SEDAR

Southeast Data, Assessment, and Review

SEDAR 33

Gulf of Mexico Gag
Stock Assessment Report

March 2014

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

Please cite this document as:

SEDAR. 2014. SEDAR 33 – Gulf of Mexico Gag Stock Assessment Report. SEDAR, North Charleston SC. 609 pp. Available online at:

http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=33

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1. Introduction

1.1 SEDAR Process Description

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

SEDAR is managed by the Caribbean, Gulf of Mexico, and South Atlantic Regional Fishery Management Councils in coordination with NOAA Fisheries and the Atlantic and Gulf States Marine Fisheries Commissions. Oversight is provided by a Steering Committee composed of NOAA Fisheries representatives: Southeast Fisheries Science Center Director and the Southeast Regional Administrator; Regional Council representatives: Executive Directors and Chairs of the South Atlantic, Gulf of Mexico, and Caribbean Fishery Management Councils; 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 process, which is conducted via a workshop and several webinars, during which assessment models are developed and population parameters are estimated using the information provided from the Data Workshop. Third and final is the Review Workshop, during which independent experts review the input data, assessment methods, and assessment products. The completed assessment, including the reports of all 3 workshops and all supporting documentation, is then forwarded to the Council SSC for certification as 'appropriate for management' and development of specific management recommendations.

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

SEDAR Review Workshop Panels consist of a chair, three reviewers appointed by the Center for Independent Experts (CIE), and one or more SSC representatives appointed by each council having jurisdiction over the stocks assessed. The Review Workshop Chair is appointed by the council having jurisdiction over the stocks assessed and is a member of that council's SSC. Participating councils may appoint representatives of their SSC, Advisory, and other panels as observers.

2. Gulf of Mexico Gag Management History

2.1. Fishery Management Plan and Amendments

Original GMFMC FMP:

The Reef Fish Fishery Management Plan was implemented in November 1984. The regulations, designed to rebuild declining reef fish stocks, included: (1) prohibitions on the use of fish traps, roller trawls, and powerhead-equipped spear guns within an inshore stressed area; (2) a minimum size limit of 13 inches total length (TL) for red snapper with the exceptions that for-hire boats were exempted until 1987 and each angler could keep 5 undersize fish; and, (3) data reporting requirements.

GMFMC FMP Amendments affecting Gag:

Description of Action	FMP/Amendment	Effective Date
Set a 20-inch total length minimum size limit on red, Nassau, yellowfin, black, and gag groupers. Set a 5-grouper recreational bag limit, with a 2-day possession limit allowed for qualified charter vessels and head boats on trips that extend beyond 24 hours. Set an 11.0 million-pound commercial quota for groupers, with the commercial quota divided into a 9.2 million pound shallow-water grouper quota and a 1.8 million-pound deepwater grouper quota. Shallow-water grouper were defined as black grouper, gag, red grouper, Nassau grouper, yellowfin grouper, yellowmouth grouper, rock hind, red hind, speckled hind, and scamp (until the shallow-water grouper quota is filled). Goliath grouper (jewfish) are not included in the quotas. Established a longline and buoy gear boundary and expanded the stressed area to the entire Gulf coast. Established a commercial reef fish permit.	Amendment 1	1990
Established a moratorium on the issuance of new reef fish permits for a maximum period of three years; established an allowance for permit transfers	Amendment 4	1992
Created an Alabama special management zone (SMZ) with fishing gear restricted to no more than three hooks within the SMZ, and a framework procedure for future specification of SMZs. Established restrictions on the use of fish traps in the Gulf of Mexico EEZ, and	Amendment 5	1994

implemented a three-year moratorium on the use of fish traps by creating a fish trap endorsement. Required that finfish be landed head and tails intact		
Established reef fish dealer permitting and record keeping.	Amendment 7	1994
Extended the reef fish permit moratorium through December 31, 1995 and allowed collections of commercial landings data for initial allocation of individual transferable quota (ITQ) shares. Established historical captain status for purposes of ITQ allocation.	Amendment 9	1994
Attempted to establish an ITQ system, which was then repealed by Congress	Amendment 8	1995
Implemented a new commercial reef fish permit moratorium for no more than five years or until December 31, 2000, permitted dealers can only buy reef fish from permitted vessels and permitted vessels can only sell to permitted dealers, established a charter and headboat reef fish permit.	Amendment 11	1996
Initiated a 10-year phase-out on the use of fish traps in the EEZ from February 7, 1997 to February 7, 2007, after which fish traps would be prohibited, and prohibited the use of fish traps west of Cape San Blas, Florida.	Amendment 14	1997
Prohibited harvest of reef fish from traps other than permitted reef fish traps, stone crab traps, or spiny lobster traps. Established 2-tier red snapper license system (Class 1 & 2).	Amendment 15	1998
(1) The possession of reef fish exhibiting the condition of trap rash on board any vessel with a reef fish permit that is fishing spiny lobster or stone crab traps is prima facie evidence of illegal trap use and is prohibited except for vessels possessing a valid fish trap endorsement; (2) that NOAA Fisheries establish a system design, implementation schedule, and protocol to require implementation of a vessel monitoring system (VMS) for vessels engaged in the fish trap fishery, with the cost of the vessel equipment, installation, and maintenance to be paid or arranged by the owners as appropriate; and, (3) that fish trap vessels submit trip initiation and trip termination reports. Prior to implementing this additional reporting requirement, there will be a	Amendment 16A	1998

one-month fish trap inspection/compliance/education period, at a time determined by the NOAA Fisheries Regional Administrator and published in the *Federal Register*. During this window of opportunity, fish trap fishermen will be required to have an appointment with NMFS enforcement for the purpose of having their trap gear, permits, and vessels available for inspection. The disapproved measure was a proposal to prohibit fish traps south of 25.05 degrees north latitude beginning February 7, 2001. The status quo 10-year phase-out of fish traps in areas in the Gulf EEZ is therefore maintained.		
Extended the commercial reef fish permit moratorium for another five years, from its previous expiration date of December 31, 2000 to December 31, 2005	Amendment 17	2000
Prohibited vessels with commercial harvests of reef fish aboard from also retaining fish caught under recreational bag and possession limits. Vessels with both for-hire and commercial permits were limited to the minimum crew size outlined in its Certificate of Inspection when fishing commercially. Prohibited the use of reef fish other than sand perches for bait. Required commercially permitted reef fish vessels to be equipped with VMS.	Amendment 18A	2006
Established two marine reserve areas off the Tortugas area and prohibits fishing for any species and anchoring by fishing vessels inside the two marine reserves.	Amendment 19	2002
Established a 3-year moratorium on the issuance of new charter and headboat vessel permits in the recreational for hire fisheries in the Gulf EEZ. Allowed transfer of permits. Required vessel captains/owners to participate in data collection efforts.	Amendment 20	2002
Continues the Madison-Swanson and Steamboat Lumps marine reserves for an additional 6 years, until July 2010. Modified the fishing restrictions within the reserves to allow surface trolling during May – October.	Amendment 21	2004
It also established bycatch reporting methodologies for the reef fish fishery.	Amendment 22	2005
Extended the commercial reef fish permit	Amendment 24	2005

moratorium indefinitely. Established a permanent limited access system for the commercial fishery for Gulf reef fish. Permits issued under the limited access system are renewable and transferable.		
Extended the recreational for-hire reef fish permit moratorium indefinitely. Established a limited access system on for-hire reef fish and CMP permits. Permits are renewable and transferable in the same manner as currently prescribed for such permits.	Amendment 25	2006
Requires all commercial and recreational reef fish fisheries to use non-stainless steel circle hooks when using natural baits, as well as venting tools and dehooking devices.	Amendment 27	2008
Established an individual fishing quota (IFQ) system for the commercial grouper and tilefish fishery, which began January 1, 2010.	Amendment 29	2009
Addresses the overfishing of Gag grouper, and defines its maximum stock size threshold (MSST) and optimum yield (OY). Sets interim allocations of gag and red grouper catches between recreational and commercial fisheries. Establishes annual catch limits (ACLs) and accountability measures (AMs) for the commercial and recreational gag fisheries, and commercial aggregate shallow-water grouper fishery. For the commercial sector, the amendment for 2009 reduces the aggregate shallow-water grouper quota from 8.80 mp to 7.8 mp and sets a gag quota of 1.32 mp. The gag and shallow-water grouper quotas are scheduled to increase in subsequent years as the gag stock rebuilds. Repeals the commercial closed season of February 15 to March 15 on gag, black and red grouper, and replaces it with a January through April seasonal area closure to all fishing at the Edges 40 fathom contour, a 390 nautical square mile gag spawning region northwest of Steamboat Lumps. In addition, the Steamboat Lumps and Madison-Swanson fishing area restrictions will be continued indefinitely.	Amendment 30B	2009

For the recreational sector, the amendment reduces the aggregate grouper bag limit from five fish to four and sets a two-fish bag limit for gag. A recreational closed season on shallow-water grouper was established from February 1 through March 31. Finally, the amendment requires that all vessels with federal commercial or charter reef fish permits must comply with the more restrictive of state or federal reef fish regulations when fishing in state waters.		
Longline endorsement requirement - Vessels must have average annual reef fish landings of 40,000 pounds gutted weight or more from 1999 through 2007. The longline boundary in the eastern Gulf is extended from the 20-fathom depth contour to the 35-fathom depth contour from June - August. Vessels are limited to 1000 hooks of which no more than 750 of which can be rigged for fishing or fished.	Amendment 31	2010
Established annual catch limits and annual catch targets for 2012 to 2015 for gag. Establishes a rebuilding plan for gag, and sets recreational bag limits, size limits and closed seasons for gag/red grouper in 2012. Contains a commercial gag and shallow-water grouper quota adjustment to account for dead discards, and makes adjustments to multi-use IFQ shares in the grouper individual fishing quota program. Reduces the commercial gag size limit, modifies the offshore time and areas closures, and revises gag, red grouper, and shallow-water grouper accountability measures.	Amendment 32	2012

GMFMC Regulatory Amendments:

July 1991:
The 1991 quota for shallow-water groupers was increased to 9.9 million pounds whole weight (using a revised gutted to whole weight conversion factor of 1.05 rather than 1.18, this corresponded to 8.8 million pounds whole weight). This action was taken to provide the commercial sector an opportunity to harvest 0.7 million pounds that went unharvested in 1990 due to an early closure of the fishery in 1990. NMFS had projected that the 9.2 million pound whole weight quota would be reached on November 7, but subsequent data showed that the

actual harvest was 8.5 million pounds whole weight (or 7.6 million pounds whole weight using the revised gutted to whole weight conversion factor).

November 1991:
Set the 1992 commercial quota for shallow-water groupers at 9.8 million pounds in adjusted whole weights. This reflected an increase of 1.6 million pounds plus an adjustment in the gutted to whole weight conversion factor from 1.18 to 1.05.

August 1999:
Implemented June 19, 2000- Increased the commercial size limit for gag from 20 to 24 inches TL, increased the recreational size limit for gag from 20 to 22 inches TL, prohibited commercial sale of gag, black, and red grouper each year from February 15 to March 15 (during the peak of gag spawning season), and established two marine reserves (Madison-Swanson and Steamboat Lumps) on areas suitable for gag and other reef fish spawning aggregations sites that are closed year-round to fishing for all species under the Council's jurisdiction. The two sites cover 219 square nautical miles near the 40-fathom contour, off west central Florida.

October 2005:
Implemented January 2006 – Established an aggregate commercial trip limit of 6,000 pounds gutted weight for both deep-water grouper and shallow-water grouper combined.

March 2006:
Implemented July 2006 - Established a one-fish recreational bag limit for red grouper; a closed recreational season for red, gag, and black grouper from February 15 - March 15; and prohibits captain and crew of for-hire vessels from retaining grouper when under charter. The purpose of the amendment is to return red grouper landings to levels specified in the red grouper rebuilding plan, and prevent or minimize impacts on gag and other grouper resulting from more restrictive recreational red grouper regulations.

August 2010:
Effective January 2011- Provides a more specific definition of buoy gear by limiting the number of hooks, limiting the terminal end weight, restricting materials used for the line, restricting the length of the drop line, and where the hooks may be attached. In addition, the Council requested that each buoy must display the official number of the vessel (USCG documentation number or state registration number) to assist law enforcement in monitoring the use of the gear, which requires rulemaking.

2.2. Emergency and Interim Rules

December 17, 2002- The National Marine Fisheries Service published an emergency rule that extended certain permit-related deadlines contained in the final rule implementing the for-hire (charter vessel/headboat) permit moratorium for reef fish and coastal migratory pelagic fish in the Gulf of Mexico (Gulf). This emergency rule was implemented because the final rule implementing the for-hire permit moratorium contained an error regarding eligibility that needed to be resolved as soon as possible. In addition, the regulations that implemented the moratorium required all for-hire vessels operating in the Gulf reef fish or coastal migratory pelagic fisheries in federal waters to have a valid "moratorium permit," as opposed to the prior open access charter permit, beginning December 26, 2002.

March 3, 2005 – An emergency rule established a commercial trip limit of 10,000 pounds for all grouper combined; reduce the trip limit to 7,500 pounds when 50 percent of either the shallow-water grouper or red grouper quota was reached; and reduce the trip limit to 5,500 pounds when 75 percent of either the shallow-water grouper or red grouper quota was reached. Fifty percent of the quota was reached on June 9 and trip limits were reduced to 7,500 pounds. The deep-water grouper quota was reached on June 23 and that component was closed. Seventy-five percent of the shallow-water grouper quota was reached on August 4 and trip limits were reduced to 5,500 pounds. The shallow-water grouper component closed on October 10.

April 1, 2005 - The National Marine Fisheries Service published an emergency rule to reopen the application process for obtaining Gulf charter vessel/headboat permits under moratorium. Permit owners who received their Gulf charter vessel/headboat permits under the moratorium, or a letter of eligibility for such a permit, need not reapply. This reopening is extended to historical participants in the fishery who, for whatever reason, failed to apply during the moratorium application period.

August 9, 2005 - NOAA's National Marine Fisheries Service (NMFS) published a temporary rule in the Federal Register implementing management measures for the recreational grouper fishery in the exclusive economic zone of the Gulf of Mexico, as requested by the Gulf of Mexico Fishery Management Council, to reduce overfishing of red grouper. This rule establishes a seasonal closure of the recreational fishery for all Gulf grouper species from November 1 through December 31, 2005 and reduces both the recreational bag limit for red grouper and the aggregate grouper bag limit. The intended effects are to reduce overfishing of red grouper in the Gulf of Mexico and to minimize potential adverse impacts on other grouper stocks that could result from a shift in fishing effort from red grouper to other grouper species. (A legal challenge resulted in a ruling that the November 1 through December 31 seasonal closure could, under an interim rule, only be applied to the stock that was undergoing overfishing, i.e., red grouper.)

January 1, 2009 - NOAA's National Marine Fisheries Service (NOAA Fisheries Service) has published a final rule implementing interim measures in the Gulf of Mexico reef fish fishery. The rule published in the Federal Register on December 2, 2008, and the measures are effective January 1, 2009. The Gulf of Mexico Fishery Management Council (Council) requested a temporary rule be effective at the beginning of 2009 to address overfishing of gag, as well as red snapper, greater amberjack, and gray triggerfish until more permanent measures can be implemented through Amendment 30B to the Fishery Management Plan for the Reef Fish Resources of the Gulf of Mexico. The Council developed Amendment 30B to end overfishing of gag, revise shallow-water grouper management measures in light of new information on gag and red grouper stocks, and improve the effectiveness of federal management measures. NOAA Fisheries Service is presently reviewing Amendment 30B with subsequent rulemaking occurring later in 2009. New Management Measures The interim rule will: 1) Establish a two-fish gag recreational bag limit (recreational grouper aggregate bag limit will remain at 5 fish); 2) Adjust the recreational closed season for gag to February 1 through March 31 (the recreational closed season for red and black groupers will remain February 15 to March 15); 3) Establish a 1.32

million pound commercial quota for gag; and 4) Require operators of federally permitted Gulf of Mexico commercial and for-hire reef fish vessels to comply with the more restrictive of federal or state reef fish regulations when fishing in state waters for red snapper, greater amberjack, gray triggerfish, and gag.

May 18, 2009 - NOAA Fisheries Service implemented an emergency rule, effective May 18, 2009, through October 28, 2009, to reduce the sea turtle bycatch in the Gulf of Mexico bottom longline reef fish fishery. The emergency rule prohibits bottom longlining for Gulf reef fish east of 85^{o} 30'W longitude (near Cape San Blas, Florida) in a portion of the Exclusive Economic Zone shoreward of the 50-fathom depth contour. Once the deepwater grouper and tilefish quotas have been filled, the use of bottom longline gear to harvest reef fish in water of all depths east of 85^{o} 30'W longitude will be prohibited. During transit no reef fish may be possessed unless bottom longline gear is appropriately stowed meaning that a longline may be left on the drum if all gangions and hooks are disconnected and stowed below deck; hooks cannot be baited, and all buoys must be disconnected from the gear, but may remain on deck.

May 2, 2010 - NOAA Fisheries Service is enacting emergency regulations to close a portion of the Gulf of Mexico (Gulf) exclusive economic zone (EEZ) to all fishing, in response to the Deepwater Horizon oil spill. The closure will be in effect for 10 days, from May 2, 2010, through 12:01 a.m. local time May 12, 2010, unless conditions allow NOAA Fisheries Service to terminate it sooner. NOAA Fisheries Service will continue to monitor and evaluate the oil spill and its impacts on Gulf fisheries and will take immediate and appropriate action to extend or reduce this closed area. This closure is implemented for public safety (subsequent frequent adjustments were made to the closed area during the summer of 2010).

January 1, 2011 - NMFS implemented a temporary rule that sets the recreational gag bag limit to zero. The Gulf of Mexico Fishery Management Council requested that NMFS implement this temporary rule to address overfishing while they developed a long term rebuilding plan through Amendment 32 to the Fishery Management Plan for the Reef Fish Resources of the Gulf of Mexico.

June 1, 2011 - A temporary rule increases the 2011 commercial quota from 100,000 pounds to 430,000 pounds, and continues the suspension of the use of red grouper IFQ multiuse allocation, which could be used to harvest gag. For the recreational sector, the rule establishes a 2011 recreational season from September 16 through November 15. The current bag limit of two gag within the four fish aggregate grouper bag limit and the minimum size of 22 inches total length will be in effect during the fishing season.

2.3. Secretarial Amendments

Secretarial Amendment 1 (2004)

Implemented July 15, 2004- Set a recreational bag limit of two red grouper out of the five aggregate grouper bag limit per person, with a double bag limit allowed for persons on qualified for-hire boats that are out over 24 hours. Changed the quota for deep-water grouper from 1.6 million pounds whole weight (equal to 1.35 million pounds landed weight) to a gutted weight quota of 1.02 million pounds (equal to the average annual harvest 1996-2000. A commercial red grouper quota of 5.31 million pounds gutted weight was set with the stipulation that the commercial shallow-water grouper fishery close when either the shallow-water grouper quota or red grouper quota is reached, whichever occurs first.

2.4. Control Date Notices

Control date notices are used to inform fishermen that a license limitation system or other method of limiting access to a particular fishery or fishing method is under consideration. If a program to limit access is established, anyone not participating in the fishery or using the fishing method by the published control date may be ineligible for initial access to participate in the fishery or to use that fishing method. However, a person who does not receive an initial eligibility may be able to enter the fishery or fishing method after the limited access system is established by transfer of the eligibility from a current participant, provided the limited access system allows such transfer. Publication of a control date does not obligate the Council to use that date as an initial eligibility criteria. A different date could be used, and additional qualification criteria could be established. The announcement of a control date is primarily intended to discourage entry into the fishery or use of a particular gear based on economic speculation during the Council's deliberation on the issues. The following summarizes control dates that have been established for the Reef Fish FMP. A reference to the full *Federal Register* notice is included with each summary.

November 1, 1989:
Anyone entering the commercial reef fish fishery in the Gulf and South Atlantic after November 1, 1989, may not be assured of future access to the reef fish resource if a management regime is developed and implemented that limits the number of participants in the fishery [54 FR 46755].

November 18, 1998:
The Council is considering whether there is a need to impose additional management measures limiting entry into the recreational-for-hire (i.e., charter vessel and headboat) fisheries for reef fish and coastal migratory pelagic fish in the EEZ of the Gulf and, if there is a need, 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 and coastal migratory pelagic [63 FR 64031] (In Amendment 20 to the Reef Fish FMP, a qualifying date of March 29, 2001, was adopted).

July 12, 2000:
The Council is considering whether there is a need to limit participation by gear type in the commercial reef fish fisheries in the exclusive economic zone of the Gulf and, if there is a need, what management measures should be imposed to accomplish this. 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 a gear endorsement on the commercial reef fish vessel permit for the appropriate gear. Gear types which may be included are longlines, buoy gear, handlines, rod-and-reel, bandit gear, spear fishing gear, and powerheads used with spears [65 FR 42978].

October 15, 2004:
The Council is considering the establishment of an individual fishing quota program to control participation or effort in the commercial grouper fisheries of the Gulf. If an individual fishing quota program is established, the Council is considering October 15, 2004, as a possible control date regarding the eligibility of catch histories in the commercial grouper fishery [69 FR 67106].

December 31, 2008:
The Council voted to establish a control date for all Gulf commercial reef fish vessel permits. The control date will allow the Council to evaluate fishery participation and address any level of overcapacity. The establishment of this control date does not commit the Council or NOAA Fisheries Service to any particular management regime or criteria for entry into this fishery. Fishermen would not be guaranteed future participation in the fishery regardless of their entry date or intensity of participation in the fishery before or after the control date under consideration. Comments were requested by close of business April 17, 2009 [74 FR 11517].

2.5. Management Program Specifications

Table 2.5.1. General Management Information

Gulf of Mexico

Species	Gag
Management Unit	Gulf of Mexico
Management Unit Definition	Gulf of Mexico EEZ
Management Entity	Gulf of Mexico Fishery Management Council
Management Contacts SERO / Council	Steven Atran Dr. Carrie Simmons
Current stock exploitation status	Overfished, undergoing overfishing (2009)
Current spawning stock biomass status	9.58 million pounds, gutted weight (2009 SEDAR Gag Update, using data through 2008)

Table 2.5.2. Specific Management Criteria

Criteria	Gulf of Mexico - Current (2009)		Gulf of Mexico - Proposed	
	Definition	Value	Definition	Value
MSST	$(1-M)*SSB_{MAX}$ M=0.15	20.41 mp gw	SEDAR 33	SEDAR 33
MFMT	F_{MAX}	0.22	SEDAR 33	SEDAR 33
MSY	F_{MAX}	0.22	SEDAR 33	SEDAR 33
F_{MSY}	F_{MAX}	0.22	SEDAR 33	SEDAR 33
OY	Equilibrium Yield @ F_{OY}	4.17 mp gw	SEDAR 33	SEDAR 33
F_{OY}	75% of F_{MAX}	0.16	F_{OY} = 65%,75%, 85% F_{MSY}	SEDAR 33
M	n/a	0.15	M	SEDAR 33

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

Stock Rebuilding Information

New measures for gag were approved in Reef Fish FMP Amendment 32:

- Incrementally increasing ACLs and ACTs through 2015.
- Setting a four-month recreational season from July 1 through October 31.
- Incrementally increasing the commercial quota through 2015.
- Adjusting the commercial quota to 86% of the ACT to account for dead discards.
- Revising how gag multi-use shares are allocated in the commercial grouper/tilefish individual fishing quota program.
- Making the grouper/tilefish individual fishing program the commercial accountability measure.
- Revising the recreational accountability measures to include an overage adjustment and in-season measures.
    - An overage adjustment is if the ACL is exceeded, the amount of the overage is deducted from the following year's ACL and ACT.
    - Gag and red grouper in-season measures are if the ACL is exceeded or projected to be exceeded during the fishing year, fishing for that species will be prohibited for the remainder of the year.

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)

Gulf of Mexico

Requested Information	Value
First Year of Management	2014
Projection Criteria during interim years should be based on (e.g., exploitation or harvest)	Fixed Exploitation
Projection criteria values for interim years should be determined from (e.g., terminal year, average 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.

Projections:

Project future stock conditions and develop rebuilding schedules if warranted, including estimated generation time. Develop stock projections in accordance with the following:

A) If stock is overfished:

$F=0$, $F_{Current}$, F_{MSY}, F_{OY}
$F=F_{Rebuild}$ (max that permits rebuild in allowed time)

B) If stock is undergoing overfishing:
$F= F_{Current}$, F_{MSY}, F_{OY}

C) If stock is neither overfished nor undergoing overfishing:
$F= F_{Current}$, F_{MSY}, F_{OY}

D) If data limitations preclude classic projections (i.e. A, B, C above), explore alternate models to provide management advice

Table 2.5.5. Quota Calculation Details
If the stock is managed by quota, please provide the following information

Current Quota Value	2.11 mp gw
Next Scheduled Quota Change	2014
Annual or averaged quota?	Annual
If averaged, number of years to average	n/a
Does the quota include bycatch/discard?	Yes

2.6. Management and Regulatory Timeline

Table 2.6.1. Annual Commercial Gag Regulatory Summary *(Note: SWG = Shallow Water Grouper, ww = whole weight, gw = gutted weight, mp = million pounds)*

	Fishing Year	Size Limit	Quota	Open date	Close date
1990	311 days	20" TL	9.2 mp ww SWG quota	Jan 1	Nov 7
1991	365 days	"	9.9 mp ww SWG quota	"	Dec 31
1992	366 days	"	9.8 mp ww SWG quota	"	"
1993	365 days	"	"	"	"
1994	"	"	"	"	"
1995	"	"	"	"	"
1996	366 days	"	"	"	"
1997	365 days	"	"	"	"
1998	"	"	"	"	"
1999	320 days	24" TL	"	Jan 1, Mar 16	Feb 15, Dec 31
2000	"	"	"	"	"
2001	"	"	"	"	"
2002	"	"	"	"	"
2003	"	"	"	"	"
2004	275 days	"	8.8 mp gw SWG quota	"	Feb 15, Nov 15
2005*	320 days	"	"	"	Feb 15, Dec 31
2006*	"	"	"	"	"
2007*	"	"	"	"	"
2008*	"	"	"	"	"
2009*	"	"	1.32 mp ww	"	"
2010	365 days IFQ	"	1.41 mp gw	Jan 1	Dec 31
2011	"	"	0.430 mp gw	"	"
2012	366 days IFQ	22" TL	0.567 mp gw	"	"

*SWG/DWG Commercial Trip Limit Info: in lbs gw
2005: 10000[1]
2006: 6000
2007: 6000
2008: 6000
2009: 6000

[1] 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 the red grouper quota, then a 5,500 pound GW trip limit takes effect [70 FR 8037]

Table 2.6.2. Annual Recreational Gag Regulatory Summary *(Note: SWG = Shallow Water Grouper, ww = whole weight, gw = gutted weight, mp = million pounds)*

	# Fishing Days	Size Limit	Bag Limit	Open date	Close date
Pre-1990	365 days	20" TL	5 fish/person/day	Jan 1	Dec 31
1990	"	"	"	"	"
1991	"	"	"	"	"
1992	"	"	"	"	"
1993	"	"	"	"	"
1994	"	"	"	"	"
1995	"	"	"	"	"
1996	"	"	"	"	"
1997	"	"	"	"	"
1998	"	"	"	"	"
1999	"	22" TL	"	"	"
2000	"	"	"	"	"
2001	"	"	"	"	"
2002	"	"	"	"	"
2003	"	"	"	"	"
2004	"	"	"	"	"
2005	320 days	"	"	Jan 1, Mar 16	Feb 15, Dec 31
2006	"	"	"	"	"
2007	"	"	2 fish/person/day	"	"
2008	"	"	"	"	"
2009	305 days	"	"	Jan 1, Apr 1	Feb 1, Dec 31
2010	"	"	"	"	"
2011	61	"	"	Sep 16	Nov 15
2012	123	"	"	Jul 1	Oct 31

3. Assessment History and Review

Gulf of Mexico Gag Grouper has been previously assessed under the SEDAR process (Southeast Data, Assessment, and Review) in 2006 and 2009. The 2006 stock assessment, SEDAR 10, was a benchmark assessment for Gag Grouper (SEDAR 2006). The 2009 stock assessment provided an update to the 2006 assessment (SEDAR 2009). Gulf of Mexico Gag Grouper was previously assessed in 1994 (Schirripa and Goodyear 1994), 1997 (Schirripa and Goodyear 1997), and 2001 (Turner et al. 2001).

The 2001 assessment used VPA methods incorporating information on landings and discards from 1986 primarily through 1999, size composition, size at age and catch rate information from multiple recreational and commercial fisheries. The assessment produced a wide range of values for current fishing mortality and stock status criteria, and determined that stock status was uncertain. Due to uncertainty in the stock-recruitment relationship, reference points were based on SPR proxies. Because Gag grouper are protogynous hermaphrodites, the status of both male and female portions of the stock was evaluated.

The 2006 assessment used a statistical forward projection catch-at-age model (CASAL; Bull et al. 2012). Data sources included abundance indices, recorded landings and catch estimates, and calculated total annual age composition from the fisheries (SEDAR 2006). The assessment time series was 1963 through 2004. Due to uncertainty in the spawner-recruitment relationship, MSY-based biomass benchmarks were not deemed useful for management and current stock status was not reported in the assessment. The stock was determined to be undergoing overfishing, with the terminal year annual fishing mortality rate (0.49) estimated to be nearly double the F_{MSY} proxy ($F_{SPR30\%}$) of 0.25 (SEDAR 2007).

The 2009 update stock assessment used the same CASAL model as the 2006 benchmark assessment (SEDAR 2009). Data sources were similar to the benchmark assessment but were updated to include data through 2008. A number of alternative model runs were developed that included different values of natural mortality, different assumptions about changing catchability over time, and the inclusions of an episodic red tide mortality event in 2005. The Gulf of Mexico Fishery Management Council Scientific and Statistical Committee recommended the red tide increasing catchability model to be used for management advice. According to the red tide increasing catchability model, the status of the stock was estimated to be SSBCURRENT/MSST = 0.47. The status of the fishery was estimated to be FCURRENT/MFMT = 2.47. Thus the stock was estimated to be overfished and undergoing overfishing.

References:

Bull, B., Francis, R.I.C.C., Dunn, A., McKenzie, A., Gilbert, D.J., Smith, M.H., Bian, R., and D. Fu. 2012. CASAL (C++ algorithmic stock assessment laboratory): CASAL User Manual v2.30-2012/-3/21. NIWA Technical Report 135: 280 p.

Schirripa, M.J., and C.P. Goodyear. 1994. Status of Gag stocks of the Gulf of Mexico: Assessment 1.0. NOAA FISHERIES SERVICE, SEFSC, Miami Laboratory Contribution No. MIA 93/94-61.

Schirripa, M.J., and C.M. Legault. 1997. Status of Gag stocks of the Gulf of Mexico: Assessment 2.0. 1 October 1997. NOAA FISHERIES SERVICE, SEFSC, Miami Laboratory. 113 p. + appendix 1 p. + tables 8 p. + fig. 1 p.

SEDAR. 2006. Southeast Data, Assessment, and Review: Stock Assessment Report of SEDAR 10: Gulf of Mexico Gag Grouper. SEDAR 10. One Southpark Circle #306, Charleston, SC 29414

SEDAR. 2007. Final model for Gulf of Mexico Gag as recommended by the SEDAR Grouper review panel: revised results and projections.

SEDAR. 2009. Stock assessment of Gag in the Gulf of Mexico: SEDAR update assessment. SEDAR, North Charleston, SC.

Turner, S.C., C.E. Porch, D. Heinemann, G.P. Scott, and M. Ortiz. 2001. Status of the Gag stocks of the Gulf of Mexico: Assessment 3.0. August 2001. NOAA FISHERIES SERVICE/SEFSC Miami Laboratory, Sustainable Fisheries Division contribution SFD-01/02-134. 32 p. + tables 25 p. + figs. 84 p.

4. Regional Maps

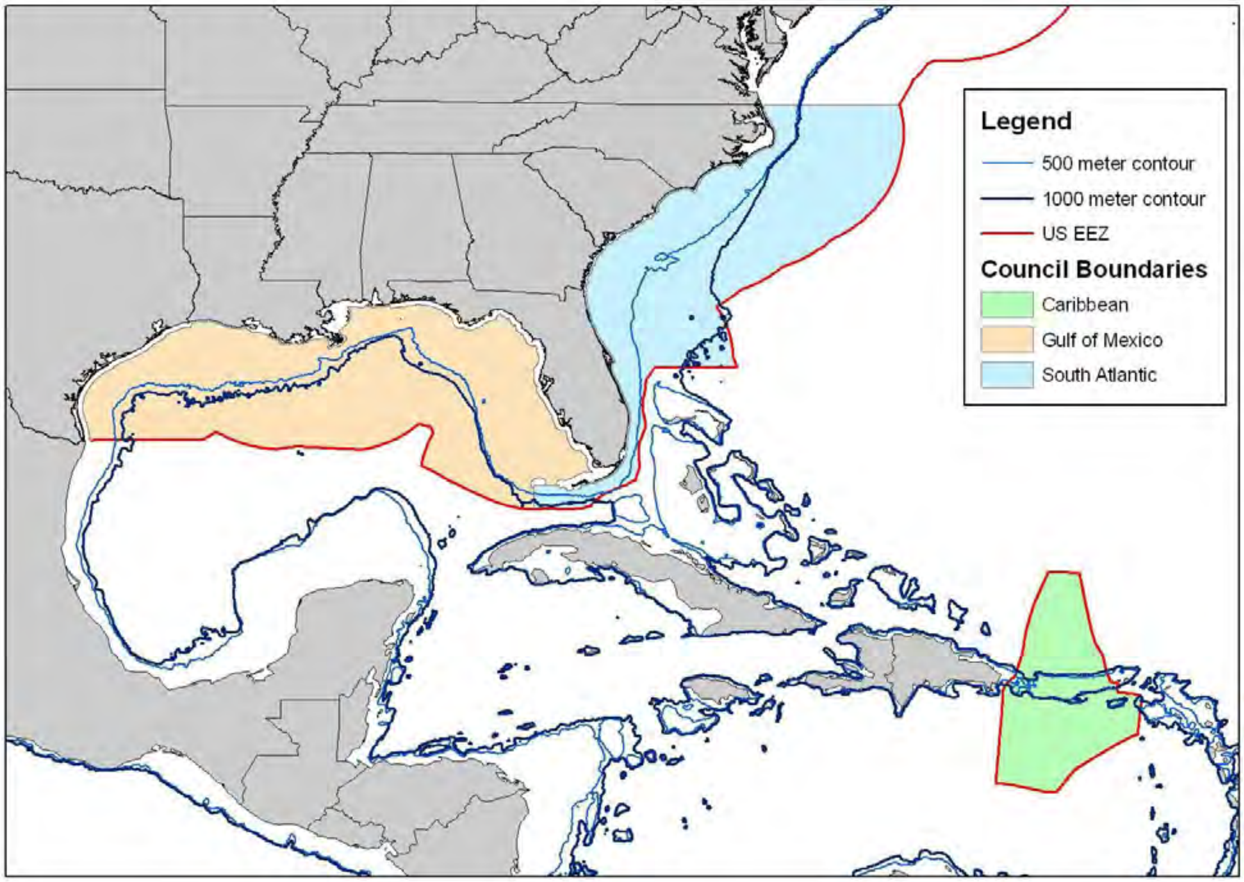

Figure 4.1. South Atlantic, Gulf of Mexico, and Caribbean Fishery Management Council boundaries, and United States EEZ.

5. Assessment Summary Report

Executive Summary

The SEDAR 33 benchmark assessment for Gulf of Mexico Gag (*Mycteroperca microlepis*) was conducted through a Data Workshop (May 20-24, 2013; Tampa, FL), 20 Assessment Workshop webinars (June 20, 2013 - January 15, 2014), and a Review Workshop (February 24-27, 2014; Miami, FL).

The Review Workshop (RW) Panel was presented outputs and results of the SEDAR 33 Gulf of Mexico Gag stock assessment, which used was Stock Synthesis (SS3), a highly flexible, integrated analysis, statistical catch-at-age model. The RW Panel concluded that the data used in the assessment were generally sound and robust, were applied properly and uncertainty in data inputs was appropriately acknowledged. Numerous sensitivity analyses and exploration of alternative scenarios were also presented during the RW. The RW Panel was very impressed with the performance of the Analytical Team (AT). It was clear that the AT had put considerable thought into the development of the assessment model, which by necessity is very complex.

Stock Status and Determination Criteria

A major consideration in the assessment was whether to base stock determination on the Spawning Stock Biomass of females only (SSB-females) or SSB for male and females (SSB-Combined). The RW Panel recommended the base model should use SSB-combined because it provides a more conservative measure of SSB given the uncertainty associated with potential male limitation for this stock. Based on this revised based case (SSB-combined), the stock is considered to be overfished ($SSB_{Current}$/MSST = 0.496) but not undergoing overfishing ($F_{Current}$/MFMT = 0.765). Under the SSB-female model, the stock is not considered overfished ($SSB_{Current}$/MSST = 2.05) nor undergoing overfishing ($F_{Current}$/MFMT = 0.322) (Table 5.1, Figures 5.1 and 5.2).

Stock Identification and Management Unit

The management unit for Gulf of Mexico Gag extends from the United States–Mexico border in the west through the northern Gulf waters and west of the Dry Tortugas and the Florida Keys (waters within the Gulf of Mexico Fishery Management Council boundaries). Currently, the Council manages Gag as one unit.

Assessment Methods

The primary assessment model selected for the Gulf of Mexico Gag stock evaluation assessment was Stock Synthesis (SS) (Methot 2010) version 3.24j (beta). Descriptions of SS algorithms and options are available in the SS user's manual (Methot 2010) and at the NOAA Fisheries Toolbox website (http://nft.nefsc.noaa.gov/). SS is an integrated statistical catch-at-age model which is widely used for stock assessments in the United States and throughout the world. SS takes relatively unprocessed input data and incorporates many of the important processes (mortality, selectivity, growth, etc.) that operate in conjunction to produce observed catch, size and age composition and CPUE indices. In addition, SS can incorporate time series of environmental data. Because many of these inputs are correlated, the concept behind SS is that they should be modeled together, which helps to ensure that uncertainties in the input data are properly accounted for in the assessment. SS has the ability to incorporate an early, data poor time period for which only catch data are available and a more recent, data-rich time-period for which indices of abundance and length and age-length or age composition data are available.

The r4ss software (www.cran.r-project.org/web/packages/r4ss/index.html) was utilized extensively to develop various graphics for the SS outputs and also was used to summarize various SS output files and to conduct the parametric bootstrap. The SS parametric bootstrap procedure was the approach used to characterize the uncertainty in final model estimates and projections of future catches for a variety of alternative scenarios recommended by the AW Panel. This tool is based on parametric bootstrap analyses used with SS (Methot 2011).

Assessment Data
Fifteen indices of abundance were presented and considered during the data workshop, seven indices were recommended for use (Figure 5.3). Three of the seven recommended indices were from fishery-independent data sources: the age-0 seagrass survey, the SEAMAP video survey, and the Panama City (PC) video survey. The DW index working group recommended four fishery-dependent indices for use: the Marine Recreational Fishery Statistics Survey (MRFSS), the Headboat Survey (HBS), the commercial vertical line index, and the commercial longline index.

Fishery-independent Data
The fishery-independent indices recommended for use were the age-0 seagrass survey, the SEAMAP video survey, and the PC video survey. The age-0 seagrass survey index was derived as the number of Gag Grouper per net haul or pull. The video survey indices were derived as the highest minimum count observed per 20 minute recording.

Fishery-dependent Data
Two of the recommended fishery-dependent indices were finalized after the data workshop, the Reef fish Commercial Logbook vertical line and longline indices. These indices provide standardized annual catch rates from the commercial fishery. Due to the implementation of the individual fishing quotas (IFQs) in 2010, the recommended terminal year for these indices was 2009. The vertical line index was derived as pounds per hook hour, whereas the longline index was derived as pounds per hook.

Other accepted fishery-dependent indices, the Headboat Survey (HBS) and the Marine Recreational Fisheries Statistical Survey (MRFSS), provided indices of abundance for the recreational fishery. The HBS index was derived as the number of Gag caught per angler hour and the MRFSS index was derived as the number of Gag caught or discarded per angler hour. The approved terminal year for the recreational indices at the DW was 2010. This terminal year was chosen because of the markedly reduced recreational fishing seasons in 2011 and 2012, which resulted in a substantial reduction in effort.

The MRFSS index that had been recommended by the DW did not implement a subsetting method to identify targeted trips. The AW panel requested that the MRFSS index be re-developed using the “guild approach” to retain trips that would have a higher probability of capturing a Gag. The guild approach included trips in the analysis if those trips also caught species determined to be in the reef fish guild, which was defined by NMFS. Lastly, two separate MRFSS indices were developed to characterize the standardized catch rates of the charterboat fishery and the private-recreational fishery. This allowed the disaggregated landings from those modes to be linked to the appropriate index of abundance.

Discard Mortality Data
Discard rates of Gag in the commercial vertical line fishery were calculated by stratifying observer and coastal logbook data by year and region (east = statistical zones 1-8, west = 9-21). Discards were calculated as: stratum specific discard rate*stratum specific effort reported to the coastal logbook program. Discards calculated for all strata within a year were summed to provide yearly discards (Figure 5.4).

Recreational discards were updated following the DW to account for changes in MRIP adjustment factors. On average, 87% of discards are from the private recreational fleet. Discards from the charterboat and headboat fleets make up 10% and 3% of the total discards on average, respectively. The number of discards have generally increased over time for each recreational fleet, peaking in 2008 for the private recreational fleet and then declining between 2010 and 2012. The number of discards peaked in 1998 for the charterboat fleet and then exhibited considerable variability until 2010 and then declined in 2011 and 2012. The pattern in the number of discards from the headboat fleet was similar to the charterboat fleet, except its peak was in 2011 and then declined substantially in 2012.

Life History Information

<u>Growth</u>
The life history data used in the assessment included natural mortality, growth, and maturity. Some life history data were included in the SS model as fixed values, while others were treated as estimable parameters. For those treated as estimable parameters, the initial parameter values were either taken directly from those provided during the DW or an updated version after the DW.

A single von Bertalanffy equation was used in the assessment model to model growth of Gag for both sexes. The von Bertalanffy parameters; L_{inf}, asymptotic length, and k, the von Bertalanffy growth coefficient, were estimated within the SS model. The estimates of the von Bertalanffy growth parameters were updated after the DW using a maximum truncated likelihood McGarvey and Fowler 2002). The estimates were as follows:

L_{inf} (mm FL) = 1277.95
k (year^{-1}) = 0.1342
t_0 (year) = -0.6687.

The estimates of L_{inf} and k were similar to what was presented at the DW; however, the estimate of t_0 was reduced. The updated estimates were used as initial starting values for L_{inf} and k. Stock Synthesis does not use t_0 as an input parameter; rather SS uses a parameterization that includes the parameters L_{min}, and A_{min} to describe the growth of fish from age 0.0 to A_{min}.

Natural Mortality
Model sensitivity to the specification of the natural mortality rate was evaluated. The natural mortality rate (M) was assumed constant over time, but decreasing with age (Figure 5.5). The form of M as a function of age was based on Lorenzen (1996). The central model uses a base $M = 0.1342\ y^{-1}$.

Selectivity and Catchability
Length-based selectivity functions were specified for each fishery and survey in the model (Figure 5.6). Selectivity patterns represent the probability of capture for a given gear and are used to model not only gear function but fishery availability (spatial patterns of fish and fishers) by spatially stratified fisheries. Functional forms of logistic or double normal curves were used in this assessment to approximate selectivity patterns. A logistic curve implies that fish below a certain size range are not vulnerable to the fishery, but then gradually increase in vulnerability to the fishery with increasing size until all fish are fully vulnerable (asymptotic selectivity curve). A double normal curve implies that the fishery selects a certain size range of fish (dome-shaped selectivity curve). Although dome-shaped selectivity curves are flexible, studies have indicated that the descending limbs of selectivity curves are confounded with natural mortality, catchability, and other model parameters if all fisheries are dome-shaped.

Release Mortality
For both the recreational and the commercial vertical line (hand-line and electric/hydraulic reels) fisheries, the DW recommended applying the depth-mortality function from Sauls (2013) that assumes 90% survivorship for Gag released in good condition. The DW recommended applying the discard mortality estimates from the baseline meta-analysis model (excluding the McGovern et al. 2005 study) to estimate discards from the commercial longline gear. The average depth used for point estimates of discard mortality for each fleet was calculated from observer data. Four of the five fishing fleets used in the assessment model have observer programs that record fate (kept/discarded alive/discarded dead) and depth of capture for each Gag during a trip. The average depth for each fishery was calculated using fish released alive (Table 5.2). Data collected as part of tagging programs by the Mote Marine Laboratory were used for the private recreational fleet.

Catch and Fishing Mortality Trends
Total fishing mortality was predicted to generally increase between 1980 and 2008 and then declined for the remainder of the time series (Figures 5.7 – 5.10). The highest predicted fishing mortality rate was in 2005, which is the year of the red tide event in the Gulf of Mexico. This red tide event was modeled as a fishing fleet that removed Gag. Its effect was not seen in the landings history, but rather, it was seen as a discard fishery and caused a substantial increase in catch in 2005. The estimated mortality rate from the red tide event was 0.708. This corresponds to a removal of 3.4 million Gag in 2005. This is substantially higher than the 1.8 million Gag Grouper estimated during the 2009 Update assessment.

Early in the time series the observed landings, catch, and predicted fishing mortality for the commercial vertical line fleet were greater than those from the other fleets and was the main source of fishing mortality prior to the late 1980s. The catch and the predicted fishing mortality from the private recreational fleet then surpassed the commercial vertical line fleet in the late

1980s. The trend in predicted fishing mortality after the late 1980s was most similar to the trends in the catch and predicted fishing mortality from the private recreational fleet. The predicted number of discards from the private recreational fishery peaked in 2008, which in turn led to the 2008 peak in the catch series. The trends in predicted fishery mortality, landings, catch, and discards for the charterboat fleet were similar to the private recreational fishery.

Predicted fishing mortality was relatively stable for the headboat fleet over time, which corresponds to relatively stable landings over time. Discards were relatively few as compared to the private recreational fishery; therefore the trend and magnitude of the catch and landings were similar over time. The fishing mortality rate of the longline fleet generally increased between 1980, when Gag first appeared in the longline landings, and 2005 and then declined over the remainder of the time-series. The trend in fishing mortality follows the trend in the observed landings. The number of discards associated with the longline fishery was relatively few as compared to the private recreational fleet; therefore, the landings and catch series are similar.

Stock Abundance and Biomass Trends

Total biomass generally increased from 1980 until 2005. Total biomass declined substantially in 2006 and in association with the red tide event in 2005. Biomass in 2007 was similar to biomass in 2006 and then increased between 2010 and 2012. Predicted female spawning biomass was relatively flat between 1980 and 1996 before increasing until 2005. Predicted spawning biomass substantially declined in 2006 (associated with red tide) and remained at a similar low level before increasing in 2010 and to a new high in 2012.

Mean age varied between age one and between 1980 and 2008. Mean age and length of the female population then increased to age 3 or 50cm in 2012. The predicted mean age and mean length of the male population were~ 11.5 years and ~100 cm in the early 1980s. Mean age and length remained between 11 and 12 years, ~100cm, until 1991, and then increased to age 13, ~106cm, between 1992 and 1997. After 1997, mean age and length of the male population declined and reached a low of 9 years and ~90cm in 2012.

The RW Panel recommended a preferred base model for Gulf of Mexico Gag similar to the model presented in the SEDAR 33 AW Report with the exception that the steepness parameter for the Beverton-Holt stock-recruitment relationship is fixed at 0.85 (Figure 5.11). In addition, the RW Panel recommended that uncertainty in steepness be incorporated into the probability distribution around the overfishing limit (range: 0.70-0.99).

Scientific Uncertainty

Uncertainty in parameter estimates and derived quantities was evaluated using multiple approaches. First, uncertainty in parameter estimates was quantified by computing asymptotic standard errors for each parameter. Asymptotic standard errors are calculated by inverting the Hessian matrix (i.e., the matrix of second derivatives of the likelihood with respect to the parameters) after the model fitting process. Asymptotic standard errors are based upon the model's analytical estimate of the variance near the converged solution.

Second, uncertainty in parameter estimates and derived quantities was investigated using a parametric bootstrap approach. Bootstrapping is a standard technique used to estimate confidence intervals for model parameters or other quantities of interest. There is a built-in option to create bootstrapped data-sets using SS. This feature performs a parametric bootstrap using the error assumptions and sample sizes from the input data to generate new observations about the fitted model expectations. The model was refit to 400 bootstrapped data-sets and the distribution of the parameter estimates was used to represent the uncertainty in the parameters and derived quantities of interest.

Likelihood profiles were completed for three key model parameters: steepness of the stock-recruit relationship (h), the log of unexploited equilibrium recruitment (R_0), and an offset parameter for initial equilibrium recruitment relative to virgin recruitment log(R_1). Likelihood profiles are commonly used to elucidate conflicting information among various data sources, to determine how asymmetric the likelihood surfaces surrounding point estimates may be, and to provide an additional evaluation of how precisely parameters are being estimated.

Sensitivities

A total of 16 sensitivities to the AW base model were presented in the SEDAR 33 AW report. During the RW, four additional sensitivities were requested by the RP. These included: 1) increased uncertainty in length-at-age for the von Bertalanffy growth model, 2) increased uncertainty in recreational landings data, 3) using trips sampled instead of individuals sampled for input sample sizes of length- and age-composition data, and 4) equally weighting all indices of abundance by setting a constant CV for all indices (Figures 5.12 and 5.13).

Significant Assessment Modifications

The greatest change between this assessment of Gag and the most recent past assessment (2009 SEDAR 10 Update) was the transition in modeling environments from CASAL to Stock Synthesis. Other substantial modifications include the integration of depth-related discard mortality rates by sector, integration of the Marine Recreational Information Program into the recreational landings data, examinations of episodic mortality events and other environmental covariates such as the *Deepwater Horizon* oil spill, and the utilization of remotely operated vehicle (ROV) derived indices of abundance. As with the previous assessment, red tide mortality was included in the model. Updated ecosystem-based modeling techniques which incorporated new data were used to include a red tide mortality index. The red tide mortality predicted in SEDAR 33 is almost double that predicted in the 2009 SEDAR 10 Update (3.4 million fish versus 1.8 million fish).

Sources of Information

The contents of this summary report were taken from the SEDAR 33 Gulf of Mexico Data, Assessment, and Review Workshop reports.

Tables

Table 5.1. Required SFA and MSRA evaluations using SPR 30% reference point for Gulf of Mexico Gag with steepness fixed at 0.85. Biomass units are in metric tons (mt).

Criteria	Definition	RW preferred - SSB Female	RW preferred - SSB Combined
Base M		0.134	0.134
Steepness		0.85	0.85
Virgin Recruitment		5,009	6,888
SSB unfished		23,416	102,947
	Mortality Rate Criteria		
$F_{MSY\ or\ proxy}$	$F_{SPR30\%}$	0.259	0.108
$F_{MSY\ or\ proxy}$	F_{MAX}	0.157	0.122
MFMT	$F_{SPR30\%}$	0.259	0.108
F_{OY}	75% of $F_{SPR30\%}$	0.194	0.081
$F_{CURRENT}$	$F_{2010-F2012}$	0.083	0.083
$F_{CURRENT}$/MFMT	$F_{2010-F2012}$	0.322	0.765
$F_{CURRENT}/F_{MSY}$	$F_{2010-F2012}/F_{SPR30\%}$	0.322	0.765
	Biomass Criteria		
$SSB_{MSY\ or\ proxy}$	Equilibrium SSB @ $F_{SPR30\%}$	6,268	27,558
$SSB_{MSY\ or\ proxy}$	Equilibrium SSB @ F_{MAX}	9,525	24,331
MSST	(1-M)*$SSB_{SPR30\%}$	5,427	23,860
$SSB_{CURRENT}$	SSB_{2012}	11,126	11,826
$SSB_{CURRENT}$/MSST	SSB_{2012}	2.050	0.496
$SSB_{CURRENT}/SSB_{MSY}$	SSB_{2012}	1.775	0.429
Equilibrium MSY	Equilibrium Yield @ $F_{SPR30\%}$	1,916	2,646
Equilibrium MSY	Equilibrium Yield @ F_{MAX}	2,216	2,634
Equilibrium OY	Equilibrium Yield @ F_{OY}	2,581	2,581
OFL	Annual Yield @ MFMT		
	OFL 2014	3,090	1,666
	OFL 2015	2,555	1,542
	OFL 2016	2,215	1,489
	OFL 2017	2,076	1,534
	OFL 2018	2,023	1,619
	OFL 2019	2,004	1,717
	OFL 2020	1,994	1,815
Annual OY (ACT)	Annual Yield @ F_{OY}		
	OY 2014	1,311	1,311
	OY 2015	1,251	1,251
	OY 2016	1,237	1,237
	OY 2017	1,295	1,295
	OY 2018	1,384	1,384
	OY 2019	1,486	1,486
	OY 2020	1,591	1,591
Annual Yield	Annual Yield @ $F_{CURRENT}$		
	Y 2014	971	885
	Y 2015	984	873
	Y 2016	1,004	886
	Y 2017	1,050	944
	Y 2018	1,109	1,024
	Y 2019	1,175	1,114
	Y 2020	1,245	1,209

Table 5.2. Calculated average depth of released Gag by fishing fleet and associated discard mortality rate estimate for Sauls (2013).

Fishing fleet	Avg. depth (m)	Sauls (2013)	SEDAR 10
Vertical line	31	0.27	0.57
Longline	58	0.27	0.76
Headboat	27	0.16	0.21
Charter boat	25	0.16	0.21
Private recreational	17	0.12	0.21

Figures

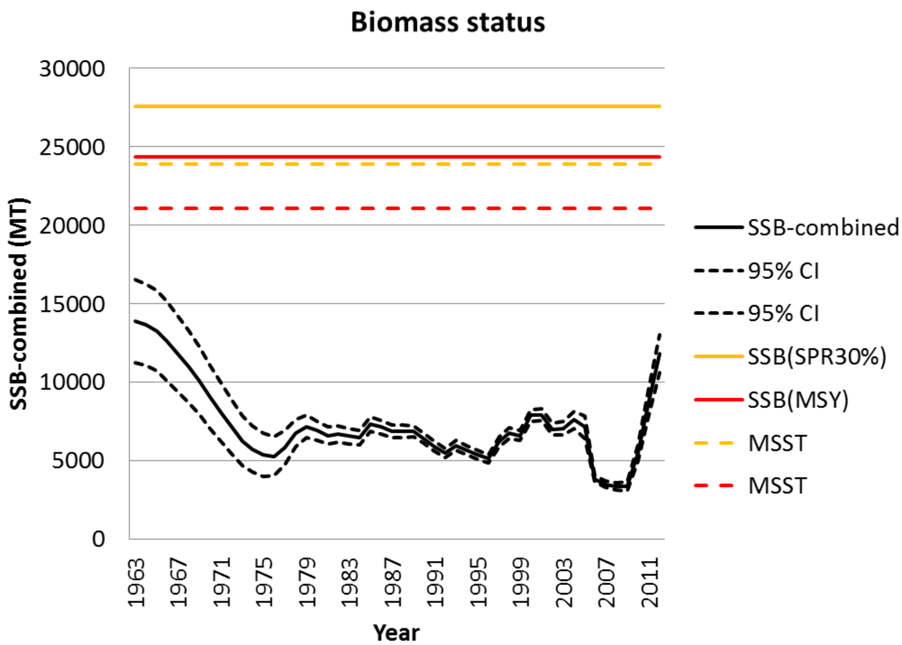

Figure 5.1. Predicted spawning stock biomass (SSB-combined) of Gulf of Mexico Gag Grouper with associated 95% asymptotic intervals. Solid horizontal lines represent $SSB_{SPR30\%}$ (orange line) and SSB_{MSY} (red line) benchmarks for SSB-combined. Dashed horizontal lines represent MSST reference points for SPR30% (orange line) and MSY (red line).

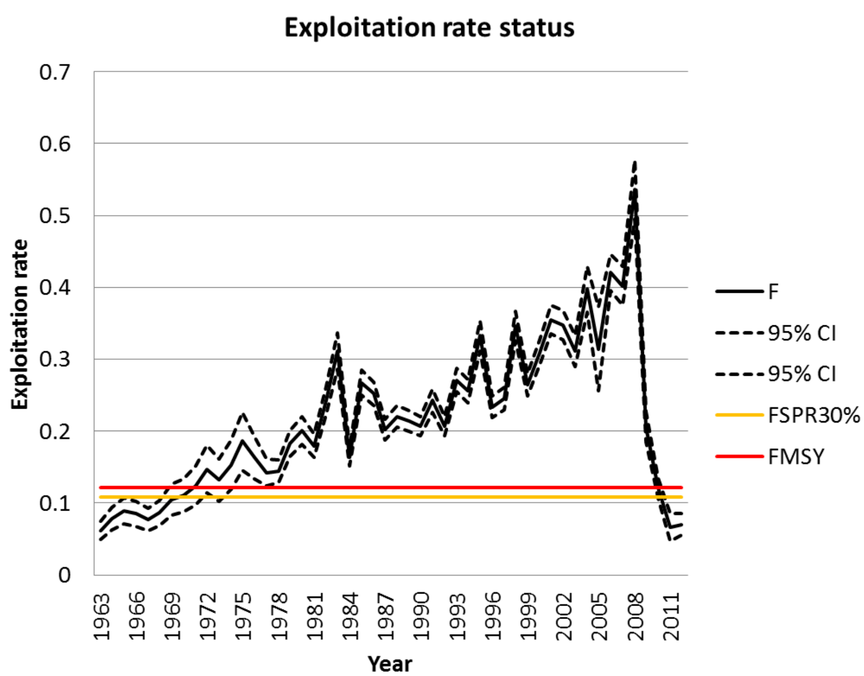

Figure 5.2. Predicted fishing mortality rate and associated 95% asymptotic intervals. Horizontal lines represent $F_{SPR30\%}$ (orange line) and F_{MSY} (red line) benchmarks for SSB-combined.

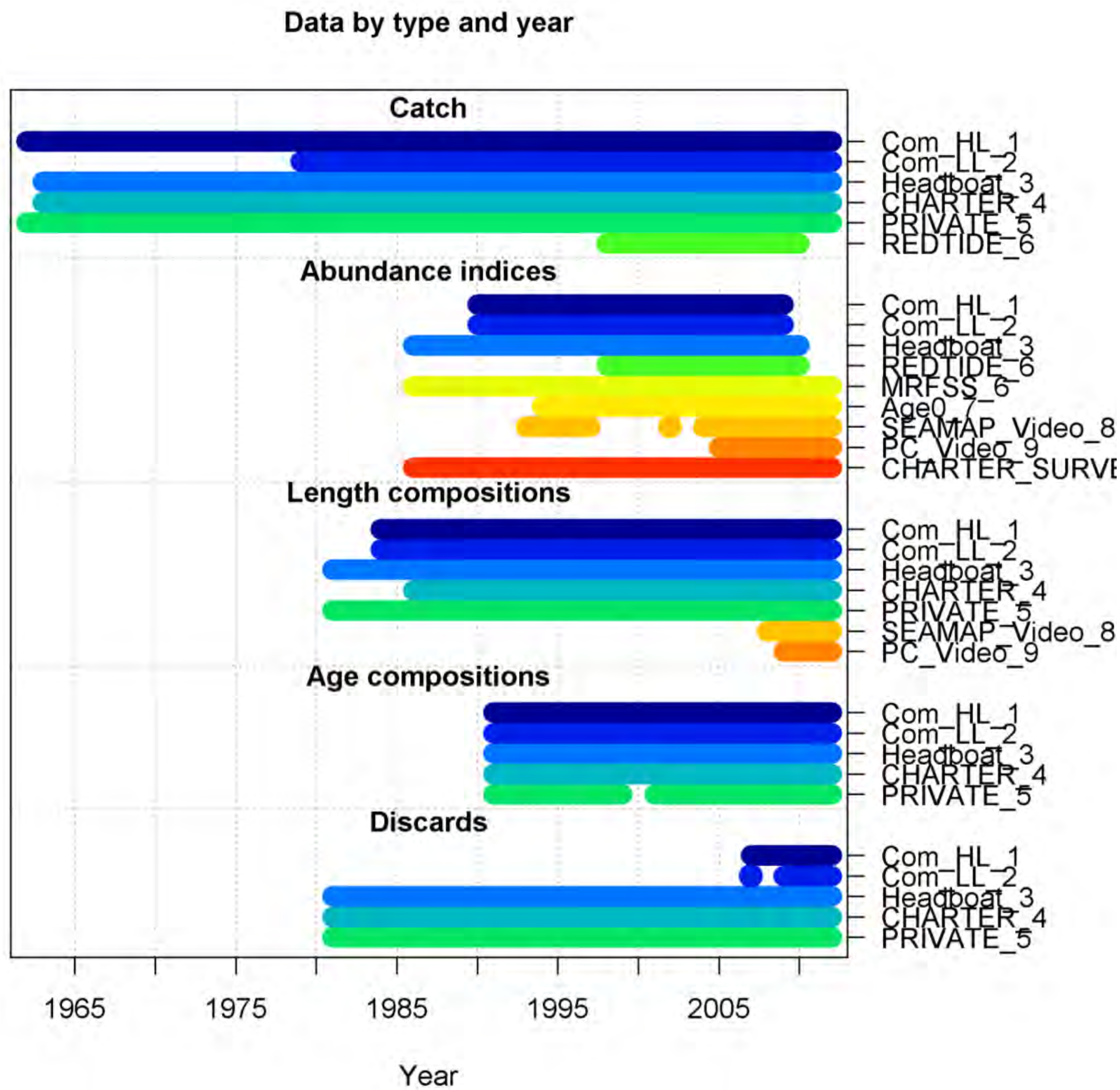

Figure 5.3. Data sources used in the assessment model.

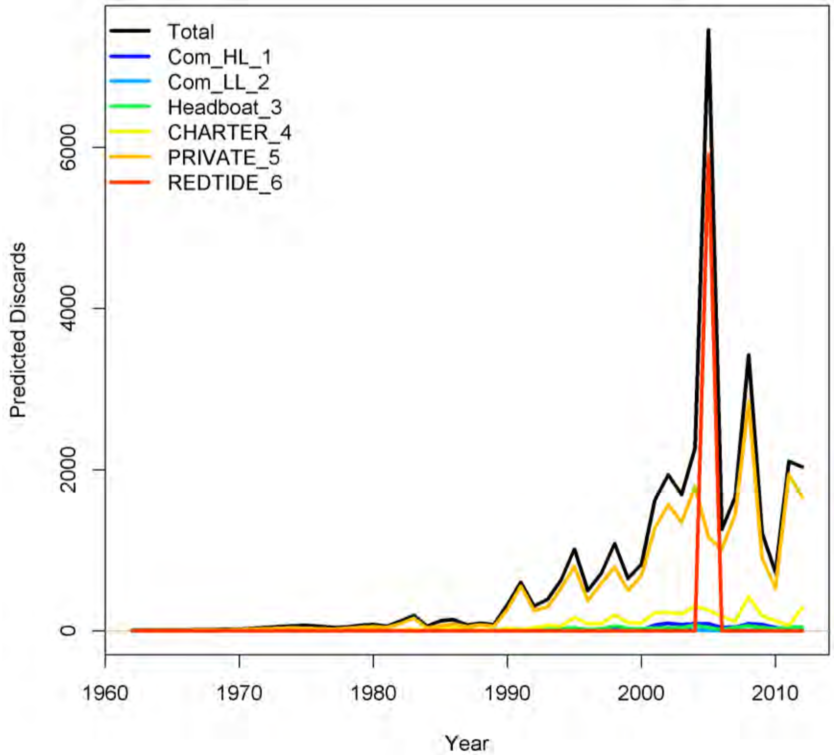

Figure 5.4. Model predicted discards (thousands of fish) by fleet. Note: The 2005 red tide event was used in the model as a discard fishery.

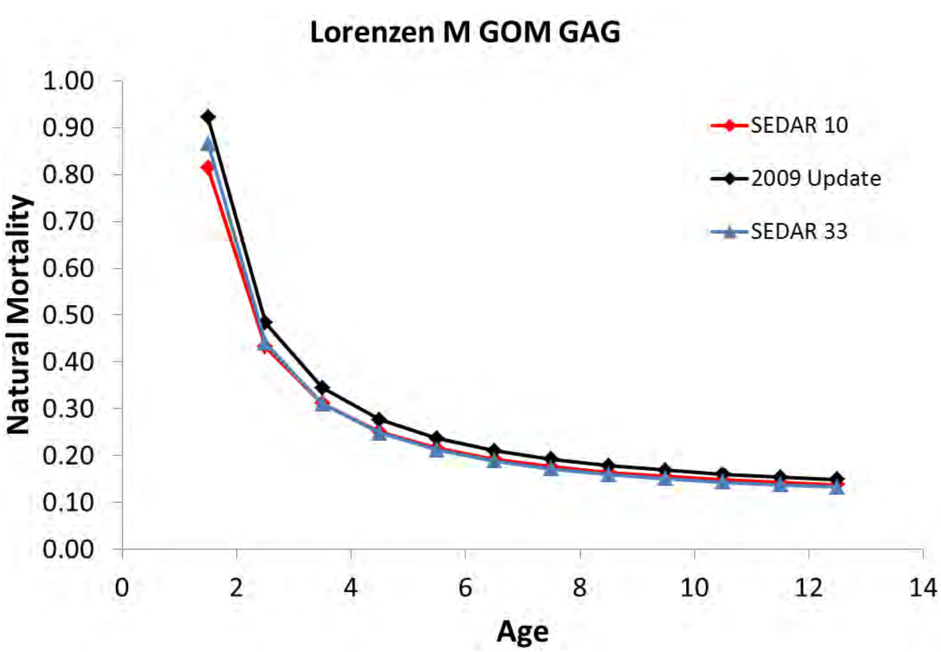

Figure 5.5. Lorenzen natural mortality as a function of age for Gag.

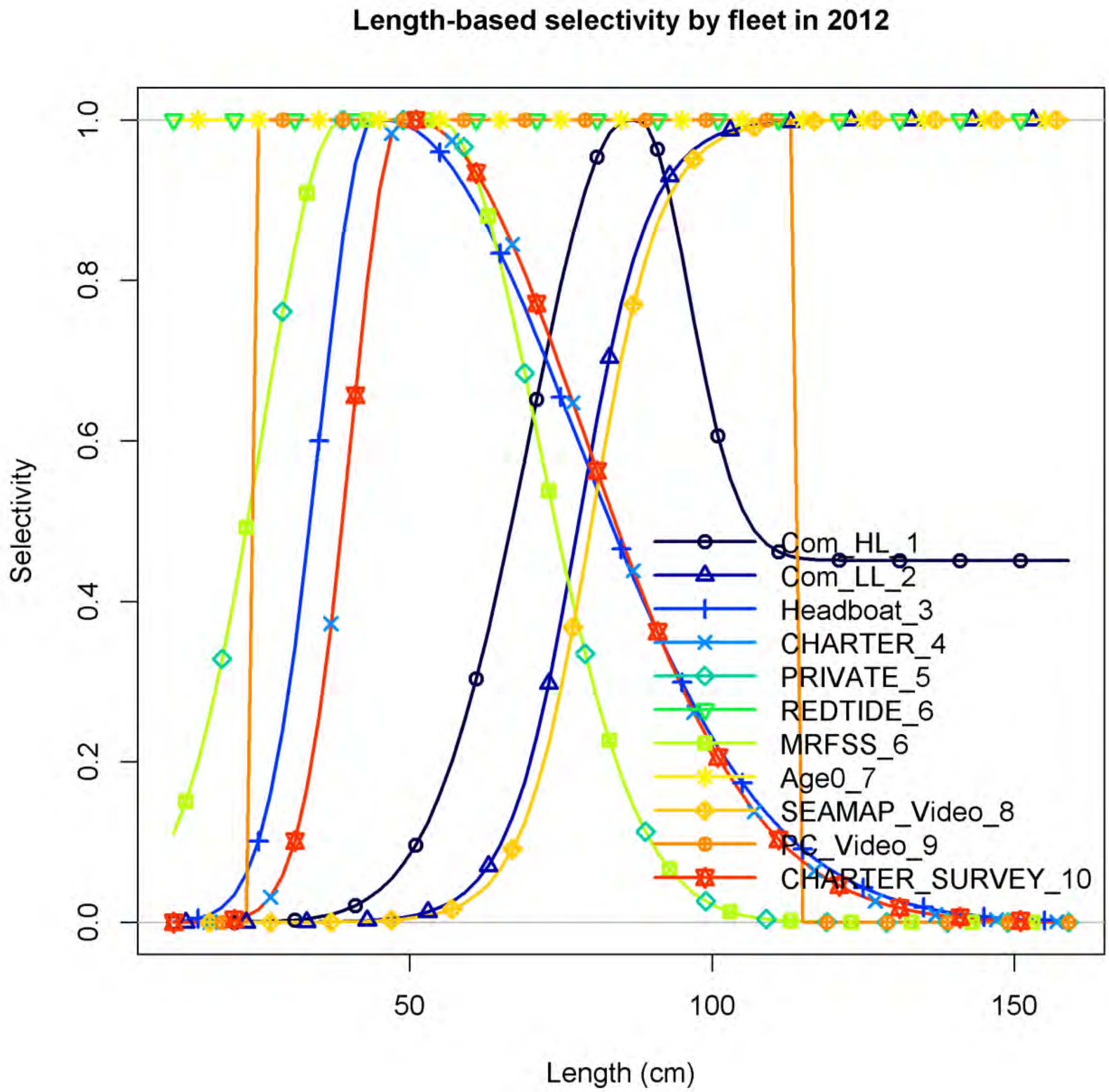

Figure 5.6. Estimated length-based selectivity patterns for the 5 fishing fleets and 2 fishery-independent surveys.

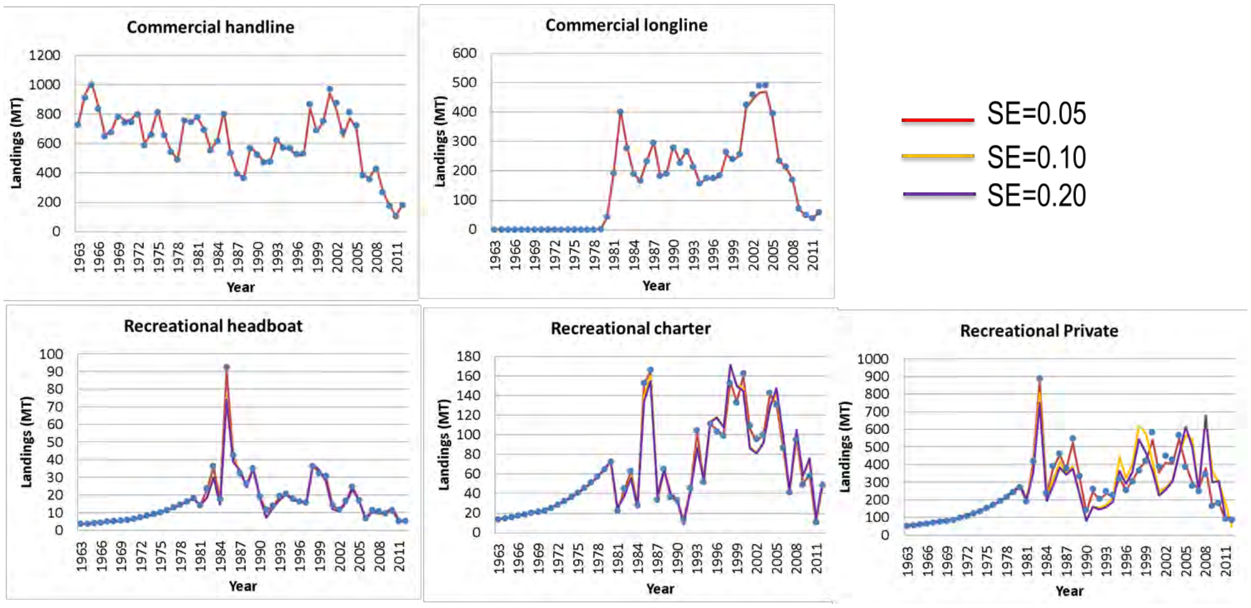

Figure 5.7. Model fit to input landings data (blue dots) for each of the five fishing fleets with three levels of SE in catch: 0.05 (red line), 0.10 (orange line), and 0.20 (purple line). Commercial landings units are MT and recreational landings units are thousands of fish.

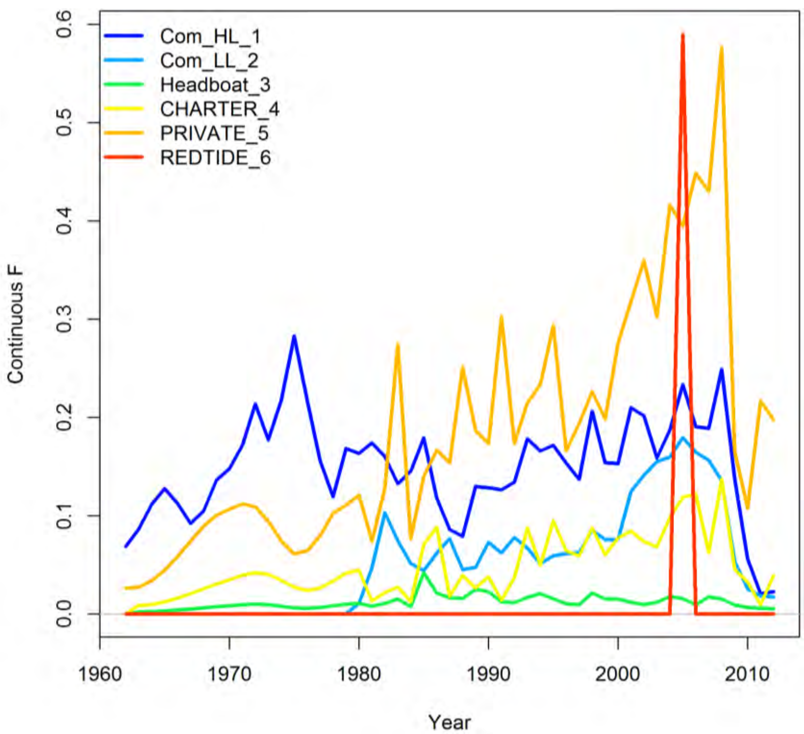

Figure 5.8. Predicted fleet specific exploitation rates.

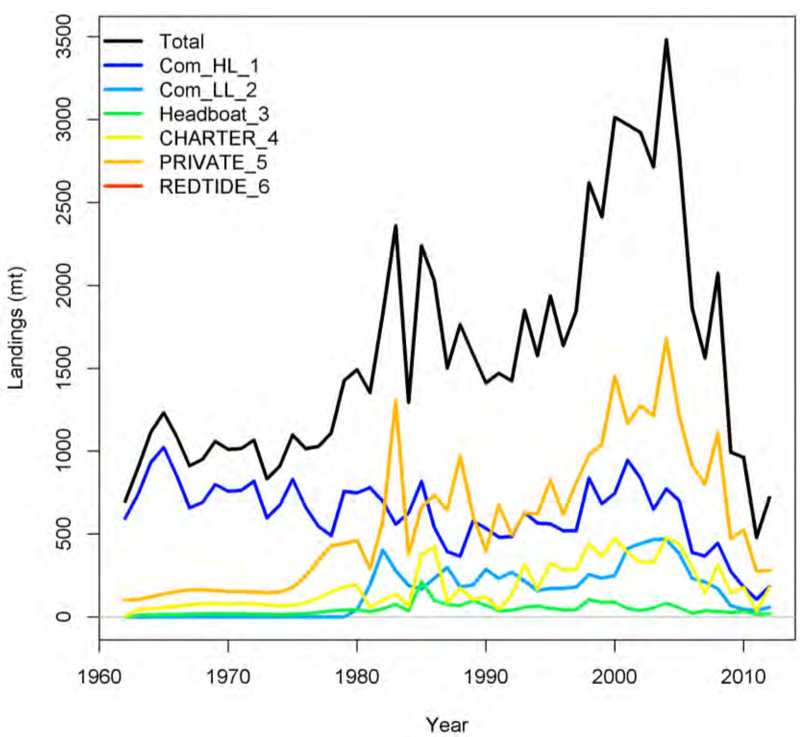

Figure 5.9. Observed landings time series for each fleet. Note, that there are no landings associated with the red tide since it was modeled as a discard only fleet.

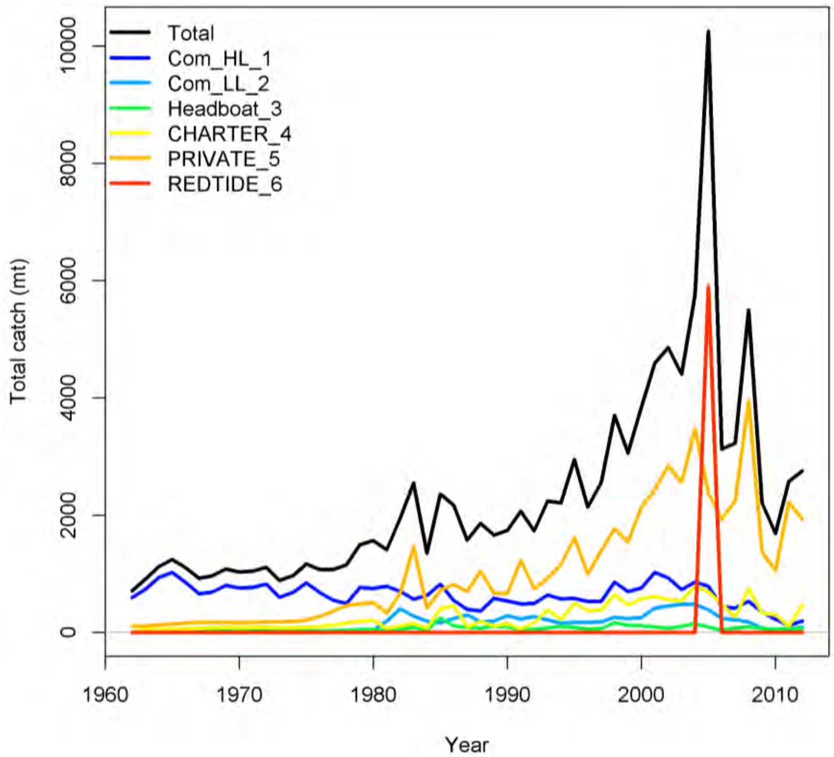

Figure 5.10. Observed catch (landings + discards) time series for each fleet. Note that the catch for the red tide fleet reflects "discards" only.

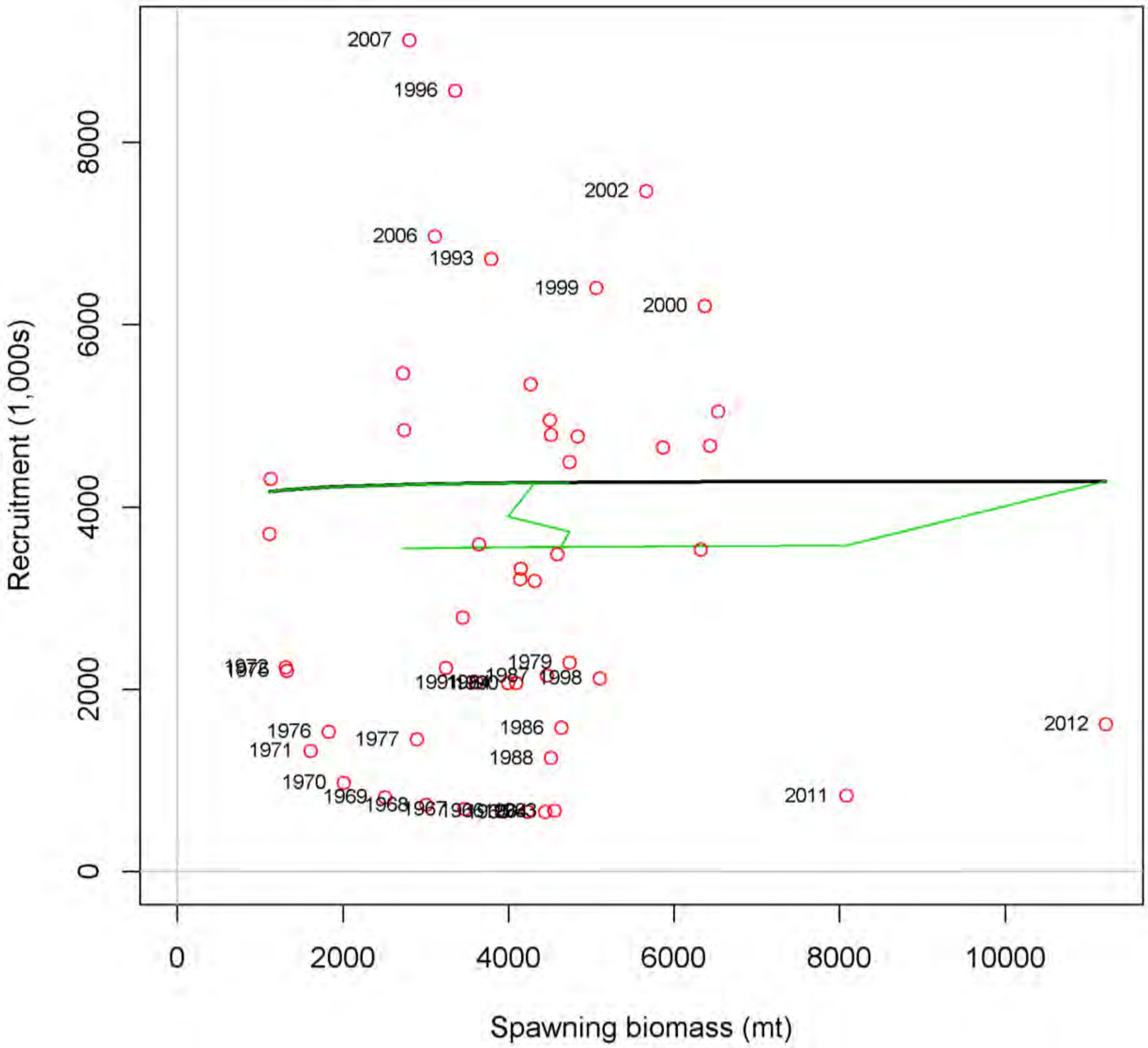

Figure 5.11. Predicted stock-recruitment relationship for Gulf of Mexico Gag Grouper for the central model. Plotted are predicted annual recruitments from SS (circles), expected recruitment from the stock-recruit relationship (black line), and bias adjusted recruitment from the stock-recruit relationship (green line).

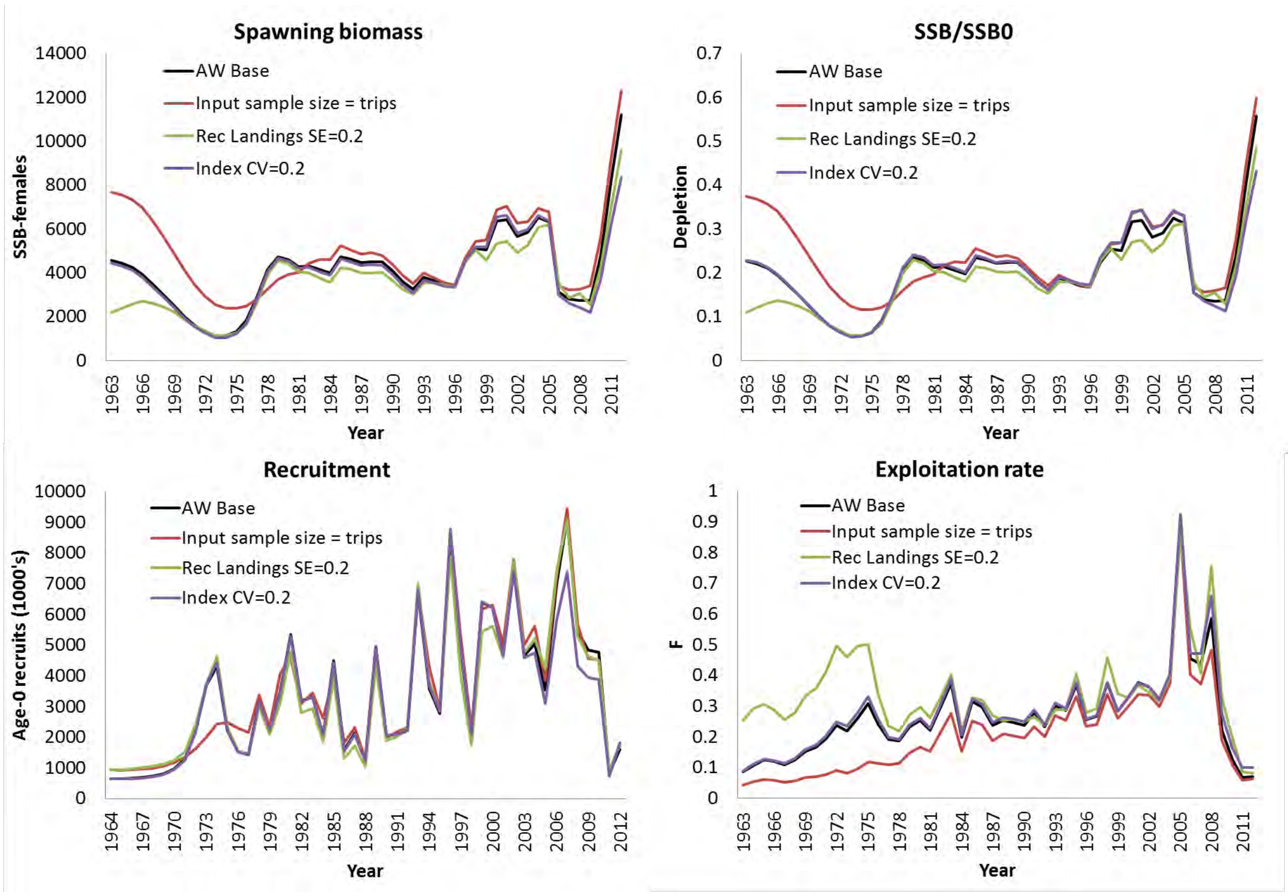

Figure 5.12. Summary of predicted trends in SSB-female, SSB-female/SSB-female unfished, recruitment, and exploitation rate for the AW base model and main sensitivities runs requested during the RW for the SSB-female model: using trips for composition data sample sizes (red line), incorporating larger uncertainty in recreational landings (green line), and equally weighting all indices of abundance using a constant CV of 0.2 (purple line).

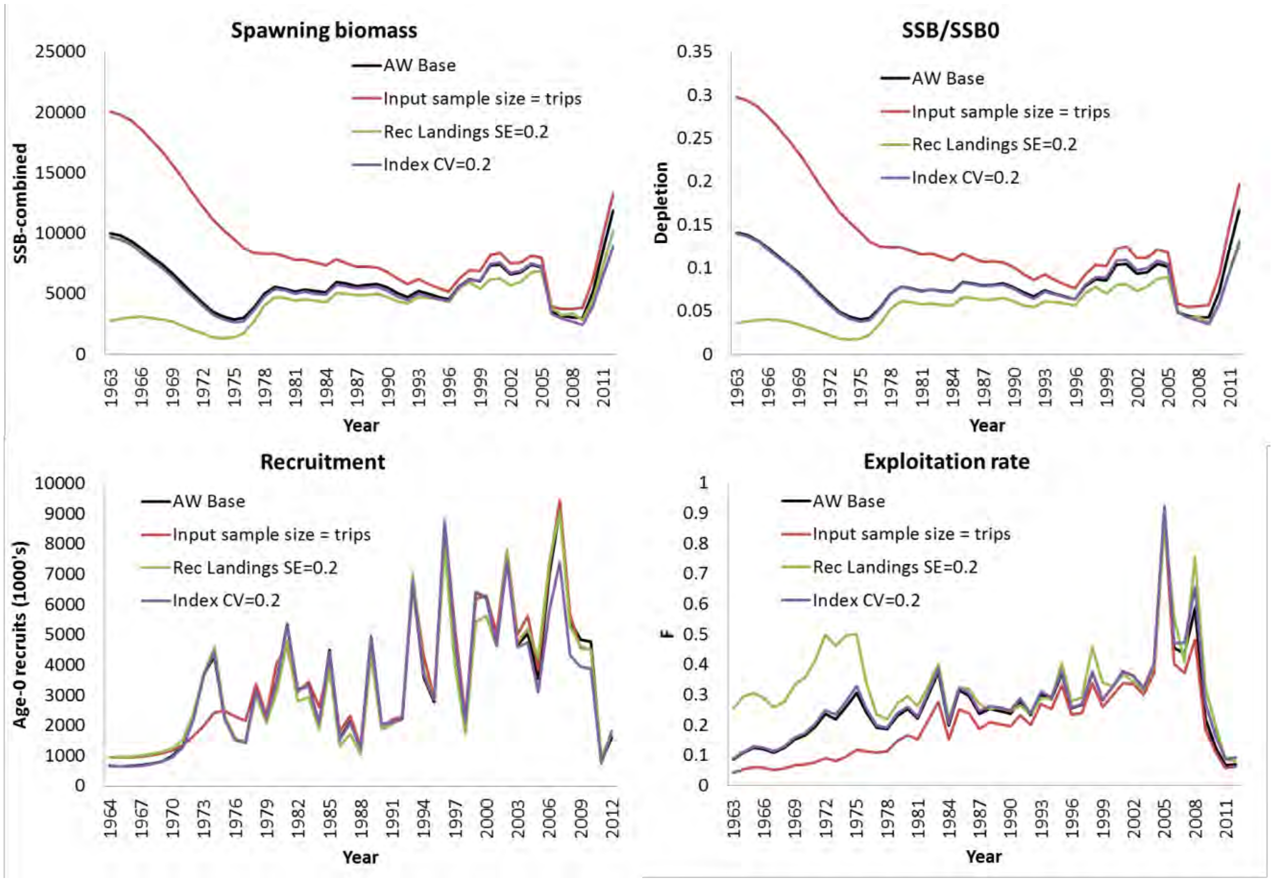

Figure 5.13. Summary of predicted trends in SSB-combined, SSB-combined/SSB-combined unfished, recruitment, and exploitation rate for the AW base model and main sensitivities runs requested during the RW: using trips for composition data sample sizes (red line), incorporating larger uncertainty in recreational landings (green line), and equally weighting all indices of abundance using a constant CV of 0.2 (purple line).

6. SEDAR Abbreviations

ABC	Acceptable Biological Catch
ACCSP	Atlantic Coastal Cooperative Statistics Program
ADMB	AD Model Builder software program
ALS	Accumulated Landings System; SEFSC fisheries data collection program
ASMFC	Atlantic States Marine Fisheries Commission
B	stock biomass level
BMSY	value of B capable of producing MSY on a continuing basis
CFMC	Caribbean Fishery Management Council
CIE	Center for Independent Experts
CPUE	catch per unit of effort
EEZ	exclusive economic zone
F	Fishing mortality (instantaneous)
FMSY	Fishing mortality to produce MSY under equilibrium conditions
FOY	Fishing mortality rate to produce Optimum Yield under equilibrium
FXX% SPR	Fishing mortality rate resulting in retaining XX% of the maximum spawning production under equilibrium conditions
FMAX	Fishing mortality that maximizes the average weight yield per fish recruited to the fishery
F_0	Fishing mortality close to, but slightly less than, F_{Max}
FL FWCC	Florida Fish and Wildlife Conservation Commission
FWRI	(State of) Florida Fisheries and Wildlife Research Institute
GA DNR	Georgia Department of Natural Resources
GLM	General Linear Model
GMFMC	Gulf of Mexico Fishery Management Council
GSMFC	Gulf States Marine Fisheries Commission
GULF FIN	GSMFC Fisheries Information Network
M	natural mortality (instantaneous)
MARMAP	Marine Resources Monitoring, Assessment, and Prediction
MFMT	Maximum Fishing Mortality Threshold, a value of F above which overfishing is deemed to be occurring
MRFSS	Marine Recreational Fisheries Statistics Survey; combines a telephone survey of households to estimate number of trips with creel surveys to estimate catch and effort per trip
MRIP	Marine Recreational Information Program
MSST	Minimum Stock Size Threshold, a value of B below which the stock is deemed to be overfished
MSY	maximum sustainable yield
NC DMF	North Carolina Division of Marine Fisheries
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
OY	Optimum Yield
SAFMC	South Atlantic Fishery Management Council
SAS	Statistical Analysis Software, SAS Corporation
SC DNR	South Carolina Department of Natural Resources
SEDAR	Southeast Data, Assessment and Review

SEFSC	Southeast Fisheries Science Center, National Marine Fisheries Service
SERO	Southeast Regional Office, National Marine Fisheries Service
SPR	Spawning Potential Ratio, stock biomass relative to an unfished state of the stock
SSB	Spawning Stock Biomass
SSC	Science and Statistics Committee
TIP	Trip Incident Program; biological data collection program of the SEFSC and Southeast States.
Z	total mortality, the sum of M and F

SEDAR

Southeast Data, Assessment, and Review

SEDAR 33
Section II: Data Workshop Report

Gulf of Mexico Gag

August 2013

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

Table of Contents

1. Introduction

1.1 Workshop Time and Place

The SEDAR 33 Data Workshop for Gulf of Mexico Gag (*Mycteroperca microlepis*) was held May 20-24, 2013 in Tampa, Florida.

1.2 Terms of Reference

1. Review stock structure and unit stock definitions, considering whether changes are required.
2. Review, discuss, and tabulate available life history information.
    - Evaluate age, growth, natural mortality, and reproductive characteristics
    - Provide appropriate models to describe growth, maturation, and fecundity by age, sex, hermaphroditism including age and size at transition, and/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. Recommend discard mortality rates.
    - Review available research and published literature
    - Consider research directed at gag as well as similar species from other areas
    - Provide estimates of discard mortality rate by fishery, gear type, depth, and other feasible or appropriate strata
    - Include thorough rationale for recommended discard mortality rates
    - Provide justification for any recommendations that deviate from the range of discard mortality provided in the last update or other prior assessment
4. Provide measures of population abundance that are appropriate for stock assessment.
    - Consider and discuss all applicable fishery dependent and independent data sources
    - Document all programs evaluated; address program objectives, methods, coverage, sampling intensity, and other relevant characteristics
    - Provide maps of fishery and survey coverage
    - Develop fishery and survey CPUE indices by appropriate strata (e.g., age, size, area, and fishery) and include measures of precision and accuracy; rank indices with regard to their suitability for use in assessment modeling
    - Discuss the degree to which available indices adequately represent fishery and population conditions
    - Recommend which data sources are considered appropriate for use in assessment modeling
    - Complete the SEDAR index evaluation worksheet for each index considered

5. Characterize commercial and recreational catch, including both landings and discards in both pounds and numbers.
    - Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by fishery sector or gear
    - Provide length and age distributions if feasible, and maps of fishery effort and harvest
    - Provide maps of fishery effort and harvest
6. Describe any environmental covariates or episodic events that would be reasonably expected to affect population abundance.
7. Provide any information available about demographics and socioeconomics of fishermen, especially as they may relate to fishing effort.
8. Provide recommendations for future research, including guidance on sampling design, intensity, and appropriate strata and coverage.
9. 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
    - Review and describe any ecosystem consideration(s) that should be included in the stock assessment report

1.3 List of Participants

Data Workshop Panel

Cameron Ainsworth	USF	Mandy Karnauskas	SEFSC
Robert Allman	SEFSC	Walter Keithly	Gulf SSC
Neil Baertlein	SEFSC	Linda Lombardi	SEFSC
Beverly Barnett	SEFSC	Behzad Mahmoudi	FWRI
Donna Bellais	GSMFC	Beverly Sauls	FWC
Dave Chagaris	FWRI	Vivian Matter	SEFSC
Mary Christman	MCCSC	John Mareska	Gulf SSC
Jason Delacruz	RFSA	Debra Murie	UF
Doug DeVries	SEFSC	Adam Pollack	SEFSC
Gary Fitzhugh	NMFS	Ted Switzer	FWRI
Dave Gloeckner	SEFSC	Michael Schirripa	SEFSC
Arnaud Gruss	RSMAS	Chris Stallings	USF
Jeff Isely	SEFSC		

Council and Agency Staff

Ryan Rindone	SEDAR	Charlotte Schiaffo	GMFMC
Jessica Stephen	SERO	Patrick Davis	SEFSC
Rich Malinowski	SERO	Steven Atran	GMFMC
Doug Gregory	GMFMC	Jessica Stephen	SERO
Kathy Guindon	FWRI	Patrick Gilles	SEFSC
Meaghan Bryan	SEFSC	Shannon Cass-Calay	SEFSC

Jakob Tetzlaff	SEFSC	Adyan Rios	SEFSC
Jay Boule	SEFSC		

Data Workshop Observers

Chad Hanson	PEG	Alicia Gray	USF

1.4 List of Data Workshop Working Papers

Document Number	Species	Title	Authors
Data Workshop Documents			
SEDAR33-DW01	Both	Greater Amberjack and Gag Grouper Catches from Mississippi Laboratories Fishery Independent Surveys	Pollack and Ingram
SEDAR33-DW02	Gag	Protection of Grouper and Red Snapper Spawning in Shelf-Edge Marine Reserves of the Northeastern Gulf of Mexico: Demographics, Movements, Survival and Spillover Effects	Koenig and Coleman
SEDAR33-DW03	Gag	Fishery-Independent Indices of Abundance for Gag (*Mycteroperca microlepis*) in the Northeastern Gulf of Mexico, with Intrinsic Habitat Quality Controlled and Contrasted	Lindberg, Christman, and Marcinek
SEDAR33-DW04	GAJ	Characterization of Greater Amberjack Discards in Recreational For-Hire Fisheries	Sauls and Cernak
SEDAR33-DW05	Gag	Characterization of Gag Discards in Recreational For-Hire Fisheries	Sauls and Cernak
SEDAR33-DW06	Gag	Condition and Relative Survival of Gag *Mycteroperca microlepis* Discards Observed Within a Recreational Hook-and-Line Fishery	Sauls
SEDAR33-DW07	Gag	Natural Mortality of Gag Grouper from 1950 to 2009 Generated by an Ecosim Model	Chagaris and Mahmoudi
SEDAR33-DW08	Gag	Satellite derived indices of red tide severity for input for Gulf of Mexico Gag grouper stock assessment	Walter, Christman, Landsberg, Linton, Steidinger, Stumpf, Tustison
SEDAR33-DW09	Gag	Use of otolith microchemistry to improve fisheries-independent indices of recruitment for gag (*Mycteroperca microlepis*): linking estuarine nurseries to nearshore reefs in the eastern Gulf of Mexico	Jones, Switzer, Houston, and Peebles

SEDAR33-DW10	Both	Incorporating various Gulf of Mexico Integrated Ecosystem Assessment products into the Stock Synthesis Integrated Assessment Model framework	Schirripa, Methot, et al.
SEDAR33-DW11	Gag	Evaluation of natural mortality rates and diet composition for gag (*Mycteroperca microlepis*) in the West Florida Shelf ecosystem using the individual-based, multi-species model OSMOSE	Gruss, Schirripa, Chagaris, Drexler, Simons, Verley, Shin, Karnauskas, Penta, de Rada, and Ainsworth
SEDAR33-DW12	GAJ	Seasonal movement and mixing rates of greater amberjack in the Gulf of Mexico and assessment of exchange with the South Atlantic spawning stock.	Murie, Parkyn, and Austin
SEDAR33-DW13	Gag	Observer reported size distribution and discard characteristics of Gulf of Mexico Gag from the commercial vertical line and bottom longline fisheries	Johnson
SEDAR33-DW14	GAJ	Observer reported size distribution and discard characteristics of Gulf of Mexico Greater Amberjack from the commercial vertical line and bottom longline fisheries	Johnson
SEDAR33-DW15	Gag	SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Gag	Campbell, Rademacher, Felts, Noble, Felts, and Salisbury
SEDAR33-DW16	GAJ	SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Greater Amberjack	Campbell, Rademacher, Felts, Noble, Felts, and Salisbury
SEDAR33-DW17	Gag	Update concerning species misidentifications in the commercial landing data of gag groupers and black groupers in the Gulf of Mexico	Chih
SEDAR33-DW18	Gag	Use of the Connectivity Modeling System to estimate movements of gag grouper (*Mycteroperca microlepis*) recruits in the northern Gulf of Mexico	Karnauskas, Paris, Zapfe, Gruss, Walter, and Schirripa
SEDAR33-DW19	Both	A meta-data analysis of discard mortality estimates for gag grouper and	Lombardi, Campbell, Sauls,

		greater amberjack	and McCarthy
SEDAR33-DW20	Gag	Gag Life History Working Group Draft Working Document	Gag Life History Working Group
SEDAR33-DW21	GAJ	Greater amberjack (*Seriola dumerili*) otolith ageing summary for Panama City laboratory (2009-2012)	Allman, Trowbridge, and Barnett
SEDAR33-DW22	Gag	Age, length, and growth of gag (*Mycteroperca microlepis*) from the northeastern Gulf of Mexico: 1978-2012	Lombardi, Fitzhugh, and Barnett
SEDAR33-DW23	Gag	Catch and bycatch of gag grouper in the Gulf of Mexico shark and reef fish bottom longline fishery based on observer data	Gulak and Carlson
SEDAR33-DW24	GAJ	Catch and bycatch of greater amberjack in the Gulf of Mexico shark and reef fish bottom longline fishery based on observer data	Gulak and Carlson
SEDAR33-DW25	GAJ	Regional stock structure of greater amberjack in the southeastern United States using otolith shape analysis	Crandall, Parkyn, and Murie
SEDAR33-DW26	Both	Relative abundance of gag grouper and greater amberjack based on observer data collected in the reef fish bottom longline fishery	Carlson, Gulak, Scott-Denton, and Pulver
SEDAR33-DW27	GAJ	Non-lethal sex determination of greater amberjack with direct application to sex ratio analysis of the Gulf of Mexico stock	Smith, Murie, and Parkyn
SEDAR33-DW28	Gag	Gag *Mycteroperca microlepis* Findings from the NMFS Panama City Laboratory Trap & Camera Fishery-Independent Survey – 2004-2012	DeVries, Gardner, Raley, and Ingram

Reference Documents			
SEDAR33-RD01	GAJ	SEDAR 9: Gulf of Mexico Greater Amberjack Stock Assessment Report	SEDAR
SEDAR33-RD02	GAJ	2010 SEDAR 9 Update: Gulf of Mexico Greater Amberjack	SEDAR
SEDAR33-RD03	Gag	SEDAR 10: Gulf of Mexico Gag Stock Assessment Report	SEDAR
SEDAR33-RD04	Gag	2009 SEDAR 10 Update: Gulf of Mexico Gag	SEDAR
SEDAR33-RD05	GAJ	Gulf of Mexico Greater Amberjack Management History	GMFMC
SEDAR33-RD06	Gag	Gulf of Mexico Gag Management	GMFMC

		History	
SEDAR33-RD07	Gag	Status of Gulf of Mexico Gag Grouper: Results and Projected Implications of the Revisions and Sensitivity Runs Suggested by the Grouper Review Panel	SEFSC
SEDAR33-RD08	Gag	Final Model for Gulf of Mexico Gag Grouper as Recommended by the SEDAR Grouper Review Panel: Revised results and projections	SEFSC
SEDAR33-RD09	Gag	Stock Assessment of Gag in the Gulf of Mexico: SEDAR Update Assessment Rerun	SEFSC
SEDAR33-RD10	GAJ	Preliminary Analysis of Tag and Recapture Data of the Greater Amberjack, *Seriola dumerili*, in the Southeastern United States	McClellan and Cummings
SEDAR33-RD11	GAJ	Trends in the Gulf of Mexico Greater Amberjack Fishery through 1998: Commercial Landings, Recreational Catches, Observed Length Frequencies, Estimates of Landed and Discarded Catch at Age, and Selectivity at Age	Cummings and McClellan
SEDAR33-RD12	GAJ	Age, growth, and reproduction of greater amberjack, *Seriola dumerili*, in the southwestern north Atlantic	Harris
SEDAR33-RD13	GAJ	Age, Growth and Sex Maturity of Greater Amberjack (*Seriola dumerili*) in the Gulf of Mexico	Murie and Parkyn
SEDAR33-RD14	Gag	Annual Indices and Trends of Abundance for Gag (*Mycteroperca microlepis*) on the Shallow Continental Shelf in the Northeastern Gulf of Mexico	Lindberg, Christman, Marcinek, and Bohrmann
SEDAR33-RD15	Gag	Stock Identification of Gag, *Mycteroperca microlepis*, Along the Southeast Coast of the United States	Chapman, Sedberry, Koenig, and Eleby
SEDAR33-RD16	Gag	A Tag and Recapture Study of Gag, *Mycteroperca microlepis*, off the Southeastern U.S.	McGovern, Sedberry, Meister, Westendorff, Wyanski, and Harris
SEDAR33-RD17	Gag	Empirical Use of Longevity Data to Estimate Mortality Rates	Hoenig
SEDAR33-RD18	Gag	Discard composition and release fate in the snapper and grouper commercial	Rudershausen, Buckel, and

		hook-and-line fishery in North Carolina, USA	Williams
SEDAR33-RD19	Gag	Modeling Protogynous Hermaphrodite Fishes Workshop	Sheperd, Shertzer, Coakley, and Caldwell
SEDAR33-RD20	GAJ	Field Based Non-Lethal Sex Determination and Effects of Sex Ratio on Population Dynamics of Greater Amberjack, *Seriola dumerili*	Smith

2 Life History

2.1 Overview

The life history workgroup (LHW) reviewed and discussed data collected since the last Gulf of Mexico gag stock assessment in 2006 and offered recommendations. Updated information was examined and new studies were reviewed regarding age, growth, reproduction, genetics, otolith chemistry, mortality, habitat and movement. A summary of the data presented, discussed and recommendations made is presented below.

2.1.1 Life History Workgroup Members

Gary Fitzhugh
Linda Lombardi
John Mareska
Robert Allman
Chris Stallings
Debra Murie
Beverly Barnett
Kathy Guindon

2.1.2 The LHW group addressed the following topics

Attributes of stock structure and unit stock definition, age data and aging error, growth, natural mortality, reproductive characteristics including maturity, alternative forms of reproductive potential (spawning stock biomass and fecundity), sex transition, sex ratio and meristic conversions.

2.2 Stock Definitions

Within U.S. waters, gag has been managed as separate south Atlantic (Atlantic) and Gulf of Mexico (Gulf) stock units. The LHW discussed stock identification issues, acknowledging work underway, and given that new data is inconclusive regarding the degree of exchange between the Gulf and Atlantic, and within the Gulf between Campeche, northern Gulf and the west Florida shelf, made a recommendation to maintain status quo as two separate US stocks for this assessment.

2.2.1 Genetic results

Genetic studies can provide both long-term and short-term estimates of connectivity among regional populations of gag. A previous study (Chapman et al. 1999) exhibited evidence for population structure among different regions of the Gulf and Atlantic coasts. Cushman et al. (2009) did not support Chapman et al. (1999) and provided evidence for little genetic divergence between Gulf and Atlantic gag. Stocks were genetically indistinguishable between the 2 basins. This genetic homogeneity can be maintained with low dispersal rates, but dispersal rates remain uncertain. Jue (2010) examined genetics and larval dispersion for years 2004- 2006 within the eastern Gulf of Mexico. There was no evidence of "chaotic genetic patchiness or sweepstakes recruitment hypothesis" due to high variability in maternal reproductive success among individuals (Jue 2010). Fluctuation in year-to-year juvenile densities was observed but there was no relationship between these abundance patterns and genetic diversity (Jue 2010). Jue (2010) also examined genetic differences between the west Florida shelf (WFS) and Campeche Bank adult gag. While some genetic differentiation was detectable, evidence pointed to a small amount of historical and ongoing one-way genetic exchange from Campeche to the WFS (Jue 2010, and see section 2.2.3 larval connectivity).

2.2.2 Otolith constituent analysis

Chemical signatures in otoliths have been used recently to discriminate gag from different nursery habitats. Hanson et al. (2004) demonstrated that chemical signatures in otoliths of gag could be used to classify juveniles from four nursery areas along the west Florida shelf (classification success ranged 66-100%). Results indicate the approach has promise for determining population structure and the relative contribution of gag from different nurseries. Renan et al. (2011) conducted otolith shape analysis from gag on the eastern, northern and western Campeche fishing grounds and found no distinct differences. Fodrie (2012) examined otolith chemistry of gag off Alabama to determine nursery signatures. Results predicted that a high proportion of the Alabama fish contained nursery signatures from Florida and Louisiana estuaries (88%). Jones et al. (2013) examined age-0 gag from the 2009 year class collected through the Florida Fish and Wildlife Conservation Commission, Fishery Independent Monitoring program (FIM) and found highly significant spatial variability among nursery habitats on the west Florida shelf. Based on the older gag from the 2009 year class, distinct cohorts of recruits had affinities for either southern or northern nursery regions. Among several studies reviewed, a theme of differing recruitment or demographic patterns detected from northern as opposed to southern nurseries along the Florida Gulf peninsula is repeated.

2.2.3 Larval transport and connectivity

During SEDAR 10 there was recognition of possible larval connectivity and transport from the Gulf to the Atlantic and for cross-basin transport within the Gulf between Campeche and the west Florida Shelf (SEDAR 2006). At that time the only exploration of transport hypotheses included a wind-driven 2-d transport model which was unable to account for cross-shelf transport (references within SEDAR 2006). New information both via genetics and oceanographic simulation has advanced our understanding. Jue (2010) provides evidence that a very small number of larvae may be provided to the west Florida shelf from the Campeche banks in a one-way flow scenario based upon genetic results. Donald Johnson, of Gulf Coast Research Laboratory reprogrammed his Campeche based model, (Johnson et al. 2012), to accommodate gag life history parameters for a January-March spawning period and a 45-day pelagic larval duration. Most Campeche gag were retained on the Mexican shelf but a small but perhaps significant percentage (about 2%) of successful US shelf landings (defined as ending in ≤ 200 m) occurred in the years that were simulated (Figure 2.1). The main difference in model results between years was principally due to the Loop Current intrusion and eddy activity in the northern Gulf. For example, the year 2010 was noted to have especially low intrusion and activity. These preliminary simulations were conducted based upon request for this data workshop and indicates that just via Loop current effects, transport mechanisms could differ between the northeastern Gulf and southern Florida peninsula. Johnson's results also highlight the potential for larval advection to the South Atlantic (Figure 2.1).

Todd (2013) modeled gag larval transport focused on the Big Bend region of the west Florida Shelf (model years 2004-2010). Typically winds in this region prevail out of the NE during the gag spawning period. In what may be a very significant finding, Todd noted 2006 and 2010 were associated with relatively high degree of upwelling favorable NW winds that may have contributed to across shelf transport of larval gag along the west Florida shelf north of 28°. The across shelf transport pathway was based upon a 4-dimensional physical model after near-surface wind-driven transport was earlier rejected as a mechanism (SEDAR10 2006). Interestingly, most larval transport projections that were successful (ending within the 10 m isobath of Big Bend nursery sites) originated from the area of the Madison-Swanson Marine reserve north of latitude 28° (Todd 2013). The importance of the 28° latitude delineation is based upon a break in the high relief offshore habitat which may relate to a break in the distribution of gag spawning aggregations along the WFS (Jue, 2010). More work is needed to identify transport mechanisms south of latitude 28° (Todd 2013). Karnauskas et al. (2013) conducted preliminary runs of the Connectivity Modeling System focused primarily in the NE Gulf for model years 2003-2012. Formal sensitivity runs of the model were yet to be completed to quantify uncertainty and construct variance estimates for the recruitment index. This model structure offers much promise as it can incorporate complex larval behaviors such as vertical migration.

2.2.4 Habitat requirements

Upon settlement, seagrass meadows are the important habitat for juvenile gag (Coleman et al. 1996). However new studies are confirming that other habitats are utilized. In South Carolina, seagrass beds are scarce and gag are reported to utilize oyster reefs as a nursery habitat (Adamski et al. 2012). In Charlotte Harbor, juvenile gag were noted to utilize significant areas of mangrove habitat in the post-settlement phase (Casey et al. 2007).

As well as habitat type there has been additional interest about patterns of juvenile settlement and duration of residence in these estuarine habitats. Casey et al. (2007) reported that while settlement occurred at similar months as other studies (April, May), gag in Charlotte Harbor were in post-settlement residence longer and emigrating offshore at a larger size compared to more temperate estuaries. Switzer et al. (2012) examined use of the seagrass in respect to latitude and duration of occupancy from Apalachicola to Charlotte Harbor. These findings also indicated latitudinal differences but with an earlier appearance and longer occupancy of juveniles in the more southerly west Florida estuaries in agreement with earlier studies. In the south Atlantic however, Adamski et al. (2012) suggested no latitudinal differences in settlement occurred between NC and SC estuaries and that pelagic larval duration had no effect on duration of estuarine occupancy. Results suggest that different factors such as habitat type, habitat quality, or oceanic transport may be leading to the observed differences across locations and basins.

Upon leaving the seagrass meadows, gag will associate with patchy hard-bottoms, rock outcrops and ledges and have demonstrated density-dependent habitat selection (Lindberg et al 2006).

Pre-reproductive females resided on reefs for an overall average of 9.8 months (Lindberg et al 2006) as they transition to the offshore spawning stock. As mature adults, gag prefer relatively steep drop-offs and rocky ridges as spawning sites. Given the importance of these spawning site characteristics, gag can be found in association with higher relief outcroppings (Coleman et al. 2011). New survey results have highlighted additional potential WFS reserve sites for gag based upon abundance of groupers and prevalence of high relief habitat in the "Extended Madison-Swanson" area and "Edges" (Harter and David 2009). As Jue (2010) noted, a potential break in outer shelf spawning habitat may occur about latitude 28°N and thus mid to outer shelf habitats throughout this region and south of 28°N needs further mapping and survey (see research recommendations).

2.2.5. Tagging and movements

Tagging studies are needed to: 1) clarify the extent of movement between the Gulf and south Atlantic and within the Gulf region, 2) aid further development of age-specific estimates of depth-related release mortality in the Gulf region and 3) further identify aggregation sites. Tagging results were reviewed in SEDAR 10 but one new study by Coleman et al. (2011) (also see Koenig and Coleman 2011) put acoustic tags on 22 gag (11 males & 11 females) and was able to track them over a period of time; up to two years for some individuals. Males clearly exhibited strong site fidelity, remaining on one or at most two spawning sites for extended periods of time within the Madison-Swanson Marine Reserve. Females tended to move more frequently among spawning sites, stopping only briefly before moving on. Most females left the Madison Swanson Reserve after the spawning season; but some unknown proportion was thought to remain. This sexual segregation and movement is much better known now than in previous assessments and is leading to better understanding of the mating system and interpretation of traits such as sex ratio (see reproduction section and recommendations).

2.2.6 Stock structure recommendations:

Increased genetic sampling should provide more precise estimations of exchange rates within the Gulf basin and the Atlantic. As well, The LHW recommends continued application of otolith chemistry methods to evaluate the population structure and connectivity of gag.

Oceanographic modeling efforts are advancing (3-d models). Larval transport and modeling efforts need to be supported and associated with development of an Integrated Coastal Ocean Observing System (ICOOS). There is evidence for different transport and retention processes operating along the northeastern Gulf and west Florida shelf. Attention should be given to different oceanic forcing mechanisms particularly focusing on wind-driven upwelling and Loop Current intrusion differences north and south of about latitude 28°. Further exploration of potential larval contribution (interannual variation) from Campeche to US waters is needed.

For the purpose of learning more about exchange between basins, and as indicated in SEDAR 10, tagging studies should be coordinated between researchers in the Gulf (including Mexico) and south Atlantic, particularly with respect to adult size and depth. Additional acoustic tagging of mature gag may contribute to identification of additional spawning aggregation sites *warranting protection. In particular more investigation of potential spawning habitats south of 28° latitude along the WFS is needed.*

2.3 Age and Growth

Gulf of Mexico gag age data, derived from otoliths, were contributed by several state and federal program sources with the majority of otoliths processed and aged at the NMFS Panama City Laboratory (Lombardi et al. 2013-SEDAR33-DW22). The age sample record extends from 1978 to 2012 and the data set is annually continuous since 1991. In all, there are 32,688 age records with 11,759 of these records added since the last SEDAR update assessment in 2009 (Table 2.1 and Lombard et al. 2013-SEDAR33-DW22).

Age reader bias and precision is gauged though the use of a gag age reference collection housed at the NMFS Panama City Laboratory. In addition, sectioned otoliths were provided by Florida FWC for a reader comparison between the lead agers at Panama City and Florida Fish and Wildlife Research Institute. Consistent with earlier workshop results (Reichart et al. 2006-SEDAR10-DW 13), recent aging was conducted with good precision (Average Percent Error < 4.0 and CV < 6.0; Lombardi et al. 2013-SEDAR33-DW22).

As noted in earlier SEDAR reports, gag year-class trends have been apparent in the raw age composition data prior to assessment model accounting of gear selectivity and catch-at-age. Strong year classes for this purpose are defined as those exceeding 30% of the total age structure during at least one year and dominating the age structure for two or more years within the record period. Strong year classes were evident from cohorts spawned in 1985, 1989, 1993, 1996, and 1999 as reported during SEDAR 10. With additional age records since SEDAR 10, strong year classes were also evident from cohorts spawned in 2002, 2006 and 2007 (Lombardi et al. 2013-SEDAR33-DW22).

In the most recent years (2011 and 2012), it is possible that changes in gear selection and fishery behavior is evident due to the implementation of catch shares and cuts in TAC. The LHW discussed the possibility that these changes result in fewer older gag being available and sampled from the commercial fishery. Maximum age remains at 31 years from a fish sampled in 2005. In more recent years, gag estimated to be as old as 29 years (2009) and 28 years (2012) have been observed (Lombardi et al. 2013-SEDAR33-DW22).

As in SEDAR 10 a modified von Bertalanffy growth model was applied to the updated age/length data to account for the influence of minimum size limits. In this model fit, the lengths used were fork lengths (mm) in comparison to total length used previously (see section on meristics and conversions). The results (L_∞, k, t_0) were very similar to the previous model and differences (e.g. change in L_∞ 1300 mm TL to 1272 mm FL) may be attributed to the use of fork- rather than total length (Figure 2.2, Table 2.2, Lombardi et al. 2013).

2.3.1 Age and growth recommendations

Gag age samples are under- represented from the recreational sector. This remains a trend over time and more attention to recreational sampling is warranted.

Reader comparison statistics can now be incorporated as uncertainty in aging within the Stock Synthesis model. Estimates of standard deviation at age will be calculated and forwarded for review at the assessment workshop.

Further review of the aging macro (the assignment of final annual age) is needed to deal with the possibility of early annulus formation (e.g. before January 1st). Thus the age macro may need to include the means of age demotion for some individual gag.

2.4 Natural Mortality

2.4.1 Juvenile (age-0 and transition to age-1)

As with most marine fishes, gag is assumed to have a typical Type III survival (Figure 2.3). Thus, the highest rate of mortality is expected to occur in their first year. Gag use seagrass beds as primary nursery habitats and nearshore live-bottom reefs as secondary ones, apparently linked by egress in the fall following their summer settlement. A mark-recapture study demonstrated high post-settlement survival during the seagrass phase, with daily instantaneous mortality (Z) ranging from 0.0027 to 0.0032 (Koenig and Coleman 1998). High post-settlement survival was again confirmed in multiple years of a Florida Panhandle survey but in one year post-settlement survival was relatively low perhaps due to environmental stressors (Bourgoin 2011). Typically high post-settlement survival may be partially attributable to gag escaping size-selective mortality via fast growth (i.e., >1.4mm d^{-1}) during their seagrass phase, a consistent pattern across North Carolina (Ross and Moser 1995), South Carolina (Mullaney and Gale 1996) and Gulf of Mexico systems (Stallings et al. 2010). However, we currently lack data on the movements both within and between the seagrass and nearshore reef habitats and very little is known about natural mortality both during and after the transition to the secondary nursery habitats. Predation and starvation are common mechanisms of natural mortality for fish in their first year and for gag, these threats may be highest during and shortly after the transition to reef habitats (Stallings et al. 2010). Once they reach the reefs, gag may experience intense predation threat from sharks and other large reef predators, including older age classes of gag. A field experiment demonstrated gag select reefs based on shelter rather than food (Lindberg et al. 2006), highlighting the potential importance of predator avoidance during their first year. Sharks and other large predatory reef fishes can be abundant on the reefs (C.D. Stallings, unpublished data) which may force the smaller gag to remain vigilant upon arrival and feed at reduced rates (e.g., Stallings 2008) and/or shift their diets to less preferred prey (O. Tzadik and C.D. Stallings, unpublished data). High resolution tagging data on artificial reefs located at similar depths and distances offshore as natural reefs used by gag as secondary nursery habitats, suggest gag have relatively high site fidelity on the reefs (Biesinger 2011). However, we generally lack the detailed information required to estimate natural mortality and other basic ecological and biological parameters necessary for accurate assessment for individuals during and post the seagrass-reef transition, highlighting a critical research need. As in SEDAR 10, expected higher juvenile and sub-adult Z values are accounted for via age-varying M, such as the Lorenzen model (see below).

2.4.2 Older age classes (age-1 +)

As reported during SEDAR 10, maximum estimated age of gag in the Gulf of Mexico is 31 years (Lombardi et al. 2006, SEDAR10-DW2) and based on this information, natural mortality (M) of gag was estimated using the regression model reported by Hoenig (1983) for teleosts: M=0.1342. This is the target value used to compute age-varying M via the Lorenzen (2005) model (Figure 2.3). Other values of M were computed based upon life history and environmental traits (Tables 2.3 and 2.4) ranging to values as high as M =0.663 exceeding most estimates of Z (below and Figure 2.4). In general, functions based on longevity return a small value of M, while functions reflecting high growth and early age at maturity such as Beverton and Holt return high estimates. The LHW noted that life history invariant functions developed largely from data obtained from high latitude fisheries may not adequately reflect traits of tropical to sub-tropical species. Validation studies are revealing that tropical groupers can be long-lived and perhaps may have greater longevity than routinely estimated (Andrews et al., 2013). Thus even low values of M via Hoenig estimates may not confidently be considered to be conservative.

Estimates of total instantaneous mortality (Z) were updated based upon catch curve analysis of strong year classes or cohorts detected in the raw age composition data (Figure 2.4 for 1985, 1989, 1993, 1996, 1999 and 2002 cohorts). For this record, full recruitment to the fishery ranged from age-3 for a particularly strong year class (1993) to age 6 (1996). Values of Z ranged from 0.29 to 0.73 which spans the values reported earlier in SEDAR 10 (Lombardi et al. 2006-SEDAR10-DW2).

2.4.3 Mortality recommendations

1.) As in SEDAR 10, recommended ranges of M: (0.10 - 0.20).

2.) Continue to investigate age-varying M models and their appropriateness.

3.) LHW recommends further research into mortality rates of pre-spawning gag as they migrate from seagrass meadows to the offshore environment.

2.5 Reproduction

Gag reproductive biology was reviewed during SEDAR 10 (see Fitzhugh et al. 2006-SEDAR10-DW3 and Reichart and Wyanski 2006-SEDAR10-DW15). Little new data regarding fecundity and reproductive histology has been added in recent years from the US Gulf. The LHW recognized there was a period during the 1990s and early 2000s wherein research attention and sampling was focused on gag reproduction via cooperative studies. Further discussion centered on the difficulty of routinely obtaining fish in the round (with reproductive tissues intact) during the winter spawning season which limits new information (see recommendations).

However, more samples (e.g. histology) from previous years (by length/age) were available when data sets were newly compiled and incomplete records were updated. As well, information on presence/absence of “copperbelly” pigmentation, a secondary sexual trait reported by port-agents working under the Trip Interview Program (TIP) has increased over time which allowed more inferences to be made regarding sex ratios and sexual transition.

2.5.1 Maturity

Maturity was estimated using the same method as in SEDAR 10 (similar for Gulf and South Atlantic). Briefly this entails distinguishing females as immature or definitely mature (based upon histology of ovaries, with mature females exhibiting vitellogenic oocytes or positive indicators of prior spawning; Fitzhugh et al. 2006-SEDAR10-DW3 and Reichart and Wyanski 2006-SEDAR10-DW15). In the past, the Gompertz model was chosen as it exhibits a better fit then the Logit model. Again, Gompertz was the more parsimonious model (Table 2.5) which may be due to the asymmetry about the inflection point which allows greater flexibility in the fit.

The LHW noted that the method of classifying immature and definite mature females results in a "knife edge" maturity function such that onset of maturity with increased size and age occurs rather suddenly. In part this may be due to the censoring of females considered to be of uncertain maturity. Factoring in uncertainty may skew the maturity function or cause it to be more asymptotic and gradual in transition if histological indicators of prior spawning are judged liberally. This may tend to shift maturity (length/age at 50% maturity) to larger sizes and ages. If other criteria were chosen to define maturity (such as early developmental or cortical alveolar phase oocytes) then (50%) maturity may shift to smaller sizes and ages. Assessment benchmarks etc., can be sensitive to maturity and there is often discussion within the scientific literature about criteria used to set maturity (see reproductive research recommendations).

During the data workshop, the maturity records were examined by two time periods which proportionately separates the data (1991-1996, n=529 records; 1997-2012, n =417 records). There is slight evidence for decrease in size at maturity over time (1991-1996, A_{50}=3.5 years, L_{50}=538 FL: 1997-2012, A_{50}=3.3 years, L_{50}=502 FL). Continued monitoring is recommended as these sizes at 50% maturity are slightly lower than the range of values reported in previous U.S. Atlantic, U.S. Gulf and Mexico studies (L_{50} ranging 615-720 mm TL, Fitzhugh et al. 2006-SEDAR10-DW-3). However, there is little evidence for change in age at maturity within the Gulf (occurring about 3-4 years based on samples from the late 1970s, Hood and Schlieder 1992). The LHW recommends using all available histological data resulting in A_{50}=3.5 years and L_{50}=543 mm FL (Figure 2.5). This increases the sample size and would be a small change from the SEDAR10 estimates (A_{50}=3.7, L_{50}= 585 TL, n=707 by TL and n=552 by age, SEDAR10-DW3). The smaller size at L_{50} may partially be accounted for by using measures of fork length rather than total length (see conversions).

2.5.2 Sex transition

Contingency table analysis of gag sampled for histology and pigment pattern showed that the presence/absence of ventral pigmentation in gag (copperbelly pattern) is a good indicator of secondary sex. Gag not noted to have ventral pigmentation (n=2506) were 98% histological females and of gag noted to have copperbelly pigmentation (n=111) 86% were histological males. These results are in agreement with Collins et al 1998 wherein gag with ventral pigmentation (n =62) were 92% male based on histology. In addition, the functions for sexual transition whether based upon histology or pigmentation have been found to be equivalent (Fitzhugh et al. 2006-SEDAR10-DW3).

Because of voluntary reporting of gag pigmentation by port agents, greater sample sizes are available and thus there is more information in recent years (vs. histological data). As in SEDAR 10, only collections that included at least one pigmented gag were used in this analysis. This dataset consisting of collections containing at least one copperbelly gag assumes that those gag with and without ventral pigment are distinctly noted with high confidence. The Logit function provides the best fit to sex transition (probability of remaining female) as in SEDAR 10 (Table 2.6). Similar to the maturity data, two time periods were examined which proportionally separates the data (1991-2004, n=2590 records; 2005-2012, n =3838 records). Also similar to the maturity data, there is a small but decreased trend over time in the size at 50% sex transition (Table 2.6). Applying data from all years, the L_{50} and A_{50} are 1022 mm FL and 10.7 years (Table 2.6) compared to SEDAR10 results (L_{50} = 1085 mm TL, and A_{50} = 10.8 years). Again the decrease in size may be partially explained by use of FL rather than TL. Similar to the recommendations for maturity, the LHW suggests continued monitoring over time (see recommendations).

2.5.3 Sex ratio

Gag are protogynous hermaphrodites (female first, then a portion of the population changes to male). By definition, protogynous populations are expected to have sex ratios skewed towards females. Harvesting of older, larger fish that are males may further skew the sex ratio. Koenig and Coleman 2011 review the gag historical sex ratio data for the Gulf of Mexico (Table 7 within Koenig and Coleman), citing Hood and Schlieder (1992) and Coleman et al. 1996 with values of 15-20% male in the late 1970s declining to 0-5% male in the 1990s. Here we summarize three additional studies that have estimated the sex ratio of gag. Two CRP-funded studies provided specimens captured by the commercial fishery for histological analysis of gonads, completed at the NMFS Panama City Laboratory. The first (Burns and Robbins 2006) primarily sampled the long-line fishery operating out of Madeira Beach, Florida in 2004 and 2005. This study returned 225 gag captured in statistical grids 3, 4, 5 with the percentage of males determined to be 1.8% (Table 2.7). The second CRP study (Ward and Brooks 2010) examined by-catch in the reef fish fishery of the eastern Gulf of Mexico in 2009. Based upon 404 sea-days 114 gag were captured largely by hook-and-line gear (97%) in statistical grids 6, 7 (91%) with the percentage male and transitional to be 2.6% (Table 2.7). Using biopsied fish Koenig and Coleman (2011) found the proportion of males inside Madison Swanson Reserve to be 12% compared to 1% outside the reserve, further supporting a harvesting effect on the sex ratio of gag. Thus, these three studies generally agree that in recent years the proportion of male gag outside of marine reserves is below 3% across the greater WFS when catch is aggregated over time.

As reported earlier, port agents working under the NMFS TIP program volunteer information on gag ventral pigmentation when collecting age samples. Although the TIP program has existed since the early 1990's, efforts to interview and instruct port agents to provide the information in a consistent manner occurred largely after the year 2000. In addition, the recent reductions in the quota of gag resulted in low sample size and reduced effort for the years 2010-2012. Thus we limit our summary of TIP data to the years 2000-2009 (Figure 2.6). Distinct from the sex transition results above, all TIP biological records were counted for this period (n=17,886) in order to estimate sex ratios. As expected, the proportion of copperbelly gag was higher in the longline fishery than the handline fishery. Additionally, more copperbelly gag were reported from southern west Florida shelf (WFS) statistical grids (3, 4, 5) compared to the northern WFS (grids 6, 7, 8, 9). Perhaps the north-south differences may be partially attributed to gag recruitment patterns along the west Florida shelf as indicated earlier in the stock delineation section, or perhaps due to the history of the fishery and the change in areas targeted over time. The LHW also discussed the possibility that the high proportion (>15%) of copperbelly gag, particularly noted in the long-line results from the southern grids by 2001-2002, could be attributed to the progression of the particularly strong 1993 year class through the fishery in concert with spatial differences in fishing effort. But the LHW noted the port agent data from the southern grids (>15% in 2004) is an order of magnitude higher than the value (1.8%) reported by Burns and Robbins (2006). The low proportion attributed to the Burns and Robbins study may be due to overall low numbers of gag captured and the targeting of low relief red grouper habitat. Otherwise, the values for gag returned by northern handline catches (<3%) were on par with the Koenig and Coleman (2011) and Ward and Brooks (2010) findings. At the DW, advisory panel fisherman Jason Delacruz indicated that the result (Figure 2.6) from the southern statistical grids showing the decline of copperbelly gag since 2002 was consistent with anecdotal reports by fishermen. The LHW felt these data have merit in that they raise interesting questions about the stock structure and made further recommendations about acquiring and testing these data in the future (see research recommendations).

2.5.4 Implications for mechanism of sex change

Directed by the terms of reference, the LHW discussed the sex transition results and sex ratio data relative to the possible mechanism for sex change. Principle documents that provided the context for this discussion are Brooks et al. 2008, Koenig and Coleman 2011, Koenig and Coleman 2012, and Shepherd et al. 2013-SEDAR33-RD19.

A concern with gag is that intensive fishing that targets large fish will reduce the proportion of the stock that is male and may ultimately lead to loss of fertility and population decline via an Allee or depensatory effect (Chapman et al. 1999, Rowe et al 2004). Gag have been observed to undergo change in sex ratio via reduced proportions of males, so understanding the mechanism of sex change (female to male) and the degree that compensation may occur is important to management (Ellis and Powers 2012). A key discussion point for protogynous hermaphrodites centers on whether the mechanism for sex change is primarily size-dependent or socially mediated. If primarily mediated by social interactions, a hypothesis is that reduction in large males would result in transition at smaller sizes and younger ages. This change may also occur in a density-dependent manner as females encountering fewer males may be induced to change. Conversely, if the mechanism is size-dependent, or size-“fixed”, the expectation is that sizes and ages at transition will remain relatively constant over time and thus the ability to compensate for altered sex ratio is limited.

Koenig and Coleman (2011) review mechanisms of sex change and cite Warner (1988) indicating that behaviorally induced sex change is the most common mechanism among fishes.

Koenig and Coleman (2011) further suggest that the behavioral mechanism offers the best explanation for sex change in gag. Gag tends to show evidence of social mediation in sex change with highest proportions of transitional fish reported in the post-aggregation period (Koenig and Coleman 2012). However, gag also show evidence of size dependence as size and age at transition have been relatively constant over time. Only recently are small decreases in size at transition detected and there is little support for plasticity with regard to size at sex transition. In discussion, the LHW noted there are some uncertainties among all the evidence brought to this question.

While gag are fairly well studied relative to many hermaphrodites, much remains to be understood regarding the mating system and may partially explain why results to date seem equivocal regarding the mechanism of change. Gag show some evidence of leking as opposed to forming harems, with males tending to reside near spawning sites along high relief outer shelf reef tracts. Females tend to move off shelf-edge reefs into shallower waters following spawning periods. Both leks and harems are forms of spawning aggregations wherein large males may monopolize matings. If leking characterizes the mating system then males may also be sperm competitors in a group spawning arena. Body size may be critical in terms of sperm competition (Stockley et al. 1997). If harems characterize the mating system then males may be competing more for mates and highest valued spawning sites with less fitness penalty for plasticity in size at transition (Shepherd et al. 2013). Additionally, we need to know more about the reproductive value of females as a function of size and age (see female reproductive potential below) to test the size-advantage model (Warner 1984). Thus better understanding of the mating system and improved collection and interpretation of data may help to resolve this question (see research recommendations).

2.5.5 Reproductive potential

In previous Gulf of Mexico assessments of gag, the form of reproductive potential used in the assessment model was spawning stock biomass of females (SSB-female), based upon a female maturity function, a sex-transition function and average weight at age. In contrast, South Atlantic assessments of gag have used spawning stock biomass of females and males (SSB-combined). Brooks et al. (2008) explored via simulation, the various SSB approaches and stock assessment performance given uncertainties regarding loss of males and reduced fertility. They concluded that the SSB-female approach best estimates biological reference points if the potential for decreased fertilization is weak. Brooks et al. (2008) determined SSB-combined is best when the potential for decreased fertility is moderate or unknown. A recent workshop on the subject noted most assessments of hermaphroditic fish to date have applied SSB-combined (Shepherd et al. 2013).

In discussion, the LHW noted that while there are concerns for decreased fertilization via altered sex ratio, there is little evidence for an effect of decreased fertilization such as genetic inbreeding. Chapman et al (1999) provided evidence of genetic subdivision in gag, possibly signaling an inbreeding effect. However a new study based upon increased numbers of microsatellite loci in gag did not confirm Chapman et al. (1999) and found no evidence for an inbreeding effect, with the caution that long generation time in gag may delay the detection of lower genetic diversity that might occur due to fishing (Cushman et al. 2009).

Just considering females, further discussion by the LHW centered on the best estimate of reproductive potential. Generally, fecundity data are preferred for use if available and of sufficient contrast by size or age. The LHW noted that when batch fecundity (BF) is fit to a power function, the exponent of the length-BF function is about 3.0 (Figure 2.7 A) indicating that reproductive potential based on either body weight at length (SSB-female, also an exponent of about 3.0) or BF would be equivalent. However, gag spawning fraction was also dependent on body size which indicates larger females produce more batches (Figure 2.7 B). Thus estimation of total annual fecundity (SSB-eggs) based on the product of BF and number of batches may indicate that larger females may have exponentially greater output of eggs than would be predicted based upon the use of SSB-female.

Recent fecundity results from Campeche gag confirmed that gag are indeterminate multiple spawners (Martinez et al. 2006). Significantly however, the Campeche investigators found no- to few females undergoing final oocyte maturation. As a result, they estimated batch fecundity for 14 females based on oocyte size assumptions (vitellogenic oocytes) to distinguish the maturing batch. Thus estimated, batch fecundity ranged much higher (to 4.2 million ova) than estimates for US Gulf females (Martinez et al. 2006).

Considering these various forms of reproductive potential and further questions regarding how they could be input into Stock Synthesis (for instance, can SSB-eggs be combined with SSB-male within the model structure?), the LHW recommends further work proceeding to the assessment workshop. Thus a recommendation is to 1) develop a total fecundity model for gag, along the lines of that completed for red snapper (SEDAR31-AW03) and 2) examine model inputs and sensitivity for SSB-eggs, SSB-female and SSB-combined. Ultimately, the best approach for expressing reproductive potential in gag is dependent on better understanding of the consequences of altered sex ratio on fertility (see research recommendations).

2.5.6 Reproduction recommendations

Maturity: Continue to gather histological samples to monitor change in maturity that may occur over time. Further examination needs to be made regarding how uncertainty in maturity can be treated within Stock Synthesis. A research recommendation is that formal decision tables be developed regarding the assignment of maturity based upon the raw histological readings for tropical/subtropical species. Changes to a decision table could be made in a standardized way to gauge the effect of uncertainty in models and for different species. The LHW recommends that this subject be presented at workshops or scientific meetings to raise awareness and develop consensus and best approaches.

Sex ratio, spawning fraction and fecundity: Promote collection of grouper reproductive samples via observer programs. Scientific observers working onboard commercial vessels will be able to sample gag in the round (prior to routine gutting) throughout the year. With improved field sampling, estimation of sex ratio needs to be made with better design or accounting of factors such as cohort effect (strong vs. weak year classes), location, gear and seasonal timing (pre-aggregation, spawning, and post-aggregation).

Sex transition and mechanism of sex change: Further review of the utility of secondary sexual traits (copperbelly pigmentation) is warranted: 1) incorporate the secondary sex field formally into TIP 2) provide training to port agents and 3) for longitudinal analysis develop means to account for changes in fishery selectivity and cohort effects.

Mating system: The LHW recommends further study of the particular type of mating system in gag (leks or harems). The distinction may depend on the particular type and amount of androgen produced (Shepherd et al 2013). An expectation is that leks would be more male biased as opposed to harems. As well, more information is needed on the timing and control of sex change in gag.

Form of reproductive potential: Because of questions about how the stock synthesis model can incorporate reproductive potential, the LHW recommends that three forms of reproductive potential be examined further at the Assessment Workshop given the data and reproductive traits reviewed at the data workshop 1) SSB-combined for male & female 2) SSB-female only and 3) SSB-eggs based upon annual fecundity.

Fertilization success: Research needs to be conducted on the consequences of sex ratio on fertility. The LHW recognizes that experiments on fertility would be difficult to conduct directly on such a large bodied species as gag (but see Rowe et al. 2004, 2008). Improved understanding of the gag mating system together with better designed field estimation of sex ratios may advance our understanding. Together with better field data, further genetic monitoring of Allee or inbreeding effects may yield much more insight on fertility and male reproductive success.

2.6 Conversion factors

Meristic relationships were calculated for gag caught in the Gulf of Mexico for length and body weights from 1991 to 2012 (Table 2.8). During another recent assessment, a concern was that different programs were reporting various forms of total length (TL) such that TL was measured by both maximum total length and by natural total length (c.f. Anderson and Gutreuter 1983) but these differences were not explicitly being communicated through the fisheries data bases. For gag, a majority of the lengths are reported as fork length (92%) thus the decision was made to report all lengths as fork length avoiding the issue previously detected with total length; only 8% of gag lengths needed to be converted from either natural or maximum total length to fork length.

Conversions from natural and maximum total length (mm) to whole weight (kg) and gutted weight (kg) and from fork length (mm) to whole weight (kg) and gutted weight (kg) were calculated by a non-linear regression (R, nls function). Conversions among lengths and weights were compared to those conversions used in previous assessments. The linear regression for converting length types (total and fork) was based on n=4789 (maximum total lengths) and n=1599 (natural total lengths) individual length measurements ($r^2 = 0.9973$, $r^2 = 0.9886$, respectively). The non-linear regressions predicting gutted weight (kg) from maximum total length had the highest correlation (RSE = 0.946, n = 540).

Comparing results from previous assessments, linear regressions varied little among length metrics (maximum and natural total lengths and fork lengths) (Figure 1 in Lombardi et al. 2013-SEDAR33-DW22). However, there were some differences among the non-linear regressions between maximum- and natural total length and gutted weight (Figure 2 in Lombardi et al. 2013-SEDAR33-DW22). Upon inspection, this occurred because the regressions in SEDAR10 were calculated using Microsoft Excel, graphic trend line function. The comparisons of the regression for whole weight and fork length also showed some dissimilarity, this may be due to the additional 1400 fish used in the SEDAR33 regression.

2.6.1 Conversion recommendations

Continue to work on adoption of consistent standards across survey and data collection programs.

Encourage programs collecting gag meristics to report fork length.

Avoid use of Excel trend line function with some known statistical deficiencies in favor of more robust algorithms for solving equations.

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2.8 Tables

Table 2.1. Summary of the number of gag otoliths collected and aged by sector (CM - Commercial, CP - Charter Party, HB – Headboat, PR - Private, SS - Scientific Survey, TRN - Tournament) and gear (HL - Hand-Line, LL - Long-Line, VLL – Vertical Long-line, SP - Spear, TR - Trap, TRW – Trawl, CM Other – includes spear, trap, and unknown for CM, SS Other – includes vertical long-line, seine net, cast net, gill net, spear, and unknown, Other sector – includes undersized fish collected by observer, specifically in 1996 and unknown). *Most of the data collected in 1979-1990 was reported as ‘recreational.’

Year	CM HL	CM LL	CM VLL	CM Other	CP HL	HB HL	PR HL	PR SP	SS HL	SS LL	SS TR	SS TRW	SS other	TRN	Other	Total
1978-1990	54			3	661	59							2		45	824
1991	210	7			78	38	1	4						14	5	357
1992	66	22			230	131	4	9	3					28		493
1993	417	12		1	281	89		11						16		827
1994	439	3		2	183	104	4	4	2		2			11		754
1995	284	31			199	101	2		26				1	13		657
1996	197	57		3	447	141	1								104	950
1997	34	6		2	162	70	2							1		277
1998	106	101		3	51	66	2				7			3	10	349
1999	145	243		2	84	11	15		14	2	2			2		520
2000	387	177		6	36	23			12		1			3		645
2001	745	867			127	31	5		24	12	1			8		1,820
2002	809	1,085		15	314	17	31		8	2	4		3	38	2	2,328
2003	520	1,117		3	180	74	77	4	38	5	16		2	15		2,051
2004	894	1,484			75	39	25		24	9	24		9			2,583
2005	740	857		9	119	127	3		17		50			12		1,934
2006	641	534		1	26	57	14	3			16	10	23			1,325
2007	408	936		2	36	25	20		4	1	7	44	8	20		1,511
2008	680	506			160	27	75	4	1		18	38	78		76	1,663
2009	1,027	772	39		158	198	48	33	118	4	36	80	88	22		2,623
2010	798	883	208	27	400	219	121	53	289	2	18	50	40	20		3,128
2011	1,436	518	5	11	255	24	122	3	75	14	17	7	6	5		2,498
2012	1,616	457	3	34	255	16	1		110		6	2	15	36		2,551
Total	12,653	10,675	255	124	4,517	1,687	573	128	765	51	225	231	275	267	242	32,668
Percent	38.7	32.7	0.8	0.4	13.8	5.2	1.8	0.4	2.3	0.2	0.7	0.7	0.8	0.8	0.7	

Table 2.2. Growth curve parameters (L_∞ - asymptotic length, k – growth coefficient, t0 – size at time zero, sigma – standard deviation for model) for gag from the northeastern Gulf of Mexico for biological ages and observed fork lengths at capture provided for the current (1991-2012) and previous size-modified growth curves (SEDAR10, years:1991-2005, Lombardi et al. 2006; update, years:1991-2008, Lombardi et al. 2009).

Model	n	L_∞	k	t_0	Sigma
current	31734	1272 (FL)	0.1412	-0.3307	76.7105
update	20507	1300 (TL)	0.1448	-0.3934	77.1723
SEDAR10	16436	1307 (TL)	0.1441	-0.3685	77.6044

Table 2.3. Equations for estimating natural mortality.

Method	Parameters	Authors & Parameter Explanations	Equation
Alverson & Carney	k, tmax	Quinn & Deriso (1999):	M = 3k/(exp(0.38*tmax*k)-1)
Beverton & Holt	k, am	Beverton and Holt (1956; a_m = age at 50% maturity)	M = 3k/(exp(a_m*k)-1)
Hoenig$_{(fish)}$	tmax	Hoenig (1983; for fish)	M=exp(1.46 - 1.01*ln(tmax))
Hoenig$_{(all\ taxa)}$	tmax	Hoenig (1983; fish plus other taxa)	M=exp(1.44-0.982*ln(tmax))
Pauly	Linf, k, T	Quinn & Deriso (1999):	M=exp(-0.0152+0.6543*ln(k)-0.279*ln(Linf, cm)+0.4634*lnT(°C))
		Pauly (1980):	M = 10^(-0.0066-0.279*(log(Linf))+0.6543*log(K)+0.4634*Log(T))
Pauly Method II (snappers and groupers)	Linf, k, T	Pauly and Binohlan (1996)	M=10^(-0.0636-0.279*(log(Linf)+0.6543*log(k)+0.4634*log(T))
			T=Average annual sea temperature at depth
Ralston	k	Ralston (1987)	M=0.0189 + 2.06*k
Ralston (geometric mean)	k	Ralston (1987)	M=-0.0666+2.52*k
Ralston Method II	k	Pauly and Binohlan (1996)	M=-0.1778+3.1687*k
Lorenzen Age-Specific	W at age	Lorenzen (1996; ocean)	M=3.69*W^(-0.305)
Jensen	k	Jensen (1996)	M = 1.5*K
Alagaraja	tmax, survivorship to tmax	Alagaraja (1984)	M=-ln[S(tmax)]/tmax; derived from S(tmax)=exp(-M*tmax)
Rule of thumb	tmax	Hewitt and Hoenig (2005)	M = 2.996/tmax

Table 2.4. Estimates of natural mortality of gag from equations in Table 2.3. Water temperature based upon annual mean estimate at bottom from the U.S. Gulf shelf (Johnson et al. 1995, DeVries 2006).

Observed max. age	31
no. fish aged	31734
$L\infty$	1272
k	0.14
Water Temp. (°C)	22
Age at 50% maturity	3.5
Alverson and Carney (1975)	0.099
Beverton and Holt (1956)	0.663
Hoenig (1983; for fish)	0.134
Hoenig (1983; fish plus other taxa)	0.145
Pauly (1980):	0.297
Pauly and Binohlan (1996)	0.260
Ralston (1987)	0.310
Ralston (1987) geometric mean	0.289
Ralston method II	0.270
Jensen (1996)	0.212
Alagaraja (1984) for survival at 0.01	0.149
Alagaraja (1984) for survival at 0.02	0.126
Alagaraja (1984) for survival at 0.05	0.097
Hewitt and Hoenig (2005)	0.097

Table 2.5. Logistic regression for histologically assessed maturity of females. For all-years data, best fit models (Gompertz) for age and length (FL mm) are highlighted. Logistic regression analysis conducted using XLSTAT software v2012.4.03 based upon weighted sums of binary data.

		Gompertz					**Logit**				
	n	b_0	b_1	r^2 (McFadden)	AIC	Value at 50% probability	b_0	b_1	r^2 (McFadden)	AIC	Value at 50% probability
FL all years	1233	-8.719	0.017	0.606	220.3	543	-11.256	0.02	0.6	223.5	555
FL 1991-1996	715	-10.699	0.021	0.736	85.4	538	-14.074	0.025	0.731	87.0	553
FL 1997-2012	526	-6.619	0.014	0.479	129.6	502	-8.370	0.016	0.477	130.2	510
Age all years	946	-6.487	1.958	0.592	194.9	3.5	-7.807	2.219	0.573	203.7	3.5
Age 1991-1996	529	-8.229	2.444	0.713	82.3	3.5	-10.839	3.013	0.697	86.9	3.6
Age 1997-2012	417	-4.574	1.477	0.459	109.3	3.3	-5.373	1.624	0.445	112.1	3.3

Maturity models: Gompertz: $\pi = \exp(-\exp(-(b_0 + b_1X)))$, Logit: $\pi = 1/(1 + \exp(-(b_0 + b_1X)))$.

Table 2.6. Logistic regression for sex transition, expressed as probability of remaining female, based upon secondary sexual characteristics (presence/absence of copperbelly pigmentation). For all-years data, best fit models (Logit) for age and length (FL mm) are highlighted. Logistic regression analysis conducted using XLSTAT software v2012.4.03 based upon weighted sums of binary data.

		Gompertz					Logit				
	n	b_0	b_1	r^2 (McFadden)	AIC	Value at 50% probability	b_0	b_1	r^2 (McFadden)	AIC	Value at 50% probability
FL all years	6428	13.234	-0.012	0.570	2981.6	1046	19.482	-0.19	0.592	2824.9	1022
FL 1991-2004	2590	12.922	-0.012	0.602	1276.3	1053	19.053	-0.18	0.616	1229.6	1032
FL 2005-2012	3838	13.906	-0.013	0.528	1693.8	1036	20.604	-0.02	0.558	1586.2	1013
Age all years	5588	4.993	-0.392	0.457	3288.3	11.8	7.221	-0.672	0.543	2768.5	10.7
Age 1991-2004	2463	4.371	-0.332	0.513	1469.5	12.0	6.930	-0.641	0.577	1278.2	10.8
Age 2005-2012	3106	5.910	-0.491	0.446	1592.56	11.03	7.837	-0.743	0.497	1444.9	10.5

Sex transition models: Gompertz: $\pi = \exp(-\exp(-(b_0 + b_1 X)))$, Logit: $\pi = 1/(1 + \exp(-(b_0 + b_1 X)))$.

Table 2.7. Gag sex ratio results, percent males (M) and transitional fish (T), obtained from biological samples collected during Cooperative Research Studies. LL: longline, Grids: NMFS Statistical Shrimp Grids.

CRP study	Total gag	M&T gag	% M&T	Years	Season	%LL	Grids
Burns and Robbins 2006	225	4	1.8	2004-2005	May, June & Jan.	100	99% (3,4,5)
Ward and Brooks 2010	114	3	2.6	2009	Year round except Feb. & Mar.	2.6	91% (6,7)

Table 2.8. Meristic regressions for gag from the Gulf of Mexico (1991-2012). Model fit criteria: linear regression models r^2 and non-linear regression models residual square error (RSE).

Conversion and units	Equation	Sample Size	r^2 or RSE values	Data Ranges
Natural TL (mm) to FL (mm)	FL = 13.15 + Natural TL * 0.96	1599	0.9886	FL (mm): 357 - 1304 Natural TL (mm): 370 - 1338
Maximum TL (mm) to FL (mm)	FL = 1.07 + Maximum TL * 0.97	4789	0.9973	FL (mm): 235 - 1240 Maximum TL (mm): 241-1287
Maximum TL (mm) to G. Wt (kg)	G. Wt = 7.31 x 10^{-09} * (maximum $TL^{\wedge 3.07}$)	540	0.9460	Maximum TL (mm): 446 - 1295 G. Wt (kg): 0.99 – 27.02
Natural TL (mm) to G. Wt (kg)	G. Wt = 3.50 x 10^{-11} * (natural $TL^{\wedge 3.85}$)	40	0.5902	Natural TL (mm): 551 - 1110 G. Wt (kg): 1.80 – 19.01
FL (mm) to G. Wt (kg)	G. Wt = 7.28 x 10^{-09} * ($FL^{\wedge 3.08}$)	9793	0.7942	FL (mm): 394 - 1040 G. Wt (kg): 0.73 – 33.10
Maximum TL (mm) to W. Wt (kg)	W. Wt = 1.05 x 10^{-08} * (maximum $TL^{\wedge 3.03}$)	4266	0.7357	Maximum TL (mm): 120 - 1360 W. Wt (kg): 0.02 – 32.74
Natural TL (mm) to W. Wt (kg)	W. Wt = 1.36 x 10^{-08} * (natural $TL^{\wedge 2.99}$)	1934	0.4848	Natural TL (mm): 290 - 1332 W. Wt (kg): 0.34 – 31.30
FL (mm) to W. Wt (kg)	W. Wt = 1.17 x 10^{-08} * ($FL^{\wedge 3.02}$)	5238	0.6683	FL (mm): 215 - 1321 W. Wt (kg):0.13 – 32.74

2.9 Figures

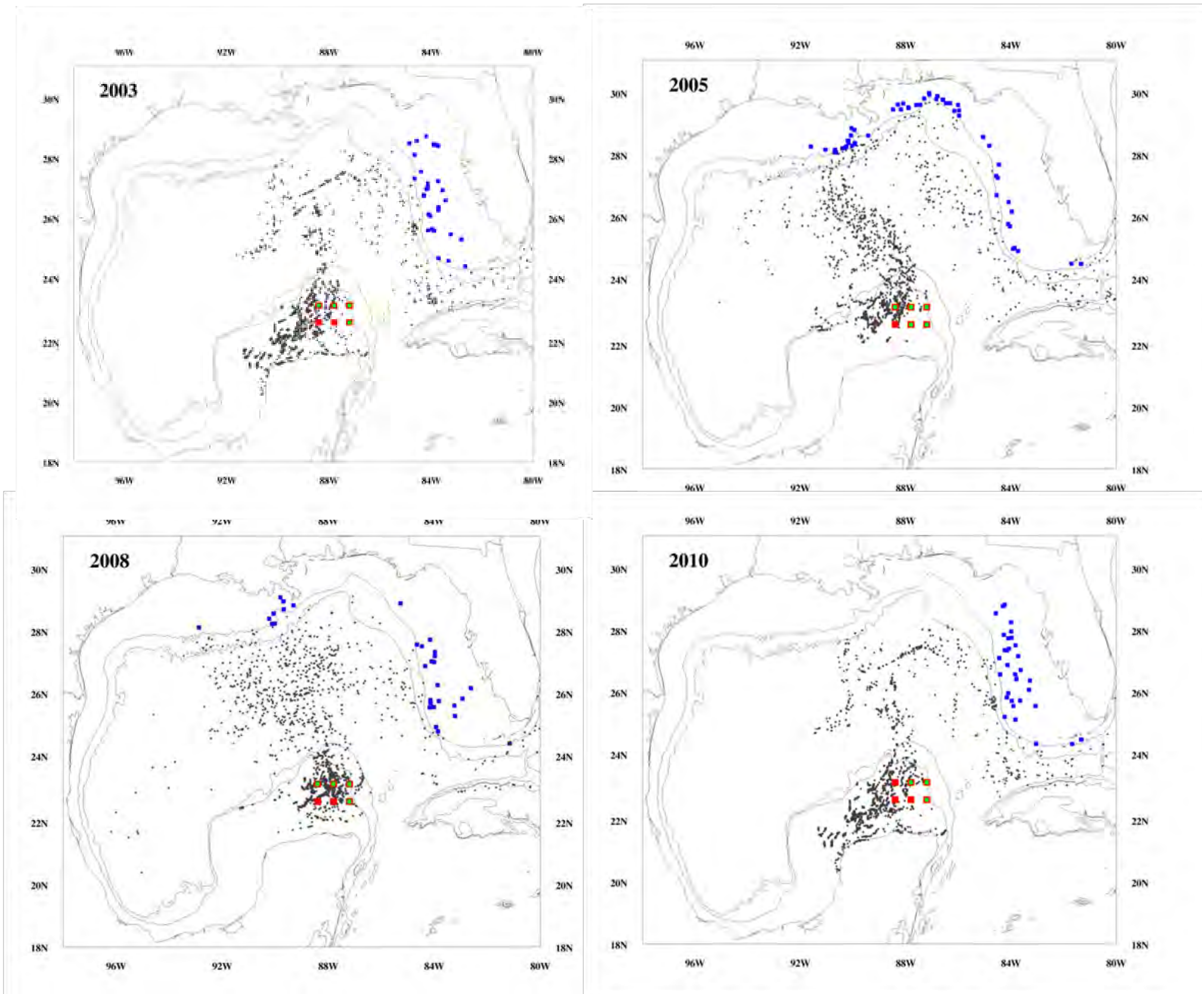
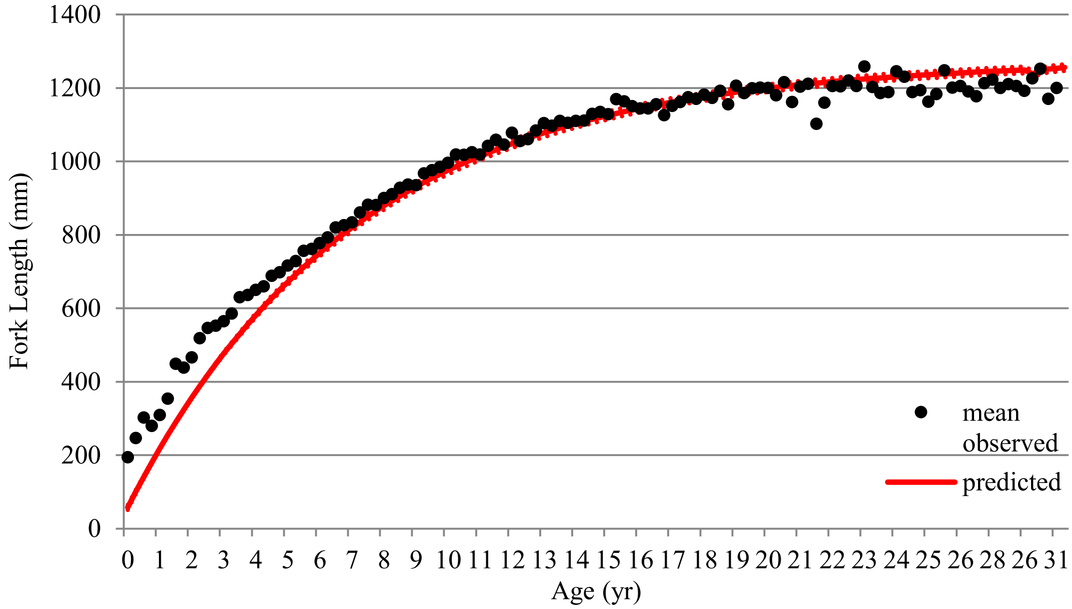


Figure 2.1. Unpublished oceanographic projections provided to the gag DW from Donald Johnson, Gulf Coast Research Laboratory, Ocean Springs Mississippi. A Campeche-based model of red snapper larval transport (Johnson et al. 2012) was used to simulate gag larval trajectories based upon January-March gag spawning releases (red) and increased larval duration (45 d). Success (blue) was based upon simulation propagule ending (≤ 200 m) on the US shelf.

A.



B.

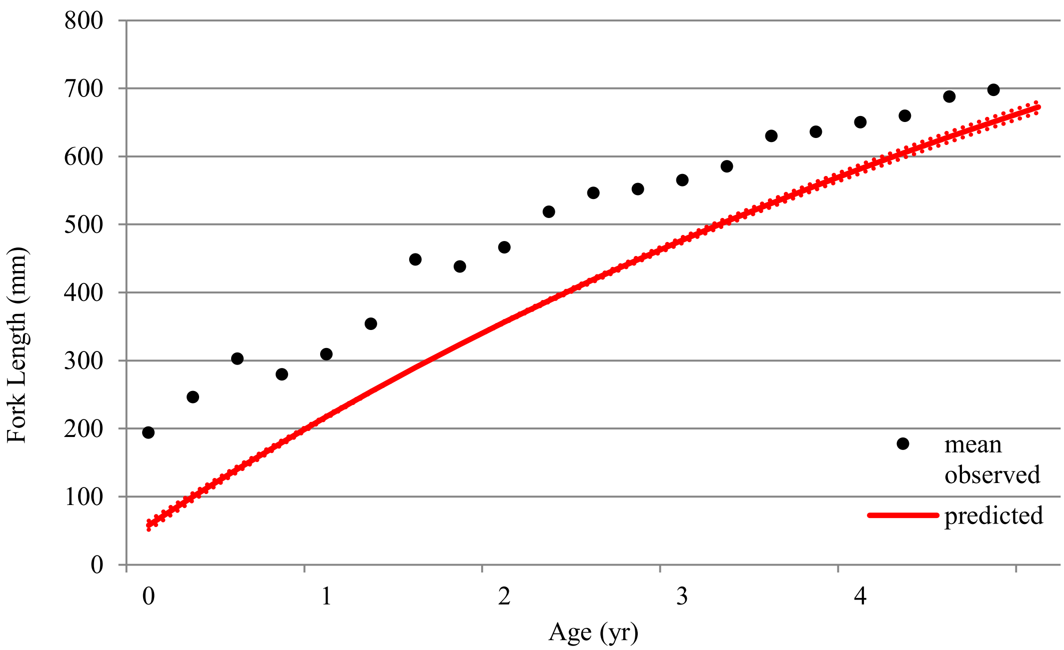


Figure 2.2. Size-modified von Bertalanffy growth curve for gag from the northeastern Gulf of Mexico for A. biological ages 0-30 years and B. ages 0-5 years. Observed mean size-at-age (black circle), estimated size-at-age (red line), and estimated 95% confidence intervals (red dotted line) (see Lombardi et al. 2012-SEDAR33-DW22).

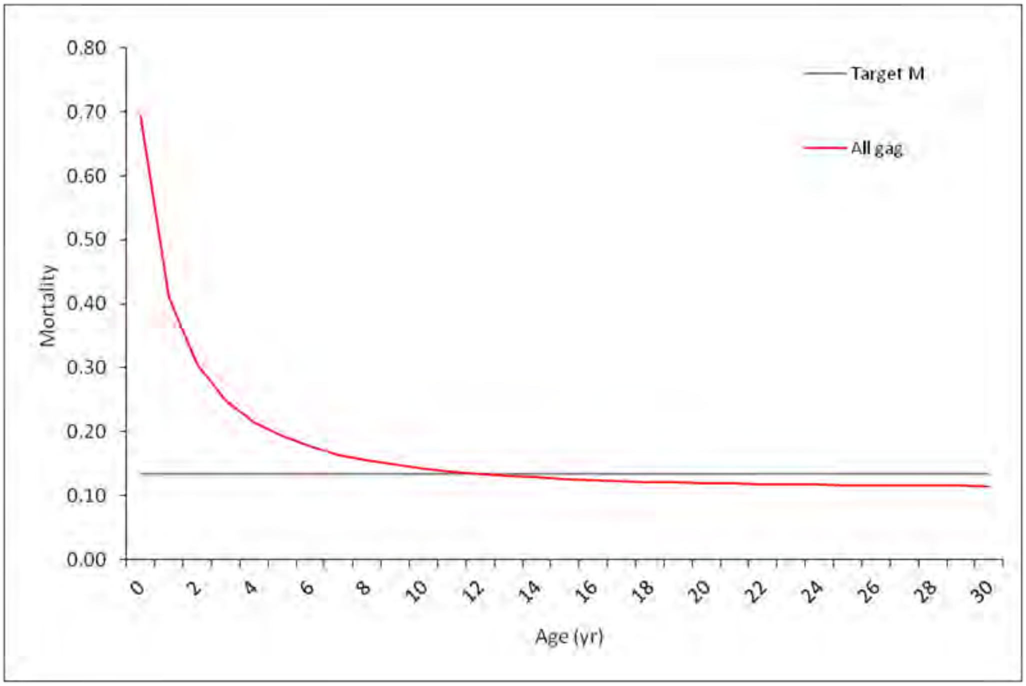


Figure 2.3. Lorenzen mortality function for gag with age at full vulnerability set to age-4 (following Lorenzen 2005) and target mortality (m = 0.134) based upon Hoenig regression for fish.

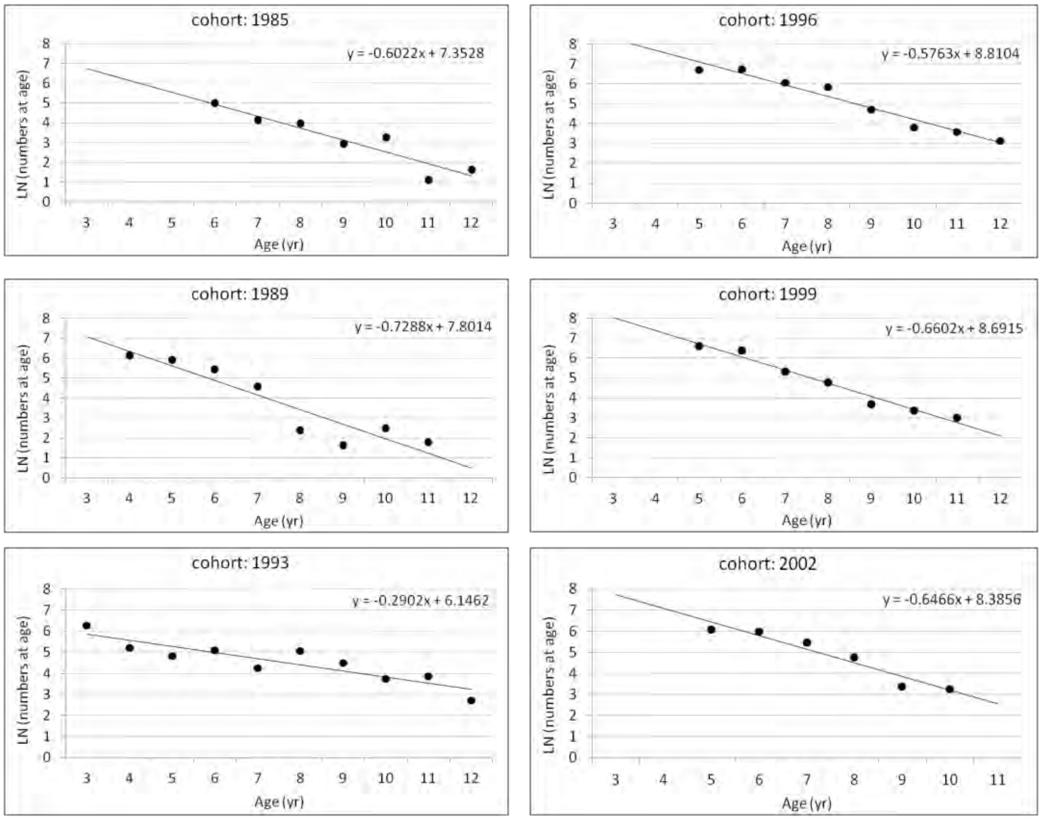
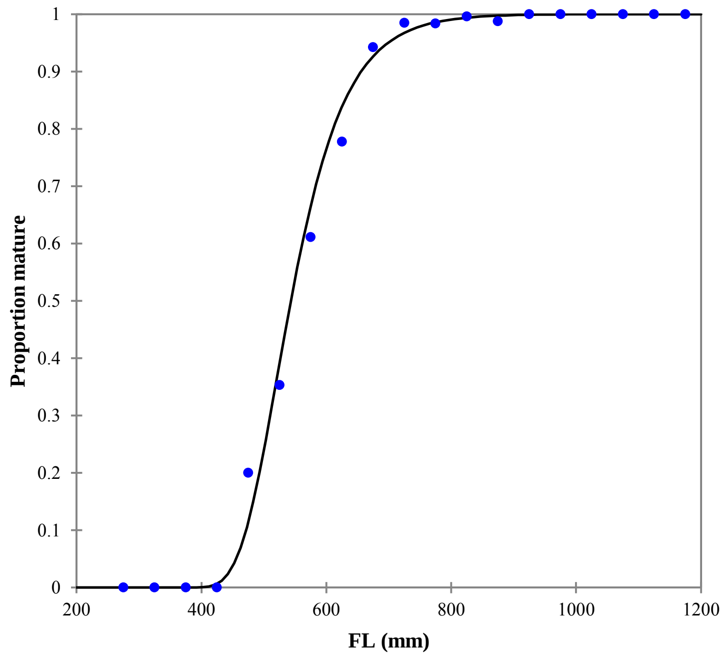


Figure 2.4. Catch curves based upon age composition data for strong cohorts of gag.

A.



B.

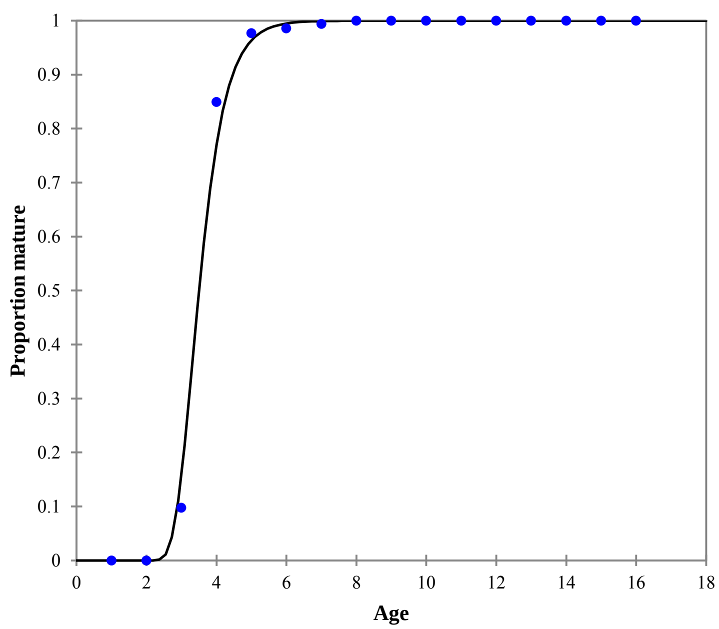


Figure 2.5. Size and age at maturity based on definitely mature and immature female gag. Logistic regression function (Gompertz): A. All years by fork length, Proportion = exp(-exp(-(-8.719+0.017*FL))), r^2 (McFadden) = 0.6, n=1233, L_{50}=543 mm FL. B. All years by age, Proportion = exp(-exp(-(-6.49+1.96*age))), r^2 (McFadden) = 0.59, n=946, A_{50}=3.5 years.

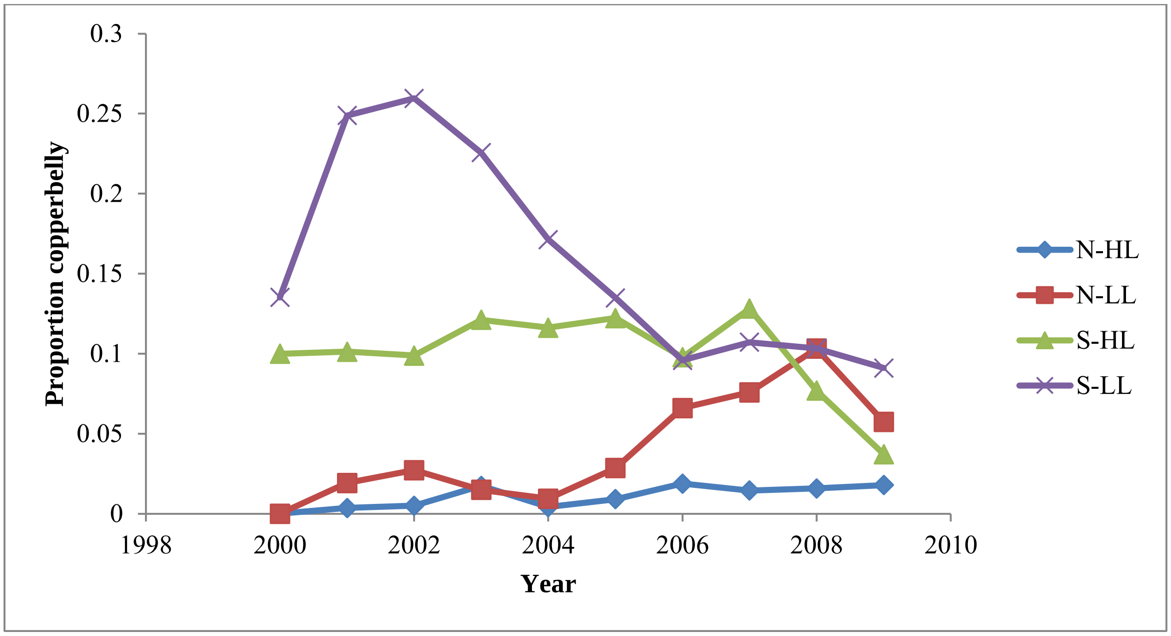
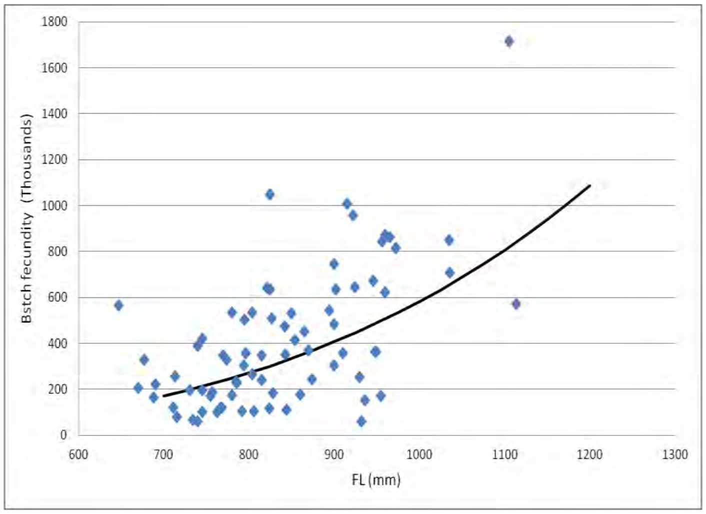


Figure 2.6. The proportion of gag with ventral pigmentation (copperbelly coloration) as a secondary sexual trait for males. Based on Trip Interview Program (TIP) port agent voluntary reporting from the longline (LL) and handline (HL) fisheries, in statistical grids 3,4,5 (South –S) and 6,7,8,9 (North – N) from 2000-2009 (n=17,886).

A



B

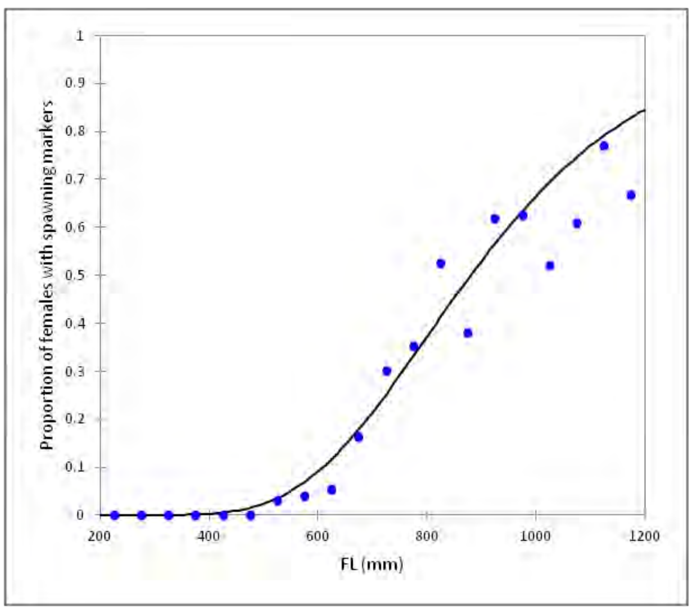


Figure 2.7. Elements of total fecundity including A) batch fecundity (BF) by length, power function, BF = 0.000033* FL^3.416, n=77, r2 = 0.28, and B) proportion of females bearing spawning markers (hydrated oocytes & postovulatory follicles) by length (all female histology data; February-April), Gompertz logistic function, proportion = exp(-exp(-(-3.532+0.004*FL))), n=1297, r2 McFadden =0.148.

3 Commercial Fishery Statistics

3.1 Overview

Commercial landings of gag grouper for the U.S. Gulf of Mexico were constructed using primarily data housed in the NOAA's Southeast Fisheries Science Center's Accumulated Landings System (ALS) from 1963 through 2012. Landings reported to Louisiana and Alabama, for 2000 and 2002 through 2012 respectively, were obtained from each of the states' trip ticket collections kept at the GulfFIN data warehouse. For historical landings between 1880 and 1962, landings were constructed using data obtained from NOAA's Office of Science and Technology. In constructing the 1963-2012 time series, port of landing was used to assign water body when water body was not present. For missing or unclassified gears, proportions from the Coastal Fisheries Logbook Program (CFLP) were used when available. Florida General Canvass gear proportions were applied to Florida landings. Total annual landings from the IFQ program were used for years 2010-2012. These landings were used to reapportion 2010-2012 ALS landings across strata. For all years, black and gag landings were summed and a gag to black ratio was applied based upon area fished, or in the case of the historical landings by state landed. A black and gag ratio to all other identified grouper were applied to unclassified grouper landings.

Discards were calculated for the directed fishery using CFLP discard data, as well as from the reef fish observer program.

Length frequency distributions were constructed for gag grouper in the years 1984-2012 using available TIP length data. Commercial landings lengths were provided by year, and gear (handline, longline, and other). Commercial discard lengths from observer data were provide for 2006-2012. Commercial landings ages were provided by year and gear.

3.1.1 Participants in SEDAR 33 Data Workshop Commercial Workgroup

Neil Baertlein, NMFS Miami (group leader)
Donna Bellais, GMFMC
Jason Delacruz, Commercial Fisherman
David Gloeckner, NMFS Miami (rapporteur)
Walter Keithly, GMFMC SSC
Kevin McCarthy, NMFS Miami
Jessica Stephen, NMFS SERO
Wayne Werner, Commercial Fisherman

Other contributors: Ching-Ping Chih, Darlene Johnson, Refik Orhun

3.1.2 Issues Discussed at the Data Workshop

Commercial landings issues the workgroup addressed included historical landings, boundaries, gears, and IFQ reported landings. Much of the landings discussions also involved the apportioning of gag from unclassified grouper landings as well as how to address the issue of misidentification of gag and black grouper. For gag grouper discards the workgroup discussed the disparity in estimates constructed from self-reported logbook and directed fishery observer data. Size composition discussions included the representativeness of lengths sampled dockside sampling, as well as from otoliths obtained from dockside samples.

3.2 Review of Working Papers

The workgroup considered data and analyses presented from the following workshop working paper.

SEDAR33-DW17: This document revisited and reconstructed gag to black landing ratios from data collected by the Trip Interview Program (TIP). The workgroup recommended using these area fished specific ratios to apply to gag and black grouper landings totals. Proportions actually applied were slightly different from those in the paper as they had been recalculated by excluding 2010-2012 data. Since sample sizes were relatively small in the western Gulf of Mexico, these areas were combined to create a single gag to black grouper ratio.

3.3 Commercial Landings

Most of the commercial landings were compiled from the ALS from 1963-2012. Gag grouper landings are provided in Table 3.1 by year and gear (handline, longline, and other). There are several situations where the landings data may not have the desired level of resolution. The following issues were identified:

1. Only annual data are available for 1962 – 1977
2. In 1962 and 1963, some landings are only reported as water body code 5000 (Gulf of Mexico).
3. For Florida, gear and fishing area are not available for monthly data for 1977 - 1984
4. For Louisiana, gear and fishing area are not available for 1990 - 1999
5. For Texas, gear and fishing area are not available for 1990 - 2011.

There is a lack of resolution for the 1962 - 1977 period, however there was no need to distribute the annual percentages by gear and fishing area by month for this time period.

For the landings on the west coast of Florida during the period 1977 - 1996, data on the allocation of landings gear and fishing area are available from the Florida general canvass data which has annual landings data by gear and water body from 1976 to 1996. Proportions from the annual general canvass were applied to the monthly ALS data to provide the desired resolution for the landings time series. The annual Florida general canvass landings data were used from 1977 – 1989 to allocate gear and statistical area to the landings.

To supply gears and areas for the Louisiana data, CFLP data were used to apportion landings accordingly.

Landings in Texas from 1978 to 1983 were classified as gear code ‘0’ or ‘215’ (unclassified gear or shrimp trawl). No vertical (hand or electric) or longline gear was present for TX landings. To account for the missing gears, apportioning of Texas landings by gear for 1978 through 1984 was performed by using proportions.

To supply gears and areas for the Texas landings beginning in 1990, CFLP data were used to apportion landings accordingly.

In summary, for landings 1990 and later the gear allocations available in the general canvass (trip ticket) data were retained and the gear allocations from the CFLP were used for Louisiana (1990 - 1999, the Louisiana trip ticket data without gear designations for 2000 - 2003) and for Texas landings.

Further details regarding the data in ALS and General Canvass can be found Appendix A.

Louisiana landings from 2000-2012, and Alabama landings from 2002-2012, were obtained from GulfFIN and subsequently replaced those found in ALS. Since ALS contains monthly summaries of state trip ticket data, the workgroup felt the use of a state's raw trip ticket data would likely produce more accurate landings.

Decision 1: It was the workgroup's recommendation to use state trip ticket data where available. This includes Louisiana's 2000-2012 and Alabama's 2002-2012 trip ticket data.

3.3.1 Boundaries

Gulf of Mexico landings are spatially distributed using the statistical areas 1 to 21, reaching from statistical area 1 in the Florida Keys to statistical area 21 bordering Mexico, see Figure 3.1.

The CFLP landings are reported by statistical area 1-21. ALS landings are reported by water body. When available, water body code is converted to statistical areas using the first two digits of the water body codes. When ALS water body is not available, county of landing is used to assign the nearest statistical area.

The Gulf of Mexico and South Atlantic stock boundary lays in areas 1 and 2. The Gulf of Mexico landings from areas 1 and 2 are taken from water bodies north of highway U.S. 1 in the Florida Keys and north of the boundary line that extends from Key West to the Dry Tortugas. Waters west of the Dry Tortugas are considered to be the Gulf of Mexico (Figure 3.2).

> **Decision 2:** The workgroup's recommendation was to maintain the region boundaries as defined by the Gulf of Mexico Council boundaries between statistical grid areas 1 and 21.

3.3.2 Gears

The workgroup investigated reported gears landing gag grouper from various data sources (ALS, CFLP, FWC, and GulfFIN) and determined the predominate gears to be handline and longline. It was the workgroup's recommendation to then categorize landings into three gear groups: handline, longline, and other. A list of gears included in the handline and longline categories can be found in Table 3.2.

> **Decision 3:** The workgroup suggested three gear groupings to characterize the gag grouper fishery (handlines, longlines, and other). Handlines include hook and line, electric/hydraulic bandit reels, and trolling.

3.3.3 Misidentification and Unclassified Grouper

As discussed in previous stock assessments (Schirripa and Goodyear, 1994; Turner *et al*.; 2001, Chih and Turner, 2006) gag has been often misidentified, or misreported, as black grouper in the Gulf of Mexico. This has been likely due to the similar appearances of the two grouper, but more likely the effect on marketability by selling a fish called 'gag'. To address this, a proportion of gag to black grouper {gag/(gag+black)} was developed using biological sampling data from TIP. These proportions have been reconstructed with the most recent data, 1984-2012, and can be found in Chih (2013). There was concern using TIP data from 2010 through 2012 as the implementation of the Gulf of Mexico grouper IFQ program began in 2010. The implementation of the IFQ program may have led to gag proportions differing from those in years prior. Therefore, the workgroup recommended using TIP data from 1986 through 2009 for the development of gag proportions (Table 3.3). The updated gag proportions were then applied to gag and black landings by area grid fished. Due to the relatively small sample sizes in the western Gulf, the workgroup also recommended using a mean proportion of gag for grid areas 12-22, which was used for landings from these same areas (Table 3.4).

> **Decision 4:** The workgroup recommended applying the TIP derived proportions to gag and black grouper landings.

> **Decision 5:** The workgroup recommended combining samples from areas 12-22 to create one gag proportion for those areas.

Prior to 1986 all grouper landings, with the exception of goliath and warsaw, were reported as unclassified grouper. After this time unclassified grouper can still be found to varying degrees depending on the state of reporting. To apportion these landings to gag, a proportion of gag and black grouper to the total identified grouper {(gag + black)/(all identified grouper species)} was developed for each year and state. The proportions were then applied to all unclassified grouper landings with the corresponding year and state. Prior to 1986 a mean gag and black proportion was created for each state using data for 1986-1995. This is deviation from SEDAR10 which used a mean proportion from years 1986 – 1989. The workgroup felt that the previously used time period did not accurately reflect the proportion of gag and black, due to the relatively low reporting to species for some states and the absence of some of other groupers such as hind and scamp. It was therefore the workgroup's recommendation to use a ten year average. Once the gag and black was apportioned from the unclassified landings, the gag proportions discussed above were applied.

Decision 6: The workgroup recommended apportioning unclassified grouper to gag and black, then to apply gag proportion.

Decision 7: The workgroup recommended using a ten year gag and black proportion as opposed to a four year, for grouper landings prior to 1986.

3.3.4 IFQ Landings

The gag grouper Individual Fishing Quota program (RS-IFQ) is an online system where all transactions (share, allocation, and landing transfers) are recorded immediately upon entry by gag-IFQ participants. Landing transactions contain the following information: shareholder, vessel, and dealer name, landing date/time, landing location, species and pounds landed, and a landing confirmation number. Landings transactions cannot be completed for more pounds than are allocated to the vessel at the time of the landing and are not completed until approved by both the dealer and shareholder. The gag-IFQ program records all weights in gutted pounds. Individual landings were summed for annual total pounds landed.

In the IFQ years (2010 and later) commercial landings were based on ALS and IFQ reporting, rather than just ALS. The workgroup felt the IFQ landings reported were more likely to be accurate as there dealers were more likely to report species more accurately and no unclassified grouper can be reported. Total IFQ landings of gag were 93.2-97.4% of the calculated ALS landings. For the assessment, ALS data are assigned to gear and statistical area (and thereby region) using logbook proportions of the landings (rather than dealer information). To maintain this resolution in ALS data, ALS landings were adjusted across strata using the percent difference between ALS and IFQ landings (Table 3.5). The resulting total ALS landings for 2010 through 2012 would then reflect that of IFQ.

Decision 8: Use total IFQ landings from 2010 through 2012. Apply the differences between ALS and IFQ to ALS data across all strata.

3.3.6 Historical Landings

Historical landings of gag grouper were constructed for 1880 through 1962 using data kept by NOAA’s Office of Science and Technology. In the historical data all landings of grouper, with the exception of goliath and warsaw groupers, were reported as unclassified grouper. The unclassified grouper data available were by year and state. Of the 83 years of unclassified grouper landings available, only 26 years had data for all states (TX, LA, MS, AL, west FL), 12 years had data for at least one of the states, and 45 years had no data available. To fill in the missing data, estimates of state landings were made for years with partial reporting. To achieve this, a state’s average proportion of the total grouper landings was calculated from the years in which all states reported. Once applied to the partial reporting years, total reported landings of grouper for 38 years were estimated or known. To fill in the remaining years with no available landings a total landing was estimated for each year based upon a linear interpolation between years where total landings were available. Once a total was assigned to the year, the landings were apportioned among states based on the proportions constructed previously. See Table 3.6 for annual estimated grouper landings.

Decision 9: Use state proportions and linear interpolation to fill in missing data.

With data available for every year and state (known or estimated) the unclassified grouper landings were apportioned to gag. To apportion these landings to gag grouper the workgroup recommended using a state specific black and gag proportion to the total known grouper (excluding goliath and warsaw). This proportion was created using ALS data from 1986 through 1995. The first year grouper can be found reported to species is 1986. Once black and gag were apportioned from the unclassified grouper, a state gag to black ratio was applied using ratios developed from the Trip Interview Program (Table 3.7). Final historic grouper and adjusted gag landings can be found in Table 3.8 and Figure 3.4.

Decision 2: Apply gag+black proportion to unclassified grouper using ALS data from 1986-1995. Apply gag to black proportion derived from TIP.

3.4 Discards and Bycatch

Commercial Discards Preliminary Analyses

Commercial gag grouper discards were calculated using discard rates as reported by fisheries observers. The discard rates were multiplied by year-specific total effort reported to the coastal logbook program to estimate total discards. Analytical methods used are briefly described here.

Gag grouper discard calculations

The SEFSC began an observer program for Gulf of Mexico commercial vertical line (handline and bandit rig) and bottom longline reef fish trips in July 2006. A fisher reported discard logbook program began in 2001; however, discard rates calculated from those data have often been much lower than those calculated from the observer reported data. The number of observed trips was much lower than the number of trips reported to the discard logbook program. For SEDAR 33, observer data reported from vertical line vessels were used to calculate nominal gag grouper discard rates. The limited sample size of the observer data set did not allow for calculation of standardized discard rates using, for example, a delta-lognormal modeling approach.

Discard rates of gag grouper were calculated by stratifying observer and coastal logbook vertical line data by year, season (open or closed to fishing) and region (east = statistical zones 1-8, west = 9-21). Gag grouper and other shallow water groupers have been managed using Individual Fishing Quotas (IFQs) since 2010. For the years 2010-2012, the data were also stratified by the amount of gag grouper IFQ allocation available to a vessel during a trip. Available allocation included gag grouper IFQ, gag grouper multi IFQ, and red grouper multi IFQ (this category of IFQ allocation was available during 2010 only). The “multi” categories allow fishers to land several species of grouper; e.g., gag multi IFQ allows gag and red grouper to be landed. A ratio estimator of stratum specific discard rate*stratum specific effort reported to the coastal logbook program was used to calculate discards. Discards calculated for all strata within a year were summed to provide yearly discards.

Effort data from the coastal logbook program are available beginning in 1990. Discards for the years 1990-2007 were calculated using the mean discard rate for the years 2007-2009 for each season/region stratum. Data from 2007-2009 were used to avoid any effect of gag grouper IFQ availability on discard rates. Those mean rates were then used along with coastal logbook effort data to calculate stratum specific discards. Yearly total discards are provided in Table 3.9. A gag grouper regulatory change occurred in 1999 when the minimum size was increased from 20 inches total length to 24 inches total length. Any effect on discard rates as a result of that minimum size change cannot be determined from the available data, therefore, total discards calculated for the years 1990-1998 may be overestimated.

Data workshop recommendations

Examine Individual Fishing Quota (IFQ) effects on discard rates of gag grouper

This issue affects the calculation of discards prior to 2007 when using observer data. Other than the first six months of the observer program, all observer data was collected when some species were managed using IFQs. Fishers report that IFQs have resulted in fundamental changes in commercial fisher behavior that may affect catch and discard rates of other species in addition to the species directly regulated through IFQs. A thorough examination of this issue will likely require months of analyses and only preliminary work has been completed. SEFSC personnel will be investigating this issue during the remainder of the year.

Use the ratio of fisher reported to observer reported discard rates to adjust fisher reported rates

This recommendation acknowledges that fisher reported discard rates are often much lower than those reported by observers. It was recommended that the pre-IFQ (2002-2006) fisher reported rates, as adjusted, be used to calculate discards for the years 1990-2002. Adjusted fisher reported rates are also recommended for calculating discards during 2007-2012. Use of fisher reported rates is recommended due to small sample size of the observer data where some strata (season, region, year) are unpopulated.

3.5 Commercial Effort

The distribution of directed commercial effort in trips by year was compiled from the Coastal Fisheries Logbook Program (CFLP) for 1993-2012 and supplied here for information purposes. These data are presented in Figure 3.5. The distribution of harvest, as reported to the CFLP, is also displayed in Figure 3.6.

3.6 Biological Sampling

Biological sample data were obtained from the TIP sample data at NMFS/SEFSC and from the reef fish observer program at SEFSC's Galveston laboratory. Data were filtered to eliminate those records that included a size or effort bias, non-random collection of length data, were not from commercial trips, fish were selected by quota sampling, or the data was not collected shore-side. 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.

3.6.1 TIP Samples

Commercial length samples are available for all gear groups between 1984 and 2012. The number of fish sampled for length had a high of 8,068 for handline gear in 1998 to lows below ten for a number of years for other gear (Table 3.10). The number of lengths sampled was consistently greater than 500 for handline gear with the exception of four years. Longline lengths showed similar sampling trends having only three years with fewer than 500 fish. For other gear, the numbers of lengths sampled reached were over 100 between 1993 and 2003, but were below 50 most of the other years.

For age samples, the numbers of sampled fish were considerably lower. With the exception of 1981 and 1983, age samples are available for 1991-2012. There were sampling highs of 1,616 and 1,484 for handline and longline respectively. However, fewer than 500 fish were sampled for twenty-one years for both handline and longline. Most of the years had fewer than five fish for other gear. It was the workgroup's recommendation to therefore combine other gear samples with the predominant gear handline. Table of age samples can be found in Table 3.11.

3.6.2 Size frequency data from commercial fisheries observers

Fishery observer data have been collected from the Gulf of Mexico reef fish fishery since July, 2006. Data collection efforts have been primarily directed towards the vertical line and bottom longline fisheries. Vessels were randomly selected for observer coverage within gear (handline/electric/hydraulic reel vertical line and bottom longline), region (eastern and western Gulf of Mexico), and season (Jan-Mar, Apr-Jun, etc.) strata. Sampling within each gear/region/season stratum was apportioned by the fishing effort (days at sea) reported within each stratum for the previous year. Strata with the highest effort received greater observer coverage (more observer days at sea) than did those strata with lower reported effort.

The observer data were more detailed than the self-reported fishing effort and landings data included in the coastal logbook data set. For example, total catch, including discarded fish, was recorded for each set; where set was defined as fishing at a specific location. A majority (96.3% longline and 97.5% vertical line) of gag grouper were measured (fork length) and the disposition (kept, discarded dead, discarded alive, kept for bait, unknown) of each fish was recorded.

Observer data was used to examine the catch and discard characteristics of the two fisheries that catch gag using data during 2006-2012. Tables were constructed for number of trips and number of discards by region and year. Regions were defined as Gulf of Mexico statistical areas 1-12 (east) and 13-21 (west). The number of trips with gag grouper observed are included in Table 3.123(sample sizes in 2006), Tables 3.14A-3.14B (trips by gear, region, and gag grouper allocation), and Tables 3.15A-3.15B (trips by gear, year, and region). Data was pooled to maintain confidentiality as covered under NOAA Administrative Order 216-100 and indicated as confidential data in tables. Cells with less than 3 vessels are not shown.

The available observer reported gag size and disposition data were used to construct size frequency histograms of discarded and kept fish for each gear. Gears included vertical lines (handline and electric/hydraulic reels) and bottom longlines. No attempt was made to account for the fraction of fish that was not measured (e.g., if 70% of discarded fish within a stratum were measured while 95% of kept fish were measured in the same stratum, no adjustment was made for that difference in sampling fraction). Length data is presented in fork length. Fifteen of the longline data (<1%) was in total length (no discards) and 44 observations (35 discards) of the vertical line (2.5%) were in total length. Total length was converted to fork length using Forklengthmm= (1.07+ (TotalLengthmm*0.97)).

Yearly changes in the size frequency of discarded and kept gag grouper were examined. Histograms were produced following stratification of the data by year, region, and gear. Sample sizes of observed fish are provided within each figure.

Beginning in 2010, the gag commercial fishery has been managed through the use of Individual Fishing Quotas (IFQs). In addition to region/gear stratification, data reported during the period 2010-2012 were further stratified by the amount of gag allocation available to the observed vessel and size frequency histograms constructed. Allocation categories were defined by dividing the data (number of measured fish) into roughly equal groups within each region and gear stratum. A “no allocation” stratum was defined for each region and gear. Other allocation strata approximated low, medium, and high amounts of allocation; based upon the range of allocation available to individual vessels in the fishery. All region/gear/allocation strata are defined in Table 3.12.

Prior to 2007, observer data were available for the period July-December, 2006. During those months, the commercial fishery was subject to seasonal closures (Feb 15-March 16). Data collected during 2006-2009 were stratified by season (open and closed), region, and gear and size frequency histograms constructed for each stratum.

Size frequency histograms of observed gag grouper discards and kept fish are provided in the figures listed below. In the western subregion, longline data could not be presented due to confidentiality restrictions.

Figure 3.7 Commercial bottom longline eastern Gulf of Mexico 2006-2012 observed gag grouper size composition by year.

Figure 3.8 Commercial vertical line eastern Gulf of Mexico 2006-2012 observed gag grouper size composition by year.

Figure 3.9 Commercial vertical line western Gulf of Mexico 2006-2012 observed gag grouper size composition by year.

Figure 3.10 Commercial bottom longline eastern Gulf of Mexico observed gag grouper size composition by gag grouper allocation (2010-2012).

Figure 3.11 Commercial vertical line eastern Gulf of Mexico observed gag grouper size composition by gag grouper allocation (2010-2012).

Figure 3.12 Commercial vertical line western Gulf of Mexico observed gag grouper size composition by gag grouper allocation (2010-2012).

Figure 3.13 Commercial bottom longline eastern and western Gulf of Mexico observed gag grouper size composition by fishing season (2006-2009).

Figure 3.14 Commercial vertical line eastern and western Gulf of Mexico observed gag grouper size composition by fishing season (2006-2009).

3.7 Comments on Adequacy of Data for Assessment Analyses

Overall the workgroup felt the landings were adequate for assessment analyses. The landings time series ran from 1880-2012. There was much uncertainty in the landings provided for 1880-1962 as reported landings of grouper were missing for the majority of years. The regional boundaries set and the landings by gear group were agreed upon by the workgroup. Total IFQ landings used for 2010 through 2012 were also agreed upon as being the most accurate.

There was some uncertainty in the discard estimations due to the disparity in discard rates between the self-reported logbook data and the observer data. Generally speaking the observer discard rates were an order of magnitude greater than those in the self-reported logbook data. It was felt that the observer data was more likely accurate but only provided discard rates back to 2007. Applying a mean discard rate from 2007-2009 back to 1990 may also be overestimating the amount of total gag discarded. The impact of red snapper, and later grouper, IFQ on discard rates was also a concern. Further investigations and analyses are ongoing.

The workgroup felt the commercial landings length samples should be adequate for assessment analyses. There appears to be an adequate number of samples for most years for both handline and longline. Other gear may also have adequate sample sizes, but for fewer years. There were fewer age samples, but the work group felt these data could be adequate if samples were combined across some strata.

3.8 Research Recommendations for Gag Grouper

Landings
-Improved dockside sampling for catch composition
-Improved dealer reporting to species
-Historical literature research for historical landings

IFQ
-Investigate dealer influence on IFQ allocation usage through dealer IFQ surveys

Discard
-Most appropriate method for incorporation of IFQ data into discard estimations
-Most appropriate method for incorporation of IFQ data into discard size compositions
-Increased observer coverage.
-More representative observer coverage.

3.9 Literature Cited

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Turner, S.C. C.E. Porch, D. Heinemann, G.P. Scott and M. Ortiz. 2001. Status of Gag in the Gulf of Mexico, Assessment 3.0. NMFS, Southeast Fisheries Center, Miami Laboratory, Miami SFD-2000/2001-118 pp.

3.10 Tables

Table 3.1 Annual gag grouper landings in gutted pounds for 1963-2012

Year	Handline	Longline	Other	Total
1963	1,601,728		480	1,602,207
1964	2,002,317		9,299	2,011,616
1965	2,196,944		447	2,197,391
1966	1,837,614		950	1,838,564
1967	1,425,214		3,406	1,428,620
1968	1,488,186		2,246	1,490,432
1969	1,723,707		1,124	1,724,830
1970	1,631,494		4,910	1,636,404
1971	1,642,791		2,581	1,645,372
1972	1,758,667		1,264	1,759,932
1973	1,291,964		2,171	1,294,135
1974	1,453,099		640	1,453,738
1975	1,790,353		3,369	1,793,722
1976	1,444,993		1,394	1,446,387
1977	1,190,142		7,170	1,197,312
1978	1,065,551		12,639	1,078,190
1979	1,658,532	1,092	7,365	1,666,990
1980	1,634,549	95,597	9,492	1,739,638
1981	1,706,545	422,274	8,539	2,137,359
1982	1,521,873	884,939	7,974	2,414,785
1983	1,216,206	608,632	6,619	1,831,456
1984	1,331,345	416,718	28,845	1,776,908
1985	1,717,886	365,663	44,529	2,128,078
1986	1,148,245	510,796	26,815	1,685,857
1987	841,907	650,584	24,028	1,516,519
1988	781,509	400,010	20,025	1,201,544
1989	1,223,372	419,620	28,206	1,671,198
1990	1,120,684	615,586	37,938	1,774,209
1991	984,769	500,369	59,353	1,544,490
1992	987,230	583,692	64,113	1,635,035
1993	1,270,678	472,532	103,598	1,846,808
1994	1,142,108	346,133	117,130	1,605,371
1995	1,151,592	384,461	103,403	1,639,456
1996	1,095,780	386,651	66,004	1,548,435
1997	1,091,772	407,960	81,711	1,581,442
1998	1,832,882	582,367	81,222	2,496,471
1999	1,455,247	530,237	65,477	2,050,961
2000	1,574,564	565,152	86,613	2,226,330

2001	2,042,174	935,194	101,305	3,078,673
2002	1,866,603	1,011,858	62,270	2,940,730
2003	1,430,950	1,077,885	65,452	2,574,286
2004	1,721,903	1,084,498	72,666	2,879,066
2005	1,528,153	871,621	68,681	2,468,455
2006	791,922	517,949	55,570	1,365,440
2007	739,090	472,789	45,034	1,256,913
2008	901,097	372,760	44,153	1,318,010
2009	551,793	155,547	39,904	747,244
2010	343,965	106,609	46,094	496,667
2011	202,892	84,788	30,902	318,582
2012	355,345	128,399	39,302	523,047

Table 3.2 ALS gear code grouping.

NMFS Code	Description	Group
600	Troll & Hand Lines Cmb	Handline
610	Lines Hand, Other	Handline
611	Rod and Reel	Handline
612	Reel, Manual	Handline
613	Reel, Electric or Hydraulic	Handline
616	Rod and Reel, Electric (Hand)	Handline
614	Long Line, Vertical	Longline
675	Lines Long Set With Hooks	Longline
676	Lines Long, Reef Fish	Longline
677	Lines Long, Shark	Longline
*	All other codes	Other

Table 3.3 TIP samples and resulting proportions of gag to black by area grid.

Area Grid	Gag N	Black N	Total N	Proportion Gag by Number	Proportion Gag by Weight
1	160	833	993	0.161	0.093
2	5,036	3,703	8,739	0.576	0.420
3	4,756	688	5,444	0.874	0.786
4	13,841	777	14,618	0.947	0.905
5	24,224	573	24,797	0.977	0.957
6	25,130	228	25,358	0.991	0.983
7	10,577	7	10,584	0.999	0.999
8	13,146	5	13,151	1.000	0.999
9	1,373	4	1,377	0.997	0.995
10	1,481	23	1,504	0.985	0.972
11	561	8	569	0.986	0.974
12	44	.	.	.	.
13	204	6	210	0.971	0.948
14	435	6	441	0.986	0.975
15	311	7	318	0.978	0.959
16	190	5	195	0.974	0.953
17	184	.	.	.	.
18	55	3	58	0.948	0.907
19	13	.	.	.	.
20	14	3	17	0.824	0.713
21	234	4	238	0.983	0.969
22	16	1	17	0.941	0.895

Table 3.4 Final gag proportions by area applied to 1963-2012 landings.

Area Grid	Proportion Gag by weight
1	9.3%
2	42.0%
3	78.6%
4	90.5%
5	95.7%
6	98.3%
7	99.9%
8	99.9%
9	99.5%
10	97.2%
11	97.4%
12	96.3%
13	96.3%
14	96.3%
15	96.3%
16	96.3%
17	96.3%
18	96.3%
19	96.3%
20	96.3%
21	96.3%

Table 3.5 Annual IFQ correction factors.

Year	IFQ landings	ALS + GulfFIN landings	IFQ correction factor
2010	496,826	509,944	0.9742757
2011	318,663	341,646	0.9327280
2012	523,138	552,987	0.9460217

Table 3.6 Historical unclassified grouper landings from Gulf of Mexico states. Calculated landings are shown in italics.

Year	TX	LA	MS	AL	w FL	Total
1880	*22,970*	*4,775*	*34,989*	*74,140*	1,764,000	*1,873,288*
1881	*20,260*	*4,212*	*30,861*	*65,393*	*1,559,523*	*1,652,278*
1882	*17,550*	*3,648*	*26,733*	*56,646*	*1,350,920*	*1,431,268*
1883	*14,840*	*3,085*	*22,605*	*47,899*	*1,142,317*	*1,210,258*
1884	*12,130*	*2,522*	*18,477*	*39,152*	*933,714*	*989,248*
1885	*9,420*	*1,958*	*14,349*	*30,405*	*725,111*	*768,238*
1886	*6,710*	*1,395*	*10,221*	*21,658*	*516,508*	*547,228*
1887	4,000	*832*	*6,093*	*12,911*	*307,905*	*326,218*
1888	7,000	*1,042*	*7,638*	*16,185*	384,000	*408,943*
1889	*5,546*	18,000	*8,449*	10,000	418,000	*452,338*
1890	*5,323*	18,000	*8,108*	11,000	399,000	*434,082*
1891	*6,063*	*1,260*	*9,235*	*19,569*	*466,696*	*494,453*
1892	*6,803*	*1,414*	*10,363*	*21,959*	*523,678*	*554,825*
1893	*7,543*	*1,568*	*11,490*	*24,348*	*580,661*	*615,196*
1894	*8,284*	*1,722*	*12,618*	*26,737*	*637,643*	*675,568*
1895	*9,024*	*1,876*	*13,746*	*29,127*	*694,625*	*735,939*
1896	*9,764*	*2,030*	*14,873*	*31,516*	*751,608*	*796,311*
1897	3,000	*2,184*	*16,001*	69,000	781,000	*856,682*
1898	*11,142*	*2,316*	*16,973*	*35,964*	*857,693*	*908,706*
1899	*11,780*	*2,449*	*17,944*	*38,023*	*906,796*	*960,729*
1900	*12,418*	*2,582*	*18,916*	*40,082*	*955,899*	*1,012,753*
1901	*13,056*	*2,714*	*19,888*	*42,141*	*1,005,003*	*1,064,777*
1902	40,000	*2,847*	*20,859*	635,000	437,000	*1,116,800*
1903	*14,788*	*3,074*	*22,527*	*47,733*	*1,138,355*	*1,206,061*
1904	*15,883*	*3,302*	*24,194*	*51,266*	*1,222,605*	*1,295,321*
1905	*16,977*	*3,529*	*25,861*	*54,799*	*1,306,855*	*1,384,582*
1906	*18,072*	*3,757*	*27,528*	*58,331*	*1,391,104*	*1,473,842*
1907	*19,166*	*3,984*	*29,195*	*61,864*	*1,475,354*	*1,563,103*
1908	*20,261*	*4,212*	*30,862*	394,000	1,231,000	*1,652,363*
1909	*25,513*	*5,304*	*38,863*	*82,350*	*1,963,920*	*2,080,727*
1910	*30,766*	*6,396*	*46,864*	*99,304*	*2,368,236*	*2,509,090*
1911	*36,018*	*7,488*	*54,865*	*116,258*	*2,772,552*	*2,937,454*
1912	*41,271*	*8,580*	*62,866*	*133,211*	*3,176,869*	*3,365,818*
1913	*46,523*	*9,671*	*70,867*	*150,165*	*3,581,185*	*3,794,182*
1914	*51,776*	*10,763*	*78,868*	*167,118*	*3,985,502*	*4,222,545*
1915	*57,028*	*11,855*	*86,869*	*184,072*	*4,389,818*	*4,650,909*
1916	*62,281*	*12,947*	*94,870*	*201,026*	*4,794,134*	*5,079,273*

1917	*67,533*	*14,039*	*102,870*	*217,979*	*5,198,451*	*5,507,636*
1918	21,000	20,000	25,000	244,000	5,626,000	5,936,000
1919	*69,607*	*14,470*	*106,030*	*224,675*	*5,358,118*	*5,676,800*
1920	*66,429*	*13,810*	*101,189*	*214,416*	*5,113,469*	*5,417,600*
1921	*63,251*	*13,149*	*96,347*	*204,157*	*4,868,820*	*5,158,400*
1922	*60,073*	*12,488*	*91,506*	*193,899*	*4,624,171*	*4,899,200*
1923	33,000	10,000	26,000	305,000	4,266,000	4,640,000
1924	*57,149*	*11,880*	*87,052*	*184,462*	*4,399,107*	*4,660,750*
1925	*57,403*	*11,933*	*87,440*	*185,283*	*4,418,692*	*4,681,500*
1926	*57,658*	*11,986*	*87,828*	*186,104*	*4,438,277*	*4,702,250*
1927	37,000	16,000	38,000	144,000	4,488,000	4,723,000
1928	22,000	1,000	49,000	199,000	3,971,000	4,242,000
1929	16,000	4,000	25,000	154,000	4,010,000	4,209,000
1930	21,000	4,000	71,000	178,000	3,020,000	3,294,000
1931	46,000	4,000	24,000	108,000	2,484,000	2,666,000
1932	18,000	3,000	16,000	100,000	3,027,000	3,164,000
1933	*40,151*	*8,347*	*61,160*	*129,597*	*3,090,677*	*3,274,500*
1934	4,000	18,000	55,000	151,000	3,157,000	3,385,000
1935	*51,444*	*10,694*	*78,363*	*166,048*	*3,959,975*	*4,195,500*
1936	34,000	4,000	150,000	196,000	4,622,000	5,006,000
1937	20,000	6,000	129,000	219,000	4,884,000	5,258,000
1938	32,000	6,000	158,000	222,000	4,168,000	4,586,000
1939	64,000	10,000	21,000	244,000	6,401,000	6,740,000
1940	85,000	4,000	18,000	265,000	4,481,000	4,853,000
1941	*65,684*	*13,655*	*100,053*	*212,010*	*5,056,082*	*5,356,800*
1942	*71,861*	*14,939*	*109,463*	*231,949*	*5,531,600*	*5,860,600*
1943	*78,039*	*16,223*	*118,873*	*251,888*	*6,007,118*	*6,364,400*
1944	*84,216*	*17,507*	*128,283*	*271,827*	*6,482,636*	*6,868,200*
1945	17,000	3,000	7,000	169,000	7,176,000	7,372,000
1946	*82,470*	*17,144*	*125,623*	*266,192*	*6,348,239*	*6,725,810*
1947	*74,547*	*15,497*	*113,554*	*240,617*	*5,738,324*	*6,079,619*
1948	101,000	4,000	35,000	257,000	*5,128,409*	*5,433,429*
1949	130,000	5,000	29,000	180,000	8,053,000	8,397,000
1950	94,000	7,000	14,000	130,000	5,377,000	5,622,000
1951	37,000	17,000	500	225,000	5,583,000	5,862,000
1952	85,000	500	*86,321*	173,000	4,355,000	*4,621,584*
1953	65,000	1,000	8,000	104,000	4,112,000	4,290,000
1954	61,000	2,000	21,000	206,000	4,655,000	4,945,000
1955	89,000	2,000	17,000	150,000	4,640,000	4,898,000
1956	14,000	*15,236*	17,000	156,000	5,876,000	*5,977,053*
1957	48,000	500	19,000	111,000	6,483,000	6,661,000

1958	31,000	*11,039*	35,000	172,000	4,155,000	*4,330,726*
1959	112,000	12,000	75,000	231,000	5,750,000	6,180,000
1960	43,000	24,000	115,000	236,000	5,923,000	6,341,000
1961	56,000	16,000	135,000	221,000	6,370,000	6,798,000
1962	114,000	53,000	246,000	237,000	6,977,000	7,627,000

Table 3.7 Final gag proportions by state applied to historical 1880-1962 landings.

State	Proportion Gag by weight
AL	78.6%
FL	88.7%
LA	96.6%
MS	94.9%
TX	96.0%

Table 3.8 Final adjusted historical, 1880-1962, gag landings.

Year	TX	LA	MS	AL	FL	Total
1880	171	248	1,737	8,583	331,790	342,530
1881	151	219	1,532	7,570	293,330	302,803
1882	131	190	1,327	6,558	254,094	262,300
1883	111	160	1,122	5,545	214,858	221,797
1884	90	131	917	4,533	175,622	181,293
1885	70	102	712	3,520	136,386	140,790
1886	50	73	508	2,507	97,150	100,287
1887	30	43	303	1,495	57,914	59,784
1888	52	54	379	1,874	72,226	74,586
1889	41	936	419	1,158	78,621	81,176
1890	40	936	403	1,273	75,048	77,699
1891	45	66	459	2,266	87,781	90,615
1892	51	74	515	2,542	98,498	101,679
1893	56	82	571	2,819	109,216	112,743
1894	62	90	627	3,095	119,934	123,807
1895	67	98	683	3,372	130,652	134,871
1896	73	106	739	3,649	141,370	145,935
1897	22	114	794	7,988	146,898	155,816
1898	83	120	843	4,164	161,323	166,533
1899	88	127	891	4,402	170,559	176,067
1900	92	134	939	4,640	179,795	185,601

1901	97	141	987	4,879	189,031	195,135
1902	298	148	1,036	73,513	82,195	157,190
1903	110	160	1,119	5,526	214,113	221,027
1904	118	172	1,201	5,935	229,959	237,386
1905	126	183	1,284	6,344	245,806	253,744
1906	135	195	1,367	6,753	261,652	270,102
1907	143	207	1,450	7,162	277,499	286,460
1908	151	219	1,532	45,613	231,538	279,053
1909	190	276	1,930	9,534	369,393	381,322
1910	229	332	2,327	11,496	445,441	459,826
1911	268	389	2,724	13,459	521,488	538,329
1912	307	446	3,121	15,422	597,536	616,833
1913	347	503	3,519	17,384	673,584	695,336
1914	386	560	3,916	19,347	749,632	773,840
1915	425	616	4,313	21,310	825,679	852,343
1916	464	673	4,711	23,272	901,727	930,847
1917	503	730	5,108	25,235	977,775	1,009,351
1918	156	1,040	1,241	28,247	1,058,193	1,088,877
1919	518	752	5,265	26,010	1,007,807	1,040,352
1920	495	718	5,024	24,823	961,791	992,850
1921	471	684	4,784	23,635	915,775	945,348
1922	447	649	4,544	22,447	869,759	897,846
1923	246	520	1,291	35,309	802,391	839,756
1924	426	618	4,322	21,355	827,427	854,147
1925	428	620	4,342	21,450	831,110	857,950
1926	429	623	4,361	21,545	834,794	861,752
1927	276	832	1,887	16,671	844,146	863,811
1928	164	52	2,433	23,038	746,904	772,591
1929	119	208	1,241	17,828	754,240	773,636
1930	156	208	3,525	20,607	568,031	592,527
1931	343	208	1,192	12,503	467,215	481,460
1932	134	156	794	11,577	569,347	582,009
1933	299	434	3,037	15,003	581,324	600,097
1934	30	936	2,731	17,481	593,799	614,977
1935	383	556	3,891	19,223	744,830	768,883
1936	253	208	7,448	22,691	869,350	899,950
1937	149	312	6,405	25,353	918,630	950,849
1938	238	312	7,845	25,701	783,958	818,054
1939	477	520	1,043	28,247	1,203,962	1,234,249
1940	633	208	894	30,679	842,830	875,243
1941	489	710	4,968	24,544	950,997	981,708
1942	535	777	5,435	26,852	1,040,437	1,074,036
1943	581	843	5,902	29,161	1,129,877	1,166,364

1944	627	910	6,370	31,469	1,219,317	1,258,693
1945	127	156	348	19,565	1,349,731	1,369,926
1946	614	891	6,238	30,817	1,194,038	1,232,598
1947	555	806	5,638	27,856	1,079,319	1,114,174
1948	752	208	1,738	29,752	964,601	997,051
1949	968	260	1,440	20,838	1,514,686	1,538,193
1950	700	364	695	15,050	1,011,358	1,028,167
1951	276	884	25	26,048	1,050,105	1,077,337
1952	633	26	4,286	20,028	819,131	844,104
1953	484	52	397	12,040	773,425	786,398
1954	454	104	1,043	23,848	875,557	901,007
1955	663	104	844	17,365	872,736	891,712
1956	104	792	844	18,060	1,105,215	1,125,015
1957	358	26	943	12,850	1,219,385	1,233,563
1958	231	574	1,738	19,912	781,513	803,967
1959	834	624	3,724	26,742	1,081,516	1,113,440
1960	320	1,248	5,710	27,321	1,114,055	1,148,654
1961	417	832	6,703	25,585	1,198,131	1,231,668
1962	849	2,755	12,215	27,437	1,312,302	1,355,558

Table 3.9 Gag grouper yearly commercial vertical line vessel discards calculated from observer reported discard data. Discards are reported in number of fish. A minimum size change of 20 to 24 inches total length occurred following the 1998 fishing year. Discards calculated prior to 1999 may be overestimated.

Year	2010 update assessment	2013 assessment
1990	110,079	160,319
1991	221,300	237,862
1992	139,610	265,807
1993	143,333	271,637
1994	205,093	287,977
1995	220,298	218,426
1996	178,827	253,727
1997	159,489	203,845
1998	159,857	192,998
1999	150,110	197,980
2000	142,530	201,798
2001	122,559	172,269
2002	135,063	188,889
2003	142,650	196,804
2004	140,853	174,928
2005	154,186	179,117
2006	167,277	213,758
2007	192,859	244,607
2008	55,612	83,156
2009	393,168	600,875
2010		852,119
2011		379,163
2012		278,582

Table 3.10 Number of commercial length samples for gag grouper.

Year	Handline	Longline	Other
1984	814	458	16
1985	749	583	130
1986	363	1,135	41
1987	555	685	4
1988	175	276	0
1989	42	170	21
1990	965	1,665	20
1991	995	943	41
1992	1,147	941	63
1993	1,684	803	247
1994	2,485	779	421
1995	2,115	987	363
1996	2,917	1,059	268
1997	3,403	1,224	392
1998	8,068	5,076	145
1999	6,070	4,659	306
2000	4,010	4,212	190
2001	5,515	4,161	287
2002	4,118	4,149	289
2003	2,204	3,931	102
2004	2,868	2,644	18
2005	1,864	2,408	95
2006	879	1,785	24
2007	400	1,034	26
2008	1,069	1,315	50
2009	886	725	3
2010	881	1,176	21
2011	1,497	535	18
2012	1,943	503	37

Table 3.11 Number of commercial age samples for gag grouper.

Year	Handline	Longline	Other
1981	54	0	0
1982	0	0	0
1983	0	0	3
1984	0	0	0
1985	0	0	0
1986	0	0	0
1987	0	0	0
1988	0	0	0
1989	0	0	0
1990	0	0	0
1991	210	7	0
1992	66	22	0
1993	417	12	1
1994	439	3	2
1995	284	31	0
1996	197	57	3
1997	34	6	2
1998	106	101	3
1999	145	243	2
2000	387	177	6
2001	745	867	0
2002	809	1,085	15
2003	520	1,117	3
2004	894	1,484	0
2005	740	857	9
2006	641	534	1
2007	408	936	2
2008	680	506	0
2009	1,027	772	39
2010	798	883	235
2011	1,436	518	16
2012	1,616	457	37

Table 3.12 Gag grouper allocation categories by gear.

Vertical line	Longline
No allocation	No allocation
1-250 pounds	1-250 pounds
250-1,350 pounds	250-1,350 pounds
>1,350 pounds	>1,350 pounds

Table 3.13 Number of trips with observed gag grouper by gear, region, and gag grouper season during 2006-2009.

Gear	Gag season	East	West
Bottom longline	Closed	3	4
	Open	49	0
Vertical line	Closed	4	Confidential data
	Open	89	11

Table 3.14 Number of trips with observed gag grouper by gear, region, and gag grouper allocation in pounds.

A. Bottom longline.

Gag allocation	East	West
0	8	Confidential data
1-250 pounds	35	
250-1,350 pounds	40	
>1,350 pounds	49	

B. Vertical line.

Gag allocation	East	West
0	31	8
1-250 pounds	141	30
250-1,350 pounds	117	6
>1,350 pounds	40	6

Table 3.15 Number of trips with observed gag grouper by gear, year, and region.

A. Bottom longline.

Year	East	West
2006	11	0
2007	8	0
2008	9	0
2009	20	4
2010	49	Confidential data
2011	68	Confidential data
2012	5	0

B. Vertical line.

Year	East	West
2006	12	5
2007	51	7
2008	30	Confidential data
2009	26	Confidential data
2010	29	0
2011	62	5
2012	129	6

3.11 Figures

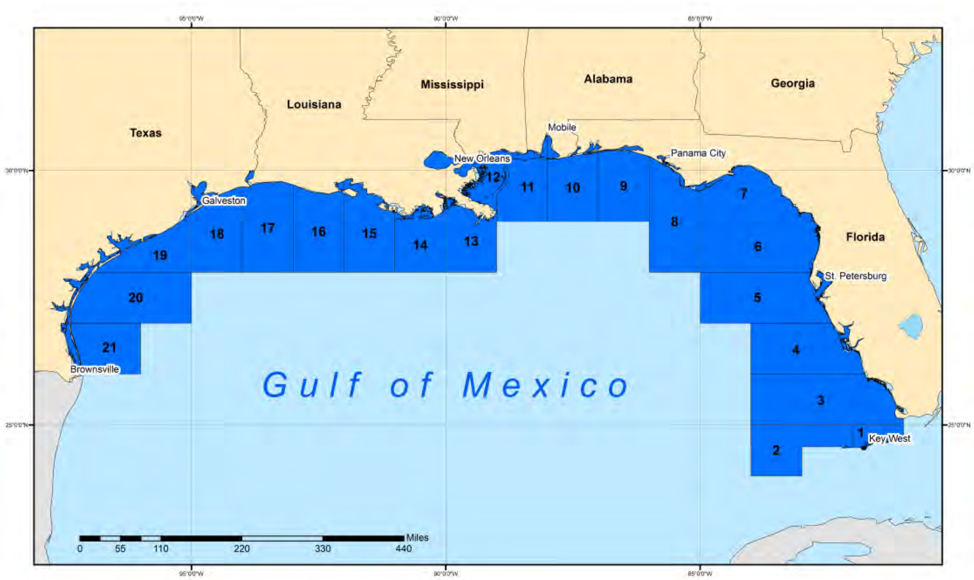

Figure 3.1 Gulf of Mexico region

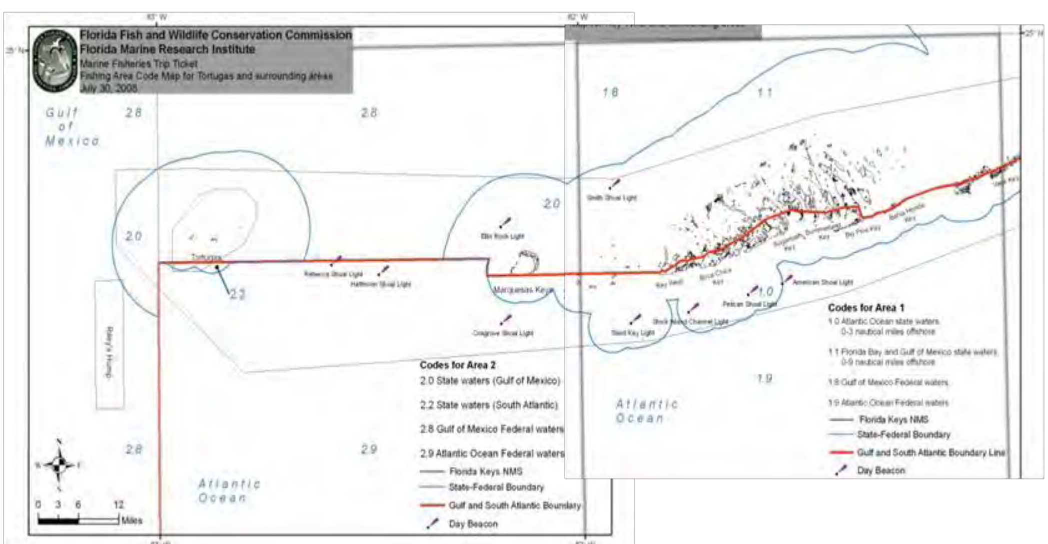

Figure 3.2 Close-up of the southern boundary as defined by the Gulf of Mexico/South Atlantic Council boundary.

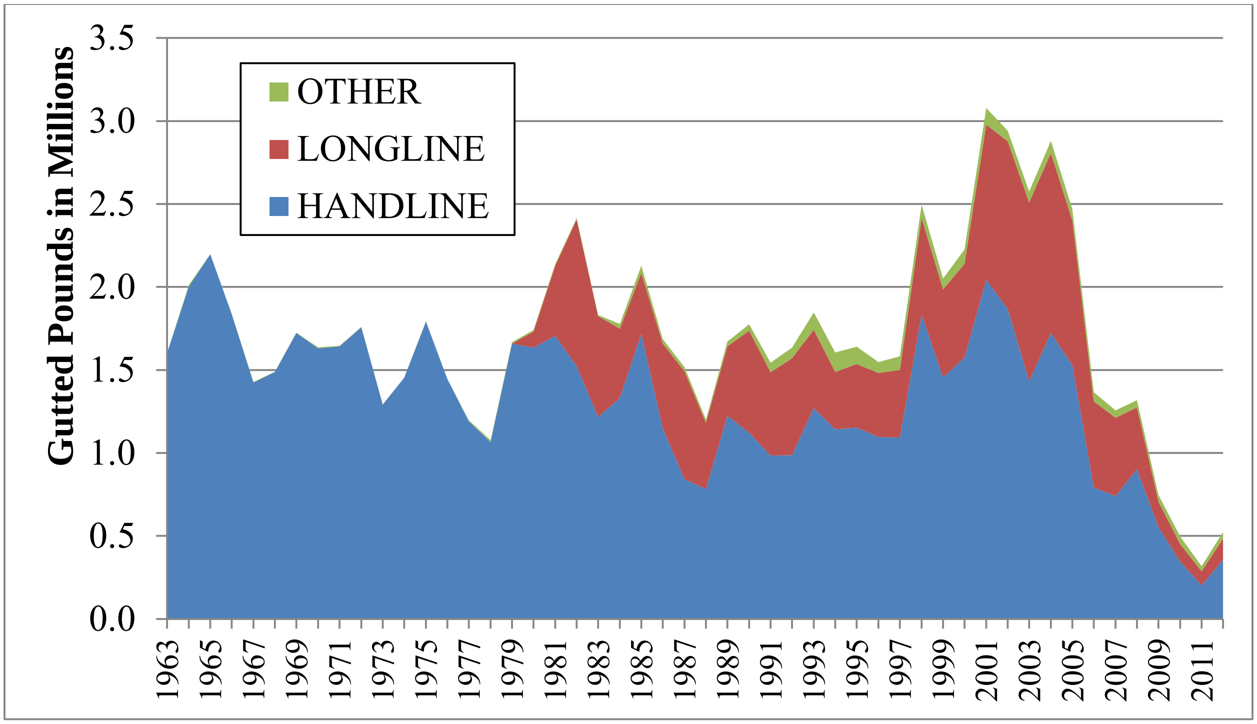

Figure 3.3 Gag grouper landings, in gutted weight pounds by gear.

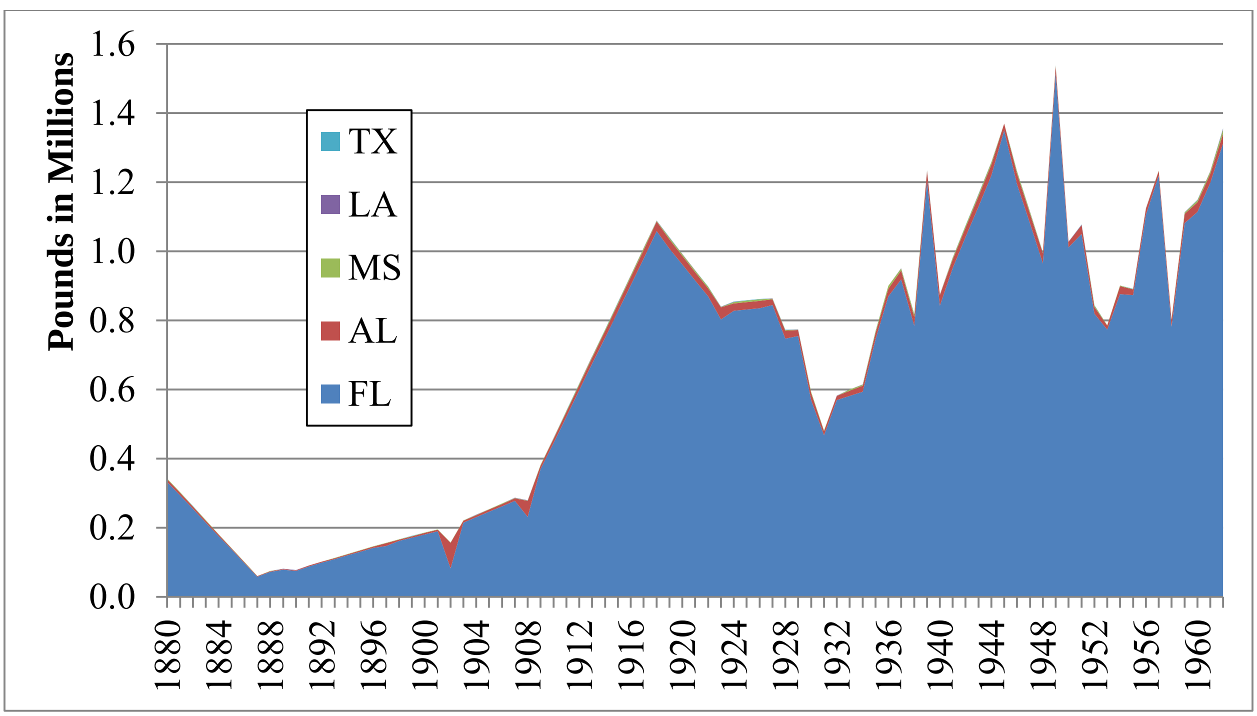

Figure 3.4 Historical gag grouper landings by state.

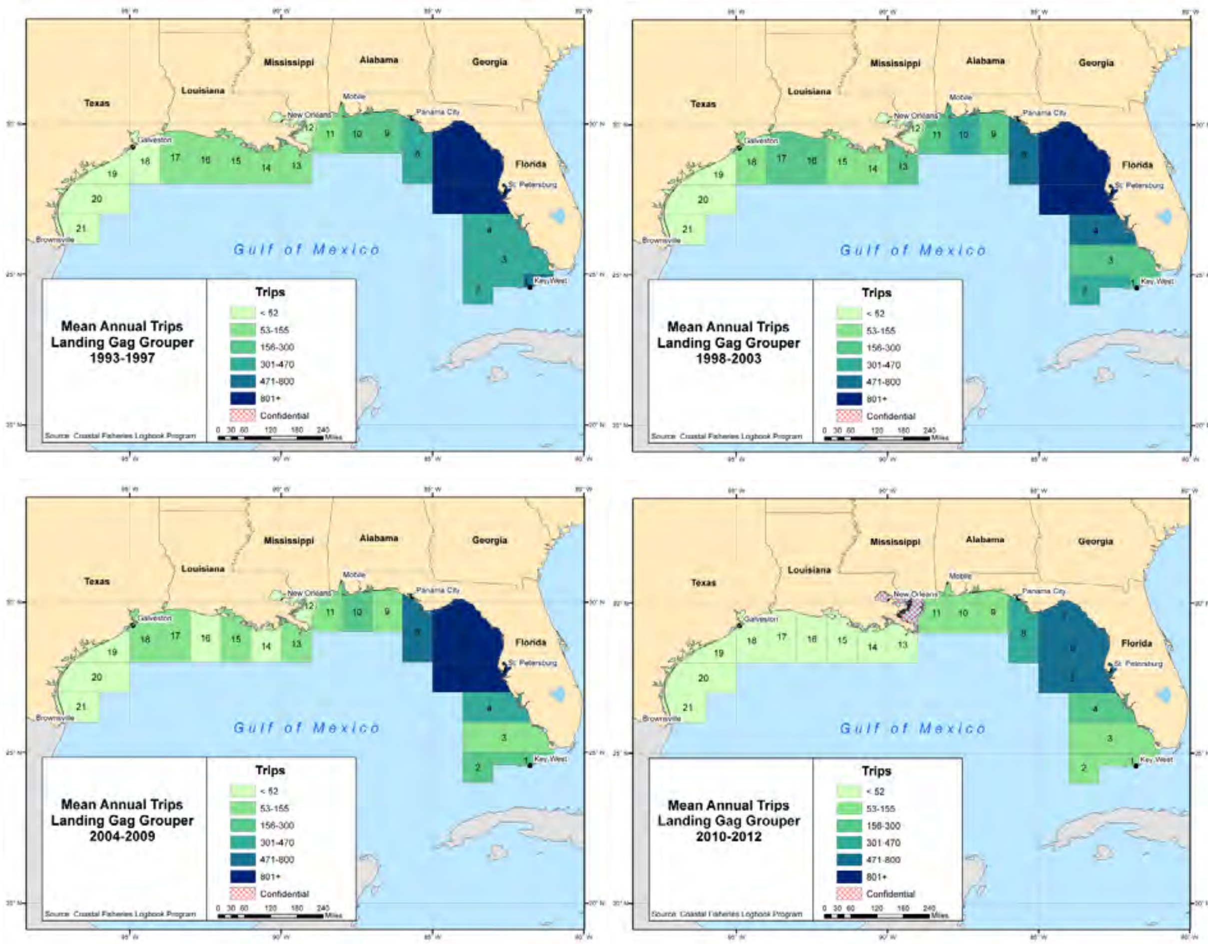

Figure 3.5 Maps of gag grouper effort in the Gulf of Mexico as reported to the CFLP

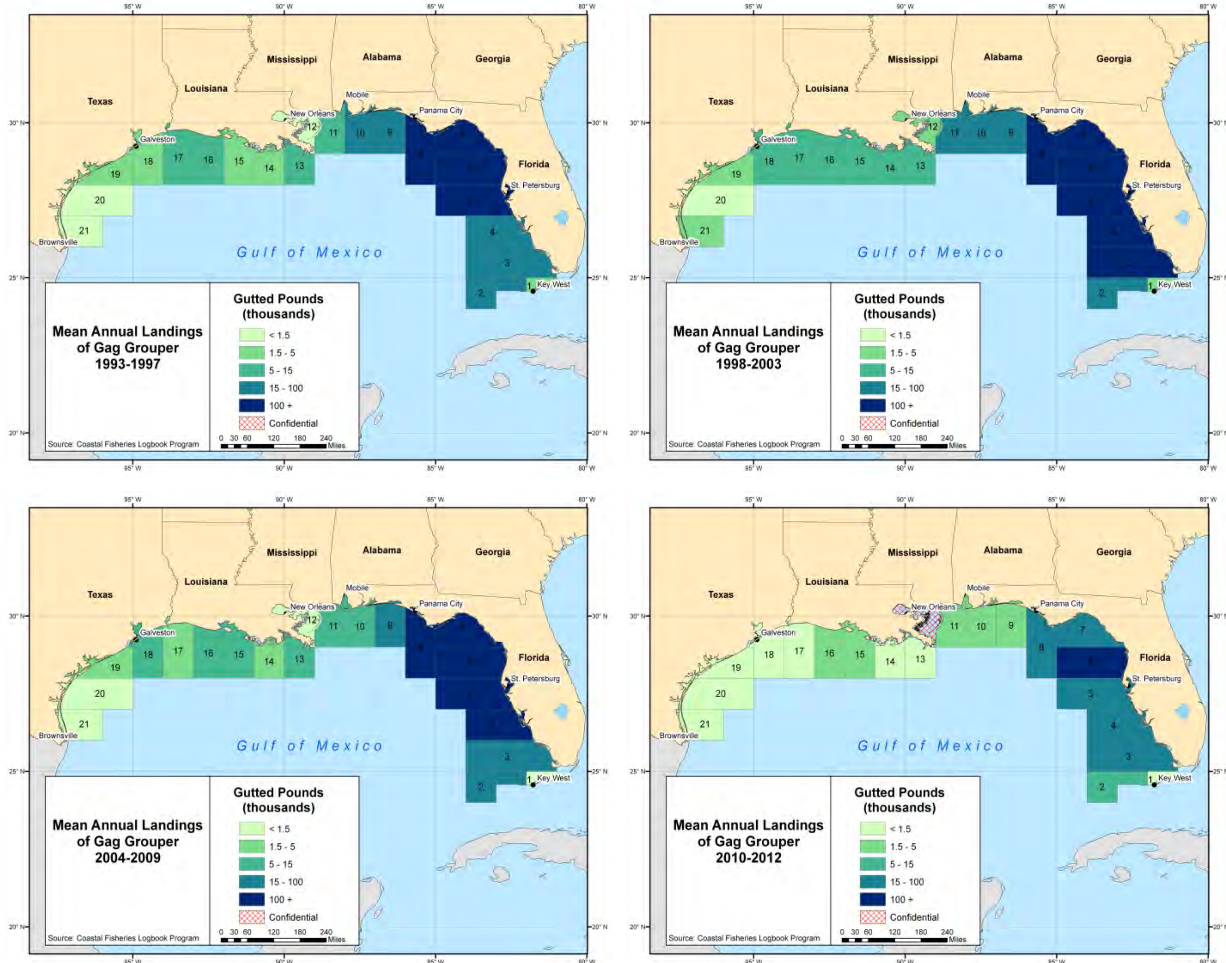

Figure 3.6 Maps of gag grouper harvest in the Gulf of Mexico as reported to the CFLP

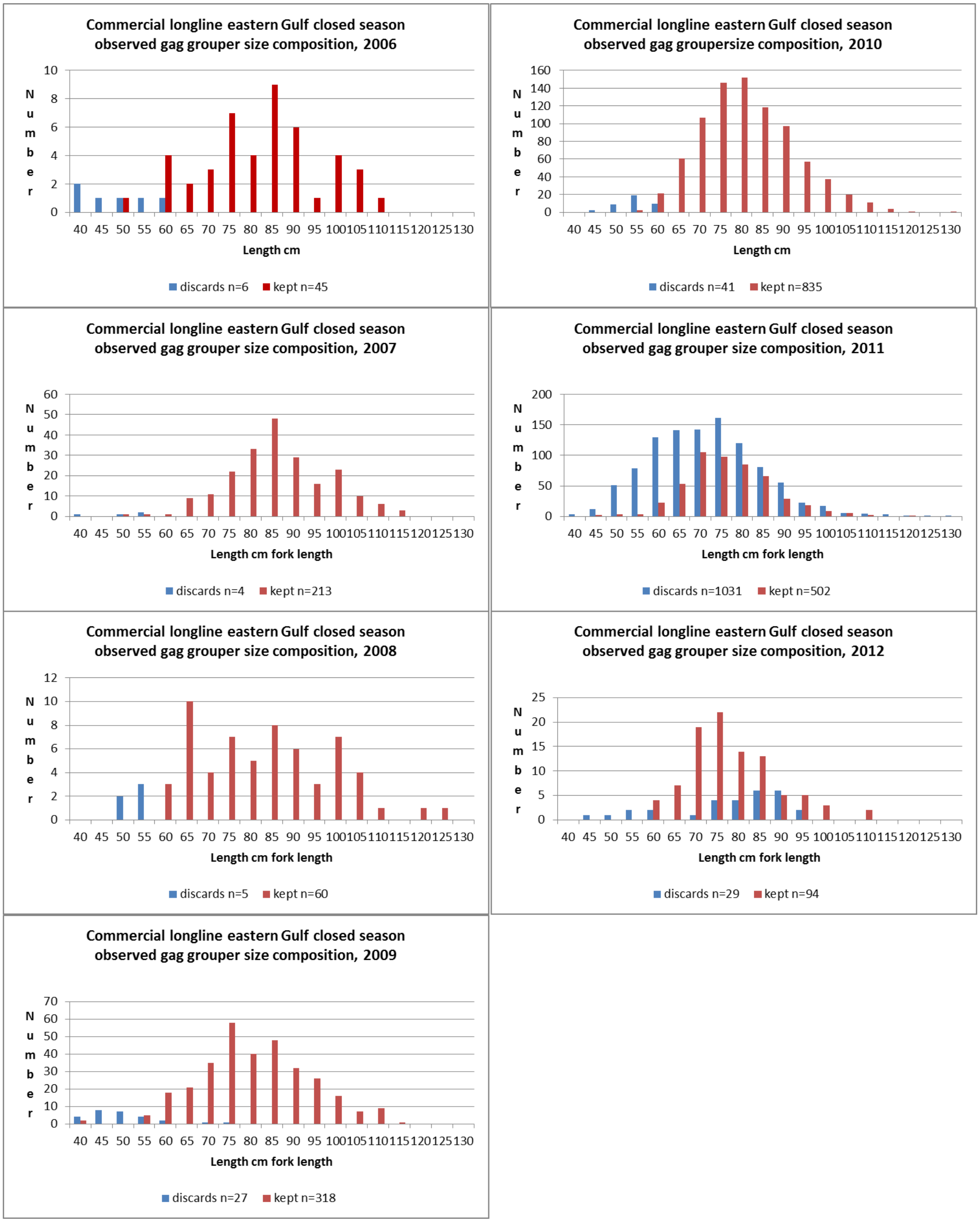

Figure 3.7 Commercial bottom longline eastern Gulf of Mexico 2006-2012 observed gag grouper size composition.

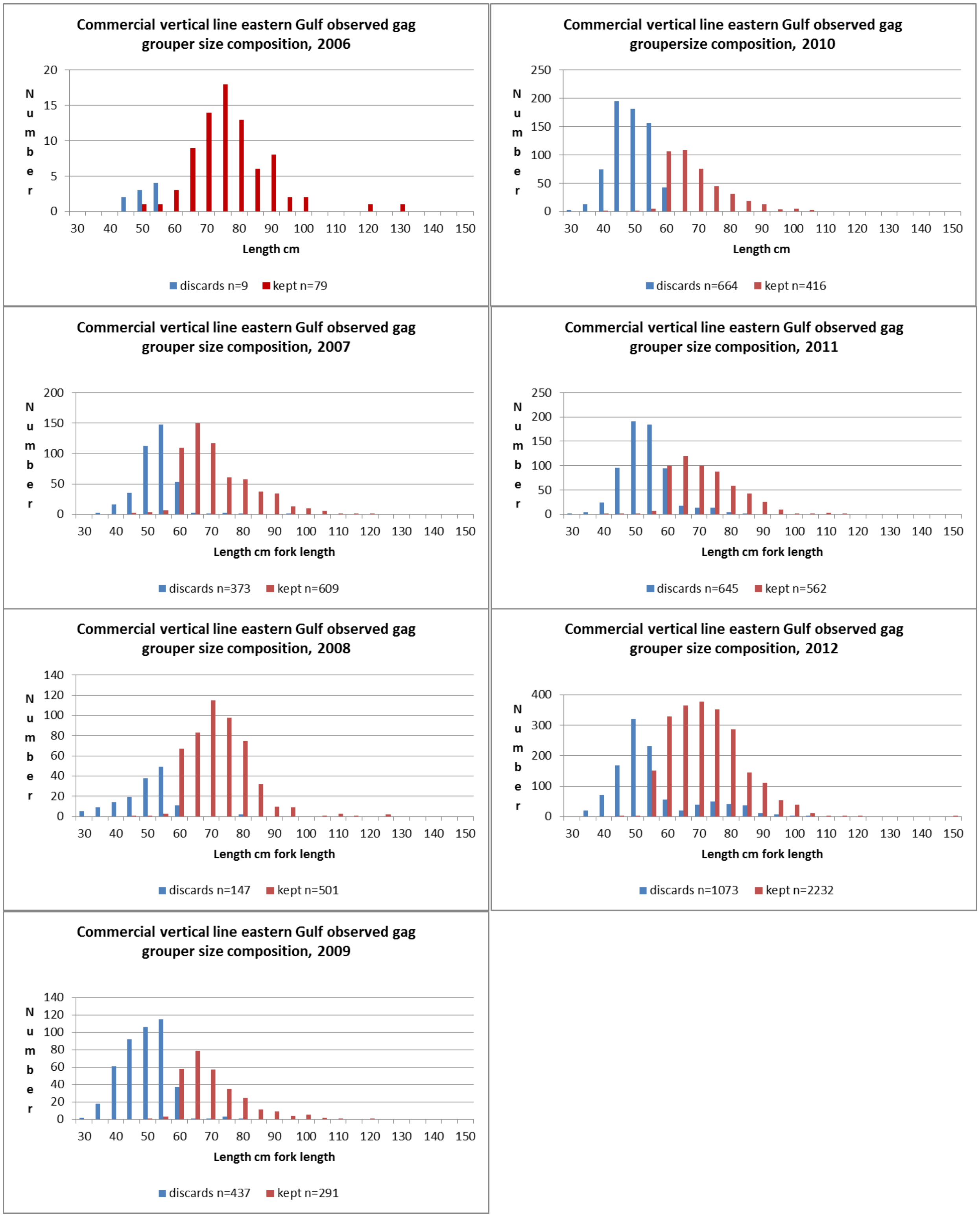

Figure 3.8 Commercial vertical line eastern Gulf of Mexico 2006-2012 observed gag grouper size composition by year.

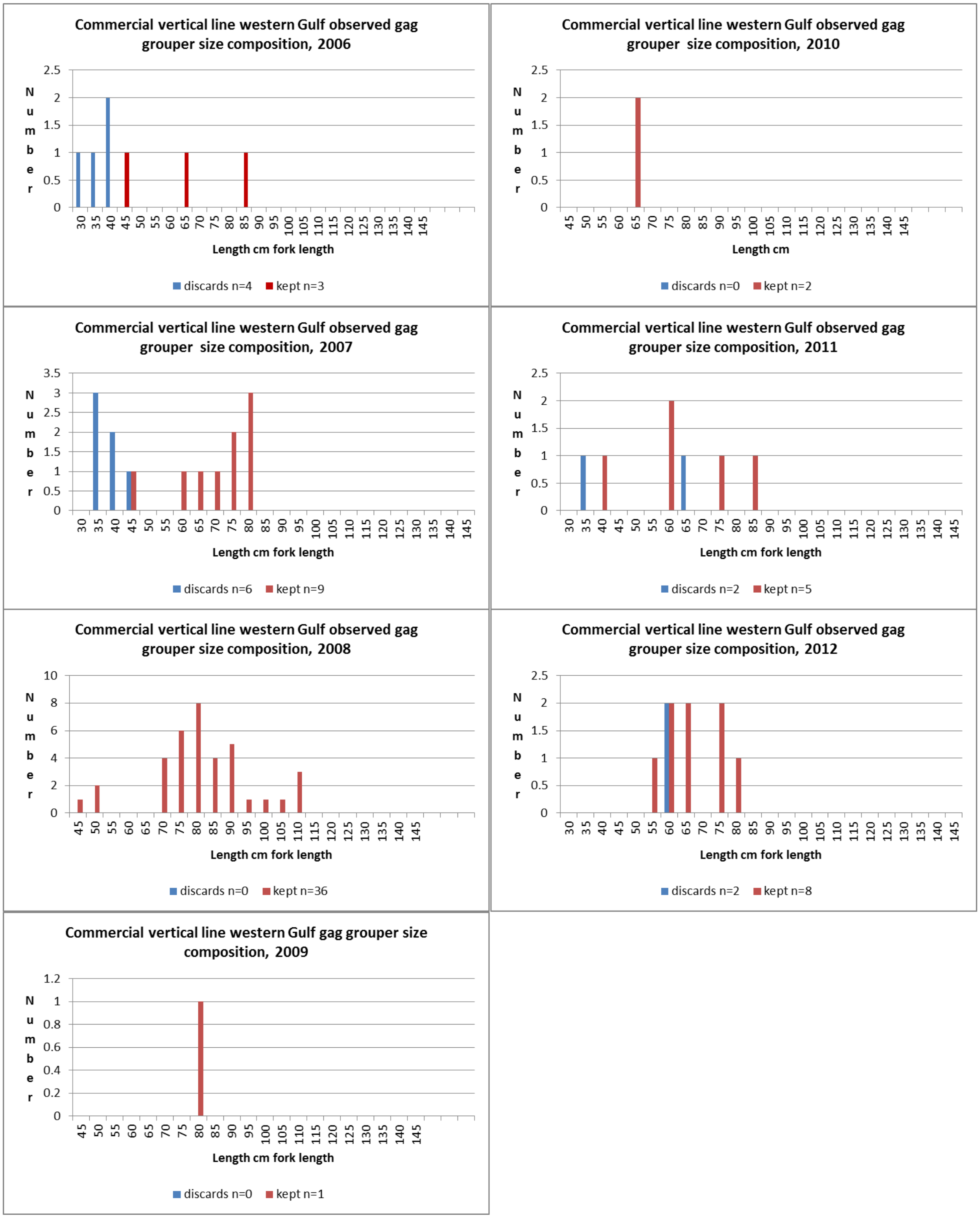

Figure 3.9 Commercial vertical line western Gulf of Mexico 2006-2012 observed gag grouper size composition**.**

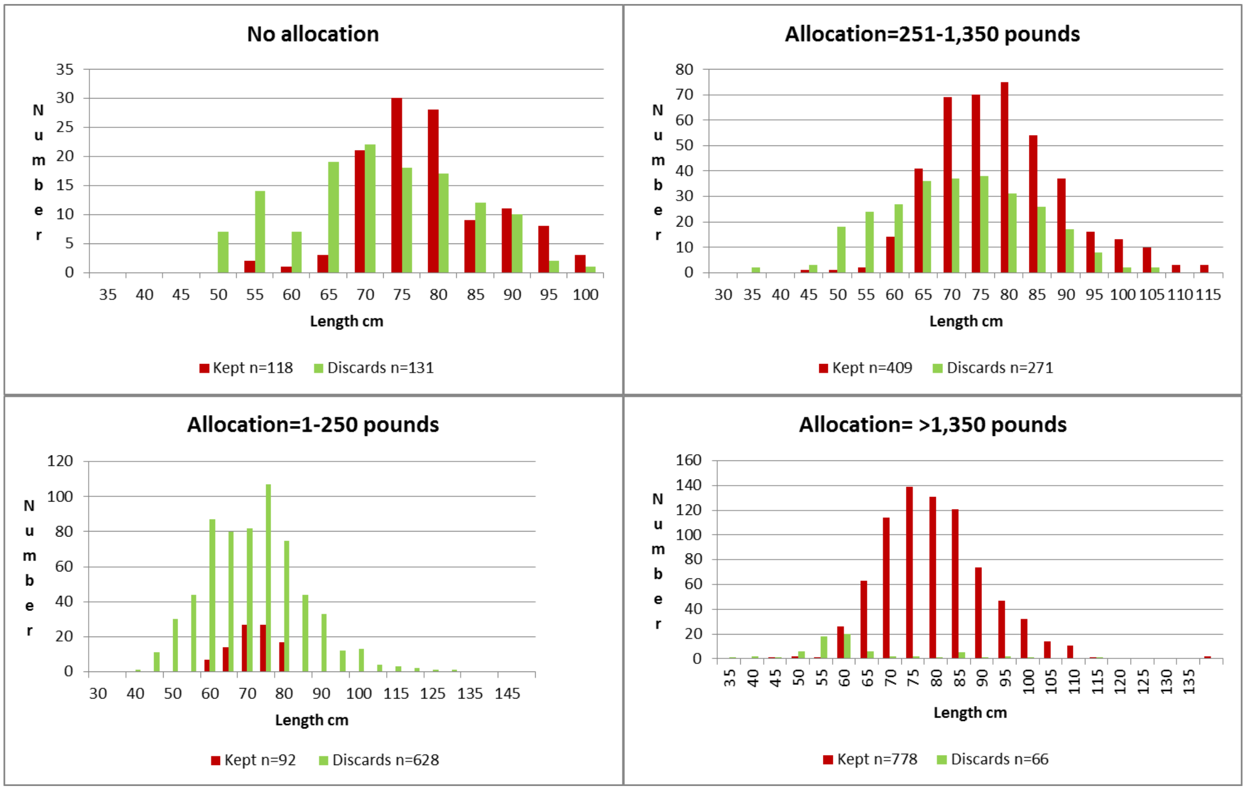

Figure 3.10 Commercial longline eastern Gulf of Mexico observed gag grouper size composition by gag allocation (2010-2012).

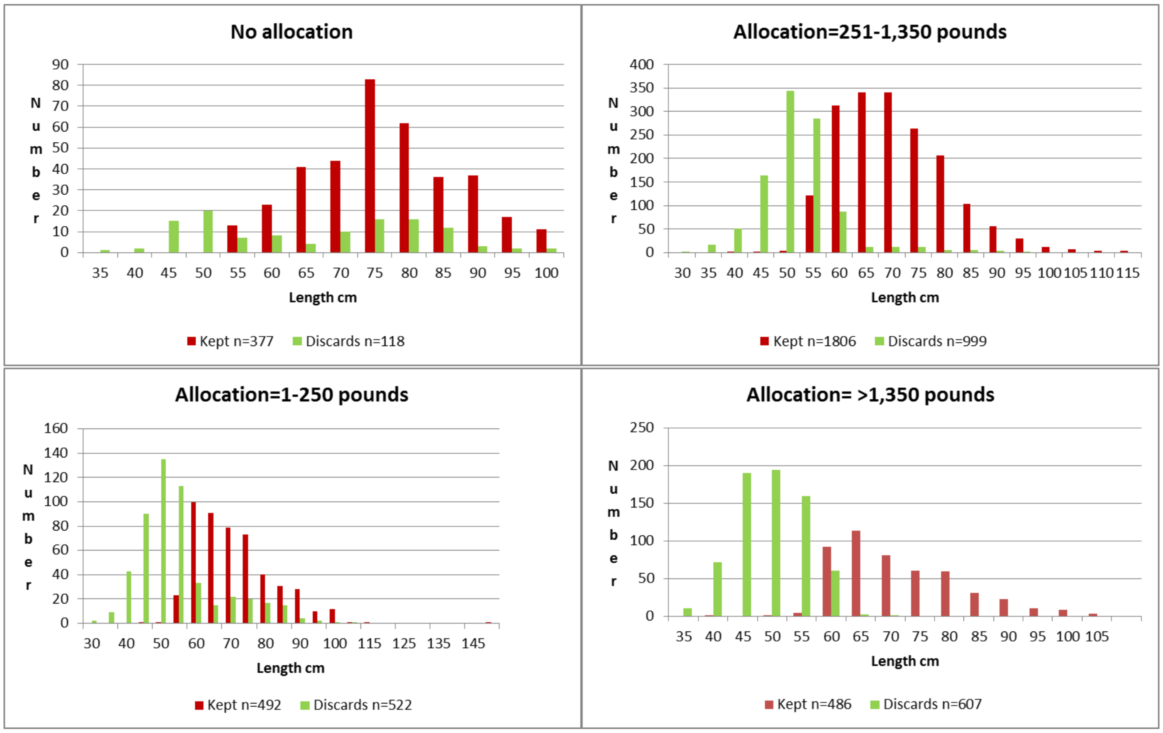

Figure 3.11 Commercial vertical line eastern Gulf of Mexico observed gag grouper size composition by gag grouper allocation (2010-2012).

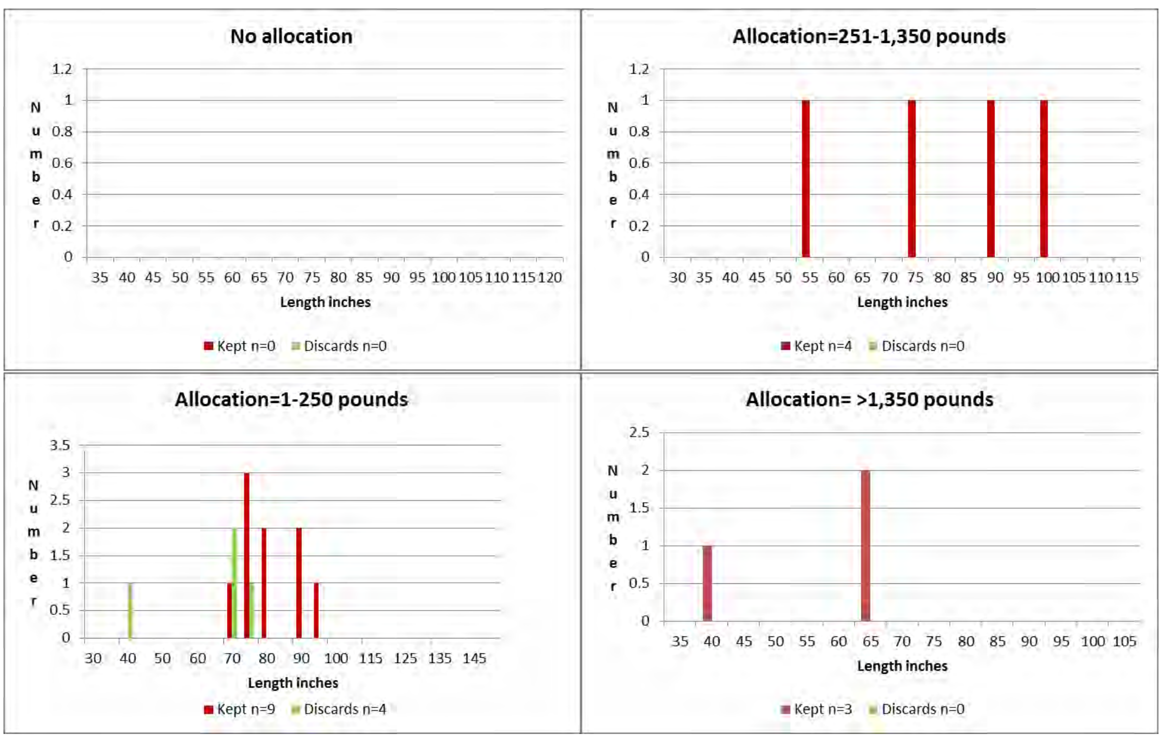

Figure 3.12 Commercial vertical line western Gulf of Mexico observed gag grouper size composition by gag grouper allocation (2010-2012).

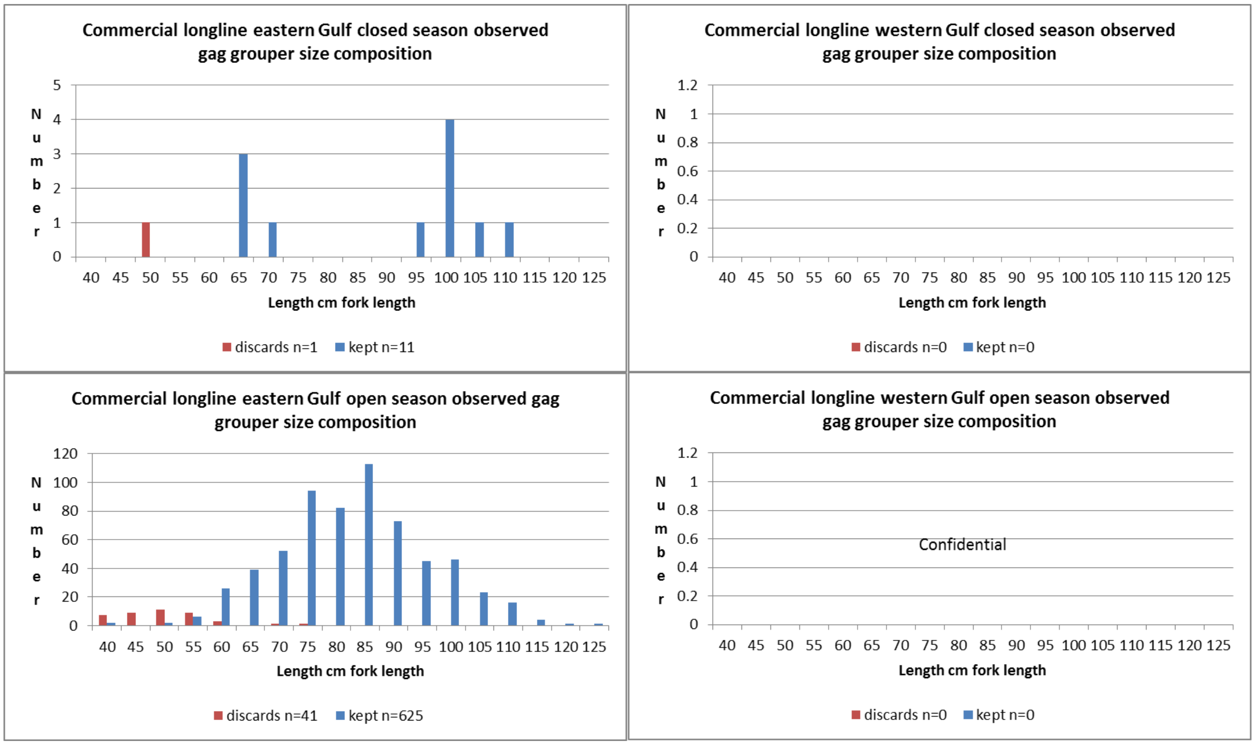

Figure 3.13 Commercial bottom longline eastern and western Gulf of Mexico observed gag grouper size composition by fishing season (2006-2009).

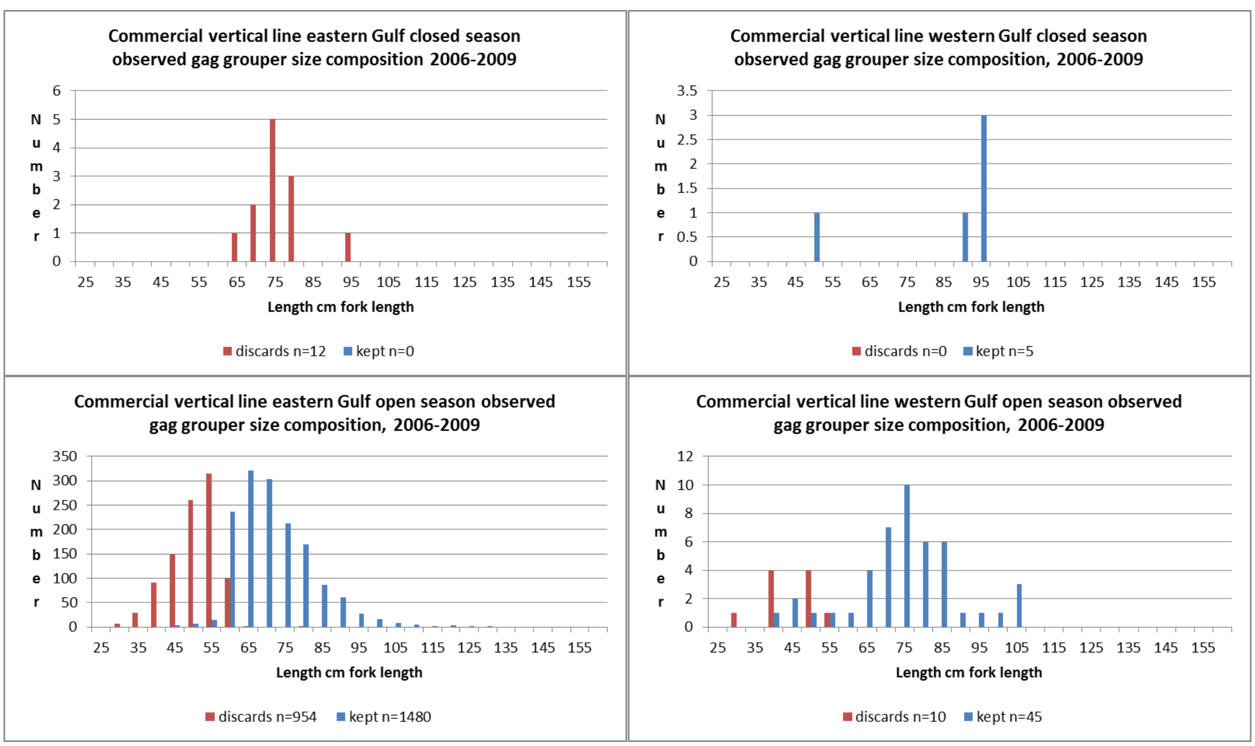

Figure 3.14 Commercial vertical line eastern and western Gulf of Mexico observed gag grouper size composition by fishing season (2006-2009).

3.12 APPENDIX A:

NMFS SECPR Accumulated Landings System (ALS)

Information on the quantity and value of seafood products caught by fishermen in the U.S. has been collected starting in the late 1800s (inaugural year is species dependent). Fairly serious collection activity began in the 1920s. The data set maintained by the Southeast Fisheries Science Center (SEFSC) in the SECPR database management system is a continuous dataset that begins in 1962.

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

Commercial landings statistics have been collected and processed by various organizations during the 1962-to-present period that the SECPR 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 until 1970. After 1970 it was run by the newly created National Marine Fisheries Service, which had replaced the Bureau of Commercial Fisheries. 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 SECPR 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 SECPR contains a standard set of data that is consistent for all states in the Region.

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

Florida

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

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

Georgia

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

South Carolina

Prior to 1972, commercial landings data were collected by various federal fisheries agents based in South Carolina, either U.S. Fish or Wildlife or National Marine Fisheries Service personnel. In 1972, South Carolina began collecting landings data from coastal dealers in cooperation with federal agents. Mandatory monthly landings reports on forms supplied by the Department are required from all licensed wholesale dealers in South Carolina. Until fall of 2003, those monthly reports were summaries collecting species, pounds landed, disposition (gutted or whole) and market category, gear type, and area fished; since September 2003, landings have been reported by a mandatory trip ticket system collecting landings by species, disposition and market category, pounds landed, ex-vessel prices with associated effort data to include gear type and amount, time fished, area fished, along with 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 were established for monthly commercial trips by gear sampling was set to collect those species with associated length frequencies. In 2005, SCDNR began collecting age structures (otoliths and spines) in addition to length frequencies, using ACCSP funding to supplement CSP funding. Typically for every four fish measured a single age structure was collected. This sampling periodicity was changed in 2010 to collect both a length and age structure from every fish intercepted as a recommendation from the SEFSC.

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.

NMFS SECPR Annual Canvas Data for Florida

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

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

4 Recreational Fishery Statistics

4.1 Overview

Recreational landings and discards of gag in the Gulf of Mexico were compiled for the period 1981-2012 from federal and state databases. Sampling intensities of fish lengths by recreational fishing mode and year were considered, and length frequency distributions were developed by year for Gulf of Mexico gag. A summary of the issues discussed and data presented at the data workshop is included here.

4.1.1 Recreational Workgroup Members

Jeff Isely (Leader), NOAA Fisheries, Miami, FL; Vivian Matter, NOAA Fisheries, Miami, FL; Beverly Sauls, FL FWC, St. Petersburg, FL.

4.1.2 Issues Discussed at the Data Workshop

The Workgroup discussed several issues that needed to be resolved before data could be compiled. The issues are listed below and are described in more detail in the following sections.

1) Calibration of Marine Recreational Fisheries Statistics Survey charterboat estimates (1981-1997).
2) Calibration of Marine Recreational Fisheries Statistics Survey estimates to Marine Recreational Information Program estimates (1981-2003).
3) Misidentification of gag as black grouper in early years
4) Use of shore mode estimates.
5) Adjustments and substitutions (1981-1985).
6) Estimating recreational landings in weight.
8) Estimating discards for the Southeast Region Headboat Survey.
9) Estimating discards for the Texas Parks and Wildlife Department.
10) Monroe county landings

4.1.3 Gulf of Mexico Fishery Management Council Jurisdictional Boundaries

Gulf of Mexico Fishery Management Council Jurisdictional Boundaries are presented in Figure 4.11.1.

4.2 Review of Working Papers

The workgroup reviewed two working papers.

SEDAR33-DW5, *Characterization of Gag Discards in Recreational For-Hire Fisheries. Beverly Sauls and Bridget Cermak.*
This report is a summary of available information on the size, release condition, and final disposition of gag collected by trained fishery observers aboard headboat and charter vessels operating in the Gulf of Mexico.

SEDAR33-DW17, *Update concerning species misidentifications in the commercial landing data of gag groupers and black groupers in the Gulf of Mexico. Ching-Ping Chih.*
This report is an update of a previous report (SEDAR10-DW-24) that estimated the gag to black grouper ratio in commercial landings from various fishing and landing areas from 1984 to 2004.

4.3 Recreational Landings

Gulf of Mexico estimated number of gag landings from MRFSS/MRIP, TPWD, and SRHS (1981-2012) by state, by state and year, and by state and mode are presented in Figure 4.11.2.

4.3.1 Marine Recreational Fisheries Statistics Survey (MRFSS) and Marine Recreational Information Program (MRIP)

Introduction

The Marine Recreational Fisheries Statistics Survey (MRFSS) and the Marine Recreational Information Program (MRIP) provide a continuous time series since 1981 of estimated catch per unit effort, total effort, landings, and discards for six two-month periods (waves) each year. MRFSS/MRIP provides estimates for three recreational fishing modes: shore-based fishing (SH), private and rental boat fishing (PR), and for-hire charter and guide fishing (CH). When the survey first began in Wave 2 (Mar/Apr), 1981, headboats (HB) were included in the for-hire mode, but were excluded after 1985 to avoid overlap with the Southeast Region Headboat Survey (SRHS) conducted by the NMFS Beaufort, NC lab.

The MRFSS/MRIP survey covers coastal Gulf of Mexico states from Florida to Louisiana. The state of Texas was included in the survey from 1981-1985, although not all modes and waves were covered. The state of Florida is sampled as two sub-regions. The east Florida sub-region includes counties adjacent to the Atlantic coast from Nassau County south through Miami-Dade County, and the west Florida sub-region includes Monroe County (Florida Keys) and counties adjacent to the Gulf of Mexico. Separate estimates are generated for each Florida sub-region, and those estimates may be post-stratified into smaller regions based on proportional sampling.

The MRFSS/MRIP design incorporates three complementary survey methods for estimating catch and effort. Catch data are collected through angler interviews during dockside intercept surveys of recreational fishing trips after they have been completed. Effort data are collected using two telephone surveys. The Coastal Household Telephone Survey (CHTS) uses random digit dialing of coastal households to obtain detailed information about the previous two months of recreational fishing trips from the anglers. The weekly For-Hire Survey interviews charterboat operators (captains or owners) to obtain the trip information with only one-week recall period. Effort estimates from the two telephone surveys are aggregated to produce total effort estimates by wave. Catch rates from dockside intercept surveys are combined with estimates of effort from telephone interviews to estimate total landings and discards by wave, mode, and area fished (inland, state, and federal waters). Catch estimates from early years of the survey are highly variable with high proportional standard errors (PSE's), and sample size in the dockside intercept portion have been increased over time to improve precision of catch estimates. Full survey documentation and ongoing efforts to review and improve survey methods are available at: http://www.st.nmfs.gov/st1/recreational.

Survey methods for the for-hire fishing mode have seen the most improvement over time. Catch rate data have improved through increased sample quotas and additional sampling to the intercept portion of the survey. As the random household telephone survey was intercepting relatively few anglers in the for-hire fishing mode, the For-Hire Telephone Survey (FHS) was developed to estimate effort in for this mode. The new method draws a random sample of known for-hire charter and guide vessels each week and vessel operators are called and asked directly to report their fishing activity. The FHS was pilot tested in the Gulf of Mexico in 1998 and officially adopted in 2000. The FHS does not consider the estimates during pilot years as official estimates; however, FHS data for these years have been used in past SEDARs (e.g. SEDAR 7 red snapper, SEDAR 16 king mackerel, etc). As a result of the Deepwater Horizon oil spill in April 2010, the MRFSS/MRIP For-Hire Survey increased sampling rates of charterboat vessel operators from 10% to 40% from May, 2010 through June 2011.

A further improvement in the FHS method was the pre-stratification of Florida into smaller sub-regions for estimating effort. Pre-stratification defines the sample unit on a sub-state level to produce separate effort estimates by these finer geographical regions. The FHS sub-regions include three distinct regions bordering the Gulf of Mexico coast: NW Florida panhandle from Escambia to Dixie counties (sub-region 1), SW Florida peninsula from Levy to Collier counties (sub-region 2), and Monroe county (sub-region 3). The coastal household telephone survey method for the for-hire fishing mode continues to run concurrently with the newer FHS method.

Calibration of traditional MRFSS charterboat estimates

Conversion factors have been estimated to calibrate the traditional MRFSS charterboat estimates with the FHS for 1986-1997 in the Gulf of Mexico (SEDAR7-AW-03). The relationship between the old charterboat method estimates of angler trips and the FHS estimates of angler trips was used to estimate the conversion factors. Since these factors are based on effort, they can be applied to all species' landings. In the Gulf of Mexico, the period of 1981-1985 could not be calibrated with the same ratios developed for 1986+ because in the earlier 1981-1985 time period, MRFSS considered charterboat and headboat as a single combined mode. Thus, in order to properly calibrate the estimates from 1981-1985, headboat data from the Southeast Region Head-boat Survey (SRHS) were included in the analysis. To calibrate the MRFSS combined charterboat and headboat mode effort estimates in 1981-1985, conversion factors were estimated using 1986-1990 effort estimates from both modes, in equivalent effort units, an angler trip (SEDAR28-DW-12). These calibration factors were applied to the charterboat estimates and are tabulated in Table 4.10.1.

MRIP weighted estimates and the calibration of MRFSS estimates

The Marine Recreational Information Program (MRIP) was implemented in 2004. The MRIP was developed to generate more accurate recreational catch rates by re-designing the MRFSS sampling protocol to address potential biases including port activity and time of day. Revised catch and effort estimates, based on this improved estimation method, were released on January 25, 2012. These estimates are available for the Atlantic and Gulf Coasts for 2004 through 2012. Table 4.10.2 shows the differences between the Gulf of Mexico gag MRIP estimates and the MRFSS estimates for the time period 2004-2011.

Since new MRIP estimates are available for a portion of the recreational time series that the MRFSS covers, conversion factors between the MRFSS estimates and the MRIP estimates were developed in order to maintain one consistent time series for the recreational catch estimates. Ratio estimators, based on the ratios of the means, were developed for Gulf of Mexico gag to hind-cast catch and variance estimates by fishing mode. In order to apply the charterboat ratio estimator back in time to 1981, charterboat landings were isolated from the combined CB/HB mode for 1981-1985. The MRFSS to MRIP calibration process is detailed in SEDAR31-DW25 and SEDAR32-DW-02. Table 4.10.3 shows the ratio estimators used in the calibration. Figure 4.11.3 shows the MRFSS versus MRIP adjusted AB1 estimates for Gulf of Mexico gag from 1981 to 2003.

Calculating landings estimates in weight

The MRFSS and the MRIP surveys use different methodologies to estimate landings in weight. To apply a consistent methodology over the entire recreational time series, the Southeast Fisheries Science Center (SEFSC) implemented a method for calculating average weights for the MRIP (and MRIP adjusted) landings. This method is detailed in SEDAR32-DW-02. In cases where the sample data include a length but not a weight, the length-weight equation from the Life History Working Group was used to convert those lengths to weights ($W=0.0000000117*(L^{3.02})$ where W is whole weight in pounds and L is fork length in inches.

1981, wave 1

MRFSS began in 1981, wave 2. In the Gulf of Mexico, catch for 1981 wave 1 was estimated by determining the proportion of catch in wave 1 to catch in all other waves for 1982-1984 by fishing mode and area. These proportions were then used to estimate wave 1 in 1981 from the estimated catches in other waves of that year. This methodology is consistent with past SEDARs (e.g. SEDAR 10 gag grouper and SEDAR 31 Gulf of Mexico red snapper).

Texas

Texas data from the MRFSS is only available from 1981-1985 and is sporadic, not covering all modes and waves. For these reasons, Texas boat mode estimates from the MRFSS were not included. Instead, TPWD data, which covers charter and private modes, were used to fill in theses modes prior to the start of the TPWD survey in May 1983. This methodology is consistent with past SEDARs (e.g. SEDAR 28 Spanish mackerel, SEDAR 31 red snapper).

Shore mode

There was some discussion about catches from MRFSS shore mode. This mode is poorly sampled, with sampling fractions ranging from 0.002 to 0.2%. Therefore, large expansion factors are used, which can make rare events appear highly variable. The working group found that shore mode contributed 2% of the total landings and 8% of total discards for all modes from 1981 to 2012. The group recommended that shore mode caught fish be included, as was done in SEDAR 10.

Misidentification of gag as black grouper

Gag grouper (Mycteroperca microlepis) and black grouper (Mycteroperca bonaci) look similar and in parts of the Gulf, Mycteroperca microlepis has traditionally been called black grouper. This issue was investigated in the previous assessment (SEDAR 10) and it was found that many gag landings were misreported as black grouper landings prior to 1990. The problem was apparently corrected with updated interviewer training, interview supervision, and contractor QA/QC work in the 1990 MRFSS contracts. In the previous assessment, gag catches prior to 1990 were adjusted to correct for this misidentification. The average ratios of gag to the sum of gag and black grouper for 1990 to 2004 were calculated by state and applied to the sum of gag and black grouper landings from 1981 to 1989.

The Recreational Workgroup agreed with the approach used in SEDAR 10. The group updated the calculation of the ratios, however, to incorporate the new MRIP (and MRFSS adjusted to MRIP) landings and additional years available. Table 4.10.4 shows the updated observed gag versus black grouper landings in the MRIP data. The effects were minimal. The ratios for Mississippi and Alabama remain the same at 1. The ratio for West Florida, not including Monroe County, changed from 99.4 to 99.3. The ratio for Louisiana changed from 97.2 to 97.4.

Monroe County

Monroe County MRFSS landings from 1981 to 2003 can be post-stratified to separate them from the MRFSS West Florida estimates. Post-stratification proportionally distributes the state-wide (FLE and FLW) effort into finer scale sub-regions and then produces effort estimates at this finer geographical scale. This is needed for the private and shore modes (all years) and charter boat mode (prior to FHS). FHS charter boat mode estimates are already pre-stratified, as discussed above. Monroe County MRIP landings from 2004 to 2012 can be estimated separately from the remaining West Florida estimates using domain estimation. The Monroe County domain includes only intercepted trips returning to that county as identified in the intercept survey data. Estimates are then calculated within this domain using standard design-based estimation which incorporates the MRIP design stratification, clustering, and sample weights.

Although Monroe county estimates can be separated using these processes, they cannot be partitioned into those from the Atlantic Ocean and those from the Gulf of Mexico. In accordance with the previous assessment (SEDAR 10), the Monroe county gag landings were allocated to the Atlantic and excluded them from this Gulf of Mexico assessment.

MRIP landings in numbers of fish and in whole weight in pounds are presented in Table 4.10.5. CVs associated with estimated landings in numbers are also shown.

4.3.2 Southeast Region Headboat Survey

Introduction

The Southeast Region Headboat Survey (SRHS) estimates landings and effort for headboats in the Gulf of Mexico. The SRHS began in the Gulf of Mexico in 1986 and extends from Naples, FL to South Padre Island, TX. Mississippi headboats were added to the survey in 2010. The South Atlantic and Gulf of Mexico Headboat Surveys generally include 70-80 vessels participating in each region annually. The Headboat Survey incorporates two components for estimating catch and effort. (1) Information about the size of fishes landed are collected by port samplers during dockside sampling, where fish are measured to the nearest mm and weighed to the nearest 0.01 kg. These data are used to generate mean weights for all species by area and month. Port samplers also collect otoliths for ageing studies during dockside sampling events. (2) Information about total catch and effort are collected via the logbook, a form filled out by vessel personnel and containing total catch and effort data for individual trips. The logbooks are summarized by vessel to generate estimated landings by species, area, and time strata. The SRHS does not generate variances of the landings estimates.

The Headboat Survey was inconsistent in LA in 2002-2006. There were no trip reports collected in LA in 2002. Trip reports from 2001 were used (by the HBS) as a substitute to generate estimates numbers caught (though there are some minor differences between the resulting estimates for the two years). In 2003, there were only a few trip reports but they were still used to generate the estimates. From 2004 to 2006 there were no trip reports or fish sampled, and no substitutes were used, so there are no estimates or samples from 2004 to 2006 due to funding issues and Hurricane Katrina. However, the MRFSS/MRIP For-Hire Survey included the LA headboats in their charter mode estimates for these years thereby eliminating this hole in the headboat mode estimates.

The SEDAR 10 DW panel (Matter, 2006) reported that greater than 99% of the trips in the Florida Keys (headboat area 12) and the Dry Tortugas (Area 17) landed fish caught from the Atlantic Ocean. As in previous Gulf of Mexico gag stock evaluations, landings from trips fishing in the Florida Keys (headboat area 12) and landings from Atlantic-based vessels to the Dry Tortugas (Area 17) were excluded.

Texas headboat estimates 1981-1985

Headboat landing estimates from 1981-1985 come from the MRFSS/MRIP survey for all states except Texas. The standard method used in past SEDARs (e.g. SEDAR 28 Spanish mackerel and cobia) is to use the average Texas headboat mode estimates from SRHS from 1986-1988 to fill in the missing years.

SRHS landings in numbers of fish and in whole weight in pounds are presented in Table 4.10.6.

4.3.3 Texas Parks and Wildlife Department

Introduction

The TPWD Sport-boat Angling Survey was implemented in May 1983 and samples fishing trips made by sport-boat anglers fishing in Texas marine waters. All sampling takes place at recreational boat access sites. The raw data include information on catch, effort and length composition of the catch for sampled boat-trips. These data are used by TPWD to generate recreational catch and effort estimates. The survey is designed to estimate landings and effort by high-use (May 15-November 20) and low-use seasons (November 21-May 14). SEFSC personnel disaggregated the TPWD seasonal estimates into waves (2 month periods) using the TPWD intercept data. This was done to make the TPWD time series compatible with the MRFSS/MRIP time series. TPWD surveys private and charterboat fishing trips. While TPWD samples all trips (private, charterboat, ocean, bay/pass), most of the sampled trips are associated with private boats fishing in bay/pass, as these trips represent most of the fishing effort. Charterboat trips in ocean waters are the least encountered in the survey.

Producing landings estimates in weight

In the TPWD survey, landings estimates are produced only in number of fish. In addition, the TPWD sample data does not provide weights, only lengths of the intercepted fish. The SEFSC method (described above) was applied to the TPWD landings to obtain estimated landings in weight.

1981-1983 Texas estimates

The TPWD survey began with the high-use season in 1983 (May15, 1983). Texas charter and private mode estimates do not exist from the start of 1981 to May of 1983. Averages from TPWD 1983-1985 by mode and wave were used to fill in the missing estimates.

TPWD landings in numbers of fish and in whole weight in pounds for Texas are presented in Table 4.10.7.

4.3.4 Estimating Historical Recreational Landings

The historic time period for gag landings in the Gulf of Mexico is defined as pre-1981, and prior to the start of the Marine Recreational Fisheries Statistics Survey (MRFSS). The recreational workgroup was unable to estimate historical landings due to delays in data acquisition. This task will be completed as part of the assessment process and presented in the assessment report.

4.4 Recreational Discards

A map and figures summarizing all recreational discards of gag in the Gulf of Mexico are provided in Figure 4.11.4.

4.4.1 MRFSS/MRIP discards

Discarded live fish are reported by the anglers interviewed by the MRIP/MRFSS. Consequently, neither the identity nor the quantities reported are verified. Lengths and weights of discarded fish are not estimated by the MRFSS/MRIP. To characterize the size distribution of live discarded fishes, at-sea sampling of headboat discards was initiated in Alabama in 2004 and expanded to FLW in 2005 as part of the improved for-hire survey (SEDAR33-DW5).

MRFSS/MRIP estimates of live released fish (B2 fish) were adjusted in the same manner as the landings (i.e. using charterboat calibration factors, MRIP adjustment, substitutions, etc. described above in section 4.3.1). MRIP discards in numbers of fish and associated CVs are presented in Table 4.10.8.

4.4.2 Headboat Logbook Discards

The Southeast Region Headboat Survey (SRHS) logbook form was modified in 2004 to include a category to collect self-reported discards for each reported trip. This category is described on the form as the number of fish by species released alive and number released dead. Port agents instructed each captain on criteria for determining the condition of discarded fish. A fish is considered “released alive” if it is able to swim away on its own. If the fish floats off or is obviously dead or unable to swim, it is considered “released dead”. These self-reported data are currently not validated within the Headboat Survey. The SRHS discard ratios were compared with the At-Sea Observer Data discard ratios in order to assess the validity of these discard estimates. The working group also compared the observer data to the MRIP charterboat discard ratio, which was used in SEDAR 10 as a proxy to estimate the headboat discards. After analyzing the different ratios, the working group chose to use the MRIP charterboat discard ratio as a proxy for all years, as charterboat ratios most closely matched the At-Sea Observer discards.

Final gag discard estimates (numbers of fish) from the SRHS by year are presented in Table 4.10.9.

4.4.3 Headboat At-Sea Observer Survey Discards

Observer surveys of recreational headboats provide detailed information of recreational catch, and in particular of recreational discards. Observer surveys were conducted in Alabama from 2004 to 2007, and in West Florida from 2005-2007 and 2009-2011. For each survey, headboat vessels were randomly selected throughout each year in each state. Trained biologists then boarded the selected vessels, with permission from a vessel’s captain, and observed anglers as they fished. The data collected included number and species of landed and discarded fish, size of landed and discarded fish, and the release condition of discarded fish (FL only). Observers also recorded 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 ran trips longer than 24 hours were also sampled to collect information on trips that fish farther from shore and for longer periods of time, primarily in the vicinity of the Dry Tortugas.

4.4.4 Texas Parks and Wildlife Department Discards

The TPWD recreational survey does not estimate discards. The recreational workgroup evaluated available data and recommended that due to extremely low catches of gag, a discard rate of zero should be applied. This is consistent with the previous assessment.

4.5 Biological Sampling

Length samples from recreational landings were obtained from the Marine Recreational Fisheries Statistics Survey, the Southeast Region Headboat Survey, the Texas Parks and Wildlife Department, the Fisheries Information Network, and the Trip Interview Program. Additionally, length data were available from observer programs operating in Florida, Alabama, and Louisiana. The years of observer coverage and the number of trips observed are described in Sauls (SEDAR33-DW5).

4.5.1 Sampling Intensity

MRFSS/MRIP Biological Sampling

The MRFSS/MRIP angler intercept survey includes the sampling of fish lengths from the harvested (landed, whole condition) catch. Up to 15 of each species landed per angler interviewed are measured to the nearest mm along a center line (defined as tip of snout to center of tail along a straight line, not curved over body). In those fish with a forked tail, this measure would typically be referred to as a fork length, and in those fish that do not have a forked tail it would typically be referred to as a total length with the exception of some fishes that have a single, or few, caudal fin rays that extend further. Weights are typically collected for the same fish measured although weights are preferred when time is constrained. Ageing structures and other biological samples are not collected during MRFSS/MRIP assignments because of concerns over the introduction of bias to survey data collection.

The number of gag measured in the Gulf of Mexico (FLW-TX) from MRFSS/MRIP by year, mode, and state are summarized in Table 4.10.10. The number of angler trips with gag measured in the Gulf of Mexico (FLW-TX) from MRFSS/MRIP by year, mode, and state are summarized in Table 4.10.11. Monroe county samples have been excluded.

Headboat Survey Biological Sampling

Lengths were collected from 1986 to 2011 by headboat dockside samplers in the Gulf of Mexico, in all of the coastal Gulf states except Mississippi, where sampling started in 2010. Weights are typically collected for the same fish measured during dockside sampling. Also, biological samples (scales, otoliths, spines, stomachs and gonads) are collected routinely and processed for aging, diet studies, and maturity studies. Number of gag measured for length (either total or fork length) in the headboat fleet by year is presented in Table 4.10.12. Numbers of trips from which gag were measured (either total or fork) are presented in Table 4.10.13.

Texas Parks and Wildlife Department Biological Sampling

The TPWD Sport-boat Angling Survey samples fishing trips made by sport-boat anglers fishing in Texas marine waters. All sampling takes place at recreational boat access sites. Length composition of the catch for sampled boat-trips has been collected since the high-season of 1983 (mid-May). Total length is measured by compressing the caudal fin lobes dorsoventrally to obtain the maximum possible total length. Weights of sampled fish are not recorded.
The number of gag measured in the TPWD charter and private-rental modes are summarized by year in Table 4.10.14. The number of trips with measured gag in the TPWD charter and private-rental modes are summarized by year in Table 4.10.15.

Observer Programs

Numbers of sampled gag on observed headboat trips in Florida and Alabama, and on observed charterboat trips in Florida are presented in Sauls (SEDAR33-DW5). Biological samples such as scales, otoliths, spines, stomachs and gonads, are not typically collected as part of this protocol.

4.5.2 Length Distributions

Recreational Landings

Length frequencies from recreational headboat landings were calculated by year (1991 to 2012). Length frequency histograms for the headboat fishery are presented in Figures 4.11.5. Gag length frequency distributions for samples collected from recreational charter boat and private boat fisheries located in the Gulf of Mexico from 1981 to 2012 are presented in Figure 4.11.6. Changes in length frequency distributions were analyzed to examine the possible changes in selectivity-on-size. Changes in length frequency distributions appear to coincide with changes in fishing regulations and fishing behavior.

Observer Programs

Length frequency histograms for harvested and discarded gag by year for Florida headboats, Florida charterboats, Alabama headboats, and Texas charterboats are presented in SEDAR31-DW05. Length frequency distributions from observed headboat data in Florida show an increase in the proportion of larger fish caught in 2009-2011 compared to 2005-2007 (SEDAR33-DW5).

4.5.3 Recreational Catch-at-Age

Catch-at-age matrices were not available at the time of the data workshop and will be presented in the assessment workshop. Reweighted age frequency distributions for gag samples collected from headboat, and recreational charter boat and private boat fisheries located in the Gulf of Mexico 2002 to 2012 are presented in figures 4.11.7 and 4.11.8, respectively.

4.6 Recreational Effort

Total recreational effort is summarized below by survey. Effort is summarized for all marine fishing by mode, regardless of what was caught. A map and figures summarizing MRFSS/MRIP and TPWD effort in angler trips are included in Figure 4.11.9. A map and figures summarizing SRHS effort in angler days are included in Figure 4.11.10.

4.6.1 MRFSS/MRIP Effort

Effort estimates for the recreational fishery survey are produced via telephone surveys of both anglers (private/rental boats and shore fishers) and for-hire boat operators (charterboat anglers, and in early years, party or charter anglers). The methods have changed during the full time series (see section 4.3 for descriptions of survey method changes and adjustments to survey estimates for uniform time-series of catch estimates). An angler-trip is a single day of fishing in the specified mode, not to exceed 24 hours. Both Texas and Monroe county effort estimates have been excluded from the MRFSS/MRIP estimates since these strata were excluded from the landings estimates of gag. Gulf of Mexico (FLW-TX) estimated number of angler trips for MRFSS (1981-2003) and MRIP (2004-2012) by year and state are presented in Table 4.10.16.

4.6.2 Headboat Effort

Headboats report catch and effort data for each trip via the SHRS logbooks. The captain of the vessel or designated crew member completes a logbook form for each trip. The form details the total number and weight of all the species kept, along with the total number of fish discarded for each species. Numbers of anglers on a given trip represents the measure of effort reported in the SRHS logbooks. Numbers of anglers are standardized, depending on the type of trip (length in hours), by converting number of anglers to “angler days” (e.g., 40 anglers on a half-day trip would yield 40 * 0.5 = 20 angler days). This standardization assumes that all anglers fished the entire time. Angler days are summed by month for individual vessels. Each month, port agents collect these logbook trip reports and check for accuracy and completeness. Although reporting via the logbooks is mandatory, compliance is not 100% and is variable by location. To account for non-reporting, a correction factor is developed based on sampler observations, angler numbers from office books and all available information. This information is used to provide estimates of total catch by month and area, along with estimates of effort.

Estimated headboat angler days are tabulated in Table 4.10.17. Estimated headboat angler days have decreased in the Gulf of Mexico in recent years. The most obvious factor which impacted the headboat fishery in both the Atlantic and Gulf of Mexico was the high price of fuel. This, coupled with the economic down, turn starting in 2008, has resulted in a marked decline in angler days in the Gulf of Mexico headboat fishery. Reports from industry staff, captains/owners, and port agents indicated fuel prices, the economy and fishing regulations are the factors that most affected the amount of trips, number of passengers, and overall fishing effort. Also important to note, is the decrease in effort in the Gulf of Mexico in 2010, the year of the Deepwater Horizon oil spill.

4.6.3 Texas Parks and Wildlife Effort

The TPWD survey is designed to estimate landings and effort by high-use (May 15-November 20) and low-use seasons (November 21-May 14). Only private and charterboat fishing modes are surveyed. Most of the sampled trips are from private boats fishing in bay/pass because these represent most of the fishing effort, but all trips (private, charterboat, ocean, bay/pass) are sampled. Charterboat trips in ocean waters are the least encountered in the survey. Estimates of TPWD angler trips are shown in Table 4.10.18 by year and season.

4.7 Tasks to Be Completed

Task: Explore existing and new methods for estimating historical recreational landings. Responsibility: Jakob Tetzlaff, NOAA Fisheries Expected Completion Date: 7/1/2013. To be developed into an Assessment Workshop working paper.

4.8 Research Recommendations

1) Evaluate the technique used to apply sample weights to landings
2) Continue and expand fishery dependent at-sea observer surveys to collect discard information.
4) Track Texas commercial and recreational discards.
5) Estimate variances associated with the headboat program.
6) Evaluate existing and new methods to estimate historical landings.

4.9 Literature Cited

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4.10 Tables

Table 4.10.1 Gulf of Mexico MRFSS charterboat conversion factors and standard errors (in parentheses).

a) Apply to 1981-1985 charterboat/headboat mode in the Gulf of Mexico.

	WAVE					
STATE	1	2	3	4	5	6
AFW	0.883 (0.03)	0.883 (0.03)	1.104 (0.05)	1.104 (0.05)	0.883 (0.03)	0.883 (0.03)
MS	1.155 (0.11)	1.155 (0.11)	2.245 (0.11)	2.245 (0.11)	1.155 (0.11)	1.155 (0.11)
LA	0.962 (0.09)	0.962 (0.09)	2.260 (0.13)	2.260 (0.13)	0.962 (0.09)	0.962 (0.09)

b) Apply to 1986 – 1997 charterboat mode in LA, MS, and AL

	WAVE					
Area	1	2	3	4	5	6
Inshore	1.26 (1.31)	1.54 (1.27)	3.82 (1.26)	4.67 (1.26)	3.28 (1.27)	1.48 (1.28)
< 3 miles	0.74 (1.37)	0.75 (1.26)	1.49 (1.25)	2.28 (1.24)	0.64 (1.28)	0.52 (1.40)
> 3 miles	0.44 (1.28)	0.63 (1.24)	2.23 (1.23)	1.87 (1.24)	1.26 (1.23)	0.53 (1.28)

c) Apply to 1986- 1997 charterboat mode in FLW

	WAVE					
Area	1	2	3	4	5	6
Inshore	3.17 (0.16)	5.31 (0.16)	5.71 (0.16)	5.33 (0.16)	3.49 (0.16)	3.70 (0.16)
< 10 miles	0.95 (0.16)	1.10 (0.16)	1.78 (0.16)	0.70 (0.16)	0.48 (0.16)	0.98 (0.16)
> 10 miles	0.38 (0.16)	0.58 (0.16)	0.77 (0.16)	0.73 (0.16)	0.59 (0.16)	0.55 (0.16)

Table 4.10.2 Gag MRIP vs. MRFSS estimates of landings (number of fish) for the Gulf of Mexico 2004-2011. See accompanying graph below table.

Estimate Status	Year	Fishing Year	Common Name	MRFSS Unweighted Total Harvest (A+B1)	MRIP Weighted Total Harvest (A+B1)	Difference: MRIP - MRFSS	% Change from MRFSS	PSE for MRIP Weighted Total Harvest (A + B1)
FULL YEAR	2004	Calendar Year (Jan 1 - Dec 31)	GAG	633,992	710,685	76,692	12.1%	11.4
FULL YEAR	2005	Calendar Year (Jan 1 - Dec 31)	GAG	488,016	517,374	29,359	6.02%	12.0
FULL YEAR	2006	Calendar Year (Jan 1 - Dec 31)	GAG	275,143	367,340	92,197	33.5%	15.9
FULL YEAR	2007	Calendar Year (Jan 1 - Dec 31)	GAG	308,711	294,320	-14,391	-4.66%	12.1
FULL YEAR	2008	Calendar Year (Jan 1 - Dec 31)	GAG	423,287	438,591	15,304	3.62%	10.8
FULL YEAR	2009	Calendar Year (Jan 1 - Dec 31)	GAG	227,454	213,456	-13,997	-6.15%	11.3
FULL YEAR	2010	Calendar Year (Jan 1 - Dec 31)	GAG	239,574	237,721	-1,853	-0.77%	10.8
FULL YEAR	2011	Calendar Year (Jan 1 - Dec 31)	GAG	96,021	100,957	4,935	5.14%	17.6

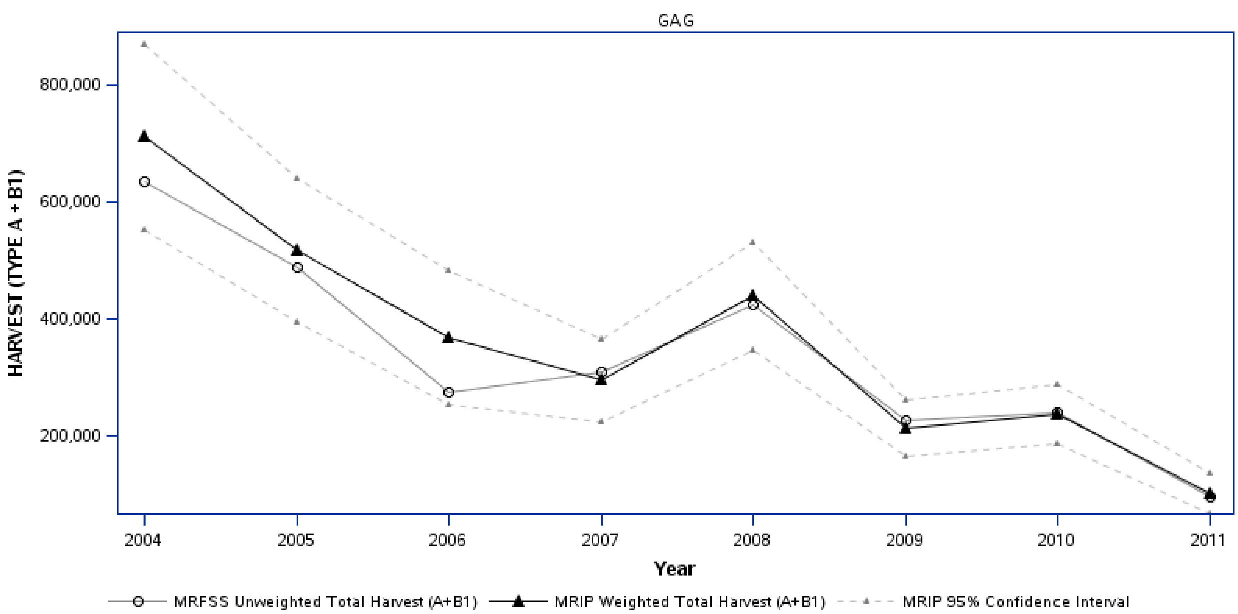


Table 4.10.3. Gulf of Mexico gag ratio estimators for adjusting MRFSS numbers and variance estimates (AB1 and B2) to MRIP numbers and variances for 1981-2003. The variances of the numbers ratio estimators are also shown.

	Numbers Ratio Estimator		Variance Ratio Estimator		Variance of Numbers Ratio Estimator	
MODE	**AB1**	**B2**	**AB1**	**B2**	**AB1**	**B2**
Charterboat	1.042065785	1.023287115	3.877106004	2.442686813	0.00142666	0.003432732
Private	1.083528963	0.980848765	2.968979831	4.148753466	0.001610604	0.000703001
Shore	0.825682195	1.076191708	1.268074214	5.750671011	0.028856789	0.001845451
All	1.069922486	0.992487515	2.982628829	4.206735081	0.00144039	0.00058493

Table 4.10.4. Estimates of observed gag versus black grouper from MRIP (and MRFSS adjusted to MRIP) landings. Observed gag landings (type A) as a percentage of observed gag + observed black grouper landings for the Gulf of Mexico by year and state. Monroe County has been excluded from West Florida.

YEAR	LA	MS	AL	FLW
1981			84	15
1982	0	0		38
1983	0		0	14
1984	50			32
1985	100		0	38
1986	21	100	23	20
1987	1	100	31	23
1988	0	0	100	25
1989	100	21	100	47
1990			100	95
1991	100		100	99
1992	100	100	100	99
1993	100	100	100	100
1994	100	100	100	99
1995	100	100	100	98
1996	100	100	100	100
1997	100	100	100	100
1998	50	100	100	99
1999	100	100	100	99
2000	100	100	100	100
2001	93	100	100	100
2002	99	100	100	100
2003	100	100	100	100
2004	100		100	100
2005	100		100	100
2006	100		100	100
2007	100		100	100
2008	100		100	100
2009	100	100	100	99
2010	100	100	100	100
2011	100		100	100
2012	100		100	100
Mean 90-12	**97.4**	**100.0**	**100.0**	**99.3**

Table 4.10.5. Gulf of Mexico (FLW-LA) gag landings (numbers of fish and whole weight in pounds) from MRIP by year. Estimates from 1981-2003 have been adjusted to MRIP numbers. *CVs for 1981-1985 only reflect the private and shore mode CVs, since charter and headboat mode CVs are unavailable.

YEAR	Number	CV_num	Weight (lbs)
1981	323,005	0.30*	2,689,413
1982	639,757	0.27*	4,927,541
1983	1,552,775	0.21*	13,548,513
1984	395,721	0.33*	3,556,706
1985	865,566	0.43*	7,921,807
1986	939,893	0.27	8,459,941
1987	629,716	0.36	5,509,547
1988	918,875	0.20	8,484,992
1989	579,397	0.34	5,261,495
1990	171,856	0.39	1,330,390
1991	274,706	0.25	1,982,080
1992	250,876	0.16	1,775,803
1993	352,022	0.16	2,331,700
1994	278,490	0.15	1,889,069
1995	430,535	0.15	2,676,305
1996	356,935	0.15	2,007,070
1997	402,937	0.13	2,722,215
1998	518,479	0.10	3,592,680
1999	553,058	0.09	3,702,797
2000	742,568	0.09	5,134,428
2001	496,012	0.11	4,211,882
2002	543,939	0.10	4,160,525
2003	525,851	0.10	3,583,564
2004	709,535	0.11	5,300,130
2005	516,982	0.12	3,882,495
2006	365,322	0.17	2,568,792
2007	289,728	0.12	2,210,897
2008	438,001	0.11	3,243,220
2009	213,082	0.11	1,473,526
2010	237,656	0.11	1,664,541
2011	100,902	0.18	727,647
2012	132,341	0.13	1,006,402

Table 4.10.6 Gulf of Mexico gag landings (number of fish) from the SRHS by year and Gulf region. 1981-1985 headboat mode landings are substitutes for missing Texas headboat mode.

YEAR	Number	Weight (lbs)
1981	432	1,697
1982	432	1,697
1983	432	1,697
1984	432	1,697
1985	432	1,697
1986	42,495	323,967
1987	32,156	178,401
1988	26,336	136,883
1989	35,145	244,559
1990	19,097	144,196
1991	11,453	80,308
1992	13,789	87,679
1993	19,335	199,171
1994	20,561	134,659
1995	17,816	113,434
1996	16,062	87,123
1997	15,623	86,450
1998	36,316	202,658
1999	32,117	166,257
2000	30,824	199,993
2001	14,494	116,647
2002	11,615	79,846
2003	16,381	109,768
2004	24,670	169,414
2005	16,784	112,442
2006	6,764	49,236
2007	11,141	74,226
2008	10,521	74,805
2009	9,483	67,255
2010	11,094	72,747
2011	5,099	50,236
2012	5,253	45,519

Table 4.10.7 Texas gag landings (number of fish and whole weight in pounds) from TPWD by year.

YEAR	Number	Weight (lbs)
1981	88	633
1982	88	633
1983	60	426
1984	86	566
1985	116	909
1986	0	0
1987	111	736
1988	0	0
1989	41	273
1990	229	1,681
1991	264	1,941
1992	0	0
1993	17	110
1994	134	857
1995	0	0
1996	281	1,528
1997	0	0
1998	411	2,968
1999	771	5,045
2000	665	4,765
2001	1,578	14,036
2002	485	4,185
2003	493	3,789
2004	157	1,235
2005	132	1,020
2006	517	3,915
2007	191	1,638
2008	270	2,071
2009	292	2,156
2010	153	1,084
2011	70	540
2012	209	1,706

Table 4.10.8 Gulf of Mexico (FLW-LA) gag discards (numbers of fish) from MRIP by year. Estimates from 1981-2003 have been adjusted to MRIP numbers. *CVs for 1981-1985 only reflect the private and shore mode CVs, since charter and headboat mode CVs are unavailable.

YEAR	Discards	CV
1981	303,284	0.58*
1982	116,513	0.53*
1983	425,268	0.75*
1984	83,551	0.86*
1985	180,585	0.65*
1986	539,608	0.36
1987	277,753	0.42
1988	328,515	0.41
1989	604,880	0.30
1990	356,592	0.47
1991	861,997	0.31
1992	719,459	0.22
1993	1,285,824	0.16
1994	1,805,411	0.12
1995	1,829,382	0.13
1996	1,201,205	0.13
1997	1,686,592	0.14
1998	2,078,054	0.11
1999	1,453,888	0.10
2000	1,410,582	0.11
2001	1,897,463	0.10
2002	2,468,577	0.11
2003	3,348,243	0.09
2004	3,866,573	0.08
2005	2,376,510	0.07
2006	1,877,975	0.09
2007	2,681,661	0.10
2008	4,104,466	0.09
2009	2,753,817	0.08
2010	2,013,858	0.08
2011	1,163,438	0.11
2012	927,938	0.10

Table 4.10.9 Headboat mode gag discards (numbers of fish) for SRHS by year. 1981-1985 headboat mode discards are substitutes for missing Texas headboat mode.

YEAR	Discards
1981	181
1982	181
1983	181
1984	181
1985	181
1986	15,034
1987	17,649
1988	6,753
1989	19,127
1990	49,606
1991	1,628
1992	13,755
1993	17,336
1994	60,349
1995	31,205
1996	30,379
1997	29,286
1998	82,585
1999	52,070
2000	25,695
2001	19,254
2002	25,975
2003	48,059
2004	58,313
2005	43,390
2006	12,909
2007	32,004
2008	34,463
2009	52,284
2010	59,882
2011	88,830
2012	18,089

Table 4.10.10 Number of gag measured in the Gulf of Mexico in the MRFSS/MRIP by year, mode, and state.

	Cbt					Hbt			Priv					Shore				Grand
YEAR	LA	MS	AL	FLW	All	LA	FLW	All	LA	MS	AL	FLW	All	TX	AL	FLW	All	Total
1981				10	10		18	18			5	14	19		1	3	4	51
1982				6	6		19	19				66	66			3	3	94
1983				3	3		78	78				40	40					121
1984				15	15	1	33	34				19	19	10		2	12	80
1985							116	116	6			13	19					135
1986	11	4	9	131	155					1	3	12	16					171
1987	1	1	10	117	129					1		74	75			1	1	205
1988		14	1	71	86							58	58					144
1989	1	8	4	63	76				1			14	15			3	3	94
1990			3	66	69							33	33					102
1991	9	1	1	16	27							81	81			4	4	112
1992	6	3	4	150	163				3	1	2	121	127		1	2	3	293
1993	5	1	4	103	113				1	4	3	137	145			6	6	264
1994	2			74	76				3	1	4	130	138			2	2	216
1995	3		9	97	109						2	122	124			3	3	236
1996	5	2	24	72	103				2	5	10	98	115			2	2	220
1997	1	2	29	362	394						1	185	186			2	2	582
1998	4		69	938	1,011				3	7	5	290	305			6	6	1,322
1999	1	1	333	1,400	1,735				7	2	29	484	522			4	4	2,261
2000	5	5	419	1,115	1,544					1	24	382	407			6	6	1,957
2001		2	64	925	991				3		9	287	299					1,290
2002	7	2	79	996	1,084				1	4	17	281	303			1	1	1,388
2003	9	1	28	1,301	1,339						13	275	288					1,627
2004	4		56	2,173	2,233						6	342	348			3	3	2,584
2005	18		158	1,405	1,581				2		20	253	275			3	3	1,859
2006	15		46	613	674						1	135	136			2	2	812
2007	7		19	360	386				2		1	169	172					558
2008	3		3	552	558						1	287	288			8	8	854
2009	7		7	304	318				1	3	2	152	158			2	2	478
2010	2		5	461	468					1	5	164	170			4	4	642
2011			2	113	115							88	88					203
2012			3	486	489						1	63	64			1	1	554
GTotal	126	47	1,389	14,498	16,060	1	264	265	35	31	164	4,869	5,099	10	2	73	85	21,509

Table 4.10.11 Number of angler trips with measured gag in the Gulf of Mexico in the MRFSS/MRIP by year, mode, and state.

	Cbt					Hbt			Priv					Shore				Grand
YEAR	LA	MS	AL	FLW	All	LA	FLW	All	LA	MS	AL	FLW	All	TX	AL	FLW	All	Total
1981				6	6		14	14			3	9	12		1	3	4	36
1982				2	2		14	14				25	25			2	2	43
1983				2	2		54	54				14	14					70
1984				3	3	1	26	27				6	6	1		1	2	38
1985							63	63	1			9	10					73
1986	7	3	5	29	44					1	2	5	8					52
1987	1	1	1	42	45					1		41	42			1	1	88
1988		4	1	22	27							23	23					50
1989	1	3	3	17	24				1			8	9			3	3	36
1990			2	16	18							21	21					39
1991	5	1	1	6	13							39	39			2	2	54
1992	4	2	4	29	39				2	1	2	78	83		1	2	3	125
1993	3	1	4	24	32				1	2	2	60	65			5	5	102
1994	2			13	15				2	1	1	65	69			2	2	86
1995	3		7	33	43						2	57	59			3	3	105
1996	2	1	12	20	35				2	1	5	63	71			2	2	108
1997	1	1	17	136	155						1	90	91			2	2	248
1998	3		41	287	331				3	3	3	143	152			6	6	489
1999	1	1	110	399	511				5	2	17	213	237			3	3	751
2000	4	2	127	360	493					1	16	153	170			4	4	667
2001		2	40	285	327				3		7	150	160					487
2002	3	2	45	287	337				1	2	11	143	157			1	1	495
2003	7	1	19	345	372						12	141	153					525
2004	4		24	481	509						6	154	160			3	3	672
2005	8		51	404	463				1		14	127	142			3	3	608
2006	10		22	196	228						1	69	70			2	2	300
2007	7		15	156	178				2		1	100	103					281
2008	3		2	179	184						1	135	136			5	5	325
2009	1		6	95	102				1	2	2	92	97			2	2	201
2010	1		5	129	135					1	4	100	105			4	4	244
2011			2	48	50							50	50					100
2012			3	148	151						1	30	31			1	1	183
GTotal	81	25	569	4,199	4,874	1	171	172	25	18	114	2,413	2,570	1	2	62	65	7,681

Table 4.10.12 Number of gag measured in the Gulf of Mexico in the SRHS by year and area. Due to SRHS area definitions, West Florida and Alabama data are combined.

year	TX	LA	AL/FLW	All States
1986	31	12	621	664
1987	38	11	602	651
1988	17	28	336	381
1989	13	14	425	452
1990	26	6	329	361
1991	8	4	144	156
1992	8	9	126	143
1993	21	27	82	130
1994	27	9	183	219
1995	9	31	151	191
1996	6	29	233	268
1997	5	24	281	310
1998	66	100	354	520
1999	3	131	355	489
2000	6	50	283	339
2001	4	25	234	263
2002	10	7	283	300
2003	2	13	369	384
2004	5		228	233
2005	5	12	204	221
2006	1	18	150	169
2007		1	160	161
2008	1	2	210	213
2009		2	116	118
2010	2		135	137
2011	1		41	42
2012	2	4	90	96
Grand Total	317	569	6,725	7,611

Table 4.10.13 Number of trips with measured gag in the Gulf of Mexico in the SRHS by year and area. Due to SRHS area definitions, West Florida and Alabama data are combined.

year	TX	LA	AL/FLW	All States
1986	26	9	226	261
1987	32	6	262	300
1988	15	19	169	203
1989	12	10	171	193
1990	19	3	112	134
1991	7	4	67	78
1992	8	8	66	82
1993	20	17	48	85
1994	16	6	64	86
1995	9	19	67	95
1996	6	20	95	121
1997	2	22	108	132
1998	32	57	144	233
1999	3	63	129	195
2000	5	27	101	133
2001	4	18	77	99
2002	4	7	83	94
2003	2	11	124	137
2004	5		85	90
2005	3	9	86	98
2006	1	8	58	67
2007		1	63	64
2008	1	2	78	81
2009		2	45	47
2010	2		54	56
2011	1		14	15
2012	2	3	37	42
Grand Total	237	351	2,633	3,221

Table 4.10.14 Number of gag measured in the state of Texas in the TPWD by year and mode. 2012 data is through Nov 20th.

YEAR	Cbt	Priv	Grand Total
1983			
1984		2	2
1985		2	2
1986			
1987	4		4
1988			
1989		1	1
1990		5	5
1991	1	4	5
1992			
1993			
1994		3	3
1995			
1996	1	6	7
1997			
1998	1	8	9
1999	5	7	12
2000	4	13	17
2001	1	16	17
2002		8	8
2003	1	8	9
2004		8	8
2005	1	3	4
2006	1	12	13
2007	1	6	7
2008	2	6	8
2009		10	10
2010	1	4	5
2011	1	2	3
2012	1	4	5
Grand Total	26	138	164

Table 4.10.15 Number of trips with measured gag in the state of Texas in the TPWD by year and mode. 2012 data is through Nov 20th.

YEAR	Cbt	Priv	Grand Total
1983			
1984		2	2
1985		2	2
1986			
1987	1		1
1988			
1989		1	1
1990		3	3
1991	1	2	3
1992			
1993			
1994		3	3
1995			
1996	1	5	6
1997			
1998	1	7	8
1999	3	5	8
2000	2	9	11
2001	1	9	10
2002		8	8
2003	1	8	9
2004		7	7
2005	1	2	3
2006	1	11	12
2007	1	6	7
2008	2	5	7
2009		9	9
2010	1	3	4
2011	1	2	3
2012	1	4	5
Grand Total	19	113	132

Table 4.10.16 Gulf of Mexico (FLW-TX) estimated number of **angler trips** for MRFSS (1981-2003) and MRIP (2004-2012) by year and state. Texas boat mode angler trip estimates have been excluded. Angler trip estimates from Texas 1981 to 1985 are from shore mode only. Florida Keys angler trip estimates have been excluded.

YEAR	FLW (fl_reg 1 and 2)	AL	MS	LA	TX	Total
1981	6,562,295	523,736	693,360	1,386,220	2,073,552	11,239,162
1982	7,577,560	1,362,929	779,065	2,603,283	2,792,944	15,115,781
1983	11,807,419	1,740,182	1,086,195	2,729,264	3,848,308	21,211,368
1984	13,258,309	612,354	826,354	1,750,442	2,066,161	18,513,620
1985	10,644,999	712,494	604,478	2,582,626	2,417,885	16,962,482
1986	13,692,071	881,666	811,544	3,043,553		18,428,834
1987	10,160,855	629,467	793,270	2,385,256		13,968,848
1988	13,838,360	1,197,906	917,534	2,973,800		18,927,600
1989	10,969,811	629,706	715,169	2,316,720		14,631,406
1990	8,739,533	742,732	691,634	1,989,157		12,163,056
1991	11,791,244	666,469	849,297	2,441,348		15,748,358
1992	11,947,502	781,098	1,005,831	2,578,108		16,312,539
1993	10,817,639	955,127	871,412	2,735,639		15,379,816
1994	11,450,904	907,336	979,743	2,522,991		15,860,973
1995	10,743,131	1,029,197	1,089,244	2,996,136		15,857,708
1996	10,469,679	945,518	961,034	2,896,335		15,272,567
1997	11,552,825	1,043,649	1,013,939	3,252,468		16,862,882
1998	11,066,276	972,549	817,863	2,667,856		15,524,545
1999	10,454,300	1,141,501	788,075	2,627,440		15,011,316
2000	14,404,820	1,086,818	1,093,144	3,751,609		20,336,390
2001	15,556,074	1,635,798	1,250,045	3,615,244		22,057,161
2002	13,903,603	1,190,004	1,038,353	3,018,946		19,150,906
2003	15,253,308	1,499,989	1,176,788	4,270,921		22,201,006
2004	16,602,497	2,250,691	1,179,292	5,203,514		25,235,993
2005	16,047,289	1,604,207	925,717	4,065,078		22,642,292
2006	16,083,180	1,938,270	923,967	3,763,274		22,708,691
2007	15,900,475	1,961,012	1,204,457	4,188,282		23,254,225
2008	16,174,734	1,703,946	968,686	4,620,056		23,467,421
2009	15,050,939	1,712,587	1,079,328	4,128,014		21,970,867
2010	13,713,793	1,686,157	1,232,593	3,862,487		20,495,030
2011	13,411,435	2,483,465	1,615,390	4,576,247		22,086,537
2012	13,967,667	2,305,286	1,950,449	4,136,564		22,359,966
Total	403,614,522	40,533,846	31,933,252	101,678,876	13,198,850	590,959,346

Table 4.10.17 Gulf of Mexico estimated number of **angler days** from SRHS by year and state.

year	AL	FLW	LA	MS	TX	Grand Total
1986	101,336	138,741	5,891		56,568	302,536
1987	76,111	140,938	6,362		63,363	286,774
1988	67,648	128,300	7,691		70,396	274,035
1989	57,233	151,092	2,867		63,389	274,581
1990	60,758	153,148	6,898		58,144	278,948
1991	62,392	111,920	6,373		59,969	240,654
1992	66,180	118,622	9,911		76,218	270,931
1993	73,703	134,195	11,256		80,904	300,058
1994	69,110	135,452	12,651		100,778	317,991
1995	67,798	114,612	10,498		90,464	283,372
1996	64,336	90,577	10,988		91,852	257,753
1997	65,599	83,843	9,008		82,207	240,657
1998	66,664	118,667	7,854		77,650	270,835
1999	60,959	115,158	8,026		58,235	242,378
2000	57,106	102,225	4,952		58,395	222,678
2001	55,748	101,495	6,222		55,361	218,826
2002	55,554	86,277	6,222		66,951	215,004
2003	62,555	81,656	6,636		74,432	225,279
2004	63,494	94,936			64,990	223,420
2005	52,797	77,436			59,857	190,090
2006	66,346	57,703	5,005		70,789	199,843
2007	67,997	68,883	3,076		63,210	203,166
2008	62,118	68,058	2,945		41,188	174,309
2009	65,623	76,815	3,268		50,737	196,443
2010	40,594	70,424	217	498	47,154	158,887
2011	77,303	79,722	1,886	1,771	47,284	207,966
2012	77,770	84,205	1,839	1,841	51,776	217,431
Grand Total	1,764,832	2,785,100	158,542	4,110	1,782,261	6,494,845

Table 4.10.18 Texas estimated number of **angler trips** from TPWD by year and season (High- May 15th -Nov 20th; Low- Nov 21st-May 14th).

Year	High	Low	Total
1983	669,126		669,126
1984	559,713	175,608	735,321
1985	611,251	261,821	873,072
1986	576,966	353,576	930,542
1987	775,656	361,874	1,137,530
1988	729,324	341,819	1,071,143
1989	714,053	243,593	957,645
1990	650,928	220,197	871,125
1991	675,614	225,488	901,102
1992	765,954	264,420	1,030,374
1993	721,964	328,451	1,050,415
1994	792,955	392,843	1,185,798
1995	727,097	426,173	1,153,270
1996	800,241	377,200	1,177,440
1997	776,296	324,887	1,101,183
1998	758,954	326,636	1,085,590
1999	887,954	432,612	1,320,566
2000	828,750	494,748	1,323,498
2001	791,628	359,044	1,150,672
2002	748,641	358,148	1,106,789
2003	762,020	369,657	1,131,677
2004	750,642	375,916	1,126,558
2005	702,874	358,604	1,061,479
2006	724,278	432,511	1,156,790
2007	720,219	337,594	1,057,814
2008	677,825	377,775	1,055,600
2009	711,885	329,143	1,041,027
2010	705,738	285,747	991,485
2011	743,213	382,188	1,125,401
2012	729,598	429,591	1,159,189
Grand Total	21,791,358	9,947,864	31,739,222

4.11 Figures

Figure 4.11.1 Gulf of Mexico Fishery Management Council Jurisdictional Boundaries.

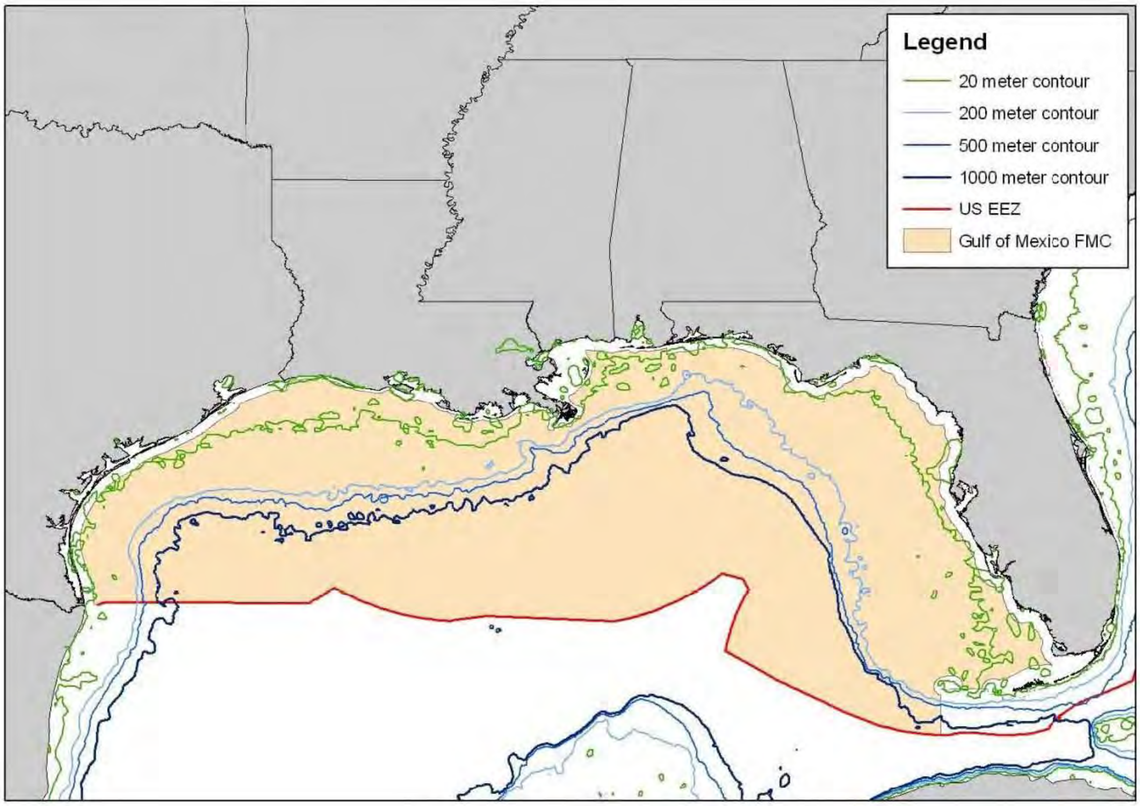
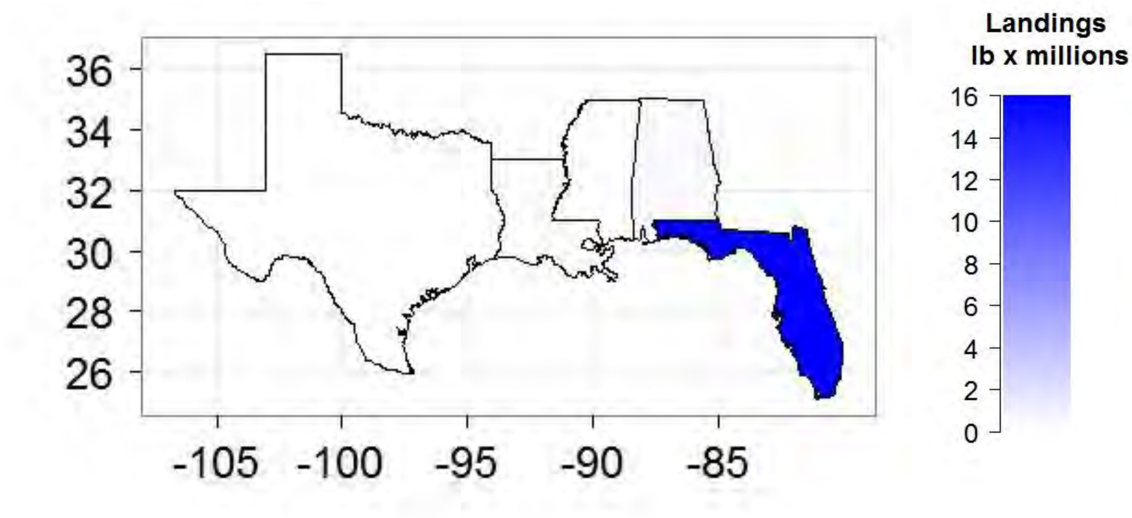
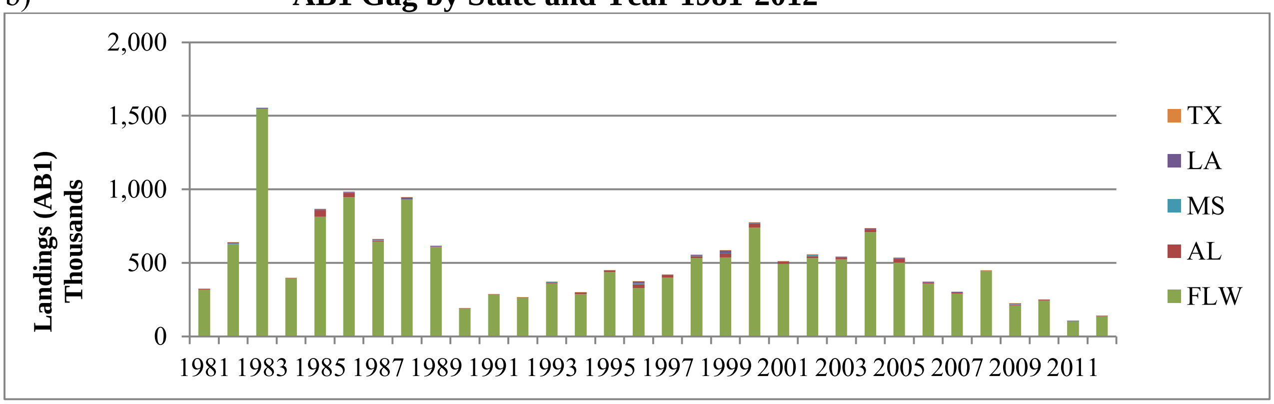


Figure 4.11.2: Gulf of Mexico estimated number of gag landings from MRFSS/MRIP, TPWD, and SRHS (1981-2012) by state (a), by state and year (b), and by state and mode (c).

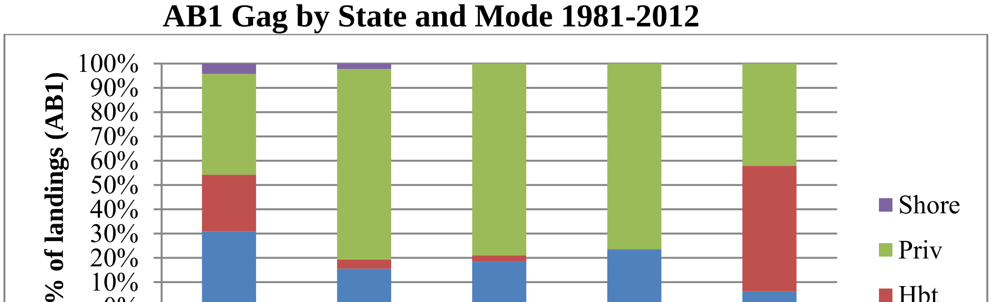
a) **AB1 Gag by State 1981-2012**



b) **AB1 Gag by State and Year 1981-2012**



c) **AB1 Gag by State and Mode 1981-2012**



	AL	FLW	LA	MS	TX
Shore	14,588	352,234	0	0	0
Priv	144,442	12,324,105	115,012	33,779	6,881
Hbt	80,665	603,276	3,833	32	8,451
Cbt	107,385	2,436,087	26,812	10,404	1,028

Figure 4.11.3 MRFSS AB1 estimates (number of fish) versus MRIP adjusted AB1 estimates for Gulf of Mexico gag 1981-2003.

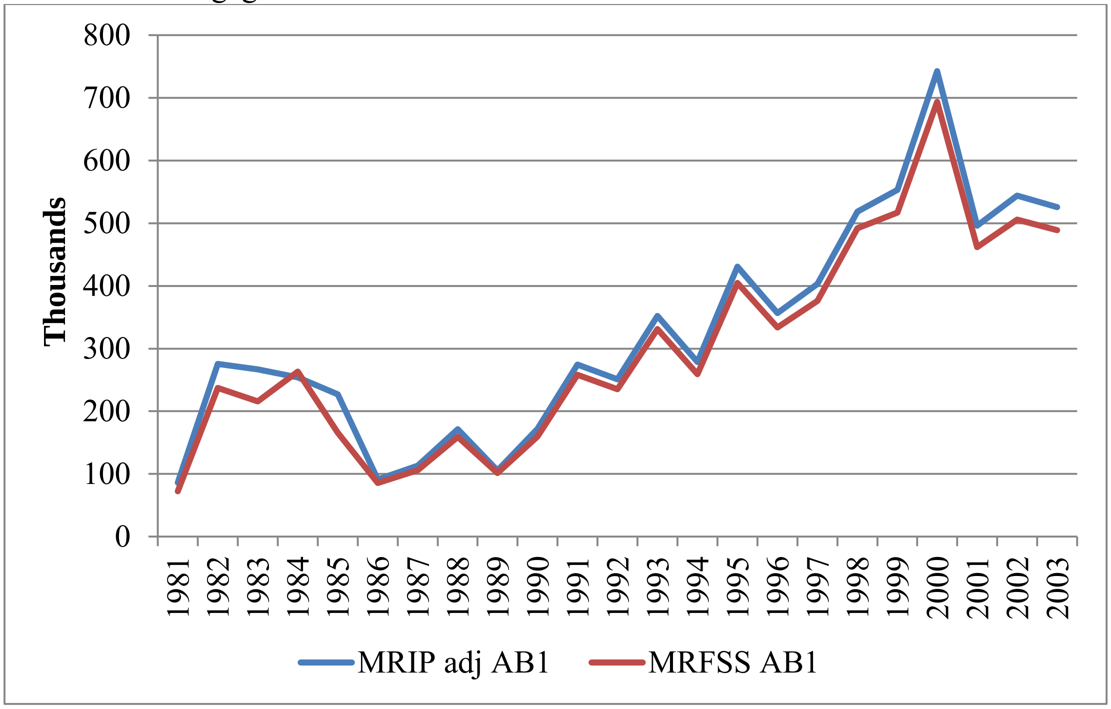
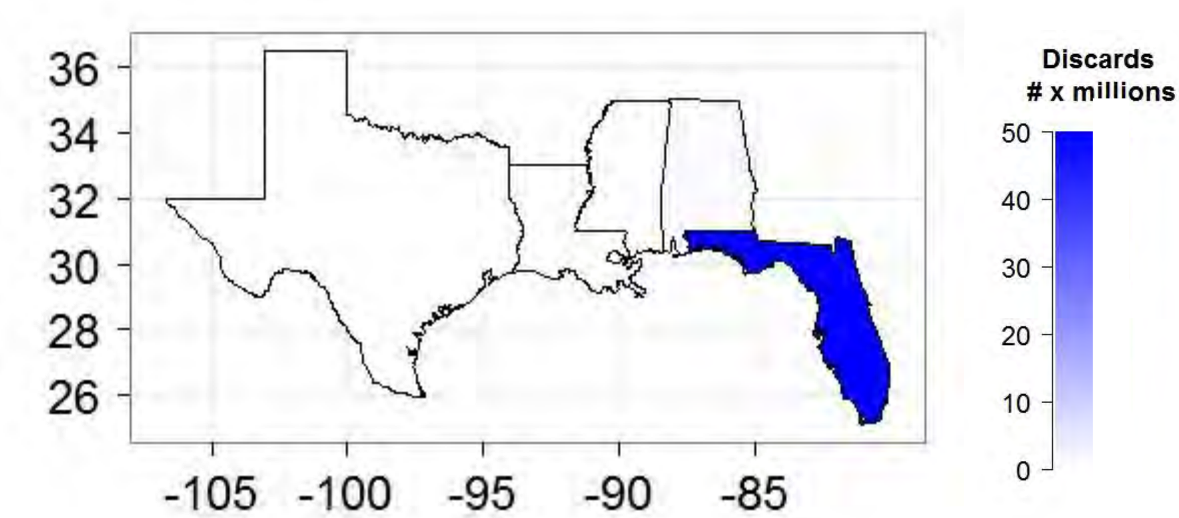
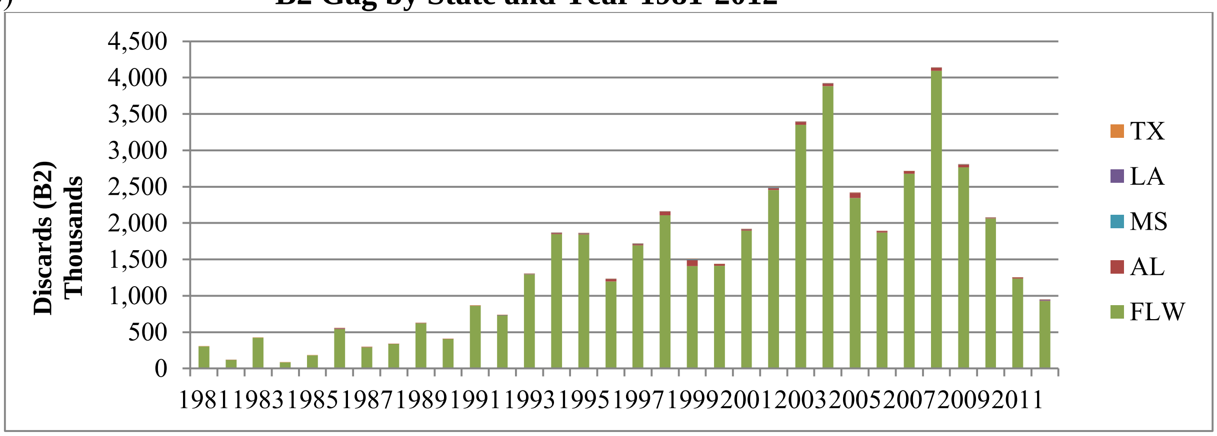


Figure 4.11.4: Gulf of Mexico estimated number of gag discards from MRFSS/MRIP, TPWD, and SRHS (1981-2012) by state (a), by state and year (b), and by state and mode (c).

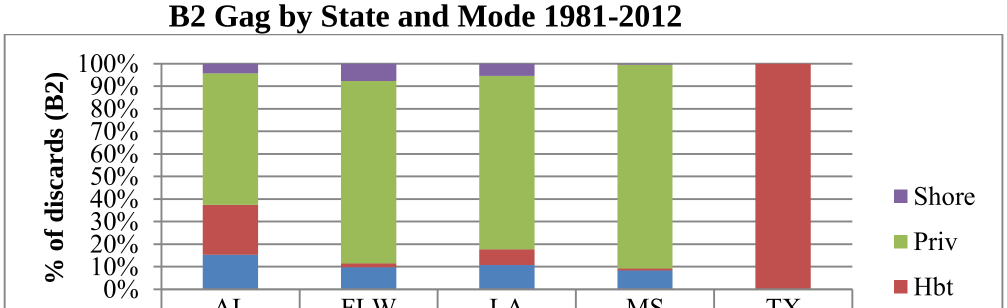
a) **B2 Gag by State 1981-2012**



b) **B2 Gag by State and Year 1981-2012**



c) **B2 Gag by State and Mode 1981-2012**



	AL	FLW	LA	MS	TX
Shore	25,136	3,667,247	4,159	193	
Priv	340,957	38,185,387	58,401	33,409	
Hbt	129,747	828,971	5,227	306	12,893
Cbt	88,889	4,584,091	8,163	3,099	

Figure 4.11.5a. Length frequency distributions for length samples collected from recreational headboat fisheries located in the Gulf of Mexico from 1991 to 1997.

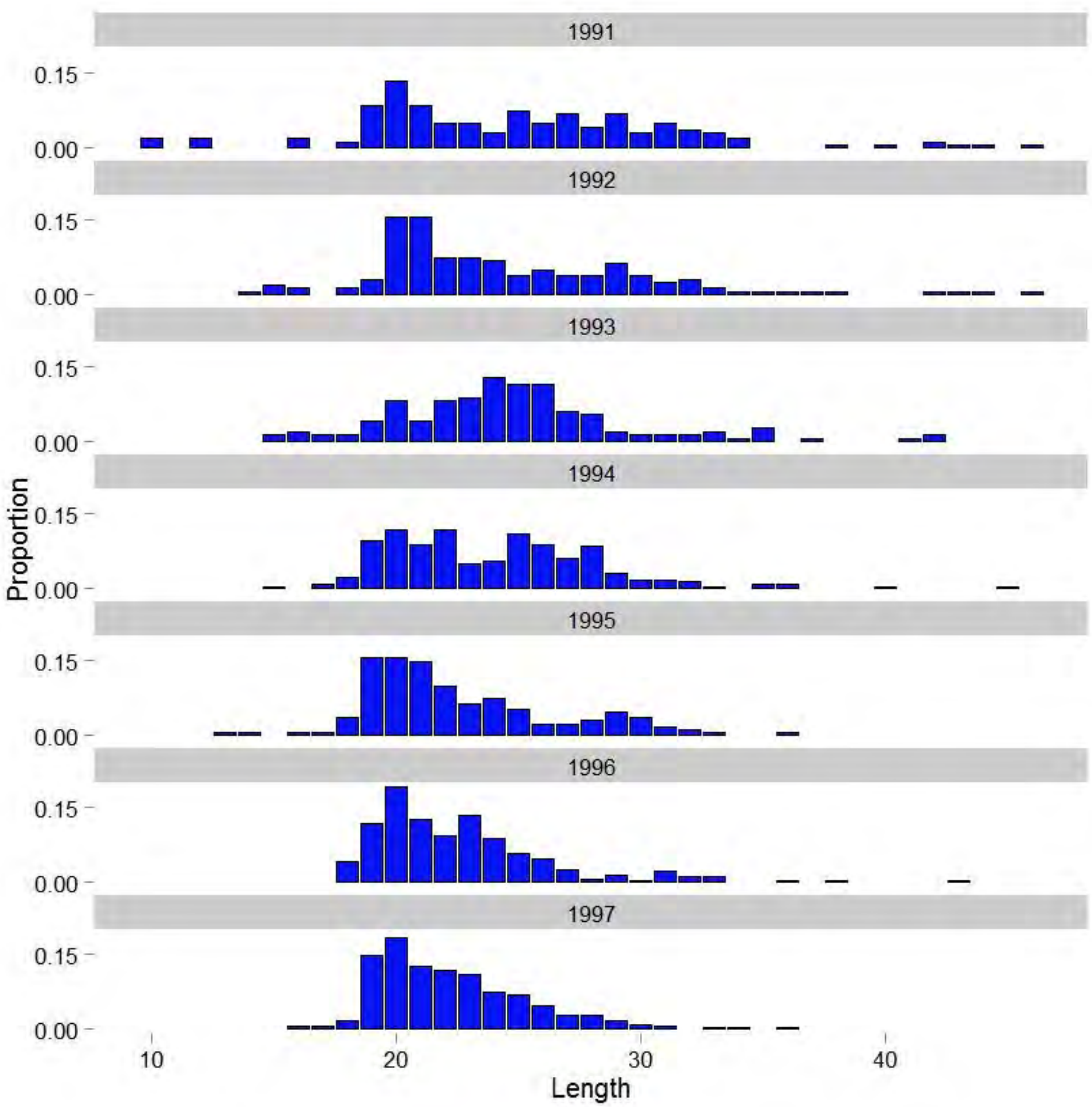


Figure 4.11.5b. Length frequency distributions for length samples collected from recreational headboat fisheries located in the Gulf of Mexico from 1998 to 2004.

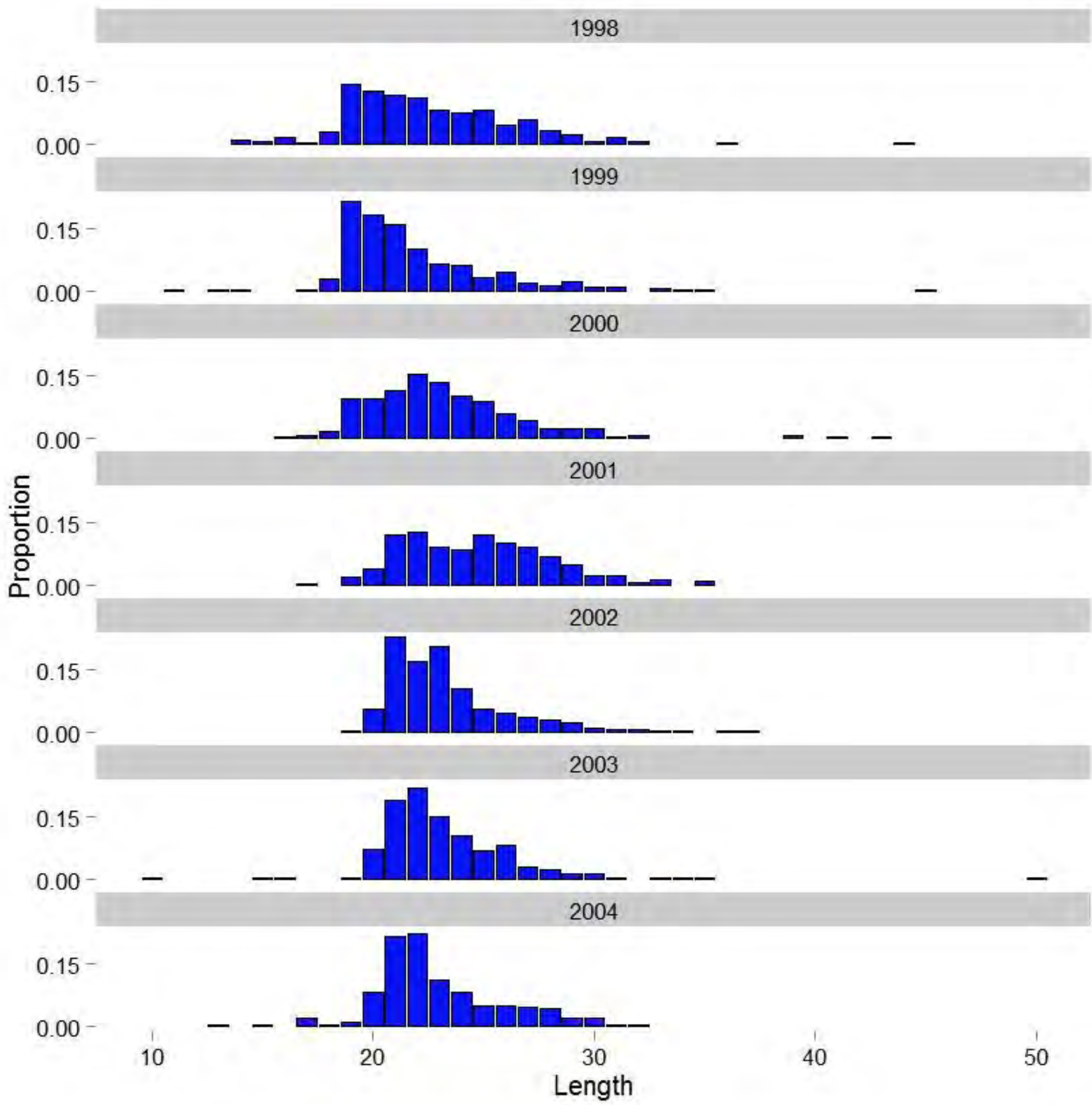


Figure 4.11.5c. Length frequency distributions of length samples collected from recreational head boat fisheries located in the Gulf of Mexico from 2005 to 2012.

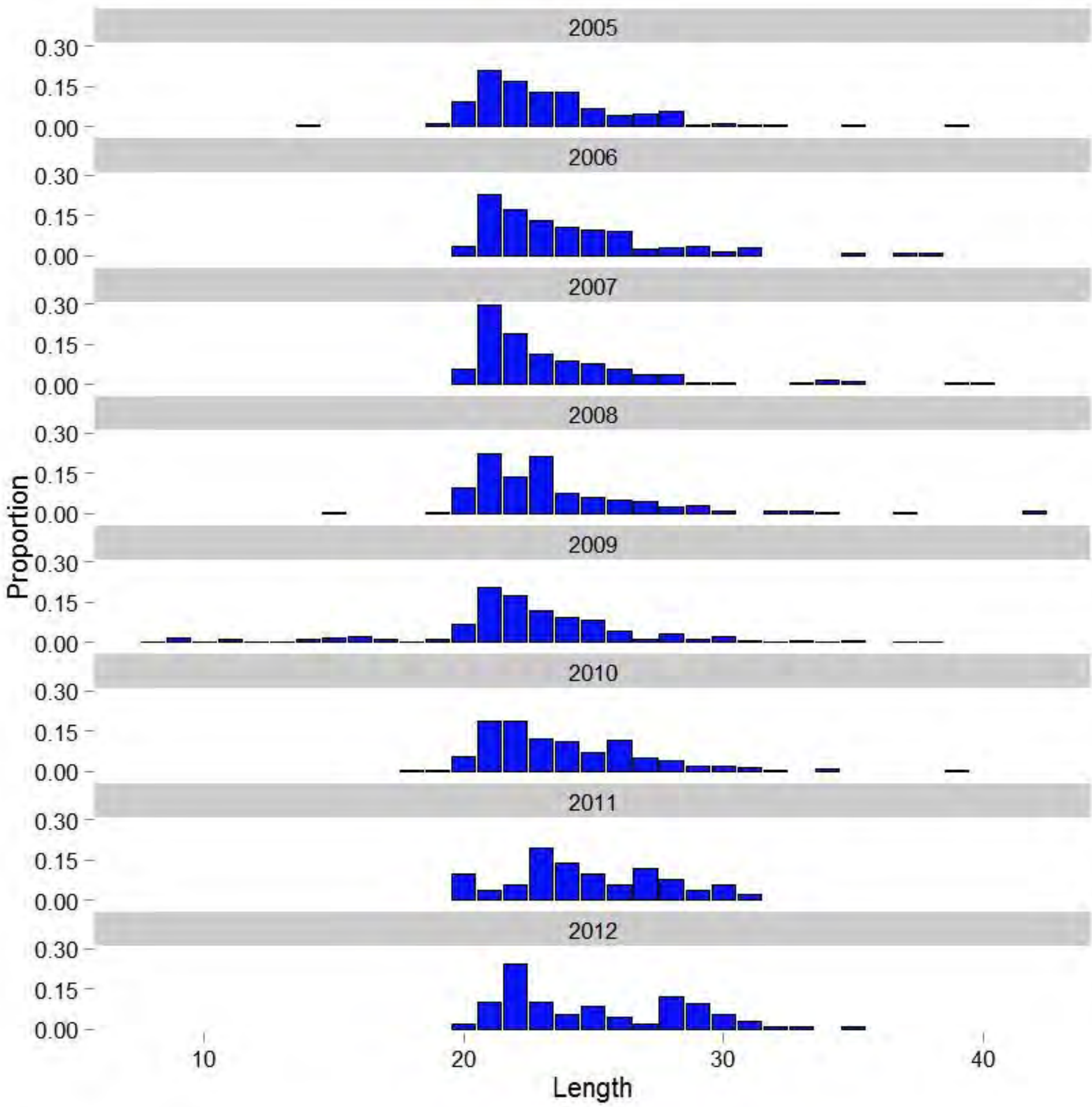


Figure 4.11.6a. Length frequency distributions for length samples collected from recreational charter boat and private boat fisheries located in the Gulf of Mexico from 1991 to 1997.

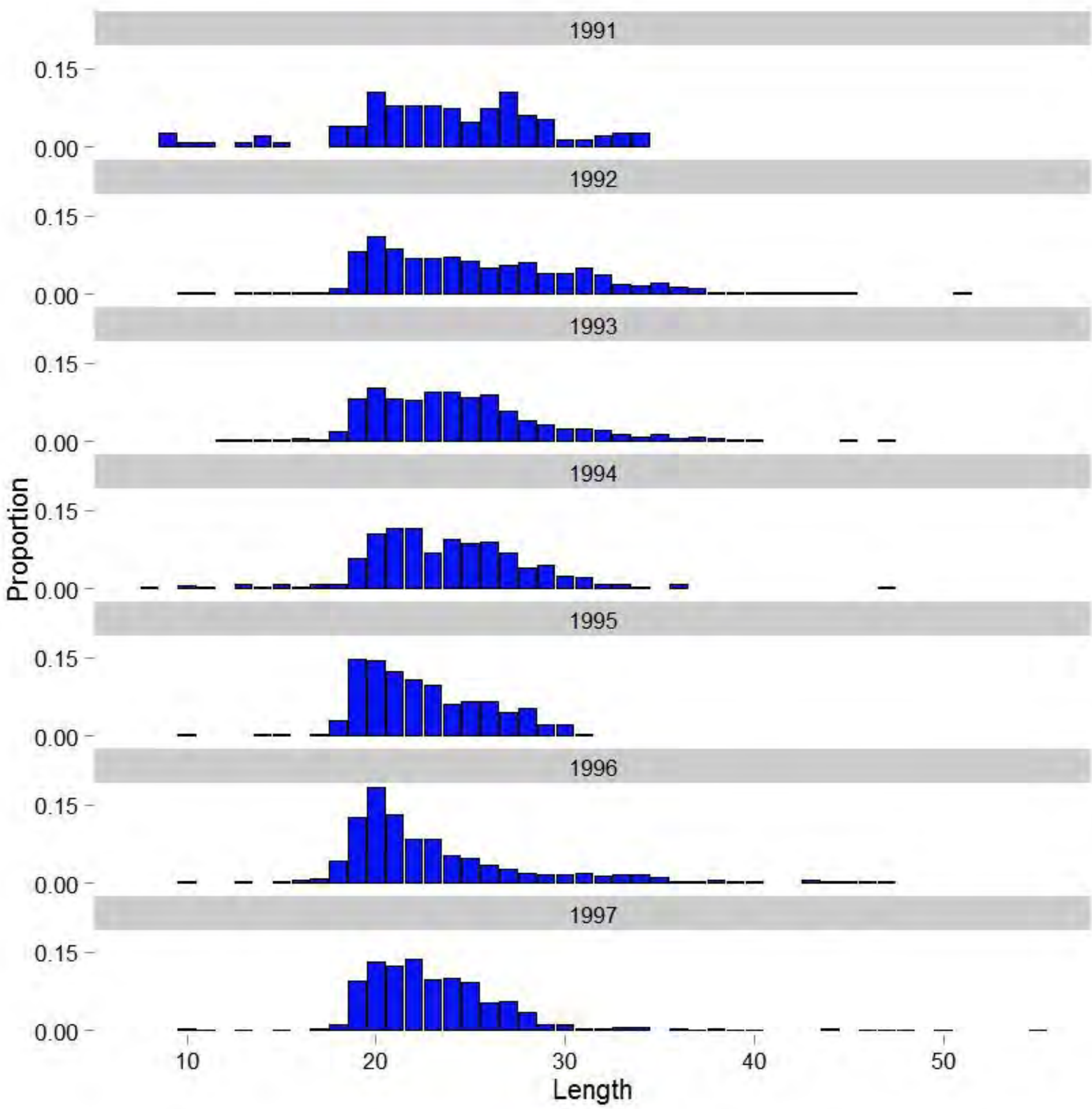


Figure 4.11.6b. Length frequency distributions for length samples collected from recreational charter boat and private boat fisheries located in the Gulf of Mexico from 1998 to 2004.

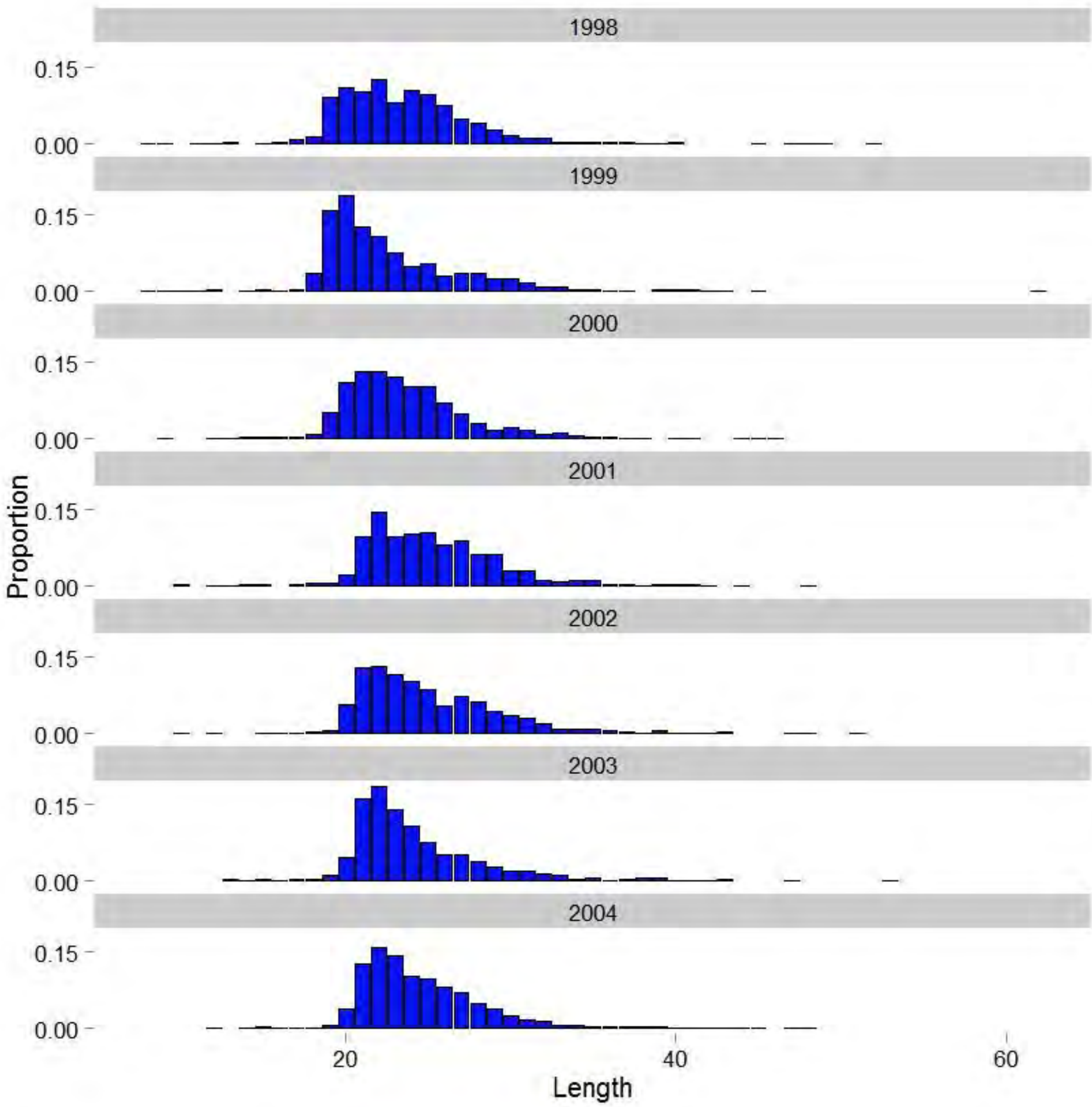


Figure 4.11.6c. . Length frequency distributions of length samples collected from recreational charter boat and private boat fisheries located in the Gulf of Mexico from 2005 to 2012.

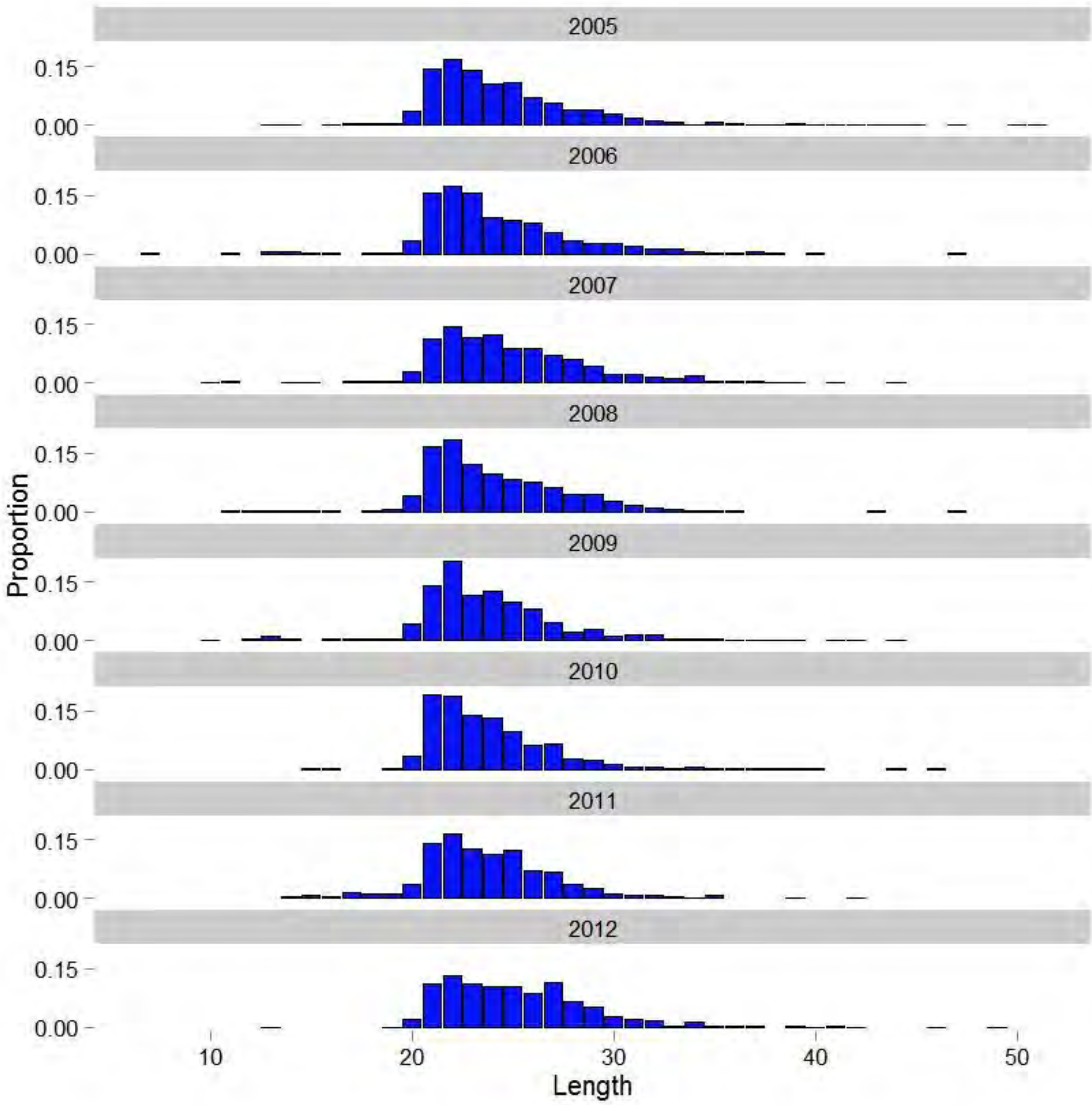


Figure 4.11.7. Reweighted age frequency distributions for gag samples collected from recreational head boat fisheries located in the Gulf of Mexico from 2007 to 2012.

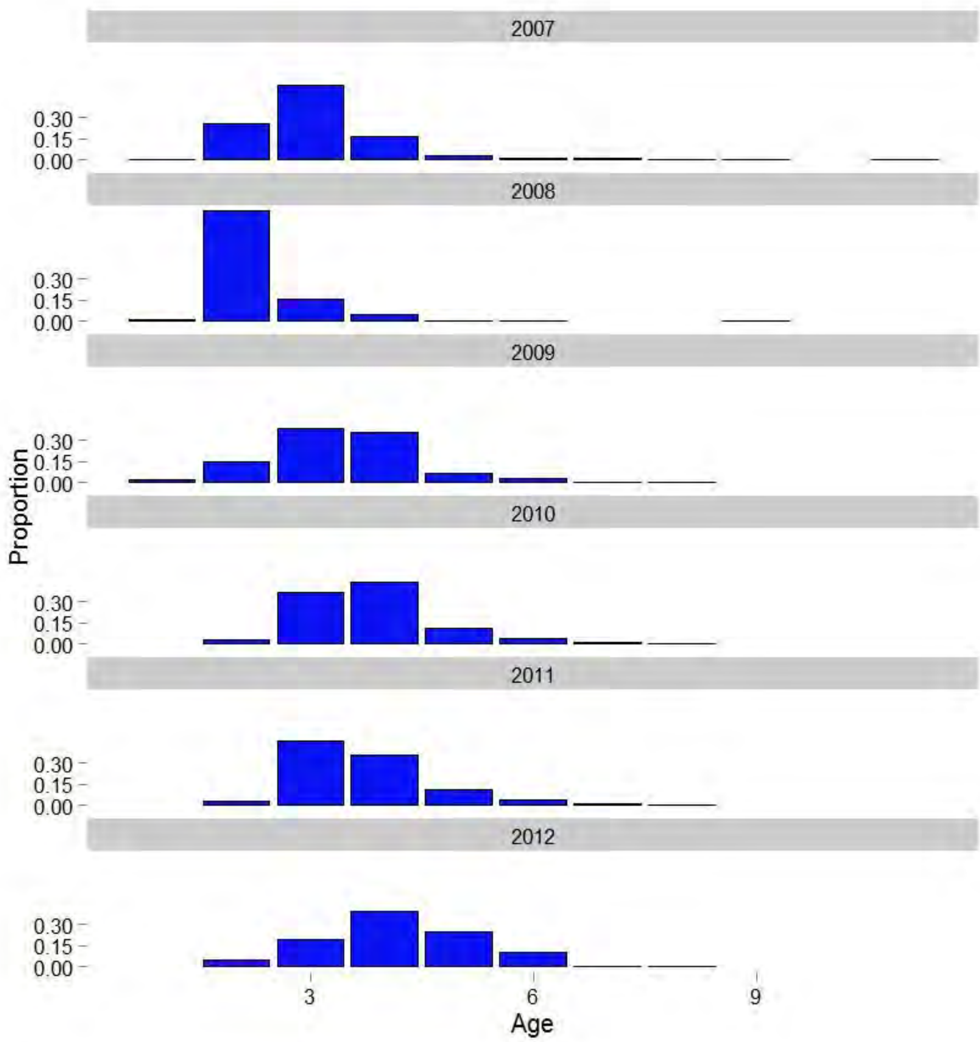


Figure 4.11.8. Reweighted age frequency distributions for gag samples collected from recreational charter boat and private boat fisheries located in the Gulf of Mexico 2002 to 2012.

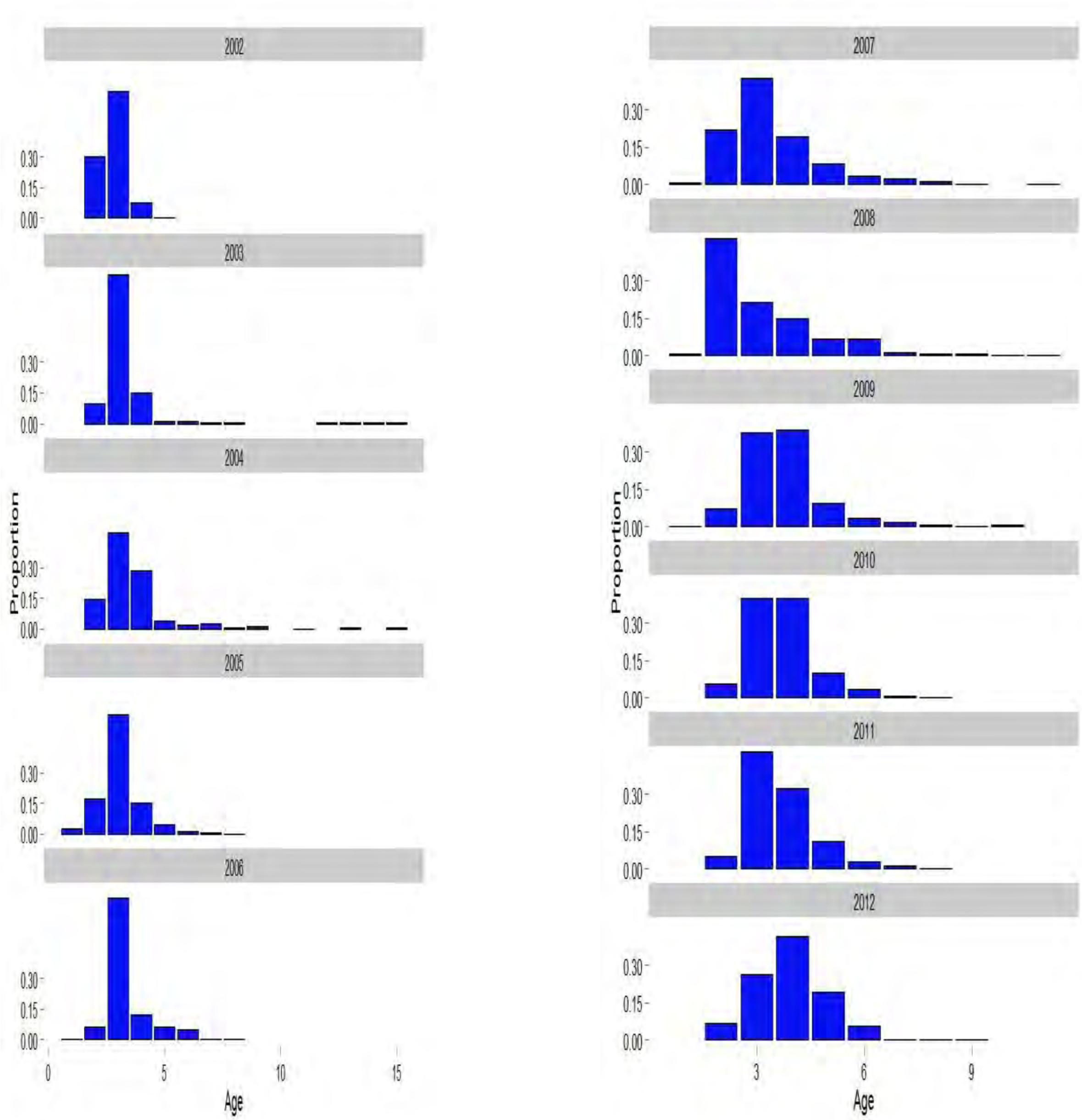
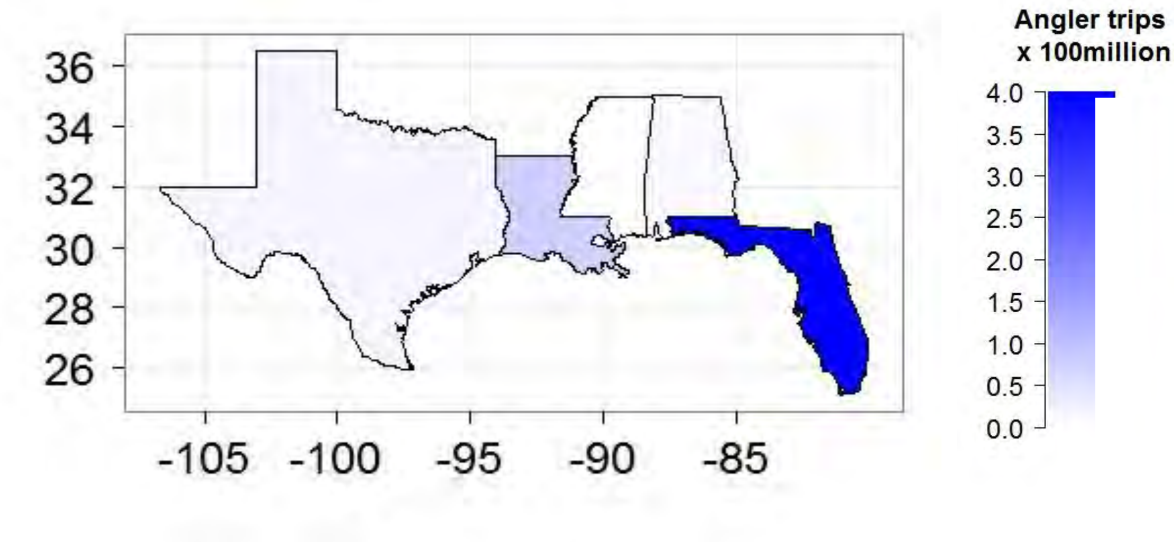
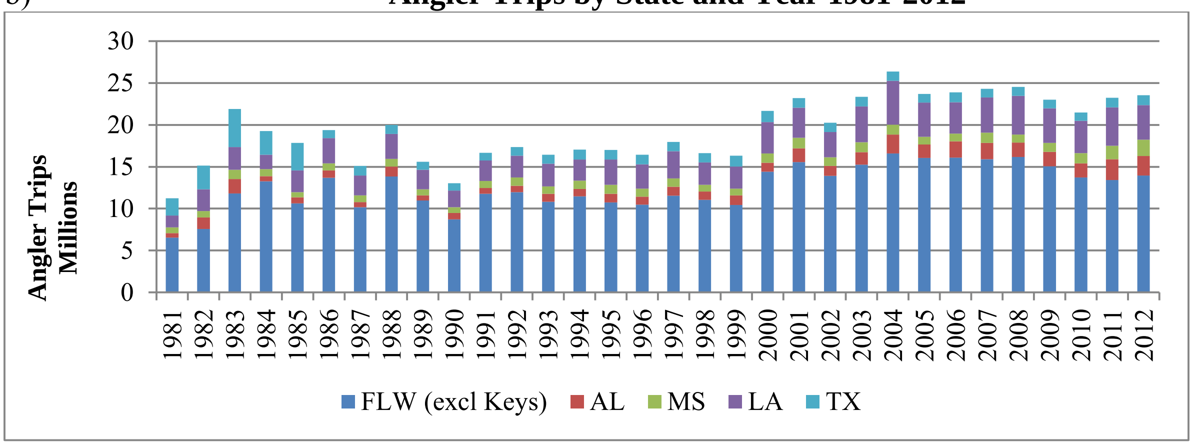


Figure 4.11.9: Gulf of Mexico estimated number of angler trips from MRFSS/MRIP (1981-2012) and TPWD (1983-2012) by state (a), by state and year (b), and by state and mode (c).

a) **Angler Trips by State 1981-2012**



b) **Angler Trips by State and Year 1981-2012**



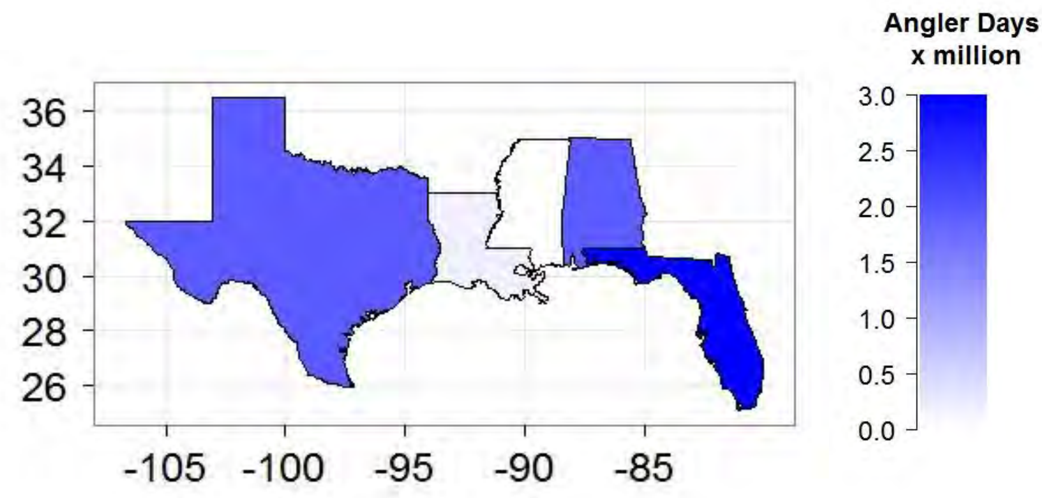
c) **Angler Trips by State and Mode 1981-2012**

	FLW (excl Keys)	AL	MS	LA	TX
Shore	186,019,831	19,331,165	13,527,668	25,459,551	13,198,850
Priv	205,911,135	19,309,977	17,202,246	72,776,443	28,832,809
Hbt	555,174	69,072		43,262	
Cbt	11,128,382	1,823,632	1,203,337	3,399,619	2,906,412

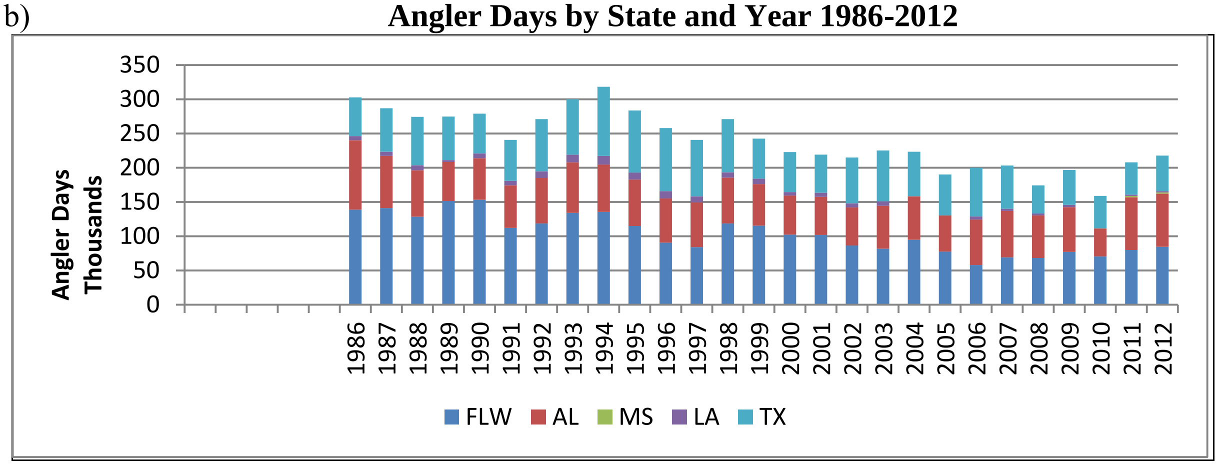
***Hbt (1981-1985); TX (1983-2012) from TPWD; TX (1981-1985) from MRFSS**

Figure 4.11.10: Gulf of Mexico estimated number of angler days from SRHS (1986-2012) by state (a) and by state and year (b)

a) **Angler Days by State 1986-2012**



b) **Angler Days by State and Year 1986-2012**



5. Measures of Population Abundance

5.1 Overview

Analytical results of numerous data sets were presented to the Index Working Group (IWG) of both fishery-dependent and fishery-independent origin. The working papers containing full descriptions of the data sets and analytical methods are listed in section 5.2. In addition, a simplified chart, depicting spatial coverage of each data set is included in Figure 5.8.1. For rationalization for the recommendation/exclusion of particular indices, see the 'Comments on Adequacy for Assessment' section for the particular index contained in the appropriate section below. Three fishery-independent and four fishery-dependent indices of abundance are recommended for use in the assessment by the IWG and include:

Fishery-independent

- SEAMAP video
- Panama City video
- Juvenile gag and seagrass

Fishery-dependent

- MRFSS
- Headboat survey
- Commercial handline survey
- Commercial longline survey

Other indices and/or datasets that were considered and not recommended for use in the assessment by the IWG include:

Fishery-independent

- FWRI video
- SEAMAP video (copperbelly gag)
- UF reef survey
- SEAMAP groundfish
- SEAMAP ichthyoplankton
- NMFS bottom longline
- NMFS pelagic survey

Fishery-dependent

- Reef fish bottom longline observer

5.1.1 Group Membership

Members of the IWG included: Meaghan Bryan, Matthew Campbell, Shannon Cass-Calay, Mary Christman, Doug DeVries, Walter Ingram, Kevin McCarthy, Adam Pollack (workgroup lead), Adyan Rios and Ted Switzer.

5.2 Review of Working Papers

The IWG reviewed the following papers:

- SEDAR33-DW01 - Greater Amberjack and Gag Grouper Catches from Mississippi Laboratories Fishery Independent Surveys
- SEDAR33-DW03 - Fishery-Independent Indices of Abundance for Gag (*Mycteroperca microlepis*) in the Northeastern Gulf of Mexico, with Intrinsic Habitat Quality Controlled and Contrasted
- SEDAR33-DW15 - SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Gag
- SEDAR33-DW26 - Relative abundance of gag grouper and greater amberjack based on observer data collected in the reef fish bottom longline fishery
- SEDAR33-DW28 - Gag, *Mycteroperca microlepis,* Findings from the NMFS Panama City Laboratory Trap & Camera Fishery-Independent Survey – 2004-2012
- SEDAR33-AW01 - Fisheries-independent data for gag and greater amberjack from reef-fish video surveys on the West Florida Shelf, 2008-2012.
- SEDAR33-AW06 - Summary of fishery-independent surveys of juvenile gag grouper in the Gulf of Mexico
- SEDAR33-AW07 - Standardized catch rate indices for gag grouper (*Mycteroperca microlepis*) landed by the commercial longline fishery in the U.S. Gulf of Mexico during 1993-2012
- SEDAR33-AW08 - Standardized catch rates for gag grouper from the United States Gulf of Mexico handline fishery during 1990-2009
- SEDAR33-AW09 - Standardized catch rates for gag grouper from the Gulf of Mexico headboat fishery during 1986-2011
- SEDAR33-AW10 - Standardized Catch Rates of Gulf of Mexico Gag Grouper from Recreational Inshore, Charterboat, and Private Boat Fisheries (MRFSS) 1986 to 2010

Note that even though some papers were submitted as Assessment Workshop documents, draft versions were reviewed during the Data Workshop.

5.3 Fishery Independent Indices

5.3.1 SEAMAP Video

The primary objective of the annual Southeast Area Monitoring and Assessment Program (SEAMAP) reef fish video survey is to provide an index of the relative abundances of fish species associated with topographic features (e.g. reefs, banks, and ledges) located on the continental shelf of the Gulf of Mexico (GOM) from Brownsville, TX to the Dry Tortugas, FL. Secondary objectives include quantification of habitat types sampled (video and side-scan), and collection of environmental data throughout the survey. Because the survey is conducted on topographic features the species assemblages targeted are typically classified as reef fish (e.g. red snapper, *Lutjanus campechanus*), but occasionally fish more commonly associated with pelagic environments are observed (e.g. hammerhead shark, *Sphyrna lewini*).

The survey has been executed from 1992-1997, 2001-2002, and 2004-2012 and historically takes place from May – August. The 2001 survey was abbreviated due to ship scheduling, during which, the only sites that were completed were located in the western Gulf of Mexico. Types of data collected on the survey include diversity, abundance (minimum count), fish length, habitat type, habitat coverage, and bottom topography. The size of fish sampled with the video gear is species specific however greater amberjack sampled over the history of the survey had fork lengths ranging from 101.0 – 2065.0 mm, and mean annual fork lengths ranging from 571.8 – 759.9 mm. Age and reproductive data cannot be collected with the camera gear but beginning with the 2012 survey, a vertical line component will be coupled with the video drops to collect hard parts, fin clips, and gonads.

5.3.1.1 Methods of Estimation

Data Filtering Techniques

Various limitations either in design, implementation, or performance of gear causes limitations in calculating minimum counts and are therefore dropped from the design-based indices development and analysis as follows. In 1992, each fish was counted every time it came into view over the entire record time and the total of all these counts was the maximum count. Maximum count methodologies are not preferred and the 1992 video tapes were destroyed during Hurricane Katrina and cannot be re-viewed, so 1992 data is excluded from analyses (unknown number of stations). The 2001 survey was abbreviated due to ship scheduling, during which, the only sites that were completed were located in the western GOM. Because of the spatial imbalance associated with data gathered in 2001, that entire year has been dropped (80 total sites). Stratum 1 (South Florida) and stratum 7 (S. Texas) are blocks that contain very little reef and were not consistently chosen for sampling and were also dropped (184 total sites). Occasionally tapes are unable to be read (i.e. organisms cannot be identified to species) for the following reasons including: 1) camera views are more than 50% obstructed, 2) sub-optimal lighting conditions, 3) increased backlighting, 4) increased turbidity, 5) cameras out of focus, 6) cameras failed to film. In all of these cases the station is flagged as ‘XX’ in the data set and dropped (190 total sites). Sites that did not receive a stratum assignment are also dropped.

Gear and deployment

The SEAMAP reef fish survey has employed several camcorders in underwater housings since 1992. Sony VX2000 DCR digital camcorders mounted in Gates PD150M underwater housings were used from 2002 to 2005 and Sony PD170 camcorders during the years 2006 and 2007. In 2008 a stereo video camera system was developed and assembled at the NMFS Mississippi Laboratories Stennis Space Center Facility and has been used in all subsequent surveys. The stereo video unit consists of a digital stereo still camera head, digital video camera, CPU, and hard drive mounted in an aluminum housing. All of the camcorder housings we have used were rated to a maximum depth of 150 meters while the stereo camera housings are rated to 600 meters. Stereo cameras are mounted orthogonally at a height of 50 cm above the bottom of the pod and the array is baited with squid during deployment.

At each sampling site the stereo video unit is deployed for 40 minutes total, however the cameras and CPU delay filming for 5 minutes to allow for descent to the bottom, and settling of suspended sediment following impact. Once turned on, the cameras film for approximately 30 minutes before shutting off and retrieval of the array. During camera deployment the vessel drifts away from the site and a CTD cast executed, collecting water depth, temperature, conductivity, and transmissivity from the surface to the maximum depth. Seabird units are the standard onboard NOAA vessels however the model employed was vessel/cruise dependent.

Video tape viewing

One video tape from each station is selected for viewing out of four possible. If all four video cameras face reef fish habitat and are in focus, tape selection is random. Videos are viewed for twenty minutes starting from the time when the view clears from suspended sediment. Viewers identify, and enumerate all species to the lowest taxonomic level during the 20 minute viewable segment. From 1993-2008 the time when each fish entered and left the field of view was recorded a procedure referred to as time in - time out (TITO) and from these data a minimum count was calculated. The minimum count is the maximum number of individuals of a selected taxon in the field of view at one instance. Each 20 minute video is evaluated to determine the highest minimum count observed during a 20 minute recording. The 2008-2011 digital video allows the viewer to record a frame number or time stamp of the image when the maximum number of individuals of a species occurred, along with the number of taxon identified in the image but does not use the TITO method. Both the TITO and current viewing procedure result in the minimum count estimator of relative abundance. Minimum count methodology is preferred because it prevents counting the same fish more than once and represents the conservative maximum number of fish that were at a location at one point in time.

Fish length measurement

Beginning in 1995 fish lengths were measured from video using lasers attached on the camera system with known geometry. However, the frequency of hitting targets with the laser is low and precluded estimating size frequency distributions. Additionally, the same fish can be measured more than once at a given station. So, the lengths measured provide the range of sizes observed. The stereo cameras used in 2008-2010 allow size estimation from fish images. The

Vision Measurement System (Geometrics Inc.) was used to estimate size of greater amberjack. We estimated a length frequency distribution by weighting station length frequencies by station Minimum Counts.

Standardization

Delta-lognormal modeling methods were used to estimate relative abundance indices for red snapper (Lo *et al*. 1992). The main advantage of using this method is allowance for the probability of zero catch (Ortiz *et al.* 2000). The index computed by this method is a mathematical combination of yearly abundance estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive abundance values (i.e. presence/absence) and a lognormal model which describes variability in only the nonzero abundance data (Lo *et al*. 1992).

The submodels of the delta-lognormal model were built using a backward selection procedure based on type 3 analyses with an inclusion level of significance of $\alpha = 0.05$. Binomial submodel performance was evaluated using AIC, while the performance of the lognormal submodel was evaluated based on analyses of residual scatter and QQ plots in addition to AIC. Additional model explored the use of other distributions (e.g. Poisson) to model the positive catch but were not used because appropriate diagnostic plots could not be produced.

Submodel Variables

Year: 1992-1997, 2002, and 2004-2012
Depth: 10 – 200 meters
Max-relief: 0-6 meters

5.3.1.2 Sampling Intensity and Time Series

During the years 1993-1997, 2001-2002, 2004-2012, a total of 2,858 total sites have been sampled in the eastern Gulf of Mexico during the reef fish survey (Table 5.7.1). Annually the number of sites sampled in the eastern GOM have varied ranging between 62 and 318, however since 1996 at least 130 sites have been sampled, and since 2005 at least 170 sites have been sampled annually.

5.3.1.3 Size/Age Data

Length frequency data gathered in this survey are constructed from survey data are presented by year for the years 1995-2011 in Table 5.7.2 and Figures 5.8.2 and 5.8.3. Length data were aggregated over years because too few gag are measured in a given sample year. Laser measured data and stereo video measured data however are presented separately as the methodology is different, despite the measurement being taken on identical morphological features of the fish. Age data was unavailable.

5.3.1.4 Catch Rates

Lo and Standardized catch rates for the Gulf of Mexico are presented in Table 5.7.1.1 and in Figure 5.8.1.4.

5.3.1.5 Uncertainty and Measures of Precision

Annual CVs of catch rates for the eastern Gulf of Mexico are presented in Table 5.7.1. Plots of the positive mincount residuals and QQ plots of positive mincount residuals were produced and are presented in figure 5.8.1.5 and 5.8.1.6.

5.3.1.6 Comments on Adequacy for Assessment

Assessment scientists evaluated the abundance indices and coefficient of variation output and advised the working group that the eastern Gulf of Mexico wide index was appropriate for use in the assessment models, therefore the east gulf index is presented in this report. The gulf-wide index runs are available in the working document that was provided prior to the workshop. Models evaluating west gulf gag populations would not converge. Evaluation of the positive catch QQ residual plots indicated that fit was poor and suggested that future models evaluate the feasibility of producing an index using other distributions (e.g. Poisson). At the time of the SEDAR data workshop the fit information (e.g. residuals) from a Poisson based model could not be produced nor evaluated so no further effort was made in this regard during the workshop and the delta log-normal model was accepted.

5.3.1.7 Exclusion of the Copperbelly Index

Following transition from female to male, gag grouper develop coloration and mottling patterns on the belly, lower lip, and tail that are indicative of gender and in various parts of the Gulf of Mexico are referred to as copperbelly gag (Figures 5.8.7 and 5.8.8). Gag retaining this color pattern after death have been verified to be males (SEDAR 33 DW life history report). Because of this trait it was thought that sex ratios and indices could be developed from Southeast Fisheries Science Center (SEFSC) reef fish video surveys. Therefore, in previous gag assessments relative abundance indices were estimated for what was thought to be fully transitioned males and also supplied information on sex ratios. Upon closer examination of the length-frequency data from commercial data sets and SEFSC reef fish video surveys it was noted that the copperbelly gag in the video surveys were significantly shorter in length than those captured and killed in the commercial fishery and which were verified to be male gag (Figures 5.8.9, 5.8.10, and 5.8.11). Furthermore the length frequency distributions from the video survey would suggest that sex ratios are 50/50 at size ranges from 700-1000, whereas the commercial data would suggest that the ratio would be 50/50 somewhere around 1050-1100 mm. Because of this very clear difference between these data that are taken from the same region of the Gulf of Mexico there is concern that the reef fish video might not be tracking fully transitioned males because landings data do not confirm what is seen on video. Furthermore in at least 1 video, SEFSC personnel found evidence that the mottling on the belly can be ephemeral and changes rapidly (~30 seconds of video). At this point it is unclear if these small fish captured on video and showing the typical copperbelly mottling are truly males and therefore a male gag index was not developed for the 2013 gag grouper assessment. Until a method is developed to directly sample reproductive tissue from these previously deemed copperbellies, it is not advised to use this data for sex ratios or development of a male gag index.

5.3.2 Panama City Video

In 2004 the SEFSC's Panama City laboratory initiated a fishery-independent trap survey (the survey) of natural reefs on the inner and mid-shelf of the eastern Gulf of Mexico off northwest Florida, and in 2005 video sampling was added. The survey's primary objective is to generate indices of relative abundance of federally-managed reef fishes for stock assessments and to inform fishery managers. Target species include snappers (red, vermilion, gray, and lane), groupers (gag, red, & scamp), gray triggerfish, red porgy, white grunt, black seabass, hogfish, and amberjacks. Secondary objectives of the survey include examining community structure, annual regional catch, recruitment, distribution, and demographic patterns of economically and ecologically important reef fish species. Annual sampling is conducted May-September. In 2008 the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute (FWRI) joined with the Panama City and Pascagoula NOAA Fisheries Service labs in an effort to expand to the entire west Florida shelf the ongoing fishery independent reef fish surveys conducted by the latter two. Every effort is made to standardize the gear, survey design, sampling protocol, and analytical methods among the three agencies. All three groups collect visual data with stereo camera systems and Panama City and FWRI both use chevron traps. . The estimator of abundance was the maximum number of a given species in the field of view at any time during the 20 min analyzed (= min count of Gledhill and Ingram 2004), and VMS measurements were only taken from a still frame showing the min count of a given species to eliminate the possibility of measuring the same fish more than once. Details on survey design and methodologies are described in SEDAR33-DW28.

5.3.2.1 Methods of Estimation

Data Filtering Techniques

Censored data sets were used in deriving the indices of relative abundance from video data. Data – both habitat classification and fish counts – from all sites were screened, and those with no evidence that hard or live bottom was in close proximity, as well as sites where the view was obscured for some reason (poor visibility, bad camera angle), were censored (excluded) from indices calculations. As a result of this screening, of video samples from east of the Cape San Blas, only 31 of 41 in 2005, 47 of 89 in 2006, 23 of 57 in 2007, 56 of 66 in 2008, 62 of 97 in 2009, 95 of 109 in 2010, 99 of 115, in 2011, and 100 of 115 in 2012 met the reef and visibility criteria and were retained. Of samples from west of the Cape, 24 of 25 sites in 2006, 29 of 29 in 2007, 29 of 31 in 2008, 42 of 47 in 2009, 52 of 53 in 2010, 57 of 64 in 2011, and 49 of 59 in 2012 were retained for analyses.

Standardization

Delta-lognormal modeling methods were used to estimate relative abundance indices for gag (Lo *et al*. 1992). The main advantage of using this method is allowance for the probability of zero catch (Ortiz *et al.* 2000). The index computed by this method is a mathematical combination of yearly abundance estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive abundance values (i.e. presence/absence) and a lognormal model which describes variability in only the nonzero abundance data (Lo *et al.* 1992).

The submodels of the delta-lognormal model were built using a backward selection procedure based on type 3 analyses with an inclusion level of significance of $\alpha = 0.05$. Binomial submodel performance was evaluated using AIC, while the performance of the lognormal submodel was evaluated based on analyses of residual scatter and QQ plots in addition to AIC.

Submodel Variables

Year: 2005-2012
Depth: 6-49 m
Month: May-October
Region: east of Cape San Blas, west of Cape San Blas (zoogeographic boundary)

Annual Abundance Indices

For a full review of the backward selection procedure for each submodel and diagnostic plots, refer to SEDAR33-DW28.

For the abundance index for gag, year, month, region and depth were retained in the binomial submodel, while only year was retained in the lognormal submodel. The AIC for the binomial and lognormal submodels were 3537.3 and 554.9, respectively. The diagnostic plots for the binomial and lognormal submodels indicated the distribution of the residuals is approximately normal.

5.3.2.2 Sampling Intensity and Time Series

A total of 800 stations were sampled from 2005 to 2012 during the Panama City NMFS lab trap and camera survey (Table 5.7.3. and Figures 5.8.12 and 5.8.13).

5.3.2.3 Size/Age Data

The sizes of gag represented in this index are presented in Figures 5.8.14 – 5.8.15. The ages of gag represented in this index are presented in Figures 5.8.16.

5.3.2.4 Catch Rates

Standardized catch rates are presented in Table 5.7.4 and Figure 5.8.17.

5.3.2.5 Uncertainty and Measures of Precision

Annual CVs of catch rates are presented in Tables 5.7.4.

5.3.2.6 Comments on Adequacy for Assessment

The Panama City NMFS lab trap and camera survey index (SEDAR33-DW28), with an 8 year time series beginning in 2005, was conditionally recommended for inclusion in the stock assessment model for gag. Although there was some concern about its somewhat limited spatial extent, this survey does cover the inner and mid-shelf of the west Florida shelf – an area with a high density of hard bottom habitat and thought to be a major gag nursery area, as well as known to be one of, if not the, most productive fishing grounds for the species. Survey sampling was also quite successful, with annual proportion of positives ranging from 0.26 to 0.52 during 2005-2011, although it dropped to 0.11 in 2012 (Table 5.7.4). This is the only recommended fishery independent index targeting primarily smaller (300-650 mm FL) and younger (ages 1-4), pre-recruit gags on natural reefs (Figures 5.8.14. - 5.8.16). Small sample size was another concern raised by some of the group, but there was no consensus that this was serious enough to justify exclusion from the model. The survey has undergone some geographic and bathymetric expansion over time and a switch from a systematic to stratified random design; however, the model was able to account for these differences with the addition of year, depth and region variables

5.3.3 FWRI Video

There has been a renewed emphasis in recent years to increase the availability of fisheries-independent data on reef fish populations in the Gulf of Mexico that reflect the status of fish populations as a whole, rather than just the portion of the population taken in the fishery. To meet the emerging needs of fisheries-independent data for reef fishes, the Fish and Wildlife Research Institute (FWRI) of the Florida Fish and Wildlife Conservation Commission has been working collaboratively with scientists from the National Marine Fisheries Service (NMFS) to expand regional monitoring capabilities and provide timely fisheries-independent data for a variety of state- and federally-managed reef fishes. One component of these efforts is a reef fish video survey designed to complement ongoing NMFS surveys of reef habitats along the shelf break (NMFS – Pascagoula) and in the northeastern Gulf of Mexico (NMFS – Panama City) by targeting portions of the West Florida Shelf off of Tampa Bay and Charlotte Harbor in depths from 10 – 110 m (Figure 5.8.18). The primary objective of this survey is to provide an index of the relative abundance of reef fishes associated with reef habitats. Types of data collected on the survey include abundance, diversity, fish length, habitat type, habitat coverage, and bottom topography.

To assure adequate spatial coverage of sampling effort, the WFS survey area is subdivided into four sampling zones comprised of two NMFS statistical zones (Tampa Bay: NMFS statistical zone 5; Charlotte Harbor: NMFS statistical zone 4) and two depth zones (Inshore: 10 – 37 m; Offshore: 37 – 110 m). Initiated in 2008, the FWRI video survey has been conducted annually through 2012, although there have been some modifications to the survey design through time. Prior to conducting exploratory sampling in 2008, the WFS survey area was subdivided into 1km x 1km sampling units. Results from 2008 indicated that 1km x 1km spatial scale was too large in relation to the small-scale habitat features characteristic of the WFS; accordingly, from 2009 onward the WFS survey area was subdivided into 0.1nm x 0.3 nm sampling units (E/W by N/S). Overall sampling effort (annual goal of n = 200 sampling units) was proportionally allocated among the four sampling zones based on habitat availability (TBN: Tampa Bay Nearshore; TBO: Tampa Bay Offshore; CHN: Charlotte Harbor Nearshore; CHO: Charlotte Harbor Offshore), and specific sampling units were selected randomly within each sampling zone.

Very little is known regarding the fine-scale distribution of reef habitat throughout much of the WFS, and due to anticipated cost and time requirements, mapping the entire WFS survey area was not feasible prior to initiating the FWRI video survey. For the 2008 video survey, the identification of sampling units with an increased probability of containing reef habitat (and inclusion in the sampling frame for the reef-fish survey) was based on bottom rugosity calculated from 100m-resolution interpolated bathymetry data. An examination of results from the 2008 survey indicated that a high proportion of sampling effort occurred at sites with no reef habitat (i.e., unconsolidated sediment). Accordingly, the sampling universe was updated in 2009 to include habitat information provided by commercial fishermen as well as published literature. Further, we implemented an adaptive strategy where a three-pass acoustic survey was conducted covering an area of 1nm to the east and west of the pre-selected sampling unit prior to sampling.

In 2009 and part of 2010, the acoustic survey was conducted using the research vessel echo sounder, while for part of 2010 and 2011 onward the acoustic survey was conducted using an L3- Klein 3900 side scan sonar. Based on results from these acoustic surveys, sampling effort was randomly relocated to a nearby sampling unit should evidence of reef habitat be identified. At each sampling station, 1-2 stationary underwater camera arrays (SUCAs) were deployed that consisted of a pair of stereo imaging system (SIS) units positioned at an angle of 180º from one another to maximize the total field of view. Each SIS unit consisted of an underwater housing containing a digital camcorder to record video and a pair of stereo cameras to capture still images at a rate of one per second. Each SUCA was baited (generally Atlantic mackerel) and deployed for thirty minutes to assure that twenty minutes of continuous video and stereo images were recorded. All individual gear deployments were spaced a minimum of 100 m apart.

Twenty minutes of video data from one SIS per SUCA deployment were processed to quantify the relative abundance of all fishes observed (MaxN, or the maximum number of gag observed on a single video frame). In addition to data on relative abundance and observed habitat, geographic coordinates, depth, physiochemical conditions (e.g., temperature, salinity, dissolved oxygen, pH), and time of day were recorded at each specific sampling site.

5.3.3.1 Methods of Estimation

Data Filtering Techniques

Data from 2008 – 2012 were included in subsequent analyses. Data were filtered prior to analyses to exclude video deployments that were too turbid to conducting meaningful reads as well as unsuccessful video deployments (i.e., array landed on the side, array that moved during video).

Standardization

Delta-lognormal modeling methods were used to estimate relative abundance indices for gag (Lo *et al*. 1992). The main advantage of using this method is allowance for the probability of zero catch (Ortiz *et al.* 2000). The index computed by this method is a mathematical combination of yearly abundance estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive abundance values (i.e. presence/absence) and a lognormal model which describes variability in only the nonzero abundance data (Lo *et al*. 1992). A backward stepwise selection procedure was employed to develop both sub-models. Type III analyses were used to test each parameter for inclusion or exclusion into the sub-model. Both variable inclusion and exclusion significance level was set as $\alpha = 0.05$, although marginal values were also considered for inclusion; year was retained in all models regardless of significance level.

Submodel Variables

Year: 2008 – 2012
Month: June – September
Depth: Inshore (10 – 37 m) and Offshore (37 – 110 m)
Latitude: North (Tampa Bay) and South (Charlotte Harbor)
Reef Habitat Observed: Y or N

5.3.3.2 Sampling Intensity and Time Series

From 2008 – 2012, a total of 968 SUCA deployments were made at 632 stations on the West Florida Shelf (Table 5.7.5). Due to weather and mechanical issues, annual sampling effort varied from 129 – 237 deployments.

5.3.3.3 Size/Age Data

Lengths of observed fishes are determined through stereo video measurements. However, due to no gag being observed during the early years of the survey and technical issues with calibration files during the recent years of the survey, no size data are currently available. Age data are unavailable.

5.3.3.4 Catch Rates

Standardized catch rates for the FWRI reef fish video survey are presented in Table 5.7.6 and Figure 5.8.19.

5.3.3.5 Uncertainty and Measures of Precision

Annual CVs of catch rates for the FWRI reef fish video survey are presented in Table 5.7.6. A QQ plot of positive MaxN residuals was produced and is presented in Figure 5.8.20.

5.3.3.6 Comments on Adequacy for Assessment

At present, this survey does not constitute a long-enough time series to be useful in the assessment of gag, especially with the absence of gag in 2008 and 2009 as well as the dramatic increase in the proportion of stations sampled that actually contained reef habitat in conjunction with the incorporation of side scan sonar in 2010. However, in time this survey should provide valuable data that can be used in subsequent assessments. In addition to expanding the time series of this data through continued sampling, consideration should be given towards combining data from this survey with data from the NMFS – Panama City survey in developing indices of abundance that are representative of a broader spatial area. Even though these surveys employ similar methods, efforts to construct a single index of abundance would benefit significantly from some spatial overlap for a brief period of time (one to several years) so that results can be appropriately calibrated.

5.3.4 Juvenile Gag and Seagrass

In order to develop abundance indices of age-0 gag grouper in the Gulf of Mexico, three available data bases were combined and subsequently analyzed. Multiple datasets (see SEDAR33-AW06 for full descriptions of datasets used) were combined by first calculating the overall mean catch rate for each data set and scaling the data in each dataset to a mean of one. Due to the presence of two gear-types in the FWRI data, each gear type was considered a separate dataset, resulting in four datasets (FWRI trawl, FWRI seine, PCNMFS trawl and FSU trawl); and a database code was assigned to each dataset in order to model for differences between datasets. Next, sampling locations in each dataset were lumped into the 9 sampling regions as described in Section 1 (Table 1.1 and Figure 1.1). Therefore, while the FSU dataset (Section 1) had nine regions sampled, the NMFS PC Lab St. Andrew Bay survey (Section 2) sampled only that region (i.e. St. Andrew Bay, SAR) and the FWC estuarine (FIM) survey (Section 3) had four regions sampled (i.e. Charlotte Harbor, CHR; Cedar Key, CKR; Mid Big Bend, MBB; and Tampa Bay, TBR).

The weight for each region was based on the seagrass coverage area in each region, between 0 and 6 feet of water depth. This depth range was said to be that in which the majority of juvenile gag are captured (Chris Koenig, personal communication). The area between 0 and 6 feet water depth was estimated in each region using a NOAA bathy model of medium scale (http://www.ngdc.noaa.gov/mgg/coastal/model.html for more details). The seagrass aerial coverage for each region was estimated using a GIS data set based a compilation of statewide seagrass data from various source agencies and scales. The GIS seagrass data were mapped from sources ranging in date from 1987 to 2007. Not all data in this compilation are mapped from photography; some are the results of field measurements. Some used the Florida Land Use Cover and Forms Classification System (FLUCCS) codes 9113 for discontinuous seagrass and 9116 for continuous seagrass; some defined only presence and absence of seagrass, and some defined varying degrees of seagrass percent cover. In order to merge all of these data sources into one compilation data set, FWRI reclassified the various source data attribute schemes into two categories: "continuous" and "discontinuous" seagrass. In areas where studies overlap, the most recent study where a given area has been interpreted is represented in this data set. The seagrass data was cross-referenced with the bathymetry data to estimate the seagrass coverage area in each region, between 0 and 6 feet of water depth (Figure 5.8.21).

5.3.4.1 Methods of Estimation

A delta-lognormal model, as described by Lo et al. (1992) was employed for each index. The GLMMIX and MIXED procedures in SAS were employed to provide yearly index values for both the binomial and lognormal sub-models, respectively. A backward stepwise selection procedure was employed to develop both sub-models. Type 3 analyses were used to test each parameter for inclusion or exclusion into the sub-model. Both variable inclusion and exclusion significance level was set at an $\alpha = 0.05$. The parameters tested for inclusion in each sub-model were categorical variables of year, database code, region code, and season (spring: months 4-5; early summer: months 6-7; late summer: month 8-9; and fall: months 10-11). The fit of each model was evaluated using the fit statistics provided by the GLMMIX macro.

Annual Abundance Indices

For a full review of the backward selection procedure for each submodel and diagnostic plots, refer to SEDAR33-AW06.

For the abundance index for gag, year, season, region code and database code were retained in the binomial and lognormal submodels. The diagnostic plots for the binomial and lognormal submodels indicated the distribution of the residuals is approximately normal.

5.3.4.2 Sampling Intensity and Time Series

After combing the 4 surveys, the time series covered from 1991 – 2012. Due to limited sampling in the early years of the survey, the final index only covers 1994 – 2012. Sampling intensity by area and survey are presented in Table 5.7.7.

5.3.4.3 Size/Age Data

This index describes the abundance of age-0 gag grouper.

5.3.4.4 Catch Rates

Standardized catch rates are presented in Table 5.7.7 and Figure 5.8.22.

5.3.4.5 Uncertainty and Measures of Precision

Annual CVs of catch rates are presented in Tables 5.7.7.

5.3.4.6 Comments on Adequacy for Assessment

During the workshop and subsequent webinars, much of the discussion centered on which version of the index should be utilized, weighted or unweighted. It is the recommendation of the

IWG that the unweighted index spanning 1994-2012 would be the most appropriate. This is a deviation from the previous recommendation of using an index weighted by seagrass area. The final decision to use the unweighted index centered on the apparent better model fit when compared to the weighted index from the same time span. In addition, this time series was the only one to address age 0 gag.

5.3.5 UF Reef Survey

Fisheries-independent annual indices of gag abundance for 2001 through 2012 were developed by an approach that controls effects of intrinsic habitat quality at sampling sites. The theory and implications for fisheries population modeling derive from MacCall's Basin Model (1990). The applicability to gag was established by Lindberg et al. (2006) through experiments confirming density-dependent habitat selection (DDHS), i.e. the ecological process driving population patterns in MacCall's model. Replicate fixed sampling sites of standardized habitat units (SHUs) were sampled once each summer (June-September) by the same skilled science divers using a standardized underwater visual census (UVC). The study system along the 13m depth contour offshore from Levy and Dixie Counties, Florida (Figure 5.8.23), and the UVC protocol, were the same as described by Lindberg et al. (2006). Except for this index, the SHUs built in 1991-1993 were well past their initial colonization period and subject to public fishing since 1996. Also, UVCs were done by divers on open-circuit SCUBA prior to 2007 and by divers on closed-circuit rebreathers since 2007. Experimental comparison of UVCs on open-circuit SCUBA versus closed-circuit rebreathers showed no significant difference between gag counts (Lindberg and Marcinek 2007). The UVC counted gag in 10 cm size classes ranging from <20 cm TL to >89cm TL. The recorded data also included SHU type (i.e., size and spacing) and location, date, time, horizontal visibility, water temperature and counts of other grouper species present (e.g. red grouper and Goliath). Given experiments reported by Lindberg et al. (2006), the SHUs used for this particular index are known to be replicates of the same, intermediate, intrinsic habitat quality. The dataset for this index is comprised of annual gag counts from 24 replicate SHUs, in 4 hexagonal arrays of 6 SHUs spaced at 225m, with no outliers, removals or exclusions. Each SHU was sampled once per year, except in 2012 when low visibility precluded UVCs for just one array. For analyses of abundance, gag counts were summed across size classes for total counts per SHU per sampling interval. Because the UVC protocol was standardized throughout this study, the total counts are the same as CPUE values.

5.3.5.1 Methods of Estimation

Data Filtering Techniques

The entire dataset includes data collected on standardized habitat units (SHUs) located in either the Suwannee Regional Reef System (SRRS) or the Steinhatchee Fisheries Management Area (SFMA). The SRRS system had widely dispersed 4-cube and 16-cube SHUs while the offshore SFMA had only 4-cube SHUs also widely dispersed. The decision was made to use only data from the 4-cube SRRS arrays ("SRRS-low") as they had a sufficiently long time series and the observed trend was confirmed by the SFMA reefs further offshore. The data from the SFMA reefs were not used as there was not a sufficiently long time period for use as an index.

Standardization

A generalized linear mixed model with a fixed categorical effect of year with random effects for the clustering of SHUs within each array [array(year)] and sampling the same arrays each year [array] was fitted to the number of fish observed by a diver. The response variable, the number of fish observed by the diver, was modeled as being distributed as a negative binomial random variable. The random effects were tested and found to be statistically significantly large than 0 (Chi-square test for H_0: No G-side Effects, $\chi_2^2 = 34.73$, p-value < 0.0001).

Annual Abundance Indices

The annual abundance indices are the back-transformed marginal means for each year (Table 5.7.8, Figures 5.8.24 and 5.8.25). The standard errors of the back-transformed values were calculated using the delta method. The –2*Log Likelihood value given the random effects was 1829.49 and the overdispersion estimate given the random effects was 0.95, indicating a reasonable fit (Table 5.7.9).

5.3.5.2 Sampling Intensity and Time Series

Table 3 gives the number of reef arrays and standardized habitat units (SHUs) sampled annually from 2001 through 2012, along with the total number of gag counted annually and their annual size distributions.

5.3.5.3 Size/Age Data

The distribution of gag length (TL) by year and length bins are given in Table 5.7.10.

5.3.5.4 Catch Rates

Linear estimates, back-transformed means, and standardized catch rates are given in Table 5.7.8. Estimated annual abundances are shown in Figures 5.8.24 and 5.8.25.

5.3.5.5 Uncertainty and Measures of Precision

Three distributions for the response variable were considered: Poisson, generalized Poisson[1], and the Negative Binomial. Earlier analysis (see SEDAR 33 DW-03 report) using the Log(Y+1) transformation was found to be inadequate for analyzing the subset of data considered for the index (SRRS-low, 2001 – 2012). The back-transformed values tended to be biased high for large means and biased low for small means even when adjusted for bias using Bradu and Mundlak's approach for lognormally distributed random variables (Bradu & Mundlak, 1970).

For comparing distributional fits, we used the Laplace method for estimating model parameters. This method provides some diagnostic statistics, namely the –2*Log Likelihood value and the

[1] The generalized Poisson has mean $\mu = \frac{\alpha}{1-\xi}$ and variance $\sigma^2 = \frac{\alpha}{(1-\xi)^3} = \frac{\mu}{(1-\xi)^2}$ where ξ is the scale parameter that allows for more dispersion than expected under the usual Poisson distribution.

Pearson χ^2/df measure of overdispersion for the conditional distributions (Table 5.7.9). Based on the results of the fit statistics, one is inclined to decide that the generalized Poisson distribution is best among the three distributions reviewed. This is not the best model though when the back-transformed predicted means are compared to the sample means (Figure 5.8.26). The behavior of the predicted values is similar to what was observed for the log(Y+1) transformation. The predictions (both the marginal means and means based on the EBLUPS) for large means are overestimates whereas the predictions for years with small means are underestimates.

A Pearson residual panel is shown in Figure 5.8.27. In addition to the diagnostics and means comparisons, we reviewed the QQ plots of the quantiles of the model residuals against the expected quantiles for two of the models, namely the Poisson and Negative Binomial random variables (Garcia Ben and Yohai, 2004; Augustin, et al. 2012), to look for systematic departures from the assumed distribution. The QQplot for the Poisson showed that the residuals were skewed and more variable than expected for the assumed Poisson distribution; the QQ plot for the Negative Binomial indicated no departures from the assumed distribution (Figure 5.8.28).

Standard errors, 95% confidence interval endpoints and CVs based on the negative binomial mixed model are given in Table 1. Estimated annual abundances with 95% confidence interval bars are displayed in Figure 3.

5.3.5.6 Comments on Adequacy for Assessment

The final decision of the IWG was to not recommend the UF reef index for use in the stock assessment model. This survey appears to capture the same size range of gag as the Panama City video survey. The assessment model estimates selectivity parameters associated with each index. Given the overlap in size-class information and in an effort to develop the most parsimonious model, this index was not recommended for use. In addition, the spatial range is more limited than the Panama City video. However, this survey does have a longer time series, but it was determined that spatial coverage was more important than temporal coverage.

5.3.6 Other Fishery Independent Datasets

5.3.6.1 SEAMAP Groundfish Survey

Groundfish surveys have been conducted in the fall (October – November) since 1972 covering an area between 88° to 91°30’. In 1982, a second trawl survey began under Southeast Area Monitoring and Assessment Program (SEAMAP) during the summer (June – July). In 1987, the SEAMAP design was adopted for the fall survey. Under SEAMAP, sampling covered an area between Brownville, TX and Mobile Bay, AL. In 2008, the sampling area was expanded eastward to cover an area to the Florida Keys, thus fully covering the northern GOM. A full review of survey methodologies and descriptions of the datasets have been presented in detail by Nichols (2004) and Pollack and Ingram (2010).

A total of 18,596 successful trawl stations have been completed during the SEAMAP groundfish survey. Catch rates of gag grouper presented in Table 5.7.11. Over the course of the survey, there have been only 36 stations with gag present, most of which are located off the Florida coast, which would explain why they are not overly abundant in the early years of the survey. Gag grouper ranged in size from 228 to 658 mm, with the majority measuring less than 500 mm. Gag grouper do not occur at a high enough frequency for abundance indices to be produced for this stock assessment.

5.3.6.2 SEAMAP Ichthyoplankton Survey

The Southeast Area Monitoring and Assessment Program has supported collection and analysis of ichthyoplankton samples in the northern GOM since 1982. There were three main time series that were available for analysis: Spring Ichthyoplankton Survey (April - May, continental shelf edge to deep GOM waters), Summer Ichthyoplankton Survey (May – July, coast to continental shelf edge) and Fall Ichthyoplankton Survey (August – October, coast to continental shelf edge) (Figure 13). A full review of the survey methodologies were presented by Lyczkowski-Shultz and Hanisko (2004). Currently in the dataset, there are 582 individuals identified as *Epinephelinae*. However, at this time there is no way, outside of genetic analysis, to positively identify either gag grouper. Therefore, no abundance indices were produced for this stock assessment.

5.3.6.3 NMFS Small Pelagics Survey

Two surveys conducted by MSLABS can fall under the Small Pelagics Survey designation. The first survey was conducted between 1988 and 1996 and was previously analyzed for greater amberjack by Ingram (2005) and presented during SEDAR 9. The second Small Pelagics Survey was conducted between 2002 and 2012. A full description of the survey methodology is presented by Ingram (2008). In the second survey, occurrences of gag grouper were very low (0.21%) (Table 5.7.12). Due to the low frequencies of occurrence for gag grouper no abundance indices were produced for this stock assessment.

5.3.6.4 NMFS Bottom Longline Survey

Standardized bottom longline surveys have been conducted by MSLABS since 1995. The bottom longline survey has evolved over time to encompass the entire northern GOM, covering depths from 9 to 366 m. A full description of the evolution of the survey and survey methodologies was presented by Ingram *et al.* (2005). A total of 2760 stations have been sampled (Table 5.7.13). Gag grouper do not occur at a high enough frequency (1.12%) for abundance indices to be produced for this stock assessment.

5.4 Fishery Dependent Indices

5.4.1 Commercial Longline

Commercial vessels operating in the U. S. Gulf of Mexico have been monitored by the NMFS Gulf of Mexico Reef Fish Logbook Program since 1990. Catch and effort data from commercial longline trips occurring within the Gulf of Mexico were used to develop standardized catch rate indices for gag grouper. The NMFS Gulf of Mexico Reef Fish Logbook Program collects catch and effort data by trip for permitted vessels that participate in fisheries managed by the Gulf of

Mexico and South Atlantic Fishery Management Councils. The program began in 1990 with a complete census of commercial reef fish trips by vessels permitted in TX, LA, MS and AL. A 20% sample of vessels permitted in FL was required until 1993, when all permitted reef fish vessels were required to submit logs. Two indices were constructed. The first considered the entire time series (1990-2012) and the second was constructed for the pre-IFQ period (1990-2009). The various size limits were not considered since Stock Synthesis (the model that will be used to assess gag grouper) can account for changes in size limits directly (i.e. by re-estimating the retention functions).

5.4.1.1 Methods of Estimation

Data Filtering Techniques

The logbook data base includes unique trip and vessel identifiers and information regarding trip date, gear class, fishing area (identical to shrimp statistical grid; Figure 5.8.29), days at sea, fishing effort, species caught and landed weight. A vessel may fish in multiple areas using multiple gears on a single trip. However, while catch is reported by gear and area, effort is not. Instead total effort by gear is reported for each trip. Therefore it is not possible to calculate the catch per unit effort by area on trips that fished in more than one area. For this reason, trips that fished in multiple areas were excluded from the analysis. For similar reasons, trips that fished with multiple gears were also excluded from the analysis.

Closures occurred as described below:

1990: Closed 11/7 – 12/31
1999 - 2003: Closed 2/15 – 3/15
2004: Closed 2/15 – 3/15, Closed 11/15 – 12/31
2005: Closed 2/15 – 3/15. Closed 10/10 – 12/31
2006-2009: Closed 2/15 – 3/15

The dataset was restricted to those time periods for which fishing on gag grouper was allowed in every year (i.e. Jan – Feb 14 and March 16 – October 10). In addition, data were restricted to those longline trips occurring within the U.S Gulf of Mexico areas 1 to 10 (Figure 5.8.29). On average, >95% of the total annual landings of gag grouper occurred in these areas.

Trips that contained obviously erroneous logbook data were also excluded. These exclusions are summarized below.

1) NUMGEAR (sets) missing or equal to 0
2) EFFORT (hooks per set) missing or equal to 0
3) EFFORT < 50 or >4000
4) LENGTH (of longline) < 1 mile or > 20 miles
5) AREA missing or equal to 0
6) Sets/Day > 24
7) Trips with long delays in reporting (i.e. >45 days)

8) Trips that reported before the date of fishing

Species Misidentification

There is concern that gag grouper is often misidentified as black grouper, particularly in South Florida and the Keys. To examine this problem, NOAA Trip Interview Program (TIP) observations of commercial longline landings were examined. TIP species identifications are made by trained scientific observers. Therefore, the species identifications may be more reliable than those reported in the Reef Fish Logbook dataset. The proportion of gag and black groupers landed by commercial longliners that were identified as gag grouper by TIP scientific samplers is summarized by area in Table 5.7.14 These proportions were used to adjust the landings of gag grouper per trip in an attempt to account for gag grouper misidentified as "black grouper" in the logbook dataset using Equation 1:

$$Gag'(lbs) = \left[Gag(lbs) + Black(lbs)\right] * propGag \qquad \text{(Eq. 1)}$$

where *Gag′* is the adjusted weight of gag landed on a trip, *Gag* and *Black* are the weight of gag and black groupers landed on a trip, and *propGag* is the proportion of gag + black groupers that were identified as gag grouper by the TIP observers, by area *a*.

Standardization

A delta-lognormal approach (Lo et al. 1992) was used to develop the standardized catch rate indices. This method combines separate generalized linear modeling (GLM) analyses of the proportion positive trips (trips that caught gag grouper) and the catch rates of successful trips to construct a single standardized index of abundance. Parameterization of each model was accomplished using a GLM procedure (GENMOD; Version 8.02 of the SAS System for Windows © 2000. SAS Institute Inc. Cary, NC, USA). For the lognormal models, the response variable, ln(CPUE), was calculated:

$$\ln(CPUE) = \ln\left[\frac{Gag'(lbs)}{\left(sets * \frac{hooks}{set}\right)}\right] \qquad \text{(Eq. 2)}$$

where Gag′ is the adjusted weight of gag grouper landed per trip (see Eq. 1). Note that the effort variable is "hooks" rather than "hooks/angler hour". This is due to a change in the logbook form that caused confusion in this variable for longline trips. Many anglers record "total hours fished per trip", but a significant portion report "average hours fished per set". Although some errors can be corrected using deductive reasoning, many cannot. Therefore, rather than deleting these trips, the response variable "hooks" was adopted.

A forward stepwise regression procedure was used to determine the set of fixed factors and interaction terms that explained a significant portion of the observed variability. For both the binomial and lognormal portions of the delta-lognormal model, deviance tables were constructed to determine the proportion of total variance explained by the addition of each factor or interaction term. In addition, a $\chi 2$ analysis was performed to test the significance of the reduction in deviance between each consecutive set of nested models (McCullagh and Nelder 1989). Factors and interaction terms were selected for final analysis if: 1) the relative percent of deviance explained by adding the factor exceeded 1% , 2) the $\chi 2$ test was significant and 3) the Type-III test was significant for the specified model.

Once a set of fixed factors was identified, the influence of the YEAR*FACTOR interactions were examined. As per the recommendation of the statistics and methods working group of the SCRS (1999), YEAR*FACTOR interaction terms were included in the model as random effects. Selection of the final mixed model was based on the Akaike's Information Criterion (AIC), Schwarz's Bayesian Criterion (BIC), and a chi-square test of the difference between the –2 log likelihood statistics between successive model formulations (Littell et al. 1996). The final delta-lognormal model was fit using the SAS macro GLIMMIX and the SAS procedure PROC MIXED (SAS Institute Inc. 1997) following the procedures described by Lo et al. (1992).

Submodel Variables (Entire Time Series 1990-2012)

Year: 1990-2012
Season: Winter (Jan-Feb), Spring (Mar-May), Summer (June-Aug), Autumn (Sept-Oct)
Area: 1&2, 3, 4, 5, 6, 7, 8, 9&10

Submodel Variables (Pre-IFQ 1990-2012)

Year: 1990-2009
Season: Winter (Jan-Feb), Spring (Mar-May), Summer (June-Aug), Autumn (Sept-Oct)
Area: 1&2, 3, 4, 5, 6, 7, 8, 9&10

Annual Abundance Index

The development of the first abundance index for the entire time series (1990-2012) is summarized in Tables 5.7.15 to 5.7.17 (Index 1 – 1990 to 2012). The nominal CPUE, number of observations, proportion positive trips, standardized CPUE and coefficient of variations can be found in Table 5.7.18.

The development of the second abundance index developed for the pre-IFQ period (1990-2009) is summarized in Tables 5.7.19 to 5.7.21 (Index 2 – 1990 to 2009). The nominal CPUE, number of observations, proportion positive trips, standardized CPUE and coefficient of variations can be found in Table 5.7.22.

Diagnostic plots for both indices were presented by the author, and evaluated by the DW working group. They were determined to be adequate. They are described in detail in working document SEDAR 33-AW16.

5.4.1.2 Sampling Intensity and Time Series

Tables of sample sizes across strata can be found in working document SEDAR 33-AW16.

5.4.1.3 Size/Age Data

No size/age data is available.

5.4.1.4 Catch Rates

Standardized catch rates are presented in Tables 5.7.18 (Index 1: 1990-2012) and 5.7.22 (Index 2: 1990-2009) and Figures 5.8.30 (Index 1: 1990-2012) and 5.8.31 (Index 2: 1990-2009).

5.4.1.5 Uncertainty and Measures of Precision

Annual CVs of catch rates are presented in Tables 5.7.18 (Index 1: 1990-2012) and 5.7.22 (Index 2: 1990-2009) and Figures 5.8.30 (Index 1: 1990-2012) and 5.8.31 (Index 2: 1990-2009).

5.4.1.6 Comments on Adequacy for Assessment

The working group recommended the use of the delta-lognormal modeling approach to standardizing CPUE using Reef Fish Logbook data from the commercial longline fishery operating in the Gulf of Mexico. Specifically, the working recommended the use of the Pre-IFQ (Individual Fishing Quotas) index (Index 2: 1990-2009). The index was recommended because:

1) The diagnostics were evaluated and deemed adequate
2) The time series is relatively long
3) The index covers a large fraction of the area where the commercial longline fishery (for shallow water groupers) operates.
4) 100s of (included) trips were reported each year and the proportion of positive trips exceeds 50% each year.
5) The index provides relative catch rate information for the commercial longline fishery.
6) No similar fishery-independent index exists.

The working group did not recommend the use of the index developed across the entire time series (Index 1: 1990-2012) because changes in fishing behavior due the introduction of IFQs could not be accounted for (i.e. changes in abundance after 2009 could not be distinguished from changes in fishing behavior in response to IFQs).

There were several changes in fishing regulations that could influence the catch rates of commercial longline trips (e.g. trip limits, size limits and closures). The index was not modified to account for changes in the size limit since these can be accounted for directly within Stock Synthesis (i.e. by re-estimating retention functions). The index accounted for fishing closures as follows: the trips used to develop the index were restricted to time and places that were open to fishing throughout the time series. The working group also examined the impact of trip limits, and determined that they could be ignored during the construction of the index because no included trips met or exceeded the trip limit during the time series. Therefore, fishing behavior was unlikely to be affected by the trip limits since they were not met or exceeded.

5.4.2 Commercial Handline

See section 5.4.1 for a description of the U.S. Gulf of Mexico's Reef fish Logbook Program.

5.4.2.1 Methods of Estimation

Data filtering

The data were evaluated to determine trips that were atypical and these trips were removed from the analysis. Trips that fell outside the 99th percentile for the number of hooks per line, number of lines fished, number of days at sea, and the number of crew members were considered to represent mis-reported data or data entry errors. Gag grouper handline trips included in this analysis were characterized by:

1. The number of hooks fished per line $\leq$ 35,
2. The number of lines fished $\leq$ 8,
3. The number of days at sea $\leq$ 12, and
4. The number of crew members $\leq$ 6.

Several fishing regulations may have influence the catch rates of the commercial handline trips and were investigated. Size limits have changed over time and historically separate indices have been developed to reflect these changes. A continuous index was developed since changes in stock size can be accounted for directly within Stock Synthesis. Fishery closures were accounted for by restricting the analysis to include only those months when the fishery was open in a given year. Trip catch limits were in place from 2005 through 2009. The number of trips capturing the trip limit was minimal, 20 trips between 2005 and 2009. These trips were retained in the database for this analysis as it was thought that changes in fishing behavior due to trip limits were unlikely.

Quota management commenced, in 2010, for the gag grouper fishery. This type of management can lead to changes in fishing behavior (e.g., avoidance of capture) that can greatly influence CPUE. Catch and effort data from 2010-2012 were excluded from this analysis.

The data were spatially restricted to areas 1 –11. These areas accounted for approximately 99% of the handline trips that caught gag grouper and 97% of the gag grouper landings during the years 1990-2009. These statistics support restricting the analyses to data reported from these areas.

Index standardization

Delta-lognormal modeling methods were used to estimate relative abundance indices for gag grouper (Lo *et al*. 1992). The main advantage of using this method is allowance for the probability of zero catch (Ortiz *et al.* 2000). The delta-lognormal modeling approach combines separate generalized linear model (GLM) analyses of the proportion of successful trips (trips that landed gag grouper) and the catch rates on successful trips to construct a single standardized CPUE index (Lo et al. 1992, Hinton and Maunder 2004, Maunder and Punt 2004).

Parameterization of each model was accomplished using a stepwise approach and Akaike's information criteria (AIC). For each GLM procedure of proportion positive trips, a type-3 model assuming a binomial error distribution was assumed and the logit link was selected. The response variable was the proportion of successful trips across strata. For the analysis of the catch rates on successful trips, a type-3 model assuming lognormal error distribution was examined.

A stepwise approach was used to quantify the relative importance of the explanatory factors. The AIC, deviance, and degrees of freedom were calculated for each iteration and compared to determine the most parsimonious model and identify the explanatory variables that explained the greatest amount of variation in the data.

Submodel Variables

Year: 1990-2009
Area: Gulf of Mexico shrimp grids 1-11
Days at Sea: 1-12 days at sea
Number of Crew Members: 1, 2, 3, 4+
Hook Hours: 54-900+ (binning increments = 54 hours)

5.4.2.2 Sampling Intensity and Time Series

Table 5.7.23 summarizes the total number of trips reported, the number of trips reporting the capture of gag grouper, the proportion of trips reporting the capture of gag grouper from the HBS.

5.4.2.3 Size/Age Data

No size/age data is available.

5.4.2.4 Catch Rates

Handline catch rate was calculated in weight of fish per hook-hour. Hook hours were calculated as product of the number of lines fished, the number of hooks per line, and the total hours fished.

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

$$PPT = \mu + \alpha_1(\text{Area}) + \alpha_2(\text{Days}) + \alpha_3(\text{Year}) + \varepsilon$$

$$\text{Ln CPUE} = \mu + \alpha_1(\text{Area}) + \alpha_2(\text{Year}) + \alpha_3(\text{Crew}) + \alpha_4(\text{Area*Year}) + \alpha_5(\text{Area*Crew}) + \varepsilon$$

The final deviance tables for the binomial and lognormal models are provided in SEDAR-AW08.

Table. 5.7.24 summarizes the relative standardized index and the corresponding confidence intervals and coefficient of variation, and the relative nominal index. Figure 5.8.32 shows the relative standardized index and the corresponding confidence intervals and the relative nominal index.

5.4.2.5 Uncertainty and Measures of Precision

Annual CVs of catch rates for the eastern Gulf of Mexico are presented in Table 5.7.24. Plots of the binomial residuals and QQ plots of lognormal residuals were produced and are presented in SEDAR 33-AW08.

5.4.2.6 Comments on Adequacy for Assessment

The commercial handline relative index of abundance was recommended for use in the gag grouper stock assessment by the SEDAR 33 Index Working group. This index was recommended because it represents a complete census of the fishing trips, it is a continuous time series of the non-IFQ years, and covers a broad geographical area.

5.4.3 MRFSS

The Marine Recreational Fishery Statistics Survey (MRFSS), conducted by NOAA Fisheries (NMFS), collects information on shore based, charterboat, and private/rental boat angler fishing. MRFSS provides information on participation, effort, and species-specific catch. Data are collected to provide catch and effort estimates in two-month periods ("waves") for each recreational fishing mode (shore fishing, private/rental boat, charterboat, or headboat/charterboat combined) and for each area of fishing (inshore, state Territorial Seas, U.S. Exclusive Economic Zone), in each Gulf of Mexico state (except Texas). Total catch information is collected by MRFSS on fish landed whole and observed by interviewers ("Type A"), fish reported as killed by the fishers ("Type B1") and fish reported as released alive by the fishers ("Type B2").

5.4.3.1 Methods of Estimation

An index of abundance was developed for eastern Gulf of Mexico gag grouper using the MRFSS data. The index spanned 1986-2010. The CPUE was calculated on an individual group basis and was equal to the number of fish caught divided by the effort, where effort was the product of the number of anglers in the group that was interviewed and the total hours fished.

Data filtering

The MRFSS dataset was looked at across different strata to assess the sample size of total interviews and successful interviews (interviews that reported having caught greater amberjack) within each of the strata. Data from Texas, present in the years 1981 through 1985, were removed from the MRFSS data because the State of Texas conducts its own survey. In addition, data from the headboat mode in MRFSS, also present in the years 1981 through 1985, were removed because this information is covered by the Headboat Survey program conducted by NMFS. Data were limited to interviews that reported using hook and line since these represented over 98% of all inshore, private, and charter interviews in the Gulf of Mexico. Data prior to 1986 were excluded due to an extremely low number of interviews resulting in missing data for multiple strata.

Approximately, 98% of the interviews that were observed with gag catch or reported the capture and release of gag grouper were in FL. All states, except FL, were removed from the database for this analysis; therefore the MRFSS index developed for gag grouper is an FL-only index. Florida was separated into three regions: 1) SW FL (Collier – Pinellas), 2) NW FL (Pasco – Franklin), 3) FL Panhandle.

Index standardization

Delta-lognormal modeling methods were used to estimate relative abundance indices for gag grouper (Lo *et al*. 1992). The main advantage of using this method is allowance for the probability of zero catch (Ortiz *et al.* 2000). The delta-lognormal modeling approach combines separate generalized linear model (GLM) analyses of the proportion of successful trips (trips that landed gag grouper) and the catch rates on successful trips to construct a single standardized CPUE index (Lo et al. 1992, Hinton and Maunder 2004, Maunder and Punt 2004). Parameterization of each model was accomplished using a stepwise approach and Akaike's information criteria (AIC). For each GLM procedure of proportion positive trips, a type-3 model assuming a binomial error distribution was assumed and the logit link was selected. The response variable was the proportion of successful trips across strata. For the analysis of the catch rates on successful trips, a type-3 model assuming lognormal error distribution was examined.

A stepwise approach was used to quantify the relative importance of the explanatory factors. The AIC, deviance, and degrees of freedom were calculated for each iteration and compared to determine the most parsimonious model and identify the explanatory variables that explained the greatest amount of variation in the data.

Submodel Variables

Year: 1986-2010
Mode: Inshore, Private, Charter
Region: SW FL, NW FL, Panhandle
Month: Dec-Jan, Feb-Mar, Apr-May, Jun-Jul, Aug-Sep, Oct-Nov
Season: Open, Closed (see management history)
Hours: 2 hour bins and a plus group (bins: 2, 4, 6, 8, 9+)

5.4.3.2 Sampling Intensity and Time Series

Table 5.7.25 summarizes the total number of trips reported, the number of trips reporting the capture of gag grouper, the proportion of trips reporting the capture of gag grouper from the HBS.

5.4.3.3 Size/Age Data

No size/age data is available.

5.4.3.4 Catch Rates

The CPUE was calculated on an individual group basis and was equal to the number of fish caught divided by the effort, where effort was the product of the number of anglers in the group that was interviewed and the total hours fished.

The following models resulted from the standardization procedures (see SEDAR 33- AW10 for final deviance tables) where PPT is a binomial indicating the proportion of interviews with observed gag grouper catch or reported the capture of gag grouper, α represents the parameter estimate of each factor, μ represents the mean, and ε represents the error term.

$$\text{Ln CPUE} = \mu + \alpha 1\text{Mode} + \alpha 2\text{ Year} + \varepsilon$$
$$\text{PPT} = \mu + \alpha 1\text{Mode} + \alpha 2\text{ Year} + \alpha 3\text{ Hours fished} + \varepsilon$$

Table. 5.7.26 summarizes the relative standardized index and the corresponding confidence intervals and coefficient of variation, and the relative nominal index. Figure 5.8.33 shows the relative standardized index and the corresponding confidence intervals and the relative nominal index.

5.4.3.5 Uncertainty and Measures of Precision

Annual CVs of catch rates for the eastern Gulf of Mexico are presented in Table 5.7.26. Plots of the binomial residuals and QQ plots of lognormal residuals were produced and are presented in SEDAR 33-AW10.

5.4.3.6 Comments on Adequacy for Assessment

The MRFSS relative index of abundance was recommended for use in the gag grouper stock assessment by the SEDAR 33 Index Working group. This index was recommended because it represents the longest time-series for the inshore, charter boat, and private boat recreational fisheries and had adequate spatial coverage. MRFSS is also the only fishery-dependent index that includes discard information.

5.4.4 Headboat Survey

Recreational catch and effort statistics are surveyed by several programs, one of which is the Headboat Survey (HBS) conducted by the National Marine Fisheries Service's Southeast Fisheries Science Center, Beaufort, NC. HBS has monitored hook and line catch and effort from party (head) boats in the Gulf of Mexico since 1986. Reported information includes landing date and location, vessel identification, the number of anglers, fishing location, trip duration and/or type (half/three-quarter/full/multi-day, day/night, morning/afternoon), and catch by species in number and weight.

5.4.4.1 Methods of Estimation

An index of abundance was developed for Gulf of Mexico gag grouper using the HBS data. The index spanned 1986-2010.

Catch rate was calculated as the number of gag grouper landed per angler hour. A half-day fishing trip was assumed to be 5 hours, a three-quarter day trip was assumed to be seven hours, and a full-day trip was assumed to be 10 hours. A fishing day was assumed to be 12 hours for multi-day trips. Many individuals fish aboard headboats; therefore, total angler hours per trip was calculated as the product of the number of fishers and the assumed hours fished.

Data filtering

The majority of 2011 and the majority of 2012 were closed to fishing and were therefore excluded from the analysis.

The data were aggregated into two larger areas, eastern and western Gulf of Mexico due to a lack of observations associated with areas in some years. The eastern Gulf of Mexico was defined by Florida and Alabama and the western Gulf of Mexico was defined by Mississippi, Louisiana, and Texas. Approximately 98% of trips catching gag grouper were in the eastern Gulf of Mexico; therefore, the index was developed for only the eastern Gulf of Mexico.

Fishing behavior was assumed to have been altered by the implementation of opened and closed seasons (see SEDAR33-RD06 for the management history of gag grouper). Trips capturing gag grouper during the closed fishing seasons between 2005 and 2010 were removed from this analysis.

Headboat trips can target any number of species on any given trip; therefore, species targeting is generally unknown. The Stephens-MacCall (2004) approach was used to identify trips that targeted gag grouper. This approach uses the species composition of each trip in a logistic regression of species presence/absence to infer if effort on that trip occurred in similar habitat to gag grouper habitat. If effort on a trip was determined to occur in similar habitat to gag grouper, then that trip was used in the analysis (Stephens and MacCall 2004).

Index standardization

Delta-lognormal modeling methods were used to estimate relative abundance indices for gag grouper (Lo *et al*. 1992). The main advantage of using this method is allowance for the probability of zero catch (Ortiz *et al.* 2000). The delta-lognormal modeling approach combines separate generalized linear model (GLM) analyses of the proportion of successful trips (trips that landed gag grouper) and the catch rates on successful trips to construct a single standardized CPUE index (Lo et al. 1992, Hinton and Maunder 2004, Maunder and Punt 2004). Parameterization of each model was accomplished using a stepwise approach and Akaike's information criteria (AIC). For each GLM procedure of proportion positive trips, a type-3 model assuming a binomial error distribution was assumed and the logit link was selected. The response variable was the proportion of successful trips across strata. For the analysis of the catch rates on successful trips, a type-3 model assuming lognormal error distribution was examined.

A stepwise approach was used to quantify the relative importance of the explanatory factors. The AIC, deviance, and degrees of freedom were calculated for each iteration and compared to determine the most parsimonious model and identify the explanatory variables that explained the greatest amount of variation in the data.

Submodel Variables

Year: 1986-2010
Season: Nov-Jan, Feb-Apr, May-July, Aug-Oct
Length of Day: Half-day, Three-qtr day, Full-day, Multi-day
Anglers: 10, 20, 30, 40, 50, 60, 70+

5.4.4.2 Sampling Intensity and Time Series

Table 5.7.27 summarizes the total number of trips reported, the number of trips reporting the capture of gag grouper, the proportion of trips reporting the capture of gag grouper from the HBS.

5.4.4.3 Size/Age Data

Recreational size limits for gag grouper have been in place since the beginning of the available headboat time series. The size limit was 20 inches total length (TL) until 1999 when the size limit changed to 22 inches TL. It is assumed that the size range of gag grouper targeted by headboats is comprised of legal sized fish.

5.4.4.4 Catch Rates

The CPUE, catch per unit effort, was calculated on an individual trip basis and was equal to the number of fish landed on a given trip divided by the effort, where effort was the product of the number of anglers and the total hours fished.

The following models resulted from the standardization procedures (see SEDAR 33-AW09 for final deviance tables) where *PPT* is a binomial indicating the proportion of trips capturing gag grouper, α represents the parameter estimate of each factor, μ represents the mean, and ε represents the error term.

$$\text{Ln CPUE} = \mu + \alpha 1 \text{Year} + \alpha 2 \text{ Season} + \varepsilon$$
$$\text{PPT} = \mu + \alpha 1 \text{Length\_day} + \alpha 2 \text{ Season} + \alpha 3 \text{ Year} + \varepsilon$$

Table. 5.7.28 summarizes the relative standardized index and the corresponding confidence intervals and coefficient of variation, and the relative nominal index. Figure 5.8.34 shows the relative standardized index and the corresponding confidence intervals and the relative nominal index.

5.4.4.5 Uncertainty and Measures of Precision

Annual CVs of catch rates for the eastern Gulf of Mexico are presented in Table 5.7.28. Plots of the binomial residuals and QQ plots of lognormal residuals were produced and are presented in SEDAR 33-AW09.

5.4.4.6 Comments on Adequacy for Assessment

The headboat relative index of abundance was recommended for use in the gag grouper stock assessment by the SEDAR 33 Index Working group. This index was recommended because it represents the longest time-series for the headboat fishery and had adequate spatial coverage.

5.4.5 Reef Fish BLL Observer

Catch rate series were developed for gag grouper and greater amberjack from a combined data set based on observer programs from the NMFS Panama City and Galveston Laboratories. On-board observers in the Reef fish Longline Fishery collected data from 2006-2012. For analysis, the data was subjected to a Generalized Linear Model (GLM) standardization technique that treats separately the proportion of sets with positive catches (i.e., where at least one fish was caught) assuming a binomial error distribution with a logit link function, and the catch rates of sets with positive catches assuming a lognormal error distribution with a log link function. Several categorical variables were constructed that were assumed to influence the probability and rate of capture. For the final gag grouper model, year and set depth were significant as the main effect in the binomial model and year, hook type and season in the lognormal model. The relative abundance index showed a general flat trend in abundance from 2006 to 2009 but increased thereafter to 2012. For greater amberjack, year, set depth, set begin and season were significant as the main effect in the binomial model and year and hook type in the lognormal model. The relative abundance index for greater amberjack was generally stable throughout the time series.

5.4.5.1 Comments on Adequacy for Assessment

The final recommendation of the IWG is to not recommend this index for use in the stock assessment model. One issue is that this index covers the same set of data as the commercial longline and although this set contains a more accurate description of effort, it is a much shorter time series. In addition, with the exclusion of the IFQ years (2010 to present), which is known to have changed fisher’s behavior, the time series is shortened even further to 5 years.

5.5. Research Recommendations made by Members of the IWG

- Expand the use of molecular genetics to identify the grouper larvae in SEAMAP samples that cannot be positively identified as gag grouper because diagnostic morphological characters are not yet developed.

- The IWG made note that the delta-lognormal index may not be the most appropriate distribution with some of the data presented. However, the lack of adequate diagnostics for different distributions prelude their use. The recommendation is that addition work be done with these other distribution (i.e. Poisson, negative binomial) in order to fully vet the methodology.

- A calibration study is needed between the FWRI/NMFS video survey and the UF diver survey (UVC). The standardized reef systems reported in SEDAR33-DW03 are well suited for rigorous calibration studies, which could also include other sampling methods.

- An exploration of the effects of the IFQ on the fishery dependent indices, specially the commercial handline and longline is needed. During the workshop, fisherman indicated that since the implementation of the IFQ, there has been a drastic change in fisheries behavior. There is also the possibility that dealers can directly influence this behavior. The need is to find a way to incorporate these years into the overall timer series or a recommendation to split the time series when the IFQ began.

- Further consideration of how to combine the data from the juvenile surveys, including perhaps revisiting the seagrass weighting approach as well as incorporating otolith microchemistry data on the relative contribution of estuaries to nearshore populations, may improve the YOY index.

5.6 Literature Cited

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5.7 Tables

Table 5.7.1. East GOM gag lo and standardized index of abundance by year for design based model.

SurveyYear	*Frequency*	*N*	*LoIndex*	*StdIndex*	*SE*	*CV*	*LCL*	*UCL*
1993	0.05263	114	0.14567	1.30734	0.07221	0.49573	0.51195	3.33849
1994	0.04000	75	0.07285	0.65383	0.05204	0.71429	0.18104	2.36132
1995	0.06452	62	0.16047	1.44017	0.10436	0.65035	0.43908	4.72371
1996	0.08029	137	0.15597	1.39982	0.05844	0.37470	0.67802	2.89002
1997	0.06757	148	0.17032	1.52856	0.07024	0.41238	0.69193	3.37679
2002	0.17391	161	0.30234	2.71344	0.07660	0.25336	1.64766	4.46861
2004	0.18792	149	0.16300	1.46292	0.04173	0.25598	0.88389	2.42129
2005	0.12205	254	0.09444	0.84758	0.02413	0.25551	0.51256	1.40157
2006	0.07143	266	0.06083	0.54597	0.02095	0.34440	0.27949	1.06652
2007	0.09677	310	0.05897	0.52926	0.01650	0.27982	0.30562	0.91655
2008	0.02367	169	0.01214	0.10893	0.00861	0.70961	0.03037	0.39069
2009	0.06098	246	0.04948	0.44405	0.01890	0.38198	0.21226	0.92894
2010	0.09694	196	0.07190	0.64532	0.02098	0.29171	0.36438	1.14286
2011	0.10692	318	0.07929	0.71162	0.02266	0.28580	0.40631	1.24633
2012	0.09486	253	0.07367	0.66119	0.02035	0.27627	0.38438	1.13734

Table 5.7.2. Gag lengths (fork lengths in mm) measured by laser from video tapes (1995-2007) and by stereo still cameras (2008-2012).

	Stereo measurements		Laser measurements	
Year	Mean	SD	Mean	SD
1996	-	-	429.00	-
1997	-	-	-	-
1998	-	-	-	-
1999	-	-	-	-
2000	-	-	-	-
2001	-	-	-	-
2002	-	-	718.91	77.20
2003	-	-	653.63	136.21
2004	-	-	692.13	77.20
2005	-	-	721.40	105.42
2006	-	-	624.64	100.63
2007	-	-	720.80	82.79
2008	782.16	172.23	-	-
2009	833.12	270.67	640.00	86.15
2010	768.03	104.26	-	-
2011	774.11	144.35	-	-
2012	734.42	149.13	-	-
Total	*771.42*	*152.92*	*682.68*	*108.93*

Table 5.7.3. Annual video survey sample sizes, % frequencies of occurrence, mean nominal video min counts, and standard errors of gag east and west of Cape San Blas, 2005-2012. Estimates calculated using censored data sets.

	Total sites sampled		% Freq of occurrence		Mean nominal min count		Standard error	
Year	East	West	East	West	East	West	East	West
2005	31		25.8		0.548		0.296	
2006	49	24	57.1	41.7	2.898	1.000	0.722	0.295
2007	29	23	44.8	39.1	1.172	0.826	0.355	0.272
2008	56	29	32.1	27.6	0.679	0.690	0.169	0.268
2009	62	42	50.0	42.9	1.194	1.095	0.263	0.281
2010	95	52	34.7	38.5	0.895	0.808	0.174	0.188
2011	100	58	21.0	36.2	0.460	0.931	0.134	0.207
2012	101	49	9.9	12.2	0.119	0.286	0.038	0.157

Table 5.7.4. Panama City lab video abundance indices for gag. The *frequency* listed is nominal frequency, *N* is the number of video stations, *Index* is the abundance index in CPUE units, *Scaled Index* is the index scaled to a mean of one over the time series, *CV* is the coefficient of variation on the index value, and *LCL* and *UCL* are 95% confidence limits.

Survey Year	*Frequency*	*N*	*Index*	*Scaled Index*	*CV*	*LCL*	*UCL*
2005	0.25806	31	0.34750	0.44435	0.55941	0.15649	1.26169
2006	0.52055	73	1.73452	2.21793	0.22158	1.43148	3.43643
2007	0.42308	52	0.87744	1.12198	0.31397	0.60766	2.07163
2008	0.30588	85	0.58788	0.75172	0.30013	0.41779	1.35253
2009	0.47115	104	0.95270	1.21821	0.21475	0.79669	1.86276
2010	0.36054	147	1.03311	1.32103	0.19160	0.90363	1.93124
2011	0.26582	158	0.55966	0.71563	0.24726	0.43965	1.16486
2012	0.10667	150	0.16356	0.20915	0.39957	0.09686	0.45159

Table 5.7.5. Summary of annual stationary underwater camera array (SUCA) sampling effort by spatial zone from 2008 – 2012. Values represent total number of sampling stations, while values in parentheses represent the total number of individual gear deployments (1 – 2 arrays deployed per station).

Region	2008	2009	2010	2011	2012	Total
TBN	5 (10)	25 (34)	16 (24)	56 (84)	54 (82)	156 (234)
TBO	18 (33)	33 (66)	25 (50)	49 (57)	36 (47)	161 (253)
CHN	20 (38)	28 (43)	23 (46)	35 (37)	36 (47)	142 (211)
CHO	24 (48)	30 (60)	29 (56)	42 (45)	48 (61)	173 (270)
Total	67 (129)	116 (203)	93 (176)	182 (223)	174 (237)	632 (968)

Table 5.7.6. Abundance indices for gag from 2008 – 2012.

Survey Year	*Frequency*	*N*	*Index*	*Standardized Index*	*CV*	*LCL*	*UCL*
2008	0.000000	109	.	.	.	.	.
2009	0.000000	182	.	.	.	.	.
2010	0.013699	73	0.01229	0.13338	1.32353	0.01783	0.99763
2011	0.064815	216	0.12951	1.40589	0.37851	0.67628	2.92267
2012	0.052174	230	0.13456	1.46073	0.43245	0.63816	3.34355

Table 5.7.7. Unweighted abundance indices developed from all data sets combined from 1994-2012.

Survey Year	*Nominal Frequency*	*N*	*DL Index*	*Scaled DL Index*	*CV*	*LCL*	*UCL*
1994	0.34921	126	0.26399	0.60379	0.26608	0.35786	1.01873
1995	0.50742	337	0.36874	0.84337	0.18106	0.58886	1.20787
1996	0.16134	626	0.14155	0.32376	0.18218	0.22556	0.46469
1997	0.13803	681	0.13857	0.31692	0.18416	0.21995	0.45665
1998	0.06140	570	0.13337	0.30503	0.26034	0.18277	0.50907
1999	0.11203	723	0.24787	0.56693	0.17943	0.39711	0.80937
2000	0.08179	648	0.20968	0.47958	0.20127	0.32194	0.71441
2001	0.05317	583	0.22191	0.50754	0.25810	0.30542	0.84343
2002	0.11000	800	0.59445	1.35962	0.16141	0.98655	1.87377
2003	0.12164	855	0.39279	0.89839	0.16267	0.65026	1.24119
2004	0.10961	812	0.26623	0.60892	0.17326	0.43170	0.85889
2005	0.13563	928	0.29398	0.67238	0.14915	0.49978	0.90460
2006	0.21150	922	0.90112	2.06103	0.12029	1.62173	2.61934
2007	0.24763	844	1.43242	3.27620	0.11083	2.62661	4.08643
2008	0.19331	1376	0.91714	2.09766	0.10547	1.69971	2.58877
2009	0.14632	1237	0.66887	1.52982	0.12224	1.19911	1.95175
2010	0.14361	1142	0.83378	1.90701	0.12739	1.47963	2.45784
2011	0.02864	1327	0.05518	0.12621	0.24008	0.07861	0.20263
2012	0.07030	1138	0.22554	0.51584	0.17360	0.36547	0.72809

Table 5.7.8. Annual estimated mean counts of gag grouper ("Estimated Mean"), the standard error of the mean, the coefficient of variation for the mean and the standardized catch rate (annual mean / grand mean) for the UF reef diver survey of SRRS 4-cube arrays. These means are the back-transformed marginal means from the GLMM described in the text. The standard errors are calculated using the delta method.

Year	Estimate (Linear Predictor)	Lower CL for Estimate	Upper CL for Estimate	Back-transformed Mean	Standard Error Mean	Lower CL for Mean	Upper CL for Mean	CV	Standardized Index
2001	3.0461	2.5452	3.547	21.0329	5.1718	12.75	34.71	0.2459	2.0284
2002	2.6755	2.1715	3.1794	14.5196	3.5922	8.77	24.03	0.2474	1.4003
2003	2.481	1.9755	2.9864	11.9527	2.9659	7.21	19.81	0.2481	1.1527
2004	2.0759	1.56	2.5918	7.9715	2.019	4.76	13.35	0.2533	0.7688
2005	2.9709	2.4695	3.4723	19.5101	4.8025	11.82	32.21	0.2462	1.8815
2006	2.372	1.8642	2.8799	10.719	2.6725	6.45	17.81	0.2493	1.0337
2007	1.9906	1.476	2.5051	7.3196	1.8491	4.38	12.25	0.2526	0.7059
2008	1.9039	1.3713	2.4366	6.7122	1.7551	3.94	11.43	0.2615	0.6473
2009	1.9774	1.4615	2.4933	7.2238	1.8296	4.31	12.10	0.2533	0.6967
2010	2.0545	1.5389	2.5702	7.8033	1.9754	4.66	13.07	0.2531	0.7525
2011	1.4541	0.9227	1.9855	4.2805	1.1167	2.52	7.28	0.2609	0.4128
2012	1.6837	1.1166	2.2508	5.3855	1.4993	3.05	9.50	0.2784	0.5194

Table 5.7.9. Diagnostic statistics for each of the distributions considered for the mixed models.

Distribution	-2 log Likelihood | random effects	Overdispersion | random effects
Poisson	2304.22	4.35
Generalized Poisson	1781.87	0.94
Negative Binomial	1829.49	0.95

Table 5.7.10. The number of replicate reef arrays and standardized habitat units (SHUs) sampled annually for the UF Diver Survey and the frequency distribution by size category (TL in cm) and year for Gag observed on the SRRS-low reefs.

Table of Sampling Intensity and Gag Year by Size												
Year	No. Reef Arrays	No. Standard Habitat Units	gag (<20)	gag (20-29)	gag (30-39)	gag (40-49)	gag (50-59)	gag (60-69)	gag (70-79)	gag (80-89)	gag (>89)	Total Gag
2001	4	24		17	112	181	105	49	31	7	0	502
2002	4	24	0	14	96	120	62	30	18	12	0	352
2003	4	24	0	25	65	47	87	52	25	12	0	313
2004	4	24	0	4	49	46	54	26	9	2	0	190
2005	4	24	5	110	129	103	65	41	22	15	0	490
2006	4	24	0	38	73	66	38	33	11	2	0	261
2007	4	24	0	3	84	65	30	13	5	0	0	200
2008	4	24	0	61	67	40	18	7	1	0	0	194
2009	4	24	0	6	73	80	19	3	0	0	0	181
2010	4	24	0	7	65	74	39	11	1	0	0	197
2011	4	24	4	24	30	40	11	2	1	0	0	112
2012	3	18	0	2	17	58	32	6	0	0	0	115

Table 5.7.11. Nominal CPUE and percent occurrence for gag grouper captured during the SEAMAP groundfish survey.

	Summer		Fall		Combined	
Year	CPUE	Percent	CPUE	Percent	CPUE	Percent
1972			0	0	0	0
1973			0	0	0	0
1974			0	0	0	0
1975			0	0	0	0
1976			0	0	0	0
1977			0	0	0	0
1978			0	0	0	0
1979			0	0	0	0
1980			0	0	0	0
1981			0	0	0	0
1982	0	0	0	0	0	0
1983	0	0	0	0	0	0
1984	0	0	0	0	0	0
1985	0	0	0	0	0	0
1986	0	0	0	0	0	0
1987	0	0	0	0	0	0
1988	0.0248	0.41	0	0	0.0124	0.21
1989	0	0	0.0020	0.39	0.0011	0.21
1990	0	0	0	0	0	0
1991	0	0	0	0	0	0
1992	0	0	0	0	0	0
1993	0	0	0.0879	0.73	0.0462	0.38
1994	0	0	0	0	0	0
1995	0	0	0	0	0	0
1996	0	0	0	0	0	0
1997	0	0	0	0	0	0
1998	0	0	0.0067	0.37	0.0036	0.20
1999	0.0244	0.41	0	0	0.0121	0.20
2000	0	0	0	0	0	0
2001	0	0	0	0	0	0
2002	0	0	0.0109	0.39	0.0055	0.20
2003	0	0	0	0	0	0
2004	0	0	0	0	0	0
2005	0	0	0	0	0	0
2006	0	0	0.0053	0.45	0.0025	0.22
2007	0	0	0	0	0	0
2008	0.0132	0.33	0.0108	0.55	0.0119	0.45
2009	0.0307	0.96	0.0363	1.37	0.0333	1.15
2010	0.0268	1.08	0.0065	0.32	0.0175	0.73
2011	0.0485	1.22	0	0	0.0293	0.74
2012	0.0245	1.00	0.0101	0.51	0.0197	0.84
Total	*0.0062*	*0.17*	*0.0051*	*0.15*	*0.0065*	*0.19*

Table 5.7.12. Nominal CPUE and percent occurrence for gag grouper captured during the small pelagics survey.

Year	Stations	CPUE	Percent
2002	132	0	0
2003	145	0.0138	0.69
2004	101	0	0
2006	73	0	0
2007	146	0.0124	0.68
2008	167	0	0
2009	122	0	0
2010	136	0	0
2011	131	0.0151	0.76
2012	111	0	0
Total	*1264*	*0.0041*	*0.21*

Table 5.7.13. Nominal CPUE and percent occurrence for gag grouper captured during the bottom longline survey.

Year	Station	CPUE	Percent
1995	77	0	0
1996	83	0	0
1997	169	0	0
1999	161	0	0
2000	137	0.0072	0.73
2001	277	0.0502	2.89
2002	212	0.0047	0.47
2003	280	0.0145	1.07
2004	249	0.0361	3.21
2005	95	0.0104	1.05
2006	150	0	0
2007	156	0.0063	0.64
2008	108	0.0090	0.93
2009	185	0.0222	1.62
2010	151	0.0194	1.99
2011	128	0.0082	0.78
2012	142	0	0
Total	*2760*	*0.0145*	*1.12*

Table 5.7.14. Proportion of the total (gag+black) that were identified as gag grouper, by area.

YEAR = 1990 to 2009

Area	Proportion GAG
area=1	0.093
area=2	0.420
area=3	0.786
area=4	0.905
area=5	0.957
area=6	0.983
area 7 to 10	0.999

YEAR = 2010 to 2012

area=1	0.087
area=2	0.299
area=3	0.547
area=4	0.791
area=5	0.942
area=6	0.993
area 7 to 10	0.998

Table 5.7.15. The deviance table for the binomial model on proportion positive trips for Index 1 (1990-2012). Factors were assumed to be significant if they explained >1% of the total deviance (shaded cells), and were significant according to a Chi-Square test.

Binomial Model Factors - Proportion Positive	DF	DF	Residual Deviance	Reduction in Deviance	% of Total Deviance	Log Like	Chi Square	P
Null	1	15101	19702.6	0.0	0.0	-9851.3		
Area	7	15094	18046.3	1656.3	77.3	-9023.2	1656.3	<0.001
Area + ***Year***	22	15072	17753.7	292.6	13.7	-8876.8	292.6	<0.001
Area + Year + ***Season***	3	15069	17708.0	45.7	2.1	-8854.0	45.7	<0.001
Area + Year + Season + ***Area*Season***	21	15048	17559.1	148.9	6.9	-8779.5	149.0	<0.001

Table 5.7.16. The deviance table for the lognormal model on catch rates of positive trips for Index 1 (1990-2012). Factors were assumed to be significant if they explained >1% of the total deviance (shaded cells), and were significant according to a Chi-Square test.

Lognormal Model Factors - CPUE

Lognormal Model Factors - CPUE	DF	DF	Residual Deviance	Reduction in Deviance	% of Total Deviance	Log Like	Chi Square	P
Null	1	9693	24517.2	0.0	0.0	-18252.6		
Year	22	9671	22003.0	2514.2	71.0	-17728.1	1048.82	<0.001
Year + ***Area***	7	9664	21267.9	735.1	20.8	-17563.4	329.41	<0.001
Year + Area + ***Season***	3	9661	21029.8	238.1	6.7	-17508.9	109.15	<0.001
Year + Area + Season + Area*Season	21	9640	20978.4	51.4	1.5	-17497.0	23.72	0.307

Table 5.7.17. Analysis of the mixed model formulations for the components of the delta-model (Index 1 1990-2012). The likelihood ratio was used to test the difference of –2 REM log likelihood between two nested models. The final model is indicated with gray shading.

ANALYSIS OF MIXED MODEL FORMULATIONS

Proportion Positive	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P	Scaled Deviance	Dispersion
Area + Year + Season + Area*Season	1799.9	1801.9	1806.4	-	-	678.08	2.18
Area + Year + Season + Area*Season + Year*Season	1765.6	1769.6	1774.6	34.3	<0.0001	649.75	1.84
Area + Year + Season + Area*Season + Year*Season + Year*Area	***1760.8***	***1766.8***	***1774.3***	***4.8***	***0.0285***	***625.61***	***1.72***

Catch Rates on Positive Trips	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P
Year + Area + Season	35132.1	35134.1	35141.3	-	-
Year + Area + Season + Year*Season	35063.9	35067.9	35072.9	68.2	<0.0001
Year + Area + Season + Year*Season + Year*Area	***35025.9***	***35031.9***	***35039.4***	***106.2***	***<0.0001***

Table 5.7.18. Nominal CPUE, number of trips, number of positive trip, proportion positive trips (PPT), standardized index of abundance and index statistics.

YEAR	Nom CPUE	Trips	Pos Trips	PPT	Relative Index	CV	LCI	UCI
1990	31.037	65	47	0.723	0.852	0.442	0.366	1.981
1991	25.427	241	139	0.577	0.690	0.359	0.344	1.384
1992	13.632	229	120	0.524	0.541	0.364	0.267	1.096
1993	15.798	428	320	0.748	0.708	0.292	0.400	1.254
1994	14.192	654	395	0.604	0.412	0.306	0.226	0.748
1995	12.148	804	453	0.563	0.526	0.299	0.293	0.944
1996	23.502	626	340	0.543	0.541	0.309	0.296	0.990
1997	12.790	989	597	0.604	0.687	0.283	0.394	1.197
1998	22.125	850	545	0.641	1.002	0.282	0.576	1.742
1999	26.221	877	583	0.665	0.886	0.287	0.504	1.555
2000	27.067	877	507	0.578	0.926	0.288	0.526	1.630
2001	36.318	1025	670	0.654	1.736	0.274	1.013	2.973
2002	47.825	961	591	0.615	1.524	0.289	0.865	2.686
2003	41.563	1005	655	0.652	1.800	0.279	1.041	3.111
2004	45.045	1046	742	0.709	2.191	0.271	1.287	3.731
2005	48.041	1053	772	0.733	2.387	0.265	1.417	4.019
2006	27.486	965	683	0.708	1.269	0.273	0.743	2.170
2007	22.999	666	432	0.649	0.980	0.290	0.555	1.728
2008	21.788	575	442	0.769	1.047	0.271	0.614	1.784
2009	10.181	324	189	0.583	0.474	0.355	0.238	0.943
2010	15.433	179	122	0.682	0.918	0.333	0.480	1.755
2011	6.277	316	170	0.538	0.346	0.345	0.177	0.678
2012	10.200	347	180	0.519	0.558	0.345	0.285	1.093

Table 5.7.19. The deviance table for the binomial model on proportion positive trips for Index 2 (1990-2009). Factors were assumed to be significant if they explained >1% of the total deviance (shaded cells), and were significant according to a Chi-Square test.

Binomial Model Factors - Proportion Positive	DF	DF	Residual Deviance	Reduction in Deviance	% of Total Deviance	Log Like	Chi Square	P
Null	1	14259	18522.7	0.0	0.0	-9261.34		
Area	7	14252	16846.8	1675.9	80.3	-8423.4	1675.9	<0.001
Area + ***Year***	19	14233	16628.9	217.9	10.4	-8314.5	217.9	<0.001
Area + Year + ***Season***	3	14230	16566.4	62.5	3.0	-8283.2	62.5	<0.001
Area + Year + Season + ***Area*Season***	21	14209	16435.8	130.6	6.3	-8217.9	130.6	<0.001

Table 5.7.20. The deviance table for the lognormal model on catch rates of positive trips for Index 2 (1990-2009). Factors were assumed to be significant if they explained >1% of the total deviance (shaded cells), and were significant according to a Chi-Square test.

Lognormal Model Factors - CPUE

Lognormal Model Factors - CPUE	DF	DF	Residual Deviance	Reduction in Deviance	% of Total Deviance	Log Like	Chi Square	P
Null	1	9221	23556.0	0.0	0.0	-17409.6		
Year	19	9202	21206.2	2349.8	70.6	-16925.0	969.11	<0.001
Year + ***Area***	7	9195	20498.2	708.0	21.3	-16768.5	313.14	<0.001
Year + Area + ***Season***	3	9192	20276.5	221.7	6.7	-16718.3	100.28	<0.001
Year + Area + Season + Area*Season	21	9171	20225.8	50.7	1.5	-16706.8	23.1	0.3384

Table 5.7.21. Analysis of the mixed model formulations for the components of the delta-model (Index 2 1990-2009). The likelihood ratio was used to test the difference of –2 REM log likelihood between two nested models. The final model is indicated with gray shading.

ANALYSIS OF MIXED MODEL FORMULATIONS

Proportion Positive	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P	Scaled Deviance	Dispersion
Area + Year + Season + Area*Season	1482.5	1484.5	1488.8	-	-	589.36	2.11
Area + Year + Season + Area*Season + Year*Season	***1460.1***	***1464.1***	***1468.8***	***22.4***	***<0.0001***	***565.85***	***1.84***
Area + Year + Season + Area*Season + Year*Season + Year*Area	1457.6	1463.6	1470.6	2.5	0.1138	546.80	1.74

Catch Rates on Positive Trips	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P
Year + Area + Season	33542.9	33544.9	33552.0	-	-
Year + Area + Season + Year*Season	33478.6	33482.6	33487.3	64.3	<0.0001
Year + Area + Season + Year*Season + Year*Area	***33440.6***	***33446.6***	***33453.7***	***102.3***	***<0.0001***

Table 5.7.22. **Index 2 (Pre-IFQ 1990-2009)** Nominal CPUE, number of trips, number of positive trip, proportion positive trips (PPT), standardized index of abundance and index statistics.

YEAR	Nom CPUE	Trips	Pos Trips	PPT	Relative Index	CV	LCI	UCI
1990	31.037	65	47	0.723	0.824	0.438	0.357	1.902
1991	25.427	241	139	0.577	0.642	0.354	0.323	1.275
1992	13.632	229	120	0.524	0.511	0.358	0.255	1.023
1993	15.798	428	320	0.748	0.670	0.293	0.377	1.190
1994	14.192	654	395	0.604	0.378	0.302	0.209	0.683
1995	12.148	804	453	0.563	0.480	0.295	0.269	0.857
1996	23.502	626	340	0.543	0.504	0.304	0.278	0.914
1997	12.790	989	597	0.604	0.642	0.281	0.369	1.115
1998	22.125	850	545	0.641	0.952	0.280	0.549	1.649
1999	26.221	877	583	0.665	0.854	0.283	0.490	1.489
2000	27.067	877	507	0.578	0.877	0.285	0.501	1.534
2001	36.318	1025	670	0.654	1.637	0.274	0.956	2.804
2002	47.825	961	591	0.615	1.438	0.285	0.821	2.516
2003	41.563	1005	655	0.652	1.706	0.277	0.991	2.939
2004	45.045	1046	742	0.709	2.063	0.272	1.209	3.519
2005	48.041	1053	772	0.733	2.260	0.266	1.339	3.816
2006	27.486	965	683	0.708	1.199	0.273	0.701	2.050
2007	22.999	666	432	0.649	0.922	0.288	0.525	1.620
2008	21.788	575	442	0.769	0.994	0.274	0.580	1.702
2009	10.181	324	189	0.583	0.448	0.346	0.229	0.878

Table 5.7.23. The annual number of total trips, trips catching gag (positives), and the proportion of commercial handline trips catching gag (proportion positives).

Year	Trips	Positive trips	Proportion of positive trips
1990	278	152	0.55
1991	1316	626	0.48
1992	1629	786	0.48
1993	4685	2138	0.46
1994	6391	2770	0.43
1995	6786	3138	0.46
1996	5004	2802	0.56
1997	6813	3987	0.59
1998	6996	4606	0.66
1999	7282	4578	0.63
2000	7213	4506	0.62
2001	7631	4788	0.63
2002	7720	4778	0.62
2003	7331	4603	0.63
2004	6380	4184	0.66
2005	4978	3425	0.69
2006	5286	3126	0.59
2007	4531	2771	0.61
2008	4713	2785	0.59
2009	5093	2572	0.50
2010	3697	52	0.01
2011	3769	50	0.01
2012	3939	81	0.02

Table 5.7.24. Index values, upper confidence limits, lower confidence limits, and coefficient of variation for the commercial handline index for the Gulf of Mexico gag grouper.

Year	Relative Index	Lower 95% CI	Upper 95% CI	Relative Nominal Index	CV
1990	0.314	0.170	0.582	0.391	0.316
1991	0.314	0.196	0.503	0.297	0.239
1992	0.562	0.355	0.889	0.727	0.232
1993	0.651	0.433	0.976	0.580	0.205
1994	0.589	0.393	0.881	0.604	0.204
1995	0.782	0.526	1.163	0.667	0.200
1996	0.930	0.629	1.377	0.709	0.198
1997	0.907	0.616	1.335	0.782	0.195
1998	1.546	1.053	2.271	1.591	0.194
1999	1.045	0.710	1.538	1.165	0.195
2000	1.109	0.753	1.634	1.257	0.196
2001	1.593	1.080	2.348	1.510	0.196

2002	1.590	1.077	2.347	1.470	0.197
2003	1.563	1.058	2.307	1.350	0.197
2004	1.991	1.349	2.939	1.841	0.197
2005	1.872	1.265	2.770	1.745	0.198
2006	1.006	0.674	1.502	0.870	0.202
2007	0.648	0.431	0.974	0.994	0.206
2008	0.640	0.424	0.967	0.980	0.209
2009	0.350	0.230	0.531	0.471	0.211

Table 5.7.25. The number of trips, the number of positive trips and the proportion of positive trips by year from the MRFSS database.

Year	Trips	Positive trips	Proportion of positive trips
1986	4552	65	1.43
1987	5934	107	1.80
1988	7450	89	1.19
1989	4936	100	2.03
1990	4123	97	2.35
1991	3944	139	3.52
1992	9700	293	3.02
1993	10630	404	3.80
1994	12451	617	4.96
1995	11526	567	4.92
1996	11384	591	5.19
1997	11671	730	6.25
1998	14223	1156	8.13
1999	18880	1516	8.03
2000	16013	1156	7.22
2001	17109	1206	7.05
2002	18704	1515	8.10
2003	19088	1867	9.78
2004	20475	2270	11.09
2005	18432	1786	9.69
2006	17561	1184	6.74
2007	18052	1356	7.51
2008	17489	1758	10.05
2009	19264	1508	7.83
2010	19319	1363	7.06

Table 5.7.26. Index values, upper confidence limits, lower confidence limits, and coefficient of variation for the MRFSS index for Gulf of Mexico gag grouper.

Year	Relative Index	Lower 95% CI	Upper 95% CI	Nominal Index	CV
1986	0.176	0.097	0.318	0.364	0.303
1987	0.144	0.091	0.230	0.177	0.236
1988	0.080	0.048	0.132	0.099	0.257
1989	0.248	0.154	0.401	0.227	0.243
1990	0.510	0.314	0.827	0.548	0.245
1991	0.656	0.438	0.984	0.690	0.205
1992	0.540	0.407	0.716	0.542	0.142
1993	0.915	0.719	1.164	0.770	0.121
1994	1.216	0.999	1.479	0.909	0.098
1995	1.426	1.165	1.746	1.067	0.101
1996	1.037	0.848	1.268	0.892	0.101
1997	1.176	0.980	1.412	1.133	0.092
1998	1.551	1.338	1.798	1.540	0.074
1999	1.232	1.080	1.406	1.228	0.066
2000	0.804	0.670	0.966	0.871	0.092
2001	0.913	0.770	1.083	0.979	0.085
2002	1.199	1.029	1.398	1.283	0.077
2003	1.487	1.287	1.718	1.662	0.072
2004	1.585	1.385	1.813	1.982	0.067
2005	1.226	1.051	1.430	1.645	0.077
2006	0.879	0.739	1.045	0.932	0.087
2007	1.393	1.197	1.622	1.298	0.076
2008	2.023	1.773	2.309	1.896	0.066
2009	1.353	1.173	1.562	1.213	0.072
2010	1.228	1.054	1.431	1.056	0.077

Table. 5.7.27. Annual number of total trips, trips catching gag grouper (positives), and the proportion of trips catching gag grouper (proportion positives) from the headboat fishery.

Year	Trips	Positive trips	Proportion positives
1986	1244	927	74.52
1987	1336	1015	75.97
1988	1622	1099	67.76
1989	1977	1160	58.67
1990	2862	1764	61.64
1991	2494	1400	56.13
1992	2527	1338	52.95
1993	2427	1420	58.51
1994	2254	1282	56.88
1995	1909	936	49.03
1996	1634	1019	62.36
1997	1503	904	60.15
1998	1819	1192	65.53
1999	1363	978	71.75
2000	1485	1045	70.37
2001	1202	714	59.40
2002	1302	760	58.37
2003	1583	1020	64.43
2004	2067	1256	60.76
2005	2019	1429	70.78
2006	1176	637	54.17
2007	1273	636	49.96
2008	1847	1109	60.04
2009	2045	1191	58.24
2010	1606	1023	63.70

Table 5.7.28. Index values, upper confidence limits, lower confidence limits, and coefficient of variation for the headboat index for Gulf of Mexico gag grouper.

Year	Relative Index	Lower 95% CI	Upper 95% CI	Nominal	CV
1986	1.399	1.187	1.649	1.605	0.082
1987	1.556	1.318	1.837	1.673	0.083
1988	1.124	0.939	1.345	1.149	0.090
1989	1.065	0.869	1.307	1.023	0.102
1990	0.979	0.819	1.169	0.972	0.089
1991	0.709	0.575	0.875	0.801	0.105
1992	0.849	0.675	1.068	0.919	0.115
1993	0.866	0.708	1.058	0.930	0.101
1994	0.907	0.721	1.140	0.947	0.115
1995	0.768	0.604	0.975	0.669	0.120
1996	1.021	0.846	1.233	0.967	0.095
1997	0.996	0.818	1.213	0.740	0.099
1998	1.165	0.978	1.388	1.141	0.088
1999	1.276	1.072	1.518	1.357	0.087
2000	1.205	0.993	1.464	1.268	0.097
2001	0.612	0.468	0.801	0.595	0.135
2002	0.722	0.564	0.924	0.771	0.124
2003	1.002	0.818	1.228	0.991	0.102
2004	1.099	0.897	1.347	1.095	0.102
2005	1.152	0.990	1.342	1.138	0.076
2006	0.538	0.412	0.702	0.479	0.134
2007	0.646	0.495	0.844	0.632	0.134
2008	0.995	0.817	1.212	0.979	0.099
2009	0.931	0.757	1.145	0.875	0.104
2010	1.419	1.189	1.693	1.282	0.089

5.8 Figures

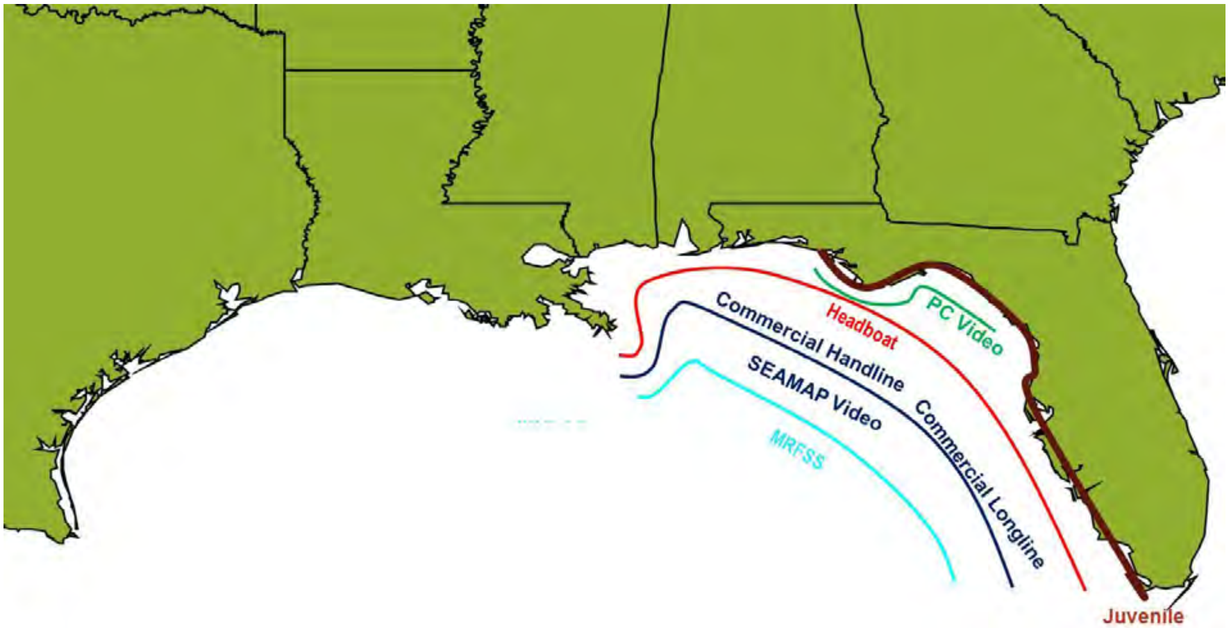

Figure 5.8.1. Spatial coverage of fishery-independent and fishery-dependent indices recommended for use.

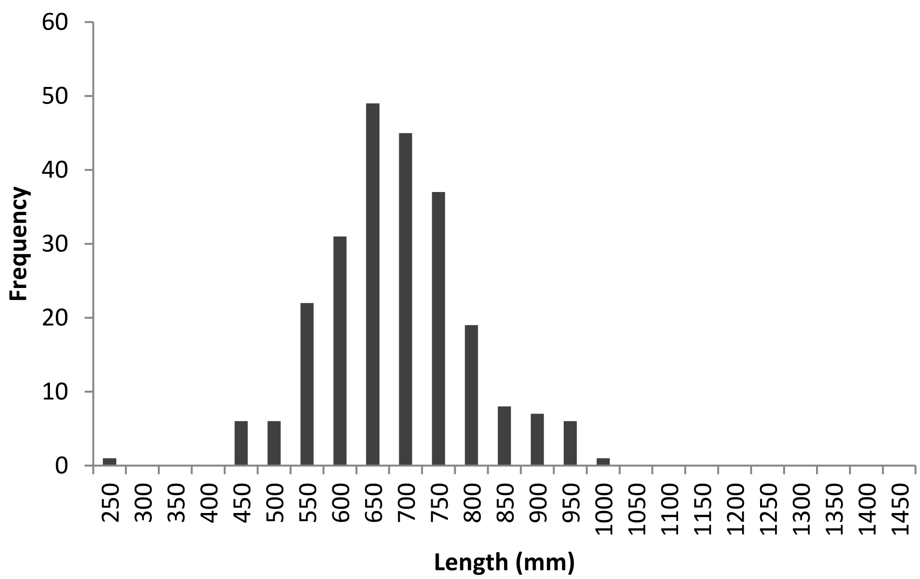

Figure 5.8.2. Gag length frequency of fish measured from SEAMAP video survey with lasers in 1995-2009.

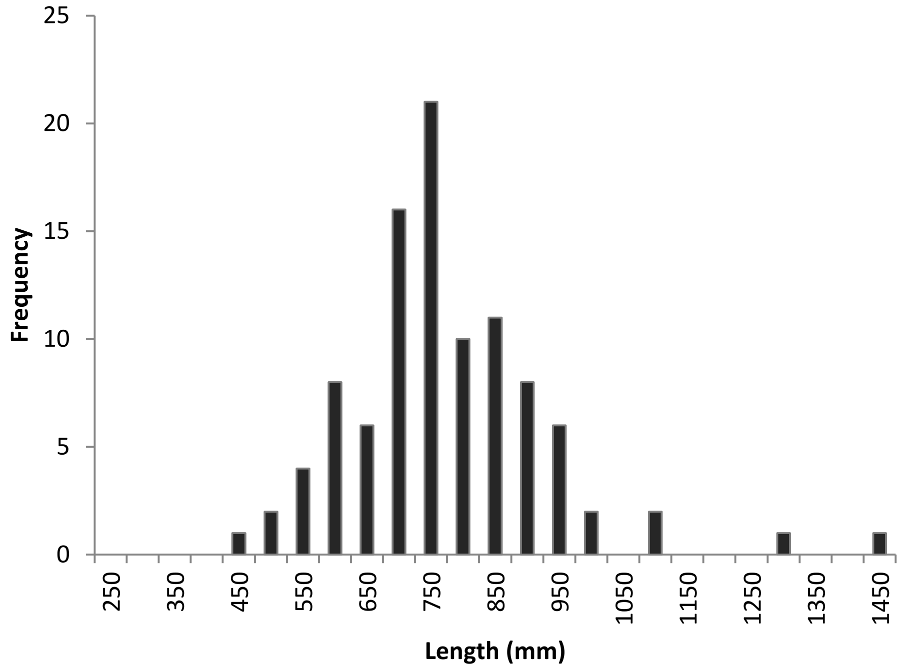

Figure 5.8.3. Gag length frequency of fish measured from SEAMAP video survey with stereo cameras in 2008-2012.

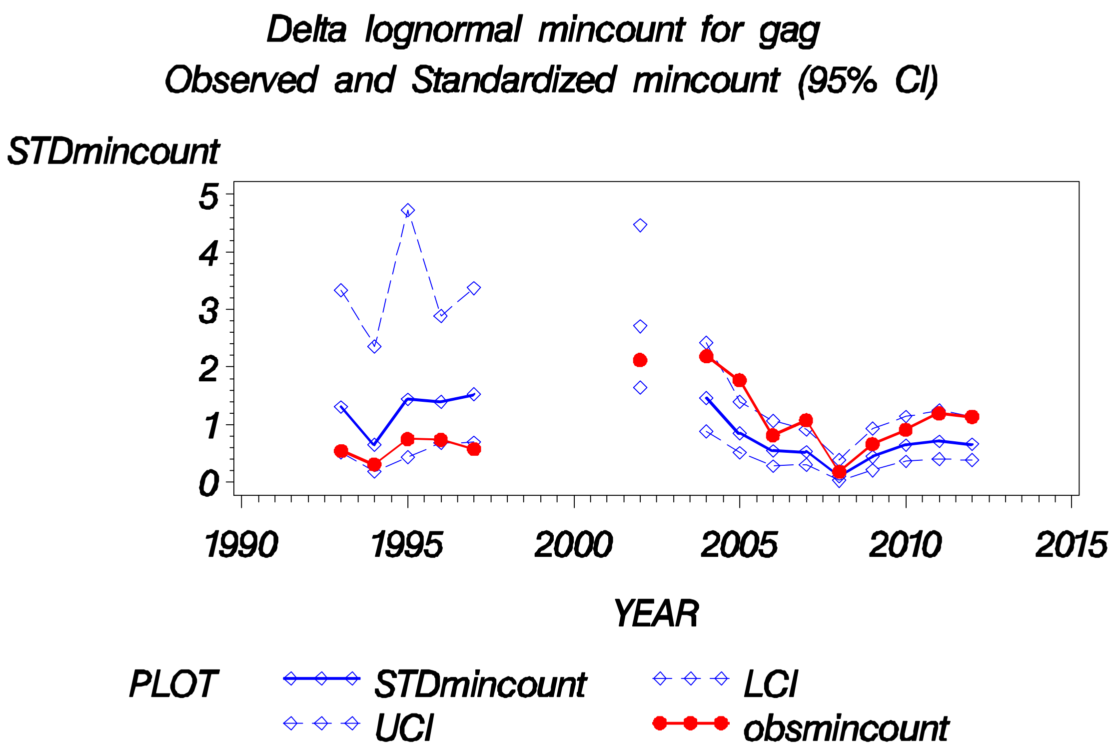

Figure 5.8.4. Observed and standardized mincounts from east GOM design based model from the SEAMAP video survey.

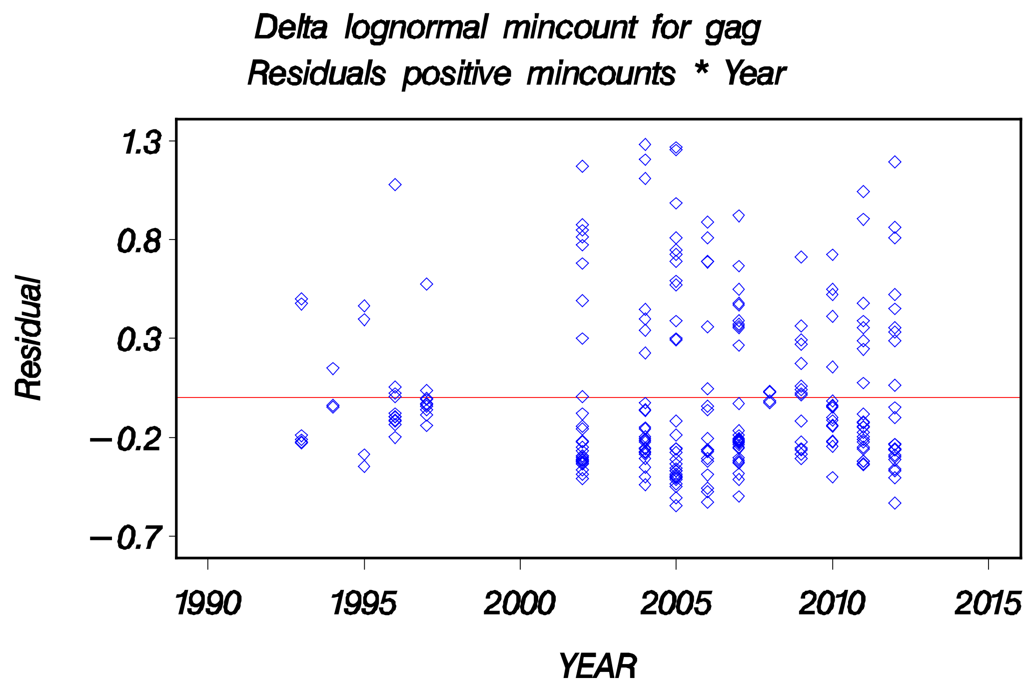

Figure 5.8.5. Residuals of positive mincounts for east GOM design based model from the SEAMAP video survey.

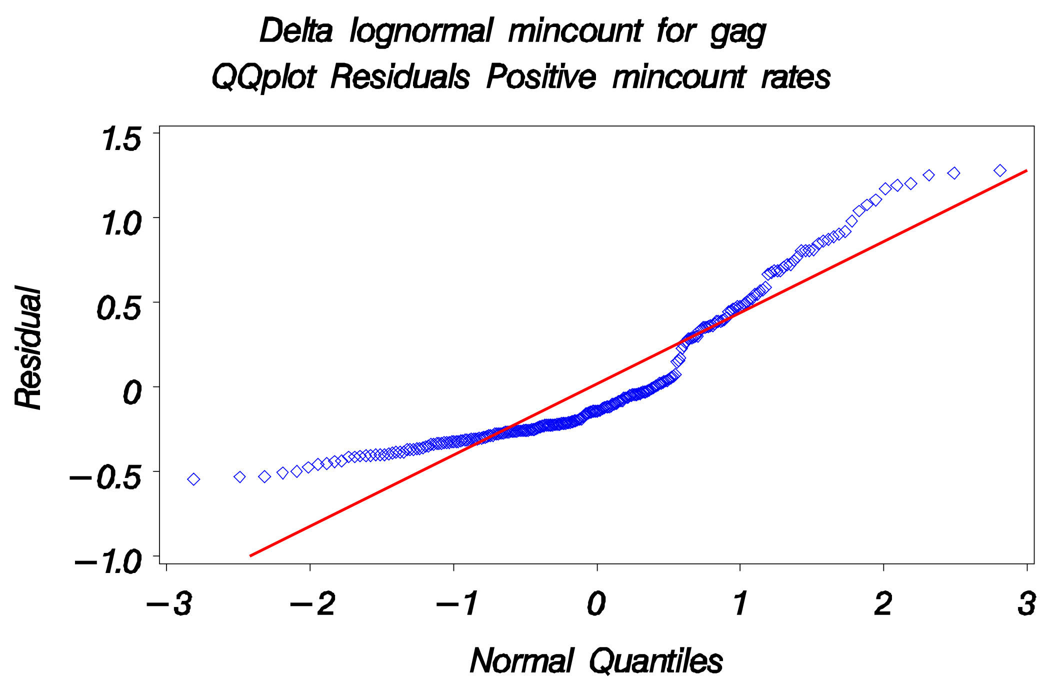

Figure 5.8.6. QQ plot of positive mincounts from east GOM design based model from the SEAMAP video survey.

Figure 5.8.7. Picture of a fully transitioned male copperbelly gag caught on the Florida Middle Grounds. Note the dark mottling on the lower lip, dorsal surface and caudal fin. The presence of mottling does not disappear following mortality.

Figure 5.8.8. Picture of a female gag. Note the absence of the dark mottling particularly on the dorsal surface of the fish.

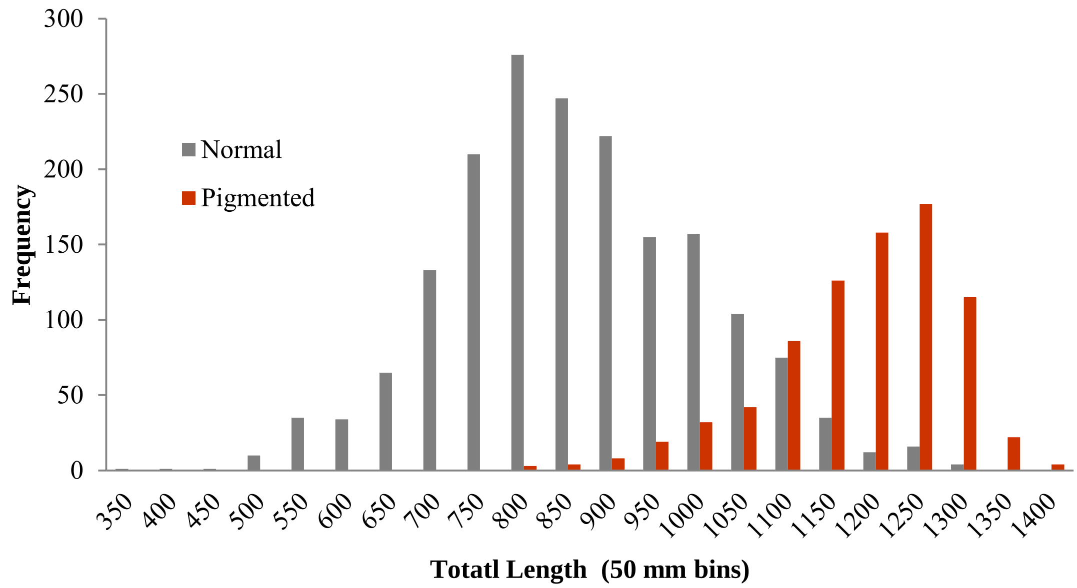

Figure 5.8.9. Commercial landings length-frequency data for gag grouper from 1991-2004 showing the difference between normal and pigmented (copperbelly) gag grouper. Pigmented gag were confirmed to be male.

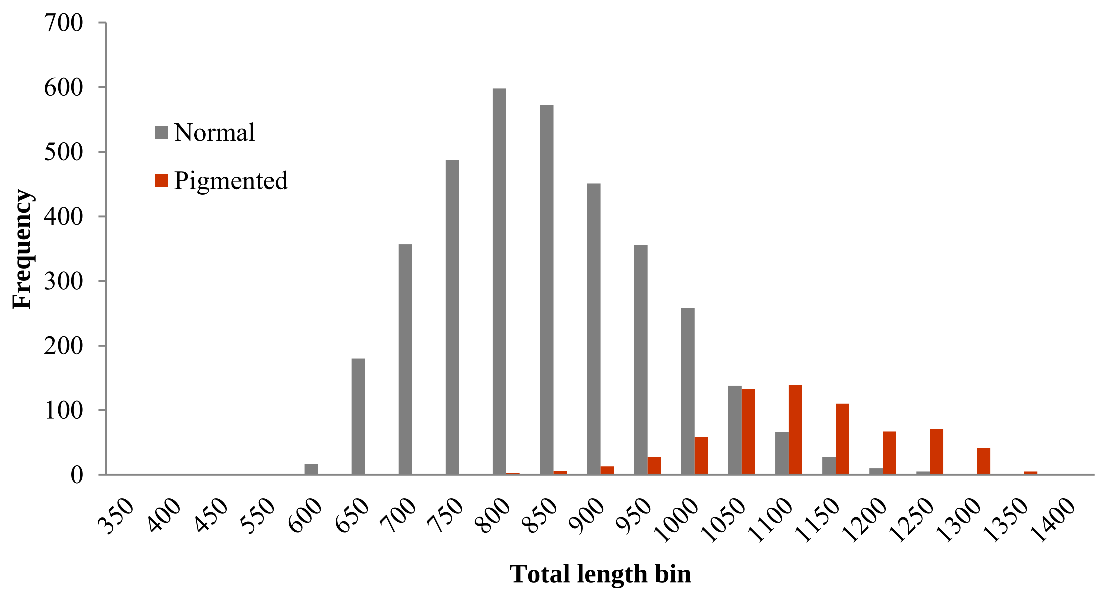

Figure 5.8.10. Commercial landings length-frequency data for gag grouper from 2005-2012 showing the difference between normal and pigmented (copperbelly) gag grouper. Pigmented gag were confirmed to be male.

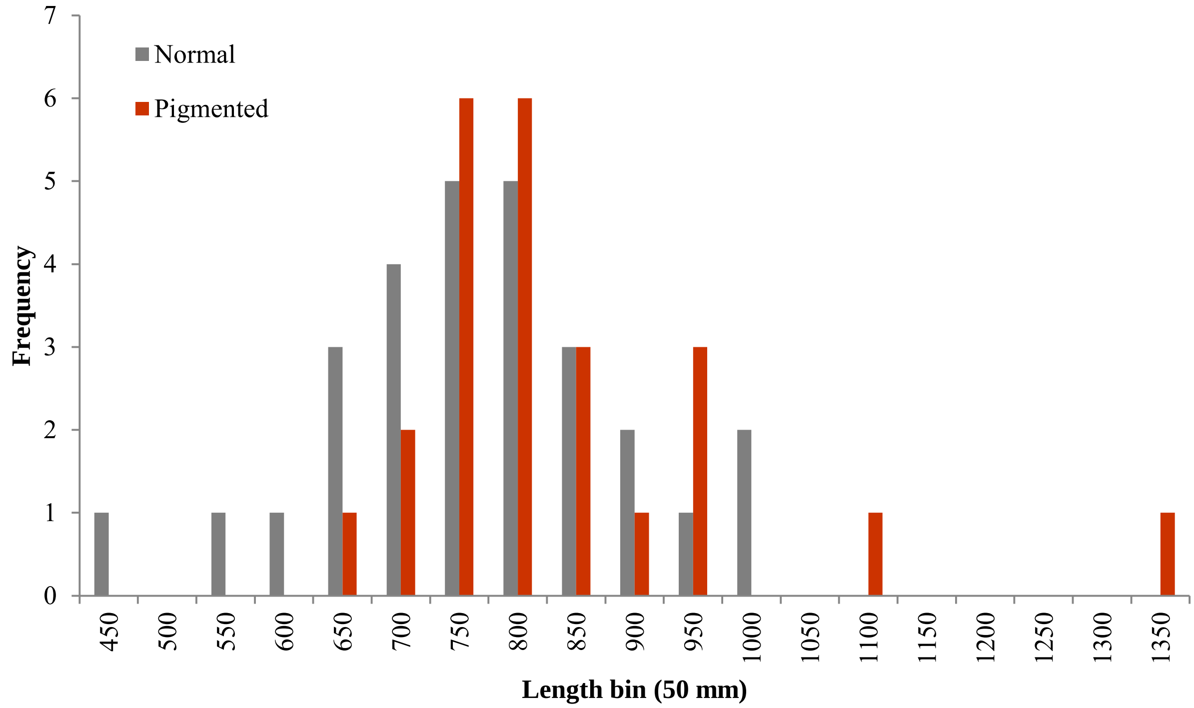

Figure 5.8.11. SEFSC reef fish video survey length-frequency data collected at Madison-Swanson marine protected area for gag grouper from 2001-2012 showing the difference between normal and pigmented (copperbelly) gag grouper. Pigmented gag could not be confirmed as males from video data.

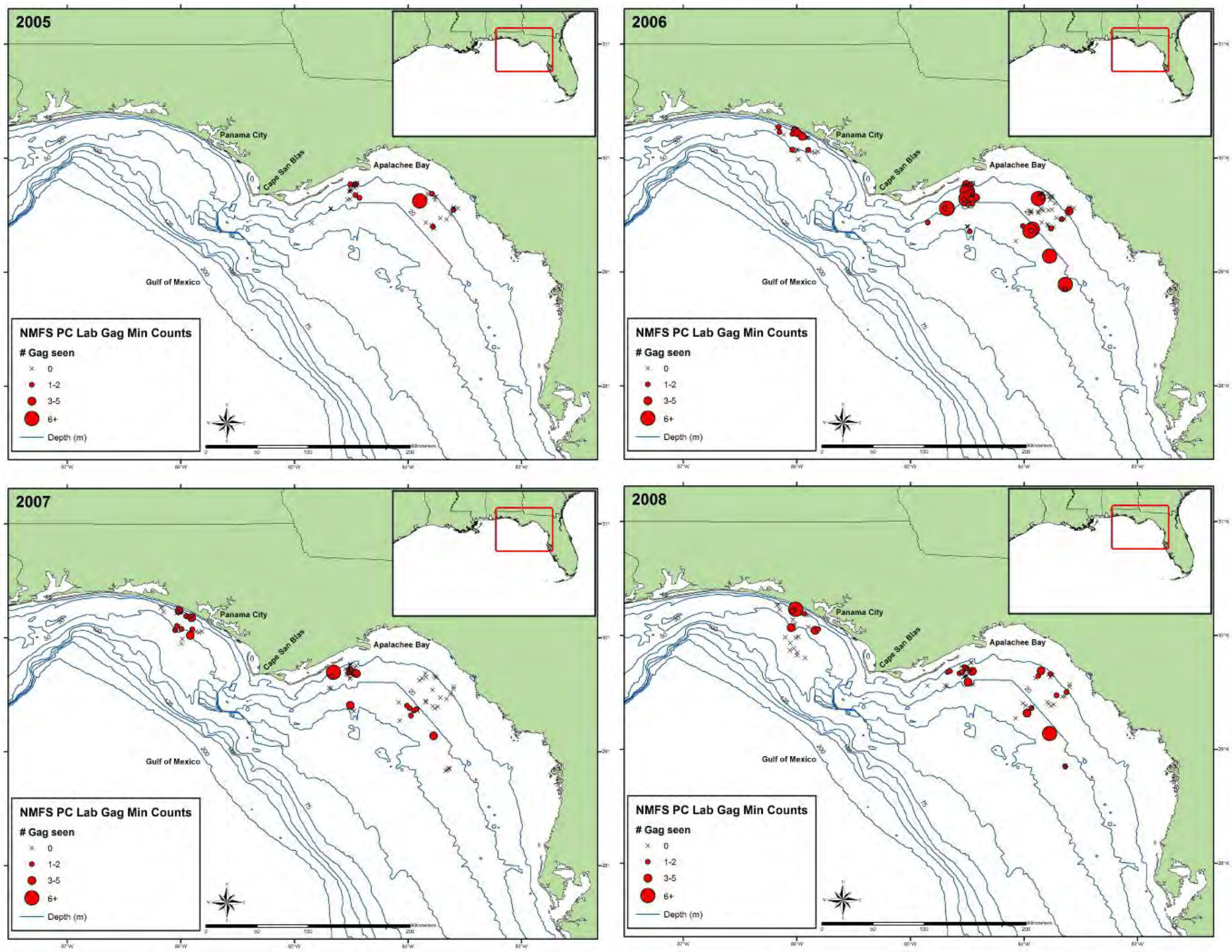

Figure 5.8.12. Annual distribution and relative abundance (min counts) of gag observed in the Panama City NMFS reef fish survey, 2005-2008, with stationary, high definition video or mpeg cameras. Sites sampled with video gear, but where no gag were observed, are indicated with an X.

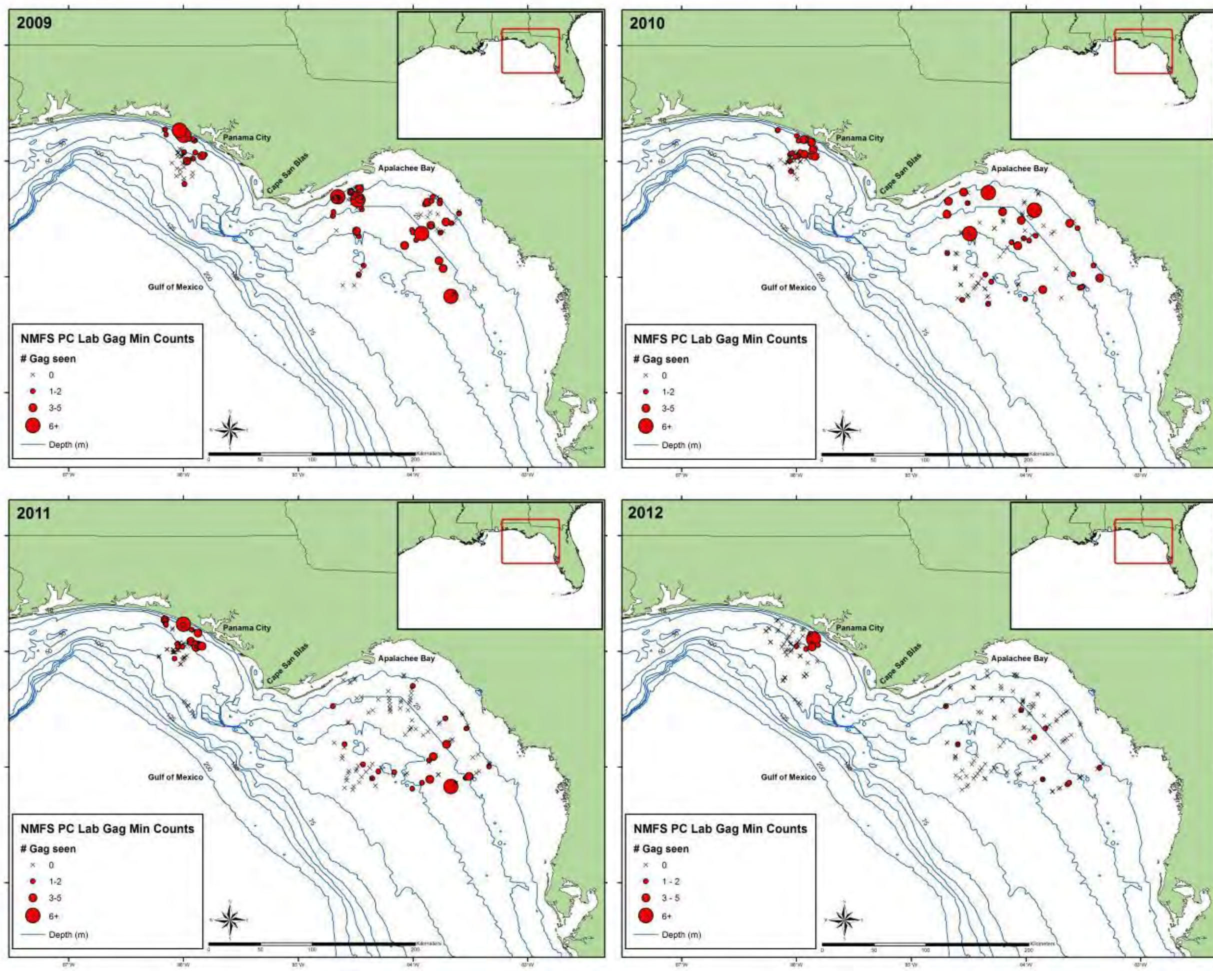

Figure 5.8.13. Annual distribution and relative abundance (min counts) of gag observed in the Panama City NMFS reef fish survey with stationary, high definition video or mpeg cameras, 2009-2012. Sites sampled with video gear, but where no gag were observed, are indicated with an X.

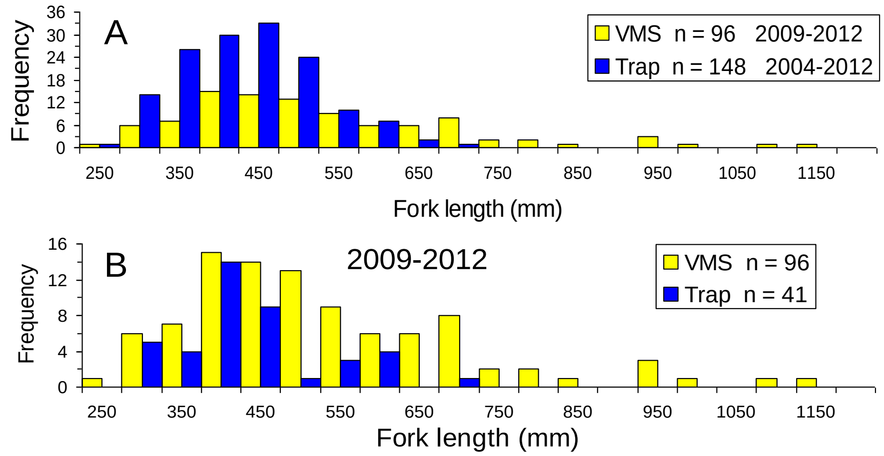

Figure 5.8.14. Overall size distributions of (A) all gag collected in chevron traps, 2004-2012, and measured in stereo still images using VMS, 2009-2012, and (B) all gag collected in chevron traps and measured in stereo still images using VMS, 2009-2012.

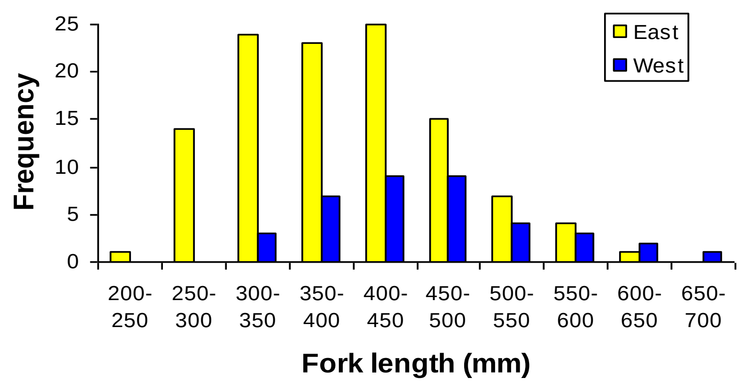

Figure 5.8.15. Overall size distributions of trap-caught gag east and west of Cape San Blas, 2004-2012.

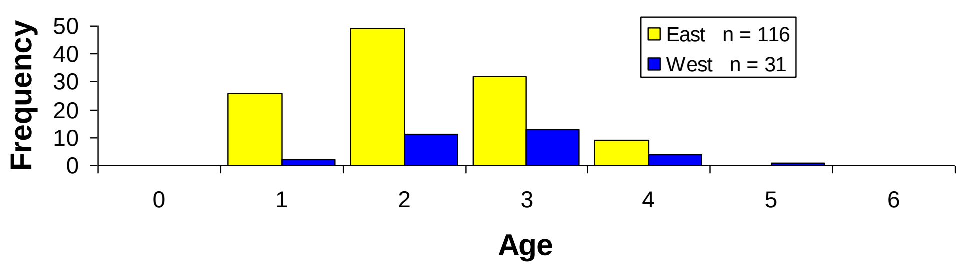

Figure 5.8.16. Overall age structure of trap-caught gag, 2004-2012, east and west of Cape San Blas.

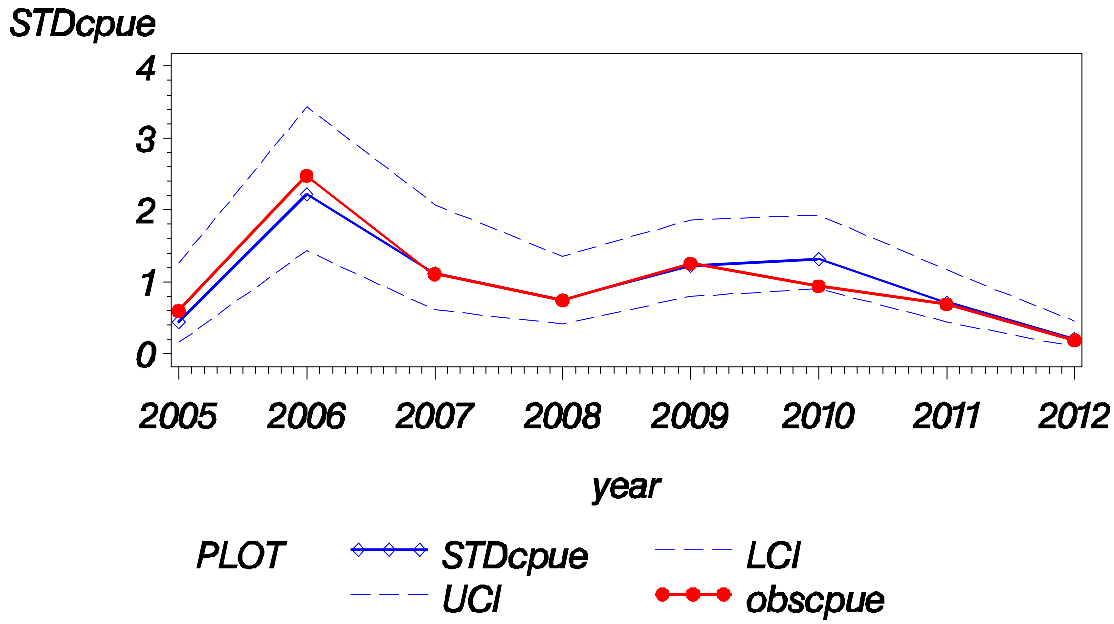

Figure 5.8.17. Annual index of abundance for gag from the Panama City NMFS lab video survey from 2005 to 2012. STDcpue is the index scaled to a mean of one over the time series. Obscpue is the average nominal CPUE, and LCI and UCI are 95% confidence limits.

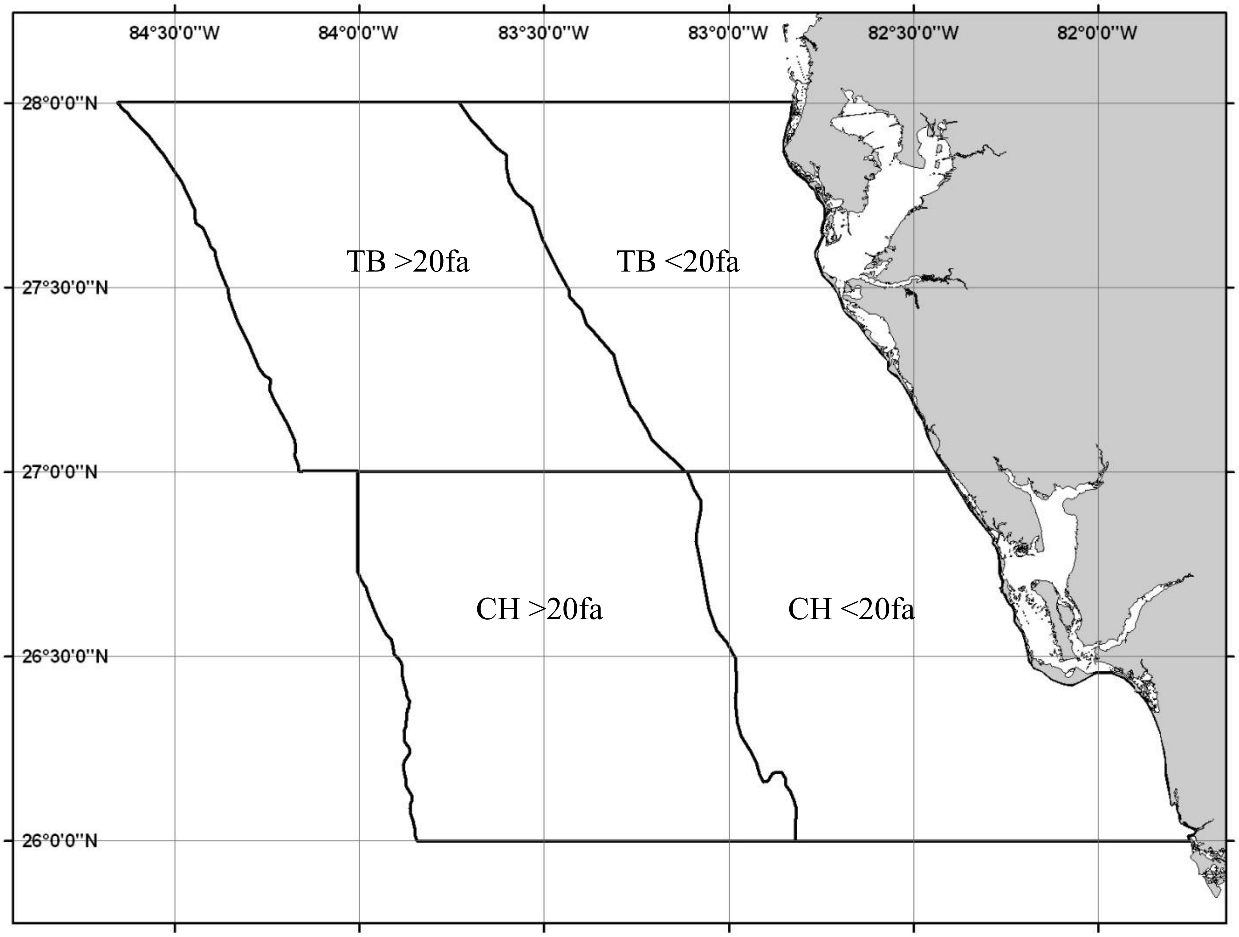

Figure 5.8.18. The West Florida Shelf survey area. The 20fa (37m) contour separates nearshore (i.e., TBN and CHN) and offshore (TBO and CHO) sampling zones. The sampling area includes waters 10m – 110m.

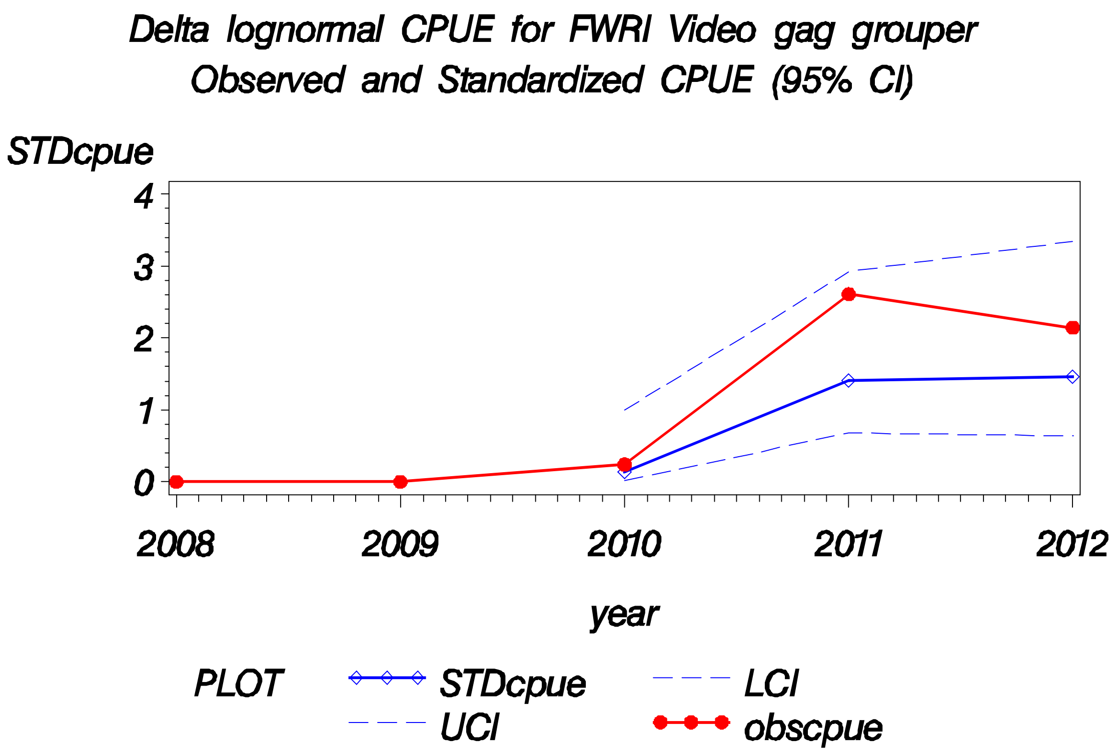

Figure 5.8.19. Abundance indices for gag from 2008 – 2012.

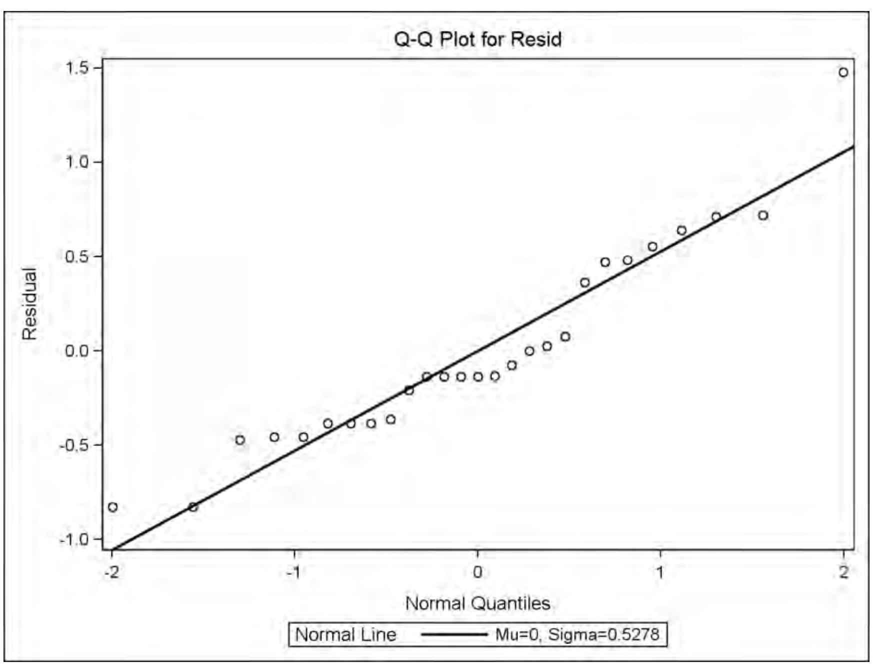

Figure 5.8.20. Q-Q plot of residuals from the lognormal sub-model for gag from 2008 – 2012.

Figure 5.8.21. Nine sampling regions used in this study. The green areas indicate seagrass coverage between 0 and 6 feet of water depth. Seagrass coverage in acres for each region is listed.

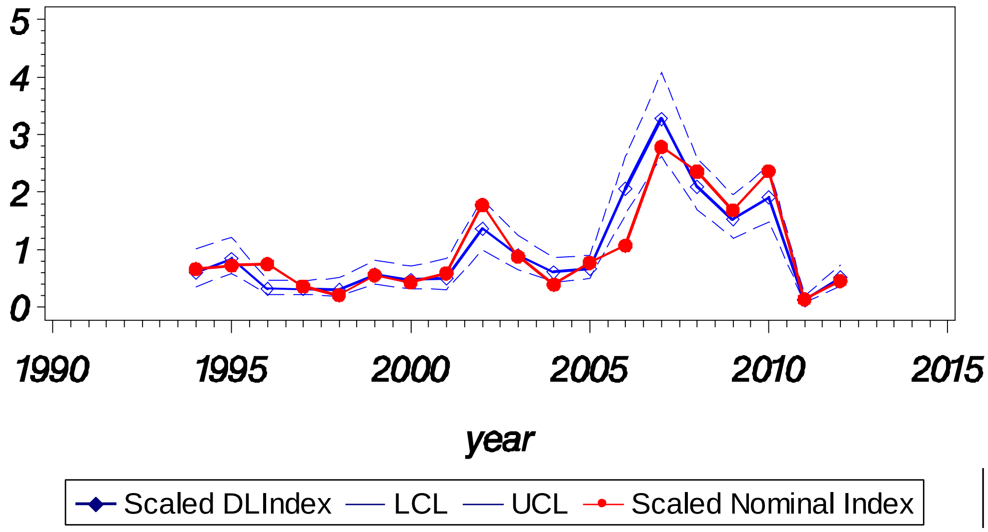

Figure 5.8.22. Unweighted abundance indices developed from all data sets combined from 1994-2012.

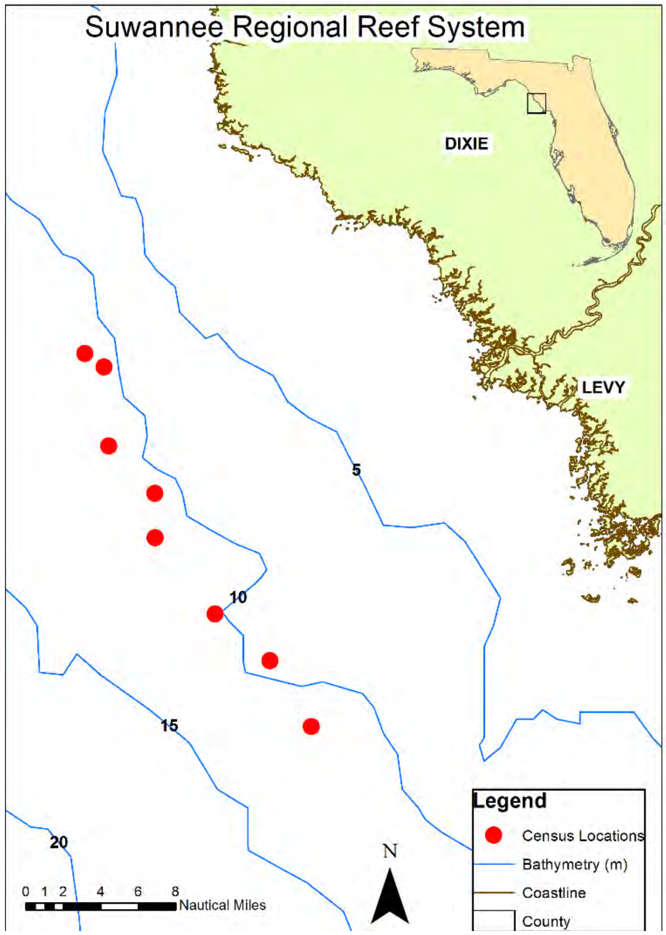

Figure 5.8.23. Location map showing the Suwannee Regional Reef System (SRRS) in the northeastern Gulf of Mexico; the 4-cube x 225m reef arrays (i.e. SRRS-low) were sampled for the UF Diver Survey, additional reefs were included in SEDAR33-DW03 for context.

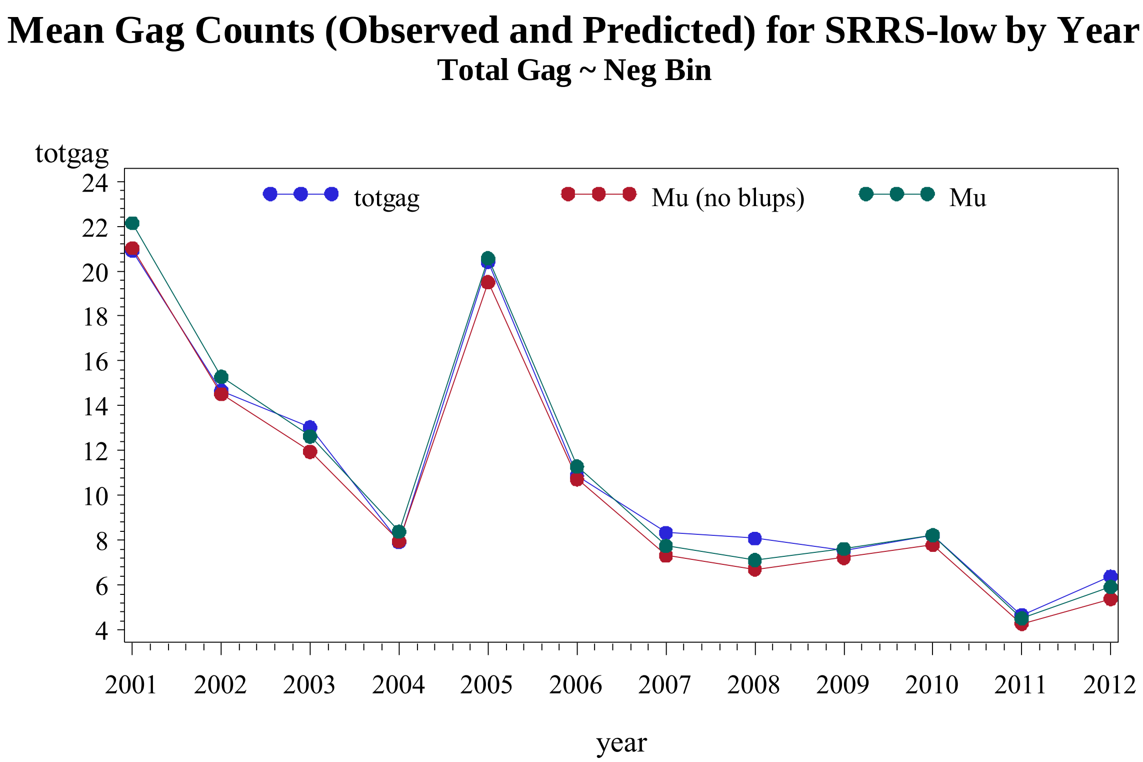

Figure 5.8.24. Observed counts of gag grouper ("totgag") for the UF reef diver survey of SRRS 4-cube arrays, the predicted marginal means ("Mu (noblups)"), and the annual means of the estimated best linear predicted values conditional on the random effects ("Mu") versus year assuming the Negative Binomial Distribution.

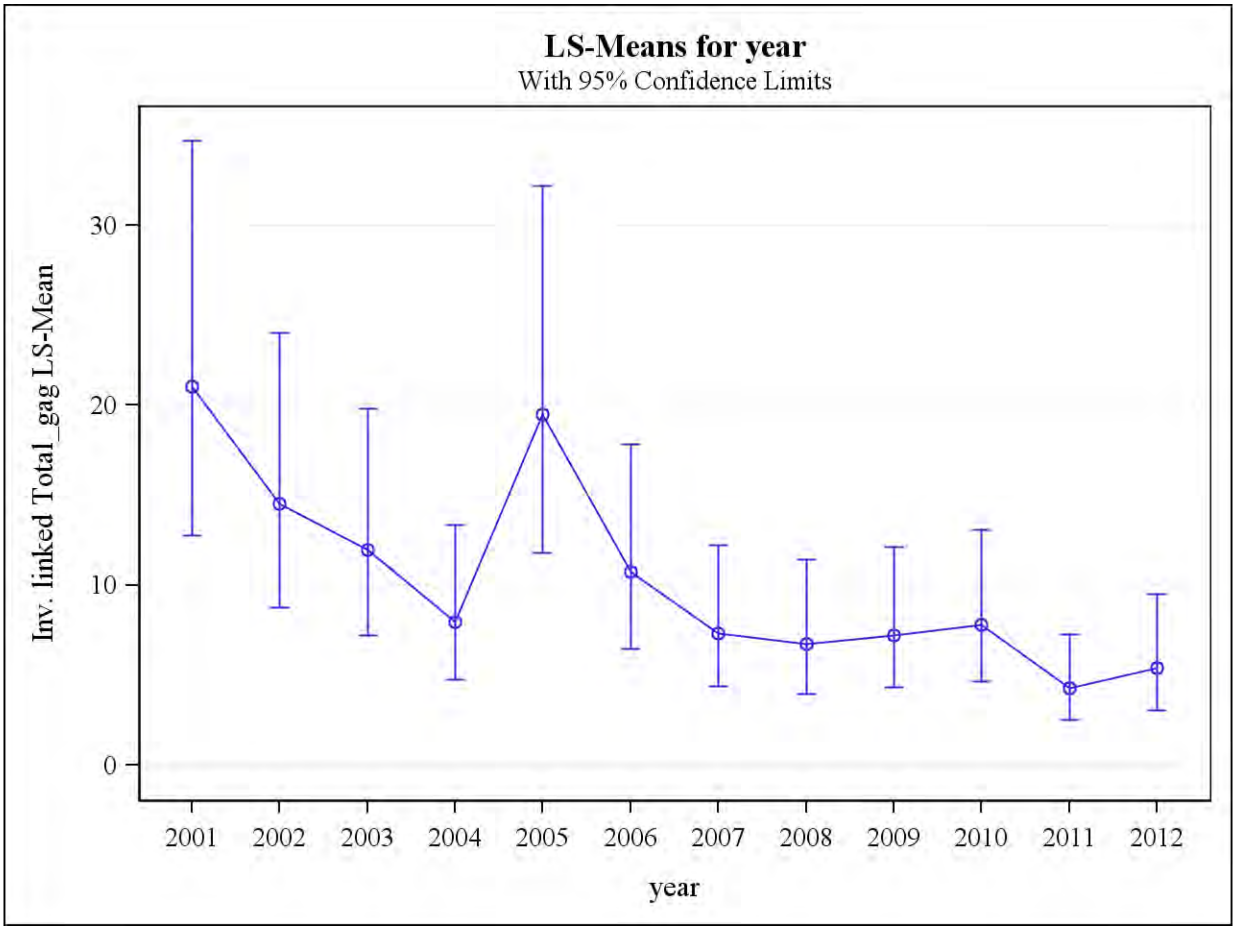

Figure 5.8.25. Annual estimated mean counts of gag grouper ("Estimated Mean"; back-transformed means from the model fit) against year with 95% confidence interval bars for the UF reef diver survey of SRRS-low arrays. The means and confidence interval end points are the back-transformed marginal means and endpoints of 95% CIs for the marginal means from the GLMM described in the text.

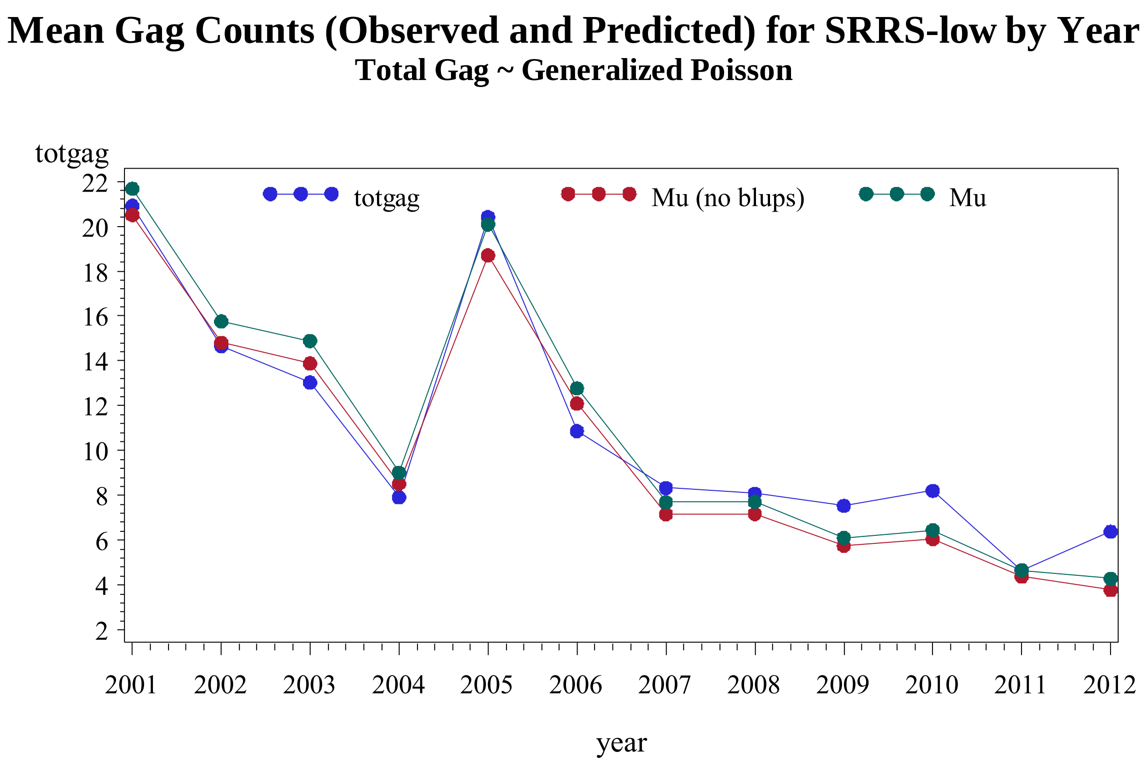

Figure 5.8.26. Observed counts of gag grouper (“totgag”) for the UF reef diver survey of SRRS–low arrays, the predicted marginal means (“Mu (noblups)”), and the annual means of the estimated best linear predicted values conditional on the random effects (“Mu”) versus year assuming the Generalized Poisson Distribution.

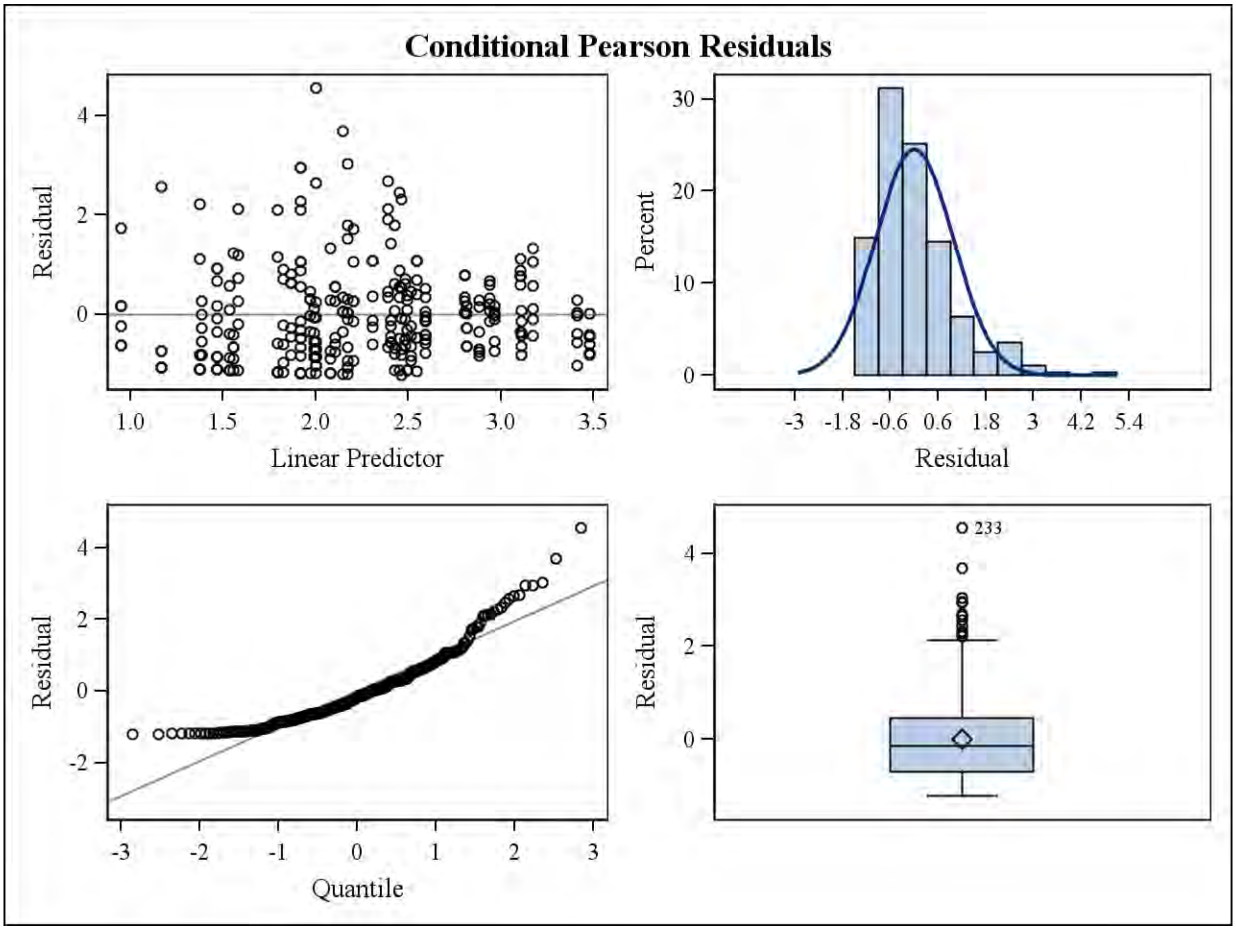

Figure 5.8.27. Pearson residual panel for the Negative Binomial mixed model.

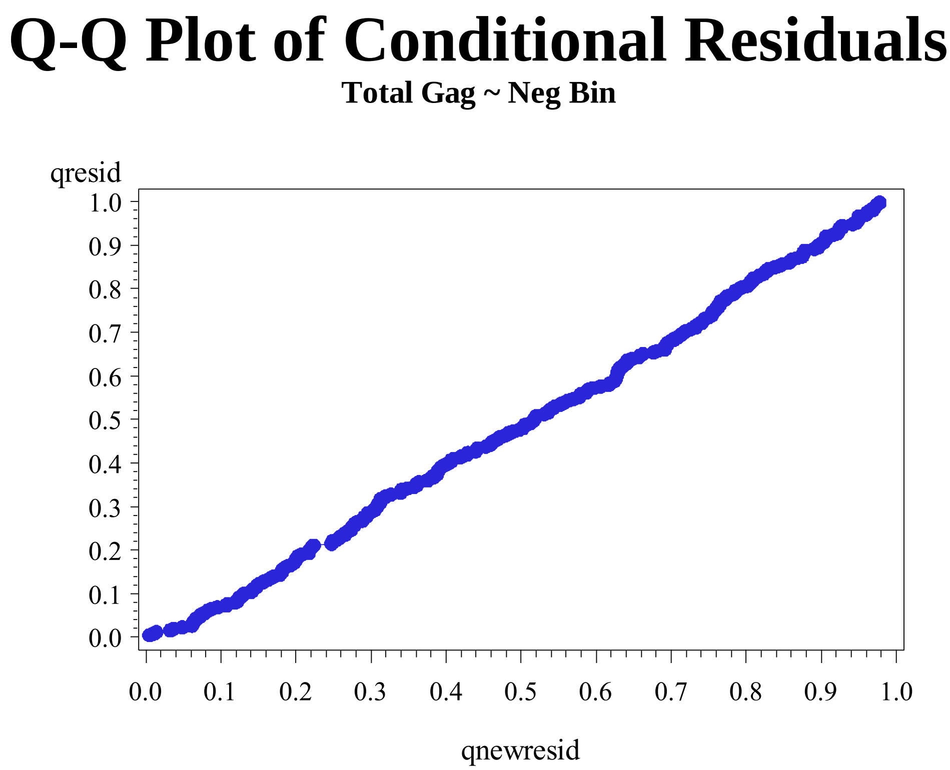

Figure 5.8.28. QQ – plot of negative binomial conditional residual quantiles versus expected quantiles for Negative Binomial distribution.

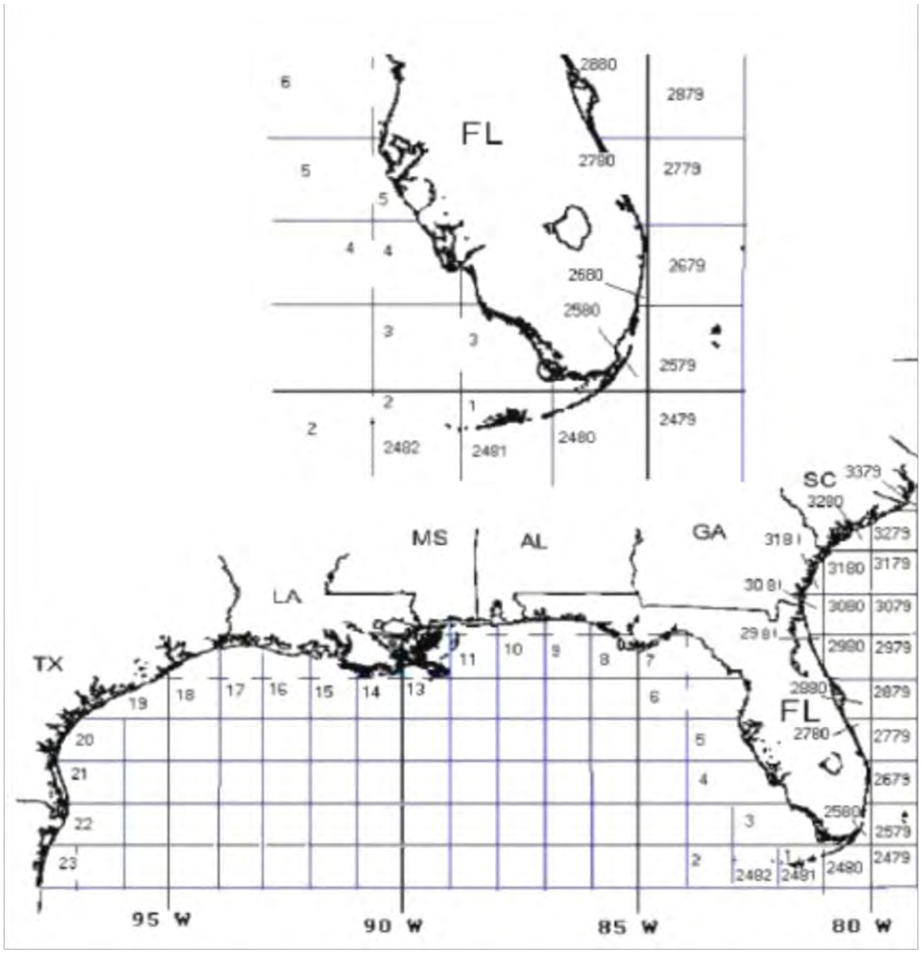

Figure 5.8.29. NMFS Statistical grid map. This analysis covered grids 1-10.

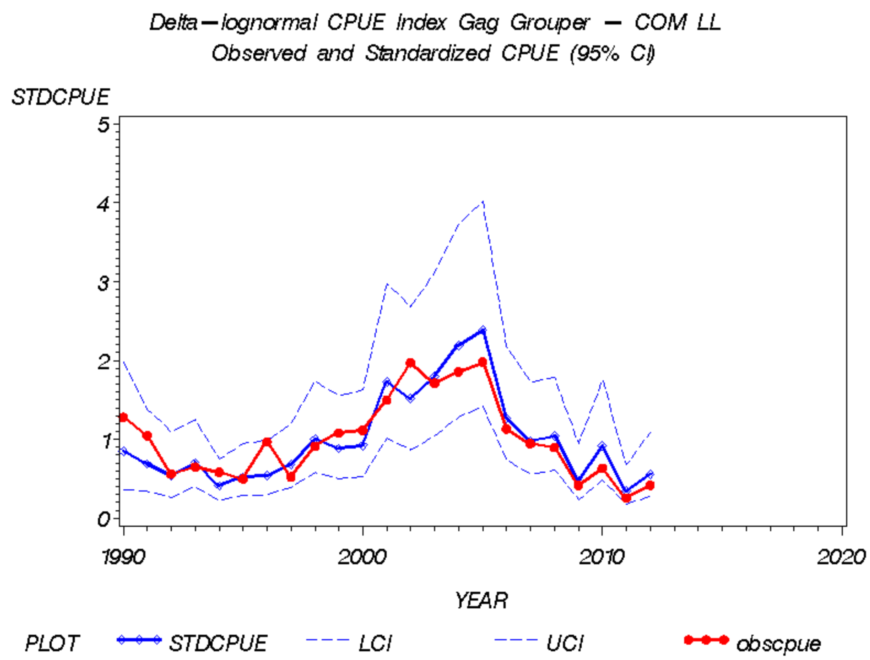

Figure 5.8.30. Relative nominal CPUE (red), relative standardized index (blue) and 95% confidence intervals (blue dotted) (*Index 1*: 1990-2012).

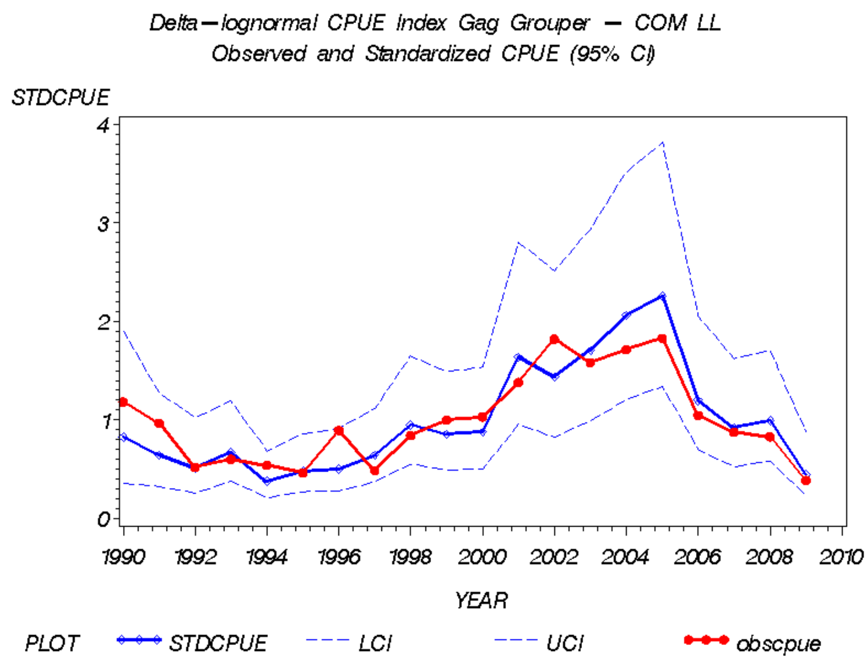

Figure 5.8.31. Relative nominal CPUE (red), relative standardized index (blue) and 95% confidence intervals (blue dotted) (***Index 2***: Pre-IFQ 1990-2009).

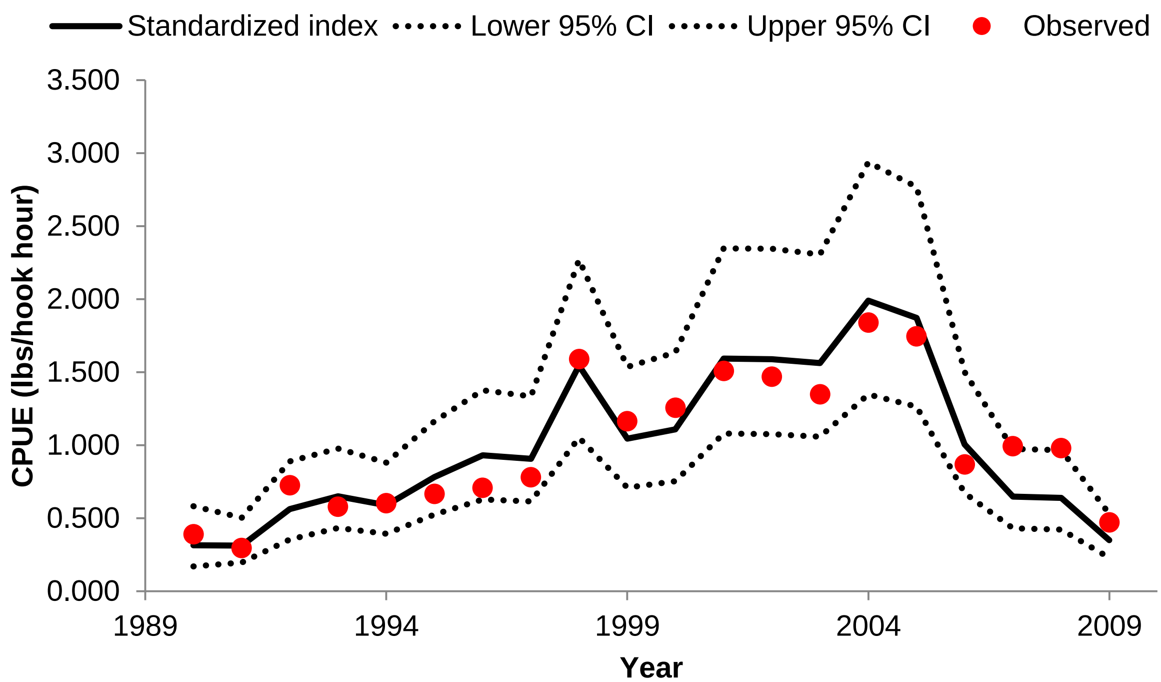

Figure 5.8.32. Nominal (observed) and standardized CPUE and the 95% confidence intervals for Gulf of Mexico gag grouper from the commercial handline fishery. CPUE values were normalized by the mean of the standardized index.

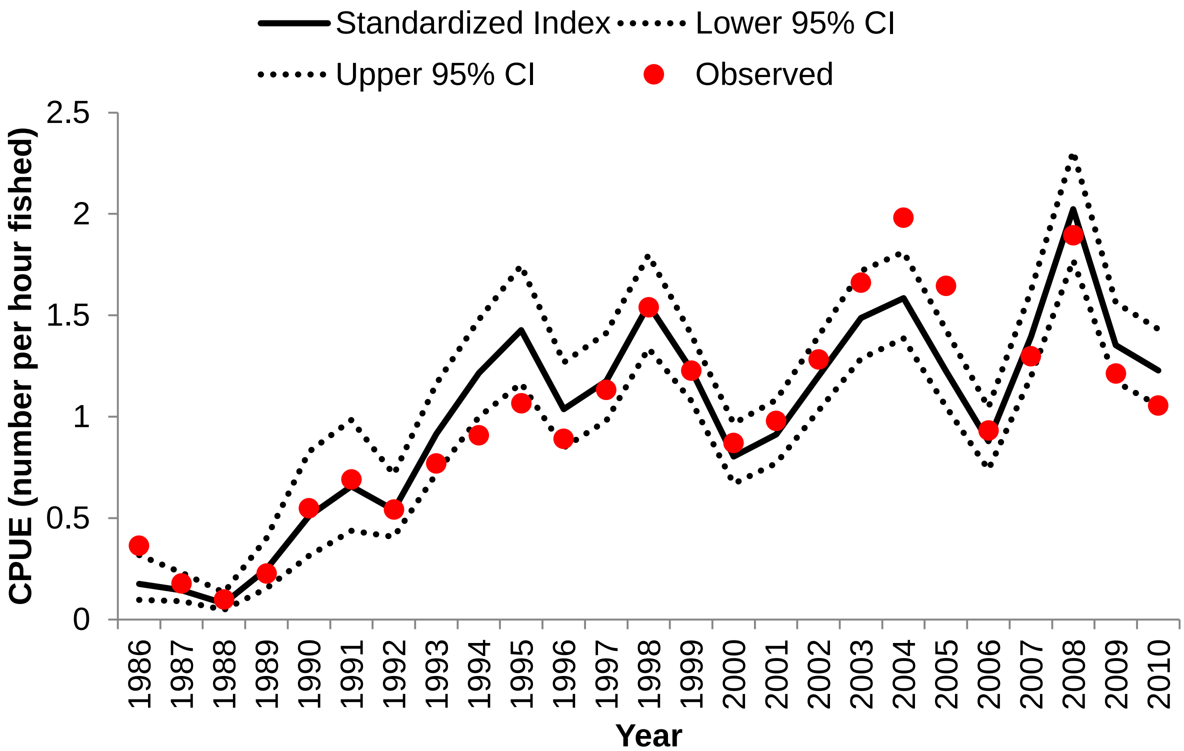

Figure 5.8.33. Nominal (observed) and standardized CPUE and the 95% confidence intervals for MRFSS Gulf of Mexico gag grouper. CPUE values were normalized by the mean standardized index.

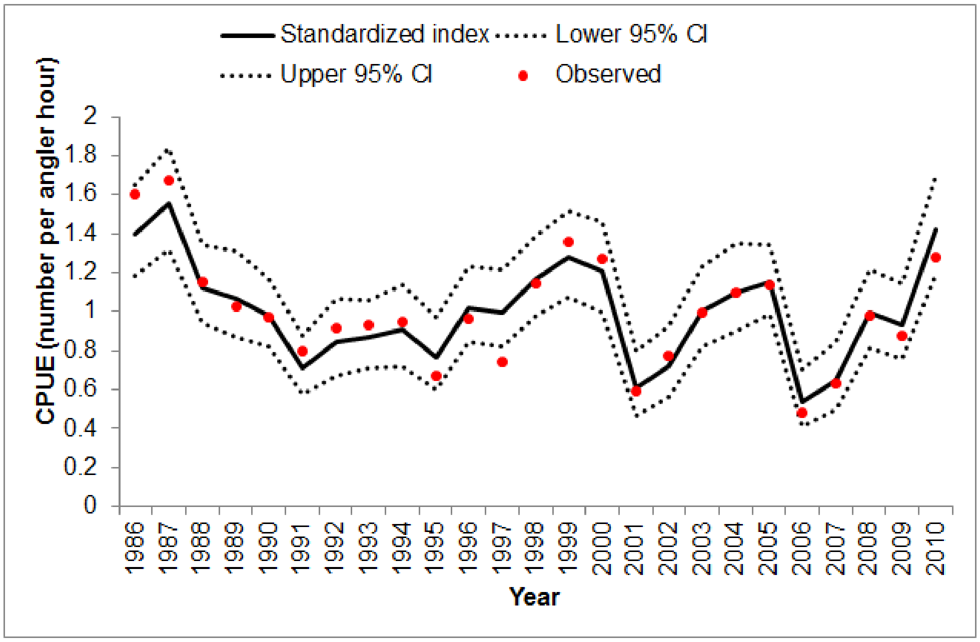

Figure 5.8.34. Nominal (observed) and standardized CPUE and the 95% confidence intervals for the eastern Gulf of Mexico gag grouper from the headboat fishery. CPUE values were normalized by the mean standardized index.

6 Ad-Hoc Discard Mortality Rate Working Group

6.1 Group Membership

Linda Lombardi, SEFSC
Matt Campbell, SEFSC
Beverly Sauls, FWRI
Kevin McCarthy, SEFSC

Agency Staff
Kathy Guindon, FWRI

Data Workshop Observer
Chad Hansen, PEW

6.2 Background

Discard mortality can be measured in three levels: immediate, short-term and long-term (Pollock and Pine 2007). Immediate discard mortality is measured from observations of fish immediately after being handled during normal fishing operations. Short-term mortality is typically measured in experimental studies, such as when fish are held in confinement (i.e., cage, holding tank) following exposure to capture or simulated capture (i.e., barometric chamber). Long-term mortality is tracked with tagging studies by modeling the recapture rate of marked fish or actively tracking individual fish with acoustic tags. Each of these methods (surface observation, experimental, and tagging) has associated caveats and assumptions that need to be considered when using resulting mortality estimates.

The previous stock assessments (SEDAR 2010 and SEDAR 2006a) for gag grouper in the GOM (Gulf of Mexico) used a combination of short-term and long-term mortality estimates to calculate a functional response of discard mortality to depth caught. This functional response was fit to data from two caging studies (Burns et al. 2002, Overton and Zabawski 2003) and to tag-recapture data (McGovern et al. 2005) (Table 6.1, red line in Figure 6.1). For the recreational sector, variable mortality rates were applied to MRFSS B2 estimates in the northern Gulf and the Florida peninsula/Keys due to the relatively shallow nature of the west Florida shelf where recreational fishing trips originating from the Florida peninsula take place. However, the source of recreational mortality estimates at depth that were used in SEDAR 10 (blue line in Figure 6.1, SEFSC 2007) is unknown.

The purpose of this report is to review the current status of discard mortality estimates from both the commercial and recreational sectors for gag grouper. Discard estimates are available directly from the commercial sector via self-reported logbook program and observer programs (Gulak and Carlson 2013, Johnson 2013), a tag-recapture study (McGovern et al. 2005), and caging studies (Burns et al. 2002, Overton et al 2008). For the recreational sector, immediate mortality estimates are available from an observer program and long-term mortality was estimated from a tag-recapture study (Sauls and Cermak 2013, Sauls 2013). This report also comments on the types of discard data collected by observer programs. Finally, the result of a meta-analysis of all the estimates of discard mortality is provided.

6.3 Methods of Estimation

6.3.1 Surface Observations

A variety of immediate discard mortalities were estimated for gag grouper released from commercial vessels and ranged from 0% to 14.7% (Table 6.3, see table for references). Commercial logbook (self-reported data) percentages were: 7.9% (hand-line), 2.4% (long-line). Commercial observer programs percentages were: 2.3% (hand-line), 11.6% (long-line, Johnson 2013), and 11.9% (long-line, Gulak and Carlson 2013). Discard mortality from self-reported logbook program and observer programs are based on the fate (condition) of the fish on release (dead or alive). Issues identified with these two sources include categories used to record discards via logbooks (most dead, all dead, most alive, all alive – more qualitative than quantitative) and the additional time fish are handled during observer commercial fishing operations (SEDAR 2013). Nonetheless, these values do provide some insight on the status of fish discarded during commercial fishing operations. It is important to note that estimates of immediate mortality only provide information on the status of the fish on release, while ignoring factors that might cause mortality over longer time periods.

Several thousand gag grouper were observed in the recreational hook-and-line fishery along the Florida's Gulf coast and percentages of gag grouper that either suffered immediate mortality or were not able to submerge immediately following release were small (1.9% headboats, 0.5% charter boats; Table 6.3)(Sauls and Cermak 2013).

6.3.2 Cage studies

Four caging studies reported a range of discard mortality rates for gag grouper, of which two studies were used to formulate the depth-mortality function used in previous assessments (Table 6.3, Figure 6.1). The first cage study reported only three gag grouper all of which died after being in cages and was not used in the depth-mortality function due to the small sample size of gag grouper (Wilson and Burns 1996). A second caging study estimated mortality rates using two different cage types (circle and square) and investigated differences between 2 hr and 48 hr holding periods, which resulted in an immediate mortality rate of 22%. Fish were caught at depths 27.1 – 34.1 m and mortality increased with increasing holding period (Overton and Zabawski 2003, Overton et al. 2008). The third study collected a total of 67 gag grouper (<500 mm) and divided the fish among cages at four depths (20 m, 35 m, 45 m, and 50 m), which resulted in a depth-mortality function with discard mortality of 50% at 43.7 m (Burns et al. 2002). The results of the Overton and Zabawski 2003 and Burns et al. 2002 cage studies were included in the data that formulated the depth-mortality function applied in the last Gulf of Mexico gag assessment (SEDAR 2010). The most recent caging study held gag for 48 hours in net pens at a mean depth of 5.7 m and resulted in 8 of the 111 gag dying (7.2% mortality rate) within the experimental time period, minimum of 48 hours (FWRI 2011).

6.3.3 Passive and acoustic tagging

Gag grouper (n = 3876) were tagged off the US South Atlantic coast over a four year period (1995-1999) through a cooperative program with the South Carolina Department of Natural Resources and commercial captains using primarily bandit reels and J hooks (McGovern et al. 2005, SEDAR 2006c). Tag and recapture percentages were reported for each 10 meter depth interval, based on depth of original capture (Table 6.3, Figure 6.1). A logit model was used to fit the nominal tag-recapture data, which was reported as a depth-mortality function and applied in the last assessment in the Gulf of Mexico (SEDAR 2010). After discussing the logit model with the primary author, (pers. comm., J. McGovern June 2013), the discard mortality workgroup for this SEDAR determined that this function is likely influenced by declining recapture rates with increasing distance from shore. The discard mortality working group does not recommend the application of this depth-mortality function, since the tag-recapture model did not include other parameters such as survivorship and the effects on recapture rate of variable fishing effort over spatial and temporal scales.

In another tag-recapture survey conducted in Florida, 3,832 gags were tagged (2009-2012) by fishery observers on recreational vessels (headboats and charter boats). From this tag-recapture data a proportional hazards model was developed that makes use of relative survival of gags in good, fair and poor condition categories by 10 m depth intervals (Sauls 2013), and additionally included covariates that controlled for variable recapture rates for gags tagged in different time periods and regions. The majority of gags were released in good condition (77.8%) and only 4% of gags were released in poor condition. Survival for gags released in fair and poor condition relative to those released in good condition were derived from the proportional hazards model (69.1% and 46.1% respectively) and were held constant in the depth-mortality functions provided in Table 6.3 and illustrated in Figure 6.1. In the absence of a true control (fish had to be captured in order to be tagged and released), the depth-mortality function was calculated based on four assumptions for gags released in good condition: 1) 100% survived, 2) 90% survived, 3) 80% survived, and 4) 70% survived (Table 6.3, Figure 6.1). Since the majority (91%) of gags released in good condition were caught in depths of 30 meters or less, the depth-mortality function from Sauls (2013) that assumes 90% survival for gags released in good condition is supported by other available studies for gag (FWRI 2011) and other species (Table 6.4) that indicate overall discard mortality (for fish released in all conditions) is less than 15% when captured in shallow depths.

6.4 Depth Effect

There is evidence to support changes in discard mortality with depth for gag grouper (Table 6.3, Figure 6.1). Gag collected by the recreational sector (Sauls and Cermak 2013, Sauls 2013) showed increased mortality with an increase in depth. Controlled caging studies also reflected an increase in mortality with depth (Burns et al. 2002, Overton et al. 2008, FWRI 2011). In addition, meta-analysis concluded depth was a significant factor among discard mortality estimates regardless of the inclusion/exclusion of the McGovern et al. 2005 estimates (see below for further information).

6.5 Thermal stress

All of the studies evaluated in this report estimated annual rates and were reflective of quarterly sampling. There are no specific information that could be used to evaluate effects of seasonality or more specifically water temperature. Therefore, at this time there is no evidence to support changes in discard mortality with respect to season or water temperature aspects.

6.6 Hook Type Effects

Circle hooks have been mandated to be used in both recreational and commercial fisheries since June 2008 (GMFMC 2013), and therefore it is important to consider the effect of hook type on release mortality. Gag grouper caught in the recreational sector experienced similar lethal injuries (given the location of the hook) from circle hooks (3.77%) compared to other hook types (5.44%) (Sauls and Ayala 2012). Immediate discard mortality for recreationally caught gag grouper is very low (<2%) and these discard mortalities were estimated from a variety of hook types, therefore, an effect of hook type on discard mortality is unlikely to be significantly different (Sauls and Cermak 2013). Similar to the Sauls and Ayala (2012) report, the meta-analysis also showed no effect by hook type.

6.7 Venting and Bottom Release Devices

Venting devices have been mandated to be used in both recreational and commercial fisheries since 2008 (GMFMC 2013), but it is evident from observed recreational and commercial vessels venting does not occur all the time. The decision to vent is likely influenced by the depth where fishing takes place. Fishery observers reported that gag discards were vented 50%-60% of the time in regions where recreational fishing takes place in deeper depths, compared to less than 10% of the time in regions where fishing takes place in shallower depths (Sauls 2013). Studies evaluated in this review show that venting devices were only used consistently in McGovern et al. 2005 tag-recapture study, while the majority of other studies report inconsistent venting (i.e. some, but not all fish were vented). It is presumed that venting gag grouper would increase their survivorship, since gag do exhibit common characteristics associated with barotrauma when captured from deep depths, including swim bladder or stomach protruding, bulging eyes, bubbles under the skin, internal hemorrhaging, and even the bursting of the swim bladder (Burns et al. 2002). In general, the effects of barotrauma are known to increase with depth given the expansion of gas with the change of pressure as depth increases. Venting was also considered to be a significant factor in the meta-analysis results regardless of inclusion/exclusion of the McGovern et al. 2005 data (see below for further information).

6.8 Commercial Sector Release Mortality

Immediate discard mortality estimates for the commercial sector were calculated using self-reported commercial logbooks and at-sea observers. These methods of data collection have issues with data reporting (logbooks) and the length of time discarded fish remain on-board prior to release. Observer programs have been collecting data on discarded fish from commercial reef fish vessels since 2006. The type of data collected on discarded fish includes: fish identification, length, weight, condition of the fish on capture (alive, dead, alive-air bladder/stomach protruding, alive-eyes protruding, unknown), release fate (released dead, released alive, kept, unknown), hook location (mouth/jaw, internal, foul, unknown) and whether or not the fish was vented (SEFSC 2011, SEFSC 2013). Observers collect data on discarded fish from vessels using vertical line (handline and electric/hydraulic reels) or long-line gear and data collection typically takes less than 30 seconds per fish (pers. comm., reef fish and shark bottom long-line observer programs' administrators). The time spent per discarded fish may increase given several factors: gear type, number of fish captured in a single haul (e.g., the number of reels and number of hooks per reel), observer experience, flow of fishing operations, and sea state.

During SEDAR31 (red snapper) discussions were conducted among commercial fishers, reef fish observer program personnel, and the discard mortality working group in regards to the discard mortality estimates derived from fish discarded during observed commercial operations (SEDAR 2013). Captains of commercial vessels expressed concern that discarded fish were kept on-board for prolonged periods of time and therefore, the release mortality estimates derived from these data might not be reflective of normal operations aboard commercial vessels. Extended fish handling time might be the result of the data collection being conducted by observers that commercial fishers would not be conducting (e.g. exact measurements of fish and precise recording of incoming data). The amount of time a discarded fish is exposed to air may increase when an observer is on-board, but the amount of time would vary given the factors identified above. In particular, it would be more likely that fish caught by multiple bandit reels with multiple hooks would be exposed to air longer than fish caught on long-line gear that have hooks spaced apart further. While no specific estimates of immediate discard mortality by gear for the commercial sector are being recommended, data on discards from observer programs do provide some insight into the commercial fishery.

Hand-line vs. Long-line
In previous assessments, recommendations were only made to the entire commercial sector and were not gear specific. For the commercial vertical line fishery, the discard mortality working group recommends the depth mortality function from Sauls (2013) that assumes 90% survival for gags released in good condition. However, this study does not include gags caught from depths greater than 70 meters, where longlines may be fished. Currently, there are no research derived discard mortality estimates specific to long-line gear. Data provided by the commercial observer program indicates that most commercial hand-line and long-line discarded gag were caught at similar depths (40-80 m) (Johnson 2013). The majority of gags caught at these depths are larger, of legal size, and less likely to be discarded (Johnson 2013). Also, commercially landed gag are primarily reported from vessels fishing vertical line (hand-line) gear.

The working group discussed the availability of discard mortality estimates from other groupers to apply to the commercial long-line sector; however, there is not an extensive list of this data. Gag grouper are classified as a shallow-water grouper along with red grouper and scamp. Currently, there are no discard estimates for scamp and the only estimate for red grouper from commercial long-line is a point estimate (discard mortality rate 45%, SEDAR 2006e). Gag are sometimes caught with deep-water groupers (e.g. yellow-edge grouper, snowy grouper) but discard estimates for these species are negligible, primarily due to lack of size limit for these species and trauma these fish experience given the depths caught (SEDAR 2011).

6.9 Developing a Functional Response

Selection of appropriate release mortality estimates to use in a stock assessment requires good knowledge of estimation methods and their associated biases. Meta-analytical methods allow inclusion of all available point estimates, includes a sample size weighting scheme, and allows for the use of covariates in a mixed-effects modeling approach (Viechtbauer 2010). The meta-analysis approach was developed, and is useful, because it reduces the introduction of bias that hinders non-parametric approaches often found in review papers (Sterne et al. 2000, Nakagawa and Santos 2012). The human selection element is reduced thereby allowing data to more properly guide the decision making process. The working group recommended a meta-analysis approach with the intent of identifying critical issues and deriving a model of discard mortality in the Gulf of Mexico gag grouper recreational and commercial fishery as a function of important covariates such as depth, discard mortality estimation type, fishing sector, gear, and venting procedures employed. Results of the meta-analysis are recommended to evaluate sensitivity of the assessment model to various levels of release mortality.

Data used in this meta-analysis were compiled from 13 sources that produced 35 distinct release mortality estimates the details of which are covered in previous sections (see Table 6.3). Data were extracted from each publication relating to proportional or percent mortality, water depth (m), study type (surface observation, cage/experimental, tag-recapture), type of discard mortality estimate derived (immediate or delayed-including short- and long-term), fishing sector evaluated (commercial or recreational), season (summer, annual), hook type (circle or j hook), degree of venting (no venting or some venting), and sample size (n). No data exclusions were made in the original run; however, a second model excluded the McGovern et al. (2005) estimates because it was discovered that they are actually representative of recapture rates rather than release mortality rates.

The meta-analytical model used is a special case of a weighted general linear model as detailed in the metafor R package (Viechtbauer 2010). The analysis was performed on effect size (*es*) rather than raw proportions, where *es* is the logit-transformed proportion and was calculated as:

$$es = \log \left(\frac{x_i}{(n_i - x_i)}\right)$$

where x_i is the total number of individuals experiencing mortality and n_i is the total sample size. The estimate and the corresponding sampling variance were calculated using the escalc function in metaphor R package (Viechtbauer 2010).

We fit *es* estimates in a mixed-effects model to evaluate the effects of depth, discard mortality estimate type, fishing sector, season, hook, and venting compliance (Viechtbauer 2010). For the categorical variables the absence of group membership (i.e. setting the value to 0) by default defines the opposite group, and therefore there is no need to have all variables included. For instance, the only discard mortality estimate type included in the model was delayed, and therefore any values set equal to 0 for the ‘delayed’ variable indicate values associated with immediate discard mortality estimates. The dummy-coded fishing sector variable was commercial (0 = recreational). Dummy-coded seasonal variables included in the model were annual (0 = summer). The dummy coded hook variables included in the model were circle and mixed (0 = J hook). Dummy coded venting compliance variables included in the model were venting (100% venting), and intermittent venting (0 = no venting). The full estimated model is shown, below:

Prob(mortality) ~ depth + estimate type + hook type + venting treatment + study

where depth of capture in meters is modeled as a continuous variable and all other variables are modeled as categorical. Estimate type refers to the timing of the mortality observation and is classified as immediate or delayed. Hook type is classified as J, circle or mixed, and study is modeled as a random effect. Venting treatment is categorized as no venting took place or some venting occurred. Study represents each individual study, or when a study was conducted with different treatments, individual studies were separated and each modeled as random effects.

Heterogeneity (τ^2) was estimated using restricted maximum-likelihood (REML) then coefficients for μ, $\beta_0,\ldots,\beta_{p'}$ were estimated using weighted least squares in which each *es* estimate is weighted by the inverse of its variance. Wald-type tests and confidence intervals were calculated for μ, $\beta_0,\ldots, \beta_{p'}$ assuming normality. Based on the fitted model we calculated predicted values, and residuals. Cochran's *Q*-test was used to assess the amount of heterogeneity among studies (i.e. a null hypothesis of $\tau^2 = 0$). Predicted values and associated upper and lower bounds were then converted back to proportions by taking the inverse of the logit transformed effect size data as:

$$Proportion = \frac{exp^{es}}{(1 + exp^{es})}$$

Average model predictions (identified as baseline in graphs) were evaluated by giving equal weighting to the coefficients within fishing sector, venting, season and hook type and inputting a depth range of 10 to 200 m. Venting model predictions were evaluated by toggling the venting effect on. Seasonal model predictions were evaluated by toggling each season variable individually. All other coefficients for the venting and seasonal predictions were set to the intercept and both effects were evaluated for each fishing sector separately.

Meta-analysis of the release mortality estimates when including the McGovern et al. (2005) data showed significant effects (Table 6.5) for depth, immediate estimates (Ti), both venting treatments (Vs and Vn), and J-hooks (Hj). This run of the model reported an AIC value of 105.05. The strength of the categorical factors influencing mortality can be determined from the model coefficients which indicate that depth, and J-hooks were the most influential factors increasing mortality while venting and immediate discard mortality estimates showed negative effects on mortality. The amount of heterogeneity in effect size from the mixed-model was estimated to be τ^2=0.6. Cochran's Q_E test for the mixed-model also shows significant residual heterogeneity ($Q_E = 2938$, $df = 28$, $p < 0.0001$), indicating that the model did not fully explain the observed variation in release mortality estimates. Average model predictions (equal weighting of the coefficients, labeled baseline in the figure) and inputting a depth range of 10 to 200 m resulted in predicted mortality from 0 to 95% and was heavily dependent on depth and mortality estimate type (Figure 6.2a).

A second run of the model with McGovern et al. 2005 data removed showed significant effects for depth, immediate estimates and for estimates that had some amount of venting. This run of the model reported an improvement in AIC value of 81.36. Similar to the first model run the depth was the most influential factor increasing mortality while venting and immediate discard mortality estimates showed negative effects on mortality. However, in this second model run the effect of J-hooks was non-significant. The amount of heterogeneity in effect size from the mixed-model was estimated to be $\tau^2=0.67$. Cochran's Q_E test for the mixed-model also shows significant residual heterogeneity ($Q_E = 2553$, $df = 19$, $p < 0.0001$), indicating that the model did not fully explain the observed variation in release mortality estimates; however, this second run explained more variation than the first. Average model predictions (equal weighting of the coefficients, labeled baseline in the figure) and inputting a depth range of 10 to 200 m resulted in predicted mortality from 0 to 78% and was also heavily dependent on depth and discard mortality estimate type (Figure 6.2b).

Similar to many other studies, and across many taxa, depth plays a significant role in release mortality and always shows increasing rates with increasing depth. Similar to a meta-analysis on red snapper (Campbell et al. *In Review*), estimates stemming from surface observations tend to underestimate release mortality due to the effects of unobserved delayed mortality. Similar to red snapper there is a positive effect on survival for fish that are vented (Table 6.5, Figure 6.3). The primary difference between the two model runs was the loss in significance of the J-hook effect, although this effect in the original model was largely confounded by the McGovern et al. 2005 in which J-hooks were used exclusively (Table 6.5, Figure 6.4). Reported mortality rates from the McGovern et al. 2005 were not estimated using models that incorporated spatio-temporal fishing effort and survivorship was estimated outside of the recapture model itself, therefore the effect that is attributed to J-hooks in the original model run may be an artifact of estimation methodology rather than gear. The removal of the McGovern et al. 2005 data reduces the predicted mortality rates, particularly for the deepest depths.

6.10 Comments and Recommendations

During most SEDARs, discard mortality rates have been assigned as part of the Terms of Reference for the life history group but for some species, whose discards account for a large proportion of the landings, a separate working group is more appropriate (as is the case for gag grouper). Having a separate working group for discard mortality rates has provided a more thorough and systematic review of past and current literature. In addition, more attention has been applied to the particular types of mortality rates (immediate, short-term, long-term) being reported in the literature and therefore, recommendations are more suitable.

The discard mortality working group has recommended using alternative estimates for mortality for both the recreational and commercial sectors, compared to what was applied in previous assessments for discard mortality. The working group does not recommend using the depth-mortality function that was applied to commercial sector in SEDAR10, since this function did not reflect release mortality by depth (instead reflected only recapture rates by depth). In addition, no justification or origin has been located for the recreational discard mortality rates that were used to estimate mortality of fish released alive (B2s) in SEDAR10. Through the use of the meta-analysis approach, the working group's recommendations are based on model fitting and objective processes rather than human selection thereby, allowing data to properly guide the decision making process.

Recreational

Discard mortalities corresponding to regions of the Gulf of Mexico (panhandle, peninsula, keys), depth zones (inshore, ocean <10 nm, ocean >10nm), and average depths (10m, 20m, 30m, 40m) were used to estimate recreational dead discards during the previous assessment (SEFSC 2007)(Figure 6.1). However, the origin of these values is unknown and with the new results of Sauls (2013) tag-recapture model, the discard working group recommends applying the depth-mortality function from Sauls (2013) that assumes 90% survivorship for gags released in good condition to calculate the recreational dead discards for SEDAR33. This tag-recapture model used a proportional hazards model that included covariates that controlled for variable recapture rates for gags tagged in different time periods and regions. This function provides mortality estimates for the depth strata common to the recreational fishery and for those strata that were used in the previous assessment.

Commercial

The SEDAR10-DW concluded that the mortality of discarded gag grouper is highly correlated with the depth of capture of the fish and recommended to include this information in the estimation of release mortality for gag grouper (SEDAR 2006a). Based on several research studies (Burns et al. 2002, Overton and Zabawski 2003, McGovern et al. 2005), a depth-mortality logistic function was estimated (Figure 6.1). Overall, 50% mortality was observed with fish caught at about 45 m deep, and above 95% for fish caught at 100 m or deeper.

The SEDAR33 discard working group also agrees that discard mortality is correlated with depth but do not recommend the use of McGovern et al. 2005 to formulate the depth-mortality function. This depth-mortality function was assumed to reflect release mortality in SEDAR10 (SEDAR 2006); however, after further investigation of the logit model (pers. comm., J. McGovern June 2013), this function only reflects the recapture rates at depth and is likely influenced by declining recapture rates with increasing distance from shore. There is also less confidence in the results of the Burns et al. 2002 study, since the report does not provide a complete description of the number of fish per cage but only that 67 gag grouper (<500 mm) were divided among cages at four depths (20 m, 35 m, 45 m, and 50 m, see Figure 20 Burns et al. 2002).

The SEDAR33 discard working group recommends applying the depth-mortality function from Sauls (2013) that assumes 90% survivorship for gags released in good condition for calculation of commercial vertical line (hand-line and electric/hydraulic reels) dead discard estimates. Although the Sauls depth-mortality function was developed from recreational fishery data, no equivalent study has been conducted using commercial fishery data. The Sauls depth-mortality function, however, does provide mortality estimates for the depth strata common to the commercial vertical line fishery. Lacking commercial fishery specific information, the working group believes that the use of the Sauls depth-mortality function for estimating gag discard mortality from the commercial vertical line fishery is warranted. In addition, the discard mortality working group recommends (as a model sensitivity run) applying the discard mortality estimates from the baseline meta-analysis model (excluding the McGovern et al. 2005 study) to estimate discards from the commercial hand-line gear.

In the past assessment, one depth-mortality function was applied to the entire commercial sector and gear-specific mortality rates were not recommended. Other than the immediate discard mortality estimates from the commercial self-reported logbook program and observer programs, there are no research derived discard mortality estimates specific to long-line gear. In addition, there are no discard mortality estimates specific to long-line gear that would be comparable from other shallow-water or deep-water grouper species. Therefore, the discard mortality working group recommends (as a model sensitivity run) applying the discard mortality estimates from the baseline meta-analysis model (excluding the McGovern et al. 2005 study) to estimate discards from the commercial long-line gear. The meta-analysis model output provides discard mortality estimates throughout the depth range of the commercial long-line sector, which are not available from Sauls (2013) tag-recapture model.

Future studies reporting discard mortality estimates should provide data tables that report the number of fish by discard condition (e.g. dead or alive), the number of fish by depth and by length bin, complete descriptions of gear (reel and hook type), and whether fish were properly vented. In addition, analyses of long-term mortality estimates from tag-recapture studies should account for survivorship and the effects of variable fishing effort over spatial and temporal scales.

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6.12 Tables

Table 6.1. Discard mortality estimates applied to previous assessments for gag grouper in the Gulf of Mexico (GOM) and South Atlantic (SA).

Assessment Year	Region	Discard mortality	Citation
2010 update[a]	GOM	Depth-mortality function Mortality = 1/(1+exp(-k(depth-50%mortality))) k = 0.058649; 50% mortality = 45.5 m	SEDAR 210
2006[a]	GOM SA	Depth-mortality function Mortality = 1/(1+exp(-k(depth-50%mortality))) k = 0.058649; 50% mortality = 45.5 m	SEDAR 2006a
2001	GOM	20% (Recreational), 30% (Commercial)	Turner et al. 2001
1998	SA	0%, 20%, 50%	Potts and Manooch 1998
1997[b]	GOM	20% (Recreational), 33% (Commercial)	Schirripa and Legault 1997
1994[c]	GOM	0%, 20%, 33% (most realistic)	Schirripa and Goodyear 1994

[a]Burns et al. 2002 and McGovern et al. 2005
[b]SEFSC 1995
[c]Schirripa et al. 1993

Table 6.2. List of citations irrelevant for discard mortality estimates for both gag grouper and greater amberjack.

Citation	Rationale for irrelevant research
Patterson et al. 2012	Primarily reporting hook selectivity for red snapper
Stephen and Harris 2010	Primary author no confidence in using discard estimate provided in manuscript due to limited number of discards
Rudershausen et al. 2010	Passive tag-recapture study in North Carolina but did not include gag grouper or greater amberjack
Burns et al. 2008	No discard mortality rate reported. The report simply evaluates tag returns with no consideration of effort.
Bacheler and Buckel 2004	No discard mortality rate reported. Hooking and barotrauma injury rates reported. Circle hooks greatly reduced the number of gut hooking incidents
Burns et al. 2002 SEDAR 2006d	No discard mortality rate reported. The report simply evaluates tag returns with no consideration of effort.
Burns and Restrepo 1999	No discard mortality rate reported. Report evaluates tag returns. No consideration of effort. Seasonal returns. Venting vs. Non-venting by depth tag returns.
Wilson and Burns 1996	No discard mortality rate reported. The project did not account for regional or annual variation in effort
Moe 1972	Does not report any data, just a review of movement study
Moe 1966	No discard mortality rate reported

Table 6.3. Meta-data of discard mortality estimates for gag grouper (in order by year of citation). Discard mortality may refer to immediate (surface observation), short-term (cage or experimental study, or long-term (tag-recapture study). Size reflects length as reported in citation. LL = Long-Line, HL = Hand-Line

Depth (m)	Season	Region	Method	Size Range (mm) Mean or Range	Discard Mortality	N	# dead	# alive	Hooks	Mode	Vent	Relevant	Citation
Unknown	All year	Gulf of Mexico	Surface Observation		7.92% (HL) 2.35% (LL)	89,929 (HL) 9,827 (LL)	7,120 (HL) 231 (LL)	82,809 (HL) 9,596 (LL)	Unknown	Commercial, Vertical line	Unknown	Yes	Commercial logbooks SEDAR33
11-220 (mean 70)	All year	Gulf of Mexico	Surface Observation	310-1300 800 (mean)	11.9% (LL)	261	31	230	Circle and J	Commercial, Long line	Selective	Yes	Gulak and Carlson 2013 SEDAR33-DW23
35-115 (majority 40-80)	All year	Gulf of Mexico	Surface Observation	305-1168 (HL) 356-1321 (LL)	2.25% (HL) 11.62% (LL)	3,517 (HL) 1,222 (LL)	79 (HL) 142 (LL)	3,438 (HL) 1,080 (LL)	Unknown	Commercial, Vertical line	Unknown	Yes	Johnson 2013 SEDAR33-DW13
10-70 (mean 38.5)	All year	Eastern Gulf of Mexico – FL, AL	Surface observation	170-980	1.19%	5141	61	5080	Circle and J	Hook and line, Headboats	Selective	Yes	Sauls and Cermak 2013 SEDAR33-DW05
10-70 (mean 38.5)	All year	Eastern Gulf of Mexico – FL, AL	Surface observation	260-900	0.52%	1725	9	1716	Circle and J	Hook and line, Charter boats	Selective	Yes	Sauls and Cermak 2013 SEDAR33-DW05
0-10	All Year	NE Gulf of Mexico (west FL shelf)	Tag-recapture		2.5%, 11.9%, 21.3%	3,832			Circle or J	Recreational, hook and line	Selective		Sauls 2013 SEDAR33-DW06
11-20	All Year	NE Gulf of Mexico (west FL shelf)	Tag-recapture		1.9%, 11.5%, 21.1%	3,832			Circle or J	Recreational, hook and line	Selective	Yes, range of mortalities based on varied assumption of survival (80%, 90%, 100%) for fish in good condition that may be used for sensitivity runs	Sauls 2013 SEDAR33-DW06
21-30	All Year	NE Gulf of Mexico (west FL shelf)	Tag-recapture		9.0%, 16.4%, 23.8%	3,832			Circle or J	Recreational, hook and line	Selective		Sauls 2013 SEDAR33-DW06
31-40	All Year	NE Gulf of Mexico (west FL shelf)	Tag-recapture		21.2%, 24.9%, 28.6%	3,832			Circle or J	Recreational, hook and line	Selective		Sauls 2013 SEDAR33-DW06
41-50	All Year	NE Gulf of Mexico (west FL shelf)	Tag-recapture		25.8%, 28.4%, 31.0%	3,832			Circle or J	Recreational, hook and line	Selective		Sauls 2013 SEDAR33-DW06
51-60	All Year	NE Gulf of Mexico (west FL shelf)	Tag-recapture		20.1%, 24.2%, 28.3%	3,832			Circle or J	Recreational, hook and line	Selective		Sauls 2013 SEDAR33-DW06
61-90	All Year	NE Gulf of	Tag-recapture		26.3%, 30.4%,	3,832			Circle or J	Recreational,	Selective		Sauls 2013

Table 6.3. Meta-data of discard mortality estimates for gag grouper (in order by year of citation)…continued

Depth (m)	Season	Region	Method	Size Range (mm) Mean or Range	Discard Mortality	N	# dead	# alive	Hooks	Mode	Vent	Relevant	Citation
		Mexico (west FL shelf)			34.5%					hook and line			SEDAR33-DW06
													Sauls 2013 SEDAR33-DW06
Range of depths	All Year	NE Gulf of Mexico (west FL shelf)	Hook location	500	3.77% potentially lethal hook injuries	1,433			Circle	Recreational, hook and line	Selective		Sauls and Ayala 2012
Range of depths	All Year	NE Gulf of Mexico (west FL shelf)	Hook location	500	5.44% potentially lethal hook injuries	772			J	Recreational, hook and line	Selective	Yes, low percentage of potentially lethal hook injuries for both circle and J hooks, no significant reduction with circle hooks	Sauls and Ayala 2012
5.7 (mean)	All Year	Lower Tampa Bay (inshore)	Net pen (holding)	< 540	7.2%	111	8	103	Circle	Recreational, hook and line	No	Yes	FWRI 2011
15-45	All Year	South Atlantic - NC	Cage and onboard holding tanks	295-573 476 (SE 14)	21.9 %	33	7	26	Circle or J	Recreational, Hook and line	Vented by lowering in cages	Yes. Low sample size.	Overton et al. 2008 Overton and Zabawski 2003
19-50	All Year	South Atlantic - Onslow Bay, NC	Surface observations		0%	55	0	55	J electric reels	Commercial, vertical line	No	Yes. Fishing depths not readily apparent. Great info on hooking location with J hooks	Rudershausen and Buckel 2007
unknown	All Year	NE Gulf of Mexico (west FL shelf)	Surface observations		14.7% dead, 0.9% kept	41,683			Not reported	Commercial, vertical line	Not reported	Yes	Commercial logbooks SEDAR 2006b
11-20	All Year	South Atlantic - NC-FL	Tag-recapture	578 (SE 166)	14.2463%	253			J	Commercial, Bandit reel	Yes-all		McGovern et al. 2005 SEDAR2006c
21-30	All Year	South Atlantic - NC-FL	Tag-recapture	709 (SE 119)	23.0274%	1,221			J	Commercial, Bandit reel	Yes-all	Provides estimates of M; however, 81% tagged off SC; noted large differences in recapture rates among regions attributed to uneven effort, which was not controlled for in the model. Also, M is estimated from survival across years after subtracting natural mortality, may still include mortality not related to initial catch-and-release event?	McGovern et al. 2005 SEDAR2006c
31-40	All Year	South Atlantic - NC-FL	Tag-recapture	771 (SE 105)	35.0113%	730			J	Commercial, Bandit reel	Yes-all		McGovern et al. 2005 SEDAR2006c
41-50	All Year	South Atlantic - NC-FL	Tag-recapture	828 (SE 77)	49.2420%	871			J	Commercial, Bandit reel	Yes-all		McGovern et al. 2005 SEDAR2006c
51-60	All Year	South Atlantic - NC-FL	Tag-recapture	842 (SE 81)	63.5966%	357			J	Commercial, Bandit reel	Yes-all		McGovern et al. 2005 SEDAR2006c
61-70	All Year	South Atlantic - NC-FL	Tag-recapture	832 (SE 56)	75.8801%	321			J	Commercial, Bandit reel	Yes-all		McGovern et al. 2005 SEDAR2006c
71-80	All Year	South Atlantic - NC-FL	Tag-recapture	787 (one length)	84.9966%	39			J	Commercial, Bandit reel	Yes-all		McGovern et al. 2005 SEDAR2006c

Table 6.3. Meta-data of discard mortality estimates for gag grouper (in order by year of citation)…continued

Depth (m)	Season	Region	Method	Size Range (mm) Mean or Range	Discard Mortality	N	# dead	# alive	Hooks	Mode	Vent	Relevant	Citation
81-90	All Year	South Atlantic - NC-FL	Tag-recapture	Not reported	91.0728%	57			J	Commercial, Bandit reel	Yes-all		McGovern et al. 2005 SEDAR2006c
91-100	All Year	South Atlantic - NC-FL	Tag-recapture	Not reported	94.8377%	11			J	Commercial, Bandit reel	Yes-all		McGovern et al. 2005 SEDAR2006c
18.8-85.2 Mean = 29.2	Summer/ Fall	South Atlantic - NC	Surface observations	683 (SE 119)	0%	29	0	29	J electric reels	Commercial, hook and line	No	Yes. Low sample size. Fishing depths not readily apparent. Great info on hooking location with J hooks	Rudershausen et al. 2005
20-50	Sumer	NE Gulf of Mexico (Apalachicola)	Cage	< 500	Estimated LD50 = 43.7 m (50% of the gag die at this depth)	67	n/a	n/a	Circle	Commercial Gear electric reels	Vented by lowering in cages.	Yes. Problem may exist in exclusion of subjects due to lost cages, shark attacks, gill and gut hooked fish not included. Logistical functional response with depth, data modeled with data from McGovern et al. 2005.	Burns et al. 2002
54 and 75	Summer/ Fall	NE Gulf of Mexico (west FL shelf)	Cage	790-840	100%	3			Not reported, likely J	hook and line	No	Low sample size	Wilson and Burns 1996

Table 6.4. List of discard mortality rates for inshore teleost species from the Gulf of Mexico.

Species	Discard mortality (%)	Citation
Spotted sea trout	7.3%	Matlock et al. 1993
Spotted sea trout	4.6%	Murphy et al. 1995
Spotted sea trout	6.0%	James et al. 2007
Spotted sea trout	11.1%	Stunz and McKee 2006
Red drum	4.1%	Matlock et al. 1993
Red drum	6.73%	Aguilar et al. 2002
Common snook	2.13%	Taylor et al. 2001
Tarpon	13.4%	Guindon 2011
Striped bass	9.32%	Caruso 2000
Gray snapper	1.4% (inshore), 14.4% (nearshore)	FWRI 2011

Table 6.5. Meta-analysis model results for all discard mortality estimates and without McGovern et al. (2005) estimates. Results include model coeficients, standard error (SE), Z-statistic, P-value and level of signficance. Model terms: depth, mortality type (Ti: immediate or delayed), hook types (Hc – C hooks, Hj – J hooks), and venting treatments (Vs - some venting, Vn - no venting). Significant levels * - 0.05, ** - 0.01, *** - 0.001, blank – not significant.

	All discard mortality estimates					without McGovern et al. 2005				
	Coefficient	SE	Z	P value	Significant	Coefficient	SE	Z	P value	Significant
Intercept	0.2014	0.7449	0.2704	0.7868		0.4515	0.8503	0.531	0.5954	
Depth	0.0349	0.0071	4.9163	<.0001	***	0.0209	0.0099	2.1194	0.0341	*
Ti	-3.9339	0.5741	-6.852	<.0001	***	-3.6436	0.666	-5.4707	<.0001	***
Hc	-0.4626	0.3604	-1.2837	0.1993		-0.3232	0.3887	-0.8314	0.4058	
Hj	0.7715	0.3774	2.0441	0.0409	*	-1.012	1.812	-0.5585	0.5765	
Vs	-2.5413	0.6359	-3.9965	<.0001	***	-2.4004	0.7029	-3.415	0.0006	***
Vn	-1.8951	0.8612	-2.2004	0.0278	*	-0.4146	1.6193	-0.256	0.7979	

6.13 Figures

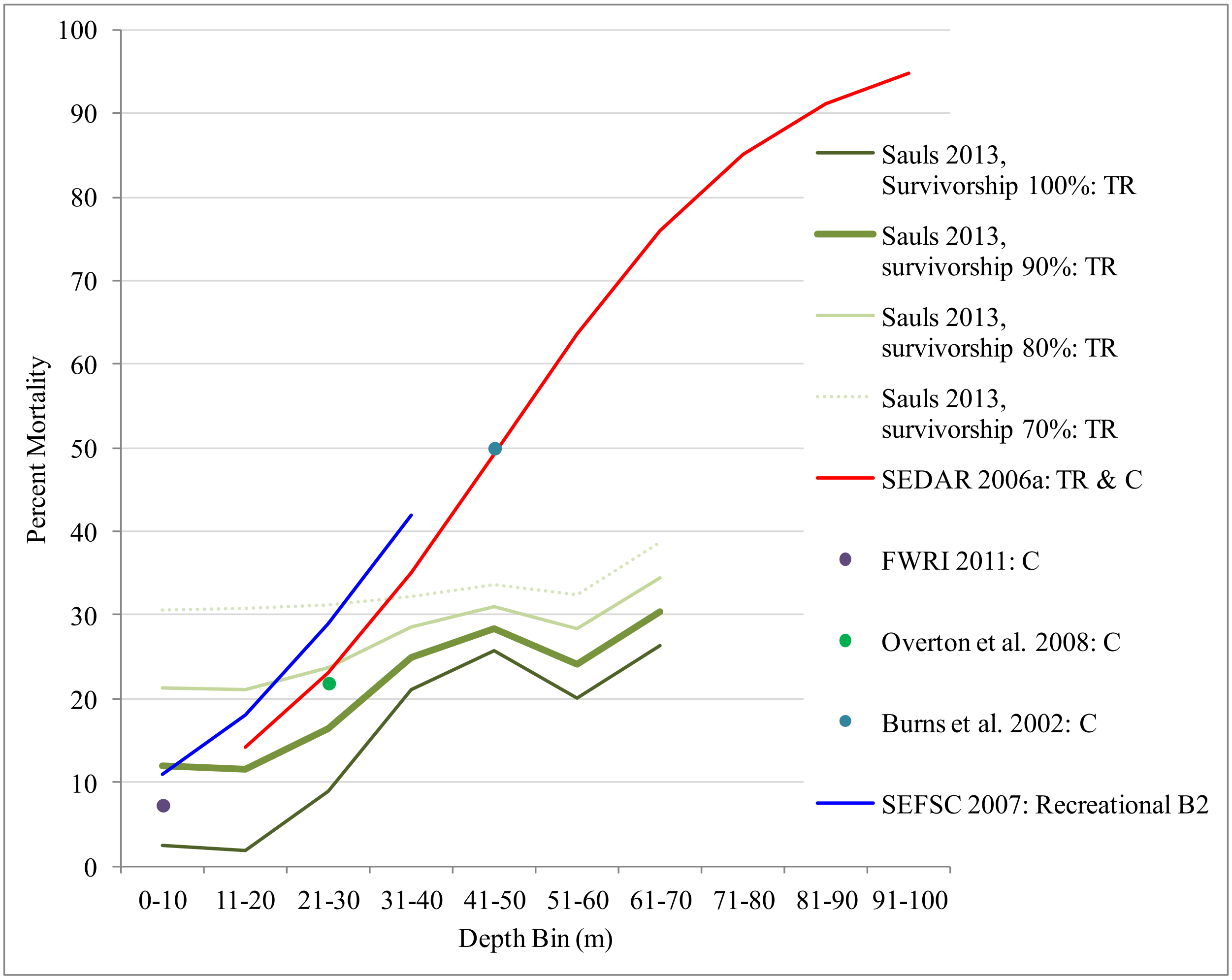


Figure 6.1. Observed functional relationship of discard mortality to depth for gag grouper. TR – tag and recpature, C – cage/experimental study

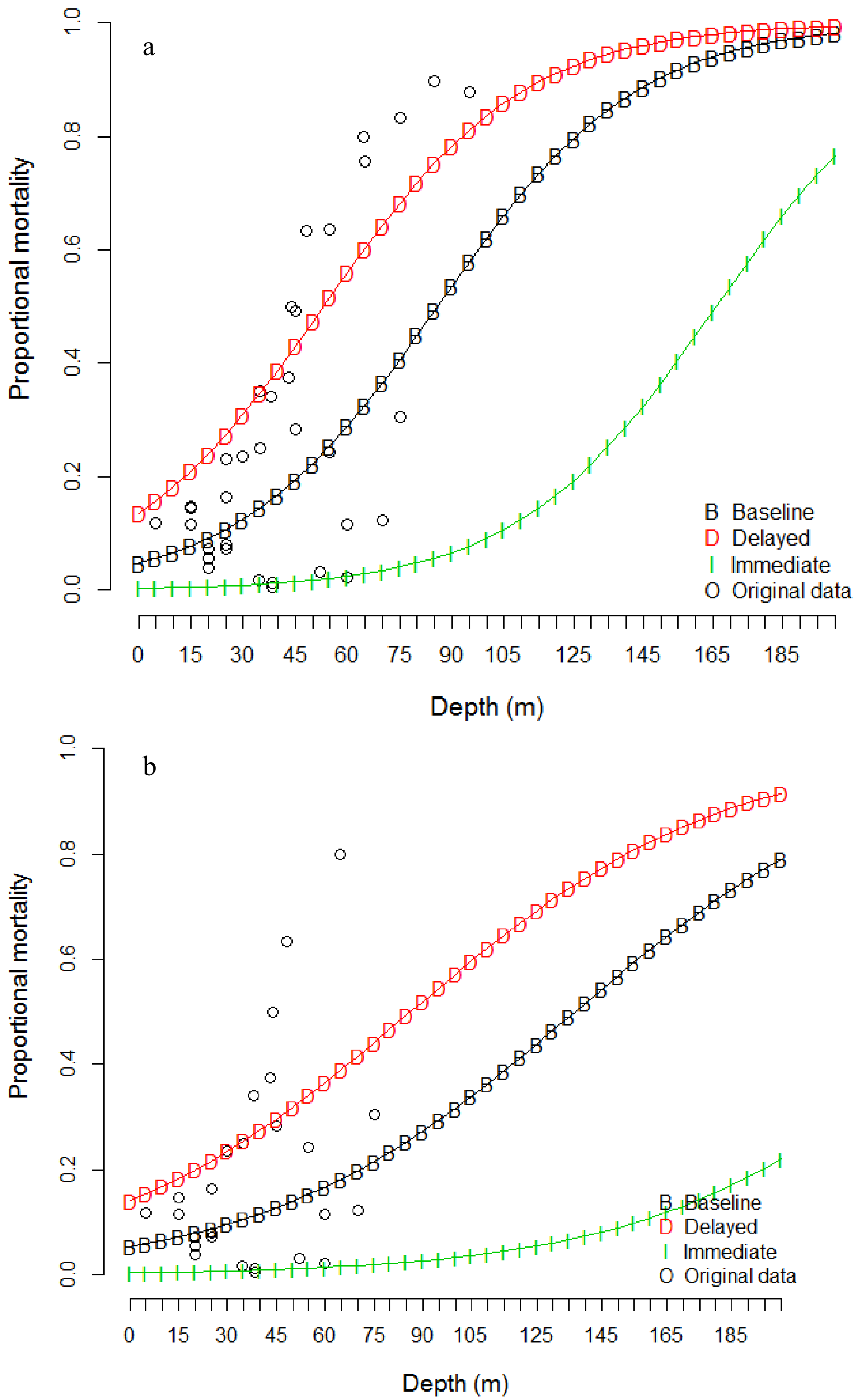
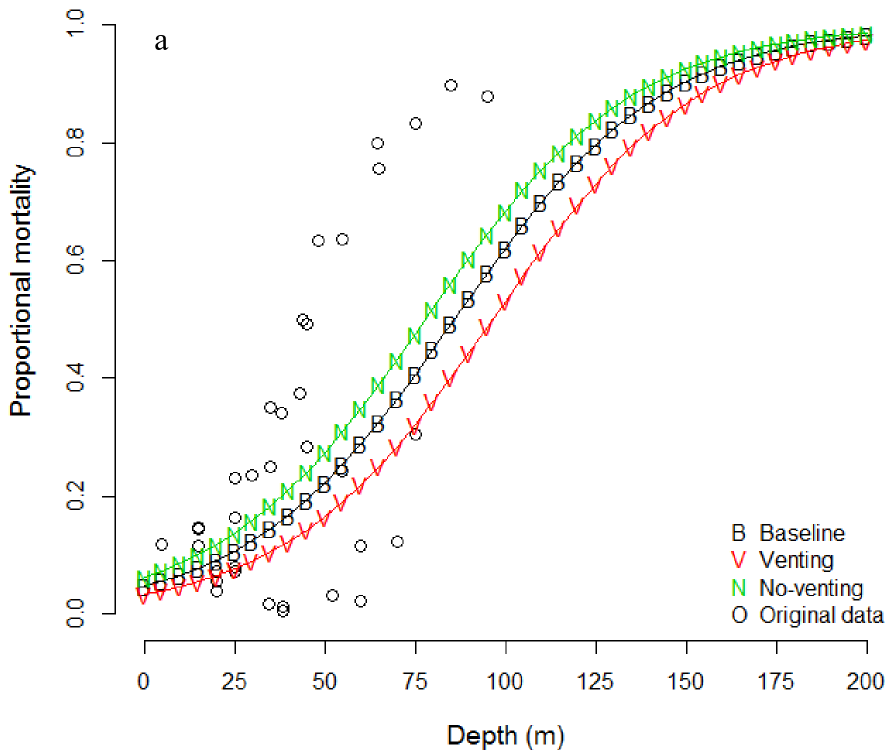


Figure 6.2. Meta-analysis model run (a) including and (b) excluding McGovern et al. (2005) data showing the effect of depth, delayed (D), and immediate (I) measurement of discard mortality. Baseline is the average model prediction.



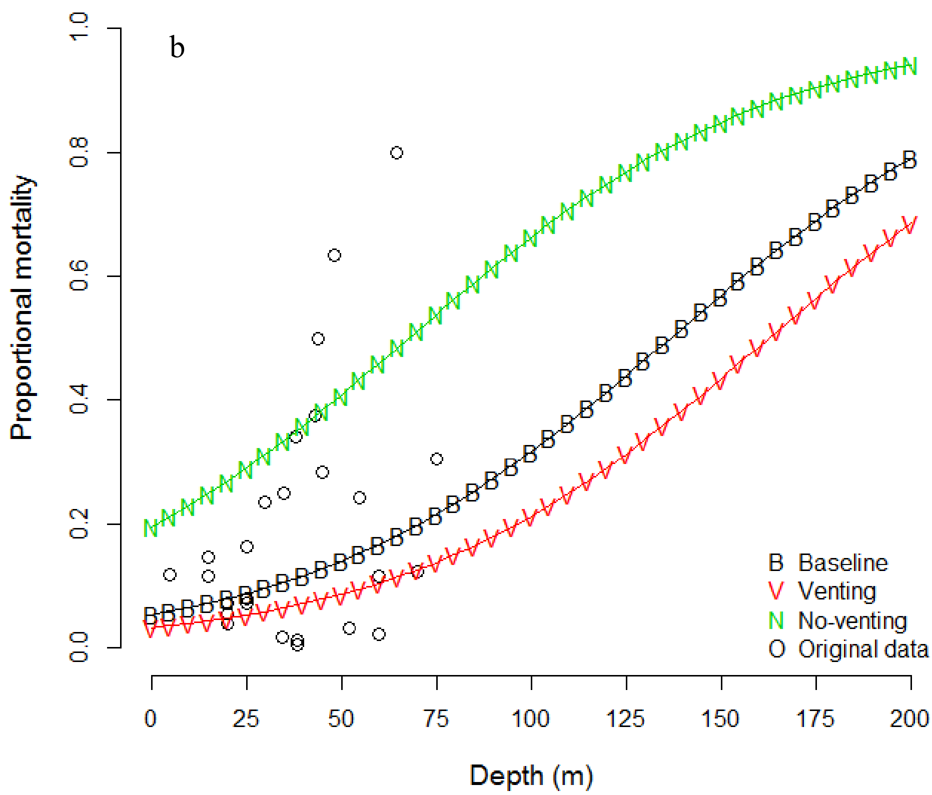


Figure 6.3. Meta-analysis model run (a) including and (b) excluding McGovern et al. (2005) data showing the effect of depth and venting and no-venting treatments on discard mortality. Baseline is the average model prediction.

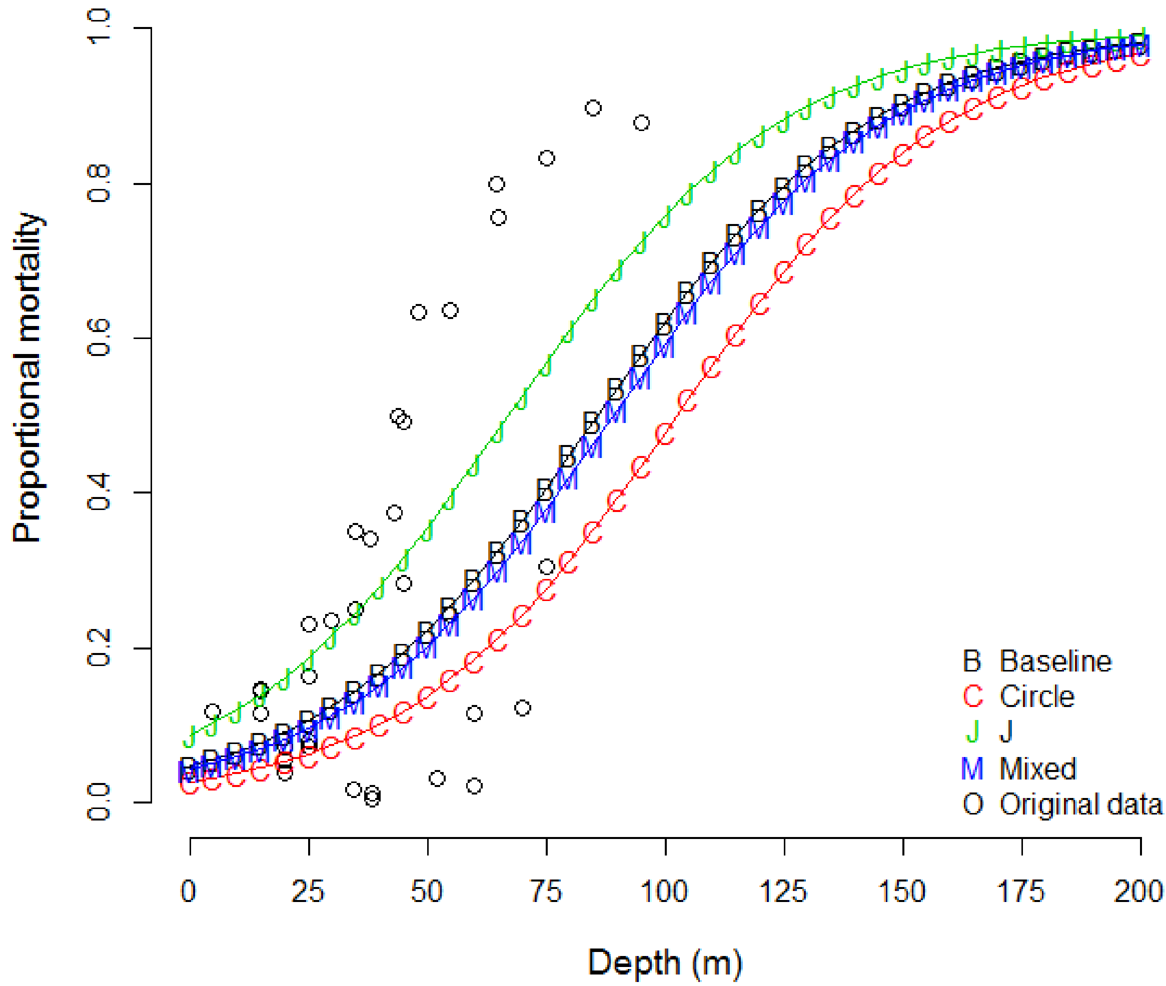


Figure 6.4. Meta-analysis model run including McGovern et al. (2005) data showing the effects of depth and hook type on discard mortality. Baseline is the average model prediction.

7. Integrated Ecosystem Assessments

7.1 Overview

The Integrated Ecosystem Assessment (IEA) group sought to develop two products for integration in the gag grouper Stock Synthesis model: 1) estimates of natural mortality due to predation and episodic events; and 2) estimates of recruitment strength, due to factors other than spawning stock biomass. Typically, the stock assessment model assumes both a natural mortality term throughout time, and recruitment is driven solely by changes in spawning stock biomass. The integration of these ecosystem products will allow us to free the assessment model from these assumptions. Rather, processes of mortality and recruitment will be assumed to be linked to ecosystem processes including predation, hypoxia, and oceanographic conditions.

The effects of environmental forces on gag and other commercial stocks have been well-established. One of the primary concerns for gag grouper on the West Florida Shelf is the presence of sporadic red tide events, which are thought to cause increased mortality in some years. This issue in particular was noted because of a well-observed severe red tide event in 2005, and an associated large decline in abundance indices for gag and other species thought to be susceptible to mortality from red tide events. It is unknown whether mortality occurs via direct toxicity, or from some indirect effect of red tide such as hypoxia. Red snapper are well-known to be affected by hypoxia; for example, low dissolved oxygen concentrations are documented to affect both juvenile and adult stages (Szedlmayer and Shipp 1994, Gallaway et al. 1999). The large drop in gag abundance indices coincident with a major documented red tide event provides good evidence that adult gag grouper are indeed affected by similar processes. However, the IEA working group felt that understanding specific mechanisms causing mortality were of importance to ecosystem modeling efforts.

Other environmental perturbations in addition to hypoxia have the potential to affect populations of demersal fishes. The passage of hurricanes, for example, appears to affect movement and site-fidelity of red snapper (Patterson et al. 2001). Periodic upwelling events and associated reductions in temperature and increases in nutrients have been documented to contribute to mass mortality of fishes and macroinvertebrates, potentially in association with the development of near-anoxic conditions (Collard and Lugo- Fernández 1999; Collard et al. 2000). Temperature reductions also appear to contribute to seasonally-dynamic movement patterns (Topping and Szedlmayer 2011). A member of the life history group noted that, in the spring of 2013, physical conditions in the northeastern Gulf of Mexico were displaying similar patterns to those observed in the spring and summer of 1998, when an extended period of stratification led to hypoxia in this region. Incorporation of this and other sporadic events should be a focus of IEA efforts in future assessments.

It is well-known that factors besides spawning stock biomass can affect recruitment strength. Typically, such factors are not included in assessment models, and therefore manifest themselves as anomalies from the stock-recruitment relationship. The accuracy and/or precision of the assessment can then potentially be improved by explaining some of this variation with a suitable index, representing some environmental force hypothesized to be a driver of recruitment. Typically, this is done by looking for correlations between recruitment deviations, and environmental variables such as climate indices (e.g., Atlantic Multidecadal Oscillation), sea surface temperature, or wind strength. Rather than relying on correlational models, which produce relationships which may or may not hold true in future years, the IEA working group has taken more of a mechanistic approach to describing anomalies in the stock recruitment relationship. This is done via a hydrodynamic model which simulates the transport of larvae, and allows us to calculate expected recruitment success based on the oceanic conditions observed for each year.

7.1.1 IEA Working Group Participants

Michael Schirripa	NMFS
Mandy Karnauskas	NMFS
Cam Ainsworth	USF
Alicia Gray	USF
Arnaud Grùss	RSMAS
Dave Chagaris	FWC
Behzad Mahmoudi	FWC

7.2 Contributed Modeling Environments

The contributed modeling environments for SEDAR 33 include:

1. Three ecosystem models:
    a. Ecopath with Ecosim Harmful Algal Bloom model for the West Florida Shelf (Gray and Ainsworth in prep.)
    b. Ecopath with Ecosim Snapper/Grouper model for the West Florida Shelf (Chagaris and Mahmoudi 2013)
    c. OSMOSE model for the West Florida Shelf
2. Connectivity Modeling System, a Lagrangian particle-tracking model (Paris et al. 2013)
3. A statistical model to predict the presence of harmful algal blooms on the West Florida Shelf (Walter et al. 2013)

Each of the modeling efforts is briefly presented below.

7.2.1 Ecopath with Ecosim

Methods

Ecopath with Ecosim (EwE) is a well-established ecosystem modeling environment which has been widely used for ecosystem research and management strategy evaluation questions. An *Ecopath* model is a description of the trophic groups in the ecosystem, and the linkages between these groups. *Ecosim* is a simulation routine which allows one to analyze the responses of all parts of an ecosystem to various pressures, such as fishing harvest or natural disturbances. Data inputs to EwE include landings, discards, diet composition, and consumption and production rates. Typically, EwE models are calibrated to fit to time series of abundance and/or catch. Once calibrated, the model can then be used to explore changes in various parameters, such as natural mortality, under different scenarios. Chagaris and Mahmoudi (SEDAR33-DW07) provide further details on the estimation of natural mortality from EwE.

A West Florida Shelf Ecopath model was originally built by Okey and Mahmoudi in 2002, to simulate various fisheries scenarios and provide management advice. This model is freely available on the web and has been well-documented (http://www.safmc.net/Portals/0/EMFoodWeb/WFSmodel.pdf). Because this model included only coarse species groupings (e.g., groupers, snappers), improvements have been made to provide more specific management advice. Currently, two “descendants” of the original Okey and Mahmoudi model are being proposed for use in SEDAR 33. The first is an improved EwE model developed by Chagaris and Mahmoudi (SEDAR33-DW07), which includes most of the commercially and recreationally important species in the Gulf of Mexico, now on a species-specific basis. Another model has been developed by Gray and Ainsworth (in prep). It has been modified to include species and age classes known to be affected by red tides as established by literature search and expert communication (K. Steidinger, FWRI, pers. comm.)

Assessment Contributions

Both EwE models will produce estimates of natural mortality for gag grouper, which may be integrated into the Stock Synthesis model. The Chagaris and Mahmoudi EwE model will produce a vector of estimates from 1950 – 2009, primarily influenced by fluctuations in predator and prey biomasses. The Gray and Ainsworth EwE model will produce a vector of natural mortality estimates from 1980 – 2010, based on both predator and prey biomasses, and a forcing function related to harmful algal bloom events.

7.2.2 OSMOSE

Methods

An ecosystem simulation model, OSMOSE-WFS, is being developed to explore the trophic functioning of the West Florida Shelf (WFS) ecosystem, and get estimates of natural mortality rates, diet composition and recruitment levels for a few emblematic species, including gag. OSMOSE-WFS is an individual-based, multi-species model, which explicitly represents major processes in the life cycle of a number of high trophic level groups of species. OSMOSE-WFS builds on WFS EwE, an Ecopath with Ecosim model for the WFS. However, OSMOSE-WFS and WFS EwE differ greatly in both their structure and assumptions. The use of the OSMOSE-WFS and WFS EwE models is interesting to have two different perspectives on the same questions, while being able to identify from where discrepancies between the two models may originate.

The construction and parameterization of OSMOSE-WFS are completed, and the model is currently being calibrated, using a specific heuristic, derivative-free method. The calibration of OSMOSE-WFS is a relatively long process, which is useful to estimate some unknown parameters, but also to detect errors in model configuration, evaluate the sensitivity of the dynamics of the modeled system to inputs, and adjust the value of a number of key parameters estimated before the calibration process. Further details on model construction can be found in Grǜss et al. 2013 (SEDAR33-DW11).

Assessment Contributions

Once OSMOSE-WFS is calibrated, the model will be used to evaluate natural mortality rates for larvae, juveniles and adults of gag in the WFS during the 2000s, as well diet compositions for juvenile and adult gags. OSMOSE-WFS will then be recalibrated using time series of biomasses and landings, so as to estimate deviations in natural mortality rates and recruitment for the different life stages of gag in the past, present and future.

7.2.3 CMS

Methods

The Connectivity Modeling System (CMS) is a biophysical modeling system based on a Lagrangian framework, and was developed to study complex larval migrations (Paris et al. 2013). The CMS uses outputs from hydrodynamic models and tracks the three-dimensional movements of advected particles through time, given a specified set of release points and particle behaviors. Optional modules are provided to allow for complex behaviors and movements, simulating observed biological phenomena such as egg buoyancy, ontogenetic vertical migration, and tidal stream transport. The specific model set up used for this study is outlined in detail in Karnauskas at al. 2013; SEDAR 33-DW18).

Assessment Contributions

The CMS modeling effort will produce an index of recruitment anomalies by year, for the years 2003 – 2013. This index represents the expected recruitment strength due to oceanographic conditions alone, without the influence of spawning stock biomass or other factors related to the fitness of adults and larvae. Sensitivity runs will be carried out to address the major sources of uncertainty in the model, and also to create a variance associated with the index.

7.2.4 Red tide model

Methods

Several indices of red tide severity were developed from a generalized additive model approach that predicts the probability of a red tide bloom. The predictive model is based on a suite of satellite derived remote sensing products, and is ground-truthed by the FWRI's Harmful Algal Bloom database. These indices can be incorporated as environmental covariates into stock assessment models. Several derived indices constituting different spatial and temporal partitions are created based upon hypotheses regarding the spatial and temporal overlap of grouper populations with red tide blooms.

Assessment Contributions

This modeling effort will produce an index of red tide severity from 1998 – 2010. This index can be directly integrated into the Stock Synthesis model as an influence on natural mortality. Alternatively, the index may be used as a forcing function within the ecosystem models, which would allow multiple components of the ecosystem to be affected simultaneously by red tide. Natural mortality estimates could then be extracted from the model, which would represent the influence of both predator/prey dynamics and mortality induced by red tides, plus any complex interactions between these dynamics.

7.3 Integration of Ecosystem Products into Stock Synthesis

The IEA working group agreed that both estimates of natural mortality and recruitment strength would be worthy of consideration for inclusion in the stock assessment process. The mechanics of actually incorporating estimates of natural mortality and recruitment strength into Stock Synthesis are outlined in detail in Schirripa and Methot (SEDAR33-DW10). Generally, the group agreed that the 'model method' would be the most appropriate method for incorporating ecosystem products. The model method allows indices of natural mortality and recruitment to be incorporated as an index with a variance, which the stock assessment model then attempts to fit. Rather than forcing the assessment models to fit natural mortality and recruitment to a specific value, this method allows the ecosystem estimates to serve as suggested values, and allows the analyst to assess how well the data in the model fit to the ecological estimates.

Only one estimate of recruitment strength was put forward by the IEA working group (based on the Connectivity Modeling System), and it was agreed that this index would be put forth for recommended inclusion in the assessment.

In regards to estimates of natural mortality (M), a number of methodologies for deriving these estimates were presented. Firstly, the statistical model of red tide presence (Walter et al. 2013) could be directly input into the stock assessment model as a regulator of M. Secondly, Chagaris and Mahmoudi (2013) presented a vector of M values based on their EwE ecosystem model, which were hypothesized to represent the natural mortality of gag based on predator/prey dynamics. Thirdly, Gray and Ainsworth presented a method whereby the Walter et al. (2013) red tide index was incorporated into an EwE ecosystem model as a fishery of only discarded bycatch, and a vector of M values were derived from the ecosystem model. The IEA working group agreed that the third approach to deriving M values would be most appropriate, since it would allow the red tide index to affect multiple components of the ecosystem and to assess the overall effect of red tide and predator/prey dynamics on mortality of gag.

A number of questions were then brought up in regards to the best methodology for incorporating the red tide index into the ecosystem model. The first challenge discussed was that the Gray and Ainsworth EwE model runs from 1980 – 2010, while the Walter et al. (2013) red tide index is only available from 1998 to present (due to lack of remote sensing data before this time). The group discussed how FWRI's cell count data might be used as a proxy for red tide, for the period 1980 – 1997. The cell count index, which is available up to the present day, will be analyzed with respect to the red tide index, to determine whether the cell count index might be representative of severity of red tides. It was proposed that a number of sensitivity analyses would be carried out to understand the uncertainty associated with defining an index for the period 1980 – 1997. Another question was how address the number of gag the red tide "fishery" in the EwE model would actually kill. As the EwE model would now be driven by effort rather than catch, a catchability factor would need to be assigned to red tide to relate kill to effort. The group decided that a range of values would be used and sensitivity analysis conducted.

The IEA working group also discussed the lack of a mechanistic understanding of how red tides affect gag mortality, in terms of both age and functional form of the relationship. The working group met with the life history group to discuss which age classes might be susceptible to red tide mortality. After discussion, the group agreed that both juvenile and adult gag were likely susceptible to red tide events, and that the red tide index should be applied to both groups. Another challenge that was discussed was in regards to the functional form of the relationship between red tide and gag mortality. For example, mortality may be a linear function of presence of red tide, or mortality may not occur at all until a certain red tide threshold is reached. The group agreed that additional research and possibly sensitivity analyses will need to be carried out to address this question.

7.4 Research Recommendations

Harmful algal blooms

A top research priority is to assess the long-term effects of periodic HAB disturbances on the biomass, spatial distribution and age distribution of exploited reef fish species and their prey. These effects are likely to impact population viability and safe extraction rates, and could become very important to Gulf of Mexico fisheries management if climate change brings with it an increased frequency and severity of HAB events. Research should explore two avenues: retrospective analysis of reef fish biomass trends using historic HAB time series as drivers of mortality and recruitment, and future projections that challenge the current management practices under a schedule of increasing HAB disturbance (e.g., as informed by IPCC climate change scenarios). Priority should be given to spatially-explicit and/or stochastic simulation methods able to integrate, at minimum, the following features: fisheries effects, age structure, trophic dynamics, habitat, nutrient loading and HAB considerations.

Extending the Walter et al. (2013) red tide index forward will also be important for species affected by harmful algal blooms. This would involve bridging the SeaWIFS-MODIS gap between 2010 and 2011 to maintain continuity of satellite data and calibration of information.

Ecosystem modeling

No stock-recruitment relationship is specified in OSMOSE-WFS. Rather, recruitment levels in OSMOSE-WFS emerge from model simulations, and are dependent on the survival of eggs and larvae in relation to the predation process and to the amount of plankton available. Therefore, the development of OSMOSE-WFS #2 will be useful to obtain estimates of recruitment deviations for gag in the past, present and future that will be compared to estimates of recruitment deviations by the Connectivity Modeling System. Discussions would then be needed on how the outputs of both the Connectivity Modeling System and OSMOSE-WFS could be integrated into Stock Synthesis.

The IEA working group would benefit from another biophysical modeling system based on a Lagrangian framework, Ichthyop (Lett et al. 2008), in the future, to obtain estimates of recruitment deviations for gag and other species evaluated within the SEDAR process. The use of the Ichthyop model would be interesting to have several different perspectives on the issue of recruitment deviations.

Estimates of natural mortality

The following research topics would be useful for improving estimates of M:

- Within-model framework hypothesis testing of whether M applies to all ages equally or whether certain size/ages more vulnerable due to life history, location, and physiology
- Simulation modeling work to determine how best to model episodic mortality in stock assessments
- Development of forecasting methods to incorporate some probability of red tide occurring in the future, i.e. is there some autocorrelation to annual events, etc.
- Field or lab based studies of the effects of red tides on fish; for example, can fish sense *K. brevis* and do they move in response?
- Research on how mortality occurs; asphyxiation, bioaccumulation of toxins, etc.
- Does the pattern of recolonization of areas decimated by red tide occur through movement of adults or through settlement of juveniles.
- Collections of fish during red tide events, which would allow for the size/age selectivity of mortality to be determined, and might also allow for some minimum estimates of total mortality

Estimates of recruitment

Increased knowledge on the reproductive behavior or adult gag and biology of larval gag grouper would lead to better parameterization of larval transport models, and thus more accurate estimates of recruitment strength. Specifically, three major areas of uncertainty exist:

- The location of gag grouper spawning. While some sites have been well-documented (e.g., the Madison-Swanson Reserve) it is unknown whether spawning occurs in other locations along the West Florida Shelf. Collaborative projects with fishers would be particularly helpful in regards to identifying other potentially important spawning sites.
- The density and size of gag grouper eggs. Because transport patterns are highly sensitive to the vertical location of eggs in the first several days after release, more realistic parameterization of particles in this initial stage would lead to more accurate estimates. In particular, knowledge on the densities of both fertilized and unfertilized eggs, and the timing of fertilization, would be useful.
- The vertical distribution of gag larvae in the post-flexion stage. Because gag grouper have an extended pelagic larval duration (up to about 2 months), the fate of these larvae is largely determined by the depth layer in which they exist. Because grouper larvae are found in relatively low abundances in plankton tows, very little data exists on the vertical distributions of Epinepheline larvae in the pelagic environment, and in most cases the larvae are only identified to subfamily level. Increased sampling and identification of

these larvae to species level will be important for understanding the vertical distributions of this species in the pelagic phase.

8 Analytic Approach

8.1 Overview

The lead analytical agency for Gulf of Mexico Gag is the Southeast Fishery Science Center in Miami, Florida.

8.2 Suggested analytic approach given available data

The assessment models to be used for SEDAR 33- Gulf of Mexico Gag are specified in the Assessment Workshop Terms of Reference. Stock Synthesis and CASAL models will be developed.

9 Research Recommendations

9.1 Life History

Stock Definition

Increased genetic sampling should provide more precise estimations of exchange rates within the Gulf basin and the Atlantic. As well, The LHW recommends continued application of otolith chemistry methods to evaluate the population structure and connectivity of gag.

Oceanographic modeling efforts are advancing (3-d models). Larval transport and modeling efforts need to be supported and associated with development of an Integrated Coastal Ocean Observing System (ICOOS). There is evidence for different transport and retention processes operating along the northeastern Gulf and west Florida shelf. Attention should be given to different oceanic forcing mechanisms particularly focusing on wind-driven upwelling and Loop Current intrusion differences north and south of about latitude 28°. Further exploration of potential larval contribution (interannual variation) from Campeche to US waters is needed.

For the purpose of learning more about exchange between basins, and as indicated in SEDAR 10, tagging studies should be coordinated between researchers in the Gulf (including Mexico) and south Atlantic, particularly with respect to adult size and depth. Additional acoustic tagging of mature gag may contribute to identification of additional spawning aggregation sites warranting protection. In particular more investigation of potential spawning habitats south of 28° latitude along the WFS is needed.

Age and Growth

Gag age samples are under- represented from the recreational sector. This remains a trend over time and more attention to recreational sampling is warranted.

Reader comparison statistics can now be incorporated as uncertainty in aging within the Stock Synthesis model. Estimates of standard deviation at age will be calculated and forwarded for review at the assessment workshop.

Further review of the aging macro (the assignment of final annual age) is needed to deal with the possibility of early annulus formation (e.g. before January 1^{st}). Thus the age macro may need to include the means of age demotion for some individual gag.

Natural Mortality

1.) As in SEDAR 10, recommended ranges of M: (0.10 - 0.20).

2.) Continue to investigate age-varying M models and their appropriateness.

3.) LHW recommends further research into mortality rates of pre-spawning gag as they migrate from seagrass meadows to the offshore environment.

Reproduction

Maturity: Continue to gather histological samples to monitor change in maturity that may occur over time. Further examination needs to be made regarding how uncertainty in maturity can be treated within Stock Synthesis. A research recommendation is that formal decision tables be developed regarding the assignment of maturity based upon the raw histological readings for tropical/subtropical species. Changes to a decision table could be made in a standardized way to gauge the effect of uncertainty in models and for different species. The LHW recommends that this subject be presented at workshops or scientific meetings to raise awareness and develop consensus and best approaches.

Sex ratio, spawning fraction and fecundity: Promote collection of grouper reproductive samples via observer programs. Scientific observers working onboard commercial vessels will be able to sample gag in the round (prior to routine gutting) throughout the year. With improved field sampling, estimation of sex ratio needs to be made with better design or accounting of factors such as cohort effect (strong vs. weak year classes), location, gear and seasonal timing (pre-aggregation, spawning, and post-aggregation).

Sex transition and mechanism of sex change: Further review of the utility of secondary sexual traits (copperbelly pigmentation) is warranted: 1) incorporate the secondary sex field formally into TIP 2) provide training to port agents and 3) for longitudinal analysis develop means to account for changes in fishery selectivity and cohort effects.

Mating system: The LHW recommends further study of the particular type of mating system in gag (leks or harems). The distinction may depend on the particular type and amount of androgen produced (Shepherd et al 2013). An expectation is that leks would be more male biased as opposed to harems. As well, more information is needed on the timing and control of sex change in gag.

Form of reproductive potential: Because of questions about how the stock synthesis model can incorporate reproductive potential, the LHW recommends that three forms of reproductive potential be examined further at the Assessment Workshop given the data and reproductive traits reviewed at the data workshop 1) SSB-combined for male & female 2) SSB-female only and 3) SSB-eggs based upon annual fecundity.

Fertilization success: Research needs to be conducted on the consequences of sex ratio on fertility. The LHW recognizes that experiments on fertility would be difficult to conduct directly on such a large bodied species as gag (but see Rowe et al. 2004, 2008). Improved understanding of the gag mating system together with better designed field estimation of sex ratios may advance our understanding. Together with better field data, further genetic monitoring of Allee or inbreeding effects may yield much more insight on fertility and male reproductive success.

Conversion Factors

Continue to work on adoption of consistent standards across survey and data collection programs.

Encourage programs collecting gag meristics to report fork length.

Avoid use of Excel trend line function with some known statistical deficiencies in favor of more robust algorithms for solving equations.

9.2 Commercial Fishery Statistics

Landings
-Improved dockside sampling for catch composition
-Improved dealer reporting to species
-Historical literature research for historical landings

IFQ
-Investigate dealer influence on IFQ allocation usage through dealer IFQ surveys

Discard
-Most appropriate method for incorporation of IFQ data into discard estimations
-Most appropriate method for incorporation of IFQ data into discard size compositions
-Increased observer coverage.
-More representative observer coverage.

9.3 Recreational Fishery Statistics

1) Evaluate the technique used to apply sample weights to landings
2) Continue and expand fishery dependent at-sea observer surveys to collect discard information.
4) Track Texas commercial and recreational discards.
5) Estimate variances associated with the headboat program.
6) Evaluate existing and new methods to estimate historical landings.

9.4 Measures of Population Abundance

Expand the use of molecular genetics to identify the grouper larvae in SEAMAP samples that cannot be positively identified as gag grouper because diagnostic morphological characters are not yet developed.

The IWG made note that the delta-lognormal index may not be the most appropriate distribution with some of the data presented. However, the lack of adequate diagnostics for different distributions prelude their use. The recommendation is that addition work be done with these other distribution (i.e. Poisson, negative binomial) in order to fully vet the methodology.

A calibration study is needed between the FWRI/NMFS video survey and the UF diver survey (UVC). The standardized reef systems reported in SEDAR33-DW03 are well suited for rigorous calibration studies, which could also include other sampling methods.

An exploration of the effects of the IFQ on the fishery dependent indices, specially the commercial handline and longline is needed. During the workshop, fisherman indicated that since the implementation of the IFQ, there has been a drastic change in fisheries behavior. There is also the possibility that dealers can directly influence this behavior. The need is to find a way to incorporate these years into the overall timer series or a recommendation to split the time series when the IFQ began.

Further consideration of how to combine the data from the juvenile surveys, including perhaps revisiting the seagrass weighting approach as well as incorporating otolith microchemistry data on the relative contribution of estuaries to nearshore populations, may improve the YOY index.

9.5 Discard Mortality Rate

Future studies reporting discard mortality estimates should provide data tables that report the number of fish by discard condition (e.g. dead or alive), the number of fish by depth and by length bin, complete descriptions of gear (reel and hook type), and whether fish were properly vented. In addition, analyses of long-term mortality estimates from tag-recapture studies should account for survivorship and the effects of variable fishing effort over spatial and temporal scales.

9.6 Integrated Ecosystem Assessment

Harmful algal blooms

A top research priority is to assess the long-term effects of periodic HAB disturbances on the biomass, spatial distribution and age distribution of exploited reef fish species and their prey. These effects are likely to impact population viability and safe extraction rates, and could become very important to Gulf of Mexico fisheries management if climate change brings with it an increased frequency and severity of HAB events. Research should explore two avenues: retrospective analysis of reef fish biomass trends using historic HAB time series as drivers of mortality and recruitment, and future projections that challenge the current management practices under a schedule of increasing HAB disturbance (e.g., as informed by IPCC climate change scenarios). Priority should be given to spatially-explicit and/or stochastic simulation methods able to integrate, at minimum, the following features: fisheries effects, age structure, trophic dynamics, habitat, nutrient loading and HAB considerations.

Extending the Walter et al. (2013) red tide index forward will also be important for species affected by harmful algal blooms. This would involve bridging the SeaWIFS-MODIS gap between 2010 and 2011 to maintain continuity of satellite data and calibration of information.

Ecosystem modeling

No stock-recruitment relationship is specified in OSMOSE-WFS. Rather, recruitment levels in OSMOSE-WFS emerge from model simulations, and are dependent on the survival of eggs and larvae in relation to the predation process and to the amount of plankton available. Therefore, the development of OSMOSE-WFS #2 will be useful to obtain estimates of recruitment deviations for gag in the past, present and future that will be compared to estimates of recruitment deviations by the Connectivity Modeling System. Discussions would then be needed on how the outputs of both the Connectivity Modeling System and OSMOSE-WFS could be integrated into Stock Synthesis.

The IEA working group would benefit from another biophysical modeling system based on a Lagrangian framework, Ichthyop (Lett et al. 2008), in the future, to obtain estimates of recruitment deviations for gag and other species evaluated within the SEDAR process. The use of the Ichthyop model would be interesting to have several different perspectives on the issue of recruitment deviations.

Estimates of natural mortality

The following research topics would be useful for improving estimates of M:

- Within-model framework hypothesis testing of whether M applies to all ages equally or whether certain size/ages more vulnerable due to life history, location, and physiology
- Simulation modeling work to determine how best to model episodic mortality in stock assessments
- Development of forecasting methods to incorporate some probability of red tide occurring in the future, i.e. is there some autocorrelation to annual events, etc.
- Field or lab based studies of the effects of red tides on fish; for example, can fish sense *K. brevis* and do they move in response?
- Research on how mortality occurs; asphyxiation, bioaccumulation of toxins, etc.
- Does the pattern of recolonization of areas decimated by red tide occur through movement of adults or through settlement of juveniles.
- Collections of fish during red tide events, which would allow for the size/age selectivity of mortality to be determined, and might also allow for some minimum estimates of total mortality

Estimates of recruitment

Increased knowledge on the reproductive behavior or adult gag and biology of larval gag grouper would lead to better parameterization of larval transport models, and thus more accurate estimates of recruitment strength. Specifically, three major areas of uncertainty exist:

- The location of gag grouper spawning. While some sites have been well-documented (e.g., the Madison-Swanson Reserve) it is unknown whether spawning occurs in other locations along the West Florida Shelf. Collaborative projects with fishers would be particularly helpful in regards to identifying other potentially important spawning sites.
- The density and size of gag grouper eggs. Because transport patterns are highly sensitive to the vertical location of eggs in the first several days after release, more realistic parameterization of particles in this initial stage would lead to more accurate estimates. In particular, knowledge on the densities of both fertilized and unfertilized eggs, and the timing of fertilization, would be useful.

- The vertical distribution of gag larvae in the post-flexion stage. Because gag grouper have an extended pelagic larval duration (up to about 2 months), the fate of these larvae is largely determined by the depth layer in which they exist. Because grouper larvae are found in relatively low abundances in plankton tows, very little data exists on the vertical distributions of Epinepheline larvae in the pelagic environment, and in most cases the larvae are only identified to subfamily level. Increased sampling and identification of these larvae to species level will be important for understanding the vertical distributions of this species in the pelagic phase.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 33

Gulf of Mexico Gag

SECTION III: Assessment Workshop Report

February 2014

Updated on 27 February 2014

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 33 Assessment Workshop for Gulf of Mexico Gag was conducted as a series of 16 webinars, which were held between July 23rd and November 20th, 2013.

1.1.2. *Terms of Reference*

1. Review and provide justification for any changes in data following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model.
2. Develop population assessment models that are compatible with available data and document input data, model assumptions and configuration, and equations for each model considered. Consider past modeling approaches (SEDAR 10 (2006), SEDAR 10 Update (2009)).
3. Incorporate known applicable environmental covariates into the selected model, and provide justification for why any of those covariates cannot be included at the time of the assessment.
4. Provide estimates of stock population parameters, if feasible.
    - Include fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, gag being a protogynous hermaphrodite, and other parameters as appropriate given data availability and modeling approaches
    - Include appropriate and representative measures of precision for parameter estimates
5. Characterize uncertainty in the assessment and estimated values.
    - Consider uncertainty in input data, modeling approach, and model configuration
    - Provide appropriate measures of model performance, reliability, and ‘goodness of fit’
    - Provide a continuity model consistent with the prior assessment configuration, if one exists, updated to include the most recent observations. Alternative approaches to a strict

continuity run that distinguish between model, population, and input data influences on findings, may be considered

- Provide measures of uncertainty for estimated parameters

6. Provide yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations.
    - Provide estimates of stock status for management criteria consistent with applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards for each model run presented for review.
    - Examine the effect of being a protogynous hermaphrodite on stock status criteria and other management benchmarks
    - Evaluate existing or proposed management criteria as specified in the management summary
    - Recommend proxy values or modifications to the current proxy value when necessary
7. Provide declarations of stock status relative to management benchmarks, or alternative data poor approaches if necessary.
8. Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules if warranted; include estimated generation time. Define FCurrent as a single year or years and provide rationale for use. Stock projections (in both biomass and number of fish) shall be developed in accordance with the following:

    A) If stock is overfished:
    $F=0$, $F_{Current}$, F_{MSY}, F_{OY}
    $F=F_{Rebuild}$ (max that permits rebuild in allowed time)
    B) If stock is undergoing overfishing:
    $F= F_{Current}$, F_{MSY}, F_{OY}
    C) If stock is neither overfished nor undergoing overfishing:
    $F= F_{Current}$, F_{MSY}, F_{OY}
    D) If data limitations preclude classic projections (i.e. A, B, C above), explore alternate models to provide management advice

9. Provide a probability density function for the base model, or a combination of models that represent alternate states of nature, presented for review.
    - Determine the yield associated with a probability of exceeding OFL at P* values of 30% to 50% in single percentage increments for use with the Tier 1 ABC control rule
    - Provide justification for the weightings used in producing combinations of models if necessary
10. Provide recommendations for future research and data collection.
    - Be as specific as practicable in describing sampling design and intensity
    - Emphasize items which will improve future assessment capabilities and reliability
    - Recommend an appropriate interval and type for the next assessment

11. Prepare a spreadsheet containing all model parameter estimates, all relevant population information resulting from model estimates, and projection and simulation exercises. Include all data included in assessment report tables and all data that support assessment workshop figures.
12. Complete the Assessment Workshop Report (Section III: SEDAR Stock Assessment Report).

1.1.3. *List of Participants*

Panelists

Luiz Barbieri	Kai Lorenzen	Shannon Calay

Analysts

Jakob Tetzlaff	Meaghan Bryan	Nancie Cummings	Adyan Rios

Appointed Observers

Linda Lombardi	Jay Gardner

Observers

Claudia Friess	Skyler Sagarese	Alisha Gray	Cameron Ainsworth
Arnaud Gruss			

Staff and Agency

Ryan Rindone	John Walter	Adyan Rios	Jakob Tetzlaff
Nancie Cummings	Jessica Stephen	Mandy Karnauskas	Nick Farmer
Rich Malinowski	Michael Schirripa	Steven Atran	Julie Neer
Mike Larkin	Jeff Isely		

1.1.4. *List of Assessment Workshop Working Papers*

Assessment Workshop Documents			
SEDAR33-AW01	Both	Fisheries-independent data for gag and greater amberjack from reef-fish video surveys on the West Florida Shelf, 2008-2012	Switzer, Keenan, McMichael, and Ingram
SEDAR33-AW02	Gag	Length frequency distributions for gag groupers in the Gulf of Mexico from 1984-2012	Chih
SEDAR33-AW03	Gag	Age frequency distributions estimated with reweighting methods for gag groupers in the Gulf of Mexico from 1991 to 2012	Chih
SEDAR33-AW04	GAJ	Length frequency distributions and reweighted age frequency distributions for greater amberjacks in the Gulf of Mexico from 1984-2012	Chih

SEDAR33-AW05	GAJ	Greater Amberjack *Seriola dumerili* Findings from the NMFS Panama City Laboratory Trap & Camera Fishery-Independent Survey – 2004-2012	DeVries, Raley, Gardner, and Ingram
SEDAR33-AW06	Gag	Summary of fishery-independent surveys of juvenile gag grouper in the Gulf of Mexico	Ingram, Pollack, and McEachron
SEDAR33-AW07	Gag	Standardized catch rate indices for gag grouper (*Mycteroperca microlepis*) landed by the commercial longline fishery in the U.S. Gulf of Mexico during 1990-2012	Cass-Calay
SEDAR33-AW08	Gag	Standardized catch rates for gag grouper from the United States Gulf of Mexico handline fishery during 1990-2009	
SEDAR33-AW09	Gag	Standardized catch rates for gag grouper from the Gulf of Mexico headboat fishery during 1986-2011	
SEDAR33-AW10	Gag	Standardized Catch Rates of Gulf of Mexico Gag Grouper from Recreational Inshore, Charterboat, and Private Boat Fisheries (MRFSS) 1986 to 2010	
SEDAR33-AW11	GAJ	Standardized Catch Rates for Greater Amberjack from the commercial longline and commercial handline fishery in the U.S. Gulf of Mexico	
SEDAR33-AW12	GAJ	Standardized Catch Rates for Greater Amberjack from the Gulf of Mexico Headboat Fishery 1986-2011	
SEDAR33-AW13	GAJ	Standardized Catch Rates of Greater Amberjack from the Gulf of Mexico Recreational Charterboat and Private Boat Fisheries (MRFSS) 1986 to 2012	
SEDAR33-AW14			Calay
SEDAR33-AW15	Gag	Standardized catch rates for gag grouper from the United States Gulf of Mexico handline fishery during 1990-2009	Bryan
SEDAR33-AW16	Gag	Standardized Catch Rates of Gulf of Mexico Gag Grouper from Recreational Inshore, Charterboat, and Private Boat Fisheries (MRFSS) 1986 to 2010	Bryan
SEDAR33-AW17	Gag	Standardized catch rates for gag	Bryan

		grouper from the Gulf of Mexico headboat fishery during 1986-2010	
SEDAR33-AW18	GAJ	Commercial Indices of Abundance for Greater Amberjack in the Gulf of Mexico	Saul
SEDAR33-AW19	GAJ	Standardized catch rates for greater amberjack from the Gulf of Mexico headboat fishery during 1986-2010	Rios
SEDAR33-AW20	GAJ	Standardized Catch Rates of Greater Amberjack from the Gulf of Mexico Recreational Charterboat and Private Boat Fisheries (MRFSS) 1986 to 2012	Rios
SEDAR33-AW21	Gag	Red tide mortality on gag grouper 1980-2009	Gray, Ainsworth, Chagaris, and Mahmoudi
SEDAR33-AW22	Both	Ageing error matrices for SEDAR33: gag grouper and greater amberjack	Lombardi
SEDAR33-AW23	Gag	Meta-analysis of release mortality in the gag grouper fishery	Campbell, Lombardi, Sauls, and McCarthy
SEDAR33-AW24	Gag	Natural mortality rates and diet patterns of gag grouper (*Mycteroperca microlepis*) in the West Florida Shelf ecosystem in the 2000s: Insights from the individual-based, multi-species model OSMOSE-WFS	Gruss, Schirripa, Chagaris, Drexler, Simons, Verley, Shin, Oliveros-Ramos, Karnauskas, and Ainsworth

1.2. Panel Recommendations and Comment on Terms of Reference

Term of Reference 1

Review and provide justification for any changes in data following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model.

All changes to the data following the data workshop are reviewed in Section 2.

Term of Reference 2

Develop population assessment models that are compatible with available data and document input data, model assumptions and configuration, and equations for each model considered. Consider past modeling approaches (SEDAR 10 (2006), SEDAR 10 Update (2009)).

A fully integrated length based statistical-catch-at-age model configured using Stock Synthesis was used for the assessment. The model configuration and data inputs are described in Section 3.1.1. See Section 2 for a complete description of all data inputs. Appendix A includes the data file to run the Stock Synthesis model.

Term of Reference 3
Incorporate known applicable environmental covariates into the selected model, and provide justification for why any of those covariates cannot be included at the time of the assessment.

The Assessment Panel recommended that mortality associated with the 2005 red tide event be incorporated into the assessment model. Three alternative approaches to incorporating red tide were explored (see section 3.1.3). Approaches were first tested by replicating the 2009 Update assessment which incorporated red tide mortality. The model predicted that the red tide event in 2005 resulted in the removal of approximately 3.8 million Gag Grouper.

Term of Reference 4
Provide estimates of stock population parameters, if feasible.

- *Include fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, gag being a protogynous hermaphrodite, and other parameters as appropriate given data availability and modeling approaches*
- *Include appropriate and representative measures of precision for parameter estimates*

Estimates of assessment model parameters and their associated standard errors are reported in Section 3.1.4 and Table 3.1.1. Estimates of assessment model parameters and standard deviations from the bootstrap analysis are presented in Table 3.1.3. Estimates of stock biomass, spawning stock biomass, recruitment, and fishing mortality are presented in Tables 3.2.1-3.2.3.

Term of Reference 5
Characterize uncertainty in the assessment and estimated values.

- *Consider uncertainty in input data, modeling approach, and model configuration*
- *Provide appropriate measures of model performance, reliability, and 'goodness of fit'*
- *Provide a continuity model consistent with the prior assessment configuration, if one exists, updated to include the most recent observations. Alternative approaches to a strict continuity run that distinguish between model, population, and input data influences on findings, may be considered*
- *Provide measures of uncertainty for estimated parameters*

Model performance and reliability are characterized in Section 3.2. Uncertainty in the assessment and estimated values was characterized using sensitivity analyses and a parametric bootstrap approach. Results of the sensitivity analyses are characterized in Section 3.2.7 and Tables 3.2.4-3.2.7. Model convergence was tested by varying starting parameters and refitting the model (Table 3.1.2). Uncertainty in the assessment parameters and estimated values is characterized in Section 3.2 and Tables 3.1.1 and 3.1.3 and Figures 3.2.63 and 3.2.73.

Term of Reference 6
Provide yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations.

- *Provide estimates of stock status for management criteria consistent with applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards for each model run presented for review.*
- *Examine the effect of being a protogynous hermaphrodite on stock status criteria and other management benchmarks*
- *Evaluate existing or proposed management criteria as specified in the management summary*
- *Recommend proxy values or modifications to the current proxy value when necessary*

The evaluation of the estimated stock-recruitment parameters is presented in Section 3.2.4. Yield-per-recruit and spawner-per-recruit evaluations are provided in Section 3.2.8 and summarized in Table 3.2.8 and Figures 3.2.103-3.2.106.

Term of Reference 7

Provide declarations of stock status relative to management benchmarks, or alternative data poor approaches if necessary.

Stock status relative to management benchmarks was dependent on the units of spawning stock biomass. Stock status relative to the minimum stock size threshold (MSST) was estimated to be 2.15 for the SSB-female model and 0.64 for the SSB-combined model. The current fishing mortality rate (2010-2012) relative to the maximum fishing mortality threshold (MFMT) was 0.32 for the SSB-female model and 0.83 for the SSB-combined model. For SSB-female, the stock is not considered overfished nor undergoing overfishing (Figures 3.2.107 and 3.2.108). For SSB-combined, the stock is considered to be overfished but not undergoing overfishing (Figures 3.2.109 and 3.2.1010).

Term of Reference 8

Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules if warranted; include estimated generation time. Define FCurrent as a single year or years and provide rationale for use. Stock projections (in both biomass and number of fish) shall be developed in accordance with the following:

A) If stock is overfished:
  $F=0$, $F_{Current}$, F_{MSY}, F_{OY}
  $F=F_{Rebuild}$ *(max that permits rebuild in allowed time)*
B) If stock is undergoing overfishing:
  $F= F_{Current}$, F_{MSY}, F_{OY}
C) If stock is neither overfished nor undergoing overfishing:
  $F= F_{Current}$, F_{MSY}, F_{OY}
D) If data limitations preclude classic projections (i.e. A, B, C above), explore alternate models to provide management advice

Projections were run to evaluate stock status and associated yields for a range of fishing mortality rate scenarios. Projections were run from 2013 to 2032 for the base model configuration (Run 1) and fixed steepness scenario (Run 12) using both SSB-female and SSB-combined. Deterministic projections were run for four fishing mortality rate scenarios for each of the model configurations and the two SSB metrics (female SSB and combined male and female SSB):

- $F_{Current}$: fishing mortality rates for all fleets were set to the geometric mean of the past three years (2010-2012)
- $F_{SPR30\%}$: the fishing mortality rate that results in an equilibrium SPR of 30%
- F_{MAX}: the fishing mortality rate that maximizes the yield-per-recruit
- F_{OY}: 75% of $F_{SPR30\%}$

Benchmarks for the SPR 30% reference point and projections for the base model are presented in Table 3.2.8. Benchmarks for the SPR 30% reference point and projections for the fixed steepness model are presented in Table 3.2.9.

Term of Reference 9

Provide a probability density function for the base model, or a combination of models that represent alternate states of nature, presented for review.

- *Determine the yield associated with a probability of exceeding OFL at P* values of 30% to 50% in single percentage increments for use with the Tier 1 ABC control rule*
- *Provide justification for the weightings used in producing combinations of models if necessary*

Probability distribution functions will be made available to the Scientific and Statistical Committee (SSC) for the development of management advice, including OFL and ABC.

Term of Reference 10

Provide recommendations for future research and data collection.

- *Be as specific as practicable in describing sampling design and intensity*
- *Emphasize items which will improve future assessment capabilities and reliability*
- *Recommend an appropriate interval and type for the next assessment*

Recommendations for future research and data collection are summarized in Section 3.3.

Term of Reference 11

Prepare a spreadsheet containing all model parameter estimates, all relevant population information resulting from model estimates, and projection and simulation exercises. Include all data included in assessment report tables and all data that support assessment workshop figures.

The model parameter estimates from the base model run can be found in Table 3.1.1 and the data file can be found in Appendix A.

Term of Reference 12

Complete the Assessment Workshop Report (Section III: SEDAR Stock Assessment Report).

2. Data Review and Update

The following list summarizes the main data inputs used in the assessment model:

1. Life history
    a. von Bertalanffy growth parameters
    b. Meristic relationships
2. Landings
    a. Commercial vertical line: 1963-2012
    b. Commercial longline: 1979-2012
    c. Recreational – Charter/Headboat/Private: 1963-2012
3. Discards
    a. Commercial vertical line: 2007-2012 (observer program)
    b. Commercial longline: 2007-2012 (observer program)
    c. Recreational Charter/Headboat/Private: 1981-2012
4. Length composition of landings
    a. Commercial vertical line: 1984-2012
    b. Commercial longline: 1984-2012
    c. Recreational Charter/Headboat/Private: 1981-2012
5. Length composition of discards
    a. Commercial vertical line: 2007-2012 (observer program)
    b. Commercial longline: 2007-2012 (observer program)
    c. Headboat: 2005-2012 (observer program)
    d. Charter: 2009-2012 (observer program)
6. Age composition
    a. Commercial vertical line: 1991-2012
    b. Commercial longline: 1991-2012
    c. Recreational Charter/Headboat/Private: 1991-2012
7. Abundance indices
    a. Fishery-dependent
        i. Commercial vertical line: 1990-2009
        ii. Commercial longline: 1990-2009
        iii. Headboat: 1986-2010
        iv. Charter: 1986-2012
        v. Private: 1986-2012
    b. Fishery-independent
        i. Age-0 survey: 1994-2012
        ii. SEAMAP video: 1993-1997, 2002, 2004-2012
        iii. PC video survey: 2005-2012
        iv. Connectivity model: 2003-2012
8. Length composition data from fishery-independent survey
    a. SEAMAP video: 2008-2012
    b. PC video: 2009-2012

A brief summary of each input will be provided in the following sections.

2.1 Life history

The life history data used in the assessment included natural mortality, growth, and maturity. Some of the life history data were included in the Stock Synthesis model as fixed values, while others were treated as estimable parameters. For those treated as estimable parameters, the initial parameter values were either taken directly from those provided during the data workshop or an updated version after the data workshop.

A single von Bertalanffy equation was used in the assessment model to model growth of Gag Grouper for both sexes. The von Bertalanffy parameters; L_{inf}, asymptotic length, and k, the von Bertalanffy growth coefficient, were estimated within the SS model. The values recommended for use as initial parameter values during the DW were:

L_{inf} (mm FL) = 1272
k (year^{-1}) = 0.1412
t_0 (year) = -0.3307.

See page 26 of SEDAR33-DW22 for model fit to the age and length data. The reader will notice that model poorly fits the lengths associated with the younger ages (0-5). The estimates of the von Bertalanffy growth parameters were updated after the data workshop using a maximum truncated likelihood (McGarvey and Fowler 2002). The estimates were as follows:

L_{inf} (mm FL) = 1277.95
k (year^{-1}) = 0.1342
t_0 (year) = -0.6687.

The estimates of L_{inf} and k were similar to what was presented at the data workshop; however, the estimate of t_0 was reduced. The updated estimates were used as initial starting values for L_{inf} and k. Stock synthesis does not use t_0 as an input parameter; rather SS uses a parameterization that includes the parameters L_{min}, and A_{min} to describe the growth of fish from age 0.0 to A_{min}.

Meristic relationships were also provided at the DW. The parameters describing these relationships are summarized in Table 2.1.1.

2.2 Landings

2.2.1. *Commercial landings*

The commercial landings reviewed at the DW were not changed and are presented in Table 2.2.1 and in Figure 2.2.1. Approximately 99 percent of the landings were from the vertical line fishery prior to 1980. After 1980, the vertical line landings made up anywhere from 60-80% of the total landings depending on the year. Less than 1% of the landings were from “other” gear types prior to 1980 and between 1-7% after 1980. Landings from the longline fishery began in 1979 and represent between 20-30% of the annual landings from 1979 through 2012.

2.2.2. *Recreational landings*

The recreational landings data (1963-2012) used in the assessment are presented in Table 2.2.2 and Figure 2.2.2. The recreational landings are available by mode; head boat, charter boat, and the combined private and shore modes. The recreational landings data were updated from those presented at the DW and finalized after the workshop after making adjustments to the MRIP adjustment factors.

To account for the misidentification of gag as black grouper, average ratios of gag to the sum of gag and black grouper for 1990 to 2012 were calculated by state and applied to the sum of gag and black grouper catch from 1981 to 1989 (Table 2.2.3). These early MRFSS catch estimates were originally adjusted to MRIP using species specific MRIP adjustment factors. However, since the gag and black grouper catch from 1981 to 1989 were combined because of the issue of misidentification, it was determined that an adjustment factor which combines both species would be more appropriate. Therefore, a new MRIP adjustment factor was calculated for the combined gag and black grouper MRFSS and MRIP catch estimates from 2004 to 2011. This combined MRIP adjustment factor was only applied to the gag and black grouper catch from 1981 to 1989. Beginning in 1990, species specific MRIP adjustment factors were applied to the gag and black grouper catch as there is more confidence in the species identification.

Following the MRIP adjustment, the average ratios by state were applied to the sum of the gag and black grouper catch estimates from 1981 to 1989 to get the final gag estimates for this time period. Average weights of gag in the survey were then used to calculate the landings estimate in weight.

2.3 Discards

2.3.1. *Commercial discards*

Discard rates of gag grouper in the commercial vertical line fishery were calculated by stratifying observer and coastal logbook data by year and region (east = statistical zones 1-8, west = 9-21). Gag grouper and other shallow water groupers have been managed using Individual Fishing Quotas (IFQs) since 2010. Additional stratification of the data by the IFQ allocation available to a vessel during a trip was attempted for the years 2010-2012. This level of stratification resulted in multiple strata being either unpopulated or poorly populated (N<5 observed trips) and stratification by allocation was not used for the final discard calculations.

Discards were calculated as: stratum specific discard rate*stratum specific effort reported to the coastal logbook program. Effort data from the coastal logbook program were limited to effort reported from trips with reef fish landings. Discards calculated for all strata within a year were summed to provide yearly discards.

Effort data from the coastal logbook program are available beginning in 1990. Discards for the years 1990-2007 were calculated using the mean discard rate for the years 2007-2012 for each region. Those mean rates were then used along with year and region specific coastal logbook effort data to calculate discards by region. A gag grouper regulatory change occurred in 1999 when the minimum size was increased from 20 inches total length to 24 inches total length. Any effect on discard rates as a result of that minimum size change cannot be determined from the available data, therefore, total discards calculated for the years 1990-1998 may be overestimated. Calculated yearly gag grouper discards from the vertical line reef fish fishery are provided in Table 2.3.1 (eastern Gulf of Mexico) and 2.3.2 (western Gulf of Mexico).

Data from the reef fish observer program were also used to calculate discard rates in the reef fish bottom longline fishery. The shark bottom longline observer data were used to calculate discard rates in the shark bottom longline fishery. Data collected in the reef fish observer program from shark permitted bottom longline vessels were included in the shark observer data set for the calculation of discard rates in the shark bottom longline fishery. The two observer programs collect discard and fishing effort data using consistent methods, allowing for the pooling of longline data across the programs. Pooling shark directed trips follows the method used in the gag grouper 2010 update assessment. Observer data collected from longline vessels without shark permits were used to calculate discard rates in the reef fish bottom longline fishery. Longline data were not stratified by region because observer coverage in the western Gulf of Mexico was low. Year specific discard rates were used along with logbook reported bottom longline effort to calculate discards for the period 2007-2012. Mean discard rates for the years 2007-2012 were used for the calculation of gag grouper discards for the years 1990-2006, as described for the vertical line fishery. Calculated yearly gag grouper discards from the reef fish bottom longline fishery are provided in Table 2.3.3 and for the shark bottom longline fishery in Table 2.3.4.

2.3.2. *Recreational discards*

Recreational discards were updated following the DW to account for change in the MRIP adjustment factors (Table 2.3.5). See the text in Section 2.2.2 for the explanation of the change in the MRIP adjustment factor. The majority, 87% on average, of the discards are from the private recreational fleet. Discards from the charterboat and headboat fleets make-up 10% and 3% of the total discards on average. The number of discards, although variable from year to year, have generally increased over time for each recreational fleet. The number of discards peaked in 2008 for the private recreational fleet and then decline between 2010 and 2012. The number of discards peaked in 1998 for the charterboat fleet and then exhibited considerable variability until 2010 and then decline in 2011 and 2012. The pattern in the number of discards from the headboat fleet was similar to the charterboat fleet, except its peak was in 2011 and then declined substantially in 2012.

2.3.3. *Discard mortality*

The DW included a working group that focused on discard mortality. The discard mortality working group recommended using alternative estimates for mortality for both the recreational and commercial sectors that differed from to what was applied in previous assessments (see the SEDAR 33 Data Workshop Report). For both the recreational fisheries and the commercial vertical line (hand-line and electric/hydraulic reels), the discard working group recommended applying the depth-mortality function from Sauls (2013) that assumes 90% survivorship for Gag Groupers released in good condition to calculate dead discards for SEDAR33. The discard mortality working group recommended applying the discard mortality estimates from the baseline meta-analysis model (excluding the McGovern et al. 2005 study) to estimate discards from the commercial long-line gear.

The average depth to be used for the point estimates of discard mortality for each fleet was calculated from observer data. Four of the five fishing fleets used in the assessment model have observer programs that record the fate (kept/discarded alive/discarded dead) and depth of capture for each Gag Grouper during a trip. We calculated the average depth for each fishery using fish that were released alive (Table 2.3.6). For the private recreational fleet we used data collected as part of tagging program by the Mote Marine Laboratory; this dataset included 6,353 Gag Grouper observations between 1991 and 2005 (SEDAR10-DW8).

2.4 Length composition

2.4.1. *Commercial length composition*

The length composition data of landings from the commercial vertical line and longline fleets are presented in Tables 2.4.1 and 2.4.2 and shown in Figures 2.4.1 and 2.4.2. Length observations were combined into 2cm bin with a minimum size of 14cm and a maximum size of 158cm.

A 20 inch (50.8cm) total length size limit was implemented between 1990 and 1999. This size limit was increased to 24 inches (60.96cm) in 1999 and then reduced to 22 inches (55.8cm) in 2012. The majority of the observed length distribution from the vertical line and longline fisheries has been above the size limit with some smaller fish being observed prior to 1990 (Figures 2.4.1 and 2.4.2).

In July 2006, a mandatory observer program was implemented to characterize the commercial reef fish fishery operating in the U.S. Gulf of Mexico. The observer program provides detailed information for each trip and each fish captured, including the size and disposition of all Gag Grouper caught. Length composition data of discarded fish from the commercial vertical line and longline fleets are shown in Figures 2.4.3 and 2.4.4.

2.4.2. *Recreational length composition*

The length composition data from the recreational fishery are presented in Tables 2.4.3-2.4.5 and shown in Figures 2.4.5-2.4.7. The recreational length composition data were collected by the MRFSS/MRIP program as well as the Head Boat Survey (HBS). Initially, the recreational length composition data were aggregated over the fishing modes. The aggregated data were divided into separate fleets by mode; charter, private, and head boat. Figures 2.4.5 and 2.4.6 summarize the annual length composition data from the charter boat and private recreational fleets. The private fleet includes the shore mode. Figure 2.4.7 summarizes the annual length composition data from the headboat fleet.

The recreational fishery, similar to the commercial fishery, has been partially managed by size limits. A 20 inch (50.8cm) total length size limit was implemented from 1990-1999. The size limit was increased to 22 inches (55.8cm) in 1999. In general, the recreational sector captured smaller Gag Grouper than the commercial sector. Throughout the 1980s the length distributions were skewed towards smaller (i.e., less than 20 inches) Gag Grouper for each recreational mode (Figures 2.4.5 - 2.4.7). The length distribution shifted towards larger Gag Grouper after the implementation of the first size limit (Figures 2.4.5 - 2.4.7).

A fisheries observer program on recreational for-hire vessels, including headboats and charter vessels, was implemented in 2005 in the U.S. Gulf of Mexico (SEDAR33-DW05). The observer program provides detailed information for each trip and each fish captured, including the size and disposition of all Gag Grouper caught. Length composition data of discarded fish from the recreational headboat and charter boat fleets are shown in Figures 2.4.8 and 2.4.9.

2.5 Age composition

2.5.1. *Commercial age composition*

The age composition data collected from the commercial vertical line and longline fleets are summarized in Figures 2.5.1 and 2.5.2. Several cohorts are apparent in the vertical line data in years 1991-1995, 2000-2004, and 2009-2012 (Figure 2.5.1). The number of age samples from the longline fishery was quite small prior to 2000 (Figure 2.5.2). Cohorts were less obvious, but a few cohorts are apparent in the early 2000s and 2007 (Figure 2.5.2).

2.5.2. *Recreational age composition*

Age composition data were available from the headboat, the charter boat, and the private boat modes of the GOM recreational fishery. Figures 2.5.3, 2.5.4, and 2.5.5 summarize the age composition data from these three recreational fleets. The annual sample sizes from the recreational fleets were smaller than those from the commercial fleets. The data also indicate that the recreational fishery targets younger Gag Grouper than the commercial fishery.

There is some evidence of cohorts moving through each of the aforementioned recreational fleets over time. The apparent cohorts from the headboat fishery were in years 1991-1995, 1995-1999, and 2007-2012 (Figure 2.5.3). Similarities were seen in the charter boat data where there were apparent cohorts in years 1991-1996, 2002/3-2005, and 2007-2012 (Figure 2.5.4). The age composition data from the private recreational fishery suffered from low sample size making it difficult to identify cohorts (Figure 2.5.5).

2.6 Indices

Fifteen indices of abundance were presented and considered during the data workshop, seven indices were recommended for use. Three of the seven recommended indices were from fishery-independent data sources: the age-0 seagrass survey, the SEAMAP video survey, and the Panama City (PC) video survey. The DW index working group recommended four fishery-dependent indices for use: the Marine Recreational Fishery Statistics Survey (MRFSS), the Headboat Survey (HBS), the commercial vertical line index, and the commercial longline index (see the SEDAR 33 Data Workshop Report).

The fishery-independent indices recommended for use were the age-0 seagrass survey, the SEAMAP video survey, and the PC video survey (Table 2.6.1 and Figures 2.6.1 - 2.6.3). The age-0 seagrass survey index was derived as the number of Gag Grouper per haul. The video survey indices were derived as the highest minimum count observed per 20 minute recording.

Two of the recommended fishery-dependent indices were finalized after the data workshop, the Reef fish Commercial Logbook vertical line and longline indices (Table 2.6.1 and Figures 2.6.4-2.6.5). These indices provide standardized annual catch rates from the commercial fishery. Due to the implementation of the individual fishing quotas (IFQs) in 2010, the recommended terminal year for these indices was 2009. The vertical line index was derived as pounds per hook hour, whereas the longline index was derived as pounds per hook. Other accepted fishery-dependent indices, the Headboat Survey (HBS) and the Marine Recreational Fisheries Statistical Survey (MRFSS), provided indices of abundance for the recreational fishery. The HBS index was derived as the number of Gag Grouper caught per angler hour and the MRFSS index was derived as the number of Gag Grouper caught or discarded per angler hour.

The approved terminal year for the recreational indices at the DW was 2010. This terminal year was chosen because of the markedly reduced recreational fishing seasons in 2011 and 2012, which resulted in a substantial reduction in effort.

Modifications were made to the MRFSS index following the DW. The AW panel considered and recommended the MRFSS index with 2012 as the terminal year. The MRFSS index represents the number of Gag Grouper caught or discarded; therefore, the influence of the closed season should be minimal. The MRFSS index that had been recommended by the DW Index Working Group did not implement a subsetting method intended to identify targeted trips. Upon the request of the AW panel, the MRFSS index was re-developed using the "guild approach" to retain trips that would have a higher probability of capturing a Gag Grouper. The guild approach included trips in the analysis if those trips also caught species determined to be in the reef fish guild, which was defined by NMFS. Lastly, two separate MRFSS indices were developed to characterize the standardized catch rates of the charterboat fishery and the private-recreational fishery (Table 2.6.1 and Figures 2.6.7 – 2.6.8). This allowed the disaggregated landings from those modes to be linked to the appropriate index of abundance.

The standardized indices of relative abundance and associated CVs used in the assessment are presented in Table 2.6.1. The coefficients of variation (CV) associated with the standardized indices were converted to log-scale standard errors by:

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

for input into the Stock Synthesis assessment model.

A brief summary of the limitations of the rejected indices will be provided here but the reader is referred to the SEDAR 33 Data Workshop Report for a more comprehensive explanation. The Florida Fish and Wildlife video survey index was rejected because it was a short time-series (four years) and the number of sampling stations within reef habitat was increased substantially starting in 2010. The University of Florida reef survey was rejected because it captures the same size range of Gag Grouper as Panama City (PC) video survey and occurs over a much smaller spatial scale than the PC video survey. The NMFS reef fish bottom longline observer survey was rejected because, although it contains a more accurate description of fishing effort, the survey has considerable data overlap with the commercial longline index and it is much shorter time-series. The SEAMAP ichthyoplankton survey was rejected because the samples could not be positively identified at the species level. The NMFS small pelagics survey, which was conducted between 1988 and 1996 and 2002 and 2012, was rejected due to the low numbers of Gag Grouper and low frequency of occurrence (less than 1% occurrence) of Gag Grouper in the samples. The NMFS bottom longline survey was rejected for the same reason. Lastly, the copperbelly index was excluded. Fully transitioned male Gag retain a copper coloration. A comparison of the length composition data where fully transitioned, copper-belly males were identified contradicted the observed lengths of identified copper-belly males from the video survey. This was the main reason for excluding this index from the assessment.

2.7 Tables

Table 2.1.1. Meristic relationships for Gulf of Mexico Gag grouper.

Conversion and units	Equation	Sample Size	r2 values
Natural TL (mm) to FL (mm)	FL = 13.15 + Natural TL * 0.96	1599	0.9886
Maximum TL (mm) to FL (mm)	FL = 1.07 + Maximum TL * 0.97	4789	0.9973
Maximum TL (mm) to G. Wt (kg)	G. Wt = 7.31 x 10-09 * (maximum TL^3.07)	540	0.946
Natural TL (mm) to G. Wt (kg)	G. Wt = 3.50 x 10-11 * (natural TL^3.85)	40	0.5902
FL (mm) to G. Wt (kg)	G. Wt = 7.28 x 10-09 * (FL^3.08)	9793	0.7942
Maximum TL (mm) to W. Wt (kg)	W. Wt = 1.05 x 10-08 * (maximum TL^3.03)	4266	0.7357
Natural TL (mm) to W. Wt (kg)	W. Wt = 1.36 x 10-08 * (natural TL^2.99)	1934	0.4848
FL (mm) to W. Wt (kg)	W. Wt = 1.17 x 10-08 * (FL^3.02)	5238	0.6683

Table 2.2.1. Gulf of Mexico commercial landings in metric tons by fleet. Landings from "other" commercial gears were combined with commercial vertical line landings in the assessment model.

Year	Handline	Longline	Other	Total
1963	726.54	0.00	0.22	726.76
1964	908.24	0.00	4.22	912.46
1965	996.53	0.00	0.20	996.73
1966	833.54	0.00	0.43	833.97
1967	646.47	0.00	1.54	648.02
1968	675.04	0.00	1.02	676.06
1969	781.87	0.00	0.51	782.38
1970	740.04	0.00	2.23	742.27
1971	745.16	0.00	1.17	746.34
1972	797.73	0.00	0.57	798.30
1973	586.03	0.00	0.98	587.02
1974	659.12	0.00	0.29	659.41
1975	812.10	0.00	1.53	813.63
1976	655.44	0.00	0.63	656.08
1977	539.85	0.00	3.25	543.10
1978	483.33	0.00	5.73	489.06
1979	752.31	0.50	3.34	756.14
1980	741.43	43.36	4.31	789.09
1981	774.08	191.54	3.87	969.50
1982	690.32	401.41	3.62	1095.34
1983	551.67	276.07	3.00	830.74
1984	603.89	189.02	13.08	806.00
1985	779.23	165.86	20.20	965.29
1986	520.84	231.70	12.16	764.70
1987	381.89	295.10	10.90	687.89

Year	Handline	Longline	Other	Total
1988	354.49	181.44	9.08	545.02
1989	554.92	190.34	12.79	758.05
1990	508.34	279.23	17.21	804.78
1991	446.69	226.97	26.92	700.58
1992	447.80	264.76	29.08	741.65
1993	576.38	214.34	46.99	837.71
1994	518.06	157.00	53.13	728.19
1995	522.36	174.39	46.90	743.65
1996	497.04	175.38	29.94	702.37
1997	495.22	185.05	37.06	717.34
1998	831.39	264.16	36.84	1132.39
1999	660.10	240.51	29.70	930.31
2000	714.22	256.35	39.29	1009.86
2001	926.32	424.20	45.95	1396.48
2002	846.69	458.98	28.25	1333.91
2003	649.07	488.93	29.69	1167.69
2004	781.05	491.92	32.96	1305.94
2005	693.17	395.36	31.15	1119.68
2006	359.21	234.94	25.21	619.36
2007	335.25	214.46	20.43	570.13
2008	408.74	169.08	20.03	597.85
2009	250.29	70.56	18.10	338.95
2010	156.07	48.37	20.91	225.36
2011	92.05	38.47	14.02	144.54
2012	161.21	58.25	17.83	237.29

Table 2.2.2. Gulf of Mexico estimated recreational landings (thousands of fish) from the headboat, charterboat, and private boat fleets.

Year	Headboat	Charterboat	Private	Total
1963	3.42	13.69	51.35	68.47
1964	3.70	14.79	55.47	73.95
1965	3.99	15.98	59.91	79.88
1966	4.31	17.25	64.70	86.27
1967	4.66	18.64	69.89	93.18
1968	5.03	20.13	75.48	100.64
1969	5.35	21.40	80.24	106.99
1970	5.68	22.73	85.24	113.65
1971	6.39	25.54	95.78	127.71
1972	7.17	28.69	107.59	143.46
1973	8.06	32.22	120.83	161.10
1974	9.04	36.17	135.65	180.87
1975	10.15	40.59	152.20	202.94
1976	11.40	45.61	171.03	228.04
1977	12.81	51.23	192.12	256.16
1978	14.40	57.60	215.99	287.98
1979	16.19	64.74	242.78	323.71
1980	18.09	72.36	271.36	361.81
1981	14.05	22.66	189.48	226.19
1982	23.65	45.22	419.42	488.29
1983	36.32	63.04	886.80	986.16
1984	17.34	28.37	237.31	283.02
1985	92.46	153.11	390.54	636.11
1986	42.50	166.35	460.22	669.06
1987	32.16	33.72	376.96	442.84

Year	Headboat	Charterboat	Private	Total
1988	26.34	65.42	548.23	639.98
1989	35.15	36.18	336.11	407.43
1990	19.10	33.09	139.00	191.18
1991	11.45	13.28	261.69	286.42
1992	13.79	45.85	205.03	264.67
1993	19.34	104.80	247.24	371.38
1994	20.56	51.70	226.92	299.19
1995	17.82	111.51	319.02	448.35
1996	16.06	103.59	253.63	373.28
1997	15.62	98.88	304.05	418.56
1998	36.32	152.66	366.23	555.21
1999	32.12	132.76	421.07	585.95
2000	30.82	162.99	580.24	774.06
2001	14.49	109.51	388.08	512.08
2002	11.62	95.51	448.92	556.04
2003	16.38	100.40	425.94	542.73
2004	24.67	142.85	566.84	734.36
2005	16.78	130.75	386.36	533.90
2006	6.76	87.13	278.71	372.60
2007	11.14	41.41	248.51	301.06
2008	10.52	94.98	343.29	448.79
2009	9.48	49.22	164.15	222.86
2010	11.09	58.22	179.58	248.90
2011	5.10	11.03	89.95	106.07
2012	5.25	48.61	83.94	137.80

Table 2.2.3. The annual percentage of gag recreational landings to the sum of gag and black recreational landings and the average ratio between 1990 and 2012 for each state. The "-" indicates that gag were not caught in the given strata.

Year	LA	MS	AL	FLW
1990	-	-	100	95.40
1991	100	-	100	98.58
1992	100	100	100	98.69
1993	100	100	100	100
1994	100	100	100	99.13
1995	100	100	100	97.83
1996	100	100	100	100
1997	100	100	100	99.75
1998	50.08	100	100	98.71
1999	100	100	100	99.04
2000	100	100	100	99.90
2001	93.23	100	100	99.99
2002	98.55	100	100	99.98
2003	100	100	100	99.67
2004	100	-	100	99.94
2005	100	-	100	99.59
2006	100	-	100	100
2007	100	-	100	99.61
2008	100	-	100	99.95
2009	100	100	100	98.71
2010	100	100	100	100
2011	100	-	100	100
2012	100	-	100	100
Mean 90-12	97.36	100	100	99.33

Table 2.3.1. Eastern Gulf of Mexico gag grouper yearly commercial vertical line vessel discards calculated from observer reported discard data. Discards are reported in number of fish.

Year	Eastern Gulf discard rate	Eastern Gulf discard rate CV	Observed trips	Hook hours	Calculated discards
1990	0.180	2.66	376	1,413,892	254,850
1991	0.180	2.66	376	1,777,594	320,406
1992	0.180	2.66	376	2,051,303	369,741
1993	0.180	2.66	376	2,089,997	376,716
1994	0.180	2.66	376	2,211,858	398,681
1995	0.180	2.66	376	1,658,370	298,916
1996	0.180	2.66	376	1,918,235	345,756
1997	0.180	2.66	376	1,472,784	265,465
1998	0.180	2.66	376	1,397,350	251,868
1999	0.180	2.66	376	1,526,476	275,143
2000	0.180	2.66	376	1,616,078	291,293
2001	0.180	2.66	376	1,261,107	227,311
2002	0.180	2.66	376	1,419,303	255,825
2003	0.180	2.66	376	1,460,764	263,298
2004	0.180	2.66	376	1,400,338	252,407
2005	0.180	2.66	376	1,607,357	289,721
2006	0.180	2.66	376	1,720,807	310,170
2007	0.201	2.79	56	1,881,140	378,551
2008	0.146	2.25	32	1,769,545	258,285
2009	0.235	2.30	34	3,215,147	756,834
2010	0.162	2.41	41	3,370,423	545,313
2011	0.184	2.64	70	3,614,432	664,629
2012	0.170	2.84	143	4,147,016	705,405

Table 2.3.2. Western Gulf of Mexico gag grouper yearly commercial vertical line vessel discards calculated from observer reported discard data. Discards are reported in number of fish.

Year	Western Gulf discard rate	Western Gulf discard rate CV	Observed trips	Hook hours	Calculated discards
1990	0.005	6.91	216	3,866,807	17,857
1991	0.005	6.91	216	8,935,198	41,262
1992	0.005	6.91	216	4,660,506	21,522
1993	0.005	6.91	216	5,359,085	24,748
1994	0.005	6.91	216	5,992,579	27,673
1995	0.005	6.91	216	6,103,363	28,185
1996	0.005	6.91	216	6,880,059	31,772
1997	0.005	6.91	216	7,809,364	36,063
1998	0.005	6.91	216	8,222,299	37,970
1999	0.005	6.91	216	8,884,157	41,026
2000	0.005	6.91	216	8,308,835	38,369
2001	0.005	6.91	216	8,132,914	37,557
2002	0.005	6.91	216	8,427,109	38,916
2003	0.005	6.91	216	8,833,696	40,793
2004	0.005	6.91	216	7,788,576	35,967
2005	0.005	6.91	216	7,179,526	33,154
2006	0.005	6.91	216	6,875,932	31,752
2007	0.009	6.25	43	6,248,437	53,400
2008	0.000	4.58	21	5,381,029	223
2009	0.000	0.00	13	6,019,031	0
2010	0.022	2.80	19	4,247,129	93,954
2011	0.004	5.96	40	4,604,980	17,702
2012	0.001	4.97	80	5,395,559	3,712

Table 2.3.3. Gulf of Mexico gag grouper yearly commercial longline vessel discards calculated from reef fish observer reported discard data. Eastern and western Gulf of Mexico data were combined due to small sample size. Discards are reported in number of fish.

Year	Reef fish observer discard rate	Reef fish observer discard rate CV	Observed trips	Hook hours	Calculated discards
1990	0.000236	2.14	147	1,504,674	355
1991	0.000236	2.14	147	2,641,827	623
1992	0.000236	2.14	147	1,603,399	378
1993	0.000236	2.14	147	1,363,681	322
1994	0.000236	2.14	147	1,726,063	407
1995	0.000236	2.14	147	2,445,031	577
1996	0.000236	2.14	147	470,950	111
1997	0.000236	2.14	147	1,967,715	464
1998	0.000236	2.14	147	4,240,150	1,000
1999	0.000236	2.14	147	9,690,351	2,286
2000	0.000236	2.14	147	25,115,702	5,926
2001	0.000236	2.14	147	25,638,981	6,049
2002	0.000236	2.14	147	24,335,972	5,742
2003	0.000236	2.14	147	24,519,124	5,785
2004	0.000236	2.14	147	26,383,888	6,225
2005	0.000236	2.14	147	19,903,297	4,696
2006	0.000236	2.14	147	21,112,402	4,981
2007	0.000025	1.26	7	18,007,883	449
2008	0		4	19,705,526	0
2009	0.000037	2.00	26	11,529,419	427
2010	0.000023	1.86	43	6,666,140	155
2011	0.00047	1.35	61	9,766,675	4,592
2012	0.000645	1.54	6	6,626,014	4,271

Table 2.3.4. Gulf of Mexico Gag Grouper yearly commercial longline vessel discards calculated from shark observer reported discard data. Eastern and western Gulf of Mexico data were combined due to small sample size. Discards are reported in number of fish.

Year	Shark observer discard rate	Shark observer discard rate CV	Observed trips	Hook hours	Calculated discards
1990	0.00013	3.57	209	33,147,814	4,790
1991	0.00013	3.57	209	58,818,203	8,347
1992	0.00013	3.57	209	36,309,395	5,003
1993	0.00013	3.57	209	30,836,664	4,259
1994	0.00013	3.57	209	38,540,100	5,442
1995	0.00013	3.57	209	30,857,914	4,588
1996	0.00013	3.57	209	36,507,854	5,304
1997	0.00013	3.57	209	40,257,360	5,546
1998	0.00013	3.57	209	34,504,146	4,803
1999	0.00013	3.57	209	33,306,937	4,749
2000	0.00013	3.57	209	16,609,749	2,257
2001	0.00013	3.57	209	14,397,779	1,968
2002	0.00013	3.57	209	12,344,275	1,675
2003	0.00013	3.57	209	14,740,477	2,366
2004	0.00013	3.57	209	13,448,565	1,926
2005	0.00013	3.57	209	9,706,350	1,453
2006	0.00013	3.57	209	13,076,847	1,901
2007	0.00001	1.95	22	13,079,842	126
2008	0		14	10,881,760	0
2009	0.00001	2.75	21	6,076,000	82
2010	0.00002	2.69	49	2,970,200	62
2011	0.00031	2.44	49	4,318,377	1,426
2012	0.00018	2.54	54	4,336,835	939

Table 2.3.5. Gulf of Mexico Gag Grouper annual recreational discards overall and by mode.

Year	Headboat	Charter	Private	Total
1981	7.88	12.63	218.90	239.41
1982	3.46	5.37	101.53	110.36
1983	5.79	9.19	400.34	415.32
1984	2.68	4.09	56.06	62.83
1985	11.85	19.15	102.02	133.02
1986	15.03	52.78	316.79	384.60
1987	17.65	17.67	203.65	238.97
1988	6.75	15.08	228.71	250.54
1989	19.13	19.08	469.90	508.10
1990	49.61	85.95	270.65	406.20
1991	1.63	1.88	860.12	863.62
1992	13.76	45.73	673.73	733.21
1993	17.34	93.96	1191.87	1303.16
1994	60.35	151.75	1653.66	1865.76
1995	31.21	195.30	1634.08	1860.59
1996	30.38	195.83	1005.37	1231.58
1997	29.29	185.36	1501.23	1715.88
1998	82.59	347.04	1731.02	2160.64
1999	52.07	214.45	1239.44	1505.96
2000	25.70	135.81	1274.77	1436.28
2001	19.25	145.44	1752.03	1916.72
2002	25.98	213.59	2254.99	2494.55
2003	48.06	294.47	3053.77	3396.30
2004	58.31	337.69	3528.88	3924.89
2005	43.39	337.98	2038.53	2419.90
2006	12.91	166.27	1711.70	1890.88
2007	32.00	118.87	2562.79	2713.66
2008	34.46	310.98	3793.49	4138.93
2009	52.28	271.33	2482.49	2806.10
2010	59.88	314.14	1699.71	2073.74
2011	88.83	191.46	971.98	1252.27
2012	18.09	167.32	760.62	946.03

Table 2.3.6. Calculated average depth of released Gag Grouper by fishing fleet and associated discard mortality estimate for Sauls (2013).

Fishing fleet	Avg. depth (m)	Sauls (2013)	SEDAR 10
Vertical line	31	0.27	0.57
Longline	58	0.27	0.76
Headboat	27	0.16	0.21
Charter boat	25	0.16	0.21
Private recreational	17	0.12	0.21

Table 2.4.1. Gulf of Mexico Gag grouper vertical line length composition data incremented by 2cm.

		Fork Length (cm)																																	
Year	Samples	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82
1984	820	0	0	0	0	0	0	0	0	3	1	0	1	2	3	1	4	7	8	3	12	24	17	23	31	27	31	44	40	53	38	45	29	39	30
1985	787	0	0	0	0	0	0	0	0	0	0	1	0	2	3	2	3	4	12	17	14	25	15	14	28	32	36	39	58	38	34	37	33	38	39
1986	356	0	0	0	0	0	0	0	0	0	1	1	1	0	2	3	4	4	9	7	16	18	19	13	25	10	17	17	17	13	15	19	16	10	10
1987	559	0	0	0	0	0	0	0	0	0	0	0	1	1	2	1	0	3	3	0	0	3	10	17	18	20	25	22	30	30	42	54	31	55	24
1988	175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	4	3	7	5	11	11	6	7	7	16	13	13
1989	42	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	1	5	1	3	2	4	1	2	1
1990	984	0	0	0	0	0	0	0	0	0	0	4	0	3	0	3	1	4	2	4	3	2	7	8	8	26	24	31	42	51	53	56	62	68	54
1991	770	0	0	0	0	0	0	0	0	1	1	0	0	1	2	1	2	5	5	7	10	13	7	11	13	17	22	47	56	52	56	70	62	49	45
1992	1149	0	0	0	0	0	0	0	1	1	1	0	1	1	2	1	5	12	34	39	53	31	25	22	26	26	31	59	46	40	41	51	62	53	61
1993	1871	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	5	24	57	64	58	68	73	96	126	118	111	108	73	72	85	69	69	77	62
1994	2858	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	28	72	79	96	131	151	219	183	188	216	193	175	148	135	124	81	73	58
1995	2453	0	0	0	0	0	0	0	0	0	1	0	2	2	5	14	37	82	112	111	127	91	127	118	100	93	115	111	149	113	137	120	101	86	78
1996	3140	0	0	0	0	0	0	0	3	1	1	5	6	16	37	53	61	185	251	239	205	177	166	180	154	150	123	106	109	103	96	96	91	64	69
1997	3398	0	0	0	0	0	0	0	0	0	0	0	0	1	0	9	71	250	282	274	244	260	259	232	192	150	166	137	139	91	88	81	57	58	56
1998	8072	0	0	0	0	0	0	0	1	0	1	0	3	4	5	11	29	194	306	355	425	509	604	649	672	684	597	518	418	330	274	232	167	143	137
1999	5926	0	0	0	0	0	0	0	0	0	0	0	0	1	5	6	19	125	246	242	202	259	253	292	356	305	410	409	383	363	350	272	259	195	142
2000	4018	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	8	82	110	137	161	196	225	231	299	230	282	254	260	231	226	181	150	131	107
2001	5514	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	20	56	127	278	379	471	430	484	467	415	392	335	285	233	205	186
2002	4114	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	6	6	13	18	60	123	178	223	202	285	287	366	334	318	315	269	234	203
2003	2213	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	5	18	70	145	153	142	119	98	116	132	126	136	167	144	133	114
2004	2826	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	3	17	54	136	174	211	186	211	204	207	171	193	175	169	162	138
2005	1844	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	3	0	10	37	86	94	146	111	132	144	144	126	140	99	90	78	68
2006	813	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	17	50	47	64	41	63	65	73	73	55	60	35	41
2007	388	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	21	25	36	28	34	31	32	19	21	24	20	18	13
2008	1069	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	16	40	74	88	86	88	104	79	84	76	80	45	46	36
2009	894	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	4	14	58	73	70	82	81	81	64	79	49	48	32	32	20
2010	1108	0	0	0	0	0	0	0	0	0	1	1	1	0	2	0	1	0	1	1	3	12	53	65	105	103	104	111	86	100	55	53	54	45	32
2011	1486	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	4	19	101	149	166	146	124	133	128	97	82	59	69	52	32
2012	1945	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	49	73	97	159	166	154	150	140	140	120	119	111	88	77	53

Table 2.4.1. Gulf of Mexico Gag grouper vertical line length composition data incremented by 2cm, continued.

		Fork Length (cm)																																					
Year	Samples	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120	122	124	126	128	130	132	134	136	138	140	142	144	146	148	150	152	154	156	158
1984	820	35	35	39	28	30	12	15	18	22	17	13	14	6	9	6	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	787	25	27	25	24	24	16	19	16	17	19	12	10	6	4	10	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	356	11	8	12	7	8	4	4	4	5	3	4	7	5	2	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	559	24	25	26	20	14	9	14	6	7	5	3	6	2	1	1	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	175	10	14	5	6	10	4	3	2	5	3	2	2	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	42	3	1	2	3	3	3	3	0	1	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
1990	984	71	55	46	51	39	32	34	25	35	16	20	5	12	7	6	7	2	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	770	38	27	18	20	19	14	14	20	12	9	5	6	4	5	0	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	1149	65	60	53	49	37	40	27	23	16	7	5	7	6	12	6	2	4	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	1871	56	66	43	41	41	34	37	26	26	20	10	9	9	11	4	11	6	2	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	2858	63	48	42	52	45	40	34	35	29	22	14	14	13	17	7	11	5	3	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	2453	61	47	30	29	31	24	24	18	32	24	19	18	15	18	10	5	3	4	4	1	0	1	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	3140	56	44	50	43	28	29	19	17	17	18	10	7	19	7	6	10	4	5	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	3398	45	41	35	22	30	14	20	13	10	15	3	7	8	12	5	2	7	6	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	8072	132	118	91	67	59	48	33	44	39	30	21	21	18	18	17	14	16	8	5	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	5926	142	98	94	72	63	54	48	37	40	41	27	15	15	16	12	18	11	8	10	6	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	4018	128	57	67	68	46	22	15	18	22	7	10	8	8	9	4	8	3	5	5	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	5514	182	87	102	86	61	45	40	25	19	20	9	14	6	4	9	10	9	4	4	5	6	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	4114	168	88	85	86	52	34	37	25	16	11	5	9	7	10	3	4	7	7	5	5	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	2213	95	59	56	42	32	22	13	15	9	3	4	7	6	4	2	4	2	5	5	2	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	2826	95	78	70	42	28	19	15	13	14	7	5	5	2	2	3	0	2	3	1	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	1844	76	36	31	34	24	21	27	14	12	11	8	5	5	4	5	3	7	3	4	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	813	18	20	17	10	9	13	8	3	5	2	3	5	2	3	4	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	388	8	15	9	9	3	2	3	3	2	1	1	0	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	1069	25	23	9	16	8	7	7	4	1	2	4	3	0	3	1	2	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	894	20	13	14	9	6	9	7	5	4	3	3	2	2	3	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	1108	19	16	7	9	9	8	8	7	12	5	5	7	2	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	1486	19	22	17	17	12	12	8	3	5	3	1	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	1945	49	46	31	22	16	18	13	10	8	7	2	5	3	4	2	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.4.2. Gulf of Mexico Gag grouper longline length composition data incremented by 2cm.

		Fork Length (cm)																																
Year	Samples	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82
1984	459	0	0	0	0	0	0	1	1	0	0	1	1	0	4	4	4	11	6	9	17	10	17	16	20	17	27	21	21	25	19	22	21	14
1985	565	0	0	0	0	0	0	0	0	0	1	1	2	2	2	4	5	6	9	14	25	32	21	30	34	28	27	26	27	22	22	21	12	15
1986	1133	0	0	0	0	0	0	0	1	0	1	1	3	3	4	8	11	11	17	17	23	31	35	37	41	56	69	61	56	65	65	66	56	48
1987	685	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	4	8	4	4	12	13	22	11	21	18	31	32	44	36	39	56	37	38
1988	276	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	2	3	2	4	3	5	5	6	1	6	9	18	7	16	16	14	16	24
1989	129	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	3	0	2	4	2	8	4	3	4	9	8
1990	1665	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	2	1	4	1	5	6	7	12	17	24	44	56	66	70	93	103	92	78
1991	943	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	3	5	8	9	12	35	24	28	43	43	68	64	71
1992	933	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	1	4	2	7	12	5	7	20	26	19	39	47	32	51	49
1993	790	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	1	4	6	8	7	8	15	7	17	18	18	27	35	37	28	37	42
1994	777	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	9	13	13	27	31	33	30	36	43	46	34	50	29	40	26
1995	1001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	9	11	10	9	20	23	25	26	40	36	60	50	61	63	47	43	50
1996	1055	0	0	0	0	0	0	0	0	0	0	0	0	1	1	5	8	24	27	24	29	19	28	27	32	22	41	42	63	43	57	54	52	63
1997	1221	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	25	22	36	34	33	39	38	37	35	54	44	41	45	53	57	51	51
1998	5063	0	0	0	0	0	0	0	0	0	1	1	2	1	1	4	13	19	44	64	101	120	179	228	240	269	271	275	275	231	234	199	218	195
1999	4659	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	9	21	36	34	50	58	86	127	156	192	227	201	252	279	227	227	233	234
2000	4201	0	0	0	0	0	0	0	0	0	0	2	0	2	2	4	4	2	8	8	15	18	29	49	60	99	119	164	212	252	275	260	271	270
2001	4159	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	5	9	30	44	69	68	111	162	221	243	260	266	257	306	299
2002	4149	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	4	13	33	52	51	100	130	182	227	269	278	330	340	291
2003	3908	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	4	6	19	19	58	58	85	95	168	172	236	278	324	332	338
2004	2672	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	5	30	51	76	75	101	111	127	151	133	163	165	177	159
2005	2401	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	7	12	29	46	67	83	108	124	117	130	144	113	121	145	140
2006	1761	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	12	36	38	53	50	78	66	79	94	106	110	106	100
2007	1034	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	2	2	2	1	6	9	13	25	32	45	41	48	58	55	60	70	71
2008	1315	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	9	29	27	25	55	55	71	63	72	99	109	108	72
2009	686	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	15	22	25	30	28	26	35	36	30	46	29	58	50
2010	949	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	4	14	9	30	39	52	55	58	59	66	68	57	51	44
2011	530	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	13	18	19	32	32	45	50	47	36	33	33	20
2012	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	12	18	19	24	35	32	30	46	46	42	35

Table 2.4.2. Gulf of Mexico Gag grouper longline length composition data incremented by 2cm, continued.

		Fork Length (cm)																																			
Year	Samples	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120	122	124	126	128	130	132	134	136	138	140	142	144	146	148	150	152	154	156	158
1984	459	17	20	14	8	15	6	12	11	11	11	4	3	5	8	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	565	18	9	18	9	10	10	13	18	7	11	17	12	7	8	2	5	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	1133	50	44	33	33	30	15	17	17	17	21	13	14	12	7	8	9	3	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	685	27	37	22	30	25	14	17	13	15	15	6	7	11	4	6	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	276	11	12	13	17	12	8	8	5	8	5	3	5	1	2	3	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	129	4	6	14	8	5	3	8	9	6	5	2	2	4	1	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	1665	107	102	119	79	84	86	78	66	65	43	26	24	23	27	14	15	13	4	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	943	56	66	61	59	38	52	32	31	39	27	19	13	5	9	8	5	2	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
1992	933	82	65	77	73	50	35	36	40	37	21	23	11	19	12	12	5	3	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	790	45	48	53	54	40	39	44	34	33	16	17	16	8	8	6	3	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	777	35	29	43	31	44	25	24	15	12	14	6	7	3	2	6	7	1	0	0	1	2	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
1995	1001	68	43	45	22	40	26	28	20	27	20	18	9	6	9	12	2	6	3	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	1055	49	53	45	38	35	34	21	12	16	16	16	8	7	13	9	6	5	4	3	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	1221	54	54	50	41	39	37	31	22	28	28	24	18	18	13	11	19	3	6	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	5063	206	170	168	169	138	125	130	104	88	84	77	53	89	72	66	49	37	26	15	6	4	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	4659	218	178	190	182	184	163	127	100	91	91	63	65	65	66	57	52	49	34	18	14	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	4201	278	186	212	203	165	145	136	91	76	83	85	60	56	63	58	56	33	39	20	19	9	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	4159	279	195	204	170	142	121	104	100	60	57	53	41	43	42	38	40	33	25	30	21	6	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	4149	309	208	217	147	146	122	95	83	88	58	61	45	31	32	31	40	34	37	30	21	8	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	3908	290	226	220	184	141	107	90	81	75	41	32	29	24	21	34	18	29	15	19	21	13	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	2672	184	137	126	111	97	75	59	45	36	28	37	29	29	24	23	16	22	23	15	11	7	4	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	2401	144	95	84	92	74	71	70	67	51	33	30	29	33	24	26	9	21	17	15	17	4	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	1761	115	91	82	79	87	57	62	54	35	27	27	26	12	13	11	10	11	13	8	3	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	1034	63	73	51	33	44	29	24	29	27	25	16	13	14	12	8	7	4	5	3	5	3	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	1315	63	75	56	59	36	31	33	22	20	28	22	12	17	10	13	4	3	5	2	6	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	686	45	26	32	34	20	18	12	17	13	8	6	6	3	2	1	2	1	2	1	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	949	53	42	28	45	31	28	25	18	19	11	14	5	7	6	3	0	1	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	530	32	22	21	12	14	5	5	12	8	6	3	2	0	1	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	500	23	13	16	22	16	11	14	12	7	4	7	0	2	1	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.4.3. Gulf of Mexico Gag grouper charter boat length composition data incremented by 2cm.

		Fork length (cm)																																		
Year	Samples	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86
1981	10	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	1	0	0	1	2	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
1982	6	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	2	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	0	0	0	0	0	0	0
1984	14	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	1	2	2	1	2	0	1	1	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	155	0	0	0	0	0	0	1	4	2	2	3	6	9	12	20	10	12	4	6	11	5	9	2	6	9	4	5	5	3	1	2	1	0	1	0
1987	129	0	1	0	0	0	0	0	0	1	1	0	2	4	3	10	8	13	6	7	2	5	6	5	3	7	5	8	8	10	1	5	0	1	1	1
1988	80	0	0	0	0	0	1	1	2	1	1	1	2	4	1	1	3	4	1	2	4	3	4	5	2	3	1	3	6	6	2	6	3	3	0	1
1989	76	0	0	0	0	2	3	1	1	0	3	1	1	2	1	3	1	2	1	4	4	4	3	4	4	3	7	5	3	5	1	1	0	2	1	0
1990	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	8	8	8	2	9	4	5	4	1	4	1	1	1	2	1	1	1	0	1
1991	26	0	0	0	0	0	0	0	0	0	1	1	0	0	0	4	0	2	2	0	0	1	2	1	0	1	2	1	2	1	1	1	1	0	1	1
1992	162	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	13	26	18	16	10	17	7	7	7	2	3	3	1	2	3	2	2	5	2	0
1993	113	0	0	0	0	0	0	0	0	1	0	1	2	1	2	3	13	19	17	2	5	7	5	8	6	4	3	4	3	1	2	2	0	1	0	1
1994	75	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	5	7	15	10	7	5	6	1	5	2	4	0	2	2	1	1	1	0	0	0
1995	107	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	15	14	12	8	9	7	10	7	5	4	5	1	2	2	1	3	0	0	0	0
1996	103	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	13	21	16	19	6	10	5	3	1	0	3	2	0	0	0	0	1	0	0	0
1997	383	0	0	0	0	0	1	0	0	1	0	0	0	0	2	2	20	36	48	31	41	31	20	26	29	28	14	17	12	7	5	2	2	0	1	0
1998	994	0	0	0	0	0	0	0	0	2	0	0	1	1	5	9	63	75	81	76	90	69	78	81	63	73	57	33	37	26	18	9	8	10	4	3
1999	1726	0	0	0	0	1	2	3	1	0	1	0	0	2	4	39	205	291	246	161	131	100	76	44	61	43	40	55	41	40	39	24	18	12	9	9
2000	1540	0	0	0	0	0	0	0	0	0	1	0	5	0	5	7	42	95	138	160	159	128	157	134	120	104	66	46	31	18	27	17	22	9	15	13
2001	978	0	0	0	1	0	0	0	0	0	0	0	0	0	2	3	0	2	24	86	108	77	80	70	79	71	73	57	53	55	31	21	21	9	7	11
2002	1075	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	2	17	71	118	101	94	89	75	68	55	53	55	57	44	31	31	28	19	11	8
2003	1329	0	0	0	0	0	0	0	0	0	1	0	2	2	3	0	0	28	82	185	191	145	139	96	75	66	45	48	40	39	22	27	19	9	11	8
2004	2226	0	0	0	0	0	0	1	0	0	1	1	1	1	1	0	4	22	122	249	267	247	229	157	168	152	130	107	85	71	54	36	22	29	10	10
2005	1580	0	0	0	0	0	0	0	0	0	2	0	0	1	2	2	2	12	96	202	178	194	173	121	109	95	82	53	47	49	43	28	22	13	10	3
2006	673	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	7	29	107	83	89	57	49	39	49	33	24	18	14	13	16	11	7	7	6
2007	378	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	12	36	38	31	38	31	27	35	21	16	24	13	7	9	7	5	7	5
2008	554	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	1	2	40	82	75	43	39	40	33	36	30	21	22	24	22	14	7	7	4	2
2009	316	0	0	0	0	0	0	0	1	3	2	0	0	2	0	0	0	3	16	36	46	36	28	25	26	26	13	10	6	10	4	3	4	4	2	1
2010	467	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	25	71	75	56	50	47	24	21	32	19	10	14	5	5	0	4	2	2
2011	115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	14	15	13	11	8	7	4	10	7	6	3	1	1	3	1	1	0
2012	486	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	57	55	49	45	40	39	32	46	26	24	15	14	6	7	7	1	0

Table 2.4.3. Gulf of Mexico Gag grouper charter boat length composition data incremented by 2cm, continued.

		Fork length (cm)																																			
Year	Samples	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120	122	124	126	128	130	132	134	136	138	140	142	144	146	148	150	152	154	156	158
1981	10	0	0	0	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
1982	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
1983	2	0	0	0	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
1984	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	155	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	129	0	1	1	0	1	0	1	0	0	0	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
1988	80	0	2	0	0	0	0	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
1989	76	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	68	0	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
1991	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	162	2	5	1	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	103	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	383	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
1998	994	3	3	3	2	2	0	3	2	0	0	0	0	0	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	1726	0	5	1	1	1	1	5	3	2	6	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	1540	4	3	5	0	3	1	0	1	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	978	10	9	2	3	1	1	3	3	0	2	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	1075	9	5	7	1	2	4	7	1	1	0	2	3	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	1329	8	6	1	3	8	4	6	1	1	1	3	2	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
2004	2226	11	5	8	5	7	2	3	3	0	0	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	1580	5	8	5	3	2	1	4	3	3	0	1	2	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	673	1	0	3	0	3	1	0	2	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	378	4	3	2	1	0	2	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
2008	554	1	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	316	2	1	1	0	1	1	0	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
2010	467	1	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
2011	115	3	1	0	0	0	0	1	0	0	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
2012	486	2	2	0	1	0	0	1	1	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.4.4. Gulf of Mexico Gag grouper private boat length composition data incremented by 2cm.

		Fork length (cm)																																		
Year	Samples	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86
1981	17	0	0	0	0	1	2	0	0	1	4	3	1	1	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1982	63	0	0	0	0	2	8	8	3	3	2	4	3	2	3	1	2	3	1	0	1	0	3	1	2	2	1	1	0	0	0	1	0	0	2	1
1983	40	0	0	0	0	2	0	1	1	4	1	3	0	2	3	3	1	4	1	4	0	2	1	2	1	1	0	1	0	0	0	1	0	1	0	0
1984	19	0	0	0	0	0	1	0	1	4	2	0	1	0	0	1	0	3	0	1	2	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
1985	19	0	0	0	0	0	0	0	0	1	0	0	1	4	1	1	2	1	0	1	1	1	0	2	0	1	0	0	2	0	0	0	0	0	0	0
1986	16	0	0	0	0	0	0	1	1	0	1	0	0	1	1	2	1	0	2	1	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0
1987	70	0	0	0	1	0	2	1	1	1	0	2	1	2	3	3	10	5	5	4	6	2	7	2	4	1	2	2	0	3	0	0	0	0	0	0
1988	58	0	0	0	0	0	1	0	1	0	1	0	1	0	1	3	3	4	2	2	4	4	9	2	6	3	1	3	1	2	1	0	2	1	0	0
1989	15	0	0	0	0	0	0	0	1	0	1	0	0	3	1	0	0	1	0	1	0	1	3	0	0	1	0	1	0	1	0	0	0	0	0	0
1990	32	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	3	0	1	0	2	1	4	4	2	3	2	0	4	2	0	1	0	0	0
1991	81	0	0	0	3	0	0	0	0	1	0	0	0	0	0	1	2	4	10	7	7	9	7	3	3	5	5	5	1	4	1	0	0	0	1	2
1992	127	0	0	0	0	1	1	1	0	1	0	0	0	2	1	1	5	20	12	13	12	6	12	9	8	5	6	3	3	0	4	0	1	0	0	0
1993	145	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	6	16	8	13	12	18	19	12	12	12	5	4	2	1	1	0	1	0	0	0
1994	138	0	0	1	0	2	0	0	1	0	0	1	1	1	0	2	5	9	13	19	14	6	18	9	7	8	8	3	2	4	2	1	0	0	1	0
1995	124	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	13	16	8	17	11	10	8	2	5	7	8	3	9	1	2	1	0	0	0	0
1996	111	0	0	0	1	0	0	0	0	0	0	0	1	0	2	4	8	17	16	15	11	6	5	4	5	7	2	1	0	2	0	2	1	1	0	0
1997	186	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	8	19	26	14	17	18	23	14	14	4	11	4	7	2	0	0	0	0	2	0
1998	299	0	0	1	0	0	0	2	0	1	0	1	0	1	3	5	12	39	30	37	32	29	12	25	25	10	12	5	4	4	4	2	1	1	0	1
1999	521	0	0	0	0	0	1	0	0	0	1	2	1	4	2	6	35	52	50	64	52	60	34	41	26	14	14	16	18	4	5	5	4	3	3	0
2000	407	0	0	0	0	0	0	0	0	0	2	0	0	0	1	1	10	38	48	52	45	39	39	29	27	13	14	21	7	6	9	3	1	1	0	1
2001	299	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	1	5	9	34	41	24	29	28	23	22	23	17	10	12	2	8	3	3	0	0
2002	303	0	0	0	0	1	0	0	0	0	0	2	0	2	1	2	1	6	17	35	42	38	28	29	17	9	20	17	12	8	6	2	3	3	0	1
2003	288	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4	6	12	39	57	37	31	22	26	11	12	9	8	1	4	5	2	0	1	0
2004	347	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2	4	24	31	45	49	38	40	26	16	16	19	13	8	7	0	2	2	2	0
2005	275	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	6	10	25	42	37	31	21	29	20	11	13	9	6	5	3	1	1	0	0
2006	136	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	5	16	20	26	12	12	14	9	7	3	3	3	2	0	0	0	1	0
2007	172	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	2	12	19	25	24	21	10	8	9	15	8	5	5	2	0	3	0	0	0
2008	288	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	3	4	11	37	46	38	31	19	21	17	17	17	8	10	1	2	1	0	1	1
2009	158	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	6	20	36	18	16	19	11	6	13	2	1	4	0	1	1	0	0	0
2010	170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	11	24	23	21	21	27	11	7	8	4	6	2	0	1	0	0	0	0
2011	88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	8	14	11	9	10	7	9	6	5	2	5	1	0	0	0	0	0	0
2012	64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	10	5	13	6	7	3	3	1	6	3	2	1	0	0	0	0	0

Table 2.4.4. Gulf of Mexico Gag grouper private boat length composition data incremented by 2cm, continued.

		Fork length (cm)																																			
Year	Samples	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120	122	124	126	128	130	132	134	136	138	140	142	144	146	148	150	152	154	156	158
1981	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	63	1	0	0	0	0	0	1	0	0	0	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
1983	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	127	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	145	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	138	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	124	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	299	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	521	2	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	1
2000	407	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	299	1	0	0	0	0	0	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
2002	303	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
2003	288	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	347	0	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
2005	275	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	172	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	288	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	158	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.4.5. Gulf of Mexico Gag grouper head boat length composition data incremented by 2cm.

		Fork length (cm)																																		
Year	Samples	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86
1981	19	0	0	0	0	0	0	0	1	1	1	0	1	1	0	1	0	1	0	3	2	1	0	0	0	1	0	0	1	1	1	0	0	0	0	1
1982	11	0	0	0	0	0	0	0	0	2	0	0	0	2	2	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1
1983	70	0	0	0	0	0	0	0	1	2	3	4	2	4	3	2	4	2	2	4	2	2	2	1	4	3	1	7	1	1	4	0	2	2	3	1
1984	31	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	2	0	3	1	2	2	0	2	2	3	3	2	3	0	2	1
1985	109	0	0	0	0	0	0	0	0	0	1	2	3	3	1	1	3	5	6	3	8	8	6	11	6	7	8	3	7	5	3	1	3	2	0	3
1986	639	0	0	0	1	2	3	6	8	18	16	29	36	29	49	36	29	25	33	29	28	29	29	36	26	26	12	20	24	14	9	10	10	6	5	6
1987	637	0	0	0	0	5	10	7	13	12	22	20	30	27	32	47	45	42	32	32	51	34	42	15	20	18	11	12	15	7	10	10	2	2	5	2
1988	374	0	1	0	0	1	1	3	12	9	18	13	11	15	9	30	34	29	28	15	15	23	32	16	12	5	8	7	5	3	5	6	1	1	1	2
1989	418	0	0	0	0	1	0	3	10	13	11	24	11	10	24	21	21	20	14	12	11	14	5	24	14	20	20	17	21	13	12	16	9	9	12	3
1990	344	0	0	0	0	0	2	0	1	4	1	6	4	4	3	7	15	14	21	13	21	14	13	13	14	24	25	21	18	19	19	14	8	10	9	6
1991	149	0	0	0	0	3	0	3	0	0	0	0	1	1	0	1	11	14	14	11	8	5	5	3	10	5	5	8	6	9	5	5	6	3	5	2
1992	151	0	0	0	0	0	0	0	0	0	1	3	1	1	0	1	3	16	16	15	8	11	6	9	4	6	4	5	4	6	6	4	4	3	1	1
1993	126	0	0	0	0	0	0	0	0	0	0	1	3	2	1	1	3	5	10	3	8	6	22	9	14	11	4	8	5	2	1	1	0	2	2	2
1994	213	0	0	0	0	0	0	0	0	0	0	1	0	0	2	5	12	19	24	13	24	7	10	13	19	16	8	16	9	3	4	3	2	2	1	0
1995	190	0	0	0	0	0	0	0	1	0	1	0	0	1	2	5	15	30	26	18	18	9	12	10	6	4	2	2	9	4	7	4	1	2	1	0
1996	267	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	26	33	33	28	22	25	25	15	12	10	8	2	1	3	2	5	2	2	3	0
1997	316	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	27	56	34	26	32	26	25	13	18	11	8	6	8	4	3	2	0	0	1	1
1998	539	0	0	0	0	0	0	0	0	1	4	2	4	5	1	14	50	70	44	41	50	36	31	32	33	21	26	13	19	5	4	4	4	3	0	0
1999	516	0	0	0	0	0	0	0	0	2	0	1	0	0	1	11	68	85	63	63	46	29	26	16	14	17	11	5	7	9	3	6	1	0	3	1
2000	356	0	0	0	0	0	0	0	0	0	0	0	0	2	1	2	25	24	25	32	42	42	29	26	22	17	14	6	9	5	7	3	0	2	0	0
2001	297	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	4	14	28	33	16	14	20	28	22	22	11	14	12	5	4	5	1	4	0
2002	343	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	24	58	48	49	34	16	14	10	10	10	4	7	2	1	4	0	1	1
2003	427	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	8	41	54	66	63	28	28	23	25	15	9	4	5	3	4	0	0	1	1
2004	282	0	0	0	0	0	0	0	1	0	0	1	0	3	2	1	2	2	28	40	39	30	18	12	8	10	8	8	8	5	4	1	1	1	0	0
2005	260	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	7	24	43	29	28	27	18	8	7	9	6	7	2	2	1	0	0	0	0
2006	179	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	34	20	21	18	15	10	14	2	8	2	5	1	4	2	0	0	0
2007	175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	20	36	22	24	10	11	7	9	9	4	3	1	0	1	0	0	1	1
2008	216	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	22	43	22	39	22	10	8	8	12	4	4	7	1	1	1	1	2	0
2009	124	0	0	4	2	1	1	0	0	0	0	0	0	0	0	0	0	2	16	25	13	13	7	8	6	4	2	3	2	2	1	2	1	0	0	0
2010	139	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	28	27	18	9	12	4	8	10	4	3	2	2	0	1	0	0	1
2011	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1	2	7	4	3	3	1	4	3	3	1	3	2	0	0	0	0
2012	105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	9	21	7	6	6	5	6	1	3	8	8	4	3	2	1	0	1

Table 2.4.5. Gulf of Mexico Gag grouper head boat length composition data incremented by 2cm, continued.

		Fork length (cm)																																	
Year	Samples	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120	122	124	126	128	130	132	134	136	138	140	142	144	146	148	150	152	154	156	158
1981	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	19	0	2	0	1	3	1	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
1983	78	1	1	1	3	1	1	0	0	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
1984	34	1	0	0	1	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
1985	116	0	0	1	1	1	1	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	663	8	1	3	5	4	0	0	0	0	1	1	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
1987	651	1	3	4	1	1	0	1	1	2	2	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	381	1	1	1	0	0	1	1	0	1	2	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	450	9	6	5	3	1	1	4	2	2	1	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
1990	361	4	8	1	1	0	1	0	0	0	2	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
1991	156	0	0	0	0	1	0	0	1	0	2	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
1992	143	1	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	130	0	1	0	0	0	0	0	0	0	2	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
1994	219	1	2	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	191	0	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
1996	268	0	0	0	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
1997	310	0	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
1998	519	0	1	0	0	0	0	0	0	0	0	0	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
1999	489	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	339	0	0	0	0	0	1	1	0	1	0	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
2001	263	0	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
2002	300	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
2003	384	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	233	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	221	0	1	0	0	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
2006	169	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
2007	161	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	213	1	0	0	0	0	0	0	0	0	1	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
2009	118	1	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
2010	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	0	0	0	0	0
2011	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	96	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

Table 2.6.1. Standardized indices of abundance and the associated log-scale standard errors for the Gulf of Mexico gag grouper.

	Fishery-dependent indices										Fishery-independent indices					
	Handline		Longline		Headboat		Charter		MRFSS		Age-0 survey		SEAMAP video		PC video survey	
Year	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV
1986	.	.	.	.	1.3992	0.0824	1.6021	0.2578	0.9202	0.2334	.	.	.	.	.	.
1987	.	.	.	.	1.5559	0.0831	0.4875	0.3257	0.4104	0.2499	.	.	.	.	.	.
1988	.	.	.	.	1.1239	0.0901	0.5404	0.3352	0.4652	0.2144	.	.	.	.	.	.
1989	.	.	.	.	1.0653	0.1024	0.4074	0.4111	0.3961	0.2638	.	.	.	.	.	.
1990	0.3142	0.3084	0.8236	0.4185	0.9787	0.0890	0.5474	0.4883	0.4843	0.3264	.	.	.	.	.	.
1991	0.3140	0.2354	0.6416	0.3434	0.7093	0.1050	0.1779	0.7371	0.7229	0.2620	.	.	.	.	.	.
1992	0.5622	0.2293	0.5108	0.3470	0.8489	0.1153	0.7367	0.3918	0.4517	0.1957	.	.	.	.	.	.
1993	0.6506	0.2030	0.6701	0.2870	0.8655	0.1009	0.8198	0.3705	0.8851	0.1774	.	.	1.3073	0.4688	.	.
1994	0.5885	0.2019	0.3778	0.2958	0.9065	0.1148	0.4698	0.4478	1.2670	0.1424	0.7930	0.3326	0.6538	0.6421	.	.
1995	0.7823	0.1985	0.4804	0.2892	0.7675	0.1199	1.5044	0.3202	1.2689	0.1472	0.5579	0.2586	1.4402	0.5939	.	.
1996	0.9304	0.1961	0.5043	0.2976	1.0211	0.0945	1.8432	0.3405	0.9819	0.1500	1.2167	0.1783	1.3998	0.3625	.	.
1997	0.9068	0.1933	0.6417	0.2761	0.9959	0.0989	1.0839	0.2762	1.3508	0.1431	0.4505	0.1998	1.5286	0.3963	.	.
1998	1.5462	0.1923	0.9517	0.2750	1.1651	0.0878	1.6516	0.2405	1.4069	0.1311	0.2069	0.3308	.	.	.	.
1999	1.0445	0.1933	0.8542	0.2779	1.2757	0.0873	1.3816	0.2316	0.9489	0.1256	0.2926	0.2741	.	.	.	.
2000	1.1093	0.1938	0.8767	0.2799	1.2053	0.0973	0.6799	0.2536	0.8362	0.1357	0.4948	0.2764	.	.	.	.
2001	1.5928	0.1940	1.6375	0.2689	0.6123	0.1351	0.7736	0.2564	0.8350	0.1282	0.6088	0.2981	.	.	.	.
2002	1.5898	0.1947	1.4376	0.2799	0.7218	0.1241	1.1155	0.2487	0.8962	0.1278	1.7145	0.2035	2.7134	0.2494	.	.
2003	1.5626	0.1949	1.7063	0.2719	1.0019	0.1019	1.5211	0.2359	1.3380	0.1212	0.7445	0.2286	.	.	.	.
2004	1.9908	0.1948	2.0630	0.2670	1.0990	0.1021	1.6681	0.2326	1.4445	0.1145	1.7011	0.1741	1.4629	0.2519	.	.
2005	1.8717	0.1960	2.2602	0.2619	1.1523	0.0762	2.1778	0.2328	1.3399	0.1240	0.7471	0.1810	0.8476	0.2515	0.4444	0.5218
2006	1.0058	0.2005	1.1990	0.2682	0.5377	0.1341	0.8885	0.2681	0.9725	0.1382	2.1743	0.1500	0.5460	0.3348	2.2179	0.2189
2007	0.6479	0.2040	0.9217	0.2819	0.6463	0.1340	0.5618	0.2816	1.2833	0.1299	2.1779	0.1496	0.5293	0.2746	1.1220	0.3066
2008	0.6400	0.2064	0.9935	0.2691	0.9952	0.0990	1.1276	0.2616	1.8698	0.1106	1.7275	0.1391	0.1089	0.6386	0.7517	0.2937
2009	0.3496	0.2087	0.4483	0.3363	0.9312	0.1035	0.9969	0.2712	1.4044	0.1234	1.3631	0.1559	0.4441	0.3691	1.2182	0.2123
2010	.	.	.	.	1.4185	0.0885	0.9405	0.2678	1.3486	0.1373	1.4232	0.1644	0.6453	0.2858	1.3210	0.1899
2011	.	.	.	.	.	.	0.5626	0.2731	0.9305	0.1471	0.1175	0.2733	0.7116	0.2802	0.7156	0.2436
2012	.	.	.	.	.	.	0.7325	0.2644	0.5408	0.1737	0.4881	0.2063	0.6612	0.2712	0.2092	0.3849

2.8 Figures

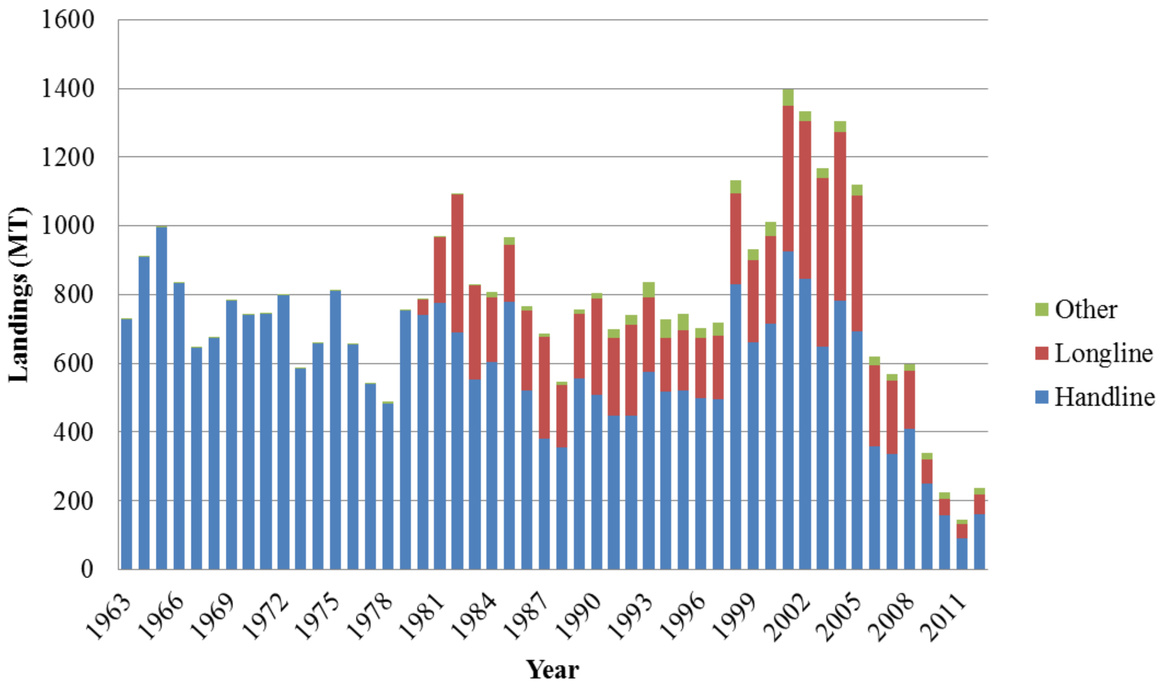


Figure 2.2.1. Gulf of Mexico commercial landings in metric tons.

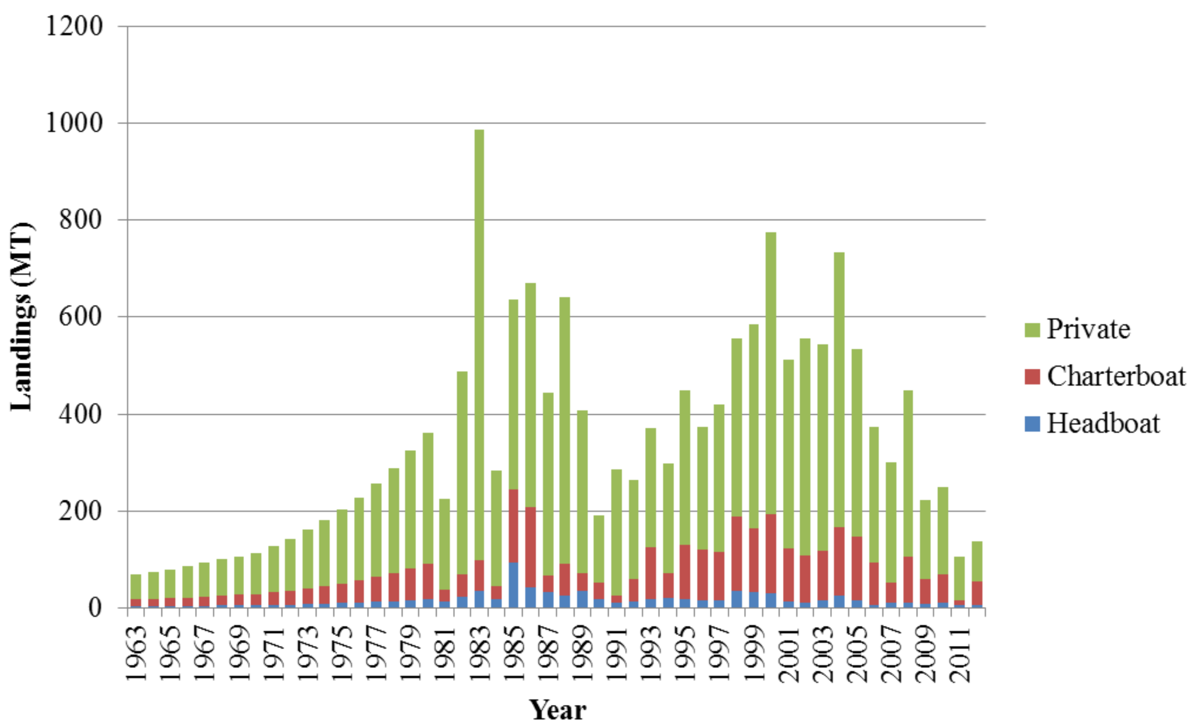


Figure 2.2.2 Gulf of Mexico recreational landings in thousands of fish.

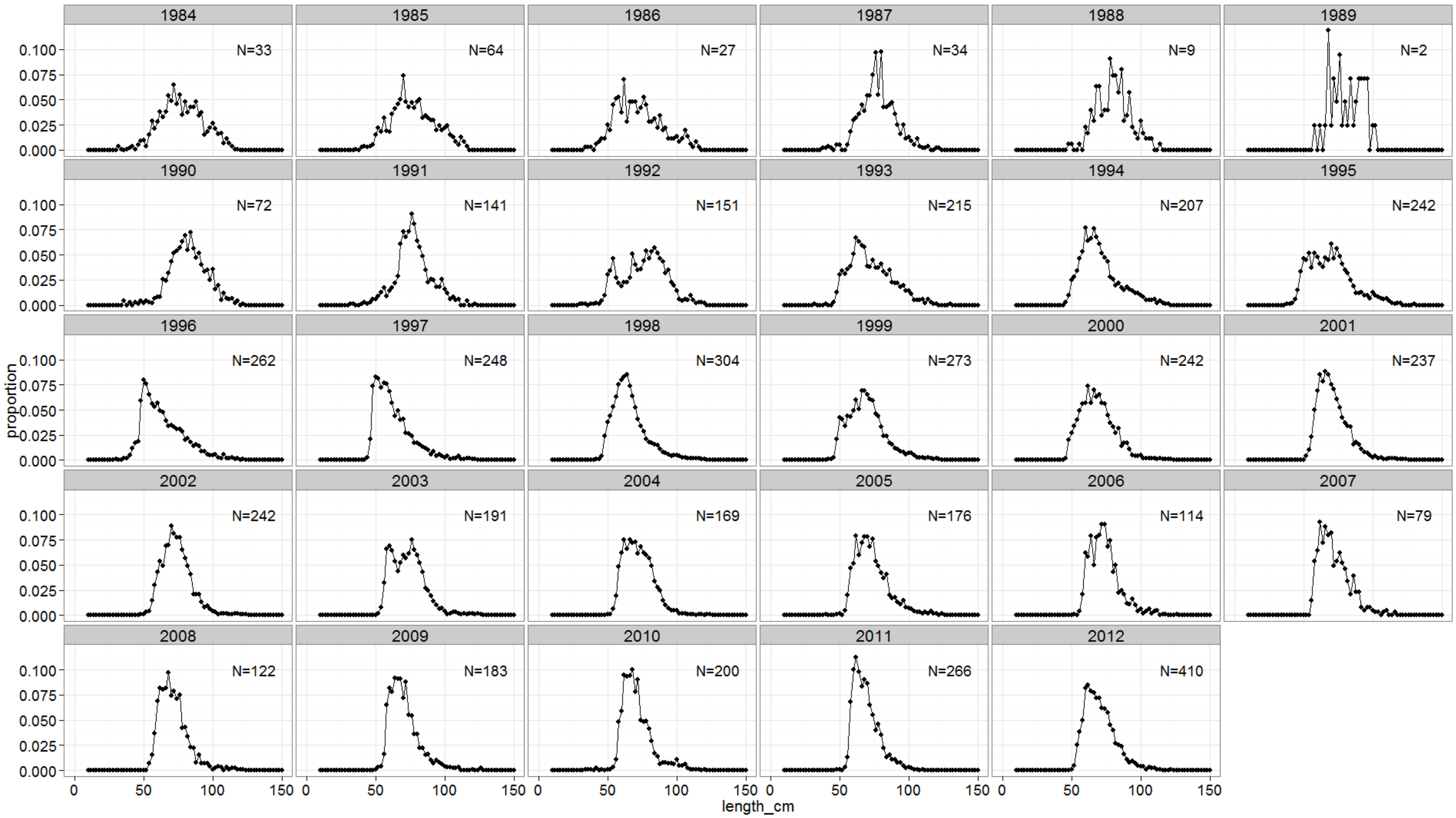


Figure 2.4.1. Annual length composition data in cm FL from the commercial vertical line fishery. N denotes the effective sample size.

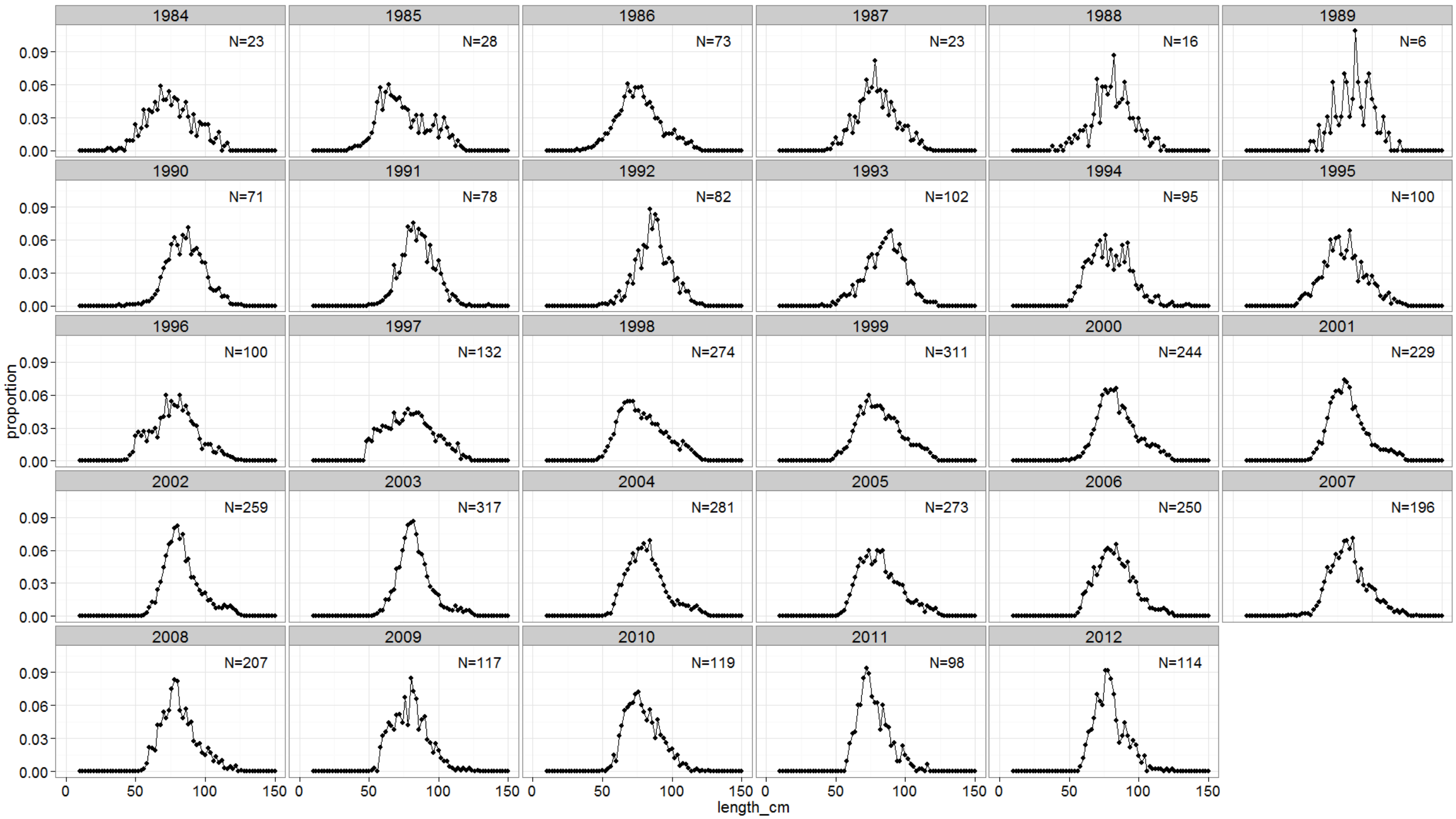


Figure 2.4.2. Annual length composition data in cm FL from the commercial longline fishery. N denotes the effective sample size.

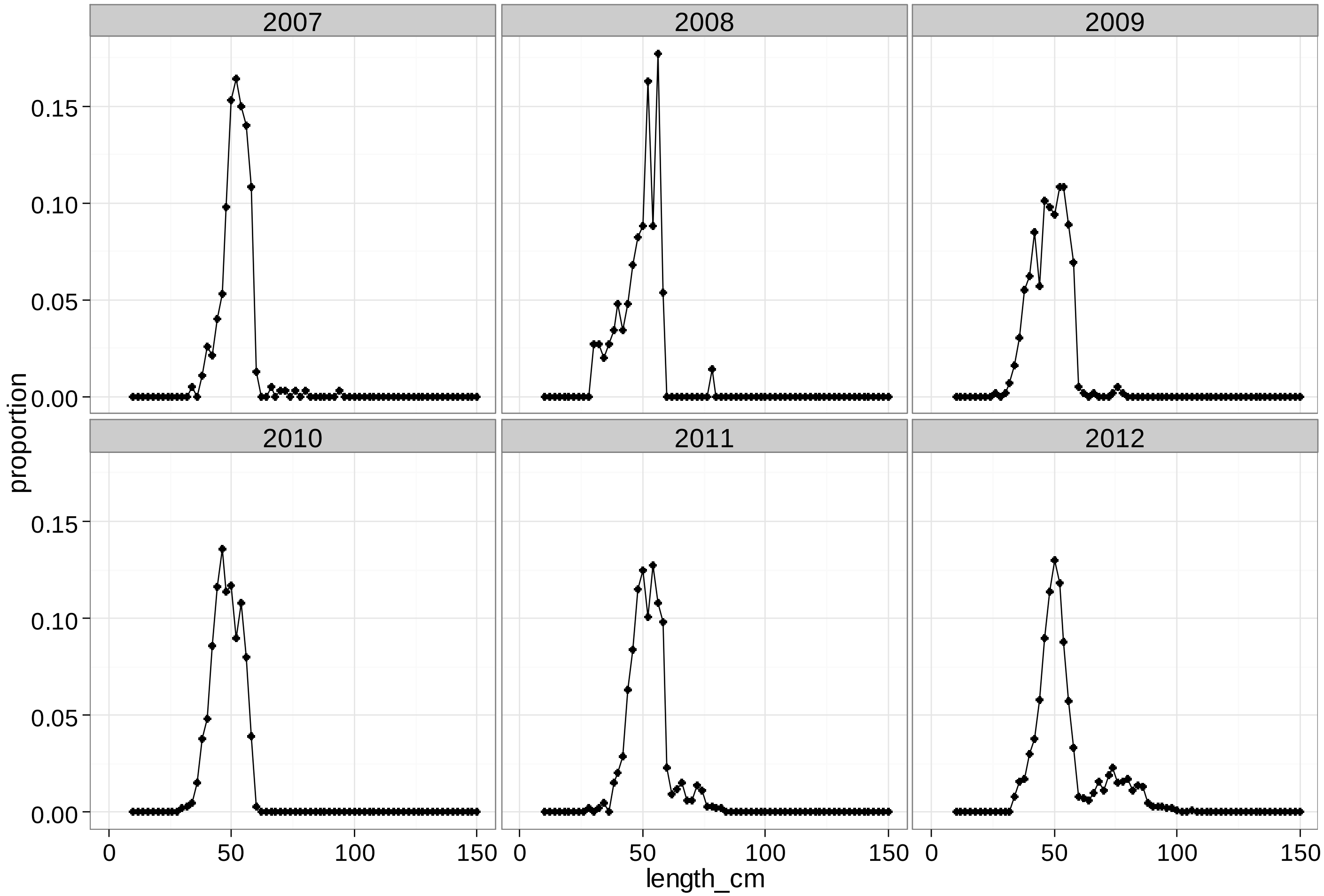


Figure 2.4.3. Annual length composition data of discarded Gag Grouper from the commercial vertical line observer program. Effective sample size, N, was 200 in all years.

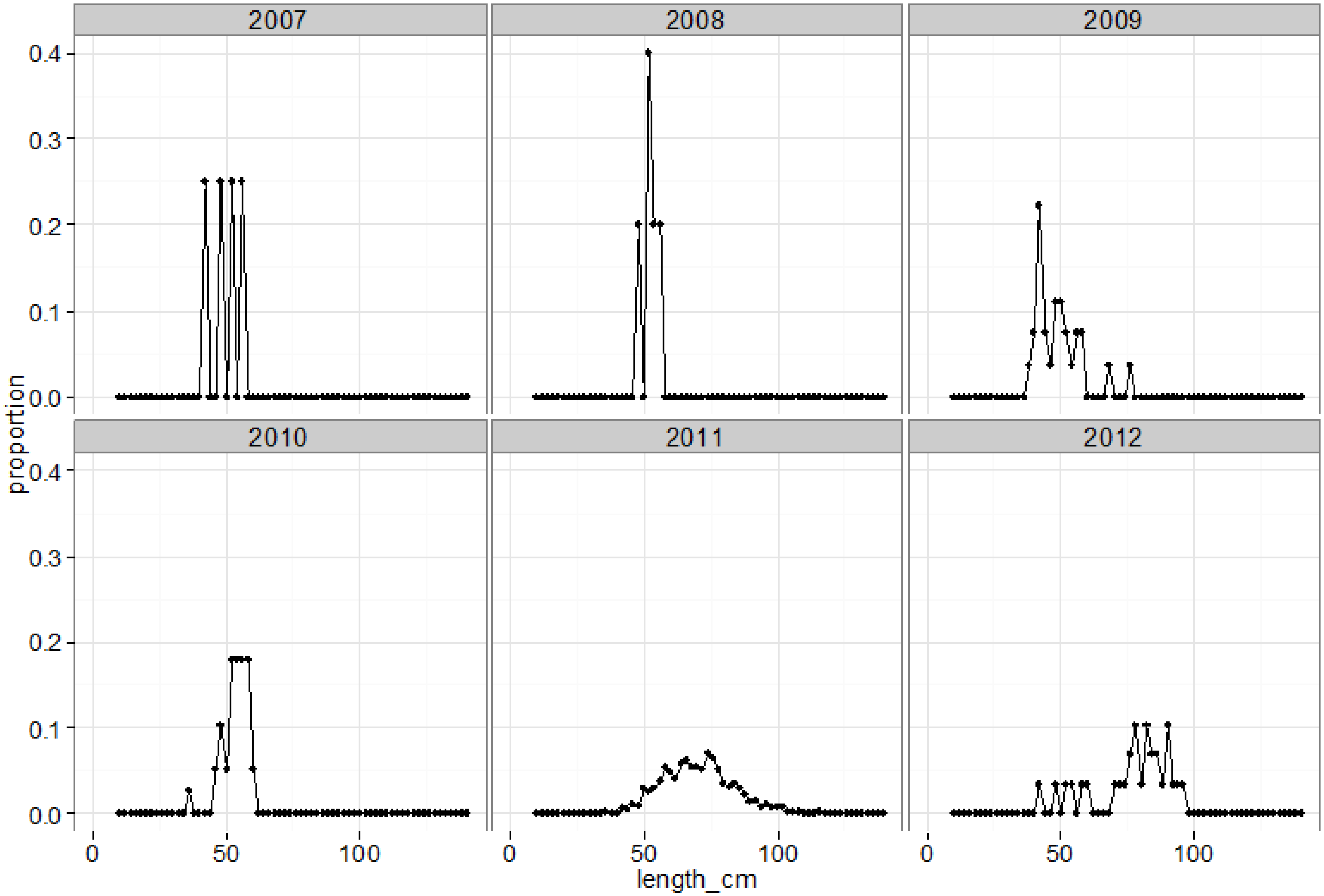


Figure 2.4.4. Annual length composition data of discarded Gag Grouper from the commercial longline observer program. Effective sample size, N, was: N_{2007}=4, N_{2008}=5, N_{2009}=27, N_{2010}=39, N_{2011}=200, N_{2012}=29.

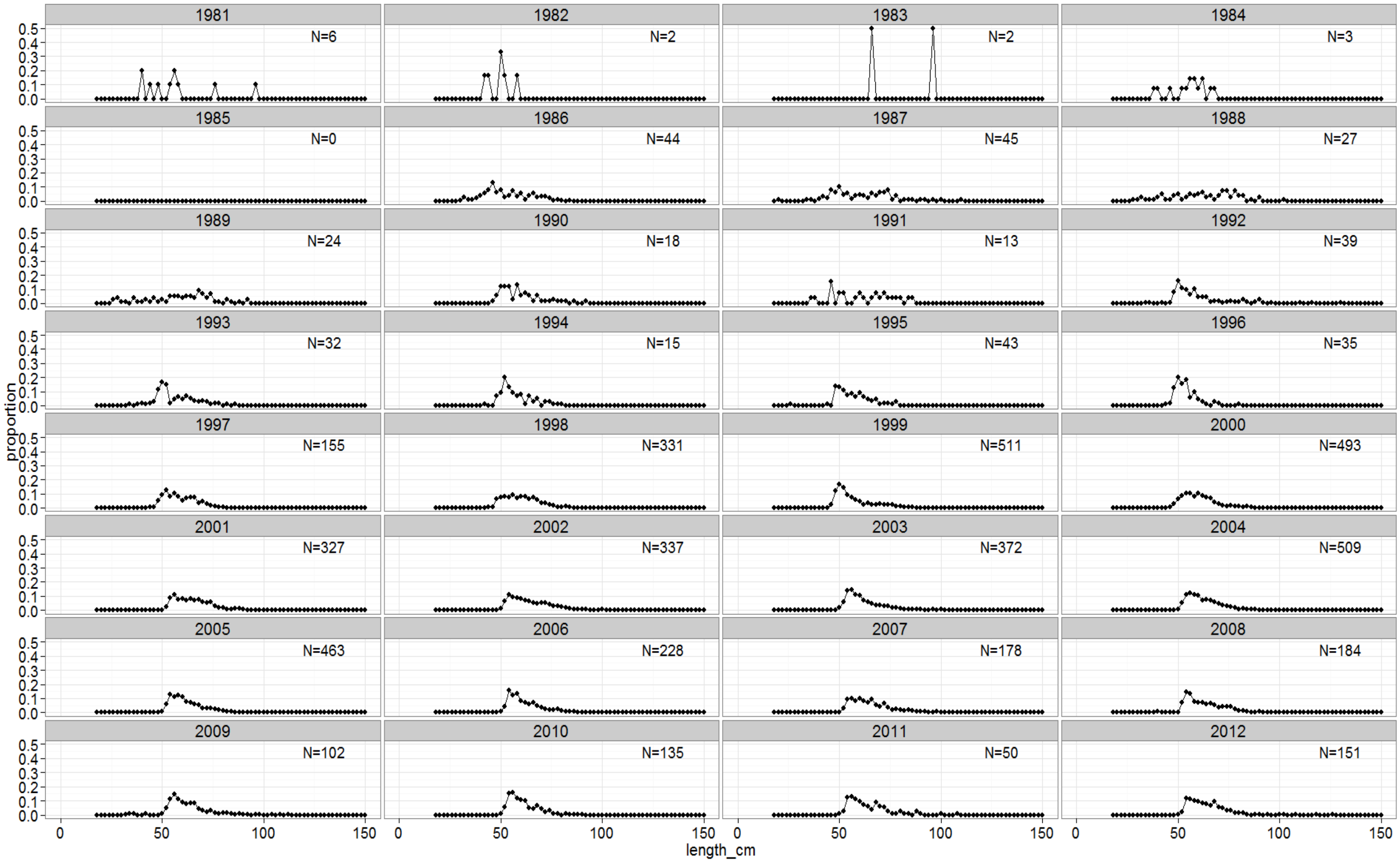


Figure 2.4.5. Annual length composition data in cm FL from the recreational charter boat fishery. N denotes the effective sample size.

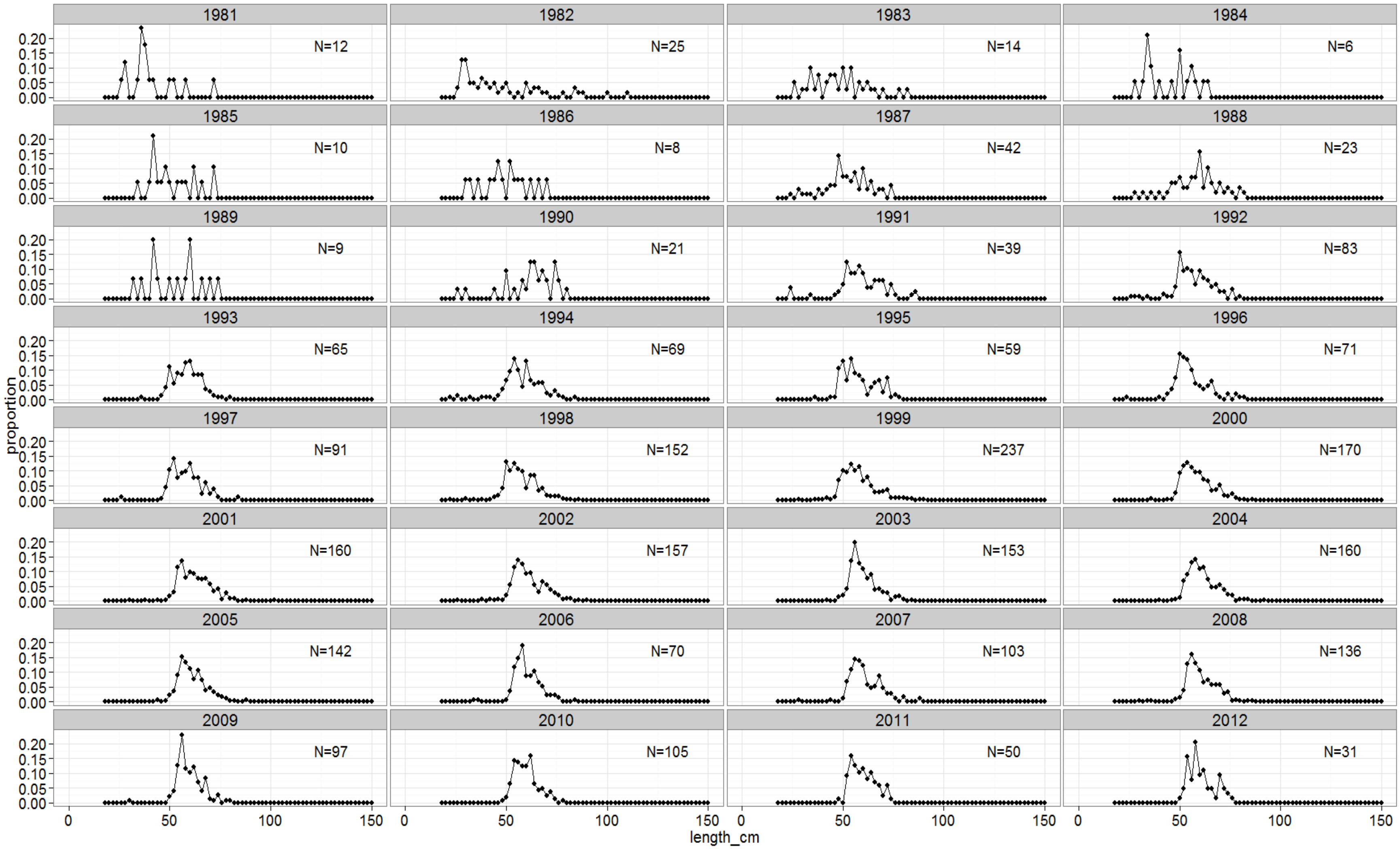


Figure 2.4.6. Annual length composition data in cm FL from the recreational private boat fishery. N denotes the effective sample size.

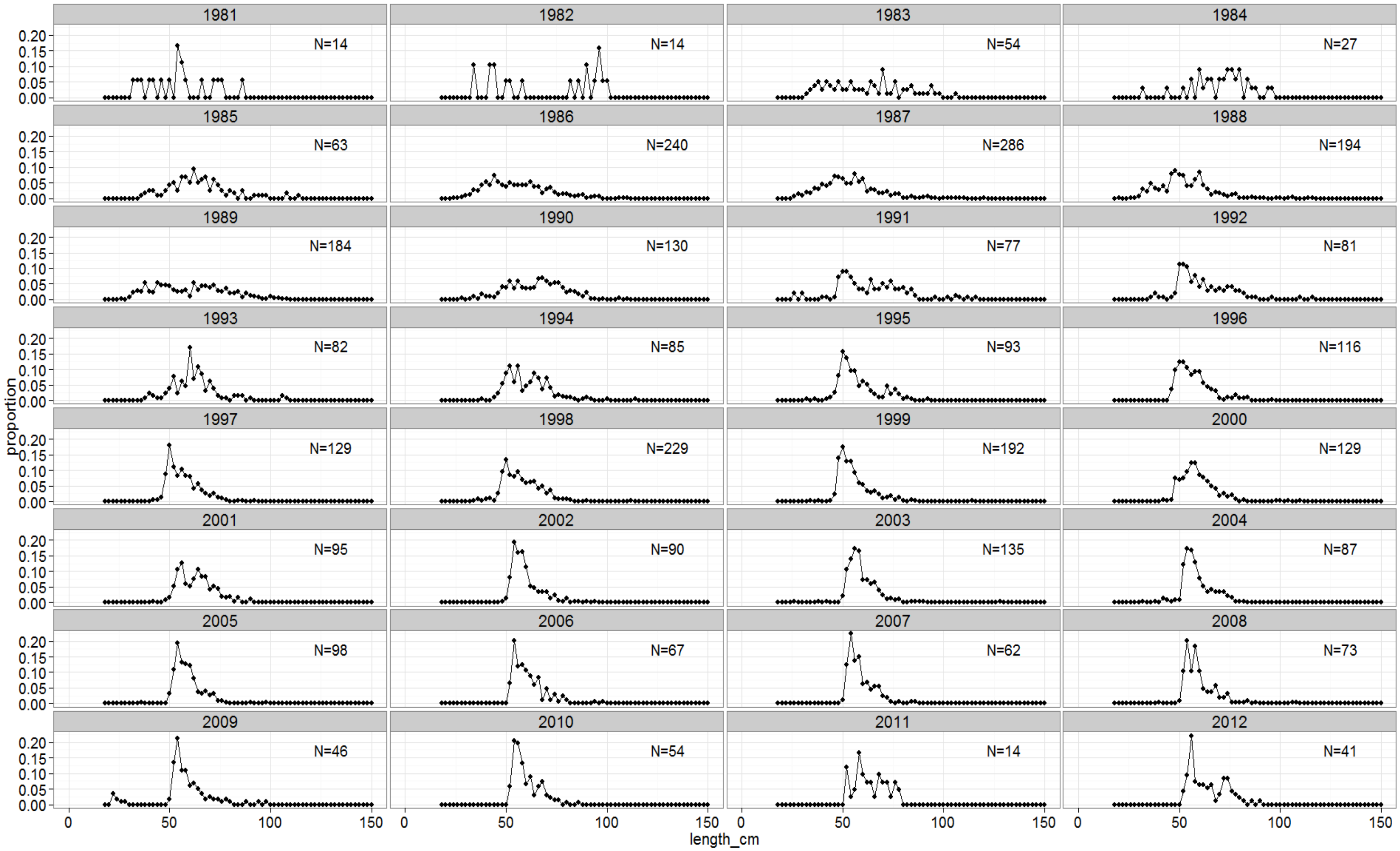


Figure 2.4.7. Annual length composition data in cm FL from the Head Boat Survey (HBS). N denotes the effective sample size.

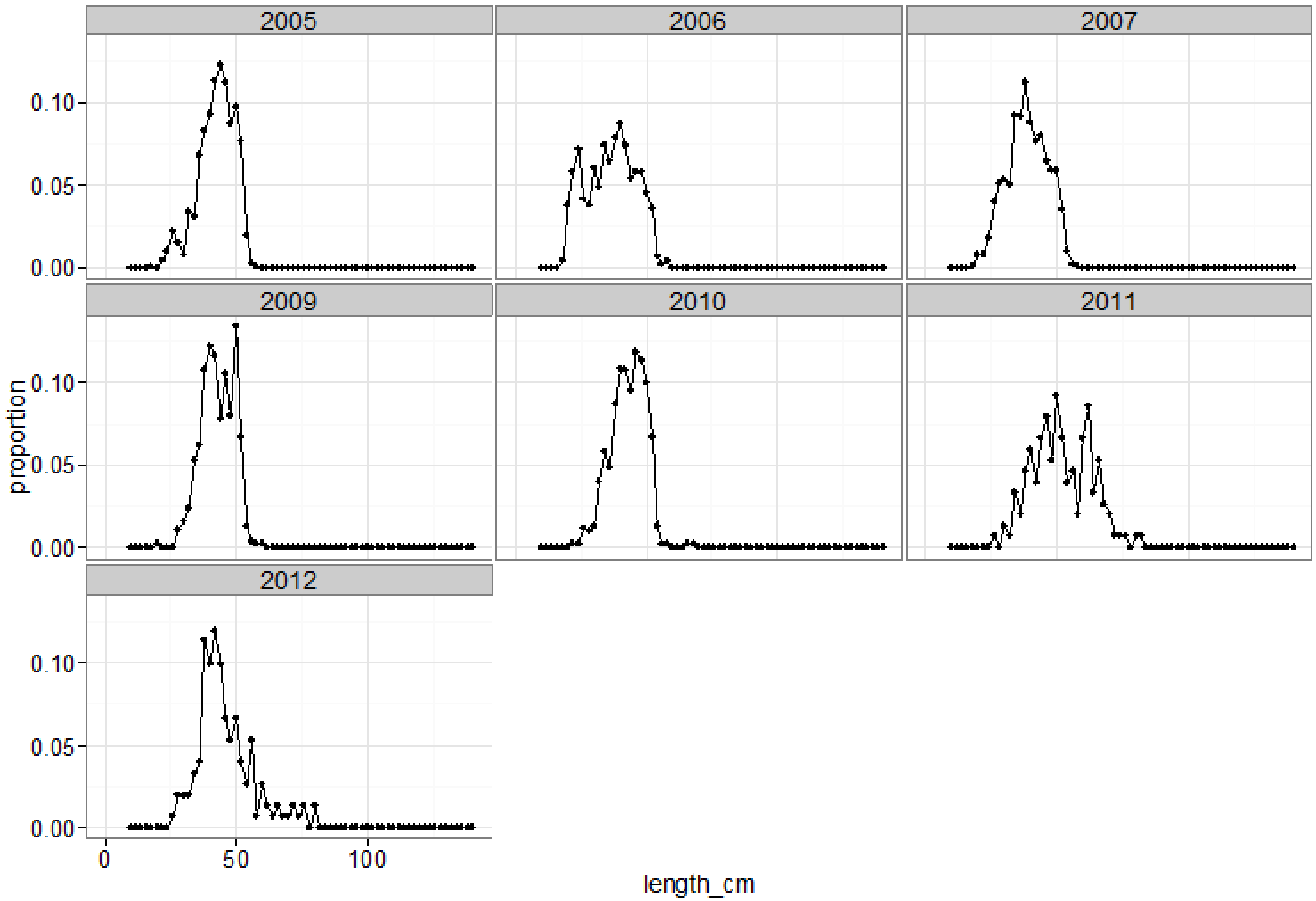


Figure 2.4.8. Annual length composition of discarded Gag Grouper from the Headboat observer program. Effective sample size, N, was equal to 200 in all years.

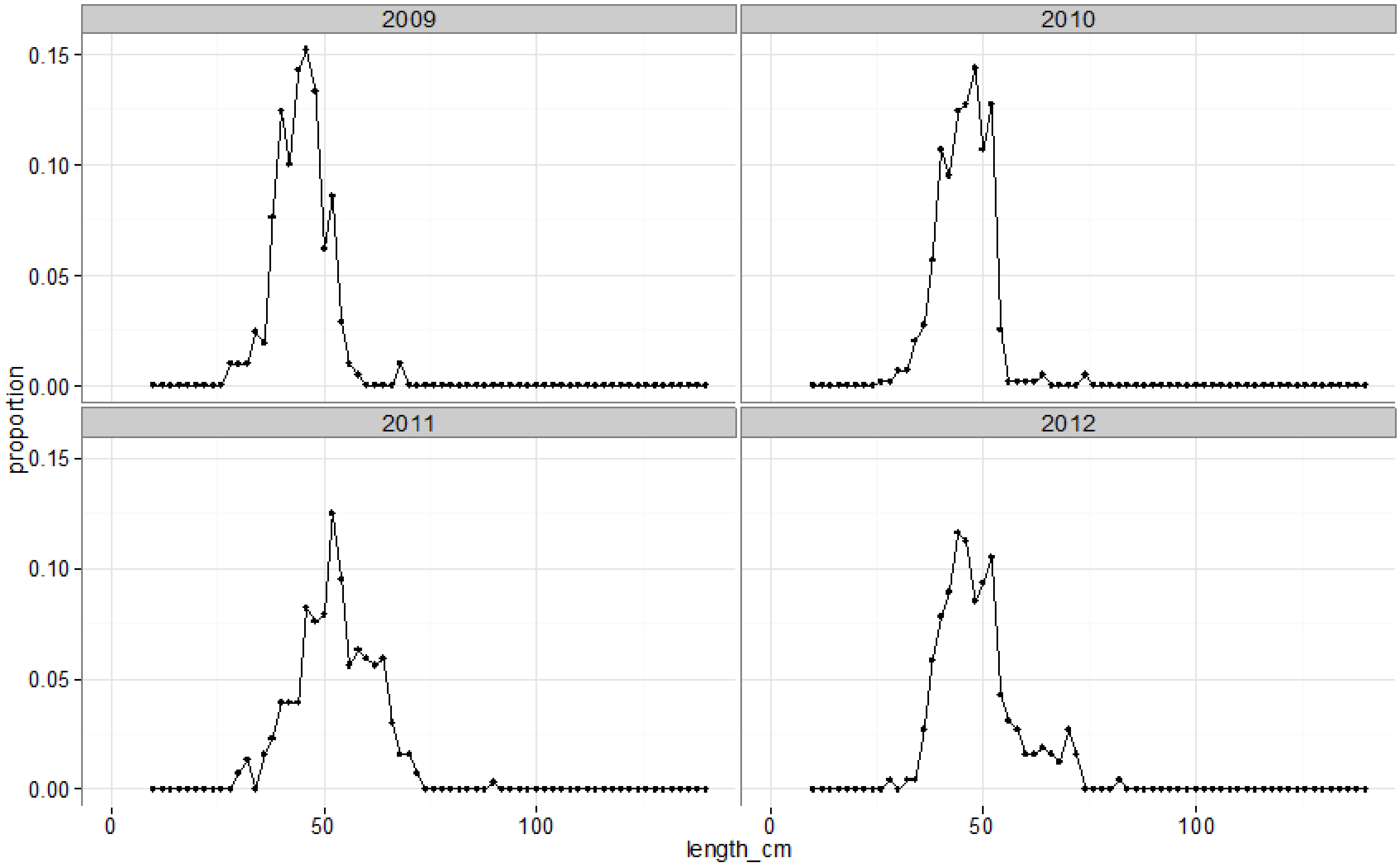


Figure 2.4.9. Annual length composition of discarded Gag Grouper from the charterboat observer program. Effective sample size was 200 in all years.

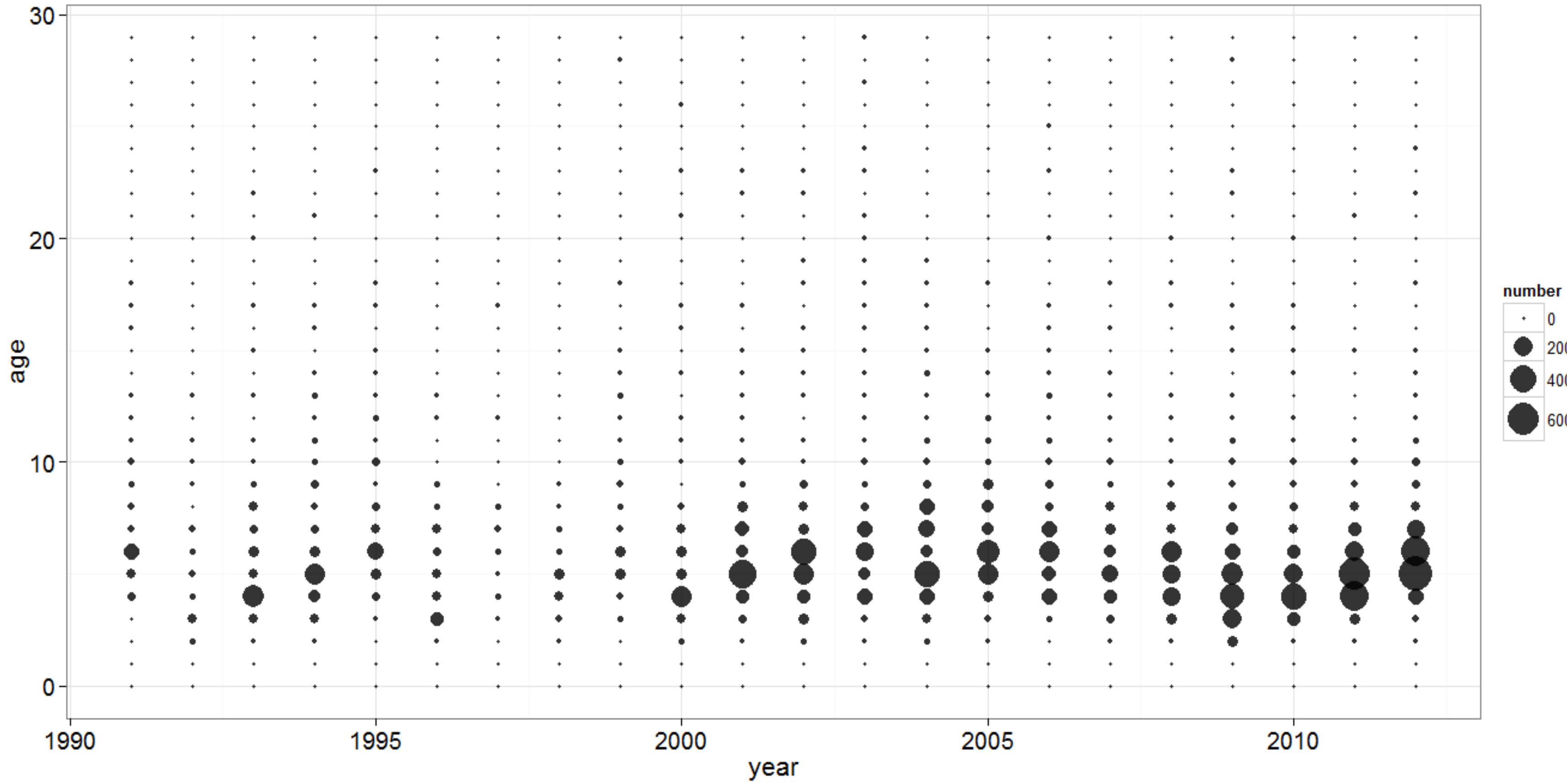


Figure 2.5.1. Annual age composition data from the vertical line fishery.

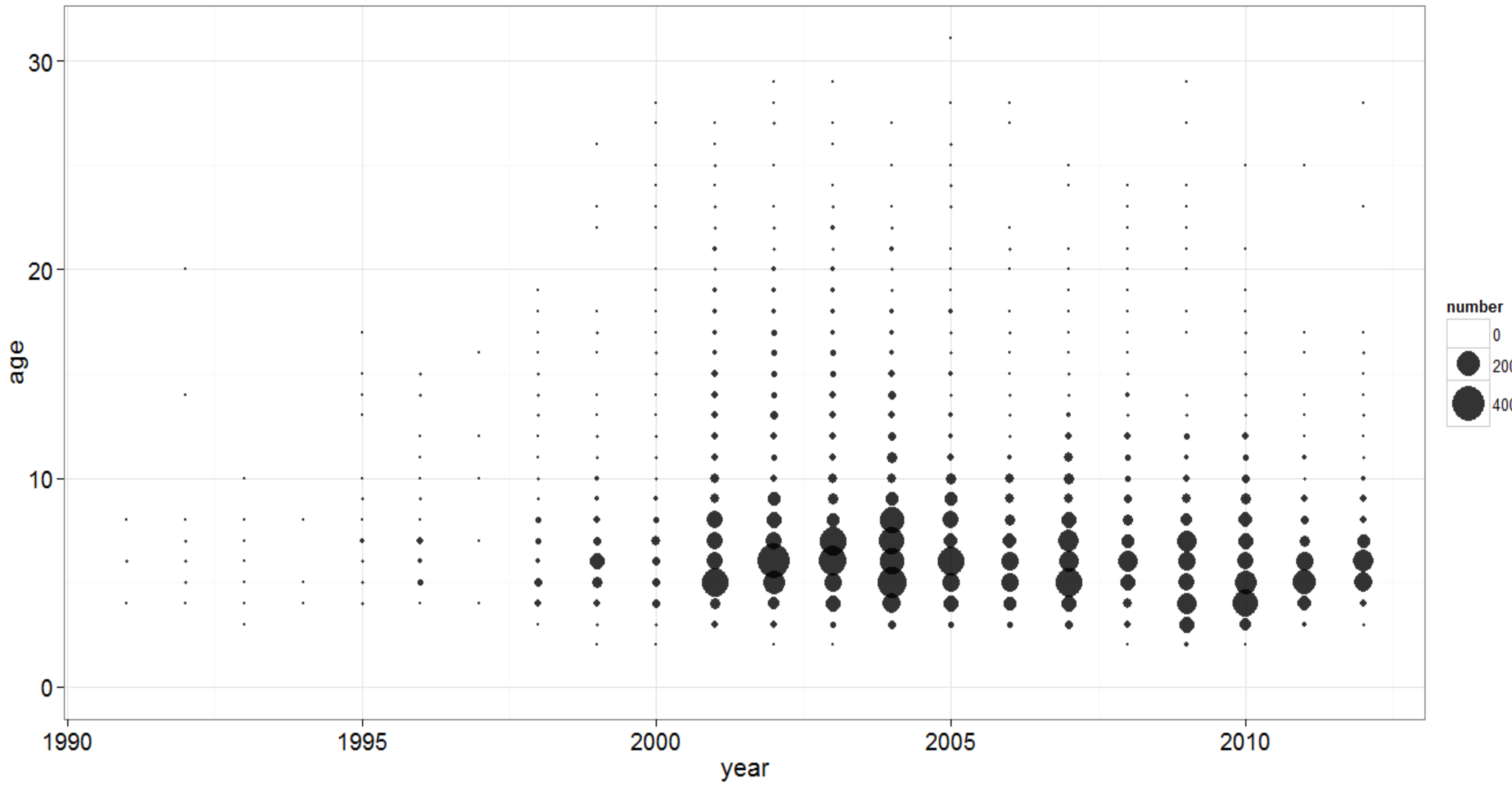


Figure 2.5.2. Annual age composition data from the longline fishery.

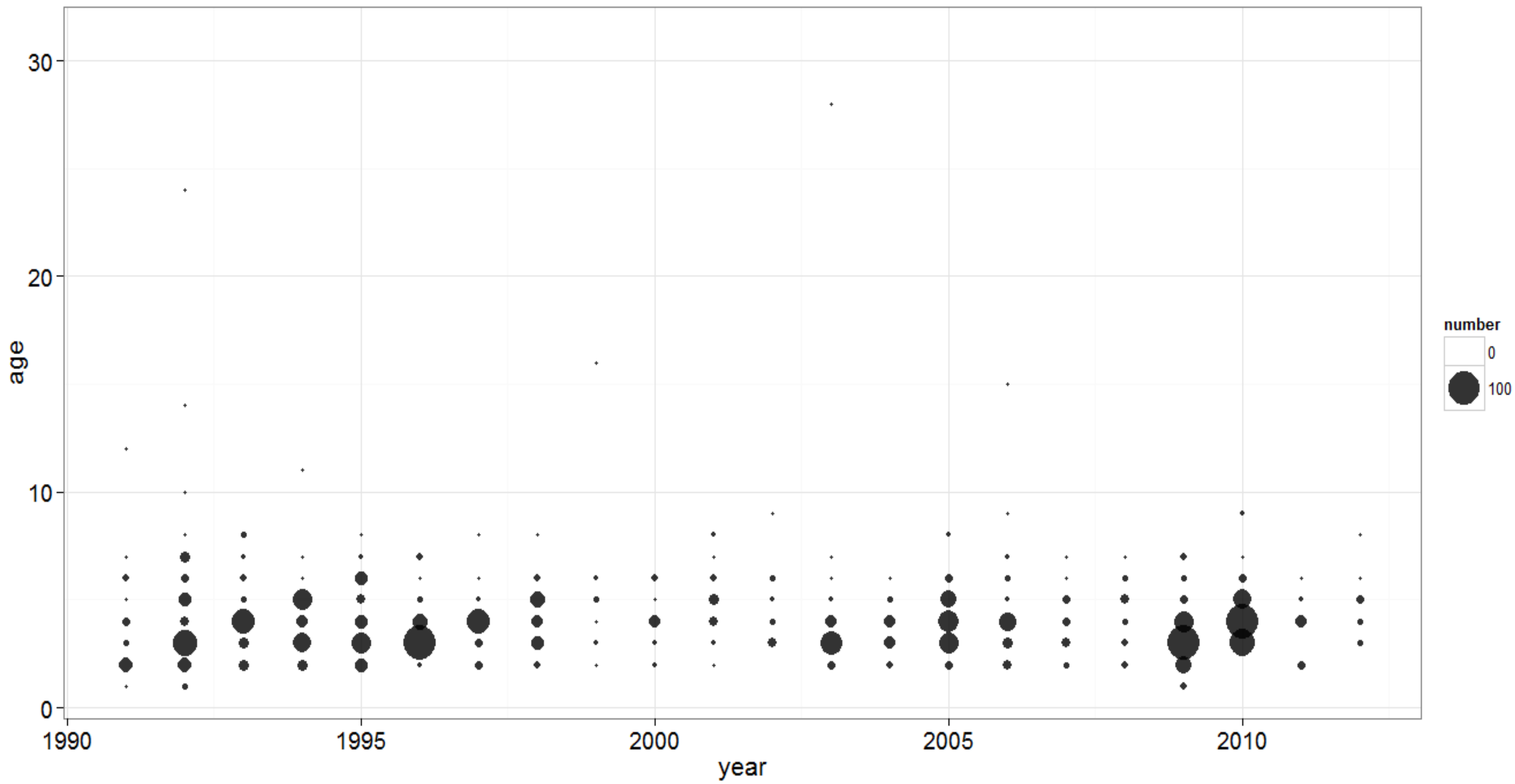


Figure 2.5.3. Annual age composition data from the headboat fishery.

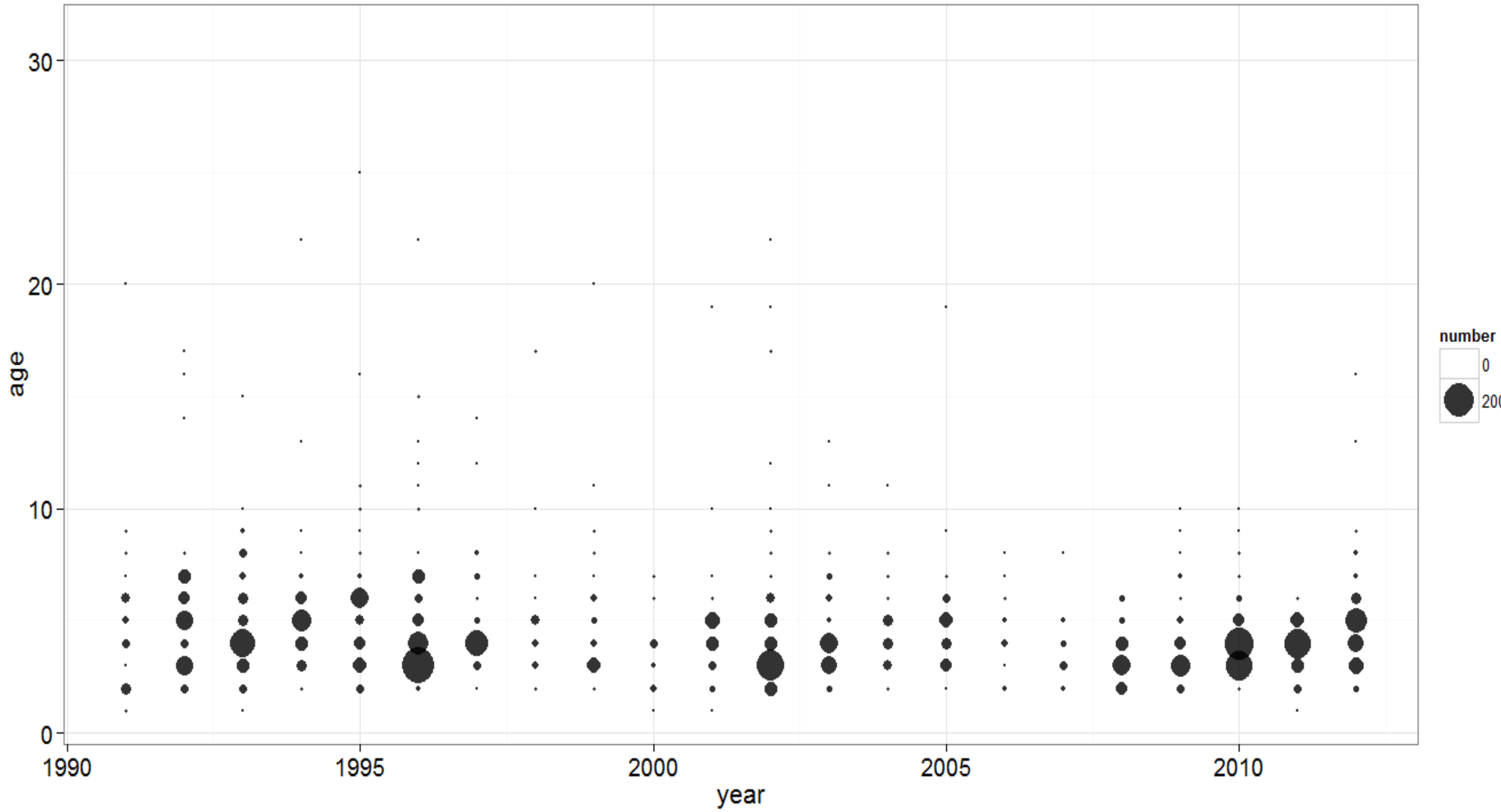


Figure 2.5.4. Annual age composition data from the recreational charter boat fishery.

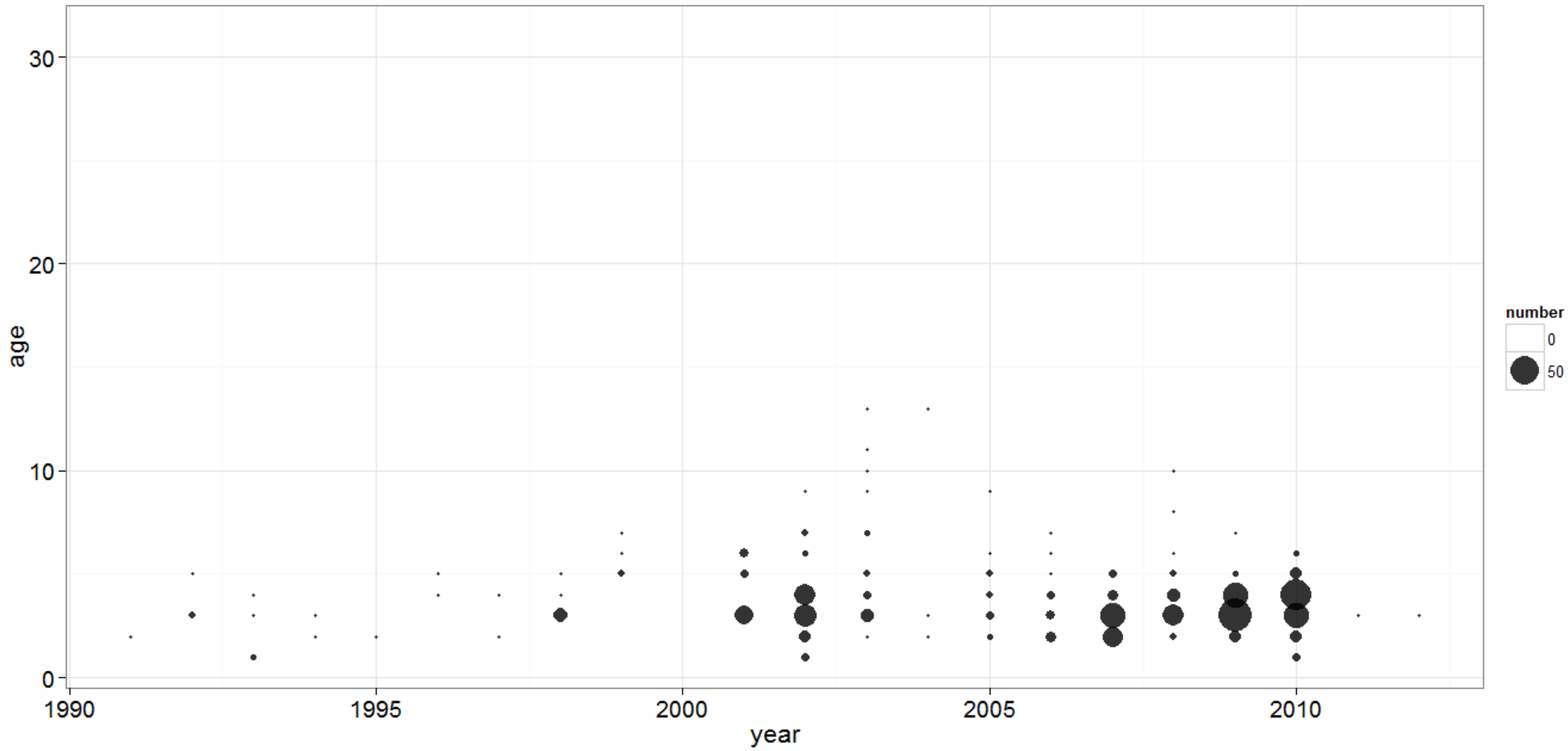


Figure 2.5.5. Annual age composition data from the recreational private boat fishery.

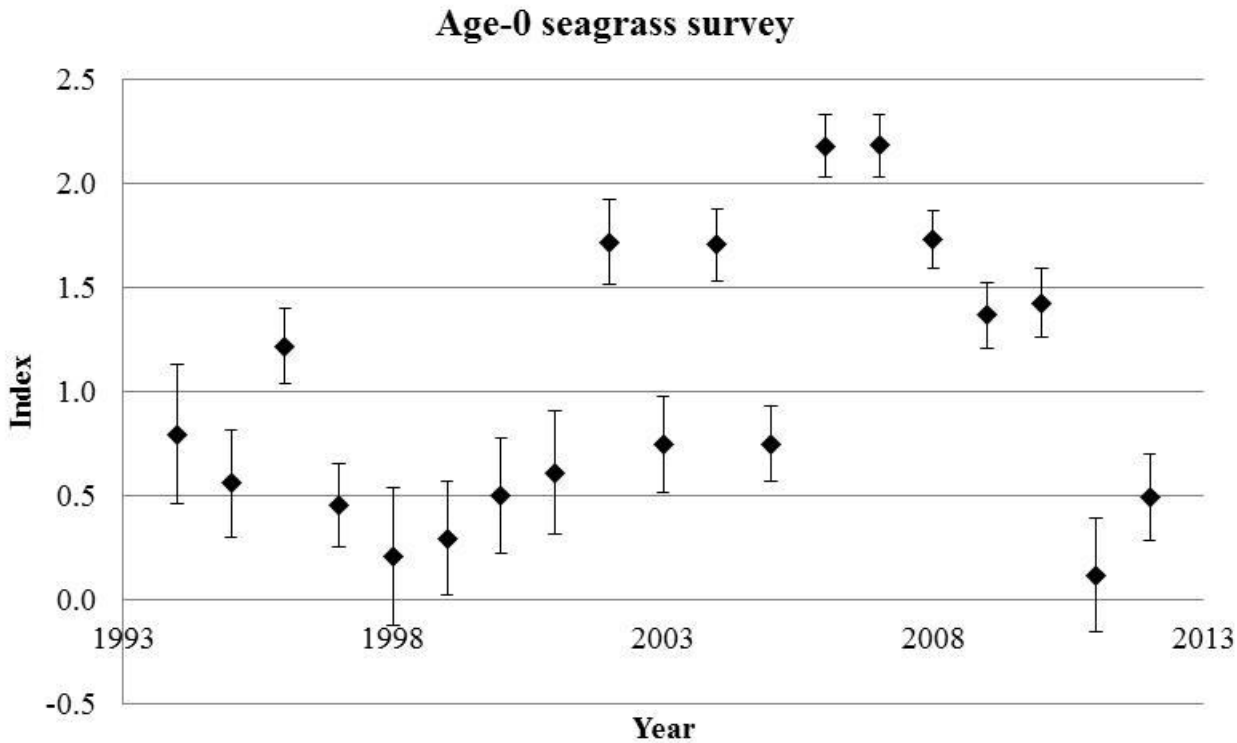


Figure 2.6.1. Standardized index of abundance and associated log-scale standard errors from the Gulf of Mexico age-0 seagrass survey. The index reflects the number of Gag grouper per haul.

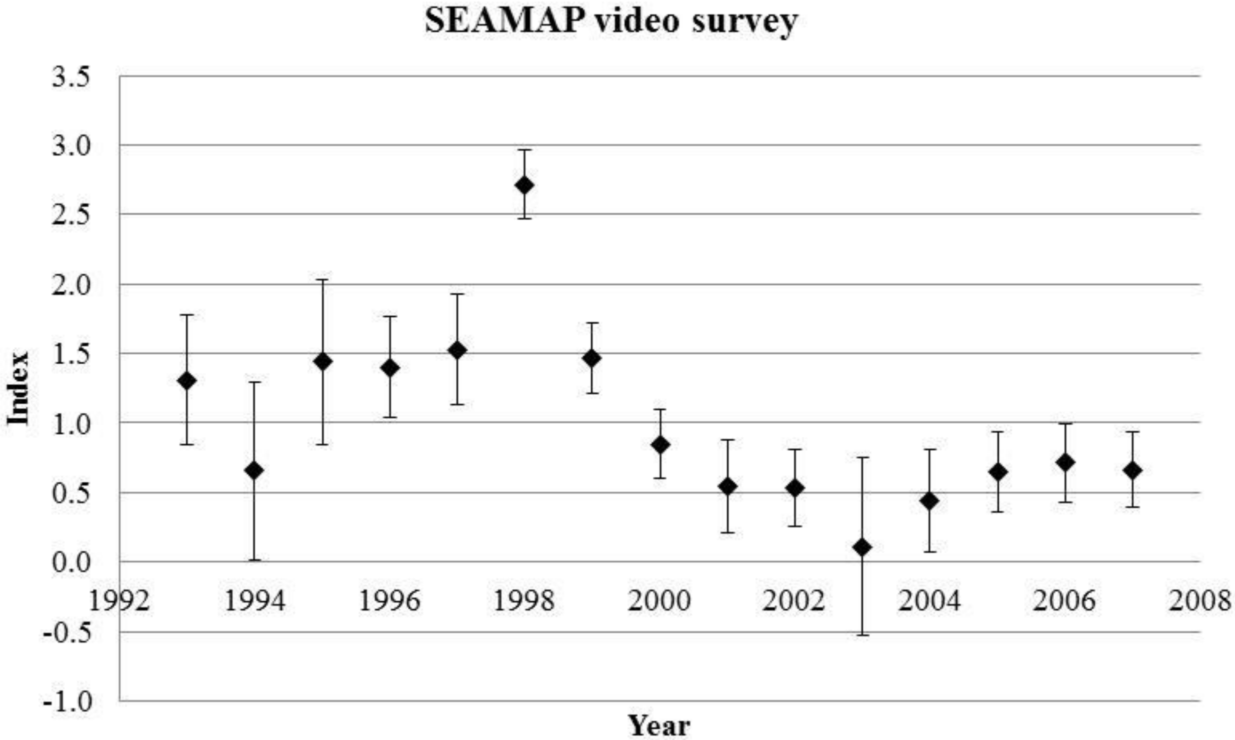


Figure 2.6.2. Standardized index of abundance and associated log-scale standard errors from the Gulf of Mexico SEAMAP video survey. The index reflects highest minimum count of Gag grouper per 20 minute recording.

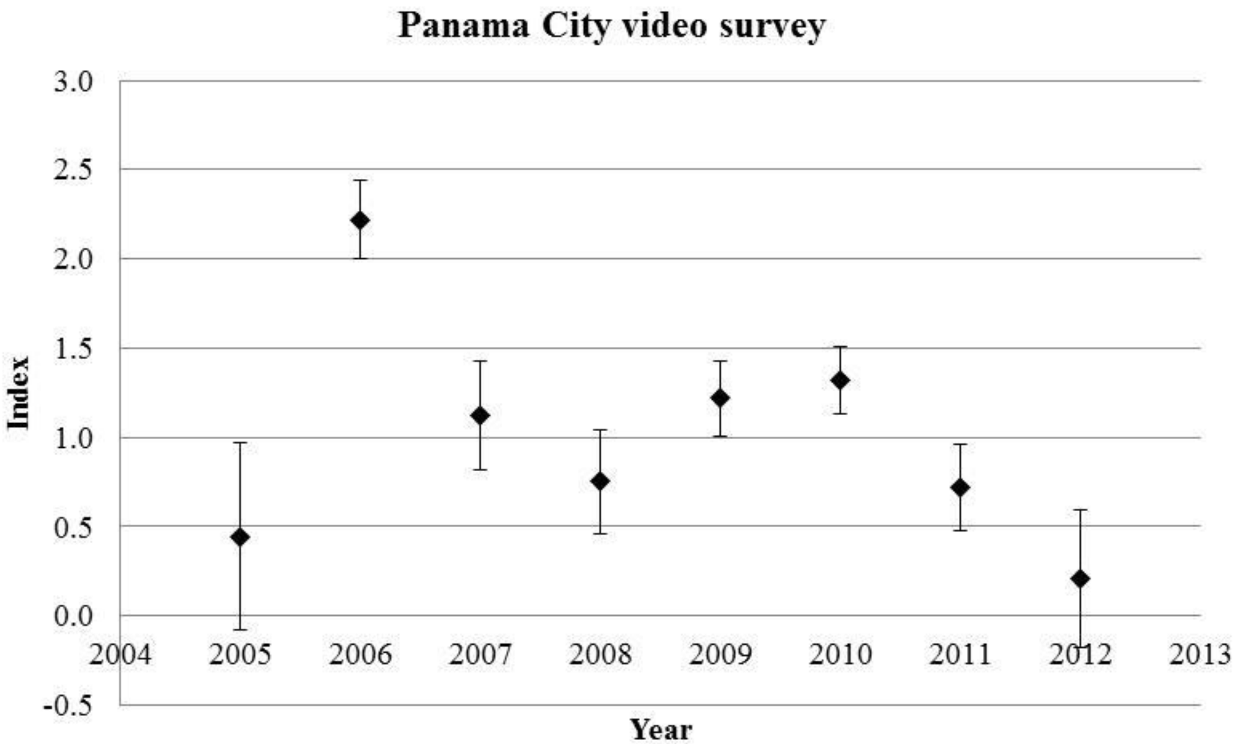


Figure 2.6.3. Standardized index of abundance and associated log-scale standard errors from the Gulf of Mexico Panama City Laboratory video survey. The index reflects the highest minimum count of Gag grouper per 20 minute recording.

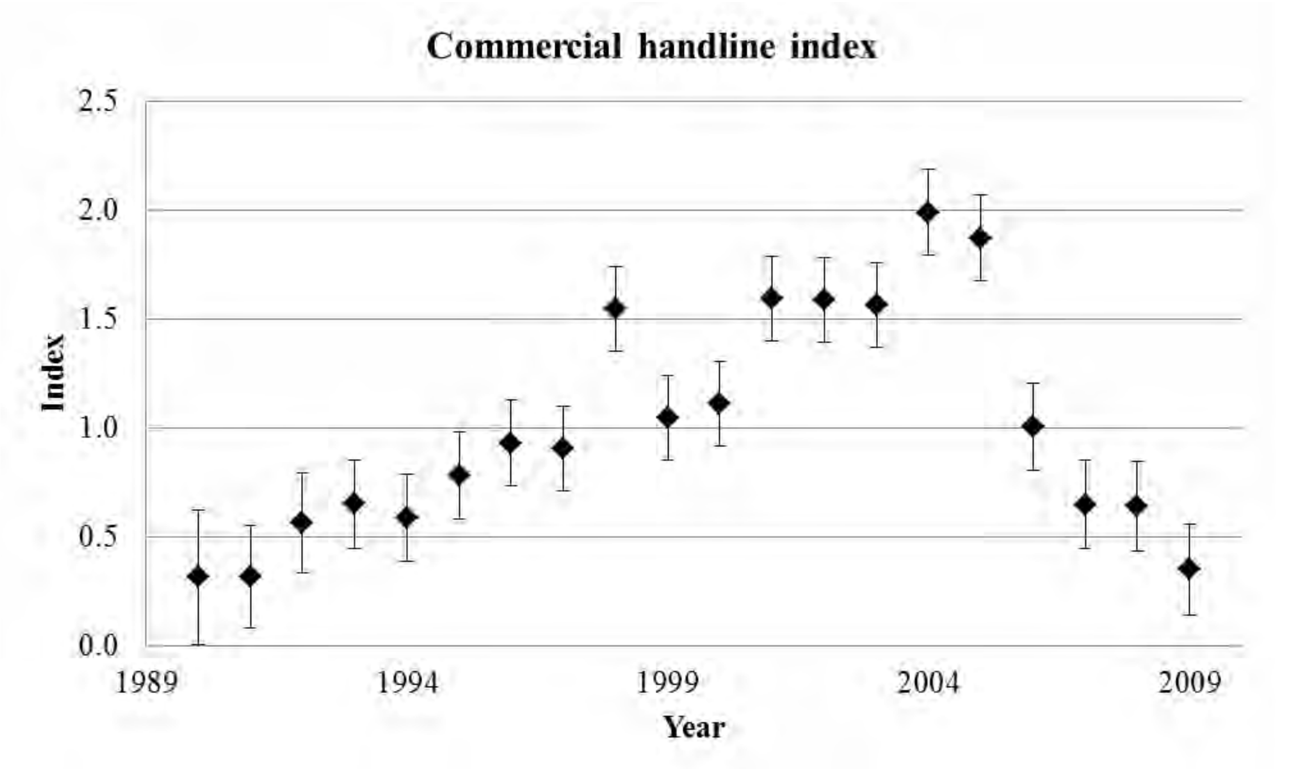


Figure 2.6.4. Standardized index of abundance and associated log-scale standard errors from the Gulf of Mexico vertical line fishery. The index reflects the pounds of Gag grouper caught per hook hour.

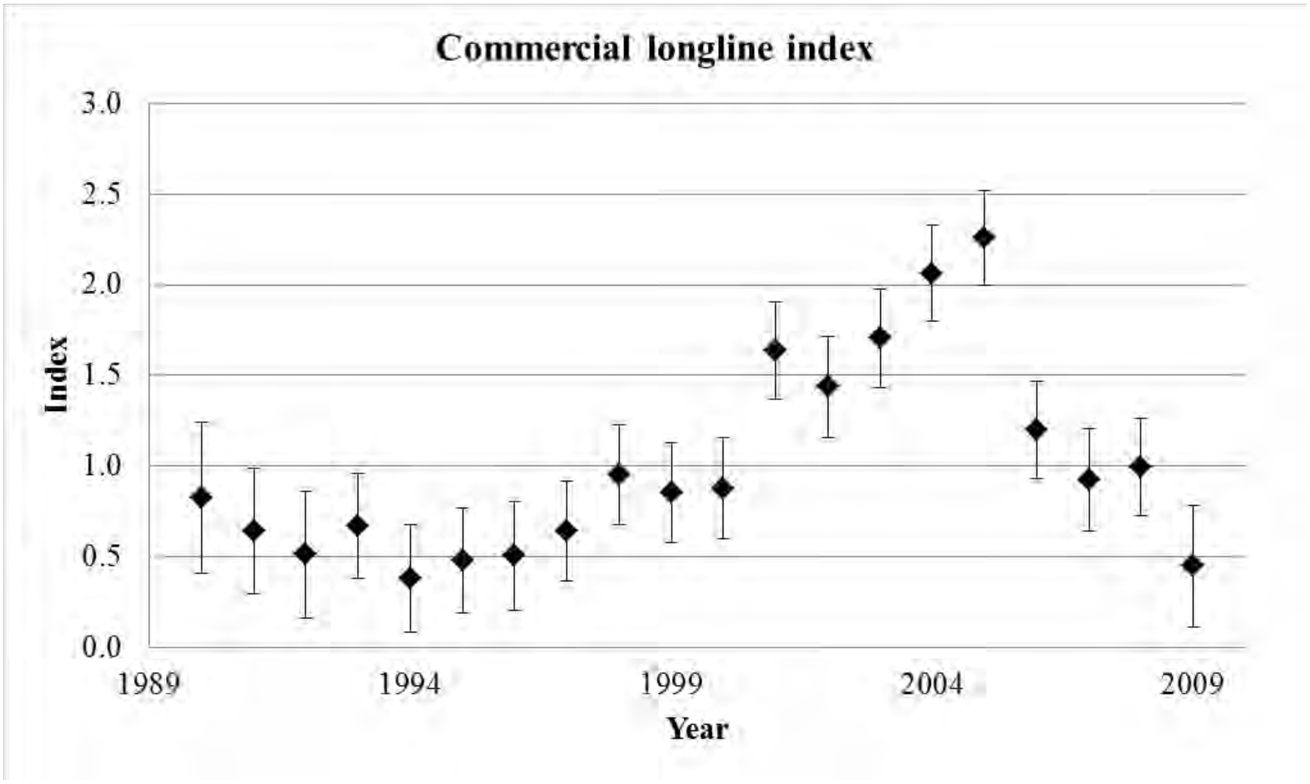


Figure 2.6.5. Standardized index of abundance and associated log-scale standard errors from the Gulf of Mexico longline fishery. The index reflects the pounds of Gag grouper caught per hook.

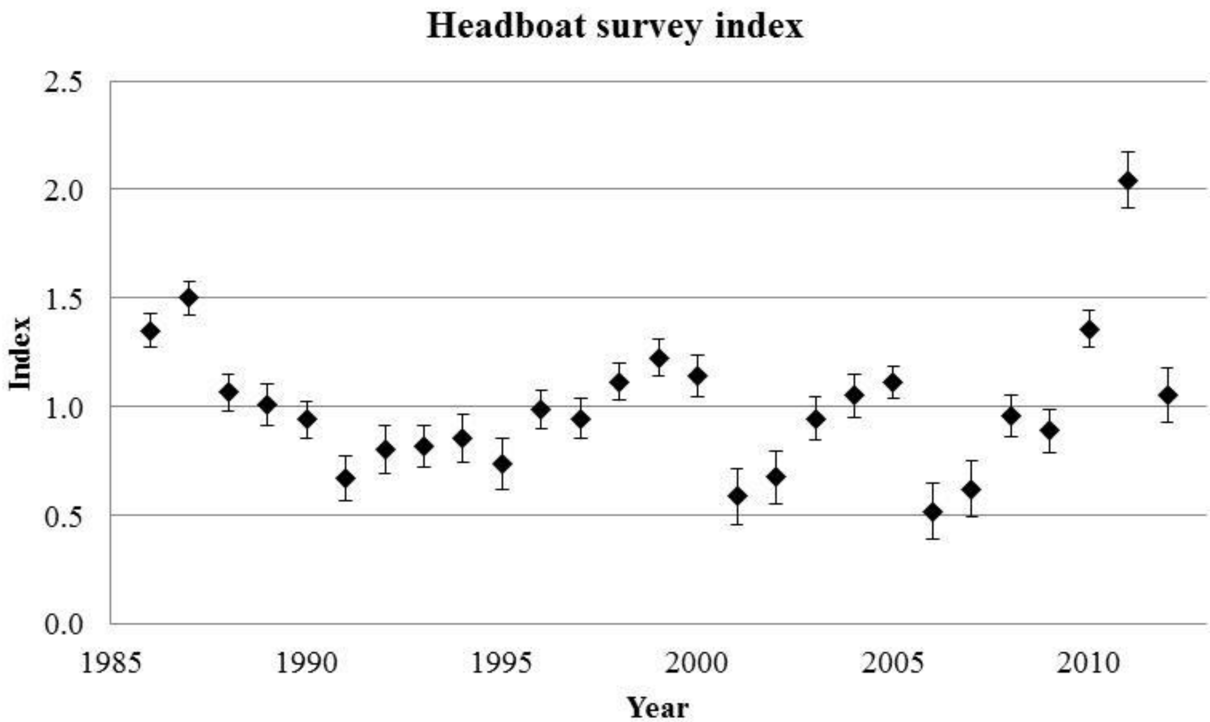


Figure 2.6.6. Standardized index of abundance and associated log-scale standard errors from the Gulf of Mexico headboat fishery. The index reflects the number of Gag grouper caught per angler hour.

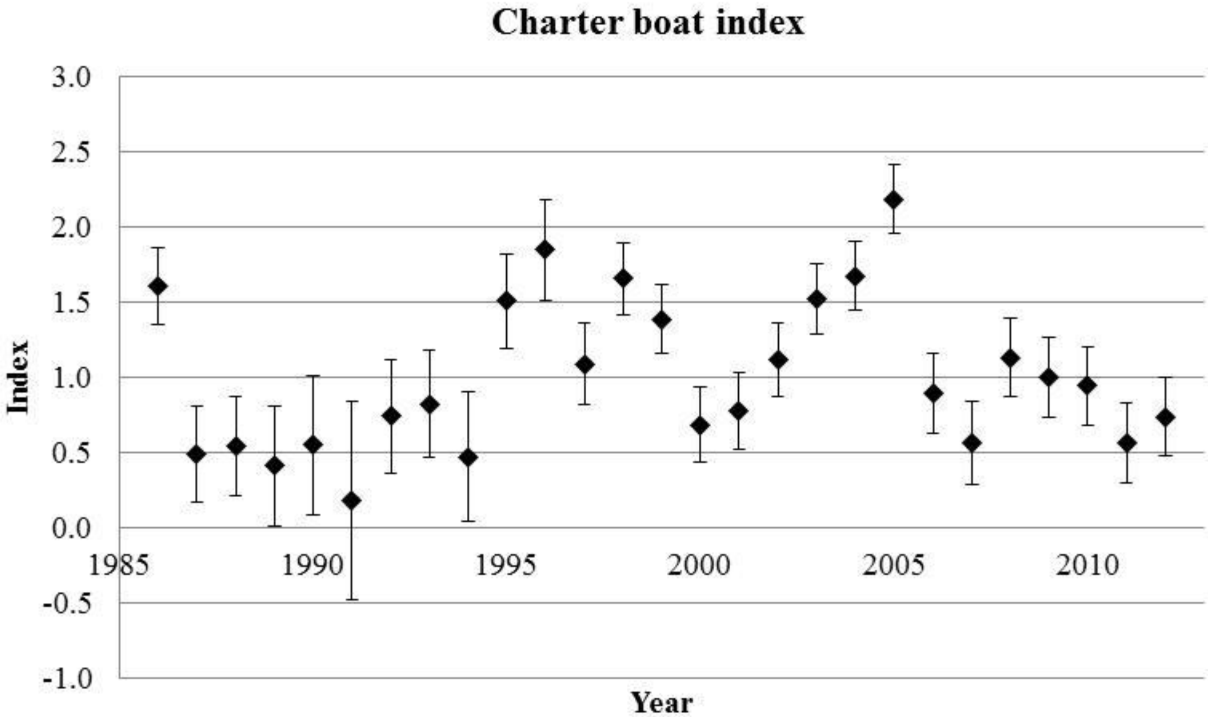


Figure 2.6.7. Standardized index of abundance and associated log-scale standard errors from the Gulf of Mexico charter boat fishery. The index reflects the number of Gag grouper caught per hour fished.

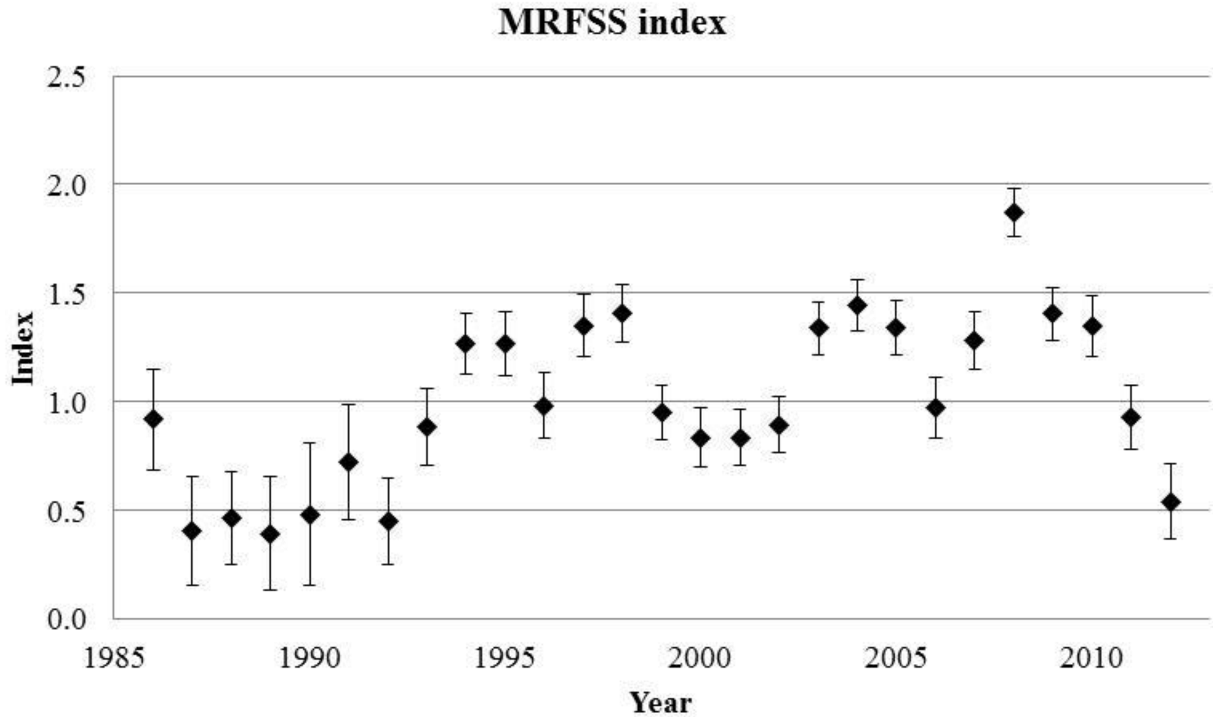


Figure 2.6.8. Standardized index of abundance and associated log-scale standard errors from the Gulf of Mexico private boat recreational fishery. The index reflects the number of Gag grouper caught per hour fished.

3. Stock Assessment Models and Results

3.1 Stock Synthesis

3.1.1. *Overview*

The primary assessment model selected for the Gulf of Mexico Gag Grouper assessment was Stock Synthesis (Methot 2013) version 3.24P. Stock Synthesis (SS) has been widely used and tested for assessment evaluations, particularly in the US west coast NMFS centers (Methot 2013). Descriptions of SS algorithms and options are available in the SS user's manual (Methot 2013; http://nft.nefsc.noaa.gov/Stock_Synthesis_3.htm) and Methot and Wetzel (2013).

Stock Synthesis is an integrated statistical catch-at-age model which is widely used for stock assessments in the United States and throughout the world (Methot and Wetzel 2013). SS takes relatively unprocessed input data and incorporates many of the important processes (mortality, selectivity, growth, etc.) that operate in conjunction to produce observed catch, size and age composition and CPUE indices. Because many of these inputs are correlated, the concept behind SS is that they should be modeled together, which helps to ensure that uncertainties in the input data are properly accounted for in the assessment. SS is comprised of three subcomponents: 1) a population subcomponent that recreates an estimate of the numbers/biomass at age using estimates of natural mortality, growth, fecundity, etc.; 2) an observational sub-component that consists of observed (measured) quantities such as CPUE or proportion at length/age; and 3) a statistical sub-component that uses likelihoods to quantify the fit of the observations to the recreated population.

For this assessment, SS was first constructed to mimic the previous Gulf of Mexico Gag Grouper assessment (SEDAR 10 Update, 2009) that used the CASAL (C++ algorithmic stock assessment laboratory) stock assessment model (Bull et al. 2012). CASAL is a statistical catch-at-age model that is able to integrate various sources of information in the estimation procedure similar to Stock Synthesis. Two SS models were constructed to mimic the CASAL results, one that incorporated red tide mortality and one that did not. After it was demonstrated that the SS model could obtain similar predictions as the CASAL model when using the same data sets and similar model configuration, the SS model was extended to include additional data sources and added flexibility and complexity that were available with Stock Synthesis. The final model configuration is detailed in the following sections.

3.1.2. *Data Sources*

The landings, discards, length composition, age composition, and indices of abundance used in the SS model are described in Section 2. Figure 3.1.1 illustrates the data sources and the temporal scale of each. Appendix A contains the data file for Stock Synthesis.

3.1.3. *Model Configuration and Equations*

A length-based, age-structured, forward-simulation population model was used to assess the status of Gulf of Mexico Gag Grouper. The model was implemented in Stock Synthesis (Methot

2011) version 3.24P. The Gulf of Mexico Gag Grouper population was modeled as a single stock that encompasses all U.S. waters of the Gulf of Mexico. The assessment uses data through 2012 and the time period of the assessment is 1963-2012. The starting year of 1963 was chosen as this represents the first year of detailed commercial landings data from the Accumulated Landing System (ALS). Data collection was assumed to be relatively continuous throughout the year; therefore, a seasonal component to the removals and biological predictions was not modeled.

3.1.3.1. Life history

Growth rates were estimated in the assessment model using a single growth curve for both sexes. Growth was modeled with a three parameter von Bertalanffy equation (L_{min}, L_{max}, and K). In SS, when fish recruit at the real age of 0.0 they have a body size equal to the lower limit of the first population bin (L_{bin}; fixed at 10 cm FL). Fish then grow linearly until they reach a real age equal to the input value of A_{min} (growth age for L_{min}) and have a size equal to the L_{min}. As they age further, they grow according to the von Bertalanffy growth equation. L_{max} was specified as equivalent to L_{∞}. Two additional parameters are used to describe the variability in size-at-age; these parameters represent the CV in length-at-age at A_{min} (age 1) and A_{max} (age 31). For intermediate ages a linear interpolation of the CV on mean size-at-age is used. Starting parameters for the von Bertalanffy growth curve and CV parameters were estimated using a maximum truncated likelihood (McGarvey and Fowler 2002) (Table 3.1.1). The three parameters of the von Bertalanffy equation (L_{min}, L_{max}, and K) were estimated in the SS model using a normal prior distribution (Table 3.1.1). The CVs for length-at-age were input as fixed parameters at 0.13 and 0.01 for age-1 and age-31 fish, respectively. A sex-combined fixed length-weight relationship was used to convert body length (cm) to body weight (kg).

The natural mortality rate (M) was assumed constant over time, but decreasing with age. The form of M as a function of age was based on Lorenzen (1996). The DW life history working group recommended using a base $M = 0.1342$ y^{-1}. The base M of 0.1342 y^{-1} was developed using the relationship between maximum age (31) and M (Hoenig 1983). The age-specific natural mortality vector developed at the DW was input into SS as a fixed vector (Figure 3.1.2). Sensitivity runs using a range of Lorenzen age-variable M values from 0.1 to 0.2 were recommended by the DW life history working group.

The assessment model was set-up with two genders to account for the reproductive biology of Gag Grouper. Gag Grouper are protogynous hermaphrodites (female at birth, then a portion of the population transitions to male). Thus, it was assumed that the sex-ratio at birth was 99.9% females. Immature females transitioned to mature females based on a fixed logistic function of age (Table 3.1.1, Figure 3.1.3). Mature females transitioned to mature males based on a fixed logistic function of age (Table 3.1.1, Figure 3.1.4). In previous Gulf of Mexico assessments of Gag Grouper, the form of reproductive potential used in the assessment model was spawning stock biomass of females (SSB-female), based upon a female maturity function, a sex-transition function and average weight-at-age. The DW report provides details on the alternative approaches for specification of SSB metrics for protogynous hermaphrodites. For this assessment, both SSB-females and SSB-combined (mature biomass of males and females) will be evaluated when calculating biological reference points.

3.1.3.2. Stock-recruitment model

A Beverton-Holt stock-recruitment model was used in this assessment. Three parameters of the stock recruitment relationship were estimated in the model; the log of unexploited equilibrium recruitment (R_0), an offset parameter for initial equilibrium recruitment relative to virgin recruitment log(R_1) and the steepness (h) parameter. The steepness parameter describes the fraction of the unexploited recruits produced at 20% of the equilibrium spawning biomass level. A fourth parameter representing the standard deviation in recruitment (σ_R) was input as a fixed value of 0.6. Rarely is σ_R directly estimable from the given data and hence it is often necessary to input as a fixed parameter.

Annual deviations from the stock-recruit function were estimated for an early data-poor period (1963-1983) and a later data-rich period (1984-2012). The central tendency that penalizes the log (recruitment) deviations for deviating from zero was assumed to sum to zero over each of the two estimated periods. Stock synthesis assumes a lognormal error structure for recruitment. Therefore, expected recruitments were bias adjusted. Methot and Taylor (2011) recommend that the full bias adjustment only be applied to data-rich years in the assessment and a few years into the data-rich period. This is done so SS will apply the full bias-correction only to those recruitment deviations that have enough data to inform the model about the full range of recruitment variability (Methot 2011). Full bias adjustment was used from 1988 to 2010. Bias adjustment was phased in from no bias adjustment prior to 1984 to full bias adjustment in 1988 linearly. Bias adjustment was phased out over the last two years (2011-2012), decreasing from full bias adjustment to no bias adjustment. There were no applicable environmental covariates to link to recruitment.

3.1.3.3. Starting conditions

The starting year of the assessment model is 1963. Removals of Gag Grouper are known to have occurred in the Gulf of Mexico prior to 1963 and thus the stock was not assumed to be at equilibrium at the start of the modeled period. During the DW there was an attempt made to reconstruct commercial landings back to 1880. A catch series starting in 1880 would have allowed for the model to start in equilibrium and assume that there was no fishing prior to 1880. However, the historical catch series was deemed unreliable prior to 1963 since Gag Grouper were not highly targeted by commercial fleets and catches of Gag Grouper were lumped with all other Grouper species in catch statistics.

Starting the assessment model in 1963 requires the estimation of initial conditions. Equilibrium catch is the catch taken from a stock for which removals and natural mortality are balanced by stable recruitment and growth. This equilibrium catch can be used to estimate the initial fishing mortality rates in the assessment model. Not fitting to the equilibrium catch is equivalent to estimating the catch and therefore the initial fishing mortality rates (Fs) that best correspond to the data during the dynamic period. For this assessment, equilibrium catches (and Fs) for the commercial vertical line (Fleet 1) and private recreational (Fleet 5) fleets were estimated. These two fleets were chosen to estimate initial Fs because they represented fleets that take large and small fish, allowing for model flexibility. In addition, early recruitment deviations (1963-1983) were estimated prior to the data-rich period to allow the initial population to better match composition information available at the start of the dynamic period of the model. The assumptions and model set-up of the initial conditions of the stock are fully explored in Section 3.2.7.

3.1.3.4. Indices of abundance

The assessment includes five fishing fleets and eight indices of abundance. The five fishing fleets in the model are commercial vertical line, commercial longline, recreational headboat, recreational charter boat, and the private recreational fishery. The previous assessment model included a commercial other fleet, which represents unspecified gears and non-vertical line or non-longline gears, and the recreational charter boat fleet was aggregated with the recreational private and shore fleets. The decision was made to merge the commercial other landings with the commercial vertical line fleet. Commercial other landings represent a small fraction of total commercial landings and composition data associated with these landings were sparse. The recreational charter boat fleet was combined with the private recreational fleet in the previous assessment model. The decision was made to separate these fleets due to differences in the size composition data; the charter boat fleet tends to catch larger fish than the private recreational fleet. In addition, there was ample age and length-composition data for the charter boat fleet as well as four years of observer data that included information on the size composition of released fish.

The eight indices of abundance include five fishery-dependent indices and three fishery-independent indices. The five fishery-dependent indices were constructed for each of the five fishing fleets used in the model. The commercial handline, commercial longline, and recreational headboat fleets were modeled as landings indices. The recreational charterboat and private recreational fleets were modeled as total catch indices. The three fishery-independent indices included the age-0 seagrass survey, the SEAMAP video survey, and the Panama City video survey. Additional details regarding the indices of abundance can be found in Section 2.6 of the Assessment Report and in the SEDAR 33 Data Workshop Report.

3.1.3.5. Selectivity and retention distributions

Length-based selectivity functions were specified for each fishery and survey in the model. Selectivity patterns represent the probability of capture for a given gear and are used to model not only gear function but fishery availability (spatial patterns of fish and fishers) by spatially stratified fisheries. Functional forms of logistic or double normal curves were used in this assessment to approximate selectivity patterns. A logistic curve implies that fish below a certain size range are not vulnerable to the fishery, but then gradually increase in vulnerability to the fishery with increasing size until all fish are fully vulnerable (asymptotic selectivity curve). A double normal curve consists of the outer sides of two adjacent normal curves with separate variance parameters for the left and right hand sides and peaks joined by a horizontal line. This implies that the fishery selects a certain size range of fish (dome-shaped selectivity curve). Although dome-shaped selectivity curves are flexible, studies have indicated that the descending limbs of selectivity curves are confounded with natural mortality, catchability, and other model parameters if all fisheries are dome-shaped.

This assessment assumed that the commercial longline fleet and the SEAMAP video survey have an asymptotic selectivity pattern. Assuming that at least one fleet has an asymptotic selectivity pattern helps to eliminate the estimation of "cryptic biomass" and to stabilize parameter estimation. This assumption meant that at least one of the fisheries sampled from the entire population after a specific size. This is a strong assumption and sensitivity to model predictions to this assumption was evaluated in Section 3.2.7. This assumption along with the observed sizes and life history parameters sets an upper bound to the population size. Two parameters described asymptotic selectivity: the length at 50% selectivity, and the difference between the length at 95% selectivity and the length at 50% selectivity, which were estimated in this assessment.

Selectivities in all other fleets assumed dome-shaped described six parameters. For the recreational fleets (Fleets 3-5) and the PC Video survey (Survey 3), estimation ignored the first and last size bins and allowed SS to decay the small and large fish selectivity according to parameters of ascending width and descending width, respectively. The parameter specifying the width of the plateau was often estimated with high uncertainty for multiple fleets; the shape of the double-normal was not sensitive to changes in this parameter over a wide range of parameter values (-5 to -15). For these fisheries (Fleets 1, 3, and 4), the width of the plateau was fixed at -9.

Selectivity patterns were assumed to be constant over time for each fishery and survey. The previous assessment model accounted for changes in management regulations by allowing time-varying selectivity. However, the previous assessment model was fit to total removals and so did not explicitly account for discards in the model. In this assessment, we account for changes in management regulations using time-varying retention patterns and model discards explicitly. The model sensitivity to the assumption of constant selectivity over time is explored in Section 3.2.7.2.5.

Retention patterns were used to account for discards and incorporate the impact of management regulations on the process of whether or not a fish is retained once it is captured. A number of management regulations in both the commercial and recreational fisheries have been enacted that would influence the process of whether or not a fish is retained given it is captured (SEDAR33-RD06). Retention is defined as a logistic function with size and four parameters are used to describe pattern: (1) inflection, (2) slope, (3) asymptotic retention, and (4) male offset to inflection.

For both commercial fleets, the first minimum size limit was implemented in 1990. Prior to 1990, there was no minimum size limit for any of the fleets. In 1990, a minimum size limit of 20 inches (50.8 cm TL) was implemented. The minimum size limit was increased from 20 to 24 inches (60.96 cm TL) in June 1999. In 2012, the minimum size limit was decreased from 24 inches to 22 inches (55.88 cm TL). In addition to changes in the minimum size limit, changes in the quota available to commercial fisherman have occurred that may influence the process of retaining Gag Grouper. Between 1990 and 2008, Gag Grouper were managed under the Shallow Water Grouper Complex (SWG) quota. During this time the SWG quota was comprised of Gag Grouper, Red Grouper, Yellowmouth Grouper, Yellowfin Grouper, Red Hind, Rock Hind, Black Grouper, and Scamp. The majority of the SWG quota consisted of landings of Red Grouper and Gag Grouper (56-98%). Gag Grouper landings accounted for 14% to 34% of SWG quota between 1990 and 2008. In 2009, the Gulf of Mexico Fisheries Management Council (GMFMC) developed Amendment 30B to end overfishing of Gag Grouper. As part of this amendment, Gag Grouper were removed from the SWG complex and assigned a species specific quota that was intended to reduce fishing mortality. Between 2009 and 2012, the quota for Gag Grouper has remained low in an effort to rebuild the stock. In 2010, the GMFMC implemented an Individual Fishing Quota (IFQ) program to manage the commercial Gag Grouper fishery.

Time blocks on the retention curves for both commercial fleets were specified to create separate retentions curves for five time periods: 1963-1989, 1990-1999, 2000-2010, 2011-2011, 2012-2012. For the period of 1963-1989, it was assumed that effective size limit (inflection of retention curve) was 16 inches (40.64 cm TL) and the slope of the retention function was 5. Initial model runs attempted to estimate both the inflection and slope but the parameters had high standard deviations. For the time periods 1990-1999 and 2000-2010, the retention function was fixed to be knife-edged (slope=1) at the size limit (20 and 24 inches TL, respectively) with an asymptote of 1 (i.e. all fish above the size limit retained). For the 2011-2011 and 2012-2012 time blocks, the retention function was assumed to be knife-edged (slope=1) at the size limit (24 inches TL and 22 inches TL) but the asymptote was estimated by the model. The asymptote of the retention function was estimated using a single parameter for 2011-2012. This was done to account for the reduction in quota in 2011 and 2012. The model was initially configured so that the asymptote was estimated for 2010-2012 to represent the implementation of the IFQ program. However, the length composition data from observer programs for both the handline and longline fleets (Figures 2.4.1.3 and 2.4.1.4) as well as the estimated discard rates for the longline fleet suggest that the behavior of fisherman pertaining to retention of captured fish changed in 2011 and not 2010.

The recreational fleets for Gag Grouper are managed using a combination of size limits, bag limits, and seasonal closures. The first management regulations were implemented in 1990; prior to 1990 there were no size limit or bag limit. A minimum size limit of 20 inches (50.8 cm TL) and a bag limit of 5 fish per person per day were implemented in 1990. In June 1999, the minimum size limit was increased to 22 inches (55.88 cm TL). In 2005, a seasonal closure (February 15-March16) was implemented in an attempt to reduce fishing pressure on Gag Grouper during the spawning season. In 2007, the bag limit was decreased from 5 fish per person per day to 2 fish per person per day. In 2009, the seasonal closure was extended an additional month (February 1-March 31). In 2011, the GMFMC closed the Gag Grouper recreational fishery. It was eventually reopened for 61 days. In 2012, the recreational fishery was open for 123 days.

Time blocks on the retention curves for each of the recreational fleets were specified to create separate retention curves for four time periods: 1963-1989, 1990-1999, 2000-2010 and 2011-2012. Data on recreational discards from MRFSS/MRIP starts in 1981 and shows that some discarding did occur prior to the implementation of management regulations. Initial model runs attempted to estimate both the inflection and slope of the retention function for the first time block but the parameters had high standard deviations. For the period of 1963-1989 the slope of the retention function was fixed at 5 and the inflection was estimated. For the time periods 1990-1999 and 2000-2010, the retention function was assumed to be knife-edged (slope=1) at the size limit with an asymptote of 1. The model did not account for changes in the bag limit over time.

The proportion of recreational trips that filled a bag limit was low throughout the time series. For the 2011-2012 time block, the retention function was assumed to be knife-edged (slope=1) at the size limit but the asymptote was estimated by the model. This was done to account for the reduced recreational season length in 2011 and 2012. Size composition data from observer programs on headboat and charterboat vessels showed that recreational fisherman released legal Gag Grouper when caught outside of the fishing season during these years.

3.1.3.6. Accounting for mortality due to red tide

The Assessment Panel recommended that mortality associated with a red tide event that occurred in 2005 be incorporated into the assessment model. The recommended model configuration used for management advice for SEDAR 10 also included the 2005 red tide event. The SEDAR 10 update assessment model incorporated the 2005 red tide event by estimating a disease mortality parameter (M_{RT}) in 2005. The point estimate for M_{RT} was applied to all ages in the model in 2005. The approach used for SEDAR 10 in the CASAL model could not be exactly replicated in SS; SS doesn't have the capability of estimating a constant M to be added to all ages. Three alternative approaches for incorporating red tide mortality were evaluated using the SS model built to mimic the previous assessment model (Figures 3.1.5-3.1.7). The objective was to incorporate red tide mortality into SS such that it would provide similar model predictions as the CASAL model.

The first approach employed the Lorenzen natural mortality option in SS. In SS, all biological parameters can vary over time. To incorporate red tide, the M at the reference age used for the Lorenzen function was allowed to deviate in 2005. The estimated deviate was added to the M at the reference age. This approach scaled the Lorenzen mortality curve upward in 2005 to account for the additional source of mortality. However, this approach could not replicate the predictions from CASAL and did not substantially improve the fit to the indices of abundance. The difference between this approach and the CASAL approach is that CASAL used an estimated constant M_{RT} that was applied to all ages, whereas, the approach in SS scales the Lorenzen function up. Thus, the CASAL approach had a disproportionally larger impact on older age classes.

The second approach used to incorporate red tide mortality involved adding a constant M deviate to all ages. This approach is similar to the approach used in CASAL; however, SS does not have the capability of estimating a constant deviate to be added to all ages. Instead, natural mortality was modeled as a vector of M_A (a parameter for each age) and then a fixed deviate was added to each M_A in 2005. The fixed deviate used in the SS model was taken as the point estimate of disease mortality from the CASAL assessment model (M_{RT} =0.356) (SEDAR 10). When applying this approach using the SS model that mimics CASAL, the two models provided very similar predictions (Figure 3.1.8).

The third approach evaluated for incorporating red tide mortality used a red tide fishing fleet to model removals of Gag Grouper from red tide. The red tide fleet was specified as a bycatch only fleet and therefore required no catch data. An index of fishing effort was input for this fleet that consisted of a time series of all zeroes and a 1 for 2005. A catchability coefficient (q) was estimated to scale fishing effort. No discards were input into the model; instead the model used information from data sources already in the model to scale red tide removals. The selectivity of the red tide fleet was set to 1 for ages 1-31. By specifying that all ages were equally vulnerable and then estimating a single constant mortality parameter, this approach is similar to approach used in SEDAR 10. The difference is that the red tide fleet approach treats red tide as a source of fishing mortality instead of natural mortality. The Assessment Panel decided to use this approach (red tide fishing fleet) as the central approach for incorporating red tide mortality. This approach gave similar results as the approach that used a fixed constant M applied to all ages (Figure 3.1.8). However, the red tide fishing fleet allows for the level of mortality to be estimated by the assessment model rather than input as a fixed parameter. This configuration should lead to a better representation of model uncertainty to the 2005 red tide mortality event. Model sensitivity to alternative approaches of incorporating red tide mortality is summarized in Section 3.1.7.

3.1.4. *Parameters Estimated*

A total of 336 parameters were estimated for the base case model (Table 3.1.1). Of the 336 parameters, 247 active parameters were annual fleet specific fishing mortality rates. Of the 89 remaining parameters estimated, 3 were used to model growth, 3 were used to model the stock-recruit relationship, 30 were used to estimate selectivity and retention curves, 50 annual recruitment deviations were estimated, 1 catchability parameter was used to scale the red tide mortality index, and 2 initial fishing mortality rate parameters were estimated.

Table 3.1.1 includes predicted parameter values and their associated standard errors from SS, initial parameter values, and minimum and maximum values a parameter could take. Parameters designated as fixed were held at their initial values. Starting values for all biological parameters were based on recommendations from the data workshop report and detailed above. Normal priors were applied to all estimated biological parameters. Steepness was estimated in the base model using a symmetrical beta prior; the mean and standard deviation associated with this parameter was taken from Shertzer et al. (2012). Uniform, non-informative priors were applied to all estimated selectivity parameters in the base model. Starting values for selectivity parameters were taken from estimated selectivity patterns from the previous Gag Grouper stock assessment (SEDAR 2009). Parameter bounds were selected to be sufficiently wide to avoid truncating the searching procedure during maximum likelihood estimation. The soft bounds option in SS was utilized when fitting the assessment model. This option creates a weak symmetric beta penalty on selectivity parameters to move parameters away from the bounds (Methot 2011).

3.1.5. *Model Convergence*

Model convergence was assessed using a jitter analysis. In large statistical models the solution surface tends to be very complex. To ensure that the model converged to a "global" solution, rather than a local minimum, it is important to start the model using alternative starting values for the model parameters. This test perturbs the initial values used for minimization with the intention of causing the search to traverse a broader region of the likelihood surface. Starting values of all estimated parameters were randomly perturbed by 10% and 50 trials were run. 38 of these trials converged on a solution that was within 2 likelihood units of the base case, inverting the Hessian and producing small gradients (Table 3.1.2). 42 of the 50 trials converged on a solution which provided similar levels of ending depletion and spawning biomass. Only one trial failed to converge on a solution. While this test cannot prove convergence of the model, it did not provide any evidence to the contrary.

3.1.6. *Uncertainty and Measures of Precision*

Uncertainty in parameter estimates and derived quantities was evaluated using multiple approaches. First, uncertainty in parameter estimates was quantified by computing asymptotic standard errors for each parameter (Table 3.1.1). Asymptotic standard errors are calculated by inverting the Hessian matrix (i.e., the matrix of second derivatives of the likelihood with respect to the parameters) after the model fitting process. Asymptotic standard errors are based upon the model's analytical estimate of the variance near the converged solution.

Second, uncertainty in parameter estimates and derived quantities was investigated using a parametric bootstrap approach. Bootstrapping is a standard technique used to estimate confidence intervals for model parameters or other quantities of interest. There is a built-in option to create bootstrapped data-sets using SS. This feature performs a parametric bootstrap using the error assumptions and sample sizes from the input data to generate new observations about the fitted model expectations. The model was refit to 400 bootstrapped data-sets and the distribution of the parameter estimates was used to represent the uncertainty in the parameters and derived quantities of interest (Table 3.1.3).

Likelihood profiles were completed for three key model parameters: steepness of the stock-recruit relationship (h), the log of unexploited equilibrium recruitment (R_0), and an offset parameter for initial equilibrium recruitment relative to virgin recruitment log(R_1). Likelihood profiles are commonly used to elucidate conflicting information among various data sources, to determine how asymmetric the likelihood surfaces surrounding point estimates may be, and to provide an additional evaluation of how precisely parameters are being estimated.

3.1.7. *Sensitivity Analysis*

Uncertainty in data inputs and model configuration was examined through sensitivity analyses. The models reported in this section are by no means meant to be a comprehensive evaluation of all possible aspects of model uncertainty, nor do they reflect the full range of models considered in developing the base case. These scenarios are intended to provide more information about sensitivity to key model parameters and potential conflict in signal among data sources. The order in which they are presented is not intended to reflect their importance; each run included here provided important information for developing or evaluating the base case model and alternate states of nature. The Assessment Panel examined 15 alternative model runs with plausible alternative model configurations and data.

Run 1: The central run off which the sensitivity runs were based. This run used the model configuration and initial parameter values described in Section 3.1.3 and Table 3.1.1.

3.1.7.1. Modeling red tide mortality

Following the recommendations from the previous assessment model (SEDAR 2009), the AW panel recommended incorporating the impact of a severe red tide mortality event that occurred in 2005 into the central model run. A variety of approaches for incorporating red tide mortality into the assessment model were evaluated during the Assessment Workshop (Section 3.1.1). The first set of sensitivity runs evaluates model sensitivity to alternative model configurations as pertaining to red tide mortality.

The central model run incorporates red tide mortality into the assessment model by specifying an additional fishing fleet to model removals of Gag Grouper from red tide. The red tide fleet was specified as a bycatch only fleet and therefore required no catch data. An index of fishing effort was input for this fleet that consisted of all zeroes and a 1 for 2005. A catchability coefficient (q) was estimated to scale fishing mortality rate. No discards were input into the model; instead the model used information from data sources already in the model to scale red tide removals. The selectivity of the red tide fleet was set to 1 for ages 1-31.

Run 2: For this run, red tide mortality is incorporated into the assessment model by adding a constant fixed M_{RT} to all ages in 2005. Since this parameter could not be estimated in the assessment model, the M_{RT} that was best supported by the data was estimated by profiling across a range of values from 0.1 to 0.9 at increments of 0.1.

Run 3: For this run, red tide mortality was not incorporated into the assessment model. This run is used to compare to the central model which incorporates red tide mortality.

3.1.7.2. Initial starting conditions

The first set of sensitivity runs were used to evaluate the sensitivity of the model to initial starting conditions. The starting year of the central run is 1963, which represents the first year of reliable commercial landings data. The data-rich period of the model begins in 1984 (Figure 3.1.8).

Run 4: For this run, the model is assumed to start in equilibrium conditions with the starting year set at 1880. The commercial landings series was taken back to 1880; it is assumed that no catches occurred prior to this time. The model configuration and data inputs are similar to the central run expect for this model does not require specification of equilibrium catches or estimation of initial F's and the R1 offset parameter.

Run 5: For this run, the model is started in non-equilibrium conditions similar to central model run; however, this model begins in 1981 which marks the start of the MRFSS data set for recreational landing and discard data. The data inputs and model configuration are similar to central model run except for the specification of early recruitment deviations that occur before the start of the model. The early recruitment deviations start in 1963 and allow the initial population to better match composition information available at the start of the dynamic period of the model. Similar to central model, this model requires specification of equilibrium catch and estimation of initial F's and the R1 offset parameter.

3.1.7.3. Natural mortality

Model sensitivity to the specification of the natural mortality rate was evaluated. The natural mortality rate (M) was assumed constant over time, but decreasing with age. The form of M as a function of age was based on Lorenzen (1996). The central model uses a base $M = 0.1342$ y^{-1}.

Run 6: For this run, a base $M = 0.1$ y^{-1} is used.

Run 7: For this run, a base $M = 0.2$ y^{-1} is used.

3.1.7.4. Discard mortality

Discard mortality represents a major source of mortality for the GOM Gag Grouper stock. For this assessment the DW recommended updating the discard mortality estimates used in the model. The updated values are substantially lower than those used in previous assessments.

Run 8: For this run, the discard mortality rate applied to each fleet uses the rates applied in SEDAR 10 (Table 2.3.1).

3.1.7.5. Assumptions of selectivity

Assumptions about the functional form of selectivity functions can have a large impact on model results. For this set of sensitivities we evaluated model sensitivity about the functional form of the commercial fleets and the assumption related to time-varying selectivity.

Run 9: All fleets were parameterized using the double-normal function. This selectivity pattern allows the model to estimate either asymptotic or dome-shaped selectivity (or something in between). This run contrasts the central model run which explicitly assumes that the commercial longline fleet has asymptotic selectivity.

Run 10: For this run, selectivity functions are allowed to vary with changes in management regulations. For both the commercial and recreational fleets this involved setting two time blocks and allowing time-varying selectivity: 1963-1999 and 2000-2012. Additional time blocks were tested; however, there was insufficient data to accurately estimate selectivity for more time blocks.

Run 11: For this run, a change in selectivity for the commercials fleets is modeled to account for the implementation of the IFQ program in 2010.

3.1.7.6. Steepness

Steepness of the stock-recruitment relationship is one of the most uncertain and critical quantities in fishery stock assessment and management. In this assessment model, steepness tends to be estimated at the upper limit of 1.0 indicating there is little information in the data about this quantity. The biology of Gag Grouper suggests that steepness should lower. Shertzer and Conn (2012) recommend a prior on steepness for demersal marine fishes with a mode at 0.84 when using the beta distribution. Conn et al. (2010) examined conditions under which steepness could be reliably estimated using Gag Grouper as an example. In this study, Conn et al. (2010) calculated a posterior distribution of steepness for South Atlantic Gag Grouper with a mode at 0.68.

Run 12: For this run, steepness is fixed at 0.7.

Run 13: For this run, steepness is fixed at 0.85.

3.1.7.7. Data weighting

In the base model run, length and age composition data were weighted by the number of fish observed, with sample sizes capped at 200 fish to prevent the model fitting the composition data to the exclusion of the indices of abundance. Indices of abundance were weighted by the log-scale standard deviations estimated as part of the index standardization process.

Run 14: In this run the length and age-composition are down-weighted in the model using a lambda of 0.1. The lambda values are multiplied by the likelihood component when calculating the overall negative log likelihood to be minimized. Lambda values less than 1 de-emphasis data components, while lambda values greater than 1 are used to emphasis data components.

Run 15: In this run, the two commercial fishery-dependent indices of abundance and the fishery-independent SEAMAP video survey are up-weighted. These three indices represent the three indices used to track mature adult biomass. In general, the model tended to provide better fits to the recreational indices than the commercial indices. In addition, the model expectation diverges strongly from the SEAMAP video survey in the most recent years. These indices are up-weighted in the assessment using a lambda of 5.

3.1.7.8. Increasing catchability

Run 16: This model run assumes a 2% annual increase in catchability for all fishery-dependent indices. The 2% annual increase in catchability was implemented by decrementing the indices of abundance externally to Stock Synthesis. The assumption of increasing catchability was taken from SEDAR 10.

3.1.7.9. Jack-knife indices of abundance

The final set of sensitivity runs was used to evaluate the model sensitivity to each of the indices of abundance. A jack-knife approach was used where each index of abundance was removed from the model and then the model was refit to the remaining data.

3.1.8. *Retrospective Analysis*

Retrospective analysis was conducted to assess the consistency of stock assessment results by sequentially eliminating the last four years of data from the terminal year while using the same model configuration. The results of this analysis were useful in assessing potential biases and uncertainty in terminal year estimates.

3.1.9. *Benchmark/Reference Point Methods*

Various stock status benchmarks and reference points are calculated in SS. The user can select reference points based on maximum sustainable yield (MSY), equilibrium spawning biomass per recruit (SPR), and spawning stock biomass (SSB). Stock Synthesis calculates SPR as the ratio of the equilibrium reproductive output per recruit that would occur with the current year's F intensities and biology, to the equilibrium reproductive output per recruit that would occur with the current year's biology and no fishing. For SPR-based reference points, SS searches for an F that will produce the specified level of spawning biomass per recruit relative to the unfished value. For spawning biomass-based reference points, SS searches for an F that produces the specified level of spawning biomass relative to the unfished value. Both MSY and spawning biomass-based reference points are dependent on the stock-recruit relationship. YPR and SPR fishing mortality reference points can be calculated independent of the stock-recruit relationship. However, biomass reference points based on YPR and SPR concepts do require knowledge of the stock-recruit relationship.

In addition to the choice of management reference points, the AW panel had to decide on appropriate units for SSB for the assessment. In previous Gulf of Mexico assessments of Gag Grouper, the form of reproductive potential used in the assessment model was spawning stock biomass of females (SSB-female), based upon a female maturity function, a sex-transition function and average weight-at-age (SEDAR 10). In contrast, South Atlantic assessments of gag have used spawning stock biomass of females and males (SSB-combined). Brooks et al. (2008) explored via simulation, the various SSB approaches and stock assessment performance given uncertainties regarding loss of males and reduced fertility. They concluded that the SSB-female approach best estimates biological reference points if the potential for decreased fertilization is weak. Brooks et al. (2008) determined SSB-combined is best when the potential for decreased fertility is moderate or unknown. The assessment model was configured using a two-gender model which allowed for either SSB-female or SSB-combined to be used when calculating SSB. The AW panel recommended that SSB-combined be used for Gag Grouper as this tends to be the most conservative approach for protogynous hermaphrodites. Both SSB-female and SSB-combined are reported in all tables. In addition, reference points and stock status are calculated for both SSB-female and SSB-combined.

The AW panel recommended using SPR-based reference points given that the stock-recruit relationship was not well defined by the assessment model. YPR and SPR reference points can be calculated independent of the stock-recruit relationship. This decision differed from the previous assessment which used F_{MAX} and associated SSB benchmarks. The previous assessment recommended F_{MAX} instead of $F_{SPR30\%}$ due to problems estimating equilibrium spawning biomass and recruitment (SEDAR 2009). In addition, the previous assessment model considered only SSB-females. For a protogynous hermaphrodite, SPR reference points are dependent on the units used for SSB. Including male biomass in spawning stock estimates tends to be a much more conservative approach. $F_{SPR30\%}$ for SSB-combined will be much lower than for SSB-female. In addition, when only considering SSB-female $F_{SPR30\%}$ may exceed F_{MSY} and

F_{MAX}. The previous assessment found F_{MAX} to be a more conservative reference point compared to $F_{SPR30\%}$. Since the AWP chose to consider both SSB-female and SSB-combined, reference points for $F_{SPR30\%}$ was the most appropriate choice.

3.1.10. *Projection Methods*

Projections were run to evaluate stock status and associated yields for a range of fishing mortality rate scenarios. Projections were run from 2013 to 2032 for the base model configuration (Run 1) and fixed steepness scenario (Run 12) using both SSB-female and SSB-combined.

Projections were run assuming that selectivity, discarding, and retention were the same as the three most recent years (2010-2012). For the deterministic projections, annual recruitment deviations were assumed to be zero. Forecast recruitments are derived from the model estimated Beverton-Holt stock-recruitment relationship, based on the recent time period (i.e., 1984-2011). The catch allocation among fleets used for the projections reflects the average distribution of fishing intensity among fleets during 2010-2012.

Deterministic projections were run for four fishing mortality rate scenarios for each of the model configurations and the two SSB metrics (female SSB and combined male and female SSB):

- $F_{Current}$: fishing mortality rates for all fleets were set to the geometric mean of the past three years (2010-2012)
- $F_{SPR30\%}$: the fishing mortality rate that results in an equilibrium SPR of 30%
- F_{MAX}: the fishing mortality rate that maximizes the yield-per-recruit
- F_{OY}: 75% of $F_{SPR30\%}$

Uncertainty in stock status and forecasted yields for the projection years was investigated using the bootstrap approach discussed in Section 3.1.6. Bootstrap datasets were created for the same four model configurations used for deterministic projections. For each model configuration, the model was refit to 400 bootstrap datasets and then projected forward at $F_{SPR30\%}$. The projections followed the same methods and assumptions described above for the deterministic projections; however, the bootstrap projections included annual recruitment deviations for the forecasted period. Random recruitment deviations for the projection period were created from a normal distribution with mean of 0 and standard deviation equal to the model estimated standard deviation in recruitment from the recent time period (1984-2011). The projections from the bootstrap runs were used to create probability distribution functions for the development of management advice, including OFL and ABC.

3.2 Model Results

3.2.1. *Measures of overall model fit*

3.2.1.1. Landings

Stock Synthesis effectively treats the landings data as being known without error. Therefore, the landings are fit precisely (Figures 3.2.1-3.2.5).

3.2.1.2. Discards

The model was fit to six years of commercial discard estimates for both the vertical line and longline fleets. Both commercial fleets used time-varying retention to account for changes in management regulations. Time-blocks for retention were used to model a reduction in quota in 2011-2012 and decrease in the minimum size limit in 2012. The model under-estimated vertical line discards for each of the six years of data (Figure 3.2.6).

The model over-estimated longline discards from 2007-2010 and then under-estimated discards in 2011 and 2012 (Figure 3.2.7). Calculated discard rate for the longline fleet increase substantially in 2011 relative to previous years. Size composition data on discarded fish from the longline observer program show a shift towards discarding larger fish in 2011. This change in discarding was likely the result of reduced quotas in 2011 and 2012.

The predicted discards from the headboat, charterboat, and private fleets are similar to the observed discards for most of the corresponding time series (Figures 3.2.8, 3.2.9, and 3.2.10). Starting in 2007 and 2008 there were greater discrepancies between the observed and predicted discards for these fleets. The model overestimates recreational discards for all three fleets in 2008 and underestimates discards in 2009 and 2010. This high predicted discards in 2008 result from the predicted strong year classes in 2006 and 2007. The charterboat fleet observed discards increase almost three-fold between 2007 and 2008 and the private recreational fleet has the highest observed discards in 2008.

3.2.1.3. Indices of abundance

The model was fit to five fishery-dependent indices (two commercial indices and three recreational) and three fishery-independent indices.

The model fit to the commercial vertical line (RMSE=0.52) and longline (RMSE=0.62) indices were similar (Figures 3.2.11 and 3.2.12). The model fit predicted a decline in the indices between 1990 and 1995. This decline is relevant to the standardized longline index. The standardized commercial vertical line index, however, increased between 1990 and 2004 (Figure 3.2.11). The model over-estimated these indices between 1990 and 2000 and after 2000 the standardized indices were under-estimated. The standardized commercial vertical line index peaked in 2004 preceded by a steady increase starting in the first year of the index and followed by steady decline (Figure 3.2.11). The model fit predicted an initial decline (1990-1995), an increase (1995-2000), and a declining trend after 2000 missing the peak of the standardized index. The standardized longline index peaked in 2005, preceded by a steady increase starting in 1995 and followed by a steady decline (Figure 3.2.12). The model predicted the index increased between 1995 and 2000, was relatively flat between 2000 and 2004, declined sharply in 2005 and 2006 before stabilizing. The model predicts a strong decline in the commercial indices between 2004 and 2005 due to the red tide event. The red tide event occurred in the fall of 2005 and so a large proportion of the commercial landings for 2005 had occurred prior to the red tide event. The model was setup to assume that data collection occurred relatively constant throughout the year and thus was unable to account for the temporal dynamics of the red tide event.

The model fit to the recreational indices generally predicted the trends in the standardized index better than those in the commercial indices (Figures 3.2.13, 3.2.14, and 3.2.15). The standardized recreational indices were similar in that they began with an initial decline in the late 1980s and then were followed by two periods of sharp declines followed by relatively sharp increases. The model fit followed the trends in the headboat index most closely (RMSE=0.24), with little pattern in the residuals (Figure 3.2.13). The early trends were predicted well and although the model under-estimated the decline between 1999 and 2000, it did capture the decline and following increase. The model fit the decline and following increase between 2005 and 2011 fairly well, but predicted a decline after 2010 rather than after 2011. The model fit to the charterboat index (RMSE=0.54) predicted an initial decline after 1985, an increasing trend between 1989 and 2004, a sharp decline in 2005 followed by an increase between 2000 and 2011 (Figure 3.2.14). The predicted trends between 1985 and 2004 are well characterized by the model fit. The model fit degrades after 2004. The model predicted a sharp decline in 2005, whereas the standardized index was still increasing. Additionally, the model failed to predict the declining trend in the index between 2008 and 2012. The model fit to the standardized private recreational index generally predicted the trends in the index throughout the time series fairly well (RMSE=0.27) with little pattern in the residuals (Figure 3.2.15).

The fit to the SEAMAP video survey index (RMSE=0.62) was flat and generally under-estimated the index between 1993 through 2004 (Figure 3.2.16). The model fit improved between 2004 and 2010 and then over-estimated the increase in the index in 2011-2012. The peak of the standardized index was in 2002, whereas the model fit predicted the index highest point in 2012. The model fit to the PC-video survey was poor (RMSE=0.82) (Figure 3.2.17). The fit was relatively flat with a predicted low in 2006. The predicted low corresponds with the peak of the standardized index. The model fit also predicts a delayed decline in 2012, whereas the standardized index declines after 2010. The parameters used to model the selectivity pattern of the PC-video survey had high uncertainty and were not consistent among the sensitivity runs. The model fit to the Age-0 index (RMSE=0.57) follows the general trend of the standardized index with some over-estimation in the late1990s and early 2000s and under-estimation later in the index (Figure 3.2.18).

3.2.1.4. Length composition

The model fits to the length composition data associated with the landings and discard series and the Pearson residuals for each fleet and data type are presented in Figures 3.2.19-3.2.38. The quality of the fit varied among the fleets and surveys. In general, the fit to the length composition data associated with the fishery-dependent landings was poor in the first several years and improved considerably in the later years. The Pearson residuals indicated that there was considerable noise in the data associated with smaller Gag Grouper (less than 60cm) for all fleets. The noise associated with these smaller fish was greater in the length composition data from the recreational fleets than the commercial fleets (Figures 3.2.28, 3.2.32, 3.2.36).

Positive residuals (i.e., observed was greater than predicted) were apparent in the 1980s for fish captured by the vertical line fleet and between ~75cm and 125cm (Figure 3.2.20). The residuals associated with this size range captured by the longline fleet were negative (Figure 3.2.24). The residual patterns in the length composition data also indicate that the fleets may target cohorts through time. This pattern of positive residuals tracking a cohort is clearly evident in Figure 3.2.22 and is difficult to see in many of the other residual plots due to the large positive residuals associated with smaller Gag Grouper. Large positive residuals were also apparent in the length composition data associated with discards (e.g., Figure 3.2.22). These large positive residuals were associated with length bins with very few observed fish and the model predicted their proportion to be close to zero.

The sample sizes associated with the length composition data from the fishery-independent sources; the SEAMAP and Panama City video surveys, were quite small (Figures 3.2.37 and 3.2.38). The figures show that the model fit these data poorly.

3.2.1.5. Age composition

The model fits to the age composition data and the Pearson residuals for the fishery-dependent fleets are shown in Figures 3.2.39-3.2.48. The model fit to the age composition data varied in quality among the fleets. The fit to the commercial vertical line and longline fleets were similar in that there were greater discrepancies between the observed and predicted earlier in the time series than later, the fit was much improved in later years (Figures 3.2.39-3.2.42). The fits to the headboat and charterboat data were consistent over the time series and acceptable, whereas, the fit to the age composition data from the private recreational fleet was variable and generally did not predict the data well (Figure 3.2.43 -3.2.48). The lack of fit to the private recreational fleet data was likely due to the considerably low sample size. The Pearson residuals suggest that the fleets may target cohorts through time. This pattern in the residuals is evident in Figures 3.2.40, 3.2.42, 3.2.44, and 3.2.46.

3.2.2. *Parameter estimates & associated measures of uncertainty*

A list of all model parameters is presented in Table 3.1.1. The table includes estimated parameter values and their associated asymptotic standard errors from SS, initial parameter values, minimum and maximum values a parameter could take, and whether the parameter was fixed or estimated.

The standard errors are low for the majority of parameters with a few exceptions. The standard errors are high for all of the early recruitment deviations. These parameters are not well informed by the model. In particular, the estimated recruitment deviations for 1972-1974 are highly uncertain. Standard errors for main recruitment deviations are generally low (<0.2), indicating the data are informative on relative recruitment strength. Two main recruitment deviations had high uncertainty, 1994 and 2004 (see section 3.2.4).

The parameters used to model the double-normal selectivity pattern for the PC video survey had high standard errors. There was little data available to inform the selectivity pattern of this survey. The survey is used from 2006-2012 and has only 98 length observations to use for informing the model on selectivity. The estimated shape of the selectivity function tended to vary considerably based on model configuration.

In general, estimates of uncertainty from the bootstrap procedure were very similar to estimates of asymptotic standard errors calculated by inverting the Hessian matrix. A list of the mean and standard deviation from the distribution of parameter estimates for the 400 bootstrap samples is presented in Table 3.1.3.

3.2.3. *Fishery Selectivity*

The estimated selectivity patterns for all fleets and surveys are presented in Figure 3.2.49. In addition, the derived age-based selectivity patterns for each of the fishing fleets are presented in Figure 3.2.50.

The commercial vertical line fleet was modeled using the double-normal function and was assumed to be dome-shaped (Figure 3.2.51). The panel contemplated whether or not to estimate the final parameter of the double-normal or fix at a low level and force the selectivity to 0 at the largest sizes. When the model is allowed to estimate this parameter, the selectivity of the largest fish is estimated in between 0 and 1 (between 0.3 and 0.4 for most configurations). When the final parameter is estimated the total likelihood is slightly lower. Somewhat surprisingly, whether or not the parameter was estimated had very little influence on the predicted dynamics of the stock. The commercial longline fleet was assumed to be asymptotic (Figure 3.2.52). The model sensitivity to this assumption was evaluated in the sensitivity runs (section 3.2.7.2.5).

All three recreational fleets were modeled with the double-normal and assumed to be dome-shaped (selectivity at first and last bin fixed at 0) (Figures 3.2.53-3.2.55). The parameter describing the width of the double-normal was not well estimated for either the headboat or charterboat fleets and was fixed at -9. The shape of the selectivity function was not sensitive to this parameter between -5 and -15. In general, the headboat and charterboat fleets selected for larger fish than the private recreational fleet.

The estimated time-varying retention curves for each fleet are depicted in Figures 3.2.56-3.2.60. Retention for both commercial fleets was fixed at for the first time block at 16 inches FL and a slope of 5. The model had difficulty estimating these parameters as the size composition data is quite variable early in the time series for both fleets. For the 1990-1999 and 2000-2010 time blocks, the retention function is fixed at the size limit. For the 2011-2011 and 2012-2012 time blocks the asymptote of retention is estimated by the model using a single parameter. For the vertical line fleet, the parameter is estimated at 0.97, suggesting that the majority of legal sized fish are retained despite the reduction in quota and implementation of the IFQ program. For the longline fleet, the parameter is estimated at 0.66, suggesting that one-third of legal sized fish caught are discarded due to low IFQ shares.

Retention for the three recreational fleets was estimated for the first time block, 1963-1989 (pre size limits). The inflection for retention was similar among the three fleets and estimated between 14 and 16 inches FL. For the 1990-1999 and 2000-2010 time blocks, the retention function is fixed at the size limit. For the 2011-2012 time block the asymptote of retention is estimated by the model. The asymptote was estimated at 0.39 for the headboat fleet, 0.50 for the charter boat fleet, and 0.20 for the private fleet. This parameter is used to account for the reduction in fishing days for the two most recent years. In 2011 the recreational fishing season was reduced from 305 days to 61 days (20%) and in 2012 the season was 123 days (40%). Thus, the estimated retention asymptotes are similar to the reduction in season length.

Figures 3.2.61 and 3.2.62 show the selectivity curves for the SEAMAP and PC video surveys. The SEAMAP survey was assumed to have an asymptotic selectivity. The size at 50% selection was estimated to be 80.1cm. Gag grouper larger than 100cm were estimated to be fully selected for. The selectivity curve for the PC video survey was assumed to have a double-normal distribution and was estimated to be knife edge to the peak at a length of 24cm (Figure 3.2.62). Gag grouper between ~24cm and 115cm were fully vulnerable to fishing and those larger than ~115cm were assumed to be invulnerable.

3.2.4. *Recruitment*

The three leading parameters for defining the stock-recruitment relationship were steepness (h), virgin recruitment (R_0), and an offset parameter for initial equilibrium recruitment relative to virgin recruitment log(R_1). All three parameters were estimated to have very low asymptotic standard errors. Steepness was estimated at the upper bound of 0.99 for the base model. The log of virgin recruitment is estimated at 8.36 (4,291,000 age-0 recruits). The R1 offset parameter was estimated at -1.14, which suggests the stock was at 32% of virgin recruitment when the model starts in 1963. The distribution of estimates from the 400 bootstrap samples show that steepness was estimated at the upper bound for the majority of the runs and that equilibrium recruitment was estimated with minimal uncertainty (Table 3.1.3, Figure 3.2.63).

The plot of the stock-recruitment relationship shows a curious pattern (Figure 3.2.64). The model predicts a series of poor recruitments for the first ten years of the model and then very variable recruitment in more recent years. The series of low recruitments are used by the model to set up the model to fit the composition data at the start of the data-rich period. This suggests that the stock-recruit relationship is not well known and that despite R_0 and R_1 being well estimated by the model, there is likely considerable uncertainty about the initial conditions of the stock prior to the 1981.

The likelihood profile for steepness shows that the most likely solution is at the upper bound (Figure 3.2.65). Each of the likelihood components suggested that steepness is estimated near the upper bound. The length and age-composition data sets provided the most evidence for estimating a high steepness. The likelihood profile of equilibrium recruitment shows that this parameter is well estimated (Figure 3.2.66). All likelihood components show a similar signal with the age composition being the most influential dataset for informing unfished recruitment. The likelihood profile for the offset parameter for initial equilibrium recruitment relative to virgin recruitment log(R_1) shows that this parameter is also well estimated (Figure 3.2.67).

Predicted age-0 recruits are presented in Figure 3.2.68 and Table 3.2.1. Average recruitment tends to increase over time from the mid-1980s to mid-2000s. The higher average recruitments in the late 1990s and early 2000s coincide with an increase in SSB and landings. In addition, the predicted recruitments in the recent data-rich period are defined by a pattern of strong year classes approximately every three or four years. In general, recruitment deviations are well informed by the model, especially during the data-rich period. The RMSE for recruitment deviations was 0.62. The age composition data provides evidence of strong year classes moving through the different fisheries. Recruitment in 2007 is predicted to be the highest recruitment over the time series. Recruitment in the two most years are predicted to be two of the lowest recruitments over the time series.

3.2.5. *Stock Biomass*

Predicted total biomass, combined mature biomass, female spawning biomass and proportion males are presented in Tables 3.2.1 and 3.2.2 and Figures 3.2.71 and 3.2.72, respectively, for the base model configuration. Total biomass generally increased from 1980 until 2005 (Figure 3.2.71). Total biomass declined substantially in 2006 and in association with the red tide event in 2005. Biomass in 2007 was similar to biomass in 2006 and then increased between 2010 and 2012. Predicted female spawning biomass was relatively flat between 1980 and 1996 before increasing until 2005 (Figure 3.2.71). Predicted spawning biomass substantially declined in 2006 (associated with red tide) and remained at a similar low level before increasing in 2010 and to a new high in 2012.

Figure 3.2.73 shows the distributions of the bootstrap estimates spawning biomass in 2012 (SPB_{2012}), unfished spawning stock biomass (SSB_o), and unfished total biomass (B_o). There was greater uncertainty in the estimate of SPB_{2012} than SSB_o and B_o (Table 3.1.3). The coefficient of variations associated with SPB_{2012} was 19%, whereas it was approximately 2% for SSB_o and $B_{o.}$

Predicted numbers at age and annual mean age are presented in Figures 3.2.74 and Figure 3.2.75 for females and males, respectively. Predicted numbers at length and the annual mean length are presented in Figures 3.2.76 and Figure 3.2.77. Mean age varied between age one and between 1980 and 2008(Figure 3.2.74). Mean age and length of the female population then increased to age 3 or 50cm in 2012. The predicted mean age and mean length of the male population were~ 11.5 years and ~100 cm in the early 1980s (Figures 3.2.7.75 and 3.2.77). Mean age and length remained between 11 and 12 years, ~100cm, until 1991, and then increased to age 13, ~106cm, between 1992 and 1997. After 1997, mean age and length of the male population declined and reached a low of 9 years and ~90cm in 2012.

3.2.6. *Fishing Mortality*

The predicted fishing mortality rates are presented in Table 3.2.3 and Figure 3.2.78. Total fishing mortality was predicted to generally increase between 1980 and 2008 and then declined for the remainder of the time-series. The highest predicted fishing mortality rate was in 2005, which is the year of the red tide event in the Gulf of Mexico (Figure 3.2.78). This red tide event was modeled as a fishing fleet that removed Gag Grouper. Its effect was not seen in the landings history, but rather, it was seen as a discard fishery and caused a substantial increase in catch in 2005 (Figures 3.2.79, 3.2.80, and 3.2.81). The estimated mortality rate from the red tide event was 0.708. This corresponds to a removal of 3.4 million Gag Grouper in 2005. This is substantially higher than the 1.8 million Gag Grouper estimated during the 2009 Update assessment.

Early in the time series the observed landings, catch, and predicted fishing mortality for the commercial vertical line fleet were greater than those from the other fleets and was the main source of fishing mortality prior to the late 1980s (Figures 3.2.79, 3.2.80, and 3.2.81). The catch and the predicted fishing mortality from the private recreational fleet then surpassed the commercial vertical line fleet in the late 1980s (Figures 3.2.79, 3.2.80 and Figure 3.2.81). The trend in predicted fishing mortality after the late 1980s was most similar to the trends in the catch and predicted fishing mortality from the private recreational fleet. The predicted number of discards from the private recreational fishery peaked in 2008, which in turn led to the 2008 peak in the catch series (Figure 3.2.82). The trends in predicted fishery mortality, landings, catch, and discards for the charterboat fleet were similar to the private recreational fishery (Figures 3.2.79- 3.2.82).

Predicted fishing mortality was relatively stable for the headboat fleet over time, which corresponds to relatively stable landings over time (Figures 3.2.79 and 3.2.80). Discards were relatively few as compared to the private recreational fishery; therefore the trend and magnitude of the catch and landings were similar over time (Figures 3.2.79-3.2.82). The fishing mortality rate of the longline fleet generally increased between 1980, when Gag Grouper first appeared in the longline landings, and 2005 and then declined over the remainder of the time-series (Figures 3.2.79 and 3.2.80). The trend in fishing mortality follows the trend in the observed landings. The number of discards associated with the longline fishery was relatively few as compared to the private recreational fleet; therefore, the landings and catch series are similar (Figures 3.2.80-3.2.81).

Predicted fishing mortality substantially declined in 2009 and continued to decline until the end of the data series in 2012 (Figure 3.2.78). This decline was predicted for all fleets and corresponds to a decline in landings (Figure 3.2.79). This decline can be explained by the implementation of Gag-specific fisheries management starting in 2009. The first Gag-specific commercial fishing quota was implemented in 2009, which then transitioned into the IFQ program in 2010. Additionally, the recreational closed season was expanded by one month in 2009. In 2011, the GMFMC closed the Gag Grouper recreational fishery. It was eventually reopened for 61 days. In 2012, the recreational fishery was open for 123 days.

3.2.7. *Evaluation of Uncertainty*

3.2.7.1. Parameter uncertainty

Estimates of asymptotic standard errors for all model parameters are presented in Table 3.1.1. A list of the mean and standard deviation from the distribution of parameter estimates for the 400 bootstrap samples is presented in Table 3.1.3. In general, estimates of uncertainty were similar between the two methods.

3.2.7.2. Sensitivity analysis

Results of the sensitivity analysis are summarized in Tables 3.2.4-3.2.6 and Figures 3.2.94-3.2.99.

3.2.7.2.1. Modeling red tide mortality

The first set of model sensitivities dealt with incorporating red tide mortality into the assessment model. For the 2009 SEDAR update assessment, a red tide mortality event that occurred in 2005 was incorporated into the assessment model to explain the large decline seen in all indices of abundance between 2005 and 2006. Two approaches were tested for incorporating red tide mortality into the Stock Synthesis model. The approach chosen by the AW panel involved specifying an additional bycatch-only fishing fleet (see Section 3.1.3). The alternative approach involved adding a constant mortality rate to all ages in 2005. The best fit to the data for both approaches occurred with a red tide mortality of 0.7 in 2005. Both approaches provided similar estimated trends in SSB and reference points (Figure 3.2.84, Table 3.2.5). Trends in fishing mortality rate differed between the models only because of the difference in specification of mortality. The red tide fleet used fishing mortality to remove animals via red tide, whereas, the alternative method calculated a natural mortality. Including red tide mortality improved the fit to all indices of abundance (Table 3.2.4) and decreased the total likelihood from 6782 to 6861.

3.2.7.2.2. Initial starting conditions

Estimates of equilibrium spawning biomass and recruitment were sensitive to assumptions regarding initial starting conditions. Given the lack of data besides catch prior to the 1980's the model could fit the data equally well using a range of alternative hypotheses. Trends in spawning biomass and recruitment after 1980 were robust to a wide range of assumptions regarding initial starting conditions (Figure 3.2.85). The model with the extended catch series back to 1880 estimated a higher unfished biomass and lower steepness than the base model (Table 3.2.5). The model configured to start in 1981 provided very similar predictions of current stock status as the base model.

3.2.7.2.3. Natural mortality rate

As expected, the model was sensitive to the estimate of natural mortality rate. Trends in SSB and F were similar among the three levels of natural mortality rate, however, their absolute values differed (Figure 3.2.86). The model scaled R_0 up for the high M scenario and down for the low M scenario. The high M model provided the most optimistic of the scenarios evaluated in terms of stock status (Table 3.2.5). The high M model also had log likelihood of the models evaluated. The high M scenario provided a better fit to the length composition and survey data but worse fit to the age composition data.

3.2.7.2.4. Discard mortality

The discard mortality rate used had little influence on predictions of SSB or fishing mortality rate over time (Figure 3.2.87). When using the 2009 discard mortality rates, the model predicted higher annual recruitments from 1981-2012 and a higher R_0 to account for the increased mortality of younger animals (Table 3.2.5). The model did predict slight higher fishing mortality rates in recent years, primarily due to private recreational discards. In general, high discard mortality rates led to slightly higher estimates of stock productivity.

3.2.7.2.5. Assumptions of selectivity

The model was sensitive to the assumption of asymptotic selectivity for the longline fleet. When a dome-shaped pattern is estimated for the longline fleet the model predicts a large "cryptic biomass" relative to the base model (Figure 3.2.88). The model predicts a higher unfished biomass, higher current biomass, and lower fishing mortality rates. The model was not very sensitive to the assumption of asymptotic selectivity for the vertical line fleet. The model was free estimate either asymptotic or dome-shaped selectivity for this fleet. The estimated selectivity was somewhere between, with only a proportion of the largest fish available to the vertical line gear.

The model was not very sensitive to the assumption of constant selectivity over time. Three alternative configurations of time-varying selectivity were attempted. The model was unable to converge on a stable solution when selectivity was configured with four time blocks for the commercial fleet (1963-1989, 1990-2000, 2001-2009, 2010-2012) and three time blocks for the recreational fleet (1963-1989, 1990-2000, 2001-2012). An alternative pattern with three time blocks for the commercial fleet (1963-1989, 1990-2000, 2001-2012) and two time blocks for the recreational fleet (1963-2000, 2001-2012) did lead to a slight improvement in the total log likelihood 6861 to 6842 but required 26 additional parameters. Predictions of current stock status relative to benchmarks were similar among the alternative time varying selectivity scenarios explored.

3.2.7.2.6. Steepness

Predicted trends in spawning stock biomass and fishing mortality rate were not sensitive to alternative values of steepness (Figure 3.2.89). The model estimated steepness at the upper bound of 0.99. When lower fixed steepness values were used the model predicted higher unfished biomass and higher unfished recruitments (R_0). Alternative values of steepness did change estimated reference points, however, trends in spawning stock biomass and fishing mortality rate relative to reference points were similar to the base model. The model likelihood for a fixed steepness of 0.85 was similar to the base model likelihood (6861 to 6888). The fixed steepness of 0.70 provided a substantially worse fit to the data than the base model (6861 to 7480). SEDAR 10 estimated a steepness value of 0.75.

3.2.7.2.7. Data weighting

Model results were sensitive to alternative weighting of data sources. Down-weighting the composition data increased the estimated productivity of the stock and the current estimate of spawning stock biomass (Figure 3.2.90). The likelihood profile of R_0 showed that the age composition data had a large influence on the estimate of R_0. Decreasing the weight of the composition data led to a better fit to the indices of abundance. In particular, the model improved the fit to the recreational indices of abundance. The fit to the longline age composition data was degraded the most when the composition data was down-weighted. The model with the composition data down-weighted gave the second most optimistic prediction of current stock biomass relative to unfished or reference levels.

Increasing the weight of the adult indices of abundance did not have a large influence on current stock biomass or predicted reference points (Figures 3.2.91). The model predicted higher biomass between 2000 and 2004 and a large influence of red tide than the base model. This was due to the model being forced to fit the commercial indices of abundance. Up-weighting the adult indices degraded the model fit to the recreational indices of abundance suggesting disagreement in the signal between indices (Table 3.2.4). The fit to the headboat index was most affected. Interestingly, the fit to the handline length composition and longline age composition improved, while the fit to the handline age composition and longline length composition was degraded.

3.2.7.2.8. *Catchability*

Assuming a 2% increasing catchability for all of the fishery-dependent indices of abundance led to predictions of lower stock productivity. Predicted spawning stock biomass peaked in 2001 rather than 2004 as predicted in the base model (Figure 3.2.92). Predicted spawning stock biomass is lower for the increasing catchability model throughout the 2000's including the estimated current stock biomass.

3.2.7.2.9. *Jack-knife analysis of abundance indices*

The jack-knife analysis of abundance indices revealed that the model was most sensitive to the recreational headboat index. Removal of the headboat index decreased the estimated productivity of the stock and dampened the predicted recovery in the most recent years (Figure 3.2.93). The headboat index is characterized by a strong increase in abundance between 2006 and 2010. The model tends to provide a strong fit to the headboat index while providing a poorer fit to the charterboat index which provides a less optimistic signal in abundance in 2009 and 2010.

3.2.7.3. *Retrospective analysis*

Results of the retrospective analysis are summarized in Table 3.10. In general, there were no major patterns or systematic bias revealed from the retrospective analysis. Estimates of spawning stock biomass (Figure 3.2.100), recruitment (Figure 3.2.101), and fishing mortality (Figure 3.2.102) were very similar among the alternative ending years. There was some uncertainty for the most recent years (2004-2011). In particular, the predicted strength of the 2007 year class tended to decrease with each year of additional data.

3.2.8. *Benchmarks/Reference points*

Reference points were calculated for both SSB-female and SSB-combined models. Yield-per-recruit, spawner biomass per-recruit and equilibrium yield were computed as a function of F to calculate reference points. The default unit for equilibrium yield in Stock Synthesis is total removals (landings plus dead discards). Reference points were also calculated for retained yield (landings only). For the base model, steepness was estimated at the upper bound of 0.99 and thus F_{MSY} is equivalent to F_{MAX}.

Similar to the previous assessment (SEDAR 10), F_{MAX} was less than $F_{SPR30\%}$ for the SSB-female model (Figures 3.2.103 and 3.2.104). For SSB-combined, F_{MAX} was greater than $F_{SPR30\%}$ (Figures 3.2.105 and 3.2.106). $F_{SPR30\%}$ was calculated at 0.26 for the SSB-female model and 0.10 for the SSB-combined model. F_{MAX} using total yield was calculated at 0.20 for both SSB-female and SSB-combined models. F_{MAX} using only retained yield was calculated at 0.17 for both SSB-female and SSB-combined models. SPR associated with F_{MAX} using total removals was 0.37 for the SSB-female model and 0.16 for SSB-combined model. SPR associated with F_{MAX} using retained yield was 0.41 for the SSB-female model and 0.20 for SSB-combined model. MSY, in terms of total removals, was estimated at 2554 MT. MSY, in terms of total landings, was estimated at 2200 MT.

Stock status and benchmarks relative to the SPR 30% reference point is presented in Table 3.2.6 for each of the sensitivity runs. The maximum fishing mortality threshold (MFMT) was the fishing mortality rate that produced a SPR of 30%, $F_{SPR30\%}$. The minimum stock size threshold (MSST) was calculated as $(1-M)*SSB_{SPR30\%}$, where $M = 0.1342$ y^{-1} for the base model. Overfishing is defined as F > MFMT and overfished as SSB < MSST. The AWP decided that current status of the fishery would be calculated as the geometric mean fishing mortality from 2010-2012. Current status of the stock is estimated to be SSB in the latest year of the assessment, 2012.

The stock status was dependent on the units of SSB. According to the base model, the status of the stock relative to MSST is estimated to be 2.15 for the SSB-female model and 0.64 for the SSB-combined model. The current fishing mortality rate (2010-2012) relative to MFMT was 0.32 for the SSB-female model and 0.83 for the SSB-combined model. For SSB-female, the stock is not considered overfished nor undergoing overfishing (Figures 3.2.107 and 3.2.108). For SSB-combined, the stock is considered to be overfished but not undergoing overfishing (Figures 3.2.109 and 3.2.110).

Uncertainty in the ratios

3.2.9. *Projections*

Benchmarks for the SPR 30% reference point and projections for the base model are presented in Table 3.2.8. Benchmarks for the SPR 30% reference point and projections for the fixed steepness model are presented in Table 3.2.9.

For the base model, current fishing mortality rate is less than either $F_{SPR30\%}$ or F_{MAX} for both the SSB-female and SSB-combined models. Fishing at $F_{SPR30\%}$ would result in higher fishing mortality rates than seen in current years for both the SSB-female and SSB-combined models. For the SSB-female model, current spawning biomass is greater than both $SSB_{SPR30\%}$ and SSB_{FMAX}. Projected yield patterns for the SSB-female model suggest yields substantially greater than equilibrium yield over the next five years before stabilizing near equilibrium levels. Equilibrium yield for $SSB_{SPR30\%}$ is 4.6 million pounds, gutted weight. For the SSB-combined model, current spawning biomass is greater than SSB_{FMAX} but less than $SSB_{SPR30\%}$. Projected yield patterns for the SSB-combined model at $F_{SPR30\%}$ are less than equilibrium yields and increase over time. Projected yield at F_{MAX} are substantially greater than equilibrium yield over the next five years before stabilizing near equilibrium levels. Equilibrium yield for $SSB_{SPR30\%}$ is 4.6 million pounds, gutted weight.

Projections for the model run with steepness fixed at 0.7 were substantially different than the projections for the base model. In addition, projections for the SSB-female and SSB-combined models were considerably different with steepness fixed at 0.7. For the model run with steepness fixed at 0.7, current fishing mortality rate is less than either $F_{SPR30\%}$ or F_{MAX} for both the SSB-female and SSB-combined models. Fishing at $F_{SPR30\%}$ would result in higher fishing mortality rates than seen in current years for both the SSB-female and SSB-combined models. For the SSB-female model, current spawning biomass is greater than $SSB_{SPR30\%}$ but less than SSB_{FMAX}. Projected yield patterns for the SSB-female model at $F_{SPR30\%}$ suggest yields substantially greater than equilibrium yield over the next five years before stabilizing near equilibrium levels at 5.1 million pounds, gutted weight. Projected yield patterns for the SSB-female model at F_{MAX} suggest increasing yield as the stock rebuilds to SSB_{FMAX}. Equilibrium yield for SSB_{FMAX} is 6.9 million pounds, gutted weight. For the SSB-combined model, current spawning biomass is less than either SSB_{FMAX} or $SSB_{SPR30\%}$. Projected yield patterns for the SSB-combined model at $F_{SPR30\%}$ and F_{MAX} are less than equilibrium yields and increase over time. Equilibrium yield for $SSB_{SPR30\%}$ is 7.7 million pounds, gutted weight.

As usual, projections should be interpreted in light of the model assumptions and key aspects of the data. In this case, projections assume that fishing patterns (i.e. selectivity and retention) in the future will be similar to average patterns over the past three years. Management of Gag Grouper has changed dramatically in the most recent years in an attempt to end overfishing and rebuild the stock. Projected biomass and fishing mortality trends suggest that these regulations have succeeded in ending overfishing. Thus, future management regulations may not be as restrictive as regulations in the most recent years. Changes in regulations would likely lead to changes in fishing behavior and thus violate model assumptions.

3.3 Discussion and Recommendations

Discussion

The assessment model predicts a strong recovery for Gag Grouper in recent years in response to restrictive management regulations designed to end overfishing and rebuild the Gag Grouper stock. Across all sensitivity runs and model configurations, the assessment model predicts that fishing mortality rate has declined substantially from peak levels in 2008. Recent landings for Gag Grouper have been in decline since the early 2000's. Gag Grouper landings in the most recent year of the assessment model were less than one fifth of the landings in 2004. The assessment model predicts that Gag Grouper biomass has increased rapidly over the past three years. Spawning biomass in 2008 and 2009 was predicted to be at historically low levels. This was due to a combination of years of overfishing and a severe episodic mortality event in 2005 due to red tide. The model assessment model predicts that the red tide event in 2005 removed approximately 3.8 million fish from the population. Across all sensitivity runs and model configurations, the assessment model predicts that the stock has rebounded rapidly from a severely depleted state in 2009. The population response is driven by two predicted strong yea classes in 2006 and 2007. Estimated recruitment trends over the past 30 years suggest that the gag recruitment is highly variable and that strong recruitment occurs on average every three to five years. Age composition data clearly shows that Gag Grouper landings are dominated by a few strong year classes that move through the fisheries. The model predicts that the 2007 year-class is the strongest year class over the model time series. Gag Grouper recruit to the recreational fishery between ages 2 and 3 and to the commercial fishery between ages 4 and 6. As the 2007 year class recruited to the fisheries, a number of management regulations were implemented to reduce the fishing mortality rate on Gag Grouper. Thus, the model is predicting a strong recovery for Gag Grouper driven by a combination of strong recruitments and reduced fishing mortality.

Research recommendations

1. Develop scientific survey to obtain reliable age/size composition data. This is needed, particularly as the composition data coming from the fisheries is substantially impacted by changing selectivity. This might be done with a handline survey of fixed sites. The idea would be not necessarily to get a random sample of the age composition but a reliable, relative estimate where selectivity can be assumed constant. An index would be nice, too.
2. Develop/Evaluate methods to maintain continuity of fishery-dependent indices in light of management regulations and ITQs.
3. Determine most appropriate methods to deal with changing selectivity in fisheries over time, particularly changing selectivity related to management actions or targeting of specific cohorts.
4. Evaluate most appropriate methods to deal with unreliable historic discard size composition data so that discard ratios can be reliably estimated.
5. Evaluate the size/age specific mortality effects of red tides on gag populations.

3.4 Acknowledgements

Many people at various state and federal agencies assisted with assembling the data sources included in this stock assessment. The assessment panel was instrumental in guiding the assessment configuration and dealing with the nuances of the data. The assessment was greatly improved with help of Clay Porch, Shannon Cass-Calay, Michael Schirripa, Brian Linton, and John F. Walter. Richard Methot and Mark Maunder provided significant advice on model configuration in Stock Synthesis 3. Ian Taylor has greatly improved the R code for plotting and diagnostics of Stock Synthesis models (http://code.google.com/p/r4ss/) with which many of the figures in this document were created.

3.5 References

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3.6 Tables

Table 3.1.1. List of SS parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values and their associated standard errors from SS Run 1, initial parameter values, minimum and maximum values a parameter could take, and prior densities assigned to parameters. Parameters designated as fixed were held at their initial values.

	Predicted		Prior				
Label	Value	SD	Type	Value	SD	Status	Description
L_at_Amin_Fem_GP_1	29.17	0.26	Sym_Beta	30.00	1.00	Estimated	Female length at age 0
L_at_Amax_Fem_GP_1	133.56	2.61	Sym_Beta	127.20	1.00	Estimated	Female Linf
VonBert_K_Fem_GP_1	0.10	0.00	Sym_Beta	0.14	1.00	Estimated	Female K
CV_young_Fem_GP_1	0.12	-	No_prior	_	_	Fixed	Young female growth CV
CV_old_Fem_GP_1	0.02	_	No_prior	_	_	Fixed	Old female growth CV
Wtlen_1_Fem	0.00	_	No_prior	_	_	Fixed	Female weight-length scalar
Wtlen_2_Fem	3.08	_	No_prior	_	_	Fixed	Female weight-length exponent
Mat50%_Fem	54.30	_	No_prior	_	_	Fixed	Maturity inflection point
Mat_slope_Fem	-0.23	_	No_prior	_	_	Fixed	Maturity slope
Eggs_scalar_Fem	1.00	_	No_prior	_	_	Fixed	Fecundity scalar
Eggs_exp_wt_Fem	1.00	_	No_prior	_	_	Fixed	Fecundity exponent
Wtlen_1_Mal	0.00	_	No_prior	_	_	Fixed	Male weight-length scalar
Wtlen_2_Mal	3.08	_	No_prior	_	_	Fixed	Male weight-length exponent
Herm_Infl_age	10.75	_	No_prior	_	_	Fixed	Sex transition inflection point
Herm_stdev	2.53	_	No_prior	_	_	Fixed	Sex transition standard deviation
Herm_asymptote	1.00	_	No_prior	_	_	Fixed	Sex transition asymptote
SR_R0	8.36	0.02	Normal	10.00	0.50	Estimated	Virgin recruit
SR_steep	0.99	0.01	Sym_Beta	0.70	1.00	Estimated	Steepness
SR_sigmaR	0.60	_	No_prior	_	_	Fixed	Stock -recruit standard deviation
SR_envlink	0.00	_	No_prior	_	_	Fixed	Stock-recruit environmental link
SR_R1_offset	-1.14	0.05	Normal	-0.50	0.50	Estimated	Stock-recruit offset
SR_autocorr	0.00	_	No_prior	_	_	Fixed	Stock-recruit autocorrelation
Early_RecrDev_1963	-1.85	0.36	_	_	_	Estimated	1963 recruit deviation
Early_RecrDev_1964	-1.87	0.36	_	_	_	Estimated	1964 recruit deviation
Early_RecrDev_1965	-1.87	0.36	_	_	_	Estimated	1965 recruit deviation
Early_RecrDev_1966	-1.86	0.36	_	_	_	Estimated	1966 recruit deviation
Early_RecrDev_1967	-1.83	0.36	_	_	_	Estimated	1967 recruit deviation
Early_RecrDev_1968	-1.76	0.37	_	_	_	Estimated	1968 recruit deviation
Early_RecrDev_1969	-1.65	0.38	_	_	_	Estimated	1969 recruit deviation
Early_RecrDev_1970	-1.46	0.40	_	_	_	Estimated	1970 recruit deviation
Early_RecrDev_1971	-1.16	0.42	_	_	_	Estimated	1971 recruit deviation
Early_RecrDev_1972	-0.62	0.43	_	_	_	Estimated	1972 recruit deviation
Early_RecrDev_1973	-0.12	0.38	_	_	_	Estimated	1973 recruit deviation
Early_RecrDev_1974	0.03	0.32	_	_	_	Estimated	1974 recruit deviation
Early_RecrDev_1975	-0.64	0.36	_	_	_	Estimated	1975 recruit deviation
Early_RecrDev_1976	-1.01	0.35	_	_	_	Estimated	1976 recruit deviation
Early_RecrDev_1977	-1.07	0.34	_	_	_	Estimated	1977 recruit deviation
Early_RecrDev_1978	-0.28	0.19	_	_	_	Estimated	1978 recruit deviation
Early_RecrDev_1979	-0.62	0.24	_	_	_	Estimated	1979 recruit deviation
Early_RecrDev_1980	-0.20	0.15	_	_	_	Estimated	1980 recruit deviation
Early_RecrDev_1981	0.23	0.09	_	_	_	Estimated	1981 recruit deviation
Early_RecrDev_1982	-0.29	0.12	_	_	_	Estimated	1982 recruit deviation
Early_RecrDev_1983	-0.20	0.09	_	_	_	Estimated	1983 recruit deviation
Main_RecrDev_1984	-0.63	0.10	_	_	_	Estimated	1984 recruit deviation
Main_RecrDev_1985	0.19	0.05	_	_	_	Estimated	1985 recruit deviation
Main_RecrDev_1986	-0.81	0.08	_	_	_	Estimated	1986 recruit deviation
Main_RecrDev_1987	-0.51	0.05	_	_	_	Estimated	1987 recruit deviation
Main_RecrDev_1988	-1.05	0.07	_	_	_	Estimated	1988 recruit deviation

Main_RecrDev_1989	0.33	0.03	_	_	_	Estimated	1989 recruit deviation
Main_RecrDev_1990	-0.54	0.05	_	_	_	Estimated	1990 recruit deviation
Main_RecrDev_1991	-0.54	0.05	_	_	_	Estimated	1991 recruit deviation
Main_RecrDev_1992	-0.46	0.05	_	_	_	Estimated	1992 recruit deviation
Main_RecrDev_1993	0.64	0.03	_	_	_	Estimated	1993 recruit deviation
Main_RecrDev_1994	0.01	0.05	_	_	_	Estimated	1994 recruit deviation
Main_RecrDev_1995	-0.24	0.05	_	_	_	Estimated	1995 recruit deviation
Main_RecrDev_1996	0.88	0.03	_	_	_	Estimated	1996 recruit deviation
Main_RecrDev_1997	0.30	0.04	_	_	_	Estimated	1997 recruit deviation
Main_RecrDev_1998	-0.52	0.06	_	_	_	Estimated	1998 recruit deviation
Main_RecrDev_1999	0.58	0.03	_	_	_	Estimated	1999 recruit deviation
Main_RecrDev_2000	0.55	0.04	_	_	_	Estimated	2000 recruit deviation
Main_RecrDev_2001	0.27	0.05	_	_	_	Estimated	2001 recruit deviation
Main_RecrDev_2002	0.74	0.05	_	_	_	Estimated	2002 recruit deviation
Main_RecrDev_2003	0.27	0.06	_	_	_	Estimated	2003 recruit deviation
Main_RecrDev_2004	0.35	0.06	_	_	_	Estimated	2004 recruit deviation
Main_RecrDev_2005	-0.01	0.04	_	_	_	Estimated	2005 recruit deviation
Main_RecrDev_2006	0.67	0.04	_	_	_	Estimated	2006 recruit deviation
Main_RecrDev_2007	0.94	0.04	_	_	_	Estimated	2007 recruit deviation
Main_RecrDev_2008	0.43	0.06	_	_	_	Estimated	2008 recruit deviation
Main_RecrDev_2009	0.31	0.07	_	_	_	Estimated	2009 recruit deviation
Main_RecrDev_2010	0.29	0.09	_	_	_	Estimated	2010 recruit deviation
Main_RecrDev_2011	-1.46	0.23	_	_	_	Estimated	2011 recruit deviation
Main_RecrDev_2012	-0.97	0.18	_	_	_	Estimated	2012 recruit deviation
InitF_1Com_HL_1	0.10	0.02	Normal	0.05	0.10	Estimated	Handline initial F
InitF_2Com_LL_2	0.00	_	Normal	_	_	Fixed	Longline initial F
InitF_3Headboat_3	0.00	_	Normal	_	_	Fixed	Headboat initial F
InitF_4CHARTER_4	0.00	_	Normal	_	_	Fixed	Charter initial F
InitF_5PRIVATE_5	0.03	0.00	Normal	0.05	0.10	Estimated	Recreational initial F
InitF_REDTIDE_6	0.00	_	Normal	_	_	Fixed	Red tide initial F
LnQ_base_6_REDTIDE_6	0.35	0.09	No_prior	_	_	Estimated	Red tide catchability parameter
SizeSel_1P_1_Com_HL_1	85.95	0.70	No_prior	_	_	Estimated	HL size select peak
SizeSel_1P_2_Com_HL_1	-9.00	_	No_prior	_	_	Fixed	HL size select top
SizeSel_1P_3_Com_HL_1	6.26	0.04	No_prior	_	_	Estimated	HL size select ascending width
SizeSel_1P_4_Com_HL_1	4.90	0.61	No_prior	_	_	Estimated	HL size select descending width
SizeSel_1P_5_Com_HL_1	-14.21	18.73	No_prior	_	_	Estimated	HL size select initial
SizeSel_1P_6_Com_HL_1	-0.20	0.27	No_prior	_	_	Estimated	HL size select final
Retain_1P_1_Com_HL_1	40.64	_	No_prior	_	_	Fixed	HL retention inflection 1963-1989
Retain_1P_2_Com_HL_1	5.00	_	No_prior	_	_	Fixed	HL retention slope 1963-1989
Retain_1P_3_Com_HL_1	1.00	_	No_prior	_	_	Fixed	HL retention asymptote 1963-1989
Retain_1P_4_Com_HL_1	0.00	_	No_prior	_	_	Fixed	HL retention male offset
DiscMort_1P_1_Com_HL_1	-10.00	_	No_prior	_	_	Fixed	HL discard mortality inflection
DiscMort_1P_2_Com_HL_1	1.00	_	No_prior	_	_	Fixed	HL discard mortality slope
DiscMort_1P_3_Com_HL_1	0.25	_	No_prior	_	_	Fixed	HL discard mortality asymptote
DiscMort_1P_4_Com_HL_1	0.00	_	No_prior	_	_	Fixed	HL discard mortality male offset
SizeSel_2P_1_Com_LL_2	77.97	0.44	No_prior	_	_	Estimated	LL size select inflection
SizeSel_2P_2_Com_LL_2	17.08	0.34	No_prior	_	_	Estimated	LL size select width
Retain_2P_1_Com_LL_2	40.64	_	No_prior	_	_	Fixed	LL retention inflection 1963-1989
Retain_2P_2_Com_LL_2	5.00	_	No_prior	_	_	Fixed	LL retention slope 1963-1989
Retain_2P_3_Com_LL_2	1.00	_	No_prior	_	_	Fixed	LL retention asymptote 1963-1989
Retain_2P_4_Com_LL_2	0.00	_	No_prior	_	_	Fixed	LL retention male offset
DiscMort_2P_1_Com_LL_2	-10.00	_	No_prior	_	_	Fixed	LL discard mortality inflection
DiscMort_2P_2_Com_LL_2	1.00	_	No_prior	_	_	Fixed	LL discard mortality slope
DiscMort_2P_3_Com_LL_2	0.25	_	No_prior	_	_	Fixed	LL discard mortality asymptote
DiscMort_2P_4_Com_LL_2	0.00	_	No_prior	_	_	Fixed	LL discard mortality male offset
SizeSel_3P_1_Headboat_3	43.94	0.83	No_prior	_	_	Estimated	HB size select peak
SizeSel_3P_2_Headboat_3	-9.00	_	No_prior	_	_	Estimated	HB size select top
SizeSel_3P_3_Headboat_3	5.05	0.09	No_prior	_	_	Estimated	HB size select ascending width
SizeSel_3P_4_Headboat_3	7.60	0.07	No_prior	_	_	Estimated	HB size select descending width

SizeSel_3P_5_Headboat_3	-999.00	_	No_prior	_	_	Fixed	HB size select initial
SizeSel_3P_6_Headboat_3	-999.00	_	No_prior	_	_	Fixed	HB size select final
Retain_3P_1_Headboat_3	40.79	0.79	No_prior	_	_	Estimated	HB retention inflection 1963-1989
Retain_3P_2_Headboat_3	5.00	_	No_prior	_	_	Fixed	HB retention slope 1963-1989
Retain_3P_3_Headboat_3	1.00	_	No_prior	_	_	Fixed	HB retention asymptote 1963-1989
Retain_3P_4_Headboat_3	0.00	_	No_prior	_	_	Fixed	HB retention male offset
DiscMort_3P_1_Headboat_3	-10.00	_	No_prior	_	_	Fixed	HB discard mortality inflection
DiscMort_3P_2_Headboat_3	1.00	_	No_prior	_	_	Fixed	HB discard mortality slope
DiscMort_3P_3_Headboat_3	0.12	_	No_prior	_	_	Fixed	HB discard mortality asymptote
DiscMort_3P_4_Headboat_3	0.00	_	No_prior	_	_	Fixed	HB discard mortality male offset
SizeSel_4P_1_CHARTER_4	48.51	0.97	No_prior	_	_	Estimated	CB size select peak
SizeSel_4P_2_CHARTER_4	-9.00	_	No_prior	_	_	Estimated	CB size select top
SizeSel_4P_3_CHARTER_4	4.90	0.16	No_prior	_	_	Estimated	CB size select ascending width
SizeSel_4P_4_CHARTER_4	7.39	0.07	No_prior	_	_	Estimated	CB size select descending width
SizeSel_4P_5_CHARTER_4	-999.00	_	No_prior	_	_	Fixed	CB size select initial
SizeSel_4P_6_CHARTER_4	-999.00	_	No_prior	_	_	Fixed	CB size select final
Retain_4P_1_CHARTER_4	39.84	1.07	No_prior	_	_	Estimated	CB retention inflection 1963-1989
Retain_4P_2_CHARTER_4	5.00	_	No_prior	_	_	Fixed	CB retention slope 1963-1989
Retain_4P_3_CHARTER_4	1.00	_	No_prior	_	_	Fixed	CB retention asymptote 1963-1989
Retain_4P_4_CHARTER_4	0.00	_	No_prior	_	_	Fixed	CB retention male offset
DiscMort_4P_1_CHARTER_4	-10.00	_	No_prior	_	_	Fixed	CB discard mortality inflection
DiscMort_4P_2_CHARTER_4	1.00	_	No_prior	_	_	Fixed	CB discard mortality slope
DiscMort_4P_3_CHARTER_4	0.12	_	No_prior	_	_	Fixed	CB discard mortality asymptote
DiscMort_4P_4_CHARTER_4	0.00	_	No_prior	_	_	Fixed	CB discard mortality male offset
SizeSel_5P_1_PRIVATE_5	38.80	1.89	No_prior	_	_	Estimated	PRI size select peak
SizeSel_5P_2_PRIVATE_5	-2.00	_	No_prior	_	_	Estimated	PRI size select top
SizeSel_5P_3_PRIVATE_5	5.86	0.33	No_prior	_	_	Estimated	PRI size select ascending width
SizeSel_5P_4_PRIVATE_5	6.29	0.13	No_prior	_	_	Estimated	PRI size select descending width
SizeSel_5P_5_PRIVATE_5	-999.00	_	No_prior	_	_	Fixed	PRI size select initial
SizeSel_5P_6_PRIVATE_5	-999.00	_	No_prior	_	_	Fixed	PRI size select final
Retain_5P_1_PRIVATE_5	33.73	1.27	No_prior	_	_	Estimated	PRI retention inflection 1963-1989
Retain_5P_2_PRIVATE_5	5.00	_	No_prior	_	_	Fixed	PRI retention slope 1963-1989
Retain_5P_3_PRIVATE_5	1.00	_	No_prior	_	_	Fixed	PRI retention asymptote 1963-1989
Retain_5P_4_PRIVATE_5	0.00	_	No_prior	_	_	Fixed	PRI retention male offset
DiscMort_5P_1_PRIVATE_5	-10.00	_	No_prior	_	_	Fixed	PRI discard mortality inflection
DiscMort_5P_2_PRIVATE_5	1.00	_	No_prior	_	_	Fixed	PRI discard mortality slope
DiscMort_5P_3_PRIVATE_5	0.12	_	No_prior	_	_	Fixed	PRI discard mortality asymptote
DiscMort_5P_4_PRIVATE_5	0.00	_	No_prior	_	_	Fixed	PRI discard mortality male offset
SizeSel_8P_1_SEAMAP_Video_8	80.10	3.24	No_prior	_	_	Estimated	SEAMAP size select inflection
SizeSel_8P_2_SEAMAP_Video_8	16.79	1.90	No_prior	_	_	Estimated	SEAMAP size select width
SizeSel_9P_1_PC_Video_9	24.10	22.81	No_prior	_	_	Estimated	PC size select peak
SizeSel_9P_2_PC_Video_9	0.67	0.26	No_prior	_	_	Estimated	PC size select top
SizeSel_9P_3_PC_Video_9	-2.11	74.03	No_prior	_	_	Estimated	PC size select ascending width
SizeSel_9P_4_PC_Video_9	-0.65	100.41	No_prior	_	_	Estimated	PC size select descending width
SizeSel_9P_5_PC_Video_9	-15.00	_	No_prior	_	_	Fixed	PC size select initial
SizeSel_9P_6_PC_Video_9	-15.00	_	No_prior	_	_	Fixed	PC size select final
AgeSel_3P_1_Headboat_3	0.10	_	No_prior	_	_	Fixed	HB min age
AgeSel_3P_2_Headboat_3	31.00	_	No_prior	_	_	Fixed	HB max age
AgeSel_5P_1_PRIVATE_5	0.10	_	No_prior	_	_	Fixed	PRI min age
AgeSel_5P_2_PRIVATE_5	31.00	_	No_prior	_	_	Fixed	PRI max age
AgeSel_7P_1_Age0_7	0.10	_	No_prior	_	_	Fixed	Age0 min age
AgeSel_7P_2_Age0_7	0.90	_	No_prior	_	_	Fixed	Age0 max age
Retain_1P_1_Com_HL_1_BLK1repl_1990	49.38	_	No_prior	_	_	Fixed	HL retention inflection 1990-1999
Retain_1P_1_Com_HL_1_BLK1repl_2001	59.24	_	No_prior	_	_	Fixed	HL retention inflection 2000-2011
Retain_1P_1_Com_HL_1_BLK1repl_2012	54.31	_	No_prior	_	_	Fixed	HL retention inflection 2012-2012
Retain_1P_2_Com_HL_1_BLK1repl_1990	1.00	_	No_prior	_	_	Fixed	HL retention slope 1990-1999
Retain_1P_2_Com_HL_1_BLK1repl_2001	1.00	_	No_prior	_	_	Fixed	HL retention slope 2000-2011
Retain_1P_2_Com_HL_1_BLK1repl_2012	1.00	_	No_prior	_	_	Fixed	HL retention slope 2012-2012
Retain_1P_3_Com_HL_1_BLK4repl_2011	0.97	0.00	No_prior	_	_	Estimated	HL retention asymptote 2011-2012

Retain_2P_1_Com_LL_2_BLK1repl_1990	49.38	_	No_prior	_	_	Fixed	LL retention inflection 1990-1999
Retain_2P_1_Com_LL_2_BLK1repl_2001	59.24	_	No_prior	_	_	Fixed	LL retention inflection 2000-2011
Retain_2P_1_Com_LL_2_BLK1repl_2012	54.31	_	No_prior	_	_	Fixed	LL retention inflection 2012-2012
Retain_2P_2_Com_LL_2_BLK1repl_1990	1.00	_	No_prior	_	_	Fixed	LL retention slope 1990-1999
Retain_2P_2_Com_LL_2_BLK1repl_2001	1.00	_	No_prior	_	_	Fixed	LL retention slope 2000-2011
Retain_2P_2_Com_LL_2_BLK1repl_2012	1.00	_	No_prior	_	_	Fixed	LL retention slope 2012-2012
Retain_2P_3_Com_LL_2_BLK4repl_2011	0.66	0.05	No_prior	_	_	Estimated	LL retention asymptote 2011-2012
Retain_3P_1_Headboat_3_BLK2repl_1990	49.38	_	No_prior	_	_	Fixed	HB retention inflection 1990-1999
Retain_3P_1_Headboat_3_BLK2repl_2001	54.31	_	No_prior	_	_	Fixed	HB retention inflection 2000-2011
Retain_3P_2_Headboat_3_BLK2repl_1990	1.00	_	No_prior	_	_	Fixed	HB retention slope 1990-1999
Retain_3P_2_Headboat_3_BLK2repl_2001	1.00	_	No_prior	_	_	Fixed	HB retention slope 2000-2011
Retain_3P_3_Headboat_3_BLK4repl_2011	0.39	0.08	No_prior	_	_	Estimated	HB retention asymptote 2011-2012
Retain_4P_1_CHARTER_4_BLK2repl_1990	49.38	_	No_prior	_	_	Fixed	CB retention inflection 1990-1999
Retain_4P_1_CHARTER_4_BLK2repl_2001	54.31	_	No_prior	_	_	Fixed	CB retention inflection 2000-2011
Retain_4P_2_CHARTER_4_BLK2repl_1990	1.00	_	No_prior	_	_	Fixed	CB retention slope 1990-1999
Retain_4P_2_CHARTER_4_BLK2repl_2001	1.00	_	No_prior	_	_	Fixed	CB retention slope 2000-2011
Retain_4P_3_CHARTER_4_BLK4repl_2011	0.49	0.07	No_prior	_	_	Estimated	CB retention asymptote 2011-2012
Retain_5P_1_PRIVATE_5_BLK2repl_1990	49.38	_	No_prior	_	_	Fixed	PRI retention inflection 1990-1999
Retain_5P_1_PRIVATE_5_BLK2repl_2001	54.31	_	No_prior	_	_	Fixed	PRI retention inflection 2000-2011
Retain_5P_2_PRIVATE_5_BLK2repl_1990	1.00	_	No_prior	_	_	Fixed	PRI retention slope 1990-1999
Retain_5P_2_PRIVATE_5_BLK2repl_2001	1.00	_	No_prior	_	_	Fixed	PRI retention slope 2000-2011
Retain_5P_3_PRIVATE_5_BLK4repl_2011	0.20	0.08	No_prior	_	_	Estimated	PRI retention asymptote 2011-2012

Table 3.1.2. Model total likelihood, predicted unfished spawning biomass (mt) and predicted 2012 spawning biomass from 50 model runs from the jitter analysis.

Run	Total likelihood	SSB unfished	SSB 2012	R0
1	6861.63	33070.9	11068.9	4287.43
2	6861.6	33070.9	11068.6	4287.35
3	6861.63	33070.9	11068.9	4287.43
4	6861.6	33070.9	11068.6	4287.35
5	6861.6	33070.9	11068.6	4287.35
6	7030.56	31979	10723.2	4157.1
7	7030.56	31979	10723.2	4157.1
8	6861.6	33069.8	11068.9	4287.21
9	6861.6	33070.9	11068.6	4287.35
10	6861.63	33070.9	11068.9	4287.43
11	6861.6	33070.9	11068.6	4287.35
12	6861.63	33070.9	11068.9	4287.43
13	6861.63	33070.9	11068.9	4287.43
14	7796.23	33601.4	10721	4335.72
15	426616	470.364	172.201	304.192
16	6868.51	33074.7	11067.7	4288.29
17	6861.6	33070.9	11068.6	4287.35
18	6861.63	33070.9	11068.9	4287.43
19	6870.28	32955.2	11073.6	4285
20	6861.63	33070.9	11068.9	4287.43
21	6861.6	33070.9	11068.6	4287.35
22	6877.07	33278.8	10937.8	4312.38
23	6861.63	33070.9	11068.9	4287.43
24	7170.17	35356.8	12123.3	4499.58
25	7071.94	35619	11686.5	4485.64
26	6861.6	33070.9	11068.6	4287.35
27	6861.6	33071.7	11068	4287.34
28	6861.6	33070.9	11068.6	4287.35
29	6877.19	33273.9	10937.4	4311.71
30	6861.63	33070.9	11068.9	4287.43
31	6861.77	33072	11069.6	4287.43
32	6887.77	32990.4	10786.5	4271.66
33	6861.63	33070.9	11068.9	4287.43
34	6861.63	33070.9	11068.9	4287.43
35	7593.43	33502.6	11010	4405.94
36	6861.63	33070.9	11068.9	4287.43
37	6861.6	33070.9	11068.6	4287.35
38	6861.6	33070.9	11068.6	4287.35
39	6861.6	33070.9	11068.6	4287.35
40	6861.86	33073.9	11071.7	4287.97
41	6861.63	33070.9	11068.9	4287.43
42	6861.6	33070.9	11068.6	4287.35
43	7030.56	31978.4	10723.3	4157.01
44	6861.63	33071	11068.8	4287.41
45	6861.63	33070.9	11068.9	4287.43
46	6861.6	33070.9	11068.6	4287.35
47	6861.6	33070.9	11068.6	4287.35
48	6861.77	33073.9	11073.7	4287.77
49	6861.6	33070.9	11068.6	4287.34
50	6861.6	33070.9	11068.6	4287.35

Table 3.1.3. Mean and standard deviation of parameter estimates from 400 bootstrap samples for Gulf of Mexico Gag Grouper. Selectivity was assumed to be logistic for the longline fleet and the SEAMAP video survey, all others were assumed double normal.

Model	**Male and Female biomass combined**			**Female biomass only**		
Parameter	**Mean**	**SD**	**CV**	**Mean**	**SD**	**CV**
Recruitment						
Steepness	0.9981	0.0002	0.0002	0.9916	0.0009	0.0009
LN(R0)	8.2780	0.0236	0.0029	8.2788	0.0232	0.0028
R1 offset	-0.8779	0.0331	-0.0377	-0.8774	0.0281	-0.0320
Biomass						
Unfished spawning biomass	62412.301	10610.3534	0.1700	18424.8048	416.6691	0.0226
Initial spawning biomass	12509.560	2375.2609	0.1899	5664.2866	228.0608	0.0403
Unfished spawning stock biomass	64135.898	1522.8569	0.0237	9809.3769	520.5841	0.0531
Unfished total biomass	67764.644	1594.5464	0.0235	18424.8048	416.6691	0.0226
Size selectivity						
Vertical line fleet						
Peak	86.027	1.4905	0.0173	85.9559	0.8567	0.0100
Top	-9	0		-9	0	0.0000
Ascending limb width	6.214	0.9023	0.1452	6.2587	0.0464	0.0074
Descending limb width	4.819	0.6158	0.1278	4.8164	0.6696	0.1390
Selectivity at first bin	-10.686	3.3269	-0.3113	-10.5744	3.1097	-0.2941
Selectivity at last bin	-0.153	0.2104	-1.3794	-0.1689	0.4006	-2.3725
Longline fleet						
Size at inflection	78.098	0.6197	0.0079	78.1068	0.6040	0.0077
Width for 95% selection	17.151	0.3935	0.0229	17.1838	0.4224	0.0246
Headboat fleet						
Peak	43.559	1.5290	0.0351	43.6407	0.8128	0.0186
Top	-9	0	-	-9	0	0.0000
Ascending limb width	4.955	1.1373	0.2295	5.0353	0.0936	0.0186
Descending limb width	7.598	0.0880	0.0116	7.5945	0.0675	0.0089
Selectivity at first bin	-999	0	-	-999	0	0.0000
Selectivity at last bin	-999	0	-	-999	0	0.0000

Table 3.1.3. Mean and standard deviation of parameter estimates from 400 bootstrap samples for Gulf of Mexico Gag Grouper. Selectivity was assumed to be logistic for the longline fleet and the SEAMAP video survey, all others were assumed double normal.

Model	**Male and Female biomass combined**			**Female biomass only**		
Parameter	**Mean**	**SD**	**CV**	**Mean**	**SD**	**CV**
Size selectivity						
Charterboat fleet						
Peak	48.3087	1.1071	0.0229	48.2429	1.5347	0.0318
Top	-9	0		-9.0000	0.0000	0.0000
Ascending limb width	4.8756	0.1771	0.0363	4.8256	1.0334	0.2142
Descending limb width	7.3898	0.0847	0.0115	7.3917	0.0940	0.0127
Selectivity at first bin	-999	0		-999	0	
Selectivity at last bin	-999	0		-999	0	
Private recreational						
Peak	38.8143	3.4680	0.0893	38.7411	4.1365	0.1068
Top	-2	0		-2	0	0.0000
Ascending limb width	5.6816	1.2000	0.2112	5.5849	2.1317	0.3817
Descending limb width	6.2246	0.9436	0.1516	6.2230	1.1693	0.1879
Selectivity at first bin	-999	0		-999	0	
Selectivity at last bin	-999	0		-999	0	
PC video survey						
Peak	32.6036	13.9488	0.4278	34.0871	17.4655	0.5124
Top	-1.0585	3.3698	-3.1834	-1.2595	3.4586	-2.7459
Ascending limb width	0.3602	5.7074	15.8445	0.2601	6.0238	23.1585
Descending limb width	-0.0739	4.9470	-66.9072	-0.6525	4.8422	-7.4205
Selectivity at first bin	-15	0		-15	0	
Selectivity at last bin	-15	0		-15	0	
SEAMAP video survey						
Size at inflection	79.7687	3.4623	0.0434	79.8795	4.0672	0.0509
Width for 95% selection	16.5492	2.0418	0.1234	16.6579	2.0898	0.1255

Table 3.2.1. Predicted total biomass (mt), mature biomass (SSB-combined) (mt), female spawning biomass (mt), proportion of age-3+ population that is male, and age-0 recruits (thousand fish), for Gulf of Mexico Gag Grouper from the base model run.

Year	Total biomass	SSB-combined	SSB-female	Proportion Male	Age-0 recruits
1963	11,228	9,999	4,552	0.208	667
1964	10,906	9,802	4,444	0.208	658
1965	10,281	9,382	4,232	0.207	655
1966	9,448	8,780	3,918	0.233	663
1967	8,678	8,091	3,468	0.258	686
1968	8,022	7,450	3,002	0.282	731
1969	7,294	6,721	2,508	0.301	815
1970	6,454	5,860	2,008	0.310	977
1971	5,702	5,053	1,607	0.304	1,325
1972	5,051	4,275	1,306	0.277	2,243
1973	4,599	3,518	1,109	0.225	3,706
1974	4,804	3,113	1,123	0.156	4,310
1975	5,352	2,889	1,319	0.084	2,205
1976	5,790	2,993	1,825	0.041	1,534
1977	6,290	3,842	2,894	0.026	1,451
1978	6,708	4,983	4,137	0.027	3,209
1979	7,150	5,566	4,739	0.034	2,292
1980	7,225	5,431	4,588	0.045	3,481
1981	7,391	5,179	4,264	0.045	5,343
1982	8,089	5,325	4,315	0.052	3,191
1983	8,321	5,210	4,147	0.052	3,324
1984	7,935	5,128	3,990	0.045	2,070
1985	8,451	5,960	4,738	0.049	4,494
1986	8,210	5,839	4,638	0.051	1,578
1987	7,803	5,653	4,461	0.060	2,149
1988	7,801	5,739	4,509	0.053	1,247
1989	7,287	5,833	4,498	0.073	4,949
1990	7,274	5,503	4,088	0.083	2,067
1991	7,284	5,069	3,615	0.102	2,074
1992	7,220	4,734	3,245	0.061	2,233
1993	7,319	5,253	3,789	0.066	6,720
1994	7,570	5,002	3,643	0.069	3,590
1995	8,028	4,732	3,446	0.069	2,789
1996	8,188	4,537	3,358	0.037	8,568
1997	9,485	5,627	4,513	0.036	4,794
1998	10,515	6,180	5,098	0.039	2,122
1999	10,553	6,051	5,060	0.024	6,400
2000	11,202	7,356	6,370	0.026	6,206
2001	11,271	7,426	6,430	0.036	4,674
2002	11,259	6,598	5,660	0.027	7,468
2003	11,672	6,754	5,862	0.024	4,654
2004	12,213	7,420	6,531	0.026	5,050
2005	11,890	7,177	6,322	0.021	3,533
2006	5,793	3,491	3,111	0.023	6,971
2007	6,250	3,150	2,804	0.023	9,120
2008	7,667	3,050	2,725	0.019	5,466
2009	8,525	3,026	2,741	0.011	4,844
2010	10,794	5,165	4,836	0.009	4,771
2011	13,259	8,524	8,083	0.011	834
2012	15,510	11,876	11,219	0.016	1,617

Table 3.2.2. Predicted female spawning biomass (mt), spawning biomass relative to unfished spawning biomass (mt), and spawning biomass relative to the reference spawning biomass ($SSB_{SPR30\%}$).

Year	SSB-female	SSB/SSB unfished	SSB/SSB(SPR30%)	SSB-combined	SSB/SSB unfished	SSB/SSB(SPR30%)
1963	4,552	0.23	0.76	9,999	0.14	0.47
1964	4,444	0.22	0.74	9,802	0.14	0.46
1965	4,232	0.21	0.70	9,382	0.13	0.44
1966	3,918	0.19	0.65	8,780	0.12	0.41
1967	3,468	0.17	0.58	8,091	0.11	0.38
1968	3,002	0.15	0.50	7,450	0.10	0.35
1969	2,508	0.12	0.42	6,721	0.09	0.32
1970	2,008	0.10	0.33	5,860	0.08	0.28
1971	1,607	0.08	0.27	5,053	0.07	0.24
1972	1,306	0.06	0.22	4,275	0.06	0.20
1973	1,109	0.06	0.18	3,518	0.05	0.17
1974	1,123	0.06	0.19	3,113	0.04	0.15
1975	1,319	0.07	0.22	2,889	0.04	0.14
1976	1,825	0.09	0.30	2,993	0.04	0.14
1977	2,894	0.14	0.48	3,842	0.05	0.18
1978	4,137	0.21	0.69	4,983	0.07	0.23
1979	4,739	0.24	0.79	5,566	0.08	0.26
1980	4,588	0.23	0.76	5,431	0.08	0.26
1981	4,264	0.21	0.71	5,179	0.07	0.24
1982	4,315	0.21	0.72	5,325	0.07	0.25
1983	4,147	0.21	0.69	5,210	0.07	0.24
1984	3,990	0.20	0.66	5,128	0.07	0.24
1985	4,738	0.24	0.79	5,960	0.08	0.28
1986	4,638	0.23	0.77	5,839	0.08	0.27
1987	4,461	0.22	0.74	5,653	0.08	0.27
1988	4,509	0.22	0.75	5,739	0.08	0.27
1989	4,498	0.22	0.75	5,833	0.08	0.27
1990	4,088	0.20	0.68	5,503	0.08	0.26
1991	3,615	0.18	0.60	5,069	0.07	0.24
1992	3,245	0.16	0.54	4,734	0.07	0.22
1993	3,789	0.19	0.63	5,253	0.07	0.25
1994	3,643	0.18	0.61	5,002	0.07	0.23
1995	3,446	0.17	0.57	4,732	0.07	0.22
1996	3,358	0.17	0.56	4,537	0.06	0.21
1997	4,513	0.22	0.75	5,627	0.08	0.26
1998	5,098	0.25	0.85	6,180	0.09	0.29
1999	5,060	0.25	0.84	6,051	0.09	0.28
2000	6,370	0.32	1.06	7,356	0.10	0.35
2001	6,430	0.32	1.07	7,426	0.10	0.35
2002	5,660	0.28	0.94	6,598	0.09	0.31
2003	5,862	0.29	0.97	6,754	0.10	0.32
2004	6,531	0.32	1.09	7,420	0.10	0.35
2005	6,322	0.31	1.05	7,177	0.10	0.34
2006	3,111	0.15	0.52	3,491	0.05	0.16
2007	2,804	0.14	0.47	3,150	0.04	0.15
2008	2,725	0.14	0.45	3,050	0.04	0.14
2009	2,741	0.14	0.46	3,026	0.04	0.14
2010	4,836	0.24	0.80	5,165	0.07	0.24
2011	8,083	0.40	1.34	8,524	0.12	0.40
2012	11,219	0.56	1.86	11,876	0.17	0.56

Table 3.2.3. Predicted fishing mortality rate, fishing mortality rate relative to the reference fishing mortality rate ($F_{SPR30\%}$), and spawning potential ratio.

	SSB-female			SSB-combined		
Year	F	F/FSPR30%	Equilibrium SPR	F	F/FSPR30%	Equilibrium SPR
1963	0.08	0.33	0.64	0.09	0.83	0.36
1964	0.11	0.41	0.58	0.11	1.04	0.29
1965	0.12	0.48	0.52	0.12	1.20	0.24
1966	0.12	0.46	0.49	0.12	1.16	0.23
1967	0.11	0.42	0.47	0.11	1.06	0.23
1968	0.12	0.48	0.41	0.12	1.20	0.19
1969	0.15	0.59	0.35	0.15	1.48	0.14
1970	0.17	0.64	0.32	0.17	1.61	0.12
1971	0.19	0.74	0.28	0.19	1.87	0.10
1972	0.24	0.91	0.25	0.24	2.29	0.09
1973	0.22	0.85	0.30	0.22	2.13	0.11
1974	0.26	1.00	0.31	0.26	2.51	0.10
1975	0.31	1.18	0.30	0.31	2.97	0.09
1976	0.24	0.93	0.36	0.24	2.34	0.12
1977	0.19	0.74	0.41	0.19	1.85	0.16
1978	0.19	0.72	0.40	0.19	1.80	0.19
1979	0.23	0.89	0.34	0.23	2.24	0.14
1980	0.25	0.97	0.32	0.25	2.45	0.13
1981	0.22	0.86	0.42	0.22	2.15	0.16
1982	0.30	1.14	0.32	0.30	2.88	0.11
1983	0.37	1.45	0.18	0.37	3.64	0.06
1984	0.20	0.76	0.44	0.20	1.92	0.17
1985	0.31	1.21	0.24	0.31	3.05	0.08
1986	0.30	1.14	0.24	0.30	2.87	0.09
1987	0.24	0.91	0.34	0.24	2.30	0.14
1988	0.25	0.97	0.23	0.25	2.45	0.09
1989	0.25	0.95	0.27	0.25	2.38	0.11
1990	0.24	0.91	0.36	0.24	2.30	0.13
1991	0.28	1.07	0.29	0.28	2.69	0.11
1992	0.23	0.90	0.36	0.23	2.26	0.13
1993	0.30	1.16	0.27	0.30	2.93	0.09
1994	0.29	1.10	0.29	0.29	2.77	0.10
1995	0.37	1.43	0.22	0.37	3.60	0.08
1996	0.26	0.99	0.34	0.26	2.49	0.12
1997	0.27	1.03	0.33	0.27	2.59	0.12
1998	0.37	1.45	0.25	0.37	3.64	0.08
1999	0.28	1.09	0.31	0.28	2.75	0.11
2000	0.33	1.27	0.25	0.33	3.19	0.09
2001	0.38	1.45	0.26	0.38	3.65	0.08
2002	0.36	1.40	0.25	0.36	3.53	0.08
2003	0.32	1.24	0.29	0.32	3.12	0.10
2004	0.40	1.55	0.22	0.40	3.91	0.07
2005*	0.91	3.51	0.01	0.91	8.84	0.00
2006	0.45	1.75	0.19	0.45	4.41	0.06
2007	0.44	1.69	0.21	0.44	4.25	0.07
2008	0.59	2.26	0.14	0.59	5.69	0.04
2009	0.22	0.85	0.42	0.22	2.14	0.16
2010	0.13	0.48	0.60	0.13	1.21	0.33
2011	0.07	0.26	0.75	0.07	0.64	0.56
2012	0.07	0.27	0.73	0.07	0.67	0.54

*Estimated *F* in 2005 includes red tide mortality

Table 3.2.4. Likelihood values for the various data components for each of the sensitivity runs.

				Fleet/Survey specific likelihood										
Run	Model	Data component	Total likelihood	1	2	3	4	5	6	7	8	9	10	11
1	BASE	Age_like:	1795.32	547.47	296.37	301.27	439.63	210.58	0.00	0.00	0.00	0.00	0.00	0.00
2	AddRT	Age_like:	1801.54	550.02	295.88	302.80	441.88	210.96	NA	0.00	0.00	0.00	0.00	0.00
3	NoRT	Age_like:	1800.42	548.76	295.32	303.37	441.22	211.75	0.00	0.00	0.00	0.00	0.00	0.00
4	1880	Age_like:	1781.45	542.01	293.97	299.88	435.42	210.17	0.00	0.00	0.00	0.00	0.00	0.00
5	1981	Age_like:	1786.85	545.91	295.01	299.45	436.03	210.46	0.00	0.00	0.00	0.00	0.00	0.00
6	MLOW	Age_like:	1785.94	547.99	293.08	297.88	435.28	211.70	0.00	0.00	0.00	0.00	0.00	0.00
7	MHIGH	Age_like:	1809.22	550.28	300.12	304.03	444.01	210.79	0.00	0.00	0.00	0.00	0.00	0.00
8	Discard	Age_like:	1793.45	546.93	296.99	301.31	438.02	210.21	0.00	0.00	0.00	0.00	0.00	0.00
9	LLDOME	Age_like:	1802.52	585.40	280.86	300.25	441.46	194.56	0.00	0.00	0.00	0.00	0.00	0.00
10	SL selex	Age_like:	1802.52	585.40	280.86	300.25	441.46	194.56	0.00	0.00	0.00	0.00	0.00	0.00
11	IFQ selex	Age_like:	1839.30	574.06	293.43	304.78	451.32	215.71	0.00	0.00	0.00	0.00	0.00	0.00
12	Steepness 0.7	Age_like:	2120.96	740.99	414.89	297.62	447.17	220.30	0.00	0.00	0.00	0.00	0.00	0.00
13	Steepness 0.85	Age_like:	1801.96	549.61	296.95	301.85	441.75	211.79	0.00	0.00	0.00	0.00	0.00	0.00
14	Comp 0.1	Age_like:	2218.46	739.89	370.49	341.62	526.35	240.11	0.00	0.00	0.00	0.00	0.00	0.00
15	Index UW	Age_like:	1808.27	534.71	316.47	302.14	445.13	209.82	0.00	0.00	0.00	0.00	0.00	0.00
1	BASE	Catch_like:	18.76	3.96	2.34	0.52	1.05	10.88	0.00	0.00	0.00	0.00	0.00	0.00
2	AddRT	Catch_like:	0.00	0.00	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00	0.00	0.00
3	NoRT	Catch_like:	31.70	5.55	2.68	0.58	1.80	21.09	0.00	0.00	0.00	0.00	0.00	0.00
4	1880	Catch_like:	15.87	2.54	2.06	0.50	1.01	9.76	0.00	0.00	0.00	0.00	0.00	0.00
5	1981	Catch_like:	16.73	2.70	2.28	0.52	1.01	10.22	0.00	0.00	0.00	0.00	0.00	0.00
6	MLOW	Catch_like:	23.99	4.11	2.92	0.57	1.27	15.11	0.00	0.00	0.00	0.00	0.00	0.00
7	MHIGH	Catch_like:	10.31	1.93	1.29	0.48	0.75	5.86	0.00	0.00	0.00	0.00	0.00	0.00
8	Discard	Catch_like:	19.26	4.07	2.33	0.52	1.05	11.29	0.00	0.00	0.00	0.00	0.00	0.00
9	LLDOME	Catch_like:	12.63	3.02	1.24	0.88	0.91	6.58	0.00	0.00	0.00	0.00	0.00	0.00
10	SL selex	Catch_like:	12.63	3.02	1.24	0.88	0.91	6.58	0.00	0.00	0.00	0.00	0.00	0.00
11	IFQ selex	Catch_like:	16.05	3.27	1.96	0.57	1.00	9.25	0.00	0.00	0.00	0.00	0.00	0.00
12	Steepness 0.7	Catch_like:	29.77	10.33	3.40	0.60	1.27	14.16	0.00	0.00	0.00	0.00	0.00	0.00
13	Steepness 0.85	Catch_like:	19.09	4.02	2.22	0.53	1.06	11.25	0.00	0.00	0.00	0.00	0.00	0.00
14	Comp 0.1	Catch_like:	4.54	0.69	0.13	0.31	0.49	2.92	0.00	0.00	0.00	0.00	0.00	0.00
15	Index UW	Catch_like:	29.91	9.36	3.44	0.54	1.58	14.99	0.00	0.00	0.00	0.00	0.00	0.00
1	BASE	Disc_like:	40.04	10.37	12.44	14.96	12.43	-10.17	0.00	0.00	0.00	0.00	0.00	0.00
2	AddRT	Disc_like:	43.20	11.09	12.64	15.94	13.41	-9.87	NA	0.00	0.00	0.00	0.00	0.00
3	NoRT	Disc_like:	42.77	10.75	11.75	16.93	12.86	-9.52	0.00	0.00	0.00	0.00	0.00	0.00
4	1880	Disc_like:	39.21	10.38	12.54	14.61	12.10	-10.41	0.00	0.00	0.00	0.00	0.00	0.00
5	1981	Disc_like:	39.38	10.16	12.61	14.97	12.17	-10.54	0.00	0.00	0.00	0.00	0.00	0.00
6	MLOW	Disc_like:	42.05	9.93	12.05	15.95	13.05	-8.93	0.00	0.00	0.00	0.00	0.00	0.00
7	MHIGH	Disc_like:	37.92	9.96	13.18	14.53	11.21	-10.96	0.00	0.00	0.00	0.00	0.00	0.00
8	Discard	Disc_like:	40.38	10.07	12.67	14.20	12.02	-8.57	0.00	0.00	0.00	0.00	0.00	0.00
9	LLDOME	Disc_like:	55.79	-1.30	4.95	42.47	15.03	-5.36	0.00	0.00	0.00	0.00	0.00	0.00
10	SL selex	Disc_like:	55.79	-1.30	4.95	42.47	15.03	-5.36	0.00	0.00	0.00	0.00	0.00	0.00
11	IFQ selex	Disc_like:	50.86	0.20	25.21	18.45	15.52	-8.52	0.00	0.00	0.00	0.00	0.00	0.00
12	Steepness 0.7	Disc_like:	45.18	1.38	15.98	20.53	14.96	-7.68	0.00	0.00	0.00	0.00	0.00	0.00
13	Steepness 0.85	Disc_like:	40.57	10.44	12.38	15.14	12.58	-9.97	0.00	0.00	0.00	0.00	0.00	0.00

14	Comp 0.1	Disc_like:	3.80	5.75	2.24	2.70	4.49	-11.38	0.00	0.00	0.00	0.00	0.00	0.00
15	Index UW	Disc_like:	38.97	11.12	11.07	13.97	12.51	-9.70	0.00	0.00	0.00	0.00	0.00	0.00
1	BASE	Length_like:	4782.07	816.13	527.23	1576.41	799.73	884.28	0.00	0.00	0.00	95.63	82.66	0.00
2	AddRT	Length_like:	4795.08	820.43	528.87	1580.38	801.05	885.61	NA	0.00	0.00	96.14	82.60	0.00
3	NoRT	Length_like:	4782.99	810.29	525.57	1580.56	799.93	889.27	0.00	0.00	0.00	95.07	82.30	0.00
4	1880	Length_like:	4771.52	815.13	523.59	1573.07	798.02	884.87	0.00	0.00	0.00	93.87	82.98	0.00
5	1981	Length_like:	4771.61	811.27	525.54	1573.84	798.74	885.07	0.00	0.00	0.00	94.08	83.07	0.00
6	MLOW	Length_like:	4778.76	804.45	526.84	1580.59	802.64	887.73	0.00	0.00	0.00	93.68	82.83	0.00
7	MHIGH	Length_like:	4763.96	815.71	528.96	1565.39	793.18	881.46	0.00	0.00	0.00	95.50	83.76	0.00
8	Discard	Length_like:	4775.87	816.28	528.26	1572.89	798.11	881.66	0.00	0.00	0.00	95.56	83.11	0.00
9	LLDOME	Length_like:	4763.62	836.05	417.25	1557.56	847.57	927.47	0.00	0.00	0.00	97.39	80.33	0.00
10	SL selex	Length_like:	4763.62	836.05	417.25	1557.56	847.57	927.47	0.00	0.00	0.00	97.39	80.33	0.00
11	IFQ selex	Length_like:	4800.58	823.10	535.95	1573.83	801.20	886.79	0.00	0.00	0.00	97.90	81.81	0.00
12	Steepness 0.7	Length_like:	4978.90	966.81	538.19	1583.23	812.39	897.38	0.00	0.00	0.00	96.43	84.47	0.00
13	Steepness 0.85	Length_like:	4783.79	816.86	526.08	1577.76	800.39	884.07	0.00	0.00	0.00	96.14	82.48	0.00
14	Comp 0.1	Length_like:	5206.15	839.62	787.47	1647.47	835.67	922.03	0.00	0.00	0.00	98.46	75.44	0.00
15	Index UW	Length_like:	4823.83	833.13	515.01	1594.76	796.10	887.31	0.00	0.00	0.00	115.34	82.19	0.00
1	BASE	Surv_like:	61.50	20.43	22.39	17.77	0.00	0.00	-59.87	-7.64	25.85	8.41	21.91	12.25
2	AddRT	Surv_like:	125.05	21.84	23.95	17.91	0.00	0.00	NA	-5.11	27.95	8.62	23.00	6.90
3	NoRT	Surv_like:	124.92	33.16	29.20	35.85	0.00	0.00	-59.87	2.63	42.16	10.49	18.38	12.93
4	1880	Surv_like:	58.76	17.67	19.96	14.62	0.00	0.00	-59.87	-4.79	21.75	10.07	23.99	15.35
5	1981	Surv_like:	60.29	19.05	21.17	16.52	0.00	0.00	-59.87	-6.21	23.74	9.15	22.97	13.77
6	MLOW	Surv_like:	72.27	19.62	22.27	24.67	0.00	0.00	-59.87	-5.16	31.39	7.45	21.41	10.50
7	MHIGH	Surv_like:	46.67	22.53	21.85	7.73	0.00	0.00	-59.87	-10.39	18.97	9.86	21.45	14.54
8	Discard	Surv_like:	59.46	21.04	22.91	19.23	0.00	0.00	-59.87	-8.54	26.62	7.29	19.92	10.86
9	LLDOME	Surv_like:	27.65	14.11	13.78	4.27	0.00	0.00	-59.87	-20.17	30.57	17.49	19.74	7.73
10	SL selex	Surv_like:	27.65	14.11	13.78	4.27	0.00	0.00	-59.87	-20.17	30.57	17.49	19.74	7.73
11	IFQ selex	Surv_like:	52.66	20.33	20.95	10.52	0.00	0.00	-59.87	-13.28	33.11	11.03	19.40	10.46
12	Steepness 0.7	Surv_like:	78.34	33.67	23.28	18.87	0.00	0.00	-59.87	-9.94	40.80	6.49	17.61	7.43
13	Steepness 0.85	Surv_like:	61.71	21.18	22.87	17.76	0.00	0.00	-59.87	-8.39	27.05	8.22	21.34	11.55
14	Comp 0.1	Surv_like:	2.07	17.96	14.23	-7.74	0.00	0.00	-59.87	-18.80	18.02	11.43	17.93	8.91
15	Index UW	Surv_like:	88.10	3.29	6.33	32.99	0.00	0.00	-59.87	-1.46	29.95	0.77	22.31	12.17

Table 3.2.5. Summary of SS results from sensitivity runs for Gulf of Mexico Gag Grouper. Results include estimated virgin recruitment (thousand fish; R0), virgin total biomass (mt; B0), total biomass in final year (mt; $B_{Current}$), virgin spawning biomass (mt; SSB0), and spawning biomass in final year (mt; SSB-2012) for both SSB-female and SSB-combined models.

Run	Model	R0	B0	SSB0 female	SSB-2012 female	R0	B0	SSB0 combined	SSB-2012 combined
1	Central	4,291	75,137	20,135	11,219	4,284	74,956	71,015	11,876
2	Fixed MRT = 0.7	4,338	74,292	20,317	11,549	4,331	74,123	70,141	12,234
3	No red tide	3,750	65,813	17,639	9,652	3,744	65,675	62,231	10,243
4	Start 1880	5,484	100,518	25,961	12,217	4,447	78,368	74,281	12,464
5	Start 1981	4,409	80,090	20,789	11,630	4,409	80,022	75,945	12,294
6	M Low	2,632	118,050	21,215	9,466	2,631	117,877	114,655	10,013
7	M High	11,436	49,127	19,574	15,378	11,371	48,812	42,611	16,304
8	2009 discard mortality	4,542	79,395	21,294	10,625	4,534	79,202	75,050	11,251
9	Longline selectivity	5,013	101,699	24,537	15,142	4,993	101,279	96,662	18,322
10	Time-varying selectivity	4,545	78,717	21,268	13,155	4,605	78,840	74,600	14,068
11	IFQ selectivity	4,319	71,580	20,206	12,367	4,272	74,281	70,350	12,264
12	Steepness fixed 0.7	6,328	114,119	29,465	10,451	11,256	167,078	156,727	12,595
13	Steepness fixed 0.85	5,009	86,518	23,416	11,126	6,888	109,246	102,947	11,826
14	Composition down-weighted	4,903	71,783	22,323	15,178	4,676	68,557	64,222	16,059
15	Adult indices up-weighted	4,502	80,595	21,301	11,230	4,513	82,151	78,009	8,183
16	2% increasing catchability	3,963	69,559	18,590	8,596	3,957	69,405	65,759	9,083
17	No headboat index	4,121	71,101	19,202	9,138	4,082	71,967	68,223	9,157

Table 3.2.6. Reference points and benchmarks from sensitivity runs for Gulf of Mexico Gag Grouper. Reference points and benchmark are calculated using SSB female biomass. Benchmarks are reported for SPR 30%. *Current* refers to the geometric mean of 2010-2012 for F. MSST = $(1-M)*SSB_{SPR30\%}$ with $M = 0.1342\ y^{-1}$ for all models except runs 6 ($M = 0.10\ y^{-1}$) and 7 ($M = 0.20\ y^{-1}$).

Run	Model	$F_{Current}$	$F_{SPR30\%}$	F/MFMT	SSB_{2012}	$SSB_{SPR30\%}$	MSST	$SSB/SSB_{SPR30\%}$	SSB/MSST
1	Central	0.08	0.26	0.32	11,219	6,016	5,209	1.86	2.15
2	Fixed MRT = 0.7	0.08	0.26	0.30	11,549	6,071	5,256	1.90	2.20
3	No red tide	0.10	0.26	0.37	9,652	5,268	4,561	1.83	2.12
4	Start 1880	0.08	0.26	0.29	12,217	6,965	6,031	1.75	2.03
5	Start 1981	0.08	0.26	0.31	11,630	6,217	5,382	1.87	2.16
6	M Low	0.10	0.22	0.47	9,466	6,353	5,718	1.49	1.66
7	M High	0.05	0.32	0.17	15,378	5,758	4,606	2.67	3.34
8	2009 discard mortality	0.12	0.22	0.53	10,625	6,365	5,511	1.67	1.93
9	Longline selectivity	0.05	0.17	0.32	15,142	7,252	6,279	2.09	2.41
10	Time-varying selectivity	0.07	0.25	0.27	13,155	6,355	5,502	2.07	2.39
11	IFQ selectivity	0.08	0.24	0.31	12,367	6,036	5,226	2.05	2.37
12	Steepness fixed 0.7	0.09	0.29	0.31	10,451	6,364	5,510	1.64	1.90
13	Steepness fixed 0.85	0.08	0.26	0.32	11,126	6,268	5,427	1.77	2.05
14	Composition data down-weighted	0.06	0.22	0.25	15,178	6,622	5,733	2.29	2.65
15	Adult indices up-weighted	0.08	0.25	0.33	11,230	6,366	5,511	1.76	2.04
16	2% increasing catchability	0.11	0.26	0.42	8,596	5,553	4,808	1.55	1.79
17	No headboat index	0.10	0.26	0.38	9,138	5,737	4,967	1.59	1.84

Table 3.2.7. Reference points and benchmarks from sensitivity runs for Gulf of Mexico Gag Grouper. Reference points and benchmark are calculated using SSB combined biomass. Benchmarks are reported for SPR 30%. *Current* refers to the geometric mean of 2010-2012 for F. MSST = $(1-M)*SSB_{SPR30\%}$ with $M = 0.1342\ y^{-1}$ for all models except runs 6 ($M = 0.10\ y^{-1}$) and 7 ($M = 0.20\ y^{-1}$).

Run	Model	$F_{Current}$	$F_{SPR30\%}$	F/MFMT	SSB_{2012}	$SSB_{SPR30\%}$	MSST	$SSB/SSB_{SPR30\%}$	SSB/MSST
1	Central	0.08	0.10	0.81	11,876	21,286	18,429	0.56	0.64
2	Fixed MRT = 0.7	0.08	0.11	0.75	12,234	21,024	18,202	0.58	0.67
3	No red tide	0.10	0.10	0.93	10,243	18,650	16,147	0.55	0.63
4	Start 1880	0.08	0.10	0.77	12,464	22,249	19,264	0.56	0.65
5	Start 1981	0.07	0.10	0.73	13,639	25,961	22,477	0.53	0.61
6	M Low	0.10	0.07	1.45	10,013	34,386	30,947	0.29	0.32
7	M High	0.05	0.17	0.33	16,304	12,702	10,161	1.28	1.60
8	2009 discard mortality	0.12	0.10	1.21	11,251	22,497	19,478	0.50	0.58
9	Longline selectivity	0.05	0.08	0.69	18,322	28,806	24,940	0.64	0.73
10	Time-varying selectivity	0.07	0.10	0.65	14,068	22,361	19,360	0.63	0.73
11	IFQ selectivity	0.08	0.11	0.75	12,192	21,092	18,261	0.58	0.67
12	Steepness fixed 0.7	0.08	0.11	0.69	12,595	33,853	29,310	0.37	0.43
13	Steepness fixed 0.85	0.08	0.11	0.76	11,826	27,558	23,860	0.43	0.50
14	Composition data down-weighted	0.07	0.11	0.64	13,918	18,898	16,362	0.74	0.85
15	Adult indices up-weighted	0.32	0.07	4.25	8,183	23,386	20,247	0.35	0.40
16	2% increasing catchability	0.11	0.10	1.06	9,083	19,709	17,064	0.46	0.53
17	No headboat index	0.11	0.10	1.01	9,157	20,449	17,704	0.45	0.52

Table 3.2.8. Required SFA and MSRA evaluations using SPR 30% reference point for Gulf of Mexico Gag Grouper. Biomass and yield units are in metric tons (mt).

Criteria	Definition	Run 1 - SSB Female	Run 1 - SSB Combined
Base M		0.134	0.134
Steepness		0.99	0.99
Virgin Recruitment		4,291	4,284
SSB unfished		20,135	71,015
	Mortality Rate Criteria		
$F_{MSY\ or\ proxy}$	$F_{SPR30\%}$	0.259	0.103
$F_{MSY\ or\ proxy}$	F_{MAX}	0.196	0.197
MFMT	$F_{SPR30\%}$	0.259	0.103
F_{OY}	75% of $F_{SPR30\%}$	0.194	0.077
$F_{CURRENT}$	$F_{2010\text{-}F2012}$	0.083	0.083
$F_{CURRENT}$/MFMT	$F_{2010\text{-}F2012}$	0.320	0.806
	Biomass Criteria		
$SSB_{MSY\ or\ proxy}$	Equilibrium SSB @ $F_{SPR30\%}$	6,016	21,286
$SSB_{MSY\ or\ proxy}$	Equilibrium SSB @ F_{MAX}	7,491	11,210
MSST	(1-M)*$SSB_{SPR30\%}$	5,209	18,429
$SSB_{CURRENT}$	SSB_{2012}	11,219	11,876
$SS_{CURRENT}$/MSST	SSB_{2012}	2.154	0.644
Equilibrium MSY	Equilibrium Yield @ $F_{SPR30\%}$	2,088	2,101
Equilibrium MSY	Equilibrium Yield @ F_{MAX}	2,160	2,158
Equilibrium OY	Equilibrium Yield @ F_{OY}	2,170	1,948
OFL	Annual Yield @ MFMT		
	OFL 2014	3,353	1,945
	OFL 2015	2,674	1,783
	OFL 2016	2,308	1,696
	OFL 2017	2,193	1,703
	OFL 2018	2,158	1,742
	OFL 2019	2,144	1,787
	OFL 2020	2,137	1,833
Annual OY (ACT)	Annual Yield @ F_{OY}		
	OY 2014	2,791	1,532
	OY 2015	2,374	1,448
	OY 2016	2,140	1,409
	OY 2017	2,082	1,436
	OY 2018	2,080	1,485
	OY 2019	2,094	1,538
	OY 2020	2,111	1,591
Annual Yield	Annual Yield @ $F_{CURRENT}$		
	Y 2014	1,333	1,332
	Y 2015	1,277	1,276
	Y 2016	1,256	1,255
	Y 2017	1,290	1,288
	Y 2018	1,341	1,339
	Y 2019	1,396	1,394
	Y 2020	1,450	1,448

Table 3.2.9. Required SFA and MSRA evaluations using SPR 30% reference point for Gulf of Mexico Gag Grouper. Biomass and yield units are in metric tons (mt).

Criteria	Definition	Run 12 - SSB Female	Run 12 - SSB Combined
Base M		0.134	0.134
Steepness		0.70	0.70
Virgin Recruitment		6,328	11,256
SSB unfished		29,465	156,727
	Mortality Rate Criteria		
$F_{MSY\ or\ proxy}$	$F_{SPR30\%}$	0.290	0.109
$F_{MSY\ or\ proxy}$	F_{MAX}	0.128	0.085
MFMT	$F_{SPR30\%}$	0.290	0.109
F_{OY}	75% of $F_{SPR30\%}$	0.218	0.082
$F_{CURRENT}$	$F_{2010\text{-}F2012}$	0.090	0.076
$F_{CURRENT}$/MFMT	$F_{2010\text{-}F2012}$	0.309	0.695
	Biomass Criteria		
$SSB_{MSY\ or\ proxy}$	Equilibrium SSB @ $F_{SPR30\%}$	6,364	33,853
$SSB_{MSY\ or\ proxy}$	Equilibrium SSB @ F_{MAX}	14,512	45,012
MSST	(1-M)*$SSB_{SPR30\%}$	5,510	29,310
$SSB_{CURRENT}$	SSB_{2012}	10,451	12,595
$SS_{CURRENT}$/MSST	SSB_{2012}	1.897	0.430
Equilibrium MSY	Equilibrium Yield @ $F_{SPR30\%}$	2,305	3,487
Equilibrium MSY	Equilibrium Yield @ F_{MAX}	3,118	3,623
Equilibrium OY	Equilibrium Yield @ F_{OY}	2,170	
OFL	Annual Yield @ MFMT		
	OFL 2014	3,014	1,753
	OFL 2015	2,453	1,462
	OFL 2016	2,262	1,393
	OFL 2017	2,327	1,514
	OFL 2018	2,394	1,662
	OFL 2019	2,395	1,782
	OFL 2020	2,356	1,877
Annual OY (ACT)	Annual Yield @ F_{OY}		
	OY 2014	2,791	1,388
	OY 2015	2,374	1,197
	OY 2016	2,140	1,161
	OY 2017	2,082	1,274
	OY 2018	2,080	1,420
	OY 2019	2,094	1,551
	OY 2020	2,111	1,664
Annual Yield	Annual Yield @ $F_{CURRENT}$		
	Y 2014	1,316	1,045
	Y 2015	1,290	926
	Y 2016	1,350	913
	Y 2017	1,501	1,011
	Y 2018	1,669	1,141
	Y 2019	1,817	1,265
	Y 2020	1,942	1,379

3.7 Figures

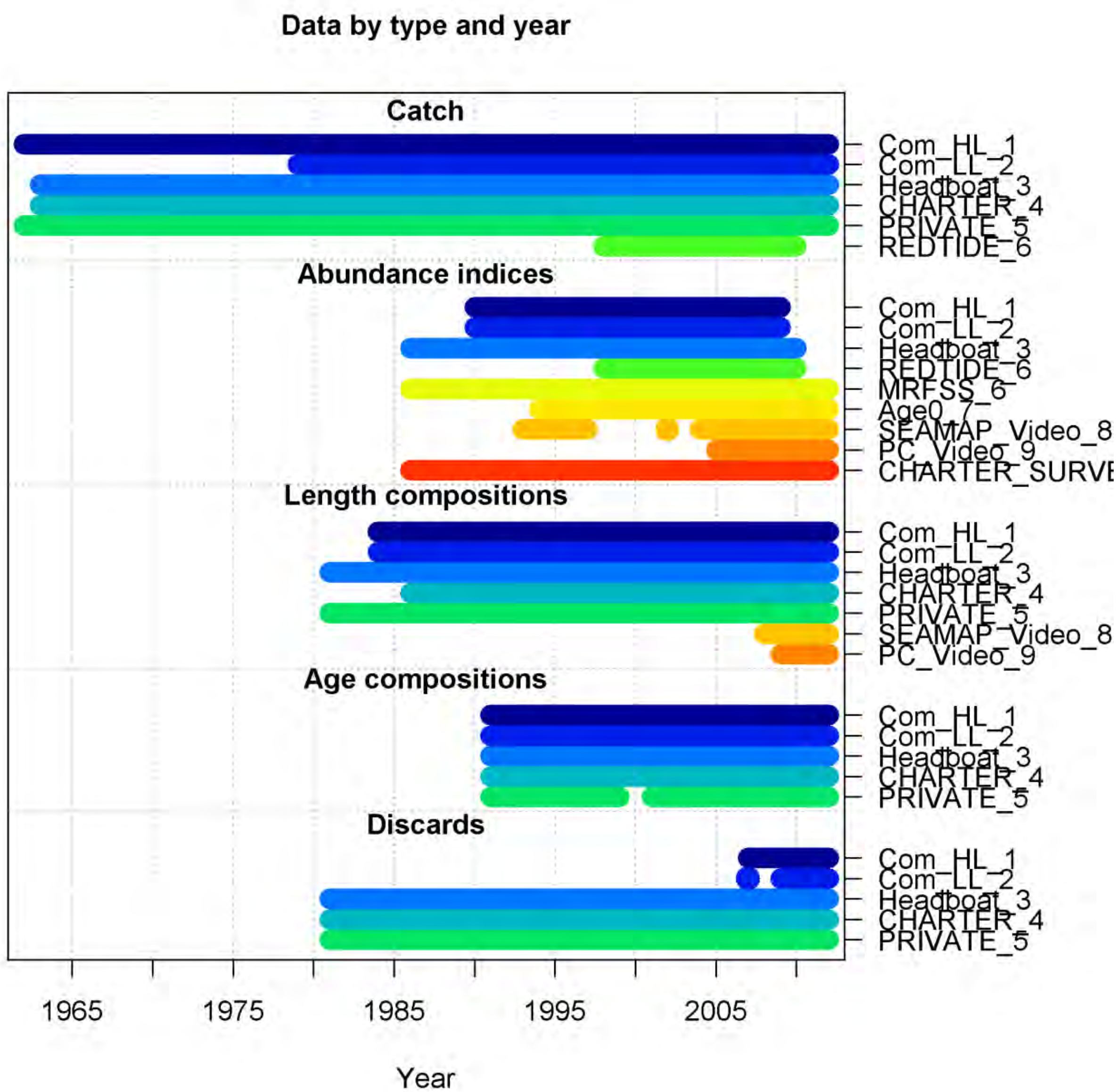


Figure 3.1.1. Data sources used in the assessment model.

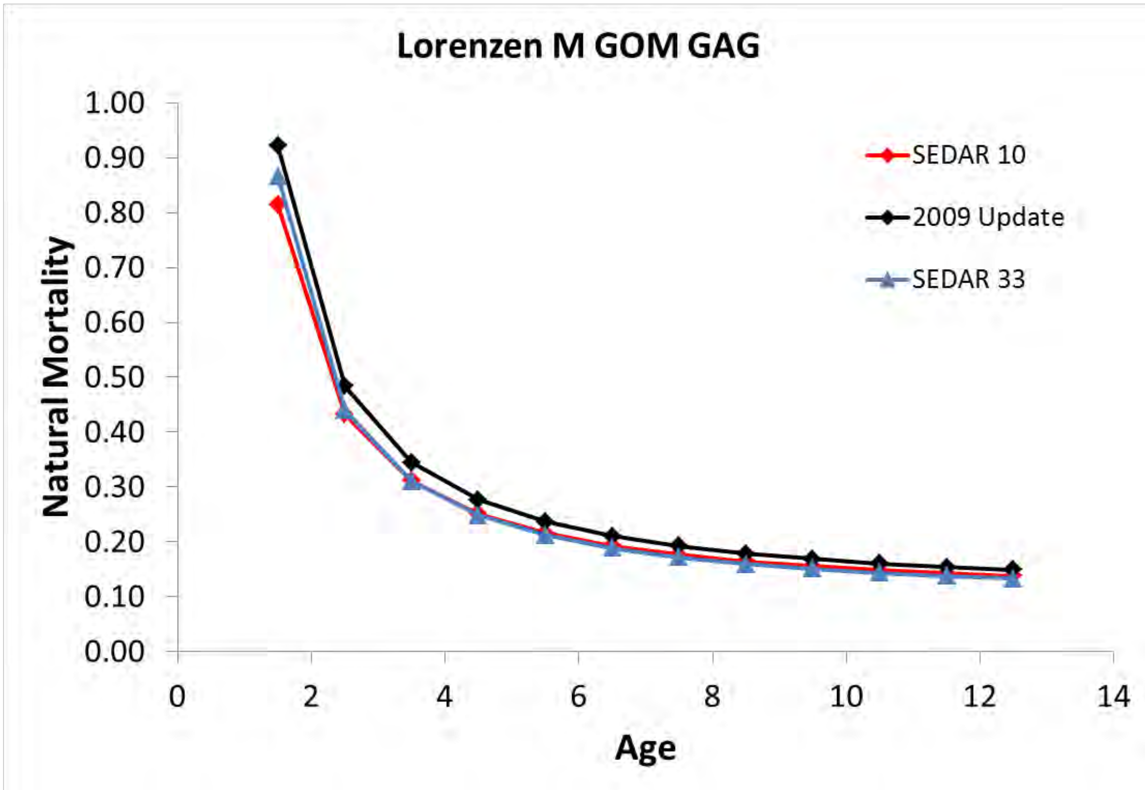


Figure 3.1.2. Lorenzen natural mortality as a function of age for Gag Grouper.

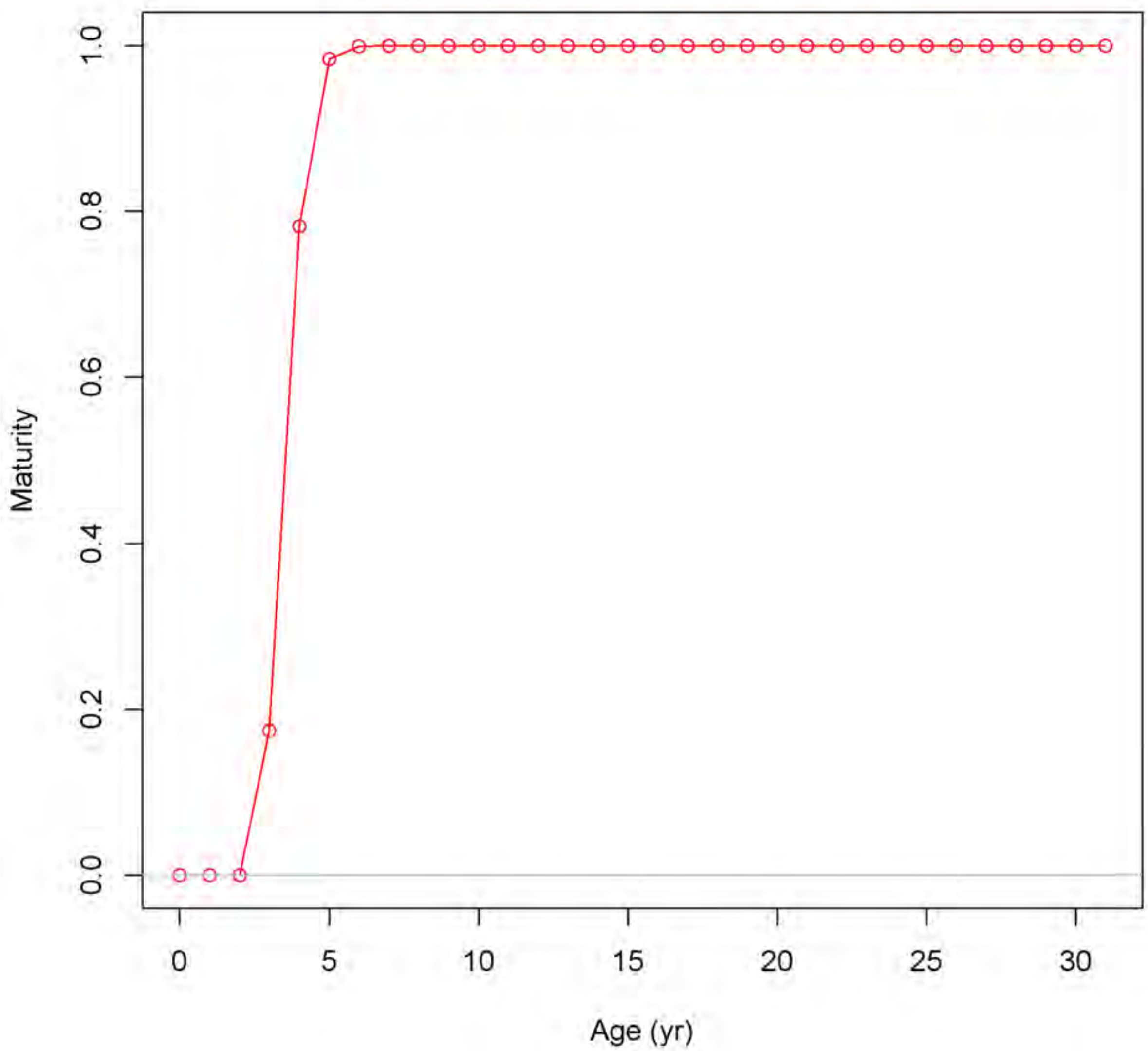


Figure 3.1.3. Female maturity as a function of age for Gag Grouper.

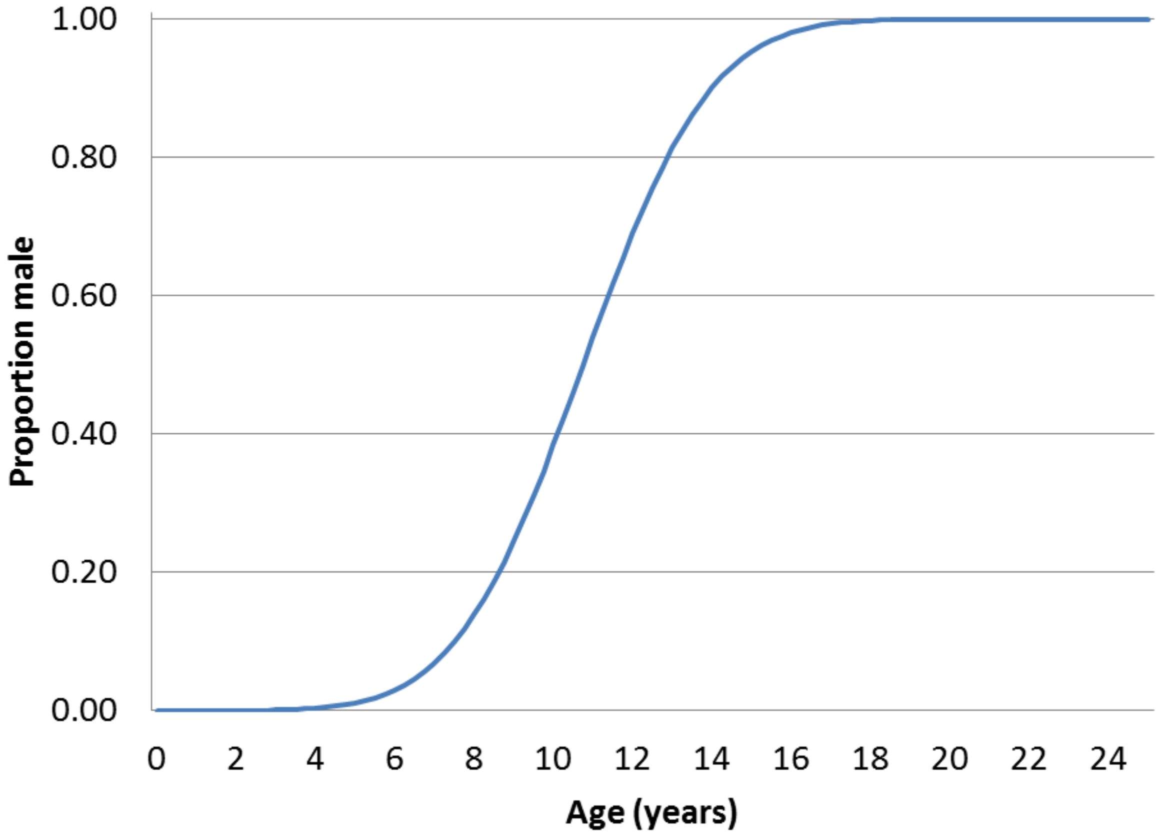


Figure 3.1.4. Sexual transition from female to male as a function of age for Gag Grouper.

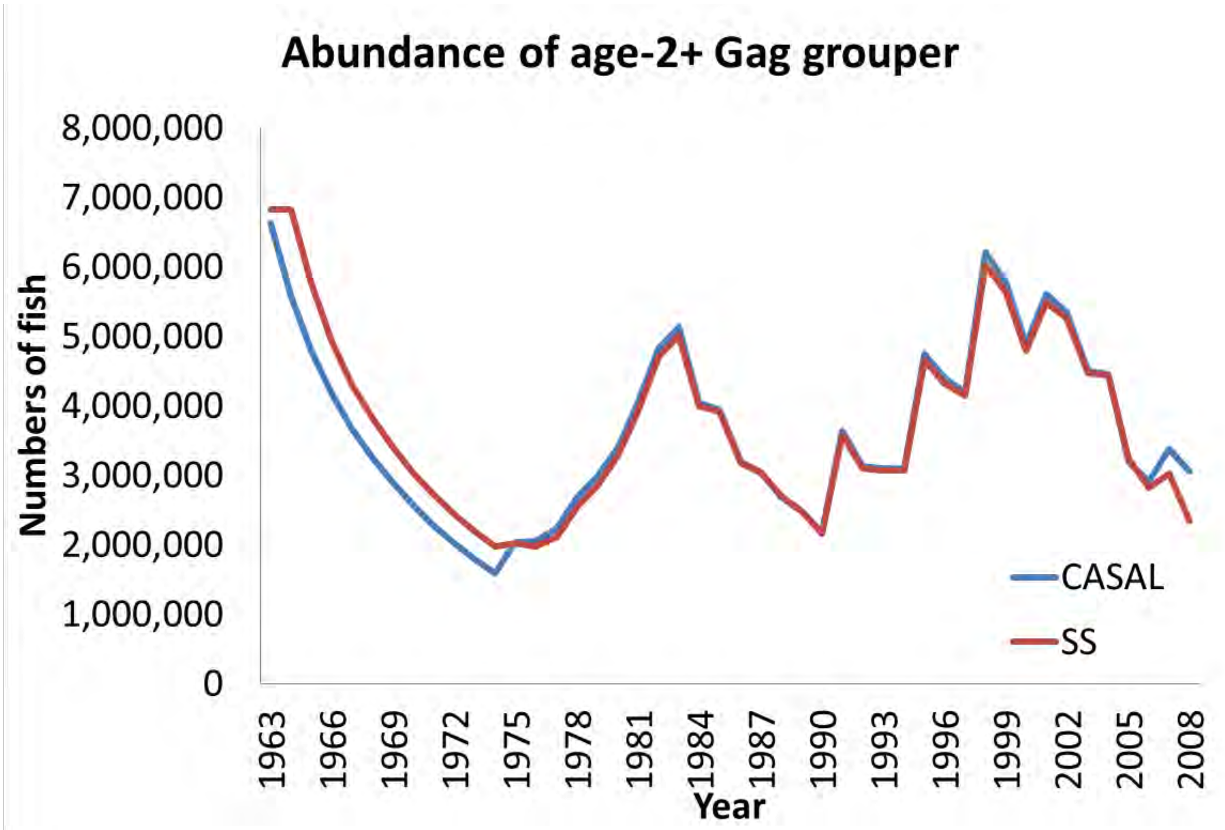


Figure 3.1.5. Predicted numbers of age-2+ Gag Grouper from the 2009 Central model run using CASAL (blue line) and from Stock Synthesis (red line) using similar model configuration and fixed parameters from CASAL.

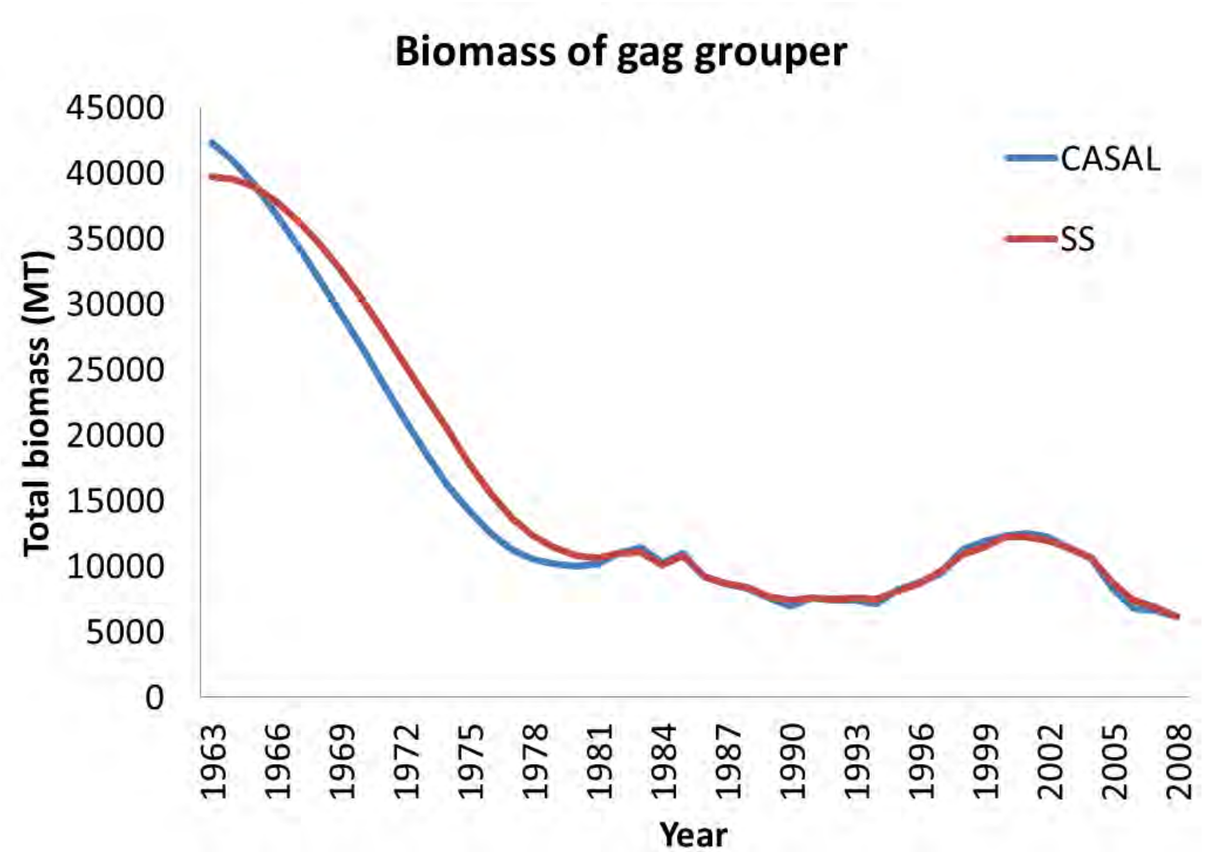


Figure 3.1.6. Predicted total biomass of Gag Grouper from the 2009 Central model run using CASAL (blue line) and from Stock Synthesis (red line) using similar model configuration and fixed parameters from CASAL.

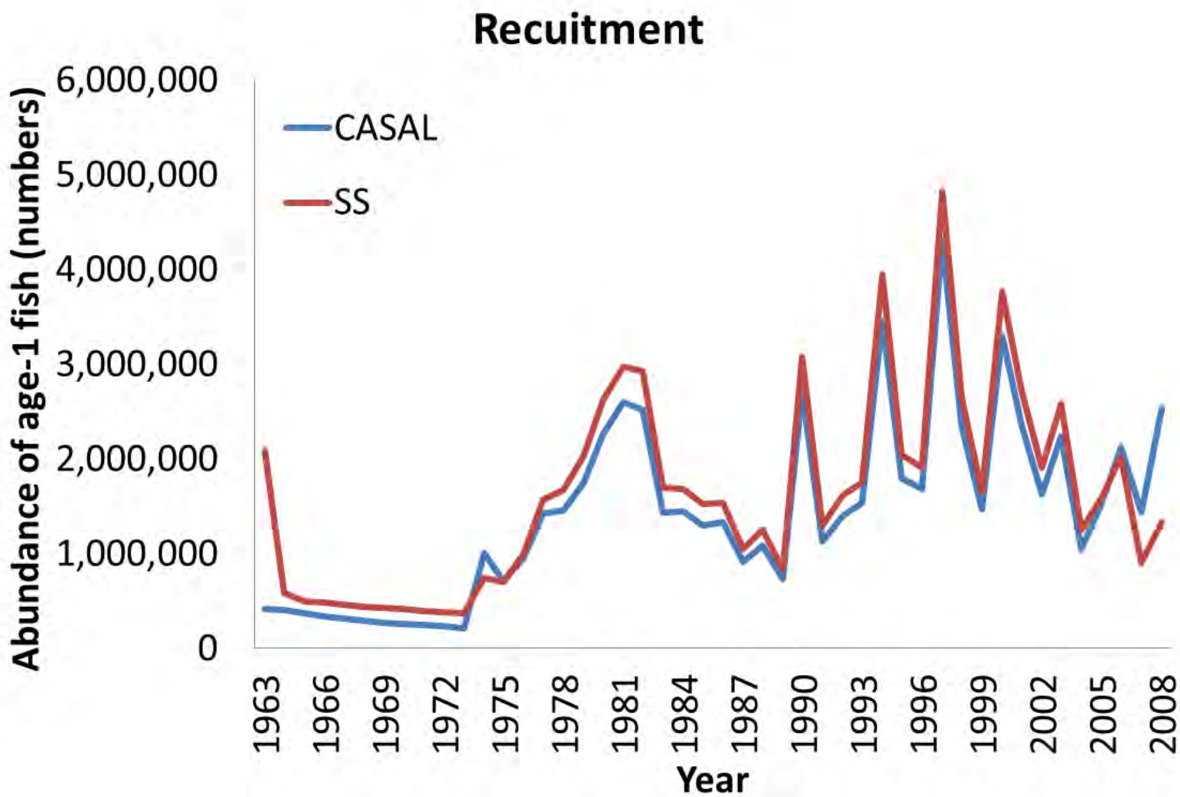


Figure 3.1.7. Predicted recruitment of Gag Grouper from the 2009 Central model run using CASAL (blue line) and from Stock Synthesis (red line) using similar model configuration and fixed parameters from CASAL.

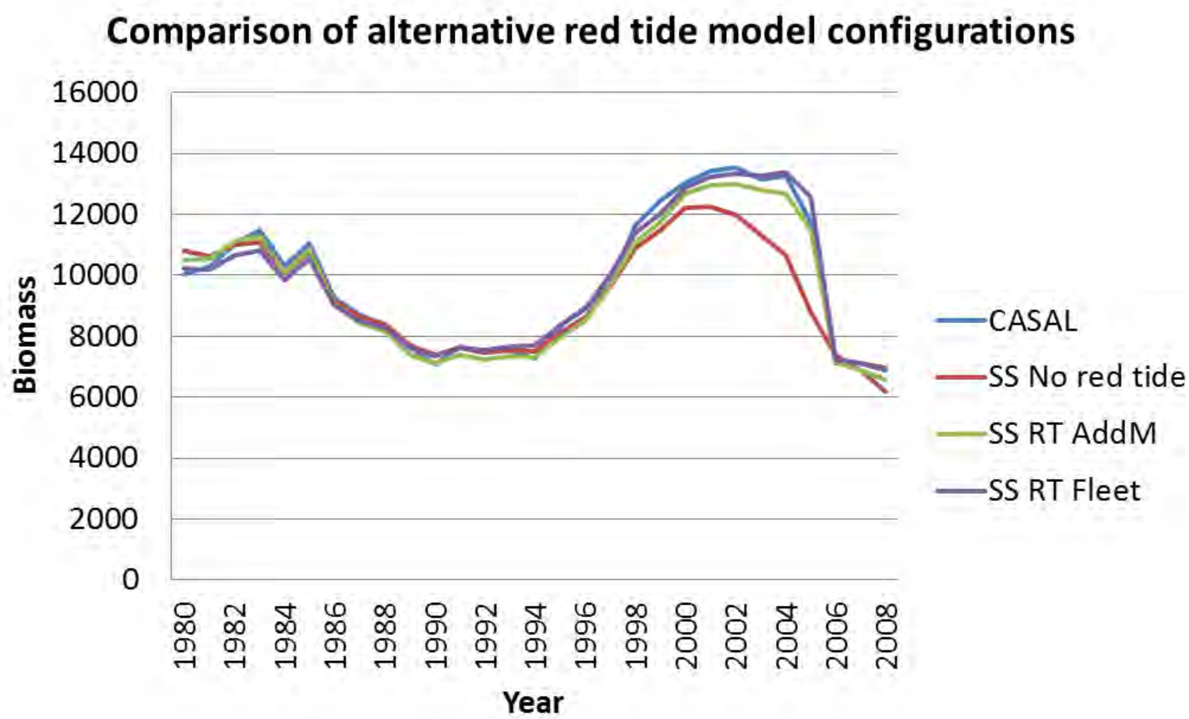


Figure 3.1.8. Comparison of predicted biomass from the 2009 CASAL assessment model with red tide (blue line) and alternative configurations of SS model: no red tide (red line), adding constant M at age (green line), and adding a red tide fishing fleet (purple line).

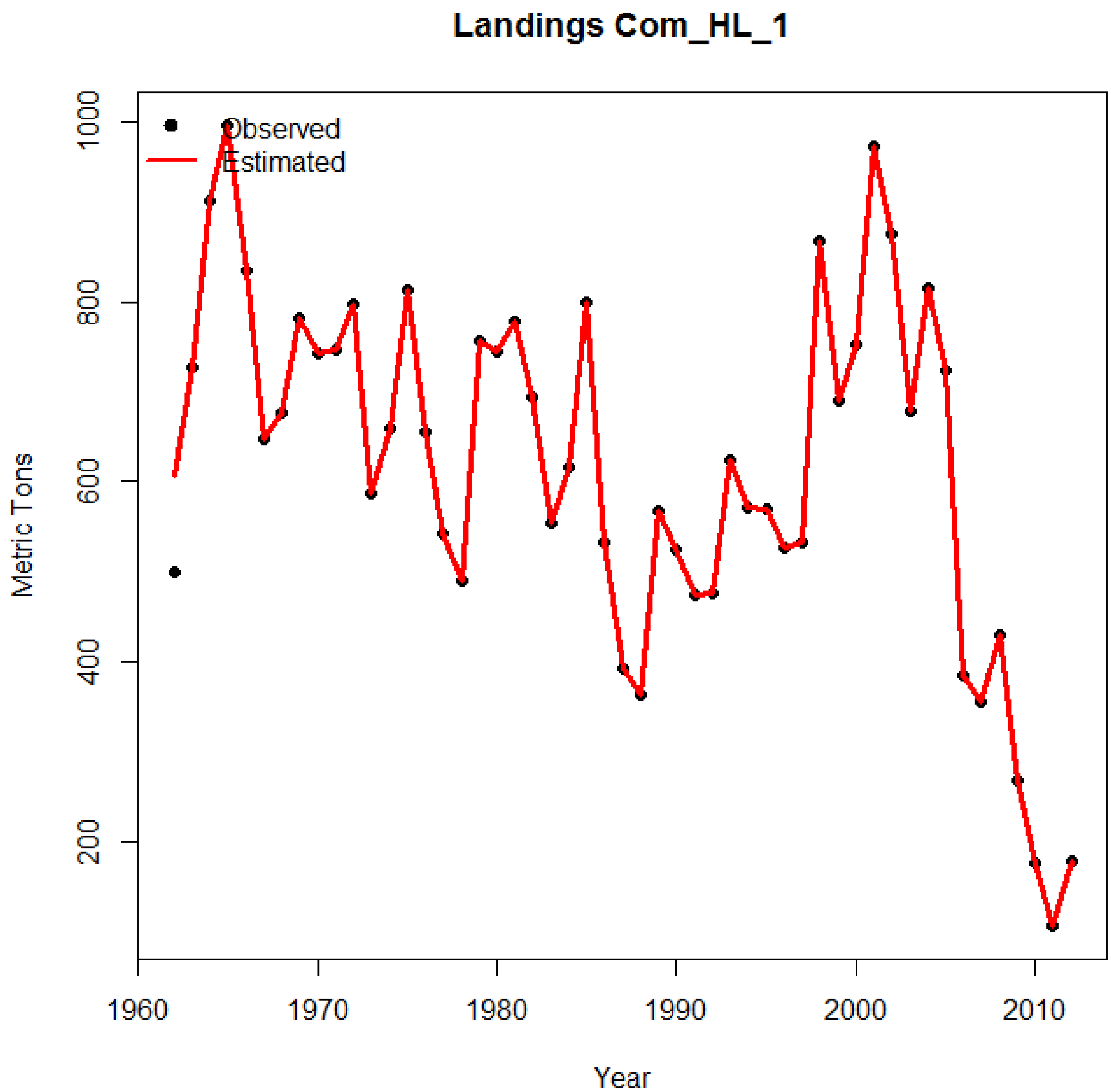


Figure 3.2.1. Observed (black dots) and predicted landings (red line) (mt) of Gulf of Mexico Gag Grouper from the commercial vertical line fishing fleet, 1963-2012.

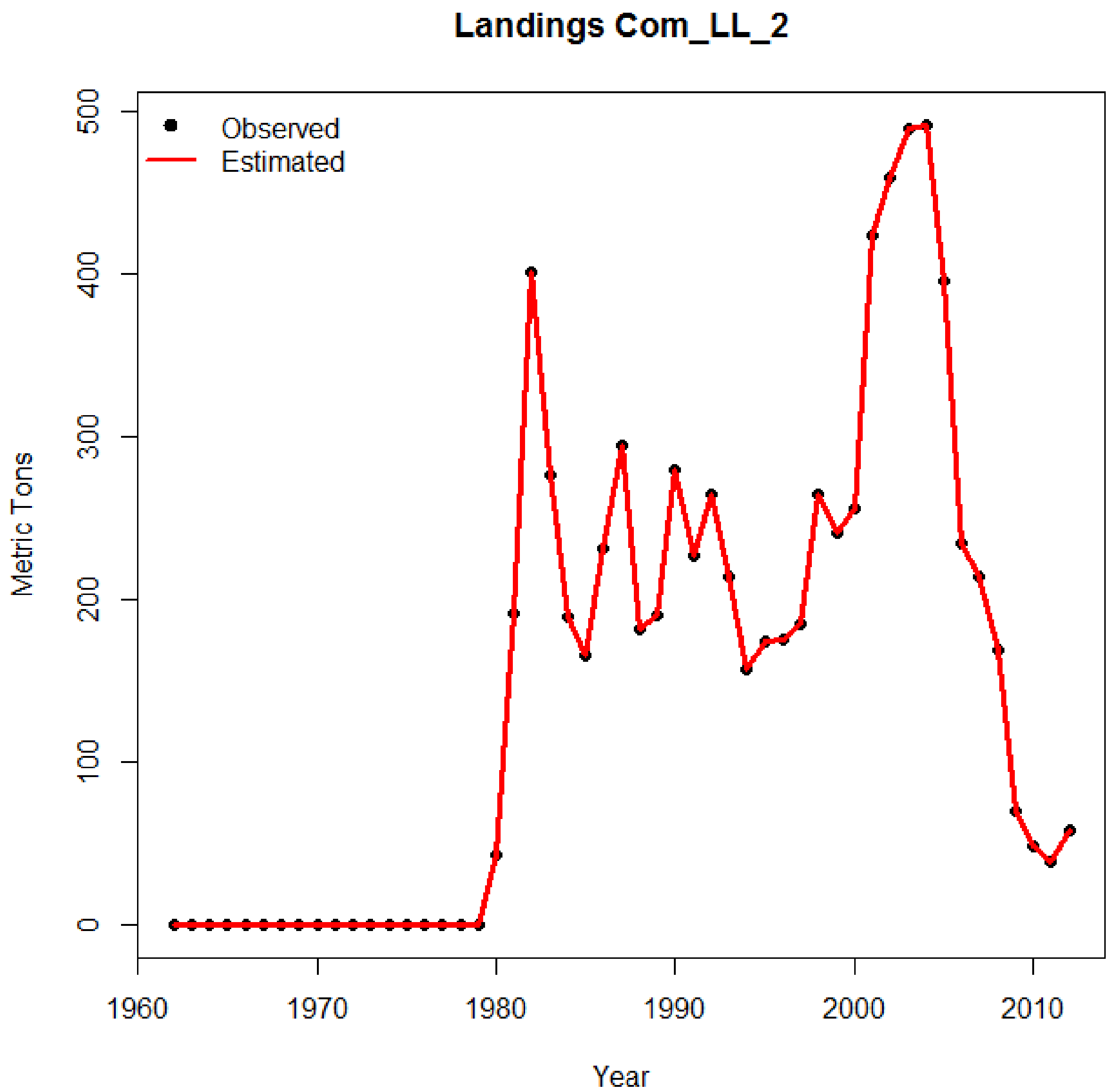


Figure 3.2.2. Observed (black dots) and predicted landings (red line) (mt) of Gulf of Mexico Gag Grouper from the commercial longline fishing fleet, 1979-2012.

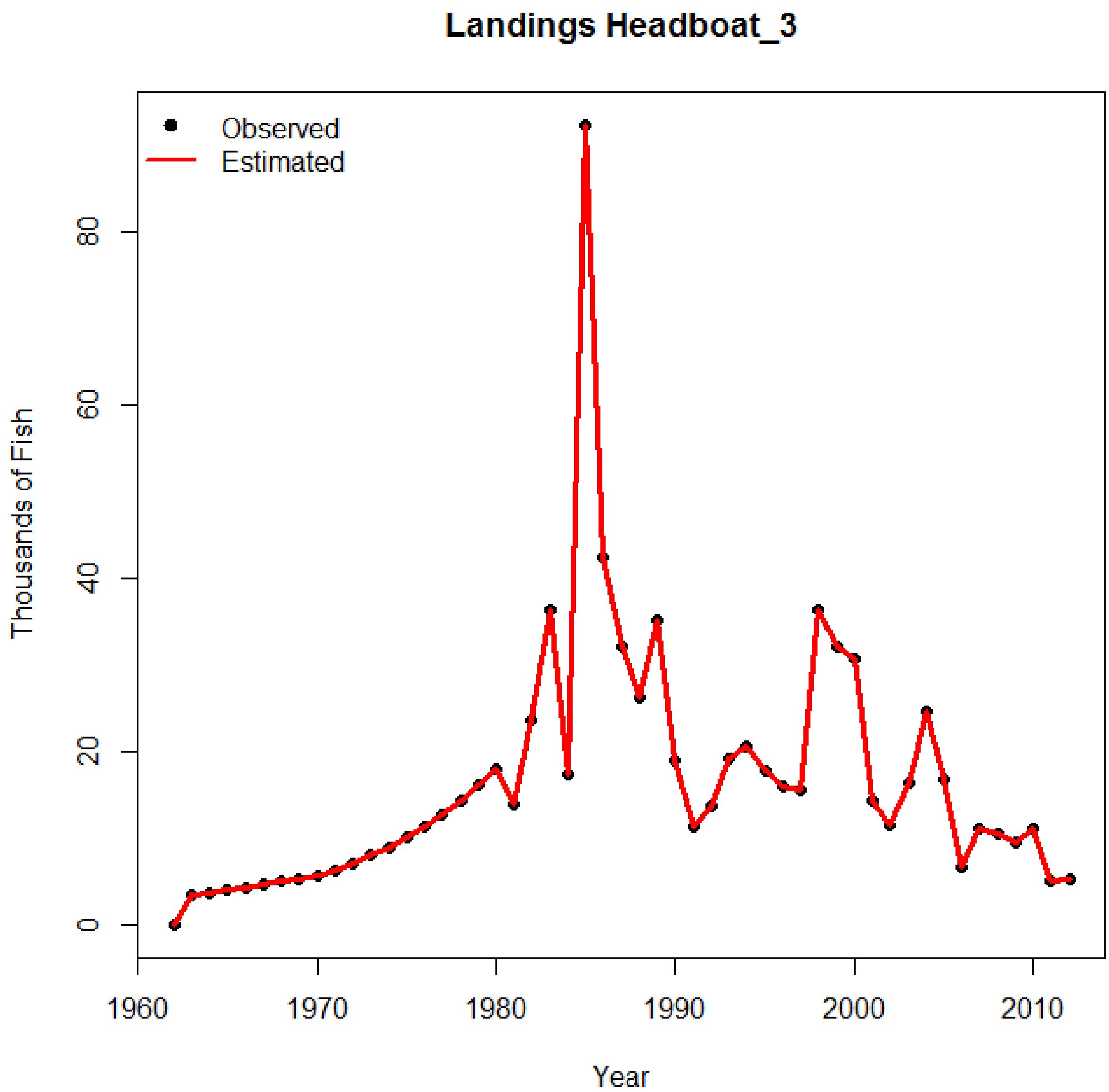


Figure 3.2.3. Observed (black dots) and predicted landings (red line) (mt) of Gulf of Mexico Gag Grouper from the recreational headboat fishing fleet, 1963-2012.

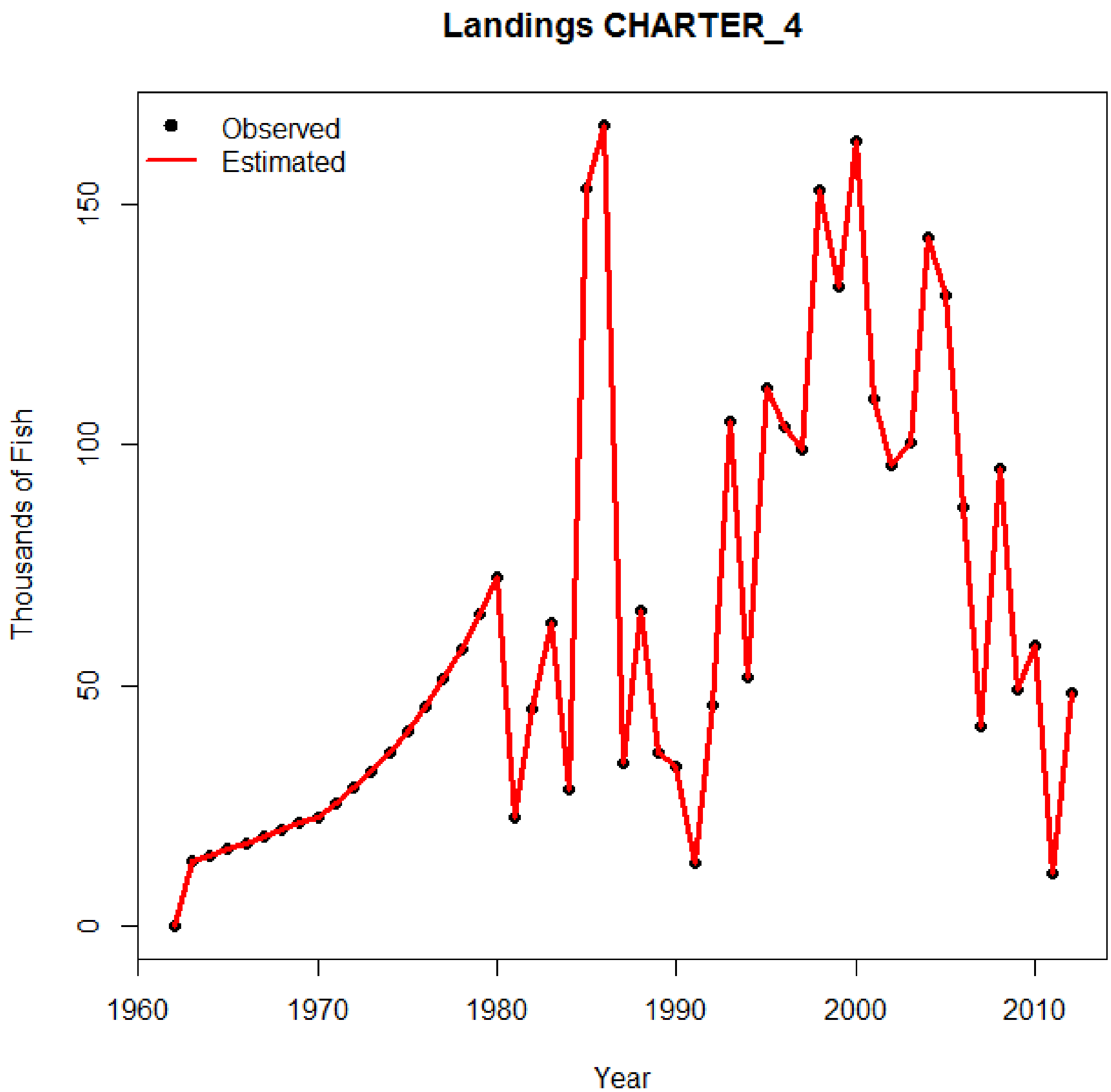


Figure 3.2.4. Observed (black dots) and predicted landings (red line) (mt) of Gulf of Mexico Gag Grouper from the recreational charterboat fishing fleet, 1963-2012.

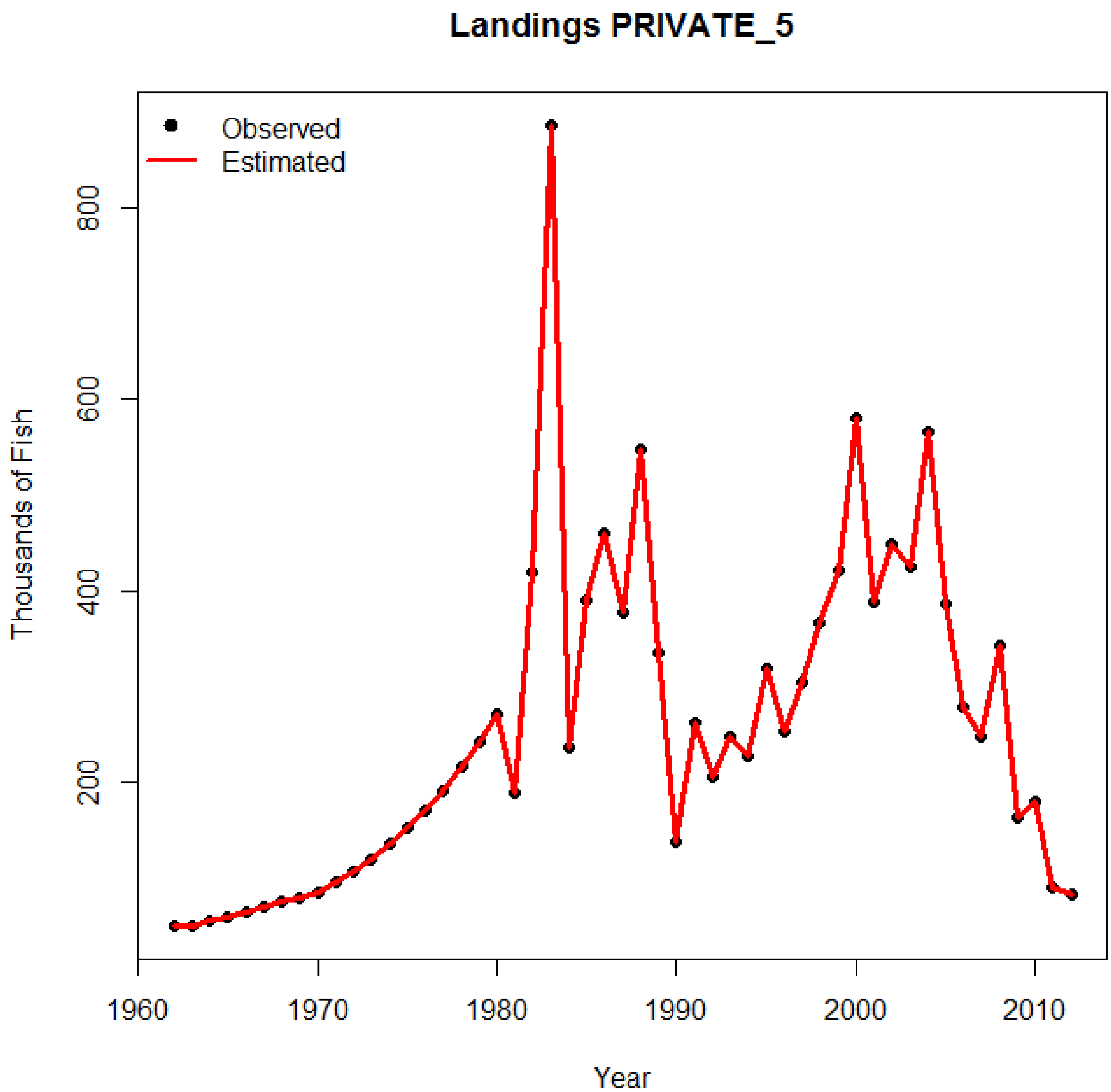


Figure 3.2.5. Observed (black dots) and predicted landings (red line) (mt) of Gulf of Mexico Gag Grouper from the private recreational fishing fleet, 1963-2012.

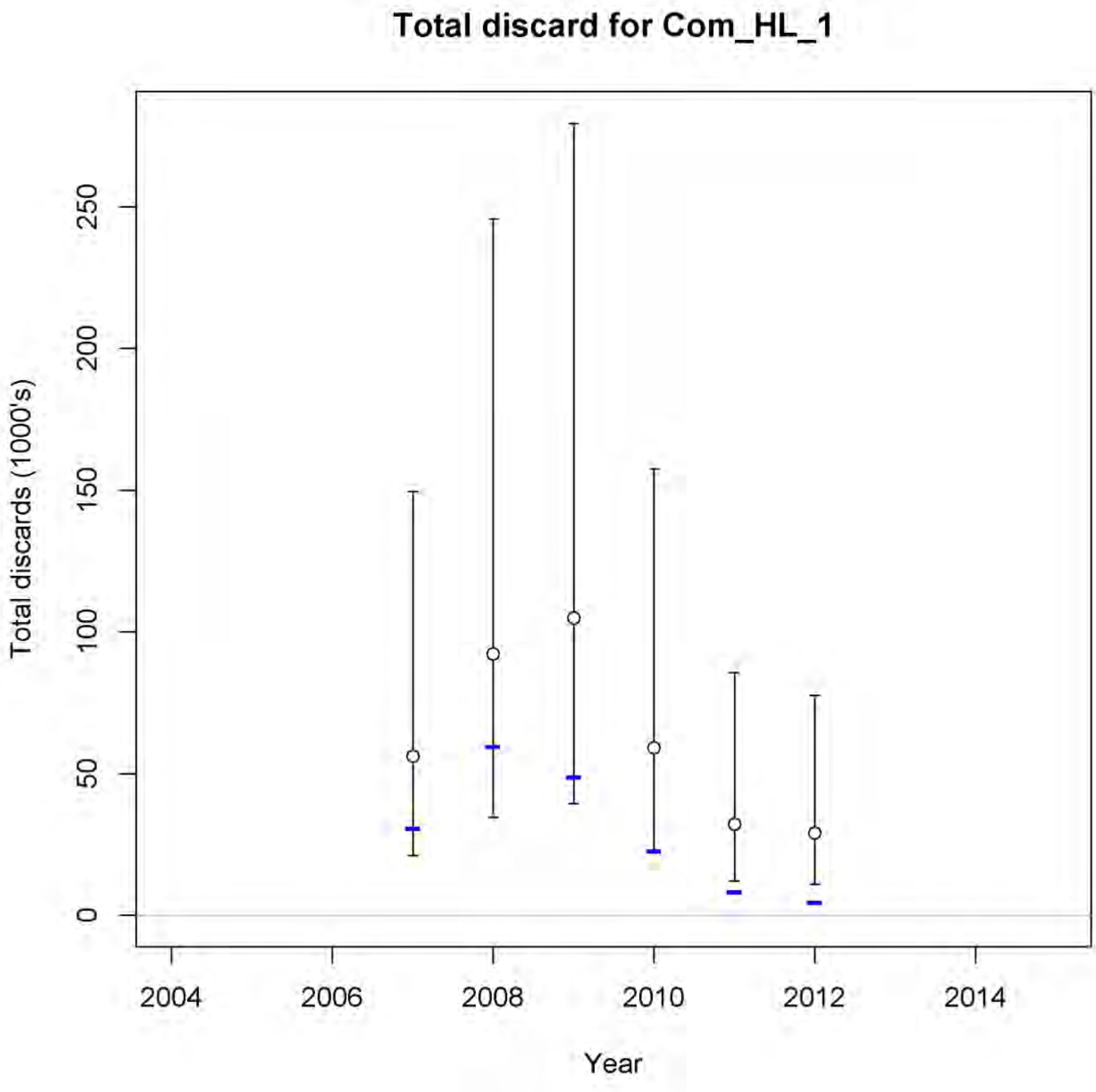


Figure 3.2.6. Observed (open circles) and predicted discards (blue dashes) (mt) of Gulf of Mexico Gag Grouper from the commercial vertical line fishing fleet, 2007-2012.

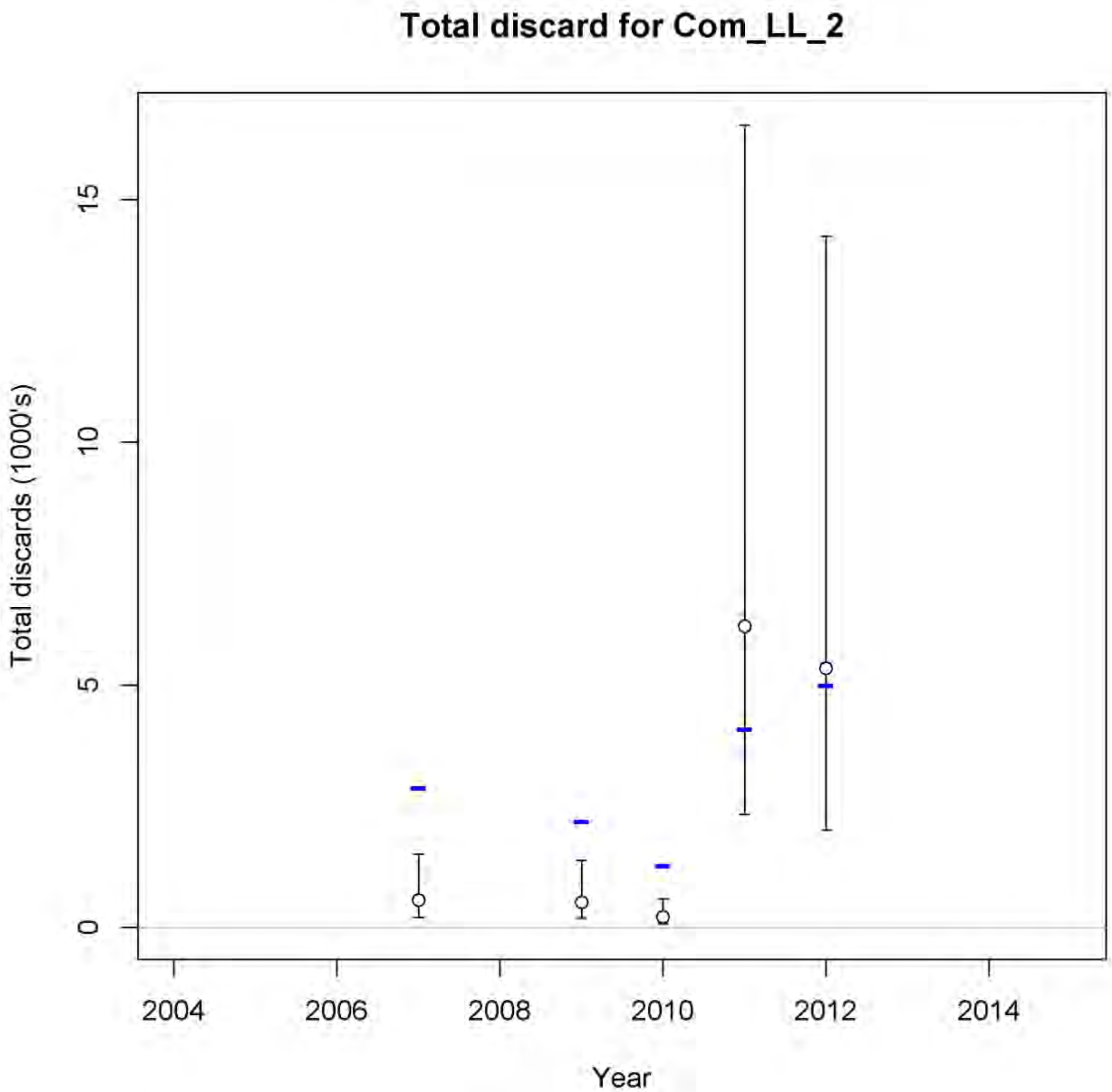


Figure 3.2.7. Observed (open circles) and predicted discards (blue dashes) (mt) of Gulf of Mexico Gag Grouper from the commercial longline fishing fleet, 2007-2012.

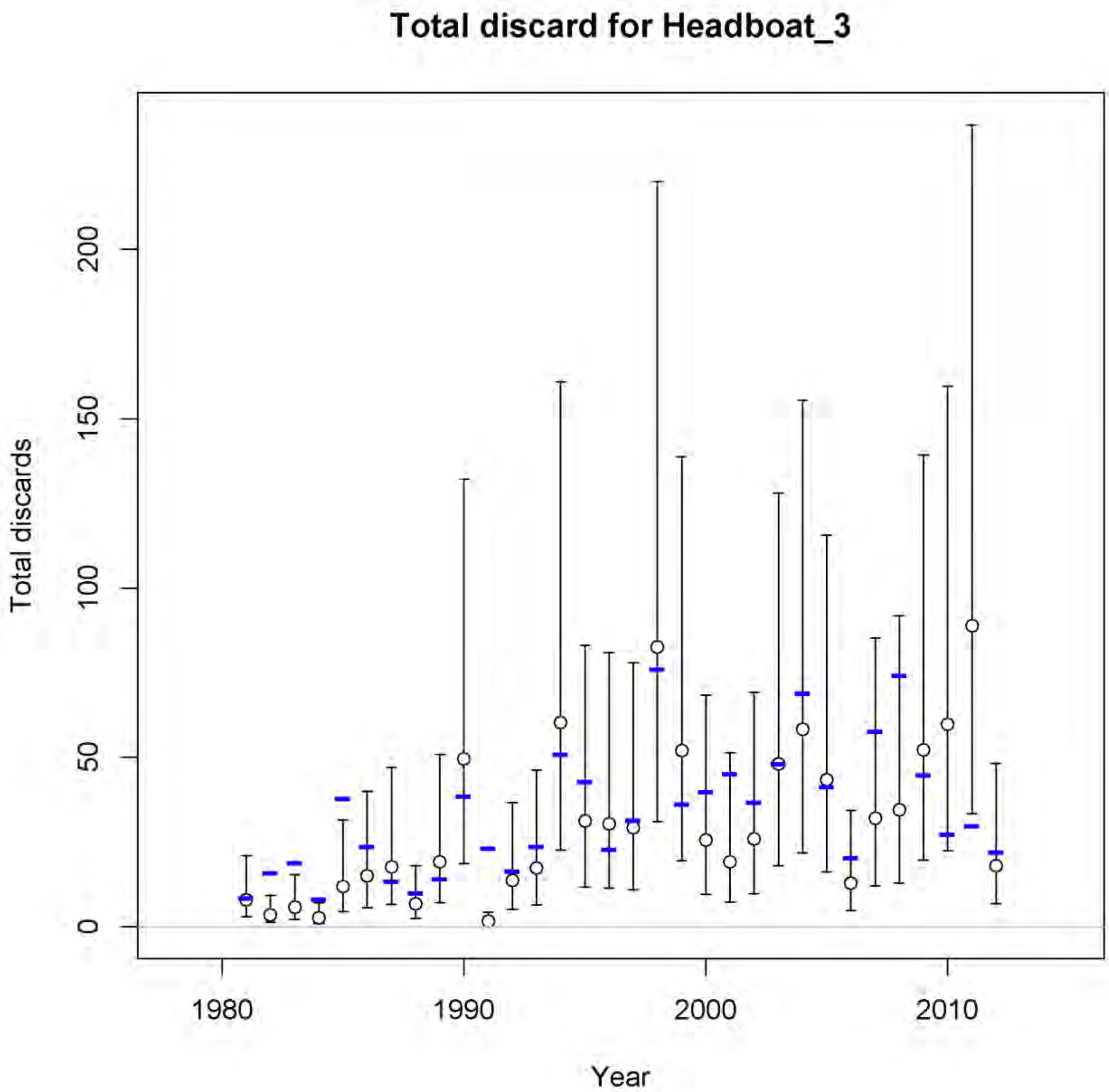


Figure 3.2.8. Observed (open circles) and predicted discards (blue dashes) (mt) of Gulf of Mexico Gag Grouper from the recreational headboat fishing fleet, 1981-2012.

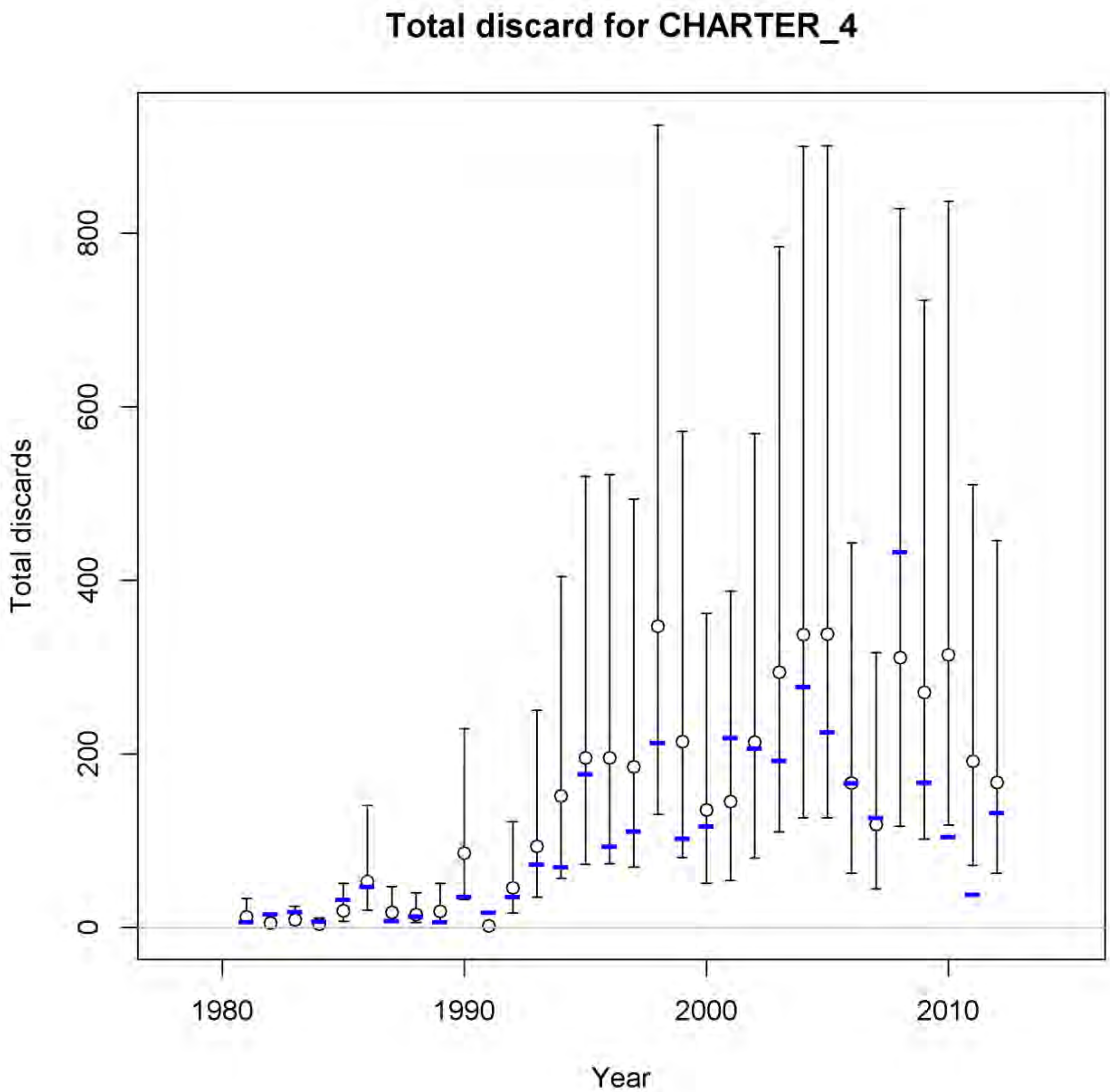


Figure 3.2.9. Observed (open circles) and predicted discards (blue dashes) (mt) of Gulf of Mexico Gag Grouper from the recreational charterboat fishing fleet, 1981-2012.

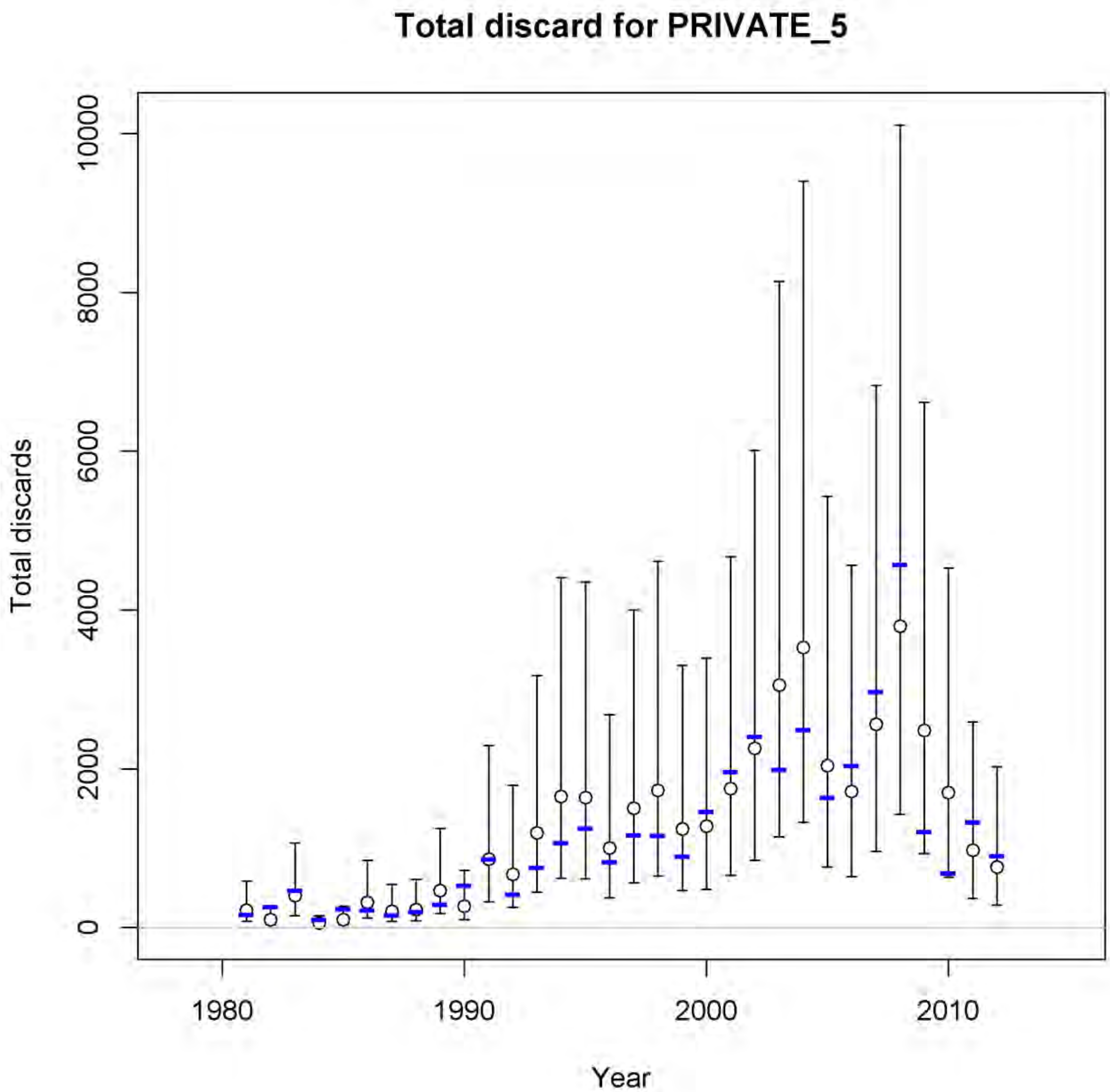


Figure 3.2.10. Observed (open circles) and predicted discards (blue dashes) (mt) of Gulf of Mexico Gag Grouper from the private recreational fishing fleet, 1981-2012.

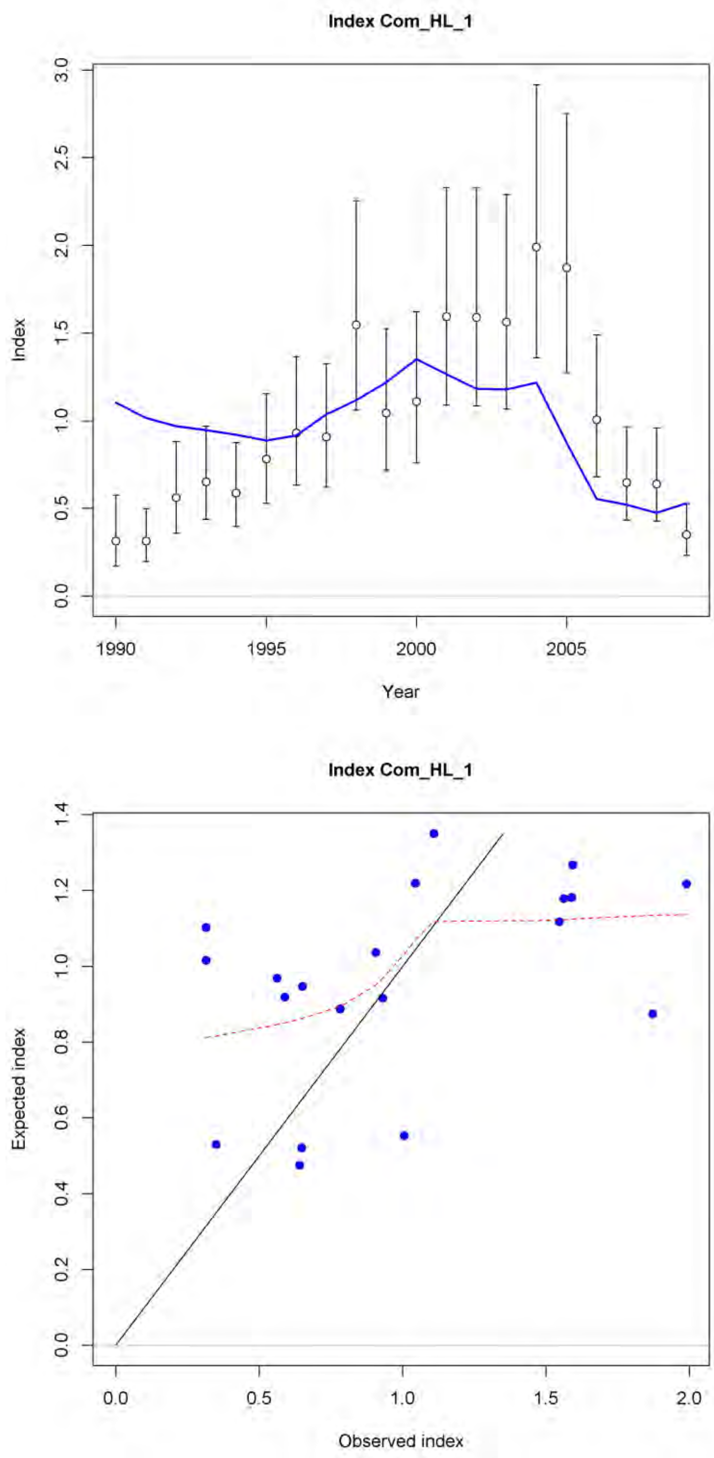
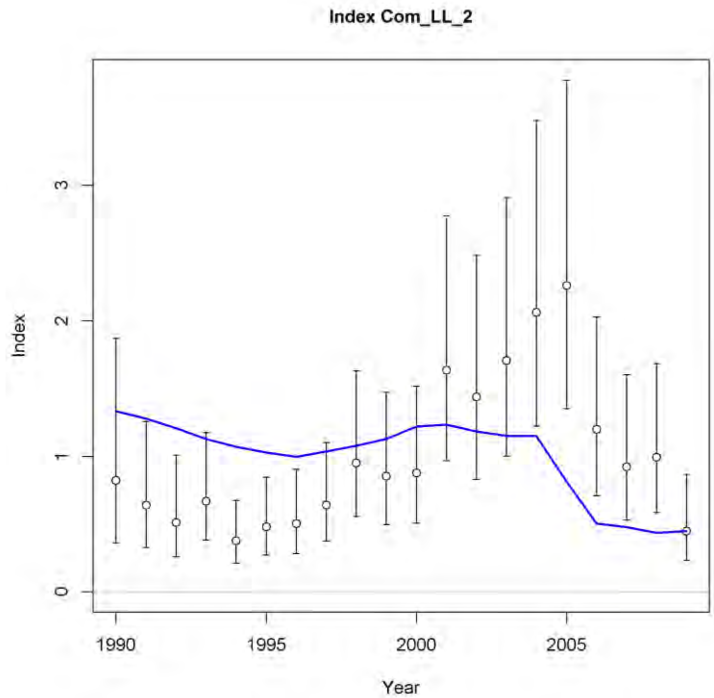


Figure 3.2.11. Model fit (blue line) to the standardized commercial vertical line CPUE index (open circles), 1990-2009 (top panel). The bottom panel also shows a comparison of the observed and predicted indices, where the black line is the 1:1 line.



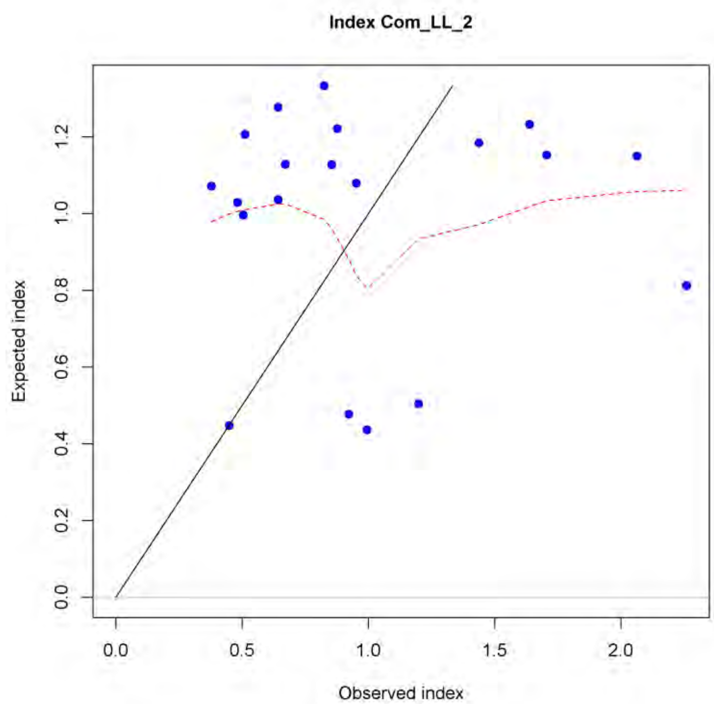


Figure 3.2.12. Model fit (blue line) to the standardized commercial longline CPUE index (open circles), 1990-2009 (top panel). The bottom panel also shows a comparison of the observed and predicted indices, where the black line is the 1:1 line.

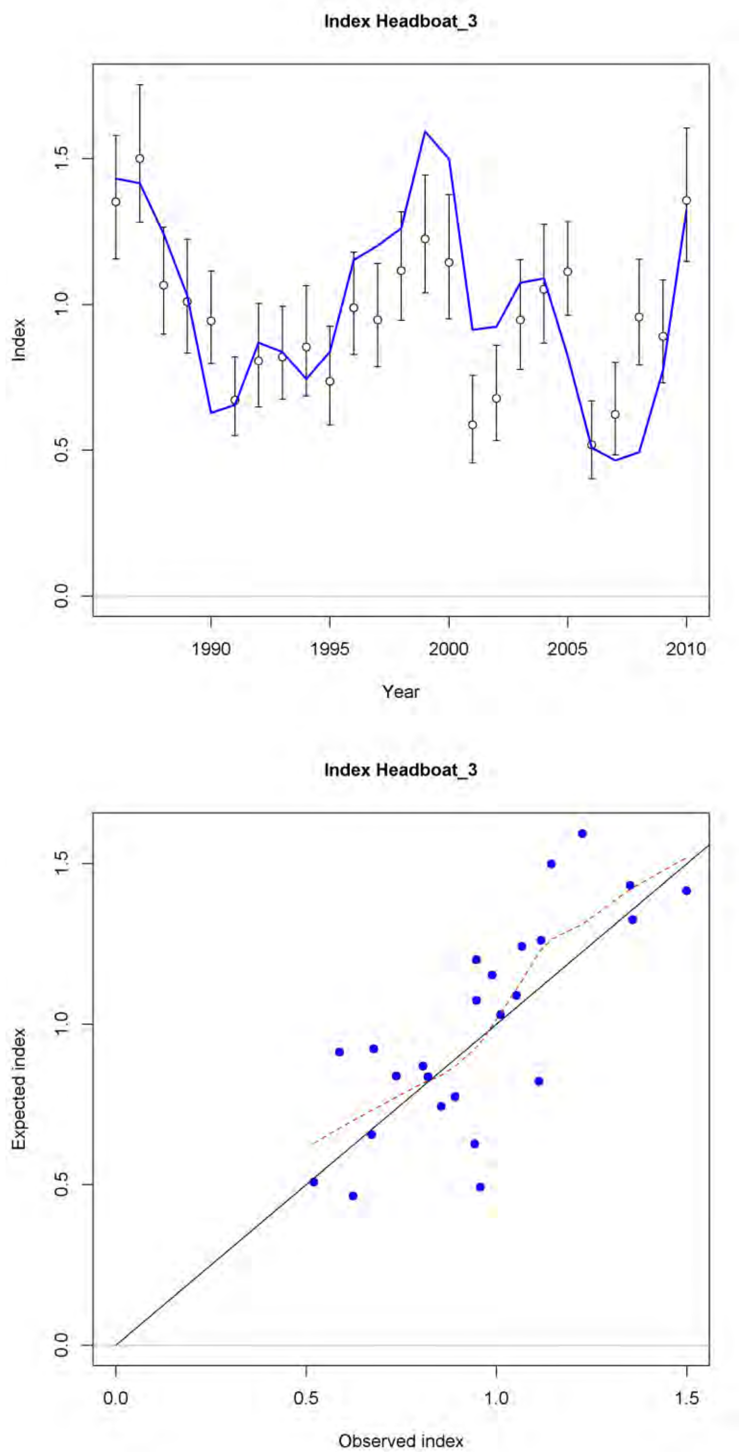


Figure 3.2.13. Model fit (blue line) to the standardized recreational headboat CPUE index, 1986-2010. The bottom panel also shows a comparison of the observed and predicted indices, where the black line is the 1:1 line.

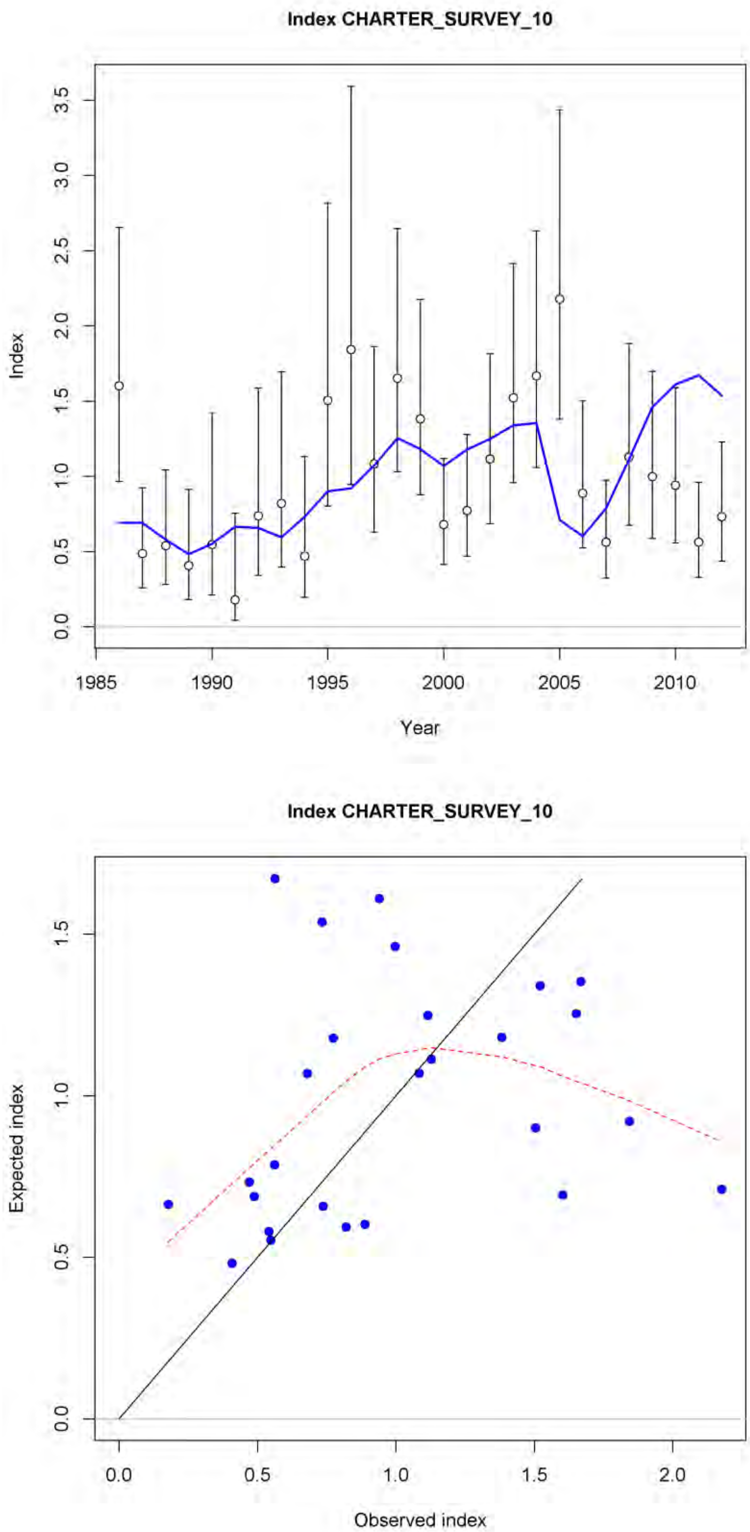


Figure 3.2.14. Model fit (blue line) to the standardized recreational charterboat CPUE index, 1986-2012. The bottom panel also shows a comparison of the observed and predicted indices, where the black line is the 1:1 line.

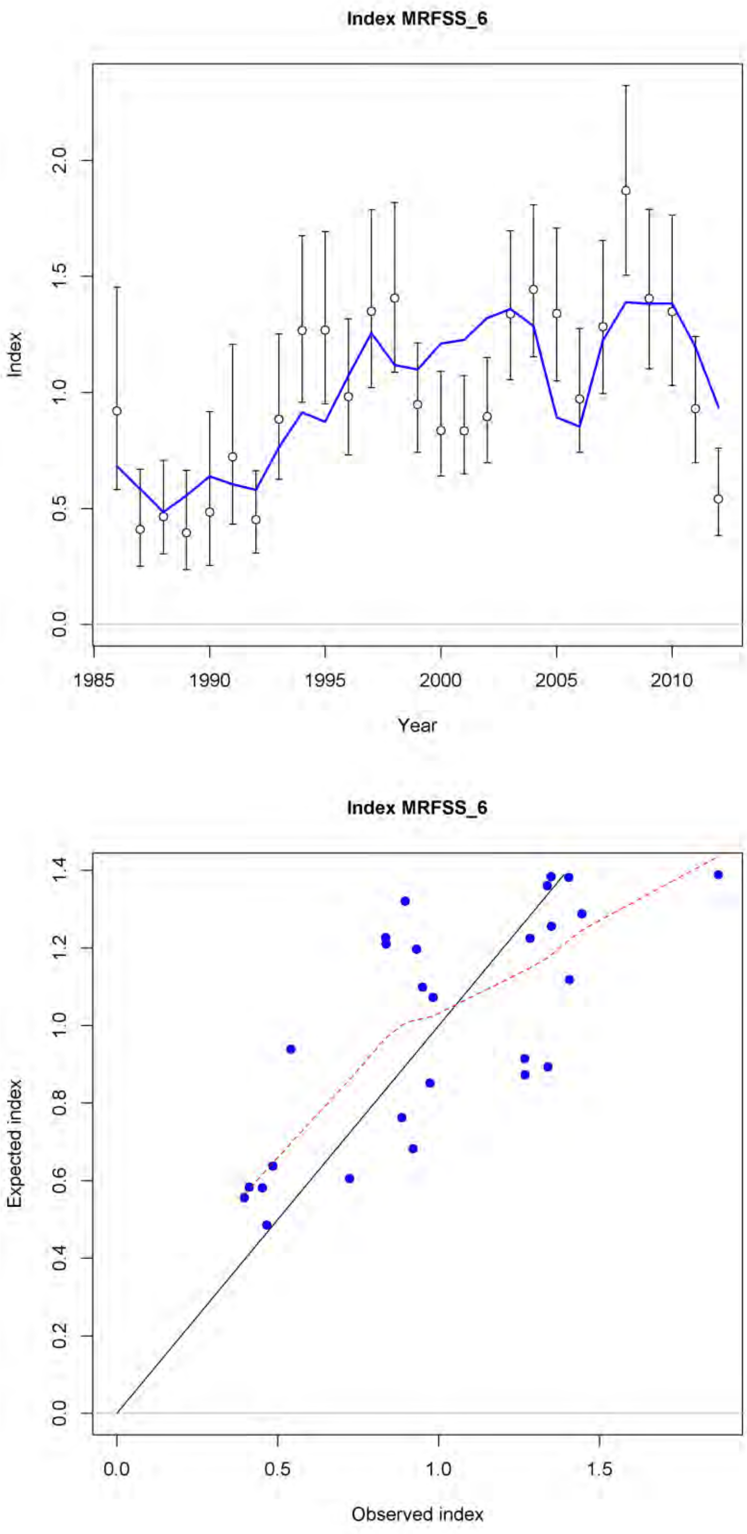


Figure 3.2.15. Model fit (blue line) to the standardized private recreational CPUE index, 1986-2012. The bottom panel also shows a comparison of the observed and predicted indices, where the black line is the 1:1 line.

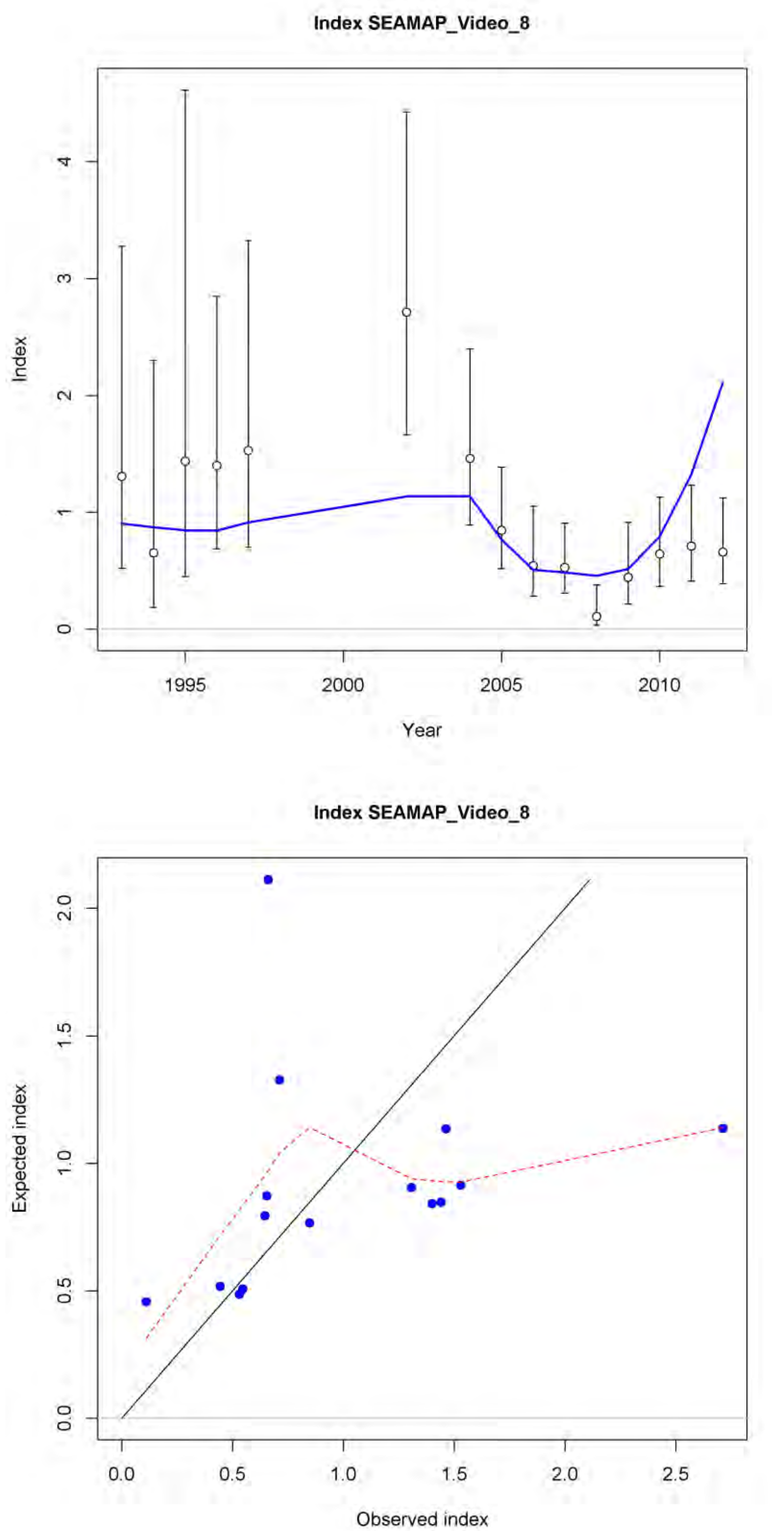
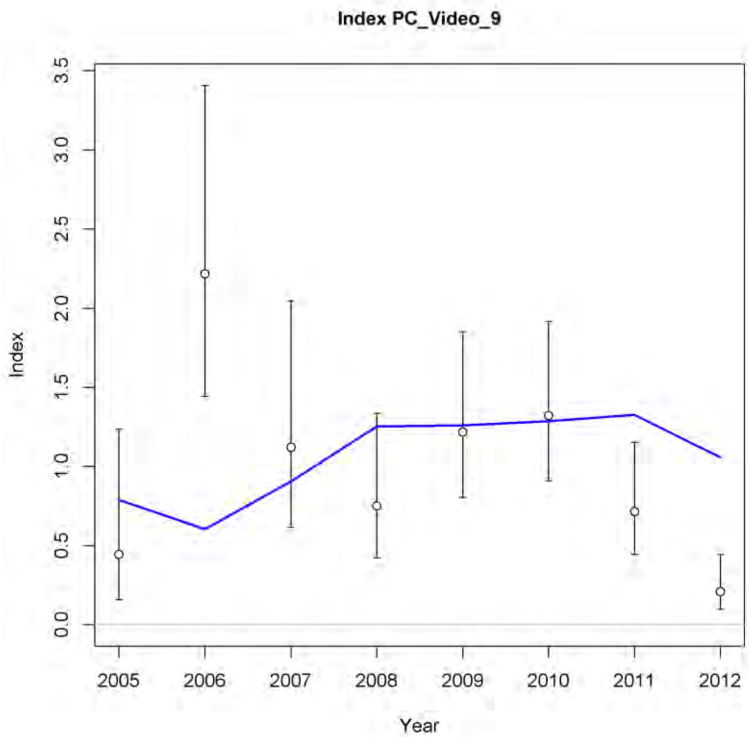


Figure 3.2.16. Model fit (blue line) to the standardized fishery-independent SEAMAP video survey. The bottom panel also shows a comparison of the observed and predicted indices, where the black line is the 1:1 line.



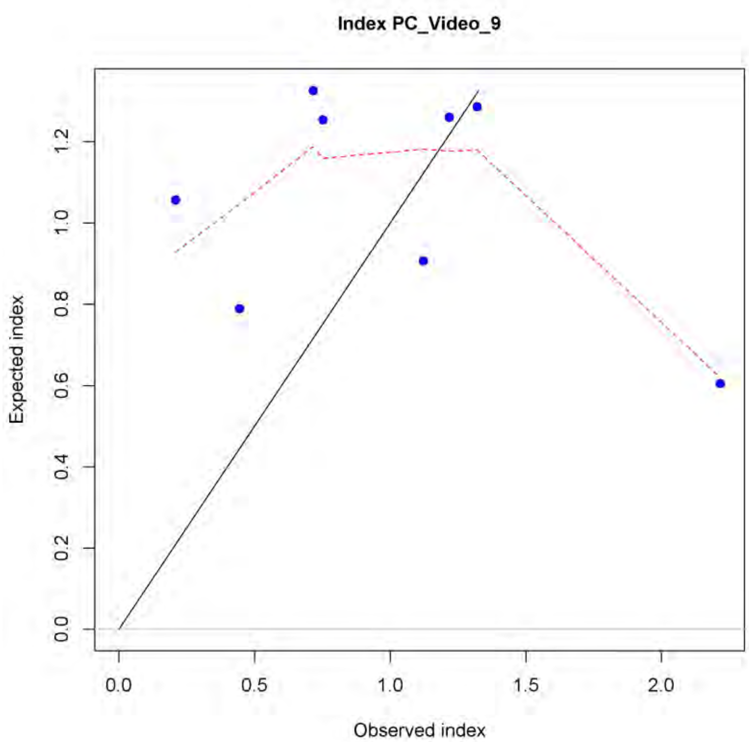


Figure 3.2.17. Model fit (blue line) to the standardized fishery-independent PC Lab video survey. The bottom panel also shows a comparison of the observed and predicted indices, where the black line is the 1:1 line.

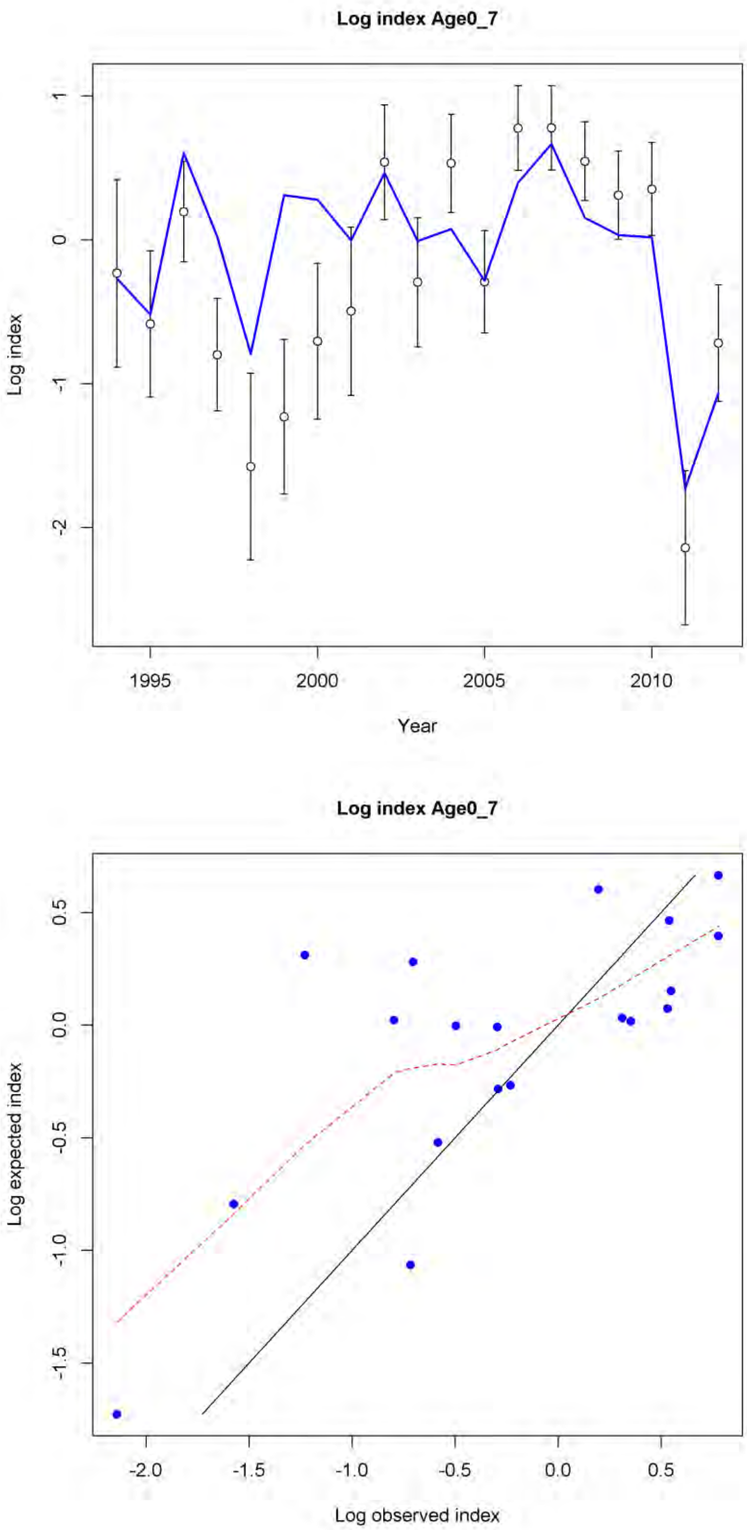


Figure 3.2.18. Model fit (blue line) to the standardized fishery-independent Age-0 trawl survey. The bottom panel also shows a comparison of the observed and predicted indices, where the black line is the 1:1 line.

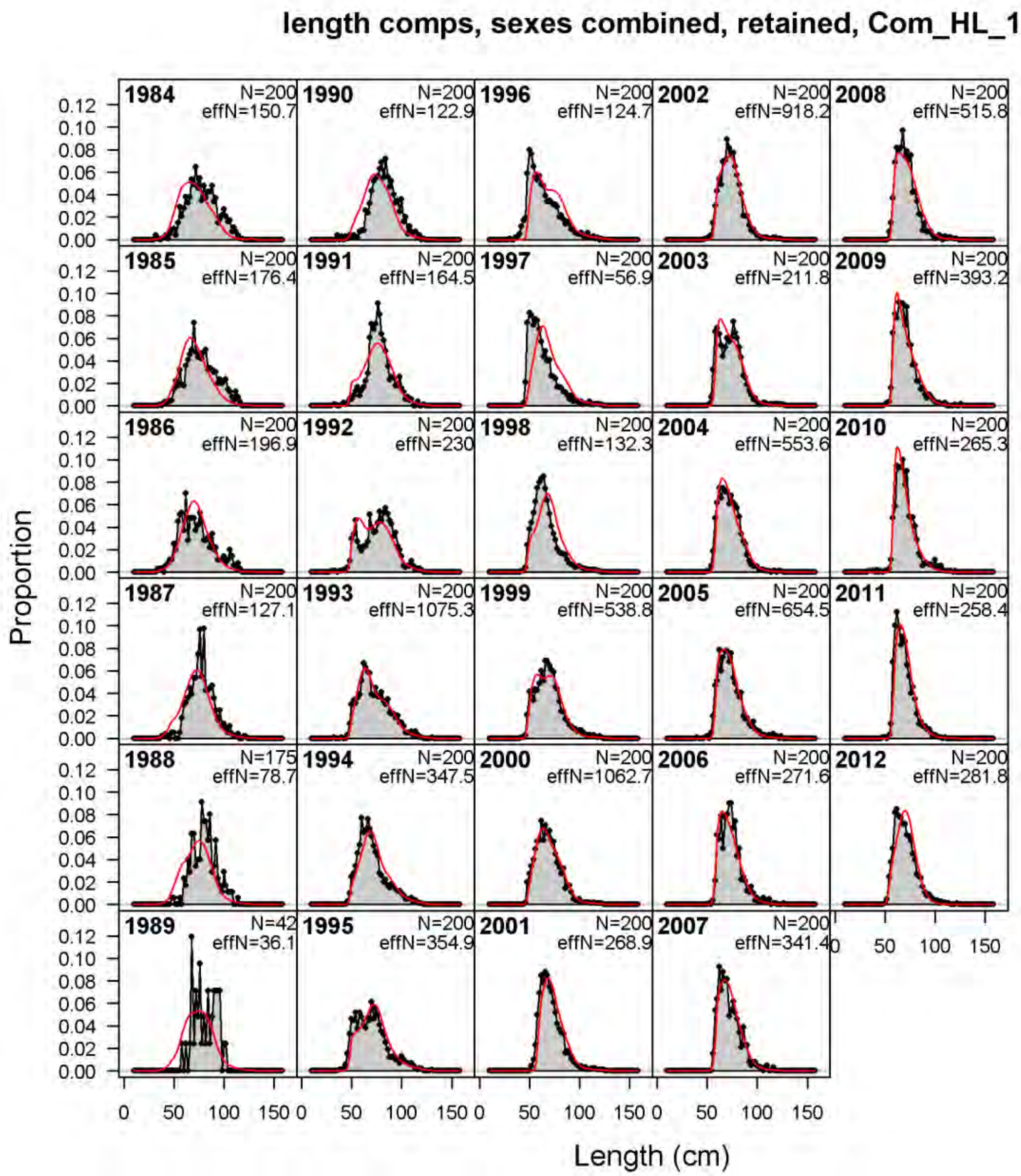


Figure 3.2.19. Observed and predicted length compositions of landings of Gag Grouper in the commercial vertical line fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

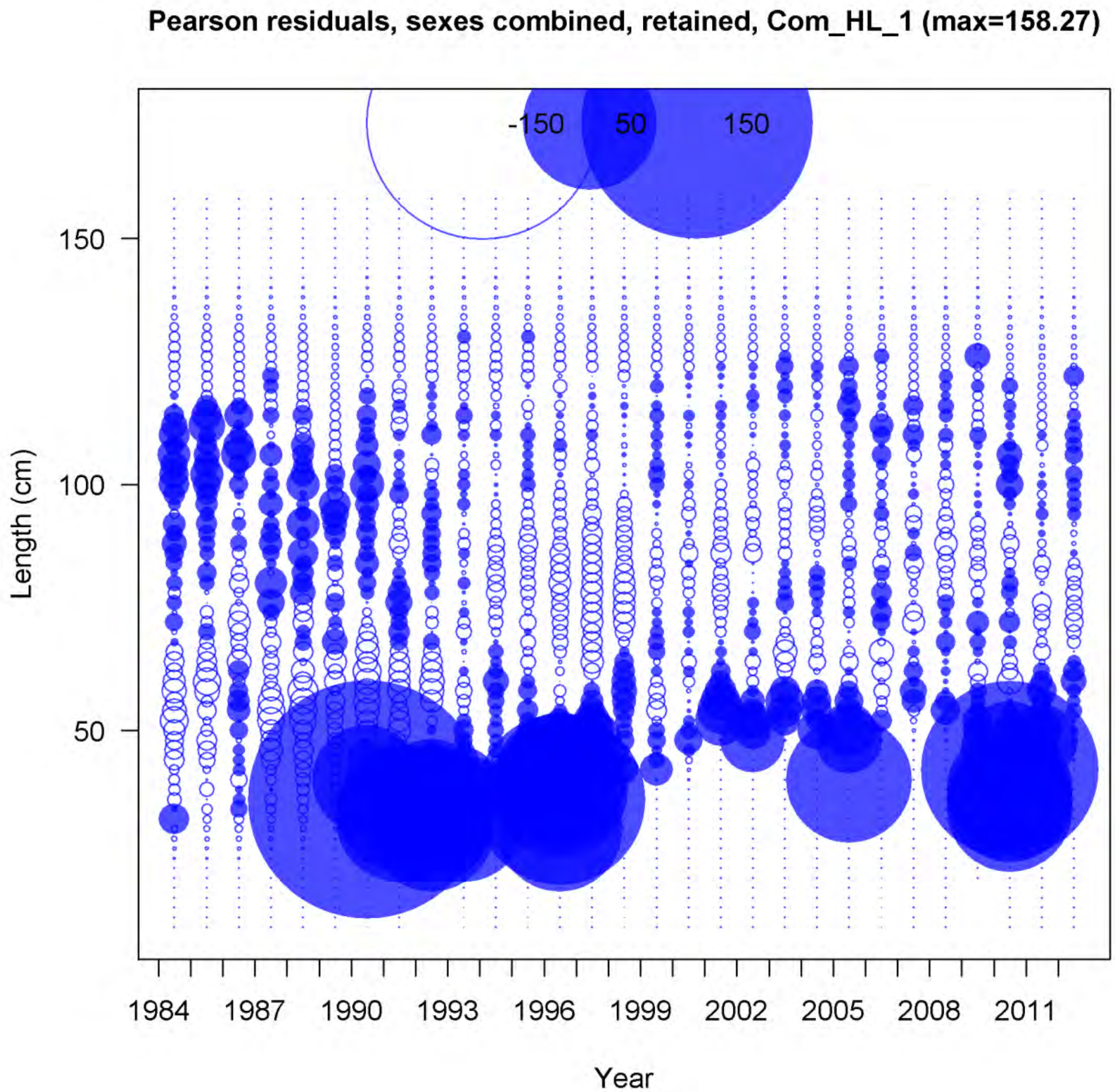


Figure 3.2.20. Pearson residuals for the length composition fit to commercial vertical line landings. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

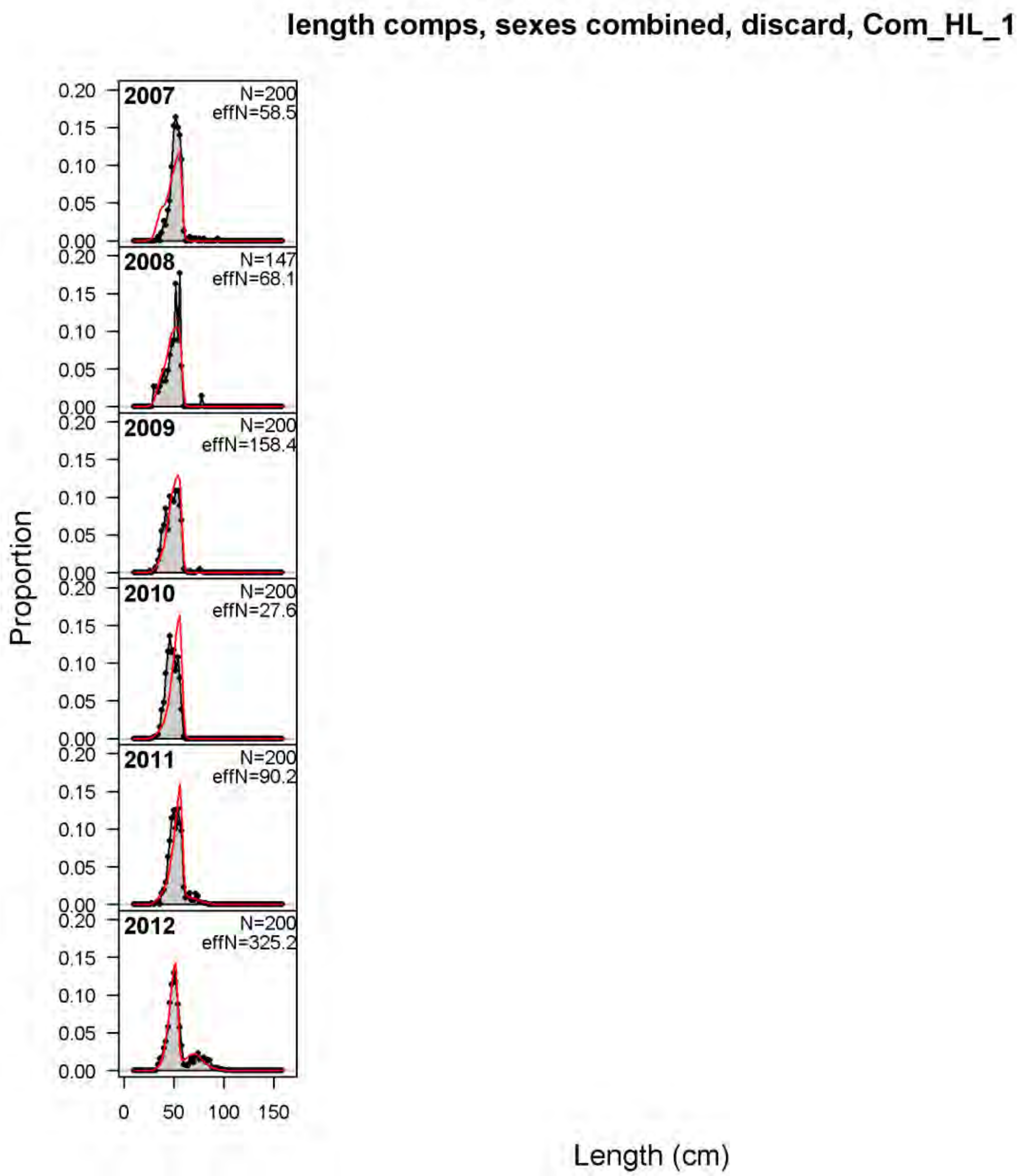


Figure 3.2.21. Observed and predicted length compositions of discards from the commercial vertical line fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

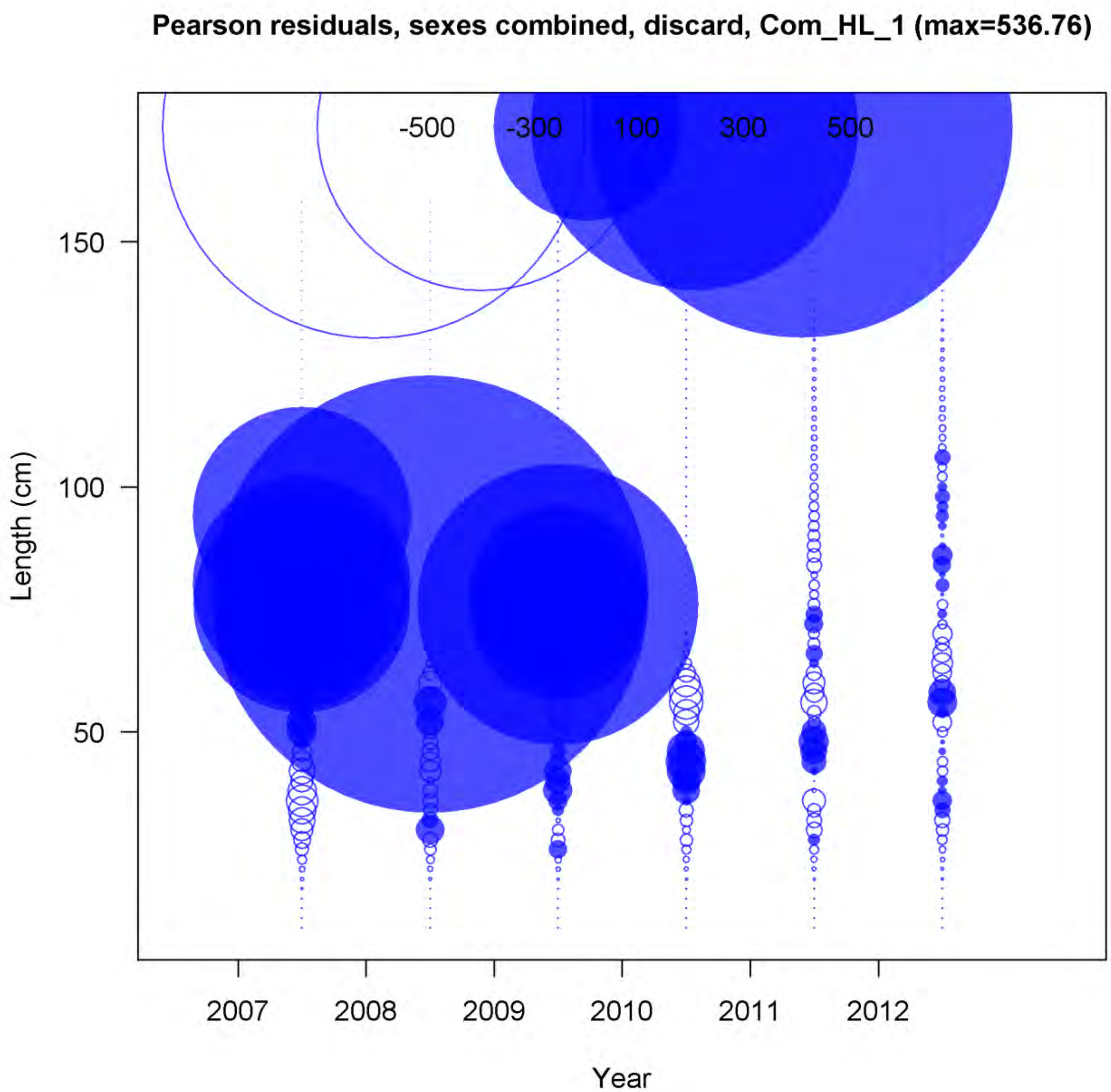


Figure 3.2.22. Pearson residuals for the length composition fit to commercial vertical line discard data. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

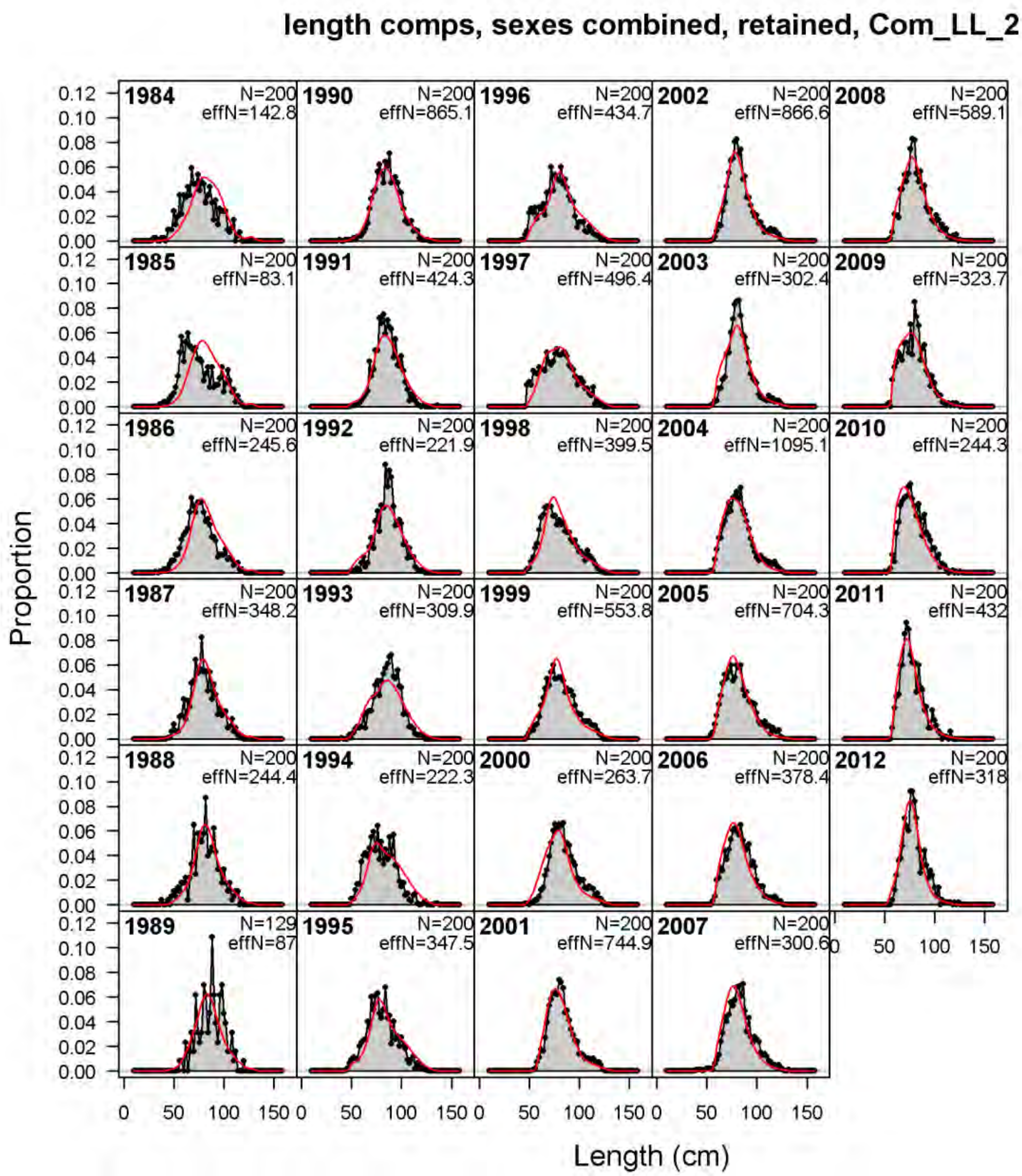


Figure 3.2.23. Observed and predicted length compositions of landings of Gag Grouper in the commercial longline fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

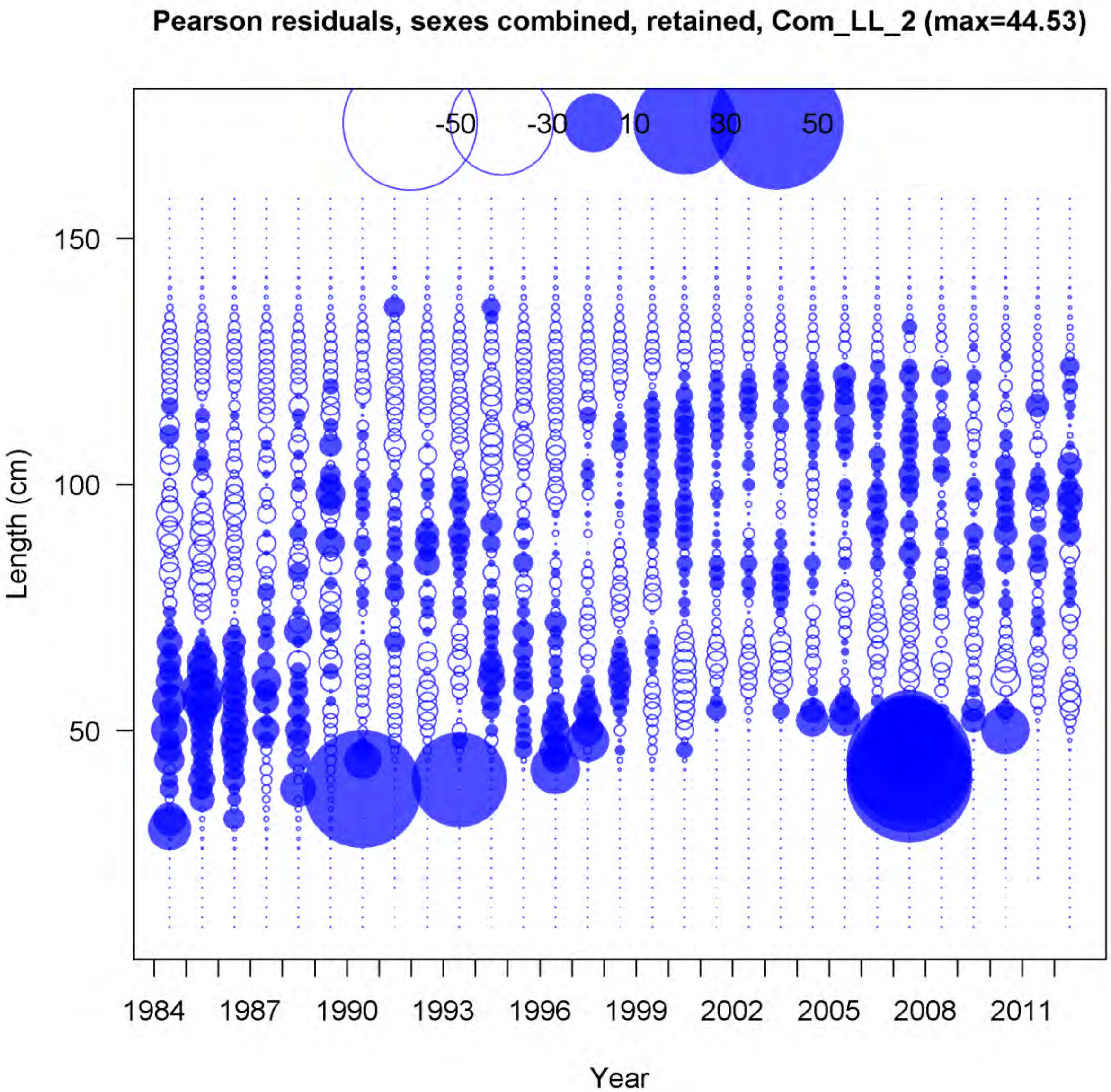


Figure 3.2.24. Pearson residuals for the length composition fit to commercial longline landings. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

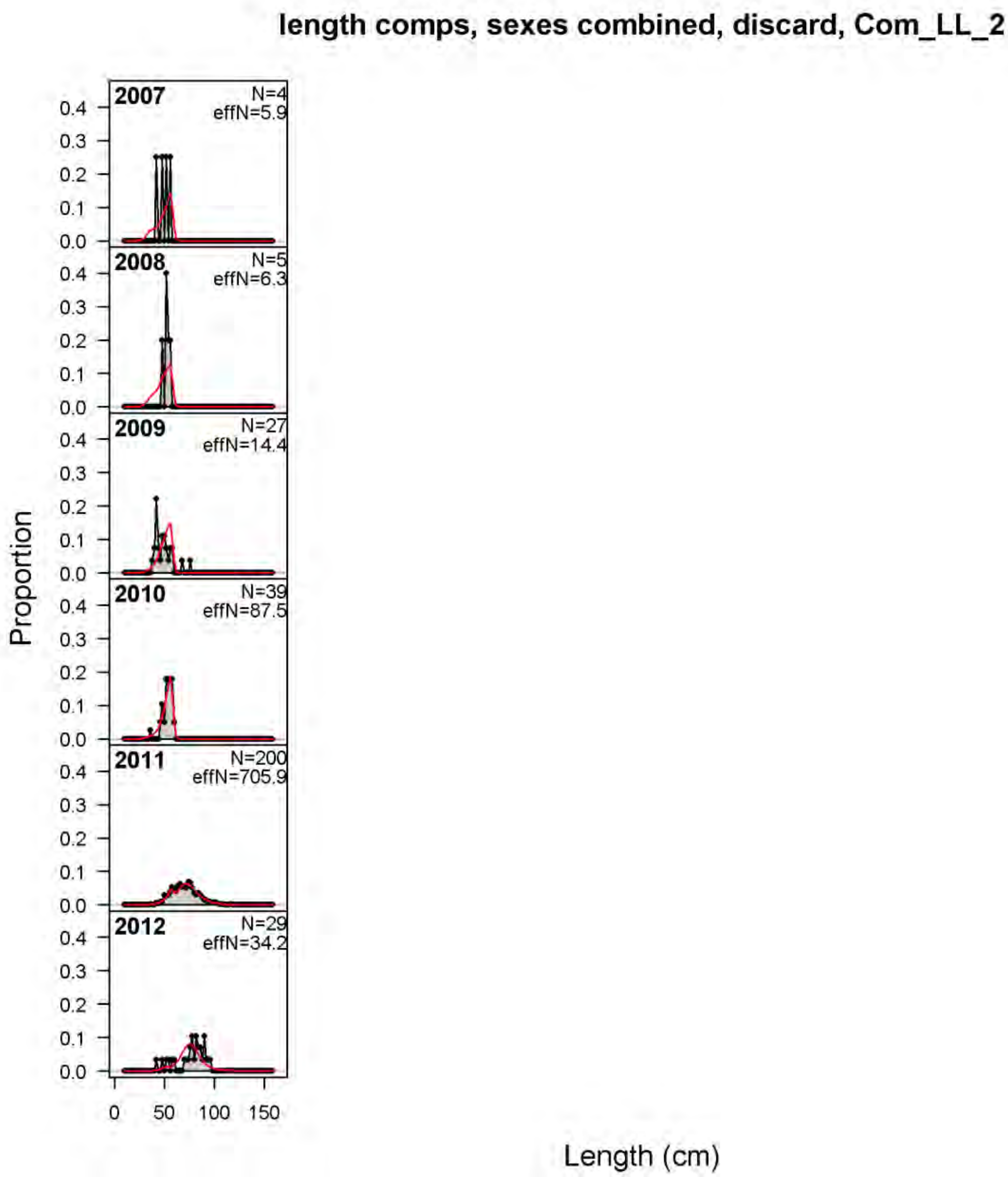


Figure 3.2.25. Observed and predicted length compositions of discards from the commercial longline fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

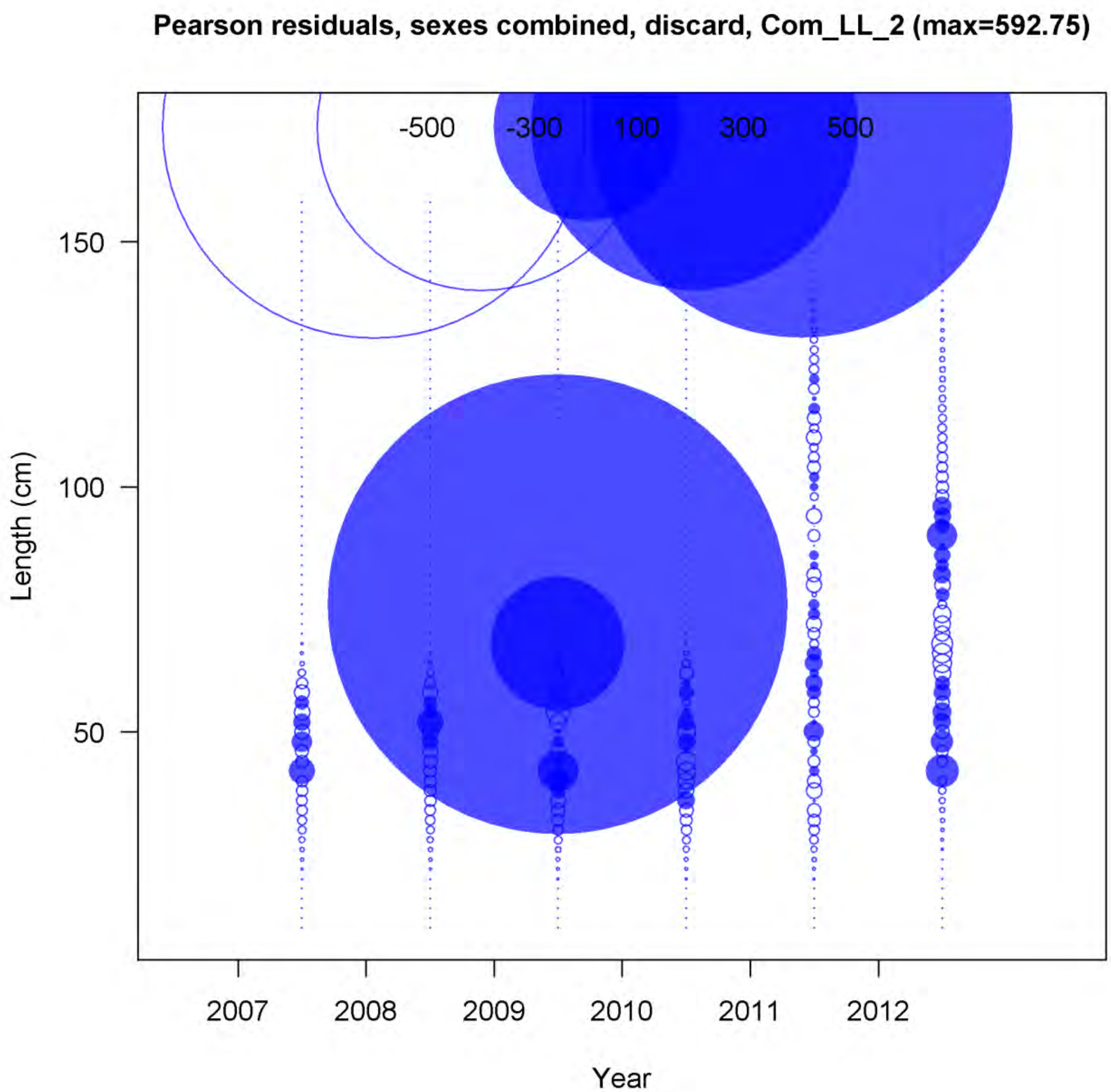


Figure 3.2.26. Pearson residuals for the length composition fit to commercial longline discard data. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

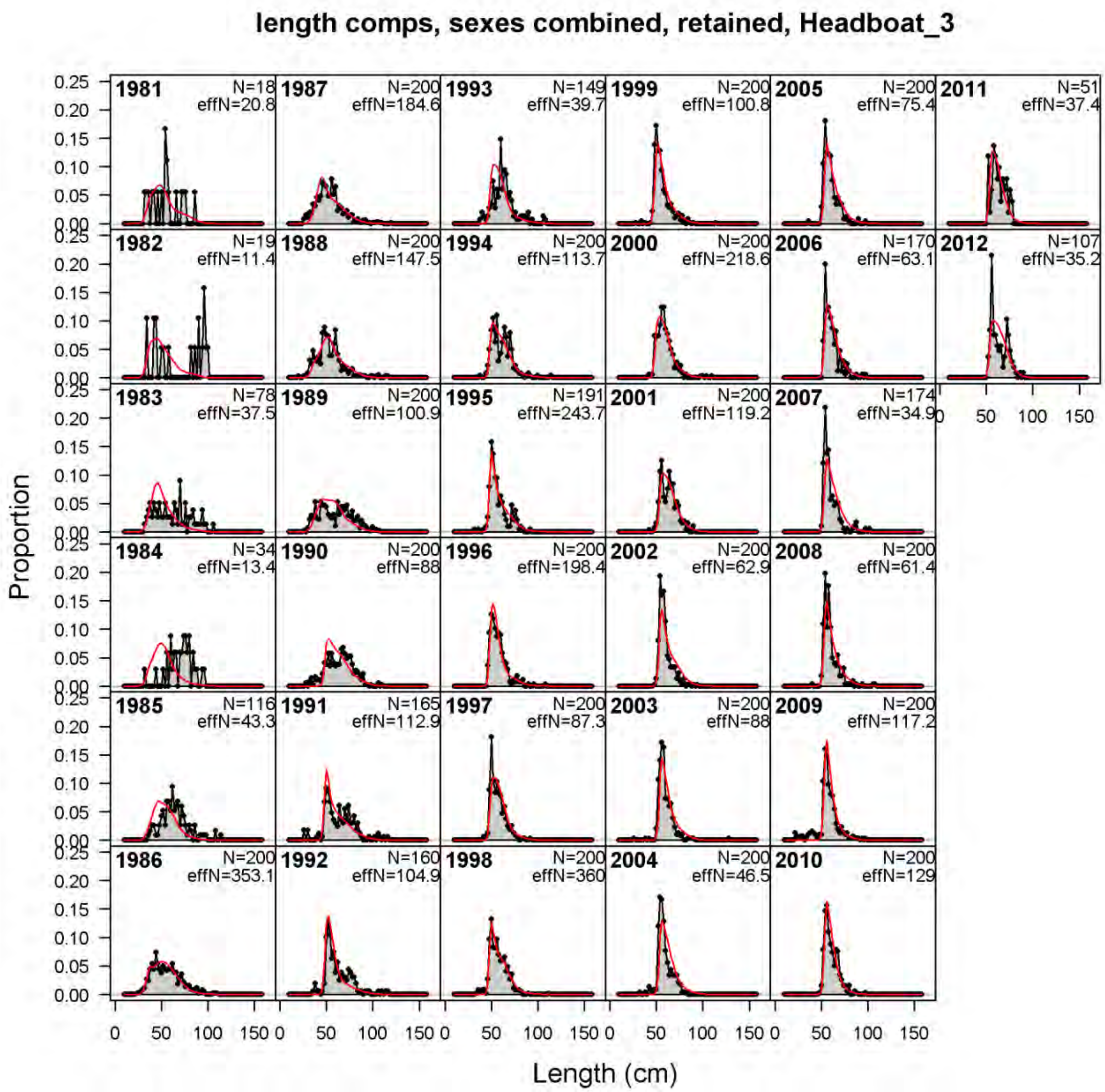


Figure 3.2.27. Observed and predicted length compositions of landings from the recreational headboat fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

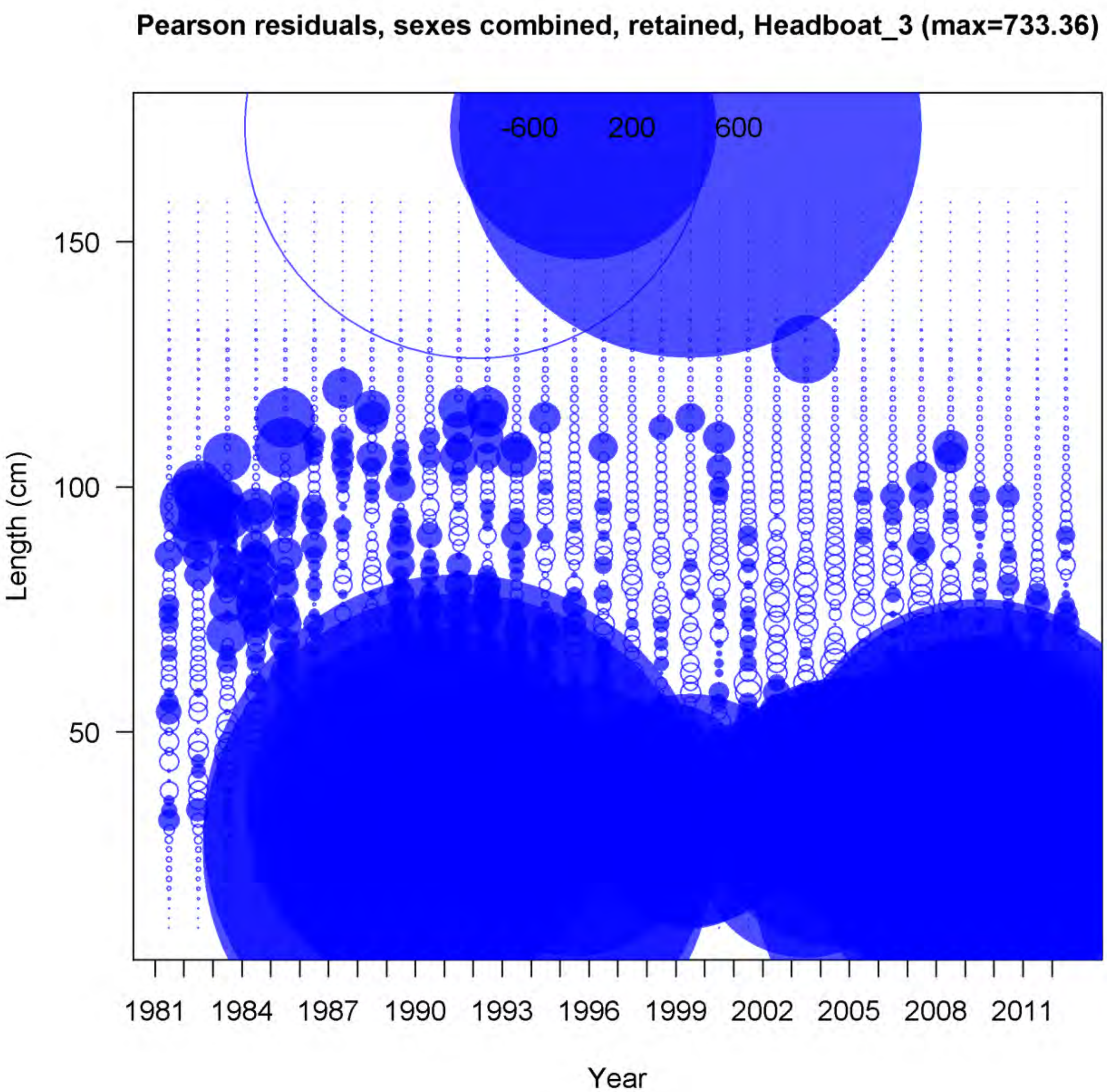


Figure 3.2.28. Pearson residuals for the length composition fit to recreational headboat landings. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

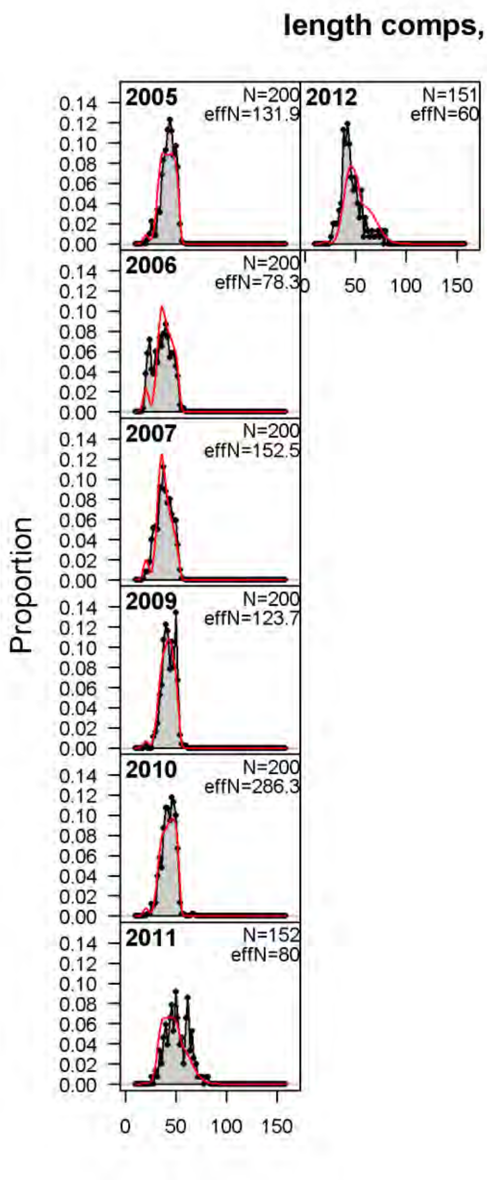


Figure 3.2.29. Observed and predicted length compositions of discards from the recreational headboat fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

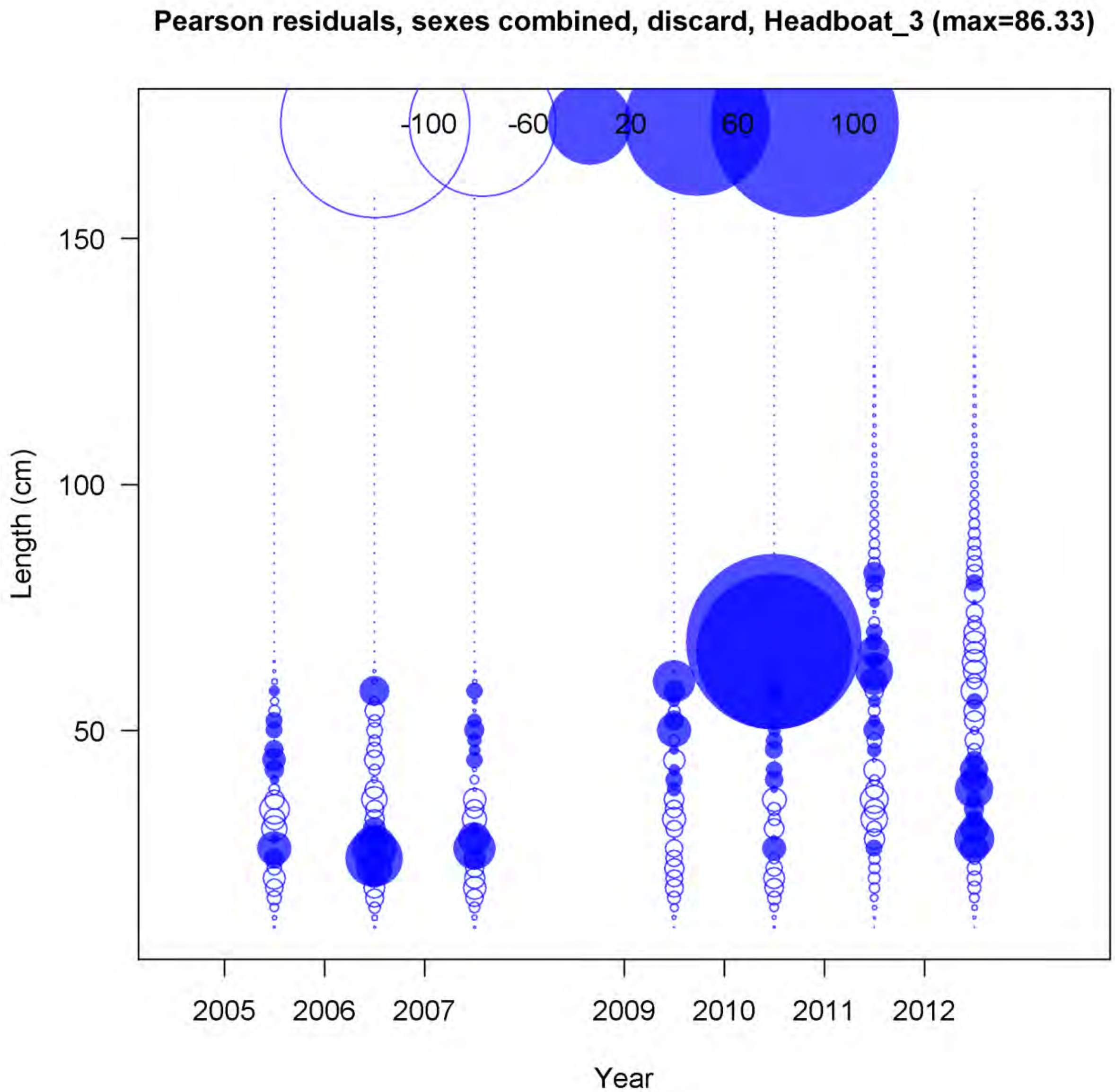


Figure 3.2.30. Pearson residuals for the length composition fit to recreational headboat discards. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

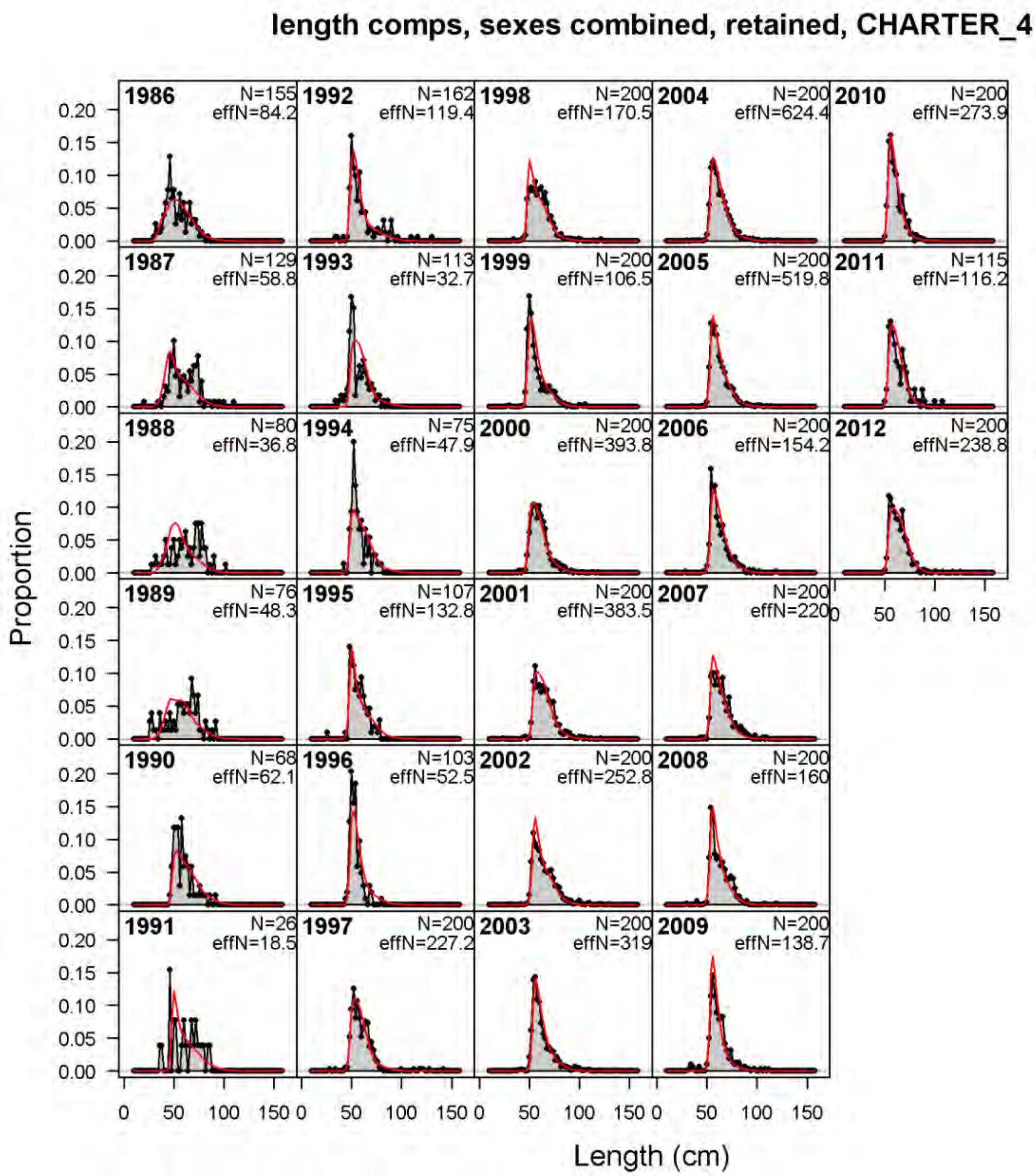


Figure 3.2.31. Observed and predicted length compositions of landings from the recreational charterboat fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

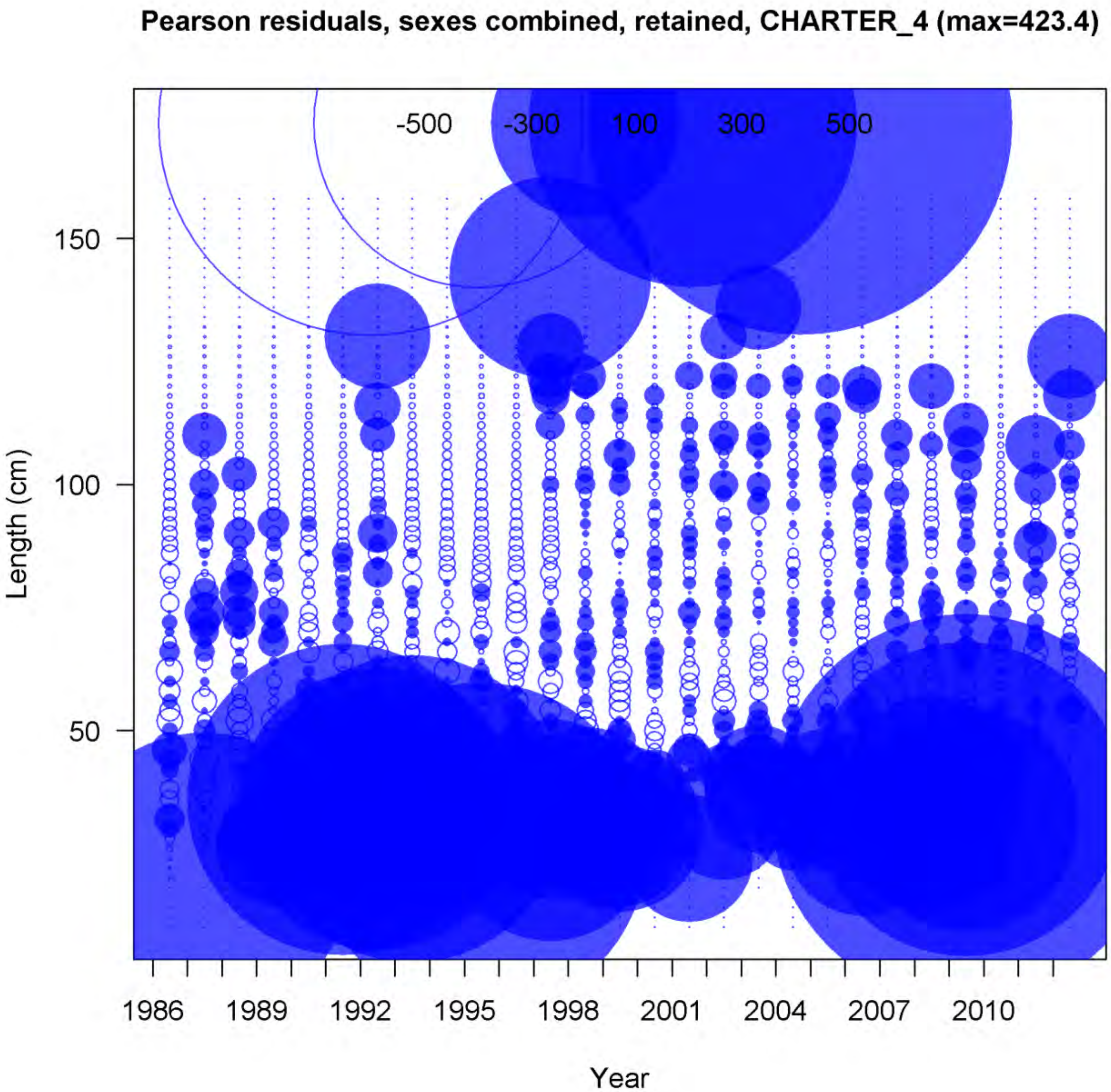


Figure 3.2. 32. Pearson residuals for the length composition fit to recreational charterboat landings. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

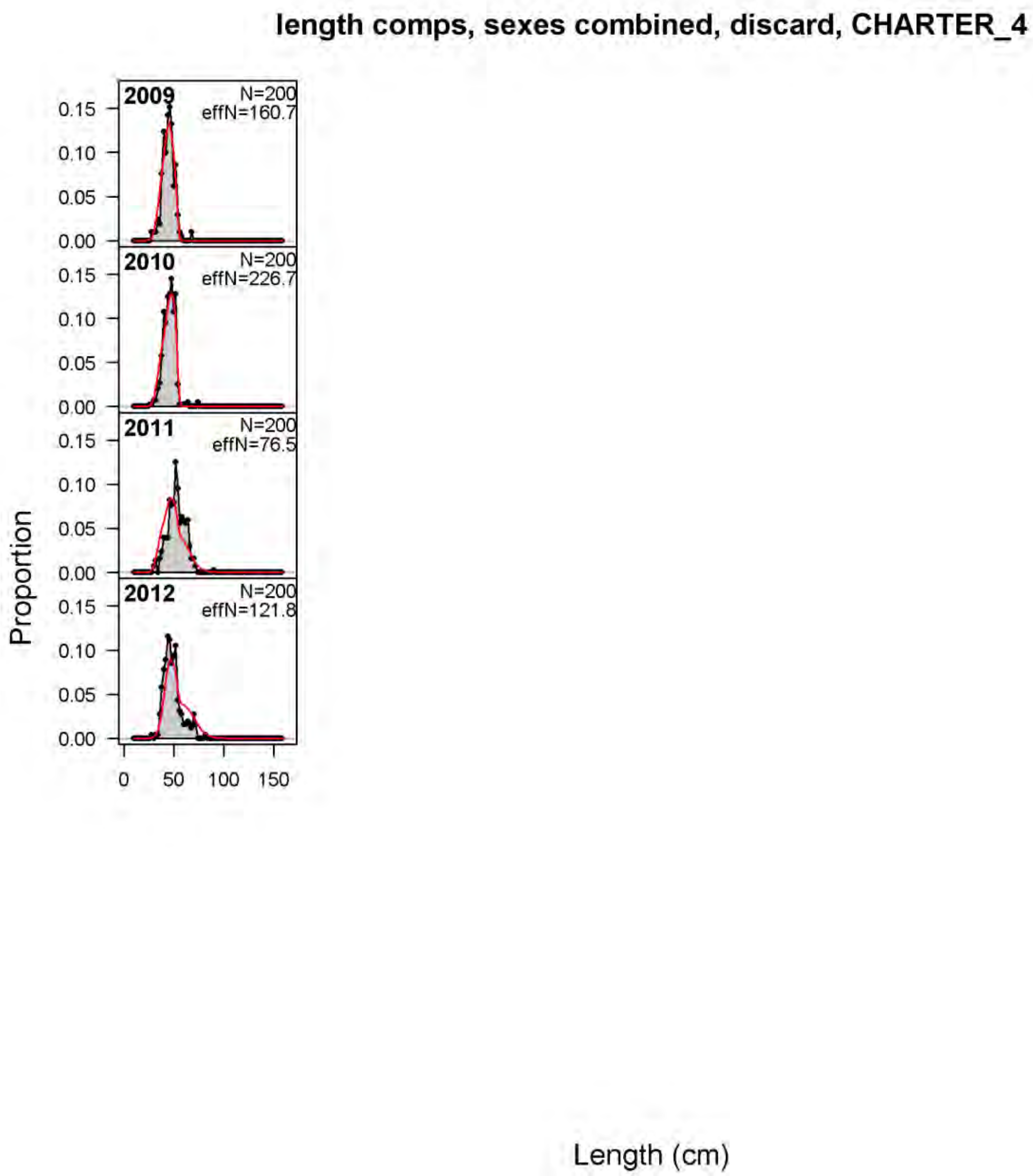


Figure 3.2.33. Observed and predicted length compositions of discards from the recreational charterboat fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

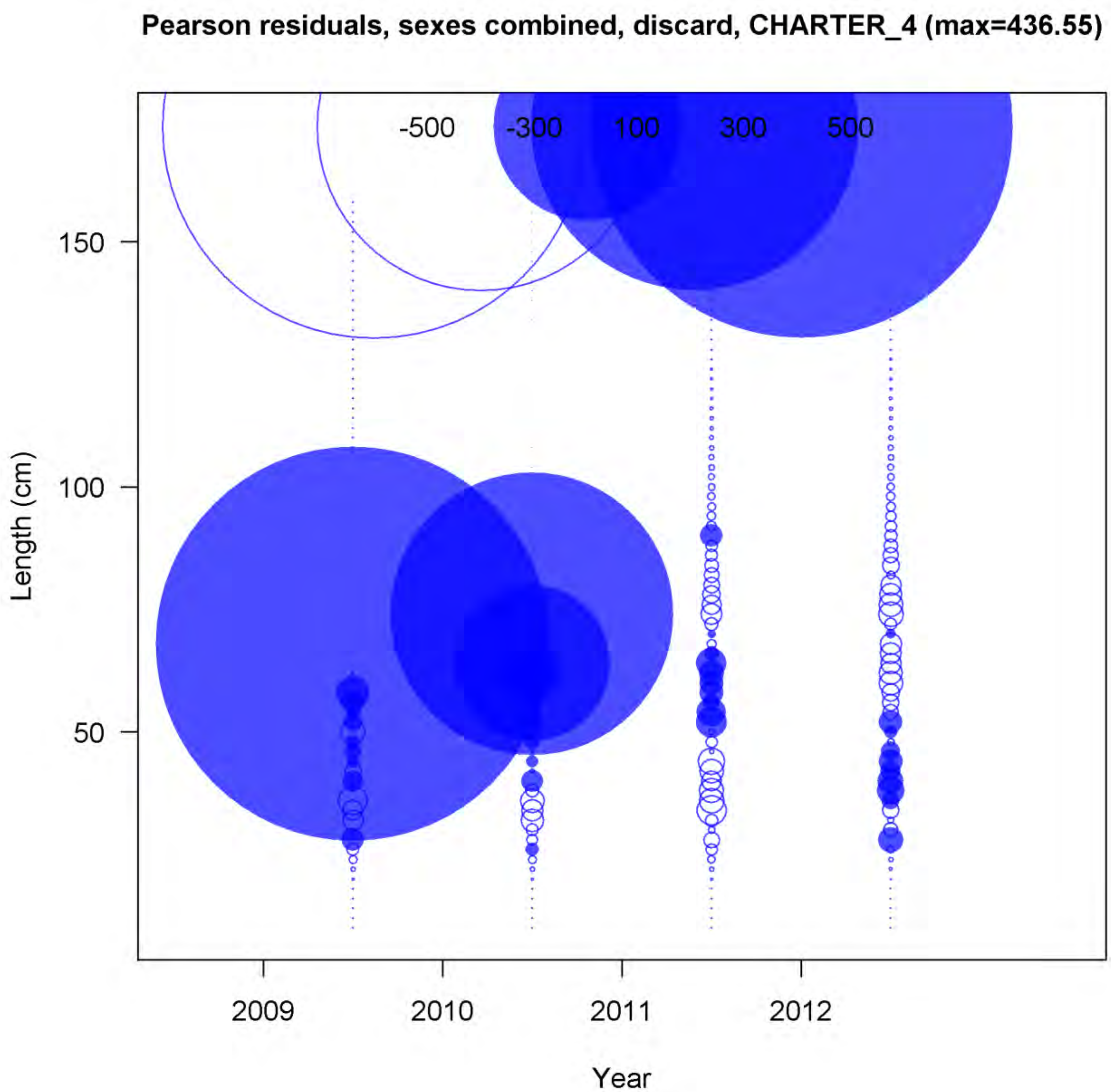


Figure 3.2.34. Pearson residuals for the length composition fit to recreational charterboat discards. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

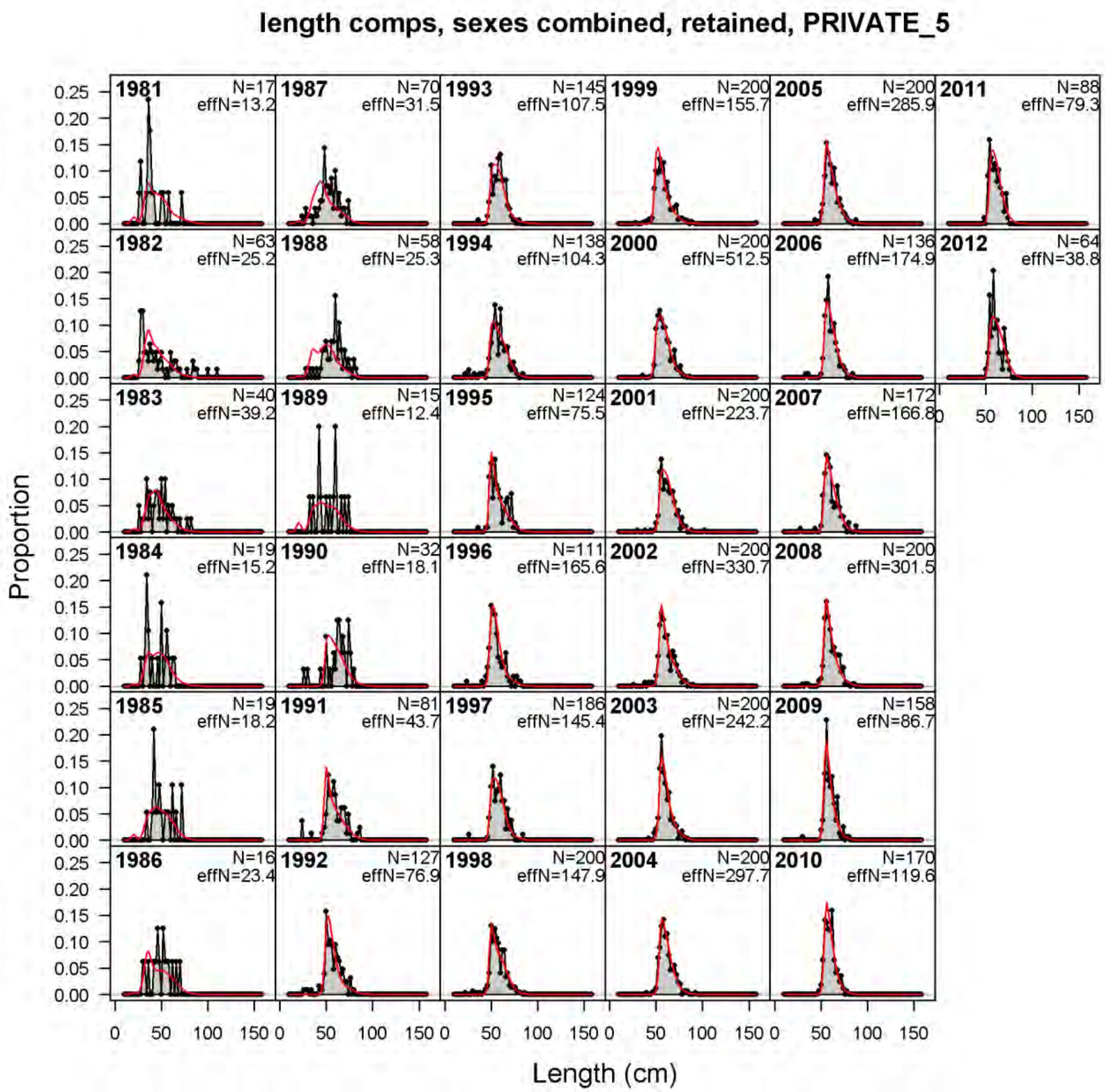


Figure 3.2.35. Observed and predicted length compositions of landings from the private recreational fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

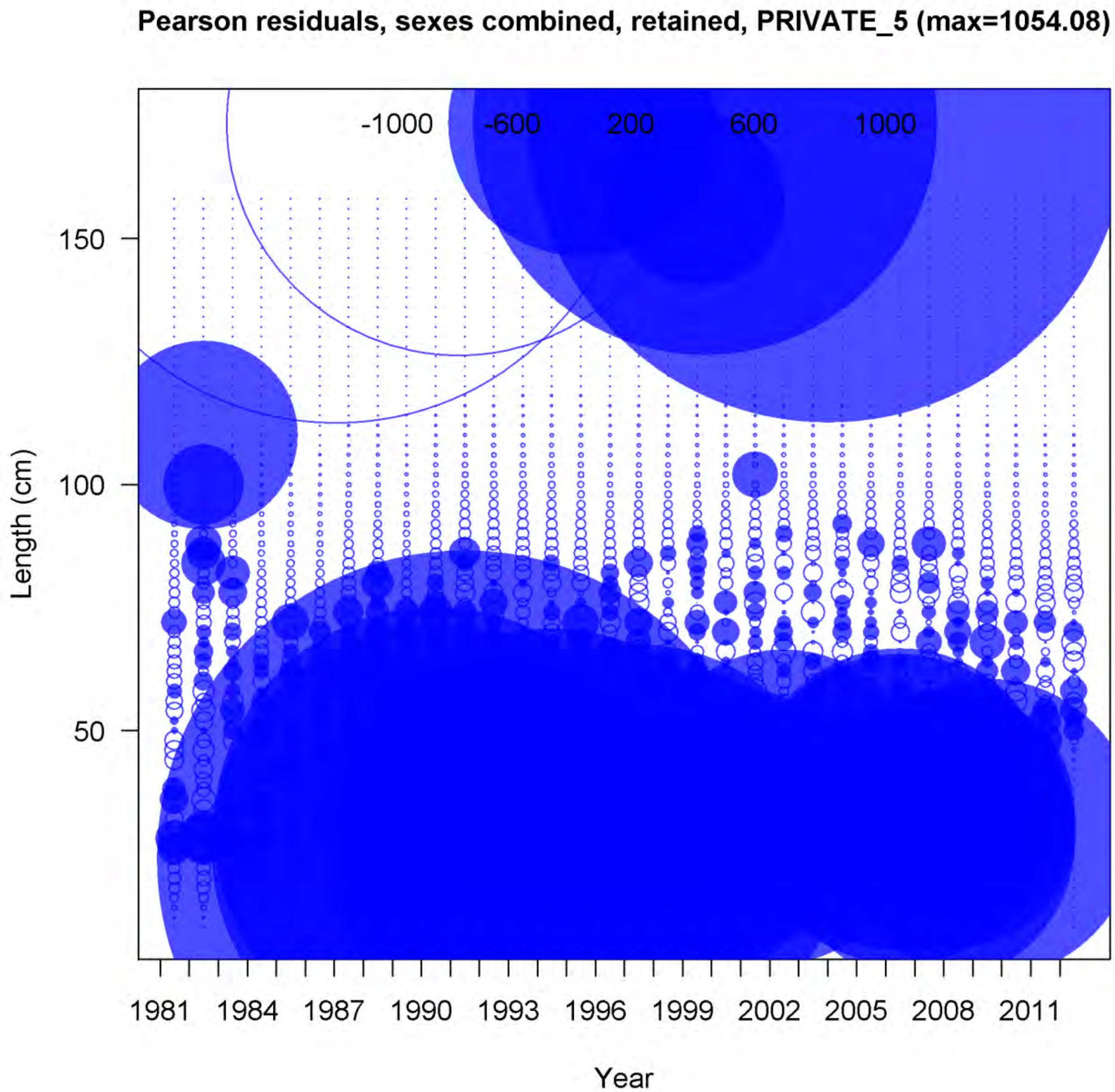


Figure 3.2.36. Pearson residuals for the length composition fit to private recreational landings. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

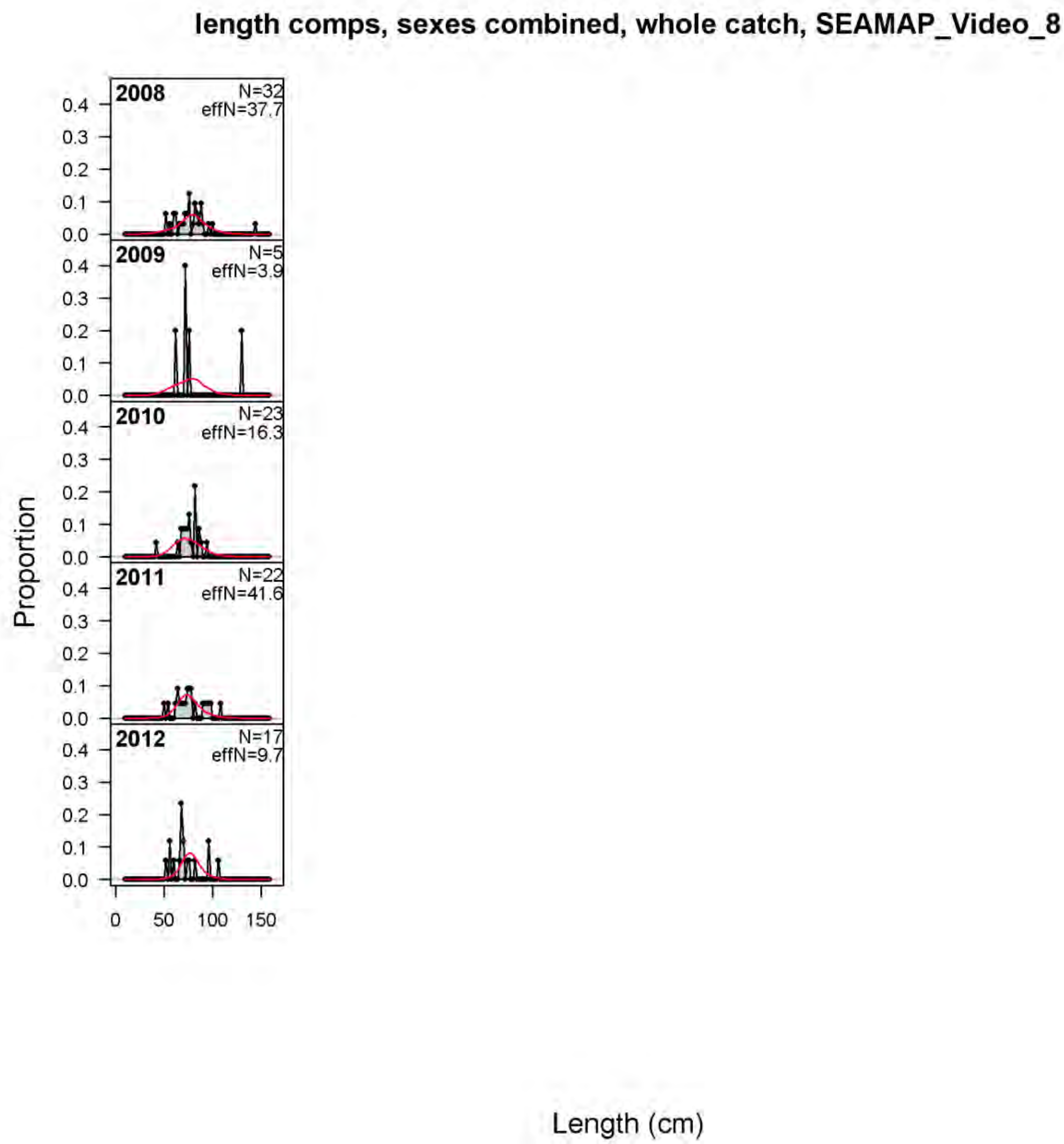


Figure 3.2.37. Observed and predicted length compositions of Gag Grouper from the SEAMAP video survey. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported.

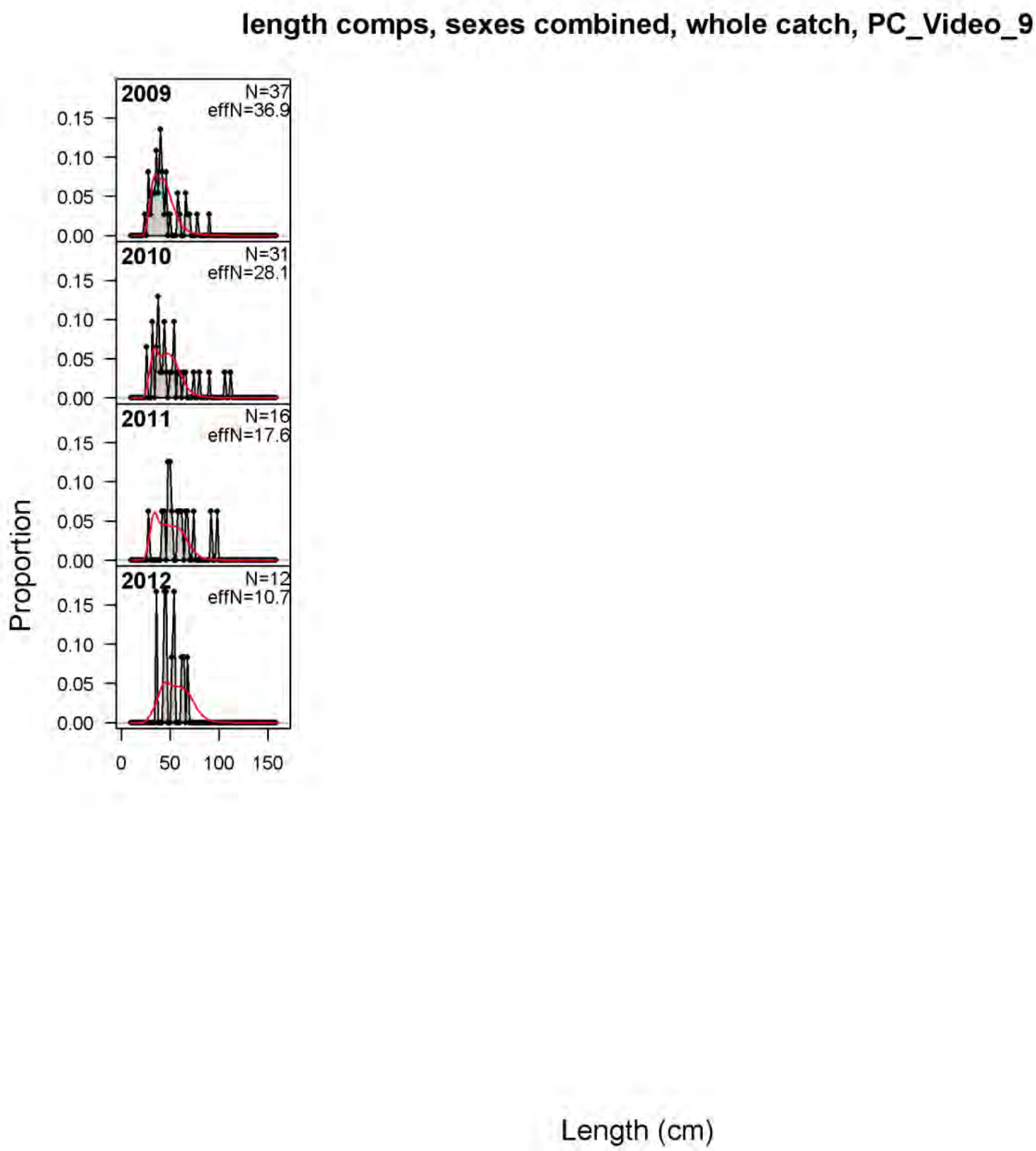


Figure 3.2.38. Observed and predicted length compositions of landings from the private recreational fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported.

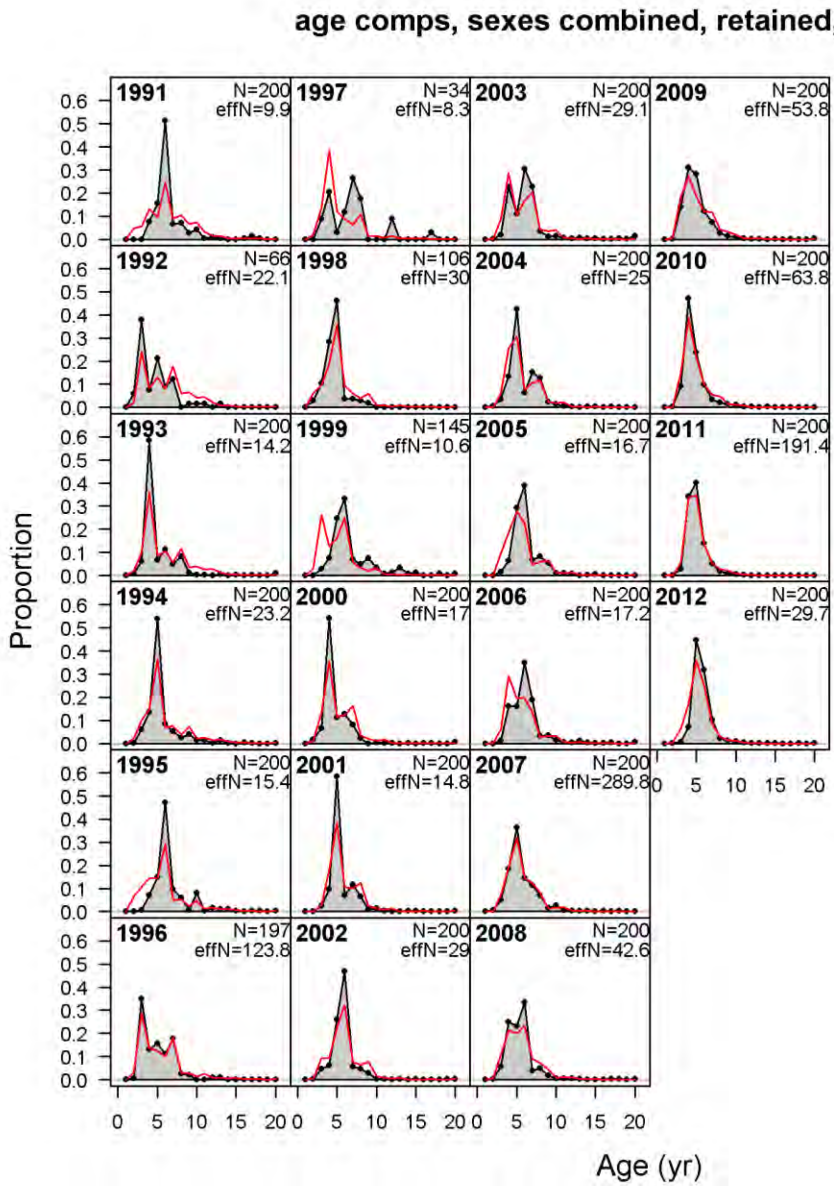


Figure 3.2.39. Observed and predicted annual age composition of landings from the commercial vertical line fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

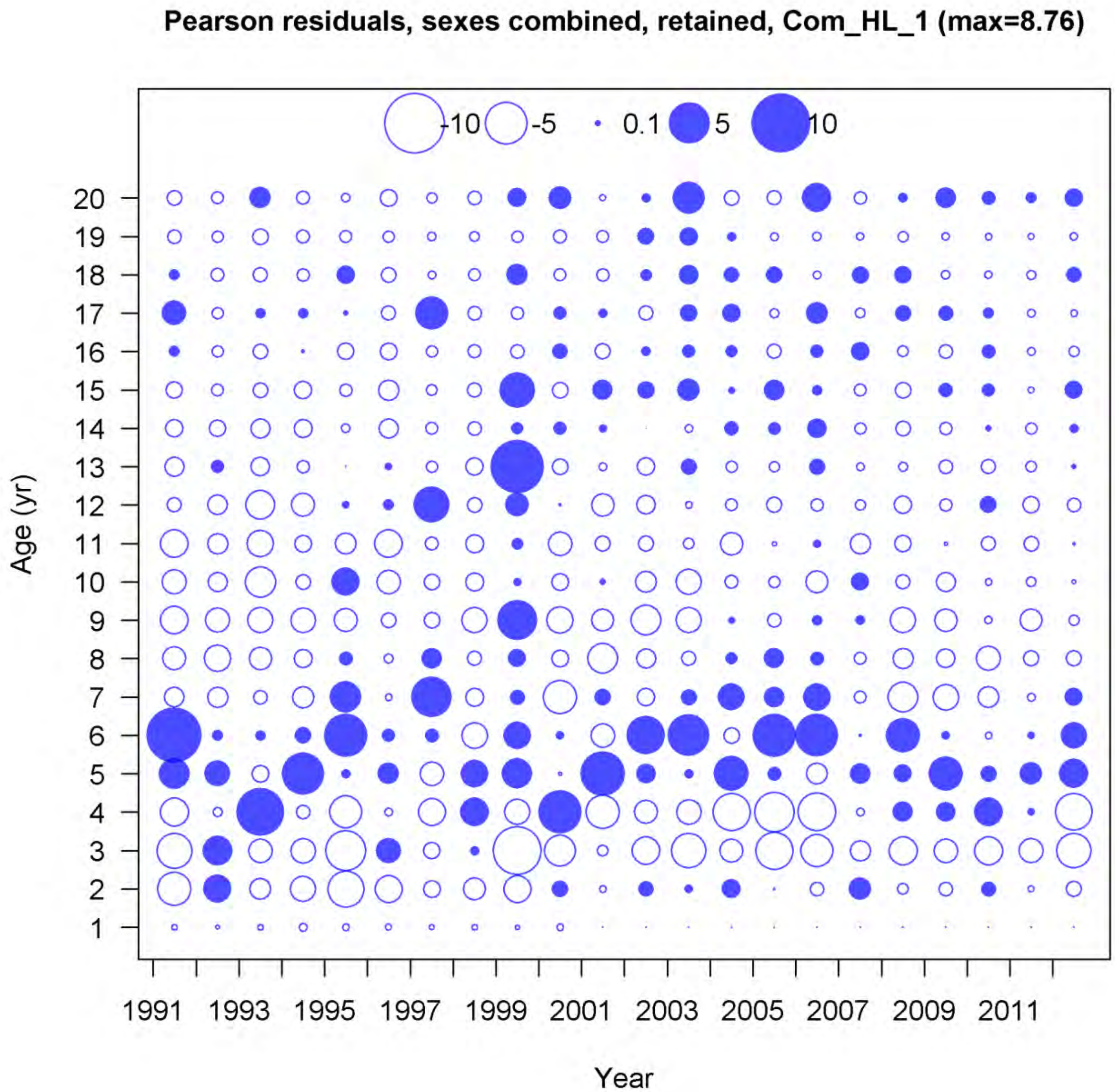


Figure 3.2.40. Pearson residuals for the age composition fit to commercial vertical line landings. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

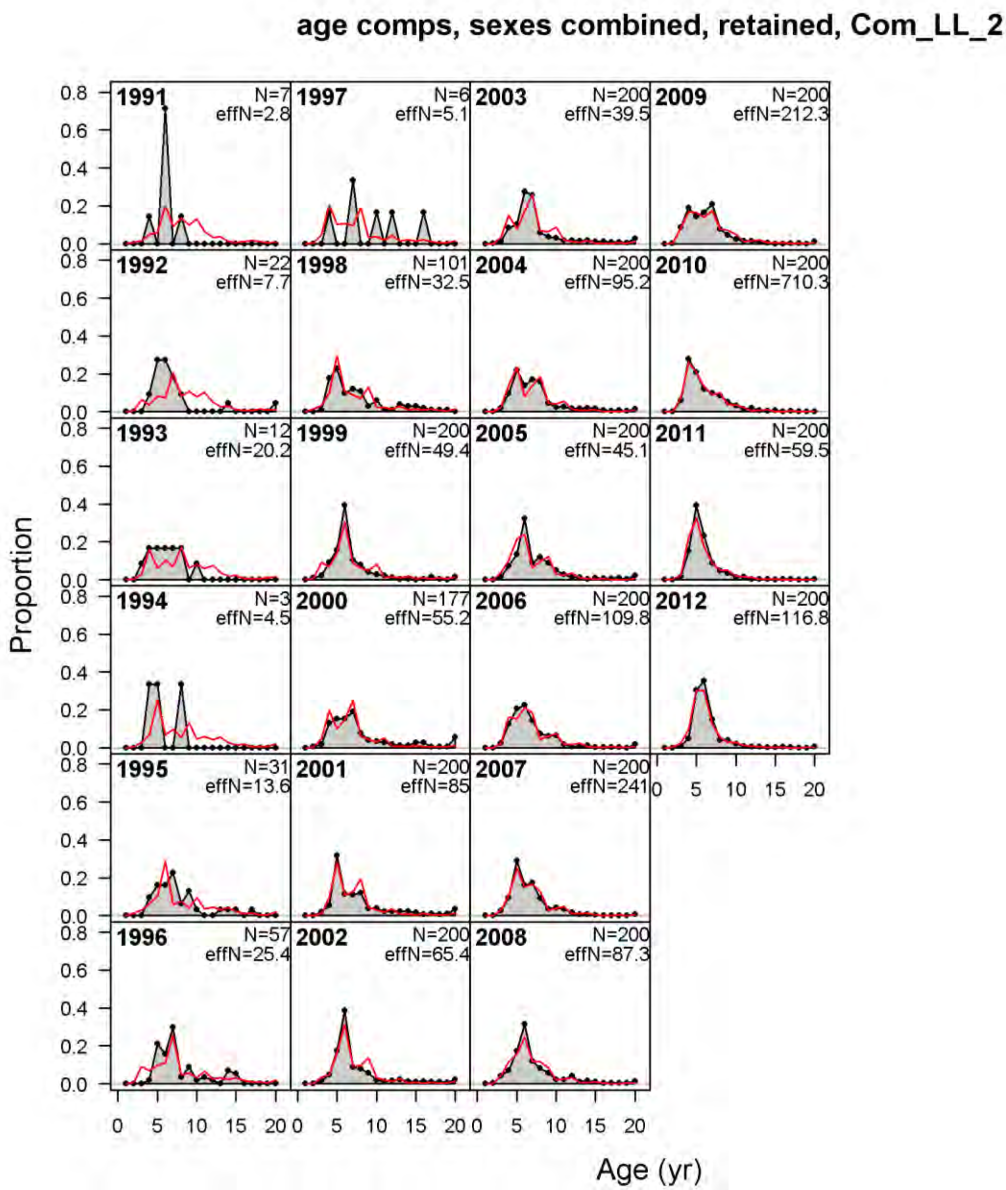


Figure 3.2.41. Observed and predicted annual age composition of landings from the commercial longline fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

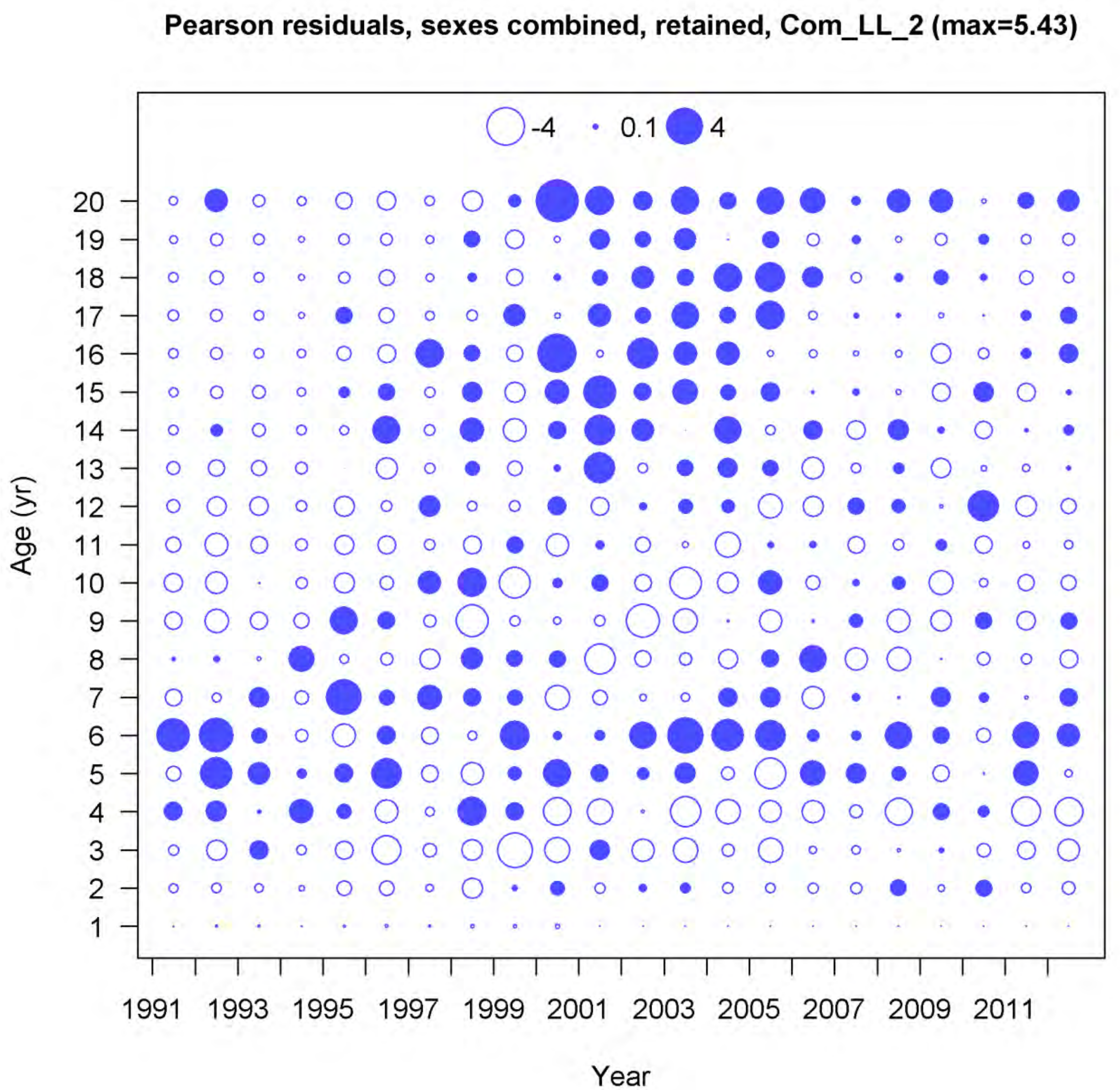


Figure 3.2.42. Pearson residuals for the age composition fit to commercial longline landings. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

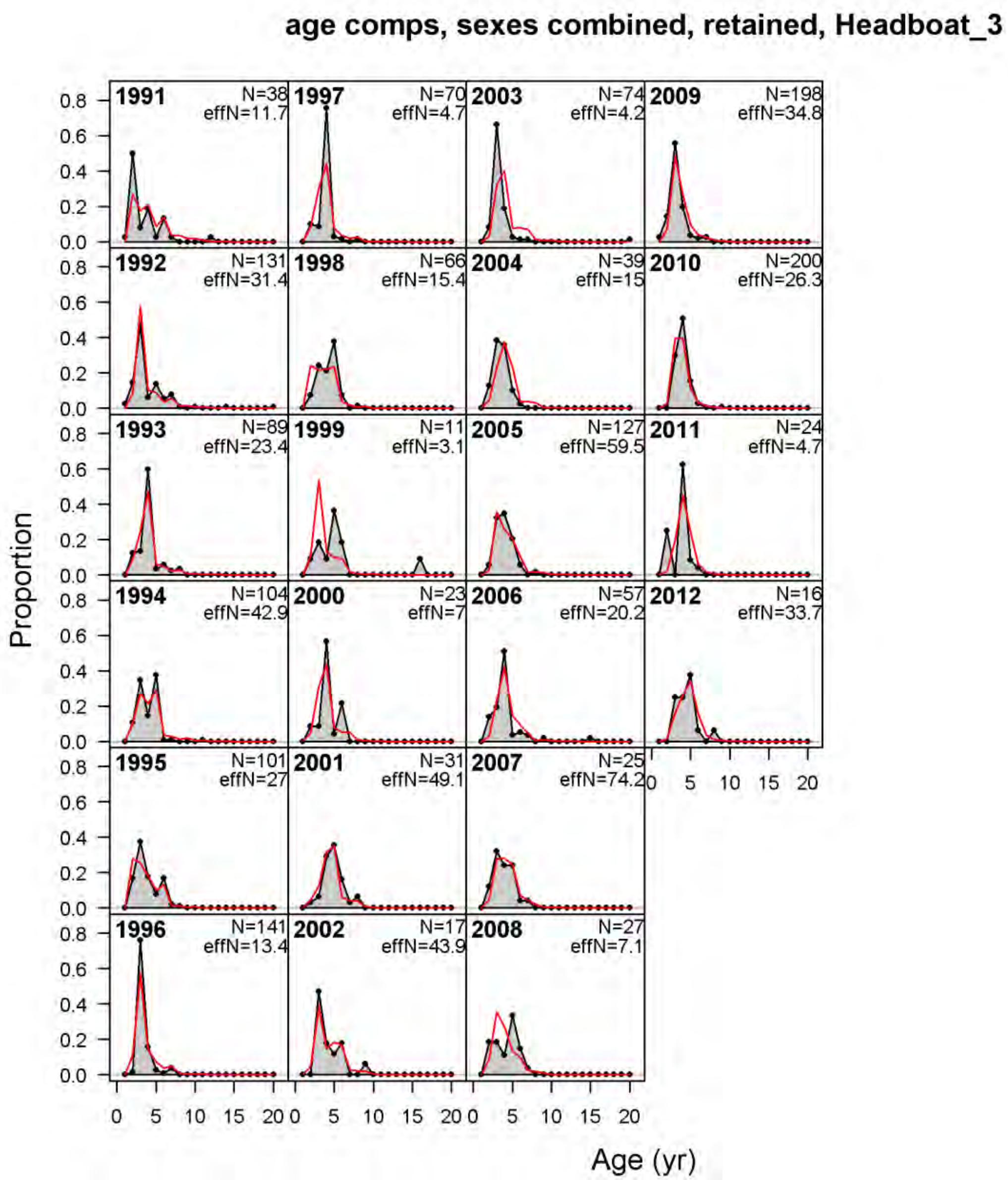


Figure 3.2.43. Observed and predicted annual age composition of landings from the recreational headboat fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

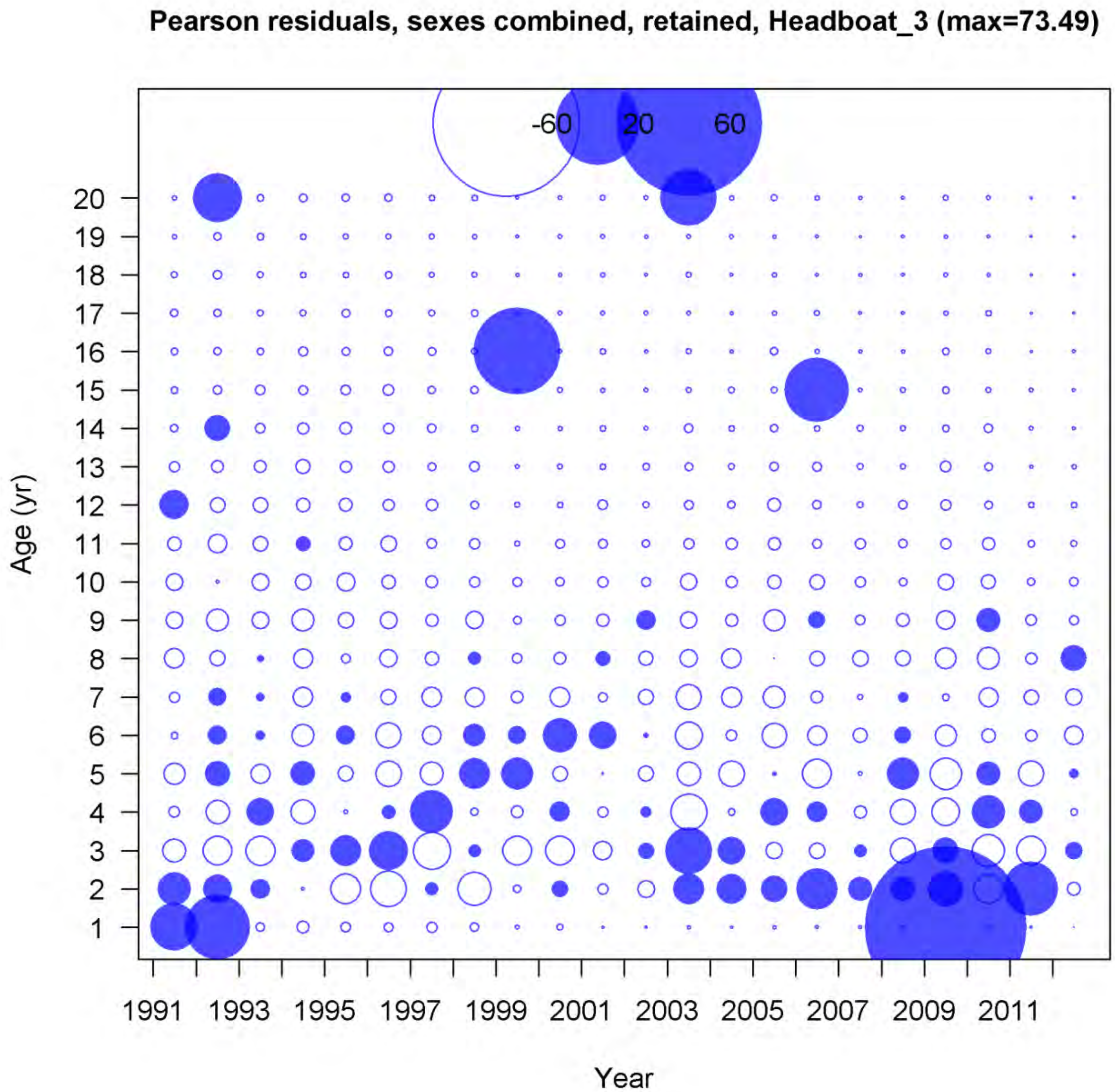


Figure 3.2.44. Pearson residuals for the age composition fit to recreational headboat landings. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

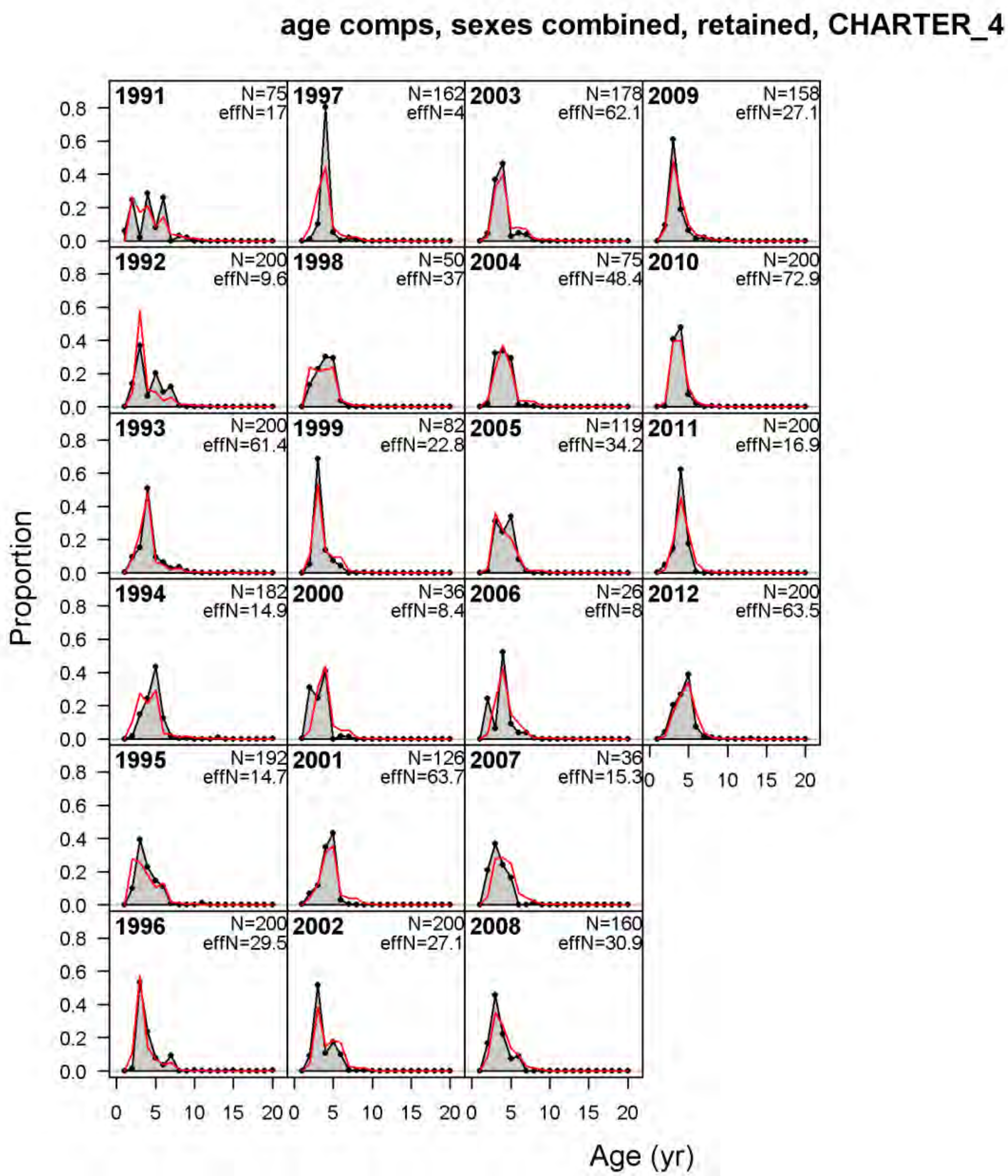


Figure 3.2.45. Observed and predicted annual age composition of landings from the recreational charterboat fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

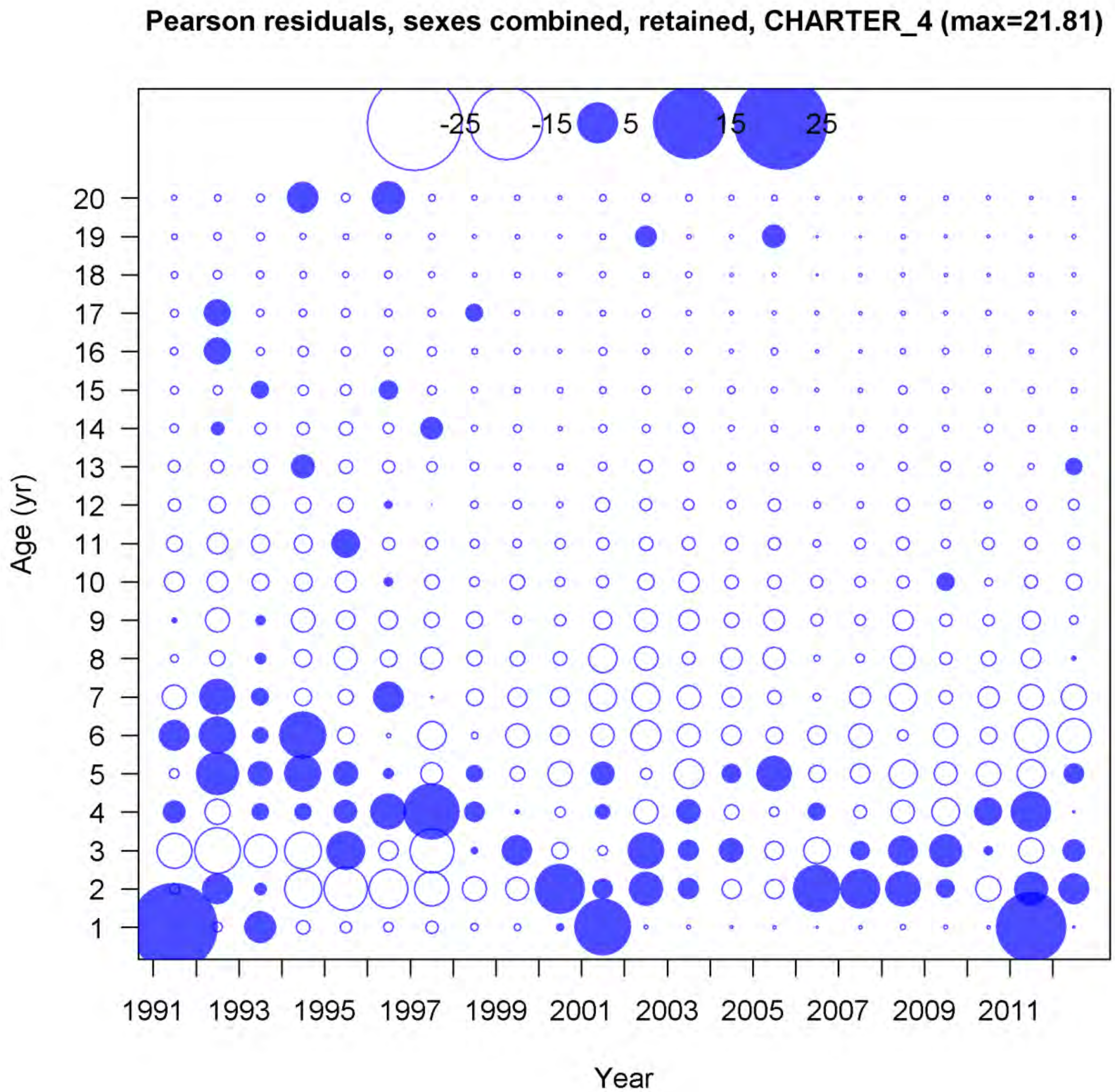


Figure 3.2.46. Pearson residuals for the age composition fit to recreational charterboat landings. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

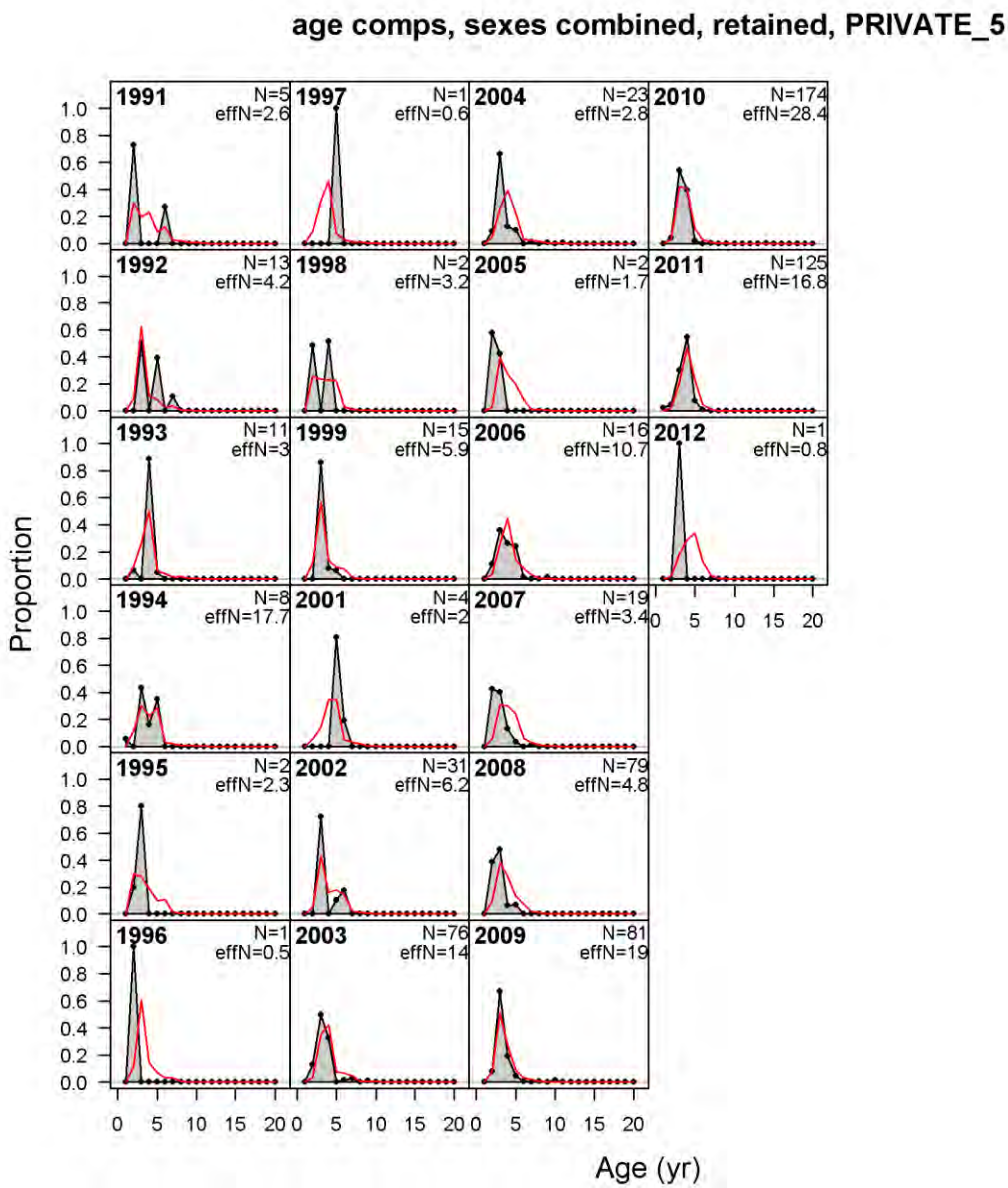


Figure 3.2.47. Observed and predicted annual age composition of landings from the private recreational fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

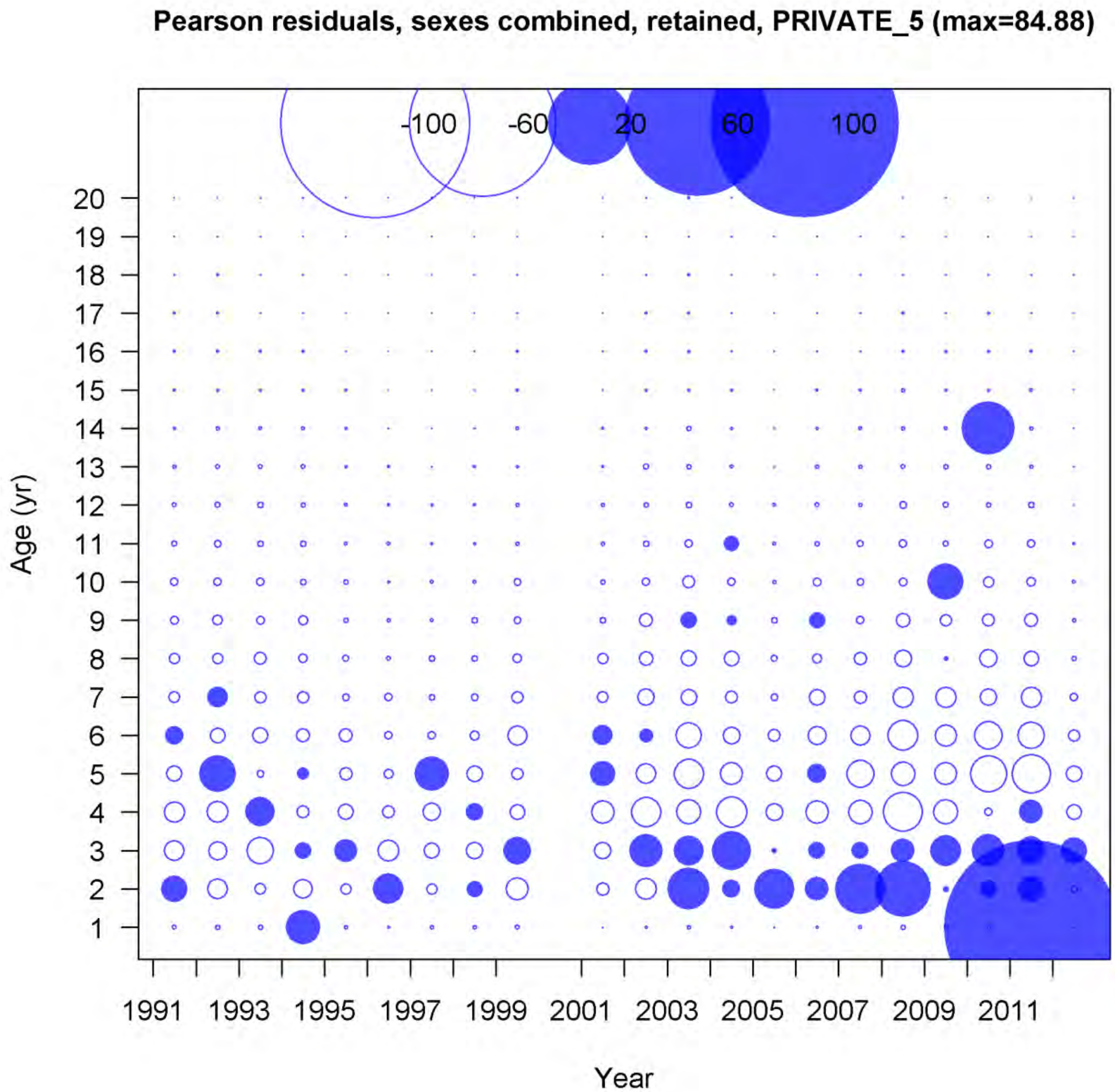


Figure 3.2.48. Pearson residuals for the age composition fit to private recreational landings. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

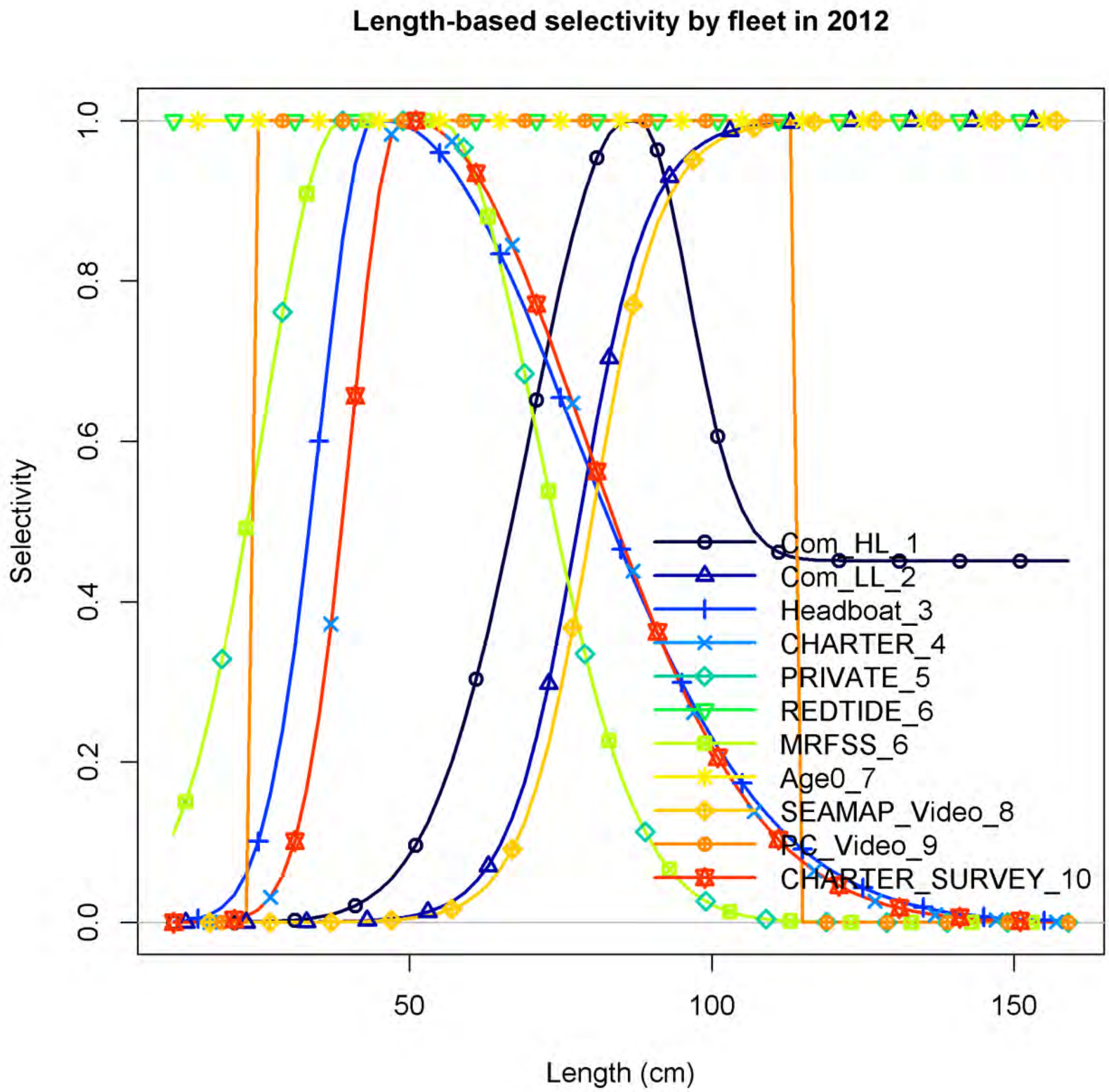


Figure 3.2.49. Estimated length-based selectivity patterns for the 5 fishing fleets and 2 fishery-independent surveys.

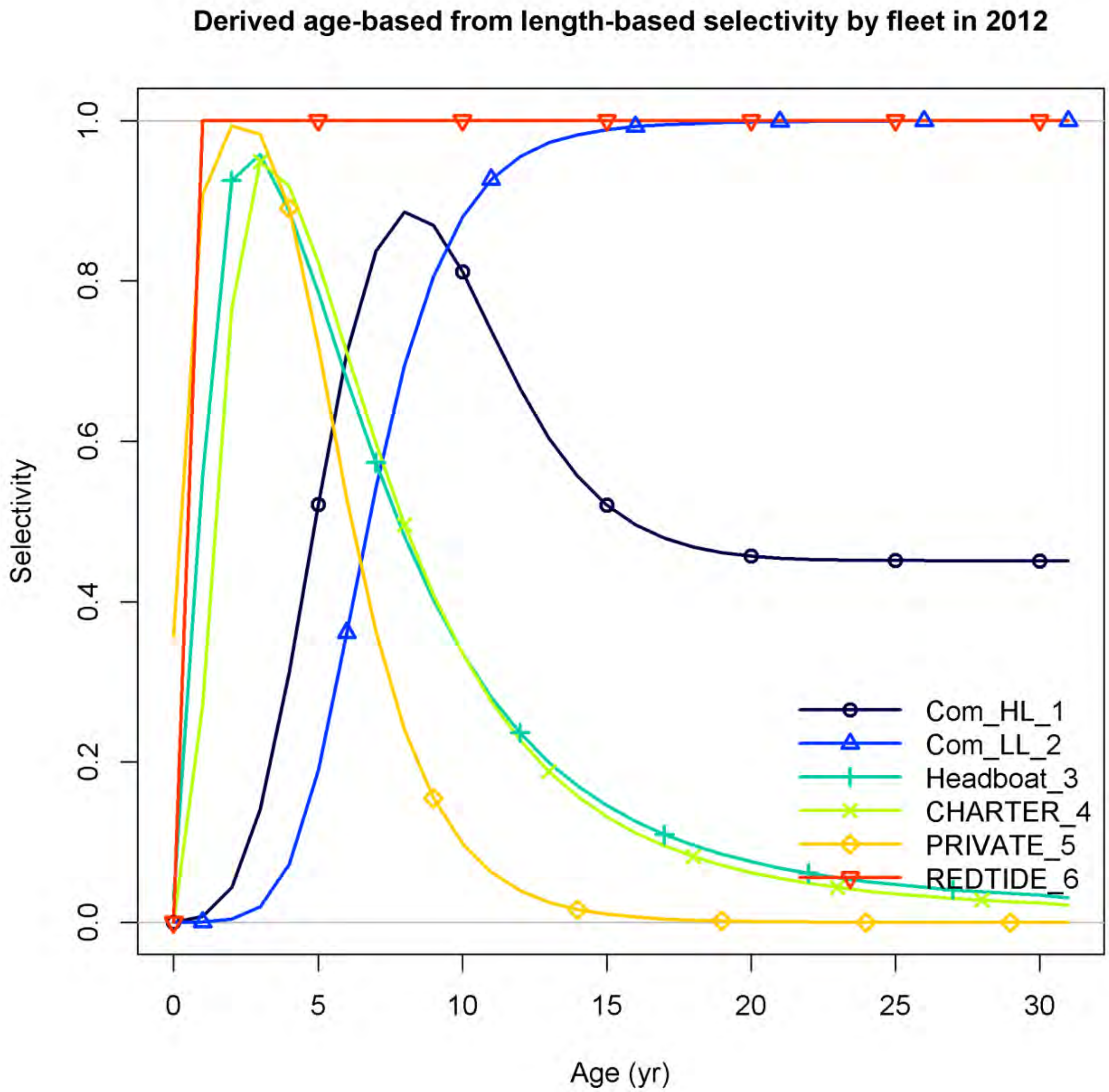


Figure 3.2.50. Derived age-based selectivity from estimated length-based selectivity patterns for the 5 fishing fleets.

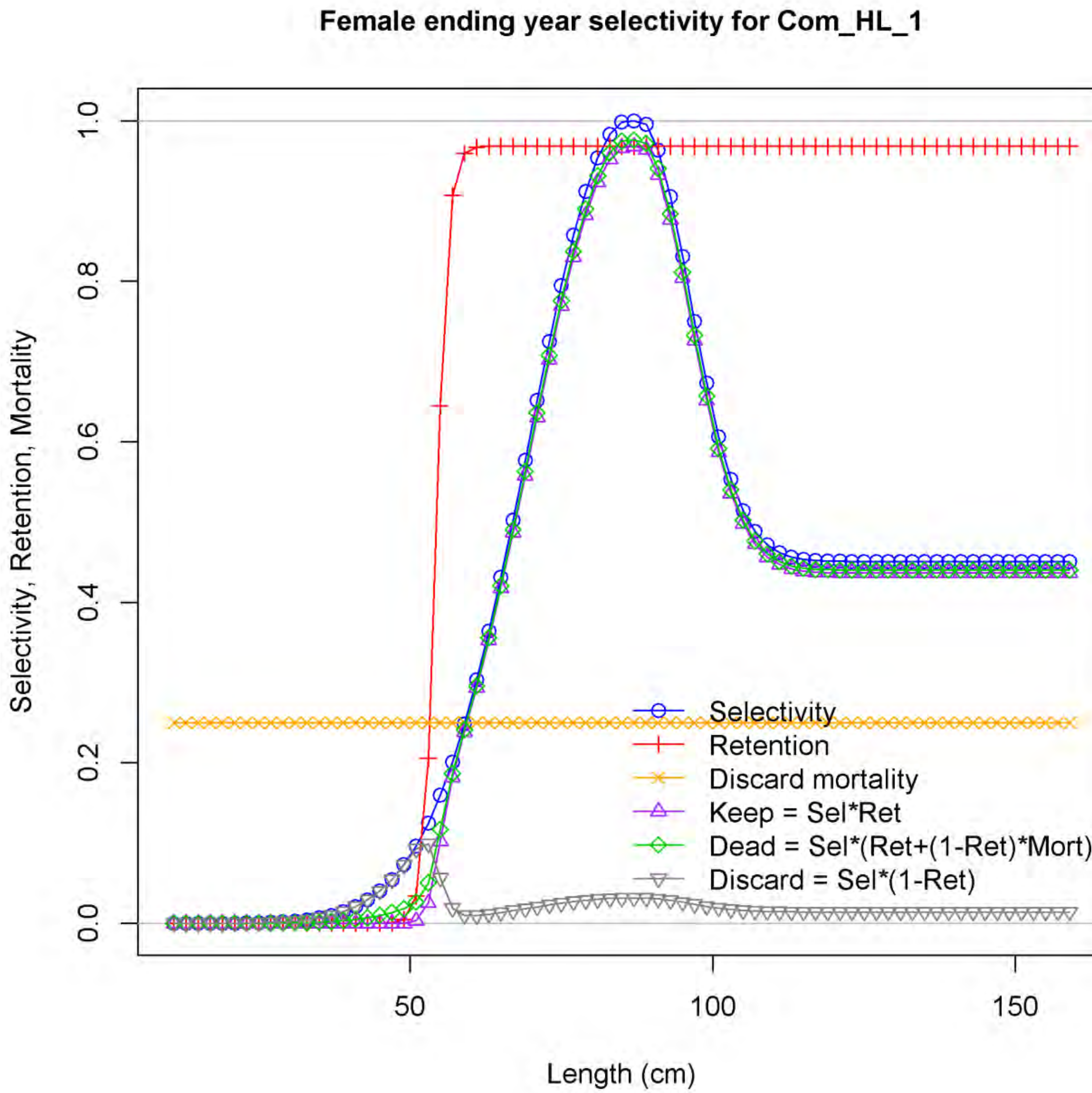


Figure 3.2.51. Length-based selectivity for the commercial vertical line fishery. Selectivity (blue line) is constant over the entire assessment time period (1963-2012). Retention (red line) is shown for time period 2012-2012. Discard mortality (orange line) is constant at 0.27.

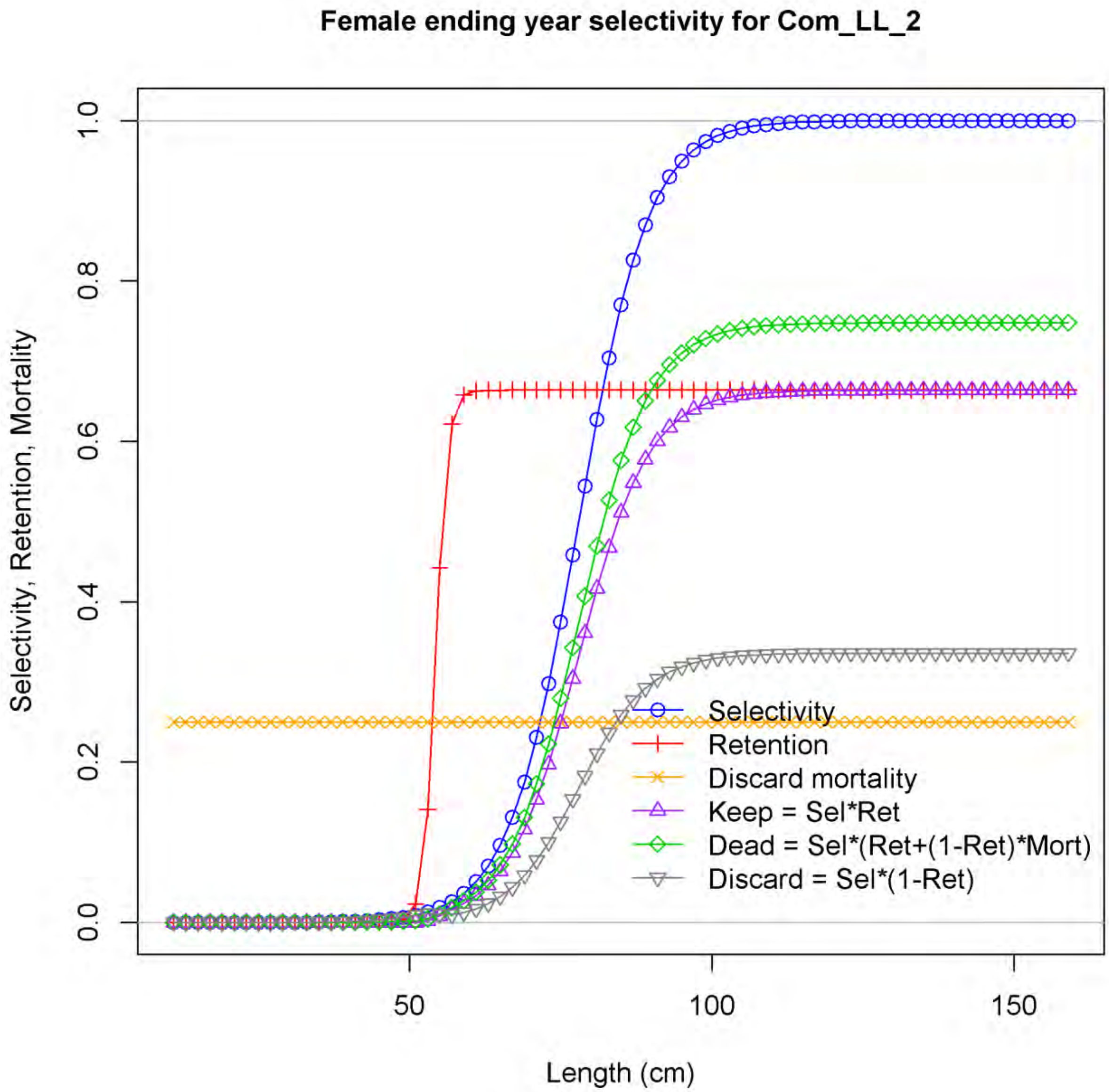


Figure 3.2.52. Length-based selectivity for the commercial longline fishery. Selectivity (blue line) is constant over the entire assessment time period (1963-2012). Retention (red line) is shown for time period 2012-2012. Discard mortality (orange line) is constant at 0.27.

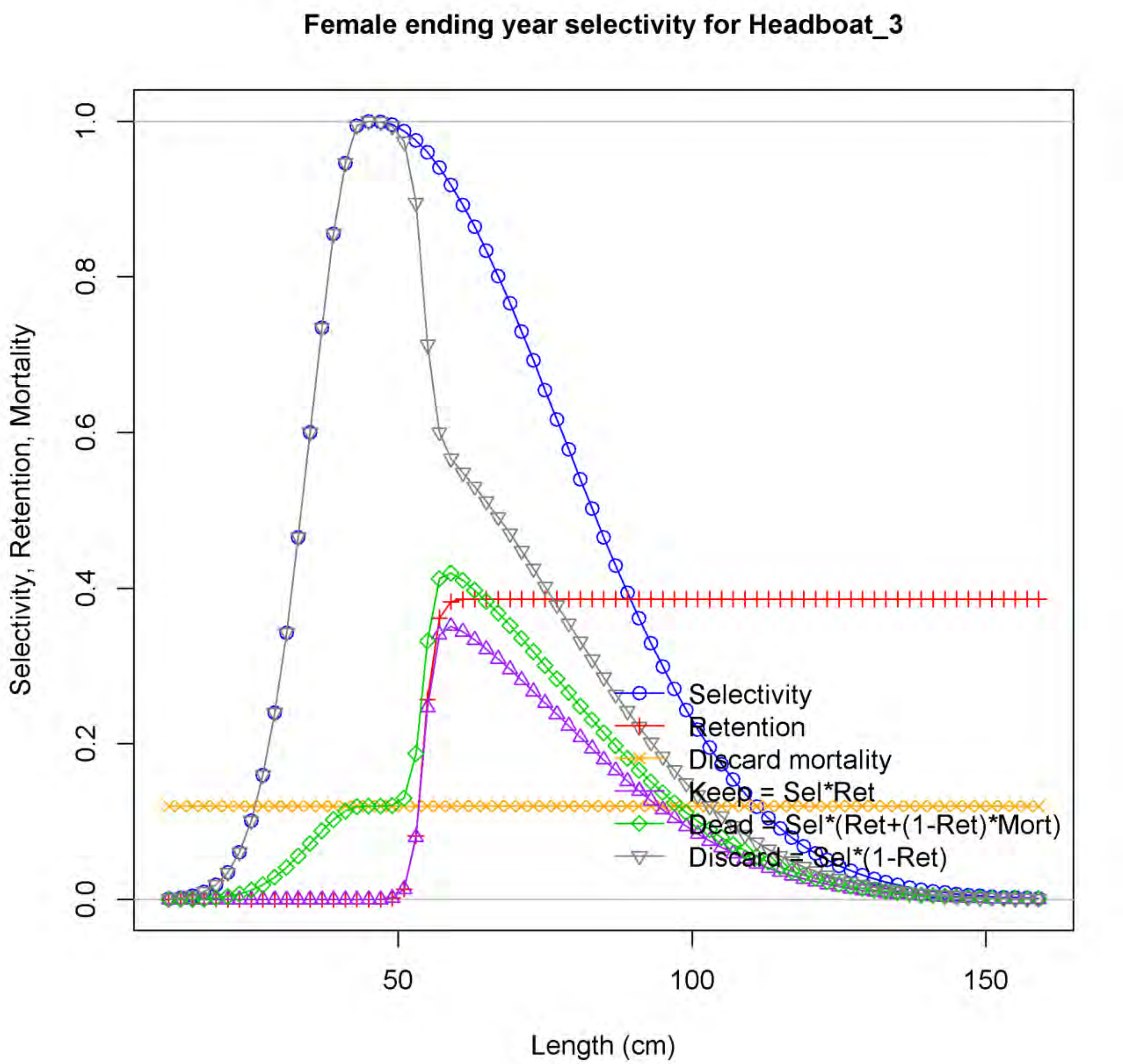


Figure 3.2.53. Length-based selectivity for the recreational headboat fishery. Selectivity (blue line) is constant over the entire assessment time period (1963-2012). Retention (red line) is shown for time period 2012-2012. Discard mortality (orange line) is constant at 0.27.

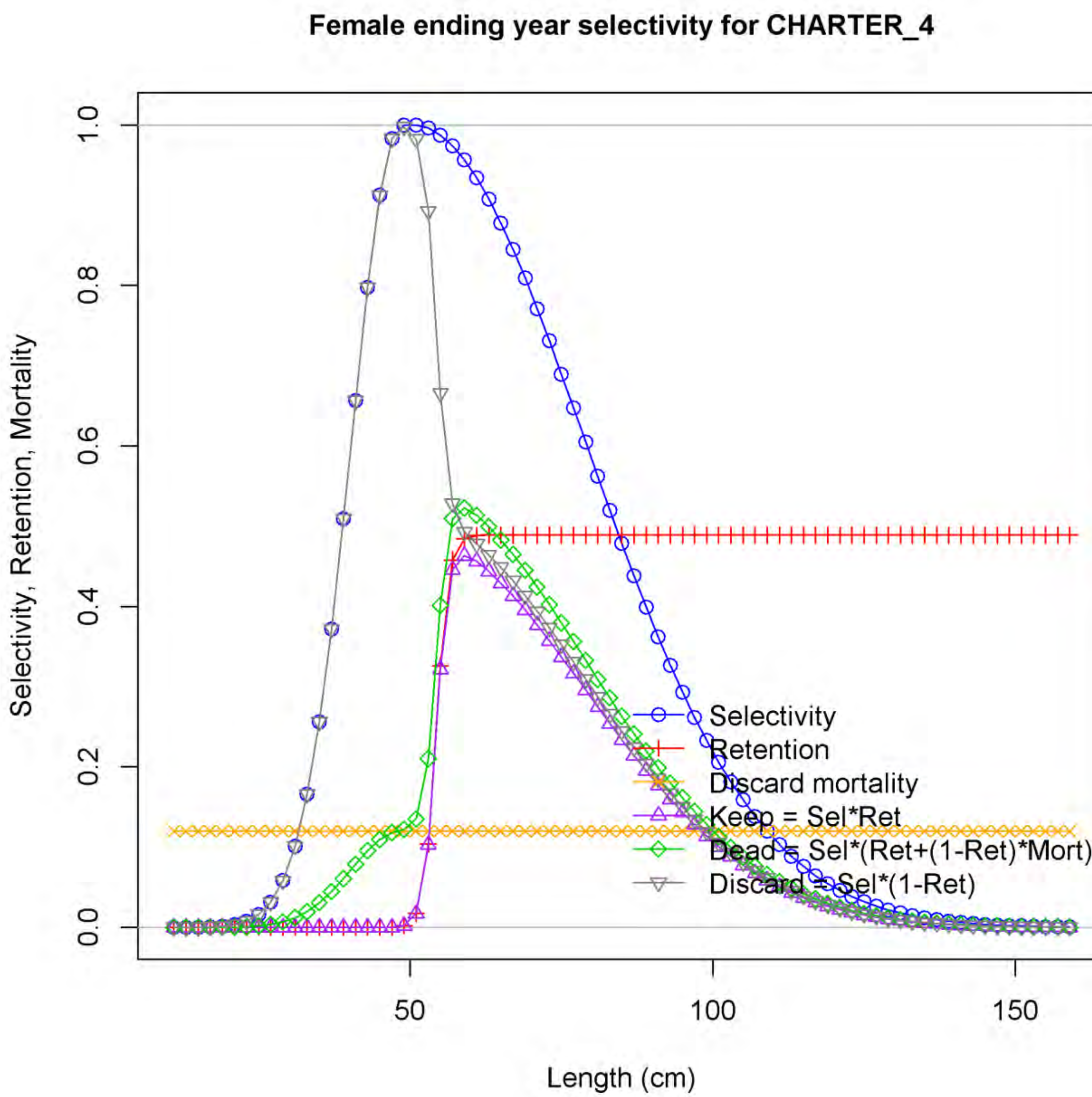


Figure 3.2.54. Length-based selectivity for the recreational charter fishery. Selectivity (blue line) is constant over the entire assessment time period (1963-2012). Retention (red line) is shown for time period 2012-2012. Discard mortality (orange line) is constant at 0.27.

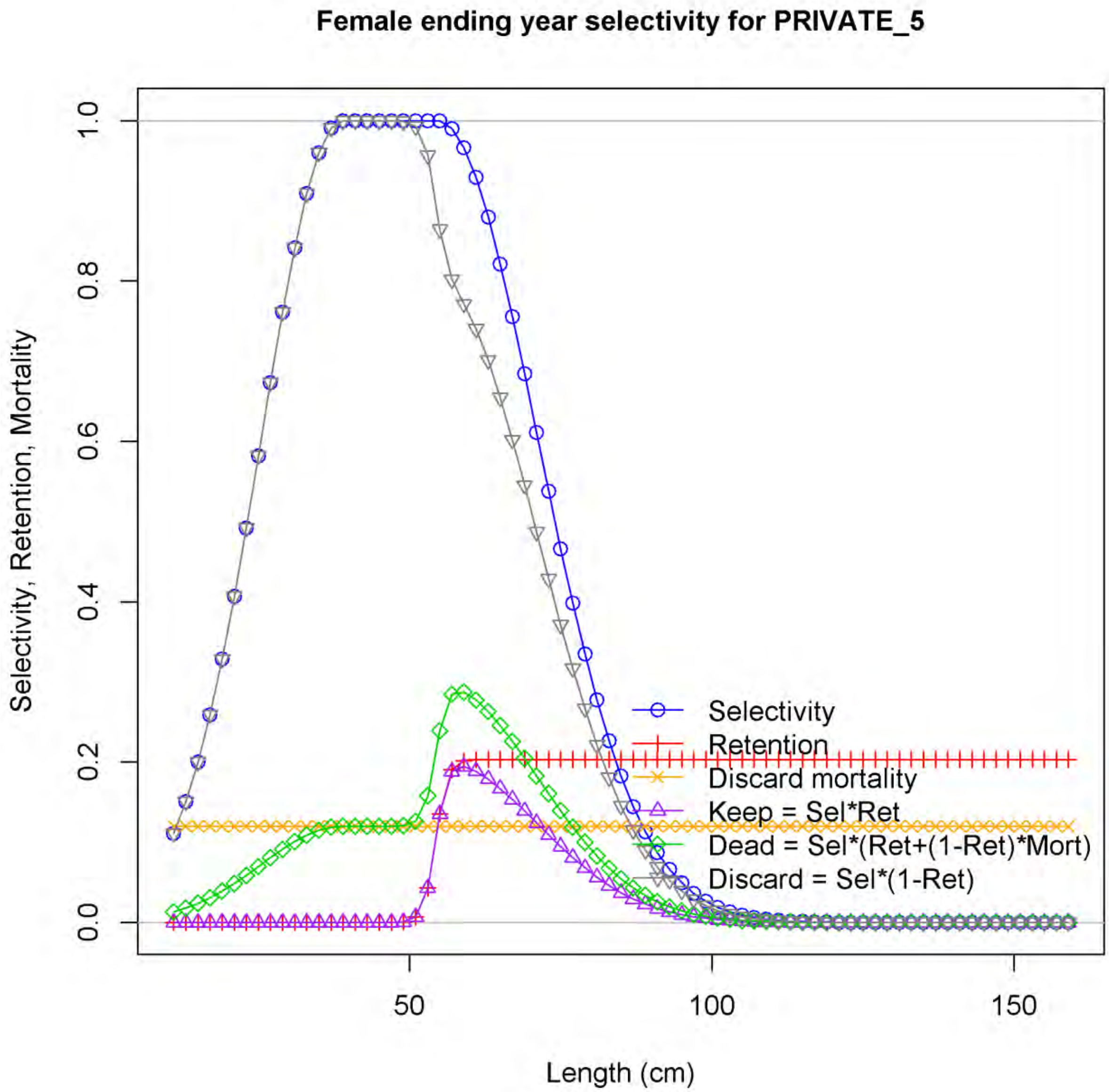


Figure 3.2.55. Length-based selectivity for the private recreational fishery. Selectivity (blue line) is constant over the entire assessment time period (1963-2012). Retention (red line) is shown for time period 2012-2012. Discard mortality (orange line) is constant at 0.27.

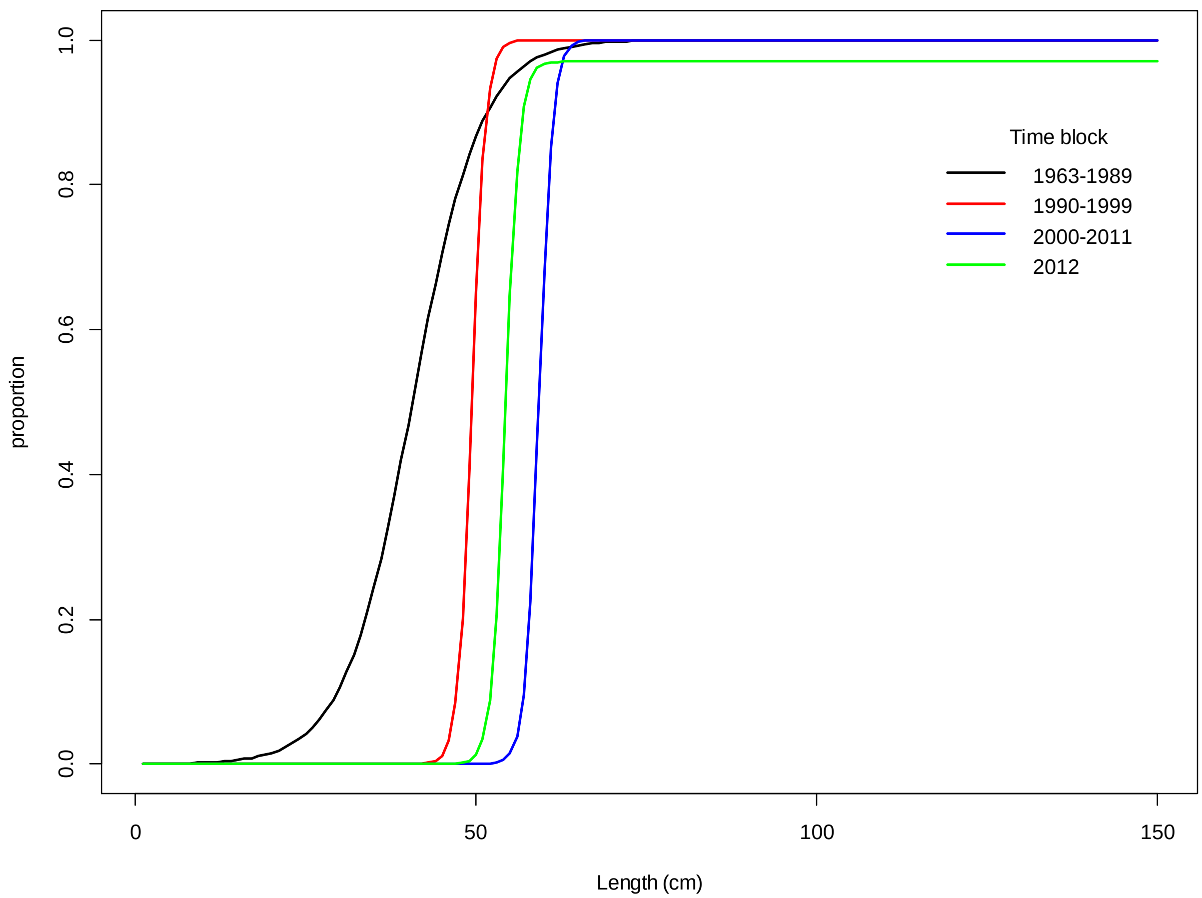


Figure 3.2.56. Retention patterns for the commercial vertical line fishery for the four time blocks modeled.

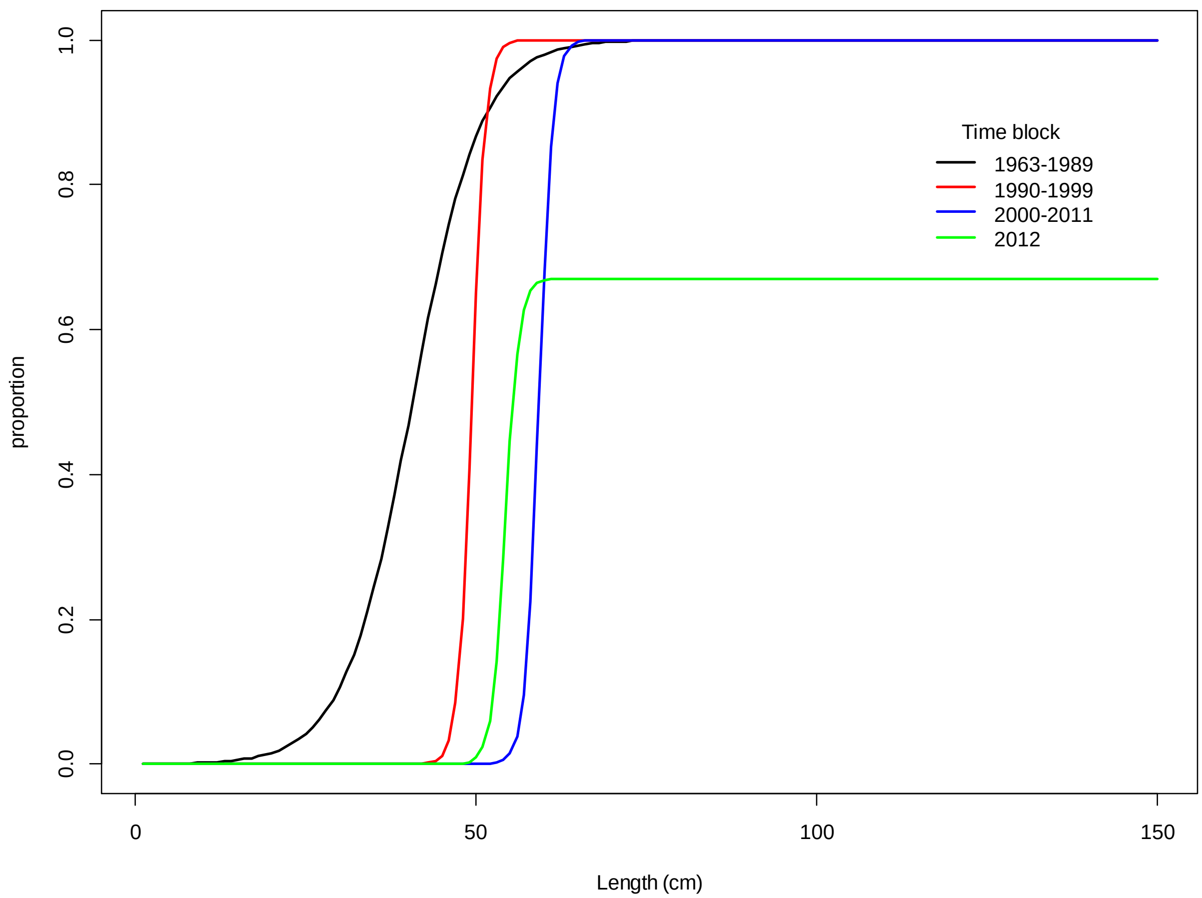


Figure 3.2.57. Retention patterns for the commercial longline fishery for the four time blocks modeled.

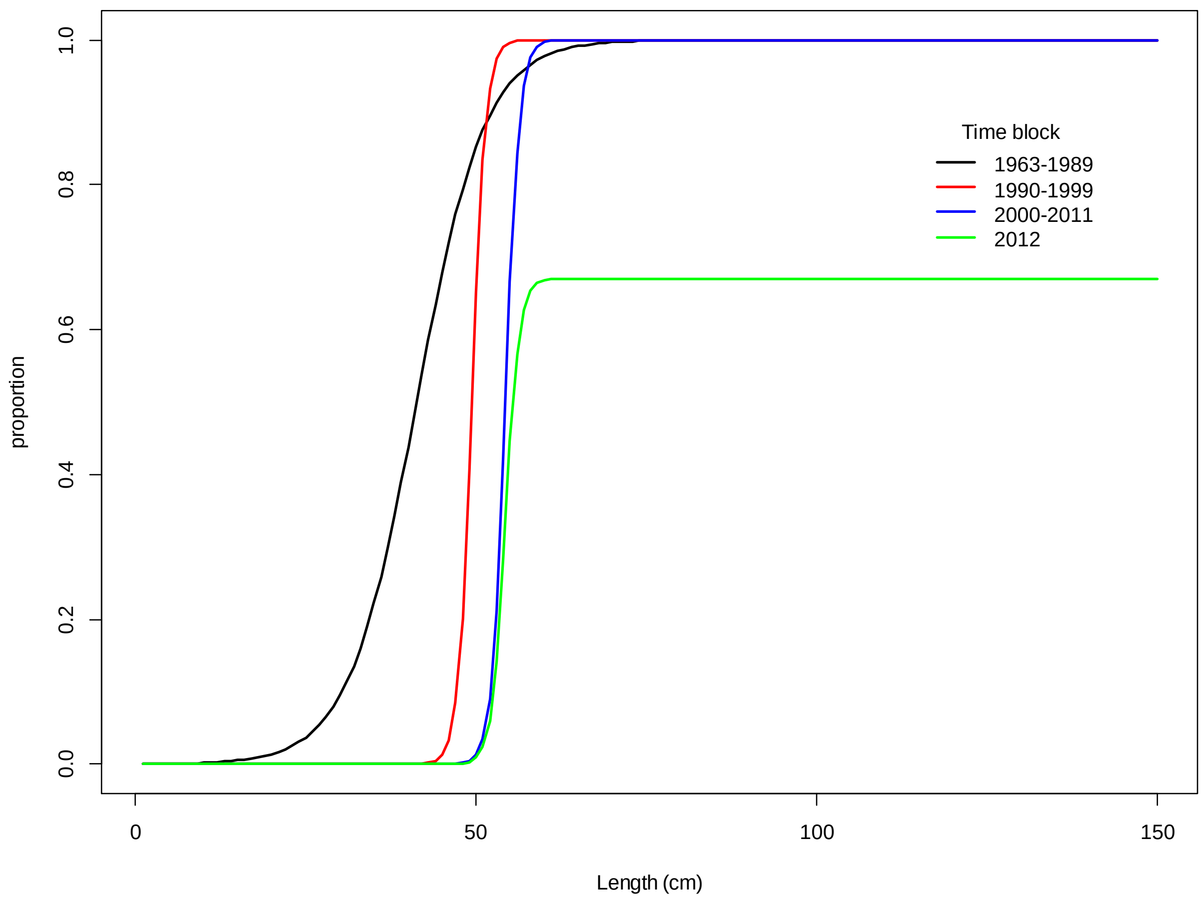


Figure 3.2.58. Retention patterns for the recreational headboat fishery for the four time blocks modeled.

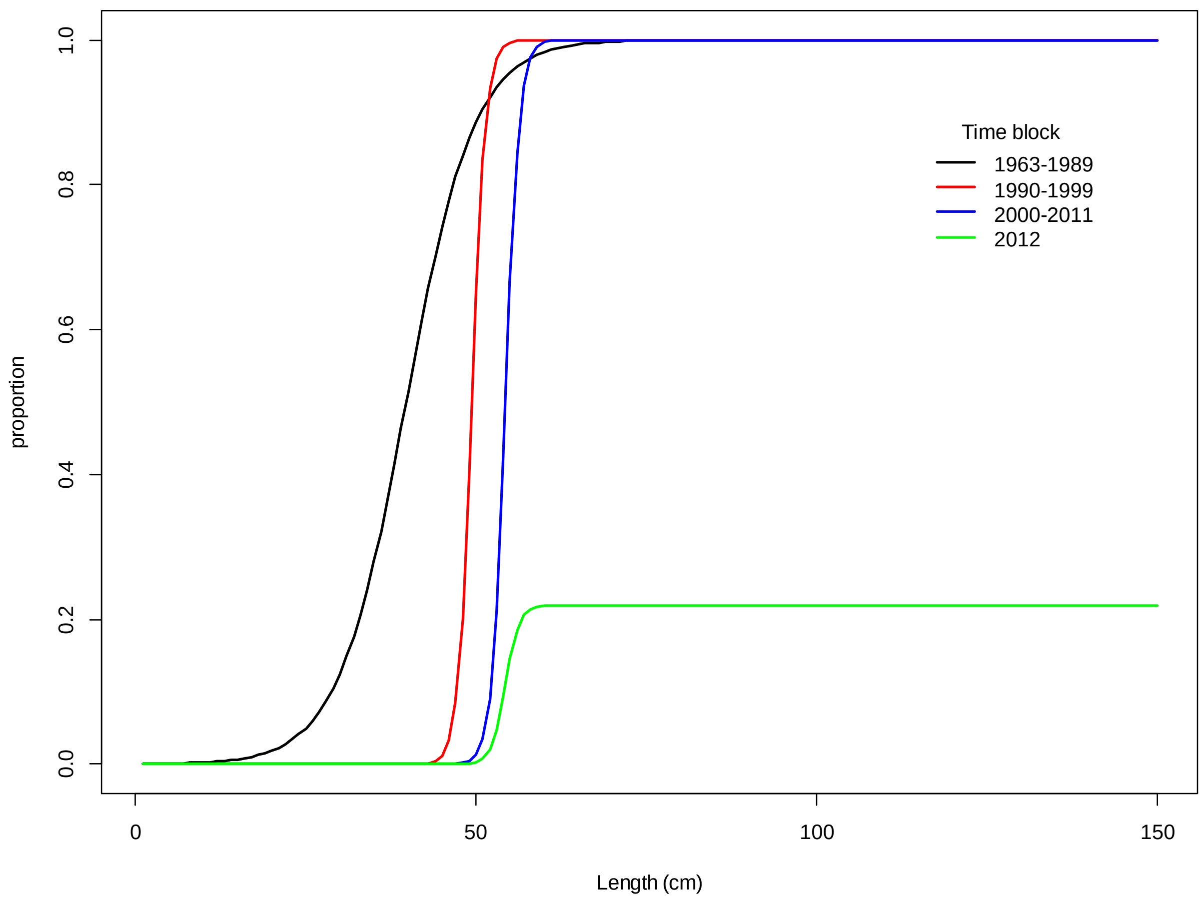


Figure 3.2.59. Retention patterns for the recreational charter fishery for the four time blocks modeled.

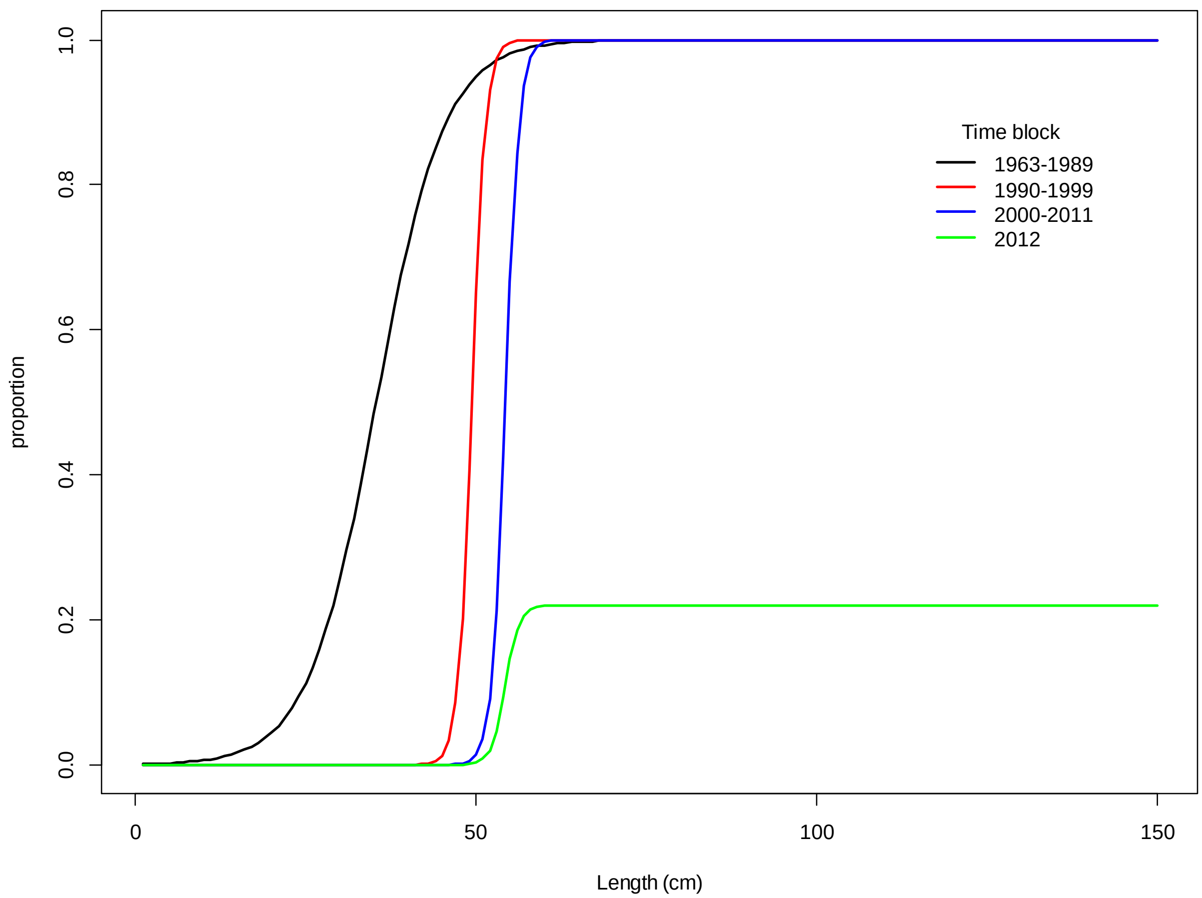


Figure 3.2.60. Retention patterns for the private recreational fishery for the four time blocks modeled.

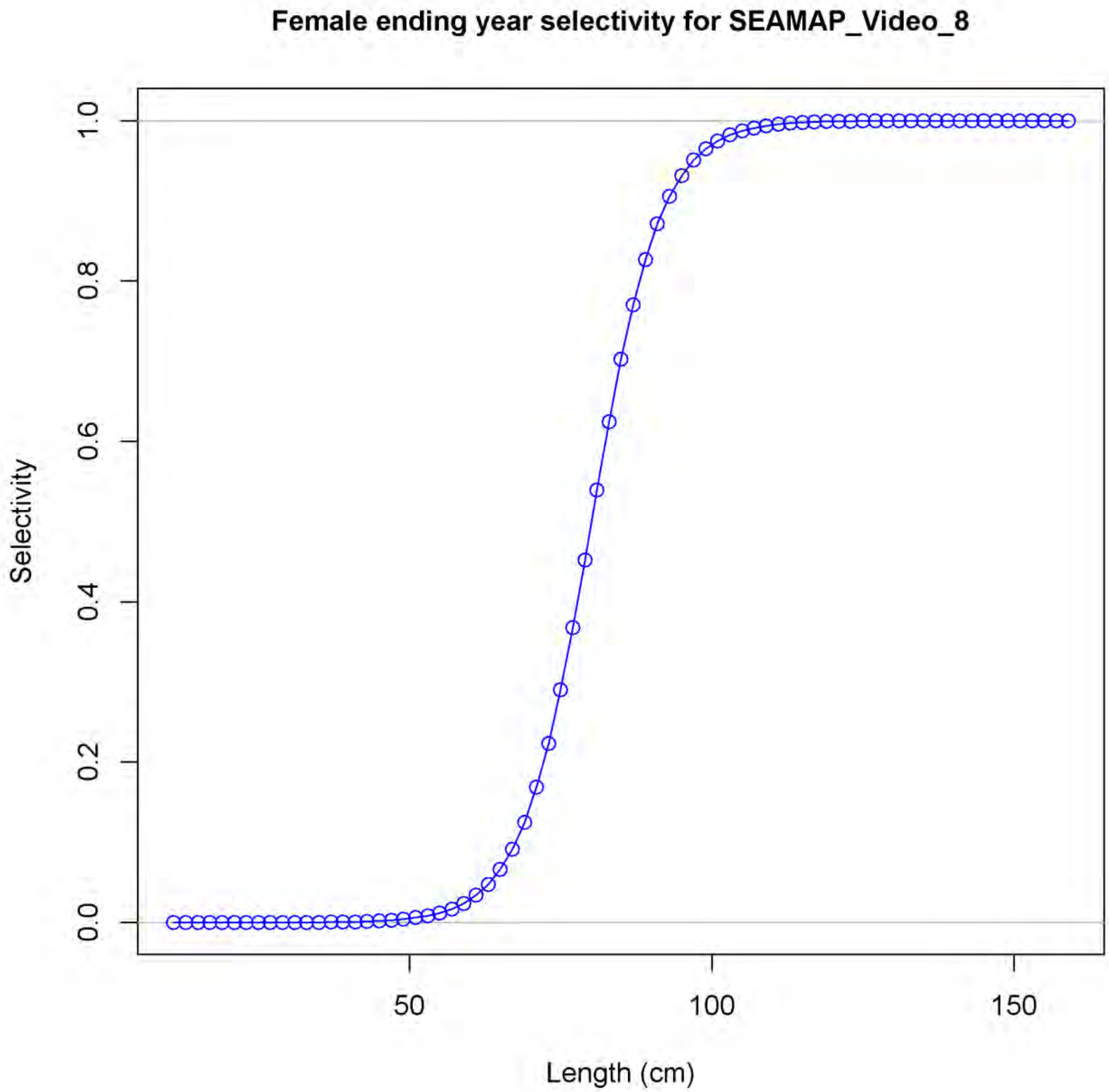


Figure 3.2.61. Length-based selectivity for the SEAMAP video survey.

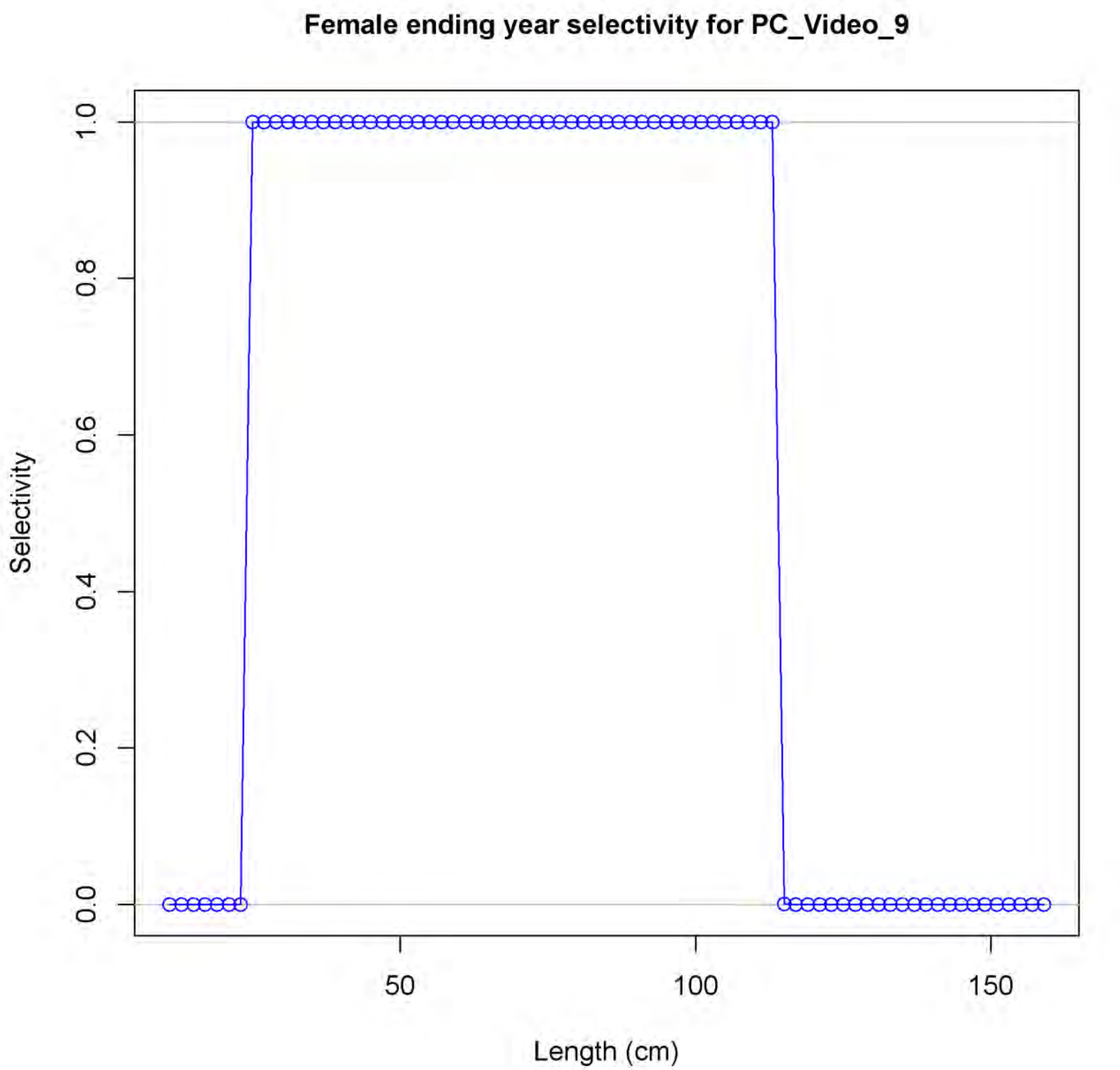


Figure 3.2.62. Length-based selectivity for the PC Lab video survey.

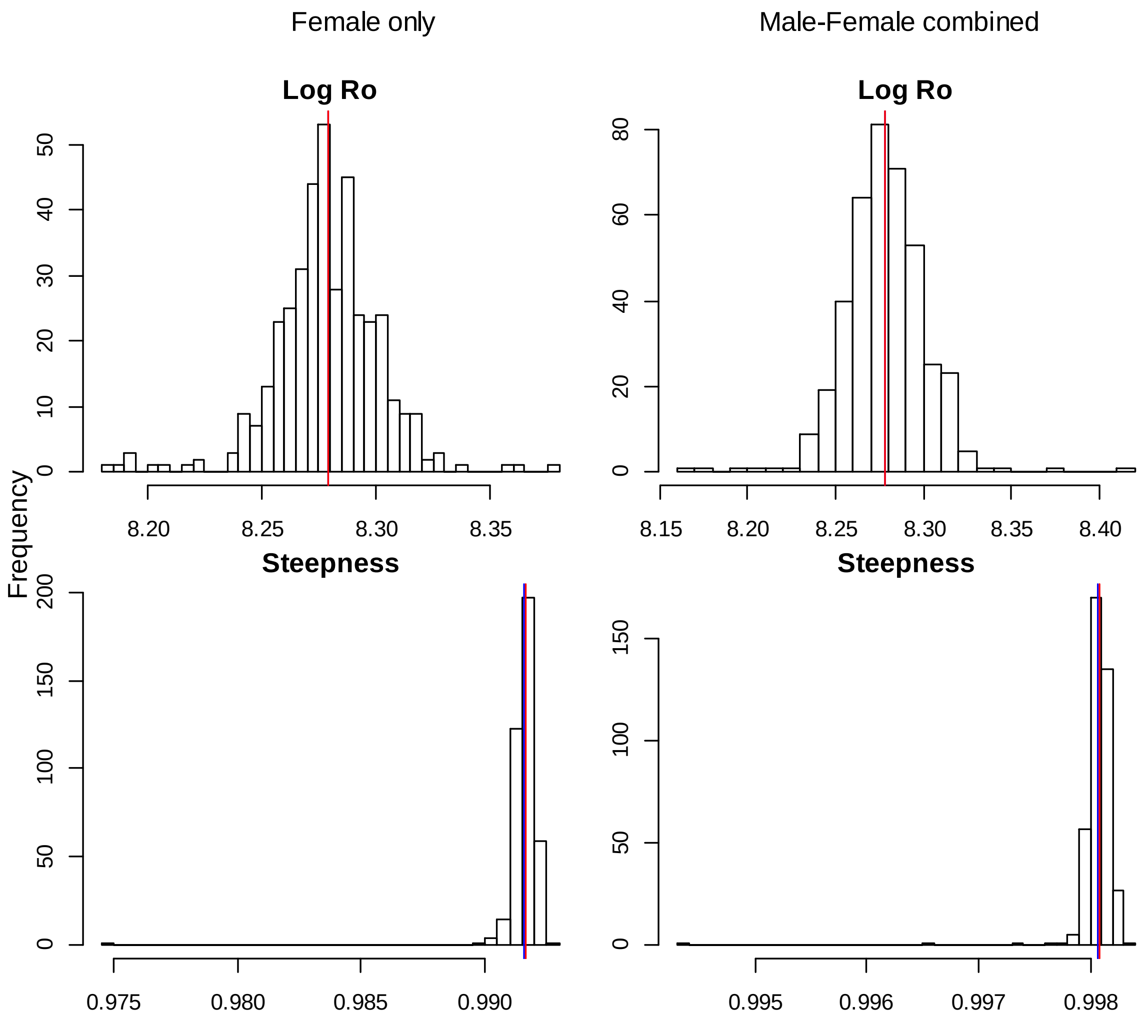


Figure 3.2.63. Distribution of estimated equilibrium recruitment and steepness from 400 bootstrap samples. The blue line represents the mean estimate from the bootstrap samples.

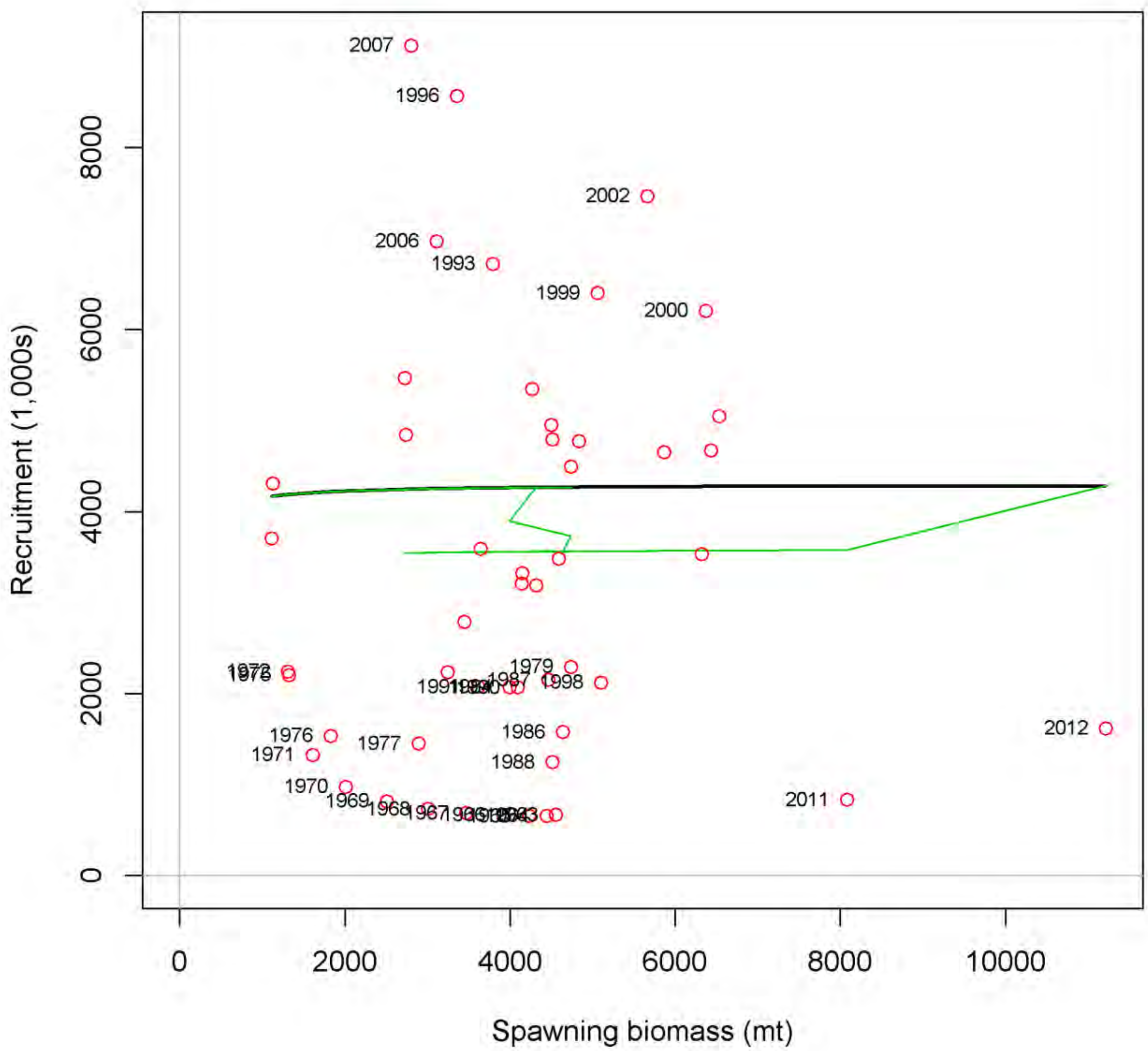


Figure 3.2.64. Predicted stock-recruitment relationship for Gulf of Mexico Gag Grouper for the central model. Plotted are predicted annual recruitments from SS (circles), expected recruitment from the stock-recruit relationship (black line), and bias adjusted recruitment from the stock-recruit relationship (green line).

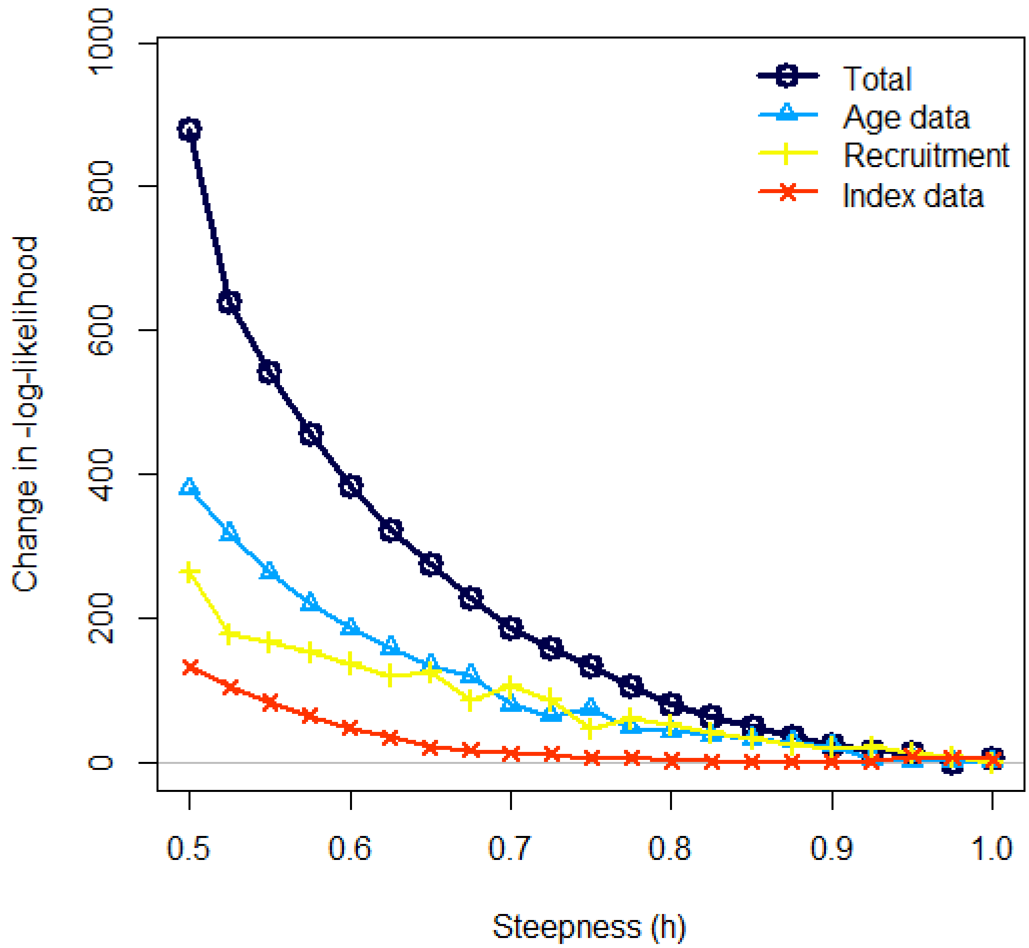


Figure 3.2.65. Likelihood profile for steepness at intervals of 0.025.

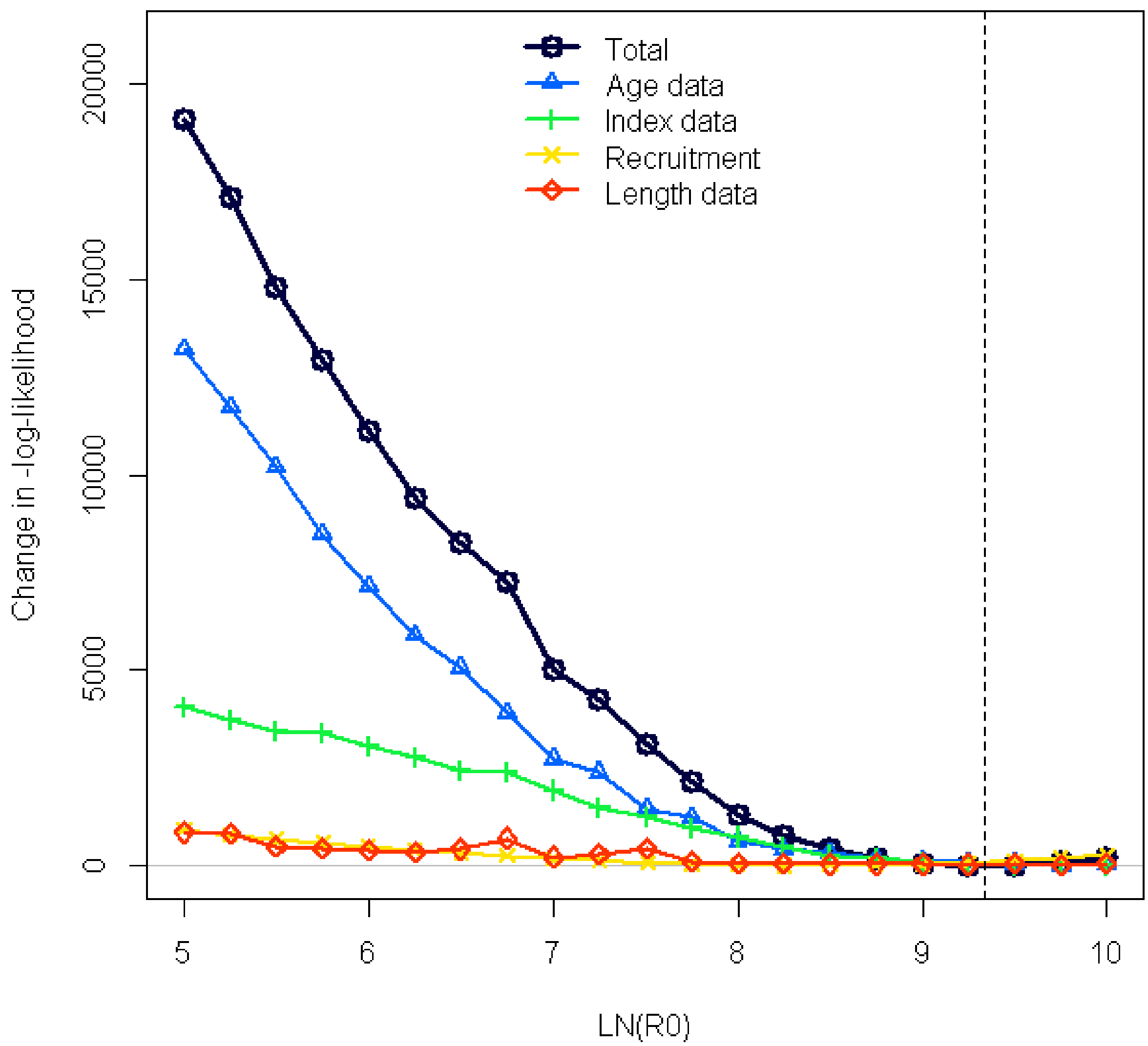


Figure 3.2.66. Likelihood profile for equilibrium recruitment. The dotted line represents the point estimate from the base model.

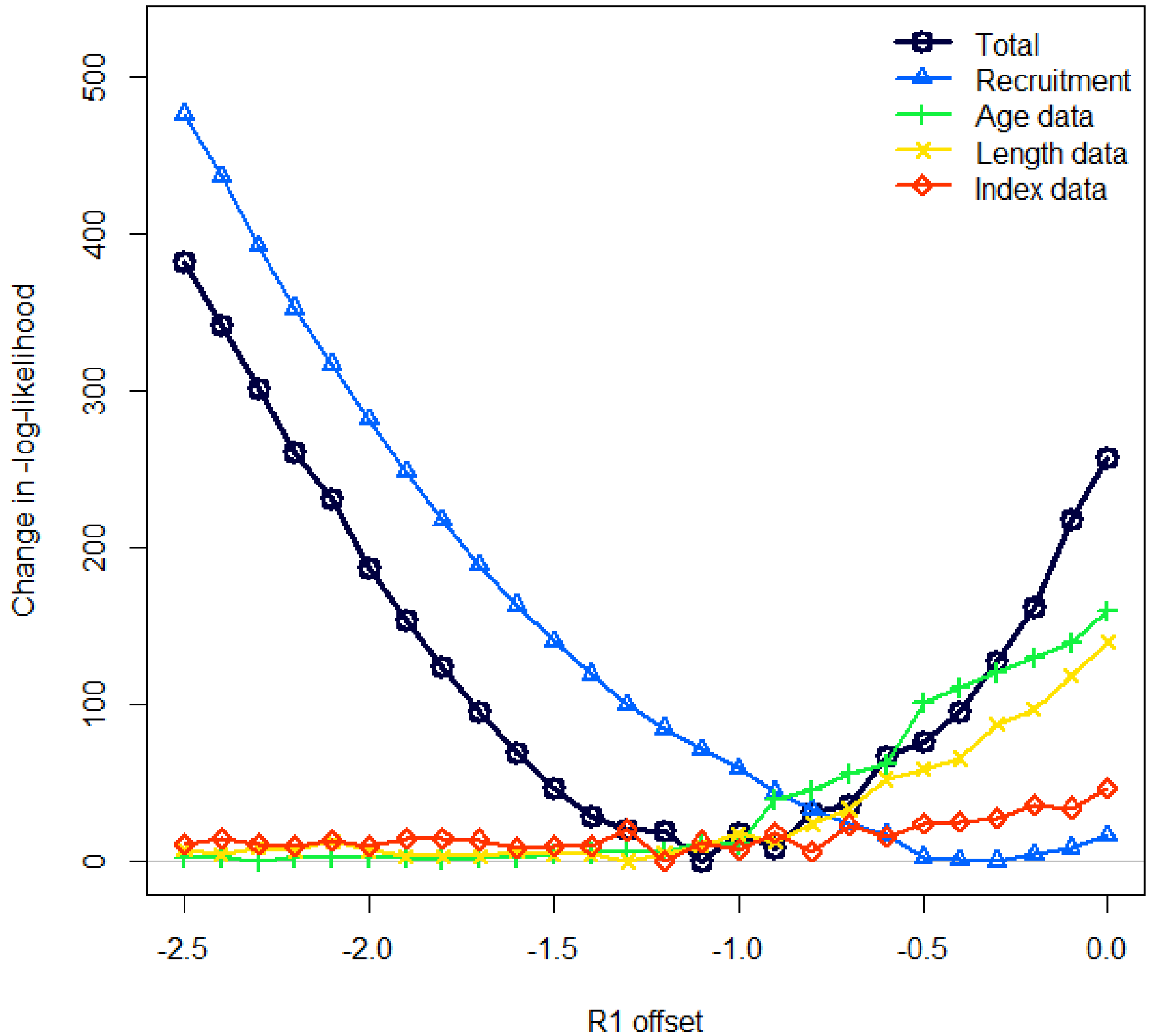


Figure 3.2.67. Likelihood profile for the offset parameter for initial equilibrium recruitment relative to virgin recruitment log(R_1).

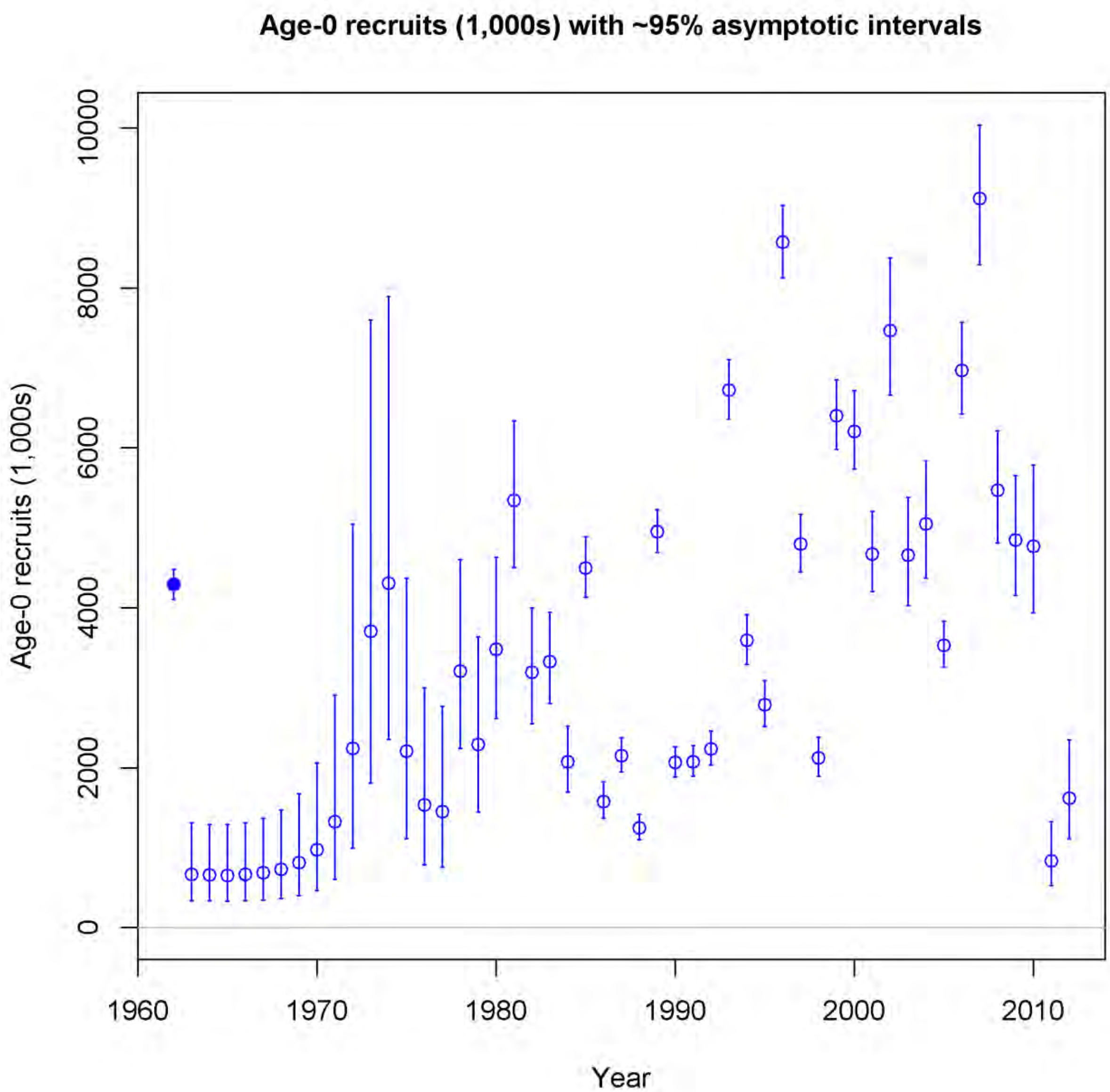


Figure 3.2.68. Predicted age-0 recruits with associated 95% asymptotic intervals.

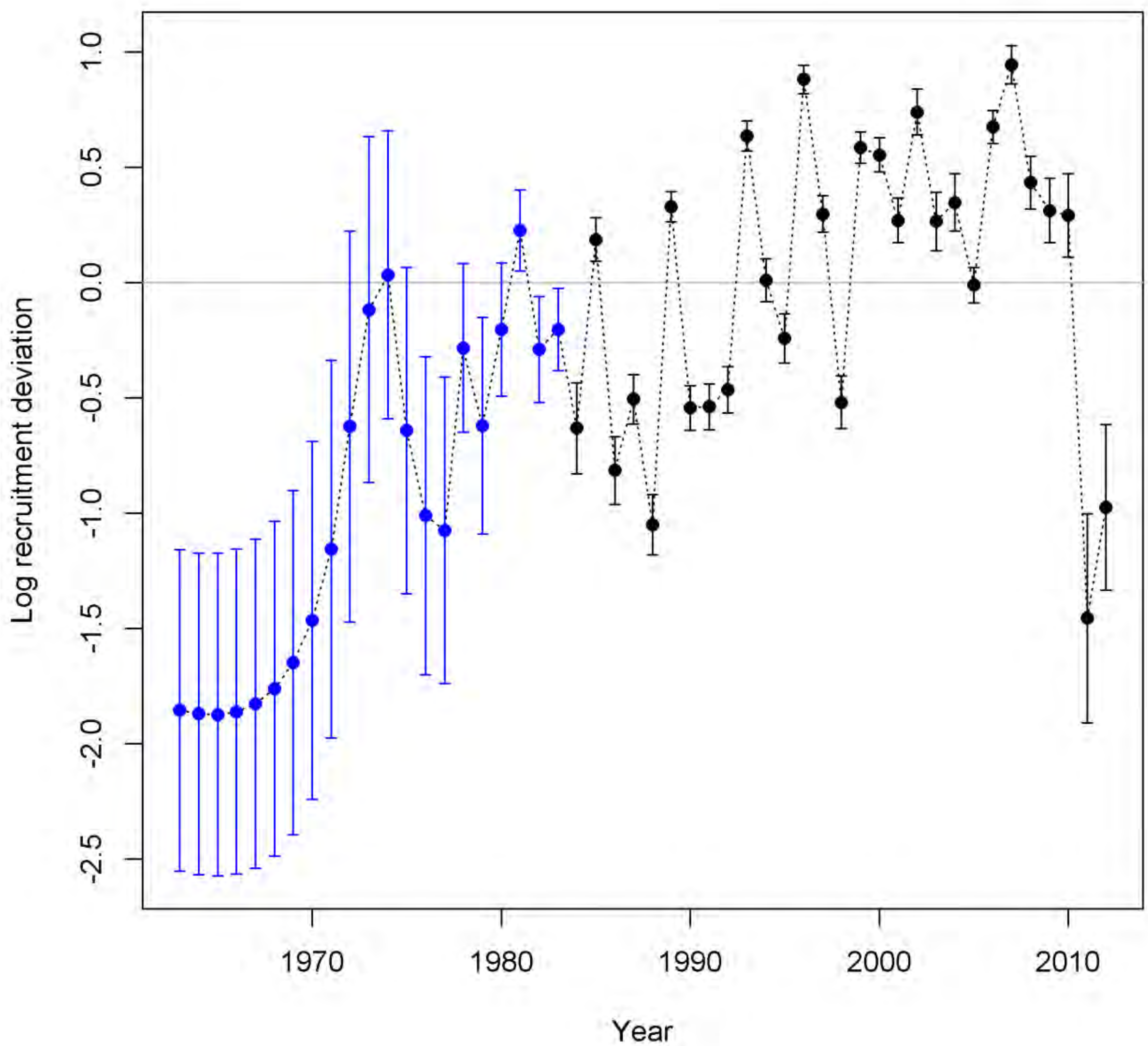


Figure 3.2.69. Predicted log recruitment deviations with associated 95% asymptotic intervals.

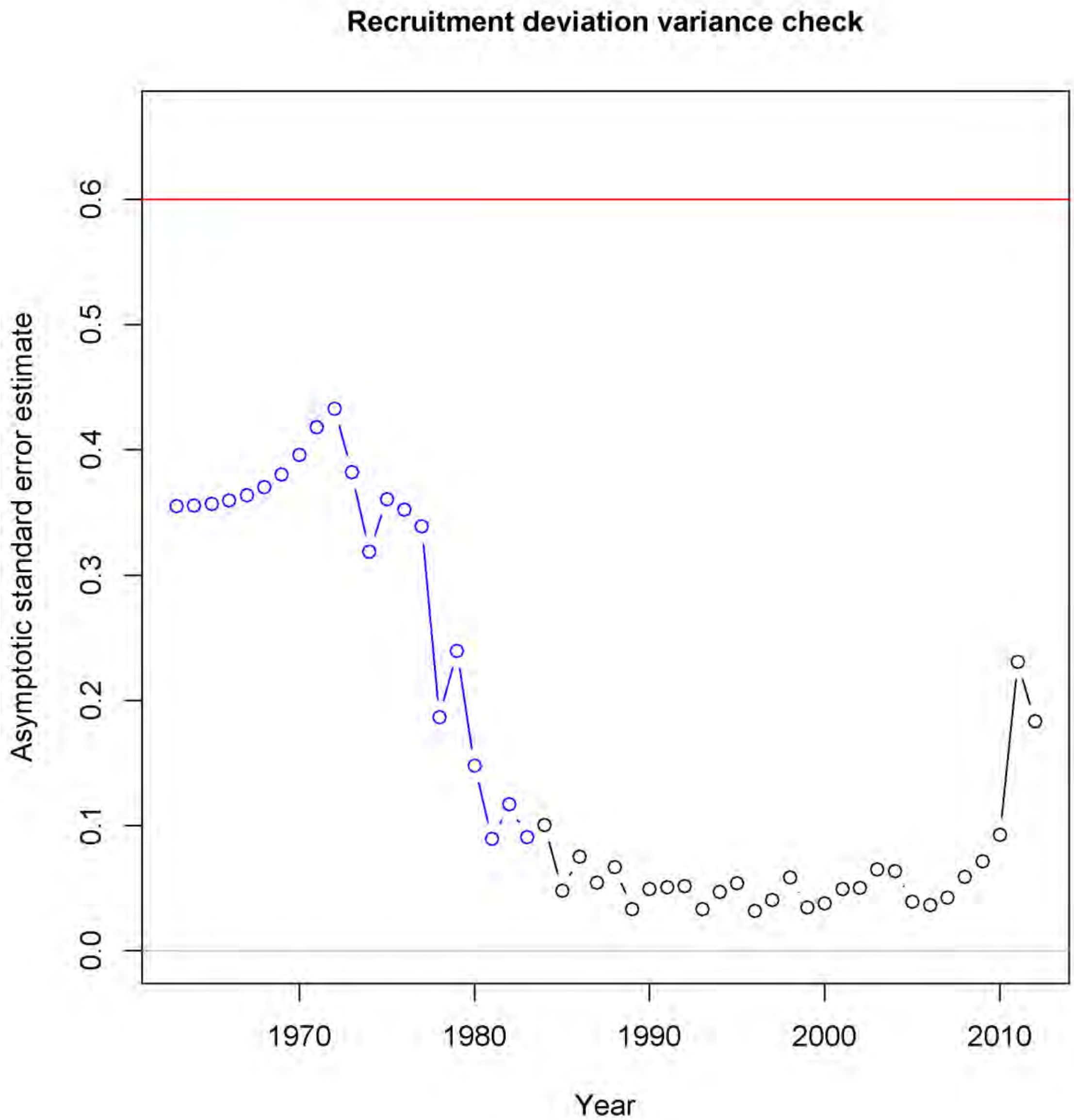


Figure 3.2.70. Asymptotic standard errors for recruitment deviations, 1963-2012. The red line represents the fixed value for sigma R used in the model.

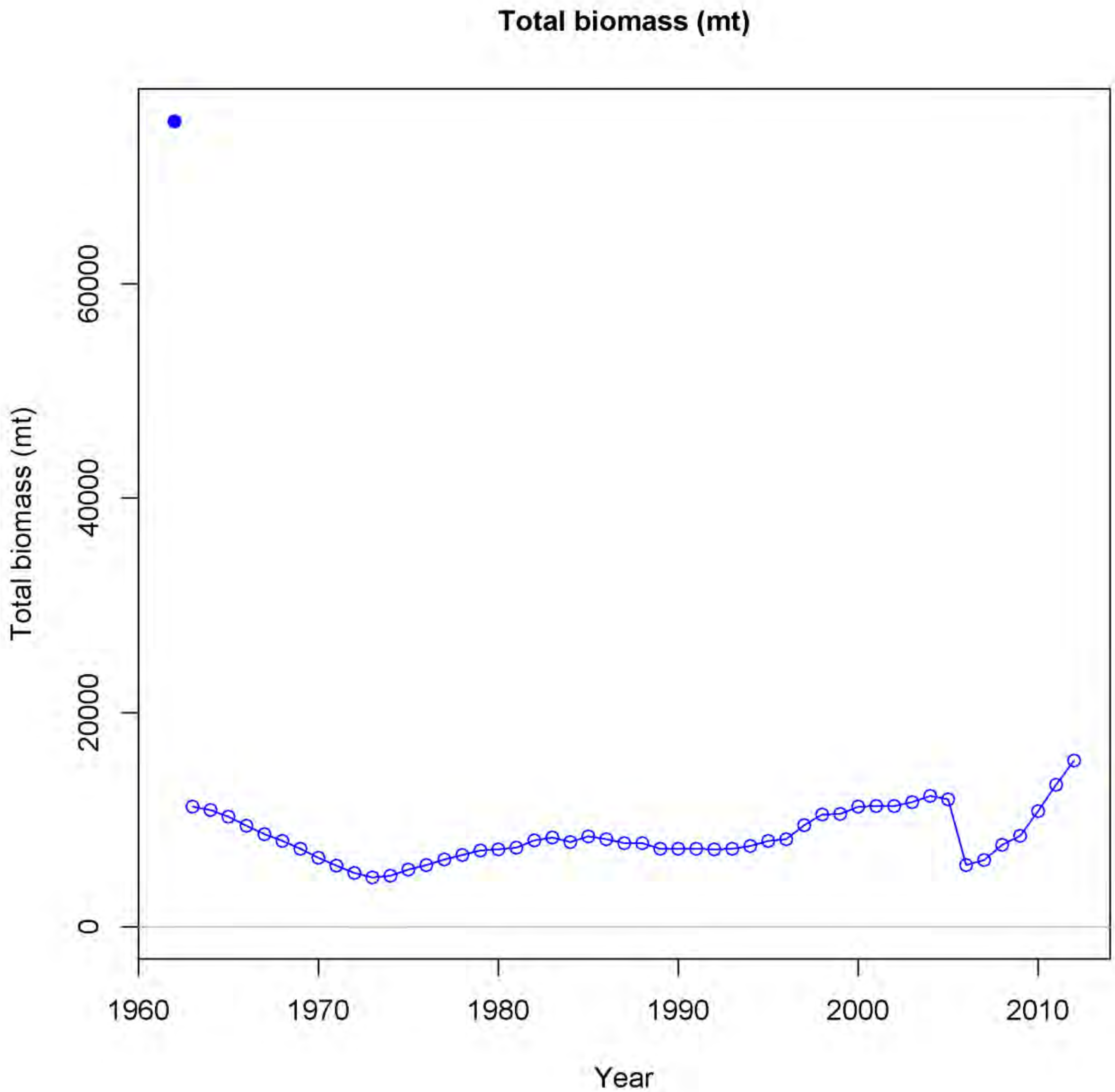


Figure 3.2.71. Predicted total biomass (mt) of Gulf of Mexico Gag Grouper from 1963-2012.

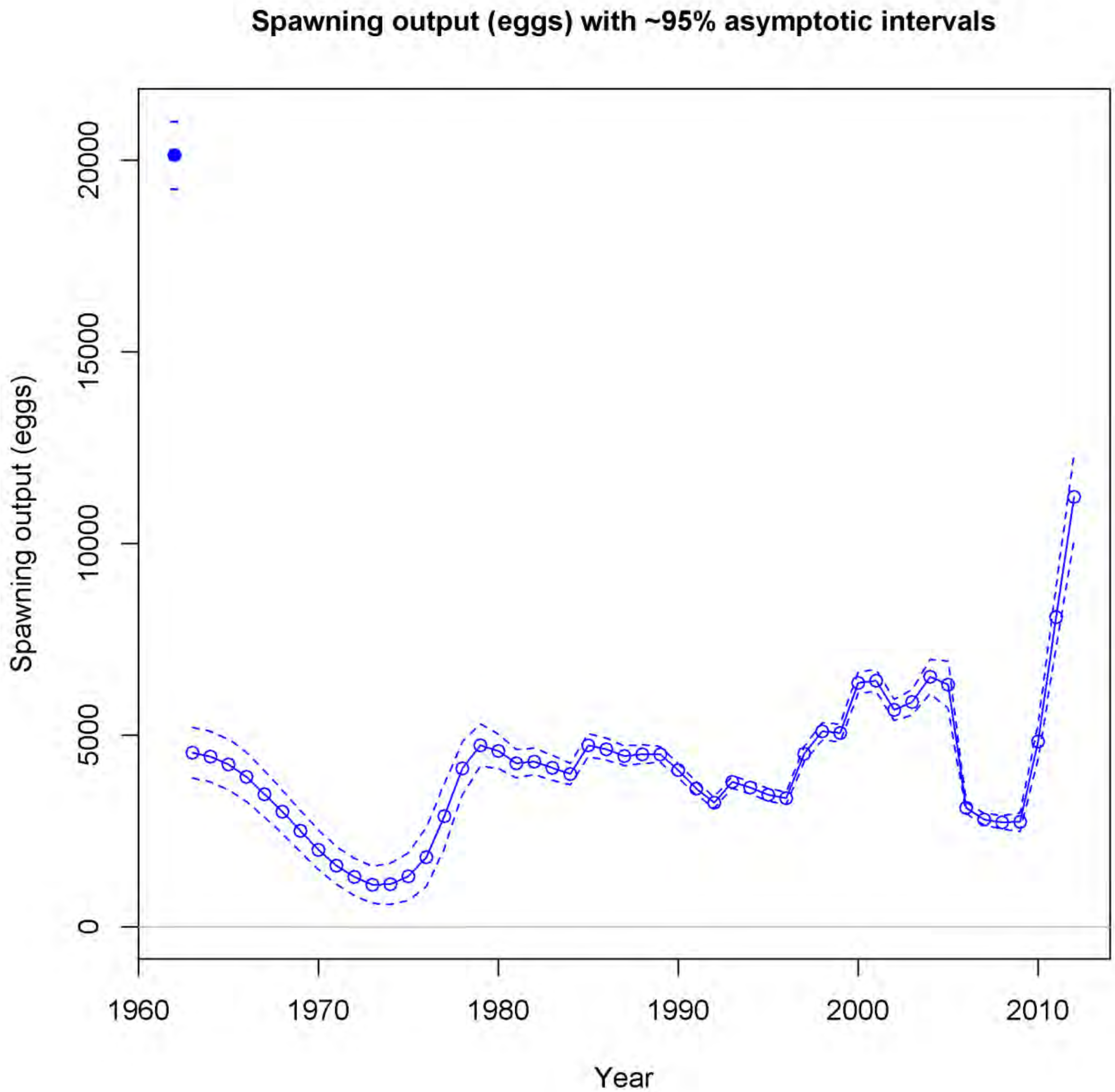


Figure 3.2.72. Predicted female spawning biomass with associated 95% asymptotic intervals.

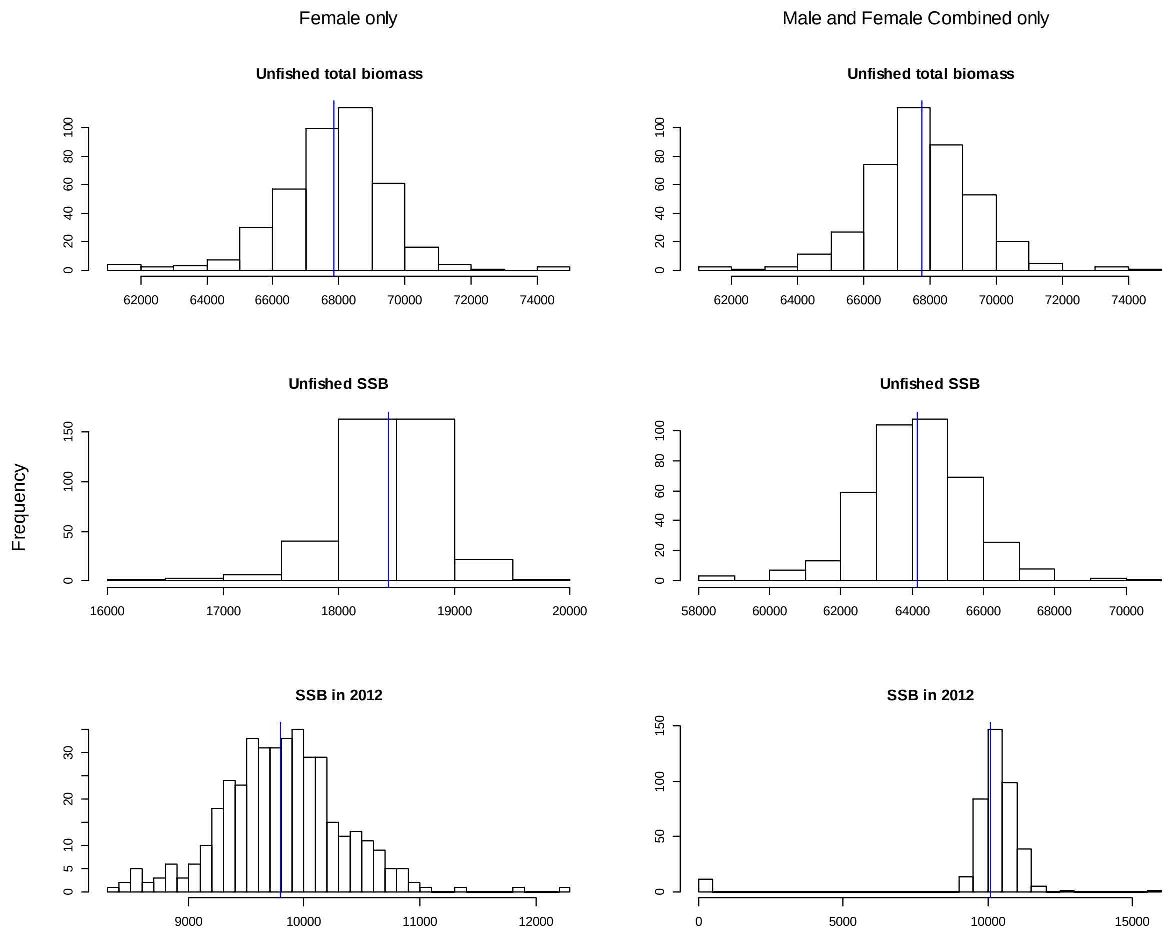


Figure 3.2.73. Distribution of estimated unfished spawning total biomass, unfished spawning stock biomass, and current spawning biomass (2012) relative to the geometric mean of SSB in 2010-2012 from 400 bootstrap samples of the base model. The blue line represents the mean estimate from the bootstrap samples.

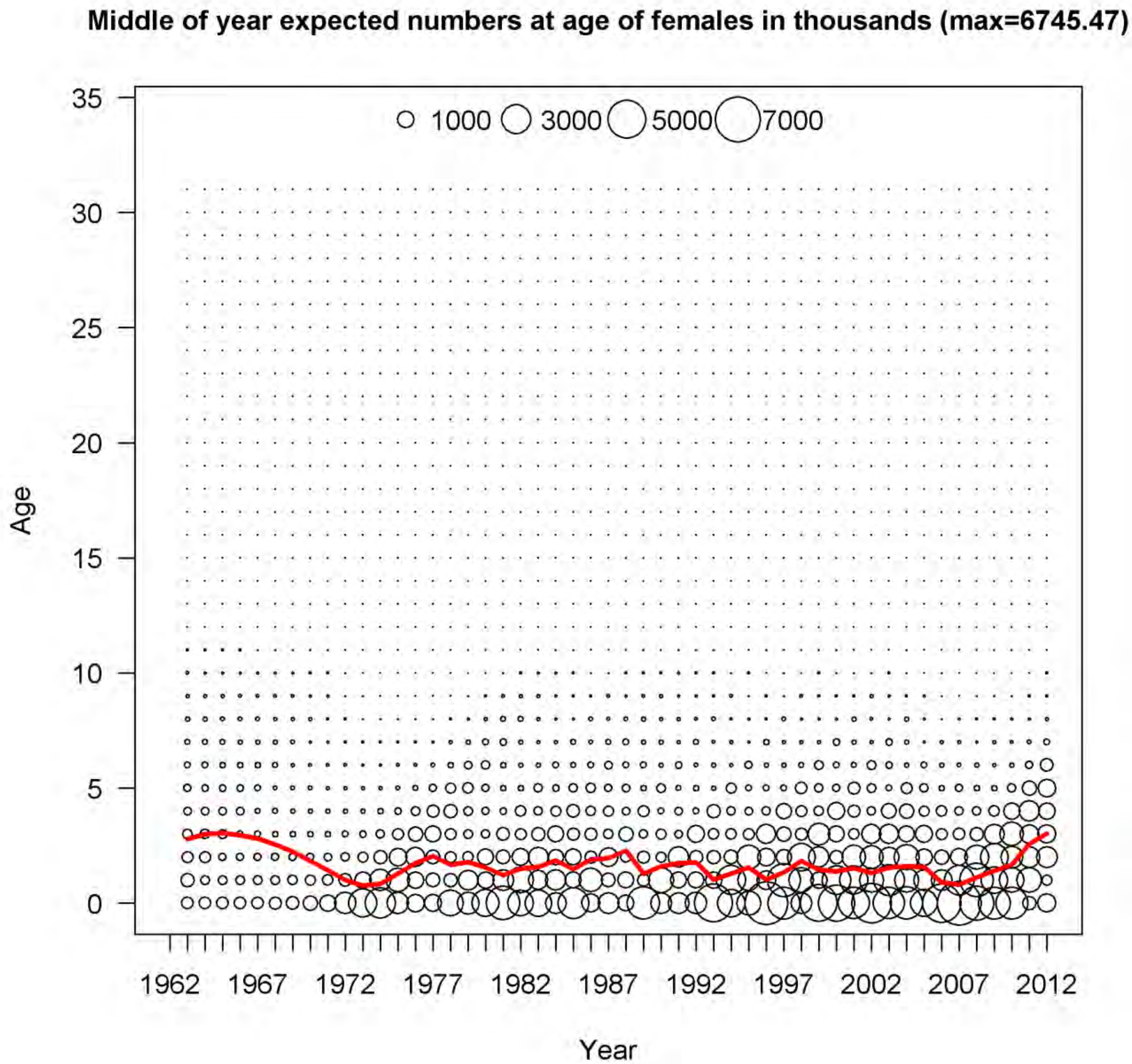


Figure 3.2.74. Predicted numbers-at-age (bubbles) and mean age of female Gag Grouper (red line).

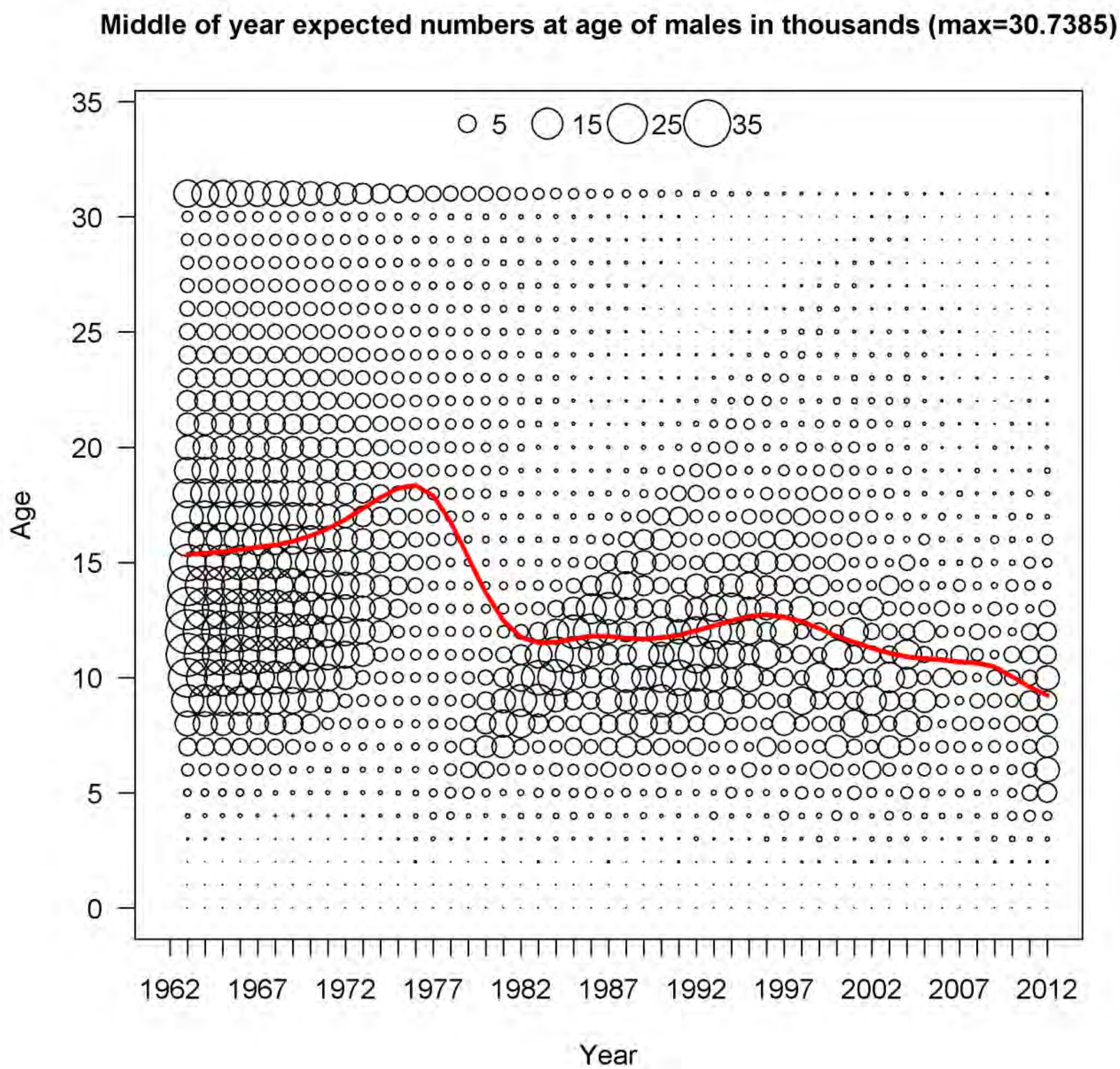


Figure 3.2.75. Predicted numbers-at-age (bubbles) and mean age of male Gag Grouper (red line).

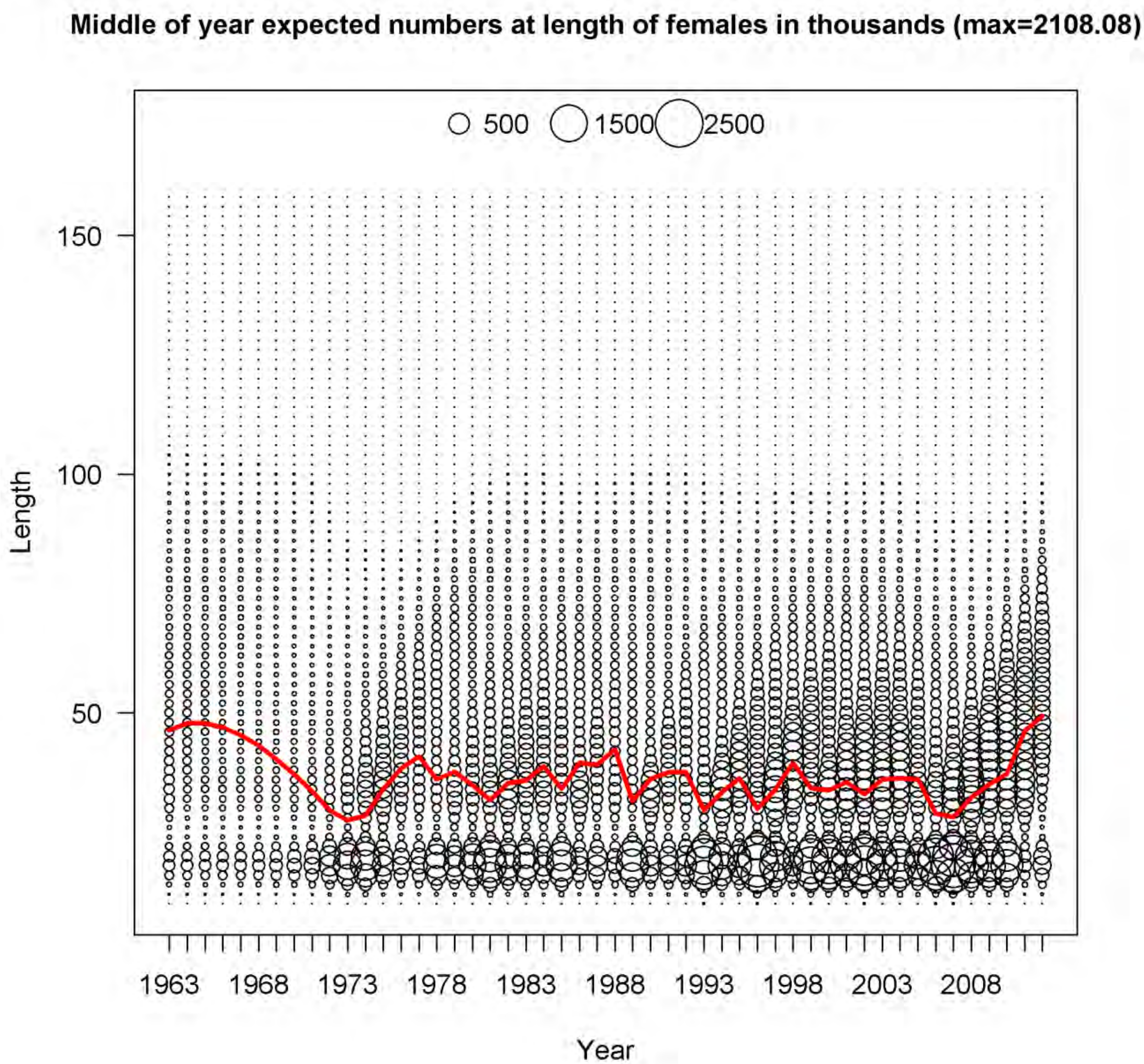


Figure 3.2.76. Predicted numbers-at-length (bubbles) and mean length of female Gag Grouper (red line).

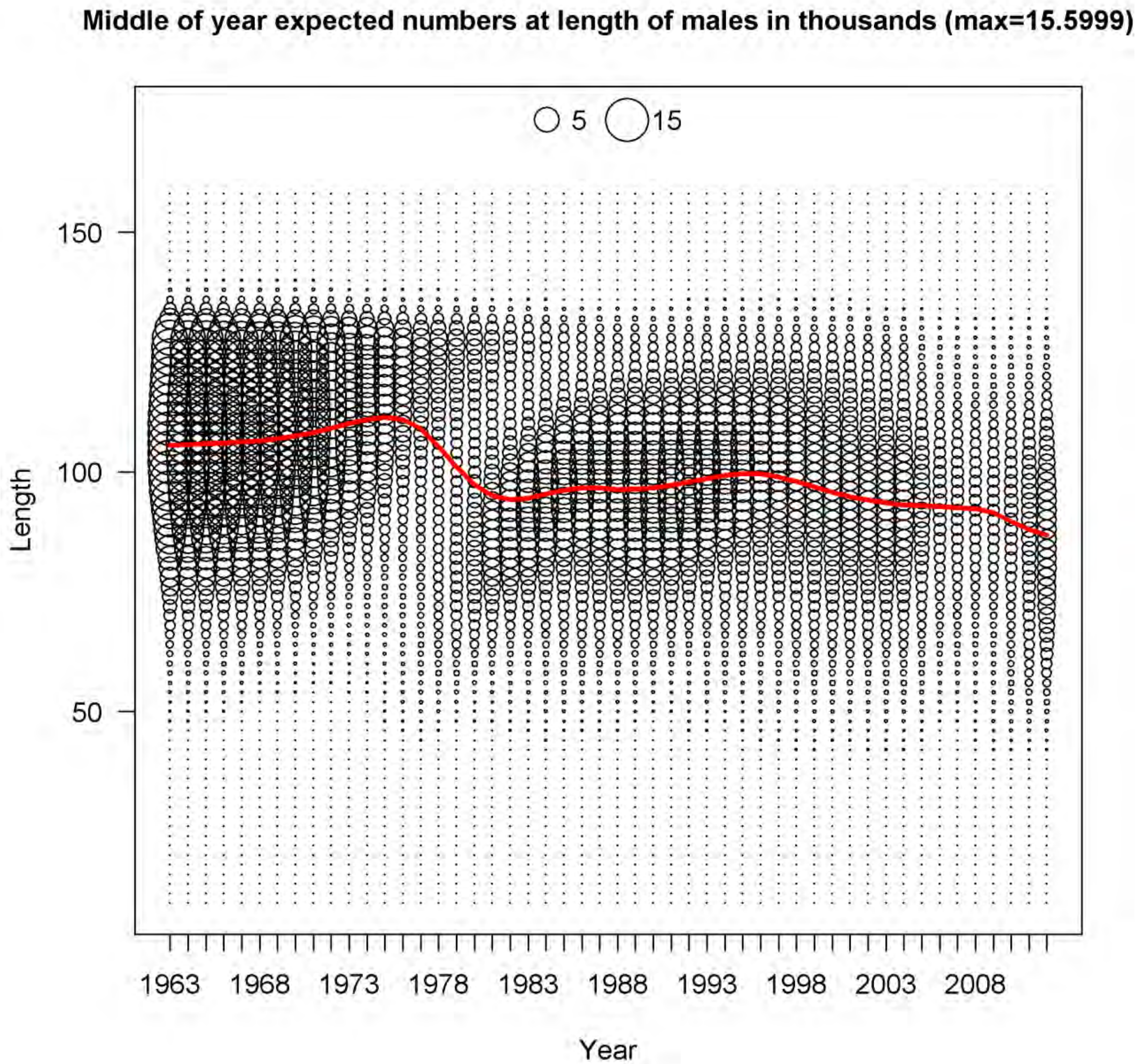


Figure 3.2.77. Predicted numbers-at-length (bubbles) and mean length of male Gag Grouper (red line).

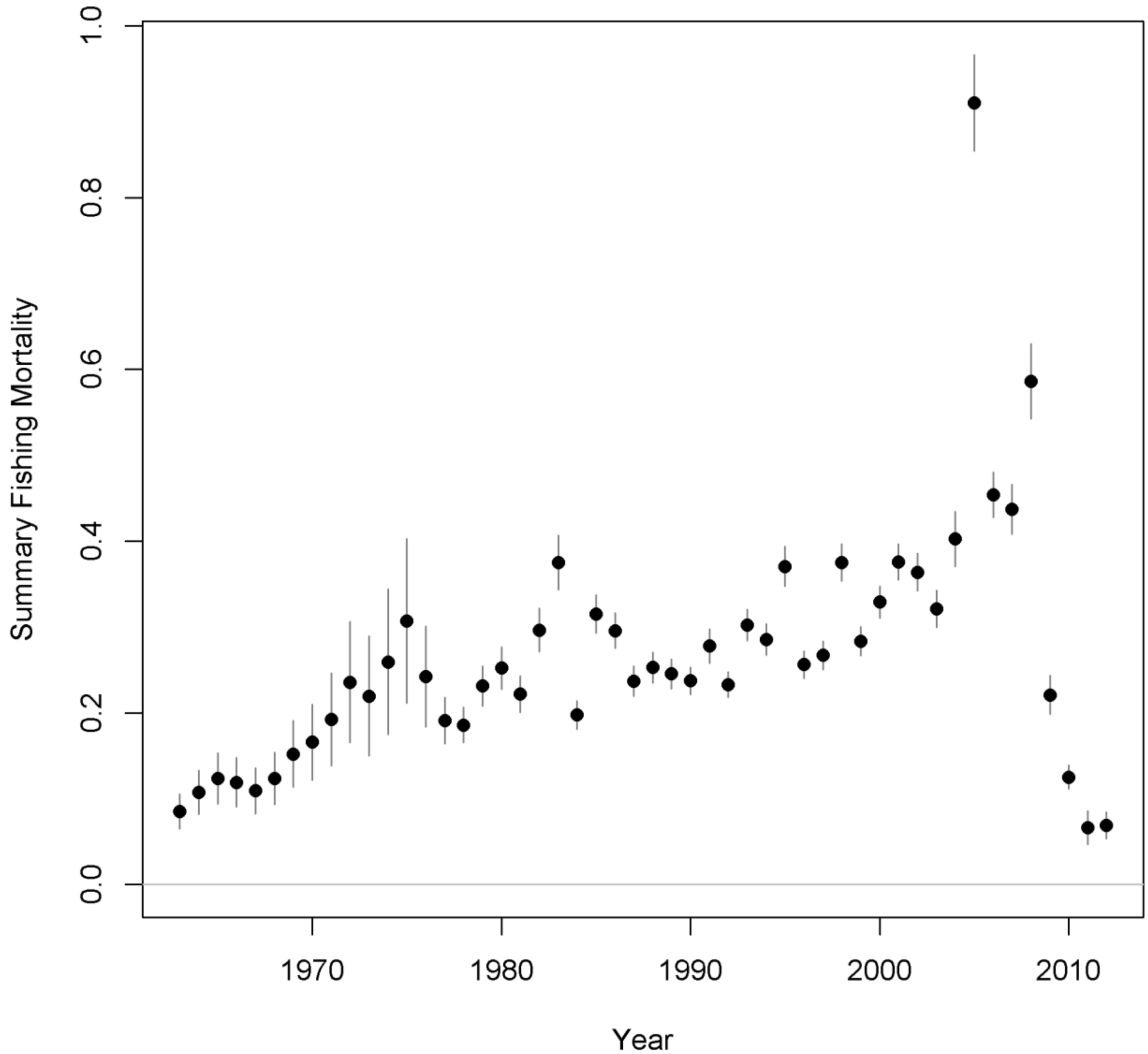


Figure 3.2.78. Predicted annual exploitation rate calculated as the ratio of the total annual catch in biomass to the summary biomass at the beginning of the year. Note that the exceptionally high 2005 data point includes an estimate of red tide mortality that was modeled as an additional ‘fishing fleet’.

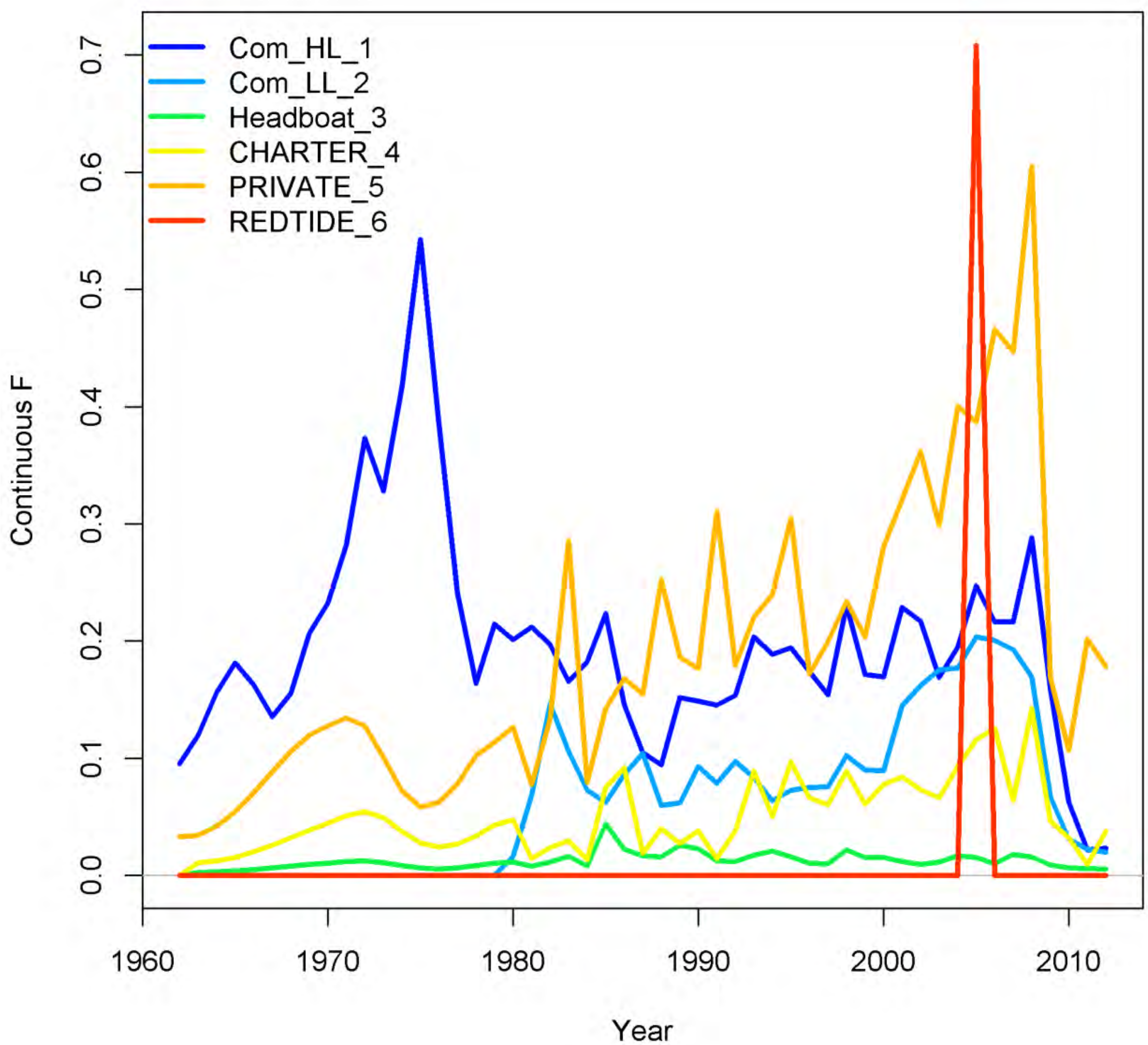


Figure 3.2.79. Predicted fleet specific exploitation rates.

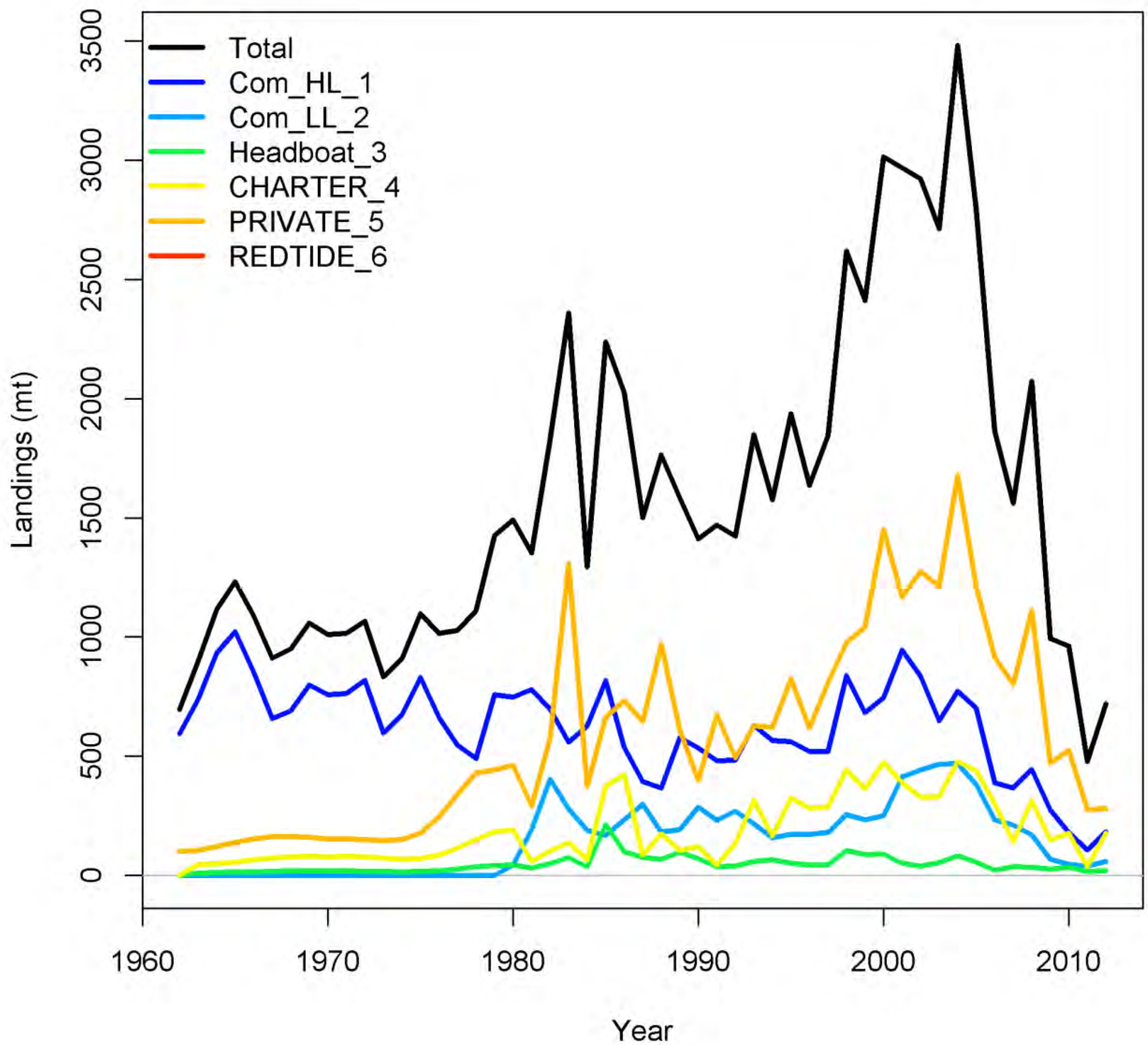


Figure 3.2.80. Observed landings time series for each fleet. Note, that there are no landings associated with the red tide since it was modeled as a discard only fleet.

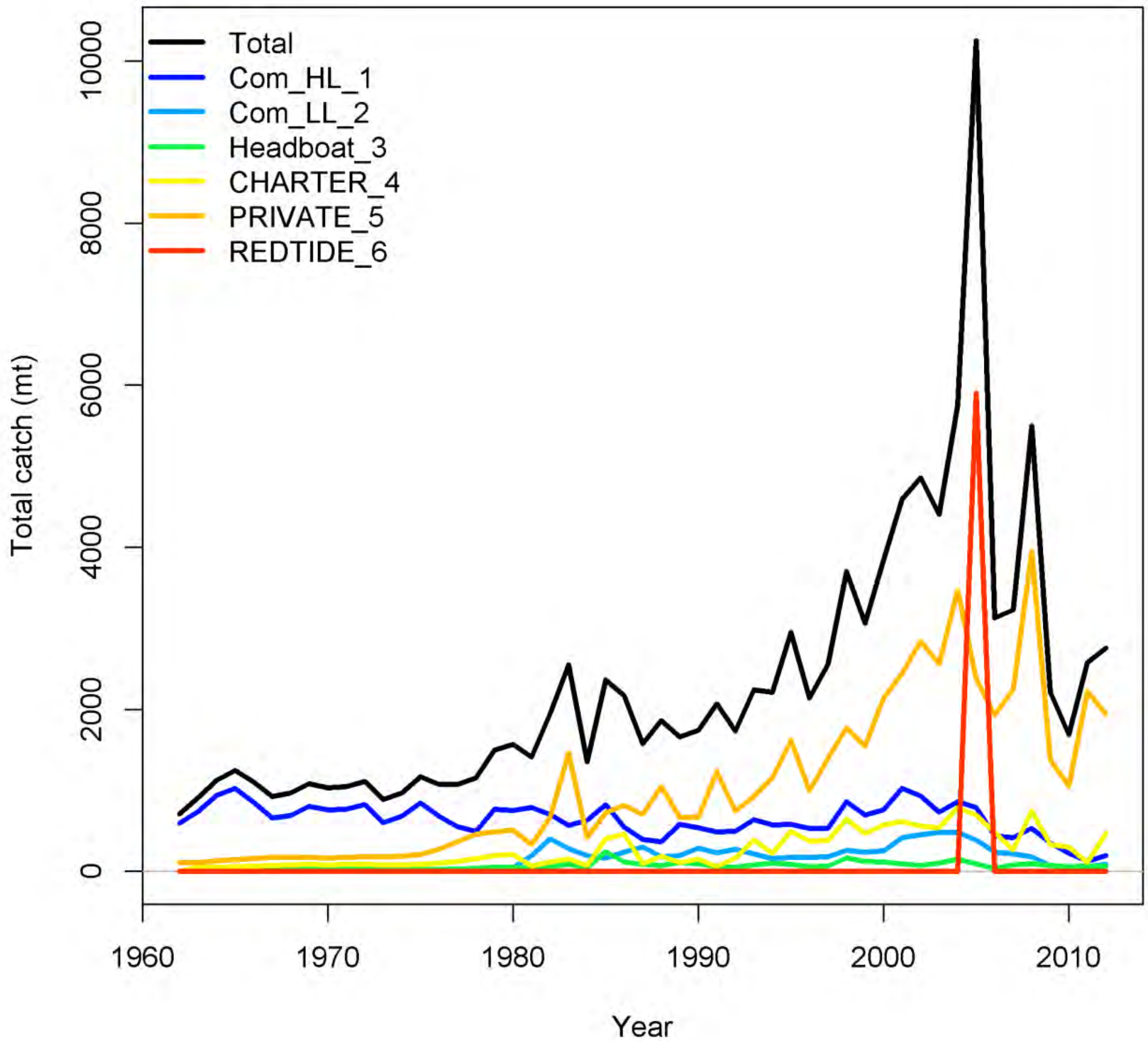


Figure 3.2.81. Observed catch (landings + discards) time series for each fleet. Note that the catch for the red tide fleet reflects "discards" only.

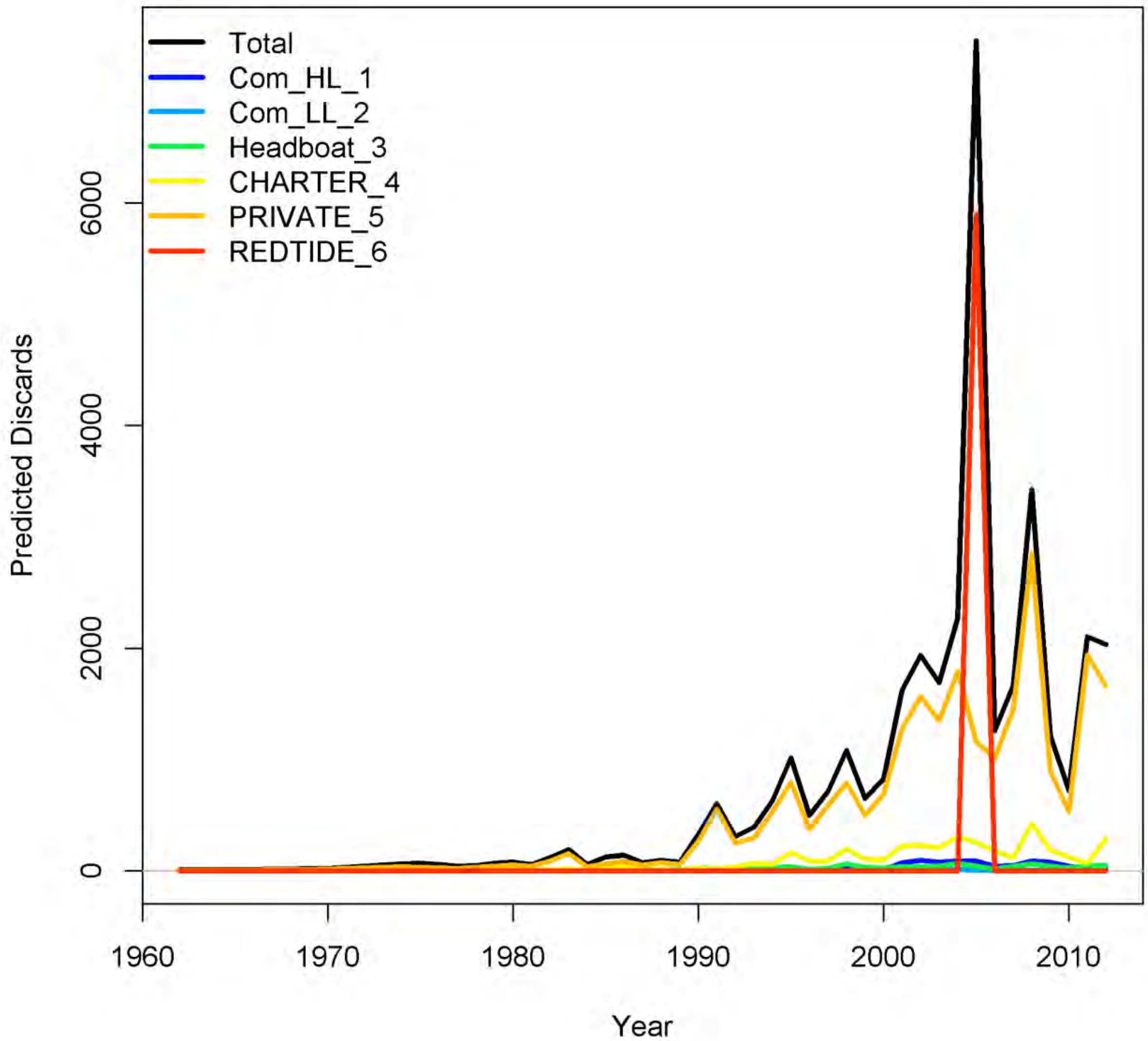


Figure 3.2.82. Model predicted discards (thousands of fish) by fleet.

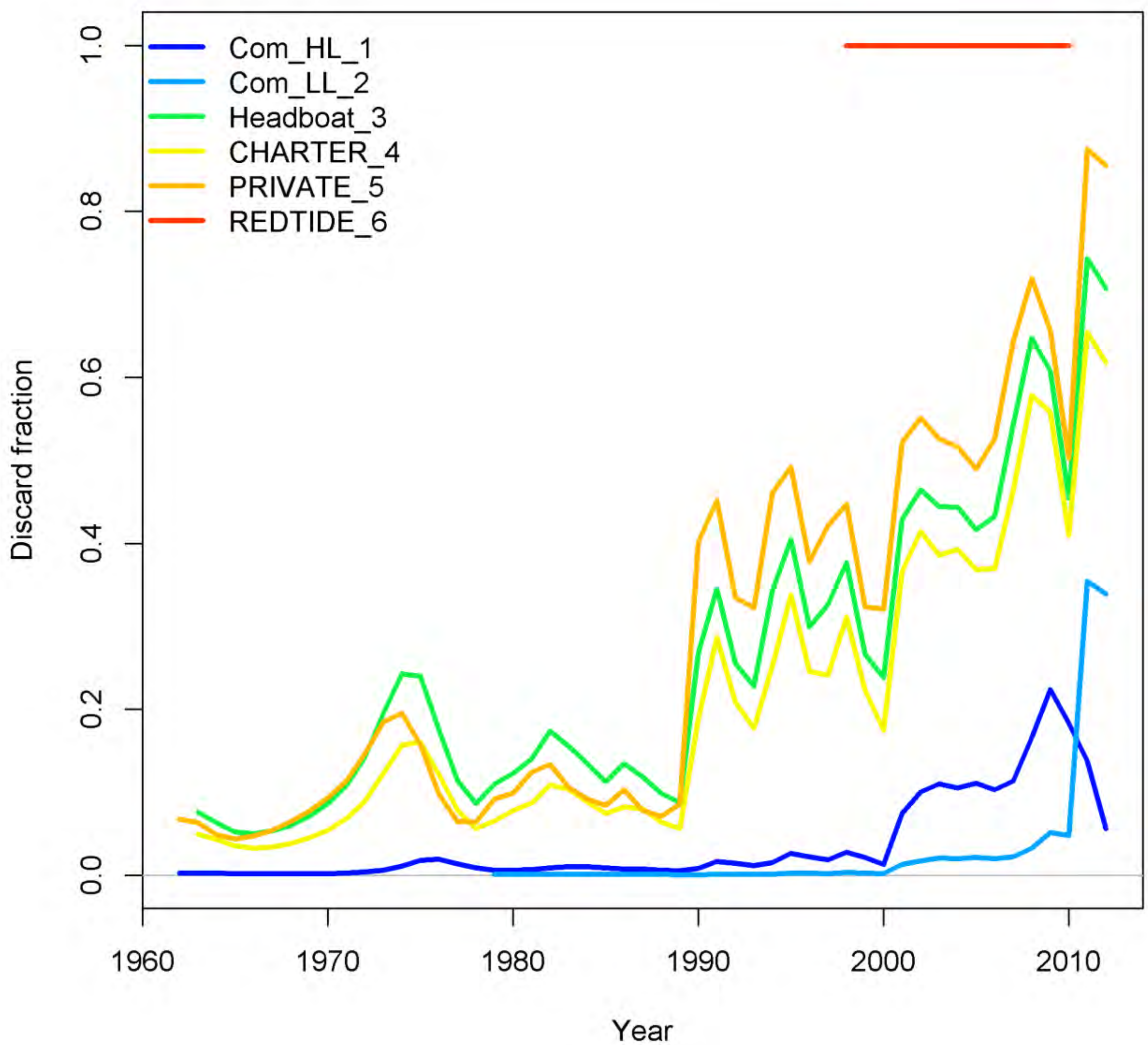


Figure 3.2.83. Model predicted discard fraction by fleet.

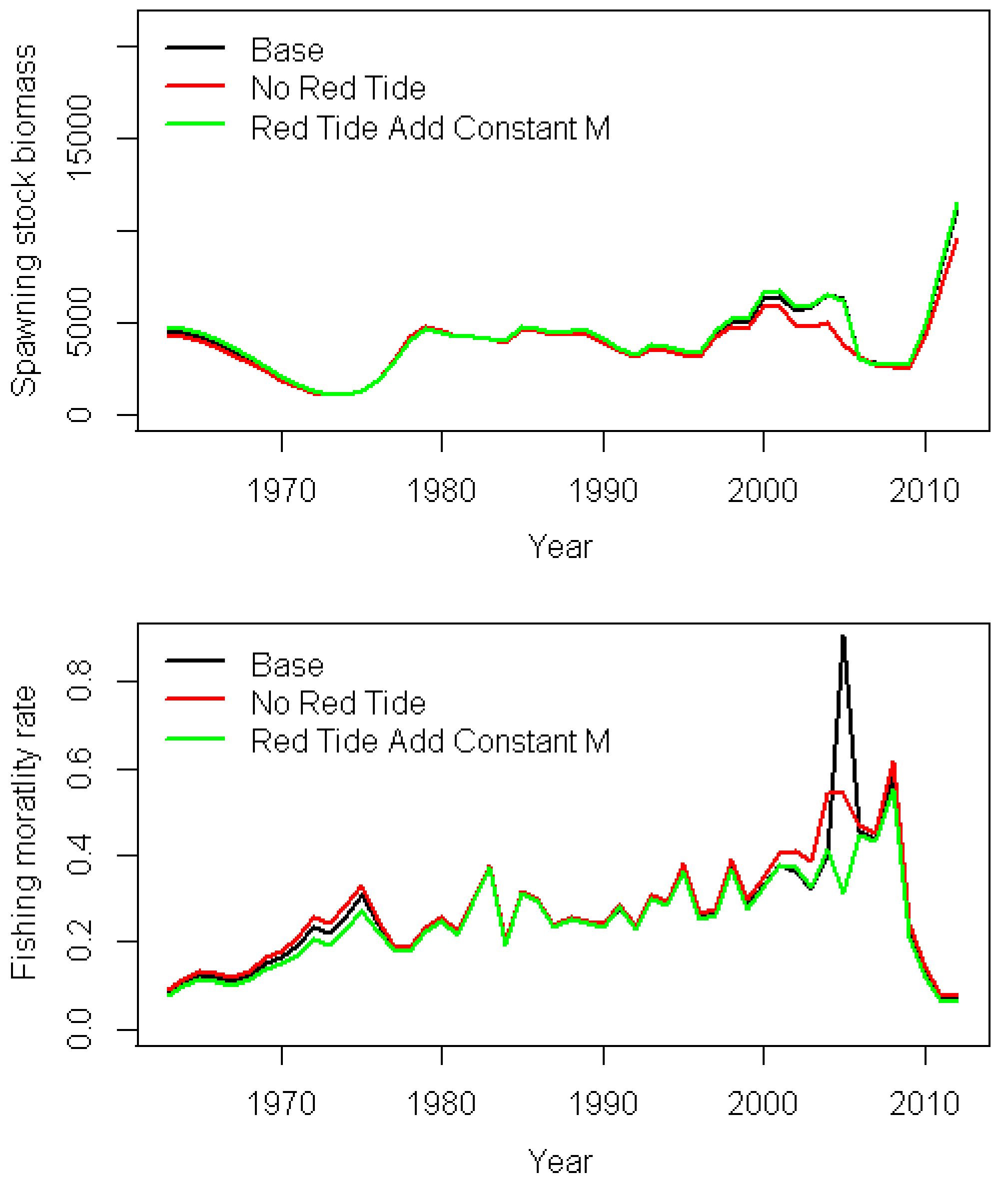


Figure 3.2.84. Predicted spawning biomass (female) and fishing mortality rate for the base model (Run 1), the no red model (Run 2), and an alternative configuration for red tide mortality (Run 3).

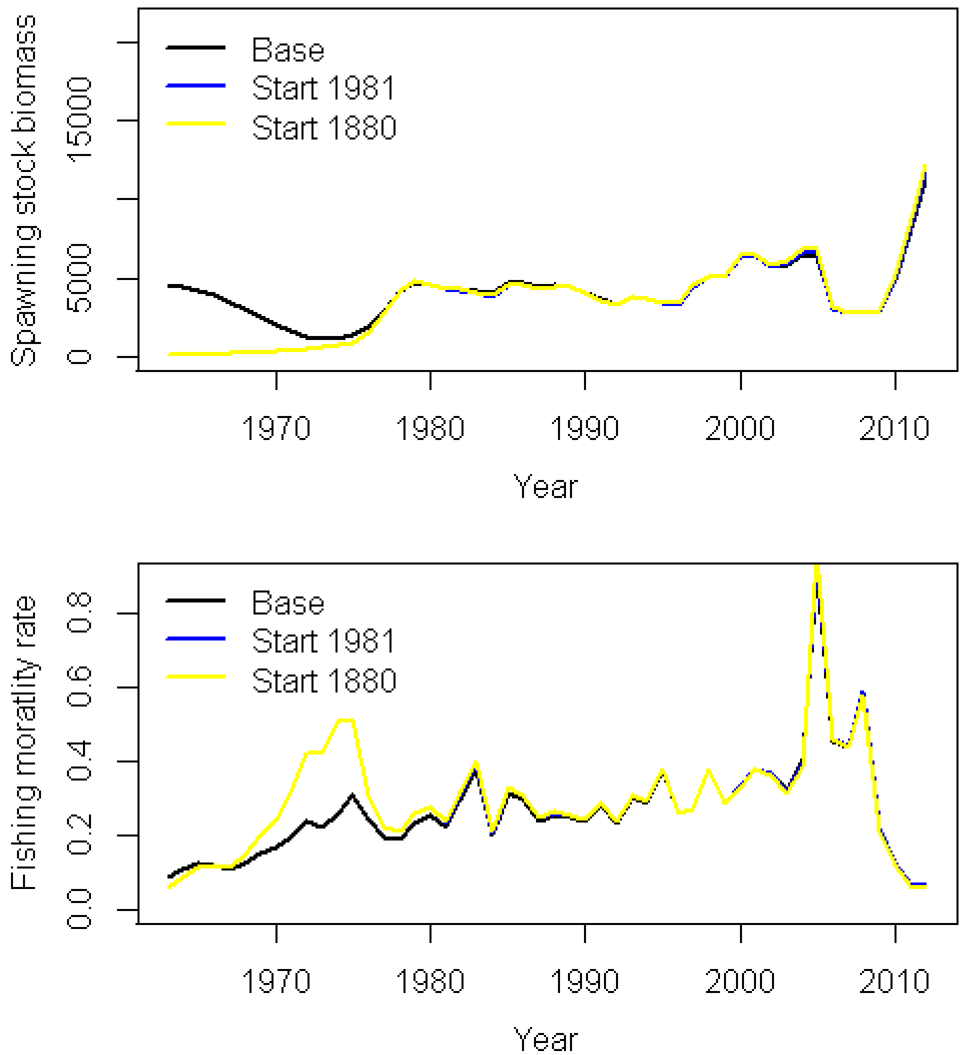


Figure 3.2.85. Predicted spawning biomass (female) and fishing mortality rate for the base model (Run 1), the model starting in 1880 (Run 4), and the model starting in 1981 (Run 5).

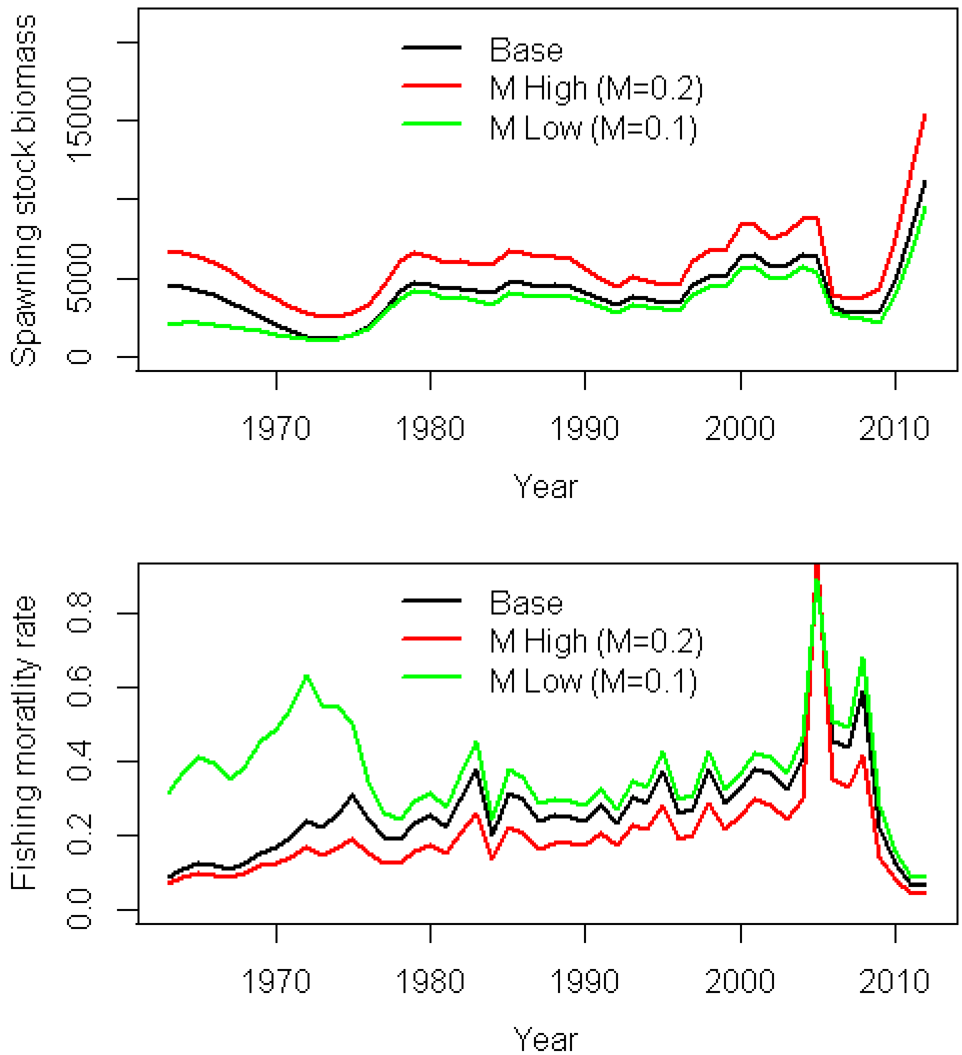


Figure 3.2.86. Predicted spawning biomass (female) and fishing mortality rate for the base model (Run 1), the low M sensitivity (Run 6), and the high M sensitivity (Run 7).

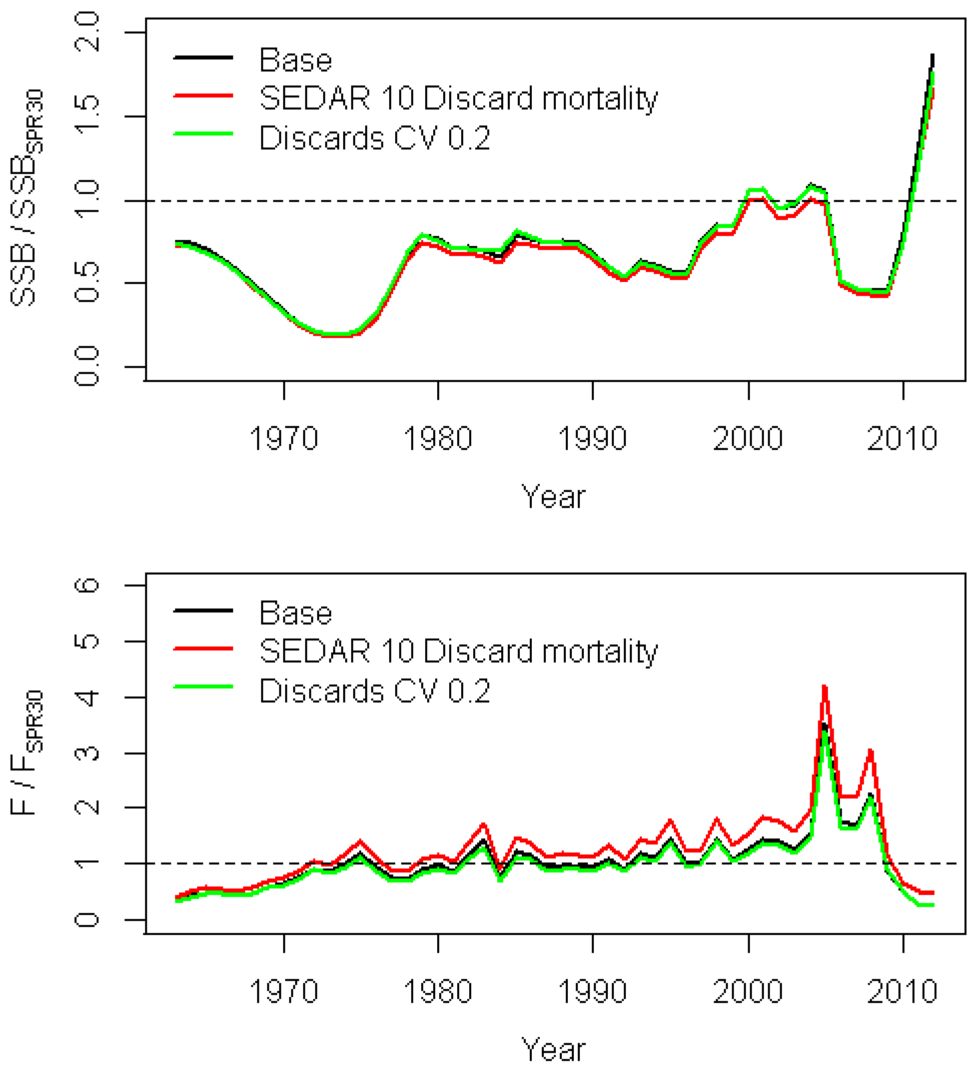


Figure 3.2.87. Predicted spawning biomass (female) and fishing mortality rate for the base model (Run 1), and the model run with SEDAR 10 discard mortality (Run 8).

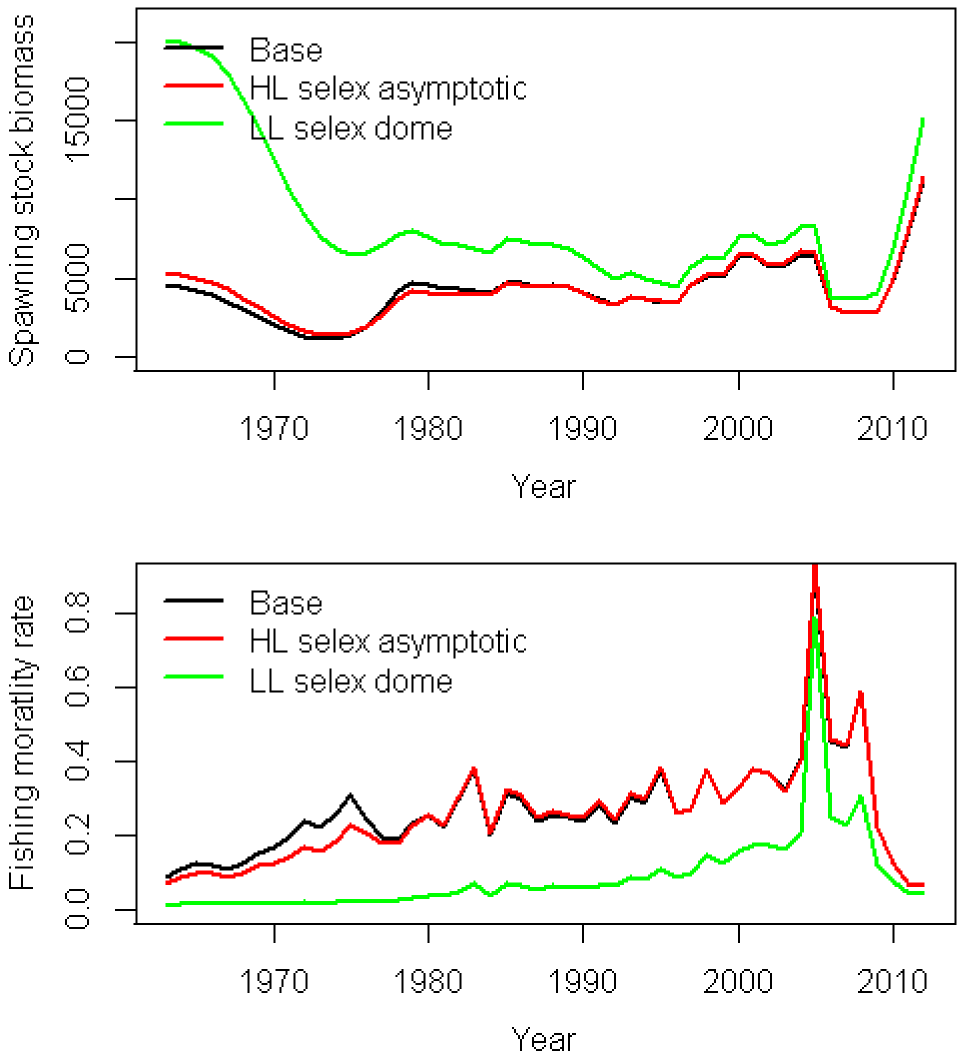


Figure 3.2.88. Predicted spawning biomass (female) and fishing mortality rate for the base model (Run 1), and the model with longline selectivity assumed to dome-shaped (Run 9).

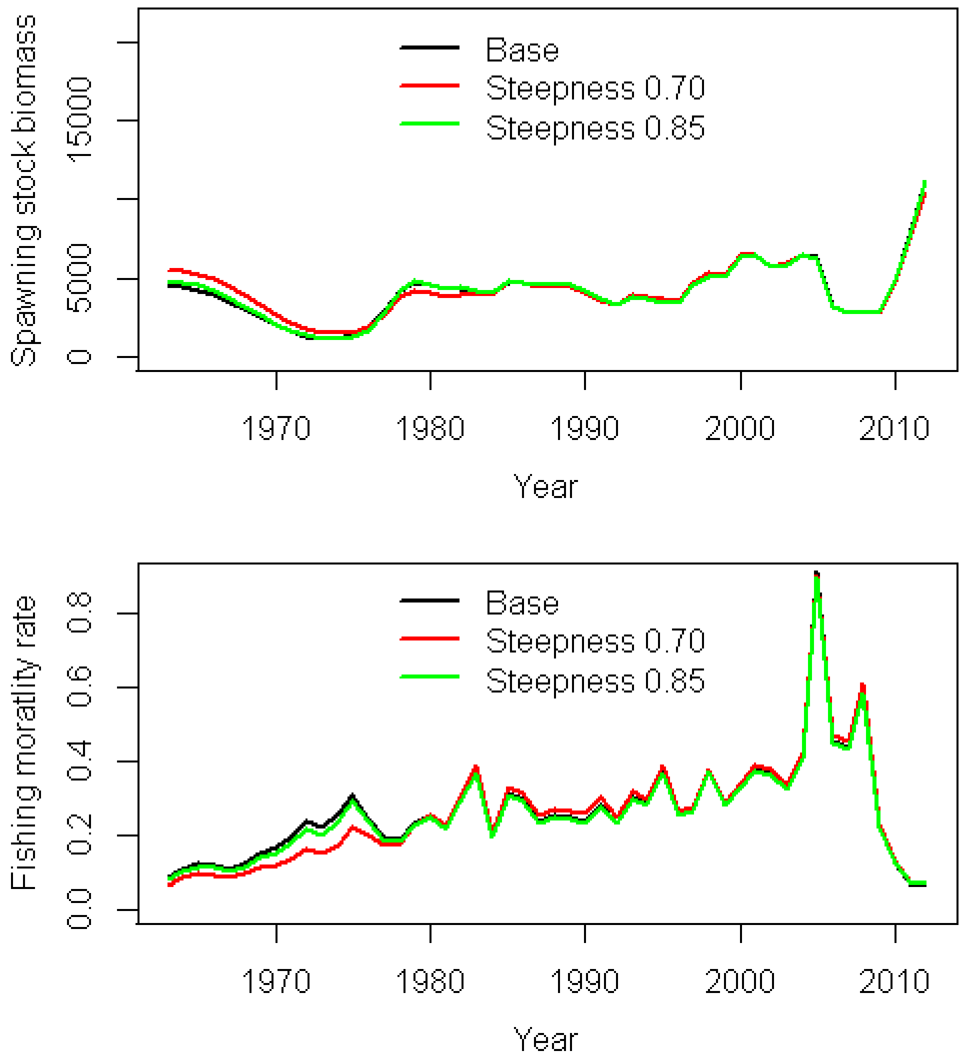


Figure 3.2.89. Predicted spawning biomass (female) and fishing mortality rate for the base model (Run 1) and model runs with steepness fixed at 0.70 (Run 12) and 0.85 (Run 13).

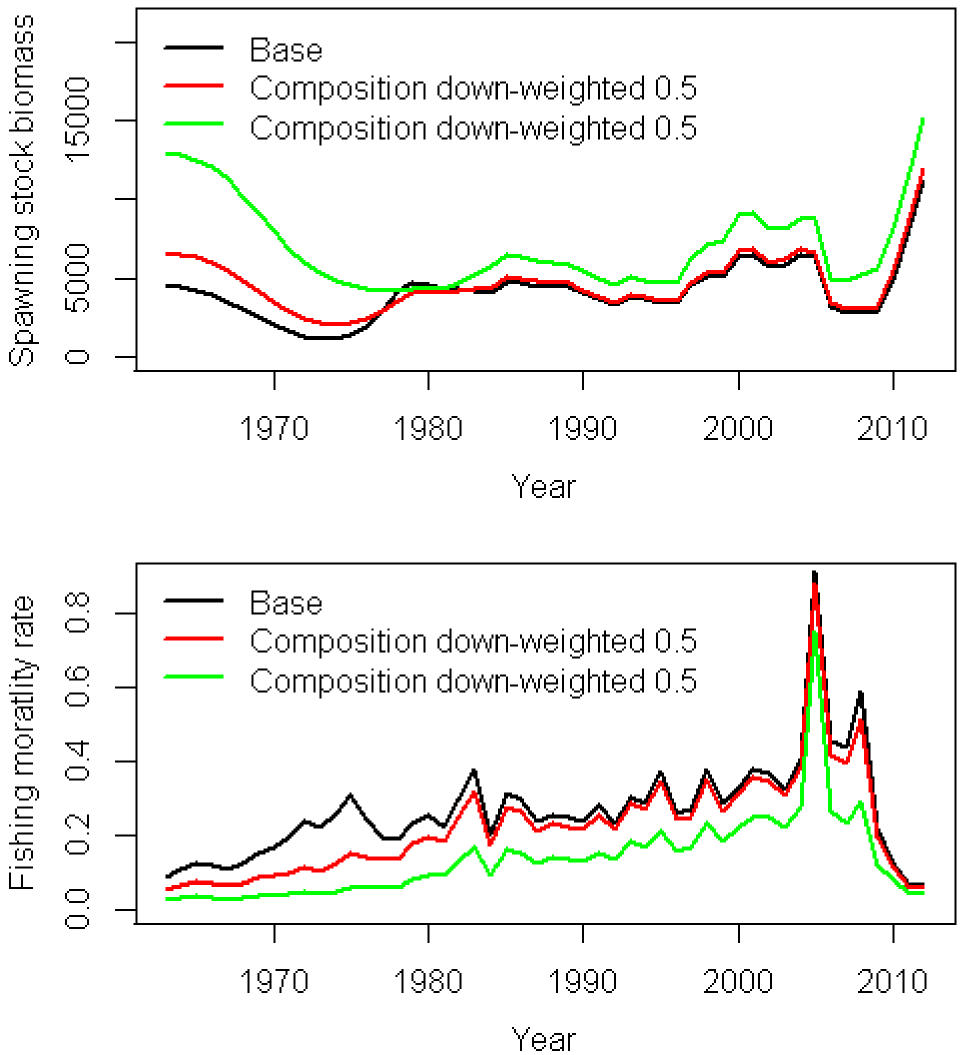


Figure 3.2.90. Predicted spawning biomass (female) and fishing mortality rate for the base model (Run 1) and runs with the composition data down-weighted by 0.5 and 0.1 (Run 14).

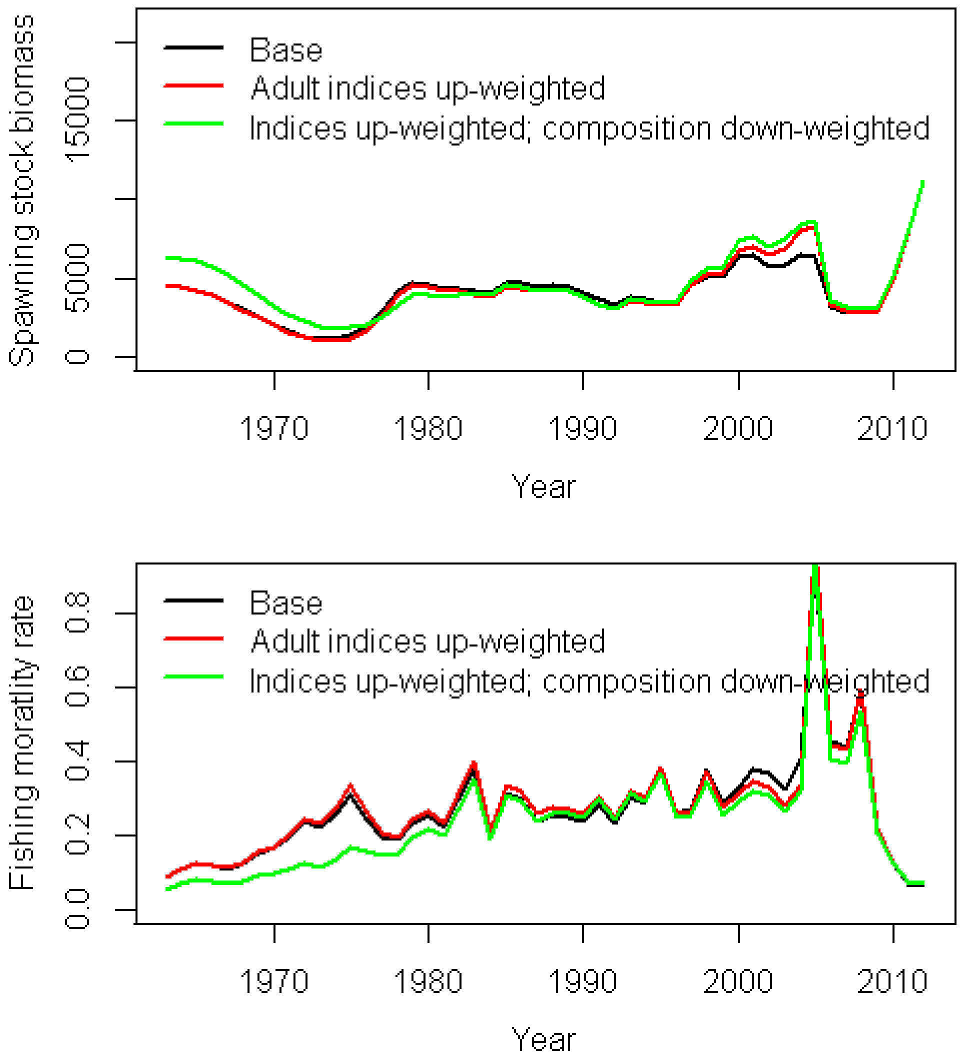


Figure 3.2.91. Predicted spawning biomass (female) and fishing mortality rate for the base model (Run 1) and run with the adult indices of abundance (commercial handline, commercial longline, and SEAMAP video) up-weighted (Run 15).

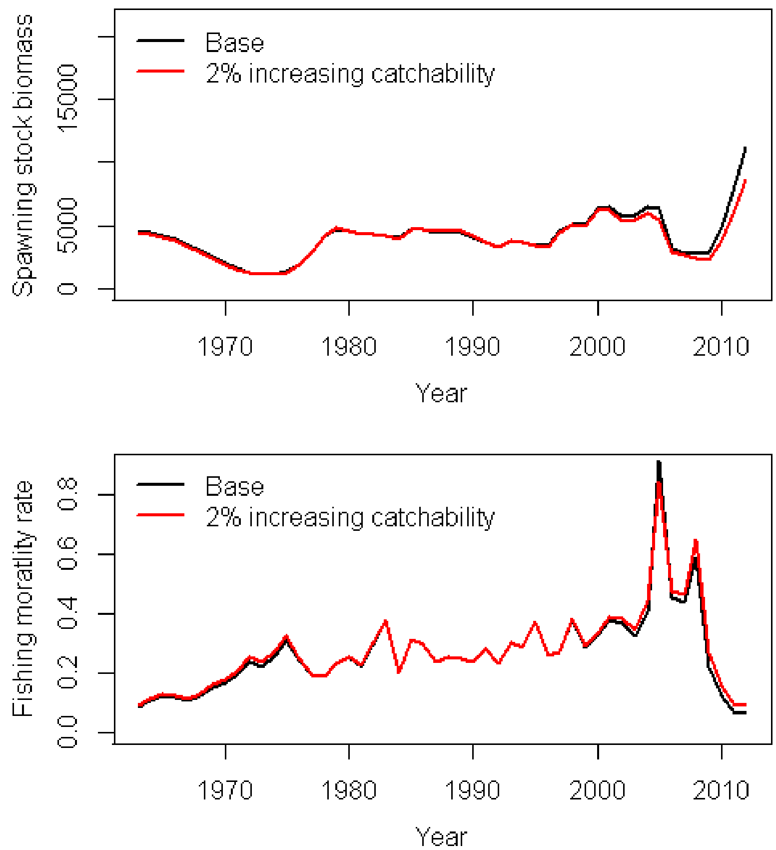


Figure 3.2.92. Predicted spawning biomass (female) and fishing mortality rate for the base model (Run 1) and model run assuming a 2% increasing catchability for all fishery-dependent indices of abundance (Run 16).

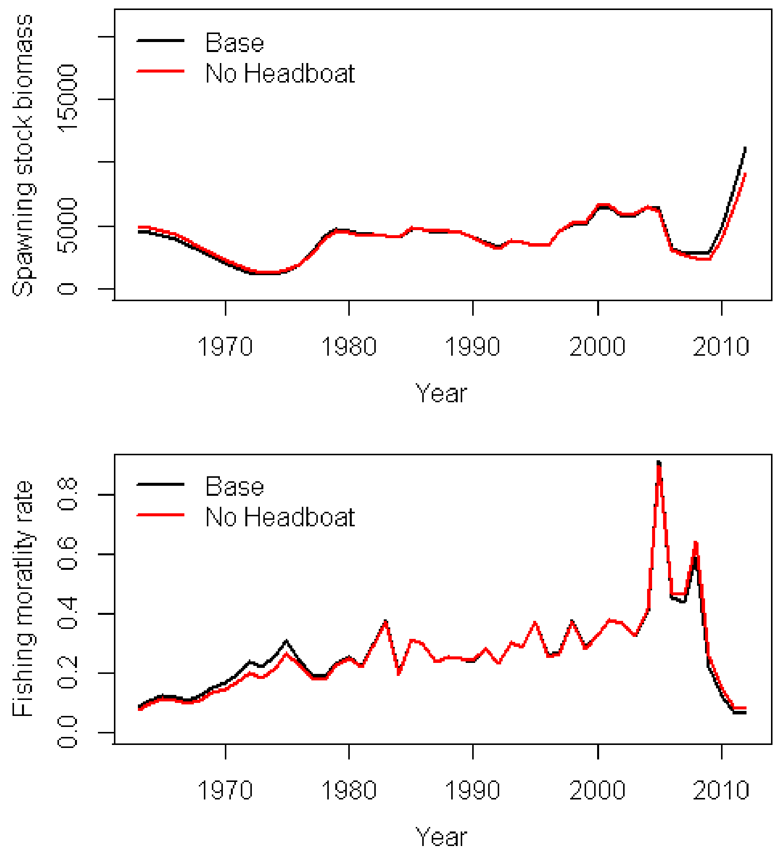


Figure 3.2.93. Predicted spawning biomass (female) and fishing mortality rate for the base model (Run 1) and model run removing the headboat index (Run 17).

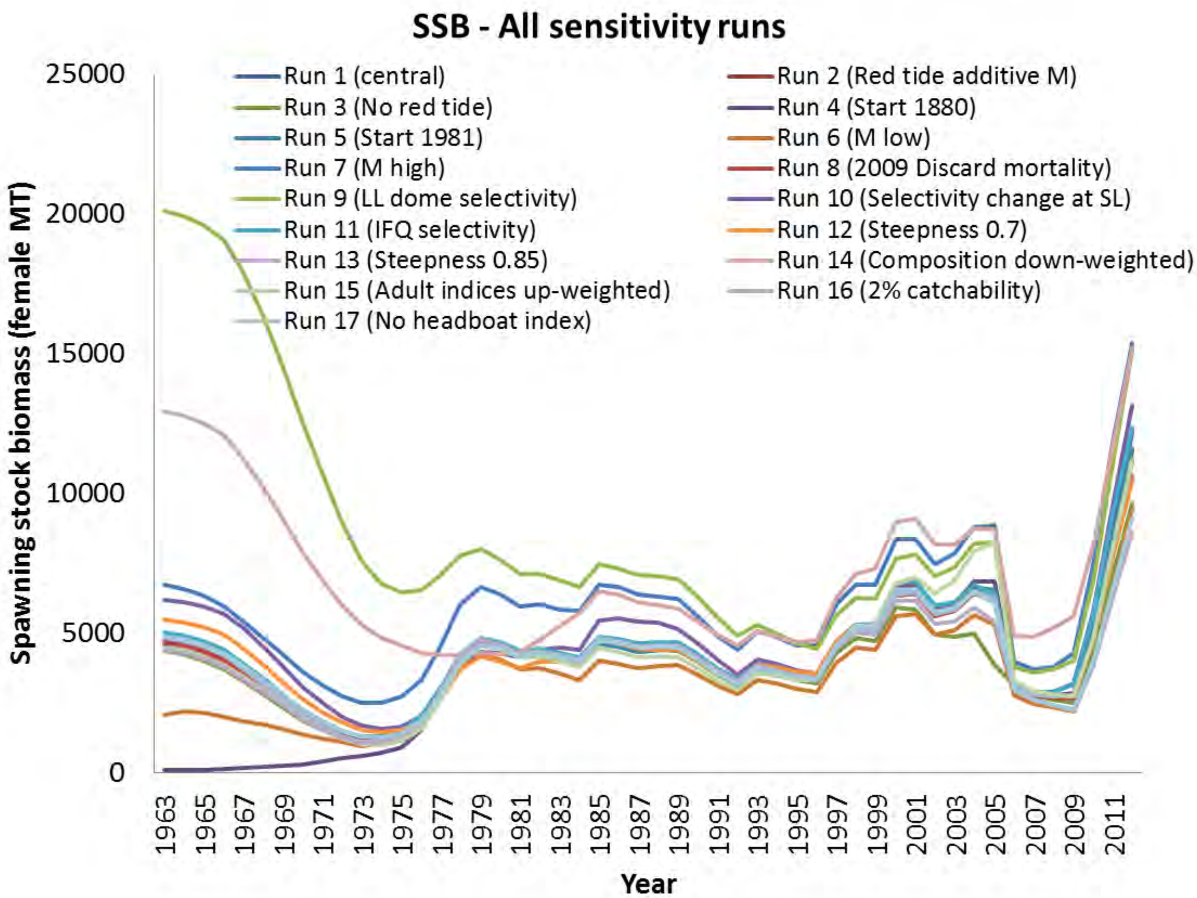


Figure 3.2.94. Predicted spawning stock biomass (female) across all sensitivity runs for the SSB female model.

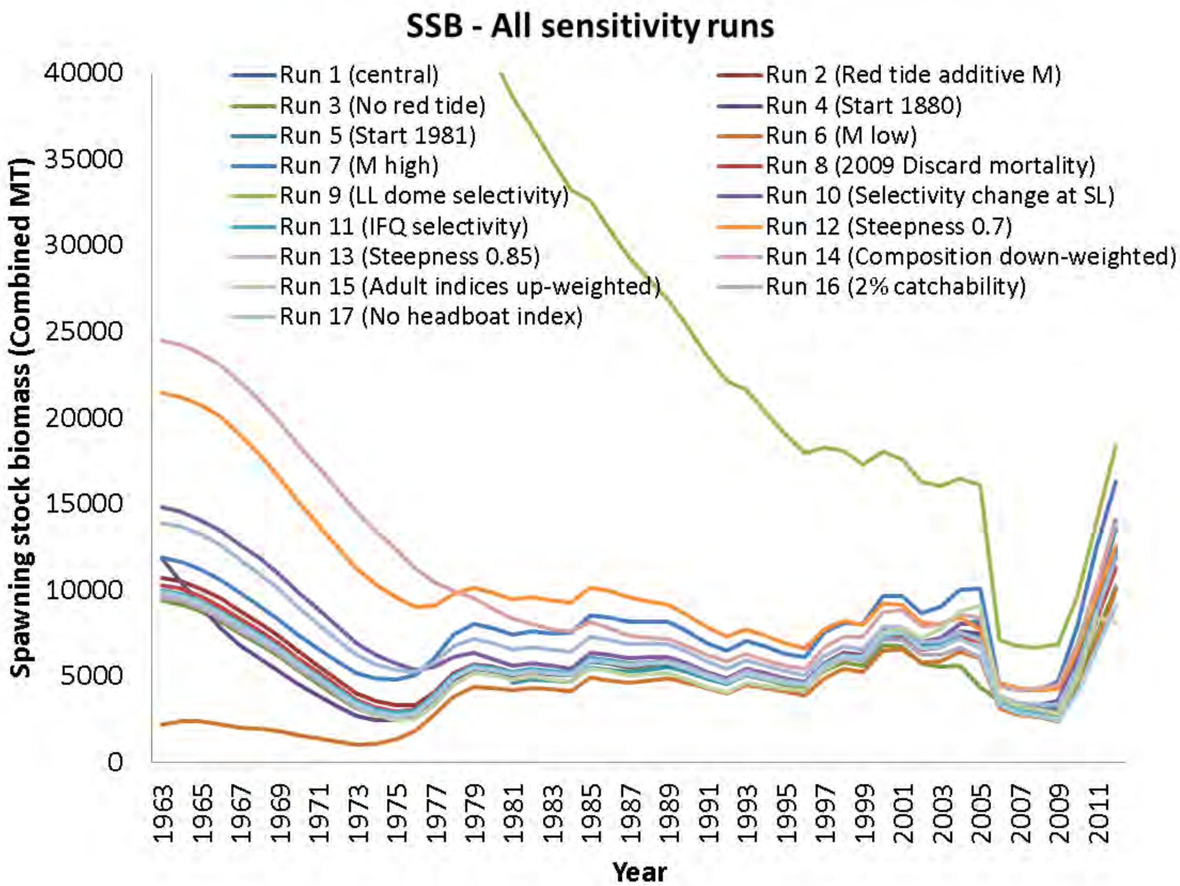


Figure 3.2.95. Predicted spawning stock biomass (female) across all sensitivity runs for the SSB combined model.

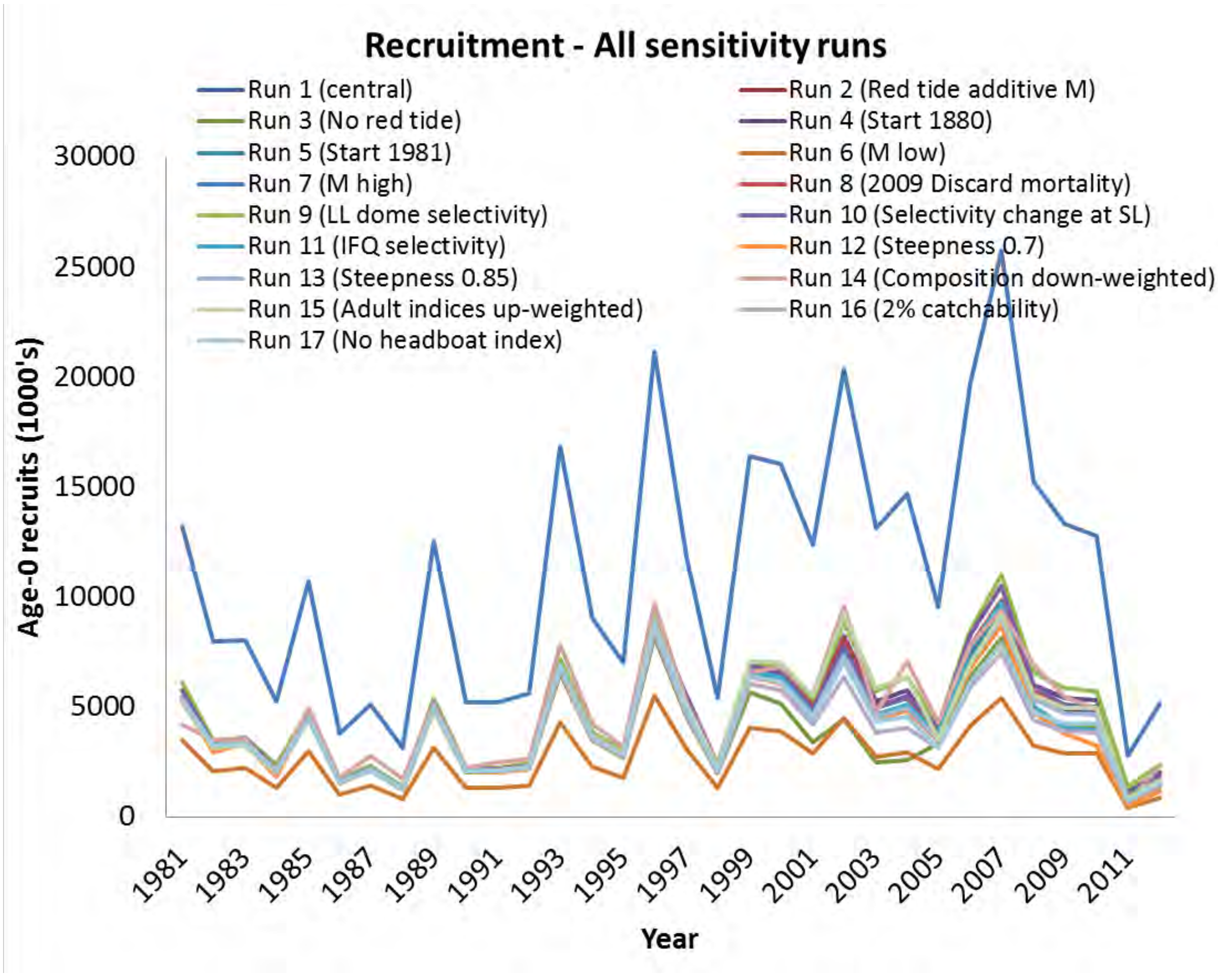


Figure 3.2.96. Predicted age-0 recruitment across all sensitivity runs for the SSB female model.

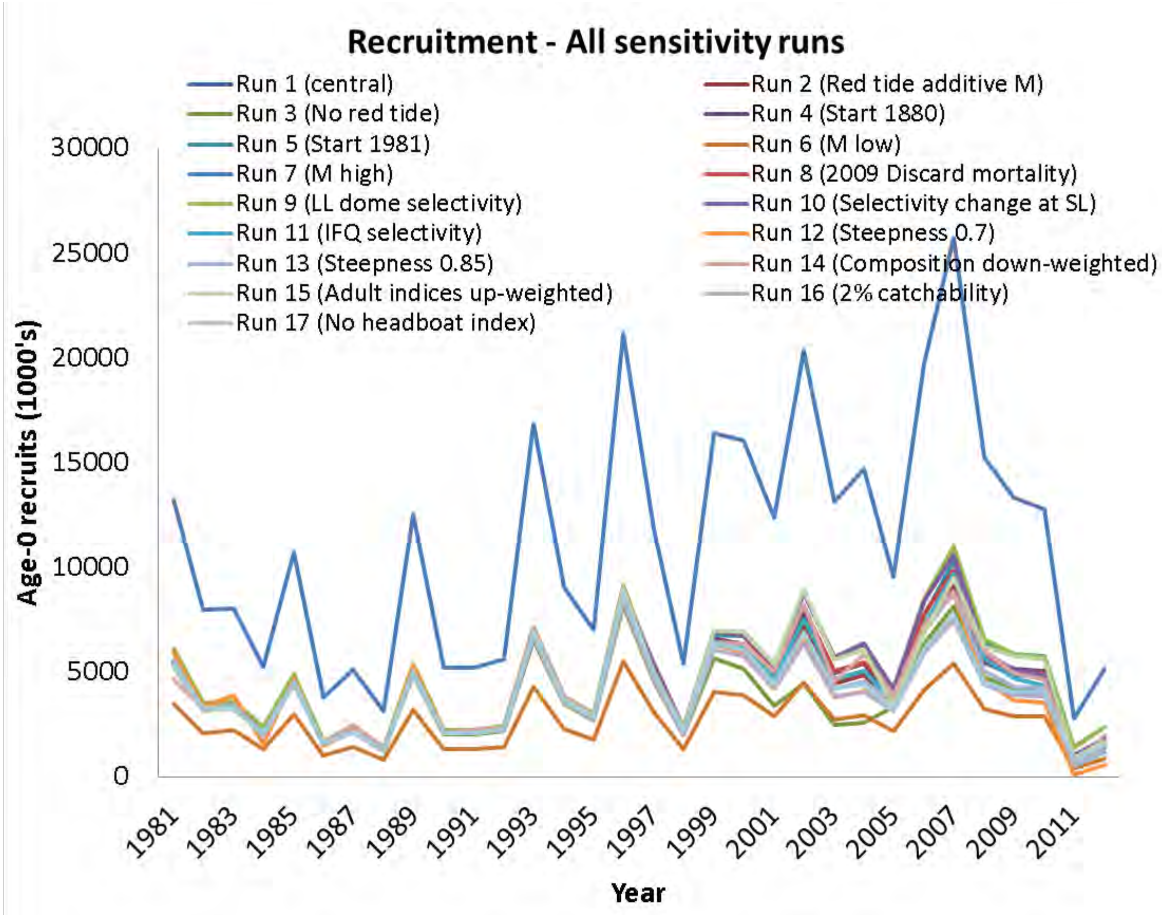


Figure 3.2.97. Predicted age-0 recruitment across all sensitivity runs for the SSB combined model.

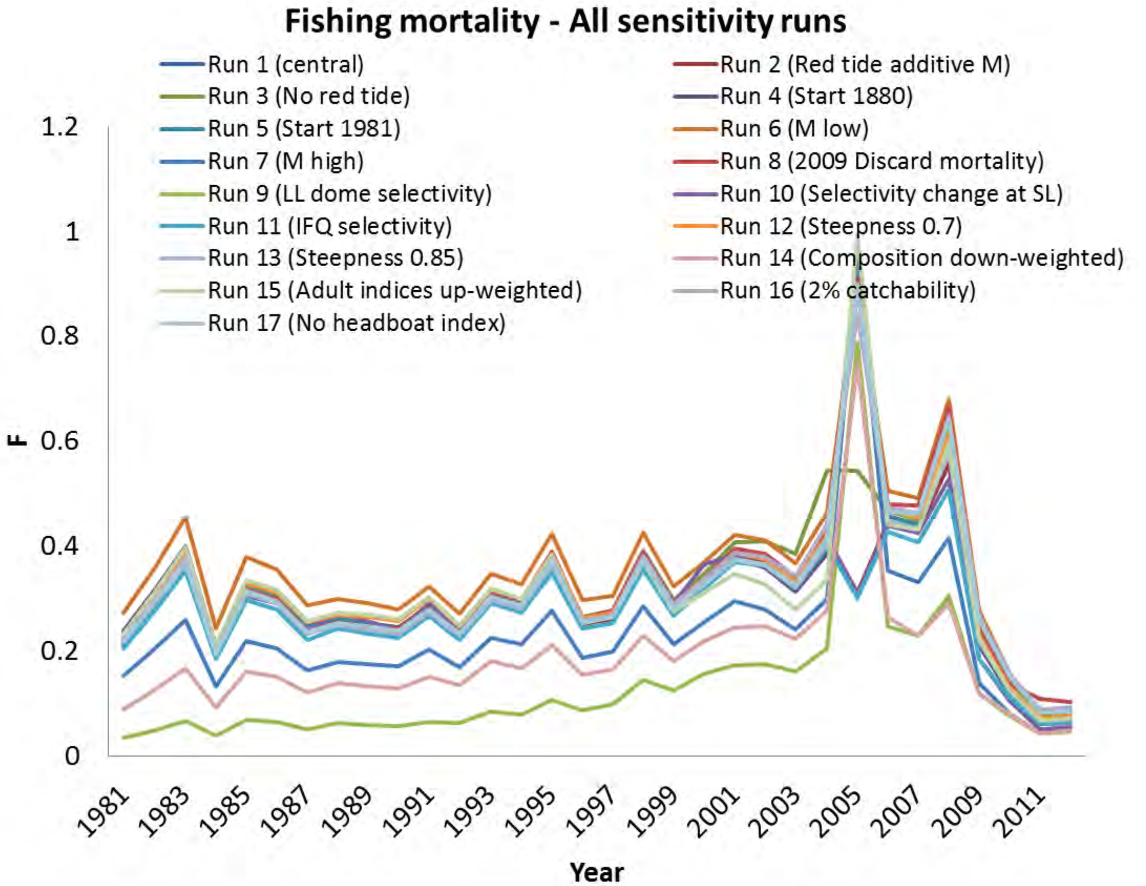


Figure 3.2.98. Predicted fishing mortality rate across all sensitivity runs for the SSB female model.

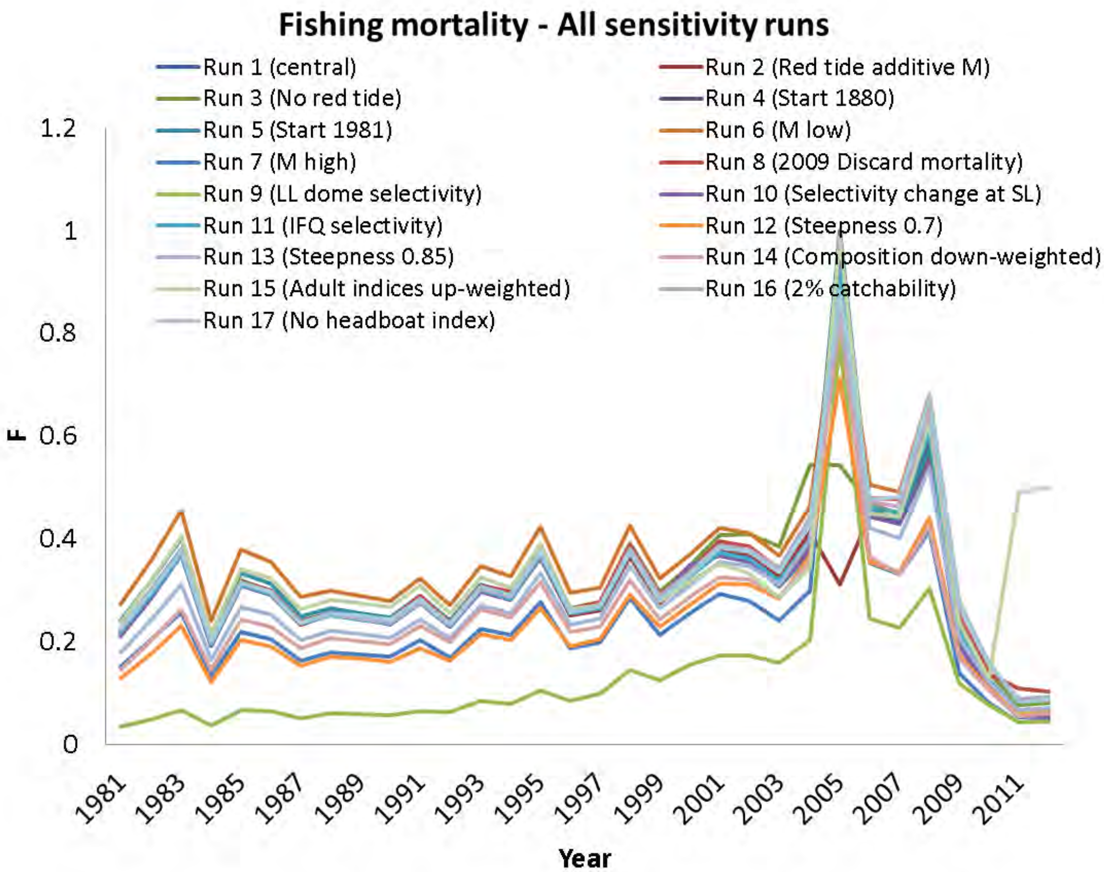


Figure 3.2.99. Predicted fishing mortality rate across all sensitivity runs for the SSB combined model.

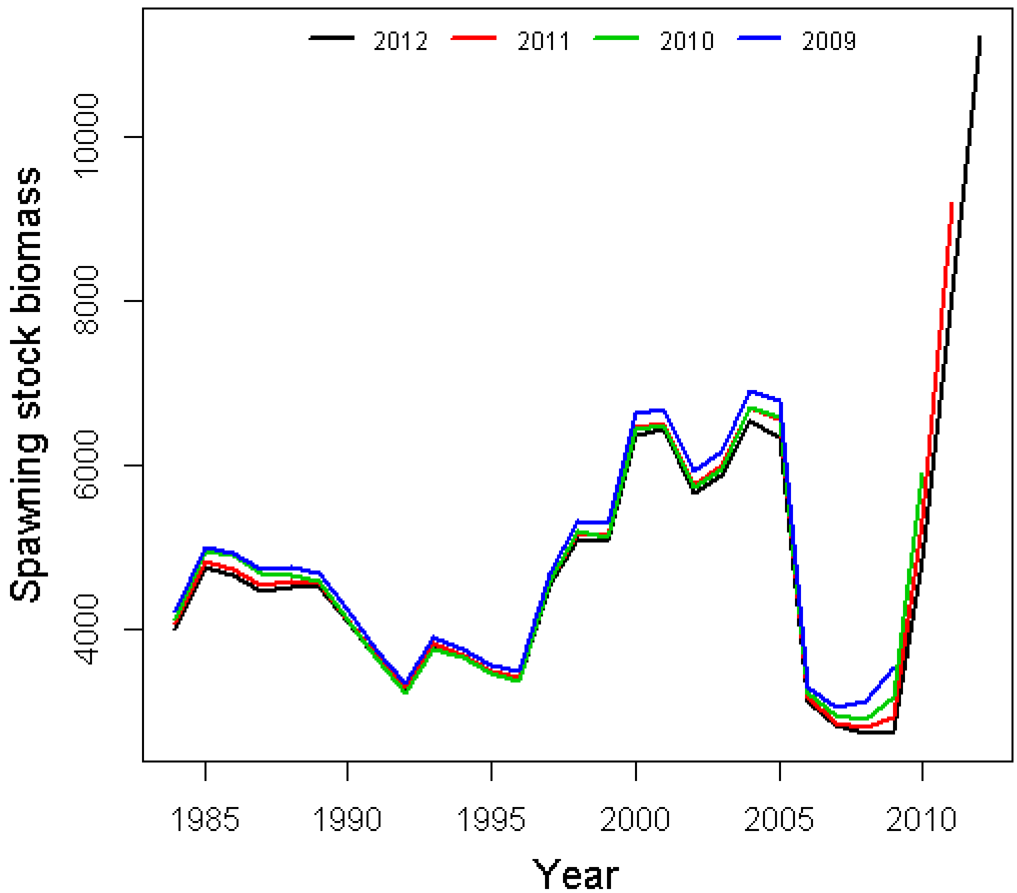


Figure 3.2.100. Predicted spawning stock biomass (female SSB) from the retrospective analysis.

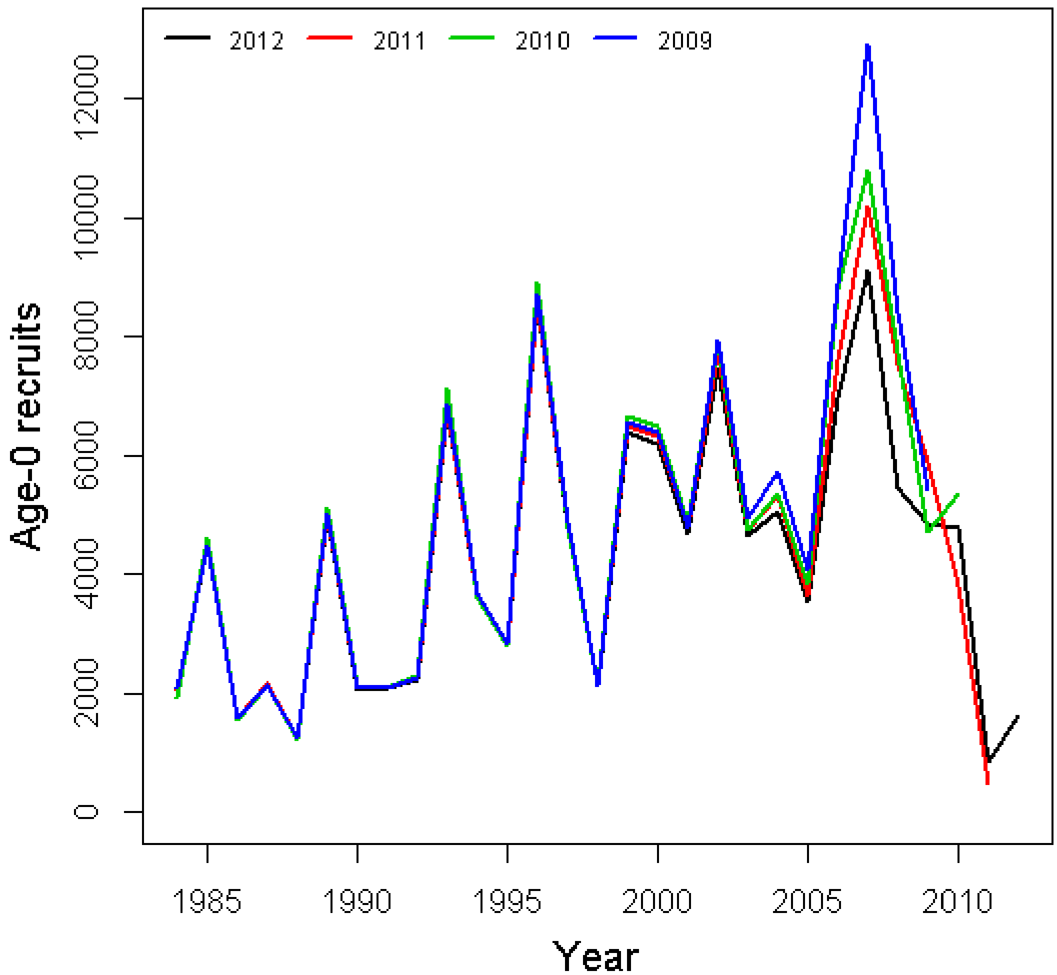


Figure 3.2.101. Predicted age-0 recruits (1000's) from the retrospective analysis.

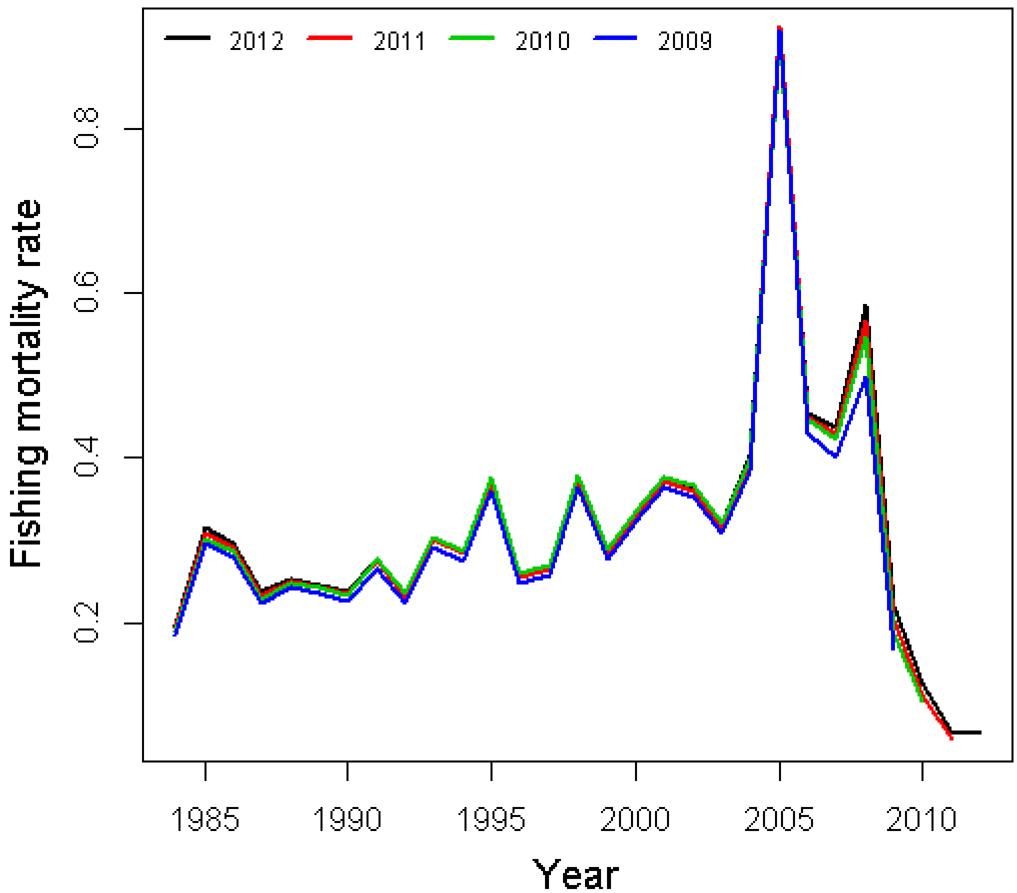


Figure 3.2.102. Predicted fishing mortality rate from the retrospective analysis.

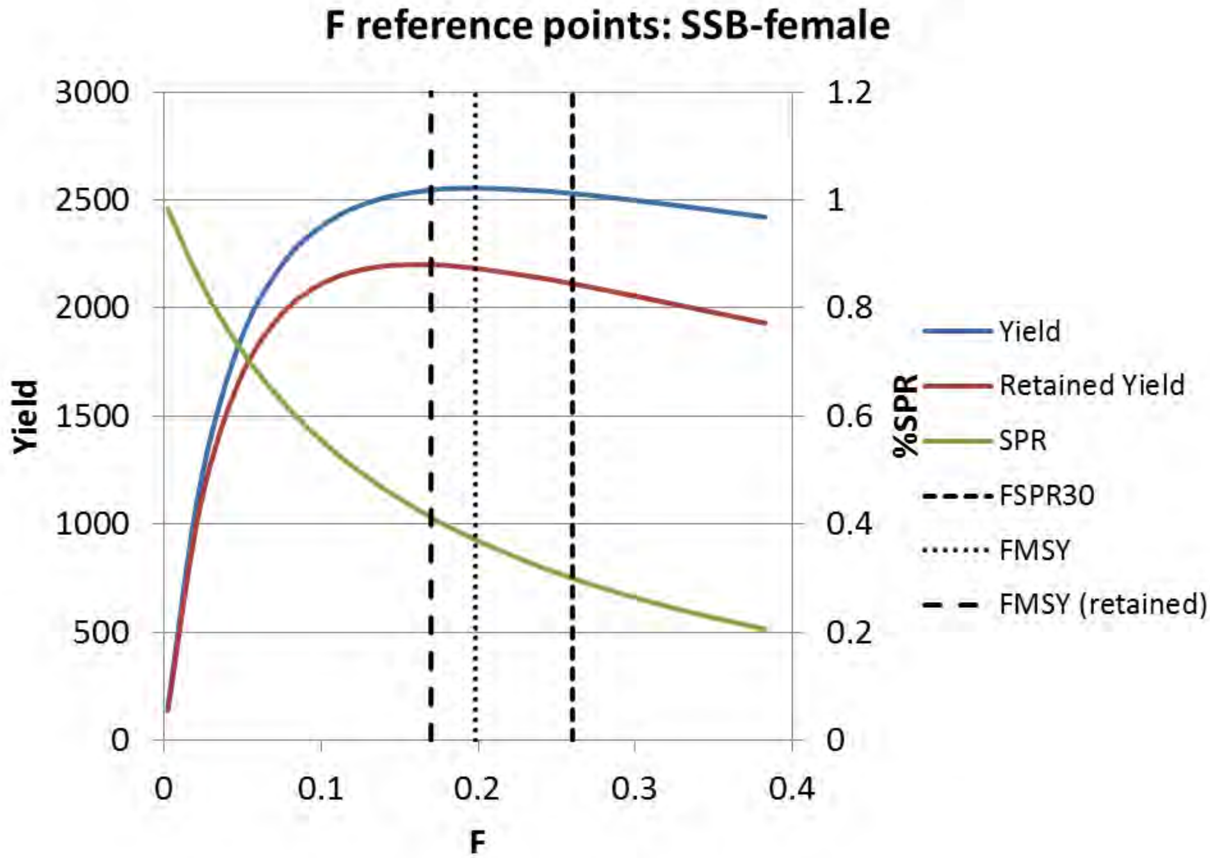


Figure 3.2.103. Equilibrium total yield (landings + dead discards), equilibrium retained yield (landings) and spawning biomass per recruit (green line) as a function of fishing mortality when using SSB-female. Vertical lines represent $F_{SPR30\%}$ (F = 0.26), F_{MSY} (F = 0.20), and $F_{MSY\text{-}RETAINED}$ (F = 0.17).

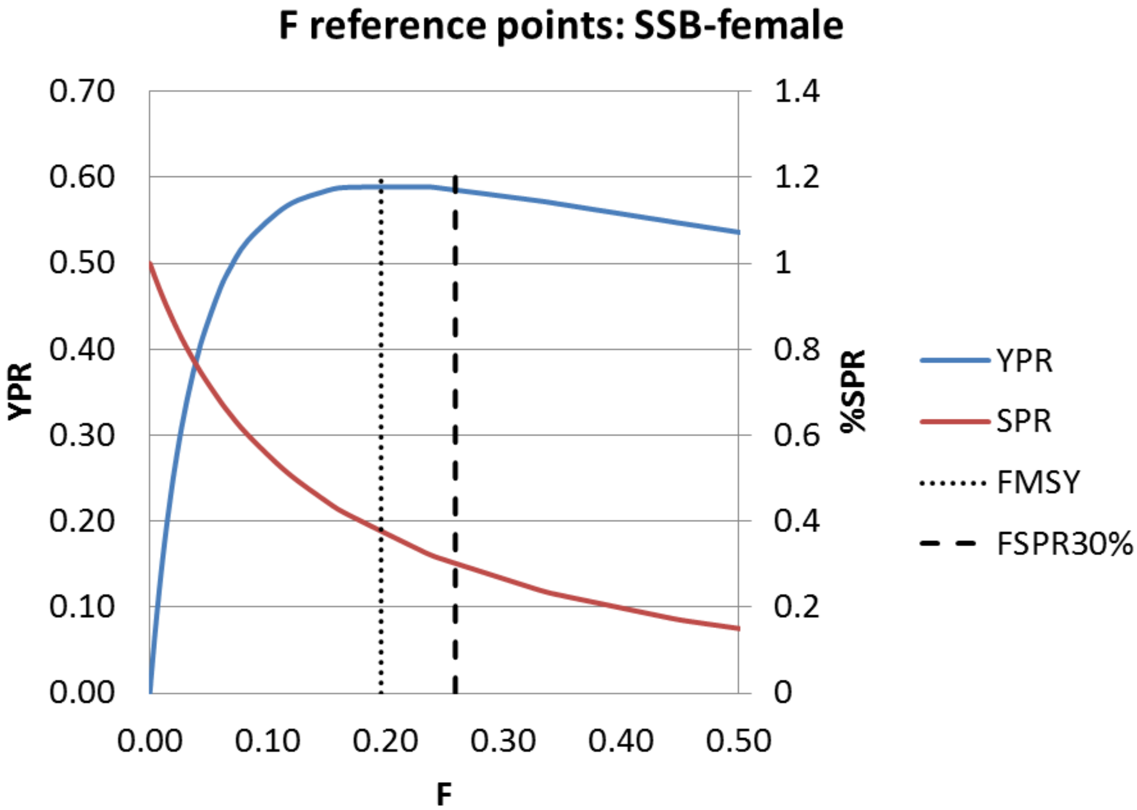


Figure 3.2.104. Yield per recruit (blue line) and spawning biomass per recruit (red line) as a function of fishing mortality rate for SSB-female. Vertical lines represent $F_{SPR30\%}$ (F = 0.26), and F_{MAX} (F = 0.20).

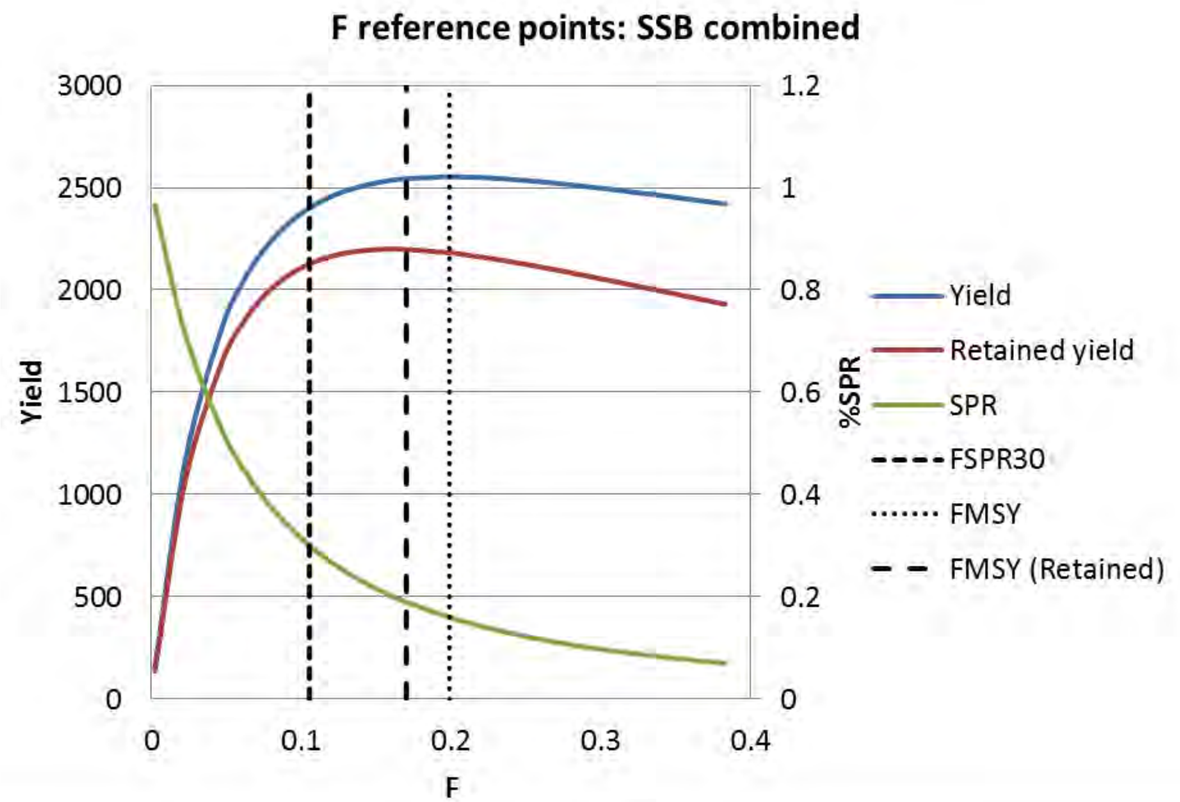


Figure 3.2.105. Equilibrium total yield (landings + dead discards), equilibrium retained yield (landings) and spawning biomass per recruit (green line) as a function of fishing mortality when using SSB-combined. Vertical lines represent $F_{SPR30\%}$ ($F = 0.10$), F_{MSY} ($F = 0.20$), and $F_{MSY\text{-}RETAINED}$ ($F = 0.17$).

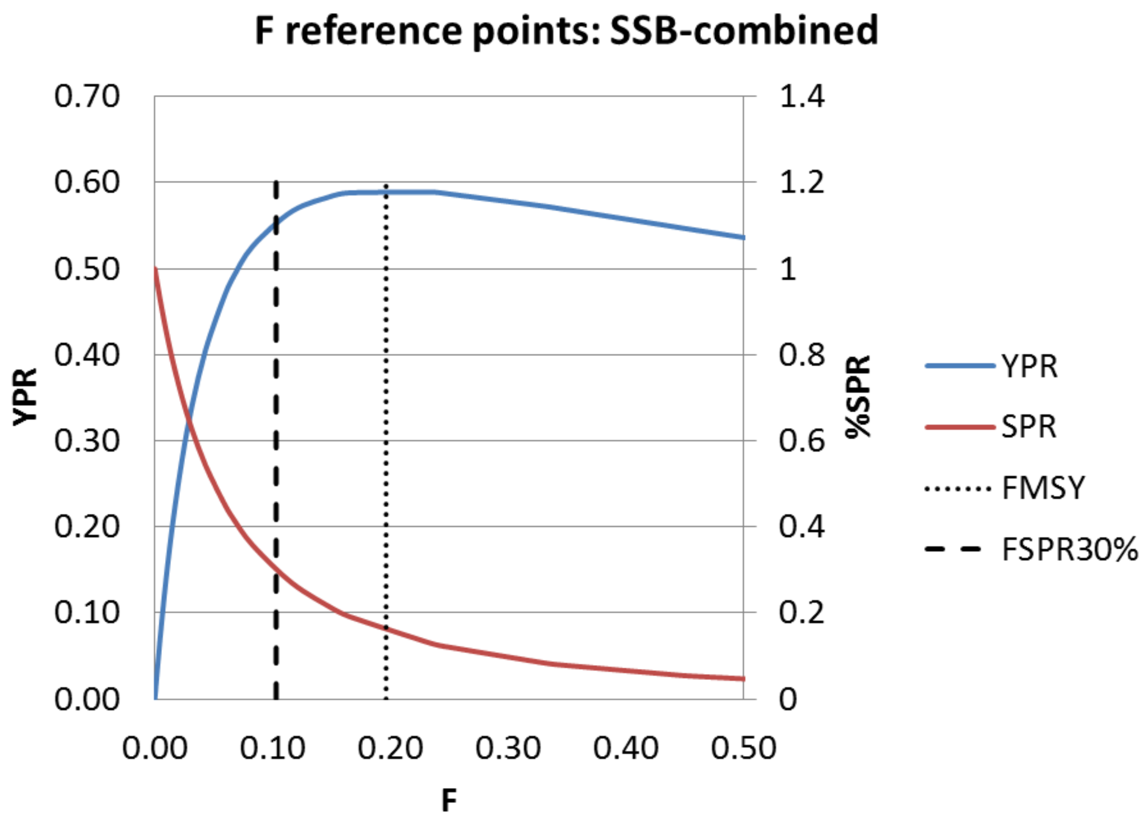


Figure 3.2.106. Yield per recruit (blue line) and spawning biomass per recruit (red line) as a function of fishing mortality rate for SSB-combined. Vertical lines represent $F_{SPR30\%}$ (F = 0.10), and F_{MAX} (F = 0.20).

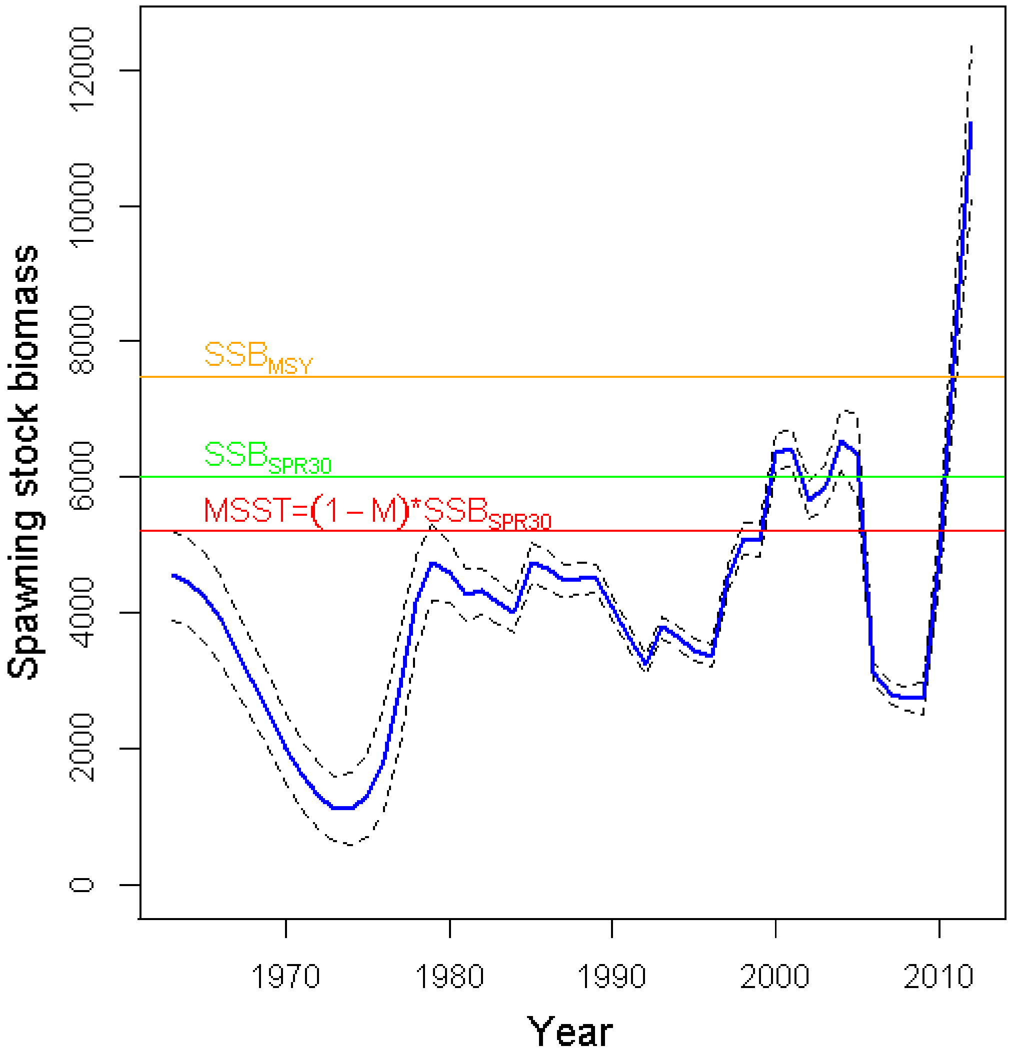


Figure 3.2.107. Predicted spawning stock biomass (SSB-female) of Gulf of Mexico Gag Grouper with associated 95% asymptotic intervals.

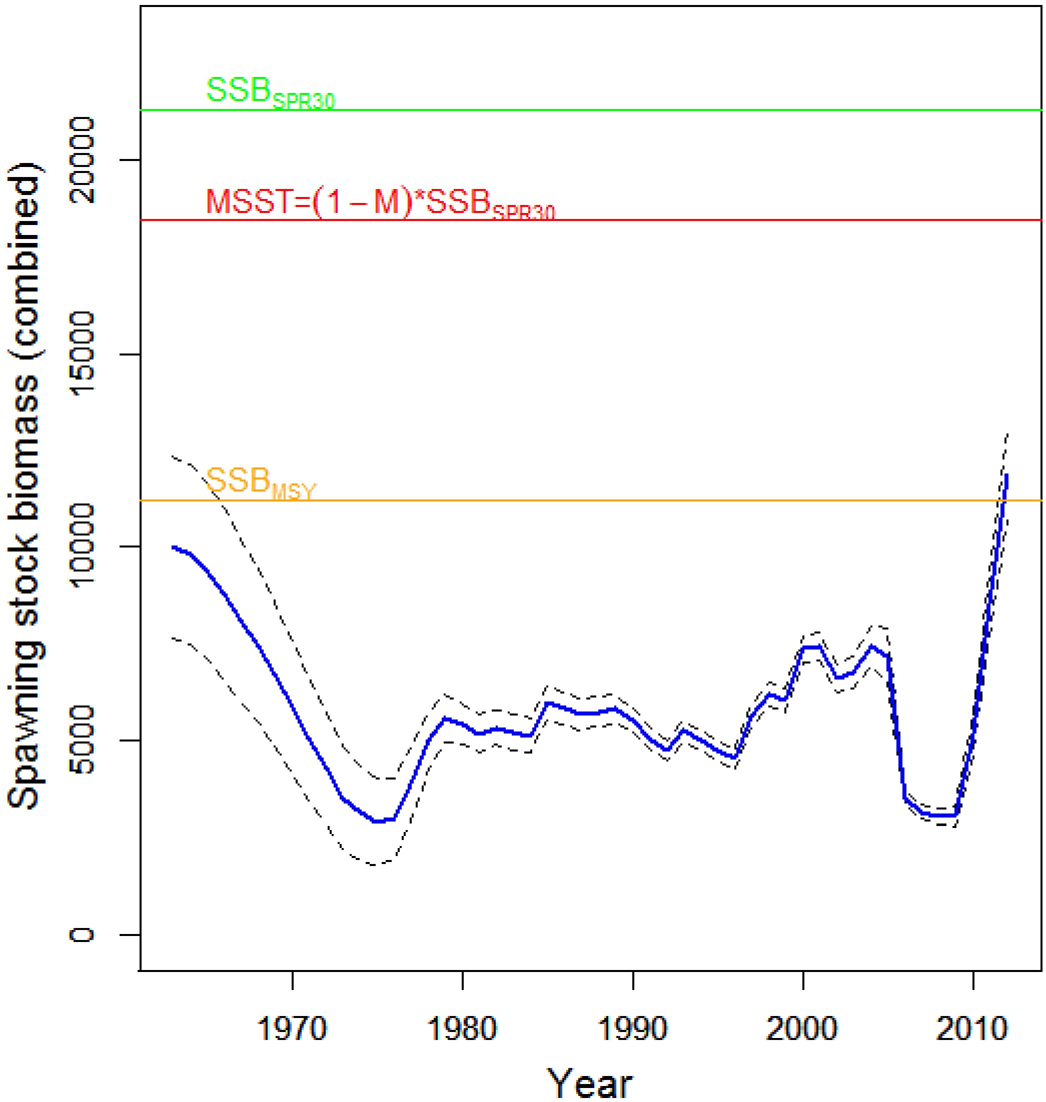


Figure 3.2.108. Predicted spawning stock biomass (SSB-combined) of Gulf of Mexico Gag Grouper with associated 95% asymptotic intervals.

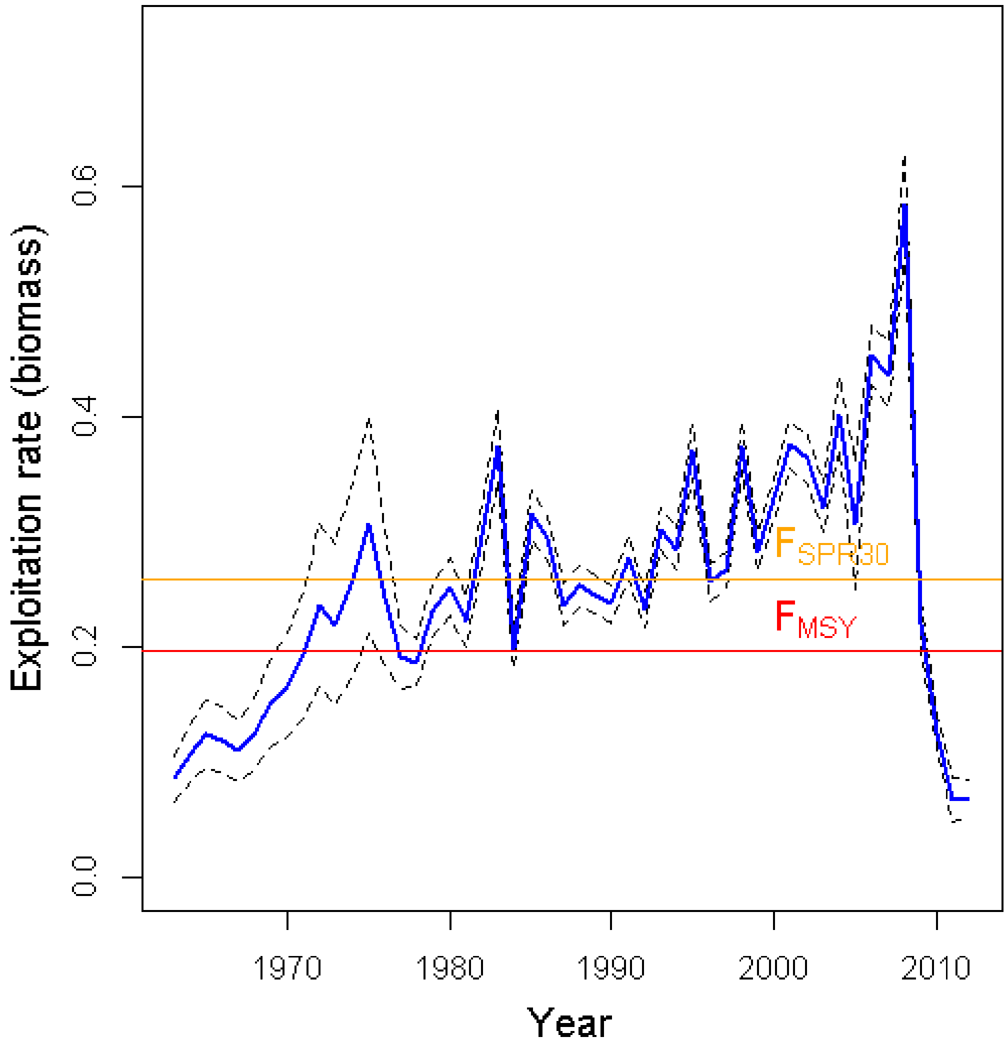


Figure 3.2.109. Predicted fishing mortality rate and associated 95% asymptotic intervals. Horizontal lines represent $F_{SPR30\%}$ (orange line) and F_{MSY} (red line) benchmarks for SSB-female.

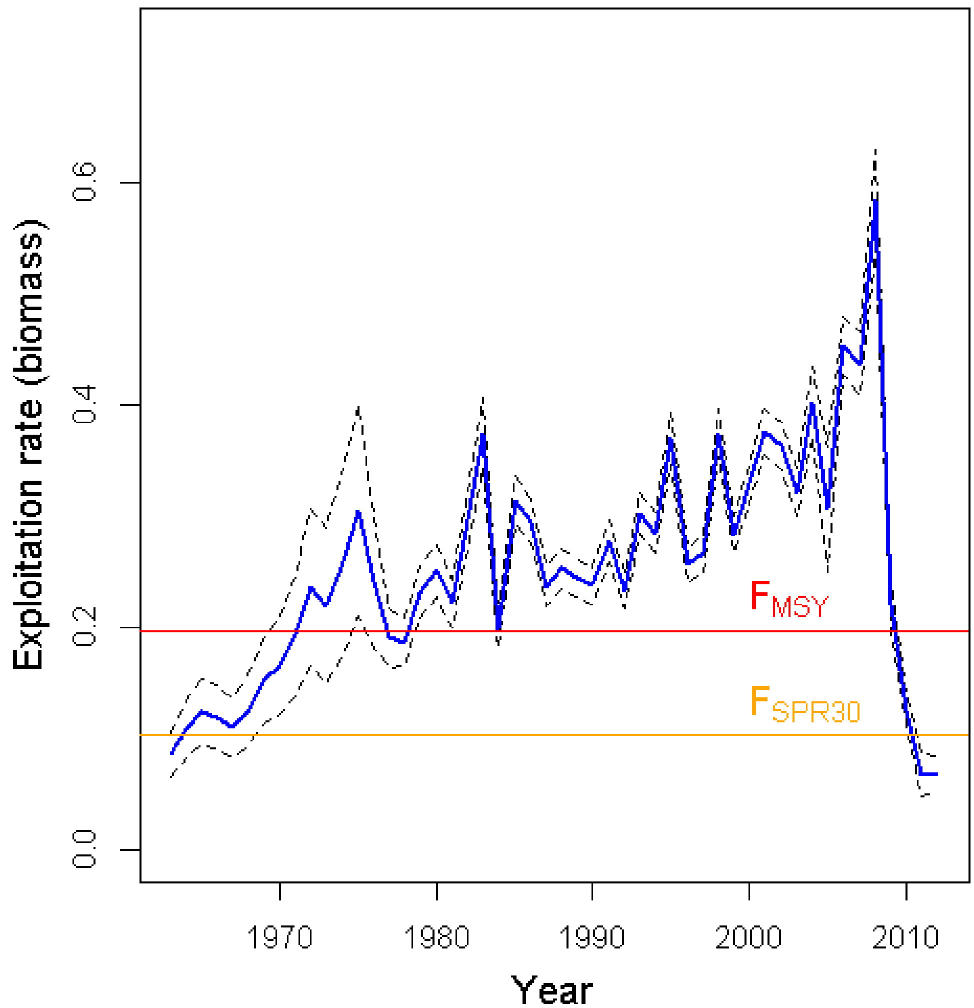


Figure 3.2.110. Predicted fishing mortality rate and associated 95% asymptotic intervals. Horizontal lines represent $F_{SPR30\%}$ (orange line) and F_{MSY} (red line) benchmarks for SSB-combined.

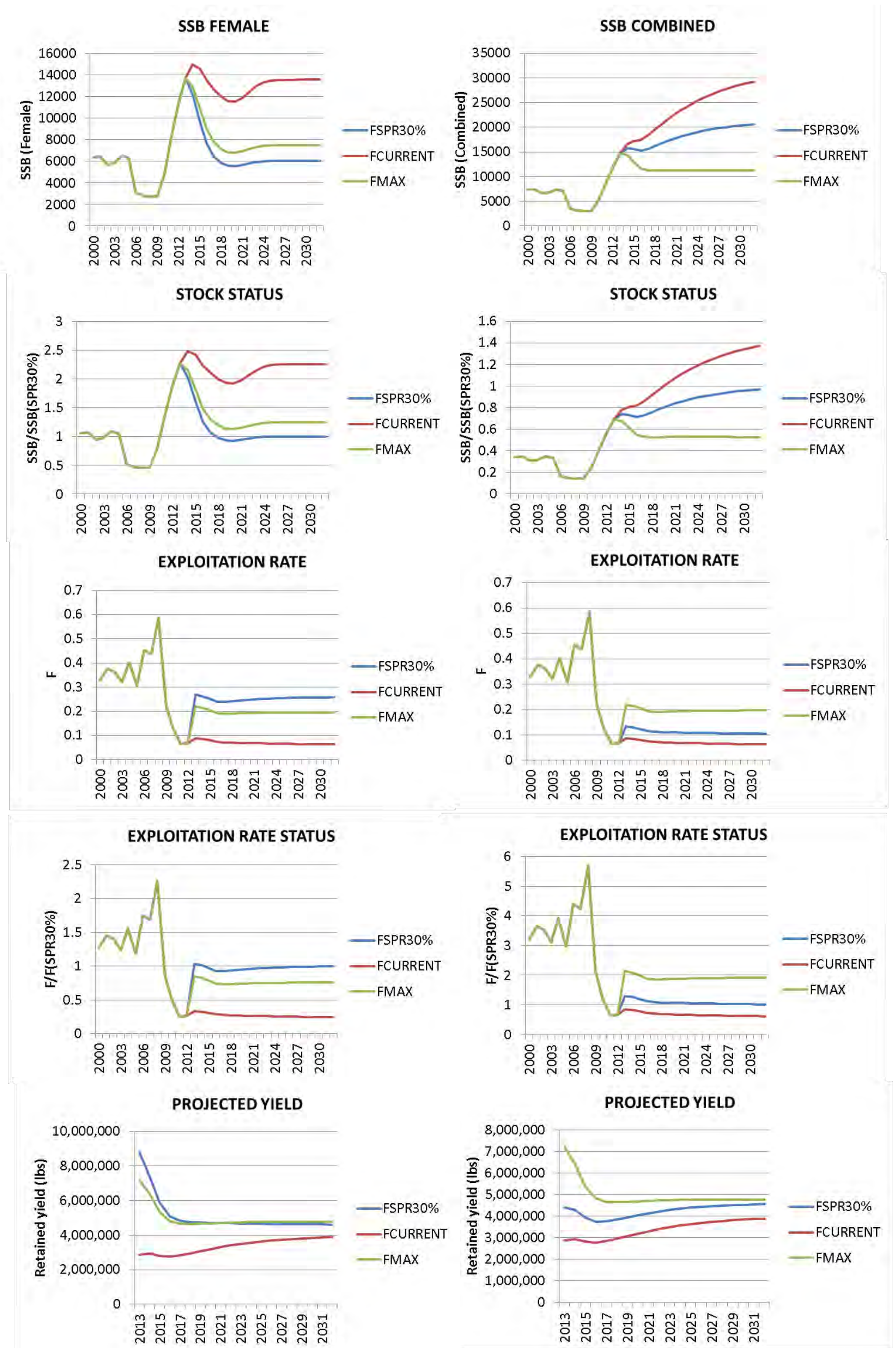


Figure 3.2.111. Projection results from three fixed F management scenarios for the base model.

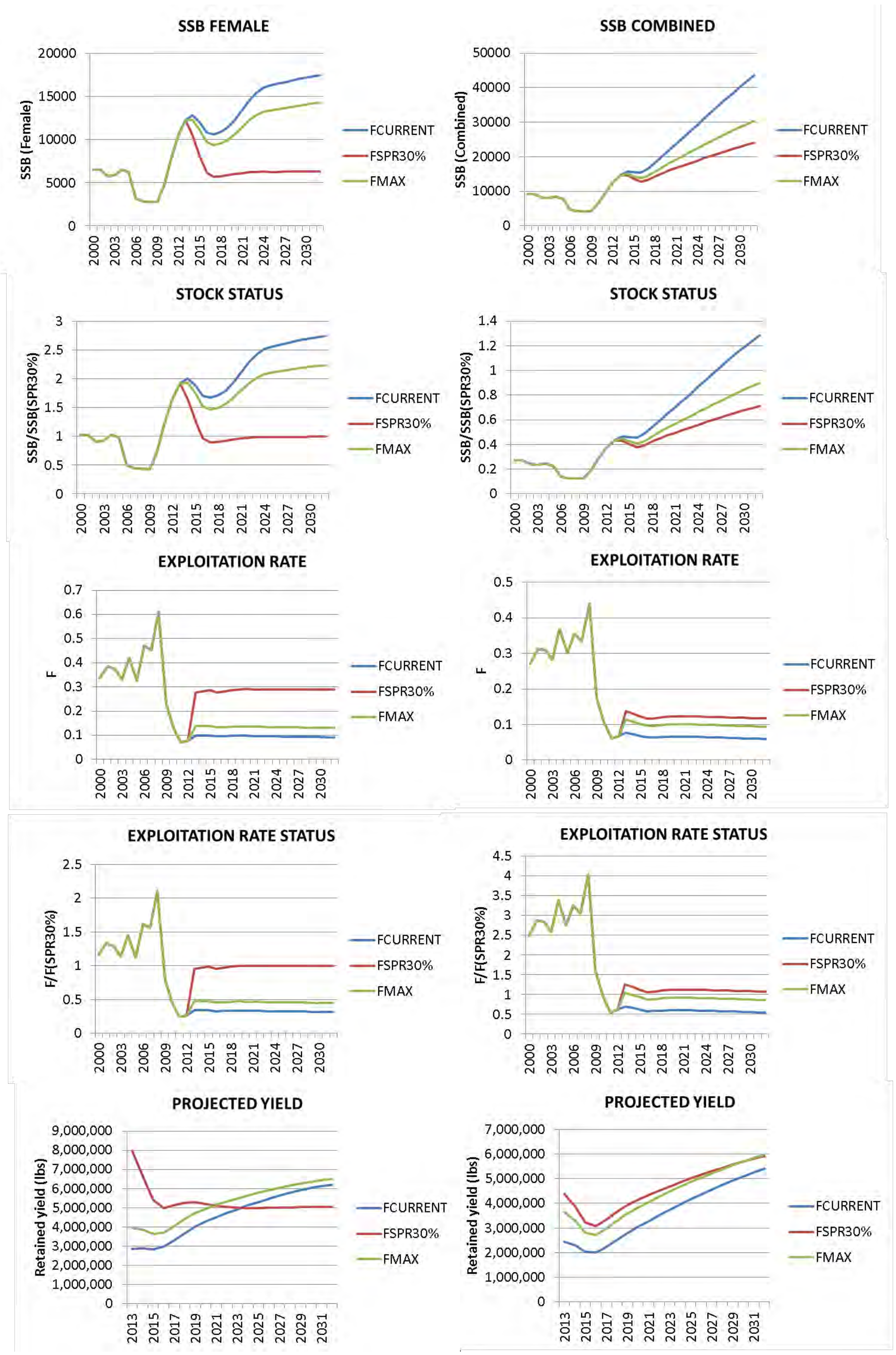


Figure 3.2.112. Projection results from three fixed F management scenarios for the model with steepness fixed at 0.7 (Run 12).

3.8 Appendix A

#C Gag Grouper 2011
#C bootstrap file: 1
1963 #_styr
2012 #_endyr
1 #_nseas
12 #_months/season
1 #_spawn_seas
6 #_N_Fishing_fleet
5 #_Nsurveys
1 #_N_areas
below are the fishery and survey names, separated by a % delimiter
Com_HL_1%Com_LL_2%Headboat_3%CHARTER_4%PRIVATE_5%REDTIDE_6%MRFSS_6%Age0_7%SEAMAP_Video_8%PC_Video_9
%CHARTER_SURVEY_10
-1 -1 -1 -1 -1 -1 -1 0.5 0.5 0.5 0.8 #_surveytiming_in_season; but use -1 for a fishery so that the expected value will be same as the whole season catch-at-age, rather than a midseason sample
1 1 1 1 1 1 1 1 1 1 1 #_area_assignments_for_each_fishery_and_survey
1 1 2 2 2 2 #_units of catch: 1=bio; 2=num
0.05 0.05 0.05 0.05 0.05 -1 #_se_of_log(catch) for each fleet. This is used for
init_eq_catch_and_for_Fmethod_2_and_3;_do_not_make_this_overly_small. Year specific values can be input in the control file if needed

2 #_Ngenders
31 #_Nages
500 0 0 0 50 0 #_init_equil_catch_for_each_fishery
50 # Number of Catch Observations

#	com_HL	com_LL	Headboat	Charter	Private	year	type
726.7564673	0	3.423500184	13.69400074	51.35250276	0	1963	1
912.4630784	0	3.697664279	14.79065712	55.46496418	0	1964	1
996.7300502	0	3.9937839	15.9751356	59.9067585	0	1965	1
833.9669538	0	4.313617635	17.25447054	64.70426452	0	1966	1
648.0175883	0	4.659064987	18.63625995	69.88597481	0	1967	1
676.0557251	0	5.032175465	20.12870186	75.48263198	0	1968	1
782.3778985	0	5.349292371	21.39716948	80.23938556	0	1969	1
742.2681519	0	5.682577137	22.73030855	85.23865705	0	1970	1
746.3357652	0	6.385330128	25.54132051	95.77995193	0	1971	1
798.2997409	0	7.172912635	28.69165054	107.5936895	0	1972	1
587.0158417	0	8.055225288	32.22090115	120.8283793	0	1973	1
659.4114491	0	9.043255342	36.17302137	135.6488301	0	1974	1
813.6270627	0	10.14691902	40.58767608	152.2037853	0	1975	1
656.0766195	0	11.40203601	45.60814405	171.0305402	0	1976	1
543.0971996	0	12.80796965	51.23187862	192.1195448	0	1977	1
489.0637187	0	14.39914088	57.59656352	215.9871132	0	1978	1
755.6461886	0.495457185	16.18558741	64.74234963	242.7838111	0	1979	1
745.7321692	43.36242188	18.09045906	72.36183623	271.3568859	0	1980	1
777.9570645	191.5424059	14.0526	22.661	189.478	0	1981	1
693.9339744	401.4055016	23.6526	45.2207	419.415	0	1982	1
554.6693892	276.0736298	36.3218	63.039	886.797	0	1983	1
616.9781149	189.0220492	17.3419	28.3723	237.306	0	1984	1
799.4261653	165.8637929	92.4634	153.11	390.541	0	1985	1
533.0040871	231.6954965	42.495	166.348	460.217	0	1986	1
392.7855774	295.1031014	32.156	33.7226	376.959	0	1987	1
363.5732456	181.443423	26.336	65.4166	548.231	0	1988	1
567.7119682	190.3383041	35.145	36.1771	336.11	0	1989	1
525.5476002	279.228103	19.097	33.086	138.999	0	1990	1
473.6104661	226.9657635	11.453	13.2807	261.69	0	1991	1
476.8860276	264.7607795	13.789	45.8502	205.026	0	1992	1
623.3676446	214.3391461	19.335	104.8	247.24	0	1993	1
571.1868182	157.0046851	20.561	51.7031	226.921	0	1994	1
569.2622168	174.390167	17.816	111.512	319.024	0	1995	1
526.981812	175.3835816	16.062	103.589	253.628	0	1996	1
532.2881405	185.049368	15.623	98.8836	304.053	0	1997	1
868.2319765	264.1597893	36.316	152.66	366.23	0.001	1998	1
689.7958804	240.5138087	32.117	132.759	421.071	0.001	1999	1
753.5051094	256.3513717	30.824	162.991	580.242	0.001	2000	1
972.2756662	424.2011822	14.494	109.513	388.076	0.001	2001	1
874.9309012	458.9756005	11.615	95.5078	448.916	0.001	2002	1
678.7632106	488.9254245	16.381	100.402	425.942	0.001	2003	1
814.0110515	491.9248556	24.67	142.853	566.839	0.001	2004	1

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724.3195057	395.3644867	16.784	130.75	386.364	0.001	2005	1
384.4195728	234.9399291	6.764	87.1317	278.707	0.001	2006	1
355.6762238	214.4556946	11.141	41.4076	248.512	0.001	2007	1
428.7626393	169.082711	10.521	94.983	343.288	0.001	2008	1
268.3919205	70.55585463	9.483	49.2203	164.153	0.001	2009	1
176.9859367	48.37285854	11.094	58.2248	179.584	0.001	2010	1
106.0750659	38.46952268	5.099	11.0256	89.9462	0	2011	1
179.0426557	58.25118447	5.253	48.6106	83.9393	0	2012	1
#
#	Abundance		Indices
174	#	Number	of	Survey	Observations
#	Fleet	Units	(0=num,	1=bio,	2=F)	error
1	1	0	#Handline index_lbs/hook hr
2	1	0	#Longline index_lbs/hook
3	0	0	#Headboat index_fish/angler hr
4	0	0	#Charterboat catches
5	0	0	#Private
6	2	0	#RED TIDE
7	0	0	#MRFSS index_fish/1000 angler hrs
8	0	0	#Age0 Survey_fish/haul
9	0	0	#SEAMAP_Video_frequency of occurrence P/A
10	0	0	#PC_LAB_VIDEO
11	0	0	#Charter index
#Year	Season	FLEET	CPUE	SD	Label
1990	1	1	0.314246824	0.308404751	#Handline index_lbs/hook hr
1991	1	1	0.313961252	0.235407538	#Handline index_lbs/hook hr
1992	1	1	0.562203356	0.229256718	#Handline index_lbs/hook hr
1993	1	1	0.650563224	0.202975538	#Handline index_lbs/hook hr
1994	1	1	0.588539088	0.201873677	#Handline index_lbs/hook hr
1995	1	1	0.782305105	0.198452797	#Handline index_lbs/hook hr
1996	1	1	0.930411221	0.196094948	#Handline index_lbs/hook hr
1997	1	1	0.906761016	0.193258333	#Handline index_lbs/hook hr
1998	1	1	1.546200115	0.192301678	#Handline index_lbs/hook hr
1999	1	1	1.044524903	0.193332031	#Handline index_lbs/hook hr
2000	1	1	1.109266907	0.193799733	#Handline index_lbs/hook hr
2001	1	1	1.592808844	0.194039336	#Handline index_lbs/hook hr
2002	1	1	1.589802108	0.194665972	#Handline index_lbs/hook hr
2003	1	1	1.562561121	0.194901813	#Handline index_lbs/hook hr
2004	1	1	1.990756568	0.194752163	#Handline index_lbs/hook hr
2005	1	1	1.871691894	0.195970406	#Handline index_lbs/hook hr
2006	1	1	1.005837263	0.20046803	#Handline index_lbs/hook hr
2007	1	1	0.647911318	0.203966426	#Handline index_lbs/hook hr
2008	1	1	0.640038016	0.206379252	#Handline index_lbs/hook hr
2009	1	1	0.349609858	0.208650628	#Handline index_lbs/hook hr
1990	1	2	0.82362	0.418516864	#Longline index_lbs/hook
1991	1	2	0.6416	0.343430299	#Longline index_lbs/hook
1992	1	2	0.51082	0.347016173	#Longline index_lbs/hook
1993	1	2	0.67012	0.2869881 #Longline index_lbs/hook
1994	1	2	0.37779	0.295818769	#Longline index_lbs/hook
1995	1	2	0.48044	0.289177807	#Longline index_lbs/hook
1996	1	2	0.50427	0.29756958	#Longline index_lbs/hook
1997	1	2	0.64167	0.276141192	#Longline index_lbs/hook
1998	1	2	0.9517	0.274950794	#Longline index_lbs/hook
1999	1	2	0.85418	0.277916254	#Longline index_lbs/hook
2000	1	2	0.8767	0.279850338	#Longline index_lbs/hook
2001	1	2	1.63748	0.268933273	#Longline index_lbs/hook
2002	1	2	1.43763	0.27987863	#Longline index_lbs/hook
2003	1	2	1.70632	0.271915488	#Longline index_lbs/hook
2004	1	2	2.06297	0.266990543	#Longline index_lbs/hook
2005	1	2	2.26021	0.261856418	#Longline index_lbs/hook
2006	1	2	1.19896	0.268165838	#Longline index_lbs/hook
2007	1	2	0.92174	0.281858243	#Longline index_lbs/hook
2008	1	2	0.99351	0.269094309	#Longline index_lbs/hook
2009	1	2	0.44826	0.336257196	#Longline index_lbs/hook
1986	1	3	1.351590184	0.079409238	#Headboat index_fish/angler hr
1987	1	3	1.499743789	0.079732776	#Headboat index_fish/angler hr
1988	1	3	1.066160356	0.087226511	#Headboat index_fish/angler hr
1989	1	3	1.009943853	0.097933681	#Headboat index_fish/angler hr
1990	1	3	0.942835428	0.085551434	#Headboat index_fish/angler hr
1991	1	3	0.671669161	0.101871083	#Headboat index_fish/angler hr
```

1992	1	3	0.806611553	0.111462264	#Headboat index_fish/angler hr
1993	1	3	0.81940919	0.098538825	#Headboat index_fish/angler hr
1994	1	3	0.854544338	0.111840777	#Headboat index_fish/angler hr
1995	1	3	0.736746236	0.11590325	#Headboat index_fish/angler hr
1996	1	3	0.988319141	0.090130659	#Headboat index_fish/angler hr
1997	1	3	0.947017774	0.09473978	#Headboat index_fish/angler hr
1998	1	3	1.116432939	0.084644788	#Headboat index_fish/angler hr
1999	1	3	1.225302266	0.083853908	#Headboat index_fish/angler hr
2000	1	3	1.144034287	0.094197262	#Headboat index_fish/angler hr
2001	1	3	0.587495212	0.128600102	#Headboat index_fish/angler hr
2002	1	3	0.677374272	0.121696026	#Headboat index_fish/angler hr
2003	1	3	0.946960916	0.100977606	#Headboat index_fish/angler hr
2004	1	3	1.052165268	0.098102226	#Headboat index_fish/angler hr
2005	1	3	1.111654313	0.073274806	#Headboat index_fish/angler hr
2006	1	3	0.519296737	0.12936286	#Headboat index_fish/angler hr
2007	1	3	0.623085912	0.128348492	#Headboat index_fish/angler hr
2008	1	3	0.957134583	0.095776974	#Headboat index_fish/angler hr
2009	1	3	0.891071588	0.100143162	#Headboat index_fish/angler hr
2010	1	3	1.357462911	0.085433508	#Headboat index_fish/angler hr
#2011	1	3	2.041029096	0.129127309	#Headboat index_fish/angler hr
#2012	1	3	1.054908695	0.123535296	#Headboat index_fish/angler hr
1986	1	11	1.602138714	0.257781988	#Charter
1987	1	11	0.487451172	0.325682453	#Charter
1988	1	11	0.540397254	0.335199738	#Charter
1989	1	11	0.40740171	0.411064541	#Charter
1990	1	11	0.547371663	0.488285022	#Charter
1991	1	11	0.177877534	0.737066585	#Charter
1992	1	11	0.736697596	0.391763921	#Charter
1993	1	11	0.819814395	0.370522261	#Charter
1994	1	11	0.46984354	0.447828067	#Charter
1995	1	11	1.50443451	0.320175443	#Charter
1996	1	11	1.843154199	0.340527821	#Charter
1997	1	11	1.083907771	0.276226864	#Charter
1998	1	11	1.6515901 0.240520746	#Charter	
1999	1	11	1.381595762	0.23160838	#Charter
2000	1	11	0.679891031	0.253561441	#Charter
2001	1	11	0.773616955	0.256406662	#Charter
2002	1	11	1.115487151	0.248717301	#Charter
2003	1	11	1.521145076	0.235920267	#Charter
2004	1	11	1.668123597	0.232632991	#Charter
2005	1	11	2.177785397	0.232806569	#Charter
2006	1	11	0.888463798	0.268097495	#Charter
2007	1	11	0.561754648	0.281608374	#Charter
2008	1	11	1.127553899	0.261613044	#Charter
2009	1	11	0.996869002	0.271159973	#Charter
2010	1	11	0.940482396	0.267819846	#Charter
2011	1	11	0.562633956	0.273054405	#Charter
2012	1	11	0.732517176	0.264351367	#Charter
1986	1	7	0.920174241	0.23344234	#MRFSS
1987	1	7	0.410392595	0.249944092	#MRFSS
1988	1	7	0.465198284	0.214389023	#MRFSS
1989	1	7	0.396091847	0.263790055	#MRFSS
1990	1	7	0.484262785	0.326413076	#MRFSS
1991	1	7	0.722861816	0.261964492	#MRFSS
1992	1	7	0.451720019	0.195747627	#MRFSS
1993	1	7	0.885118433	0.177371336	#MRFSS
1994	1	7	1.267029405	0.142416394	#MRFSS
1995	1	7	1.268894785	0.147175889	#MRFSS
1996	1	7	0.981931332	0.150020785	#MRFSS
1997	1	7	1.350791174	0.143139745	#MRFSS
1998	1	7	1.40694618	0.131061553	#MRFSS
1999	1	7	0.948927205	0.125607059	#MRFSS
2000	1	7	0.836240574	0.135681173	#MRFSS
2001	1	7	0.834983463	0.128244393	#MRFSS
2002	1	7	0.896202512	0.127846946	#MRFSS
2003	1	7	1.337977399	0.121218783	#MRFSS
2004	1	7	1.444542137	0.114452961	#MRFSS
2005	1	7	1.339877673	0.123956301	#MRFSS
2006	1	7	0.972511998	0.138248081	#MRFSS
2007	1	7	1.28330825	0.129882872	#MRFSS

2008	1	7	1.869762458	0.110620108	#MRFSS
2009	1	7	1.404379106	0.123356135	#MRFSS
2010	1	7	1.348589452	0.137263105	#MRFSS
2011	1	7	0.930507457	0.147066565	#MRFSS
2012	1	7	0.540777419	0.173715964	#MRFSS
1994	1	8	0.79297	0.332633298	#Age0 Survey_fish/haul
1995	1	8	0.55785	0.25863401	#Age0 Survey_fish/haul
1996	1	8	1.21665	0.178254585	#Age0 Survey_fish/haul
1997	1	8	0.45054	0.199770215	#Age0 Survey_fish/haul
1998	1	8	0.20694	0.330763613	#Age0 Survey_fish/haul
1999	1	8	0.29259	0.274147419	#Age0 Survey_fish/haul
2000	1	8	0.49479	0.276396201	#Age0 Survey_fish/haul
2001	1	8	0.60876	0.298065552	#Age0 Survey_fish/haul
2002	1	8	1.71449	0.203543491	#Age0 Survey_fish/haul
2003	1	8	0.74451	0.228571811	#Age0 Survey_fish/haul
2004	1	8	1.70112	0.174082749	#Age0 Survey_fish/haul
2005	1	8	0.74714	0.18095843	#Age0 Survey_fish/haul
2006	1	8	2.17426	0.150041574	#Age0 Survey_fish/haul
2007	1	8	2.1779	0.149599082	#Age0 Survey_fish/haul
2008	1	8	1.72754	0.139055081	#Age0 Survey_fish/haul
2009	1	8	1.36309	0.155917583	#Age0 Survey_fish/haul
2010	1	8	1.42322	0.164393038	#Age0 Survey_fish/haul
2011	1	8	0.11754	0.273296499	#Age0 Survey_fish/haul
2012	1	8	0.48808	0.206314914	#Age0 Survey_fish/haul
1993	1	9	1.30734	0.468760429	#SEAMAP_Video_frequency of occurrence P/A
1994	1	9	0.65383	0.642066078	#SEAMAP_Video_frequency of occurrence P/A
1995	1	9	1.44017	0.593915635	#SEAMAP_Video_frequency of occurrence P/A
1996	1	9	1.39982	0.362462628	#SEAMAP_Video_frequency of occurrence P/A
1997	1	9	1.52856	0.39629874	#SEAMAP_Video_frequency of occurrence P/A
2002	1	9	2.71344	0.249429666	#SEAMAP_Video_frequency of occurrence P/A
2004	1	9	1.46292	0.251929254	#SEAMAP_Video_frequency of occurrence P/A
2005	1	9	0.84758	0.251481027	#SEAMAP_Video_frequency of occurrence P/A
2006	1	9	0.54597	0.334795548	#SEAMAP_Video_frequency of occurrence P/A
2007	1	9	0.52926	0.274563317	#SEAMAP_Video_frequency of occurrence P/A
2008	1	9	0.10893	0.638612991	#SEAMAP_Video_frequency of occurrence P/A
2009	1	9	0.44405	0.369050084	#SEAMAP_Video_frequency of occurrence P/A
2010	1	9	0.64532	0.285774888	#SEAMAP_Video_frequency of occurrence P/A
2011	1	9	0.71162	0.28020868	#SEAMAP_Video_frequency of occurrence P/A
2012	1	9	0.66119	0.271205763	#SEAMAP_Video_frequency of occurrence P/A
2005	1	10	0.44435	0.521793593	#PC_LAB_VIDEO
2006	1	10	2.21793	0.218930258	#PC_LAB_VIDEO
2007	1	10	1.12198	0.306620046	#PC_LAB_VIDEO
2008	1	10	0.75172	0.293682258	#PC_LAB_VIDEO
2009	1	10	1.21821	0.212334057	#PC_LAB_VIDEO
2010	1	10	1.32103	0.189875689	#PC_LAB_VIDEO
2011	1	10	0.71563	0.243601012	#PC_LAB_VIDEO
2012	1	10	0.20915	0.384868249	#PC_LAB_VIDEO
1998	1	6	0.0001	0.01	#REDTIDE
1999	1	6	0.0001	0.01	#REDTIDE
2000	1	6	0.0001	0.01	#REDTIDE
2001	1	6	0.0001	0.01	#REDTIDE
2002	1	6	0.0001	0.01	#REDTIDE
2003	1	6	0.0001	0.01	#REDTIDE
2004	1	6	0.0001	0.01	#REDTIDE
2005	1	6	1	0.01	#REDTIDE
2006	1	6	0.0001	0.01	#REDTIDE
2007	1	6	0.0001	0.01	#REDTIDE
2008	1	6	0.0001	0.01	#REDTIDE
2009	1	6	0.0001	0.01	#REDTIDE
2010	1	6	0.0001	0.01	#REDTIDE

6 #_N_fleets with discard_obs
#_discard_units (1=same_as_catchunits(bio/num); 2=fraction; 3=numbers)
#_discard_errtype: >0 for DF of T-dist(read CV below); 0 for normal with CV; -1 for normal with se; -2 for lognormal

#Fleet	Disc_units	err_type
1	3	-2
2	3	-2
3	1	-2
4	1	-2
5	1	-2

6	1	-2		
108 # number of discard observations				
# year	season	fleet	discard	error
2007	1	1	56.15	0.5
2008	1	1	92.231	0.5
2009	1	1	104.887	0.5
2010	1	1	59.115	0.5
2011	1	1	32.132	0.5
2012	1	1	29.102	0.5
2007	1	2	0.566325362	0.5
-2008	1	2	0.01	0.5
2009	1	2	0.519588399	0.5
2010	1	2	0.22094426	0.5
2011	1	2	6.206494791	0.5
1981	1	3	7.880889619	0.5
1982	1	3	3.456661869	0.5
1983	1	3	5.78546467	0.5
1984	1	3	2.6762511	0.5
1985	1	3	11.85476879	0.5
1986	1	3	15.034	0.5
1987	1	3	17.649	0.5
1988	1	3	6.753	0.5
1989	1	3	19.127	0.5
1990	1	3	49.606	0.5
1991	1	3	1.628	0.5
1992	1	3	13.755	0.5
1993	1	3	17.336	0.5
1994	1	3	60.349	0.5
1995	1	3	31.205	0.5
1996	1	3	30.379	0.5
1997	1	3	29.286	0.5
1998	1	3	82.585	0.5
1999	1	3	52.07	0.5
2000	1	3	25.695	0.5
2001	1	3	19.254	0.5
2002	1	3	25.975	0.5
2003	1	3	48.059	0.5
2004	1	3	58.313	0.5
2005	1	3	43.39	0.5
2006	1	3	12.909	0.5
2007	1	3	32.004	0.5
2008	1	3	34.463	0.5
2009	1	3	52.284	0.5
2010	1	3	59.882	0.5
2011	1	3	88.83	0.5
2012	1	3	18.089	0.5
1981	1	4	12.62955774	0.5
1982	1	4	5.373389615	0.5
1983	1	4	9.193553384	0.5
1984	1	4	4.093205248	0.5
1985	1	4	19.14962854	0.5
1986	1	4	52.77599356	0.5
1987	1	4	17.67084192	0.5
1988	1	4	15.08341376	0.5
1989	1	4	19.07672219	0.5
1990	1	4	85.94522445	0.5
1991	1	4	1.880369793	0.5
1992	1	4	45.73203598	0.5
1993	1	4	93.9575134	0.5
1994	1	4	151.7479316	0.5
1995	1	4	195.2981827	0.5
1996	1	4	195.8306475	0.5
1997	1	4	185.358087	0.5
1998	1	4	347.035007	0.5
1999	1	4	214.4530083	0.5
2000	1	4	135.8071185	0.5
2001	1	4	145.4367969	0.5
2002	1	4	213.5851392	0.5
2003	1	4	294.4737371	0.5
2004	1	4	337.6922082	0.5

2005	1	4	337.9775098	0.5
2006	1	4	166.2733985	0.5
2007	1	4	118.8706376	0.5
2008	1	4	310.9796783	0.5
2009	1	4	271.3268169	0.5
2010	1	4	314.1430468	0.5
2011	1	4	191.4618377	0.5
2012	1	4	167.3171973	0.5
1982	1	5	101.5299129	0.5
1983	1	5	400.3376209	0.5
1984	1	5	56.06373076	0.5
1985	1	5	102.018987	0.5
1986	1	5	316.7895682	0.5
1987	1	5	203.6511293	0.5
1988	1	5	228.707788	0.5
1989	1	5	469.8988472	0.5
1990	1	5	270.6465516	0.5
1991	1	5	860.1161972	0.5
1992	1	5	673.7272917	0.5
1993	1	5	1191.866081	0.5
1994	1	5	1653.662625	0.5
1995	1	5	1634.084237	0.5
1996	1	5	1005.374157	0.5
1997	1	5	1501.233427	0.5
1998	1	5	1731.018824	0.5
1999	1	5	1239.435012	0.5
2000	1	5	1274.774973	0.5
2001	1	5	1752.026648	0.5
2002	1	5	2254.991568	0.5
2003	1	5	3053.769333	0.5
2004	1	5	3528.880929	0.5
2005	1	5	2038.532096	0.5
2006	1	5	1711.701397	0.5
2007	1	5	2562.790336	0.5
2008	1	5	3793.486453	0.5
2009	1	5	2482.48983	0.5
2010	1	5	1699.714711	0.5
2011	1	5	971.9760087	0.5
2012	1	5	760.6203749	0.5
#1998	1	6	0.001	0.1
#1999	1	6	0.001	0.1
#2000	1	6	0.001	0.1
#2001	1	6	0.001	0.1
#2002	1	6	0.001	0.1
#2003	1	6	0.001	0.1
#2004	1	6	0.001	0.1
#2005	1	6	1832.856	0.5
#2006	1	6	0.001	0.1
#2007	1	6	0.001	0.1
#2008	1	6	0.001	0.1
#2009	1	6	0.001	0.1
#2010	1	6	0.001	0.1

#

0 #_N_meanbodywt_obs

30 #degrees of freedom (must be here)

#

#Population length bins are needed even if there are no size data These define the resolution at which the mean weight-at-length, maturity-at-length and size-selectivity are based. Calculations use the mid-length of the population bins.

2 # length bin method: 1=use databins; 2=generatefrom binwidth,min,max below; 3=read vector

2 # binwidth for population size comp

10 # minimum size in the population (lower edge of first bin and size at age 0.00)

158 # maximum size in the population (lower edge of last bin)

-0.0001 #_comp_tail_compression

1.00E-07 #_add_to_comp

0 #_combinemales into females at or below this bin number

75 #_Nbins for length composition data

10	12	14	16	18	20	22	24	26	28	30	32	34
	36	38	40	42	44	46	48	50	52	54	56	58
	60	62	64	66	68	70	72	74	76	78	80	82
	84	86	88	90	92	94	96	98	100	102	104	106
	108	110	112	114	116	118	120	122	124	126	128	130
	132	134	136	138	140	142	144	146	148	150	152	154
	156	158										
181	#_N_Length_obs											
#_year	season	fleet	gender	part	nsamp	10	12	14	16	18	20	22
	24	26	28	30	32	34	36	38	40	42	44	46
	48	50	52	54	56	58	60	62	64	66	68	70
	72	74	76	78	80	82	84	86	88	90	92	94
	96	98	100	102	104	106	108	110	112	114	116	118
	120	122	124	126	128	130	132	134	136	138	140	142
	144	146	148	150	152	154	156	158				
1984	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0.004	0.001	0	0.001	0.002	0.004	0.001	0.005
	0.009	0.01	0.004	0.015	0.029	0.021	0.028	0.038	0.033	0.038	0.054	0.049
	0.065	0.046	0.055	0.035	0.048	0.037	0.043	0.043	0.048	0.034	0.037	0.015
	0.018	0.022	0.027	0.021	0.016	0.017	0.007	0.011	0.007	0.004	0.001	0.001
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1985	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0.001	0	0.003	0.004	0.003	0.004
	0.005	0.015	0.022	0.018	0.032	0.019	0.018	0.036	0.041	0.046	0.05	0.074
	0.048	0.043	0.047	0.042	0.048	0.05	0.032	0.034	0.032	0.03	0.03	0.02
	0.024	0.02	0.022	0.024	0.015	0.013	0.008	0.005	0.013	0.008	0.004	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1986	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0.003	0.003	0.003	0	0.006	0.008	0.011
	0.011	0.025	0.02	0.045	0.051	0.053	0.037	0.07	0.028	0.048	0.048	0.048
	0.037	0.042	0.053	0.045	0.028	0.028	0.031	0.022	0.034	0.02	0.022	0.011
	0.011	0.011	0.014	0.008	0.011	0.02	0.014	0.006	0.003	0.008	0.003	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1987	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0.002	0.002	0.004	0.002	0
	0.005	0.005	0	0	0.005	0.018	0.03	0.032	0.036	0.045	0.039	0.054
	0.054	0.075	0.097	0.055	0.098	0.043	0.043	0.045	0.047	0.036	0.025	0.016
	0.025	0.011	0.013	0.009	0.005	0.011	0.004	0.002	0.002	0.004	0	0
	0.002	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	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1988	1	1	0	2	175	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0.006	0.006	0	0	0.006	0	0.023	0.017	0.04	0.029	0.063	0.063

	0.034	0.04	0.04	0.091	0.074	0.074	0.057	0.08	0.029	0.034	0.057	0.023
	0.017	0.011	0.029	0.017	0.011	0.011	0.011	0	0	0.006	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1989	1	1	0	2	42	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0.024	0	0.024	0	0.024	0.119	0.024
	0.071	0.048	0.095	0.024	0.048	0.024	0.071	0.024	0.048	0.071	0.071	0.071
	0.071	0	0.024	0.024	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1990	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0.004	0	0.003	0	0.003	0.001
	0.004	0.002	0.004	0.003	0.002	0.007	0.008	0.008	0.026	0.024	0.032	0.043
	0.052	0.054	0.057	0.063	0.069	0.055	0.072	0.056	0.047	0.052	0.04	0.033
	0.035	0.025	0.036	0.016	0.02	0.005	0.012	0.007	0.006	0.007	0.002	0.004
	0	0.001	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1991	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0.001	0.001	0	0	0.001	0.003	0.001	0.003
	0.006	0.006	0.009	0.013	0.017	0.009	0.014	0.017	0.022	0.029	0.061	0.073
	0.068	0.073	0.091	0.081	0.064	0.058	0.049	0.035	0.023	0.026	0.025	0.018
	0.018	0.026	0.016	0.012	0.006	0.008	0.005	0.006	0	0	0.004	0
	0	0.001	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1992	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0.001	0.001	0.001	0	0.001	0.001	0.002	0.001	0.004
	0.01	0.03	0.034	0.046	0.027	0.022	0.019	0.023	0.023	0.027	0.051	0.04
	0.035	0.036	0.044	0.054	0.046	0.053	0.057	0.052	0.046	0.043	0.032	0.035
	0.023	0.02	0.014	0.006	0.004	0.006	0.005	0.01	0.005	0.002	0.003	0.003
	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	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1993	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0.001	0	0	0	0.001	0	0	0.003
	0.013	0.03	0.034	0.031	0.036	0.039	0.051	0.067	0.063	0.059	0.058	0.039
	0.038	0.045	0.037	0.037	0.041	0.033	0.03	0.035	0.023	0.022	0.022	0.018
	0.02	0.014	0.014	0.011	0.005	0.005	0.005	0.006	0.002	0.006	0.003	0.001
	0.001	0	0	0	0	0.001	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0

	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1994	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0.003
	0.01	0.025	0.028	0.034	0.046	0.053	0.077	0.064	0.066	0.076	0.068	0.061
	0.052	0.047	0.043	0.028	0.026	0.02	0.022	0.017	0.015	0.018	0.016	0.014
	0.012	0.012	0.01	0.008	0.005	0.005	0.005	0.006	0.002	0.004	0.002	0.001
	0.001	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1995	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0.001	0.001	0.002	0.006	0.015
	0.033	0.046	0.045	0.052	0.037	0.052	0.048	0.041	0.038	0.047	0.045	0.061
	0.046	0.056	0.049	0.041	0.035	0.032	0.025	0.019	0.012	0.012	0.013	0.01
	0.01	0.007	0.013	0.01	0.008	0.007	0.006	0.007	0.004	0.002	0.001	0.002
	0.002	0	0	0	0	0.001	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1996	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0.001	0	0	0.002	0.002	0.005	0.012	0.017	0.019
	0.059	0.08	0.076	0.065	0.056	0.053	0.057	0.049	0.048	0.039	0.034	0.035
	0.033	0.031	0.031	0.029	0.02	0.022	0.018	0.014	0.016	0.014	0.009	0.009
	0.006	0.005	0.005	0.006	0.003	0.002	0.006	0.002	0.002	0.003	0.001	0.002
	0	0.001	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1997	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0.003	0.021
	0.074	0.083	0.081	0.072	0.077	0.076	0.068	0.057	0.044	0.049	0.04	0.041
	0.027	0.026	0.024	0.017	0.017	0.016	0.013	0.012	0.01	0.006	0.009	0.004
	0.006	0.004	0.003	0.004	0.001	0.002	0.002	0.004	0.001	0.001	0.002	0.002
	0.001	0.001	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1998	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0.001	0.001	0.004
	0.024	0.038	0.044	0.053	0.063	0.075	0.08	0.083	0.085	0.074	0.064	0.052
	0.041	0.034	0.029	0.021	0.018	0.017	0.016	0.015	0.011	0.008	0.007	0.006
	0.004	0.005	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.001
	0.001	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	

1999	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0.001	0.001	0.003
	0.021	0.042	0.041	0.034	0.044	0.043	0.049	0.06	0.051	0.069	0.069	0.065
	0.061	0.059	0.046	0.044	0.033	0.024	0.024	0.017	0.016	0.012	0.011	0.009
	0.008	0.006	0.007	0.007	0.005	0.003	0.003	0.003	0.002	0.003	0.002	0.001
	0.002	0.001	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2000	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0.002
	0.02	0.027	0.034	0.04	0.049	0.056	0.057	0.074	0.057	0.07	0.063	0.065
	0.057	0.056	0.045	0.037	0.033	0.027	0.032	0.014	0.017	0.017	0.011	0.005
	0.004	0.004	0.005	0.002	0.002	0.002	0.002	0.002	0.001	0.002	0.001	0.001
	0.001	0.001	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2001	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0.004	0.01	0.023	0.05	0.069	0.085	0.078	0.088	0.085	0.075
	0.071	0.061	0.052	0.042	0.037	0.034	0.033	0.016	0.018	0.016	0.011	0.008
	0.007	0.005	0.003	0.004	0.002	0.003	0.001	0.001	0.002	0.002	0.002	0.001
	0.001	0.001	0.001	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2002	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0.001	0.001	0.003	0.004	0.015	0.03	0.043	0.054	0.049	0.069	0.07	0.089
	0.081	0.077	0.077	0.065	0.057	0.049	0.041	0.021	0.021	0.021	0.013	0.008
	0.009	0.006	0.004	0.003	0.001	0.002	0.002	0.002	0.001	0.001	0.002	0.002
	0.001	0.001	0.001	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2003	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0.002	0.008	0.032	0.066	0.069	0.064	0.054	0.044	0.052	0.06
	0.057	0.061	0.075	0.065	0.06	0.052	0.043	0.027	0.025	0.019	0.014	0.01
	0.006	0.007	0.004	0.001	0.002	0.003	0.003	0.002	0.001	0.002	0.001	0.002
	0.002	0.001	0.002	0.001	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2004	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0.001	0.001	0.006	0.019	0.048	0.062	0.075	0.066	0.075	0.072	0.073
	0.061	0.068	0.062	0.06	0.057	0.049	0.034	0.028	0.025	0.015	0.01	0.007
	0.005	0.005	0.005	0.002	0.002	0.002	0.001	0.001	0.001	0	0.001	0.001

	0	0.001	0.001	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2005	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0.001	0	0	0
	0.001	0.002	0	0.005	0.02	0.047	0.051	0.079	0.06	0.072	0.078	0.078
	0.068	0.076	0.054	0.049	0.042	0.037	0.041	0.02	0.017	0.018	0.013	0.011
	0.015	0.008	0.007	0.006	0.004	0.003	0.003	0.002	0.003	0.002	0.004	0.002
	0.002	0	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	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2006	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0.001	0	0.004	0.021	0.062	0.058	0.079	0.05	0.077	0.08
	0.09	0.09	0.068	0.074	0.043	0.05	0.022	0.025	0.021	0.012	0.011	0.016
	0.01	0.004	0.006	0.002	0.004	0.006	0.002	0.004	0.005	0	0.001	0.001
	0	0	0	0.001	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2007	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0.015	0.054	0.064	0.093	0.072	0.088	0.08	0.082
	0.049	0.054	0.062	0.052	0.046	0.034	0.021	0.039	0.023	0.023	0.008	0.005
	0.008	0.008	0.005	0.003	0.003	0	0.003	0.005	0	0	0.003	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2008	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0.007	0.015	0.037	0.069	0.082	0.08	0.082	0.097	0.074
	0.079	0.071	0.075	0.042	0.043	0.034	0.023	0.022	0.008	0.015	0.007	0.007
	0.007	0.004	0.001	0.002	0.004	0.003	0	0.003	0.001	0.002	0.002	0.001
	0.001	0.001	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2009	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0.001	0.003	0.004	0.016	0.065	0.082	0.078	0.092	0.091	0.091	0.072
	0.088	0.055	0.054	0.036	0.036	0.022	0.022	0.015	0.016	0.01	0.007	0.01
	0.008	0.006	0.004	0.003	0.003	0.002	0.002	0.003	0	0	0	0
	0.001	0	0	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	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0

	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2010	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0.001	0.001	0.001	0	0.002	0	0.001
	0	0.001	0.001	0.003	0.011	0.048	0.059	0.095	0.093	0.094	0.1	0.078
	0.09	0.05	0.048	0.049	0.041	0.029	0.017	0.014	0.006	0.008	0.008	0.007
	0.007	0.006	0.011	0.005	0.005	0.006	0.002	0.001	0.001	0.001	0.001	0
	0.001	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2011	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0.001	0.001	0	0.003	0.013	0.068	0.1	0.112	0.098	0.083	0.09	0.086
	0.065	0.055	0.04	0.046	0.035	0.022	0.013	0.015	0.011	0.011	0.008	0.008
	0.005	0.002	0.003	0.002	0.001	0.001	0	0.001	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2012	1	1	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0.001	0.005	0.025	0.038	0.05	0.082	0.085	0.079	0.077	0.072	0.072
	0.062	0.061	0.057	0.045	0.04	0.027	0.025	0.024	0.016	0.011	0.008	0.009
	0.007	0.005	0.004	0.004	0.001	0.003	0.002	0.002	0.001	0.001	0	0
	0	0.001	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2007	1	1	0	1	200	0	0	0	0	0	0	0
	0	0	0	0	0	0.005	0	0.011	0.026	0.021	0.04	0.053
	0.098	0.153	0.164	0.15	0.14	0.108	0.013	0	0	0.005	0	0.003
	0.003	0	0.003	0	0.003	0	0	0	0	0	0	0.003
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2008	1	1	0	1	147	0	0	0	0	0	0	0
	0	0	0	0.027	0.027	0.02	0.027	0.034	0.048	0.034	0.048	0.068
	0.082	0.088	0.163	0.088	0.177	0.054	0	0	0	0	0	0
	0	0	0	0.014	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2009	1	1	0	1	200	0	0	0	0	0	0	0
	0	0.002	0	0.002	0.007	0.016	0.03	0.055	0.062	0.085	0.057	0.101

	0.098	0.094	0.108	0.108	0.089	0.069	0.005	0.002	0	0.002	0	0
	0	0.002	0.005	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	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2010	1	1	0	1	200	0	0	0	0	0	0	0
	0	0	0	0.002	0.003	0.005	0.015	0.038	0.048	0.086	0.116	0.136
	0.114	0.117	0.09	0.108	0.08	0.039	0.003	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2011	1	1	0	1	200	0	0	0	0	0	0	0
	0	0	0.002	0	0.002	0.005	0	0.015	0.02	0.029	0.063	0.084
	0.115	0.125	0.101	0.127	0.108	0.098	0.023	0.009	0.012	0.015	0.006	0.006
	0.014	0.011	0.003	0.003	0.002	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	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2012	1	1	0	1	200	0	0	0	0	0	0	0
	0	0	0	0	0	0.008	0.016	0.017	0.03	0.038	0.058	0.09
	0.114	0.13	0.118	0.088	0.057	0.033	0.008	0.007	0.006	0.01	0.016	0.011
	0.019	0.023	0.015	0.016	0.017	0.011	0.014	0.013	0.005	0.003	0.003	0.003
	0.002	0.002	0.001	0	0	0.001	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1984	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0.002	0.002	0	0	0.002	0.002	0	0.009	0.009
	0.009	0.024	0.013	0.02	0.037	0.022	0.037	0.035	0.044	0.037	0.059	0.046
	0.046	0.054	0.041	0.048	0.046	0.031	0.037	0.044	0.031	0.017	0.033	0.013
	0.026	0.024	0.024	0.024	0.009	0.007	0.011	0.017	0	0.004	0.007	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1985	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0.002	0.002	0.004	0.004	0.004	0.007
	0.009	0.011	0.016	0.025	0.044	0.057	0.037	0.053	0.06	0.05	0.048	0.046
	0.048	0.039	0.039	0.037	0.021	0.027	0.032	0.016	0.032	0.016	0.018	0.018
	0.023	0.032	0.012	0.019	0.03	0.021	0.012	0.014	0.004	0.009	0.004	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	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1986	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0.001	0	0.001	0.001	0.003	0.003	0.004	0.007
	0.01	0.01	0.015	0.015	0.02	0.027	0.031	0.033	0.036	0.049	0.061	0.054
	0.049	0.057	0.057	0.058	0.049	0.042	0.044	0.039	0.029	0.029	0.026	0.013
	0.015	0.015	0.015	0.019	0.011	0.012	0.011	0.006	0.007	0.008	0.003	0.003
	0.001	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1987	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0.001	0.001
	0.006	0.012	0.006	0.006	0.018	0.019	0.032	0.016	0.031	0.026	0.045	0.047
	0.064	0.053	0.057	0.082	0.054	0.055	0.039	0.054	0.032	0.044	0.036	0.02
	0.025	0.019	0.022	0.022	0.009	0.01	0.016	0.006	0.009	0.003	0.001	0.001
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1988	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0.004	0	0	0.004	0
	0.007	0.011	0.007	0.014	0.011	0.018	0.018	0.022	0.004	0.022	0.033	0.065
	0.025	0.058	0.058	0.051	0.058	0.087	0.04	0.043	0.047	0.062	0.043	0.029
	0.029	0.018	0.029	0.018	0.011	0.018	0.004	0.007	0.011	0.011	0	0.004
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1989	1	2	0	2	129	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0.008	0.008	0	0.023	0	0.016	0.031	0.016
	0.062	0.031	0.023	0.031	0.07	0.062	0.031	0.047	0.109	0.062	0.039	0.023
	0.062	0.07	0.047	0.039	0.016	0.016	0.031	0.008	0.016	0	0	0
	0.008	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1990	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0.001	0	0	0.001	0.001
	0.001	0.001	0.002	0.001	0.003	0.004	0.004	0.007	0.01	0.014	0.026	0.034
	0.04	0.042	0.056	0.062	0.055	0.047	0.064	0.061	0.071	0.047	0.05	0.052
	0.047	0.04	0.039	0.026	0.016	0.014	0.014	0.016	0.008	0.009	0.008	0.002
	0.001	0.001	0.001	0.001	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0

	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1991	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0.001	0.001	0.001	0.002	0.003	0.005	0.008	0.01	0.013	0.037	0.025
	0.03	0.046	0.046	0.072	0.068	0.075	0.059	0.07	0.065	0.063	0.04	0.055
	0.034	0.033	0.041	0.029	0.02	0.014	0.005	0.01	0.008	0.005	0.002	0.001
	0	0.001	0	0	0	0	0	0	0.001	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1992	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0.001	0.002	0.002	0.001	0.004	0.002	0.008	0.013	0.005	0.008	0.021	0.028
	0.02	0.042	0.05	0.034	0.055	0.053	0.088	0.07	0.083	0.078	0.054	0.038
	0.039	0.043	0.04	0.023	0.025	0.012	0.02	0.013	0.013	0.005	0.003	0.002
	0.002	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	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1993	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0.001	0	0	0
	0.003	0.001	0.005	0.008	0.01	0.009	0.01	0.019	0.009	0.022	0.023	0.023
	0.034	0.044	0.047	0.035	0.047	0.053	0.057	0.061	0.067	0.068	0.051	0.049
	0.056	0.043	0.042	0.02	0.022	0.02	0.01	0.01	0.008	0.004	0.003	0.003
	0.003	0.003	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1994	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0.005	0.005	0.012	0.017	0.017	0.035	0.04	0.042	0.039	0.046	0.055
	0.059	0.044	0.064	0.037	0.051	0.033	0.045	0.037	0.055	0.04	0.057	0.032
	0.031	0.019	0.015	0.018	0.008	0.009	0.004	0.003	0.008	0.009	0.001	0
	0	0.001	0.003	0	0	0	0	0.001	0.001	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1995	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0.002
	0.006	0.009	0.011	0.01	0.009	0.02	0.023	0.025	0.026	0.04	0.036	0.06
	0.05	0.061	0.063	0.047	0.043	0.05	0.068	0.043	0.045	0.022	0.04	0.026
	0.028	0.02	0.027	0.02	0.018	0.009	0.006	0.009	0.012	0.002	0.006	0.003
	0.003	0.002	0.001	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1996	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0.001	0.001	0.005
	0.008	0.023	0.026	0.023	0.027	0.018	0.027	0.026	0.03	0.021	0.039	0.04

	0.06	0.041	0.054	0.051	0.049	0.06	0.046	0.05	0.043	0.036	0.033	0.032
	0.02	0.011	0.015	0.015	0.015	0.008	0.007	0.012	0.009	0.006	0.005	0.004
	0.003	0.001	0.001	0.001	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1997	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0.018	0.02	0.018	0.029	0.028	0.027	0.032	0.031	0.03	0.029	0.044	0.036
	0.034	0.037	0.043	0.047	0.042	0.042	0.044	0.044	0.041	0.034	0.032	0.03
	0.025	0.018	0.023	0.023	0.02	0.015	0.015	0.011	0.009	0.016	0.002	0.005
	0.003	0.003	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1998	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0.001
	0.003	0.004	0.009	0.013	0.02	0.024	0.035	0.045	0.047	0.053	0.054	0.054
	0.054	0.046	0.046	0.039	0.043	0.039	0.041	0.034	0.033	0.033	0.027	0.025
	0.026	0.021	0.017	0.017	0.015	0.01	0.018	0.014	0.013	0.01	0.007	0.005
	0.003	0.001	0.001	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1999	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0.002	0.005	0.008	0.007	0.011	0.012	0.018	0.027	0.033	0.041	0.049	0.043
	0.054	0.06	0.049	0.049	0.05	0.05	0.047	0.038	0.041	0.039	0.039	0.035
	0.027	0.021	0.02	0.02	0.014	0.014	0.014	0.014	0.012	0.011	0.011	0.007
	0.004	0.003	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2000	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0.001
	0.001	0	0.002	0.002	0.004	0.004	0.007	0.012	0.014	0.024	0.028	0.039
	0.05	0.06	0.065	0.062	0.065	0.064	0.066	0.044	0.05	0.048	0.039	0.035
	0.032	0.022	0.018	0.02	0.02	0.014	0.013	0.015	0.014	0.013	0.008	0.009
	0.005	0.005	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	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2001	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0.001	0.002	0.007	0.011	0.017	0.016	0.027	0.039	0.053
	0.058	0.063	0.064	0.062	0.074	0.072	0.067	0.047	0.049	0.041	0.034	0.029
	0.025	0.024	0.014	0.014	0.013	0.01	0.01	0.01	0.009	0.01	0.008	0.006
	0.007	0.005	0.001	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0

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	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2002	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0.001	0.003	0.008	0.013	0.012	0.024	0.031	0.044
	0.055	0.065	0.067	0.08	0.082	0.07	0.074	0.05	0.052	0.035	0.035	0.029
	0.023	0.02	0.021	0.014	0.015	0.011	0.007	0.008	0.007	0.01	0.008	0.009
	0.007	0.005	0.002	0.001	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2003	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0.001	0.002	0.005	0.005	0.015	0.015	0.022	0.024	0.043
	0.044	0.06	0.071	0.083	0.085	0.086	0.074	0.058	0.056	0.047	0.036	0.027
	0.023	0.021	0.019	0.01	0.008	0.007	0.006	0.005	0.009	0.005	0.007	0.004
	0.005	0.005	0.003	0.001	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2004	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0.001	0.002	0.002	0.011	0.019	0.028	0.028	0.038	0.042	0.048
	0.057	0.05	0.061	0.062	0.066	0.06	0.069	0.051	0.047	0.042	0.036	0.028
	0.022	0.017	0.013	0.01	0.014	0.011	0.011	0.009	0.009	0.006	0.008	0.009
	0.006	0.004	0.003	0.001	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2005	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0.001	0.003	0.005	0.012	0.019	0.028	0.035	0.045	0.052	0.049
	0.054	0.06	0.047	0.05	0.06	0.058	0.06	0.04	0.035	0.038	0.031	0.03
	0.029	0.028	0.021	0.014	0.012	0.012	0.014	0.01	0.011	0.004	0.009	0.007
	0.006	0.007	0.002	0.001	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2006	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0.003	0.007	0.02	0.022	0.03	0.028	0.044	0.037
	0.045	0.053	0.06	0.062	0.06	0.057	0.065	0.052	0.047	0.045	0.049	0.032
	0.035	0.031	0.02	0.015	0.015	0.015	0.007	0.007	0.006	0.006	0.006	0.007
	0.005	0.002	0.003	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	

2007	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0.001	0.001	0.001	0
	0.001	0.002	0.002	0.002	0.001	0.006	0.009	0.013	0.024	0.031	0.044	0.04
	0.046	0.056	0.053	0.058	0.068	0.069	0.061	0.071	0.049	0.032	0.043	0.028
	0.023	0.028	0.026	0.024	0.015	0.013	0.014	0.012	0.008	0.007	0.004	0.005
	0.003	0.005	0.003	0.001	0	0	0.001	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2008	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0.001	0.002	0.007	0.022	0.021	0.019	0.042	0.042	0.054
	0.048	0.055	0.075	0.083	0.082	0.055	0.048	0.057	0.043	0.045	0.027	0.024
	0.025	0.017	0.015	0.021	0.017	0.009	0.013	0.008	0.01	0.003	0.002	0.004
	0.002	0.005	0	0.001	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2009	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0.001	0.003	0	0.022	0.032	0.036	0.044	0.041	0.038	0.051
	0.052	0.044	0.067	0.042	0.085	0.073	0.066	0.038	0.047	0.05	0.029	0.026
	0.017	0.025	0.019	0.012	0.009	0.009	0.004	0.003	0.001	0.003	0.001	0.003
	0.001	0.003	0.001	0	0.001	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2010	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0.001	0	0.002	0.004	0.015	0.009	0.032	0.041	0.055	0.058	0.061
	0.062	0.07	0.072	0.06	0.054	0.046	0.056	0.044	0.03	0.047	0.033	0.03
	0.026	0.019	0.02	0.012	0.015	0.005	0.007	0.006	0.003	0	0.001	0.002
	0	0.001	0	0.001	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2011	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0.009	0.025	0.034	0.036	0.06	0.06	0.085
	0.094	0.089	0.068	0.062	0.062	0.038	0.06	0.042	0.04	0.023	0.026	0.009
	0.009	0.023	0.015	0.011	0.006	0.004	0	0.002	0.002	0	0.006	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2012	1	2	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0.004	0.012	0.024	0.036	0.038	0.048	0.07
	0.064	0.06	0.092	0.092	0.084	0.07	0.046	0.026	0.032	0.044	0.032	0.022
	0.028	0.024	0.014	0.008	0.014	0	0.004	0.002	0.002	0.002	0.002	0

	0.002	0	0.002	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2007	1	2	0	1	4	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0.25	0	0
	0.25	0	0.25	0	0.25	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	0	0	
2008	1	2	0	1	5	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0.2	0	0.4	0.2	0.2	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2009	1	2	0	1	27	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0.037	0.074	0.222	0.074	0.037
	0.111	0.111	0.074	0.037	0.074	0.074	0	0	0	0	0.037	0
	0	0	0.037	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2010	1	2	0	1	39	0	0	0	0	0	0	0
	0	0	0	0	0	0	0.026	0	0	0	0	0.051
	0.103	0.051	0.179	0.179	0.179	0.179	0.051	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2011	1	2	0	1	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0.002	0	0.001	0.006	0.004	0.01
	0.009	0.029	0.025	0.029	0.039	0.054	0.049	0.041	0.059	0.062	0.054	0.055
	0.052	0.07	0.065	0.052	0.036	0.031	0.035	0.03	0.022	0.014	0.015	0.007
	0.01	0.007	0.008	0.007	0.002	0.002	0.002	0	0.001	0	0.002	0.001
	0	0.001	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0

	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2012	1	2	0	1	29	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0.034	0	0
	0.034	0	0.034	0.034	0	0.034	0.034	0	0	0	0	0.034
	0.034	0.034	0.069	0.103	0.034	0.103	0.069	0.069	0.034	0.103	0.034	0.034
	0.034	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1981	1	3	0	2	18	0	0	0	0	0	0	0
	0	0	0	0	0.056	0.056	0.056	0	0.056	0.056	0	0.056
	0	0.056	0	0.167	0.111	0.056	0	0	0	0.056	0	0
	0.056	0.056	0.056	0	0	0	0	0.056	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1982	1	3	0	2	19	0	0	0	0	0	0	0
	0	0	0	0	0	0.105	0	0	0	0.105	0.105	0
	0	0.053	0.053	0	0	0.053	0	0	0	0	0	0
	0	0	0	0	0	0.053	0	0.053	0	0.105	0	0.053
	0.158	0.053	0.053	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1983	1	3	0	2	78	0	0	0	0	0	0	0
	0	0	0	0	0.013	0.026	0.038	0.051	0.026	0.051	0.038	0.026
	0.051	0.026	0.026	0.051	0.026	0.026	0.026	0.013	0.051	0.038	0.013	0.09
	0.013	0.013	0.051	0	0.026	0.026	0.038	0.013	0.013	0.013	0.013	0.038
	0.013	0.013	0	0	0	0.013	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1984	1	3	0	2	34	0	0	0	0	0	0	0
	0	0	0	0	0.029	0	0	0	0	0	0.029	0
	0	0	0.029	0	0.059	0	0.088	0.029	0.059	0.059	0	0.059
	0.059	0.088	0.088	0.059	0.088	0	0.059	0.029	0.029	0	0	0.029
	0.029	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1985	1	3	0	2	116	0	0	0	0	0	0	0
	0	0	0	0	0	0	0.009	0.017	0.026	0.026	0.009	0.009

	0.026	0.043	0.052	0.026	0.069	0.069	0.052	0.095	0.052	0.06	0.069	0.026
	0.06	0.043	0.026	0.009	0.026	0.017	0	0.026	0	0	0.009	0.009
	0.009	0.009	0	0	0	0	0.017	0	0	0.009	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1986	1	3	0	2	200	0	0	0	0	0	0	0
	0.002	0.003	0.005	0.009	0.012	0.027	0.024	0.044	0.054	0.044	0.074	0.054
	0.044	0.038	0.05	0.044	0.042	0.044	0.044	0.054	0.039	0.039	0.018	0.03
	0.036	0.021	0.014	0.015	0.015	0.009	0.008	0.009	0.012	0.002	0.005	0.008
	0.006	0	0	0	0	0.002	0.002	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
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1987	1	3	0	2	200	0	0	0	0	0	0	0
	0	0.008	0.015	0.011	0.02	0.018	0.034	0.031	0.046	0.041	0.049	0.072
	0.069	0.065	0.049	0.049	0.078	0.052	0.065	0.023	0.031	0.028	0.017	0.018
	0.023	0.011	0.015	0.015	0.003	0.003	0.008	0.003	0.002	0.005	0.006	0.002
	0.002	0	0.002	0.002	0.003	0.003	0.002	0.002	0	0	0	0
	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	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1988	1	3	0	2	200	0	0	0	0	0	0.003	0
	0	0.003	0.003	0.008	0.031	0.024	0.047	0.034	0.029	0.039	0.024	0.079
	0.089	0.076	0.073	0.039	0.039	0.06	0.084	0.042	0.031	0.013	0.021	0.018
	0.013	0.008	0.013	0.016	0.003	0.003	0.003	0.005	0.003	0.003	0.003	0
	0	0.003	0.003	0	0.003	0.005	0	0	0	0.003	0.003	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1989	1	3	0	2	200	0	0	0	0	0	0	0
	0	0.002	0	0.007	0.022	0.029	0.024	0.053	0.024	0.022	0.053	0.047
	0.047	0.044	0.031	0.027	0.024	0.031	0.011	0.053	0.031	0.044	0.044	0.038
	0.047	0.029	0.027	0.036	0.02	0.02	0.027	0.007	0.02	0.013	0.011	0.007
	0.002	0.002	0.009	0.004	0.004	0.002	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	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1990	1	3	0	2	200	0	0	0	0	0	0	0
	0	0	0.005	0	0.008	0.014	0.003	0.016	0.011	0.011	0.008	0.022
	0.041	0.038	0.057	0.035	0.057	0.041	0.035	0.038	0.038	0.065	0.068	0.057
	0.049	0.052	0.052	0.038	0.022	0.027	0.025	0.016	0.011	0.022	0.003	0.003
	0	0.003	0	0	0	0.005	0	0.003	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0

	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1991	1	3	0	2	165	0	0	0	0	0	0	0
	0	0.018	0	0.018	0	0	0	0	0.006	0.012	0	0.006
	0.067	0.091	0.085	0.067	0.048	0.036	0.03	0.024	0.061	0.036	0.03	0.055
	0.036	0.061	0.03	0.03	0.042	0.018	0.03	0.012	0.006	0	0	0
	0.006	0	0	0.006	0	0.012	0.006	0	0.006	0	0.006	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1992	1	3	0	2	160	0	0	0	0	0	0	0
	0	0	0	0	0	0	0.006	0.019	0.006	0.006	0	0.006
	0.019	0.1	0.125	0.106	0.063	0.075	0.038	0.056	0.025	0.038	0.031	0.031
	0.025	0.044	0.038	0.031	0.031	0.019	0.006	0.006	0.006	0	0.006	0.006
	0.006	0	0	0	0	0.006	0	0.006	0	0.006	0.006	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1993	1	3	0	2	149	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0.007	0.02	0.013	0.007	0.013
	0.027	0.034	0.074	0.027	0.06	0.047	0.148	0.06	0.094	0.087	0.047	0.054
	0.04	0.013	0.02	0.007	0.007	0.013	0.013	0.013	0.007	0.02	0	0.007
	0	0	0	0	0	0.013	0.007	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1994	1	3	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0.004	0	0	0.008	0.021
	0.05	0.084	0.105	0.063	0.109	0.029	0.042	0.063	0.088	0.071	0.038	0.079
	0.05	0.017	0.021	0.013	0.008	0.008	0.004	0	0.004	0.008	0.004	0
	0	0	0.004	0	0	0	0	0	0	0.004	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1995	1	3	0	2	191	0	0	0	0	0	0	0
	0	0	0	0	0.005	0	0.005	0	0	0.005	0.01	0.026
	0.079	0.157	0.136	0.094	0.094	0.047	0.063	0.052	0.031	0.021	0.01	0.01
	0.047	0.021	0.037	0.021	0.005	0.01	0.005	0	0	0	0.005	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0

	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1996	1	3	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0.036
	0.094	0.126	0.119	0.101	0.087	0.094	0.09	0.058	0.043	0.04	0.029	0.007
	0.004	0.011	0.007	0.018	0.007	0.007	0.011	0	0	0.004	0	0
	0.004	0	0	0	0	0	0.004	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1997	1	3	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0.006	0.006	0.013
	0.088	0.181	0.106	0.084	0.103	0.084	0.078	0.047	0.059	0.038	0.025	0.019
	0.025	0.013	0.009	0.006	0	0	0.003	0.003	0	0	0.003	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1998	1	3	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0.002	0.008	0.004	0.008	0.009	0.002	0.027
	0.097	0.133	0.083	0.082	0.097	0.07	0.059	0.061	0.065	0.04	0.049	0.027
	0.036	0.011	0.008	0.008	0.008	0.006	0	0	0	0.002	0	0
	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
1999	1	3	0	2	200	0	0	0	0	0	0	0
	0	0	0.002	0	0	0.004	0	0.002	0	0	0.002	0.022
	0.138	0.172	0.128	0.128	0.093	0.059	0.053	0.032	0.028	0.034	0.022	0.01
	0.014	0.018	0.006	0.014	0.002	0	0.008	0.002	0	0.002	0	0
	0	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2000	1	3	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0.006	0.003	0.006
	0.074	0.071	0.074	0.094	0.124	0.124	0.086	0.077	0.065	0.05	0.041	0.018
	0.027	0.015	0.021	0.009	0	0.006	0	0	0	0	0	0
	0	0.003	0.003	0	0.003	0	0	0.003	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2001	1	3	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0.004	0	0
	0.008	0.015	0.053	0.106	0.125	0.061	0.053	0.076	0.106	0.084	0.084	0.042

	0.053	0.046	0.019	0.015	0.019	0.004	0.015	0	0	0.011	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2002	1	3	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0.003	0.013	0.08	0.193	0.159	0.166	0.113	0.053	0.047	0.033	0.033	0.033
	0.013	0.023	0.007	0.003	0.013	0	0.003	0.003	0	0.003	0	0.003
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2003	1	3	0	2	200	0	0	0	0	0	0	0
	0	0.003	0	0	0	0	0	0.003	0	0.003	0	0
	0	0.021	0.107	0.141	0.172	0.164	0.073	0.073	0.06	0.065	0.039	0.023
	0.01	0.013	0.008	0.01	0	0	0.003	0.003	0.003	0.003	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0.003	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2004	1	3	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0.004	0	0	0.004	0	0.013	0.009	0.004
	0.009	0.009	0.12	0.171	0.167	0.128	0.077	0.056	0.034	0.043	0.034	0.034
	0.034	0.021	0.017	0.004	0.004	0.004	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2005	1	3	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0.004	0	0	0	0	0
	0	0.029	0.105	0.181	0.126	0.122	0.118	0.076	0.046	0.034	0.046	0.034
	0.034	0.008	0.008	0.013	0.004	0	0	0	0	0.008	0	0
	0	0.004	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2006	1	3	0	2	170	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0.065	0.2	0.118	0.124	0.106	0.088	0.059	0.082	0.012	0.047
	0.012	0.029	0.006	0.024	0.012	0	0	0	0.006	0	0	0.006
	0	0.006	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0

	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2007	1	3	0	2	174	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0.011	0.121	0.218	0.138	0.144	0.057	0.063	0.046	0.052	0.052	0.023
	0.017	0.006	0	0.006	0	0	0.006	0.011	0.017	0	0	0
	0	0.006	0	0.006	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2008	1	3	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0.004	0	0	0
	0	0.018	0.108	0.197	0.103	0.175	0.103	0.049	0.04	0.036	0.054	0.018
	0.018	0.031	0.004	0.004	0.004	0.004	0.009	0	0.004	0	0	0.004
	0	0	0	0	0	0.004	0.004	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2009	1	3	0	2	200	0	0	0	0	0	0	0.013
	0.007	0.003	0.007	0.007	0	0.003	0.01	0.013	0.016	0.013	0.01	0.003
	0.01	0.01	0.104	0.16	0.15	0.098	0.081	0.078	0.055	0.029	0.02	0.013
	0.023	0.013	0.01	0.013	0.003	0.003	0.007	0.003	0.003	0.003	0	0.003
	0	0.003	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2010	1	3	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0.003	0.015	0.079	0.147	0.156	0.109	0.088	0.074	0.05	0.079	0.076	0.035
	0.026	0.015	0.015	0.006	0.015	0	0	0.006	0.003	0	0	0
	0	0.003	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2011	1	3	0	2	51	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0.118	0.02	0.059	0.137	0.118	0.078	0.098	0.039	0.078	0.059
	0.078	0.02	0.059	0.039	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	

2012	1	3	0	2	107	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0.037	0.084	0.215	0.075	0.075	0.056	0.047	0.056	0.019	0.037
	0.103	0.075	0.047	0.028	0.019	0.009	0	0.009	0	0.009	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2005	1	3	0	1	200	0	0	0	0	0.001	0	0.004
	0.01	0.022	0.015	0.008	0.034	0.031	0.068	0.083	0.093	0.113	0.123	0.112
	0.087	0.097	0.076	0.019	0.003	0.001	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2006	1	3	0	1	200	0	0	0	0	0.004	0.038	0.058
	0.072	0.042	0.038	0.06	0.049	0.074	0.065	0.078	0.087	0.074	0.054	0.058
	0.058	0.045	0.036	0.007	0.002	0.004	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2007	1	3	0	1	200	0	0	0	0	0.001	0.008	0.008
	0.018	0.04	0.051	0.053	0.05	0.092	0.091	0.112	0.088	0.076	0.08	0.065
	0.059	0.059	0.035	0.01	0.002	0.001	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2009	1	3	0	1	200	0	0	0	0	0	0.002	0
	0	0	0.011	0.016	0.024	0.053	0.062	0.107	0.122	0.116	0.078	0.105
	0.08	0.134	0.067	0.013	0.004	0.002	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	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2010	1	3	0	1	200	0	0	0	0	0	0	0.002
	0.002	0.012	0.01	0.013	0.04	0.058	0.048	0.087	0.108	0.107	0.095	0.118
	0.113	0.1	0.067	0.013	0.002	0.002	0	0	0	0.002	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	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2011	1	3	0	1	152	0	0	0	0	0	0	0
	0	0.007	0	0.013	0.007	0.033	0.02	0.046	0.059	0.039	0.066	0.079
	0.053	0.092	0.066	0.039	0.046	0.02	0.066	0.086	0.033	0.053	0.026	0.02
	0.007	0.007	0.007	0	0.007	0.007	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
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2012	1	3	0	1	151	0	0	0	0	0	0	0
	0	0.007	0.02	0.02	0.02	0.033	0.04	0.113	0.099	0.119	0.099	0.066
	0.053	0.066	0.04	0.026	0.053	0.007	0.026	0.013	0.007	0.013	0.007	0.007
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	0	0	0.1	0	0	0	0	0	0	0	0	0
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	0	0										
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0
2006 1 4 0 2 200 0 0 0 0 0 0 0
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        0 0 0 0
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        0 0
2008    1 4 0 2 200 0 0 0 0 0 0 0
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        0 0 0 0 0 0 0 0 0 0 0 0
        0
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2011	1	4	0	2	115	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0.008695652	0.026086957	0.12173913	0.130434783	0.113043478						
	0.095652174	0.069565217	0.060869565	0.034782609	0.086956522	0.060869565						
	0.052173913	0.026086957	0.008695652	0.008695652	0.026086957	0.008695652						
	0.008695652	0	0.026086957	0.008695652	0	0	0	0				
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2012	1	4	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0.004115226	0.022633745	0.117283951	0.113168724	0.100823045						
	0.092592593	0.082304527	0.080246914	0.065843621	0.094650206	0.053497942						
	0.049382716	0.030864198	0.028806584	0.012345679	0.014403292	0.014403292						
	0.002057613	0	0.004115226	0.004115226	0	0.002057613	0	0				
	0.002057613	0.002057613	0	0	0.002057613	0	0	0	0			
	0.002057613	0	0	0	0.002057613	0	0	0	0	0		
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	0	0	0	0	0	0	0	0	0	0	0	0
	0	0										
2009	1	4	0	1	200	0	0	0	0	0	0	0
	0	0	0.01	0.01	0.01	0.024	0.019	0.076	0.124	0.1	0.143	0.152
	0.133	0.062	0.086	0.029	0.01	0.005	0	0	0	0	0.01	0
	0	0	0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	0	0	
2010	1	4	0	1	200	0	0	0	0	0	0	0
	0	0.002	0.002	0.007	0.007	0.02	0.027	0.057	0.107	0.095	0.124	0.127
	0.144	0.107	0.127	0.025	0.002	0.002	0.002	0.002	0.005	0	0	0
	0	0.005	0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	0	0	
2011	1	4	0	1	200	0	0	0	0	0	0	0
	0	0	0	0.007	0.013	0	0.016	0.023	0.039	0.039	0.039	0.082
	0.076	0.079	0.125	0.095	0.056	0.063	0.059	0.056	0.059	0.03	0.016	0.016
	0.007	0	0	0	0	0	0	0	0	0.003	0	0
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	0	0	0	0	0	0	0	0	0	0	0	
2012	1	4	0	1	200	0	0	0	0	0	0	0
	0	0	0.004	0	0.004	0.004	0.027	0.058	0.078	0.089	0.116	0.112
	0.085	0.093	0.105	0.043	0.031	0.027	0.016	0.016	0.019	0.016	0.012	0.027
	0.016	0	0	0	0	0.004	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	0	0	
1981	1	5	0	2	17	0	0	0	0	0	0	0
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	0.176470588		0.058823529		0.058823529		0	0	0	0.058823529		
	0.058823529		0	0	0.058823529		0	0	0	0	0	0
	0.058823529		0	0	0	0	0	0	0	0	0	0
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1982	1	5	0	2	63	0	0	0	0	0	0	0
	0	0.031746032		0.126984127		0.126984127		0.047619048		0.047619048		
	0.031746032		0.063492063		0.047619048		0.031746032		0.047619048		0.015873016	
	0.031746032		0.047619048		0.015873016		0	0.015873016		0	0.047619048	
	0.015873016		0.031746032		0.031746032		0.015873016		0.015873016		0	0
	0	0.015873016		0	0	0.031746032		0.015873016		0.015873016		0
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1983	1	5	0	2	40	0	0	0	0	0	0	0
	0	0.05	0	0.025	0.025	0.1	0.025	0.075	0	0.05	0.075	0.075
	0.025	0.1	0.025	0.1	0	0.05	0.025	0.05	0.025	0.025	0	0.025
	0	0	0	0.025	0	0.025	0	0	0	0	0	0
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1984	1	5	0	2	19	0	0	0	0	0	0	0
	0	0	0.052631579		0	0.052631579		0.210526316		0.105263158		0
	0.052631579		0	0	0.052631579		0	0.157894737		0	0.052631579	
	0.105263158		0.052631579		0	0.052631579		0.052631579		0	0	0
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1985	1	5	0	2	19	0	0	0	0	0	0	0
	0	0	0	0	0	0.052631579		0	0	0.052631579		
	0.210526316		0.052631579		0.052631579		0.105263158		0.052631579		0	
	0.052631579		0.052631579		0.052631579		0	0.105263158		0	0.052631579	
	0	0	0.105263158		0	0	0	0	0	0	0	0
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	0	0										
1986	1	5	0	2	16	0	0	0	0	0	0	0
	0	0	0	0.0625	0.0625	0	0.0625	0	0	0.0625	0.0625	0.125
	0.0625	0	0.125	0.0625	0.0625	0.0625	0	0.0625	0	0.0625	0	0.0625
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1987	1	5	0	2	70	0	0	0	0	0	0	0
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	0.028571429		0.014285714		0.028571429		0.042857143		0.042857143		0.142857143	
	0.071428571		0.071428571		0.057142857		0.085714286		0.028571429		0.1	
	0.028571429		0.057142857		0.014285714		0.028571429		0.028571429		0	
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1988	1	5	0	2	58	0	0	0	0	0	0	0
	0	0	0.017241379		0	0.017241379		0	0.017241379		0	
	0.017241379		0	0.017241379		0.051724138		0.051724138		0.068965517		
	0.034482759		0.034482759		0.068965517		0.068965517		0.155172414		0.034482759	
	0.103448276		0.051724138		0.017241379		0.051724138		0.017241379		0.034482759	
	0.017241379		0	0.034482759		0.017241379		0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
1989	1	5	0	2	15	0	0	0	0	0	0	0
	0	0	0	0	0.066666667		0	0.066666667		0	0	0.2
	0.066666667		0	0	0.066666667		0	0.066666667		0	0.066666667	
	0.2	0	0	0.066666667		0	0.066666667		0	0.066666667		0
	0	0	0	0	0	0	0	0	0	0	0	0

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	0	0	0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0				
1990	1	5	0	2	32	0	0	0	0	0	0	0
	0	0.03125	0	0.03125	0	0	0	0	0	0	0.03125	0
	0	0.09375	0	0.03125	0	0.0625	0.03125	0.125	0.125	0.0625	0.09375	0.0625
	0	0.125	0.0625	0	0.03125	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
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1991	1	5	0	2	81	0	0	0	0	0	0	0
	0.037037037		0	0	0	0	0.012345679		0	0	0	0
	0	0.012345679		0.024691358		0.049382716		0.12345679		0.086419753		
	0.086419753		0.111111111		0.086419753		0.037037037		0.037037037		0.061728395	
	0.061728395		0.061728395		0.012345679		0.049382716		0.012345679		0	0
	0	0.012345679		0.024691358		0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0				
1992	1	5	0	2	127	0	0	0	0	0	0	0
	0	0.007874016		0.007874016		0.007874016		0	0.007874016		0	0
	0	0.015748031		0.007874016		0.007874016		0.039370079		0.157480315		
	0.094488189		0.102362205		0.094488189		0.047244094		0.094488189		0.070866142	
	0.062992126		0.039370079		0.047244094		0.023622047		0.023622047		0	
	0.031496063		0	0.007874016		0	0	0	0	0	0	0
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1993	1	5	0	2	145	0	0	0	0	0	0	0
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	0.013793103		0.04137931		0.110344828		0.055172414		0.089655172		0.082758621	
	0.124137931		0.131034483		0.082758621		0.082758621		0.082758621		0.034482759	
	0.027586207		0.013793103		0.006896552		0.006896552		0	0.006896552		0
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	0	0	0	0	0							
1994	1	5	0	2	138	0	0	0	0	0	0	
	0.007246377		0	0.014492754		0	0	0.007246377		0	0	
	0.007246377		0.007246377		0.007246377		0	0.014492754		0.036231884		

	0.065217391		0.094202899		0.137681159		0.101449275		0.043478261		0.130434783	
	0.065217391		0.050724638		0.057971014		0.057971014		0.02173913		0.014492754	
	0.028985507		0.014492754		0.007246377		0	0	0.007246377		0	0
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	0	0	0	0	0	0	0	0	0	0	0	0
	0	0										
1995	1	5	0	2	124	0	0	0	0	0	0	0
	0	0	0	0	0	0	0.008064516		0	0	0	
	0.008064516		0.008064516		0.10483871		0.129032258		0.064516129		0.137096774	
	0.088709677		0.080645161		0.064516129		0.016129032		0.040322581		0.056451613	
	0.064516129		0.024193548		0.072580645		0.008064516		0.016129032		0.008064516	
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	0	0	0	0	0	0	0					
1996	1	5	0	2	111	0	0	0	0	0	0	0
	0.009009009		0	0	0	0	0	0	0	0.009009009		0
	0.018018018		0.036036036		0.072072072		0.153153153		0.144144144		0.135135135	
	0.099099099		0.054054054		0.045045045		0.036036036		0.045045045		0.063063063	
	0.018018018		0.009009009		0	0.018018018		0	0.018018018		0.009009009	
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1997	1	5	0	2	186	0	0	0	0	0	0	0
	0	0.010752688	0		0	0	0	0	0	0	0	0
	0.005376344		0.043010753		0.102150538		0.139784946		0.075268817		0.091397849	
	0.096774194		0.123655914		0.075268817		0.075268817		0.021505376		0.059139785	
	0.021505376		0.037634409		0.010752688		0	0	0	0	0.010752688	
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	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0								
1998	1	5	0	2	200	0	0	0	0	0	0	
	0.003344482		0	0	0	0.006688963		0	0.003344482		0	
	0.003344482		0	0.003344482		0.010033445		0.016722408		0.040133779		
	0.130434783		0.100334448		0.123745819		0.107023411		0.096989967		0.040133779	
	0.08361204		0.08361204		0.033444816		0.040133779		0.016722408		0.013377926	
	0.013377926		0.013377926		0.006688963		0.003344482		0.003344482		0	
	0.003344482		0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0							
1999	1	5	0	2	200	0	0	0	0	0	0	0
	0	0	0.001919386		0	0	0	0.001919386		0.003838772		
	0.001919386		0.007677543		0.003838772		0.011516315		0.067178503		0.099808061	
	0.09596929		0.122840691		0.099808061		0.115163148		0.065259117		0.078694818	
	0.049904031		0.026871401		0.026871401		0.030710173		0.034548944		0.007677543	
	0.009596929		0.009596929		0.007677543		0.005758157		0.005758157		0	
	0.003838772		0.001919386		0	0	0	0	0	0	0	0
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	0	0.001919386		0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0						
2000	1	5	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0.004914005		0	0	0	
	0.002457002		0.002457002		0.024570025		0.093366093		0.117936118		0.127764128	
	0.110565111		0.095823096		0.095823096		0.071253071		0.066339066		0.031941032	
	0.034398034		0.051597052		0.017199017		0.014742015		0.022113022		0.007371007	
	0.002457002		0.002457002		0	0.002457002		0	0	0	0	0
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2001	1	5	0	2	200	0	0	0	0	0	0	0
	0	0	0	0.003344482		0	0	0	0.003344482		0	0
	0.003344482		0	0.003344482		0.016722408		0.030100334		0.113712375		
	0.137123746		0.080267559		0.096989967		0.093645485		0.076923077		0.073578595	
	0.076923077		0.056856187		0.033444816		0.040133779		0.006688963		0.026755853	
	0.010033445		0.010033445		0	0	0.003344482		0	0	0	0
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2002	1	5	0	2	200	0	0	0	0	0	0	0
	0	0.00330033		0	0	0	0	0	0.00660066		0	
	0.00660066		0.00330033		0.00660066		0.00330033		0.01980198		0.056105611	
	0.115511551		0.138613861		0.125412541		0.092409241		0.095709571		0.056105611	
	0.02970297		0.066006601		0.056105611		0.03960396		0.02640264		0.01980198	
	0.00660066		0.00990099		0.00990099		0	0.00330033		0	0.00330033	
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	0											
2003	1	5	0	2	200	0	0	0	0	0	0	0
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	0.128472222		0.107638889		0.076388889		0.090277778		0.038194444		0.041666667	

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	0	0	0	0	0	0						
2004	1	5	0	2	200	0	0	0	0	0	0	0
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	0.141210375	0.109510086	0.115273775	0.074927954	0.04610951	0.04610951						
	0.054755043	0.037463977	0.023054755	0.020172911	0	0.005763689						
	0.005763689	0.005763689	0	0	0	0.002881844	0	0	0			
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	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0			
2005	1	5	0	2	200	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0.007272727	
	0	0.003636364	0.021818182	0.036363636	0.090909091	0.152727273						
	0.134545455	0.112727273	0.076363636	0.105454545	0.072727273	0.04						
	0.047272727	0.032727273	0.021818182	0.018181818	0.010909091	0.003636364						
	0.003636364	0	0	0.007272727	0	0	0	0	0	0		
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	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0				
2006	1	5	0	2	136	0	0	0	0	0	0	0
	0	0	0	0	0	0.007352941	0.007352941	0	0	0		
	0	0	0	0.007352941	0.036764706	0.117647059	0.147058824					
	0.191176471	0.088235294	0.088235294	0.102941176	0.066176471	0.051470588						
	0.022058824	0.022058824	0.022058824	0.014705882	0	0	0					
	0.007352941	0	0	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0						
2007	1	5	0	2	172	0	0	0	0	0	0	0
	0	0	0.005813953	0	0	0	0	0	0	0		
	0.005813953	0	0	0.011627907	0.069767442	0.110465116	0.145348837					
	0.139534884	0.122093023	0.058139535	0.046511628	0.052325581	0.087209302						
	0.046511628	0.029069767	0.029069767	0.011627907	0	0.01744186	0					
	0	0	0.011627907	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0

	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0						
2008	1	5	0	2	200	0	0	0	0	0	0	0
	0	0	0	0.003472222	0	0.003472222	0.003472222	0	0			
	0	0	0	0.010416667	0.013888889	0.038194444	0.128472222					
	0.159722222	0.131944444	0.107638889	0.065972222	0.072916667	0.059027778						
	0.059027778	0.059027778	0.027777778	0.034722222	0.003472222	0.006944444						
	0.003472222	0	0.003472222	0.003472222	0	0	0	0	0			
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0		
2009	1	5	0	2	158	0	0	0	0	0	0	0
	0	0	0	0.006329114	0	0	0	0	0	0	0	
	0	0	0.018987342	0.037974684	0.126582278	0.227848101	0.113924051					
	0.101265823	0.120253165	0.069620253	0.037974684	0.082278481	0.012658228						
	0.006329114	0.025316456	0	0.006329114	0.006329114	0	0	0				
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0									
2010	1	5	0	2	170	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0.005882353	0.017647059	0.064705882	0.141176471	0.135294118	0.123529412						
	0.123529412	0.158823529	0.064705882	0.041176471	0.047058824	0.023529412						
	0.035294118	0.011764706	0	0.005882353	0	0	0	0	0			
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0										
2011	1	5	0	2	88	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0.011363636	0	0.090909091	0.159090909	0.125	0.102272727	0.113636364					
	0.079545455	0.102272727	0.068181818	0.056818182	0.022727273	0.056818182						
	0.011363636	0	0	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2012	1	5	0	2	64	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0.015625	0.046875	0.15625	0.078125	0.203125	0.09375	0.109375	0.046875	0.046875	0.015625	0.09375
	0.046875	0.03125	0.015625	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0

	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2008	1	9	0	0	32	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0.0625	0	0.03125	0	0.0625	0.0625	0	0.03125	0.03125	0.03125
	0.0625	0.0625	0.125	0	0.03125	0.09375	0.0625	0.03125	0.09375	0.03125	0	0
	0.03125	0	0.03125	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0.03125	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2009	1	9	0	0	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	0.2	0	0	0	0
	0.4	0	0.2	0	0	0	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	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2010	1	9	0	0	23	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0.043478261		0
	0	0	0	0	0	0	0	0	0	0.043478261		0
	0.086956522		0.086956522		0.086956522		0.086956522		0.130434783		0.043478261	
	0	0.217391304		0	0.086956522		0.043478261		0	0	0.043478261	
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2011	1	9	0	0	22	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0.045454545		0	0.045454545		0	0	0	0.045454545		
	0.090909091		0.045454545		0.045454545		0.045454545		0.045454545		0.090909091	
	0.090909091		0.090909091		0	0.045454545		0	0	0	0.045454545	
	0.045454545		0.045454545		0.045454545		0.045454545		0	0	0	0
	0.045454545		0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0						
2012	1	9	0	0	17	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0.058823529		0	0.117647059		0	0.058823529		0	0
	0.058823529		0.235294118		0.117647059		0	0.058823529		0.058823529		0
	0	0.058823529		0	0	0	0	0	0	0.117647059		0
	0	0	0	0.058823529		0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0

	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0		
2009	1	10	0	0	37	0	0	0	0	0	0	0
	0.027027027	0	0.081081081	0.027027027	0.054054054	0.054054054						
	0.108108108	0.054054054	0.135135135	0.081081081	0.027027027	0.081081081						
	0	0.027027027	0	0	0	0.054054054	0.027027027	0	0			
	0.054054054	0.027027027	0.027027027	0	0	0	0.027027027	0				
	0	0	0	0	0.027027027	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0					
2010	1	10	0	0	31	0	0	0	0	0	0	0
	0	0.064516129	0	0	0.096774194	0	0.064516129	0.129032258				
	0.032258065	0.032258065	0.096774194	0.032258065	0	0.032258065						
	0.032258065	0.096774194	0	0.032258065	0.032258065	0	0.032258065					
	0.032258065	0	0	0	0.032258065	0	0	0.032258065	0			
	0	0	0	0.032258065	0	0	0	0	0	0	0	
	0.032258065	0	0	0.032258065	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0				
2011	1	10	0	0	16	0	0	0	0	0	0	0
	0	0	0.0625	0	0	0	0	0	0	0.0625	0.0625	0
	0.125	0.125	0.0625	0	0	0.0625	0.0625	0.0625	0	0.0625	0.0625	0
	0	0.0625	0	0	0	0	0	0	0	0	0.0625	0
	0	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
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	
2012	1	10	0	0	12	0	0	0	0	0	0	0
	0	0	0	0	0	0	0.166666667	0	0	0		
	0.166666667	0.166666667	0	0	0.083333333	0.166666667	0	0				
	0	0.083333333	0.083333333	0	0.083333333	0	0	0	0			
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0				

#
20 #_N_age'_bins; these are in terms of age', not true age. Age' is estimated age taking into account any ageing bias and imprecision# following vector is the lower edge of the integer age' for each age' bin; by starting at age' = 1, any zero-year-old fish that are in the expected values will be accumulated up into the age 1 bin.

1 2 3 4 5 6 7 8 9 10 11 12 13
14 15 16 17 18 19 20

2 #_N_ageerror_definitions; these define how SS will convert true age into a distribution of expected ages to represent the effect of ageing bias and imprecision

```
0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5
	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	24.5
	25.5	26.5	27.5	28.5	29.5	30.5	31.5
0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	0.001	0.001	0.001	0.001	0.001	0.001	0.001
0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5
	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	24.5
	25.5	26.5	27.5	28.5	29.5	30.5	31.5
0.01	0.27	0.96	1.37	1.65	1.88	2.06	2.21	2.35	2.4	3.003333333
	3.273757576	3.544181818	3.814606061	4.085030303	4.355454545	4.625878788
	4.89630303	5.166727273	5.437151515	5.707575758	5.978	6.248424242
	6.518848485	6.789272727	7.05969697	7.330121212	7.600545455	7.870969697
	8.141393939	8.411818182	8.6
#
109	#_N_Agecomp_obs
2	#_Lbin_method:	1=poplenbins;	2=datalenbins;	3=lengths

0	#_combinemales	into	females	at	or	below	this	bin	number

#year	season	fleet	gender	part	age	Low	hi	Nsamp	1	2	3	4
	5	6	7	8	9	10	11	12	13	14	15	16
	17	18	19	20
1991	1	1	0	2	1	-1	-1	200	0	0	0
	0.076190476	0.157142857	0.514285714	0.066666667	0.071428571	0.028571429
	0.042857143	0.004761905	0.00952381	0.004761905	0	0	0.004761905
	0.014285714	0.004761905	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0
1992	1	1	0	2	1	-1	-1	66	0	0.060606061
	0.378787879	0.075757576	0.212121212	0.090909091	0.121212121	0
	0.015151515	0.015151515	0.015151515	0	0.015151515	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
1993	1	1	0	2	1	-1	-1	200	0	0.007194245
	0.06235012	0.585131894	0.067146283	0.112709832	0.047961631	0.081534772
	0.011990408	0.002398082	0.002398082	0	0.004796163	0	0.002398082
	0	0.002398082	0	0	0.009592326	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0
1994	1	1	0	2	1	-1	-1	200	0	0.002277904
	0.061503417	0.134396355	0.539863326	0.08428246	0.0523918 0.025056948
	0.041002278	0.01594533	0.01594533	0.002277904	0.013667426	0.002277904
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	0	0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0					
2009	1	3	0	2	1	-1	-1	198	0.025252525		0.141414141	
	0.555555556		0.196969697		0.035353535		0.02020202		0.025252525		0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0					
2010	1	3	0	2	1	-1	-1	200	0	0	0.296803653	
	0.506849315		0.155251142		0.02739726		0.00456621		0	0.00913242		0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0						
2011	1	3	0	2	1	-1	-1	24	0	0.25	0	0.625
	0.083333333		0.041666667		0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0										
2012	1	3	0	2	1	-1	-1	16	0	0	0.25	0.25
	0.375	0.0625	0	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
1991	1	4	0	2	1	-1	-1	75	0.06	0.2467	0.02	0.2853
	0.0787	0.2593	0	0.03	0.02	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
1992	1	4	0	2	1	-1	-1	200	0	0.1386	0.3696	0.0656
	0.2012	0.0885	0.1201	0.0088	0	0	0	0	0	0.0025	0	0.0025
	0.0025	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
1993	1	4	0	2	1	-1	-1	200	0.0051	0.0954	0.152	0.5096
	0.0956	0.0623	0.0289	0.0358	0.0102	0.0026	0	0	0	0	0.0026	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
1994	1	4	0	2	1	-1	-1	182	0	0.0159	0.1464	0.2428
	0.4328	0.125	0.0171	0.004	0.002	0	0	0	0.01	0	0	0
	0	0	0	0.004	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
1995	1	4	0	2	1	-1	-1	192	0	0.1015	0.3927	0.2289
	0.1447	0.1114	0.0097	0	0	0	0.0111	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
1996	1	4	0	2	1	-1	-1	200	0	0.0129	0.5324	0.2363
	0.0782	0.0366	0.0908	0.0012	0	0.0029	0.0015	0.0015	0	0	0.0029	0
	0	0	0	0.0029	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
1997	1	4	0	2	1	-1	-1	162	0	0.0083	0.1014	0.8042
	0.0501	0.0038	0.0189	0.0076	0	0	0	0.0019	0	0.0038	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
1998	1	4	0	2	1	-1	-1	50	0	0.1328	0.2286	0.3029
	0.2956	0.0351	0.0025	0	0	0	0	0	0	0	0	0
	0.0025	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
1999	1	4	0	2	1	-1	-1	82	0	0.0538	0.686	0.1376
	0.076	0.0423	0.0007	0.0014	0.0023	0	0	0	0	0	0	0

	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2000	1	4	0	2	1	-1	-1	36	0.0017	0.3115	0.2472	0.4104
	0	0.0158	0.0133	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2001	1	4	0	2	1	-1	-1	126	0.0039	0.0685	0.1165	0.3464
	0.4316	0.0283	0.0036	0	0	0.0012	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2002	1	4	0	2	1	-1	-1	200	0	0.0909	0.5169	0.1056
	0.175	0.1008	0.0028	0.0033	0.0038	0	0	0	0	0	0	0
	0	0	0.0009	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2003	1	4	0	2	1	-1	-1	178	0	0.0438	0.3695	0.4665
	0.0282	0.0479	0.0371	0.0071	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2004	1	4	0	2	1	-1	-1	75	0	0.0177	0.3216	0.3365
	0.2937	0.0121	0.0129	0.005	0	0	0.0005	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2005	1	4	0	2	1	-1	-1	119	0	0.0098	0.3113	0.2478
	0.3399	0.0806	0.0093	0	0.0006	0	0	0	0	0	0	0
	0	0	0.0006	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2006	1	4	0	2	1	-1	-1	26	0	0.2444	0.0617	0.5222
	0.0901	0.037	0.0395	0.0049	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2007	1	4	0	2	1	-1	-1	36	0	0.2095	0.3676	0.2431
	0.1632	0	0	0.0166	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2008	1	4	0	2	1	-1	-1	160	0	0.1663	0.4544	0.2176
	0.0729	0.0889	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2009	1	4	0	2	1	-1	-1	158	0	0.0942	0.6097	0.1889
	0.0607	0.0123	0.0202	0.0045	0.0023	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
2010	1	4	0	2	1	-1	-1	200	0	0.0048	0.4078	0.4787
	0.0753	0.0238	0.0024	0.0048	0.0012	0.0012	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2011	1	4	0	2	1	-1	-1	200	0.003	0.0506	0.1434	0.622
	0.1751	0.006	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2012	1	4	0	2	1	-1	-1	200	0	0.0414	0.2031	0.2665
	0.3865	0.0742	0.0126	0.0112	0.003	0	0	0	0.0015	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
1991	1	5	0	2	1	-1	-1	5	0	0.7273	0	0
	0	0.2727	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
1992	1	5	0	2	1	-1	-1	13	0	0	0.5	0
	0.3929	0	0.1071	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
1993	1	5	0	2	1	-1	-1	11	0	0.0645	0	0.8871
	0.0484	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
1994	1	5	0	2	1	-1	-1	8	0.0541	0	0.4324	0.1622
	0.3514	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0

1995	1	5	0	2	1	-1	-1	2	0	0.2	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	0	0
1996	1	5	0	2	1	-1	-1	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
1997	1	5	0	2	1	-1	-1	1	0	0	0	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
1998	1	5	0	2	1	-1	-1	2	0	0.4839	0	0.5161
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
1999	1	5	0	2	1	-1	-1	15	0	0	0.8595	0.0785
	0.062	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
# 2000	1	5	0	2	1	-1	-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	0	0	0
2001	1	5	0	2	1	-1	-1	4	0	0	0	0
	0.8065	0.1935	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2002	1	5	0	2	1	-1	-1	31	0	0	0.7206	0
	0.1029	0.1765	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2003	1	5	0	2	1	-1	-1	76	0	0.1293	0.4981	0.3244
	0	0.0122	0.0279	0	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	0
2004	1	5	0	2	1	-1	-1	23	0	0.0914	0.6613	0.1263
	0.0995	0	0.0108	0	0.0054	0	0.0054	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2005	1	5	0	2	1	-1	-1	2	0	0.575	0.425	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2006	1	5	0	2	1	-1	-1	16	0	0.109	0.359	0.2628
	0.2436	0.0128	0	0	0.0128	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2007	1	5	0	2	1	-1	-1	19	0	0.4231	0.4011	0.1319
	0.033	0	0.011	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2008	1	5	0	2	1	-1	-1	79	0	0.3873	0.4804	0.0647
	0.0676	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2009	1	5	0	2	1	-1	-1	81	0	0.0795	0.6662	0.1877
	0.0444	0.0044	0	0.0044	0	0.0133	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2010	1	5	0	2	1	-1	-1	174	0	0.0404	0.5398	0.3956
	0.0184	0	0.0029	0	0	0	0	0	0	0.0029	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2011	1	5	0	2	1	-1	-1	125	0.0239	0.0468	0.2996	0.5452
	0.075	0.0096	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
2012	1	5	0	2	1	-1	-1	1	0	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	#_N_MeanSize-at-Age_obs											
0	#_N_environ_variables											
0	#	N	sizefreq	methods	to	read						
0	#	N	super	periods								
0	#	no	tag	data								
0	#	no	morphcomp		data							
#												
999	ENDDATA											

SEDAR

Southeast Data, Assessment, and Review

SEDAR 33
Gulf of Mexico Gag

SECTION IV: Research Recommendations
March 2014

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

Section IV: Research Recommendations

Contents

Data Workshop Research Recommendations:
Gulf of Mexico Gag

Life History

Stock Definition

Increased genetic sampling should provide more precise estimations of exchange rates within the Gulf basin and the Atlantic. As well, The LHW recommends continued application of otolith chemistry methods to evaluate the population structure and connectivity of gag.

Oceanographic modeling efforts are advancing (3-d models). Larval transport and modeling efforts need to be supported and associated with development of an Integrated Coastal Ocean Observing System (ICOOS). There is evidence for different transport and retention processes operating along the northeastern Gulf and west Florida shelf. Attention should be given to different oceanic forcing mechanisms particularly focusing on wind-driven upwelling and Loop Current intrusion differences north and south of about latitude 28°. Further exploration of potential larval contribution (interannual variation) from Campeche to US waters is needed.

For the purpose of learning more about exchange between basins, and as indicated in SEDAR 10, tagging studies should be coordinated between researchers in the Gulf (including Mexico) and south Atlantic, particularly with respect to adult size and depth. Additional acoustic tagging of mature gag may contribute to identification of additional spawning aggregation sites warranting protection. In particular more investigation of potential spawning habitats south of 28° latitude along the WFS is needed.

Age and Growth

Gag age samples are under- represented from the recreational sector. This remains a trend over time and more attention to recreational sampling is warranted.

Reader comparison statistics can now be incorporated as uncertainty in aging within the Stock Synthesis model. Estimates of standard deviation at age will be calculated and forwarded for review at the assessment workshop.

Further review of the aging macro (the assignment of final annual age) is needed to deal with the possibility of early annulus formation (e.g. before January 1st). Thus the age macro may need to include the means of age demotion for some individual gag.

Natural Mortality

1.) As in SEDAR 10, recommended ranges of M: (0.10 - 0.20).

2.) Continue to investigate age-varying M models and their appropriateness.

3.) LHW recommends further research into mortality rates of pre-spawning gag as they migrate from seagrass meadows to the offshore environment.

Reproduction

Maturity: Continue to gather histological samples to monitor change in maturity that may occur over time. Further examination needs to be made regarding how uncertainty in maturity can be treated within Stock Synthesis. A research recommendation is that formal decision tables be developed regarding the assignment of maturity based upon the raw histological readings for tropical/subtropical species. Changes to a decision table could be made in a standardized way to gauge the effect of uncertainty in models and for different species. The LHW recommends that this subject be presented at workshops or scientific meetings to raise awareness and develop consensus and best approaches.

Sex ratio, spawning fraction and fecundity: Promote collection of grouper reproductive samples via observer programs. Scientific observers working onboard commercial vessels will be able to sample gag in the round (prior to routine gutting) throughout the year. With improved field sampling, estimation of sex ratio needs to be made with better design or accounting of factors such as cohort effect (strong vs. weak year classes), location, gear and seasonal timing (pre-aggregation, spawning, and post-aggregation).

Sex transition and mechanism of sex change: Further review of the utility of secondary sexual traits (copperbelly pigmentation) is warranted: 1) incorporate the secondary sex field formally into TIP 2) provide training to port agents and 3) for longitudinal analysis develop means to account for changes in fishery selectivity and cohort effects.

Mating system: The LHW recommends further study of the particular type of mating system in gag (leks or harems). The distinction may depend on the particular type and amount of androgen produced (Shepherd et al 2013). An expectation is that leks would be more male biased as opposed to harems. As well, more information is needed on the timing and control of sex change in gag.

Form of reproductive potential: Because of questions about how the stock synthesis model can incorporate reproductive potential, the LHW recommends that three forms of reproductive potential be examined further at the Assessment Workshop given the data and reproductive traits reviewed at the data workshop 1) SSB-combined for male & female 2) SSB-female only and 3) SSB-eggs based upon annual fecundity.

Fertilization success: Research needs to be conducted on the consequences of sex ratio on fertility. The LHW recognizes that experiments on fertility would be difficult to conduct directly on such a large bodied species as gag (but see Rowe et al. 2004, 2008). Improved understanding of the gag mating system together with better designed field estimation of sex ratios may advance our understanding. Together with better field data, further genetic monitoring of Allee or inbreeding effects may yield much more insight on fertility and male reproductive success.

Conversion Factors
Continue to work on adoption of consistent standards across survey and data collection programs. Encourage programs collecting gag meristics to report fork length. Avoid use of Excel trend line function with some known statistical deficiencies in favor of more robust algorithms for solving equations.

Commercial Fishery Statistics

Landings
-Improved dockside sampling for catch composition
-Improved dealer reporting to species
-Historical literature research for historical landings

IFQ
-Investigate dealer influence on IFQ allocation usage through dealer IFQ surveys

Discard
-Most appropriate method for incorporation of IFQ data into discard estimations
-Most appropriate method for incorporation of IFQ data into discard size compositions
-Increased observer coverage.
-More representative observer coverage.

Recreational Fishery Statistics

1) Evaluate the technique used to apply sample weights to landings
2) Continue and expand fishery dependent at-sea observer surveys to collect discard information.
4) Track Texas commercial and recreational discards.
5) Estimate variances associated with the headboat program.
6) Evaluate existing and new methods to estimate historical landings.

Measures of Population Abundance

Expand the use of molecular genetics to identify the grouper larvae in SEAMAP samples that cannot be positively identified as gag grouper because diagnostic morphological characters are not yet developed.

The IWG made note that the delta-lognormal index may not be the most appropriate distribution with some of the data presented. However, the lack of adequate diagnostics for different distributions prelude their use. The recommendation is that addition work be done with these other distribution (i.e. Poisson, negative binomial) in order to fully vet the methodology.

A calibration study is needed between the FWRI/NMFS video survey and the UF diver survey (UVC). The standardized reef systems reported in SEDAR33-DW03 are well suited for rigorous calibration studies, which could also include other sampling methods.

An exploration of the effects of the IFQ on the fishery dependent indices, specially the commercial handline and longline is needed. During the workshop, fisherman indicated that since the implementation of the IFQ, there has been a drastic change in fisheries behavior. There is also the possibility that dealers can directly influence this behavior. The need is to find a way to incorporate these years into the overall timer series or a recommendation to split the time series when the IFQ began.

Further consideration of how to combine the data from the juvenile surveys, including perhaps revisiting the seagrass weighting approach as well as incorporating otolith microchemistry data on the relative contribution of estuaries to nearshore populations, may improve the YOY index.

Discard Mortality Rate

Future studies reporting discard mortality estimates should provide data tables that report the number of fish by discard condition (e.g. dead or alive), the number of fish by depth and by length bin, complete descriptions of gear (reel and hook type), and whether fish were properly vented. In addition, analyses of long-term mortality estimates from tag-recapture studies should account for survivorship and the effects of variable fishing effort over spatial and temporal scales.

Integrated Ecosystem Assessment

Harmful algal blooms

A top research priority is to assess the long-term effects of periodic HAB disturbances on the biomass, spatial distribution and age distribution of exploited reef fish species and their prey. These effects are likely to impact population viability and safe extraction rates, and could become very important to Gulf of Mexico fisheries management if climate change brings with it an increased frequency and severity of HAB events. Research should explore two avenues: retrospective analysis of reef fish biomass trends using historic HAB time series as drivers of mortality and recruitment, and future projections that challenge the current management practices under a schedule of increasing HAB disturbance (e.g., as informed by IPCC climate change scenarios). Priority should be given to spatially-explicit and/or stochastic simulation methods able to integrate, at minimum, the following features: fisheries effects, age structure, trophic dynamics, habitat, nutrient loading and HAB considerations.

Extending the Walter et al. (2013) red tide index forward will also be important for species affected by harmful algal blooms. This would involve bridging the SeaWIFS-MODIS gap between 2010 and 2011 to maintain continuity of satellite data and calibration of information.

Ecosystem modeling

No stock-recruitment relationship is specified in OSMOSE-WFS. Rather, recruitment levels in OSMOSE-WFS emerge from model simulations, and are dependent on the survival of eggs and larvae in relation to the predation process and to the amount of plankton available. Therefore, the development of OSMOSE-WFS #2 will be useful to obtain estimates of recruitment deviations for gag in the past, present and future that will be compared to estimates of recruitment deviations by the Connectivity Modeling System. Discussions would then be needed on how the outputs of both the Connectivity Modeling System and OSMOSE-WFS could be integrated into Stock Synthesis.

The IEA working group would benefit from another biophysical modeling system based on a Lagrangian framework, Ichthyop (Lett et al. 2008), in the future, to obtain estimates of recruitment deviations for gag and other species evaluated within the SEDAR process. The use of the Ichthyop model would be interesting to have several different perspectives on the issue of recruitment deviations.

Estimates of natural mortality

The following research topics would be useful for improving estimates of M:

- Within-model framework hypothesis testing of whether M applies to all ages equally or whether certain size/ages more vulnerable due to life history, location, and physiology

- Simulation modeling work to determine how best to model episodic mortality in stock assessments
- Development of forecasting methods to incorporate some probability of red tide occurring in the future, i.e. is there some autocorrelation to annual events, etc.
- Field or lab based studies of the effects of red tides on fish; for example, can fish sense *K. brevis* and do they move in response?
- Research on how mortality occurs; asphyxiation, bioaccumulation of toxins, etc.
- Does the pattern of recolonization of areas decimated by red tide occur through movement of adults or through settlement of juveniles.
- Collections of fish during red tide events, which would allow for the size/age selectivity of mortality to be determined, and might also allow for some minimum estimates of total mortality

Estimates of recruitment

Increased knowledge on the reproductive behavior or adult gag and biology of larval gag grouper would lead to better parameterization of larval transport models, and thus more accurate estimates of recruitment strength. Specifically, three major areas of uncertainty exist:

- The location of gag grouper spawning. While some sites have been well-documented (e.g., the Madison-Swanson Reserve) it is unknown whether spawning occurs in other locations along the West Florida Shelf. Collaborative projects with fishers would be particularly helpful in regards to identifying other potentially important spawning sites.
- The density and size of gag grouper eggs. Because transport patterns are highly sensitive to the vertical location of eggs in the first several days after release, more realistic parameterization of particles in this initial stage would lead to more accurate estimates. In particular, knowledge on the densities of both fertilized and unfertilized eggs, and the timing of fertilization, would be useful.

The vertical distribution of gag larvae in the post-flexion stage. Because gag grouper have an extended pelagic larval duration (up to about 2 months), the fate of these larvae is largely determined by the depth layer in which they exist. Because grouper larvae are found in relatively low abundances in plankton tows, very little data exists on the vertical distributions of Epinepheline larvae in the pelagic environment, and in most cases the larvae are only identified to subfamily level. Increased sampling and identification of these larvae to species level will be important for understanding the vertical distributions of this species in the pelagic phase.

Assessment Workshop Research Recommendations:
Gulf of Mexico Gag

1. Develop scientific survey to obtain reliable age/size composition data. This is needed, particularly as the composition data coming from the fisheries is substantially impacted by changing selectivity. This might be done with a handline survey of fixed sites. The idea would be not necessarily to get a random sample of the age composition but a reliable, relative estimate where selectivity can be assumed constant. An index would be nice, too.

2. Develop/Evaluate methods to maintain continuity of fishery-dependent indices in light of management regulations and ITQs.

3. Determine most appropriate methods to deal with changing selectivity in fisheries over time, particularly changing selectivity related to management actions or targeting of specific cohorts.

4. Evaluate most appropriate methods to deal with unreliable historic discard size composition data so that discard ratios can be reliably estimated.

5. Evaluate the size/age specific mortality effects of red tides on gag populations.

Review Workshop Research Recommendations:
Gulf of Mexico Gag

Below, the RW Panel highlights research recommendations they feel should be emphasized, and provides new recommendations partly based on assessment methodology and results.

A. Research needs and new suggestions partly based on assessment methodology and results:

(1) Research should be conducted for the most appropriate value of steepness to be used for Gag – either through across a range of species (e.g. Ram database) or use of a well-estimated value from a closely related stock or species.

(2) If an appropriate fixed value for steepness is found, further research to explore the estimation of parameters currently fixed in the model, such as natural mortality.

(3) Further work on improving selectivity parameters that are poorly estimated from the data available, or highly correlated with other model parameters.

(4) Need more work on whether it is best to use either female or sexes combines (more conservative). The combined was what the assessment panel recommended.

(5) More research on video survey methodology or increasing samples size, as there is concern as to why video estimates do not match other indices.

B. Recommendations to improve the SEDAR Process:

(1) Due to the inherent complexity of highly parameterized statistical catch at age models (i.e. stock synthesis) and the relative scarcity of expert users, the review panel recommends that each SEDAR assessment workshop panel include at least one nationally recognized expert in the model used (e.g. SS). This expert could participate in person or by electronic means and would greatly facilitate the review process.

(2) There is concern over a variety of issues that emerge as a result of the Assessment Workshop was exclusively performed via webinars. The Review Panel emphasizes the importance of face-to-face meetings for improving the model development during the assessment phase. The panel feels that many of the issues uncovered during the review process could have been avoided and may have enabled the assessment team to provide a more polished product for review and in the end resulting in the best model possible.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 33

Section V: Review Workshop Report

Gulf of Mexico Gag

March 2014

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

Table of Contents

1. Review Workshop Proceedings

1.1 Introduction

1.1.1 Method of Review

The SEDAR 33 stock assessment Review Workshop for Gulf of Mexico Gag (*Mycteroperca microlepis*) was conducted as an in-person review workshop at the Doubletree Grand Hotel in Miami Florida from February 24-27, 2014.

1.1.2 Terms of Reference

1. Evaluate the data used in the assessment, addressing the following:
    - Are data decisions made by the Data and Assessment Workshops sound and robust?
    - Are data uncertainties acknowledged, reported and within normal or expected levels?
    - Are data applied properly within the assessment model?
    - Are input data series reliable and sufficient to support the assessment approach and findings?
2. Evaluate the methods used to assess the stock, accounting for only the available data:
    - Are the methods scientifically sound, robust, and appropriate for the available data?
    - Are assessment models properly configured and used consistent with standard practices?
3. Evaluate the assessment findings with respect to the following:
    - Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support inferences on stock status?
    - Is the stock overfished? What information helps you reach this conclusion?
    - Is the stock undergoing overfishing? What information helps you reach this conclusion?
    - Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?
    - Are quantitative estimates of status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?
4. Evaluate the stock projections, addressing the following:
    - Are the methods consistent with accepted practices and available data?
    - Are the methods appropriate for the assessment model and outputs?
    - Are results informative and robust, and useful to support inferences of probable future conditions?

- Are key uncertainties acknowledged, discussed, and reflected in the projection results?

5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.
    - Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods
    - Ensure that the implications of uncertainty in technical conclusions are clearly stated.
6. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted.
    - Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments with particular emphasis on the Deepwater Horizon Oil Spill
    - Provide recommendations on possible ways to improve the SEDAR process
7. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.
8. Prepare a Peer Review Summary Report 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 Peer Review Summary Report in accordance with the project guidelines.

1.1.3 Participants

Analytical Team

Jake Tetzlaff	Lead Analyst- Gag	SEFSC
Meaghan Bryan	Analyst- Gag	SEFSC
Nancie Cummings	Lead Analyst- GAJ	SEFSC
Meaghan Bryan	Analyst- GAJ	SEFSC
Shannon Cass-Calay	Analyst	SEFSC
Jeff Isely	Analyst	SEFSC

Review Panel

Sean Powers	Chair	Gulf SSC
Ben Blount	Panelist	Gulf SSC
Greg Stunz	Panelist	Gulf SSC
Neil Klaer	Panelist	CIE
Mike Armstrong	Panelist	CIE
Anders Nielsen	Panelist	CIE

Observers

Skyler Sagarese	SEFSC	Jessica Stephen	SEFSC
John Froeschke	GMFMC	Katyana Vert	UF

Justin Grubiche	PEG	Mike Murphy	FWC-FWRI

Staff

Ryan Rindone	SEDAR Coordinator	SEDAR
Charlotte Schiaffo	Administrative Support	GMFMC

1.1.4 Review Workshop Working Documents

Review Workshop Documents			
SEDAR33-RW01	Gag	Linking an environmental index to natural mortality within the stock synthesis integrated assessment model framework: A case study for Gulf of Mexico gag grouper (*Mycteroperca microlepis*) and red tide	Sagarese, Tetzlaff, Bryan, Walter, and Schirripa

2. Review Workshop Panel Report

2.1 Executive Summary

The review workshop panelists found the assessment to be a rigorous analysis of current stock condition and concluded that projections for future yields were based on acceptable practices. The panel concluded that the model performed well with very good fits to the fishery dependent data and indices. Fits to the fishery independent indices were more variable. The rapid recovery of the spawning stock over the last three years was quite striking and the panelists devoted considerable time to investigating this pattern. The reviewers noticed that this recovery is indicated mostly by the headboat index and were concerned that the last points of this index alone were heavily influencing this recovery. Sensitivity runs were performed down weighting and leaving out the headboat index, and it was concluded that the estimated increase in biomass was robust to those changes. A major consideration in the assessment was whether to base stock determination on the Spawning Stock Biomass of females only (SSB-females) or SSB for male and females (SSB-Combined). Analyst performed several sensitivities with both configurations. In addition to reviewing the 16 sensitivities to the AW base model that were presented in the SEDAR 33 AW, the RW requested four additional sensitivities: (1) increased uncertainty in length-at-age for the von Bertalanffy growth model, (2) increased uncertainty in recreational landings data,(3) using trips sampled instead of individuals sampled for input sample sizes of length- and age-composition data, and (4) equally weighting all indices of abundance by setting a constant CV for all indices. After review of these sensitivities, the RP recommended a changed in the preferred base model for Gulf of Mexico Gag Grouper. The base model is similar to the model presented in the SEDAR 33 AW Report with the exception that the steepness parameter for the Beverton-Holt stock-recruitment relationship is fixed at 0.85 instead of estimated within the model. In addition, the RP recommended the base model should use SSB-combined because it provides a more conservative measure of SSB given the uncertainty associated with potential male limitation for this stock. Based on this revised based case (SSB-combined), the stock is considered to be overfished but not undergoing overfishing. Under the SSB-female model, the stock is not considered overfished nor undergoing overfishing. Some caution should be exercised in projecting future yields as the current rapid recovery of the stock is being driven by one or two strong year classes and recent recruitment predictions are low. Because steepness of the S-R is not estimated reliably by the model, fixed at 0.85, predicting future recruitment has a high degree of uncertainty. Finally, abundance estimates in the fishery independent indices and some fisheries dependent indices in the last years of the assessment are lower than predicted by the model.

2.2 Terms of Reference Addressed

1. Evaluate the data used in the assessment.

A. Are data decisions made by the Data and Assessment Workshops sound and robust?

Overall, the Review Panel concludes that the decisions made by the Data and Assessment Workshops were sound and robust, and that the data used in the assessment are adequate and appropriate for that purpose. The Data and Assessment Workshops had to make a number of important decisions around key parameters such as natural mortality, discard mortality, growth and maturity, and had to decide on reliable methods for making imputations where data are missing or inadequate, for extrapolating data series back in time, and for filtering and modeling fishery-dependent and –independent abundance index data. All decisions were well explained in the workshop reports and presentations to the Review Panel. In most cases the Review Panel found the decisions to be sound and robust, and their effect on the assessment was adequately explored in sensitivity analyses. The Panel however disagreed with the Assessment Workshop decision to treat recreational catches as exact (as they are estimated from surveys, with known precision), or to use numbers of fish measured or aged, capped at 200, as input effective sample sizes for composition data. These approaches degrade the ability of the model to appropriately weight data according to their precision. Additional assessment model runs were requested at the Review Meeting to treat the recreational catch estimates as subject to survey error rather than being exact, and using numbers of trips sampled for length or age as proxies for effective sample sizes, without any capping. These had relatively small impact on recent stock trends and status, and whilst the panel agreed that this remained a desirable approach, further work would be needed to identify the most suitable model inputs on effective sample size and recreational survey precision.

B. Are data uncertainties acknowledged, reported and within normal or expected levels?

The Panel considers that data uncertainties have been explored and reported, although would have found it more helpful to see a clearer summary of the relative quality of the different data sets. Where they could be quantified, uncertainties appeared to be within normal or expected levels given the design of data collection schemes and the amount of sampling that has taken place. The Gag assessment is comparatively data rich, although individual data sets vary according to their coverage of years or areas and in other aspects of data quality. The workshop reports indicate clearly where sample sizes are small or where data are absent. Procedures for imputing missing data for years, fleets or areas are well described, although potential biases caused by this are not clearly indicated. Recreational fisheries take a large fraction of the catches, and the catch estimates are based on statistically-sound sampling designs that have been improved in the recent MRIPS surveys to reduce bias and allow more accurate estimates of precision. In general, a clearer framework for documenting known or potential data quality issues (bias and precision) in relation to design, implementation, sampling achievement and analysis of data over different periods would be very helpful for assessment analysts and reviewers.

C. Are data applied properly within the assessment model?

The Panel concluded that the data have been properly applied within the assessment model, based on the workshop reports and presentations at the Review Meeting.

D. Are input data series reliable and sufficient to support the assessment approach and findings?

The Panel concludes that the input data series are reliable and are sufficient to support the assessment approach and findings. The Data and Assessment teams are commended for their work in compiling and evaluating the wide range of data and parameters used in the assessment. The data are reliable in the sense that deficiencies and uncertainties in the data have been explored in detail and that assumptions and decisions made in compiling input parameters and data have been clearly presented and their effect on the assessment shown through sensitivity analyses. Good fits to the data and the ability of Stock Synthesis to find a stable solution also indicate that the data are sufficient to support the additional complexities in the model structure around selectivity and retention that are necessitated by the series of changes in minimum landing sizes and IFQs which affect size compositions of retained and discarded fish.

2. Evaluate the methods used to assess the stock, accounting for only the available data:

Stock Synthesis 3 (Methot and Wetzel 2013) was applied for Gag. Stock Synthesis is not a single model, but a modelling framework for full parametric stock assessments. It is well tested, as it has been applied to numerous thoroughly reviewed assessments, and many configurations have also been simulation-tested. It can be configured to match almost any situation in terms of stock dynamics and observational likelihoods. In terms of data sources it can be configured to use many different data sources from highly processed indices of abundances to fairly raw length and age data. An additional advantage of using such a widely used framework (in combination with graphics from the R-package r4ss) is that reviewers are familiar with it and the associated standard diagnostics. Stock Synthesis is a sound and robust choice, which can be configured to be appropriate for the available data.

The assessment team initiated their analysis by configuring a version of the Gag assessment in Stock Synthesis which closely mimics the previous accepted assessment, which was done in an independent framework CASAL (Bull et al. 2012). CASAL and Stock Synthesis are truly independent programs without any shared code base, as they are implemented via different software, and so have some differences in their structural detail and configuration options. The ability to get very similar, but not identical, results from both model configurations (AW report Fig 3.1.5-3.1.8) strengthens confidence in both implementations and configurations.

The Gag assessment has a number of interesting non-standard features and the assessment team should be acknowledged for capturing these in the assessment model. Firstly, Gag are protogynous hermaphrodites (female at birth, then a proportion of the population transition into males). This feature was elegantly included in the model as a (fixed) logistic function of age. Secondly, a red tide event (an algal bloom, which had harmful effect on Gag) occurred in 2005, and is well supported by most indices. The assessment team investigated several ways to include this additional mortality in the model, and decided to include it as an additional “fleet” with positive effort only in 2005. In this approach the mortality caused by the red tide was estimated as a constant value for all ages above age zero.

The size-dependence and rate of discarding in the commercial and recreational fisheries has changed over time due to the introduction and changing of IFQs, bag-limits and size limits. This was accounted for in the model via different retention functions corresponding to the different periods, selectivity parameters constant.

A few issues did raise some concern in review panel. The model allows for annual deviations from the stock recruitment relationship. The first 10 years (1963-1972) of the estimated logarithmic recruitment deviations are all estimated to be negative (AW report Figs 3.2.68 and 3.2.69). According to the assessment team this is a technical matter where the model tries to adapt recruitments in that first period without composition data to better fit the composition data at the start of the dynamic period of the model commencing in 1984. It is preferable to construct models that do not require such deviation trends in periods uninformed by composition data. These low recruitment estimates may interfere with the models ability to estimate the steepness of the stock-recruitment relationship. A number of sensitivity runs were performed (e.g., cutting off the first period and fixing steepness at different values) and the reviewers were satisfied that the key output metrics and all recent estimates were robust and not greatly influenced by the initial low recruitment estimates. It would nevertheless be preferable if a configuration could be found where the issue could be avoided.

The recovery of Gag is predicted to be very strong and rapid. The reviewers noticed that this recovery is indicated mostly by the headboat index (Fig 3.2.13) and were concerned that the last points of this index alone were heavily influencing this recovery. Sensitivity runs were performed down weighting and leaving out the headboat index, and it was concluded that the estimated increase in biomass was robust to those changes.

Issues with fixing model parameters and ad hoc weighting of different data sources were raised by the reviewers (more under TOR 5), but these were within the range of standard practices.

3. Evaluate the assessment findings with respect to the following:

A. Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support inferences on stock status?

1. <u>Abundance indices</u>

The model fit to the fishery-dependent headboat index was best overall, influenced by the relatively low CV for that index, partly contributing to the model prediction of a steep increase in biomass in recent years.

Of the fishery-independent indices, the SEAMAP Video has a selectivity that should allow the steep increase in biomass in recent years to be observed. However, the observations at least in 2011 and 2012 are well below the expected values. The PC Video index was not well fitted, but has a large CV and short time span. The Age 0 sea grass survey provided very low indices in

2011 and 2012. As these provide almost all information (other than discards) on very recent recruitments these produce low model estimates for recruitment in those years, with implications for projections.

The input CVs for abundance indices in the model were those determined by the delta-lognormal standardization model, and no further adjustment was made. If additional iterative reweighting, for example, had been applied, then most or all of the index CVs would have been adjusted upwards, thus giving the abundance indices less weight in the model. Recent advice on model weighting by e.g. Francis (2011) recommend that abundance indices be weighted more heavily than iterative weighting of all data sources would normally provide, so the indices as weighted in the model tend to conform to those recommendations (although simply using observed CVs denies the existence of process error in addition to the measurement error).

The abundance indices tend to show auto-correlated residuals in the Stock Synthesis model fit for Gag. The most pronounced trends in residuals are in the commercial long line and hand line indices, but there is a general tendency across many of the indices for the residuals to increase during the first half of the 2000s then to decrease.

2. Exploitation estimates

These are reliant on the exploitable biomass estimate per fleet, and the catch level per fleet annually. Exploitable biomass depends on estimated selectivity patterns and the total biomass (discussed below).

Different selectivity patterns among fleets are evident from the composition data and the Panel is satisfied with the characterization of selectivity within the current model. Given the large number of abundance indices, further work on fixing selectivity parameters that are badly estimated from the data, or highly correlated with other model parameters is encouraged.

A considerable portion of Gag catch is from recreational fisheries and discards and is estimated using sampling surveys rather than from logbook records as for the commercial landings, so has increased uncertainty. To account for this, the Panel has recommended that the recreational catch not be fitted exactly by the assessment model, using an associated CV of 0.2. Uncertainty in the total catch for all fleets, particularly in earlier years, is caused by the need to infer Gag catches within unspecified grouper records based on observed ratios in years where species compositions are known more precisely.

3. Biomass estimates

The fishery for Gag underwent a long period of exploitation prior to 1963, with only landings estimates available from 1880 to 1963. The ability to estimate the absolute virgin biomass and its trajectory to the data-rich period of the assessment is dependent on knowledge of productivity related to the shape of the stock recruit curve and the natural mortality. The stock-recruit steepness value for this stock is highly uncertain (see below), so also is the estimate of virgin biomass. Sensitivity runs showed that the trends in biomass and recruitment in the data-rich period of the assessment were relatively robust to changes in model settings but led to quite wide changes in virgin biomass and trends in the model burn-in period.

The sharp increase in spawning stock biomass subsequent to the recent imposition of reduced IFQs is estimated to be caused by fish of strong 2006 and 2007 year classes attaining maturity whilst experiencing much reduced fishing mortality. A sharp biomass increase was also observed after 1996, despite much higher fishing mortality. The recent biomass trend given by the assessment is not supported by all abundance indices but is robust to a wide range of model settings. The predicted rate of increase is partially dependent on the assumed discard mortality, as the IFQs resulted in a large increase in discarding across the size range.

Whether males are included in the spawning biomass affects assessment results considerably, with overall stock depletion and the sustainability of current *F* lower for the combined case. Without evidence to support the use of female-only SSB, the Panel agreed with the earlier assessment workshop recommendation that the combined biomass is preferred.

B. Is the stock overfished? What information helps you reach this conclusion?

The perception of whether the stock is overfished depends on how the SSB is calculated. The SSB-female model indicates that the stock is no longer overfished in relation to any of the proposed reference points. However, the SSB-combined (male plus female) model indicates that the stock is overfished in relation to $SSB_{SPR30\%}$, but the SSB is marginally above SSB_{MSY}.

C. Is the stock undergoing overfishing? What information helps you reach this conclusion?

No. A combination of management interventions of lower IFQs on the commercial fishery and size and season limits on the recreational fishery appear to have successfully lowered recent *F* values to below F_{msy} and also F_{spr30} for the agreed base model. Further enhancing the recovery of the stock was two strong year classes reaching maturity during this period.

D. Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

For the period where year class strength can be estimated by the model based on composition data (since about 1970), the stock was estimated to have generally increased, except for the sharp decline attributed to the red tide event. The stock has therefore only provided a very short period of increase from which to characterize the shape of the stock-recruitment relationship. Steepness is estimated in the Assessment base model to be high at >0.9. Steepness is certainly not well characterized by the estimated stock/recruitment points and therefore the Panel recommended that a fixed value of 0.85 be used for the base case, with results also to be provided for management using the estimated high value and a lower fixed value of 0.7.

E. Are quantitative estimates of status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

Biomass reference points derived from stock-recruit parameters, and current status relative to these, are greatly influenced by the value of stock-recruit steepness. They are also affected by the choice of whether to include males in the spawning biomass. Dimensions of uncertainty that the Panel agreed to carry forward in management recommendations were therefore (SSBfemale only/SSBfemales+males) x (Steepness estimated/ 0.85/0.7), resulting in 6 alternatives. Biomass trends under these alternatives are provided in the appendix to this report.

4. Evaluate the stock projections, addressing the following:

A. Are the methods consistent with accepted practices and available data?

<u>The review panel agreed that the methods were consistent with accepted practices and available data</u>.

Deterministic projections were run to evaluate stock status and associated yields for a range of fishing mortality rate scenarios: $F_{Current}$ (fishing mortality rates for all fleets set to the geometric mean of the past three years, 2010-2012), $F_{SPR30\%}$ (the fishing mortality rate that results in an equilibrium SPR of 30%), F_{Max} (the fishing mortality rate that maximizes the yield-per-recruit), Foy (75% of $F_{SPR30\%}$). Projections for six model configurations (Review Panel Base, and five alternatives) were produced at the request of the review panel. The review panel recommended that the Base assessment should use SSB-Combined with steepness fixed at 0.85 and all other parameters set as the Base run from the Assessment Report. The five alternatives represent the alteration of three steepness values (SS estimated, 0.85 and 0.7) and the SSB combined and SSB female only.

Benchmarks for the SPR 30% reference point and projections for the base model are presented in Table 3.2.8. Benchmarks for the SPR 30% reference point and projections for the fixed steepness model are presented in Table 3.2.9.

B. Are the methods appropriate for the assessment model and outputs?

The panel felt the methods for projections were appropriate. Projections were run assuming that selectivity, discarding, and retention were the same as the three most recent years (2010-2012). Forecast recruitments are derived from the model estimated Beverton-Holt stock-recruitment relationship, based on the recent time period (i.e., 1984-2011). The catch allocation among fleets used for the projections reflects the average distribution of fishing intensity among fleets during 2010-2012. Uncertainty in stock status and forecasted yields for the projection years was investigated using the bootstrap approach discussed. Random recruitment deviations for the projection period were created from a normal distribution with mean of 0 and standard deviation equal to the model estimated standard deviation in recruitment from the recent time period (1984-2011). These approaches are widely adopted in other assessments. The Bootstrap datasets were not available during the review workshop but were sent to the panel shortly thereafter

C. Are results informative and robust, and useful to support inferences of probable future conditions?

The panel found the projections to be informative, and robust (bracketing a range of model configurations). With regard to probable future states, projections should be interpreted with respect to model assumptions and the limitations associated with data inputs. Of particular note, projections assume that fishing patterns (i.e. selectivity and retention) in the future will be similar to average patterns over the past three years.

5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

Uncertainties generally play an important role in assessment models. If a likelihood approach is applied, which it is for Gag, the uncertainties determine the relative weighting of the different information sources entering the assessment. Furthermore it is important to correctly quantify the uncertainties on important output metrics to evaluate the risks of future fishing scenarios.

The Gag assessment supplies standard deviations derived from the inverse hessian matrix of the objective function at its minimum. This is a standard output from most model fitting software, but it requires two things for these numbers to represent the uncertainty of our estimates: 1) The objective function should be well approximated by a quadratic function, and 2) The model should correctly describe the observations including their observation uncertainties. The first requirement is less of a concern, as standard approaches are available to circumvent this issue.

For the Gag assessment, a parametric bootstrap is provided. An alternative could be to use an MCMC approach. The review panel debated the difference, so a brief summary of the difference is described here. Parametric bootstrap simulates multiple independent data sets according to the assumptions in the model and the parameters estimated from the real observations. Estimation is then carried out for each data set. Parametric bootstrap is useful to obtain a simulation-based, but otherwise exact, error propagation. It is also useful for revealing biases in the estimation procedure, as estimates can be compared to the assumed truth used when simulating the datasets. An MCMC approach simulates a Markov chain, such that its equilibrium distribution is the Bayesian posterior distribution of the model parameters (assuming flat priors where no prior is specified). The MCMC approaches are useful for error propagation, but not for identifying biases, as no truth is assumed with which the estimates can be compared.

Uncertainty about all model parameters are summarized by the estimated (hessian based) standard deviations (AW report Table 3.1.1) and supplemented by bootstrapped standard deviations and CVs for selected quantities of interest based on 400 simulated data sets (AW Tables 3.1.3 and Fig. 3.2.73). Finally, likelihood profiles were plotted for three important quantities: steepness, log of R0, and log of R1 (AW Fig. 3.2.65 - 3.2.67). These are all good ways to represent uncertainties, but they are all based on the assumption that the model is describing the observations and their uncertainties correctly.

For the assessment of Gag it was chosen to fix uncertainty parameters for different data sources at arbitrary values (e.g CVs for length-at-age were fixed at 0.13 and 0.01 for age 1 and age 31 respectively, sample sizes for composition data were capped at 200). These arbitrary values are mainly based on experience and subjective judging of the relative weighting between data sources, but they translate directly into scaling the estimated uncertainties.

The residual plots and plots of fitted lines and observations (AW Figs 3.2.1-3.2.48) indicate that some fits are unrealistically close to the observations and others are too far off. Some of the plots of the fitted indices also exhibit auto-correlated residual errors (periods of only negative residuals followed by periods of positive residuals), which is in contrast with the assumed independent error structure.

Certain parameters are fixed in the model (e.g. natural mortality, some selection parameters and gender transition parameters (see AW Table 3.1.1 for more)). This is necessary in these highly parameterized models, and some of these unacknowledged uncertainties would be picked up as larger observation uncertainties if the observation uncertainties were estimated. These are all reasons to be skeptical about the estimated uncertainties, and suspect the real uncertainties to be larger. This is expected in such complex models, and the approaches adopted by the assessment team are certainly within standard practices.

One additional source of uncertainty is the so-called model uncertainty, where the variation between different plausible model configurations is investigated. A wide array of sensitivity runs were presented in the assessment report and additional runs were requested by the reviewers. These included different natural mortality, inputting effective sample sizes as numbers of trips sampled (without capping), and different data weightings. The overall impression from these sensitivity analyses was that the model results were very robust over the recent period with respect to important output metrics, but more sensitive in the first ca. 12 years of the data period.

To verify model convergence, 50 runs were presented where the starting value was randomly shifted by 10%. Of the 50 runs, 38 converged to a solution within two likelihood units of the base case. This is not optimal, but it was demonstrated that 42 of the runs provided similar key outputs.

The implications of uncertainty are clearly stated in all relevant graphs and tables.

6. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted.

The Review Workshop Panelists considered the research recommendations provided by both the Data and Assessment workshops and provide additional recommendations. These research and monitoring recommendations were also made while considering improving the information and reliability of future assessments with particular emphasis on the Deepwater Horizon Oil Spill. Finally, this report provides recommendations on possible ways to improve the SEDAR process.

A. Research needs and new suggestions partly based on assessment methodology and results:

(1) Research should be conducted for the most appropriate value of steepness to be used for Gag – either through across a range of species (e.g. Ram database) or use of a well-estimated value from a closely related stock or species.
(2) If an appropriate fixed value for steepness is found, further research to explore the estimation of parameters currently fixed in the model, such as natural mortality.
(3) Further work on improving selectivity parameters that are poorly estimated from the data available, or highly correlated with other model parameters.
(4) Need more work on whether it is best to use either female or sexes combines (more conservative). The combined was what the assessment panel recommended.
(5) More research on video survey methodology or increasing samples size, as there is concern as to why video estimates do not match other indices.

B. Recommendations to improve the SEDAR Process:

(1) Due to the inherent complexity of highly parameterized statistical catch at age models (i.e. stock synthesis) and the relative scarcity of expert users, the review panel recommends that each SEDAR assessment workshop panel include at least one nationally recognized expert in the model used (e.g. SS). This expert could participate in person or by electronic means and would greatly facilitate the review process.

(2) There is concern over a variety of issues that emerge as a result of the Assessment Workshop was exclusively performed via webinars. The Review Panel emphasizes the importance of face-to-face meetings for improving the model development during the assessment phase. The panel feels that many of the issues uncovered during the review process could have been avoided and may have enabled the assessment team to provide a more polished product for review and in the end resulting in the best model possible.

7. Provide guidance on key improvements in data or modelling approaches which should be considered when scheduling the next assessment

The Panel considers that for Gag grouper, the Stock Synthesis modelling framework remains appropriate for the type of data available, allowing flexibility to account for changes in size limits or IFQs that affect patterns of discarding in commercial and recreational fisheries. Currently the model structure and implementation appears appropriate, although further work is needed to resolve the issue of poor definition of the initial slope of the stock recruit curve.

Future improvements are likely to be achieved through improvements in key data sets and in the understanding of the biology. A key aspect of biology where there is currently only limited understanding is what determines the probability of transition from female to male, how far the male population can be depleted before sperm limitation starts to impact productivity, and if reduced numbers of males would lead to transitioning at a lower size with impact on population egg production. Further work is needed to resolve these uncertainties which impact mainly the choice of biomass reference points and monitoring of biomass relative to these.

Ensuring the continued quality of length and age compositions for retained and discarded fish is important for fitting year class strength, selectivity and retention.

Currently, the most influential relative abundance indices are from recreational and commercial fisheries, i.e. the same data sets used for estimating catch compositions and recreational catches, but filtered using information on species guilds in catches to try and identify trips where gag grouper have a probability of being caught. The Panel considers that further work may be needed to identify potential biases in these approaches, for example where gag grouper were initially targeted in a recreational trip but zero or low catch rates led to a switch to other areas or methods that do not catch Gag Other factors affecting catch rates in hook fisheries, particularly longlines (e.g. gear saturation, competition with other species) should be considered in evaluating if the commercial index series are reliable. Further investigation into the robustness of the design of the video surveys should also be carried out in relation to coverage of the stock and density-dependent selection of habitats.

References

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Methot, R.D. and Wetzel C.R. 2013. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management, Fisheries Research 142: 86-99.

3. Appendix: SEDAR 33 Review Workshop: Gulf of Mexico Gag Grouper

3.1 Summary

This appendix summarizes the additional sensitivity runs and preferred base model configuration requested by the Review Panel (RP) during the SEDAR 33 Review Workshop (RW). Additional sensitivities requested by the RP during the RW included: 1) increased uncertainty in length-at-age for the von Bertalanffy growth model, 2) increased uncertainty in recreational landings data, 3) using trips sampled instead of individuals sampled for input sample sizes of length- and age-composition data, and 4) equally weighting all indices of abundance by setting a constant CV of 0.2 for all indices. The RP recommended a preferred base model for Gulf of Mexico Gag Grouper similar to the model presented in the SEDAR 33 AW Report with the exception that the steepness parameter for the Beverton-Holt stock-recruitment relationship is fixed at 0.85. In addition, the RP recommended that uncertainty in steepness be incorporated into the probability distribution around the overfishing limit (range: 0.70-0.99).

3.2 Sensitivities

A total of 16 sensitivities to the AW base model were presented in the SEDAR 33 AW report. During the RW, four additional sensitivities were requested by the RP. These included: 1) increased uncertainty in length-at-age for the von Bertalanffy growth model, 2) increased uncertainty in recreational landings data, 3) using trips sampled instead of individuals sampled for input sample sizes of length- and age-composition data, and 4) equally weighting all indices of abundance by setting a constant CV for all indices.

The AW base model used a fixed CV for length_at A_{MAX} (length-at-age of age-31 fish) of 0.02. This results in low variation in length-at-age for older fish which is somewhat counter-intuitive. However, the age-length data does suggest a low variation in length-at-age for the oldest individuals (Figure 1), and this CV was estimated both outside the model and within the assessment model to be quite low. The AW base model was not very sensitive to the alternative configuration explored with CV-age-31 fixed at 0.10.

The AW base model used a fixed standard error on the log(landings) (SE) of 0.05 for all five fishing fleets. Thus, the model provides a precise fit to the landings data. The RP requested sensitivity runs with higher values of SE for the recreational landings data. Two values for SE were used, 0.10 and 0.20. Based upon examination of the recreational landings data the true SE for recreational landings is closer to 0.20. When allowing for uncertainty in recreational landings, the model is not forced to fit precisely to landings and predicted landings can vary from observed input (Figure 2). The sensitivity with SE=0.20 did diverge from the AW base model during the initial years as well during the late 1990's and early 2000's (Figures 3 and 4). Allowing for uncertainty in recreational catch did result in a lower predicted SSB in 2012 than the base model (Table 1).

The AW base model used the number of fish sampled for the input sample sizes for both the length and age-composition data. Input sample sizes were capped at 200 for the base model. The RP recommended using the number of trips from which fish were sampled instead of the number of fish sampled for the input sample sizes for composition data. Using the number of trips reduces the potential for any biases associated with cluster sampling many individuals from a small number of trips. The number of trips sampled for the commercial fleets can be easily obtained from the TIP sampling program. However, it is more difficult to obtain the number of recreational trips from which the composition data is derived. For the RW, the number of trips was estimated for the recreational fleets using the MRFSS interview data. However, recreational composition data comes from multiple sources and trip identification is not available for all data sources. By using the number of trips instead of the number of individuals, the influence of the early composition data was down-weighted. Early in the time series, the number of samples per trip was higher than later in the time series. This sensitivity was similar to other runs that either down-weighted all composition data or ignored composition data collected prior to 1990. This sensitivity diverges from the AW base model early in the predicted time series (Figures 3 and 4). The AW base model uses early recruitment deviations to better fit the early composition data. Trends in SSB and reference points were similar between the two models after 1984. The model which used trips instead of individuals predicted a higher 2012 SSB than the AW base model (Table 1).

The AW base model used the coefficient of variations calculated for the standardized indices of abundance as an input into the assessment model. Thus, the CVs associated with each index were used to weight each of the indices relative to each other. The lower the CVs, the higher weight that index will receive from the assessment model. In the AW base model, the recreational headboat index had the lowest input CVs of all the indices and was therefore the index that received the highest weighting in the model. Consequently, the model predictions closely fit the observed catch per unit effort. The headboat index is characterized by a strong increase in relative abundance between 2006 and 2010, thus providing the model with a strong increasing signal in recent years. Two sensitivity runs were completed prior to the RW to address the weight of the headboat index on model predictions: 1) remove the HB index, and 2) equally weighting all indices of abundance using a constant CV of 0.2. The sensitivity of the model to removing the HB index is presented in the AW report (Run 17). The constant CV model down-weights the influence of the headboat index and results in a model that diverges from the AW base model in the most recent years in that the model predicts lower recruitment in 2006-2010, and a slightly slower recovery in SSB in recent years than the AW base model (Figures 3 and 4).

3.3 RW preferred base model

The RP recommended a preferred base model for Gulf of Mexico Gag Grouper similar to the model presented in the SEDAR 33 AW Report with the exception that the steepness parameter for the Beverton-Holt stock-recruitment relationship is fixed at 0.85 instead of estimated within the model. In addition, the RP recommended the base model should use SSB-combined because it provides a more conservative measure of SSB given the uncertainty associated male limitation for this stock. Table 2 and Figures 5-10 provide the summary model output for the SSB-combined model with steepness fixed at 0.85. The AW report details the model runs with steepness estimated near 0.99.

Stock status and benchmarks relative to the SPR 30% reference point reference point are presented in Table 2 for the RW preferred base model. The maximum fishing mortality threshold (MFMT) was calculated using the proxy $F_{SPR30\%}$, the fishing mortality rate that will produce a SPR of 30% at equilibrium,. The minimum stock size threshold (MSST) was calculated as $(1-M)*SSB_{SPR30\%}$, where $M = 0.1342\ y^{-1}$ for the base model (the average M of ages 3-31 calculated using the Lorenzen M). Overfishing is defined as F > MFMT and overfished as SSB < MSST. The AW Panel recommended that current fishing mortality be calculated as the geometric mean fishing mortality from 2010-2012 and that current SSB be calculated using the terminal year of the assessment, 2012. These definitions were used to calculate the current stock status (MFMT, and MSST). The perceived stock status was dependent on the assumed units of SSB (e.g. female biomass, combined biomass). According to the RW base model, the status of the stock relative to MSST was estimated to be 2.05 for the SSB-female model and 0.50 for the SSB-combined model. The current fishing mortality rate (2010-2012) relative to MFMT was 0.32 for the SSB-female model and 0.77 for the SSB-combined model. For SSB-female, the stock is not considered overfished nor undergoing overfishing. For SSB-combined, the stock is considered to be overfished but not undergoing overfishing.

3.4 Tables

Table 1. Summary of sensitivity runs evaluated during RW. Biomass units are in mt.

LABEL	AW Base	Input N=Trips	SE(Rec landings)=0.2	Index CV=0.2
SSB_Unfished	20,135	20,514	20,280	19,333
TotBio_Unfished	75,137	71,546	84,105	73,142
Recr_Unfished	4,291	4,475	4,247	4,109
SSB_SPR30%	6,016	6,121	5,987	5,777
Fstd_SPR30%	0.26	0.25	0.24	0.25
TotYield_SPR30%	2,503	2,453	2,396	2,363
SSB_MSY	7,491	7,646	7,938	7,056
SPR_MSY	0.37	0.37	0.40	0.37
Fstd_MSY	0.20	0.19	0.16	0.19
TotYield_MSY	2,529	2,481	2,446	2,383
RetYield_MSY	2,160	1,879	1,922	1,996
Steepness	0.99	0.99	0.97	0.99
R1 offset	-1.14	-0.79	-0.42	-1.12
R1/R0	0.32	0.46	0.65	0.33
SSB_2012	11,219	12,284	8,642	8,347
SSB2012/SSB0	0.56	0.60	0.43	0.43

LABEL	AW Base	Input N=Trips	SE(Rec landings)=0.2	Index CV=0.2
SSB_Unfished	71,015	67,367	76,993	69,221
TotBio_Unfished	74,956	71,403	80,829	73,002
Recr_Unfished	4,284	4,467	4,141	4,105
SSB_SPR30%	21,286	20,182	23,050	20,749
Fstd_SPR30%	0.10	0.11	0.10	0.10
TotYield_SPR30%	2,414	2,344	2,365	2,291
SSB_MSY	12,521	11,343	13,529	11,005
SPR_MSY	0.18	0.17	0.18	0.16
Fstd_MSY	0.18	0.19	0.16	0.19
TotYield_MSY	2,535	2,479	2,486	2,438
RetYield_MSY	1,994	1,876	1,970	2,083
Steepness	1.00	1.00	1.00	1.00
R1 offset	-1.14	-0.78	-0.67	-1.12
R1/R0	0.32	0.46	0.51	0.33
SSB_2012	11,876	13,248	10,159	8,897
SSB2012/SSB0	0.17	0.20	0.13	0.13

Table 2. Required SFA and MSRA evaluations using SPR 30% reference point for Gulf of Mexico Gag Grouper with steepness fixed at 0.85. Biomass units are in metric tons.

Criteria	Definition	RW preferred - SSB Female	RW preferred - SSB Combined
Base M		0.134	0.134
Steepness		0.85	0.85
Virgin Recruitment		5,009	6,888
SSB unfished		23,416	102,947
	Mortality Rate Criteria		
$F_{MSY\ or\ proxy}$	$F_{SPR30\%}$	0.259	0.108
$F_{MSY\ or\ proxy}$	F_{MAX}	0.157	0.122
MFMT	$F_{SPR30\%}$	0.259	0.108
F_{OY}	75% of $F_{SPR30\%}$	0.194	0.081
$F_{CURRENT}$	$F_{2010-F2012}$	0.083	0.083
$F_{CURRENT}$/MFMT	$F_{2010-F2012}$	0.322	0.765
	Biomass Criteria		
$SSB_{MSY\ or\ proxy}$	Equilibrium SSB @ $F_{SPR30\%}$	6,268	27,558
$SSB_{MSY\ or\ proxy}$	Equilibrium SSB @ F_{MAX}	9,525	24,331
MSST	(1-M)*$SSB_{SPR30\%}$	5,427	23,860
$SSB_{CURRENT}$	SSB_{2012}	11,126	11,826
$SSB_{CURRENT}$/MSST	SSB_{2012}	2.050	0.496
$SSB_{CURRENT}$/MSY	SSB_{2012}	1.775	0.429
Equilibrium MSY	Equilibrium Yield @ $F_{SPR30\%}$	1,916	2,646
Equilibrium MSY	Equilibrium Yield @ F_{MAX}	2,216	2,634
Equilibrium OY	Equilibrium Yield @ F_{OY}	2,581	2,581
OFL	Annual Yield @ MFMT		
	OFL 2014	3,090	1,666
	OFL 2015	2,555	1,542
	OFL 2016	2,215	1,489
	OFL 2017	2,076	1,534
	OFL 2018	2,023	1,619
	OFL 2019	2,004	1,717
	OFL 2020	1,994	1,815
Annual OY (ACT)	Annual Yield @ F_{OY}		
	OY 2014	1,311	1,311
	OY 2015	1,251	1,251
	OY 2016	1,237	1,237
	OY 2017	1,295	1,295
	OY 2018	1,384	1,384
	OY 2019	1,486	1,486
	OY 2020	1,591	1,591
Annual Yield	Annual Yield @ $F_{CURRENT}$		
	Y 2014	971	885
	Y 2015	984	873
	Y 2016	1,004	886
	Y 2017	1,050	944
	Y 2018	1,109	1,024
	Y 2019	1,175	1,114
	Y 2020	1,245	1,209

3.5 Figures

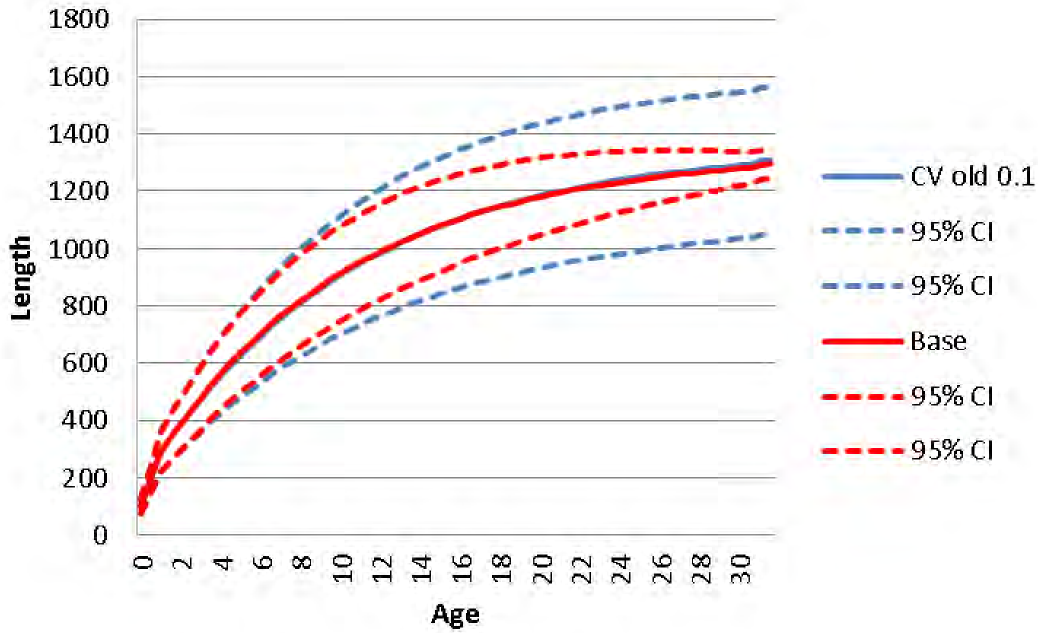

Figure 1. Predicted von-Bertalanffy growth curve with 95% confidence intervals for the base model (red lines) and sensitivity run with CV-old fixed at 0.10 (blue line)

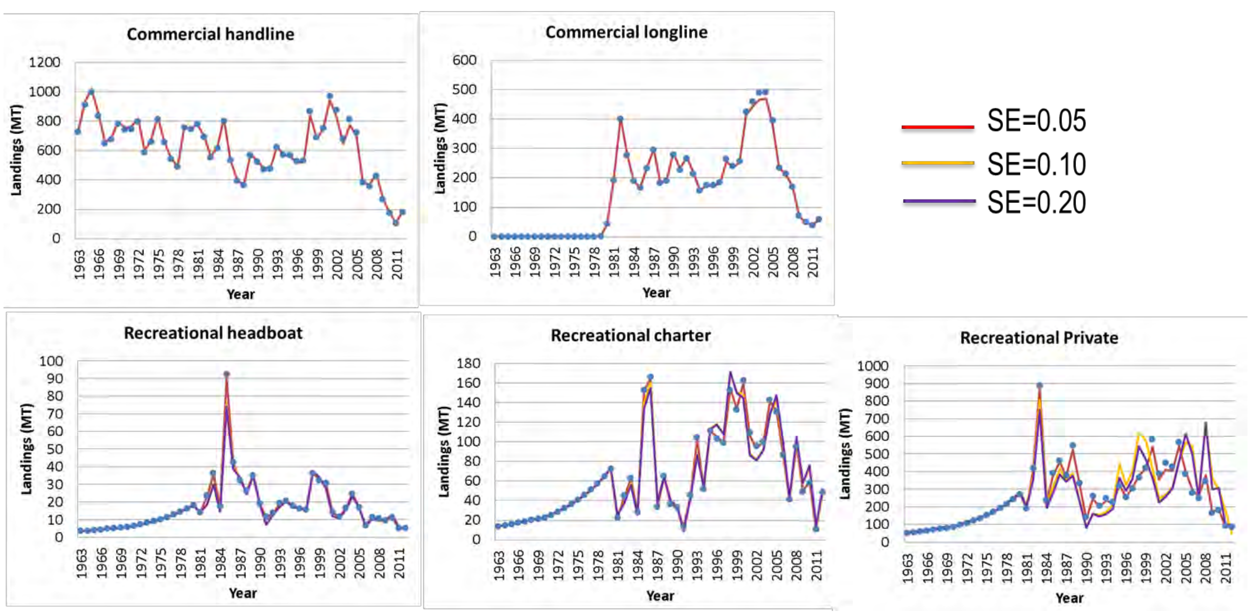

Figure 2. Model fit to input landings data (blue dots) for each of the five fishing fleets with three levels of SE in catch: 0.05 (red line), 0.10 (orange line), and 0.20 (purple line). Commercial landings units are MT and recreational landings units are thousands of fish.

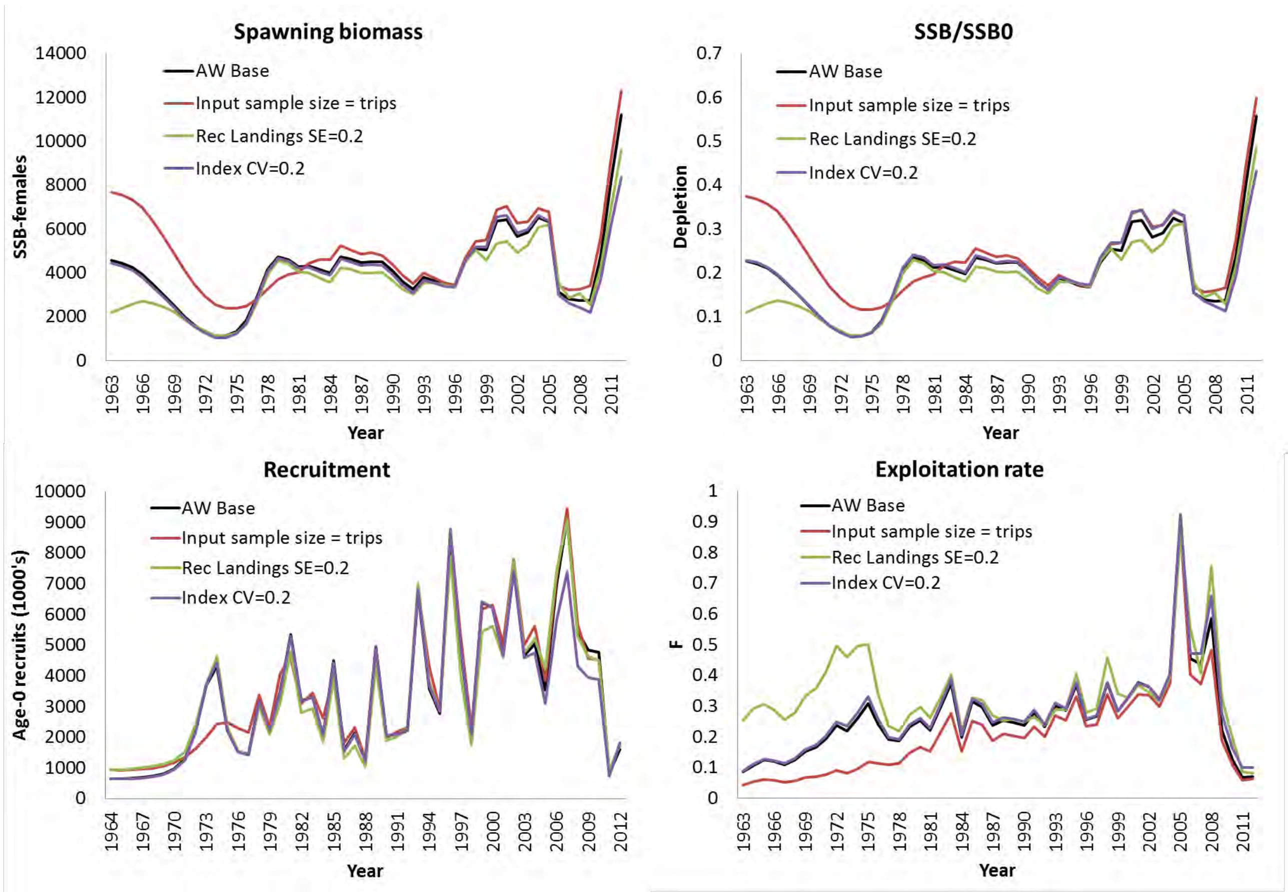

Figure 3. Summary of predicted trends in SSB-female, SSB-female/SSB-female unfished, recruitment, and exploitation rate for the AW base model and main sensitivities runs requested during the RW for the SSB-female model: using trips for composition data sample sizes (red line), incorporating larger uncertainty in recreational landings (green line), and equally weighting all indices of abundance using a constant CV of 0.2 (purple line).

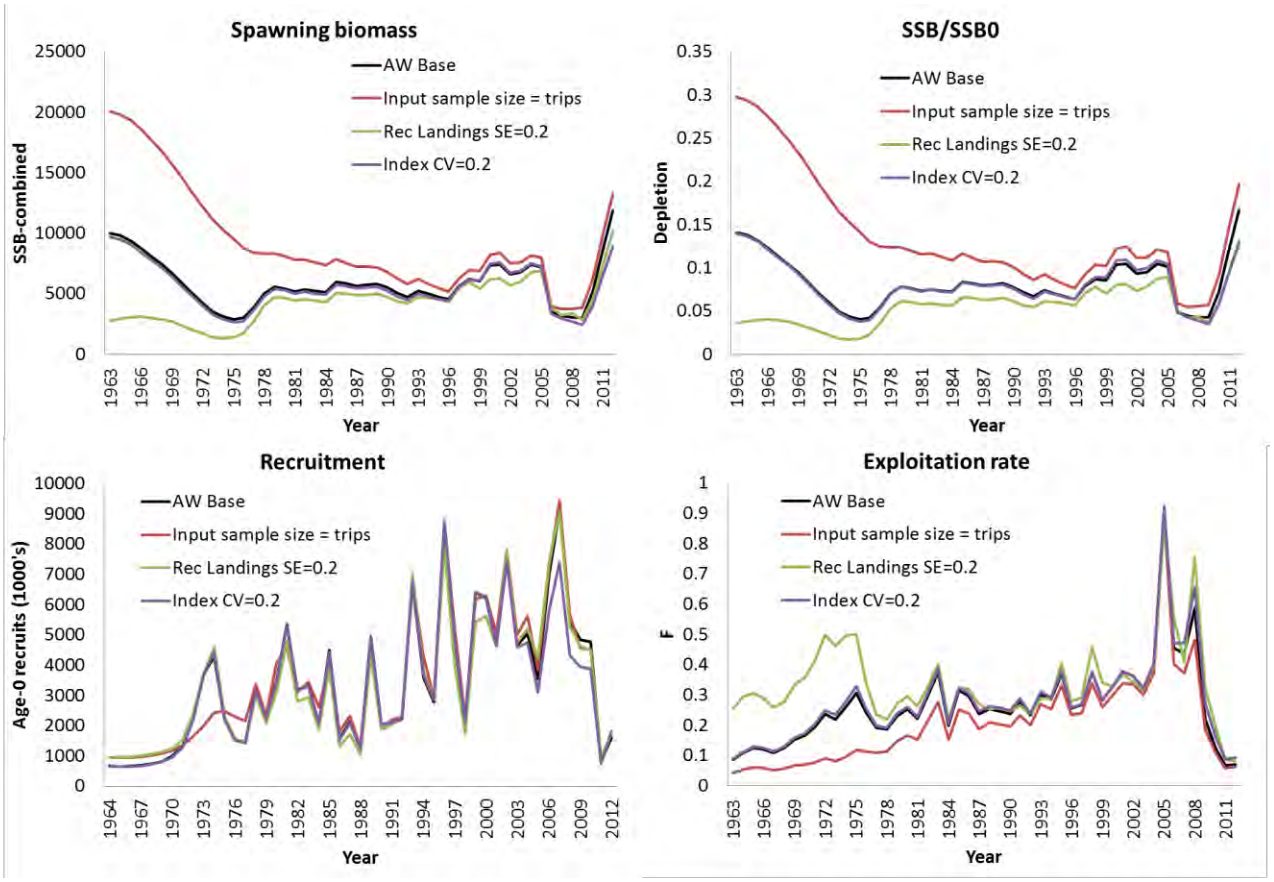

Figure 4. Summary of predicted trends in SSB-combined, SSB-combined/SSB-combined unfished, recruitment, and exploitation rate for the AW base model and main sensitivities runs requested during the RW: using trips for composition data sample sizes (red line), incorporating larger uncertainty in recreational landings (green line), and equally weighting all indices of abundance using a constant CV of 0.2 (purple line).

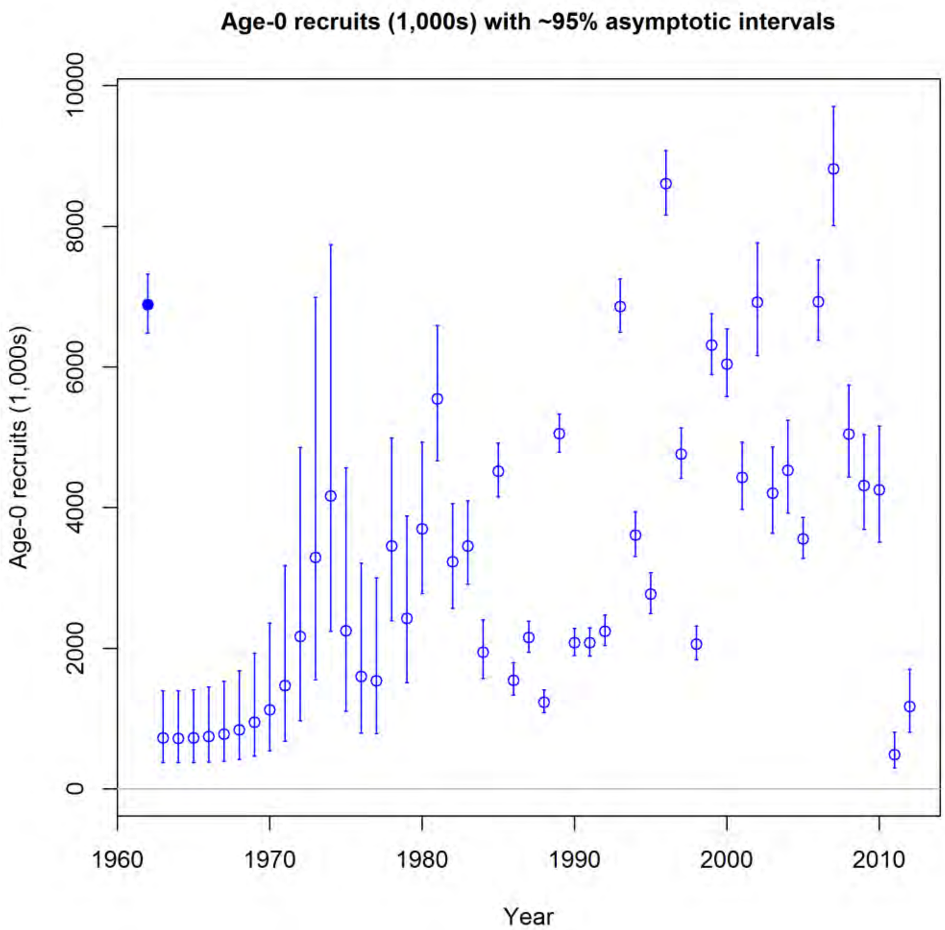

Figure 5. Predicted age-0 recruits with associated 95% asymptotic intervals for the RW preferred model.

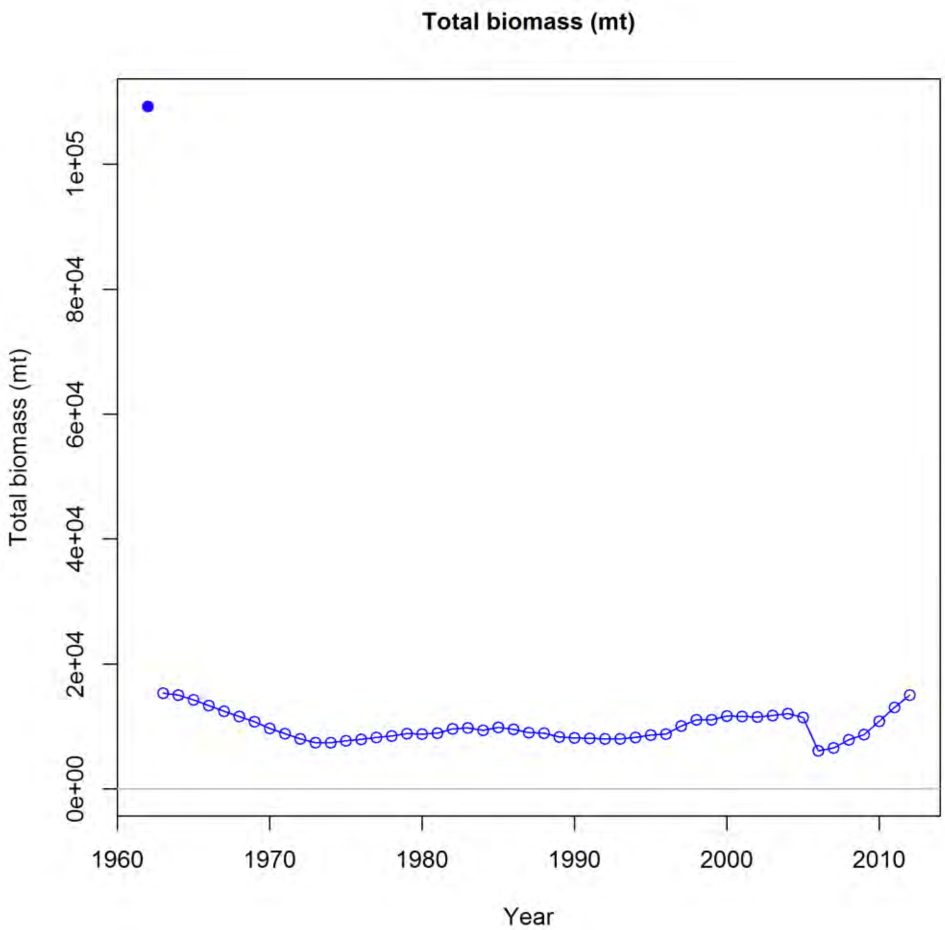

Figure 6. Predicted total biomass (mt) of Gulf of Mexico Gag Grouper from 1963-2012.

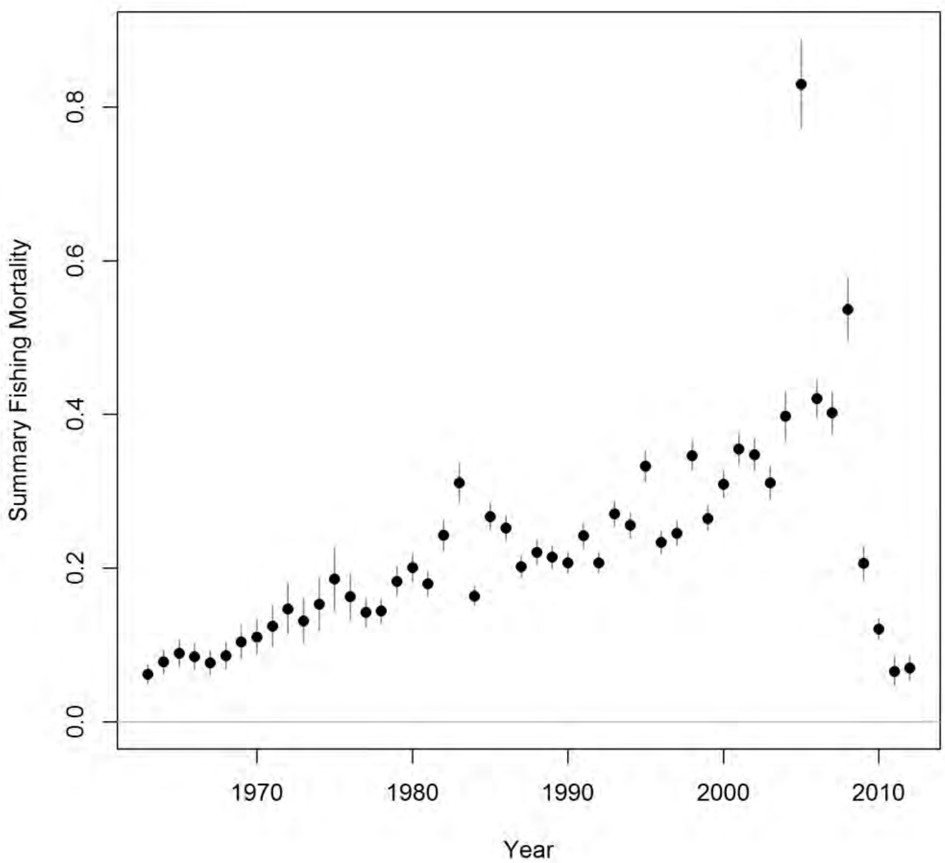

Figure 7. Predicted annual exploitation rate calculated as the ratio of the total annual catch in biomass to the summary biomass at the beginning of the year. Note that the exceptionally high 2005 data point includes an estimate of red tide mortality that was modeled as an additional 'fishing fleet'.

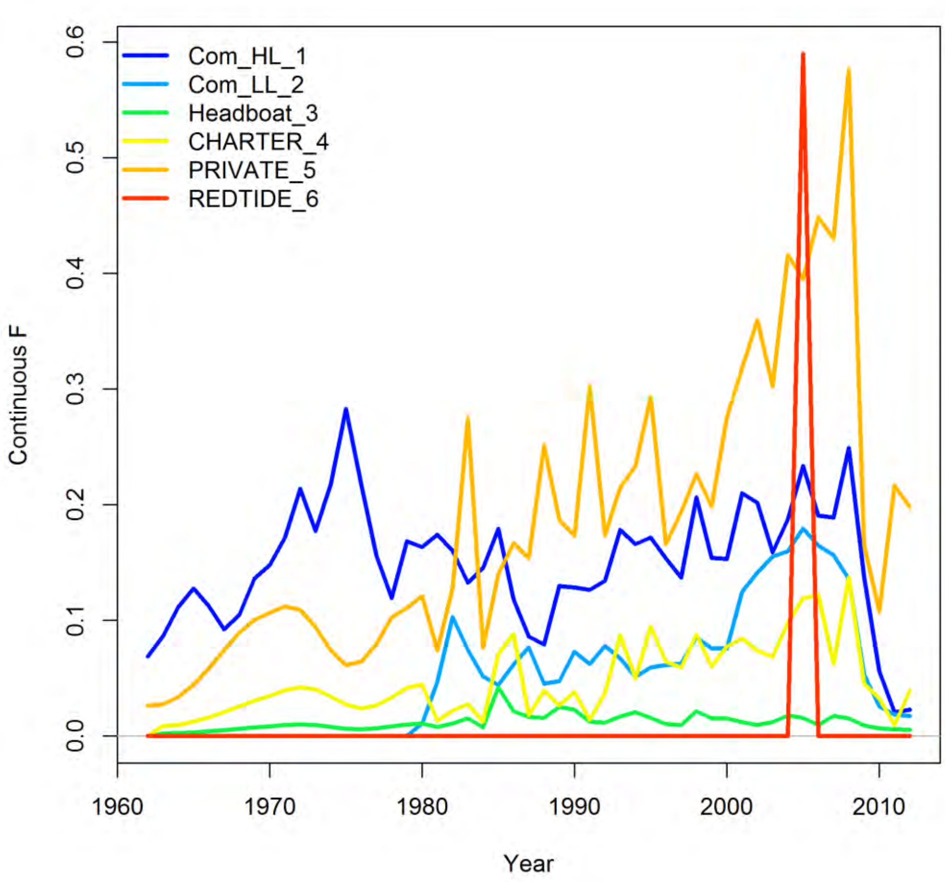

Figure 8. Predicted fleet specific exploitation rates over time.

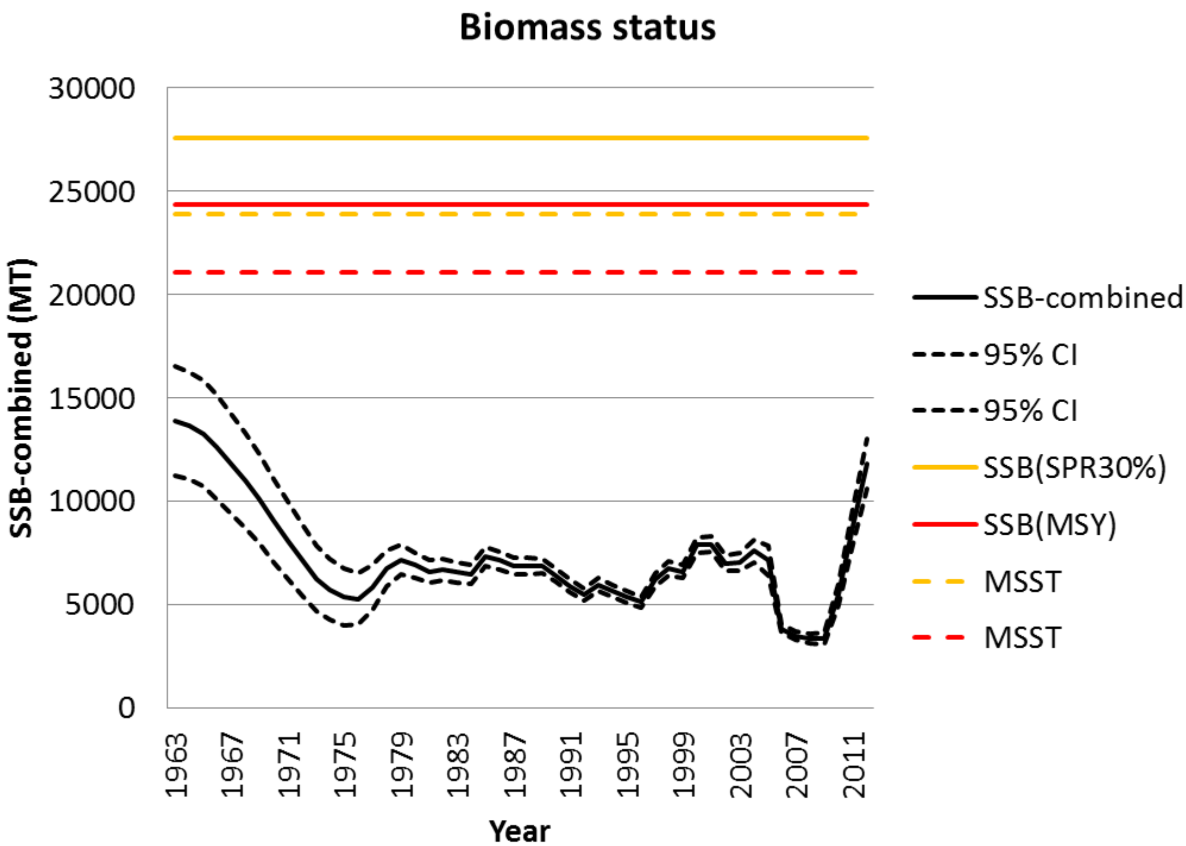

Figure 9. Predicted spawning stock biomass (SSB-combined) of Gulf of Mexico Gag Grouper with associated 95% asymptotic intervals. Solid horizontal lines represent $SSB_{SPR30\%}$ (orange line) and SSB_{MSY} (red line) benchmarks for SSB-combined. Dashed horizontal lines represent MSST reference points for SPR30% (orange line) and MSY (red line).

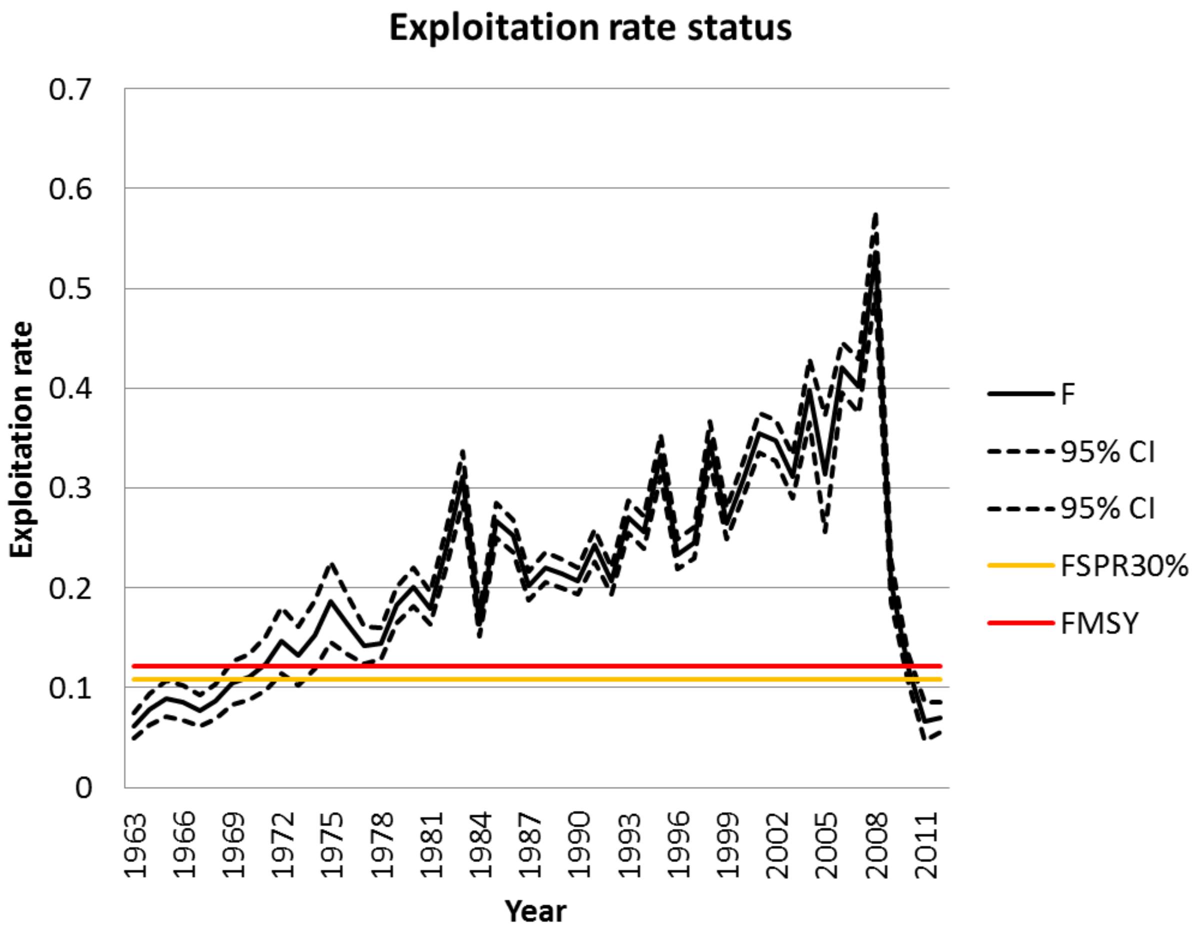

Figure 10. Predicted fishing mortality rate and associated 95% asymptotic intervals. Horizontal lines represent $F_{SPR30\%}$ (orange line) and F_{MSY} (red line) benchmarks for SSB-combined.