SEDAR

Southeast Data, Assessment, and Review

SEDAR 72

Stock Assessment Report

Gulf of Mexico Gag Grouper

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SEDAR

4055 Faber Place Drive, Suite 201

North Charleston, SC 29405

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Gulf of Mexico Gag Grouper

SECTION I: Introduction

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

Introduction

SEDAR 72 addressed the stock assessment for Gulf of Mexico gag grouper. The assessment process consisted of a series of webinars. Data and Assessment webinars were held between February and July 2021.

The Stock Assessment Report is organized into 2 sections. Section I – Introduction contains a brief description of the SEDAR Process, Assessment and Management Histories for the species of interest, and the management specifications requested by the Cooperator. Section II is the Assessment Process report. This section details the assessment model, as well as documents any data recommendations that arise for new data sets presented during this assessment process, or changes to data sets used previously.

The final Stock Assessment Report (SAR) for Gulf of Mexico gag grouper was disseminated to the public in September 2021. The Council's Scientific and Statistical Committee (SSC) will review the SAR for its stock. The SSCs are tasked with recommending whether the assessments represent Best Available Science, whether the results presented in the SARs are useful for providing management advice and developing fishing level recommendations for the Council. An SSC may request additional analyses be conducted or may use the information provided in the SAR as the basis for their Fishing Level Recommendations (e.g., Overfishing Limit and Acceptable Biological Catch). The Gulf of Mexico Fishery Management Council's SSC will review the assessment at its September 2021 meeting, followed by the Council receiving that information at its October 2021 meeting. Documentation on SSC recommendations is not part of the SEDAR process and is handled through each Council.

1 SEDAR PROCESS DESCRIPTION

SouthEast Data, Assessment, and Review (**SEDAR**) is a cooperative Fishery Management Council process initiated in 2002 to improve the quality and reliability of fishery stock assessments in the South Atlantic, Gulf of Mexico, and US Caribbean. SEDAR seeks improvements in the scientific quality of stock assessments and the relevance of information available to address fishery management issues. SEDAR emphasizes constituent and stakeholder participation in assessment development, transparency in the assessment process, and a rigorous and independent scientific review of completed stock assessments. SEDAR is managed by the Caribbean, Gulf of Mexico, and South Atlantic Regional Fishery Management Councils in coordination with NOAA Fisheries and the Atlantic and Gulf States Marine Fisheries Commissions. Oversight is provided by a Steering Committee composed of NOAA Fisheries representatives: Southeast Fisheries Science Center Director and the Southeast Regional Administrator; Regional Council representatives: Executive Directors and Chairs of the South Atlantic, Gulf of Mexico, and Caribbean Fishery Management Councils; a representative from the Highly Migratory Species Division of NOAA Fisheries, and Interstate Commission representatives: Executive Directors of the Atlantic States and Gulf States Marine Fisheries Commissions.

SEDAR is normally organized around two workshops and a series of webinars. First is the Data Workshop, during which fisheries, monitoring, and life history data are reviewed and compiled. The second stage is the Assessment Process, which is conducted via a workshop and/or a series of webinars, during which assessment models are developed and population parameters are estimated using the information provided from the Data Workshop. The final step 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 stages 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 Cooperator. 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.

2 MANAGEMENT OVERVIEW

2.1. Reef Fish 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 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	Amendment 5	1994
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 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.	Amendment 16A	1998
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	Amendment 18A	2006

fish vessels to be equipped with VMS.		
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
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.	Amendment 24	2005
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	Amendment 30B	2009

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. 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 adjusts 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
Revised the post-season recreational accountability measure (AM) that reduces the length of the recreational season for all shallow-water grouper in the year following a year in which the annual catch limit (ACL) for gag or red grouper is exceeded. The modified AM reduces the recreational season of only the species for which the ACL was exceeded.	Amendment 38	March 2013
Standardized the minimum stock size threshold for gag as equal to 50% of the biomass at maximum sustainable yield.	Amendment 44	December 2017

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.

July 2013:
Effective July 5, 2013 - Established a 2013 gag recreational fishing season and eliminated the February 1 through March 31 shallow-water grouper closure shoreward of 20 fathoms.

May 2016:
Effective May 25, 2016 - Revised the gag recreational closed season to January 1 to May 31, annually. Increased the recreational minimum size limit in Gulf Federal waters to 24 inches TL.

July 2018:
Effective July 23, 2018 - Increased the commercial minimum size limit for gag to 24 inches TL.

<u>Emergency and Interim Rules</u>

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.

<u>Secretarial Amendments</u>

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.

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].

Management Program Specifications

Table 2.5.1. General Management Information Gulf of Mexico

Species	Gag Grouper
Management Unit	Gulf of Mexico
Management Unit Definition	Gulf of Mexico EEZ
Management Entity	Gulf of Mexico Fishery Management Council
Management Contacts SERO / Council	Peter Hood / Ryan Rindone
Current stock exploitation status	Not overfished, not undergoing overfishing (2015)
Current spawning stock biomass status	As of 2015: 9,688.07 metric tons, gutted weight (SEDAR 33 Update 2016)

Table 2.5.2. Specific Management Criteria

Criteria	Current (2016 SEDAR 33 Update)		Gulf of Mexico - Proposed	
	Definition	Value	Definition	Value
MSST	1-M * B_{MSY}	6,210.1 mt	0.5 * B_{MSY}	SEDAR 72

SSB_{MSY}	SSB_{FMAX}	7,171 mt	SSB_{FMAX}	SEDAR 72
$SSB_{Current}$	SSB_{2015}	9,688.07 mt	SSB_{2019}	SEDAR 72
MFMT	F_{MSY}	0.1964	F_{MSY}	SEDAR 72
MSY	F_{MSY}	0.1964	F_{MSY}	SEDAR 72
FMSY	F_{MAX}	0.1964	F_{MAX}	SEDAR 72
$F_{Current}$	Geom mean of last 3 fishing years	0.0817	Geom mean of last 3 fishing years	SEDAR 72
OY	Equilibrium yield at F_{MSY}	-	Equilibrium yield at F_{MSY}	SEDAR 72
FOY	75% of F_{MSY}	-	75% of F_{MSY}	SEDAR 72
M	-	0.134	-	SEDAR 72

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.

<u>Stock Rebuilding Information</u>

Gulf of Mexico gag is not currently under a rebuilding plan.

<u>Table 2.5.4. Stock projection information</u>

(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	2023
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)	Actual or preliminary landings; else, 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.

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	2.842 mp gw
Next Scheduled Quota Change	2022
Annual or averaged quota?	Annual
If averaged, number of years to average	-
Does the quota include bycatch/discard?	No

2.5. Management and Regulatory Timeline

Table 2.5.1. Pertinent Federal Management Regulations

Harvest Restrictions – Trip Limits

*Trip limits do not apply during closures (if season is closed, then trip limit is zero.)

First Yr In Effect	Effective Date	End Date	Fishery	Bag Limit Per Person/Day	Bag Limit Per Boat/Day	Region Affected	FR Reference	Amendment Number or Rule Type
1990	4/23/90	8/8/05	Rec	5 grouper aggregate	NA	Gulf of Mexico EEZ	55 FR 2078	Reef Fish Amendment 1
2005	3/3/05	6/8/05	Com	NA	10,000 lbs gw; DWG[1] & SWG[2]	Gulf of Mexico EEZ	70 FR 8037	Emergency Rule
2005	8/9/05	1/23/06	Rec	3 grouper aggregate	NA	Gulf of Mexico EEZ	70 FR 42510	Temporary Rule
2005	6/9/05	8/3/05	Com	NA	7,500 lbs gw; DWG[1] & SWG[2]	Gulf of Mexico EEZ	70 FR 33033	Temporary Rule
2005	8/4/05	12/31/05	Com	NA	5,500 lbs gw; SWG[2]	Gulf of Mexico EEZ	70 FR 42279	Temporary Rule
2006	1/1/06	12/31/09	Com	NA	6,000 lbs gw; DWG[1] & SWG[2]	Gulf of Mexico EEZ	70 FR 77057	RF Regulatory Amendment
2006	1/24/06	12/31/08	Rec	5 grouper aggregate	NA	Gulf of Mexico EEZ	71 FR 3018 71 FR 34534	Temporary Rule Regulatory Amendment
2009	1/1/09	5/17/09	Rec	2 gag 5 grouper aggregate	NA	Gulf of Mexico EEZ	73 FR 73193	Temporary Rule
2009	5/18/09	Ongoing	Rec	2 gag 4 grouper aggregate	NA	Gulf of Mexico EEZ	74 FR 17603	Reef Fish Amendment 30B
2010	1/1/10	Ongoing	Com	NA	IFQ	Gulf of Mexico EEZ	74 FR 44732	Reef Fish Amendment 29

[1]DWG: deep-water grouper (misty grouper, snowy grouper, yellowedge grouper, warsaw grouper, and speckled hind)

[2]SWG: shallow-water grouper (black, gag, red, red hind, rock hind, scamp, yellowfin, and yellowmouth)

Harvest Restrictions - Size Limits*

*Size limits do not apply during closures

First Yr In Effect	Effective Date	End Date	Fishery	Size Limit	Length Type	Region Affected	FR Reference	Amendment Number or Rule Type
1990	2/21/90	6/18/00	Both	20"	Minimum TL	Gulf of Mexico EEZ	55 FR 2078	Reef Fish Amendment 1
2000	6/19/00	3/11/12	Com	24"	Minimum TL	Gulf of Mexico EEZ	65 FR 31827	Reef Fish Regulatory Amendment
2000	6/19/00	5/24/16	Rec	22"	Minimum TL	Gulf of Mexico EEZ	65 FR 31827	Reef Fish Regulatory Amendment
2012	3/12/12	7/22/18	Com	22"	Minimum TL	Gulf of Mexico EEZ	77 FR 6988	Reef Fish Amendment 32
2016	5/25/16	ongoing	Rec	24"	Minimum TL	Gulf of Mexico EEZ	81 FR 24038	Reef Fish Framework Action
2018	7/23/18	ongoing	Com	24"	Minimum TL	Gulf of Mexico EEZ	83 FR 29041	Reef Fish Framework Action

Harvest Restrictions – Fishery Closures*

*Area specific regulations are documented under spatial restrictions

First Yr In Effect	Effective Date	End Date	Fishery	Closure Type	First Day Closed	Last Day Closed	Region Affected	FR Reference	Amendment Number or Rule Type	Species Associated with Closure
1990	11/8/90	12/31/90	Com	Quota	8-Nov	31-Dec	Gulf of Mexico EEZ	55 FR 46955	Notice of Closure	SWG
2001	6/19/00	12/31/09	Com	Seasonal	15-Feb	15-Mar	Gulf of Mexico EEZ	65 FR 31827 74 FR 44732	Reef Fish Regulatory Amendment Amendement 29 (IFQ)	Black, Red and Gag
2004	11/15/04	12/31/04	Com	Quota	15-Nov	31-Dec	Gulf of Mexico EEZ	69 FR 65092	Notice of Closure	SWG
2005	10/10/05	12/31/05	Com	Quota	10-Oct	31-Dec	Gulf of Mexico EEZ	70 FR 57802	Temporary Rule	SWG
2005	8/9/05	1/23/06	Rec	Seasonal	1-Nov	31-Dec	Gulf of Mexico EEZ	70 FR 42510	Temporary Rule	Groupers
2007	12/18/06	12/31/08	Rec	Seasonal	15-Feb	15-Mar	Gulf of Mexico EEZ	71 FR 66878	Reef Fish Regulatory Amendment	Black, Red and Gag
2009	1/1/09	5/17/09	Rec	Seasonal	1-Feb	31-Mar	Gulf of Mexico EEZ	73 FR 73192	Temporary Rule	Gag
2010	5/18/09	12/31/10	Rec	Seasonal	1-Feb	31-Mar	Gulf of Mexico EEZ	74 FR 17603	Reef Fish Amendment 30B	SWG
2011	1/1/11	5/31/11	Rec	Temporary	1-Jan	31-May	Gulf of Mexico EEZ	75 FR 74650	Temporary Rule	Gag
2011	6/1/11	3/11/12	Rec	Seasonal	1-Jan 16-Nov	15-Sep 31-Dec	Gulf of Mexico EEZ	76 FR 31874 76 FR 69136	Temporary Rule Temporary Rule Extension	Gag
2012	3/12/12	7/4/13	Rec	Seasonal	1-Jan 1-Nov	30-Jun 31-Dec	Gulf of Mexico EEZ	77 FR 6988	Reef Fish Amendment 32	Gag
2013	7/5/13	5/24/16	Rec	Seasonal	1-Jan 3-Dec	30-Jun 31-Dec	Gulf of Mexico EEZ	78 FR 33259	Reef Fish Framework Action	Gag
2016	5/25/16	Ongoing	Rec	Seasonal	1-Jan	31-May	Gulf of Mexico EEZ	81 FR 24038	Reef Fish Framework Action	Gag

Harvest Restrictions – Spatial Restrictions

Area	First Yr In Effect	Effective Date	End Date	Fishery	First Day Closed	Last Day Closed	Restriction in Area	FR Reference	Amendment Number or Rule Type
Gulf of Mexico Stressed Areas	1984	11/8/84	Ongoing	Both	Year round		Prohibited powerheads for Reef FMP	49 FR 39548	Original Reef Fish FMP
	1984	11/8/84	Ongoing	Both	Year round		Prohibited pots and traps for Reef FMP	49 FR 39548	Original Reef Fish FMP
Alabama Special Management Zones	1994	2/7/94	Ongoing	Both	Year round		Allow only hook-and line gear with three or less hooks per line and spearfishing gear for fish in Reef FMP	59 FR 966	Reef Fish Amendment 5
EEZ, inside 50 fathoms west of Cape San Blas, FL	1990	2/21/90	Ongoing	Both	Year round		Prohibited longline and buoy gear for Reef FMP	55 FR 2078	Reef Fish Amendment 1
EEZ, inside 20 fathoms east of Cape San Blas, FL	1990	2/21/90	4/17/09	Both	Year round		Prohibited longline and buoy gear for Reef FMP	55 FR 2078	Reef Fish Amendment 1
EEZ, inside 50 fathoms east of Cape San Blas, FL	2009	5/18/09	10/15/09	Both	18-May	28-Oct	Prohibited bottom longline for Reef FMP	74 FR 20229	Emergency Rule
EEZ, inside 35 fathoms east of Cape San Blas, FL	2009	10/16/09	5/25/10	Both	Year round		Prohibited bottom longline for Reef FMP	74 FR 53889	Sea Turtle ESA Rule
	2010	5/26/10	Ongoing	Rec	Year round		Prohibited bottom longline for Reef FMP	75 FR 21512	Reef Fish Amendment 31
	2010	5/26/10	Ongoing	Com	1-Jun	31-Aug	Prohibited bottom longline for Reef FMP	75 FR 21512	Reef Fish Amendment 31
Madison-Swanson	2000	6/19/00	6/2/04	Both	Year round		Fishing prohibited except HMS[1]	65 FR 31827	Reef Fish Regulatory Amendment
	2004	6/3/04	Ongoing	Both	1-May	31-Oct	Fishing prohibited except surface trolling	70 FR 24532 74 FR 17603	Reef Fish Amendment 21 Reef Fish Amendment 30B
	2004	6/3/04	Ongoing	Both	1-Nov	30-Apr	Fishing prohibited except HMS[1]	70 FR 24532 74 FR 17603	Reef Fish Amendment 21 Reef Fish Amendment 30B
Steamboat Lumps	2000	6/19/00	6/2/04	Both	Year round		Fishing prohibited except HMS[1]	65 FR 31827	Reef Fish Regulatory Amendment
	2004	6/3/04	Ongoing	Both	1-May	31-Oct	Fishing prohibited except surface trolling	70 FR 24532 74 FR 17603	Reef Fish Amendment 21 Reef Fish Amendment 30B
	2004	6/3/04	Ongoing	Both	1-Nov	30-Apr	Fishing prohibited except HMS[1]	70 FR 24532 74 FR 17603	Reef Fish Amendment 21 Reef Fish Amendment 30B
The Edges	2010	7/24/09	Ongoing	Both	1-Jan	30-Apr	Fishing prohibited	74 FR 30001	Reef Fish Amendment 30B Supplement

20 Fathom Break	2014	7/5/13	Ongoing	Rec	1-Feb	31-Mar	Fishing for SWG prohibited[2]	78 FR 33259	Reef Fish Framework Action
Flower Garden	1992	1/17/92	Ongoing	Both	Year round		Fishing with bottom gears prohibited[3]	56 FR 63634	Sanctuary Designation
Riley's Hump	1994	2/7/94	8/18/02	Both	1-May	30-Jun	Fishing prohibited	59 FR 966	Reef Fish Amendment 5
Tortugas Reserves	2002	8/19/02	Ongoing	Both	Year round		Fishing prohibited	67 FR 47467	Tortugas Amendment
Pulley Ridge	2006	1/23/06	Ongoing	Both	Year round		Fishing with bottom gears prohibited[3]	70 FR 76216	Essential Fish Habitat (EFH) Amendment 3
McGrail Bank	2006	1/23/06	Ongoing	Both	Year round		Fishing with bottom gears prohibited[3]	70 FR 76216	Essential Fish Habitat (EFH) Amendment 3
Stetson Bank	2006	1/23/06	Ongoing	Both	Year round		Fishing with bottom gears prohibited[3]	70 FR 76216	Essential Fish Habitat (EFH) Amendment 3

[1]HMS: highly migratory species (tuna species, marlin, oceanic sharks, sailfishes, and swordfish). HMS regs are commensurate with NMFS Regs.

[2]SWG: shallow-water grouper (black, gag, red, red hind, rock hind, scamp, yellowfin, and yellowmouth)

[3]Bottom gears: Bottom longline, bottom trawl, buoy gear, pot, or trap

<u>Harvest Restrictions – Gears*</u>
*Area specific gear regulations are documented under spatial restrictions

Gear Type	First Yr In Effect	Effective Date	End Date	Gear/Harvesting Restrictions	Region Affected	FR Reference	Amendment Number or Rule Type
Poison	1984	11/8/84	Ongoing	Prohibited for Reef FMP	Gulf of Mexico EEZ	49 FR 39548	Original Reef Fish FMP
Explosives	1984	11/8/84	Ongoing	Prohibited for Reef FMP	Gulf of Mexico EEZ	49 FR 39548	Original Reef Fish FMP
Pots and Traps	1984	11/23/84	2/3/94	Established fish trap permit	Gulf of Mexico EEZ	50 FR 39548	Original Reef Fish FMP
	1984	11/23/84	2/20/90	Set max number of traps fish by a vessel at 200	Gulf of Mexico EEZ	50 FR 39548	Original Reef Fish FMP
	1990	2/21/90	2/3/94	Set max number of traps fish by a vessel at 100	Gulf of Mexico EEZ	55 FR 2078	Reef Fish Amendment 1
	1994	2/4/94	2/7/97	Moratorium on additional commercial trap permits	Gulf of Mexico EEZ	59 FR 966	Reef Fish Amendment 5
	1997	3/25/97	2/6/07	Phase out of fish traps begins	Gulf of Mexico EEZ	62 FR 13983	Reef Fish Amendment 14
	1997	12/30/97	2/6/07	Prohibited harvest of reef fish from traps other than permitted reef fish, stone crab, or spiny lobster traps.	Gulf of Mexico EEZ	62 FR 67714	Reef Fish Amendment 15
	2007	2/7/07	Ongoing	Traps prohibited	Gulf of Mexico EEZ	62 FR 13983	Reef Fish Amendment 14
All	1992	4/8/92	12/31/95	Moratorium on commercial permits for Reef FMP	Gulf of Mexico EEZ	68 FR 11914 59 FR 39301	Reef Fish Amendment 4 Reef Fish Amendment 9
	1994	2/7/94	Ongoing	Finfish must have head and fins intact through landing, can be eviscerated, gilled, and scaled but must otherwise be whole (HMS and bait exceptions)	Gulf of Mexico EEZ	59 FR 39301	Reef Fish Amendment 9
	1996	6/1/96	12/31/05	Moratorium on commercial permits for Gulf reef fish.	Gulf of Mexico EEZ	61 FR 34930 65 FR 41016	Interim Rule Reef Fish Amendment 17
	2006	9/8/06	Ongoing	Use of Gulf reef fish as bait prohibited.[1]	Gulf of Mexico EEZ	71 FR 45428	Reef Fish Amendment 18A
Vertical Line	2008	6/1/08	Ongoing	Requires non-stainless steel circle hooks and dehooking devices	Gulf of Mexico EEZ	74 FR 5117	Reef Fish Amendment 27
	2008	6/1/08	9/3/13	Requires venting tools	Gulf of Mexico EEZ	74 FR 5117 78 FR 46820	Reef Fish Amendment 27 Framework Action
Longline	2009	10/16/09		750 hooks fishing	Gulf of Mexico EEZ		Endangered Species Act and regulatory action

Quota Information – Commercial

First Yr In Effect	Last YR In Effect	Effective Date	End Date	Fishery	Species Affected	Quota	ACL	Units	Dataset	Region Affected	FR Reference	FR Section	Amendment Number or Rule Type
1990	1991	2/21/90	12/31/91	Com	All Groupers Excluding DWG[1] and Goliath	9.2	-	mp ww	Trip Ticket/ ALS	Gulf of Mexico EEZ	55 FR 2078	641.25	Reef Fish Amendment 1
1992	2003	6/22/92	12/31/03	Com	All Groupers Including Scamp Excluding DWG[1] and Goliath	9.8	-	mp ww	Trip Ticket/ ALS	Gulf of Mexico EEZ	57 FR 21752	641.25	Reef Fish Regulatory Amendment
2004	2008	7/15/04	12/31/08	Com	All Groupers Including Scamp Excluding DWG[1], Goliath, and Nassau	8.8	-	mp gw	Trip Ticket/ ALS	Gulf of Mexico EEZ	69 FR 33315	622.42	Secretarial Amendment 1
2009	2009	5/18/09	12/31/09	Com	Gag	1.32	-	mp gw	Trip Ticket/ ALS	Gulf of Mexico EEZ	74 FR 17603	622.42	Reef Fish Amendment 30B
2010	2010	5/18/09	12/31/10	Com	Gag	1.41	-	mp gw	IFQ	Gulf of Mexico EEZ	74 FR 17603	622.42	Reef Fish Amendment 30B
2011	2011	11/2/11	12/31/11	Com	Gag	0.43	0.616	mp gw	IFQ	Gulf of Mexico EEZ	76 FR 67618	622.42	Reef Fish Regulatory Amendment
2012	2012	3/12/12	12/31/12	Com	Gag	0.567	0.788	mp gw	IFQ	Gulf of Mexico EEZ	77 FR 6988	622.49	Reef Fish Amendment 32
2013	2013	3/12/12	12/31/13	Com	Gag	0.708	0.956	mp gw	IFQ	Gulf of Mexico EEZ	77 FR 6988	622.49	Reef Fish Amendment 32
2014	2014	1/7/15	12/31/14	Com	Gag	0.835	1.11	mp gw	IFQ	Gulf of Mexico EEZ	79 FR 72556	622.39	Reef Fish Framework Action
2015	Ongoing	1/7/15	Ongoing	Com	Gag	0.939	1.217	mp gw	IFQ	Gulf of Mexico EEZ	79 FR 72556	622.39	Reef Fish Framework Action
2016	Ongoing	1/7/15	Ongoing	Com	Gag	0.939	1.217	mp gw	IFQ	Gulf of Mexico EEZ	79 FR 72556	622.39	Reef Fish Framework Action
2017	Ongoing	1/7/15	Ongoing	Com	Gag	0.939	1.217	mp gw	IFQ	Gulf of Mexico EEZ	79 FR 72556	622.39	Reef Fish Framework Action
2018	Ongoing	1/7/15	Ongoing	Com	Gag	0.939	1.217	mp gw	IFQ	Gulf of Mexico EEZ	79 FR 72556	622.39	Reef Fish Framework Action

[1]DWG: deep-water grouper (misty grouper, snowy grouper, yellowedge grouper, warsaw grouper)
[2]SWG: shallow-water grouper (black, gag, red, red hind, rock hind, scamp, yellowfin, and yellowmouth)
[3]Other SWG: other shallow-water grouper (black grouper, scamp, yellowmouth grouper, yellowfin grouper)

Quota Information – Recreational

First Yr In Effect	Last YR In Effect	Effective Date	End Date	Fishery	Species Affected	ACT	ACL	Units	Dataset	Region Affected	FR Reference	FR Section	Amendment Number or Rule Type
2009	2009	5/18/09	12/31/09	Rec	Gag	2.06	2.59	mp gw	MRFSS	Gulf of Mexico EEZ	74 FR 17603	622.42	Reef Fish Amendment 30B
2010	2010	5/18/09	12/31/10	Rec	Gag	2.14	2.64	mp gw	MRFSS	Gulf of Mexico EEZ	74 FR 17603	622.42	Reef Fish Amendment 30B
2011	2011	11/2/11	12/31/11	Rec	Gag	0.781	0.964	mp gw	MRFSS	Gulf of Mexico EEZ	76 FR 67618	622.42	Reef Fish Regulatory Amendment
2012	2012	3/12/12	12/31/12	Rec	Gag	1.031	1.232	mp gw	MRFSS	Gulf of Mexico EEZ	77 FR 6988	622.49	Reef Fish Amendment 32
2013	2013	3/12/12	12/31/13	Rec	Gag	1.287	1.495	mp gw	MRFSS	Gulf of Mexico EEZ	77 FR 6988	622.49	Reef Fish Amendment 32
2014	2014	1/7/15	12/31/14	Rec	Gag	1.519	1.72	mp gw	MRFSS	Gulf of Mexico EEZ	79 FR 72556	622.39	Reef Fish Framework Action
2015	2015	1/7/15	Ongoing	Rec	Gag	1.708	1.903	mp gw	MRFSS	Gulf of Mexico EEZ	79 FR 72556	622.39	Reef Fish Framework Action
2016	2016	1/7/15	Ongoing	Rec	Gag	1.708	1.903	mp gw	MRIP-CHTS	Gulf of Mexico EEZ	79 FR 72556	622.39	Reef Fish Framework Action
2017	2017	1/7/15	Ongoing	Rec	Gag	1.708	1.903	mp gw	MRIP-CHTS	Gulf of Mexico EEZ	79 FR 72556	622.39	Reef Fish Framework Action
2018	2018	1/7/15	Ongoing	Rec	Gag	1.708	1.903	mp gw	MRIP-CHTS	Gulf of Mexico EEZ	79 FR 72556	622.39	Reef Fish Framework Action

[1]DWG: deep-water grouper (misty grouper, snowy grouper, yellowedge grouper, warsaw grouper)
[2]SWG: shallow-water grouper (black, gag, red, red hind, rock hind, scamp, yellowfin, and yellowmouth)
[3]Other SWG: other shallow-water grouper (black grouper, scamp, yellowmouth grouper, yellowfin grouper)

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 (GMFMC) Scientific and Statistical Committee (SSC) 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 $SSB_{CURRENT}$/MSST = 0.47. The status of the fishery was estimated to be $F_{CURRENT}$/MFMT = 2.47. Thus the stock was estimated to be overfished and undergoing overfishing.

In 2013, a benchmark assessment was conducted for Gulf of Mexico Gag Grouper (SEDAR 33; SEDAR 2014a). For this assessment, Stock Synthesis (SS; Methot and Wetzel 2013) was first constructed to mimic the previous Gulf of Mexico Gag Grouper assessment (SEDAR 10 Update, 2009) that used the CASAL stock assessment model (Bull et al. 2012). 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 Gulf of Mexico Fishery Management Council Scientific and

Statistical Committee chose a model that assumed steepness was equal to 0.855, spawning stock biomass included only females, and a Fmsy proxy of Fmax (SEDAR 2014b). The ratio of $SSB_{CURRENT}$ and SSB_{FMAX} was above 1 indicating that gag grouper were not overfished. Comparing the current fishing mortality ($F_{CURRENT}$), calculated as the geometric mean of the fishing mortality between 2010 and 2012, to F_{MAX} indicated that the stock was not undergoing overfishing.

In 2016, an update assessment to the 2013 SEDAR 33 Gag Benchmark assessment was conducted, with the terminal year extended to 2015 (SEDAR 2015). Recreational landings for 1963-1980 were re-estimated following suggested SEDAR best practices, and revisions were made to the recreational landings between 1981 and 2015 due mainly to the recent adjustments to the Access Point Angler Intercept Survey. The red tide event in 2005 was reevaluated, and sensitivity runs conducted on the 2014, and 2015 red tide events. F_{MAX} was used as a proxy for F_{MSY}. The current fishing mortality rate was defined as the geometric mean of the fishing mortality rate for the most recent 3 years (2012-2015). $SSB_{CURRENT}$ was defined as the female-only biomass in 2015. MSST was defined as (1-M)* SSB_{FMAX}, where M is the base natural mortality estimate. The assessment concluded that the stock was not overfished as of 2015 and that the stock was not experiencing overfishing (SEDAR 2017).

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4 REGIONAL MAPS

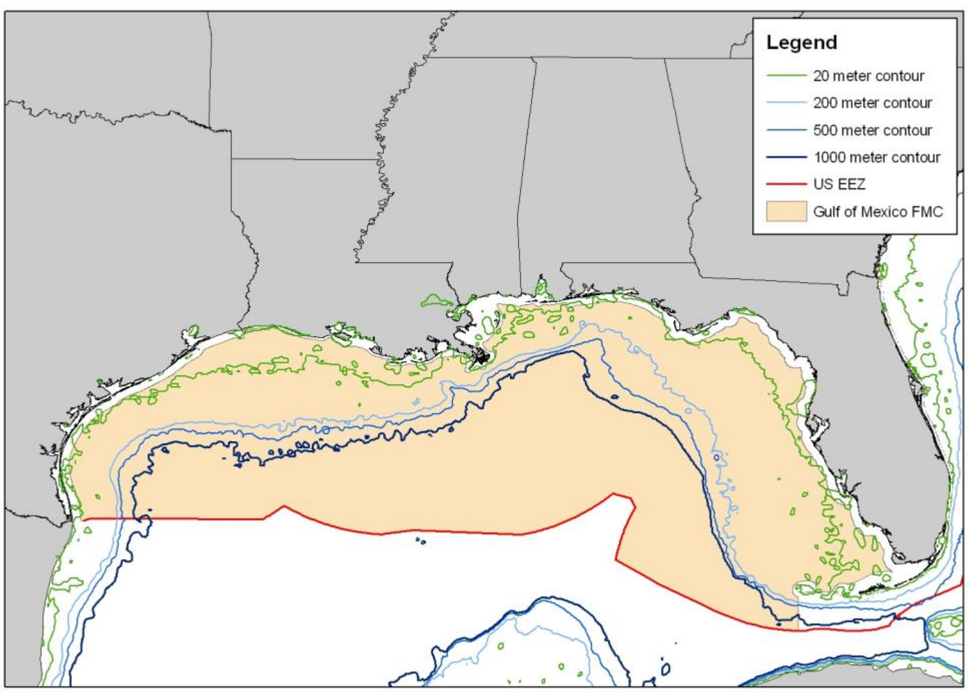

Figure 4.1 Southeast Region including Council and EEZ Boundaries.

5 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
AMRD	Alabama Marine Resources Division
ASMFC	Atlantic States Marine Fisheries Commission
B	stock biomass level
BAM	Beaufort Assessment Model
BMSY	value of B capable of producing MSY on a continuing basis
CFMC	Caribbean Fishery Management Council
CIE	Center for Independent Experts
CPUE	catch per unit of effort
EEZ	exclusive economic zone
F	fishing mortality (instantaneous)
FMSY	fishing mortality to produce MSY under equilibrium conditions
FOY	fishing mortality rate to produce Optimum Yield under equilibrium
FXX% SPR	fishing mortality rate that will result in retaining XX% of the maximum spawning production under equilibrium conditions
FMAX	fishing mortality that maximizes the average weight yield per fish recruited to the fishery
F0	a fishing mortality close to, but slightly less than, Fmax
FL FWCC	Florida Fish and Wildlife Conservation Commission
FWRI	(State of) Florida Fish and Wildlife Research Institute
GA DNR	Georgia Department of Natural Resources
GLM	general linear model
GMFMC	Gulf of Mexico Fishery Management Council
GSMFC	Gulf States Marine Fisheries Commission
GULF FIN	GSMFC Fisheries Information Network
HMS	Highly Migratory Species
LDWF	Louisiana Department of Wildlife and Fisheries
M	natural mortality (instantaneous)
MARMAP	Marine Resources Monitoring, Assessment, and Prediction

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

SEDAR

Southeast Data, Assessment, and Review

SEDAR 72

Gulf of Mexico Gag Grouper

SECTION II: Assessment Process Report

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

August 2021

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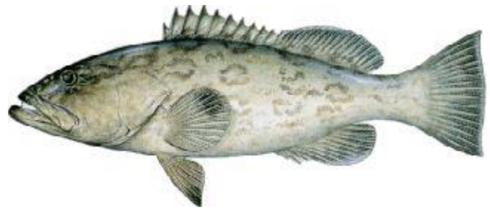
Document History

August 27, 2021 Original release

October 25, 2021 Revisions

- The lead analyst identified an error in the Private + Shore fleet catches and discards input to the GRFS sensitivity run (the black/gag grouper correction factor for 1981-1989 had been mistakenly omitted). This error was corrected and the sensitivity model was re-run and all figures updated (Figure 129). The error only affected the GRFS sensitivity run and the impact on the results were negligible.
- Additional details were added to the GRFS sensitivity run methodology section (Section 3.4.6).
- Mohn's rho values were added to the figure captions of the retrospective analyses (Figures 99-101, 126-128).
- The diagnostic plots for the "SSB combined" sensitivity run were added (Figures 124-128).



SEDAR 72 Gulf of Mexico Gag Grouper Operational Assessment Report

Gulf Branch
Sustainable Fisheries Division
NOAA Fisheries - Southeast Fisheries Science Center

Original Release: August 26, 2021

Updated: 25 October 2021

1. Assessment Process Proceedings

1.1. Introduction

SEDAR72 addressed the stock assessment for Gulf of Mexico Gag Grouper using data inputs through 2019 as implemented in the Stock Synthesis 3 modeling framework (Methot and Wetzel 2013).

1.1.1. Workshop Time and Place

SEDAR 72 Gulf of Mexico gag grouper assessment process consisted of a as a series of webinars. Data and Assessment webinars were held between February 2021 and July 2021.

1.1.2. Terms of Reference

The terms of reference approved by the Gulf of Mexico Fishery Management Council (GMFMC) are listed below.

1. Update the approved 2016 Update of SEDAR 33 Gulf of Mexico gag grouper base model with data through 2019.

2. Document any changes or corrections made to model and input datasets and provide updated input data tables.

    a. Re-evaluate the potential effects of red tide on gag, with consideration of past red tide events through 2018.
    b. Document changes in MRIP data, both pre- and post-recalibration, in terms of the magnitude of changes to catch and effort.
    c. Reconsider the way the retention and selectivity parameters were specified for recreational fleets based on past work with gag grouper.
    d. Consider the SEFSC's improved approach for estimating commercial discards.

3. Update model parameter estimates and their variances, model uncertainties, estimates of stock status and management benchmarks, and provide the probability of overfishing occurring at specified future harvest and exploitation levels. Provide commercial and recreational landings and discards in pounds and numbers.

    a. Examine spawning stock biomass with respect to females only, and males and females combined, as the data allow.
    b. Use the following status determination criteria (SDC) adopted in Amendment 30B:
        i. MSY proxy = yield at F_{MAX} or $F_{Rebuild}$ (if overfished)
        ii. MSST = 0.5*B_{MAX}
        iii. MFMT = F_{MAX} and $F_{Rebuild}$ (if overfished)
        iv. If different SDC are recommended, provide outputs for both the current and recommended SDC.

c. Unless otherwise recommended, use the geometric mean of the previous three years' fishing mortality to determine $F_{Current}$. If an alternative approach is recommended, provide justification and outputs for the current and alternative approach.
d. Provide yield streams for the overfishing limit and acceptable biological catch in pounds:
    i. Annually for five years
    ii. Under a "constant catch" scenario for both three and five years
    iii. For the equilibrium yield at F_{MSY}, when estimable

4. Develop a stock assessment report to address these TORS and fully document the input data and results of the stock assessment and the comparison model.

1.1.3. List of Participants

Panelists
Lisa Ailloud (Lead analyst) .... NMFS Miami
Robert Allman........ NMFS Panama City
Luiz Barbieri .... FWC
Beverly Barnett .... NMFS Panama City
Ken Brennan .... NMFS Beaufort
Matt Campbell .... NMFS Pascagoula
Dave Chagaris........ UFL/SSC
Jim Eliason........ Tech Comm
Kelly Fitzpatrick .... NMFS Beaufort
Francesca Forrestal .... NMFS Miami
Chris Gardner........ NMFS Panama City
Bob Gill........ SSC
Dominique Lazarre .... FWC, St. Pete
Susan Lowerre-Barbieri .... FWC
Vivian Matter .... NMFS Miami
Kevin McCarthy........ NMFS Miami
Jay Mullins........ Tech Committee
Jim Nance........ SSC
Refik Orhun .... NMFS Miami
Kate Overly .... NMFS Panama City
Adam Pollack........ NMFS Pascagoula
Skyler Sagarese........ NMFS, Miami
Beverly Sauls .... FWC
Eric Schmidt........ Data AP
Katie Siegfried .... NMFS Beaufort
Chris Stallings........ USF
Molly Stevens .... NMFS Miami

Ed Walker .... Reef Fish AP

Attendees

Sarina Atkinson.. UM-CIMAS, Miami
Oscar Ayala... FWC
Rob Cheshire... NMFS Beaufort
Tiffanie Cross... FWC
LaTreese Denson .... NMFS Miami
Michael Drexler .... Ocean Conservancy
Claudia Friess... FWC
Alisha Gray .... NMFS Panama City
Martha Guyas.. FWC/GMFMC
Ron Hill.. NMFS Panama City
Max Lee .... Mote Marine Lab
Rich Malinowski .... NMFS
Stephanie Martinez-Rivera .... NMFS Miami
Carole Neidig .... Mote Marine Lab
Matt Nuttall.. NMFS Miami
Jeff Pulver .... NMFS SERO
Adyan Rios.. NMFS Miami
Daniel Roberts ....
Matt Smith .... NMFS Miami
Steve Smith .... NMFS Miami
CJ Sweetman... FWC
Ted Switzer .... FWC, St. Petersburg
Kevin Thompson.. FWC, St. Petersburg
Brendan Turley .... NMFS
Julie Vecchio... FWC
Daniel Vilas .... UFL
Carlos Zayas Santiago... UPR

Staff

Julie Neer .... SEDAR
Chip Collier... SAFMC Staff
Emily Muehlstein .... GMFMC Staff
Ryan Rindone.. GMFMC Staff
Carly Somerset.. GMFMC Staff

1.1.4. List of Assessment Process Working Papers and Reference Documents

Document #	Title	Authors	Date Submitted
Documents Prepared for the Assessment Process			
SEDAR72-WP-01	Red tide mortality on gag grouper from 2002-2018 generated by an Ecospace model of the West Florida Shelf	Daniel Vilas. David Chagaris, and Joe Buczkowski	September 4, 2020 Updated: December 17, 2020 Updated: January 29, 2021
SEDAR72-WP-02	General Recreational Survey Data for Gag in the Gulf of Mexico	Vivian M. Matter and Matthew A. Nuttall	December 7, 2020 Updated: April 23, 2021
SEDAR72-WP-03	SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Gag	Matthew D. Campbell, Kevin R. Rademacher, Paul Felts, Brandi Noble, Joseph Salisbury, and John Moser	December 4, 2020
SEDAR72-WP-04	A ratio-based method for calibrating GRFS and MRIP-FCAL estimates of total landings (numbers and pounds of fish), and releases (numbers of fish)	Tiffanie A. Cross, Colin P. Shea, and Beverly Sauls	December 7, 2020 Updated: April 26, 2021 Updated: July 1, 2021
SEDAR72-WP-05	Estimates of Historic Recreational Landings of Gag Grouper in the Gulf of Mexico Using the FHWAR Census Method	Ken Brennan, Beaufort Lab, SEFSC	January 19, 2021
SEDAR72-WP-06	Gag Mycteroperca microlepis Findings from the NMFS Panama City Laboratory Trap & Camera Fishery-Independent Survey – 2005-2019	C.L. Gardner, K.E. Overly, and A.G. Pollack	January 13, 2021
SEDAR72-WP-07	Standardized Catch Rate Indices for Gag Grouper (Mycteroperca microlepis) during 1986-2019 by the U.S. Gulf of Mexico Charterboat and Private Boat Recreational Fishery	Gulf and Caribbean Branch, Sustainable Fisheries Division NOAA Fisheries - Southeast Fisheries Science Center	January 25, 2021

Document #	Title	Authors	Date Submitted
SEDAR72-WP-08	Gag grouper reproduction in the Gulf of Mexico	Susan Lowerre-Barbieri, Hayden Menendez, and Claudia Friess	February 9, 2021
SEDAR72-WP-09	Local ecological knowledge outlining severe red tide events between 2000 – 2019 on the West Florida Shelf	B. Turley, M. Karnauskas, M. McPherson, S. Sagarese, A. Rios, M. Jepson, A. Stoltz and S. Blake	January 29, 2021
SEDAR72-WP-10	Association between hypoxia and red tide between 2003-2019 on the West Florida Shelf	B. Turley, C. Kelble, and M. Karnauskas	January 29, 2021
SEDAR72-WP-11	Indices of abundance for Gag (Mycteroperca microlepis) using combined data from three independent video surveys	Kevin A. Thompson, Theodore S. Switzer, Mary C. Christman, Sean F. Keenan, Christopher Gardner, Katherine E. Overly, Matt Campbell	February 5, 2021 Updated: March 3, 2021
SEDAR72-WP-12	Fishery-independent surveys of juvenile gag grouper in the Gulf of Mexico (1994-2019)	Walter Ingram	February 23, 2021
SEDAR72-WP-13	Size Distribution and Release Condition of Gag Grouper Discards from Recreational Fishery Surveys in the Eastern Gulf of Mexico	Dominique Lazarre, Rachel Germeroth, Beverly Sauls	March 4, 2021
SEDAR72-WP-14	Something's Fishy with Gag Response Summary	Gulf Council Staff	March 2, 2021
SEDAR72-WP-15	Re-Analysis of Gag/Black Grouper Mis-Reporting Correction Factors in the Gulf of Mexico	Steven G. Smith, M. Refik Orhun, Kevin J. McCarthy, Lawrence Beerkircher, Sarina F. Atkinson, Stephanie Martínez-Rivera, Molly H. Stevens	March 9, 2021

Document #	Title	Authors	Date Submitted
SEDAR72-WP-16	CPUE Expansion Estimation for Commercial Discards of Gulf of Mexico Gag	Steven G. Smith, Kevin J. McCarthy, Sarina F. Atkinson, Stephanie Martinez-Rivera	March 12, 2021
SEDAR72-WP-17	Gulf of Mexico Gag Grouper (Mycteroperca microlepis) Commercial and Recreational Length and Age Compositions	Molly H. Stevens	May 10, 2021
Final Stock Assessment Reports			
SEDAR72-SAR	Gulf of Mexico Gag Grouper	SEDAR 72 Panel	September 1, 2021

2. Data Review and Update

A variety of data sources were used in the SEDAR72 Operational Assessment. Where practicable, the SEDAR72 base model used the same data sets as the SEDAR33 Benchmark and SEDAR33 Update models with an updated time series. However, there were a few new or revised datasets provided for consideration in the SEDAR72 stock evaluation. These included the National Marine Fisheries Service's (NMFS) Marine Recreational Information Program (MRIP) Fishing Effort Survey (FES) catch and discard time series, a new black/gag grouper correction factor for commercial landings and discards, improved commercial fishery discard estimates, improved Southeast Region Headboat Survey discard proxy estimates, updated variance about the growth curve given newly available age-length pairs, updated information on maturity and the hermaphroditism transition function based on recent findings, a new combined private/charter index (replacing the individual time series), a new fishery-independent combined video survey (considered in a sensitivity run) and updated information on red tide mortality for Gulf of Mexico Gag Grouper. These new data series were considered because they had not previously been available for the SEDAR 33 Benchmark or Update assessments or represented improved data inputs for use in the assessment. The data utilized in the SEDAR72 base model are summarized below and illustrated in **Figure 1** along with their corresponding temporal scale. Comprehensive descriptions of individual data components are provided within each subsection below.

1. Life history
    a. Meristics
    b. Age and growth
    c. Natural mortality
    d. Maturity
    e. Sex transition
    f. Discard mortality
2. Landings

   a. Commercial Vertical Line + Other: 1963-2019 (metric tons gutted weight)
   b. Commercial Longline: 1979-2019 (metric tons gutted weight)
   c. Recreational Headboat: 1963-2019 (thousands of fish)
   d. Recreational Charter: 1963-2019 (thousands of fish)
   e. Recreational Private + Shore: 1963-2019 (thousands of fish)
3. Discards (thousands of fish)
   a. Commercial Vertical Line + Other: 1993-2019 (thousands of fish)
   b. Commercial Longline: 1993-2019 (thousands of fish)
   c. Recreational Headboat: 1981-2019 (thousands of fish)
   d. Recreational Charter: 1981-2019 (thousands of fish)
   e. Recreational Private + Shore: 1981-2019 (thousands of fish)
4. Age composition of landings (1-year age bins, plus group ages 20 and older)
   a. Commercial Vertical Line + Other: 1991-2019
   b. Commercial Longline: 1991-2019
   c. Recreational Headboat: 1991-2019
   d. Recreational Charter: 1991-2019
   e. Recreational Private + Shore: 1991-2019
5. Length composition of landings (20:158, 2cm Fork Length bins)
   a. Commercial Vertical Line + Other: 1984-2019
   b. Commercial Longline: 1984-2019
   c. Recreational Headboat: 1981-2019
   d. Recreational Charter: 1986-2019
   e. Recreational Private + Shore: 1982-2019
6. Length composition of discards (20:158, 2cm Fork Length bins)
   a. Commercial Vertical Line + Other: 2006-2019 (Reef Fish Observer Program)
   b. Commercial Longline: 2006-2019 (Reef Fish Observer Program)
   c. Recreational Headboat: 2005-2019 (FWRI At-Sea Observer Program)
   d. Recreational Charter: 2009-2019 (FWRI At-Sea Observer Program)
7. Abundance indices
   a. Fishery-independent:
      i. Age-0 Survey: 1994-2019
      ii. SEAMAP Video Survey: 1993-2019
      iii. PC Video Survey: 2006-2019
      iv. Combined (SEAMAP, PC and FWRI video survey) : 1993-2019 (sensitivity run)
   b. Fishery-dependent:
      i. Vertical Line CPUE: 1990-2009
      ii. Longline CPUE: 1990-2009
      iii. Headboat CPUE: 1986-2010
      iv. Charter + Private CPUE: 1986-2019
8. Length composition of surveys (20:158, 2cm Fork Length bins)

a. SEAMAP Video Survey: 1996-2019
b. PC Video Survey: 2009-2019
c. Combined (SEAMAP, PC and FWRI video survey) : 2009-2019 (sensitivity run)

2.1. Stock Structure and Management Unit

Two regions (Atlantic and GOM) are currently used by the South Atlantic Fishery Management Council (SAFMC) and GMFMC for Gag Grouper management. The geographic boundary of these management units extends from approximately the Dry Tortugas through the Florida Keys (U.S. Highway 1) to mainland Florida. The management unit for Gulf of Mexico Gag Grouper 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. Currently, the Council manages Gulf of Mexico Gag Grouper as one unit. No new literature was presented during the SEDAR72 Data Webinar (DW), therefore the stock definition was left unchanged from SEDAR33 Update.

2.2. Life History Parameters

Life history data used in the assessment included length-length and length-weight relationships, age and growth, natural mortality, maturity and hermaphroditic transition rates. Some of the life history data were input to the population model (Stock Synthesis) as fixed values, while other life history parameters were estimated.

2.2.1. Morphometric and Conversion Factors

The length-weight relationship ($W = aFL^b$) for sexes combined was developed at the SEDAR 10 Benchmark DW, and used as a fixed model input (**Table 1**, **Figure 2**). Although not a direct input into the model, the maximum total length to fork length conversion developed at the SEDAR 33 Benchmark DW (**Table 1**) was used to convert the minimum size limits for input into the model retention functions (**see Section 3.1.8**).

2.2.2. Age and Growth

Additional pairs of length and age were made available during the SEDAR72 DW. Though growth was estimated internally to Stock Synthesis using a single von Bertalanffy growth curve for both sexes combined (**Table 2**, **Figure 2**), the newly available data were used to update estimates of variability about the growth curve, modeled as a linear function of age (CV_{Amax} and CV_{Amin} inputs to Stock Synthesis; **Table 2**, **Figure 2**). The new data were also used to revise the estimate of maximum age from 31 (based on a sample of 31,734 fish) to 33 (based on a sample of 53,870 fish).

2.2.3. Natural Mortality

The age-specific vector of natural mortality (*M*) was updated during the SEDAR72 DW (**Table 3**). This updated *M* vector assumes a size-dependent mortality schedule (Lorenzen 2000) in which the instantaneous mortality rate-at-age is inversely proportional to length-at-age and requires: (1) von Bertalanffy growth parameters; (2) the age at full recruitment to the fishery (4 years); and (3) an estimate of peak spawning (March 1st). The growth parameters used for scaling were obtained by taking the von Bertalanffy parameter point estimates from the SEDAR 33 Update model (asymptotic length $L\infty = 132.21$ cm FL; growth coefficient $K = 0.107$ year^{-1}) and back-calculating the theoretical age at size 0, $t_0 = -1.22$ years). The age-specific M vector was then scaled to the Then et al. (2015) point estimate of 0.159 yr^{-1}, which was obtained by recalculating the t_{max} regression using Serranid-only data and a maximum age of 33 years (**Table 3**, **Figure 2**).

2.2.4. Maturity

Gag Grouper are protogynous hermaphrodites (i.e., transition from female to male), and all male or transitioning fish were considered mature in this assessment. A logistic relationship with a logit link function based on fish collected during the period when actively spawning individuals were observed was recommended at the SEDAR72 DW to model maturity as a function of age (see SEDAR72-WP-08). The slope was estimated at 2.513 and the age at 50% maturity predicted around 3.9 years based on 881 samples collected between 1991 and 2019 (**Figure 3**). The first age mature was lowered from 3 (SEDAR 33 Update) to 2 (SEDAR72) based on the maturity data presented (see SEDAR72-WP-08).

2.2.5. Sexual Transition

Hermaphroditism in Stock Synthesis is modeled as the proportion of individuals transitioning at a given age using a scaled cumulative normal distribution based on three parameters. The inflection age represents the age at which 50% of individuals transition to male, and differs from the traditional 50% probability of being male, which was predicted around 11.6 years (SEDAR72-WP-08 Non MS 1991-2019 model fit; **Figure 3**). The SD controls how quickly the asymptote is reached. Lastly, the maximum value represents the asymptotic proportion of transition, and can be less than 1 if females still occur in the plus group (i.e., not 100% transition by the maximum age). The preferred model predicting the probability of being mature was a binomial generalized linear model with a probit link based on a sample size of 3,638 individuals and excluded fish collected in the Madison Swanson protected area. The resulting hermaphroditism transition function parameters for input in Stock Synthesis (hermaphroditism transition rate curve in **Figure 3**) were estimated as follows: inflection age = 13.83, SD in age = 4.51 and asymptote = 1. It was assumed that the sex ratio at birth was 99.9% females and that females first transitioned at age 4 (new option introduced in SS version 3.30.17).

2.2.6. Fecundity

Fecundity was assumed to be equivalent to spawning biomass (i.e., $eggs = aW^b$, where $a = 1$ and $b = 1$) as in SEDAR33 Update. Female-only spawning stock biomass (SSB) was used as the measure of reproductive potential for the Base Model. An alternative run using combined male and female SSB (“SSB combined”) was considered as a sensitivity for calculating benchmarks and reference points. This alternative configuration implies that 1 kg of male biomass is equally important to the likelihood of spawning success as 1 kg of female biomass and is recommended in situations where the potential for decreased fertility is moderate or unknown (Brooks et al. 2008). Recent research estimated ~1% male sex ratio in the fished stock and ~5% in the Madison Swanson Marine Protected Area (Lowerre-Barbieri et al., 2020).

2.3. Fishery-Dependent Data

2.3.1. Commercial Landings

Commercial landings data (1963-2019) used in the assessment are presented in **Table 4** and **Figure 4**. The commercial landings are partitioned into two fleets: Commercial Vertical Line + Other gear, and Commercial Longline. They represent the two main commercial harvesting gears capturing Gulf of Mexico Gag Grouper. Commercial landings were reported in pounds gutted weight and converted to metric tons for input to the assessment model.

The commercial landings time-series used for this operational assessment differed only slightly from what was used during SEDAR33 Update (**Figure 4**). A new set of Gag/Black Grouper correction factors were developed and applied using improved methodologies (see SEDAR72-WP-15). These mis-identification ratios were derived from the Trip Interview Program (TIP) by statistical areas, year, and gear group. The new procedure distinguishes between periods of unclassified groupers 1963-1985, classified groupers 1986-2009, and IFQ beginning in 2010. For the IFQ period it is now assumed that this misreporting is no longer happening (2010-2019).

The majority of commercial landings over time have been from the Commercial Vertical Line + Other fleet (**Figure 4**). The Commercial Vertical Line + Other landings exceed that of the Commercial Longline fleet across the majority of the time series until 2015 when catches were nearly equal. An individual fishing quota (IFQ) system was implemented in 2010. The quota was greatly reduced in 2011 and corresponded with the lowest landings of the time series (**Figure 4**, **Table 4**). Commercial Vertical Line + Other landings declined sharply between 2001 and 2011 and have remained low even though the quota has increased. Commercial Longline landings peaked in 2003, which was followed by a decline until 2011 (**Figure 4**). Commercial Longline landings have increased since 2011. Annual total landings have remained below the commercial quota. Uncertainty estimates were not provided for commercial landings from the Gulf of Mexico. A CV of 0.05 was assigned to landings pre-IFQ, and a tighter CV of 0.01 to landings post-IFQ.

Starting the assessment model in 1963, when the stock is already in a fished state, requires the estimation of initial conditions via initial equilibrium catches which are used to calculate initial fishing mortality rates. Initial equilibrium catches were calculated for the Commercial Vertical Line + Other fleet as the average landings over the first five years of the assessment time series.

2.3.2. Recreational Landings

Recreational landings data (1963-2019) used in the assessment are presented in **Table 5** and **Figure 4**. For the data period (1981-2019), final recreational landings were computed using fully calibrated estimates from the MRIP using FES, the Southeast Region Headboat Survey (SRHS), Louisiana Creel, and the Texas Parks and Wildlife Department (TPWD) data (see SEDAR72-WP-02). Recreational landings are reported by mode and include Charter, Headboat, Private, and Shore modes. For the assessment, recreational landings from the private and shore modes were aggregated, as was done in SEDAR33 Update. Private landings represented the dominant mode in the total recreational landings by numbers since 1981. Recreational landings were reported in numbers of fish and input into the assessment model as 1000s of fish.

The fully calibrated estimates differed from the time series of recreational landings used in SEDAR33 Update, particularly for the private mode where annual differences ranged from 8% to 346% (average 152%). Differences in the Charter mode were less, ranging from -32% to 365% (average 31%). Differences in the MRIP period for Headboat (1981-1985) ranged from -33% to 425% (average 12%).

The fully calibrated time series originally submitted for the Private mode exhibited a very strong peak in 1983 (3,968,602 fish). This peak was discussed during the SEDAR72 DW. Given that: 1. it was beyond the range of the rest of the data series, 2. it was largely driven by a single intercept survey of 1 angler trip with four contributors to group catch that harvested 36 Black Grouper (SEDAR72-WP-02), and 3. it had a major influence on the historical time series (which uses the average CPUE from 1981-1985 as a scalar, see SEDAR72-WP-05), the decision was made to replace the 1983 peak landings for private mode with the geometric mean of 1981, 1982, 1984, and 1985 private mode landings. This resulted in a 78% decrease in the point estimate of landings for that year and mode (down to 870,324 fish).

Historical estimates (1963-1980) for recreational landings were estimated using the National Survey of Fishing, Hunting, & Wildlife-Associated Recreation (FHWAR) method (SEDAR72-WP-05). The FHWAR method utilizes a combination of information including U.S. angler population estimates and angling effort estimates from 1955 – 1985 to estimate effort (saltwater days) for the GOM for every five years when the survey is conducted. For the years in between, a linear interpolation of the estimates is applied. Estimates of effort for 1963-1980 are then multiplied by the mean CPUE for Gulf of Mexico Gag Grouper for 1981 to 1985 (MRIP, SRHS and TPWD combined) to estimate annual landings for the historical time period (1963-1980). For SEDAR33 and SEDAR33 Update, total historical recreational catches were apportioned by mode using the ratios 20%Charter/5%Headboat/75%Private. These ratios were based on the average proportion of landings by fleet over the period 1981-2012. These ratios were re-calculated over the period 1981-2019 during SEDAR72 to reflect the changes brought about by the new fully calibrated time series of MRIP landings. The new ratios were 10.5% Charter, 2% Headboat, and 87.5% Private.

Uncertainty estimates were provided for the Recreational Charter and Recreational Private + Shore landings for 1981-2019 and for the Recreational Headboat mode for 1981-1985 (SEDAR72-WP-02). However, attempts to input these CVs directly in Stock Synthesis were unsuccessful, likely due to the wide range of CVs (0.08-0.82). Ultimately, a CV of 0.2 was chosen by the Panel and applied to recreational landings across the entire time series. This is a departure from SEDAR33 Update where CVs were fixed at 0.01, but believed by the SEDAR72 Panel to be a better reflection of uncertainty about catch estimates and allow for better overall fits to the model (**see Section 4.8.6.**).

Starting the assessment model in 1963, when the stock is already in a fished state, requires the estimation of initial conditions via initial equilibrium catches, which are used to calculate initial fishing mortality rates. Initial equilibrium catches were calculated for the Recreational Private + Shore fleet as the average landings over the first five years of the assessment time series. Initial runs attempted estimating initial fishing mortality rates for the Recreational Headboat and Recreational Charter fleets but the estimates bounded at 0 and were highly correlated with one another. As such the decision was made to only calculate initial fishing mortality rates for the

Recreational Private + Shore fleet and fix the initial F of the Recreational Headboat and Recreational Charter fleets at 0, as was done in SEDAR33 Update.

2.3.3. Commercial Discards

Commercial discards (1993-2019) used in SEDAR72 are presented in **Table 6** and **Figure 5**. The commercial discards for Gulf of Mexico Gag Grouper were estimated using methods revised since the SEDAR 33 Update. The improved methodology made use of CPUE from the coastal reef fish observer program and total fishing effort from the commercial reef logbook program to estimate total catch. A full description of the commercial Gulf of Mexico Gag Grouper discards and CPUE-expansion estimation procedures is given in SEDAR72-WP-16. The same methodology has been recently applied to other SEDAR assessments including for GOM Red Grouper, Gray Triggerfish, Vermilion Snapper, Scamp and Greater Amberjack.

The discard estimates reported in numbers were input into the assessment as 1,000s of fish with corresponding log-scale standard errors (SE, **Table 6**). A discard mortality rate of 25%, as recommended by the SEDAR 33 DW, was applied to the commercial discards.

2.3.4. Recreational Discards

Recreational discards from the Recreational Headboat, Recreational Charter and Recreational Private + Shore fleets (1981-2019) used in the assessment are presented in **Table 7** and **Figure 5**. Final recreational discards were computed using fully calibrated estimates from MRIP using FES (SEDAR72-WP-02) for Recreational Charter (1981-2019), Recreational Private + Shore (1981-2019) and Recreational Headboat (1981-1985). SRHS discard estimates were provided for 2008-2019. For the intermediate years where neither MRIP nor SRHS estimates were available (1986-2007), the SEDAR Best Practices method was used (Mean SRHS:MRIP Charter discard ratio (2008-2019), and LA proxy for TX).

Recreational discards were reported as numbers of fish and input into the assessment as 1000s of fish with corresponding log-scale standard errors (SE, **Table 7**). For the Recreational Headboat fleet, SEs were only available for 1981-1985 through MRIP. A CV of 0.2 was used for the remainder of the time series. A discard mortality rate of 12%, as recommended by the SEDAR33 DW, was applied to all recreational fleets.

2.3.5. Commercial Size Composition

Commercial Vertical Line length compositions of landed (retained) (1984-2019) and discarded (2006-2019) fish are presented in **Figure 6** and **Figure 7**, respectively. Likewise, Commercial Longline length compositions of landed (retained) (1984-2019) and discarded (2006-2019) fish are presented in **Figure 8** and **Figure 9**.

The annual length compositions were combined into 2-cm fork length interval bins (20:158). Length compositions of landings were constructed using the same data sources approved in SEDAR33 (the commercial trip intercept program (TIP) and GulfFIN) but were processed using revised practices for calculating final compositions. Length samples were weighted by the commercial landings at the finest spatial and temporal scale available. A description of the revised methods used to develop the length composition data was provided in SEDAR72-WP-17. The input sample size associated with each year/fleet was calculated by multiplying the number of trips sampled with the percentage of landings represented in the length composition for that fleet/year. Year/fleet combinations with less than 10 trips sampled were removed from the assessment model.

Data from the Reef Fish Observer Program (RFOP) were used to characterize the length compositions from commercial discards. Similar to what was observed in the SEDAR33 Update, the annual discard length composition data show that some Gulf of Mexico Gag Grouper above the size limit were discarded by the Vertical Line and Longline fleets (see SEDAR72-WP-16). The pattern in the size of discards was fairly consistent for the Commercial Vertical Line fleet, with a greater frequency in discards above the size limit in 2011-2013, after the implementation of the IFQ program. The discard length composition data from the Longline fleet suggested that since the implementation of the IFQ program a large majority of discarded fish were above the size limit (see SEDAR72-WP-16).

For the pre-IFQ period 2007-2009, the disposition (kept or discarded) of Gulf of Mexico Gag Grouper corresponded with the minimum size limit (SEDAR72-WP-16). For the IFQ period, 2010-2019, discards included fish below and above the minimum size limit (SEDAR72-WP-16). This was particularly apparent in the commercial Longline length compositions where the majority of discarded fish fell above the size limit. In both fleets, legal-sized fish were discarded on some of the same trips that kept legal-sized fish (SEDAR72-WP-16). The input sample size associated with each year/fleet was the number of trips sampled. Given the few samples available to characterize the size of discarded fish, no minimum sample size threshold was applied.

2.3.6. Recreational Size Composition

Recreational Headboat length compositions of landed (1981-2019) and discarded (2005-2019) fish are presented in **Figure 10** and **Figure 11**, respectively. Recreational Charter length compositions of landed fish (1986-2019) and discarded (2009-2019) fish are presented in **Figure 12** and **Figure 13**, respectively. Recreational Private length compositions of landed fish (1982-2019) are presented in **Figure 14**.

The annual length compositions were combined into 2-cm fork length interval bins (20:158). Length compositions of landings were constructed using the same data sources approved in SEDAR 33 (MFRSS/MRIP, SRHS, TPWD, the GulfFIN database, and the TIP database) but were processed using revised practices for calculating final compositions. Length samples were weighted by the recreational landings at the finest spatial and temporal scale available. A description of the revised methods used to develop the length composition data was provided in SEDAR72-WP-17. The input sample size associated with each year/fleet was calculated by multiplying the number of trips sampled with the percentage of landings that represented in the length composition for that fleet/year. Year/fleet combinations with less than 10 trips sampled were removed from the assessment model.

Data from the Florida Fish and Wildlife Commission (FWC) Fish and Wildlife Research Institute (FWRI) At-Sea Observer Program (2006-2019) were used to characterize the length compositions from recreational discards (SEDAR72-WP-13). The annual length compositions were combined into 2-cm fork length interval bins (20:158). These compositions were constructed using the same data sources approved in SEDAR33 but were processed using revised practices for calculating final compositions. Recreational Headboat discard length compositions were weighted by trip length and region to correct for the fact that Headboat trips were not sampled proportional to fishing effort (SEDAR72-WP-13). Nominal length compositions were used for Recreational Charter. A description of the revised methods used to develop the length composition data was provided in SEDAR72-WP-13. The input sample size associated with each year/fleet was the number of trips sampled. Given the few samples available to characterize the size of discarded fish, no minimum sample size threshold was applied.

The Recreational Headboat discard length composition data shows that prior to 2011, the majority of discards were below the size limit. An increasing frequency of discards above the size limit can be observed after 2011, which corresponds to years with a shortened Gulf of Mexico Gag Grouper recreational fishing season. The time-series of Recreational Charter discard length composition is shorter than that of Headboat and corresponds mainly to years with a shortened fishing season, 2011-2019. The length composition of discards in the Recreational Charter fleet for those years include fish above the size limit. There were no data available to characterize the discard length composition of the Recreational Private + Shore fleet.

2.3.7. Commercial Age Composition

Commercial age compositions of landed fish used in the assessment are presented in **Figure 15** and **Figure 16**. The commercial age compositions were input as nominal ages with sample sizes specified as number of trips (SEDAR72-WP-17).

The apparent cohorts in the commercial vertical line data include 1989, 1993, 1996, 2006, 2007 and 2010 (**Figure 17**). The 1996 and 2006 cohorts are visible in the Commercial Longline age composition data (**Figure 18**). The main age classes captured were 3-7 year olds and 4-8 year olds for the Vertical Line and Longline fleets, respectively.

2.3.8. Recreational Age Composition

Recreational age compositions of landed fish used in the assessment are presented in **Figures 19-21**. The recreational age compositions were input as nominal ages with sample sizes specified as number of trips (SEDAR72-WP-17).

The apparent cohorts in the Recreational Headboat and Recreational Charter data include 1989, 1993, 1996, 2006, 2007 and 2010 (**Figures 22-23**). No obvious cohorts were apparent in the private mode data (**Figure 24**). The main age classes captured by the Recreational Headboat and Recreational Charter fleets were 2-6 year olds. The main age classes captured by the Recreational Private + Shore were 2-4 year olds.

2.3.9. Commercial Catch Per Unit of Effort Indices of Abundance

The standardized CPUE indices for the Commercial Vertical Line and Longline fleets used in the assessment are summarized in **Table 8** and **Figures 25 and 26**, respectively. Those indices were unchanged from the SEDAR33 Update and only cover the pre-IFQ period (1990-2009). Annual CVs associated with each of the standardized indices were converted to log-scale SEs for input into SS (**Table 9**) and an additional SE was estimated for each index as part of the data weighting process (see **Section 3.2**).

2.3.10. Recreational Catch Per Unit of Effort Indices of Abundance

The standardized CPUE indices for the Recreational fleets used in the assessment are summarized in **Table 8**. Two recreational indices were used in the SEDAR72 assessment model: the Southeast Region Headboat Survey (SRHS) Index (**Figure 27**) and the MRIP Charter+Private index (**Figure 28**). The MRIP Charter+Private index tracks total catches of Gag Grouper (landed plus discards), whereas the Headboat index tracks only landed fish. As in the SEDAR33 Update, the Headboat index was thus truncated in 2010 due to the inability to account for the reduced recreational fishing season. In SEDAR33 Update, separate indices were used for Charter and Private modes and the guild approach had been used to select trips with higher probability of encountering Gag Grouper. However, during SEDAR72, the indices were redeveloped using the Stephens and MacCall (2004) approach for subsetting, which was considered an improvement over the guild approach, and a combined index was developed in addition to the two mode-specific indices. Given the similarities between the fleets operations and given that the indices showed similar trends, the SEDAR72 Assessment Panel recommended to replace the separate indices with the combined Chaterboat + Private index to avoid redundancy. The decision to favor a single, more representative index was also made on the basis that the combined index had superior diagnostics than the separate indices. Details pertaining to the development of this index are specified in SEDAR72-WP-07. Annual CVs were converted to log-scale SEs for input into SS (**Table 9**) and an additional SE was estimated for each index as part of the data weighting process (see **Section 3.2**).

2.4. Fishery-Independent Surveys

2.4.1. Age-0 Survey

An age-0 Gag Grouper index was developed for the Gulf of Mexico using three available databases, the Florida State University Estuarine Gag Survey, the NMFS PC Lab St. Andrew Bay Survey, and the State of Florida FWC Estuarine (FIM) Survey (**Table 8, Figure 29**). The combined index was weighted by the aerial coverage of seagrass in each sampling region. See SEDAR72-WP-12 for a full description of the methods used to develop this index.

Overall, the index remained relatively unchanged with the inclusion of additional years of data, although a few years (1996, 2008, and 2009) did show some change compared with SEDAR33 Update. Annual CVs were converted to log-scale SEs for input in Stock Synthesis (**Table 9**) and an additional SE was estimated as part of the data weighting process (**see Section 3.2**).

2.4.2. NMFS SEAMAP Video Survey

The primary objective of the NMFS SEAMAP reef fish video survey is to provide an index of the relative abundance of fish species associated with natural topographic features (e.g. reefs, banks, and ledges) located on the continental shelf of the 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 survey index for Gag Grouper is restricted to the Eastern GOM and covers the following years: 1993-1997, 2002, and 2004-2019. See SEDAR72-WP-03 for a full description of the methods used to develop this index.

This index was updated through 2019 (**Table 8, Figure 30**). With the updated data, a negative binomial model fit the data best (SEDAR72-WP-03) and the resulting index was used for input in the assessment. This represents a departure from SEDAR33 Update where a delta-lognormal model was selected. One notable difference between the SEDAR33 Update and SEDAR72 index is the relatively lower index values associated with the early part of the time series compared to the remainder of the time series. Annual CVs were converted to log-scale SEs for input into SS (**Table 9**) and an additional SE was estimated as part of the data weighting process (see **Section 3.2**).

Length composition for the survey comprised a total of 148 individuals measured in 1996, 2002, 2004-2019. Length compositions were input as nominal lengths with sample sizes specified as the number of camera drops from which successful measurements were obtained (**Figure 31**).

2.4.3. Panama City Video Survey

The PC Video survey targets the inner shelf of the northeast GOM, both East and West of Cape San Blas. The index of abundance was standardized using a delta-lognormal model (**Table 8, Figure 32**). There were no major changes to this index with the updated data; however, the year 2005, which was included in SEDAR33 Update, was dropped from the index for SEDAR72 because video sampling was only completed in Apalachee Bay (East of Cape San Blas) in that year. Annual CVs were converted to log-scale SEs for input into SS (**Table 9**) and an additional SE was estimated as part of the data weighting process (see **Section 3.2**).

Length composition for the survey comprised a total of 122 individuals measured in 2009-2012, 2014-2015, and 2017-2019. Length compositions were input as nominal lengths with sample sizes specified as the number of camera drops from which successful measurements were obtained (**Figure 33**).

2.5. Environmental Considerations & Contributions from Stakeholders

2.5.1. Something's Fishy Questionnaire

A "Something's Fishy with Gag" questionnaire was released in advanced of the SEDAR72 assessment. The web-based questionnaire allows stakeholders to share anecdotal trends about a particular fishery with the GMFMC. Results from this questionnaire were reported in SEDAR72-WP-14. Of the 418 individual comments manually analyzed, 365 directly addressed stock condition. Of those, 158 noted a positive perception of the stock, while the remainder were either negative (n=132) or neutral (n=75) in their perception of the gag stock health. The majority of responses came from the private angling component of the recreational sector, and from the west central coast of Florida. Generally, fishers claimed to be observing more juveniles than in previous years; however, fishers also noted an increase in observed fishing pressure and depredation by other marine predators.

2.5.2. Local ecological knowledge

During a series of summer 2018 workshops led by the Southeast Fisheries Science Center with stakeholders on the southwest Florida coast, serious concerns were highlighted regarding the multifaceted impacts of red tide (also referred to as harmful algal blooms or HABs). In addition to the obvious fish kills and water quality issues, stakeholders have observed extensive habitat damage related to red tide and have noted that recovery of fish populations has been increasingly delayed following recent and frequent red tides. SEDAR72-WP-09 details relevant information that was extracted from each of the oral histories and quantifies red tide events to compare the recent 2017-2018 event to previous events in terms of severity, recovery time, temporal extent and species killed. Across interviews, three exceptional red tide events were consistently identified by fishermen in the past 20 years: 2005, 2014, and 2018. All three red tide events were therefore modeled in the SEDAR72 assessment model (see **Section 3.1.6**). Additional anecdotal evidence of changes in catchability were described and warrant further investigation in a future research track assessment (see **Section 7**).

2.5.3. Association between hypoxia and red tide

SEDAR72-WP-10 used a variety of data sources to examine the occurrence of hypoxia from 2003 to 2019. The objective of this WP was to better understand the spatiotemporal expression hypoxia on the west Florida shelf, particularly near the Big Bend region of Florida, to inform SEDAR72. Between 2003 and 2019, hypoxia was present 9 out the 17 years examined (2005, 2008-11, 2014-16, 2019). The spatial distribution of all the hypoxia events extended the whole range of the west Florida shelf shoreward of the 50-meter bathymetry line. As such, these hypoxia events are likely to have impacted Gulf of Mexico Gag Grouper.

2.5.4. Red tide mortality generated by an Ecospace model of the West Florida Shelf

SEDAR72-WP-01 estimated age-specific time series of natural mortality rates caused by red tide events for Gag Grouper from 2002-2018 using an Ecospace model of the West Florida Shelf (WFS). Ecospace is the the spatially explicit simulation module of the Ecopath with Ecosim software package. The WFS Ecospace model includes 17 fishing fleets and 83 functional groups which represent individual species, life stages, or groups of functionally similar species, and encompasses an area ranging from 30.5 to 25 degrees latitude and from - 87.5 to -81 degrees longitude. This spatially explicit approach uses synoptic satellite imagery to define the spatial extent of blooms, in situ K. brevis cell concentrations (cells/liter) to approximate the severity, a spatially explicit ecosystem model to provide the spatial distribution patterns of Gag Grouper, and defines Red tide response functions to generate direct mortality and sub-lethal effects (i.e. reduced feeding & growth, and movement) of red tides in each map cell. A total of 160 Ecospace scenarios representing different sensitivities and combinations of response functions were run. Goodness of fit was evaluated for each run to retain only valid runs, and a validation process was carried out to investigated how well model spatial predictions match empirical observations. In all, 133 out of 160 runs were selected and included in the mean index calculation. The mean red tide mortality rate fluctuated over time with the highest values in 2005 followed by 2006, 2018, 2012, and 2015-2016. Mortality rates were generally higher for younger age stanzas, except for 2005 when the bloom persisted far offshore. In years where the bloom remained close to shore (2006, 2012, 2016, and 2018) age-0 gag was more strongly impacted. Gag 5+ was predicted to have the lowest mean red tide mortality rate over time and the model only estimated a noticeable red tide mortality rate peak in 2005. This information was used as a basis for developing two SEDAR72 sensitivity runs (see **Section 4.8.6.**).

2.6. Additional datasets considered in sensitivity runs

2.6.1. GRFS landings and discards estimates

In response to a region-wide need for more precise and timely estimates of recreational catch, Florida's Gulf Reef Fish Survey (GRFS) was developed in collaboration with NOAA Fisheries alongside similar efforts in other states (Detailed methodology of the GRFS is described in Sauls et al. 2019). The GRFS was implemented in May 2015. The GRFS runs concurrent with the MRIP survey in Florida and produces estimates that are consistently lower (SEDAR72-WP-04). During SEDAR72, a ratio-based method for calibrating GRFS and MRIP-FCAL estimates from the private mode of total landings (numbers and pounds of fish), and releases (numbers of fish) was presented (SEDAR72-WP-04). The intent of this dataset was that it be considered in a sensitivity run (**Figure 34**) as described in the TORs.

2.6.2. Combined Video Survey Index

A new combined video survey index was presented at the SEDAR72 DW (SEDAR72-WP-11). This index combines the two video surveys described above (SEAMAP, PC) as well as a more recent survey carried out by the FWRI (starting year 2008; **Figure 35**). While the three surveys use standardized deployment, camera field of view, and fish abundance methods to assess fish abundances on reef or structured habitat, there are variations in survey design and habitat characteristics collected in addition to the time period and area sampled. Updates to the two video survey indices (SEAMAP and PC) considered in SEDAR 33 Update were available and used in the SEDAR72 base model run. This new combined index was presented for review as well (SEDAR72-WP-11) and the methodology has successfully been used for other reef stocks (e.g. GOM Vermillion Snapper, GOM Greater Amberjack). Although the Panel believed that using a combined index would be preferable over using separate indices, two concerns ultimately let to the SEDAR72 Assessment Panel recommending its use in a sensitivity run rather than for the Base run (See **Section 3.4.6.** and **Section 7**). The first concern was that, for Gag Grouper, the proportion present varied substantially between surveys (SEAMAP 7.3%, PC 20.8%, FWRI 3.2%). The second was that selectivity varied substantially across surveys due to the ontogenetic migration patters of Gag Grouper. The Panel believed that more work was needed to better account for both these aspects in the standardization process before the index could be considered for the Base run.

Length compositions for the combined index comprised samples from all three surveys and were weighted using area weighting values from the index development process (**Figures 36 and 37**; see SEDAR72-WP-11 for a full description of the methods). In addition to the length samples available through the SEAMAP Video Survey and PC Video Survey, 38 length samples from the FWRI Video Survey were available from 2010-2019 (excluding 2013).

3. Stock Assessment Model Configuration and Methods

3.1. Stock Synthesis Model Configuration

The assessment model used was Stock Synthesis (SS), version 3.30.17. Descriptions of SS algorithms and options are available in the SS User's Manual (Methot et al. 2020), the NOAA Fisheries Toolbox website (*http://nft.nefsc.noaa.gov/*), and Methot and Wetzel (2013). Stock

Synthesis (SS) is a widely used integrated statistical catch-at-age model (SCAA) that has been tested for stock assessments in the United States (US), particularly on the West Coast and Southeast, and also throughout the world (see Dichmont et al. 2016 for review). SCAA models consist of three closely linked modules: the population dynamics module, an observation module, and a likelihood function. Input biological parameters (e.g., **Section 2.2**) are used to propagate abundance and biomass forward from initial conditions (population dynamics model) and SS develops predicted data sets based on estimates of fishing mortality, selectivity, and catchability (the observation model). The observed and predicted data are compared (the likelihood module) to determine best-fit parameter estimates using a statistical maximum likelihood framework (detailed in Methot and Wetzel (2013)). Because many inputs are correlated, the concept behind SS is that processes should be modeled together, which helps to ensure that uncertainties in the input data are properly accounted for in the assessment.

The Gulf of Mexico Gag Grouper SS model assumed a similar configuration structure as developed for the previous SEDAR 33 Gulf of Mexico Gag Grouper Benchmark. The fully configured SS model included observations of catch and discards for five fishery fleets (an aggregated Commercial Vertical Line + Other fleet, Commercial Longline, Recreational Headboat, Recreational Charter, and an aggregated Recreational Private + Shore fleet). The model included four fishery dependent CPUE indices of abundance (Vertical Line CPUE, Longline CPUE, Headboat CPUE, and Charter + Private CPUE), and three fishery independent time series (Age-0 Survey, SEAMAP Video Survey, and PC Video Survey). Model estimated parameters include growth parameters, fishing mortality by fleet for each year, red tide mortality, selectivity and retention parameters for each directed fleet, parameters describing the stock-recruit function, stock-recruit deviation parameters, index catchabilities, and Dirichlet multinomial parameters.

The SS modeling framework provides estimates for key derived quantities including: time series of recruitment (units: 1,000s of age-0 recruits), abundance (units: 1,000s of fish), biomass (units: metric tons), SSB (units: metric tons; must be specified as female-only SSB or combined SSB), and harvest rate (units for Gag Grouper: total biomass killed age 3+ / total biomass age 3+). The r4ss software (Taylor et al. 2021) was utilized extensively to develop various graphics for model outputs and was also used to summarize various output files and perform diagnostic runs.

Projections are implemented within SS starting from the year succeeding the terminal year of the assessment model utilizing the same population dynamics equations and modeling assumptions.

3.1.1. Initial Conditions

The Gulf of Mexico Gag Grouper assessment begins in 1963 and has a terminal year of 2019. Since removals of Gag Grouper are known to have occurred in the Gulf of Mexico prior to 1963 for both commercial and recreational fisheries, the stock was not assumed to be at equilibrium and initial conditions were estimated from initial equilibrium catches (mean landings over the first five years for the Commercial Vertical Line + Other and Recreational Private + Shore fleets, 1963-1967). Preliminary runs attempted to estimate an initial fishing mortality rate for the Recreational Headboat and Recreational Charter fleets, but ultimately these initial fishing mortality rates were not estimated in the SEDAR72 Base Model because they bounded out near zero due to very minimal catches by these two fleets (**Figure 4**).

3.1.2. Temporal Structure

The Gag Grouper population was modeled from age-0 through age-33 (the maximum age), with data bins spanning age-0 through age-20+, with the last age representing a plus group (encompassing only 0.4% of otoliths). Stock Synthesis starts at age-0 (Methot et al. 2020). Data collection and fishing activities were assumed relatively continuous throughout the year; therefore, inclusion of a seasonal component to the removals was not deemed necessary. The fishing season was assumed to be continuous and homogeneously distributed throughout the year.

3.1.3. Spatial Structure

A single area model was implemented where recruits are assumed to homogeneously settle across the entire Gulf of Mexico region.

3.1.4. Life History

A fixed length-weight relationship was used to convert body length (cm Fork Length, FL) to body weight (kg gutted weight; **Table 1, Figure 2**). Stock Synthesis moves fish among age classes and length bins on January 1st of each modeled year starting from birth at age-0. Because the 'true' birth date often does not occur on January 1st, with peak spawning occurring around March 1st for Gag Grouper in the Gulf of Mexico, some slight alterations in growth (t_0, or the age at length 0) and natural mortality parameters are required to account for the difference between true age and modeled age when parameters are input instead of estimated.

Growth within SS was modeled with a three parameter von Bertalanffy equation: (1) L_{Amin} (cm FL), the mean size at age-1 Gag Grouper; (2) L_{Amax} (cm FL), the mean size at maximum aged Gag Grouper; and (3) K (year^{-1}), the growth coefficient. In Stock Synthesis, 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 (fixed at 20 cm FL). Fish then grow linearly until they reach a real age equal to the input value of A_{min} (growth age for L_{Amin}) and have a size equal to L_{Amin}. As they age further, they grow according to the von Bertalanffy growth equation (**Figure 2**). L_{Amax} was specified as equivalent to L_{inf}. Two additional parameters are used to describe the variability in size-at-age and represent the CV in length-at-age at A_{min} (age 1) and A_{max} (age 33). For intermediate ages, a linear interpolation of the CV on mean size-at-age is used.

The von Bertalanffy growth model parameters L_{Amin}, L_{Amax} and K were re-estimated internally to SS using updated length and age compositions. Variance parameters CV_{Amin} (0.107) and CV_{Amax} (0.108) were fixed at the values recommended at the SEDAR72 DW (**Table 2**).

The age-specific vector of M (**Section 2.2.3**) was fixed within the SS model (**Table 3, Figure 2**).

The assessment model was set-up with two sexes to account for the reproductive biology of Gag Grouper. As protogynous hermaphrodites, Gag Grouper are born female (i.e., 99% female at birth), and starting at age-4, a portion of the population transitions to male. The two-sex SS model treated males and females identically, and data were input as combined due to the lack of sex-specific fisheries data. Immature females transitioned to mature females based on a fixed logistic function of age (**Figure 3**). The three required parameters to define the hermaphroditism transition rate (inflection age = 13.83, SD in age = 4.507, and asymptote = 1) were estimated externally to SS (**Section 2.2.5**) and fixed in the assessment model (**Figure 3**). Reproductive potential was defined in terms of females only in the SEDAR72 Base Model run, though management quantities were calculated for both female-only SSB and SSB combined (see **Section 6**).

3.1.5. Recruitment Dynamics

A Beverton-Holt stock-recruit function was used to parameterize the relationship between spawning output and resulting recruitment of age-0 fish. The stock-recruit function (representing the arithmetic mean spawner-recruit levels) requires three parameters: (1) steepness (h) characterizes the initial slope of the ascending limb (i.e., the fraction of virgin recruits produced at 20% of the equilibrium spawning biomass); (2) the virgin recruitment (R_0, estimated in log space) represents the asymptote or virgin recruitment levels; and (3) the variance or recruitment variability term (*sigmaR*) which is the SD of the log of recruitment (it both penalizes deviations from the spawner-recruit curve and defines the offset between the arithmetic mean spawner-recruit curve and the expected geometric mean from which the deviations are calculated). Similar to SEDAR33 and the SEDAR33 Update, h and *sigmaR* were fixed at 0.855 and 0.6, respectively, in the SEDAR72 Base Model, while virgin recruitment (lnR_0) was freely estimated.

Annual deviations from the stock-recruit function were estimated in SS as a vector of deviations forced to sum to zero and assuming a lognormal error structure. A lognormal bias adjustment factor was applied to recruitment estimates as recommended by Methot et al. (2020), but only to the data-rich years in the assessment. This was done so that 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 et al. 2020). For the SEDAR72 Base Model, main period (i.e. data rich) recruitment deviations spanned 1984-2019, while early period (i.e. data poor) recruitment deviations spanned 1963-1983. Full bias adjustment was used from 1987 to 2017 when length or age composition data are available. Bias adjustment was phased in linearly, from no bias adjustment prior to 1960 to full bias adjustment in 1987. Bias adjustment was phased out in 2017, decreasing from full bias adjustment to no bias adjustment in that year, because the age composition data contains less information on recruitment in more recent years. The years selected for full bias adjustment were estimated following the methods of Methot and Taylor (2011).

Lastly, given that the stock was not assumed to be at unexploited equilibrium level in the beginning year of the assessment (See **Section 3.1.1.**) initial conditions had to be estimated using the stock recruitment regime parameter, SR_{regime}. In the SEDAR 33 Benchmark and Update (which used SS3.24_S) this was handled through implementing an offset parameter (*R1*). In SS 3.30 (used in the SEDAR72 Operational assessment) this was handled through the implementation of the SR regime parameter. The SR_{regime} parameter is estimated internally to SS and implemented by replacing R_0 with $R_0 * exp(SRregime_y)$ and adding a block on SR_{regime} for y = startyr -1.

3.1.6. Fleet Structure and Surveys

Five fishing fleets were modeled and had associated length and age compositions. The SS fleet codes were: Commercial Vertical Line + Other (Com_VL_OTH_1), Commercial Longline (Com_LL_2), Recreational Headboat (Rec_HBT_3), Recreational Charter (Rec_CBT_4) and

Recreational Private + Shore (Rec_PRIV_SH_5). Fleet structure was characterized by the availability of length and age composition data, comparisons of length distributions between gears (commercial) or modes (recreational), and resulting sample sizes. This structure is unchanged from the SEDAR33 Update. Fishing was assumed to be continuous and homogeneous across the entire year.

Four fishery-dependent CPUE indices were included in the SEDAR72 Base Model: pre-IFQ Vertical Line CPUE (CPUE units: biomass kept per hook hour), pre-IFQ Longline CPUE (CPUE units: biomass kept per hook), SRHS (pre-reduced fishing season) Headboat CPUE (CPUE units: number kept per angler hour), and Charter + Private CPUE (CPUE units: number kept or discarded per angler hour). CPUE was treated as an index of biomass or abundance where the observed standardized CPUE time series was assumed to reflect annual variation in population trajectories. The Vertical Line CPUE, Longline CPUE and Headboat CPUE indices were of landings only, and the selectivity of each was assumed identical to the associated fleet. The Charter + Private CPUE was input as a survey into SS (see **Section 2.3.10**) and its selectivity was mirrored to that of the Recreational Charter fleet.

Three fishery-independent surveys were included in the SEDAR72 Base Model: the Age-0 Survey, the SEAMAP Video Survey, and the PC Video Survey. The Age-0 Survey was set up as a special survey of Age-0 recruits (i.e. age based selectivity restricted to, and fully selecting, age 0). The SEAMAP Video Survey and PC Video Survey had length observations available which were fit directly based on estimated length-based selectivity functions.

Red tide mortality was modeled as a bycatch-only fleet (Srv_RT_6). A bycatch fleet creates a fishing mortality but has all catch discarded so the input value for retained catch is ignored. However, an input value for retained catch is needed to indicate which year/season the bycatch fleet was active in. In SEDAR72, the years 2005, 2014 and 2018 were specified as being active red tide years (see **Section 2.5.2.**). No discards were input into the model; SS was left to rely solely on the contrast in other data to attempt to estimate the magnitude of the red tide kill that occurred. Modeling red tide mortality as a fishing fleet allows for the level of mortality to be estimated by the assessment model rather than input as a fixed parameter. It also allows for the additional mortality to be decoupled from the natural mortality so that the magnitude of Gag Grouper killed by red tide can be estimated. “Dead catch” from the red tide mortality was omitted from total catch in the search for MSY.

3.1.7. Selectivity

Selectivity represents the probability of capture by age or length for a given fleet and represents the net result of multiple interrelated factors (e.g., gear type, targeting, and availability of fish due to spatial and temporal constraints). SS allows users to specify length-based selectivity, age-based selectivity, or both. The final selectivity curve governing each fleet/survey reflects the additive effect of both age- and length- based processes.

Selectivity patterns were assumed to be constant over time for each fleet and survey. The Gulf of Mexico Gag Grouper fishery has experienced changes in management regulations over time (**Figure 38**), which were assumed to influence the discard patterns more so than selectivity. As such, these changes were accounted for in the assessment model using time-varying retention patterns (see **Section 3.1.8.**) and modeling discards explicitly (see **Section 3.1.10.**) .

3.1.7.1. Length-based Selectivity

Length-based selectivity patterns were specified for each fleet and survey and were characterized as one of three functional forms: (1) a two-parameter logistic function (SS pattern 1), (2) a six-parameter double normal function (SS pattern 24), and (3) a four-parameter double normal function with plateau (SS pattern 22). A logistic curve implies that fish below a certain size range are not vulnerable, but then gradually increase in vulnerability with increasing size until all fish are fully vulnerable (asymptotic selectivity curve). Two parameters describe logistic selectivity: (1) the length at 50% selectivity, and (2) the difference between the length at 95% selectivity and the length at 50% selectivity, which were both estimated in this assessment. The double normal has the feature that it allows for domed or logistic selectivity and is a combination of two normal distributions; the first describes the ascending limb, while the second describes the descending limb. A line segment joins the maximum selectivity of the two functions. However, the double normal functional form can be more unstable than other selectivity functions due to the increased number of parameters. When robust length or age compositions are available with sufficient numbers of larger or older fish, it may be appropriate to freely estimate all parameters (especially the descending limb). If that is not the case, certain parameters can be fixed to improve model stability as long as fixing the parameter does not largely influence the point estimates of the remaining selectivity parameters. Unless strong evidence exists for domed selectivity, it is generally advisable to use the logistic function. The four-parameter double normal function assumes that fish within a certain size range are equally vulnerable.

In the SEDAR72 Base Model, separate selectivity patterns were defined for each fleet/survey: 1) Commercial Vertical Line + Other (logistic), 2) Commercial Longline (logistic), 3) Recreational Headboat (double normal), 4) Recreational Charter (double normal), 5) Recreational Private + Shore (double normal), 6) SEAMAP Video Survey (logistic), and 7) PC Video Survey (double normal with plateau).

A logistic selectivity pattern was assumed for both commercial fleets (with all parameters freely estimated) because there was little evidence in the age data suggesting availability issues that might make older fish less vulnerable. This was evident in catch curves developed for each fleet, where the lognormally distributed catch-at-age was regressed against age using the equation (Quinn and Deriso 1999):

$$ln(C_a) = [ln(\mu N_f) + fZ)] - Z_a$$

where μ is the probability of catching a fish, N_f is the abundance at the start of age a, and Z is the total mortality at age-a. The estimate of Z is the negative of the slope estimated from the linear regression, and its SE is equal to the SE of the slope. The corresponding estimate of survival-at-age (S_a) is exp(Z). A catch curve typically shows an increasing section of the curve for younger ages, due to increasing availability of fish or selectivity of the gear, followed by a decreasing trend for older ages due to increased mortality stemming from full selectivity by the fishing or survey gear. Steep slopes (e.g., > 1) are generally evidence for dome-shaped selectivity. Catch curves for both commercial fleets showed increases in selection of younger fish, full selection by 5-6 years, and a gradual decline with age characterized by a relatively shallow slope (**Figure 39**). Exploratory runs attempted to fit a dome shape selectivity function to the Commercial Vertical Line + Other (to mimic the SEDAR33 Update setup). However, parameter estimation was very unstable and often resulted in a strongly dome-shaped pattern with poor diagnostics (i.e. a persistent pattern of positive residuals was clearly apparent over the largest lengths in the fit to the length composition).

Double normal selectivity was implemented for all three recreational fleets because dome-shaped selectivity was considered highly likely due to areas fished (e.g., closer to shore, shallower) and targeting behavior. For Recreational Charter, selectivity at the first length bin was fixed at 0 since the fleet operates further offshore than the waters small Gag Grouper are known to occupy. For the Recreational Private + Shore fleet, the 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, to reduce the number of parameters being estimated and improve model stability. It is clear from the length composition available for that fleet that the largest fish are not available to the fishery (**Figures 14**). In contrast, large fish are apparent in the length composition of the Recreational Headboat and Recreational Charter fleets (**Figures 10 and 12**), thus the final selectivity was left to be freely estimated (unlike in SEDAR33 Update where the final selectivity was forced to decay to 0 at the largest lengths for those two fleets). The parameter specifying the width of the plateau was estimated with high uncertainty for the Recreational Headboat, Recreational Charter, and Recreational Private + Shore fleets. That is because the parameters controlling the width of the plateau and the slope of the descending side become redundant if the parameter controlling the final selectivity moves to a value indicating asymptotic selectivity. Since the shape of the double normal was not sensitive to changes in the width of the plateau parameter over a wide range of parameter values, these parameters were fixed at intermediate values.

Logistic selectivity was assumed for the SEAMAP Video Survey since the survey targeted high relief areas that the largest individuals are known to occupy. Both parameters were freely estimated. For the PC Video Survey, initial model runs attempted to fit a six-parameter double normal selectivity function to the nominal length composition. However, the results were counter-intuitive, with the model estimating full selection of the largest individuals (i.e. logistic selectivity) when in fact the survey is known to be restricted to shallower depths where the oldest/largest fish in the population are relatively less available to the camera gear than the younger/smaller individuals in the population. This was likely being caused by the low sample sizes of measured fish available and the presence of large fish in the sample. It is important to note that although the survey started in 2006, length data were only available starting in 2009. As such, the available size samples may not be fully representative of the population surveyed. As a result, the SEDAR72 Panel agreed to implement the simpler double normal with plateau selectivity function and fix or place priors on certain parameters (beginning size for the plateau fixed at 20cm FL, remaining three parameters estimated with beta priors) based on *a priori* knowledge of the selectivity of the camera gear and relative availability of different size classes to the camera gear given the range of depths covered by the survey.

3.1.7.2. Age-based Selectivity

Age-based selectivity was specified for Commercial Vertical Line + Other, Commercial Longline, Recreational Charter, and the SEAMAP Video Survey. Given that the spatial extent of these fleets/surveys did not overlap with age-0 Gag Grouper habitat, age selectivity was restricted to ages 1+. All other fleets specified full selection across all ages.

The selectivity of the red tide mortality was set to 1 for all ages, implying that ages 0-33 were fully vulnerable to red tide mortality. This is a departure from the SEDAR33 Update where red tide selected ages 1 through the maximum age, however, it is more in line with the knowledge gathered about the spatial extent of the red tide mortality (see **Section 2.5.**). The assumption of full and equal selection across all ages was relaxed in subsequent Sensitivity Runs (see **Section 4.8.6.**)

The selectivity of the Age-0 Survey did not need to be specified as the survey was set up as a recruitment index (i.e. pre-specified to select age-0 fish only).

3.1.7.3. Mirroring

The age and length-based selectivity patterns of the Vertical Line CPUE, Longline CPUE and Headboat CPUE indices were assumed to mirror the selectivity pattern of their respective fleets. The age and length-based selectivity patterns of the Charter + Private CPUE index was made to mirror the selectivity pattern of the Recreational Charter fleet.

3.1.8. Retention

Time-varying retention functions are commonly used in Gulf stock assessments to allow for varying discards at size due to the impacts of management regulations (**Figure 38**). For Gag Grouper, time blocks were based on changes in the minimum size limits, the implementation of the Grouper-Tilefish Individual Fishing Quota (IFQ) program in 2010 and post-2011 restrictions on the recreational fishing season. The time varying retention blocks were defined as:

1. Commercial Vertical Line + Other and Commercial Longline
    1. 1963 - 1989: no minimum size limit regulation in place, an effective size limit was fixed at 16 inches TL
    2. 1990-2000: 20 inches TL minimum size limit
    3. 2001-2011: 24 inches TL minimum size limit
    4. 2012-2018: 22 inches TL minimum size limit
    5. 2019- 2019: 24 inches TL minimum size limit
    6. 2011- 2019: post-IFQ
2. Recreational Headboat, Recreational Charter and Recreational Private + Shore
    1. 1963 - 1989: no minimum size limit regulation in place, an effective size limit was estimated
    2. 1990-2000: 20 inches TL minimum size limit
    3. 2001-2016: 22 inches TL minimum size limit
    4. 2017- 2019: 24 inches TL minimum size limit
    5. 2011-2012: recreational fishing season seasonal closures (most restrictive)
    6. 2013-2015: recreational fishing season seasonal closures (mildly restrictive)
    7. 2016- 2019: recreational fishing season seasonal closures (least restrictive)

For each fleet, the retention function was specified as a logistic function consisting of four parameters: (1) the inflection point, (2) the slope, (3) the asymptote, and (4) the male offset inflection (not applicable to this model and assumed to be zero). The blocks related to the minimum size limits were linked to the inflection point parameters, while the blocks related to the IFQ and reduced recreational fishing seasons were linked to the asymptote parameters.

The first minimum size limit for the commercial fleets was implemented in 1990. Prior to 1990, there was no minimum size limit for any of the fleets. In February 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 2000. In March 2012, the minimum size limit was decreased from 24 inches to 22 inches (55.88 cm TL). In July 2018 the minimum size limit was increased back to 24 inches (60.96 cm TL). In January 2010, the GMFMC implemented an Individual Fishing Quota (IFQ) program to manage the commercial grouper-tilefish fishery.

For the period of 1963-1989, an effective size limit (inflection of retention curve) of 16 inches (40.64 cm TL) was assumed and the slope of the retention function was fixed at 5. For 1990-2000, 2001-2011, 2012-2018, and 2019 on, the retention function was fixed to be knife-edged (slope=1) at the size limit. The asymptote was fixed at 1 (i.e. all fish above the size limit retained) for 1963-2009, and left to be freely estimated from 2010-2019 (with separate parameters for each fleet). This was done to represent the implementation of the IFQ program. Size composition data from observer programs on vertical line and longline vessels showed that commercial fishermen released legal Gag Grouper when caught outside of the fishing season during the post-IFQ years.

The first minimum size limit for the recreational fleets was implemented in 1990. Prior to 1990, there was no minimum size limit for any of the fleets. In February 1990, a minimum size limit of 20 inches (50.8 cm TL) was implemented. The minimum size limit was increased 22 inches (55.88 cm TL) in June 2000. In May 2016, the minimum size limit was increased to 24 inches (60.96 cm TL). Though several bag limits and spatial/seasonal closures have been imposed on the Gag Grouper recreational fishery along the years (**Figure 38**), only the impact of the most recent (post-2011) seasonal closures were modeled using the retention curves based on data availability. In 2011, the GMFMC closed the Gag Grouper recreational fishery. It was eventually re-opened for 61 days. The recreational fishery was open for 123 days in 2012 and 156 days in 2013, 2014, and 2015. Since 2016, the recreational fishery has been open 215 days a year. In Florida state waters, the recreational fishing season was consistent with the Federal ruling in 2011. In 2012, Florida state waters were open February through December. From 2013 to 2016, the season was restricted to April 1 - June 20 in the Big Bend region and July-December elsewhere. Starting in 2017, additional months were added to the Big Bend season so that the recreational fishery was open April 1 – June 30 and again from September 1 – December 31 each year in FL state waters.

Data on recreational discards from MRFSS/MRIP starts in 1981 and shows that some discarding did occur prior to the implementation of management regulations. 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 1990-2010, the retention function was assumed to be knife-edged (slope=1) at the size limits with an asymptote fixed at 1. For the 2011-2012, 2013-2015 and 2016-2019 time blocks, the retention function was assumed to be knife-edged (slope=1) at the size limit but the asymptotes were estimated (individually, by fleet). This was done to account for the different levels of reductions in the recreational fishing season. Size composition data from observer programs on Headboat and Charter vessels showed that recreational fisherman released legal Gag Grouper when caught outside of the fishing season during these years.

3.1.9. Landings and Age Compositions

Landings by fleet and associated length and age compositions were estimated using fleet-specific continuous fishing mortality rates and length-specific selectivity curves following Baranov's catch equation.

The commercial landings were assumed the most representative and reliable data source in the model, especially over the most recent time period, because this information was collected in the form of a census as opposed to being collected as part of a survey. A CV of 0.05 was assumed for the pre-IFQ period, and 0.01 for the post-IFQ period (see **Section 2.3.1**). The recreational landings were assumed to be less precise than the commercial landings. A CV of 0.2 was assumed for all three recreational fleets (see **Section 2.3.2**). An alternative scenario with tighter CVs around the recreational catches (0.05) was explored in earlier runs (see **Section 3.4.6**) but ultimately the Panel chose a CV of 0.2 for the Base Run due to superior diagnostics (see **Section 4.8.6.**). All CVs were converted to a log-scale SE (see **Section 3.2.**).

A new feature available for fitting composition data in SS is the Dirichlet Multinomial (DM) which differs from the standard multinomial in that it included an estimable parameter (theta) which scales the input sample size (Thorson et al. 2017; Methot et al. 2020). The DM is self-weighting, which avoids the potential for subjectivity as when the Francis re-weighting procedure is applied (Francis 2011). The DM approach also allows for observed zeros in the data, and the effective sample sizes calculated are directly interpretable. The DM uses the input sample sizes directly, adjusted by an estimated variance inflation factor. The more positive the inflation factor, the more weight the data carry in the likelihood. The DM is considered an improved practice and recommended for use by the SS model developers, and was first used in a Gulf stock assessment during SEDAR70 in 2020 for Gulf of Mexico Greater Amberjack. A normal prior was used on the DM parameters of 0 (SD = 1.813), which is recommended to counteract the effect of the logistic transformation between the DM parameter and the data weighting (Methot et al. 2020).

Because SS models the growth internally and tracks individual fish from birth, it actually grows fish by length bins before eventually converting lengths to ages (based on the growth curve). As such, it is possible to fit both age and length composition simultaneously. For SEDAR72, the age and length composition data for each fleet/survey were assumed to follow a Dirichlet multinomial error structure where sample size represented the number of trips (of adjusted number of trips, see **Sections 2.3.5.** and **2.3.6.**), adjusted by an estimated variance inflation factor. Input sample sizes were related to the number of trips/sets rather than the number of measurements taken because using the number of lengths can overestimate sample sizes in fisheries data, as samples are rarely truly random or independent (Hulson et al. 2012). In addition, using higher effective sample sizes can lead to the composition data dominating the likelihood and reduce fit to other data sources. See **Sections 2.3.5-2.3.8** and **Sections 2.4.2-2.4.3** for more detail on input sample sizes for each fleet/survey. Iterative reweighting is often undertaken in order to adjust the effective sample size to better represent the residual variance between observed and predicted values (Methot and Wetzel 2013). The final effective sample sizes for each year are provided on the figures illustrating the age composition and length composition (given by N adj in each panel; **Figures 15-16, 19-21**).

3.1.10. Discards

Discard data for each fleet were directly fit in the SS model using size-based retention functions, and a log-normal error structure was assumed. The model estimates total discards based on the selectivity and retention functions, then calculates dead discards based on the discard mortality rates of 25% and 12% for the commercial and recreational fleets, respectively (**Sections 2.3.3-2.3.4**).

3.1.11. Indices

The indices are assumed to have a lognormal error structure. The CVs provided by the index standardization were converted to a log-scale SE required for input to SS for lognormal error structures (**Section 3.2.**).

3.2. Goodness of Fit and Assumed Error Structure

A maximum likelihood approach was used to assess goodness of model fit to each of the data sources (e.g., catch, indices, compositions, etc.). For each separate data set, an assumed error distribution and an associated likelihood component was specified, the value of which was determined by the difference in observed and predicted values along with the assumed variance of the error distribution. The total likelihood was the sum of each individual component. A nonlinear iterative search algorithm was used to minimize the total negative log-likelihood across the multidimensional parameter space to determine the parameter values that provide the best fit to the data. With this type of integrated modeling approach, data weighting (i.e., the variance associated with each data set) can impact model results, particularly if the various data sets indicate differing population trends.

Where lognormal error structures were used, annual CVs associated with each of the data sources were converted to log-scale SEs using the approximation: $log_e(SE) = \sqrt{(log_e(1 + CV^2))}$ provided in Methot et al. (2020).

In the SS model fitting, iterative reweighting of index variances (i.e. Francis weighting) was applied by adding the SS estimated variance adjustment to the survey input error (i.e., the SE) for each index and then re-running the model and repeated until the estimated new variance adjustment did not change. This commonly requires from one to two iterations.

Weak penalty functions were implemented to keep parameter estimates from hitting their bounds, which includes a symmetric-beta penalty on selectivity parameters (Methot et al. 2020). Parameter bounds were set to be relatively wide and were unlikely to truncate the search algorithm.

Uncertainty in parameter estimates was quantified by computing asymptotic SEs for each parameter. Asymptotic SEs are calculated by inverting the Hessian matrix (i.e., the matrix of second derivatives) after the model fitting process (Methot and Wetzel, 2013). Asymptotic SEs provide a minimum estimate of uncertainty in parameter values.

3.3. Estimated Parameters

In all, 488 parameters were included in the analysis for the SEDAR72 Base Model, of which 375 were active parameters (**Table 10**). These parameters include: year specific (1963-2019) fishing mortality for each fleet, the stock-recruit deviations for the data-poor time period (1963-1983) the stock-recruit deviations for the data-rich time period (1984-2019), three von Bertalanffy growth parameters (L_{Amin}, L_{Amax}, K), one stock-recruit relationship parameter ($ln(R_0)$), one SR_{regime} parameter, initial fishing mortality rates for the Commercial Vertical Line + Other and the Recreational Private + Shore fleets, size selectivity parameters for each fleet or survey, logistic retention parameters for each fleet, catchability parameters for each index, 4 parameters informing the Dirichlet multinomial length and age composition weightings, and red tide mortality (in 2015, 2014 and 2018).

3.4. Model Diagnostics

3.4.1. Residual Analysis

The main approach used to address model fit and performance was residual analysis of model fit to each of the data sets (e.g., catch, indices, length/age compositions, discards). Any temporal trends in model residuals (or trends with age or length for compositions data) can be indicative of model mis-specification and poor performance. It is not expected that any model will perfectly fit any of the observed data sets, but ideally, residuals will be randomly distributed and conform to the assumed error structure for that data source. Any extreme patterns of positive or negative residuals are indicative of poor model performance and potential unaccounted for process or observation error.

3.4.2. Correlation Analysis

High correlation among parameters can lead to flat likelihood response surfaces and poor model stability. By performing a correlation analysis, modeling assumptions that lead to inadequate model parameterizations can be highlighted. Because of the highly parameterized nature of stock assessment models, it is expected that some parameters will always be correlated (e.g., stock recruit parameters). However, a large number of extremely correlated parameters warrant reconsideration of modeling assumptions and parametrization. A correlation analysis was carried out and correlations with an absolute value greater than 0.7 were reported.

3.4.3. Profile Likelihoods

Profile likelihoods are used to examine the change in log-likelihood for each data source in order to address the stability of a given parameter estimate, and to see how each individual data source influences the estimate. The analysis is performed by holding the given parameter at a constant value and rerunning the model. This is repeated for a range of reasonable parameter values. Ideally, the graph of negative log likelihood values against parameter values will give a well-defined minimum, indicating that data sources are in agreement. When a given parameter is not well estimated, the profile plot may show conflicting signals across the data sources. The resulting total likelihood surface will often be flat, indicating that multiple parameter values are equally likely given the data. In such instances, the model assumptions need to be reconsidered.

For this assessment, a profile on the log of virgin recruitment ($ln(R_0)$) was carried out.

3.4.4. Jitter Analysis

Jitter analysis is a relatively simple method that can be used to assess model stability and to determine whether a global as opposed to local minima has been found by the search algorithm. The premise is that all of the starting values are randomly altered (or 'jittered') by an input constant value and the model is rerun from the new starting values. If the resulting population trajectories across a number of runs converge to the same final solution, it can be reasonably assumed that a global minimum has been obtained. This process is not fault-proof and no guarantee can ever be made that the 'true' solution has been found or that the model does not contain misspecification. However, if the jitter analysis results are consistent, it provides additional support that the model is performing well and has come to a stable solution. For this assessment, a jitter value of 0.1 (10%) was applied to the starting values and 100 runs were completed.

3.4.5. Retrospective Analysis

A retrospective analysis is a useful approach for addressing the consistency of terminal year model estimates. The analysis sequentially removes a year of data at a time and reruns the model. If the resulting estimates of derived quantities such as SSB or recruitment differ significantly, particularly if there is serial over- or underestimation of any important quantities, it can indicate that the model has some unidentified process error, and requires reassessing model assumptions. It is expected that removing data will lead to slight differences between the new terminal year estimates and the updated estimates for that year in the model with the full data. Oftentimes additional data, especially compositional data, will improve estimates in years prior to the new terminal year, because the information on cohort strength becomes more reliable. Therefore, slight differences are expected between model runs as more years of data are peeled away. Ideally, the difference in estimates will be slight and more or less randomly distributed above and below the estimates from the model with the complete data sets. A five-year retrospective analysis was carried out for the SEDAR72 Base Model. The severity of the retrospective bias was quantified using the Mohn's rho (ρ) statistic, which measures "the relative difference between an estimated quantity from an assessment with a reduced time-series and the same quantity estimated from the full time-series" (see Hurtado-Ferro et al., 2015). Mohn's ρ between -0.15 and +0.20 is within the acceptable range for a species like Gag Grouper (Hurtado-Ferro et al., 2015).

3.4.6. Sensitivity Runs

Sensitivity runs were conducted with the SEDAR72 Base Model to investigate critical uncertainty in data and reactivity to modeling assumptions. An exhaustive evaluation of model uncertainty was not carried out, but the aspects of model uncertainty judged to be the most important for model performance and accuracy were investigated. Only the most important sensitivity runs are presented below, but many additional exploratory runs were also implemented. 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. Focus of the sensitivity runs was on population trajectories, improvements in fit and important parameter estimates (e.g., recruitment).

Uncertainty in Recreational Landings - Uncertainty surrounding recreational landings was a key discussion point during SEDAR72. In SEDAR33 Update, CVs were fixed at 0.01, forcing the model to fit very closely to the recreational landings. For SEDAR72, annual CVs for recreational landings by mode were provided but not incorporated into the final SEDAR72 Base Model due to poor model behavior and instability based on model diagnostics. However, an intermediate CV of 0.2 (lower than the highest CV provided through MRIP, but higher than the SEDAR33 Update input CV) was supported by the Panel and successfully used in the SEDAR72 Base Run. A sensitivity run was conducted where recreational CVs were fixed at a lower value of 0.05.

Natural Mortality (*M*) - Model sensitivity to the specification of the natural mortality rate was evaluated. A sensitivity run using the SEDAR33 Update M vector (target *M* equal to 0.134 per year based on Hoenig et al. 1998 and an assumed maximum age of 31) was conducted.

Combined Video Survey Index - A novel Combined Video Survey Index was presented at the SEDAR72 Data Webinar (see **Section 2.6.2.**). A sensitivity run replacing the two video indices (SEAMAP Video Survey and PC Video Survey) with the Combined Video Survey was conducted. Length compositions from individual video surveys were replaced with a single area-weighted Combined Video Survey length composition (see **Section 2.6.2.**). Because different surveys enter the times series in different years, and because each survey has a slightly different selectivity due to the variation in habitat surveyed, the overall selectivity of the Combined Video Survey Index in this sensitivity run was estimated separately for 3 different blocks: 1993-2005, 2006-2009, 2010 2019. The first block represents the portion of the time series where only the SEAMAP Video Survey was operating, the second block represents the portion of the time series where both the SEAMAP Video Survey and the PC Video Survey were operating, and the third block represents the portion of the time series where all three surveys (SEAMAP Video Survey, SEAMAP Video Survey, and FWRI Video Survey) were operating. All selectivity functions were defined as logistic and both parameters were freely estimated separately for each block.

Recreational Private + Shore fleet retention - In the SEDAR72 Base Model, the asymptote of the retention function of the Recreational Private + Shore was freely estimated in each of the three blocks (2011, 2013, and 2016). However, only for the most restrictive fishing season (2011-2012) was the model able to estimate an asymptote <1 (i.e. not all fish above the size limit were retained; see **Section 4.4.**) and with reasonable precision. Unlike Recreational Headboat and Recreational Charter, Recreational Private + Shore lacked size composition for discarded fish, making it difficult to estimate the retention curves. As such, a sensitivity run was carried out where the retention asymptote of the Recreational Private + Shore fleet was mirrored after the Recreational Headboat fleet. Of the two recreational fleets, the Recreational Headboat fleet was chosen as the best fleet from which to mirror retention given our understanding of the fishing depth preferences of each fleet (see SEDAR72-WP-13).

Red Tide - In the SEDAR72 Base Model, red tide was modeled as a bycatch-only fleet (**Section 3.1.6.**) fully selecting all ages (0-33), and only operating in 2005, 2014, and 2018 (see **Section 3.1.7.2.**). The model was left to rely solely on the contrast between different data sources to estimate the magnitude of the red tide kill in each year. Two alternative sensitivity runs were carried out to test the model's response to additional information concerning the red tide impact, information that was generated by the Ecospace model of the West Florida Shelf (**Section 2.5.4.**; SEDAR72-WP-01):

1. *Red Tide Selectivity*

For this run, the red tide bycatch fleet was "turned on" for all years between 2002 and 2018 (excluding 2010 where no red tide was detected in the ecosystem model). In addition, age-specific selectivity vectors were constructed for ages 0-5+ (selectivity was assumed constant above ages 5) for each year in which red tide mortality was active. These empirical selectivity vectors were constructed by taking the estimated mean red tide mortality estimates for each age in each year (see Table 3 in SEDAR72-WP-01), re-scaling each yearly vector to a maximum of 1, and linking each fixed yearly age-selectivity vector to a separate time block. The resulting empirical selectivity-at-age functions are shown in **Figure 40**.

2. *Red Tide Time Blocks on M*

For this run, a set of one-year time blocks that encompass the time period of the available red tide mortality (spanning 2002-2018, excluding 2010) were created and linked to the natural mortality-at-age parameters for ages 0 to 5 using an additive deviation. As such, natural mortality was estimated as a baseline *M* vector (fixed input to SS) plus an additional additive deviation from the vector (estimated using a highly informative normal prior whose mean and standard deviation equal to the red tide mortality estimated mean and standard error provided in SEDAR72-WP-01 for each age/year). The intent was that the new annual value of natural mortality would be indexed by the red tide mortality estimates from the Ecoystem model, but not strictly dictated by these.

Male Contribution to SSB - In the SEDAR72 Base Model, reproductive potential is measured in the form of female-only SSB. Sensitivity runs were recommended by the SEDAR72 Panel to explore differences in model results given the alternative hypothesis that males and females contribute equally to SSB (i.e. that 1 kg of male biomass is equally important to the likelihood of spawning success as 1 kg of female biomass).

Florida's Gulf Reef Fish Survey - In this sensitivity run, the FL private mode portion of the Recreational Private + Shore fleet's catches and discards was replaced by the GRFS calibrated time series of catches and discards (**Figure 34**). As with the base run, the 1983 peak landings for private mode was replaced with the geometric mean of 1981, 1982, 1984, and 1985 private mode landings. In addition, historical recreational landings (1963-1980) had to be re-calibrated to the GRFS time series. This was done by replacing the Private mode FL landings with GRFS estimates, re-calculating the average recreational CPUE from 1981-1985, and using this recalculated CPUE to scale the historical landings (see Section 2.3.2). A measure of effort in GRFS units was required for recalculating the average recreational CPUE from 1981-1985. However, since there was no GRFS survey operating in those years, a measure of effort had to be back-calculated from the MRIP yearly CPUE values and the yearly estimated GRFS catches. Since both GRFS and MRIP calculate total catch (effort*CPUE) using similar values for CPUE, effort in GRFS units for 1981-1985 FL Private mode was back-calculated by dividing GRFS yearly catch estimates with MRIP yearly CPUE. Total historical recreational catches (1963-1980) were then apportioned by mode using the ratios 20% Charter, 4% Headboat, and 76% Private + Shore. These ratios were based on the average proportion of landings by fleet over the period 1981-2019. The log transformed CVs of the GRFS calibrated FL private mode time series of landings and discards was used to characterized the uncertainty around the Recreational Private + Shore fleet's catches and discards (**Figure 34**).

4. Stock Assessment Model - Results

4.1. Estimated Parameters and Derived Quantities

Table 10 contains a summary of model parameters for the SEDAR72 Base Model. Results included are estimated parameter values and their associated CVs from SS, initial parameter values, minimum and maximum bounds on parameters, and the prior densities assigned to each parameter (if a prior was used). Most parameter estimates and variances were reasonably well estimated (i.e., CV < 1). Of the 375 active parameters, 9 exhibited CVs above 1 and were poorly estimated, including 5 recruitment deviations, the asymptote of the Recreational Private + Shore retention curve for the 2013-2015 and 2016-2019 time blocks, the parameter defining the downslope of the selectivity for the PC Video Survey, and the red tide mortality in 2018.

4.2. Fishing Mortality

The exploitation rate (total biomass killed age 3+ / total biomass age 3+) for the entire stock are provided in **Table 11** and **Figure 41**. Since 1963, the exploitation rate for the stock has averaged around 0.287, and ranged between 0.087 in 1963 to 0.692 in 2008, (note peak due to including red tide mortality). The exploitation rate gradually increased from low levels (less than ~0.1) to approximately 0.25 in the early 1980s. It then plateaued off until the mid-1990's after which rates started to increase again with larger inter-annual variations. From 2008-2011, the stock experience a sharp decline in exploitation rate, followed by a variable increase from 2011 to the end of the time series. The red tide years (2005, 2014, and 2018) show clear peaks in exploitation with relatively higher uncertainty about the estimate compared to neighboring years. The terminal year (2019) exploitation rate for the entire stock was 0.398, which is slightly above the time series mean.

Table 12 and **Figure 42** provide estimates of exploitation rate by fleet and year. The results show that the exploitation rate for the stock was driven largely by the Recreational Private + Shore fleet throughout the entire time series (unlike SEDAR33 Update (pre-FES calibration) where the Commercial Vertical Line fleet had the largest exploitation rates of the fleets prior to 1985). The next largest exploitation rates were that of Commercial Vertical Line + Other. The Recreational Private + Shore fleet has generally exhibited an increasing pattern of exploitation rate from the beginning of the time series to 2008 where it peaked at 0.553. This was followed by a sharp decline from 2008 to 2012 and variable rates from 2012 onward. Commercial Vertical Line + Other exploitation rates were relatively more stable across the time series. The fleet exhibited a sharp decline from 2008 to 2011 (first year post-IFQ) after which it began to rise again. The Commercial Vertical Line + Other and Recreational Charter exploitation rates were fairly close in magnitude across the time series. In the most recent years (2013+), Commercial Longline and Commercial Vertical Line + Other exploitation rates have been very similar. Generally, the Recreational Headboat exhibits consistently low levels of exploitation (averaged 0.005), peaking at 0.021 in 1985. The terminal year (2019) fishing mortality rates for the Commercial Vertical Line + Other, Commercial Longline, Recreational Headboat, Recreational Charter and Recreational Private + Shore fleets were 0.042, 0.021, 0.003, 0.03 and 0.302, respectively (**Table 12**).

4.3. Selectivity

A comparison of the SS estimated length-based selectivity functions for each directed fleet for Gulf of Mexico Gag Grouper from the SEDAR72 and SEDAR33 Update models is shown in **Figure 43**. The top panel shows the results from using the logistic function to model selectivity of the Commercial Vertical Line + Other fleet in the SEDAR72 assessment instead of the double normal function applied in SEDAR33 Update. The logistic function allowed the length composition observation data to be fit better than the double normal. **Figures 44-48** provide fleet specific terminal year (2019) selectivity, retention, discard mortality and fraction of fish kept, dead and discarded for the 5 directed fisheries for both the SEDAR72 and SEDAR33 Update assessments. **Figure 49** presents SS derived age-based selectivity for each fleet in 2019. The Commercial Vertical Line + Other fleet reached 50% selectivity at age 6, while the Commercial Longline fleet reached 50% selectivity at age 8. The Recreational Headboat and Recreational Charter fleets both attain maximum selection at age 5, while the Recreational Private + Shore fleet attains maximum selection at age 4. All recreational fleets indicate higher selection for younger fish with the Recreational Headboat and Recreational Charter fleets showing 50% selectivity around age 2 and Recreational Private + Shore around 0. In addition, selectivity plateaus around age 12 for both the Recreational Headboat and Recreational Charter fleets, which differs from SEDAR33 Update where selectivities were forced to go to 0 at the oldest ages.

The estimated length-based selectivity functions for the SEAMAP Video Survey and PC Video Survey for the SEDAR72 vs. SEDAR33 Update are shown in **Figure 50**. The derived age-based selectivity functions are shown in **Figure 51**. The estimated selectivity of the SEAMAP survey from SEDAR72 is considerably different than that of SEDAR33 Update. SEDAR72 shows 50% selection at age 5 instead of 27 in SEDAR33 Update. Maximum (full) selectivity occurred at around 9 in SEDAR72 while SEDAR33 Update selectivity reached just above 50% at the oldest age group. The shapes of the PC Video Survey selectivity from SEDAR33 Update and SEDAR72 are similar due to the constraints imposed on the selectivity parameters in SEDAR72 (**See Section 3.1.7.1.**).

All selectivity parameter estimates and associated uncertainty are listed in **Table 10** with the Label prefix “Size_”.

4.4. Retention

Time-varying retention functions, by time block, are provided for each directed fleet and are shown in **Figures 52-56**. All retention parameter estimates and associated uncertainty are listed in **Table 10** with the Label prefix “Retain_”.

Most retention parameters appeared well estimated except for the asymptotes for the 2013-2015 and 2016-2019 time blocks on the Recreational Private + Shore (**Table 10**). The post-IFQ asymptote for Commercial Vertical Line + Other was slightly higher than that of Commercial Longline (**Figures 52 and 53**) which is in line with our understanding of the discarding behavior of each fleet. The asymptotes of the Recreational Headboat and Recreational Charter were estimated to gradually higher values for each consecutive block (**Figures 54 and 55**), which is in line with the easing of restrictions on the recreational fishing season. For Recreational Private + Shore, however, the model was only able to estimate an asymptote for the first block (most restrictive fishing season). The asymptotes for the two other blocks were estimated around 1 with very high variance, likely due to the lack of data on size composition of the discards to inform its height (**Figure 56, Table 10**).

4.5. Recruitment

As noted in the description of the SS model configuration, two of three of the S/R parameters were fixed at values agreed upon during SEDAR33: steepness (0.855) and *sigmaR* the recruit variance parameter (0.6). The corresponding Beverton-Holt stock recruit relationship is show in **Figure 57**. Estimated annual recruitment of age-0 fish (1000s) from 1963-2019 including recruitment deviations and variance are shown in **Table 13** and **Figures 58-60**. Virgin recruitment in log-space (Ln(R_0)) was estimated at 9.343 (**Table 10**), which equates to 11.42 million age-0 Gag Grouper. The estimated (and applied) recruitment bias adjustment ramp is shown in **Figure 61**.

During the main recruitment period (1984-2019, see **Section 3.1.5.**), estimated recruitment averaged 9.08 million Gag Grouper and was lowest in 2011 at 1.68 million Gag Grouper and highest in 1996 at 22.61 million Gag Grouper (**Figure 58**). Recruitment deviations were characterized by a period of lower than average recruitment in the late 1980's followed by a period of above average recruitment from the mid-1990s to the late 2000s and below average recruitment after 2011. There was a noticeable drop in recruitment in 2011 (an 78% drop from the previous year), which coincides with a strong signal of recruitment failure in the age-0 survey index (**Figure 29**) and the age composition of the Commercial Vertical Line + Other, Commercial Longline, Recreational Headboat and Recreational Charter fleets (**Figures 17, 18, 22, 23**).

CVs for recruitment deviations during the main recruitment period averaged 0.104 between 2017 and 2016, and ranged from 0.051 in 1996 to 0.233 in 2014 (**Figure 60**). For the last two years of the assessment (2018, 2019), recruitment deviations were largely informed by the age-0 index, as age-0 and 1 fish had not yet fully recruited to the fisheries. Estimated recruitment for those terminal years were below average, their estimated values and associated CVs were 2.96 million Gag Grouper (CV=0.237) and 3.856 million Gag Grouper (CV=0.37), respectively.

4.6. Biomass and Abundance Trajectories

The estimated annual total biomass (metric tons), exploitable biomass (ages 3+, metric tons), SSB (metric tons), SSB ratio (SSB/virgin SSB) and exploitable abundance (1,000s of fish) from 1963 to 2019 are provided in **Table 13**. Total biomass averaged 16,703 metric tons, and ranged from 4,996 metric tons in 2015 to 33,605 metric tons in 1963 (**Figure 62**). Exploitable biomass and numbers, which were comprised of Gag Grouper age-3 or older, averaged 13,459 metric tons and 3,916,063 Gag Grouper, respectively. Exploitable biomass was lowest in 2015 at 3,625 metric tons and peaked in 1964 at 30,154 metric tons, whereas exploitable numbers ranged from 1,153,774 Gag Grouper in 2015 to 7,077,922 Gag Grouper in 2003 (**Table 13**). SSB averaged 7,242 metric tons, and ranged from 2,102 metric tons in 2019 to 15,643 metric tons in 1964 (**Figure 63**). Both total biomass and SSB show a steady decline from 1963 to the late 1970s, followed by a plateauing off in the 1980s to early 1990s. Starting in the mid 1990s, biomass trends show a sharper increase followed by a drop in 2005 (coinciding with the red tide event), followed by a small increase in the early 2010s again followed by a drop in 2014 (red tide event).

Since 2014, the biomass trends have remained relatively flat, at levels well below the average of the time series.

The SSB ratio averaged 0.2, and ranged from 0.06 in 2019 to 0.43 in 1964 (**Table 13**). Estimated SSB ratio has stayed below 10% since 2015, with estimated spawning stock biomass in the most recent year (2019) predicted to be at 6% of the corresponding unfished spawning stock biomass (**Table 13**).

Estimated SSB (metric tons), exploitable biomass (ages 3+, metric tons), and exploitable abundance (1,000s of fish) by sex are provided in **Table 14**. Also included is the predicted sex ratio of exploitable male to female Gag Grouper, which averaged 6.8% and ranged from 0.7% in 2010 to 20.5% in 1971. The predicted sex ratio of exploitable male to female Gag Grouper equaled 1.4% in the terminal year of the assessment. The sex ratios predicted by the model were close to those observed in the field (see SEDAR72-WP-08). The predicted numbers-at-age and biomass-at-age of female and male Gag Grouper at virgin conditions are shown in **Figure 64**. The sex ratio predicted by the model at virgin conditions was 32%. At virgin conditions, age-0 and age-6 female Gag Grouper dominated in numbers and biomass, respectively, whereas age 20+ male Gag Grouper were most abundant and dominated biomass (**Figure 64**). Predicted numbers at age and mean age over the entire time series for both SEDAR33 Update and SEDAR72 is shown in **Figure 65**.

4.7. Model Fit and Residual Analysis

4.7.1. Landings

Landings for the Commercial Vertical Line + Other and Commercial Longline fleets were fit almost exactly given their relatively small SEs (**Table** , **Figure 66**). The model expected slightly lower catches for Commercial Longline from 2001-2004. Given the large SEs assigned to the recreational fleet landings, there were considerable differences between input and predicted landings in numbers (**Table** , **Figure 66**). For Recreational Headboat, observed and predicted values matched well until 1985, after which there were noticeable departures, particularly at the peaks and troughs where the model expected more variability than was observed. From 2007-2010, the model expected consistently higher catches. For Recreational Charter, observations and predictions matched well up until the mid 1990s. From 1996 to 2015, the model generally expected higher catches than observed. For Recreational Private + Shore, the departures from observed to expected were more randomly distributed, alternating between the model expecting relatively lower and higher catches than observed, except for 2008-2014 where the model generally expected higher catches than observed. A lot of the differences coincided with the model being better able to fit to the discard data (see **Section 4.7.2, Figure 67**). In general, there was a closer fit to the landings data in SEDAR33 Update compared with SEDAR72 due to increased CVs.

4.7.2. Discards

The time series of commercial discards begins in 1993, three years after the implementation of the first minimum size limit. Observed and expected values are summarized in **Tables 20-21** and **Figure 67**. Generally, the discards were relatively low for both the Commercial Vertical Line + Other and Commercial Longline fleets, though the Commercial Longline had fewer discards than the Commercial Vertical Line + Other. Discards were estimated with a large assumed uncertainty, and therefore were characterized by large confidence intervals for both commercial fleets (**Figures 68-69**). For the Commercial Vertical Line + Other fleet, the model expected fewer discards than observed in 2000 and 2011. There was a noticeable peak in expected discards in 2008, where the model expected twice as many discards as were observed. For the Commercial Longline fleet, the model expected higher discards than observed from 2001-2009, and again in 2016. The model expected lower discards than observed in 1993, 1994, 2000, and again from 2010-2011. There were two noticeable peaks in expected discards in 2001-2005 and 2016, where the model expected twice as many discards as were observed. The difference in discard rates between 2010-2011 and the remainder of the time series may be indicative of a change in selectivity of the fleets as a response to the IFQ. However, such a change was not modeled here.

The time series of discards for the recreational fleets begins in 1981 (**Tables 22-24**, **Figures 70-72**). The model was able to fit discard observations very well throughout the time series for the Recreational Private + Shore fleet (**Figure 72**). For fleets Recreational Headboat and Recreational Charter (**Figure 70, 71**), the model was able to fit discard observations relatively well except in 2009-2010 the model expected Recreational Charter discards well below observed values. Recreational Headboat discards were very variable from year to year with no apparent trend.

Looking at discards as a percent of total catch, increases in discard rates from the Recreational Headboat and Recreational Charter appear consistent with implementation of size limits and reductions in fishing seasons (**Figure 73 and 74**). Discard rates for the Recreational Charter fleet were generally estimated below observed values. For the Recreational Private + Shore fleet, there is a sharp increase in discard rate in 1990, coinciding with the first minimum size limit and another, smaller, increase in 2000 and 2017 corresponding to the increase in the minimum size limit from 20 to 22 to 24 inches TL (**Figure 75**). However, the impact of the shortened fishing season post 2011 is less apparent than it is in the Recreational Headboat and Recreational Charter fleets.

4.7.3. Indices

Observed and predicted CPUE are provided in **Tables 25 and 26** and **Figure 76**.

The model fit best to the Charter + Private CPUE and Headboat CPUE indices (root mean squared error [RMSE] = 0.326 and 0.342, respectively; with variance adjustment recommended of 0.098 and 0.092, respectively). Both indices had similar trends (**Figure 76**), with the index generally decreasing from 1985-1990, staying relatively flat from 1990-1995, then increasing to the late 1990s and generally decreasing from 1999 to 2010 in the case of the truncated Headboat CPUE index, and even further to 2015 in the case of the Charter + Private CPUE index. Since 2015, the Charter + Private CPUE has shown a somewhat increasing trend.

Both commercial CPUE indices showed a gradually increasing trend from 1990 to 2005 but the fit to the index was relatively flat over that time period given the relatively high variance adjustment factor (0.293 for VL and 0.252 for LL). Both indices exhibited a drop from 2005 to 2009 coinciding with the drop in catches. The decline in the indices was steeper than that of the fitted values (**Figure 76**).

Of the two video indices, the model fit better to the PC Video Survey (RMSE= 0.455) than to the SEAMAP Video Survey (RMSE= 0.809) (**Figure 76**). The fits to the fishery-independent indices were much improved between SEDAR33 Update and SEDAR72, particularly in the last 5 years of the time series.

The age-0 survey had the highest suggested variance adjustment (0.523), likely to counter the very small values of the index, where input CVs made uncertainty appear unrealistically small (**Figure 76**). The RMSE for that index was 0.773.

With the added variance adjustment (see **Section 3.2.**), the SEDAR72 base model admits more uncertainty in the indices than was assumed during SEDAR33 Update. Fits to the various indices over the last 5 years of the assessment are much improved in SEDAR72 compared to the fits from SEDAR33 Update (**Figure 76**).

4.7.4. Length Compositions

Model fits to the retained and discarded length composition data are provided in **Figures 77-87**. Fits to retained length compositions were generally better than to discarded length compositions for each fleet, which is to be expected given that sample sizes were notably smaller for discard length compositions.

The aggregate fit to the retained length composition data were fairly similar between SEDAR33 Update and SEDAR72 (**Figure 86**), but unlike the SEDAR33 Update, no strong residual pattern in the tails was evident and residuals were generally smaller across fleets (**Figure 87**). The fit to the SEAMAP Video Survey length compositions was improved with the inclusion of additional samples (**Figure 88**). The fit to the PC Video Survey length compositions degraded but the number of available samples was small and the chosen selectivity pattern was thought to be more in line with the true selectivity of the survey than what SS would have estimated freely (**Figure 89**; see **Section 3.1.7.1.**).

Though residuals were generally small, there was a persistent trend in residuals in the last 5 years of fit to the commercial fleets' length compositions (**Figure 77 and 79**), most apparent in the Commercial Vertical Line + Other. There was also a strong pattern of positive residuals at the largest lengths from 1998-2008 in the Commercial Longline fleet, where the model expected younger fish than observed.

The Recreational Headboat showed fairly distinct patterns in residuals pre-1996 and post-1996 (**Figure 81**). Residual patterns were more randomly distributed for the Recreational Charter (**Figure 83**). The length composition of the Recreational Private + Shore fleet showed individuals being retained below the size limit and consistent increase in mean length of the retained catch across the time series (**Figure 85**).

4.7.5. Age Compositions

Model fits to the age composition data are provided in **Figures 90-96**. Generally, the fits to the age composition were similar between SEDAR33 Update and SEDAR72. In both cases, Recreational Private + Shore had the poorest fit with the model expecting a greater proportion of larger fish than observed (**Figure 94**).

Across all fleets, there was a tradeoff between fitting to the weighted retained length compositions and fitting to the nominal age compositions. Overall, the model fit more closely to the length compositions due to the larger sample sizes and larger contribution to the total likelihood.

4.7.6. Red Tide Mortality

Red tide was detected in all three years (2005, 2014, 2018) (**Figure 42**). Red tide mortality as estimated at 0.72, 0.47, and 0.2, respectively. This corresponds to removals of 13.67, 3.34, 1.3, and million Gag Grouper, respectively.

4.8. Model Diagnostics

4.8.1. Correlation Analysis

A summary of correlations for the base model parameters considered as outliers is contained in **Table 27**. Given the highly parametrized nature of this model, some parameters were mildly correlated (correlation coefficient > 70%) and two combinations displayed a strong correlation (> 95%; **Table 27**). Correlation among many of these parameters is not surprising, especially for the selectivity parameters, because the parameters of selectivity functions are inherently correlated (i.e., as the value of one parameter changes the other value will compensate). The same can be said for the von Bertanffy growth parameters (K and L_{Amax}), which are by their very nature correlated. Moderate correlations occurred between the parameters defining the peak and the width of the ascending and/or descending limb of the double normal selectivity functions for all recreational fleets. A number of the recruitment deviations were also moderately correlated.

4.8.2. Profile Likelihoods

The total likelihood component from the lnR_0 likelihood profile indicates that the global solution for this parameter is approximately 9.3 (**Figure 97**). The SEDAR72 Base Model estimating lnR_0 at 9.343 (CV = 0.006; **Table 10**). lnR_0 = 9.3 and 9.4 were within 2 negative log-likelihood units of one another. Almost all data sources supported this estimate, with the exception of the index data which supported a slightly higher lnR_0 near 9.5.

4.8.3. Jitter Analysis

A jitter analysis was conducted using a jitter value of 0.1. With this procedure, the starting model parameter values are randomly adjusted by 10% from the SEDAR72 Base Model best fit over 100 runs. The model converged to the same likelihood as the SEDAR72 Base Model in 91% of runs, with no runs demonstrating a lower negative log-likelihood solution (**Figure 98**). For the 9 remaining runs, given that the total negative log-likelihood values were much higher than that of the base run, it is probable that non-optimal solutions were found (i.e., the model search was stuck in local minima). Given these results, the jitter analysis indicates that the base model is relatively stable and represents the lowest log-likelihood solution.

4.8.4. Retrospective Analysis

Results from the retrospective analysis do not indicate any directional retrospective patterns. As the last few years of data are peeled off, the model estimates of SSB, recruitment and F in each successive terminal year do not change by a large margin (and remain within the confidence intervals; **Figures 99-101**). Mohn's ρ statistics are reported in the figure captions. The year with the largest differences in SSB between peels is 2014. This is a red tide year. As the model is given additional information on the impact of the red tide with additional years of data, the estimate of SSB for 2014 is brought down to lower levels. Similarly, estimates of F for that year increase as more information enters the model.

4.8.5. Bridging analysis

The general flow of model building runs that led to the final SEDAR72 base model is shown in **Table 28**. Changes in estimated quantities are shown in **Table 29** and **Figures 102-105**.

The SEDAR33 Update model that used the SS3.24_S version was successfully converted to the new SS3.30 version without any issues (Step 2). Key derived quantities and important parameters (e.g., S/R parameters, growth) were estimated similarly in SS3.30. When the new revised MRIP-FES landings and discard data were substituted for the recreational fleet inputs in Step 3, estimates of virgin SSB (SSB_0) and virgin recruitment (R_0) increased by 82% and 85% respectively. Substituting the new MRIP-FES estimates generally increased SSB across the time series without drastically affecting the trajectory of the stock over the data period, except for the last few years (2010+) where the trajectory of the stock went from strictly increasing to increasing until 2013 and subsequently decreasing. The impact of FES is particularly apparent in the SSB ratio plot where the trajectory of the stock in the last 5 years of the model is drastically different and estimates in the terminal year (SSB_{2019}/SSB_0) drop from 39% to 14% (**Figure 103**). The next step in the bridging analysis, Step 4, involved updating all new data streams (changing the terminal year to 2019, altering the fleet structure and including all new catches, discards, indices, length comps, age comps and associated CVs). The following step, Step 5, updated the biology inputs (M, maturity, hermaphroditism, growth CVs) and extended the time blocks for the most recent minimum size limits and changes in the recreational season length. Step 6 involved adjusting selectivities to fit the updated data and run 7 added two more years of red tide (2014, 2018). Step 8 adjusted the age and length comp effective sample sizes using the Dirichlet weighting approach. Step 9 applied the recruitment deviations bias adjustment ramp as recommended by SS developers. Step 10 adjusted the index CVs using Francis weighting and Step 11, the final step, applied the recruitment deviations bias adjustment ramp as the final tuning step. Many additional runs were conducted during the development of SEDAR72 but the above mentioned 11 steps show the most important stepping stones that govern the changes observed between the SEDAR33 Update and SEDAR72. Most changes affecting the trajectory of the stock occurred prior to step 5.

4.8.6. Sensitivity Model Runs

Results for the sensitivity runs summarized in **Section 3.4.6** are discussed below.

Uncertainty in Recreational Landings

Decreasing CVs around recreational landings from 0.2 to 0.05 led to a worse overall fit (by 234 negative log likelihood units). Looking at the impact on each likelihood component, tighter CVs led to a worse fit to the age and length compositions of several fleets. Not surprisingly, it led to an improved fit to the catches of the recreational fleets which in turn degraded the fit to the discards for those fleets (**Figure 106**).

Overall, trends in SSB were similar, though decreasing CVs around recreational landings led to a higher estimate of virgin SSB and a significantly steeper increase and subsequent decline in estimates of SSB around the red tide year 2014 (**Figure 107**). Estimates of *F* were also more variable from 2009 to 2014 in the sensitivity run and estimates of recruits were generally higher for 2011-2014 (**Figure 107**).

This sensitivity run was further investigated through a R_0 profile (**Figure 108**). The profile showed some level of disagreement between the data sources with the age and length data favoring a lower R_0 than the rest of the datasets. The R_0 profile of the Base Run was indicative of a better behaved model (**Figure 97**).

Natural Mortality

Using the SEDAR33 Update *M* vector equated to decreasing *M* across all ages. This led to a very slight degradation in overall fit (the total negative log likelihood increased by just 4 likelihood units (**Figure 109**).

Overall trends in SSB were similar, with overlapping confidence intervals, though the sensitivity run estimated a slightly higher virgin SSB and thus lower levels of fraction unfished across the entire time series (**Figure 110**). Exploitation rates were similar across runs and recruitment was lower across the time series for the run that used the SEDAR33 Update *M* vector.

Combined Video Index

The fit to the Combined Video Index was quite good (RMSE=0.268) but didn't quite capture the drop from 2006 to 2008 nor did it capture the increase in the last year of the index (**Figure 111**). The fit to the length composition was acceptable, with no clear pattern in the residuals (**Figure 112**). Three logistic selectivity functions were estimated for the separate blocks corresponding to the introduction of new surveys (**Figure 113**). As expected, the selectivity function shifted to the left (towards smaller fish) with the introduction of the PC Video Survey in 2006. However, the selectivity for the last block was shifted farther to the right than the other two blocks, which was counter-intuitive given that we know the FWRI tends to survey fish across all sizes observed by both the PC and SEAMAP surveys. Given the limited number of measured lengths available, it is likely that the selectivities will be refined in the future as new length composition data are added. While it was necessary to separate out the length composition into different blocks to account for potential changes in the segment of the population being tracked by the index, this process reduces sample sizes available to estimate selectivity parameters.

Trends in SSB were very similar between the Base Run and the Combined Video sensitivity run, except for the final year where the sensitivity run showed an uptick in SSB while the Base Run showed a decrease in SSB (**Figure 114**). This was linked to a much higher exploitation rate being estimated by the base run in 2018 (red tide year) compared with the sensitivity run. Recruitment estimates were similar across runs.

Recreational Private + Shore fleet retention

Mirroring the Recreational Private + Shore retention asymptote to the Recreational Headboat fleet led to a degradation in overall fit (the total negative log likelihood increased by 37 likelihood units.) (**Figure 115**). It degraded the fit to the Recreational Private + Shore catches, discards and lengths while improving the fit to the Commercial Vertical Line + Other, Commercial Longline, Recreational Headboat, Recreational Charter age composition. Interestingly, it also degraded the fit to the two commercial fleet discard data.

The most notable difference between the two runs was the estimate of virgin biomass (**Figure 116**). Mirroring the Recreational Private + Shore retention asymptote to the Recreational Headboat fleet made the virgin SSB go from 36.6657 million Gag Grouper to 76.5017 million Gag Grouper. This resulted in a heightened state of depletion from 1980 to 2019 compared with the base run and a change in the terminal year (2019) depletion level from 6% to 3%. Estimated recruitments were also more variable in the sensitivity run and consistently higher than the Base Run across the time series.

Red Tide

1. *Red Tide Selectivity*

Estimating red tide mortality in additional years and informing the selectivity patterns in each year had unexpected results. It lessened the year-to-year variability in the SSB trend and shifted the patterns of exploitation rates along the red tide years (**Figure 117**). The model detected noticeable red tide events in 2002, 2004, 2005, 2006, 2008, 2011, 2017, 2018 ranging from a low of 1.23 million fish killed in 2018 to a high of 12.92 million fish killed in 2004. These results do not align with our historical accounting of red tide and data driven ecosystem model results (**See Section 2.5.**). It appears that freely estimating red tide mortality in each year may be including too many confounding variables (*F*, time varying retention, recruitment deviations) for the model to be able to estimate the magnitude of red tide events in each year. The assumptions on selectivity coming from the ecosystem output (i.e. forcing mortality on the youngest fish in the population) may be too restrictive. Trends in SSB and recruitment were fairly similar between the sensitivity and base run, with some differences in estimates of virgin conditions (**Figure 118**). The trends in exploitation rates differed in recent years with different red tide years being detected.

2. *Red Tide Time Blocks on M*

Adding information on the magnitude of the red tide events through time blocks and priors on M-at-age yielded different results. The model estimates of the deviation on *M* did not deviate much from the input prior values (**Figure 119**, compare with SEDAR72-WP-01). Some model results were questionable, however, including the estimate of Recreational Private + Shore catches in 2013, where the model estimated much higher catches than observed (**Figure 120**). There was a four-fold difference between expected and observed catches for that year (**Figure 120**). Overall, this sensitivity run resulted in mostly non-significant differences in the trend in SSB through time but did cause significant differences in recruitment, particularly over the time period 2006-2009 where the sensitivity run estimated higher recruitment than the Base Run (**Figure 121**). One important point to note is that the Ecosystem model (SEDAR72-WP-01) treated age 5 as a plus group, thus allowing for red tide mortality on ages older than 5, whereas in this sensitivity run, only ages 0 through 5 were allowed to be affected by red tide mortality. More work is needed to determine if red tide mortality can be extended to the oldest ages (by adding additional blocks) while still achieving model convergence.

Contribution of Male SSB

The fits to the different data components was very similar to the Base Run (**Figure 122**). As expected, the magnitude of both virgin and annual SSB estimates increased as the contribution of male SSB increased from 0% in the SEDAR72 Base Model to 100% (i.e., a combined SSB model; **Figure 123**). The combined SSB sensitivity run estimated a slightly higher virgin recruitment (14.29 million fish vs 11.42 million fish) and there were small but non-significant differences in annual recruitment in the early 2000s and 2010s. Annual estimates of *F* were comparable though differences were apparent in 2013 and 2018 where the sensitivity run estimated lower *F* values for those years. Diagnostics pertaining to the combined SSB sensitivity run are shown in Figures 124-128. The likelihood profile for the natural log of the unfished recruitment parameter exhibits a slight conflict between the age data (favoring a slightly higher R0 than the total likelihood) and the length data (favoring a slightly lower R0 than the total likelihood) (**Figure 124**). The jitter analysis resulted in most runs converging to the same negative log-likelihood as the SSB combined sensitivity run, with no runs demonstrating a lower negative log-likelihood solution (**Figure 125**). The five-year restrospective analysis showed a well behaved model, with no systematic bias pattern observed (**Figure 126-128**). Mohn's ρ statistics are reported in the figure captions.

Florida's Gulf Reef Fish Survey

Replacing the Private mode catches and discards with the GRFS calibrated time series resulted in lower SSB and recruitment across the time series (**Figure 129**). Virgin SSB and recruitment were estimated to be about half of the Base Run values. Exploitation rates were generally lower than the base run with the exception of 2014, a red tide year. Spawning stock biomass in the terminal year was estimated (2019) was predicted to be at 6.5% of the corresponding unfished spawning stock biomass (i.e. very close to the 6% estimated in the base run). The estimated parameter representing the ascending limb of the double normal selectivity pattern of the Private + Shore fleet hit the upper bound, which could indicate poor convergence.

5. Discussion

The SEDAR72 Gag Grouper assessment included several important changes to data inputs and model parameterization that affected the assessment results including the following:

1. incorporating the MRIP-FES in estimation of recreational landings and discards;
2. revising historical landings for the recreational fleets;
3. incorporating revised black/gag grouper correction factors for the commercial fleets' landings and discard estimates;
4. incorporating additional uncertainty around recreational landings;
5. applying the SEFSC's improved approach for estimating commercial discards;
6. considering additional years of red tide mortality;
7. updating estimates of maturity and hermaphroditism;
8. updating estimates of maximum age and *M*;

9. updating estimates of variability in growth;
10. including additional blocks for defining changes in retention in the commercial and recreational fisheries;
11. combining the Charter and Private mode indices into a single Charter + Private CPUE index;
12. applying an internal re-weighting approach to both age and length compositions;
13. applying an internal re-weighting approach to indices of abundance.

The most significant of the SEDAR33 Update to SEDAR72 model changes (data or model configuration) was the revision in recreational catch and discards estimates (**Figure 102**), which ultimately scaled the population size upward due to much higher estimated Recreational Private + Shore landings. The remaining changes did not have as large an impact on the overall assessment results and estimates of parameters (growth rate, R0, etc.) or key derived quantities. However, the remaining changes did lead to significant improvements in model fits and a more stable model. This was demonstrated through faster model run times, fewer highly correlated parameters, the elimination of bounded parameters from the previous SEDAR33 Update model, an improved characterization of uncertainty around recreational catches, and better fits to the indices of abundance (particularly in the terminal years of the assessment). Additionally, converting the previous SEDAR 33 SS 3.24s model to the upgraded SS 3.30 version had virtually no impact on model results but was seen as an overall improvement in the assessment as the updated SS version (3.30_17) allows even greater flexibility in handling a number of processes including the hermaphroditism option, data weighting and projections.

The SEDAR72 model fit most of the data sources well with no major residual patterns and the fits were much improved from SEDAR33 and SEDAR33 Update. As with SEDAR 33, the dominant data inputs were the length and age compositions as these produced the greatest impact on the model fit (as measured in the contribution to the total likelihood). There were only a few parameters with high correlations and they did not appear to be the source of any major model stability issues. The jitter analyses did not indicate instability as most runs converged to the same (and lowest) solution space. No substantial retrospective patterns are present in the model fits, indicating internal consistency within the model. Likelihood profiles on *R0* showed general agreement between data sources.

It is important to note that uncertainties remain in some components of the Gag Grouper data series used in the assessment. The landings data are dominated by the recreational fishery, and recreational landings are more uncertain than commercial data. Additionally, before 1981, recreational data are estimated using a hindcasting procedure that is very sensitive to the assumed catches in 1981-1985 (as was shown by the impact that a single year's peak in Recreational Private + Shore landings had on the historical time series). Additionally, discards prior to 1981 are not quantified. Some data on the size of discarded fish are available for the Recreational Headboat and Recreational Charter fleets, but no such data are available for the Recreational Private + Shore fleet, which makes it difficult to quantify the impact of changing regulations on discarding behavior (such as the impact of the reduced recreational fishing season post 2011).

During initial runs, an attempt was made to input recreational catches in weight rather than numbers, to match management units. However, doing so caused instability in the estimates of initial fishing mortality (with the Commercial Vertical Line initial F bounding at 1). While the data period can easily make use of MRIP weight estimates to create a time series of catches in weight, more thought needs to be put into how to appropriately transform the historical time series into weights. This initial exercise raised concerns that converting the entirety of the historical time series with a single number-weight conversion factor is likely to introduce a directional bias into the assessment. This topic will therefore need to be investigated more thoroughly during a research track assessment.

There was a clear trade-off between fitting lengths and fitting ages. Earlier SEDAR72 runs attempted to input commercial ages as conditional-age-at-length (CAAL), which allows ages to be treated as a measure of the age distribution for a specific length. It assumes that each age observation is a random sample from the population for the given length bin. However, inputting commercial ages as CAAL caused a gross overestimation of asymptotic length (to 140cm FL) and an inability of the model to fit to the Private fleet length composition. The model was consistently shifting the selectivity for that fleet to the right of the observed data, essentially creating removals of larger/older fish in the Recreational Private + Shore fleet where such removals were not supported by the data. With the CAAL option turned on, increasing CVs around recreational catches caused additional model instability. In addition, the red tide effect could not be detected. Lee et al. (2019) warn modelers that using unrepresentative CAAL can cause bias in dynamics and management quantities. Given all the difficulties encountered when attempting to input commercial ages as CAAL, it appears that the age data indeed violated the assumptions required of the CAAL method.

Aggregating all years, the length composition of the retained catch for the commercial fleets was well fit. However, looking at individual years, a couple of patterns are apparent. The first is a strong pattern of positive residuals in the largest fish in the early 2000s in the Commercial Longline fleet. The second is a pattern that is visible in both the Commercial Vertical Line + Other and Commercial Longline fleets in the last 5 years of the time series. These patterns may signal time varying catchability and/or selectivity related to changes in fishing behavior due to changes in fishing practices and/or as a response to changes in management. There was anecdotal evidence of changes in catchability in the longline fleet in the 2000s gathered from the oral history exercise (see SEDAR72-WP-09) but not enough information to define exactly how and when changes occur. In addition, changes in regulations (depth of fishing, closed areas) have likely caused shifts in selectivity through time. This issue will need to be investigated in further detail during a research track assessment.

Though scales differ (largely due to the introduction of MRIP-FES estimates), the SEDAR72 Gag Grouper assessment and SEDAR33 Update assessments both predict similar stock trends up until 2009. This trend is characterized by a steady decline in stock biomass associated with a steady increase in exploitation rates from the beginning of the time series (1963) to 1980, followed by a period of relatively steady stock size until the late 1990s when the stock begins to increase and exploitation rates from the commercial fleets and Recreational Private + Shore ramp up (**Figure 63 and 42**). Catches from the commercial fleets then dramatically drop in the mid-2000s, as do stock sizes. Beyond 2009, the stock trajectories differ between SEDAR72 and the SEDAR33 Update. Where the SEDAR33 Update showed a steady increase in stock size from 2010 to 2015, SEDAR72 shows a milder incline followed by a downward trend post-2014. At the time that the SEDAR33 Update assessment was conducted, the analysts acknowledged that the terminal year stock size was very sensitive to assumptions on retention. The inclusion of new data post-2015 provides additional information on the impact of the 2014 red tide. This is clear in the retrospective analysis where just two additional years of data beyond 2014 considerably reduces uncertainty around the estimate of red tide kill for that year (**Figure 101**). In SEDAR72, the magnitude of the 2018 red tide is similarly uncertain as evident in the high CV (0.38) associated with the exploitation rate for that year (**Figure 41**).

Other important factors informing the 2009-2019 stock trend that were not available for SEDAR33 Update is the extended time series on discards for the commercial fleets, and the inclusion of additional years of discard length composition for the Recreational Headboat and Recreational Charter fleets which help inform retention curves (**Figure 67**). In addition, in the SEDAR33 Update, the fits to the video surveys and the Private and Charter CPUE indices were poor for the last 4 years of the time series (**Figure 76**), showing estimated values falling consistently above the observed index. In SEDAR72, fits to these indices are much improved (**Figure 76**).

A number of research questions were raised during the SEDAR72 assessment process. While attempts were made to address these questions through sensitivity runs and preliminary data exploration, the Operational nature of this assessment did not leave enough time to thoroughly evaluate each and every one of these questions. The SEFSC strongly recommends that these topics (listed in **Section 8**) be more thoroughly examined during a future Research Track assessment.

Overall, the SEDAR72 base model is improved since the SEDAR33 Benchmark and Update assessments, and it incorporates the best available data and addressed modeling issues evident in prior assessments.

6. Projections

6.1. Introduction

The SEDAR72 projections were run for the F_{max} key fishing mortality scenarios: F_0 and F_{OFL}. As the stock is overfished, rebuilding projections will need to be run once a rebuilding year is determined by the SSC.

6.2. Projection methods

The simulated dynamics used for projections assumed nearly identical parameter values and population dynamics as the SS base model. **Table 30** provides a summary of projection settings. Projections were run assuming that selectivity, discarding and retention were the same as the most recent year (to accommodate the fact that a block is imposed in 2019 due to the recent change in minimum size limit for the commercial fleet). Forecast recruitment values were derived from the model-estimated Beverton-Holt stock-recruitment relationship. The catch allocation among fleets used for the projections was unchanged from the SEDAR33 Update (0.39 commercial: 0.61 recreational).

The terminal year of the SEDAR72 assessment was 2019 and the first year of management advice was 2023. Retained catch for the interim years (2020-2022) used landings statistics when available, and the average of the last 3 years of retained catches, when not. Finalized landings statistics for 2020 were available for the Commercial Vertical Line + Other, Commercial Longline, and Recreational Headboat fleets. For the Recreational Charter and Recreational Private + Shore fleets, 2020 landings statistics were available but considered preliminary as they were missing Texas catch estimates for the last month and a half of 2020. Given the small proportion of catches missing, this preliminary estimate was used as the 2020 interim catch estimate. For the other two interim years (2021 and 2022), the average of the last 3 years of available landings, by fleet, were used as interim catch (i.e. 2018-2020), see **Table 30**.

F_{max} was determined using a long-term 100-year projection assuming that equilibrium was obtained over the last 10 years (2109-2119). For the OFL projection, the F_{max} was applied to the stock starting in 2023 while maintaining the fleet allocations currently in place (**Table 30**).

The minimum stock size threshold (MSST) was determined by multiplying the reference spawning stock biomass, SSB_{Fmax}, by 0.5 (per the SEDAR72 TORS) and was used to determine stock status (**Table 31**). The maximum fishing mortality threshold (MFMT) was equivalent to the harvest rate (F_{max}; total biomass killed age 3+ / total biomass age 3+) that achieved SSB_{Fmax}, and was used to assess whether overfishing was occurring in a given year (**Table 31**).

Once the proxy values were calculated, 2019 stock status was used to determine whether a rebuilding plan was required (i.e., if SSB < MSST then Gulf of Mexico Gag Grouper would be considered overfished and a rebuilding plan would be required). Since no rebuilding year was decided upon during the SEDAR72 assessment process, F_0 projections were run to determine the year in which the stock would rebuild in the absence of fishing mortality, which helps to determine the rebuilding year.

6.3. Projection results

Following the Terms of Reference, benchmarks and reference points were calculated in two ways: 1. assuming an SSB defined in terms of females only (“female-only SSB”), 2. assuming an SSB defined in terms of males and females combined (“SSB combined”).

6.3.1. Biological Reference Points

The following status determination criteria (SDCs) were adopted for Gulf of Mexico Gag Grouper:

- MSY proxy = yield at F_{max},
- MSST = 0.5*SSB_{Fmax} (Amendment 44),
- MFMT = F_{max} or $F_{rebuild}$ if overfished.

The harvest rate that results in SSB_{Fmax} over the long-term (100 years) was 0.303 for female-only SSB and 0.275 for SSB combined (**Table 31**). The resulting SSB_{Fmax} was 10,185 metric tons for female-only SSB and 13,401 for SSB combined. The minimum stock size threshold (MSST) was 5,092 metric tons and 6,700 metric tons, respectively (**Figure 130**).

6.3.2. Stock Status

Benchmarks and reference points for the two model specifications (female-only SSB and SSB combined) are shown in **Table 31**. Detailed time series assuming an SSB defined in terms of females only are presented in **Table 32**, and time series assuming an SSB defined in terms of males and females combined is presented in **Table 33**. Both scenarios give similar estimates of stock status. In both scenarios, the Gulf of Mexico Gag Grouper stock is undergoing overfishing ($F_{current} > MFMT$) and is overfished ($SSB_{2019} < MSST$) based on the definition of MSST ($0.5 * SSB_{Fmax}$), $F_{current}$ (geometric mean of the harvest rate over 2017-2019, including the 2018 red tide) and MFMT (F_{MAX}) for the final SEDAR72 base model (**Table 31**). The terminal year SSB is also well below the recovery target, SSB_{Fmax} in both scenarios (**Figure 130**). In 2019, SSB was only 21% of the biomass level needed to support MSY (17% under the combined SSB scenario). From 2017 to 2019 the estimated stock harvest rate, using the geometric mean, was 0.457 (0.453 for SSB-combined), which was equivalent to 151% of F_{max} (165 for SSB-combined) (**Table 31**, **Figure 130**).

The Kobe plot for the female-only SSB scenario (**Figure 131**) indicates that over the time horizon of the assessment (i.e., 1963 - 2019), the stock has experienced overfishing for 22 of the 57 assessment years and has experienced overfishing consistently since 2016, including the terminal (2019) year of the SEDAR72 assessment. The Kobe plot for the SSB combined scenario (**Figure 132**) indicates that over the time horizon of the assessment (i.e., 1963 - 2019), the stock has experienced overfishing for 26 of the 57 assessment years and has experienced overfishing consistently since 2016, including the terminal (2019) year of the SEDAR72 assessment.

As expected, prolonged overfishing reduced stock biomass below SSB_{Fmax} for 52 of the 57 assessment years (45 in the SSB-combined scenario). Using the MSST definition for Gulf of Mexico Gag Grouper, the stock has been in a consistent overfished state since 2014 (2000 for SSB-combined) dipping to just 6% of SSB_0 in 2019 (2% for SSB combined in 2019). Across the time series, there have been brief periods of moderate improvements in SSB, in the late 1990's/early 2000s and again around 2010, but each were followed by sharp declines in SSB (**Figure 130**) often following large red tide events.

6.3.3. Overfishing Limits and F0 projections

OFL projection results are provided in **Tables 34 and 35**. Forecasts begin in 2023 because management based on this stock assessment is not expected to begin until 2023. Since the stock is overfished (**Table 31**), a rebuilding projection will need to be conducted. The F0 projections show the stock rebuilding in 2025 in the female-only SSB scenario and 2026 in the SSB-combined scenario (**Tables 36 and 37**).

Since the stock is currently below the F_{max} target, forecasts indicate that a reduction in yield is required in the near-term in order to allow the stock to build towards the target SSB_{Fmax} (**Figures 133 and 134**).

7. Acknowledgements

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8. Research Recommendations

Recommendations for considerations of future research are provided below and do not indicate any particular order of priority.

Recreational Landings and Discards data

- Further develop best practices for correcting for prominent peaks and troughs in the earlier part of the time series where uncertainty is high and catch/discard estimates are driven by few but influencial intercept records.
- Develop estimates of uncertainty around Headboat discard estimates.
- Develop estimates of uncertainty around estimates of Recreational landings in weight.

Age and length composition

- Quantify and evaluate appropriate modeling and weighting procedures of length and age compositions to ensure age and length composition inputs are representative of the segment of the population being modeled.

Selectivity and catchability of the commercial fleets

- Further investigate and quantify changes in selectivity/catchability through time to improve fit to the discards and length compositions in recent years.
- Attempt to model changes in fishing behavior caused by the implementation of the IFQ through the use of time-varying selectivity and retention.
- Continue data collection from observer programs or electronic monitoring programs.

Selectivity and retention of the recreational fleets

- Further investigate and quantify changes in selectivity/catchability through time to improve fit to the length compositions across the time series.

Combined Video Index

- Continue the development of the Gulf of Mexico Gag Grouper Combined Video Index. Particularly, exploring ways to account for the survey and habitat effects. One possibility discussed during SEDAR72 would be to develop a separate index for the shallow/inshore and deep/offshore components of the surveys to better represent and track the various segments of the Gulf of Mexico Gag Grouper population through time.

Landings and Discards

- Explore approaches for assigning uncertainty estimates to commercial landings and revisit estimation of historic landings.
- Further investigate best practices for converting historical recreational landings from numbers to weight.

Recreational CPUE indices

- Additional research is needed to investigate if assumptions are appropriate across full time series (e.g., targeting, trip length, effects of various regulations, red snapper).

Natural mortality

- Explore ways to better reflect uncertainty about the mortality at age vector.

Red Tide and other sources of episodic mortality

- Continue to improve the way red tide mortality is modeled inside SS (e.g., extending the blocks-on-M method to older ages, including a vector of biomass loss), explore whether additional historical red tide years should also be modelled, and investigate other potential sources of episodic mortality (e.g. cold snaps) on the Gulf of Mexico Gag Grouper population.

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Tables

Table 1. Conversion factors used to convert fork length (FL) in millimeters to gutted weight (GW) in kilograms and to convert maximum total length (MaxTL) to fork length (FL) for Gulf of Mexico Gag males and females combined. Model fit criteria: linear regression models r2 and non-linear regression models residual square error (RSE).

Model	N	Range	R2 or RSE value	Years
GW=9x10-09*(FL^3.05)	2,407	FL (mm): 432-1335	0.980	1991-2005
		GW (kg): 0.99-32.21		
FL=1.07+MaxTL*0.97	4,789		0.997	1991-2012

Table 2. Growth parameters recommended for Gulf of Mexico Gag Grouper. The von Bertalanffy parameters (Linf, K, t0) were obtained from Lombardi et al. 2013. The CVs around young and old fish were updated during SEDAR 72 data workshop using a larger sample of fish.

Parameter	Value
Linf (mm FL)	1,272
K (year^{-1})	0.141
t0 (year)	-0.331
CV_{Amin}	0.107
CV_{Amax}	0.108

Table 3. Age-specific natural mortality (per year) for Gulf of Mexico Gag Grouper. The previously used mortality vector (from SEDAR 33 update) was considered for a sensitivity run. Female and male natural mortality were assumed equivalent.

Age	Base M	SEDAR33U (sensitivity run)
0	0.649	0.552
1	0.455	0.370
2	0.359	0.287
3	0.302	0.241
4	0.265	0.211
5	0.238	0.190
6	0.218	0.175
7	0.203	0.164
8	0.191	0.155
9	0.182	0.148
10	0.174	0.142
11	0.167	0.138
12	0.162	0.134
13	0.158	0.131
14	0.154	0.128
15	0.150	0.126
16	0.147	0.124
17	0.145	0.122
18	0.143	0.121
19	0.141	0.120
20	0.139	0.119
21	0.138	0.118

Table 3 Continued. Age-specific natural mortality (per year) for Gulf of Mexico Gag Grouper. The previously used mortality vector (from SEDAR 33 update) was considered for a sensitivity run. Female and male natural mortality were assumed equivalent.

Age	Base M	SEDAR33U (sensitivity run)
22	0.136	0.117
23	0.135	0.117
24	0.134	0.116
25	0.133	0.116
26	0.133	0.115
27	0.132	0.115
28	0.131	0.114
29	0.131	0.114
30	0.130	0.114
31	0.130	0.114
32	0.129	0.113
33	0.129	0.113

Table 4. Gulf of Mexico Gag Grouper commercial landings in pounds gutted weight. Landings by "Other" gears were lumped into the Commercial Vertical Line + Other fleet for input into the stock assessment. In the absence of uncertainty estimates provided at the SEDAR72 DW, commercial landings were assigned a log-scale SE of 0.05 for 1963-2009 and 0.01 for 2010-2019 (after implementation of the IFQ program).

Year	Vertical line	Longline	Other
1963	1,635,206		283
1964	2,032,352		9,190
1965	2,232,265		215
1966	1,870,118		552
1967	1,445,101		730
1968	1,510,120		763
1969	1,748,350		249
1970	1,661,050		3,608
1971	1,657,512		1,313
1972	1,767,927		1,160
1973	1,303,409		2,208
1974	1,463,371		651
1975	1,802,280		1,935
1976	1,449,027		48
1977	1,195,295		1,424
1978	1,069,058		1,109
1979	1,670,010	1,135	5,929
1980	1,646,986	96,132	6,076
1981	1,715,115	422,655	7,312
1982	1,532,289	886,011	2,468
1983	1,225,255	608,043	6,174
1984	1,343,374	415,961	14,200

Table 4 Continued. Gulf of Mexico Gag Grouper commercial landings in pounds gutted weight. Landings by "Other" gears were lumped into the Commercial Vertical Line + Other fleet for input into the stock assessment. In the absence of uncertainty estimates provided at the SEDAR72 DW, commercial landings were assigned a log-scale SE of 0.05 for 1963-2009 and 0.01 for 2010-2019 (after implementation of the IFQ program).

Year	Vertical line	Longline	Other
1985	1,735,687	369,959	21,442
1986	1,140,752	513,126	11,985
1987	842,029	648,598	7,641
1988	777,638	392,547	8,647
1989	1,215,190	417,686	9,787
1990	1,137,978	622,177	26,911
1991	995,060	501,969	42,342
1992	1,000,715	579,848	46,238
1993	1,273,479	457,451	89,179
1994	1,147,339	338,143	110,903
1995	1,155,902	373,377	98,788
1996	1,101,682	377,000	61,868
1997	1,092,849	395,610	78,488
1998	1,832,055	548,539	78,520
1999	1,457,853	518,929	61,322
2000	1,597,549	544,606	83,818
2001	2,056,505	912,854	102,535
2002	1,877,959	985,768	58,639
2003	1,446,925	1,052,862	63,277
2004	1,738,170	1,041,948	71,251
2005	1,527,939	831,898	68,052
2006	797,968	507,840	55,431

Table 4 Continued. Gulf of Mexico Gag Grouper commercial landings in pounds gutted weight. Landings by "Other" gears were lumped into the Commercial Vertical Line + Other fleet for input into the stock assessment. In the absence of uncertainty estimates provided at the SEDAR72 DW, commercial landings were assigned a log-scale SE of 0.05 for 1963-2009 and 0.01 for 2010-2019 (after implementation of the IFQ program).

Year	Vertical line	Longline	Other
2007	743,857	458,034	44,584
2008	902,389	364,403	43,939
2009	552,165	148,559	39,940
2010	344,021	108,494	44,304
2011	211,952	79,245	27,457
2012	355,606	127,927	39,599
2013	358,399	185,757	31,143
2014	316,632	210,220	59,501
2015	238,224	253,392	51,071
2016	465,093	399,769	46,075
2017	278,454	176,062	37,577
2018	278,408	170,430	44,095
2019	317,767	179,081	35,167

Table 5. Gulf of Mexico Gag Grouper recreational landings in numbers. Landings from Private, Shore and Private/Shore (from LA Creel) were lumped into the Recreational Private + Shore fleet for input into the stock assessment. Recreational landings were assigned a log-scale SE of 0.20.

Year	Charter	Headboat	Private	Shore	Private/Shore
1981	117,237	73,757	608,723	63,871	
1982	106,427	66,110	1,915,257	36,127	
1983	99,849	61,752	3,968,602*	78,197	
1984	69,957	43,780	516,838	36,820	
1985	164,180	103,116	952,189	127,425	
1986	367,116	29,289	862,311	9,735	
1987	106,620	25,801	885,599	21,354	
1988	86,865	24,467	920,196	25,036	
1989	74,357	33,840	743,073	31,739	
1990	26,279	18,280	534,198		
1991	35,079	10,714	551,502	25,401	
1992	156,110	12,960	449,852	21,937	
1993	137,481	17,229	664,643	49,510	
1994	66,607	18,495	437,080	6,013	
1995	112,353	15,465	860,043	36,256	
1996	199,052	10,720	465,773	11,111	
1997	139,119	10,494	789,805	2,606	
1998	199,321	31,098	901,778	66,796	
1999	137,899	27,845	1,160,379	24,736	
2000	127,608	27,625	1,300,642	22,105	
2001	84,576	11,875	1,020,875		

*The 1983 peak in Private landings was replaced by the geometric mean of Private mode landings for 1981, 1982, 1984, 1985. The new value is 870,324 fish.

Table 5 Continued. Gulf of Mexico Gag Grouper recreational landings in numbers. Landings from Private, Shore and Private/Shore (from LA Creel) were lumped into the Recreational Private + Shore fleet for input into the stock assessment. Recreational landings were assigned a log-scale SE of 0.20.

Year	Charter	Headboat	Private	Shore	Private/Shore
2002	114,051	9,796	1,169,815	5,463	
2003	92,980	13,012	880,899	6,904	
2004	134,341	20,063	1,411,016	2,279	
2005	126,872	12,932	1,100,299	47,178	
2006	70,445	4,728	653,196	6,164	
2007	33,991	10,029	523,377	7,250	
2008	89,110	9,414	854,330	15,831	
2009	46,692	8,600	416,932	1,596	
2010	60,233	10,340	538,069	13,556	
2011	10,632	4,921	306,268	1,425	
2012	46,754	4,362	235,197	1,837	
2013	24,939	4,889	441,836		
2014	12,425	5,976	312,987		462
2015	12,977	3,416	263,782		82
2016	17,623	2,109	194,463		294
2017	25,424	2,659	253,994		105
2018	19,823	2,657	280,114	3,828	210
2019	28,537	2,366	223,082	2,151	254

Table 6. Gulf of Mexico Gag Grouper commercial discards in numbers with associated log-scale standard errors (SE) input into the assessment model. Discards refer to the total number of fish discarded before applying the discard mortality rate.

Year	Vertical Line	Vertical Line SE	Longline	Longline SE
1993	17,085	0.218	588	0.238
1994	16,824	0.218	673	0.238
1995	18,991	0.218	660	0.238
1996	21,238	0.218	809	0.238
1997	22,344	0.218	779	0.238
1998	33,497	0.218	807	0.238
1999	28,141	0.218	819	0.238
2000	84,100	0.221	1,304	0.231
2001	100,510	0.221	1,586	0.231
2002	92,724	0.221	1,627	0.231
2003	79,853	0.221	1,727	0.231
2004	85,584	0.221	1,693	0.231
2005	79,540	0.221	1,457	0.231
2006	46,882	0.221	1,351	0.231
2007	34,192	0.221	764	0.231
2008	32,203	0.221	878	0.231
2009	37,010	0.221	457	0.231
2010	34,423	0.251	4,252	0.161
2011	28,390	0.251	4,503	0.161
2012	10,016	0.159	2,017	0.245
2013	9,958	0.159	2,473	0.245
2014	10,341	0.159	3,012	0.245
2015	8,010	0.159	3,242	0.245

Table 6 Continued. Gulf of Mexico Gag Grouper commercial discards in numbers with associated log-scale standard errors (SE) input into the assessment model. Discards refer to the total number of fish discarded before applying the discard mortality rate.

Year	Vertical Line	Vertical Line SE	Longline	Longline SE
2016	9,503	0.159	3,642	0.245
2017	7,887	0.159	3,505	0.245
2018	6,716	0.159	3,086	0.245
2019	20,621	0.251	6,193	0.161

Table 7. Gulf of Mexico Gag Grouper recreational discards in numbers with associated log-scale standard errors (SE) input into the assessment model. Discards refer to the total number of fish discarded before applying the discard mortality rate.

Year	Charter	Charter SE	Headboat	Headboat SE*	Private+Shore	Private+Shore SE
1981	89,783	0.844	56,153	1.046	615,085	0.567
1982	14,601	0.808	9,132	1.004	449,415	0.376
1983	15,011	0.617	9,388	0.731	823,774	0.514
1984	6,215	0.764	3,887	0.833	176,365	0.752
1985	22,980	0.562	14,373	0.827	256,737	0.628
1986	91,324	0.421	7,385	0.198	796,323	0.429
1987	17,620	0.367	4,304	0.198	648,759	0.340
1988	20,296	0.547	5,814	0.198	453,159	0.340
1989	46,217	0.514	21,810	0.198	1,075,491	0.275
1990	71,078	0.514	51,036	0.198	845,307	0.331
1991	3,502	0.744	1,187	0.198	2,284,401	0.263
1992	86,121	0.421	7,347	0.198	1,619,457	0.186
1993	97,098	0.489	12,369	0.198	3,530,464	0.183
1994	113,478	0.376	35,261	0.198	3,345,565	0.123
1995	308,655	0.284	43,452	0.198	4,335,845	0.142
1996	240,693	0.294	13,292	0.198	2,133,037	0.108
1997	168,734	0.275	12,984	0.198	3,597,320	0.115
1998	351,124	0.159	54,357	0.198	4,956,251	0.126
1999	233,276	0.090	48,522	0.198	4,342,616	0.106
2000	134,811	0.237	30,277	0.198	2,828,745	0.087
2001	201,966	0.376	30,345	0.198	5,096,702	0.125

*Headboat CVs were only provided from 1981 to 1985 (MRIP). CV was fixed to 0.2 from 1986 onward.

Table 7 Continued. Gulf of Mexico Gag Grouper recreational discards in numbers with associated log-scale standard errors (SE) input into the assessment model. Discards refer to the total number of fish discarded before applying the discard mortality rate.

Year	Charter	Charter SE	Headboat	Headboat SE*	Private+Shore	Private+Shore SE
2002	246,969	0.188	24,157	0.198	5,799,453	0.095
2003	296,289	0.129	43,680	0.198	6,765,832	0.085
2004	337,988	0.090	52,364	0.198	8,915,107	0.105
2005	339,608	0.090	36,512	0.198	5,606,645	0.102
2006	140,619	0.159	9,848	0.198	3,679,859	0.114
2007	113,324	0.188	35,003	0.198	5,067,763	0.105
2008	313,363	0.179	53,173	0.198	9,134,811	0.102
2009	267,022	0.256	52,392	0.198	5,976,209	0.096
2010	325,174	0.275	46,592	0.198	4,758,116	0.092
2011	190,736	0.149	45,679	0.198	3,436,386	0.152
2012	170,375	0.120	37,878	0.198	2,388,552	0.121
2013	234,277	0.322	34,756	0.198	2,403,121	0.131
2014	67,971	0.237	20,162	0.198	1,945,896	0.139
2015	72,623	0.256	15,967	0.198	1,211,294	0.130
2016	104,765	0.198	20,739	0.198	2,037,197	0.195
2017	145,159	0.294	16,555	0.198	3,215,085	0.166
2018	126,194	0.217	21,040	0.198	2,141,792	0.175
2019	99,177	0.246	18,297	0.198	2,333,626	0.170

*Headboat CVs were only provided from 1981 to 1985 (MRIP). CV was fixed to 0.2 from 1986 onward.

Table 8. Standardized indices of relative abundance for Gulf of Mexico Gag Grouper.

Year	CPUE Com VL	CPUE Com LL	CPUE Rec Hbt	CPUE CharPri Ind	CPUE Age-0 Surv	CPUE SEAMAP Surv	CPUE PC Surv
1986			1.529	1.704			
1987			1.588	0.360			
1988			1.306	0.495			
1989			1.154	0.319			
1990	0.314	0.823	1.025	0.724			
1991	0.313	0.642	0.751	0.712			
1992	0.561	0.511	0.714	0.788			
1993	0.649	0.670	0.725	1.001		0.441	
1994	0.587	0.378	0.756	1.100	0.804	0.107	
1995	0.781	0.481	0.801	1.575	0.619	0.295	
1996	0.929	0.504	1.114	1.358	2.063	0.798	
1997	0.905	0.642	1.151	1.232	0.468	0.447	
1998	1.544	0.953	1.118	1.565	0.202		
1999	1.074	0.854	1.312	1.240	0.309		
2000	1.106	0.880	1.026	0.904	0.487		
2001	1.591	1.639	0.658	1.078	0.416		
2002	1.588	1.438	0.684	1.228	1.350	1.977	
2003	1.561	1.708	0.971	1.773	0.795		
2004	1.988	2.064	1.033	1.694	1.883	2.058	
2005	1.869	2.261	1.273	1.860	0.854	2.491	
2006	1.004	1.199	0.563	1.082	2.516	1.223	2.300
2007	0.646	0.910	0.612	1.121	2.287	1.676	1.610
2008	0.639	0.994	0.948	1.572	3.236	0.267	1.074

Table 8 Continued. Standardized indices of relative abundance for Gulf of Mexico Gag Grouper.

Year	CPUE Com VL	CPUE Com LL	CPUE Rec Hbt	CPUE CharPri Ind	CPUE Age-0 Surv	CPUE SEAMAP Surv	CPUE PC Surv
2009	0.349	0.448	0.937	1.205	0.873	0.796	1.650
2010			1.251	1.190	1.248	1.080	1.450
2011				0.843	0.088	1.463	1.075
2012				0.775	0.495	1.674	0.351
2013				0.544	0.805	1.484	0.642
2014				0.447	0.379	0.713	0.438
2015				0.301	0.756	1.136	0.288
2016				0.448	1.111	0.258	0.530
2017				0.568	1.078	0.384	0.686
2018				0.660	0.283	0.436	0.525
2019				0.530	0.595	0.798	1.383

Table 9. Log scale standard error associated with each standardized relative abundance index for Gulf of Mexico Gag Grouper. *Note: these values represent the original estimates of uncertainty and do not include the additional standard error estimated through the Francis data weighting procedure.*

Year	SE Com VL	SE Com LL	SE Rec Hbt	SE CharPri Ind	SE Age-0 Surv	SE SEAMAP Surv	SE PC Surv
1986			0.166	0.177			
1987			0.163	0.281			
1988			0.170	0.380			
1989			0.171	0.301			
1990	0.309	0.418	0.172	0.290			
1991	0.235	0.343	0.190	0.299			
1992	0.229	0.347	0.201	0.207			
1993	0.203	0.287	0.194	0.194		0.385	
1994	0.202	0.296	0.197	0.187	0.319	0.439	
1995	0.198	0.289	0.189	0.169	0.245	0.343	
1996	0.196	0.298	0.170	0.174	0.164	0.367	
1997	0.193	0.276	0.162	0.157	0.193	0.292	
1998	0.192	0.275	0.168	0.130	0.311		
1999	0.193	0.278	0.163	0.127	0.256		
2000	0.194	0.280	0.183	0.140	0.257		
2001	0.194	0.269	0.200	0.135	0.277		
2002	0.194	0.280	0.203	0.133	0.193	0.456	
2003	0.195	0.272	0.190	0.123	0.214		
2004	0.195	0.267	0.187	0.120	0.162	0.259	
2005	0.196	0.262	0.159	0.122	0.170	0.421	
2006	0.200	0.268	0.211	0.144	0.143	0.338	0.190
2007	0.204	0.282	0.214	0.148	0.142	0.411	0.243

Table 9 Continued. Log scale standard error associated with each standardized relative abundance index for Gulf of Mexico Gag Grouper. *Note: these values represent the original estimates of uncertainty and do not include the additional standard error estimated through the Francis data weighting procedure.*

Year	SE Com VL	SE Com LL	SE Rec Hbt	SE CharPri Ind	SE Age-0 Surv	SE SEAMAP Surv	SE PC Surv
2008	0.206	0.269	0.189	0.132	0.095	0.349	0.237
2009	0.208	0.336	0.187	0.144	0.151	0.258	0.169
2010			0.181	0.153	0.154	0.196	0.168
2011				0.154	0.252	0.175	0.195
2012				0.159	0.158	0.259	0.305
2013				0.179	0.155	0.378	0.347
2014				0.168	0.193	0.255	0.250
2015				0.205	0.162	0.400	0.361
2016				0.193	0.137	0.209	0.305
2017				0.183	0.147	0.238	0.259
2018				0.186	0.201	0.211	0.322
2019				0.217	0.158	0.826	0.238

Table 10. List of Stock Synthesis parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values, lower and upper bounds of the parameters, associated standard errors and coefficients of variation, the prior type and densities (value, SE) assigned to the parameters as applicable, and phases (negative identifies parameters that were fixed). Parameters designated as fixed were held at their initial values and have no associated range or SE.

Label	Value	Range	SE	CV	Prior	Phase
L_at_Amin_Fem_GP_1	28.9	(10,40)	0.477	0.017	Sym_Beta(0.8)	3
L_at_Amax_Fem_GP_1	122.38	(80,160)	2.67	0.022	Sym_Beta(0.8)	3
VonBert_K_Fem_GP_1	0.119	(0.05,0.3)	0.006	0.048	Sym_Beta(0.8)	3
CV_young_Fem_GP_1	0.107					Fixed
CV_old_Fem_GP_1	0.108					Fixed
Wtlen_1_Fem_GP_1	8.75e-06					Fixed
Wtlen_2_Fem_GP_1	3.08					Fixed
Mat50%_Fem_GP_1	3.89					Fixed
Mat_slope_Fem_GP_1	-2.51					Fixed
Eggs_scalar_Fem_GP_1	1					Fixed
Eggs_exp_wt_Fem_GP_1	1					Fixed
Herm_Infl_age	13.83					Fixed
Herm_stdev	4.51					Fixed
Herm_asymptote	1					Fixed
CohortGrowDev	1					Fixed
FracFemale_GP_1	1					Fixed
SR_LN(R0)	9.34	(1,40)	0.054	0.006		1
SR_BH_steep	0.855					Fixed
SR_sigmaR	0.6					Fixed
SR_regime	0.00e+00					Fixed
SR_autocorr	0.00e+00					Fixed
SR_regime_BLK4add_1962	-0.184	(-5,5)	0.084	-		1
Early_RecrDev_1963	-0.503	(-5,5)	0.49	-		6
Early_RecrDev_1964	-0.518	(-5,5)	0.488	-		6
Early_RecrDev_1965	-0.527	(-5,5)	0.486	-		6
Early_RecrDev_1966	-0.528	(-5,5)	0.486	-		6
Early_RecrDev_1967	-0.518	(-5,5)	0.487	-		6
Early_RecrDev_1968	-0.498	(-5,5)	0.49	-		6
Early_RecrDev_1969	-0.466	(-5,5)	0.495	-		6

Table 10 Continued. List of Stock Synthesis parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values, lower and upper bounds of the parameters, associated standard errors and coefficients of variation, the prior type and densities (value, SE) assigned to the parameters as applicable, and phases (negative identifies parameters that were fixed). Parameters designated as fixed were held at their initial values and have no associated range or SE.

Label	Value	Range	SE	CV	Prior	Phase
Early_RecrDev_1970	-0.419	(-5,5)	0.504	-		6
Early_RecrDev_1971	-0.348	(-5,5)	0.517	-		6
Early_RecrDev_1972	-0.236	(-5,5)	0.533	-		6
Early_RecrDev_1973	-0.084	(-5,5)	0.545	-		6
Early_RecrDev_1974	0.105	(-5,5)	0.541	5.140		6
Early_RecrDev_1975	0.106	(-5,5)	0.524	4.950		6
Early_RecrDev_1976	-0.009	(-5,5)	0.49	-		6
Early_RecrDev_1977	-0.109	(-5,5)	0.459	-		6
Early_RecrDev_1978	0.323	(-5,5)	0.293	0.908		6
Early_RecrDev_1979	-0.184	(-5,5)	0.325	-		6
Early_RecrDev_1980	-0.168	(-5,5)	0.249	-		6
Early_RecrDev_1981	0.337	(-5,5)	0.145	0.430		6
Early_RecrDev_1982	-0.268	(-5,5)	0.192	-		6
Early_RecrDev_1983	0.004	(-5,5)	0.141	38.01		6
Main_RecrDev_1984	-0.164	(-5,5)	0.125	-		3
Main_RecrDev_1985	0.028	(-5,5)	0.09	3.180		3
Main_RecrDev_1986	-0.831	(-5,5)	0.119	-		3
Main_RecrDev_1987	-0.467	(-5,5)	0.092	-		3
Main_RecrDev_1988	-0.969	(-5,5)	0.116	-		3
Main_RecrDev_1989	0.428	(-5,5)	0.065	0.153		3
Main_RecrDev_1990	-0.573	(-5,5)	0.095	-		3
Main_RecrDev_1991	-0.334	(-5,5)	0.088	-		3
Main_RecrDev_1992	-0.174	(-5,5)	0.088	-		3
Main_RecrDev_1993	0.823	(-5,5)	0.063	0.076		3
Main_RecrDev_1994	0.465	(-5,5)	0.076	0.163		3
Main_RecrDev_1995	0.181	(-5,5)	0.083	0.461		3
Main_RecrDev_1996	1.08	(-5,5)	0.056	0.052		3

Table 10 Continued. List of Stock Synthesis parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values, lower and upper bounds of the parameters, associated standard errors and coefficients of variation, the prior type and densities (value, SE) assigned to the parameters as applicable, and phases (negative identifies parameters that were fixed). Parameters designated as fixed were held at their initial values and have no associated range or SE.

Label	Value	Range	SE	CV	Prior	Phase
Main_RecrDev_1997	0.437	(-5,5)	0.066	0.152		3
Main_RecrDev_1998	-0.208	(-5,5)	0.082	-		3
Main_RecrDev_1999	0.71	(-5,5)	0.063	0.088		3
Main_RecrDev_2000	0.614	(-5,5)	0.065	0.107		3
Main_RecrDev_2001	0.393	(-5,5)	0.076	0.193		3
Main_RecrDev_2002	0.737	(-5,5)	0.085	0.115		3
Main_RecrDev_2003	0.402	(-5,5)	0.104	0.259		3
Main_RecrDev_2004	0.393	(-5,5)	0.107	0.274		3
Main_RecrDev_2005	0.668	(-5,5)	0.104	0.156		3
Main_RecrDev_2006	0.462	(-5,5)	0.053	0.114		3
Main_RecrDev_2007	0.49	(-5,5)	0.051	0.104		3
Main_RecrDev_2008	-0.058	(-5,5)	0.058	-		3
Main_RecrDev_2009	-0.345	(-5,5)	0.068	-		3
Main_RecrDev_2010	0.112	(-5,5)	0.081	0.726		3
Main_RecrDev_2011	-1.47	(-5,5)	0.152	-		3
Main_RecrDev_2012	-0.679	(-5,5)	0.164	-		3
Main_RecrDev_2013	-0.347	(-5,5)	0.175	-		3
Main_RecrDev_2014	-0.254	(-5,5)	0.163	-		3
Main_RecrDev_2015	-0.285	(-5,5)	0.095	-		3
Main_RecrDev_2016	0.01	(-5,5)	0.108	10.99		3
Main_RecrDev_2017	-0.108	(-5,5)	0.147	-		3
Main_RecrDev_2018	-0.731	(-5,5)	0.214	-		3
Main_RecrDev_2019	-0.433	(-5,5)	0.349	-		3
InitF_seas_1_flt_1Com_VL_OTH_1	0.041	(0,1)	0.014	0.353		1
InitF_seas_1_flt_5Rec_PRIV_SH_5	0.115	(0,1)	0.035	0.301		1
F_fleet_1_YR_1963_s_1	0.036	(0,2.9)	0.013	0.346		1
F_fleet_1_YR_1964_s_1	0.045	(0,2.9)	0.015	0.336		1

Table 10 Continued. List of Stock Synthesis parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values, lower and upper bounds of the parameters, associated standard errors and coefficients of variation, the prior type and densities (value, SE) assigned to the parameters as applicable, and phases (negative identifies parameters that were fixed). Parameters designated as fixed were held at their initial values and have no associated range or SE.

Label	Value	Range	SE	CV	Prior	Phase
F_fleet_1_YR_1965_s_1	0.05	(0,2.9)	0.016	0.326		1
F_fleet_1_YR_1966_s_1	0.043	(0,2.9)	0.014	0.316		1
F_fleet_1_YR_1967_s_1	0.034	(0,2.9)	0.011	0.306		1
F_fleet_1_YR_1968_s_1	0.038	(0,2.9)	0.011	0.297		1
F_fleet_1_YR_1969_s_1	0.047	(0,2.9)	0.014	0.292		1
F_fleet_1_YR_1970_s_1	0.048	(0,2.9)	0.014	0.288		1
F_fleet_1_YR_1971_s_1	0.053	(0,2.9)	0.015	0.284		1
F_fleet_1_YR_1972_s_1	0.063	(0,2.9)	0.018	0.281		1
F_fleet_1_YR_1973_s_1	0.052	(0,2.9)	0.014	0.276		1
F_fleet_1_YR_1974_s_1	0.066	(0,2.9)	0.018	0.268		1
F_fleet_1_YR_1975_s_1	0.093	(0,2.9)	0.024	0.259		1
F_fleet_1_YR_1976_s_1	0.084	(0,2.9)	0.02	0.244		1
F_fleet_1_YR_1977_s_1	0.075	(0,2.9)	0.017	0.220		1
F_fleet_1_YR_1978_s_1	0.071	(0,2.9)	0.014	0.192		1
F_fleet_1_YR_1979_s_1	0.117	(0,2.9)	0.02	0.167		1
F_fleet_1_YR_1980_s_1	0.123	(0,2.9)	0.018	0.147		1
F_fleet_1_YR_1981_s_1	0.135	(0,2.9)	0.018	0.132		1
F_fleet_1_YR_1982_s_1	0.125	(0,2.9)	0.015	0.123		1
F_fleet_1_YR_1983_s_1	0.105	(0,2.9)	0.012	0.116		1
F_fleet_1_YR_1984_s_1	0.112	(0,2.9)	0.012	0.109		1
F_fleet_1_YR_1985_s_1	0.138	(0,2.9)	0.014	0.104		1
F_fleet_1_YR_1986_s_1	0.091	(0,2.9)	0.009	0.100		1
F_fleet_1_YR_1987_s_1	0.068	(0,2.9)	0.007	0.097		1
F_fleet_1_YR_1988_s_1	0.062	(0,2.9)	0.006	0.093		1
F_fleet_1_YR_1989_s_1	0.098	(0,2.9)	0.009	0.090		1
F_fleet_1_YR_1990_s_1	0.098	(0,2.9)	0.009	0.089		1
F_fleet_1_YR_1991_s_1	0.093	(0,2.9)	0.008	0.088		1

Table 10 Continued. List of Stock Synthesis parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values, lower and upper bounds of the parameters, associated standard errors and coefficients of variation, the prior type and densities (value, SE) assigned to the parameters as applicable, and phases (negative identifies parameters that were fixed). Parameters designated as fixed were held at their initial values and have no associated range or SE.

Label	Value	Range	SE	CV	Prior	Phase
F_fleet_1_YR_1992_s_1	0.098	(0,2.9)	0.009	0.088		1
F_fleet_1_YR_1993_s_1	0.135	(0,2.9)	0.012	0.086		1
F_fleet_1_YR_1994_s_1	0.123	(0,2.9)	0.01	0.085		1
F_fleet_1_YR_1995_s_1	0.127	(0,2.9)	0.011	0.083		1
F_fleet_1_YR_1996_s_1	0.116	(0,2.9)	0.01	0.084		1
F_fleet_1_YR_1997_s_1	0.099	(0,2.9)	0.008	0.083		1
F_fleet_1_YR_1998_s_1	0.151	(0,2.9)	0.012	0.080		1
F_fleet_1_YR_1999_s_1	0.126	(0,2.9)	0.01	0.081		1
F_fleet_1_YR_2000_s_1	0.137	(0,2.9)	0.011	0.081		1
F_fleet_1_YR_2001_s_1	0.164	(0,2.9)	0.013	0.080		1
F_fleet_1_YR_2002_s_1	0.148	(0,2.9)	0.012	0.081		1
F_fleet_1_YR_2003_s_1	0.114	(0,2.9)	0.01	0.087		1
F_fleet_1_YR_2004_s_1	0.138	(0,2.9)	0.014	0.099		1
F_fleet_1_YR_2005_s_1	0.182	(0,2.9)	0.017	0.092		1
F_fleet_1_YR_2006_s_1	0.162	(0,2.9)	0.014	0.085		1
F_fleet_1_YR_2007_s_1	0.151	(0,2.9)	0.013	0.089		1
F_fleet_1_YR_2008_s_1	0.215	(0,2.9)	0.02	0.093		1
F_fleet_1_YR_2009_s_1	0.166	(0,2.9)	0.017	0.103		1
F_fleet_1_YR_2010_s_1	0.097	(0,2.9)	0.01	0.100		1
F_fleet_1_YR_2011_s_1	0.049	(0,2.9)	0.005	0.108		1
F_fleet_1_YR_2012_s_1	0.061	(0,2.9)	0.007	0.116		1
F_fleet_1_YR_2013_s_1	0.059	(0,2.9)	0.009	0.162		1
F_fleet_1_YR_2014_s_1	0.077	(0,2.9)	0.011	0.144		1
F_fleet_1_YR_2015_s_1	0.081	(0,2.9)	0.006	0.080		1
F_fleet_1_YR_2016_s_1	0.151	(0,2.9)	0.014	0.093		1
F_fleet_1_YR_2017_s_1	0.099	(0,2.9)	0.011	0.114		1
F_fleet_1_YR_2018_s_1	0.112	(0,2.9)	0.013	0.119		1

Table 10 Continued. List of Stock Synthesis parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values, lower and upper bounds of the parameters, associated standard errors and coefficients of variation, the prior type and densities (value, SE) assigned to the parameters as applicable, and phases (negative identifies parameters that were fixed). Parameters designated as fixed were held at their initial values and have no associated range or SE.

Label	Value	Range	SE	CV	Prior	Phase
F_fleet_1_YR_2019_s_1	0.148	(0,2.9)	0.037	0.250		1
F_fleet_2_YR_1979_s_1	1.06e-04	(0,2.9)	2.31e	0.217		1
F_fleet_2_YR_1980_s_1	0.01	(0,2.9)	0.002	0.193		1
F_fleet_2_YR_1981_s_1	0.047	(0,2.9)	0.008	0.170		1
F_fleet_2_YR_1982_s_1	0.107	(0,2.9)	0.017	0.154		1
F_fleet_2_YR_1983_s_1	0.079	(0,2.9)	0.011	0.141		1
F_fleet_2_YR_1984_s_1	0.053	(0,2.9)	0.007	0.128		1
F_fleet_2_YR_1985_s_1	0.045	(0,2.9)	0.005	0.118		1
F_fleet_2_YR_1986_s_1	0.063	(0,2.9)	0.007	0.112		1
F_fleet_2_YR_1987_s_1	0.079	(0,2.9)	0.008	0.106		1
F_fleet_2_YR_1988_s_1	0.046	(0,2.9)	0.005	0.100		1
F_fleet_2_YR_1989_s_1	0.049	(0,2.9)	0.005	0.096		1
F_fleet_2_YR_1990_s_1	0.074	(0,2.9)	0.007	0.094		1
F_fleet_2_YR_1991_s_1	0.062	(0,2.9)	0.006	0.092		1
F_fleet_2_YR_1992_s_1	0.077	(0,2.9)	0.007	0.091		1
F_fleet_2_YR_1993_s_1	0.07	(0,2.9)	0.006	0.091		1
F_fleet_2_YR_1994_s_1	0.054	(0,2.9)	0.005	0.091		1
F_fleet_2_YR_1995_s_1	0.061	(0,2.9)	0.005	0.090		1
F_fleet_2_YR_1996_s_1	0.065	(0,2.9)	0.006	0.090		1
F_fleet_2_YR_1997_s_1	0.063	(0,2.9)	0.006	0.089		1
F_fleet_2_YR_1998_s_1	0.082	(0,2.9)	0.007	0.088		1
F_fleet_2_YR_1999_s_1	0.081	(0,2.9)	0.007	0.088		1
F_fleet_2_YR_2000_s_1	0.083	(0,2.9)	0.007	0.087		1
F_fleet_2_YR_2001_s_1	0.116	(0,2.9)	0.01	0.087		1
F_fleet_2_YR_2002_s_1	0.12	(0,2.9)	0.011	0.088		1
F_fleet_2_YR_2003_s_1	0.127	(0,2.9)	0.012	0.092		1
F_fleet_2_YR_2004_s_1	0.13	(0,2.9)	0.014	0.105		1

Table 10 Continued. List of Stock Synthesis parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values, lower and upper bounds of the parameters, associated standard errors and coefficients of variation, the prior type and densities (value, SE) assigned to the parameters as applicable, and phases (negative identifies parameters that were fixed). Parameters designated as fixed were held at their initial values and have no associated range or SE.

Label	Value	Range	SE	CV	Prior	Phase
F_fleet_2_YR_2005_s_1	0.155	(0,2.9)	0.015	0.098		1
F_fleet_2_YR_2006_s_1	0.164	(0,2.9)	0.015	0.090		1
F_fleet_2_YR_2007_s_1	0.15	(0,2.9)	0.014	0.094		1
F_fleet_2_YR_2008_s_1	0.144	(0,2.9)	0.014	0.098		1
F_fleet_2_YR_2009_s_1	0.075	(0,2.9)	0.008	0.109		1
F_fleet_2_YR_2010_s_1	0.058	(0,2.9)	0.006	0.109		1
F_fleet_2_YR_2011_s_1	0.043	(0,2.9)	0.005	0.119		1
F_fleet_2_YR_2012_s_1	0.049	(0,2.9)	0.006	0.124		1
F_fleet_2_YR_2013_s_1	0.062	(0,2.9)	0.01	0.165		1
F_fleet_2_YR_2014_s_1	0.087	(0,2.9)	0.013	0.146		1
F_fleet_2_YR_2015_s_1	0.136	(0,2.9)	0.011	0.084		1
F_fleet_2_YR_2016_s_1	0.226	(0,2.9)	0.022	0.097		1
F_fleet_2_YR_2017_s_1	0.111	(0,2.9)	0.013	0.119		1
F_fleet_2_YR_2018_s_1	0.13	(0,2.9)	0.016	0.124		1
F_fleet_2_YR_2019_s_1	0.168	(0,2.9)	0.043	0.254		1
F_fleet_3_YR_1963_s_1	0.003	(0,2.9)	4.36e	0.165		1
F_fleet_3_YR_1964_s_1	0.003	(0,2.9)	7.36e	0.264		1
F_fleet_3_YR_1965_s_1	0.003	(0,2.9)	8.29e	0.267		1
F_fleet_3_YR_1966_s_1	0.004	(0,2.9)	9.83e	0.278		1
F_fleet_3_YR_1967_s_1	0.004	(0,2.9)	0.001	0.290		1
F_fleet_3_YR_1968_s_1	0.005	(0,2.9)	0.001	0.299		1
F_fleet_3_YR_1969_s_1	0.005	(0,2.9)	0.002	0.306		1
F_fleet_3_YR_1970_s_1	0.006	(0,2.9)	0.002	0.312		1
F_fleet_3_YR_1971_s_1	0.006	(0,2.9)	0.002	0.316		1
F_fleet_3_YR_1972_s_1	0.007	(0,2.9)	0.002	0.321		1
F_fleet_3_YR_1973_s_1	0.008	(0,2.9)	0.003	0.326		1
F_fleet_3_YR_1974_s_1	0.009	(0,2.9)	0.003	0.328		1

Table 10 Continued. List of Stock Synthesis parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values, lower and upper bounds of the parameters, associated standard errors and coefficients of variation, the prior type and densities (value, SE) assigned to the parameters as applicable, and phases (negative identifies parameters that were fixed). Parameters designated as fixed were held at their initial values and have no associated range or SE.

Label	Value	Range	SE	CV	Prior	Phase
F_fleet_3_YR_1975_s_1	0.009	(0,2.9)	0.003	0.319		1
F_fleet_3_YR_1976_s_1	0.009	(0,2.9)	0.003	0.302		1
F_fleet_3_YR_1977_s_1	0.008	(0,2.9)	0.002	0.280		1
F_fleet_3_YR_1978_s_1	0.008	(0,2.9)	0.002	0.263		1
F_fleet_3_YR_1979_s_1	0.008	(0,2.9)	0.002	0.248		1
F_fleet_3_YR_1980_s_1	0.008	(0,2.9)	0.002	0.238		1
F_fleet_3_YR_1981_s_1	0.022	(0,2.9)	0.005	0.229		1
F_fleet_3_YR_1982_s_1	0.018	(0,2.9)	0.004	0.228		1
F_fleet_3_YR_1983_s_1	0.016	(0,2.9)	0.004	0.223		1
F_fleet_3_YR_1984_s_1	0.011	(0,2.9)	0.002	0.225		1
F_fleet_3_YR_1985_s_1	0.026	(0,2.9)	0.006	0.221		1
F_fleet_3_YR_1986_s_1	0.006	(0,2.9)	0.001	0.167		1
F_fleet_3_YR_1987_s_1	0.006	(0,2.9)	9.41e	0.169		1
F_fleet_3_YR_1988_s_1	0.007	(0,2.9)	0.001	0.166		1
F_fleet_3_YR_1989_s_1	0.02	(0,2.9)	0.003	0.160		1
F_fleet_3_YR_1990_s_1	0.014	(0,2.9)	0.002	0.155		1
F_fleet_3_YR_1991_s_1	0.001	(0,2.9)	2.08e	0.202		1
F_fleet_3_YR_1992_s_1	0.004	(0,2.9)	6.85e	0.160		1
F_fleet_3_YR_1993_s_1	0.006	(0,2.9)	0.001	0.160		1
F_fleet_3_YR_1994_s_1	0.008	(0,2.9)	0.001	0.158		1
F_fleet_3_YR_1995_s_1	0.008	(0,2.9)	0.001	0.156		1
F_fleet_3_YR_1996_s_1	0.003	(0,2.9)	5.01e	0.158		1
F_fleet_3_YR_1997_s_1	0.002	(0,2.9)	3.86e	0.159		1
F_fleet_3_YR_1998_s_1	0.009	(0,2.9)	0.001	0.156		1
F_fleet_3_YR_1999_s_1	0.009	(0,2.9)	0.001	0.154		1
F_fleet_3_YR_2000_s_1	0.007	(0,2.9)	0.001	0.157		1
F_fleet_3_YR_2001_s_1	0.004	(0,2.9)	6.88e	0.155		1

Table 10 Continued. List of Stock Synthesis parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values, lower and upper bounds of the parameters, associated standard errors and coefficients of variation, the prior type and densities (value, SE) assigned to the parameters as applicable, and phases (negative identifies parameters that were fixed). Parameters designated as fixed were held at their initial values and have no associated range or SE.

Label	Value	Range	SE	CV	Prior	Phase
F_fleet_3_YR_2002_s_1	0.004	(0,2.9)	5.48e	0.157		1
F_fleet_3_YR_2003_s_1	0.005	(0,2.9)	8.13e	0.160		1
F_fleet_3_YR_2004_s_1	0.007	(0,2.9)	0.001	0.169		1
F_fleet_3_YR_2005_s_1	0.007	(0,2.9)	0.001	0.163		1
F_fleet_3_YR_2006_s_1	0.003	(0,2.9)	5.23e	0.160		1
F_fleet_3_YR_2007_s_1	0.008	(0,2.9)	0.001	0.158		1
F_fleet_3_YR_2008_s_1	0.01	(0,2.9)	0.002	0.156		1
F_fleet_3_YR_2009_s_1	0.01	(0,2.9)	0.001	0.155		1
F_fleet_3_YR_2010_s_1	0.011	(0,2.9)	0.002	0.157		1
F_fleet_3_YR_2011_s_1	0.011	(0,2.9)	0.002	0.182		1
F_fleet_3_YR_2012_s_1	0.011	(0,2.9)	0.002	0.190		1
F_fleet_3_YR_2013_s_1	0.011	(0,2.9)	0.002	0.211		1
F_fleet_3_YR_2014_s_1	0.012	(0,2.9)	0.002	0.193		1
F_fleet_3_YR_2015_s_1	0.01	(0,2.9)	0.002	0.173		1
F_fleet_3_YR_2016_s_1	0.008	(0,2.9)	0.001	0.174		1
F_fleet_3_YR_2017_s_1	0.008	(0,2.9)	0.001	0.187		1
F_fleet_3_YR_2018_s_1	0.009	(0,2.9)	0.002	0.186		1
F_fleet_3_YR_2019_s_1	0.009	(0,2.9)	0.002	0.266		1
F_fleet_4_YR_1963_s_1	0.016	(0,2.9)	0.003	0.174		1
F_fleet_4_YR_1964_s_1	0.016	(0,2.9)	0.004	0.269		1
F_fleet_4_YR_1965_s_1	0.018	(0,2.9)	0.005	0.270		1
F_fleet_4_YR_1966_s_1	0.021	(0,2.9)	0.006	0.279		1
F_fleet_4_YR_1967_s_1	0.023	(0,2.9)	0.007	0.291		1
F_fleet_4_YR_1968_s_1	0.027	(0,2.9)	0.008	0.301		1
F_fleet_4_YR_1969_s_1	0.03	(0,2.9)	0.009	0.309		1
F_fleet_4_YR_1970_s_1	0.033	(0,2.9)	0.01	0.315		1
F_fleet_4_YR_1971_s_1	0.039	(0,2.9)	0.012	0.320		1

Table 10 Continued. List of Stock Synthesis parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values, lower and upper bounds of the parameters, associated standard errors and coefficients of variation, the prior type and densities (value, SE) assigned to the parameters as applicable, and phases (negative identifies parameters that were fixed). Parameters designated as fixed were held at their initial values and have no associated range or SE.

Label	Value	Range	SE	CV	Prior	Phase
F_fleet_4_YR_1972_s_1	0.045	(0,2.9)	0.014	0.325		1
F_fleet_4_YR_1973_s_1	0.05	(0,2.9)	0.017	0.330		1
F_fleet_4_YR_1974_s_1	0.055	(0,2.9)	0.018	0.333		1
F_fleet_4_YR_1975_s_1	0.057	(0,2.9)	0.018	0.325		1
F_fleet_4_YR_1976_s_1	0.053	(0,2.9)	0.016	0.308		1
F_fleet_4_YR_1977_s_1	0.051	(0,2.9)	0.014	0.285		1
F_fleet_4_YR_1978_s_1	0.051	(0,2.9)	0.014	0.266		1
F_fleet_4_YR_1979_s_1	0.051	(0,2.9)	0.013	0.251		1
F_fleet_4_YR_1980_s_1	0.05	(0,2.9)	0.012	0.239		1
F_fleet_4_YR_1981_s_1	0.042	(0,2.9)	0.01	0.225		1
F_fleet_4_YR_1982_s_1	0.033	(0,2.9)	0.008	0.226		1
F_fleet_4_YR_1983_s_1	0.03	(0,2.9)	0.007	0.219		1
F_fleet_4_YR_1984_s_1	0.02	(0,2.9)	0.004	0.224		1
F_fleet_4_YR_1985_s_1	0.046	(0,2.9)	0.01	0.214		1
F_fleet_4_YR_1986_s_1	0.117	(0,2.9)	0.023	0.200		1
F_fleet_4_YR_1987_s_1	0.035	(0,2.9)	0.007	0.199		1
F_fleet_4_YR_1988_s_1	0.034	(0,2.9)	0.007	0.209		1
F_fleet_4_YR_1989_s_1	0.039	(0,2.9)	0.008	0.202		1
F_fleet_4_YR_1990_s_1	0.019	(0,2.9)	0.004	0.204		1
F_fleet_4_YR_1991_s_1	0.017	(0,2.9)	0.004	0.221		1
F_fleet_4_YR_1992_s_1	0.069	(0,2.9)	0.014	0.197		1
F_fleet_4_YR_1993_s_1	0.063	(0,2.9)	0.013	0.198		1
F_fleet_4_YR_1994_s_1	0.036	(0,2.9)	0.007	0.192		1
F_fleet_4_YR_1995_s_1	0.065	(0,2.9)	0.012	0.176		1
F_fleet_4_YR_1996_s_1	0.075	(0,2.9)	0.014	0.181		1
F_fleet_4_YR_1997_s_1	0.042	(0,2.9)	0.008	0.179		1
F_fleet_4_YR_1998_s_1	0.08	(0,2.9)	0.011	0.139		1

Table 10 Continued. List of Stock Synthesis parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values, lower and upper bounds of the parameters, associated standard errors and coefficients of variation, the prior type and densities (value, SE) assigned to the parameters as applicable, and phases (negative identifies parameters that were fixed). Parameters designated as fixed were held at their initial values and have no associated range or SE.

Label	Value	Range	SE	CV	Prior	Phase
F_fleet_4_YR_1999_s_1	0.081	(0,2.9)	0.008	0.102		1
F_fleet_4_YR_2000_s_1	0.039	(0,2.9)	0.006	0.165		1
F_fleet_4_YR_2001_s_1	0.033	(0,2.9)	0.006	0.189		1
F_fleet_4_YR_2002_s_1	0.047	(0,2.9)	0.007	0.149		1
F_fleet_4_YR_2003_s_1	0.051	(0,2.9)	0.007	0.129		1
F_fleet_4_YR_2004_s_1	0.069	(0,2.9)	0.009	0.125		1
F_fleet_4_YR_2005_s_1	0.103	(0,2.9)	0.012	0.115		1
F_fleet_4_YR_2006_s_1	0.064	(0,2.9)	0.009	0.143		1
F_fleet_4_YR_2007_s_1	0.036	(0,2.9)	0.006	0.154		1
F_fleet_4_YR_2008_s_1	0.094	(0,2.9)	0.014	0.150		1
F_fleet_4_YR_2009_s_1	0.056	(0,2.9)	0.01	0.172		1
F_fleet_4_YR_2010_s_1	0.069	(0,2.9)	0.012	0.176		1
F_fleet_4_YR_2011_s_1	0.049	(0,2.9)	0.007	0.151		1
F_fleet_4_YR_2012_s_1	0.077	(0,2.9)	0.011	0.147		1
F_fleet_4_YR_2013_s_1	0.079	(0,2.9)	0.02	0.253		1
F_fleet_4_YR_2014_s_1	0.047	(0,2.9)	0.01	0.212		1
F_fleet_4_YR_2015_s_1	0.067	(0,2.9)	0.013	0.201		1
F_fleet_4_YR_2016_s_1	0.058	(0,2.9)	0.01	0.169		1
F_fleet_4_YR_2017_s_1	0.08	(0,2.9)	0.017	0.206		1
F_fleet_4_YR_2018_s_1	0.067	(0,2.9)	0.013	0.189		1
F_fleet_4_YR_2019_s_1	0.078	(0,2.9)	0.022	0.282		1
F_fleet_5_YR_1963_s_1	0.086	(0,2.9)	0.012	0.141		1
F_fleet_5_YR_1964_s_1	0.097	(0,2.9)	0.026	0.264		1
F_fleet_5_YR_1965_s_1	0.111	(0,2.9)	0.031	0.277		1
F_fleet_5_YR_1966_s_1	0.127	(0,2.9)	0.037	0.291		1
F_fleet_5_YR_1967_s_1	0.143	(0,2.9)	0.043	0.302		1
F_fleet_5_YR_1968_s_1	0.159	(0,2.9)	0.049	0.310		1

Table 10 Continued. List of Stock Synthesis parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values, lower and upper bounds of the parameters, associated standard errors and coefficients of variation, the prior type and densities (value, SE) assigned to the parameters as applicable, and phases (negative identifies parameters that were fixed). Parameters designated as fixed were held at their initial values and have no associated range or SE.

Label	Value	Range	SE	CV	Prior	Phase
F_fleet_5_YR_1969_s_1	0.174	(0,2.9)	0.055	0.316		1
F_fleet_5_YR_1970_s_1	0.187	(0,2.9)	0.06	0.320		1
F_fleet_5_YR_1971_s_1	0.212	(0,2.9)	0.069	0.324		1
F_fleet_5_YR_1972_s_1	0.236	(0,2.9)	0.077	0.328		1
F_fleet_5_YR_1973_s_1	0.253	(0,2.9)	0.083	0.330		1
F_fleet_5_YR_1974_s_1	0.258	(0,2.9)	0.084	0.326		1
F_fleet_5_YR_1975_s_1	0.251	(0,2.9)	0.077	0.308		1
F_fleet_5_YR_1976_s_1	0.234	(0,2.9)	0.066	0.281		1
F_fleet_5_YR_1977_s_1	0.232	(0,2.9)	0.059	0.255		1
F_fleet_5_YR_1978_s_1	0.237	(0,2.9)	0.057	0.241		1
F_fleet_5_YR_1979_s_1	0.222	(0,2.9)	0.051	0.228		1
F_fleet_5_YR_1980_s_1	0.228	(0,2.9)	0.05	0.220		1
F_fleet_5_YR_1981_s_1	0.123	(0,2.9)	0.026	0.212		1
F_fleet_5_YR_1982_s_1	0.242	(0,2.9)	0.047	0.194		1
F_fleet_5_YR_1983_s_1	0.171	(0,2.9)	0.034	0.200		1
F_fleet_5_YR_1984_s_1	0.089	(0,2.9)	0.019	0.215		1
F_fleet_5_YR_1985_s_1	0.157	(0,2.9)	0.032	0.206		1
F_fleet_5_YR_1986_s_1	0.167	(0,2.9)	0.031	0.189		1
F_fleet_5_YR_1987_s_1	0.186	(0,2.9)	0.033	0.177		1
F_fleet_5_YR_1988_s_1	0.197	(0,2.9)	0.034	0.173		1
F_fleet_5_YR_1989_s_1	0.173	(0,2.9)	0.028	0.164		1
F_fleet_5_YR_1990_s_1	0.176	(0,2.9)	0.03	0.171		1
F_fleet_5_YR_1991_s_1	0.254	(0,2.9)	0.038	0.148		1
F_fleet_5_YR_1992_s_1	0.199	(0,2.9)	0.027	0.133		1
F_fleet_5_YR_1993_s_1	0.25	(0,2.9)	0.032	0.128		1
F_fleet_5_YR_1994_s_1	0.226	(0,2.9)	0.025	0.109		1
F_fleet_5_YR_1995_s_1	0.375	(0,2.9)	0.044	0.118		1

Table 10 Continued. List of Stock Synthesis parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values, lower and upper bounds of the parameters, associated standard errors and coefficients of variation, the prior type and densities (value, SE) assigned to the parameters as applicable, and phases (negative identifies parameters that were fixed). Parameters designated as fixed were held at their initial values and have no associated range or SE.

Label	Value	Range	SE	CV	Prior	Phase
F_fleet_5_YR_1996_s_1	0.132	(0,2.9)	0.014	0.108		1
F_fleet_5_YR_1997_s_1	0.233	(0,2.9)	0.026	0.110		1
F_fleet_5_YR_1998_s_1	0.43	(0,2.9)	0.047	0.109		1
F_fleet_5_YR_1999_s_1	0.329	(0,2.9)	0.033	0.102		1
F_fleet_5_YR_2000_s_1	0.198	(0,2.9)	0.018	0.092		1
F_fleet_5_YR_2001_s_1	0.3	(0,2.9)	0.031	0.105		1
F_fleet_5_YR_2002_s_1	0.309	(0,2.9)	0.03	0.096		1
F_fleet_5_YR_2003_s_1	0.352	(0,2.9)	0.035	0.099		1
F_fleet_5_YR_2004_s_1	0.466	(0,2.9)	0.054	0.115		1
F_fleet_5_YR_2005_s_1	0.451	(0,2.9)	0.051	0.113		1
F_fleet_5_YR_2006_s_1	0.403	(0,2.9)	0.043	0.106		1
F_fleet_5_YR_2007_s_1	0.437	(0,2.9)	0.043	0.099		1
F_fleet_5_YR_2008_s_1	0.872	(0,2.9)	0.071	0.082		1
F_fleet_5_YR_2009_s_1	0.632	(0,2.9)	0.055	0.087		1
F_fleet_5_YR_2010_s_1	0.557	(0,2.9)	0.057	0.102		1
F_fleet_5_YR_2011_s_1	0.566	(0,2.9)	0.092	0.163		1
F_fleet_5_YR_2012_s_1	0.476	(0,2.9)	0.082	0.173		1
F_fleet_5_YR_2013_s_1	0.568	(0,2.9)	0.142	0.250		1
F_fleet_5_YR_2014_s_1	0.385	(0,2.9)	0.062	0.161		1
F_fleet_5_YR_2015_s_1	0.29	(0,2.9)	0.036	0.123		1
F_fleet_5_YR_2016_s_1	0.296	(0,2.9)	0.043	0.145		1
F_fleet_5_YR_2017_s_1	0.499	(0,2.9)	0.073	0.147		1
F_fleet_5_YR_2018_s_1	0.6	(0,2.9)	0.099	0.165		1
F_fleet_5_YR_2019_s_1	0.559	(0,2.9)	0.147	0.262		1
F_fleet_6_YR_2005_s_1	0.724	(0,2.9)	0.12	0.165		1
F_fleet_6_YR_2014_s_1	0.466	(0,2.9)	0.233	0.499		1
F_fleet_6_YR_2018_s_1	0.202	(0,2.9)	0.226	1.120		1

Table 10 Continued. List of Stock Synthesis parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values, lower and upper bounds of the parameters, associated standard errors and coefficients of variation, the prior type and densities (value, SE) assigned to the parameters as applicable, and phases (negative identifies parameters that were fixed). Parameters designated as fixed were held at their initial values and have no associated range or SE.

Label	Value	Range	SE	CV	Prior	Phase
LnQ_base_Com_VL_OTH_1(1)	-8.49	(-25,25)				Float
LnQ_base_Com_LL_2(2)	-7.94	(-25,25)				Float
LnQ_base_Rec_HBT_3(3)	-7.84	(-25,25)				Float
LnQ_base_Srv_CBT_PRIV_7(7)	-8.32	(-25,25)				Float
LnQ_base_Srv_AGE0_8(8)	-9.2	(-25,25)				Float
LnQ_base_Srv_SEAMAP_VIDEO_9(9)	-6.71	(-25,25)				Float
LnQ_base_Srv_PC_VIDEO_10(10)	-8.91	(-25,25)				Float
Size_inflection_Com_VL_OTH_1(1)	71.21	(20,125)	0.833	0.012		3
Size_95%width_Com_VL_OTH_1(1)	23.57	(0,50)	0.508	0.022		3
Retain_L_infl_Com_VL_OTH_1(1)	40.64					Fixed
Retain_L_width_Com_VL_OTH_1(1)	5					Fixed
Retain_L_asymptote_logit_Com_VL_OTH_1	10					Fixed
DiscMort_L_infl_Com_VL_OTH_1(1)	-10					Fixed
DiscMort_L_width_Com_VL_OTH_1(1)	1					Fixed
DiscMort_L_level_old_Com_VL_OTH_1(1)	0.25					Fixed
Size_inflection_Com_LL_2(2)	81.09	(20,125)	0.527	0.006		3
Size_95%width_Com_LL_2(2)	16.62	(0,50)	0.239	0.014		3
Retain_L_infl_Com_LL_2(2)	40.64					Fixed
Retain_L_width_Com_LL_2(2)	5					Fixed
Retain_L_asymptote_logit_Com_LL_2(2)	10					Fixed
DiscMort_L_infl_Com_LL_2(2)	-10					Fixed
DiscMort_L_width_Com_LL_2(2)	1					Fixed
DiscMort_L_level_old_Com_LL_2(2)	0.25					Fixed
Size_DblN_peak_Rec_HBT_3(3)	68.48	(20,100)	2.75	0.040		3
Size_DblN_top_logit_Rec_HBT_3(3)	-9					Fixed
Size_DblN_ascend_se_Rec_HBT_3(3)	8.48	(-15,15)	0.703	0.083		4
Size_DblN_descend_se_Rec_HBT_3(3)	5.32	(-15,15)	0.661	0.124		4

Table 10 Continued. List of Stock Synthesis parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values, lower and upper bounds of the parameters, associated standard errors and coefficients of variation, the prior type and densities (value, SE) assigned to the parameters as applicable, and phases (negative identifies parameters that were fixed). Parameters designated as fixed were held at their initial values and have no associated range or SE.

Label	Value	Range	SE	CV	Prior	Phase
Size_DblN_start_logit_Rec_HBT_3(3)	-5.4	(-15,15)	0.564	-		3
Size_DblN_end_logit_Rec_HBT_3(3)	-0.407	(-15,15)	0.373	-		3
Retain_L_infl_Rec_HBT_3(3)	40.2	(10,85)	0.763	0.019		3
Retain_L_width_Rec_HBT_3(3)	5					Fixed
Retain_L_asymptote_logit_Rec_HBT_3(3)	10					Fixed
DiscMort_L_infl_Rec_HBT_3(3)	-10					Fixed
DiscMort_L_width_Rec_HBT_3(3)	1					Fixed
DiscMort_L_level_old_Rec_HBT_3(3)	0.12					Fixed
Size_DblN_peak_Rec_CBT_4(4)	71.51	(20,100)	1.76	0.025		3
Size_DblN_top_logit_Rec_CBT_4(4)	-9					Fixed
Size_DblN_ascend_se_Rec_CBT_4(4)	7.22	(-15,15)	0.177	0.024		4
Size_DblN_descend_se_Rec_CBT_4(4)	4.81	(-15,15)	0.647	0.134		4
Size_DblN_start_logit_Rec_CBT_4(4)	-15					Fixed
Size_DblN_end_logit_Rec_CBT_4(4)	-0.398	(-15,15)	0.346	-		3
Retain_L_infl_Rec_CBT_4(4)	39.58	(10,85)	1.56	0.039		3
Retain_L_width_Rec_CBT_4(4)	5					Fixed
Retain_L_asymptote_logit_Rec_CBT_4(4)	10					Fixed
DiscMort_L_infl_Rec_CBT_4(4)	-10					Fixed
DiscMort_L_width_Rec_CBT_4(4)	1					Fixed
DiscMort_L_level_old_Rec_CBT_4(4)	0.12					Fixed
Size_DblN_peak_Rec_PRIV_SH_5(5)	61.79	(20,100)	4.24	0.069		3
Size_DblN_top_logit_Rec_PRIV_SH_5(5)	-2					Fixed
Size_DblN_ascend_se_Rec_PRIV_SH_5(5)	8.58	(-15,15)	0.294	0.034		4
Size_DblN_descend_se_Rec_PRIV_SH_5(5)	5.16	(-15,15)	0.573	0.111		4
Size_DblN_start_logit_Rec_PRIV_SH_5(5)	-999					Fixed
Size_DblN_end_logit_Rec_PRIV_SH_5(5)	-999					Fixed
Retain_L_infl_Rec_PRIV_SH_5(5)	34.99	(10,85)	1.52	0.044		3

Table 10 Continued. List of Stock Synthesis parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values, lower and upper bounds of the parameters, associated standard errors and coefficients of variation, the prior type and densities (value, SE) assigned to the parameters as applicable, and phases (negative identifies parameters that were fixed). Parameters designated as fixed were held at their initial values and have no associated range or SE.

Label	Value	Range	SE	CV	Prior	Phase
Retain_L_width_Rec_PRIV_SH_5(5)	5					Fixed
Retain_L_asymptote_logit_Rec_PRIV_SH_5	10					Fixed
DiscMort_L_infl_Rec_PRIV_SH_5(5)	-10					Fixed
DiscMort_L_width_Rec_PRIV_SH_5(5)	1					Fixed
DiscMort_L_level_old_Rec_PRIV_SH_5(5)	0.12					Fixed
Size_inflection_Srv_SEAMAP_VIDEO_9(9)	67.07	(20,125)	2.07	0.031		3
Size_95%width_Srv_SEAMAP_VIDEO_9(9)	13.07	(0,50)	1.88	0.144		3
SizeSel_P1_Srv_PC_VIDEO_10(10)	20					Fixed
SizeSel_P2_Srv_PC_VIDEO_10(10)	0.56	(0,1)	0.089	0.159	Sym_Beta(2)	4
SizeSel_P3_Srv_PC_VIDEO_10(10)	-2.07	(-15,15)	1.9	-	Sym_Beta(2)	4
SizeSel_P4_Srv_PC_VIDEO_10(10)	0.19	(-15,15)	8.36	44.07	Sym_Beta(2)	4
ln(DM_theta)_1	7.11					Fixed
ln(DM_theta)_2	6.94					Fixed
ln(DM_theta)_3	6.18					Fixed
ln(DM_theta)_4	5.47					Fixed
ln(DM_theta)_5	4.82	(-5,20)	0.702	0.146	Normal(0,1.81	3
ln(DM_theta)_6	3.12	(-5,20)	0.637	0.205	Normal(0,1.81	3
ln(DM_theta)_7	4.66	(-5,20)	0.715	0.153	Normal(0,1.81	3
ln(DM_theta)_8	4.19	(-5,20)	0.68	0.162	Normal(0,1.81	3
Retain_L_infl_Com_VL_OTH_1(1)_BLK1re	49.38					Fixed
Retain_L_infl_Com_VL_OTH_1(1)_BLK1re	59.24					Fixed
Retain_L_infl_Com_VL_OTH_1(1)_BLK1re	54.31					Fixed
Retain_L_infl_Com_VL_OTH_1(1)_BLK1re	59.24					Fixed
Retain_L_width_Com_VL_OTH_1(1)_BLK1	1					Fixed
Retain_L_width_Com_VL_OTH_1(1)_BLK1	1					Fixed
Retain_L_width_Com_VL_OTH_1(1)_BLK1	1					Fixed
Retain_L_width_Com_VL_OTH_1(1)_BLK1	1					Fixed

Table 10 Continued. List of Stock Synthesis parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values, lower and upper bounds of the parameters, associated standard errors and coefficients of variation, the prior type and densities (value, SE) assigned to the parameters as applicable, and phases (negative identifies parameters that were fixed). Parameters designated as fixed were held at their initial values and have no associated range or SE.

Label	Value	Range	SE	CV	Prior	Phase
Retain_L_asymptote_logit_Com_VL_OTH_1	3.11	(-10,10)	0.172	0.055		4
Retain_L_infl_Com_LL_2(2)_BLK1repl_199	49.38					Fixed
Retain_L_infl_Com_LL_2(2)_BLK1repl_200	59.24					Fixed
Retain_L_infl_Com_LL_2(2)_BLK1repl_201	54.31					Fixed
Retain_L_infl_Com_LL_2(2)_BLK1repl_201	59.24					Fixed
Retain_L_width_Com_LL_2(2)_BLK1repl_1	1					Fixed
Retain_L_width_Com_LL_2(2)_BLK1repl_2	1					Fixed
Retain_L_width_Com_LL_2(2)_BLK1repl_2	1					Fixed
Retain_L_width_Com_LL_2(2)_BLK1repl_2	1					Fixed
Retain_L_asymptote_logit_Com_LL_2(2)_B	1.32	(-10,10)	0.085	0.065		4
Retain_L_infl_Rec_HBT_3(3)_BLK2repl_19	49.38					Fixed
Retain_L_infl_Rec_HBT_3(3)_BLK2repl_20	54.31					Fixed
Retain_L_infl_Rec_HBT_3(3)_BLK2repl_20	59.24					Fixed
Retain_L_width_Rec_HBT_3(3)_BLK2repl_	1					Fixed
Retain_L_width_Rec_HBT_3(3)_BLK2repl_	1					Fixed
Retain_L_width_Rec_HBT_3(3)_BLK2repl_	1					Fixed
Retain_L_asymptote_logit_Rec_HBT_3(3)_B	-0.971	(-10,10)	0.26	-		4
Retain_L_asymptote_logit_Rec_HBT_3(3)_B	-0.043	(-10,10)	0.268	-		4
Retain_L_asymptote_logit_Rec_HBT_3(3)_B	0.256	(-10,10)	0.247	0.965		4
Retain_L_infl_Rec_CBT_4(4)_BLK2repl_19	49.38					Fixed
Retain_L_infl_Rec_CBT_4(4)_BLK2repl_20	54.31					Fixed
Retain_L_infl_Rec_CBT_4(4)_BLK2repl_20	59.24					Fixed
Retain_L_width_Rec_CBT_4(4)_BLK2repl_	1					Fixed
Retain_L_width_Rec_CBT_4(4)_BLK2repl_	1					Fixed
Retain_L_width_Rec_CBT_4(4)_BLK2repl_	1					Fixed
Retain_L_asymptote_logit_Rec_CBT_4(4)_B	-1.18	(-10,10)	0.213	-		4
Retain_L_asymptote_logit_Rec_CBT_4(4)_B	-0.917	(-10,10)	0.229	-		4

Table 10 Continued. List of Stock Synthesis parameters for Gulf of Mexico Gag Grouper. The list includes predicted parameter values, lower and upper bounds of the parameters, associated standard errors and coefficients of variation, the prior type and densities (value, SE) assigned to the parameters as applicable, and phases (negative identifies parameters that were fixed). Parameters designated as fixed were held at their initial values and have no associated range or SE.

Label	Value	Range	SE	CV	Prior	Phase
Retain_L_asymptote_logit_Rec_CBT_4(4)_B	0.727	(-10,10)	0.282	0.388		4
Retain_L_infl_Rec_PRIV_SH_5(5)_BLK2re	49.38					Fixed
Retain_L_infl_Rec_PRIV_SH_5(5)_BLK2re	54.31					Fixed
Retain_L_infl_Rec_PRIV_SH_5(5)_BLK2re	59.24					Fixed
Retain_L_width_Rec_PRIV_SH_5(5)_BLK2	1					Fixed
Retain_L_width_Rec_PRIV_SH_5(5)_BLK2	1					Fixed
Retain_L_width_Rec_PRIV_SH_5(5)_BLK2	1					Fixed
Retain_L_asymptote_logit_Rec_PRIV_SH_5	-0.089	(-10,10)	0.338	-		4
Retain_L_asymptote_logit_Rec_PRIV_SH_5	9.1	(-10,10)	20.87	2.290		4
Retain_L_asymptote_logit_Rec_PRIV_SH_5	8.54	(-10,10)	30.03	3.520		4

Table 11. Estimates of annual exploitation rate (total biomass killed age 3+ / total biomass age 3+) combined across all fleets for Gulf of Mexico Gag Grouper, which was used as the proxy for annual fishing mortality rate. Estimates are provided for SEDAR72 Operational Assessment and SEDAR33 Update.

Year	SEDAR72	SEDAR33 Update
1963	0.087	0.055
1964	0.100	0.067
1965	0.108	0.078
1966	0.112	0.078
1967	0.114	0.076
1968	0.123	0.086
1969	0.136	0.104
1970	0.144	0.114
1971	0.162	0.133
1972	0.186	0.164
1973	0.196	0.168
1974	0.219	0.201
1975	0.249	0.258
1976	0.249	0.268
1977	0.250	0.207
1978	0.255	0.203
1979	0.279	0.247
1980	0.305	0.268
1981	0.235	0.239
1982	0.342	0.330
1983	0.281	0.408
1984	0.178	0.213
1985	0.280	0.348
1986	0.303	0.331
1987	0.255	0.276
1988	0.232	0.283
1989	0.248	0.271
1990	0.222	0.262
1991	0.270	0.310

Table 11 Continued. Estimates of annual exploitation rate (total biomass killed age 3+ / total biomass age 3+) combined across all fleets for Gulf of Mexico Gag Grouper, which was used as the proxy for annual fishing mortality rate. Estimates are provided for SEDAR72 Operational Assessment and SEDAR33 Update.

Year	SEDAR72	SEDAR33 Update
1992	0.251	0.261
1993	0.308	0.350
1994	0.280	0.329
1995	0.433	0.422
1996	0.230	0.294
1997	0.281	0.298
1998	0.497	0.401
1999	0.384	0.299
2000	0.270	0.353
2001	0.344	0.408
2002	0.328	0.397
2003	0.346	0.347
2004	0.440	0.451
2005	0.333	0.351
2006	0.411	0.443
2007	0.425	0.484
2008	0.692	0.698
2009	0.519	0.339
2010	0.458	0.211
2011	0.290	0.117
2012	0.269	0.131
2013	0.418	0.129
2014	0.278	0.079
2015	0.291	0.072
2016	0.337	
2017	0.370	
2018	0.382	
2019	0.398	

Table 12. Estimates of annual exploitation rate (total biomass killed age 3+ / total biomass age 3+) by fleet and red tide mortality for Gulf of Mexico Gag Grouper.

Year	Com VL	Com LL	Rec Hbt	Rec Char	Rec Pri	Red Tide	Total
1963	0.025	0.000	0.002	0.010	0.050	0	0.087
1964	0.031	0.000	0.002	0.011	0.056	0	0.100
1965	0.034	0.000	0.002	0.012	0.061	0	0.108
1966	0.030	0.000	0.002	0.013	0.068	0	0.112
1967	0.024	0.000	0.003	0.014	0.073	0	0.114
1968	0.027	0.000	0.003	0.016	0.078	0	0.123
1969	0.033	0.000	0.003	0.018	0.082	0	0.136
1970	0.035	0.000	0.003	0.019	0.087	0	0.144
1971	0.038	0.000	0.004	0.022	0.099	0	0.162
1972	0.044	0.000	0.004	0.026	0.111	0	0.186
1973	0.036	0.000	0.005	0.029	0.125	0	0.196
1974	0.045	0.000	0.006	0.033	0.136	0	0.219
1975	0.060	0.000	0.006	0.035	0.147	0	0.249
1976	0.052	0.000	0.006	0.035	0.156	0	0.249
1977	0.044	0.000	0.006	0.035	0.165	0	0.250
1978	0.040	0.000	0.006	0.035	0.174	0	0.255
1979	0.064	0.000	0.006	0.036	0.172	0	0.279
1980	0.067	0.004	0.006	0.037	0.191	0	0.305
1981	0.068	0.017	0.017	0.031	0.102	0	0.235
1982	0.061	0.035	0.014	0.025	0.207	0	0.342
1983	0.054	0.027	0.014	0.025	0.162	0	0.281
1984	0.055	0.017	0.009	0.016	0.082	0	0.178
1985	0.067	0.014	0.021	0.036	0.141	0	0.280
1986	0.044	0.020	0.005	0.089	0.145	0	0.303
1987	0.035	0.026	0.005	0.027	0.162	0	0.255
1988	0.031	0.016	0.005	0.025	0.155	0	0.232
1989	0.053	0.018	0.015	0.028	0.133	0	0.248
1990	0.055	0.029	0.010	0.013	0.115	0	0.222
1991	0.054	0.026	0.001	0.012	0.177	0	0.270

Table 12 Continued. Estimates of annual exploitation rate (total biomass killed age 3+ / total biomass age 3+) by fleet and red tide mortality for Gulf of Mexico Gag Grouper.

Year	Com VL	Com LL	Rec Hbt	Rec Char	Rec Pri	Red Tide	Total
1992	0.045	0.025	0.003	0.045	0.133	0.000	0.251
1993	0.063	0.021	0.005	0.044	0.176	0.000	0.308
1994	0.060	0.017	0.007	0.026	0.171	0.000	0.280
1995	0.058	0.018	0.006	0.049	0.302	0.000	0.433
1996	0.045	0.015	0.003	0.056	0.111	0.000	0.230
1997	0.037	0.013	0.002	0.033	0.197	0.000	0.281
1998	0.058	0.017	0.007	0.060	0.356	0.000	0.497
1999	0.043	0.015	0.007	0.058	0.262	0.000	0.384
2000	0.052	0.016	0.005	0.030	0.166	0.000	0.270
2001	0.066	0.026	0.003	0.023	0.225	0.000	0.344
2002	0.054	0.025	0.002	0.031	0.215	0.000	0.328
2003	0.040	0.025	0.003	0.033	0.244	0.000	0.346
2004	0.048	0.025	0.005	0.044	0.318	0.000	0.440
2005	0.043	0.021	0.003	0.047	0.219	0.669	1.002
2006	0.054	0.030	0.002	0.042	0.284	0.000	0.411
2007	0.051	0.027	0.006	0.024	0.318	0.000	0.425
2008	0.059	0.021	0.006	0.054	0.553	0.000	0.692
2009	0.040	0.009	0.006	0.034	0.429	0.000	0.519
2010	0.023	0.006	0.007	0.042	0.380	0.000	0.458
2011	0.015	0.005	0.003	0.013	0.254	0.000	0.290
2012	0.024	0.008	0.003	0.020	0.213	0.000	0.269
2013	0.021	0.010	0.004	0.019	0.364	0.000	0.418
2014	0.027	0.016	0.004	0.010	0.220	0.478	0.756
2015	0.037	0.034	0.004	0.018	0.198	0.000	0.291
2016	0.061	0.050	0.003	0.027	0.195	0.000	0.337
2017	0.036	0.021	0.003	0.032	0.278	0.000	0.370
2018	0.034	0.019	0.003	0.024	0.302	0.277	0.659
2019	0.042	0.021	0.003	0.030	0.302	0.000	0.398

Table 13. Expected biomass (metric tons) for all Gag Grouper and exploited Gag Grouper (3+ years), spawning stock biomass (SSB, metric tons), exploited numbers (3+years, 1,000s of fish), age-0 recruits (1,000s of fish), and SSB ratio (SSB/SSB_0) where SSB_0 = 36,665 metric tons for Gulf of Mexico Gag Grouper. **SSB defined as female-only SSB**

Year	Biomass (all)	Biomass (exploited)	SSB	Abundance (exploited)	Recruits	SSB ratio
1963	33,605	29,911	15,470	6,371	6,394	0.42
1964	33,414	30,153	15,642	6,452	6,265	0.43
1965	32,545	30,035	15,605	6,449	6,169	0.43
1966	31,144	28,692	15,281	5,740	6,112	0.42
1967	29,545	27,138	14,372	5,180	6,094	0.39
1968	27,897	25,520	13,039	4,727	6,117	0.36
1969	26,112	23,749	11,605	4,338	6,192	0.32
1970	24,228	21,861	10,197	3,996	6,338	0.28
1971	22,471	20,074	8,952	3,714	6,635	0.24
1972	20,708	18,248	7,797	3,444	7,212	0.21
1973	19,004	16,404	6,754	3,194	8,124	0.18
1974	17,754	14,896	5,950	3,022	9,509	0.16
1975	16,844	13,603	5,347	2,953	9,232	0.15
1976	16,089	12,607	4,993	3,025	8,047	0.14
1977	15,633	12,374	5,044	3,328	7,254	0.14
1978	15,227	12,275	5,388	3,475	11,273	0.15
1979	15,200	11,898	5,727	3,350	6,845	0.16
1980	14,755	11,221	5,824	3,153	6,936	0.16
1981	14,155	11,501	5,764	3,683	11,387	0.16
1982	14,768	11,426	6,435	3,516	6,325	0.18
1983	13,917	10,412	6,280	3,167	8,208	0.17
1984	14,068	11,362	6,387	3,902	6,919	0.17
1985	15,056	12,004	7,472	3,791	8,587	0.20
1986	14,819	11,942	7,584	3,799	3,622	0.21
1987	13,696	11,185	7,176	3,424	5,129	0.20
1988	13,046	11,446	7,134	3,609	3,093	0.20
1989	12,246	10,485	7,076	2,835	12,485	0.19
1990	12,370	9,781	6,498	2,629	4,515	0.18
1991	12,622	8,907	5,879	2,261	5,614	0.16

Table 13 Continued. Expected biomass (metric tons) for all Gag Grouper and exploited Gag Grouper (3+ years), spawning stock biomass (SSB, metric tons), exploited numbers (3+years, 1,000s of fish), age-0 recruits (1,000s of fish), and SSB ratio (SSB/SSB_0) where SSB_0 = 36,665 metric tons for Gulf of Mexico Gag Grouper. **SSB defined as female-only SSB**

Year	Biomass (all)	Biomass (exploited)	SSB	Abundance (exploited)	Recruits	SSB ratio
1992	12,735	10,746	5,324	3,962	6,441	0.14
1993	12,830	10,293	5,920	3,329	17,891	0.16
1994	13,905	9,571	5,954	3,037	12,518	0.16
1995	15,785	9,581	5,771	3,135	9,355	0.16
1996	16,453	11,850	5,290	5,176	22,614	0.14
1997	20,090	14,342	7,501	5,857	12,735	0.20
1998	22,158	14,799	9,368	5,392	6,929	0.26
1999	20,314	16,120	8,221	7,021	16,989	0.22
2000	20,046	15,740	9,029	6,215	15,676	0.25
2001	21,720	15,220	10,597	5,129	12,856	0.29
2002	22,504	16,673	9,977	6,491	17,980	0.27
2003	23,715	17,897	10,298	7,078	12,923	0.28
2004	23,940	17,696	10,996	6,662	12,910	0.30
2005	22,444	17,382	9,988	7,024	16,794	0.27
2006	10,363	7,596	4,501	2,982	11,667	0.12
2007	11,008	7,280	4,447	2,832	11,966	0.12
2008	12,062	7,563	4,286	3,129	6,845	0.12
2009	10,736	7,107	3,207	3,424	4,703	0.09
2010	10,348	8,085	3,753	3,886	7,810	0.10
2011	9,829	7,640	4,431	3,222	1,679	0.12
2012	9,788	7,751	5,338	2,817	3,890	0.15
2013	9,684	8,665	5,603	3,233	5,484	0.15
2014	8,101	6,360	4,611	1,947	5,742	0.13
2015	4,995	3,625	2,520	1,154	4,579	0.07
2016	5,457	3,864	2,313	1,387	5,938	0.06
2017	6,063	4,047	2,306	1,553	5,279	0.06
2018	6,613	4,451	2,418	1,829	2,960	0.07
2019	5,450	4,087	2,102	1,786	3,856	0.06

Table 14. Expected spawning stock biomass (SSB, metric tons), exploitable biomass (3+ years, metric tons) and exploitable abundance (3+ years, 1,000s of fish) by sex and associated sex ratio (exploitable male:female) for Gulf of Mexico Gag Grouper.

Year	SSB (female)	SSB (male)	Biomass (female)	Biomass (male)	Abundance (female)	Abundance (male)	Sex ratio
1963	15,470	10,620	19,290	10,620	5,585.94	784.69	14.0
1964	15,642	10,629	19,524	10,629	5,665.20	786.68	13.9
1965	15,605	10,533	19,502	10,533	5,668.82	780.47	13.8
1966	15,281	10,363	18,329	10,363	4,972.15	767.97	15.4
1967	14,372	10,222	16,916	10,222	4,423.49	756.18	17.1
1968	13,039	10,098	15,421	10,098	3,985.47	741.39	18.6
1969	11,605	9,864	13,884	9,864	3,621.85	715.75	19.8
1970	10,197	9,467	12,393	9,467	3,319.12	677.07	20.4
1971	8,952	8,984	11,089	8,984	3,082.15	632.21	20.5
1972	7,797	8,375	9,872	8,375	2,865.45	579.05	20.2
1973	6,754	7,627	8,777	7,627	2,676.18	517.86	19.4
1974	5,950	6,925	7,970	6,925	2,560.30	462.01	18.0
1975	5,347	6,142	7,460	6,142	2,549.53	403.63	15.8
1976	4,993	5,278	7,328	5,278	2,681.35	343.48	12.8
1977	5,044	4,578	7,795	4,578	3,030.88	297.24	9.8
1978	5,388	4,014	8,261	4,014	3,212.68	262.37	8.2
1979	5,727	3,549	8,348	3,549	3,114.25	236.15	7.6
1980	5,824	3,038	8,182	3,038	2,944.83	208.49	7.1
1981	5,764	2,598	8,902	2,598	3,497.93	184.87	5.3
1982	6,435	2,200	9,225	2,200	3,350.55	165.79	4.9
1983	6,280	1,818	8,593	1,818	3,020.79	146.28	4.8
1984	6,387	1,644	9,718	1,644	3,761.43	140.32	3.7
1985	7,472	1,605	10,399	1,605	3,645.44	145.09	4.0
1986	7,584	1,536	10,406	1,536	3,653.34	146.14	4.0
1987	7,176	1,490	9,694	1,490	3,279.39	144.23	4.4
1988	7,134	1,530	9,915	1,530	3,459.76	149.71	4.3
1989	7,076	1,615	8,869	1,615	2,678.16	157.01	5.9
1990	6,498	1,645	8,135	1,645	2,469.75	159.41	6.5
1991	5,879	1,649	7,258	1,649	2,103.81	157.00	7.5

Table 14 Continued. Expected spawning stock biomass (SSB, metric tons), exploitable biomass (3+ years, metric tons) and exploitable abundance (3+ years, 1,000s of fish) by sex and associated sex ratio (exploitable male:female) for Gulf of Mexico Gag Grouper.

Year	SSB (female)	SSB (male)	Biomass (female)	Biomass (male)	Abundance (female)	Abundance (male)	Sex ratio
1992	5,324	1,634	9,112	1,634	3,810.90	151.45	4.0
1993	5,920	1,547	8,746	1,547	3,189.83	139.62	4.4
1994	5,954	1,419	8,152	1,419	2,906.05	130.67	4.5
1995	5,771	1,351	8,230	1,351	3,009.29	125.57	4.2
1996	5,290	1,203	10,647	1,203	5,065.41	110.30	2.2
1997	7,501	1,147	13,195	1,147	5,748.88	107.91	1.9
1998	9,368	1,153	13,645	1,153	5,273.51	118.34	2.2
1999	8,221	1,026	15,094	1,026	6,911.63	108.92	1.6
2000	9,029	966	14,773	966	6,110.95	103.97	1.7
2001	10,597	1,020	14,199	1,020	5,009.44	119.82	2.4
2002	9,977	1,025	15,647	1,025	6,366.25	124.82	2.0
2003	10,298	1,026	16,871	1,026	6,955.16	122.76	1.8
2004	10,996	1,046	16,650	1,046	6,535.45	126.14	1.9
2005	9,988	986	16,396	986	6,906.12	118.32	1.7
2006	4,501	418	7,177	418	2,932.19	49.68	1.7
2007	4,447	392	6,887	392	2,784.17	47.99	1.7
2008	4,286	375	7,187	375	3,083.17	46.22	1.5
2009	3,207	271	6,836	271	3,392.20	31.48	0.9
2010	3,753	242	7,843	242	3,857.29	28.34	0.7
2011	4,431	247	7,392	247	3,190.44	31.15	1.0
2012	5,338	321	7,430	321	2,772.52	44.39	1.6
2013	5,603	415	8,250	415	3,175.24	57.93	1.8
2014	4,611	436	5,923	436	1,890.79	55.93	3.0
2015	2,520	305	3,319	305	1,115.96	37.81	3.4
2016	2,313	331	3,532	331	1,348.36	38.74	2.9
2017	2,306	314	3,732	314	1,517.87	35.38	2.3
2018	2,418	304	4,147	304	1,795.32	33.24	1.9
2019	2,102	227	3,860	227	1,761.18	24.61	1.4

Table 15. Input (with log-scale standard errors, SE) and expected (Exp) landings for the Commercial Vertical Line + Other fleet in weight (B, million pounds gutted weight) and number (1,000s of fish) for Gulf of Mexico Gag Grouper. The mean body weight (MW, gutted pounds per fish) was determined by dividing the expected landings in weights by the expected landings in numbers .

Year	Input B SE	Input B	Exp B	Exp N	MW
1963	0.05	1.635	1.636	88.222	18.5
1964	0.05	2.042	2.043	110.304	18.5
1965	0.05	2.232	2.234	119.874	18.6
1966	0.05	1.871	1.872	98.651	19.0
1967	0.05	1.446	1.447	74.165	19.5
1968	0.05	1.511	1.512	75.225	20.1
1969	0.05	1.749	1.750	84.898	20.6
1970	0.05	1.665	1.666	79.404	21.0
1971	0.05	1.659	1.660	78.294	21.2
1972	0.05	1.769	1.771	83.200	21.3
1973	0.05	1.306	1.307	61.635	21.2
1974	0.05	1.464	1.466	70.238	20.9
1975	0.05	1.804	1.807	90.008	20.1
1976	0.05	1.449	1.451	77.078	18.8
1977	0.05	1.197	1.198	68.460	17.5
1978	0.05	1.070	1.071	64.895	16.5
1979	0.05	1.676	1.678	106.563	15.8
1980	0.05	1.653	1.655	110.540	15.0
1981	0.05	1.722	1.725	121.815	14.2
1982	0.05	1.535	1.536	113.761	13.5
1983	0.05	1.231	1.234	94.566	13.0
1984	0.05	1.358	1.362	107.405	12.7
1985	0.05	1.757	1.768	140.477	12.6
1986	0.05	1.153	1.159	90.973	12.7
1987	0.05	0.850	0.854	65.837	13.0
1988	0.05	0.786	0.790	59.003	13.4
1989	0.05	1.225	1.234	88.340	14.0
1990	0.05	1.165	1.175	79.104	14.9
1991	0.05	1.037	1.046	69.907	15.0

Table 15 Continued. Input (with log-scale standard errors, SE) and expected (Exp) landings for the Commercial Vertical Line + Other fleet in weight (B, million pounds gutted weight) and number (1,000s of fish) for Gulf of Mexico Gag Grouper. The mean body weight (MW, gutted pounds per fish) was determined by dividing the expected landings in weights by the expected landings in numbers .

Year	Input B SE	Input B	Exp B	Exp N	MW
1992	0.05	1.047	1.058	76.874	13.8
1993	0.05	1.363	1.413	106.595	13.3
1994	0.05	1.258	1.249	94.633	13.2
1995	0.05	1.255	1.219	95.271	12.8
1996	0.05	1.164	1.153	102.835	11.2
1997	0.05	1.171	1.163	108.873	10.7
1998	0.05	1.911	1.858	171.016	10.9
1999	0.05	1.519	1.522	145.400	10.5
2000	0.05	1.681	1.795	169.485	10.6
2001	0.05	2.159	2.168	175.518	12.4
2002	0.05	1.937	1.933	151.746	12.7
2003	0.05	1.510	1.521	122.200	12.4
2004	0.05	1.809	1.810	146.587	12.3
2005	0.05	1.596	1.600	130.240	12.3
2006	0.05	0.853	0.871	72.540	12.0
2007	0.05	0.788	0.794	66.064	12.0
2008	0.05	0.946	0.933	77.456	12.0
2009	0.05	0.592	0.593	52.618	11.3
2010	0.01	0.388	0.389	36.866	10.5
2011	0.01	0.239	0.240	22.498	10.7
2012	0.01	0.395	0.396	36.500	10.8
2013	0.01	0.390	0.391	33.580	11.6
2014	0.01	0.376	0.377	30.278	12.5
2015	0.01	0.289	0.290	21.957	13.2
2016	0.01	0.511	0.510	39.494	12.9
2017	0.01	0.316	0.316	26.018	12.1
2018	0.01	0.323	0.321	28.407	11.3
2019	0.01	0.353	0.353	30.214	11.7

Table 16. Input (with log-scale standard errors, SE) and expected (Exp) landings for the Commercial Longline fleet in weight (B, million pounds gutted weight) and number (1,000s of fish) for Gulf of Mexico Gag Grouper. The mean body weight (MW, gutted pounds per fish) was determined by dividing the expected landings in weights by the expected landings in numbers .

Year	Input B SE	Input B	Exp B	Exp N	MW
1963	0.05	1.635	1.636	88.222	18.5
1964	0.05	2.042	2.043	110.304	18.5
1965	0.05	2.232	2.234	119.874	18.6
1966	0.05	1.871	1.872	98.651	19.0
1967	0.05	1.446	1.447	74.165	19.5
1968	0.05	1.511	1.512	75.225	20.1
1969	0.05	1.749	1.750	84.898	20.6
1970	0.05	1.665	1.666	79.404	21.0
1971	0.05	1.659	1.660	78.294	21.2
1972	0.05	1.769	1.771	83.200	21.3
1973	0.05	1.306	1.307	61.635	21.2
1974	0.05	1.464	1.466	70.238	20.9
1975	0.05	1.804	1.807	90.008	20.1
1976	0.05	1.449	1.451	77.078	18.8
1977	0.05	1.197	1.198	68.460	17.5
1978	0.05	1.070	1.071	64.895	16.5
1979	0.05	1.676	1.678	106.563	15.8
1980	0.05	1.653	1.655	110.540	15.0
1981	0.05	1.722	1.725	121.815	14.2
1982	0.05	1.535	1.536	113.761	13.5
1983	0.05	1.231	1.234	94.566	13.0
1984	0.05	1.358	1.362	107.405	12.7
1985	0.05	1.757	1.768	140.477	12.6
1986	0.05	1.153	1.159	90.973	12.7
1987	0.05	0.850	0.854	65.837	13.0
1988	0.05	0.786	0.790	59.003	13.4
1989	0.05	1.225	1.234	88.340	14.0
1990	0.05	1.165	1.175	79.104	14.9
1991	0.05	1.037	1.046	69.907	15.0

Table 16 Continued. Input (with log-scale standard errors, SE) and expected (Exp) landings for the Commercial Longline fleet in weight (B, million pounds gutted weight) and number (1,000s of fish) for Gulf of Mexico Gag Grouper. The mean body weight (MW, gutted pounds per fish) was determined by dividing the expected landings in weights by the expected landings in numbers .

Year	Input B SE	Input B	Exp B	Exp N	MW
1992	0.05	1.047	1.058	76.874	13.8
1993	0.05	1.363	1.413	106.595	13.3
1994	0.05	1.258	1.249	94.633	13.2
1995	0.05	1.255	1.219	95.271	12.8
1996	0.05	1.164	1.153	102.835	11.2
1997	0.05	1.171	1.163	108.873	10.7
1998	0.05	1.911	1.858	171.016	10.9
1999	0.05	1.519	1.522	145.400	10.5
2000	0.05	1.681	1.795	169.485	10.6
2001	0.05	2.159	2.168	175.518	12.4
2002	0.05	1.937	1.933	151.746	12.7
2003	0.05	1.510	1.521	122.200	12.4
2004	0.05	1.809	1.810	146.587	12.3
2005	0.05	1.596	1.600	130.240	12.3
2006	0.05	0.853	0.871	72.540	12.0
2007	0.05	0.788	0.794	66.064	12.0
2008	0.05	0.946	0.933	77.456	12.0
2009	0.05	0.592	0.593	52.618	11.3
2010	0.01	0.388	0.389	36.866	10.5
2011	0.01	0.239	0.240	22.498	10.7
2012	0.01	0.395	0.396	36.500	10.8
2013	0.01	0.390	0.391	33.580	11.6
2014	0.01	0.376	0.377	30.278	12.5
2015	0.01	0.289	0.290	21.957	13.2
2016	0.01	0.511	0.510	39.494	12.9
2017	0.01	0.316	0.316	26.018	12.1
2018	0.01	0.323	0.321	28.407	11.3
2019	0.01	0.353	0.353	30.214	11.7

Table 17. Input (with log-scale standard errors, SE) and expected (Exp) landings for the Recreational Headboat fleet in numbers (N, 1,000s of fish) and weight (B, million pounds gutted weight) for Gulf of Mexico Gag Grouper. The mean body weight (MW, gutted pounds per fish) was determined by dividing the expected landings in weights by the expected landings in numbers .

Year	Input N SE	Input N	Exp N	Exp B	MW
1963	0.05	15.349	15.350	0.119	7.7
1964	0.20	15.815	15.830	0.125	7.9
1965	0.20	16.281	16.298	0.135	8.3
1966	0.20	16.780	16.800	0.144	8.6
1967	0.20	17.278	17.302	0.152	8.8
1968	0.20	17.777	17.803	0.157	8.8
1969	0.20	18.276	18.304	0.160	8.7
1970	0.20	18.774	18.804	0.160	8.5
1971	0.20	20.516	20.552	0.170	8.3
1972	0.20	22.258	22.298	0.177	8.0
1973	0.20	23.999	24.043	0.182	7.5
1974	0.20	25.741	25.786	0.182	7.0
1975	0.20	27.483	27.523	0.177	6.4
1976	0.20	27.594	27.622	0.165	6.0
1977	0.20	27.706	27.724	0.162	5.8
1978	0.20	27.817	27.832	0.166	6.0
1979	0.20	27.928	27.939	0.162	5.8
1980	0.20	28.040	28.046	0.158	5.6
1981	0.20	73.757	75.756	0.436	5.8
1982	0.20	66.110	62.227	0.349	5.6
1983	0.20	61.752	56.962	0.313	5.5
1984	0.20	43.780	39.538	0.223	5.6
1985	0.20	103.116	96.249	0.560	5.8
1986	0.20	29.289	21.968	0.129	5.9
1987	0.20	25.801	18.603	0.113	6.0
1988	0.20	24.467	20.962	0.136	6.5
1989	0.20	33.840	50.279	0.344	6.8
1990	0.20	18.280	24.365	0.210	8.6
1991	0.20	10.714	1.831	0.014	7.9

Table 17 Continued. Input (with log-scale standard errors, SE) and expected (Exp) landings for the Recreational Headboat fleet in numbers (N, 1,000s of fish) and weight (B, million pounds gutted weight) for Gulf of Mexico Gag Grouper. The mean body weight (MW, gutted pounds per fish) was determined by dividing the expected landings in weights by the expected landings in numbers .

Year	Input N SE	Input N	Exp N	Exp B	MW
1992	0.2	12.960	9.985	0.069	6.9
1993	0.2	17.229	14.038	0.103	7.3
1994	0.2	18.495	17.495	0.131	7.5
1995	0.2	15.465	18.000	0.122	6.8
1996	0.2	10.720	10.700	0.065	6.1
1997	0.2	10.494	9.353	0.061	6.5
1998	0.2	31.098	33.669	0.222	6.6
1999	0.2	27.845	39.799	0.249	6.3
2000	0.2	27.625	27.358	0.184	6.7
2001	0.2	11.875	12.619	0.103	8.2
2002	0.2	9.796	10.430	0.082	7.9
2003	0.2	13.012	16.882	0.129	7.7
2004	0.2	20.063	22.727	0.177	7.8
2005	0.2	12.932	15.917	0.121	7.6
2006	0.2	4.728	4.622	0.035	7.6
2007	0.2	10.029	11.029	0.085	7.7
2008	0.2	9.414	11.898	0.088	7.4
2009	0.2	8.600	12.924	0.088	6.8
2010	0.2	10.340	17.151	0.117	6.8
2011	0.2	4.921	5.159	0.038	7.3
2012	0.2	4.362	4.817	0.039	8.0
2013	0.2	4.889	7.453	0.061	8.2
2014	0.2	5.976	5.140	0.045	8.7
2015	0.2	3.416	2.971	0.026	8.8
2016	0.2	2.109	2.857	0.023	8.2
2017	0.2	2.659	2.054	0.019	9.2
2018	0.2	2.657	2.402	0.021	8.9
2019	0.2	2.366	2.429	0.021	8.5

Table 18. Input (with log-scale standard errors, SE) and expected (Exp) landings for the Recreational Charter fleet in numbers (N, 1,000s of fish) and weight (B, million pounds gutted weight) for Gulf of Mexico Gag Grouper. The mean body weight (MW, gutted pounds per fish) was determined by dividing the expected landings in weights by the expected landings in numbers .

Year	Input N SE	Input N	Exp N	Exp B	MW
1963	0.05	80.585	80.608	0.675	8.4
1964	0.20	83.030	83.460	0.709	8.5
1965	0.20	85.475	85.979	0.760	8.8
1966	0.20	88.093	88.681	0.816	9.2
1967	0.20	90.711	91.387	0.863	9.4
1968	0.20	93.329	94.090	0.896	9.5
1969	0.20	95.946	96.783	0.914	9.4
1970	0.20	98.564	99.463	0.922	9.3
1971	0.20	107.708	108.780	0.982	9.0
1972	0.20	116.853	118.084	1.029	8.7
1973	0.20	125.997	127.357	1.059	8.3
1974	0.20	135.141	136.562	1.065	7.8
1975	0.20	144.285	145.603	1.041	7.1
1976	0.20	144.870	145.813	0.963	6.6
1977	0.20	145.454	146.080	0.937	6.4
1978	0.20	146.039	146.554	0.951	6.5
1979	0.20	146.624	146.973	0.935	6.4
1980	0.20	147.208	147.419	0.909	6.2
1981	0.20	117.237	125.424	0.783	6.2
1982	0.20	106.427	99.864	0.612	6.1
1983	0.20	99.849	93.608	0.561	6.0
1984	0.20	69.958	64.141	0.392	6.1
1985	0.20	164.180	151.899	0.956	6.3
1986	0.20	367.116	364.362	2.316	6.4
1987	0.20	106.620	102.094	0.666	6.5
1988	0.20	86.866	88.550	0.616	7.0
1989	0.20	74.357	88.330	0.648	7.3
1990	0.20	26.279	29.852	0.265	8.9
1991	0.20	35.080	28.370	0.234	8.3

Table 18 Continued. Input (with log-scale standard errors, SE) and expected (Exp) landings for the Recreational Charter fleet in numbers (N, 1,000s of fish) and weight (B, million pounds gutted weight) for Gulf of Mexico Gag Grouper. The mean body weight (MW, gutted pounds per fish) was determined by dividing the expected landings in weights by the expected landings in numbers .

Year	Input N SE	Input N	Exp N	Exp B	MW
1992	0.2	156.110	146.420	1.053	7.2
1993	0.2	137.481	129.363	0.978	7.6
1994	0.2	66.607	68.392	0.531	7.8
1995	0.2	112.353	138.736	0.982	7.1
1996	0.2	199.052	226.218	1.427	6.3
1997	0.2	139.119	149.626	0.998	6.7
1998	0.2	199.321	275.428	1.885	6.8
1999	0.2	137.899	309.013	2.006	6.5
2000	0.2	127.608	146.260	1.015	6.9
2001	0.2	84.576	89.926	0.751	8.3
2002	0.2	114.051	131.962	1.065	8.1
2003	0.2	92.980	159.733	1.248	7.8
2004	0.2	134.341	206.599	1.639	7.9
2005	0.2	126.872	220.188	1.710	7.8
2006	0.2	70.445	85.429	0.663	7.8
2007	0.2	33.991	45.580	0.357	7.8
2008	0.2	89.110	108.737	0.820	7.5
2009	0.2	46.692	70.665	0.490	6.9
2010	0.2	60.233	102.689	0.712	6.9
2011	0.2	10.632	18.110	0.135	7.5
2012	0.2	46.754	27.388	0.223	8.2
2013	0.2	24.939	31.154	0.259	8.3
2014	0.2	12.425	11.543	0.102	8.8
2015	0.2	12.977	10.846	0.098	9.0
2016	0.2	17.624	24.006	0.200	8.3
2017	0.2	25.424	24.860	0.232	9.3
2018	0.2	19.823	21.092	0.189	8.9
2019	0.2	28.537	25.421	0.219	8.6

Table 19. Input (with log-scale standard errors, SE) and expected (Exp) landings for the Recreational Private + Shore fleet in numbers (N, 1,000s of fish) and weight (B, million pounds gutted weight) for Gulf of Mexico Gag Grouper. The mean body weight (MW, gutted pounds per fish) was determined by dividing the expected landings in weights by the expected landings in numbers .

Year	Input N SE	Input N	Exp N	Exp B	MW
1963	0.05	671.538	672.804	3.296	4.9
1964	0.20	691.914	716.723	3.701	5.2
1965	0.20	712.291	741.239	4.018	5.4
1966	0.20	734.106	767.139	4.239	5.5
1967	0.20	755.922	792.509	4.337	5.5
1968	0.20	777.738	817.002	4.328	5.3
1969	0.20	799.554	840.305	4.251	5.1
1970	0.20	821.370	862.259	4.147	4.8
1971	0.20	897.571	942.529	4.311	4.6
1972	0.20	973.772	1,019.910	4.414	4.3
1973	0.20	1,049.970	1,092.950	4.440	4.1
1974	0.20	1,126.170	1,160.630	4.390	3.8
1975	0.20	1,202.370	1,222.820	4.328	3.5
1976	0.20	1,207.250	1,212.530	4.248	3.5
1977	0.20	1,212.120	1,207.960	4.430	3.7
1978	0.20	1,216.990	1,210.150	4.618	3.8
1979	0.20	1,221.860	1,209.130	4.436	3.7
1980	0.20	1,226.740	1,211.800	4.650	3.8
1981	0.20	672.594	642.400	2.546	4.0
1982	0.20	1,951.380	1,356.200	5.128	3.8
1983	0.20	948.521	930.135	3.660	3.9
1984	0.20	553.659	498.453	2.031	4.1
1985	0.20	1,079.610	870.918	3.679	4.2
1986	0.20	872.046	893.329	3.772	4.2
1987	0.20	906.953	866.153	3.962	4.6
1988	0.20	945.232	801.679	3.875	4.8
1989	0.20	774.812	630.127	3.039	4.8
1990	0.20	534.198	306.531	2.338	7.6
1991	0.20	576.903	469.916	3.234	6.9

Table 19 Continued. Input (with log-scale standard errors, SE) and expected (Exp) landings for the Recreational Private + Shore fleet in numbers (N, 1,000s of fish) and weight (B, million pounds gutted weight) for Gulf of Mexico Gag Grouper. The mean body weight (MW, gutted pounds per fish) was determined by dividing the expected landings in weights by the expected landings in numbers .

Year	Input N SE	Input N	Exp N	Exp B	MW
1992	0.2	471.789	489.153	3.006	6.1
1993	0.2	714.153	572.478	3.773	6.6
1994	0.2	443.094	486.029	3.300	6.8
1995	0.2	896.299	934.842	5.747	6.1
1996	0.2	476.884	478.525	2.704	5.7
1997	0.2	792.411	950.182	5.791	6.1
1998	0.2	968.573	1,734.010	10.777	6.2
1999	0.2	1,185.110	1,485.600	8.825	5.9
2000	0.2	1,322.750	851.955	5.459	6.4
2001	0.2	1,020.880	873.903	6.864	7.9
2002	0.2	1,175.280	947.423	7.143	7.5
2003	0.2	887.804	1,198.460	8.768	7.3
2004	0.2	1,413.290	1,513.760	11.252	7.4
2005	0.2	1,147.480	1,049.680	7.640	7.3
2006	0.2	659.360	586.238	4.282	7.3
2007	0.2	530.626	605.531	4.472	7.4
2008	0.2	870.160	1,103.260	7.816	7.1
2009	0.2	418.529	883.059	5.795	6.6
2010	0.2	551.625	926.130	6.137	6.6
2011	0.2	307.693	461.400	3.301	7.2
2012	0.2	237.034	369.779	2.882	7.8
2013	0.2	441.836	839.041	6.598	7.9
2014	0.2	313.449	349.721	2.884	8.2
2015	0.2	263.864	172.992	1.429	8.3
2016	0.2	194.757	193.174	1.469	7.6
2017	0.2	254.099	233.212	2.010	8.6
2018	0.2	284.152	287.379	2.405	8.4
2019	0.2	225.488	278.243	2.276	8.2

Table 20. Input (with log-scale standard errors, SE) and expected (Exp) discards for the Commercial Vertical Line + Other fleet in number (N, 1,000s of fish) and biomass (B, thousand pounds gutted weight) for Gulf of Mexico Gag Grouper. Dead discards in numbers (discard mortality rate = 0.25), dead discards in biomass, and mean weight (MW, gutted pounds per fish) are included. Mean weight was determined by dividing the expected discards in weights by the expected discards in numbers .

Year	Input N SE	Input N	Exp N	Exp Dead N	Exp B	Exp Dead B	MW
1963			2.585	0.646	6.281	1.570	2.4
1964			2.808	0.702	7.390	1.847	2.6
1965			2.682	0.671	7.209	1.808	2.7
1966			2.088	0.522	5.472	1.369	2.6
1967			1.577	0.394	3.990	0.996	2.5
1968			1.670	0.418	4.109	1.027	2.5
1969			2.023	0.506	4.861	1.215	2.4
1970			2.067	0.517	4.870	1.217	2.4
1971			2.253	0.563	5.205	1.301	2.3
1972			2.702	0.676	6.098	1.523	2.3
1973			2.325	0.581	5.090	1.272	2.2
1974			3.174	0.793	6.729	1.682	2.1
1975			5.038	1.259	10.364	2.590	2.1
1976			4.830	1.208	10.185	2.546	2.1
1977			4.167	1.042	9.266	2.315	2.2
1978			3.615	0.904	8.316	2.079	2.3
1979			7.086	1.772	14.601	3.651	2.1
1980			6.808	1.702	15.510	3.878	2.3
1981			6.810	1.703	16.052	4.012	2.4
1982			7.692	1.923	15.988	3.997	2.1
1983			5.794	1.449	13.457	3.364	2.3
1984			6.209	1.552	14.359	3.589	2.3
1985			7.327	1.832	17.401	4.350	2.4
1986			4.964	1.241	11.166	2.791	2.2
1987			2.830	0.707	7.328	1.832	2.6
1988			2.227	0.557	5.624	1.407	2.5
1989			2.820	0.705	7.399	1.850	2.6
1990			8.397	2.099	14.248	3.560	1.7
1991			10.553	2.638	23.243	5.809	2.2

Table 20 Continued. Input (with log-scale standard errors, SE) and expected (Exp) discards for the Commercial Vertical Line + Other fleet in number (N, 1,000s of fish) and biomass (B, thousand pounds gutted weight) for Gulf of Mexico Gag Grouper. Dead discards in numbers (discard mortality rate = 0.25), dead discards in biomass, and mean weight (MW, gutted pounds per fish) are included. Mean weight was determined by dividing the expected discards in weights by the expected discards in numbers .

Year	Input N SE	Input N	Exp N	Exp Dead N	Exp B	Exp Dead B	MW
1992			8.087	2.022	17.670	4.418	2.2
1993	0.218	17.085	10.746	2.687	21.967	5.492	2.0
1994	0.218	16.824	16.875	4.219	29.687	7.421	1.8
1995	0.218	18.991	24.056	6.014	49.935	12.485	2.1
1996	0.218	21.238	19.071	4.768	41.859	10.465	2.2
1997	0.218	22.344	19.428	4.857	36.180	9.046	1.9
1998	0.218	33.497	34.804	8.701	74.424	18.605	2.1
1999	0.218	28.141	19.989	4.997	45.744	11.435	2.3
2000	0.221	84.100	20.723	5.181	39.573	9.894	1.9
2001	0.221	100.510	66.302	16.576	213.275	53.308	3.2
2002	0.221	92.724	70.325	17.581	241.937	60.486	3.4
2003	0.221	79.853	56.280	14.070	195.193	48.797	3.5
2004	0.221	85.584	65.234	16.308	223.879	55.969	3.4
2005	0.221	79.540	61.058	15.264	216.379	54.095	3.5
2006	0.221	46.882	33.955	8.489	115.919	28.980	3.4
2007	0.221	34.193	35.714	8.929	113.470	28.367	3.2
2008	0.221	32.203	58.606	14.652	183.674	45.918	3.1
2009	0.221	37.010	47.853	11.964	163.872	40.968	3.4
2010	0.251	34.423	24.514	6.128	91.055	22.765	3.7
2011	0.251	28.390	11.296	2.824	47.580	11.896	4.2
2012	0.159	10.016	8.662	2.166	38.016	9.504	4.4
2013	0.159	9.958	6.407	1.602	31.859	7.965	5.0
2014	0.159	10.341	6.188	1.547	28.832	7.207	4.7
2015	0.159	8.009	6.171	1.543	26.167	6.541	4.2
2016	0.159	9.503	13.681	3.420	53.590	13.397	3.9
2017	0.159	7.887	10.706	2.677	38.420	9.606	3.6
2018	0.159	6.716	12.608	3.152	44.487	11.122	3.5
2019	0.251	20.621	20.400	5.100	84.422	21.107	4.1

Table 21. Input (with log-scale standard errors, SE) and expected (Exp) discards for the Commercial Longline fleet in number (N, 1,000s of fish) and biomass (B, thousand pounds gutted weight) for Gulf of Mexico Gag Grouper. Dead discards in numbers (discard mortality rate = 0.25), dead discards in biomass, and mean weight (MW, gutted pounds per fish) are included. Mean weight was determined by dividing the expected discards in weights by the expected discards in numbers .

Year	Input N SE	Input N	Exp N	Exp Dead N	Exp B	Exp Dead B	MW
1979			0.000	0.000	0.001	0.000	3.4
1980			0.026	0.006	0.092	0.023	3.6
1981			0.118	0.029	0.439	0.110	3.7
1982			0.293	0.073	1.019	0.256	3.5
1983			0.210	0.052	0.758	0.190	3.6
1984			0.143	0.036	0.531	0.132	3.7
1985			0.121	0.030	0.465	0.117	3.9
1986			0.165	0.041	0.619	0.154	3.8
1987			0.179	0.045	0.730	0.183	4.1
1988			0.090	0.022	0.384	0.095	4.3
1989			0.079	0.020	0.353	0.088	4.5
1990			0.226	0.057	0.467	0.117	2.1
1991			0.306	0.077	0.747	0.187	2.4
1992			0.277	0.069	0.692	0.172	2.5
1993	0.238	0.588	0.227	0.057	0.538	0.134	2.4
1994	0.238	0.673	0.271	0.068	0.560	0.141	2.1
1995	0.238	0.660	0.478	0.120	1.107	0.278	2.3
1996	0.238	0.809	0.464	0.116	1.131	0.282	2.4
1997	0.238	0.779	0.474	0.118	1.023	0.256	2.2
1998	0.238	0.807	0.800	0.200	1.887	0.472	2.4
1999	0.238	0.819	0.578	0.145	1.455	0.364	2.5
2000	0.231	1.304	0.490	0.123	1.093	0.273	2.2
2001	0.231	1.586	2.944	0.736	11.378	2.844	3.9
2002	0.231	1.627	3.800	0.950	15.144	3.785	4.0
2003	0.231	1.727	4.215	1.054	17.178	4.295	4.1
2004	0.231	1.693	4.082	1.020	16.345	4.087	4.0
2005	0.231	1.457	3.583	0.896	14.665	3.666	4.1
2006	0.231	1.351	2.293	0.573	9.262	2.315	4.0
2007	0.231	0.764	2.191	0.548	8.426	2.105	3.8

Table 21 Continued. Input (with log-scale standard errors, SE) and expected (Exp) discards for the Commercial Longline fleet in number (N, 1,000s of fish) and biomass (B, thousand pounds gutted weight) for Gulf of Mexico Gag Grouper. Dead discards in numbers (discard mortality rate = 0.25), dead discards in biomass, and mean weight (MW, gutted pounds per fish) are included. Mean weight was determined by dividing the expected discards in weights by the expected discards in numbers .

Year	Input N SE	Input N	Exp N	Exp Dead N	Exp B	Exp Dead B	MW
2008	0.231	0.878	2.388	0.597	8.946	2.238	3.7
2009	0.231	0.457	1.428	0.357	5.624	1.406	3.9
2010	0.161	4.252	1.047	0.262	4.392	1.098	4.2
2011	0.161	4.503	2.126	0.532	23.839	5.960	11.2
2012	0.245	2.017	2.691	0.673	35.118	8.779	13.1
2013	0.245	2.473	3.517	0.879	50.533	12.633	14.4
2014	0.245	3.012	3.697	0.924	56.896	14.223	15.4
2015	0.245	3.242	4.357	1.089	68.901	17.225	15.8
2016	0.245	3.642	6.946	1.737	109.294	27.324	15.7
2017	0.245	3.505	3.235	0.809	48.576	12.144	15.0
2018	0.245	3.086	3.392	0.848	47.512	11.878	14.0
2019	0.161	6.193	4.458	1.114	54.053	13.513	12.1

Table 22. Input (with log-scale standard errors, SE) and expected (Exp) discards for the Recreational Headboat fleet in number (N, 1,000s of fish) and biomass (B, thousand pounds gutted weight) for Gulf of Mexico Gag Grouper. Dead discards in numbers (discard mortality rate = 0.12), dead discards in biomass, and mean weight (MW, gutted pounds per fish) are included. Mean weight was determined by dividing the expected discards in weights by the expected discards in numbers .

Year	Input N SE	Input N	Exp N	Exp Dead N	Exp B	Exp Dead B	MW
1963			5.002	0.600	7.707	0.925	1.5
1964			4.220	0.507	6.994	0.839	1.7
1965			4.101	0.492	6.624	0.795	1.6
1966			4.416	0.530	6.900	0.828	1.6
1967			4.881	0.586	7.483	0.898	1.5
1968			5.404	0.648	8.187	0.982	1.5
1969			5.963	0.716	8.949	1.074	1.5
1970			6.552	0.786	9.747	1.170	1.5
1971			7.657	0.919	11.279	1.354	1.5
1972			8.996	1.079	13.067	1.568	1.5
1973			10.681	1.282	15.239	1.829	1.4
1974			12.712	1.525	17.821	2.138	1.4
1975			14.864	1.784	20.709	2.485	1.4
1976			14.265	1.712	20.579	2.470	1.4
1977			12.651	1.518	18.939	2.273	1.5
1978			11.928	1.431	17.639	2.117	1.5
1979			14.951	1.794	20.665	2.480	1.4
1980			11.914	1.430	18.521	2.222	1.6
1981	1.046	56.153	30.703	3.684	45.816	5.498	1.5
1982	1.004	9.132	32.465	3.896	44.941	5.393	1.4
1983	0.731	9.388	23.150	2.778	36.383	4.365	1.6
1984	0.833	3.887	16.231	1.948	24.198	2.903	1.5
1985	0.827	14.373	36.753	4.410	55.997	6.720	1.5
1986	0.198	7.385	9.235	1.108	13.652	1.638	1.5
1987	0.198	4.304	5.541	0.665	9.473	1.137	1.7
1988	0.198	5.814	6.568	0.788	10.188	1.223	1.6
1989	0.198	21.810	15.432	1.852	23.201	2.784	1.5
1990	0.198	51.036	39.560	4.747	55.198	6.624	1.4
1991	0.198	1.187	2.823	0.339	5.346	0.642	1.9

Table 22 Continued. Input (with log-scale standard errors, SE) and expected (Exp) discards for the Recreational Headboat fleet in number (N, 1,000s of fish) and biomass (B, thousand pounds gutted weight) for Gulf of Mexico Gag Grouper. Dead discards in numbers (discard mortality rate = 0.12), dead discards in biomass, and mean weight (MW, gutted pounds per fish) are included. Mean weight was determined by dividing the expected discards in weights by the expected discards in numbers .

Year	Input N SE	Input N	Exp N	Exp Dead N	Exp B	Exp Dead B	MW
1992	0.198	7.347	8.978	1.077	15.935	1.912	1.8
1993	0.198	12.369	14.423	1.731	23.144	2.777	1.6
1994	0.198	35.261	36.624	4.395	52.570	6.308	1.4
1995	0.198	43.452	38.322	4.599	66.842	8.021	1.7
1996	0.198	13.292	13.329	1.599	23.807	2.857	1.8
1997	0.198	12.984	14.246	1.710	21.529	2.583	1.5
1998	0.198	54.357	51.236	6.148	93.185	11.182	1.8
1999	0.198	48.522	35.824	4.299	68.085	8.170	1.9
2000	0.198	30.277	30.282	3.634	46.178	5.541	1.5
2001	0.198	30.345	28.683	3.442	56.250	6.750	2.0
2002	0.198	24.157	22.824	2.739	48.879	5.865	2.1
2003	0.198	43.680	34.828	4.179	70.329	8.440	2.0
2004	0.198	52.364	46.703	5.604	99.340	11.921	2.1
2005	0.198	36.512	30.612	3.673	65.357	7.843	2.1
2006	0.198	9.848	10.045	1.205	19.682	2.362	2.0
2007	0.198	35.003	32.534	3.904	60.602	7.272	1.9
2008	0.198	53.173	43.956	5.275	86.135	10.336	2.0
2009	0.198	52.392	37.152	4.458	82.773	9.933	2.2
2010	0.198	46.592	30.213	3.626	69.982	8.398	2.3
2011	0.198	45.679	44.161	5.299	161.598	19.392	3.7
2012	0.198	37.878	35.217	4.226	156.058	18.727	4.4
2013	0.198	34.756	24.496	2.940	100.135	12.016	4.1
2014	0.198	20.162	22.704	2.724	78.460	9.415	3.5
2015	0.198	15.967	17.793	2.135	55.888	6.706	3.1
2016	0.198	20.739	16.024	1.923	44.875	5.385	2.8
2017	0.198	16.555	20.218	2.426	56.181	6.742	2.8
2018	0.198	21.040	22.872	2.745	66.705	8.005	2.9
2019	0.198	18.297	17.942	2.153	59.427	7.131	3.3

Table 23. Input (with log-scale standard errors, SE) and expected (Exp) discards for the Recreational Charter fleet in number (N, 1,000s of fish) and biomass (B, thousand pounds gutted weight) for Gulf of Mexico Gag Grouper. Dead discards in numbers (discard mortality rate = 0.12), dead discards in biomass, and mean weight (MW, gutted pounds per fish) are included. Mean weight was determined by dividing the expected discards in weights by the expected discards in numbers .

Year	Input N SE	Input N	Exp N	Exp Dead N	Exp B	Exp Dead B	MW
1963			17.257	2.071	29.041	3.486	1.7
1964			14.665	1.760	26.724	3.208	1.8
1965			13.965	1.676	25.031	3.003	1.8
1966			14.869	1.784	25.772	3.093	1.7
1967			16.413	1.970	27.864	3.344	1.7
1968			18.232	2.188	30.554	3.666	1.7
1969			20.215	2.426	33.541	4.026	1.7
1970			22.312	2.677	36.691	4.403	1.6
1971			26.175	3.141	42.644	5.117	1.6
1972			30.837	3.700	49.591	5.950	1.6
1973			36.725	4.407	58.070	6.969	1.6
1974			43.908	5.269	68.266	8.192	1.6
1975			52.233	6.268	80.003	9.599	1.5
1976			50.910	6.109	80.325	9.639	1.6
1977			45.110	5.413	74.025	8.882	1.6
1978			40.964	4.916	68.132	8.175	1.7
1979			52.582	6.310	78.972	9.475	1.5
1980			42.620	5.115	72.475	8.697	1.7
1981	0.844	89.783	32.971	3.957	55.605	6.673	1.7
1982	0.808	14.601	34.787	4.175	52.247	6.270	1.5
1983	0.617	15.011	25.686	3.082	44.469	5.335	1.7
1984	0.764	6.215	17.510	2.101	28.742	3.448	1.6
1985	0.562	22.980	38.144	4.578	64.538	7.745	1.7
1986	0.421	91.324	102.937	12.352	164.575	19.753	1.6
1987	0.367	17.620	20.503	2.460	38.610	4.634	1.9
1988	0.547	20.296	18.249	2.190	31.105	3.732	1.7
1989	0.514	46.217	16.035	1.924	28.982	3.479	1.8
1990	0.514	71.078	31.490	3.779	46.886	5.626	1.5
1991	0.744	3.502	31.749	3.810	63.605	7.632	2.0

Table 23 Continued. Input (with log-scale standard errors, SE) and expected (Exp) discards for the Recreational Charter fleet in number (N, 1,000s of fish) and biomass (B, thousand pounds gutted weight) for Gulf of Mexico Gag Grouper. Dead discards in numbers (discard mortality rate = 0.12), dead discards in biomass, and mean weight (MW, gutted pounds per fish) are included. Mean weight was determined by dividing the expected discards in weights by the expected discards in numbers .

Year	Input N SE	Input N	Exp N	Exp Dead N	Exp B	Exp Dead B	MW
1992	0.421	86.122	93.870	11.265	180.225	21.627	1.9
1993	0.489	97.098	87.516	10.502	157.399	18.887	1.8
1994	0.376	113.478	94.336	11.320	145.928	17.511	1.5
1995	0.284	308.655	212.170	25.460	394.113	47.294	1.9
1996	0.294	240.693	200.795	24.095	392.881	47.146	2.0
1997	0.275	168.734	155.242	18.629	252.308	30.278	1.6
1998	0.159	351.124	304.158	36.499	584.842	70.180	1.9
1999	0.090	233.276	201.525	24.183	414.865	49.785	2.1
2000	0.237	134.811	108.603	13.032	180.133	21.616	1.7
2001	0.376	201.966	142.569	17.108	303.382	36.407	2.1
2002	0.188	246.969	207.513	24.902	484.062	58.087	2.3
2003	0.129	296.289	234.153	28.098	516.673	62.001	2.2
2004	0.090	337.988	306.221	36.746	704.270	84.514	2.3
2005	0.090	339.608	304.422	36.531	711.217	85.345	2.3
2006	0.159	140.619	129.004	15.480	280.029	33.603	2.2
2007	0.188	113.324	92.482	11.098	189.652	22.758	2.1
2008	0.179	313.363	285.848	34.301	606.526	72.783	2.1
2009	0.256	267.022	152.286	18.274	363.112	43.574	2.4
2010	0.275	325.174	135.065	16.208	339.511	40.741	2.5
2011	0.149	190.736	148.487	17.818	636.396	76.368	4.3
2012	0.120	170.375	200.720	24.086	1,012.026	121.444	5.0
2013	0.322	234.277	163.154	19.579	856.413	102.771	5.2
2014	0.237	67.971	73.932	8.872	346.291	41.555	4.7
2015	0.256	72.623	90.388	10.847	379.013	45.482	4.2
2016	0.198	104.765	79.002	9.480	241.184	28.941	3.1
2017	0.294	145.159	144.665	17.360	440.675	52.882	3.0
2018	0.217	126.194	122.194	14.663	384.155	46.098	3.1
2019	0.246	99.177	117.848	14.142	416.318	49.959	3.5

Table 24. Input (with log-scale standard errors, SE) and expected (Exp) discards for the Recreational Private + Shore fleet in number (N, 1,000s of fish) and biomass (B, thousand pounds gutted weight) for Gulf of Mexico Gag Grouper. Dead discards in numbers (discard mortality rate = 0.12), dead discards in biomass, and mean weight (MW, gutted pounds per fish) are included. Mean weight was determined by dividing the expected discards in weights by the expected discards in numbers .

Year	Input N SE	Input N	Exp N	Exp Dead N	Exp B	Exp Dead B	MW
1963			428	51	277	33	0.6
1964			424	51	260	31	0.6
1965			461	55	266	32	0.6
1966			516	62	289	35	0.6
1967			576	69	317	38	0.6
1968			638	77	348	42	0.5
1969			703	84	379	45	0.5
1970			769	92	409	49	0.5
1971			902	108	471	57	0.5
1972			1,069	128	543	65	0.5
1973			1,268	152	626	75	0.5
1974			1,491	179	716	86	0.5
1975			1,493	179	767	92	0.5
1976			1,278	153	708	85	0.6
1977			1,140	137	644	77	0.6
1978			1,531	184	689	83	0.4
1979			1,161	139	700	84	0.6
1980			1,056	127	605	73	0.6
1981	0.567	615	799	96	354	42	0.4
1982	0.376	449	1,219	146	761	91	0.6
1983	0.514	824	874	105	463	56	0.5
1984	0.752	176	430	52	245	29	0.6
1985	0.628	257	835	100	426	51	0.5
1986	0.429	796	570	68	413	50	0.7
1987	0.340	649	599	72	338	41	0.6
1988	0.340	453	481	58	314	38	0.7
1989	0.275	1,075	1,063	128	355	43	0.3
1990	0.331	845	1,280	154	1,237	148	1.0
1991	0.263	2,284	1,738	209	2,056	247	1.2

Table 24 Continued. Input (with log-scale standard errors, SE) and expected (Exp) discards for the Recreational Private + Shore fleet in number (N, 1,000s of fish) and biomass (B, thousand pounds gutted weight) for Gulf of Mexico Gag Grouper. Dead discards in numbers (discard mortality rate = 0.12), dead discards in biomass, and mean weight (MW, gutted pounds per fish) are included. Mean weight was determined by dividing the expected discards in weights by the expected discards in numbers .

Year	Input N SE	Input N	Exp N	Exp Dead N	Exp B	Exp Dead B	MW
1992	0.186	1.619	1.268	152	1.227	147	1.0
1993	0.183	3,530	2,945	353	1,797	216	0.6
1994	0.123	3,346	3,064	368	2,594	311	0.8
1995	0.142	4,336	4,680	562	5,254	631	1.1
1996	0.108	2,133	2,230	268	1,730	208	0.8
1997	0.115	3,597	3,802	456	3,630	436	1.0
1998	0.126	4,956	5,379	646	6,982	838	1.3
1999	0.106	4,343	4,430	532	3,911	469	0.9
2000	0.087	2,829	2,988	359	2,473	297	0.8
2001	0.125	5,097	4,881	586	5,838	701	1.2
2002	0.095	5,799	5,598	672	6,462	775	1.2
2003	0.085	6,766	5,942	713	7,325	879	1.2
2004	0.105	8,915	7,399	888	9,511	1,141	1.3
2005	0.102	5,607	5,551	666	6,294	755	1.1
2006	0.114	3,680	4,097	492	3,891	467	0.9
2007	0.105	5,068	5,218	626	5,213	626	1.0
2008	0.102	9,135	9,070	1,088	11,682	1,402	1.3
2009	0.096	5,976	5,032	604	7,694	923	1.5
2010	0.092	4,758	4,262	511	5,251	630	1.2
2011	0.152	3,436	3,441	413	8,097	972	2.4
2012	0.121	2,389	2,597	312	6,391	767	2.5
2013	0.131	2,403	2,779	333	2,967	356	1.1
2014	0.139	1,946	1,759	211	1,712	205	1.0
2015	0.130	1,211	1,264	152	1,277	153	1.0
2016	0.195	2,037	1,628	195	1,604	192	1.0
2017	0.166	3,215	3,080	370	3,902	468	1.3
2018	0.175	2,142	2,901	348	4,672	561	1.6
2019	0.170	2,334	2,422	291	3,725	447	1.5

Table 25. Observed (Obs) versus predicted (Exp) standardized fishery-dependent catch-per-unit-effort (CPUE) indices for Gulf of Mexico Gag Grouper. Values are normalized to the mean. CVs as estimated by the standardization process were converted to log-scale SEs and further adjusted based on the Francis weighting method.

Yr	VL (Obs)	VL (Exp)	VL (SE)	LL (Obs)	LL (Exp)	LL (SE)	Hbt (Obs)	Hbt (Exp)	Hbt (SE)	Char Pri (Obs)	Char Pri (Exp)	Char Pri (SE)
1986							1.53	1.42	0.26	1.70	0.97	0.28
1987							1.59	1.32	0.26	0.36	0.85	0.38
1988							1.31	1.17	0.26	0.49	0.77	0.48
1989							1.15	1.01	0.26	0.32	0.65	0.40
1990	0.31	1.12	0.60	0.82	1.37	0.67	1.02	0.67	0.26	0.72	0.80	0.39
1991	0.31	1.06	0.53	0.64	1.31	0.60	0.75	0.70	0.28	0.71	0.84	0.40
1992	0.56	1.01	0.52	0.51	1.22	0.60	0.71	0.92	0.29	0.79	0.85	0.31
1993	0.65	0.98	0.50	0.67	1.12	0.54	0.72	0.87	0.29	1.00	0.83	0.29
1994	0.59	0.95	0.49	0.38	1.06	0.55	0.76	0.81	0.29	1.10	1.10	0.29
1995	0.78	0.90	0.49	0.48	1.00	0.54	0.80	0.92	0.28	1.58	1.29	0.27
1996	0.93	0.93	0.49	0.50	0.95	0.55	1.11	1.33	0.26	1.36	1.39	0.27
1997	0.91	1.10	0.49	0.64	1.02	0.53	1.15	1.52	0.25	1.23	1.74	0.26
1998	1.54	1.15	0.48	0.95	1.06	0.53	1.12	1.49	0.26	1.57	1.75	0.23
1999	1.07	1.13	0.49	0.85	1.03	0.53	1.31	1.66	0.26	1.24	1.52	0.22
2000	1.11	1.23	0.49	0.88	1.10	0.53	1.03	1.60	0.28	0.90	1.58	0.24
2001	1.59	1.24	0.49	1.64	1.20	0.52	0.66	1.12	0.29	1.08	1.71	0.23
2002	1.59	1.23	0.49	1.44	1.25	0.53	0.68	1.17	0.30	1.23	1.76	0.23
2003	1.56	1.25	0.49	1.71	1.26	0.52	0.97	1.31	0.28	1.77	1.87	0.22
2004	1.99	1.23	0.49	2.06	1.22	0.52	1.03	1.25	0.28	1.69	1.80	0.22
2005	1.87	0.82	0.49	2.26	0.81	0.51	1.27	0.89	0.25	1.86	1.16	0.22
2006	1.00	0.50	0.49	1.20	0.48	0.52	0.56	0.56	0.30	1.08	0.81	0.24
2007	0.65	0.49	0.50	0.91	0.47	0.53	0.61	0.53	0.31	1.12	0.93	0.25
2008	0.64	0.41	0.50	0.99	0.39	0.52	0.95	0.48	0.28	1.57	1.00	0.23
2009	0.35	0.33	0.50	0.45	0.30	0.59	0.94	0.53	0.28	1.20	0.95	0.24
2010							1.25	0.63	0.27	1.19	0.83	0.25
2011										0.84	0.82	0.25
2012										0.77	0.72	0.26
2013										0.54	0.59	0.28

Table 25 Continued. Observed (Obs) versus predicted (Exp) standardized fishery-dependent catch-per-unit-effort (CPUE) indices for Gulf of Mexico Gag Grouper. Values are normalized to the mean. CVs as estimated by the standardization process were converted to log-scale SEs and further adjusted based on the Francis weighting method.

Yr	VL (Obs)	VL (Exp)	VL (SE)	LL (Obs)	LL (Exp)	LL (SE)	Hbt (Obs)	Hbt (Exp)	Hbt (SE)	Char Pri (Obs)	Char Pri (Exp)	Char Pri (SE)
2014										0.45	0.43	0.27
2015										0.30	0.37	0.30
2016										0.45	0.43	0.29
2017										0.57	0.51	0.28
2018										0.66	0.51	0.28
2019										0.53	0.44	0.31

Table 26. Observed (Obs) versus predicted (Exp) standardized fishery-independent indices and associated lognormal standard error (as estimated by the standardization process) for Gulf of Mexico Gag Grouper. Values are normalized to the mean. CVs as estimated by the standardization process were converted to log-scale SEs and further adjusted based on the Francis weighting method.

Year	Age0 (Obs)	Age0 (Exp)	Age0 (SE)	SEAMAP Video (Obs)	SEAMAP Video (Exp)	SEAMAP Video (SE)	PC Video (Obs)	PC Video (Exp)	PC Video (SE)
1993				0.441	1.058	0.771			
1994	0.804	1.259	0.842	0.107	1.064	0.826			
1995	0.619	0.941	0.768	0.295	1.013	0.730			
1996	2.063	2.274	0.688	0.798	1.117	0.753			
1997	0.468	1.280	0.716	0.447	1.444	0.679			
1998	0.202	0.697	0.834						
1999	0.309	1.708	0.780						
2000	0.487	1.576	0.780						
2001	0.416	1.293	0.801						
2002	1.350	1.808	0.716	1.977	1.745	0.842			
2003	0.795	1.299	0.738						
2004	1.883	1.298	0.685	2.058	1.773	0.646			
2005	0.854	1.688	0.694	2.491	1.130	0.807			
2006	2.516	1.173	0.667	1.223	0.755	0.725	2.300	1.376	0.348
2007	2.287	1.203	0.666	1.676	0.742	0.798	1.610	1.624	0.401
2008	3.236	0.688	0.618	0.267	0.619	0.736	1.074	1.516	0.395
2009	0.873	0.473	0.675	0.796	0.581	0.645	1.650	1.221	0.327
2010	1.248	0.785	0.677	1.080	0.675	0.583	1.450	1.124	0.326
2011	0.088	0.169	0.775	1.462	0.816	0.562	1.075	0.957	0.353
2012	0.495	0.391	0.682	1.674	0.940	0.646	0.351	0.785	0.464
2013	0.805	0.551	0.679	1.484	0.873	0.765	0.642	0.774	0.506
2014	0.379	0.577	0.717	0.713	0.591	0.642	0.438	0.657	0.408
2015	0.756	0.460	0.686	1.136	0.423	0.787	0.288	0.603	0.520
2016	1.111	0.597	0.660	0.258	0.398	0.596	0.530	0.739	0.463
2017	1.078	0.531	0.670	0.384	0.400	0.625	0.686	0.831	0.417
2018	0.283	0.298	0.724	0.436	0.379	0.597	0.525	0.694	0.480
2019	0.595	0.388	0.682	0.798	0.373	1.213	1.383	0.591	0.396

Table 27. Summary of correlated parameters with correlation coefficients > 0.7 parameters for Gulf of Mexico Gag Grouper from the SEDAR72 base model.

Parameter 1	Parameter 2	Correlation
InitF_seas_1_flt_5Rec_PRIV_SH_5	InitF_seas_1_flt_1Com_VL_OTH_1	0.908
Main_RecrDev_2005	Main_RecrDev_2004	0.729
Main_RecrDev_2012	Main_RecrDev_2010	0.728
Main_RecrDev_2012	Main_RecrDev_2011	0.758
Main_RecrDev_2013	Main_RecrDev_2011	0.765
Main_RecrDev_2013	Main_RecrDev_2012	0.899
Main_RecrDev_2014	Main_RecrDev_2011	0.706
Main_RecrDev_2014	Main_RecrDev_2012	0.853
Main_RecrDev_2014	Main_RecrDev_2013	0.896
Size_95%width_Srv_SEAMAP_VIDEO_9(9)	Size_inflection_Srv_SEAMAP_VIDEO_9(9)	0.796
Size_DblN_ascend_se_Rec_CBT_4(4)	Size_DblN_peak_Rec_CBT_4(4)	0.771
Size_DblN_ascend_se_Rec_HBT_3(3)	Size_DblN_peak_Rec_HBT_3(3)	0.709
Size_DblN_descend_se_Rec_CBT_4(4)	Size_DblN_peak_Rec_CBT_4(4)	-0.778
Size_DblN_descend_se_Rec_HBT_3(3)	Size_DblN_peak_Rec_HBT_3(3)	-0.842
Size_DblN_descend_se_Rec_PRIV_SH_5(5)	Size_DblN_peak_Rec_PRIV_SH_5(5)	-0.956
Size_DblN_end_logit_Rec_CBT_4(4)	Size_DblN_descend_se_Rec_CBT_4(4)	-0.737
VonBert_K_Fem_GP_1	L_at_Amin_Fem_GP_1	-0.816
VonBert_K_Fem_GP_1	L_at_Amax_Fem_GP_1	-0.975

Table 28. Summary of key model building steps towards the SEDAR72 Base Model for Gulf of Mexico Gag Grouper and associated convergence diagnostics. Note that steps within each model progression are not shown due to the vast number of intermediate runs conducted.

Model Name	Description	SS Version	NLL	Gradient	Bounded Parms
1_S33U	SEDAR 33 Update	3.24	8,630	0.0486	2
2_S33U_convert	SEDAR 33 Update converted to newest SS version	3.30	8,586	0.0012	2
3_2+FES	Step 2 + replace recreational catches and discards with FES estimates, no change to CVs nor end yr	3.30	8,504	0.0064	2
4_3+AllNewData	Step 3 + end year 2019 + fleet structure changes + all new data added catches, discards, indices, length comps, age comps nominal	3.30	5,251	0.2090	0
5_4+NewBiology _ExtraTimeBlocks	Step 4 + new M, maturity, hermaphroditism, growth CVs + time blocks extended and added for new minimum size limit and reduced recreational season	3.30	4,051	0.0002	1
6_5+Selectivities	Step 5 + adjust selectivities, remove prior on initial Fs, extend recruitment deviations to 2019	3.30	4,016	0.0026	1
7_6+RT1418	Step 6 + estimate red tide mortality in 2014 and 2018	3.30	3,951	0.0004	0
8_7+Dirichlet	Step 7 + Dirichlet weighting of length and age compositions	3.30	15,430	0.2970	0
9_8+RecBias	Step 8 + apply recruitment deviations bias adjustment ramp and fix Dirichlet params > 5	3.30	15,423	0.0160	0
10_9+Francis	Step 9 + Francis weighting of indices	3.30	15,182	0.0530	0
11_10+RecBias	Step 10 + apply recruitment deviations bias adjustment ramp	3.30	15,182	0.0312	0

Table 29. Summary of key model building steps towards the SEDAR72 Base Model for Gulf of Mexico Gag Grouper and associated key estimates and derived quantities (note that steepness and sigmaR were fixed at 0.855 and 0.6, respectively, across all runs). Steps within each model progression are not shown due to the vast number of intermediate runs conducted.

Model Name	Ln(R0)	R1 Offset/ Regime	Target M	Virgin SSB (mt)	Virgin Recr (1000s)	Depletion Start Yr	Depletion End Yr
1_S33U	8.52	-1.07	0.134	24,913	5,032	0.29	0.39
2_S33U_convert	8.52	-1.06	0.134	24,818	5,017	0.29	0.39
3_2+FES	9.13	-0.73	0.134	45,053	9,264	0.23	0.14
4_3+AllNewData	8.98	-0.08	0.134	38,624	7,920	0.54	0.10
5_4+NewBiology _ExtraTimeBlocks	9.27	-0.15	0.159	35,734	10,650	0.45	0.09
6_5+Selectivities	9.24	-0.11	0.159	34,395	10,348	0.50	0.09
7_6+RT1418	9.37	-0.20	0.159	37,932	11,698	0.39	0.07
8_7+Dirichlet	9.36	-0.20	0.159	37,735	11,656	0.40	0.07
9_8+RecBias	9.37	-0.20	0.159	38,097	11,768	0.40	0.07
10_9+Francis	9.35	-0.18	0.159	36,796	11,458	0.42	0.06
11_10+RecBias	9.34	-0.18	0.159	36,666	11,417	0.42	0.06

Table 30. Settings used for Gulf of Mexico Gag Grouper projections.

Parameter	Value	Comment
Relative F	Average from 2017 - 2019	Average relative fishing mortality (apical F) over terminal three years of model (Red Tide F excluded)
Selectivity	2019	Fleet specific selectivity estimated in the terminal year of the model
Retention	2019	Fleet specific retention estimated in the terminal year of the model
Recruitment	Beverton-Holt stock-recruitment relationship	Derived from the model estimated Beverton-Holt stock-recruitment relationship
Interim Landings (2020-2022)	73.79/126.72/126.72 mt (Comm. Vertical Line) 133.69/97.41/97.41 mt (Comm. Longline) 2.61/2.54/2.54 thousands of fish (Headboat) 37.61/28.66/28.66 thousands of fish (Charter) 305.4/271.68/271.68 thousands of fish (Private)	Landings provided for 2020; For 2021-2022, used 3-year average of landings (2018-2020)
Allocation Ratio	39:61	Commercial:Recreational

Table 31. Summary of Magnuson-Stevens Reauthorization Act benchmarks and reference points for the SEDAR72 Gulf of Mexico Gag Grouper assessment. Spawning Stock Biomass (SSB) is in metric tons, whereas F is a harvest rate (total biomass killed age 3+ / total biomass age 3+).

Criteria	Definition	Female-only SSB	SSB combined
Base M	Target M for fully selected ages in the Lorenzen (2005) scaling	0.159	0.159
Steepness	Steepness of the Beverton-Holt stock-recruit relationship (fixed)	0.855	0.855
R0	Virgin Recruitment (1000s)	11,417	14,292
Generation Time	Fecundity-weighted mean age	7.9	7.9
SSB0	Virgin spawning stock biomass (mt)	36,666	105,978
	Mortality Rate Criteria		
Fmsy proxy	Fmax - fishing mortality rate that achieves maximum yield per recruit	0.303	0.275
MFMT	Fmax	0.303	0.275
%SPR equivalent of Fmsy proxy	%SPR equivalent of Fmax	31	16
Fcurrent	Geometric mean of the last 3 years of the assessment (F2017-2019), including red tide mortality	0.457	0.453
Fcurrent/MFMT	Current stock status based on MFMT	1.512	1.647
	Biomass Criteria		
SSBmsy proxy	Equilibrium SSB at Fmax	10,186	13,401
MSST	0.5*SSBFmax	5,093	6,701
SSBcurrent	SSB2019	2,102	2,295
SSBcurrent/SSBFmax	Current stock status based on SSBFmax	0.206	0.171
SSBcurrent/MSST	Current stock status based on MSST	0.413	0.343
SSBcurrent/SSB0	SSB ratio in 2019	0.057	0.022

Table 32. Time series of fishing mortality and SSB relative to associated biological reference points. SSB is in metric tons, whereas F is a harvest rate (total biomass killed age 3+ / total biomass age 3+). Reference points include F_{MAX} = 0.303, SSB_{FMAX} = 10,185 metric tons, and $MSST_{FMAX}$ = 5,092 metric tons which was calculated as (0.5) * SSB_{FMAX}. SSB ratio was calculated as annual SSB divided by SSB_0 where SSB_0 = 36,665 metric tons. Red indicates overfishing and/or overfished states. **SSB defined as female-only SSB**

Year	F	F/FMAX	SSB	SSB/ SSBFMAX	SSB/MSST	SSB/SSB0
1963	0.086	0.284	15,470	1.519	3.038	0.422
1964	0.098	0.324	15,642	1.536	3.072	0.427
1965	0.107	0.354	15,605	1.532	3.064	0.426
1966	0.111	0.367	15,281	1.500	3.001	0.417
1967	0.113	0.373	14,372	1.411	2.822	0.392
1968	0.122	0.403	13,039	1.280	2.560	0.356
1969	0.134	0.443	11,605	1.139	2.279	0.317
1970	0.142	0.469	10,197	1.001	2.002	0.278
1971	0.160	0.529	8,952	0.879	1.758	0.244
1972	0.183	0.605	7,797	0.766	1.531	0.213
1973	0.193	0.638	6,754	0.663	1.326	0.184
1974	0.216	0.714	5,950	0.584	1.168	0.162
1975	0.246	0.813	5,347	0.525	1.050	0.146
1976	0.246	0.813	4,993	0.490	0.980	0.136
1977	0.247	0.816	5,044	0.495	0.991	0.138
1978	0.253	0.836	5,388	0.529	1.058	0.147
1979	0.276	0.912	5,727	0.562	1.125	0.156
1980	0.303	1.001	5,824	0.572	1.144	0.159
1981	0.234	0.773	5,764	0.566	1.132	0.157
1982	0.340	1.124	6,435	0.632	1.264	0.176
1983	0.279	0.922	6,280	0.617	1.233	0.171
1984	0.177	0.585	6,387	0.627	1.254	0.174
1985	0.278	0.919	7,472	0.734	1.467	0.204
1986	0.301	0.995	7,584	0.745	1.489	0.207
1987	0.253	0.836	7,176	0.705	1.409	0.196
1988	0.230	0.760	7,134	0.700	1.401	0.195
1989	0.246	0.813	7,076	0.695	1.389	0.193

Table 32 Continued. Time series of fishing mortality and SSB relative to associated biological reference points. SSB is in metric tons, whereas F is a harvest rate (total biomass killed age 3+ / total biomass age 3+). Reference points include F_{MAX} = 0.303, SSB_{FMAX} = 10,185 metric tons, and $MSST_{FMAX}$ = 5,092 metric tons which was calculated as (0.5) * SSB_{FMAX}. SSB ratio was calculated as annual SSB divided by SSB_0 where SSB_0 = 36,665 metric tons. Red indicates overfishing and/or overfished states. **SSB defined as female-only SSB**

Year	F	F/FMAX	SSB	SSB/ SSBFMAX	SSB/MSST	SSB/SSB0
1990	0.220	0.727	6,498	0.638	1.276	0.177
1991	0.267	0.882	5,879	0.577	1.154	0.160
1992	0.249	0.823	5,324	0.523	1.045	0.145
1993	0.306	1.011	5,920	0.581	1.162	0.161
1994	0.278	0.919	5,954	0.585	1.169	0.162
1995	0.430	1.421	5,771	0.567	1.133	0.157
1996	0.229	0.757	5,290	0.519	1.039	0.144
1997	0.280	0.925	7,501	0.737	1.473	0.205
1998	0.495	1.636	9,368	0.920	1.840	0.256
1999	0.383	1.266	8,221	0.807	1.614	0.224
2000	0.269	0.889	9,029	0.886	1.773	0.246
2001	0.343	1.134	10,597	1.040	2.081	0.289
2002	0.326	1.077	9,977	0.980	1.959	0.272
2003	0.345	1.140	10,298	1.011	2.022	0.281
2004	0.438	1.447	10,996	1.080	2.159	0.300
2005	0.998 (0.329)*	3.298 (1.087)*	9,988	0.981	1.961	0.272
2006	0.409	1.352	4,501	0.442	0.884	0.123
2007	0.424	1.401	4,447	0.437	0.873	0.121
2008	0.690	2.280	4,286	0.421	0.842	0.117
2009	0.517	1.709	3,207	0.315	0.630	0.087
2010	0.457	1.510	3,753	0.369	0.737	0.102
2011	0.289	0.955	4,431	0.435	0.870	0.121
2012	0.268	0.886	5,338	0.524	1.048	0.146
2013	0.416	1.375	5,603	0.550	1.100	0.153
2014	0.752 (0.274)*	2.485 (0.905)*	4,611	0.453	0.905	0.126
2015	0.289	0.955	2,520	0.247	0.495	0.069
2016	0.335	1.107	2,313	0.227	0.454	0.063

*The number in parenthesis represents the total exploitation rate excluding red tide mortality.

Table 32 Continued. Time series of fishing mortality and SSB relative to associated biological reference points. SSB is in metric tons, whereas F is a harvest rate (total biomass killed age 3+ / total biomass age 3+). Reference points include F_{MAX} = 0.303, SSB_{FMAX} = 10,185 metric tons, and $MSST_{FMAX}$ = 5,092 metric tons which was calculated as (0.5) * SSB_{FMAX}. SSB ratio was calculated as annual SSB divided by SSB_0 where SSB_0 = 36,665 metric tons. Red indicates overfishing and/or overfished states. **SSB defined as female-only SSB**

Year	F	F/FMAX	SSB	SSB/ SSBFMAX	SSB/MSST	SSB/SSB0
2017	0.368	1.216	2,306	0.226	0.453	0.063
2018	0.656 (0.379)*	2.168 (1.252)*	2,418	0.237	0.475	0.066
2019	0.397	1.312	2,102	0.206	0.413	0.057

*The number in parenthesis represents the total exploitation rate excluding red tide mortality.

Table 33. Time series of fishing mortality and SSB relative to associated biological reference points. SSB is in metric tons, whereas F is a harvest rate (total biomass killed age 3+ / total biomass age 3+). Reference points include F_{MAX} = 0.275, SSB_{FMAX} = 13,401 metric tons, and $MSST_{FMAX}$ = 6,700 metric tons which was calculated as (0.5) * SSB_{FMAX}. SSB ratio was calculated as annual SSB divided by SSB_0 where SSB_0 = 105,978 metric tons. Red indicates overfishing and/or overfished states. **SSB defined as SSB combined.**

Year	F	F/FMAX	SSB	SSB/ SSBFMAX	SSB/MSST	SSB/SSB0
1963	0.078	0.284	29,032	2.166	4.333	0.274
1964	0.088	0.320	29,538	2.204	4.408	0.279
1965	0.096	0.349	29,752	2.220	4.440	0.281
1966	0.100	0.364	29,565	2.206	4.412	0.279
1967	0.102	0.371	28,593	2.134	4.267	0.270
1968	0.110	0.400	26,995	2.014	4.029	0.255
1969	0.122	0.443	25,100	1.873	3.746	0.237
1970	0.129	0.469	23,020	1.718	3.436	0.217
1971	0.146	0.531	20,989	1.566	3.133	0.198
1972	0.167	0.607	18,893	1.410	2.820	0.178
1973	0.178	0.647	16,751	1.250	2.500	0.158
1974	0.200	0.727	14,895	1.112	2.223	0.141
1975	0.228	0.829	13,172	0.983	1.966	0.124
1976	0.230	0.836	11,635	0.868	1.736	0.110
1977	0.234	0.851	10,703	0.799	1.597	0.101
1978	0.240	0.872	10,237	0.764	1.528	0.097
1979	0.264	0.960	9,937	0.742	1.483	0.094
1980	0.289	1.051	9,428	0.704	1.407	0.089
1981	0.223	0.811	8,882	0.663	1.326	0.084
1982	0.324	1.178	9,135	0.682	1.363	0.086
1983	0.266	0.967	8,589	0.641	1.282	0.081
1984	0.170	0.618	8,512	0.635	1.270	0.080
1985	0.270	0.982	9,549	0.713	1.425	0.090
1986	0.291	1.058	9,540	0.712	1.424	0.090
1987	0.245	0.891	9,029	0.674	1.348	0.085
1988	0.223	0.811	8,979	0.670	1.340	0.085
1989	0.238	0.865	8,959	0.669	1.337	0.085

Table 33 Continued. Time series of fishing mortality and SSB relative to associated biological reference points. SSB is in metric tons, whereas F is a harvest rate (total biomass killed age 3+ / total biomass age 3+). Reference points include F_{MAX} = 0.275, SSB_{FMAX} = 13,401 metric tons, and $MSST_{FMAX}$ = 6,700 metric tons which was calculated as (0.5) * SSB_{FMAX}. SSB ratio was calculated as annual SSB divided by SSB_0 where SSB_0 = 105,978 metric tons. Red indicates overfishing and/or overfished states. **SSB defined as SSB combined.**

Year	F	F/FMAX	SSB	SSB/ SSBFMAX	SSB/MSST	SSB/SSB0
1990	0.215	0.782	8,376	0.625	1.250	0.079
1991	0.261	0.949	7,713	0.576	1.151	0.073
1992	0.244	0.887	7,100	0.530	1.060	0.067
1993	0.299	1.087	7,574	0.565	1.130	0.071
1994	0.273	0.992	7,464	0.557	1.114	0.070
1995	0.421	1.530	7,192	0.537	1.073	0.068
1996	0.225	0.818	6,549	0.489	0.977	0.062
1997	0.275	1.000	8,659	0.646	1.292	0.082
1998	0.485	1.763	10,498	0.783	1.567	0.099
1999	0.375	1.363	9,264	0.691	1.383	0.087
2000	0.265	0.963	10,030	0.748	1.497	0.095
2001	0.341	1.240	11,631	0.868	1.736	0.110
2002	0.328	1.192	10,975	0.819	1.638	0.104
2003	0.352	1.280	11,181	0.834	1.669	0.106
2004	0.452	1.643	11,689	0.872	1.745	0.110
2005	0.945 (0.35)*	3.435 (1.272)*	10,356	0.773	1.546	0.098
2006	0.405	1.472	4,978	0.372	0.743	0.047
2007	0.422	1.534	4,894	0.365	0.730	0.046
2008	0.693	2.519	4,685	0.350	0.699	0.044
2009	0.524	1.905	3,428	0.256	0.512	0.032
2010	0.471	1.712	3,864	0.288	0.577	0.036
2011	0.297	1.080	4,420	0.330	0.660	0.042
2012	0.285	1.036	5,286	0.395	0.789	0.050
2013	0.475	1.727	5,486	0.409	0.819	0.052
2014	0.578 (0.334)*	2.101 (1.214)*	4,152	0.310	0.620	0.039
2015	0.293	1.065	2,832	0.211	0.423	0.027
2016	0.345	1.254	2,622	0.196	0.391	0.025

*The number in parenthesis represents the total exploitation rate excluding red tide mortality.

Table 33 Continued. Time series of fishing mortality and SSB relative to associated biological reference points. SSB is in metric tons, whereas F is a harvest rate (total biomass killed age 3+ / total biomass age 3+). Reference points include F_{MAX} = 0.275, SSB_{FMAX} = 13,401 metric tons, and $MSST_{FMAX}$ = 6,700 metric tons which was calculated as (0.5) * SSB_{FMAX}. SSB ratio was calculated as annual SSB divided by SSB_0 where SSB_0 = 105,978 metric tons. Red indicates overfishing and/or overfished states. **SSB defined as SSB combined.**

Year	F	F/FMAX	SSB	SSB/ SSBFMAX	SSB/MSST	SSB/SSB0
2017	0.389	1.414	2,541	0.190	0.379	0.024
2018	0.559 (0.421)*	2.032 (1.53)*	2,539	0.189	0.379	0.024
2019	0.427	1.552	2,295	0.171	0.343	0.022

*The number in parenthesis represents the total exploitation rate excluding red tide mortality.

Table 34. Results of the OFL projections (fishing set at F_{MAX}) for Gulf of Mexico Gag Grouper. Recruitment (R) is in 1000s of age-0 fish, SSB is in metric tons, F is a harvest rate (total biomass killed age 3+ / total biomass age 3+), and OFL is the overfishing limit in millions of pounds gutted weight. Reference points include F_{MAX} = 0.303, SSBFMAX = 10,185 metric tons, and MSST = 5,092 metric tons which was calculated as 0.5*SSB_{FMAX}. SSB ratio was calculated as annual SSB divided by SSB0. **SSB defined as female-only SSB.**

Year	R	F	F/FMAX	SSB	SSB/ SSBFMAX	SSB/MSST	SSB/SSB0	OFL
2023	7,124	0.303	1	2,410	0.237	0.473	0.066	2.715
2024	7,981	0.303	1	3,287	0.323	0.645	0.090	3.641
2025	8,710	0.303	1	4,401	0.432	0.864	0.120	4.466
2026	9,138	0.303	1	5,327	0.523	1.046	0.145	5.109
2027	9,396	0.303	1	6,037	0.593	1.185	0.165	5.731

Table 35. Results of the OFL projections (fishing set at F_{MAX}) for Gulf of Mexico Gag Grouper. Recruitment (R) is in 1000s of age-0 fish, SSB is in metric tons, F is a harvest rate (total biomass killed age 3+ / total biomass age 3+), and OFL is the overfishing limit in millions of pounds gutted weight. Reference points include F_{MAX} = 0.275, SSBFMAX = 13,401 metric tons, and MSST = 6,700 metric tons which was calculated as 0.5*SSB_{FMAX}. SSB ratio was calculated as annual SSB divided by SSB0. **SSB defined as SSB combined.**

Year	R	F	F/FMAX	SSB	SSB/ SSBFMAX	SSB/MSST	SSB/SSB0	OFL
2023	4,217	0.275	1	1,848	0.138	0.276	0.017	1.748
2024	5,177	0.275	1	2,492	0.186	0.372	0.024	2.370
2025	6,188	0.275	1	3,323	0.248	0.496	0.031	2.899
2026	6,877	0.275	1	4,010	0.299	0.598	0.038	3.223
2027	7,307	0.275	1	4,500	0.336	0.672	0.042	3.587

Table 36. Results of projections at F = 0 for Gulf of Mexico Gag Grouper. Recruitment (R) is in 1000s of age-0 fish, SSB is in metric tons, F is a harvest rate (total biomass killed age 3+ / total biomass age 3+), and retained yield in millions of pounds gutted weight. Reference points include SSB_{FMAX} = 10,185 metric tons and $MSST_{FMAX}$ = 5,092 metric tons (0.5 * SSB_{FMAX}). SSB ratio was calculated as annual SSB divided by SSB_0 (36,665 metric tons). **SSB defined as female-only SSB.**

Year	R	F	SSB	SSB/SSBFMAX	SSB/MSST	SSB/SSB0	Yield
2023	7,124	0	2,410	0.237	0.473	0.066	0
2024	7,980	0	4,288	0.421	0.842	0.117	0
2025	8,709	0	6,899	0.677	1.355	0.188	0
2026	9,137	0	9,731	0.955	1.911	0.265	0
2027	9,395	0	12,582	1.235	2.471	0.343	0

Table 37. Results of projections at F = 0 for Gulf of Mexico Gag Grouper. Recruitment (R) is in 1000s of age-0 fish, SSB is in metric tons, F is a harvest rate (total biomass killed age 3+ / total biomass age 3+), and retained yield in millions of pounds gutted weight. Reference points include SSB_{FMAX} = 13,401 metric tons and $MSST_{FMAX}$ = 6,700 metric tons (0.5 * SSB_{FMAX}). SSBratio was calculated as annual SSB divided by SSB_0 (105,978 metric tons). **SSB defined as SSB combined.**

Year	R	F	SSB	SSB/SSBFMAX	SSB/MSST	SSB/SSB0	Yield
2023	4,216	0	1,847	0.138	0.276	0.017	0
2024	5,177	0	3,206	0.239	0.479	0.030	0
2025	6,187	0	5,115	0.382	0.763	0.048	0
2026	6,877	0	7,199	0.537	1.074	0.068	0
2027	7,306	0	9,298	0.694	1.388	0.088	0

Figures

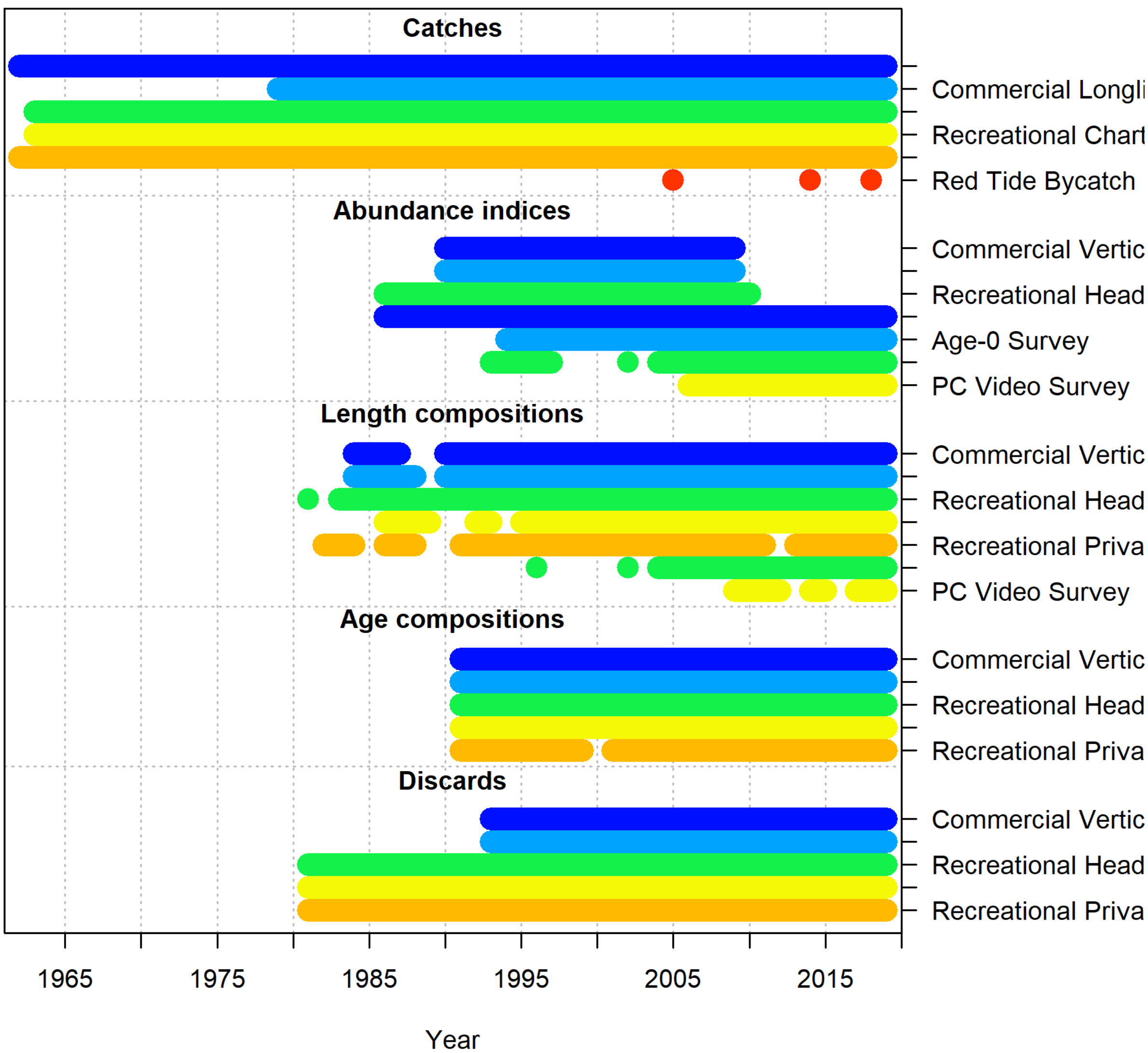


Figure 1. Data sources used in the Gulf of Mexico Grouper Stock Synthesis assessment model.

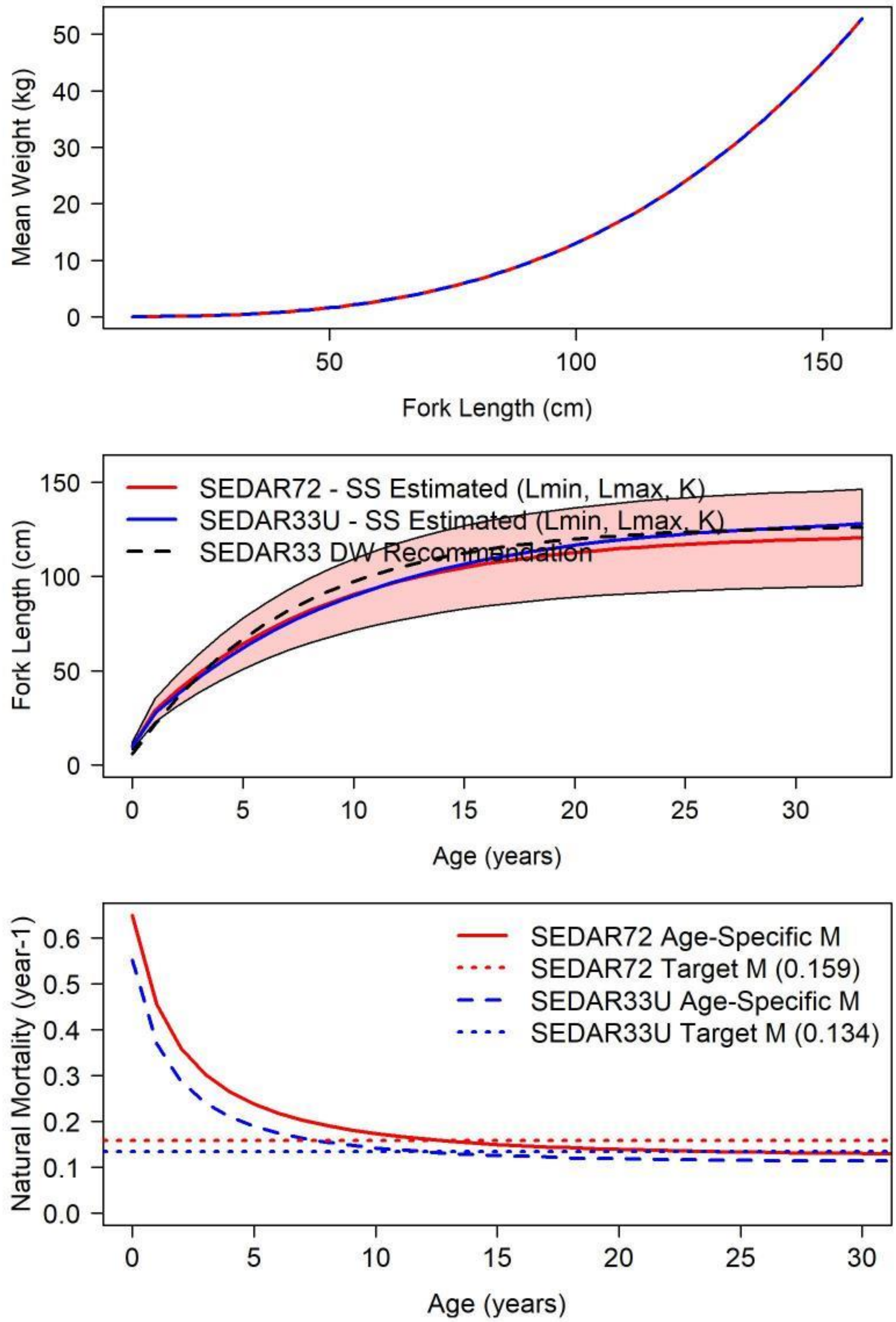


Figure 2. Mean weight-at-length (top panel), recommended and estimated growth curves (with 95% confidence intervals; middle panel), and natural mortality (bottom panel) used in the assessment model for Gulf of Mexico Gag Grouper. SEDAR33 Update and SEDAR72 inputs are presented for comparison.

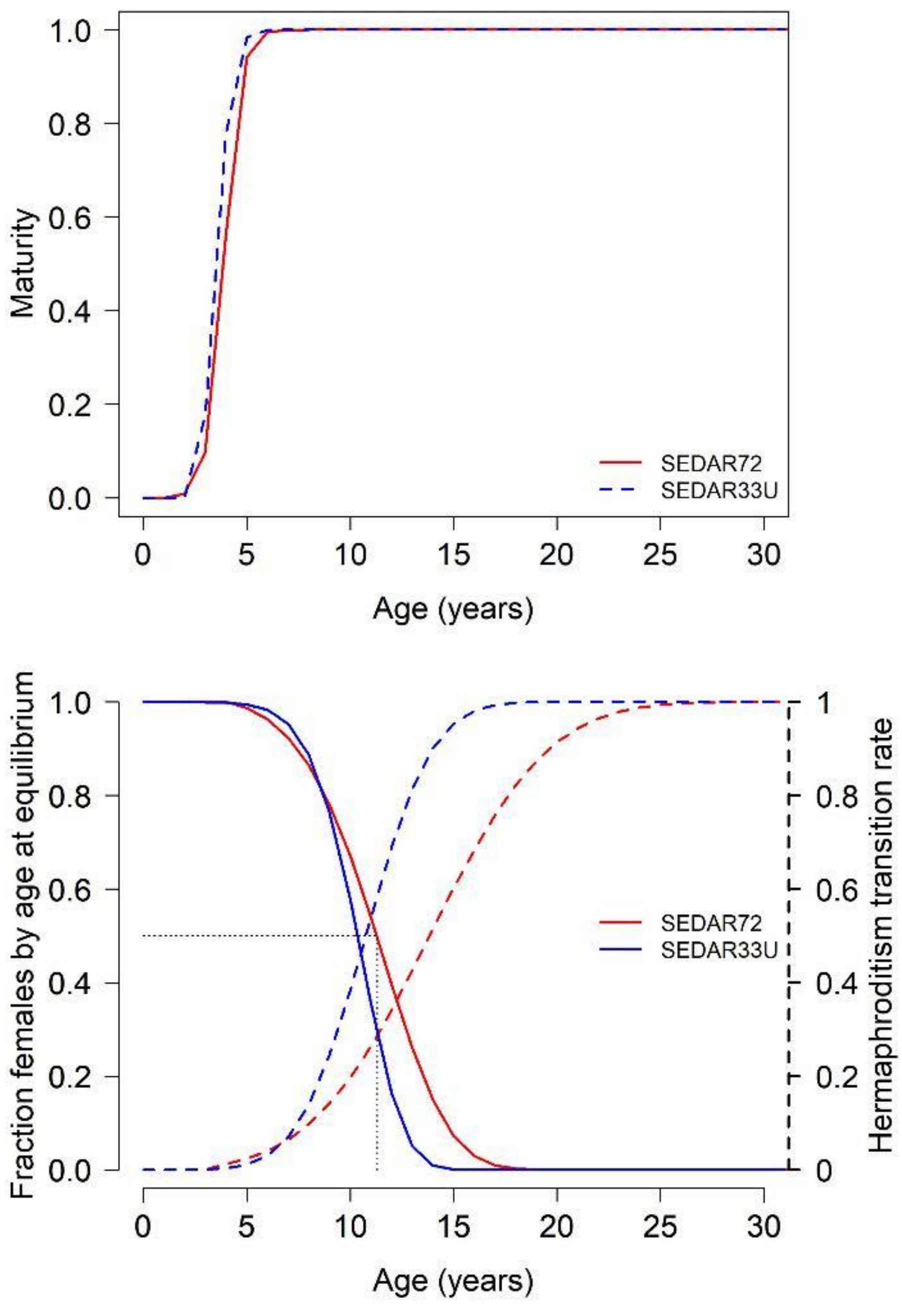


Figure 3. Maturity (top panel) and hermaphroditism functions (bottom panel) used in SEDAR72 and SEDAR33 Update for Gulf of Mexico Gag Grouper.

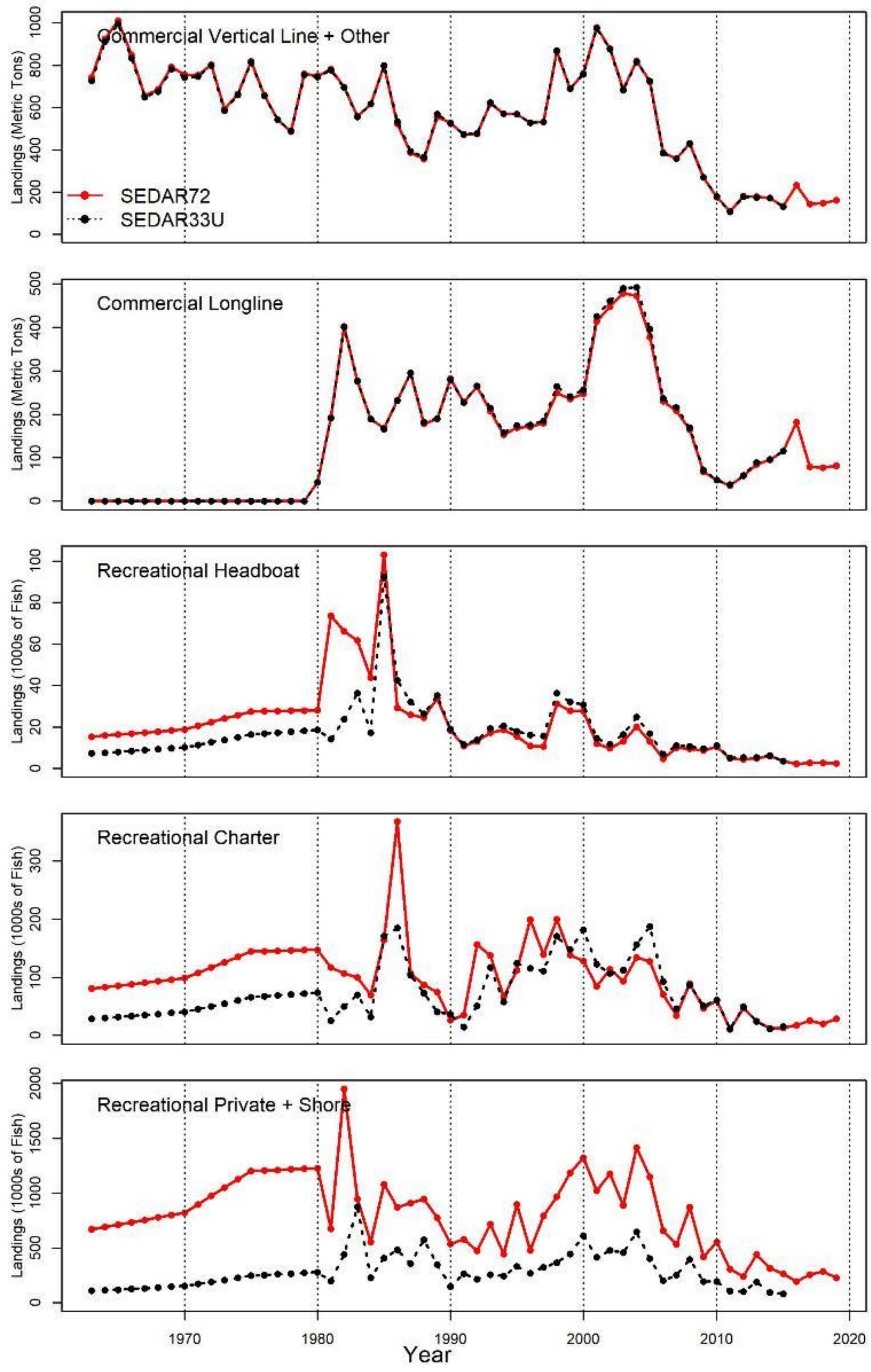


Figure 4. Gulf of Mexico Gag Grouper observed landings by fishery for SEDAR72 and SEDAR33 Update. Commercial and recreational landings are in metric tons and numbers of fish, respectively. Dashed vertical lines identify ten year intervals.

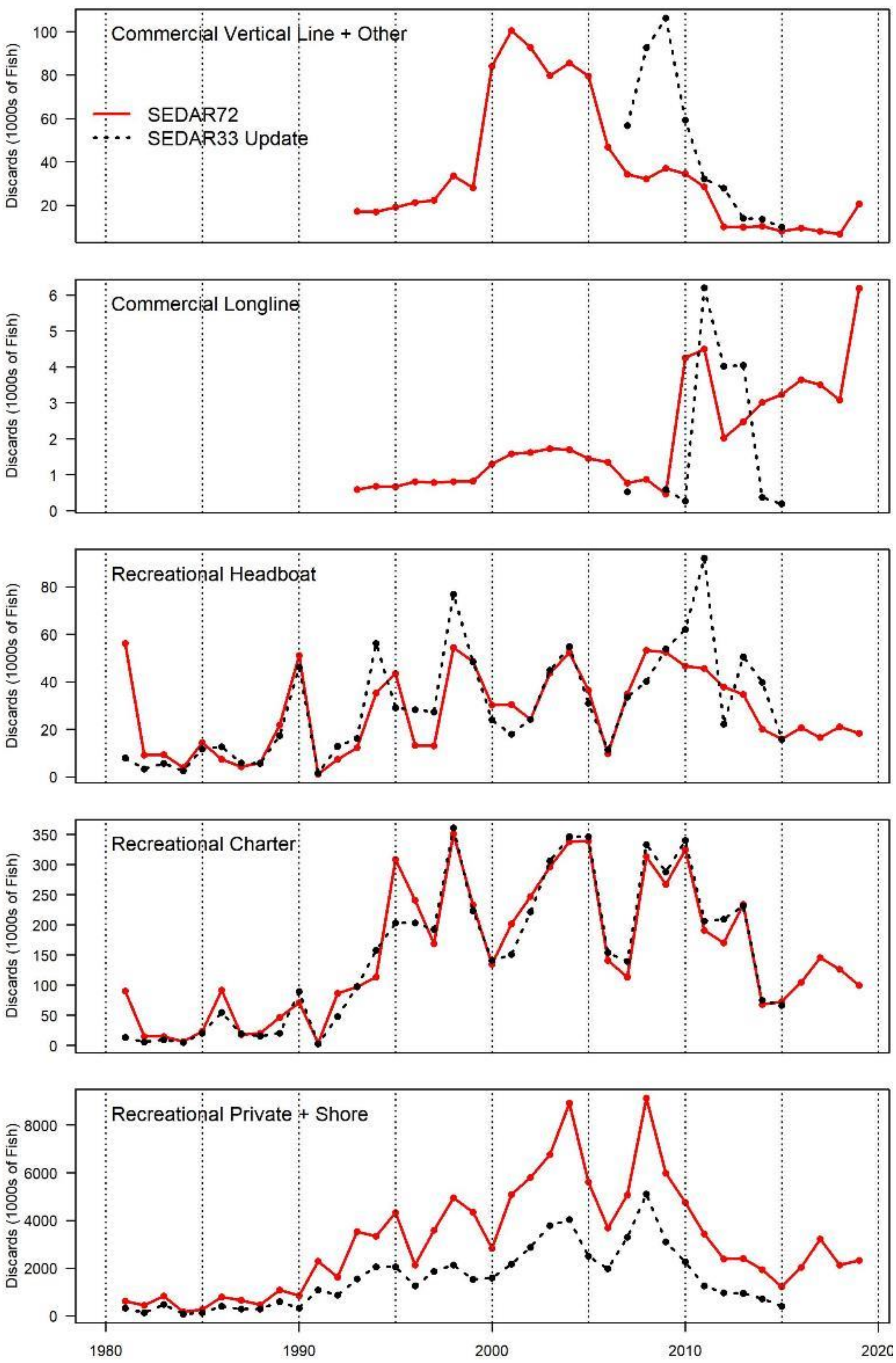


Figure 5. Gulf of Mexico Gag Grouper observed discards by fishery for SEDAR72 and SEDAR33 Update. Commercial and recreational discards are both in numbers of fish. Dashed vertical lines identify five year intervals.

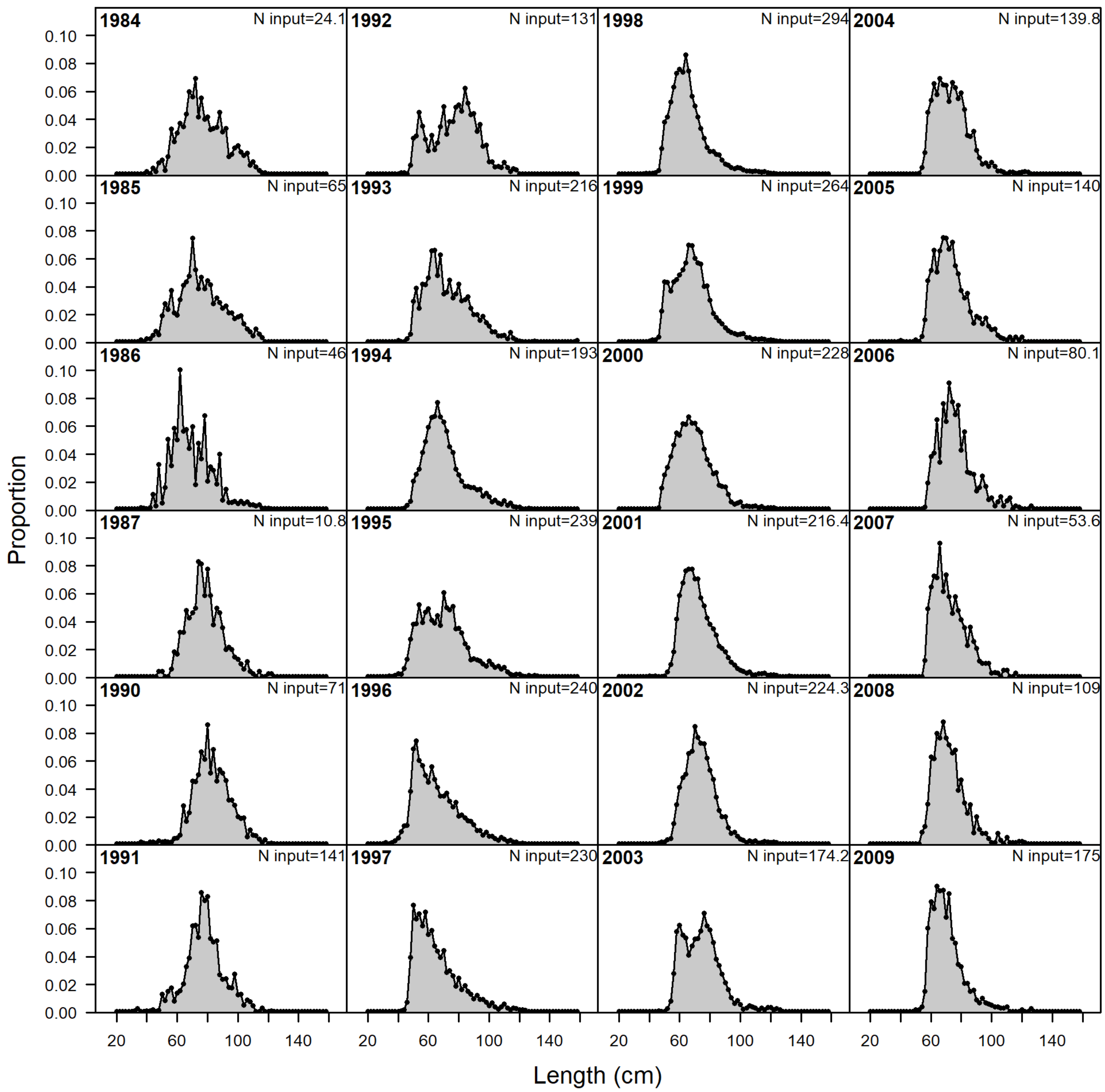


Figure 6. Observed length composition data (retained) of Gulf of Mexico Gag Grouper in the Commercial Vertical Line + Other fishery.

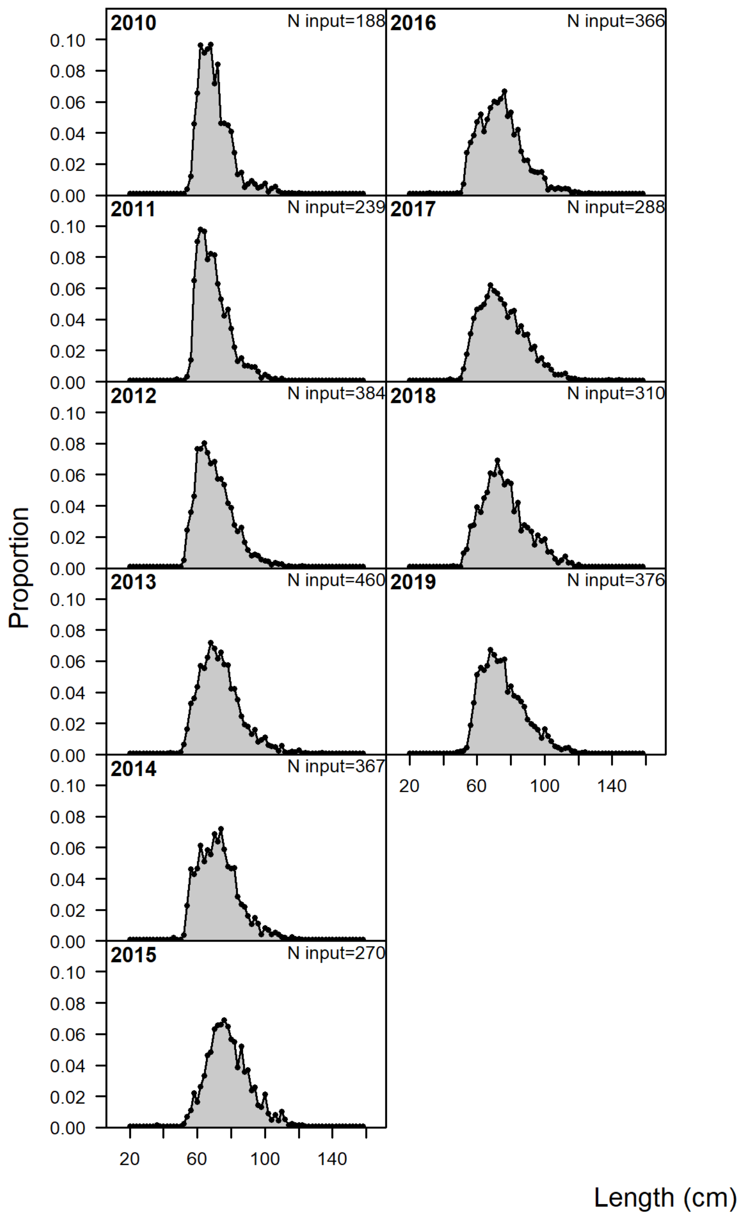


Figure 6 Continued. Observed length composition data (retained) of Gulf of Mexico Gag Grouper in the Commercial Vertical Line + Other fishery.

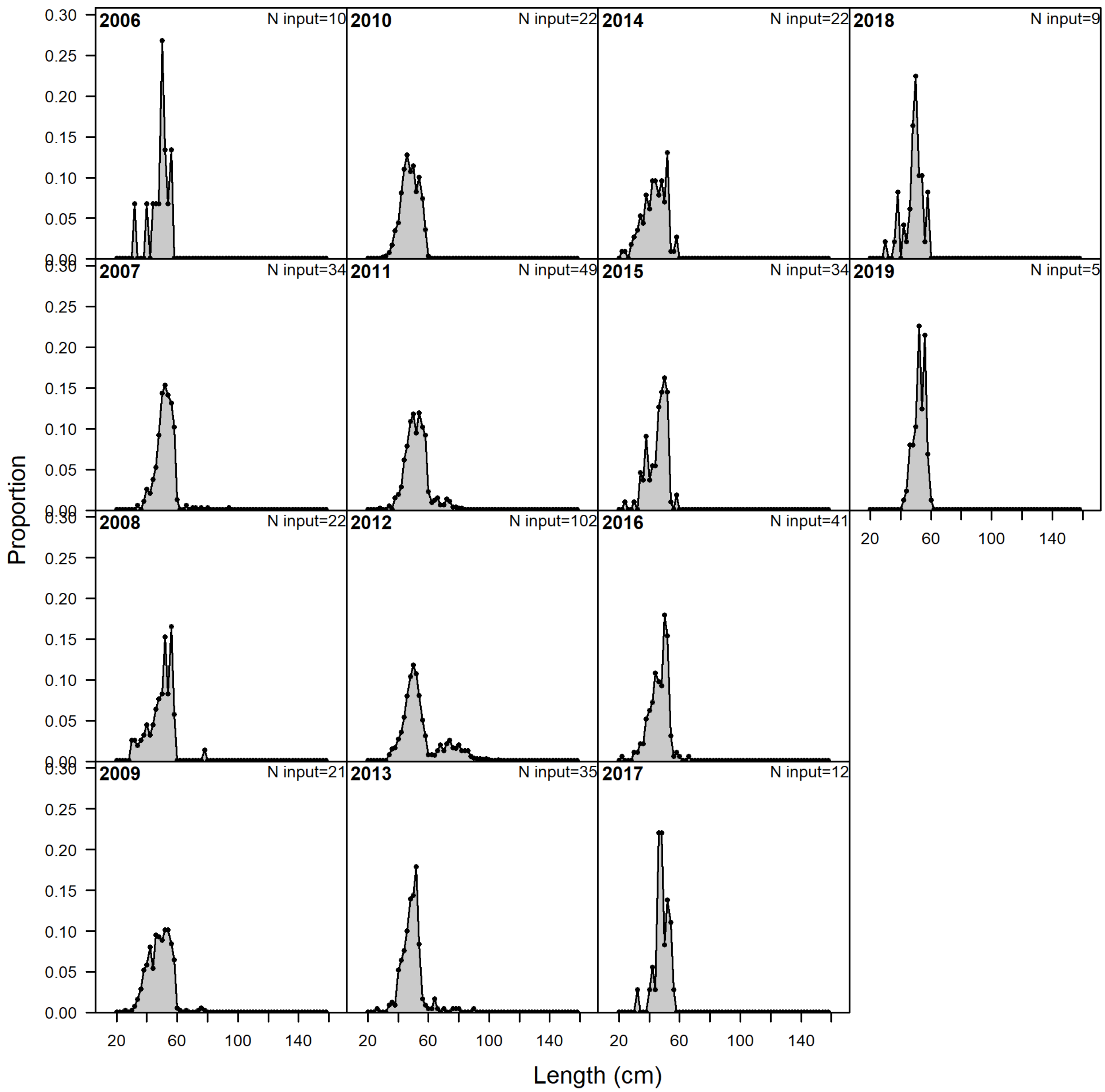


Figure 7. Observed length composition data (discarded) for Gulf of Mexico Gag Grouper from the Reef Fish Observer Program for the Commercial Vertical Line + Other fishery.

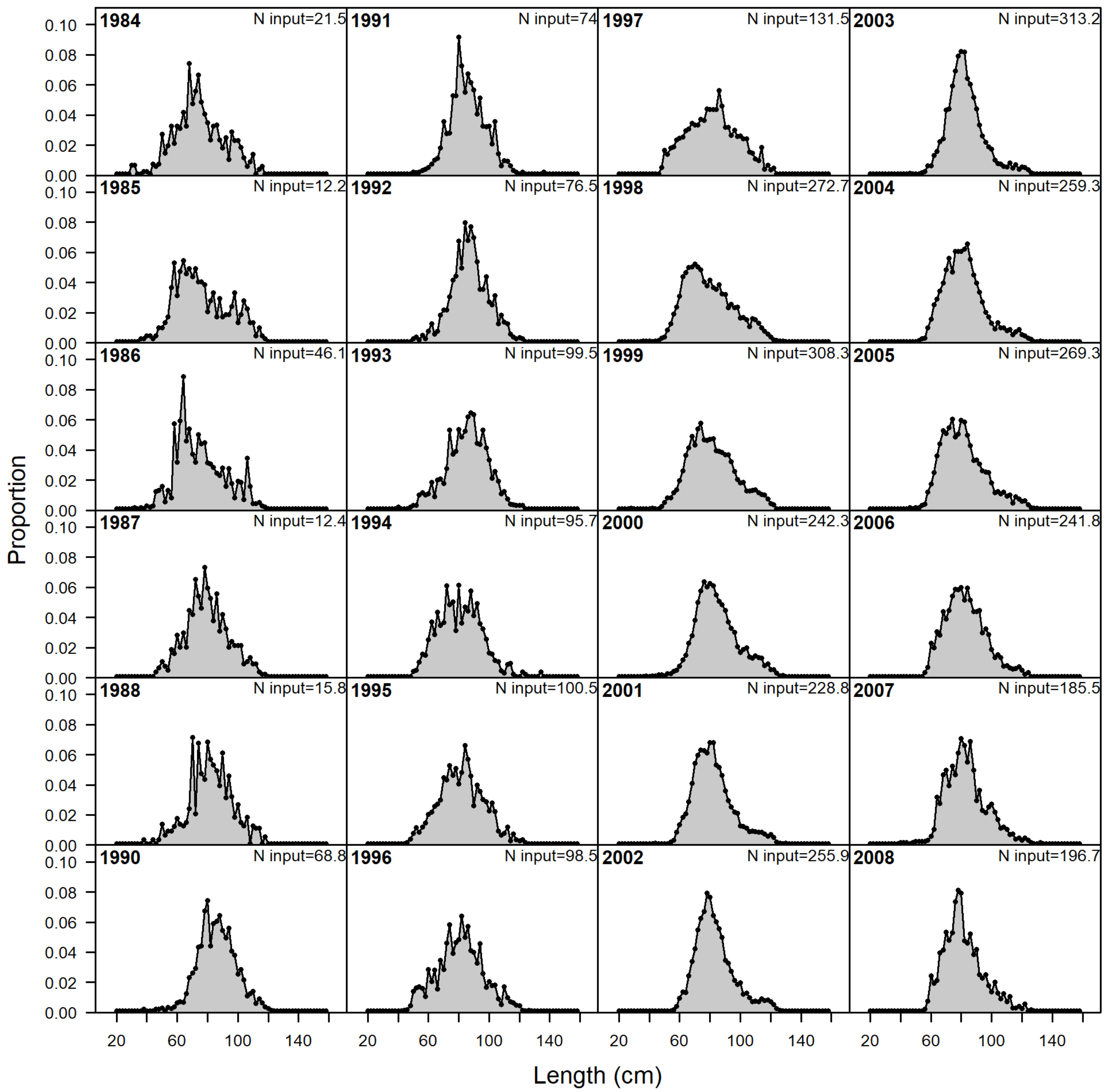


Figure 8. Observed length composition data (retained) of Gulf of Mexico Gag Grouper in the Commercial Longline fishery.

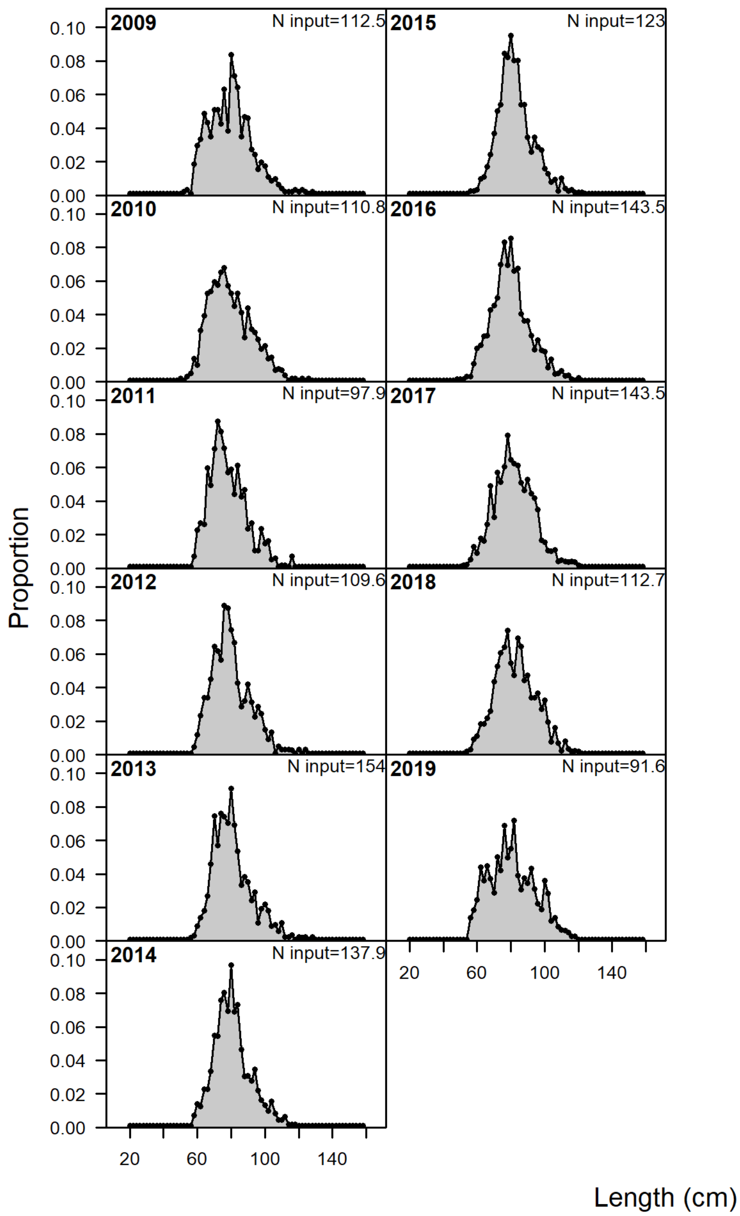


Figure 8 Continued. Observed length composition data (retained) of Gulf of Mexico Gag Grouper in the Commercial Longline fishery.

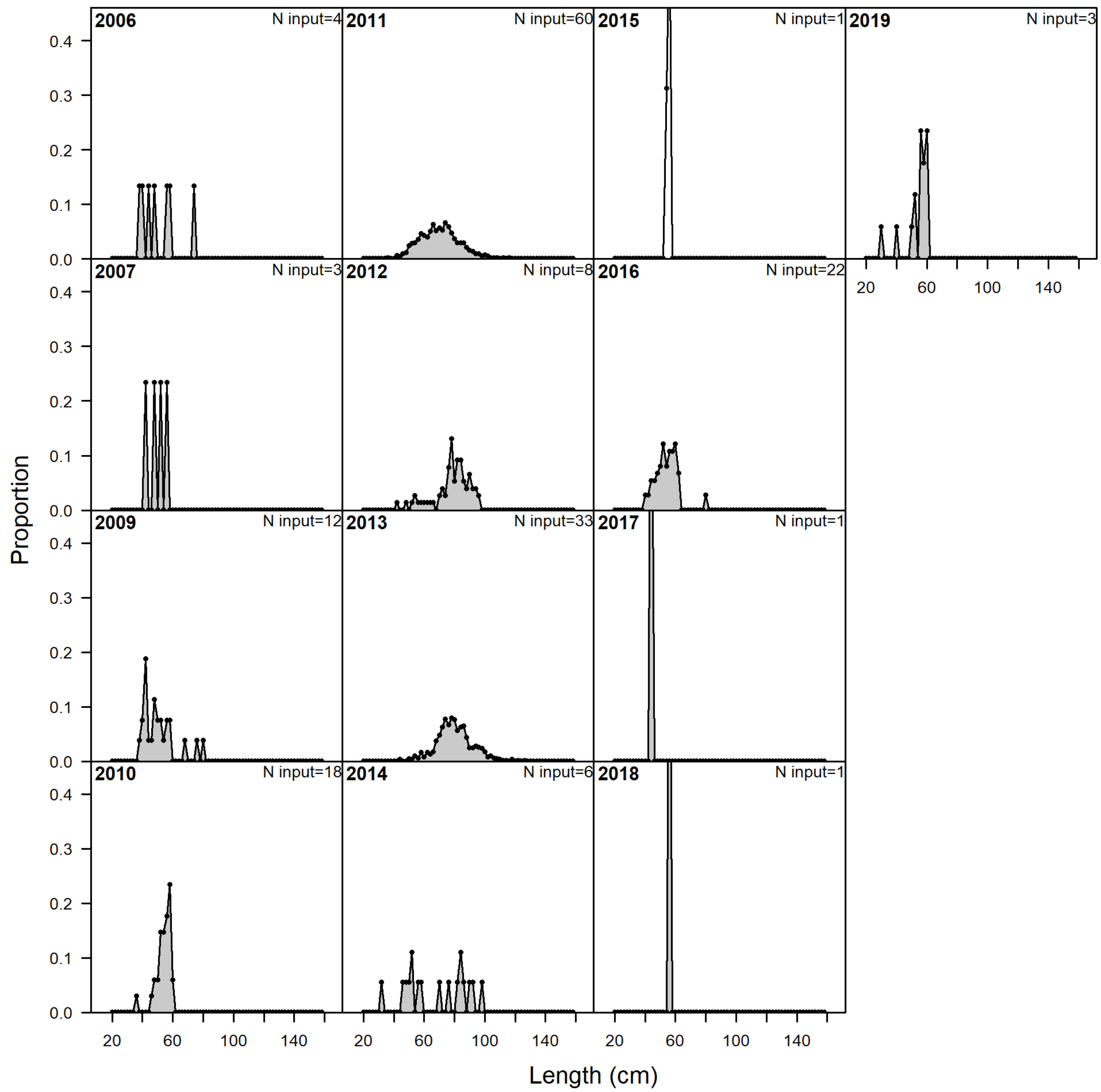


Figure 9. Observed length composition data (discarded) for Gulf of Mexico Gag Grouper from the Reef Fish Observer Program for the Commercial Longline fishery.

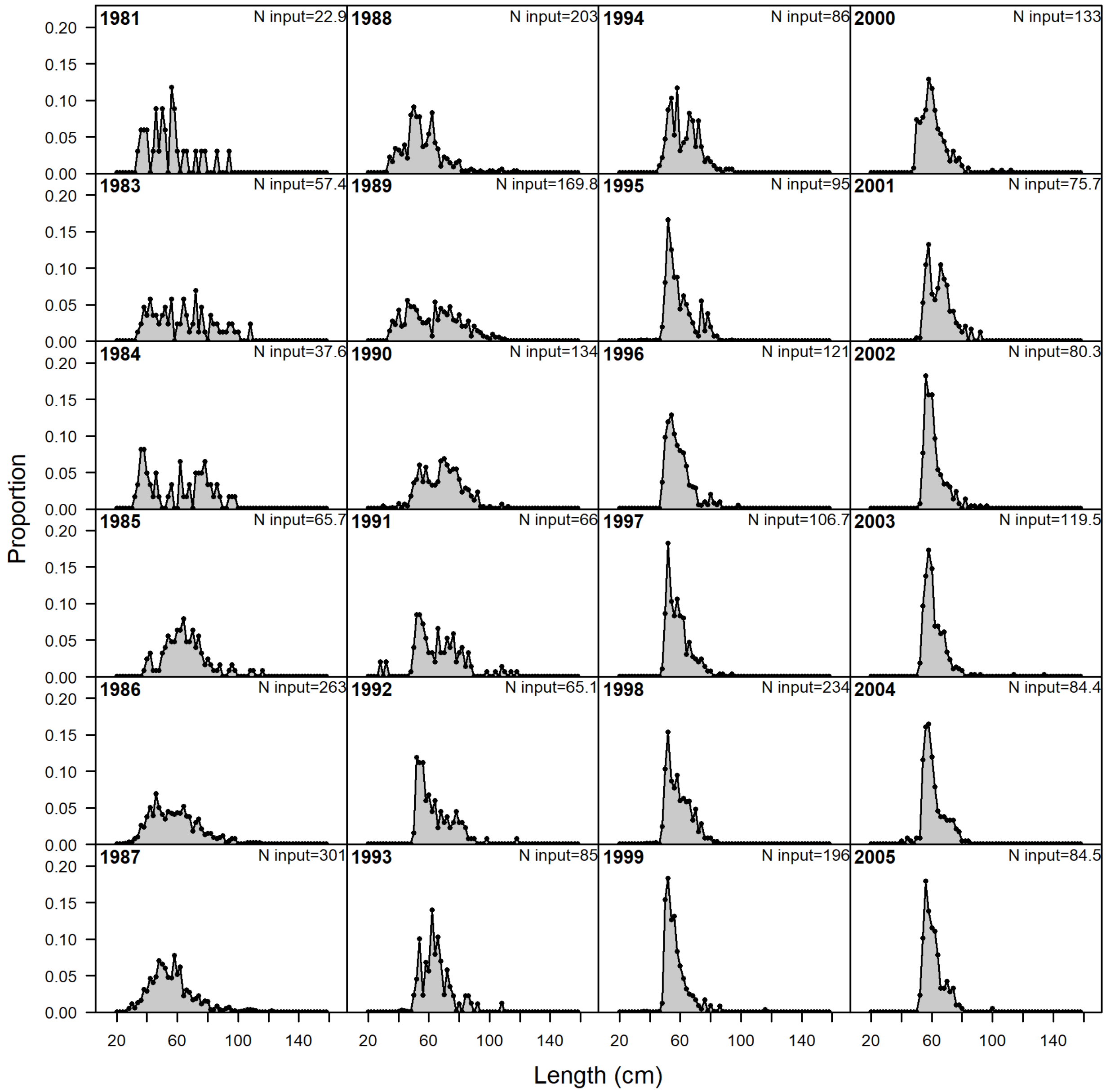


Figure 10. Observed length composition data (retained) of Gulf of Mexico Gag Grouper in the Recreational Headboat fishery.

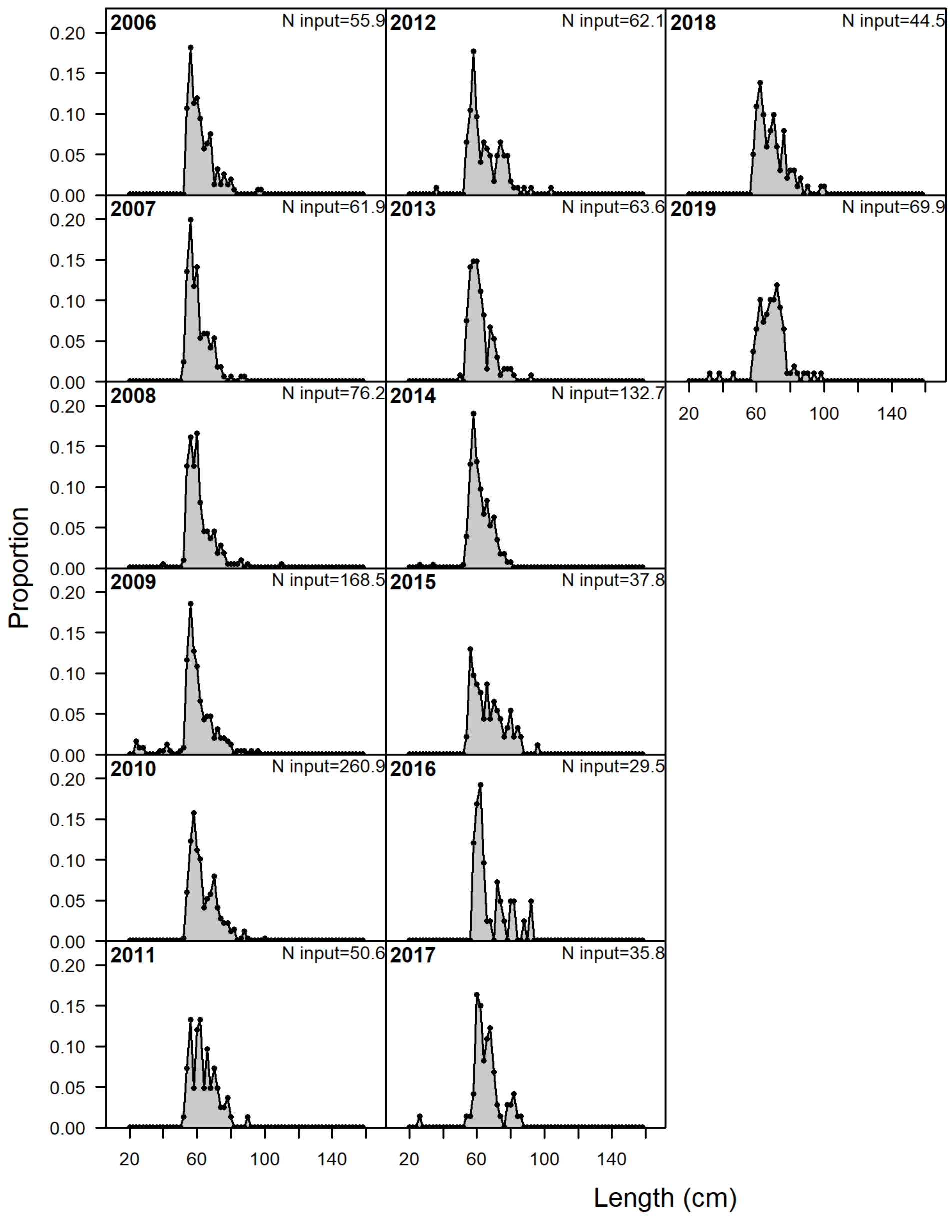


Figure 10 Continued. Observed length composition data (retained) of Gulf of Mexico Gag Grouper in the Recreational Headboat fishery.

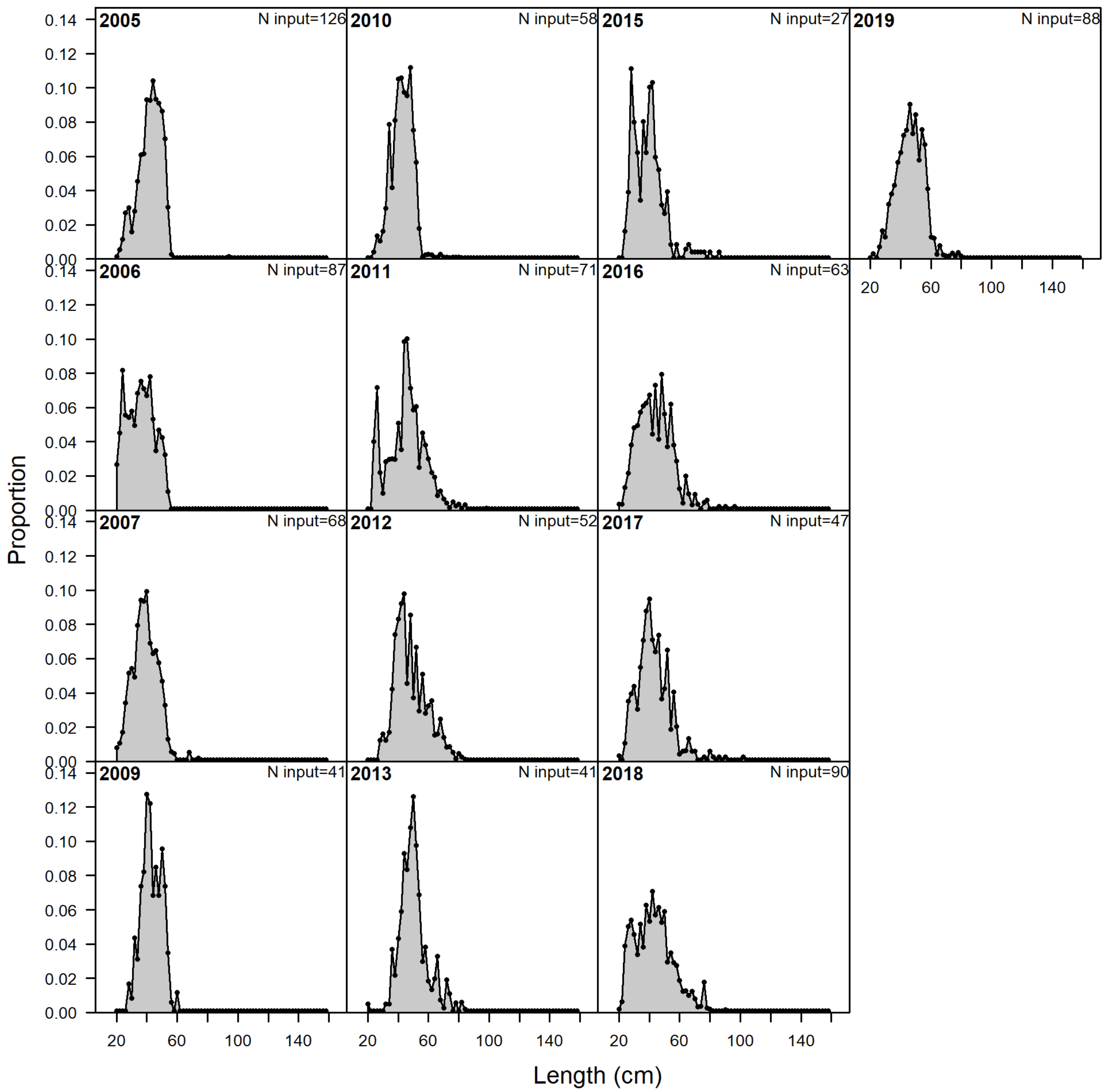


Figure 11. Observed length composition data (discarded) for Gulf of Mexico Gag Grouper from the FWRI At-Sea Observer Program for the Recreational Headboat fishery.

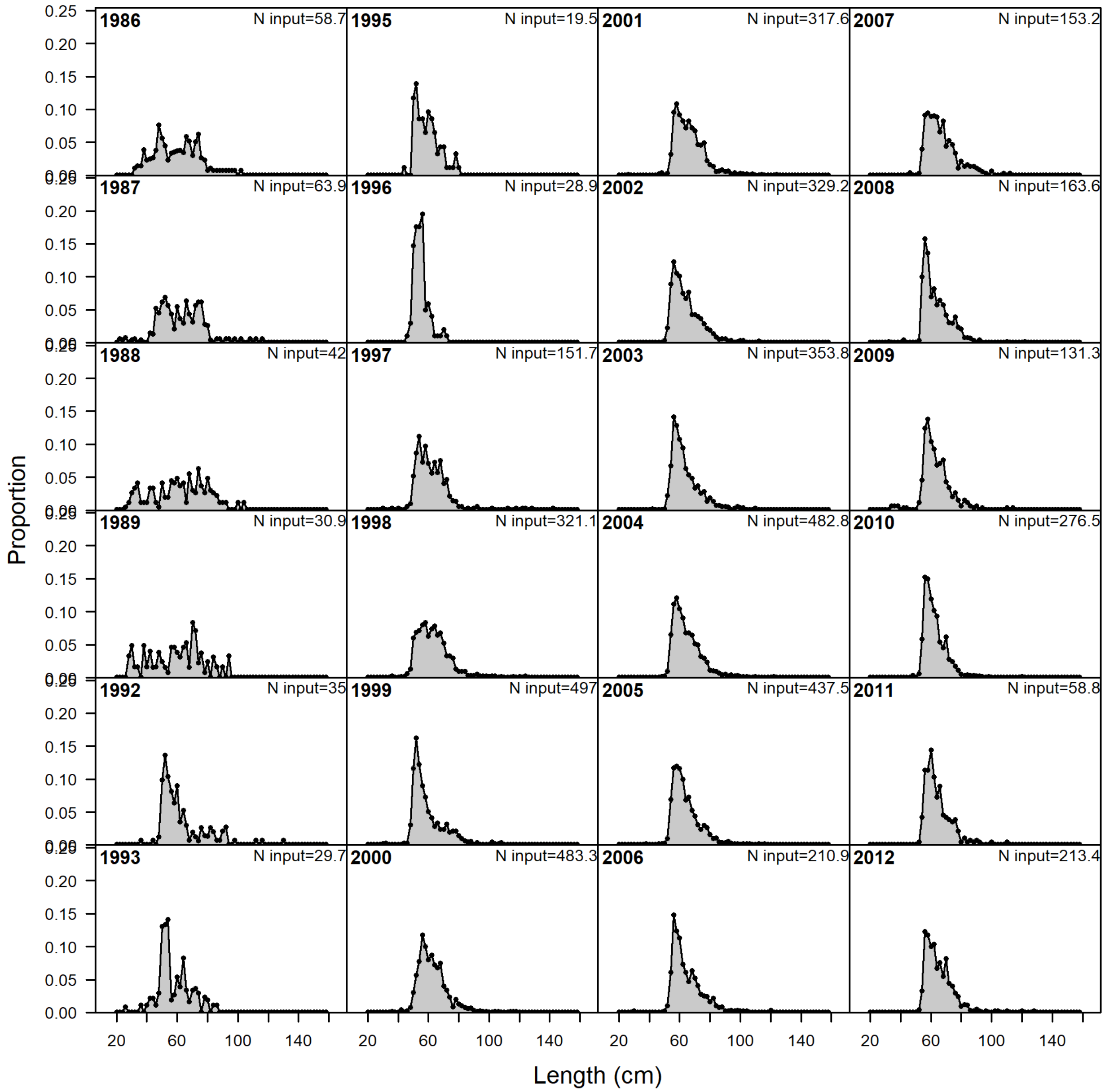


Figure 12. Observed length composition data (retained) of Gulf of Mexico Gag Grouper in the Recreational Charter fishery.

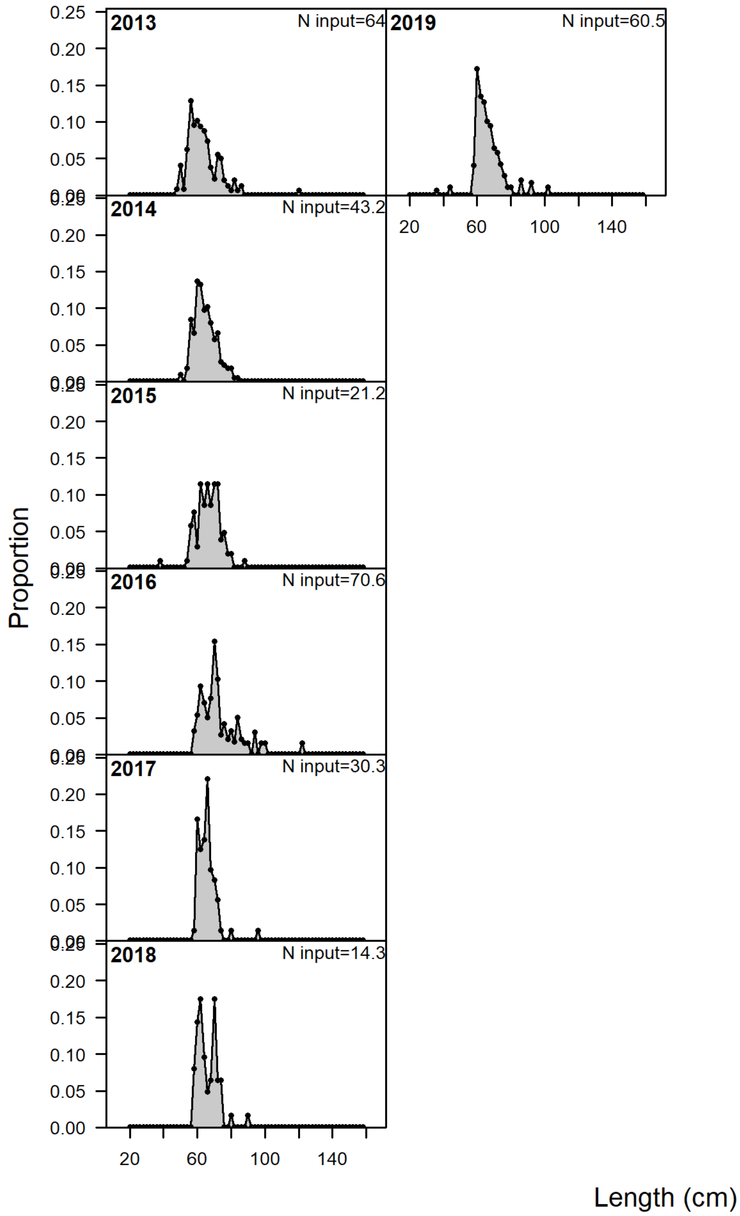


Figure 12 Continued. Observed length composition data (retained) of Gulf of Mexico Gag Grouper in the Recreational Charter fishery.

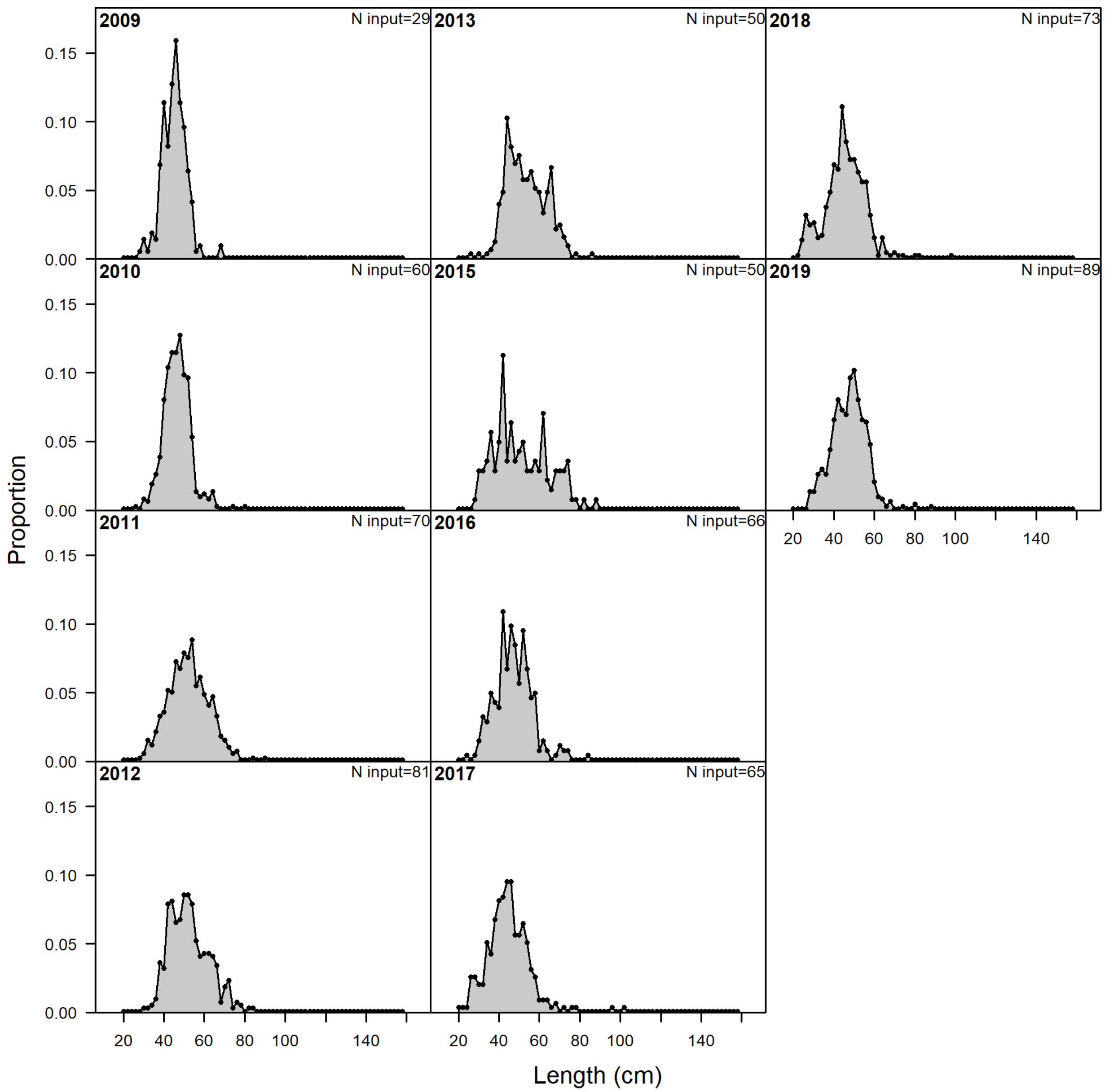


Figure 13. Observed length composition data (discarded) for Gulf of Mexico Gag Grouper from the FWRI At-Sea Observer Program for the Recreational Charter fishery.

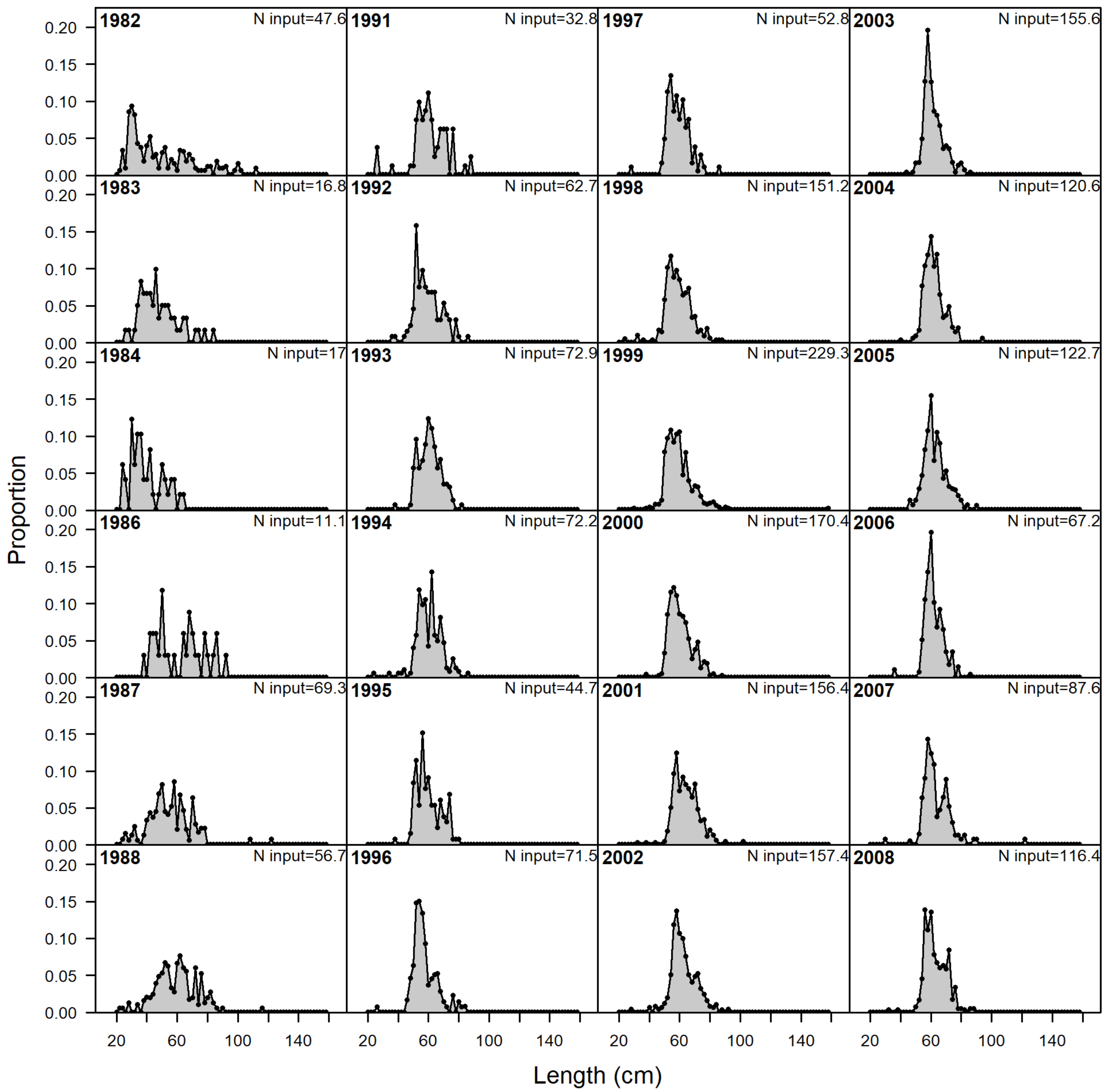


Figure 14. Observed length composition data (retained) of Gulf of Mexico Gag Grouper in the Recreational Private + Shore fishery.

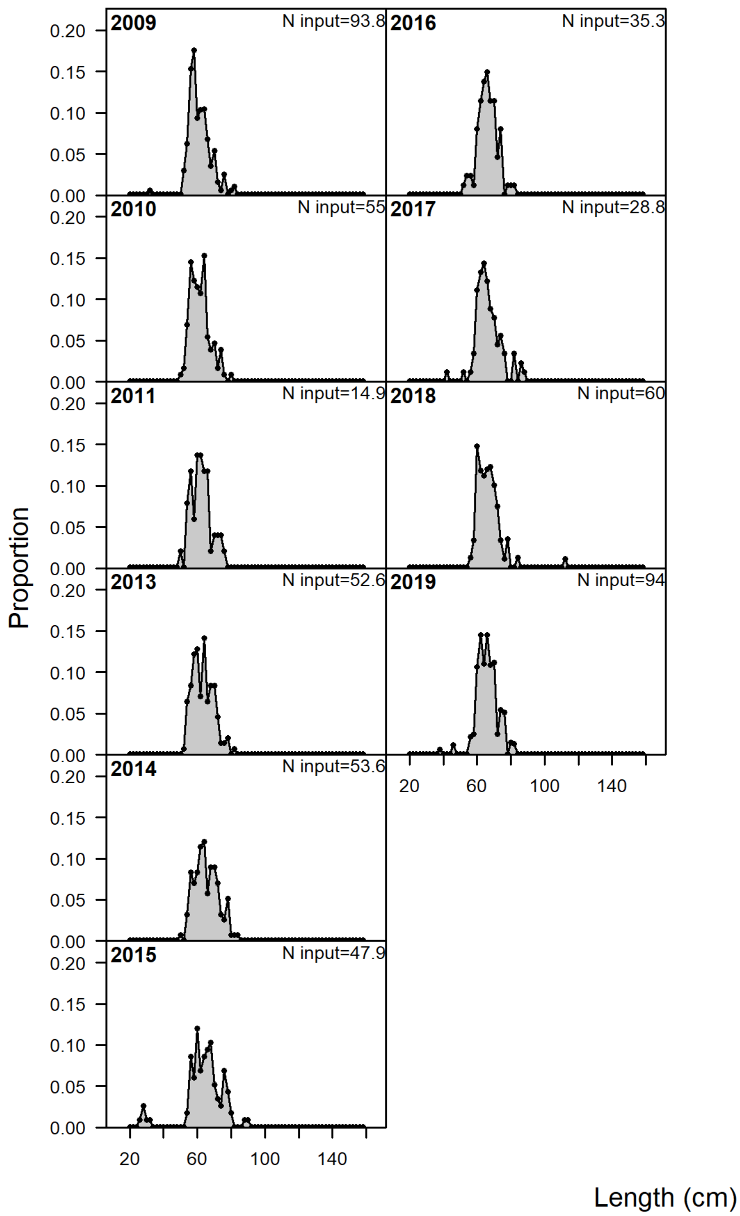


Figure 14 Continued. Observed length composition data (retained) of Gulf of Mexico Gag Grouper in the Recreational Private + Shore fishery.

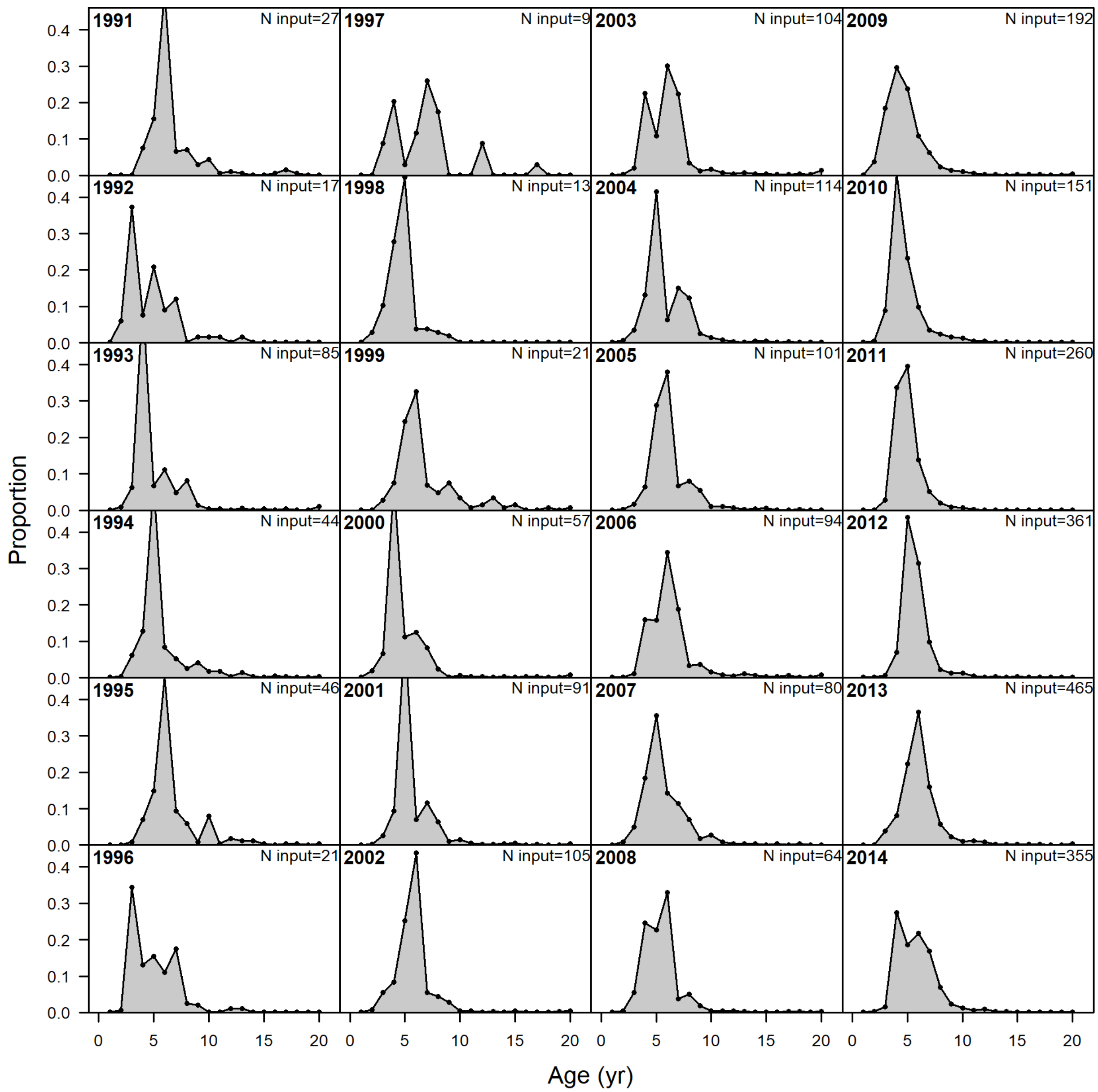


Figure 15. Observed age composition data (retained) of Gulf of Mexico Gag Grouper in the Commercial Vertical Line + Other fishery.

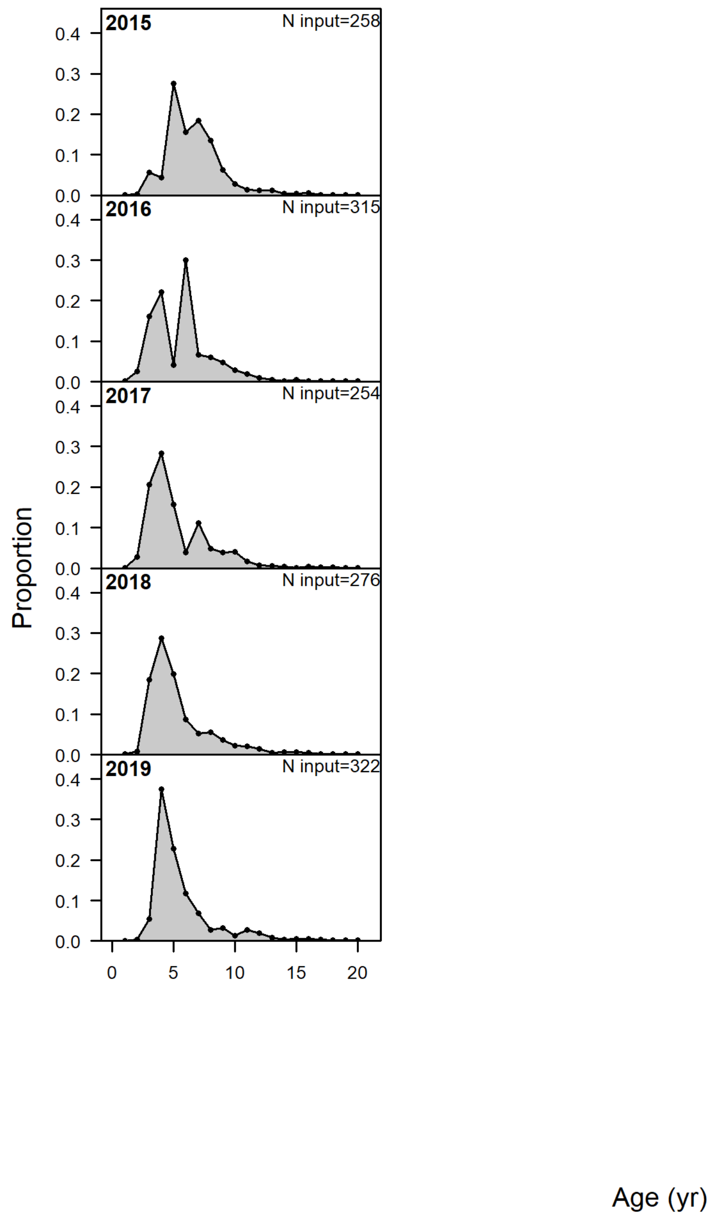


Figure 15 Continued. Observed age composition data (retained) of Gulf of Mexico Gag Grouper in the Commercial Vertical Line + Other fishery.

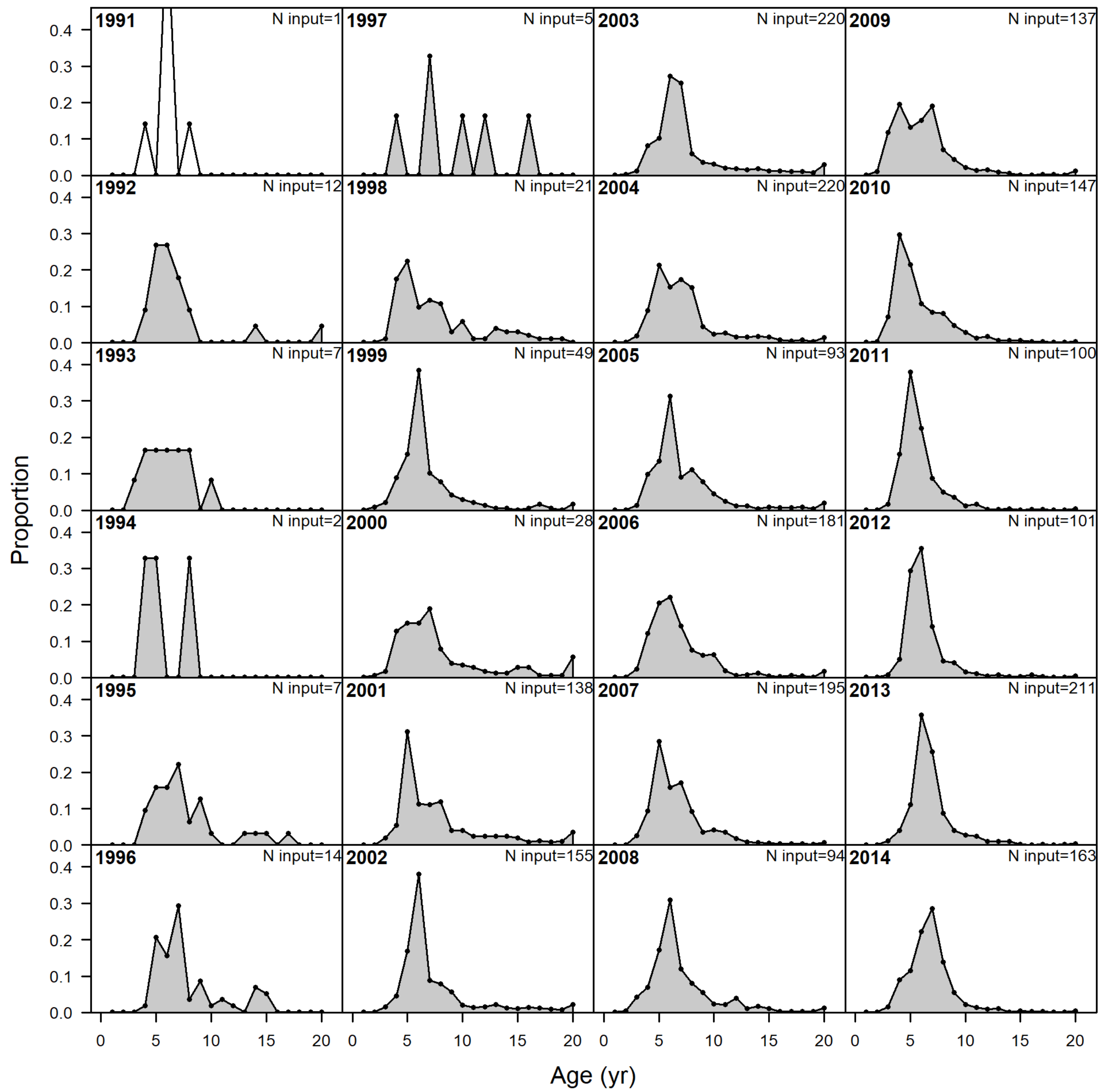


Figure 16. Observed age composition data (retained) of Gulf of Mexico Gag Grouper in the Commercial Longline fishery.

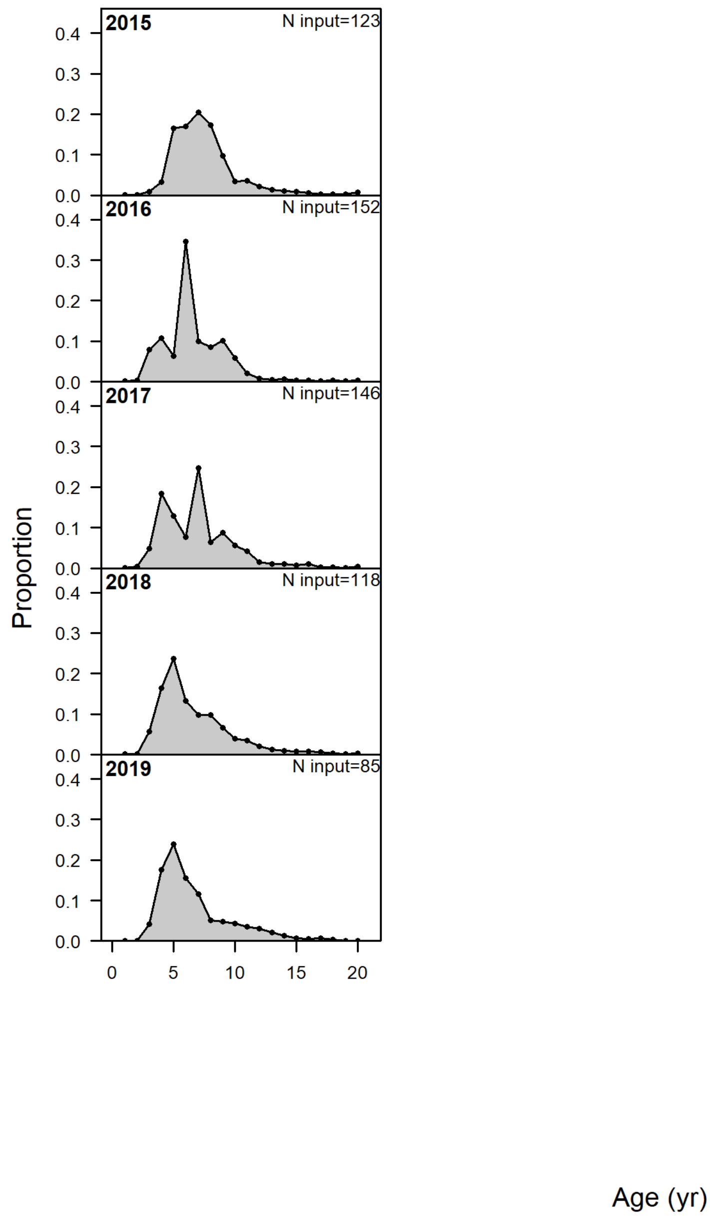


Figure 16 Continued. Observed age composition data (retained) of Gulf of Mexico Gag Grouper in the Commercial Longline fishery.

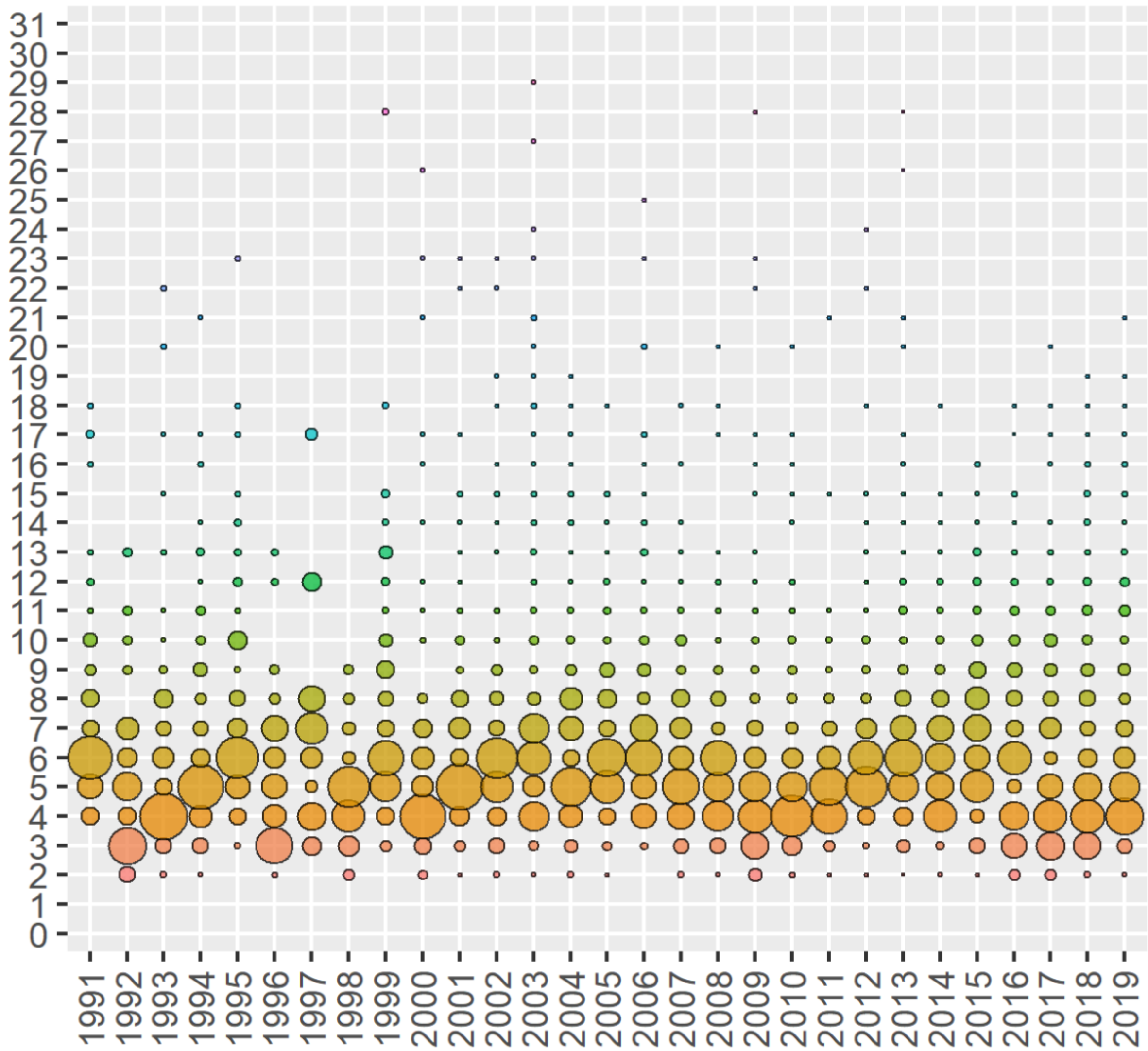


Figure 17. Observed relative age proportions in each year for Gulf of Mexico Gag Grouper in the Commercial Vertical Line + Other fishery. Cohort progressions are evident.

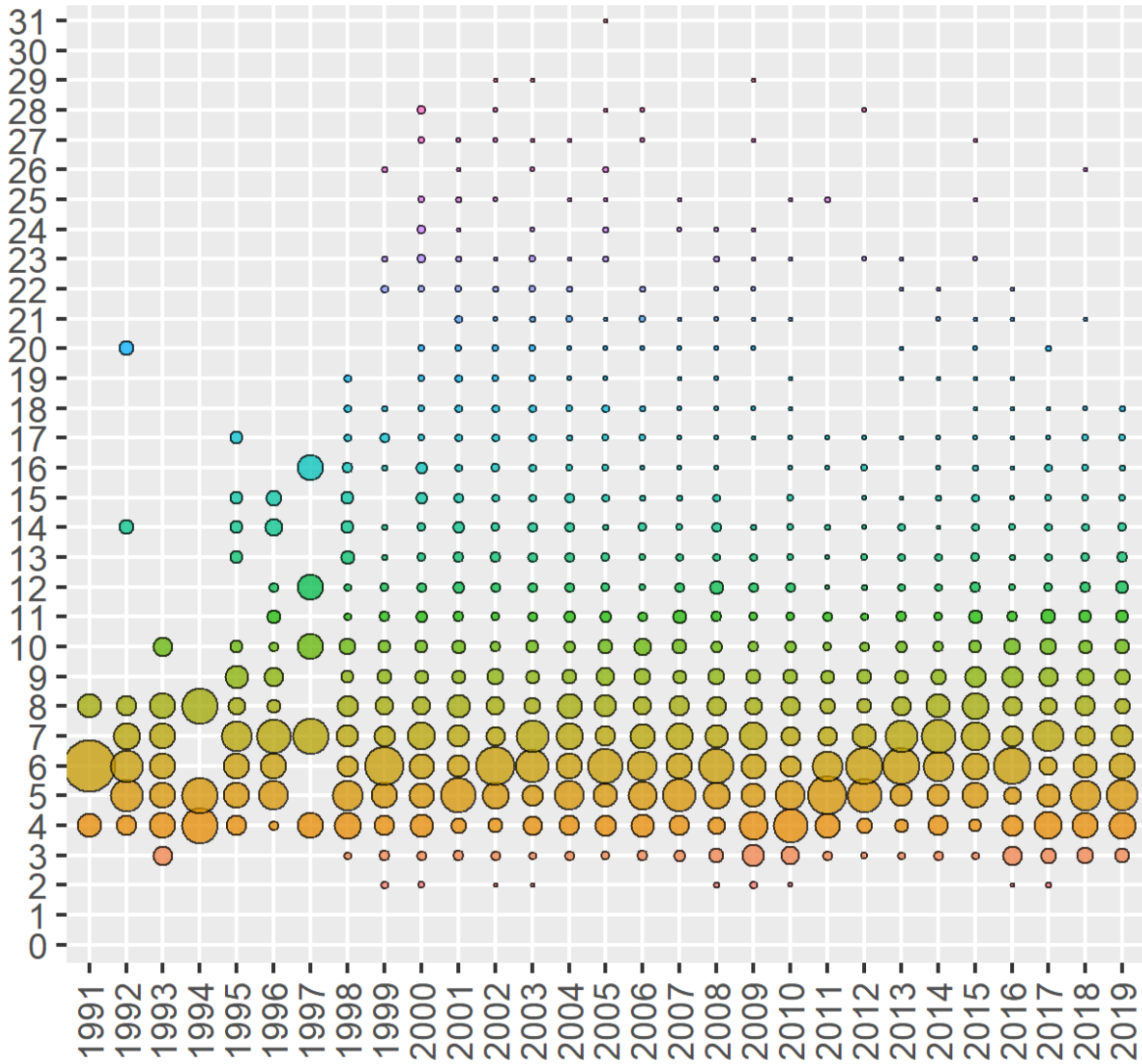


Figure 18. Observed relative age proportions in each year for Gulf of Mexico Gag Grouper in the Commercial Longline fishery. Cohort progressions are evident.

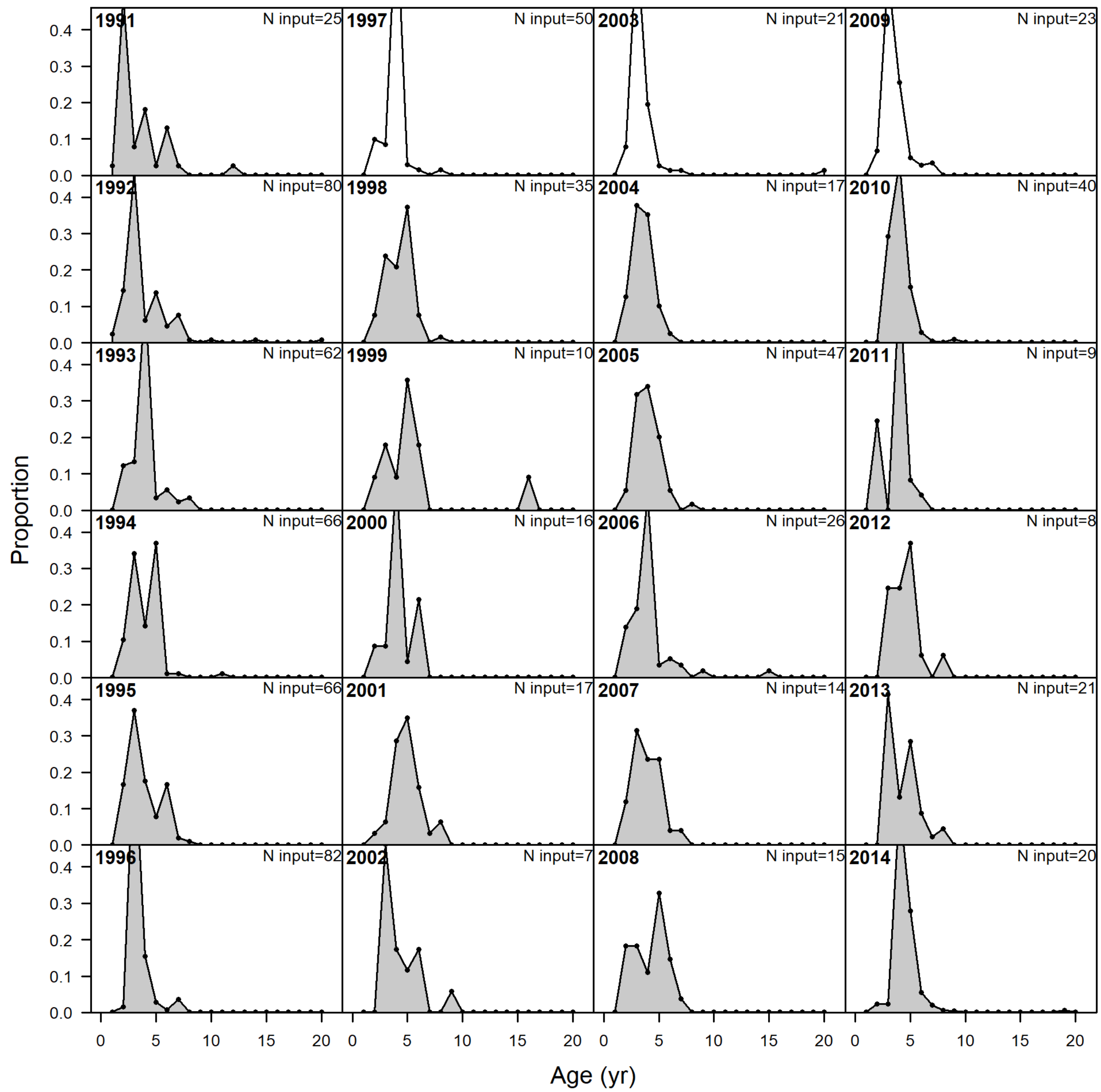


Figure 19. Observed age composition data (retained) of Gulf of Mexico Gag Grouper in the Recreational Headboat fishery.

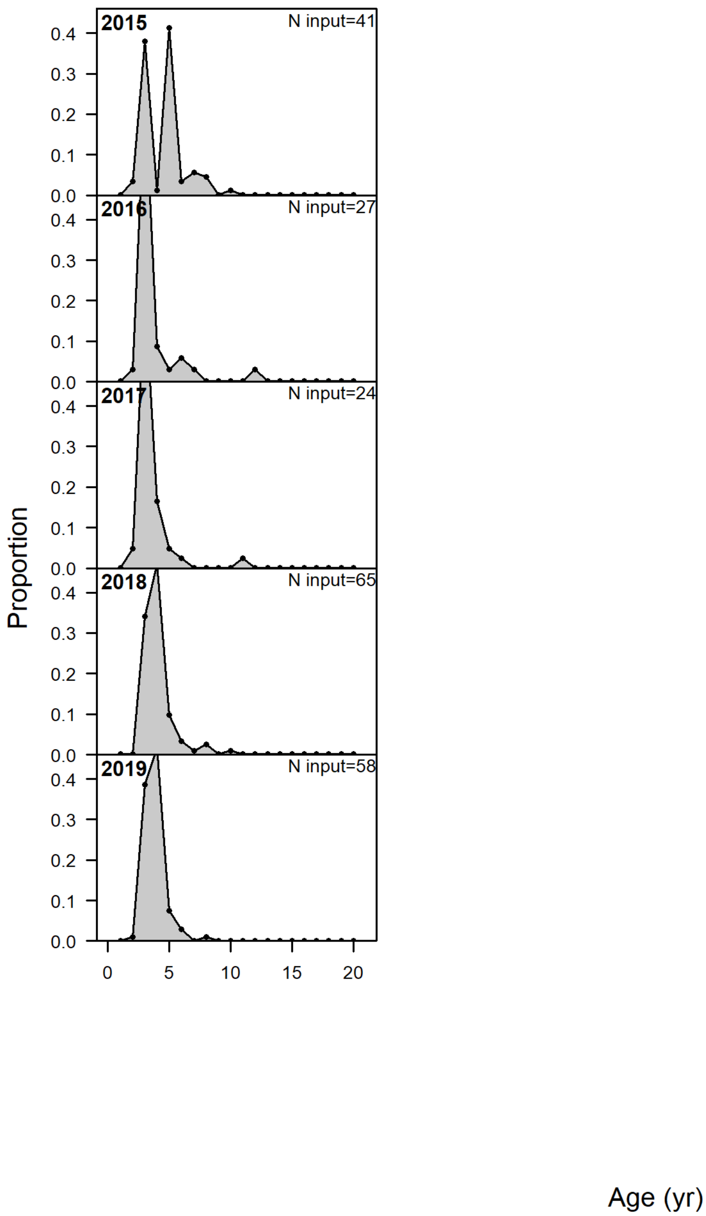


Figure 19 Continued. Observed age composition data (retained) of Gulf of Mexico Gag Grouper in the Recreational Headboat fishery.

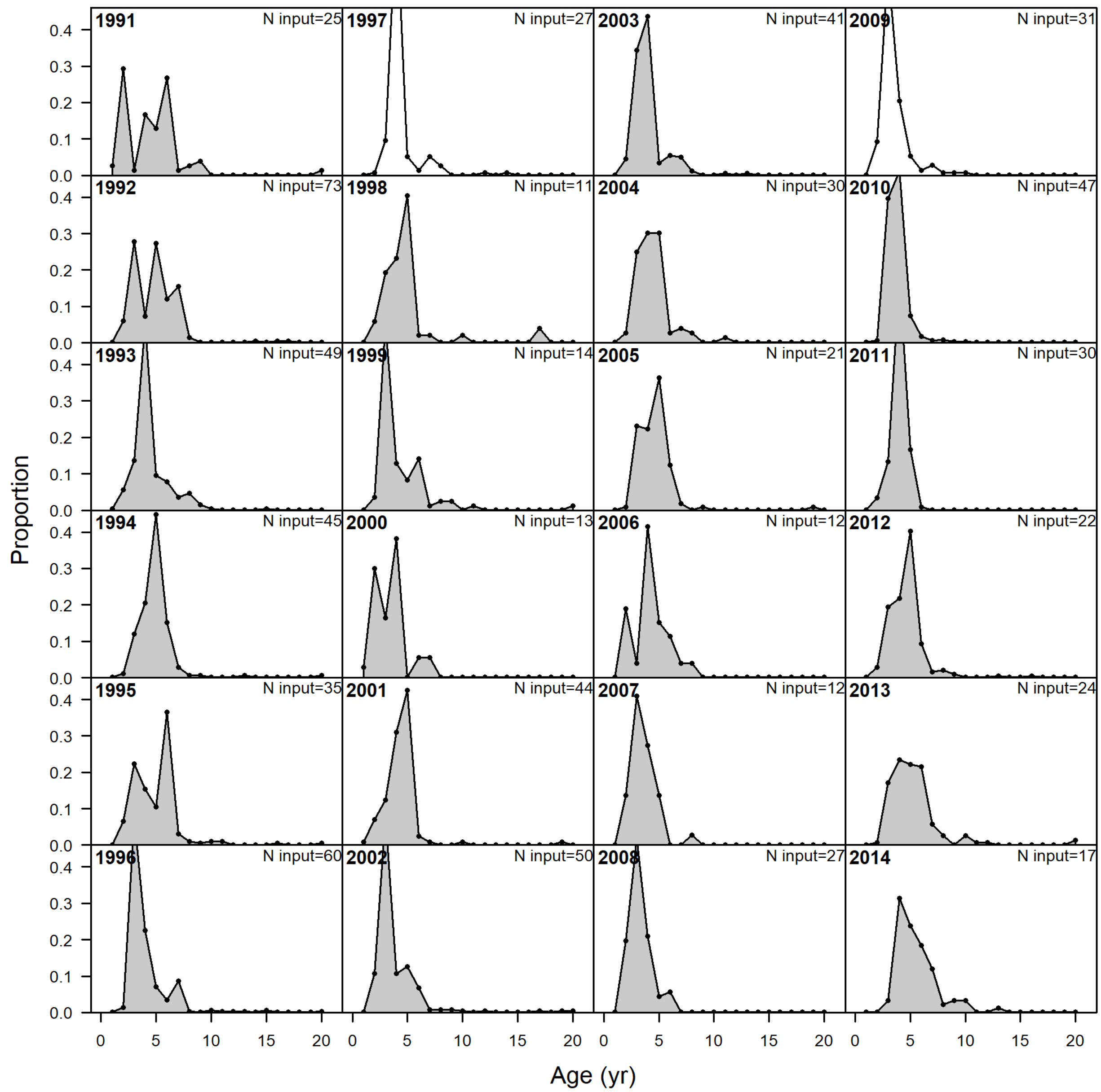


Figure 20. Observed age composition data (retained) of Gulf of Mexico Gag Grouper in the Recreational Charter fishery.

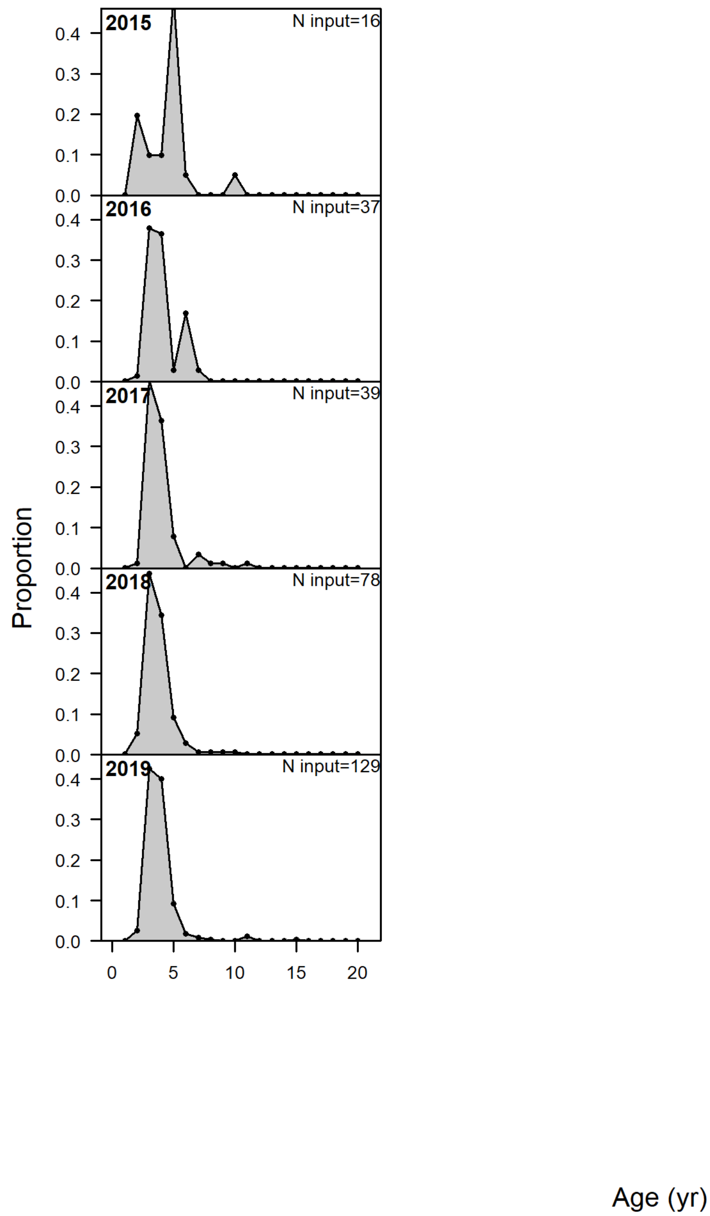


Figure 20 Continued. Observed age composition data (retained) of Gulf of Mexico Gag Grouper in the Recreational Charter fishery.

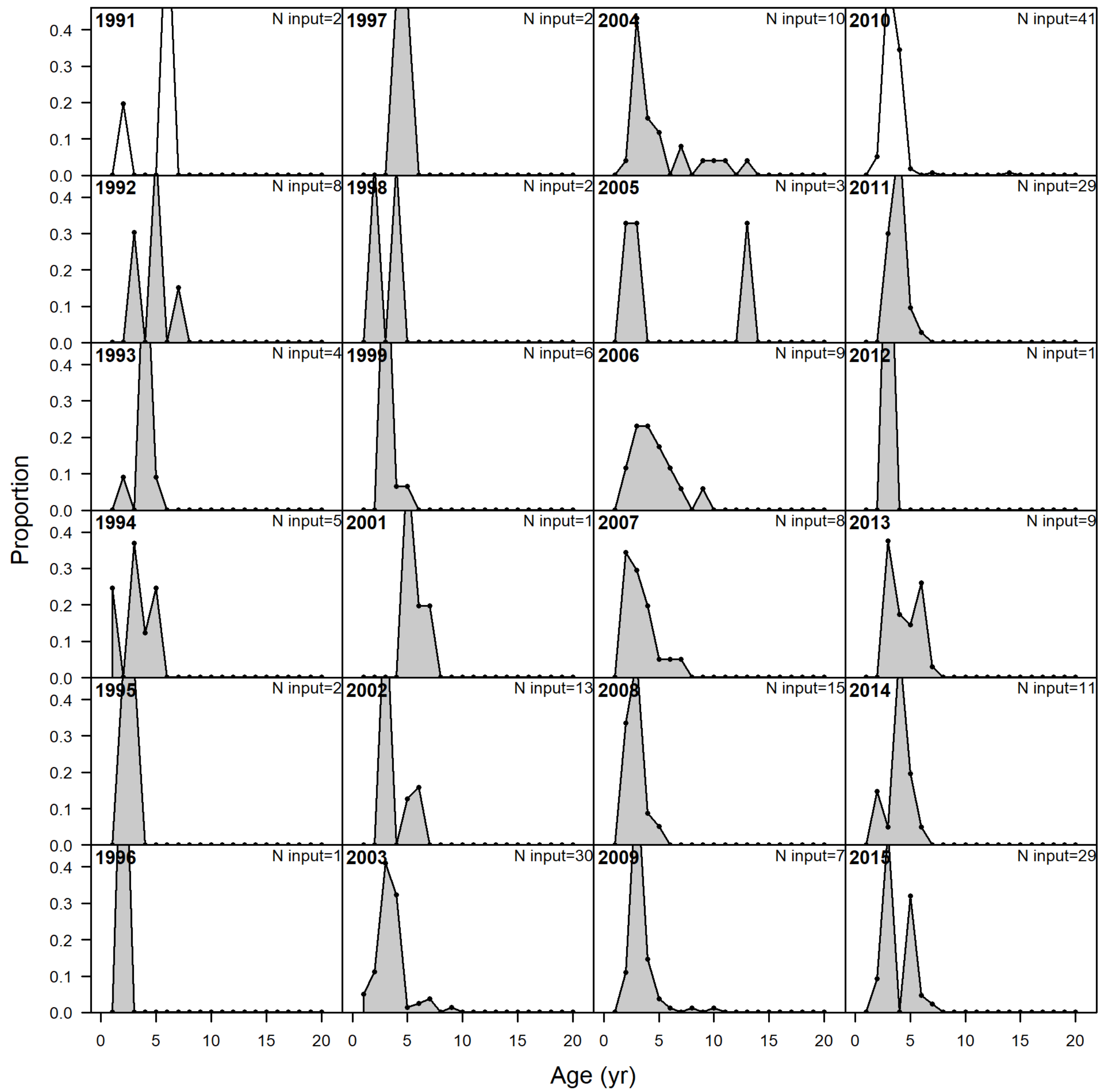


Figure 21. Observed age composition data (retained) of Gulf of Mexico Gag Grouper in the Recreational Private + Shore fishery.

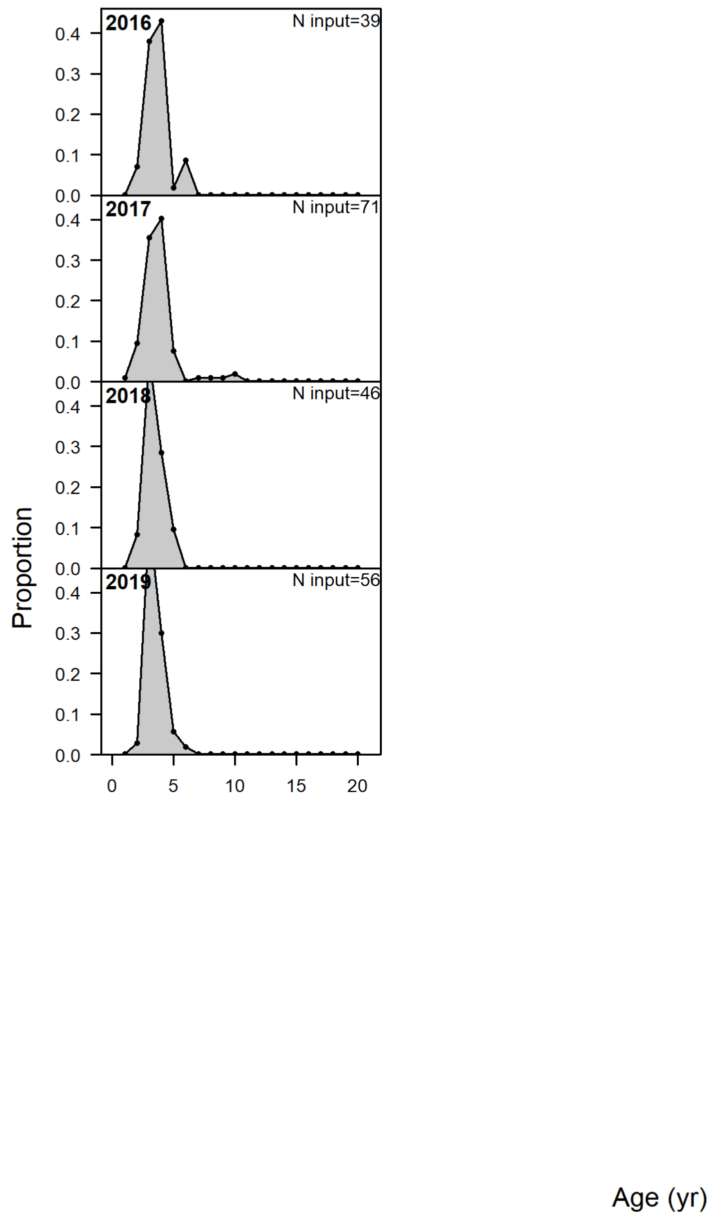


Figure 21 Continued. Observed age composition data (retained) of Gulf of Mexico Gag Grouper in the Recreational Private + Shore fishery.

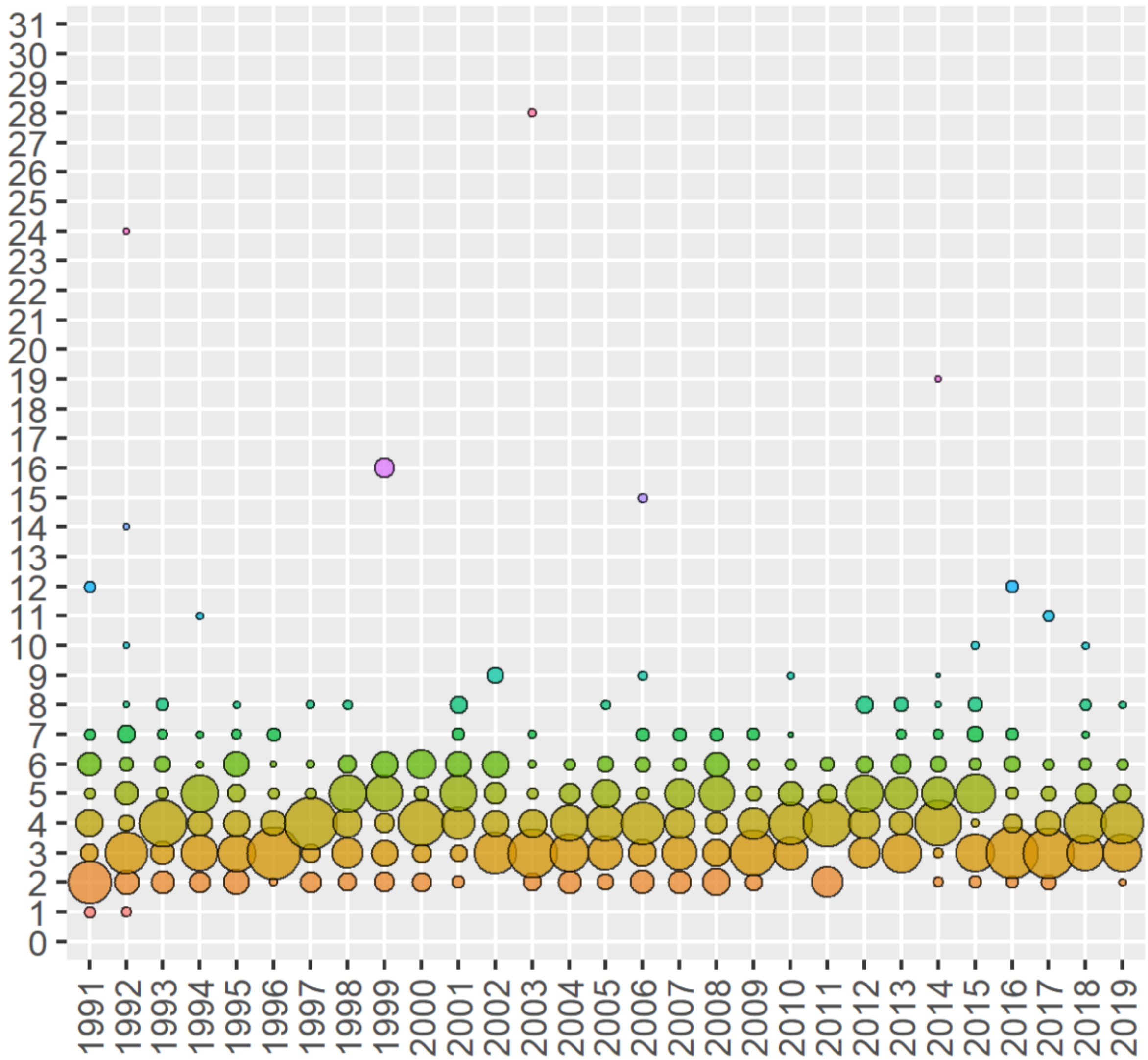


Figure 22. Observed relative age proportions in each year for Gulf of Mexico Gag Grouper in the Recreational Headboat fishery. Cohort progressions are evident.

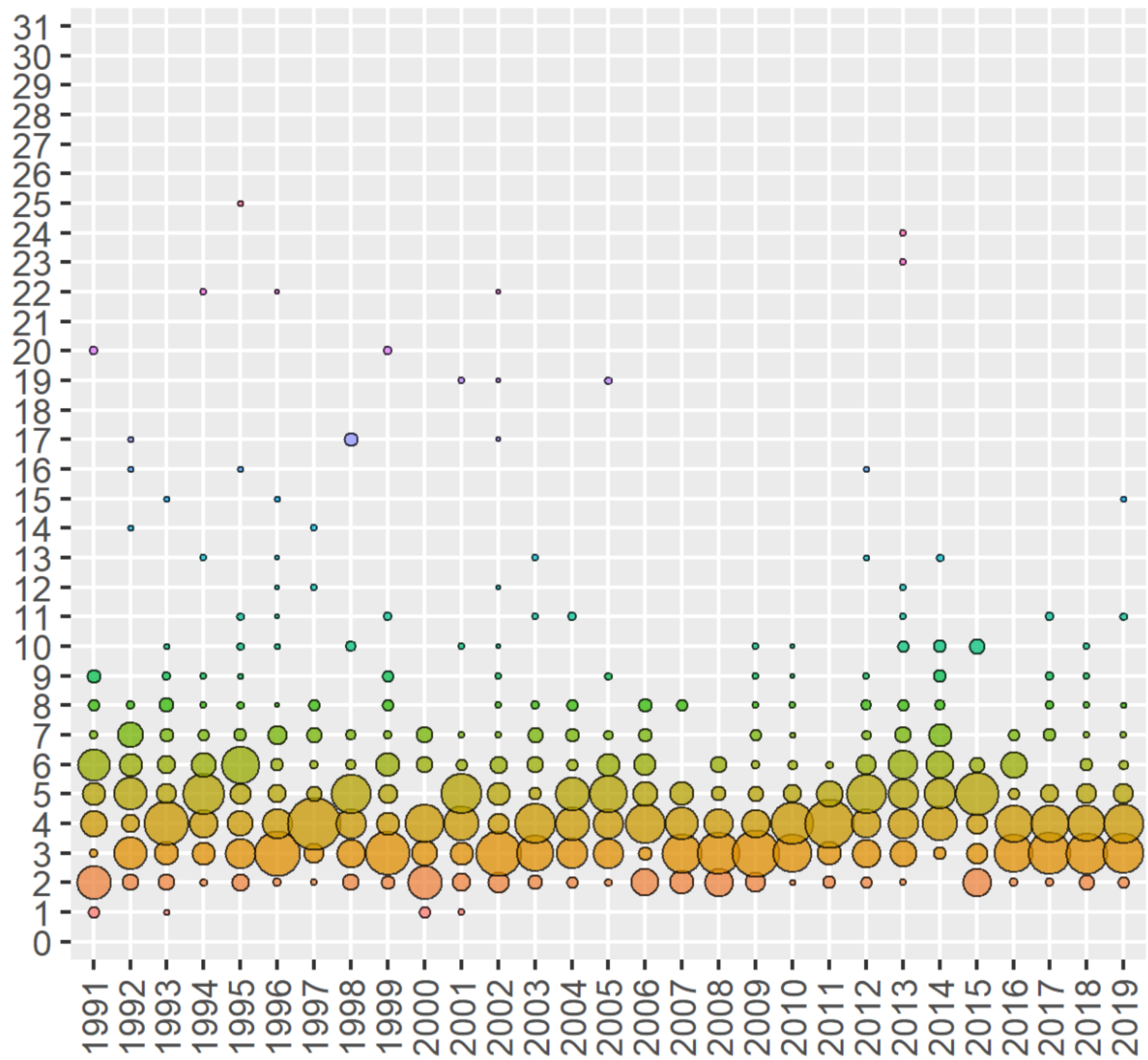


Figure 23. Observed relative age proportions in each year for Gulf of Mexico Gag Grouper in the Recreational Charter fishery. Cohort progressions are evident.

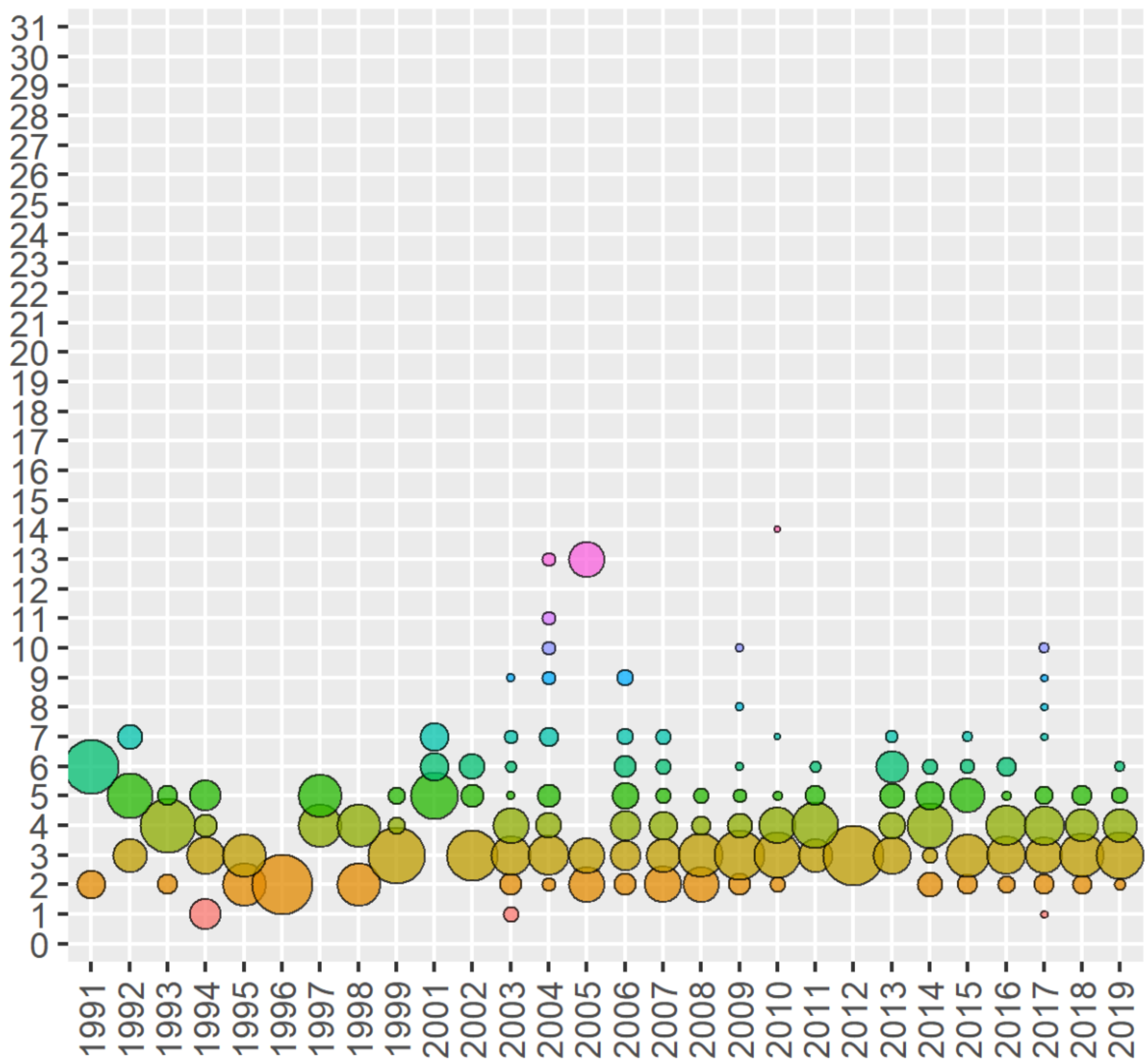


Figure 24. Observed relative age proportions in each year for Gulf of Mexico Gag Grouper in the Recreational Private + Shore fishery. No cohort progressions are evident.

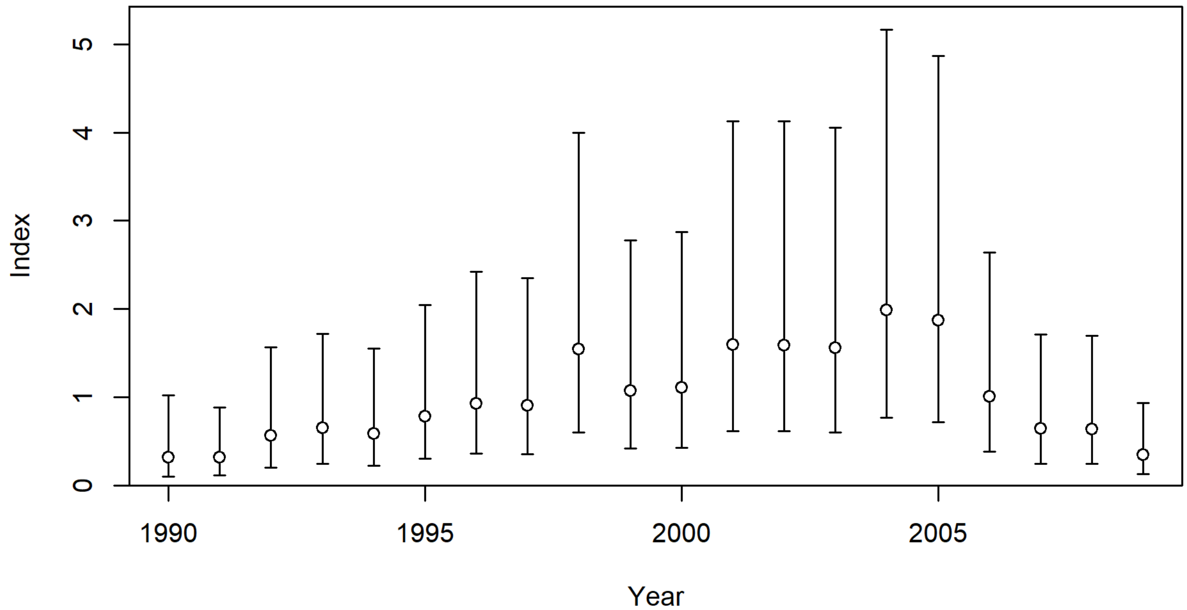


Figure 25. Standardized index of relative abundance and associated 95% uncertainty interval around index values based on the model assumption of lognormal error for Gulf of Mexico Gag Grouper from the Commercial Vertical Line + Other fishery. The uncertainty displayed includes the additional SE parameter estimated as part of the data weighting process.

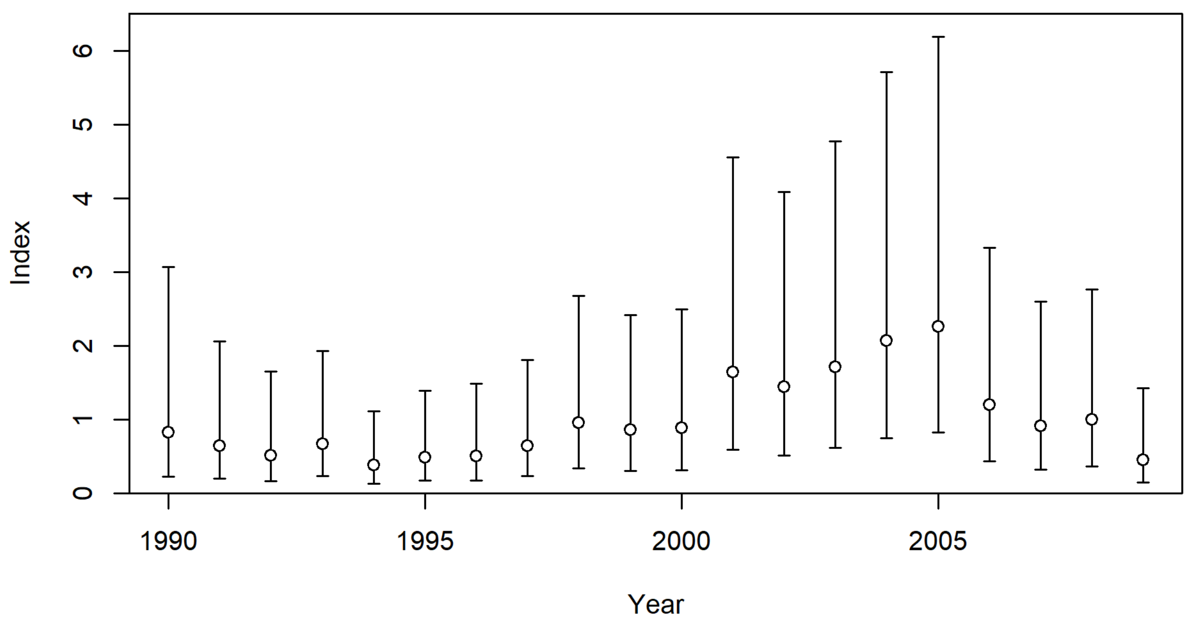


Figure 26. Standardized index of relative abundance and associated 95% uncertainty interval around index values based on the model assumption of lognormal error for Gulf of Mexico Gag Grouper from the Commercial Longline fishery. The uncertainty displayed includes the additional SE parameter estimated as part of the data weighting process.

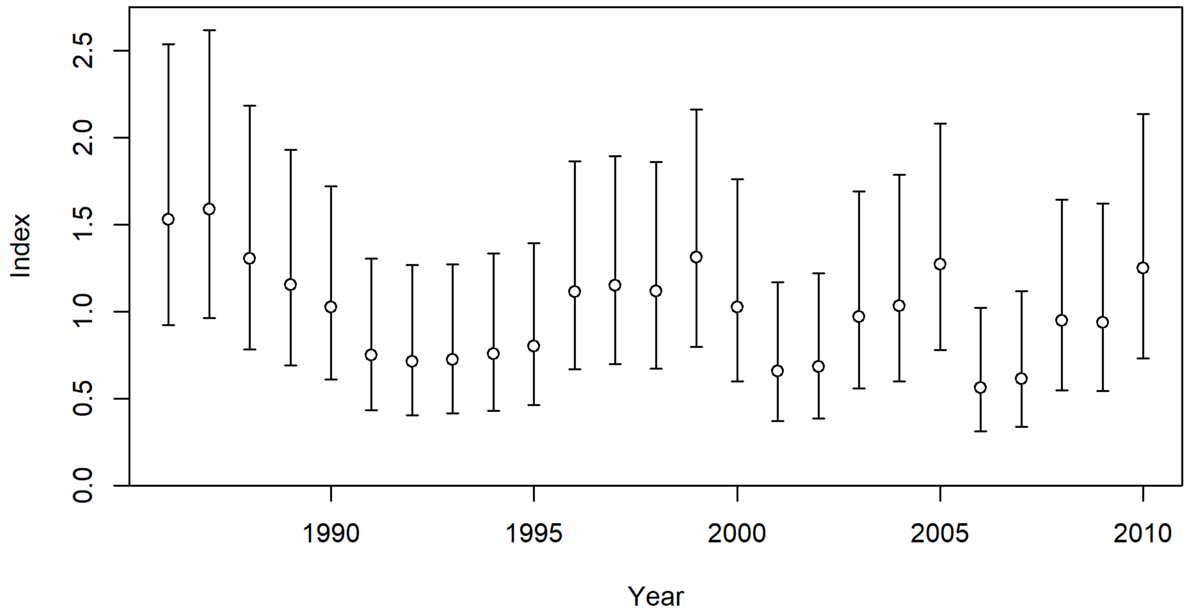


Figure 27. Standardized index of relative abundance and associated 95% uncertainty interval around index values based on the model assumption of lognormal error for Gulf of Mexico Gag Grouper from the Recreational Headboat fishery. The uncertainty displayed includes the additional SE parameter estimated as part of the data weighting process.

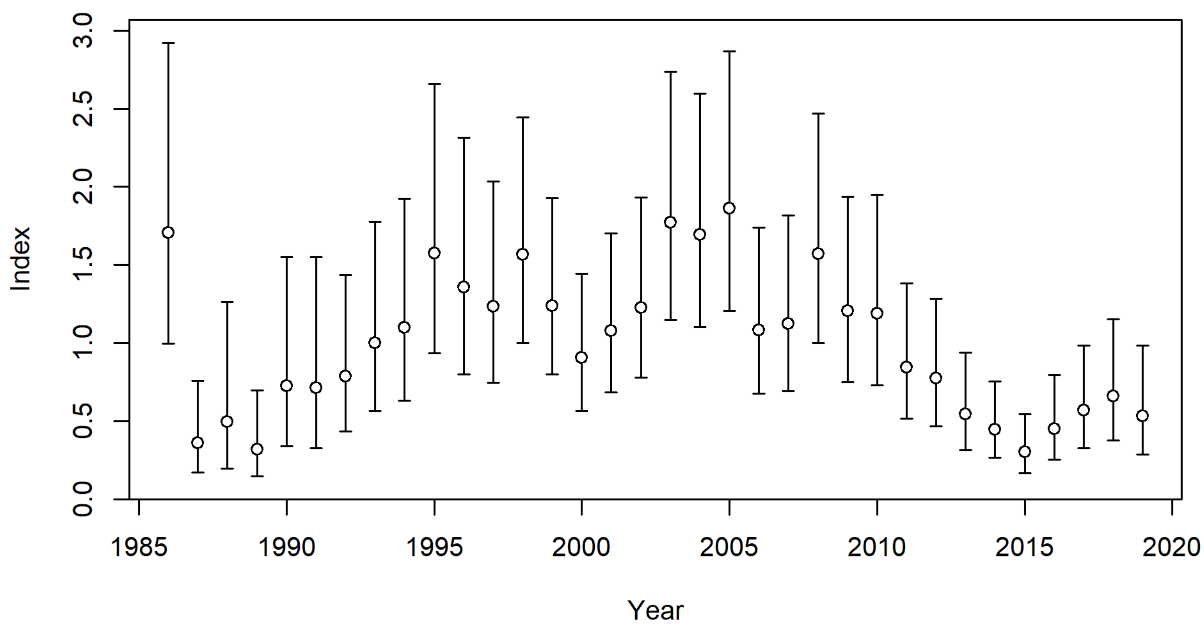


Figure 28. Standardized index of relative abundance and associated 95% uncertainty interval around index values based on the model assumption of lognormal error for Gulf of Mexico Gag Grouper from the Charter + Private fisheries. The uncertainty displayed includes the additional SE parameter estimated as part of the data weighting process.

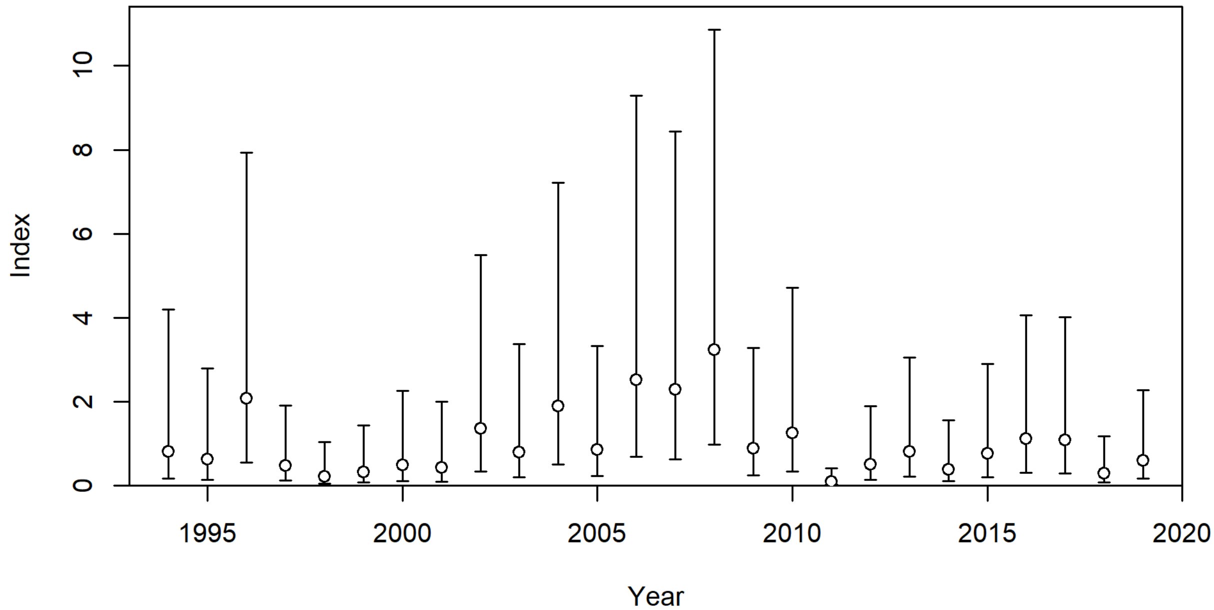


Figure 29. Standardized index of relative abundance and associated 95% uncertainty interval around index values based on the model assumption of lognormal error for Gulf of Mexico Gag Grouper from the Age-0 Survey. The uncertainty displayed includes the additional SE parameter estimated as part of the data weighting process.

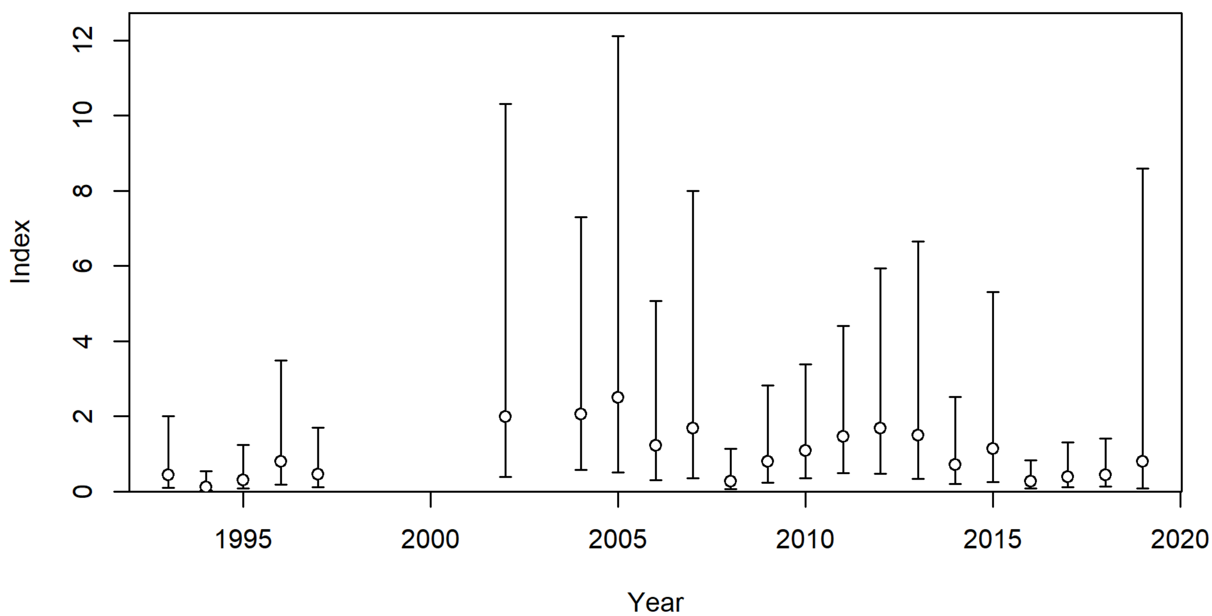


Figure 30. Standardized index of relative abundance and associated 95% uncertainty interval around index values based on the model assumption of lognormal error for Gulf of Mexico Gag Grouper from the SEAMAP Video Survey. The uncertainty displayed includes the additional SE parameter estimated as part of the data weighting process.

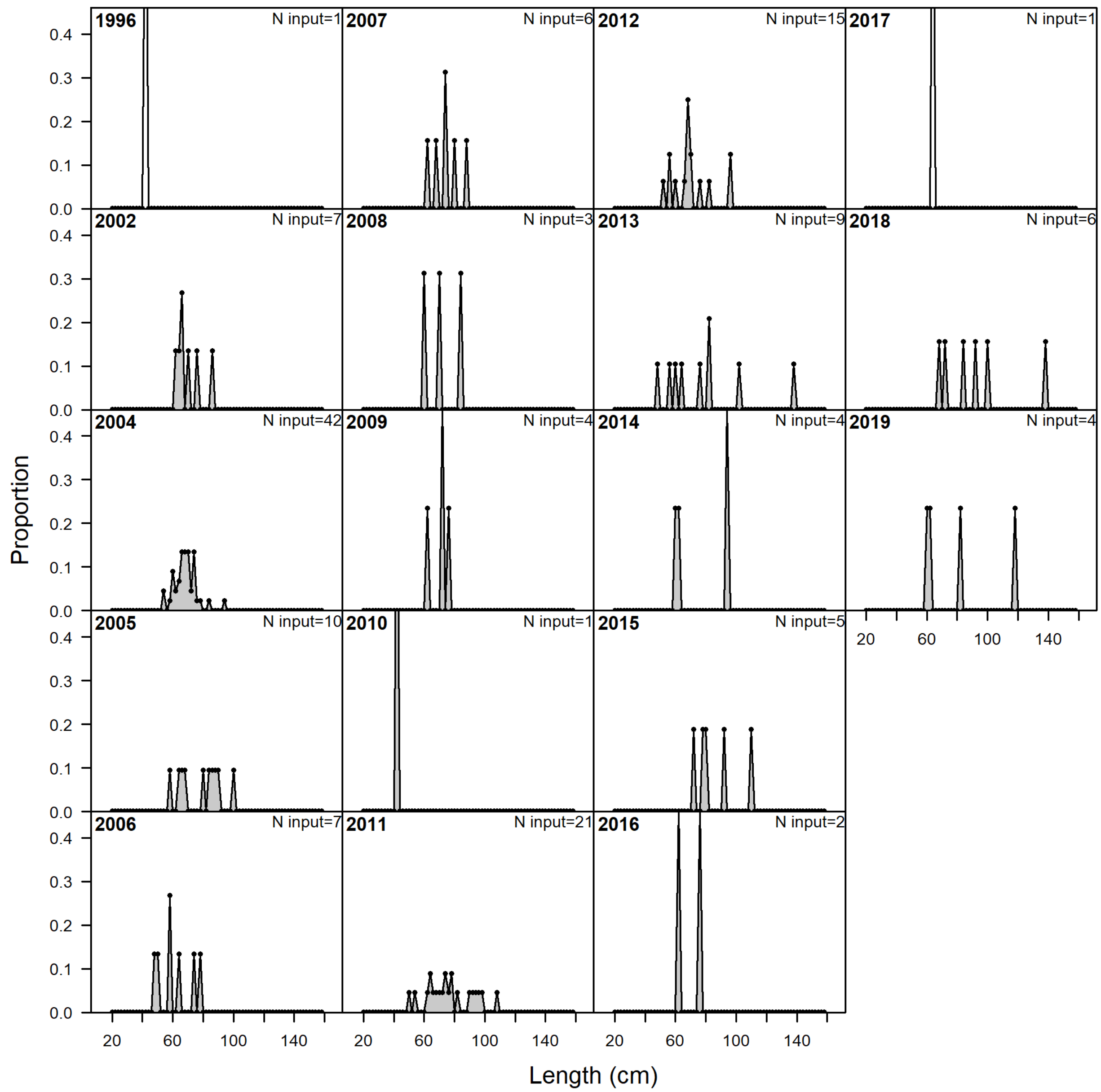


Figure 31. Observed length composition data of Gulf of Mexico Gag Grouper from the SEAMAP Video Survey.

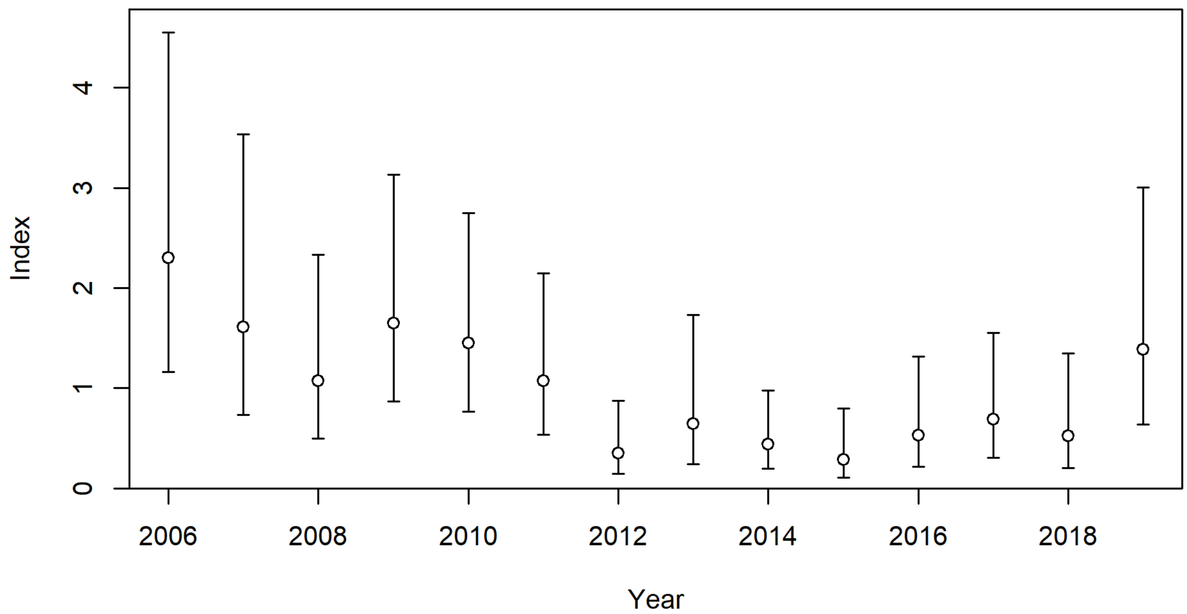


Figure 32. Standardized index of relative abundance and associated 95% uncertainty interval around index values based on the model assumption of lognormal error for Gulf of Mexico Gag Grouper from the PC Video Survey. The uncertainty displayed includes the additional SE parameter estimated as part of the data weighting process.

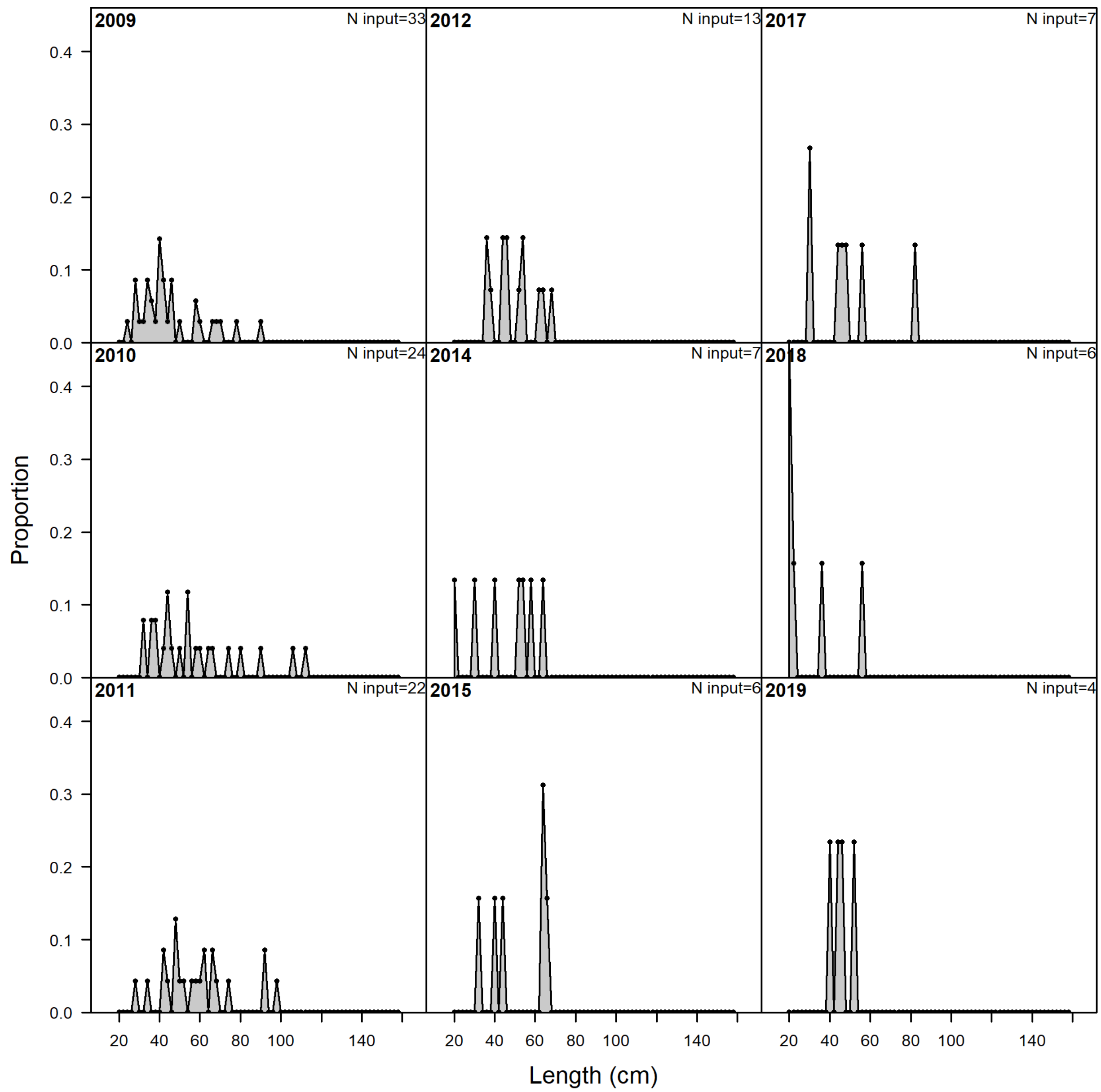


Figure 33. Observed length composition data of Gulf of Mexico Gag Grouper from the PC Video Survey.

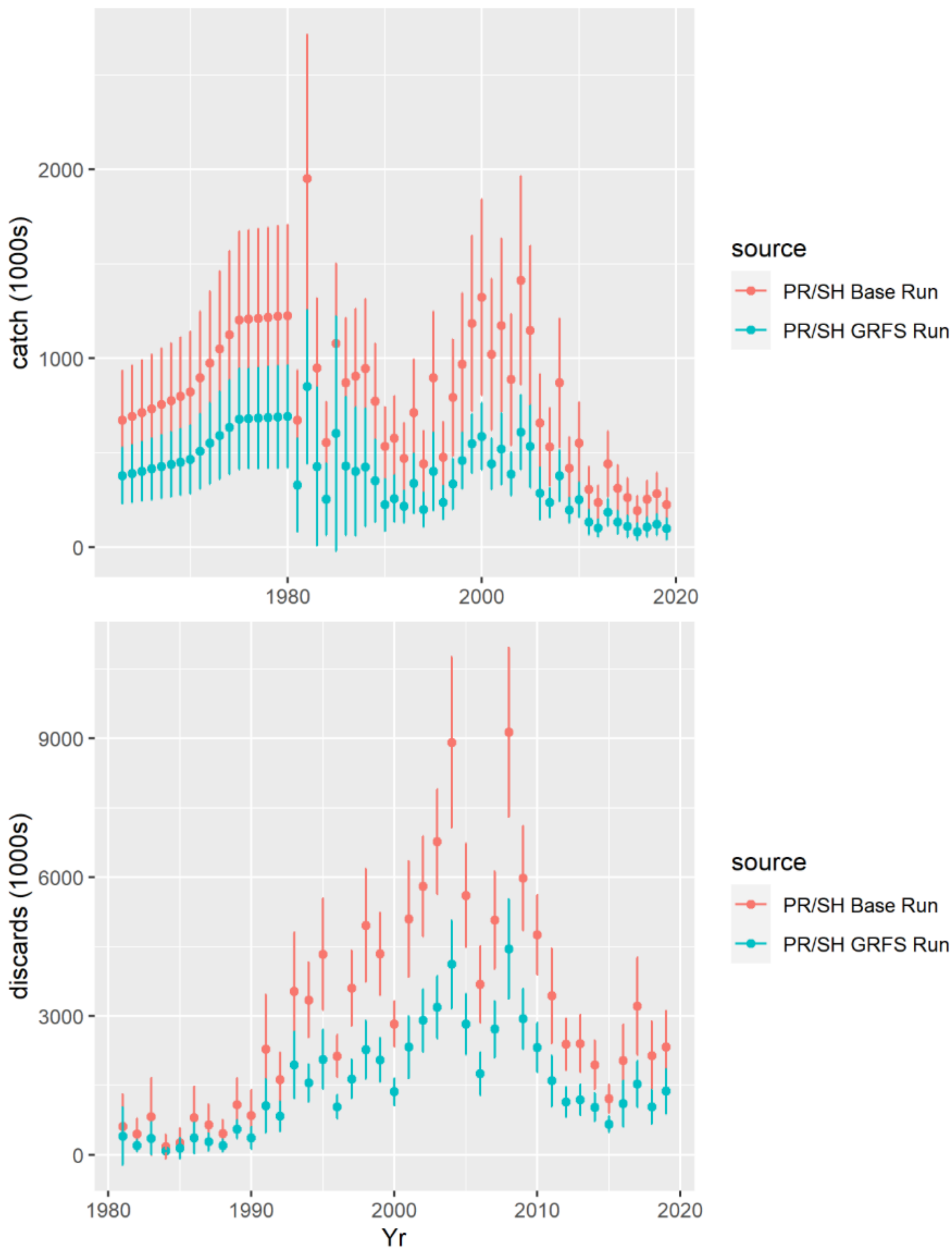


Figure 34. Time series of the Private + Shore fleet landings and discards in thousands of fish, and associated uncertainty, estimated by replacing FL Private mode catches/discards with the FL Private GRFS calibrated catches/discards time series ("PR/SH GRFS Run") vs. the MRIP fully calibrated time series ("PR/SH Base Run"). These data were considered in a sensitivity run.

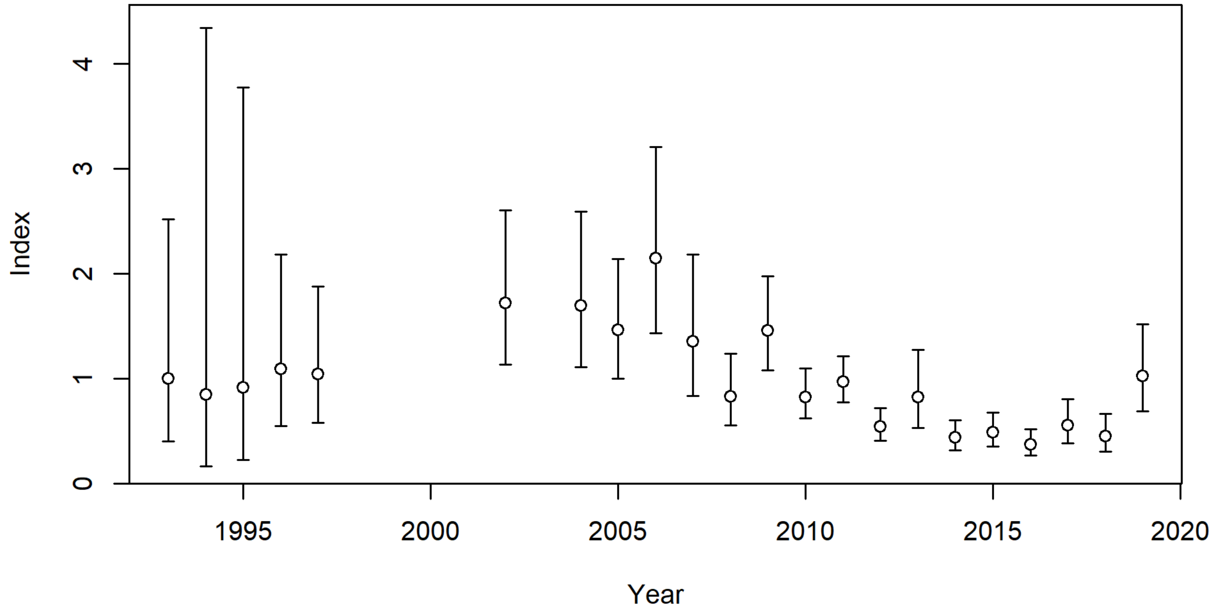


Figure 35. Standardized index of relative abundance and associated 95% uncertainty interval around index values based on the model assumption of lognormal error for Gulf of Mexico Gag Grouper from the Combined Video Index (sensitivity run). The uncertainty displayed includes the additional SE parameter estimated as part of the data weighting process.

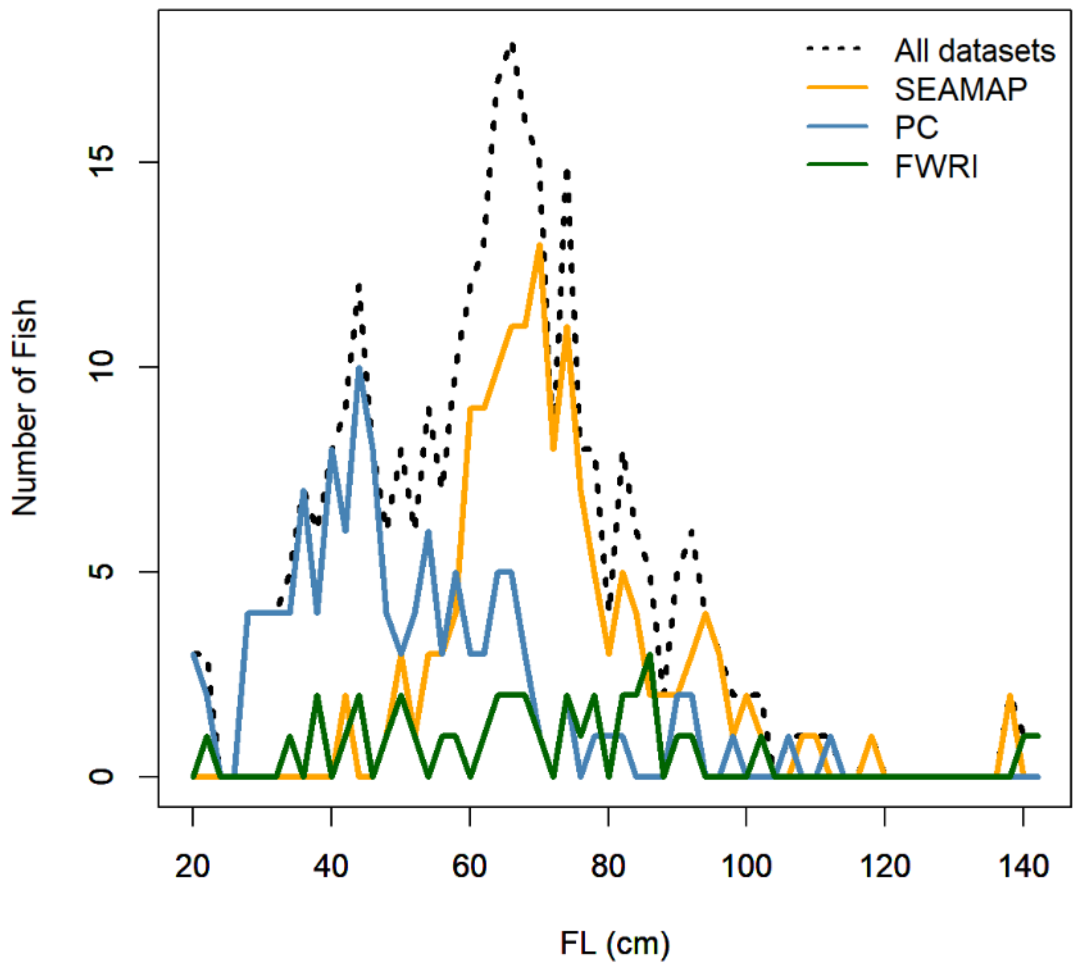


Figure 36. Raw length composition available for the three surveys that make up the Combined Video Index. Length compositions have been aggregated over all years to show overall differences in selectivity of each survey.

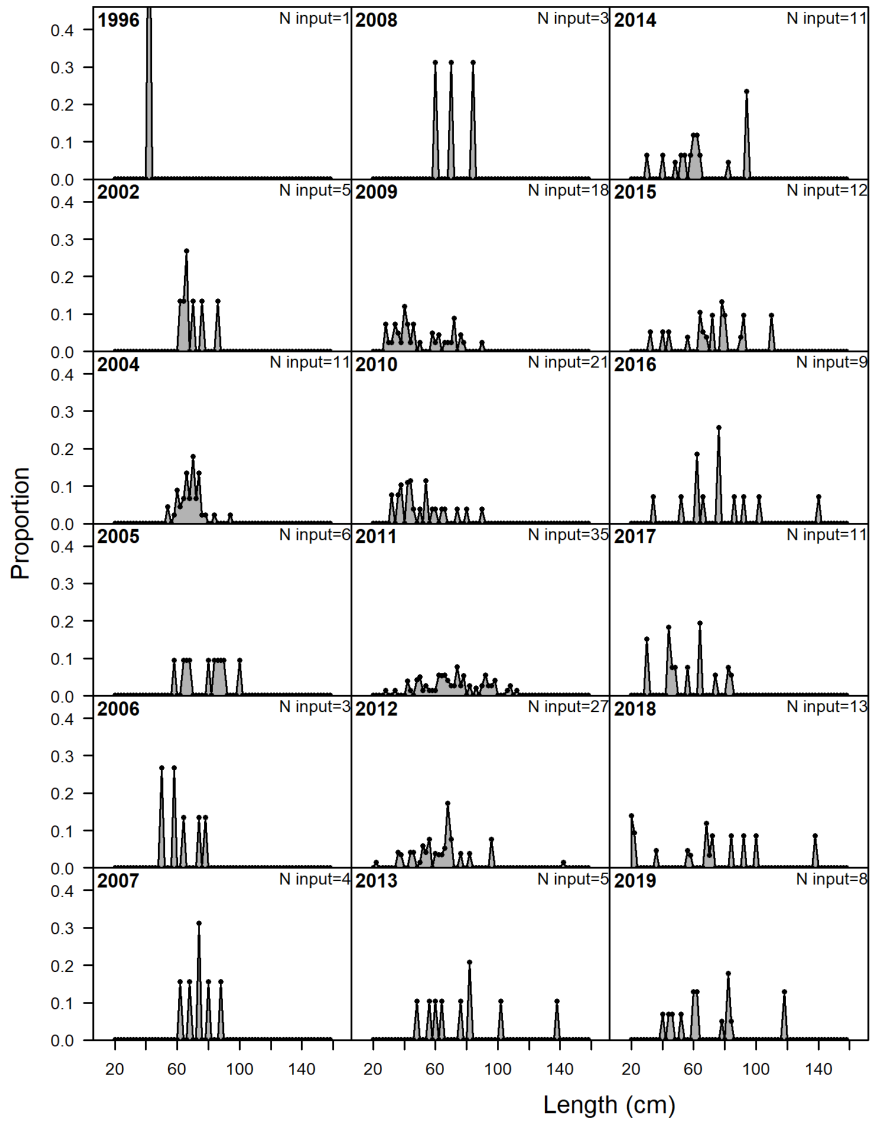


Figure 37. Area-weighted length composition data of Gulf of Mexico Gag Grouper from the Combined Video Survey Index.

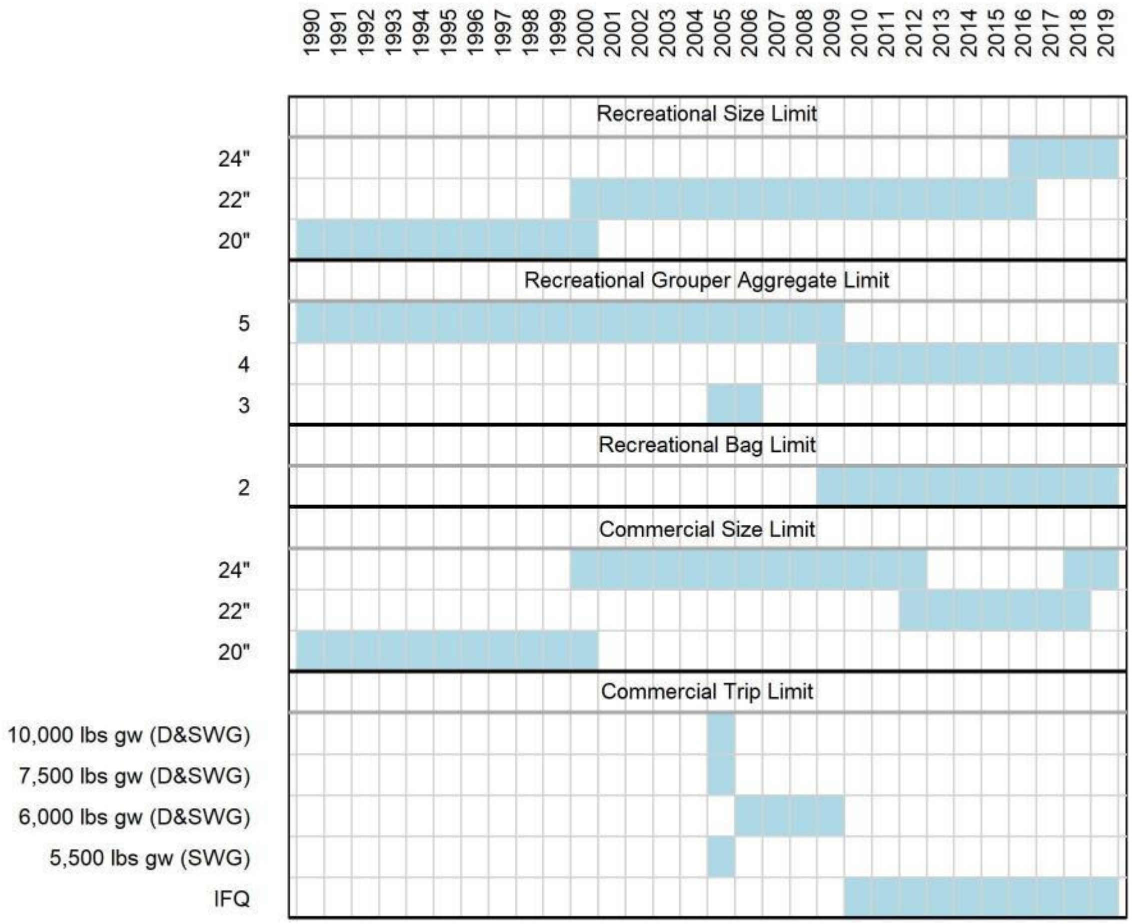


Figure 38. Summary of federal management regulations for Gulf of Mexico Gag Grouper. Size limits shown are for inches maximum total length (TL) and trip limits in pounds gutted weight (lbs gw) are shown for either shallow-water grouper (SWG) or deep and shallow-water grouper (D&SWG). IFQ refers to the implementation of the Grouper-Tilefish Individual Fishing Quota program. Not included are time and area closures.

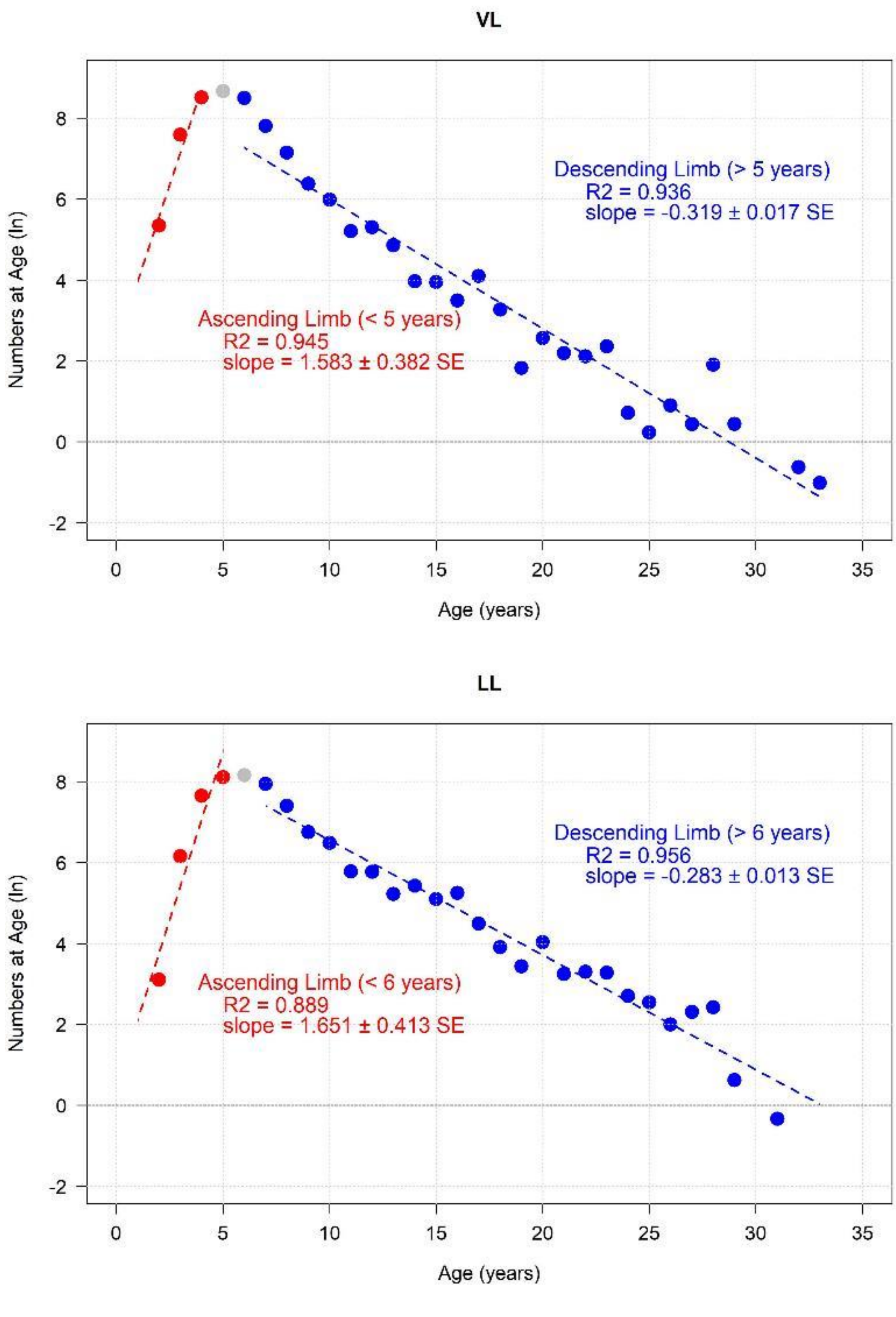


Figure 39. Catch curve analysis from the aggregated Commercial Vertical Line (top panel) and Longline (bottom panel) data. The gray dot reflects the first age fully selected for by the gear.

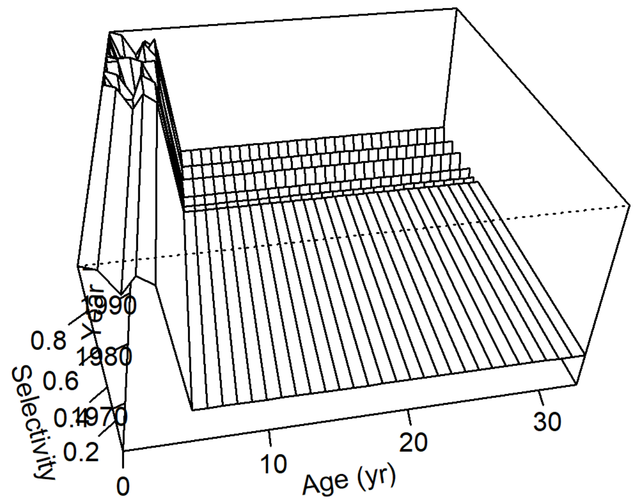
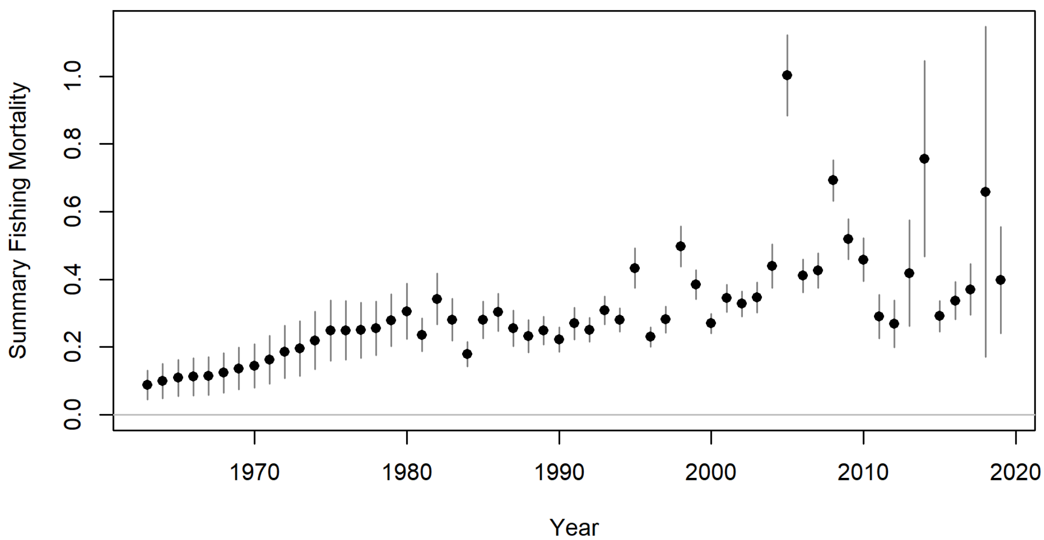


Figure 40. Empirical selectivity at age input characterizing the red tide bycatch fleet in the sensitivity run.

SEDAR72



SEDAR33 Update

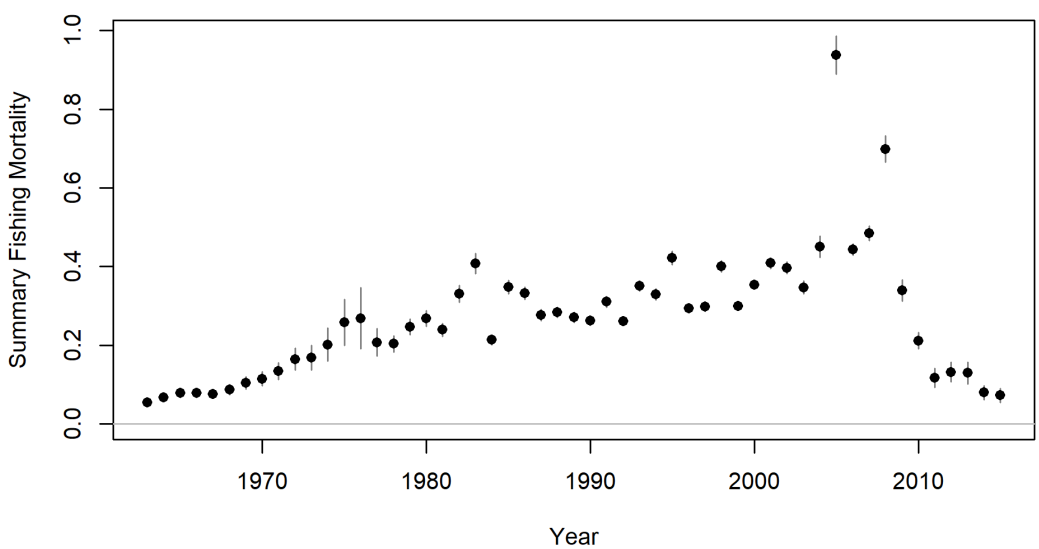
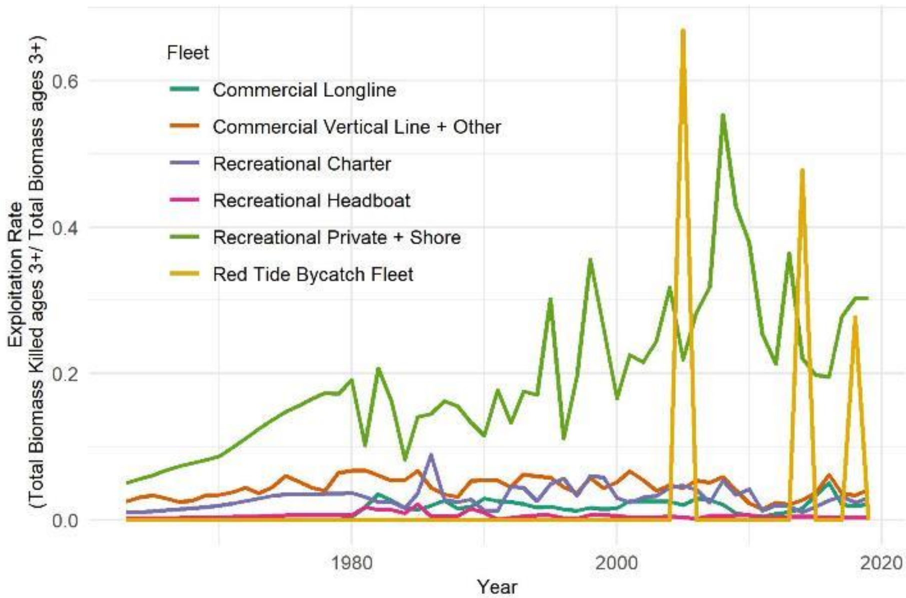


Figure 41. Annual exploitation rate estimates (total biomass killed age 3+ / total biomass age 3+) for Gulf of Mexico Gag Grouper.

SEDAR72



SEDAR33 Update

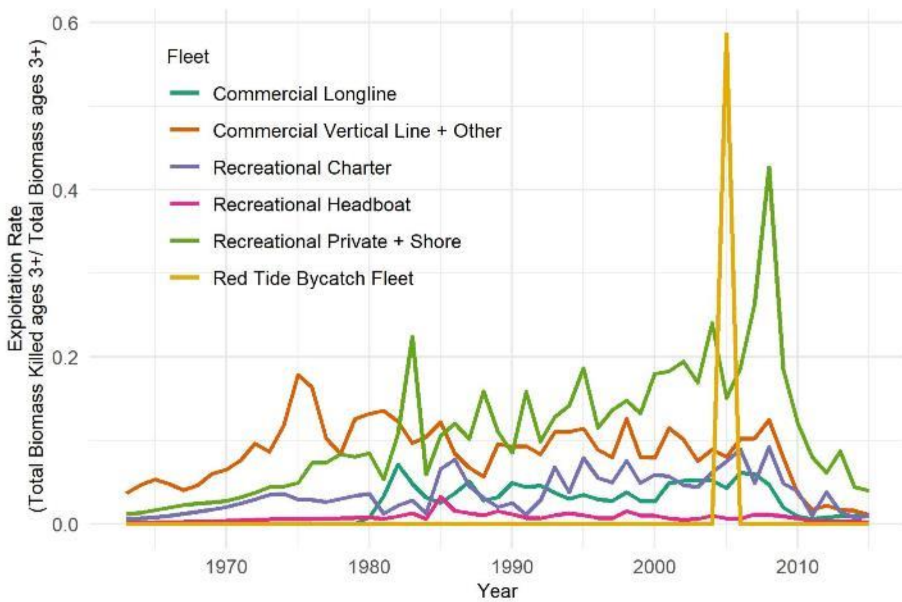


Figure 42. Annual exploitation rate (total biomass killed age 3+ / total biomass age 3+) by fleet for Gulf of Mexico Gag Grouper.

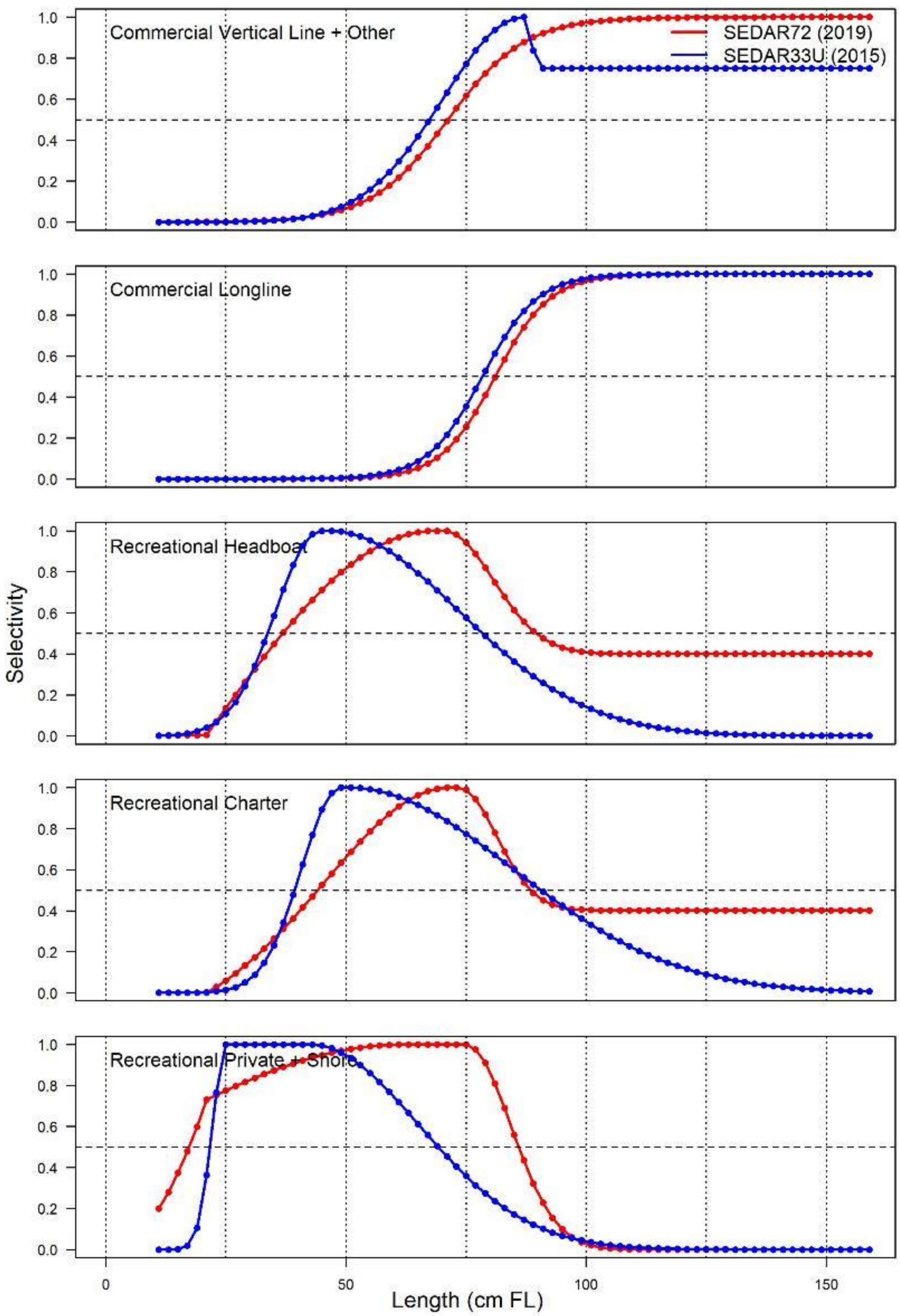
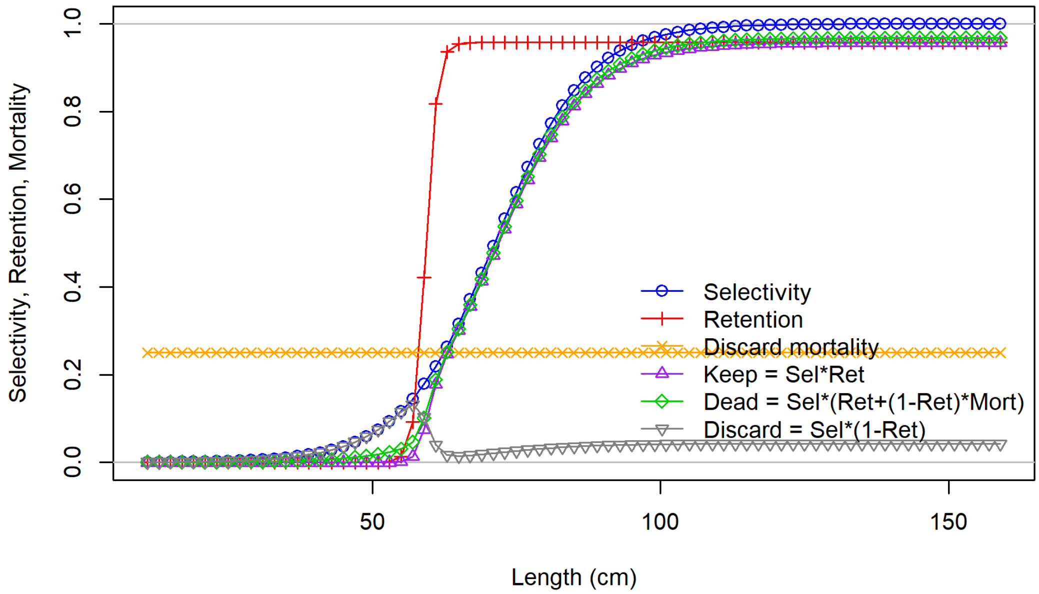


Figure 43. Length-based selectivity for each fleet for Gulf of Mexico Gag Grouper in the terminal year of the assessment (given in parentheses). Dashed horizontal line indicates 50%, whereas the dashed vertical lines identify lengths in 25 cm FL intervals.

SEDAR72



SEDAR33 Update

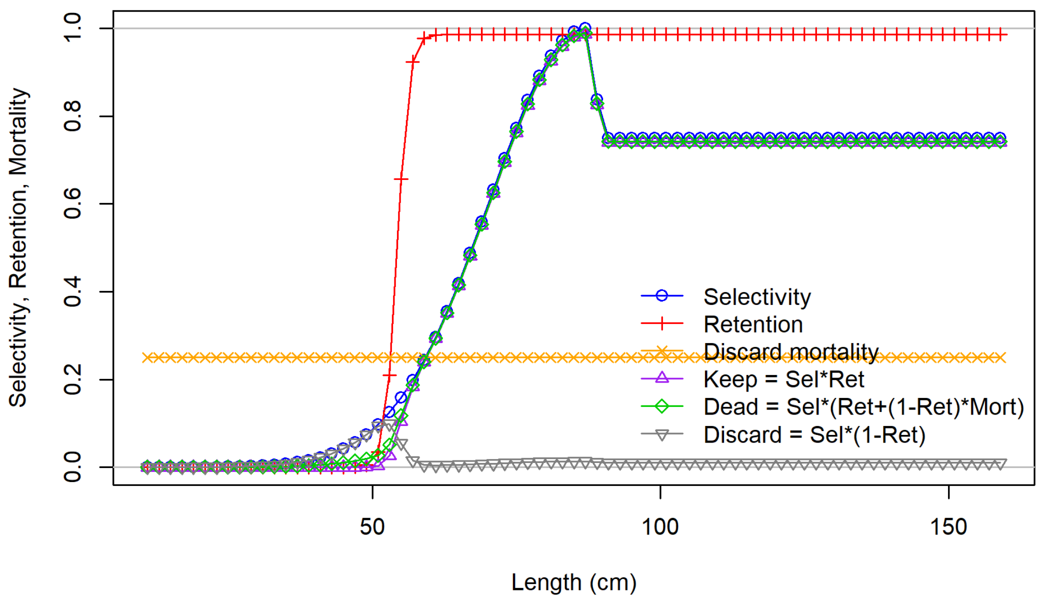
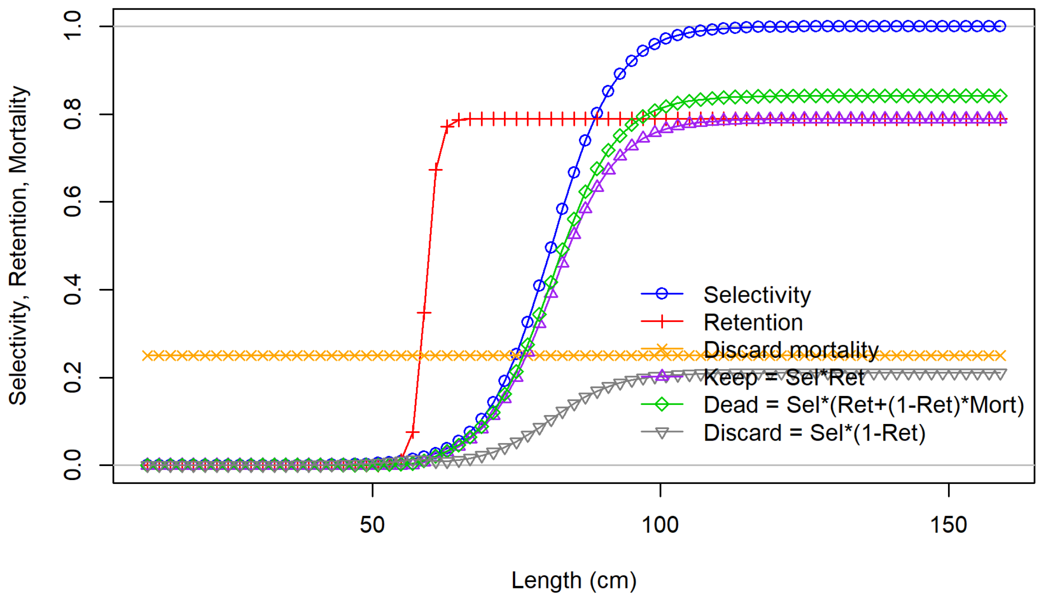


Figure 44. Length-based selectivity for the Commercial Vertical Line + Other fishery. Selectivity (blue line) is constant over the entire assessment time period (1963 - 2019). Retention (red line) is shown for the most recent time period. Discard mortality (orange line) is constant at 0.25.

SEDAR72



SEDAR33 Update

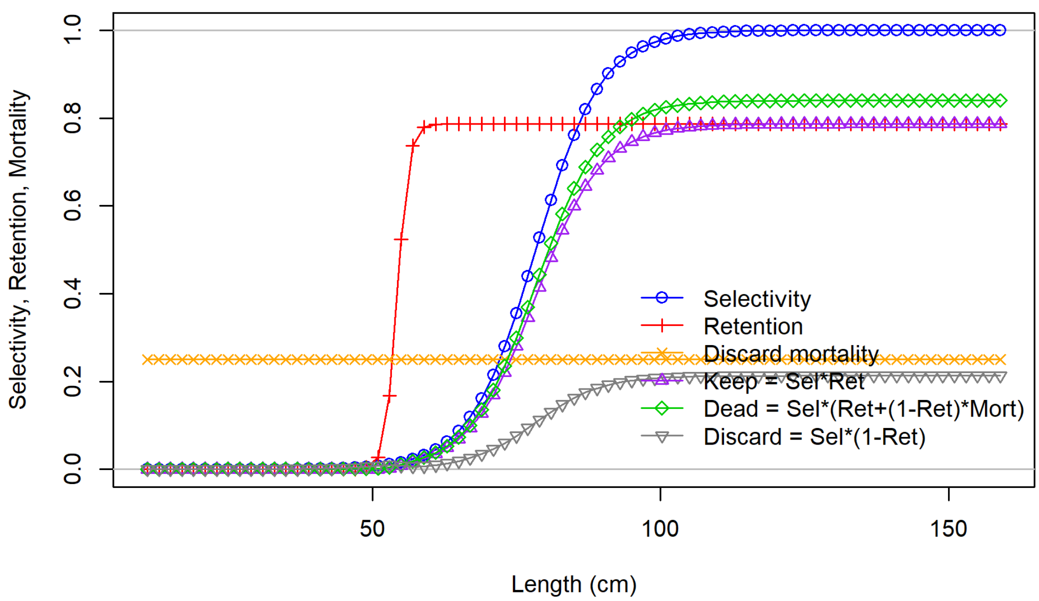
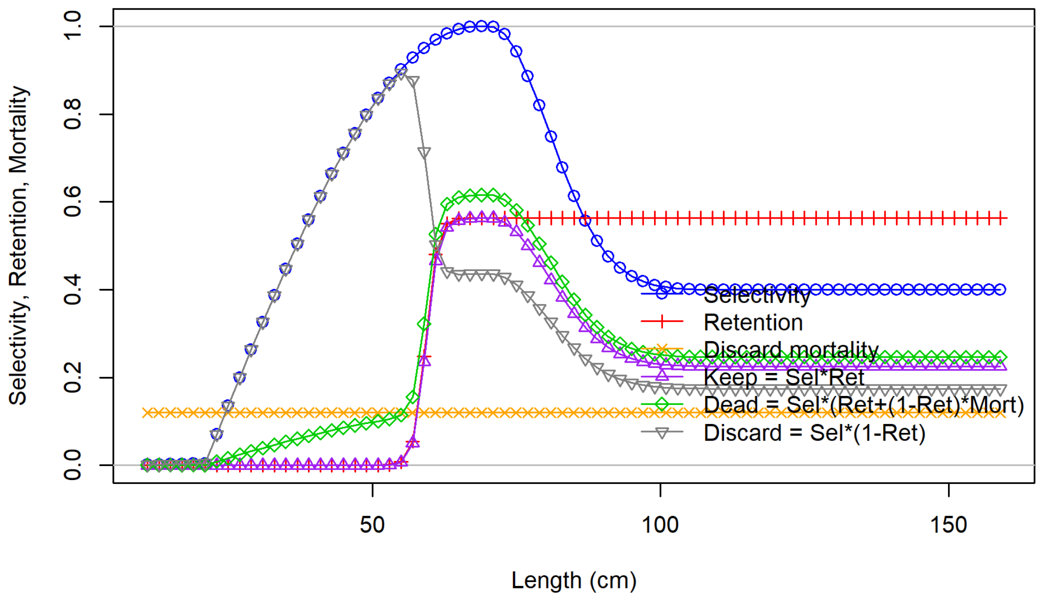


Figure 45. Length-based selectivity for the Commercial Longline fishery. Selectivity (blue line) is constant over the entire assessment time period (1963 - 2019). Retention (red line) is shown for the most recent time period. Discard mortality (orange line) is constant at 0.25.

SEDAR72



SEDAR33 Update

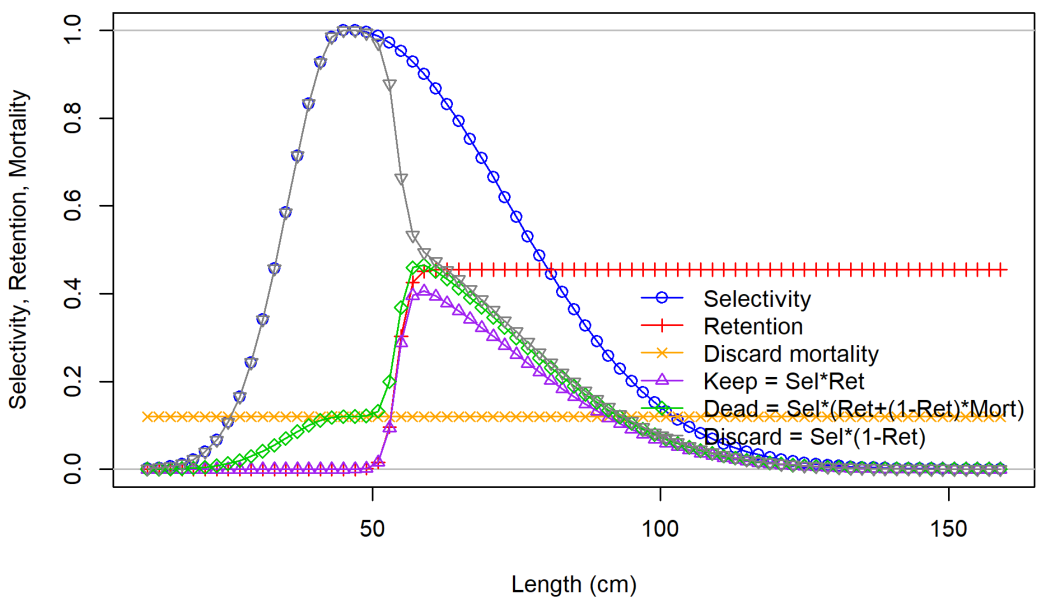
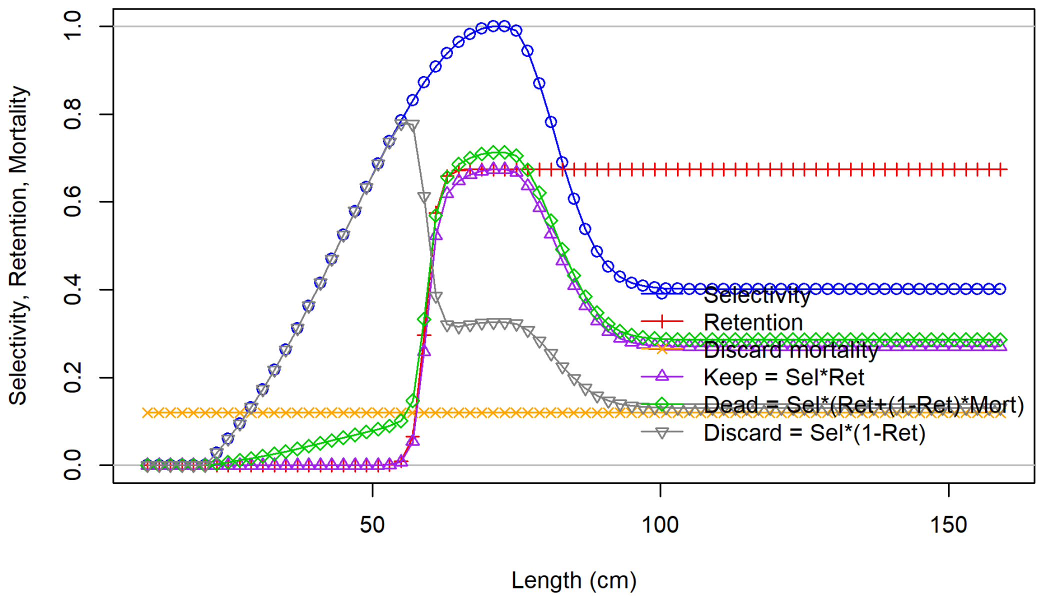


Figure 46. Length-based selectivity for the Recreational Headboat fishery. Selectivity (blue line) is constant over the entire assessment time period (1963 - 2019). Retention (red line) is shown for the most recent time period. Discard mortality (orange line) is constant at 0.12.

SEDAR72



SEDAR33 Update

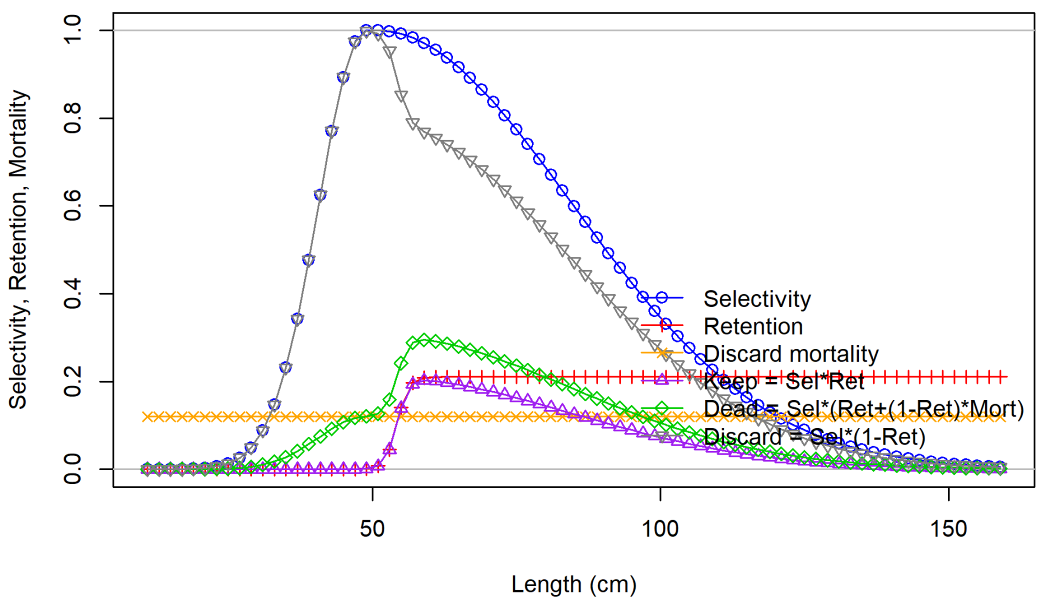
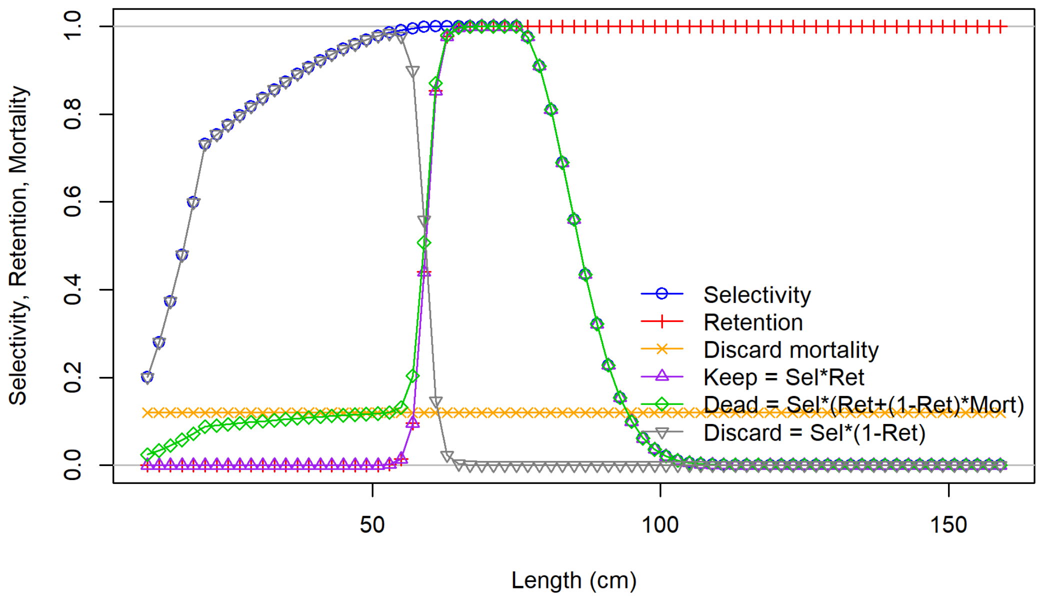


Figure 47. Length-based selectivity for the Recreational Charter fishery. Selectivity (blue line) is constant over the entire assessment time period (1963 - 2019). Retention (red line) is shown for the most recent time period. Discard mortality (orange line) is constant at 0.12.

SEDAR72



SEDAR33 Update

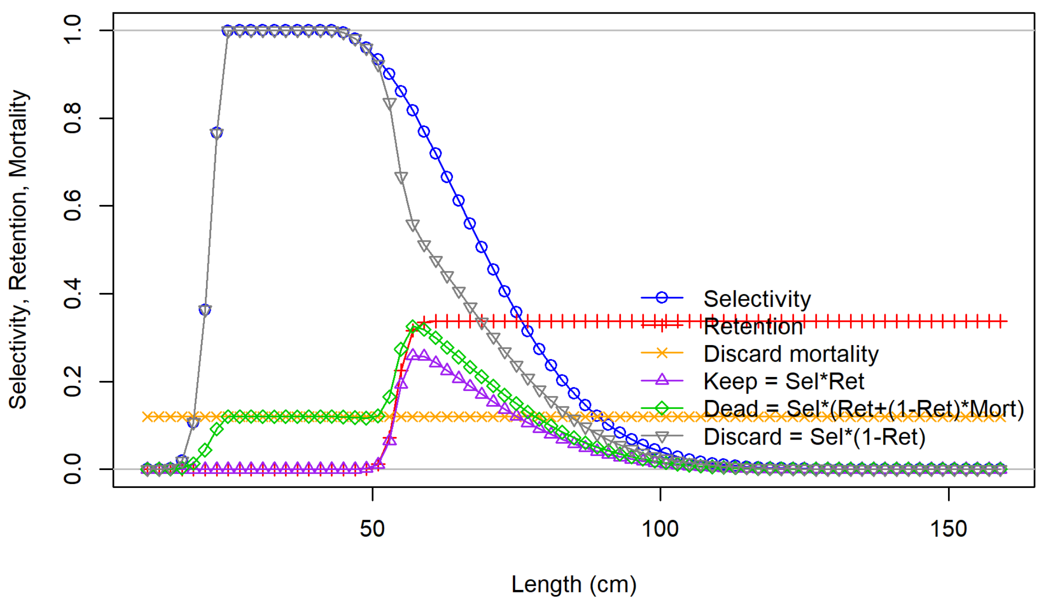


Figure 48. Length-based selectivity for the Recreational Private + Shore fishery. Selectivity (blue line) is constant over the entire assessment time period (1963 - 2019). Retention (red line) is shown for the most recent time period. Discard mortality (orange line) is constant at 0.12.

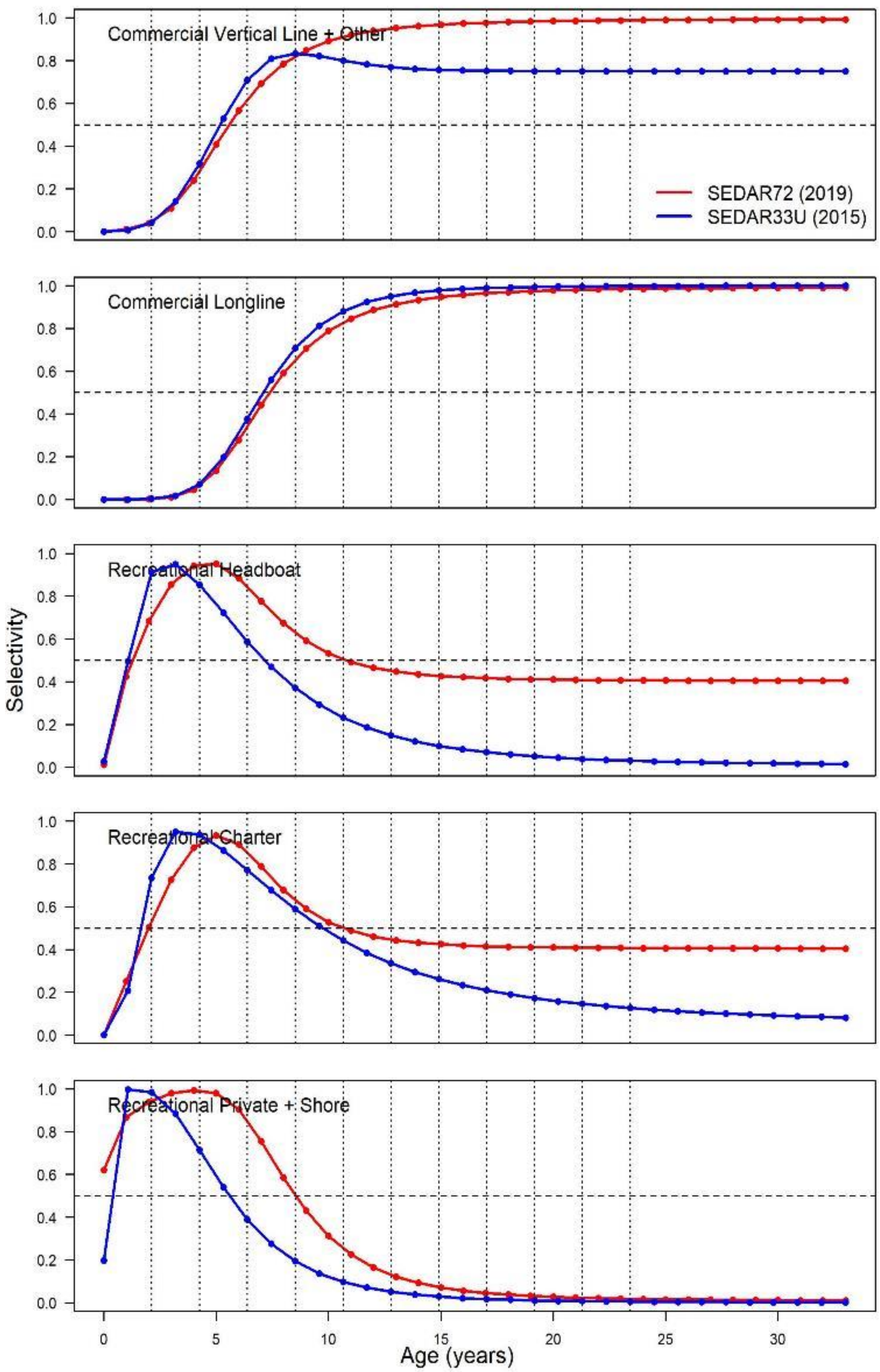


Figure 49. Derived age-based selectivity for each fleet for Gulf of Mexico Gag Grouper in the terminal year of the assessment (given in parentheses). Dashed horizontal line indicates 50%, whereas the dashed vertical lines identify ages in 2 year intervals.

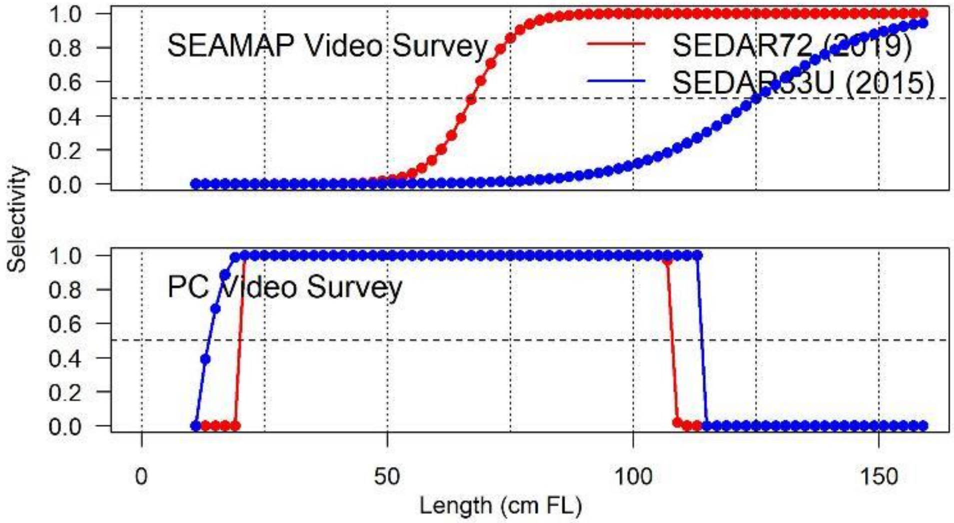


Figure 50. Length-based selectivity for each survey for Gulf of Mexico Gag Grouper in the terminal year of the assessment (given in parentheses). Dashed horizontal line indicates 50%, whereas the dashed vertical lines identify lengths in 25 cm FL intervals.

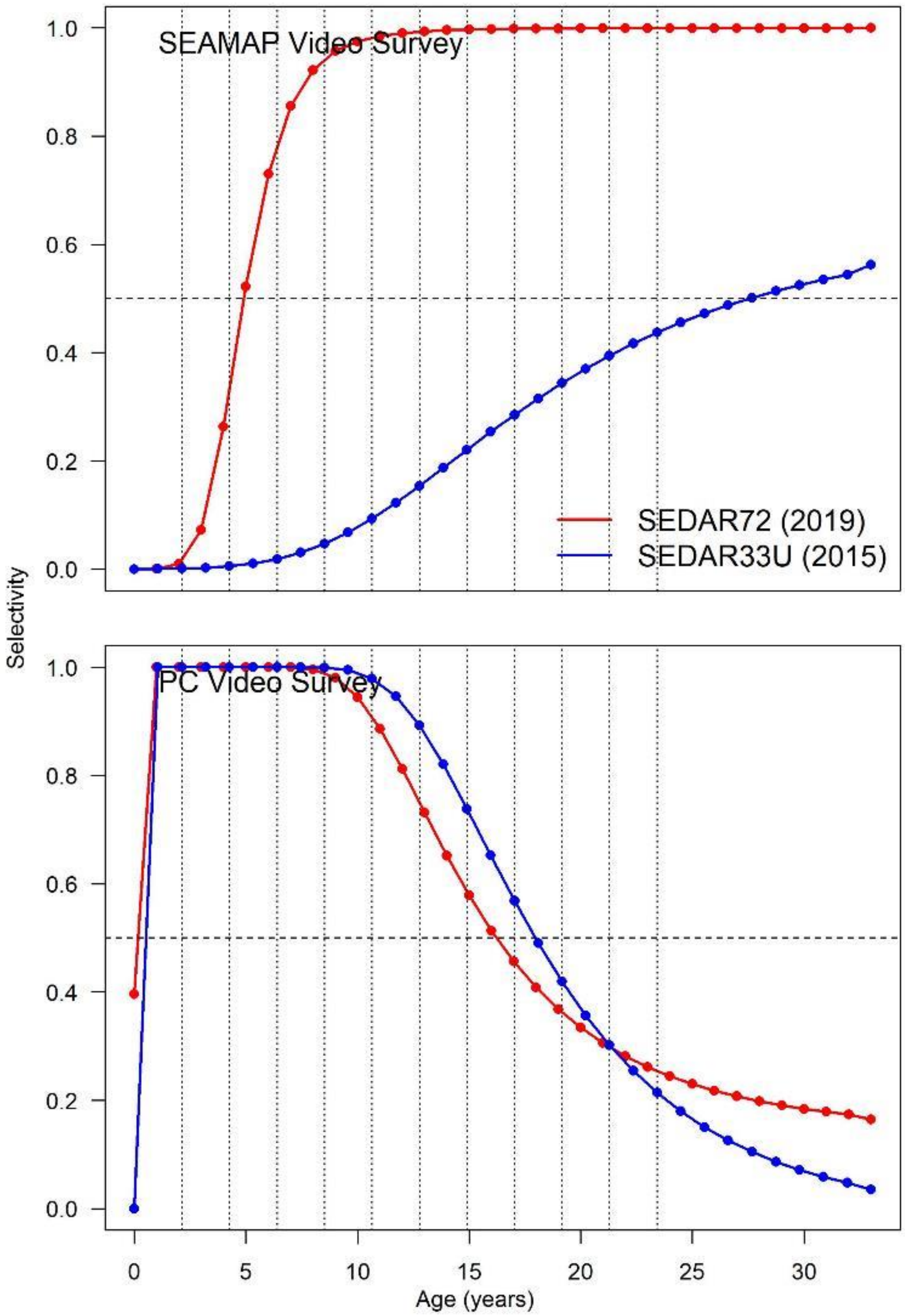


Figure 51. Derived age-based selectivity for each survey for Gulf of Mexico Gag Grouper in the terminal year of the assessment (given in parentheses). Dashed horizontal line indicates 50%, whereas the dashed vertical lines identify ages in 2 year intervals.

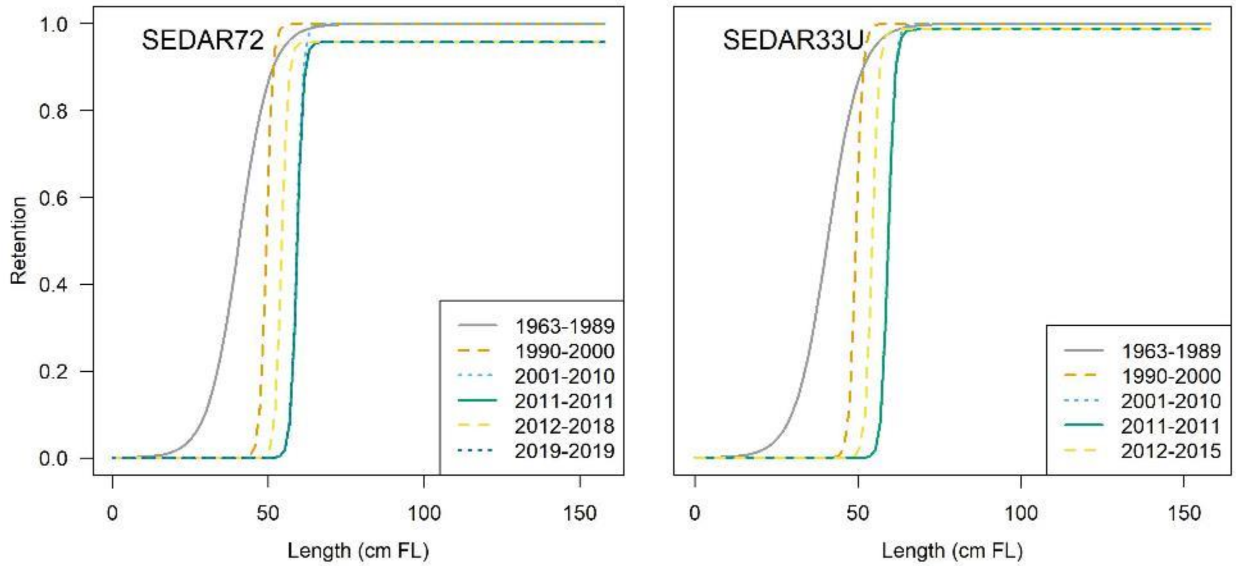


Figure 52. Time-varying retention functions for the Commercial Vertical Line + Other fishery for Gulf of Mexico Gag Grouper from SEDAR72 and SEDAR33 Update.

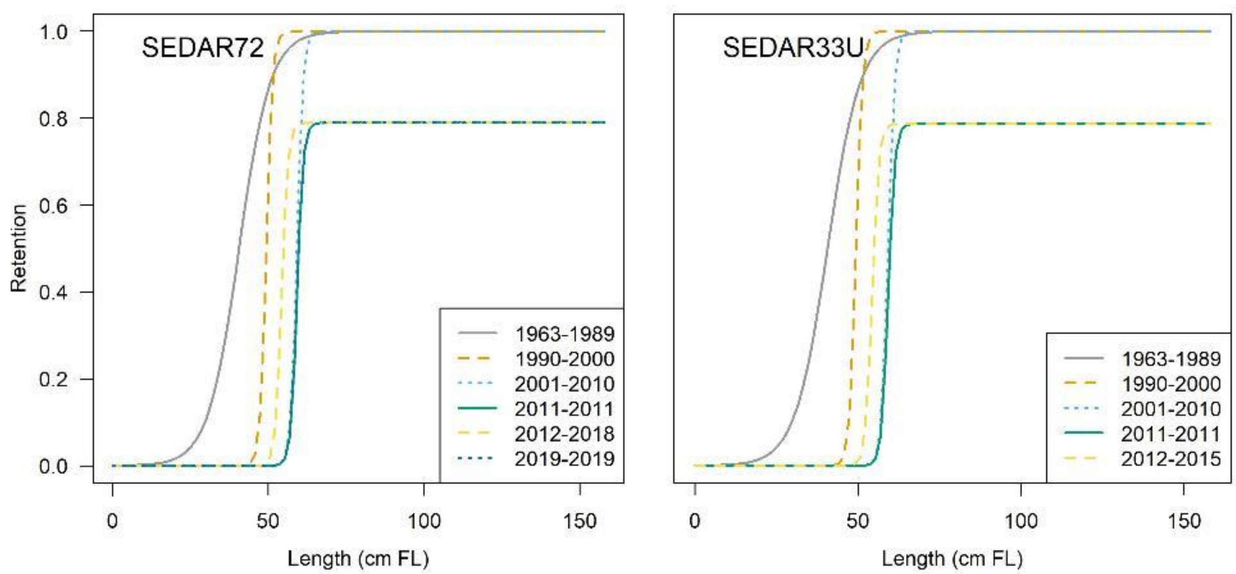


Figure 53. Time-varying retention functions for the Commercial Longline fishery for Gulf of Mexico Gag Grouper from SEDAR72 and SEDAR33 Update.

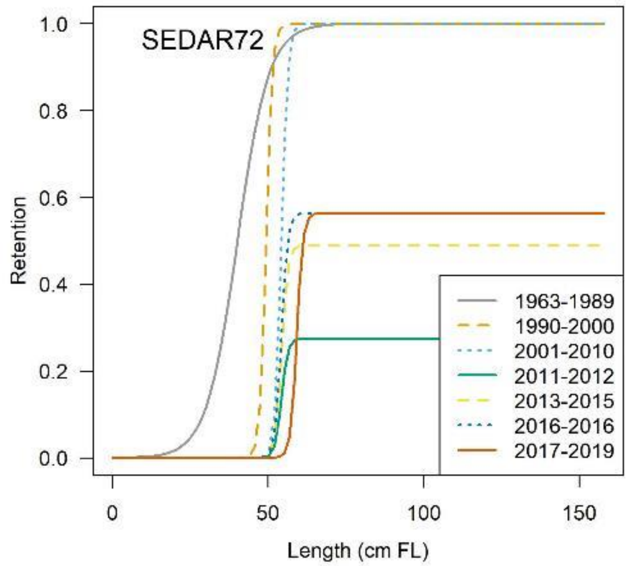


Figure 54. Time-varying retention functions for the Recreational Headboat fishery for Gulf of Mexico Gag Grouper from SEDAR72 and SEDAR33 Update.

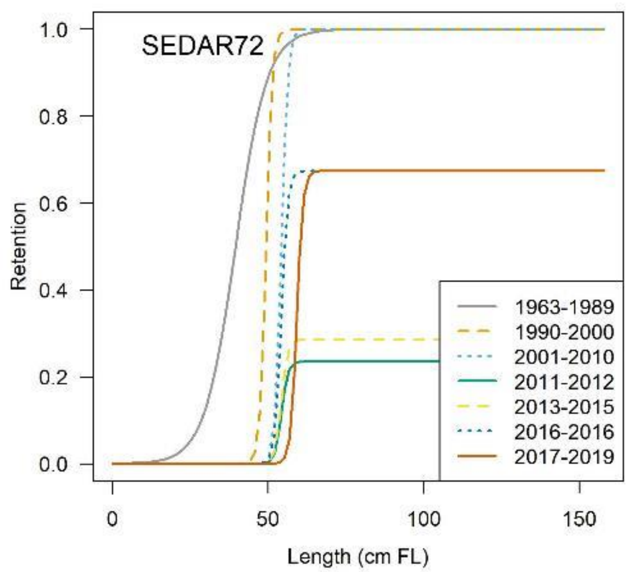


Figure 55. Time-varying retention functions for the Recreational Charter fishery for Gulf of Mexico Gag Grouper from SEDAR72 and SEDAR33 Update.

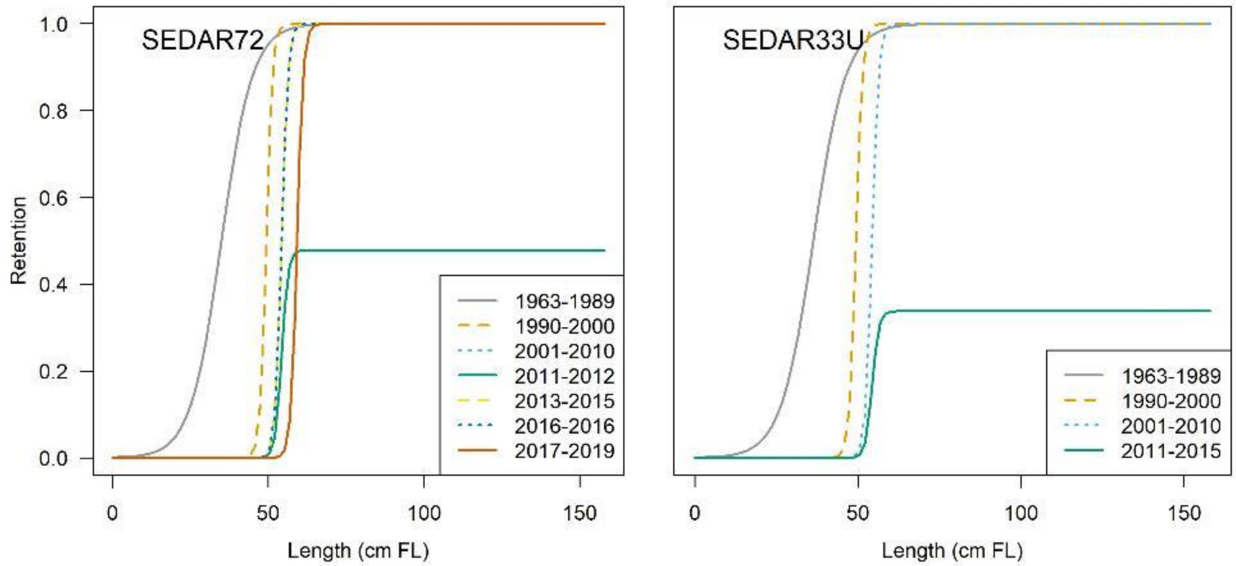
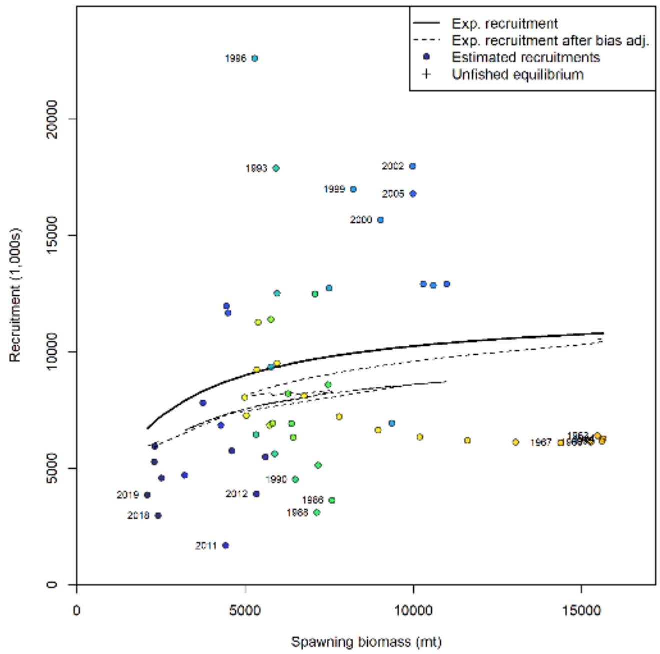


Figure 56. Time-varying retention functions for the Recreational Private + Shore fishery for Gulf of Mexico Gag Grouper from SEDAR72 and SEDAR33 Update.

SEDAR72



SEDAR33 Update

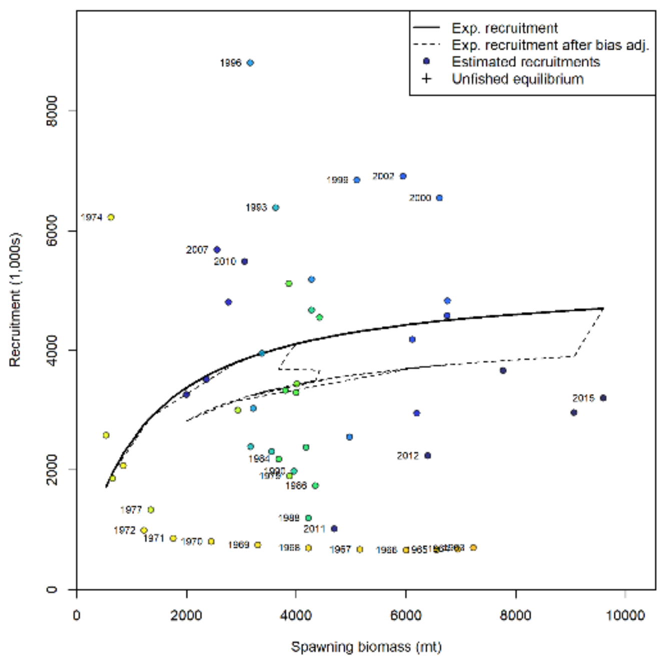
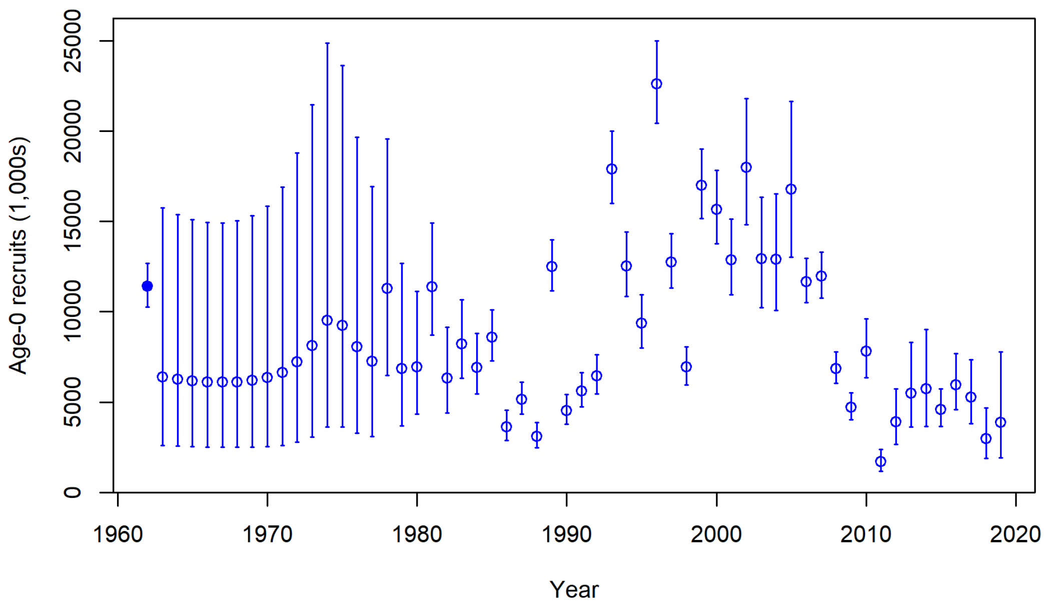


Figure 57. Predicted stock-recruitment relationship for Gulf of Mexico Gag Grouper (steepness and SigmaR were fixed at 0.855 and 0.6, respectively). Plotted are predicted annual recruitments from Stock Synthesis (circles), expected recruitment from the stock-recruit relationship (black line), and bias adjusted recruitment from the stock-recruit relationship (dashed line).

SEDAR72



SEDAR33 Update

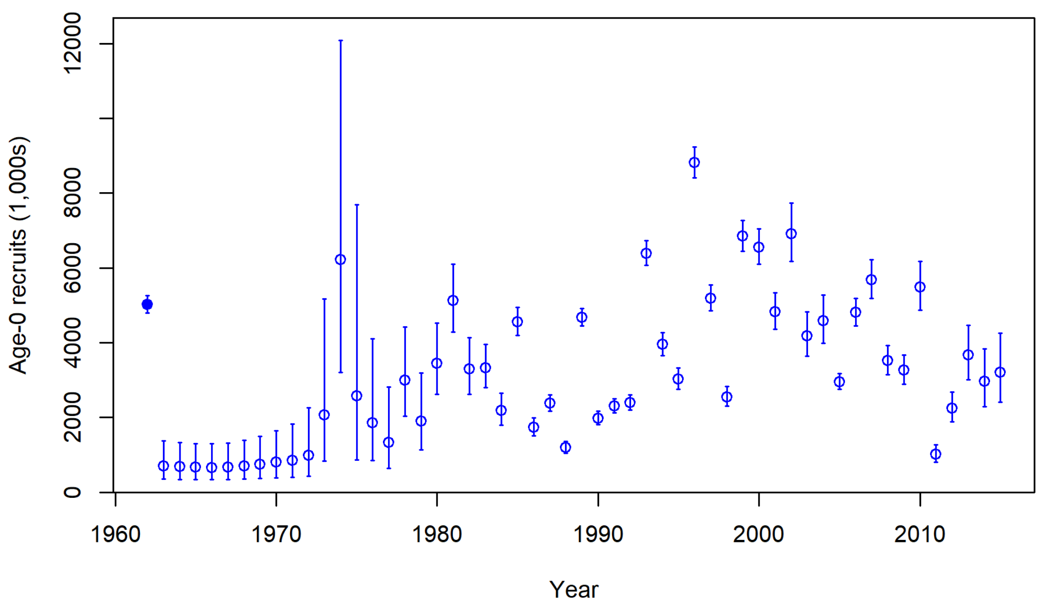
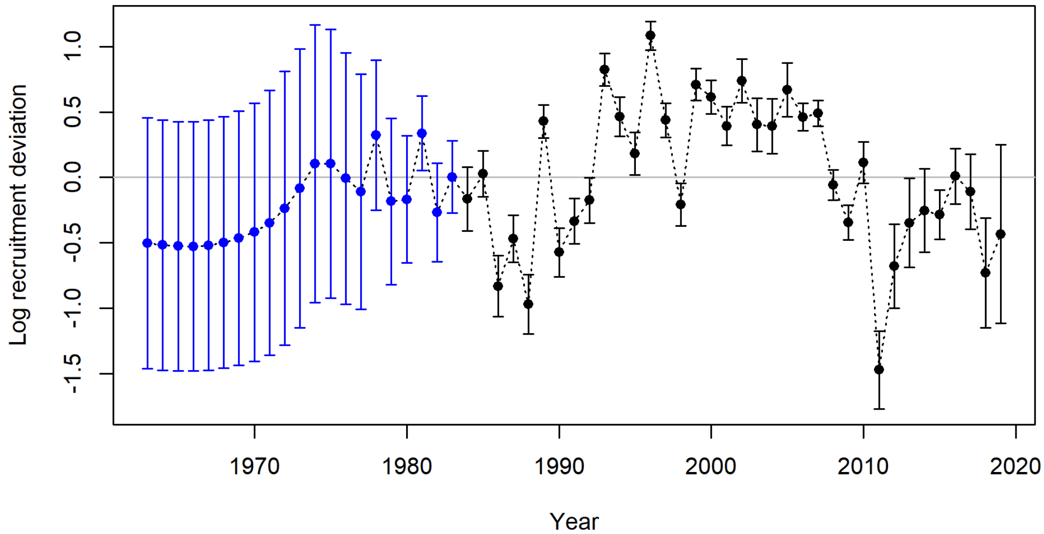


Figure 58. Estimated Age-0 recruitment with 95% confidence intervals for Gulf of Mexico Gag Grouper (steepness and SigmaR were fixed at 0.855 and 0.6, respectively).

SEDAR72



SEDAR33 Update

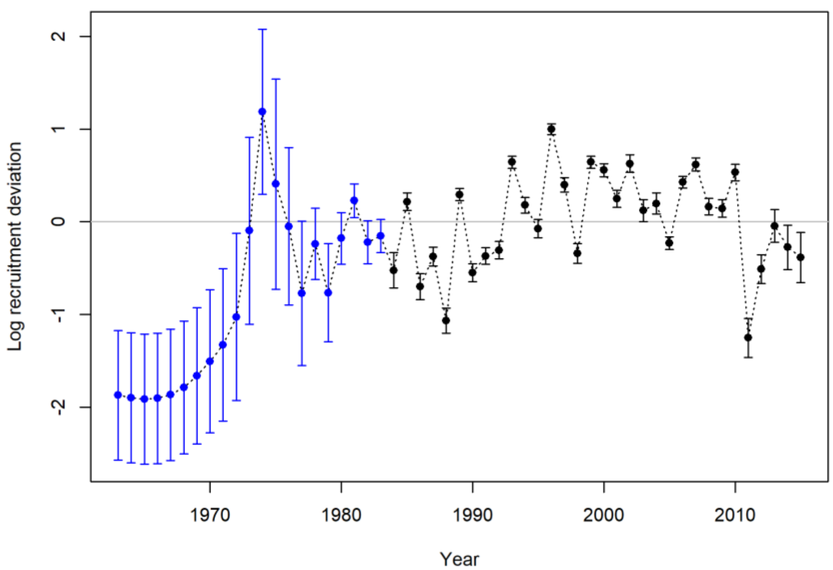
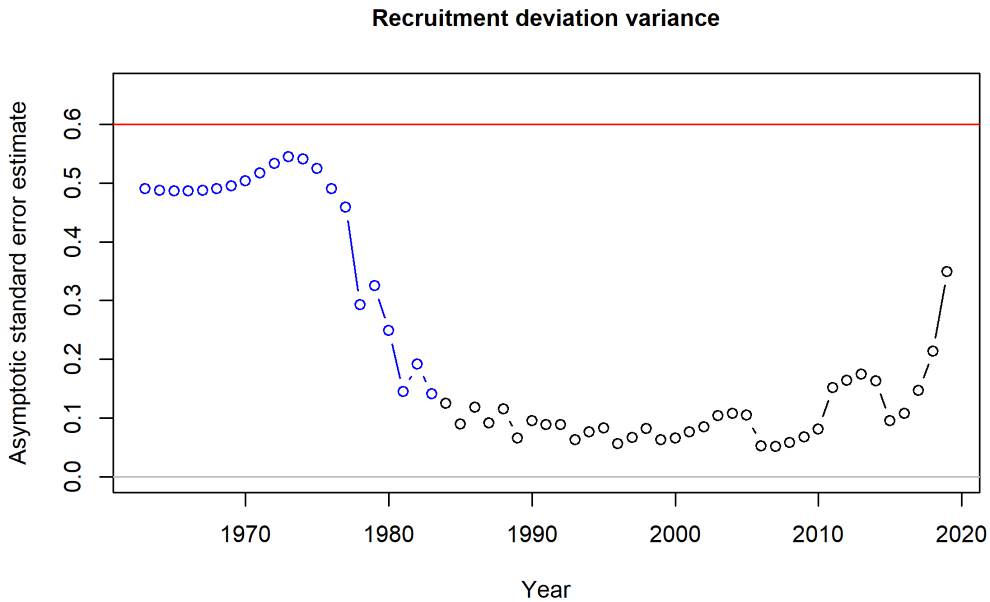


Figure 59. Estimated log recruitment deviations for Gulf of Mexico Gag Grouper (steepness and SigmaR were fixed at 0.855 and 0.6, respectively).

SEDAR72



SEDAR33 Update

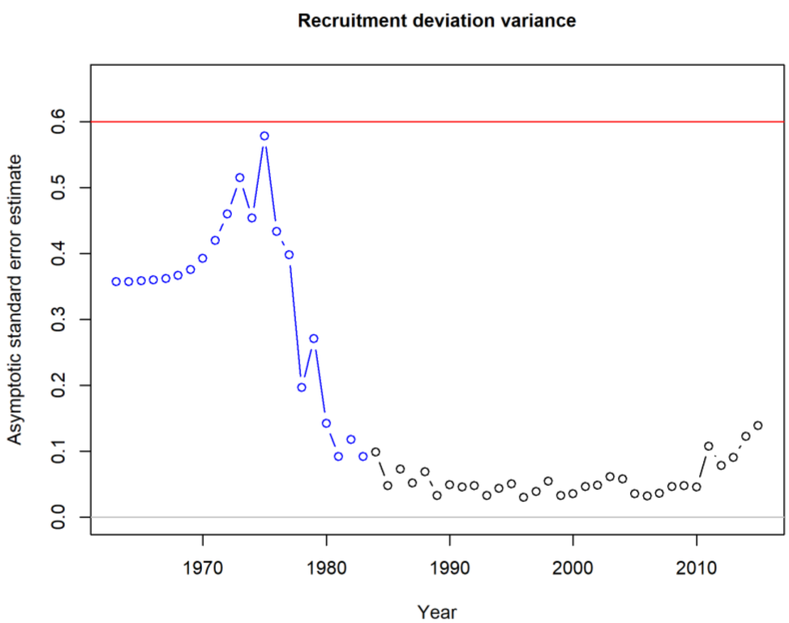


Figure 60. Asymptotic standard errors for recruitment deviations for Gulf of Mexico Gag Grouper. The red line represents the fixed value of 0.6 of 0.6 used in the SEDAR72 and SEDAR33 Update models.

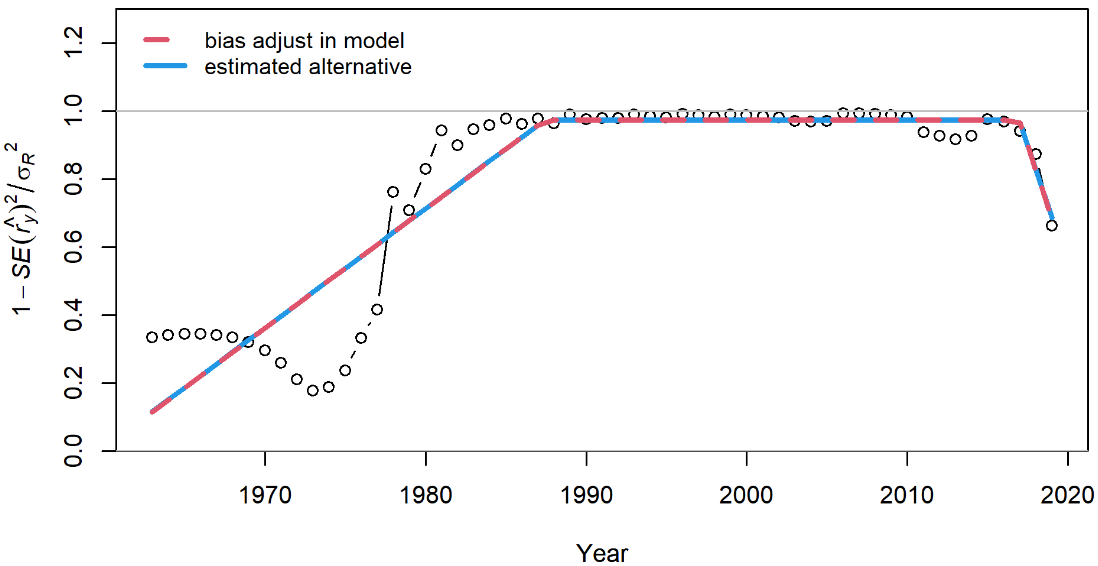


Figure 61. Points are transformed variances. Red line shows current settings for bias adjustment specified for the Base Run, which coincides with the least squares estimate of alternative bias adjustment relationship for recruitment deviations (dashed orange line). For more information, see Methot and Taylor 2011.

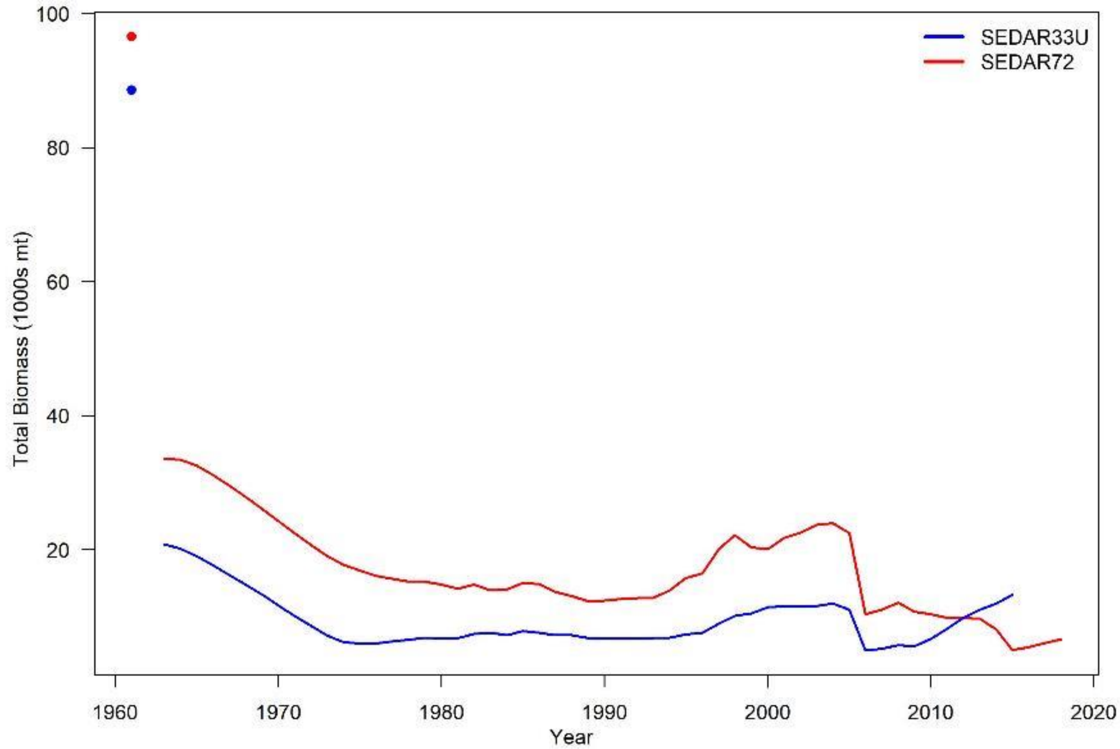


Figure 62. Estimate of total biomass (in 1000s of metric tons) for Gulf of Mexico Gag Grouper.

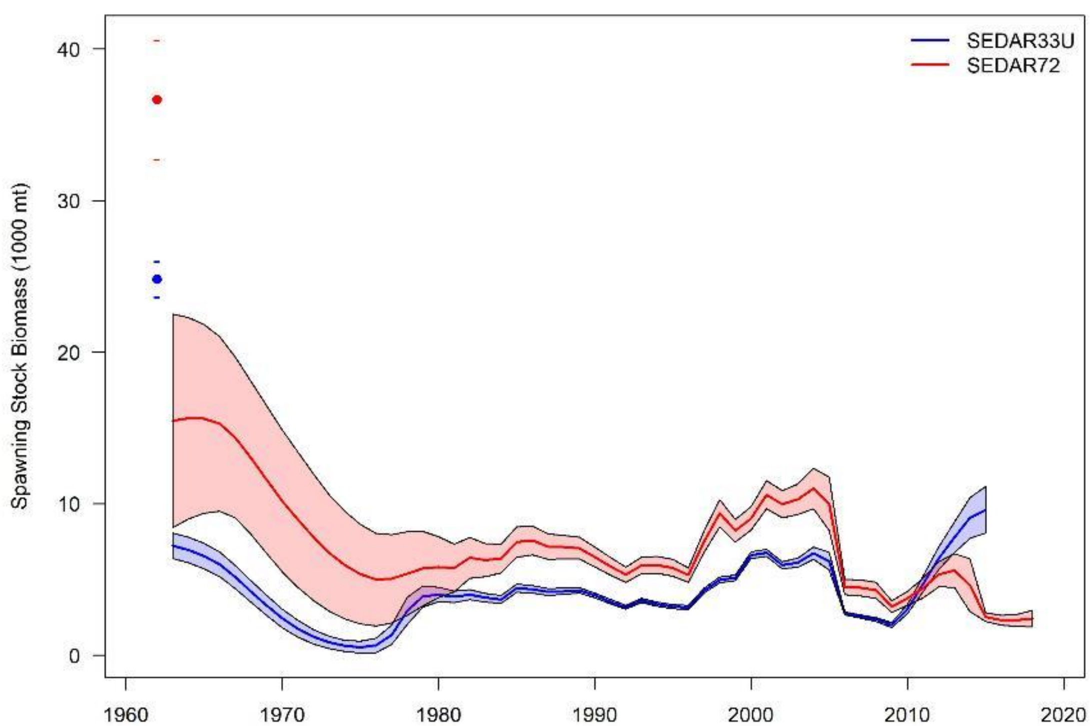


Figure 63. Estimate of spawning stock biomass (in 1000s of metric tons) and associated 95% conifdence intervals for Gulf of Mexico Gag Grouper.

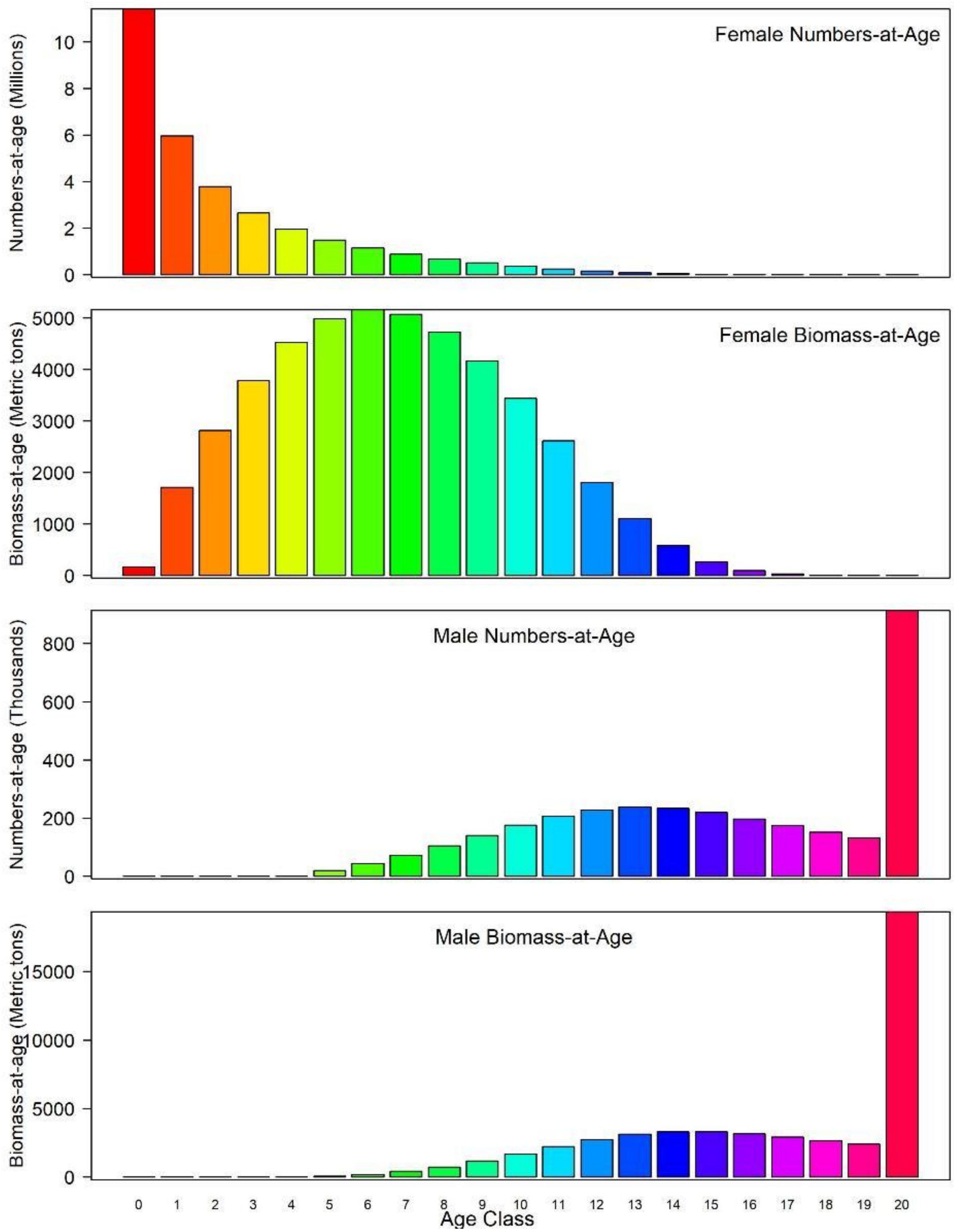
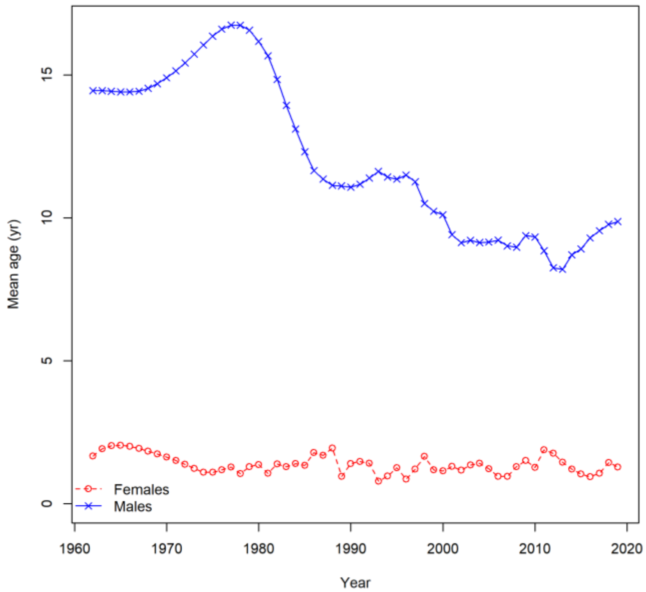


Figure 64. Expected numbers-at-age and biomass-at-age for female and male Gag Grouper in the Gulf of Mexico at virgin stock conditions.

SEDAR72



SEDAR33 Update

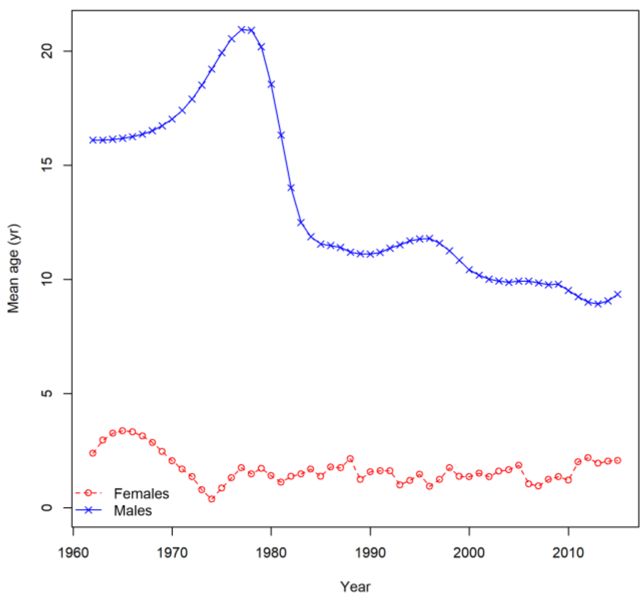


Figure 65. Predicted beginning of year mean age in the population by sex for Gulf of Mexico Gag Grouper.

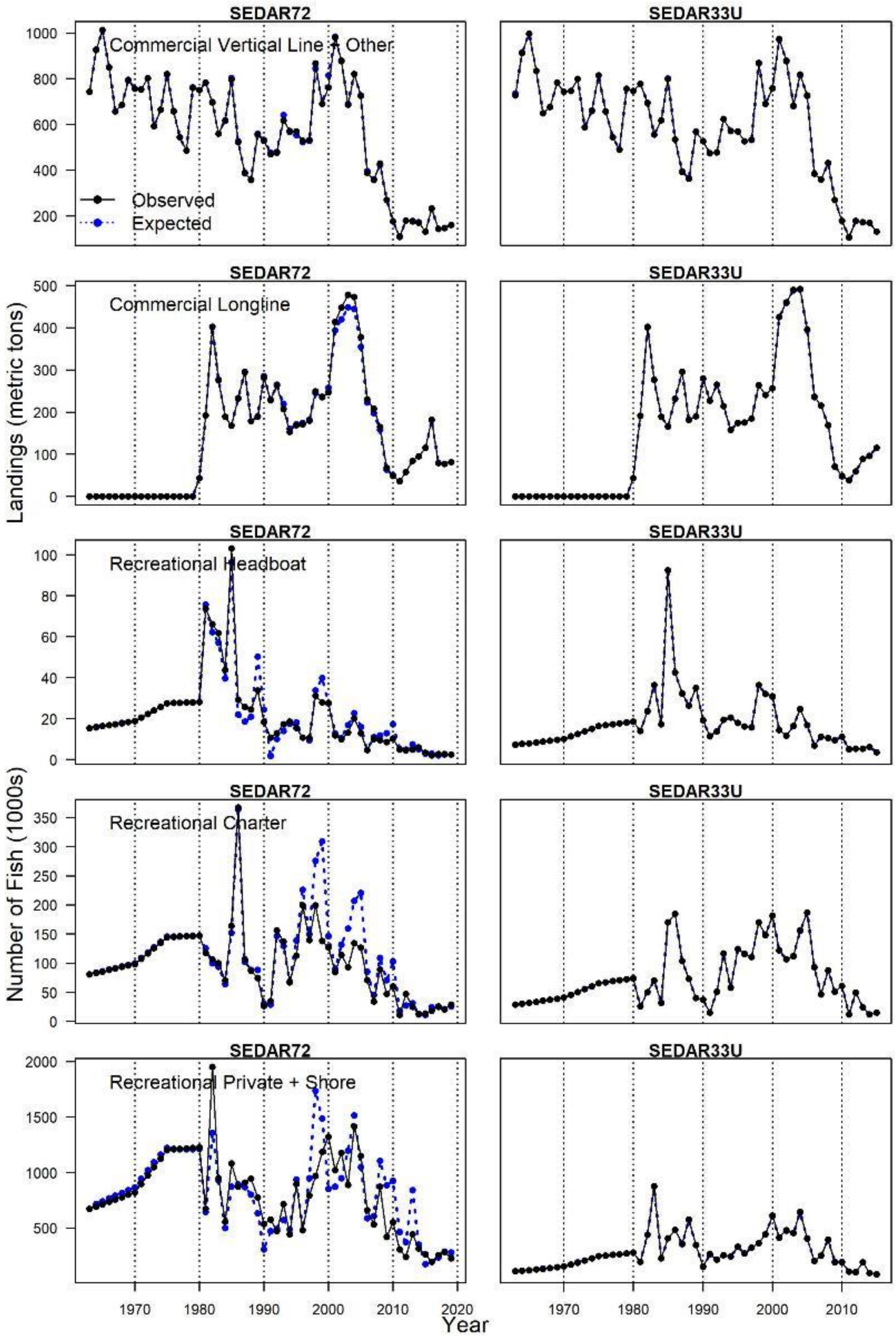


Figure 66. Gulf of Mexico Gag Grouper observed and expected landings by fishery for SEDAR72 (left panels) and SEDAR33 Update (right panels). Commercial and recreational landings are in metric tons and numbers of fish, respectively. Dashed vertical lines identify ten year intervals.

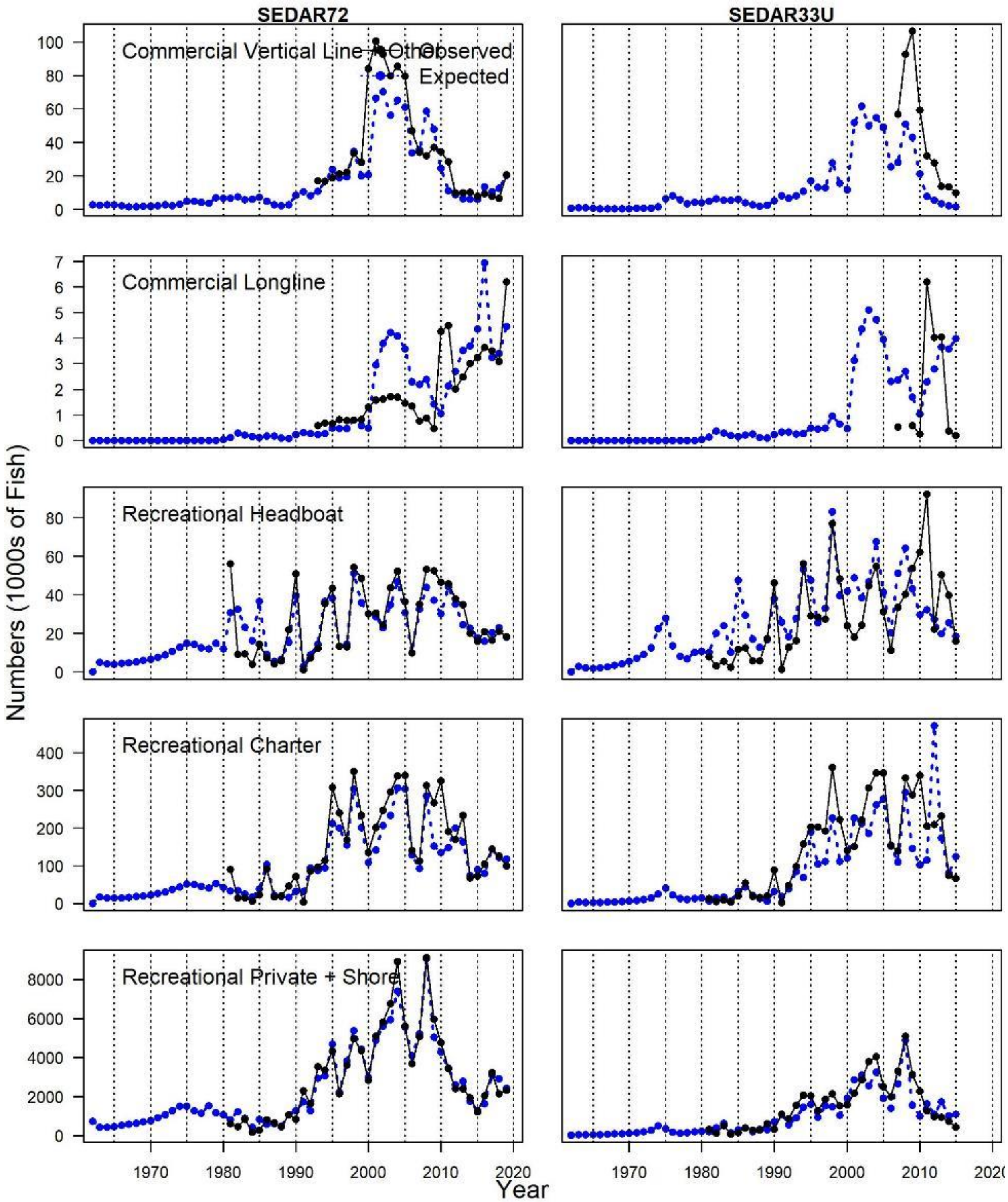


Figure 67. Gulf of Mexico Gag Grouper observed and expected discards by fishery for SEDAR72 (left panels) and SEDAR33 Update (right panels). Commercial and recreational discards are in numbers of fish, respectively. Dashed vertical lines identify five year intervals.

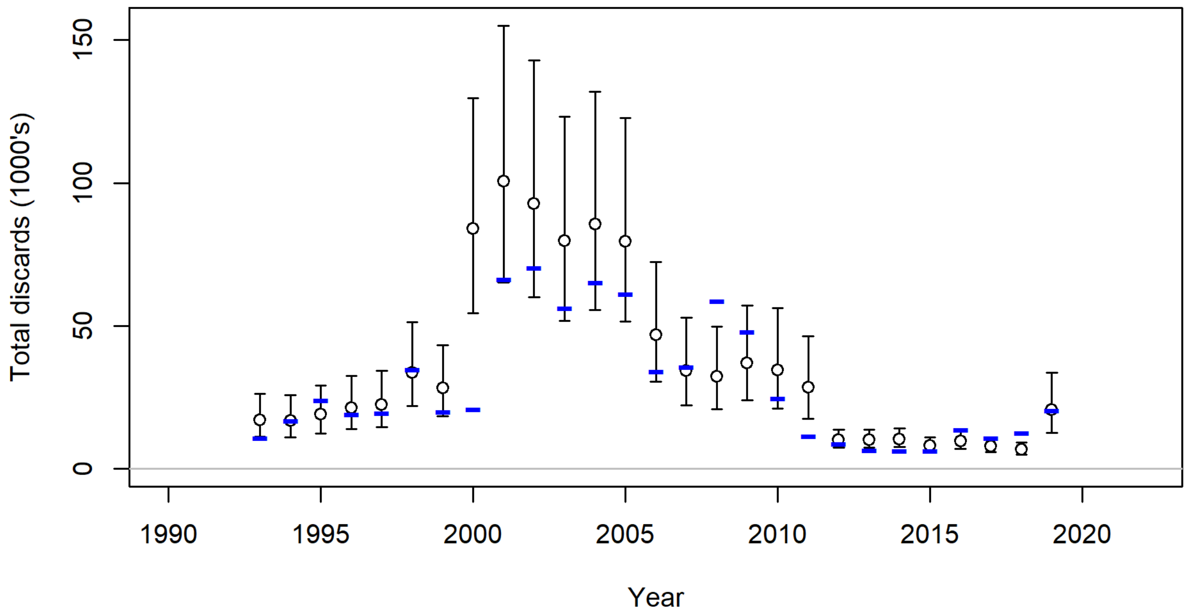


Figure 68. Input (dots with 95% confidence intervals) and expected (blue lines) discards by the Commercial Vertical Line + Other for Gulf of Mexico Gag Grouper. Discards are in numbers of fish (1,000s) and reflect released fish (i.e., before discard mortality has been applied).

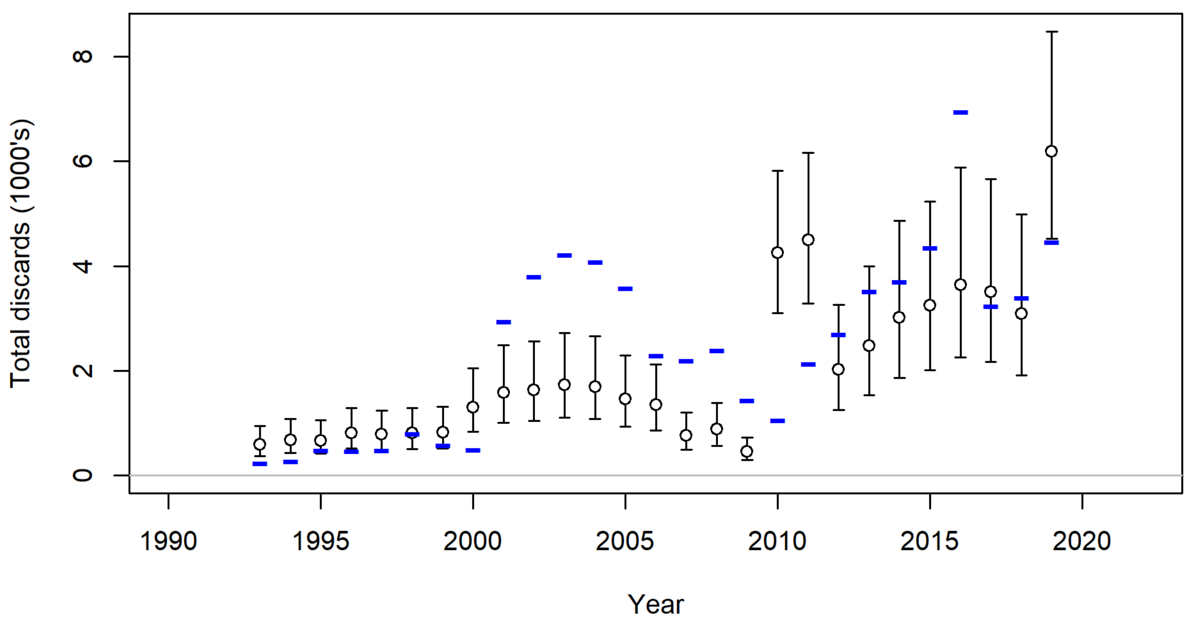


Figure 69. Input (dots with 95% confidence intervals) and expected (blue lines) discards by the Commercial Longline for Gulf of Mexico Gag Grouper. Discards are in numbers of fish (1,000s) and reflect released fish (i.e., before discard mortality has been applied).

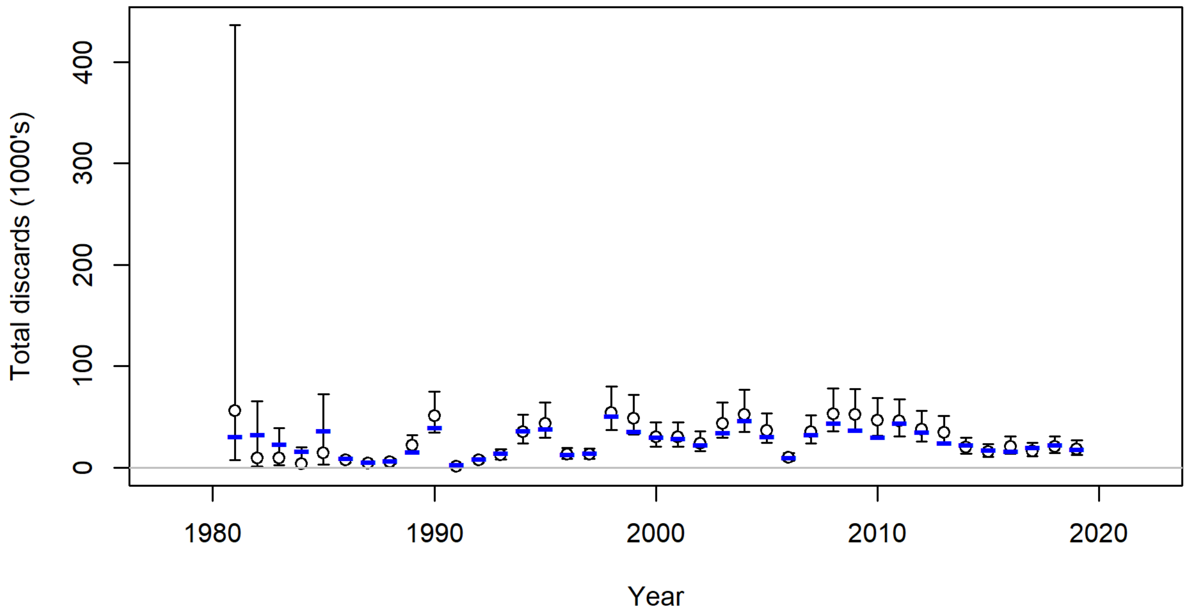


Figure 70. Input (dots with 95% confidence intervals) and expected (blue lines) discards by the Recreational Headboat for Gulf of Mexico Gag Grouper. Discards are in numbers of fish (1,000s) and reflect released fish (i.e., before discard mortality has been applied).

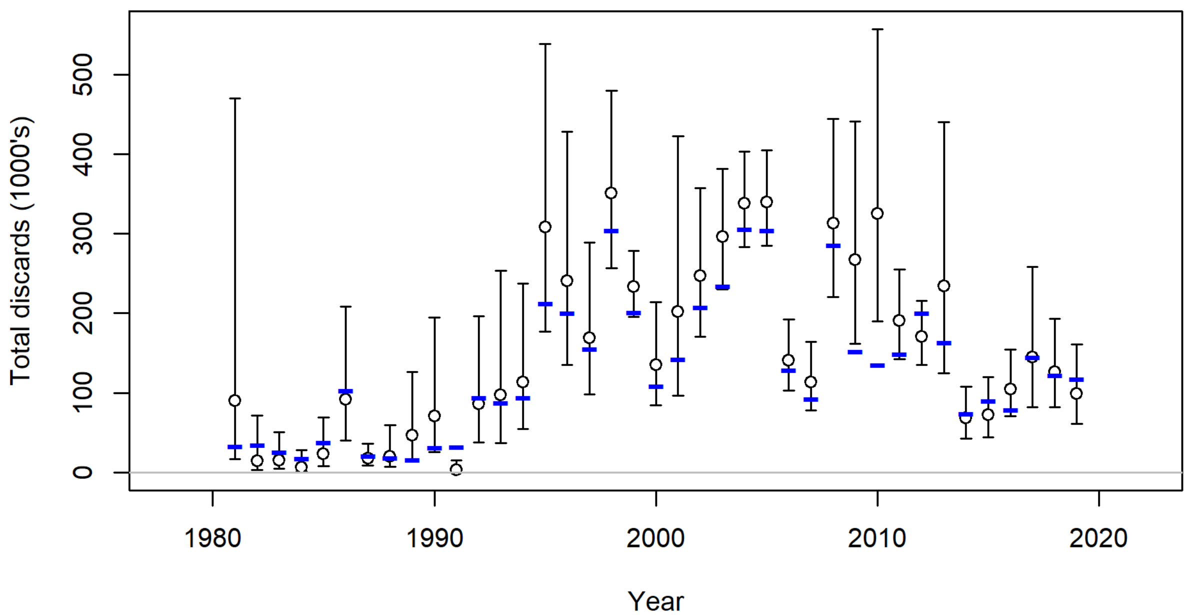


Figure 71. Input (dots with 95% confidence intervals) and expected (blue lines) discards by the Recreational Charter for Gulf of Mexico Gag Grouper. Discards are in numbers of fish (1,000s) and reflect released fish (i.e., before discard mortality has been applied).

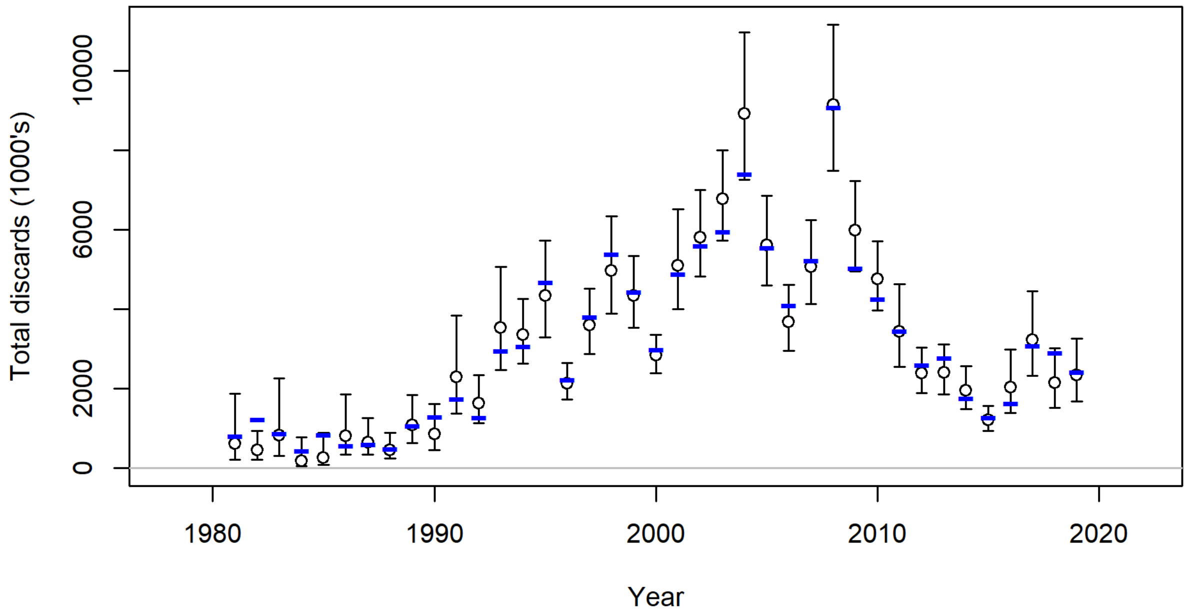


Figure 72. Input (dots with 95% confidence intervals) and expected (blue lines) discards by the Recreational Private + Shore for Gulf of Mexico Gag Grouper. Discards are in numbers of fish (1,000s) and reflect released fish (i.e., before discard mortality has been applied).

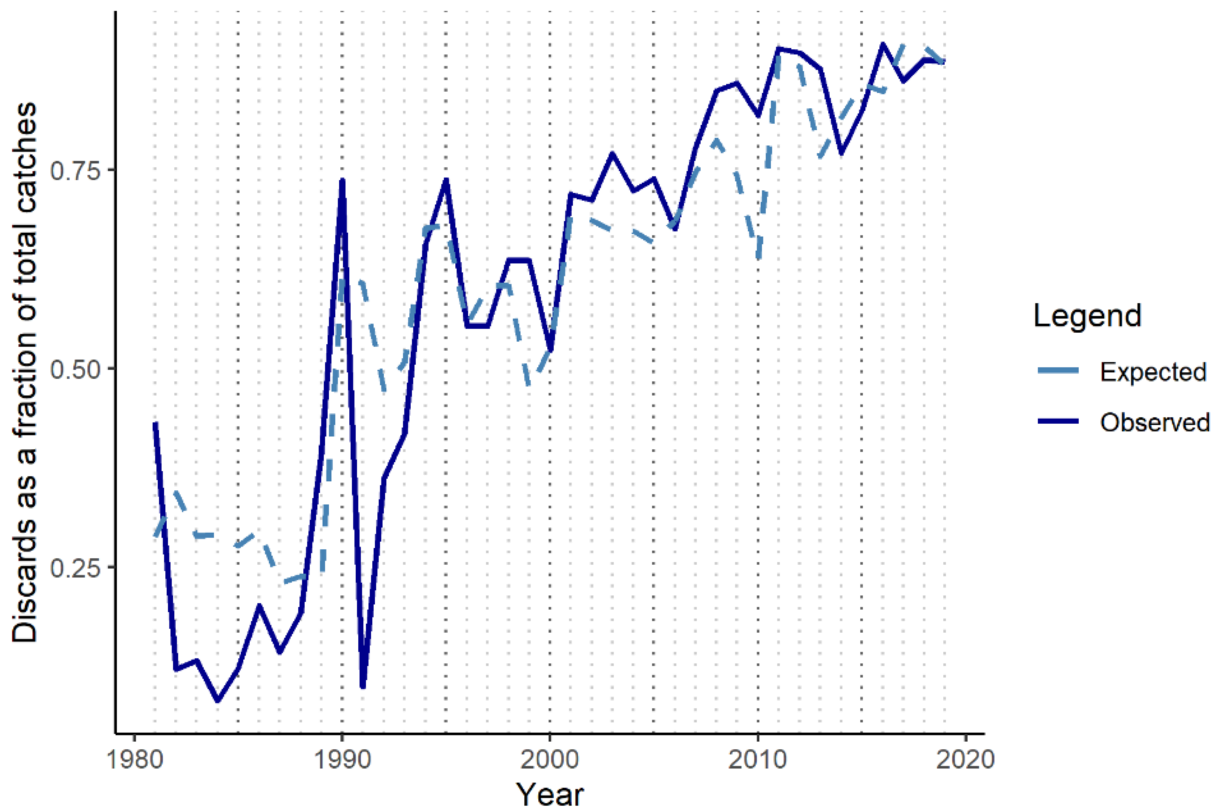


Figure 73. Observed and expected discard rates by the Recreational Headboat for Gulf of Mexico Gag Grouper.

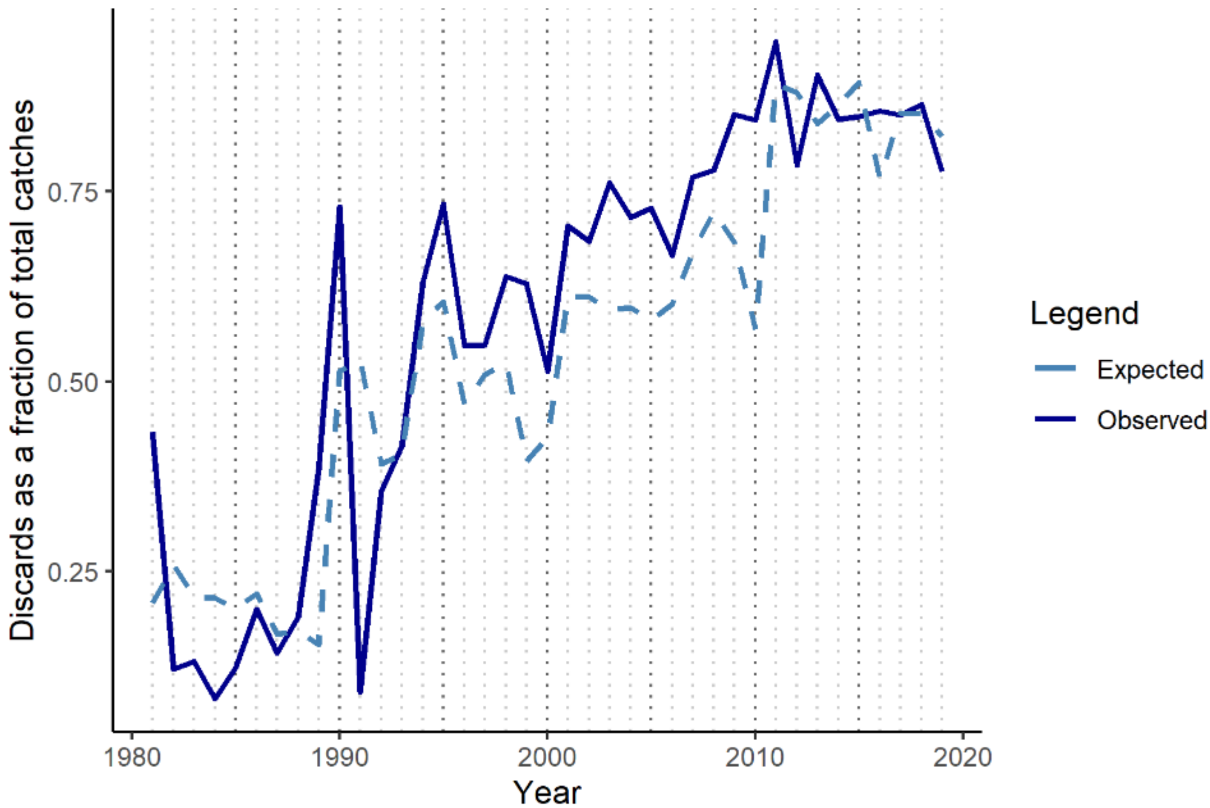


Figure 74. Observed and expected discard rates by the Recreational Charter for Gulf of Mexico Gag Grouper.

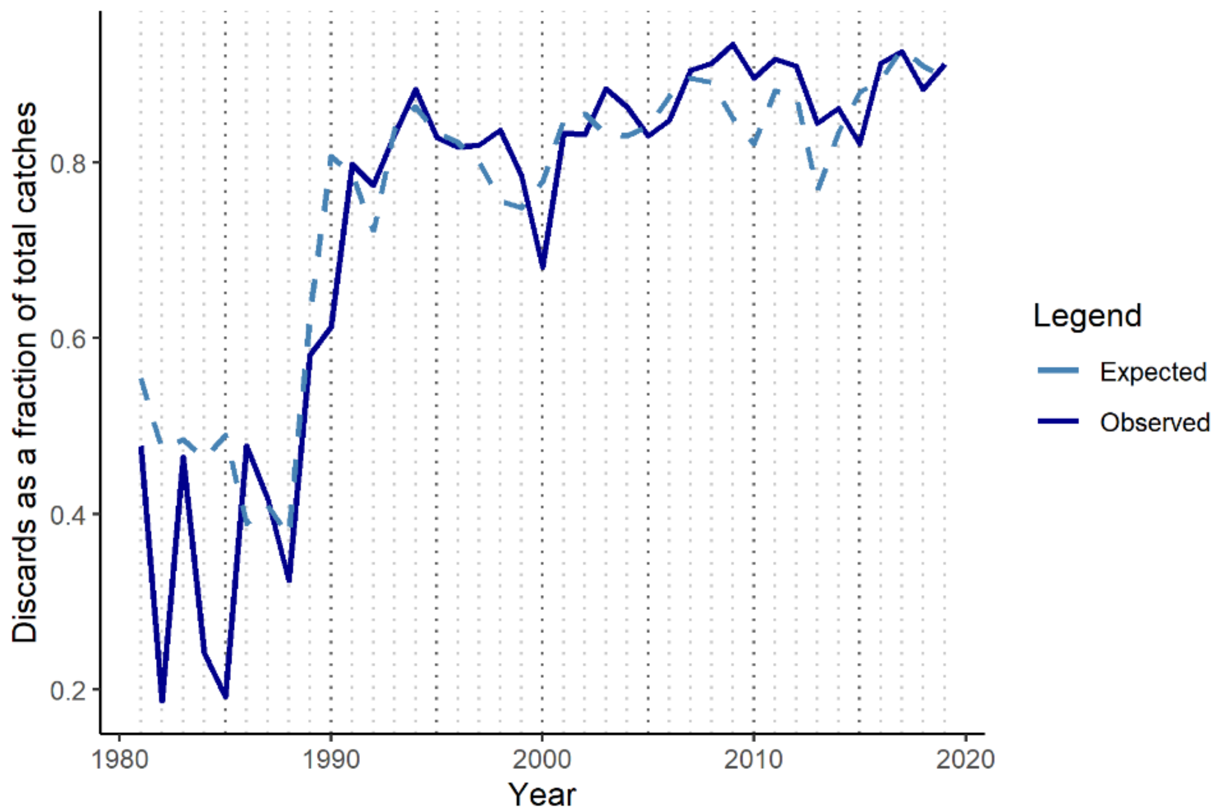


Figure 75. Observed and expected discard rates by the Recreational Private + Shore for Gulf of Mexico Gag Grouper.

SEDAR72

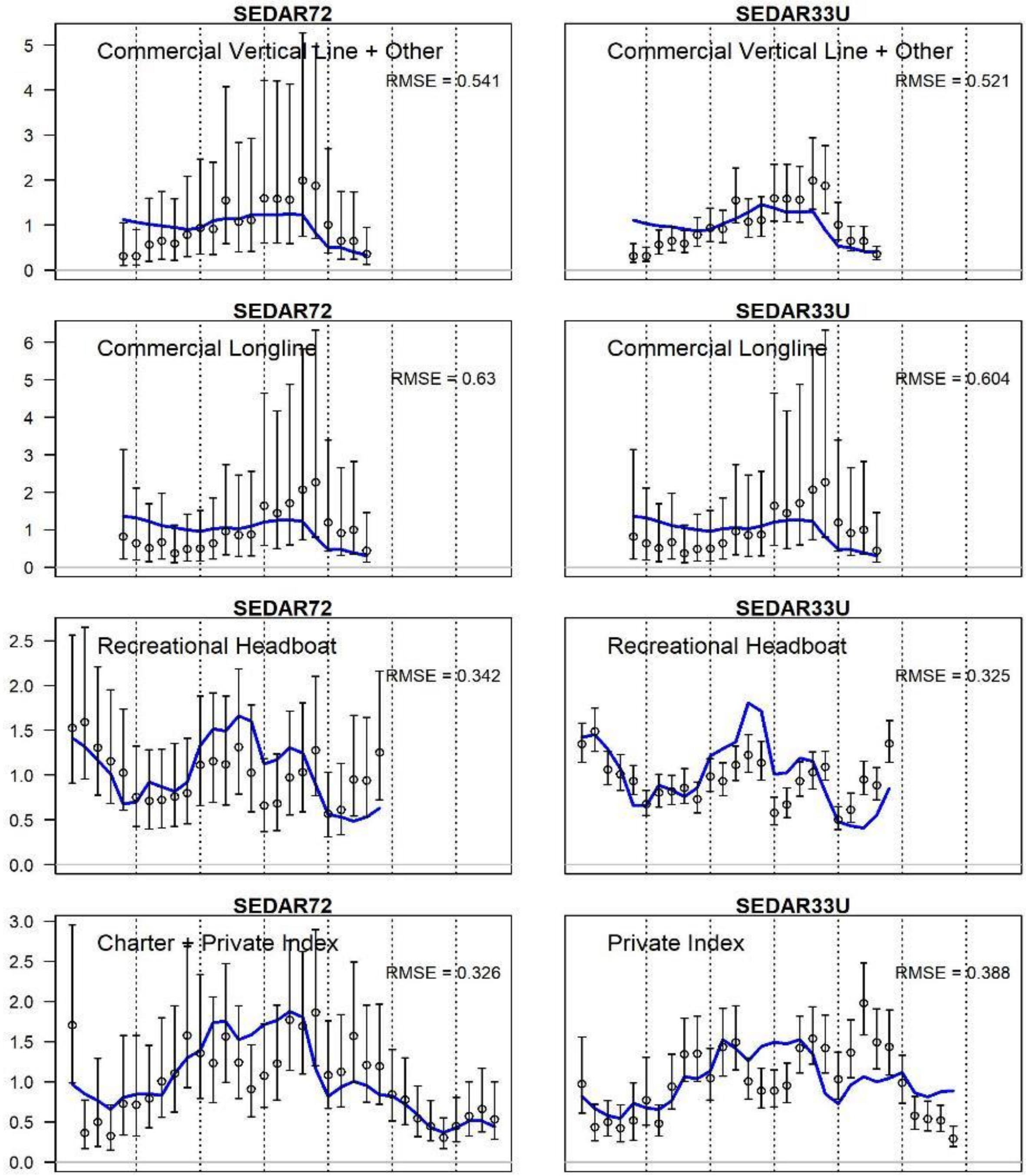


Figure 76. Gulf of Mexico Gag Grouper observed and expected indices for SEDAR72 (left panels) and SEDAR33 Update (right panels). Dashed vertical lines identify five year intervals. The root mean squared error (RMSE) is also provided.

SEDAR33 Update

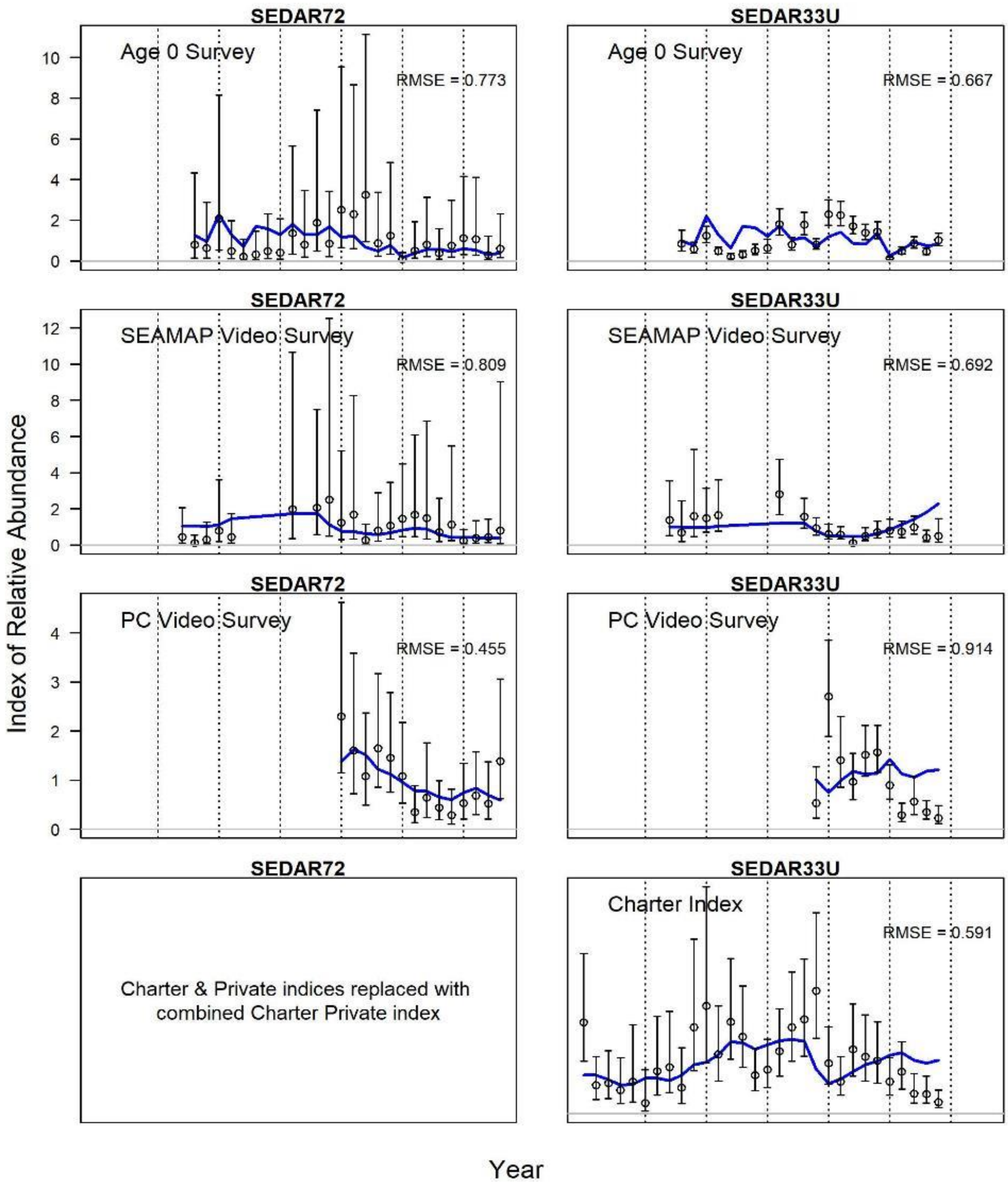


Figure 76 Continued. Gulf of Mexico Gag Grouper observed and expected indices for SEDAR72 (left panels) and SEDAR33 Update (right panels). Dashed vertical lines identify five year intervals. The root mean squared error (RMSE) is also provided.

SEDAR72

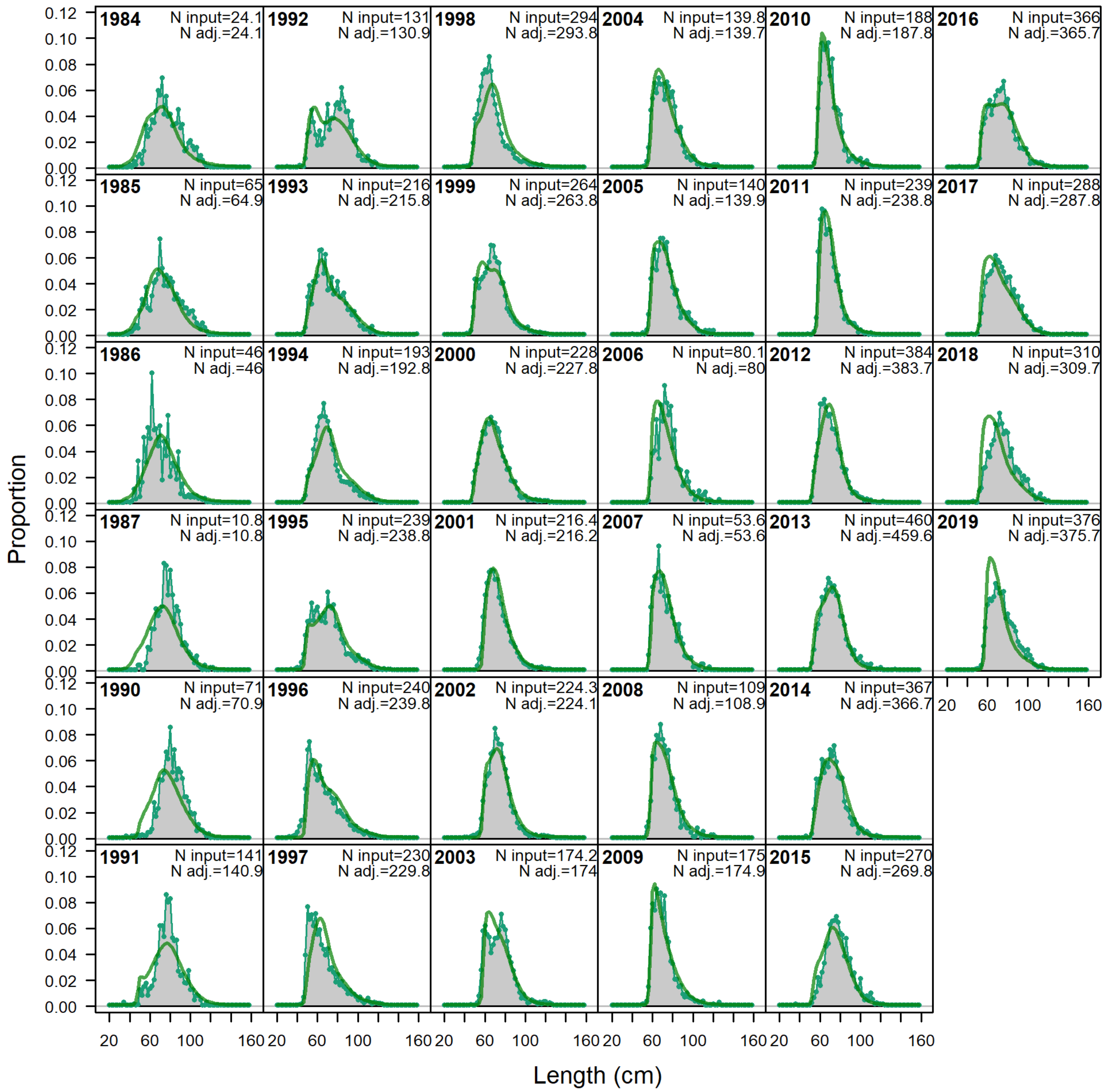


Figure 77. Observed and predicted length compositions (retained) for Gulf of Mexico Gag Grouper in the Commercial Vertical Line + Other fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR33 Update

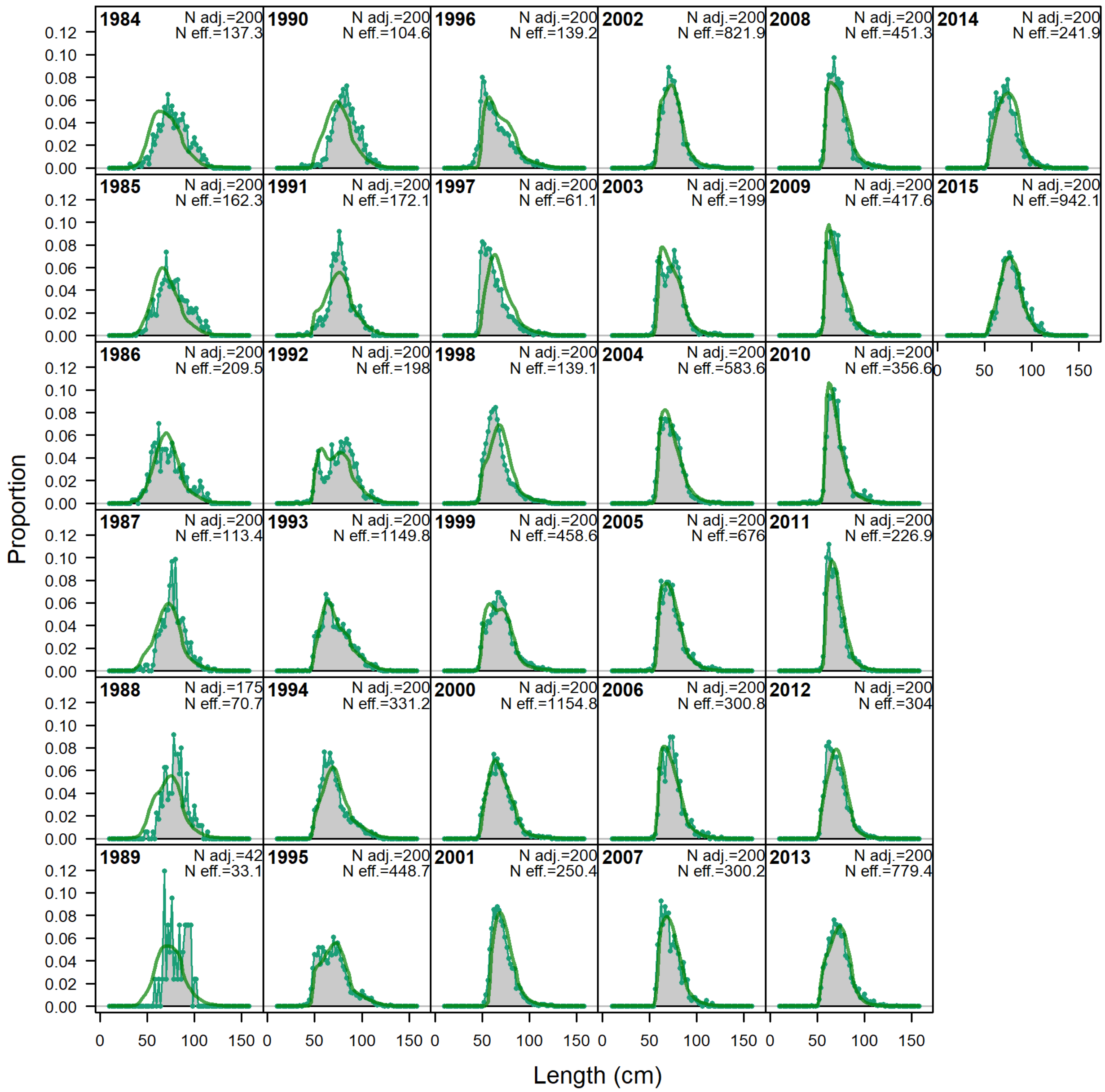


Figure 77 Continued. Observed and predicted length compositions (retained) for Gulf of Mexico Gag Grouper in the Commercial Vertical Line + Other fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

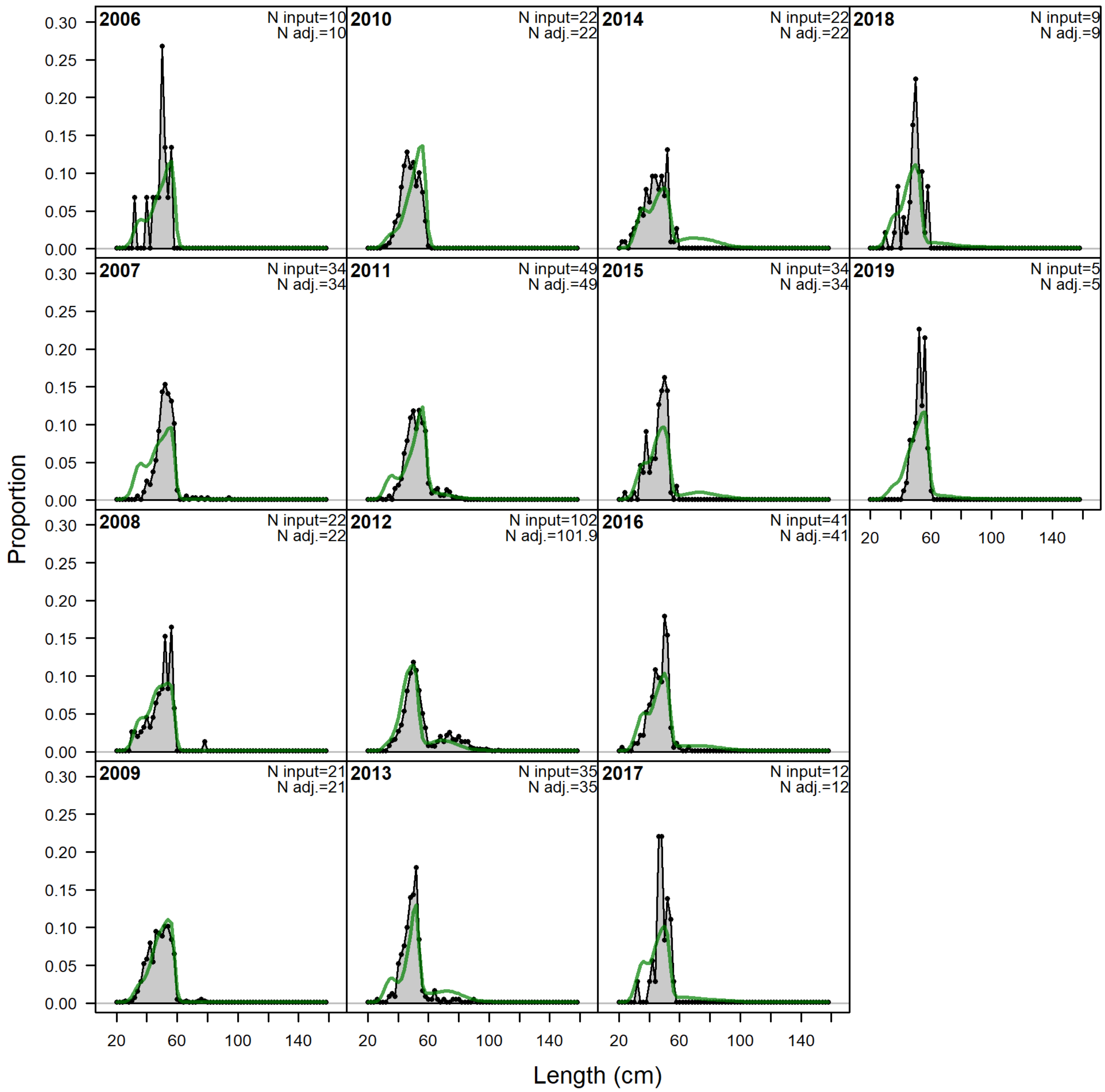


Figure 78. Observed and predicted length compositions (discarded) for Gulf of Mexico Gag Grouper in the Commercial Vertical Line + Other fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR33 Update

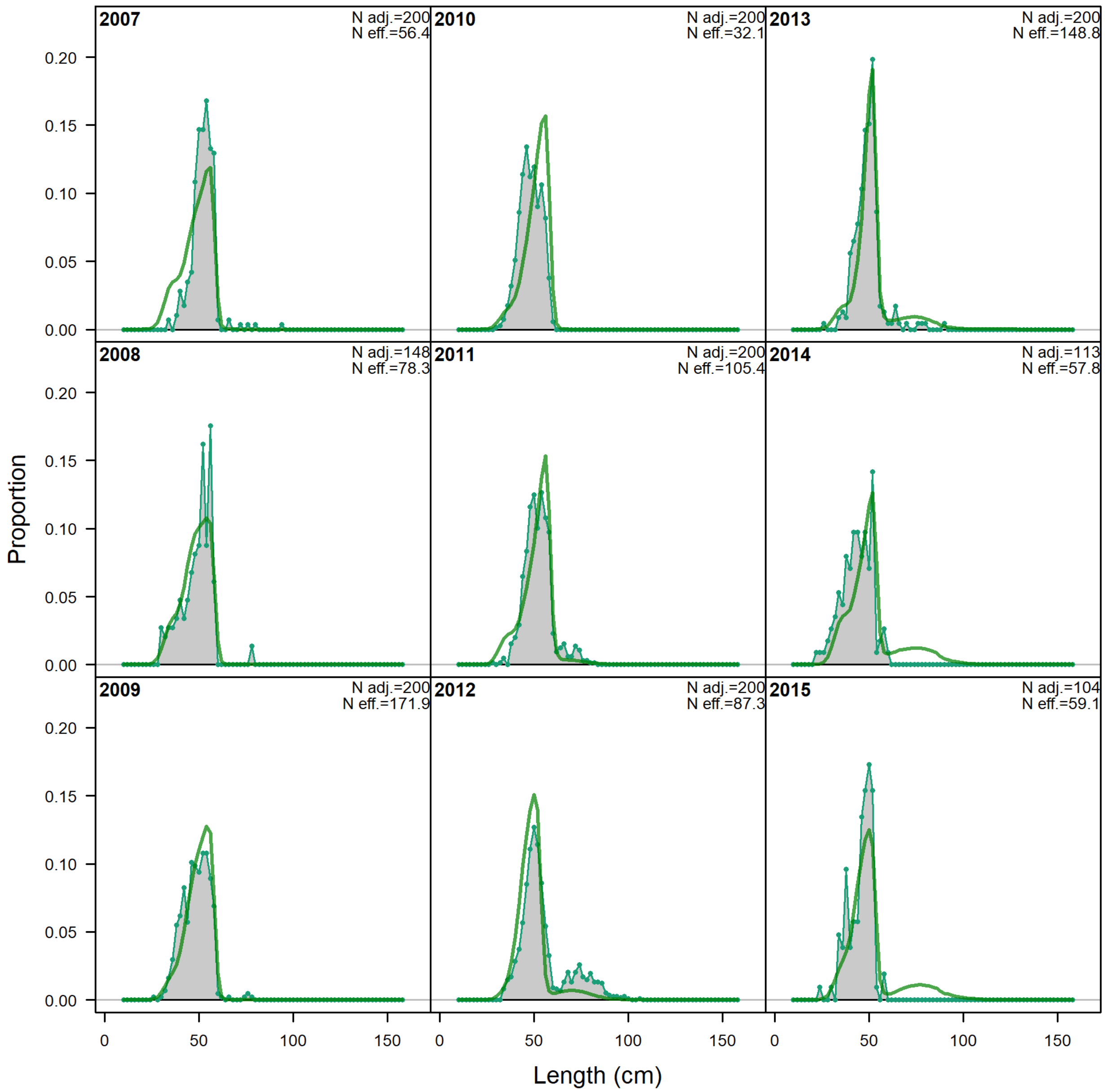


Figure 78 Continued. Observed and predicted length compositions (discarded) for Gulf of Mexico Gag Grouper in the Commercial Vertical Line + Other fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR72

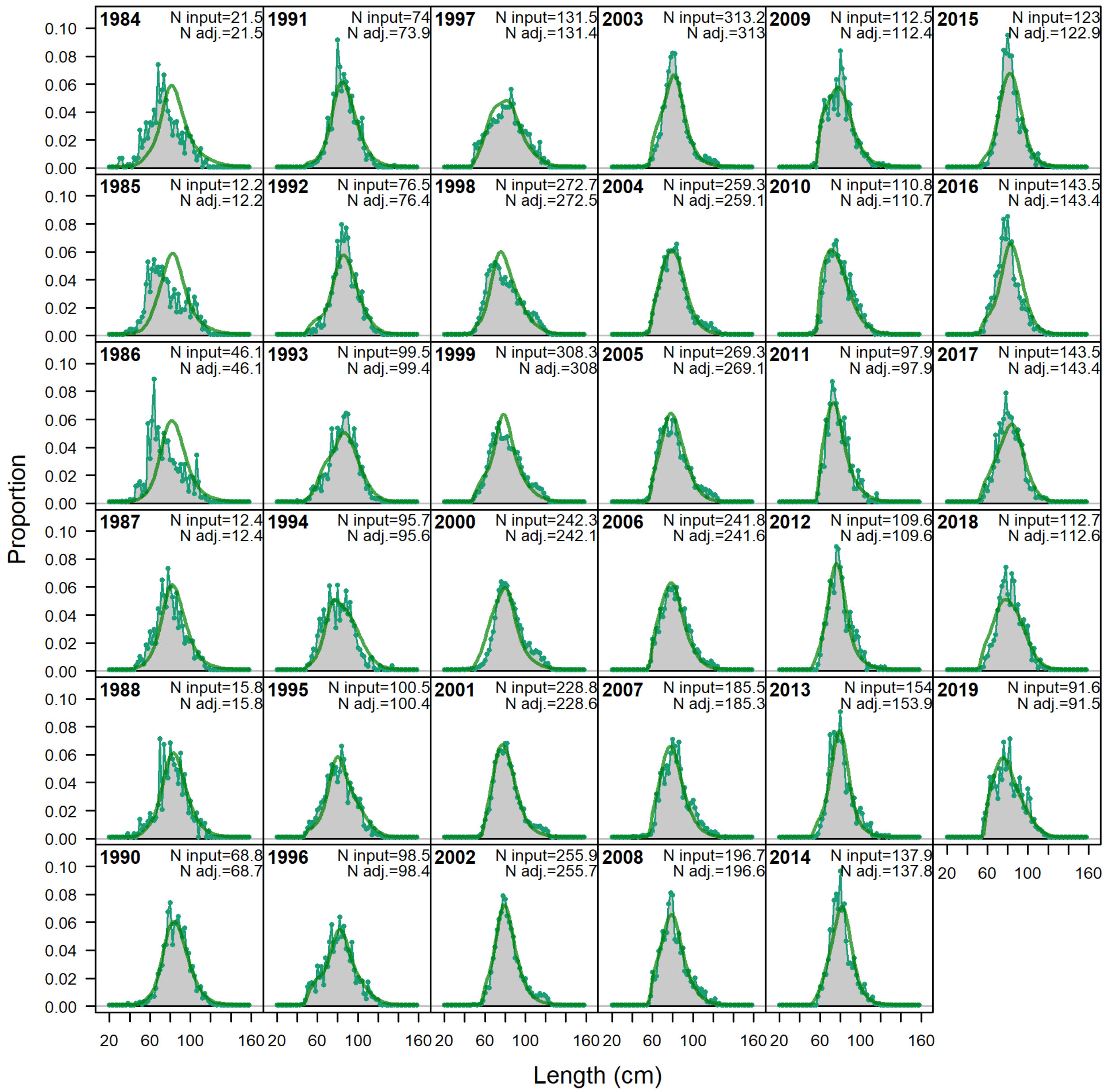


Figure 79. Observed and predicted length compositions (retained) for Gulf of Mexico Gag Grouper in the Commercial Longline fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR33 Update

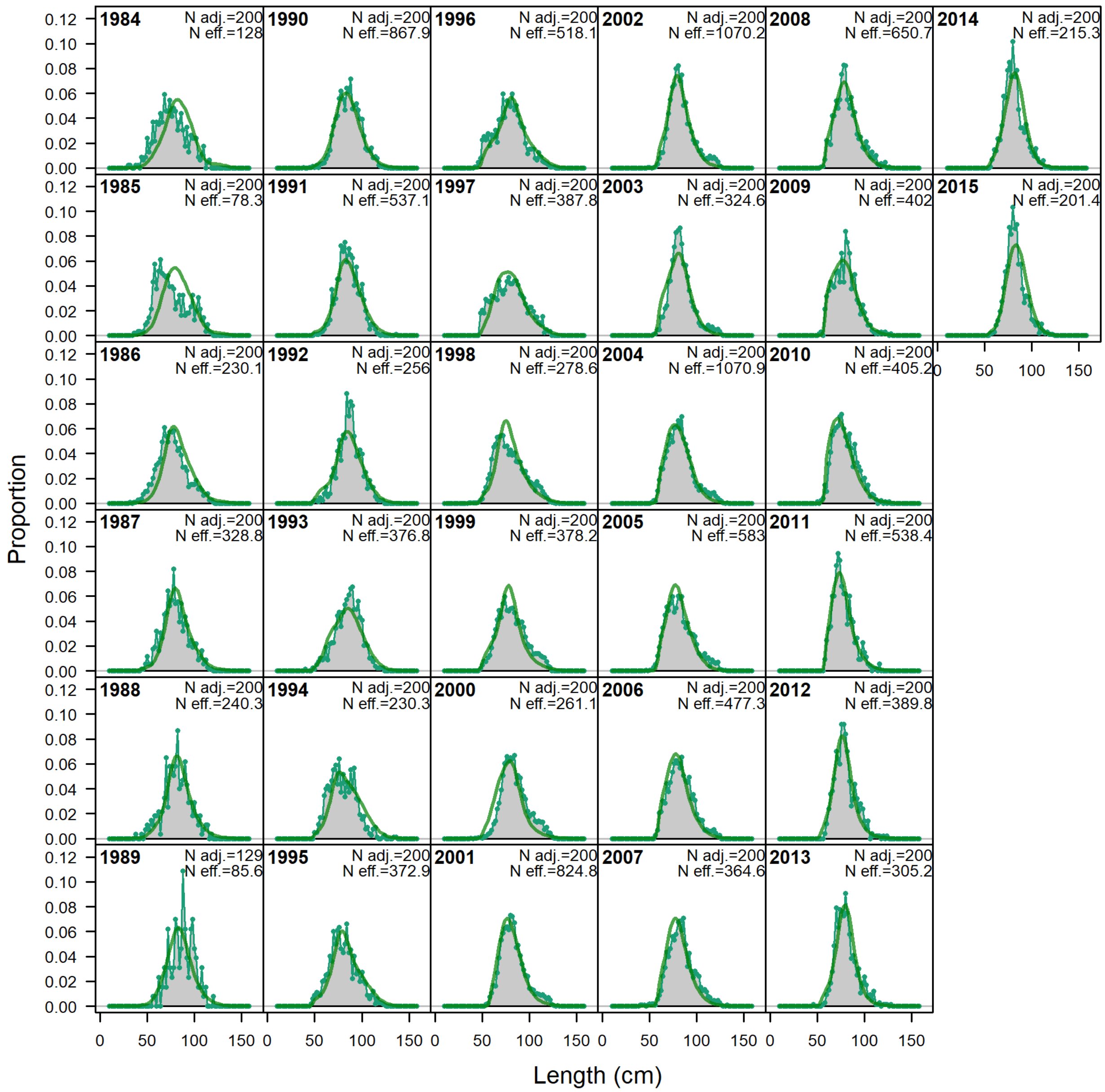


Figure 79 Continued. Observed and predicted length compositions (retained) for Gulf of Mexico Gag Grouper in the Commercial Longline fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

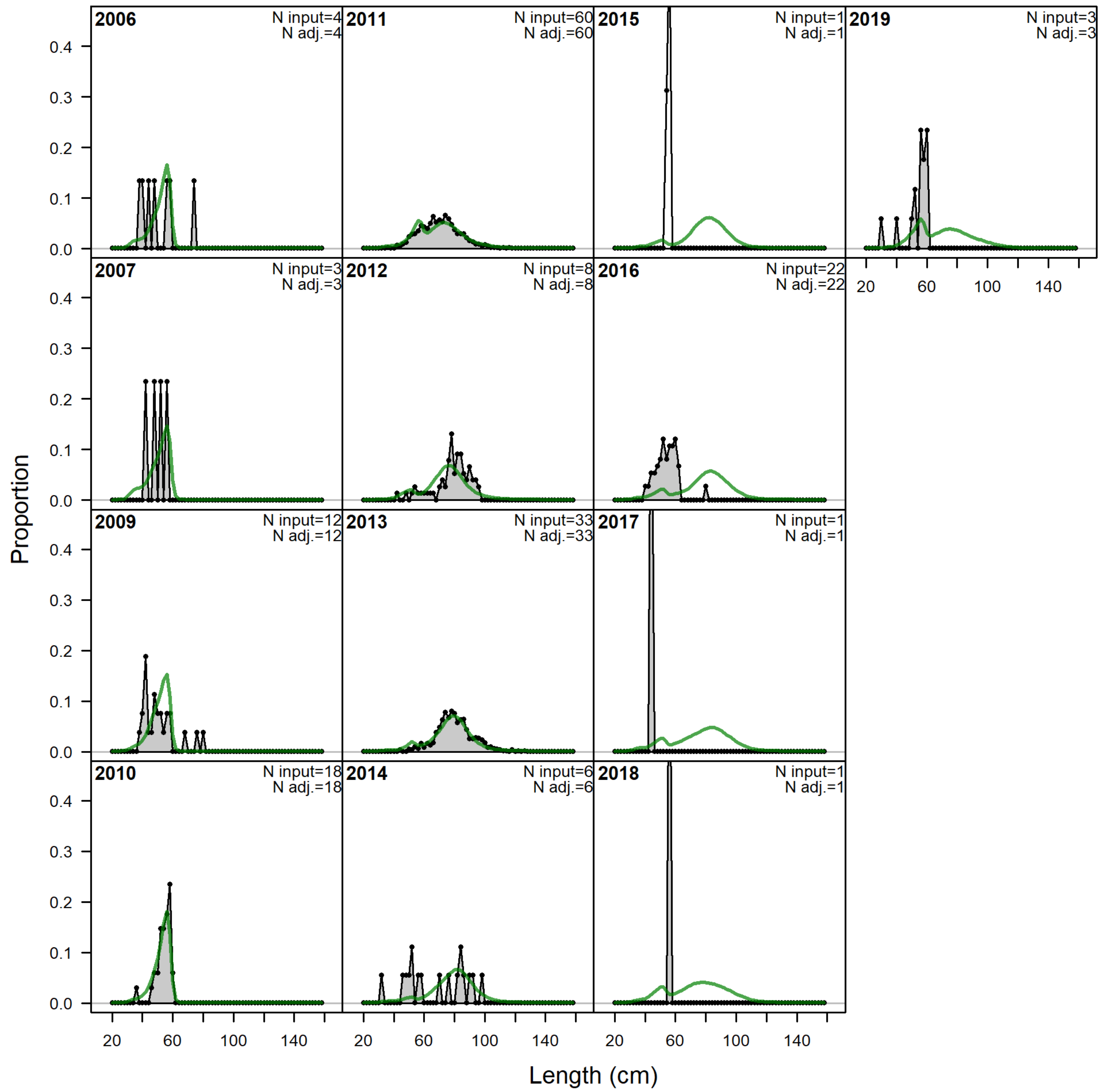


Figure 80. Observed and predicted length compositions (discarded) for Gulf of Mexico Gag Grouper in the Commercial Longline fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR33 Update

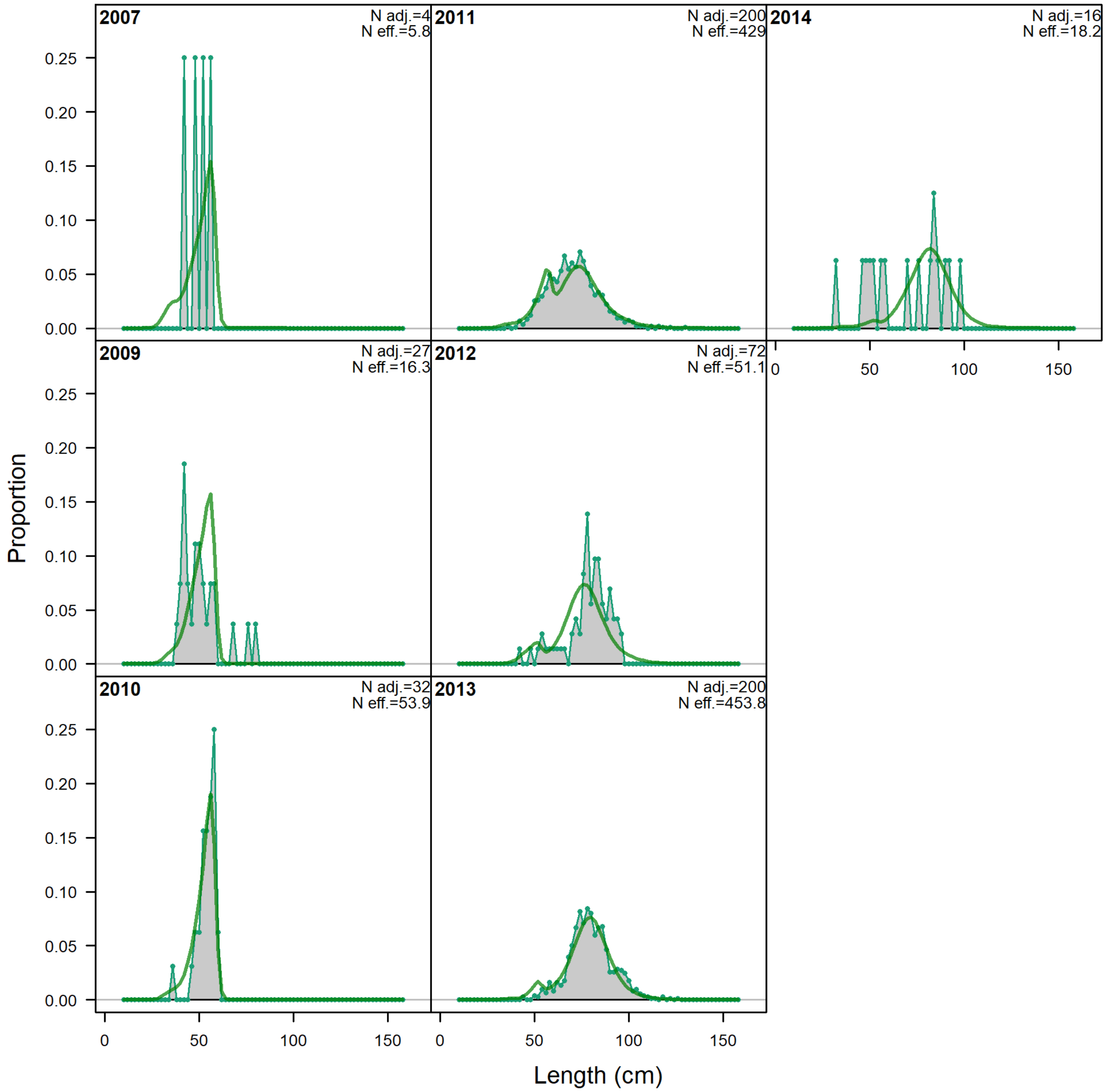


Figure 80 Continued. Observed and predicted length compositions (discarded) for Gulf of Mexico Gag Grouper in the Commercial Longline fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR72

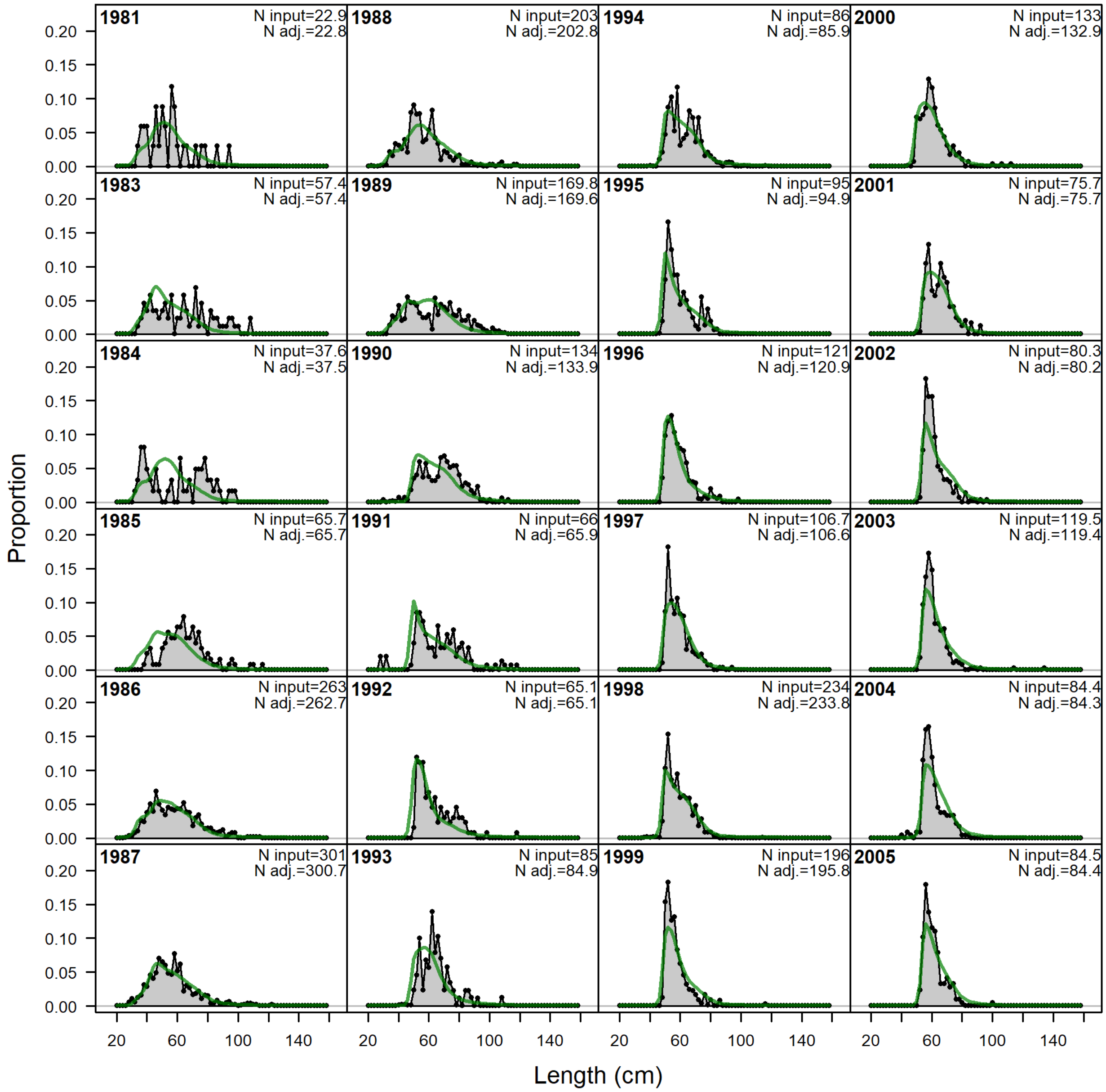


Figure 81. Observed and predicted length compositions (retained) for Gulf of Mexico Gag Grouper in the Recreational Headboat fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR33 Update

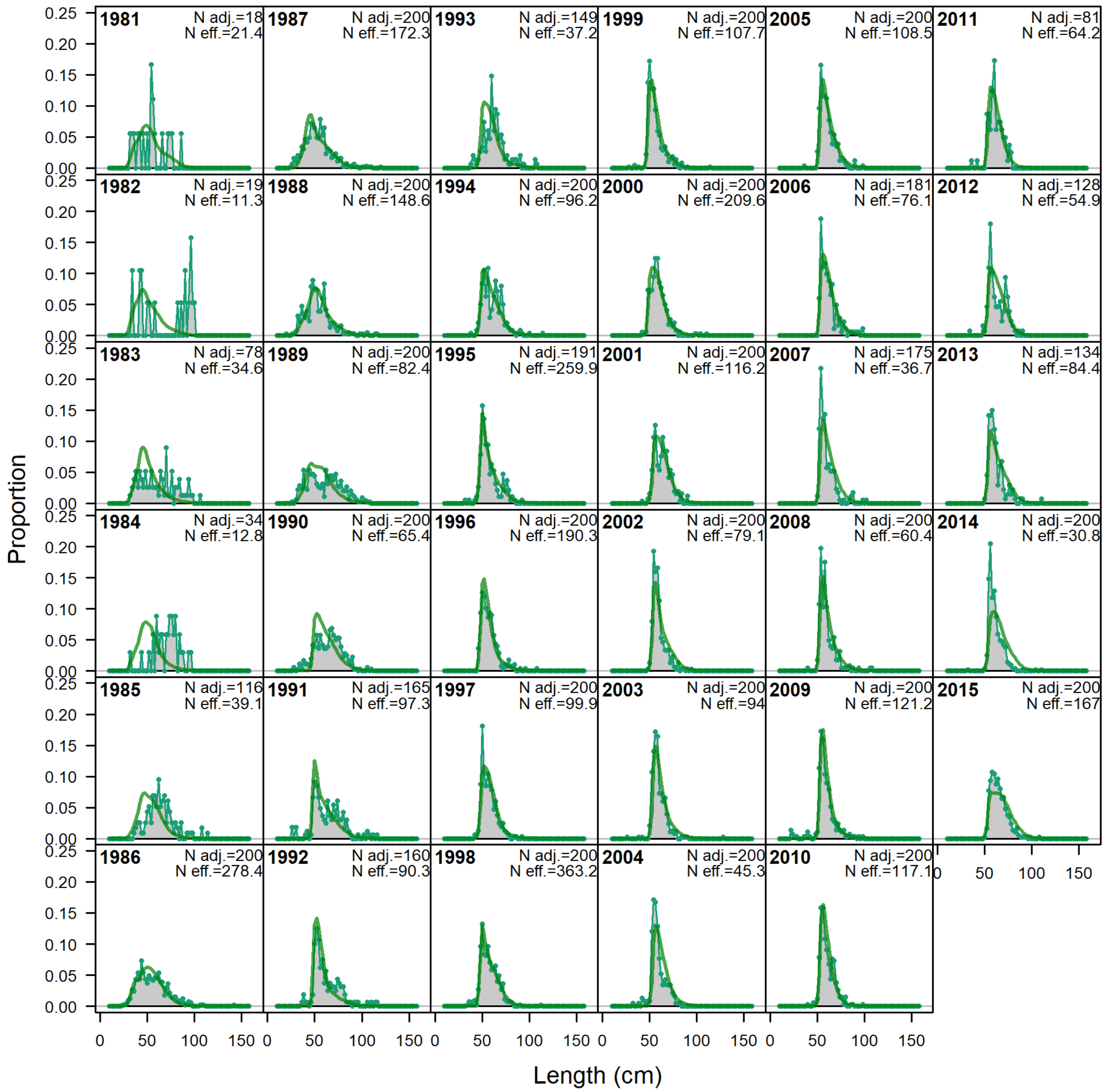


Figure 81 Continued. Observed and predicted length compositions (retained) for Gulf of Mexico Gag Grouper in the Recreational Headboat fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR72

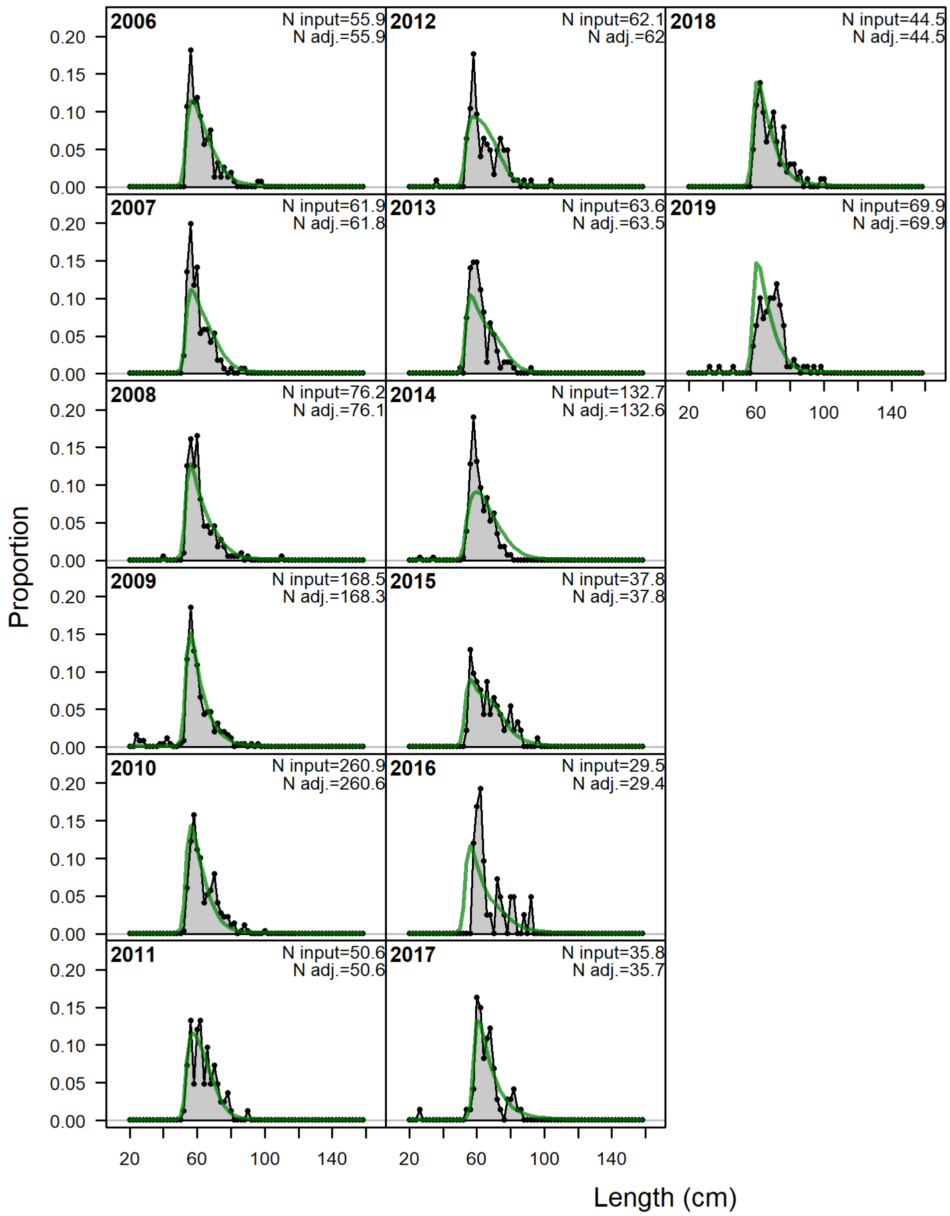


Figure 81 Continued. Observed and predicted length compositions (retained) for Gulf of Mexico Gag Grouper in the Recreational Headboat fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR72

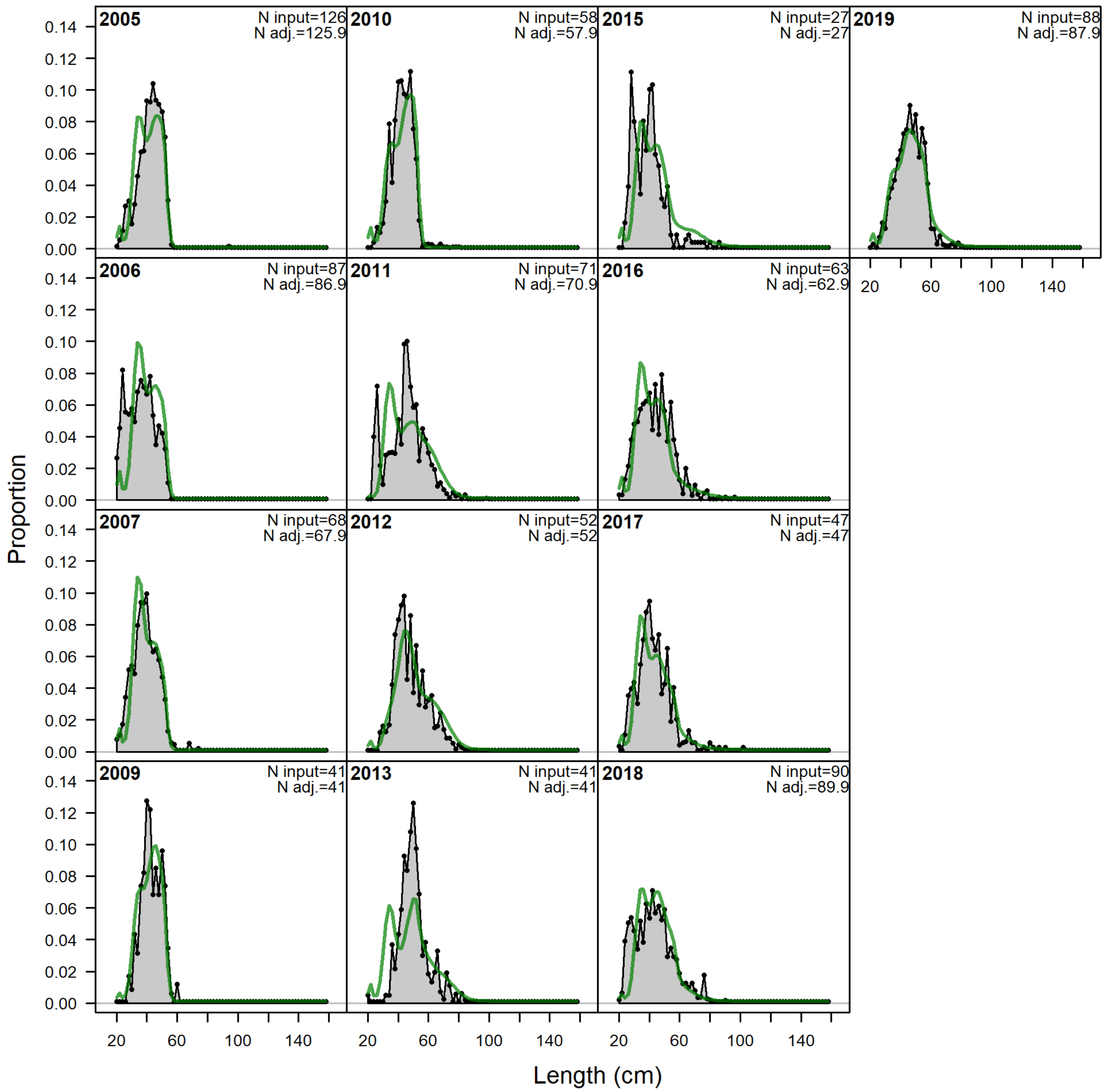


Figure 82. Observed and predicted length compositions (discarded) for Gulf of Mexico Gag Grouper in the Recreational Headboat fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR33 Update

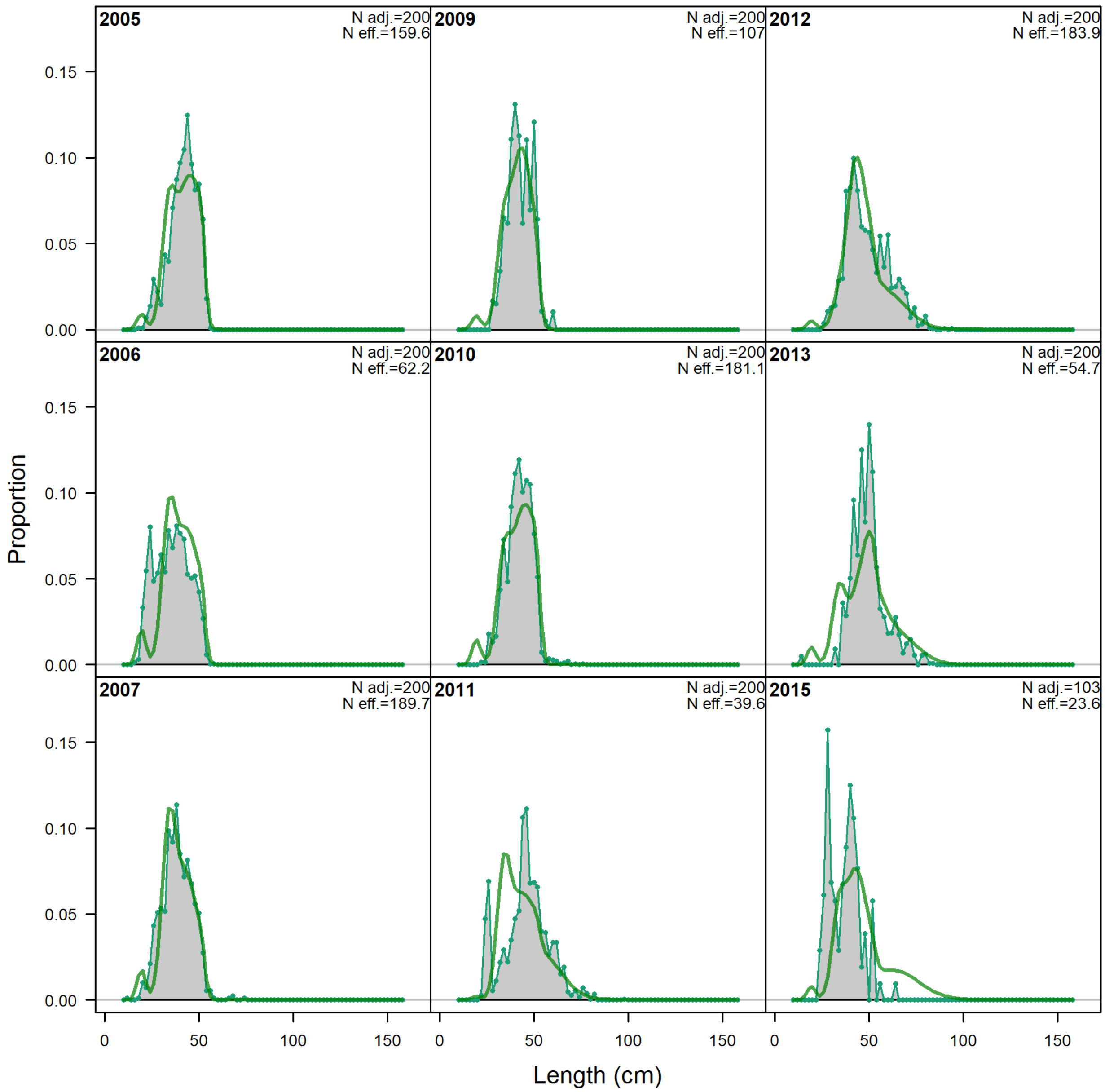


Figure 82 Continued. Observed and predicted length compositions (discarded) for Gulf of Mexico Gag Grouper in the Recreational Headboat fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR72

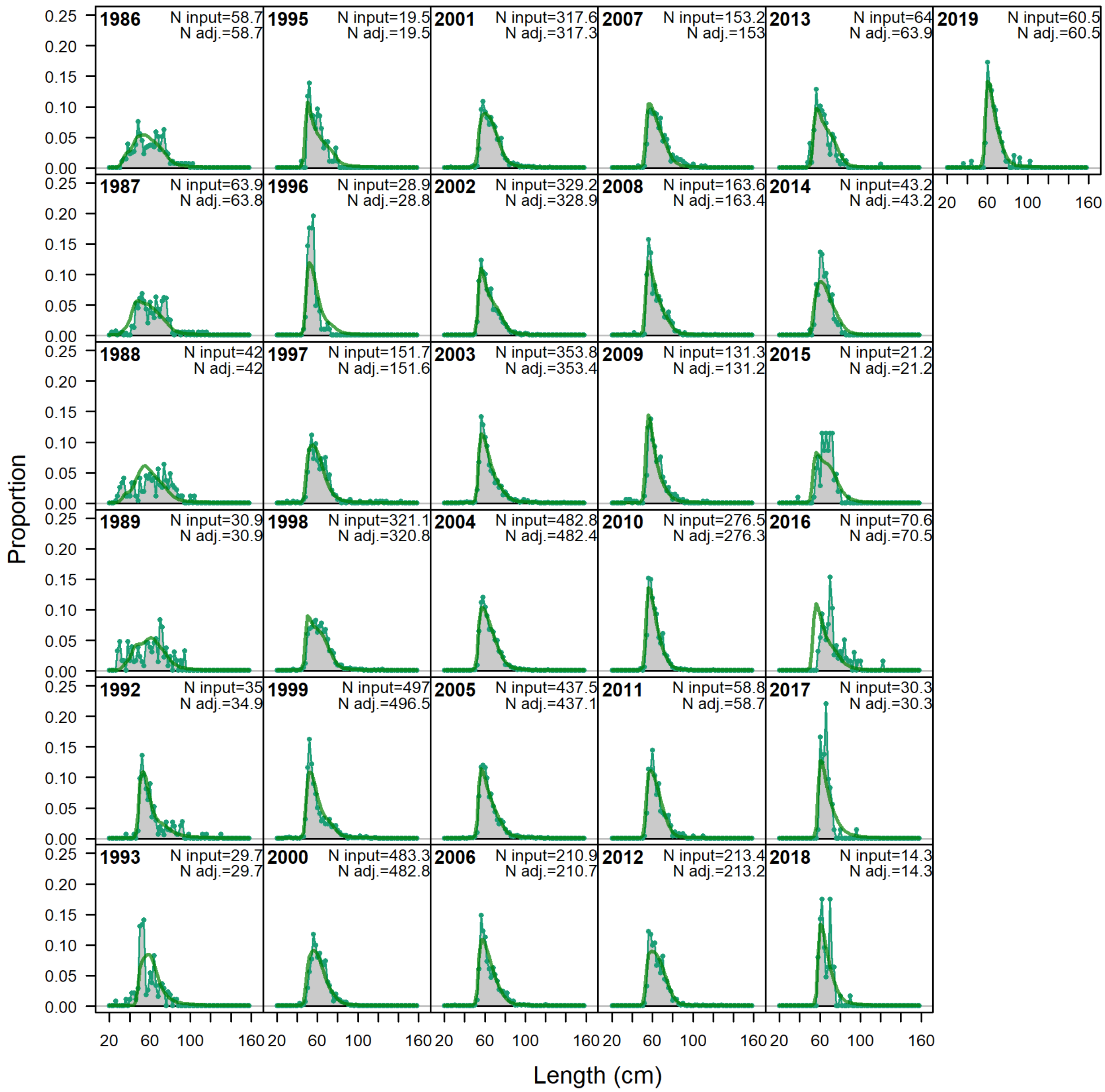


Figure 83. Observed and predicted length compositions (retained) for Gulf of Mexico Gag Grouper in the Recreational Charter fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR33 Update

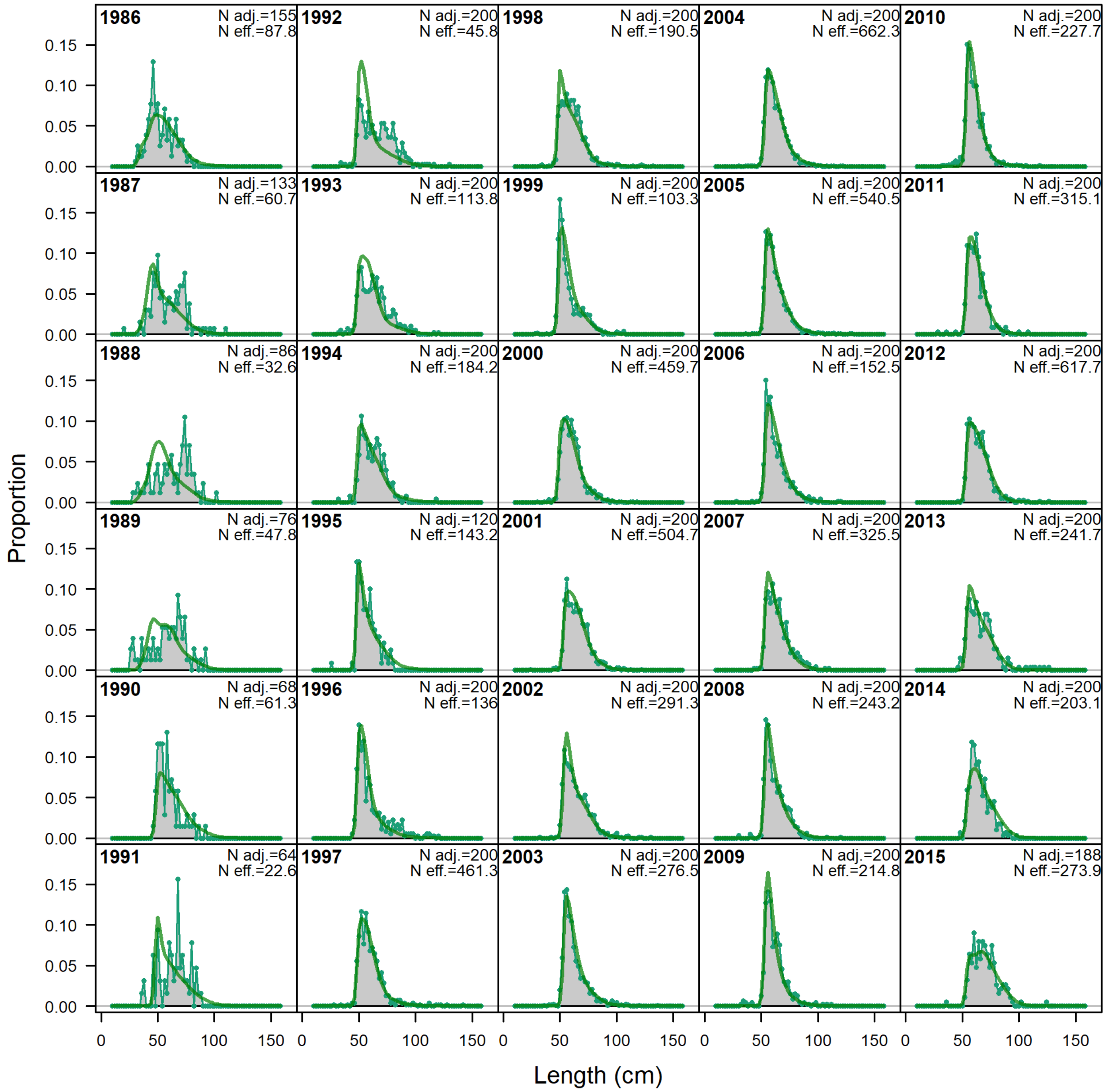


Figure 83 Continued. Observed and predicted length compositions (retained) for Gulf of Mexico Gag Grouper in the Recreational Charter fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR72

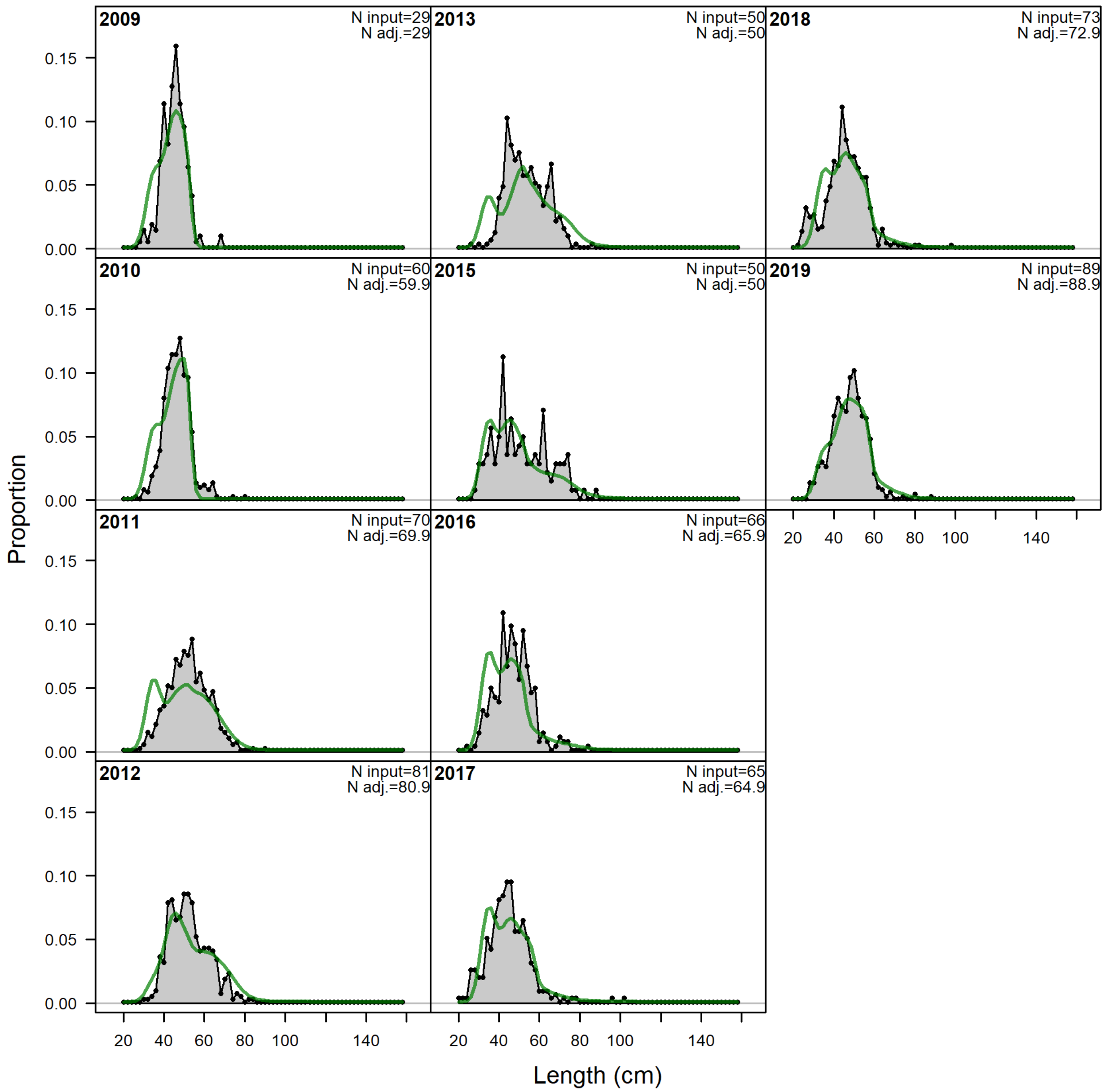


Figure 84. Observed and predicted length compositions (discarded) for Gulf of Mexico Gag Grouper in the Recreational Charter fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR33 Update

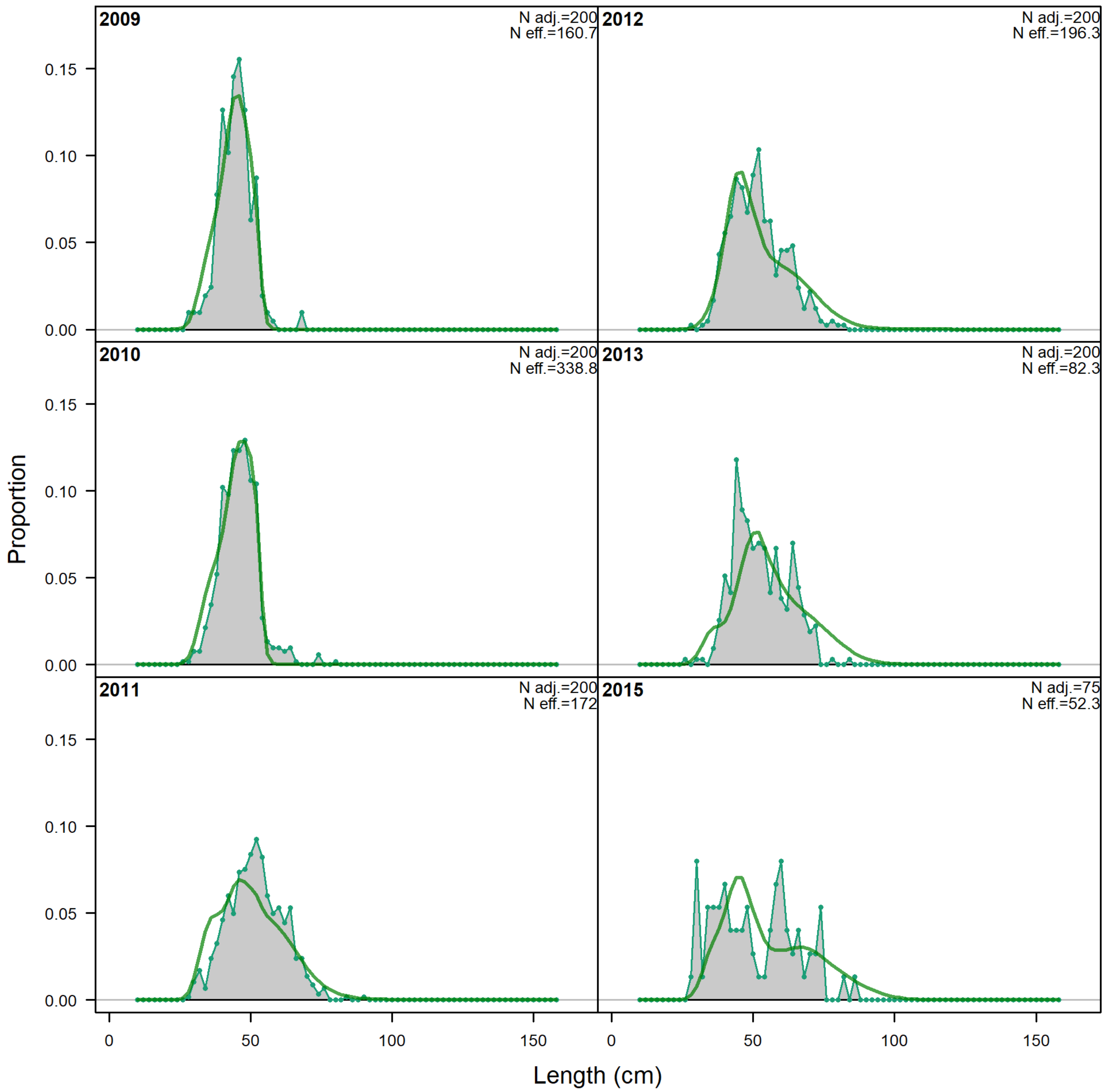


Figure 84 Continued. Observed and predicted length compositions (discarded) for Gulf of Mexico Gag Grouper in the Recreational Charter fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR72

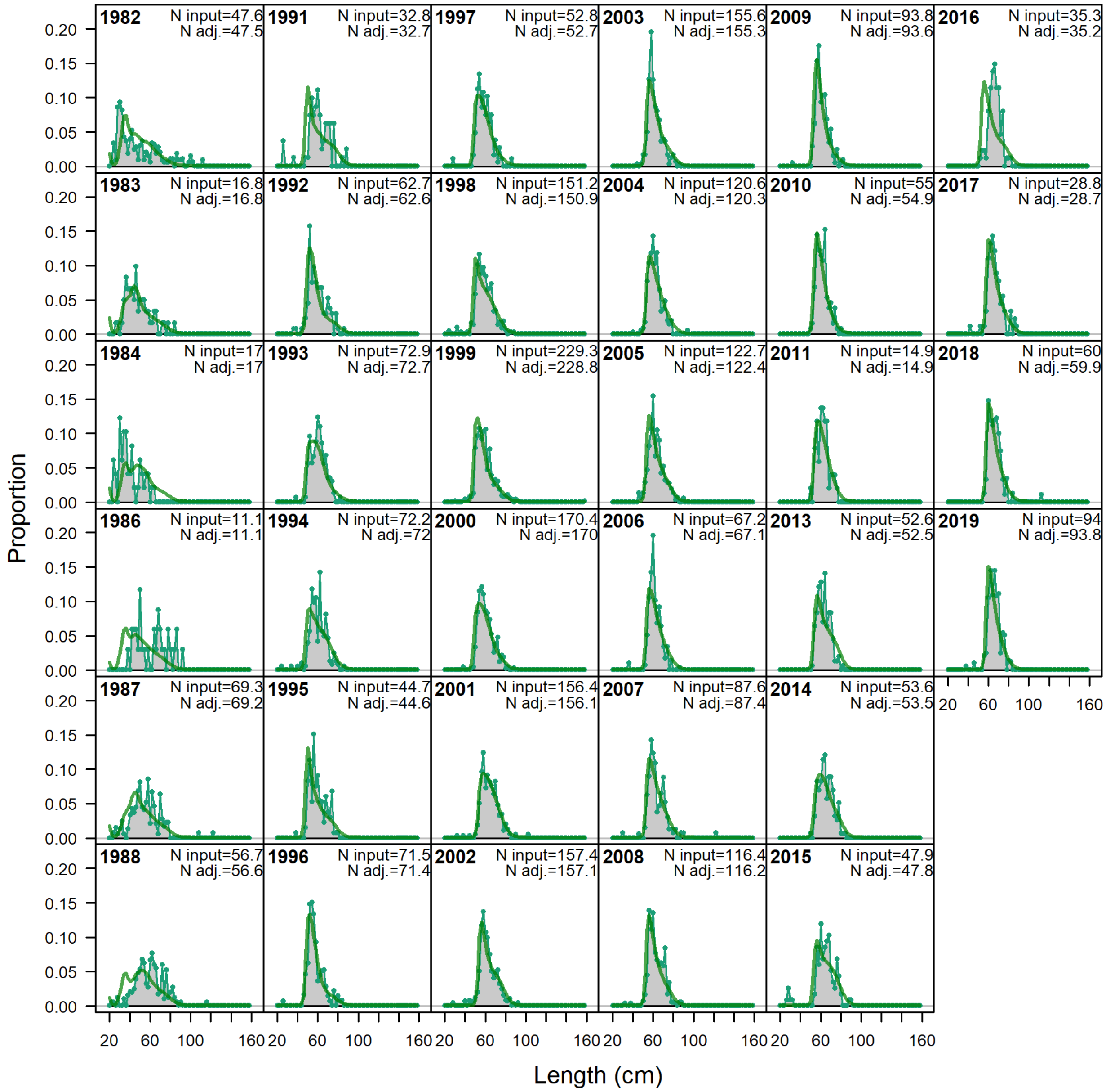


Figure 85. Observed and predicted length compositions (retained) for Gulf of Mexico Gag Grouper in the Recreational Private + Shore fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR33 Update

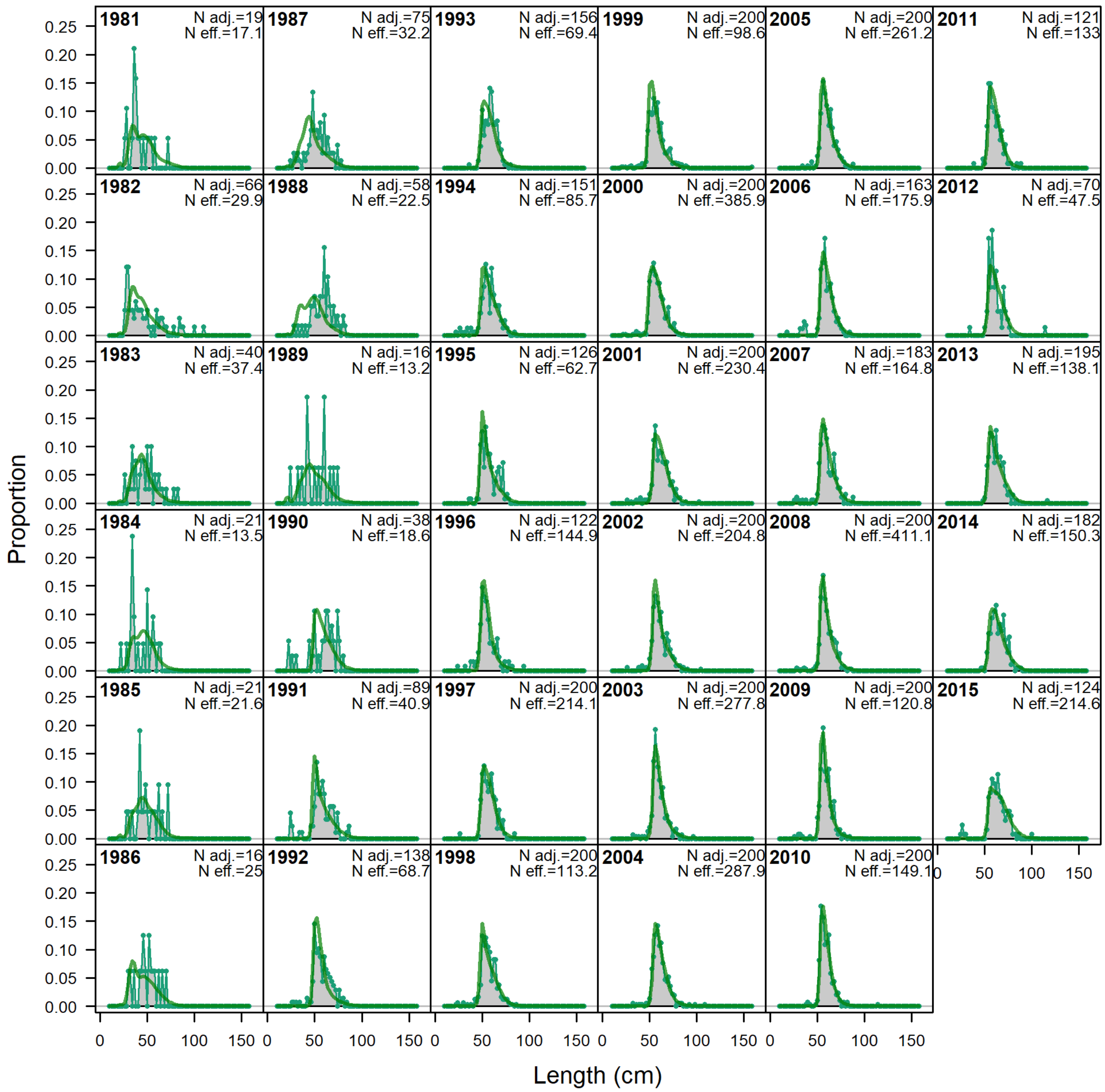


Figure 85 Continued. Observed and predicted length compositions (retained) for Gulf of Mexico Gag Grouper in the Recreational Private + Shore fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR72

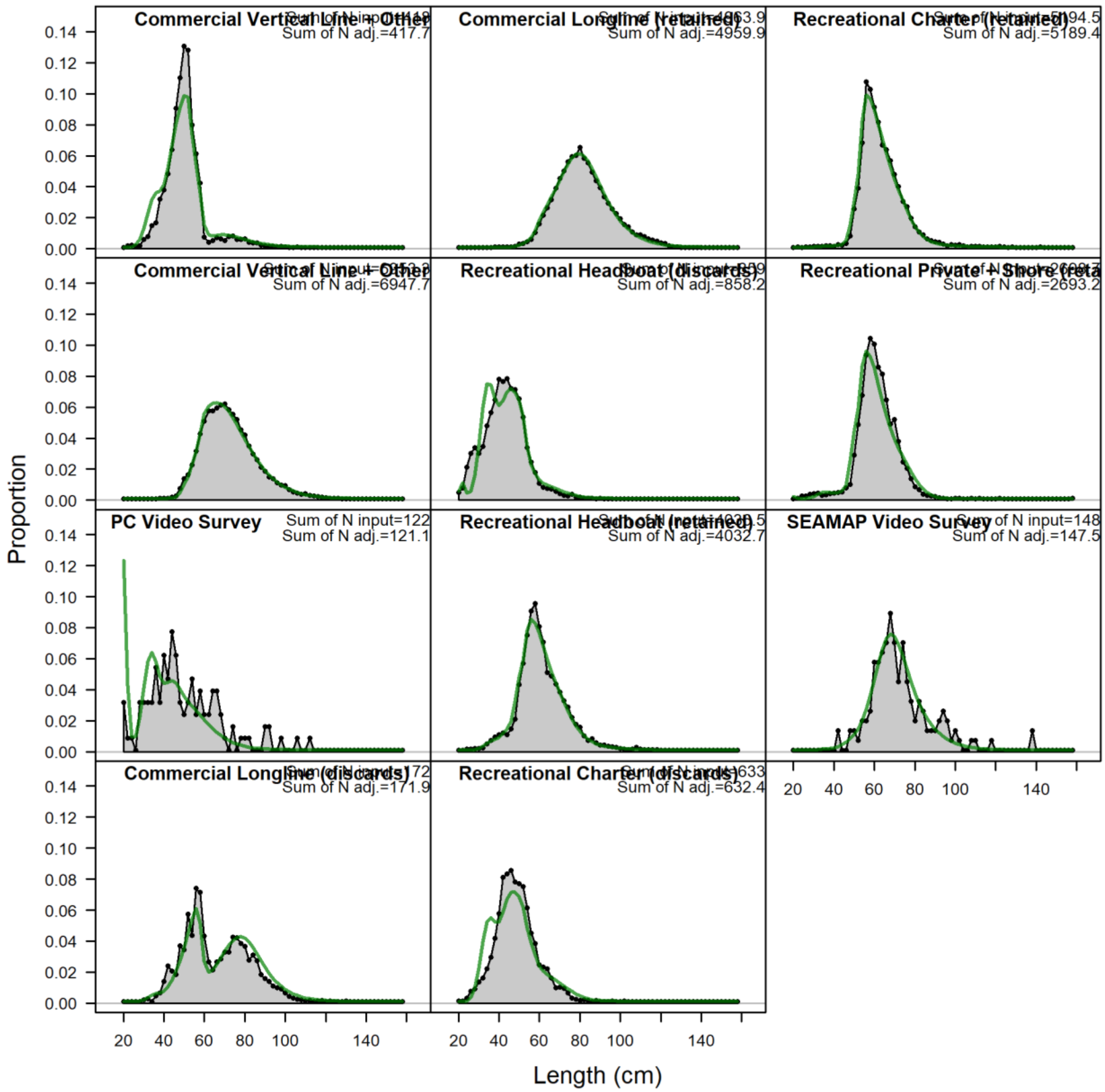


Figure 86. Model fits to the length composition of discarded or retained catch aggregated across years within a given fleet for Gulf of Mexico Gag Grouper. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'Sum of N input' is the total input sample size and 'Sum of N adj.' is the total sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'Sum of N adj.' is the input sample size and 'Sum of N eff.' can be ignored as it was not used.

SEDAR33 Update

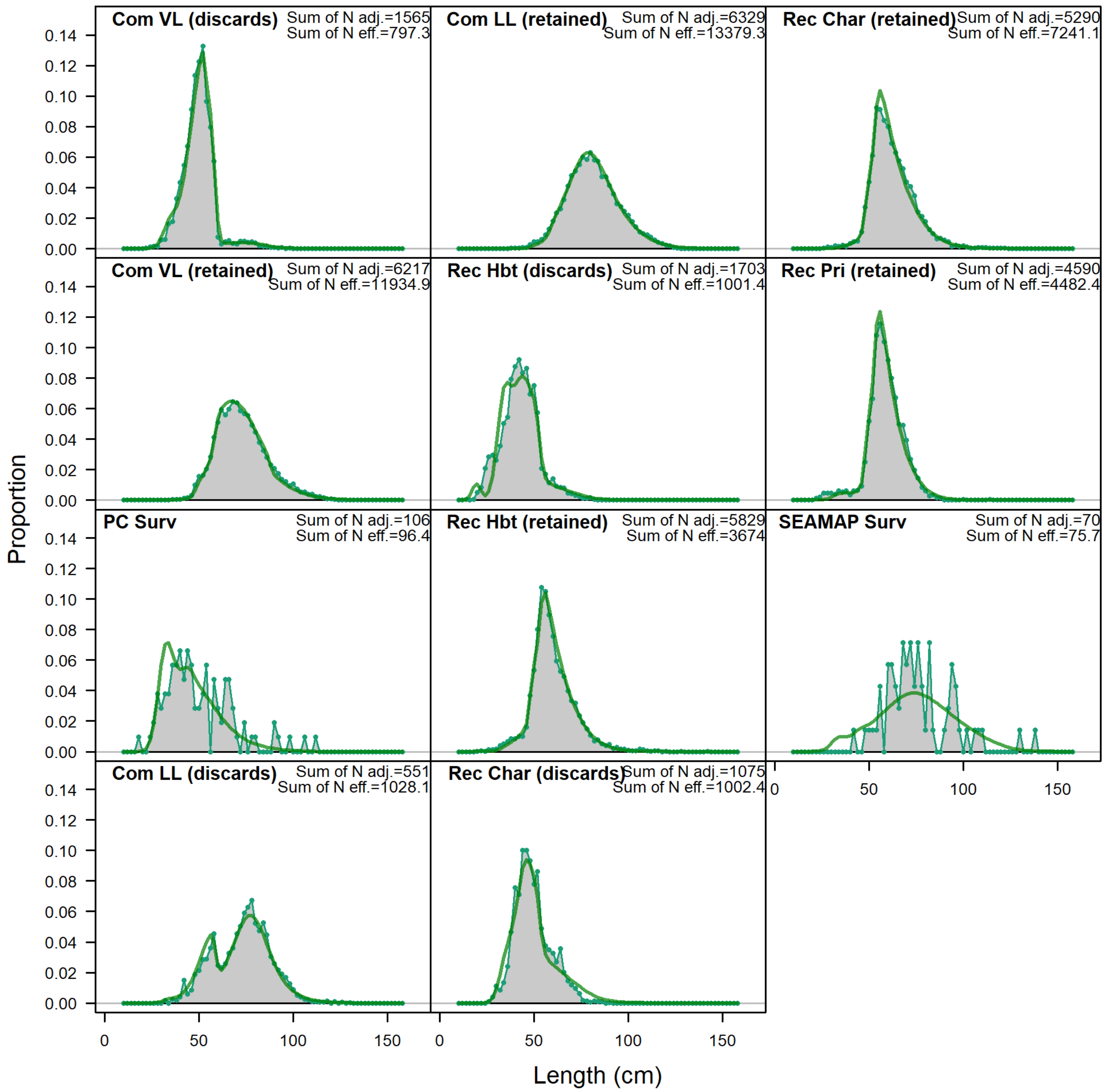


Figure 86 Continued. Model fits to the length composition of discarded or retained catch aggregated across years within a given fleet for Gulf of Mexico Gag Grouper. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'Sum of N input' is the total input sample size and 'Sum of N adj.' is the total sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'Sum of N adj.' is the input sample size and 'Sum of N eff.' can be ignored as it was not used.

SEDAR72

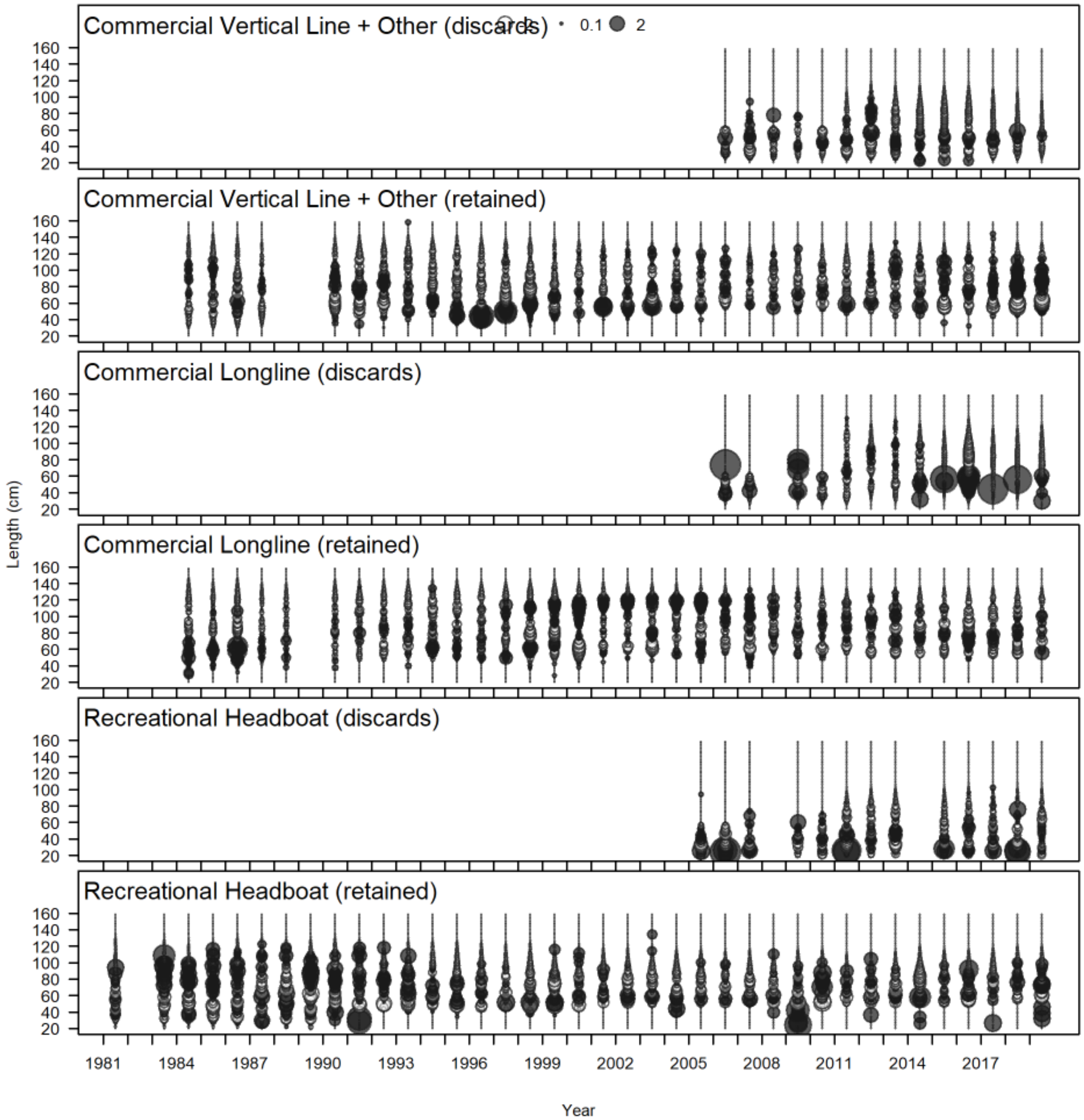


Figure 87. Pearson residuals for discard and retained length composition data by year compared across fleets and surveys for Gulf of Mexico Gag Grouper for SEDAR72 (Upper panel) and SEDAR33 Update (Lower Panel). Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

SEDAR33 Update

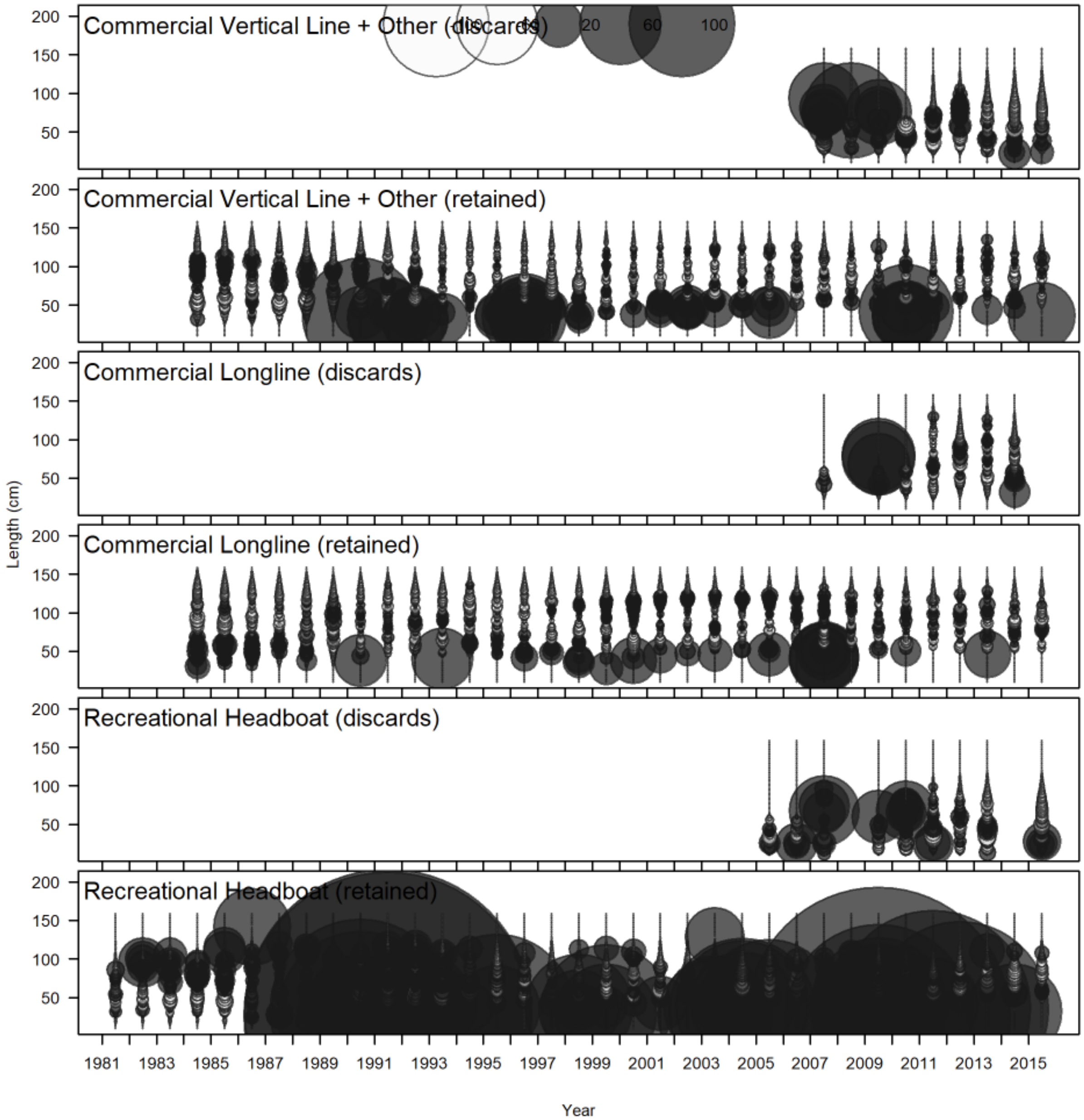


Figure 87 Continued. Pearson residuals for discard and retained length composition data by year compared across fleets and surveys for Gulf of Mexico Gag Grouper for SEDAR72 (Upper panel) and SEDAR33 Update (Lower Panel). Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

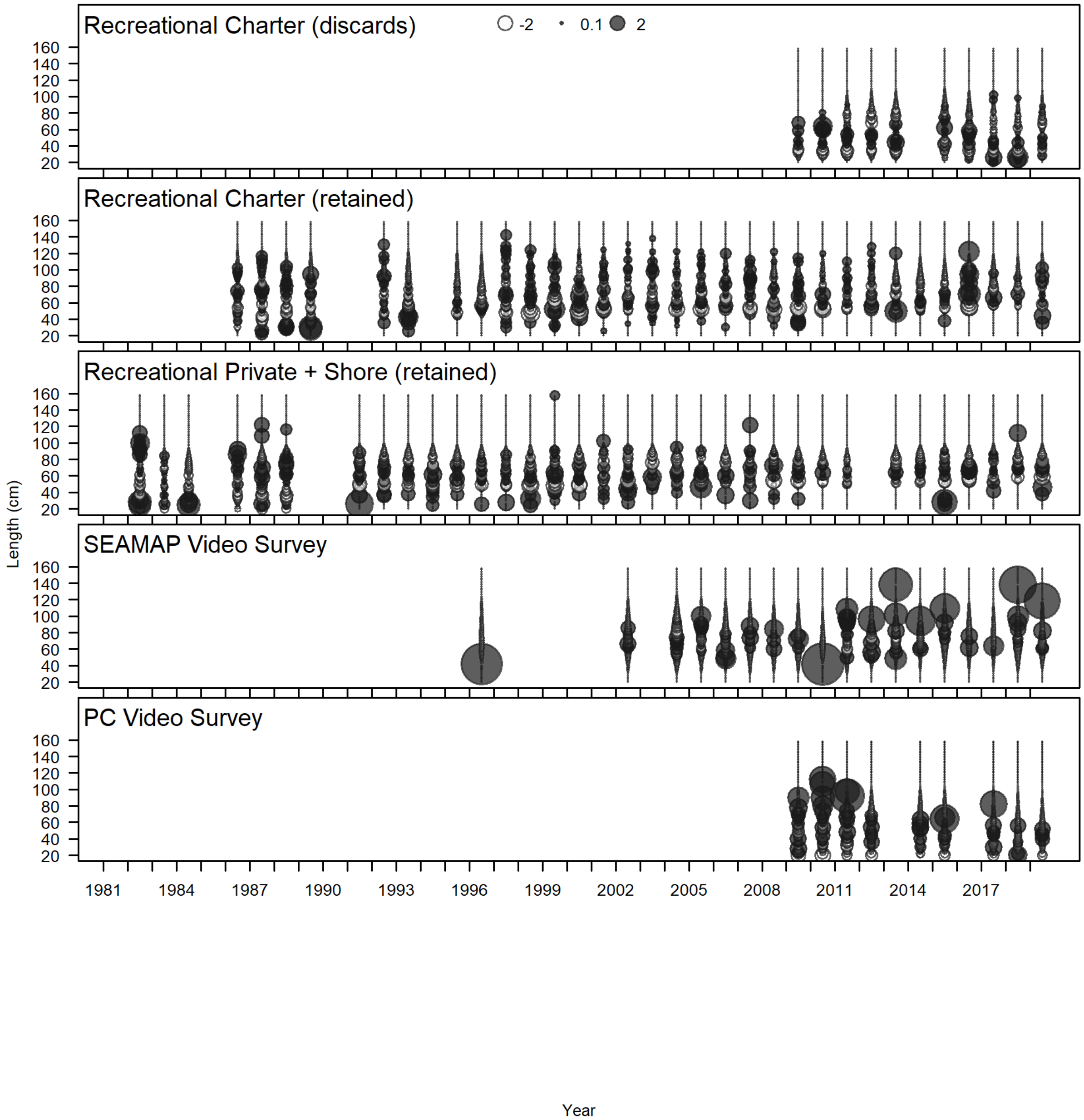


Figure 87 Continued. Pearson residuals for discard and retained length composition data by year compared across fleets and surveys for Gulf of Mexico Gag Grouper for SEDAR72 (Upper panel) and SEDAR33 Update (Lower Panel). Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

SEDAR33 Update

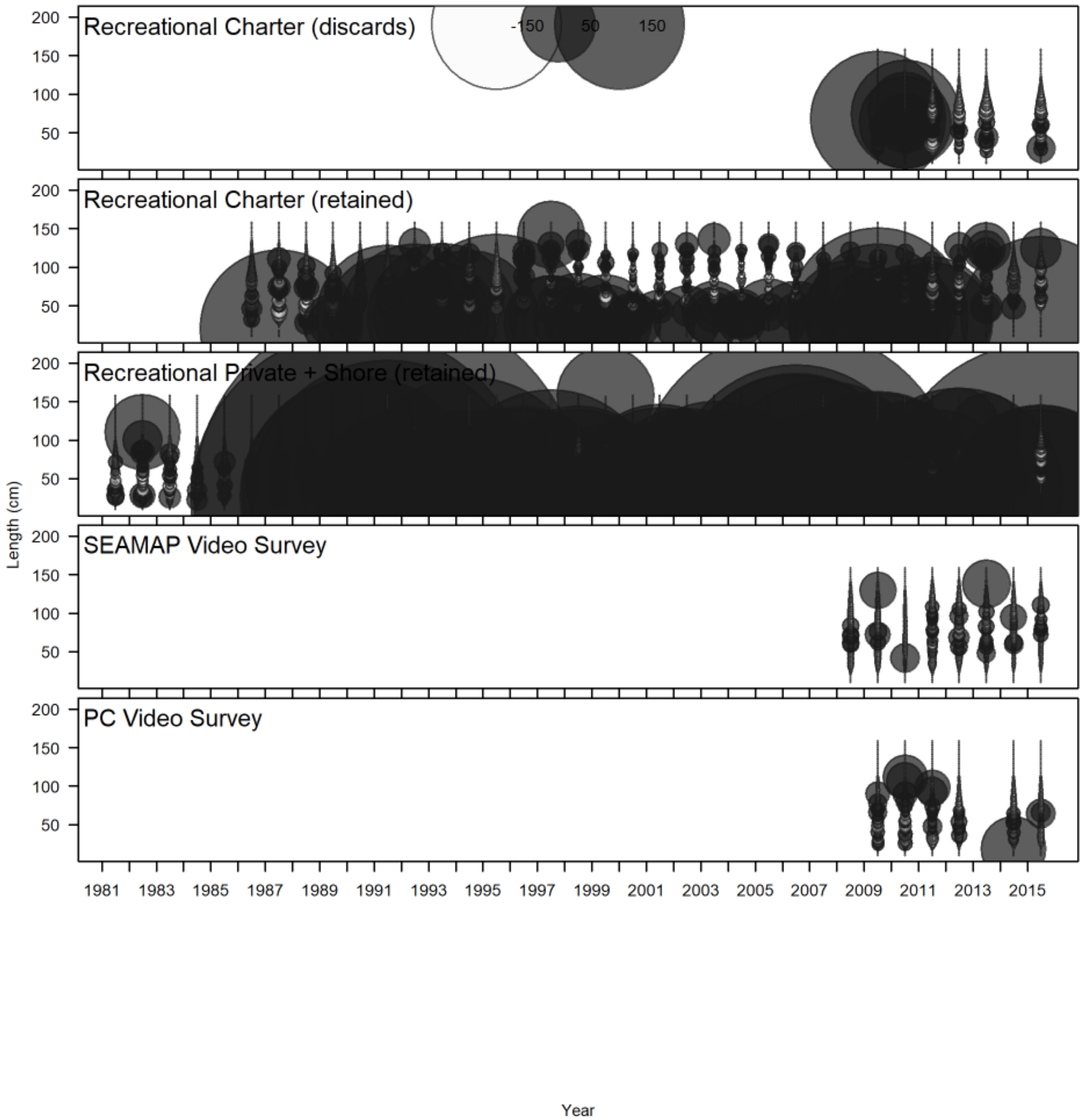


Figure 87 Continued. Pearson residuals for discard and retained length composition data by year compared across fleets and surveys for Gulf of Mexico Gag Grouper for SEDAR72 (Upper panel) and SEDAR33 Update (Lower Panel). Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

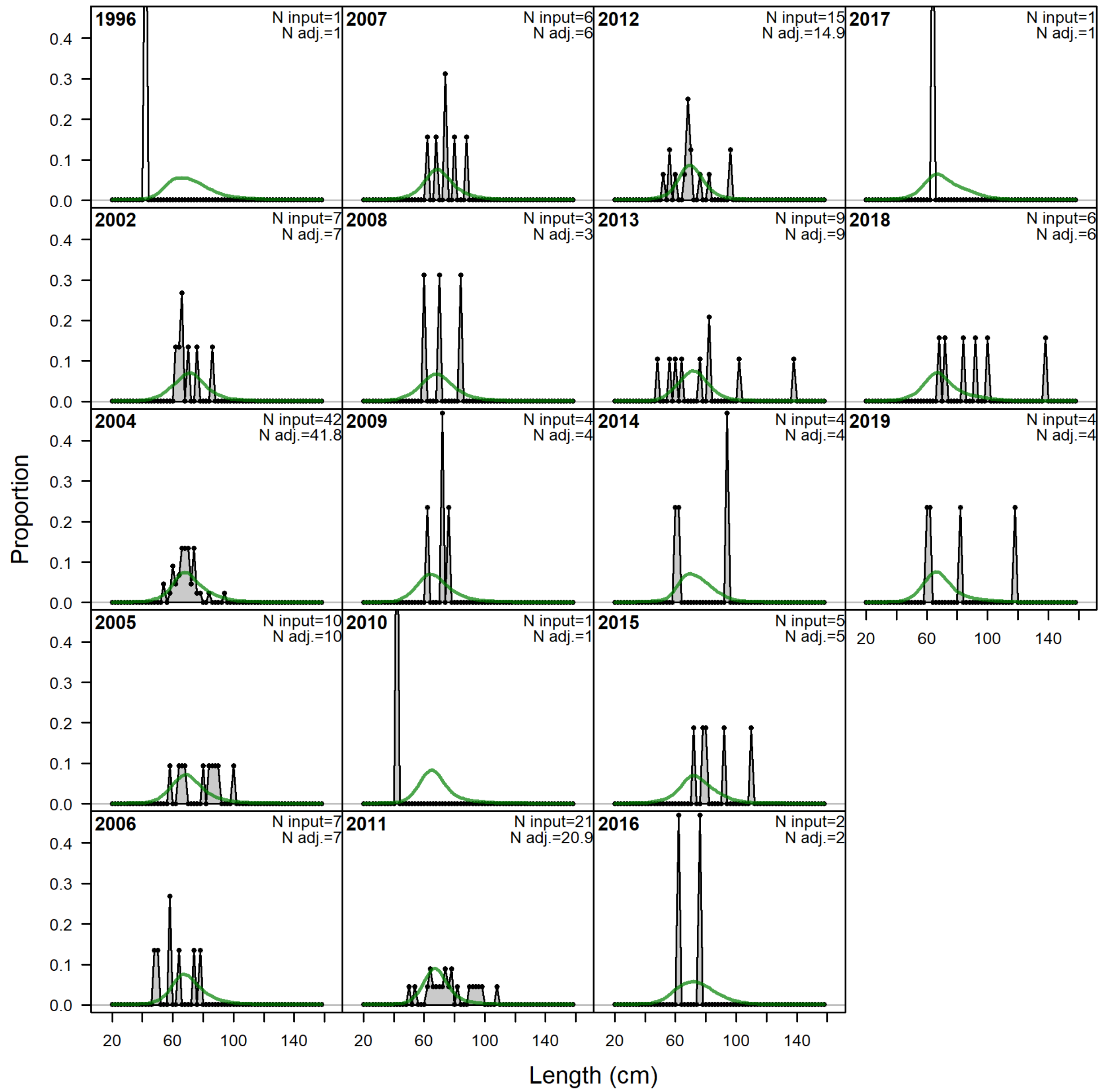


Figure 88. Observed and predicted length compositions (retained) for Gulf of Mexico Gag Grouper in the SEAMAP Video Survey fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR33 Update

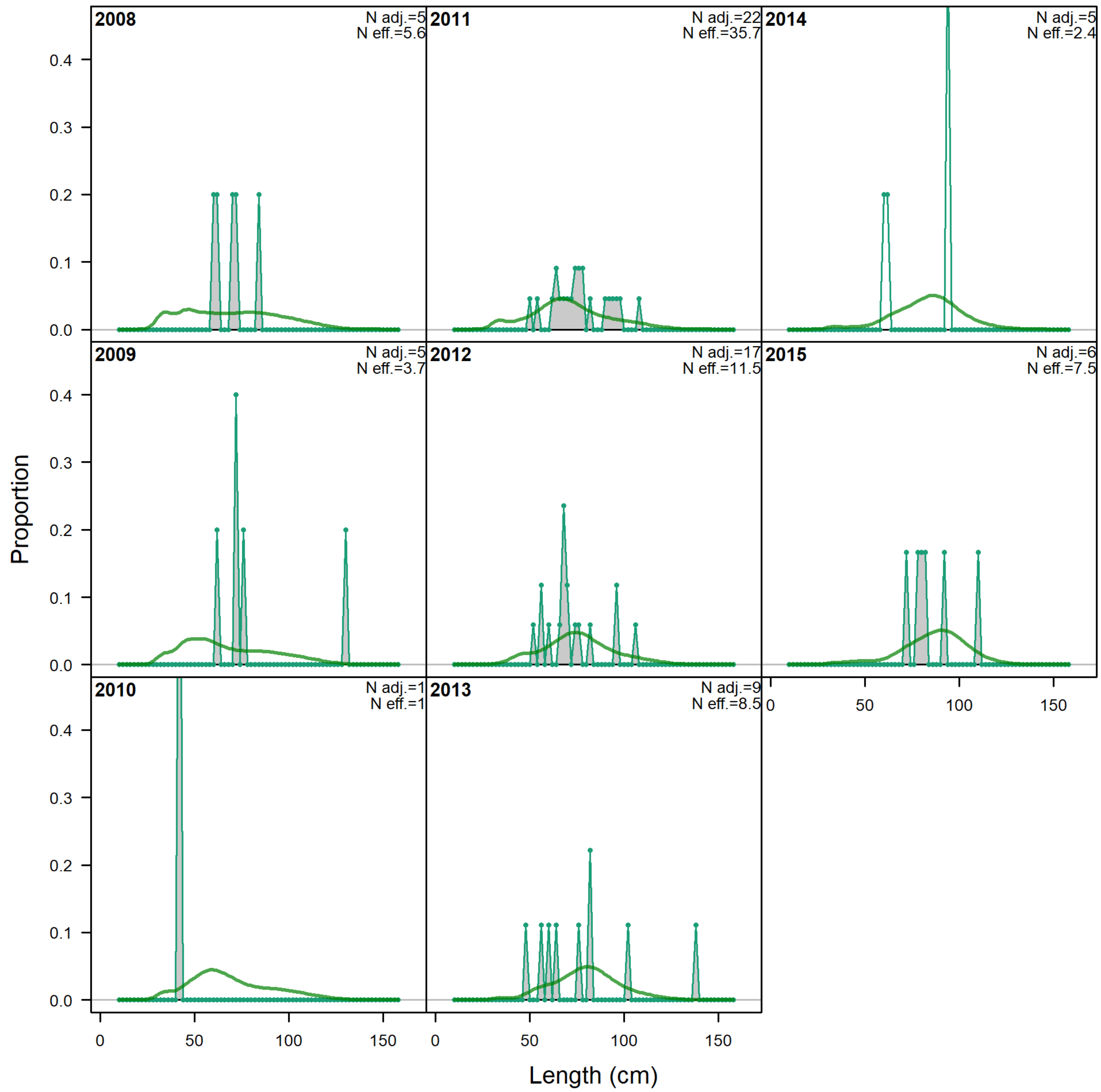


Figure 88 Continued. Observed and predicted length compositions (retained) for Gulf of Mexico Gag Grouper in the SEAMAP Video Survey fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR72

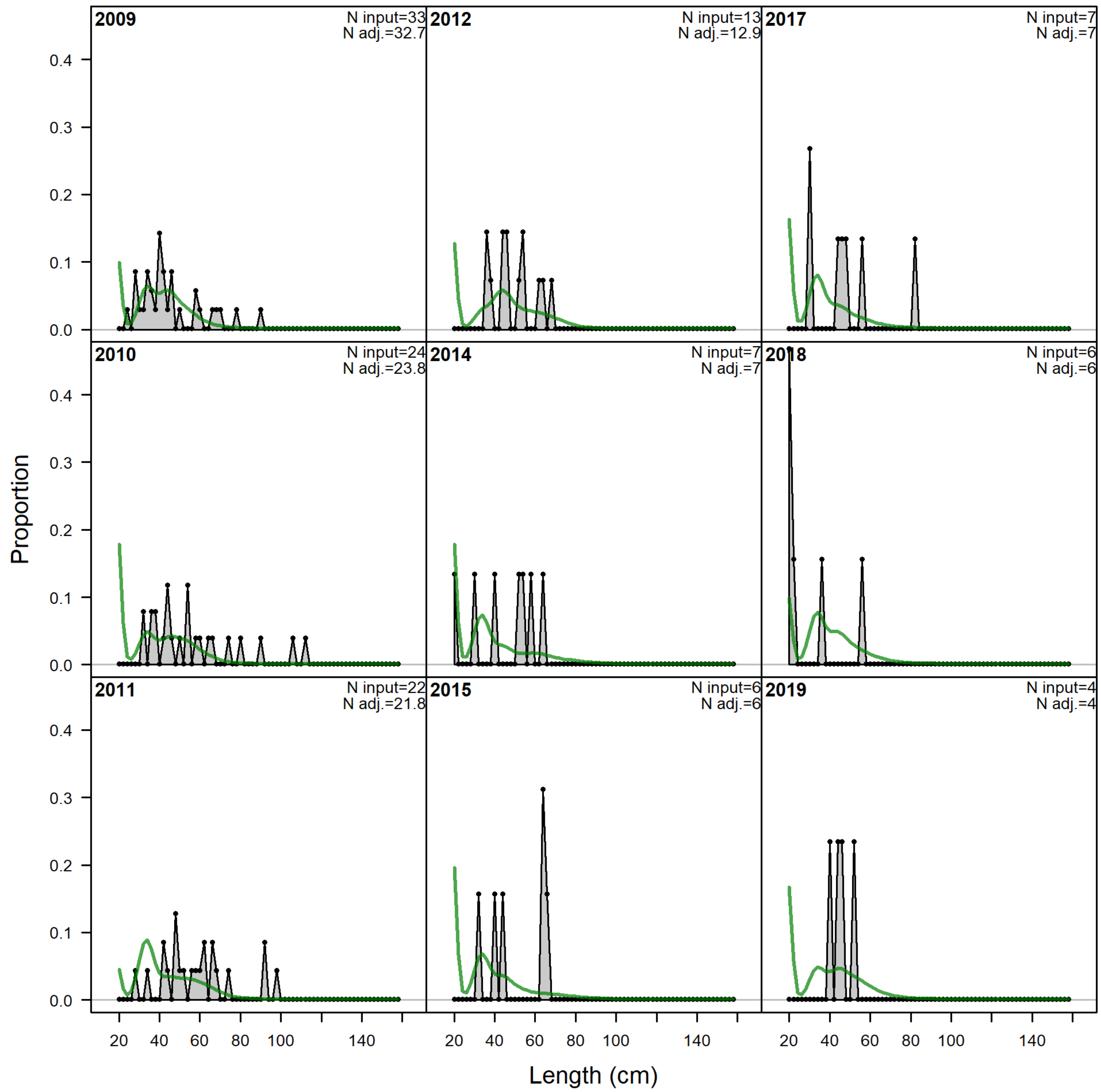


Figure 89. Observed and predicted length compositions (retained) for Gulf of Mexico Gag Grouper in the PC Video Survey fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR33 Update

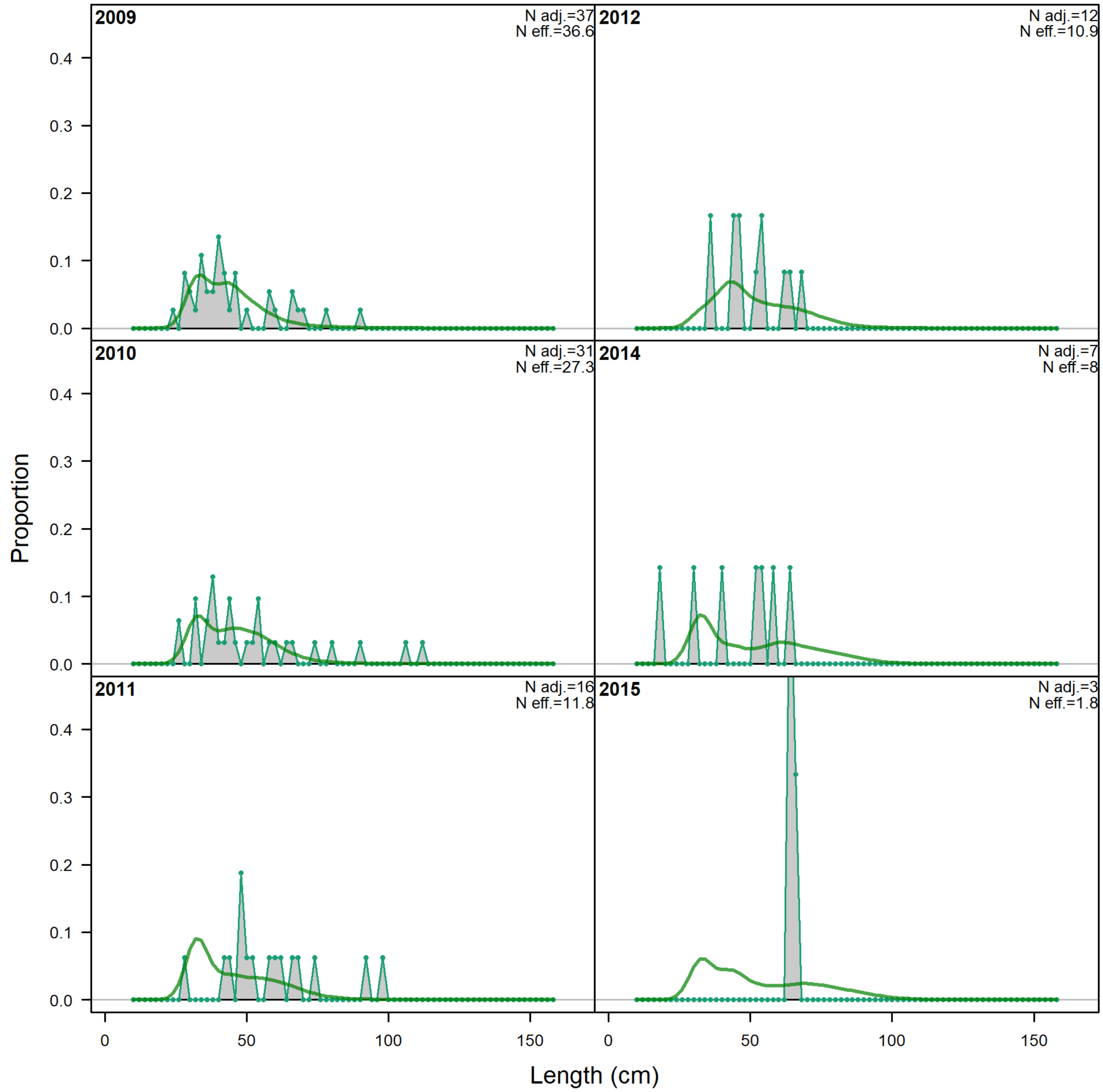


Figure 89 Continued. Observed and predicted length compositions (retained) for Gulf of Mexico Gag Grouper in the PC Video Survey fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR72

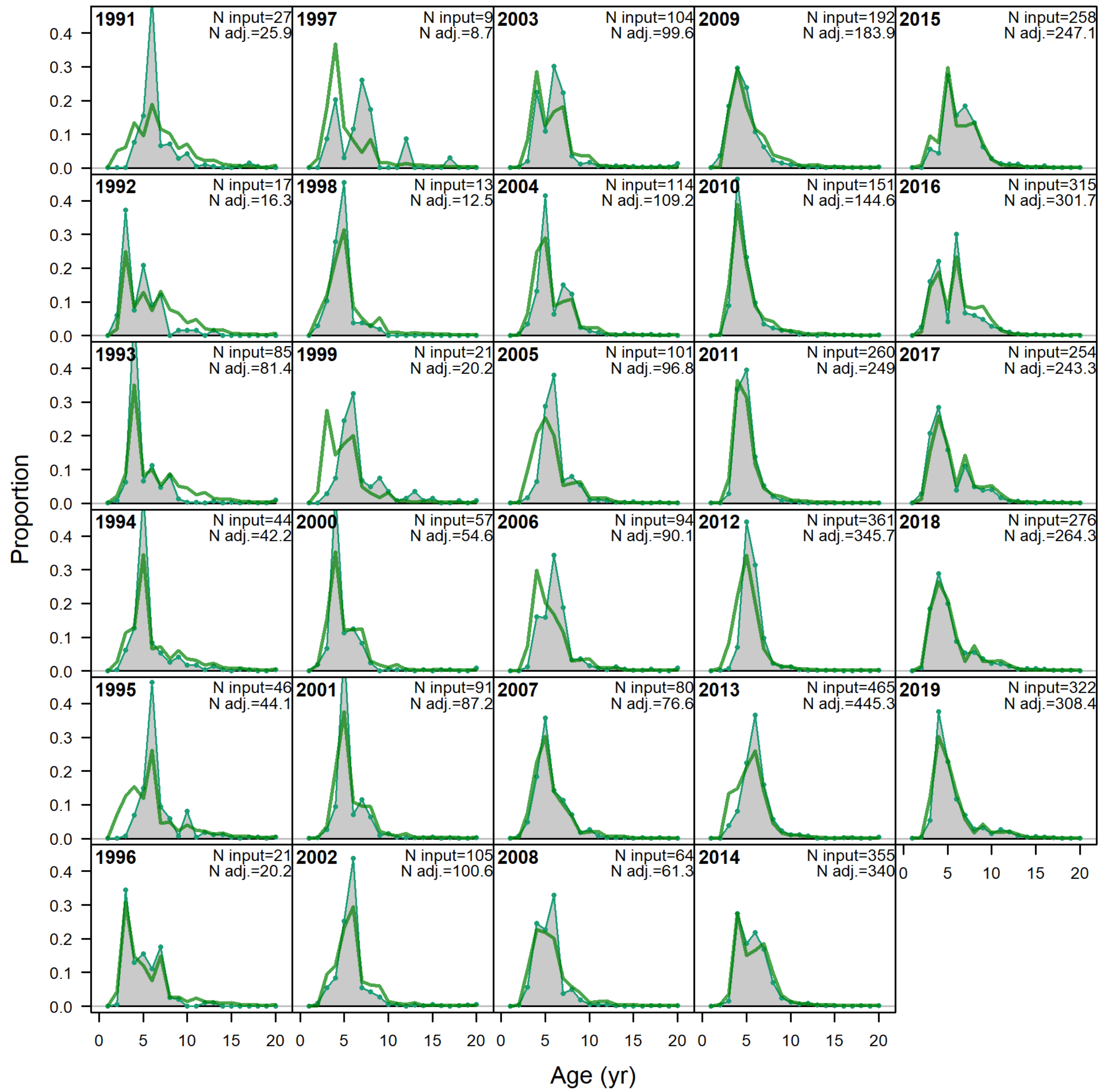


Figure 90. Observed and predicted age compositions (retained) for Gulf of Mexico Gag Grouper in the Commercial Vertical Line + Other fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR33 Update

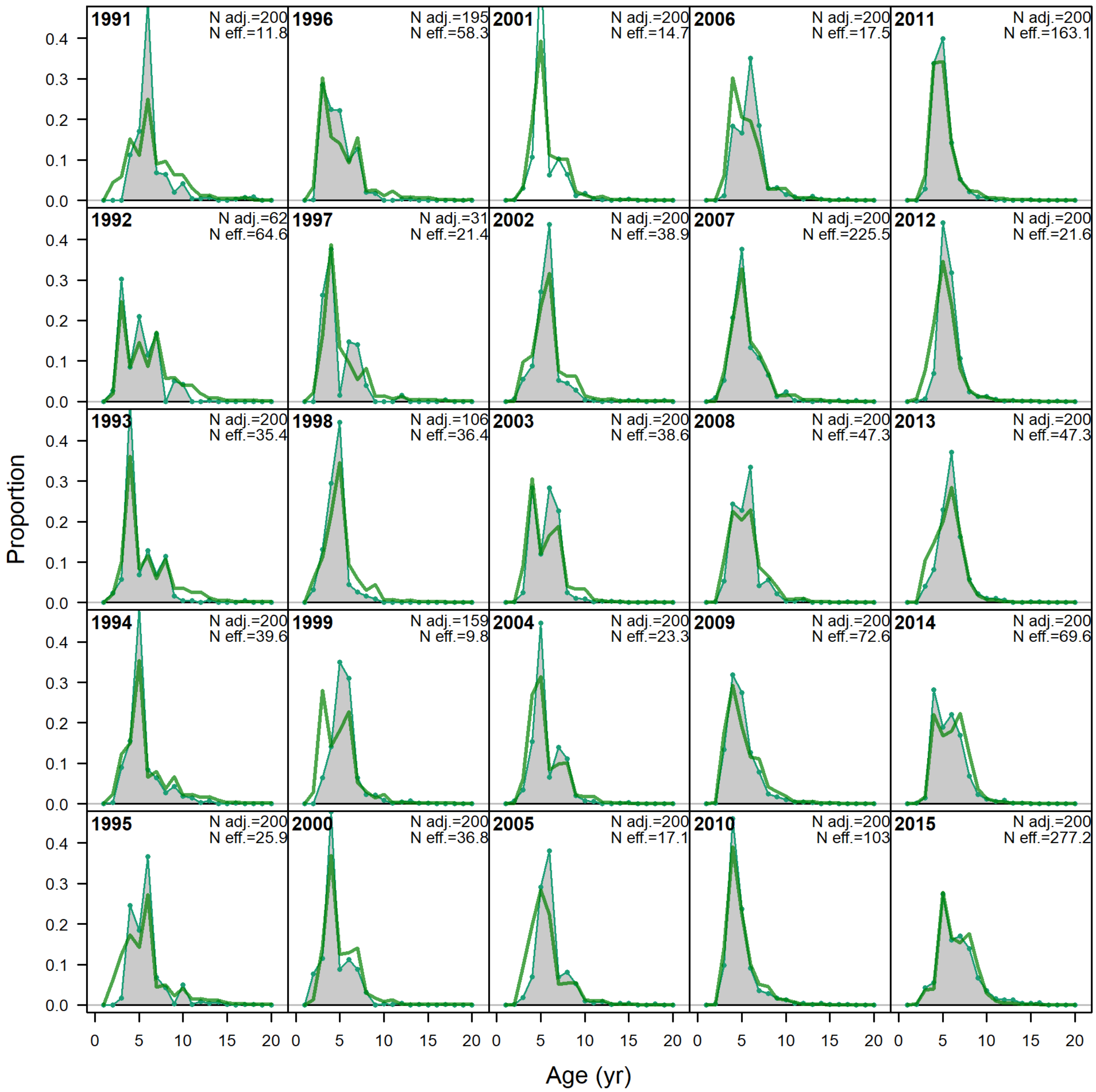


Figure 90 Continued. Observed and predicted age compositions (retained) for Gulf of Mexico Gag Grouper in the Commercial Vertical Line + Other fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

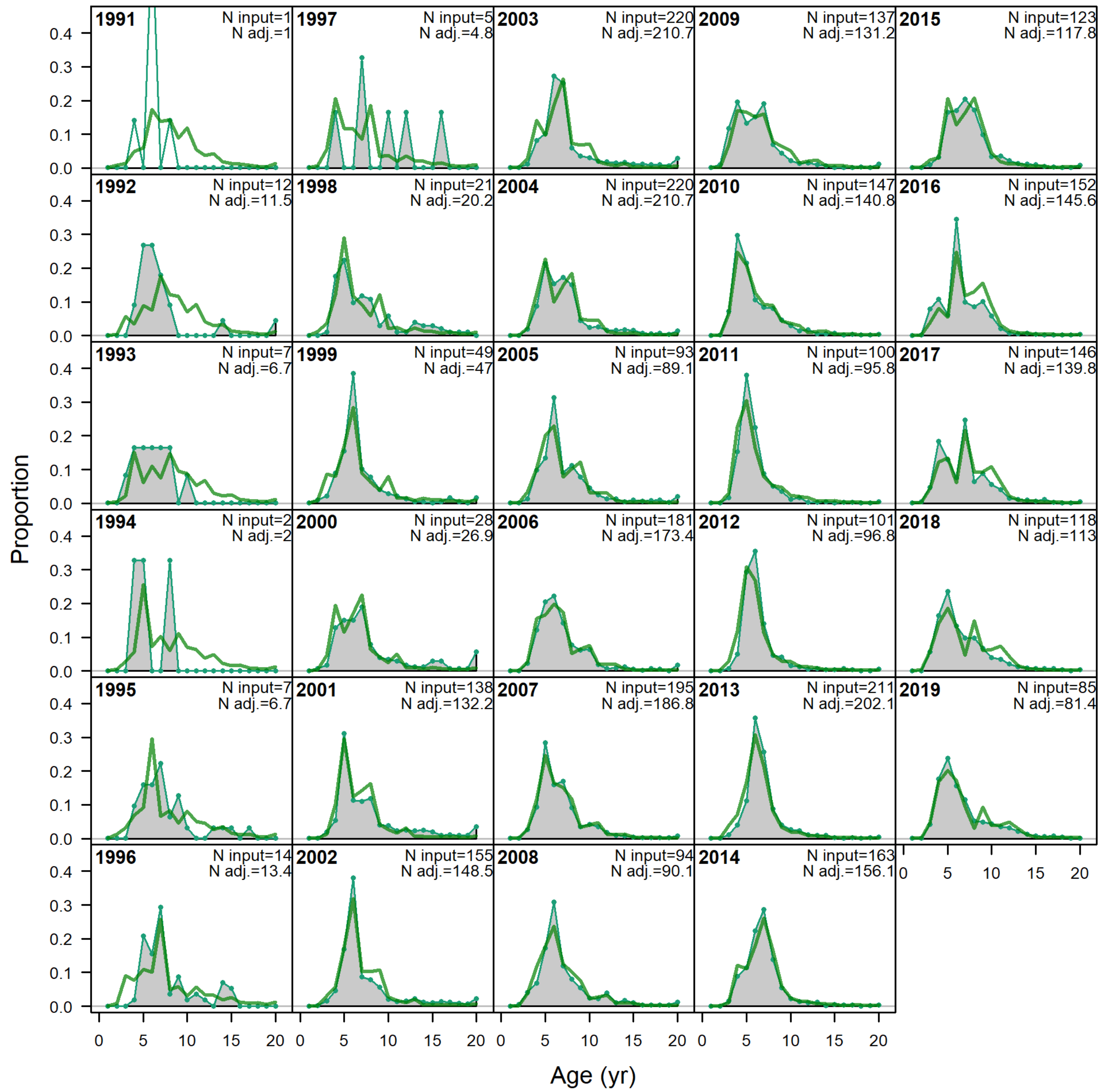


Figure 91. Observed and predicted age compositions (retained) for Gulf of Mexico Gag Grouper in the Commercial Longline fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR33 Update

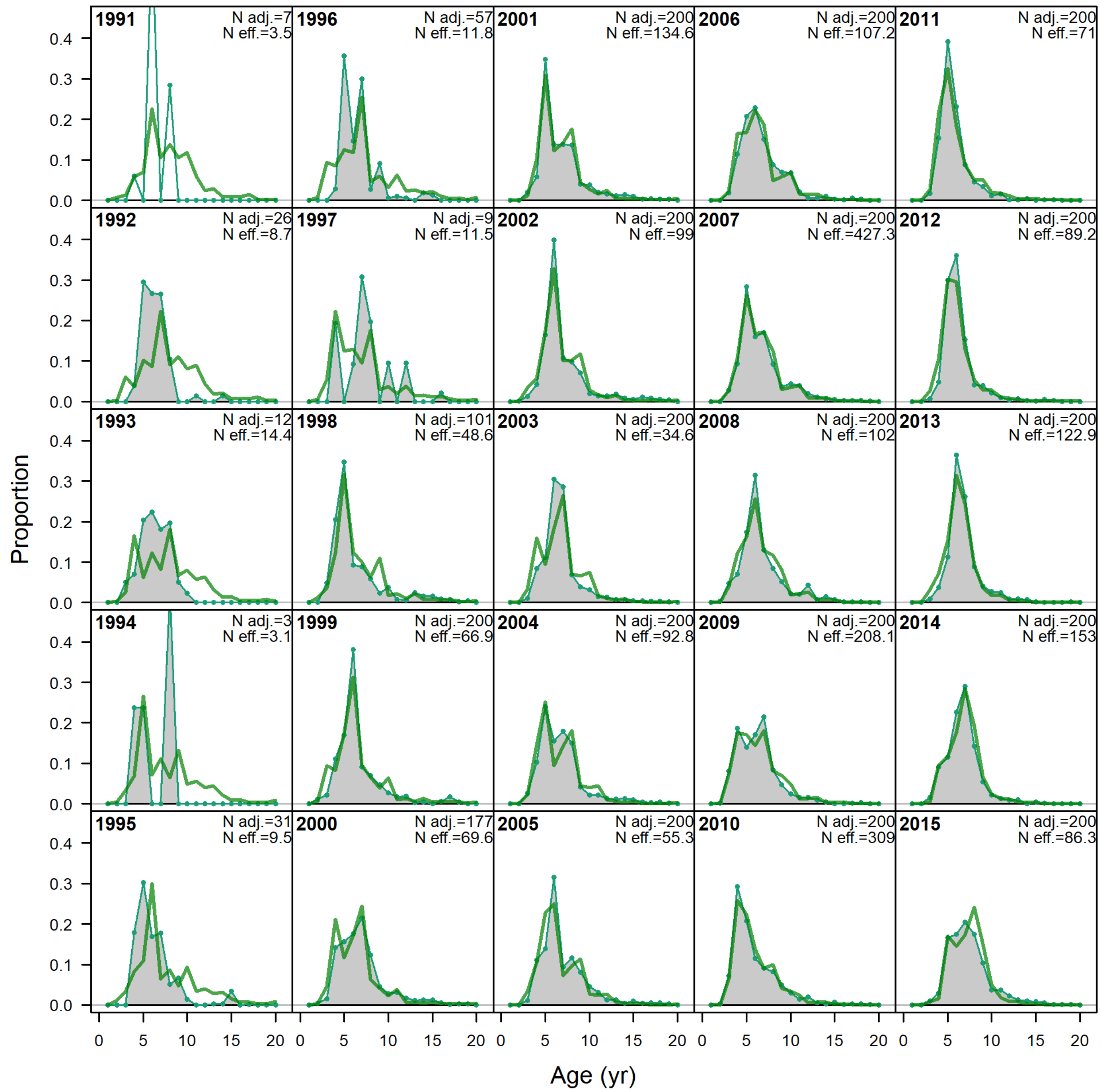


Figure 91 Continued. Observed and predicted age compositions (retained) for Gulf of Mexico Gag Grouper in the Commercial Longline fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR72

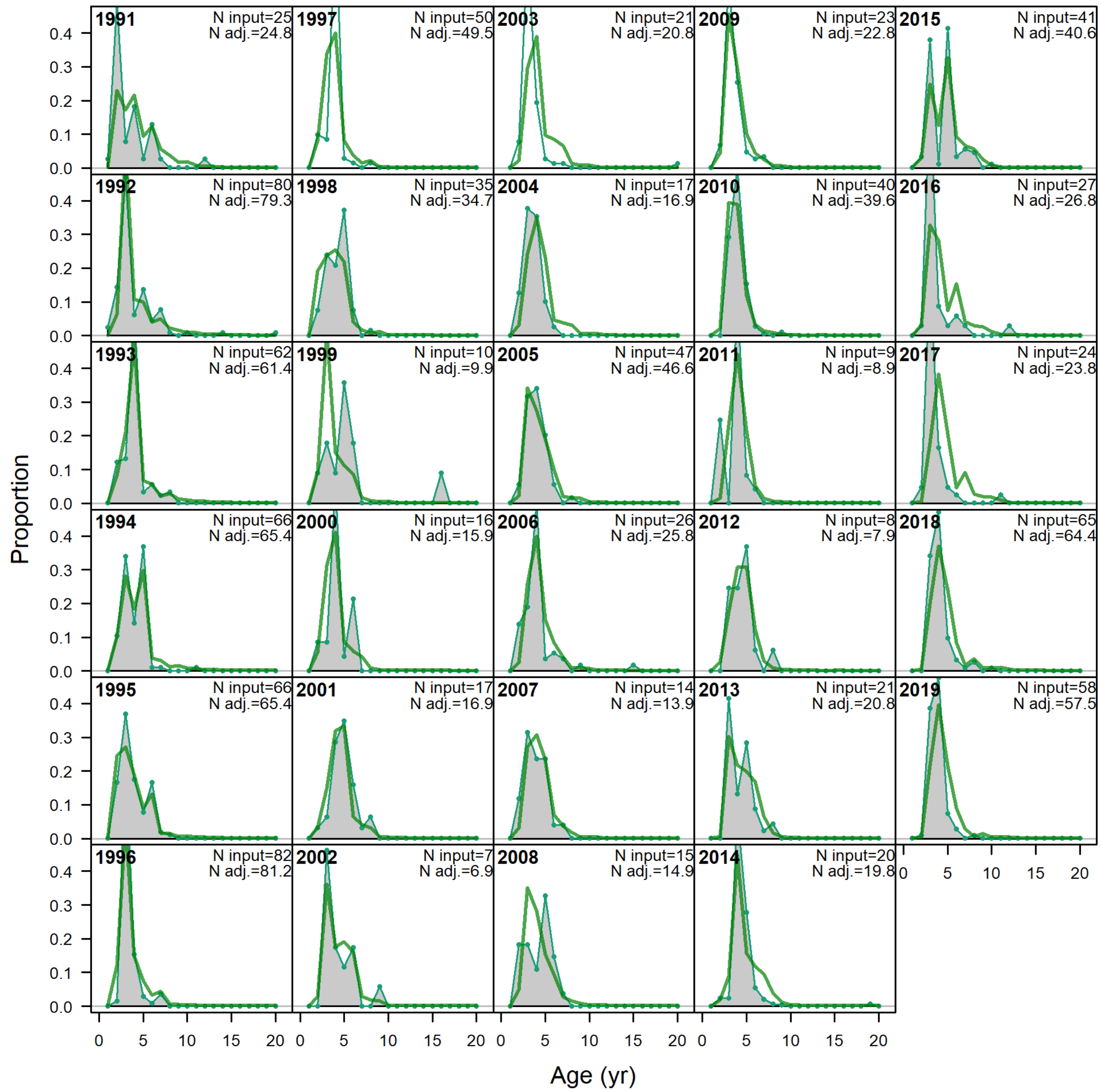


Figure 92. Observed and predicted age compositions (retained) for Gulf of Mexico Gag Grouper in the Recreational Headboat fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR33 Update

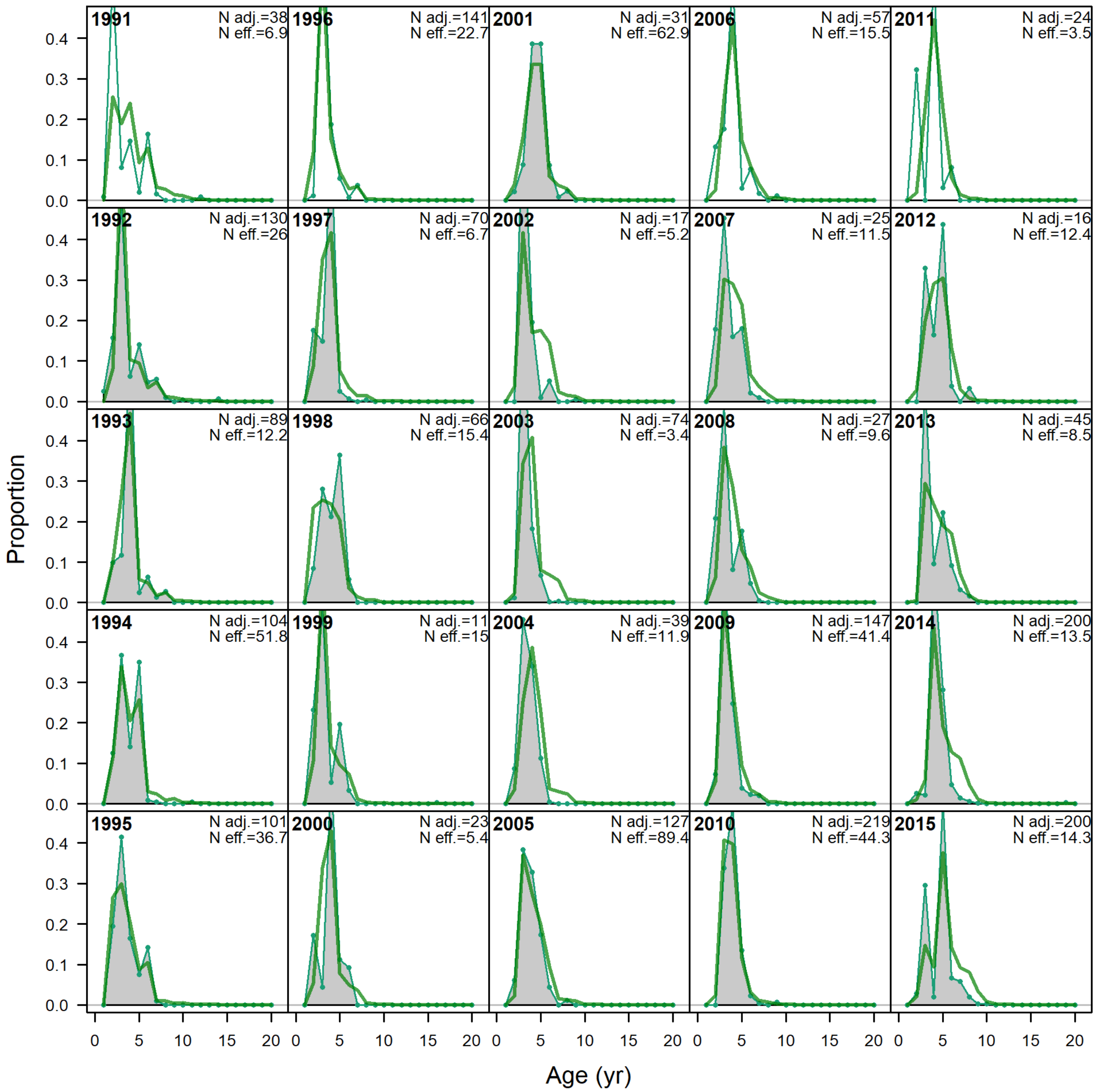


Figure 92 Continued. Observed and predicted age compositions (retained) for Gulf of Mexico Gag Grouper in the Recreational Headboat fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR72

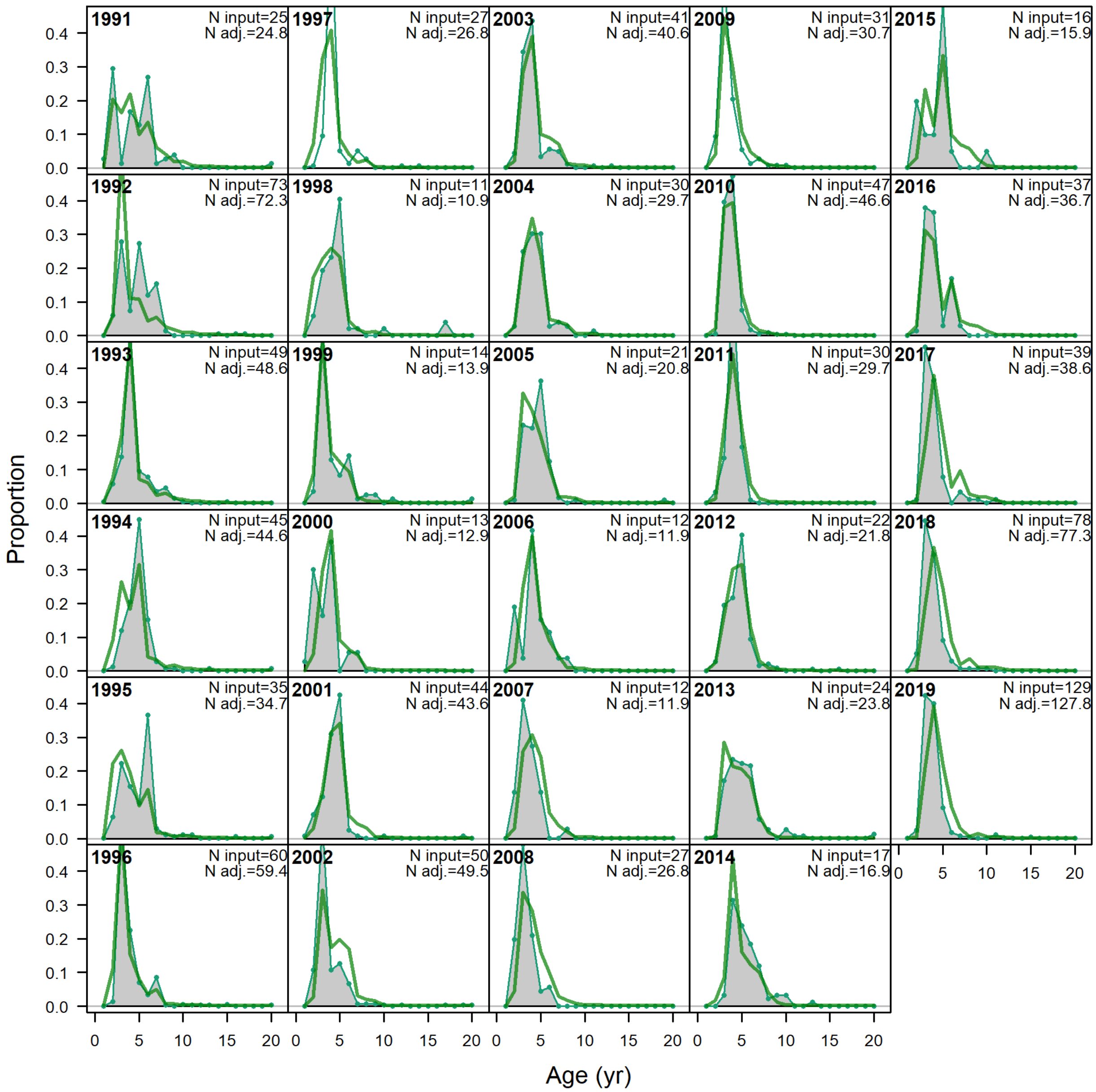


Figure 93. Observed and predicted age compositions (retained) for Gulf of Mexico Gag Grouper in the Recreational Charter fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR33 Update

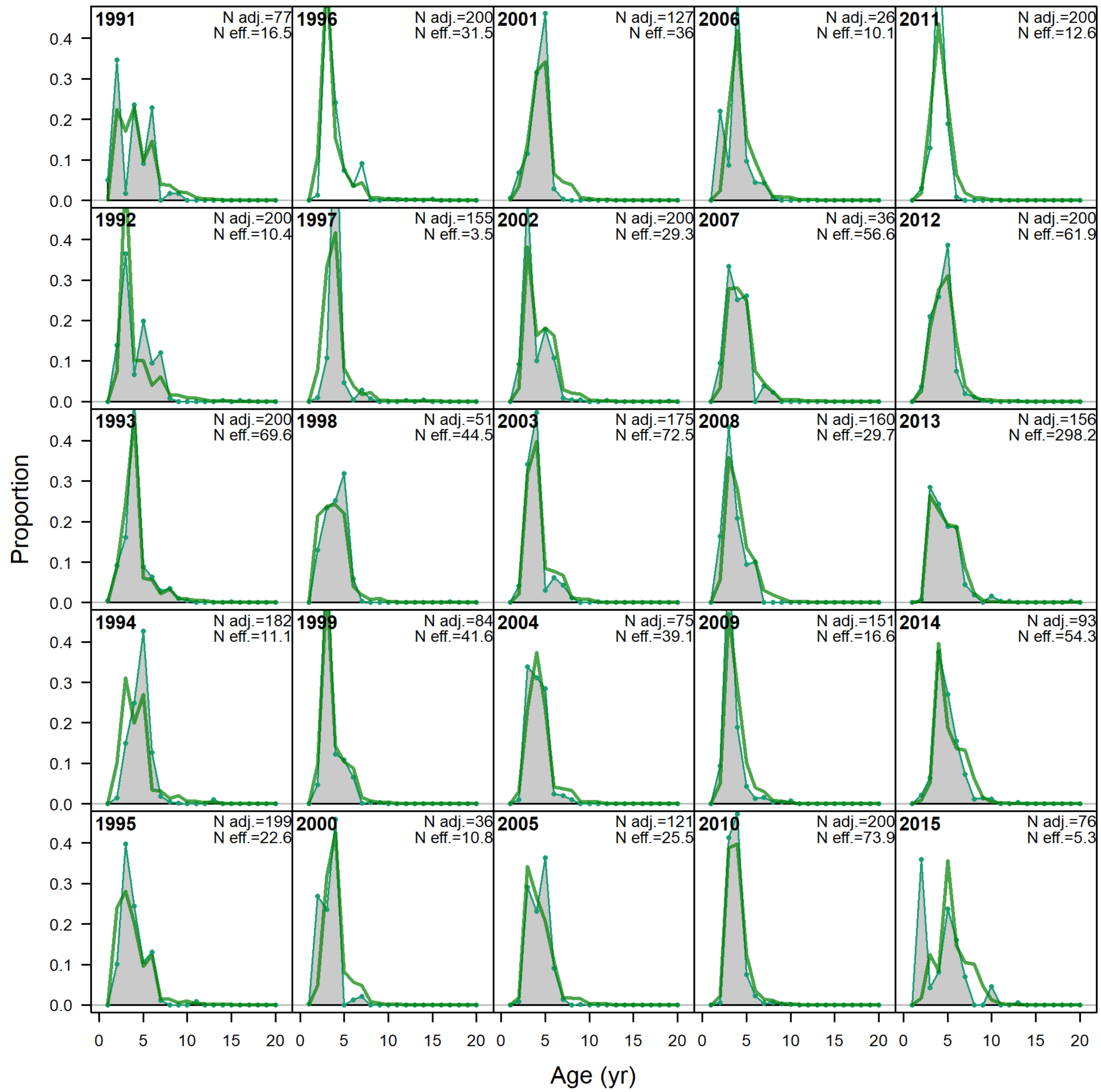


Figure 93 Continued. Observed and predicted age compositions (retained) for Gulf of Mexico Gag Grouper in the Recreational Charter fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR72

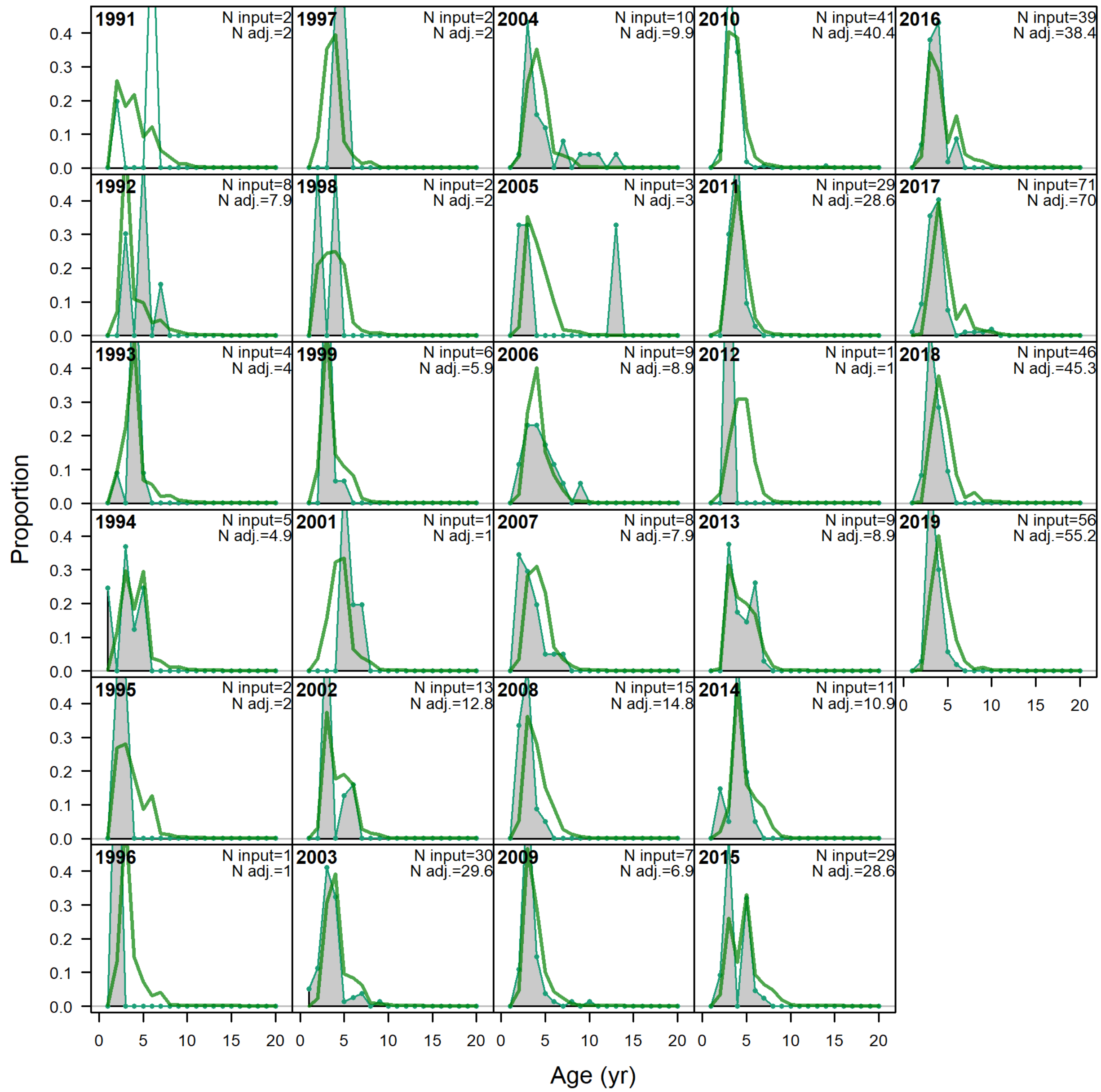


Figure 94. Observed and predicted age compositions (retained) for Gulf of Mexico Gag Grouper in the Recreational Private + Shore fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR33 Update

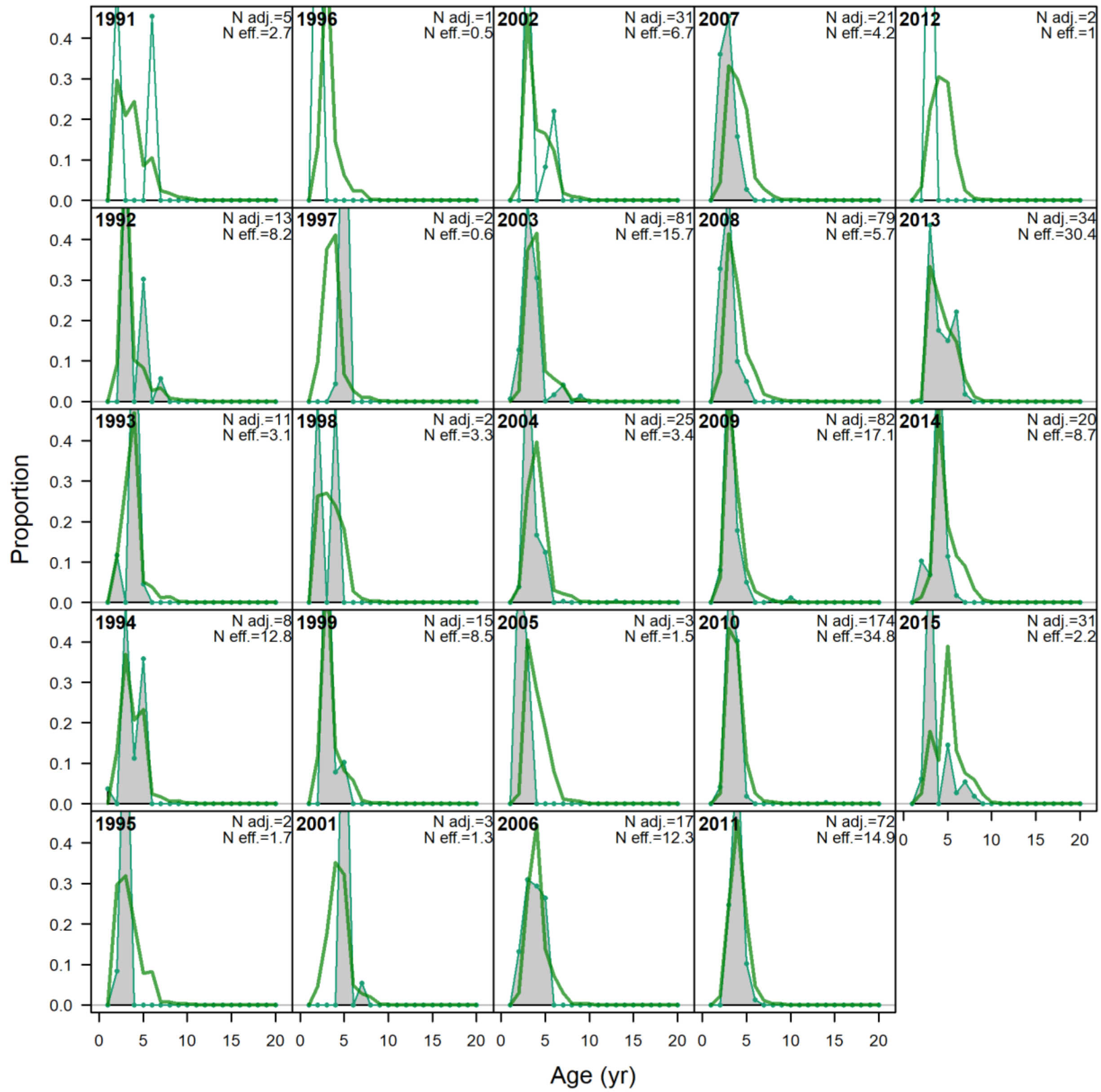


Figure 94 Continued. Observed and predicted age compositions (retained) for Gulf of Mexico Gag Grouper in the Recreational Private + Shore fishery. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'N adj.' is the input sample size and 'N eff.' can be ignored as it was not used.

SEDAR72

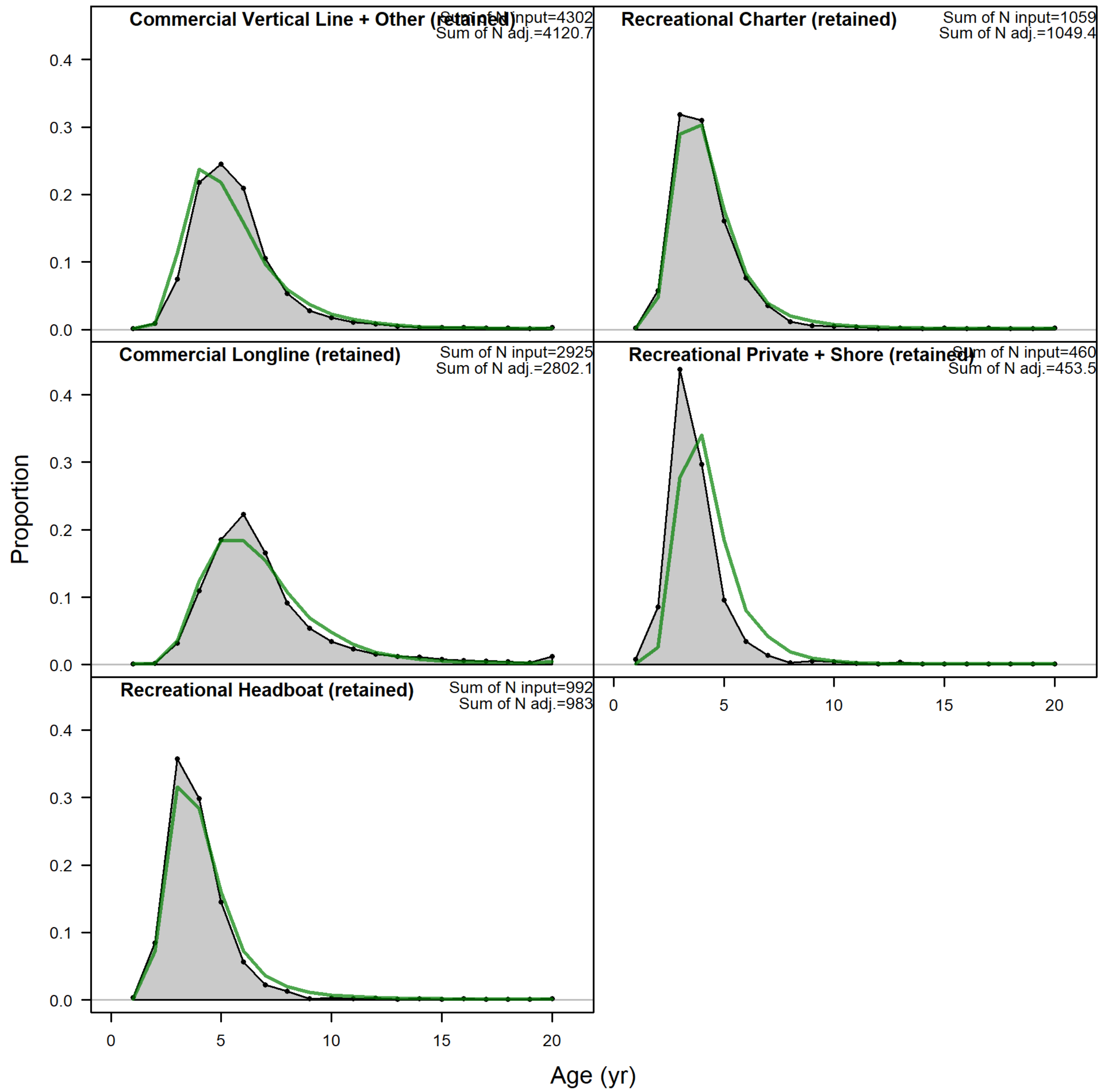


Figure 95. Model fits to the age composition of retained catch aggregated across years within a given fleet for Gulf of Mexico Gag Grouper. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'Sum of N input' is the total input sample size and 'Sum of N adj.' is the total sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'Sum of N adj.' is the input sample size and 'Sum of N eff.' can be ignored as it was not used.

SEDAR33 Update

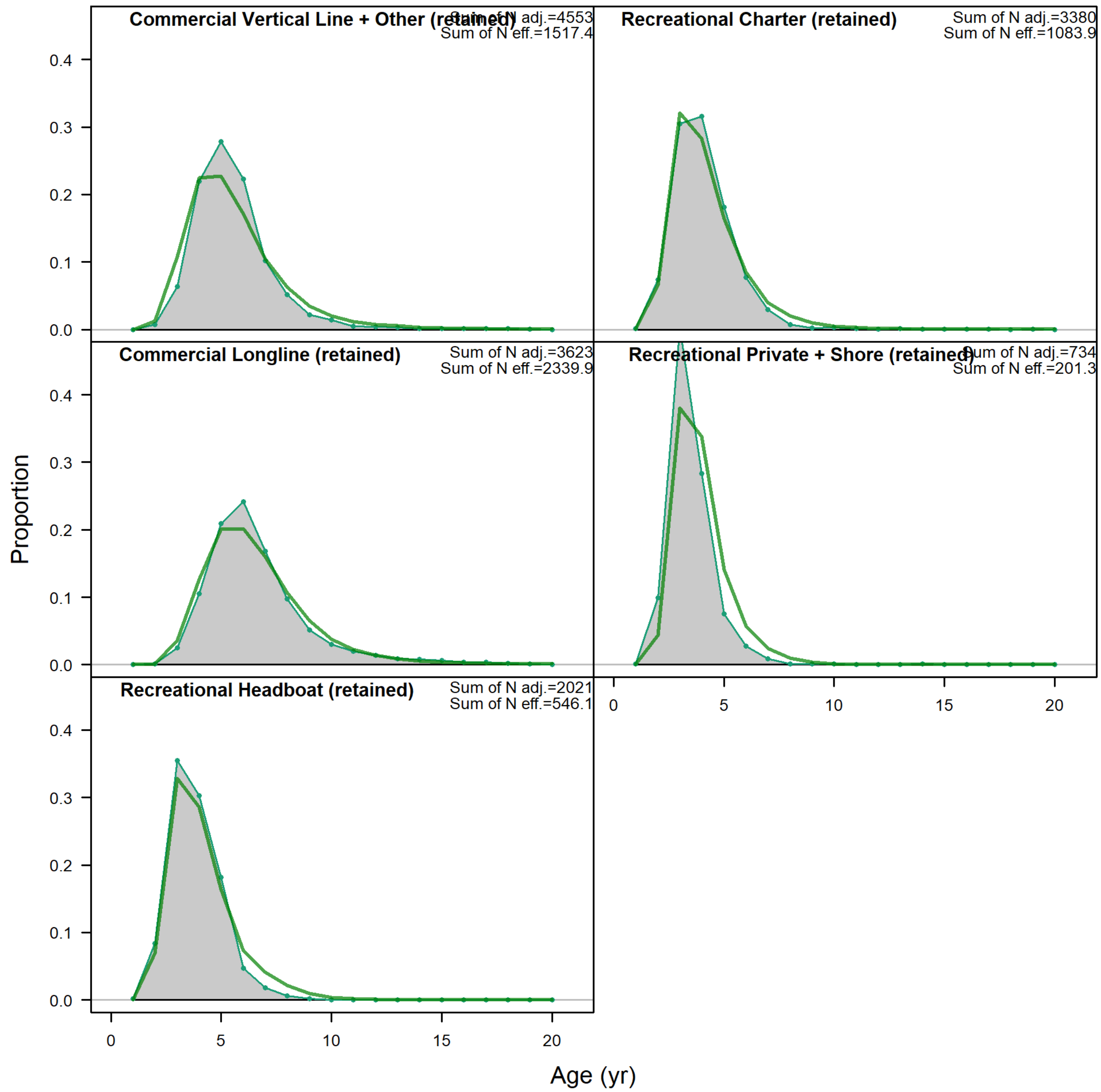


Figure 95 Continued. Model fits to the age composition of retained catch aggregated across years within a given fleet for Gulf of Mexico Gag Grouper. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. For SEDAR72, 'Sum of N input' is the total input sample size and 'Sum of N adj.' is the total sample size after adjustment by the Dirichlet-Multinomial parameter. For the SEDAR33 Update, 'Sum of N adj.' is the input sample size and 'Sum of N eff.' can be ignored as it was not used.

SEDAR72

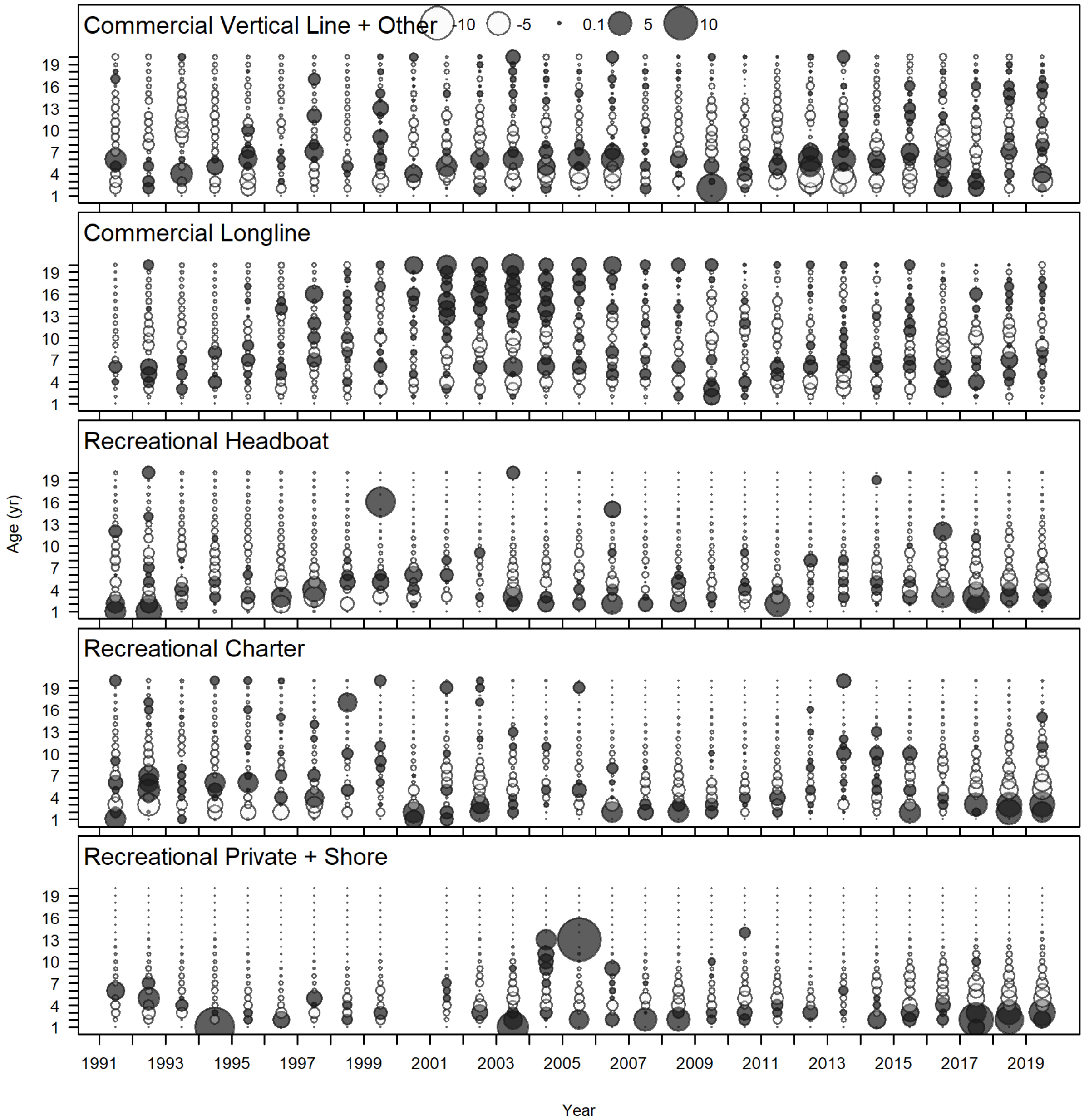


Figure 96. Pearson residuals for retained age composition data by year compared across fleets for Gulf of Mexico Gag Grouper for SEDAR72 (Upper panel) and SEDAR33 Update (Lower Panel). Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

SEDAR33 Update

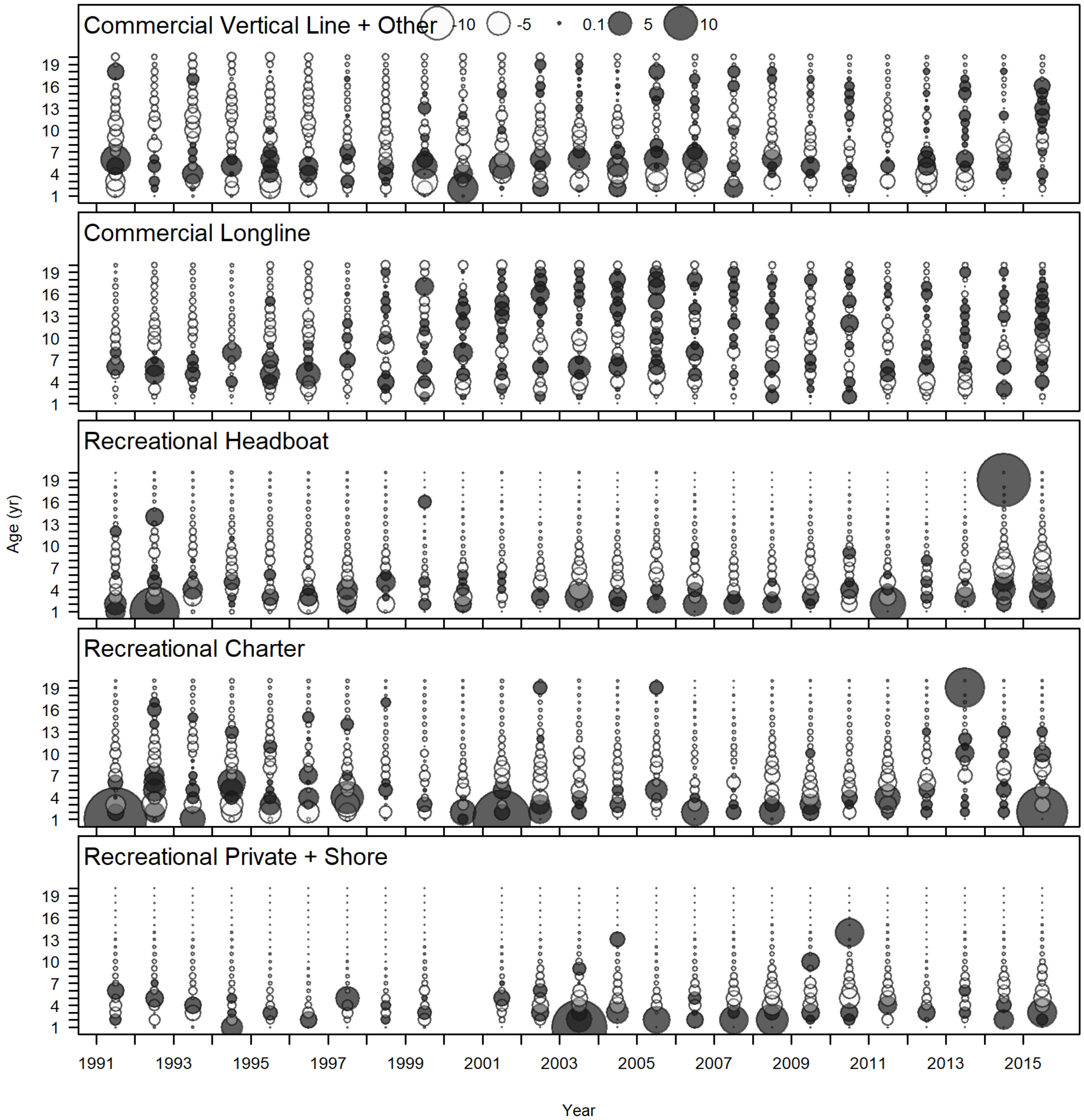


Figure 96 Continued. Pearson residuals for retained age composition data by year compared across fleets for Gulf of Mexico Gag Grouper for SEDAR72 (Upper panel) and SEDAR33 Update (Lower Panel). Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

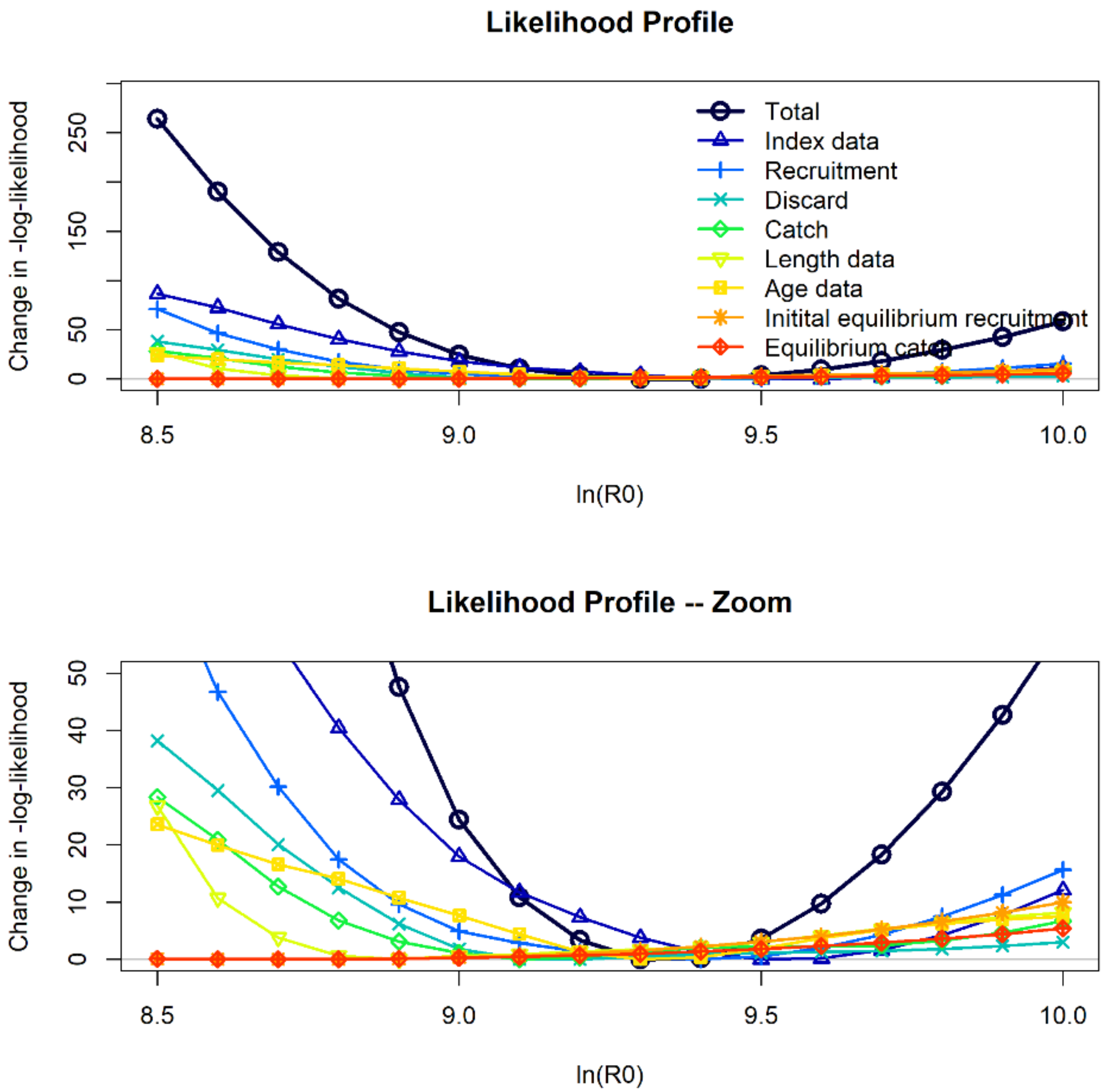


Figure 97. The profile likelihood for the natural log of the unfished recruitment parameter of the Beverton – Holt stock-recruit function for Gulf of Mexico Gag Grouper. Each line represents the change in negative log-likelihood value for each of the data sources fit in the model across the range of fixed steepness values tested in the profile diagnostic run. The MLE for the base model was 9.343. The bottom panel shows a close up of the top panel to better detect significant differences between runs.

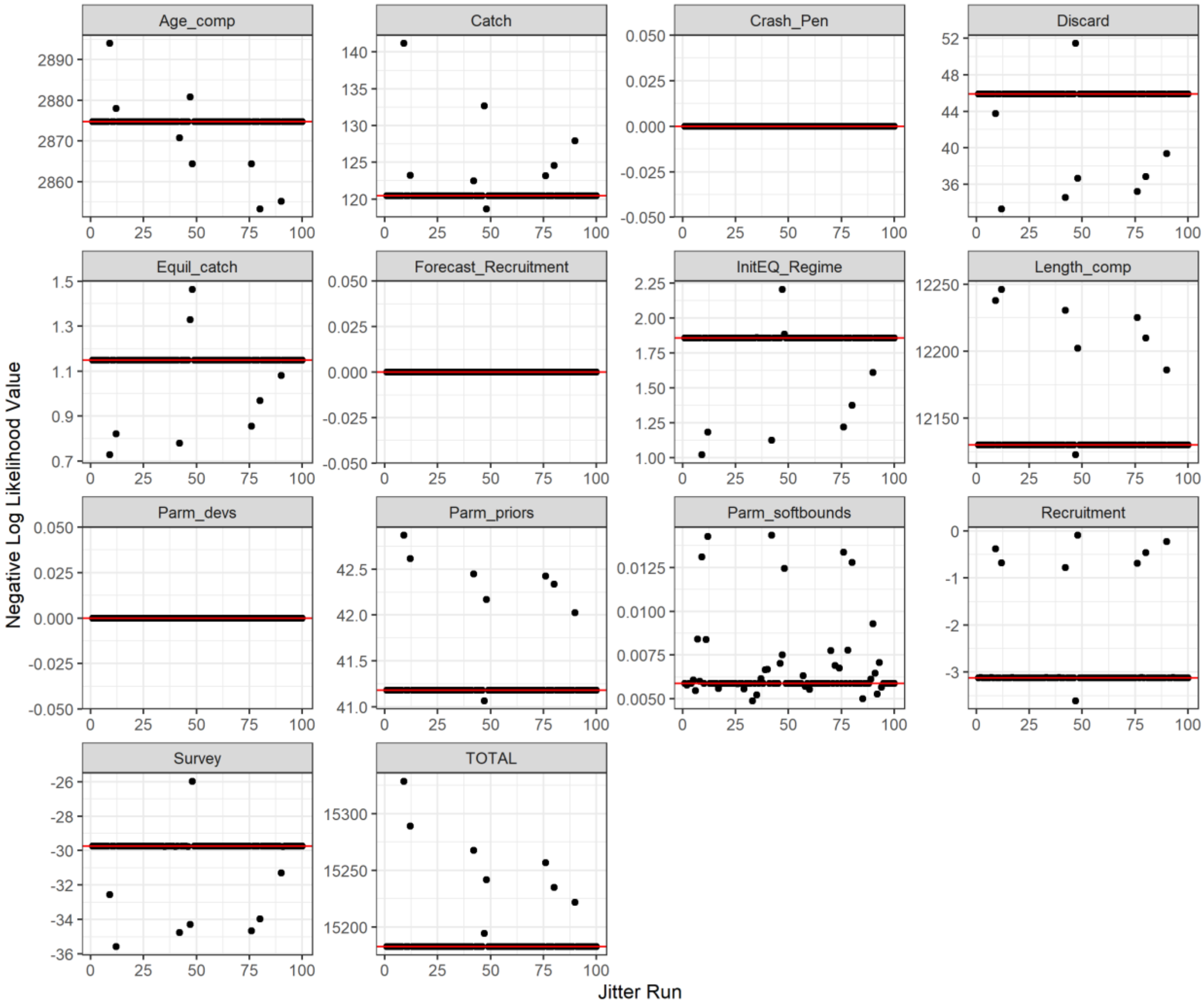


Figure 98. Results of the jitter analysis for various likelihood components for the Gulf of Mexico Gag Grouper Base Model. Each panel gives the results of 100 model runs where the starting parameter values for each run were randomly changed ('jittered') by 10% from the base model best fit values. The Base Run value for each panel is indicated by a red line.

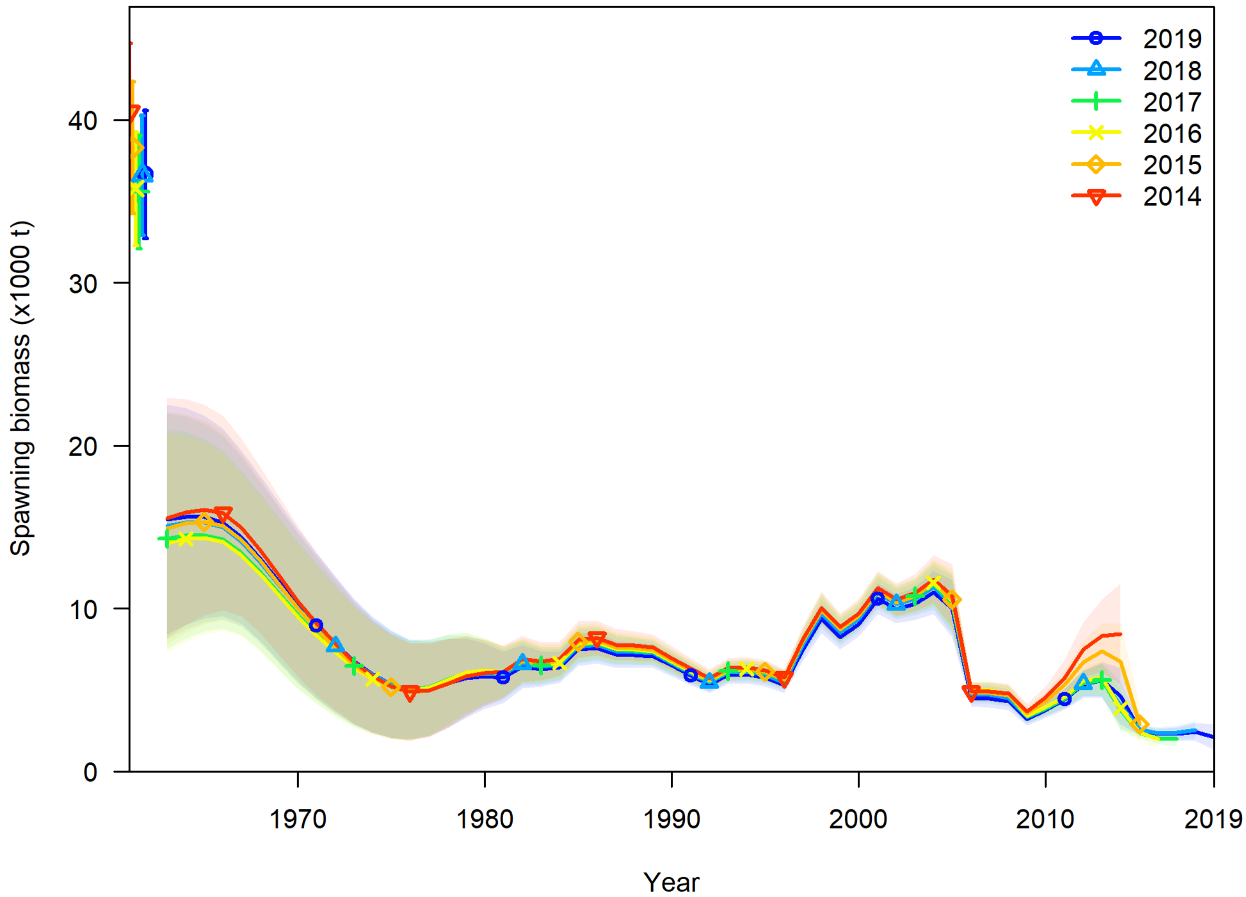


Figure 99. Results of a five year retrospective analysis for spawning biomass (metric tons) for the Gulf of Mexico Gag Grouper Base Model. There is no discernible systematic bias because each data peel is not consistently over or underestimating any of the population quantities. Mohn's $\rho = 0.149$ *– Mohn's ρ between -0.15 and +0.20 is within the acceptable range, see Hurtado-Ferro et al., 2015.*

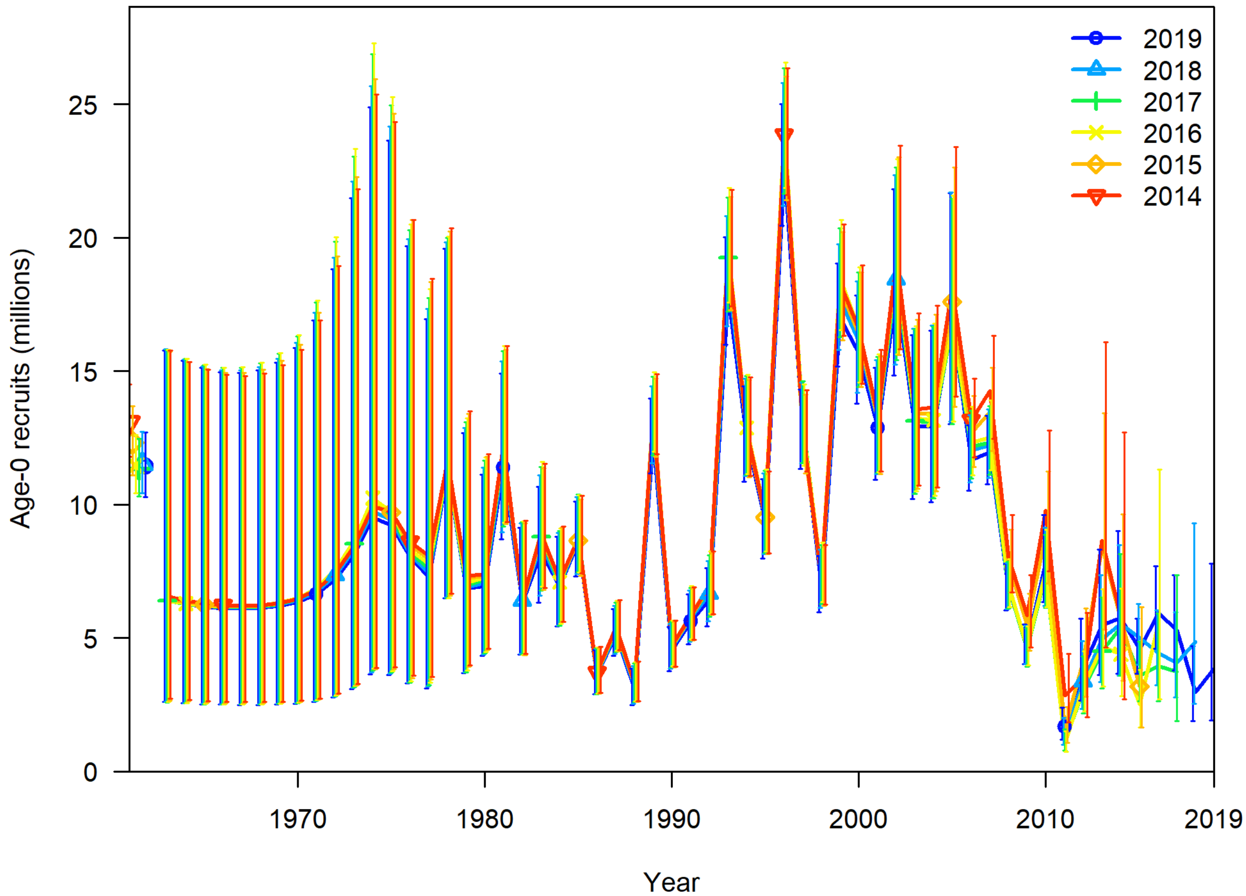


Figure 100. Results of a five year retrospective analysis for recruitment (millions of fish) for the Gulf of Mexico Gag Grouper Base Model. There is no discernible systematic bias because each data peel is not consistently over or underestimating any of the population quantities. Mohn's $\rho = -0.002$ *– Mohn's ρ between -0.15 and +0.20 is within the acceptable range, see Hurtado-Ferro et al., 2015.*

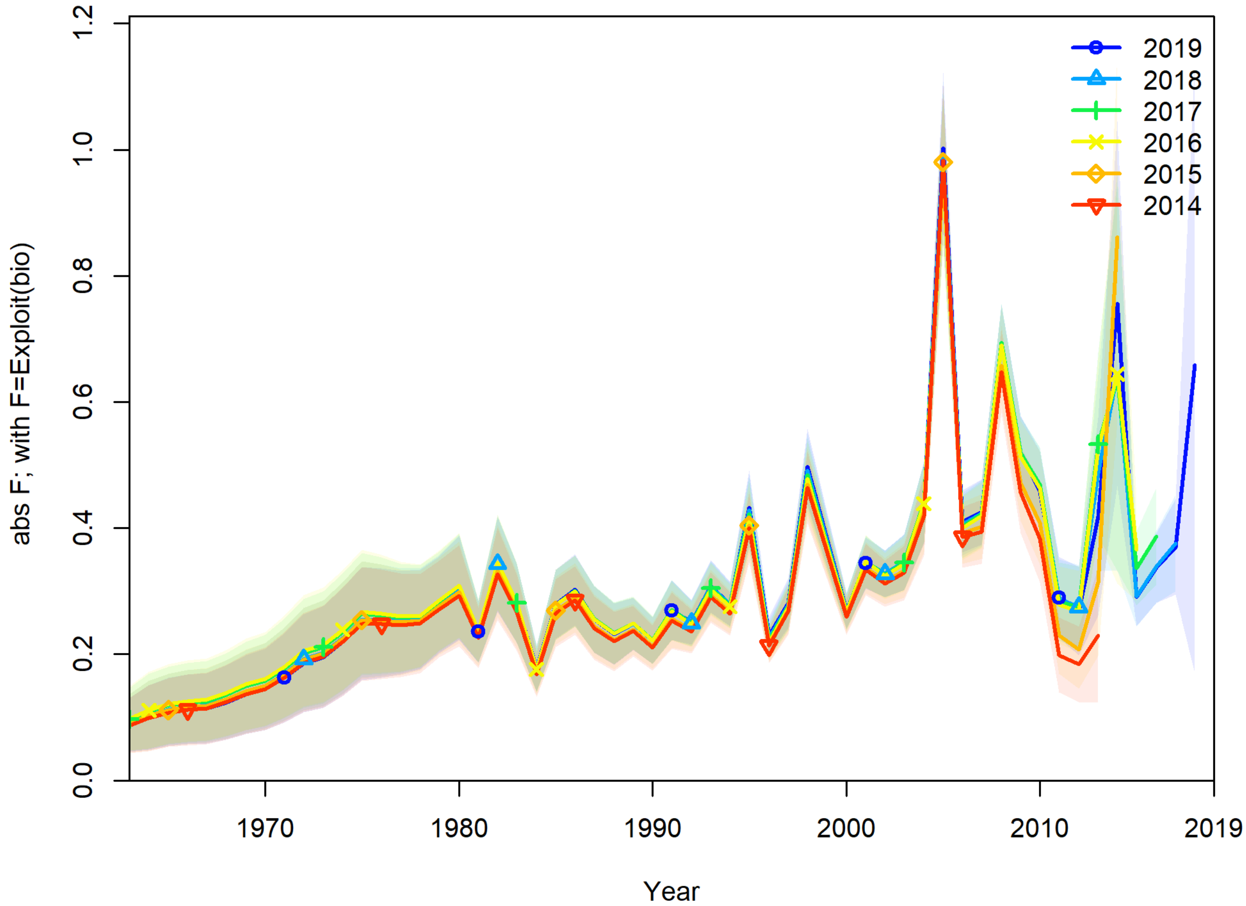


Figure 101. Results of a five year retrospective analysis for spawning biomass fishing mortality (total biomass killed age 3+ / total biomass age 3+; bottom panel) for the Gulf of Mexico Gag Grouper Base Model. There is no discernible systematic bias because each data peel is not consistently over or underestimating any of the population quantities. Mohn's $\rho = 0.043$ – Mohn's ρ between -0.15 and +0.20 is within the acceptable range, see Hurtado-Ferro et al., 2015.

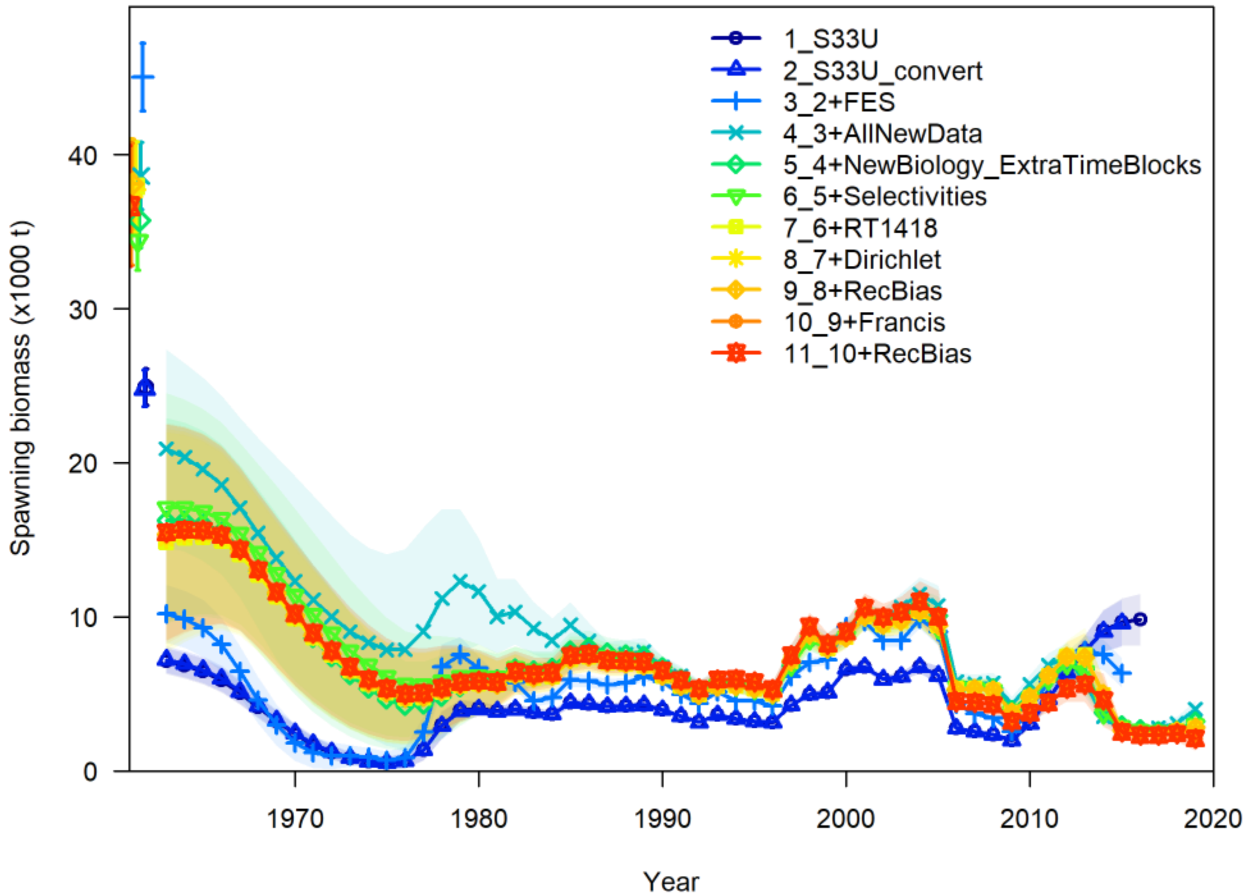


Figure 102. Bridging analysis showing changes in estimates of SBB (female-only) and associated uncertainty through each major step of model building between SEDAR33 Update and SEDAR72.

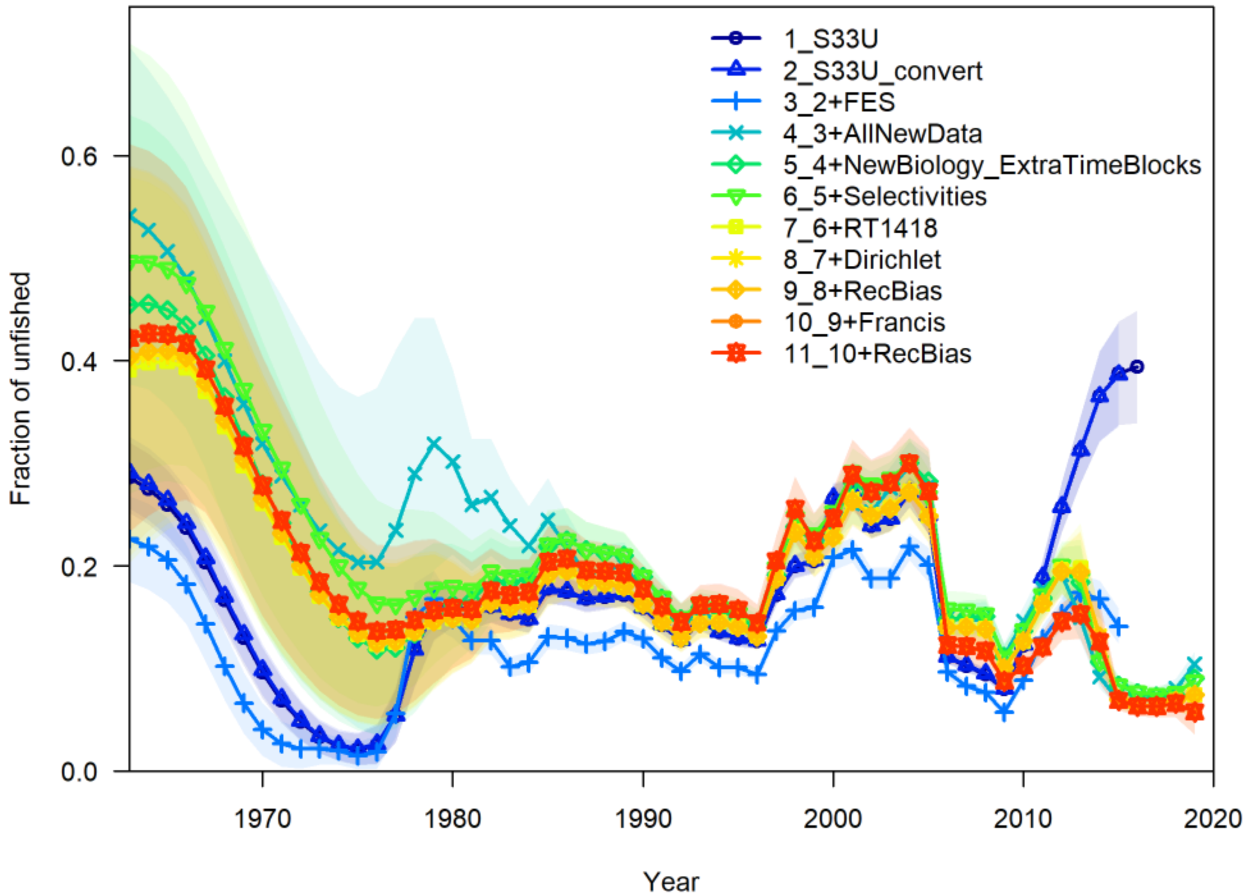


Figure 103. Bridging analysis showing changes in estimates of fraction unfished and associated uncertainty through each major step of model building between SEDAR33 Update and SEDAR72.

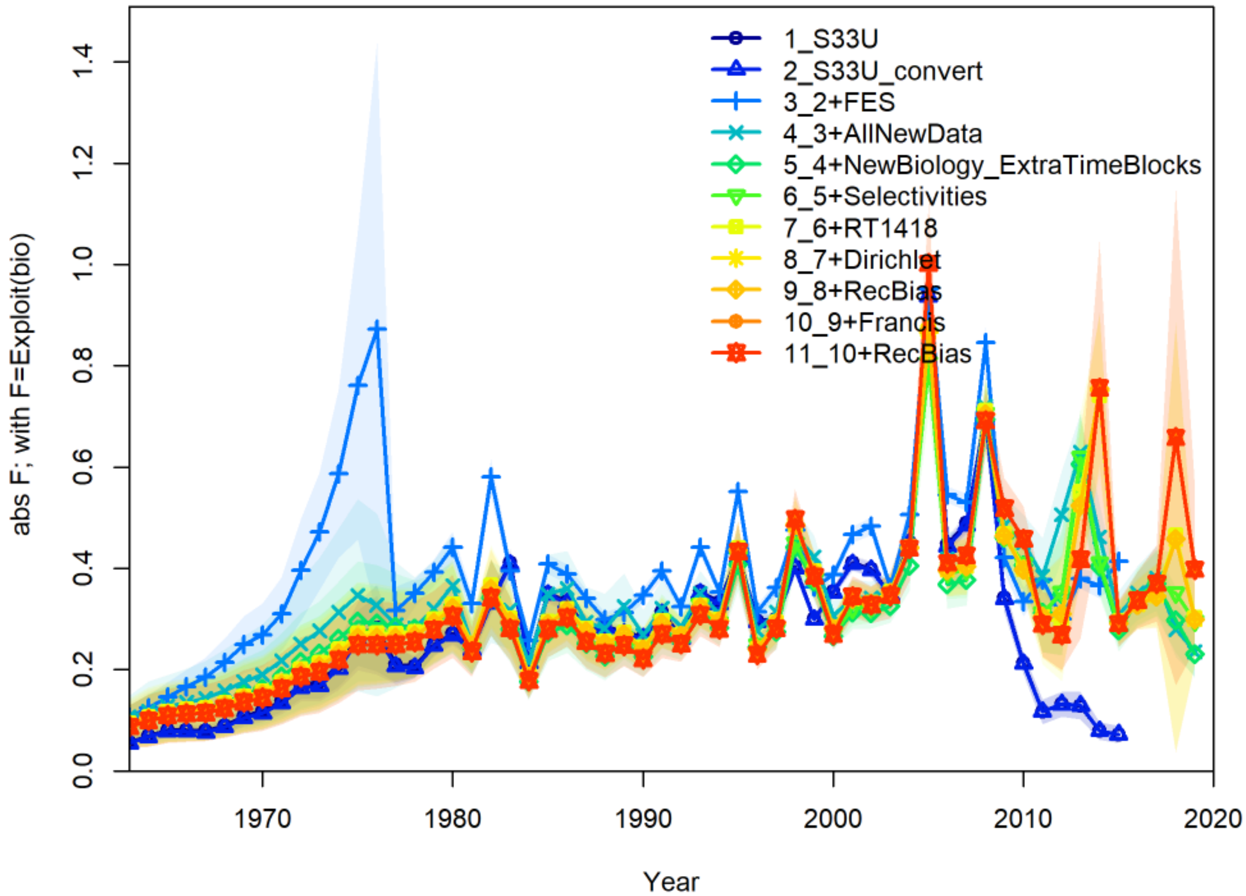


Figure 104. Bridging analysis showing changes in estimates of annual exploitation rates (total biomass killed age 3+ / total biomass age 3+) and associated uncertainty through each major step of model building between SEDAR33 Update and SEDAR72.

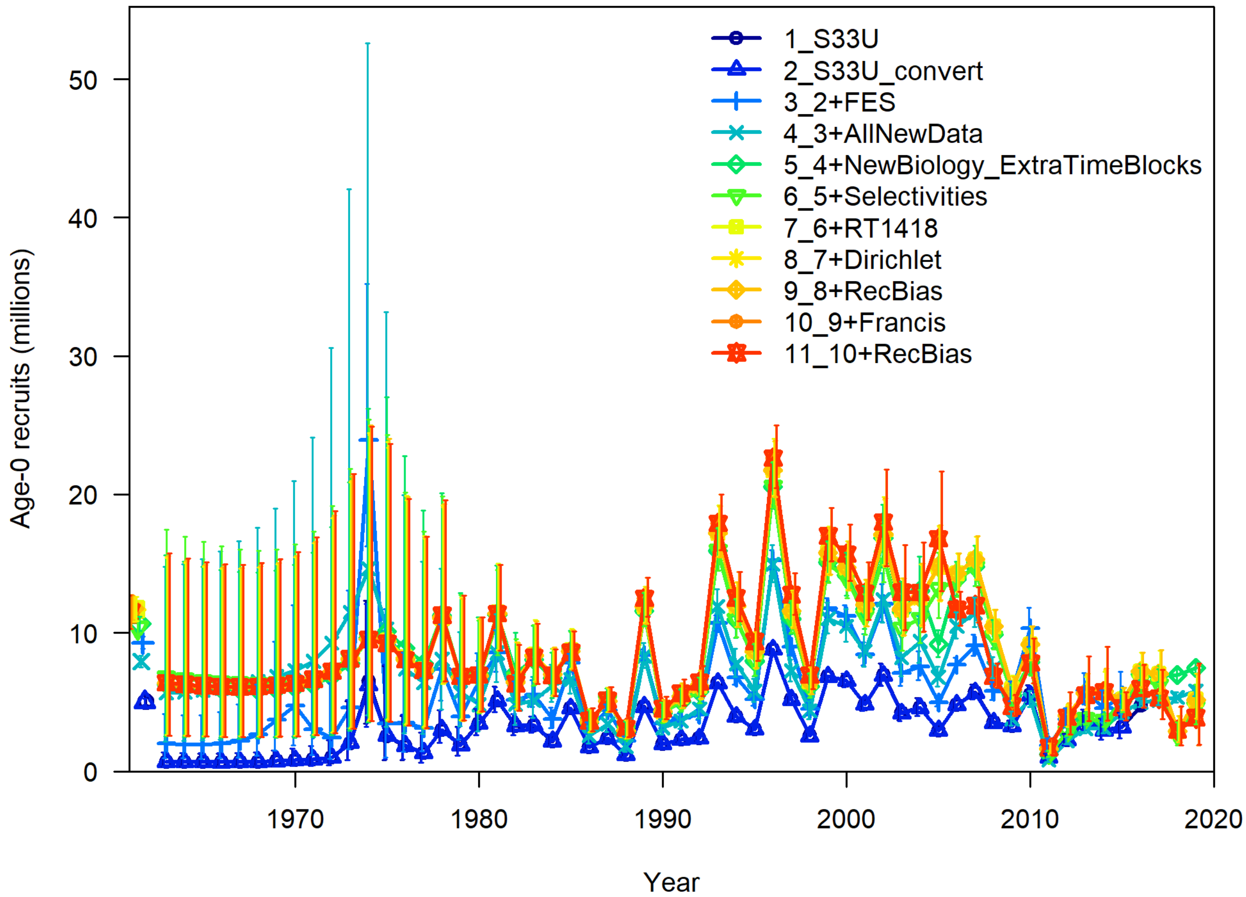


Figure 105. Bridging analysis showing changes in estimates of annual recruitment and associated uncertainty through each major step of model building between SEDAR33 Update and SEDAR72.

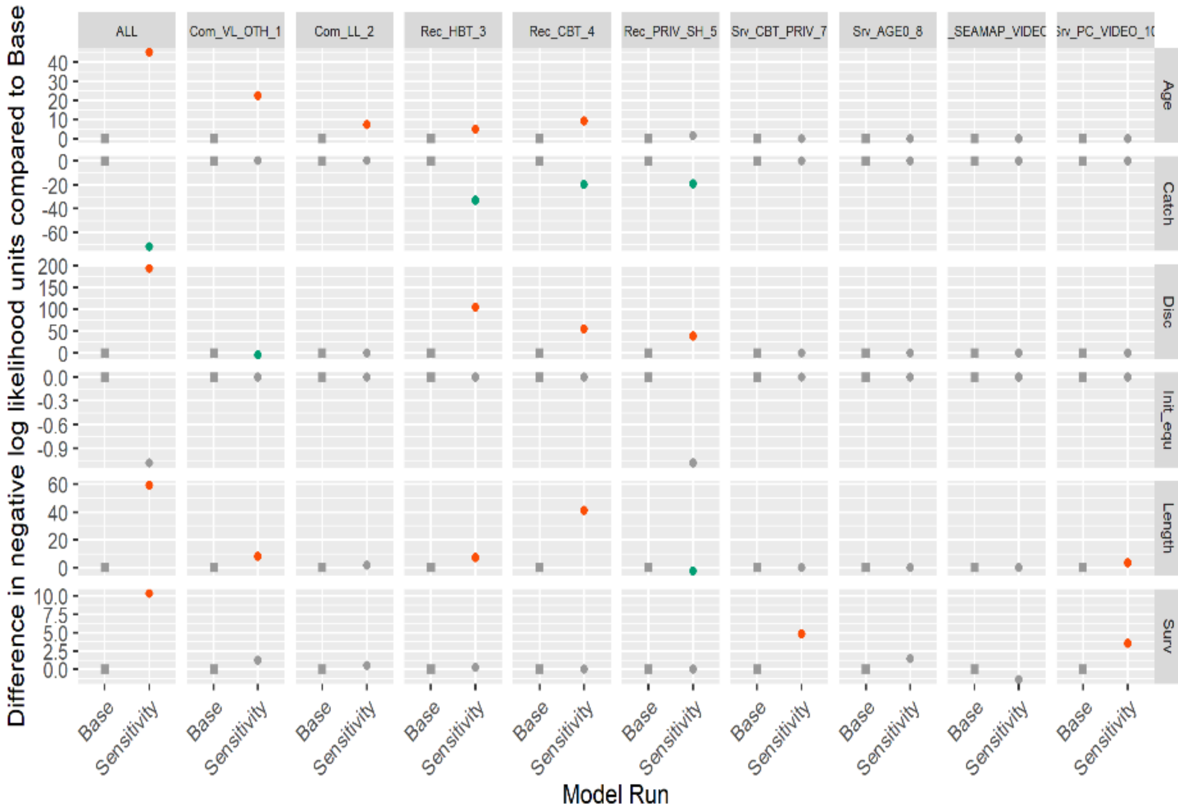


Figure 106. Changes in negative log likelihood values by likelihood component between the SEDAR72 Base Run and the 0.05 CV on recreational landings sensitivity run. Green dots signal improvement in fit, red dots signal degradation in fit, grey dots show no significant difference in fit.

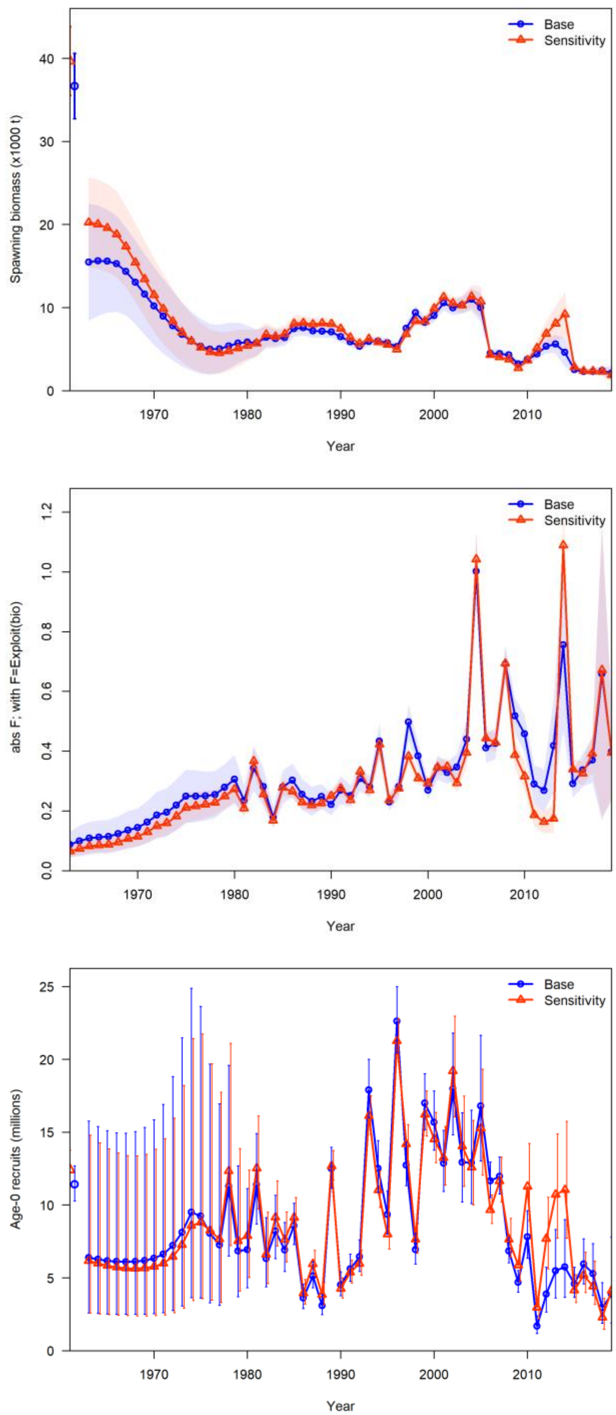


Figure 107. Differences in SSB estimates (top panel), annual exploitation rates (total biomass killed age 3+ / total biomass age 3+) (middle panel) and annual recruitment (bottom panel), and associated uncertainty between the SEDAR72 Base Run and the 0.05 CV on recreational landings sensitivity run.

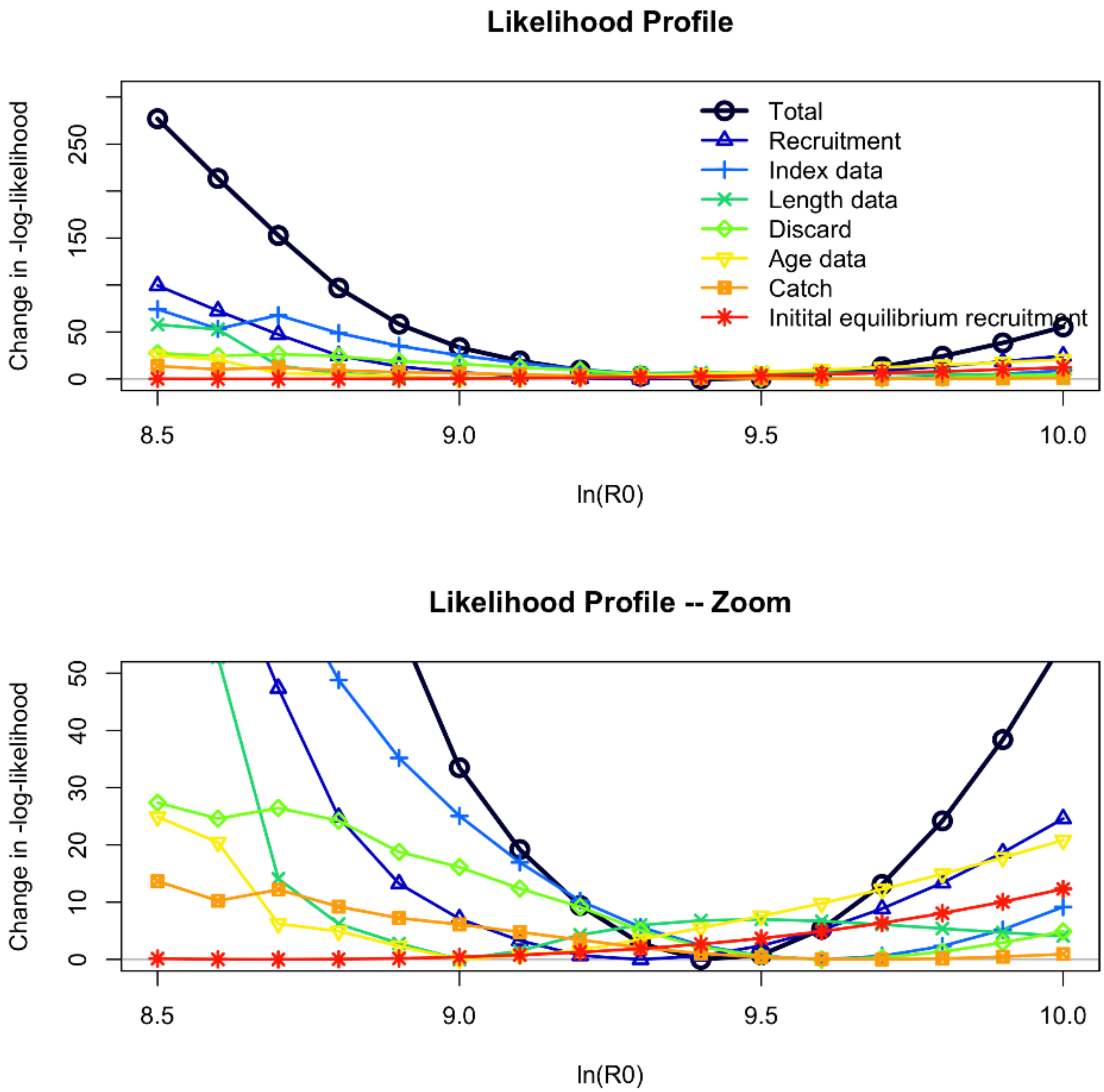


Figure 108. The profile likelihood for the natural log of the unfished recruitment parameter of the Beverton – Holt stock-recruit function for Gulf of Mexico Gag Grouper assuming a tighter CV (0.05) on Recreational catches. Each line represents the change in negative log-likelihood value for each of the data sources fit in the model across the range of fixed steepness values tested in the profile diagnostic run.

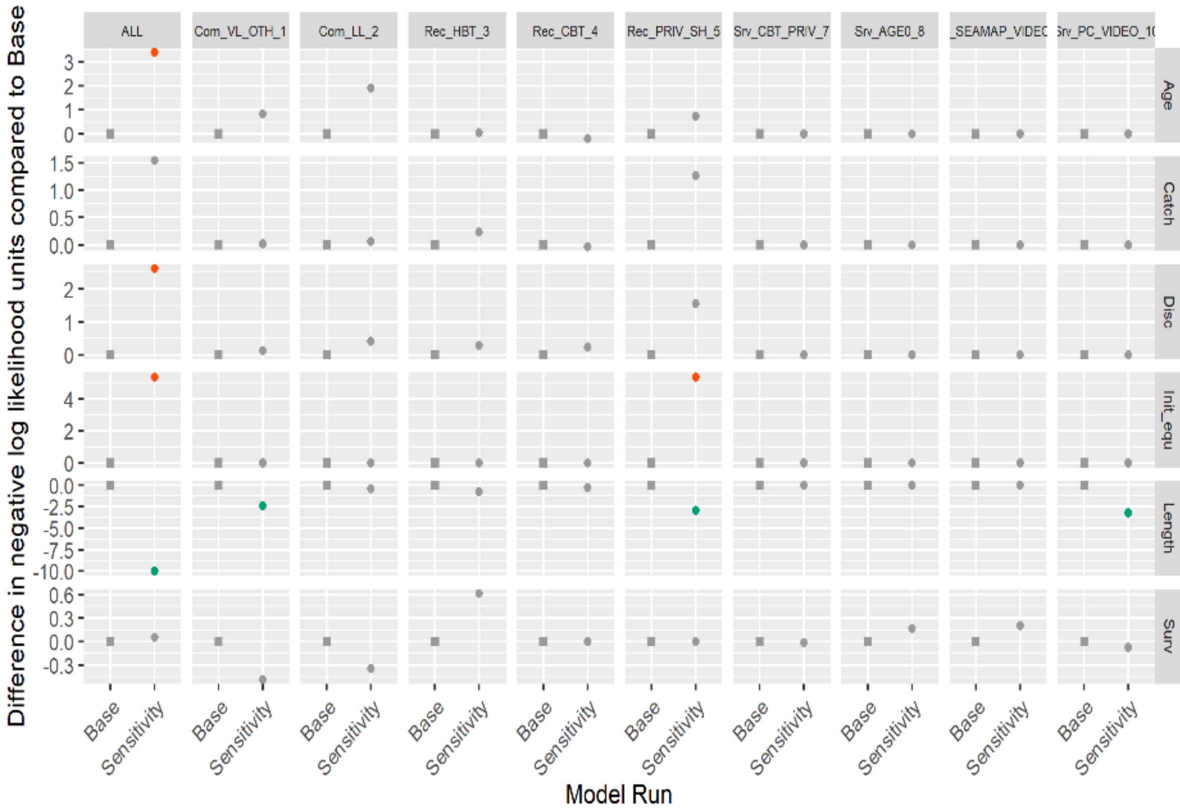


Figure 109. Changes in negative log likelihood values by likelihood component between the SEDAR72 Base Run and the SEDAR33 natural mortality sensitivity run. Green dots signal improvement in fit, red dots signal degradation in fit, grey dots show no significant difference in fit.

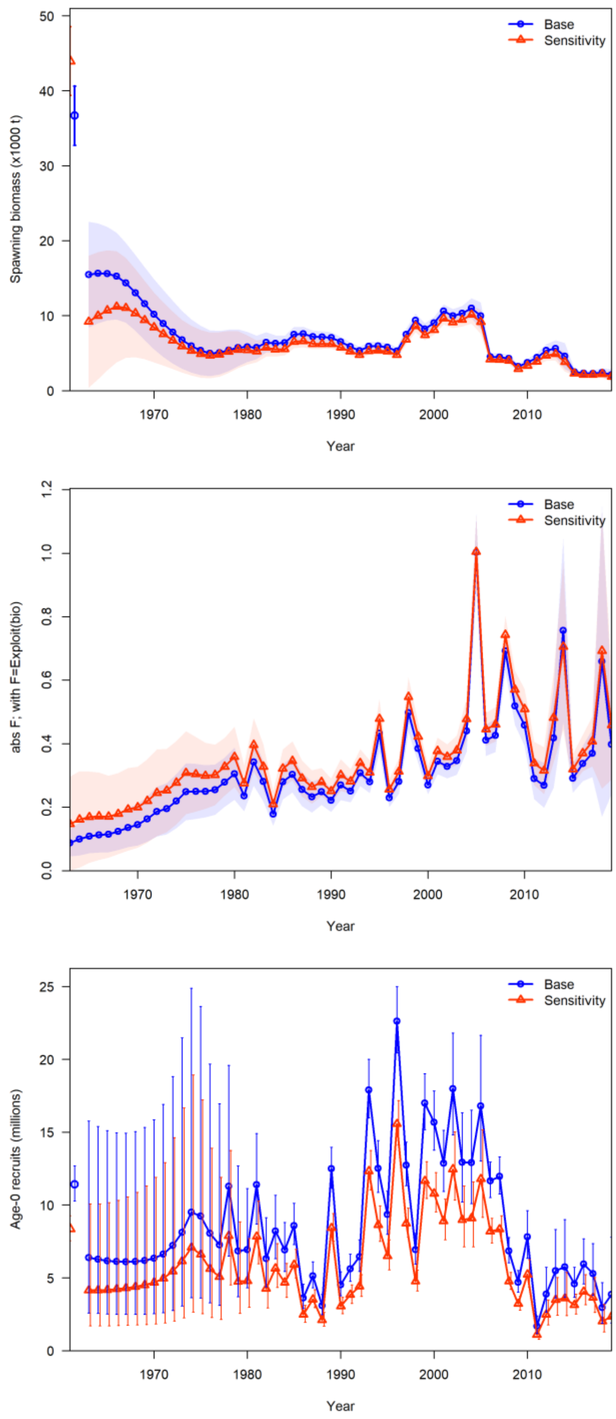


Figure 110. Differences in SSB estimates (top panel), annual exploitation rates (total biomass killed age 3+ / total biomass age 3+) (middle panel) and annual recruitment (bottom panel), and associated uncertainty between the SEDAR72 Base Run and the SEDAR33 natural mortality sensitivity run.

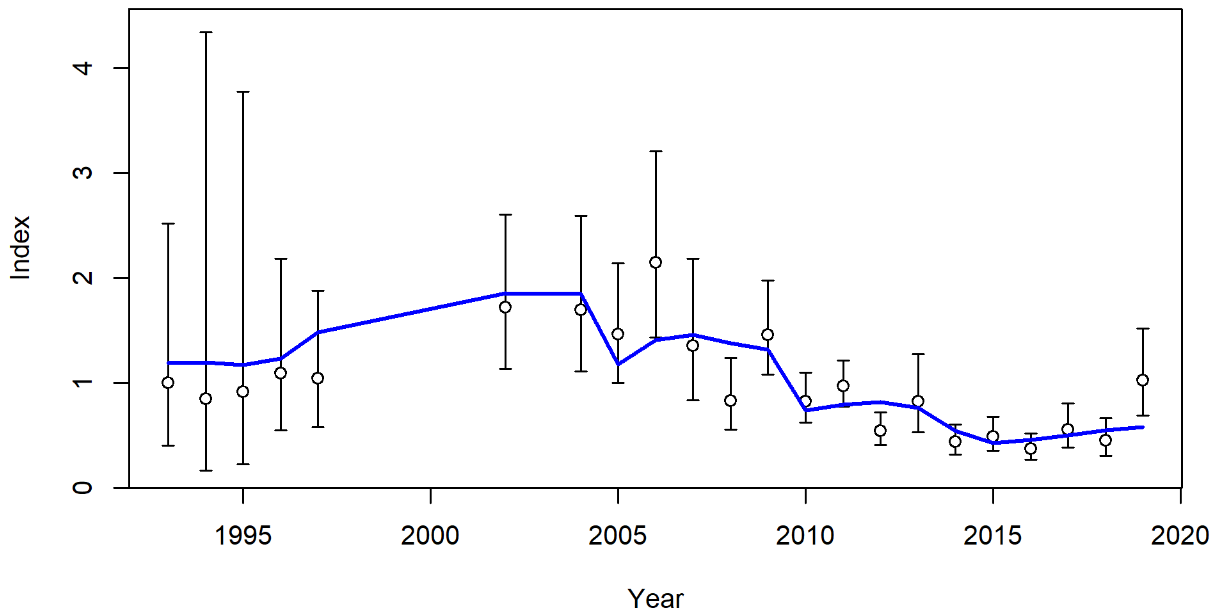


Figure 111. Fit (blue) to the Combine Video Survey index and associated 95% uncertainty interval (after addition of estimated additional uncertainty parameter).

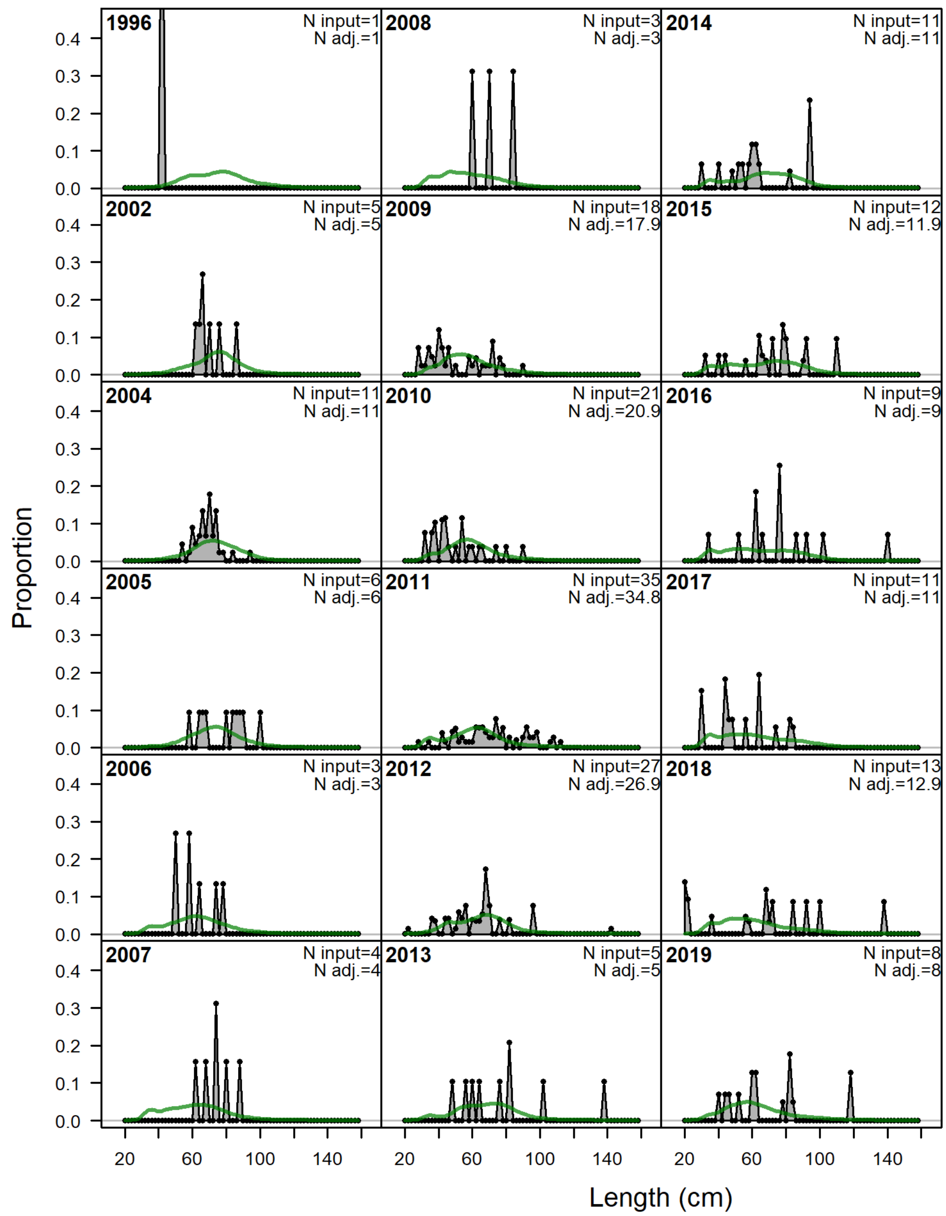


Figure 112. Observed and predicted length compositions (retained) for Gulf of Mexico Gag Grouper in the Combined Video Survey. Green lines represent predicted length compositions, while grey shaded regions represent observed length compositions. 'N input' is the input sample size and 'N adj.' is the sample size after adjustment by the Dirichlet-Multinomial parameter.

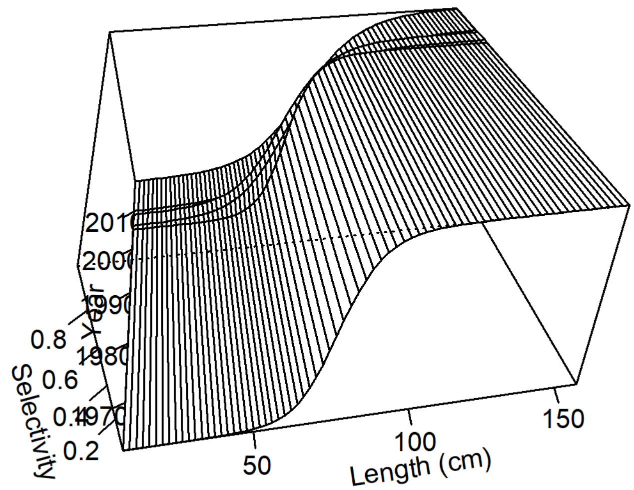


Figure 113. Time varying selectivity estimated for the three blocks of the Combined Video Survey Index.

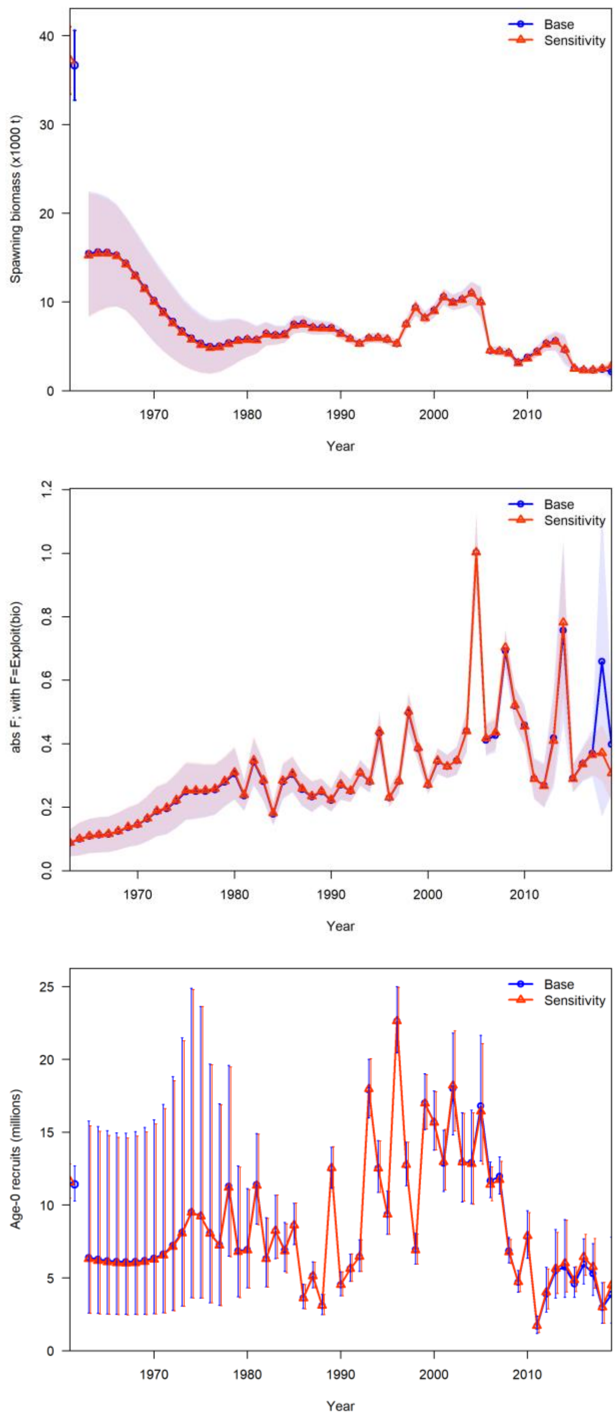


Figure 114. Differences in SSB estimates (top panel), annual exploitation rates (total biomass killed age 3+ / total biomass age 3+) (middle panel) and annual recruitment (bottom panel), and associated uncertainty between the SEDAR72 Base Run and the Combined Video sensitivity run.

Figure 115. Changes in negative log likelihood values by likelihood component between the SEDAR72 Base Run and the Private + Shore Fleet retention sensitivity run. Green dots signal improvement in fit, red dots signal degradation in fit, grey dots show no significant difference in fit.

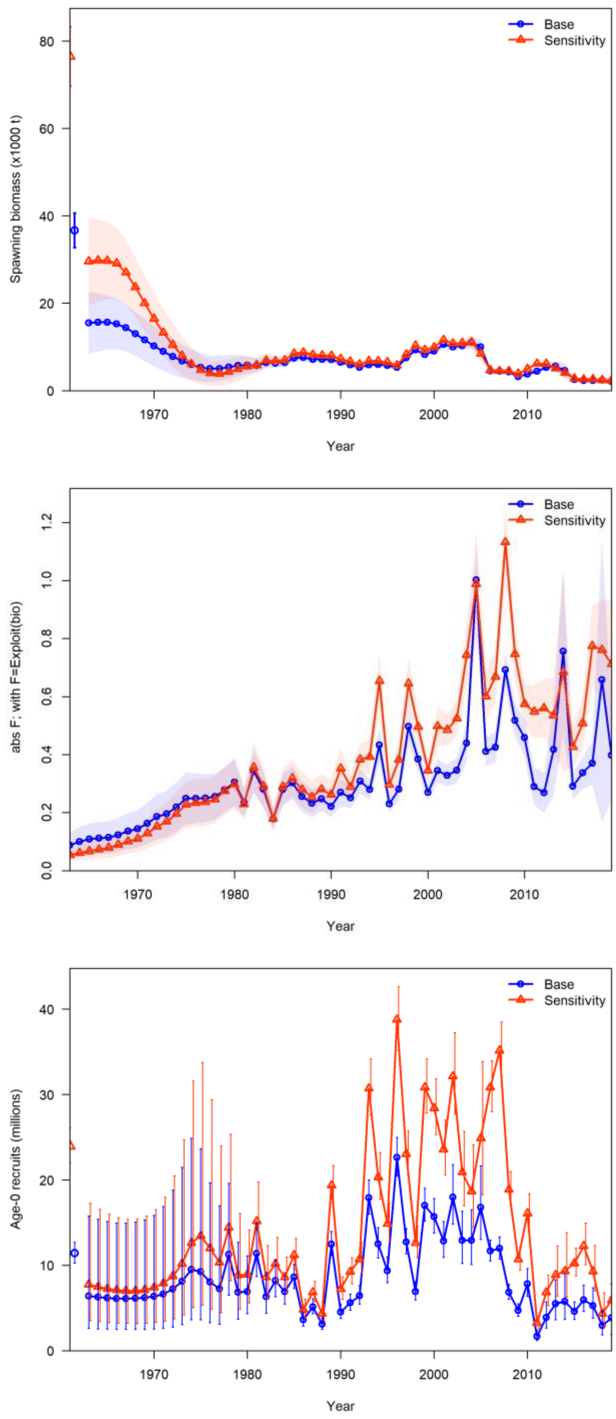


Figure 116. Differences in SSB estimates (top panel), annual exploitation rates (total biomass killed age 3+ / total biomass age 3+) (middle panel) and annual recruitment (bottom panel), and associated uncertainty between the SEDAR72 Base Run and the Private Fleet Retention sensitivity run.

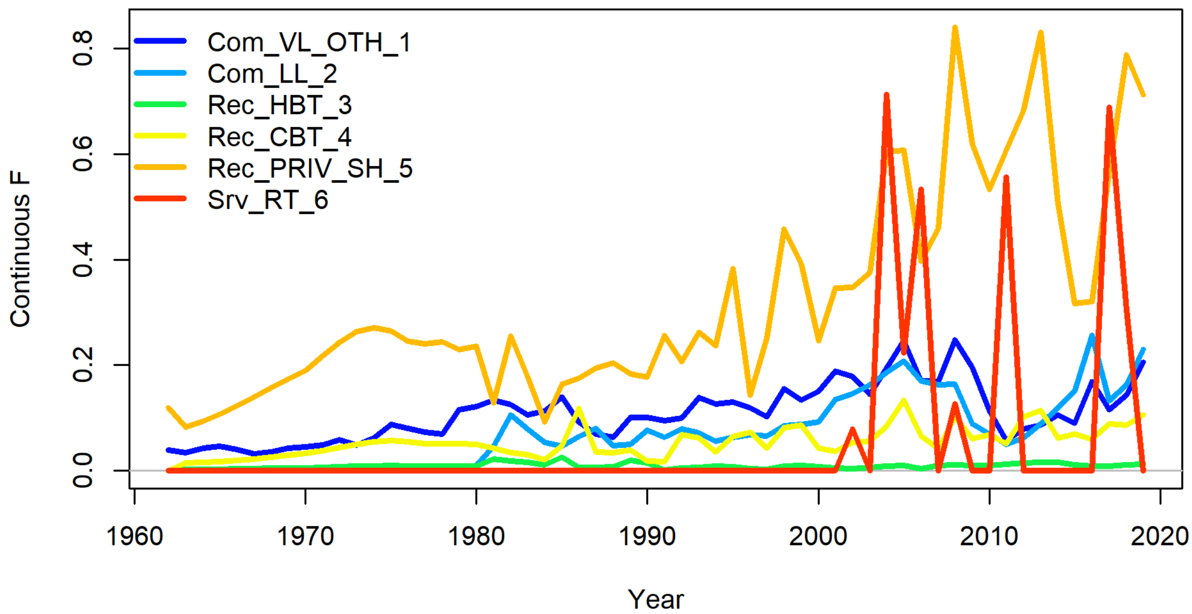


Figure 117. Apical Fs (i.e. fishing mortality rate for fully-selected fish) by fleet in the Red Tide Selectivity sensitivity run.

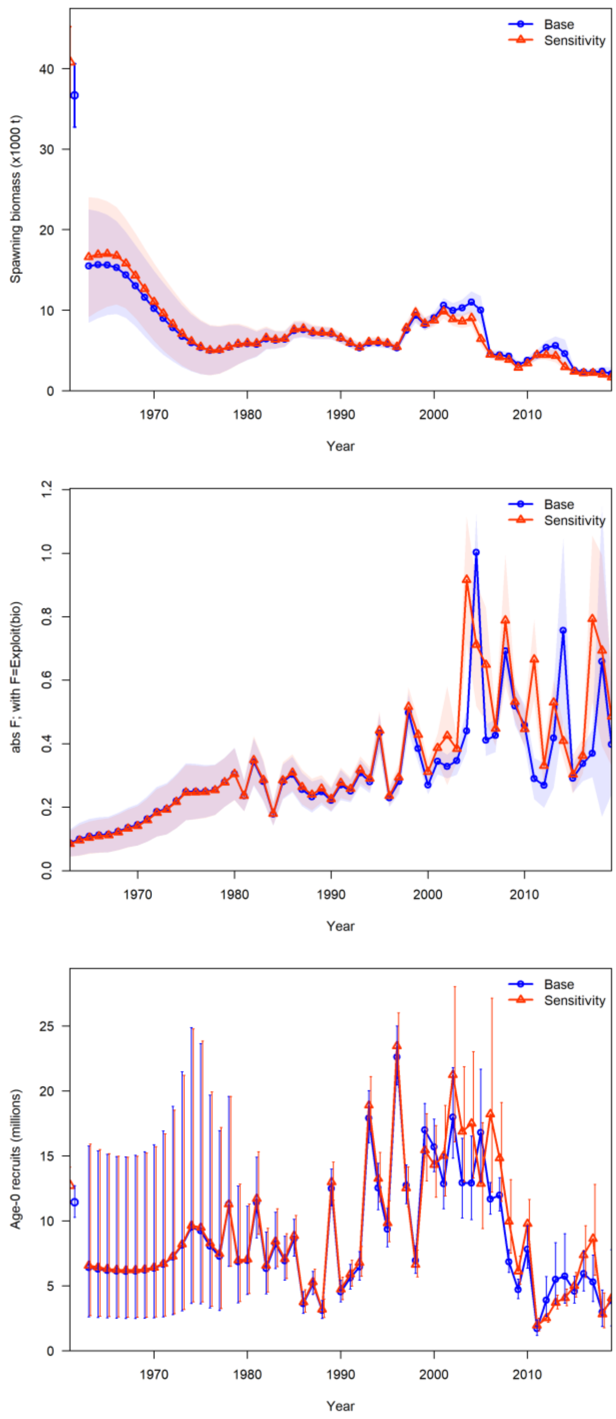


Figure 118. Differences in SSB estimates (top panel), annual exploitation rates (total biomass killed age 3+ / total biomass age 3+) (middle panel) and annual recruitment (bottom panel), and associated uncertainty between the SEDAR72 Base Run and the Red Tide Selectivity sensitivity run.

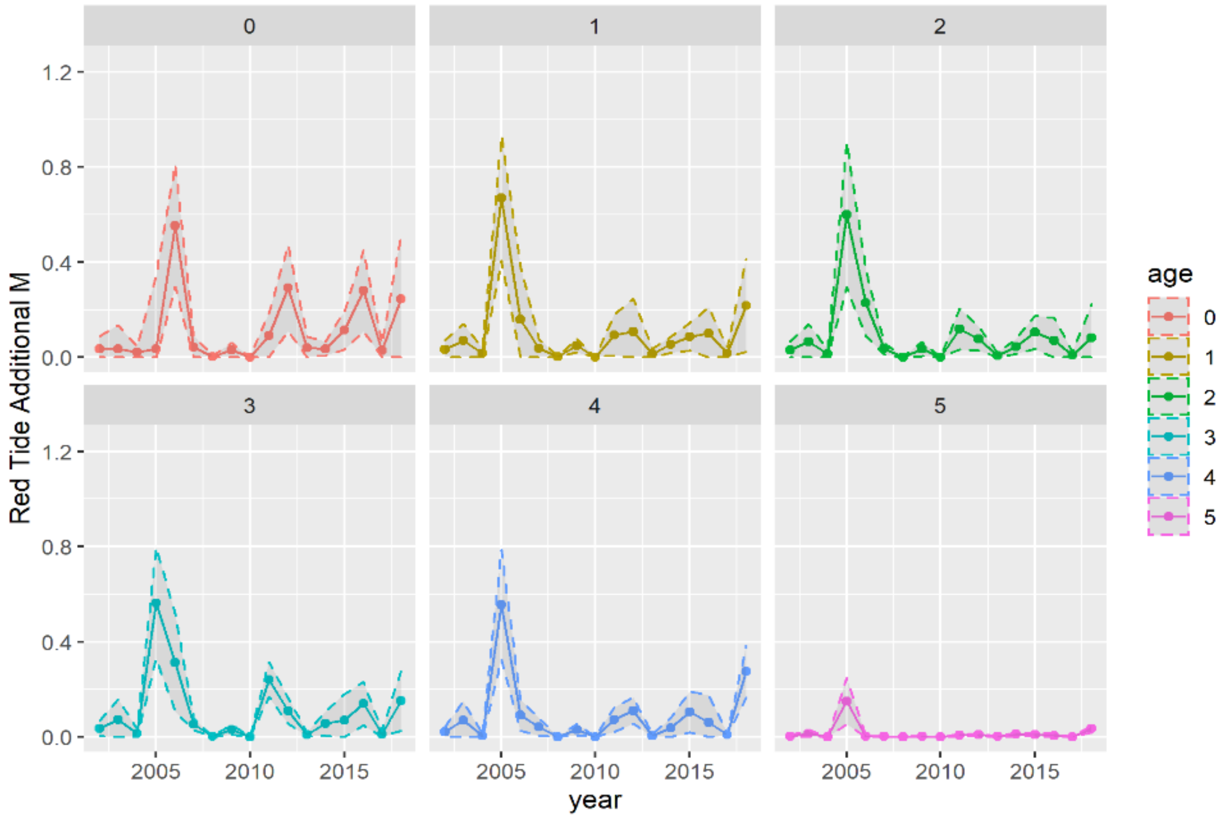


Figure 119. Red tide mortality-at-age estimated in the Red Tide Time Blocks on M sensitivity run. The estimated values did not stray far from the prior means (see SEDAR72-WP-01 for input values).

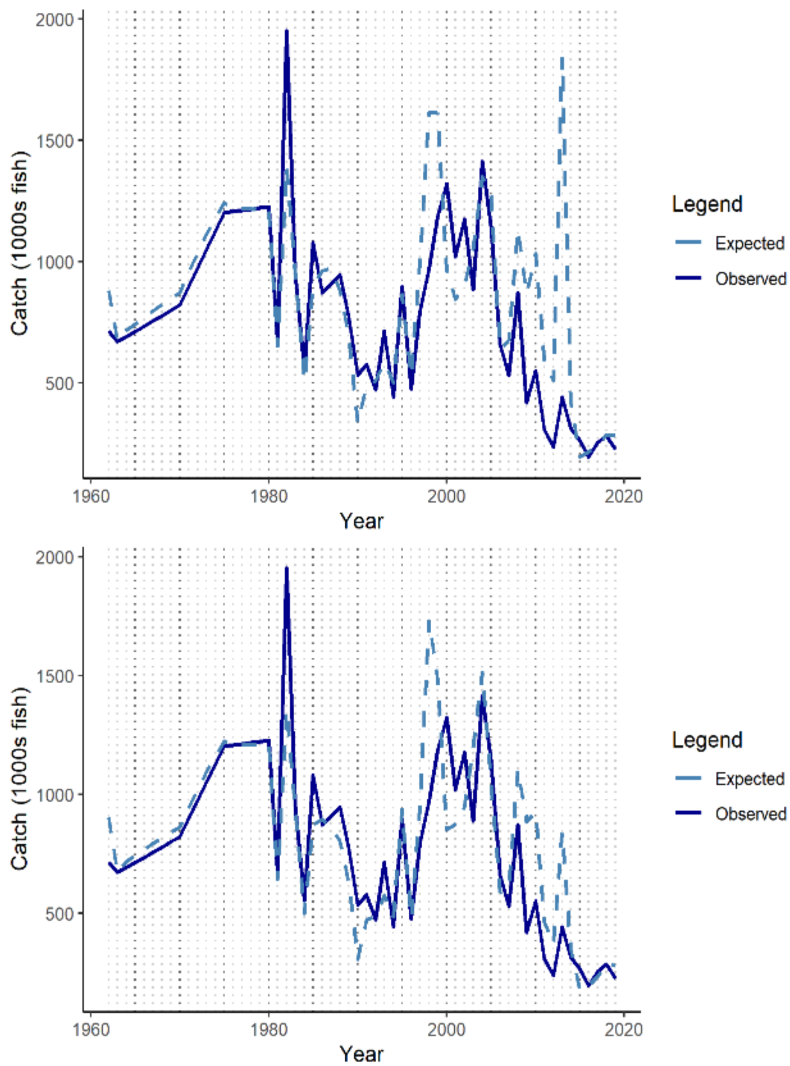


Figure 120. Observed and expected landings from the Recreational Private + Shore fleet between the Red Tide Time Blocks on M sensitivity run (top panel) and the Base Run (bottom panel).

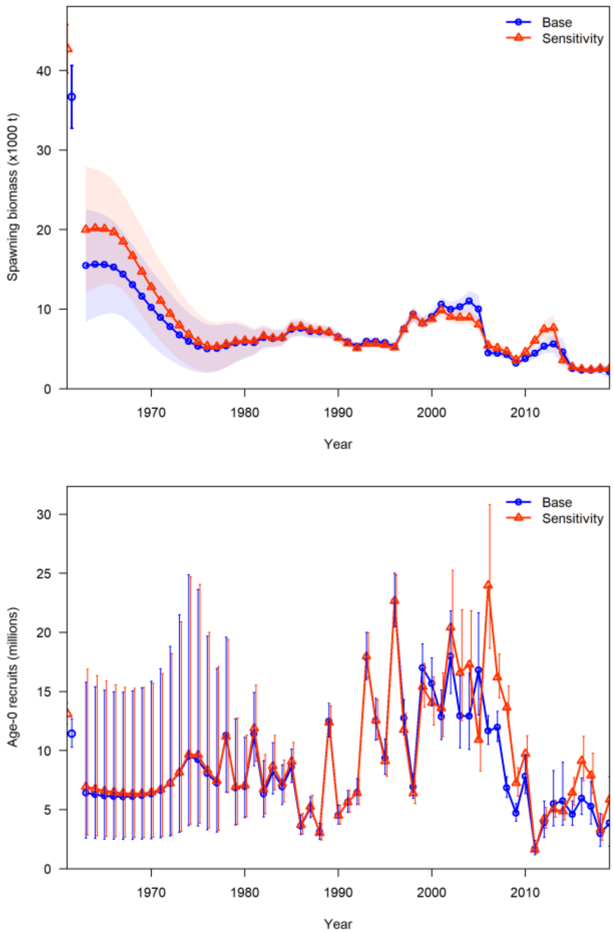


Figure 121. Differences in SSB estimates (top panel), annual exploitation rates (total biomass killed age 3+ / total biomass age 3+) (middle panel) and annual recruitment (bottom panel), and associated uncertainty between the SEDAR72 Base Run and the Red Tide Time Blocks on M sensitivity run. Note: the exploitation rates are not directly comparable between runs and thus not shown.

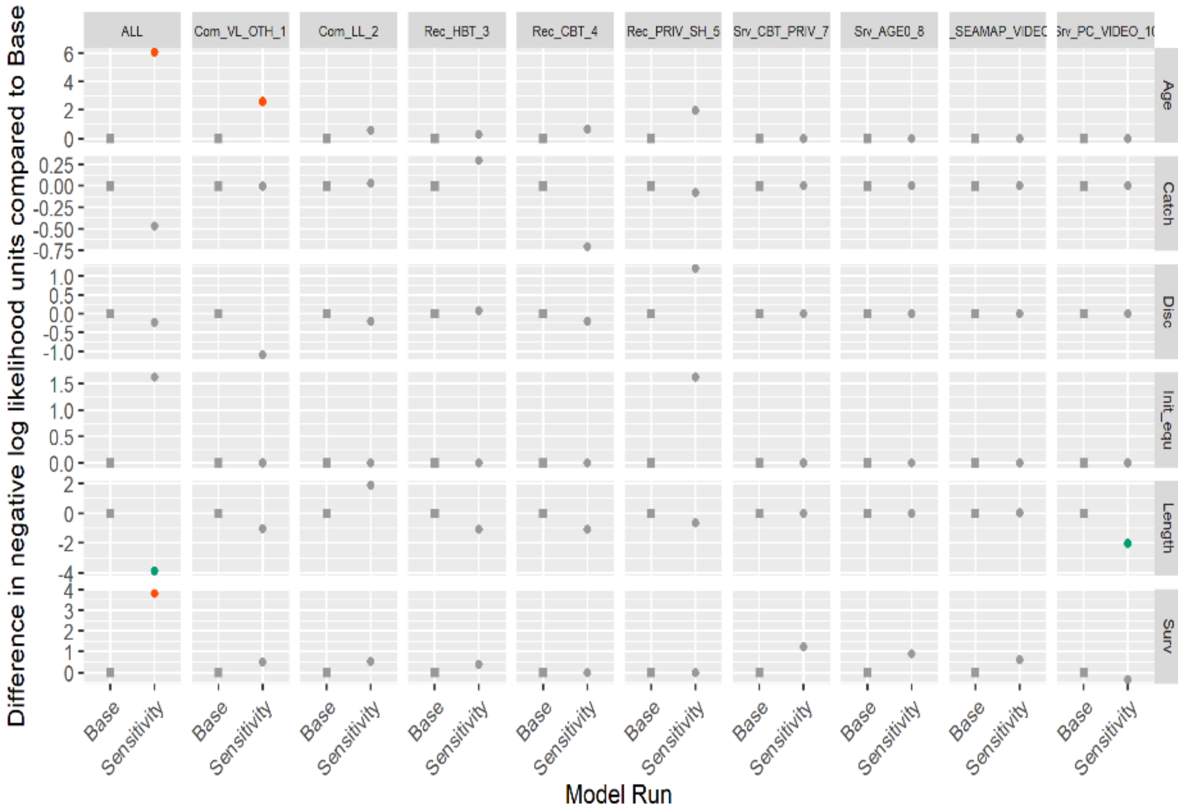


Figure 122. Changes in negative log likelihood values by likelihood component between the SEDAR72 Base Run and the SSB combined sensitivity run. Green dots signal improvement in fit, red dots signal degradation in fit, grey dots show no significant difference in fit.

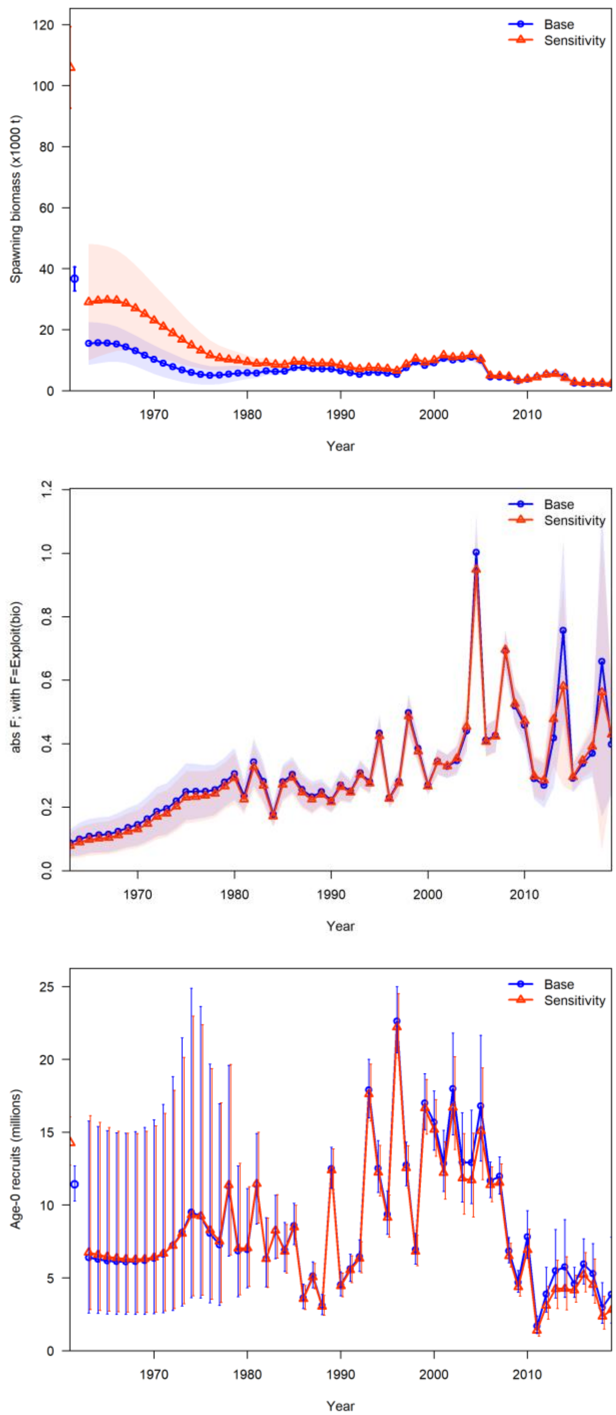


Figure 123. Differences in SSB estimates (top panel), annual exploitation rates (total biomass killed age 3+ / total biomass age 3+) (middle panel) and annual recruitment (bottom panel), and associated uncertainty between the SEDAR72 Base Run and the SSB combined sensitivity run.

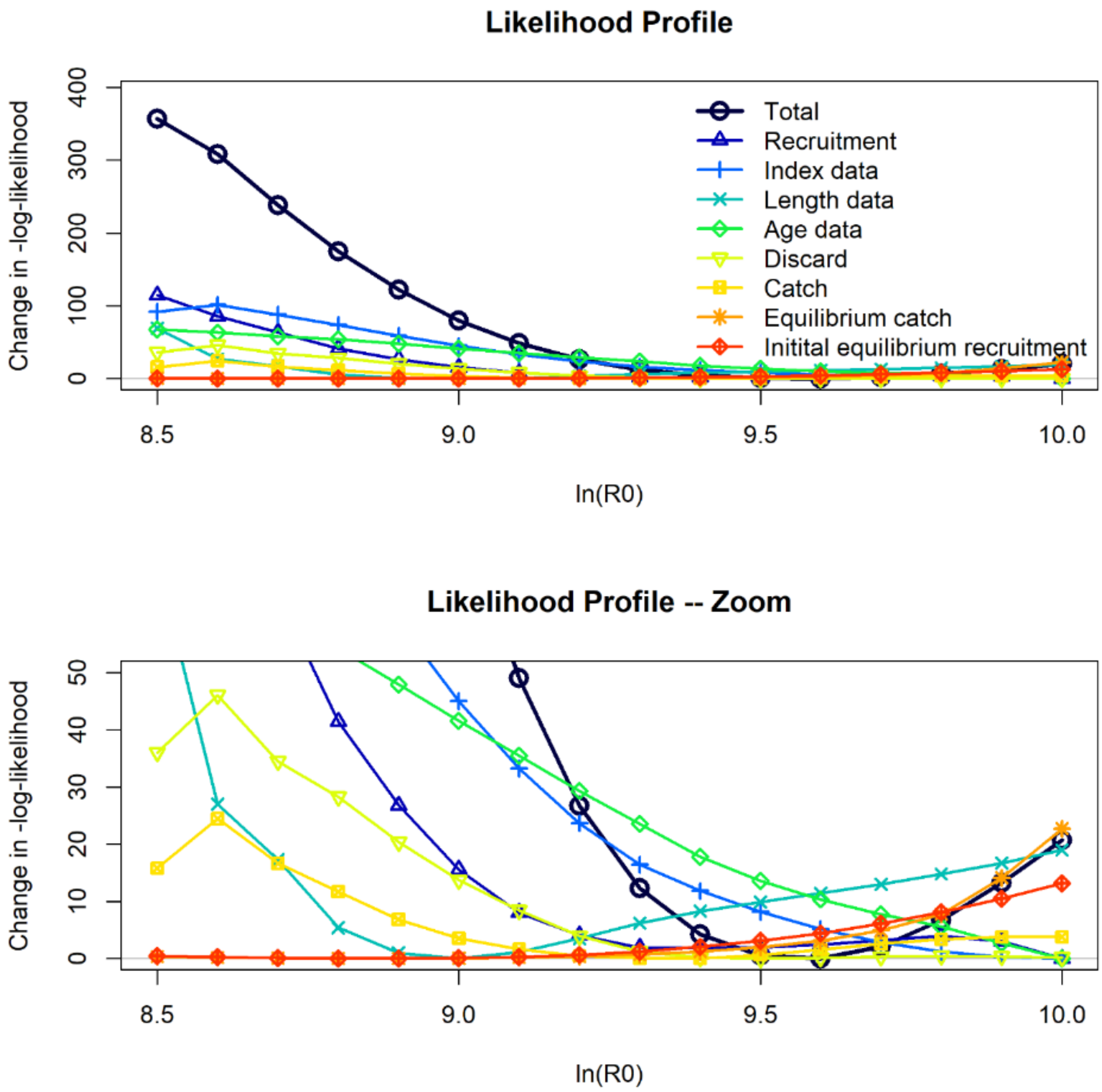


*Figure 124. The profile likelihood for the natural log of the unfished recruitment parameter of the Beverton – Holt stock-recruit function for Gulf of Mexico Gag Grouper for the **SSB combined** sensitivity run. Each line represents the change in negative log-likelihood value for each of the data sources fit in the model across the range of fixed steepness values tested in the profile diagnostic run. The bottom panel shows a close up of the top panel to better detect significant differences between runs.*

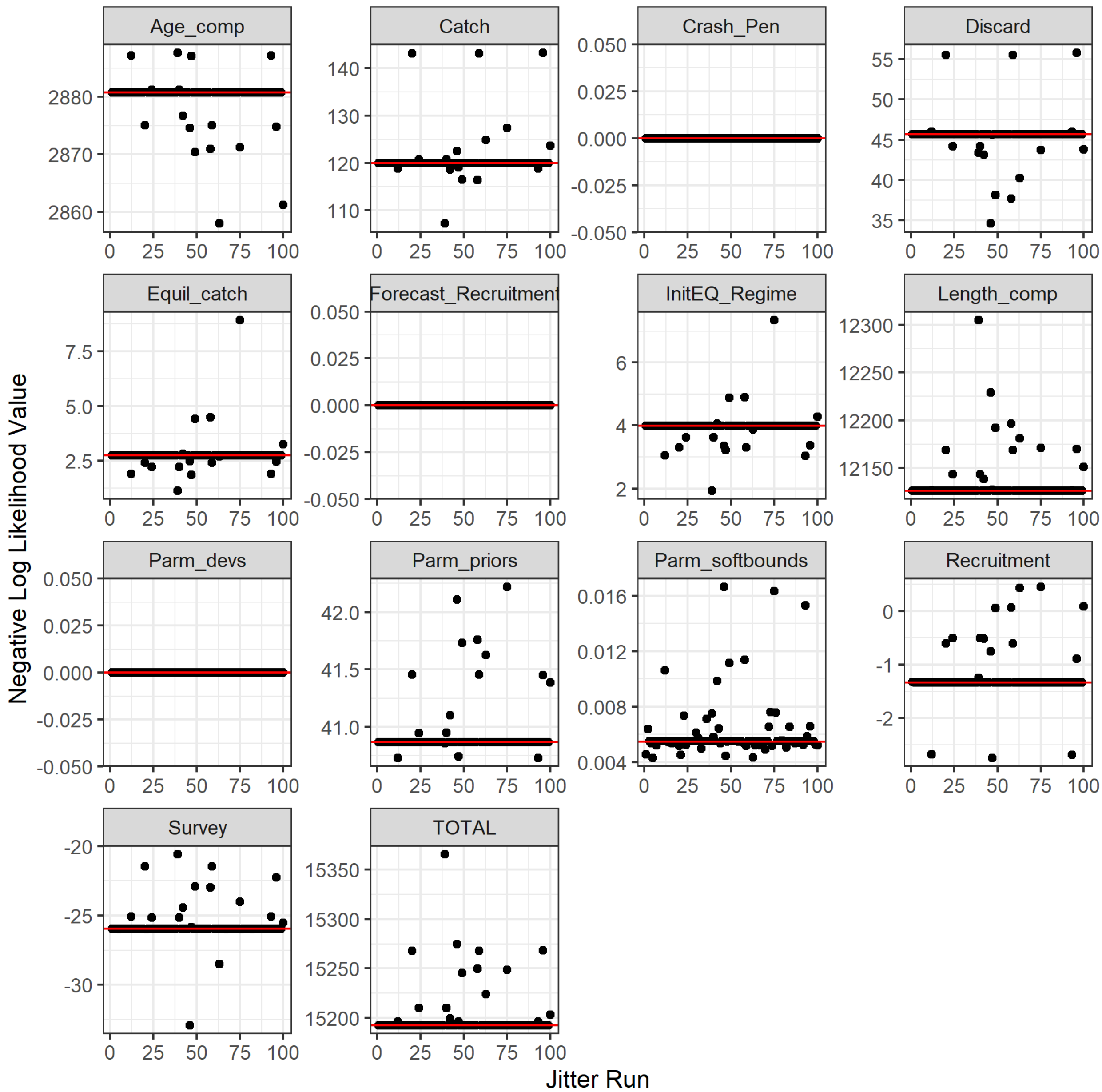


Figure 125. Results of the jitter analysis for various likelihood components for the Gulf of Mexico Gag Grouper for the ***SSB combined*** *sensitivity run. Each panel gives the results of 100 model runs where the starting parameter values for each run were randomly changed ('jittered') by 10% from the base model best fit values. The SSB Combined Sensitivity Run value for each panel is indicated by a red line.*

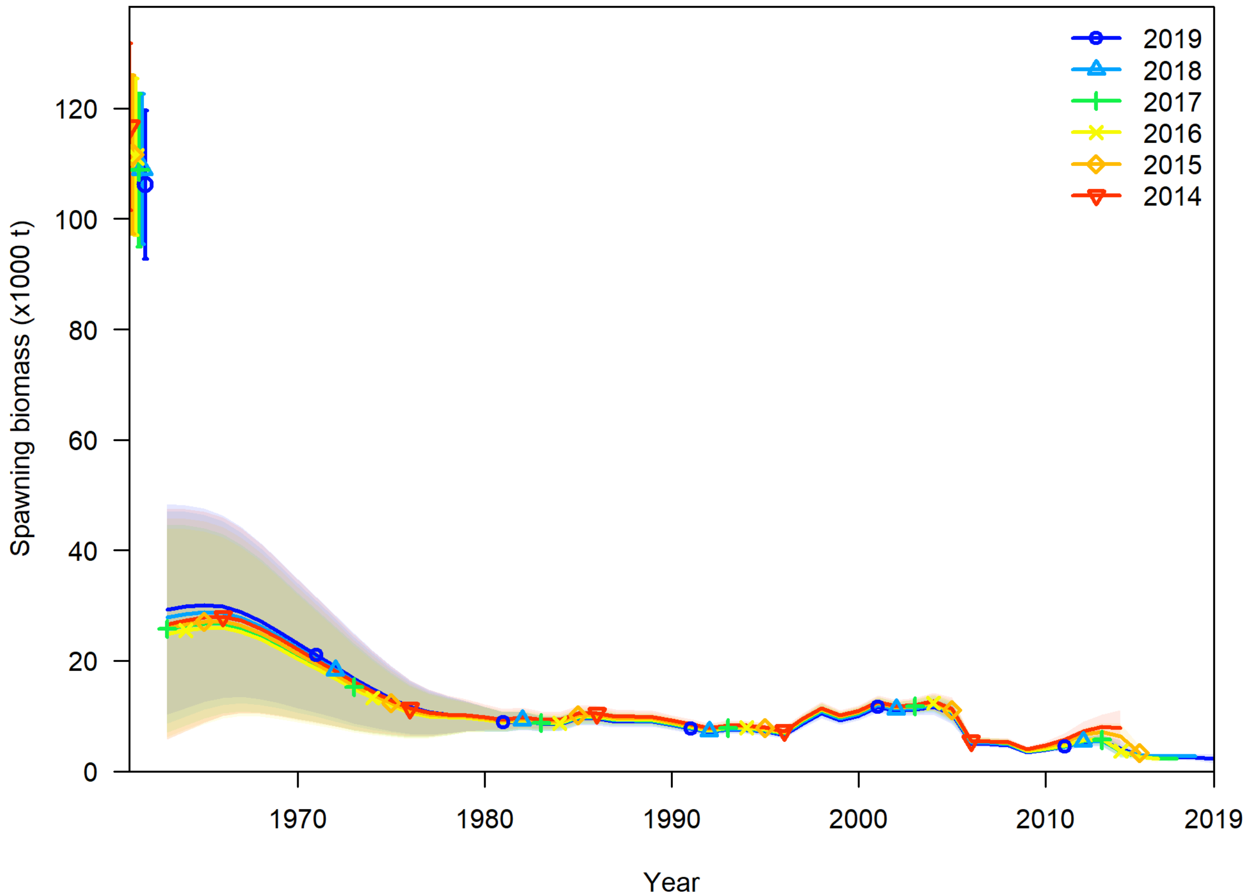


Figure 126. Results of a five year retrospective analysis for spawning biomass (metric tons) for the Gulf of Mexico Gag Grouper for the ***SSB combined*** *sensitivity run. There is no discernible systematic bias because each data peel is not consistently over or underestimating any of the population quantities. Mohn's* $\rho = 0.171$ *– Mohn's* ρ *between -0.15 and +0.20 is within the acceptable range, see Hurtado-Ferro et al., 2015.*

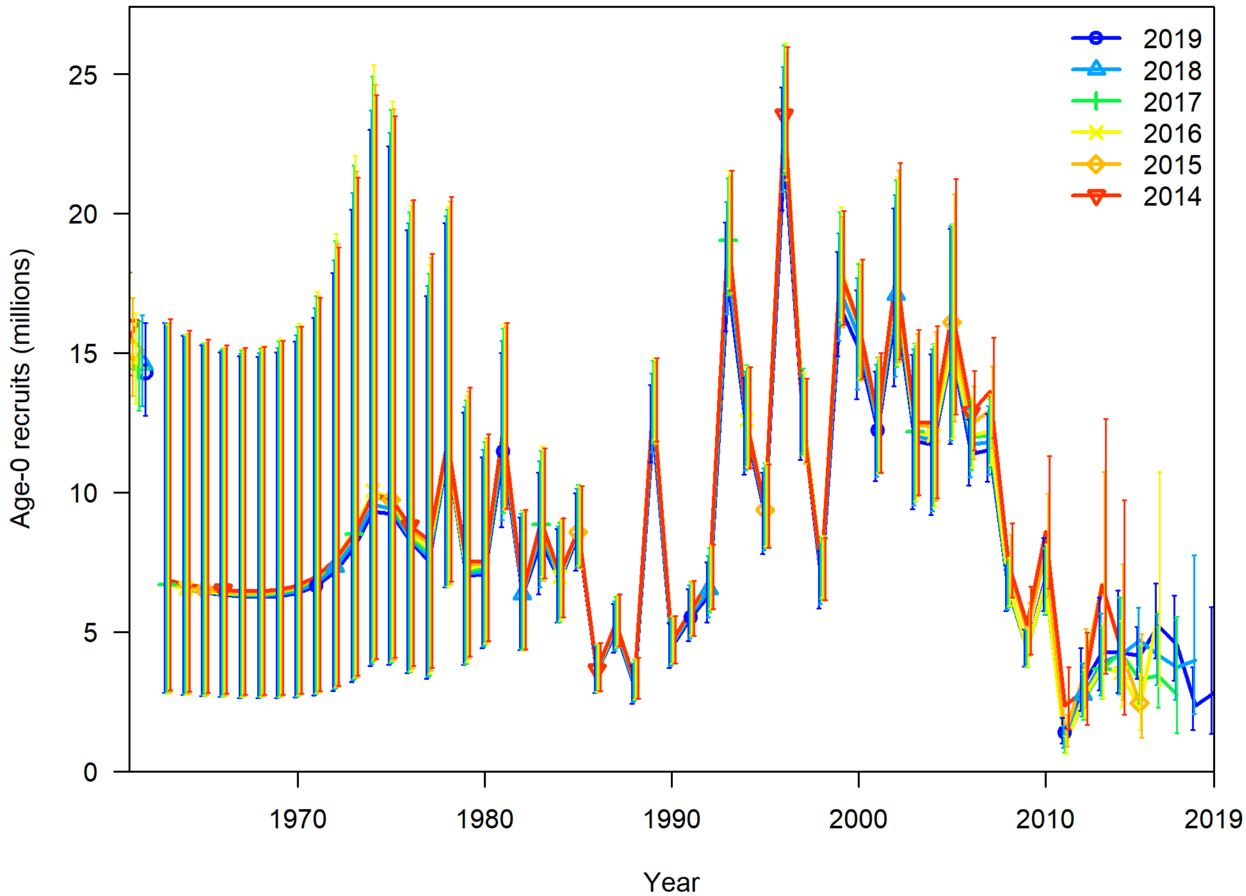


Figure 127. Results of a five year retrospective analysis for recruitment (millions of fish) for the Gulf of Mexico Gag Grouper for the ***SSB combined*** *sensitivity run. There is no discernible systematic bias because each data peel is not consistently over or underestimating any of the population quantities. Mohn's* $\rho = 0.0059$ *– Mohn's* ρ *between -0.15 and +0.20 is within the acceptable range, see Hurtado-Ferro et al., 2015.*

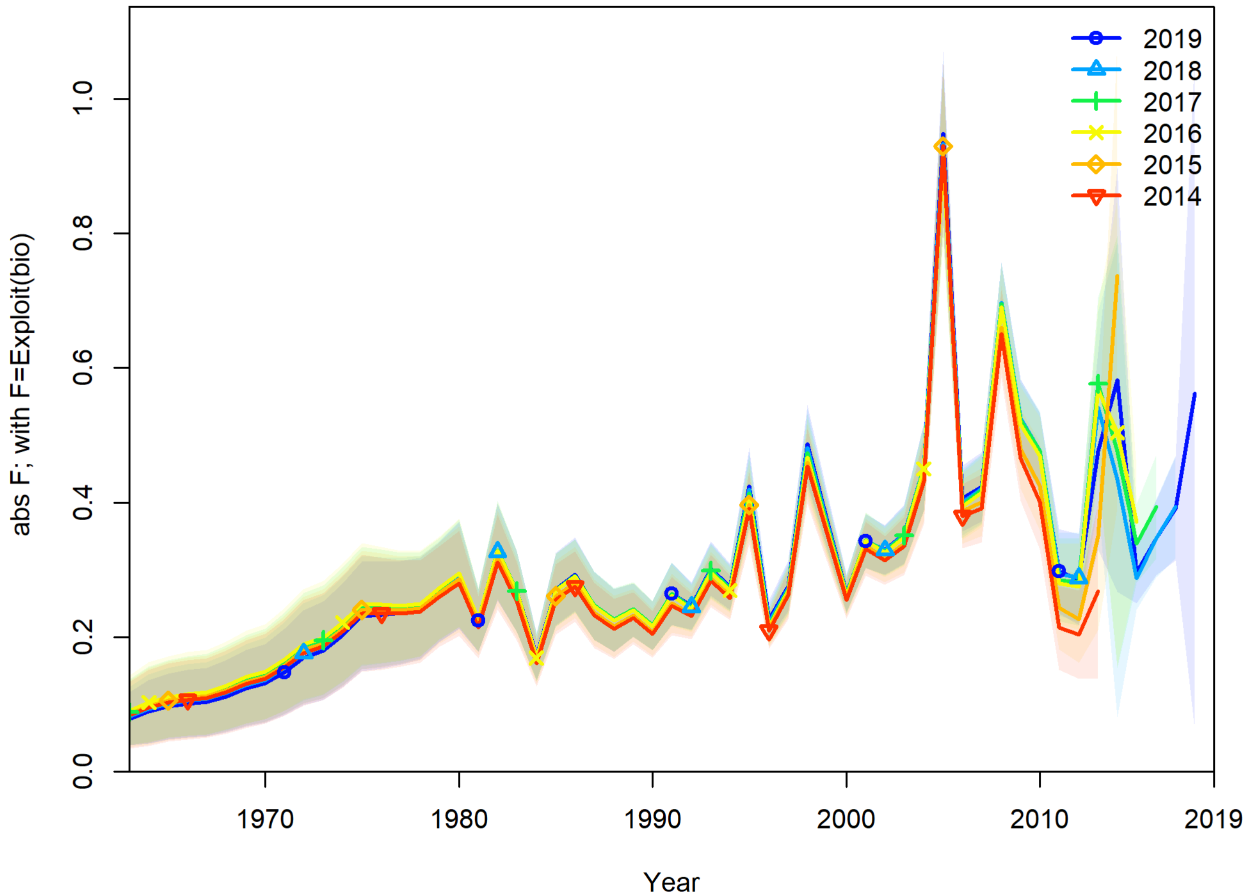


*Figure 128. Results of a five year retrospective analysis for spawning biomass fishing mortality (total biomass killed age 3+ / total biomass age 3+; bottom panel) for the Gulf of Mexico Gag Grouper for the **SSB combined** sensitivity run. There is no discernible systematic bias because each data peel is not consistently over or underestimating any of the population quantities. Mohn's* $\rho = 0.112$ *– Mohn's* ρ *between -0.15 and +0.20 is within the acceptable range, see Hurtado-Ferro et al., 2015.*

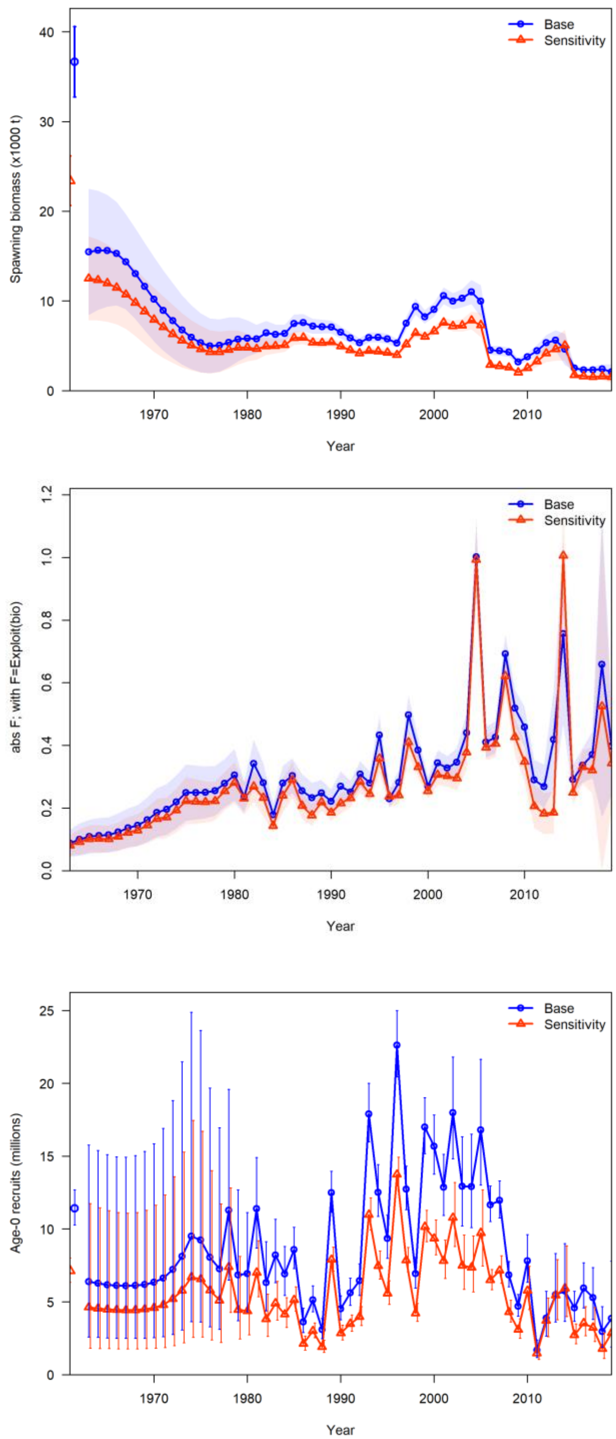
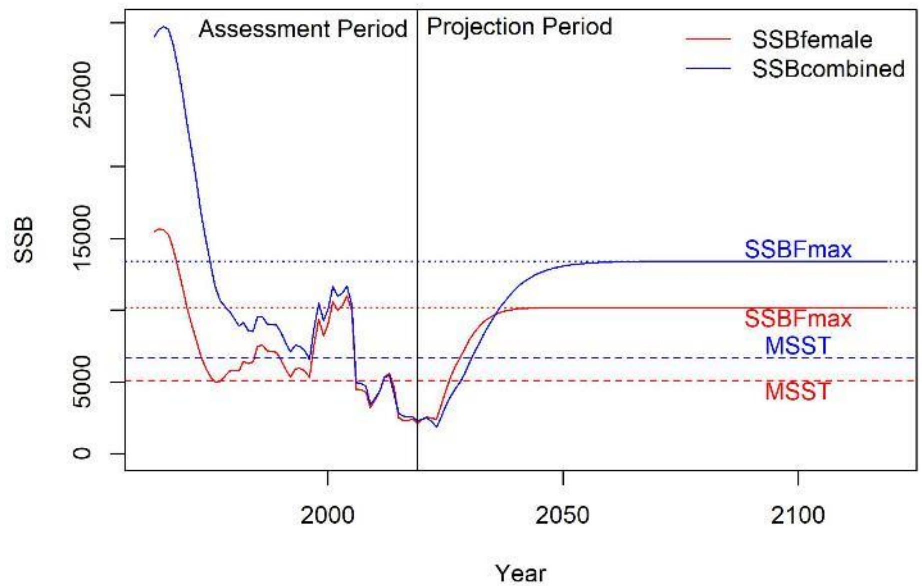


Figure 129. Differences in SSB estimates (top panel), annual exploitation rates (total biomass killed age 3+ / total biomass age 3+) (middle panel) and annual recruitment (bottom panel), and associated uncertainty between the SEDAR72 Base Run and the GRFS sensitivity run.



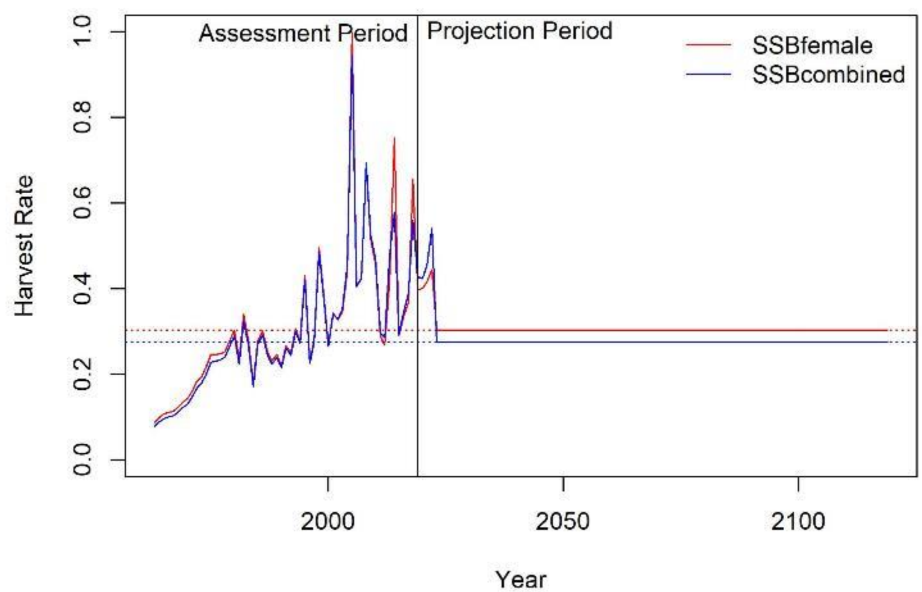


Figure 130. Time series of SSB and harvest rate (total biomass killed age 3+ / total biomass age 3+) for the SSB female-only and SSB combined scenarios with respect to status determination criteria for the SEDAR72 Gulf of Mexico Gag Grouper assessment.

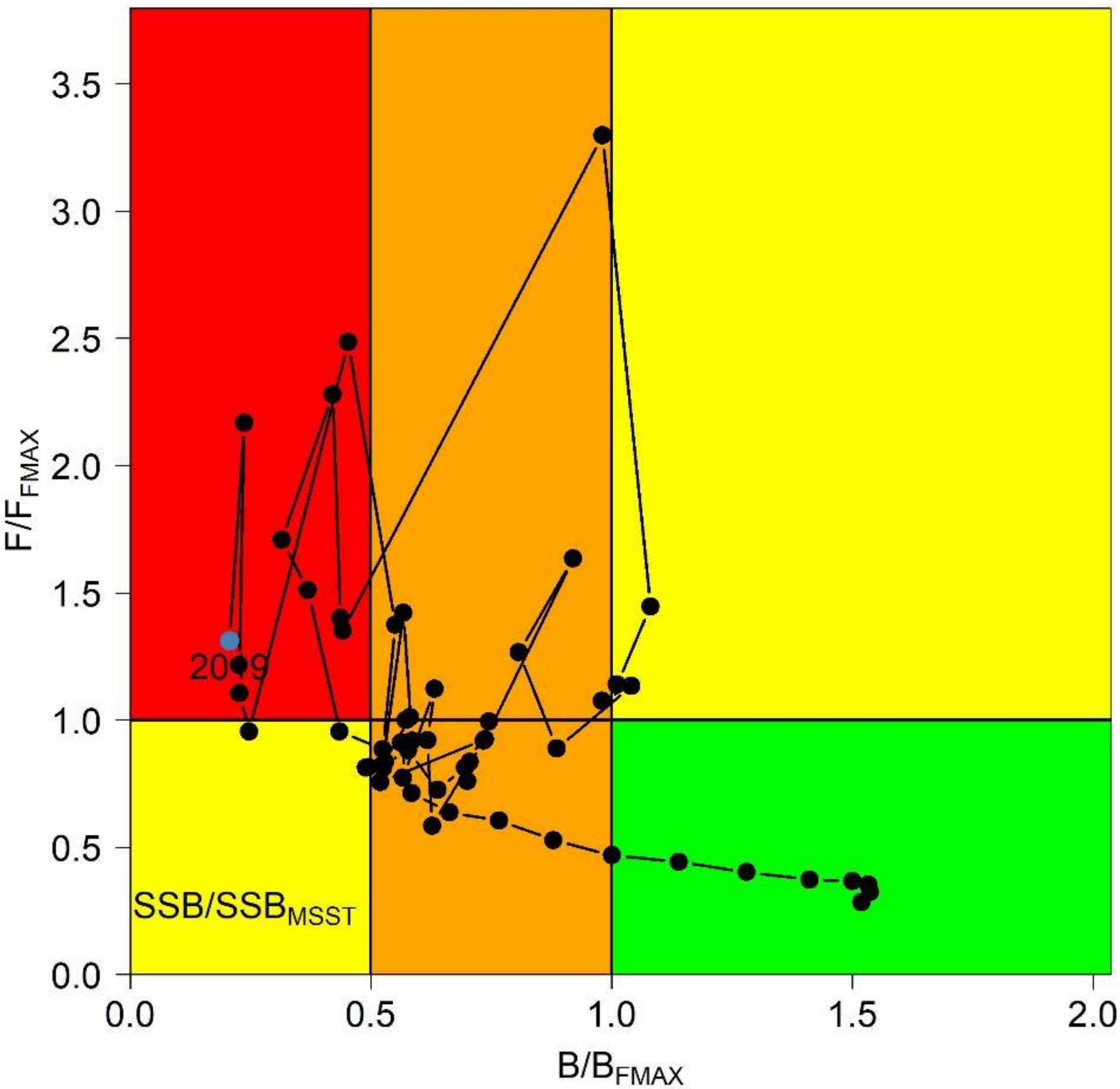


Figure 131. Kobe plot illustrating the trajectory of stock status. The orange coloring indicates regions where the stock is below the biomass target but above the biomass threshold (MSST = 0.5 x SSB_{FMAX}). The 2019 terminal year stock status is indicated by the gray dot. See **Table 32** *for specifics on the years above F/F_{MAX}=1 and below B/B_{MSST}<0.5. Annual exploitation rates used to calculate F/F_{MAX} include red tide F from the bycatch-only fleet.* ***SSB defined as female-only SSB.***

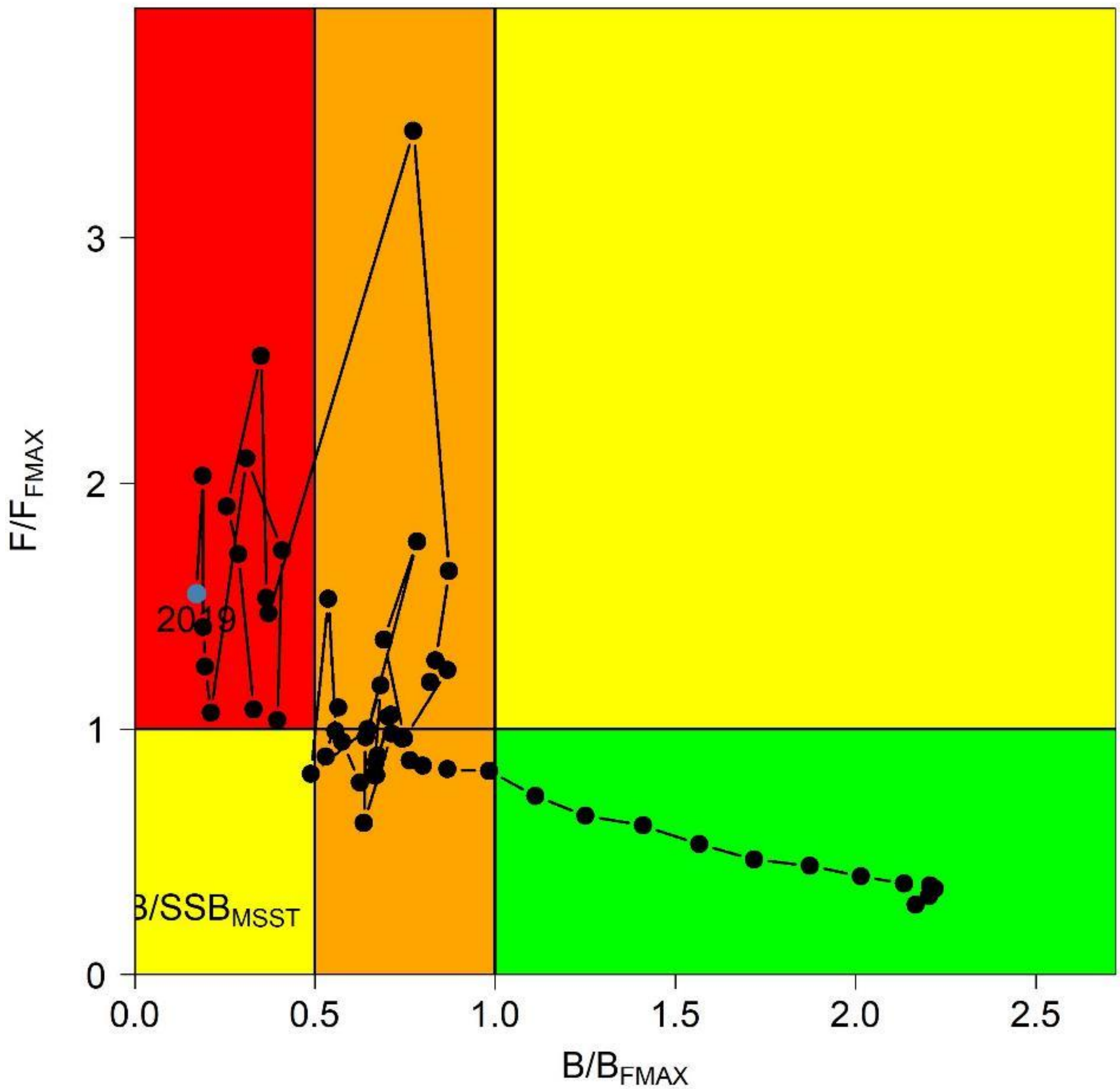


Figure 132. Kobe plot illustrating the trajectory of stock status. The orange coloring indicates regions where the stock is below the biomass target but above the biomass threshold (MSST = 0.5 x SSB_{FMAX}). The 2019 terminal year stock status is indicated by the gray dot. See **Table 33** *for specifics on the years above F/F_{MAX}=1 and below B/B_{MSST}<0.5. Annual exploitation rates used to calculate F/F_{MAX} include red tide F from the bycatch-only fleet.* ***SSB defined as SSB combined.***

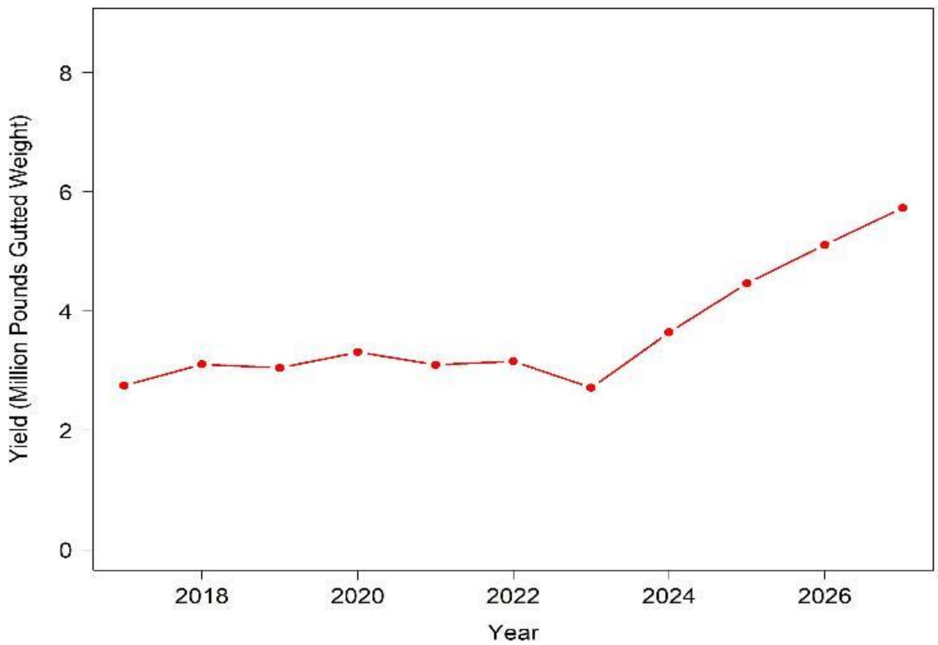


Figure 133. Historic and forecasted yields for the OFL projections. ***SSB defined as female-only SSB.***

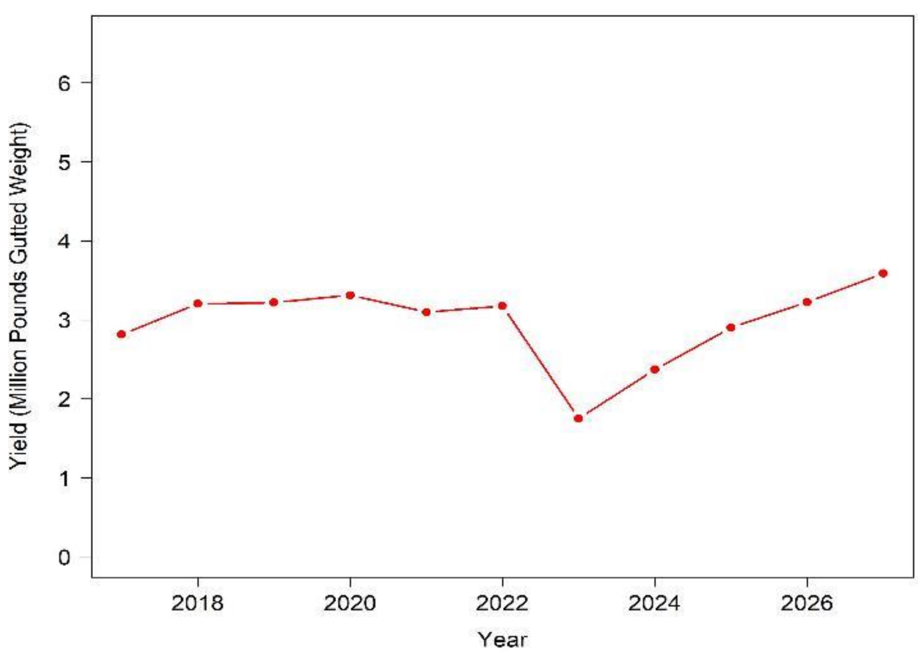


Figure 134. Historic and forecasted yields for the OFL projections. ***SSB defined as SSB combined.***