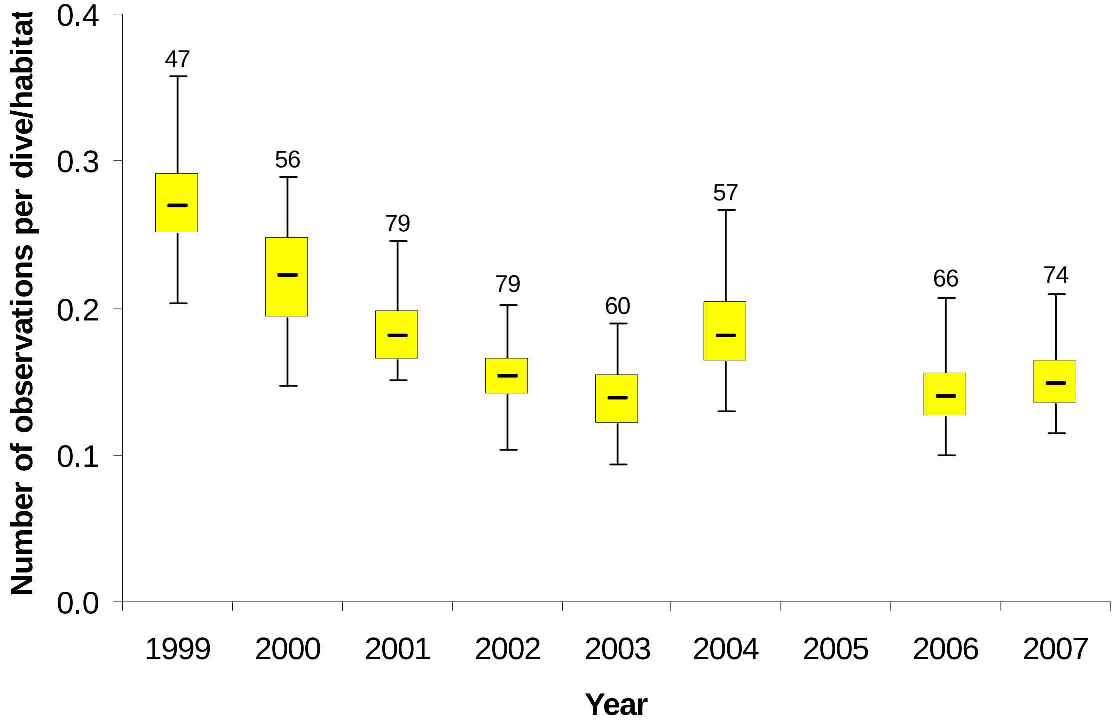

Figure 5.3. The estimated number of black grouper per dive/habitat point-count by year observed by the visual survey. Vertical line – 95% confidence interval, box – inter-quartile range, horizontal line – median, and the number is the number of dive/habitats where black grouper were observed.

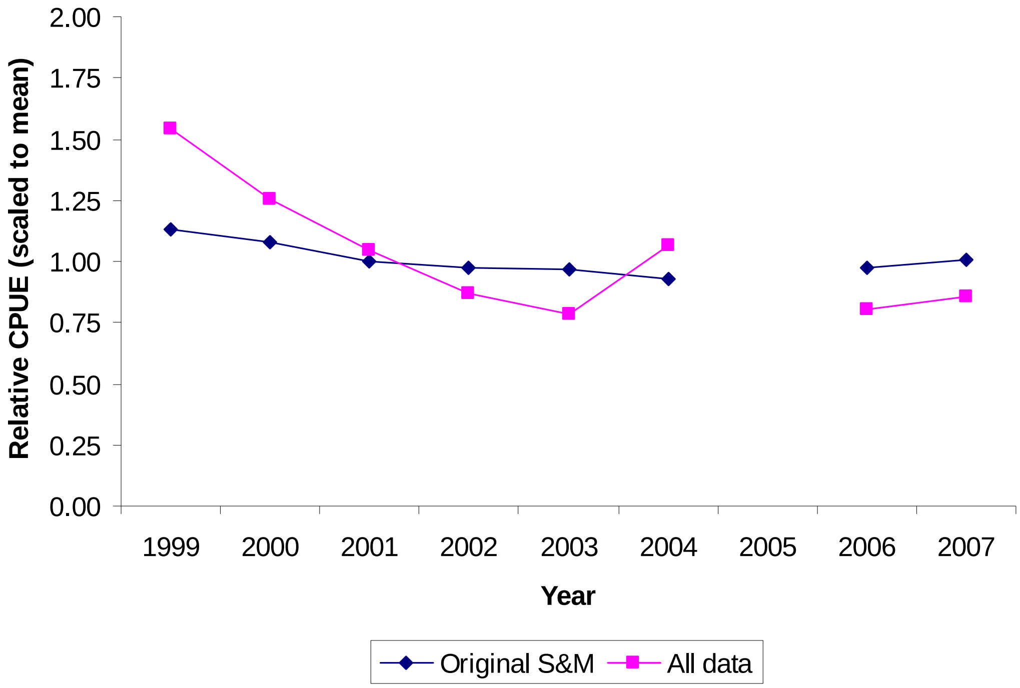

Figure 5.4. Comparison of nominal black grouper catch rates (number observed per dive/habitat) to standardized catch rates from the FWC visual survey.

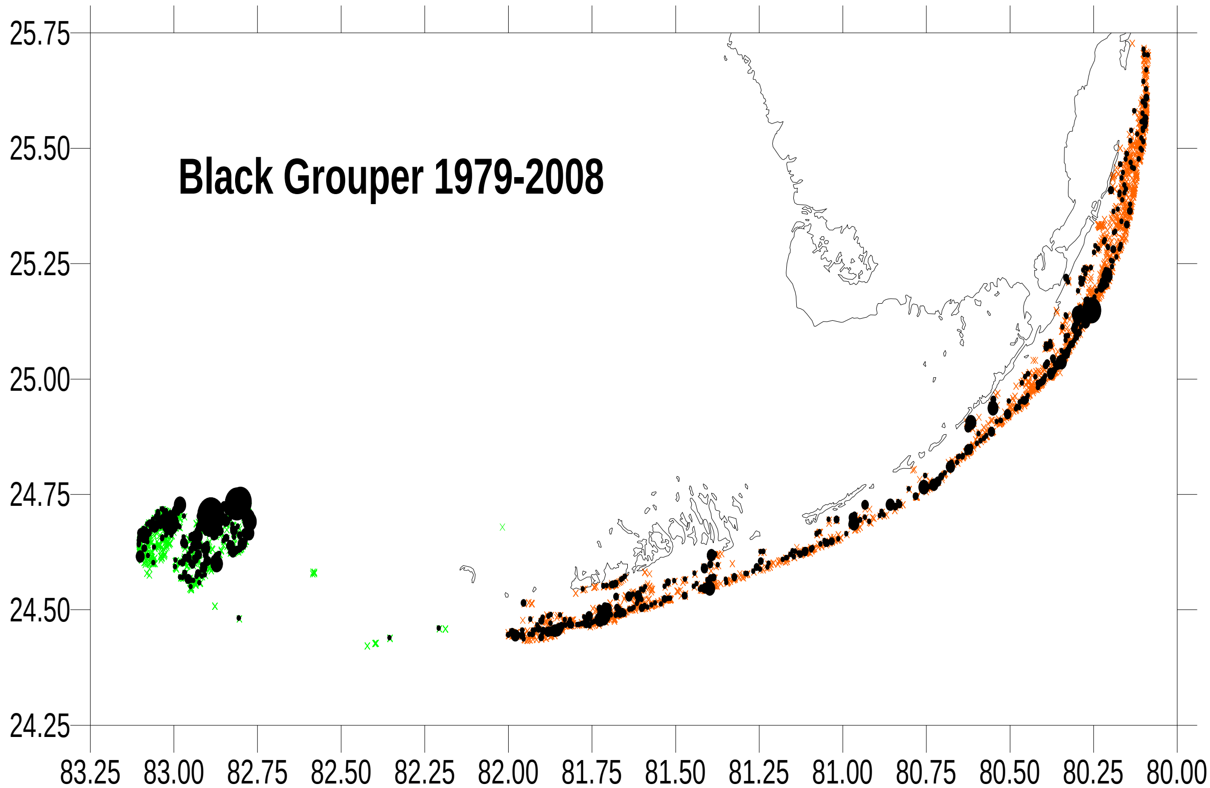

Figure 5.5. Effort and number of black grouper observed per sampling plot during the RVC for both the Florida Keys (1979 – 2007) and Dry Tortugas (1994 – 2008). Orange crosses represent RVC effort for the Florida Keys sampling area (14715 sampling plots); while green crosses represent RVC effort for the Dry Tortugas sampling area (4005 sampling plots). Black circles indicate plots where black grouper were observed. The diameters of the circles are linearly related to the number of black grouper observed at each sampling plot (non-zero range: 1 – 15 black grouper per sampling plot).

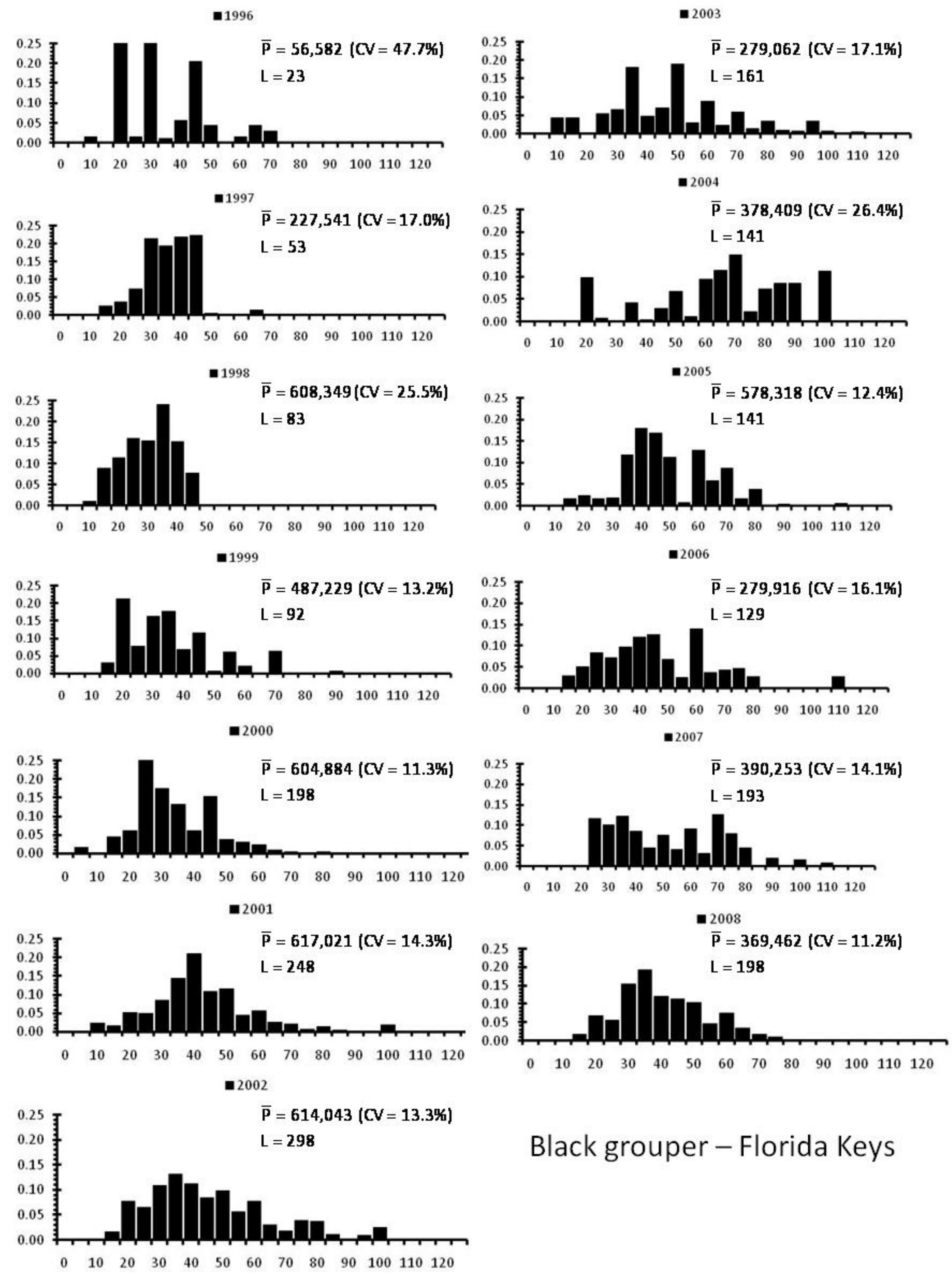

Figure 5.6. Proportion of population abundance ($\overline{P}$) at length binned at 5 cm intervals for black grouper (*Mycteroperca bonaci*) in the Florida Keys RVC sampling domain for the years 1996-2008. CV is the coefficient of variation of population abundance, and *L* is the raw number of black grouper observations in the survey.

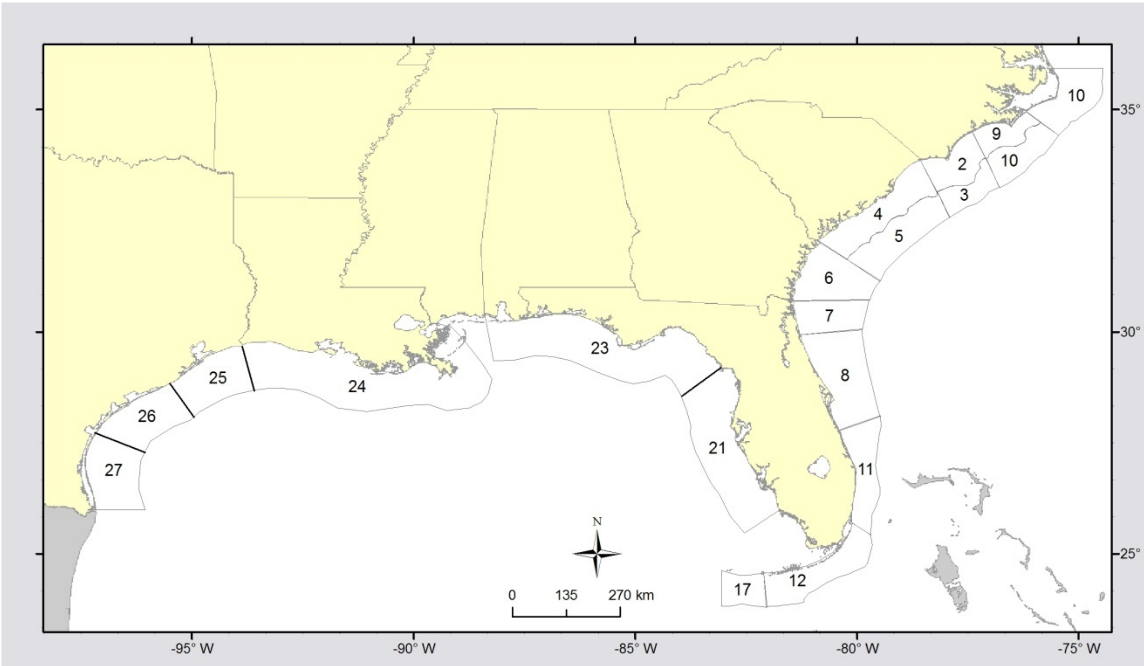

Figure 5.7. Spatial sampling strata from the headboat survey off the southeast U.S. Spatial strata 11, 12, 17, and 21 were considered as likely to have caught black grouper and were included in CPUE standardization.

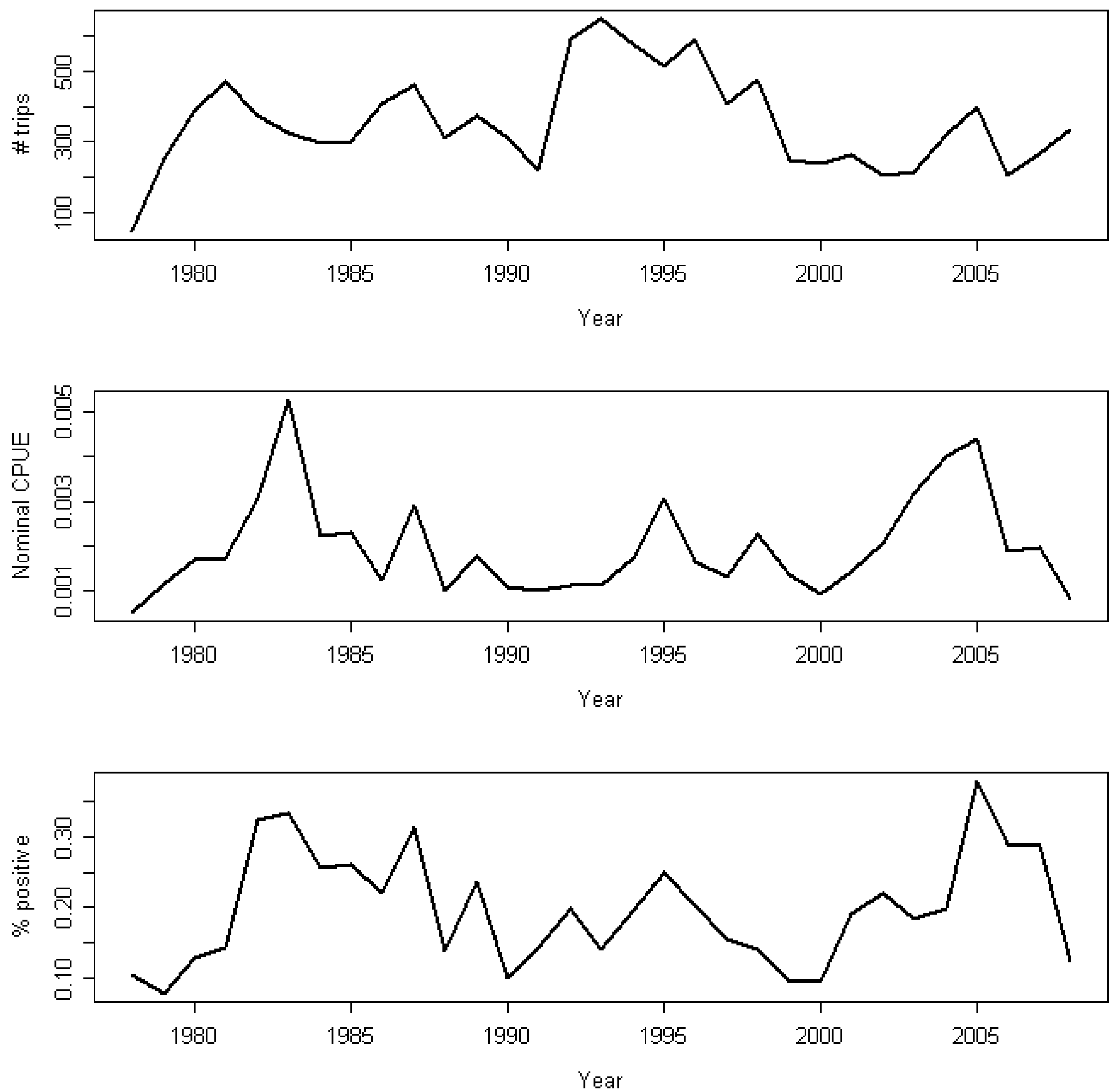

Figure 5.8. Sample sizes, nominal CPUE, and % of positive observations by year for headboat trips selected by the method of Stephens and MacCall (2004).

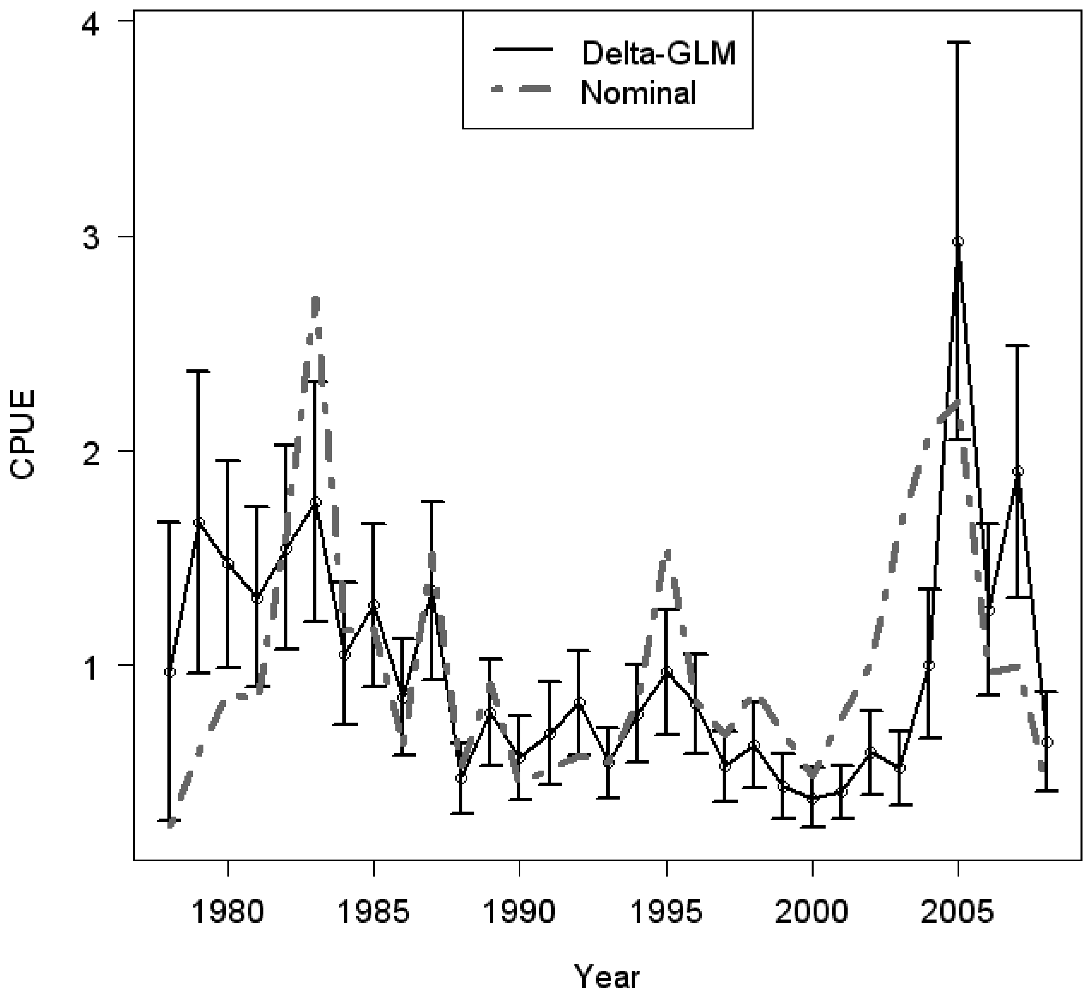

Figure 5.9. The standardized delta-GLM headboat index for black grouper. Black circles and error bars (+/- 1 SE) represent values from the standardized index. Also presented for reference is nominal CPUE for those trips selected by the method of Stephens and MacCall (2004; red dashed line).

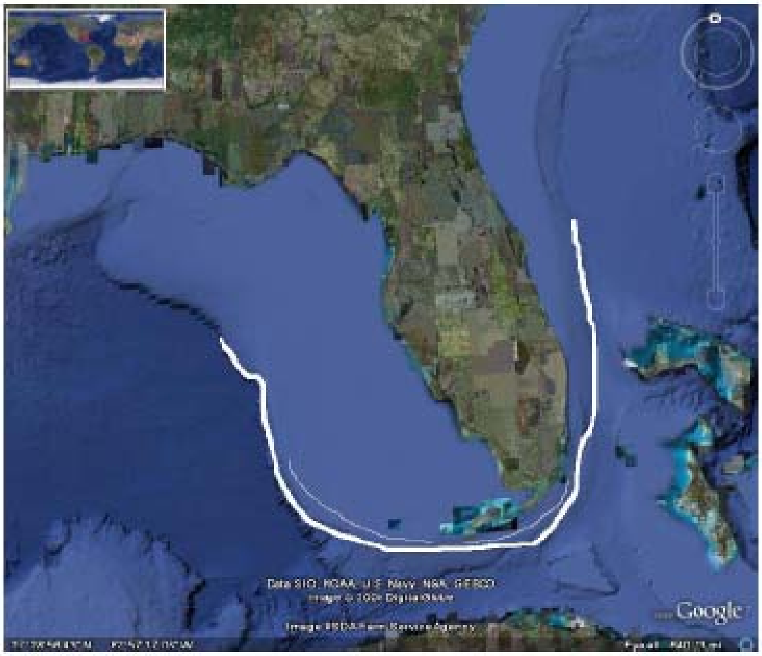

Figure 5.10. A map of Florida indicating the region from Tampa Bay to Cape Canaveral (thick line) and the Florida keys (thin line). Intercepts and records from these areas were used to construct the MRFSS index for black grouper.

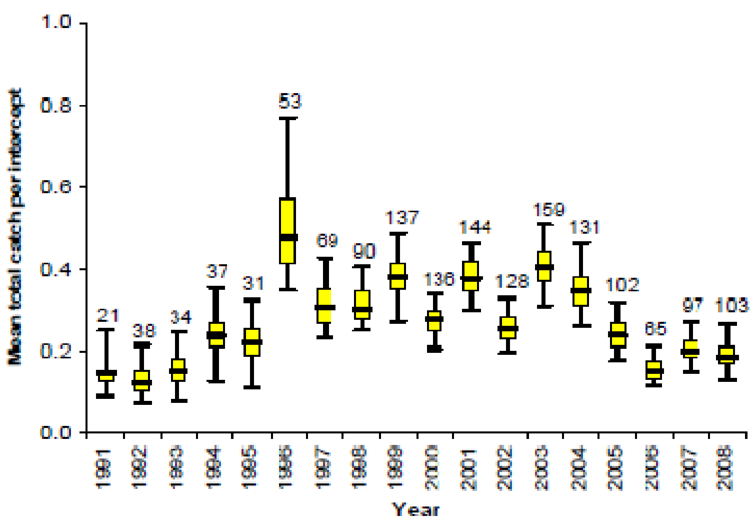

Figure 5.11. A classical box-and-whisker plot summarizing standardized total catch of black grouper per MRFSS intercept with intercepts selected by cluster analysis. The number above the lines are the number of subsetted intercepts that caught black grouper that year.

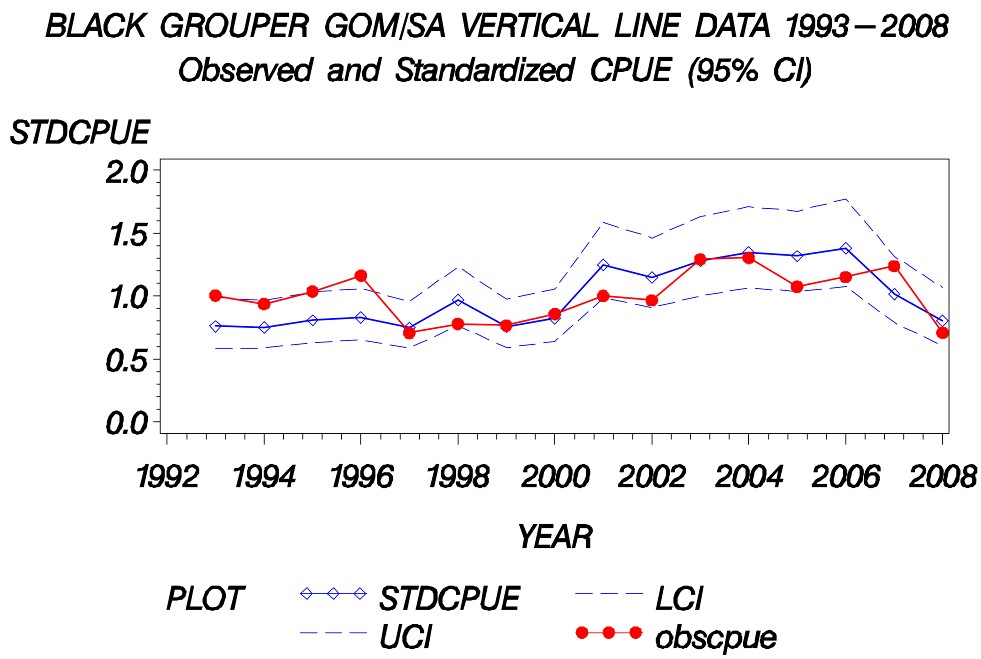

Figure 5.12. Black grouper nominal CPUE (solid circles), standardized CPUE (open diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dashed lines) for vessels fishing vertical line gear in the Gulf of Mexico and South Atlantic.

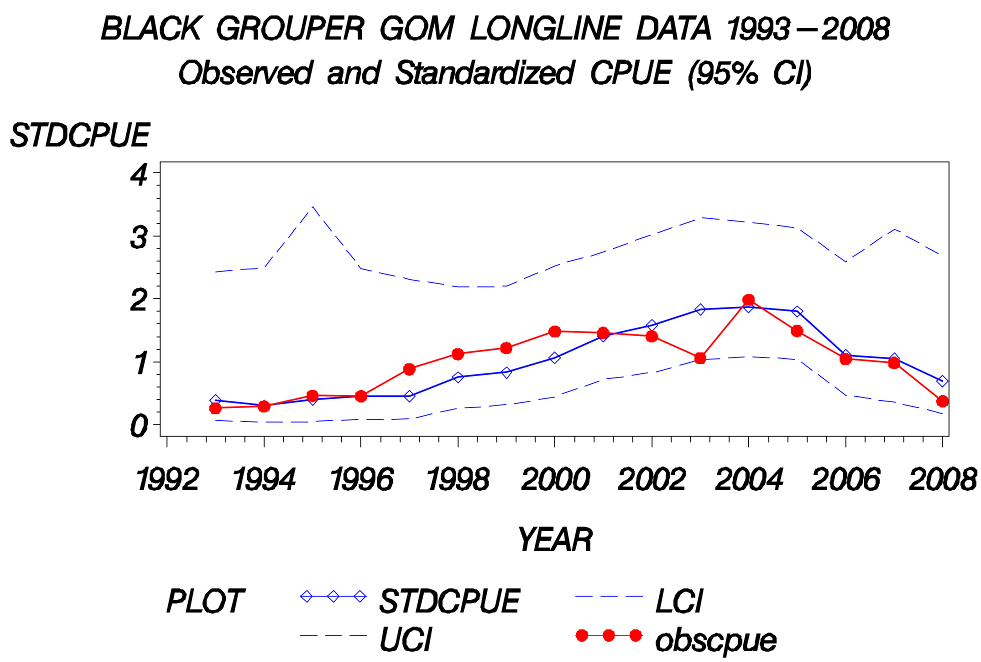

Figure 5.13. Black grouper nominal CPUE (solid circles), standardized CPUE (open diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dashed lines) for vessels fishing longline gear in the Gulf of Mexico.

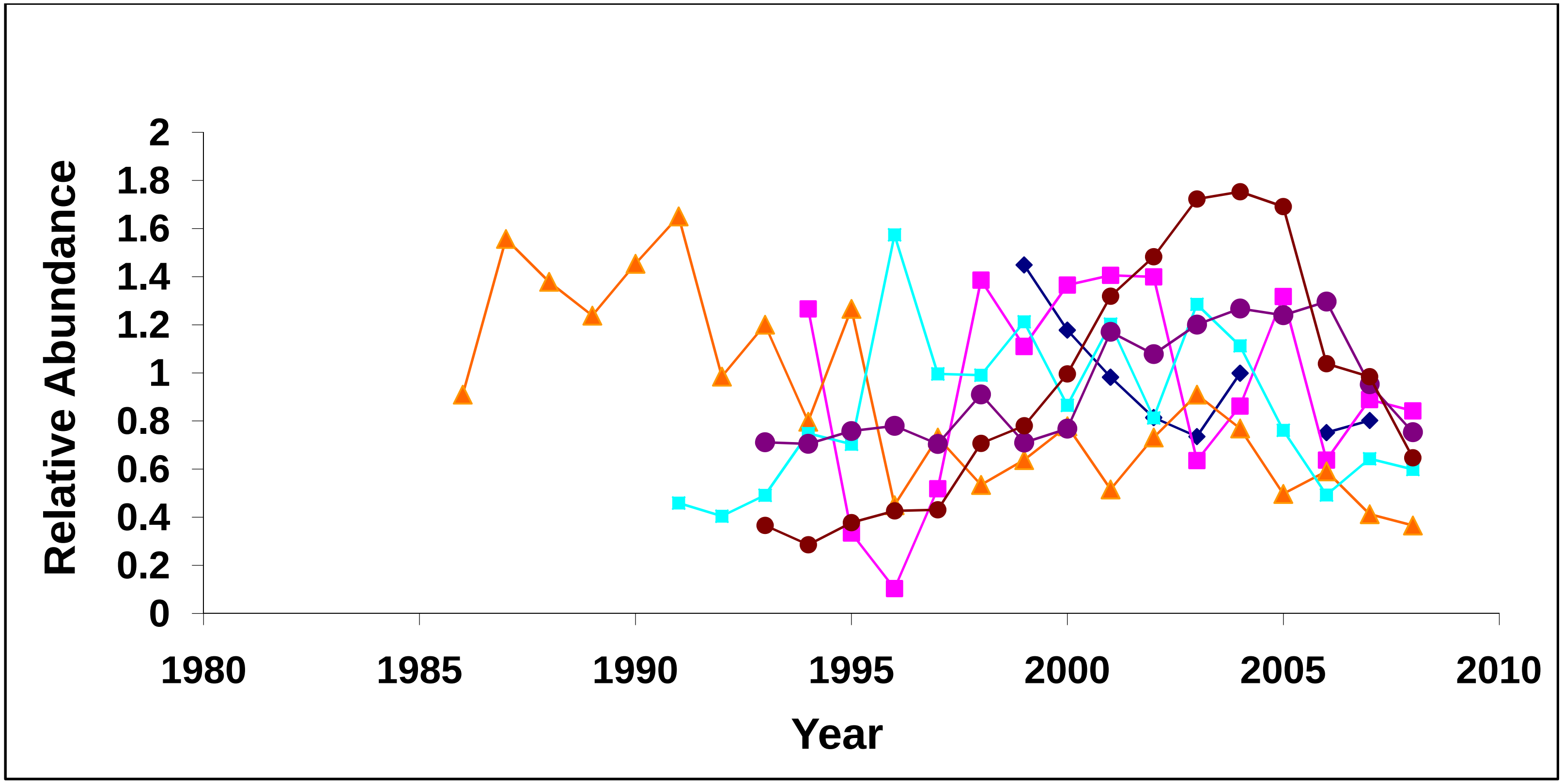

Figure 5.14. Black grouper CPUE time series recommended for use in stock assessment. Orange triangles represent recreational headboat, large pink squares represent the RVC survey, small aqua squares represent MRFSS, large purple circles represent commercial logbooks (vertical lines), small brown circles represent commercial logbooks (longline), and navy diamonds represent the FWC visual survey. All indices are standardized to a common time scale.

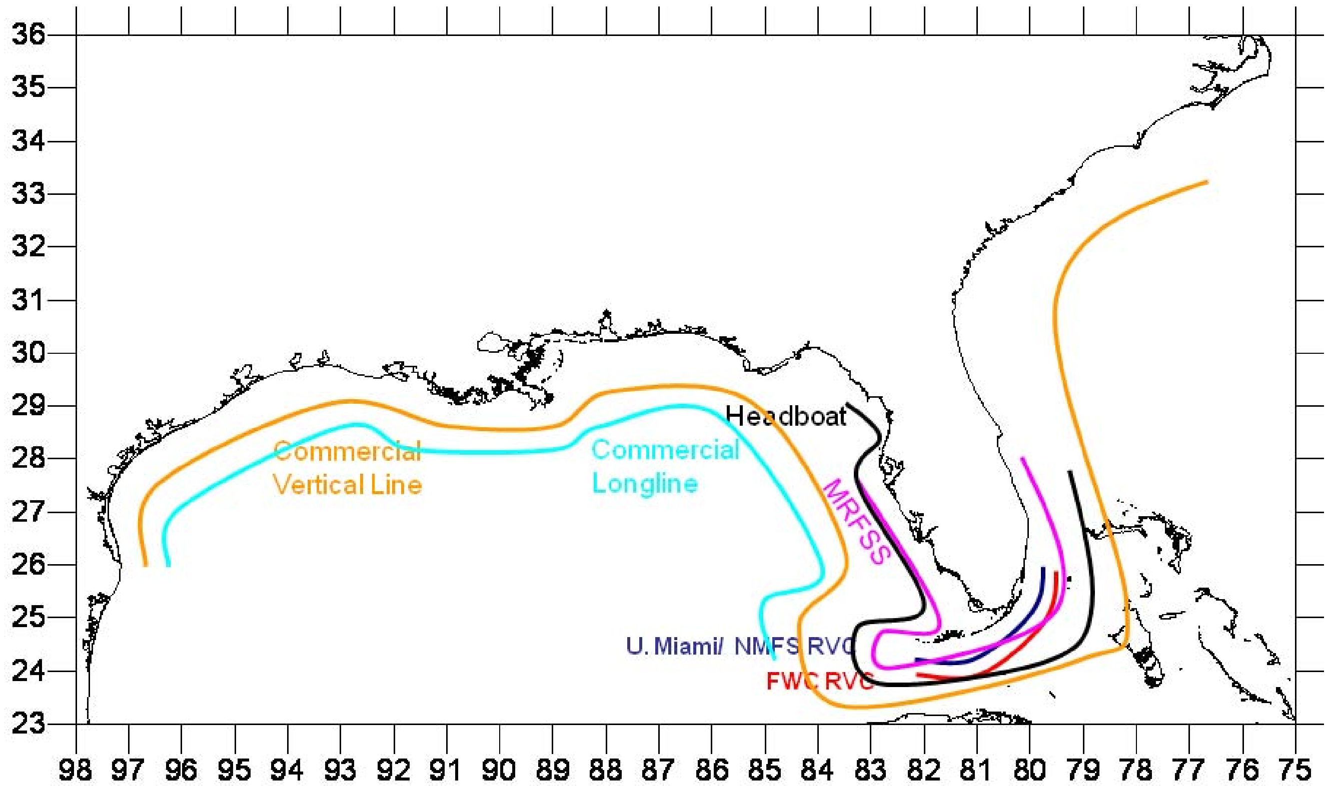

Figure 5.15. A map showing the spatial coverage of each survey recommended for use in index construction for SEDAR 19 (black grouper).

6. RESEARCH RECOMMENDATIONS

6.1. *LIFE HISTORY*

- The DW LH WG recognized the value of continuing the otolith workshops and exchange of otoliths in preparation for SEDAR data workshops. These workshops are especially important for species that have been recognized as relatively difficult to age.
- The DW LH WG also recognizes the value of similar workshops to discuss the interpretation of reproductive samples, and the possible exchange of histological sections between labs in preparation for SEDAR Data Workshops. This will be especially important for species that have been recognized as relatively difficult to stage.
- Because little or no fecundity information is available for *M. bonaci* (black grouper) from the South Atlantic or the Gulf of Mexico, the DW LH WG recommends initiating a study to further identify aggregations and spawning locations, movements relating to aggregations and spawning, and to estimate fecundity for female age classes in both the GOM and Atlantic populations.
- The data on catch distributions of black grouper (*M. bonaci*) presented at the DW suggest that there are habitat and depth characteristics in the Florida Keys and the shelf areas of the South Atlantic and west Florida that are influencing the movements of this species. The DW LH WG recommends a study to further investigate movements of this species, especially individuals that are mature females and males, by use of genetic tagging, external tagging, or other relevant techniques.
- There is a need for improved collection and collection strategy for hard parts, in particular from the recreational sector. Samplers' encounter rate with anglers that have caught black grouper (*M. bonaci*) are low, particularly in recreational fisheries where bag limits restrict the number of available specimens. Some ingenuity in sampling design will probably be required.
- Increase of fishery independent data to include the entire area of black grouper (*M. bonaci*) distribution in the Atlantic and Gulf of Mexico in the southeastern U.S. Although the SEAMAP video surveys covers general areas (e.g., Florida Middle Grounds, West Florida shelf, Pulley Ridge, etc.) where black grouper are caught, few black grouper have been seen in this survey. Perhaps either some additional research on

habitat preferences may aid in locating this species in these areas, or some other type of fishery independent sampling might be more successful in encountering black grouper and generating estimates of abundance in areas outside of the Florida Keys.

- Virtually no information on the life history and distribution of young juveniles (age 0-1) black grouper (*M. bonaci*) is available. The DW LH WG recommends a study to gather information on these early ages. These studies should include sampling for postlarvae in the months (March-June) after spawning is presumed to occur, location of habitats in Florida (particularly in the Florida Keys) where these fish occur (presumably rocky habitats not presently sampled by the fishery independent program in Florida), and diet composition, growth, and movements of juveniles.

Procedural recommendation:

- The DW recommends that the report of the natural mortality workshop organized by NMFS (Seattle, WA, August 2009) be made available to the DW LH WG before the next SEDAR as a guide in the discussions concerning natural mortality.

6.2. *COMMERCIAL STATISTICS*

- Still need observer coverage for the snapper-grouper fishery
  - 5-10% allocated by strata within states
  - Get maximum information from fish
- Expand TIP sampling to better cover all statistical strata
- Trade off with lengths versus ages, need for more ages (i.e., hard parts)
- Workshop to resolve historical commercial landings for a suite of snapper-grouper species
  - Monroe County (SA-GoM division)
  - Historical species identification (mis-identification and unclassified)

6.3. *RECREATIONAL STATISTICS*

- Need more detailed information about where the fish are caught (depth, spatial, etc.)
- More detailed information on recreational discards, such as hooking location, depth fished, etc. that are likely to impact discard mortality and discard size/age.
- Additional information on sector (mode) differences.

6.4. *INDICES OF ABUNDANCE*

1. Expand fishery independent sampling to provide indices of abundance. The DW Panel noted that this recommendation has been the first on the list for virtually all previous SEDAR's in the south Atlantic.
2. Examine variability in catchability
   - Environmental effects
   - Changes over time associated with increases in technology and potential changes in fishing practices. This is of particular importance when considering fishery dependent indices.
   - Potential density-dependent changes in catchability. This is of particular importance for schooling fishes.
3. Conduct studies to examine how the behavior of fisherman changes over time and how these changes relate to factors such as gas prices and economic trends
4. Consider optimal sample allocation for species of interest when designing surveys to increase sample sizes.
5. Examine possible temporal changes in species assemblages. Such changes could influence how the Stephens and MacCall method is applied when determining effective effort.
6. Continue to expand fishery dependent at-sea-observer surveys. Such surveys collects discard information, which would provide for a more accurate index of abundance.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 19

Gulf of Mexico and South Atlantic
Black Grouper

SECTION III: Assessment Workshop Report

December 2009

NOTE: Modifications to the base model reported in this report were made during the Review Workshop held 25-29 January 2010. For compete 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

1.1. INTRODUCTION

1.1.1 Workshop time and Place

The SEDAR 19 Assessment Workshop was held October 5 - 9, 2009 in Saint Petersburg, Florida.

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.
   A. In addition, for black grouper, the Gulf Council requests that the Panel specify OFL, and recommend a range of ABCs for review by its SSC.

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),

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.

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), prepare a first draft of the Summary Report, and develop a list of tasks to be completed following the workshop.

1.1.3. List of Participants

Workshop Panel

Anne Lange .... SAFMC SSC
Bob Speath .... GMFMC AP
Chip Collier .... SAFMC SSC/NC DMF
Dennis O'Hern .... GMFMC AP
Frank Hester .... SFAECFS
Joe O'Hop .... FWC FWRI
Kevin McCarthy .... NMFS/SEFSC
Kyle Shertzer .... NMFS/SEFSC
Luiz Barbieri .... SAFMC and GMFMC SSC/FWC FWRI
Paul Conn .... NMFS/SEFSC
Richard Fulford .... GMFMC/USM-GCRC
Rob Cheshire .... NMFS/SEFSC
Robert Muller .... FWC FWRI
Sven Kupschus .... CIE

Council Representation

Brian Cheuvront .... SAFMC/NC DMF
George Geiger .... SAFMC
Mark Robison .... SAFMC/ FL FWRI
Kay Williams .... GMFMC

Observers

Behzad Mahmoudi .... FWC FWRI
Beverly Sauls .... FWC FWRI
Bill Arnold .... NOAA SERO

Bob Shipp .... Univ. of Alabama
Jack McGovern .... NOAA SERO
Joseph Munyandorero .... FWC FWRI
Karen Burns .... GMFMC Staff
Kenny Fex .... SAFMC AP
Nick Framer .... NOAA SERO
Nikhil Mehta .... NOAA SERO
Rich Malinowski .... NOAA SERO
Roy Crabtree .... NOAA SERO
Rusty Hudson .... DSF/SFAECFS
Steve Bortone .... GMFMC Staff

Staff
Carrie Simmons .... GMFMC Staff
Julie Neer .... SEDAR
Rick DeVictor .... SAFMC Staff
Tina O'Hern .... GMFMC Staff
Tyree Davis .... NMFS Miami

1.1.4. List of Data Workshop Working and Reference Papers

Documents Prepared for the Assessment Workshop		
SEDAR19-AW-01	A hierarchical analysis of red grouper indices.	Paul Conn
SEDAR19-AW-02	Red grouper: Regression and Chapman−Robson estimators of total mortality from catch curve data	Sustainable Fisheries Branch
SEDAR19-AW-03	Additions and Updates to Red Grouper data since the SEDAR 19 Data Workshop	Sustainable Fisheries Branch
SEDAR19-AW-04	Red Grouper: Predecisional Surplus–production Model Results	Sustainable Fisheries Branch
SEDAR19-AW-05	A non-equilibrium surplus production model of black grouper (*Mycteroperca bonaci*) in southeast United States waters	Robert G. Muller
SEDAR19-AW-06	Catch curves from two periods in the black grouper fishery	Robert G. Muller
SEDAR19-AW-07	A statistical catch-age model for red grouper: mathematical description, implementation details, and computer code.	Sustainable Fisheries Branch
SEDAR19-AW-08	Assessment history of black grouper (*Mycteroperca bonaci*) in the southeast U. S. waters	Robert G. Muller

Reference Documents		
SEDAR19-RD29	A Review for Estimating Natural Mortality in Fish Populations	Kate. I. Siegfried & Bruno Sansó
SEDAR19-RD30	Bottom longline fishery bycatch of black grouper from observer data	Loraine Hale and John Carlson
SEDAR19-RD31	Characterization of the shark bottom longline fishery: 2007	Loraine Hale, Lisa D. Hollensead, and John Carlson
SEDAR19-RD32	2009 Gulf of Mexico Red Grouper Update Report	

1.1.5. Notice of Addenda

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.

The analytical team presented a summary overview of black grouper data and input parameters. The Assessment Workshop Panel (AW Panel) discussed the use of the gag to black grouper ratio as a potential source of bias with the landings and indices data. The Commercial and Recreational Landings Working groups in the Data Workshop expressed a high degree of confidence in the species identification/reporting data post-1991and felt it could appropriately back-adjust landings to 1986 (i.e., correct for potential identification errors by applying the correct gag to black grouper ratio). Based on this the AW Panel recommended starting the assessment period in 1986.

Since no reliable recruitment index for black grouper was presented at the Data Workshop, the analytical team built age-1 recruitment indices from the visual survey observations to provide some guidance to the model on the magnitude of recruitment. The AW Panel supported this decision.

The age composition data used to run the preliminary assessment models differed from the DW because: 1) there was a lack of recreational age composition data and 2) the fact that commercial age composition data was limited to direct ageing, with many years when few fish were aged. To correct for this the analytical team generated gear-specific, year-specific von Bertalanffy growth curves to generate age composition data from length data using two methods: 1) inverting the von Bertalanffy growth curve, and 2) using stochastic probabilistic estimation. After much discussion the AW Panel recommended use the probabilistic estimation method (because it captures the overlap in ages for similar sized fish especially in the older ages).

Discard weights for commercial fisheries were recalculated to reflect regulatory discards of fish below the minimum size limit. As a result the average weight of commercial discards (average discard weight ~4 lbs.) were much lower than those determined in the DW (average discard weight ~20 lbs.). The AW Panel agreed this approach was sensible and prevented biased estimates of the magnitude of commercial discards.

The analytical team suggested that commercial fisheries data from hook-and-line, diving, traps, and "other gears" be combined. The available age data summed over all years supported these grouping (pair-wise comparisons with the Kolmogorov-Smirnov Two Sample test) as the longline catches contained significant numbers of older fish (over 30 years) not seen in the other gears. The AW Panel agreed with this decision.

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.

The analytical team presented results from preliminary runs using two models from the NMFS Tool Box: 1) ASPIC, a non-equilibrium surplus production model that allows the use of indices of abundance as well as catch and effort data, and 2) ASAP2, an stochastic catch-at-age model. Results from ASPIC as well as a catch curve analysis were used to provide a context for the more complex statistical catch-at-age model and provide lower and upper bounds for total mortality (Z).

ASPIC initially showed poor fits to both fishery-dependent and fishery-independent indices (very large residuals). The AW Panel suggested sub-dividing the indices into time blocks based on the implementation of regulations since ASPIC cannot handle temporal regulatory changes. Overall, ASPIC indicated a generally stable stock with declining fishing mortality rates and increasing biomass during the period covered by the assessment. Model convergence suggested landings data and indices contained enough information to warrant exploratory use of an age-structured model.

Z estimates ranged from 0.15 to 0.18 when using the older ages coming out of the longline fishery. The AW Panel recommended the use of these results as indicators of meaningful upper limits to natural mortality (M) values to use for sensitivity analyses.

Although ASAP2 showed relatively better model fits (to landings and indices), the AW Panel made several recommendations regarding parameter choices and data inputs. Discussion focused on whether the age data contained enough information to support the use of an age-structured model. The analytical team explained that not in an ideal sense but problems with landings (because of the gag/black grouper identification/reporting issue) make the decision of going with a surplus production model more difficult. Use of an age-structured surplus production modeling approach (i.e., use ASAP2 with all the age comp information turned off) was explored but the model showed instabilities and undesirable residual patterns. The Panel recommended use of ASAP2 with age composition generated by the probabilistic estimation method.

Preliminary model runs were based on increasing catchability (2% per year) for fishery-dependent indices (DW recommendation). The AW Panel discussed the validity of this assumption in light of black grouper's distribution and habitat utilization patterns, and recommended exploratory model runs using constant catchability as well as summary analyses to evaluate whether time-varying catchability was indeed the correct assumption. Results did not support the time-varying catchability hypothesis and the AW Panel recommended the use of constant catchability for the base run.

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.

The analytical team and the AW Panel discussed the methods and data used to estimate selectivity curves for each fishery (headboat, MRFSS, commercial hook-and-line, and commercial longline). These fisheries only caught fish that were mid-teens or younger while the long-line fishery caught fish up to 33 years old. The information contained in the data was investigated by allowing the selectivity at age to vary freely for the hook-and-line fishery. The results indicated a dome shaped selectivity with some noise which is consistent with the younger ages being caught, justifying the choice of a double logistic selectivity pattern in the final model. The same assumption was made for the headboat and MRFSS data as the age information also suggested that few older fish were caught in these fisheries. The longline fishery was set to a flat-topped selectivity because there was no reason to assume that selectivities would decline at older ages based on the gear or the spatial distribution of the fishery.

Steepness of the stock-recruitment relationship was constrained to be between 0.65 and 0.85 because this range was considered the most realistic for a species with life history and population dynamics characteristics as those shown by black grouper. Unconstraining steepness caused it to approach the upper boundary (h=0.97, sd = 0.24). Considering the inability of the model to generate a reliable steepness estimate the AW Panel recommended the use of proxy, SPR-based reference points.

Estimates of stock population parameters and associated measures of precision are presented in the stock assessment report.

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'.

Assessment uncertainty was evaluated by sensitivity analyses, retrospective analysis, and by evaluating the probability distributions of key model outputs (annual fishing mortality rates, annual spawning biomass, F_{MSY}, MSY, SSB_{MSY}, $F_{30\%SPR}$, $SSB_{30\%SPR}$ and the number of fish by age) through a Monte-Carlo Markov Chain (MCMC) process.

Retrospective patterns for stock biomass, F, and recruitment were evaluated for different model configurations. The AW Panel discussed the fact that retrospective biases were identified for each of these parameters.

The point estimate of M recommended by the DW was 0.14 y^{-1} with a recommended range of 0.10-0.15 y^{-1} for sensitivity analyses (based on Z values estimated by catch curve analysis). The

AW Panel discussed this issue and based on input from workshop participants decided to recommend a wider range of M values for sensitivity analyses (0.10-0.20 y^{-1}).

Extensive discussion focused on the values of discard mortality used for the base run and sensitivity analyses. The AW Panel received input from several workshop attendees and after much discussion and deliberation decided to support the point estimates and range of values recommended by the DW: 20% (range of 10-30%) for hook-and-line and 30% (range of 25-35%) for longline.

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.

The analytical team presented results and outputs from several preliminary model runs during the Assessment Workshop. Yield-per-recruit and spawner-per-recruit outputs, including figures and tables of complete parameters are presented in the stock assessment report.

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.

The AW Panel did not think that the stock-recruitment function could be reliably estimated for black grouper and, therefore, recommended the use of SPR-based proxy reference points. The Panel discussed the SPR level to use (i.e., 30% or 40% SPR) and eventually recommended proxy benchmarks be generated for both SPR levels.

Tables and figures of black grouper SPR-based proxy reference points for fishing mortality and biomass are presented in the stock assessment report.

1.2.7. Term of Reference 7

Provide declarations of stock status relative to SFA benchmarks.

Preliminary runs indicate the stock is not overfished nor undergoing overfishing. Final declarations of stock status are provided in the stock assessment report.

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.

During the Assessment Workshop the analytical team presented preliminary probability density functions of fishing mortality and biomass reference points developed through a Monte-Carlo Markov Chain (MCMC) process. The AW Panel requested that a P* analysis be also developed and included in the stock assessment report.

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.

There was considerable discussion as to whether it was appropriate to provide projections at this time, given the number of regulatory changes that have taken place since the final year of input data (2008) and that will occur before management would be able to incorporate assessment results into future measures (2011). The AW Panel suggested making projections based on the current knowledge, with the intent to rerun the models once the impacts of recent measures are better understood. The following list of projections is presented in the stock assessment report:

$F=0$, $F=F_{current}$, $F=F_{30\%SPR}$, $F=F_{40\%SPR}$, and $F= F_{target}$ (OY) with F_{OY} = 65%, 75%, and 85% of F_{MSY}.

2. DATA REVIEW AND UPDATE

The life history information including stock definition, age-specific natural mortality rates, maturity, and average weight-at-ages were used as developed in the Data Workshop (Table 2.1.1). Landings in numbers and weight (Table 2.1.2) were also used without modification. However, the only observed discard length measurements came from the MRFSS At-Sea-Headboat sampling program (2005-2007). Therefore, we had to approximate the discard sizes for other years and for other fleets of the black grouper fishery. For the recreational fleets prior to 1992 when there was an 18 inch (457 mm TL) minimum size in the State of Florida waters, we estimated the sizes of discards as the proportions by age of fish expected to be less than 18 inches based on the age-specific natural mortality, the overall von Bertalanffy growth curve, and constant recruitment (R = 1). The proportions were 0.935 for Age-1 and 0.065 for Age-2. For other years, we applied the proportion of fish by age observed below either 20 inches (508 mm TL) or 24 inches (610 mm TL) depending upon the minimum size limit in effect . The fish lengths were converted to age using the stochastic aging method. The weight of discarded fish was calculated from the proportions at age and the average weights-at-age of the catch. The weights of dead discards from the recreational fleets are shown in Table 2.1.2.

With commercial discards, the weight of discards was provided by the Data Workshop Commercial Working group for the commercial hook-and-line and longline fleets. However, that group did not provide the lengths that the group assigned to discarded fish and the average weights were much heavier (average weights of 9.4 to 47.4 lb per fish) than would be expected if all the fish being discarded were less than the minimum size limits. While there was a prohibition on the sale of black grouper in March and April in the South Atlantic waters and in February 15 to March 15 in the Gulf of Mexico waters, both of closures were implemented in 1999, the majority of reef fish effort occurs in other months indicating that many of discards were probably due to fish being less than the minimum size rather than due to the closed season. By using smaller sizes for discarded fish, the discard weights used in the models were less than the original weights (Table 2.1.2). Effort, in either angler-days or trips, by fleet was not used by any of the models directly but is presented to illustrate that effort has been declining in the headboat and commercial fleets (Table 2.1.3).

The ages in the Data Workshop Report were too sparse to develop age compositions directly, especially in the recreational fleets (Figure 2.2.1). The Life History Working Group developed an overall von Bertalanffy growth curve using as many of the otoliths as was possible by associating each otolith from the fishery with a minimum size limit. However in assigning ages to landings, we took an alternative approach, which was to develop von Bertalanffy growth curves by gear and year whenever possible. The rationale was that each otolith was assumed to be drawn from a random sample of ages associated with the observed length by gear and year. Before combining ages by gears, the ages by fleet were compared, pair-wise, with Kolmogorov-Smirnov two-sample tests to determine which fleets could be pooled. Longlines caught older fish for the same sizes of fish than the other gears (maximum difference = 0.41, test statistic = 0.11, df = 178, 1127, $P < 0.05$). Therefore, we used two age-gear distributions, hook-and-line and longline, for aging. On the temporal scale, we grouped adjacent years within a gear until at least 20 fish were available for calculating the growth curves. To prevent excessively negative t_0 terms, we also included Age-0 fish from fishery independent sampling when estimating the curves. The coefficients and mean square error term of the resulting growth curves are shown in Table 2.1.4.

Two methods of assigning ages were brought to the Assessment Workshop: inverted von Bertalanffy curves and a stochastic aging method. The inverted von Bertalanffy was merely algebraically rearranging the von Bertalanffy curve (Equation 2.1) from estimating length at age, $L_{t,}$

$$L_t = L_\infty (1 - e^{-K(t-t_0)}) , \qquad (2.1)$$

where L_∞ is the asymptotic length, K is the growth coefficient, and t_0 is the age at which the length would be zero to estimating the age of a fish, t, with length, L_t (Equation 2.2)

$$t = t_0 - \frac{\ln(1 - \frac{L_t}{L_\infty})}{K} . \qquad (2.2)$$

The stochastic aging used the predicted mean length-at-age from the von Bertalanffy growth curves by gear and year and the overall standard deviations of length for each age (Bartoo and Parker 1983). The pattern of standard deviations of length by age was determined to be small at very young ages, broader in the middle ages and narrow again at the oldest ages (Figure 2. 2.2). Using normal distributions for lengths at each age, we assigned probabilities for each length bin (10-170 cm) within each age (0-33 years). Age-specific, natural mortality rates were incorporated to partially account for the decline of animals with age. The decision of the AW was to use the stochastic aging method because, with black grouper, there is extensive overlap of ages for fish greater than 120 cm that could not be captured by the inverted growth curve that assigns a single age to each length.

Given the ten von Bertalanffy growth curves for hook-and-line gears including the recreational fleets and another ten growth curves for the longline fleet, the age compositions by fleet were based upon the length measurements (Table 2.1.5). The age compositions are fit in the model as multinomial and so as to not over emphasize the ages from a given year, the number of ages used in the calculation of the multinomial was the lesser of either the number of lengths by fleet and year or the number of ages used to calculate that period's growth curve.

Another change from the Data Workshop was to develop Age-1 indices from the FWC Visual Survey and from the NMFS-UM Reef Visual Census (RVC) to provide guidance on recruitment to the models. The FWC Visual Survey groups fish counts into 5-cm fish-length bins up to 60 cm, 10-cm bins from 70-100 cm, and a 100+ group. The lengths of Age-1 fish from the overall von Bertalanffy growth curve ranged from 32 to 45 cm. Therefore, the sum of the numbers of fish counted in the 30-45 cm length bins per dive-habitat per year was considered the Age-1 fish index. The numbers of age-1 fish were analyzed using the same generalized linear model procedure as was used for the FWC Visual Survey including all ages. The best fit was with a gamma distribution using a log link. The Age-1 index values and their coefficients of variation (CV) are shown in Table 2.1.6. The NMFS-UM Reef Visual Census tallies their lengths in one cm bins and, therefore, the RVC Age-1 index was the number of fish from 32 to 45 cm by year and these were scaled to their mean (Table 2.1.6). Because we only had the aggregate data, we used the same CV values as were developed for the multi-age RVC index.

2.1. TABLES

Table	Description
2.1.1	Age-specific natural mortality at the beginning of the year, maturity, average weights-at-age (January 1, spawning – March 15, and catch -- mid-year) and average spawning biomass (maturity times spawning weight).
2.1.2	Landings and discards in numbers and pounds by fleet and year.
2.1.3	Annual effort by fleet and year.
2.1.4	Von Bertalanffy growth curves used to assign ages to lengths of fish from the different fishery fleets. The hook-and-line (HL) equations were used for aging headboat, general recreational, commercial hook-and-line, traps, and other while longline (LL) equations were used to assign ages to the lengths from the longline fishery. Linf is the asymptotic length in mm, Linf-se is the standard error of Linf, K is the growth coefficient, K-se is the standard error of the growth coefficient, t_0 is the age at zero length, t_0_se is the standard error of t_0, rmse is the root mean square error for the equation, df is the degrees of freedom in determining the equation, F-val is the ratio of the explained mean squares of the residuals to the unexplained mean of squares, and the P-value is the probability that the null hypothesis for the length-age relationship is solely due to chance.
2.1.5	Age composition, number of lengths, and the number of ages used in the stochastic von Bertalanffy growth curves for assigning ages to lengths by fleet and year.
2.1.6	Fishery independent age-1 indices using the FWC Visual Survey number of black grouper per dive-habitat combinations and the NMFS-UM Reef Visual Census number of black grouper in the Florida reef track.

Table 2.1.1. Age-specific natural mortality at the beginning of the year, maturity, average weights-at-age (January 1, spawning – March 15, and catch -- mid-year) and average spawning biomass (maturity times spawning weight).

Age (yr)	Age-specific natural mortality (per year)	Maturity (proportion)	Average weights: Jan-1 (lb)	Average weights: Spawning (lb)	Average weights: Catch (lb)	Average spawning biomass (lb)
1	0.396	0.000	0.895	1.182	1.658	0.000
2	0.297	0.001	2.772	3.292	4.102	0.002
3	0.244	0.003	5.772	6.504	7.607	0.019
4	0.212	0.015	9.733	10.631	11.957	0.161
5	0.190	0.076	14.411	15.422	16.896	1.178
6	0.174	0.308	19.548	20.623	22.176	6.343
7	0.163	0.705	24.913	26.009	27.582	18.326
8	0.154	0.928	30.312	31.397	32.944	29.123
9	0.147	0.986	35.599	36.646	38.134	36.121
10	0.141	0.997	40.664	41.657	43.062	41.544
11	0.137	0.999	45.436	46.363	47.672	46.340
12	0.133	1.000	49.871	50.726	51.932	50.721
13	0.130	1.000	53.947	54.728	55.828	54.727
14	0.128	1.000	57.659	58.367	59.362	58.367
15	0.126	1.000	61.014	61.652	62.547	61.652
16	0.124	1.000	64.028	64.599	65.399	64.599
17	0.123	1.000	66.721	67.230	67.942	67.230
18	0.121	1.000	69.117	69.568	70.200	69.568
19	0.120	1.000	71.240	71.640	72.198	71.640
20	0.116	1.000	79.802	79.978	80.224	79.978

Table 2.1.2. Landings and discards in numbers and pounds by fleet and year.

	Landings (numbers)				Landings (pounds)				
Year	Headboat	MRFSS	Comm HL	Comm LL	Headboat	MRFSS	Comm HL	Comm LL	Total
1986	4,803	62,293	34,185	7,492	19,976	447,266	426,270	129,457	1,022,970
1987	3,231	55,769	64,461	11,337	39,603	382,021	567,539	125,101	1,114,264
1988	3,056	29,269	25,835	5,144	24,288	188,198	365,587	83,995	662,067
1989	2,084	28,002	35,478	4,998	19,806	181,452	384,267	82,395	667,920
1990	1,921	21,959	25,711	6,765	17,764	74,441	299,700	109,944	501,850
1991	1,703	32,959	13,817	2,594	15,378	398,475	163,451	53,681	630,985
1992	2,546	34,094	14,018	1,546	20,965	281,616	218,010	58,787	579,378
1993	2,128	26,831	12,070	982	25,129	140,596	165,666	35,670	367,061
1994	2,474	21,996	8,518	643	24,053	166,073	139,558	25,401	355,084
1995	4,525	25,993	7,546	571	31,760	236,796	115,303	24,975	408,834
1996	2,911	37,155	9,105	788	36,613	316,559	120,418	29,915	503,505
1997	3,763	43,409	6,215	828	48,274	450,156	89,464	34,644	622,538
1998	6,122	30,635	6,133	1,066	84,984	389,372	88,334	41,778	604,468
1999	1,873	15,280	3,625	1,418	25,267	169,613	79,719	51,646	326,245
2000	1,065	8,763	4,362	1,304	15,118	112,952	92,434	50,077	270,581
2001	2,073	10,350	4,731	1,390	31,013	136,623	100,951	55,020	323,607
2002	1,120	11,663	4,265	1,498	15,271	139,377	89,052	53,496	297,196
2003	1,270	16,914	6,135	1,856	11,940	262,670	97,394	77,142	449,147
2004	1,613	15,585	4,280	2,113	18,414	139,018	91,732	73,385	322,549
2005	2,000	12,943	3,358	1,563	25,733	135,772	73,266	45,734	280,505
2006	1,130	7,732	3,373	1,792	17,862	92,165	72,223	61,444	243,695
2007	1,282	14,614	2,431	1,300	17,828	156,224	54,849	43,457	272,357
2008	339	14,671	1,451	536	3,930	162,408	33,236	17,843	217,417

	Discards (numbers)				Discards (pounds)				
Year	Headboat	MRFSS	Comm HL	Comm LL	Headboat	MRFSS	Comm HL	Comm LL	Total
1986	5,018	6,694			8,014	10,691			18,705
1987	3,376	31,074			5,391	49,626			55,017
1988	3,193	3,192			5,099	5,097			10,196
1989	2,177	4,118			3,477	6,576			10,053
1990	2,007	3,509			3,205	5,604			8,809
1991	1,779	15,025			2,842	23,995			26,837
1992	2,660	17,345			13,767	83,614			97,380
1993	2,223	10,488	1,114	40	11,506	50,558	6,517	96	68,676
1994	2,585	15,158	1,357	49	13,377	73,074	7,934	116	94,501
1995	4,728	6,564	1,225	44	22,505	29,113	6,587	103	58,308
1996	3,041	17,646	1,330	46	14,478	78,264	7,152	122	100,016
1997	3,932	14,565	1,407	50	18,715	64,599	7,566	134	91,014
1998	6,396	11,943	1,301	48	30,448	52,970	6,995	126	90,540
1999	1,957	11,035	1,459	53	8,628	82,449	11,586	340	103,003
2000	1,113	8,805	1,443	49	4,906	65,786	11,457	312	82,461
2001	2,166	7,026	1,249	46	9,550	52,493	9,915	293	72,250
2002	1,170	9,173	1,315	42	3,788	63,012	8,339	355	75,494
2003	1,327	10,590	1,665	48	4,296	24,531	10,555	330	39,712
2004	1,685	10,592	940	44	7,273	79,234	7,483	380	94,371
2005	2,090	4,124	1,880	33	8,959	23,541	11,452	219	44,170
2006	1,181	6,315	231	39	3,362	36,501	1,424	259	41,545
2007	1,339	8,884	1,777	35	4,181	58,075	12,385	260	74,902
2008	354	10,686	259	31	1,514	82,197	2,123	276	86,110

Table 2.1.3. Annual effort by fleet and year.

Year	Headboat[1] South Florida Angler-days	MRFSS[2] Recreational Trips	Hook-and-line[3] Trips	Longline[4] Trips
1986	342,701	742,640		
1987	359,835	710,435		
1988	320,918	544,858		
1989	365,036	887,629		
1990	377,809	568,672		
1991	306,831	1,146,385		
1992	292,336	1,050,856		
1993	296,671	1,060,515	1,549	382
1994	312,486	921,624	2,175	462
1995	257,121	743,596	1,881	295
1996	243,194	723,958	1,923	403
1997	204,354	806,215	2,647	619
1998	222,221	706,959	2,693	578
1999	222,200	658,633	2,375	596
2000	224,703	565,592	2,337	498
2001	209,087	595,263	2,571	584
2002	188,912	736,907	2,317	517
2003	173,872	784,322	2,224	630
2004	218,093	949,868	2,017	636
2005	200,736	874,227	1,819	591
2006	184,309	950,311	1,393	656
2007	172,268	1,482,694	1,136	460
2008	139,650	1,141,446	1,101	498

1. SEDAR19- DW Final Report Tables 4.6.5 and 4.6.6
2. Directed trips = Total trips*(black grouper intercepts/total intercepts) by sub-region, year,state,wave,mode_fx,and area-x
3. SEDAR19-DW Final Report Table 3.13.9.
4. SEDAR19-DW Final Report Table 3.13.10.

Table 2.1.4. Von Bertalanffy growth curves used to assign ages to lengths of fish from the different fishery fleets. The hook-and-line (HL) equations were used for aging headboat, general recreational, commercial hook-and-line, traps, and 'other' while longline (LL) equations were used to assign ages to the lengths from the longline fishery. Linf is the asymptotic length in mm, Linf-se is the standard error of Linf, K is the growth coefficient, K-se is the standard error of the growth coefficient, t_0 is the age at zero length, t_0_se is the standard error of t_0, rmse is the root mean square error for the equation, df is the degrees of freedom in determining the equation, F-val is the ratio of the explained mean squares of the residuals to the unexplained mean of squares, and the P-value is the probability that the null hypothesis (the length-age relationship is solely due to chance) is true.

Gear	Period	Linf	Linf_se	K	K_se	t0	t0_se	rmse	error_df	F_val	P_val
HL	< 1992	1459	54.66	0.120	0.0097	-0.94	0.150	79.629	51	593.23	4.82E-36
HL	1992-94	1387	93.26	0.136	0.0172	-0.88	0.112	55.283	42	817.93	2.34E-34
HL	1995-98	1402	46.99	0.128	0.0103	-0.94	0.143	76.337	48	723.38	1.45E-36
HL	1999-01	975	40.30	0.278	0.0320	-0.64	0.112	79.478	61	388.76	1.93E-35
HL	2002-03	1390	87.97	0.132	0.0158	-0.98	0.151	76.308	57	467.98	4.26E-36
HL	2004	1017	59.13	0.259	0.0393	-0.62	0.095	59.340	33	525.5	9.5E-26
HL	2005	1386	95.61	0.134	0.0180	-0.87	0.130	66.463	33	538.1	6.5E-26
HL	2006	1278	146.56	0.151	0.0341	-0.85	0.143	63.325	39	604.16	4.51E-30
HL	2007	1190	61.84	0.182	0.0210	-0.75	0.117	70.130	56	615.35	7.65E-39
HL	2008	1172	51.02	0.204	0.0206	-0.70	0.093	60.044	49	788.19	5.51E-38
LL	1992-95	1291	14.23	0.161	0.0061	-0.80	0.093	61.499	134	1991.13	2.2E-100
LL	1996-98	1315	17.18	0.148	0.0062	-0.80	0.105	66.056	119	1716.53	1.74E-88
LL	1999-01	1364	34.69	0.149	0.0106	-0.82	0.136	85.399	58	753.29	3.18E-42
LL	2002	1397	68.15	0.137	0.0137	-0.85	0.104	56.967	51	1150.17	3.75E-43
LL	2003	1396	24.21	0.139	0.0067	-0.82	0.113	70.453	99	1454.2	4.11E-74
LL	2004	1380	25.37	0.131	0.0063	-0.87	0.126	73.298	128	1314.58	4.7E-86
LL	2005	1417	33.95	0.119	0.0066	-0.95	0.140	76.065	170	1205.83	3.8E-101
LL	2006	1478	39.73	0.113	0.0066	-0.93	0.143	77.441	254	1310.66	1.4E-134
LL	2007	1424	35.98	0.124	0.0072	-0.95	0.132	73.641	150	1223.67	1.31E-93
LL	2008	1288	46.07	0.153	0.0136	-0.82	0.118	68.909	89	1079.96	3.85E-63

Table 2.1.5. Age composition, number of lengths, and the number of ages used in the stochastic von Bertalanffy growth curves for assigning ages to lengths by fleet and year.

a. Headboat age composition

			Proportion																			
Year	Num len	Num ages	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	56	15	0.0735	0.1935	0.2061	0.1380	0.1165	0.1093	0.0771	0.0484	0.0233	0.0108	0.0036	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1987	28	15	0.0285	0.1068	0.2064	0.1922	0.1423	0.1032	0.0819	0.0641	0.0391	0.0214	0.0107	0.0036	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1988	18	15	0.1000	0.1389	0.1833	0.1611	0.1333	0.1000	0.0556	0.0278	0.0222	0.0222	0.0222	0.0167	0.0111	0.0056	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1989	27	15	0.0260	0.2007	0.1933	0.1599	0.1375	0.1078	0.0743	0.0483	0.0260	0.0149	0.0074	0.0037	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1990	25	15	0.0040	0.1205	0.1928	0.2530	0.2249	0.1165	0.0402	0.0080	0.0040	0.0040	0.0080	0.0080	0.0080	0.0040	0.0040	0.0000	0.0000	0.0000	0.0000	0.0000
1991	10	15	0.0000	0.0101	0.1515	0.3535	0.2828	0.1313	0.0606	0.0101	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1992	11	28	0.0636	0.2273	0.2000	0.1364	0.1636	0.1000	0.0545	0.0273	0.0182	0.0091	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1993	18	28	0.0000	0.0663	0.2652	0.2320	0.1713	0.1215	0.0608	0.0221	0.0055	0.0055	0.0055	0.0055	0.0055	0.0055	0.0055	0.0055	0.0055	0.0055	0.0055	0.0000
1994	21	28	0.0000	0.0766	0.2727	0.2919	0.1866	0.1005	0.0478	0.0191	0.0048	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1995	14	34	0.1079	0.1942	0.3094	0.1727	0.1295	0.0647	0.0216	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1996	24	34	0.0000	0.0500	0.1208	0.1542	0.1958	0.1917	0.1333	0.0792	0.0417	0.0208	0.0083	0.0042	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1997	26	34	0.0000	0.0269	0.1231	0.2269	0.2500	0.1846	0.1115	0.0500	0.0192	0.0077	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1998	30	34	0.0000	0.0535	0.1806	0.1773	0.1572	0.1538	0.1137	0.0736	0.0435	0.0234	0.0134	0.0067	0.0033	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1999	13	47	0.0000	0.0781	0.1719	0.1875	0.1641	0.1094	0.0703	0.0469	0.0313	0.0234	0.0234	0.0156	0.0156	0.0078	0.0078	0.0078	0.0078	0.0078	0.0078	0.0156
2000	8	47	0.0000	0.0625	0.2500	0.2000	0.1250	0.0750	0.0500	0.0375	0.0250	0.0250	0.0250	0.0125	0.0125	0.0125	0.0000	0.0250	0.0125	0.0125	0.0125	0.0250
2001	10	47	0.0000	0.0707	0.1717	0.1818	0.1515	0.1010	0.0707	0.0505	0.0404	0.0303	0.0202	0.0202	0.0202	0.0101	0.0101	0.0101	0.0101	0.0101	0.0101	0.0101
2002	9	43	0.0000	0.0330	0.1978	0.1648	0.1538	0.2088	0.1429	0.0659	0.0220	0.0110	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2003	8	43	0.0000	0.0250	0.1250	0.2375	0.2875	0.1875	0.1000	0.0250	0.0125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2004	6	19	0.0000	0.0517	0.2069	0.2241	0.1897	0.1207	0.0690	0.0517	0.0345	0.0172	0.0172	0.0172	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2005	7	19	0.0000	0.0141	0.1972	0.3239	0.1690	0.0845	0.0704	0.0563	0.0423	0.0282	0.0141	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2006	10	25	0.0000	0.0102	0.0816	0.2041	0.2449	0.1939	0.1122	0.0510	0.0306	0.0204	0.0204	0.0102	0.0102	0.0102	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2007	11	42	0.0459	0.0550	0.1376	0.2385	0.2202	0.1376	0.0826	0.0459	0.0183	0.0092	0.0092	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2008	2	35	0.0000	0.0000	0.2632	0.4211	0.2632	0.0526	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 2.1.5 (continued). Age composition, number of lengths, and the number of ages used in the stochastic von Bertalanffy growth curves for assigning ages to lengths by fleet and year.

b. Recreational (MRFSS) age composition

			Proportion																			
Year	Num len	Num ages	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	17	15	0.2907	0.1802	0.1337	0.0988	0.0581	0.0523	0.0640	0.0640	0.0349	0.0174	0.0058	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1987	21	15	0.1000	0.3524	0.3143	0.0905	0.0286	0.0286	0.0238	0.0143	0.0143	0.0095	0.0095	0.0095	0.0048	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1988	5	15	0.1837	0.1224	0.3265	0.1633	0.0204	0.0000	0.0000	0.0204	0.0408	0.0408	0.0408	0.0204	0.0204	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1989	7	15	0.0143	0.2143	0.0571	0.1000	0.2000	0.1429	0.0857	0.0429	0.0429	0.0286	0.0286	0.0286	0.0143	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1990	1	15	0.0000	0.0000	0.0000	0.1111	0.4444	0.3333	0.1111	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1991	9	15	0.0220	0.1648	0.3297	0.2527	0.1648	0.0549	0.0110	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1992	22	28	0.0279	0.2093	0.3674	0.2186	0.0977	0.0419	0.0233	0.0093	0.0047	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1993	27	28	0.0892	0.2379	0.3829	0.2193	0.0558	0.0112	0.0037	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1994	24	28	0.0209	0.0795	0.2427	0.2971	0.1925	0.0879	0.0460	0.0209	0.0084	0.0042	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1995	21	34	0.0571	0.1429	0.2619	0.2095	0.1619	0.0857	0.0429	0.0190	0.0095	0.0048	0.0048	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1996	40	34	0.0275	0.1450	0.3475	0.2325	0.1325	0.0700	0.0325	0.0100	0.0025	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1997	42	34	0.0000	0.1100	0.2656	0.2895	0.1866	0.0909	0.0407	0.0120	0.0048	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1998	96	34	0.0000	0.0563	0.2002	0.2471	0.2096	0.1230	0.0667	0.0334	0.0198	0.0136	0.0083	0.0063	0.0042	0.0031	0.0021	0.0021	0.0010	0.0010	0.0010	0.0010
1999	63	47	0.0334	0.0922	0.2273	0.2067	0.1431	0.0874	0.0556	0.0350	0.0238	0.0175	0.0143	0.0095	0.0079	0.0064	0.0048	0.0064	0.0032	0.0032	0.0032	0.0191
2000	66	47	0.0030	0.1180	0.2587	0.2209	0.1437	0.0802	0.0484	0.0272	0.0182	0.0136	0.0106	0.0076	0.0061	0.0061	0.0030	0.0076	0.0030	0.0030	0.0030	0.0182
2001	81	47	0.0111	0.0815	0.2420	0.2198	0.1444	0.0827	0.0531	0.0309	0.0222	0.0185	0.0148	0.0099	0.0086	0.0086	0.0062	0.0074	0.0049	0.0049	0.0037	0.0247
2002	57	43	0.0158	0.0474	0.2281	0.3263	0.2105	0.0947	0.0439	0.0175	0.0088	0.0035	0.0018	0.0018	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2003	77	43	0.0000	0.0091	0.1182	0.2610	0.2584	0.1636	0.0896	0.0429	0.0221	0.0117	0.0078	0.0052	0.0039	0.0026	0.0013	0.0013	0.0013	0.0000	0.0000	0.0000
2004	46	19	0.0000	0.0587	0.2478	0.2696	0.1739	0.0935	0.0543	0.0304	0.0196	0.0130	0.0087	0.0065	0.0043	0.0043	0.0022	0.0043	0.0022	0.0022	0.0022	0.0022
2005	31	19	0.0000	0.0065	0.0971	0.2686	0.2880	0.1715	0.0906	0.0388	0.0194	0.0097	0.0065	0.0032	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2006	17	25	0.0000	0.0118	0.1183	0.2426	0.2189	0.1479	0.1124	0.0769	0.0414	0.0178	0.0118	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2007	45	42	0.0000	0.0134	0.1790	0.2931	0.2371	0.1298	0.0716	0.0358	0.0201	0.0112	0.0067	0.0022	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2008	26	35	0.0000	0.1042	0.3359	0.2587	0.1467	0.0811	0.0425	0.0154	0.0077	0.0039	0.0039	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 2.1.5 (continued). Age composition, number of lengths, and the number of ages used in the stochastic von Bertalanffy growth curves for assigning ages to lengths by fleet and year.

c. Commercial hook-and-line age composition

			Proportion																			
Year	Num len	Num ages	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	296	15	0.0443	0.2170	0.2612	0.1767	0.0963	0.0595	0.0412	0.0294	0.0206	0.0149	0.0108	0.0078	0.0057	0.0041	0.0027	0.0024	0.0017	0.0010	0.0010	0.0017
1987	258	15	0.0240	0.2295	0.3225	0.2043	0.0969	0.0516	0.0302	0.0174	0.0101	0.0054	0.0027	0.0012	0.0008	0.0008	0.0008	0.0004	0.0004	0.0004	0.0004	0.0004
1988	264	15	0.0345	0.1725	0.1930	0.1904	0.1597	0.1092	0.0645	0.0338	0.0182	0.0102	0.0057	0.0027	0.0011	0.0008	0.0004	0.0008	0.0004	0.0004	0.0004	0.0015
1989	253	15	0.0549	0.2572	0.2825	0.1893	0.1102	0.0636	0.0300	0.0091	0.0024	0.0008	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1990	464	15	0.0246	0.1525	0.2402	0.2200	0.1555	0.0910	0.0498	0.0246	0.0140	0.0086	0.0056	0.0035	0.0022	0.0017	0.0013	0.0011	0.0009	0.0006	0.0006	0.0017
1991	159	15	0.0195	0.0622	0.1653	0.1810	0.1647	0.1238	0.0855	0.0559	0.0339	0.0220	0.0163	0.0126	0.0113	0.0088	0.0075	0.0057	0.0050	0.0038	0.0031	0.0119
1992	243	28	0.0004	0.0699	0.1719	0.1986	0.1908	0.1349	0.0839	0.0493	0.0313	0.0201	0.0127	0.0074	0.0049	0.0037	0.0025	0.0029	0.0021	0.0016	0.0016	0.0095
1993	339	28	0.0024	0.0923	0.2628	0.2605	0.1735	0.0882	0.0457	0.0230	0.0133	0.0080	0.0050	0.0032	0.0024	0.0021	0.0018	0.0018	0.0015	0.0015	0.0015	0.0097
1994	119	28	0.0000	0.0545	0.1837	0.2122	0.1611	0.1007	0.0730	0.0587	0.0436	0.0294	0.0193	0.0126	0.0092	0.0076	0.0059	0.0050	0.0042	0.0034	0.0025	0.0134
1995	133	34	0.0000	0.0399	0.1453	0.1980	0.1837	0.1250	0.0798	0.0512	0.0361	0.0279	0.0211	0.0158	0.0120	0.0090	0.0060	0.0068	0.0045	0.0045	0.0045	0.0286
1996	140	34	0.0000	0.0966	0.2568	0.2268	0.1631	0.0930	0.0486	0.0236	0.0150	0.0107	0.0079	0.0050	0.0043	0.0043	0.0036	0.0043	0.0043	0.0043	0.0036	0.0243
1997	179	34	0.0000	0.0296	0.1112	0.1531	0.1665	0.1408	0.1067	0.0793	0.0542	0.0369	0.0263	0.0184	0.0140	0.0106	0.0073	0.0073	0.0050	0.0045	0.0039	0.0246
1998	172	34	0.0000	0.0459	0.1488	0.1988	0.2058	0.1599	0.1006	0.0570	0.0326	0.0186	0.0105	0.0052	0.0029	0.0023	0.0012	0.0017	0.0012	0.0006	0.0006	0.0058
1999	190	47	0.0047	0.1121	0.1811	0.1616	0.1179	0.0795	0.0563	0.0400	0.0311	0.0263	0.0232	0.0174	0.0153	0.0153	0.0105	0.0200	0.0095	0.0100	0.0095	0.0589
2000	170	47	0.0012	0.0606	0.1388	0.1488	0.1176	0.0835	0.0641	0.0494	0.0406	0.0359	0.0318	0.0253	0.0224	0.0218	0.0159	0.0235	0.0141	0.0141	0.0135	0.0771
2001	308	47	0.0000	0.0480	0.1655	0.1772	0.1389	0.0931	0.0655	0.0461	0.0357	0.0299	0.0260	0.0191	0.0165	0.0165	0.0110	0.0198	0.0104	0.0107	0.0107	0.0594
2002	228	43	0.0000	0.0114	0.1010	0.1962	0.2076	0.1558	0.1076	0.0737	0.0487	0.0312	0.0193	0.0110	0.0070	0.0053	0.0031	0.0035	0.0022	0.0022	0.0018	0.0114
2003	166	43	0.0000	0.0241	0.1025	0.1894	0.2002	0.1417	0.0959	0.0645	0.0434	0.0296	0.0211	0.0151	0.0115	0.0097	0.0078	0.0066	0.0060	0.0048	0.0042	0.0217
2004	88	19	0.0023	0.0667	0.1493	0.1686	0.1516	0.1075	0.0724	0.0486	0.0351	0.0271	0.0226	0.0158	0.0136	0.0136	0.0090	0.0181	0.0079	0.0090	0.0090	0.0520
2005	163	19	0.0049	0.0111	0.1468	0.2807	0.2346	0.1388	0.0762	0.0369	0.0190	0.0117	0.0086	0.0061	0.0055	0.0043	0.0031	0.0025	0.0018	0.0018	0.0012	0.0043
2006	73	25	0.0000	0.0068	0.0698	0.1477	0.1669	0.1341	0.0999	0.0766	0.0602	0.0465	0.0356	0.0274	0.0219	0.0178	0.0137	0.0123	0.0096	0.0082	0.0068	0.0383
2007	95	42	0.0000	0.0126	0.0829	0.1920	0.2267	0.1689	0.1091	0.0672	0.0399	0.0252	0.0168	0.0105	0.0073	0.0063	0.0042	0.0052	0.0031	0.0031	0.0031	0.0157
2008	66	35	0.0000	0.0182	0.1275	0.1866	0.1775	0.1335	0.0910	0.0607	0.0425	0.0303	0.0228	0.0167	0.0121	0.0121	0.0076	0.0106	0.0061	0.0076	0.0061	0.0303

Table 2.1.5 (continued). Age composition, number of lengths, and the number of ages used in the stochastic von Bertalanffy growth curves for assigning ages to lengths by fleet and year.

d. Commercial longline age composition

			Proportion																			
Year	Num len	Num ages	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	0	0																				
1987	0	0																				
1988	0	0																				
1989	0	0																				
1990	0	0																				
1991	0	0																				
1992	78	120	0.0013	0.0230	0.0256	0.0524	0.0972	0.1202	0.1138	0.0997	0.0767	0.0575	0.0448	0.0332	0.0269	0.0243	0.0179	0.0217	0.0166	0.0166	0.0153	0.1151
1993	48	120	0.0000	0.0000	0.0167	0.0480	0.0835	0.1294	0.1315	0.1148	0.0814	0.0585	0.0438	0.0334	0.0292	0.0271	0.0230	0.0230	0.0188	0.0188	0.0167	0.1023
1994	40	120	0.0000	0.0025	0.0201	0.0352	0.0427	0.0553	0.0804	0.0980	0.1030	0.0930	0.0779	0.0653	0.0503	0.0402	0.0276	0.0302	0.0226	0.0201	0.0176	0.1181
1995	78	120	0.0000	0.0128	0.0103	0.0141	0.0449	0.0924	0.0950	0.0847	0.0680	0.0565	0.0488	0.0424	0.0398	0.0385	0.0347	0.0359	0.0321	0.0295	0.0270	0.1926
1996	55	105	0.0000	0.0055	0.0128	0.0255	0.0493	0.0894	0.1131	0.1186	0.0967	0.0748	0.0584	0.0438	0.0365	0.0328	0.0255	0.0274	0.0219	0.0201	0.0182	0.1296
1997	129	105	0.0000	0.0000	0.0047	0.0179	0.0381	0.0630	0.0785	0.0871	0.0894	0.0832	0.0739	0.0653	0.0552	0.0474	0.0404	0.0350	0.0303	0.0264	0.0226	0.1415
1998	353	105	0.0000	0.0017	0.0071	0.0255	0.0519	0.0839	0.0887	0.0830	0.0717	0.0635	0.0567	0.0505	0.0454	0.0417	0.0366	0.0343	0.0315	0.0281	0.0249	0.1735
1999	480	44	0.0000	0.0033	0.0256	0.0535	0.0772	0.0989	0.1037	0.0999	0.0864	0.0727	0.0608	0.0512	0.0425	0.0350	0.0294	0.0242	0.0208	0.0175	0.0148	0.0827
2000	363	44	0.0000	0.0019	0.0118	0.0482	0.0964	0.1181	0.1088	0.0936	0.0735	0.0600	0.0512	0.0443	0.0394	0.0347	0.0314	0.0253	0.0237	0.0198	0.0168	0.1010
2001	278	44	0.0000	0.0007	0.0147	0.0687	0.1108	0.1205	0.1161	0.1082	0.0903	0.0698	0.0529	0.0392	0.0306	0.0259	0.0209	0.0187	0.0162	0.0137	0.0119	0.0705
2002	293	37	0.0000	0.0017	0.0157	0.0649	0.1260	0.1530	0.1325	0.1062	0.0816	0.0639	0.0502	0.0396	0.0311	0.0249	0.0198	0.0161	0.0130	0.0106	0.0089	0.0403
2003	460	85	0.0000	0.0013	0.0159	0.0444	0.0925	0.1318	0.1296	0.1162	0.0925	0.0709	0.0542	0.0409	0.0320	0.0268	0.0211	0.0191	0.0161	0.0139	0.0120	0.0690
2004	321	114	0.0000	0.0000	0.0047	0.0349	0.0803	0.1205	0.1258	0.1171	0.0931	0.0719	0.0561	0.0439	0.0355	0.0299	0.0240	0.0221	0.0190	0.0165	0.0146	0.0900
2005	350	156	0.0000	0.0037	0.0171	0.0577	0.0997	0.1255	0.1303	0.1246	0.1006	0.0755	0.0560	0.0412	0.0312	0.0246	0.0189	0.0163	0.0131	0.0109	0.0091	0.0440
2006	350	240	0.0049	0.0174	0.0277	0.0597	0.0934	0.1309	0.1337	0.1214	0.0991	0.0780	0.0597	0.0446	0.0323	0.0234	0.0160	0.0134	0.0091	0.0071	0.0057	0.0223
2007	181	136	0.0000	0.0000	0.0072	0.0376	0.0895	0.1547	0.1558	0.1365	0.1039	0.0762	0.0547	0.0381	0.0276	0.0215	0.0155	0.0144	0.0110	0.0094	0.0077	0.0387
2008	109	75	0.0000	0.0009	0.0202	0.0569	0.0909	0.1359	0.1396	0.1295	0.1047	0.0799	0.0597	0.0450	0.0321	0.0239	0.0156	0.0147	0.0101	0.0083	0.0064	0.0257

Table 2.1.6. Fishery independent age-1 indices using the FWC Visual Survey numbers of black grouper counted per dive-habitat combinations and the NMFS-UM Reef Visual Census' estimated numbers of black grouper in the Florida reef track.

Year	FWC Visual Survey			NMFS-UM Reef Visual Census		
	Index Number/dive-habitat	Scaled to mean	CV	Index Number	Scaled to mean	CV
1994				59489	0.43	0.16
1995				684	0.00	0.19
1996				12295	0.09	0.48
1997				144196	1.04	0.17
1998				286678	2.07	0.26
1999	0.27	1.20	0.15	171920	1.24	0.13
2000	0.42	1.85	0.14	204573	1.48	0.11
2001	0.21	0.93	0.17	286225	2.07	0.14
2002	0.23	1.01	0.15	201817	1.46	0.13
2003	0.20	0.91	0.16	77990	0.56	0.17
2004	0.24	1.04	0.16	28979	0.21	0.26
2005				261831	1.89	0.12
2006	0.14	0.62	0.19	96264	0.69	0.16
2007	0.18	0.81	0.16	94532	0.68	0.14
2008				150232	1.08	0.11

2.2. FIGURES

Figure	**Description**
2.2.1	Proportion of ages by fleet together with the number of otoliths ages for that fleet that were collected from 1979-2008.
2.2.2	Standard deviations of length (mm) at age.

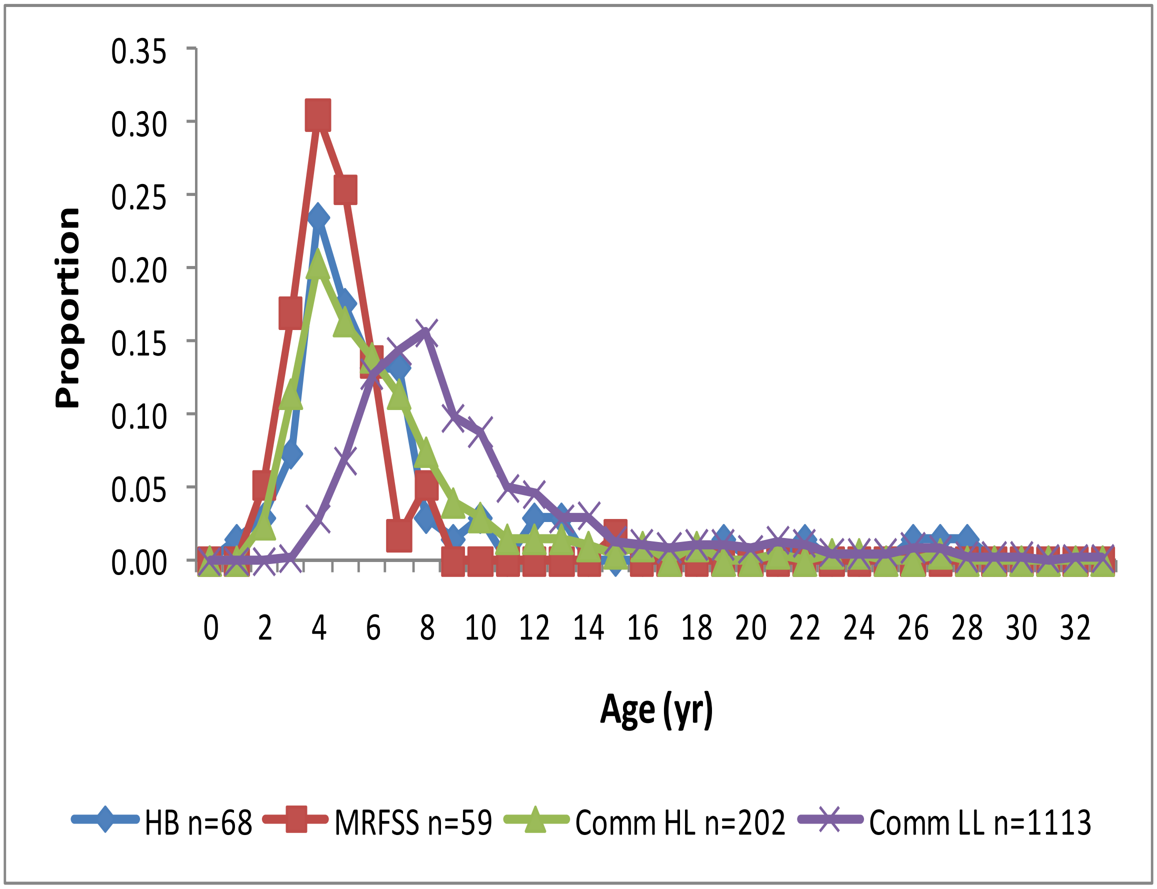

Figure 2.2.1. Proportion of ages by fleet together with the number of otoliths ages for that fleet that were collected from 1979-2008.

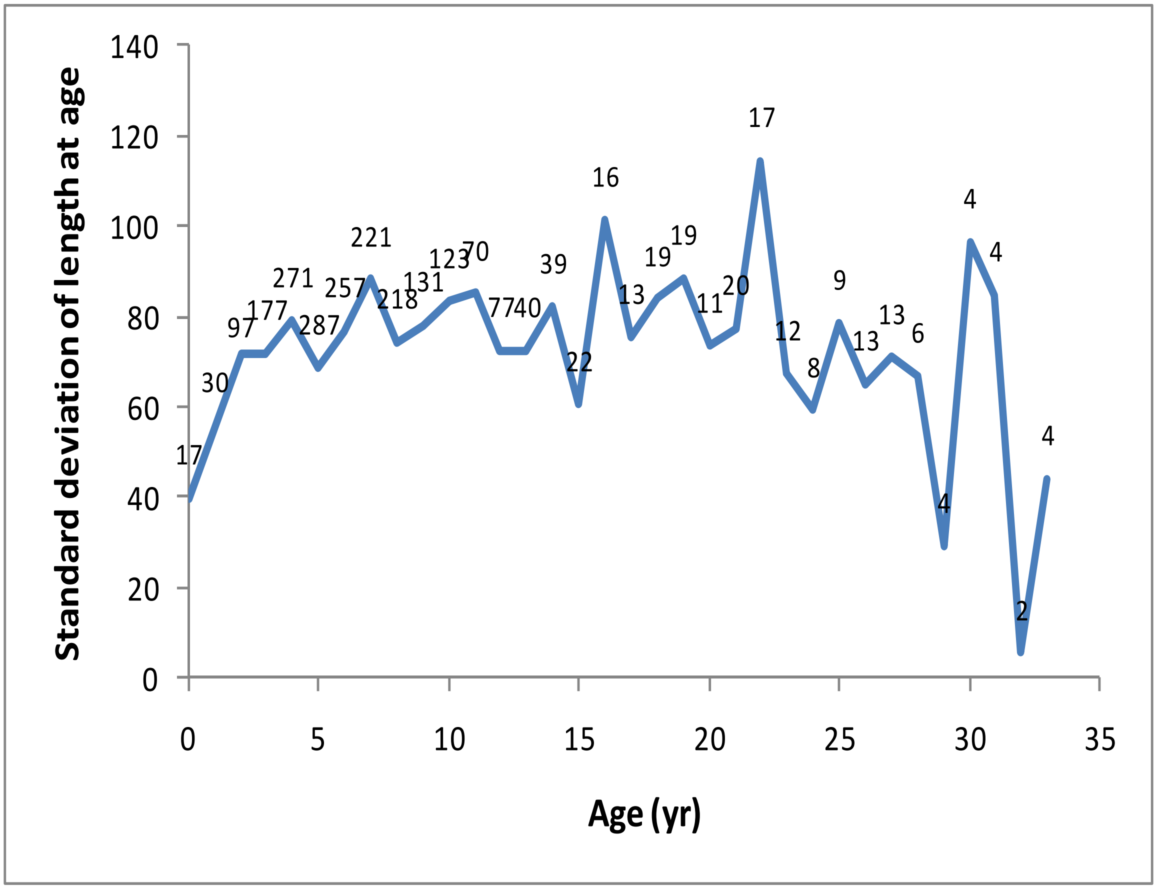

Figure 2.2.2. Standard deviations of length (mm) at age. The numbers above the line are the numbers of lengths per age.

2.3. REFERENCES

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3. STOCK ASSESSMENT MODELS AND RESULTS

Three models were developed for black grouper ranging from catch curves to provide a reasonable scale for natural mortality, a non-equilibrium surplus production to investigate whether the landings and indices contained useful information, and the main assessment model, a statistical catch-at-age model (ASAP2), to estimate population sizes, spawning biomass trends, benchmarks, stock status, and projections.

3.1. MODEL 1. CATCH CURVE ANALYSIS

The only assessments of black grouper in U.S. waters prior to this SEDAR endeavor came from catch curves using fish collected by headboat samplers as part of the NMFS Headboat Survey(Manooch and Mason 1987, Potts and Brennan 2001). The estimates of total mortality in these studies were approximately 0.75 per year, which depending upon natural mortality, could correspond to static spawning potential levels of 10%. However, catch curves assume that all fish above a certain age are equally vulnerable to the gear as well as the population being in equilibrium, i.e., constant recruitment, constant selectivity, and constant mortality. As more otoliths have been collected from other fleets of the black grouper fishery, older ages are being recorded. Out of a total of 2,288 fish, one hundred twenty-nine fish were age-20 or older and of those, fourteen were age-30 or older with the four oldest fish having an age of 33 years. SEDAR19 AW-06 presents the catch curve analyses for black grouper's longline and headboat fisheries.

3.1.1. Model 1. Catch-curve Methods

The earlier catch curves used ages from fish primarily collected from the headboat fleet and we wanted to calculate a catch curve for the longline fleet to provide a context for reasonable values of natural mortality. Because there were only 68 ages from the headboat fishery, ages were assigned to the lengths of fish measured in the headboat fishery using inverted von Bertalanffy hook-and-line growth curves by corresponding year or years. The inverted von Bertalanffy curves were used because, when we conducted this analysis, we had not yet developed the stochastic aging method. For the lengths collected from the longline fishery, we used inverted von Bertalanffy longline growth curves to assign their ages. We grouped the data for the two, recent regulatory periods: 1992-1998 and 1999-2008.

The numbers of fish at age were used to estimate total mortality using the Chapman Robson (1960) method. The Chapman-Robson method was used because the estimates of annual survival are unbiased (Murphy 1997).

<u>Overview Data and Sources</u>

The lengths and otoliths for the headboat fleet came from the NMFS Headboat Survey while the lengths and otoliths for the longline fleet came from the Trip Interview Program. The FWC's Life History Group prepared the otoliths and determined the age. The number of fish by age for the two fleets and the two time periods are listed in Table 3.1.4.1.

<u>Model Configuration and Equations</u>

Separate models were developed for the longline and headboat fleets for the two time periods.
The Chapman-Robson equation for the annual survival, *S*, is:

$$S = \frac{T}{\Sigma N + T - 1} \qquad (1)$$

where *T = N1 + 2N2 + 3N3 + …* and *ΣN = N0 + N1 + N2 + …*.The sampling variance of *S* is

$$Var(S) = S(S - \frac{T-1}{\Sigma N + T - 2}) \,. \qquad (2)$$

Total mortality, *Z*, is calculated from annual survival as *Z = -ln(S).* Similarly, the confidence interval for total mortality is

$$-\ln(S + 1.96\sqrt{Var(S)}) \le Z \le -\ln(S - 1.96\sqrt{Var(S)}) \,. \qquad (3)$$

<u>Parameters Estimated</u>

Given the numbers at age, the model calculates the survival rate, *S*, using equation (1) and its variance, *Var(S),* using equation (2). The instantaneous total mortality rate, *Z*, follows from survival as *Z = -ln(S).*

<u>Uncertainty and Measures of Precision</u>

The variance of survival is given above in equation (2) and can provide a measure of uncertainty in the total mortality by back-transforming the confidence limits of survival to their instantaneous rates equation (3).

<u>Benchmark / Reference Points Methods</u>

No stock status benchmarks were developed because this model was not developed to determine stock status but rather to provide a rough magnitude for realistic natural mortality estimates.

<u>Projection methods</u>

As with benchmarks, projections are not appropriate for this model.

3.1.2. Model 1. Catch-curve Results

<u>Measures of Overall Model Fit</u>

Since catch curves are deterministic, the only measures of fit would be the t-values which are the ratios of the survival estimates to their standard errors. These values were significant at the $\alpha = 0.05$ level (Table 3.1.4.2).

<u>Parameter estimates and associated measures of uncertainty</u>

The survival rate for the longline fleet in 1992-1998 was 0.86 (SE = 0.0062) or Z = 0.15 per year (0.14 –

0.17 per year, 95% confidence interval) and 0.84 (SE = 0.0037) or Z = 0.18 per year (0.17 – 0.18 per year, 95% confidence interval) in 1999-2008 (Table 3.1.4.2). In a discussion at the assessment workshop, one of the participants asked how the catch-curve results would differ if the actual age samples were used instead of using growth curves to assign ages to the lengths. Only the longline fleet had sufficient numbers of fish (n = 1127) to repeat the analysis using the raw age data. The survival rate of the longline fleet in 1992-1998 using the raw ages was 0.87 (SE = 0.0089) which was very similar to the rate calculated using ages derived from lengths and the growth curve (0.86, SE = 0.0062). The total mortality equivalent for the longline fleet was 0.14 per year (0.12 – 0.16 per year, 95% confidence interval). The survival in the recent period, 1999-2008, was lower at S = 0.80 (SE = 0.0091) as compared to 0.84 (SE = 0.0037) and the total mortality was correspondingly higher at 0.22 per year (0.20 – 0.25 per year, 95% confidence interval). The increase in mortality resulted from the greater proportion of fish ages 10 to 17 years in the raw ages.

Stock Abundance and Recruitment

Not applicable.

Stock Biomass (total and spawning stock)

Not applicable.

Fishery Selectivity

Table 3.1.4.1 shows the ages that were included in calculating the catch curve. The nature of catch curves assumes that all of these ages were equally vulnerable to the gear.

Fishing Mortality

A catch curve estimates annual survival which can be converted into an instantaneous total mortality rate. With an estimate of natural mortality, fishing mortality can be estimated as the difference between the total mortality and the natural mortality. In the case of black grouper with a maximum observed age of 33 years, we used the Data Workshop's recommended value of 0.136 per year for natural mortality derived from Hoenig's equation for all species (Hoenig 1983, Hewitt and Hoenig 2005). This would indicate low fishing mortality rates for the longline fleet during 1992-1998 of 0.017 per year and 0.04 per year during 1999-2008.

Stock-Recruitment Parameters

Not applicable.

Evaluation of Uncertainty

While the variance of the survival rates were calculated, those measure precision or observation error and do not include any uncertainty in assigning ages to fish, uncertainty due to sampling, or any other sources of uncertainty usually lumped under the term, "process error".

Benchmarks / Reference Points / ABC values

Not applicable.

Projections

Not applicable.

3.1.3. Discussion

Black grouper are not usually targeted other than by spearfishers participating in tournaments but rather black grouper are captured incidentally by fishers as the fishers set their gear on reefs or hard bottom habitats. Thus, the landings for black grouper are much less than those of other grouper species in the southeast U.S. such as red grouper, *Epinephelus morio*, or gag, *Mycteroperca microlepis*. As mentioned above, the purpose of generating the catch curves was to provide estimates of total mortality realizing that the catch curve results provide only rough estimates of the mortality magnitudes because of the assumption of constant selectivity across the included ages plus the usual equilibrium concerns. That said, the total mortality of black grouper appears to be low and the upper range of natural mortality rates to be explored with sensitivity analysis recommended by the Data Workshop, 0.25 per year, is unrealistically high and perhaps a more reasonable upper limit would be 0.18 per year.

3.1.4. Tables

Table	Description
3.1.4.1	The numbers of fish by age from the longline and headboat fleets in two time periods.
3.1.4.2	The ages included in the analyses, annual survival (S), variance of annual survival, standard error of survival, t-values, probabilities of the null hypothesis, instantaneous total mortality per year, and the confidence limits of total mortality by fleet and period.

Table 3.1.4.1. The numbers of fish by age from the longline and headboat fleets in the two time periods. Note that the oldest observed fish was 33 years old while the calculated values, using the inverted von Bertalanffy growth curves, extended the range to age-40.

	Fishery and time periods			
	Longline		Headboat	
	1992-98	1999-08	1992-98	1999-08
Age (yr)	Number	Number	Ave Num	Ave Num
1	1	4	3	1
2	5	14	22	5
3	8	70	32	18
4	21	200	29	23
5	52	375	26	14
6	84	450	19	11
7	91	407	8	6
8	53	358	2	1
9	59	255	2	1
10	57	216	0	1
11	44	144	0	2
12	35	135	0	0
13	31	94	0	0
14	19	68	0	0
15	16	46	0	0
16	18	44	0	0
17	21	50	0	0
18	13	40	0	0
19	10	29	0	0
20	13	26	0	0
21	11	23	0	0
22	6	15	0	0
23	6	12	0	0
24	11	15	0	0
25	5	11	0	0
26	2	6	0	0
27	4	10	0	0
28	3	3	0	0
29	1	4	0	0
30	3	1	0	0
31	2	4	0	0
32	0	0	0	0
33	4	3	0	0
34	0	2	0	0
35	1	1	0	0
36	3	0	0	0
37	0	2	0	0
38	1	0	0	0
39	0	2	0	0
40	2	5	0	0

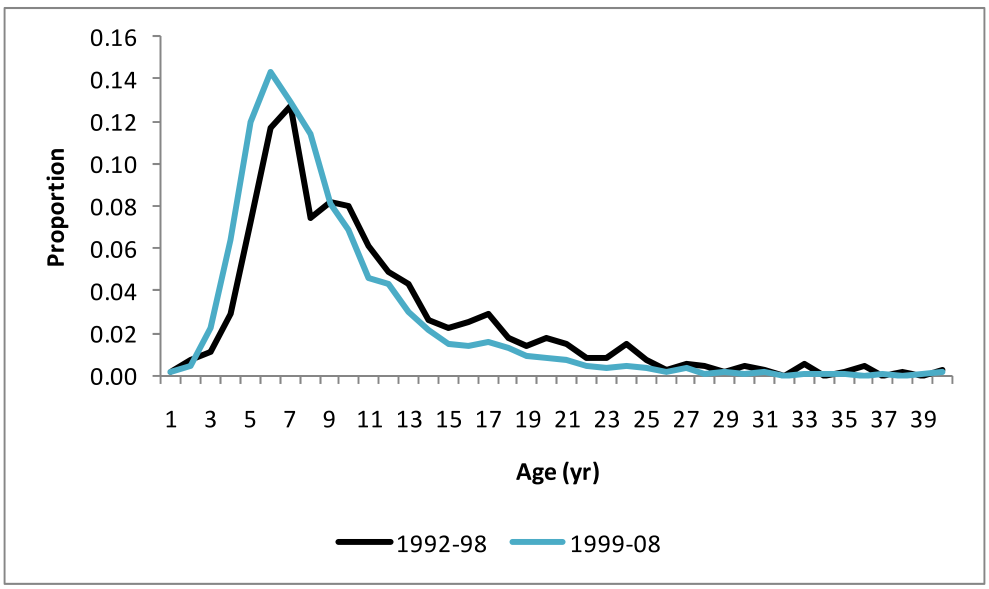
Table 3.1.4.2. The ages included in the analyses, annual survival (S), variance of annual survival, standard error of survival, t-values, probabilities of the null hypothesis, instantaneous total mortality per year, and the confidence limits of total mortality by fleet and period.

Fleet	Period	Ages	Annual Survival (S)	Variance Survival	Standard Error	t-values	Probability of null hypothesis	Total mortality (Z) per year	Total mortality Confidence interval Lower 95%	Upper 95%
Longline	1992-98	8-40	0.86	3.807E-05	0.0062	139.091	0.000	0.15	0.14	0.17
	1999-08	7-40	0.84	1.349E-05	0.0037	228.298	0.000	0.18	0.17	0.18
Headboat	1992-98	4-9	0.58	1.209E-03	0.0348	16.578	0.000	0.55	0.44	0.68
	1999-08	5-11	0.57	3.020E-03	0.0550	10.429	0.000	0.56	0.38	0.76

3.1.5. Figures

Figure	Description
3.1.5	Proportion of black grouper ages from the longline fishery for 1992-1998 and 1999-2008.

Figure 3.1.5 Proportion of black grouper ages from the longline fishery for 1992-1998 and 1999-2008.



3.1.6. References

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3.2. MODEL 2. NON-EQUILIBRIUM SURPLUS PRODUCTION (ASPIC) MODEL

Surplus production models summarize landings and effort information to estimate the vulnerable biomass and fishing mortality rates and, based on the shape of the production curve, benchmarks against which to evaluate the condition of the stock. These models are simple with minimal data requirements. As with the catch curve analysis (Section 3.1), this model was intended for exploration rather than status determination. The program used in the black grouper analyses was a non-equilibrium, surplus production model (ASPIC 5.34.6, Prager 1994) that allows covariates or tuning indices and was part of the National Marine Fisheries Stock (NMFS) Assessment Toolbox. The program can be downloaded from http://nft.nefsc.noaa.gov. SEDAR19 AW-05 presents the non-equilibrium, surplus production model for black grouper.

3.2.1. Model 2 Non-equilibrium Surplus Production Methods

The surplus production model groups the processes that change the population biomass into the total kill (landings and dead discards); the intrinsic rate of increase, a term that combines natural mortality, growth, and recruitment; and the environment's carrying capacity. Because the population magnitude is scaled by the catch, the surplus production model only looks at that portion of the population that is vulnerable to fishing. The model fits the rate of increase, carrying capacity, initial biomass, and catchability coefficients for the fleets and for the indices of abundance.

Overview and Data Sources

Annual landings from the recreational fleets, headboat and MRFSS, in pounds were taken directly from the SEDAR19 Data Workshop Report. Commercial landings were reported in gutted weight (GW) and the AW converted the gutted weights to whole weights (WW) using the gutted weight to whole weight conversion from the Data Workshop Report's Table 2.14.7: WW = 1.061 GW. The number of discards came from the Data Workshop Report and the release mortality rates were 20% for the recreational and commercial hook-and-line fisheries and 30% for the longline fishery (Section 2.5, SEDAR 19 Data Workshop Report). The weight of dead discards was calculated from the lengths of fish smaller than the minimum sizes in earlier years by fishery. This method is an approximation necessitated by the absence of observed discard measurements for black grouper. As noted in Section 2, the calculated weight of dead commercial discards differed from the weight given in the DW report. The indices of abundance included headboat (SEDAR19-DW-04), general recreational (MRFSS, SEDAR19-DW-01), and commercial logbook indices (SEDAR19-DW-13) for hook-and-line and longline plus the FWC Visual Survey (SEDAR19-DW-02) and the NMFS-UM Reef Visual Survey (Ault and Smith 2009). The landings and dead discards are shown in Table 3.2.4.1 and the indices are shown in Table 3.2.4.2.

Model Configuration and Equations

In its simplest implementation (a logistic or Schaefer (1954) model), the surplus production model has two equations (Hilborn and Walters 1992). The first equation relates the biomass at a particular time (*t*) to the biomass at a future time (*t*+1):

$$B_{t+1} = B_t + rB_t(1 - B_t / K) - \sum_{f=1}^{fleets} C_{f,t} \qquad (1)$$

where B_t is the biomass at time *t*, *r* is the dimensionless intrinsic rate of increase, *K* is the carrying capacity (biomass) of the environment and $C_{f,t}$ is the catch for fishery *f* during time *t*. The second equation relates the catch to the biomass:

$$\hat{C}_{f,t} = q_f E_{f,t} B_t \qquad (2)$$

where q_f is the catchability coefficient (per unit effort) for fleet *f*, which links effort by fleet to biomass, and $E_{f,t}$ is the effort expended by that fleet during time *t*.

Recent versions of ASPIC using Schaefer's logistic model (1954) solve for Maximum Sustainable Yield (MSY) directly instead of *r.* This change was easily accomplished by rearranging the equation for MSY = Kr/4.

Two configurations of the model were developed. The first configuration used constant catchability through time while the second configuration had time-varying catchability with the catchability increasing by 2% annually over the time period. The time-varying catchability was implemented by decreasing the fishery-dependent indices by 2% each year (Table 3.2.4.2). All indices were equally weighted by giving each a weight of one.

Parameters Estimated

The surplus production model solves for the carrying capacity, *K*; the ratio of the starting biomass to the carrying capacity, *B1/K*; the maximum sustainable yield, *MSY*; and the catchability coefficients, q_f, relating the fleets or indices to the population biomass.

Uncertainty and Measures of Precision

Uncertainty in the parameters is evaluated through a bootstrapping procedure. In this analysis, the bootstraps were repeated for 1000 iterations of annual biomass and fishing mortality rates. Bootstrapping provides information on precision or observation error but cannot address process errors such as the species identification problem with black grouper and gag especially in the early part of the time series. Bootstrapping also assumes that the sampling was adequate to represent the entire spectrum of possibility meaning that a particular value can only occur in the bootstrap results if it was first present in the original data.

Benchmark / Reference Point Methods

The program, ASPIC, provides benchmarks as part of its output. ASPIC solves for MSY directly as well as producing estimates of the fishing mortality at MSY (F_{MSY}) and the biomass at MSY (B_{MSY}). From these values, one can calculate the ratio of fishing mortality in any year to F_{MSY} and the ratio of biomass in any year to B_{MSY}. The benchmarks from ASPIC were not meant to be the actual measures used to evaluate the condition of the stock but rather they were included to corroborate the results from the statistical catch-at-age model (Section 3.3).

Projection methods

No projections were made with the surplus production model.

3.2.2. Model 2 Non-equilibrium Surplus Production Results

Measures of Overall Model Fit

Plots of the model fits to the four fishery-dependent and two fishery-independent indices are shown in Figure 3.2.5.1. Commercial hook-and-line had the best fit (mean square error (MSE) = 0.031) and the NMFS-UM Reef Visual Census has the worst fit (MSE = 0.522, Table 3.2.4.3). The configuration of the model with the time-varying catchability coefficients was not stable and the results varied with different starting values. The time-varying catchability configuration will not be discussed further. As will be noted below, the AW decided to go with constant catchability coefficients in the statistical catch-at-age model because when the catchability coefficients were allowed to vary, there was no consistency in the resulting catchability temporal patterns.

Parameter estimates and associated measures of uncertainty

The point estimates of parameters that are estimated by ASPIC, the bootstrap means, and the 95% confidence intervals from the 1000 bootstrap iterations are shown in Table 3.2.4.4. The agreement was reasonable between the point estimates and the medians of the bootstrap estimates for all of the parameters, i.e., the differences were all within 6.5% except for the carrying capacity. The carrying capacity shows a large difference between the point estimate and the bootstrap mean (62%) because of a few very large values in the bootstrap run. Figure 3.2.5.2 shows the total objective function for each of the 1000 bootstrap iterations plotted against the parameters.

Stock Abundance and Recruitment

Not applicable.

Stock Biomass (total and spawning stock)

Surplus production models do not distinguish between total and spawning stock biomass but rather consider the biomass that is vulnerable to exploitation. The trajectory of vulnerable biomass dropped initially to about 1.4 million lb in 1988, remained at that level until 1994 and has been increasing afterwards (Table 3.2.4.5 and Figure 3.2.5.3). The mean biomass value at the beginning of 2009 was 3.64 million lb (CV = 0.67, log-normal distribution).

Fishery Selectivity

Because surplus production models only use biomass landed, selectivity is not included in the model explicitly.

Fishing Mortality

Fishing mortality rates ($F = q_f*E_f$) were high in the early years of the time series and then declined such that the lowest value in the time series was 0.108 per year in 2006 (Table 3.2.4.5 and Figure 3.2.5.4). Fishing mortality rates have shifted among the fleets in the fishery from the commercial hook-and-line fleet in the early years of the time series to the general recreational (MRFSS) fleet (Figure 3.2.5.4b). The landings from the headboat and longline fleets have been low over the entire time series.

Stock-Recruitment Parameters

Not applicable.

Evaluation of Uncertainty

Uncertainty of the different parameters was evaluated with 1000 bootstrap iterations (Figures 3.2.5.2). However, those measures do not include any uncertainty in species identification in the recreational fisheries, uncertainty due to sampling, or any other sources of uncertainty usually lumped under the term, “process error”.

Benchmarks / Reference Points / ABC values

The benchmarks or reference points from ASPIC were maximum sustainable yield (MSY = 641,100 lb), the fishing mortality rate at MSY (F_{MSY} = 0.40 per year) and the biomass at MSY (B_{MSY} = 1,601,000 lb). With these benchmarks, one can calculate the council reference points of the fishing mortality rate compared to F_{MSY} (F/F_{MSY}) and biomass compared to B_{MSY} (B/B_{MSY}). In 2008 the fishing mortality ratio was 0.42 and none of the fishing mortality ratios estimated by the 1000 bootstrap iterations was above 1.00 (Figure 3.2.5.5a and 3.2.5.6). The biomass ratio was 1.63 in 2008 and 11 of the 1000 biomass ratio bootstrap iterations was below 1.00 (Figure 3.2.5.5b and 3.2.5.6). For perspective, the fishing mortality ratio has been below 1.00 since 1993 and the biomass ratio has been above 1.00 since 1995 (Figure 3.2.5.7). However as mentioned above, the surplus production model was not intended to be the model used to evaluate the condition of the stock, so while the model estimates maximum sustainable yield (MSY), the fishing mortality rate associated with MSY (F_{MSY}), and the biomass associated with MSY (SSB_{MSY}), these measures were intended to corroborate the results of the statistical catch at age model (Section 3.3).

Projections

Not applicable.

3.2.3. Discussion

The surplus production model converged with four fisheries (standardized fishery dependent CPUE and landings plus dead discards) and two fishery independent indices of abundance. The fits of the landings and indices were reasonable and plots of the parameters against the objective function from the bootstrap iterations showed that the parameters’ point estimates tended to be in the middle of the clouds of points. The plot for carrying capacity was distorted because there were a few very high values such that the point estimate appears to be off-center (Figure 3.2.5.2c) and, because of the linkage of maximum sustainable yield (MSY) with carrying capacity, the plot for MSY was also distorted although to a lesser extent (Figure 3.2.5.2a). The decline in landings was interpreted by the model as an increase in biomass and a reduction in fishing mortality rates. The three levels in the trajectory of fishing mortality correspond to the period without a minimum size in the South Atlantic waters, the 20-inch minimum size limit which was implemented in 1992, and 24 inch-minimum size implemented in 1999 (Figure

3.2.5.4). The low fishing mortality rates were consistent with the catch curves (Muller 2009, SEDAR19 AW 06) and with how fishers catch black grouper, i.e. black grouper are captured incidentally by fishers as the fishers set their gear on reefs or hard bottom habitats. This model, lacking information on age and reproduction, was not meant to be a definitive assessment but it did indicate that additional investigation was merited.

3.2.4. Tables

Table	Description
3.2.4.1	Directed landings, dead discards, and combined landings in pounds of black grouper by fleet and year..
3.2.4.2	Fishery dependent and independent indices for black grouper. The table numbers refer to tables in the SEDAR 19 black grouper Data Workshop Report.
3.2.4.3	Goodness of fit for the black grouper non-equilibrium, surplus production model, ASPIC, configured for constant catchability.
3.2.4.4	Comparison of parameter point estimates from non-equilibrium, surplus production model, bootstrap means from 1000 iterations, and 95% confidence interval from bootstraps.
3.2.4.5	Point estimates and bootstrap results (mean, standard deviation, and 95%confidene interval) for fishing mortality rate a vulnerable biomass.

Table 3.2.4.1. Directed landings, dead discards, and combined landings in pounds of black grouper by fleet and year.

	Headboat			MRFSS			Commercial Hook-and-line			Commercial Longline		
Year	Landings	Dead Discards	Combined	Landings	Dead Discards	Combined	Landings	Dead Discards	Combined	Landings	Dead Discards	Combined
1,986	19,976	8,017	27,993	447,266	10,694	457,961	426,270		426,270	129,457		129,457
1,987	39,603	5,393	44,996	382,021	49,642	431,663	567,539		567,539	125,101		125,101
1,988	24,288	5,101	29,389	188,198	5,099	193,297	365,587		365,587	83,995		83,995
1,989	19,806	3,479	23,284	181,452	6,578	188,030	384,267		384,267	82,395		82,395
1,990	17,764	3,206	20,971	74,441	5,606	80,047	299,700		299,700	109,944		109,944
1,991	15,378	2,843	18,221	398,475	24,003	422,478	163,451		163,451	53,681		53,681
1,992	20,965	13,767	34,732	281,616	83,614	365,229	218,010		218,010	58,787		58,787
1,993	25,129	11,506	36,635	140,596	50,558	191,154	165,666	6,517	172,183	35,670	86	35,756
1,994	24,053	13,377	37,430	166,073	73,074	239,147	139,558	7,934	147,492	25,401	104	25,504
1,995	31,760	22,505	54,266	236,796	29,113	265,908	115,303	6,587	121,889	24,975	93	25,068
1,996	36,613	14,478	51,091	316,559	78,264	394,823	120,418	7,152	127,570	29,915	110	30,025
1,997	48,274	18,715	66,989	450,156	64,599	514,755	89,464	7,566	97,030	34,644	120	34,764
1,998	84,984	30,448	115,432	389,372	52,970	442,342	88,334	6,995	95,329	41,778	114	41,891
1,999	25,267	8,628	33,895	169,613	82,449	252,062	79,719	11,586	91,304	51,646	340	51,986
2,000	15,118	4,906	20,024	112,952	65,786	178,738	92,434	11,457	103,891	50,077	312	50,389
2,001	31,013	9,550	40,563	136,623	52,493	189,116	100,951	9,915	110,866	55,020	293	55,313
2,002	15,271	3,788	19,060	139,377	63,012	202,389	89,052	8,339	97,390	53,496	355	53,851
2,003	11,940	4,296	16,236	262,670	24,531	287,201	97,394	10,555	107,949	77,142	330	77,472
2,004	18,414	7,273	25,687	139,018	79,234	218,253	91,732	7,483	99,215	73,385	380	73,765
2,005	25,733	8,959	34,692	135,772	23,541	159,313	73,266	11,452	84,718	45,734	219	45,953
2,006	17,862	3,362	21,224	92,165	36,501	128,666	72,223	1,424	73,647	61,444	259	61,703
2,007	17,828	4,181	22,009	156,224	58,075	214,299	54,849	12,385	67,234	43,457	260	43,717
2,008	3,930	1,514	5,444	162,408	82,197	244,605	33,236	2,123	35,359	17,843	276	18,120

Table 3.2.4.2. Fishery dependent and independent indices for black grouper. The table numbers refer to tables in the SEDAR 19 black grouper Data Workshop Report.

Year	Headboat Scaled Table 5.12	Headboat Decremented by 2% per year	MRFSS Scaled Table 5.14	MRFSS Total catch/ trip Table 5.14	MRFSS Decremented by 2% per year	Comm HL Scaled Table 5.15	Comm HL Decremented by 2% per year	Comm LL Scaled Table 5.16	Comm LL Decremented by 2% per year	NMFS-UM RVC Scaled Table 5.18	FWC VS Scaled Table 5.5	Number/ dive habitat Table 5.5
1986	0.85	0.85										
1987	1.35	1.32										
1988	0.48	0.46										
1989	0.78	0.73										
1990	0.57	0.52										
1991	0.68	0.61	0.49	0.15	0.15							
1992	0.83	0.73	0.43	0.13	0.13							
1993	0.55	0.47	0.52	0.16	0.15	0.76	0.76	0.39	0.39			
1994	0.78	0.66	0.80	0.24	0.22	0.75	0.74	0.30	0.30	1.35		
1995	0.97	0.80	0.75	0.22	0.21	0.81	0.78	0.40	0.39	0.36		
1996	0.82	0.66	1.68	0.50	0.45	0.83	0.78	0.46	0.43	0.11		
1997	0.53	0.41	1.06	0.32	0.28	0.75	0.69	0.46	0.42	0.55		
1998	0.63	0.48	1.06	0.31	0.27	0.97	0.87	0.75	0.68	1.48		
1999	0.44	0.33	1.29	0.38	0.32	0.76	0.67	0.83	0.73	1.18	1.54	0.27
2000	0.39	0.28	0.92	0.27	0.23	0.82	0.70	1.06	0.91	1.46	1.26	0.22
2001	0.41	0.29	1.28	0.38	0.31	1.25	1.05	1.41	1.18	1.50	1.05	0.18
2002	0.59	0.40	0.87	0.26	0.20	1.15	0.94	1.58	1.30	1.49	0.87	0.15
2003	0.52	0.34	1.37	0.41	0.31	1.28	1.02	1.84	1.47	0.68	0.78	0.14
2004	1.00	0.64	1.19	0.35	0.26	1.35	1.05	1.87	1.46	0.92	1.06	0.19
2005	2.97	1.84	0.81	0.24	0.17	1.32	1.00	1.80	1.37	1.40		
2006	1.26	0.76	0.53	0.16	0.11	1.38	1.02	1.11	0.82	0.68	0.80	0.14
2007	1.90	1.10	0.69	0.20	0.14	1.02	0.73	1.05	0.76	0.95	0.85	0.15
2008	0.64	0.36	0.64	0.19	0.13	0.80	0.56	0.69	0.48	0.90		

Table 3.2.4.3. Goodness of fit for the black grouper non-equilibrium, surplus production model, ASPIC, configured for constant catchability.

GOODNESS-OF-FIT AND WEIGHTING (NON-BOOTSTRAPPED ANALYSIS)

Loss component number and title	Weighted SSE	N	Weighted MSE	Current weight	Inv. var. weight
Loss(-1) SSE in yield	0.000				
Loss(0) Penalty for B1 > K	0.000	1	N/A	1.00	
Loss(1) Headboat	5.099	23	0.2428	1.00	0.456
Loss(2) MRFSS	2.554	18	0.1596	1.00	0.694
Loss(3) Comm_HL	0.440	16	0.0314	1.00	3.524
Loss(4) Comm_LL	3.347	16	0.2391	1.00	0.463
Loss(5) FWC VS	0.878	8	0.1464	1.00	0.757
Loss(6) NMFS-UM RVC	6.792	15	0.5224	1.00	0.212
TOTAL OBJECTIVE FUNCTION, MSE, RMSE:	19.110		0.220	0.469	
Estimated contrast index (ideal = 1.0):	0.441		C* = (Bmax-Bmin)/K		
Estimated nearness index (ideal = 1.0):	1		N* = 1 - |min(B-Bmsy)|/K		

Table 3.2.4.4. Comparison of parameter point estimates from non-equilibrium, surplus production model, bootstrap means from 1000 iterations, and 95% confidence interval from bootstraps.

Parameter	Point Estimate	Mean (bootstraps)	Lower 95%-tile	Upper 95%-tile
MSY	641,100	699,668	579,046	1,033,984
K	3,201,000	5,013,154	1,600,693	20,767,478
B1/K	0.743	0.780	0.305	1.352
Catchability coefficients				
Headboat	4.03E-07	4.19E-07	9.32E-08	8.21E-07
MRFSS	1.27E-07	1.32E-07	2.67E-08	2.51E-07
Commercial Hook-and-line	4.65E-07	4.84E-07	1.02E-07	9.35E-07
Commercial Longline	4.06E-07	4.24E-07	8.48E-08	8.02E-07
FWC Visual survey	7.55E-08	7.91E-08	1.61E-08	1.62E-07
NMFS-UM Reef visual census	3.95E-07	4.07E-07	8.12E-08	7.63E-07
F ratio	0.416	0.404	0.275	0.517
Biomass ratio	1.630	1.596	1.191	1.732

Table 3.2.4.5. Point estimates and bootstrap results (mean, standard deviation, and 95%confidene interval) for fishing mortality rate a vulnerable biomass.

year	Point estimate	Bootstrap outcomes mean	stdev	97.5%-tile	2.5%-tile
Fishing mortality rate					
1986	0.493	0.480	0.164	0.822	0.160
1987	0.727	0.754	0.341	1.498	0.186
1988	0.498	0.535	0.277	1.162	0.109
1989	0.523	0.569	0.310	1.268	0.109
1990	0.385	0.415	0.221	0.894	0.081
1991	0.483	0.514	0.265	1.084	0.100
1992	0.514	0.556	0.300	1.184	0.101
1993	0.310	0.332	0.174	0.699	0.062
1994	0.280	0.290	0.138	0.561	0.060
1995	0.262	0.267	0.119	0.477	0.058
1996	0.322	0.329	0.145	0.581	0.072
1997	0.388	0.402	0.186	0.732	0.084
1998	0.393	0.413	0.200	0.780	0.080
1999	0.230	0.241	0.115	0.439	0.047
2000	0.169	0.174	0.078	0.306	0.037
2001	0.174	0.179	0.079	0.314	0.039
2002	0.155	0.159	0.071	0.285	0.036
2003	0.199	0.206	0.094	0.375	0.045
2004	0.169	0.175	0.082	0.323	0.038
2005	0.126	0.130	0.061	0.240	0.028
2006	0.108	0.111	0.052	0.206	0.024
2007	0.128	0.132	0.063	0.247	0.028
2008	0.167	0.173	0.085	0.330	0.035
Vulnerable biomass (lb)					
1986	2,380,000	2,860,300	1,246,299	6,664,422	1,637,658
1987	1,909,000	2,332,170	1,365,953	6,429,757	1,068,021
1988	1,375,000	1,818,530	1,427,639	6,084,739	593,587
1989	1,328,000	1,795,636	1,493,264	6,187,446	564,588
1990	1,267,000	1,760,173	1,567,833	6,206,531	512,120
1991	1,379,000	1,898,724	1,644,785	6,403,360	621,005
1992	1,348,000	1,897,430	1,722,542	6,637,547	591,778
1993	1,292,000	1,869,879	1,805,887	6,758,661	531,453
1994	1,489,000	2,093,675	1,887,785	7,233,287	700,236
1995	1,683,000	2,312,542	1,966,529	7,721,831	878,453
1996	1,852,000	2,503,123	2,048,738	8,180,367	1,038,366
1997	1,876,000	2,550,399	2,131,799	8,417,444	1,030,665
1998	1,793,000	2,495,617	2,209,177	8,569,605	930,728
1999	1,736,000	2,465,394	2,282,408	8,792,222	864,988
2000	1,937,000	2,689,427	2,357,289	9,233,994	1,039,777
2001	2,175,000	2,947,910	2,442,441	9,722,626	1,217,003
2002	2,317,000	3,117,783	2,538,380	10,140,153	1,267,649
2003	2,436,000	3,274,015	2,641,047	10,567,502	1,325,068
2004	2,422,000	3,305,754	2,739,323	10,864,664	1,267,132
2005	2,470,000	3,401,453	2,833,552	11,211,169	1,287,991
2006	2,576,000	3,555,784	2,934,562	11,671,853	1,353,353
2007	2,669,000	3,697,944	3,044,619	12,168,236	1,395,188
2008	2,679,000	3,760,583	3,153,230	12,486,251	1,375,361

3.2.5. Figures

Figure	Description
3.2.5.1	Fits of the first model to the four fisheries' catch per unit effort values and two fishery independent indices.
3.2.5.2	Point-estimates of parameters (triangles) from ASPIC compared to the bootstrap results showing the objective function plotted on the different parameters
3.2.5.3	The estimated vulnerable biomass by year
3.2.5.4	A box-whisker plot of the combined fishing mortality rates by year (a) and the estimated fishing mortality rates by fleet and year (b).
3.2.5.5.	The distribution of outcomes from bootstrapping for the ratio of fishing mortality in 2008 to the fishing mortality at MSY (a) and the ratio of biomass in 2008 to the biomass at MSY.
3.2.5.6	Ratio of fishing mortality in 2008 to fishing mortality at MSY and the ratio of biomass in 2008 to biomass at MSY from the 1000 bootstrap iterations. The dot is the point estimate.
3.2.5.7	Trajectories of the fishing mortality ratio (F/F_{msy}) and the biomass ratio (B/B_{msy}) as compared to the reference line at 1.0.

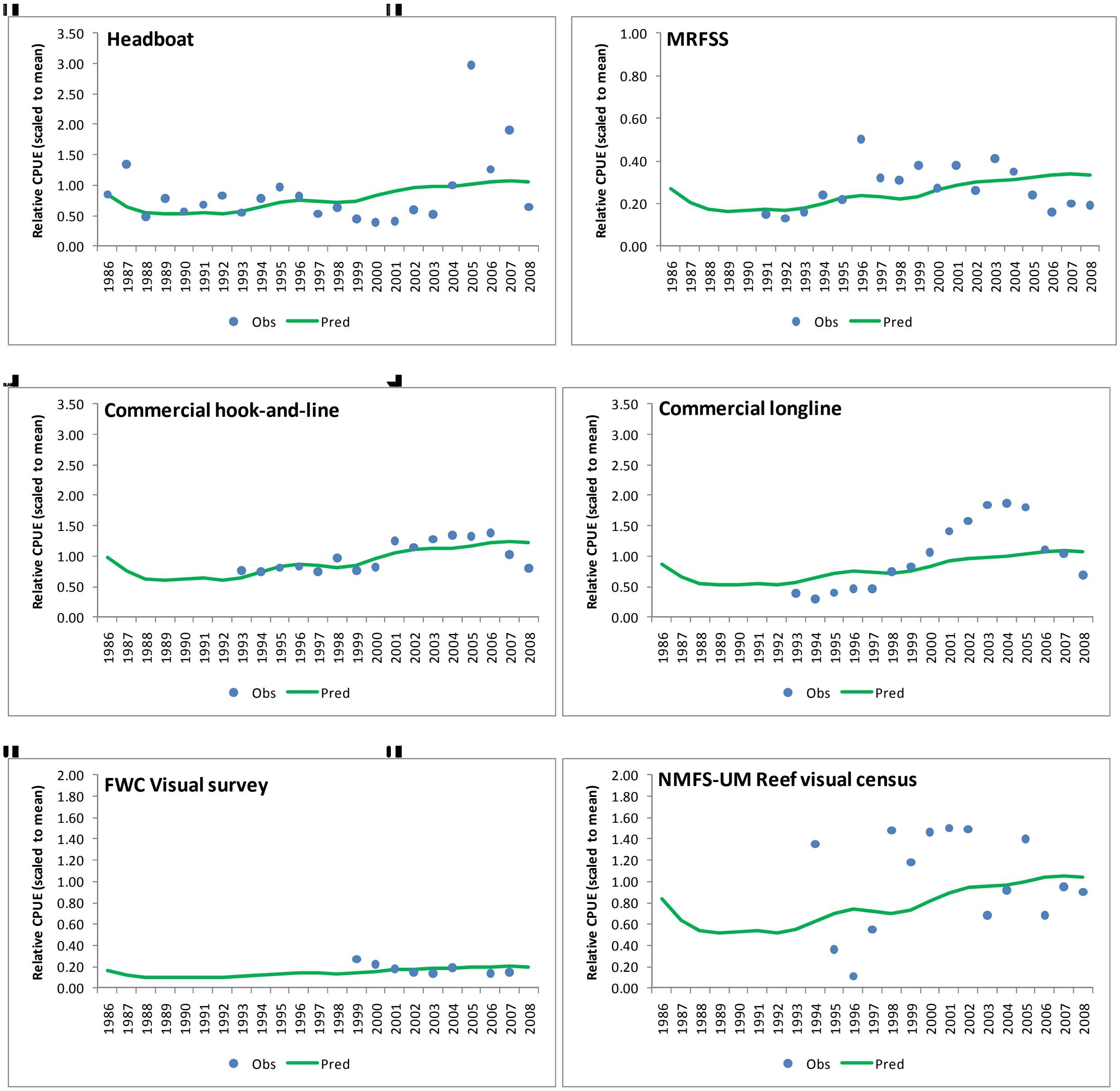


Figure 3.2.5.1. Fits of the first model to the four fisheries' catch per unit effort values and two fishery independent indices.

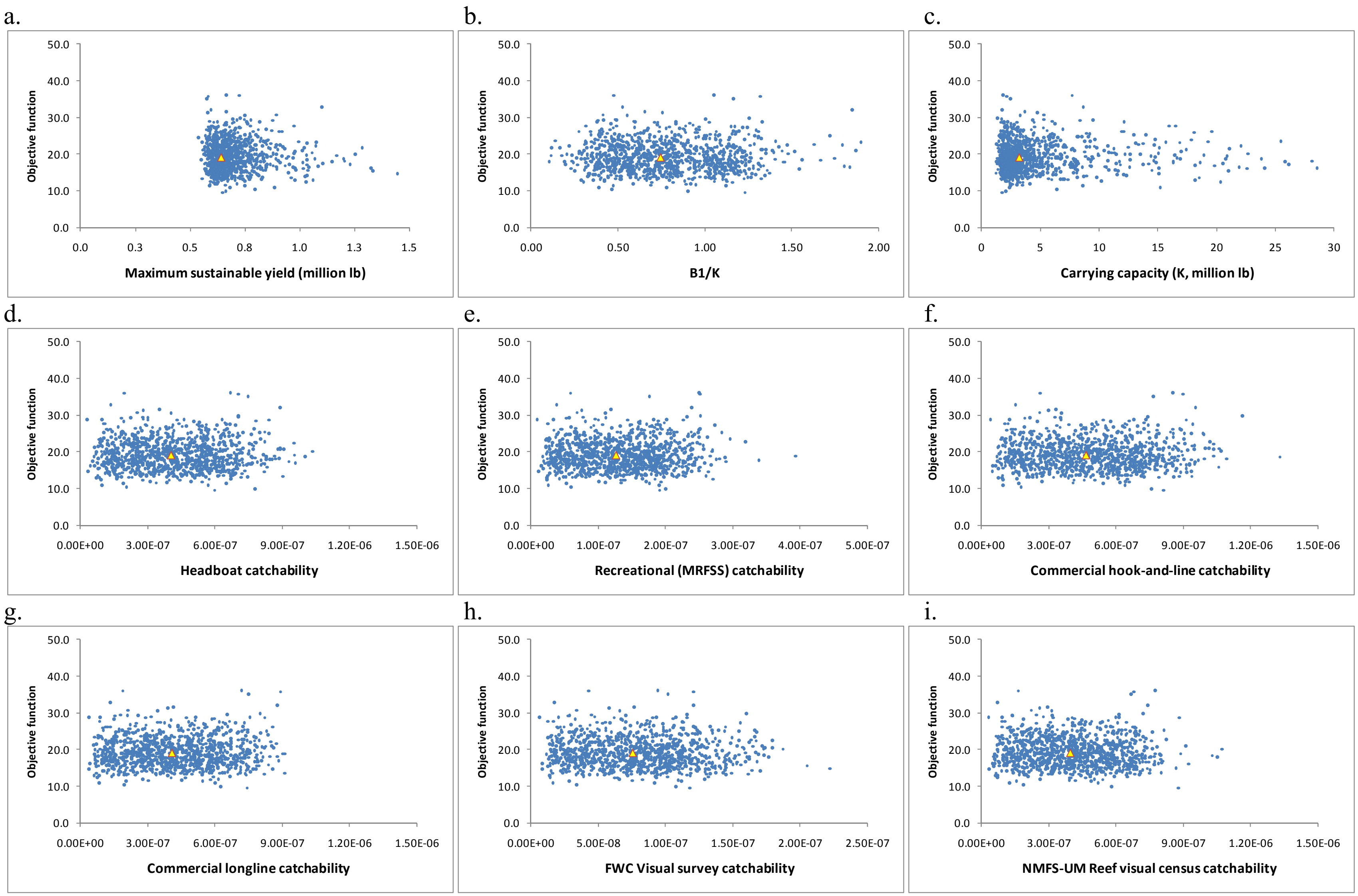


Figure 3.2.5.2. Point-estimates of parameters (triangles) from ASPIC compared to the bootstrap results showing the objective function plotted on the different parameters.

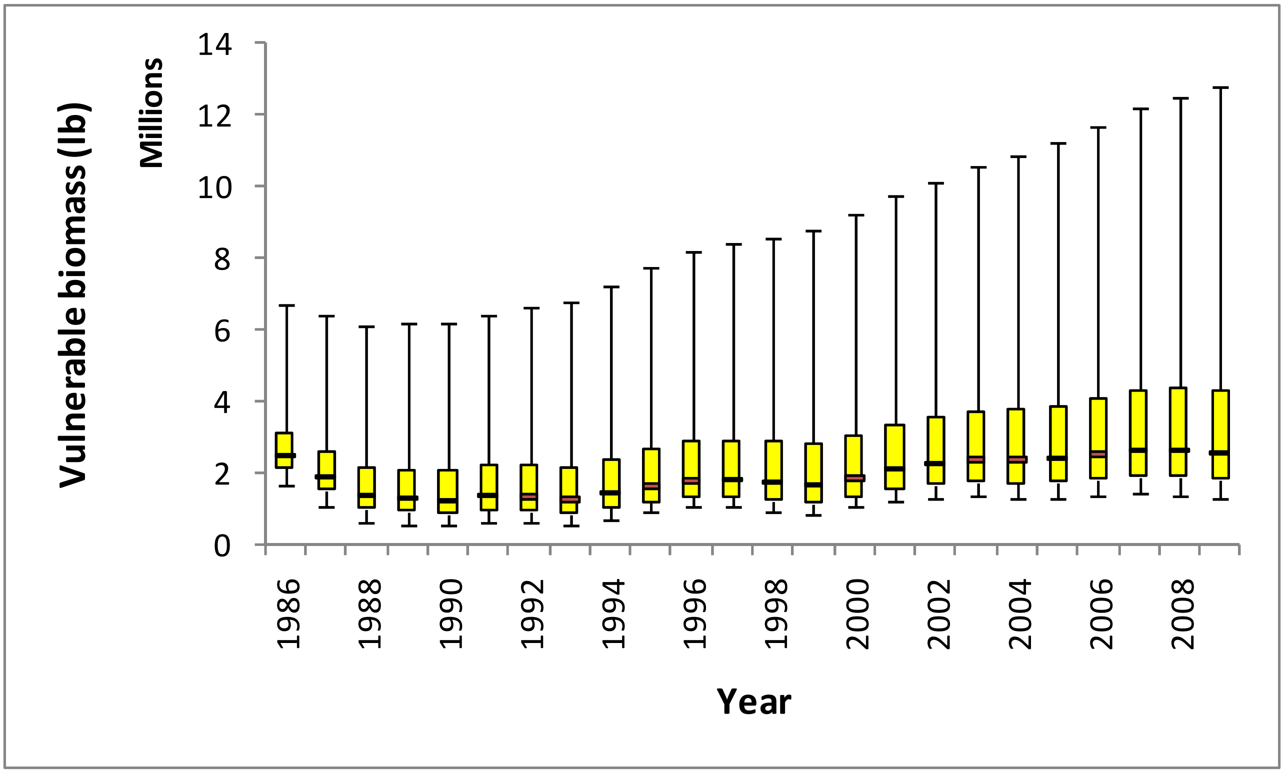
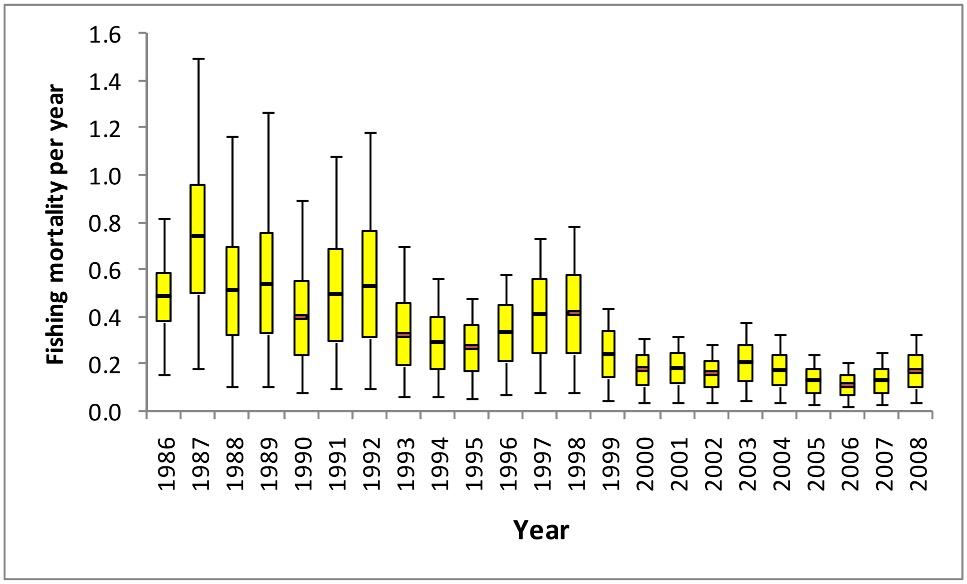


Figure 3.2.5.3. The estimated vulnerable biomass by year. The vertical bars are the 95% confidence intervals, the box is the inter-quartile range, and the horizontal line is the median.

a.



b.

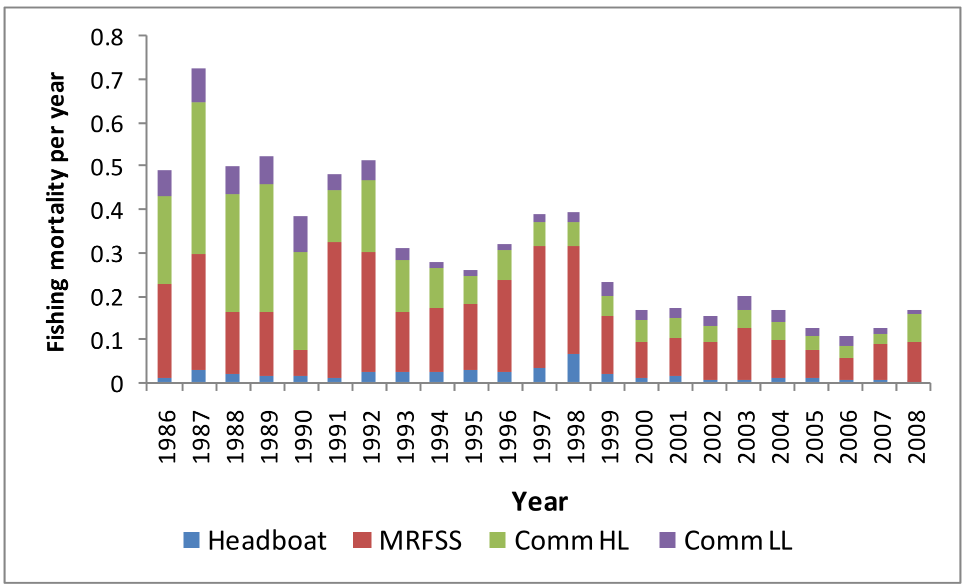
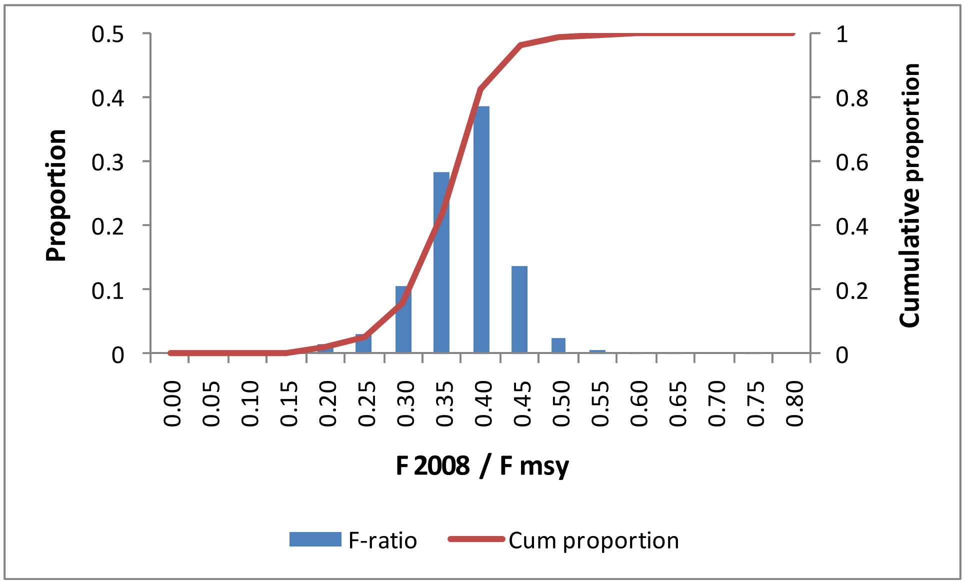


Figure 3.2.5.4. A box-whisker plot of the combined fishing mortality rates by year (a) and the estimated fishing mortality rates by fleet and year (b).The vertical bars are the 95% confidence intervals, the box is the inter-quartile range, and the horizontal line is the median.

a.



b.

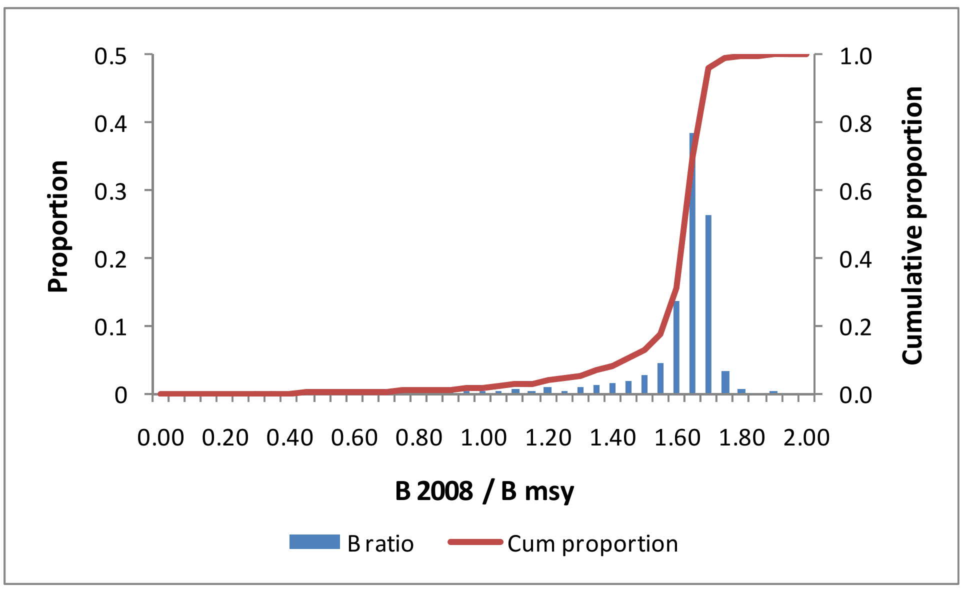


Figure 3.2.5.5. The distribution of outcomes from bootstrapping for the ratio of fishing mortality in 2008 to the fishing mortality at MSY (a) and the ratio of biomass in 2008 to the biomass at MSY.

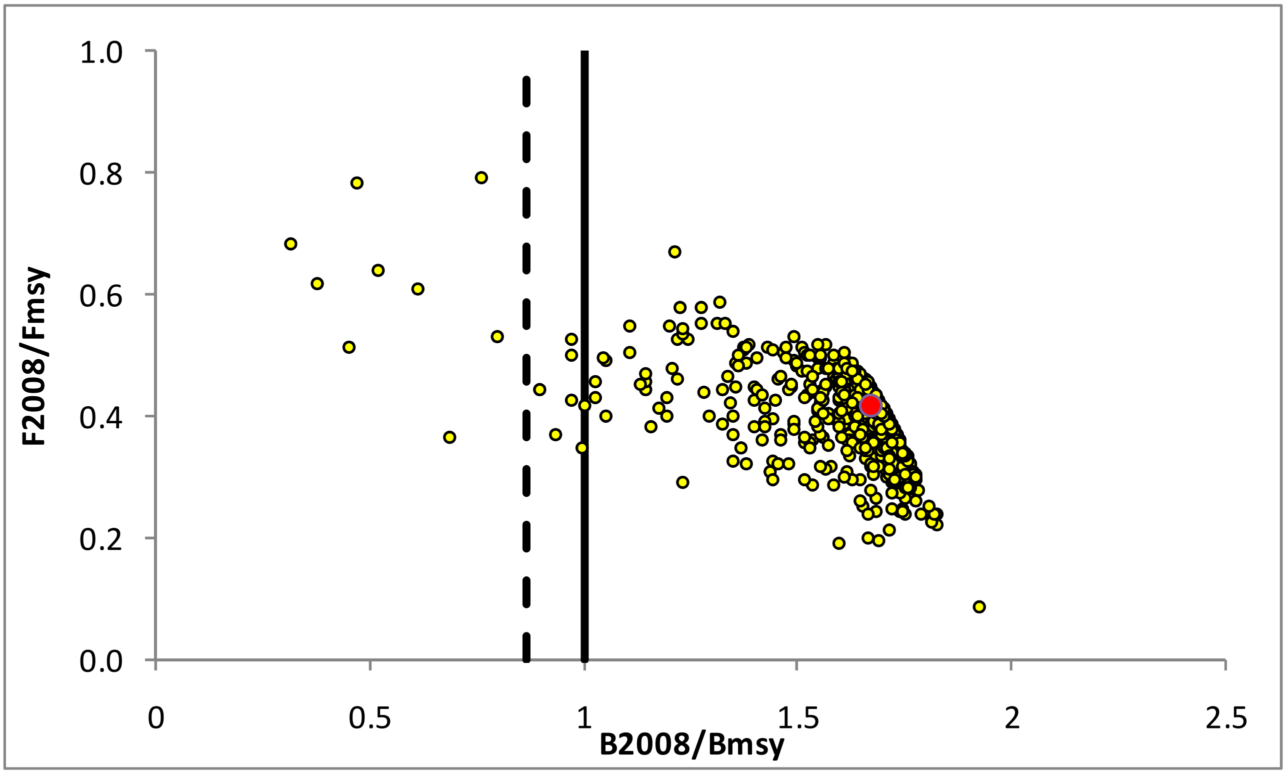


Figure 3.2.5.6. Ratio of fishing mortality in 2008 to fishing mortality at MSY and the ratio of biomass in 2008 to biomass at MSY from 1000 bootstrap iterations. The dashed line is the MSST (1-M)*Bmsy and the red dot is the point estimate.

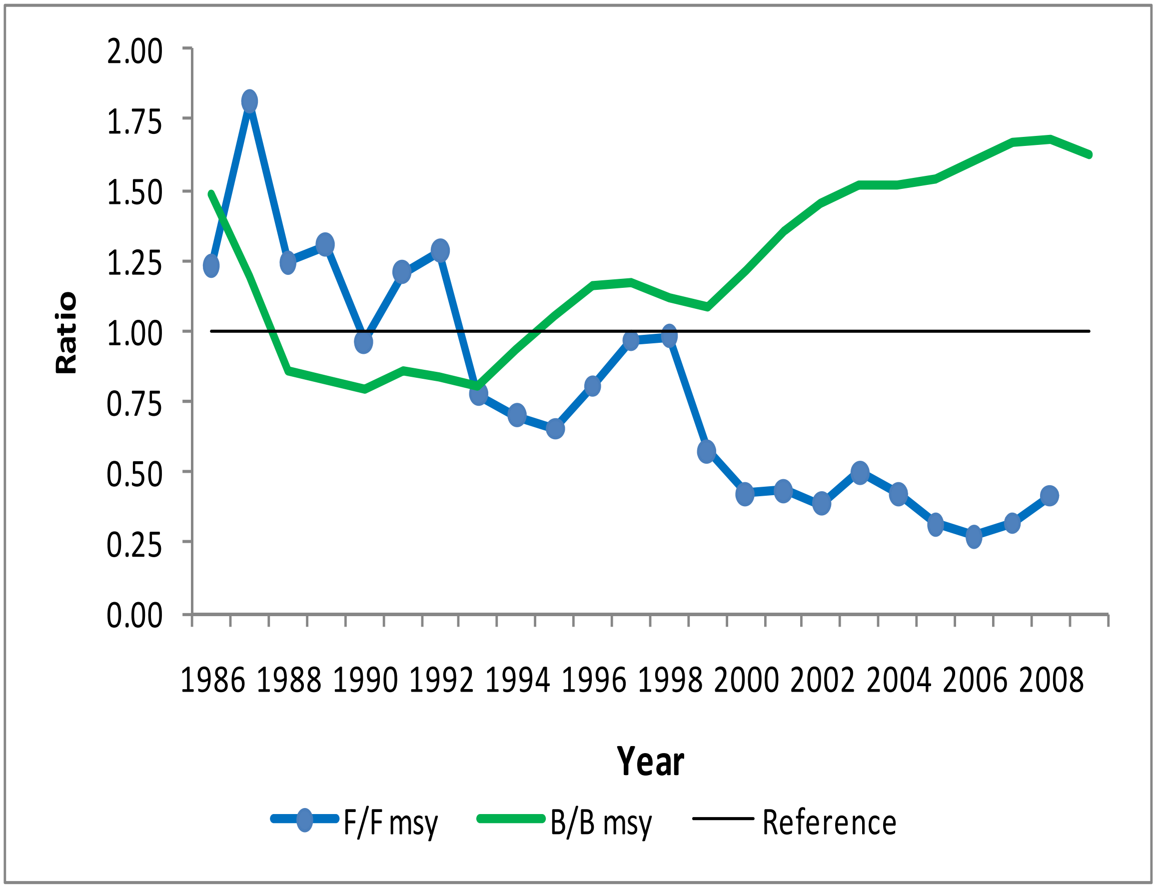


Figure 3.2.5.7. Trajectories of the fishing mortality ratio (F/F_{msy}) and the biomass ratio (B/B_{msy}) as compared to the reference line at 1.0.

3.2.6. References

Ault, J. and S. Smith. 2009. Ault-Smith Notes on Reef-fish Visual Census (RVC) Population Statistics Estimation for Black Grouper (*Mycteroperca bonaci*) and Red Grouper (*Epinephelus morio*) in the Florida Keys and Dry Tortugas Regions. University of Miami RSMAS. DRAFT of June 3, 2009.

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3.3. MODEL 3: STATISTICAL CATCH-AT-AGE (ASAP2)

The main assessment model chosen for black grouper was Legault and Restrepo's (1998) Age-Structured Assessment Program (ASAP2, version 2.0.19) which also is available from the NOAA Fisheries Toolbox (http://nft.nefsc.noaa.gov/). ASAP2 is a forward-projecting, statistical catch-at-age model written in ADModelbuilder (Copyright (c) 2008 Regents of the University of California) that uses the Toolbox's graphical interface to facilitate data entry and presentation of model results. The model allows for age- and year-specific values for natural mortality rates, average spawning weights, average catch weight, and average stock weight at the beginning of the year. It accommodates multiple fleets with one or more selectivity blocks within the fleets, incomplete age-composition to accommodate fisheries that are not sampled every year, and indices of abundance in either numbers or biomass that are offset by month. Discards by fleet can be linked to their fishery as can fishery-dependent indices. The original version of ASAP only solved for selectivity by specific ages while this second version allows for modeling selectivity with logistic or double logistic curves as well as age-specific selectivities. The model estimates population numbers, fishing mortality rates, stock-recruit parameters, and management benchmarks such as maximum sustainable yield (MSY), the fishing mortality rate at MSY, the spawning biomass at MSY, and the fishing mortality rate corresponding to 30% or 40% spawning potential ratios. Precisions of parameters can be evaluated by their standard deviations from the covariance matrix or through Markov Chain Monte Carlo simulations.

3.3.1. Model 3. Statistical Catch-at-Age Methods

Overview and Data Sources

ASAP2, being an age-structured model, integrates life history aspects such as age, reproduction, and natural mortality with fishery information like landings, discards, and selectivity to estimate past exploitation patterns and management benchmarks to determine whether the management objectives are being met. However, the model only addresses a single stock but this limitation of the program does not present a problem for black grouper because the Data Workshop recommended treating the stock as a single unit rather than developing separate assessments for the South Atlantic and the Gulf of Mexico (SEDAR19-DW-Final Report Sections 2.3.1 – 2.3.3). Zatcoff (2001), using DNA microsatellites, demonstrated that black grouper from Belize, Mexico, and Florida could not be differentiated while black grouper in Bermuda were distinct. Given that the direction of flow of the Caribbean Current and the Loop Current is towards Florida from the northern Caribbean (Gyory 2008 a and b, Figure 3.3.5.1) and black grouper's larval duration of four to five weeks (Keener et al. 1988), it is feasible that Florida receives some unknown quantity of recruits from the Caribbean, i.e., it is not surprising that black grouper are most abundant in the Florida Keys and then drop off with distance away from those reef and hard bottom habitats.

Black grouper landings from the Headboat Survey, Marine Recreational Fisheries Statistics Survey (MRFSS), and NMFS's Accumulated Landings System were tallied annually by fleet for the period of 1986 through 2008. As noted in the Data Workshop, the lack of commercial grouper landings reported to the species level prior to 1986 coupled with the widely used name "black grouper": for both *Mycteroperca bonaci* and *M. microlepis* (gag, Moe 1963) muddied the early landings records and the 18-inch (457 mm) TL minimum size limit implemented in 1985 by Florida's Marine Fisheries Commission precluded extending the time series back to an earlier starting time. Fishery dependent indices of abundance were generated from the headboat (SEDAR19-DW-04) and MRFSS data (SEDAR19-DW-01) and from NMFS's commercial Logbook Program (SEDAR19-DW-13). Fishery independent indices included the FWC Visual

Survey (SEDAR19-DW-02) and the NMFS-UM Reef Visual Census (Ault and Smith 2009). Indices of recruitment (age-1 fish) were also developed from the two fishing independent surveys (Table 2.1.6). Length information was retrieved from the Trip Information Program Headboat Survey, and MRFSS and age information was obtained from Florida Fish and Wildlife Research Institute's Age Database.

Additional refinements to the input data [adjusting natural mortality to the beginning of the year [an average of $M=0.136 \cdot y^{-1}$ based on longevity (Hoenig 1983, Hewitt and Hoenig 2005) to conform to the ASAP model rather than the mid-year vector provided by the DW, an offset to mid-March for the estimated spawning date based on field observations of post larval ages (Keener et al. 1988), and other normal tuning adjustments] were developed after the AW.

Model Configuration and Equations

The model was configured with four fleets (headboat, general recreational (MRFSS), commercial hook-and-line which includes landings from traps and spears, and commercial longlines) and eight indices of abundance (four fishery-dependent indices and four fishery-independent indices) for the period of 1986 through 2008. Because of changes in minimum size limits, a separate selectivity block for each regulatory period (1986-1991, 1992-1998, and 1999-2009) was used to estimate the age composition for each fleet except for the longline fleet which did not have age samples from the first period (1986-1991). Discards were linked to their fleets. While time-varying catchability coefficients were proposed for the fleets, the AW panel decided to hold those coefficients constant over the 23 years because of the lack of consistency in the annual patterns in catchability coefficients by fleet. Also the different selectivity blocks by fleet tended to mitigate the constant catchability assumption.

The following equations for ASAP2 were based on those in the Technical Documentation for ASAP Version 2.0 which is supplied with the program from the NOAA Fisheries Toolbox.

Selectivity

Most of the selectivity patterns used in the black grouper model were double logistic curves because the recreational and commercial hook-and-line fleets do not normally encounter the full range of ages of black grouper. For example, the number of ages sampled by fleet shows that while the recreational fleets rarely encountered fish age-10 or older and the commercial hook-and-line fleet rarely encountered fish older than 15 years, the longline fleet landed fish that were up to 33 years old (Figure 2.2.1). Selectivity for the longline fleet was modeled with a logistic curve. The equation for the double logistic curve for the selectivity of fleet, *f* and age, *a*, (four parameters: $\alpha_{1,f}$, $\beta_{1,f}$, $\alpha_{2,f}$, $\beta_{2,f}$) was

$$Sel_{f,a} = \left(\frac{1}{1 + e^{-(a-\alpha_{1,f})/\beta_{1,f}}} \right) \left(1 - \frac{1}{1 + e^{-(a-\alpha_{2,f})/\beta_{2,f}}} \right). \qquad 3.3.1.1$$

Similarly the equation for the logistic curve for the selectivity of longline fleet, *f* and age, *a*, (two parameters: $\alpha_{1,f}$, and $\beta_{1,f}$) was

$$Sel_{f,a} = \left(\frac{1}{1 + e^{-(a-\alpha_{1,f})/\beta_{1,f}}} \right). \qquad 3.3.1.2$$

For these two equations, the fleet selectivities were divided by the selectivity for the age with the maximum value ensuring that the final selectivity pattern for the fleet had a maximum value of 1.0.

Mortality

Natural mortality is incorporated into the model as a year and age matrix. Black grouper did not have different natural mortality vectors by year and so every year used the same Lorenzen based age-specific values adjusted to the beginning of the year.

Fishing mortality is treated as separable, i.e., it is the product of a year effect, the fishing mortality multiplier, and the age-specific selectivity. The fishing mortality multiplier, *Fmult*, is estimated by fleet in the first year (1986) and by an annual fleet-specific fishing mortality multiplier deviation, *Fmultdev*. Both *Fmult* and *Fmultdev* are estimated in log space and then exponentiated as

$$Fmult_{f,1} = e^{\log\_Fmult_{f,1}} \qquad 3.3.1.3$$

and

$$Fmult_{f,t} = Fmult_{f,t-1} e^{\log\_Fmultdev_{f,t}} . \qquad 3.3.1.4$$

The directed fishing mortality per year for a fleet, year, and age, $Fdir_{f,t,a}$, is calculated from the fishing mortality multiplier for the fleet and year, $Fmult_{f,t}$, selectivity for the fleet and age, $Sel_{f,a}$, and the proportion of the catch of the fleet for that year and age that was released, $prop\_release_{f,t,a}$ or

$$Fdir_{f,t,a} = Fmult_{f,t} Sel_{f,a} (1 - prop\_release_{f,t,a}) . \qquad 3.3.1.5$$

The dead discards, $Fby\_catch_{f,t,a}$, are similar but with the addition of the fleet's release mortality rate or

$$Fby\_catch_{f,t,a} = Fmult_{f,t} Sel_{f,a} prop\_release_{f,t,a} release\_mort_{f} . \qquad 3.3.1.6$$

The fishing mortality for the fleet, year, and age is the sum of the directed and discarded fishing mortality components

$$F_{f,t,a} = Fdir_{f,t,a} + Fby\_catch_{f,t,a} . \qquad 3.3.1.7$$

Total mortality, *Z,* is the sum of the fishing mortalities by fleet and natural mortality

$$Z_{t,a} = M_{t,a} + \sum_{f} F_{f,t,a} . \qquad 3.3.1.8$$

Population Abundance

The population abundances in the first year, 1986, for ages 2 to 20+ are calculated from the initial guesses, $N1ini_a$, and deviations. The equation for age, *a*, is

$$N_{1,a} = N1ini_a e^{\log\_Nyear1dev_a} . \qquad 3.3.1.9$$

The population abundances for remainder of the ages less than the plus group are calculated from

$$N_{t,a} = N_{t-1,a-1} e^{-Z_{t-1,a-1}} \qquad 3.3.1.10$$

and the population abundance in the plus group, *A*, is calculated from

$$N_{t,A} = N_{t-1,A-1}e^{-Z_{t-1,A-1}} + N_{t-1,A}e^{-Z_{t-1,A}} . \qquad 3.3.1.11$$

The spawning biomass, SSB_t, is calculated from population abundances by year and age; average weight offset to the beginning of the spawning season by year and age, $\overline{w}ssb_{t,a}$, maturity by age, m_a; and total mortality offset to the beginning of the spawning season, p_{SSB}, which was the 0.20 years or mid-March (Kenner et al. 1988). Brooks et al. (2008) recommended including both sexes when calculating spawning biomass in protogynous hermaphrodites such as black grouper. The equation for spawning biomass is

$$SSB_t = \sum_a N_{t,a}\overline{w}ssb_{t,a}m_{t,a}e^{-p_{SSB}Z_{t,a}} . \qquad 3.3.1.12$$

The spawning biomass per recruit at for any F, $(SSB/R)_F$, where the number of recruits starts with $N_1 = 1$ is

$$SSB/R_{F_{tot}} = \sum_a N_a e^{-(F_{tot}+M_a)p_{SSB}}\overline{w}_{SSB,a}m_a . \qquad 3.3.1.13$$

Recruitment, the number of age-1 fish, is assumed to follow the Beverton-Holt stock recruitment relationship

$$\hat{R}_{t+1} = \frac{\alpha SSB_t}{\beta + SSB_t} . \qquad 3.3.1.14$$

However, the equation was reparameterized to steepness, *h*, which is only defined over the range of 0.20-1.00 (Mace and Doonan 1988); the spawning biomass without fishing SSB_o; and $(SSB/R)_{F=0}$, the product of relative numbers-at-age calculated from natural mortality, average weight at age, and the maturity at age (Equation 3.3.1.13 with F = 0).

$$\alpha = \frac{4hSSB_0/(SSB/R)_{F=0}}{5h-1} \qquad 3.3.1.15$$

and

$$\beta = \frac{SSB_0(1-h)}{5h-1} . \qquad 3.3.1.16$$

With the Beverton-Holt stock recruitment relationship, the spawning biomass at any F is

$$SSB_F = \alpha(SSB/R)_F - \beta \qquad 3.3.1.17$$

and recruitment at any F is

$$R_F = \frac{SSB_F}{(SSB/R)_F} . \qquad 3.3.1.18$$

Actual recruitment, $N_{t,1}$, is a product of the predicted value from the Beverton-Holt stock recruitment, $\hat{R}_t$, and an annual recruitment deviation

$$N_{t,1} = \hat{R}_t e^{\log\_Rdev_t} . \quad 3.3.1.19$$

The predicted catch in biomass is the sum of the directed catch and the by-catch and these terms are calculated from the Baranov equation (Ricker 1975) and the average catch weight by year and age

$$\hat{L}dir_{f,t,a} = N_{t,a} Fdir_{f.t.a} (1 - e^{-Z_{t,a}}) \overline{w}cat_{t,a} / Z_{t,a} \quad 3.3.1.20$$

and

$$\hat{L}disc_{f,t,a} = N_{t,a} Fby\_catch_{f,t,a} (1 - e^{-Z_{t.a}}) \overline{w}cat_{t,a} / Z_{t,a} . \quad 3.3.1.21$$

The calculation of catchability for each index is similar to the fishing mortality calculation with a value for the first year and annual deviations which can be turned on or off. For the black grouper assessment, the catchability deviations were turned off in accordance with the AW recommendation to not use time-varying catchabilities. The equation for catchability is

$$q_{ind,t} = e^{\log\_q1_{ind} + \log\_q\_dev_{ind,t}} \quad 3.3.1.22$$

and the predicted index value is

$$\hat{I}_{ind,t} = q_{ind,t} \sum_{a=start\_age}^{end\_age} N_{t,a} Sel_{ind,t,a} e^{-(Z_{t,a})t\_offset_{ind}}$$

where t_offset_{ind} is offset within the year for the index's sampling period. 3.3.1.23

Parameters Estimated

As ASAP2 was configured for black grouper, the model estimated values for 196 parameters. A breakdown of those parameters is: 40 selectivity coefficients for the 11 selectivity blocks for the fleets, 4 fleet fishing mortality multipliers in 1986, 8 fishing mortality multiplier deviations (4 fleets*22 years), 23 recruitment deviations, 19 age deviations in 1986, 8 index catchability coefficients, 12 index selectivity coefficients, spawning biomass without fishing, and steepness.

Uncertainty and Measures of Precision

When ASAP2 achieves valid convergence, the model generates a covariance matrix and, thus, the diagonal of that matrix estimates the variance for the 196 parameters. To explore the precision beyond the standard deviations of the parameters, we ran Markov Chain Monte Carlo simulations (MCMC) that used ASAP2's covariance matrix to start the Metropolis-Hastings method algorithm. The initial runs used the ASAP2 default values of 10,000 outcomes with a thinning rate of 200 (2 million runs). However, we also made a run with 4.68 million simulations with keeping every simulation result without thinning. From that run, we were able to examine the breakdown of the number of iterations in a given step until a successful jump to determine the acceptance rate and we were able to determine the appropriate burn in period instead of following Gelman et al.'s (1998) recommendation to just use the last half of the outcomes. We used the Geweke convergence diagnostic in the R package 'boa' (http://www.public-health.uiowa.edu/boa) that compares the first 10% of the observations with the last 50% of the observations to evaluate convergence with alternate starting points (burn-in periods) to eliminate effects of the starting values. We also used that extended run to examine lags of 0 to 15,000 to identify a suitable thinning interval to eliminate the effects of autocorrelation. The 1,000 simulation thinning rate was confirmed with a run that used a 15,000 thinning rate. For some parameters, we were able to generate likelihood profiles for comparison to the MCMC results.

Retrospective bias (Mohn 1999) is a potential source of uncertainty in estimating fishing mortality rates, spawning biomass, or recruitment. ASAP2 has an option to run retrospective analyses and we went back five years, i.e., we used terminal years of 2004 through 2008.

In addition to the MCMC runs, the DW recommended sensitivity runs for alternative values of natural mortality of 0.10 per year and 0.15 per year but because the value of 0.15 per year was so close to the recommended value of 0.136 per year, we explored an upper value of 0.20 per year. The sensitivity runs with alternate natural mortality rates (average of 0.10 per year or 0.20 per year for ages 3-33 years) used the same model inputs except for the natural mortality per year by age, age-compositions, initial selectivities, proportion released, average catch weight-at-age, and the weight of dead discards. With a different natural mortality rate, the relative proportion of ages within a given length change. Since the ages were based on lengths, all of the fleets and their discards were recalculated. The proportion released changes because of the ratio of discards to total catch-at-age changes and the weight of dead discards changes because of the different proportions at age.

The DW recommended point estimates for release mortalities of 20% for hook and line catches, and 30% for longline catches, but they also recommended that sensitivity runs should include a range of 10-30% release mortalities for hook and line catches, and 25-35% for longline catches. Preliminary examinations of model sensitivity to estimated release mortalities were conducted and presented during AW using model input data compiled prior to the AW. After the AW, we ran the nine estimates (10%, 20%, and 30% for hook and line gears, and 25%, 30%, and 35% for longline gear) developed from the DW recommendations. Additional estimates (50%, 75%, and 90% release mortalities) were produced to further explore the impact of estimated release mortalities on the assessment model estimates. The variables investigated included steepness, spawning biomass in 2008, fishing mortality rate in 2008, the benchmarks of the councils' OFL of $F_{30\%SPR}$ and the spawning biomass associated with $F_{30\%SPR}$, the fishing ratio ($F_{2008}/F_{30\%SPR}$), and the spawning biomass ratio ($SSB_{2008}/SSB_{F30\%SPR}$). The sensitivity runs used the same model inputs used in the assessment with the exception of the adjustment for the weight of released fish (discards) by fishery which would die after release (annual estimates by fishery which are supplied as inputs to the model) and the proportion of released fish which would die after being caught (parameters by fishery used in the model). The amount of released black grouper (in terms of weight) was calculated from the estimates of the number of fish annually released by fishery (headboat, MRFSS, commercial hook and line, and commercial longline), the estimated proportion of fish released by age class in each fishery, the calculated average weight for each age class based on the von Bertalanffy growth curve parameters and natural mortality (Lorenzen-adjusted) vector, and the proportion of released fish that would be released dead or would subsequently die after release (from the percentages recommended by the DW for the sensitivity runs).

Because of the importance of steepness in the Beverton-Holt stock-recruit relationship (Equation

3.3.1.14), we made sensitivity runs over a range of values from 0.60 to 0.85 to cover the range of likely values for a species that is long lived and matures later (Rose et al. 2001).

Benchmark / Reference points / ABC methods

The South Atlantic Fishery Management Council (SAFMC) adopted benchmark proxies for the snappers and groupers in 1998 (Amendment 11) of $F_{30\%SPR}$ as their Maximum Fishing Mortality Threshold (MFMT, now called the overfishing limit, OFL) and the Minimum Stock Size Threshold (MSST) is (1 – M) $SSB_{30\%SPR}$ or 0.86 $SSB_{30\%SPR}$. In the same amendment, the SAFMC chose the yield corresponding to $F_{45\%SPR}$ as their optimum yield (OY) goal. The Gulf of Mexico Fishery Management Council (GMFMC) also has adopted $F_{30\%SPR}$ as their OFL for reef fish and they chose 0.8 $SSB_{30\%SPR}$ as their MSST. The GMFMC's amendment that contained their optimum yield definition (Amendment 18B) was not accepted and the council is considering OY alternatives at this time.

ASAP2 has the ability to estimate commonly used reference points such as F_{MSY}, $F_{30\%SPR,}$ or $F_{40\%SPR.}$ The program uses the bisection method to identify a particular fishing mortality rate with a given spawning potential ratio (SPR) and then using that fishing mortality rate, the program determines the spawning biomass, recruitment, and yield-per-recruit to estimate the equilibrium yield associated with at that fishing mortality rate. The senior author of ASAP2, Dr. Chris Legault, supplied us with the ASAP2's ADMB template and we easily made the slight modifications to have ASAP2 estimate the biomass at $F_{30\%SPR}$ and to estimate $F_{45\%SPR}$ together with its biomass to provide a probabilistic evaluation of the SAFMC's management objectives.

SEDAR 19's Term of Reference 6a asked the AW panel to identify the overfishing level (OFL) and to recommend Acceptable Biological Catch (ABC) levels to the GMFMC. To provide that guidance, we used Shertzer et al. (2008) P* approach to generate a series of yield projections with differing probabilities of exceeding OFL. The P*program was obtained from the lead author and configured for black grouper using the ASAP2 output files. The ASAP2 MCMC output file provided 2499 values of $F_{30\%SPR}$ to capture some of the uncertainty in the projections. Because the councils have not specified which level of risk they would accept for black grouper, projections were run with probabilities of exceeding OFL from 0.05 to 0.50 in 0.05 increments. Each run entailed 2,000 bootstrap iterations.

Projection methods

Deterministic projections can be run in ASAP2; however, we developed a stochastic projection model as a complement to P* that uses the output from the ASAP2 MCMC runs to provide uncertainty in the number of fish by age in 2008, recruitment variability, fishing mortality rates on the fully selected ages in 2006-2008, and $F_{30\%SPR}$ (OFL proxy), $F_{40\%SPR}$, and $F_{45\%SPR}$ to project landings, discards, spawning biomass, fishing mortality rate on fully selected ages, and recruitment beginning in 2009. The AW panel agreed that the projections would use the geometric mean of the fishing mortality rates in 2006-2008 to estimate the current fishing mortality rate ($F_{current}$) and that changes in management would begin in 2011. The model used the directed and discard fishing mortality rates by fleet, weighted by number of fish from ASAP2 for the years 2006-2008, to estimate the directed and discard selectivities. Recruitment was calculated from the spawning biomass (Equation 3.3.1.18) and a log recruitment deviation (Equation 3.3.1.19). The log recruitment deviations were estimated as the log residuals from the MCMC results of the number of age-1 fish in 2008 and were randomly drawn with replacement. The duration of the projections was 12 years or until 2020 which would be 10 years after the implementation of new management measures. For simplicity, the projection model assumed that the selectivities would not change with management which is the same assumption that was made in P* (Shertzer et al. 2008). This assumption is equivalent to implying that the management measures would vary effort not sizes. The current fishing mortality rate was applied in 2009 and 2010 and then new regulations would begin in 2011. The eight projections were run: no directed fishing (F directed = 0), fishing at OFL (F_{OFL} or $F_{30\%SPR}$), maintaining current fishing mortality rates, F = $F_{40\%SPR}$, F = $F_{45\%SPR}$, and F = 0.65 F_{OFL}, 0.75 F_{OFL} and 0.85 F_{OFL}.

The ASAP2 input file for the base run, M14_5_5.DAT, is included in Appendix B.

3.3.2. Model 3. Statistical Catch-at-Age Results

Measures of Overall Model Fit

Fits of the ASAP2 model to the directed landings and dead discards in pounds by fleet and the indices of abundance are presented together with their standardized residuals (Figure 3.3.5.2). Overall, the fits were very good. The best fit for directed landings was with commercial hook-and-line landings (lowest root mean square error term, rmse = 0.58, Table 3.3.4.1,) and MRFSS and headboat directed landings had the poorest fits (rmse = 1.40). The best fit for the discards (Figure 3.3.5.3) was also for the commercial hook-and-line fleet (rmse = 0.76) and worst fit was for the headboat fleet (rmse = 1.97). The best fit by the model to the indices of abundance (Figure 3.3.5.4) was to the commercial longline fleet index (rmse = 0.99) and the worst fit was to the NMFS-UM Reef Visual Census Age-1 index (rmse = 7.18).

Because of the number of fleets and years, the ASAP2 model fits to the fleet age composition and their standardized residuals are in Appendix-A, Figure A-1. The fits to the headboat age composition estimated more young fish than were observed in the early regulatory period (1986-1991), the fits improved in the 1992-1998 period and were somewhat reasonable in the recent period. For the general recreational data, the model fit some of the early year's data well, e.g. 1987 and other years not so well, e.g. 1989. The fits were generally good in the later years. The fits to the commercial hook-and-line age data were good. Following a recommendation made at the AW, the longline age composition was excluded from the fitting process because their inclusion added little to the overall fit. However, the agreement between the observed and the predicted longline age compositions were better than would be expected especially in the later years considering that the longline age composition was not included in the objective function.

As with the age compositions for the directed fleet, the discard age compositions are shown in Appendix A (Figure A-2). Probably because of the few ages involved, the fits to the discards are good. The model fits to the fishery independent indices of abundance are also good in most years (Appendix A, Figure A-3).

Parameter estimates and associated measures of uncertainty

The age-specific selectivity of the directed fleets were modeled with either double logistic (headboat, general recreational, commercial hook-and-line) or single logistic (commercial longline) curves (Table 3.3.4.2, Figure 3.3.5.5a-d). The age-specific selectivities of the indices of abundance were modeled with double logistic curves (Table 3.3.4.3, Figure 3.3.5.5e). The fleet selectivities and the index selectivities together accounted for 52 parameters. The general recreational (MRFSS) index was treated as a fishery-independent index because that program has always collected information on the total catch by species per intercept (numbers kept and number discarded alive) and the MRFSS index had a selectivity curve separate from the three selectivity blocks in the MRFSS fleet.

The model estimated fishing mortality by first estimating the fishing mortality in 1986 by fleet for the fully selected ages and then estimating multiplicative deviations for the later years (Table 3.3.4.4). These calculations were conducted on the logarithms of the fishing mortality multiplier and the deviations. This rate, when multiplied by the selectivity by year and age, can be considered the total catch rate because this rate was split using the proportion released by fleet into the portion kept (directed fishery) and the portion discarded. The discarded portion was then multiplied by the fleet's release mortality rate to estimate the discards that died after being released. The proportion of fish by fleet, year, and age that were released was an input to ASAP2 and was the ratio of the total number of discards (alive and dead) divided by the sum of the number of fish landed and the total number of discards or

$$\Pr op\_released_{f,t,a} = \frac{Tot\_discards_{f,t,a}}{Number\_landed_{f,t,a} + Tot\_discards_{f,t,a}}. \qquad 3.3.2.1$$

There were four, fleet-specific, 1986 log fishing mortality multiplier parameters and 88 log fishing mortality deviation parameters.

Logarithms of the number of fish at-age in the population at the beginning of 1986 (ages two through 20+) were estimated by applying deviations to the initial guesses (19 parameters, Table 3.3.4.5).

Annual recruitment was the predicted number of age-1 fish from the Beverton-Holt stock recruitment relationship (Equation 3.3.1.14) calculated from the spawning biomass in the previous year and adjusted by a log recruitment deviation (Equation 3.3.1.19). The model fit steepness (h = 0.788, sd = 0.0699) and the log spawning biomass without fishing (log SSB_0 = 17.165, sd = 0.126) in the reparameterized stock-recruit relationship. There were 23 log recruitment deviation parameters (Table 3.3.4.6). Recruitment in the initial year (1986) was calculated with the predicted spawning biomass in the first year less any contribution from age-1 fish and then the model estimated a recruitment deviation for 1986.

There were eight log catchability coefficients, one for each index of abundance, and these coefficients are used to relate the number or biomass of fish at age to the index values (Table 3.3.4.7).

Altogether, the ASAP2 model for black grouper in this configuration fit 196 parameters. A feature of ADMB is that parameters can be estimated in phases instead of trying to fit all of them at once and the order of estimation is shown in Table 3.3.4.8. We made runs with different orders of estimation and the results had only minute differences. Proper convergence of the model runs was confirmed by checking that the eigenvalues were positive which yielded a valid variance-covariance matrix.

Stock Abundance and Recruitment

The number of fish in the population was estimated to be steady from 1986 to 1998 at an average level of 808,000 fish, then the population increased to a new plateau of 1,1 million fish in 2000 and stayed at that level until 2008 when 1.2 million fish were estimated (Table 3.3.4.9a and Figure 3.3.5.6). Recruitment (the number of age-1 fish) has been variable but has increased overall since the mid-1990s and the highest recruitment (383,000 age-1 fish) was observed in 2008 (Table 3.3.4.9a and Figure 3.3.5.7). Early in the time series, recruitment comprised approximately 30-35% of the stock by number but more recently, 2002-2007, the percentage has been lower at 22-27%. In numbers of fish, the plus group of age-20 and older fish was approximately 1.5% of the annual total number in the early part of the time series and slightly over 2% after 2003.

Stock Biomass (total and spawning stock)

The total biomass was stable at 8.7 million pounds until 1991 when it began to increase and has continued to increase such that the highest total biomass was in 2008 (17 million pounds, Table 3.3.4.9 and Figure 3.3.5.8). The spawning biomass, including both males and females, had a similar pattern and was stable at 5.5 million pounds until 1992 when it began to increase (Figure 3.3.5.9). In 2008, the spawning biomass was 12.3 million pounds (Table 3.3.4.10). The plus group has accounted for 10% to 14% of the total biomass and that proportion has been increasing slightly over the time series (Table 3.3.4.9, t-test of slope in trend $t = 3.45$, $df = 21$, $P < 0.05$).

Fishery Selectivity

The fishery selectivities by fleet and regulatory period are show in Figure 3.3.5.5a-d. Selectivity with ASAP2 is for total catch, including discards, and it was not surprising that the two recreational fleets had similar selectivity patterns: in 1986-1991, age-1 was the age with the highest selectivity and then selectivity dropped off for the older ages. In 1992-1998 for both recreational fleets, age-3 was the age with the highest selectivity; however, in 1999-2008 with the 24-inch minimum size, selectivity shifted to younger ages (headboat fleet to age-1 and MRFSS to age-2) possibly reflecting increased discards. The commercial fleets both show higher selectivity on older aged fish reflecting that they operate in deeper waters than recreational anglers and selectivity increased on older fish with the larger minimum size limits.

The only discard size information came from the headboat fleet and those data were only from 2005-2007 with just three black grouper from 2008. Discards for earlier years and from the other fleets were approximated by using the sizes of fish that were caught with smaller size limits and assuming that the fleets caught similar sized fish under the larger minimum sizes and that the smaller fish were discarded (Section 2). The lack of size information for discards is a major data gap in conducting stock assessments in the southeast U.S.

Fishing Mortality

The instantaneous total catch rates (F-multipliers) for commercial hook-and-line and for MRFSS in the beginning of the time series were approximately 0.15 per year (Figure 3.3.5.10a) but then the commercial hook-and-line catch rate declined while the total catch rate for MRFSS was variable but remained at the higher level. While the decline in the commercial hook-and-line total catch rate could have resulted from improved species identification, it could also come from changes in estimating discards because only MRFSS has collected discard data over the entire time series. The commercial fleets began to collect discard information with logbooks in 2002 and headboats began even later in 2005.

In the beginning of the time series, the commercial hook-and-line fleet accounted for much of the directed fishing mortality with MRFSS being the next highest (Figure 3.3.5.10b). However, the fishing mortality from the commercial hook-and-line fleet has decreased since 1987 to a low of 0.007 per year in 2008 while the fishing mortality rate for MRFSS increased from 1990 to 1998 and then has declined from a peak in 1997 to a low in 2003. The directed fishing mortality on age-5 (fully selected) fish for MRFSS was 0.065 per year in 2008. The other fleets, headboats and longlines, only accounted for a small portion of the fishing mortality.

The combined (directed and discards) fishing mortality rate on age-5 fish, the fully selected age, has declined from values exceeding 0.20 per year in the beginning of the time series to less than half that level in recent years even with the upturn in 2008 (Figure 3.3.5.11a). The combined fishing mortality rate in 2008 was 0.076 per year. There was concern at the AW that the longline age composition was driving the declining trends in fishing mortality rates; however, when the model was run both with and without the longline age composition, the patterns were very similar (Figure 3.3.5.11b). The decision of the AW was to run the base model without the longline age composition.

Stock-Recruitment Parameters

The model estimates recruitment with a Beverton-Holt stock-recruitment relationship (Equation 3.3.1.14). Based on life history considerations of longevity and age of maturity, the initial value for steepness was set at 0.75 (CV = 0.1). The model converged with a steepness value of 0.79 but the MCMC results showed a range of 0.58 to 0.98 with half of the outcomes between 0.73 and 0.83 (Figure 3.3.5.12a). The other term that ASAP2 estimated is the spawning biomass at F = 0 and the point estimate was 28.5 million lb and the MCMC results had a range of 18 to 46 million lb with half of the outcomes between 26 and 30 million lb (Figure 3.3.5.11b). The final term necessary to predict the number of recruits from the previous year's spawning biomass is the spawning biomass per recruit at F=0 which was 88.1 lb. This term is used to estimate the recruitment at F= 0, R_0 , and is fixed for a given input configuration being determined by natural mortality, the offset to the beginning of the spawning season (March 15), maturity at age, and the average weight-at-age of a fish in the spawning season. The pattern of spawning biomass and recruitment one year later was quite variable with the spawning biomass increasing from 1990 on and recruitment varied from a low in 1995 of 144,000 age-1 fish to a high of 383,000 fish in 2008 (Figure 3.3.5.13).

Evaluation of Uncertainty

ASAP2 estimates uncertainty with the covariance matrix of the estimated parameters and through Markov Chain Monte Carlo (MCMC) simulations. The uncertainty in the model's 196 parameters is presented in Tables 3.3.4.2-3.3.4.7. To explore uncertainty beyond the estimated standard deviations of the parameters, we made MCMC runs. As was mentioned in the Methods section above, an MCMC run of 4.68 million simulations allowed us to develop a breakdown of the number of simulations spent in a step before making a successful jump (Table 3.3.4.12). The 4.68 million simulations had 1.27 million accepted runs or an acceptance rate of 0.272. The Geweke convergence diagnostic (Geweke 1992) also showed that the MCMC converged with a thinning rate of 500. However, the investigation of the autocorrelation with lags of 1 to 15,000 showed that thinning by 1000 was necessary to eliminate much of the autocorrelation and the trace plots confirmed that an interval of 1000 ensured that the outcomes did not have cyclical patterns (Figure 3.3.5.14).

The distribution of MCMC outcomes for the fishing mortality per year in 2008 on fully selected ages and the spawning biomass in 2008 are shown in Figure 3.3.5.15. Likelihood profiles for the same parameters are shown in Figure 3.3.5.16. The profiles were similar to their normal approximations but the F_{2008} point estimate was higher than the mode of the MCMC estimates.

The two, main parameters of interest to the councils were their overfishing measure -- the ratio of fishing mortality in 2008 compared to the fishing mortality at 30% SPR, and overfished measure --the spawning biomass in 2008 compared to the spawning biomass at 30% SPR. Both of these measures indicated that the black grouper stock was in compliance with the councils' objectives. The F-ratio was less than 1.00 (0.357) and the spawning biomass ratio was greater than 1.00 (1.73). The distributions of the MCMC outcomes for these two measures showed that none of the MCMC outcomes failed to meet the councils' objectives (Figure 3.3.5.17).

<u>Retrospective Analysis</u>

A retrospective analysis covering the period of 2004 to 2008 found that fishing mortality rates increased each year at an average of 12% with the addition of more years of data in the analysis while spawning biomass did not show any pattern except that the estimates for spawning biomass for 2004 to 2007 all declined in 2008 (Figure 3.3.5.18). Recruitment was more variable and did not show a consistent pattern.

<u>Sensitivity Runs</u>

Sensitivity runs were conducted to investigate alternative values for natural mortality, release mortalities and initial steepness. The DW recommended evaluating natural mortality rates of 0.10 per year and 0.15 per year. However because 0.15 per year was so similar to the recommended base rate of 0.136 per year, the AW expanded the range to 0.20 per year. The sensitivity runs like the base assessment used age-specific natural mortality rates (Lorenzen 2005). After approximately 1996, the fishing mortality rates on the fully recruited age (age-5) were very similar for M = 0.10 per year and the base rate (M = 0.136 per year) while the fishing mortality rates for M = 0.20 per year were lower (Figure 3.3.5.19a). Although the fishing mortality rates were similar, the spawning biomass estimates with M = 0.10 per year were much higher than at the other natural mortality rates and had a steeper, increasing trajectory. The spawning biomass at M = 0.20 per year was almost flat until the last few years (Figure 3.3.5.19b). Recruitment estimates increased with natural mortality but followed similar patterns including the dip in 1995 (Figure 3.3.5.19c).

The range of release of mortalities (especially those recommended by the DW) used for the sensitivity runs had little impact on the model outputs (Table 3.3.4.13). The results were more sensitive to changes in the commercial hook-and-line release rate than in the longline release rate probably because the longline fleet rarely encounters small fish that have to be released. Steepness (an important parameter in the stock recruitment relationship assumed for black grouper) ranged from 0.786 at the lowest release mortalities for hook-and-line gears (HL) and longline (LL) to 0.792 at the highest release mortality rate for HL (Table 3.3.4.13) recommended by the DW. Similar results were seen for F_{2008}, ranging from $0.072 \cdot y^{-1}$ at the lowest HL release mortality up to $0.079 \cdot y^{-1}$ at the highest HL release mortality recommended by the DW (Table 3.3.4.13). The estimated SSB_{2008} was about 10% higher at the lowest HL release mortalities than at the high end of the HL release mortalities recommended by the DW. The model was adjusting in a predictable and sensible way its calculations of fishing mortality rates (F) and estimates of spawning stock biomass (SSB) based upon release mortality rates and annual estimates of released fish which died. As release mortality increased, fishing mortality rates increased causing the model to compensate by changing the stock-recruitment relationship (represented in the sensitivity runs by the steepness parameter) and spawning stock biomass. For the fishing mortality rate and spawning stock biomass at points corresponding to the councils' OFL proxy of 30% spawning potential ratio (SPR) computed by the model, the $F_{30\%\ SPR}$ was relatively high at lower release mortalities while the spawning stock biomass at $F_{30\%\ SPR}$ was lower (i.e., it took a smaller SSB to produce enough young to compensate for the lower release mortality rates). At higher release mortalities, the $F_{30\%SPR}$ was lower and the $SSB_{30\%SPR}$ adjusted higher. The fishing ratio, $F_{2008}/F_{30\%SPR}$, one of the fishery management reference points, reached 0.40 at the higher end of the release mortality range recommended by the DW, and did not exceed 0.64 even when release mortalities were increased to

90% for both gears (Table 3.3.4.13). The SSB-ratio, $SSB_{2008}/SSB_{F30\%SPR}$, another of the fishery management reference points, ranged from 1.82 at the lower release mortalities to 1.61 at the higher release mortalities recommended by the DW, and did not fall below 1.2 even when release mortalities were pushed to 90% for both gears (Table 3.3.4.13). At the higher end of the release mortality range recommended by the DW, and also at the highest release mortalities (90%) used in these sensitivity runs, none of the fishery management reference point thresholds ($F_{2008}/F_{30\%SPR}$>1; $SSB_{2008}/SSB_{F30\%SPR}$<1-M) were exceeded.

Initial steepness values from 0.6 to 0.85 with CVs of 0.1 were run to see whether the conclusions regarding the condition of the stock were sensitive to the initial steepness values (Table 3.3.4.14). The difference between the initial steepness values and the final steepness point estimate decreased with higher starting values, e.g., the final steepness with an initial value of 0.6 was 0.67 which is greater than the CV while the final steepness with an initial value of 0.85 was 0.87 which was much smaller than the CV. The fishing mortality rate in 2008 on the fully selected age, age-5, increased slightly from 0.075 per year to 0.077 year over the range of steepness values; the spawning biomass in 2008 declined about 3%; and the spawning biomass at 30%SPR increased about 2%.

Benchmarks / Reference Points / ABC values

Both the SAFMC and the GMFMC have chosen $F_{30\%SPR}$ as their overfishing limit (OFL, the former Maximum Fishing Mortality Threshold). Using $F_{30\%SPR}$ in lieu of F_{MSY} has the advantage of being a per-recruit measure and does not depend upon the stock-recruit relationship. By not depending upon the stock-recruitment relationship, $F_{30\%SPR}$ is more consistent than F_{MSY} across different model configurations, which, in turn, aids managers. The point estimate for $F_{30\%SPR}$ in the base run was 0.212 per year (fully recruited age, age-5) and 7.11 million lb for the spawning biomass associated with $F_{30\%SPR}$. The Minimum Spawning Stock Threshold (MSST= (1-M)$SSB_{30\%SPR}$ was 6.14 million lb.

The fishing mortality rate in 2008 on the fully recruited age (age-5) was 0.076 per year, the F-ratio ($F_{2008}/F_{30\%SPR}$) was 0.357 and none of the MCMC outcomes exceeded 1.0 indicating that the fleets were not overfishing the stock in 2008. Another way of visualizing an F-ratio of 0.357 is to plot both parameters on the same scale and note separation between the two distributions (Figure 3.3.5.20). The spawning biomass in 2008 was 12.2 million lb and the SSB-ratio was 1.73 and none of the MCMC outcomes was less than 1.0 indicating the black grouper were not overfished. The distributions of these two ratios are shown in Figure 3.3.5.17.

Term of Reference 6A specifies that a range of ABC values be generated for the GMFMC's Scientific and Statistical Committee to consider. We estimated those values using the P* approach (Shertzer et al. 2008) which identifies the landings based upon a given probability of exceeding the overfishing limit ($F_{30\%SPR}$). In other words, for a given overfishing limit, what are the directed landings associated with alternate probabilities of overfishing? We generated directed landings over the period of 2009-2020 for probabilities of overfishing of 0.05 to 0.50 in 0.05 increments (Table 3.3.4.15 and Figure 3.3.5.21). The directed landings peaked (839,000 lb) in 2011 with probabilities of 0.35 or greater and then afterward. The highest discards (171,000 lb) were projected to occur in 2012 with an overfishing probability of 0.50 and then decline as the stock declined.

Projections

Black grouper were not deemed to be either undergoing overfishing nor were they overfished in 2008 and no rebuilding plan needs to be developed. Regardless, we ran eight projections: F = 0, $F_{current}$, $F_{30\%SPR}$

(both councils' overfishing limit), 0.65*$F_{30\%SPR}$, 0.75*$F_{30\%SPR}$, 0.85*$F_{30\%SPR}$, $F_{40\%SPR}$, and $F_{45\%SPR}$ (the SAFMC's optimum yield measure, Table 3.3.4.16 and Figures 3.3.5.22 and 3.3.5.23). The first two years of the projection, 2009 and 2010, used the current fishing mortality rate (geometric mean of fishing mortality per year for 2006-2008) and then one of the alternative fishing mortality rates began in 2011. The pattern of fishing mortality rates was interesting in that the current fishing mortality rate was lowest other than F = 0. $F_{30\%SPR}$ had the highest fishing mortality rate (0.217 per year on fully selected ages) followed by 0.85*$F_{30\%SPR}$ (F= 0.184 per year on fully selected ages), F40%SPR and 0.85*$F_{30\%SPR}$ had similar rates (0.164 and 0.163 per year on fully selected ages respectively) and 0.65*$F_{30\%SPR}$ and $F_{45\%SPR}$ also had similar rates at (F = 0.141 and 0.143 per year on fully selected ages, respectively). As expected, recruitment was inverse to fishing mortality, i.e. the lowest fishing mortality rates, F = 0 or F = $F_{current}$, had the highest recruitment. The spawning biomass increased under the no directed fishing and the current fishing mortality rates and declined under the higher fishing mortality rates. Because we assume that the fishery for reef species will continue to operate on suitable bottom habitat, when the directed fishery closes, i.e., F = 0, the discards were projected to increase because the directed fishery was converted to discards and those were in addition to the existing level of discard of undersized fish. The spawning biomass decreases even at the SAFMC's OY fishing rate because that rate was higher than the current fishing mortality rate. A long term projection at $F_{30\%SPR}$ indicated that the spawning biomass would approach an asymptote of approximately 5.6 million lb or less than half of the 2008 estimate of 12.2 million lb.

3.3.3. Discussion

When we started to develop the black grouper stock assessment, we had concerns whether there was enough information available to determine the status of the stock. To address those concerns, we used three models with differing data requirements in a stepwise manner. The catch curves with the longline fleet indicated low fishing mortality rates (Section 3.1) and the non-equilibrium surplus production model (ASPIC, Section 3.2) indicated that fishing mortality rates had been higher in the early part of the time series and that the rates had decreased to low levels in recent years. The fishing mortality rates that ASAP2 estimated followed a trend similar to those from ASPIC. This downward trend was similar to that decline in effort observed in the commercial hook-and-line fleet (SEDAR19 DW Report, Table 3.13.9) in the southeast US and in the headboat fleet in southern Florida ((SEDAR19 DW Report, Tables 4.6.5 and 4.6.6). The low effort in 2008 could be partly due to the high cost of diesel fuel in the spring and summer months, Figure 4.7.1). Fishing effort for black grouper can depend upon fuel costs because the legal-sized individuals tend to found on hard bottom habitat on the shelf and not inshore. The preliminary ASAP2 runs showed low fishing mortality rates and the question arose at the AW that the longline fleet age composition might be driving the low fishing mortality rates, so the base model was set the annual sample sizes for the multinomial at zero which removed the longline age composition from the model fitting process but the results were essentially the same. The average natural mortality rate may have been too high at (M = 0.136 per year) but running the model with a lower natural mortality rate (an average M of 0.10 per year) did not change the conclusions nor did the conclusions change with the different sensitivity runs. The consistency among the sensitivity runs and with the different models indicates that the status determination of the stock in 2008 was not overfished nor was it undergoing overfishing is robust.

3.3.4. Tables

Table	Description
3.3.4.1.	ASAP2 model fits to landings, discards, and indices of abundance.
3.3.4.2.	Selectivity coefficients and their standard deviations by fleet, period, and logistic curve type.
3.3.4.3	Selectivity coefficients and their standard deviations for the indices of abundance.
3.3.4.4	Fishing mortality parameters and their standard deviations by fleet and year.
3.3.4.5	Initial stock size parameters and their standard deviations to estimate the age-structure in 1986 for ages 2-20+ years.
3.3.4.6	Recruitment deviation parameters and their standard deviations by year.
3.3.4.7	Index catchability parameters and their standard deviations.
3.3.4.8	The order of estimation of the parameters in ASAP2 by phase.
3.3.4.9	Estimated annual population numbers-at-age (a) and stock biomass (lb, b) at the beginning of the year.
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3.3.4.11	Fishing mortality per year for directed (a), dead discards (b), and combined (c) for black grouper by year and age.
3.3.4.12	Number of simulations in step before successful jump in Markov Chain Monte Carlo run.
3.3.4.13	Results of sensitivity runs of release mortality rates for Hook and Line gears and Longline gear on model estimates for various parameters.
3.3.4.14	Final steepness estimates and their standard deviation (SD), objective functions for the runs, fishing mortality rates in 2008 on fully selected fish (age-5), the spawning biomasses in 2008, the management fishing mortality limits, $F_{30\%SPR}$, and the spawning biomasses at $F_{30\%SPR}$, over a range of initial steepness values.
3.3.4.15	Landings, dead discards, fishing mortality rates, and spawning biomass projections over a range of probabilities of overfishing (0.05 to 0.50 in 0.05 increments) from P*.
3.3.4.16	Landings, dead discards, fishing mortality rates, and spawning biomass projections for a variety of fishing mortality rates.

Table 3.3.4.1. ASAP2 model fits to landings, discards, and indices of abundance. The column labeled 'SS' is the sum of the squared standardized residuals, n is the number of years, 'MSE' is the sum of squares divided by n-1 which is equivalent to a variance, and observations, and 'RMSE' is the square root of MSE which is equivalent to the standard deviation.

Type	Fleet or Index	SS	n	MSE	RMSE
Landings	Headboat	42.86	23	1.95	1.40
	MRFSS	42.99	23	1.95	1.40
	Commercial hook-and-line	7.43	23	0.34	0.58
	Commercial long-line	14.71	23	0.67	0.82
Discards	Headboat	85.33	23	3.88	1.97
	MRFSS	59.47	23	2.70	1.64
	Commercial hook-and-line	23.85	16	1.59	1.26
	Commercial long-line	8.72	16	0.58	0.76
Indices	FWC Visual Survey	15.75	8	2.25	1.50
	NMFS-UM Reef Visual Census	86.53	15	6.18	2.49
	Headboat	64.33	23	2.92	1.71
	MRFSS	87.27	18	5.13	2.27
	Commercial hook-and-line	25.47	16	1.70	1.30
	Commercial long-line	14.59	16	0.97	0.99
	FWC Visual Survey age-1	15.18	8	2.17	1.47
	NMFS-UM Reef Visual Census age-1	721.74	15	51.55	7.18

Table 3.3.4.2. Selectivity coefficients and their standard deviations by fleet, period, and logistic curve type. The fleets were modeled with different types of logistics curves. The headboat (HB), general recreation (MRFSS), and commercial hook-and-line fleets were fit with double logistic curve while the longline fleet was modeled with a single logistic curve.

		Type of	Parameters							
Fleet	Period	logistic	α1	α1 sd	β1	β1 sd	α2	α2 sd	β2	β2 sd
HB	1986-1991	Double	1.9338	0.3084	7.1153	1.9381	3.7406	0.1943	0.9931	0.0894
	1992-1998		1.0402	0.0802	0.8771	0.2696	4.0896	0.1007	1.3656	0.0891
	1999-2008		0.9834	0.0181	15.3520	10.9980	1.9573	0.2678	1.6530	0.0974
MRFSS	1986-1991	Double	0.9389	0.0637	0.0116	0.0145	3.3611	1.3201	3.1556	0.6570
	1992-1998		1.0880	0.0973	1.2667	0.2756	4.4941	0.0944	1.2591	0.0978
	1999-2008		1.0390	0.0100	0.0296	0.0090	3.3962	0.0999	1.8718	0.0949
HL	1986-1991	Double	1.9196	0.0664	0.2999	0.0525	6.3899	0.1416	1.5515	0.1362
	1992-1998		1.8739	0.0835	0.3859	0.0404	6.8550	0.2256	2.6188	0.2175
	1999-2008		1.7969	0.0737	0.3076	0.0273	4.8893	0.3518	3.9587	0.2680
LL	1986-1991	Single			No age data					
	1992-1998		5.3598	0.3293	1.5693	0.1705	--		--	
	1999-2008		6.8096	1.8319	1.8800	0.7087	--		--	

Table 3.3.4.3. Selectivity coefficients and their standard deviations for the indices of abundance. All were fit with double logistic curves. The fishery dependent indices were linked to their fleets and the selectivity for the age-1 indices was 1.0 for age-1 and zero for the other ages.

	Parameters							
Index	α1	α1 sd	β1	β1 sd	α2	α2 sd	β2	β2 sd
FWC Visual Survey	0.0444	0.0072	0.0192	0.0347	3.2128	0.0680	0.8998	0.0585
NMFS-UM Reef Visual Census	0.3381	0.0910	0.1635	0.0353	5.4402	0.2199	2.8554	0.1969
MRFSS	2.5818	0.0528	0.3030	0.0202	5.6672	0.0554	0.9705	0.0502

Table 3.3.4.4. Fishing mortality parameters and their standard deviations by fleet and year. The fishing multiplier deviations are applied to the previous year's fishing multiplier in a sequential manner. The standard deviations of the log_Fmult_devs come from the covariance matrix and these are not dev-vector in ADMB parlance.

		Fishing mortality parameters							
		Headboat		MRFSS		HL		LL	
Year	Parameter	Estimate	sd	Estimate	sd	Estimate	sd	Estimate	sd
1986	log_Fmult	-3.8592	0.1230	-1.9019	0.1336	-2.0169	0.1721	-3.6438	0.2775
1987	log_Fmult_devs	0.2937	0.1136	-0.0205	0.1603	0.0476	0.1807	-0.2451	0.1881
1988	log_Fmult_devs	-0.3278	0.1123	-0.4095	0.1745	-0.1349	0.1819	-0.2563	0.1838
1989	log_Fmult_devs	-0.2287	0.1113	-0.1305	0.1730	-0.1193	0.1827	-0.1240	0.1834
1990	log_Fmult_devs	-0.0967	0.1103	-0.0992	0.1796	-0.2409	0.1846	-0.0780	0.1853
1991	log_Fmult_devs	-0.0525	0.1093	0.4718	0.1863	-0.3372	0.1858	-0.3309	0.1869
1992	log_Fmult_devs	0.4920	0.1331	0.2283	0.1825	-0.1579	0.1857	-0.2308	0.1867
1993	log_Fmult_devs	0.0899	0.1088	-0.1492	0.1684	-0.1345	0.1772	-0.3848	0.1824
1994	log_Fmult_devs	-0.0353	0.1086	0.0890	0.1653	-0.1602	0.1660	-0.1490	0.1675
1995	log_Fmult_devs	0.2533	0.1083	-0.0994	0.1596	-0.1569	0.1649	0.0043	0.1661
1996	log_Fmult_devs	0.1185	0.1081	0.3048	0.1440	0.0001	0.1641	0.1217	0.1659
1997	log_Fmult_devs	0.2631	0.1080	0.1453	0.1332	-0.1085	0.1635	-0.0086	0.1659
1998	log_Fmult_devs	0.4397	0.1078	-0.0992	0.1330	-0.0492	0.1649	0.0513	0.1692
1999	log_Fmult_devs	-0.6980	0.1284	0.1053	0.1390	-0.0055	0.1673	0.1677	0.1929
2000	log_Fmult_devs	-0.5786	0.1081	-0.2817	0.1557	-0.0348	0.1683	-0.0363	0.1713
2001	log_Fmult_devs	0.3602	0.1079	-0.1799	0.1611	-0.0820	0.1699	0.0001	0.1701
2002	log_Fmult_devs	-0.6668	0.1079	0.0230	0.1533	-0.1199	0.1708	0.0478	0.1702
2003	log_Fmult_devs	-0.2155	0.1078	-0.3470	0.1407	-0.0008	0.1716	0.0601	0.1704
2004	log_Fmult_devs	0.3429	0.1079	0.4270	0.1316	-0.1035	0.1719	-0.0173	0.1704
2005	log_Fmult_devs	0.3392	0.1080	-0.3535	0.1517	-0.1144	0.1720	-0.1529	0.1705
2006	log_Fmult_devs	-0.4275	0.1080	0.0358	0.1610	-0.4025	0.1720	0.0223	0.1708
2007	log_Fmult_devs	-0.1356	0.1080	0.2328	0.1581	0.0865	0.1724	-0.2815	0.1715
2008	log_Fmult_devs	-1.1171	0.1103	0.2728	0.1649	-0.4181	0.1799	-0.2906	0.1794

Table 3.3.4.5. Initial stock size parameters and their standard deviations to estimate the age-structure in 1986 for ages 2-20+ years. These deviations are applied to the age-specific initial guesses of population size.

		Initial stock size parameters	
Age	Description	Estimate	sd
2	log_N_year1_devs	-0.9180	0.1415
3	log_N_year1_devs	-1.4747	0.1815
4	log_N_year1_devs	-1.4473	0.2206
5	log_N_year1_devs	-1.5767	0.2716
6	log_N_year1_devs	-1.2606	0.3255
7	log_N_year1_devs	-0.7480	0.3834
8	log_N_year1_devs	-0.4051	0.4359
9	log_N_year1_devs	-0.4226	0.4821
10	log_N_year1_devs	-0.5398	0.5073
11	log_N_year1_devs	-0.6246	0.5205
12	log_N_year1_devs	-0.6471	0.5281
13	log_N_year1_devs	-0.5942	0.5338
14	log_N_year1_devs	-0.4635	0.5388
15	log_N_year1_devs	-0.3158	0.5429
16	log_N_year1_devs	-0.1364	0.5471
17	log_N_year1_devs	0.0535	0.5505
18	log_N_year1_devs	0.2507	0.5537
19	log_N_year1_devs	0.4584	0.5572
20+	log_N_year1_devs	2.7440	0.5866

Table 3.3.4.6. Recruitment deviation parameters and their standard deviations by year.

		Recruitment parameters	
Year	Description	Estimate	sd
1986	log_recruit_devs	0.2185	0.1183
1987	log_recruit_devs	0.0278	0.1241
1988	log_recruit_devs	-0.0767	0.1139
1989	log_recruit_devs	-0.1449	0.1009
1990	log_recruit_devs	-0.0113	0.0909
1991	log_recruit_devs	0.0571	0.0804
1992	log_recruit_devs	-0.0303	0.0739
1993	log_recruit_devs	-0.0039	0.0691
1994	log_recruit_devs	-0.0264	0.0614
1995	log_recruit_devs	-0.5983	0.0721
1996	log_recruit_devs	-0.0907	0.0607
1997	log_recruit_devs	0.0041	0.0548
1998	log_recruit_devs	0.0833	0.0544
1999	log_recruit_devs	0.2222	0.0482
2000	log_recruit_devs	0.2836	0.0482
2001	log_recruit_devs	0.1891	0.0521
2002	log_recruit_devs	0.1096	0.0541
2003	log_recruit_devs	-0.0957	0.0605
2004	log_recruit_devs	-0.1730	0.0668
2005	log_recruit_devs	0.0473	0.0664
2006	log_recruit_devs	-0.1852	0.0757
2007	log_recruit_devs	-0.0672	0.0826
2008	log_recruit_devs	0.2612	0.0963

Table 3.3.4.7. Index catchability parameters and their standard deviations.

Index	Description	Catchability parameters	
		Estimate	sd
FWC Visual Survey	log_q_year1	-13.1540	0.1103
NMFS-UM Reef Visual Census	log_q_year1	-13.3690	0.1032
Headboat	log_q_year1	-13.3560	0.1033
MRFSS	log_q_year1	-12.6320	0.1120
Commercial HL	log_q_year1	-15.4050	0.1116
Commercial LL	log_q_year1	-15.6020	0.2074
FWC Visual Survey Age-1	log_q_year1	-12.3790	0.1090
NMFS-UM Reef Visual Census Age-1	log_q_year1	-12.5670	0.0994

Table 3.3.4.8. The order of estimation of the parameters in ASAP2 by phase.

Phase	**Parameter**	**Description**
1	$N_{1,a}$	Numbers-at-age in year 1
2	$Fmult_{f,1}$ q_{ind}	Fishing multiplier in year 1 by fleet Catchabilities in year 1 by index
3	SSB_0	Unexploited stock size
4	$Sel_{f,a}$	Selectivity blocks by fleet
5	Sel_{ind}	Selectivity of fishery-independent indices
6	h	Steepness
7	Log_Rdev_t	Recruitment deviations
8	$Log\_Fmultdev_{f,t}$	Fishing multiplier deviations by fleet and year

Table 3.3.4.9. Estimated annual population numbers-at-age (a) and stock biomass (lb, b) at the beginning of the year.

a. Population abundance.

	Ages																			
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	312,201	205,648	85,836	57,588	43,591	36,936	31,598	25,501	17,215	11,502	8,074	5,963	4,664	3,876	3,230	2,747	2,342	1,998	1,716	11,724
1987	257,995	192,763	123,760	51,228	36,494	29,267	26,160	23,459	19,710	13,725	9,384	6,690	5,000	3,943	3,294	2,757	2,354	2,011	1,721	11,639
1988	233,467	165,586	117,980	73,196	32,254	24,422	20,721	19,459	18,196	15,787	11,257	7,820	5,641	4,251	3,371	2,829	2,377	2,034	1,742	11,636
1989	218,234	149,262	105,229	74,349	48,696	22,598	17,946	15,874	15,444	14,837	13,132	9,488	6,657	4,836	3,660	2,913	2,453	2,064	1,771	11,710
1990	249,678	142,831	96,335	68,115	50,651	34,799	16,870	13,915	12,712	12,677	12,404	11,112	8,103	5,722	4,174	3,171	2,531	2,135	1,801	11,823
1991	268,237	164,158	98,648	64,315	47,736	37,081	26,486	13,271	11,257	10,507	10,648	10,532	9,514	6,979	4,948	3,621	2,759	2,206	1,865	11,963
1992	247,774	174,825	109,252	65,153	44,777	34,804	28,141	20,781	10,708	9,283	8,811	9,034	9,018	8,202	6,044	4,301	3,159	2,411	1,933	12,181
1993	256,889	160,964	118,321	74,669	45,677	32,087	26,277	22,258	16,964	8,927	7,855	7,529	7,781	7,812	7,133	5,274	3,764	2,769	2,118	12,463
1994	253,535	167,186	111,338	82,670	53,169	33,410	24,556	20,983	18,300	14,221	7,587	6,738	6,507	6,762	6,814	6,241	4,627	3,308	2,439	12,906
1995	144,382	166,074	118,369	80,218	59,360	38,681	25,601	19,659	17,302	15,383	12,117	6,522	5,833	5,663	5,905	5,968	5,481	4,070	2,916	13,592
1996	242,084	93,841	115,634	83,780	57,452	43,470	29,848	20,597	16,267	14,581	13,131	10,429	5,652	5,080	4,947	5,173	5,243	4,821	3,588	14,622
1997	268,919	157,270	64,943	80,430	58,965	40,990	32,922	23,774	16,956	13,672	12,427	11,290	9,030	4,918	4,435	4,332	4,542	4,609	4,248	16,119
1998	293,981	174,357	107,954	44,676	54,739	41,118	30,706	26,094	19,537	14,247	11,655	10,690	9,780	7,861	4,295	3,884	3,804	3,993	4,062	18,028
1999	340,592	190,472	121,095	75,393	30,833	38,263	30,803	24,340	21,446	16,417	12,146	10,025	9,259	8,513	6,864	3,761	3,410	3,344	3,518	19,551
2000	364,398	224,680	132,459	88,260	56,009	22,843	29,428	24,584	19,959	17,924	13,913	10,390	8,641	8,025	7,406	5,991	3,293	2,990	2,940	20,384
2001	332,724	242,243	159,017	98,413	67,140	42,607	17,887	23,761	20,307	16,758	15,235	11,924	8,967	7,496	6,986	6,467	5,247	2,888	2,630	20,616
2002	308,240	221,015	172,344	118,266	74,718	51,358	33,626	14,522	19,701	17,094	14,269	13,073	10,300	7,783	6,529	6,103	5,665	4,604	2,540	20,550
2003	252,644	205,268	158,300	129,115	89,889	57,306	40,652	27,359	12,059	16,602	14,567	12,251	11,296	8,943	6,780	5,704	5,346	4,970	4,049	20,410
2004	236,181	168,769	148,662	120,199	99,443	69,957	45,902	33,322	22,822	10,189	14,168	12,515	10,589	9,808	7,788	5,921	4,995	4,689	4,369	21,606
2005	298,117	157,231	120,200	110,571	91,061	76,040	55,255	37,306	27,660	19,230	8,683	12,165	10,816	9,194	8,543	6,804	5,187	4,381	4,123	22,950
2006	239,412	198,632	113,587	90,852	84,368	70,633	60,893	45,332	31,166	23,412	16,442	7,474	10,534	9,406	8,020	7,473	5,966	4,555	3,857	23,944
2007	272,897	159,749	143,696	86,234	70,132	65,937	56,794	50,133	37,982	26,444	20,057	14,175	6,480	9,170	8,211	7,019	6,556	5,241	4,010	24,592
2008	382,985	181,905	114,891	108,077	65,834	54,163	52,593	46,525	41,887	32,184	22,646	17,296	12,298	5,646	8,014	7,195	6,166	5,766	4,620	25,335

Table 3.3.4.9 (continued). Estimated annual population numbers-at-age (a) and stock biomass (lb, b) at the beginning of the year.

b. Stock biomass.

	Ages																			
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	279,420	570,056	495,444	560,507	628,196	722,021	787,201	772,986	612,840	467,721	366,831	297,379	251,606	223,471	197,056	175,911	156,258	138,098	122,243	935,607
1987	230,906	534,339	714,343	498,600	525,918	572,111	651,734	711,101	701,646	558,130	426,389	333,654	269,713	227,324	201,005	176,553	157,085	139,016	122,593	928,823
1988	208,953	459,004	680,981	712,415	464,810	477,407	516,225	589,847	647,759	641,950	511,464	389,976	304,337	245,087	205,651	181,131	158,567	140,555	124,116	928,568
1989	195,319	413,754	607,382	723,640	701,764	441,742	447,084	481,158	549,773	603,336	596,643	473,164	359,112	278,813	223,317	186,521	163,651	142,678	126,162	934,497
1990	223,462	395,928	556,043	662,965	729,926	680,255	420,275	421,801	452,538	515,510	563,606	554,182	437,157	329,931	254,693	203,016	168,891	147,561	128,327	943,531
1991	240,072	455,046	569,396	625,979	687,921	724,861	659,833	402,255	400,727	427,244	483,812	525,216	513,265	402,417	301,882	231,874	184,069	152,474	132,875	954,639
1992	221,758	484,615	630,603	634,131	645,278	680,349	701,069	629,911	381,201	377,499	400,352	450,535	486,508	472,905	368,777	275,404	210,753	166,638	137,712	972,044
1993	229,916	446,192	682,949	726,749	658,247	627,227	654,626	674,678	603,916	362,990	356,884	375,482	419,772	450,456	435,208	337,682	251,149	191,370	150,921	994,564
1994	226,914	463,440	642,643	804,623	766,213	653,101	611,759	636,046	651,447	578,279	344,742	336,025	351,050	389,878	415,745	399,597	308,747	228,629	173,749	1,029,957
1995	129,222	460,357	683,226	780,759	855,434	756,142	637,793	595,898	615,945	625,538	550,553	325,260	314,697	326,516	360,273	382,132	365,703	281,306	207,747	1,084,685
1996	216,665	260,128	667,439	815,428	827,942	849,759	743,598	624,348	579,092	592,930	596,611	520,100	304,890	292,887	301,852	331,242	349,789	333,244	255,635	1,166,849
1997	240,683	435,952	374,850	782,823	849,742	801,273	820,196	720,647	603,613	555,942	564,633	563,044	487,154	283,573	270,600	277,367	303,033	318,562	302,662	1,286,297
1998	263,113	483,318	623,110	434,832	788,849	803,773	764,969	790,946	695,494	579,320	529,561	533,096	527,595	453,253	262,067	248,703	253,788	276,015	289,356	1,438,694
1999	304,830	527,988	698,960	733,797	444,327	747,963	767,390	737,803	763,449	667,569	551,852	499,972	499,497	490,823	418,814	240,816	227,514	231,110	250,652	1,560,177
2000	326,136	622,813	764,553	859,033	807,149	446,525	733,135	745,181	710,528	728,845	632,165	518,150	466,179	462,711	451,859	383,622	219,685	206,676	209,419	1,626,652
2001	297,788	671,498	917,846	957,854	967,553	832,876	445,624	720,243	722,920	681,460	692,208	594,677	483,735	432,224	426,252	414,095	350,099	199,633	187,336	1,645,206
2002	275,875	612,654	994,770	1,151,083	1,076,761	1,003,942	837,735	440,188	701,325	695,090	648,317	651,944	555,649	448,772	398,342	390,755	378,001	318,202	180,976	1,639,963
2003	226,116	569,003	913,708	1,256,676	1,295,393	1,120,216	1,012,753	829,297	429,299	675,108	661,848	610,970	609,407	515,625	413,654	365,189	356,688	343,535	288,429	1,628,759
2004	211,382	467,828	858,077	1,169,897	1,433,070	1,367,514	1,143,554	1,010,066	812,423	414,317	643,715	624,141	571,250	565,504	475,198	379,132	333,250	324,056	311,282	1,724,202
2005	266,815	435,844	693,794	1,076,188	1,312,283	1,486,428	1,376,570	1,130,816	984,651	781,973	394,523	606,691	583,469	530,129	521,255	435,632	346,050	302,829	293,693	1,831,432
2006	214,274	550,608	655,624	884,263	1,215,829	1,380,736	1,517,025	1,374,091	1,109,486	952,026	747,050	372,754	568,278	542,361	489,344	478,465	398,090	314,809	274,744	1,910,803
2007	244,243	442,824	829,413	839,315	1,010,666	1,288,927	1,414,899	1,519,622	1,352,118	1,075,311	911,287	706,941	349,590	528,757	501,015	449,433	437,419	362,262	285,675	1,962,515
2008	342,772	504,241	663,151	1,051,913	948,727	1,058,786	1,310,259	1,410,251	1,491,139	1,308,734	1,028,925	862,584	663,435	325,567	488,961	460,682	411,378	398,556	329,164	2,021,776

Table 3.3.4.10. Spawning biomass offset to the spawning season (mid-March) and recruitment of age-1 fish by year.

Year	Spawning biomass (lb)	Recruitment Number of age-1 fish
1986	5,379,590	312201
1987	5,471,240	257995
1988	5,484,730	233467
1989	5,506,030	218234
1990	5,572,850	249678
1991	5,744,140	268237
1992	5,961,610	247774
1993	6,186,330	256889
1994	6,412,630	253535
1995	6,663,460	144382
1996	6,969,230	242084
1997	7,283,840	268919
1998	7,566,880	293981
1999	7,788,550	340592
2000	7,924,500	364398
2001	8,044,880	332724
2002	8,302,540	308240
2003	8,737,240	252644
2004	9,350,780	236181
2005	10,086,500	298117
2006	10,909,600	239412
2007	11,679,000	272897
2008	12,287,600	382985

Table 3.3.4.11. Fishing mortality per year for directed (a), dead discards (b), and combined (c) for black grouper by year and age.

a. Directed fishing mortality per year.

	Ages																			
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	0.063	0.204	0.272	0.244	0.208	0.171	0.135	0.104	0.080	0.062	0.051	0.043	0.038	0.035	0.032	0.030	0.029	0.028	0.028	0.027
1987	0.014	0.181	0.281	0.251	0.212	0.171	0.133	0.100	0.075	0.057	0.045	0.038	0.032	0.029	0.026	0.025	0.023	0.023	0.022	0.022
1988	0.033	0.150	0.218	0.196	0.166	0.134	0.104	0.077	0.057	0.043	0.034	0.028	0.024	0.022	0.020	0.019	0.018	0.017	0.017	0.017
1989	0.008	0.136	0.191	0.172	0.146	0.118	0.091	0.068	0.050	0.038	0.030	0.025	0.021	0.019	0.018	0.016	0.016	0.015	0.015	0.015
1990	0.005	0.057	0.160	0.144	0.122	0.099	0.077	0.058	0.044	0.033	0.027	0.022	0.019	0.017	0.016	0.015	0.015	0.014	0.014	0.014
1991	0.005	0.097	0.171	0.150	0.126	0.102	0.080	0.061	0.046	0.035	0.027	0.022	0.018	0.016	0.014	0.013	0.012	0.011	0.011	0.010
1992	0.010	0.066	0.113	0.128	0.140	0.107	0.072	0.049	0.035	0.026	0.020	0.016	0.014	0.012	0.010	0.009	0.009	0.008	0.008	0.008
1993	0.012	0.044	0.092	0.114	0.119	0.093	0.062	0.042	0.029	0.022	0.016	0.013	0.010	0.009	0.008	0.007	0.006	0.006	0.006	0.005
1994	0.002	0.013	0.052	0.103	0.126	0.092	0.059	0.039	0.027	0.019	0.014	0.011	0.009	0.008	0.007	0.006	0.005	0.005	0.005	0.005
1995	0.013	0.037	0.078	0.109	0.120	0.085	0.054	0.035	0.024	0.017	0.013	0.010	0.008	0.007	0.006	0.006	0.005	0.005	0.005	0.005
1996	0.004	0.032	0.087	0.120	0.145	0.104	0.065	0.041	0.027	0.019	0.014	0.011	0.009	0.008	0.007	0.006	0.006	0.006	0.005	0.005
1997	0.000	0.034	0.092	0.154	0.168	0.115	0.069	0.042	0.027	0.019	0.014	0.011	0.009	0.007	0.007	0.006	0.006	0.005	0.005	0.005
1998	0.000	0.018	0.072	0.137	0.165	0.115	0.069	0.042	0.027	0.019	0.014	0.011	0.009	0.008	0.007	0.006	0.006	0.006	0.005	0.005
1999	0.003	0.018	0.035	0.064	0.106	0.088	0.063	0.044	0.032	0.024	0.019	0.016	0.013	0.011	0.010	0.009	0.008	0.008	0.007	0.007
2000	0.000	0.012	0.024	0.044	0.080	0.070	0.051	0.037	0.028	0.022	0.017	0.014	0.012	0.011	0.009	0.009	0.008	0.008	0.007	0.007
2001	0.001	0.011	0.028	0.050	0.076	0.063	0.045	0.033	0.025	0.020	0.016	0.013	0.012	0.010	0.009	0.008	0.008	0.007	0.007	0.007
2002	0.001	0.005	0.021	0.050	0.074	0.060	0.043	0.032	0.024	0.019	0.015	0.013	0.011	0.010	0.009	0.008	0.008	0.007	0.007	0.007
2003	0.000	0.002	0.012	0.040	0.060	0.048	0.036	0.027	0.022	0.018	0.015	0.013	0.011	0.010	0.009	0.009	0.008	0.008	0.008	0.007
2004	0.000	0.009	0.028	0.053	0.076	0.062	0.044	0.032	0.024	0.019	0.015	0.013	0.011	0.010	0.009	0.008	0.008	0.008	0.007	0.007
2005	0.000	0.002	0.016	0.051	0.063	0.048	0.035	0.026	0.020	0.016	0.013	0.011	0.010	0.009	0.008	0.007	0.007	0.007	0.006	0.006
2006	0.000	0.002	0.012	0.038	0.055	0.044	0.031	0.023	0.017	0.014	0.011	0.010	0.009	0.008	0.007	0.007	0.007	0.006	0.006	0.006
2007	0.000	0.002	0.018	0.047	0.067	0.052	0.036	0.026	0.019	0.014	0.011	0.009	0.008	0.007	0.006	0.006	0.005	0.005	0.005	0.005
2008	0.000	0.014	0.032	0.048	0.073	0.060	0.040	0.027	0.019	0.013	0.010	0.008	0.006	0.005	0.005	0.004	0.004	0.004	0.004	0.004

Table 3.3.4.11 (continued). Fishing mortality per year for directed (a), dead discards (b), and combined (c) for black grouper by year and age.

b. Dead discard fishing mortality per year.

	Ages																			
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	0.023	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1987	0.034	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.018	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1989	0.020	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1990	0.018	0.016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.027	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.025	0.028	0.024	0.015	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.022	0.027	0.023	0.013	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.025	0.035	0.032	0.016	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.022	0.028	0.024	0.013	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.031	0.039	0.032	0.019	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.037	0.045	0.038	0.018	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.038	0.050	0.043	0.022	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.017	0.048	0.037	0.021	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.012	0.036	0.029	0.017	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.012	0.032	0.024	0.013	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.010	0.032	0.024	0.012	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.007	0.024	0.019	0.009	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.011	0.033	0.024	0.013	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.010	0.027	0.020	0.008	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.008	0.025	0.019	0.009	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.009	0.031	0.022	0.011	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.010	0.035	0.025	0.014	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 3.3.4.11 (continued). Fishing mortality per year for directed (a), dead discards (b), and combined (c) for black grouper by year and age.

c. Combined fishing mortality per year.

	Ages																			
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	0.086	0.211	0.272	0.244	0.208	0.171	0.135	0.104	0.080	0.062	0.051	0.043	0.038	0.035	0.032	0.030	0.029	0.028	0.028	0.027
1987	0.047	0.194	0.281	0.251	0.212	0.171	0.133	0.100	0.075	0.057	0.045	0.038	0.032	0.029	0.026	0.025	0.023	0.023	0.022	0.022
1988	0.051	0.156	0.218	0.196	0.166	0.134	0.104	0.077	0.057	0.043	0.034	0.028	0.024	0.022	0.020	0.019	0.018	0.017	0.017	0.017
1989	0.028	0.141	0.191	0.172	0.146	0.118	0.091	0.068	0.050	0.038	0.030	0.025	0.021	0.019	0.018	0.016	0.016	0.015	0.015	0.015
1990	0.023	0.073	0.160	0.144	0.122	0.099	0.077	0.058	0.044	0.033	0.027	0.022	0.019	0.017	0.016	0.015	0.015	0.014	0.014	0.014
1991	0.032	0.110	0.171	0.150	0.126	0.102	0.080	0.061	0.046	0.035	0.027	0.022	0.018	0.016	0.014	0.013	0.012	0.011	0.011	0.010
1992	0.035	0.093	0.137	0.143	0.143	0.107	0.072	0.049	0.035	0.026	0.020	0.016	0.014	0.012	0.010	0.009	0.009	0.008	0.008	0.008
1993	0.034	0.072	0.115	0.128	0.123	0.093	0.062	0.042	0.029	0.022	0.016	0.013	0.010	0.009	0.008	0.007	0.006	0.006	0.006	0.005
1994	0.027	0.048	0.084	0.119	0.128	0.092	0.059	0.039	0.027	0.019	0.014	0.011	0.009	0.008	0.007	0.006	0.005	0.005	0.005	0.005
1995	0.035	0.065	0.102	0.122	0.122	0.085	0.054	0.035	0.024	0.017	0.013	0.010	0.008	0.007	0.006	0.006	0.005	0.005	0.005	0.005
1996	0.035	0.071	0.119	0.139	0.148	0.104	0.065	0.041	0.027	0.019	0.014	0.011	0.009	0.008	0.007	0.006	0.006	0.006	0.005	0.005
1997	0.037	0.079	0.130	0.173	0.170	0.115	0.069	0.042	0.027	0.019	0.014	0.011	0.009	0.007	0.007	0.006	0.006	0.005	0.005	0.005
1998	0.038	0.068	0.115	0.159	0.168	0.115	0.069	0.042	0.027	0.019	0.014	0.011	0.009	0.008	0.007	0.006	0.006	0.006	0.005	0.005
1999	0.020	0.066	0.072	0.085	0.110	0.089	0.063	0.044	0.032	0.024	0.019	0.016	0.013	0.011	0.010	0.009	0.008	0.008	0.007	0.007
2000	0.012	0.049	0.053	0.062	0.084	0.071	0.051	0.037	0.028	0.022	0.017	0.014	0.012	0.011	0.009	0.009	0.008	0.008	0.007	0.007
2001	0.013	0.043	0.052	0.063	0.078	0.063	0.045	0.033	0.025	0.020	0.016	0.013	0.012	0.010	0.009	0.008	0.008	0.007	0.007	0.007
2002	0.011	0.037	0.045	0.062	0.075	0.060	0.043	0.032	0.024	0.019	0.015	0.013	0.011	0.010	0.009	0.008	0.008	0.007	0.007	0.007
2003	0.007	0.026	0.031	0.049	0.061	0.048	0.036	0.027	0.022	0.018	0.015	0.013	0.011	0.010	0.009	0.009	0.008	0.008	0.008	0.007
2004	0.011	0.042	0.052	0.066	0.078	0.062	0.044	0.032	0.024	0.019	0.015	0.013	0.011	0.010	0.009	0.008	0.008	0.008	0.007	0.007
2005	0.010	0.028	0.036	0.058	0.064	0.048	0.035	0.026	0.020	0.016	0.013	0.011	0.010	0.009	0.008	0.007	0.007	0.007	0.006	0.006
2006	0.009	0.027	0.032	0.047	0.056	0.044	0.031	0.023	0.017	0.014	0.011	0.010	0.009	0.008	0.007	0.007	0.007	0.006	0.006	0.006
2007	0.010	0.033	0.041	0.058	0.068	0.052	0.036	0.026	0.019	0.014	0.011	0.009	0.008	0.007	0.006	0.006	0.005	0.005	0.005	0.005
2008	0.010	0.048	0.057	0.063	0.076	0.060	0.040	0.027	0.019	0.013	0.010	0.008	0.006	0.005	0.005	0.004	0.004	0.004	0.004	0.004

Table 3.3.4.12. Number of simulations in step before successful jump in Markov Chain Monte Carlo run.

Number of simulations in step	Frequency	Proportion	Cumulative Proportion
1	347602	0.2734	0.2734
2	252234	0.1984	0.4718
3	182826	0.1438	0.6156
4	132806	0.1045	0.7200
5	96276	0.0757	0.7958
6	70146	0.0552	0.8509
7	50879	0.0400	0.8910
8	37526	0.0295	0.9205
9	26901	0.0212	0.9416
10	19822	0.0156	0.9572
11	14502	0.0114	0.9686
12	10703	0.0084	0.9771
13	7662	0.0060	0.9831
14	5647	0.0044	0.9875
15	4180	0.0033	0.9908
16	3019	0.0024	0.9932
17	2272	0.0018	0.9950
18	1680	0.0013	0.9963
19	1195	0.0009	0.9972
20	943	0.0007	0.9980
21	682	0.0005	0.9985
22	465	0.0004	0.9989
23	350	0.0003	0.9992
24	265	0.0002	0.9994
25	198	0.0002	0.9995
26	159	0.0001	0.9996
27	102	0.0001	0.9997
28	71	0.0001	0.9998
29	60	0.0000	0.9998
30	57	0.0000	0.9999
31	32	0.0000	0.9999
32	24	0.0000	0.9999
33	30	0.0000	0.9999
34	17	0.0000	0.9999
35	16	0.0000	1.0000
36	13	0.0000	1.0000
37	11	0.0000	1.0000
38	5	0.0000	1.0000
39	2	0.0000	1.0000
40	5	0.0000	1.0000
41	2	0.0000	1.0000
44	3	0.0000	1.0000
45	1	0.0000	1.0000
47	1	0.0000	1.0000
49	1	0.0000	1.0000
50	1	0.0000	1.0000
53	1	0.0000	1.0000
61	1	0.0000	1.0000
91	1	0.0000	1.0000
201	1	0.0000	1.0000
Total	1271398		

Table 3.3.4.13. Results of sensitivity runs of release mortality rates for Hook and Line gears and Longline gear on model estimates for various parameters. Shaded cells represent the range of sensitivity runs recommended by the DW panel, and the cell in the center of the shaded range is the point estimate for the model parameter at the release mortalities by gear recommended by the DW panel.

Steepness (h)		Hook and Line Release Mortality (estimated %)					
		10	20	30	50	75	90
Longline Release Mortality (estimated %)	25	0.786	0.788	0.792	0.797	0.804	0.809
	30	0.784	0.788	0.791	0.797	0.804	0.809
	35	0.786	0.788	0.791	0.797	0.804	0.807
	50	0.784	0.788	0.791	0.797	0.804	0.807
	75	0.784	0.788	0.791	0.797	0.804	0.809
	90	0.785	0.788	0.792	0.797	0.804	0.808
SSB_{2008}		Hook and Line Release Mortality (estimated %)					
		10	20	30	50	75	90
Longline Release Mortality (estimated %)	25	12,680,000	12,244,000	11,825,000	11,379,000	11,195,000	11,216,000
	30	12,725,000	12,237,000	11,869,000	11,372,000	11,195,000	11,208,000
	35	12,682,000	12,241,000	11,868,000	11,377,000	11,195,000	11,279,000
	50	12,671,000	12,276,000	11,864,000	11,368,000	11,193,000	11,272,000
	75	12,662,000	12,224,000	11,864,000	11,364,000	11,191,000	11,230,000
	90	12,611,000	12,220,000	11,809,000	11,362,000	11,190,000	11,124,000
$SSB_{F30\%SPR}$		Hook and Line Release Mortality (estimated %)					
		10	20	30	50	75	90
Longline Release Mortality (estimated %)	25	6,940,200	7,085,900	7,340,100	7,840,500	8,682,300	9,305,200
	30	6,906,200	7,084,500	7,304,400	7,839,500	8,682,600	9,304,000
	35	6,940,600	7,085,200	7,304,400	7,840,200	8,682,900	9,263,300
	50	6,893,700	7,093,700	7,304,000	7,839,800	8,683,100	9,263,400
	75	6,892,500	7,083,600	7,304,500	7,840,000	8,684,900	9,312,700
	90	6,926,000	7,082,700	7,339,300	7,840,400	8,685,000	9,224,500
F_{2008} (Age 5)		Hook and Line Release Mortality (estimated %)					
		10	20	30	50	75	90
Longline Release Mortality (estimated %)	25	0.072	0.076	0.079	0.084	0.088	0.089
	30	0.072	0.076	0.079	0.084	0.088	0.089
	35	0.072	0.076	0.079	0.084	0.088	0.089
	50	0.073	0.076	0.079	0.084	0.088	0.089
	75	0.073	0.076	0.079	0.084	0.088	0.089
	90	0.073	0.076	0.079	0.084	0.088	0.090
$F_{30\%SPR}$ (Age 5)		Hook and Line Release Mortality (estimated %)					
		10	20	30	50	75	90
Longline Release Mortality (estimated %)	25	0.232	0.212	0.196	0.172	0.151	0.141
	30	0.232	0.212	0.196	0.172	0.151	0.141
	35	0.232	0.212	0.196	0.172	0.151	0.141
	50	0.232	0.212	0.196	0.172	0.151	0.141
	75	0.232	0.212	0.196	0.172	0.151	0.141
	90	0.232	0.212	0.196	0.172	0.151	0.141

Table 3.3.4.13 (continued). Results of sensitivity runs of release mortality rates for Hook and Line gears and Longline gear on model estimates for various parameters. Shaded cells represent the range of sensitivity runs recommended by the DW panel, and the cell in the center of the shaded range is the point estimate for the model parameter at the release mortalities by gear recommended by the DW panel.

$SSB_{2008}/SSB_{F30\%SPR}$		Hook and Line Release Mortality (estimated %)					
		10	20	30	50	75	90
Longline Release Mortality (estimated %)	25	1.827	1.728	1.611	1.451	1.289	1.205
	30	1.843	1.727	1.625	1.451	1.289	1.205
	35	1.827	1.728	1.625	1.451	1.289	1.218
	50	1.838	1.731	1.624	1.450	1.289	1.217
	75	1.837	1.726	1.624	1.449	1.289	1.206
	90	1.821	1.725	1.609	1.449	1.288	1.206
$F_{2008}/F_{30\%SPR}$ (Age 5)		Hook and Line Release Mortality (estimated %)					
		10	20	30	50	75	90
Longline Release Mortality (estimated %)	25	0.312	0.357	0.403	0.489	0.582	0.630
	30	0.311	0.357	0.402	0.489	0.582	0.631
	35	0.312	0.357	0.402	0.489	0.582	0.629
	50	0.313	0.356	0.402	0.489	0.583	0.629
	75	0.313	0.358	0.403	0.489	0.583	0.630
	90	0.314	0.358	0.404	0.490	0.583	0.636

Table 3.3.4.14. Final steepness estimates and their standard deviation (SD), objective functions for the runs, fishing mortality rates in 2008 on fully selected fish (age-5), the spawning biomasses in 2008, the management fishing mortality limits, $F_{30\%SPR}$, and the spawning biomasses at $F_{30\%SPR}$, over a range of initial steepness values.

Initial	Final steepness		Objective	F 2008		SSB 2008		F 30% SPR		SSB 30% SPR	
Steepness	Estimate	SD	Function	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD
0.60	0.67	0.056	4013.14	0.075	0.013	12,528,000	1,659,000	0.212	0.00014	7,008,000	808,440
0.65	0.71	0.061	4006.83	0.075	0.013	12,519,000	1,653,200	0.212	0.00014	7,061,400	720,590
0.70	0.75	0.065	4015.92	0.075	0.013	12,358,000	1,632,800	0.212	0.00014	7,154,700	672,610
0.75	0.79	0.070	4005.80	0.076	0.013	12,288,000	1,619,300	0.212	0.00014	7,107,900	626,550
0.80	0.83	0.075	4001.84	0.076	0.013	12,196,000	1,608,200	0.212	0.00014	7,084,600	599,730
0.85	0.87	0.080	4005.46	0.076	0.014	12,126,000	1,599,100	0.212	0.00014	7,053,800	582,940

Table 3.3.4.15. Landings, dead discards, fishing mortality rates, and spawning biomass projections over a range of probabilities of overfishing (0.05 to 0.50 in 0.05 increments) from P* with the implementation CV = 0.0.

	Landings (lb)									
Year	Pr=0.05	Pr=0.10	Pr=0.15	Pr=0.20	Pr=0.25	Pr=0.30	Pr=0.35	Pr=0.40	Pr=0.45	Pr=0.50
2009	310,942	310,942	310,942	310,942	310,942	310,942	310,942	310,942	310,942	310,942
2010	310,942	310,942	310,942	310,942	310,942	310,942	310,942	310,942	310,942	310,942
2011	792,219	806,216	815,892	823,668	830,452	836,641	838,809	838,809	838,809	838,809
2012	747,756	762,851	773,852	782,889	790,758	797,951	805,249	812,483	819,688	826,934
2013	733,375	751,062	764,259	775,108	784,342	792,575	800,696	808,884	817,037	825,202
2014	728,539	747,975	761,337	771,832	780,853	788,657	796,438	804,129	811,812	819,501
2015	730,658	748,767	760,670	770,116	778,179	785,448	792,377	799,170	805,690	812,138
2016	731,767	748,034	759,081	767,827	775,325	782,010	788,289	794,266	800,000	805,672
2017	730,758	745,168	755,046	763,525	770,998	787,695	783,734	789,262	794,381	799,318
2018	728,421	742,994	752,727	760,455	766,979	783,459	777,649	782,394	786,994	791,629
2019	727,412	741,214	751,427	758,578	763,929	778,421	772,663	776,939	781,344	785,888
2020	726,307	739,467	747,900	754,051	759,326	773,607	768,733	773,198	777,586	781,976
	Dead discards (lb)									
2009	43,957	43,957	43,957	43,957	43,957	43,957	43,957	43,957	43,957	43,957
2010	51,959	51,959	51,959	51,959	51,959	51,959	51,959	51,959	51,959	51,959
2011	152,860	155,556	157,429	158,928	160,233	161,426	161,844	161,844	161,844	161,844
2012	153,903	157,120	159,465	161,388	163,058	164,588	166,109	167,599	169,083	170,575
2013	148,060	151,989	154,917	157,327	159,385	161,231	162,994	164,738	166,480	168,222
2014	145,323	149,889	153,074	155,600	157,795	159,707	161,540	163,338	165,136	166,941
2015	145,168	149,766	152,902	155,420	157,571	159,537	161,368	163,134	164,867	166,595
2016	144,295	148,791	151,956	154,482	156,642	158,587	160,431	162,193	163,897	165,590
2017	144,022	148,422	151,435	154,029	156,324	158,402	160,254	162,046	163,778	165,421
2018	143,712	148,194	151,312	153,888	156,035	157,950	159,718	161,428	163,091	164,715
2019	143,329	147,748	151,008	153,532	155,525	157,298	158,950	160,597	162,297	164,056
2020	142,685	147,057	150,077	152,422	154,409	156,229	157,992	159,720	161,454	163,211
	Fishing mortality per year on fully selected ages									
2009	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071
2010	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073
2011	0.194	0.197	0.200	0.202	0.204	0.205	0.206	0.206	0.206	0.206
2012	0.188	0.193	0.196	0.199	0.201	0.203	0.205	0.207	0.209	0.211
2013	0.182	0.188	0.192	0.195	0.198	0.201	0.203	0.206	0.208	0.211
2014	0.179	0.186	0.190	0.194	0.197	0.200	0.203	0.206	0.208	0.211
2015	0.179	0.186	0.190	0.194	0.197	0.200	0.203	0.206	0.208	0.211
2016	0.179	0.185	0.190	0.194	0.197	0.200	0.203	0.206	0.208	0.211
2017	0.178	0.185	0.190	0.194	0.197	0.200	0.203	0.206	0.209	0.211
2018	0.178	0.185	0.190	0.194	0.197	0.200	0.203	0.206	0.208	0.211
2019	0.178	0.185	0.190	0.194	0.197	0.200	0.203	0.205	0.208	0.211
2020	0.178	0.185	0.190	0.193	0.197	0.200	0.203	0.205	0.208	0.211
	Spawning biomass (lb)									
2009	10,616,556	10,616,556	10,616,556	10,616,556	10,616,556	10,616,556	10,616,556	10,616,556	10,616,556	10,616,556
2010	10,898,960	10,898,960	10,898,960	10,898,960	10,898,960	10,898,960	10,898,960	10,898,960	10,898,960	10,898,960
2011	11,039,436	11,037,866	11,036,780	11,035,904	11,035,142	11,034,443	11,034,198	11,034,198	11,034,198	11,034,198
2012	10,891,945	10,881,180	10,873,428	10,867,158	10,861,629	10,856,907	10,854,759	10,854,014	10,853,273	10,852,508
2013	10,674,373	10,650,717	10,634,006	10,620,569	10,609,689	10,600,458	10,593,882	10,588,648	10,583,423	10,577,742
2014	10,475,785	10,436,919	10,409,046	10,386,222	10,366,420	10,348,525	10,334,360	10,322,548	10,310,989	10,299,221
2015	10,355,123	10,296,496	10,254,615	10,221,543	10,192,208	10,165,835	10,143,788	10,124,586	10,105,584	10,086,325
2016	10,283,883	10,203,988	10,147,607	10,101,235	10,061,816	10,026,348	9,996,043	9,968,918	9,942,041	9,915,154
2017	10,213,399	10,110,860	10,037,658	9,977,926	9,926,185	9,881,231	9,842,061	9,805,608	9,769,657	9,733,446
2018	10,143,306	10,017,433	9,928,727	9,856,998	9,795,921	9,741,562	9,693,701	9,649,997	9,607,102	9,563,955
2019	10,097,048	9,949,806	9,846,656	9,763,480	9,691,217	9,627,435	9,570,816	9,518,326	9,466,830	9,416,624
2020	10,051,269	9,881,429	9,763,813	9,668,972	9,587,650	9,516,031	9,451,294	9,390,676	9,331,072	9,271,739

Table 3.3.4.16. Landings, dead discards, fishing mortality rates, and spawning biomass projections for a variety of fishing mortality rates.

Year	F = 0	F=Fcurrent	F = 0.65FOFL	F=F0.75FOFL	F=0.85FOFL	F=F30%SPR	F=F40%SPR	F=F45%SPR
	Directed landings (lb)							
2009	356,288	356,288	356,288	356,288	356,288	356,288	356,288	356,288
2010	356,298	356,298	356,298	356,298	356,298	356,298	356,298	356,298
2011	0	354,883	733,965	841,552	947,820	1,105,401	850,987	745,078
2012	0	360,091	712,444	805,458	895,876	1,025,296	813,685	721,933
2013	0	369,171	699,306	782,112	859,446	965,479	788,104	708,106
2014	0	377,566	690,365	764,244	830,052	921,145	769,841	698,646
2015	0	384,397	683,741	751,014	810,543	888,444	756,741	691,237
2016	0	389,579	680,527	743,112	797,295	865,127	748,433	686,149
2017	0	393,315	677,941	736,595	788,010	851,562	741,886	683,792
2018	0	397,216	675,833	731,694	779,947	839,433	736,859	680,939
2019	0	399,845	674,324	728,025	772,699	829,125	732,591	679,909
2020	0	402,476	672,210	723,680	767,510	819,154	729,619	677,836
	Dead discards (lb)							
2009	53,874	53,874	53,874	53,874	53,874	53,874	53,874	53,874
2010	55,514	55,541	55,502	55,449	55,530	55,461	55,451	55,454
2011	135,796	58,322	120,503	138,603	156,254	181,757	139,861	122,580
2012	141,169	59,842	120,257	137,332	153,413	176,513	138,445	122,343
2013	145,720	60,451	120,111	136,232	151,992	173,948	137,482	121,592
2014	149,455	60,673	120,091	135,962	151,478	173,110	137,595	121,908
2015	152,549	60,837	120,205	135,751	151,329	173,299	137,856	121,867
2016	155,071	61,230	120,466	135,950	150,945	172,617	137,322	121,760
2017	157,358	61,117	120,265	135,335	150,086	171,673	137,101	121,593
2018	159,224	61,087	120,191	135,209	149,729	170,522	136,834	121,693
2019	161,064	61,383	119,902	135,038	149,542	169,907	136,832	121,794
2020	162,446	61,920	120,025	135,034	149,398	169,135	136,294	121,525
	Fishing mortality per year on fully selected ages							
2009	0.067	0.067	0.067	0.067	0.067	0.067	0.067	0.067
2010	0.067	0.067	0.067	0.067	0.067	0.067	0.067	0.067
2011	0.000	0.067	0.141	0.163	0.184	0.217	0.164	0.143
2012	0.000	0.067	0.141	0.163	0.184	0.217	0.164	0.143
2013	0.000	0.067	0.141	0.163	0.184	0.217	0.164	0.143
2014	0.000	0.067	0.141	0.163	0.184	0.217	0.164	0.143
2015	0.000	0.067	0.141	0.163	0.184	0.217	0.164	0.143
2016	0.000	0.067	0.141	0.163	0.184	0.217	0.164	0.143
2017	0.000	0.067	0.141	0.163	0.184	0.217	0.164	0.143
2018	0.000	0.067	0.141	0.163	0.184	0.217	0.164	0.143
2019	0.000	0.067	0.141	0.163	0.184	0.217	0.164	0.143
2020	0.000	0.067	0.141	0.163	0.184	0.217	0.164	0.143
	Spawning biomass (lb)							
2009	12,230,935	12,230,935	12,230,935	12,230,935	12,230,935	12,230,935	12,230,935	12,230,935
2010	12,675,203	12,675,201	12,675,207	12,675,206	12,675,205	12,675,206	12,675,197	12,675,205
2011	13,068,529	13,040,866	13,004,083	12,992,832	12,981,383	12,964,219	12,991,784	13,002,954
2012	13,587,588	13,389,003	13,104,832	13,024,730	12,944,132	12,827,601	13,017,724	13,095,832
2013	14,100,012	13,675,188	13,102,451	12,939,060	12,788,349	12,557,497	12,926,768	13,084,344
2014	14,653,763	13,964,768	13,058,495	12,810,043	12,573,863	12,235,158	12,793,002	13,032,653
2015	15,258,284	14,278,862	12,994,796	12,664,699	12,331,197	11,882,249	12,625,365	12,959,311
2016	15,902,084	14,627,887	12,930,187	12,517,824	12,092,401	11,533,829	12,463,764	12,898,252
2017	16,533,297	14,953,961	12,873,214	12,368,161	11,858,539	11,199,680	12,315,583	12,828,083
2018	17,109,607	15,266,289	12,820,591	12,220,956	11,641,905	10,891,974	12,163,842	12,759,416
2019	17,711,062	15,563,514	12,767,595	12,085,852	11,453,854	10,606,257	12,020,258	12,697,405
2020	18,244,012	15,847,295	12,722,907	11,967,016	11,262,246	10,335,192	11,889,772	12,648,700

Table 3.3.4.16 (continued). Landings, dead discards, fishing mortality rates, and spawning biomass projections for a variety of fishing mortality rates.

	Recruitment (number age-1 fish)							
Year	F = 0	F=Fcurrent	F = 0.65FOFL	F=F0.75FOFL	F=0.85FOFL	F=F30%SPR	F=F40%SPR	F=F45%SPR
2009	291,202	291,202	291,202	291,202	291,202	291,202	291,202	291,202
2010	294,330	296,167	295,009	295,445	296,474	295,595	295,157	295,941
2011	296,080	295,825	295,963	296,621	297,487	297,411	295,577	295,808
2012	298,412	297,098	297,888	298,321	299,913	298,003	298,423	297,483
2013	299,334	299,823	298,203	299,073	298,458	298,341	298,866	298,488
2014	301,848	300,238	298,747	297,280	298,620	298,672	299,074	297,854
2015	303,132	302,616	298,760	298,589	296,179	296,244	296,679	298,066
2016	305,585	300,916	298,516	295,030	294,053	294,026	297,264	297,928
2017	305,926	302,399	297,992	294,805	295,474	292,562	295,624	297,936
2018	307,222	301,998	297,765	296,133	293,990	291,252	296,625	297,568
2019	306,951	305,529	296,961	296,215	292,661	290,435	294,226	297,727
2020	308,794	304,658	297,742	295,842	293,521	289,852	295,842	297,118

3.3.5. Figures

Figure	Description
3.3.5.1	The Caribbean Current schematic (a) and velocity (b, cm/s) and the Loop Current schematic (c) and velocity with regions with the higher velocities shown in red (d, cm/s).
3.3.5.2	ASAP2 model fits to log(landings in pounds) by fishery fleet together with their standardized residuals.
3.3.5.3	ASAP2 model fits to log(discards in pounds) by fishery fleet together with their standardized residuals.
3.3.5.4	ASAP2 model fits to log(index values) together with their standardized residuals.
3.3.5.5	Selectivity patterns for landings by fleet for the three regulatory periods (a-d) and for the fishery independent indices (e).
3.3.5.6	Population size in numbers of fish by year and age.
3.3.5.7	Box-whisker plot of recruitment expressed as number of age-1 fish by year from Markov Chain Monte Carlo simulations. The vertical line is the 95% confidence interval, the box is the inter-quartile range (the 25^{th} percentile and the 75^{th} percentile), and the horizontal line is the median.
3.3.5.8	Total biomass in pounds by year and age.
3.3.5.9	Box-whisker plot of the spawning biomass in pounds by year from Markov Chain Monte Carlo simulations. The vertical line is the 95% confidence interval, the box is the inter-quartile range (the 25^{th} percentile and the 75^{th} percentile), and the horizontal line is the median.
3.3.5.10	Total catch rate (a) and the directed fishing mortality rate (b) by fleet and year.
3.3.5.11	Total fishing mortality rate on age-5 fish (fully selected age0 by year (a) and a comparison of the total fishing mortality rates calculated with and without longline age composition (b).
3.3.5.12	The distribution of steepness from the Markov Chain Monte Carlo simulation (a) and the spawning biomass at F=0 (b) for the Beverton-Holt stock-recruit relationship for black grouper. The black vertical lines are the point estimates.
3.3.5.13	The estimated Beverton-Holt stock-recruit relationship for black grouper. The point estimate for steepness was 0.79 and 28.4 million lb for the spawning biomass at F= 0.
3.3.5.14	Trace plots of the fishing mortality in 2008 (a), the spawning biomass in 2008 (b), the objective function(c), the fishing mortality-ratio (d), steepness (e), and the spawning biomass-ratio (f).
3.3.5.15	Distribution of Markov Chain Monte Carlo simulations, the cumulative proportion, and the point estimate for the fishing mortality per year for age-5 black grouper (a) and for the spawning biomass in 2008 (b).
3.3.5.16	Likelihood profiles and their normal approximation from the standard deviations from ASAP2 for the fishing mortality rate in 2008 (Fcurrent) on the fully selected age, age-5, (a) and for the spawning biomass in 2008 (SSB2008, b). The point estimates are also shown in the plots as a vertical line.
3.3.5.17	The distribution of the ratio of fishing mortality in 2008 (F 2008) to the fishing mortality rate at 30% SPR (F30% SPR) from the MCMC simulations (2.5 million runs with a 1000 run burn-in and 1000 thinning rate, a) the objective function values from the MCMC simulations plotting on the F-ratio and the point estimate for F2008/F30%SPR (b), the distribution of the ratio of the spawning biomass in 2008 to the spawning biomass at 30% SPR (c), the objective function values from the MCMC simulations plotted spawning biomass ratio (d), and the fishing mortality ratio plotted on the spawning biomass ratio (e).

3.3.5. Figures continued

Figure	Description
3.3.5.18	Retrospective analysis for fishing mortality rates (a), spawning biomass (b), and recruitment (c) for the years 2004 through 2008.
3.3.5.19	Sensitivity runs with natural mortality rates averaging 0.10 per year and 0.20 per year compared to the base rate of 0.14 per year for fishing mortality rate on age-5 (a), spawning biomass (b), and recruitment (c).
3.3.5.20	Distributions of MCMC outcomes for F_{2008} and $F_{30\%SPR}$ (a) and for the spawning biomass in 2008 and $SPR_{F30\%SPR}$.
3.3.5.21	Potential fishing mortality rates (a), landings (b), and spawning biomass(c) estimates for alternative probabilities of exceeding the overfishing limit ($F_{30\%SPR}$).
3.3.5.22	Projections of spawning biomass, landings, and discards for F = 0, F = $F_{current}$ (geometric mean of 2006-2008 fishing mortalities per year on fully selected age, age-5), F = 0.65 $F_{30\%SPR}$, F = 0.75 $F_{30\%SPR}$, F = 0.85 $F_{30\%SPR}$, F = $F_{30\%SPR}$, F = $F_{40\%SPR}$, and F = $F_{45\%SPR}$.
3.3.5.23	Comparison of projections for spawning biomass (a), landings (b) and discards across the alternative fishing mortality rates.

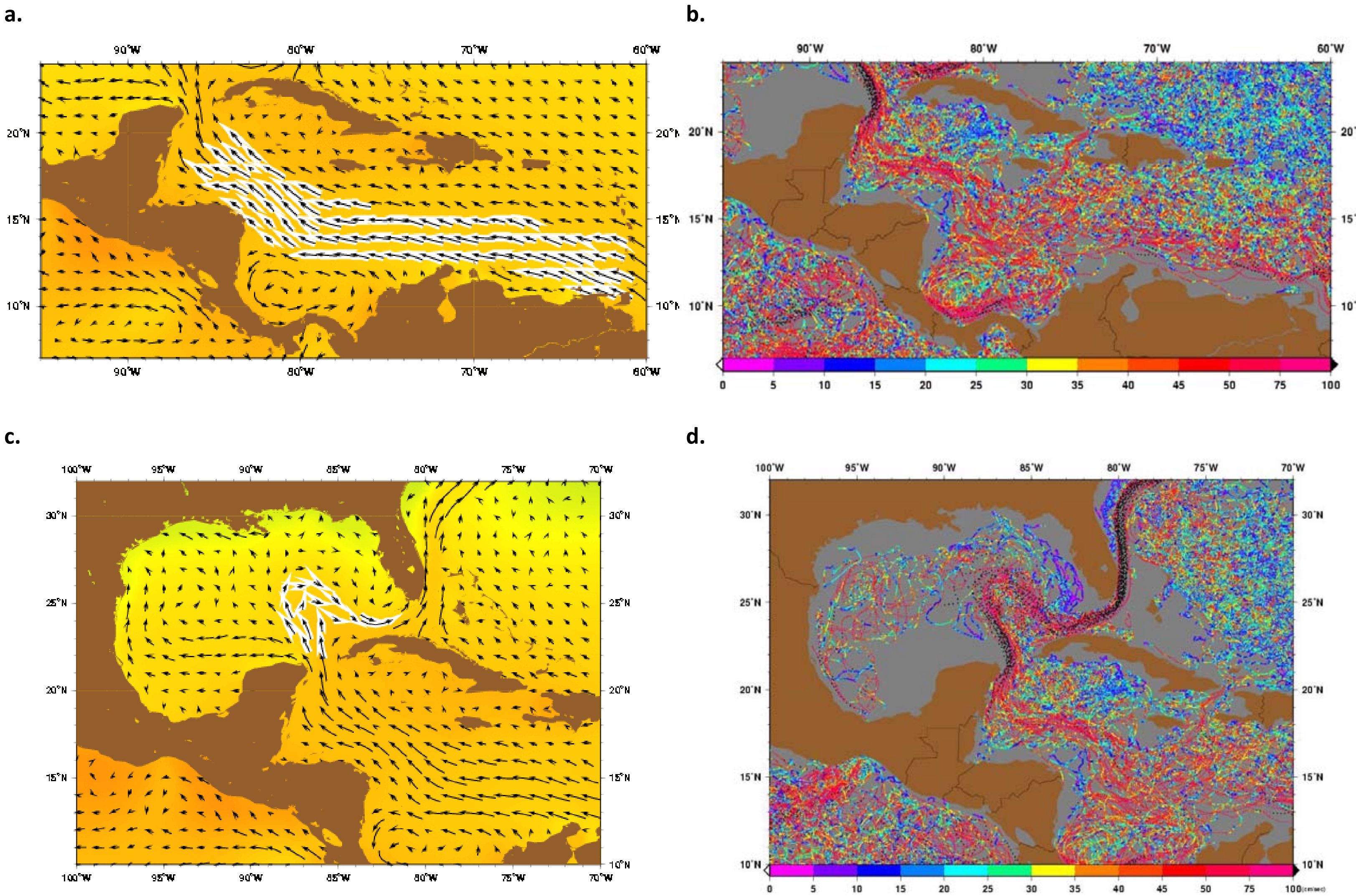


Figure 3.3.5.1. The Caribbean Current schematic (a) and velocity (b, cm/s) and the Loop Current schematic (c) and velocity with regions with the higher velocities shown in red (d, cm/s).

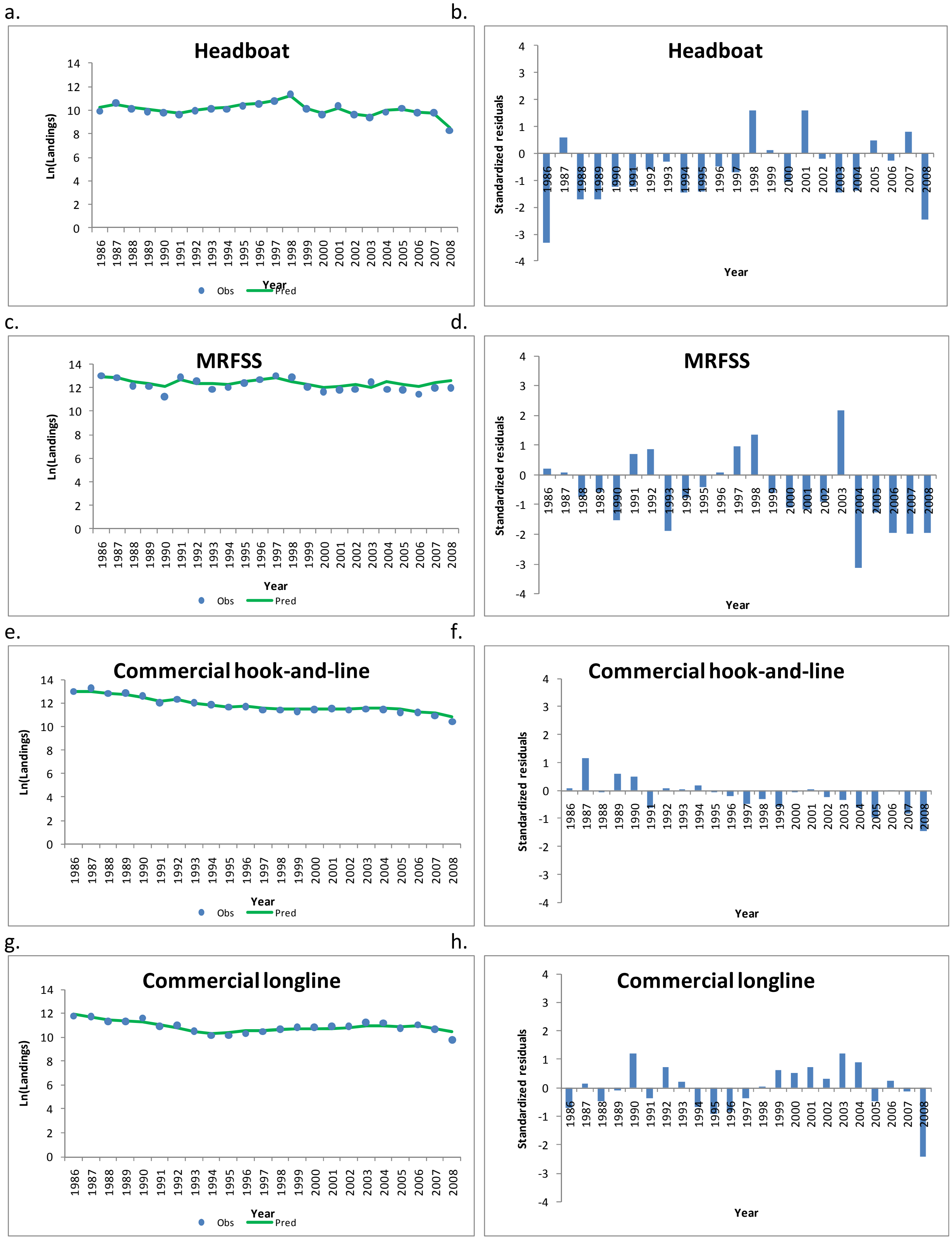


Figure 3.3.5.2. ASAP2 model fits to log(landings in pounds) by fishery fleet together with their standardized residuals.

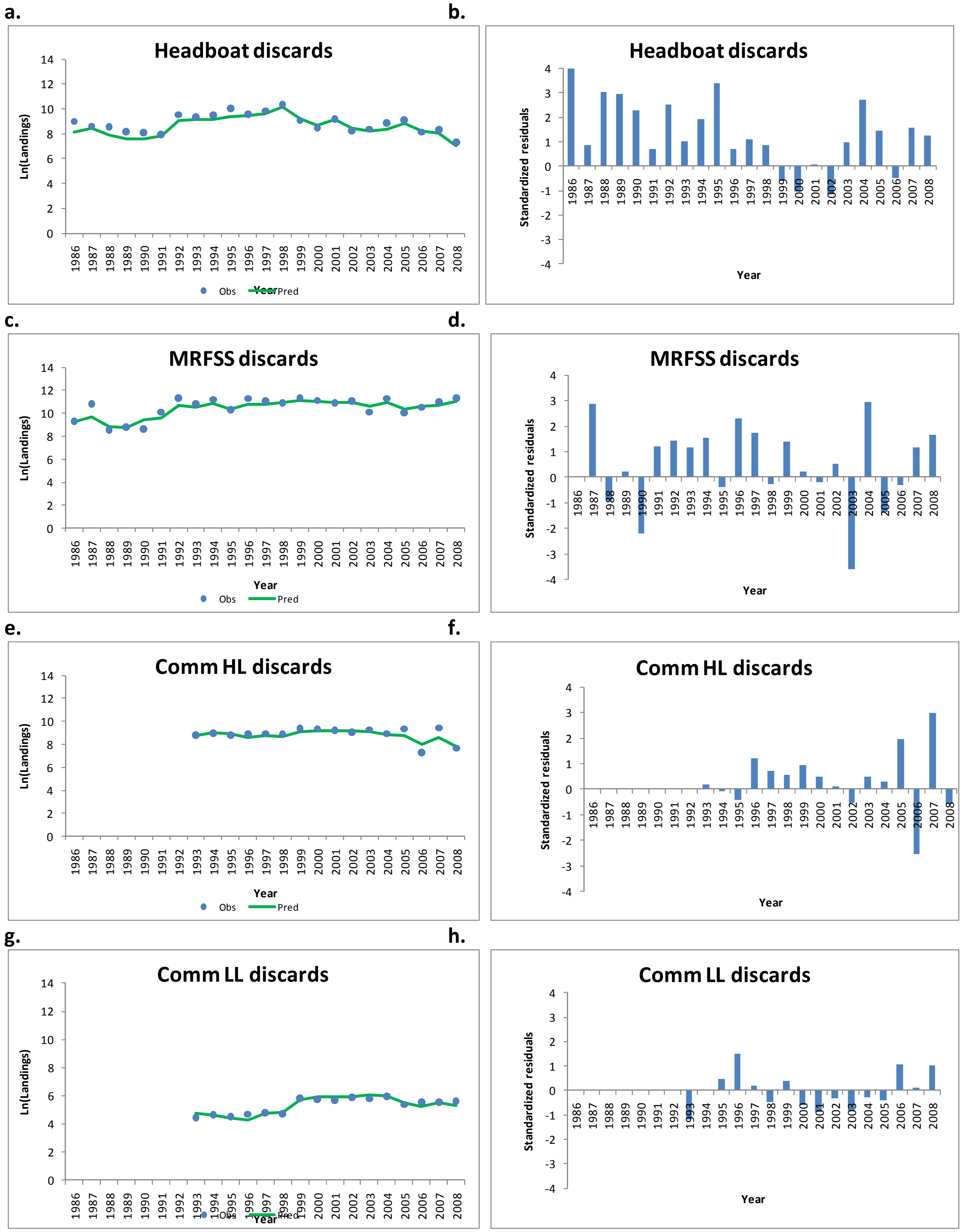


Figure 3.3.5.3. ASAP2 model fits to log(discards in pounds) by fishery fleet together with their standardized residuals.

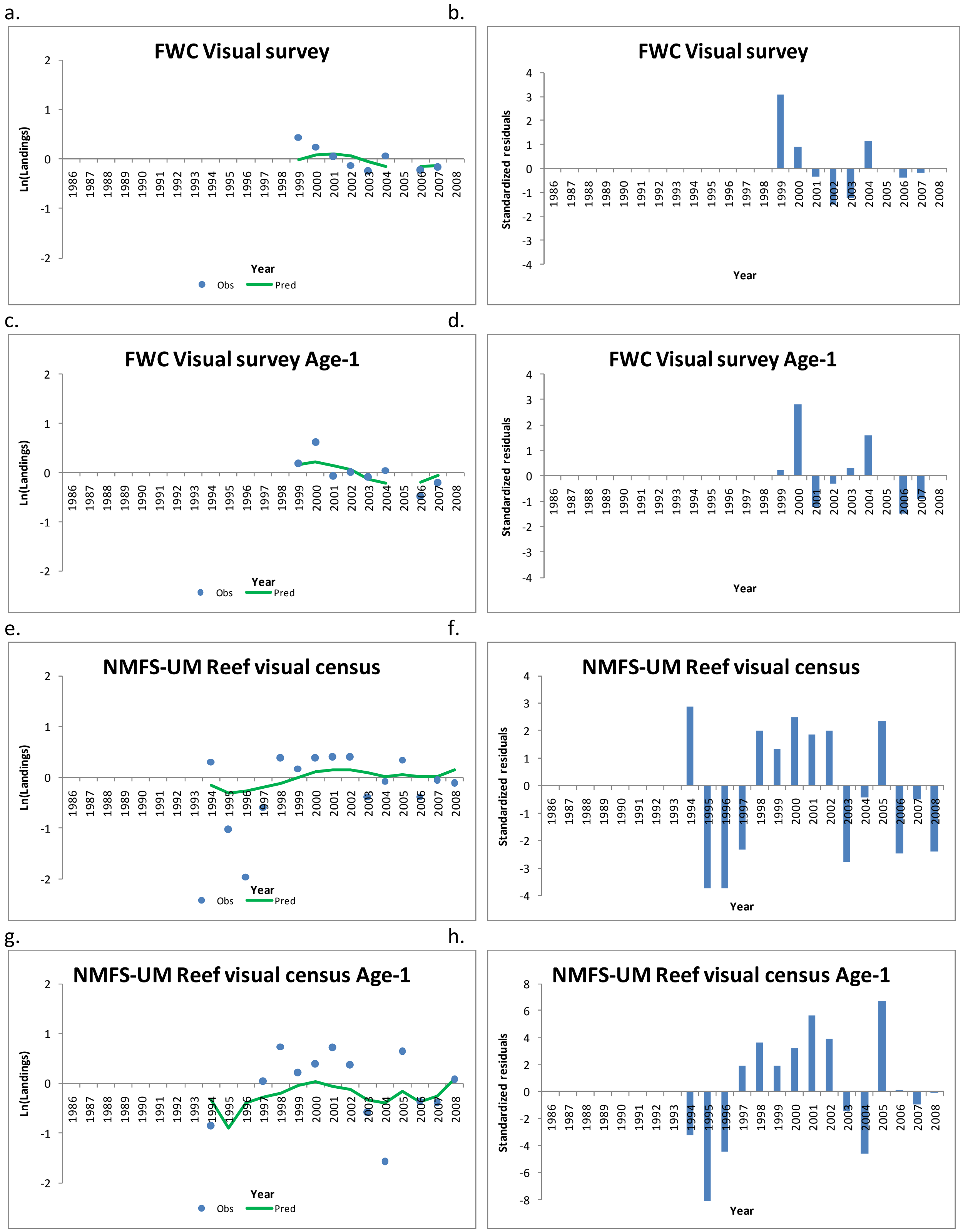


Figure 3.3.5.4. ASAP2 model fits to log(index values) together with their standardized residuals.

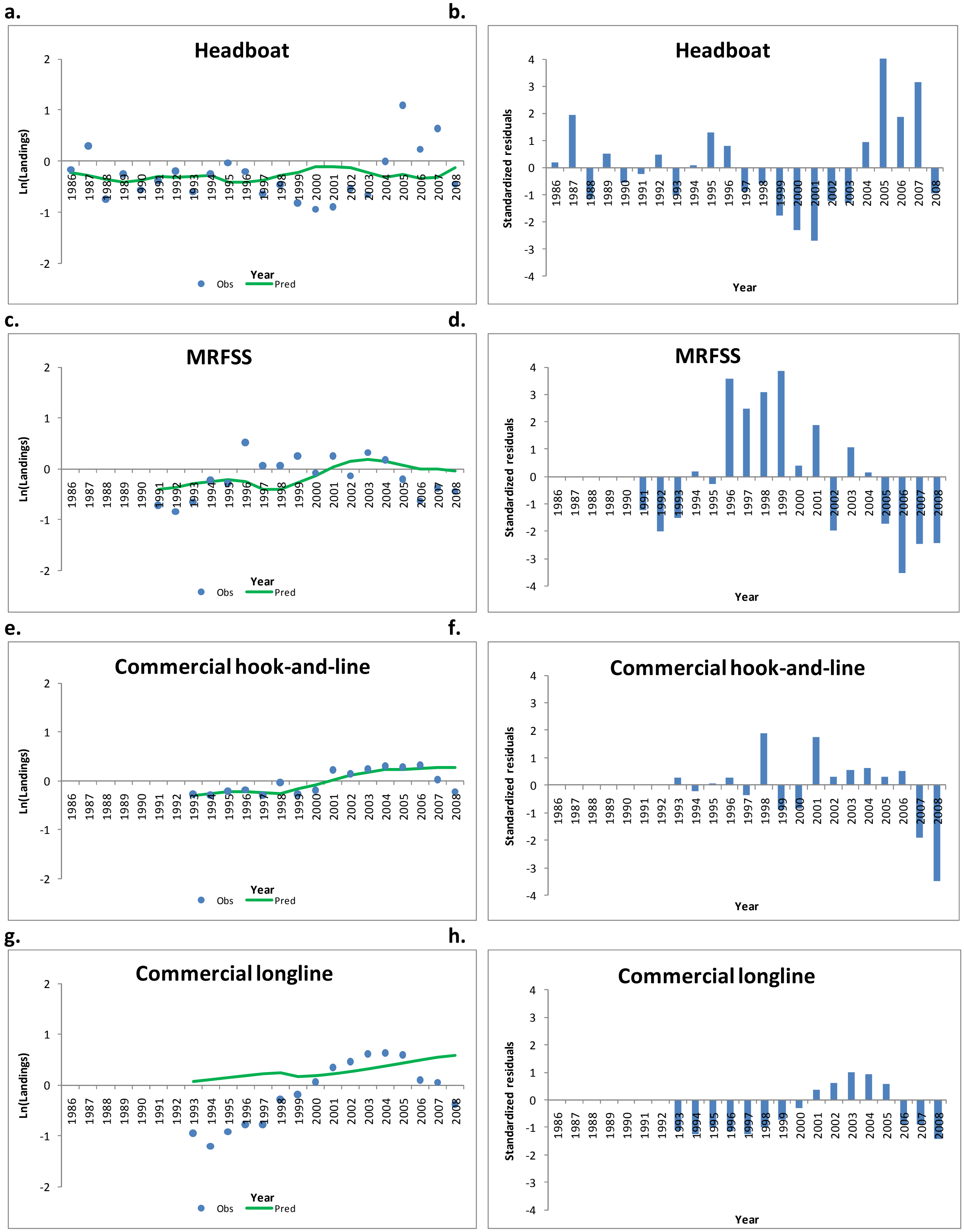


Figure 3.3.5.4 continued. ASAP2 model fits to log(index values) together with their standardized residuals.

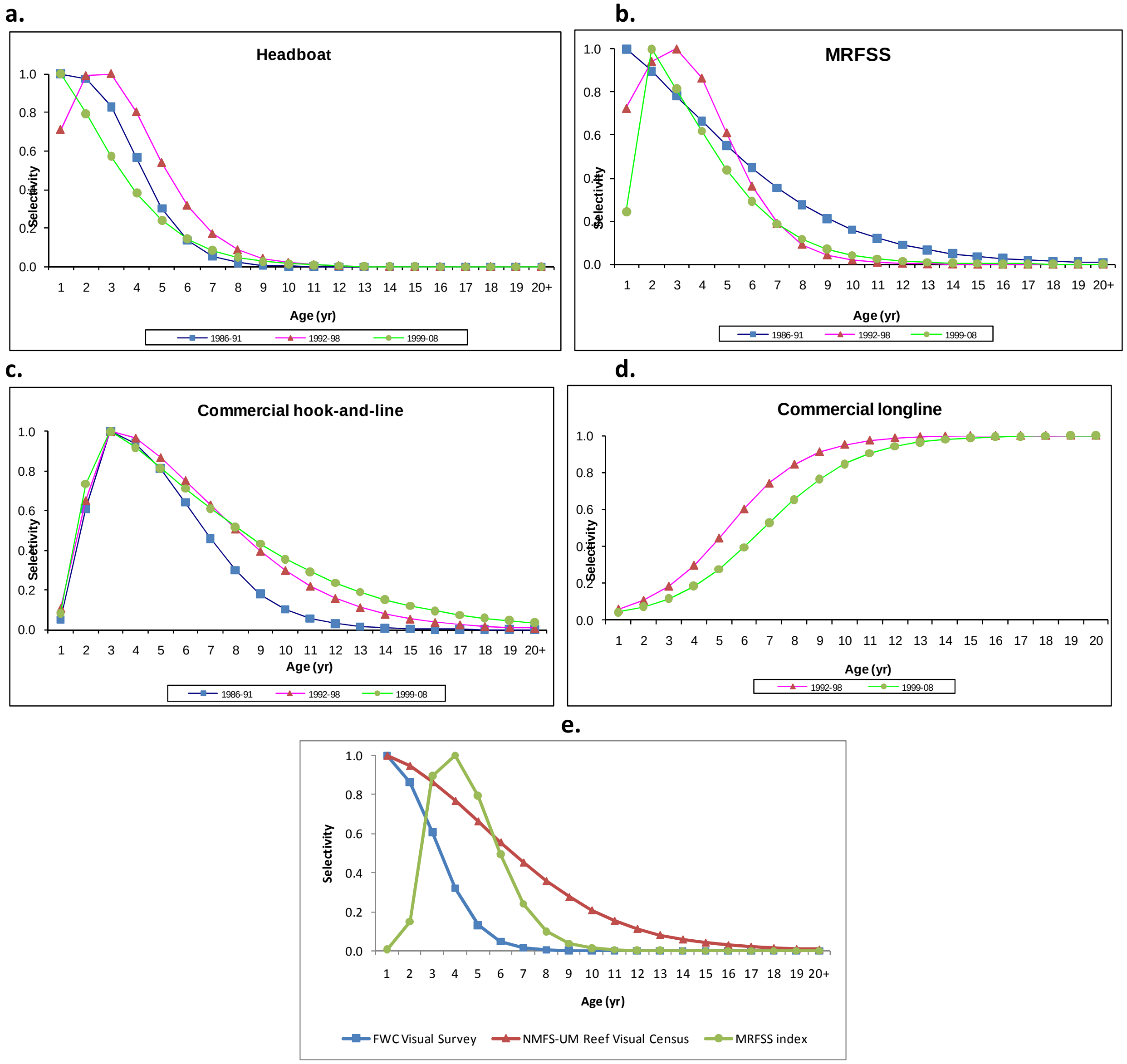


Figure 3.3.5.5. Selectivity patterns for landings by fleet for the three regulatory periods (a-d) and for the fishery independent indices (e).

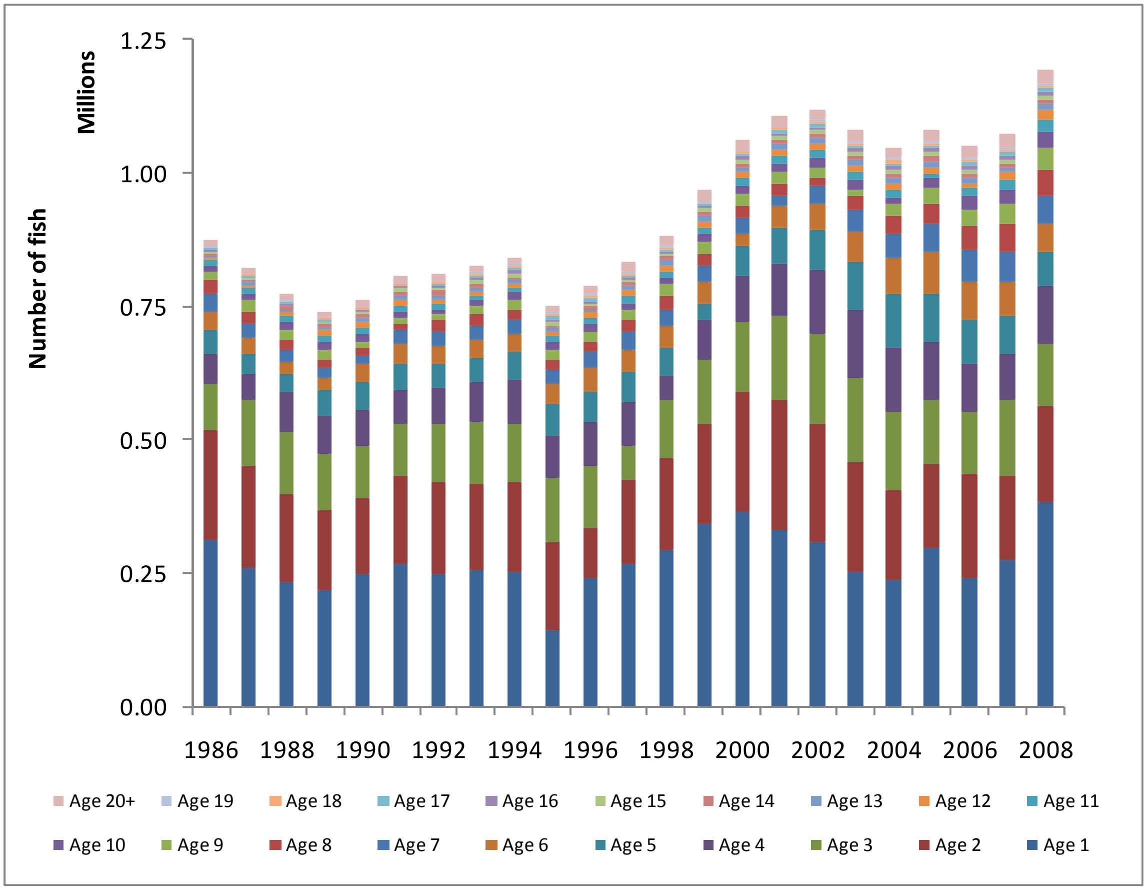


Figure 3.3.5.6. Population size in numbers of fish by year and age.

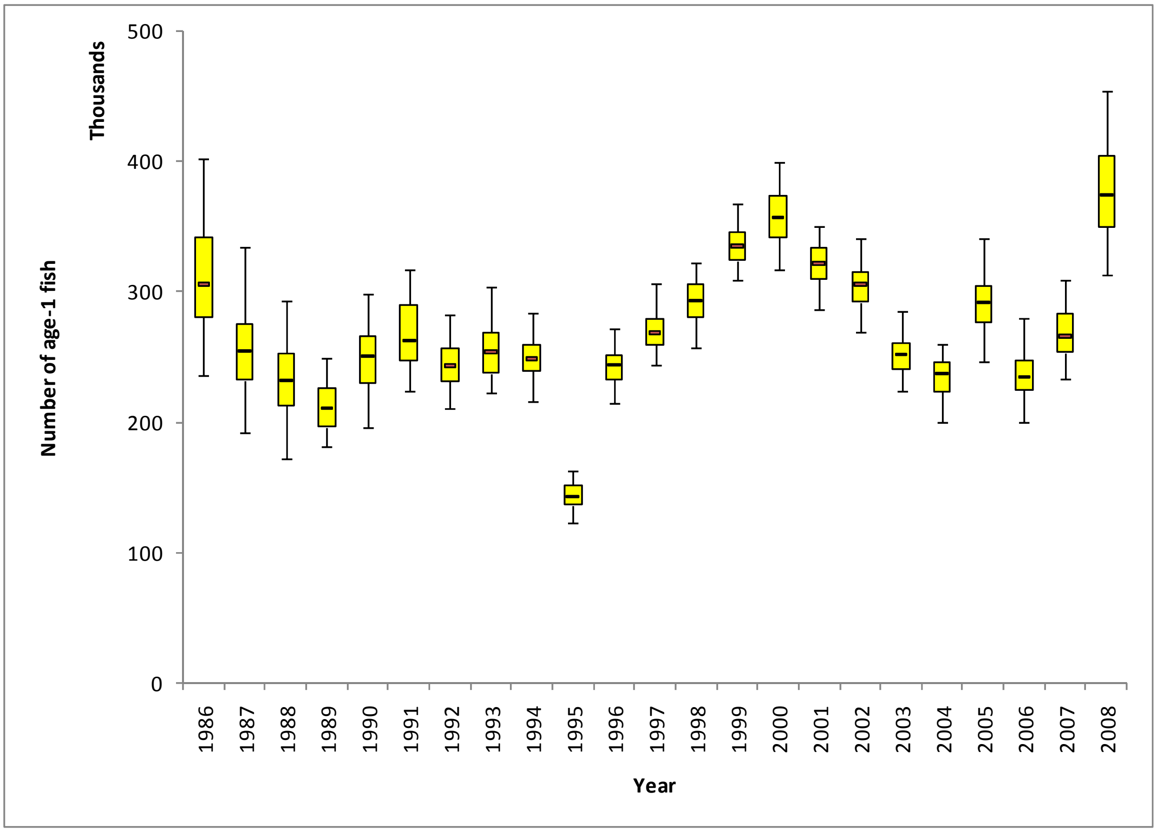


Figure 3.3.5.7. Box-whisker plot of recruitment expressed as number of age-1 fish by year from Markov Chain Monte Carlo simulations. The vertical line is the 95% confidence interval, the box is the inter-quartile range (the 25th percentile and the 75th percentile), and the horizontal line is the median.

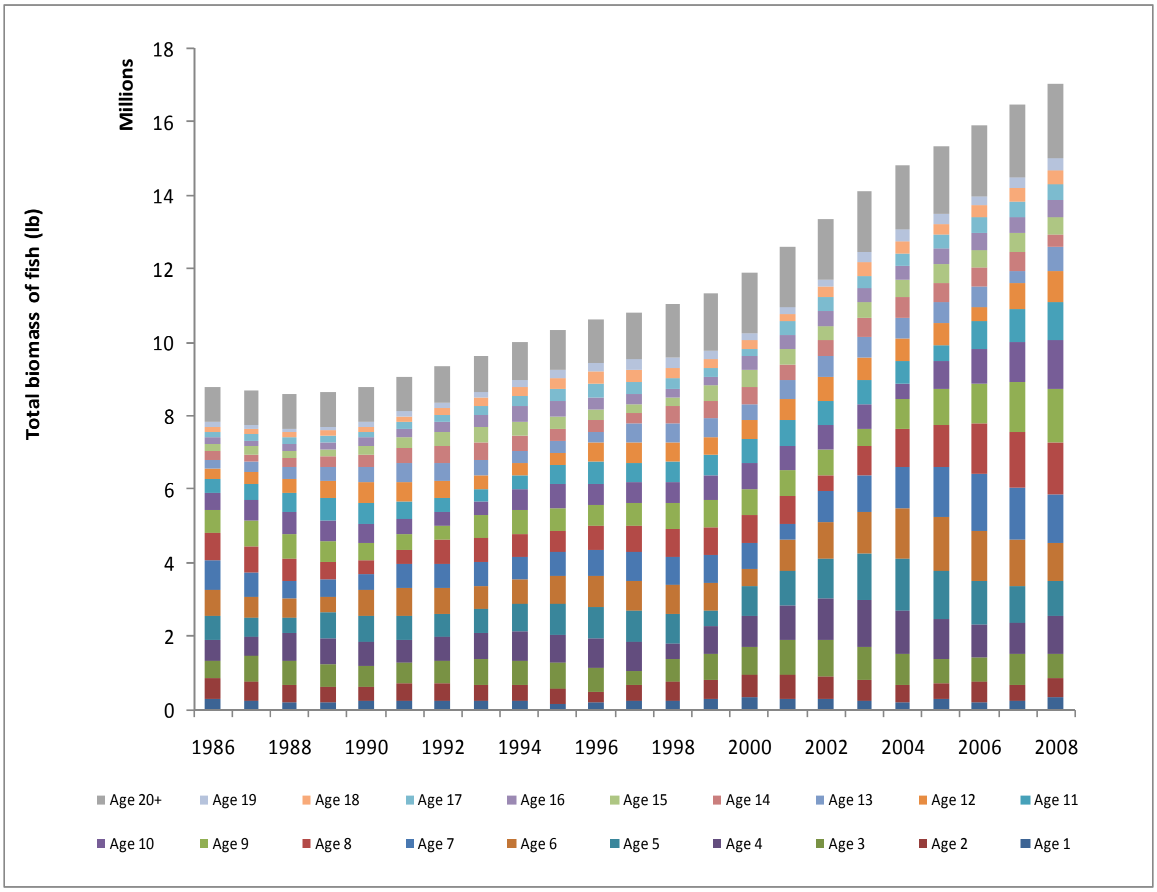


Figure 3.3.5.8. Total biomass in pounds by year and age.

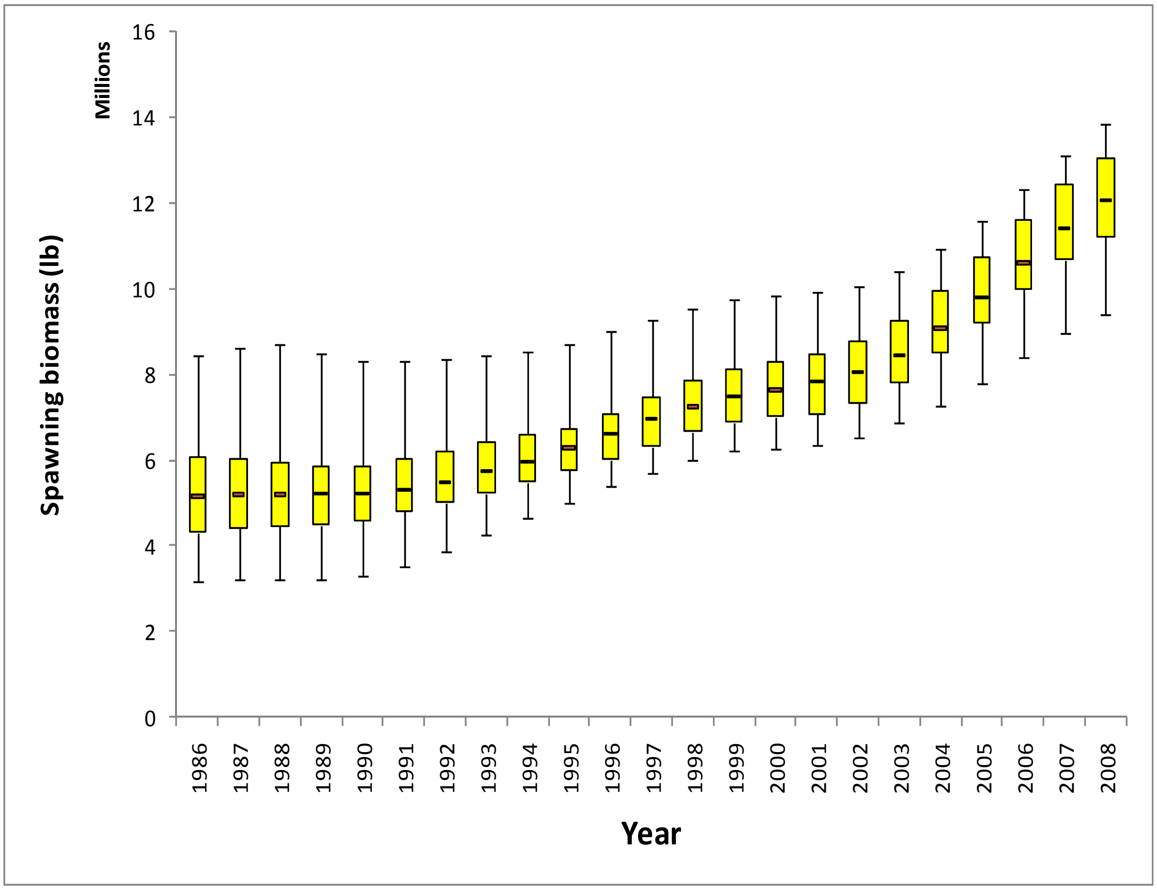
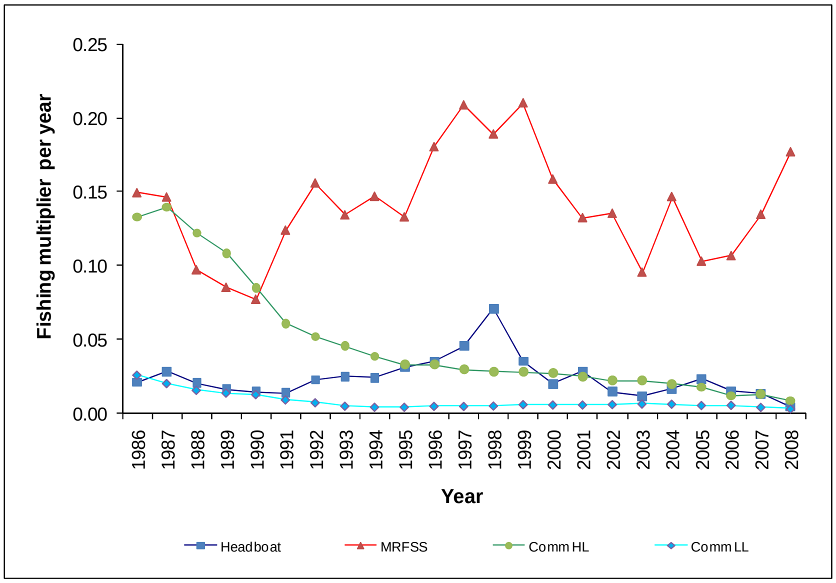


Figure 3.3.5.9. . Box-whisker plot of the spawning biomass in pounds by year from Markov Chain Monte Carlo simulations. The vertical line is the 95% confidence interval, the box is the inter-quartile range (the 25th percentile and the 75th percentile), and the horizontal line is the median.

a.



b.

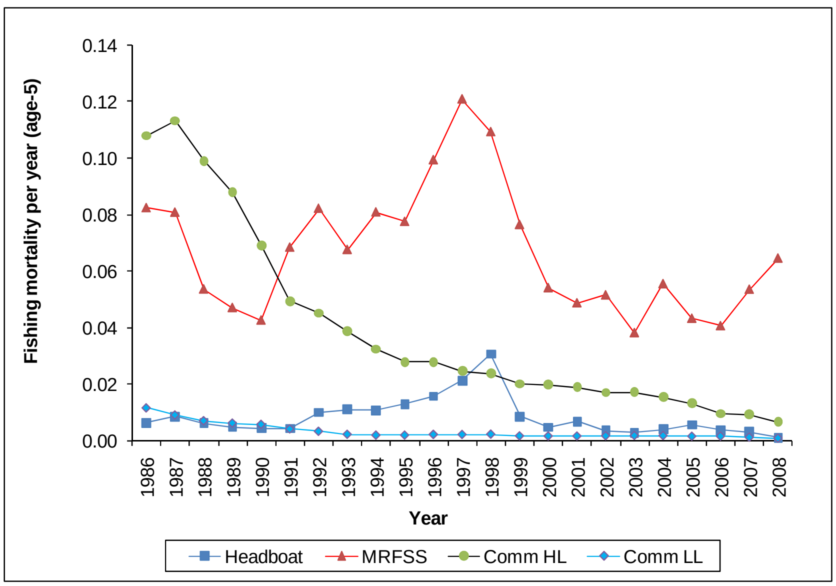
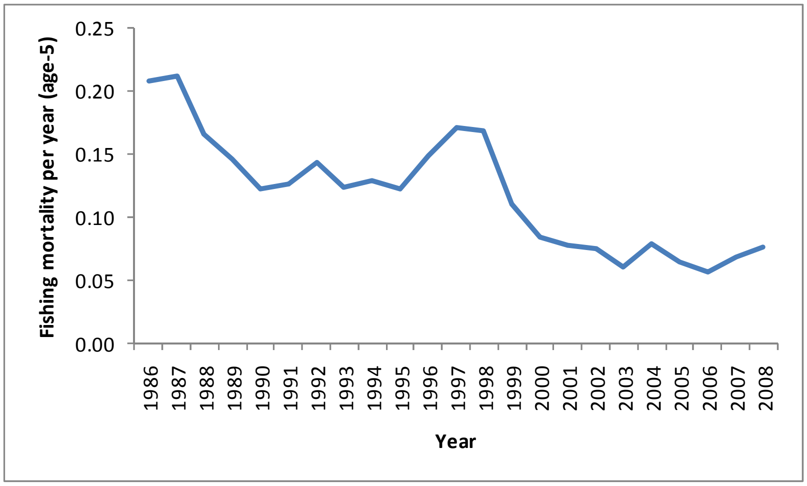


Figure 3.3.5.10. Fishing multiplier (directed and discards, a) and the directed fishing mortality rate (b) by fleet and year.

a.



b.

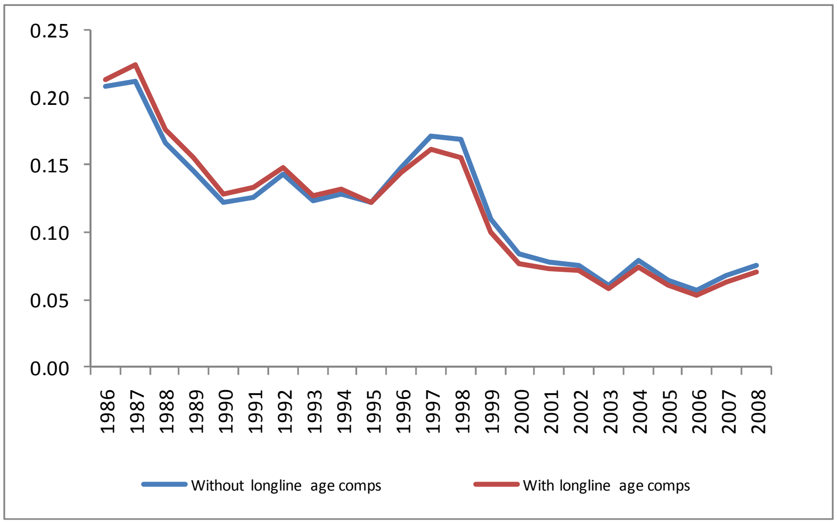
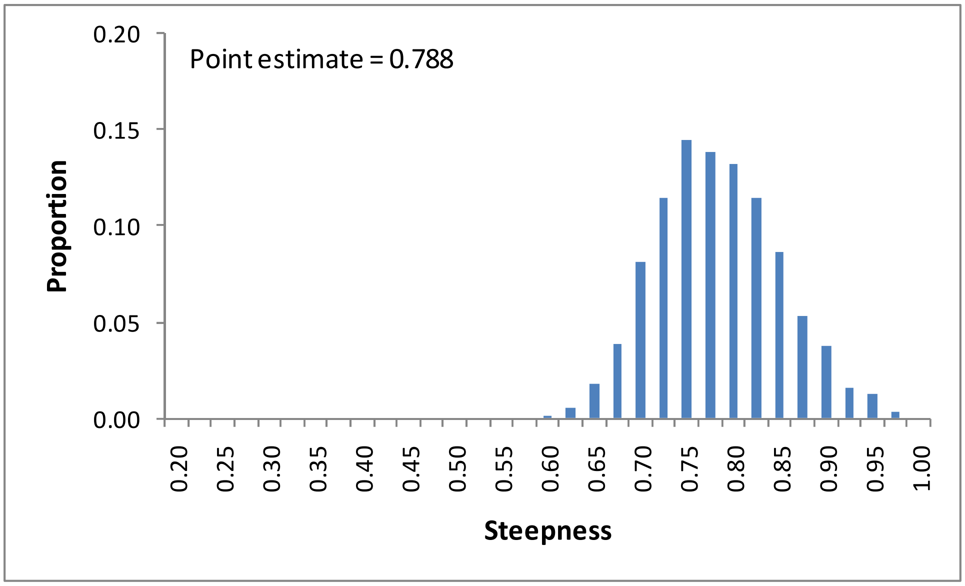


Figure 3.3.5.11. Total fishing mortality rate on age-5 fish (fully selected age) by year (a) and a comparison of the total fishing mortality rates calculated with and without longline age composition (b).

a.



b.

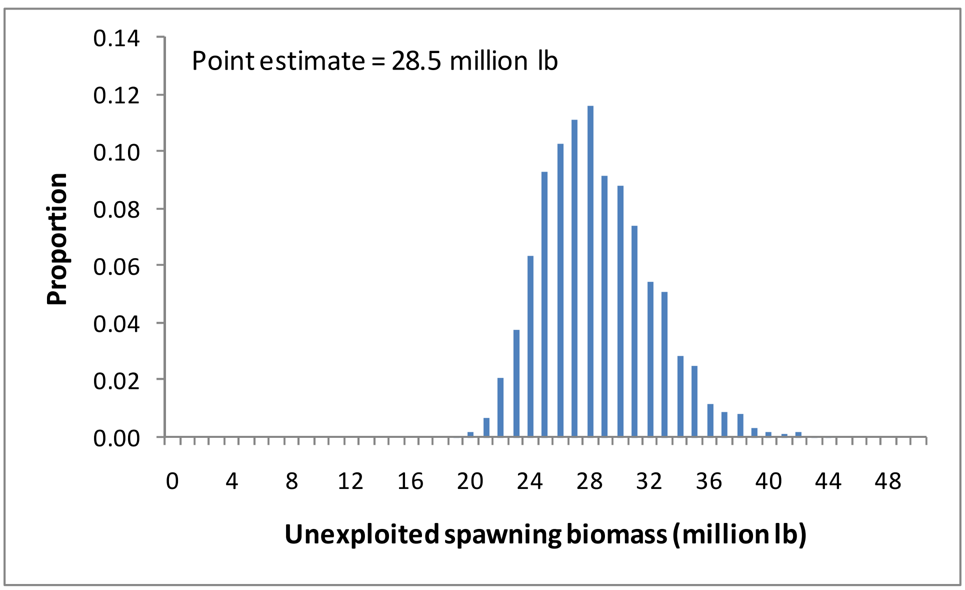


Figure 3.3.5.12. The distribution of steepness from the Markov Chain Monte Carlo simulation (a) and the spawning biomass at F=0 (b) for the Beverton-Holt stock-recruit relationship for black grouper. The black vertical lines are the point estimates.

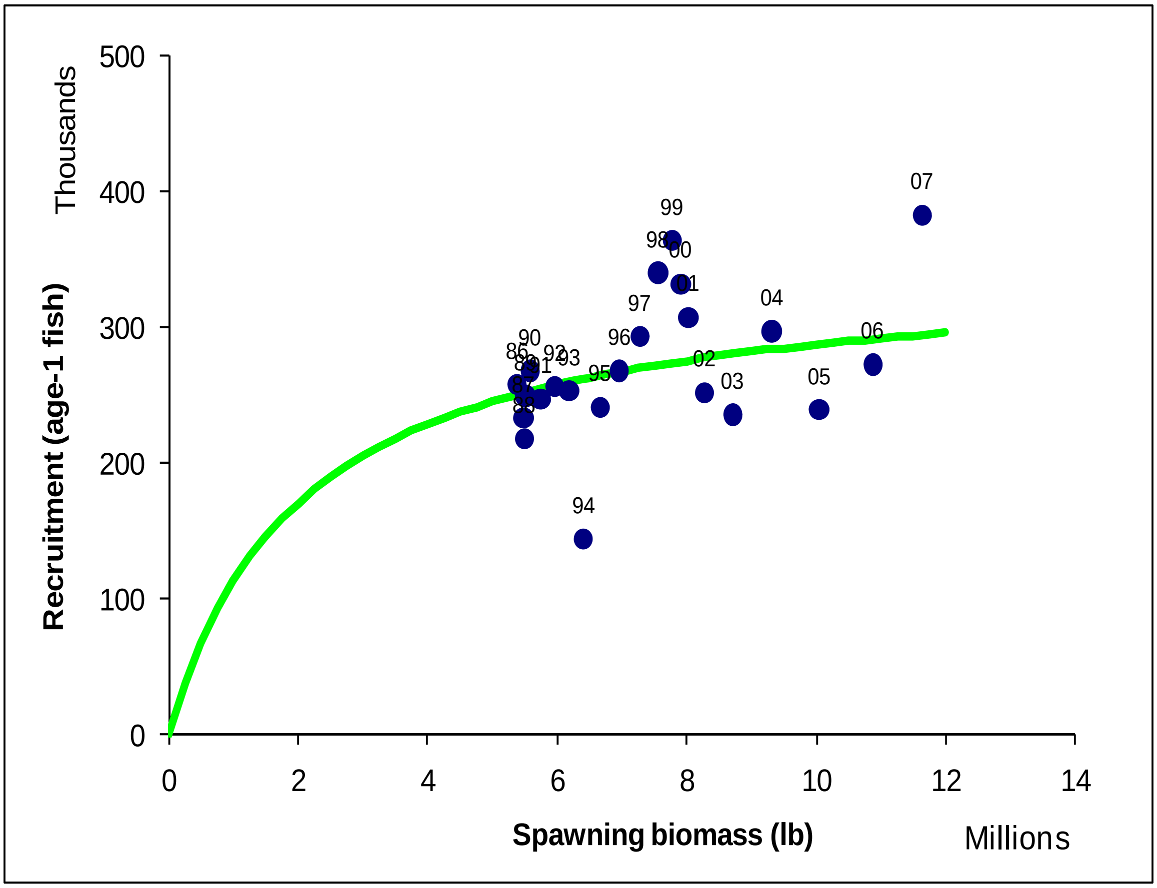


Figure 3.3.5.13. The estimated Beverton-Holt stock-recruit relationship for black grouper. The point estimate for steepness was 0.79 and 28.4 million lb for the spawning biomass at F= 0.

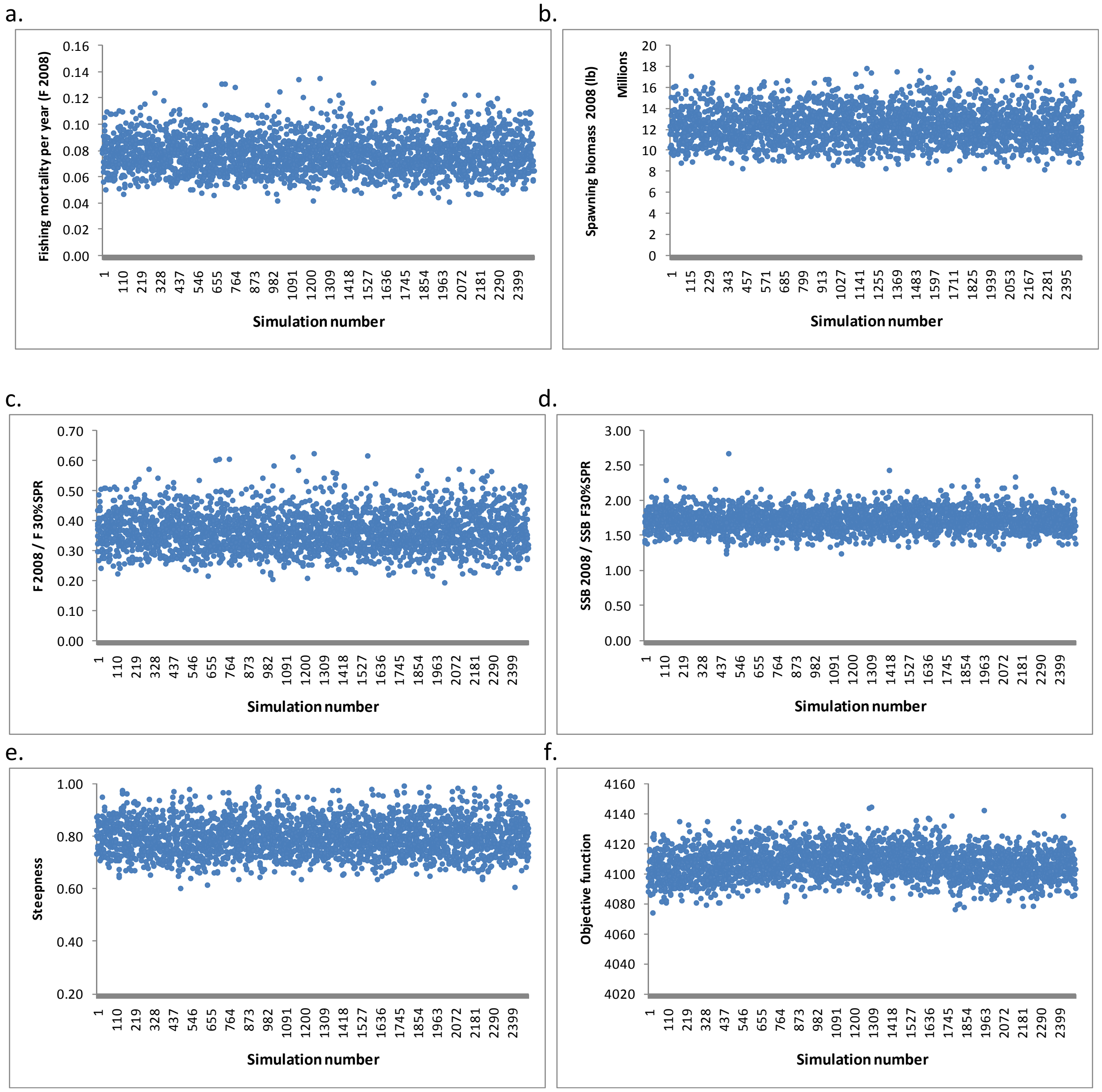
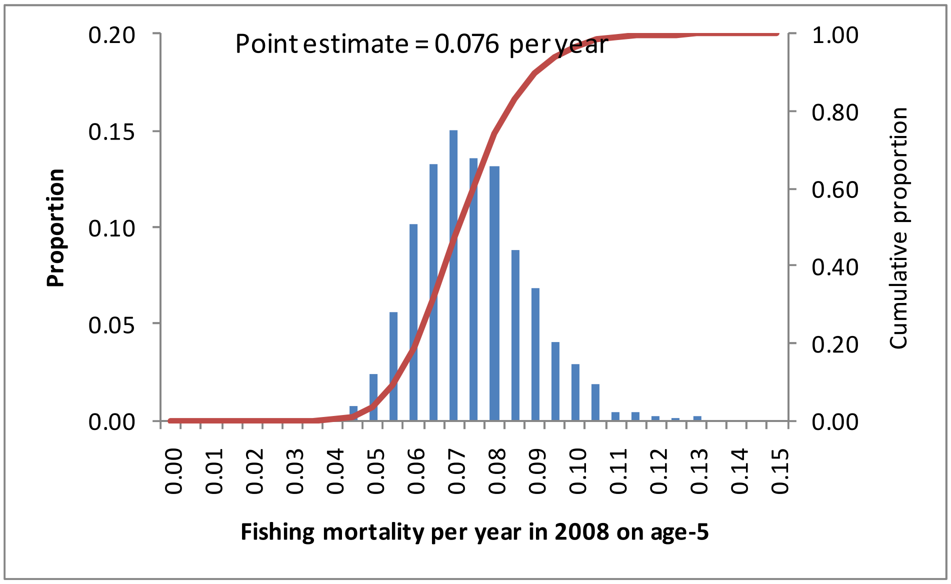


Figure 3.3.5.14. Trace plots of the fishing mortality in 2008 (a), the spawning biomass in 2008 (b), the fishing mortality-ratio (c), the spawning biomass-ratio (d), steepness (e), and the objective function (f).

a.



b.

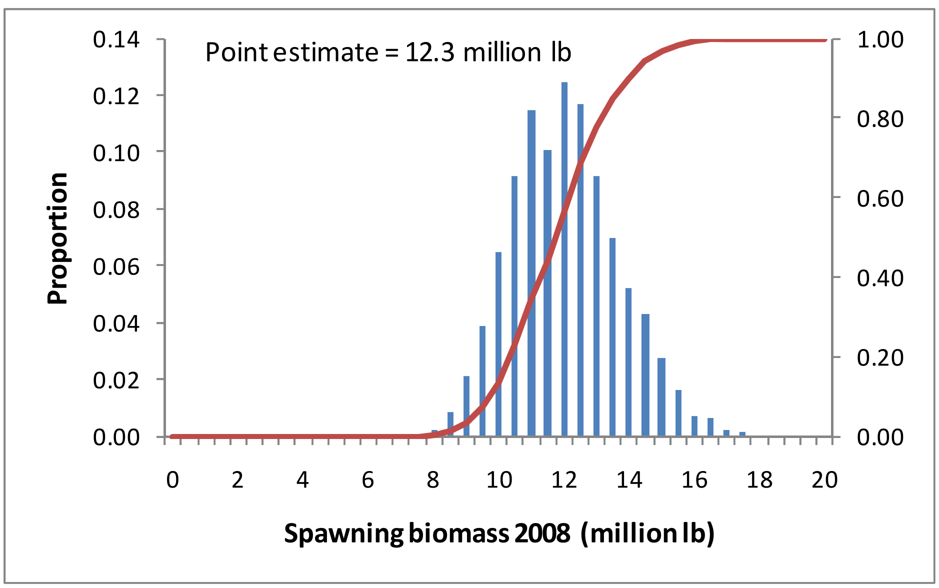
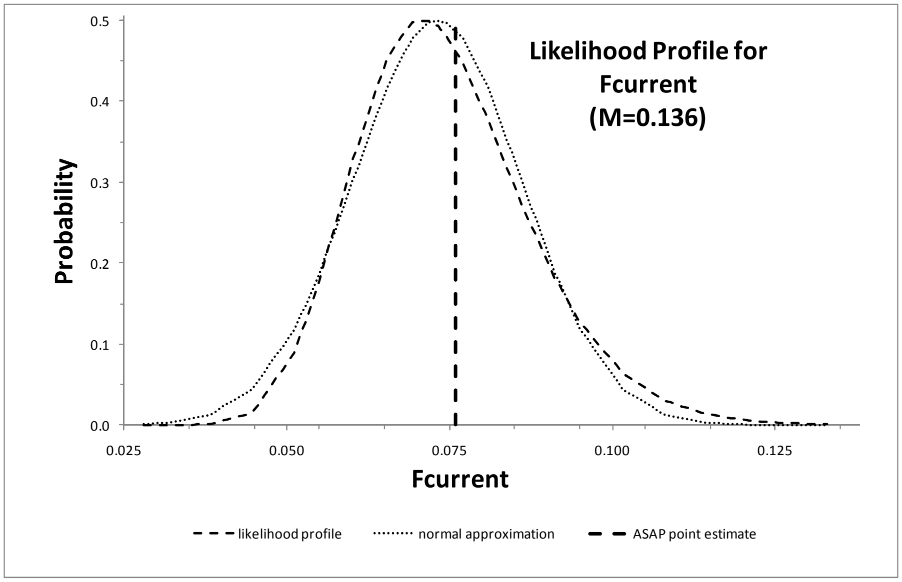


Figure 3.3.5.15. Distribution of Markov Chain Monte Carlo simulations, the cumulative proportion, and the point estimate for the fishing mortality per year for age-5 black grouper (a) and for the spawning biomass in 2008 (b).

a.



b.

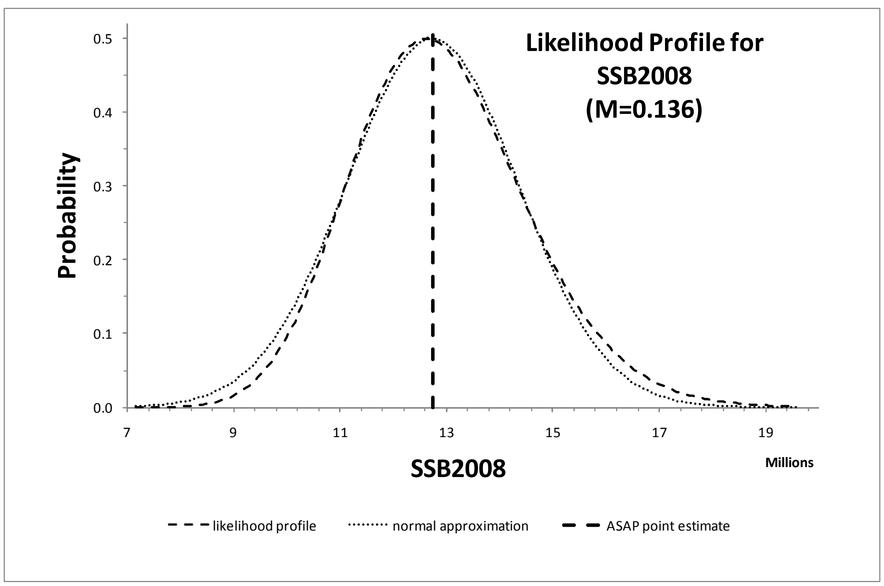


Figure 3.3.5.16. Likelihood profiles and their normal approximation from the standard deviations from ASAP2 for the fishing mortality rate in 2008 (Fcurrent) on the fully selected age, age-5, (a) and for the spawning biomass in 2008 (SSB2008, b). The point estimates are also shown in the plots as a vertical line.

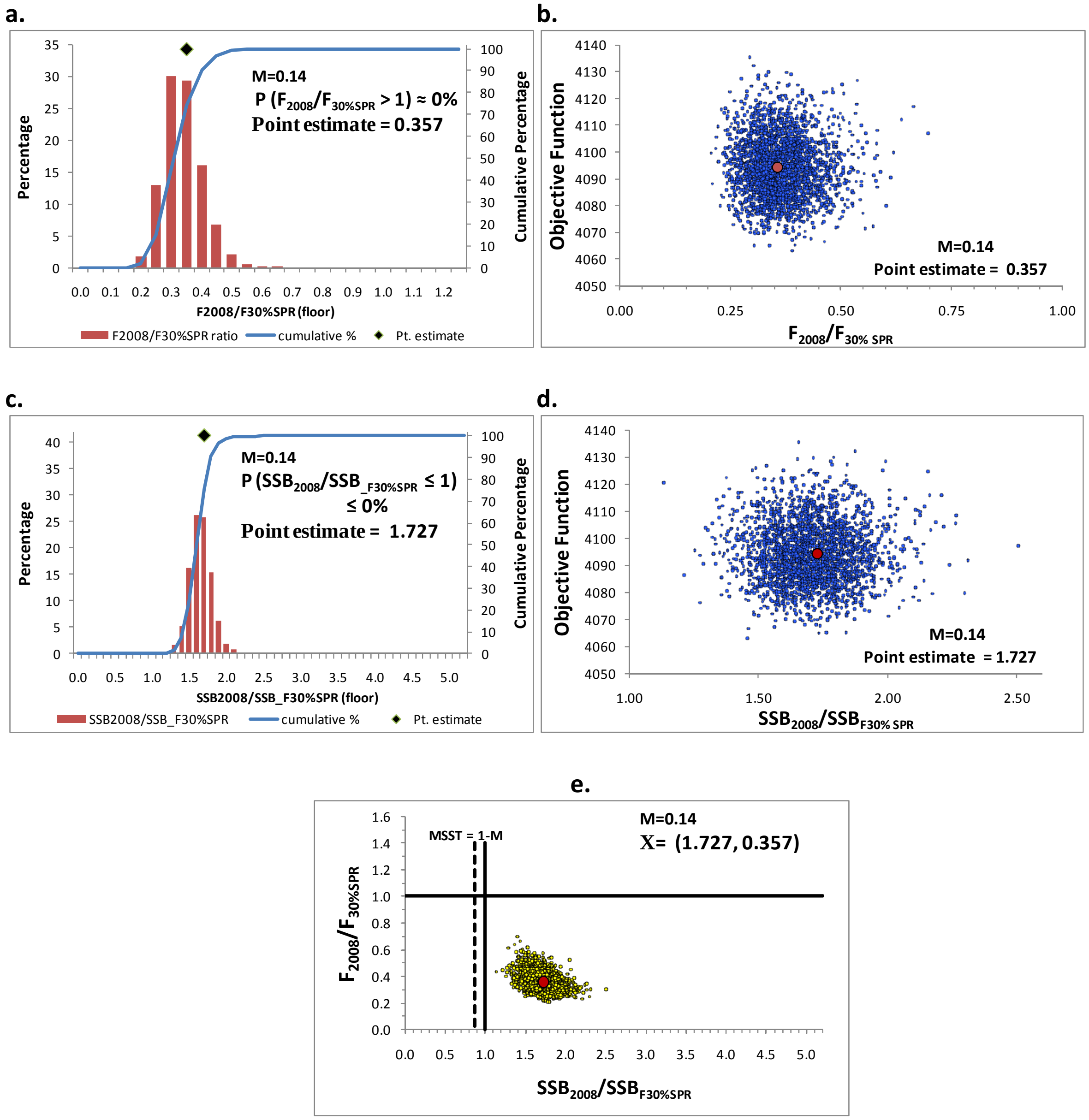
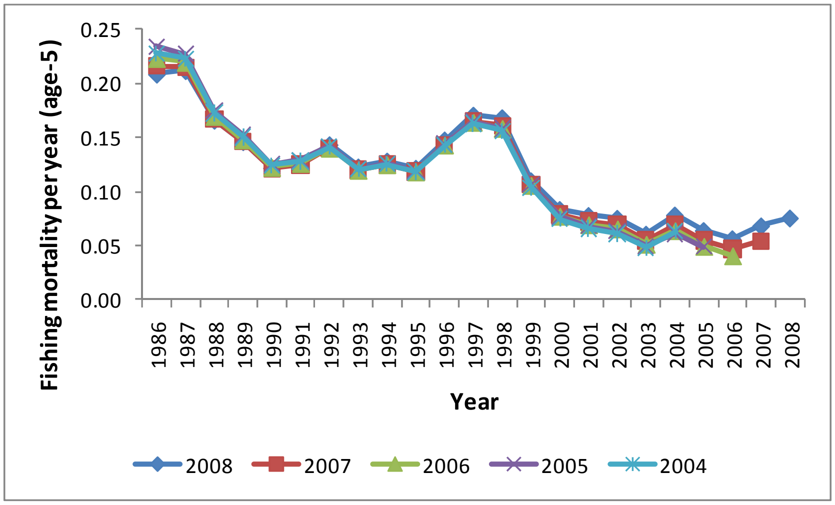
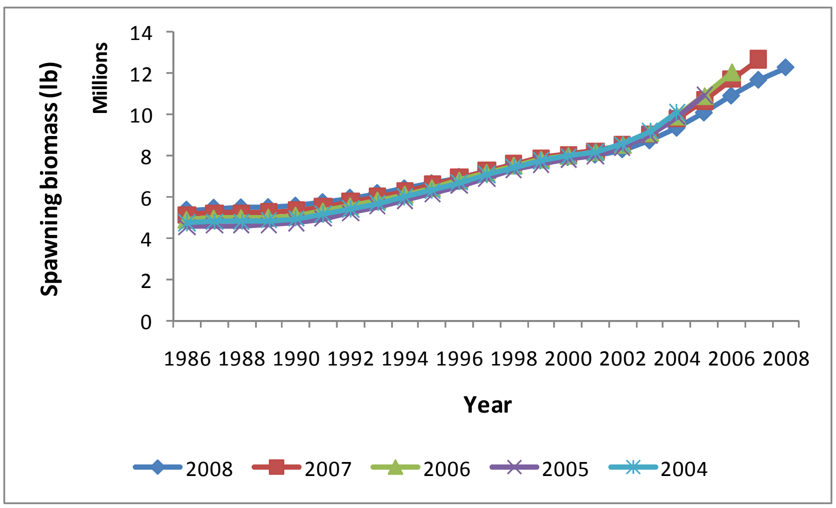


Figure 3.3.5.17. The distribution of the ratio of fishing mortality in 2008 (F 2008) to the fishing mortality rate at 30% SPR (F30% SPR) from the MCMC simulations (2.5 million runs with a 1000 run burn-in and 1000 thinning rate, a) the objective function values from the MCMC simulations plotting on the F-ratio and the point estimate for F2008/F30%SPR (b), the distribution of the ratio of the spawning biomass in 2008 to the spawning biomass at 30% SPR (c), the objective function values from the MCMC simulations plotted spawning biomass ratio (d), and the fishing mortality ratio plotted on the spawning biomass ratio (e).

a.



b.



c.

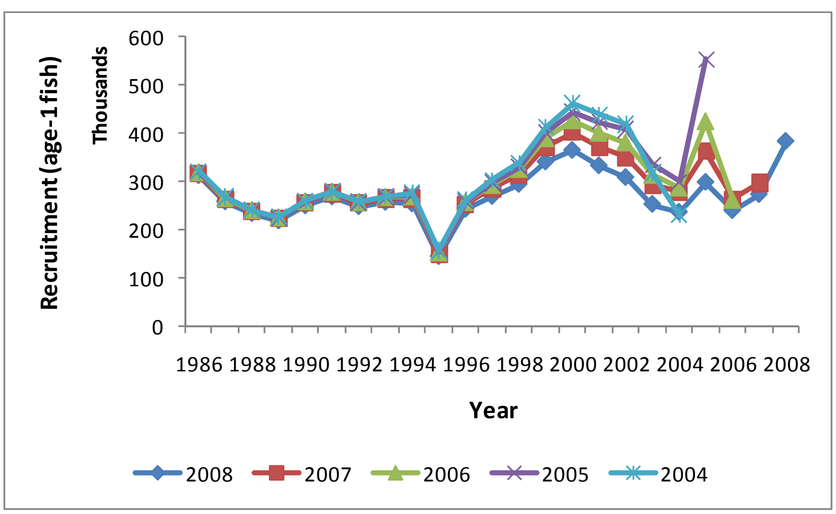
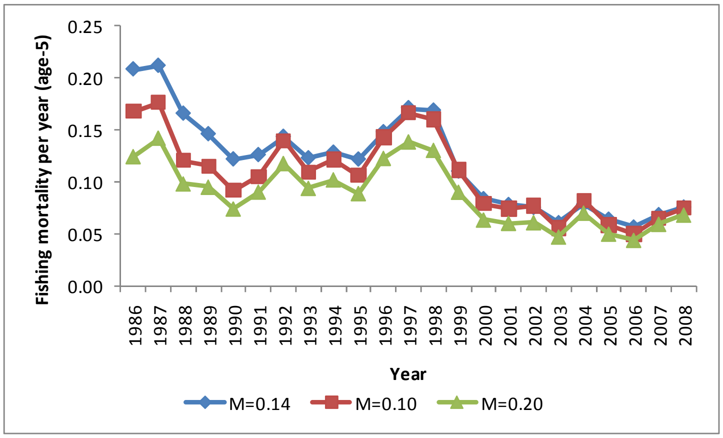
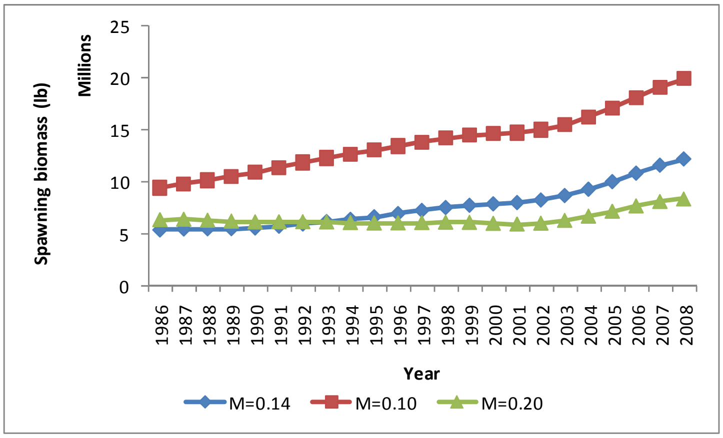


Figure 3.3.5.18. Retrospective analysis for fishing mortality rates (a), spawning biomass (b), and recruitment (c) for the years 2004 through 2008.

a.



b.



c.

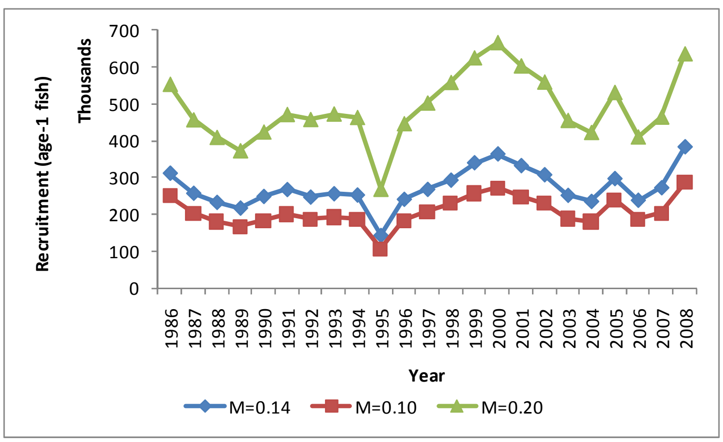
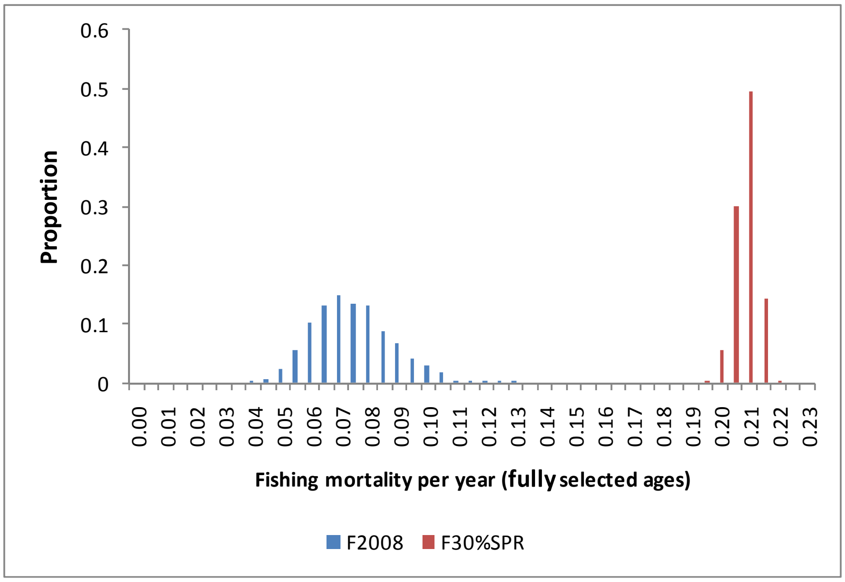


Figure 3.3.5.19. Sensitivity runs with natural mortality rates averaging 0.10 per year and 0.20 per year compared to the base rate of 0.14 per year for fishing mortality rate on age-5 (a), spawning biomass (b), and recruitment (c).

a.

a.



b.

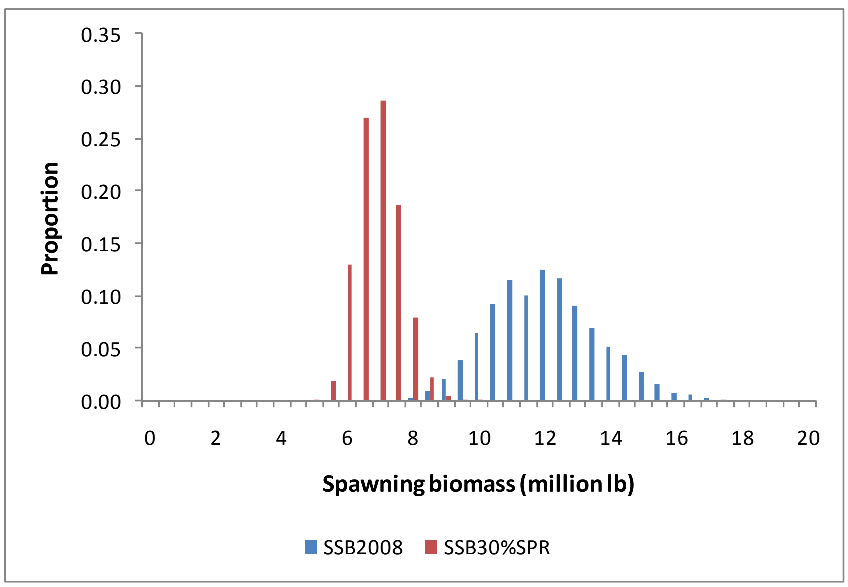


Figure 3.3.5.20. Distributions of MCMC outcomes for F_{2008} and $F_{30\%SPR}$ (a) and for the spawning biomass in 2008 and $SPR_{F30\%SPR}$.

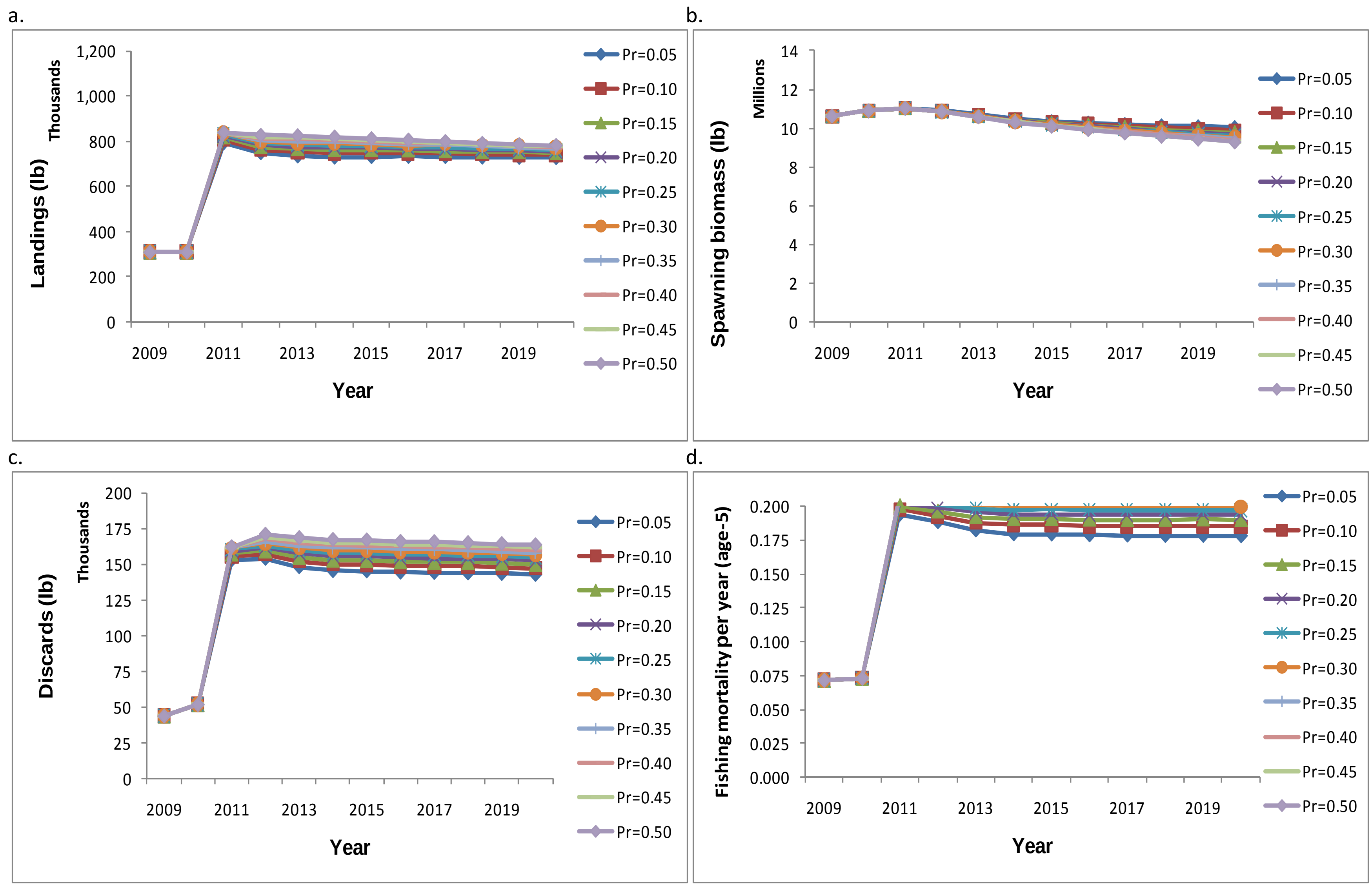


Figure 3.3.5.21. P* estimates of potential landings (a), spawning biomass, discards, and fishing mortality on fully selected fish for alternative probabilities of exceeding the overfishing limit ($F_{30\%SPR}$).

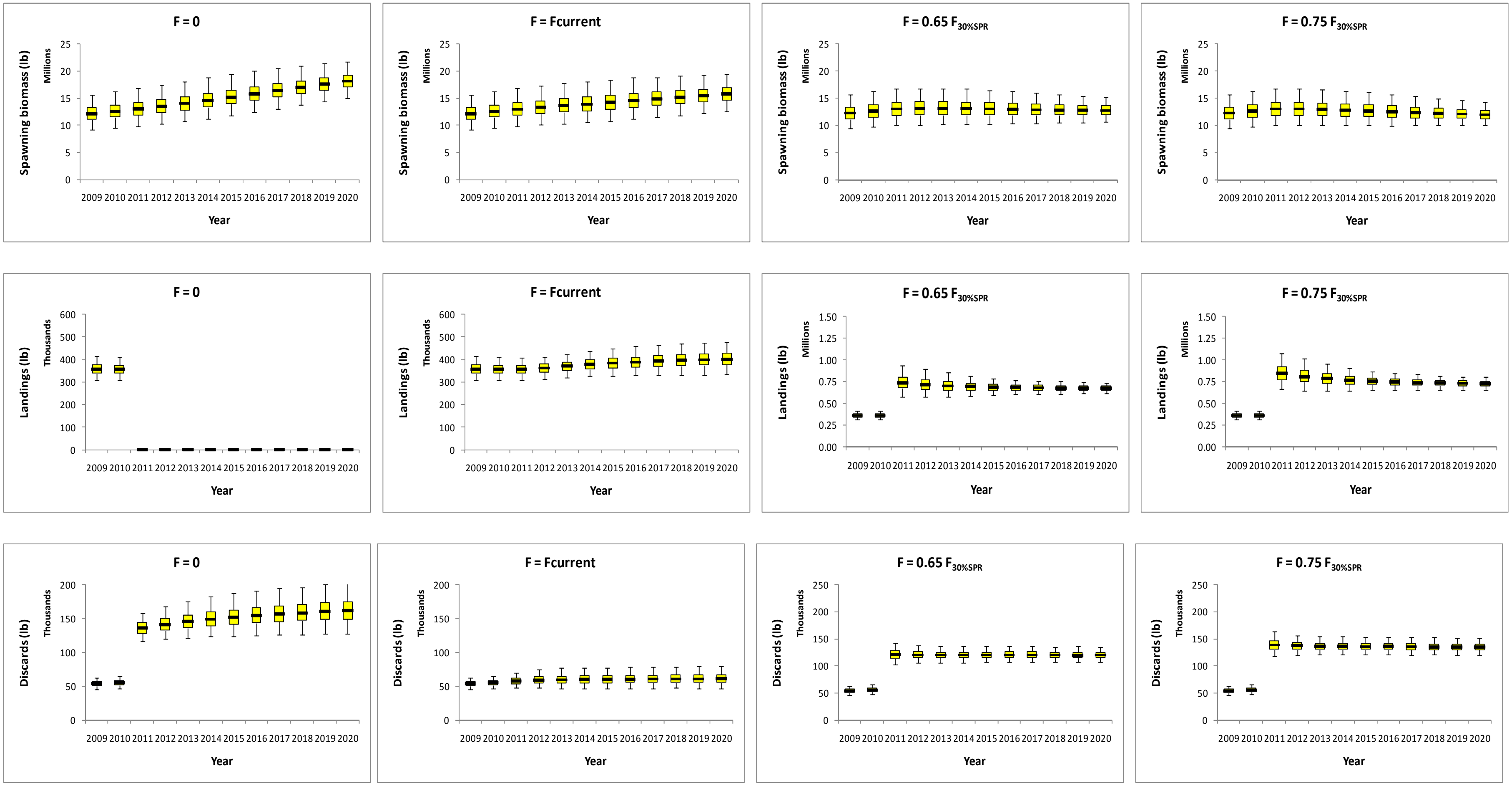


Figure 3.3.5.22. Projections of spawning biomass, landings, and discards for F = 0, F = $F_{current}$ (geometric mean of 2006-2008 fishing mortalities per year on fully selected age, age-5), F = 0.65 $F_{30\%SPR}$, F = 0.75 $F_{30\%SPR}$, F = 0.85 $F_{30\%SPR}$, F = $F_{30\%SPR}$, F = $F_{40\%SPR}$, and F = $F_{45\%SPR}$.

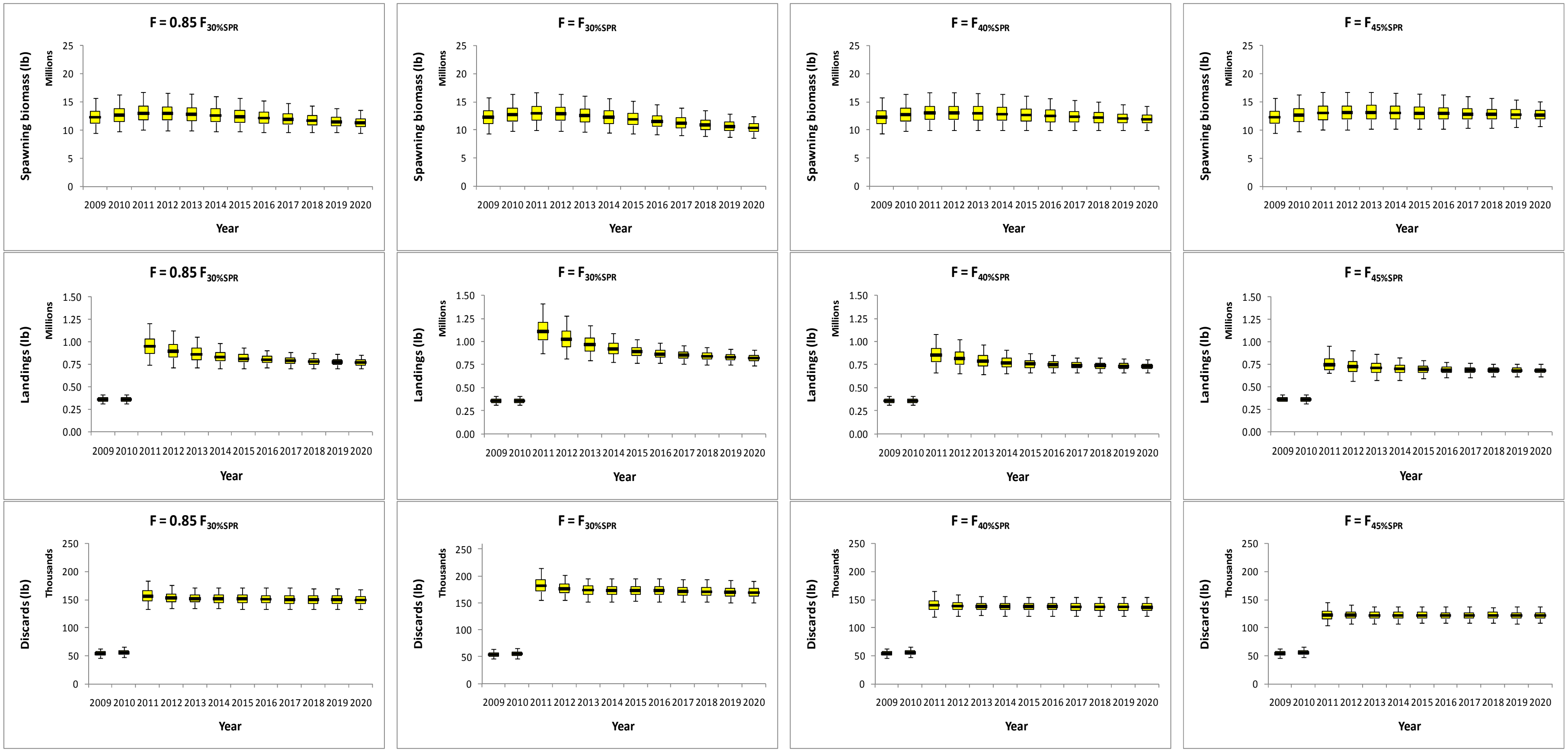


Figure 3.3.5.22 (continued). Projections of spawning biomass, landings, and discards for F = 0, F = $F_{current}$ (geometric mean of 2006-2008 fishing mortalities per year on fully selected age, age-5), F = 0.65 $F_{30\%SPR}$, F = 0.75 $F_{30\%SPR}$, F = 0.85 $F_{30\%SPR}$, F = $F_{30\%SPR}$, F = $F_{40\%SPR}$, and F = $F_{45\%SPR}$.

a.

b.

c.

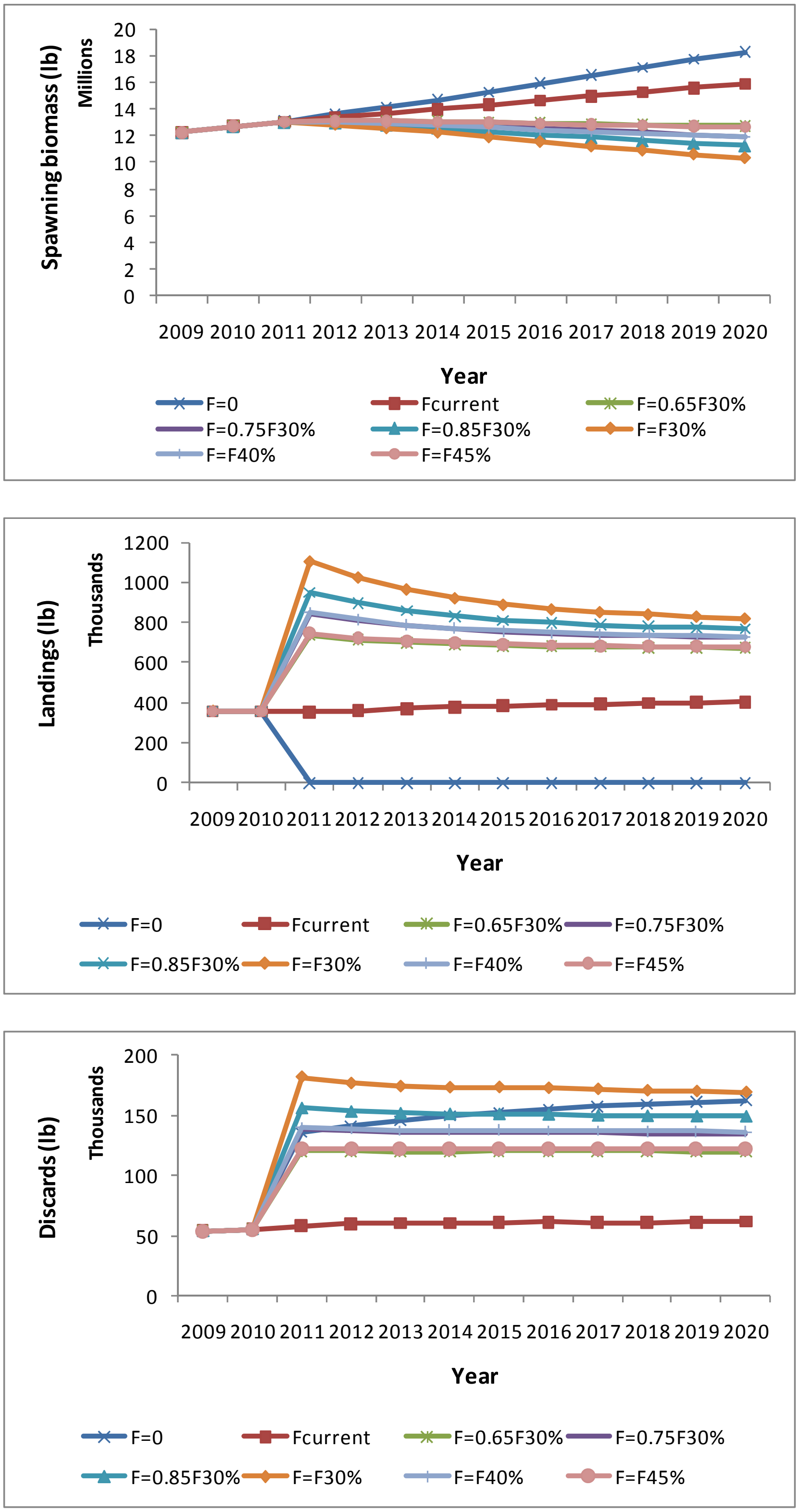


Figure 3.3.5.23. Comparison of projections for spawning biomass (a), landings (b) and discards across the alternative fishing mortality rates.

3.3.6. References

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3.4. APPENDIX A

Annual age compositions and standardized residuals by the directed fleet (Figure A-1), discards by fleet (Figure A-2), and fishery independent indices of abundance (Figure A-3). The standardized residuals allow for comparisons of the fits across years and fleets but they amplify the residuals. Also, if a plot for a year is missing, then there was no age information from that fleet for that year. For example, there was no age information for MRFSS in 1990 nor were there age observations for longlines prior to 1992.

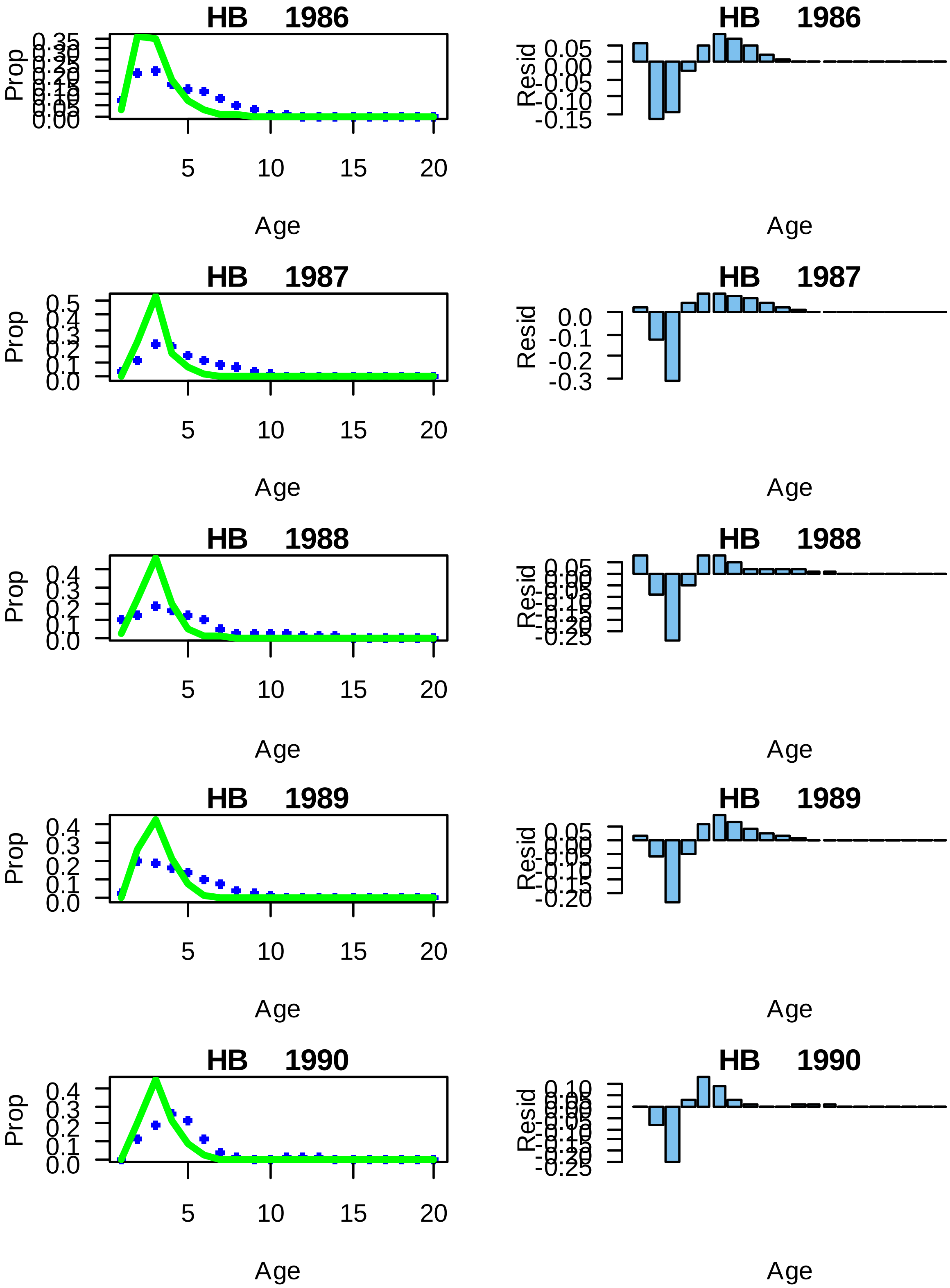
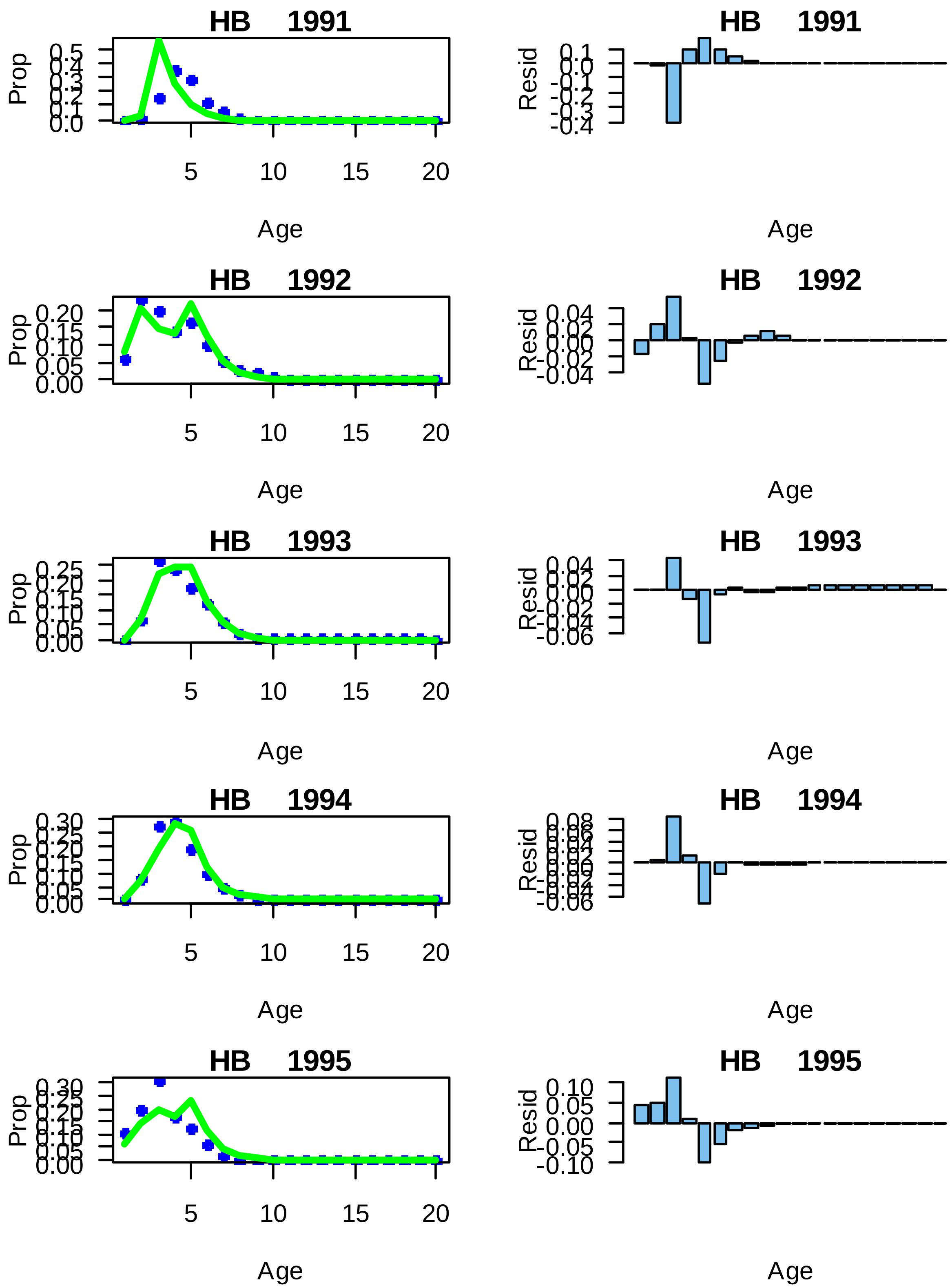


Figure A-1. ASAP2 model fits and standardized residuals of fleet age composition.



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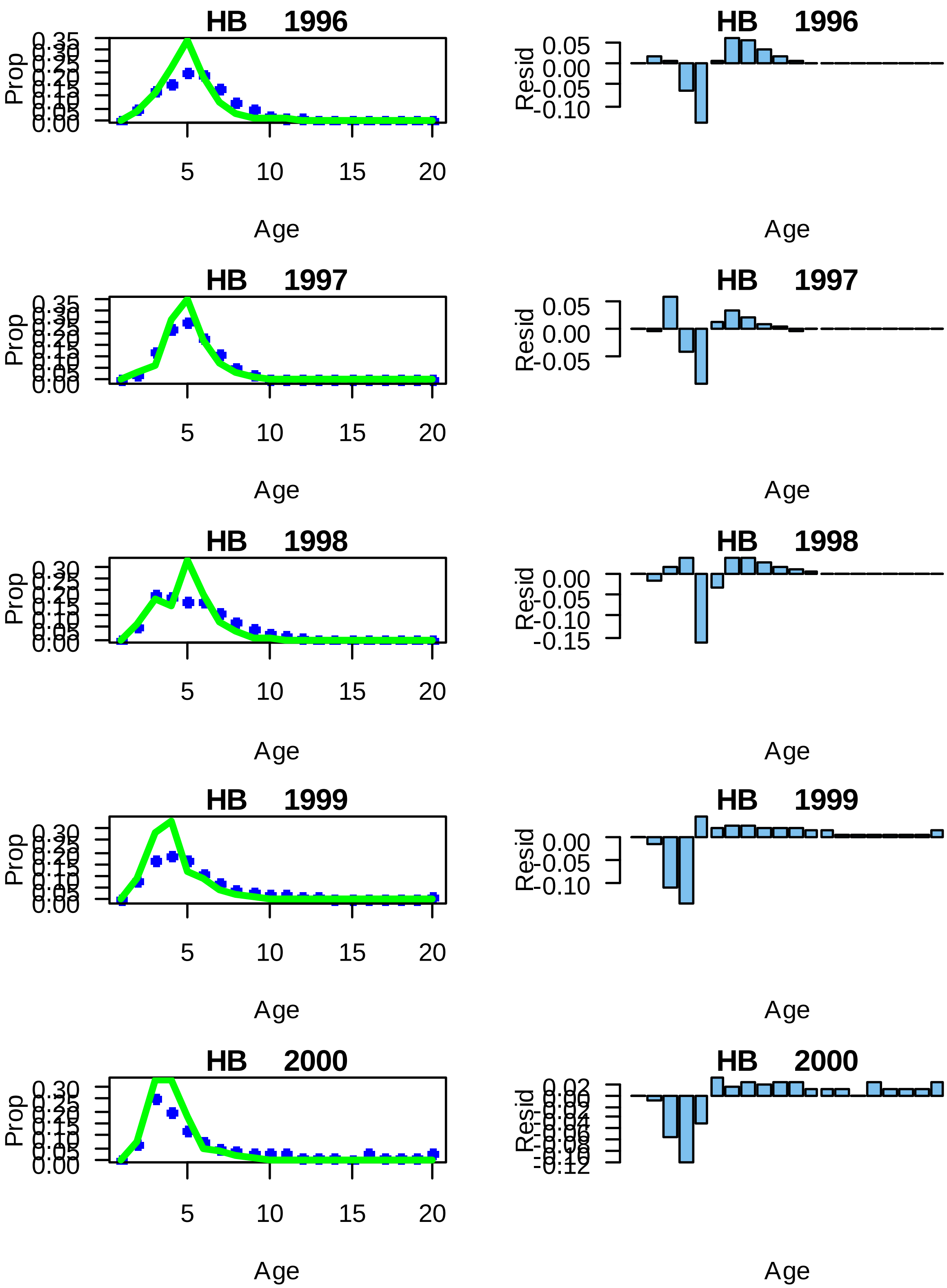

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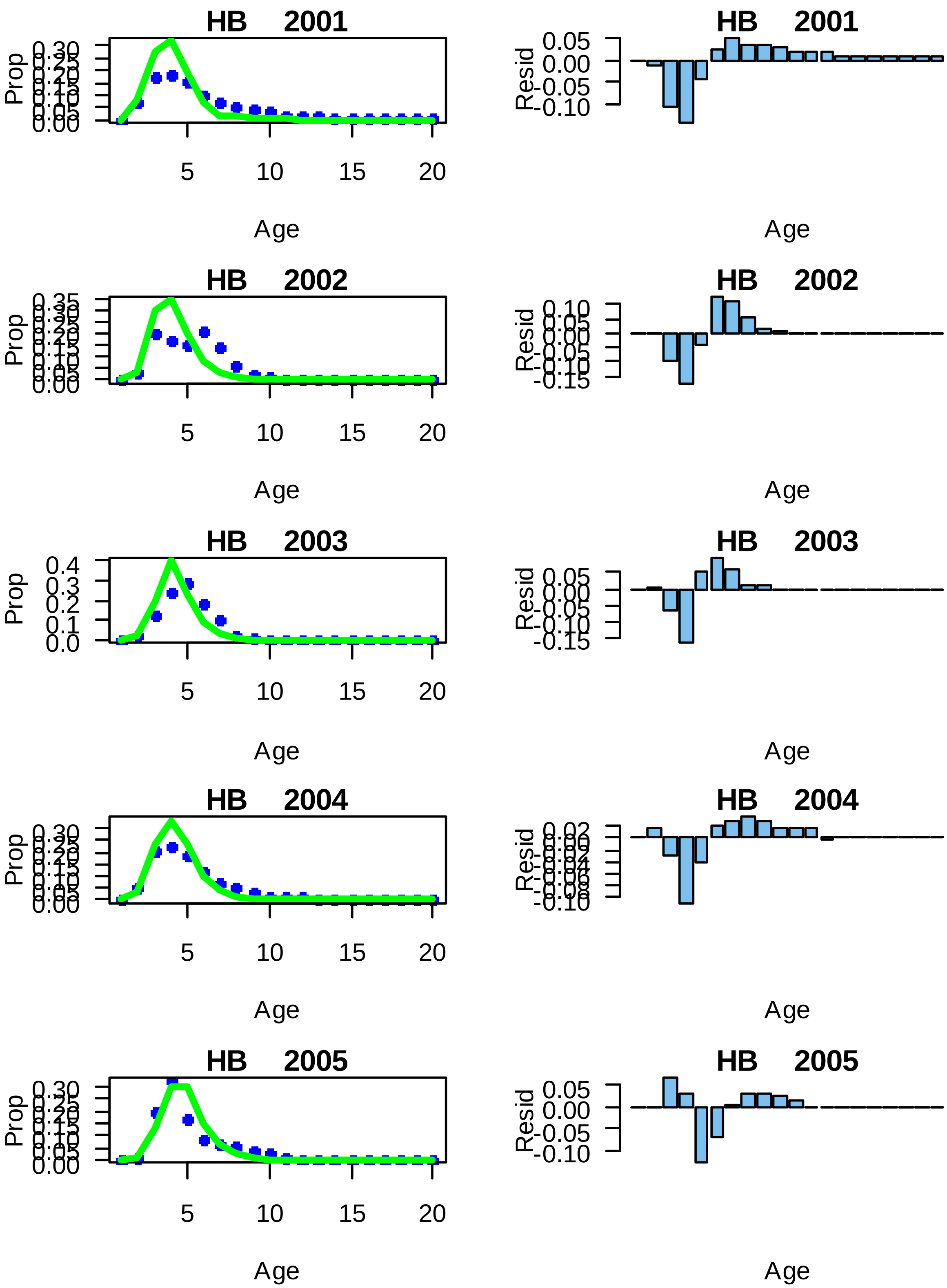

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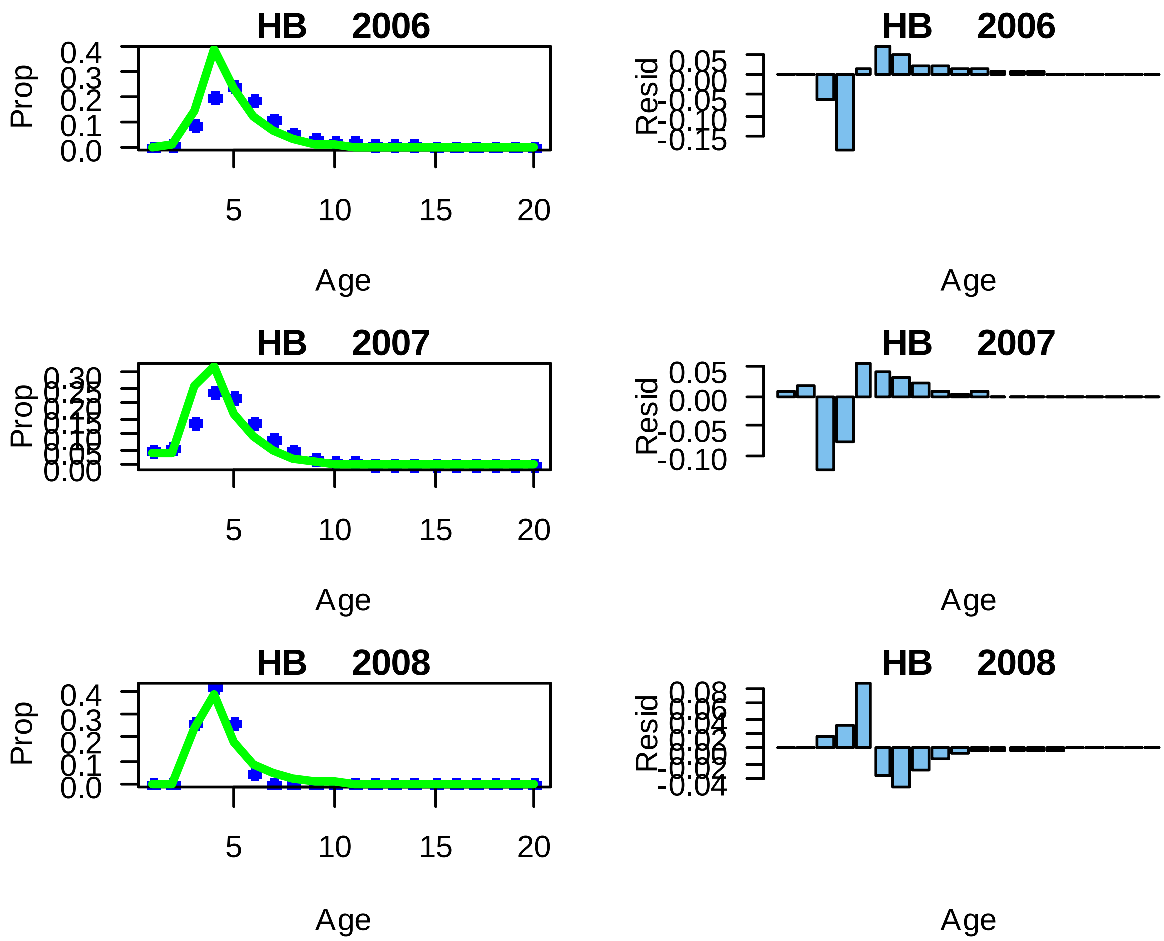

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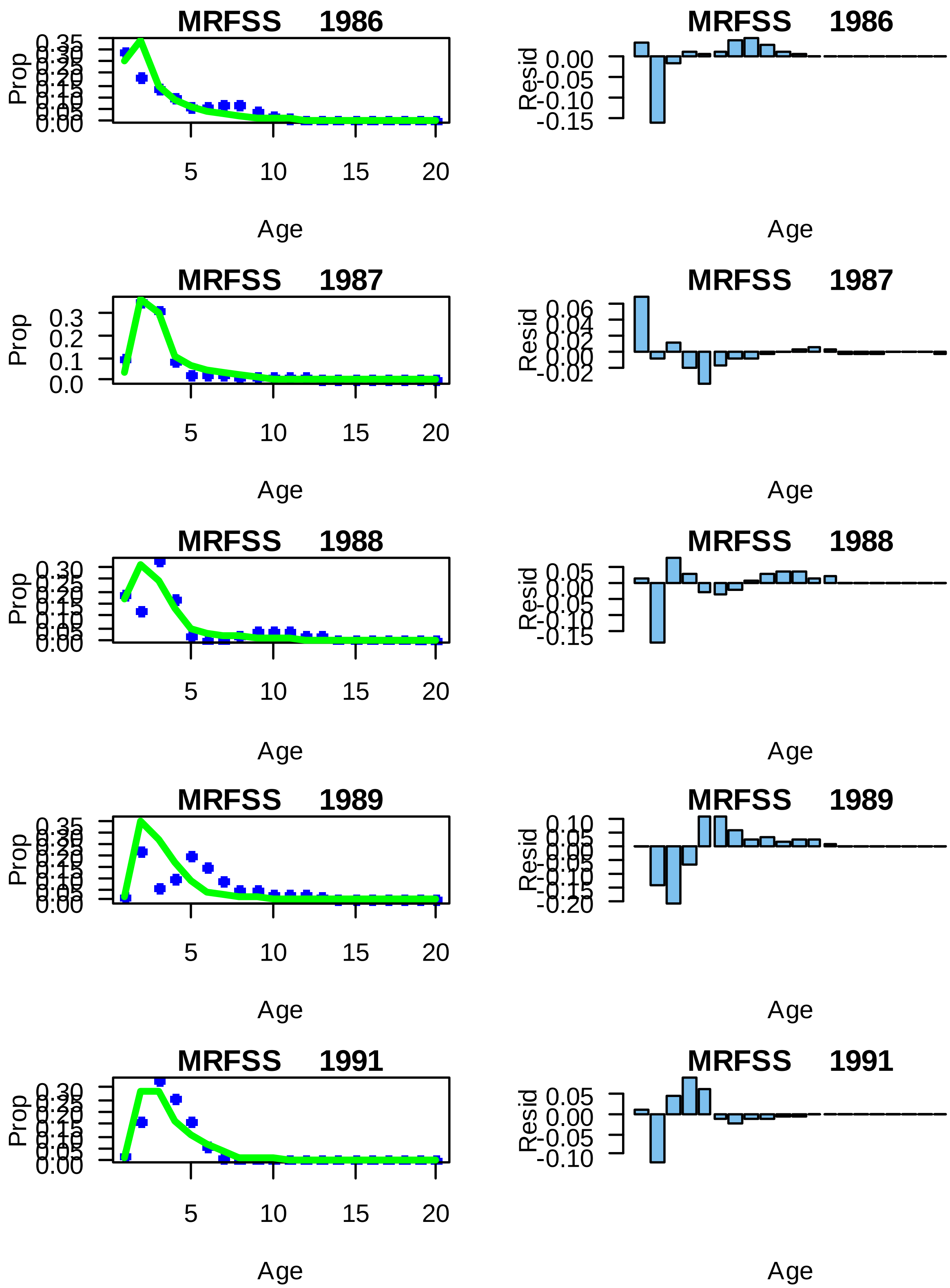

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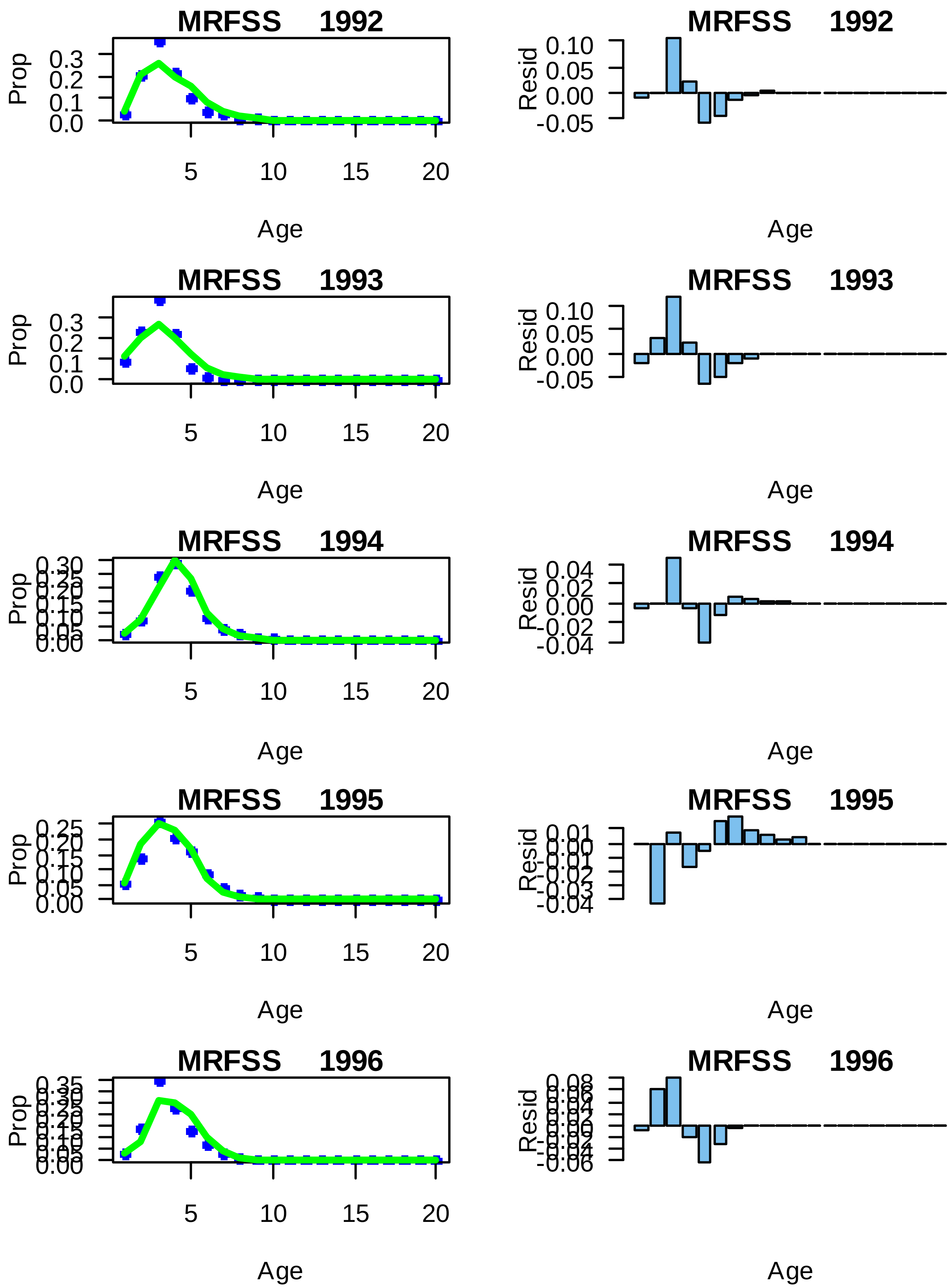

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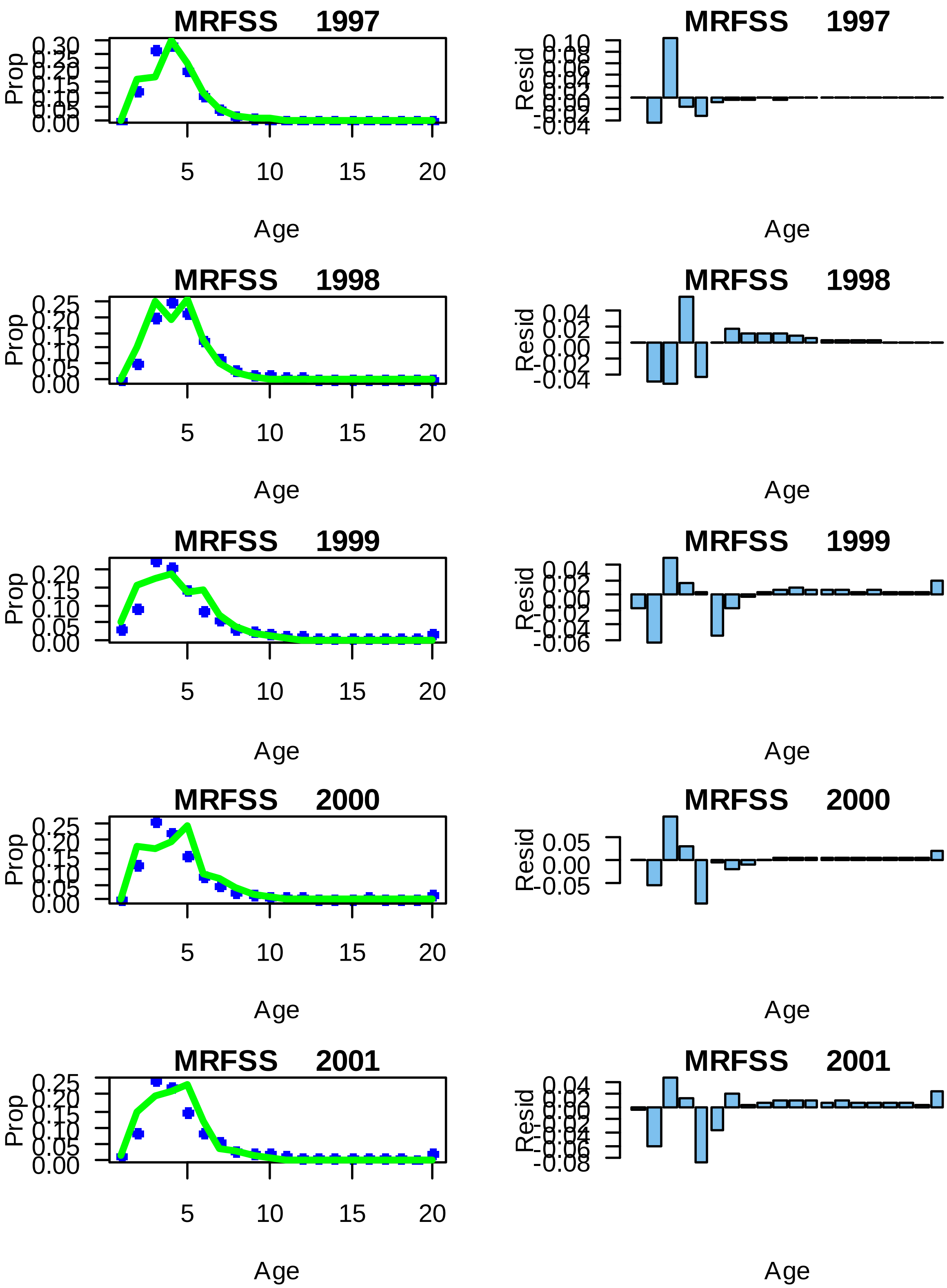


Figure A-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

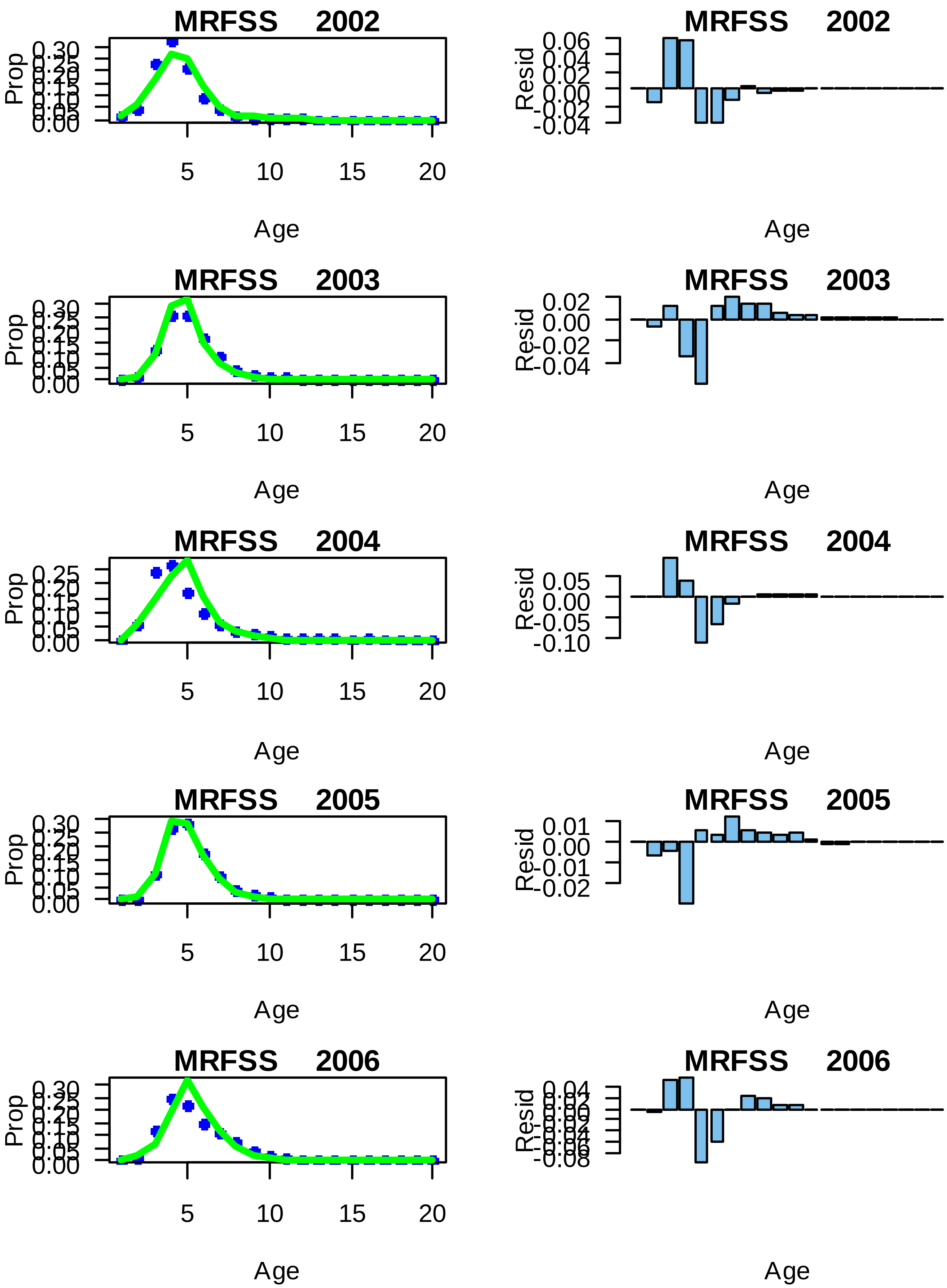


Figure A-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

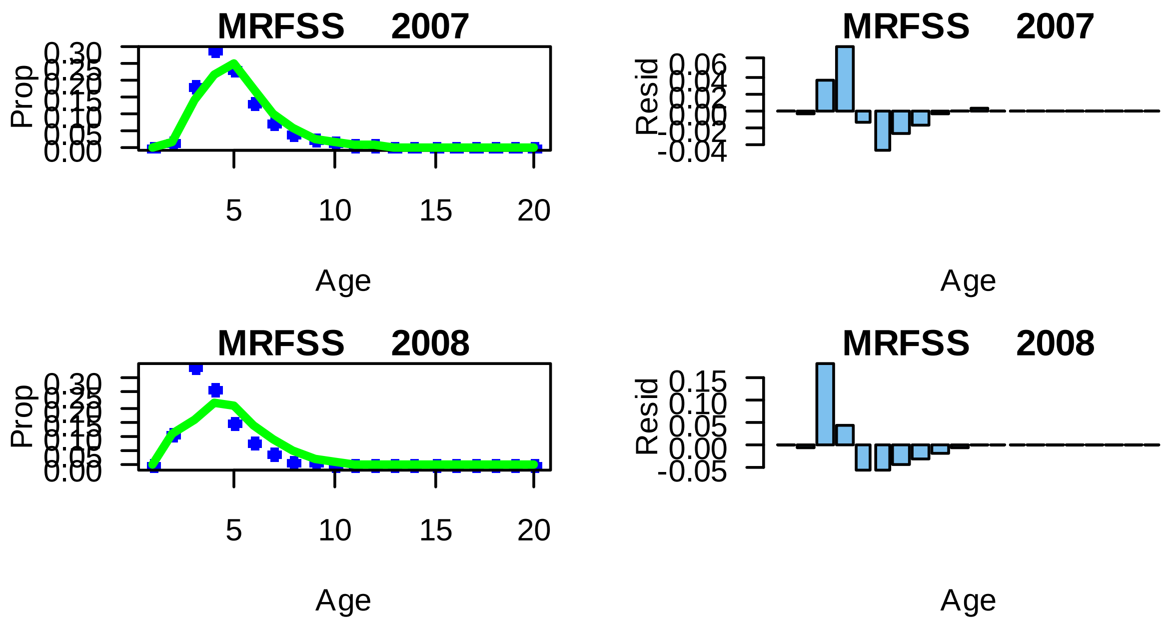
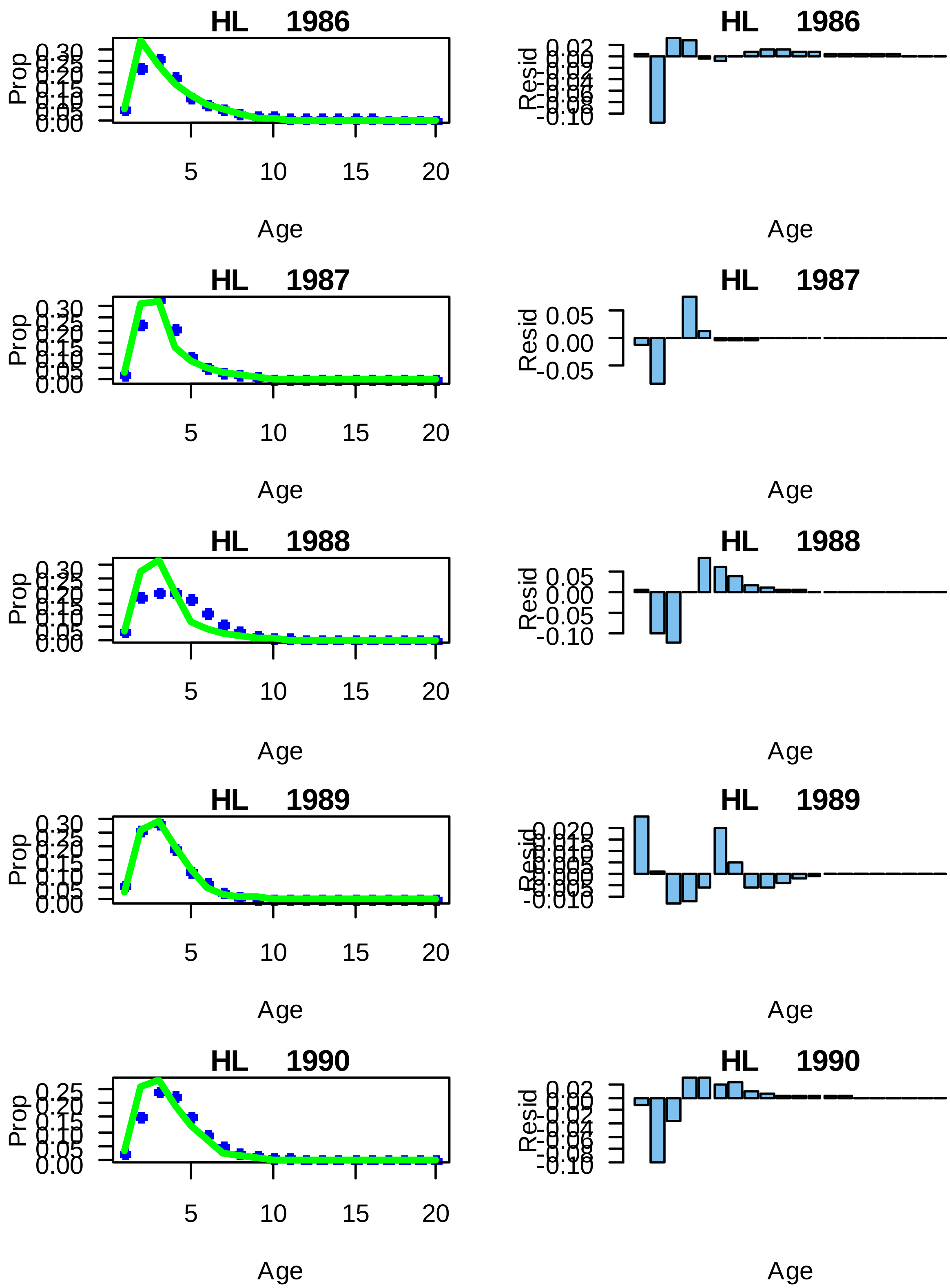


Figure A-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.



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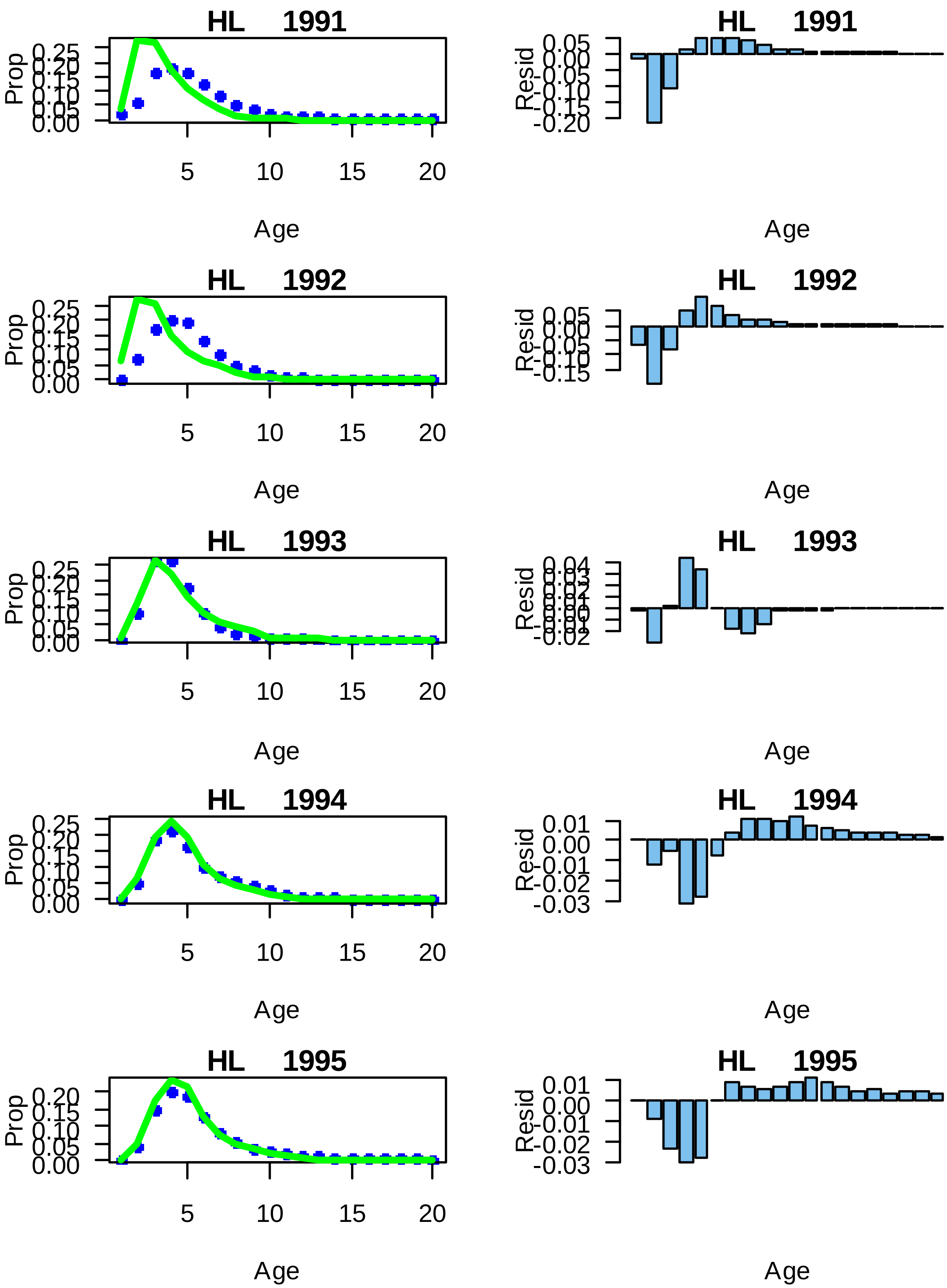


Figure A-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

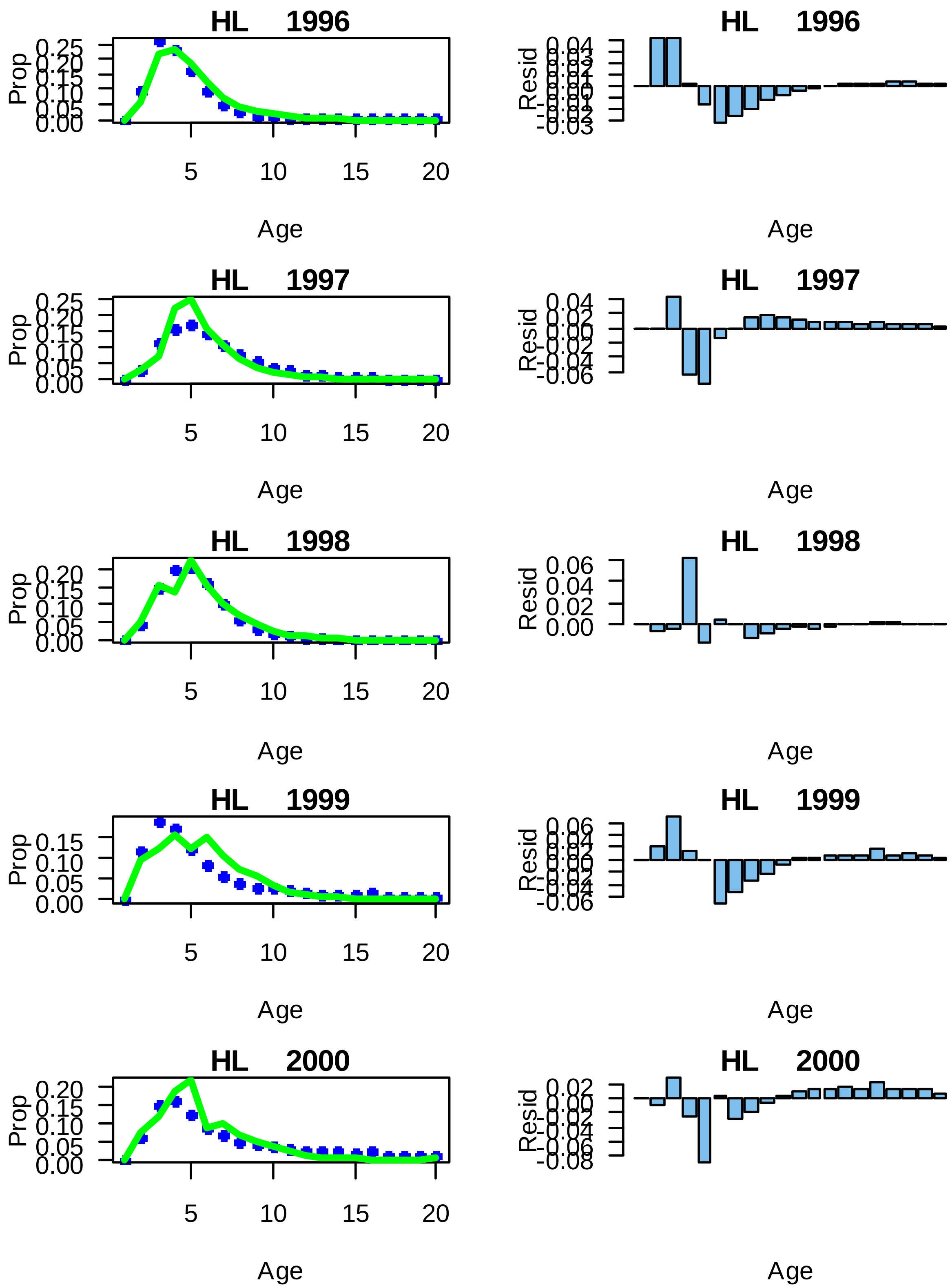
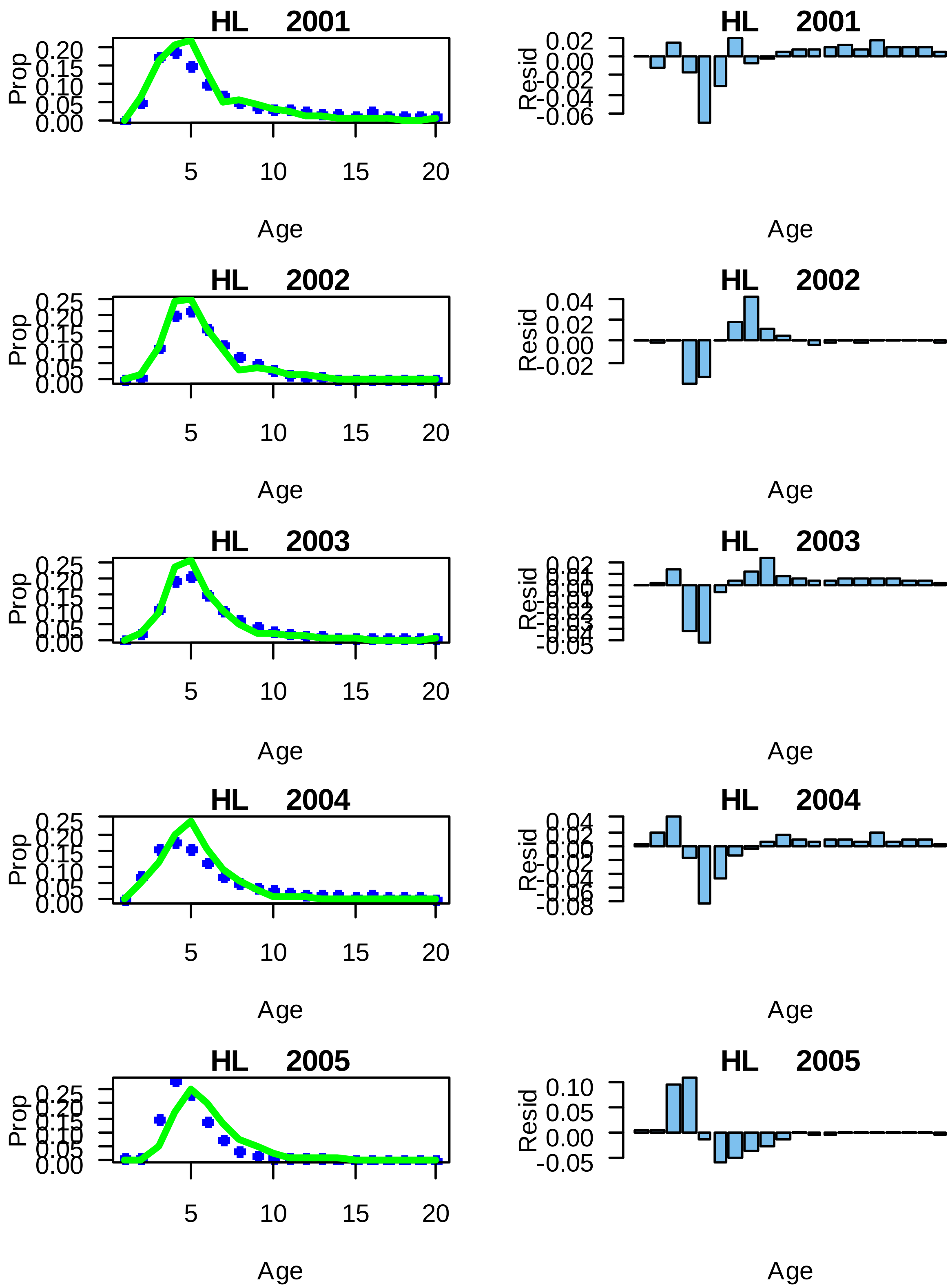


Figure A-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.



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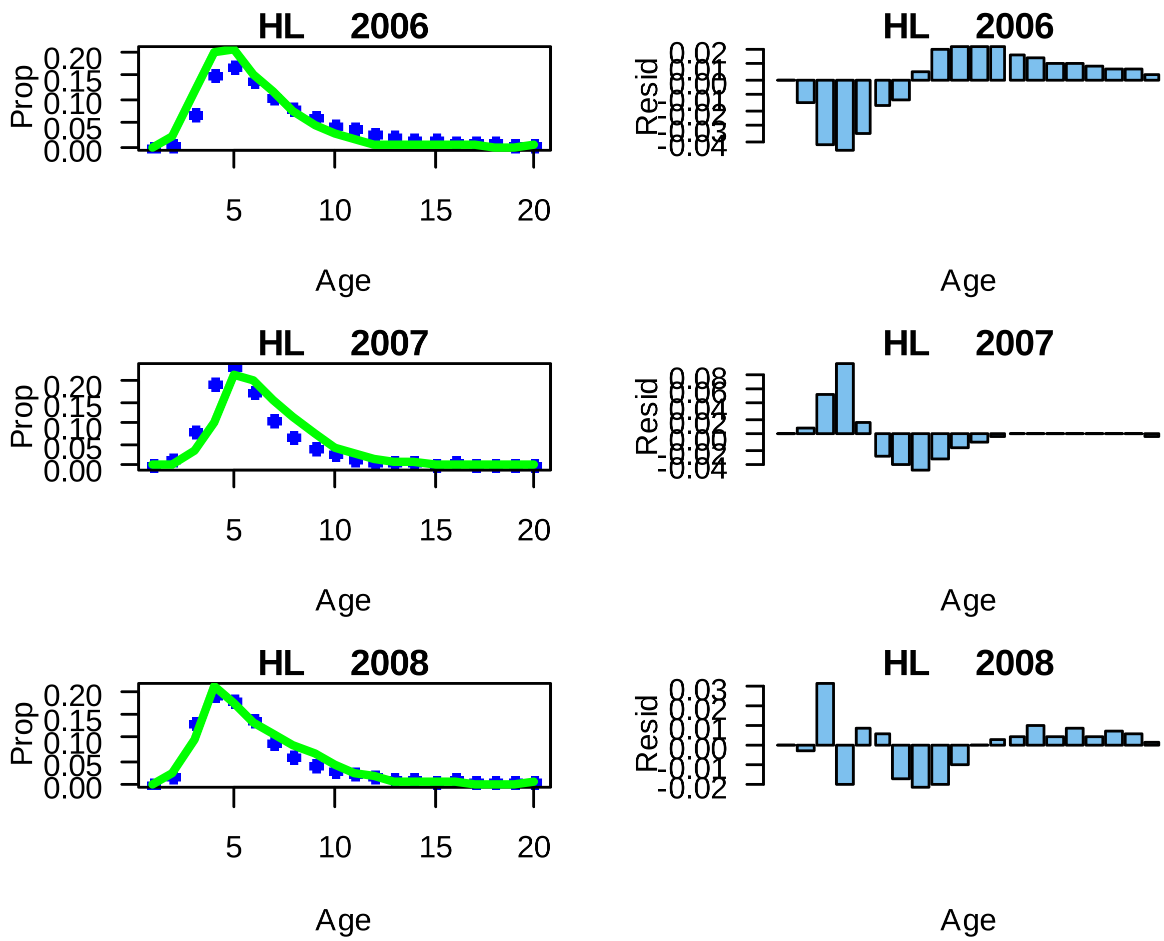

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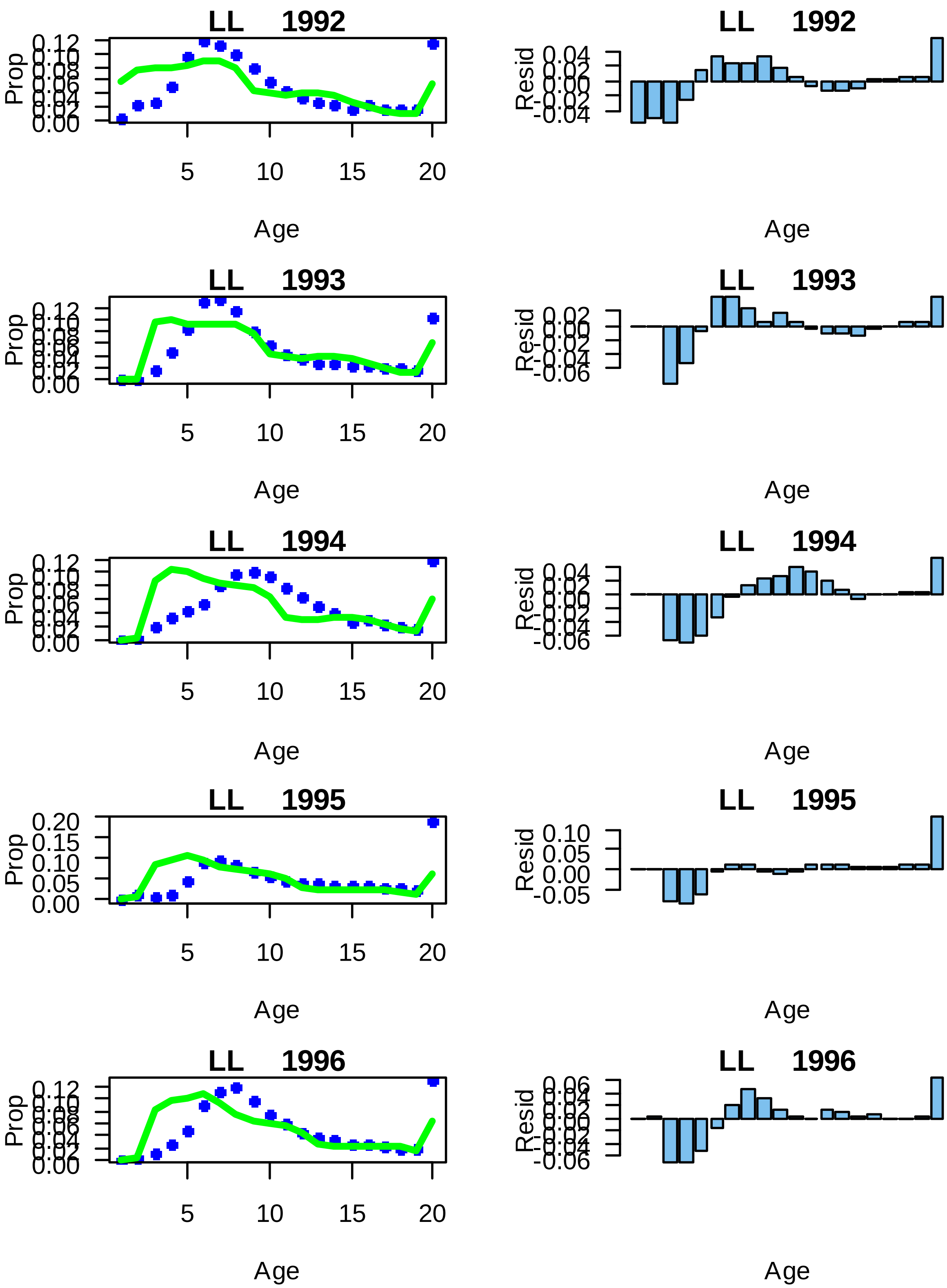

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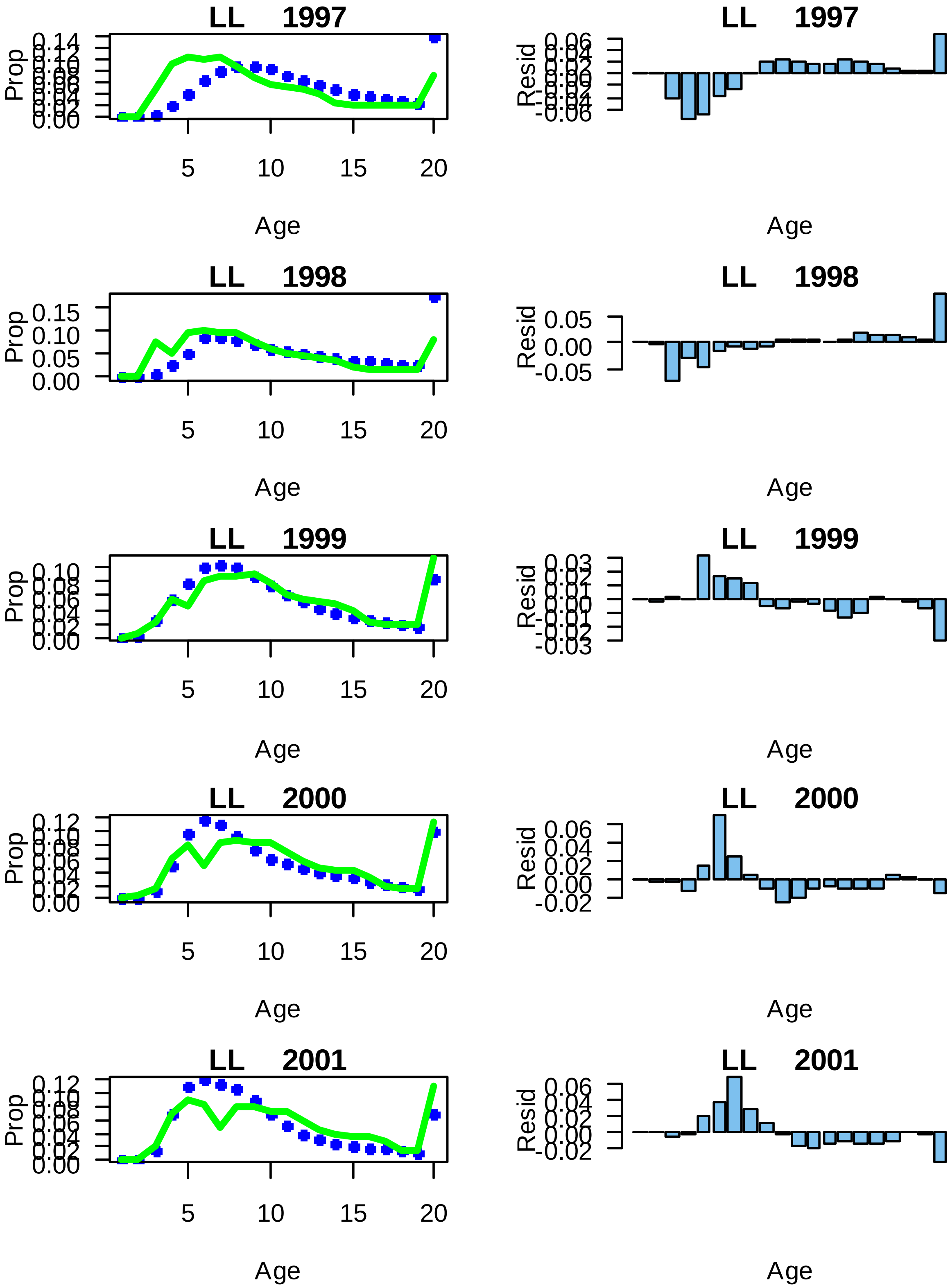

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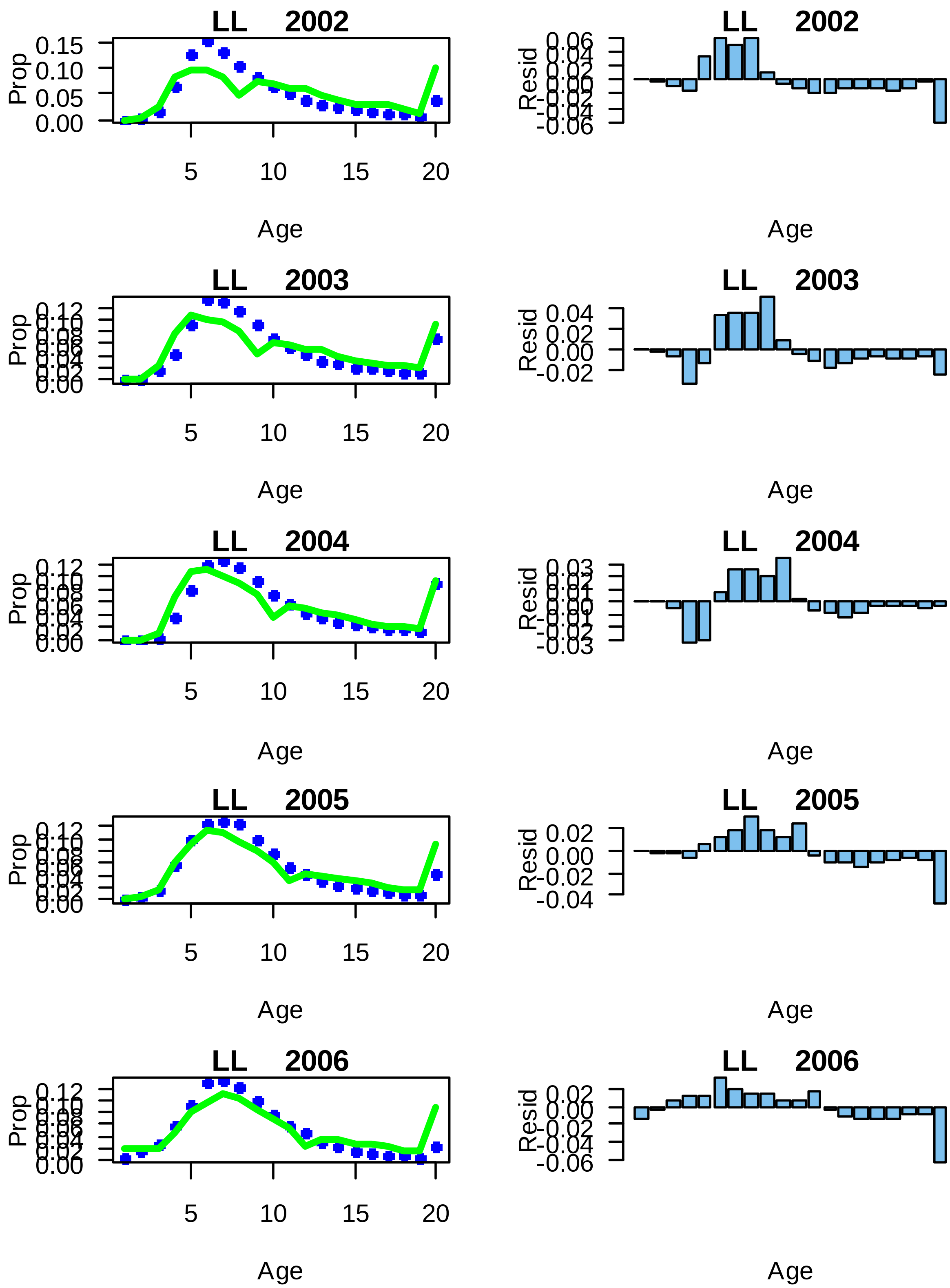

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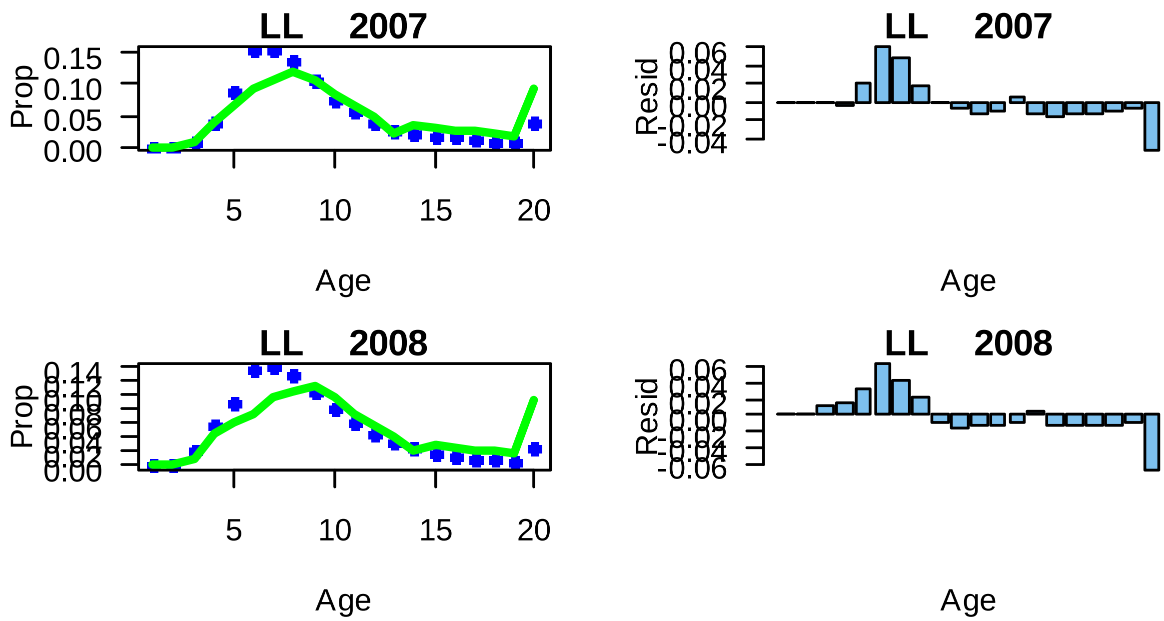

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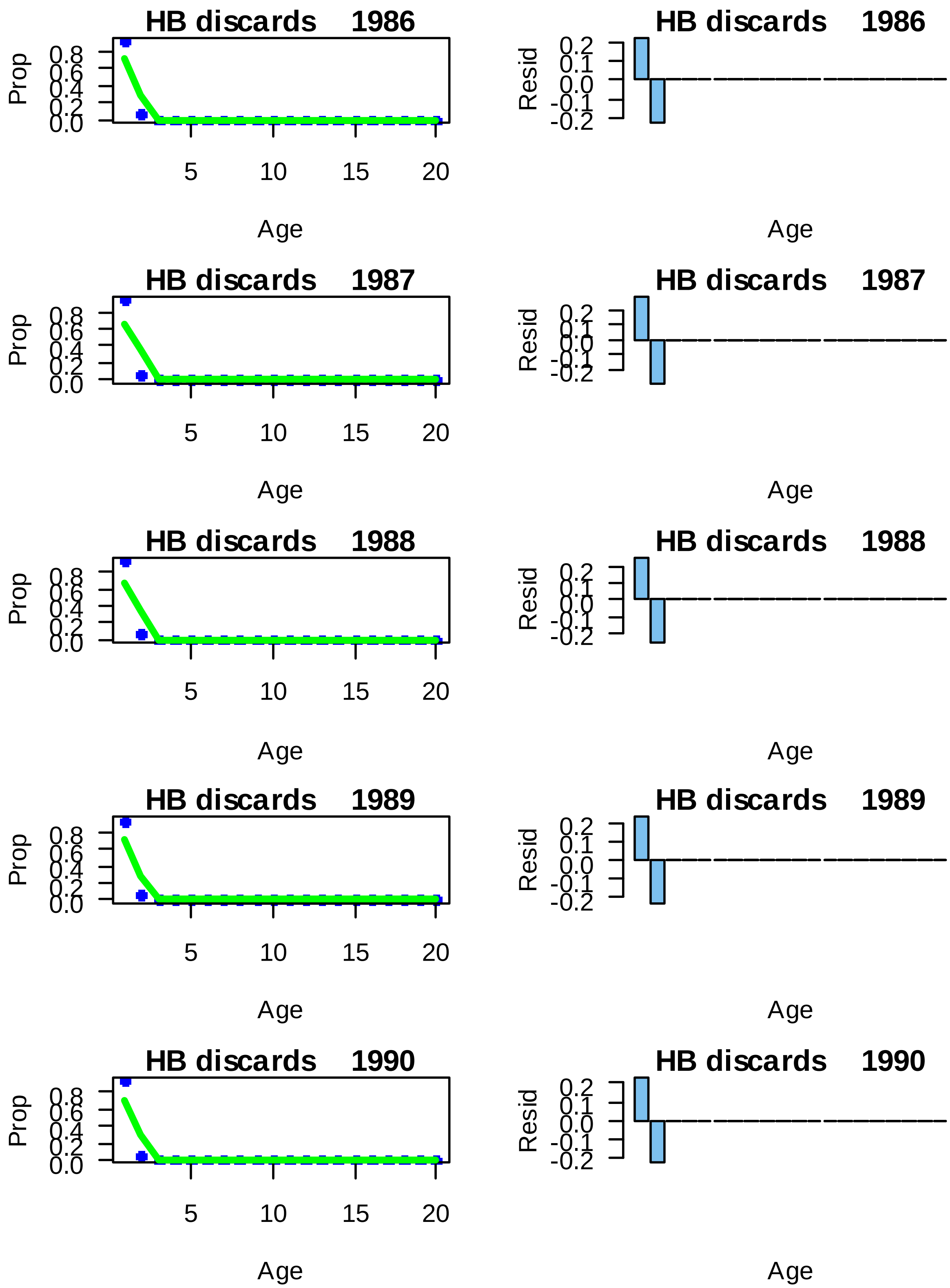
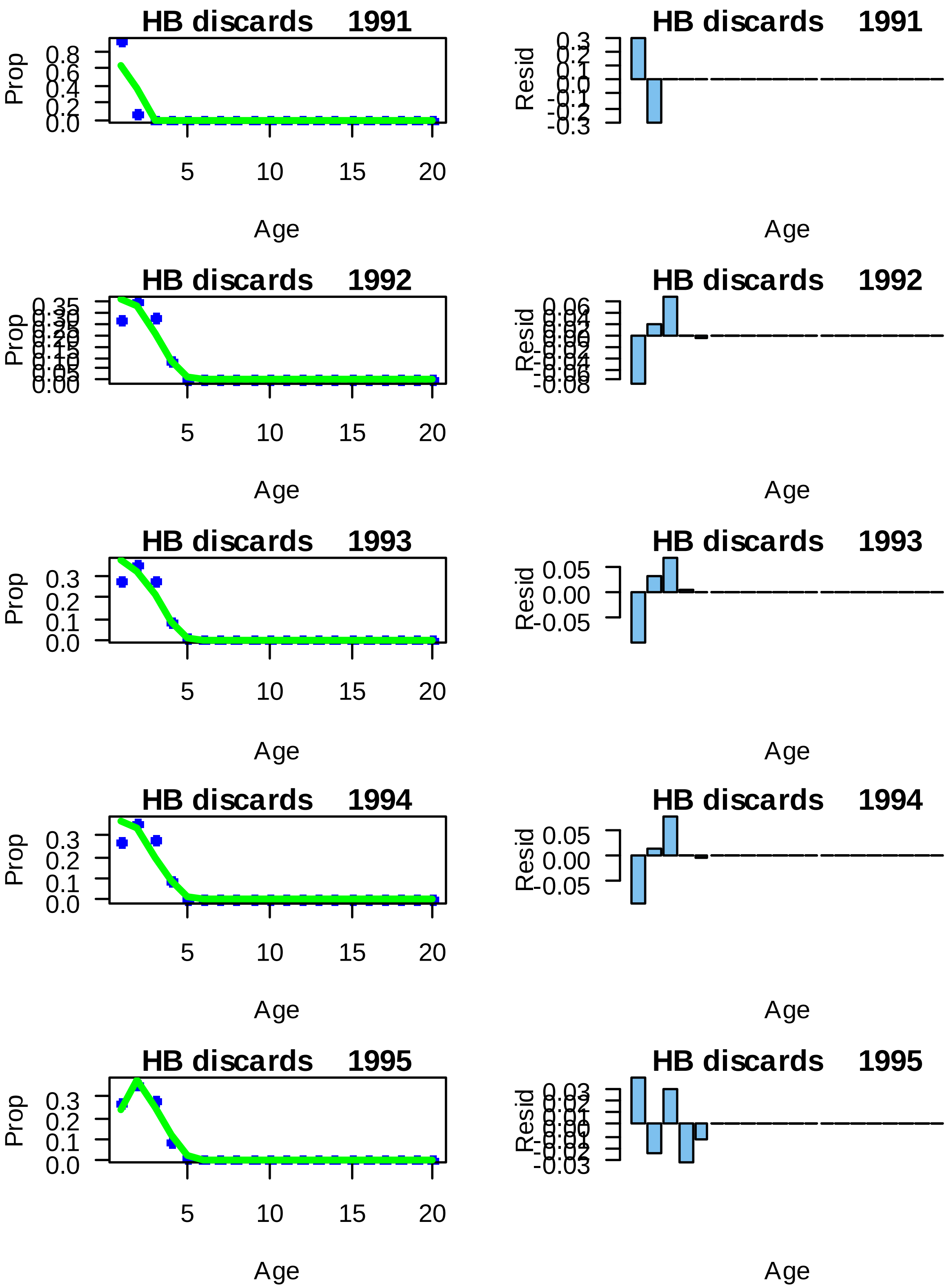


Figure A-2. ASAP2 model fits and standardized residuals of discard age composition by fleet.



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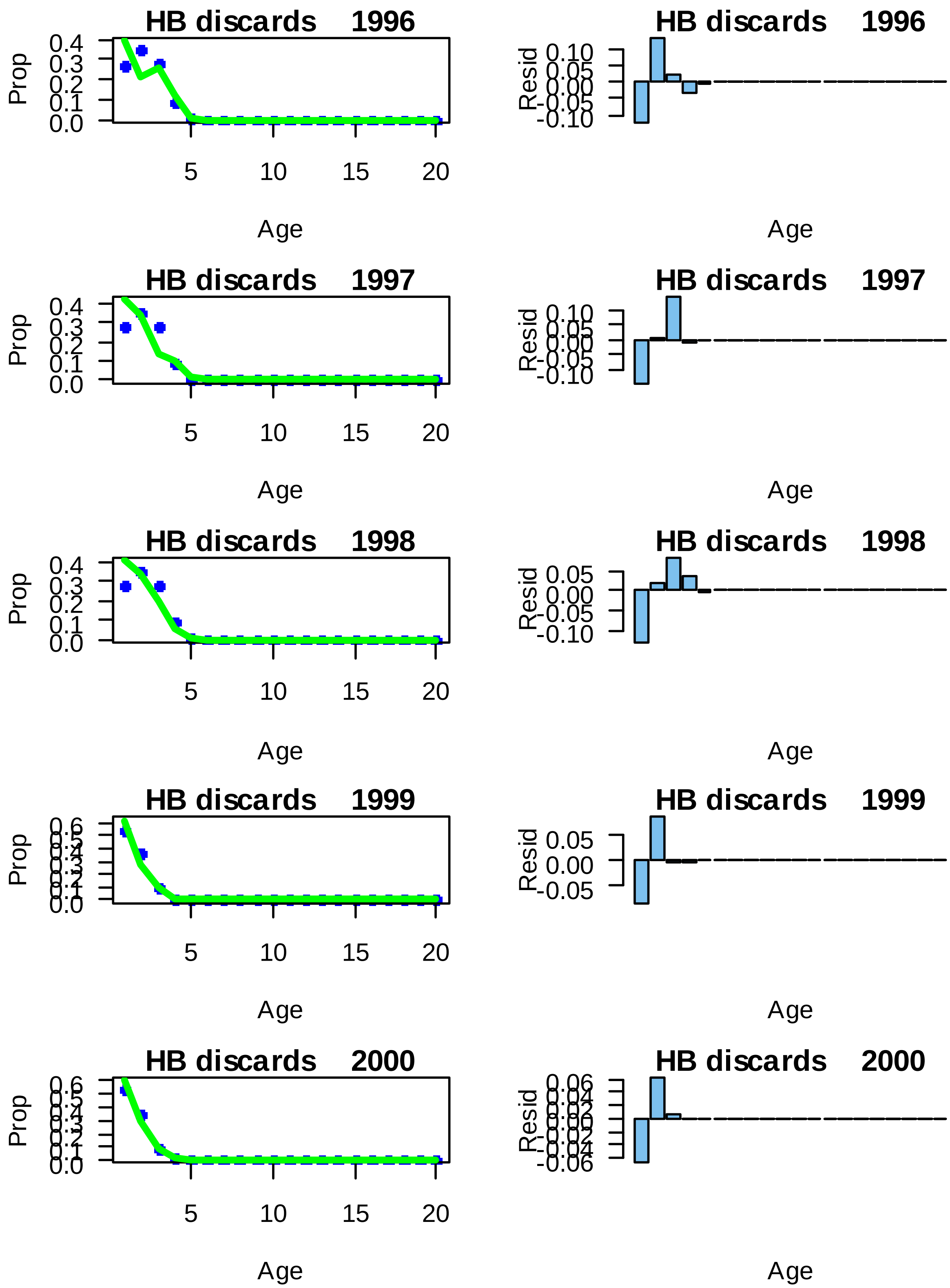

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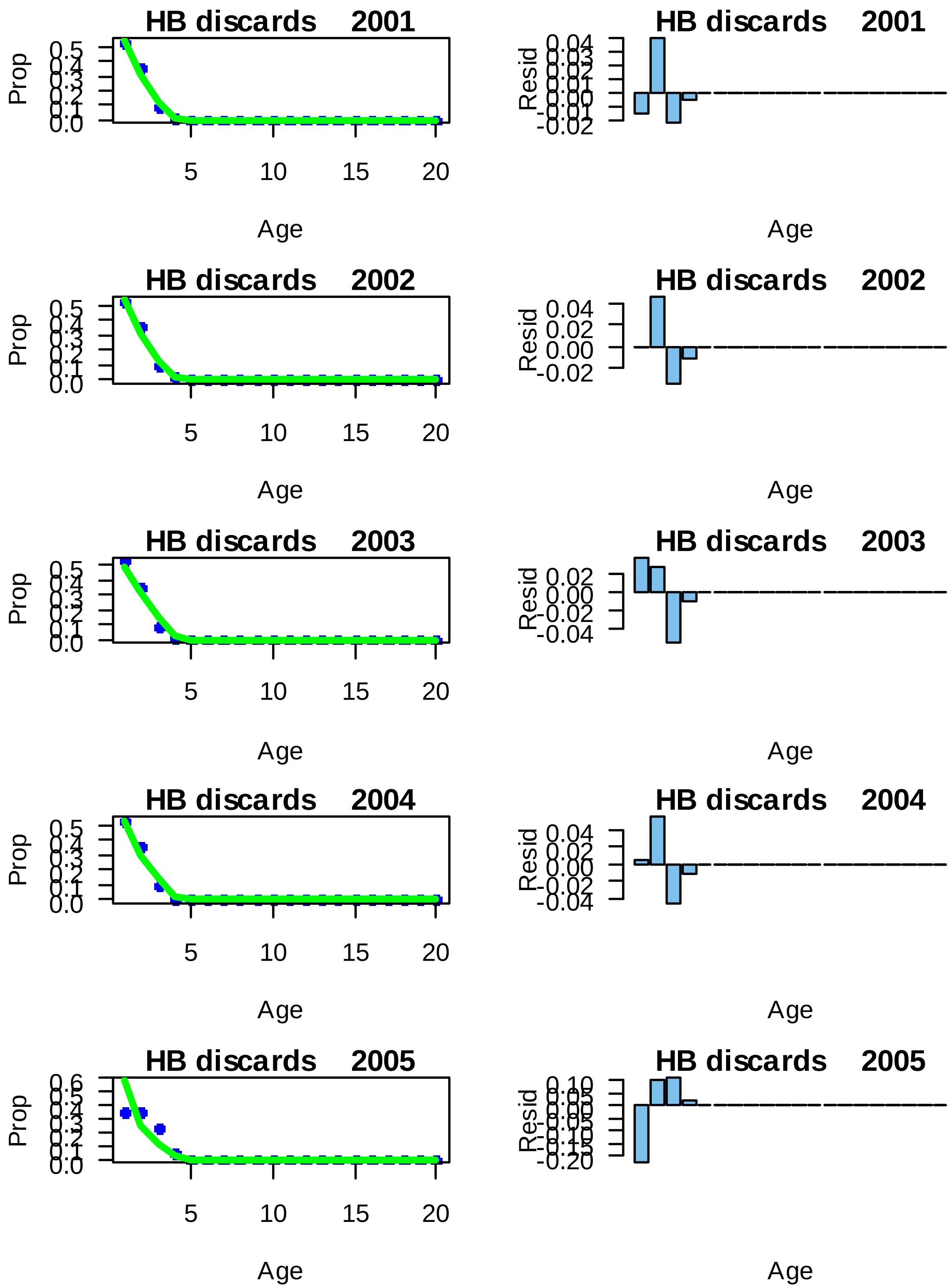

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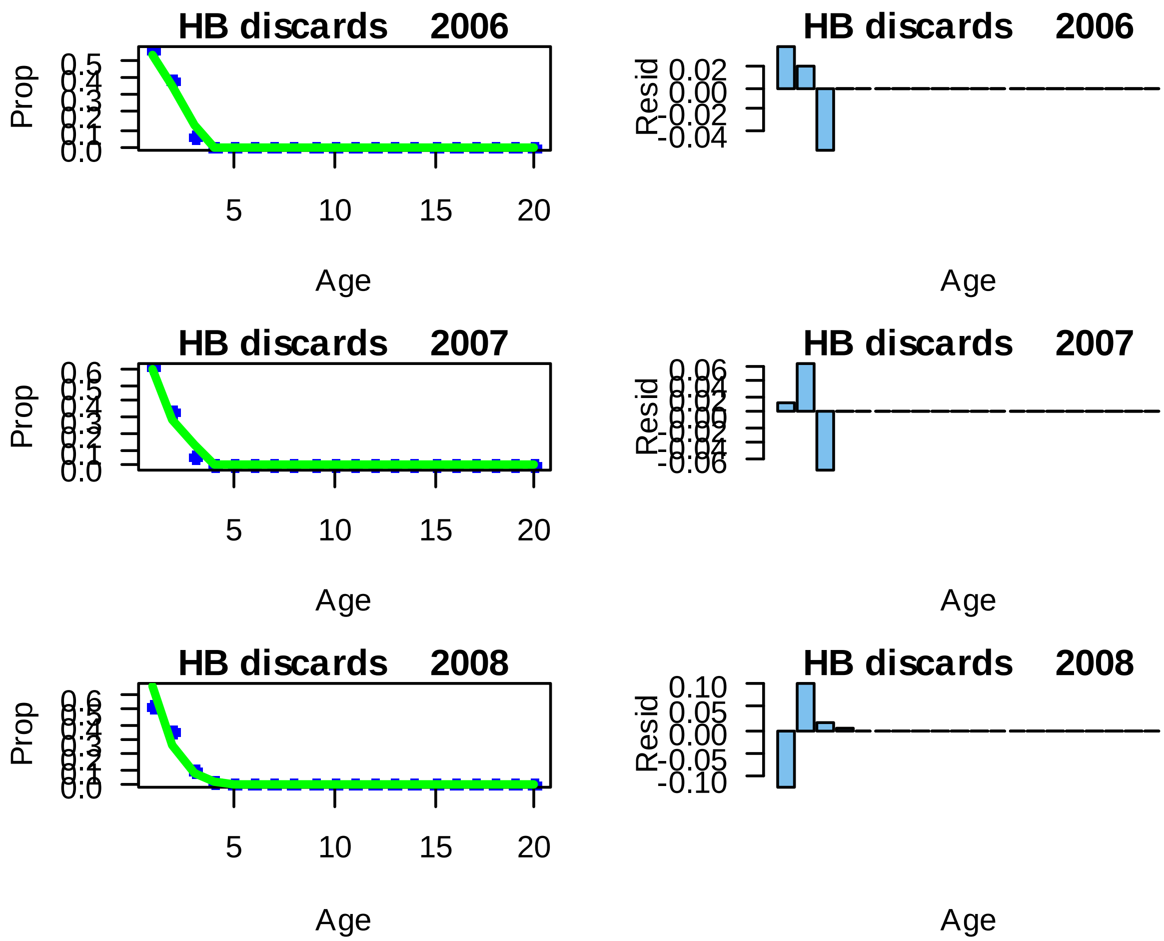

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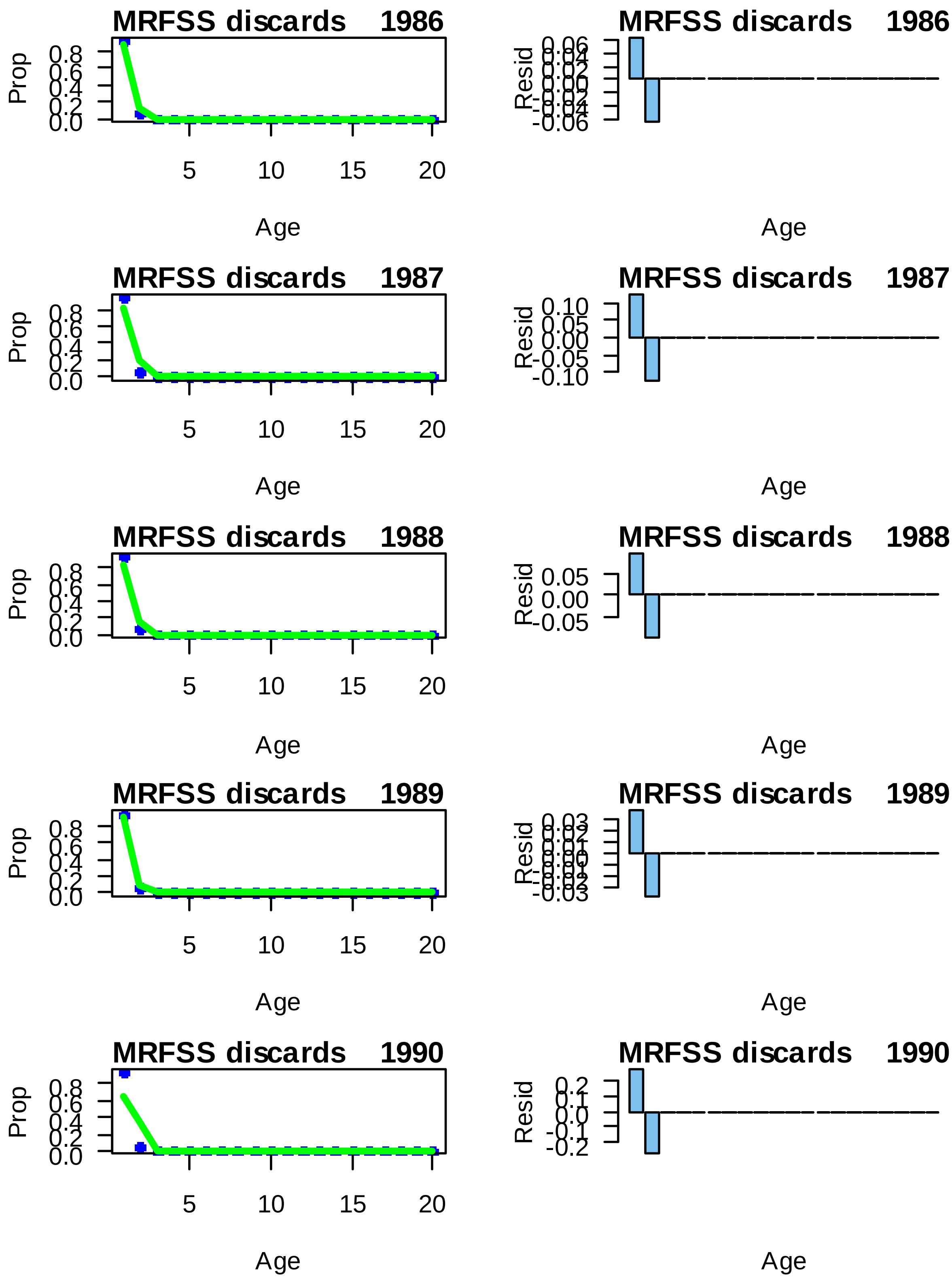

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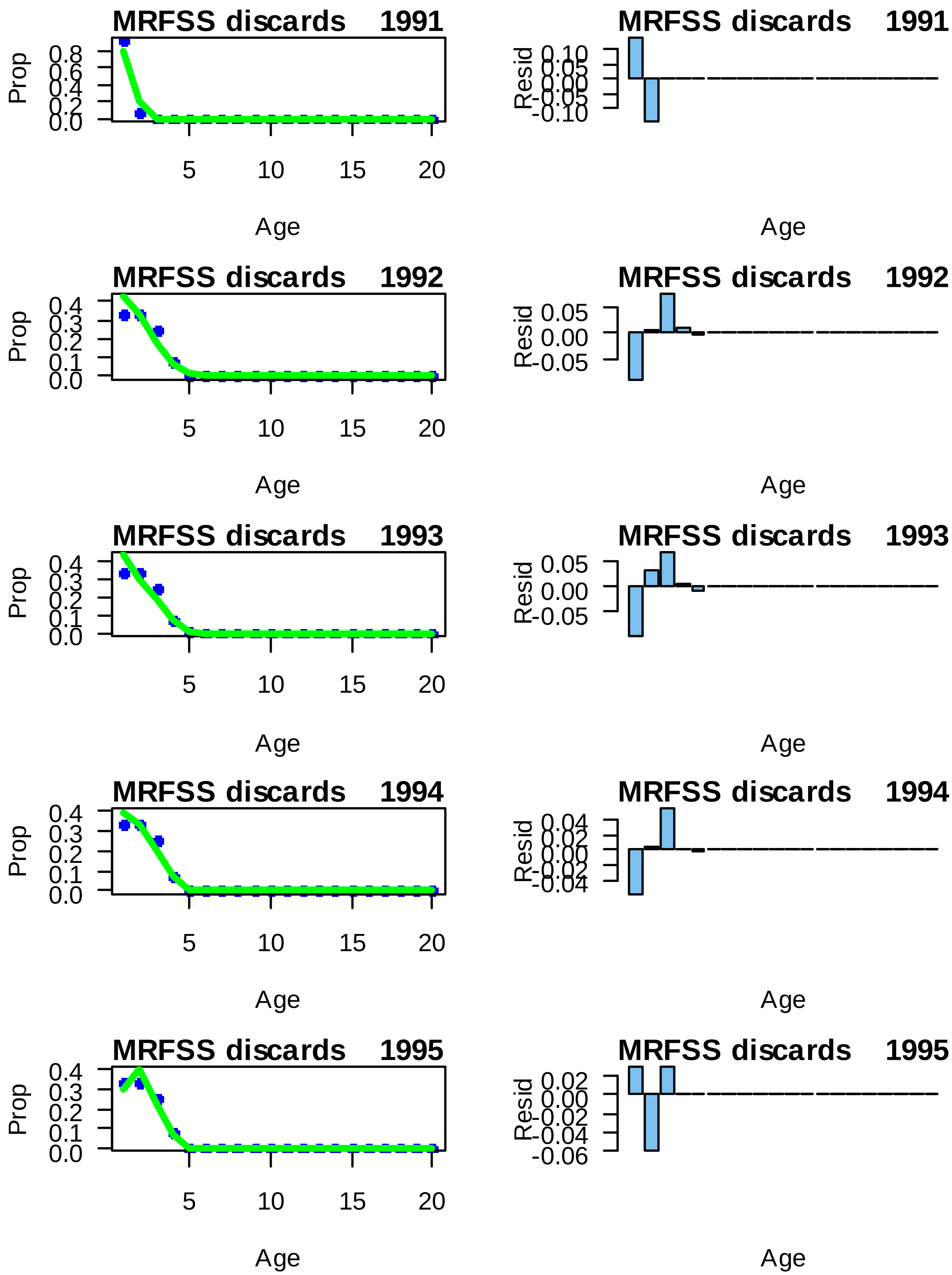

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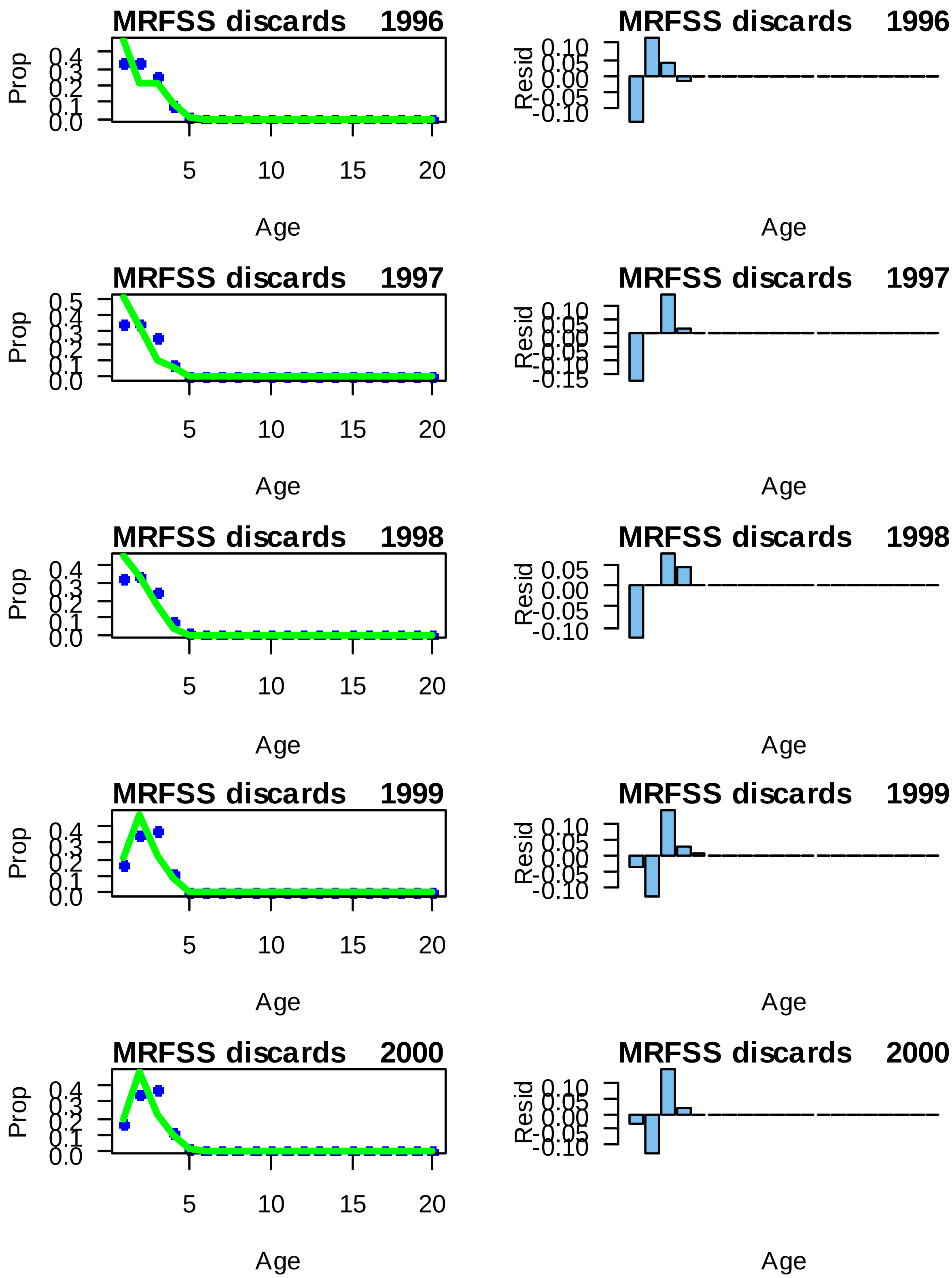

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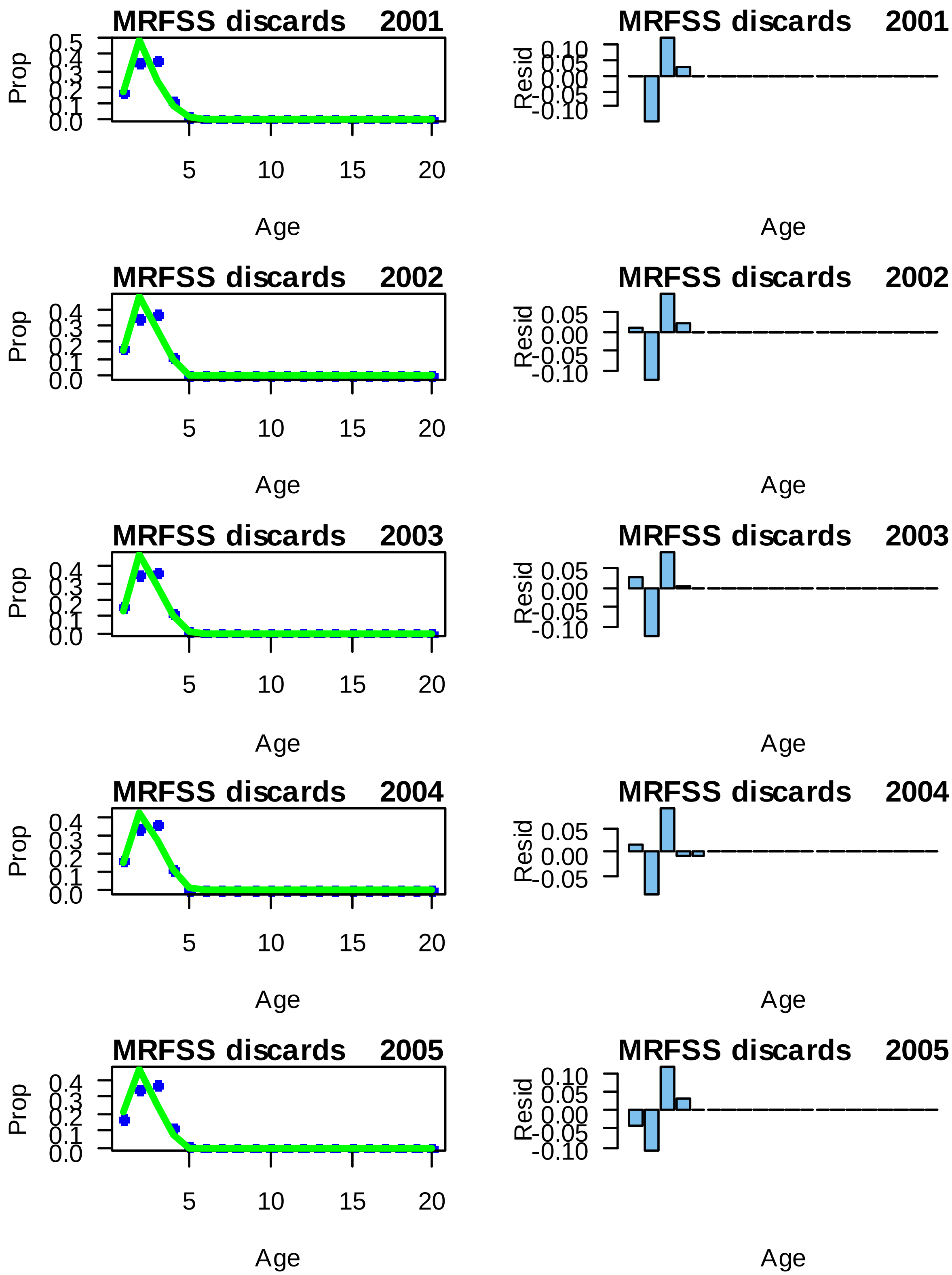

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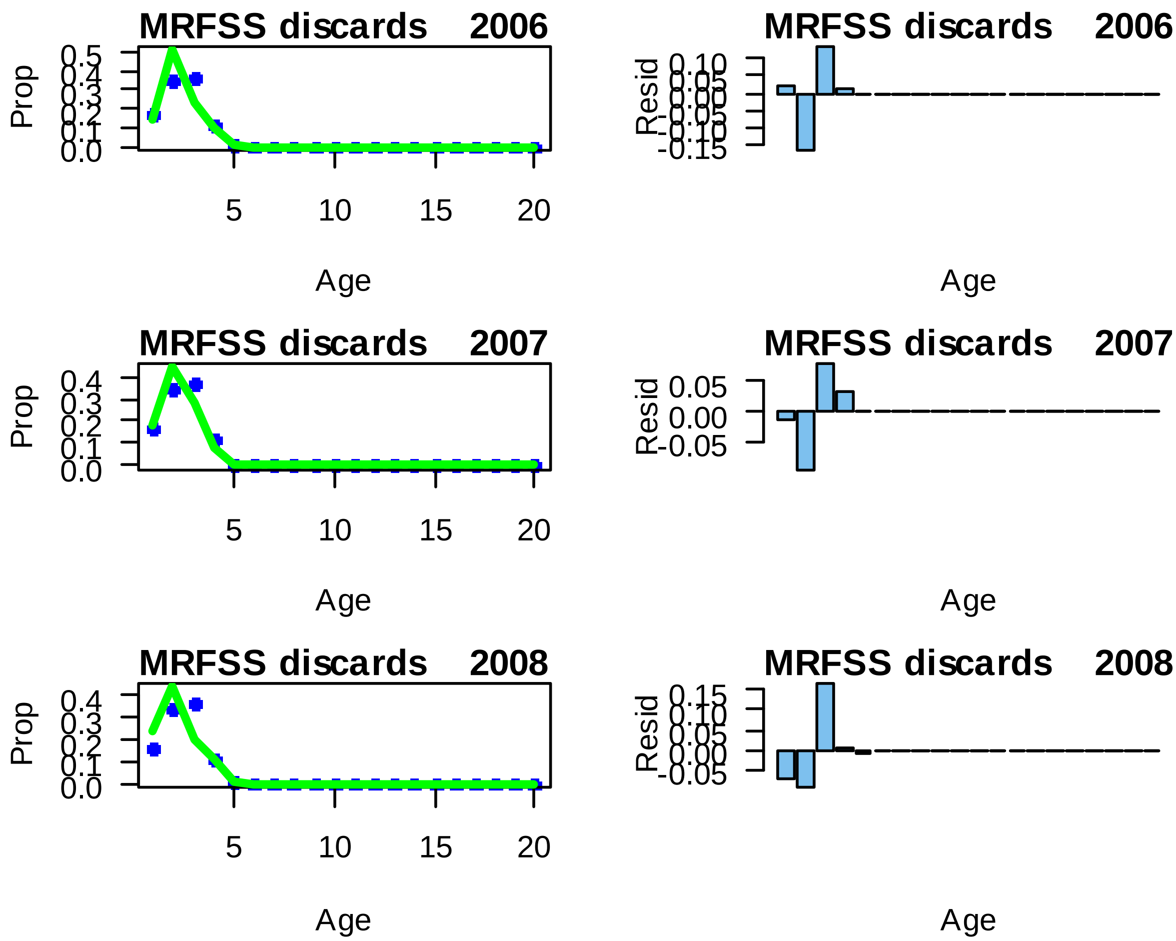

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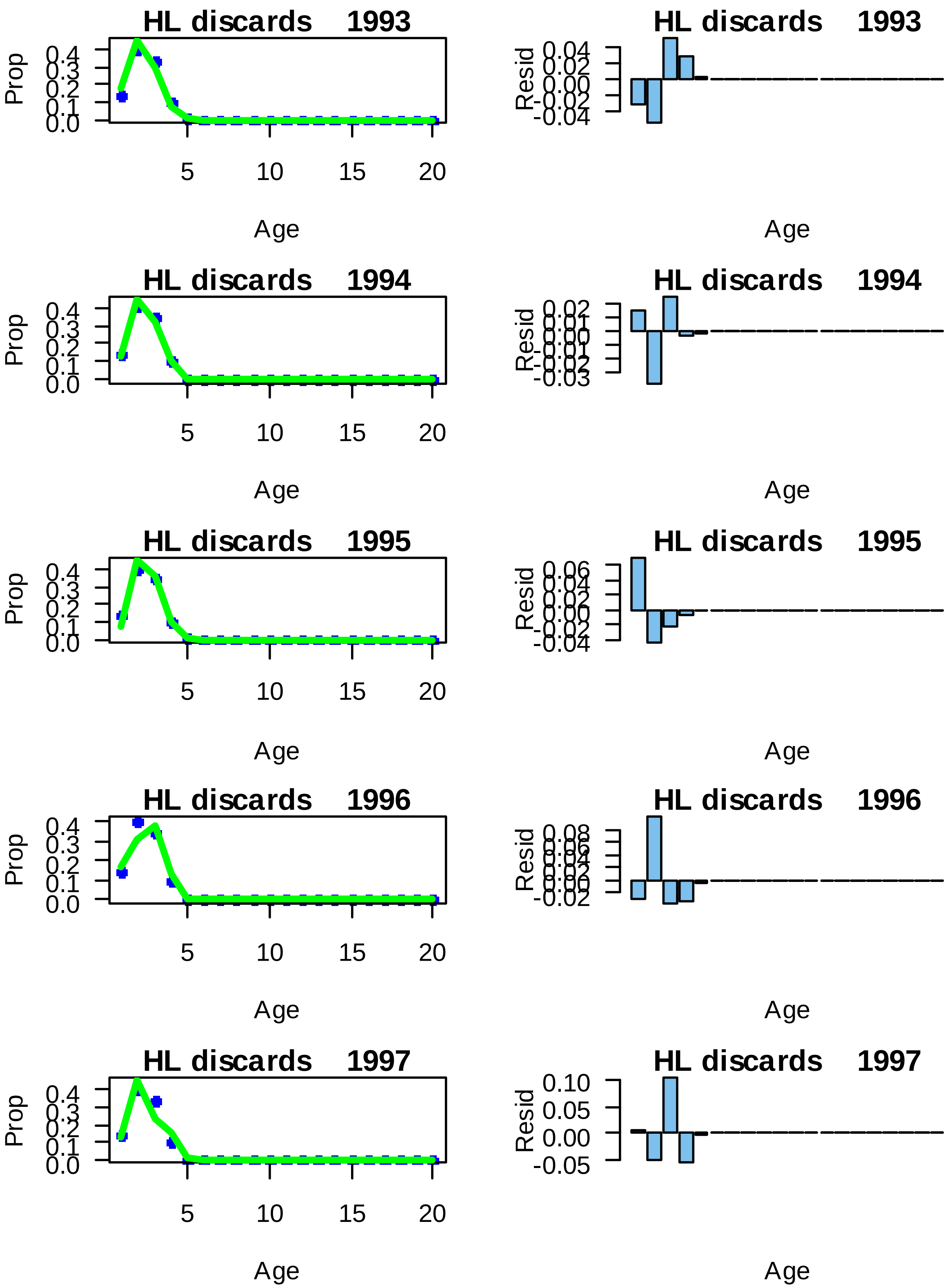

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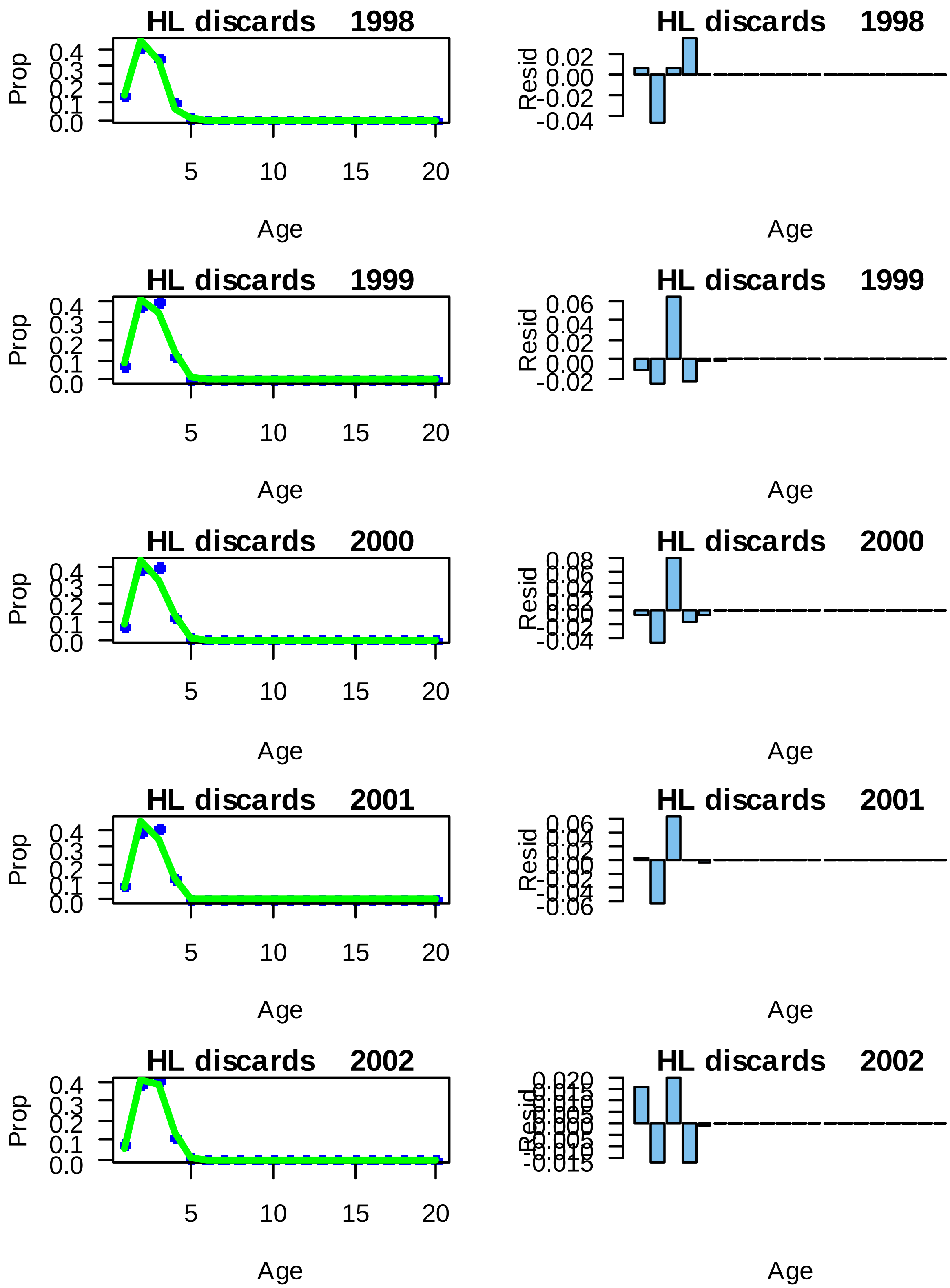

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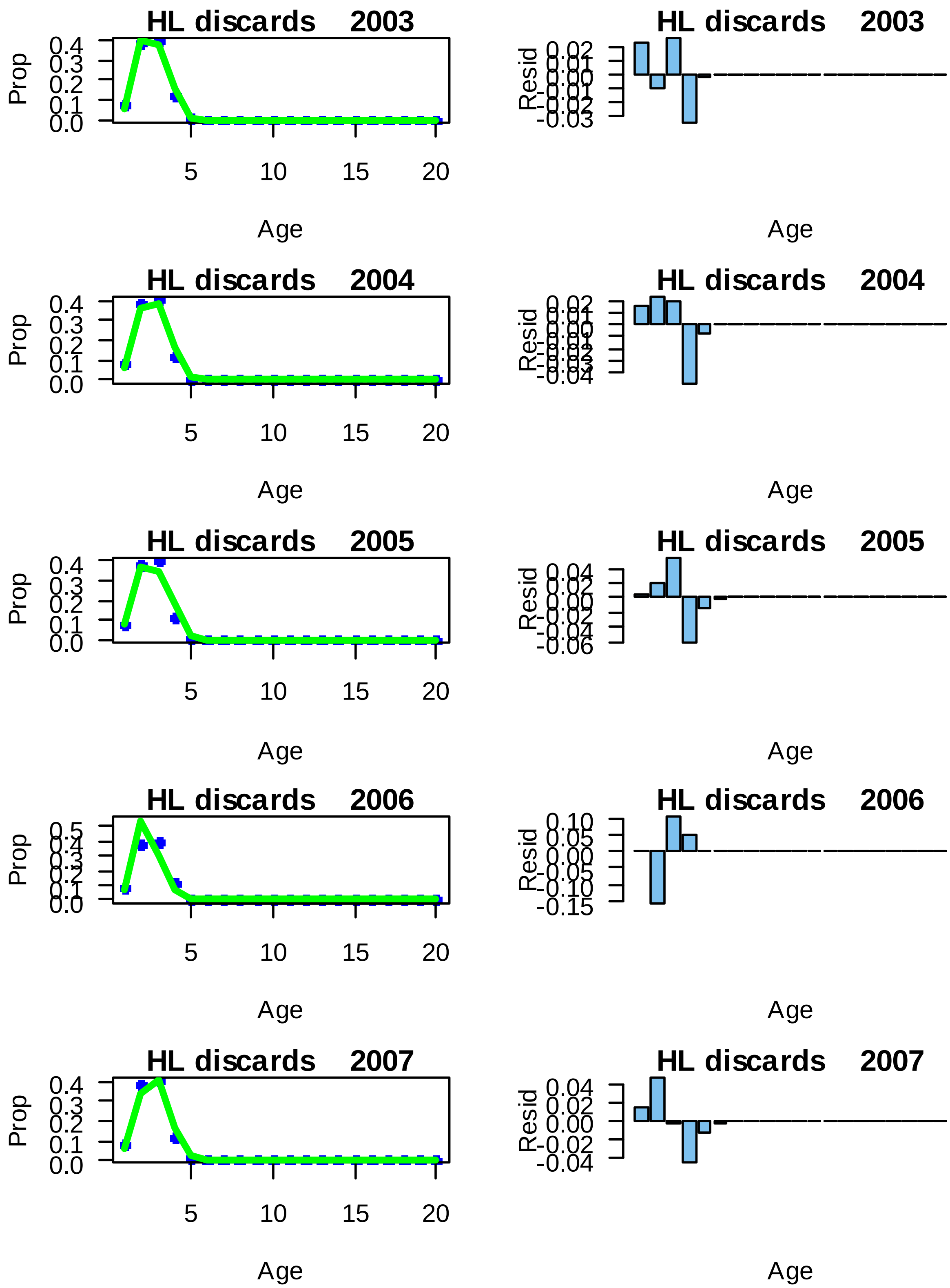

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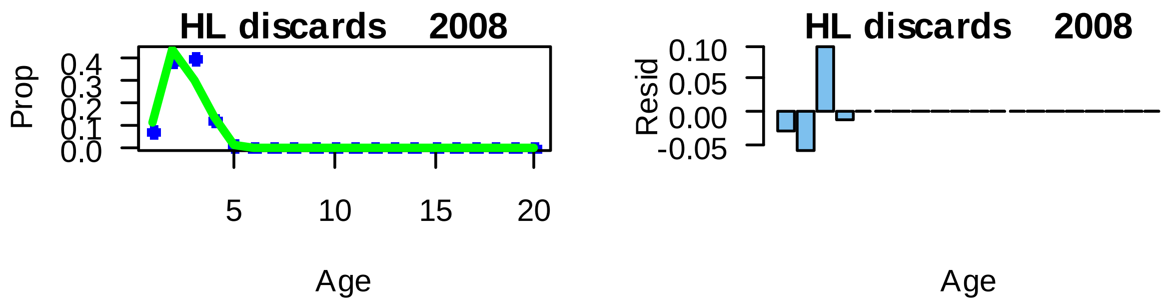

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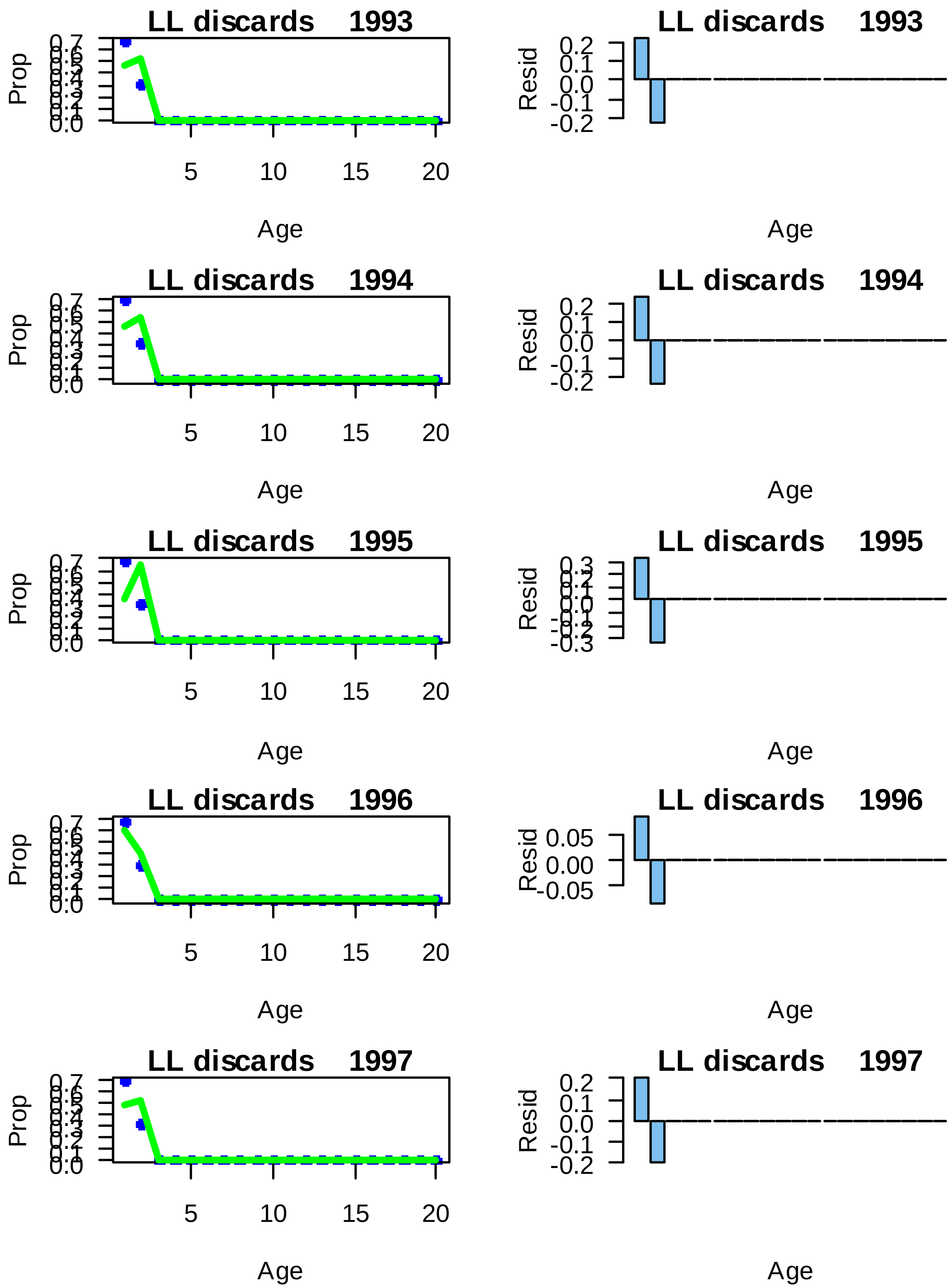

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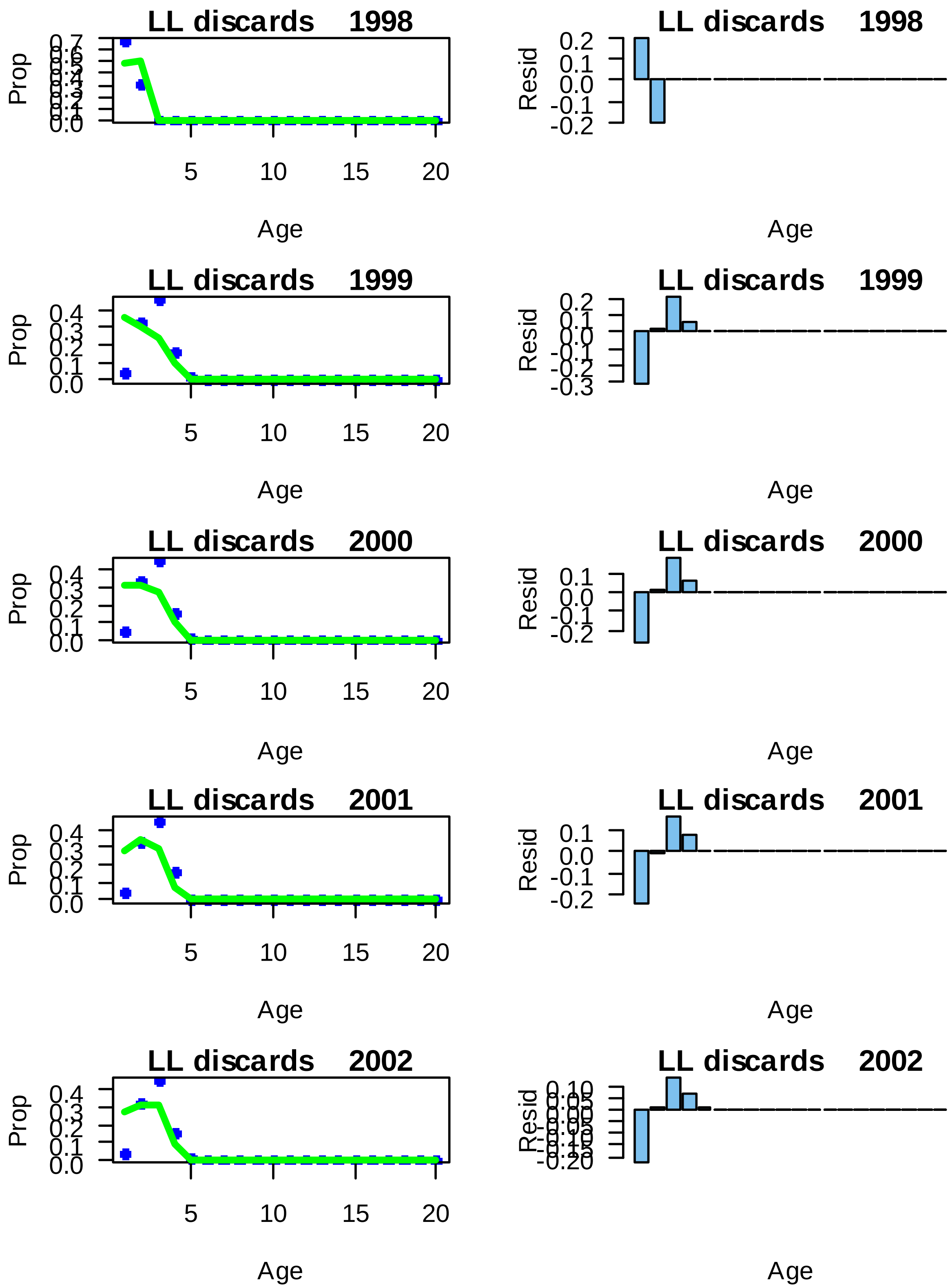

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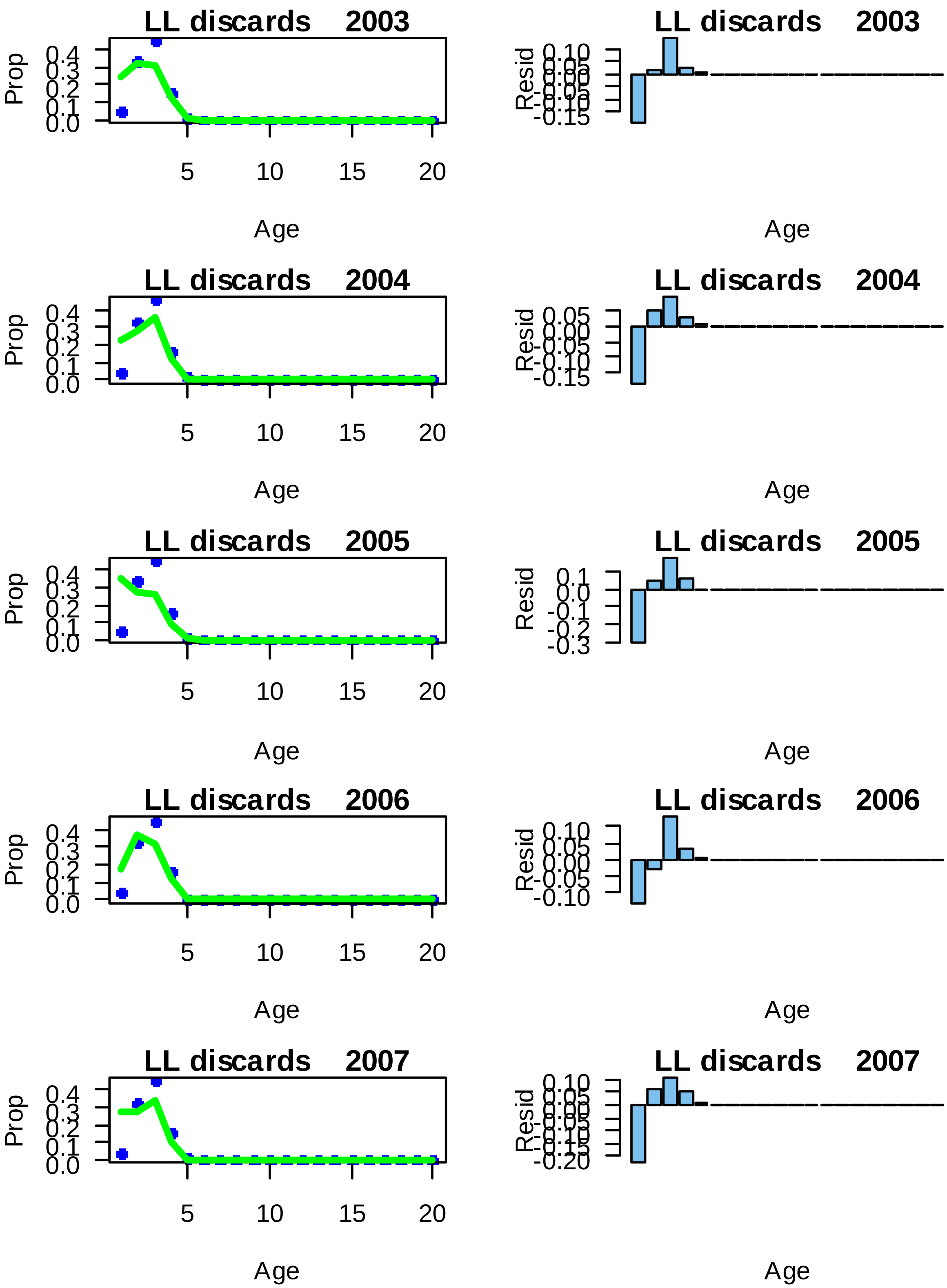

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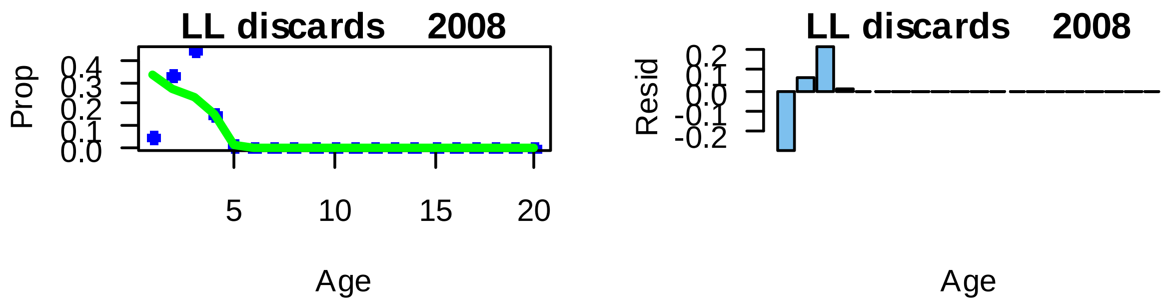

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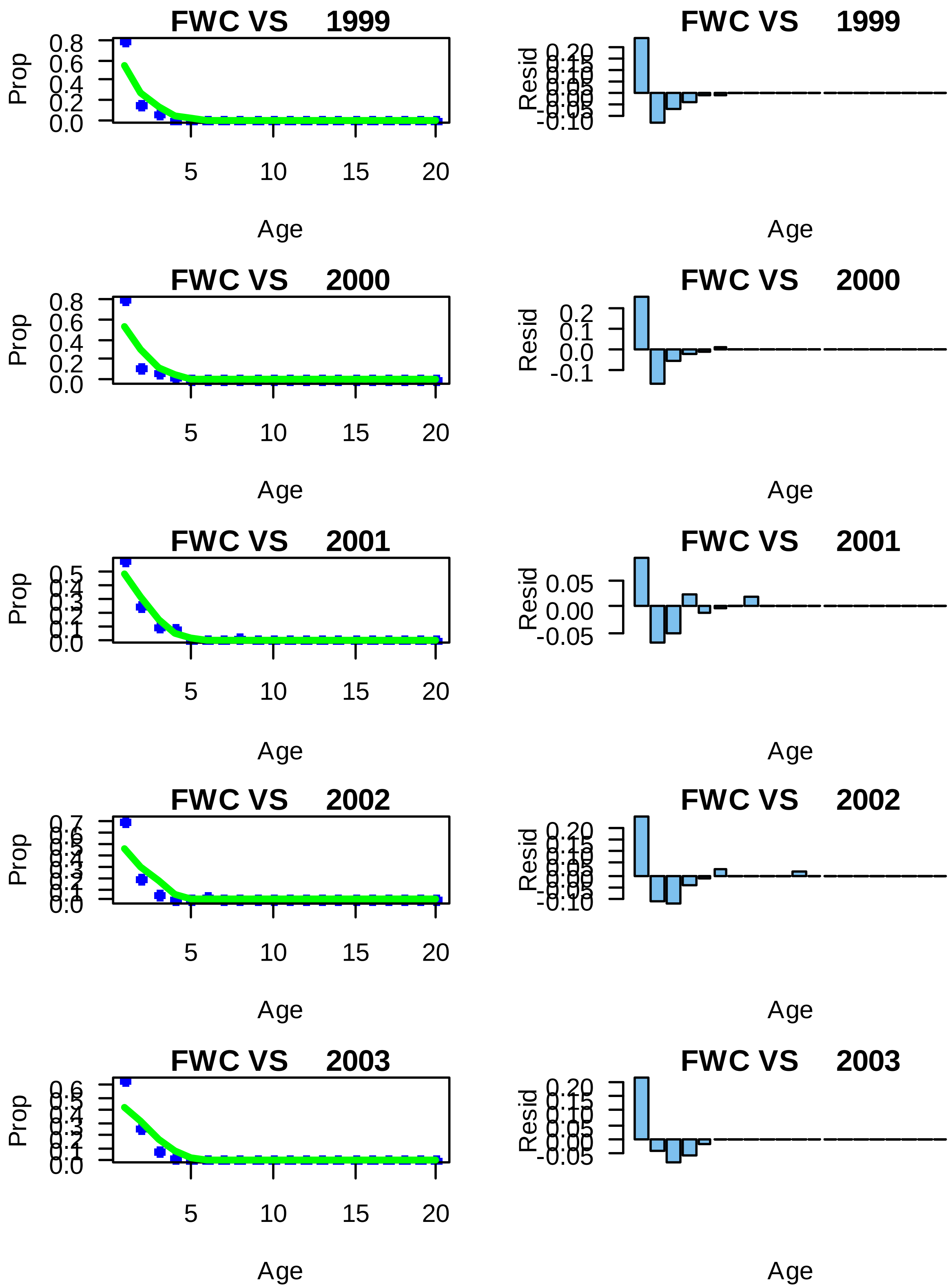
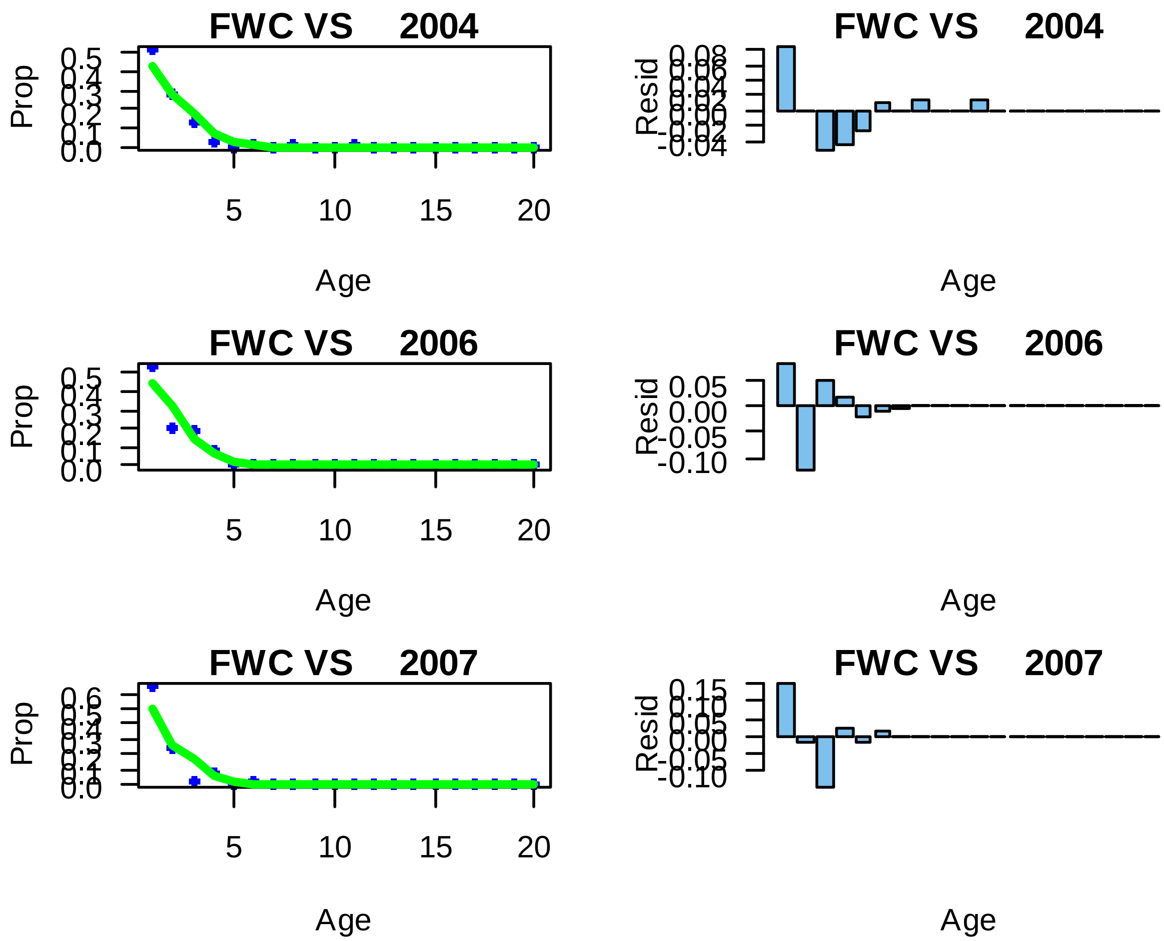


Figure A-3. ASAP2 model fits and standardized residuals of age composition by indices of abundance.



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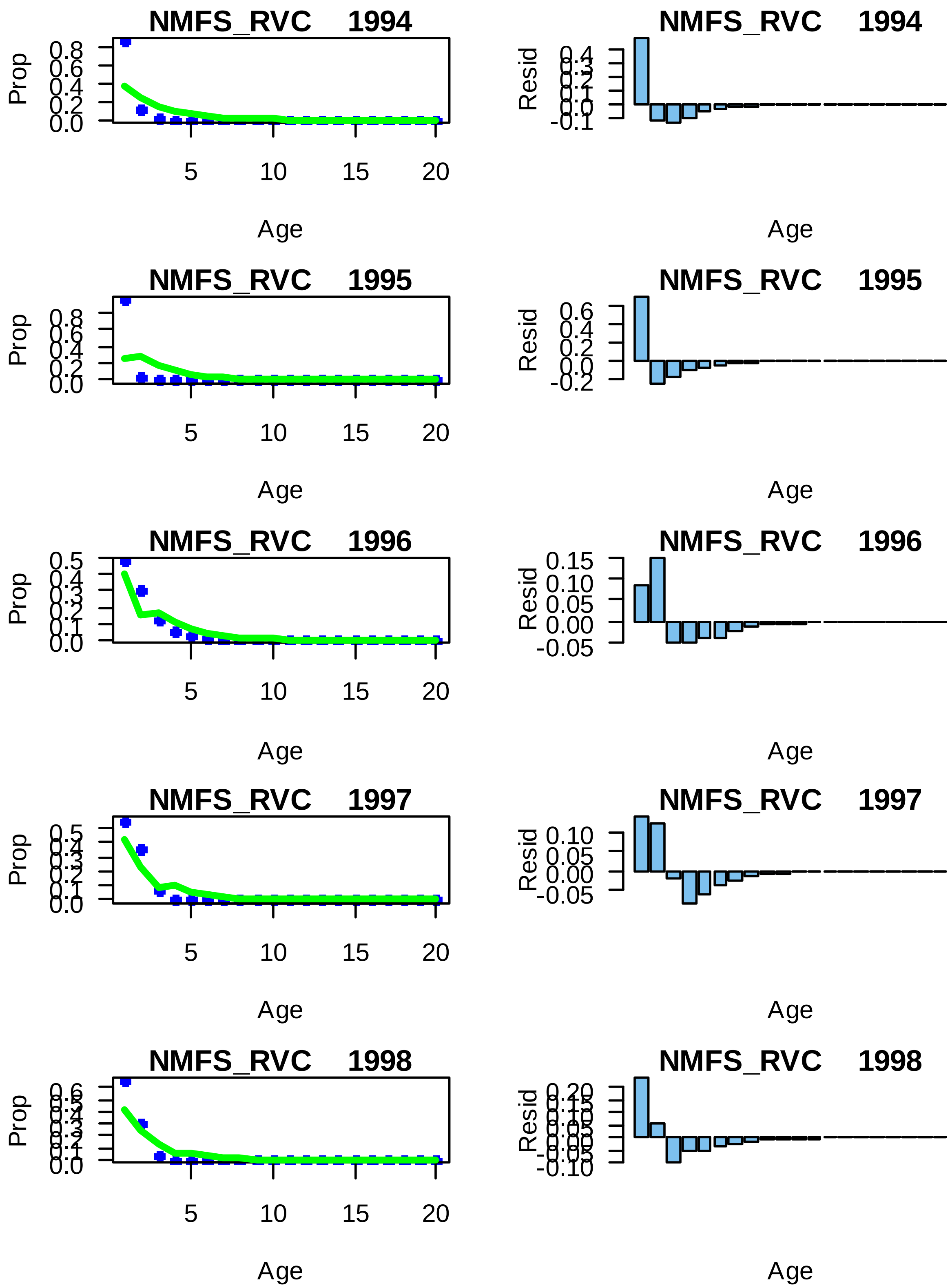

Figure A-3 continued. ASAP2 model fits and standardized residuals of age composition by indices of abundance.

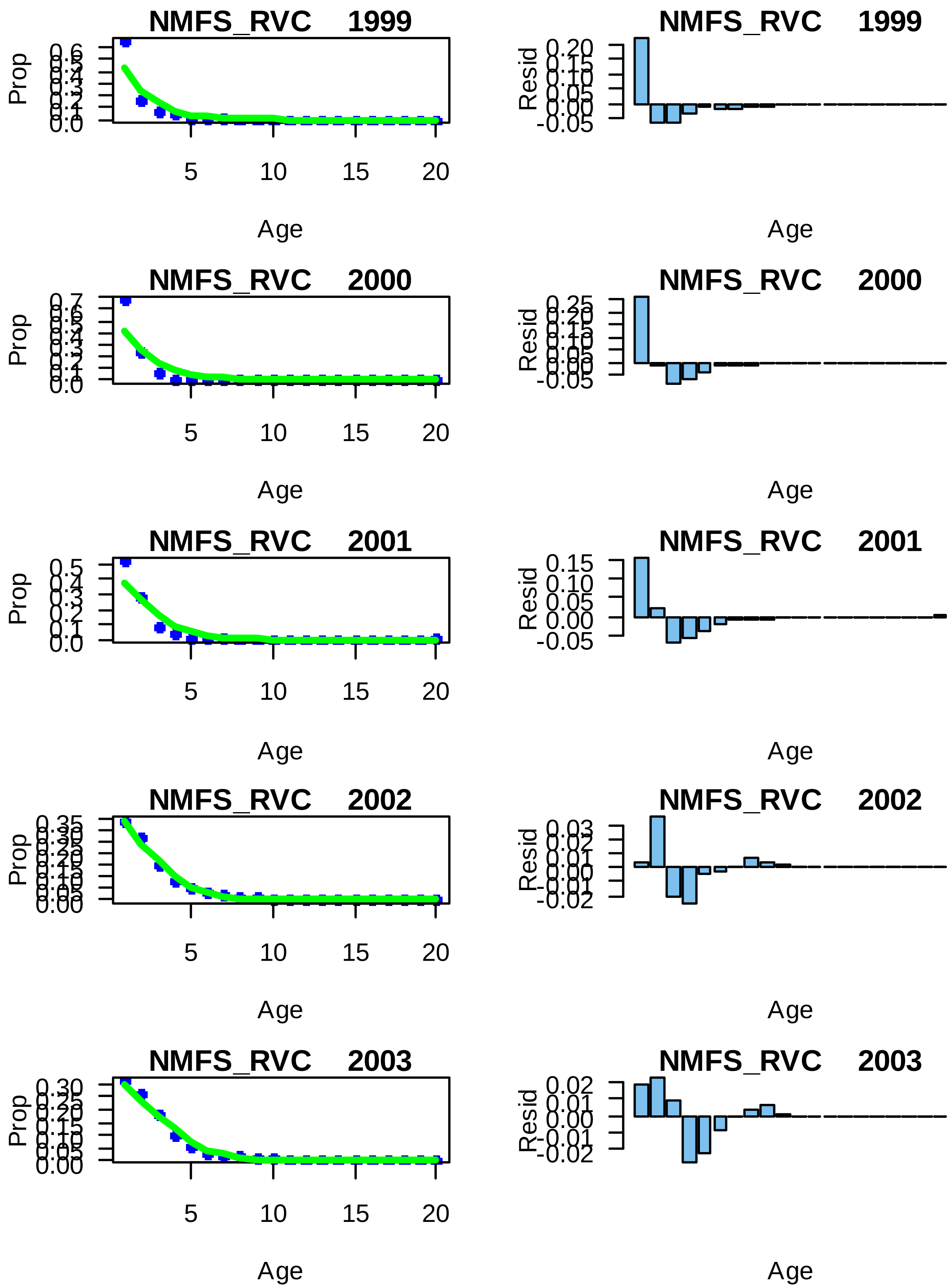

Figure A-3 continued. ASAP2 model fits and standardized residuals of age composition by indices of abundance.

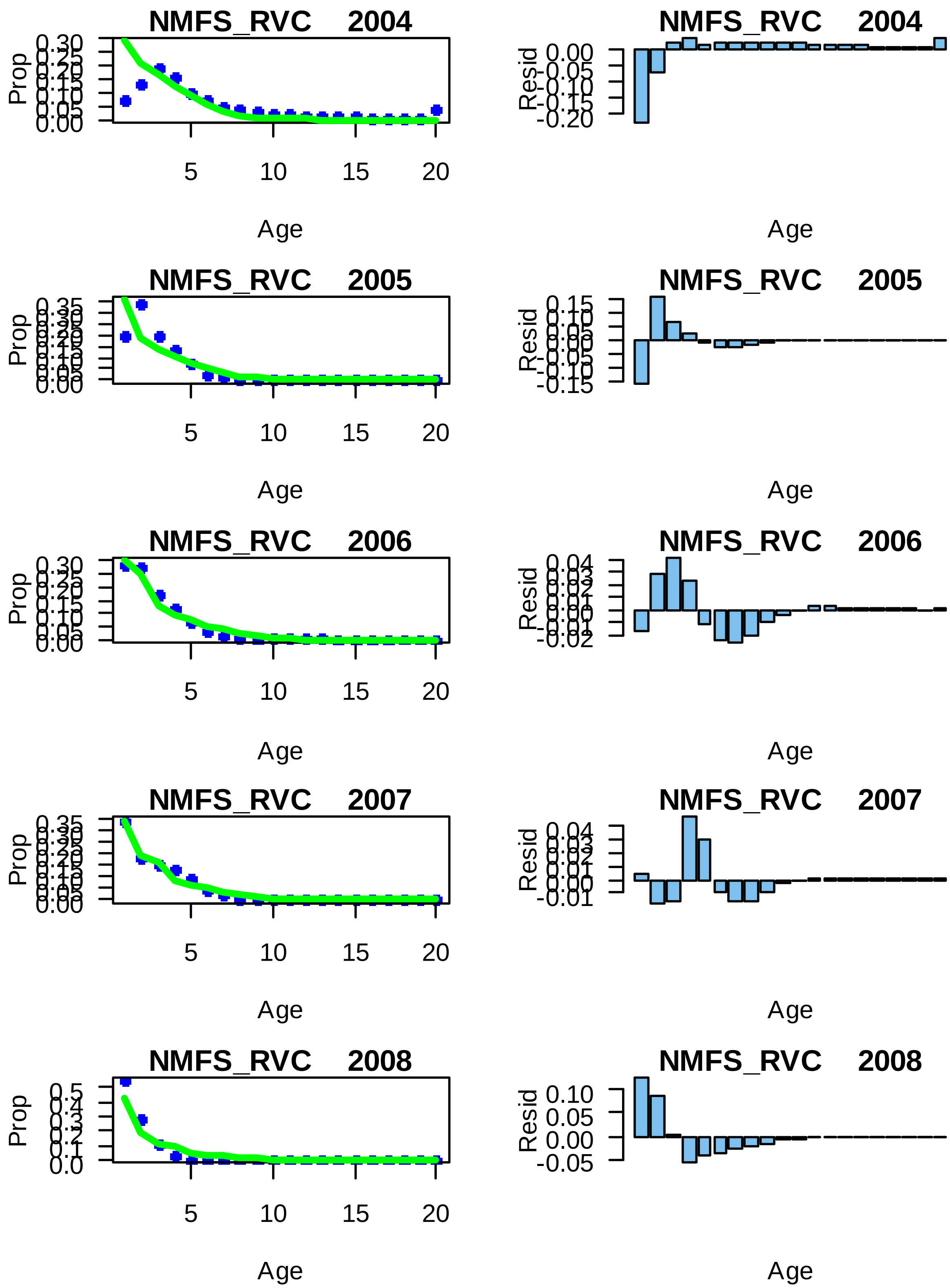

Figure A-3 continued. ASAP2 model fits and standardized residuals of age composition by indices of abundance.

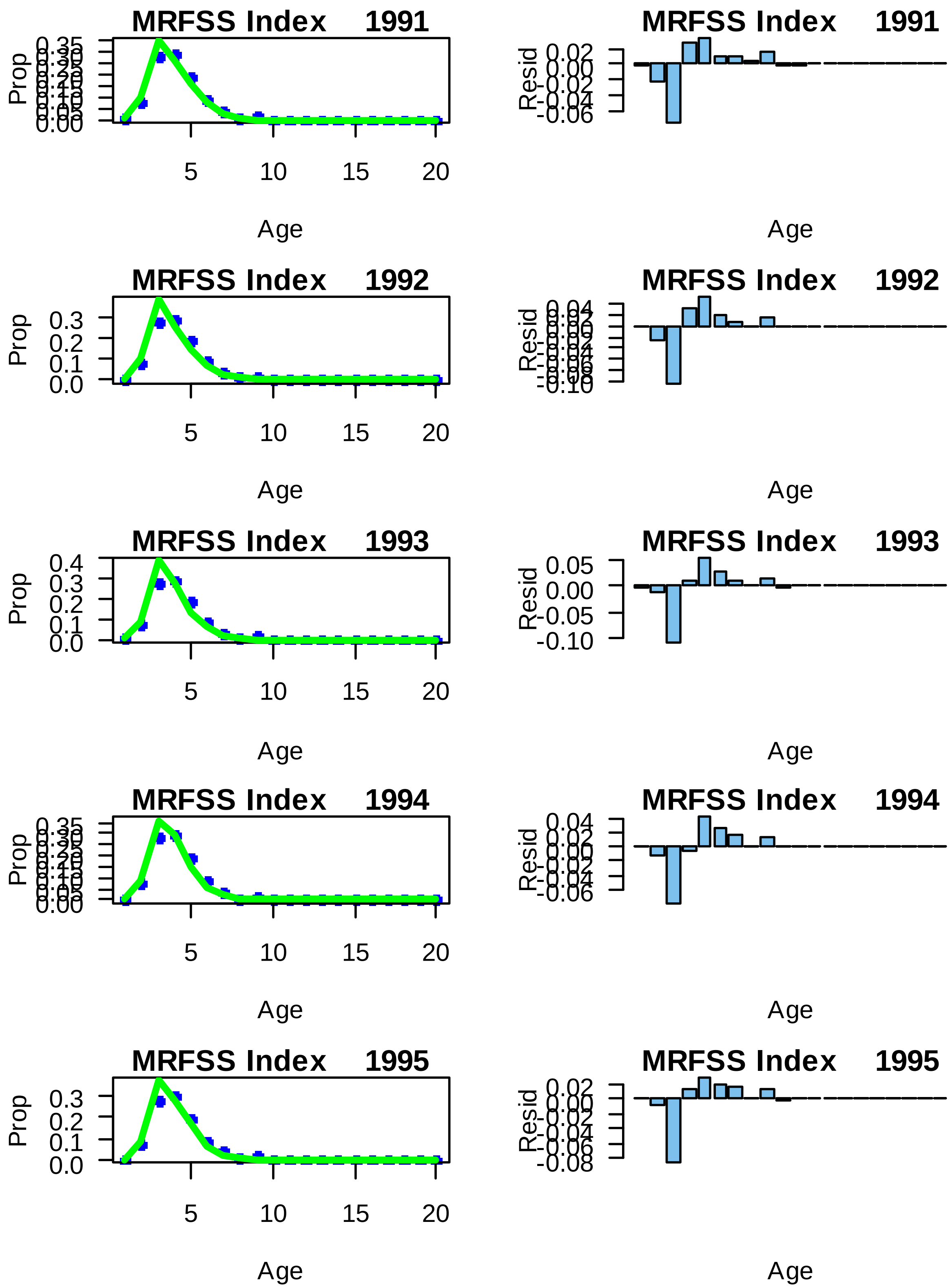

Figure A-3 continued. ASAP2 model fits and standardized residuals of age composition by indices of abundance.

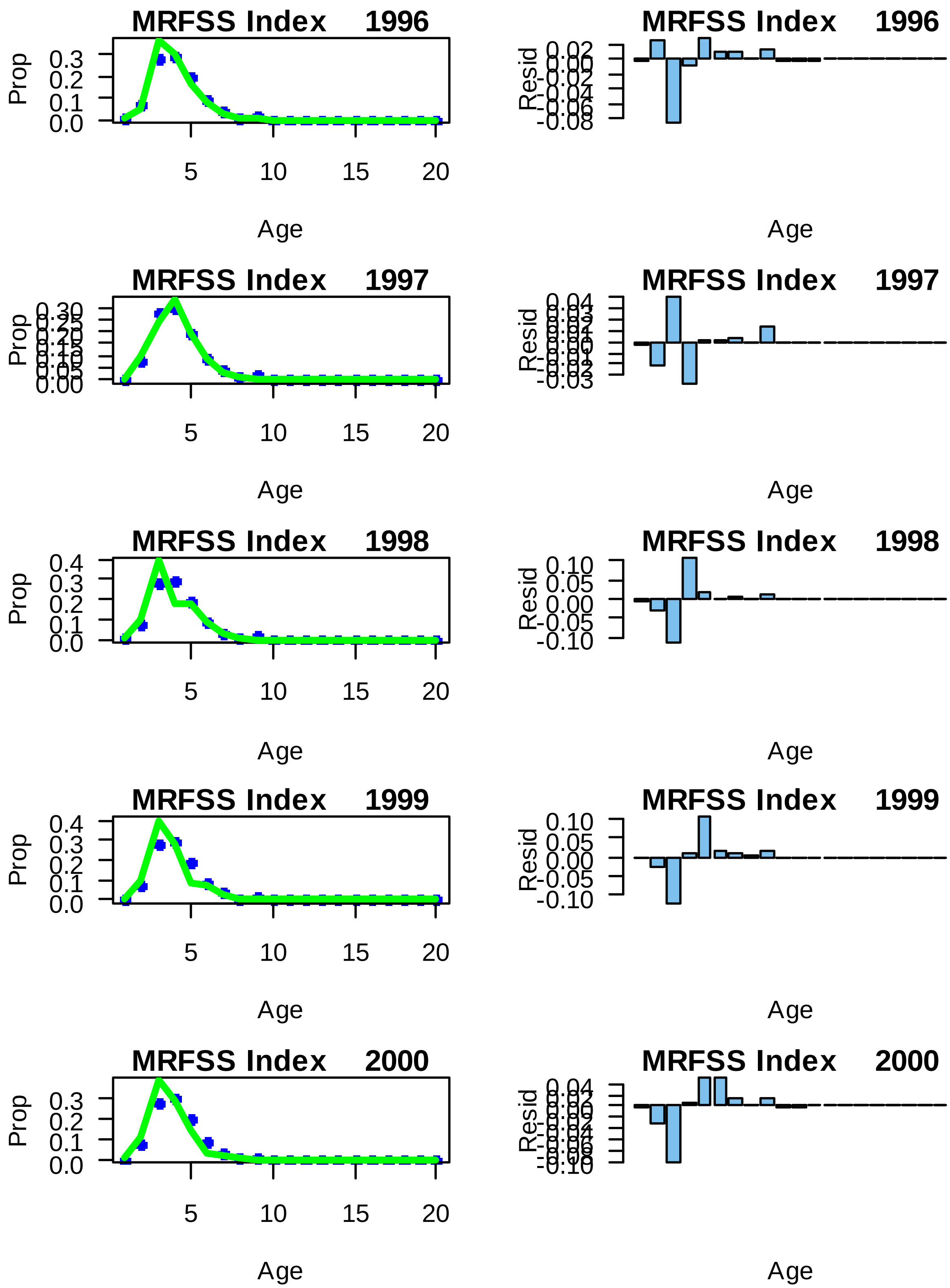

Figure A-3 continued. ASAP2 model fits and standardized residuals of age composition by indices of abundance.

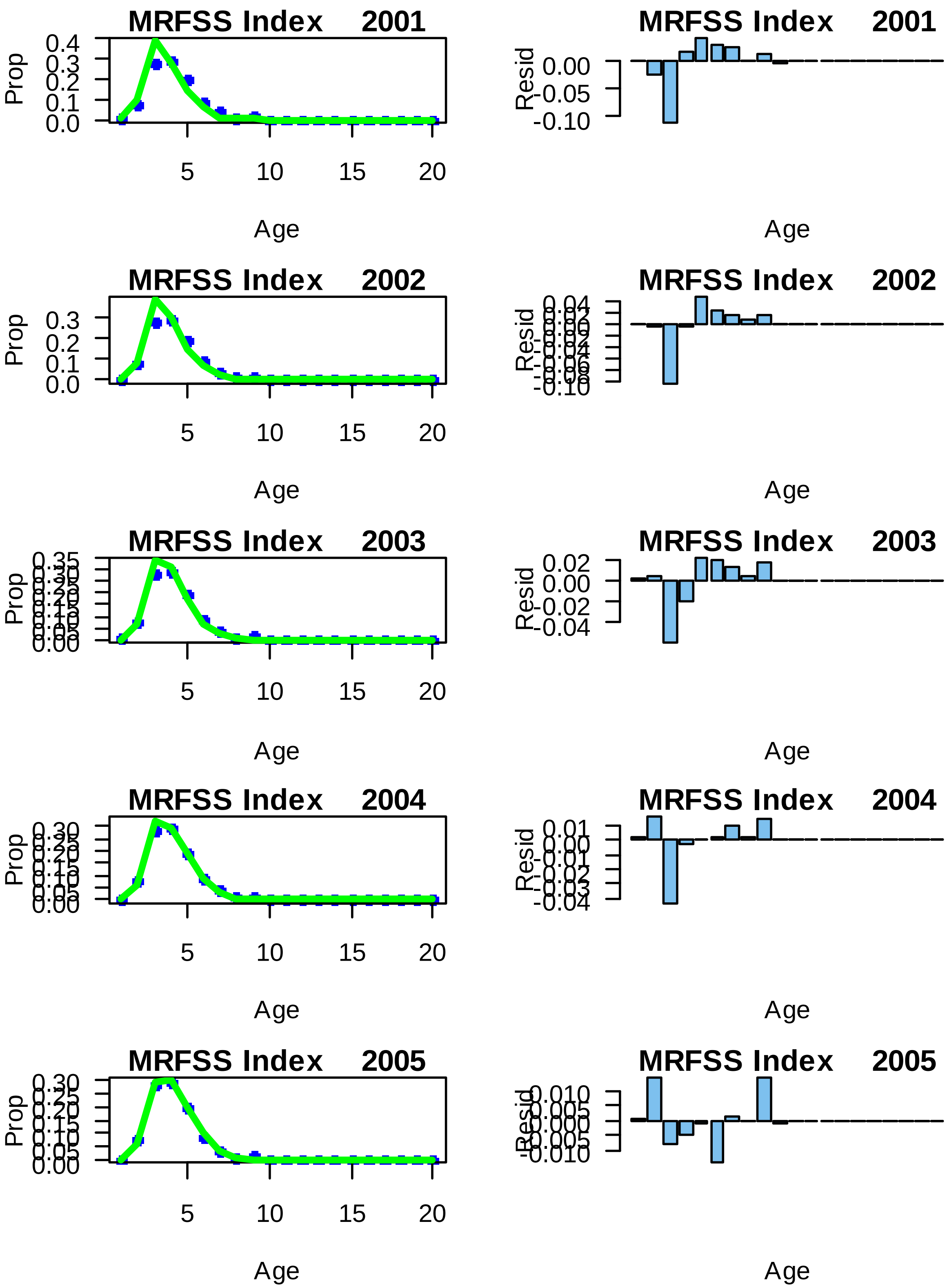

Figure A-3 continued. ASAP2 model fits and standardized residuals of age composition by indices of abundance.

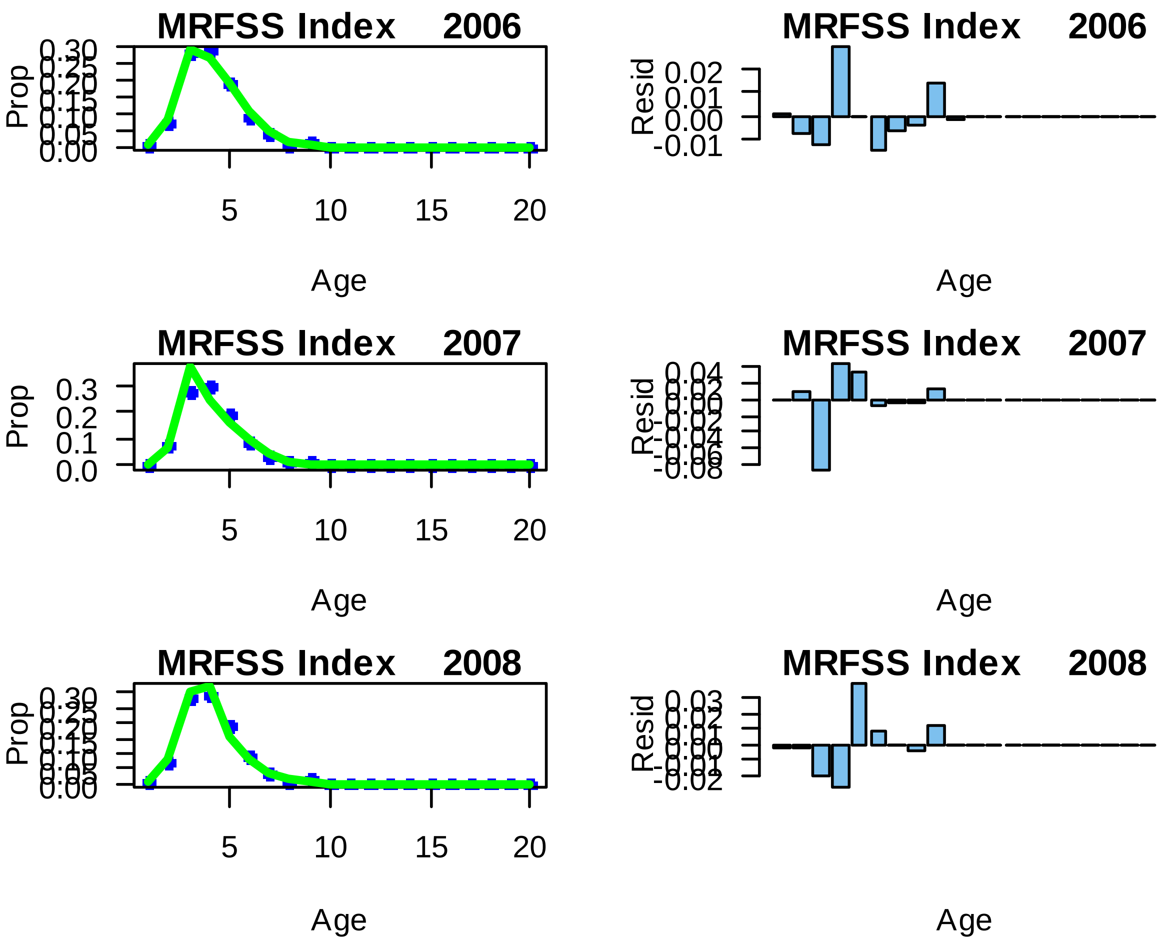

Figure A-3 continued. ASAP2 model fits and standardized residuals of age composition by indices of abundance.

3.5. APPENDIX B

This appendix contains the input data file for the base run, M14_5_5.DAT. That configuration was with the Lorenzen natural mortality curve with an average of 0.136 per year for ages 3-33, four fleets: headboat; general recreational, MRFSS; commercial hook-and-line which contains fish caught with spears and traps; and commercial longline; four fishery independent indices of abundance: FWC Visual Survey incorporating all ages and FWC Visual Survey age-1, NMFS-UM Reef Visual Census incorporating all ages and NMFS-UM Reef Visual Census age-1; initial steepness, 0.75; and release mortality rates of 0.20 for hook-and-line fleets and 0.30 for the long-line fleet, and constant catchability for the fishery-dependent indices.

```
# ASAP VERSION 2.0
# Black grouper 2009  LL logistic  adjusted effective sample sizes FD
constant q
#
# ASAP GUI - 15 JAN 2008
#
# Number of Years
23
# First Year
1986
# Number of Ages
20
# Number of Fleets
4
# Number of Selectivity Blocks (sum over all fleets)
11
# Number of Available Indices
8
# Fleet Names
#$Headboat
#$MRFSS
#$HL
#$LL
# Index Names
#$FWC VS
#$RVC
#$HB
#$MRFSS
#$Logbook HL
#$Logbook LL
#$FWC VS Age 1
#$RVC Age 1
#
# Natural Mortality Rate Matrix
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
```

```
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
0.396  0.297  0.244  0.212  0.190  0.174  0.163  0.154  0.147  0.141
0.137  0.133  0.130  0.128  0.126  0.124  0.123  0.121  0.120  0.116
# Fecundity Option
0
# Fraction of year that elapses prior to SSB calculation (0=Jan-1)
0.202600958
# Maturity Matrix
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
```

```
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
0.000  0.001  0.003  0.015  0.076  0.308  0.705  0.928  0.986  0.997
0.999  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
# Weight at Age for Catch Matrix
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
```

```
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
1.658  4.102  7.607  11.957  16.896  22.176  27.582  32.944  38.134
43.062  47.672  51.932  55.828  59.362  62.547  65.399  67.942  70.200
72.198  80.224
# Weight at Age for Spawning Stock Biomass Matrix
1.182  3.292  6.504  10.631  15.422  20.623  26.009  31.397  36.646
41.657  46.363  50.726  54.728  58.367  61.652  64.599  67.230  69.568
71.640  79.978
1.182  3.292  6.504  10.631  15.422  20.623  26.009  31.397  36.646
41.657  46.363  50.726  54.728  58.367  61.652  64.599  67.230  69.568
71.640  79.978
```

1.182 3.292 6.504 10.631 15.422 20.623 26.009 31.397 36.646
41.657 46.363 50.726 54.728 58.367 61.652 64.599 67.230 69.568
71.640 79.978
1.182 3.292 6.504 10.631 15.422 20.623 26.009 31.397 36.646
41.657 46.363 50.726 54.728 58.367 61.652 64.599 67.230 69.568
71.640 79.978
1.182 3.292 6.504 10.631 15.422 20.623 26.009 31.397 36.646
41.657 46.363 50.726 54.728 58.367 61.652 64.599 67.230 69.568
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41.657 46.363 50.726 54.728 58.367 61.652 64.599 67.230 69.568
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1.182 3.292 6.504 10.631 15.422 20.623 26.009 31.397 36.646
41.657 46.363 50.726 54.728 58.367 61.652 64.599 67.230 69.568
71.640 79.978
1.182 3.292 6.504 10.631 15.422 20.623 26.009 31.397 36.646
41.657 46.363 50.726 54.728 58.367 61.652 64.599 67.230 69.568
71.640 79.978
1.182 3.292 6.504 10.631 15.422 20.623 26.009 31.397 36.646
41.657 46.363 50.726 54.728 58.367 61.652 64.599 67.230 69.568
71.640 79.978

```
1.182  3.292  6.504  10.631  15.422  20.623  26.009  31.397  36.646
41.657  46.363  50.726  54.728  58.367  61.652  64.599  67.230  69.568
71.640  79.978
1.182  3.292  6.504  10.631  15.422  20.623  26.009  31.397  36.646
41.657  46.363  50.726  54.728  58.367  61.652  64.599  67.230  69.568
71.640  79.978
1.182  3.292  6.504  10.631  15.422  20.623  26.009  31.397  36.646
41.657  46.363  50.726  54.728  58.367  61.652  64.599  67.230  69.568
71.640  79.978
# Weight at Age for Jan-1 Biomass Matrix
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
```

```
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
0.895  2.772  5.772  9.733  14.411  19.548  24.913  30.312  35.599  40.664
45.436  49.871  53.947  57.659  61.014  64.028  66.721  69.117  71.240
79.802
# Selectivity Blocks (fleet outer loop, year inner loop)
# Sel block for fleet 1
1
1
1
1
1
1
2
2
2
2
2
2
2
3
3
3
3
3
3
3
3
3
3
# Sel block for fleet 2
4
4
4
4
4
4
```

```
5
5
5
5
5
5
5
6
6
6
6
6
6
6
6
6
6
# Sel block for fleet 3
7
7
7
7
7
7
8
8
8
8
8
8
8
9
9
9
9
9
9
9
9
9
9
# Sel block for fleet 4
10
10
10
10
10
10
10
10
10
10
10
10
10
11
```

```
11
11
11
11
11
11
11
11
11
# Selectivity Options for each block 1=by age, 2=logisitic, 3=double
logistic
3  3  3  3  3  3  3  3  3  2  2
# Selectivity initial guess, phase, lambda, and CV
# (have to enter values for nages + 6 parameters for each block)
# Sel Block 1
1              4              1              5
0.1375         4              1              5
0.0725         4              1              5
0.0898         4              1              5
0.0904         4              1              5
0.076          4              1              5
0.056          4              1              5
0.0379         4              1              5
0.0247         4              1              5
0.0177         4              1              5
0.0135         4              1              5
0.01           -4             0              5
0.01           -4             0              5
0.01           -4             0              5
0.01           -4             0              5
0.01           -4             0              5
0.01           -4             0              5
0.01           -4             0              5
0.01           -4             0              5
0.01           -4             0              5
3.0754         4              1              0.2758
1.1358         4              1              0.7826
2.0074         4              1              0.1623
0.6199         4              1              0.5204
6.4724         4              1              0.0753
1.6111         4              1              0.3377
# Sel Block 2
1              4              1              0.25
0.6534         4              1              0.25
0.2908         4              1              0.25
0.2022         4              1              0.25
0.1607         4              1              0.25
0.1248         4              1              0.25
0.073          4              1              0.25
0.011          4              1              0.25
0.0119         4              1              0.25
0              4              1              0.25
0              4              1              0.25
0              4              1              0.25
0              4              1              0.25
0              4              1              0.25
```

```
0           4     1     0.25
0           4     1     0.25
0           4     1     0.25
0           4     1     0.25
0           4     1     0.25
0           4     1     0.25
2.5838      4     1     0.0943
0.7727      4     1     0.2917
1.0392      4     1     0.0804
2.6993      4     1     0.3629
4.1657      4     1     0.026
1.7151      4     1     0.1732
# Sel Block 3
1           4     1     5
0.9925      4     1     5
0.5103      4     1     5
0.275       4     1     5
0.1979      4     1     5
0.1606      4     1     5
0.1206      4     1     5
0.0835      4     1     5
0.0609      4     1     5
0.0458      4     1     5
0.0405      4     1     5
0.0283      4     1     5
0.025       -4    0     1
0.025       -4    0     1
0.025       -4    0     1
0.025       -4    0     1
0.025       -4    0     1
0.025       -4    0     1
0.025       -4    0     1
0.025       -4    0     1
2.773       4     1     0.3608
1.6822      4     1     0.7991
0.9834      4     1     0.0184
0.0516      4     1     10
2.7547      4     1     0.1844
0.1488      4     1     2.0524
# Sel Block 4
1           4     1     5
0.2966      4     1     5
0.2845      4     1     5
0.2028      4     1     5
0.1544      4     1     5
0.1175      4     1     5
0.1056      4     1     5
0.101       4     1     5
0.096       4     1     5
0.0748      4     1     5
0.0689      4     1     5
0.0528      4     1     5
0.0395      4     1     5
0.03        -4    0     5
0.03        -4    0     5
0.03        -4    0     5
```

```
0.03        -4    0    5
0.03        -4    0    5
0.03        -4    0    5
0.03        -4    0    5
2.9383      4     1    0.6337
2.6439      4     1    1.3838
0.9674      4     1    0.0923
0.0333      4     1    10
4.9297      4     1    0.5787
6.0583      4     1    1.1686
# Sel Block 5
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
5.891       4     1    0.8913
5.2309      4     1    1.9282
1.0586      4     1    0.09
1.872       4     1    0.2351
4.5109      4     1    0.022
1.4026      4     1    0.133
# Sel Block 6
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
0           0     0    0
```

```
0          0          0          0
0          0          0          0
3.886      4          1          0.6387
4.0755     4          1          1.4733
1.0329     4          1          0.0104
21.8469    4          1          5
3.4295     4          1          0.0301
1.4191     4          1          0.1333
# Sel Block 7
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
1.5451     4          1          0.3062
0.3589     4          1          0.9356
1.8764     4          1          0.0366
0.261      4          1          0.3812
6.3243     4          1          0.0223
1.3617     4          1          0.0956
# Sel Block 8
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
0          0          0          0
```

```
1.5451        4             1             0.3062
0.3589        4             1             0.9356
1.7697        4             1             0.0588
0.3244        4             1             0.2922
6.7031        4             1             0.0331
1.8691        4             1             0.1143
# Sel Block 9
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
1.0521        4             1             10
0.0809        4             1             10
1.6574        4             1             0.1251
0.2665        4             1             0.4859
5.0352        4             1             0.075
1.7608        4             1             0.2215
# Sel Block 10
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
5.2998        4             1             0.062
0.9234        4             1             0.3134
```

```
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
# Sel Block 11
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
5.6417        4             1             1.1584
19.4775       4             1             0.9714
0             0             0             0
0             0             0             0
0             0             0             0
0             0             0             0
# Selectivity Start Age by fleet
1  1  1  1
# Selectivity End Age by fleet
20  20  20  20
# Age range for average F
5  5
# Average F report option (1=unweighted, 2=Nweighted, 3=Bweighted)
2
# Use likelihood constants? (1=yes)
1
# Release Mortality by fleet
0.2  0.2  0.2  0.3
# Fleet 1 Catch at Age - Last Column is Total Weight
0.0735     0.1935     0.2061     0.138     0.1165     0.1093     0.0771
0.0484     0.0233     0.0108     0.0036     0.000     0.000     0.000
0.000     0.000     0.000     0.000     0.000     0.000     19976.0
0.0285     0.1068     0.2064     0.1922     0.1423     0.1032     0.0819
0.0641     0.0391     0.0214     0.0107     0.0036     0.000     0.000
0.000     0.000     0.000     0.000     0.000     0.000     39603.0
0.100     0.1389     0.1833     0.1611     0.1333     0.100     0.0556
0.0278     0.0222     0.0222     0.0222     0.0167     0.0111     0.0056
0.000     0.000     0.000     0.000     0.000     0.000     24288.0
0.026     0.2007     0.1933     0.1599     0.1375     0.1078     0.0743
0.0483     0.026     0.0149     0.0074     0.0037     0.000     0.000
0.000     0.000     0.000     0.000     0.000     0.000     19806.0
```

0.004	0.1205	0.1928	0.253	0.2249	0.1165	0.0402
0.008	0.004	0.004	0.008	0.008	0.008	0.004
0.004	0.000	0.000	0.000	0.000	0.000	17764.0
0.000	0.0101	0.1515	0.3535	0.2828	0.1313	0.0606
0.0101	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	15378.0
0.0636	0.2273	0.200	0.1364	0.1636	0.100	0.0545
0.0273	0.0182	0.0091	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	20965.0
0.000	0.0663	0.2652	0.232	0.1713	0.1215	0.0608
0.0221	0.0055	0.0055	0.0055	0.0055	0.0055	0.0055
0.0055	0.0055	0.0055	0.0055	0.0055	0.000	25129.0
0.000	0.0766	0.2727	0.2919	0.1866	0.1005	0.0478
0.0191	0.0048	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	24053.0
0.1079	0.1942	0.3094	0.1727	0.1295	0.0647	0.0216
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	31760.0
0.000	0.050	0.1208	0.1542	0.1958	0.1917	0.1333
0.0792	0.0417	0.0208	0.0083	0.0042	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	36613.0
0.000	0.0269	0.1231	0.2269	0.250	0.1846	0.1115
0.050	0.0192	0.0077	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	48274.0
0.000	0.0535	0.1806	0.1773	0.1572	0.1538	0.1137
0.0736	0.0435	0.0234	0.0134	0.0067	0.0033	0.000
0.000	0.000	0.000	0.000	0.000	0.000	84984.0
0.000	0.0781	0.1719	0.1875	0.1641	0.1094	0.0703
0.0469	0.0313	0.0234	0.0234	0.0156	0.0156	0.0078
0.0078	0.0078	0.0078	0.0078	0.0078	0.0156	25267.0
0.000	0.0625	0.250	0.200	0.125	0.075	0.050
0.0375	0.025	0.025	0.025	0.0125	0.0125	0.0125
0.000	0.025	0.0125	0.0125	0.0125	0.025	15118.0
0.000	0.0707	0.1717	0.1818	0.1515	0.101	0.0707
0.0505	0.0404	0.0303	0.0202	0.0202	0.0202	0.0101
0.0101	0.0101	0.0101	0.0101	0.0101	0.0101	31013.0
0.000	0.033	0.1978	0.1648	0.1538	0.2088	0.1429
0.0659	0.022	0.011	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	15271.0
0.000	0.025	0.125	0.2375	0.2875	0.1875	0.100
0.025	0.0125	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	11940.0
0.000	0.0517	0.2069	0.2241	0.1897	0.1207	0.069
0.0517	0.0345	0.0172	0.0172	0.0172	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	18414.0
0.000	0.0141	0.1972	0.3239	0.169	0.0845	0.0704
0.0563	0.0423	0.0282	0.0141	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	25733.0
0.000	0.0102	0.0816	0.2041	0.2449	0.1939	0.1122
0.051	0.0306	0.0204	0.0204	0.0102	0.0102	0.0102
0.000	0.000	0.000	0.000	0.000	0.000	17862.0
0.0459	0.055	0.1376	0.2385	0.2202	0.1376	0.0826
0.0459	0.0183	0.0092	0.0092	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	17828.0

```
0.000     0.000     0.2632     0.4211     0.2632     0.0526     0.000
0.000     0.000     0.000     0.000     0.000     0.000     0.000
0.000     0.000     0.000     0.000     0.000     0.000     3930.0
# Fleet 2 Catch at Age - Last Column is Total Weight
0.2907     0.1802     0.1337     0.0988     0.0581     0.0523     0.064
0.064     0.0349     0.0174     0.0058     0.000     0.000     0.000
0.000     0.000     0.000     0.000     0.000     0.000     447266.5
0.100     0.3524     0.3143     0.0905     0.0286     0.0286     0.0238
0.0143     0.0143     0.0095     0.0095     0.0095     0.0048     0.000
0.000     0.000     0.000     0.000     0.000     0.000     382020.6
0.1837     0.1224     0.3265     0.1633     0.0204     0.000     0.000
0.0204     0.0408     0.0408     0.0408     0.0204     0.0204     0.000
0.000     0.000     0.000     0.000     0.000     0.000     188198.1
0.0143     0.2143     0.0571     0.100     0.200     0.1429     0.0857
0.0429     0.0429     0.0286     0.0286     0.0286     0.0143     0.000
0.000     0.000     0.000     0.000     0.000     0.000     181452.1
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     74441.0
0.022     0.1648     0.3297     0.2527     0.1648     0.0549     0.011
0.000     0.000     0.000     0.000     0.000     0.000     0.000
0.000     0.000     0.000     0.000     0.000     0.000     398474.9
0.0279     0.2093     0.3674     0.2186     0.0977     0.0419     0.0233
0.0093     0.0047     0.000     0.000     0.000     0.000     0.000
0.000     0.000     0.000     0.000     0.000     0.000     281615.7
0.0892     0.2379     0.3829     0.2193     0.0558     0.0112     0.0037
0.000     0.000     0.000     0.000     0.000     0.000     0.000
0.000     0.000     0.000     0.000     0.000     0.000     140596.2
0.0209     0.0795     0.2427     0.2971     0.1925     0.0879     0.046
0.0209     0.0084     0.0042     0.000     0.000     0.000     0.000
0.000     0.000     0.000     0.000     0.000     0.000     166073.3
0.0571     0.1429     0.2619     0.2095     0.1619     0.0857     0.0429
0.019     0.0095     0.0048     0.0048     0.000     0.000     0.000
0.000     0.000     0.000     0.000     0.000     0.000     236795.5
0.0275     0.145     0.3475     0.2325     0.1325     0.070     0.0325
0.010     0.0025     0.000     0.000     0.000     0.000     0.000
0.000     0.000     0.000     0.000     0.000     0.000     316559.2
0.000     0.110     0.2656     0.2895     0.1866     0.0909     0.0407
0.012     0.0048     0.000     0.000     0.000     0.000     0.000
0.000     0.000     0.000     0.000     0.000     0.000     450156.3
0.000     0.0563     0.2002     0.2471     0.2096     0.123     0.0667
0.0334     0.0198     0.0136     0.0083     0.0063     0.0042     0.0031
0.0021     0.0021     0.001     0.001     0.001     0.001     389371.9
0.0334     0.0922     0.2273     0.2067     0.1431     0.0874     0.0556
0.035     0.0238     0.0175     0.0143     0.0095     0.0079     0.0064
0.0048     0.0064     0.0032     0.0032     0.0032     0.0191     169613.4
0.003     0.118     0.2587     0.2209     0.1437     0.0802     0.0484
0.0272     0.0182     0.0136     0.0106     0.0076     0.0061     0.0061
0.003     0.0076     0.003     0.003     0.003     0.0182     112952.4
0.0111     0.0815     0.242     0.2198     0.1444     0.0827     0.0531
0.0309     0.0222     0.0185     0.0148     0.0099     0.0086     0.0086
0.0062     0.0074     0.0049     0.0049     0.0037     0.0247     136623.3
0.0158     0.0474     0.2281     0.3263     0.2105     0.0947     0.0439
0.0175     0.0088     0.0035     0.0018     0.0018     0.000     0.000
0.000     0.000     0.000     0.000     0.000     0.000     139376.9
```

0.000	0.0091	0.1182	0.261	0.2584	0.1636	0.0896
0.0429	0.0221	0.0117	0.0078	0.0052	0.0039	0.0026
0.0013	0.0013	0.0013	0.000	0.000	0.000	262670.4
0.000	0.0587	0.2478	0.2696	0.1739	0.0935	0.0543
0.0304	0.0196	0.013	0.0087	0.0065	0.0043	0.0043
0.0022	0.0043	0.0022	0.0022	0.0022	0.0022	139018.2
0.000	0.0065	0.0971	0.2686	0.288	0.1715	0.0906
0.0388	0.0194	0.0097	0.0065	0.0032	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	135772.1
0.000	0.0118	0.1183	0.2426	0.2189	0.1479	0.1124
0.0769	0.0414	0.0178	0.0118	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	92165.4
0.000	0.0134	0.179	0.2931	0.2371	0.1298	0.0716
0.0358	0.0201	0.0112	0.0067	0.0022	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	156223.7
0.000	0.1042	0.3359	0.2587	0.1467	0.0811	0.0425
0.0154	0.0077	0.0039	0.0039	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	162408.0

Fleet 3 Catch at Age - Last Column is Total Weight

0.0443	0.217	0.2612	0.1767	0.0963	0.0595	0.0412
0.0294	0.0206	0.0149	0.0108	0.0078	0.0057	0.0041
0.0027	0.0024	0.0017	0.001	0.001	0.0007	426270.4
0.024	0.2295	0.3225	0.2043	0.0969	0.0516	0.0302
0.0174	0.0101	0.0054	0.0027	0.0012	0.0008	0.0008
0.0008	0.0004	0.0004	0.0004	0.0004	0.0004	567539.1
0.0345	0.1725	0.193	0.1904	0.1597	0.1092	0.0645
0.0338	0.0182	0.0102	0.0057	0.0027	0.0011	0.0008
0.0004	0.0008	0.0004	0.0004	0.0004	0.0004	365586.7
0.0549	0.2572	0.2825	0.1893	0.1102	0.0636	0.030
0.0091	0.0024	0.0008	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	384266.8
0.0246	0.1525	0.2402	0.220	0.1555	0.091	0.0498
0.0246	0.014	0.0086	0.0056	0.0035	0.0022	0.0017
0.0013	0.0011	0.0009	0.0006	0.0006	0.0004	299700.1
0.0195	0.0622	0.1653	0.181	0.1647	0.1238	0.0855
0.0559	0.0339	0.022	0.0163	0.0126	0.0113	0.0088
0.0075	0.0057	0.005	0.0038	0.0031	0.0025	163450.6
0.0004	0.0699	0.1719	0.1986	0.1908	0.1349	0.0839
0.0493	0.0313	0.0201	0.0127	0.0074	0.0049	0.0037
0.0025	0.0029	0.0021	0.0016	0.0016	0.0012	218010.4
0.0024	0.0923	0.2628	0.2605	0.1735	0.0882	0.0457
0.023	0.0133	0.008	0.005	0.0032	0.0024	0.0021
0.0018	0.0018	0.0015	0.0015	0.0015	0.0012	165666.2
0.000	0.0545	0.1837	0.2122	0.1611	0.1007	0.073
0.0587	0.0436	0.0294	0.0193	0.0126	0.0092	0.0076
0.0059	0.005	0.0042	0.0034	0.0025	0.0025	139557.8
0.000	0.0399	0.1453	0.198	0.1837	0.125	0.0798
0.0512	0.0361	0.0279	0.0211	0.0158	0.012	0.009
0.006	0.0068	0.0045	0.0045	0.0045	0.0038	115302.6
0.000	0.0966	0.2568	0.2268	0.1631	0.093	0.0486
0.0236	0.015	0.0107	0.0079	0.005	0.0043	0.0043
0.0036	0.0043	0.0043	0.0043	0.0036	0.0036	120418.1
0.000	0.0296	0.1112	0.1531	0.1665	0.1408	0.1067
0.0793	0.0542	0.0369	0.0263	0.0184	0.014	0.0106
0.0073	0.0073	0.005	0.0045	0.0039	0.0034	89464.2

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0.000     0.0459     0.1488     0.1988     0.2058     0.1599     0.1006
0.057     0.0326     0.0186     0.0105     0.0052     0.0029     0.0023
0.0012     0.0017     0.0012     0.0006     0.0006     0.0006     88333.9
0.0047     0.1121     0.1811     0.1616     0.1179     0.0795     0.0563
0.040     0.0311     0.0263     0.0232     0.0174     0.0153     0.0153
0.0105     0.020     0.0095     0.010     0.0095     0.0063     79718.6
0.0012     0.0606     0.1388     0.1488     0.1176     0.0835     0.0641
0.0494     0.0406     0.0359     0.0318     0.0253     0.0224     0.0218
0.0159     0.0235     0.0141     0.0141     0.0135     0.010     92434.1
0.000     0.048     0.1655     0.1772     0.1389     0.0931     0.0655
0.0461     0.0357     0.0299     0.026     0.0191     0.0165     0.0165
0.011     0.0198     0.0104     0.0107     0.0107     0.0071     100950.7
0.000     0.0114     0.101     0.1962     0.2076     0.1558     0.1076
0.0737     0.0487     0.0312     0.0193     0.011     0.007     0.0053
0.0031     0.0035     0.0022     0.0022     0.0018     0.0013     89051.5
0.000     0.0241     0.1025     0.1894     0.2002     0.1417     0.0959
0.0645     0.0434     0.0296     0.0211     0.0151     0.0115     0.0097
0.0078     0.0066     0.006     0.0048     0.0042     0.0036     97394.4
0.0023     0.0667     0.1493     0.1686     0.1516     0.1075     0.0724
0.0486     0.0351     0.0271     0.0226     0.0158     0.0136     0.0136
0.009     0.0181     0.0079     0.009     0.009     0.0057     91731.5
0.0049     0.0111     0.1468     0.2807     0.2346     0.1388     0.0762
0.0369     0.019     0.0117     0.0086     0.0061     0.0055     0.0043
0.0031     0.0025     0.0018     0.0018     0.0012     0.0012     73266.0
0.000     0.0068     0.0698     0.1477     0.1669     0.1341     0.0999
0.0766     0.0602     0.0465     0.0356     0.0274     0.0219     0.0178
0.0137     0.0123     0.0096     0.0082     0.0068     0.0055     72223.5
0.000     0.0126     0.0829     0.192     0.2267     0.1689     0.1091
0.0672     0.0399     0.0252     0.0168     0.0105     0.0073     0.0063
0.0042     0.0052     0.0031     0.0031     0.0031     0.0021     54849.2
0.000     0.0182     0.1275     0.1866     0.1775     0.1335     0.091
0.0607     0.0425     0.0303     0.0228     0.0167     0.0121     0.0121
0.0076     0.0106     0.0061     0.0076     0.0061     0.0046     33236.2
# Fleet 4 Catch at Age - Last Column is Total Weight
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     129456.9
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     125101.3
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     83994.8
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     82395.2
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     109944.5
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
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-999.000     -999.000     -999.000     -999.000     -999.000     -999.000
-999.000     -999.000     53681.3
0.0013     0.023     0.0256     0.0524     0.0972     0.1202     0.1138
0.0997     0.0767     0.0575     0.0448     0.0332     0.0269     0.0243
0.0179     0.0217     0.0166     0.0166     0.0153     0.1151     58786.7
0.000     0.000     0.0167     0.048     0.0835     0.1294     0.1315
0.1148     0.0814     0.0585     0.0438     0.0334     0.0292     0.0271
0.023     0.023     0.0188     0.0188     0.0167     0.1023     35669.6
0.000     0.0025     0.0201     0.0352     0.0427     0.0553     0.0804
0.098     0.103     0.093     0.0779     0.0653     0.0503     0.0402
0.0276     0.0302     0.0226     0.0201     0.0176     0.1181     25400.6
0.000     0.0128     0.0103     0.0141     0.0449     0.0924     0.095
0.0847     0.068     0.0565     0.0488     0.0424     0.0398     0.0385
0.0347     0.0359     0.0321     0.0295     0.027     0.1926     24975.3
0.000     0.0055     0.0128     0.0255     0.0493     0.0894     0.1131
0.1186     0.0967     0.0748     0.0584     0.0438     0.0365     0.0328
0.0255     0.0274     0.0219     0.0201     0.0182     0.1296     29915.0
0.000     0.000     0.0047     0.0179     0.0381     0.063     0.0785
0.0871     0.0894     0.0832     0.0739     0.0653     0.0552     0.0474
0.0404     0.035     0.0303     0.0264     0.0226     0.1415     34643.7
0.000     0.0017     0.0071     0.0255     0.0519     0.0839     0.0887
0.083     0.0717     0.0635     0.0567     0.0505     0.0454     0.0417
0.0366     0.0343     0.0315     0.0281     0.0249     0.1735     41777.6
0.000     0.0033     0.0256     0.0535     0.0772     0.0989     0.1037
0.0999     0.0864     0.0727     0.0608     0.0512     0.0425     0.035
0.0294     0.0242     0.0208     0.0175     0.0148     0.0827     51645.8
0.000     0.0019     0.0118     0.0482     0.0964     0.1181     0.1088
0.0936     0.0735     0.060     0.0512     0.0443     0.0394     0.0347
0.0314     0.0253     0.0237     0.0198     0.0168     0.101     50076.9
0.000     0.0007     0.0147     0.0687     0.1108     0.1205     0.1161
0.1082     0.0903     0.0698     0.0529     0.0392     0.0306     0.0259
0.0209     0.0187     0.0162     0.0137     0.0119     0.0705     55019.9
0.000     0.0017     0.0157     0.0649     0.126     0.153     0.1325
0.1062     0.0816     0.0639     0.0502     0.0396     0.0311     0.0249
0.0198     0.0161     0.013     0.0106     0.0089     0.0403     53496.1
0.000     0.0013     0.0159     0.0444     0.0925     0.1318     0.1296
0.1162     0.0925     0.0709     0.0542     0.0409     0.032     0.0268
0.0211     0.0191     0.0161     0.0139     0.012     0.069     77141.9
0.000     0.000     0.0047     0.0349     0.0803     0.1205     0.1258
0.1171     0.0931     0.0719     0.0561     0.0439     0.0355     0.0299
0.024     0.0221     0.019     0.0165     0.0146     0.090     73384.9
0.000     0.0037     0.0171     0.0577     0.0997     0.1255     0.1303
0.1246     0.1006     0.0755     0.056     0.0412     0.0312     0.0246
0.0189     0.0163     0.0131     0.0109     0.0091     0.044     45734.1
0.0049     0.0174     0.0277     0.0597     0.0934     0.1309     0.1337
0.1214     0.0991     0.078     0.0597     0.0446     0.0323     0.0234
0.016     0.0134     0.0091     0.0071     0.0057     0.0223     61444.0
0.000     0.000     0.0072     0.0376     0.0895     0.1547     0.1558
0.1365     0.1039     0.0762     0.0547     0.0381     0.0276     0.0215
0.0155     0.0144     0.011     0.0094     0.0077     0.0387     43456.8
0.000     0.0009     0.0202     0.0569     0.0909     0.1359     0.1396
0.1295     0.1047     0.0799     0.0597     0.045     0.0321     0.0239
0.0156     0.0147     0.0101     0.0083     0.0064     0.0257     17843.3
# Fleet 1 Discards at Age - Last Column is Total Weight
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0.9351     0.0649     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     8014.2
0.9351     0.0649     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     5391.2
0.9351     0.0649     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     5099.2
0.9351     0.0649     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     3477.3
0.9351     0.0649     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     3205.4
0.9351     0.0649     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     2841.6
0.2732     0.3534     0.2782     0.0877     0.0075     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     13766.6
0.2732     0.3534     0.2782     0.0877     0.0075     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     11506.4
0.2732     0.3534     0.2782     0.0877     0.0075     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     13377.3
0.2732     0.3534     0.2782     0.0877     0.0075     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     22505.2
0.2732     0.3534     0.2782     0.0877     0.0075     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     14477.9
0.2732     0.3534     0.2782     0.0877     0.0075     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     18715.3
0.2732     0.3534     0.2782     0.0877     0.0075     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     30447.9
0.5342     0.3562     0.0959     0.0137     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     8628.2
0.5342     0.3562     0.0959     0.0137     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     4906.1
0.5342     0.3562     0.0959     0.0137     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     9549.5
0.5342     0.3562     0.0959     0.0137     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     3788.2
0.5342     0.3562     0.0959     0.0137     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     4295.6
```

```
0.5342    0.3562    0.0959    0.0137    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    7272.8
0.3529    0.3529    0.2353    0.0588    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    8958.9
0.5625    0.375    0.0625    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    3361.7
0.6053    0.3421    0.0526    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    4181.1
0.5342    0.3562    0.0959    0.0137    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    1514.0
# Fleet 2 Discards at Age - Last Column is Total Weight
0.9351    0.0649    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    10690.8
0.9351    0.0649    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    49625.8
0.9351    0.0649    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    5097.3
0.9351    0.0649    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    6575.9
0.9351    0.0649    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    5603.8
0.9351    0.0649    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    23995.1
0.3323    0.3354    0.25    0.0762    0.0061    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    83613.7
0.3323    0.3354    0.25    0.0762    0.0061    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    50557.6
0.3323    0.3354    0.25    0.0762    0.0061    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    73073.6
0.3323    0.3354    0.25    0.0762    0.0061    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    29112.6
0.3323    0.3354    0.25    0.0762    0.0061    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    78263.9
0.3323    0.3354    0.25    0.0762    0.0061    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    64598.7
0.3323    0.3354    0.25    0.0762    0.0061    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    52970.4
```

```
0.1652    0.3443    0.3673    0.115    0.0082    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    82449.0
0.1652    0.3443    0.3673    0.115    0.0082    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    65786.0
0.1652    0.3443    0.3673    0.115    0.0082    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    52492.5
0.1652    0.3443    0.3673    0.115    0.0082    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    63012.0
0.1652    0.3443    0.3673    0.115    0.0082    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    24530.9
0.1652    0.3443    0.3673    0.115    0.0082    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    79234.4
0.1652    0.3443    0.3673    0.115    0.0082    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    23541.0
0.1652    0.3443    0.3673    0.115    0.0082    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    36501.0
0.1652    0.3443    0.3673    0.115    0.0082    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    58075.3
0.1652    0.3443    0.3673    0.115    0.0082    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    82196.9
# Fleet 3 Discards at Age - Last Column is Total Weight
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    -999.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    -999.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    0.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    -999.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    -999.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    0.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    -999.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    -999.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    0.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    -999.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    -999.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    0.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    -999.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    -999.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    0.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    -999.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    -999.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    0.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    -999.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    -999.0
-999.0    -999.0    -999.0    -999.0    -999.0    -999.0    0.0
0.1431    0.4037    0.3429    0.1023    0.0072    0.0008    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    6516.7
```

```
0.1431     0.4037     0.3429     0.1023     0.0072     0.0008     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     7934.5
0.1431     0.4037     0.3429     0.1023     0.0072     0.0008     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     6586.6
0.1431     0.4037     0.3429     0.1023     0.0072     0.0008     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     7152.2
0.1431     0.4037     0.3429     0.1023     0.0072     0.0008     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     7566.2
0.1431     0.4037     0.3429     0.1023     0.0072     0.0008     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     6995.2
0.0789     0.3872     0.4045     0.1201     0.0085     0.0008     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     11585.6
0.0789     0.3872     0.4045     0.1201     0.0085     0.0008     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     11457.0
0.0789     0.3872     0.4045     0.1201     0.0085     0.0008     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     9915.1
0.0789     0.3872     0.4045     0.1201     0.0085     0.0008     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     8338.5
0.0789     0.3872     0.4045     0.1201     0.0085     0.0008     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     10555.0
0.0789     0.3872     0.4045     0.1201     0.0085     0.0008     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     7483.3
0.0789     0.3872     0.4045     0.1201     0.0085     0.0008     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     11452.1
0.0789     0.3872     0.4045     0.1201     0.0085     0.0008     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     1423.8
0.0789     0.3872     0.4045     0.1201     0.0085     0.0008     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     12384.8
0.0789     0.3872     0.4045     0.1201     0.0085     0.0008     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     2123.1
# Fleet 4 Discards at Age - Last Column is Total Weight
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     -999.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     -999.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     0.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     -999.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     -999.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     0.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     -999.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     -999.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     0.0
```

```
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     -999.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     -999.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     0.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     -999.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     -999.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     0.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     -999.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     -999.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     0.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     -999.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     -999.0
-999.0     -999.0     -999.0     -999.0     -999.0     -999.0     0.0
0.6873     0.3127     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     85.9
0.6873     0.3127     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     103.8
0.6873     0.3127     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     92.9
0.6873     0.3127     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     110.0
0.6873     0.3127     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     120.0
0.6873     0.3127     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     113.5
0.0462     0.3333     0.4538     0.1564     0.0103     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     340.4
0.0462     0.3333     0.4538     0.1564     0.0103     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     311.7
0.0462     0.3333     0.4538     0.1564     0.0103     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     292.6
0.0462     0.3333     0.4538     0.1564     0.0103     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     355.1
0.0462     0.3333     0.4538     0.1564     0.0103     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     330.2
0.0462     0.3333     0.4538     0.1564     0.0103     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     380.1
0.0462     0.3333     0.4538     0.1564     0.0103     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     218.6
0.0462     0.3333     0.4538     0.1564     0.0103     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     258.9
```

```
0.0462    0.3333    0.4538    0.1564    0.0103    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    260.4
0.0462    0.3333    0.4538    0.1564    0.0103    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    276.5
# Fleet 1 Release Proportion at Age
0.9852    0.6366    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0
0.9942    0.7605    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0
0.9799    0.7094    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0
0.9947    0.6281    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0
0.9992    0.7378    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0
1.0    0.9711    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0
0.9573    0.8904    0.879    0.7707    0.1936    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0
1.0    0.9653    0.8457    0.6638    0.1866    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0
1.0    0.9602    0.842    0.6109    0.1739    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0
0.9297    0.9048    0.8245    0.7263    0.2327    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0
1.0    0.9736    0.9232    0.7483    0.1671    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0
1.0    0.9856    0.9219    0.6688    0.1358    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0
1.0    0.9718    0.8895    0.7211    0.1999    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0
1.0    0.9597    0.7445    0.2762    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0
1.0    0.9675    0.6671    0.2635    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0
1.0    0.9634    0.7447    0.2824    0.0    0.0    0.0    0.0
0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
0.0    0.0    0.0
```

```
1.0     0.9826     0.7169     0.3027     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9867     0.8003     0.2315     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.973     0.7077     0.242     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
1.0     0.9924     0.8618     0.4868     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9948     0.8     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
0.9857     0.9701     0.6664     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     1.0     0.6556     0.1453     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
# Fleet 2 Release Proportion at Age
0.6335     0.1621     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
0.963     0.3391     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
0.7352     0.2242     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
0.9796     0.1821     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
1.0     1.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
0.9898     0.473     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
0.968     0.803     0.6338     0.47     0.137     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
0.8792     0.7337     0.5606     0.4045     0.1761     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
0.9821     0.9356     0.7802     0.4692     0.0984     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
0.8801     0.7477     0.5465     0.3147     0.0454     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
0.9663     0.846     0.6308     0.4377     0.0985     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
```

```
1.0     0.8364     0.6123     0.3064     0.052     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9207     0.7088     0.3755     0.0537     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
0.947     0.9309     0.8537     0.6677     0.1717     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
0.9964     0.9361     0.877     0.7235     0.2231     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
0.9806     0.9348     0.8374     0.6399     0.1618     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
0.9763     0.9662     0.8636     0.5809     0.1331     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9916     0.9068     0.5798     0.0905     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9522     0.8343     0.5919     0.1383     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9883     0.8577     0.4056     0.0435     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9917     0.9269     0.6595     0.1329     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9873     0.8618     0.544     0.0953     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9232     0.7993     0.6182     0.1694     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
# Fleet 3 Release Proportion at Age
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
```

```
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
0.9655     0.6686     0.3759     0.1535     0.0188     0.0042     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0
1.0     0.855     0.5978     0.2774     0.0343     0.0063     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.8914     0.657     0.2955     0.0308     0.0052     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.7533     0.4938     0.2479     0.0312     0.0062     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9392     0.7774     0.4308     0.0466     0.0064     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9031     0.7096     0.3531     0.0357     0.0053     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
0.971     0.8742     0.8181     0.5994     0.1263     0.0191     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0
0.9911     0.9136     0.8282     0.5717     0.1064     0.015     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0
1.0     0.9141     0.7634     0.4722     0.0745     0.0108     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9812     0.8607     0.4855     0.0592     0.0076     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9561     0.8426     0.4625     0.0543     0.0073     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
0.9746     0.8644     0.7485     0.439     0.0578     0.0078     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0
0.9782     0.9899     0.8852     0.545     0.0918     0.0153     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0
1.0     0.9509     0.665     0.2177     0.0171     0.002     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9912     0.9469     0.6957     0.1201     0.0164     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9499     0.7391     0.3648     0.0408     0.0051     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
# Fleet 4 Release Proportion at Age
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
```

```
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
1.0     1.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
1.0     0.9691     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
1.0     0.8607     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
1.0     0.9178     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
1.0     1.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
1.0     0.9648     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
1.0     0.9263     0.69     0.2685     0.0164     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9558     0.8274     0.2887     0.0131     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9808     0.7722     0.2005     0.0101     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9477     0.7283     0.1827     0.0075     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     0.9566     0.7113     0.2331     0.0095     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     1.0     0.8719     0.239     0.0089     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
```

```
1.0     0.8632     0.6506     0.1601     0.0072     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
0.4063     0.5793     0.5411     0.1587     0.0078     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
1.0     1.0     0.8482     0.2691     0.01     0.0     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0
1.0     0.986     0.8135     0.3479     0.0214     0.0     0.0     0.0
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
0.0     0.0     0.0
# Index Units
2  2  2  2  1  1  2  2
# Index Month
7  7  -1  -1  -1  -1  7  7
# Index Selectivity Choice
-1  -1  1  -1  3  4  -1  -1
# Index Selectivity Option for each Index 1=by age, 2=logisitic, 3=double
logistic
3  3  3  3  3  3  1  1
# Index Start Age
1  1  1  1  1  1  1  1
# Index End Age
20  20  20  20  20  20  1  1
# Use Index? 1=yes
1  1  1  1  1  1  1  1
# Index Selectivity initial guess, phase, lambda, and CV
# (have to enter values for nages + 6 parameters for each block)
# Index-1
1             5             1             5
0.6265        5             1             5
0.3373        5             1             5
0.1741        5             1             5
0.0803        5             1             5
0             -5            0             5
0             -5            0             5
0             -5            0             5
0             -5            0             5
0             -5            0             5
0             -5            0             5
0             -5            0             5
0             -5            0             5
0             -5            0             5
0             -5            0             5
0             -5            0             5
0             -5            0             5
0             -5            0             5
0             -5            0             5
0             -5            0             5
0             0             0             0
0             0             0             0
0.0444        5             1             0.1642
0.0192        5             1             5
3.2542        5             1             0.0215
0.885         5             1             0.0713
```

```
# Index-2
1            5            1            5
0.7061       5            1            5
0.4217       5            1            5
0.3079       5            1            5
0.2102       5            1            5
0.1302       5            1            5
0.0899       5            1            5
0            -5           0            5
0            -5           0            5
0            -5           0            5
0            -5           0            5
0            -5           0            5
0            -5           0            5
0            -5           0            5
0            -5           0            5
0            -5           0            5
0            -5           0            5
0            -5           0            5
0            -5           0            5
0            -5           0            5
0            0            0            0
0            0            0            0
0.4284       5            1            0.3427
0.2402       5            1            0.3106
5.7987       5            1            0.0433
1.6471       5            1            0.1412
# Index-3
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            -1           0            0
0            -1           0            0
0            -1           0            0
0            -1           0            0
# Index-4
0            0            0            0
```

```
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
2.2263       5            1            0.0265
0.2152       5            1            0.2384
5.5227       5            1            0.0098
0.6215       5            1            0.0771
# Index-5
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            -1           0            0
0            -1           0            0
0            -1           0            0
0            -1           0            0
# Index-6
0            0            0            0
0            0            0            0
0            0            0            0
```

```
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
0           -1          0           0
0           -1          0           0
0           -1          0           0
0           -1          0           0
# Index-7
1           -1          1           1
0           -1          0           1
0           -1          0           1
0           -1          0           1
0           -1          0           1
0           -1          0           1
0           -1          0           1
0           -1          0           1
0           -1          0           1
0           -1          0           1
0           -1          0           1
0           -1          0           1
0           -1          0           1
0           -1          0           1
0           -1          0           1
0           -1          0           1
0           -1          0           1
0           -1          0           1
0           -1          0           1
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
0           0           0           0
# Index-8
1           -1          0           1
0           -1          0           1
0           -1          0           1
0           -1          0           1
0           -1          0           1
```

```
0            -1           0            1
0            -1           0            1
0            -1           0            1
0            -1           0            1
0            -1           0            1
0            -1           0            1
0            -1           0            1
0            -1           0            1
0            -1           0            1
0            -1           0            1
0            -1           0            1
0            -1           0            1
0            -1           0            1
0            -1           0            1
0            -1           0            1
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
0            0            0            0
# Index Data - Year, Index Value, CV, proportions at age and input
effective sample size (only used if estimating parameters)
# Index-1
1986     -999     1         0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1987     -999     1         0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1988     -999     1         0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1989     -999     1         0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1990     -999     1         0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1991     -999     1         0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1992     -999     1         0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1993     -999     1         0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
```

```
1994      -999      1         0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0
1995      -999      1         0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0
1996      -999      1         0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0
1997      -999      1         0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0
1998      -999      1         0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0
1999      1.54      0.15      0.8000    0.1429    0.0571    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    16
2000      1.26      0.16      0.7850    0.1215    0.0654    0.0187
0.0000    0.0093    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    19
2001      1.05      0.14      0.5729    0.2396    0.0938    0.0729
0.0000    0.0000    0.0000    0.0208    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    21
2002      0.87      0.13      0.7031    0.1875    0.0469    0.0156
0.0000    0.0313    0.0000    0.0000    0.0000    0.0000    0.0156
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    21
2003      0.78      0.16      0.6393    0.2623    0.0820    0.0164
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    22
2004      1.06      0.19      0.5231    0.2769    0.1231    0.0308
0.0000    0.0154    0.0000    0.0154    0.0000    0.0000    0.0154
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    21
2005      -999      1         0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0
2006      0.8       0.17      0.5283    0.2075    0.1887    0.0755
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    21
2007      0.85      0.16      0.6481    0.2407    0.0185    0.0741
0.0000    0.0185    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    21
```

```
2008      -999      1         0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0
# Index-2
1986      -999      1         0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0
1987      -999      1         0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0
1988      -999      1         0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0
1989      -999      1         0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0
1990      -999      1         0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0
1991      -999      1         0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0
1992      -999      1         0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0
1993      -999      1         0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0
1994      1.35      0.16      0.8677      0.1209      0.0104      0.0010
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      10
1995      0.36      0.19      0.9561      0.0376      0.0038      0.0022
0.0003      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      10
1996      0.14      0.48      0.4841      0.3012      0.1221      0.0599
0.0257      0.0056      0.0013      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      10
1997      0.55      0.17      0.5541      0.3612      0.0681      0.0128
0.0032      0.0005      0.0001      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
0.0000      0.0000      10
1998      1.47      0.26      0.6571      0.3017      0.0382      0.0028
0.0001      0.0000      0.0000      0.0000      0.0000      0.0000      0.0000
```

```
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    10
1999    1.18    0.13    0.6611    0.1727    0.0763    0.0440
0.0207    0.0089    0.0052    0.0023    0.0017    0.0013    0.0010
0.0007    0.0006    0.0005    0.0004    0.0004    0.0003    0.0003
0.0002    0.0013    109
2000    1.46    0.11    0.6773    0.2419    0.0566    0.0152
0.0038    0.0019    0.0011    0.0005    0.0003    0.0003    0.0002
0.0001    0.0001    0.0001    0.0001    0.0001    0.0001    0.0001
0.0001    0.0003    109
2001    1.49    0.14    0.5228    0.2841    0.0936    0.0379
0.0162    0.0090    0.0062    0.0038    0.0032    0.0029    0.0025
0.0021    0.0019    0.0017    0.0016    0.0013    0.0012    0.0010
0.0009    0.0062    109
2002    1.49    0.13    0.3447    0.2761    0.1547    0.0820
0.0536    0.0321    0.0197    0.0138    0.0100    0.0061    0.0035
0.0015    0.0008    0.0006    0.0003    0.0003    0.0001    0.0001
0.0001    0.0001    109
2003    0.68    0.17    0.3148    0.2603    0.1803    0.0967
0.0536    0.0324    0.0231    0.0170    0.0102    0.0056    0.0030
0.0013    0.0007    0.0004    0.0001    0.0002    0.0001    0.0001
0.0000    0.0001    109
2004    0.92    0.26    0.0695    0.1328    0.1890    0.1555
0.1003    0.0702    0.0517    0.0388    0.0304    0.0243    0.0197
0.0165    0.0139    0.0115    0.0106    0.0083    0.0074    0.0063
0.0055    0.0377    109
2005    1.4    0.12    0.2015    0.3465    0.1981    0.1346
0.0704    0.0277    0.0106    0.0029    0.0019    0.0016    0.0013
0.0011    0.0007    0.0004    0.0001    0.0002    0.0001    0.0001
0.0000    0.0001    109
2006    0.68    0.16    0.2861    0.2774    0.1749    0.1188
0.0655    0.0299    0.0125    0.0036    0.0031    0.0039    0.0042
0.0046    0.0040    0.0028    0.0024    0.0015    0.0012    0.0009
0.0007    0.0020    109
2007    0.95    0.14    0.3464    0.1795    0.1493    0.1357
0.0928    0.0408    0.0203    0.0094    0.0063    0.0046    0.0033
0.0025    0.0019    0.0014    0.0011    0.0009    0.0007    0.0006
0.0005    0.0020    109
2008    0.89    0.11    0.5481    0.2828    0.1190    0.0394
0.0081    0.0019    0.0006    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    109
# Index-3
1986    0.85    0.32    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0
1987    1.35    0.31    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0
1988    0.48    0.34    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0
```

1989	0.78	0.32	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1990	0.57	0.35	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1991	0.68	0.35	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1992	0.83	0.3	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1993	0.55	0.3	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1994	0.78	0.29	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1995	0.97	0.3	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1996	0.82	0.28	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1997	0.53	0.31	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1998	0.63	0.32	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1999	0.44	0.35	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
2000	0.39	0.37	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
2001	0.41	0.3	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
2002	0.59	0.33	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				

```
2003     0.52     0.33     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2004     1     0.35     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2005     2.97     0.31     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2006     1.26     0.31     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2007     1.9     0.31     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2008     0.64     0.36     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
# Index-4
1986     -999     1     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1987     -999     1     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1988     -999     1     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1989     -999     1     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1990     -999     1     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1991     0.49     0.25     0.0170     0.2580     0.9570     1.0000
0.6660     0.3040     0.1300     0.0340     0.0590     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     16
1992     0.43     0.24     0.0170     0.2580     0.9570     1.0000
0.6660     0.3040     0.1300     0.0340     0.0590     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     32
1993     0.52     0.24     0.0170     0.2580     0.9570     1.0000
0.6660     0.3040     0.1300     0.0340     0.0590     0.0000     0.0000
```

```
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     33
1994     0.8      0.22     0.0170     0.2580     0.9570     1.0000
0.6660     0.3040     0.1300     0.0340     0.0590     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     33
1995     0.75     0.23     0.0170     0.2580     0.9570     1.0000
0.6660     0.3040     0.1300     0.0340     0.0590     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     18
1996     1.68     0.22     0.0170     0.2580     0.9570     1.0000
0.6660     0.3040     0.1300     0.0340     0.0590     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     33
1997     1.06     0.19     0.0170     0.2580     0.9570     1.0000
0.6660     0.3040     0.1300     0.0340     0.0590     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     52
1998     1.06     0.15     0.0170     0.2580     0.9570     1.0000
0.6660     0.3040     0.1300     0.0340     0.0590     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     68
1999     1.29     0.14     0.0170     0.2580     0.9570     1.0000
0.6660     0.3040     0.1300     0.0340     0.0590     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     103
2000     0.92     0.13     0.0170     0.2580     0.9570     1.0000
0.6660     0.3040     0.1300     0.0340     0.0590     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     112
2001     1.28     0.12     0.0170     0.2580     0.9570     1.0000
0.6660     0.3040     0.1300     0.0340     0.0590     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     115
2002     0.87     0.14     0.0170     0.2580     0.9570     1.0000
0.6660     0.3040     0.1300     0.0340     0.0590     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     105
2003     1.37     0.13     0.0170     0.2580     0.9570     1.0000
0.6660     0.3040     0.1300     0.0340     0.0590     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     124
2004     1.19     0.15     0.0170     0.2580     0.9570     1.0000
0.6660     0.3040     0.1300     0.0340     0.0590     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     100
2005     0.81     0.16     0.0170     0.2580     0.9570     1.0000
0.6660     0.3040     0.1300     0.0340     0.0590     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     71
2006     0.53     0.18     0.0170     0.2580     0.9570     1.0000
0.6660     0.3040     0.1300     0.0340     0.0590     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     54
2007     0.69     0.15     0.0170     0.2580     0.9570     1.0000
0.6660     0.3040     0.1300     0.0340     0.0590     0.0000     0.0000
```

```
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     78
2008       0.64       0.17       0.0170     0.2580     0.9570     1.0000
0.6660     0.3040     0.1300     0.0340     0.0590     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     85
# Index-5
1986       -999       1          0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1987       -999       1          0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1988       -999       1          0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1989       -999       1          0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1990       -999       1          0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1991       -999       1          0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1992       -999       1          0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1993       0.76       0.13       0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1994       0.75       0.12       0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1995       0.81       0.12       0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1996       0.83       0.12       0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1997       0.75       0.12       0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
```

```
1998     0.97     0.12     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1999     0.76     0.13     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2000     0.82     0.13     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2001     1.25     0.12     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2002     1.15     0.12     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2003     1.28     0.12     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2004     1.35     0.12     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2005     1.32     0.12     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2006     1.38     0.13     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2007     1.02     0.13     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2008     0.8      0.14     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
# Index-6
1986     -999     1        0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1987     -999     1        0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1988     -999     1        0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
```

0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1989	-999	1	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1990	-999	1	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1991	-999	1	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1992	-999	1	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1993	0.39	1.14	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1994	0.3	1.42	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1995	0.4	1.48	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1996	0.46	1.03	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1997	0.46	0.96	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1998	0.75	0.57	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
1999	0.83	0.52	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
2000	1.06	0.45	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
2001	1.41	0.34	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0				
2002	1.58	0.33	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

```
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2003     1.84     0.3      0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2004     1.87     0.28     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2005     1.8      0.28     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2006     1.11     0.45     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2007     1.05     0.59     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
2008     0.69     0.76     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
# Index-7
1986     -999     1        1.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1987     -999     1        1.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1988     -999     1        1.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1989     -999     1        1.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1990     -999     1        1.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1991     -999     1        1.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
1992     -999     1        1.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0
```

```
1993    -999    1       1.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0
1994    -999    1       1.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0
1995    -999    1       1.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0
1996    -999    1       1.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0
1997    -999    1       1.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0
1998    -999    1       1.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0
1999    1.2     0.15    1.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  16
2000    1.85    0.14    1.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  19
2001    0.93    0.17    1.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  34
2002    1.01    0.15    1.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  31
2003    0.91    0.16    1.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  22
2004    1.04    0.16    1.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  21
2005    -999    1       1.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0
2006    0.62    0.19    1.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
0.0000  0.0000  28
```

```
2007      0.81      0.16      1.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    30
2008      -999      1         1.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0
# Index-8
1986      -999      1         1.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0
1987      -999      1         1.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0
1988      -999      1         1.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0
1989      -999      1         1.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0
1990      -999      1         1.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0
1991      -999      1         1.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0
1992      -999      1         1.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0
1993      -999      1         1.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0
1994      0.429     0.16      1.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    126
1995      0.005     0.19      1.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    200
1996      0.089     0.48      1.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
0.0000    0.0000    151
1997      1.041     0.17      1.0000    0.0000    0.0000    0.0000
0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
```

```
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     200
1998     2.07     0.26     1.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     200
1999     1.241     0.13     1.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     200
2000     1.477     0.11     1.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     200
2001     2.066     0.14     1.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     200
2002     1.457     0.13     1.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     200
2003     0.563     0.17     1.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     200
2004     0.209     0.26     1.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     200
2005     1.89     0.12     1.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     200
2006     0.695     0.16     1.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     200
2007     0.682     0.14     1.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     200
2008     1.085     0.11     1.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000
0.0000     0.0000     200
# Phase Control Data
# Phase for F mult in 1st Year
2
# Phase for F mult Deviations
8
# Phase for Recruitment Deviations
7
# Phase for N in 1st Year
1
# Phase for Catchability in 1st Year
```

```
2
# Phase for Catchability Deviations
-7
# Phase for Stock Recruitment Relationship
3
# Phase for Steepness
6
# Recruitment CV by Year
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
0.5
#Lambda for Each Index
1  1  1  1  1  1  1  1
# Lambda for Total Catch in Weight by Fleet
1  1  1  1
# Lambda for Total Discards at Age by Fleet
1  1  1  1
# Catch Total CV by Year and Fleet
0.100  0.260  0.240  0.240
0.100  0.200  0.250  0.250
0.100  0.460  0.250  0.250
0.100  0.370  0.250  0.250
0.100  0.600  0.270  0.270
0.100  0.350  0.270  0.270
0.100  0.240  0.270  0.270
0.100  0.250  0.270  0.270
0.100  0.330  0.270  0.270
0.100  0.250  0.270  0.270
0.100  0.170  0.270  0.270
0.100  0.220  0.270  0.270
0.100  0.250  0.280  0.280
0.100  0.390  0.280  0.280
0.100  0.350  0.290  0.290
0.100  0.210  0.290  0.290
0.100  0.440  0.290  0.290
0.100  0.230  0.290  0.290
```

```
0.100  0.220  0.290  0.290
0.100  0.360  0.290  0.290
0.100  0.370  0.290  0.290
0.100  0.220  0.290  0.290
0.100  0.330  0.290  0.290
# Discard Total CV by Year and Fleet
0.200  0.160  0.000  0.000
0.200  0.430  0.000  0.000
0.200  0.290  0.000  0.000
0.200  0.190  0.000  0.000
0.200  0.360  0.000  0.000
0.200  0.420  0.000  0.000
0.200  0.460  0.270  0.270
0.200  0.280  0.270  0.270
0.200  0.250  0.270  0.270
0.200  0.220  0.270  0.270
0.200  0.220  0.270  0.270
0.200  0.160  0.270  0.270
0.200  0.160  0.280  0.280
0.200  0.140  0.280  0.280
0.200  0.240  0.290  0.290
0.200  0.250  0.290  0.290
0.200  0.150  0.290  0.290
0.200  0.140  0.290  0.290
0.200  0.130  0.290  0.290
0.200  0.210  0.290  0.290
0.200  0.180  0.290  0.290
0.200  0.230  0.290  0.290
0.200  0.190  0.290  0.290
# Input Effective Sample Size for Catch at Age by Year & Fleet
7  15  15  0
7  15  15  0
7  5  15  0
7  7  15  0
7  0  15  0
7  9  15  0
11  22  28  0
18  27  28  0
21  24  28  0
14  21  34  0
24  34  34  0
26  34  34  0
30  34  34  0
13  47  47  0
8  47  47  0
10  47  47  0
9  43  43  0
8  43  43  0
6  19  19  0
7  19  19  0
10  17  25  0
11  42  42  0
2  26  35  0
# Input Effective Sample Size for Discards at Age by Year & Fleet
0  0  0  0
0  0  0  0
```

```
0  0  0  0
0  0  0  0
0  0  0  0
0  0  0  0
28  28  0  0
28  28  28  0
28  28  28  0
34  33  34  0
34  33  34  0
34  33  34  0
34  33  34  0
47  25  47  0
47  25  47  0
47  25  47  0
43  25  43  0
43  25  43  0
19  19  19  0
17  19  19  0
16  25  25  0
37  25  42  0
2  25  35  0
# Lambda for F mult in first year by fleet
1  1  1  1
# CV for F mult in first year by fleet
0.5  0.5  0.5  0.5
# Lambda for F mult Deviations by Fleet
1  1  1  1
# CV for F mult deviations by Fleet
0.25  0.25  0.25  0.25
# Lambda for N in 1st Year Deviations
1
# CV for N in 1st Year Deviations
0.5
# Lambda for Recruitment Deviations
1
# Lambda for Catchability in first year by index
1  1  1  1  1  1  1  1
# CV for Catchability in first year by index
0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
# Lambda for Catchability Deviations by Index
1  1  1  1  1  1  1  1
# CV for Catchability Deviations by Index
0.001  0.001  0.5  0.1  0.5  0.5  0.001  0.001
# Lambda for Deviation from Initial Steepness
1
# CV for Deviation from Initial Steepness
0.1
# Lambda for Deviation from Initial unexploited Stock Size
1
# CV for Deviation from Initial unexploited Stock Size
0.5
# NAA for Year 1
765297  514990  375083  244835  210941  130297  66761  38239  26268  19734
15077  11389  8449  6161  4429  3149  2220  1555  1085  754
# F mult in 1st year by Fleet
.1  .15  .15  .1
```

```
# Catchability in 1st year by index
4.09E-07  4.09E-07  4.09E-07  4.09E-07  4.09E-07  4.09E-07  4.09E-07
4.09E-07
# Initial unexploited Stock Size
8000000
# Initial Steepness
0.75
# Maximum F
5
# Ignore Guesses
0
# Projection Control Data
# Do Projections? (1=yes, 0=no), still need to enter values even if not
doing projections
0
# Fleet Directed Flag
1  1  1  1
# Final Year of Projections
2021
# Year Projected Recruits, What Projected, Target, non- directed F mult
2009     -1     4     0     1
2010     -1     4     0     1
2011     -1     5     0     1
2012     -1     5     0     1
2013     -1     5     0     1
2014     -1     5     0     1
2015     -1     5     0     1
2016     -1     5     0     1
2017     -1     5     0     1
2018     -1     5     0     1
2019     -1     5     0     1
2020     -1     5     0     1
2021     -1     5     0     1
# MCMC info
# doMCMC (1=yes)
1
# MCMCnyear option (0=use final year values of NAA, 1=use final year + 1
values of NAA)
0
# MCMCnboot
10000
# MCMCnthin
200
# MCMCseed
138846
# R in agepro.bsn file (enter 0 to use NAA, 1 to use stock-recruit
relationship, 2 to used geometric mean of previous years)
2
# Starting year for calculation of R
2006
# Starting year for calculation of R
2008
# Test Value
-23456
#####
# ---- FINIS ----
```

SEDAR

Southeast Data, Assessment, and Review

SEDAR 19

Gulf of Mexico and South Atlantic Black 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

Research recommendations.

- The DW LH WG recognized the value of continuing the otolith workshops and exchange of otoliths in preparation for SEDAR data workshops. These workshops are especially important for species that have been recognized as relatively difficult to age.

- The DW LH WG also recognizes the value of similar workshops to discuss the interpretation of reproductive samples, and the possible exchange of histological sections between labs in preparation for SEDAR Data Workshops. This will be especially important for species that have been recognized as relatively difficult to stage.
- Because little or no fecundity information is available for *M. bonaci* (black grouper) from the South Atlantic or the Gulf of Mexico, the DW LH WG recommends initiating a study to further identify aggregations and spawning locations, movements relating to aggregations and spawning, and to estimate fecundity for female age classes in both the GOM and Atlantic populations.
- The data on catch distributions of black grouper (*M. bonaci*) presented at the DW suggest that there are habitat and depth characteristics in the Florida Keys and the shelf areas of the South Atlantic and west Florida that are influencing the movements of this species. The DW LH WG recommends a study to further investigate movements of this species, especially individuals that are mature females and males, by use of genetic tagging, external tagging, or other relevant techniques.
- There is a need for improved collection and collection strategy for hard parts, in particular from the recreational sector. Samplers' encounter rate with anglers that have caught black grouper (*M. bonaci*) are low, particularly in recreational fisheries where bag limits restrict the number of available specimens. Some ingenuity in sampling design will probably be required.
- Increase of fishery independent data to include the entire area of black grouper (*M. bonaci*) distribution in the Atlantic and Gulf of Mexico in the southeastern U.S. Although the SEAMAP video surveys covers general areas (e.g., Florida Middle

Grounds, West Florida shelf, Pulley Ridge, etc.) where black grouper are caught, few black grouper have been seen in this survey. Perhaps either some additional research on habitat preferences may aid in locating this species in these areas, or some other type of fishery independent sampling might be more successful in encountering black grouper and generating estimates of abundance in areas outside of the Florida Keys.

- Virtually no information on the life history and distribution of young juveniles (age 0-1) black grouper (*M. bonaci*) is available. The DW LH WG recommends a study to gather information on these early ages. These studies should include sampling for postlarvae in the months (March-June) after spawning is presumed to occur, location of habitats in Florida (particularly in the Florida Keys) where these fish occur (presumably rocky habitats not presently sampled by the fishery independent program in Florida), and diet composition, growth, and movements of juveniles.

Procedural recommendation:

- The DW recommends that the report of the natural mortality workshop organized by NMFS (Seattle, WA, August 2009) be made available to the DW LH WG before the next SEDAR as a guide in the discussions concerning natural mortality.

1.2 COMMERCIAL STATISTICS WORKING GROUP

• Still need observer coverage for the snapper-grouper fishery
– 5-10% allocated by strata within states
– get maximum information from fish

• Expand TIP sampling to better cover all statistical strata

• Trade off with lengths versus ages, need for more ages (i.e., hard parts)

• Workshop to resolve historical commercial landings for a suite of snapper-grouper species
– Monroe County (SA-GoM division)
– Historical species identification (mis-identification and unclassified)

1.3 RECREATIONAL STATISTICS WORKING GROUP

-Need more detailed information about where the fish are caught (depth, spatial, etc.)

-More detailed information on recreational discards, such as hooking location, depth fished, etc. that are likely to impact discard mortality and discard size/age.

- Additional information on sector (mode) differences.

1.4 INDICES OF ABUNDANCE WORKING GROUP

1. Expand fishery independent sampling to provide indices of abundance. The DW Panel noted that this recommendation has been the first on the list for virtually all previous SEDAR's in the south Atlantic.

2. Examine variability in catchability
   - Environmental effects
   - Changes over time associated with increases in technology and potential changes in fishing practices. This is of particular importance when considering fishery dependent indices.
   - Potential density-dependent changes in catchability. This is of particular importance for schooling fishes.

3. Conduct studies to examine how the behavior of fisherman changes over time and how these changes relate to factors such as gas prices and economic trends

4. Consider optimal sample allocation for species of interest when designing surveys to increase sample sizes.

5. Examine possible temporal changes in species assemblages. Such changes could influence how the Stephens and MacCall method is applied when determining effective effort.

6. Continue to expand fishery dependent at-sea-observer surveys. Such surveys collects discard information, which would provide for a more accurate index of abundance.

2. ASSESSMENT WORKSHOP RESEARCH RECOMMENDATIONS

The two primary data weaknesses identified by the stock assessment were the paucity of age information from the recreational sectors and almost absence of size information for fish that were discarded alive. Therefore, the main research recommendations are:

1. Obtain age samples from all sectors of the fishery. Currently, very few otoliths are collected from the headboat survey or from the general recreational (MRFSS).

2. Size samples of discarded fish by sector. The only measurements of discarded black grouper came from a short term (three year) observer program on headboats.

Additional research recommendations include

3. Use TIP samplers to interview fish house owners regarding their use of the label 'black grouper' for gag to improve both future gag and black grouper assessments. The current procedure is very coarse but it could be improved by getting information to allow the adjustments to be made at the year-month/season-county-fish house level.

4. Expand the fishery independent sampling to cover the mid-shelf to shelf edge so as to be able to develop fishery independent indices of the adult portion of the stock. The existent visual surveys mostly encounter and collect information on the juveniles and sub-adults.

5. Collecting depth information from the fishery sectors to better estimate release mortality rates.

3. REVIEW PANEL RESEARCH RECOMMENDATIONS

Members of the Data and Assessment workshops identified a number of shortcomings in the data available for black grouper, and the RP felt that future research efforts should be focused on obtaining more precise estimates for parameters that displayed a strong potential effect and high uncertainty on the output of the assessment models. This opinion was reinforced by the fact that black grouper are not abundant, nor do they represent substantial fisheries; hence data acquisition efforts are hampered by both low abundances and low availability of samples from fishery sources. Many of the research recommendations have a reasonable biological basis, but a number are not directly linked to the assessment models used in the stock assessment.

The RP felt that future research should focus on discard mortality (especially from the recreational fishery), acquiring better fishery-independent abundance estimates, improving methods for estimating catch by recreational anglers, improving age and growth data, and efforts to quantify linkages (i.e., recruitment effects) between western Caribbean and US stocks of black grouper. Given that fecundity data are not currently used in the stock assessment models, nor are histological gonadal stages utilized other than to distinguish mature from immature specimens, we suggest that these studies have lower priority than the research needs identified above. The role of proposed movement studies on improving stock assessment estimates also is unclear, especially given that comparisons of commercial and recreational catches document a depth-size relationship for this species. Studies directed towards identifying locations of spawning aggregations may be difficult to conduct for a species with low abundance, although such studies would be useful if spatially-based fisheries closures were to be employed for black grouper.

The RP recommends a strategic approach should be taken towards research for the snapper-grouper complex. The criteria which would be used to evaluate the strategy should be:

- Efficiency: for example sampling for sex ratio, length, and age could cover a range of species simultaneously.
- Impact: the resulting information should have clear implications for decision making.

To achieve this, managers and scientists will both need to be involved in developing a strategic research plan.

As noted in section 2.1.3, the RP recommends future research to determine which F metric behaves best under this management system.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 19

South Atlantic and Gulf of Mexico Black Grouper

SECTION V: Review Workshop Report

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

1. INTRODUCTION

1.1. Workshop Time and Place

The SEDAR 19 Review Workshop was held January 25-29, 2010 in Savannah, Georgia.

1.2. Terms of Reference

1. Evaluate the adequacy, appropriateness, and application of data used in the assessment.
2. Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.
3. Recommend appropriate estimates of stock abundance, biomass, and exploitation.
4. Evaluate the methods used to estimate population benchmarks and management parameters (*e.g., MSY, Fmsy, Bmsy, MSST, MFMT, or their proxies*); recommend appropriate management benchmarks and provide estimated values for management benchmarks, a range of ABC, and declarations of stock status.
    A. In addition, for black grouper, the Gulf Council requests that the Panel evaluate the methods used to estimate OFL.
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, including the Summary 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 Consensus Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks to be completed following the workshop. Complete and submit the Consensus Report within 3 weeks of workshop conclusion.

* The review panel may request additional sensitivity analyses, evaluation of alternative assumptions, and correction of errors identified in the assessments provided by the assessment workshop panel; the review panel may not request a new assessment. Additional details regarding the latitude given the

review panel to deviate from assessments provided by the assessment workshop panel are provided in the *SEDAR Guidelines* and the *SEDAR Review Panel Overview and Instructions*.

** The panel shall ensure that corrected estimates are provided by addenda to the assessment report in the event corrections are made in the assessment, alternative model configurations are recommended, or additional analyses are prepared as a result of review panel findings regarding the TORs above.

1.3. List of Participants

Appointee	Function	Affiliation
Review Panel		
Chris Legault	Review Panel Chair	NEFSC
Paul Medley	CIE Reviewer	
Stuart Reeves	CIE Reviewer	CEFAS
Neil Klaer	CIE Reviewer	CSIRO
Gary Grossman	Council Appointed Reviewer	SAFMC
Sean Powers	Council Appointed Reviewer	GMFMC
Analytical Team Representation		
Kyle Sherzter	Red grouper lead analyst	NMFS Beaufort
Bob Muller	Black grouper lead analyst	FWRI
Rob Cheshire	Analytic support	NMFS Beaufort
Joe O'Hop	Analytic support	FWRI
Official Observers		
Dennis O'Hern	AP/Fisherman rep – Black grouper (GMFMC)	West Central FL/private
Council Representation		
Brian Cheuvront	South Atlantic Council Member	SAFMC
George Geiger	South Atlantic Council Member	SAFMC
Bob Gill	Gulf of Mexico Council Member	GMFMC
Luiz Barbieri	AW Rep– Black grouper	SAFMC and GMFMC SSC
Anne Lange	AW Rep – Red grouper	SAFMC SSC
Staff		
Julie A Neer	SEDAR Coordinator	SEDAR
Rachael Lindsay	Administrative Assistant	SEDAR
Carrie Simmons	Gulf of Mexico Council Staff	GMFMC

	Lead	
John Carmichael	South Atlantic Council Staff	SAFMC
Kari Fenske	South Atlantic Council Staff	SAFMC
Gregg Waugh	South Atlantic Council Staff	SAFMC
Patrick Gilles	IT Support	NMFS Miami
Other Observers		
Rusty Hudson		DSF, Inc.
Marcus Drymon		NMFS - Pascagoula

2. Review Panel Summary Report

The stock assessment presented by the Assessment Workshop (AW) was accepted after minor modifications made during the review meeting. It was concluded that overfishing was not occurring and the stock was not overfished in 2008. All terms of reference were addressed by the Data Workshop (DW) and AW. 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.

2.1 Terms of Reference

2.1.1 Evaluate the adequacy, appropriateness, and application of data used in the assessment.

The majority of information for black grouper was derived from landings data because few fishery independent indices were available. The RP identified several areas of concern relative to the quality and reliability of the fishery-dependent-data. Many of these issues were noted by the DW as well as the AW, but deserve re-examination here because they weighed heavily in the RP review. The least problematic of the fishery-dependent data was the commercial long-line data and the index of abundance derived from these data and effort as reported in the logbooks. The RP discussed some potential problems with unknown or changing selectivity and catchability of the long-line data, particularly on the Atlantic coast where changes in the fishery may have occurred as a result of regulations. Similar to the longline data, the head boat data, a fairly small component of the grouper fishery, was viewed as reliable.

The RP was very concerned about the recreational landings derived from the MRFSS data set. Central to this problem for the black grouper assessment was the lack of species-specific landings in the earlier data sets (grouper was treated as an aggregate category prior to 1986) and the reliability of species identification, particularly black versus gag grouper, in the 1990's and pre-1990's MRFSS data. Both of these points were discussed in the DW, where it was concluded that the data could be used for assessment, although they would contribute to the uncertainty of the final results. Further, inspection of the landings data for black grouper indicates disproportionally higher recreational catches earlier in the fishery. The weight of MRFSS data in the model and the validity of the MRFSS data were questioned. However, lacking an alternative, the data were accepted for use in stock assessment models.

The RP was concerned with the lack of empirical data to support the discard mortality estimate of 20%. Given that discards are approximately five times larger than landings, relatively small changes in discard mortality could have major implications. The 20% value was arrived by consensus in the DW and AW. Sensitivity runs were performed that varied this estimate from 10 – 90%. These results support the high impact of this parameter. In the absence of any substantive empirical data the panel did not see a strong basis to change the value from 20%, however attempts should be made to obtain a more accurate estimate of both acute and chronic discard mortality.

Insufficient age data were available to generate annual age-length keys for this stock, so a stochastic age-slicing approach was used to convert the observed length frequencies to age frequencies. This conversion will smooth the relative strength of neighboring cohorts, making the estimated recruitment time series less variable than it should be. The lack of aging data limits the precision of the current black grouper assessment.

Four fishery-dependent abundance indices were used in the assessment: 1) commercial longline data, 2) commercial hook and line data, 3) headboat data, and 4) MRFSS data. The RP expressed concern regarding the effort data used in the CPUE indices. The RP felt that effort data should have been presented more prominently in the report. Further, recent declines in indices of abundance were assumed to be related to decreases in effort; however, besides the imposition of more stringent trip limits in the longline fishery, little evidence was presented to support the assumption. The fishery-dependent indices relied on a form of cluster analysis to determine which observations to include in the index. This approach may be influenced by changes in relative abundance of the associated species.

The DW and AW have examined catchability changes through time for the snapper-grouper fishery complex and have concluded that increased use of GPS may have caused an increase in fishing efficiency. A simple approach for including the effect on fishery-dependent indices was to assume a 2% increase per year in catchability. The RP accepts that it is useful to examine plausible scenarios of catchability change as sensitivities to the base run, and note the difficulty in assigning relative probabilities to such scenarios.

The black grouper assessment used two fishery-independent abundance indices: 1) Florida Wildlife Commission Visual Survey (FWC), and 2) the NMFS-UM Reef Visual Census (RVC). The advantage of these surveys is that they were generally located within the area of the fishery. Although the panel recognized that fishery-independent data are difficult to obtain, both sets of data had shortcomings warranting discussion. For example, both visual abundance indices conflicted with other sources of information, and CV’s for both indices were very high. Consequently their contribution to the assessment models was questionable. In addition, the original configuration of the assessment models contained both an overall abundance estimate and an age-1 recruitment index from FWC and RVC sources, which produced double counting of these data in the analysis. Finally, there were changes in RVC sampling methodology in 1998 that made comparability of early and late samples questionable. Consequently, the panel recommended removal of the RVC and FWC overall abundance data and the RVC recruitment index from the models. Nonetheless, the panel recommended that the FWC recruitment index be retained, because this had a more representative design and should provide an index of abundance unaffected by management controls.

The RP recommends that future management actions affect the monitoring data as little as possible, and where monitoring is affected, changes should be accounted for by implementing controls in a way that allows the effect to be estimated. Fishery-dependent abundance indices in particular may be compromised as measures of population abundance when affected by management actions, making it difficult or impossible to evaluate whether the management is achieving its objectives. It appears that the longline index, which is probably the most important abundance index for this fishery, has been compromised through the use of trip limits.

Alternatively, the RP recommends that new and better sources of fishery independent indices be developed.

2.1.2 Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.

Catch curves

Catch curves use available age and/or length data to provide a useful upper bound on natural mortality, particularly if data are available from periods when fishing intensity is low. However, the method assumes logistic flat-topped selectivity and equilibrium over the ages of fish being used in the assessment. Where domed selectivity or non-equilibrium is suspected, the estimates should not be used. A standard approach, developed by Hoenig (1983), was used to estimate natural mortality.

The estimated Z from the catch curve did not take account of the Lorenzen (1996) natural mortality model used in the age-structured models, but assumed constant mortality with age. Although this is not likely to affect the estimate much because the Lorenzen natural mortality is fairly constant over the ages used in the catch curve, the two approaches are not entirely consistent.

ASPIC

The production model stock assessment provided a useful comparison with age-structured models. ASPIC provides a standard maximum likelihood method to fit models with multiple indices. The data for this assessment were adequate for the use of this method. Production models ignore age and length information, but use catch weight and indices of abundance only. Therefore, where age and length information are available, production models are not the preferred assessment method.

In the case of black grouper, the model fitted the data reasonably well and could be used to provide management advice. The RP noted that where multiple indices with different selectivities are available, they may be indexing different vulnerable biomass components. As such, it may be better to focus on one index which can be used to monitor one component appropriate for management advice. In this case, this would likely be longline which is indexing mature fish. However, the RP recommended that the production model not be used as the main assessment for black grouper because it ignores available age and length data which contribute information on stock dynamics.

ASAP

The black grouper AW focused their efforts on the statistical catch at age model ASAP2. This model is part of the NOAA Fisheries Toolbox and has been used for many other assessments. The model was applied appropriately given the data. The major concern of the RP was that the estimated recruitment appeared far more autocorrelated (smooth) than would be expected. This overly smooth recruitment was believed to be due to the use of stochastic age assignments from sparse length distributions smearing the cohort signals among adjacent years. The inability to track large or small cohorts in the data does not negate the use of this model, it just results in a less variable recruitment series than most likely actually occurred. This has implications for the projected recruitment uncertainty, which was probably underestimated. The advantage of the ASAP2 model over an age-aggregated model, such as a production model, is that the strong differences in gear selectivity at age can be accommodated in an obvious and direct manner. These differences in gear selectivity are thought to be an important aspect of the fishery, hence it is desirable that the assessment accounts for the length or age structure of the catches.

In future assessments, the AW may wish to consider the use of stock assessment models such as Stock Synthesis that incorporate length data directly instead converting length data to age as a process outside of the assessment model. An additional advantage of such a modeling approach would be the ability to model fishery selectivity as a function of length instead of age.

2.1.3 Recommend appropriate estimates of stock abundance, biomass, and exploitation.

The RP notes the different approaches used to estimate current exploitation levels between the black grouper and red grouper AW. Specifically, the current F for black grouper was determined from the F at age 5 in 2008 whereas the red grouper current F was determined as the average of the apical F over the years 2006 through 2008. The RP recognized that different metrics can be used, as long as they are consistent with the reference point calculations, as they were in both cases. However, if the method were the same among stocks, it would facilitate review and comparison. The RP recommends future research to determine which metric behaves best under this management system.

Current estimates of stock abundance, biomass, and exploitation are summarized in the table below. See the addendum for the full time series of each parameter.

Parameter	Metric	Year	Units	Value
Stock Abundance	N (all ages)	2008	thousands of fish	720
Biomass	SSB	2008	million pounds	7.6
Exploitation	F age 5	2008	per year	0.11

2.1.4 Evaluate the methods used to estimate population benchmarks and management parameters (e.g., MSY, 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.
A. In addition, for black grouper, the Gulf Council requests that the Panel evaluate the methods used to estimate OFL.

The current benchmarks for black grouper are based on spawner-per-recruit calculations. Choice of the spawner-per-recruit benchmark will depend on the expected decline in recruitment associated with that level of spawning stock biomass. A steepness of 0.9, implies 90%

unexploited recruitment at SPR20%. Where lower steepness is suspected, as in this case for black grouper, higher SPR benchmarks would be needed to achieve the same performance.

The panel believes that steepness values in the region of 0.8 are reasonable for this species, and higher steepness should be avoided, unless well supported by data. A steepness of 0.8 implies that 90% of unexploited recruitment will be achieved at 36% SPR or higher. An SPR30% should achieve 87% or more of the unexploited recruitment in the long term.

The RP recommends that SPR30% is used. Proxies are more robust in most cases 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. The SPR30% benchmark appears consistent with an assumed steepness of 0.8 in this case.

Current benchmarks for black grouper are provided in the table below.

Parameter	Metric	Units	Value
MSY	Yield in eq. when F=F30%	million pounds	0.52
Bmsy	SSB in eq. when F=F30%	million pounds	5.9
Fmsy	F30%	per year	0.22

The P* method used to estimate the OFL for black grouper is a standard approach used in the Southeast and was applied appropriately (Shertzer et al. 2008).

2.1.5 Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; recommend appropriate estimates of future stock condition (e.g., exploitation, abundance, biomass).

Projections were made from 2009 to 2020 using a standard age-structured forward catch equation method. The directed and discard mortality rates for 2009 and 2010 by fleet were estimated from a geometric mean of those rates from 2006 to 2008 from the ASAP2 assessment. The start year for catches affected by future management actions was 2011. Uncertainty in initial stock abundance was captured in projection by using replicate MCMC fits as starting points. 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 (Shertzer et al. 2008). The RP also agreed that projections correctly modeled the time series of future F and biomass values required for evaluation of the various management options examined (see addendum). The P* software package is the preferred method for projection of the probability of overfishing, and was used for projections.

2.1.6 Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters. Ensure that the implications of uncertainty in technical conclusions are clearly stated.

The methods used to quantify uncertainty in the black grouper assessment included Markov Chain Monte Carlo methods and sensitivity analyses which are standard and appropriate. The

RP felt that there was substantial uncertainty in the assessment that was produced by weaknesses in the data set and by the fact that the assessment models did not provide strong fits to the existing data. The sensitivity analysis was particularly helpful in identifying structural uncertainty in the assessment models and further analyses of uncertainty should focus on model structures that displayed high uncertainty such as discard survivorship rates, natural mortality rates and the interpretation of abundance index data.

2.1.7 Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report, including the Summary Report, and that reported results are consistent with Review Panel recommendations.

There is a need to develop standard diagnostics for the different models and data used in the assessment. Diagnostic plots should include fits of all observed to expected data, and also residual plots that emphasize systematic patterns. For age and length composition residuals, bubble plots are effective as a check on the modeling of the cohorts. Where the likelihood function is composed of a number of separate components, their unweighted contributions to the likelihood should be routinely reported. Typically, detailed graphical diagnostics are examined at least for the base case, and a table of unweighted likelihood components should be prepared that includes the base case and all sensitivity analyses.

Standard diagnostic tables and figures were provided on request and the AW provided sufficient information about the assessment model fits and results. The RP noted that this TOR seems unnecessary, as the RP must meet it in order to meet the other TOR. The RP suggests that this TOR not be included in future SEDAR TOR.

2.1.8 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.

Prior to the SEDAR 19 Review meeting, the DW had delivered a comprehensive set of data for both stocks considered. These data enabled the AW to develop assessments of the state of the stock using a range of different approaches in both cases. As a result it was clear to the RP that the SEDAR process that preceded the review meeting had been effective in achieving its intended purpose. The RP noted one term of reference which the DW did not appear to have addressed, which was the provision of maps of effort and harvest. While these might have been useful to inform some of the RP's discussions, their absence did not hinder the main purpose of the work, i.e. the provision of agreed stock assessments for the two stocks of concern.

The DW was asked to "Recommend which data sources are considered adequate and reliable for use in assessment modeling". The RP noted that choices related to the use of data within stock assessments are typically more complex than simply the inclusion/exclusion of particular datasets, because even noisy data may inform an assessment with an appropriate weighting. Consequently, the RP recommends that future DW provide a semi-quantitative evaluation (e.g. score) of the relative reliability of each data set. This information could then be used to inform the weightings used in stock assessments.

The focus of the SEDAR 19 review was two species of grouper, red and black. These two species are not targeted fisheries. Instead, they are caught as relatively minor components of a general reef-fish fishery. To some extent this is reflected in their inclusion in a general snapper/grouper management plan rather than being the subject of specific management plans. The RP had some reservations about the amount of effort and resources being focused on these two species through the SEDAR review process. These reflected both the relatively small contribution these species make to the area's fisheries, and the fact that these two species were being considered in isolation of all other components of the snapper/grouper complex. An efficient multispecies approach to managing the snapper/grouper complex fisheries could pave the way to developing a comprehensive ecosystem approach required for responsible fisheries management[1].

Vessels that are fishing on the mixed snapper/grouper complex generally are not specifically targeting black or red grouper. Consequently, it is difficult to interpret how vessels are likely to respond to management measures intended to protect these species. Similarly, vessels may also change their behavior in response to management measures that are directed towards other species in the complex, which complicates the application of fishery-dependent data in this assessment. This information might be lost through not addressing the full assemblage of target species within the same review. Although it may not be practical or desirable to attempt full assessments of all species in the complex at the same time, other approaches might be considered. In particular, it might be possible to identify one or two key species within the assemblage, and focus on these, while providing information about the complex as a whole as well. The key species might be those of highest commercial value and/or of greatest vulnerability in terms of their life-history characteristics. Such an approach would facilitate a more integrated perspective of the fishery and also help focus resources where they would be most effectively used.

2.1.9 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.

Members of the Data and Assessment workshops identified a number of shortcomings in the data available for black grouper, and the RP felt that future research efforts should be focused on obtaining more precise estimates for parameters that displayed a strong potential effect and high uncertainty on the output of the assessment models. This opinion was reinforced by the fact that black grouper are not abundant, nor do they represent substantial fisheries; hence data acquisition efforts are hampered by both low abundances and low availability of samples from fishery sources. Many of the research recommendations have a reasonable biological basis, but a number are not directly linked to the assessment models used in the stock assessment. The RP felt that future research should focus on discard mortality (especially from the recreational

[1] FAO (1995) Code of Conduct for Responsible Fisheries. FAO, Rome.
FAO (2003) Fisheries Management FAO Technical Guidelines for Responsible Fisheries 4 Suppl. 2. FAO, Rome.

fishery), acquiring better fishery-independent abundance estimates, improving methods for estimating catch by recreational anglers, improving age and growth data, and efforts to quantify linkages (i.e., recruitment effects) between western Caribbean and US stocks of black grouper. Given that fecundity data are not currently used in the stock assessment models, nor are histological gonadal stages utilized other than to distinguish mature from immature specimens, we suggest that these studies have lower priority than the research needs identified above. The role of proposed movement studies on improving stock assessment estimates also is unclear, especially given that comparisons of commercial and recreational catches document a depth-size relationship for this species. Studies directed towards identifying locations of spawning aggregations may be difficult to conduct for a species with low abundance, although such studies would be useful if spatially-based fisheries closures were to be employed for black grouper.

The RP recommends a strategic approach should be taken towards research for the snapper-grouper complex. The criteria which would be used to evaluate the strategy should be:

- Efficiency: for example sampling for sex ratio, length, and age could cover a range of species simultaneously.
- Impact: the resulting information should have clear implications for decision making.

To achieve this, managers and scientists will both need to be involved in developing a strategic research plan.

As noted in section 2.1.3, the RP recommends future research to determine which F metric behaves best under this management system.

The RP recommends that the time frame for the next assessment be set according to the requirements of the main target and/or most vulnerable species within the snapper/grouper complex. The current assessment is sufficiently strong for black grouper that the next assessment could be just an update. However, consideration should be given to either joint assessments or assessments based on those species constraining fishing activity, which would then determine the time frame for the next assessment of this stock.

2.1.10 Prepare a Peer Review Consensus Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Develop a list of tasks to be completed following the workshop. Complete and submit the Consensus Report within 3 weeks of workshop conclusion.

No response needed.

2.2 Summary of RP discussions and resultant changes to assessments

The preferred model in this case was ASAP2. The panel had some concerns about this given the high number of parameters involved (196) and the very sparse age data. The stochastic approach used to estimate age compositions from the limited age reading data also led to autocorrelated recruitment estimates. There also were concerns about the reliability of the earlier years of data due to species identification issues. It was also not clear why the commercial longline age compositions had not been included in the base case.

To address these concerns, the panel requested the following exploratory runs:

- Replace Commercial longline age compositions
- Remove pre-1998 RVC data
- Run from 1991 onwards, removing earlier data
- Increase weighting on longline data (to 10)
- Increase weightings on all abundance indices (to 10)
- A run with only two selectivity curves (one flat, one domed) in order to try and reduce the number of parameters fitted.

The Panel also requested more detailed effort data, and suggested that the ASAP2 parameter correlations be investigated to identify any potential redundancy in the parameters.

These runs yielded reduced correlations in the ASAP2 parameter estimates. The panel still had concerns about the use of the FWC and RVC surveys twice, as both abundance and recruitment indices, and also about the lack of fit to the longline data, particularly the apparent decline in catch rate in the last three years. The RP suggested that the introduction of catch limits in the fishery may have led to a change in the behavior of fishing vessels, invalidating the assumption of constant catchability. Nonetheless, removing the last three points in the series made little difference to the ASAP2 results. Further, subsequent investigation of the effort data did not indicate any obvious changes in behavior in response to the trip limits so the last three years of longline data were retained in the final run. All RVC data, and the FWC combined index were removed from the final run.

2.3 References

Hoenig, J. M. 1983. Empirical use of longevity data to estimate mortality rates. Fishery Bulletin 81: 898-903.

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystems and aquaculture. Journal of Fish Biology 49:627–642.

Shertzer, K. W., M. H. Prager, and E. H. Williams. 2008. A probability-based approach to setting annual catch levels. Fishery Bulletin 106:225–232.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 19

Gulf of Mexico and South Atlantic Black Grouper

SECTION VI: Addenda

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SEDAR19-AW-Addendum Black Grouper

At the SEDAR19 Review Workshop held in Savannah, GA the week of 25-29 January 2010, the reviewers, after seeing the presentations and the results of exploratory model runs, recommended reinstating the longline age compositions and deleting three of the fishery independent indices for a new base run. This addendum presents the results from the new base run together with the revised sensitivity runs and projections.

A3.3. Model3. Statistical Catch-at-Age (ASAP2)

The reviewers did not recommend any changes, other than data inputs, in the statistical catch-at-age model used to assess black grouper (Age-Structured Assessment Program version 2.0.19, ASAP2; Legault and Restrepo ,1998). See Section 3.3 in the original SEDAR19 black grouper stock assessment report for a description of the model.

A3.3.1. Model 3. Statistical Catch-at-Age Methods

The methods did not change from what was done originally. However, additional runs were conducted to explore the influence of different data inputs such as indices or years to include in the analyses. These exploratory runs ultimately led the reviewers to select a new base run. The differences in configuration between the original base run and the new base run were 1) to reinstate the longline age compositions in the model which had been removed at the recommendation of the AW, 2) exclude the NMFS-UM Reef Census Survey (RVC) and the RVC age-1 index, and 3) exclude the FWC Visual Survey. In reviewing the data inputs for the final configuration after the review workshop, we found that the longline discard weight had been calculated with the average hook-and-line weight at age instead of the longline average weight-at-age (revised longline discard weights are provided in Table A2.1.2) and that the initial effective sample sizes used the lesser of the number of lengths in the fleet or the number of ages in the von Bertalanffy growth curve i.e. by period instead of the number of ages by year. Those additional corrections were incorporated into the new base run, sensitivity runs, and projections.

Overview and Data Sources

The overview and data sources were unchanged.

Model Configuration and Equations

The new base run was configured with four fleets (headboat, general recreational (MRFSS), commercial hook-and-line which includes landings from traps and spears, and commercial longlines) and five indices of abundance (four fishery-dependent indices and the FWC Visual Survey Age-1 index) instead of eight indices of abundance for the period of 1986 through 2008. Because of changes in minimum size limits, a separate selectivity block for each regulatory period (1986-1991, 1992-1998, and 1999-2009) was used to estimate the age composition for each fleet except for the longline fleet which did not have age samples from the first period (1986-1991). Discards were linked to their fleets. The review panel agreed with the AW's use of constant catchability. The constant catchability assumption was partially mitigated by the use of three different selectivity blocks by fleet except for the longline fleet which had two selectivity blocks instead of three because of the lack of age data prior to 1992.

The new base run in ASAP2 estimated 185 parameters which was less than the 196 parameters in the original model. The parameters were: 40 selectivity coefficients for the 11 selectivity blocks for the fleets, 4 fleet fishing mortality multipliers in 1986, 88 fishing mortality multiplier deviations (4 fleets*22 years), 23 recruitment deviations, 19 age deviations in 1986, 5 index catchability coefficients, 4 index selectivity coefficients, spawning biomass without fishing, and steepness.

The equations for ASAP2 were unchanged from those presented in Section 3.3.1 of the original black grouper stock assessment report.

Uncertainty and Measures of Precision

When ASAP2 achieves valid convergence, the program estimates a variance-covariance matrix from the Hessian and, thus, the variance-diagonal of that matrix provides the variance for the 185 parameters. We re-ran the Markov Chain Monte Carlo simulations (MCMC) that used ASAP2's covariance matrix to start the Metropolis-Hastings algorithm. The first MCMC re-run was set to run five million simulations keeping every simulation (we got an out of memory error after 4.3 million simulations). From that run, we determined the acceptance rate, an appropriate burn-in period and thinning rate. The thinning rate is used to reduce the number of outcomes to a manageable level. We found no patterns in the outcomes after a burn-in period of 1999 simulations and we used a thinning rate of 1000 simulations. The final MCMC run was a total run of 2.501 million accepted simulations of which we kept 2501 outcomes, and after discarding the first observation as the burn-in, we ended up with 2500 outcomes for determining the parameter distributions.

As in the original analysis, ASAP2 has retrospective analysis (Mohn 1999) as an option and we examined the retrospective bias in the black grouper assessment model by using terminal years of 2004 through 2008.

To gain further understanding of the model and the data, the reviewers suggested additional sensitivity runs and we re-ran the original sensitivity runs identified at the Data workshop. The additional sensitivity runs requested by the reviewers were reinstating the longline age compositions, removing the years 1994-1997 from the NMFS-UM RVC indices, removing the years 2006-2008 from the longline index because of trip limits, weighting the longline index by 10, weighting all of the indices by 10, using a single hook-and-line selectivity block and a single longline selectivity block for all years, excluding the 1986-1990 from of the time series in the analysis, repeating these runs with the shortened time series, and a run with the FWC Visual Survey age-1index but excluding the RVC indices and FWC Visual Survey. This exercise led to making additional runs using just the RVC indices, the RVC multi-age index, the RVC age-1 index, the FWC VS indices, the FWC VS multi-age index, the FWC VS age-1 index, keeping the RVC and the FWC multi-age indices after removing the age-1 indices. The original sensitivity runs included two alternative natural mortality rates, 0.10 per year and 0.20 per year; alternative release mortality rates of 0.10, 0.20, 0.30, 0.50, 0.75, and 0.90 for hook-and-line fleets including the recreational fleets coupled to longline release mortality rates of 0.25, 0.30, 0.35, 0.50, 0.75, 0.90; and setting steepness values at 0.60 to 0.95 plus free in 0.05 increments and then running that range again but allowing the steepness to vary with CV=0.10 There were 75 sensitivity runs.

Benchmark / Reference points / ABC methods

The reviewers did not recommend any changes to the current overfishing limit (OFL) based on the F_{MSY} proxy of $F_{30\%SPR}$ and the Minimum Stock Size Threshold (MSST) is (1 – M) $SSB_{30\%SPR}$ or 0.86 $SSB_{30\%SPR}$. The two necessary measures, $F_{30\%SPR}$ and $SSB_{30\%SPR}$, are estimated internally by ASAP2. The program also estimates F_{msy}, $F_{40\%SPR}$, $F_{45\%SPR}$, SSB_{msy}, $SSB_{F40\%SPR}$, and $SSB_{F45\%SPR}$. The range of Acceptable Biological Catches (ABC) were estimated using the P* approach (Shertzer et al. 2008) with probabilities of 0.05 to 0.50 in 0.05 increments of exceeding the OFL. To approximate uncertainty in the OFL, we used the 2500 $F_{30\%SPR}$ estimates from the MCMC run. The current fishing mortality rate was the geometric mean of the directed fishing mortality rates on fully selected ages from 2006 through 2008, and that rate was applied in 2009 and 2010 and then new regulations began in 2011 and ran through 2020 which would be 10 years after implementing new management measures. Also for simplicity, the model assumed that the proportion of the catch by fleet remains constant such that the model used a selectivity pattern for the combined, directed portion of the catch and another selectivity pattern for the combined discard portion. The assumption that the selectivities would not change with management implies that the management measures would vary effort and not sizes of fish legal to harvest.

Projection methods

As in the original analysis, we used the MCMC results to generate stochastic projections for eight different fishing mortality rates: no directed fishing (F directed = 0), fishing at OFL (F_{OFL} or $F_{30\%SPR}$), maintaining current fishing mortality rates, F = $F_{40\%SPR}$, F = $F_{45\%SPR}$, and F = 0.65 F_{OFL}, 0.75 F_{OFL} and 0.85 F_{OFL}. The stochastic projections used the number of fish by age in 2008, the fishing mortality rates for 2006-2008, as well as $F_{30\%SPR}$ from the MCMC to generate uncertainty in the projections. This model also used the geometric mean from 2006-08 for $F_{current}$ and made the same assumption that the combined selectivities for the directed fishery and the discards would not change.

A3.3.2. Model 3. Statistical Catch-at-Age Results

Measures of Overall Model Fit

Fits of the ASAP2 to the directed landings and dead discards in pounds by fleet and the indices of abundance are presented together with their standardized residuals in Figure A3.3.5.2. Overall, the fits were very close even without applying any additional weights to the removals. As with the original model, the fleet with the best fit for directed landings was the commercial hook-and-line fleet (lowest root mean square error term, rmse = 0.56, Table A3.3.4.1,) and headboat fleet had the poorest fit to the directed landings (rmse = 1.22). The fleet with the best fit for the discards (Figure A3.3.5.3) was the commercial longline fleet (rmse = 0.61) and worst fits were for the recreational fleets (headboat and MRFSS, rmse = 1.55). The index with the best fit (Figure A3.3.5.4) was the commercial longline fleet index (rmse = 0.77) but there was a pattern to the residuals in that the model predicted higher values until 2001 and the lower values until 2006 and the index with the worst fit was the headboat index (rmse = 1.78) which also had a pattern to the residuals with the model predicting higher values from 1996 to 2003 and then lower values for 2004 through 2007.

The ASAP2 model fits to the fleet and age compositions and their standardized residuals for the new base run are in Addendum Appendix-A, Figure AA-1. The fits to the headboat age composition estimated more young fish than were observed in the early regulatory period (1986-1991), the fits improved in the 1992-1998 period and were somewhat reasonable in the recent period. For the general recreational data, the model fit some of the early year's data well, e.g. 1987 and other years not so well, e.g. 1989 while the fits were generally good in the later years. The fits to the commercial hook-and-line age data were good. The fits to the longline age composition were good from 2000 and later.

As with the age compositions for the directed fleet, the discard age compositions are shown in

Addendum Appendix A (Figure AA-2). Probably because of the few ages involved, the fits to the discards are good. Only one index had age composition (MRFSS) because the fishery dependent indices were linked to their fleets and the fishery independent index (FWC Visual Survey Age-1) only comprised a single age. The model fits to the MRFSS index were also good in most years (Addendum Appendix A Figure AA-3). The input file for ASAP2 is provided in Addendum Appendix B.

Parameter estimates and associated measures of uncertainty

The age-specific selectivities of the directed fleets were modeled with either double logistic (headboat, general recreational, commercial hook-and-line) or single logistic (commercial longline) curves (Table A3.3.4.2, Figure A3.3.5.5a-d). The table includes the standard deviations (square root of the variance from the covariance matrix) of the coefficients. The fishery independent indices were deleted except for the FWC Visual survey Age-1 index which was not fit (because this index contained only Age-1 fish, the proportion that this age class represented in this index equaled 1). The general recreational (MRFSS) index was treated as a fishery-independent index because that program has always collected information on the total catch by species per intercept (numbers kept and number discarded alive) and MRFSS's index had a selectivity curve distinct from the three selectivity blocks in the MRFSS fleet (Table A3.3.4.3). The fleet selectivities and the index selectivities together accounted for 44 parameters.

As before, the model estimated fishing mortality by first estimating the fishing mortality in 1986 by fleet for the fully selected ages and then estimating annual multiplicative deviations for the later years (Table A3.3.4.4). Therefore there were four, fleet-specific, 1986 log fishing mortality multiplier parameters and 88 log fishing mortality deviation parameters.

Logarithms of the number of fish at-age in the population at the beginning of 1986 (ages two through 20+) were estimated by applying age deviations to the initial guesses (19 parameters, Table A3.3.4.5).

Annual recruitment was the predicted number of age-1 fish from the Beverton-Holt stock recruitment relationship (SEDAR19-BG SA final, Equation 3.3.1.14) calculated from the spawning biomass in the previous year and adjusted by a log recruitment deviation (Equation 3.3.1.19). The model fit steepness (h = 0.838, sd = 0.0721) and the log spawning biomass without fishing (log SSB_0 = 16.924, sd = 0.127) in the reparameterized BH stock-recruitment relationship. There were 23 log recruitment deviation parameters because the analysis covered a 23 year time period (Table A3.3.4.6).

There were five log catchability coefficients, one for each index of abundance, and these coefficients were used to relate the number or biomass of fish at age to the index values (Table A3.3.4.7).

Altogether, the ASAP2 model for black grouper in this configuration fit 185 parameters. The sequence of phases for estimating the parameters remained the same as in the original (Table A3.3.4.8) and we confirmed the convergence of the model runs by checking that the eigenvalues (resulting from inverting the Hessian matrix generated by the nonlinear modeling software [ADMB Version 9]) were positive which yielded valid variance-covariance matrices.

Stock Abundance and Recruitment

The stock abundance in the new base run was lower than in the original base run mostly due to lower recruitment and higher fishing mortality rates. The number of fish in the population decreased until 1990 and then increased until 2000 and has declined afterwards (Table A3.3.4.9a and Figure A3.3.5.6).

Over the whole time series, the total number per year has increased (t-test of slope equal zero, $t = 4.29$, $df = 21$, $P < 0.05$). Recruitment, expressed as the number of age-1 fish, has been variable but decreased after 1994 (Table A3.3.4.9a and Figure A3.3.5.7). Early in the time series, recruitment comprised approximately 30-35% of the stock by number but more recently, 2002-2008, the percentage has been lower at 23-27%. In numbers of fish, the plus group of age-20 and older fish was approximately 2% of the annual total number in the early part of the time series and then declined to 1.4% in 1994-1997 and has returned to 2%in 2008.

Stock Biomass (total and spawning stock)

The total biomass was stable at 6.0 million pounds until 1993 when it began to increase and has continued to increase such that the highest total biomass was in 2008 (11 million pounds, Table A3.3.4.9b and Figure A3.3.5.8). The spawning biomass, including both males and females, had a similar pattern and was stable at 3.5 million pounds until 1993 when it began to increase (Figure A3.3.5.9). In 2008, the spawning biomass was 8.3 million pounds (Table A3.3.4.10). The plus group has decreased from 19% to 9% of the total biomass and was 10% in 2008 (t-test of slope in trend, $t = -10.66$, $df = 21$, $P < 0.05$, from the data in Table A3.3.4.9b).

Fishery Selectivity

The fishery selectivities by fleet and regulatory period (Table A3.3.4.2) were shown in Figure A3.3.5.5a-d. Note that selectivity with ASAP2 is for total catch including discards, and it was not surprising that the two recreational fleets had similar selectivity patterns because they operate in similar water depths and fishing areas. The commercial fleets both show higher selectivity on older aged fish reflecting that they operate in deeper waters than recreational anglers.

Fishing Mortality

As mentioned above, the fishing mortality rates were higher in the new base run. For example, the F-multiplier for MRFSS in 2008 was 0.18 per year in the original report and 0.28 per year in the new base run. The instantaneous total catch rates (F-multipliers) for commercial hook-and-line and for MRFSS in the beginning of the time series were approximately 0.17 per year (Figure A3.3.5.10a) but then the commercial hook-and-line catch rate declined while the total catch rate for MRFSS was variable but remained at the higher level and the total catch rate in 2008 (0.28 per year) was the highest of the time series.

Prior to 1991, the commercial hook-and-line fleet accounted for much of the directed fishing mortality with MRFSS being the next highest (Figure A3.3.5.10b). However, the fishing mortality from the commercial hook-and-line fleet has declined since 1987 to a low of 0.010 per year in 2008 while the fishing mortality rate for MRFSS increased from 1990 to 1998 and then has declined from a peak in 1997 to a low in 2003. The directed fishing mortality on age-5 (fully selected) fish for MRFSS was 0.091 per year in 2008. The other fleets, headboats and longlines, accounted for only a small portion of the fishing mortality.

The combined (directed and discards) fishing mortality rate on age-5 fish, the fully selected age, has declined from values exceeding 0.25 per year in the beginning of the time series to less than half that level in recent years even with the upturn in 2008 (Table 3.3.4.11 and Figure A3.3.5.11). The combined fishing mortality rate in 2008 was 0.108 per year.

The yield-per-recruit and the static spawning potential ratio (SPR) are shown in Figure A3.3.5.12. The maximum yield per-recruit occurred with a fishing mortality rate of 0.32 per year which is greater than the fishing mortality rate in 2008 (0.108 per year) and is greater than the management objective of $F_{30\%SPR}$ which is 0.216 per year. The fishing mortality rate in 2008 corresponds to a static SPR of 54%.

Stock-Recruitment Parameters

The model estimates recruitment with a Beverton-Holt stock-recruitment relationship (SEDAR19 BG Sa final, Equation 3.3.1.14). Based on life history considerations of longevity and age of maturity, the initial value for steepness was set at 0.75 (CV = 0.1). The model converged with a steepness value of 0.84 but the MCMC results from 2.5 million simulations produced a range of values from 0.61 to 1.00 with half of the outcomes between 0.80 and 0.89 (Figure A3.3.5.13a). The other term in the stock-recruitment relationship that ASAP2 estimated was the spawning biomass at F = 0; the point estimate was 22.4million lb and the MCMC produced a range of 16 to 38 million lb with half of the outcomes between 21 and 24 million lb (Figure A3.3.5.13b). The final term necessary to predict the number of recruits from the previous year's spawning biomass was the spawning biomass per recruit at F=0 (88.1 lb). This term depends upon the natural mortality rate, average spawning weight at age, and selectivity. The pattern of recruitment one year later was variable with an initial decline to 1989 a general increase until 2000 and then another decline afterwards (Figure A3.3.5.14). The decline after 2000 follows the age-1 index (Figure A3.3.5.4).

Evaluation of Uncertainty

ASAP2 estimates uncertainty with a covariance matrix of the estimated parameters and through Markov Chain Monte Carlo (MCMC) simulations. The uncertainty in the model's 185 parameters from the covariance matrix was presented in Tables A3.3.4.2-A3.3.4.7. To explore uncertainty beyond the estimated standard deviations of the parameters, we first made an MCMC run of 4.31 million simulations with a thinning rate of one (i.e., no MCMC iterations were thinned). The 4.31 million simulations had 1.18 million accepted runs or an acceptance rate of 0.274 (Table A3.3.4.12). Trace plots confirmed that a thinning rate of 1000 ensured that the outcomes did not have cyclical patterns (Figure A3.3.5.15). The final MCMC run was for 2.5 million accepted simulations.

The distributions of MCMC outcomes for the fishing mortality per year on fully selected ages in 2008 and the spawning biomass in 2008 are shown in Figure A3.3.5.16 and likelihood profiles for the same parameters are shown in Figures A3.3.5.17. The profiles were similar to their normal approximations but the F_{2008} point estimate was higher than the mode of the MCMC estimates.

The two, main parameters of interest to the councils were their overfishing measure -- the ratio of fishing mortality in 2008 compared to the fishing mortality at 30% SPR ($F_{30\%SPR}$), and overfished measure --the spawning biomass in 2008 compared to the spawning biomass at $F_{30\%SPR}$. Both of these measures indicated that the black grouper stock was in compliance with the councils' objectives. The F-ratio was less than 1.00 (0.50) and the spawning biomass ratio was greater than 1.00 (1.40). The distributions of the MCMC outcomes for these two measures showed that all of the MCMC outcomes met the councils' objectives (Figure A3.3.5.18).

Retrospective Analysis

The retrospective analysis used terminal years of 2004 to 2008; however, the run ending in 2005 did not converge. Looking at the runs with valid convergence, there were minimal retrospective patterns. As more years were included in the analysis, the fishing mortality rate on fully selected ages increased by an average of only 0.006 per year (Figure A3.3.5.19a). Spawning biomass decreased an average of 199,000 lb a year or about 3% (Figure A3.3.5.19b). Recruitment was more variable but decreased by an average of 3600 fish or 1% per year (Figure A3.3.5.19c).

Sensitivity Runs

The review panel suggested some additional runs to explore the influence of different data inputs to the model solutions. In Table A3.3.4.13, the first 18 runs were exploration runs from which the new base run was chosen and runs 19-73 examined alternative natural mortality rates, steepness, and release mortality rates. The first run restored the longline age compositions and as noted in the original report, the results differed little with or without these age compositions. The second run omitted the 1994-1997 NMFS-M Reef Visual Census index values (short RVC) again with little impact on the results. Emphasizing the longline index by weighting it with a value of 10 (Run 3) increased the spawning biomass estimates as did emphasizing all the indices by 10; however when the weights were increased on all of the indices the spawning biomass at $F_{30\%SPR}$ declined such that the SSB-ratio was 2.48. When only two selectivity blocks were used instead of 11 blocks (Run 5), the benchmark, $F_{30\%SPR}$, declined. The next set of runs (Run 6-10) repeated the above configuration except that the time series excluded 1986-1990 because of the species identification questions in those early years. The results were that the estimates of fishing mortality were higher with corresponding reductions in spawning biomass. Runs 9 and 10 using the short time series and weighted indices were the only runs with fishing mortality rates higher than the benchmarks indicating possible overfishing, and Run 10 which used only two selectivity blocks had the spawning biomass ratio below MSST. The next set of runs examined the effects of the fishery independent indices on the results. These runs included only using the RVC indices, only using the FWC indices, only including the RVC age-1 index, and only the FWC age-1 index. Another run looked at dropping the years 2006-2008 from the longline index because of the potential bias from trip limits.

After examining the results from the exploratory runs, the review panel decided upon a new base run that omitted the fishery independent indices except for the FWC age-1 index, included the longline age compositions, and excluded the longline index values for 2006-2008 (Run 17). The three, recent points in the longline index were re-instated after we reviewed the working paper on the development of the longline index (SEDAR19-DW-13) and decided that the measure of effort, number of sets x hooks per set, would accommodate trip limits such that Run 16 became the new base run. However as mentioned in Section A3.3.1, errors were found after the review workshop in the longline discard weights and in the initial hook-and-line fleets' effective sample sizes. We notified the Review Panel Chair, made the corrections, and the new base run is included in the table as the un-numbered run after Run 18. As has been presented in the results, the new base run had higher fishing mortality rates and lower spawning biomass estimates than did the original base run.

Using the configuration of the new base run, we re-ran the original sensitivity runs regarding natural mortality, release mortality rates, and alternative steepness values. With M = 0.10 per year, the fishing mortality rates were lower after 1990 than the new base run (Figure 3.3.5.20a) and the spawning biomass estimates were higher than at the other natural mortality rates. The spawning biomass at M = 0.20 per year was almost flat until the last few years (Figure 3.3.5.20b). Recruitment estimates increased with natural mortality but followed similar patterns (Figure 3.3.5.20c). Recruitment no longer has the dip in 1995 because that dip was related to a decline in the RVC Age-1 index in 1995 and the RVC

Age-1 index was omitted in the new base run.

The range of release of mortalities (especially those recommended by the DW) used for the sensitivity runs had little impact on the model outputs (Table A3.3.4.14). The results were more sensitive to changes in the recreational and commercial hook-and-line release rate than in the longline release rate probably because the longline fleet rarely encounters small fish that have to be released. Steepness (an important parameter in the stock recruitment relationship) ranged from 0.832 at the lowest release mortalities for hook-and-line gears (HL) to 0.869 at the highest release mortality rate for HL (Table A3.3.4.14). Similar results were seen for F_{2008}, ranging from 0.107 per year at the lowest HL release mortality up to 0.112 per year at the highest HL release mortality (Table A3.3.4.14). The estimated SSB_{2008} increased with HL release mortality rates was about 8% higher at a HL release mortality of 90%. For the fishing mortality rate and spawning stock biomass at points corresponding to the councils' OFL proxy of 30% spawning potential ratio (SPR) computed by the model, the $F_{30\%\ SPR}$ was relatively high at lower release mortalities while the spawning stock biomass at $F_{30\%\ SPR}$ was lower (i.e., it took a smaller SSB to produce enough young to compensate for the lower release mortality rates). At higher release mortalities, the $F_{30\%SPR}$ was lower and the $SSB_{30\%SPR}$ adjusted higher. The fishing ratio, $F_{2008}/F_{30\%SPR}$, one of the fishery management reference points, reached 0.80 when release mortalities were increased to 90% for both gears (Table A3.3.4.14). The SSB-ratio, $SSB_{2008}/SSB_{F30\%SPR}$, another of the fishery management reference points, ranged from 1.49 at the lower release mortalities to 1.05 when release mortalities were pushed to a HL release rate of 90% and a longline release rate of 75% (the SSB-ratio was 1.07 when both rates were 90%, Table A3.3.4.14). At the higher end of the release mortality range recommended by the DW, and also at the highest release mortalities (90%) used in these sensitivity runs, neither the F-ratio exceeded 1.0 nor the SSB-ratio was less than 1.0.

Fixed initial steepness values from 0.6 to 0.9 in 0.05 increments were run to see whether the conclusions regarding the condition of the stock were sensitive to the initial steepness values and then that range of steepness values were run with CVs of 0.1 (Table A3.3.4.15). The difference between the initial steepness values and the final steepness point estimate decreased with higher starting values, e.g., the final steepness with an initial value of 0.6 was 0.72 the difference of which is greater than the CV while the final steepness with an initial value of 0.95 was 1.00, the difference of which was smaller than the CV. The fishing mortality rate in 2008 on the fully selected age, age-5, increased slightly from 0.106 per year to 0.110 year over the range of steepness values; the spawning biomass in 2008 declined about 6%; and the spawning biomass at 30%SPR increased about 12%. The benchmarks of $F_{2008}/F_{30\%SPR}$ was insensitive to steepness varying between 0.49 and 0.51 while $SSB_{2008}/SSB_{F30\%SPR}$ varies from 1.34 at steepness = 0.6 to 1.46 at steepness = 0.95.

The variance-covariance matrix and the MCMC simulations evaluate observation error but sensitivity runs can be considered a means to partially evaluate process error. Towards that end, we plotted the distribution of the management measures, the F-ratios and the SSB-ratios for all of the sensitivity runs plus the original base run and the new base run. Altogether there were 75 runs but three didn't converge leaving a total of 72 runs. Of these 72 runs, two had F-ratios above 1.0 (3%) and one run had a SSB-ratio below MSST (1%, Figures A3.3.5.21 and A3.3.5.22).

Benchmarks / Reference Points / ABC values

Both the SAFMC and the GMFMC have chosen $F_{30\%SPR}$ as their overfishing limit (OFL, the former Maximum Fishing Mortality Threshold). Using $F_{30\%SPR}$ in lieu of F_{MSY} has the advantage of being based on a per-recruit measure and does not depend upon the stock-recruitment relationship and is more consistent across different models than F_{MSY} which does depend upon the stock-recruitment relationship. Consistency in the benchmark aids managers. The point estimate for $F_{30\%SPR}$ in the base run was 0.216 per year (fully recruited age, age-5) and 5.92 million lb for the spawning biomass associated with $F_{30\%SPR}$. The Minimum Spawning Stock Threshold (MSST= (1-M)$SSB_{30\%SPR}$) was 5.12 million lb.

The fishing mortality rate in 2008 on the fully recruited age (age-5) was 0.108 per year, the F-ratio ($F_{2008}/F_{30\%SPR}$) was 0.50 and one of the 2500 kept MCMC outcomes exceeded 1.0 indicating that the fleets were not overfishing the stock in 2008. Another way of visualizing an F-ratio of 0.50 is to plot both parameters on the same scale and note separation between the two distributions (Figure A3.3.5.23). The spawning biomass in 2008 was 8.3 million lb and the SSB-ratio was 1.40 and five out of 2500 kept MCMC outcomes (0.2%) were less than 1.0 indicating the black grouper were not overfished. The distributions of these two ratios from MCMC were shown in Figure A3.3.5.18.

Using the P* approach, the Acceptable Biological Catch (ABC) levels would have landings from 503,000 to 530,000 lb in 2011 and discards from 122,000 to 129,000 lb depending upon which level of risk the councils choose (Table A3.3.4.16). For 2020, the corresponding levels would be landings from 551,000 to 570,000 lb and discards from 122,000 to 131,000 lb. To provide a context for these levels, the projected 2010 landings were 311,000 lb and discards were 49,000 lb. Because the current fishing mortality rates are low relative to the benchmarks, attempting to have harvests near the benchmarks requires increasing the fishing mortality rates. Given that the overfishing limit is defined as $F_{30\%SPR}$ and the main source of variability is the uncertainty in the limit and the range of MCMC estimates for $F_{30\%SPR}$, was 0.200 to 0.225 per year, the P* approach produced very similar fishing mortality values from 0.20 per year to 0.22 year across the different probabilities (Table A3.3.4.16, Figure A3.3.5.24).

Projections

Black grouper were not deemed to be either undergoing overfishing nor were they overfished in 2008 and no rebuilding plan needs to be developed. Regardless, we ran eight stochastic projections using F = 0, $F_{current}$, $F_{30\%SPR}$ (both councils' overfishing limit), 0.65*$F_{30\%SPR}$, 0.75*$F_{30\%SPR}$, 0.85*$F_{30\%SPR}$, $F_{40\%SPR}$, and $F_{45\%SPR}$ (the SAFMC's optimum yield measure). The stochastic projections encompassed a wider range of fishing mortality rates and the projections include more variability than did the P* estimates because they used the number of fish in 2008 and the fishing mortality rates for 2006-2008 from the MCMC results to provide variability in the starting number of fish in the population in addition to the variability in the overfishing limit. The overfishing limit, $F_{30\%SPR}$ had the highest fishing mortality rate (0.217 per year on fully selected ages) followed by 0.85*$F_{30\%SPR}$ (F= 0.185 per year on fully selected ages), $F_{40\%SPR}$ and 0.75*$F_{30\%SPR}$ had similar rates (0.165 and 0.163 per year on fully selected ages respectively) and 0.65*$F_{30\%SPR}$ and $F_{45\%SPR}$ also had similar rates at (F = 0.141 and 0.144 per year on fully selected ages, respectively, Table A3.3.4.17 and Figure A3.3.5.25). Recruitment was inverse to fishing mortality, i.e. the lowest fishing mortality rates, F = 0 or F = $F_{current}$, had higher recruitment. The spawning biomass increased with $F_{45\%SPR}$ or lower fishing mortality rates and declined under higher fishing mortality rates (Figure A3.3.5.26). Because we assume that the fishery for reef species will continue to operate on suitable bottom habitat, when the directed fishery closes, i.e., F = 0, the discards were projected to increase because the directed fishery was converted to discards and those were in addition to the existing level of discard of undersized fish.

A3.3.3. Discussion

The addendum presents the revised results of the new base run. It followed the same outline as the original report and includes updated tables, figures, and appendices. By eliminating the fishery independent multi-age indices and the RVC age-1 index, the estimated productivity was less as evidenced by the lower population sizes, spawning biomass, and higher steepness. The lower productivity raised the fishing mortality in 2008 from 0.76 per year to 0.108 per year but even with this change, the stock was met the management objectives. Further, the consistency among the sensitivity runs and with the different models (Table A3.3.4.13 and Figure A3.3.5.22) indicates that the status determination of the stock in 2008 was robust and that the population of black grouper in US waters of the southeast and Gulf of Mexico was neither overfished nor undergoing overfishing.

A3.3.4. Tables

Table	Description
A2.1.2	Landings and discards in numbers and pounds by fleet and year.
A3.3.4.1.	ASAP2 model fits to landings, discards, and indices of abundance.
A3.3.4.2.	Selectivity coefficients and their standard deviations by fleet, period, and logistic curve type.
A3.3.4.3	Selectivity coefficients and their standard deviations for the index of abundance that was not linked to the corresponding fleet (MRFSS).
A3.3.4.4	Fishing mortality parameters and their standard deviations by fleet and year.
A3.3.4.5	Initial stock size parameters and their standard deviations to estimate the age-structure in 1986 for ages 2-20+ years.
A3.3.4.6	Recruitment deviation parameters and their standard deviations by year.
A3.3.4.7	Index catchability parameters and their standard deviations.
A3.3.4.8	The order of estimation of the parameters in ASAP2 by phase.
A3.3.4.9	Estimated annual population numbers-at-age (a) and stock biomass (lb, b) at the beginning of the year.
A3.3.4.10	Spawning biomass offset to the spawning season (mid-March) and recruitment of age-1 fish by year.
A3.3.4.11	Fishing mortality per year for directed (a), dead discards (b), and combined (c) for black grouper by year and age.
A3.3.4.12	Number of simulations within step before successful jump in Markov Chain Monte Carlo run.
A3.3.4.13	Sensitivity runs.
A3.3.4.14	Results of sensitivity runs of release mortality rates for hook-and-line gears and longline gear on model estimates for various parameters.
A3.3.4.15	Fixed and final steepness estimates and their standard deviation (SD), objective functions for the runs, fishing mortality rates in 2008 on fully selected aged fish (age-5), the spawning biomasses in 2008, the management fishing mortality limits, $F_{30\%SPR}$, and spawning biomasses at $F_{30\%SPR}$, F_{msy} and spawning biomass at F_{msy} over a range of initial steepness values.
A3.3.4.16	Landings, dead discards, fishing mortality rates, and spawning biomass projections over a range of probabilities of overfishing (0.05 to 0.50 in 0.05 increments) from P* with the implementation CV = 0.0.
A3.3.4.17	Landings, dead discards, fishing mortality rates, and spawning biomass projections for a variety of fishing mortality rates.

Table A2.1.2. Landings and discards in numbers and pounds by fleet and year.

	Landings (numbers)				Landings (pounds)				
Year	Headboat	MRFSS	Comm HL	Comm LL	Headboat	MRFSS	Comm HL	Comm LL	Total
1986	4,803	62,293	34,185	7,492	19,976	447,266	426,270	129,457	1,022,970
1987	3,231	55,769	64,461	11,337	39,603	382,021	567,539	125,101	1,114,264
1988	3,056	29,269	25,835	5,144	24,288	188,198	365,587	83,995	662,067
1989	2,084	28,002	35,478	4,998	19,806	181,452	384,267	82,395	667,920
1990	1,921	21,959	25,711	6,765	17,764	74,441	299,700	109,944	501,850
1991	1,703	32,959	13,817	2,594	15,378	398,475	163,451	53,681	630,985
1992	2,546	34,094	14,018	1,546	20,965	281,616	218,010	58,787	579,378
1993	2,128	26,831	12,070	982	25,129	140,596	165,666	35,670	367,061
1994	2,474	21,996	8,518	643	24,053	166,073	139,558	25,401	355,084
1995	4,525	25,993	7,546	571	31,760	236,796	115,303	24,975	408,834
1996	2,911	37,155	9,105	788	36,613	316,559	120,418	29,915	503,505
1997	3,763	43,409	6,215	828	48,274	450,156	89,464	34,644	622,538
1998	6,122	30,635	6,133	1,066	84,984	389,372	88,334	41,778	604,468
1999	1,873	15,280	3,625	1,418	25,267	169,613	79,719	51,646	326,245
2000	1,065	8,763	4,362	1,304	15,118	112,952	92,434	50,077	270,581
2001	2,073	10,350	4,731	1,390	31,013	136,623	100,951	55,020	323,607
2002	1,120	11,663	4,265	1,498	15,271	139,377	89,052	53,496	297,196
2003	1,270	16,914	6,135	1,856	11,940	262,670	97,394	77,142	449,147
2004	1,613	15,585	4,280	2,113	18,414	139,018	91,732	73,385	322,549
2005	2,000	12,943	3,358	1,563	25,733	135,772	73,266	45,734	280,505
2006	1,130	7,732	3,373	1,792	17,862	92,165	72,223	61,444	243,695
2007	1,282	14,614	2,431	1,300	17,828	156,224	54,849	43,457	272,357
2008	339	14,671	1,451	536	3,930	162,408	33,236	17,843	217,417

	Discards (numbers)				Discards (pounds)				
Year	Headboat	MRFSS	Comm HL	Comm LL	Headboat	MRFSS	Comm HL	Comm LL	Total
1986	5,018	6,694			8,014	10,691			18,705
1987	3,376	31,074			5,391	49,626			55,017
1988	3,193	3,192			5,099	5,097			10,196
1989	2,177	4,118			3,477	6,576			10,053
1990	2,007	3,509			3,205	5,604			8,809
1991	1,779	15,025			2,842	23,995			26,837
1992	2,660	17,345			13,767	83,614			97,380
1993	2,223	10,488	1,114	40	11,506	50,558	6,517	121	68,702
1994	2,585	15,158	1,357	49	13,377	73,074	7,934	147	94,532
1995	4,728	6,564	1,225	44	22,505	29,113	6,587	131	58,336
1996	3,041	17,646	1,330	46	14,478	78,264	7,152	120	100,014
1997	3,932	14,565	1,407	50	18,715	64,599	7,566	131	91,011
1998	6,396	11,943	1,301	48	30,448	52,970	6,995	124	90,538
1999	1,957	11,035	1,459	53	8,628	82,449	11,586	419	103,082
2000	1,113	8,805	1,443	49	4,906	65,786	11,457	384	82,533
2001	2,166	7,026	1,249	46	9,550	52,493	9,915	360	72,318
2002	1,170	9,173	1,315	42	3,788	63,012	8,339	297	75,436
2003	1,327	10,590	1,665	48	4,296	24,531	10,555	349	39,730
2004	1,685	10,592	940	44	7,273	79,234	7,483	276	94,266
2005	2,090	4,124	1,880	33	8,959	23,541	11,452	186	44,138
2006	1,181	6,315	231	39	3,362	36,501	1,424	216	41,502
2007	1,339	8,884	1,777	35	4,181	58,075	12,385	219	74,860
2008	354	10,686	259	31	1,514	82,197	2,123	217	86,051

Table A3.3.4.1. ASAP2 model fits to landings, discards, and indices of abundance. The column labeled 'SS' is the sum of the squared standardized residuals, n is the number of years, 'MSE' is the sum of squares divided by n-1 which is equivalent to a variance, and 'RMSE' is the square root of MSE which is equivalent to the standard deviation.

Type	Fleet or Index	SS	n	MSE	RMSE
Landings	Headboat	32.67	23	1.48	1.22
	MRFSS	29.39	23	1.34	1.16
	Commercial hook-and-line	6.96	23	0.32	0.56
	Commercial longline	13.82	23	0.63	0.79
Discards	Headboat	53.02	23	2.41	1.55
	MRFSS	52.61	23	2.39	1.55
	Commercial hook-and-line	22.93	16	1.53	1.24
	Commercial longline	5.66	16	0.38	0.61
Indices	Headboat	69.85	23	3.17	1.78
	MRFSS	48.49	18	2.85	1.69
	Commercial hook-and-line	23.67	16	1.58	1.26
	Commercial longline	8.89	16	0.59	0.77
	FWC Visual Survey age-1	18.52	8	2.65	1.63

Table A3.3.4.2. Selectivity coefficients and their standard deviations by fleet, period, and logistic curve type. The fleets were modeled with different types of logistics curves. The headboat (HB), general recreation (MRFSS), and commercial hook-and-line fleets were fit with double logistic curve while the longline fleet was modeled with a single logistic curve.

		Type of	Parameters							
Fleet	Period	logistic	α1	α1 sd	β1	β1 sd	α2	α2 sd	β2	β2 sd
HB	1986-1991	Double	1.9150	0.3058	5.2808	1.5667	3.8195	0.1926	0.7844	0.0955
	1992-1998		1.0386	0.0831	1.8087	0.8450	4.1359	0.1037	1.3607	0.1020
	1999-2008		0.9771	0.0152	0.0067	0.0063	2.0209	0.2833	1.6949	0.0920
MRFSS	1986-1991	Double	0.9575	0.0646	0.0260	0.0416	3.7043	1.5154	2.7463	0.8220
	1992-1998		1.0671	0.0958	1.6141	0.3757	4.5089	0.0969	1.3333	0.1289
	1999-2008		1.0389	0.0100	0.0317	0.0102	3.4151	0.1007	1.6307	0.0915
HL	1986-1991	Double	1.8744	0.0677	0.2616	0.0771	6.3352	0.1409	1.4208	0.1312
	1992-1998		1.8691	0.0970	0.3698	0.0545	6.8396	0.2231	2.2627	0.2249
	1999-2008		1.7736	0.0943	0.3104	0.0361	4.9532	0.3587	3.5626	0.2784
LL	1986-1991	Single			No age data					
	1992-1998		6.2388	0.3207	1.5234	0.1131	--		--	
	1999-2008		4.8993	0.1676	0.9576	0.0499	--		--	

TableA 3.3.4.3. Selectivity coefficients and their standard deviations for the index of abundance that was not linked to the corresponding fleet (MRFSS). The selectivity was fit with a double logistic curve. The selectivity for the FWC Visual Survey age-1 index was 1.0 for age-1 and zero for the other ages.

	Parameters							
Index	α1	α1 sd	β1	β1 sd	α2	α2 sd	β2	β2 sd
MRFSS	2.5784	0.0534	0.3041	0.0205	5.6659	0.0554	0.9745	0.0506

Table A3.3.4.4. Fishing mortality parameters and their standard deviations by fleet and year. The fishing multiplier deviations are applied to the previous year's fishing multiplier in a sequential manner. The standard deviations of the log_Fmult_devs come from the covariance matrix and these are not dev-vector in ADMB parlance.

		Fishing mortality parameters							
		Headboat		MRFSS		HL		LL	
Year	Parameter	Estimate	sd	Estimate	sd	Estimate	sd	Estimate	sd
1986	log_Fmult	-3.5616	0.1240	-1.7834	0.2045	-1.7648	0.1514	-3.3388	0.2229
1987	log_Fmult_devs	0.2575	0.1172	0.1083	0.1575	0.1778	0.1766	-0.1293	0.1849
1988	log_Fmult_devs	-0.3238	0.1155	-0.4157	0.1771	-0.0894	0.1824	-0.1959	0.1832
1989	log_Fmult_devs	-0.2127	0.1129	-0.1334	0.1739	-0.1238	0.1833	-0.0857	0.1832
1990	log_Fmult_devs	-0.0762	0.1114	-0.0895	0.1852	-0.2578	0.1845	-0.0460	0.1850
1991	log_Fmult_devs	-0.0379	0.1103	0.4854	0.1895	-0.3535	0.1852	-0.2937	0.1864
1992	log_Fmult_devs	0.4531	0.1361	0.2257	0.1952	-0.1561	0.1849	-0.1711	0.1860
1993	log_Fmult_devs	0.0818	0.1091	-0.1633	0.1692	-0.1615	0.1764	-0.2597	0.1810
1994	log_Fmult_devs	-0.0597	0.1087	0.0507	0.1651	-0.1918	0.1659	-0.1556	0.1674
1995	log_Fmult_devs	0.1945	0.1085	-0.1443	0.1601	-0.2141	0.1652	-0.0781	0.1661
1996	log_Fmult_devs	0.0682	0.1084	0.2976	0.1464	-0.0700	0.1651	0.0038	0.1660
1997	log_Fmult_devs	0.1888	0.1086	0.0936	0.1377	-0.1459	0.1649	0.0441	0.1662
1998	log_Fmult_devs	0.3881	0.1085	-0.0838	0.1370	-0.0369	0.1664	0.0271	0.1680
1999	log_Fmult_devs	-0.6165	0.1343	0.1819	0.1405	0.0291	0.1684	-0.0294	0.1768
2000	log_Fmult_devs	-0.4924	0.1082	-0.2501	0.1542	-0.0018	0.1688	-0.0799	0.1699
2001	log_Fmult_devs	0.4442	0.1078	-0.1261	0.1581	-0.0438	0.1696	-0.0110	0.1702
2002	log_Fmult_devs	-0.5794	0.1078	0.0996	0.1495	-0.0815	0.1698	-0.0327	0.1703
2003	log_Fmult_devs	-0.1534	0.1078	-0.2870	0.1373	0.0250	0.1701	0.0510	0.1704
2004	log_Fmult_devs	0.3738	0.1079	0.4121	0.1292	-0.0900	0.1702	-0.1085	0.1705
2005	log_Fmult_devs	0.3578	0.1080	-0.3864	0.1487	-0.1021	0.1704	-0.1494	0.1707
2006	log_Fmult_devs	-0.4540	0.1084	0.0655	0.1583	-0.3785	0.1711	0.0121	0.1708
2007	log_Fmult_devs	-0.1397	0.1085	0.2904	0.1564	0.1110	0.1719	-0.2627	0.1717
2008	log_Fmult_devs	-1.0790	0.1112	0.2826	0.1647	-0.4062	0.1799	-0.2968	0.1795

Table A3.3.4.5. Initial stock size parameters and their standard deviations to estimate the age-structure in 1986 for ages 2-20+ years. These deviations are applied to the age-specific initial guesses of population size.

		Initial stock size parameters	
Age	Description	Estimate	sd
2	log_N_year1_devs	-0.9382	0.1609
3	log_N_year1_devs	-1.8392	0.2256
4	log_N_year1_devs	-1.8166	0.2579
5	log_N_year1_devs	-1.9599	0.3034
6	log_N_year1_devs	-1.7251	0.3370
7	log_N_year1_devs	-1.3778	0.3650
8	log_N_year1_devs	-1.1448	0.3831
9	log_N_year1_devs	-1.0888	0.3991
10	log_N_year1_devs	-1.0671	0.4422
11	log_N_year1_devs	-1.0605	0.5667
12	log_N_year1_devs	-1.0661	0.5640
13	log_N_year1_devs	-1.0141	0.5523
14	log_N_year1_devs	-0.9065	0.5462
15	log_N_year1_devs	-0.7766	0.5417
16	log_N_year1_devs	-0.6310	0.5395
17	log_N_year1_devs	-0.4609	0.5376
18	log_N_year1_devs	-0.2801	0.5363
19	log_N_year1_devs	-0.0886	0.5361
20	log_N_year1_devs	2.9697	0.5322

Table A3.3.4.6. Recruitment deviation parameters and their standard deviations by year.

		Recruitment parameters	
Year	Description	Estimate	sd
1986	log_recruit_devs	0.3021	0.1389
1987	log_recruit_devs	0.1183	0.1303
1988	log_recruit_devs	0.0117	0.1208
1989	log_recruit_devs	-0.0927	0.1026
1990	log_recruit_devs	-0.0046	0.1007
1991	log_recruit_devs	0.0457	0.0941
1992	log_recruit_devs	0.0378	0.0883
1993	log_recruit_devs	0.1253	0.0833
1994	log_recruit_devs	0.2412	0.0787
1995	log_recruit_devs	0.1761	0.0756
1996	log_recruit_devs	0.1228	0.0702
1997	log_recruit_devs	0.1079	0.0656
1998	log_recruit_devs	0.1076	0.0624
1999	log_recruit_devs	0.0913	0.0577
2000	log_recruit_devs	0.0734	0.0570
2001	log_recruit_devs	-0.0430	0.0607
2002	log_recruit_devs	-0.0789	0.0638
2003	log_recruit_devs	-0.1517	0.0687
2004	log_recruit_devs	-0.2168	0.0747
2005	log_recruit_devs	-0.2313	0.0860
2006	log_recruit_devs	-0.2043	0.0927
2007	log_recruit_devs	-0.2109	0.1108
2008	log_recruit_devs	-0.3268	0.2402

Table A3.3.4.7. Index catchability parameters and their standard deviations.

		Catchability parameters	
Index	Description	Estimate	sd
Headboat	log_q_year1	-13.1500	0.0992
MRFSS	log_q_year1	-12.3560	0.1119
Commercial HL	log_q_year1	-15.0520	0.1114
Commercial LL	log_q_year1	-15.4010	0.1713
FWC Visual Survey Age-1	log_q_year1	-12.0220	0.1068

Table A3.3.4.8. The order of estimation of the parameters in ASAP2 by phase.

Phase	**Parameter**	**Description**
1	$N_{1,a}$	Numbers-at-age in year 1
2	$Fmult_{f,1}$ q_{ind}	Fishing multiplier in year 1 by fleet Catchabilities in year 1 by index
3	SSB_0	Unexploited stock size
4	$Sel_{f,a}$	Selectivity blocks by fleet
5	Sel_{ind}	Selectivity of fishery-independent indices
6	h	Steepness
7	Log_Rdev_t	Recruitment deviations
8	$Log\_Fmultdev_{f,t}$	Fishing multiplier deviations by fleet and year

Table A3.3.4.9. Estimated annual population numbers-at-age (a) and stock biomass (lb, b) at the beginning of the year.

a. Population abundance.

	Ages																			
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	276,734	201,534	59,614	39,803	29,717	23,213	16,833	12,171	8,842	6,788	5,221	3,922	3,065	2,489	2,037	1,675	1,400	1,175	993	14,692
1987	230,281	170,049	113,811	33,049	23,746	19,060	15,919	12,237	9,282	6,986	5,498	4,297	3,266	2,572	2,099	1,726	1,424	1,192	1,003	13,467
1988	206,163	146,521	94,864	59,603	18,774	14,652	12,706	11,359	9,234	7,297	5,650	4,528	3,585	2,749	2,177	1,785	1,473	1,218	1,022	12,477
1989	184,453	130,538	85,906	53,943	36,295	12,250	10,205	9,379	8,796	7,404	5,994	4,712	3,818	3,045	2,345	1,865	1,533	1,267	1,051	11,707
1990	200,271	120,104	78,411	50,838	34,013	24,365	8,723	7,656	7,346	7,110	6,118	5,021	3,987	3,252	2,605	2,013	1,606	1,323	1,096	11,087
1991	210,105	131,083	79,716	48,640	33,456	23,674	17,847	6,677	6,076	5,987	5,905	5,142	4,259	3,403	2,787	2,239	1,736	1,386	1,145	10,599
1992	209,365	136,005	82,678	48,748	31,752	23,189	17,299	13,631	5,288	4,945	4,970	4,968	4,370	3,646	2,927	2,406	1,940	1,506	1,206	10,273
1993	230,107	134,038	88,882	53,759	32,393	21,466	16,682	13,220	10,866	4,336	4,134	4,208	4,246	3,760	3,150	2,537	2,092	1,689	1,315	10,072
1994	260,137	147,733	90,567	59,835	36,623	22,594	15,776	12,943	10,655	8,984	3,648	3,519	3,613	3,668	3,261	2,741	2,214	1,828	1,480	10,023
1995	245,559	168,746	103,200	63,771	41,485	25,525	16,709	12,316	10,491	8,852	7,590	3,116	3,030	3,129	3,188	2,843	2,396	1,938	1,604	10,140
1996	234,841	157,915	115,910	71,573	44,432	29,397	19,167	13,185	10,058	8,761	7,507	6,499	2,688	2,628	2,723	2,782	2,487	2,099	1,702	10,361
1997	233,863	151,058	107,838	78,963	49,024	30,616	21,622	14,960	10,711	8,381	7,423	6,426	5,607	2,331	2,287	2,376	2,434	2,179	1,843	10,641
1998	236,399	150,410	102,682	73,127	52,520	33,177	22,349	16,822	12,142	8,925	7,102	6,356	5,544	4,863	2,029	1,995	2,078	2,132	1,913	11,009
1999	235,117	151,885	103,626	70,793	49,367	35,627	24,217	17,391	13,655	10,118	7,564	6,081	5,483	4,808	4,230	1,770	1,745	1,820	1,871	11,392
2000	233,464	154,389	104,171	74,502	51,869	36,058	27,167	19,234	14,216	11,385	8,556	6,456	5,229	4,741	4,172	3,683	1,545	1,526	1,596	11,687
2001	210,197	154,639	107,913	76,429	55,930	38,866	27,943	21,790	15,815	11,895	9,649	7,314	5,559	4,526	4,118	3,636	3,219	1,352	1,339	11,715
2002	205,130	138,961	108,471	78,994	57,001	41,973	30,265	22,485	17,955	13,252	10,091	8,254	6,300	4,813	3,932	3,589	3,177	2,818	1,187	11,514
2003	192,852	135,893	97,985	79,821	58,687	42,676	32,677	24,364	18,541	15,057	11,252	8,639	7,116	5,459	4,184	3,429	3,138	2,783	2,473	11,208
2004	182,592	128,277	97,152	73,307	60,164	44,585	33,597	26,469	20,156	15,573	12,792	9,634	7,446	6,163	4,743	3,647	2,997	2,747	2,442	12,063
2005	181,721	120,790	89,462	70,523	53,999	44,681	34,529	26,978	21,807	16,902	13,227	10,958	8,310	6,455	5,361	4,139	3,190	2,626	2,413	12,802
2006	188,252	120,399	86,119	66,555	52,562	40,934	35,237	28,049	22,392	18,377	14,406	11,360	9,471	7,216	5,623	4,684	3,625	2,799	2,309	13,444
2007	188,386	125,012	85,958	64,416	50,326	40,202	32,437	28,748	23,366	18,928	15,702	12,396	9,833	8,234	6,292	4,916	4,105	3,182	2,462	13,921
2008	168,761	124,801	88,242	63,229	47,782	37,733	31,458	26,274	23,861	19,719	16,165	13,515	10,738	8,558	7,188	5,508	4,315	3,607	2,803	14,500

Table A3.3.4.9 (continued). Estimated annual population numbers-at-age (a) and stock biomass (lb, b) at the beginning of the year.

b. Stock biomass.

	Ages																			
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	247,677	558,652	344,094	387,404	428,253	453,776	419,358	368,918	314,780	276,038	237,226	195,592	165,338	143,487	124,303	107,278	93,421	81,223	70,741	1,172,459
1987	206,101	471,376	656,917	321,663	342,199	372,593	396,598	370,925	330,445	284,081	249,799	214,290	176,164	148,305	128,090	110,496	95,019	82,419	71,487	1,074,717
1988	184,516	406,156	547,554	580,115	270,551	286,408	316,545	344,317	328,719	296,734	256,729	225,838	193,422	158,482	132,846	114,289	98,255	84,169	72,841	995,682
1989	165,085	361,851	495,848	525,029	523,053	239,455	254,245	284,284	313,128	301,089	272,346	235,009	205,963	175,558	143,081	119,382	102,306	87,586	74,841	934,234
1990	179,243	332,928	452,588	494,805	490,156	476,291	217,315	232,077	261,516	289,126	277,958	250,416	215,100	187,517	158,934	128,906	107,122	91,409	78,054	884,781
1991	188,044	363,362	460,118	473,413	482,127	462,779	444,630	202,384	216,314	243,473	268,311	256,461	229,766	196,207	170,026	143,386	115,814	95,825	81,554	845,837
1992	187,382	377,006	477,216	474,468	457,571	453,293	430,963	413,192	188,243	201,082	225,839	247,751	235,770	210,197	178,563	154,049	129,429	104,120	85,941	819,798
1993	205,946	371,553	513,026	523,234	466,820	419,608	415,606	400,725	386,829	176,301	187,827	209,849	229,050	216,786	192,174	162,458	139,586	116,771	93,690	803,726
1994	232,823	409,516	522,752	582,373	527,775	441,658	393,037	392,340	379,304	365,310	165,762	175,474	194,912	211,482	198,956	175,474	147,718	126,362	105,425	799,816
1995	219,775	467,764	595,670	620,680	597,843	498,961	416,264	373,332	373,473	359,952	344,867	155,380	163,440	180,395	194,502	182,019	159,841	133,954	114,274	809,200
1996	210,183	437,740	669,033	696,617	640,305	574,651	477,498	399,664	358,037	356,270	341,066	324,131	145,012	151,500	166,116	178,130	165,956	145,070	121,236	826,805
1997	209,307	418,733	622,441	768,546	706,486	598,472	538,676	453,477	381,315	340,786	337,288	320,471	302,490	134,422	139,513	152,138	162,412	150,620	131,295	849,181
1998	211,577	416,937	592,681	711,746	756,860	648,544	556,791	509,915	432,232	362,927	322,699	316,982	299,097	280,385	123,768	127,745	138,674	147,357	136,271	878,508
1999	210,430	421,025	598,129	689,023	711,424	696,427	603,321	527,144	486,104	411,426	343,669	303,252	295,805	277,196	258,114	113,303	116,414	125,791	133,287	909,064
2000	208,950	427,966	601,275	725,131	747,481	704,860	676,804	583,009	506,065	462,939	388,733	321,960	282,107	273,372	254,569	235,833	103,097	105,475	113,682	932,662
2001	188,126	428,659	622,874	743,883	806,006	759,747	696,151	660,483	563,012	483,690	438,415	364,754	299,865	260,963	251,268	232,775	214,746	93,477	95,389	934,841
2002	183,591	385,200	626,095	768,844	821,434	820,482	753,992	681,550	639,162	538,863	458,499	411,648	339,890	277,495	239,935	229,813	212,005	194,742	84,550	918,872
2003	172,603	376,695	565,567	776,901	845,734	834,230	814,070	738,509	660,055	612,282	511,241	430,850	383,860	314,732	255,276	219,555	209,399	192,333	176,211	894,405
2004	163,420	355,584	560,762	713,501	867,025	871,548	837,002	802,337	717,533	633,252	581,222	480,438	401,683	355,328	289,415	233,492	199,964	189,885	173,955	962,652
2005	162,640	334,830	516,372	686,398	778,184	873,426	860,209	817,742	776,300	687,299	601,000	546,466	448,281	372,184	327,075	264,988	212,871	181,507	171,906	1,021,585
2006	168,486	333,746	497,077	647,783	757,467	800,174	877,864	850,212	797,140	747,290	654,565	566,525	510,937	416,074	343,109	299,880	241,893	193,457	164,513	1,072,818
2007	168,605	346,533	496,151	626,958	725,242	785,865	808,100	871,412	831,817	769,668	713,432	618,206	530,487	474,777	383,906	314,787	273,877	219,910	175,388	1,110,956
2008	151,041	345,948	509,331	615,405	688,592	737,603	783,721	796,430	849,410	801,841	734,487	674,007	579,304	493,433	438,580	352,664	287,876	249,333	199,654	1,157,105

Table A3.3.4.10. Spawning biomass offset to the spawning season (mid-March) and recruitment of age-1 fish by year.

Year	Spawning biomass (lb)	Recruitment Number of age-1 fish
1986	3,706,670	276,734
1987	3,644,680	230,281
1988	3,541,110	206,163
1989	3,457,730	184,453
1990	3,424,660	200,271
1991	3,486,200	210,105
1992	3,587,180	209,365
1993	3,691,590	230,107
1994	3,811,990	260,137
1995	3,961,100	245,559
1996	4,160,390	234,841
1997	4,385,590	233,863
1998	4,630,100	236,399
1999	4,896,800	235,117
2000	5,213,420	233,464
2001	5,570,170	210,197
2002	5,958,520	205,130
2003	6,371,550	192,852
2004	6,809,070	182,592
2005	7,225,420	181,721
2006	7,636,630	188,252
2007	8,000,670	188,386
2008	8,291,540	168,761

Table A3.3.4.11. Fishing mortality per year for directed (a), dead discards (b), and combined (c) for black grouper by year and age.

a. Directed fishing mortality per year.

	Ages																			
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	0.066	0.265	0.346	0.305	0.254	0.203	0.156	0.117	0.089	0.070	0.058	0.050	0.045	0.042	0.040	0.039	0.038	0.037	0.036	0.036
1987	0.015	0.268	0.403	0.354	0.293	0.232	0.175	0.128	0.094	0.071	0.057	0.048	0.042	0.039	0.036	0.035	0.034	0.033	0.032	0.032
1988	0.039	0.228	0.321	0.284	0.237	0.188	0.141	0.102	0.074	0.056	0.045	0.038	0.033	0.031	0.029	0.028	0.027	0.027	0.026	0.026
1989	0.009	0.206	0.281	0.249	0.209	0.166	0.124	0.090	0.066	0.050	0.040	0.034	0.030	0.028	0.027	0.026	0.025	0.024	0.024	0.024
1990	0.005	0.090	0.234	0.206	0.172	0.137	0.104	0.077	0.058	0.045	0.037	0.032	0.028	0.026	0.025	0.024	0.024	0.023	0.023	0.023
1991	0.005	0.145	0.248	0.215	0.177	0.140	0.106	0.079	0.059	0.045	0.036	0.030	0.026	0.023	0.021	0.020	0.019	0.018	0.018	0.017
1992	0.014	0.092	0.156	0.176	0.197	0.155	0.106	0.073	0.052	0.038	0.030	0.024	0.020	0.018	0.017	0.016	0.015	0.015	0.015	0.014
1993	0.016	0.059	0.122	0.154	0.165	0.134	0.091	0.062	0.043	0.032	0.024	0.019	0.016	0.014	0.013	0.012	0.012	0.011	0.011	0.011
1994	0.003	0.017	0.067	0.133	0.168	0.128	0.085	0.056	0.038	0.028	0.021	0.017	0.014	0.012	0.011	0.011	0.010	0.010	0.010	0.010
1995	0.017	0.044	0.093	0.134	0.152	0.112	0.074	0.049	0.033	0.024	0.018	0.015	0.012	0.011	0.010	0.010	0.009	0.009	0.009	0.009
1996	0.006	0.039	0.102	0.143	0.179	0.133	0.085	0.054	0.035	0.025	0.018	0.015	0.012	0.011	0.010	0.010	0.009	0.009	0.009	0.009
1997	0.000	0.038	0.102	0.175	0.198	0.141	0.088	0.055	0.035	0.024	0.018	0.015	0.012	0.011	0.010	0.010	0.010	0.009	0.009	0.009
1998	0.000	0.020	0.080	0.156	0.195	0.141	0.088	0.055	0.035	0.024	0.018	0.015	0.013	0.011	0.011	0.010	0.010	0.010	0.009	0.009
1999	0.004	0.022	0.042	0.074	0.120	0.097	0.067	0.048	0.035	0.027	0.021	0.018	0.015	0.014	0.012	0.012	0.011	0.010	0.010	0.010
2000	0.000	0.016	0.030	0.054	0.095	0.081	0.058	0.042	0.031	0.024	0.020	0.017	0.014	0.013	0.012	0.011	0.010	0.010	0.009	0.009
2001	0.001	0.015	0.036	0.064	0.094	0.076	0.054	0.040	0.030	0.023	0.019	0.016	0.014	0.013	0.011	0.011	0.010	0.010	0.009	0.009
2002	0.001	0.007	0.029	0.069	0.097	0.076	0.054	0.039	0.029	0.023	0.018	0.015	0.013	0.012	0.011	0.010	0.010	0.009	0.009	0.009
2003	0.000	0.002	0.018	0.058	0.084	0.065	0.048	0.036	0.027	0.022	0.018	0.016	0.014	0.012	0.011	0.011	0.010	0.010	0.009	0.009
2004	0.000	0.014	0.041	0.076	0.105	0.082	0.056	0.040	0.029	0.022	0.018	0.015	0.013	0.011	0.010	0.010	0.009	0.009	0.008	0.008
2005	0.000	0.002	0.023	0.071	0.086	0.063	0.045	0.032	0.024	0.019	0.015	0.013	0.011	0.010	0.009	0.008	0.008	0.008	0.007	0.007
2006	0.000	0.002	0.018	0.055	0.076	0.059	0.041	0.029	0.021	0.016	0.013	0.011	0.010	0.009	0.008	0.008	0.008	0.007	0.007	0.007
2007	0.000	0.003	0.028	0.071	0.096	0.071	0.048	0.032	0.023	0.017	0.013	0.011	0.009	0.008	0.007	0.007	0.006	0.006	0.006	0.006
2008	0.000	0.022	0.050	0.073	0.105	0.081	0.051	0.033	0.022	0.015	0.011	0.008	0.007	0.006	0.005	0.005	0.005	0.004	0.004	0.004

Table A3.3.4.11 (continued). Fishing mortality per year for directed (a), dead discards (b), and combined (c) for black grouper by year and age.

b. Dead discard fishing mortality per year.

	Ages																			
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	0.025	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1987	0.041	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.022	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1989	0.024	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1990	0.022	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.034	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.036	0.036	0.031	0.021	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.031	0.036	0.030	0.018	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.034	0.044	0.040	0.021	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.029	0.034	0.029	0.016	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.040	0.046	0.038	0.023	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.045	0.051	0.043	0.021	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.046	0.055	0.048	0.025	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.021	0.058	0.044	0.025	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.016	0.046	0.036	0.021	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.017	0.043	0.032	0.017	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.015	0.045	0.034	0.016	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.012	0.036	0.028	0.013	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.017	0.049	0.036	0.018	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.016	0.039	0.029	0.011	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.013	0.038	0.028	0.013	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.015	0.048	0.035	0.016	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.016	0.055	0.039	0.021	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table A3.3.4.11 (continued). Fishing mortality per year for directed (a), dead discards (b), and combined (c) for black grouper by year and age.

c. Combined fishing mortality per year.

	Ages																			
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1986	0.091	0.274	0.346	0.305	0.254	0.203	0.156	0.117	0.089	0.070	0.058	0.050	0.045	0.042	0.040	0.039	0.038	0.037	0.036	0.036
1987	0.056	0.287	0.403	0.354	0.293	0.232	0.175	0.128	0.094	0.071	0.057	0.048	0.042	0.039	0.036	0.035	0.034	0.033	0.032	0.032
1988	0.061	0.237	0.321	0.284	0.237	0.188	0.141	0.102	0.074	0.056	0.045	0.038	0.033	0.031	0.029	0.028	0.027	0.027	0.026	0.026
1989	0.033	0.213	0.281	0.249	0.209	0.166	0.124	0.090	0.066	0.050	0.040	0.034	0.030	0.028	0.027	0.026	0.025	0.024	0.024	0.024
1990	0.028	0.113	0.234	0.206	0.172	0.137	0.104	0.077	0.058	0.045	0.037	0.032	0.028	0.026	0.025	0.024	0.024	0.023	0.023	0.023
1991	0.039	0.164	0.248	0.215	0.177	0.140	0.106	0.079	0.059	0.045	0.036	0.030	0.026	0.023	0.021	0.020	0.019	0.018	0.018	0.017
1992	0.050	0.128	0.186	0.197	0.201	0.155	0.106	0.073	0.052	0.038	0.030	0.024	0.020	0.018	0.017	0.016	0.015	0.015	0.015	0.014
1993	0.047	0.095	0.152	0.172	0.170	0.134	0.091	0.062	0.043	0.032	0.024	0.019	0.016	0.014	0.013	0.012	0.012	0.011	0.011	0.011
1994	0.037	0.062	0.107	0.154	0.171	0.128	0.085	0.056	0.038	0.028	0.021	0.017	0.014	0.012	0.011	0.011	0.010	0.010	0.010	0.010
1995	0.045	0.079	0.122	0.149	0.154	0.112	0.074	0.049	0.033	0.024	0.018	0.015	0.012	0.011	0.010	0.010	0.009	0.009	0.009	0.009
1996	0.045	0.084	0.140	0.166	0.182	0.133	0.085	0.054	0.035	0.025	0.018	0.015	0.012	0.011	0.010	0.010	0.009	0.009	0.009	0.009
1997	0.045	0.089	0.144	0.196	0.200	0.141	0.088	0.055	0.035	0.024	0.018	0.015	0.012	0.011	0.010	0.010	0.010	0.009	0.009	0.009
1998	0.046	0.076	0.128	0.181	0.198	0.141	0.088	0.055	0.035	0.024	0.018	0.015	0.013	0.011	0.011	0.010	0.010	0.010	0.009	0.009
1999	0.025	0.080	0.086	0.099	0.124	0.097	0.067	0.048	0.035	0.027	0.021	0.018	0.015	0.014	0.012	0.012	0.011	0.010	0.010	0.010
2000	0.016	0.061	0.066	0.075	0.099	0.081	0.058	0.042	0.031	0.024	0.020	0.017	0.014	0.013	0.012	0.011	0.010	0.010	0.009	0.009
2001	0.018	0.058	0.068	0.081	0.097	0.076	0.054	0.040	0.030	0.023	0.019	0.016	0.014	0.013	0.011	0.011	0.010	0.010	0.009	0.009
2002	0.016	0.052	0.063	0.085	0.099	0.076	0.054	0.039	0.029	0.023	0.018	0.015	0.013	0.012	0.011	0.010	0.010	0.009	0.009	0.009
2003	0.012	0.039	0.046	0.071	0.085	0.065	0.048	0.036	0.027	0.022	0.018	0.016	0.014	0.012	0.011	0.011	0.010	0.010	0.009	0.009
2004	0.017	0.063	0.076	0.094	0.108	0.082	0.056	0.040	0.029	0.022	0.018	0.015	0.013	0.011	0.010	0.010	0.009	0.009	0.008	0.008
2005	0.016	0.041	0.052	0.082	0.087	0.063	0.045	0.032	0.024	0.019	0.015	0.013	0.011	0.010	0.009	0.008	0.008	0.008	0.007	0.007
2006	0.013	0.040	0.046	0.068	0.078	0.059	0.041	0.029	0.021	0.016	0.013	0.011	0.010	0.009	0.008	0.008	0.008	0.007	0.007	0.007
2007	0.016	0.051	0.063	0.087	0.098	0.071	0.048	0.032	0.023	0.017	0.013	0.011	0.009	0.008	0.007	0.007	0.006	0.006	0.006	0.006
2008	0.016	0.077	0.089	0.095	0.108	0.081	0.051	0.033	0.022	0.015	0.011	0.008	0.007	0.006	0.005	0.005	0.005	0.004	0.004	0.004

Table A3.3.4.12. Number of simulations within step before successful jump in Markov Chain Monte Carlo run. The total number of simulations run was 4,311,625 with an acceptance rate of 27.4%.

Number of simulations in step	Frequency	Proportion	Cumulative proportion
1	325,975	0.2762	0.2762
2	235,761	0.1998	0.4759
3	169,287	0.1434	0.6194
4	122,703	0.1040	0.7233
5	89,251	0.0756	0.7990
6	64,629	0.0548	0.8537
7	46,743	0.0396	0.8933
8	33,980	0.0288	0.9221
9	24,439	0.0207	0.9428
10	18,202	0.0154	0.9582
11	13,453	0.0114	0.9696
12	9,420	0.0080	0.9776
13	6,934	0.0059	0.9835
14	5,130	0.0043	0.9878
15	3,715	0.0031	0.9910
16	2,768	0.0023	0.9933
17	2,061	0.0017	0.9951
18	1,520	0.0013	0.9964
19	1,104	0.0009	0.9973
20	844	0.0007	0.9980
21	574	0.0005	0.9985
22	443	0.0004	0.9989
23	300	0.0003	0.9991
24	245	0.0002	0.9993
25	181	0.0002	0.9995
26	144	0.0001	0.9996
27	122	0.0001	0.9997
28	80	0.0001	0.9998
29	60	0.0001	0.9998
30	32	0.0000	0.9999
31	42	0.0000	0.9999
32	30	0.0000	0.9999
33	20	0.0000	0.9999
34	16	0.0000	0.9999
35	14	0.0000	1.0000
36	9	0.0000	1.0000
37	6	0.0000	1.0000
38	3	0.0000	1.0000
39	9	0.0000	1.0000
40	1	0.0000	1.0000
41	3	0.0000	1.0000
42	1	0.0000	1.0000
43	1	0.0000	1.0000
44	1	0.0000	1.0000
45	2	0.0000	1.0000
47	3	0.0000	1.0000
50	3	0.0000	1.0000
51	1	0.0000	1.0000
52	1	0.0000	1.0000
58	1	0.0000	1.0000
75	1	0.0000	1.0000
200	1	0.0000	1.0000
Total	1,180,269		

Table A3.3.5.13. Sensitivity runs. The first line in the table shows the original base run and the new base run is labeled 'New base 2'.

Run	Description	Objective function	F2008	F30%SPR	Fmsy	SSB2008	SSBF30%SPR	SSBmsy	MSY	Yield 30%	Steepness	F/F30%	F/Fmsy	3B/SSBF30	SSB/SSBmsy
	No LL age comps	4005.80	0.076	0.212	0.205	12,287,600	7,107,880	7,513,960	667,760	667,123	0.79	0.36	0.37	1.73	1.64
1	Include LL age comps	4425.79	0.071	0.212	0.205	12,839,000	7,437,540	7,828,820	697,186	696,621	0.79	0.33	0.34	1.73	1.64
2	Short rvc	4373.64	0.072	0.213	0.206	12,846,700	7,372,200	7,756,430	688,705	688,157	0.79	0.34	0.35	1.74	1.66
3	short rvc LL x 10	4373.12	0.070	0.214	0.208	13,481,500	7,837,880	8,134,030	726,255	725,949	0.79	0.33	0.33	1.72	1.66
4	short rvc all ind x10	5221.36	0.080	0.220	0.207	16,843,700	6,804,700	7,454,260	599,825	598,256	0.78	0.37	0.39	2.48	2.26
5	Two sel blocks	4726.23	0.075	0.198	0.205	11,116,300	7,593,750	7,217,260	740,595	740,037	0.83	0.38	0.36	1.46	1.54
6	91-08	3965.77	0.084	0.210	0.198	10,561,800	6,499,510	7,090,160	619,067	617,598	0.78	0.40	0.42	1.63	1.49
7	91-08 short rvc	3548.33	0.148	0.210	0.203	6,339,210	4,840,290	5,108,010	459,964	459,552	0.79	0.70	0.73	1.31	1.24
8	91-08 short ll 10	3549.25	0.139	0.211	0.206	6,890,240	5,186,590	5,381,920	486,839	486,635	0.79	0.66	0.68	1.33	1.28
9	91-08 short rvc all ind 10	3651.92	0.238	0.216	0.217	5,501,230	4,627,150	4,592,670	425,392	425,385	0.81	1.10	1.09	1.19	1.20
10	91-08 short rvc all ind 2 sel	3988.71	0.289	0.189	0.205	3,811,750	4,667,420	4,154,610	516,957	515,006	0.84	1.53	1.41	0.82	0.92
11	LL_only RVC indices	4374.49	0.080	0.212	0.207	10,797,700	6,830,640	7,058,550	646,447	646,234	0.80	0.38	0.39	1.58	1.53
12	LL_only RVC_multi-age	3911.66	0.148	0.211	0.216	5,923,440	5,121,010	4,935,740	488,206	488,011	0.82	0.70	0.68	1.16	1.20
13	LL_onlyRVC_age-1	3971.09	0.071	0.211	0.206	11,404,600	7,203,600	7,455,660	682,999	682,753	0.80	0.34	0.35	1.58	1.53
14	LL_only FWC indices	3605.47	0.110	0.212	0.217	8,251,600	5,806,720	5,598,030	541,798	541,585	0.82	0.52	0.50	1.42	1.47
15	LL_only_FWC_multi-age	3599.49	0.116	0.211	0.217	7,141,800	5,556,370	5,313,500	525,806	525,499	0.83	0.55	0.54	1.29	1.34
16	LL_only FWC vs_age-1	3560.21	0.116	0.211	0.218	7,611,600	5,626,820	5,387,210	528,706	528,413	0.83	0.55	0.53	1.35	1.41
17	LL_only FWC vs_age-1 short LL ind	3561.46	0.114	0.211	0.218	7,722,410	5,674,500	5,429,380	532,827	532,523	0.83	0.54	0.52	1.36	1.42
18	LL_no_age-1 indices	3954.28	0.140	0.211	0.216	6,352,020	5,260,750	5,090,680	498,847	498,688	0.82	0.66	0.65	1.21	1.25
	New base 2	3124.37	0.108	0.216	0.226	8,291,540	5,924,460	5,531,620	520,568	519,864	0.84	0.50	0.48	1.40	1.50
19	M = 0.10 per year	3052.53	0.098	0.215	0.228	14,076,900	11,814,400	10,856,300	572,088	570,928	0.87	0.45	0.43	1.19	1.30
20	M = 0.20 per year	2980.63	0.090	0.220	0.210	6,684,400	2,895,880	3,107,670	512,818	512,025	0.77	0.41	0.43	2.31	2.15
21	Steepness = 0.60	3138.72	0.106	0.216	0.146	8,704,200	6,471,900	13,337,000	678,583	564,938	0.60	0.49	0.72	1.34	0.65
22	Steepness = 0.65	3133.20	0.105	0.216	0.196	8,671,900	6,438,900	7,144,300	612,978	562,899	0.65	0.49	0.54	1.35	1.21
23	Steepness = 0.70	3131.60	0.106	0.216	0.177	8,541,800	6,306,500	8,650,500	571,242	552,114	0.70	0.49	0.60	1.35	0.99
24	Steepness = 0.75	3126.72	0.107	0.216	0.194	8,431,600	6,151,300	7,266,100	543,969	539,075	0.75	0.50	0.55	1.37	1.16
25	Steepness = 0.80	Did not converge													
26	Steepness = 0.85	3128.97	0.108	0.216	0.231	8,292,700	5,899,600	5,343,900	519,046	517,619	0.85	0.50	0.47	1.41	1.55
27	Steepness = 0.90	3124.71	0.109	0.216	0.254	8,215,700	5,775,000	4,568,100	514,024	506,966	0.90	0.51	0.43	1.42	1.80
28	Steepness = 0.95	3127.83	0.110	0.216	0.283	8,190,100	5,659,100	3,831,400	513,195	496,668	0.95	0.51	0.39	1.45	2.14
29	Steepness = free	3123.98	0.111	0.216	0.326	8,112,300	5,578,100	3,043,800	520,736	489,922	1.00	0.51	0.34	1.45	2.67
30	Steepness = 0.60 CV=0.1	3134.07	0.108	0.216	0.183	8,331,800	6,231,300	8,089,000	559,003	546,351	0.72	0.50	0.59	1.34	1.03
31	Steepness = 0.65 CV=0.1	3129.62	0.107	0.216	0.196	8,438,200	6,139,000	7,144,300	541,972	537,952	0.76	0.50	0.55	1.37	1.18
32	Steepness = 0.70 CV=0.1	3138.01	0.104	0.216	0.209	8,705,200	6,129,900	6,424,100	536,803	536,440	0.79	0.48	0.50	1.42	1.36
33	Steepness = 0.75 CV=0.1	3124.37	0.108	0.216	0.226	8,291,540	5,924,460	5,531,620	520,568	519,864	0.84	0.50	0.48	1.40	1.50
34	Steepness = 0.80 CV=0.1	Did not converge													
35	Steepness = 0.85 CV=0.1	3126.99	0.109	0.216	0.266	8,206,700	5,730,900	4,240,900	513,949	503,064	0.92	0.51	0.41	1.43	1.94
36	Steepness = 0.90 CV=0.1	3136.01	0.106	0.216	0.293	8,473,100	5,757,600	3,709,200	524,873	504,621	0.96	0.49	0.36	1.47	2.28
37	Steepness = 0.95 CV=0.1	3126.31	0.110	0.216	0.326	8,129,000	5,583,800	3,046,900	521,164	490,322	1.00	0.51	0.34	1.46	2.67

Table A3.3.5.13 continued. Sensitivity runs. The first line in the table shows the original base run and the new base run is labeled 'New base 2'.

Run	Description	Objective function	F2008	F30%SPR	Fmsy	SSB2008	SSBF30%SPR	SSBmsy	MSY	Yield 30%	Steepness	F/F30%	F/Fmsy	SB/SSBF30'	SSB/SSBmsy
38	Rel Mort HL=0.10, LL=0.25	3121.30	0.106	0.239	0.259	8,344,860	5,589,270	4,952,170	579,490	577,147	0.83	0.45	0.41	1.49	1.69
39	Rel Mort HL=0.10, LL=0.30	3121.48	0.106	0.239	0.259	8,344,490	5,589,310	4,952,440	579,441	577,101	0.83	0.45	0.41	1.49	1.68
40	Rel Mort HL=0.10, LL=0.35	3128.61	0.108	0.239	0.260	8,168,130	5,570,120	4,891,180	578,291	575,611	0.83	0.45	0.42	1.47	1.67
41	Rel Mort HL=0.10, LL=0.50	3122.20	0.106	0.239	0.260	8,337,120	5,606,980	4,949,310	581,232	578,742	0.83	0.45	0.41	1.49	1.68
42	Rel Mort HL=0.10, LL=0.75	3122.39	0.107	0.239	0.259	8,341,140	5,591,080	4,955,830	578,973	576,648	0.83	0.45	0.41	1.49	1.68
43	Rel Mort HL=0.10, LL=0.90	3122.58	0.107	0.239	0.259	8,340,020	5,591,550	4,956,840	578,819	576,500	0.83	0.45	0.41	1.49	1.68
44	Rel Mort HL=0.20, LL=0.25	3134.67	0.110	0.216	0.227	8,143,740	5,894,860	5,478,190	518,583	517,784	0.84	0.51	0.49	1.38	1.49
45	Rel Mort HL=0.20, LL=0.30	3124.37	0.108	0.216	0.226	8,291,540	5,924,460	5,531,620	520,568	519,864	0.84	0.50	0.48	1.40	1.50
46	Rel Mort HL=0.20, LL=0.35	3131.23	0.110	0.216	0.226	8,150,280	5,870,420	5,483,470	516,121	515,431	0.84	0.51	0.49	1.39	1.49
47	Rel Mort HL=0.20, LL=0.50	3140.96	0.109	0.215	0.226	8,286,410	5,934,330	5,511,270	523,174	522,355	0.84	0.51	0.48	1.40	1.50
48	Rel Mort HL=0.20, LL=0.75	3125.29	0.108	0.216	0.226	8,288,870	5,926,570	5,534,770	520,273	519,574	0.84	0.50	0.48	1.40	1.50
49	Rel Mort HL=0.20, LL=0.90	3129.17	0.108	0.216	0.226	8,304,220	5,932,140	5,541,670	520,512	519,819	0.84	0.50	0.48	1.40	1.50
50	Rel Mort HL=0.30, LL=0.25	3129.85	0.110	0.198	0.201	8,336,740	6,248,250	6,097,150	477,427	477,341	0.84	0.55	0.55	1.33	1.37
51	Rel Mort HL=0.30, LL=0.30	3130.03	0.110	0.198	0.201	8,336,510	6,248,280	6,097,520	477,409	477,324	0.84	0.55	0.55	1.33	1.37
52	Rel Mort HL=0.30, LL=0.35	3130.19	0.110	0.198	0.201	8,336,300	6,248,310	6,097,890	477,387	477,303	0.84	0.55	0.55	1.33	1.37
53	Rel Mort HL=0.30, LL=0.50	3130.54	0.110	0.198	0.201	8,335,620	6,249,310	6,098,740	477,325	477,241	0.84	0.55	0.55	1.33	1.37
54	Rel Mort HL=0.30, LL=0.75	3130.95	0.110	0.198	0.201	8,334,500	6,250,400	6,100,640	477,217	477,133	0.84	0.56	0.55	1.33	1.37
55	Rel Mort HL=0.30, LL=0.90	3131.13	0.110	0.198	0.201	8,333,830	6,251,400	6,101,760	477,154	477,071	0.84	0.56	0.55	1.33	1.37
56	Rel Mort HL=0.50, LL=0.25	3133.80	0.111	0.171	0.168	8,495,690	6,961,790	7,152,830	424,711	424,614	0.85	0.65	0.66	1.22	1.19
57	Rel Mort HL=0.50, LL=0.30	3133.99	0.111	0.171	0.168	8,495,580	6,962,080	7,152,900	424,705	424,608	0.85	0.65	0.66	1.22	1.19
58	Rel Mort HL=0.50, LL=0.35	3134.16	0.111	0.171	0.169	8,458,150	6,981,220	7,136,800	426,121	426,057	0.85	0.65	0.66	1.21	1.19
59	Rel Mort HL=0.50, LL=0.50	3134.52	0.111	0.171	0.169	8,457,790	6,982,100	7,137,730	426,095	426,031	0.85	0.65	0.66	1.21	1.18
60	Rel Mort HL=0.50, LL=0.75	3134.91	0.111	0.171	0.168	8,494,600	6,964,730	7,156,090	424,621	424,524	0.85	0.65	0.66	1.22	1.19
61	Rel Mort HL=0.50, LL=0.90	3131.41	0.111	0.171	0.169	8,439,150	6,978,470	7,132,490	425,779	425,717	0.85	0.65	0.66	1.21	1.18
62	Rel Mort HL=0.75, LL=0.25	3138.87	0.111	0.149	0.142	8,865,860	7,908,010	8,439,050	387,707	387,176	0.86	0.75	0.78	1.12	1.05
63	Rel Mort HL=0.75, LL=0.30	3138.95	0.111	0.149	0.143	8,804,190	7,923,890	8,410,690	388,868	388,421	0.86	0.75	0.78	1.11	1.05
64	Rel Mort HL=0.75, LL=0.35	3139.10	0.111	0.149	0.143	8,804,180	7,924,470	8,411,000	388,865	388,419	0.86	0.75	0.78	1.11	1.05
65	Rel Mort HL=0.75, LL=0.50	3139.57	0.111	0.149	0.142	8,865,810	7,910,170	8,441,150	387,699	387,168	0.86	0.75	0.78	1.12	1.05
66	Rel Mort HL=0.75, LL=0.75	3139.99	0.111	0.149	0.142	8,865,780	7,911,540	8,443,240	387,683	387,151	0.86	0.75	0.78	1.12	1.05
67	Rel Mort HL=0.75, LL=0.90	Did not converge													
68	Rel Mort HL=0.90, LL=0.25	3145.12	0.112	0.139	0.132	8,929,860	8,472,730	9,094,270	373,548	372,934	0.87	0.81	0.85	1.05	0.98
69	Rel Mort HL=0.90, LL=0.30	3138.33	0.111	0.139	0.131	9,056,600	8,501,660	9,161,340	374,196	373,508	0.87	0.80	0.84	1.07	0.99
70	Rel Mort HL=0.90, LL=0.35	3138.49	0.111	0.139	0.131	9,056,650	8,501,490	9,161,780	374,196	373,507	0.87	0.80	0.84	1.07	0.99
71	Rel Mort HL=0.90, LL=0.50	3138.85	0.111	0.139	0.131	9,056,740	8,502,860	9,163,150	374,196	373,508	0.87	0.80	0.84	1.07	0.99
72	Rel Mort HL=0.90, LL=0.75	3149.92	0.112	0.139	0.132	8,945,120	8,481,860	9,106,220	373,669	373,050	0.87	0.81	0.85	1.05	0.98
73	Rel Mort HL=0.90, LL=0.90	3143.14	0.111	0.139	0.131	9,074,290	8,511,570	9,176,110	374,363	373,667	0.87	0.80	0.84	1.07	0.99

Table A3.3.4.14. Results of sensitivity runs of release mortality rates for hook-and-line gears and longline gear on model estimates for various parameters. Shaded cells represent the range of sensitivity runs recommended by the DW panel, and the cell in the center of the shaded range is the point estimate for the model parameter at the release mortalities by gear recommended by the DW panel.

Parameter	Longline Release mortality	Hook-and-line release mortality 0.10	0.20	0.30	0.50	0.75	0.90
Steepness	0.25	0.832	0.840	0.841	0.850	0.859	0.869
F30%SPR		0.239	0.216	0.198	0.171	0.149	0.139
Fcurrent		0.106	0.110	0.110	0.111	0.111	0.112
Fcurrent/F30%SPR		0.445	0.510	0.555	0.649	0.745	0.807
Fmsy		0.259	0.227	0.201	0.168	0.142	0.132
Fcurrent/Fmsy		0.411	0.485	0.545	0.661	0.782	0.851
SSB_30SPR		5589270	5894860	6248250	6961790	7908010	8472730
SSB_2008		8344860	8143740	8336740	8495690	8865860	8929860
SSBcurrent/SSBF30%SPR		1.493	1.381	1.334	1.220	1.121	1.054
SSBmsy		4952170	5478190	6097150	7152830	8439050	9094270
SSBmsy_ratio		1.685	1.487	1.367	1.188	1.051	0.982
Steepness	0.30	0.832	0.838	0.841	0.850	0.862	0.866
F30%SPR		0.239	0.216	0.198	0.171	0.149	0.139
Fcurrent		0.106	0.108	0.110	0.111	0.111	0.111
Fcurrent/F30%SPR		0.445	0.503	0.555	0.649	0.748	0.798
Fmsy		0.259	0.226	0.201	0.168	0.143	0.131
Fcurrent/Fmsy		0.411	0.480	0.545	0.661	0.781	0.844
SSB_30SPR		5589310	5924460	6248280	6962080	7923890	8501660
SSB_2008		8344490	8291540	8336510	8495580	8804190	9056600
SSBcurrent/SSBF30%SPR		1.493	1.400	1.334	1.220	1.111	1.065
SSBmsy		4952440	5531620	6097520	7152900	8410690	9161340
SSBmsy_ratio		1.685	1.499	1.367	1.188	1.047	0.989
Steepness	0.35	0.835	0.838	0.841	0.852	0.862	0.866
F30%SPR		0.239	0.216	0.198	0.171	0.149	0.139
Fcurrent		0.108	0.110	0.110	0.111	0.111	0.111
Fcurrent/F30%SPR		0.453	0.510	0.555	0.650	0.748	0.798
Fmsy		0.260	0.226	0.201	0.169	0.143	0.131
Fcurrent/Fmsy		0.416	0.487	0.545	0.660	0.781	0.844
SSB_30SPR		5570120	5870420	6248310	6981220	7924470	8501490
SSB_2008		8168130	8150280	8336300	8458150	8804180	9056650
SSBcurrent/SSBF30%SPR		1.466	1.388	1.334	1.212	1.111	1.065
SSBmsy		4891180	5483470	6097890	7136800	8411000	9161780
SSBmsy_ratio		1.670	1.486	1.367	1.185	1.047	0.989
Steepness	0.50	0.833	0.841	0.841	0.852	0.859	0.866
F30%SPR		0.239	0.215	0.198	0.171	0.149	0.139
Fcurrent		0.106	0.109	0.110	0.111	0.111	0.111
Fcurrent/F30%SPR		0.446	0.509	0.555	0.650	0.745	0.798
Fmsy		0.260	0.226	0.201	0.169	0.142	0.131
Fcurrent/Fmsy		0.410	0.484	0.545	0.660	0.782	0.844
SSB_30SPR		5606980	5934330	6249310	6982100	7910170	8502860
SSB_2008		8337120	8286410	8335620	8457790	8865810	9056740
SSBcurrent/SSBF30%SPR		1.487	1.396	1.334	1.211	1.121	1.065
SSBmsy		4949310	5511270	6098740	7137730	8441150	9163150
SSBmsy_ratio		1.685	1.504	1.367	1.185	1.050	0.988

run did not converge or failed

Table A3.3.4.14 (continued). Results of sensitivity runs of release mortality rates for hook-and-line gears and longline gear on model estimates for various parameters. Shaded cells represent the range of sensitivity runs recommended by the DW panel, and the cell in the center of the shaded range is the point estimate for the model parameter at the release mortalities by gear recommended by the DW panel.

Parameter	Longline Release mortality	Hook-and-line release mortality 0.10	0.20	0.30	0.50	0.75	0.90
Steepness	**0.75**	0.832	0.838	0.841	0.850	0.859	0.868
F30%SPR		0.239	0.216	0.198	0.171	0.149	0.139
Fcurrent		0.107	0.108	0.110	0.111	0.111	0.112
Fcurrent/F30%SPR		0.446	0.503	0.555	0.649	0.745	0.806
Fmsy		0.259	0.226	0.201	0.168	0.142	0.132
Fcurrent/Fmsy		0.412	0.480	0.546	0.662	0.782	0.850
SSB_30SPR		5591080	5926570	6250400	6964730	7911540	8481860
SS_2008		8341140	8288870	8334500	8494600	8865780	8945120
SSBcurrent/SSBF30%SPR		1.492	1.399	1.333	1.220	1.121	1.055
SSBmsy		4955830	5534770	6100640	7156090	8443240	9106220
SSBmsy_ratio		1.683	1.498	1.366	1.187	1.050	0.982
Steepness	**0.90**	0.832	0.838	0.842	0.853		0.866
F30%SPR		0.239	0.216	0.198	0.171		0.139
Fcurrent		0.107	0.108	0.110	0.111		0.111
Fcurrent/F30%SPR		0.446	0.502	0.555	0.651		0.797
Fmsy		0.259	0.226	0.201	0.169		0.131
Fcurrent/Fmsy		0.412	0.480	0.546	0.662		0.843
SSB_30SPR		5591550	5932140	6251400	6978470		8511570
SSB_Fcurrent		11926500	11698700	11477700	11216200		11207700
SSBcurrent/SSBF30%SPR		1.492	1.400	1.333	1.209		1.066
SSBmsy		4956840	5541670	6101760	7132490		9176110
SSBmsy_ratio		1.683	1.499	1.366	1.183		0.989
SS_2008		8340020	8304220	8333830	8439150		9074290
run did not converge or failed							

Table A3.3.4.15. Fixed and final steepness estimates and their standard deviation (SD), objective functions for the runs, fishing mortality rates in 2008 on fully selected aged fish (age-5), the spawning biomasses in 2008, the management fishing mortality limits, $F_{30\%SPR}$, and spawning biomasses at $F_{30\%SPR}$, F_{msy} and spawning biomass at F_{msy} over a range of initial steepness values.

Initial	Final steepness		Objective	F 2008		SSB 2008		F 30% SPR		SSB 30% SPR				F msy		SSB msy			
Steepness	Estimate	SD	Function	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD	F -ratio	SSB-ratio	Estimate	SD	Estimate	SD	F -ratio	SSB-ratio
0.60	fixed	--	3138.72	0.106	0.019	8,704,200	1,236,600	0.216	0.00015	6,471,900	748,800	0.49	1.34	0.146	0.00010	13,337,000	1,487,800	0.72	0.65
0.65	fixed	--	3133.20	0.105	0.019	8,671,900	1,239,200	0.216	0.00015	6,438,900	603,570	0.49	1.35	0.196	0.00014	7,144,300	638,090	0.54	1.21
0.70	fixed	--	3131.60	0.106	0.019	8,541,800	1,222,500	0.216	0.00015	6,306,500	518,300	0.49	1.35	0.177	0.00012	8,650,500	692,560	0.60	0.99
0.75	fixed	--	3126.72	0.107	0.019	8,431,600	1,205,800	0.216	0.00015	6,151,300	470,820	0.50	1.37	0.194	0.00014	7,266,100	547,870	0.55	1.16
0.80*	fixed	--	3127.83	0.110	0.019	8,200,500	1,169,200	0.216	0.00015	5,976,100	440,880	0.51	1.37	0.211	0.00015	6,166,800	453,640	0.52	1.33
0.85	fixed	--	3128.97	0.108	0.019	8,292,700	1,177,500	0.216	0.00015	5,899,600	435,480	0.50	1.41	0.231	0.00016	5,343,900	397,820	0.47	1.55
0.90	fixed	--	3124.71	0.109	0.019	8,215,700	1,165,200	0.216	0.00015	5,775,000	429,410	0.51	1.42	0.254	0.00018	4,568,100	346,040	0.43	1.80
0.95	fixed	--	3127.83	0.110	0.019	8,190,100	1,156,100	0.216	0.00015	5,659,100	425,520	0.51	1.45	0.283	0.00020	3,831,400	296,290	0.39	2.14
0.60	0.72	0.057	3134.07	0.108	0.019	8,331,800	1,199,000	0.216	0.00015	6,231,300	531,510	0.50	1.34	0.183	0.00013	8,089,000	805,790	0.59	1.03
0.65	0.76	0.062	3129.62	0.107	0.019	8,438,200	1,208,900	0.216	0.00015	6,139,000	504,190	0.50	1.37	0.196	0.00014	7,144,300	638,090	0.55	1.18
0.70	0.79	0.067	3138.01	0.104	0.019	8,705,200	1,246,900	0.216	0.00015	6,129,900	497,840	0.48	1.42	0.209	0.00015	6,424,100	533,290	0.50	1.36
0.75	0.84	0.072	3124.37	0.108	0.019	8,291,500	1,183,800	0.216	0.00015	5,924,500	477,850	0.50	1.40	0.226	0.00016	5,531,600	434,080	0.48	1.50
0.80*	0.88	0.077	3130.54	0.111	0.020	8,077,500	1,151,100	0.216	0.00015	5,783,000	465,810	0.51	1.40	0.245	0.00017	4,806,200	365,440	0.45	1.68
0.85	0.92	0.082	3126.99	0.109	0.019	8,206,700	1,164,400	0.216	0.00015	5,730,900	462,040	0.51	1.43	0.266	0.00019	4,240,900	324,090	0.41	1.94
0.90	0.96	0.086	3136.01	0.106	0.019	8,473,100	1,204,000	0.216	0.00015	5,757,600	471,210	0.49	1.47	0.293	0.00021	3,709,200	299,070	0.36	2.28
0.95	1.00	0.001	3126.31	0.110	0.019	8,129,000	1,147,100	0.216	0.00015	5,583,800	428,420	0.51	1.46	0.326	0.00023	3,046,900	242,870	0.34	2.67
Free	1.00	0.000	3123.98	0.111	0.020	8,112,300	1,146,600	0.216	0.00015	5,578,100	428,520	0.51	1.45	0.326	0.00023	3,043,800	242,930	0.34	2.67

Table A3.3.4.16. Landings, dead discards, fishing mortality rates, and spawning biomass projections over a range of probabilities of overfishing (0.05 to 0.50 in 0.05 increments) from P* with the implementation CV = 0.0. This table was Table 3.3.4.15 in the original report.

	Landings (lb)									
Year	Pr=0.05	Pr=0.10	Pr=0.15	Pr=0.20	Pr=0.25	Pr=0.30	Pr=0.35	Pr=0.40	Pr=0.45	Pr=0.50
2009	310,891	310,891	310,891	310,891	310,891	310,891	310,891	310,891	310,891	310,891
2010	310,893	310,893	310,893	310,893	310,893	310,893	310,893	310,893	310,893	310,893
2011	503,552	509,394	513,329	516,464	519,167	521,615	523,901	526,087	528,232	530,367
2012	499,791	506,600	511,132	514,787	517,986	520,907	523,657	526,262	528,828	531,374
2013	518,801	526,823	532,210	536,536	540,295	543,683	546,828	549,840	552,780	555,714
2014	532,443	540,361	545,759	550,062	553,710	556,916	559,859	562,637	565,355	568,066
2015	542,059	548,694	553,342	557,123	560,338	563,163	565,739	568,169	570,495	572,780
2016	547,162	553,259	557,484	560,819	563,601	566,025	568,221	570,282	572,273	574,225
2017	549,971	555,507	559,219	562,034	564,305	566,600	568,658	570,615	572,501	574,326
2018	550,792	555,561	558,757	561,256	563,444	565,476	567,318	569,160	570,922	572,633
2019	550,865	555,471	558,465	560,748	562,705	564,447	566,147	567,781	569,392	571,014
2020	550,798	555,321	558,005	560,053	561,848	563,484	565,095	566,639	568,195	569,743
	Dead discards (lb)									
2009	49,288	49,288	49,288	49,288	49,288	49,288	49,288	49,288	49,288	49,288
2010	63,659	63,659	63,659	63,659	63,659	63,659	63,659	63,659	63,659	63,659
2011	122,077	123,484	124,432	125,187	125,838	126,428	126,978	127,505	128,021	128,535
2012	126,472	128,244	129,424	130,375	131,211	131,972	132,689	133,370	134,040	134,707
2013	123,868	125,981	127,417	128,562	129,563	130,467	131,309	132,115	132,901	133,686
2014	122,814	125,055	126,583	127,810	128,863	129,792	130,652	131,469	132,265	133,063
2015	122,786	124,892	126,360	127,559	128,585	129,502	130,346	131,145	131,926	132,696
2016	122,474	124,577	126,063	127,236	128,227	129,106	129,921	130,687	131,433	132,173
2017	121,841	123,928	125,340	126,450	127,376	128,262	129,074	129,862	130,626	131,359
2018	122,011	124,005	125,356	126,432	127,367	128,221	129,009	129,768	130,513	131,272
2019	122,127	124,096	125,423	126,469	127,387	128,212	128,992	129,744	130,485	131,226
2020	122,339	124,304	125,593	126,619	127,502	128,310	129,070	129,817	130,562	131,306
	Fishing mortality per year on fully selected ages									
2009	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120
2010	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
2011	0.209	0.211	0.213	0.214	0.215	0.216	0.217	0.218	0.219	0.220
2012	0.205	0.208	0.210	0.212	0.214	0.215	0.216	0.218	0.219	0.220
2013	0.201	0.205	0.208	0.210	0.212	0.214	0.215	0.217	0.219	0.220
2014	0.200	0.204	0.207	0.209	0.211	0.213	0.215	0.217	0.218	0.220
2015	0.200	0.204	0.207	0.209	0.212	0.213	0.215	0.217	0.218	0.220
2016	0.200	0.204	0.207	0.210	0.212	0.214	0.215	0.217	0.219	0.220
2017	0.200	0.204	0.207	0.209	0.211	0.213	0.215	0.217	0.218	0.220
2018	0.200	0.204	0.207	0.209	0.211	0.213	0.215	0.217	0.218	0.220
2019	0.200	0.204	0.207	0.210	0.212	0.213	0.215	0.217	0.219	0.220
2020	0.200	0.204	0.207	0.209	0.211	0.213	0.215	0.217	0.218	0.220
	Spawning biomass (lb)									
2009	7,315,435	7,315,435	7,315,435	7,315,435	7,315,435	7,315,435	7,315,435	7,315,435	7,315,435	7,315,435
2010	7,397,357	7,397,357	7,397,357	7,397,357	7,397,357	7,397,357	7,397,357	7,397,357	7,397,357	7,397,357
2011	7,388,132	7,387,514	7,387,097	7,386,765	7,386,479	7,386,219	7,385,977	7,385,745	7,385,517	7,385,290
2012	7,238,476	7,234,109	7,231,106	7,228,749	7,226,723	7,224,885	7,223,183	7,221,568	7,219,949	7,218,341
2013	7,068,362	7,058,755	7,052,308	7,047,349	7,042,903	7,038,837	7,035,039	7,031,453	7,027,931	7,024,398
2014	6,940,282	6,923,511	6,912,272	6,903,270	6,895,462	6,888,384	6,881,770	6,875,463	6,869,318	6,863,231
2015	6,893,044	6,867,362	6,850,087	6,836,268	6,824,255	6,813,442	6,803,417	6,793,889	6,784,548	6,775,261
2016	6,885,813	6,849,440	6,824,893	6,805,105	6,788,054	6,772,770	6,758,551	6,744,986	6,731,756	6,718,625
2017	6,877,824	6,830,753	6,798,863	6,773,321	6,751,248	6,731,490	6,713,127	6,695,641	6,678,669	6,661,909
2018	6,873,942	6,816,187	6,777,216	6,746,298	6,719,510	6,695,275	6,672,884	6,651,703	6,631,107	6,610,883
2019	6,870,839	6,802,953	6,757,475	6,721,072	6,689,726	6,661,440	6,635,434	6,610,756	6,586,690	6,562,898
2020	6,863,462	6,786,919	6,735,212	6,694,003	6,658,580	6,626,560	6,597,029	6,569,065	6,541,793	6,514,768

Table A3.3.4.17. Landings, dead discards, fishing mortality rates, and spawning biomass projections for a variety of fishing mortality rates. This table was Table 3.3.4.16 in the original report.

Year	F = 0	F=Fcurrent	F = 0.65FOFL	F=F0.75FOFL	F=0.85FOFL	F=F30%SPR	F=F40%SPR	F=F45%SPR
				Directed landings (lb)				
2009	335,158	335,158	335,158	335,158	335,158	335,158	335,158	335,158
2010	332,145	332,140	332,143	332,144	332,140	332,140	332,151	332,147
2011	0	331,922	461,759	529,577	596,251	695,007	535,348	468,925
2012	0	334,738	455,314	513,924	570,794	652,810	519,400	461,366
2013	0	343,198	455,480	508,674	557,880	627,552	514,417	461,717
2014	0	358,949	467,428	516,044	561,289	619,665	520,824	472,007
2015	0	371,733	478,822	522,942	564,945	615,801	527,629	482,015
2016	0	381,798	485,285	528,026	565,950	612,005	531,129	489,287
2017	0	388,605	489,573	530,875	566,792	609,185	533,098	493,984
2018	0	393,989	493,244	532,374	566,233	605,749	535,495	496,695
2019	0	398,406	495,164	533,944	565,348	602,946	536,746	498,988
2020	0	402,596	496,625	534,369	565,674	599,884	536,408	500,329
				Dead discards (lb)				
2009	54,629	54,629	54,629	54,629	54,629	54,629	54,629	54,629
2010	54,937	54,834	54,939	54,917	54,905	54,875	54,882	54,877
2011	132,541	58,956	82,067	94,472	106,259	123,952	95,425	83,419
2012	141,307	63,254	87,229	98,886	110,439	127,396	99,980	88,505
2013	149,161	66,405	90,541	102,361	113,857	130,213	103,496	91,739
2014	155,453	67,058	91,207	102,851	114,393	130,237	103,799	92,520
2015	160,826	67,256	91,236	102,949	114,487	130,207	104,034	92,246
2016	164,849	67,320	91,149	103,222	114,176	129,976	104,204	92,338
2017	167,993	67,658	91,292	103,254	114,138	129,722	103,817	92,441
2018	170,652	68,022	91,222	102,934	114,213	129,262	103,708	92,531
2019	173,004	68,267	91,284	102,627	113,824	129,187	103,671	92,549
2020	174,995	68,261	91,579	102,997	113,630	129,154	103,962	92,448
				Fishing mortality per year on fully selected ages				
2009	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
2010	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
2011	0.000	0.100	0.141	0.163	0.185	0.217	0.165	0.144
2012	0.000	0.100	0.141	0.163	0.185	0.217	0.165	0.144
2013	0.000	0.100	0.141	0.163	0.185	0.217	0.165	0.144
2014	0.000	0.100	0.141	0.163	0.185	0.217	0.165	0.144
2015	0.000	0.100	0.141	0.163	0.185	0.217	0.165	0.144
2016	0.000	0.100	0.141	0.163	0.185	0.217	0.165	0.144
2017	0.000	0.100	0.141	0.163	0.185	0.217	0.165	0.144
2018	0.000	0.100	0.141	0.163	0.185	0.217	0.165	0.144
2019	0.000	0.100	0.141	0.163	0.185	0.217	0.165	0.144
2020	0.000	0.100	0.141	0.163	0.185	0.217	0.165	0.144
				Spawning biomass (lb)				
2009	7,578,231	7,578,231	7,578,231	7,578,231	7,578,231	7,578,231	7,578,231	7,578,231
2010	7,786,430	7,786,430	7,786,429	7,786,429	7,786,430	7,786,431	7,786,428	7,786,427
2011	7,981,565	7,956,648	7,944,427	7,937,413	7,930,535	7,920,146	7,936,769	7,943,585
2012	8,276,035	8,094,821	7,998,227	7,949,718	7,900,836	7,829,020	7,945,186	7,993,084
2013	8,612,315	8,227,341	8,028,783	7,928,714	7,830,044	7,689,992	7,920,327	8,015,715
2014	8,972,472	8,354,203	8,048,544	7,894,555	7,742,703	7,530,496	7,876,746	8,031,826
2015	9,364,400	8,492,484	8,071,996	7,847,312	7,642,063	7,362,099	7,822,524	8,027,082
2016	9,844,951	8,687,481	8,128,041	7,837,368	7,577,294	7,209,973	7,813,488	8,077,771
2017	10,346,004	8,906,076	8,206,105	7,847,782	7,529,629	7,080,617	7,819,044	8,154,745
2018	10,857,982	9,124,456	8,279,217	7,859,593	7,487,649	6,964,457	7,827,231	8,227,592
2019	11,345,548	9,339,504	8,352,644	7,870,946	7,447,309	6,861,538	7,836,513	8,294,863
2020	11,803,445	9,542,873	8,420,233	7,883,001	7,401,602	6,750,092	7,843,520	8,360,429

Table A3.3.4.17 (continued). Landings, dead discards, fishing mortality rates, and spawning biomass projections for a variety of fishing mortality rates. This table was Table 3.3.4.16 in the original report.

	Recruitment (number age-1 fish)							
Year	F = 0	F=Fcurrent	F = 0.65FOFL	F=F0.75FOFL	F=0.85FOFL	F=F30%SPR	F=F40%SPR	F=F45%SPR
2009	176,525	176,525	176,525	176,525	176,525	176,525	176,525	176,525
2010	225,384	224,395	224,690	224,597	224,574	225,978	224,883	223,852
2011	225,839	224,691	226,385	224,779	226,730	224,499	225,319	227,014
2012	227,583	226,735	227,413	227,092	226,336	226,085	226,050	226,462
2013	227,119	227,060	227,578	226,068	226,351	224,788	225,966	226,375
2014	228,099	227,606	225,972	226,174	226,497	225,951	227,321	225,229
2015	230,575	227,408	226,536	227,408	224,687	223,721	225,996	226,592
2016	230,953	228,717	226,515	225,556	226,013	224,244	225,840	227,148
2017	232,307	229,669	226,765	225,168	225,895	223,764	225,331	226,142
2018	234,055	230,457	227,618	225,610	224,256	223,075	226,771	226,071
2019	235,151	230,073	229,038	226,689	225,257	223,265	226,249	227,449
2020	234,408	231,794	227,232	226,046	224,685	220,879	226,010	227,927

A3.3.5. Figures

Figure	Description
A3.3.5.1	Not included in the addendum
A3.3.5.2	ASAP2 model fits to log(landings in pounds) by fishery fleet together with their standardized residuals.
A3.3.5.3	ASAP2 model fits to log(discards in pounds) by fishery fleet together with their standardized residuals.
A3.3.5.4	ASAP2 model fits to log(index values) together with their standardized residuals.
A3.3.5.5	Selectivity patterns for landings by fleet for the three regulatory periods (a-d) and for the fishery independent indices (e).
A3.3.5.6	Population size in numbers of fish by year and age.
A3.3.5.7	Box-whisker plot of recruitment expressed as number of age-1 fish by year from Markov Chain Monte Carlo simulations.
A3.3.5.8	Total biomass in pounds by year and age.
A3.3.5.9	Box-whisker plot of the spawning biomass in pounds by year from Markov Chain Monte Carlo simulations.
A3.3.5.10	Fishing multiplier (directed and discards, a) and the directed fishing mortality rate (b) by fleet and year.
A3.3.5.11	Fishing mortality per year on age-5 fish (fully selected) by fleet.
A3.3.5.12	Yield-per-recruit and static spawning potential ratio for black grouper.
A3.3.5.13	The distribution of steepness from the Markov Chain Monte Carlo simulation (a) and the spawning biomass at F=0 (b) for the Beverton-Holt stock-recruitment relationship for black grouper.
A3.3.5.14	The estimated Beverton-Holt stock-recruit relationship for black grouper.
A3.3.5.15	Trace plots of the fishing mortality in 2008 (a), spawning biomass in 2008 (b), fishing mortality-ratio (c), spawning biomass-ratio (d), steepness (e), and objective function (f).
A3.3.5.16	Distribution of Markov Chain Monte Carlo simulations, the cumulative proportion, and the point estimate for the fishing mortality per year for age-5 black grouper (a) and for the spawning biomass in 2008 (b).
A3.3.5.17	Likelihood profiles and their normal approximation from the standard deviations from ASAP2 for the fishing mortality rate in 2008 (F_{2008}) on the fully selected age, age-5, (a), spawning biomass in 2008 (SSB_{2008}, b), and steepness (c).
A3.3.5.18	The distribution of the ratio of fishing mortality in 2008 (F_{2008}) to the fishing mortality rate at 30% SPR ($F_{30\%\,SPR}$) from the MCMC simulations (2.5 million simulations with a 1999 run burn-in and 1000 thinning rate, a) the objective function values from the MCMC simulations plotting on the F-ratio and the point estimate for $F_{2008}/F_{30\%SPR}$ (b), the distribution of the ratio of the spawning biomass in 2008 to the spawning biomass at $F_{30\%SPR}$ (c), the objective function values from the MCMC simulations plotted spawning biomass ratio (d), and the fishing mortality ratio plotted on the spawning biomass ratio (e).
A3.3.5.19	Retrospective analysis for fishing mortality rates (a), spawning biomass (b), and recruitment (c) for the years 2004 through 2008 except that the run ending in 2005 did not converge.
A3.3.5.20	Sensitivity runs with natural mortality rates averaging 0.10 per year and 0.20 per year compared to the base rate of 0.14 per year for fishing mortality rate on age-5 (a), spawning biomass (b), and recruitment (c).
A3.3.5.21	Distributions of $F_{2008}/F_{30\%SPR}$ (a) and $SSB_{2008}/SSB_{F30\%SPR}$ (b) from the exploratory and

	sensitivity runs plus the original base run and the new base run.

A3.3.5. Figures continued.

Figure	Description
A3.3.5.22	Fishing mortality ratios ($F_{2008}/F_{30\%SPR}$) and spawning biomass ratios ($SSB_{2008}/SSB_{F30\%SPR}$) for the exploratory and sensitivity runs.
A3.3.5.23	Distributions of Markov Chain Monte Carlo outcomes for F_{2008} and $F_{30\%SPR}$ (a) and for the spawning biomass in 2008 and $SSB_{F30\%SPR}$.
A3.3.5.24	P* estimates of potential landings (a), spawning biomass (b), discards (c), and fishing mortality on fully selected fish (d) for alternative probabilities of exceeding the overfishing limit ($F_{30\%SPR}$).
A3.3.5.25	Projections of spawning biomass, landings, and discards for F = 0, F = Fcurrent (geometric mean of 2006-2008 fishing mortalities per year on fully selected age, age-5), F = $F_{30\%SPR}$, and F = $F_{45\%SPR}$.
A3.3.5.26	Comparison of projections for spawning biomass (a), landings (b) and discards across the alternative fishing mortality rates.

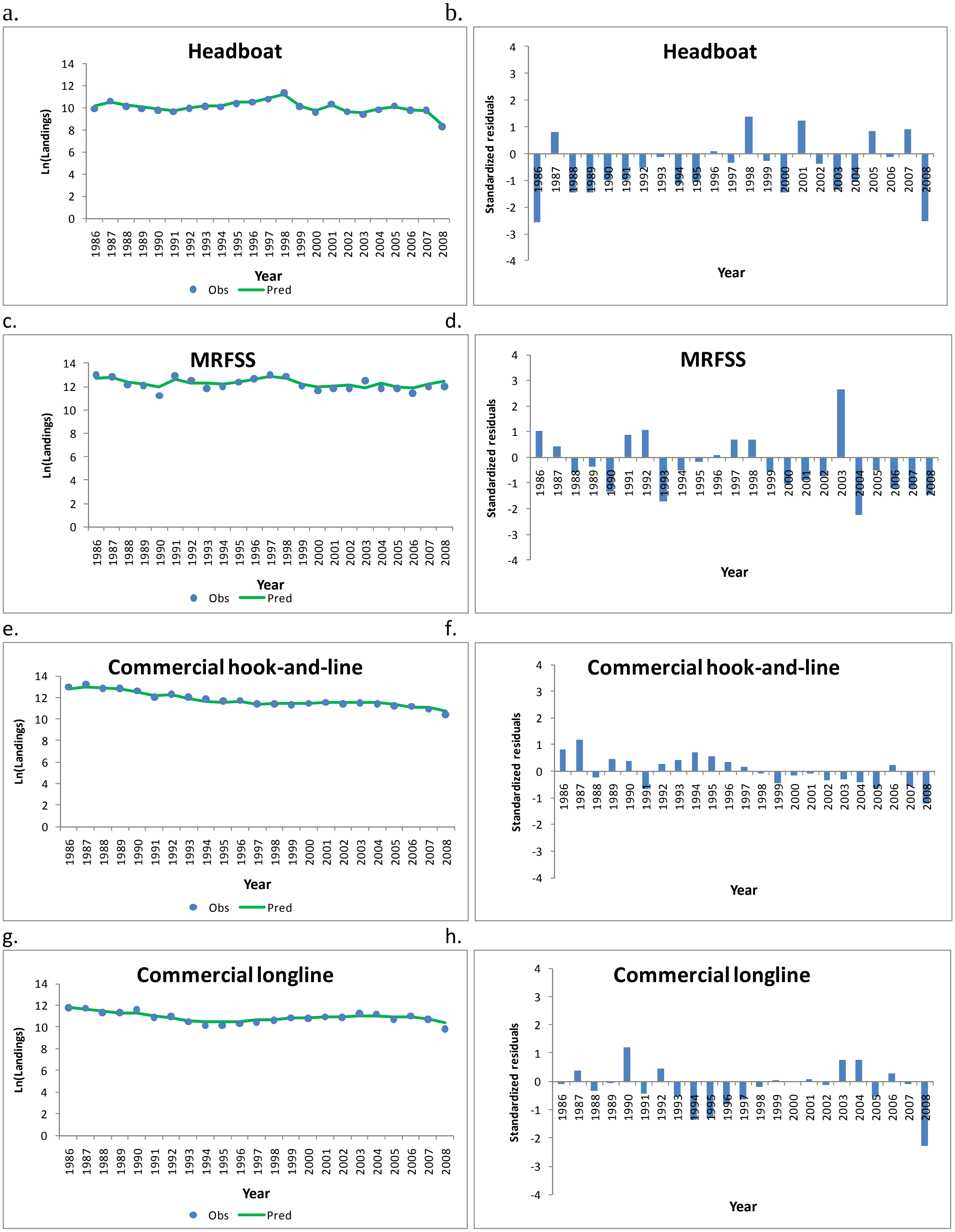
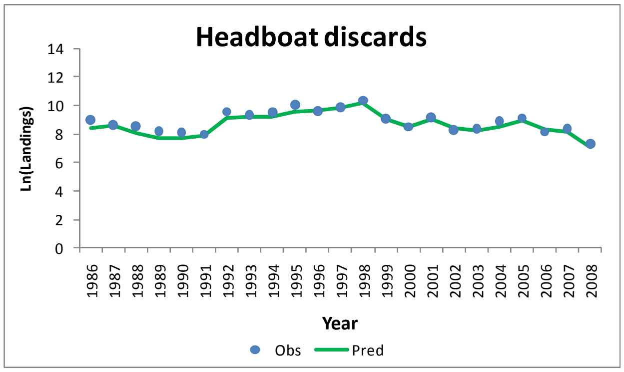
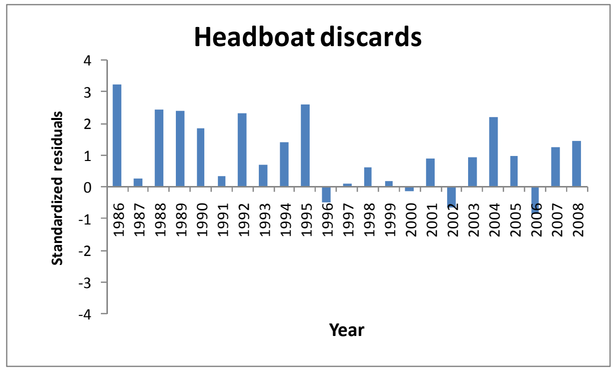


Figure A3.3.5.2. ASAP2 model fits to log(landings in pounds) by fishery fleet together with their standardized residuals.

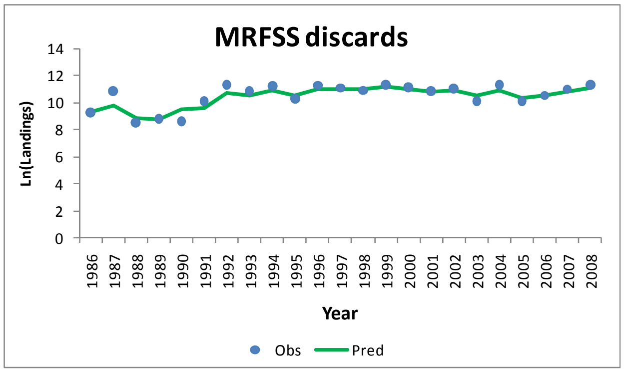
a.


Headboat discards
Ln(Landings)
Year
Obs
Pred

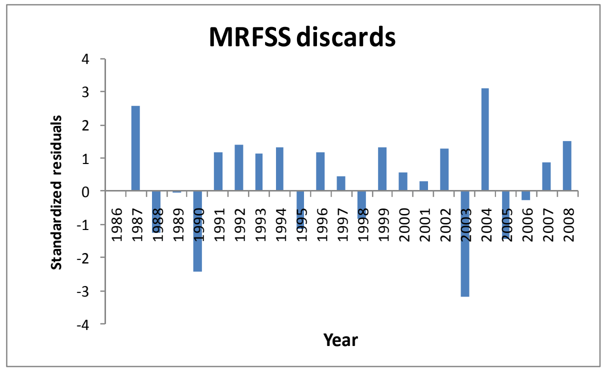
b.


Headboat discards
Standardized residuals
Year

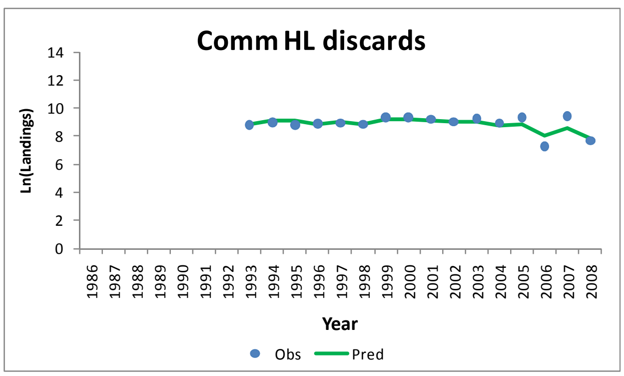
c.


MRFSS discards
Ln(Landings)
Year
Obs
Pred

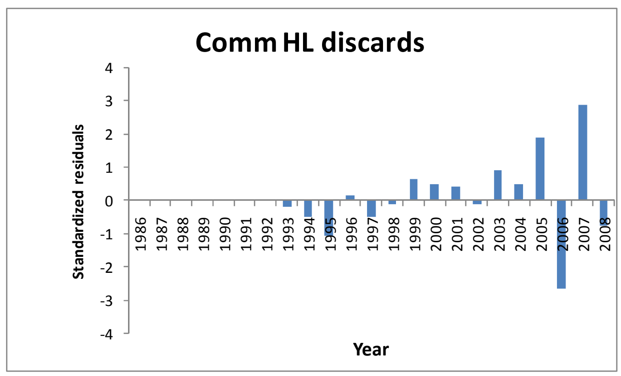
d.


MRFSS discards
Standardized residuals
Year

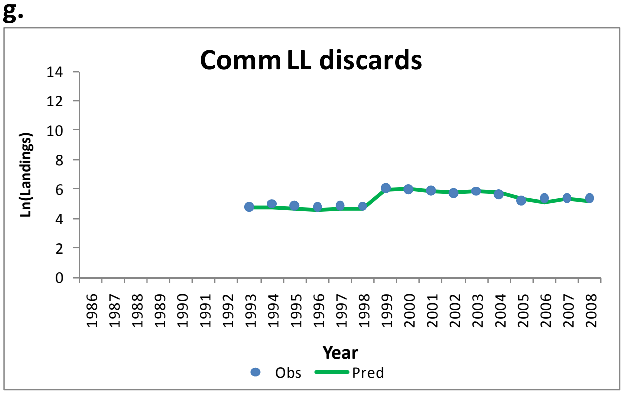
e.


Comm HL discards
Ln(Landings)
Year
Obs
Pred

f.


Comm HL discards
Standardized residuals
Year

g.


Comm LL discards
Ln(Landings)
Year
Obs
Pred

h.

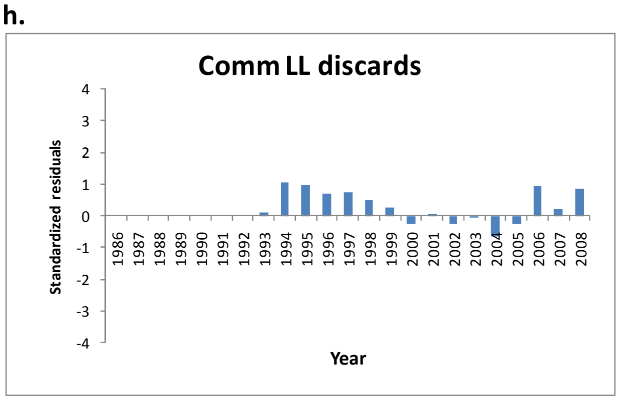

Comm LL discards
Standardized residuals
Year

Figure A3.3.5.3. ASAP2 model fits to log(discards in pounds) by fishery fleet together with their standardized residuals.

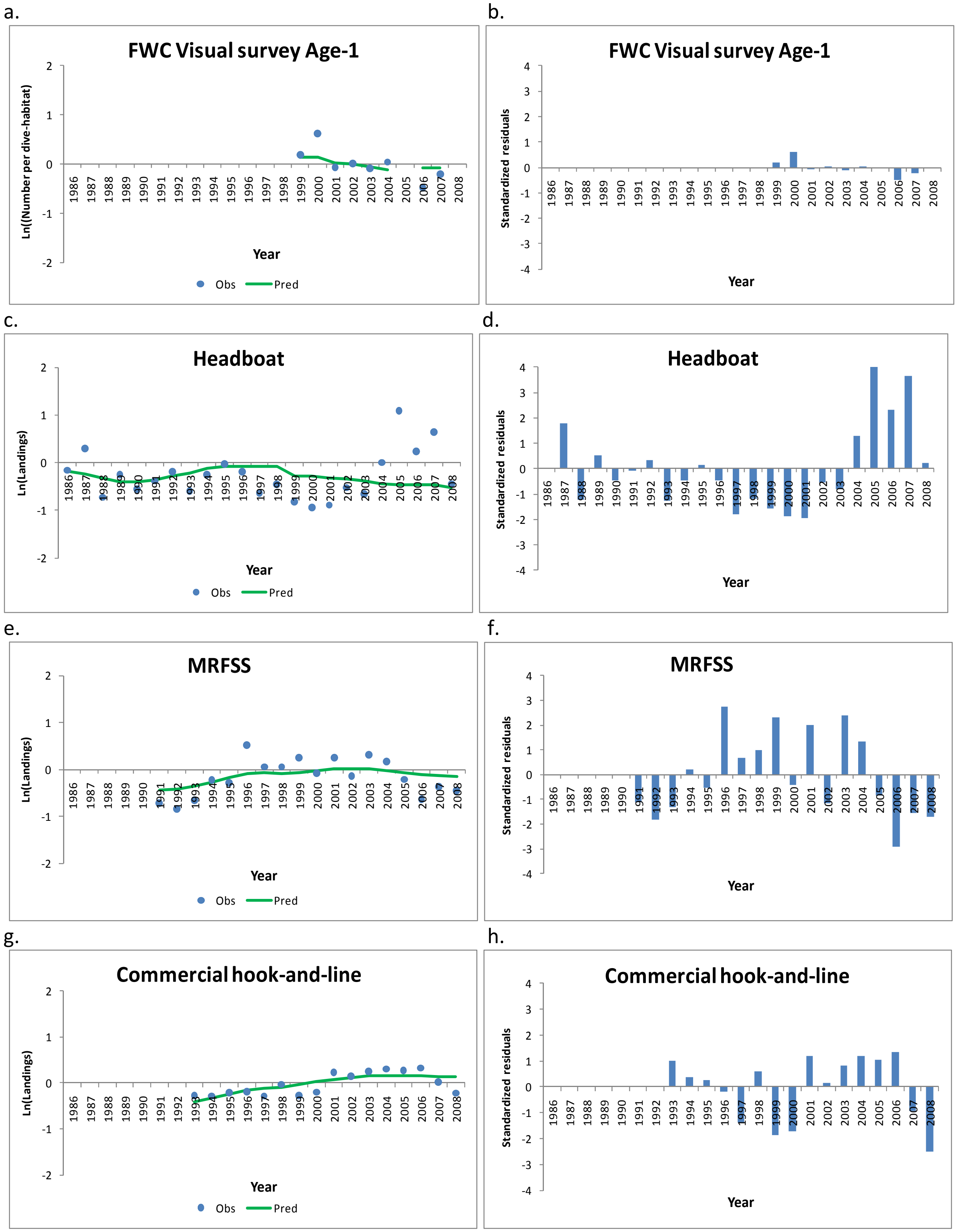
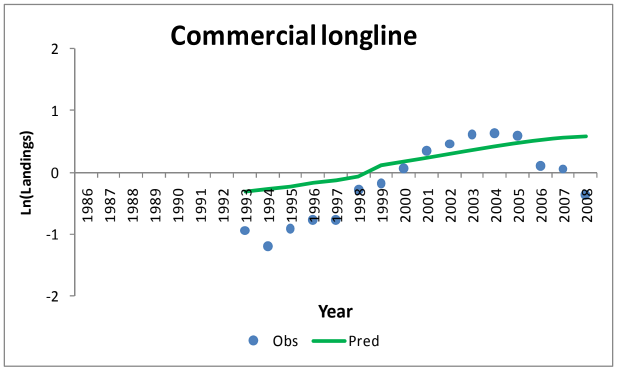


Figure A3.3.5.4. ASAP2 model fits to log(index values) together with their standardized residuals.

i.



j.

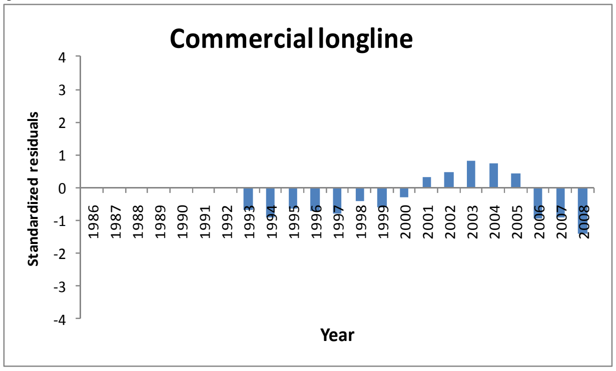


Figure A3.3.5.4 (continued). ASAP2 model fits to log(index values) together with their standardized residuals.

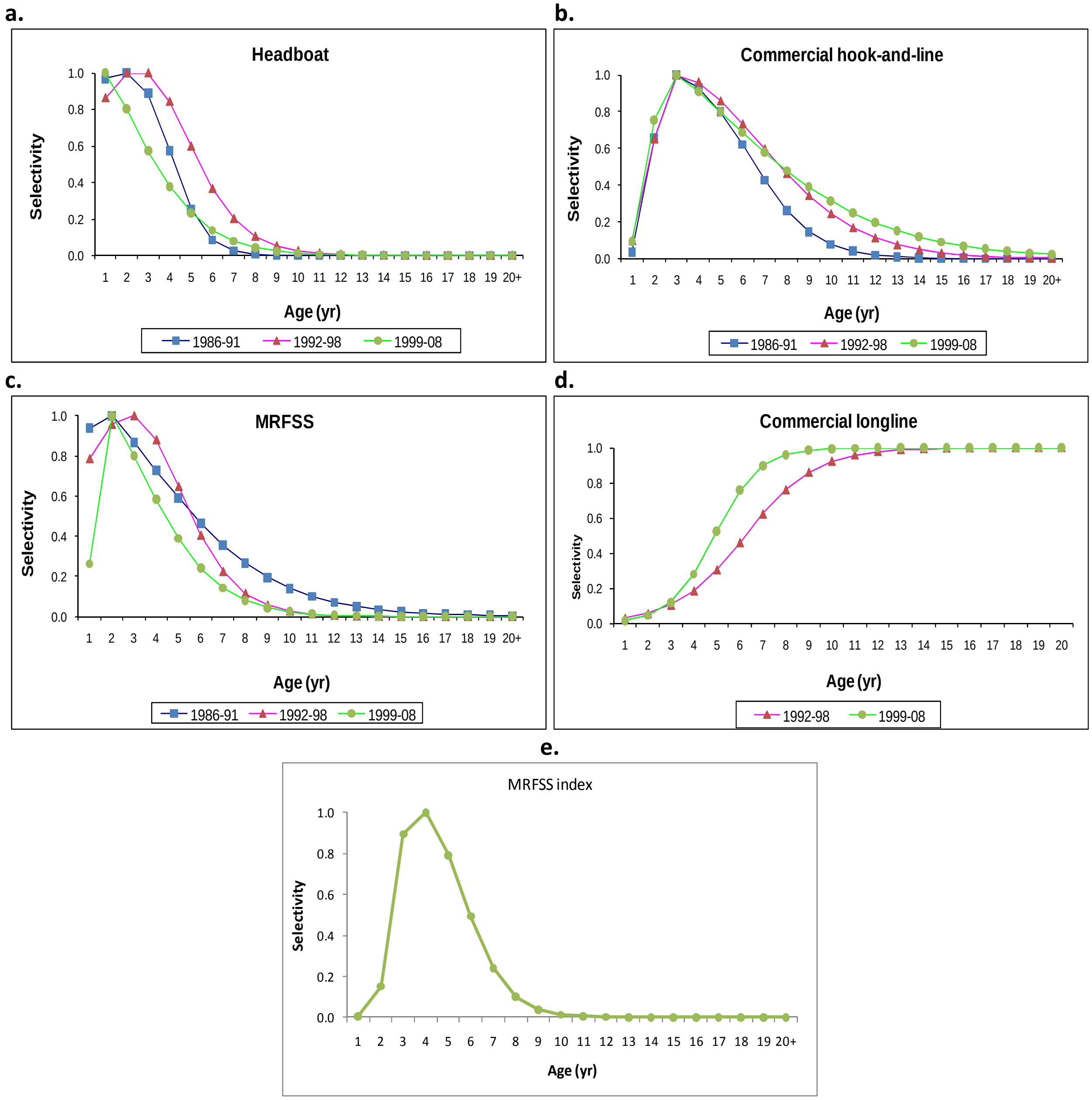


Figure A3.3.5.5. Selectivity patterns for landings by fleet for the three regulatory periods (a-d) and for the MRFSS index (e).

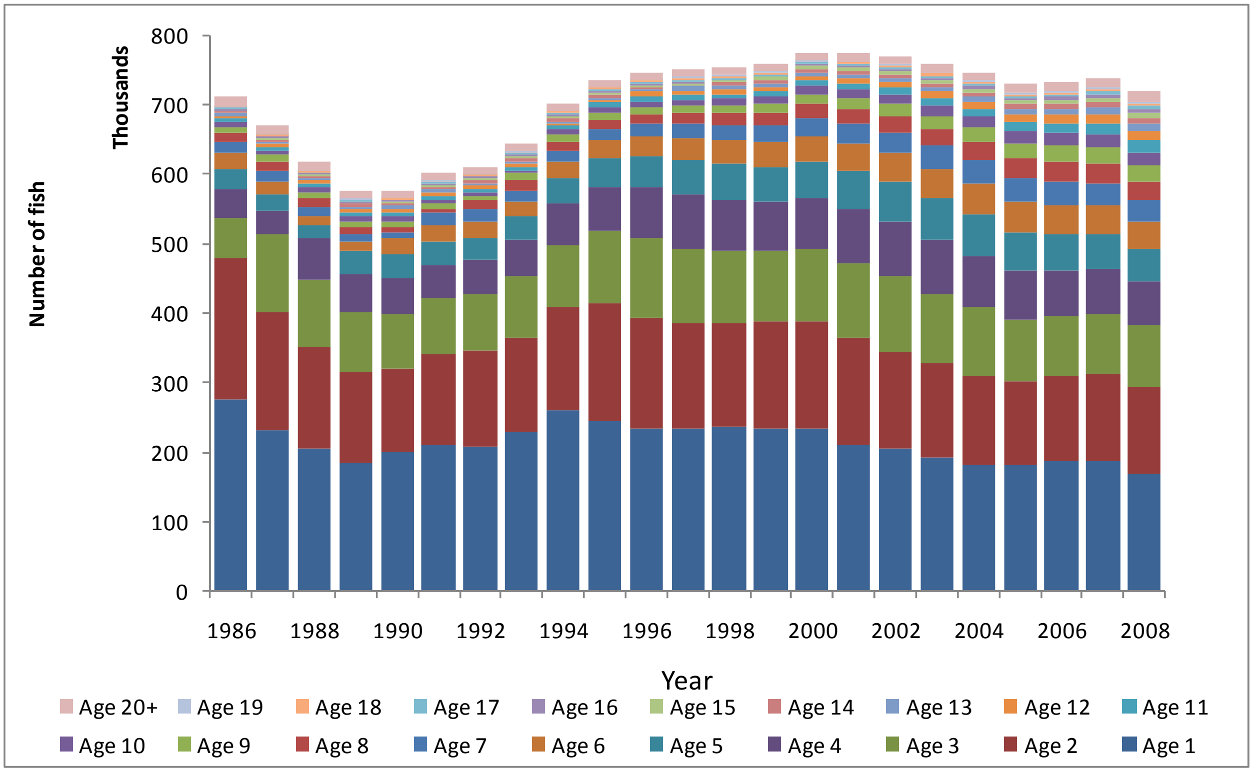


Figure A3.3.5.6. Population size in numbers of fish by year and age.

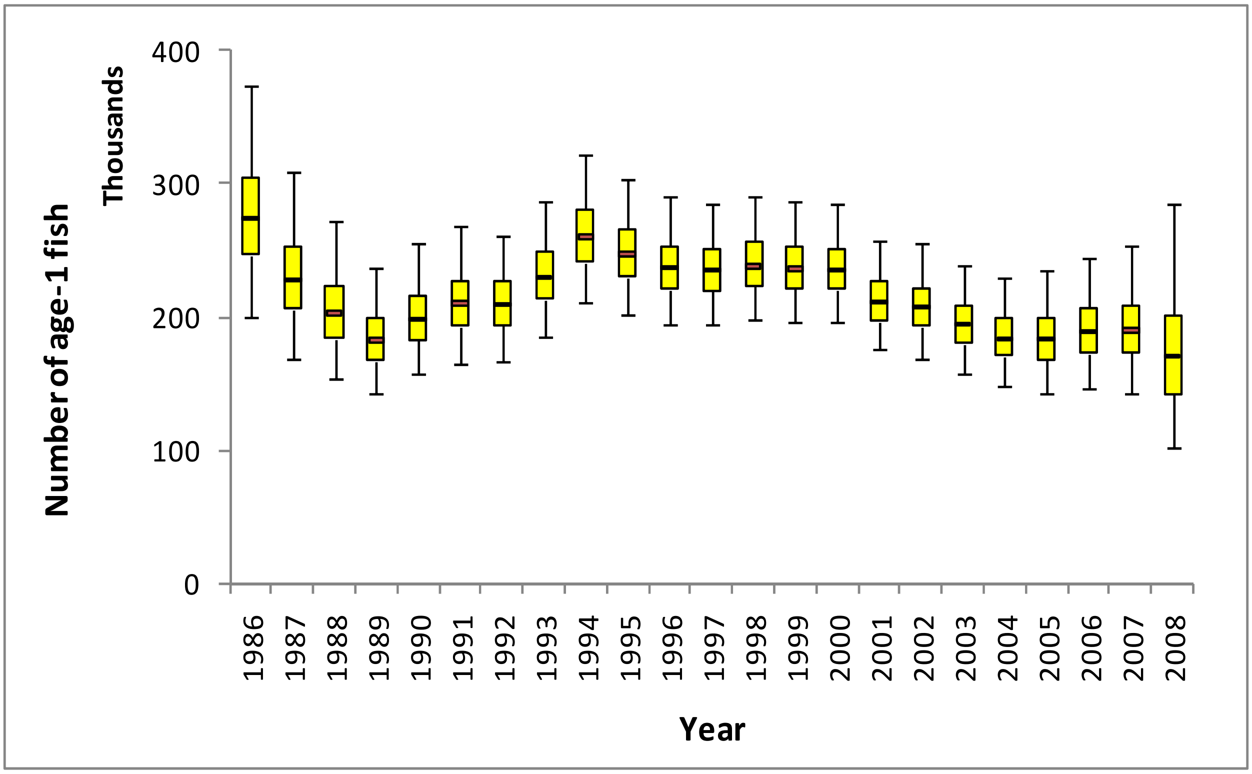


Figure A3.3.5.7. Box-whisker plot of recruitment expressed as number of age-1 fish by year from Markov Chain Monte Carlo simulations. The vertical line is the 95% confidence interval, the box is the inter-quartile range (the 25th percentile and the 75th percentile), and the horizontal line is the median.

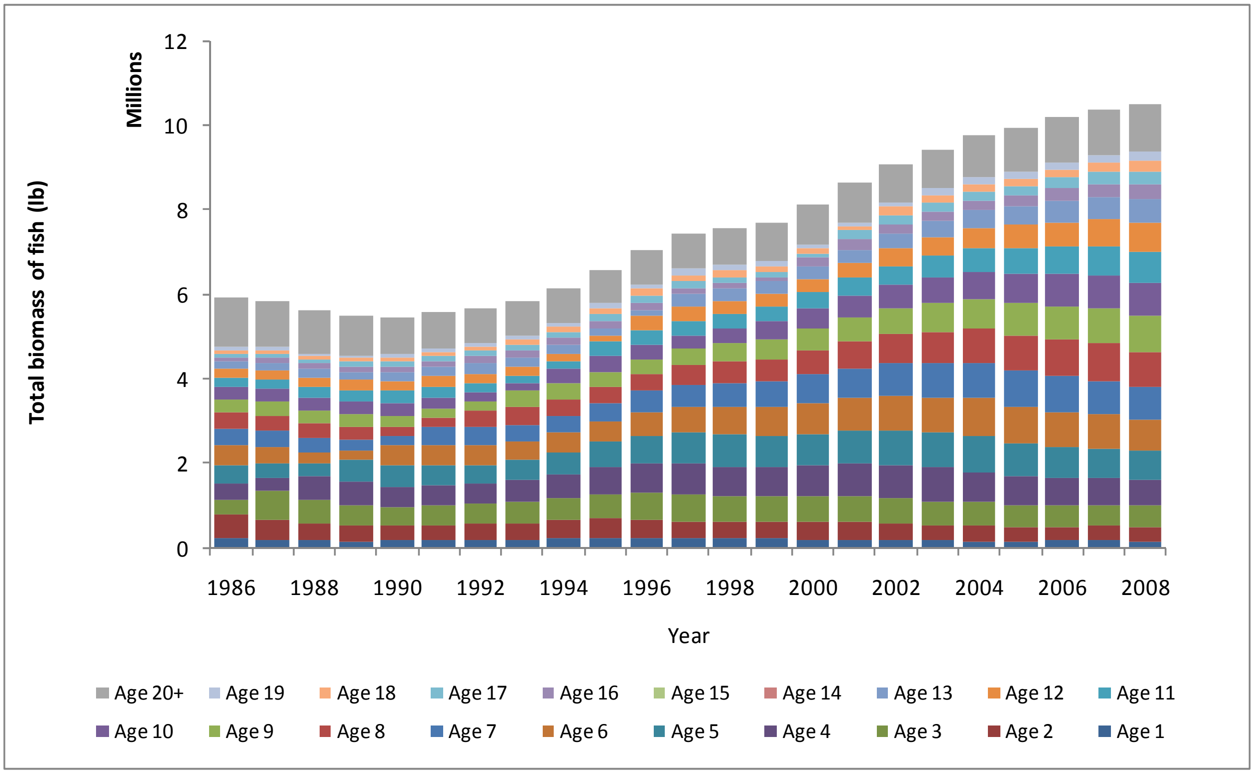


Figure A3.3.5.8. Total biomass in pounds by year and age.

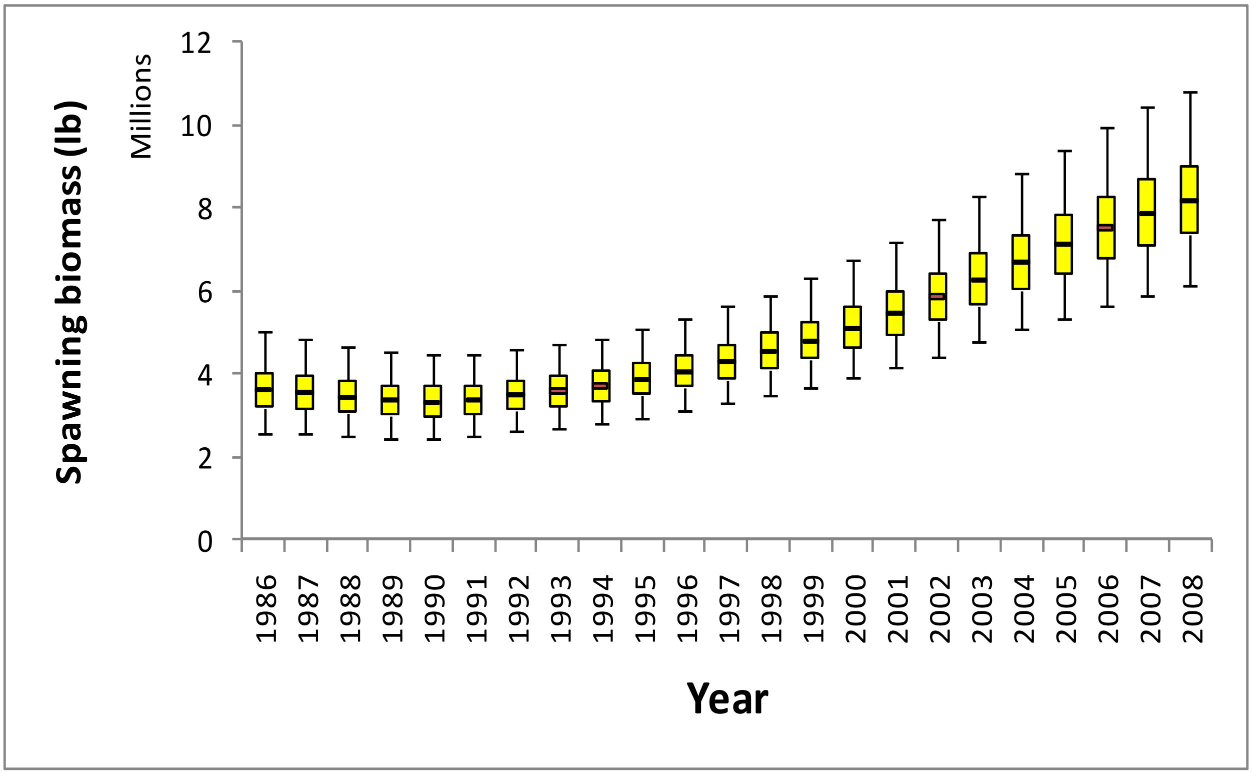
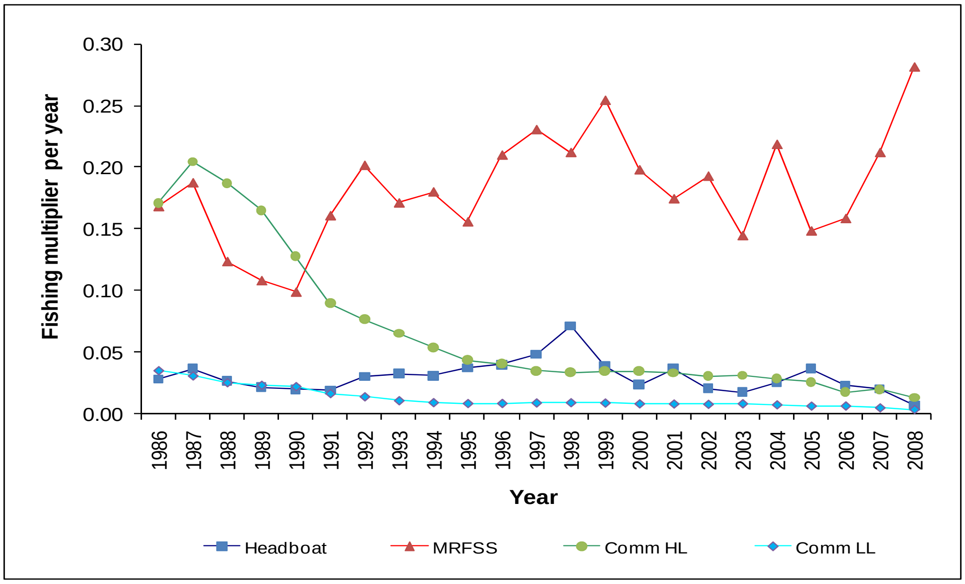


Figure A3.3.5.9. Box-whisker plot of the spawning biomass in pounds by year from Markov Chain Monte Carlo simulations. The vertical line is the 95% confidence interval, the box is the inter-quartile range (the 25^{th} percentile and the 75^{th} percentile), and the horizontal line is the median.

a.



b.

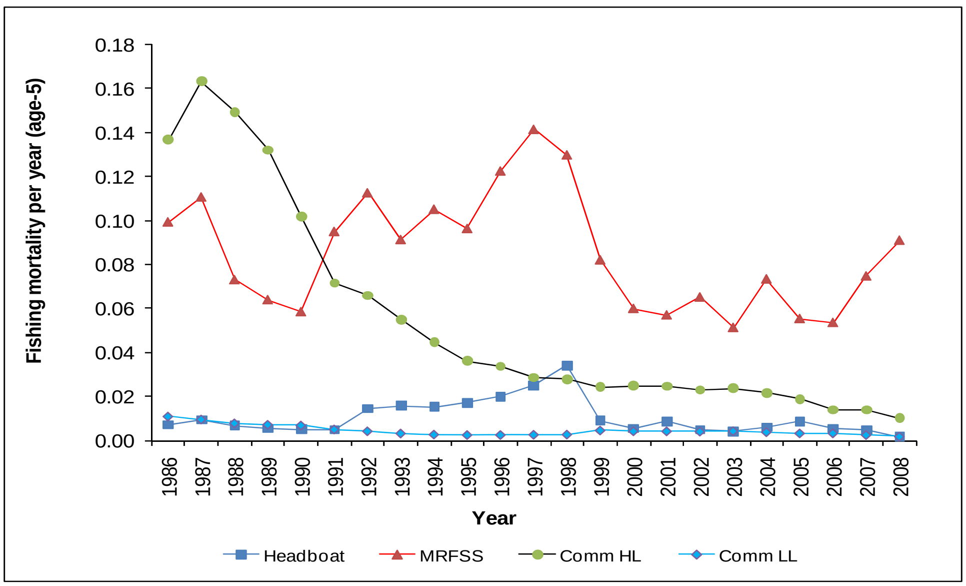


Figure A3.3.5.10. Fishing multiplier (directed and discards, a) and the directed fishing mortality rate (b) by fleet and year.

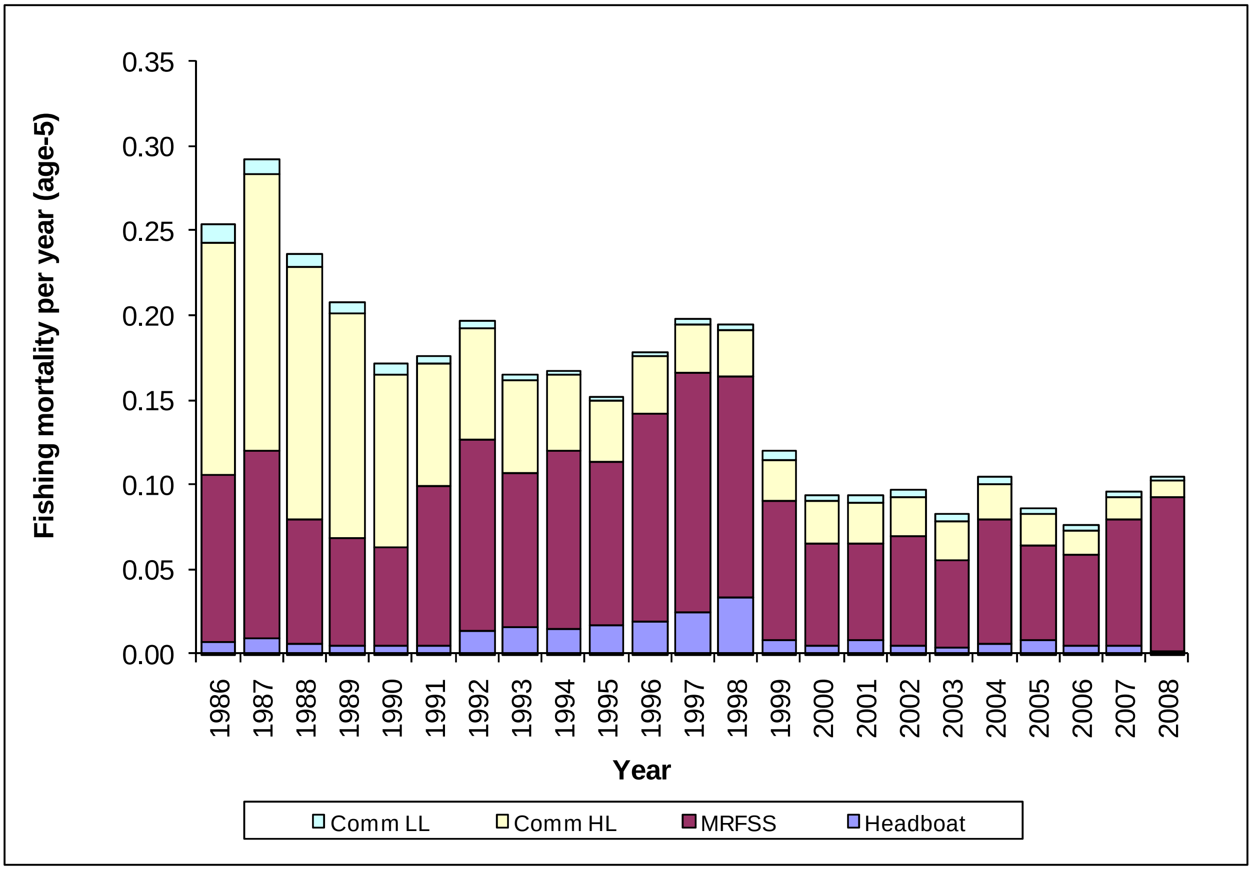


Figure A3.3.5.11. Fishing mortality per year on age-5 fish (fully selected) by fleet.

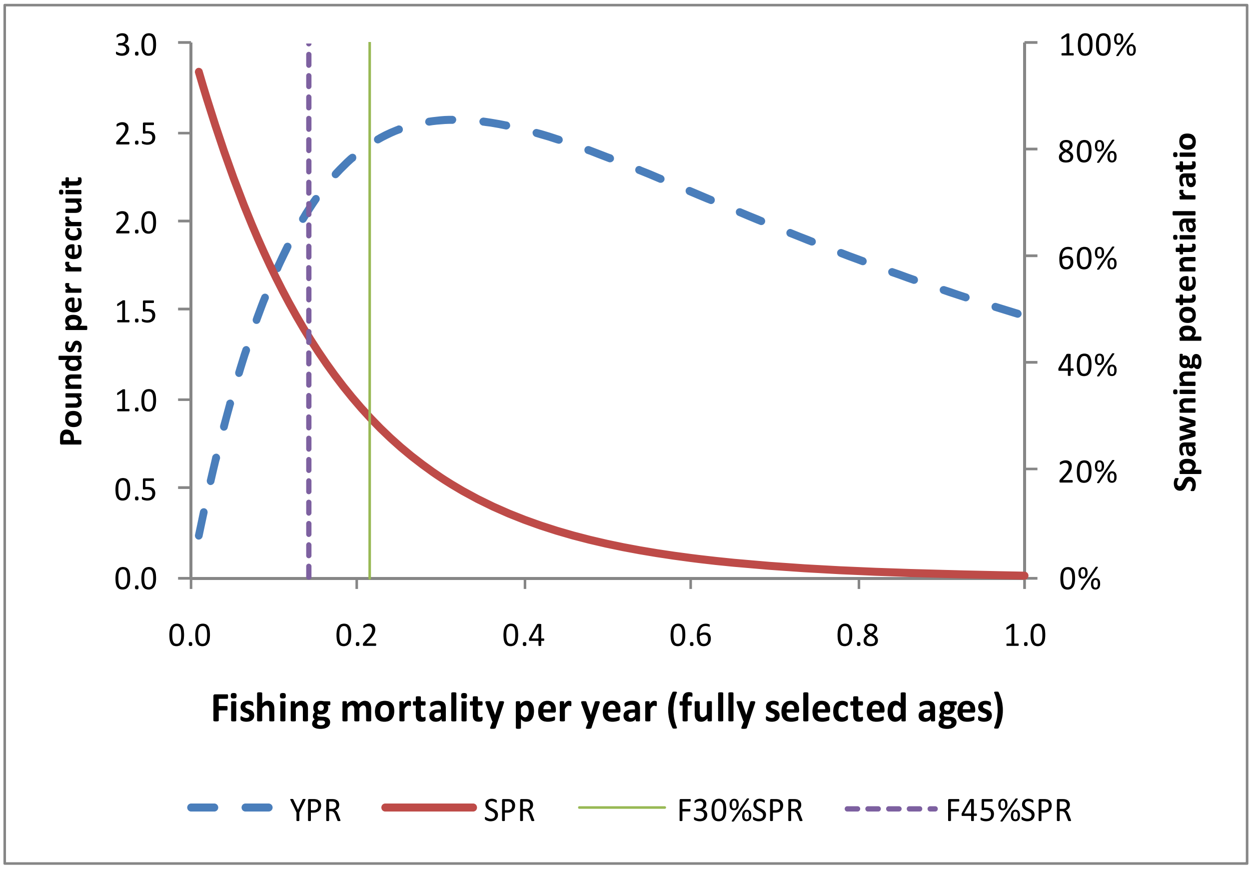
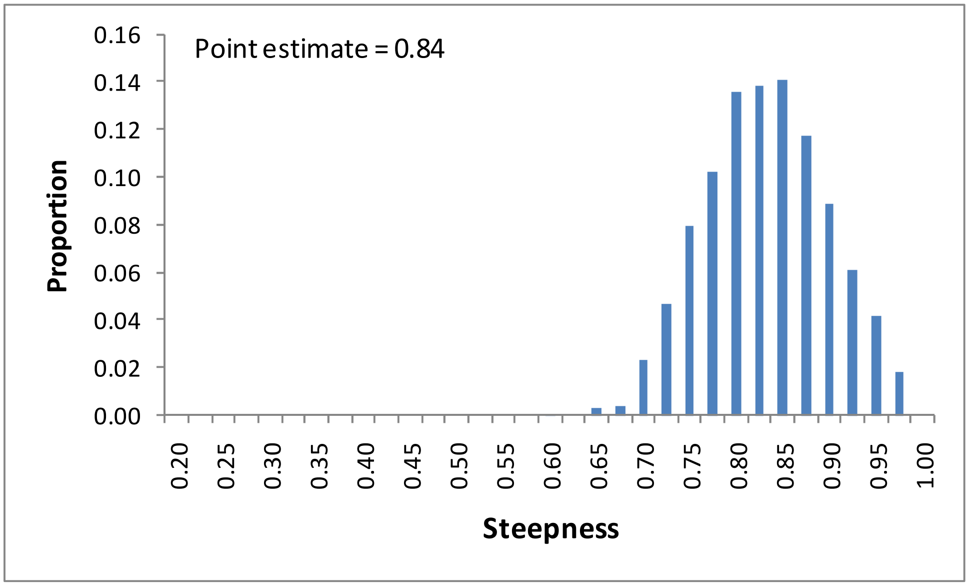


Figure A3.3.5.12. Yield-per-recruit and static spawning potential ratio for black grouper.

a.



b.

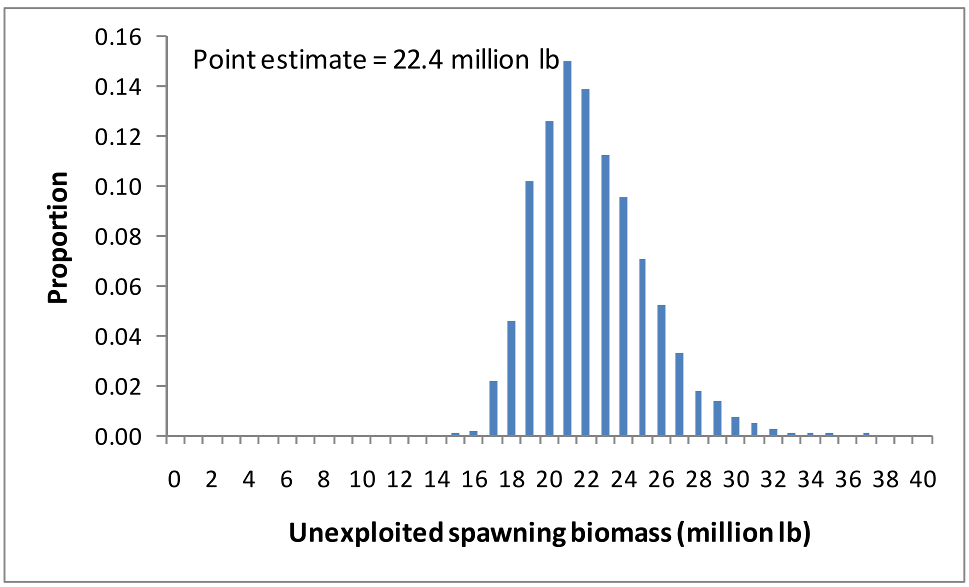


Figure A3.3.5.13. The distribution of steepness from the Markov Chain Monte Carlo simulation (a) and the unexploited spawning biomass (F=0, b) for the Beverton-Holt stock-recruitment relationship for black grouper. The equivalent figure in the original report was Figure 3.3.5.12.

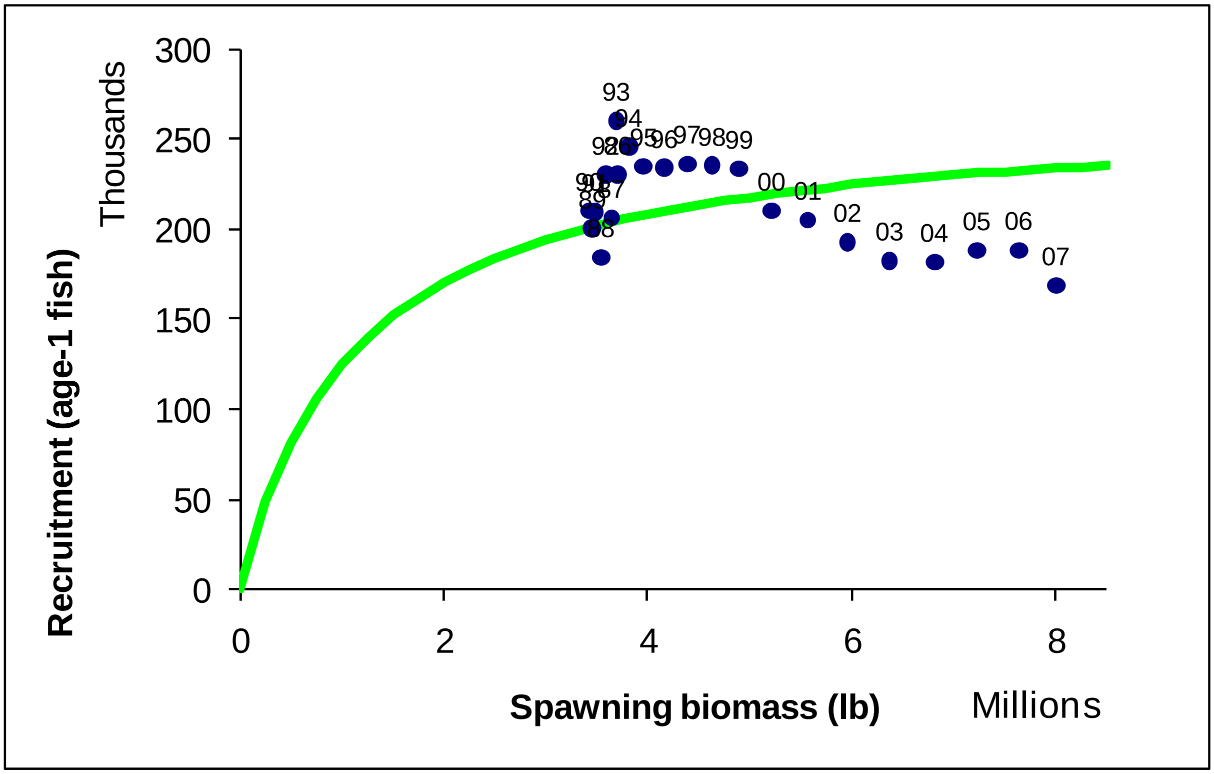


Figure A3.3.5.14. The estimated Beverton-Holt stock-recruitment relationship for black grouper. The point estimate for steepness was 0.84 and 22.4 million lb for the spawning biomass at F= 0. The equivalent figure in the original report was Figure 3.3.5.13.

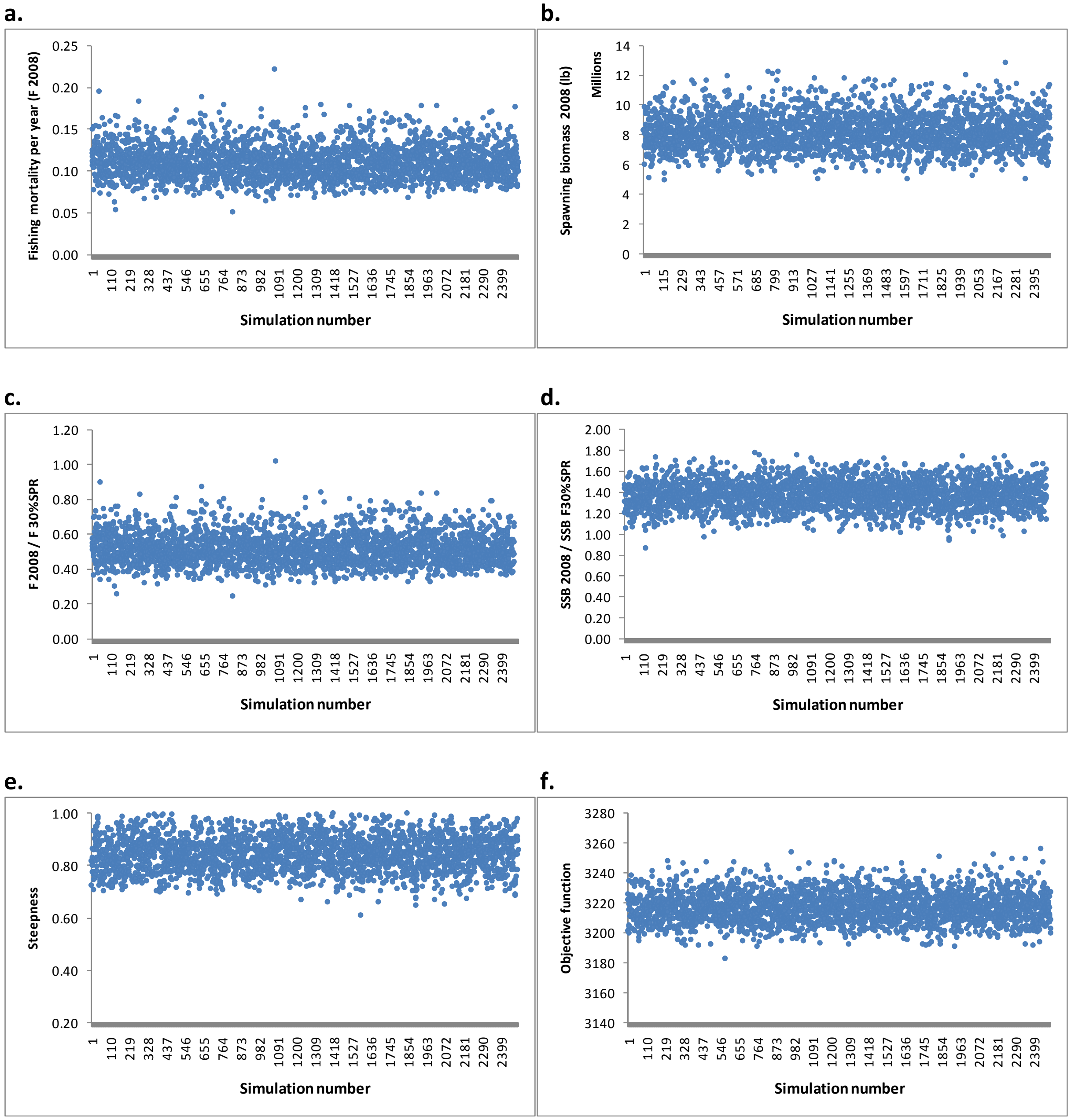
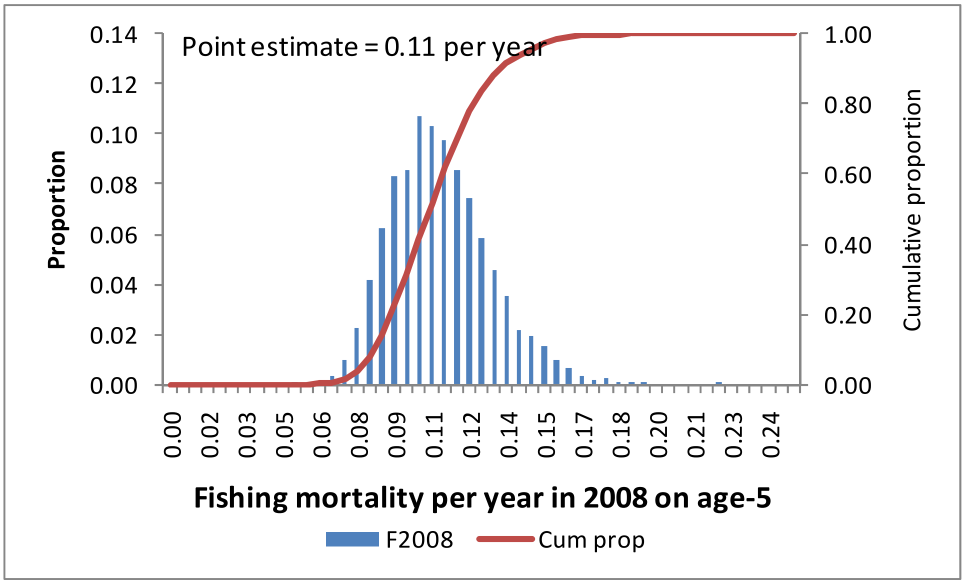


Figure A3.3.5.15. Trace plots of the fishing mortality in 2008 (a), spawning biomass in 2008 (b), fishing mortality-ratio (c), spawning biomass-ratio (d), steepness (e), and objective function (f). The equivalent figure in the original report was Figure 3.3.5.14.

a.



b.

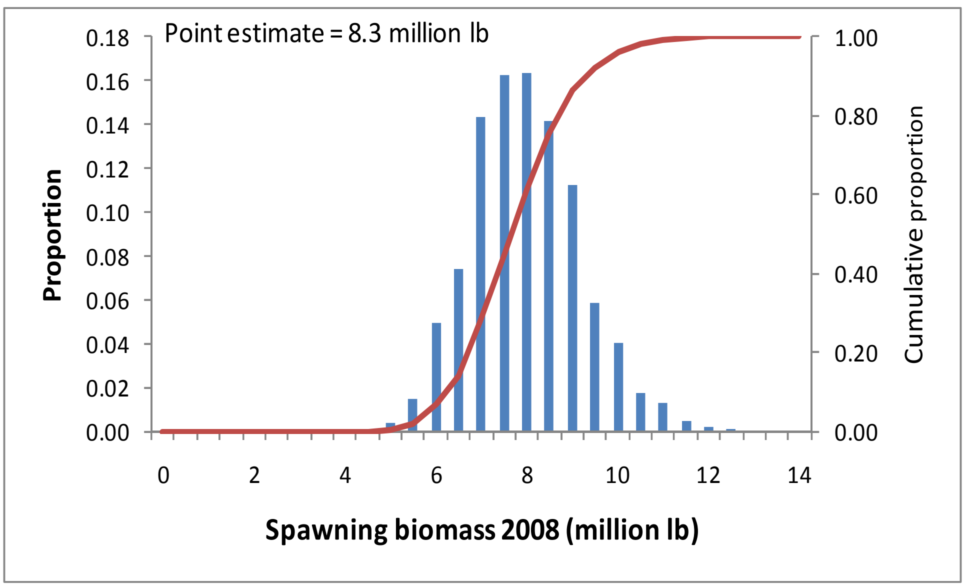
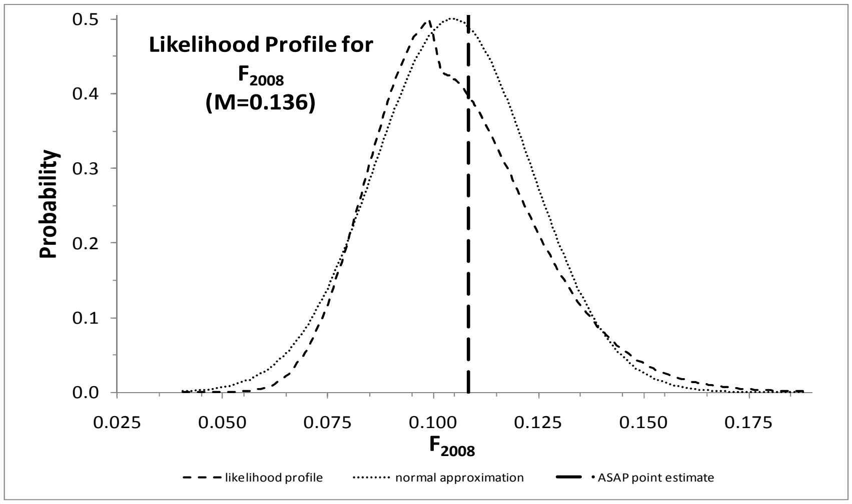
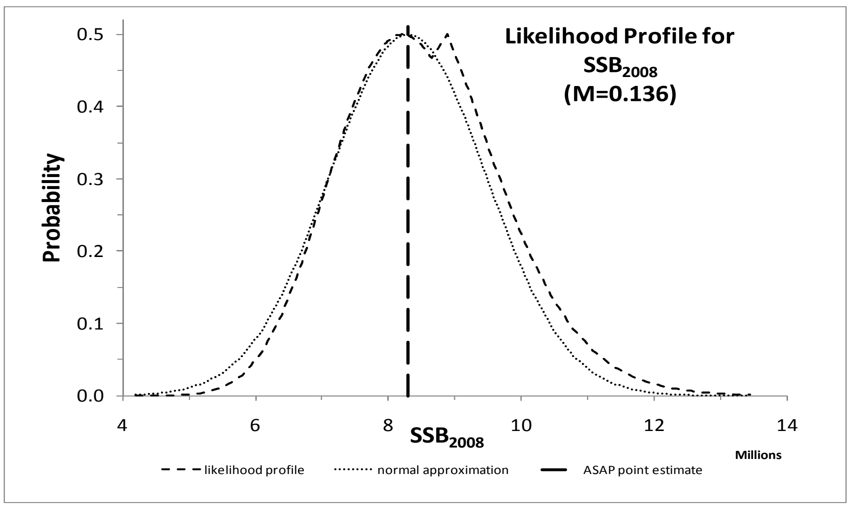


Figure A3.3.5.16. Distribution of Markov Chain Monte Carlo simulations, the cumulative proportion, and the point estimate for the fishing mortality per year for age-5 (fully selected) black grouper (a) and for the spawning biomass in 2008 (b). The equivalent figure in the original report was Figure 3.3.5.15.

a.



b.



c.

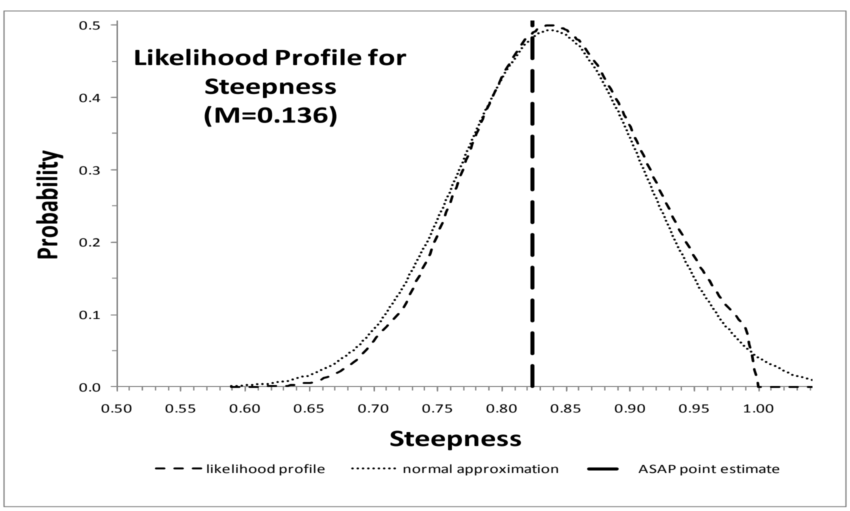


Figure A3.3.5.17. Likelihood profiles and their normal approximation from the standard deviations from ASAP2 for the fishing mortality rate in 2008 (F_{2008}) on the fully selected age, age-5, (a), spawning biomass in 2008 (SSB_{2008}, b), and steepness (c). The point estimates are also shown in the plots as a vertical line. The equivalent figure in the original report was Figure 3.3.5.16.

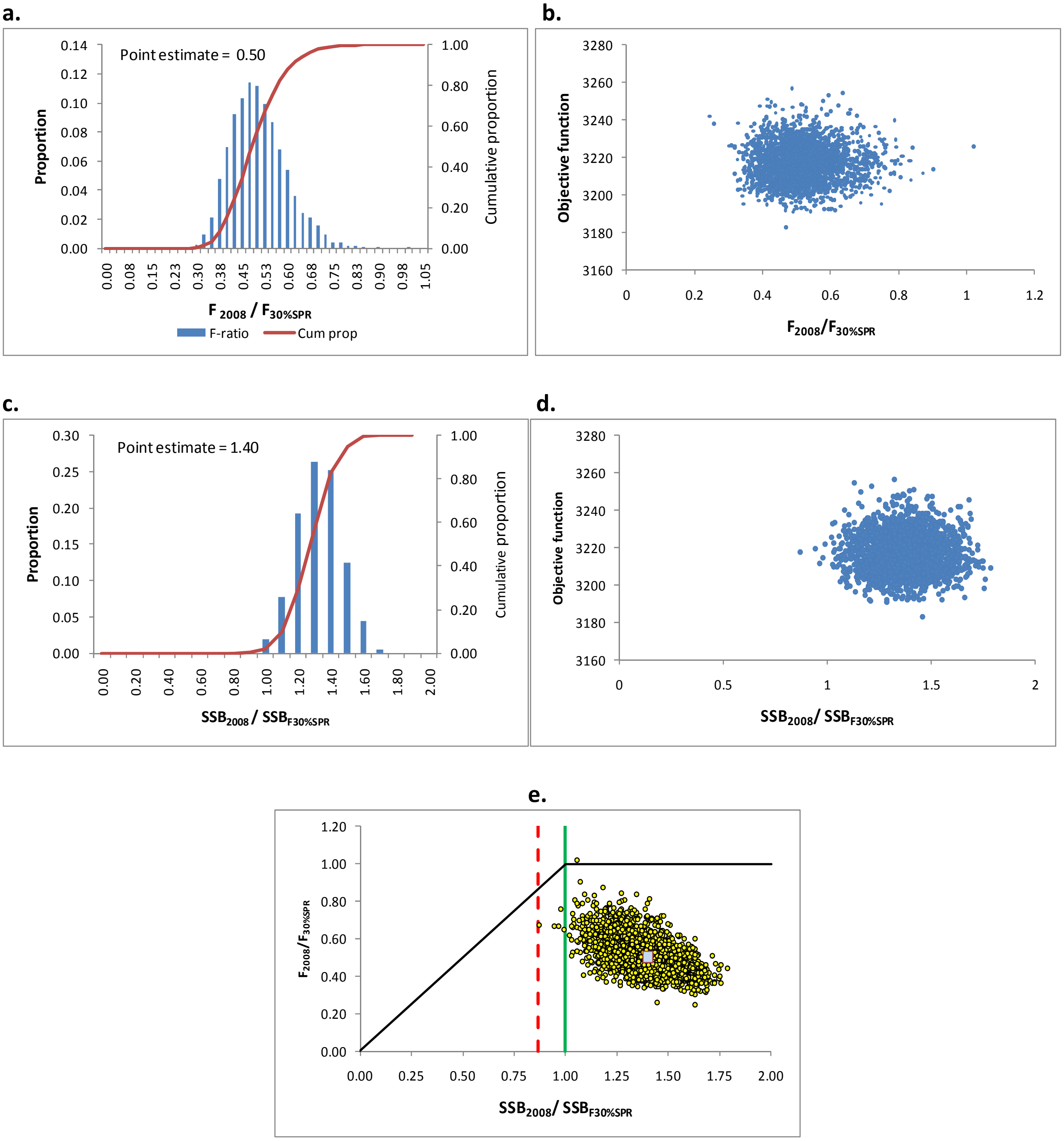
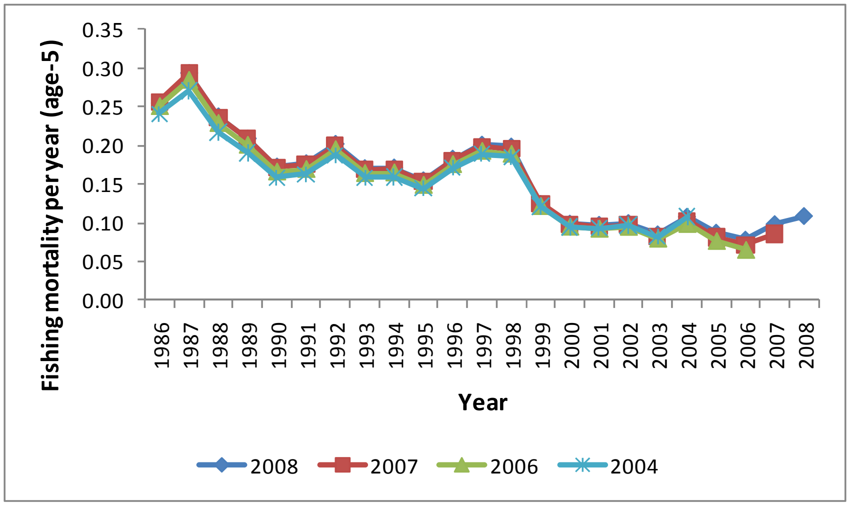
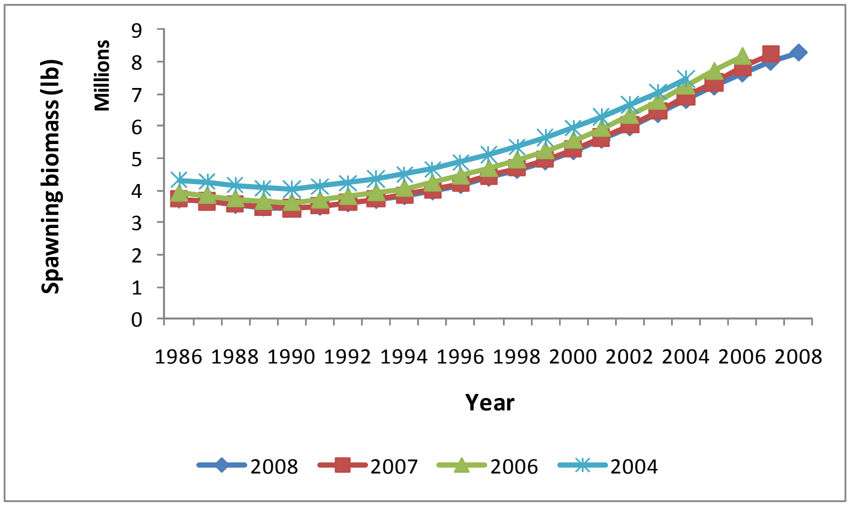


Figure A3.3.5.18. The distribution of the ratio of fishing mortality in 2008 (F_{2008}) to the fishing mortality rate at 30% SPR ($F_{30\%\ SPR}$) from the MCMC simulations (2.5 million simulations with a 1999 run burn-in and 1000 thinning rate, a) the objective function values from the MCMC simulations plotting on the F-ratio and the point estimate for $F_{2008}/F_{30\%SPR}$ (b), the distribution of the ratio of the spawning biomass in 2008 to the spawning biomass at F30% SPR (c), the objective function values from the MCMC simulations plotted spawning biomass ratio (d), and the fishing mortality ratio plotted on the spawning biomass ratio (e). The light colored square is the point estimate. The equivalent figure in the original report was Figure 3.3.5.17.

a.



b.



c.

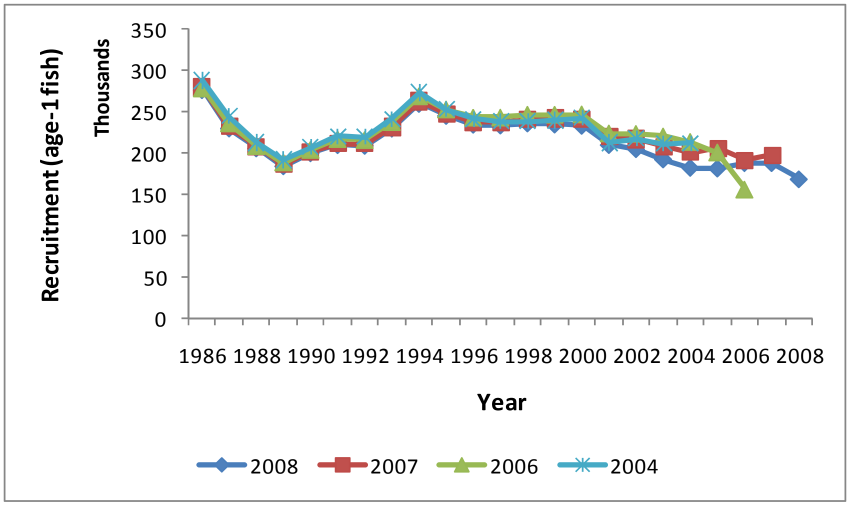
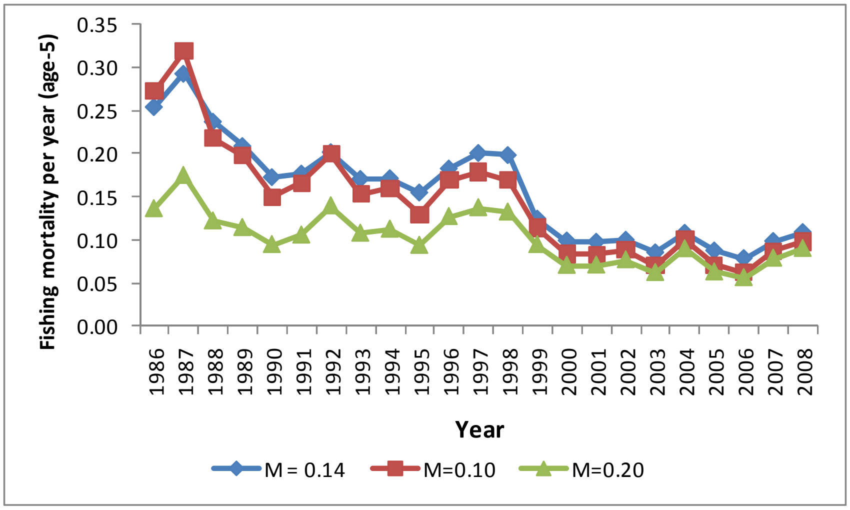
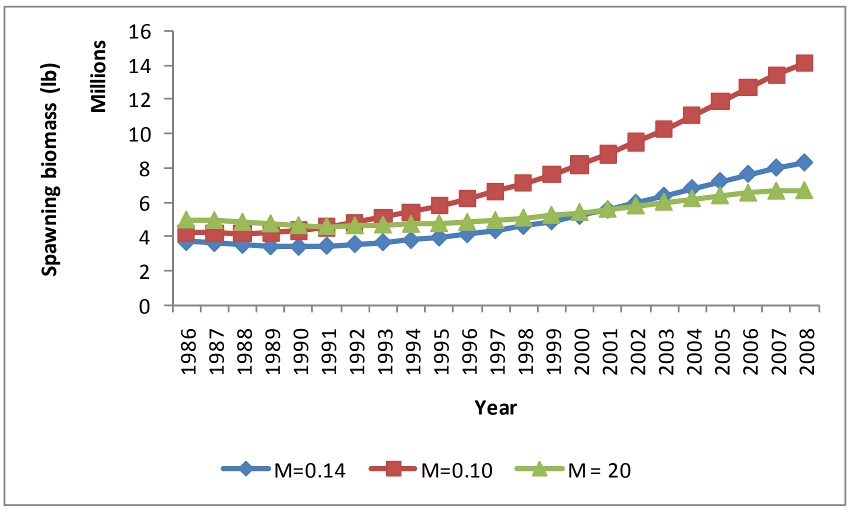


Figure A3.3.5.19. Retrospective analysis for fishing mortality rates (a), spawning biomass (b), and recruitment (c) for the years 2004 through 2008 except that the run ending in 2005 did not converge. The equivalent figure in the original report was Figure 3.3.5.18.

a.



b.



c.

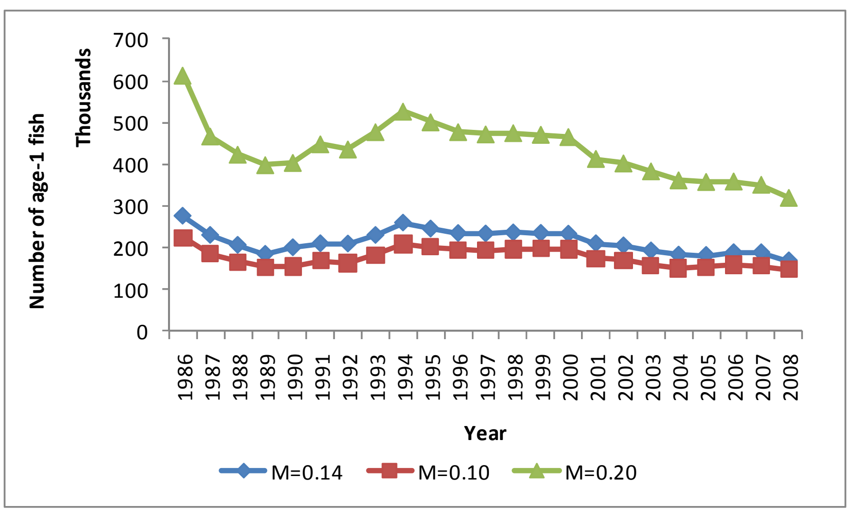
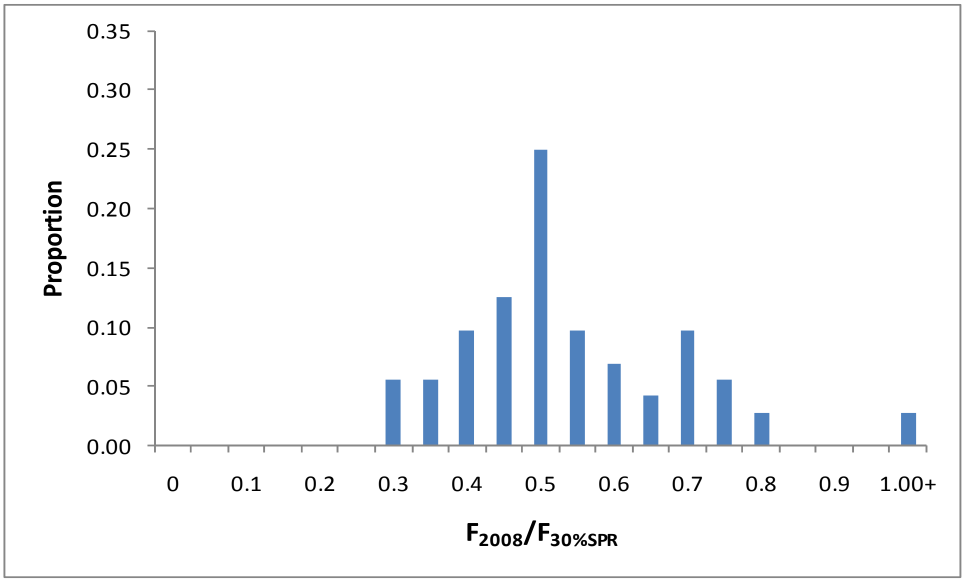


Figure A3.3.5.20. Sensitivity runs with natural mortality rates averaging 0.10 per year and 0.20 per year compared to the base rate of 0.14 per year for fishing mortality rate on age-5 (a), spawning biomass (b), and recruitment (c). The equivalent figure in the original report was Figure 3.3.5.19.

a.



b.

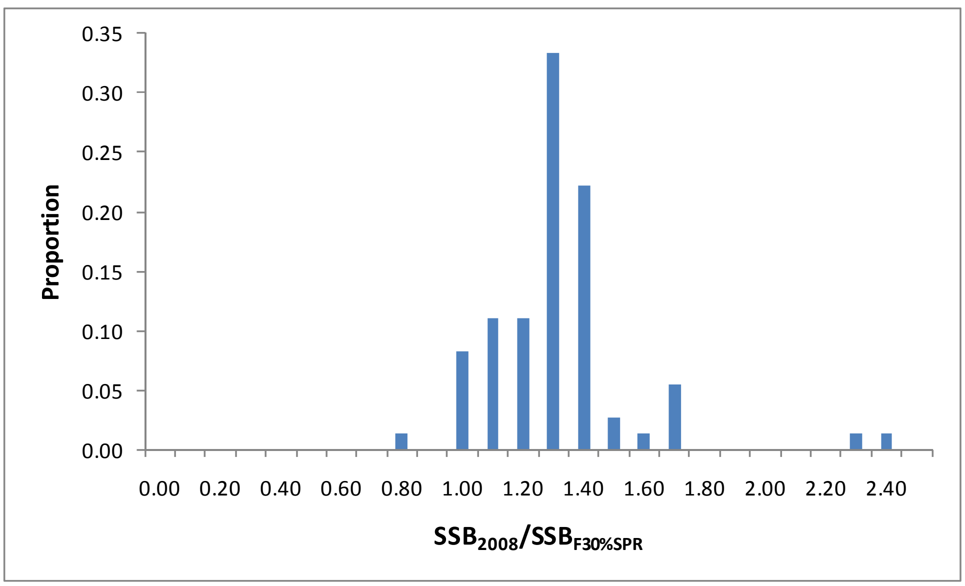


Figure A3.3.5.21. Distributions of $F_{2008}/F_{30\%SPR}$ (a) and $SSB_{2008}/SSB_{F30\%SPR}$ (b) from the exploratory and sensitivity runs plus the original base run and the new base run. There were two out of 72 runs with F-ratios exceeding 1.0 and one run out of 72 with a SSB-ratio less than MSST (0.86).

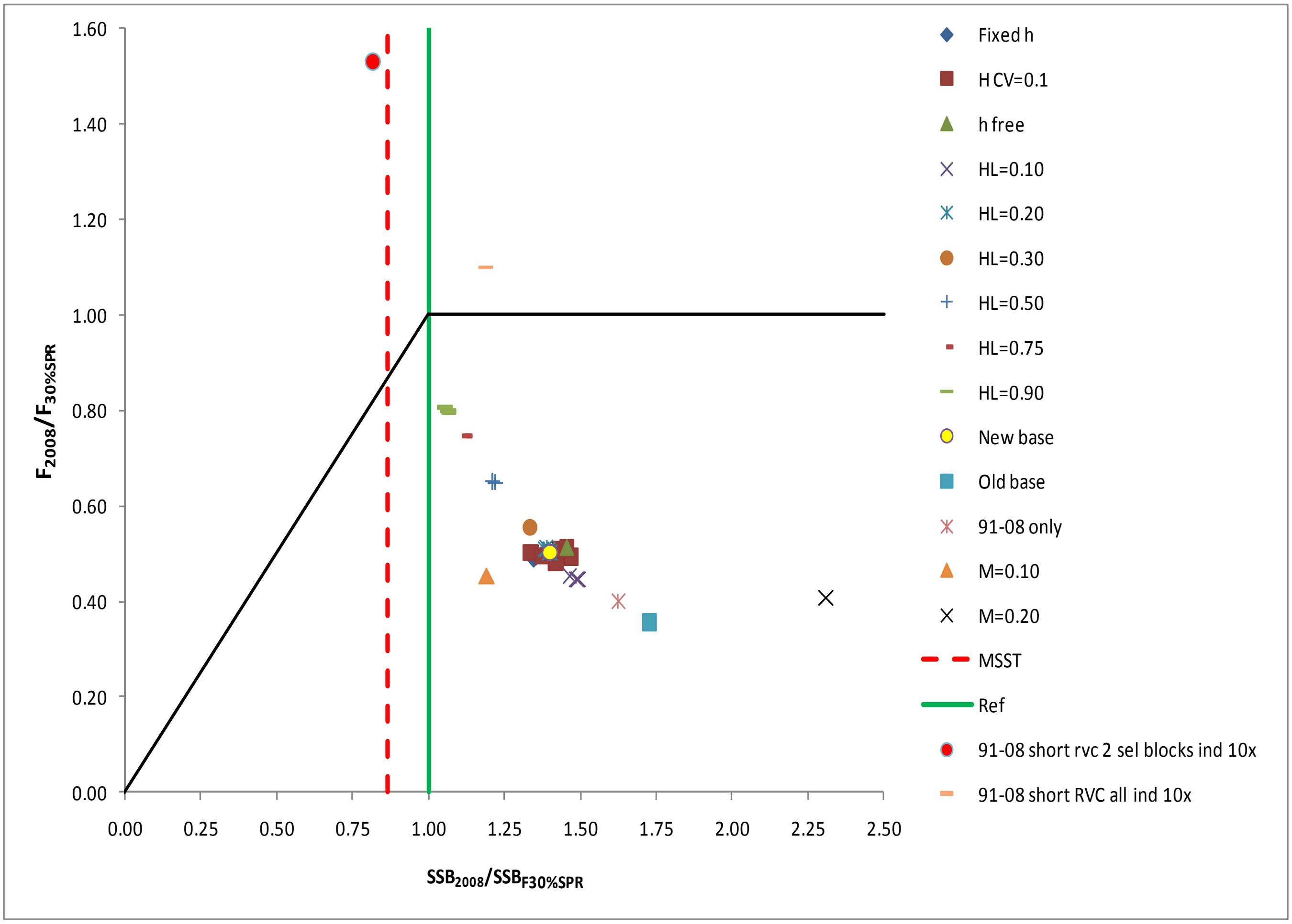
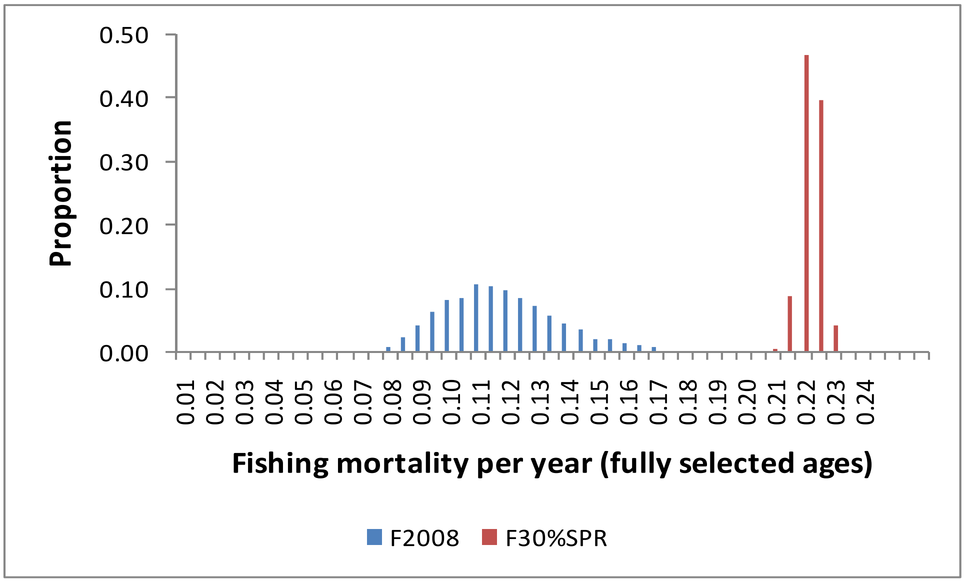


Figure A3.3.5.22. Fishing mortality ratios ($F_{2008}/F_{30\%SPR}$) and spawning biomass ratios ($SSB_{2008}/SSB_{F30\%SPR}$) for the exploratory and sensitivity runs.

a.



b.

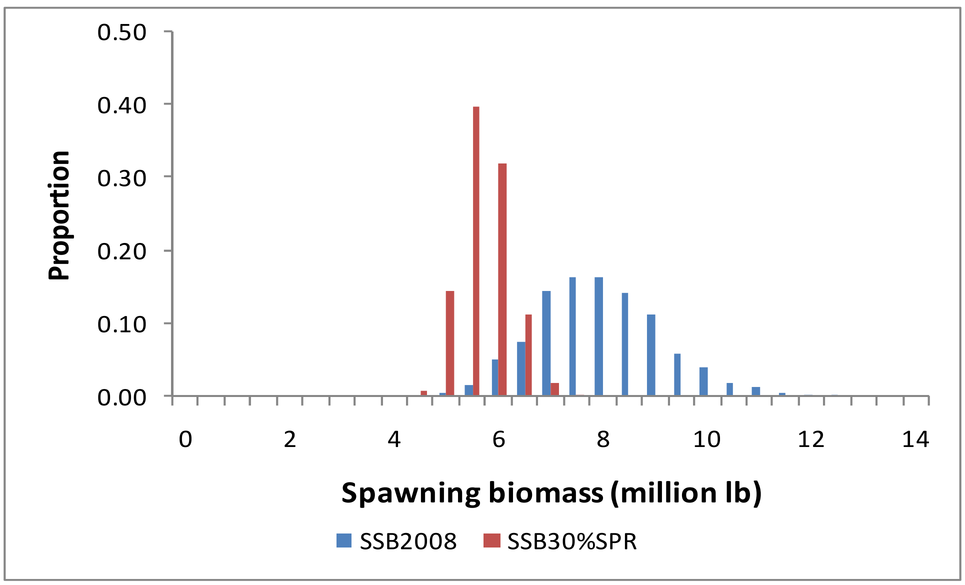


Figure A3.3.5.23. Distributions of Markov Chain Monte Carlo outcomes for F_{2008} and $F_{30\%SPR}$ (a) and for the spawning biomass in 2008 and $SSB_{F30\%SPR}$. One F_{2008} outcome overlapped with $F_{30\%SPR}$ and 858 SSB_{2008}outcomes out of 2500 outcomes (34%) overlapped $SSB_{F30\%SPR}$. The equivalent figure in the original report was Figure 3.3.5.20.

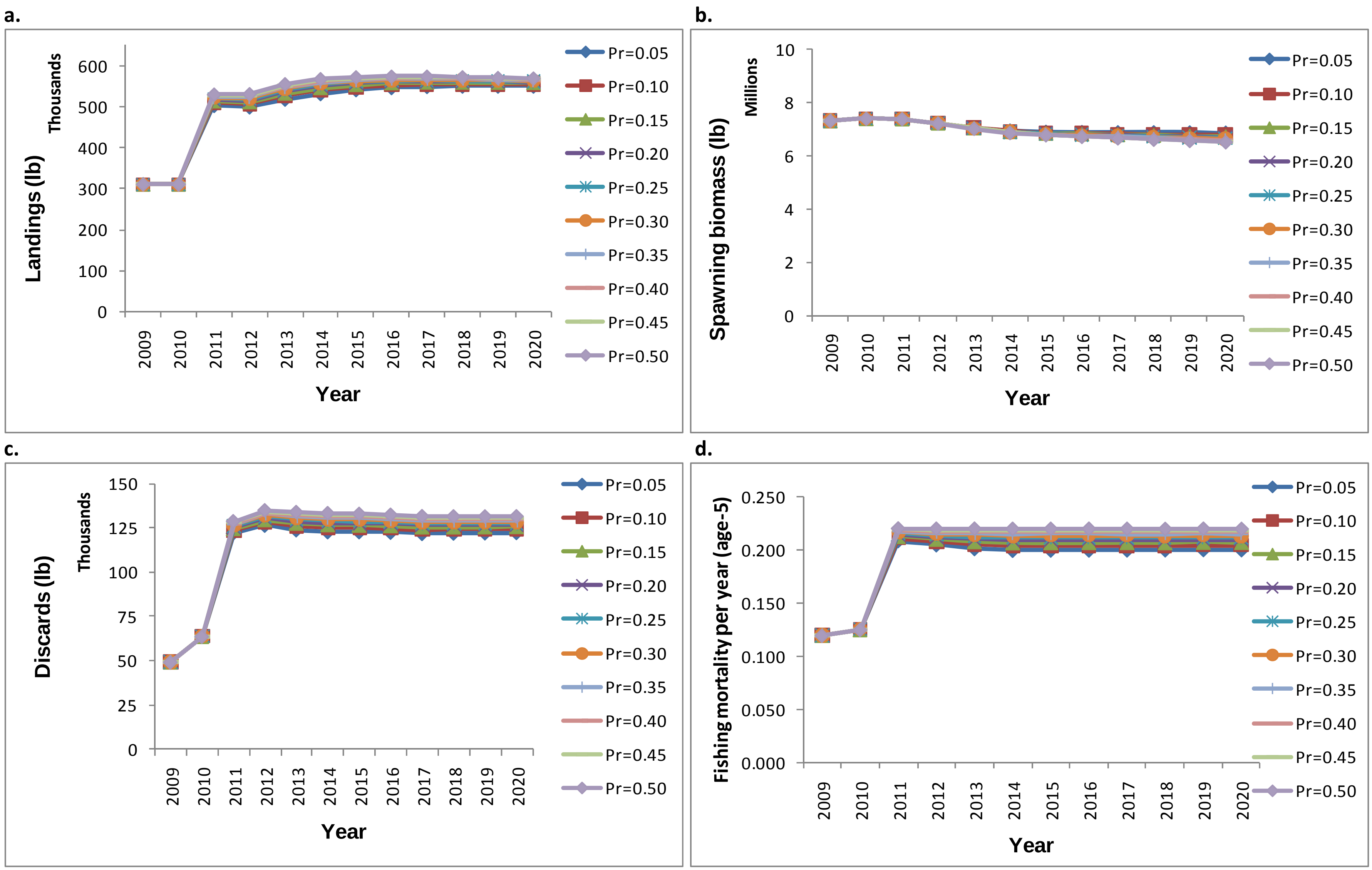


Figure A3.3.5.24. P* estimates of potential landings (a), spawning biomass (b), discards (c), and fishing mortality on fully selected fish (d) for alternative probabilities of exceeding the overfishing limit ($F_{30\%SPR}$). The equivalent figure in the original report was Figure 3.3.5.21.

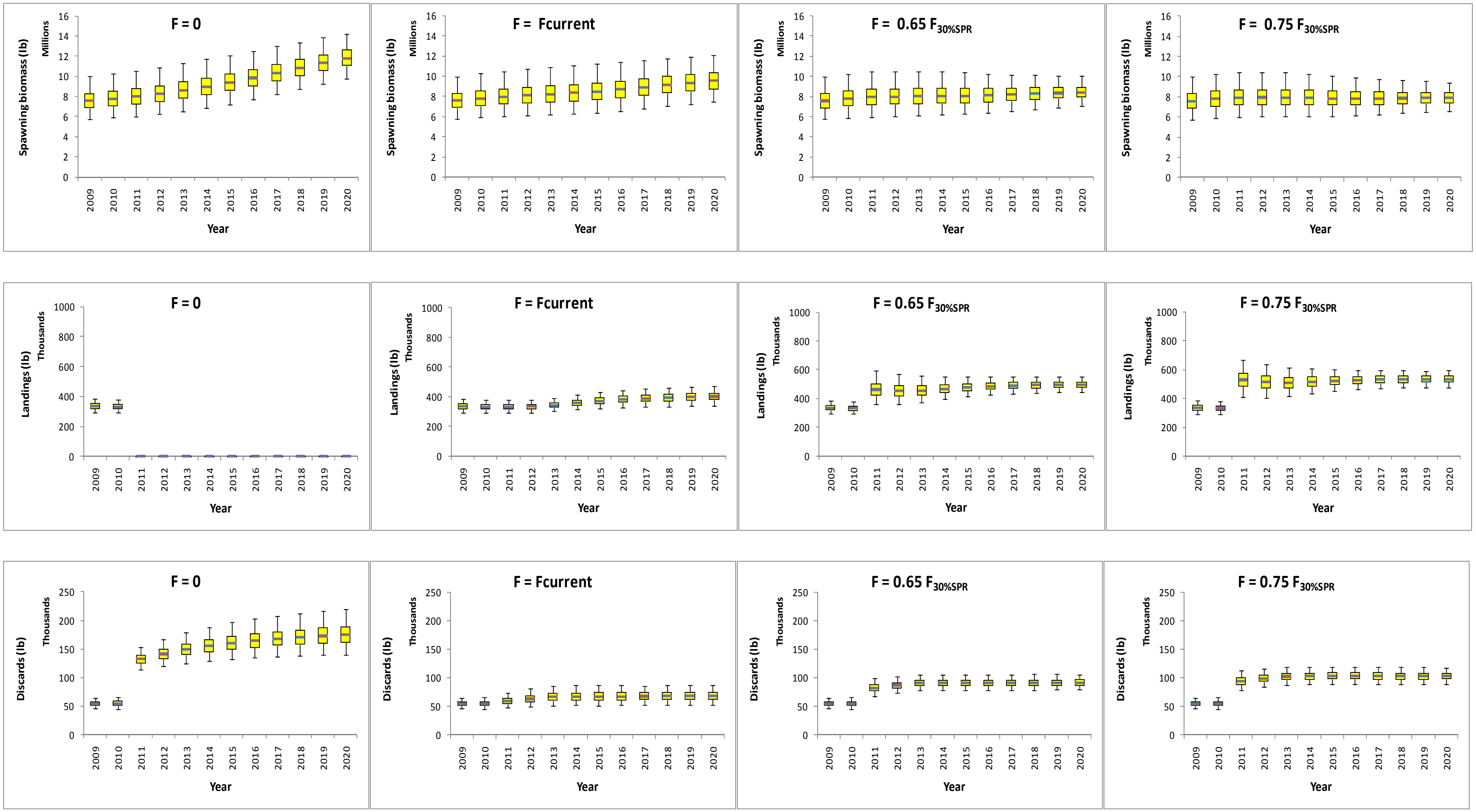


Figure A3.3.5.25. Projections of spawning biomass, landings, and discards for F = 0, F = Fcurrent (geometric mean of 2006-2008 fishing mortalities per year on fully selected age, age-5), F = $F_{30\%SPR}$, and F = $F_{45\%SPR}$. The equivalent figure in the original report was Figure 3.3.5.22.

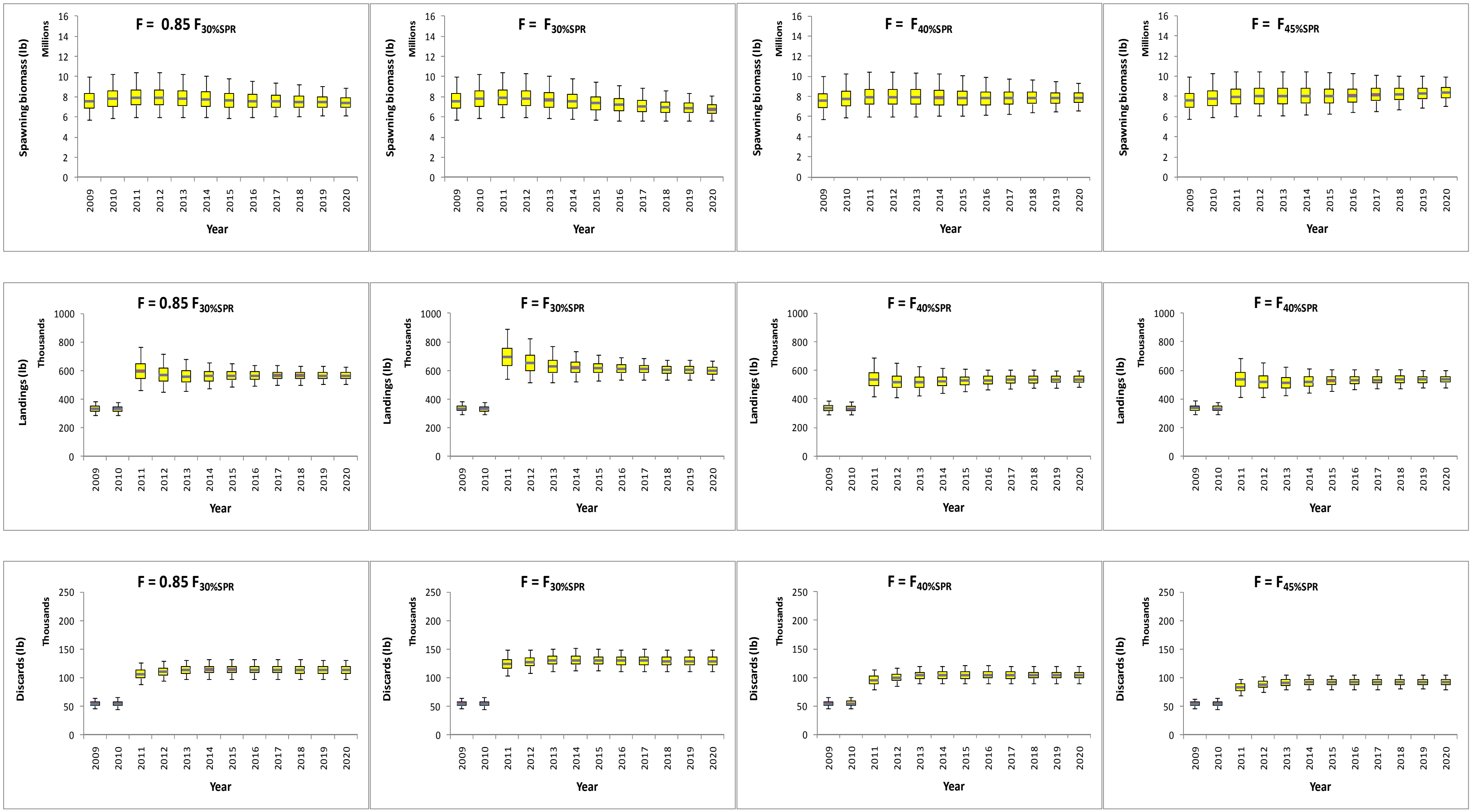


Figure A3.3.5.25 (continued). Projections of spawning biomass, landings, and discards for F = 0, F = Fcurrent (geometric mean of 2006-2008 fishing mortalities per year on fully selected age, age-5), F = $F_{30\%SPR}$, and F = $F_{45\%SPR}$. The equivalent figure in the original report was Figure 3.3.5.22.

a.

b.

c.

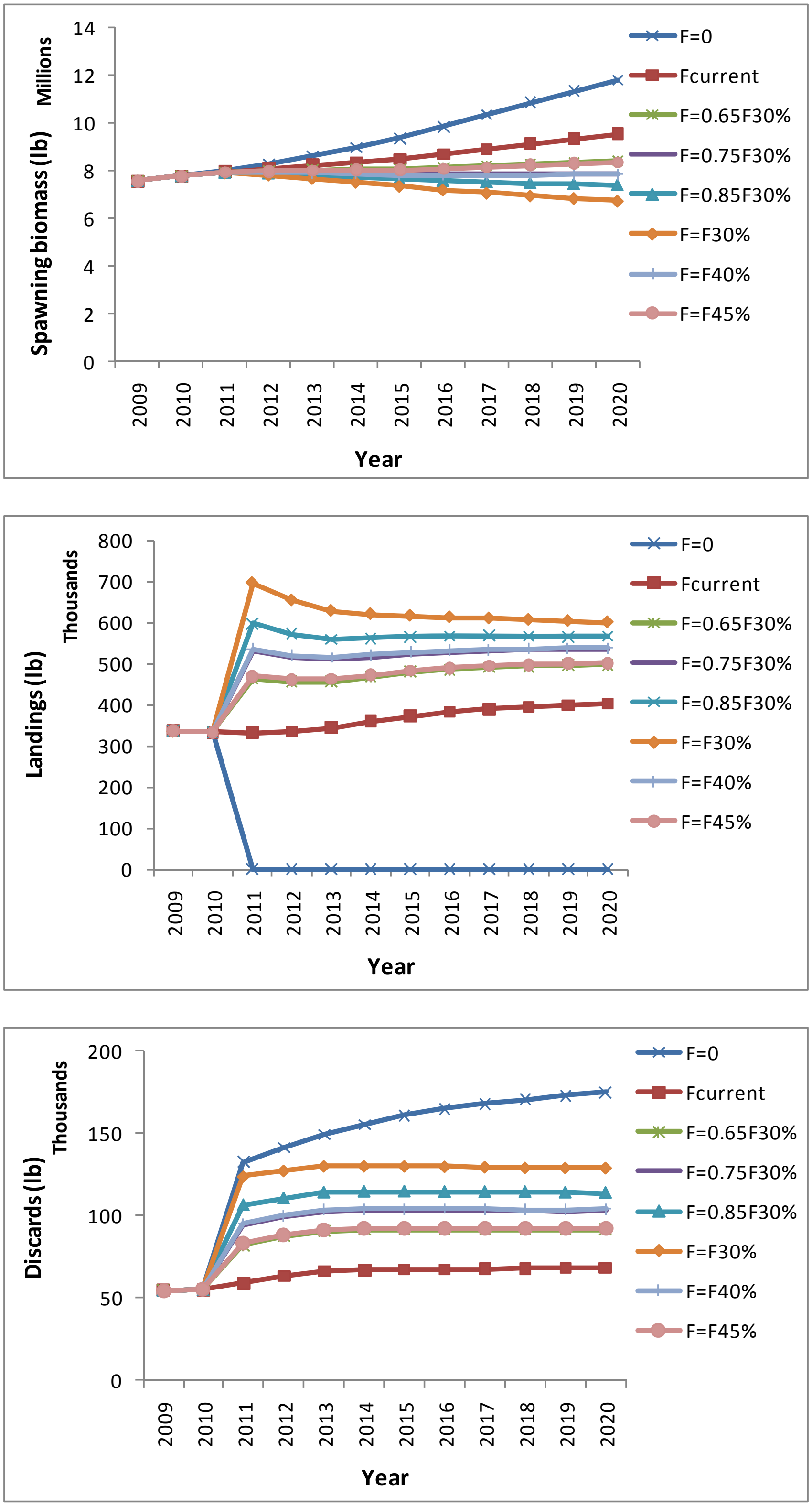


Figure A3.3.5.26. Comparison of projections for spawning biomass (a), landings (b) and discards across alternative fishing mortality rates. The equivalent figure in the original report was Figure 3.3.5.23.

A**3.3.6. References**

Legault, C. M. and V. R. Restrepo. 1998. A flexible forward age-structured assessment program. ICCAT Working Document SCRS/98/58. 15 pp.

Mohn, R. 1999. The retrospective problem in sequential analysis: an investigation using cod fishery and simulated data. ICES Journal of Marine Science 56: 473-488.

Shertzer, K. W., M. H. Prager, and E. H. Williams. 2008. A probability-based approach to setting annual catch limits. Fishery Bulletin 106:225-232.

SEDAR19-AW-Addendum Black Grouper Appendix A.

The annual age compositions and standardized residuals by the directed fleet (Figure A-1), discards by fleet (Figure A-2), and fishery independent indices of abundance (Figure A-3) were regenerated with the new base run. The standardized residuals allow for comparisons of the fits across years and fleets but they amplify the residuals. Also, if a plot for a year is missing, then there was no age information from that fleet for that year. For example, there was no age information for MRFSS in 1990 nor were there age observations for longlines prior to 1992.

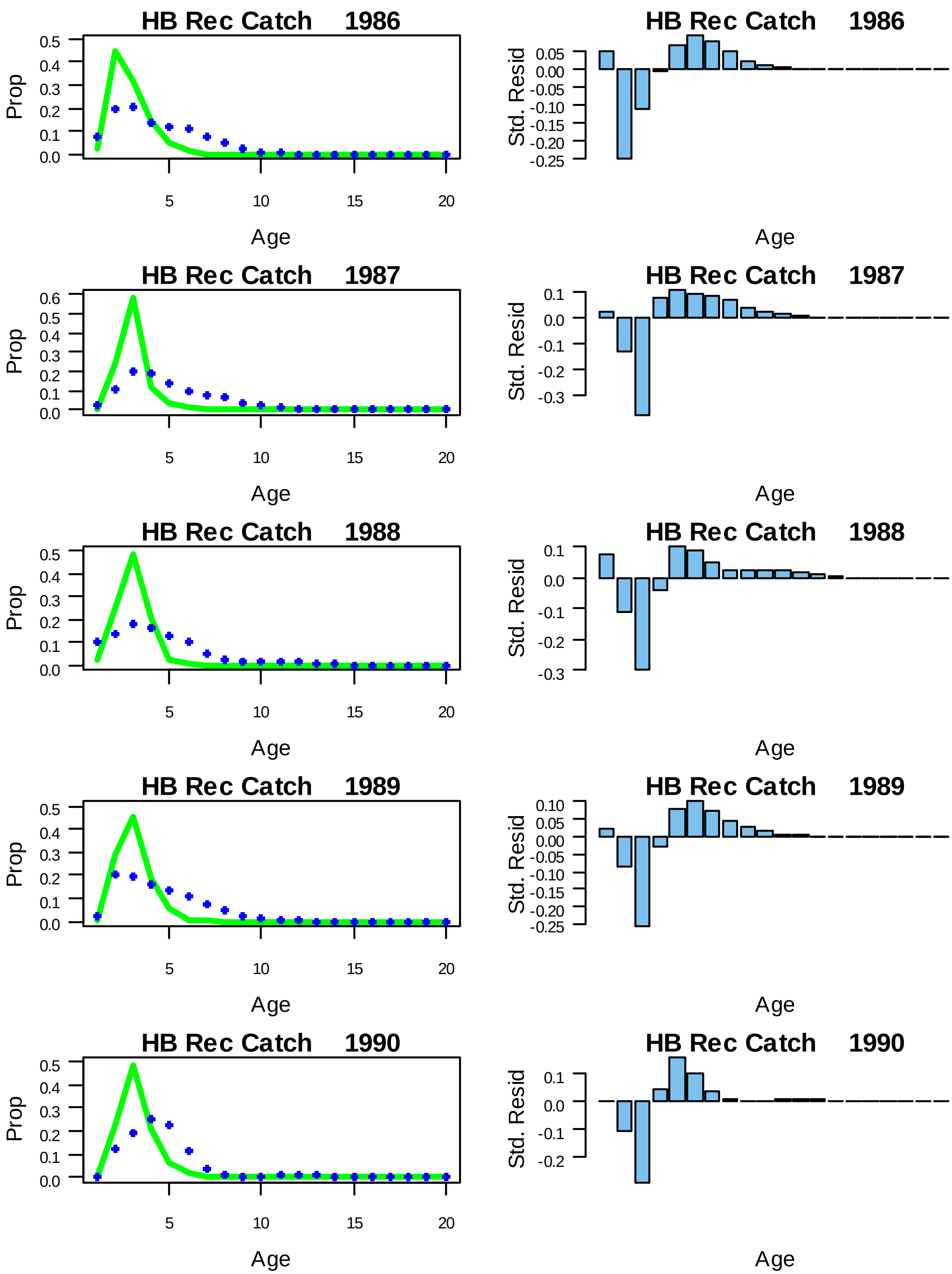


Figure AA-1. ASAP2 model fits and standardized residuals of fleet age composition.

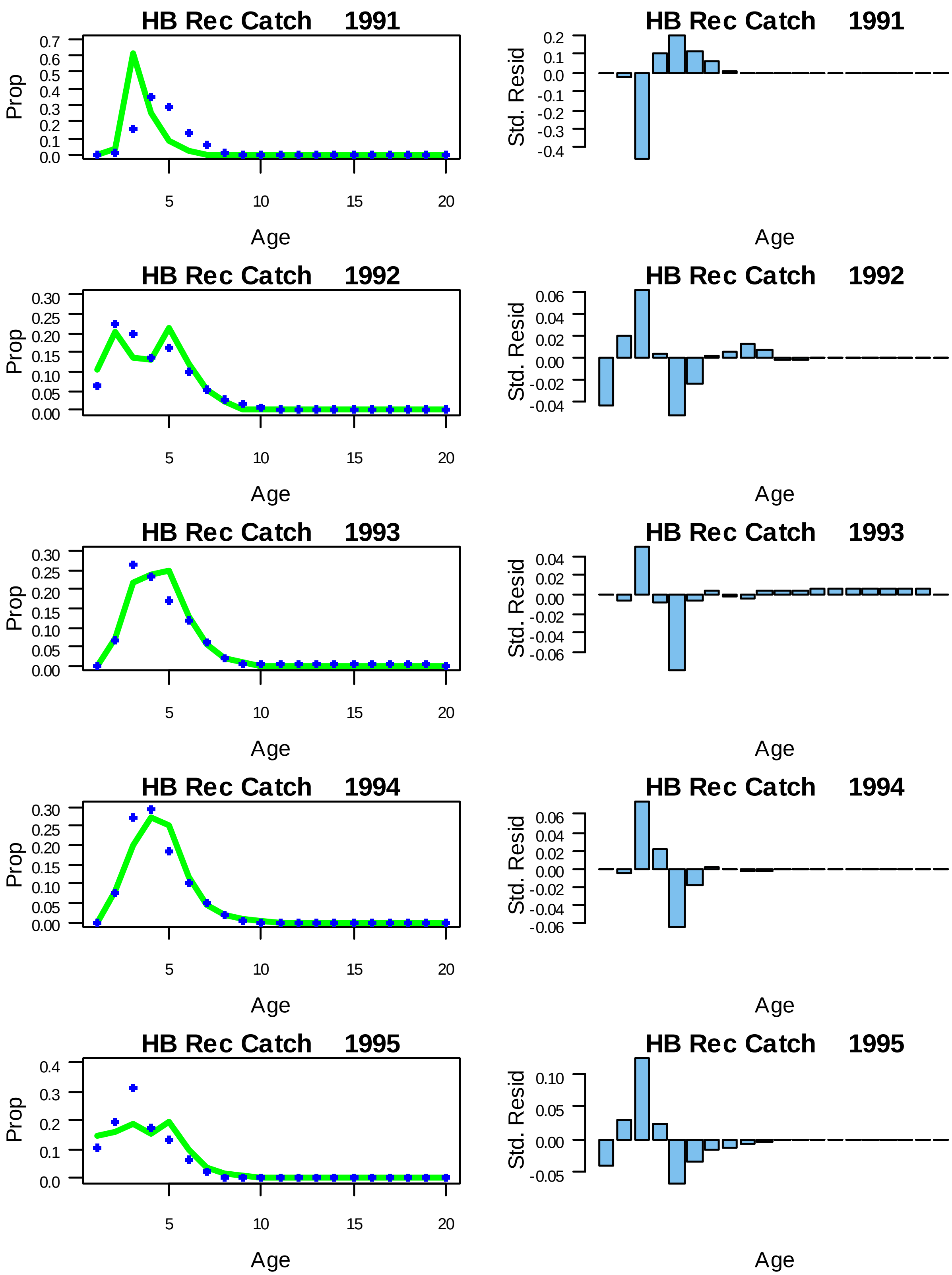


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

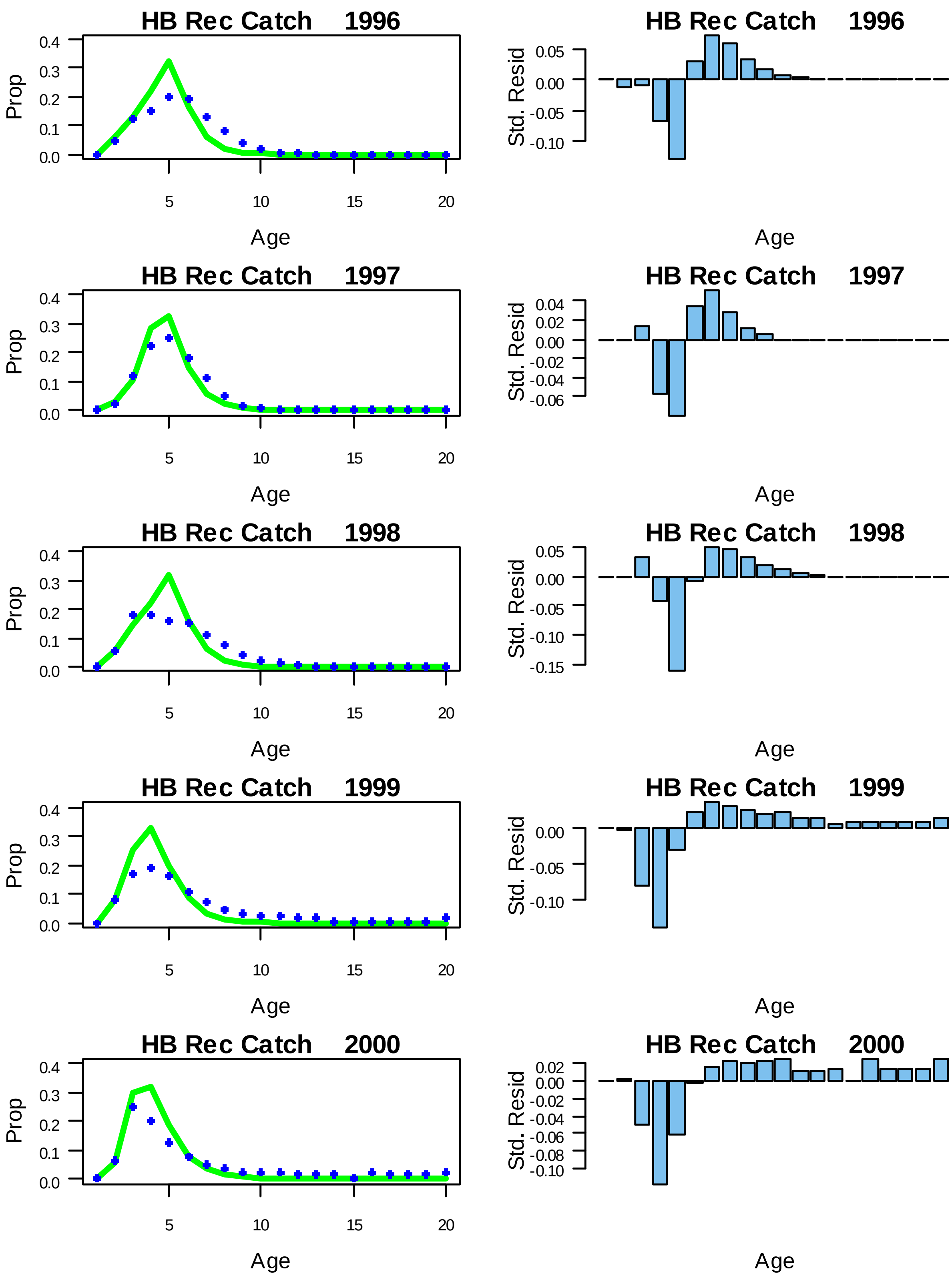


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

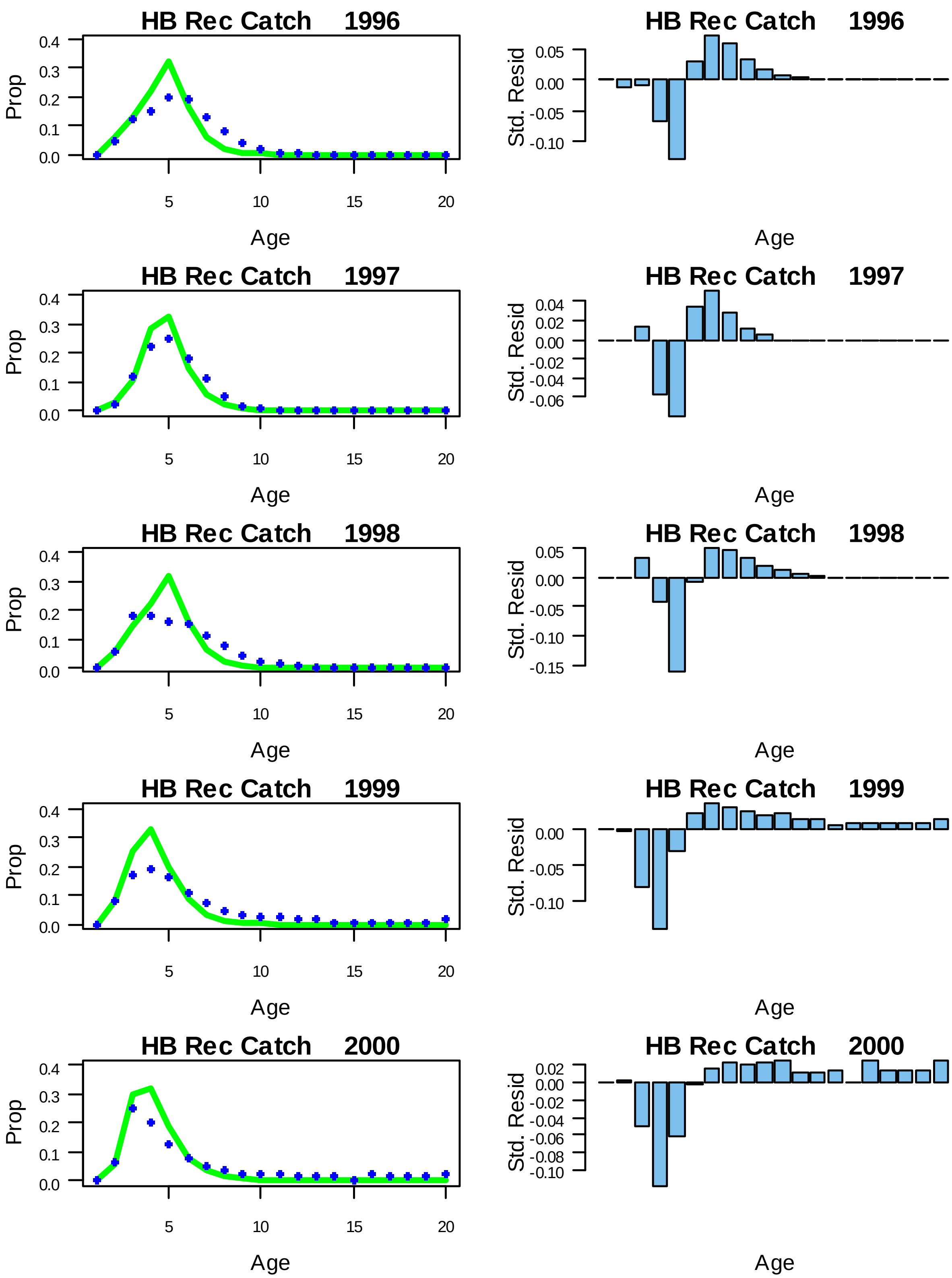


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

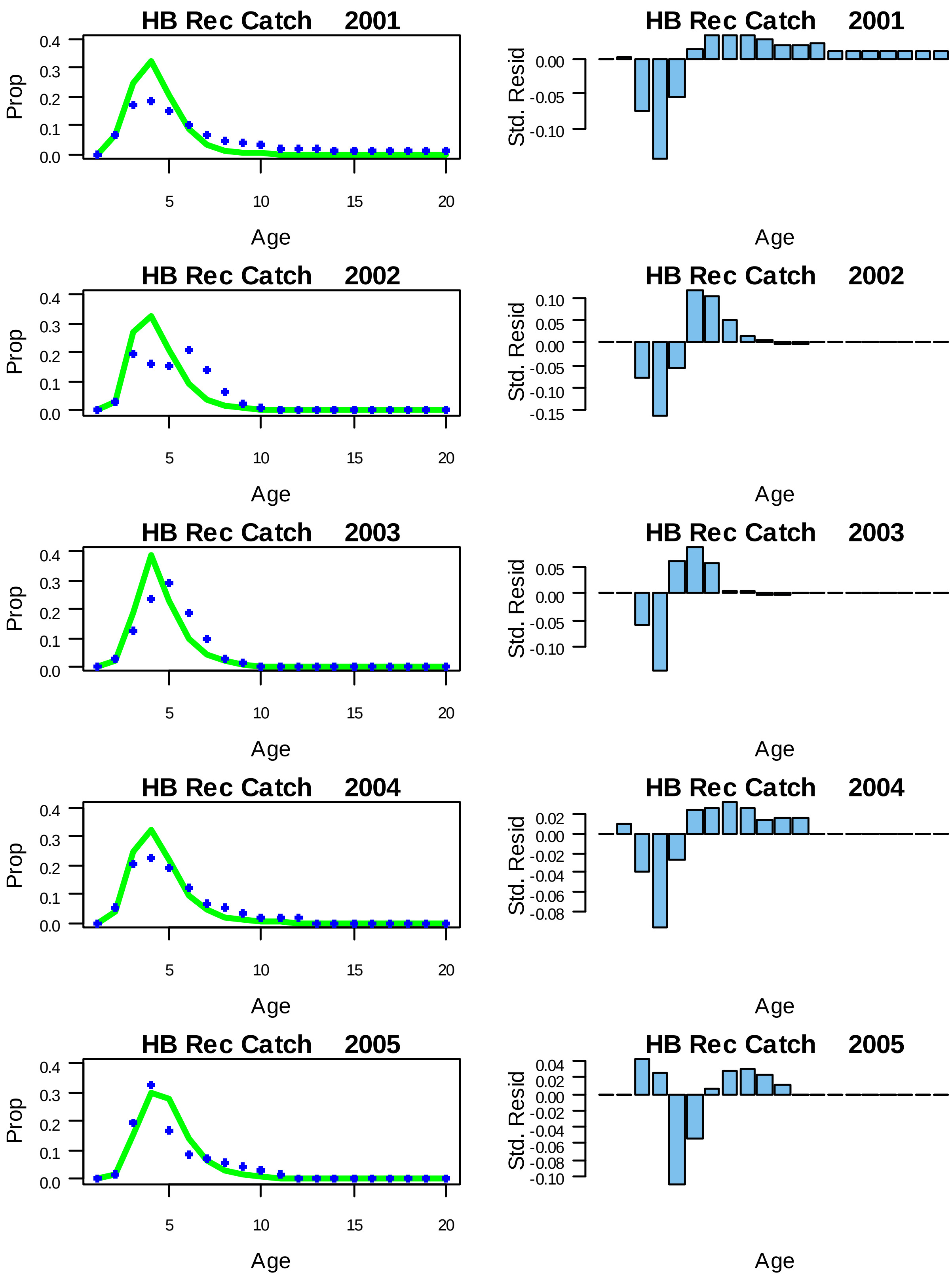


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

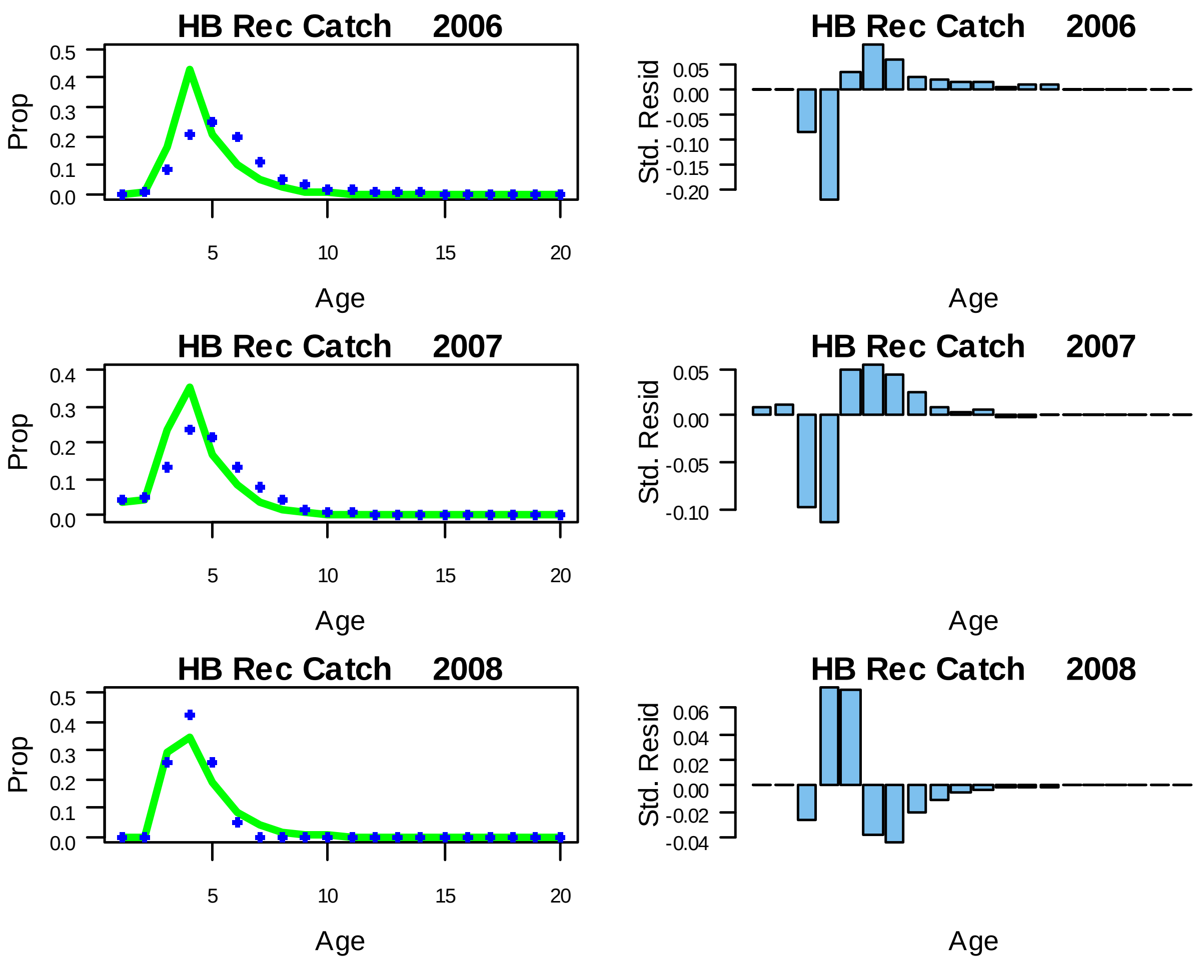


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

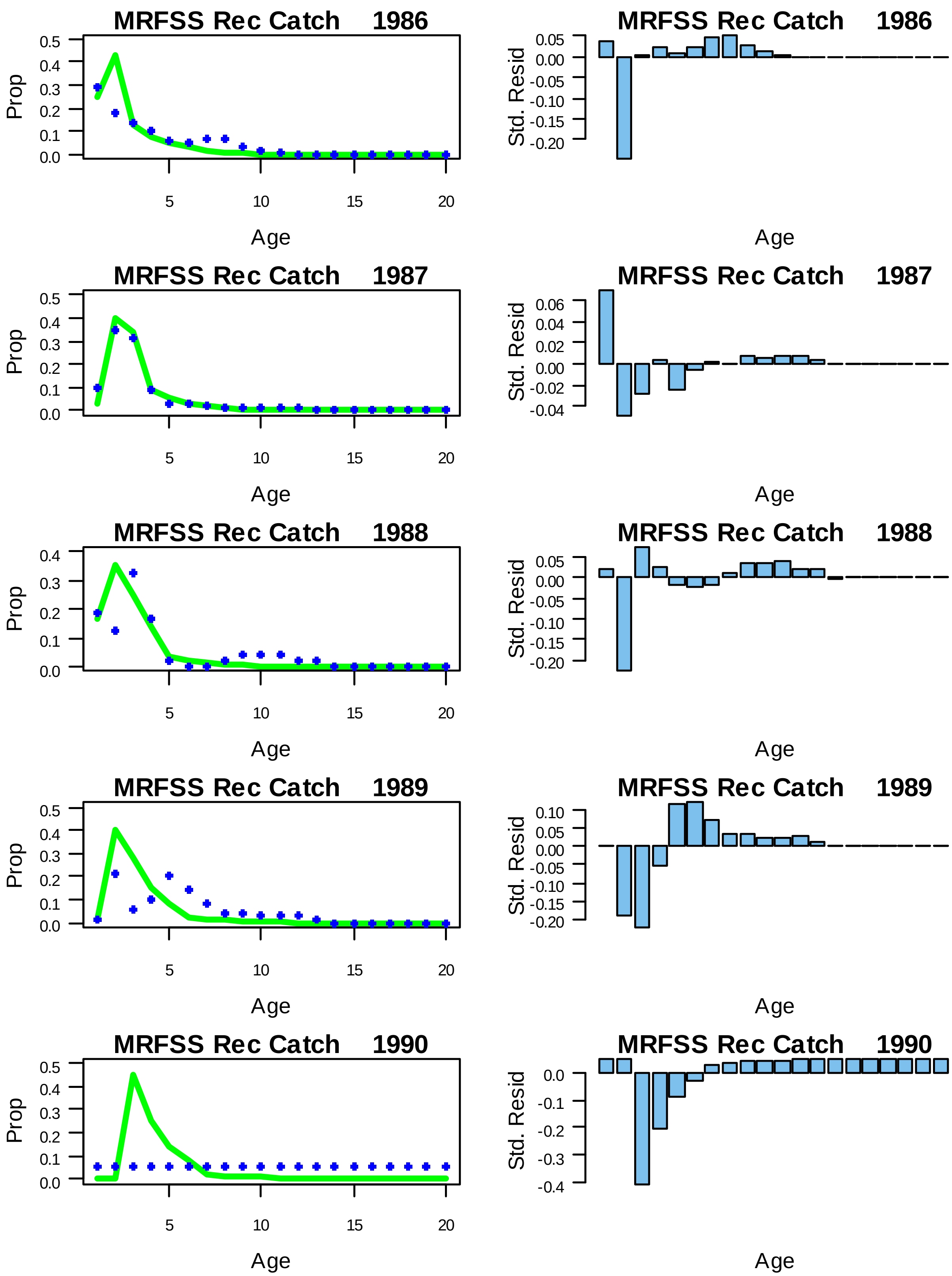


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

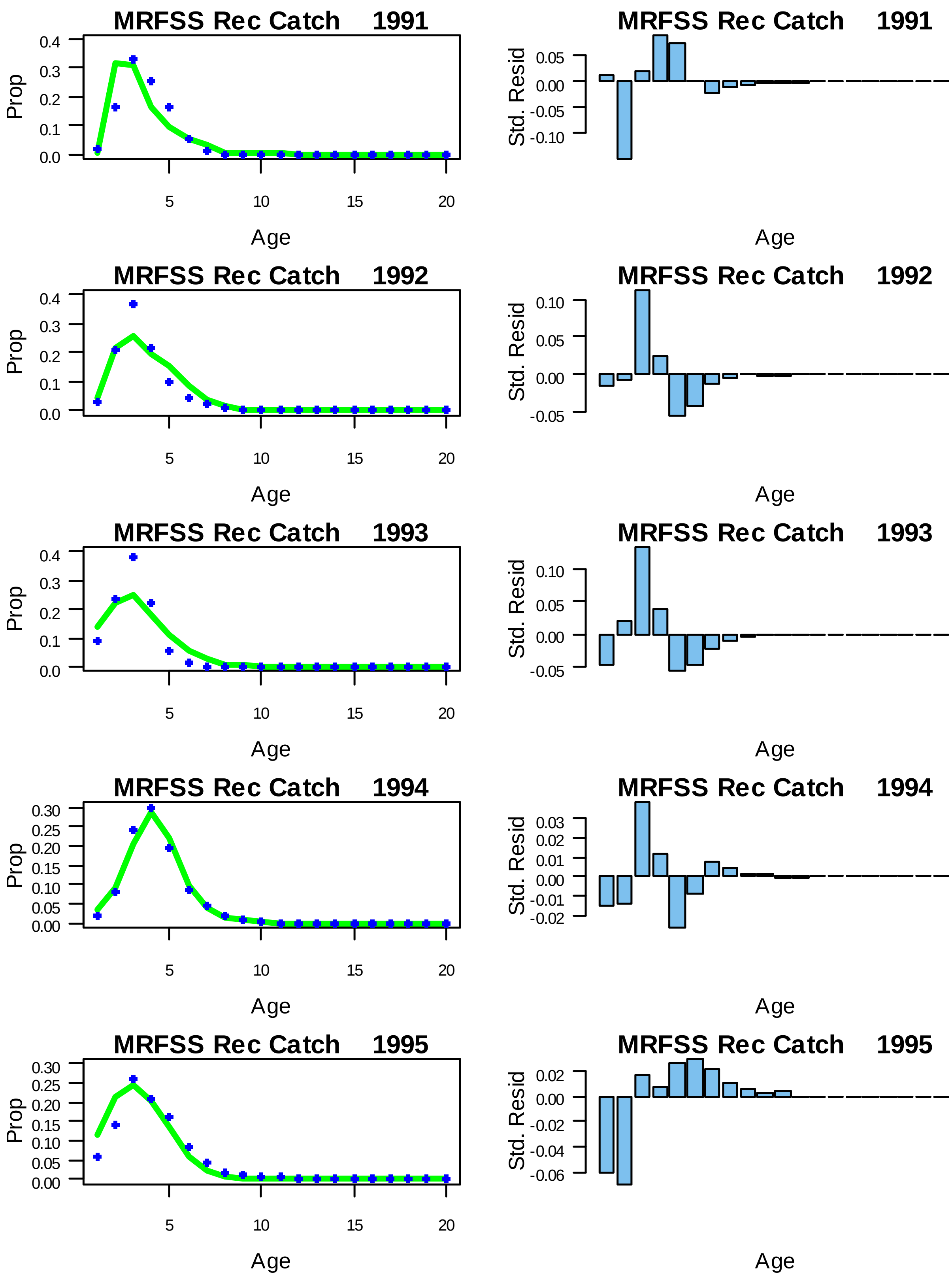


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

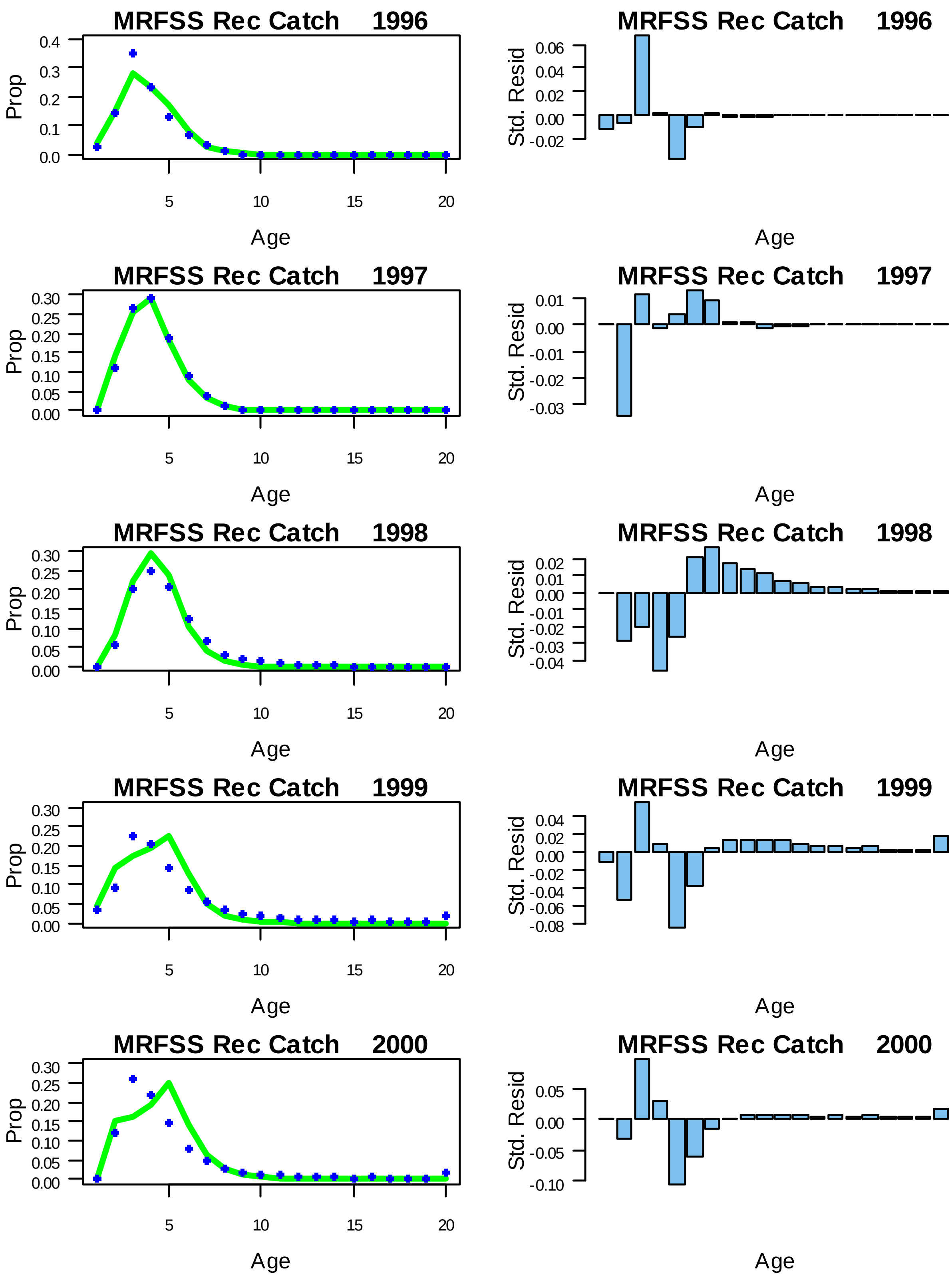


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

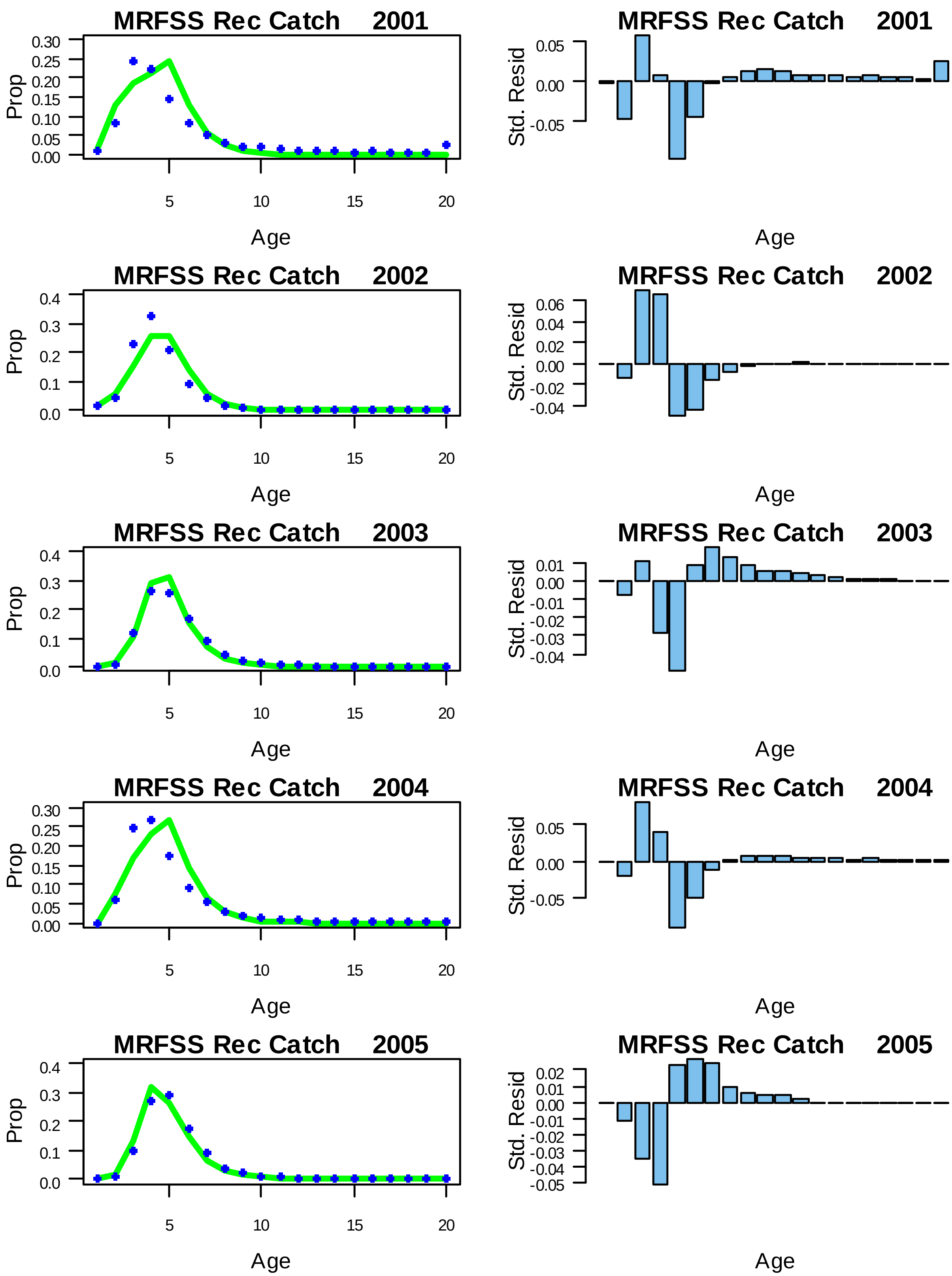


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

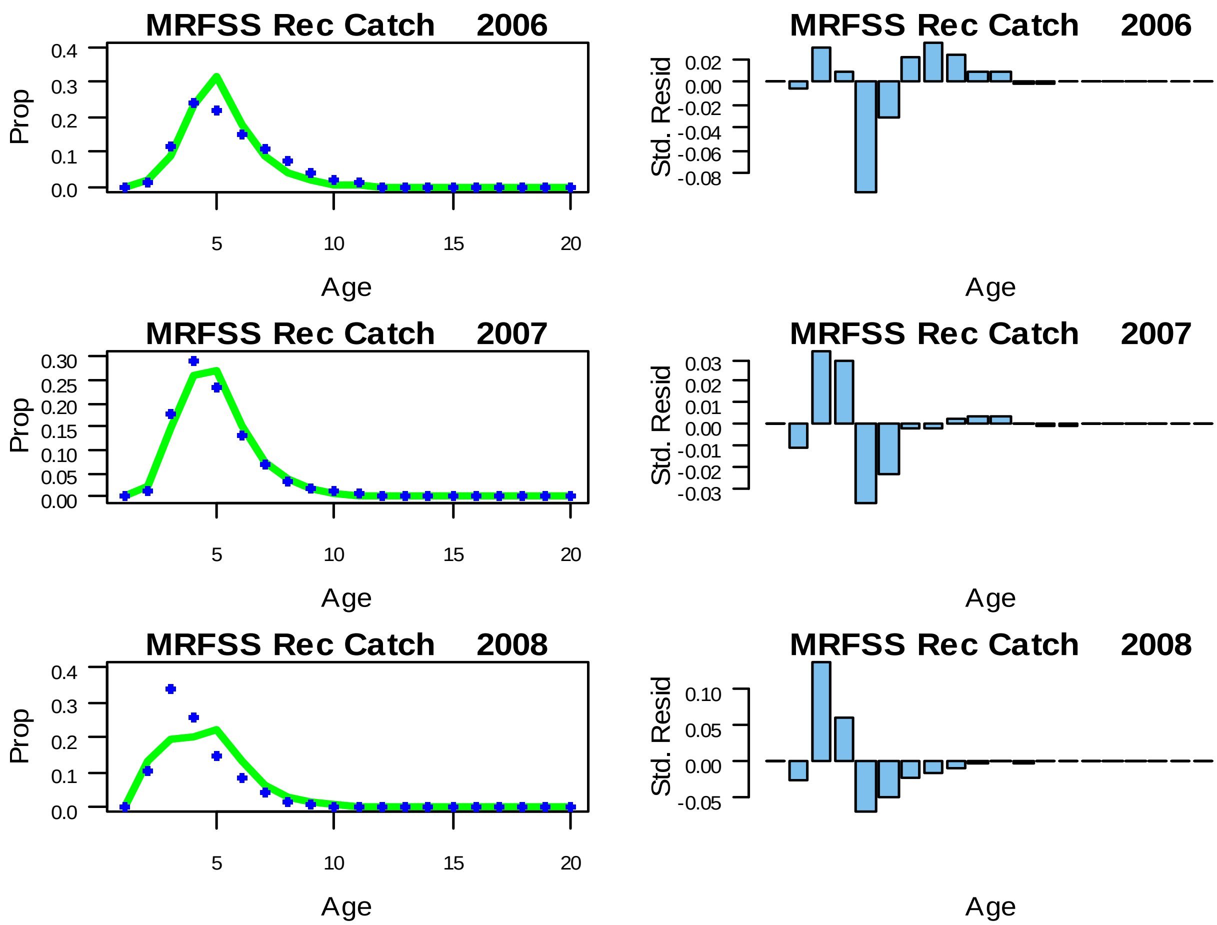


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

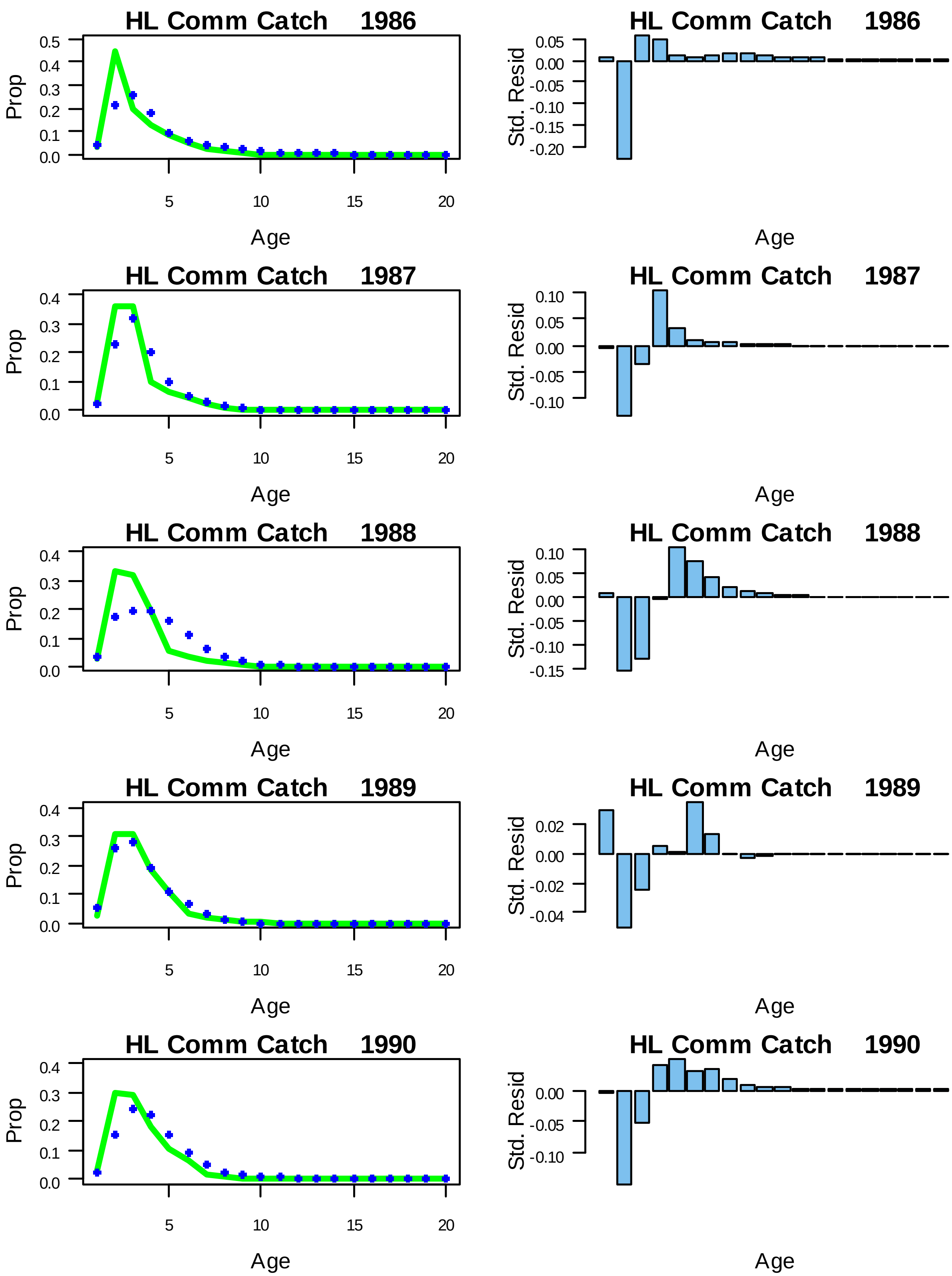


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

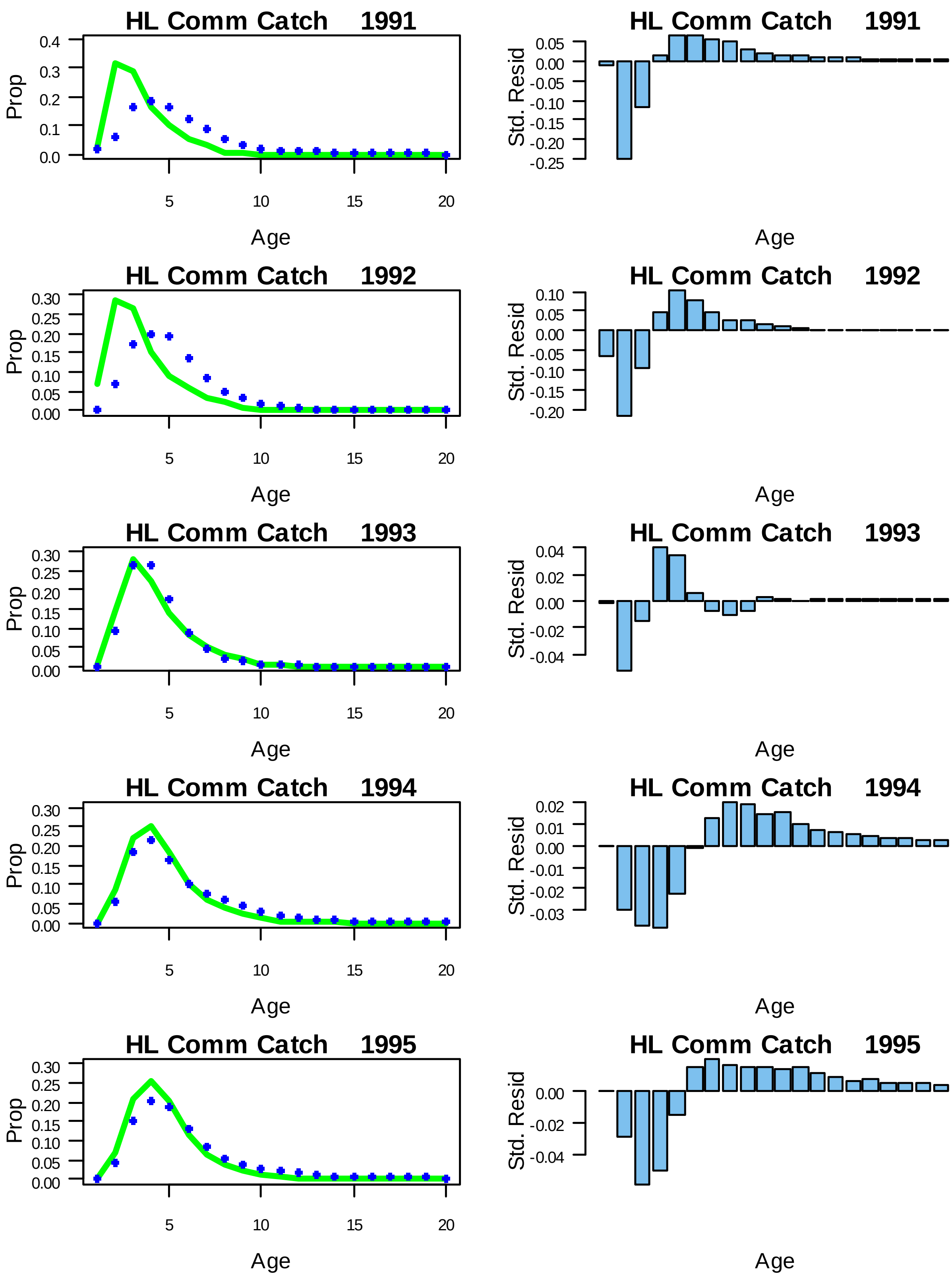


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

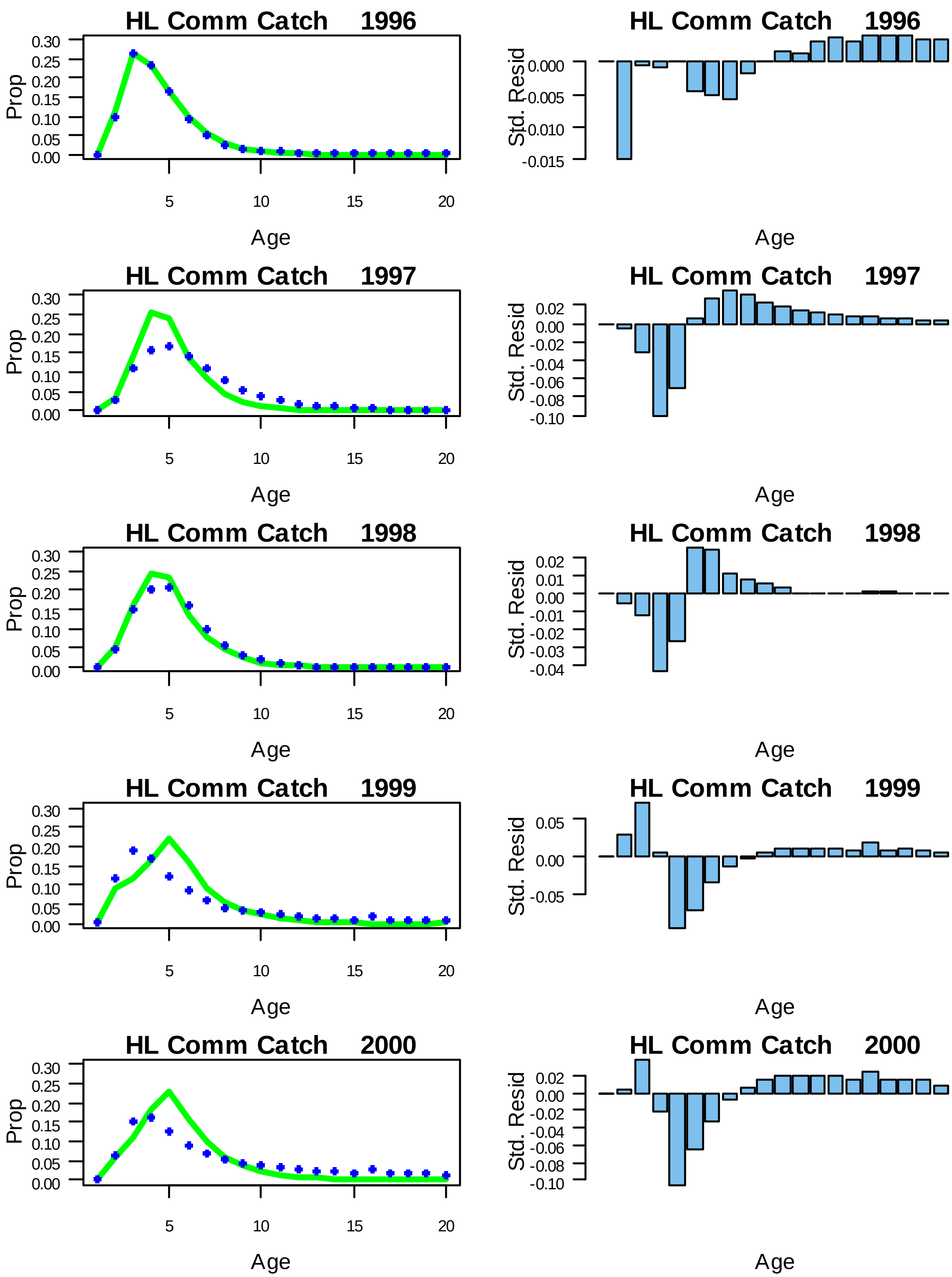


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

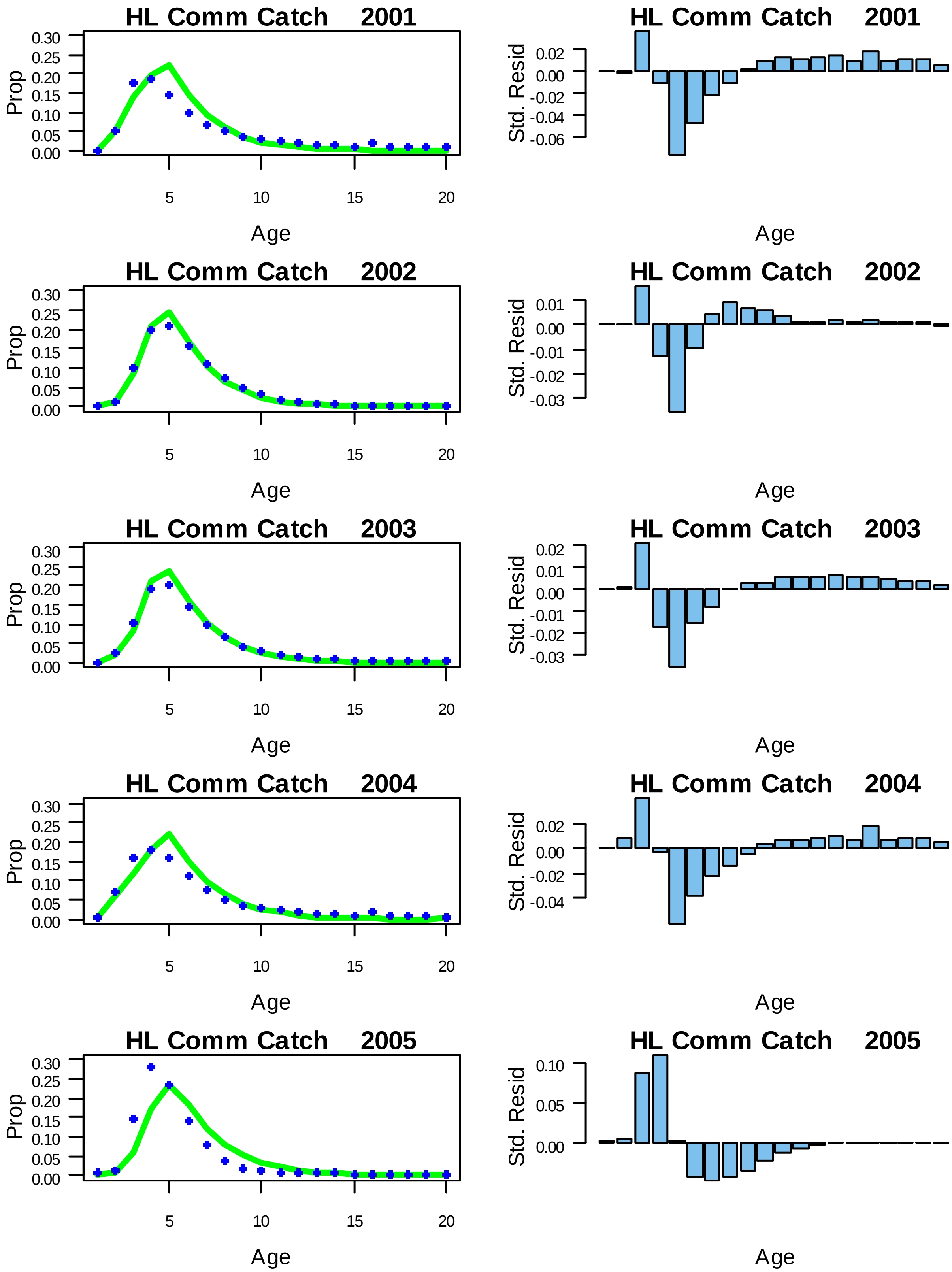


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

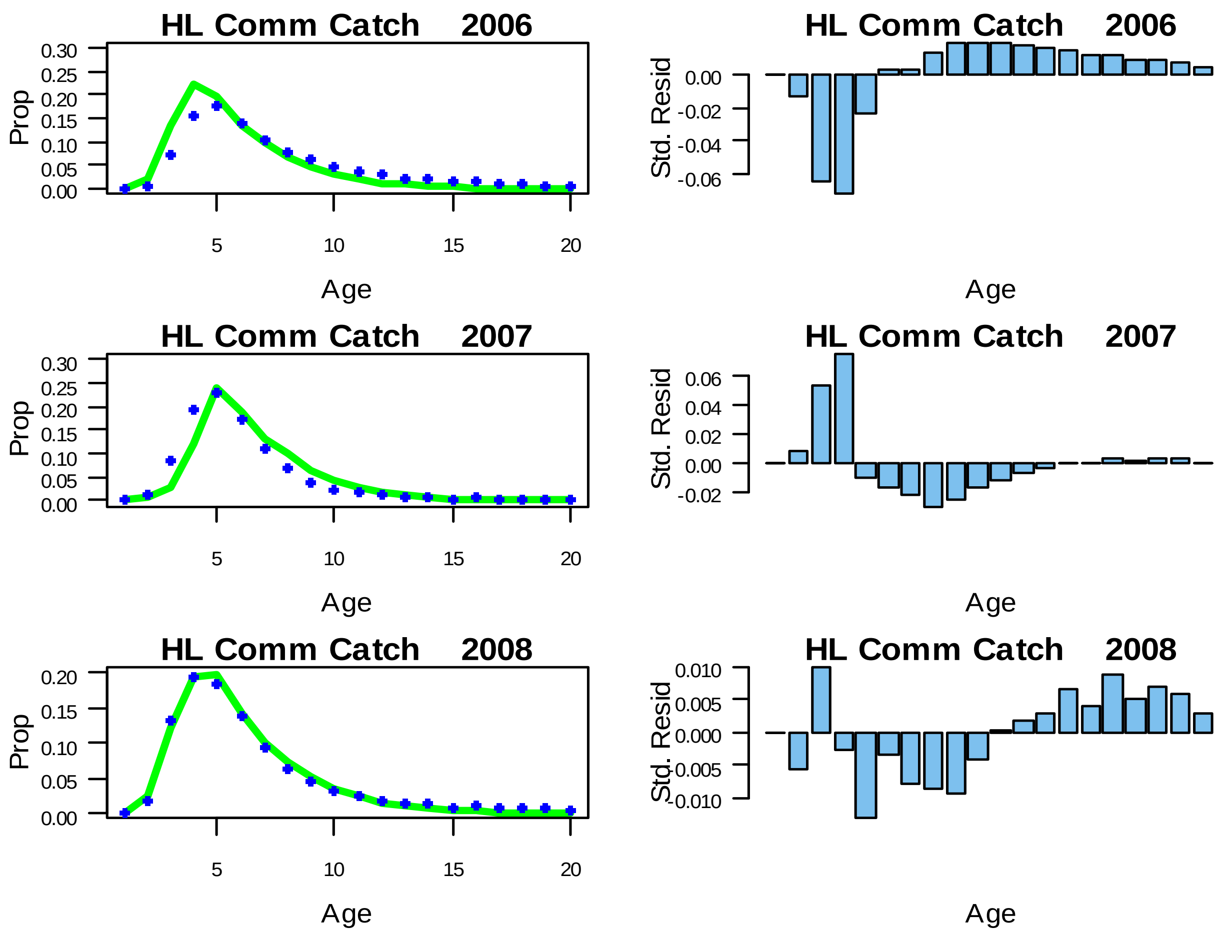


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

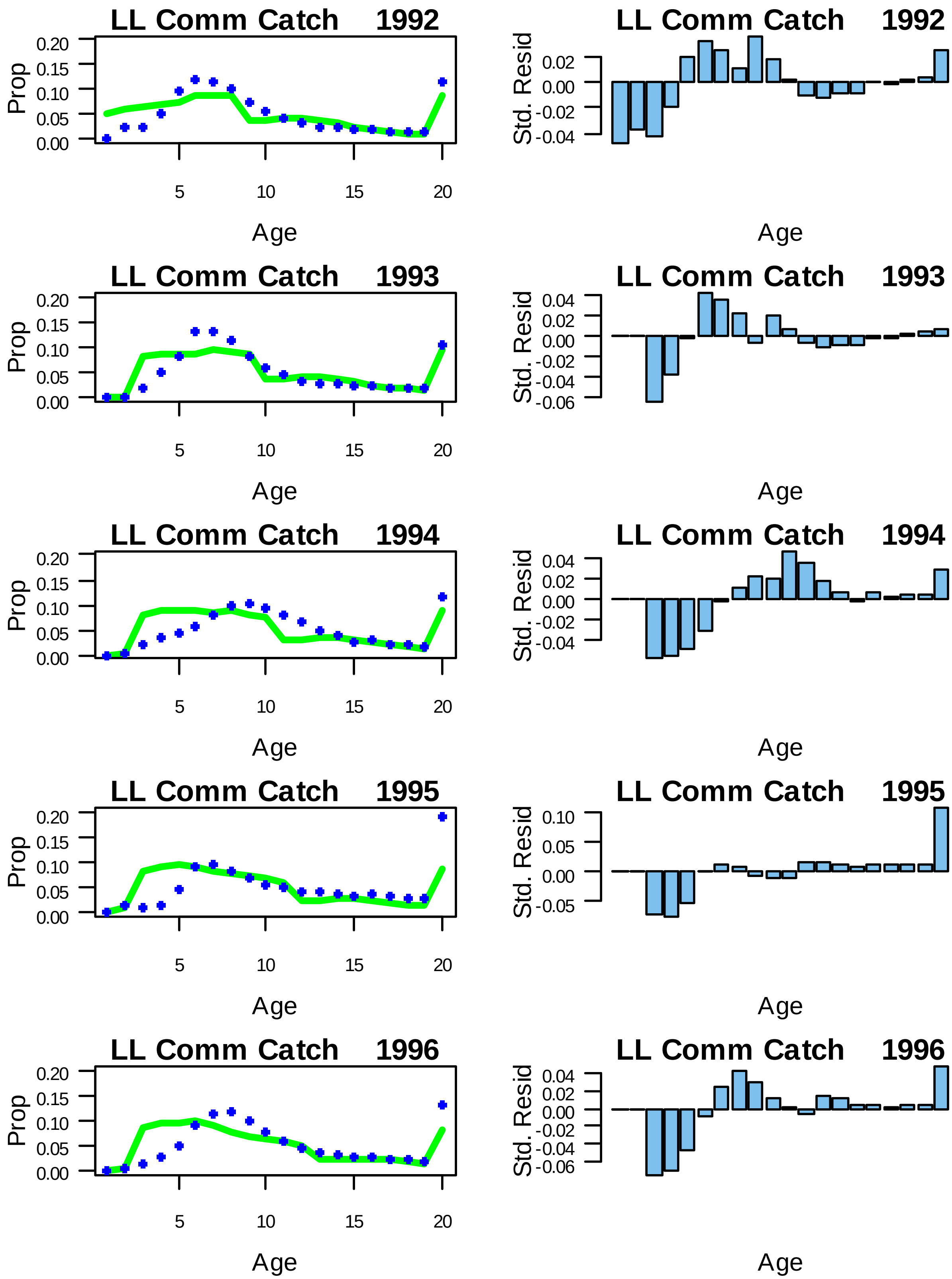


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

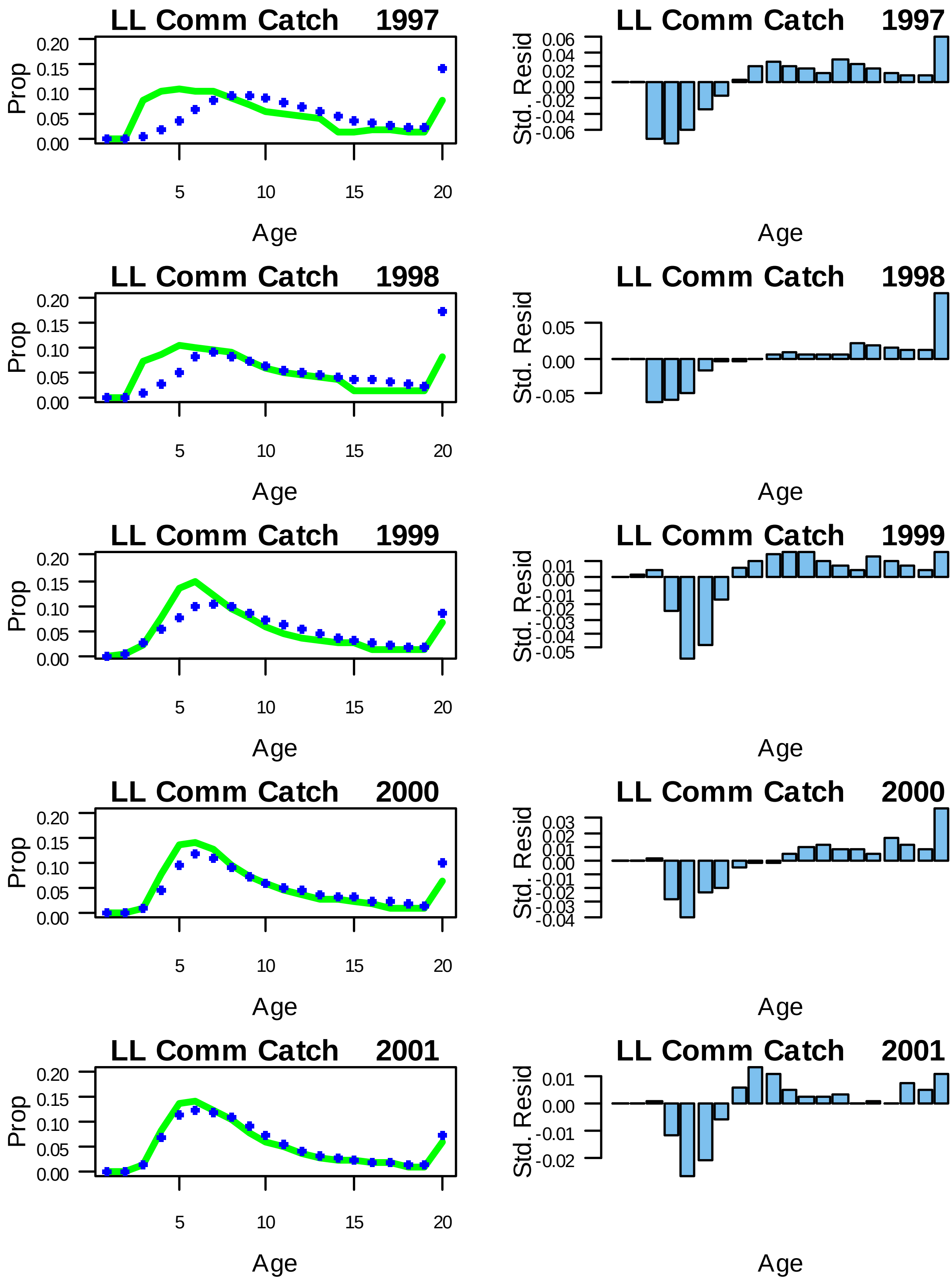


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

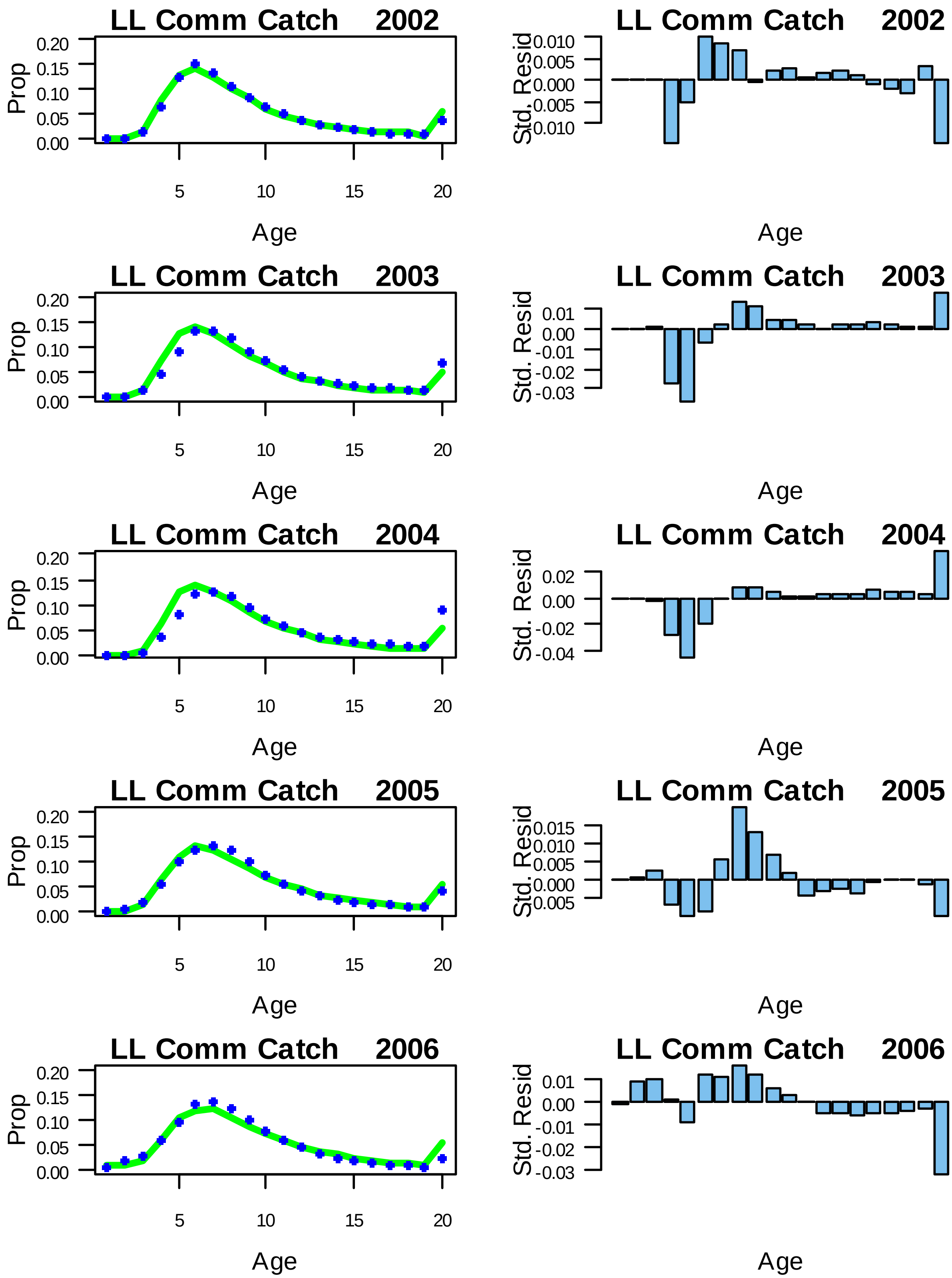


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

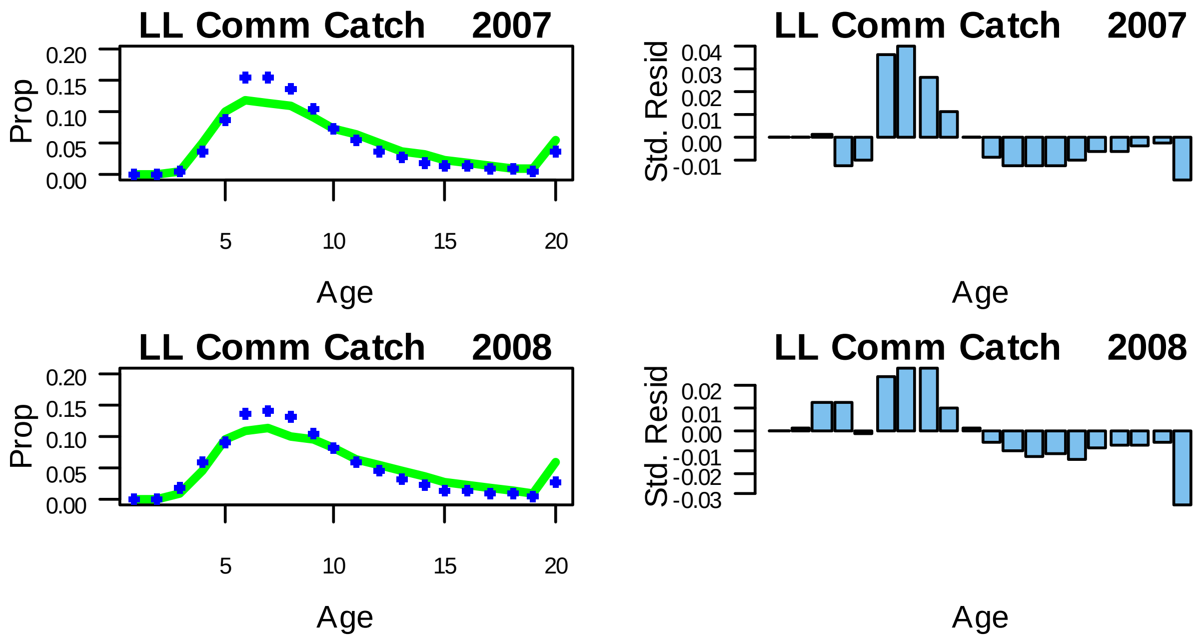


Figure AA-1 continued. ASAP2 model fits and standardized residuals of fleet age composition.

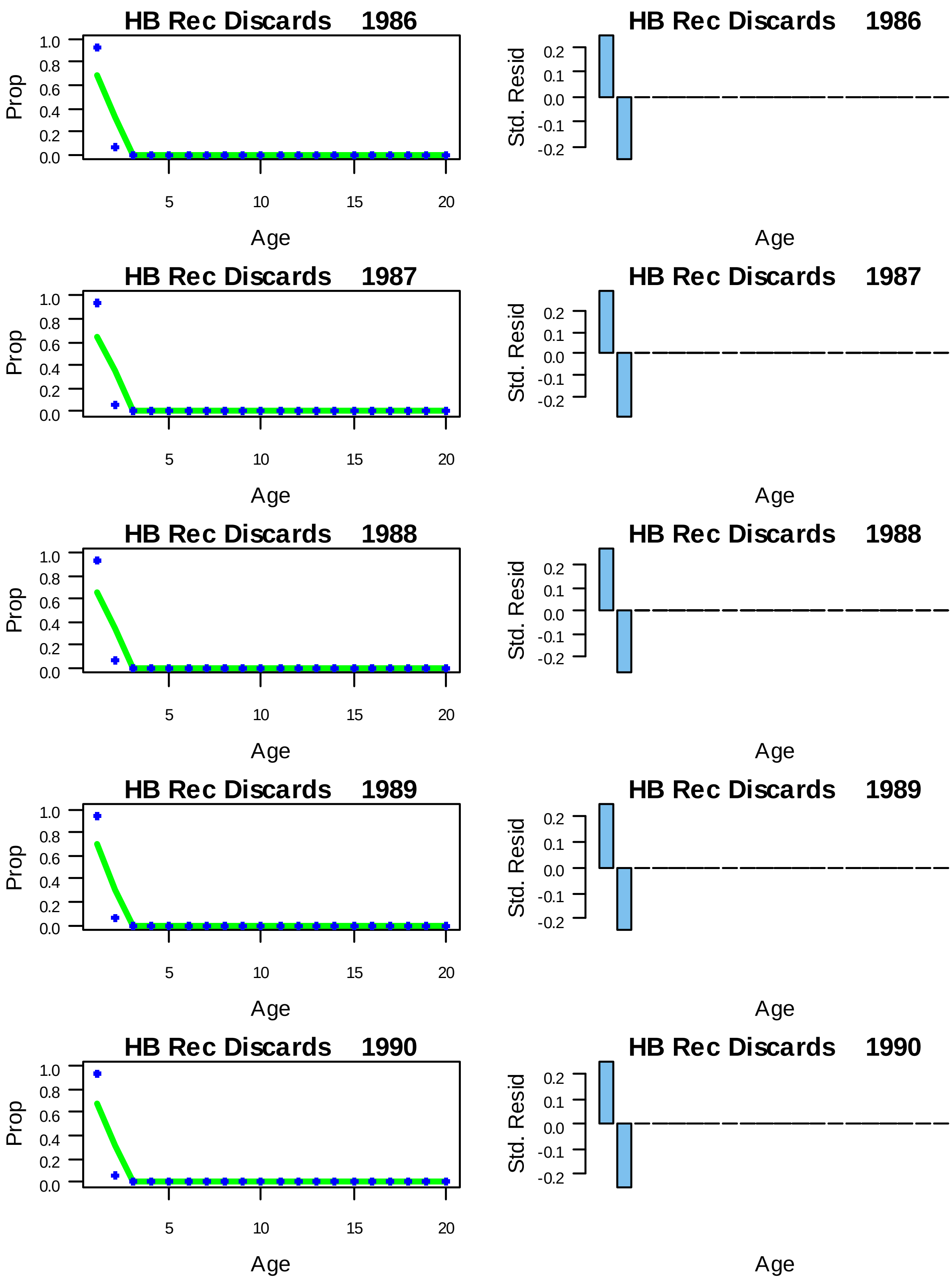


Figure AA-2. ASAP2 model fits and standardized residuals of fleet discard age composition.

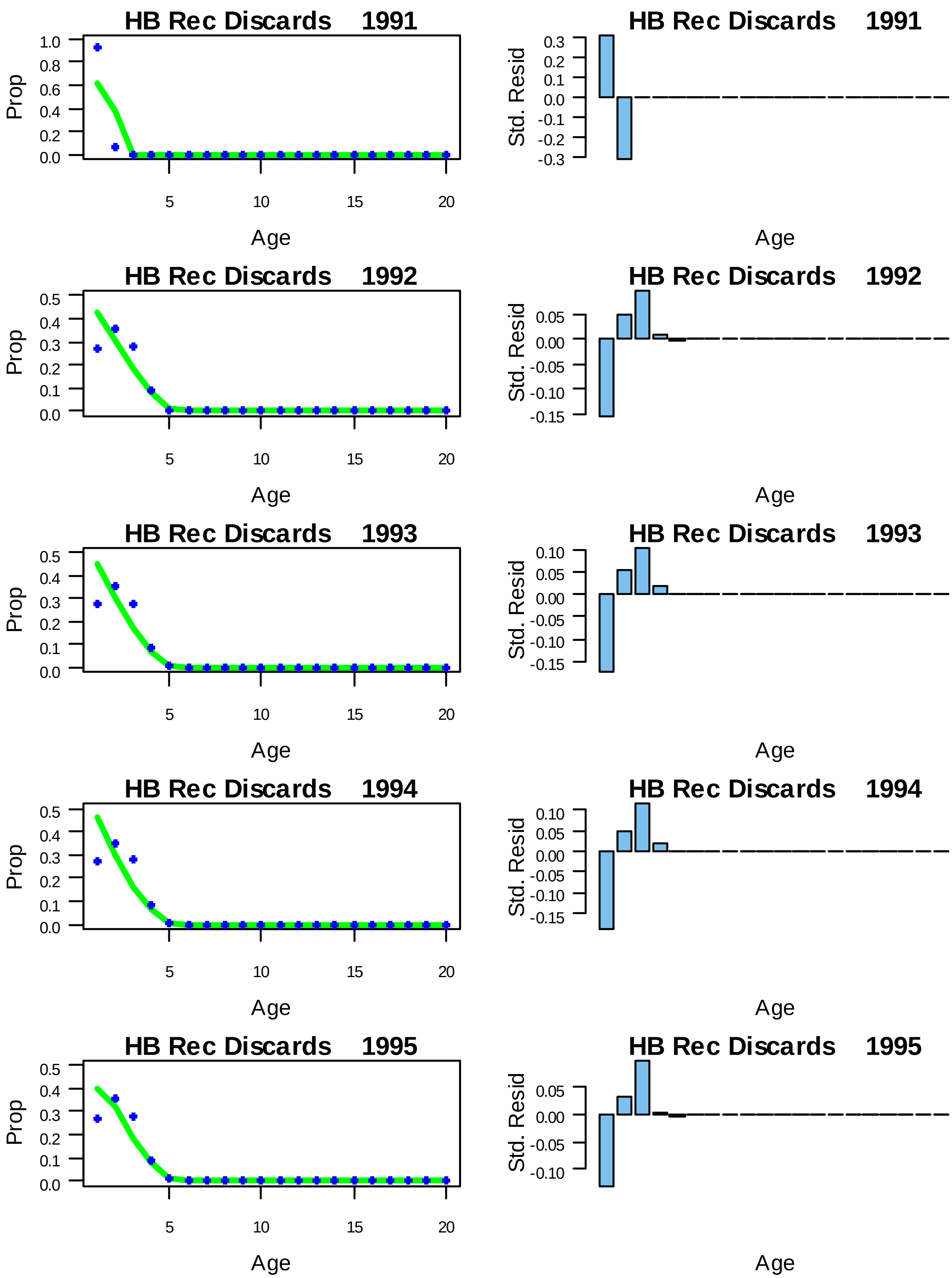


Figure AA-2 continued. ASAP2 model fits and standardized residuals of fleet discard age composition.

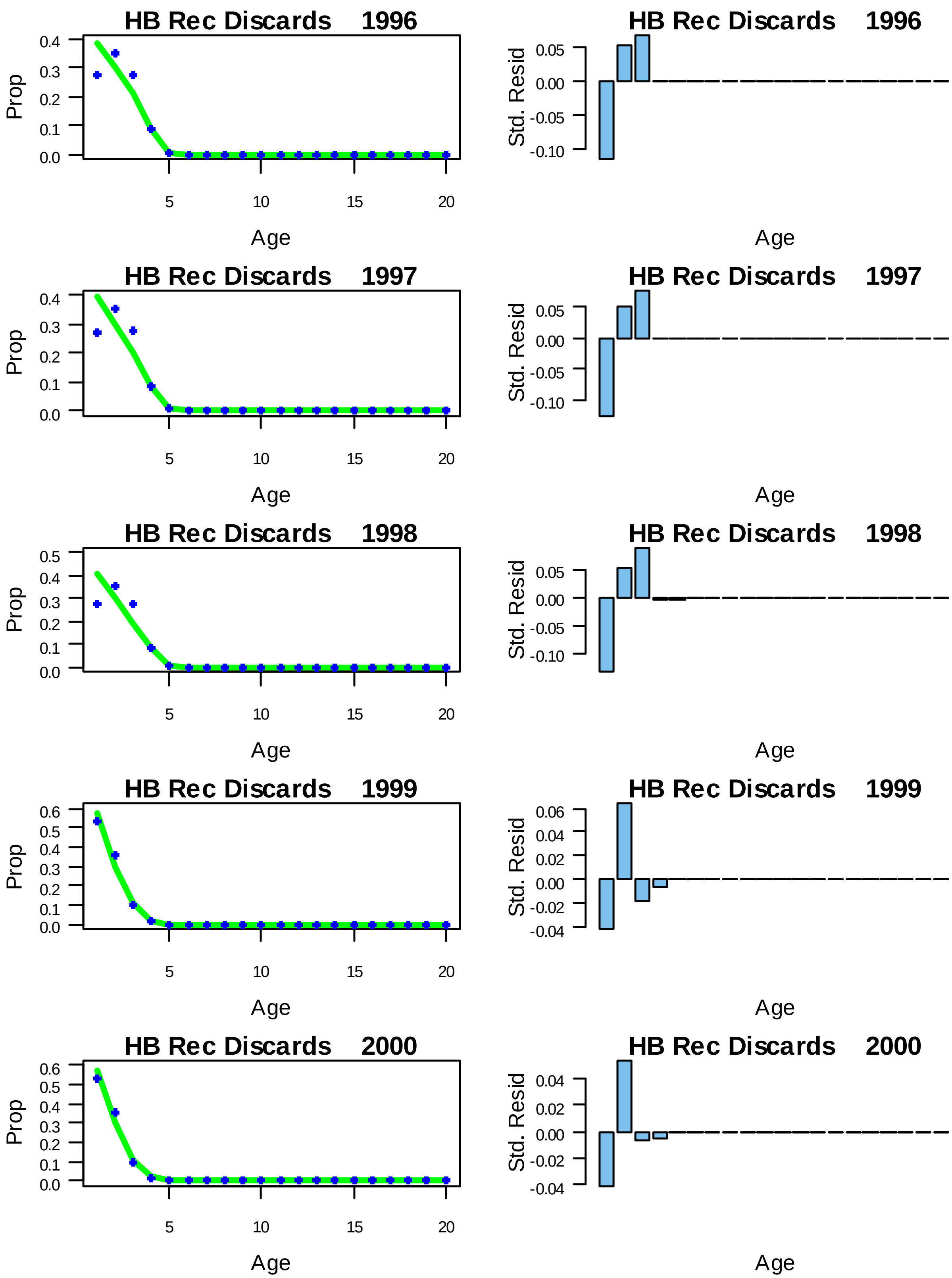


Figure AA-2 continued. ASAP2 model fits and standardized residuals of fleet discard age composition.

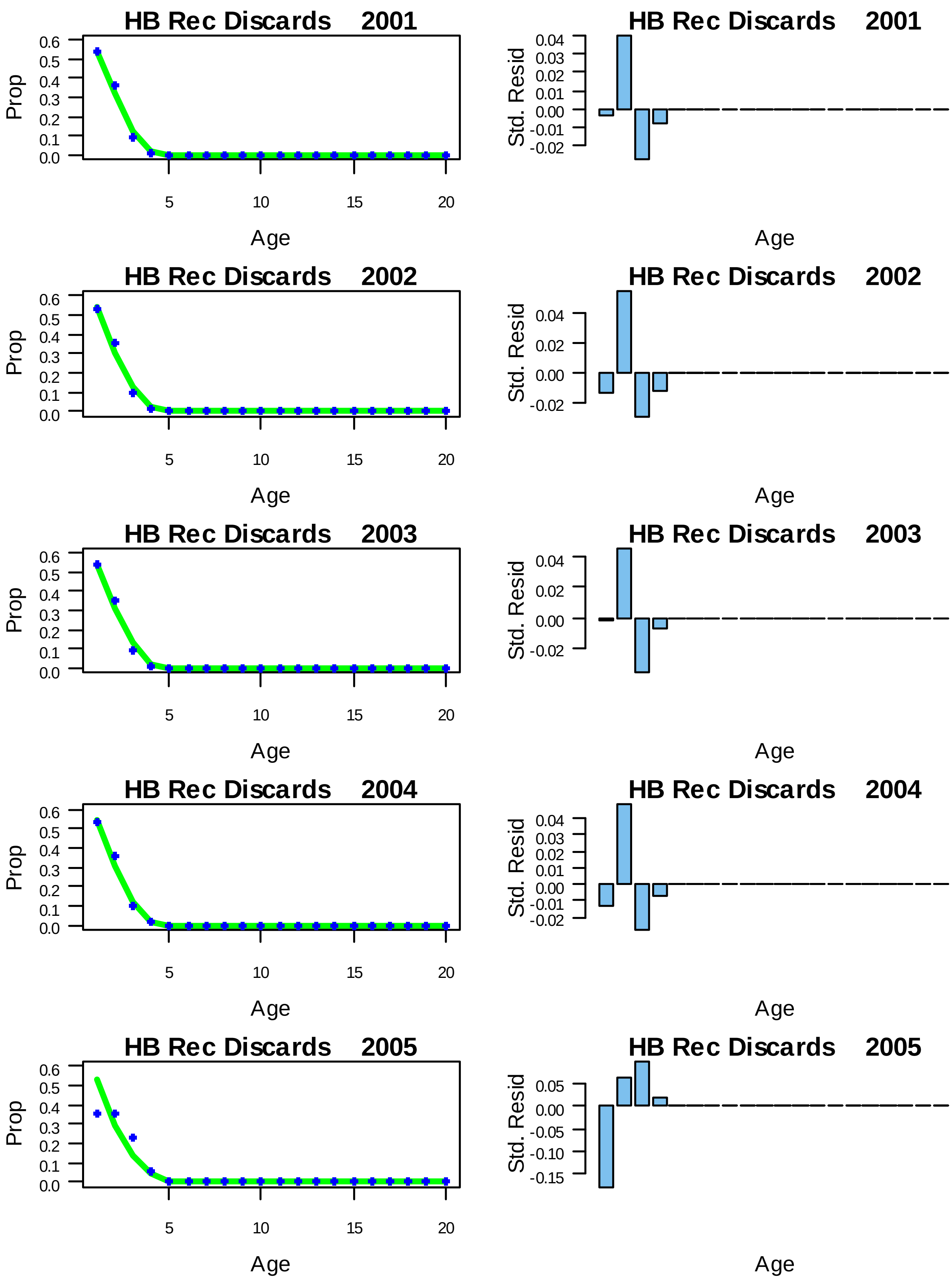


Figure AA-2 continued. ASAP2 model fits and standardized residuals of fleet discard age composition.

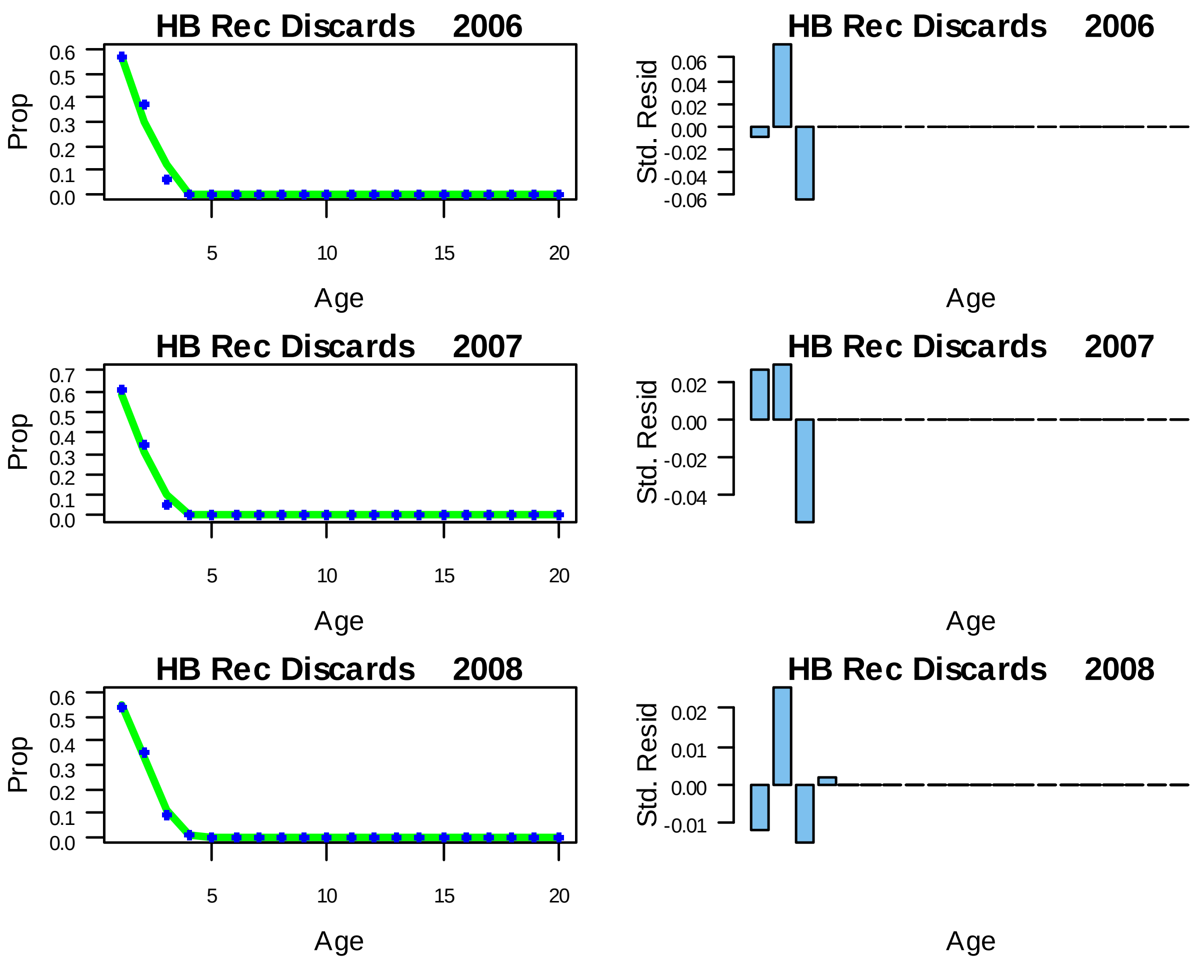


Figure AA-2 continued. ASAP2 model fits and standardized residuals of fleet discard age composition.

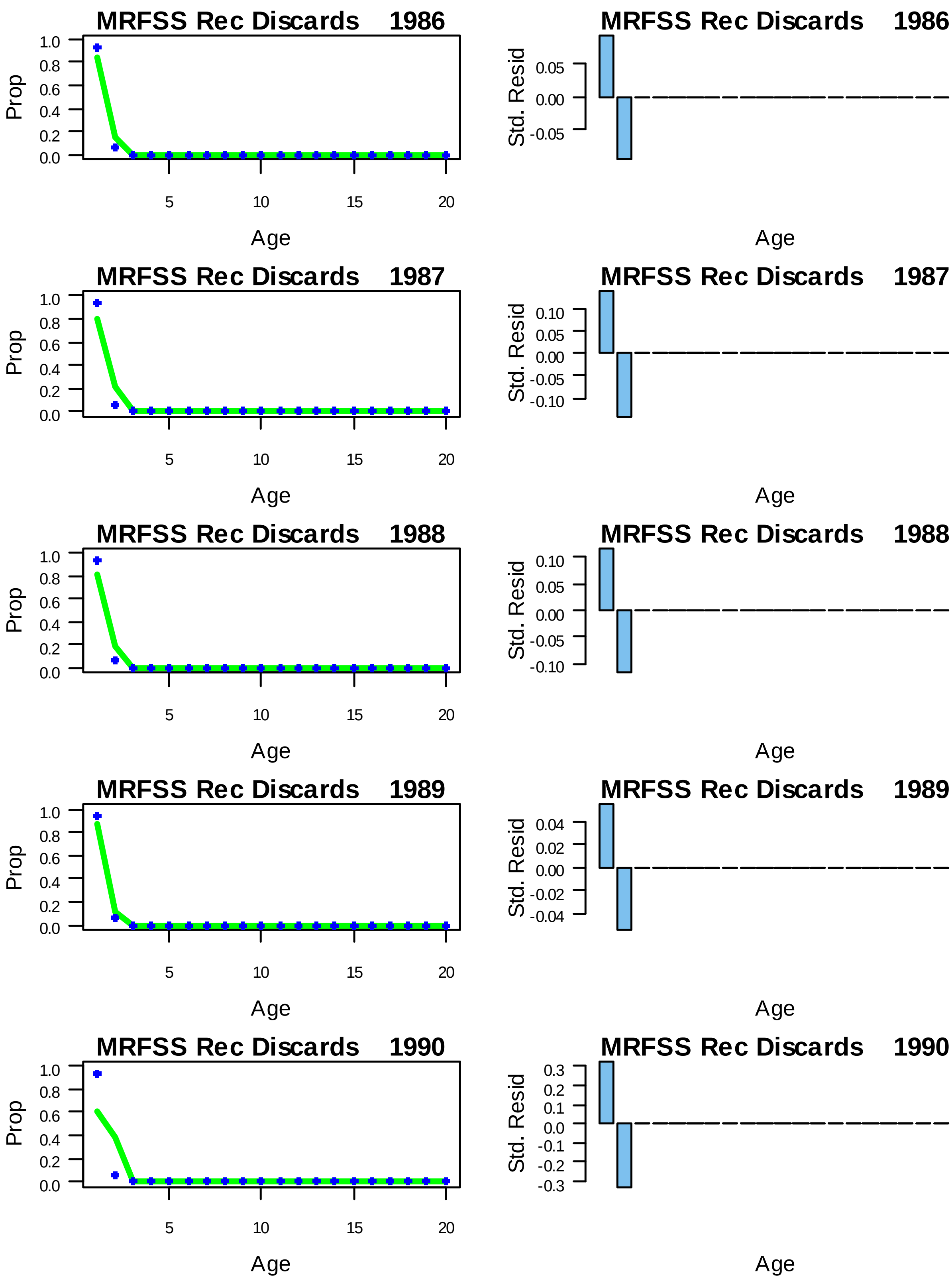


Figure AA-2 continued. ASAP2 model fits and standardized residuals of fleet discard age composition.

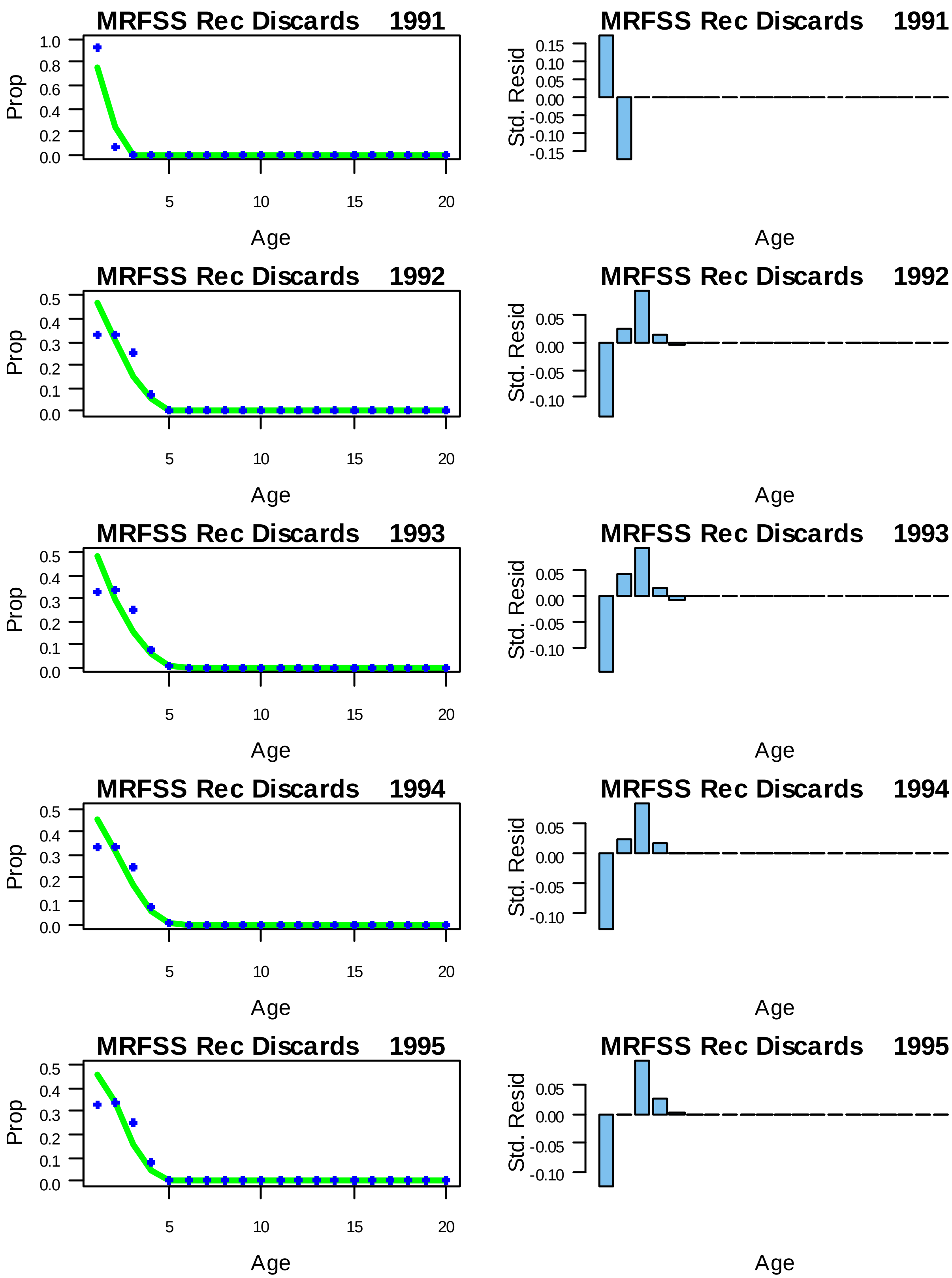


Figure AA-2 continued. ASAP2 model fits and standardized residuals of fleet discard age composition.

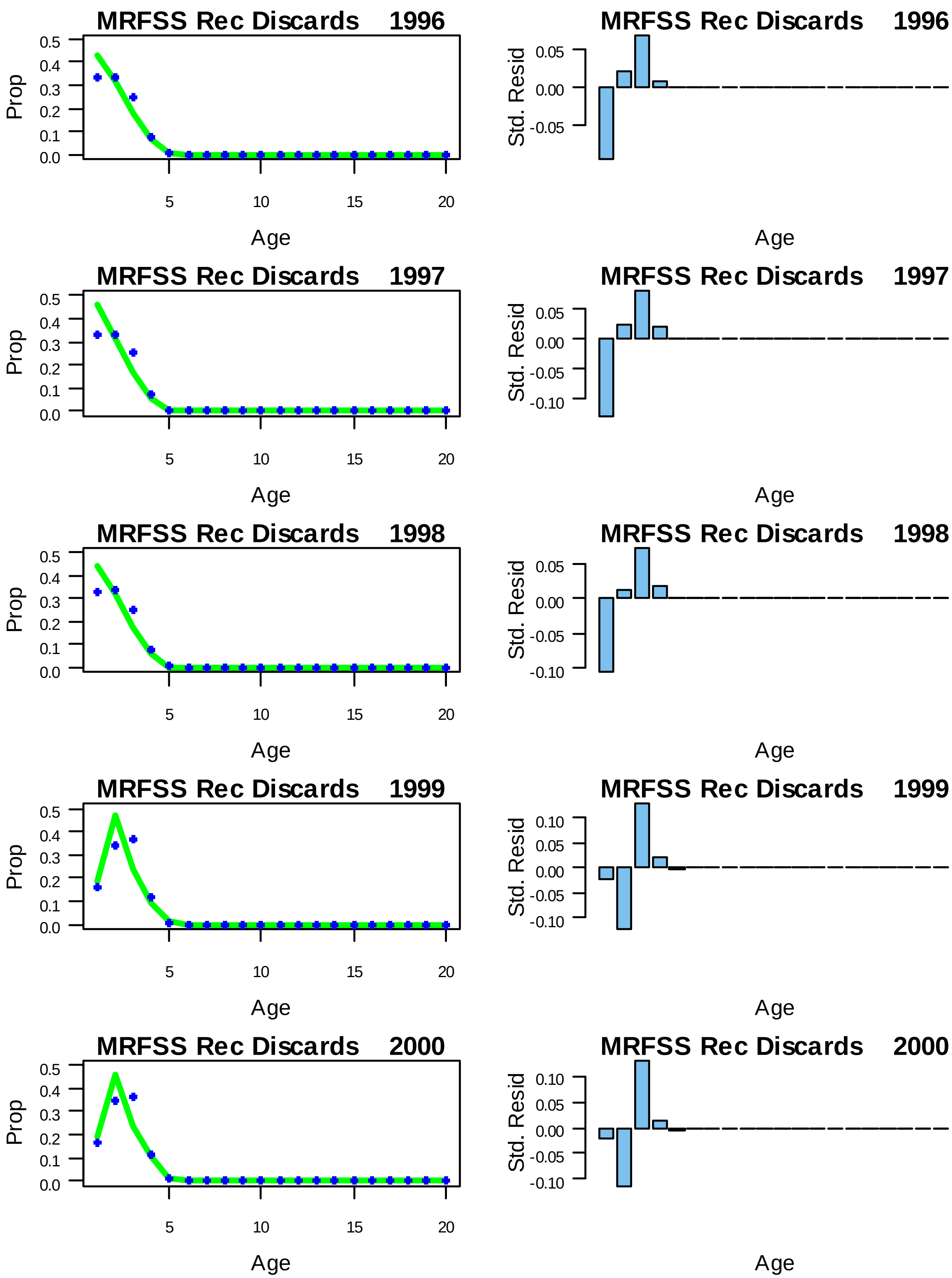


Figure AA-2 continued. ASAP2 model fits and standardized residuals of fleet discard age composition.

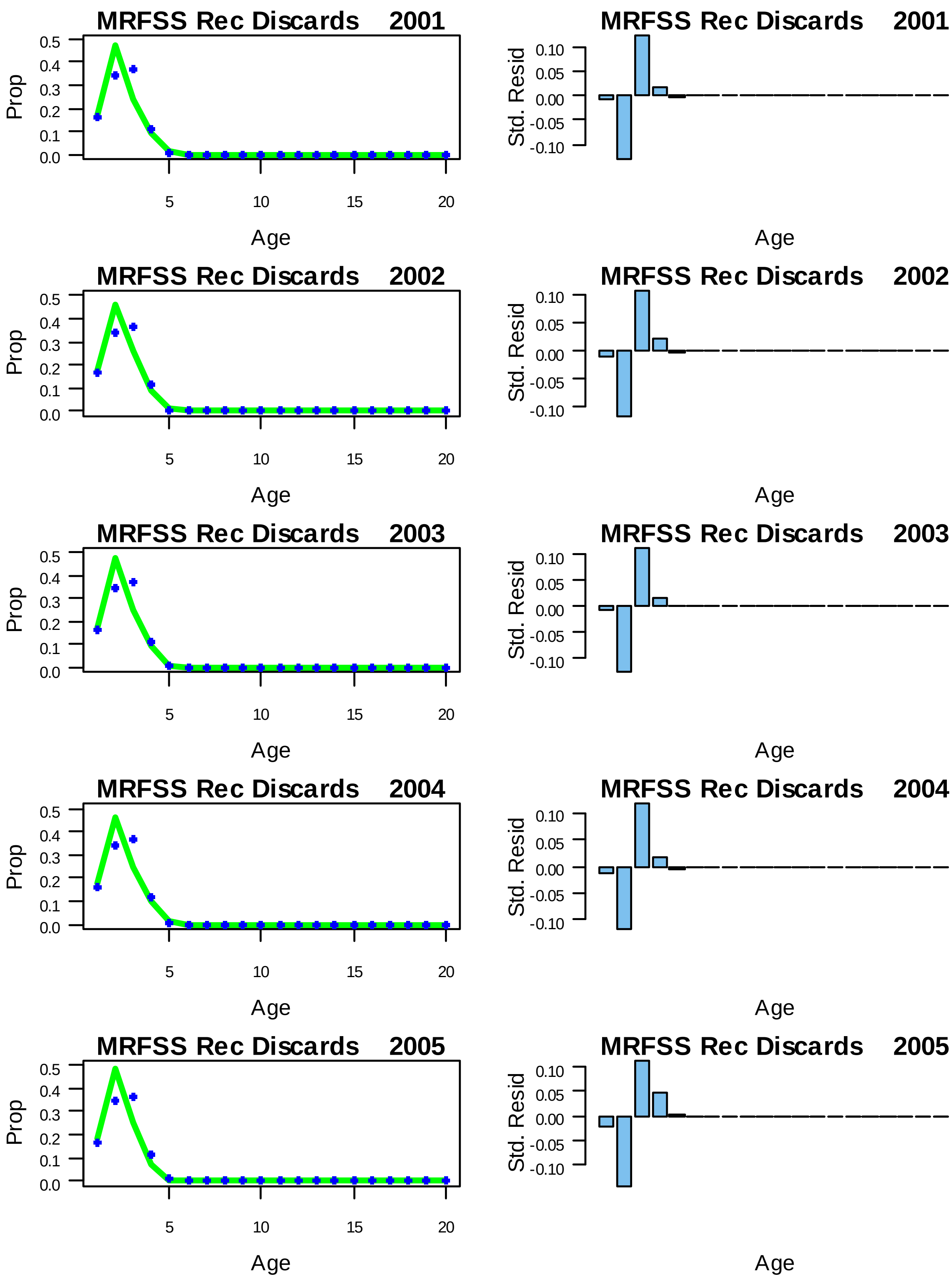


Figure AA-2 continued. ASAP2 model fits and standardized residuals of fleet discard age composition.

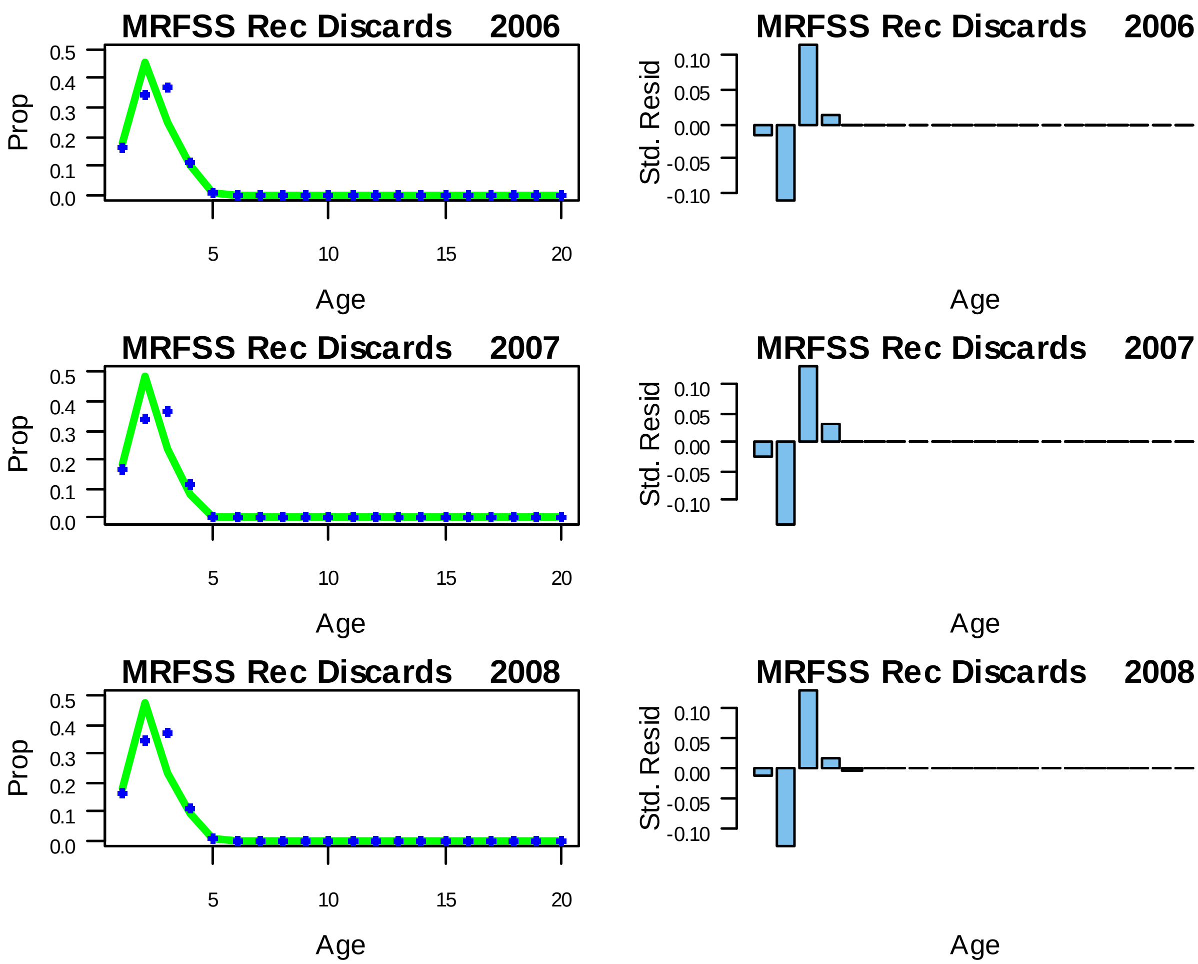


Figure AA-2 continued. ASAP2 model fits and standardized residuals of fleet discard age composition.

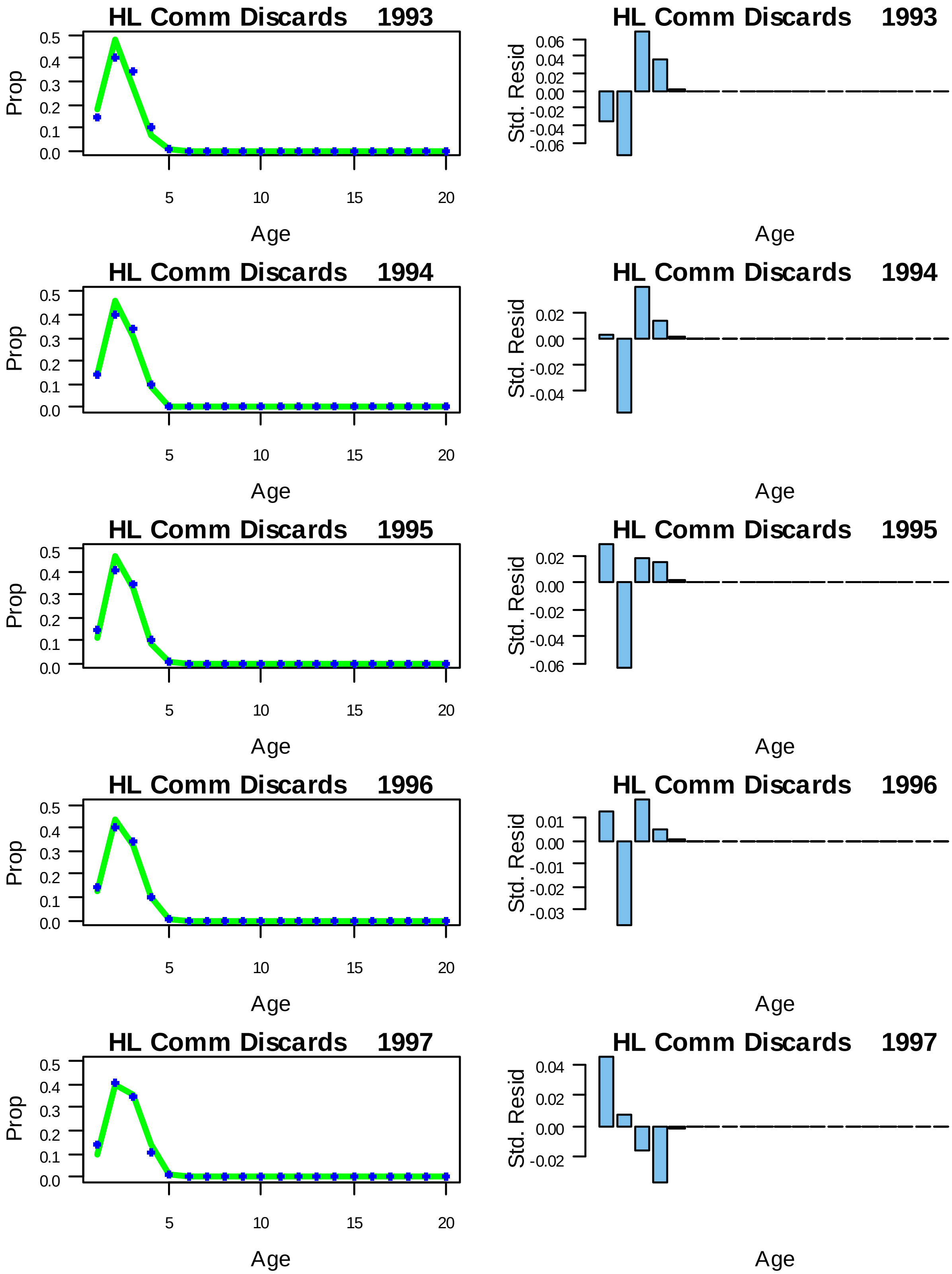


Figure AA-2 continued. ASAP2 model fits and standardized residuals of fleet discard age composition.

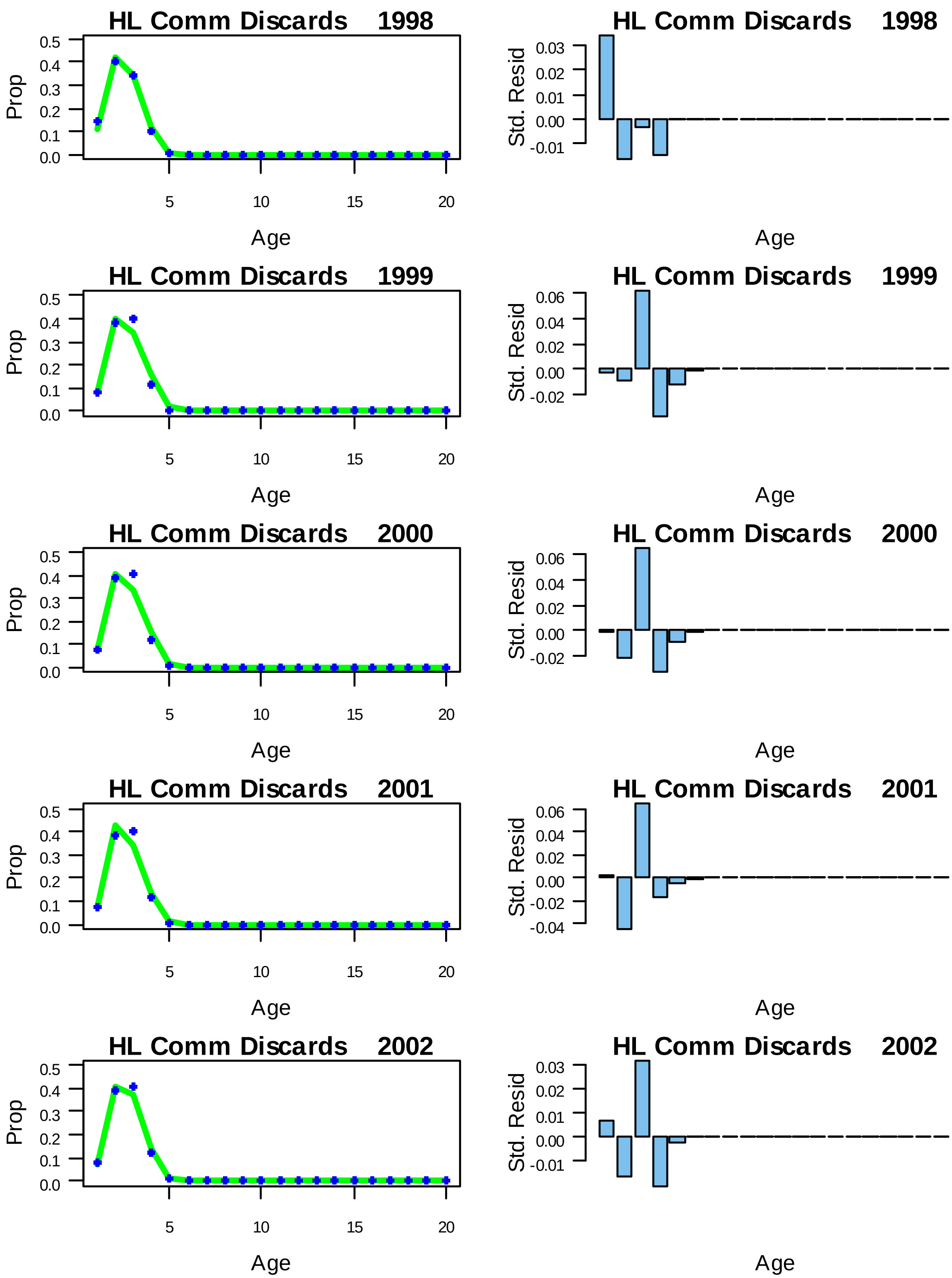


Figure AA-2 continued. ASAP2 model fits and standardized residuals of fleet discard age composition.

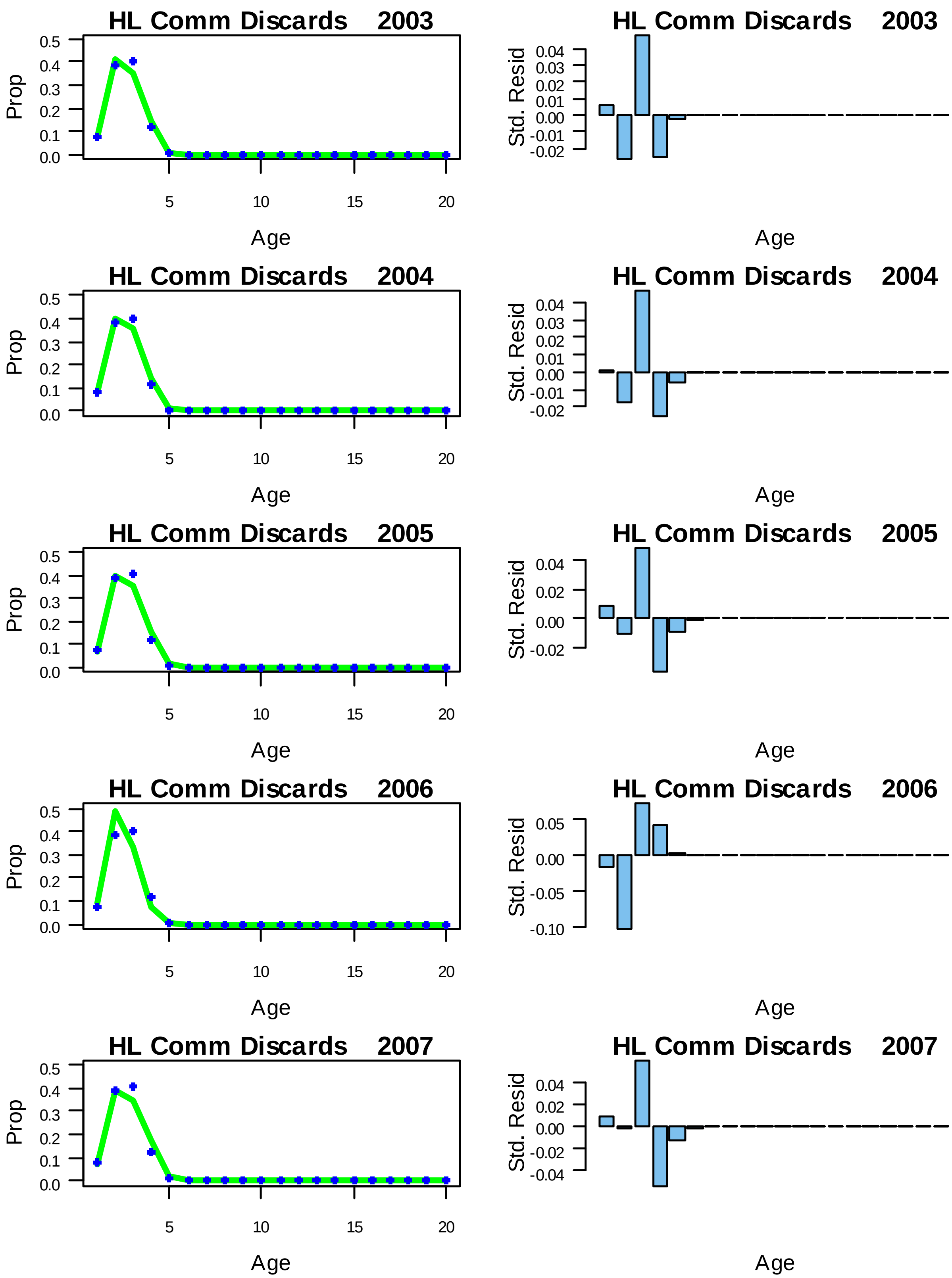
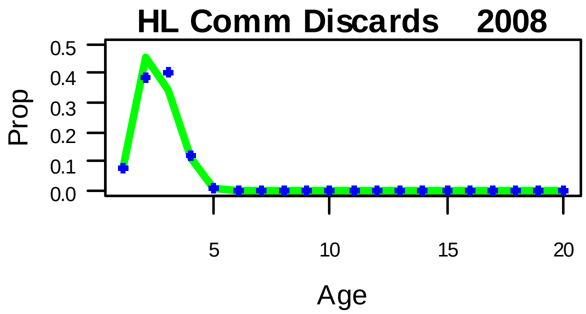


Figure AA-2 continued. ASAP2 model fits and standardized residuals of fleet discard age composition.



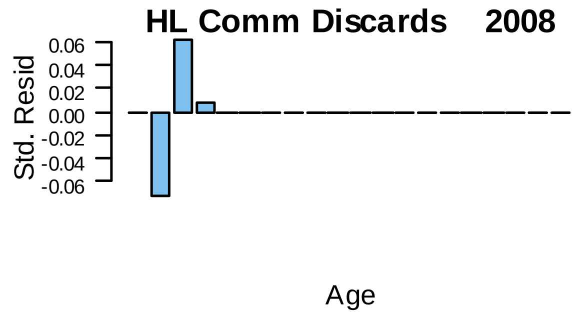


Figure AA-2 continued. ASAP2 model fits and standardized residuals of fleet discard age composition.

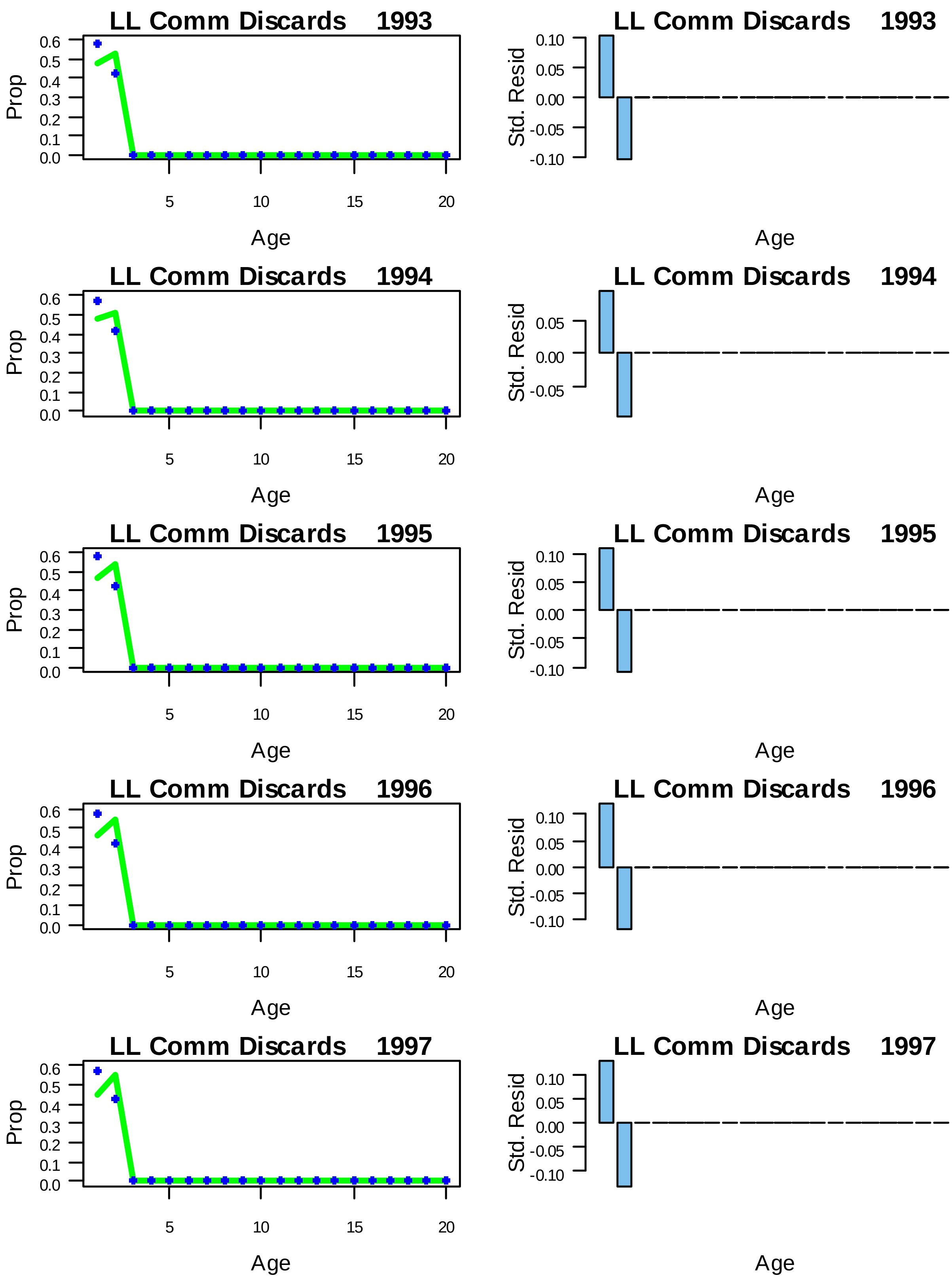


Figure AA-2 continued. ASAP2 model fits and standardized residuals of fleet discard age composition.

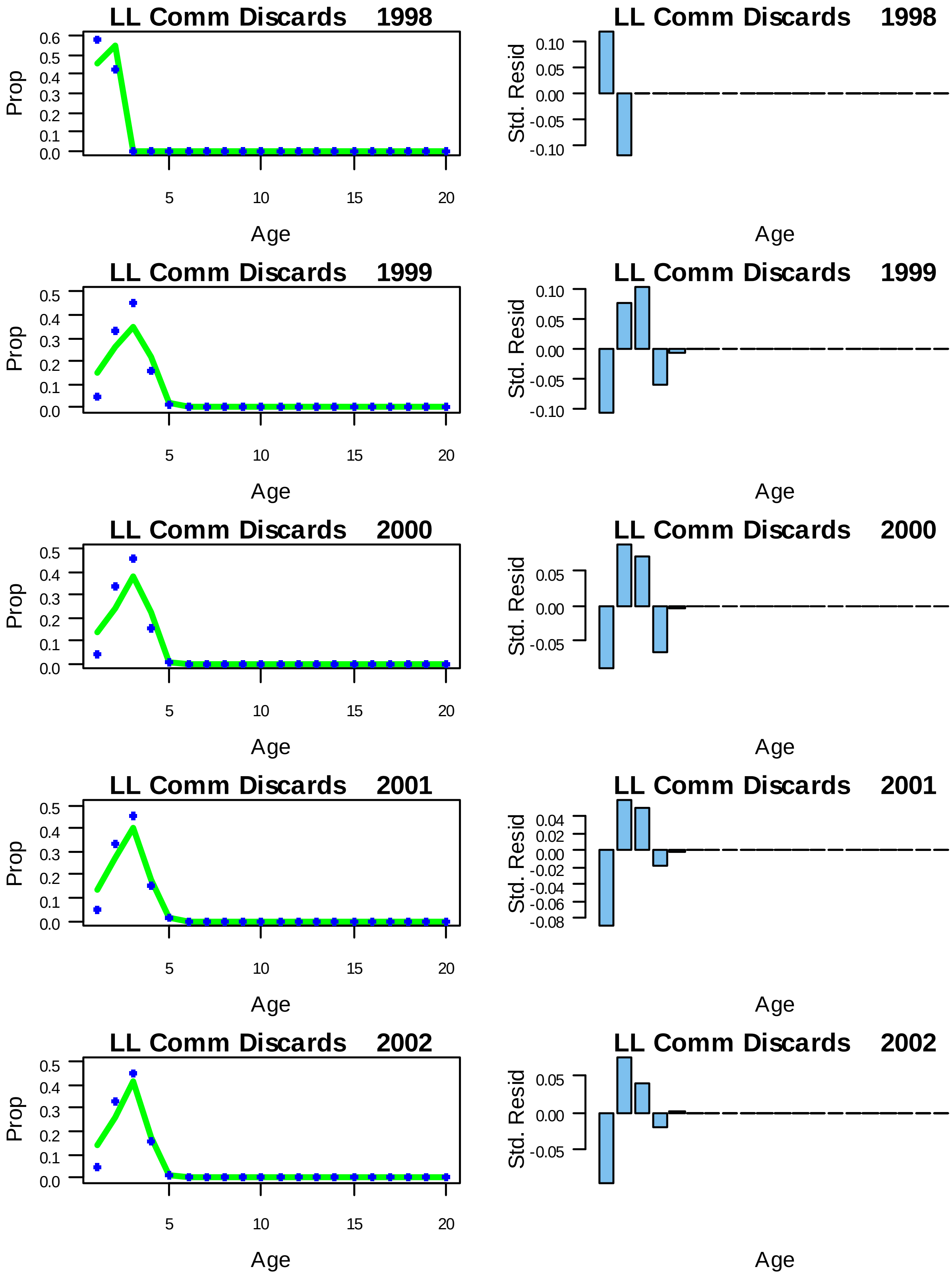


Figure AA-2 continued. ASAP2 model fits and standardized residuals of fleet discard age composition.

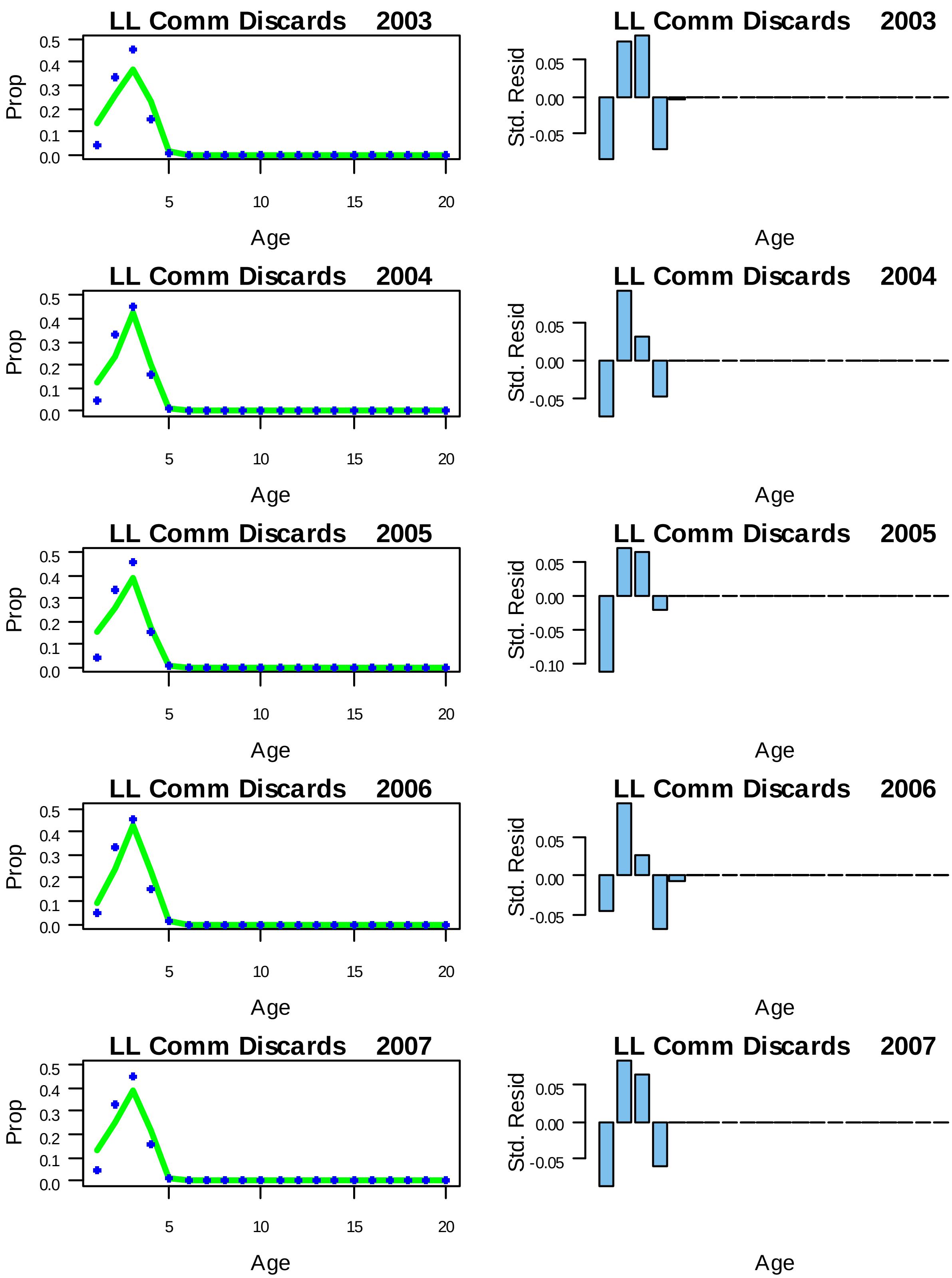


Figure AA-2 continued. ASAP2 model fits and standardized residuals of fleet discard age composition.

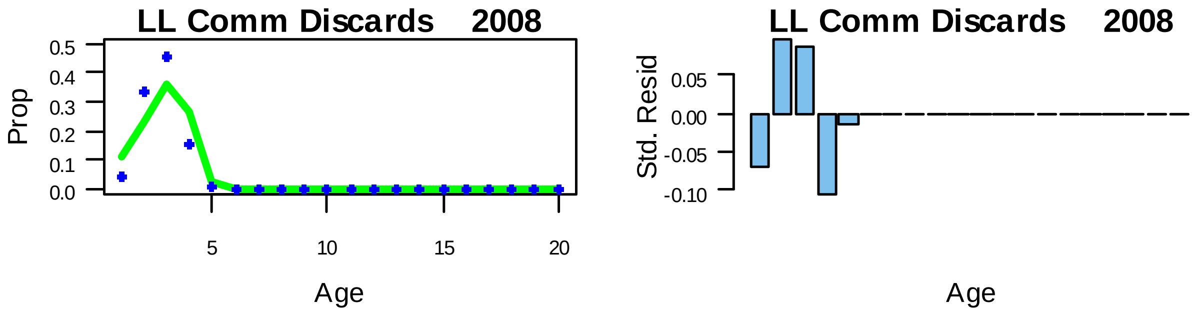


Figure AA-2 continued. ASAP2 model fits and standardized residuals of fleet discard age composition.

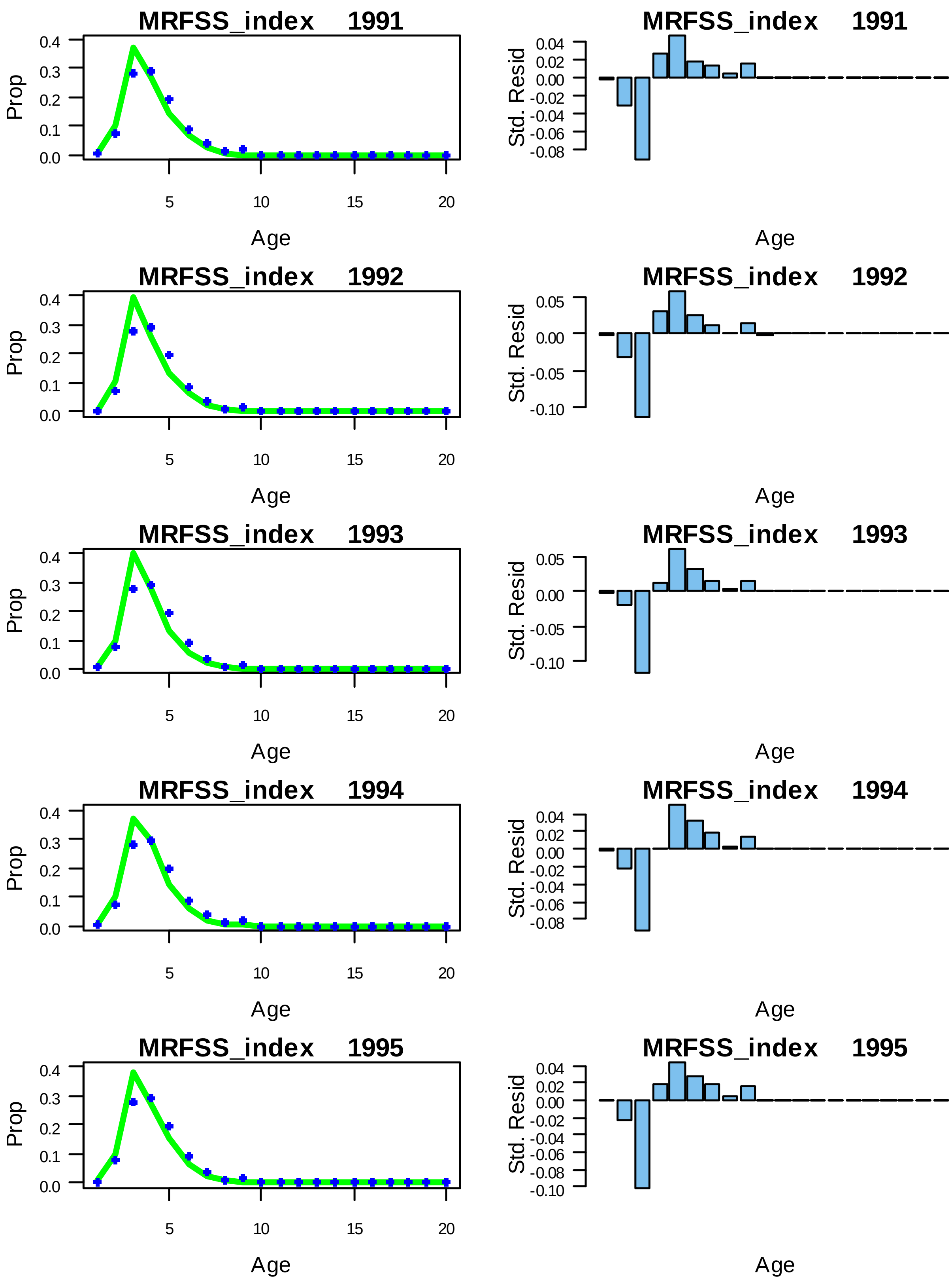
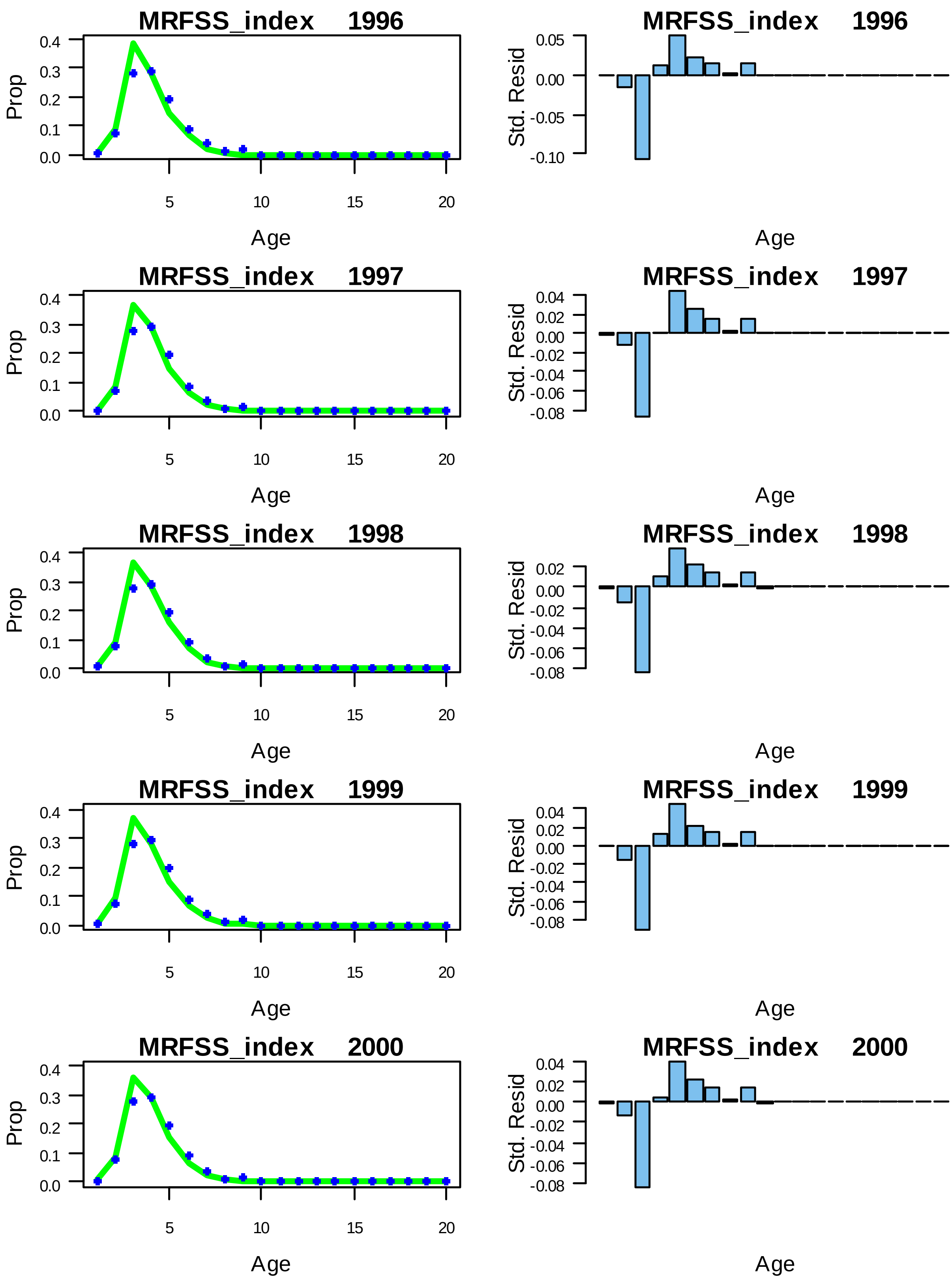


Figure AA-3. ASAP2 model fits and standardized residuals of MRFSS index age composition.



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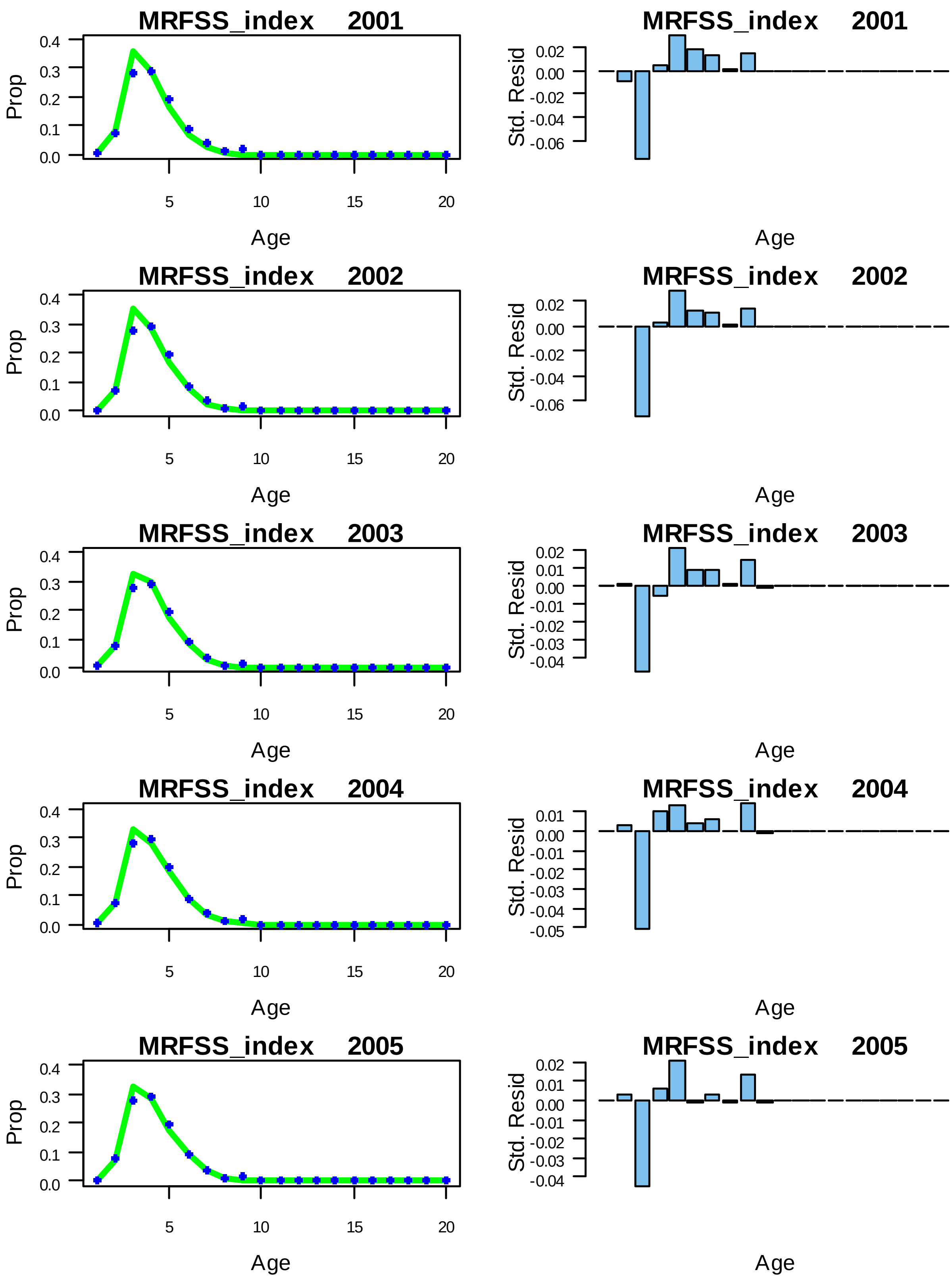

Figure AA-3 continued. ASAP2 model fits and standardized residuals of MRFSS index age composition.

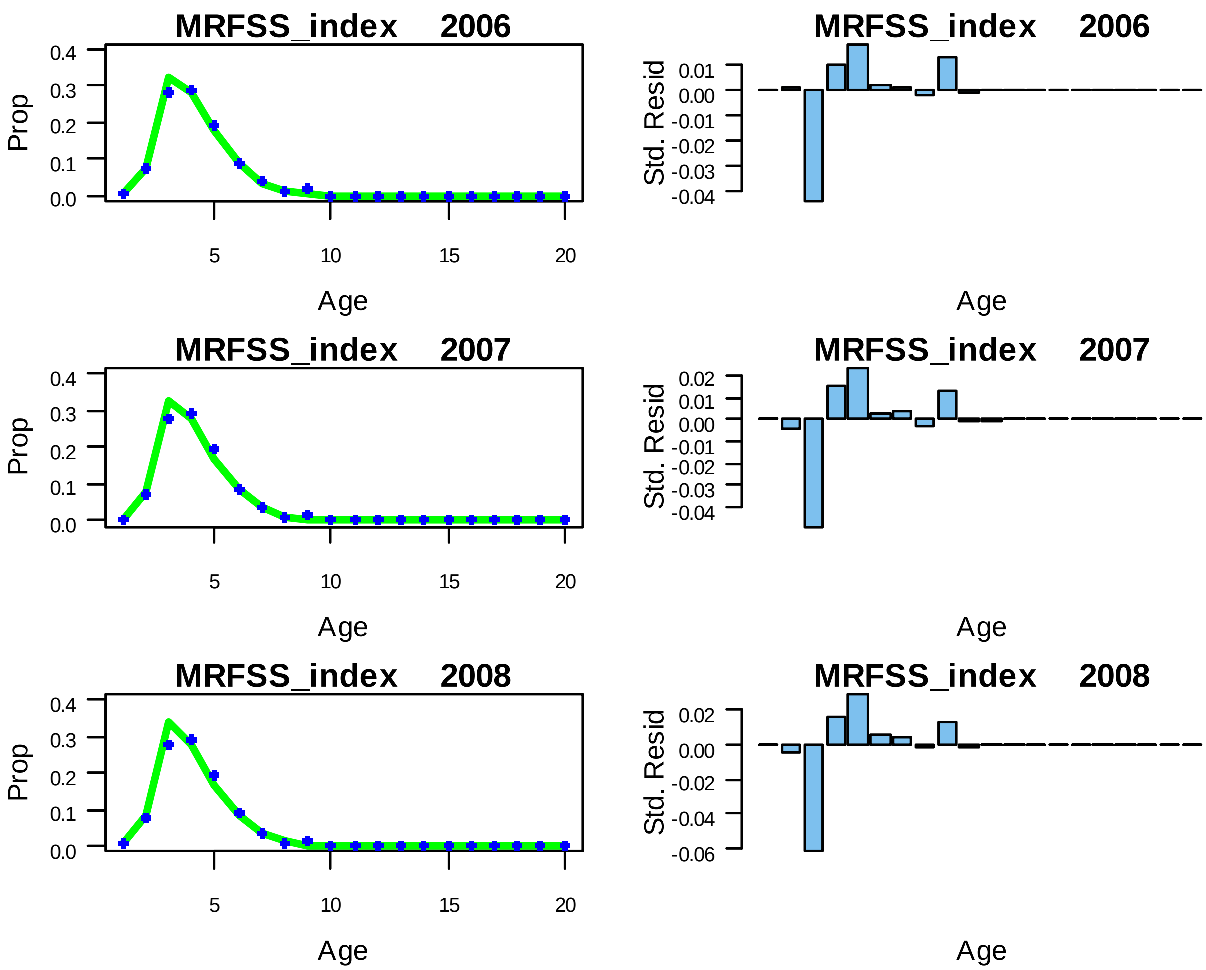

Figure AA-3 continued. ASAP2 model fits and standardized residuals of MRFSS index age composition.

SEDAR19-AW-Addendum Black Grouper Appendix B.

This appendix contains the input data file for the new base run, NEW_BASE2.DAT. The new base run was configured with the Lorenzen natural mortality curve with an average of 0.136 per year for ages 3-33, four fleets: headboat; general recreational, MRFSS; commercial hook-and-line which contains fish caught with spears and traps; and commercial longline; one fishery independent index of abundance: FWC Visual Survey age-1; initial steepness, 0.75 (CV=0.1); and release mortality rates of 0.20 for hook-and-line fleets and 0.30 for the long-line fleet, and constant catchability for the fishery-dependent indices.

```
# ASAP VERSION 2.0
# Black grouper 2009  LL logistic  adjusted effective sample sizes FD constant q  new base run
#
# ASAP GUI - 15 JAN 2008
#
# Number of Years
23
# First Year
1986
# Number of Ages
20
# Number of Fleets
4
# Number of Selectivity Blocks (sum over all fleets)
11
# Number of Available Indices
8
# Fleet Names
#$Headboat
#$MRFSS
#$HL
#$LL
# Index Names
#$FWC VS
#$RVC
#$HB
#$MRFSS
#$Logbook HL
#$Logbook LL
#$FWC VS Age 1
#$RVC Age 1
```

#

Natural Mortality Rate Matrix

0.396 0.297 0.244 0.212 0.190 0.174 0.163 0.154 0.147 0.141 0.137 0.133 0.130 0.128 0.126 0.124 0.123 0.121 0.120 0.116

0.396 0.297 0.244 0.212 0.190 0.174 0.163 0.154 0.147 0.141 0.137 0.133 0.130 0.128 0.126 0.124 0.123 0.121 0.120 0.116

0.396 0.297 0.244 0.212 0.190 0.174 0.163 0.154 0.147 0.141 0.137 0.133 0.130 0.128 0.126 0.124 0.123 0.121 0.120 0.116

0.396 0.297 0.244 0.212 0.190 0.174 0.163 0.154 0.147 0.141 0.137 0.133 0.130 0.128 0.126 0.124 0.123 0.121 0.120 0.116

0.396 0.297 0.244 0.212 0.190 0.174 0.163 0.154 0.147 0.141 0.137 0.133 0.130 0.128 0.126 0.124 0.123 0.121 0.120 0.116

0.396 0.297 0.244 0.212 0.190 0.174 0.163 0.154 0.147 0.141 0.137 0.133 0.130 0.128 0.126 0.124 0.123 0.121 0.120 0.116

0.396 0.297 0.244 0.212 0.190 0.174 0.163 0.154 0.147 0.141 0.137 0.133 0.130 0.128 0.126 0.124 0.123 0.121 0.120 0.116

0.396 0.297 0.244 0.212 0.190 0.174 0.163 0.154 0.147 0.141 0.137 0.133 0.130 0.128 0.126 0.124 0.123 0.121 0.120 0.116

0.396 0.297 0.244 0.212 0.190 0.174 0.163 0.154 0.147 0.141 0.137 0.133 0.130 0.128 0.126 0.124 0.123 0.121 0.120 0.116

0.396 0.297 0.244 0.212 0.190 0.174 0.163 0.154 0.147 0.141 0.137 0.133 0.130 0.128 0.126 0.124 0.123 0.121 0.120 0.116

0.396 0.297 0.244 0.212 0.190 0.174 0.163 0.154 0.147 0.141 0.137 0.133 0.130 0.128 0.126 0.124 0.123 0.121 0.120 0.116

0.396 0.297 0.244 0.212 0.190 0.174 0.163 0.154 0.147 0.141 0.137 0.133 0.130 0.128 0.126 0.124 0.123 0.121 0.120 0.116

0.396 0.297 0.244 0.212 0.190 0.174 0.163 0.154 0.147 0.141 0.137 0.133 0.130 0.128 0.126 0.124 0.123 0.121 0.120 0.116

0.396 0.297 0.244 0.212 0.190 0.174 0.163 0.154 0.147 0.141 0.137 0.133 0.130 0.128 0.126 0.124 0.123 0.121 0.120 0.116

0.396 0.297 0.244 0.212 0.190 0.174 0.163 0.154 0.147 0.141 0.137 0.133 0.130 0.128 0.126 0.124 0.123 0.121 0.120 0.116

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0.396 0.297 0.244 0.212 0.190 0.174 0.163 0.154 0.147 0.141 0.137 0.133 0.130 0.128 0.126 0.124 0.123 0.121 0.120 0.116

0.396 0.297 0.244 0.212 0.190 0.174 0.163 0.154 0.147 0.141 0.137 0.133 0.130 0.128 0.126 0.124 0.123 0.121 0.120 0.116

Fecundity Option

0

Fraction of year that elapses prior to SSB calculation (0=Jan-1)

0.202600958

Maturity Matrix

0.000 0.001 0.003 0.015 0.076 0.308 0.705 0.928 0.986 0.997 0.999 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000

0.000 0.001 0.003 0.015 0.076 0.308 0.705 0.928 0.986 0.997 0.999 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000

0.000 0.001 0.003 0.015 0.076 0.308 0.705 0.928 0.986 0.997 0.999 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000

0.000 0.001 0.003 0.015 0.076 0.308 0.705 0.928 0.986 0.997 0.999 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000

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0.000 0.001 0.003 0.015 0.076 0.308 0.705 0.928 0.986 0.997 0.999 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000

0.000 0.001 0.003 0.015 0.076 0.308 0.705 0.928 0.986 0.997 0.999 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000

0.000 0.001 0.003 0.015 0.076 0.308 0.705 0.928 0.986 0.997 0.999 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000

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Weight at Age for Catch Matrix

1.658 4.102 7.607 11.957 16.896 22.176 27.582 32.944 38.134 43.062 47.672 51.932 55.828 59.362 62.547 65.399 67.942 70.200 72.198 80.224

1.658 4.102 7.607 11.957 16.896 22.176 27.582 32.944 38.134 43.062 47.672 51.932 55.828 59.362 62.547 65.399 67.942 70.200 72.198 80.224

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80.224

Weight at Age for Spawning Stock Biomass Matrix

1.182 3.292 6.504 10.631 15.422 20.623 26.009 31.397 36.646 41.657 46.363 50.726 54.728 58.367 61.652 64.599 67.230 69.568 71.640
79.978

1.182 3.292 6.504 10.631 15.422 20.623 26.009 31.397 36.646 41.657 46.363 50.726 54.728 58.367 61.652 64.599 67.230 69.568 71.640
79.978

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Weight at Age for Jan-1 Biomass Matrix

0.895 2.772 5.772 9.733 14.411 19.548 24.913 30.312 35.599 40.664 45.436 49.871 53.947 57.659 61.014 64.028 66.721 69.117 71.240 79.802

0.895 2.772 5.772 9.733 14.411 19.548 24.913 30.312 35.599 40.664 45.436 49.871 53.947 57.659 61.014 64.028 66.721 69.117 71.240 79.802

0.895 2.772 5.772 9.733 14.411 19.548 24.913 30.312 35.599 40.664 45.436 49.871 53.947 57.659 61.014 64.028 66.721 69.117 71.240 79.802

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0.895 2.772 5.772 9.733 14.411 19.548 24.913 30.312 35.599 40.664 45.436 49.871 53.947 57.659 61.014 64.028 66.721 69.117 71.240 79.802

Selectivity Blocks (fleet outer loop, year inner loop)

Sel block for fleet 1

1

1
1
1
1
1
2
2
2
2
2
2
2
3
3
3
3
3
3
3
3
3
3
Sel block for fleet 2
4
4
4
4
4
4
5
5
5

5
5
5
5
6
6
6
6
6
6
6
6
6
6
Sel block for fleet 3
7
7
7
7
7
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8
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9
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Sel block for fleet 4

10

10

10

10

10

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10

11

11

11

11

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11

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11

11

11

Selectivity Options for each block 1=by age, 2=logisitic, 3=double logistic

3 3 3 3 3 3 3 3 3 2 2

Selectivity initial guess, phase, lambda, and CV

(have to enter values for nages + 6 parameters for each block)

Sel Block 1

1	4	1	5
0.1375	4	1	5
0.0725	4	1	5
0.0898	4	1	5
0.0904	4	1	5
0.076	4	1	5
0.056	4	1	5
0.0379	4	1	5
0.0247	4	1	5
0.0177	4	1	5
0.0135	4	1	5
0.01	-4	0	5
0.01	-4	0	5
0.01	-4	0	5
0.01	-4	0	5
0.01	-4	0	5
0.01	-4	0	5
0.01	-4	0	5
0.01	-4	0	5
0.01	-4	0	5
3.0754	4	1	0.2758
1.1358	4	1	0.7826
2.0074	4	1	0.1623
0.6199	4	1	0.5204
6.4724	4	1	0.0753
1.6111	4	1	0.3377

Sel Block 2

1	4	1	0.25
0.6534	4	1	0.25

0.2908 4 1 0.25

0.2022 4 1 0.25

0.1607 4 1 0.25

0.1248 4 1 0.25

0.073 4 1 0.25

0.011 4 1 0.25

0.0119 4 1 0.25

0 4 1 0.25

0 4 1 0.25

0 4 1 0.25

0 4 1 0.25

0 4 1 0.25

0 4 1 0.25

0 4 1 0.25

0 4 1 0.25

0 4 1 0.25

0 4 1 0.25

0 4 1 0.25

2.5838 4 1 0.0943

0.7727 4 1 0.2917

1.0392 4 1 0.0804

2.6993 4 1 0.3629

4.1657 4 1 0.026

1.7151 4 1 0.1732

Sel Block 3

1 4 1 5

0.9925 4 1 5

0.5103 4 1 5

0.275 4 1 5

0.1979 4 1 5

0.1606 4 1 5

0.1206 4 1 5

0.0835	4	1	5
0.0609	4	1	5
0.0458	4	1	5
0.0405	4	1	5
0.0283	4	1	5
0.025	-4	0	1
0.025	-4	0	1
0.025	-4	0	1
0.025	-4	0	1
0.025	-4	0	1
0.025	-4	0	1
0.025	-4	0	1
0.025	-4	0	1
2.773	4	1	0.3608
1.6822	4	1	0.7991
0.9834	4	1	0.0184
0.0516	4	1	10
2.7547	4	1	0.1844
0.1488	4	1	2.0524

Sel Block 4

1	4	1	5
0.2966	4	1	5
0.2845	4	1	5
0.2028	4	1	5
0.1544	4	1	5
0.1175	4	1	5
0.1056	4	1	5
0.101	4	1	5
0.096	4	1	5
0.0748	4	1	5
0.0689	4	1	5
0.0528	4	1	5

0.0395	4	1	5
0.03	-4	0	5
0.03	-4	0	5
0.03	-4	0	5
0.03	-4	0	5
0.03	-4	0	5
0.03	-4	0	5
0.03	-4	0	5
2.9383	4	1	0.6337
2.6439	4	1	1.3838
0.9674	4	1	0.0923
0.0333	4	1	10
4.9297	4	1	0.5787
6.0583	4	1	1.1686

Sel Block 5

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

0	0	0	0
0	0	0	0
0	0	0	0
5.891	4	1	0.8913
5.2309	4	1	1.9282
1.0586	4	1	0.09
1.872	4	1	0.2351
4.5109	4	1	0.022
1.4026	4	1	0.133
# Sel Block 6			
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
3.886	4	1	0.6387
4.0755	4	1	1.4733

1.0329	4	1	0.0104
21.8469	4	1	5
3.4295	4	1	0.0301
1.4191	4	1	0.1333

Sel Block 7

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
1.5451	4	1	0.3062
0.3589	4	1	0.9356
1.8764	4	1	0.0366
0.261	4	1	0.3812
6.3243	4	1	0.0223
1.3617	4	1	0.0956

Sel Block 8

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
1.5451	4	1	0.3062
0.3589	4	1	0.9356
1.7697	4	1	0.0588
0.3244	4	1	0.2922
6.7031	4	1	0.0331
1.8691	4	1	0.1143

Sel Block 9

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
1.0521	4	1	10
0.0809	4	1	10
1.6574	4	1	0.1251
0.2665	4	1	0.4859
5.0352	4	1	0.075
1.7608	4	1	0.2215

Sel Block 10

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
5.2998	4	1	0.062
0.9234	4	1	0.3134
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

Sel Block 11

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

0 0 0 0

0 0 0 0

0 0 0 0

0 0 0 0

0 0 0 0

5.6417 4 1 1.1584

19.4775 4 1 0.9714

0 0 0 0

0 0 0 0

0 0 0 0

0 0 0 0

Selectivity Start Age by fleet

1 1 1 1

Selectivity End Age by fleet

20 20 20 20

Age range for average F

5 5

Average F report option (1=unweighted, 2=Nweighted, 3=Bweighted)

2

Use likelihood constants? (1=yes)

1

Release Mortality by fleet

0.2 0.2 0.2 0.3

Fleet 1 Catch at Age - Last Column is Total Weight

0.0735 0.1935 0.2061 0.138 0.1165 0.1093 0.0771 0.0484 0.0233 0.0108 0.0036 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 19976.0

0.0285 0.1068 0.2064 0.1922 0.1423 0.1032 0.0819 0.0641 0.0391 0.0214 0.0107 0.0036 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 39603.0

0.100 0.1389 0.1833 0.1611 0.1333 0.100 0.0556 0.0278 0.0222 0.0222 0.0222 0.0167 0.0111 0.0056 0.000 0.000 0.000 0.000 0.000 0.000 24288.0

0.026 0.2007 0.1933 0.1599 0.1375 0.1078 0.0743 0.0483 0.026 0.0149 0.0074 0.0037 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 19806.0

0.004 0.1205 0.1928 0.253 0.2249 0.1165 0.0402 0.008 0.004 0.004 0.008 0.008 0.008 0.004 0.004 0.000 0.000 0.000 0.000 0.000 17764.0

0.000 0.0101 0.1515 0.3535 0.2828 0.1313 0.0606 0.0101 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 15378.0

0.0636 0.2273 0.200 0.1364 0.1636 0.100 0.0545 0.0273 0.0182 0.0091 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 20965.0

0.000 0.0663 0.2652 0.232 0.1713 0.1215 0.0608 0.0221 0.0055 0.0055 0.0055 0.0055 0.0055 0.0055 0.0055
0.0055 0.0055 0.0055 0.0055 0.000 25129.0

0.000 0.0766 0.2727 0.2919 0.1866 0.1005 0.0478 0.0191 0.0048 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 24053.0

0.1079 0.1942 0.3094 0.1727 0.1295 0.0647 0.0216 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 31760.0

0.000 0.050 0.1208 0.1542 0.1958 0.1917 0.1333 0.0792 0.0417 0.0208 0.0083 0.0042 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 36613.0

0.000 0.0269 0.1231 0.2269 0.250 0.1846 0.1115 0.050 0.0192 0.0077 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 48274.0

0.000 0.0535 0.1806 0.1773 0.1572 0.1538 0.1137 0.0736 0.0435 0.0234 0.0134 0.0067 0.0033 0.000 0.000
0.000 0.000 0.000 0.000 0.000 84984.0

0.000 0.0781 0.1719 0.1875 0.1641 0.1094 0.0703 0.0469 0.0313 0.0234 0.0234 0.0156 0.0156 0.0078 0.0078
0.0078 0.0078 0.0078 0.0078 0.0156 25267.0

0.000 0.0625 0.250 0.200 0.125 0.075 0.050 0.0375 0.025 0.025 0.025 0.0125 0.0125 0.0125 0.000 0.025
0.0125 0.0125 0.0125 0.025 15118.0

0.000 0.0707 0.1717 0.1818 0.1515 0.101 0.0707 0.0505 0.0404 0.0303 0.0202 0.0202 0.0202 0.0101 0.0101
0.0101 0.0101 0.0101 0.0101 0.0101 31013.0

0.000 0.033 0.1978 0.1648 0.1538 0.2088 0.1429 0.0659 0.022 0.011 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 15271.0

0.000 0.025 0.125 0.2375 0.2875 0.1875 0.100 0.025 0.0125 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 11940.0

0.000 0.0517 0.2069 0.2241 0.1897 0.1207 0.069 0.0517 0.0345 0.0172 0.0172 0.0172 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 18414.0

0.000 0.0141 0.1972 0.3239 0.169 0.0845 0.0704 0.0563 0.0423 0.0282 0.0141 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 25733.0

0.000 0.0102 0.0816 0.2041 0.2449 0.1939 0.1122 0.051 0.0306 0.0204 0.0204 0.0102 0.0102 0.0102 0.000
0.000 0.000 0.000 0.000 0.000 17862.0

0.0459 0.055 0.1376 0.2385 0.2202 0.1376 0.0826 0.0459 0.0183 0.0092 0.0092 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 17828.0

0.000 0.000 0.2632 0.4211 0.2632 0.0526 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 3930.0

Fleet 2 Catch at Age - Last Column is Total Weight

0.2907 0.1802 0.1337 0.0988 0.0581 0.0523 0.064 0.064 0.0349 0.0174 0.0058 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 447266.5

0.100 0.3524 0.3143 0.0905 0.0286 0.0286 0.0238 0.0143 0.0143 0.0095 0.0095 0.0095 0.0048 0.000 0.000
0.000 0.000 0.000 0.000 0.000 382020.6

0.1837 0.1224 0.3265 0.1633 0.0204 0.000 0.000 0.0204 0.0408 0.0408 0.0408 0.0204 0.0204 0.000 0.000 0.000
0.000 0.000 0.000 0.000 188198.1

0.0143 0.2143 0.0571 0.100 0.200 0.1429 0.0857 0.0429 0.0429 0.0286 0.0286 0.0286 0.0143 0.000 0.000 0.000
0.000 0.000 0.000 0.000 181452.1

-999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -
999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 74441.0

0.022 0.1648 0.3297 0.2527 0.1648 0.0549 0.011 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 398474.9

0.0279 0.2093 0.3674 0.2186 0.0977 0.0419 0.0233 0.0093 0.0047 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 281615.7

0.0892 0.2379 0.3829 0.2193 0.0558 0.0112 0.0037 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 140596.2

0.0209 0.0795 0.2427 0.2971 0.1925 0.0879 0.046 0.0209 0.0084 0.0042 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 166073.3

0.0571 0.1429 0.2619 0.2095 0.1619 0.0857 0.0429 0.019 0.0095 0.0048 0.0048 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 236795.5

0.0275 0.145 0.3475 0.2325 0.1325 0.070 0.0325 0.010 0.0025 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 316559.2

0.000 0.110 0.2656 0.2895 0.1866 0.0909 0.0407 0.012 0.0048 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 450156.3

0.000 0.0563 0.2002 0.2471 0.2096 0.123 0.0667 0.0334 0.0198 0.0136 0.0083 0.0063 0.0042 0.0031 0.0021
0.0021 0.001 0.001 0.001 0.001 389371.9

0.0334 0.0922 0.2273 0.2067 0.1431 0.0874 0.0556 0.035 0.0238 0.0175 0.0143 0.0095 0.0079 0.0064 0.0048
0.0064 0.0032 0.0032 0.0032 0.0191 169613.4

0.003 0.118 0.2587 0.2209 0.1437 0.0802 0.0484 0.0272 0.0182 0.0136 0.0106 0.0076 0.0061 0.0061 0.003
0.0076 0.003 0.003 0.003 0.0182 112952.4

0.0111 0.0815 0.242 0.2198 0.1444 0.0827 0.0531 0.0309 0.0222 0.0185 0.0148 0.0099 0.0086 0.0086 0.0062
0.0074 0.0049 0.0049 0.0037 0.0247 136623.3

0.0158 0.0474 0.2281 0.3263 0.2105 0.0947 0.0439 0.0175 0.0088 0.0035 0.0018 0.0018 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 139376.9

0.000 0.0091 0.1182 0.261 0.2584 0.1636 0.0896 0.0429 0.0221 0.0117 0.0078 0.0052 0.0039 0.0026 0.0013
0.0013 0.0013 0.000 0.000 0.000 262670.4

0.000 0.0587 0.2478 0.2696 0.1739 0.0935 0.0543 0.0304 0.0196 0.013 0.0087 0.0065 0.0043 0.0043 0.0022
0.0043 0.0022 0.0022 0.0022 0.0022 139018.2

0.000 0.0065 0.0971 0.2686 0.288 0.1715 0.0906 0.0388 0.0194 0.0097 0.0065 0.0032 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 135772.1

0.000 0.0118 0.1183 0.2426 0.2189 0.1479 0.1124 0.0769 0.0414 0.0178 0.0118 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 92165.4

0.000 0.0134 0.179 0.2931 0.2371 0.1298 0.0716 0.0358 0.0201 0.0112 0.0067 0.0022 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 156223.7

0.000 0.1042 0.3359 0.2587 0.1467 0.0811 0.0425 0.0154 0.0077 0.0039 0.0039 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 162408.0

Fleet 3 Catch at Age - Last Column is Total Weight

0.0443 0.217 0.2612 0.1767 0.0963 0.0595 0.0412 0.0294 0.0206 0.0149 0.0108 0.0078 0.0057 0.0041 0.0027
0.0024 0.0017 0.001 0.001 0.0007 426270.4

0.024 0.2295 0.3225 0.2043 0.0969 0.0516 0.0302 0.0174 0.0101 0.0054 0.0027 0.0012 0.0008 0.0008 0.0008
0.0004 0.0004 0.0004 0.0004 0.0004 567539.1

0.0345 0.1725 0.193 0.1904 0.1597 0.1092 0.0645 0.0338 0.0182 0.0102 0.0057 0.0027 0.0011 0.0008 0.0004
0.0008 0.0004 0.0004 0.0004 0.0004 365586.7

0.0549 0.2572 0.2825 0.1893 0.1102 0.0636 0.030 0.0091 0.0024 0.0008 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 384266.8

0.0246 0.1525 0.2402 0.220 0.1555 0.091 0.0498 0.0246 0.014 0.0086 0.0056 0.0035 0.0022 0.0017 0.0013
0.0011 0.0009 0.0006 0.0006 0.0004 299700.1

0.0195 0.0622 0.1653 0.181 0.1647 0.1238 0.0855 0.0559 0.0339 0.022 0.0163 0.0126 0.0113 0.0088 0.0075
0.0057 0.005 0.0038 0.0031 0.0025 163450.6

0.0004 0.0699 0.1719 0.1986 0.1908 0.1349 0.0839 0.0493 0.0313 0.0201 0.0127 0.0074 0.0049 0.0037 0.0025
0.0029 0.0021 0.0016 0.0016 0.0012 218010.4

0.0024 0.0923 0.2628 0.2605 0.1735 0.0882 0.0457 0.023 0.0133 0.008 0.005 0.0032 0.0024 0.0021 0.0018
0.0018 0.0015 0.0015 0.0015 0.0012 165666.2

0.000 0.0545 0.1837 0.2122 0.1611 0.1007 0.073 0.0587 0.0436 0.0294 0.0193 0.0126 0.0092 0.0076 0.0059
0.005 0.0042 0.0034 0.0025 0.0025 139557.8

0.000 0.0399 0.1453 0.198 0.1837 0.125 0.0798 0.0512 0.0361 0.0279 0.0211 0.0158 0.012 0.009 0.006 0.0068
0.0045 0.0045 0.0045 0.0038 115302.6

0.000 0.0966 0.2568 0.2268 0.1631 0.093 0.0486 0.0236 0.015 0.0107 0.0079 0.005 0.0043 0.0043 0.0036
0.0043 0.0043 0.0043 0.0036 0.0036 120418.1

0.000 0.0296 0.1112 0.1531 0.1665 0.1408 0.1067 0.0793 0.0542 0.0369 0.0263 0.0184 0.014 0.0106 0.0073
0.0073 0.005 0.0045 0.0039 0.0034 89464.2

0.000 0.0459 0.1488 0.1988 0.2058 0.1599 0.1006 0.057 0.0326 0.0186 0.0105 0.0052 0.0029 0.0023 0.0012
0.0017 0.0012 0.0006 0.0006 0.0006 88333.9

0.0047 0.1121 0.1811 0.1616 0.1179 0.0795 0.0563 0.040 0.0311 0.0263 0.0232 0.0174 0.0153 0.0153 0.0105
0.020 0.0095 0.010 0.0095 0.0063 79718.6

0.0012 0.0606 0.1388 0.1488 0.1176 0.0835 0.0641 0.0494 0.0406 0.0359 0.0318 0.0253 0.0224 0.0218 0.0159
0.0235 0.0141 0.0141 0.0135 0.010 92434.1

0.000 0.048 0.1655 0.1772 0.1389 0.0931 0.0655 0.0461 0.0357 0.0299 0.026 0.0191 0.0165 0.0165 0.011
0.0198 0.0104 0.0107 0.0107 0.0071 100950.7

0.000 0.0114 0.101 0.1962 0.2076 0.1558 0.1076 0.0737 0.0487 0.0312 0.0193 0.011 0.007 0.0053 0.0031
0.0035 0.0022 0.0022 0.0018 0.0013 89051.5

0.000 0.0241 0.1025 0.1894 0.2002 0.1417 0.0959 0.0645 0.0434 0.0296 0.0211 0.0151 0.0115 0.0097 0.0078
0.0066 0.006 0.0048 0.0042 0.0036 97394.4

0.0023 0.0667 0.1493 0.1686 0.1516 0.1075 0.0724 0.0486 0.0351 0.0271 0.0226 0.0158 0.0136 0.0136 0.009
0.0181 0.0079 0.009 0.009 0.0057 91731.5

0.0049 0.0111 0.1468 0.2807 0.2346 0.1388 0.0762 0.0369 0.019 0.0117 0.0086 0.0061 0.0055 0.0043 0.0031
0.0025 0.0018 0.0018 0.0012 0.0012 73266.0

0.000 0.0068 0.0698 0.1477 0.1669 0.1341 0.0999 0.0766 0.0602 0.0465 0.0356 0.0274 0.0219 0.0178 0.0137
0.0123 0.0096 0.0082 0.0068 0.0055 72223.5

0.000 0.0126 0.0829 0.192 0.2267 0.1689 0.1091 0.0672 0.0399 0.0252 0.0168 0.0105 0.0073 0.0063 0.0042
0.0052 0.0031 0.0031 0.0031 0.0021 54849.2

0.000 0.0182 0.1275 0.1866 0.1775 0.1335 0.091 0.0607 0.0425 0.0303 0.0228 0.0167 0.0121 0.0121 0.0076
0.0106 0.0061 0.0076 0.0061 0.0046 33236.2

Fleet 4 Catch at Age - Last Column is Total Weight

-999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -
999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 129456.9

-999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -
999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 125101.3

-999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -
999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 83994.8

-999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -
999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 82395.2

-999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -
999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 109944.5

-999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -
999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 -999.000 53681.3

0.0013 0.023 0.0256 0.0524 0.0972 0.1202 0.1138 0.0997 0.0767 0.0575 0.0448 0.0332 0.0269 0.0243 0.0179
0.0217 0.0166 0.0166 0.0153 0.1151 58786.7

0.000 0.000 0.0167 0.048 0.0835 0.1294 0.1315 0.1148 0.0814 0.0585 0.0438 0.0334 0.0292 0.0271 0.023 0.023
0.0188 0.0188 0.0167 0.1023 35669.6

0.000 0.0025 0.0201 0.0352 0.0427 0.0553 0.0804 0.098 0.103 0.093 0.0779 0.0653 0.0503 0.0402 0.0276
0.0302 0.0226 0.0201 0.0176 0.1181 25400.6

0.000 0.0128 0.0103 0.0141 0.0449 0.0924 0.095 0.0847 0.068 0.0565 0.0488 0.0424 0.0398 0.0385 0.0347
0.0359 0.0321 0.0295 0.027 0.1926 24975.3

0.000 0.0055 0.0128 0.0255 0.0493 0.0894 0.1131 0.1186 0.0967 0.0748 0.0584 0.0438 0.0365 0.0328 0.0255
0.0274 0.0219 0.0201 0.0182 0.1296 29915.0

0.000 0.000 0.0047 0.0179 0.0381 0.063 0.0785 0.0871 0.0894 0.0832 0.0739 0.0653 0.0552 0.0474 0.0404
0.035 0.0303 0.0264 0.0226 0.1415 34643.7

0.000 0.0017 0.0071 0.0255 0.0519 0.0839 0.0887 0.083 0.0717 0.0635 0.0567 0.0505 0.0454 0.0417 0.0366
0.0343 0.0315 0.0281 0.0249 0.1735 41777.6

0.000 0.0033 0.0256 0.0535 0.0772 0.0989 0.1037 0.0999 0.0864 0.0727 0.0608 0.0512 0.0425 0.035 0.0294
0.0242 0.0208 0.0175 0.0148 0.0827 51645.8

0.000 0.0019 0.0118 0.0482 0.0964 0.1181 0.1088 0.0936 0.0735 0.060 0.0512 0.0443 0.0394 0.0347 0.0314
0.0253 0.0237 0.0198 0.0168 0.101 50076.9

0.000 0.0007 0.0147 0.0687 0.1108 0.1205 0.1161 0.1082 0.0903 0.0698 0.0529 0.0392 0.0306 0.0259 0.0209
0.0187 0.0162 0.0137 0.0119 0.0705 55019.9

0.000 0.0017 0.0157 0.0649 0.126 0.153 0.1325 0.1062 0.0816 0.0639 0.0502 0.0396 0.0311 0.0249 0.0198
0.0161 0.013 0.0106 0.0089 0.0403 53496.1

0.000 0.0013 0.0159 0.0444 0.0925 0.1318 0.1296 0.1162 0.0925 0.0709 0.0542 0.0409 0.032 0.0268 0.0211
0.0191 0.0161 0.0139 0.012 0.069 77141.9

0.000 0.000 0.0047 0.0349 0.0803 0.1205 0.1258 0.1171 0.0931 0.0719 0.0561 0.0439 0.0355 0.0299 0.024
0.0221 0.019 0.0165 0.0146 0.090 73384.9

0.000 0.0037 0.0171 0.0577 0.0997 0.1255 0.1303 0.1246 0.1006 0.0755 0.056 0.0412 0.0312 0.0246 0.0189
0.0163 0.0131 0.0109 0.0091 0.044 45734.1

0.0049 0.0174 0.0277 0.0597 0.0934 0.1309 0.1337 0.1214 0.0991 0.078 0.0597 0.0446 0.0323 0.0234 0.016
0.0134 0.0091 0.0071 0.0057 0.0223 61444.0

0.000 0.000 0.0072 0.0376 0.0895 0.1547 0.1558 0.1365 0.1039 0.0762 0.0547 0.0381 0.0276 0.0215 0.0155
0.0144 0.011 0.0094 0.0077 0.0387 43456.8

0.000 0.0009 0.0202 0.0569 0.0909 0.1359 0.1396 0.1295 0.1047 0.0799 0.0597 0.045 0.0321 0.0239 0.0156 0.0147 0.0101 0.0083 0.0064 0.0257 17843.3

Fleet 1 Discards at Age - Last Column is Total Weight

0.9351 0.0649 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 8014.2

0.9351 0.0649 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 5391.2

0.9351 0.0649 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 5099.2

0.9351 0.0649 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 3477.3

0.9351 0.0649 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 3205.4

0.9351 0.0649 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 2841.6

0.2732 0.3534 0.2782 0.0877 0.0075 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 13766.6

0.2732 0.3534 0.2782 0.0877 0.0075 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 11506.4

0.2732 0.3534 0.2782 0.0877 0.0075 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 13377.3

0.2732 0.3534 0.2782 0.0877 0.0075 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 22505.2

0.2732 0.3534 0.2782 0.0877 0.0075 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 14477.9

0.2732 0.3534 0.2782 0.0877 0.0075 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 18715.3

0.2732 0.3534 0.2782 0.0877 0.0075 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 30447.9

0.5342 0.3562 0.0959 0.0137 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 8628.2

0.5342 0.3562 0.0959 0.0137 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 4906.1

0.5342 0.3562 0.0959 0.0137 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 9549.5

0.5342 0.3562 0.0959 0.0137 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 3788.2

0.5342 0.3562 0.0959 0.0137 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 4295.6

0.5342 0.3562 0.0959 0.0137 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 7272.8

0.3529 0.3529 0.2353 0.0588 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 8958.9

0.5625 0.375 0.0625 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 3361.7

0.6053 0.3421 0.0526 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 4181.1

0.5342 0.3562 0.0959 0.0137 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 1514.0

Fleet 2 Discards at Age - Last Column is Total Weight

0.9351 0.0649 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 10690.8

0.9351 0.0649 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 49625.8

0.9351 0.0649 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 5097.3

0.9351 0.0649 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 6575.9

0.9351 0.0649 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 5603.8

0.9351 0.0649 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 23995.1

0.3323 0.3354 0.25 0.0762 0.0061 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 83613.7

0.3323 0.3354 0.25 0.0762 0.0061 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 50557.6

0.3323 0.3354 0.25 0.0762 0.0061 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 73073.6

0.3323 0.3354 0.25 0.0762 0.0061 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 29112.6

0.3323 0.3354 0.25 0.0762 0.0061 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 78263.9

0.3323 0.3354 0.25 0.0762 0.0061 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 64598.7

0.3323 0.3354 0.25 0.0762 0.0061 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 52970.4

0.1652 0.3443 0.3673 0.115 0.0082 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 82449.0

0.1652 0.3443 0.3673 0.115 0.0082 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 65786.0

0.1652 0.3443 0.3673 0.115 0.0082 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 52492.5

0.1652 0.3443 0.3673 0.115 0.0082 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 63012.0

0.1652 0.3443 0.3673 0.115 0.0082 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 24530.9

0.1652 0.3443 0.3673 0.115 0.0082 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 79234.4

0.1652 0.3443 0.3673 0.115 0.0082 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 23541.0

0.1652 0.3443 0.3673 0.115 0.0082 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 36501.0

0.1652 0.3443 0.3673 0.115 0.0082 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 58075.3

0.1652 0.3443 0.3673 0.115 0.0082 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 82196.9

Fleet 3 Discards at Age - Last Column is Total Weight

-999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0
-999.0 -999.0 -999.0 -999.0 0.0

-999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0
-999.0 -999.0 -999.0 -999.0 0.0

-999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0
-999.0 -999.0 -999.0 -999.0 0.0

-999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0
-999.0 -999.0 -999.0 -999.0 0.0

-999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0
-999.0 -999.0 -999.0 -999.0 0.0

-999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0
-999.0 -999.0 -999.0 -999.0 0.0

-999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0
-999.0 -999.0 -999.0 -999.0 0.0

0.1431 0.4037 0.3429 0.1023 0.0072 0.0008 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
6516.7

0.1431 0.4037 0.3429 0.1023 0.0072 0.0008 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
7934.5

0.1431 0.4037 0.3429 0.1023 0.0072 0.0008 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
6586.6

0.1431 0.4037 0.3429 0.1023 0.0072 0.0008 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
7152.2

0.1431 0.4037 0.3429 0.1023 0.0072 0.0008 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
7566.2

0.1431 0.4037 0.3429 0.1023 0.0072 0.0008 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
6995.2

0.0789 0.3872 0.4045 0.1201 0.0085 0.0008 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
11585.6

0.0789 0.3872 0.4045 0.1201 0.0085 0.0008 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
11457.0

0.0789 0.3872 0.4045 0.1201 0.0085 0.0008 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
9915.1

0.0789 0.3872 0.4045 0.1201 0.0085 0.0008 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
8338.5

0.0789 0.3872 0.4045 0.1201 0.0085 0.0008 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
10555.0

0.0789 0.3872 0.4045 0.1201 0.0085 0.0008 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
7483.3

0.0789 0.3872 0.4045 0.1201 0.0085 0.0008 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
11452.1

0.0789 0.3872 0.4045 0.1201 0.0085 0.0008 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1423.8

0.0789 0.3872 0.4045 0.1201 0.0085 0.0008 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
12384.8

0.0789 0.3872 0.4045 0.1201 0.0085 0.0008 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
2123.1

Fleet 4 Discards at Age - Last Column is Total Weight

-999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0
-999.0 -999.0 -999.0 -999.0 0.0

-999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0
-999.0 -999.0 -999.0 -999.0 0.0

-999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0
-999.0 -999.0 -999.0 -999.0 0.0

-999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0
-999.0 -999.0 -999.0 -999.0 0.0

-999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0
-999.0 -999.0 -999.0 -999.0 0.0

-999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0
-999.0 -999.0 -999.0 -999.0 0.0

-999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0 -999.0
-999.0 -999.0 -999.0 -999.0 0.0

0.5765 0.4235 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 121.5

0.5765 0.4235 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 146.9

0.5765 0.4235 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 131.5

0.5765 0.4235 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 120.1

0.5765 0.4235 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 131.0

0.5765 0.4235 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 124.0

0.0462 0.3333 0.4538 0.1564 0.0103 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 419.2

0.0462 0.3333 0.4538 0.1564 0.0103 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 383.9

0.0462 0.3333 0.4538 0.1564 0.0103 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 360.3

0.0462 0.3333 0.4538 0.1564 0.0103 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 297.3

0.0462 0.3333 0.4538 0.1564 0.0103 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 348.6

0.0462 0.3333 0.4538 0.1564 0.0103 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 275.7

0.0462 0.3333 0.4538 0.1564 0.0103 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 185.9

0.0462 0.3333 0.4538 0.1564 0.0103 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 215.6

0.0462 0.3333 0.4538 0.1564 0.0103 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 218.7

0.0462 0.3333 0.4538 0.1564 0.0103 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 217.1

Fleet 1 Release Proportion at Age

0.9852 0.6366 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.9942 0.7605 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.9799 0.7094 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.9947 0.6281 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.9992 0.7378 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

1.0 0.9711 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.9573 0.8904 0.879 0.7707 0.1936 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

1.0 0.9653 0.8457 0.6638 0.1866 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

1.0 0.9602 0.842 0.6109 0.1739 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.9297 0.9048 0.8245 0.7263 0.2327 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

1.0 0.9736 0.9232 0.7483 0.1671 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

1.0 0.9856 0.9219 0.6688 0.1358 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

1.0 0.9718 0.8895 0.7211 0.1999 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

1.0 0.9597 0.7445 0.2762 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

```
1.0 0.9675 0.6671 0.2635 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9634 0.7447 0.2824 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9826 0.7169 0.3027 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9867 0.8003 0.2315 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.973 0.7077 0.242 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9924 0.8618 0.4868 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9948 0.8 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.9857 0.9701 0.6664 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 1.0 0.6556 0.1453 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
# Fleet 2 Release Proportion at Age
0.6335 0.1621 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.963 0.3391 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.7352 0.2242 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.9796 0.1821 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.9898 0.473 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.968 0.803 0.6338 0.47 0.137 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.8792 0.7337 0.5606 0.4045 0.1761 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.9821 0.9356 0.7802 0.4692 0.0984 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.8801 0.7477 0.5465 0.3147 0.0454 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.9663 0.846 0.6308 0.4377 0.0985 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.8364 0.6123 0.3064 0.052 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9207 0.7088 0.3755 0.0537 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.947 0.9309 0.8537 0.6677 0.1717 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.9964 0.9361 0.877 0.7235 0.2231 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.9806 0.9348 0.8374 0.6399 0.1618 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.9763 0.9662 0.8636 0.5809 0.1331 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9916 0.9068 0.5798 0.0905 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9522 0.8343 0.5919 0.1383 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9883 0.8577 0.4056 0.0435 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9917 0.9269 0.6595 0.1329 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9873 0.8618 0.544 0.0953 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
```

1.0 0.9232 0.7993 0.6182 0.1694 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

Fleet 3 Release Proportion at Age

0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.9655 0.6686 0.3759 0.1535 0.0188 0.0042 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

1.0 0.855 0.5978 0.2774 0.0343 0.0063 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

1.0 0.8914 0.657 0.2955 0.0308 0.0052 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

1.0 0.7533 0.4938 0.2479 0.0312 0.0062 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

1.0 0.9392 0.7774 0.4308 0.0466 0.0064 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

1.0 0.9031 0.7096 0.3531 0.0357 0.0053 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.971 0.8742 0.8181 0.5994 0.1263 0.0191 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.9911 0.9136 0.8282 0.5717 0.1064 0.015 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

1.0 0.9141 0.7634 0.4722 0.0745 0.0108 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

1.0 0.9812 0.8607 0.4855 0.0592 0.0076 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

1.0 0.9561 0.8426 0.4625 0.0543 0.0073 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.9746 0.8644 0.7485 0.439 0.0578 0.0078 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.9782 0.9899 0.8852 0.545 0.0918 0.0153 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

1.0 0.9509 0.665 0.2177 0.0171 0.002 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

1.0 0.9912 0.9469 0.6957 0.1201 0.0164 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

1.0 0.9499 0.7391 0.3648 0.0408 0.0051 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

Fleet 4 Release Proportion at Age

0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

```
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9691 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.8607 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9178 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 1.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9648 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9263 0.69 0.2685 0.0164 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9558 0.8274 0.2887 0.0131 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9808 0.7722 0.2005 0.0101 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9477 0.7283 0.1827 0.0075 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.9566 0.7113 0.2331 0.0095 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 1.0 0.8719 0.239 0.0089 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.8632 0.6506 0.1601 0.0072 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
0.4063 0.5793 0.5411 0.1587 0.0078 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 1.0 0.8482 0.2691 0.01 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.986 0.8135 0.3479 0.0214 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
# Index Units
2 2 2 2 1 1 2 2
# Index Month
7 7 -1 -1 -1 -1 7 7
# Index Selectivity Choice
-1 -1 1 -1 3 4 -1 -1
# Index Selectivity Option for each Index 1=by age, 2=logisitic, 3=double logistic
3 3 3 3 3 3 1 1
# Index Start Age
1 1 1 1 1 1 1 1
# Index End Age
20 20 20 20 20 20 1 1
# Use Index? 1=yes
0 0 1 1 1 1 1 0
# Index Selectivity initial guess, phase, lambda, and CV
```

```
# (have to enter values for nages + 6 parameters for each block)
# Index-1
1	5	1	5
0.6265	5	1	5
0.3373	5	1	5
0.1741	5	1	5
0.0803	5	1	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	0	0	0
0	0	0	0
0.0444	5	1	0.1642
0.0192	5	1	5
3.2542	5	1	0.0215
0.885	5	1	0.0713
# Index-2
1	5	1	5
0.7061	5	1	5
0.4217	5	1	5
```

0.3079	5	1	5
0.2102	5	1	5
0.1302	5	1	5
0.0899	5	1	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	-5	0	5
0	0	0	0
0	0	0	0
0.4284	5	1	0.3427
0.2402	5	1	0.3106
5.7987	5	1	0.0433
1.6471	5	1	0.1412

Index-3

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	-1	0	0
0	-1	0	0
0	-1	0	0
0	-1	0	0

Index-4

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
2.2263	5	1	0.0265
0.2152	5	1	0.2384
5.5227	5	1	0.0098
0.6215	5	1	0.0771

Index-5

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	-1	0	0
0	-1	0	0
0	-1	0	0
0	-1	0	0

Index-6

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	-1	0	0

0 -1 0 0

0 -1 0 0

0 -1 0 0

Index-7

1 -1 1 1

0 -1 0 1

0 -1 0 1

0 -1 0 1

0 -1 0 1

0 -1 0 1

0 -1 0 1

0 -1 0 1

0 -1 0 1

0 -1 0 1

0 -1 0 1

0 -1 0 1

0 -1 0 1

0 -1 0 1

0 -1 0 1

0 -1 0 1

0 -1 0 1

0 -1 0 1

0 -1 0 1

0 -1 0 1

0 0 0 0

0 0 0 0

0 0 0 0

0 0 0 0

0 0 0 0

0 0 0 0

Index-8

1 -1 0 1

0	-1	0	1
0	-1	0	1
0	-1	0	1
0	-1	0	1
0	-1	0	1
0	-1	0	1
0	-1	0	1
0	-1	0	1
0	-1	0	1
0	-1	0	1
0	-1	0	1
0	-1	0	1
0	-1	0	1
0	-1	0	1
0	-1	0	1
0	-1	0	1
0	-1	0	1
0	-1	0	1
0	-1	0	1
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

Index Data - Year, Index Value, CV, proportions at age and input effective sample size (only used if estimating parameters)

Index-1

1986 -999 1 0.0000 0

1987 -999 1 0.0000 0

1988 -999 1 0.0000 0

1989 -999 1 0.0000 0

1990 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1991 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1992 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1993 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1994 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1995 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1996 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1997 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1998 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1999 1.54 0.15 0.8000 0.1429 0.0571 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 16

2000 1.26 0.16 0.7850 0.1215 0.0654 0.0187 0.0000 0.0093 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 19

2001 1.05 0.14 0.5729 0.2396 0.0938 0.0729 0.0000 0.0000 0.0000 0.0208 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 21

2002 0.87 0.13 0.7031 0.1875 0.0469 0.0156 0.0000 0.0313 0.0000 0.0000 0.0000 0.0000 0.0156 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 21

2003 0.78 0.16 0.6393 0.2623 0.0820 0.0164 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 22

2004 1.06 0.19 0.5231 0.2769 0.1231 0.0308 0.0000 0.0154 0.0000 0.0154 0.0000 0.0000 0.0154 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 21

2005 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2006 0.8 0.17 0.5283 0.2075 0.1887 0.0755 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 21

2007 0.85 0.16 0.6481 0.2407 0.0185 0.0741 0.0000 0.0185 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 21

2008 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

Index-2

1986 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1987 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1988 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1989 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1990 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1991 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1992 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1993 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1994 -999 -999 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -
999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999

1995 -999 -999 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -
999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999

1996 -999 -999 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -
999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999

1997 -999 -999 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -
999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999.0000 -999

1998 1.47 0.26 0.6571 0.3017 0.0382 0.0028 0.0001 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 10

1999 1.18 0.13 0.6611 0.1727 0.0763 0.0440 0.0207 0.0089 0.0052 0.0023 0.0017 0.0013 0.0010 0.0007 0.0006
0.0005 0.0004 0.0004 0.0003 0.0003 0.0002 0.0013 109

2000 1.46 0.11 0.6773 0.2419 0.0566 0.0152 0.0038 0.0019 0.0011 0.0005 0.0003 0.0003 0.0002 0.0001 0.0001
0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0003 109

2001 1.49 0.14 0.5228 0.2841 0.0936 0.0379 0.0162 0.0090 0.0062 0.0038 0.0032 0.0029 0.0025 0.0021 0.0019
0.0017 0.0016 0.0013 0.0012 0.0010 0.0009 0.0062 109

2002 1.49 0.13 0.3447 0.2761 0.1547 0.0820 0.0536 0.0321 0.0197 0.0138 0.0100 0.0061 0.0035 0.0015 0.0008
0.0006 0.0003 0.0003 0.0001 0.0001 0.0001 0.0001 109

2003 0.68 0.17 0.3148 0.2603 0.1803 0.0967 0.0536 0.0324 0.0231 0.0170 0.0102 0.0056 0.0030 0.0013 0.0007
0.0004 0.0001 0.0002 0.0001 0.0001 0.0000 0.0001 109

2004 0.92 0.26 0.0695 0.1328 0.1890 0.1555 0.1003 0.0702 0.0517 0.0388 0.0304 0.0243 0.0197 0.0165 0.0139
0.0115 0.0106 0.0083 0.0074 0.0063 0.0055 0.0377 109

2005 1.4 0.12 0.2015 0.3465 0.1981 0.1346 0.0704 0.0277 0.0106 0.0029 0.0019 0.0016 0.0013 0.0011 0.0007
0.0004 0.0001 0.0002 0.0001 0.0001 0.0000 0.0001 109

2006 0.68 0.16 0.2861 0.2774 0.1749 0.1188 0.0655 0.0299 0.0125 0.0036 0.0031 0.0039 0.0042 0.0046 0.0040
0.0028 0.0024 0.0015 0.0012 0.0009 0.0007 0.0020 109

2007 0.95 0.14 0.3464 0.1795 0.1493 0.1357 0.0928 0.0408 0.0203 0.0094 0.0063 0.0046 0.0033 0.0025 0.0019
0.0014 0.0011 0.0009 0.0007 0.0006 0.0005 0.0020 109

2008 0.89 0.11 0.5481 0.2828 0.1190 0.0394 0.0081 0.0019 0.0006 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 109

Index-3

1986	0.85	0.32	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
1987	1.35	0.31	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
1988	0.48	0.34	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
1989	0.78	0.32	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
1990	0.57	0.35	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
1991	0.68	0.35	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
1992	0.83	0.3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
1993	0.55	0.3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
1994	0.78	0.29	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
1995	0.97	0.3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
1996	0.82	0.28	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
1997	0.53	0.31	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
1998	0.63	0.32	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
1999	0.44	0.35	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
2000	0.39	0.37	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
2001	0.41	0.3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
2002	0.59	0.33	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
2003	0.52	0.33	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
2004	1	0.35	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
2005	2.97	0.31	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
2006	1.26	0.31	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0
2007	1.9	0.31	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0

2008 0.64 0.36 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

Index-4

1986 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1987 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1988 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1989 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1990 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1991 0.49 0.25 0.0170 0.2580 0.9570 1.0000 0.6660 0.3040 0.1300 0.0340 0.0590 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 16

1992 0.43 0.24 0.0170 0.2580 0.9570 1.0000 0.6660 0.3040 0.1300 0.0340 0.0590 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 32

1993 0.52 0.24 0.0170 0.2580 0.9570 1.0000 0.6660 0.3040 0.1300 0.0340 0.0590 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 33

1994 0.8 0.22 0.0170 0.2580 0.9570 1.0000 0.6660 0.3040 0.1300 0.0340 0.0590 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 33

1995 0.75 0.23 0.0170 0.2580 0.9570 1.0000 0.6660 0.3040 0.1300 0.0340 0.0590 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 18

1996 1.68 0.22 0.0170 0.2580 0.9570 1.0000 0.6660 0.3040 0.1300 0.0340 0.0590 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 33

1997 1.06 0.19 0.0170 0.2580 0.9570 1.0000 0.6660 0.3040 0.1300 0.0340 0.0590 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 52

1998 1.06 0.15 0.0170 0.2580 0.9570 1.0000 0.6660 0.3040 0.1300 0.0340 0.0590 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 68

1999 1.29 0.14 0.0170 0.2580 0.9570 1.0000 0.6660 0.3040 0.1300 0.0340 0.0590 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 103

2000 0.92 0.13 0.0170 0.2580 0.9570 1.0000 0.6660 0.3040 0.1300 0.0340 0.0590 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 112

2001 1.28 0.12 0.0170 0.2580 0.9570 1.0000 0.6660 0.3040 0.1300 0.0340 0.0590 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 115

2002 0.87 0.14 0.0170 0.2580 0.9570 1.0000 0.6660 0.3040 0.1300 0.0340 0.0590 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 105

2003 1.37 0.13 0.0170 0.2580 0.9570 1.0000 0.6660 0.3040 0.1300 0.0340 0.0590 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 124

2004 1.19 0.15 0.0170 0.2580 0.9570 1.0000 0.6660 0.3040 0.1300 0.0340 0.0590 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 100

2005 0.81 0.16 0.0170 0.2580 0.9570 1.0000 0.6660 0.3040 0.1300 0.0340 0.0590 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 71

2006 0.53 0.18 0.0170 0.2580 0.9570 1.0000 0.6660 0.3040 0.1300 0.0340 0.0590 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 54

2007 0.69 0.15 0.0170 0.2580 0.9570 1.0000 0.6660 0.3040 0.1300 0.0340 0.0590 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 78

2008 0.64 0.17 0.0170 0.2580 0.9570 1.0000 0.6660 0.3040 0.1300 0.0340 0.0590 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 85

Index-5

1986 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1987 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1988 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1989 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1990 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1991 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1992 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1993 0.76 0.13 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1994 0.75 0.12 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1995 0.81 0.12 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1996 0.83 0.12 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1997 0.75 0.12 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1998 0.97 0.12 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1999 0.76 0.13 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2000 0.82 0.13 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2001 1.25 0.12 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2002 1.15 0.12 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2003 1.28 0.12 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2004 1.35 0.12 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2005 1.32 0.12 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2006 1.38 0.13 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2007 1.02 0.13 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2008 0.8 0.14 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

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1986 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1987 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1988 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1989 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1990 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1991 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1992 -999 1 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1993 0.39 1.14 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1994 0.3 1.42 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1995 0.4 1.48 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1996 0.46 1.03 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1997 0.46 0.96 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1998 0.75 0.57 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1999 0.83 0.52 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2000 1.06 0.45 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2001 1.41 0.34 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2002 1.58 0.33 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2003 1.84 0.3 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2004 1.87 0.28 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2005 1.8 0.28 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2006 1.11 0.45 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2007 1.05 0.59 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2008 0.69 0.76 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

Index-7

1986 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1987 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1988 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1989 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1990 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1991 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1992 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1993 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1994 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1995 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1996 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1997 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1998 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1999 1.2 0.15 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 16

2000 1.85 0.14 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 19

2001 0.93 0.17 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 34

2002 1.01 0.15 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 31

2003 0.91 0.16 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 22

2004 1.04 0.16 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 21

2005 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

2006 0.62 0.19 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 28

2007 0.81 0.16 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 30

2008 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

Index-8

1986 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1987 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1988 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1989 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1990 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1991 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1992 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1993 -999 1 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0

1994 0.429 0.16 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 126

1995 0.005 0.19 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 200

1996 0.089 0.48 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 151

1997 1.041 0.17 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 200

1998 2.07 0.26 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 200

1999 1.241 0.13 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 200

2000 1.477 0.11 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 200

2001 2.066 0.14 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 200

2002 1.457 0.13 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 200

2003 0.563 0.17 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 200

2004 0.209 0.26 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 200

2005 1.89 0.12 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 200

2006 0.695 0.16 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 200

2007 0.682 0.14 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 200

2008 1.085 0.11 1.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 200

Phase Control Data

Phase for F mult in 1st Year

2

Phase for F mult Deviations

8

Phase for Recruitment Deviations

7

Phase for N in 1st Year

1

Phase for Catchability in 1st Year

2

Phase for Catchability Deviations

-7

Phase for Stock Recruitment Relationship

3

Phase for Steepness

6

Recruitment CV by Year

0.5

0.5

0.5

0.5

0.5

0.5

0.5

0.5

0.5

0.5

0.5

0.5

0.5

0.5

0.5

0.5

0.5

0.5

0.5

0.5

0.5

0.5

0.5

0.5

#Lambda for Each Index

1 1 1 1 1 1 1 1

Lambda for Total Catch in Weight by Fleet

1 1 1 1

Lambda for Total Discards at Age by Fleet

1 1 1 1

Catch Total CV by Year and Fleet

0.100 0.260 0.240 0.240

0.100 0.200 0.250 0.250

0.100 0.460 0.250 0.250

0.100 0.370 0.250 0.250

0.100 0.600 0.270 0.270

0.100 0.350 0.270 0.270

0.100 0.240 0.270 0.270

0.100 0.250 0.270 0.270

0.100 0.330 0.270 0.270

0.100 0.250 0.270 0.270

0.100 0.170 0.270 0.270

0.100 0.220 0.270 0.270

0.100 0.250 0.280 0.280

0.100 0.390 0.280 0.280

0.100 0.350 0.290 0.290

0.100 0.210 0.290 0.290

0.100 0.440 0.290 0.290

0.100 0.230 0.290 0.290

0.100 0.220 0.290 0.290

0.100 0.360 0.290 0.290

0.100 0.370 0.290 0.290

0.100 0.220 0.290 0.290

0.100 0.330 0.290 0.290

Discard Total CV by Year and Fleet

0.200 0.160 0.000 0.000

0.200 0.430 0.000 0.000

0.200 0.290 0.000 0.000

0.200 0.190 0.000 0.000

0.200 0.360 0.000 0.000

0.200 0.420 0.000 0.000

0.200 0.460 0.270 0.270

0.200 0.280 0.270 0.270

0.200 0.250 0.270 0.270

0.200 0.220 0.270 0.270

0.200 0.220 0.270 0.270

0.200 0.160 0.270 0.270

0.200 0.160 0.280 0.280

0.200 0.140 0.280 0.280

0.200 0.240 0.290 0.290

0.200 0.250 0.290 0.290

0.200 0.150 0.290 0.290

0.200 0.140 0.290 0.290

0.200 0.130 0.290 0.290

0.200 0.210 0.290 0.290

0.200 0.180 0.290 0.290

0.200 0.230 0.290 0.290

0.200 0.190 0.290 0.290

Input Effective Sample Size for Catch at Age by Year & Fleet

4 4 4 0

0 0 0 0

0 0 0 0

0 0 0 0

5 1 5 0

6 6 6 0

4 4 4 0

10 10 10 0

14 14 14 11

14 14 14 78

12 12 12 55

3 3 3 0

5 5 5 0

13 15 15 3

8 9 9 7

10 23 23 34

9 20 20 37

8 23 23 85

6 19 19 114

7 19 19 156

10 17 25 240

11 42 42 136

2 26 35 75

Input Effective Sample Size for Discards at Age by Year & Fleet

0 0 0 0

0 0 0 0

0 0 0 0

0 0 0 0

0 0 0 0

0 0 0 0

4 4 0 0

10 10 10 0

14 14 14 0

14 14 14 0

12 12 12 0

3 3 3 0

5 5 5 0

15 15 15 3

9 9 9 7

23 23 23 34

20 20 20 37

23 23 23 39

19 19 19 39

17 19 19 39

16 25 25 39

38 32 42 39

2 32 35 39

Lambda for F mult in first year by fleet

1 1 1 1

CV for F mult in first year by fleet

0.5 0.5 0.5 0.5

Lambda for F mult Deviations by Fleet

1 1 1 1

CV for F mult deviations by Fleet

0.25 0.25 0.25 0.25

Lambda for N in 1st Year Deviations

1

CV for N in 1st Year Deviations

0.5

Lambda for Recruitment Deviations

1

Lambda for Catchability in first year by index

1 1 1 1 1 1 1 1

CV for Catchability in first year by index

0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5

Lambda for Catchability Deviations by Index

1 1 1 1 1 1 1 1

CV for Catchability Deviations by Index

0.001 0.001 0.5 0.1 0.5 0.5 0.001 0.001

Lambda for Deviation from Initial Steepness

1

CV for Deviation from Initial Steepness

0.1

Lambda for Deviation from Initial unexploited Stock Size

1

CV for Deviation from Initial unexploited Stock Size

0.5

NAA for Year 1

765297 514990 375083 244835 210941 130297 66761 38239 26268 19734 15077 11389 8449 6161 4429 3149 2220 1555 1085 754

F mult in 1st year by Fleet

.1 .15 .15 .1

Catchability in 1st year by index

4.09E-07 4.09E-07 4.09E-07 4.09E-07 4.09E-07 4.09E-07 4.09E-07 4.09E-07

Initial unexploited Stock Size

8000000

Initial Steepness

0.75

Maximum F

5

Ignore Guesses

0

Projection Control Data

Do Projections? (1=yes, 0=no), still need to enter values even if not doing projections

0

Fleet Directed Flag

1 1 1 1

Final Year of Projections

2021

Year Projected Recruits, What Projected, Target, non- directed F mult

2009 -1 4 0 1

2010 -1 4 0 1

2011 -1 5 0 1

2012 -1 5 0 1

2013 -1 5 0 1

2014 -1 5 0 1

2015 -1 5 0 1

2016 -1 5 0 1

2017 -1 5 0 1

2018 -1 5 0 1

2019 -1 5 0 1

2020 -1 5 0 1

2021 -1 5 0 1

```
# MCMC info
# doMCMC (1=yes)
1
# MCMCnyear option (0=use final year values of NAA, 1=use final year + 1 values of NAA)
0
# MCMCnboot
10000
# MCMCnthin
200
# MCMCseed
138846
# R in agepro.bsn file (enter 0 to use NAA, 1 to use stock-recruit relationship, 2 to used geometric mean of previous years)
2
# Starting year for calculation of R
2006
# Starting year for calculation of R
2008
# Test Value
-23456
#####
# ---- FINIS ----
```