SEDAR

Southeast Data, Assessment, and Review

SEDAR 42

Stock Assessment Report

Gulf of Mexico Red Grouper

October 2015

SEDAR
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North Charleston, SC 29405

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SECTION I: Introduction

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EXECUTIVE SUMMARY

SEDAR 42 addressed the stock assessment for Gulf of Mexico red grouper. The assessment process consisted of two in-person workshops, as well as a series of webinars. The Data Workshop was held November 17-21, 2014 in St. Petersburg, FL, the Assessment Process was conducted via webinars February -June, 2015, and the Review Workshop took place July 14-16, 2015 in Miami, FL.

The Stock Assessment Report is organized into 6 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. The Data Workshop Report can be found in Section II. It documents the discussions and data recommendations from the Data Workshop Panel. Section III is the Assessment Process report. This section details the assessment model, as well as documents any changes to the data recommendations that may have occurred after the data workshop. Consolidated Research Recommendations from all three stages of the process (data, assessment, and review) can be found in Section IV for easy reference. Section V documents the discussions and findings of the Review Workshop (RW). Finally, Section VI – Addenda and Post-Review Workshop Documentation consists of any analyses conducted during or after the RW to address reviewer concerns or requests. It may also contain documentation of the final RW-recommended base model, should it differ from the model put forward in the Assessment Report for review.

The final Stock Assessment Reports (SAR) for Gulf of Mexico red grouper was disseminated to the public in Ocotber 2015. 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 January 2016 meeting, followed by the Council receiving that information at its January 2016. Documentation on SSC recommendations is not part of the SEDAR process and is handled through each Council.

During the assessment process several data and modeling topics received a lot of discussion. Those topics included:

- *Combining of the Charter and Private recreational components and keeping Headboat separate*: During the development of the assessment, the AW Panel recommended combining the charter and private components, and keeping the headboat component separate, in part as an effort to mirror previous Gulf of Mexico assessments. The Review

Panel noted that the Headboat landings were a very small component of the landings and recommended combining all fleets into one Recreational fleet.

- *Units of Spawning Stock Biomass:* Fecundity in this model was derived as a function of the proportion of mature females and the batch fecundity estimates (in number of eggs) provided by the life history working group at the S42 Data Workshop. SSB was expressed as number of eggs. The review panel questioned the whether batch fecundity was a better metric of fecundity than gonad weight, which was used in SEDAR 12 and the 2009 update. The life history working group recommended using batch fecundity rather than gonad weight due to the high variability in the gonad weight measurements.

- *Start year of model:* The AW Panel had discussions regarding the start yeat of the assessment. They weighed the options of 1880 vs 1986 and decided to recommend 1986. The Review Panel reviewed this recommendation and recommended starting the model runs with 1993. The Main justification for this was that the majority of informative data, the composition data and indices, start in the early1990s.

- *Use of FI And FD indices:* The Data Workshop Panel recommended a series of fishery-dependent (FD) and fishery-independent (FI) indices for use in the model and the Assessment Panel agreed with those recommendations. The Review Panel expressed concerns with including the FD indices due to possible hyper-stability. They recommended sensitivity runs which in included only FI or FD indices. Their Review Panel's final recommend base configuration included both FI and FD indices.

- *NMFS bottom longline survey selectivity pattern:* The Assessment Panel discussed the option of fixing the selectivity for this survey or allowing the model to estimate it. They selected to let the model estimate it, which produced a double-normal selectivity pattern. The Review Panel reviewed this recommendation and decided to change it to a fixed asymptotic pattern.

- *Discard Estimates:* The Review Panel spent much of its time discussing the poor model fits to the discard information for the commercial fleets. Procedures for reporting discards were not consistent across the fleets, and the fit to indices were poor, leading to major sources of uncertainty. Numerous sensitivity runs helped to reduce the lack of fit, especially up-weighting the commercial fishery dependent data, but problems remain. Discards were missing from the shark longline fishery, raising questions about the amount of resultant uncertainty.

- *F_{MSY}-based benchmarks or proxy:* The review panel recommended using spawning potential ratio (SPR) benchmarks to determine stock status rather than MSY-based benchmarks, which was recommended by the assessment panel. SPR benchmarks were recommended by the review panel given the relatively flat relationship between stock size and recruitment.

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 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.

Description of Action	FMP/Amendment	Effective Date
Established a survival rate of biomass into the stock of spawning age fish to achieve at least 20% spawning stock biomass per recruit (SSBR). Set an 11.0 million-pound whole weight commercial quota for groupers, with the commercial quota divided into a 9.2 million pound whole weight shallow-water grouper quota and a 1.8 million-pound whole weight deepwater grouper quota. As a result of a change in the gutted to whole weight conversion ratio (from 1.18 to 1.05), these quotas were subsequently adjusted to 9.8 million pounds whole weight for all groupers, 8.2 million pounds whole weight shallow-water grouper, and 1.6 million pounds whole weight deep-water grouper. 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). Deep-water grouper were defined as misty grouper, snowy grouper, yellowedge grouper, warsaw grouper, and scamp once the shallow-water grouper quota is filled. Set a 20 inch total length	Amendment 1	1990

minimum size limit and a five-grouper recreational daily bag limit. Limited trawl vessels to the recreational size and daily bag limits of reef fish.		
Speckled hind moved from shallow-water grouper to deep-water grouper aggregate. Rebuilding target changed from 20% SSBR to 20% spawning potential ratio (SPR). The time frame to rebuild overfished stocks is specified as 1 ½ generation times.	Amendment 3	1991
Commercial reef fish permit moratorium established for three years	Amendment 4	1992
Fish trap endorsement and three year moratorium established	Amendment 5	1994
Extended commercial reef fish permit moratorium until January 1996.	Amendment 9	1994
Commercial reef fish permit moratorium extended until December 30, 2000. Reef fish permit requirement established for headboats and charter vessels.	Amendment 11	1996
10-year phase-out of fish traps in EEZ established (February 7, 1997 – February 7, 2007).	Amendment 14	1997
Commercial reef fish permit moratorium extended until December 31, 2005.	Amendment 17	2000
(1) Prohibits vessels from retaining reef fish caught under recreational bag/possession limits when commercial quantities of Gulf reef fish are aboard, (2) adjusts the maximum crew size on charter vessels that also have a commercial reef fish permit and a USCG certificate of inspection (COI) to allow the minimum crew size specified by the COI when the vessel is fishing commercially for more than 12 hours, (3) prohibits the use of reef fish for bait except for sand perch or dwarf sand perch, and (4) requires electronic VMS aboard vessels with federal reef fish permits, including vessels with both commercial and charter vessel permits (implemented May 6, 2007).	Amendment 18A	2006

Also known as Generic Essential Fish Habitat (EFH) Amendment 2. Established two marine reserves off the Dry Tortugas where fishing for any species and anchoring by fishing vessels is prohibited.	Amendment 19	2002
3-year moratorium on reef fish charter/headboat permits established	Amendment 20	2002, but implementation deferred until June 16, 2003
Continued the Steamboat Lumps and Madison-Swanson reserves for an additional six years, until June 2010. In combination with the initial four-year period (June 2000-June 2004), this allowed a total of ten years in which to evaluate the effects of these reserves.	Amendment 21	2003
Permanent moratorium established for commercial reef fish permits.	Amendment 24	2005
Permanent moratorium established for charter and headboat reef fish permits, with periodic reviews at least every 10 years.	Amendment 25	2006
Addressed the use of non-stainless steel circle hooks when using natural baits to fish for Gulf reef fish effective June 1, 2008, and required the use of venting tools and dehooking devices when participating in the commercial or recreational reef fish fisheries effective June 1, 2008.	Amendment 27	2008
Established an individual fishing quota (IFQ) system for the commercial grouper and tilefish fisheries.	Amendment 29	2010
Sets interim allocations of gag and red grouper catches between recreational and commercial fisheries, and makes adjustments to the red grouper total allowable catch (TAC) to reflect the current status of the stock, which is currently at OY levels. Additionally, the amendment establishes annual catch limits (ACLs) and accountability measures (AMs) for the commercial and recreational red grouper fisheries and commercial aggregate shallow-water fishery. For the commercial sector, the amendment for	Amendment 30B	2009

2009 reduces the aggregate shallow-water grouper quota from 8.80 mp to 7.8 mp, and increases the red grouper quota from 5.31 mp to 5.75 mp. 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. Increases the red grouper recreational bag limit from one fish to two.		
Established additional restrictions on the use of bottom longline gear in the eastern Gulf of Mexico in order to reduce bycatch of endangered sea turtles, particularly loggerhead sea turtles. (1) Prohibits the use of bottom longline gear shoreward of a line approximating the 35-fathom contour from June through August; (2) reduces the number of longline vessels operating in the fishery through an endorsement provided only to vessel permits with a demonstrated history of landings, on average, of at least 40,000 pounds of reef fish annually with fish traps or longline gear during 1999-2007; and (3) restricts the total number of hooks that may be possessed onboard each reef fish bottom longline vessel to 1,000, only 750 of which may be rigged for fishing. The boundary line was initially moved from 20 to 50 fathoms by emergency rule effective May 18, 2009. That rule was replaced on October 16, 2009 by a rule under the Endangered Species Act moving the boundary to 35 fathoms and implementing the maximum hook provisions.	Amendment 31	2010
Set the commercial and recreational gag annual catch limits for 2012 through 2015 and beyond. Set the constant catch commercial red grouper annual catch limit at 6.03 mp and the recreational red grouper annual catch limit at 1.90 mp. Set the commercial and recreational gag annual catch targets for 2012 through 2015 and beyond.	Amendment 32	2012

Implemented commercial gag quotas for 2012 through 2015 and beyond that included a 14% reduction from the annual catch target to account for additional dead discards of gag resulting from the reduced harvest. Modified grouper IFQ multi-use allocations. Simplified the commercial shallow-water grouper accountability measures by using the individual fishing quota program to reduce redundancy. Added an overage adjustment and in-season measures to the recreational gag and red grouper accountability measures to avoid exceeding the annual catch limit. Added an accountability measure for the red grouper bag limit that would reduce the four red grouper bag limit in the future to three red grouper, and then to two red grouper, if the red grouper recreational annual catch limit is exceeded.		
Revised the post-season recreational accountability measure that reduces the length of the recreational season for all shallow-water grouper in the year following a year in which the ACL for gag or red grouper is exceeded. The modified accountability measure reduces the recreational season of only the species for which the ACL was exceeded. Modified the reef fish framework procedure to include accountability measures to the list of items that can be changed through the standard framework procedure.	Amendment 38	2013

2.2 GENERIC AMENDMENTS

Generic Sustainable Fisheries Act Amendment: partially approved and implemented in **November 1999**, set the Maximum Fishing Mortality Threshold (MFMT) for most reef fish stocks at $F_{30\%}$ SPR. Estimates of maximum sustainable yield, Minimum Stock Size Threshold (MSST), and optimum yield were disapproved because they were based on SPR proxies rather than biomass based estimates.

Generic ACL/AM Amendment: Established in-season and post-season accountability measures for all stocks that did not already have such measures defined. This includes the "other shallow-water grouper species" complex. The accountability measure states that if an ACL is exceeded, in subsequent years an in-season accountability measure will be implemented that would close shallow-water grouper fishing (for all shallow-water grouper species combined) when the ACL is reached or projected to be reached.

2.3 REGULATORY AMENDMENTS

July 1991: Implemented November 12, 1991, provided a one-time increase in the 1991 quota for shallow-water grouper from 9.2 mp ww to 9.9 mp ww to provide the commercial fishery an opportunity to harvest 0.7 MP that was not harvested in 1990 [56 FR 58188].

In 1991, the conversion factor used to convert grouper gutted weight to whole weight was changed from 1.18 to 1.05. Consequently the base quotas for grouper were changed to 9.8 mp ww (all grouper), 8.2 mp ww (shallow-water grouper), and 1.6 mp ww (deep-water grouper). Since commercially harvested grouper are typically landed in gutted condition, this did not change the actual landings, only the whole weight equivalents.

November 1991: Implemented June 22, 1992, raised the 1992 commercial quota for shallow-water grouper to 9.8 mp ww after a red grouper stock assessment indicated that the red grouper SPR was substantially above the Council's minimum target of 20% [57 FR 21751].

August 1999: Implemented June 19, 2000, increased the commercial size limit for gag and black grouper from 20 to 24 inches TL, increased the recreational size limit for gag from 20 to 22 inches TL, implemented a seasonal closure on commercial harvest and 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 (Steamboat Lumps and Madison-Swanson) with a 4-year sunset clause that are closed year-round to fishing for all species under the Council's jurisdiction [65 FR 31827].

October 2005: Implemented January 1, 2006, established a 6,000 lb gw aggregate deepwater grouper and shallow-water grouper trip limit for the commercial grouper fishery, replacing the 10,000/7,500/5,500 step-down trip limit that had been implemented by emergency rule for 2005 [70 FR 77057].

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

September 2010: Implemented January 1, 2011, reduced the total allowable catch for red grouper from 7.57 million pounds gutted weight to 5.68 million pounds gutted weight, based on the optimum yield projection from a March 2010 re-run of the projections from the 2009 red grouper update assessment. Although the stock was found to be neither overfished nor undergoing overfishing, the update assessment found that spawning stock biomass levels had decreased since 2005, apparently due to an episodic mortality even in 2005 which appeared to be related to an extensive red tide that year. Based on the 76%:34% commercial and recreational allocation of red grouper, the commercial quota was reduced from 5.75 to 4.32 million pounds gutted weight, and the recreational allocation was reduced from 1.82 to 1.36 million pounds gutted weight. No changes were made to the recreational fishing regulations as the recreational landings were already below the adjusted allocation in recent years.

August 2011: Increased the 2011 total allowable catch to 6.88 million pounds gutted weight and allowed the total allowable catch to increase from 2012 to 2015. The increases in TAC are contingent upon the TAC not being exceeded in previous years. If TAC is exceeded in a given year, it will remain at that year's level until the effects of the overage are evaluated by the Scientific and Statistical Committee. The amendment also increases the red grouper bag limit to 4 fish per person.

Framework Action - December 2012: Established the 2013 gag recreational fishing season to open on July 1 and remain open until the recreational annual catch target is projected to be taken. Also eliminated the February 1 through March 31 recreational shallow-water grouper closed season shoreward of 20 fathoms (except for gag). However, the closed season remains in effect beyond 20 fathoms to protect spawning aggregations of gag and other species that spawn offshore during that time.

2.4 SECRETARIAL AMENDMENTS

Secretarial Amendment 1: Implemented July 15, 2004. Beginning with this amendment, all grouper TACs, quotas, and other catch levels are expressed in units of gutted weight rather than whole weight to avoid complications from the Accumulated Landings System using a different gutted-to-whole weight conversion factor than the Southeast Fisheries Science Center. Established a rebuilding plan, a 5.31 mp gutted weight (gw) commercial quota, and a 1.25 mp gw recreational target catch level for red grouper. Also reduced the commercial quota for shallow-water grouper from 9.35 to 8.8 mp gw and reduced the commercial quota for deepwater grouper from 1.35 to 1.02 mp gw. The recreational bag limit for red grouper was reduced to two fish per person per day.

2.5 EMERGENCY AND INTERIM RULES

Emergency Rule - Published February 15, 2005: established a series of trip limits for the commercial grouper fishery in order to extend the commercial fishing season. The trip limit was initially set at 10,000 lbs gw. If on or before August 1 the fishery is estimated to have landed more than 50% of either the shallow-water grouper or the red grouper quota, then a 7,500 lb gw trip limit takes effect (*took effect July 9, 2005*); and if on or before October 1 the fishery is estimated to have landed more than 75% of either the shallow-water grouper or the red grouper quota, then a 5,500 lb gw trip limit takes effect (*took effect August 4, 2005*) [70 FR 8037].

Interim Rule - Published July 25, 2005: proposed for the period August 9, 2005 through January 23, 2006, a temporary reduction in the recreational red grouper bag limit from two to one fish per person per day, in the aggregate grouper bag limit from five to three grouper per day, and a closure of the recreational fishery, from November - December 2005, for all grouper species [70 FR 42510]. These measures were proposed in response to an overharvest of the recreational allocation of red grouper under the Secretarial Amendment 1 red grouper rebuilding plan. The closed season was applied to all grouper in order to prevent effort shifting from red grouper to other grouper species and an increased bycatch mortality of incidentally caught red grouper. However, the rule was challenged by organizations representing recreational fishing interests. On October 31, 2005, a U.S. District Court judge ruled that an interim rule to end overfishing can only be applied to the species that is undergoing overfishing. Consequently, the reduction in the aggregate grouper bag limit and the application of the closed season to all grouper were overturned. The reduction in the red grouper bag limit to one per person and the November-December 2005 recreational closed season on red grouper only were allowed to proceed. The approved measures were subsequently extended through July 22, 2006 by a temporary rule extension published January 19, 2006 [71 FR 3018].

Emergency Rule - Implemented May 18, 2009 through October 28, 2009: Prohibited the use of bottom longline gear to harvest reef fish east of 85°30′ W longitude in the portion of the exclusive economic zone (EEZ) shoreward of the coordinates established to approximate a line following the 50–fathom (91.4–m) contour as long as the 2009 deepwater grouper and tilefish quotas are unfilled. After the quotas have been filled, the use of bottom longline gear to harvest reef fish in water of all depths east of 85°30′ W longitude are prohibited [74 FR 20229].

Emergency Rule - Implemented May 3, 2010 through November 15, 2010: NMFS issued an emergency rule to temporarily close a portion of the Gulf of Mexico EEZ to all fishing [75 FR 24822] in response to an uncontrolled oil spill resulting from the explosion on April 20, 2010 and subsequent sinking of the Deepwater Horizon oil rig approximately 36 nautical miles (41 statute miles) off the Louisiana coast. The initial closed area extended from approximately the mouth of the Mississippi River to south of Pensacola, Florida and covered an area of 6,817 square statute miles. The coordinates of the closed area were subsequently modified periodically in response to changes in the size and location of the area affected by the spill. At its largest size on June 1, 2010, the closed area covered 88,522 square statute miles, or approximately 37 percent of the Gulf of Mexico EEZ. This closure was implemented for public safety.

Interim Rule - Published on December 1, 2010: [75 FR 74654] Reduced gag landings consistent with ending overfishing. This interim rule implemented conservative management measures while a rerun of the update stock assessment was being completed. At issue was the treatment of dead discarded fish in the assessment. The rule reduced the commercial quota to 100,000 pounds gutted weight, suspended the use of red grouper multi-use individual fishing quota allocation so it would not be used to harvest gag, and to temporarily halted the recreational harvest of gag until recreational fishing management measures being developed in Amendment 32 could be implemented to allow harvest at the appropriate levels.

Interim Rule – Effective from June 1, 2011 through November 27, 2011: Set the commercial gag quota at 430,000 pounds gutted weight (including the 100,000 pounds previously allowed) for the 2011 fishing year, and temporarily suspended the use of red grouper multi-use IFQ allocation so it cannot be used to harvest gag. It also set a two-month recreational gag fishing season from September 16 through November 15. This temporary rule can be extended for another 186 days [76 FR 31874].

2.6 MANAGEMENT PARAMETERS AND PROJECTION SPECIFICATIONS

Table 2.6.1. General Management Information

Species	Red Grouper
Management Unit	Red Grouper
Management Unit Definition	Gulf of Mexico
Management Entity	Gulf of Mexico Fishery Management Council
Management Contacts SERO / Council	Steven Atran, Dr. Carrie Simmons - GMFMC Peter Hood
Current stock exploitation status	Not experiencing overfishing (2009)
Current stock biomass status	Not overfished (2009)

Table 2.6.2. Specific Management Criteria

(Provide details on the management criteria to be estimated in this assessment) Note: mp = million pounds; gw = gutted weight.

Criteria	Current- 2009 Update Assessment (Red Tide)		Proposed	
	Definition	Value	Definition	Value
MSST	$(1\text{-}M)*SSB_{MSY}$ M=0.14	612.9 mp gw	Value from the most recent stock assessment based on MSST = [(1-M) or 0.5 whichever is greater]*BMSY	SEDAR 42
MFMT	F_{MSY}	0.1865	F_{MSY} or proxy from the most recent stock assessment (median from probabilistic analysis)	SEDAR 42
MSY	F_{MSY}	0.1865	Yield at F_{MSY} , landings and discards, pounds and numbers (median from probabilistic analysis)	SEDAR 42
F_{MSY}	F_{MSY}	0.1865		
SSB_{MSY}	Equilibrium SSB	615.5 mp gw	Spawning stock	SEDAR 42

	@ F_{MSY}		biomass (median from probabilistic analysis)	
F Targets (i.e., F_{OY})	75% of F_{MSY}	0.1399	75% F_{MSY}	SEDAR 42
Yield at F_{Target} (Equilibrium)	Equilibrium Yield @ FOY		landings and discards, pounds and numbers	SEDAR 42
M		0.14	Natural Mortality, average across ages	SEDAR 42
Terminal F	Geometric mean 2005-2007	0.161	Exploitation	SEDAR 42
Terminal Biomass[1]	SSB_{2008}	712.7 mp gw	Biomass	SEDAR 42
Exploitation Status	$F_{CURRENT}$/MFMT	0.863	F/MFMT	SEDAR 42
Biomass Status[1]	$SSB_{CURRENT}$/MSST	1.00	B/MSST B/B_{MSY}	SEDAR 42

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

Table 2.6.3. General projection information.

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

Requested Information	Value
First Year of Management	2016 Fishing Year
Interim basis	- ACL, if ACL is met - Average exploitation, if ACL is not met
Projection Outputs	By stock and fishing year
Landings	pounds and numbers
Discards	pounds and numbers
Exploitation	F & Probability F>MFMT
Biomass (total or SSB, as appropriate)	SSB & Probability SSB>MSST (and Prob. SSB>B_{MSY} if under rebuilding plan)
Recruits	Number

Table 2.6.4. Base Run Projections Specifications. Long Term and Equilibrium conditions.

Criteria	Definition	If overfished	if overfishing	Not overfished, no overfishing
Projection Span	Years	$T_{Rebuild}$	10	10
Projection Values	$F_{Current}$	X	X	X
	F_{MSY} (proxy)	X	X	X
	75% F_{MSY}	X	X	X
	$F_{Rebuild}$	X		
	F=0	X		

NOTE: Exploitation rates for projections may be based on point estimates from the base run (current process) or the median of such values from the MCBS evaluation of uncertainty. The objective is for projections to be based on the same criteria as the management specifications.

Table 2.6.5. P-Star Projections. Short term specifications for OFL and ABC recommendations. Additional P-star projections may be requested by the SSC once the ABC control rule is applied.

Criteria		Overfished	Not overfished
Projection Span	Years	10	10
Probability Values	50%	Probability of stock rebuild	Probability of overfishing
	27.5%[1]		

[1] Based on the SA SSC recommended P*, December 2008.

The following should be provided regardless of whether the stock is healthy or overfished:

- OFL: yield at F_{MSY} (or $F_{30\%\ SPR}$ proxy)
- OY: yield at 75% for $F_{30\%\ SPR}$
- Equilibrium MSY and equilibrium OY

If the stock is overfished, the following should also be provided:

- $F_{REBUILD}$ and the yield at $F_{REBUILD}$ (where the rebuilding time frame is 10 years)
- A probability distribution function (PDF) that can be used along with the P* selected by the SSC to determine ABC. If multiple model runs are provided, this may need to wait until the SSC selects which model run to use for management.

The SSC typically recommends OFL and ABC yield streams for 3-5 years out. Yield streams provided by assessment scientists should go beyond five years. If a 10-year rebuilding plan is needed, yield streams should be provided for 10 years.

Table 2.6.6. Quota Calculation Details

Note: mp = million pounds; gw = gutted weight.

Current Quota Value (2014)	7.408 mp gw
Next Scheduled Quota Change	2015
Annual or averaged quota?	Annual
Does the quota include bycatch/discard?	No- Landed only

Quotas are conditioned upon exploitation. Bycatch/discard estimates are considered in setting the quota; however, quota values are for landed fish only.

2.7 MANAGEMENT AND REGULATORY TIMELINE

Table 2.7.1. Annual Commercial Regulatory Summary

Note: mp = million pounds; gw = gutted weight.

Year	Days Open	Date Closed	Size Limit (TL)	Quota[1] (mp gw)
1990	311	Nov 8	20”	6.9 SWG
1991	365	-	20”	7.5 SWG
1992	366	-	20”	8.3 SWG
1993	365	-	20”	8.3 SWG
1994	365	-	20”	8.3 SWG
1995	365	-	20”	8.3 SWG
1996	366	-	20”	8.3 SWG
1997	365	-	20”	8.3 SWG
1998	365	-	20”	8.3 SWG
1999	337[a]	-	20”	8.3 SWG
2000	337[a]	-	20”	8.3 SWG
2001	337[a]	-	20”	8.3 SWG
2002	337[a]	-	20”	8.3 SWG
2003	337[a]	-	20”	8.3 SWG
2004	291[a]	Nov 15	20”	5.31
2005	265[a]	Oct 10	20”	5.31
2006	337[a]	-	20”	5.31[b]
2007	337[a]	-	20”	5.31[b]
2008	337[a]	-	20”	5.31[b]
2009	365	-	18”	5.75[b]
2010	365	-	18”	5.75[c]
2011	365	-	18”	5.23[c]
2012	366	-	18”	5.37[c]
2013	365	-	18”	5.53[c]
2014	365	-	18”	5.63[c]

[a] Commercial seasonal closure from February 15-March 15 to protect spawning aggregations.

[b] Commercial trip limit of 6,000 lbs gutted weight in effect.
[c] Individual Fishing Quota management system in effect
[1] Prior to 2004, red grouper was included in the shallow-water groupers (SWG) quota. During this time, SWG included: black grouper, gag, red grouper, yellowfin grouper, yellowmouth grouper, rock hind, red hind, speckled hind (only for 1990, moved to deepwater grouper complex in 1991), and scamp.

Note: Harvest from 1990-2009 taken from the SEFSC ACL database; harvest from 2010 to 2013 from IFQ database.

Table 2.7.2. Annual Recreational Regulatory Summary

Note: There was no recreational grouper allocation explicitly specified prior to 2009, but the assumed commercial/recreational allocation of shallow-water grouper was 65%/35%. Therefore, the implied recreational allocation of SWG was the commercial quota*(0.35/0.65).

Year	Days Open	Closed Season	Size Limit (TL)	Bag Limit	Agg. Bag Limit	Effective Date	ACL (mp gw)
1990-2003	365	-	20”	5	5	1990	-
2004	366	-	20”	2	5	July 2004	-
2005	304	11/1 – 12/31	20”	1	3	Aug 2005	-
2006-2008	337	2/15 – 3/14	20”	1	5 (0 C&C)	Mar 2006	-
2009	337	2/15 – 3/14	20”	2	4	May 2009	1.85
2010	306	2/1 – 3/31	20”	2	4		1.85
2011	306	2/1 – 3/31	20”	4	4	Aug 2011	1.65
2012	306	2/1 – 3/31	20”	4	4		1.90
2013	306[a] 365[b]	2/1 – 3/31[a]	20”	4	4		1.90
2014	217[a], 276[b]	2/1 – 3/31[a], 10/4 – 12/31[a,b]	20”	3	4	May 2014[c]	1.78

[a]: In waters > 20 fathoms
[b]: In waters < 20 fathoms
[c]: If no formal management change is adopted, the bag limit will revert back to 4/person/day on Jan 1, 2015.

3 ASSESSMENT HISTORY AND REVIEW

Pre-SEDAR assessments of Gulf of Mexico resources were typically prepared by scientists of the Southeast Fisheries Science Center and reviewed by the Gulf of Mexico Fishery Management Council (GMFMC) Reef Fish Stock Assessment Panel (RFSAP) and Science and Statistics Committee (SSC). Excerpts from RFSAP reports addressing previous assessments are compiled into a single document for convenience (SEDAR12-RW01). Previous stock assessments referenced below are provided for reference and organized under the SEDAR 12 research document listing as follows: Goodyear and Schirripa, 1991 (SEDAR12-RD04), Goodyear and Schirripa, 1993 (SEDAR12-RD07), Schirripa et al, 1999 (SEDAR12-RD05), and SEFSC, 2001 (SEDAR12-RD02).

The first documented assessment of the Gulf of Mexico stock of red grouper is Goodyear and Schirripa, 1991 (SEFSC cont. MIA-90/91-86). This assessment compiled available life history and fishery data from the 1960's through 1990, evaluated and interpreted trends in data sources, evaluated recent regulatory changes, and estimated mortality through catch curve analysis. Some of the challenges identified included difficulty evaluating SPR for a hermaphroditic species with limited life history research, interpretation of growth models based on competing data sources, estimation of release and natural mortality, inadequate biological sampling of grouper fisheries, a lack of direct age observations from the fisheries, and uncertainties in landings statistics due to incomplete and imprecise reporting.

Published natural mortality estimates evaluated in the 1991 assessment ranged from 0.17 to 0.32; the assessment adopted a natural mortality value of M=0.2 with little justification while acknowledging that it could be excessive given the abundance of older ages in the population.

Discard losses are identified as an increasing challenge to stock productivity. Although the discard mortality rate is uncertain, the high number of discards resulting from recent size limit changes raised concern. The authors suggested that eliminating the minimum size limit could increase yield per recruit for even moderate discard mortality assumptions.

Implementation of an 18" minimum size limit by Florida in 1986 had little perceived impact of commercial fisheries but led to an initial decline in recreational harvest followed by recovery as the fishery moved from near shore state waters to offshore federal (EEZ) waters. Additional regulations implemented in 1990 included an increase in minimum size to 20", a 5 fish recreational creel restriction, and a commercial quota intended to reduce commercial exploitation 20%. Fishery changes attributed to these actions include a 70% decline in recreational harvest numbers, a 20% decline in commercial harvest (exacerbated by premature fishery closure), and notable shifts in harvest length compositions.

Because fishery age samples are lacking, growth models were used to assign catches by length to age classes for use in the catch curve analyses. Two alternative catch-age matrices were developed to address differences in estimated growth rate observed between a study conducted in the mid1960's and another in the late 1980's. It was not known whether the growth disparity was legitimate or simply reflected methodological differences between separate studies, although several hypothesis enabling a change in population growth were proposed.

Upon review of this assessment in October, 1991, the GMFMC RFSAP endorsed status estimates based on recent growth data and biological references based on yield per recruit analyses. Fishing mortality rates were stated as being between F0.1 and Fmax depending on the assumed discard mortality rate. Estimated SPR exceeded the 20% SPR limit then in effect for all discard mortality assumptions.

The next assessment, also prepared by Goodyear and Schirripa, was completed in 1993 with through 1992. Enhancements in this version included inclusion of landings and effort data from the Cuban fleets operating off the west coast of Florida, 1950-1976; development of CPUE indices for several fisheries based on the logbook program introduced in 1990; and development of a VPA analysis. There was no resolution of the growth disparity and only minor improvement in fishery dependent sampling. Growth modeling was again used to develop catches at age. Results of the catch curves and VPA analyses remained quite variable when uncertainties in growth and age assignment were considered, although no notable changes in stock status were suggested by this assessment. The RFSAP reviewed this assessment in August 1993 and accepted the findings.

In 1994 the GMFMC RFSAP reviewed two detailed analyses of the red grouper growth disparity and determined that differences were related to sampling (Goodyear 1994 and undated). This work led to acknowledgement that significant bias is introduced into stock assessments when catch ages are determined from growth models based on data from length-stratified sampling, size-selective gears, or fisheries restricted by minimum sizes. Although it was believed that sampling bias could be addressed, bias introduced by the minimum size could not be removed and therefore the results of previous red grouper assessments were deemed invalid at this time.

Major revisions were included in the next assessment, prepared by Schirripa, Legault, and Ortiz in 1999 including data through 1997. The catch time series was extended, with landings statistics evaluated back to the 1940's and acknowledgement of a fishery back to at least 1880. Recreational landings for 1940-1981 were inferred through regression with population to enable estimation of total harvest removals prior to inception of MRFSS. Additional indices were developed, including headboat CPUE, tag-recapture study CPUE, and two fishery-independent indices provided through SEAMAP beginning in 1992. Growth models were evaluated further and a probabilistic approach for converting catch at length to catch at age was incorporated. Two assessment approaches were considered: a production model and a catch-age model.

Considerable effort was devoted to evaluating growth models and trends in growth rates by comparing newly available capture-recapture growth estimates with those obtained through traditional back-calculation from hard parts. The authors concluded that both approaches were useful in estimating growth parameters and noted that consistency in estimates between the two methods suggested that estimated values were reliable.

Both production models (ASPIC) and forward projection catch-age models (ASAP) were developed to evaluate stock status. Neither of the previous assessment approaches (catch curves and VPA) were updated in this assessment. Ages were determined for the forward projecting model through the Goodyear (1995) probabilistic approach that also enables estimation of discards.

The production model performed reasonably well, but lacked ability to address perceived changes in fishery characteristics (e.g., catchability and selectivity) over time and did not allow inclusion of available information on size or age of capture. The catch-age model provided greater flexibility and incorporated more available data, but was highly parameterized and sensitive to steepness and data series duration. Both models suggested that the stock was overfished and overfishing was occurring in 1997. Both models indicated that fishing mortality was increasing while both SSB and recruitment were decreasing, and that peak abundance occurred sometime during the 1940's or 1950's.

The RFSAP reviewed the assessment in September 1999 and accepted the methods and results. Management recommendations were based on the ASAP model incorporating the long time series (1940-1997). The stock was considered overfished and overfishing was occurring in the terminal year (1997).

The sequence of events becomes less clear after this point. The December 2000 RFSAP report indicates that the RFSAP questioned aspects of the assessment following the September 1999 meeting noted above, setting off a chain of analyses and reviews extending over several years. In response to concerns about the assessment, NMFS/SEFSC prepared additional analyses that were presented to the RFSAP in August 2000. This led to further requests to conduct an extensive suite of additional analyses evaluating a range of alternative assumptions, culminating in a RFSAP meeting in December 2000 to review the results of the August recommendations. The RFSAP based its December 2000 recommendations on runs configured with a short landings time series, updated 1998-99 harvest data, a 33% release mortality rate for the longline fishery, longline discards estimated through the probabilistic approach, and steepness values of 0.7 and 0.8. There was no change in the estimated stock status despite these efforts. According to estimates from the chose configuration, the stock was both overfished and overfishing in the terminal year 1997 .

The basic configuration agreed to by the RFSAP in December 2000 was updated by NMFS/SEFSC in 2002, including data through 2001. New data sources included additional age and growth information provided by a 1992-2001 life history study and subsequent improved catch-age allocations, and updated fecundity information based on 1992-2001 sampling.

The RFSAP reviewed the updated assessment in September, 2002. The panel based management advice on assessment configurations including the newly available life history information. Steepness values of 0.7 and 0.8 were used to develop a range for management parameter estimates, with a caveat that the 0.8 value was well above both the estimated value (0.68) and expected values for species of similar life history. It was believed at this time that the stock was showing some signs of recovery, as the stock was no longer overfished and runs based on steepness 0.8 suggesting that overfishing was no longer occurring. The panel noted that increases in catch in the terminal years may be the result of recent strong year classes while acknowledging a lack of information available at the time to evaluate such a hypothesis. The panel also commented that recent increases in abundance and thus biomass appeared the result of recent increased recruitment.

In 2006, red grouper was assessed under the umbrella of the SEDAR process (SEDAR 2006). Two models were considered. The first was a model configured using the age-structured assessment program (ASAP, Legault and Restrepo 1998) and the second was a production model. The production model was ultimately rejected due to a lack of convergence; therefore, the ASAP model was used to evaluate stock status and provide management advice. The assessment time-series started in 1986 and ended in 2005. The age-structure of the population was assumed to start with age-1 recruits and the terminal age bin, age-20, represented a plus group. The main data inputs for the ASAP model included indices of abundance (commercial handline, commercial longline, MRFSS recreational, headboat survey (1986 – 1990, 18” TL size limit), headboat survey (1990 – 2005, 20” TL size limit), and SEAMAP video survey), catch-at-age, discards-at-age, catch in weight, and discards in weight. The catchabilities of the fishery-dependent indices were assumed to increase by 2% annually. Catch-at-age and discards-at-age were modeled using the Goodyear approach (Goodyear 1997). The results of the 2006 stock assessment indicated that the stock was not be overfished (SSB/SSB_{MSY} = 1.27) and was not experiencing overfishing (F/F_{MSY} = 0.73).

The 2006 assessment was revisited in 2009 as an update assessment. The update assessment time-series started in 1986 and was extended by three years, ending in 2008. The basic model structure and data inputs were similar to the 2006 assessment. The main difference in the data inputs was the inclusion of observed discard lengths from the recreational (2005-2007) and commercial longline and handline fleets (2006-2008) that were converted to ages. The 2006 model was changed to include an episodic red tide mortality event in 2005 and no longer assumed an annually increasing catchability in the fishery-dependent indices. The results of the update assessment indicated that the stock was not overfished in 2008 and was not experiencing overfishing.

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4 REGIONAL MAPS

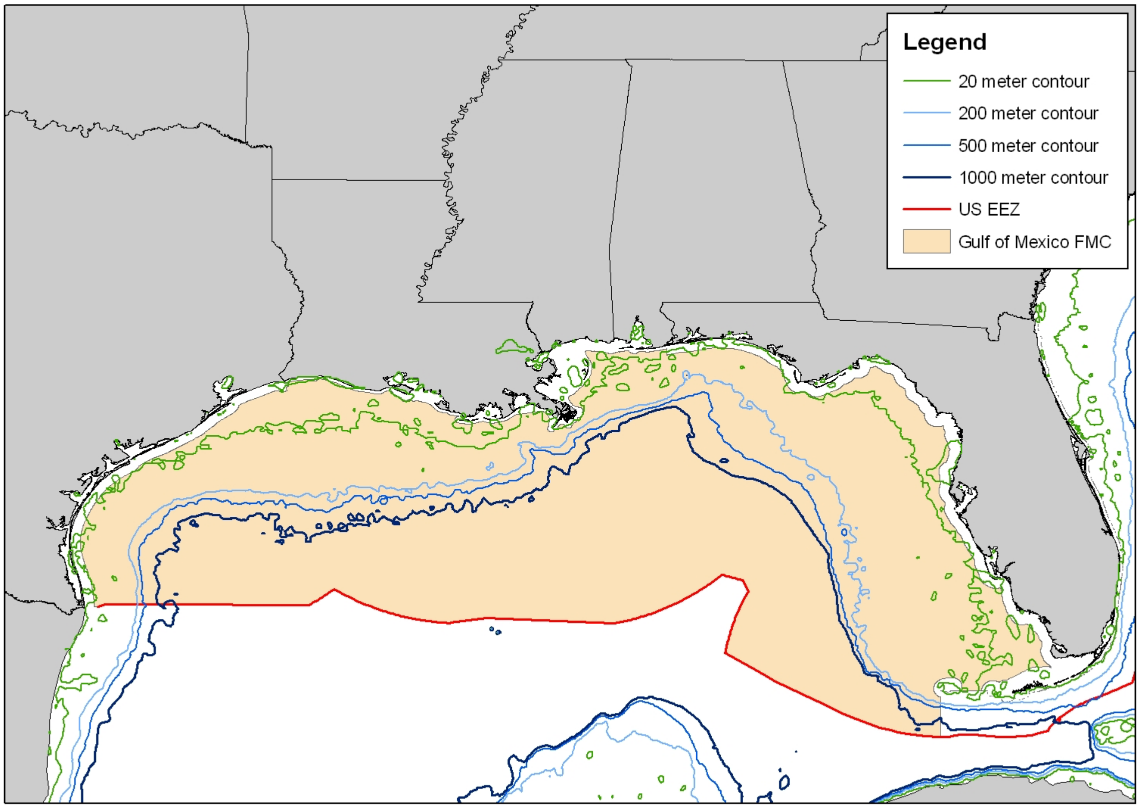

Figure 4.1 Southeast Region including Council and EEZ Boundaries.

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 42

Gulf of Mexico Red Grouper

SECTION II: Data Workshop Report

February 2015

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

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1 INTRODUCTION

1.1 WORKSHOP TIME AND PLACE

The SEDAR 42 Data Workshop was held November 17-21, 2014 in St. Petersburg, Florida.

1.2 TERMS OF REFERNCE

1. Review stock structure and unit stock definitions and consider whether changes are required.
2. Review, discuss, and tabulate available life history information.
   - Evaluate age, growth, natural mortality, and reproductive characteristics
   - Provide appropriate models to describe growth, maturation, and fecundity by age, sex, hermaphroditism including age and size at transition, and/or length as applicable.
   - Evaluate the adequacy of available life history information for conducting stock assessments and recommend life history information for use in population modeling.
   - Evaluate and discuss the sources of uncertainty and error, and data limitations (such as temporal and spatial coverage) for each data source. Provide ranges and/or distributions of uncertainty for data sources used in the stock assessment models[1].
3. Recommend discard mortality rates.
   - Review available research and published literature
   - Consider research directed at red grouper as well as similar species from the southeastern United States and other areas.
   - Provide estimates of discard mortality rate by fishery, gear type, depth, and other feasible or appropriate strata.
   - Include thorough rationale for recommended discard mortality rates.
   - Provide justification for any recommendations that deviate from the range of discard mortality provided in the last benchmark or other prior assessment.
   - Evaluate, discuss, and characterize the sources of uncertainty, and data limitations (such as temporal and spatial coverage) for each data source. Provide ranges and/or distributions of uncertainty for data sources used in the stock assessment models[1].
4. Provide measures of population abundance that are appropriate for stock assessment.
   - Consider and discuss all available and relevant fishery-dependent and -independent data sources.
   - Document all programs evaluated; address program objectives, methods, coverage, sampling intensity, and other relevant characteristics.
   - Provide maps of fishery and survey coverage.
   - Develop fishery and survey CPUE indices by appropriate strata (e.g., age, size, area, and fishery) and include measures of precision and accuracy.
   - Discuss the degree to which available indices adequately represent fishery and population conditions.

- Recommend which data sources adequately and reliably represent population abundance for use in assessment modeling.
- Evaluate and discuss the sources of uncertainty and error, and data limitations (such as temporal and spatial coverage) for each data source. Provide ranges and/or distributions of uncertainty for data sources used in the stock assessment models[1].
- Complete the SEDAR index evaluation worksheet for each index considered.
- Rank the available indices with regard to their reliability and suitability for use in assessment modeling.

5. Identify and describe ecosystem, climate, species interactions, habitat considerations, and/or episodic events that would be reasonably expected to affect population dynamics.
6. Incorporate socioeconomic information into considerations of environmental events that affect stock status and related fishing effort and catch levels as practicable.
7. Provide commercial catch statistics, including both landings and discards in both pounds and number.
    - Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector or gear.
    - Evaluate and discuss the sources of uncertainty and error, and data limitations (such as temporal and spatial coverage) for each data source. Provide ranges and/or distributions of uncertainty for data sources used in the stock assessment models[1].
    - Provide length and age distributions for both landings and discards if feasible.
    - Provide maps of fishery effort and harvest by species and fishery sector or gear.
8. Provide recreational catch statistics, including both landings and discards in both pounds and number.
    - Evaluate and discuss the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector or gear.
    - Evaluate and discuss the sources of uncertainty and error, and data limitations (such as temporal and spatial coverage) for each data source. Provide ranges and/or distributions of uncertainty for data sources used in the stock assessment models[1].
    - Provide length and age distributions for both landings and discards if feasible.
    - Provide maps of fishery effort and harvest by species and fishery sector or gear.
9. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Include specific guidance on sampling intensity (number of samples including age and length structures) and appropriate strata and coverage.
10. Prepare the Data Workshop report providing complete documentation of workshop actions and decisions in accordance with project schedule deadlines (Section II of the SEDAR assessment report).

[1] In providing ranges for uncertain or incomplete information, data workshop groups should consider and distinguish between those ranges and bounds that represent probable values (i.e., likely alternative states) to be included in structured uncertainty analyses, and those that represent extreme values to be considered in evaluating model performance through sensitivity analyses.

1.3 LIST OF PARTICIPANTS

Workshop Panel

Meaghan Bryan, Lead Analyst .... NMFS Miami
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Adyan Rios .... NMFS Miami
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Beverly Sauls .... FL FWC
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John Ward .... SSC

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Ryan Rindone...GMFMC
Charlotte Schiaffo ....GMFMC

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Chris Gardner...NMFS Panama City
Chris Kelble ....NOAA AOML
Michael Schirripa..NMFS Miami
Elizabeth Scott-Denton ....NMFS Galveston
John Walter ....NMFS Miami
Jason Whitaker..Private Angler

1.4 LIST OF DATA WORKSHOP WORKING PAPERS & REFERNCE DOCUMENTS

Document #	Title	Authors	Date Submitted
AnglerDocuments Prepared for the Data Workshop			
SEDAR42-DW-01	Summary of commercial red grouper (*Epinephelus morio*) catch data based on fishery observer coverage of the Gulf of Mexico reef fish fishery	Jeffrey R. Pulver, Linda Lombardi, and Elizabeth Scott-Denton	27 Oct 2014
SEDAR42-DW-02	Evaluation of the natural mortality rates of red grouper (*Epinephelus morio*) in the West Florida Shelf ecosystem using the individual-based, multi-species model OSMOSE-WFS	A. Grüss, M. J. Schirripa, D. Chagaris, P. Verley, Y.-J. Shin, L. Velez, C. H. Ainsworth, S. R. Sagarese, and M. Karnauskas[2]	1 Nov 2014
SEDAR42-DW-03	Use of the Connectivity Modeling System to estimate the larval dispersal, settlement patterns and annual recruitment anomalies due to oceanographic factors of red grouper (*Epinephelus morio*) on the West Florida Shelf	A. Grüss, M. Karnauskas, S. R. Sagarese, C.B. Paris, G. Zapfe, J.F. Walter III, W. Ingram, and M. J. Schirripa	2 Nov 2014 Updated: 14 Nov 2014
SEDAR42-DW-04	Ontogenetic spatial distributions of red grouper (*Epinephelus morio)* within the northeastern Gulf of	S. R. Sagarese, A. Grüss, M. Karnauskas, J.F.	3 Nov 2014

	Mexico and spatio-temporal overlap with red tide events	Walter III	
SEDAR42-DW-05	Red Grouper Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico	Adam G. Pollack and G. Walter Ingram, Jr.	7 Nov 2014 Updated: 26 Nov 2014
SEDAR42-DW-06	Red Grouper Abundance Indices from NMFS Bottom Longline Surveys in the Northern Gulf of Mexico	Adam G. Pollack and G. Walter Ingram, Jr.	19 Nov 2014
SEDAR42-DW-07	Maturity, sexual transition, and spawning seasonality in the protogynous red grouper on the West Florida Shelf	Susan Lowerre-Barbieri, Laura Crabtree, Theodore S. Switzer, and Robert H. McMichael, Jr.	17 Nov 2014 Updated: 21 Nov 2014
SEDAR42-DW-08	Indices of abundance for Red Grouper (*Epinephelus morio*) from the Florida Fish and Wildlife Research Institute (FWRI) video survey on the West Florida Shelf	Cameron B. Guenther, Theodore S. Switzer, Sean F. Keenan, and Robert H. McMichael, Jr.	12 Nov 2014
SEDAR42-DW-09	Indices of abundance for Red Grouper (*Epinephelus morio*) from the Florida Fish and Wildlife Research Institute (FWRI) chevron trap survey on the West Florida Shelf	Cameron B. Guenther, Theodore S. Switzer, Sean F. Keenan, and Robert H. McMichael, Jr.	12 Nov 2014
SEDAR42-DW-10	An age and growth description of Red Grouper (*Epinephelus morio*) from the northeastern Gulf of Mexico: 1978-2013 for SEDAR42	Linda Lombardi-Carlson	13 Nov 2014 Updated: 10 Dec 2014
SEDAR42-DW-11	SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Red Grouper	Matthew D. Campbell, Kevin R. Rademacher, Michael Hendon, Paul Felts, Brandi Noble, Michael Felts, Joseph Salisbury, and John Moser	13 Nov 2014
SEDAR42-DW-12	Variations in length frequency distributions and age length keys for red groupers collected in the Gulf of	Ching-Ping Chih	14 Nov 2014

	Mexico		
SEDAR42-DW-13	The use of Otolith Reference Collections to Determine Ageing Precision of Red Grouper *(Epinephelus morio)* Between Fisheries Laboratories	Palmer, C.L., L. Lombardi, J. Carroll, and E. Crow	18 Nov 2014 Updated: 16 Dec 2014
SEDAR42-DW-14	Size Distribution of Red Grouper Observed in For-Hire Recreational Fisheries in the Gulf of Mexico	Alisha Gray and Beverly Sauls	20 Nov 2014 Updated: 15 Dec 2014
SEDAR42-DW-15	Red Grouper *Epinephelus morio* Findings from the NMFS Panama City Laboratory Trap & Camera Fishery-Independent Survey – 2004-2014	D.A. DeVries, C.L. Gardner, P. Raley, and W. Ingram	5 Dec 2014
SEDAR42-DW-16	Estimates of Historical Private/Charterboat and Headboat Fishery Red Grouper Angler Catch in the Gulf of Mexico 19xx-1980	Jeff Isely, Nancie Cummings and Adyan Rios	9 Dec 2014
SEDAR42-DW-17	Discards of red grouper (*Epinephelus morio*) for the headboat fishery in the US Gulf of Mexico	Fisheries Ecosystems Branch, Beaufort, NC	21 Nov 2014 Updated: 10 Dec 2014
SEDAR42-DW-18	Length and age frequency distributions for red groupers collected in the Gulf of Mexico from 1984 to 2013	Ching-Ping Chih	11 Dec 2014
SEDAR42-DW-19	Index report cards	Indices Working Group	17 Dec 2014

2 LIFE HISTORY

2.1 OVERVIEW

The life history workgroup (LHW) reviewed and discussed data collected since the last Gulf of Mexico red grouper stock assessment in 2006 and the update assessment in 2009 (SEDAR 2006, SEFSC 2009). Updated information was examined and new studies were reviewed regarding age, growth, reproduction, mortality, habitat and movement. A summary of the data presented, discussions and recommendations made during SEDAR42 Data Workshop are presented below.

2.1.1 Life History Workgroup (LHW) members

Member Name	Affiliation
Linda Lombardi-Carlson (group leader)	SEFSC/NMFS Panama City, FL
Gary Fitzhugh	SEFSC/NMFS Panama City, FL
John Mareska	Alabama Marine Resources, Mobile, AL
Sue Lowerre-Barbieri	FL FWCC/FWRI St. Petersburg, FL
Jon Dodrill	FL FWCC Tallahassee, FL
Mike Drexler (observer)	Ocean Conservancy, St. Petersburg, FL

2.1.2 LHW Topics addressed

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

2.2 REVIEW OF WORKING PAPERS

These SEDAR42 Data Workshop Working Papers were taken into consideration within the corresponding life history topics discussed below.

Chih, C-P. 2014a. Variations in length frequency distributions and age length keys for red groupers collected in the Gulf of Mexico. SEDAR42-DW-12. SEDAR, North Charleston, SC. 26 pp.

Chih, C-P. 2014b. Length and age frequency distributions for red groupers collected in the Gulf of Mexico from 1984-2013. SEDAR42-DW-18. SEDAR, North Charleston, SC. 42 pp.

Grüss, A., M. Karnauskas, S. R. Sagarese, C.B. Paris, G. Zapfe, J.F. Walter III, W. Ingram, and M. J. Schirripa. 2014. Use of the Connectivity Modeling System to estimate the larval dispersal, settlement patterns and annual recruitment anomalies due to oceanographic factors of red grouper (*Epinephelus morio*) on the West Florida Shelf. SEDAR42-DW-03. SEDAR, North Charleston, SC. 24 pp.

Lombardi-Carlson, L. 2014. An age and growth description of Red Grouper (*Epinephelus morio*) from the northeastern Gulf of Mexico: 1978-2013 for SEDAR42. SEDAR42-DW-10. SEDAR, North Charleston, SC. 37 pp.

Lowerre-Barbieri, S., L. Crabtree, T.S. Switzer, and R.H. McMichael, Jr. 2014. Maturity, sexual transition, and spawning seasonality in the protogynous red grouper on the West Florida Shelf. SEDAR42-DW-07. SEDAR, North Charleston, SC. 20 pp.

Palmer, C.L., L. Lombardi, J. Carroll, and E. Crow. 2014. The use of otolith reference collections to determine ageing precision of Red Grouper (*Epinephelus morio*) between fisheries laboratories. SEDAR42-DW-13. SEDAR, North Charleston, SC. 10 pp.

2.3 STOCK STRUCTURE

The red grouper fishery has been managed as separate Gulf and Atlantic stock units with the boundary being U.S. Highway 1 in the Florida Keys. The life history workgroup (LHW) discussed and reviewed the available stock structure information and inquired about new evidence to suggest changing stock management units. Many researchers have indicated due to red grouper's high site fidelity that over an evolutionary scale, sub-populations may emerge throughout red groupers range.

Recommendation

Given that no new information was presented related to the mixing of the Atlantic and Gulf of Mexico stock units, the LHW recommends that the red grouper fishery be managed as a separate stock within the Gulf of Mexico, until further studies may suggest otherwise.

2.3.1 Population genetics, larval transport, and connectivity

Genetic studies have not revealed any separate stock structure or reproductive isolation among southeastern U.S. Atlantic, northeastern Gulf of Mexico, and southwestern Mexico, Gulf of Mexico (Yucatan peninsula) collections of red grouper based on mitochondrial DNA (Richardson and Gold 1997) or microsatellite genetic markers (Zatcoff et al. 2004). Based on recent biophysical modeling of transport from the Campeche Banks of red snapper and Gag, it is hypothesized that little connectivity exists for red grouper mixing of Mexico and US stocks as well (unpublished data, M. Karnauskas, SEFSC/NMFS Miami, FL). Red grouper may have a more complex stock structure based on possible separated distributions and evidence of little movement but a longer timescale of generations may be needed to detect genetic differences (Zatcoff et al. 2004).

Red grouper spend their larval phase in the plankton carried across the Florida shelf or in some cases are self-recruiting (Grüss et al. 2014). Wallace et al. (2014) analyzed stable isotopes form eye lenses of red snapper (n=8), red grouper (n=4) and Gag (n=3) from the west Florida shelf. Samples sizes (n) were small and groups across the shelf were detected for red snapper and Gag. No clear grouping emerged for red grouper. Juvenile red grouper are found settling and residing on a variety of suitable habitat at ages 0-2 predominantly out to 30m depth contour (Figure 2.1).

Based on recent biophysical modeling of transport from the Campeche Banks of red snapper and Gag, it is hypothesized that little connectivity exists for red grouper mixing of Mexico and US stocks as well (unpublished data, M. Karnauskas, SEFSC/NMFS Miami, FL).

2.3.2 Habitat Requirements

Juvenile red grouper are generally characterized as inhabiting shallow water habitats, but some are found in waters deeper than 30m. Florida Fish and Wildlife Conservation Commission (personal communication, T. Switzer, FL FWCC/FWRI, St. Petersburg, FL) has reported numerous sub-legal (≤ 508 mm TL) size red grouper in association with natural and artificial structures in the 6 to 30m depth ranges. Juveniles utilize spaces between structures, as well as, create holes beneath. Red grouper are associated with the low relief artificial patch reefs deployed for Gag (personal communication, B. Lindberg, UF/SFRC/FAS Gainesville, FL). For the patch reefs along the 12m and 21m depth contours, red grouper were approximately 1% and 6% of Gag abundance, respectively.

Coleman et al. (2011) list low relief, hard bottom covered with a thin veneer of sand as essential habitat for adult red grouper. Within the depths of the study area, 60 to 100m, red grouper were abundant from 60 to 73m in Steamboat Lumps and Madison Swanson marine reserves. Red grouper were characterized as either few or none for depths out to 100m. Burns and Robbins (2006) collected red grouper from Tampa Bay to Florida Keys predominantly at 40-60m and 80-90m. Sites within the marine reserves were mostly characterized as low relief, with some large cobble to boulders size rocks with less than 2m in vertical relief. Sponges, seafans, corkscrew sea whips and small clusters of stony coral are other characteristics of habitat that may hold red grouper. Areas that contain red grouper are indicated by conical depressions 2m in depth by 5 to 6.8m in width. These depressions are the result of excavation activities by red grouper that clean rocky surfaces and provide attachment sites for sessile invertebrates and other species such as vermilion snapper and spiny lobster (Coleman et al. 2010).

In general, red grouper are hypothesized to have high site fidelity due to the investment they make in excavating and creating habitat (Coleman et al. 2010, Coleman et al. 2011, Wall et al. 2011). Wall et al. (2011) studying red grouper holes in the Steamboat Lumps Marine Reserve indicated that hole density was increasing over time (2006-2009) and, in response to increasing density, individual hole depth and slope increased. In addition, red grouper were collected from depths ranging from 6.5 to 94m and mature red grouper inhabited a preferred range (30-80m) as indicated by females collected while in spawning condition (unpublished data, S. Lowerre-Barbieri, FL FWCC/FWRI, St. Petersburg, FL), however, spawning females were found in deeper depths (Figure 2.2). These depths also are representative of immature and mature males (Figure 2.3).

2.3.3 Tagging, movements, and migrations

Tagging at artificial reef sites (2005-2007) off the western Florida panhandle indicated collective groupers (Gag [n=101], Scamp [n=20], red grouper [n=34]) had high site fidelity with 33% being recaptured at the tagging site (Addis et al. 2007). A high percentage of the tagged grouper were below the minimum size limit and authors acknowledged that off shore movement in these shallow grouper species increases ontogenetically.

Extensive tagging of snapper and grouper species (n=15,000+) in the northeastern Gulf, centered off Manatee and Sarasota counties, by Mote Marine Laboratory strongly suggested that red grouper (age 2-4 yr) move very little. No verifiable recaptures were made in the Atlantic Ocean. Of the 243 recaptured red grouper, 89% of these moved less than 1.9 km (Burns et al. 2008). Coleman et al. (2011) were able to tag and recapture 9 red grouper and after 100 to 300 days at liberty 8 red grouper had shown no movement.

Movement by recaptured red grouper (n=388) indicated that approximately 63% moved less than 1 kilometer and 16% moved between 2-5 km (Burns et al. 2008). A plot of length tagged as sub-adults by recaptured length, 43-1200 days later, at distance from shore, shows that overall fish length increased with distance. Sub-adults were tagged and released at depths ranging 6 to 30m and recaptured at depths ranging from 30 to 85m (Burns et al. 2008). These data agree with those of Bullock and Smith (1991) who reported that smaller red grouper usually occur in shallow water (3-18m) off southwest Florida, and then following several years, are found in commercial catches at depths greater than 36m. The maximum distance moved was 375 km (Burns et al. 2008). Recaptures of larger red grouper were either recaptured at the original site or a few kilometers away (Burns and Robbins 2006). Koenig and Coleman (2006) reported that older red grouper exhibit high site fidelity upon reaching mid- to outer shelf depths, which they attributed to the species habitat-structuring and harem mating behavior. None of their tagged fish moved more than 1.2nm. Thus, in general, tagging data reveal that most red grouper exhibit limited movements throughout their life span, which could give rise to complex sub-stock structure.

Rare fish do exhibit long distance movements and it is postulated that some of these movements are the result of hurricane forces (Burns and Robbins 2006). One individual was recaptured 375 km from the release site (Burns et al. 2008). There have been some reports of movements in red grouper that do not appear related to ontogeny. Some onshore/offshore movements have been explained by anglers as inshore summer feeding migrations (personal communication, M. Fischer, stakeholder representative). Commercial fishers have also noted seasonal movements of adult red grouper offshore (27-91m) in the Florida Keys (Bullock and Smith 1991). Moe (1972) reported 22 tagged red grouper traveled 16ml within 50 days. The Mote tagging data also revealed that groups of similar sized fish caught together on the same date at the same location were recaptured together on the same date at some other same site. This type of pattern has been characterized as “cohort movement” (personal communication, K. Burns, Mote Marine Laboratory, Sarasota, FL). These cohort movements (recapture groups of 2-5 fish) have occurred during all months of various years, however it is unknown how common or widespread these might be due to the nature of fishery-dependent recaptures. There is further information that red grouper movements occur after spawning, possibly following prey to shallower depths (Moe 1969; personal communication, W. Ward, commercial fisher). Perhaps similar to “cohort movement”, red grouper may move in large numbers in response to events such as hurricanes. Following Hurricane Lili in (2002), juvenile and adult red grouper were commonly caught on artificial reefs and petroleum platforms off Mississippi (Franks 2003). After Hurricane Ivan

(2004) juvenile and adult red grouper were commonly caught within Alabama's artificial reef zone (personal communication, J. Mareska, Alabama Marine Resources, Mobile, AL).

2.4 AGE AND GROWTH DATA

2.4.1 Source of samples

Age data were provided to the LHW by NMFS Panama City with data from the Gulf of Mexico commercial and recreational fisheries, and fishery independent surveys (1978-2013, n=95,343; Lombardi-Carlson 2014). Age data were collected by multiple sources (Table 2.1), incorporating a variety of fishing modes and gears (Table 2.2). Of the 95,343 otoliths collected, 39,857 were aged (Table 2.3). Due to an increase in otolith sampling that has occurred in the commercial hand-line and long-line sectors, records (minimum n = 500) from each year and gear were randomly sub-sampled based on the percentage of commercial landings by National Marine Fisheries Service (NMFS) Shrimp Grids (see Lombardi-Carlson 2014 for further information).

Recommendation

The LHW recommends the use of all age and growth data from multiple sources for SEDAR42.

Adequacy of the data

- Sample sizes of red grouper intercepted by commercial sector were low prior to 2000 and currently (2009-2013) there is in over sampling of this sector.
- The recreational sector is still being under sampling for biological samples (e.g., hard parts, n<100/year, all years). It is recommended that an increase in the number of trips intercepted by year by both the MRFSS/MRIP and SRHS occurs in the future and for a higher percentage of the intercepts include collecting biological samples (length, weight, and hard parts).
– In the past 4 years, only 166 trips (on average, 2010-2013; Table 4.8.11) intercepted included collecting biological samples (e.g., length, hard parts) by MRFSS/MRIP port agents and there was an estimated 22 million recreational trips made by recreational anglers in the more recent years (2010-2013; Table 4.8.17). Biological data collected at such a low percentage (< 0.0001%), provide very minimal information regarding age and growth of red grouper. An

increase in the number of fish intercepted for biological samples will increase our knowledge of the size and age structure being intercepted by recreational anglers.

2.4.2 Age Reader Precision

Two ageing facilities provided red grouper ages to SEDAR42 (NMFS Panama City and FL FWCC/FWRI St. Pete), involving 11 individual readers over the entire time series of data collection (Palmer et al. 2014). Indices of precision (APE = Average Percent Error, CV = Coefficient of Variation and D = Index of Precision) were calculated to determine the agreement among readers for specific time periods. Overall reader agreement values show high precision among all five groupings of readers (APE, range 3.21-5.10; CV, 4.23-6.50; D, 2.12-3.25). Standard deviations at age among readers showed little bias, up to age 12 (Figure 2.4).

Recommendation

Apply the ageing error matrix, if warranted, given the models predictions of annual age frequencies.

2.4.3 Year Class progressions

Red grouper year-class trends are apparent for the Gulf of Mexico due to the ease of aging red grouper otoliths and the availability of a continuous series of age structure sampling from 1991 to 2013 from the Gulf. Strong year classes were evident in the Gulf of Mexico 1989, 1990, 1991, 1996, 1999, 2002, 2006 and 2007 (Lombardi-Carlson 2014).

2.4.4 Age and Length data

Red grouper for SEDAR42 were represented from a wide range of fork lengths (116-1010 mm, 540 ± 114 mm, mean ± std dev) with most lengths from the 500 – 600 mm length bin. The ages of these fish also encompassed a wide distribution (range = 0-29 yrs, 6.8 ± 3 yr) (Lombardi-Carlson 2014). There was more variation in the modal age (than length) given the presence/absence of a strong cohort in a specific year. In more recent years, there seems to be fewer (<10) fish older than 20 years collected but is uncertain if this is due to a decline in older fish in the population or due to recent changes in the fishery management regulations (Table 2.4).

2.4.5 Modeling Growth

A growth curve, based on fractional ages and observed fork lengths at capture, was modeled using the von Bertalanffy growth model and was executed in ADMB (Auto Differentiate Model Builder). The size-modified growth model takes into account the non-random sampling due to minimum size restrictions (Diaz et al. 2004) used in this assessment has structural similarities with the model applied in the previous assessments (Lombardi-Carlson et al. 2006, Lombardi-Carlson et al. 2009), but now the size-modified growth model is compiled in ADMB with alternative variance structures. Since not all species have the same variability in the variations of sizes-at-age, it is valuable to model growth with the variance structure most representative of the species. The model choices of the variance structures in the size-at-age data are: constant standard deviation (SD) with age, constant coefficient of variation (CV) with age, variance proportion to the mean, coefficient of variation (CV) increase linearly with age, and coefficient of variation (CV) increases linearly with size. Multiple model compilations were examined using three difference variance structures (constant SD with age, constant CV with age, and CV increases linearly with age) in the size-at-age data. Model convergence was based on value of the model objective function (minimal log-likelihood) and Akaike Information Criteria (AIC).

Red grouper displayed a constant CV with age (Figure 2.5b). The growth models using the variance structure of constant CV with age and CV increases linearly with age had similar objective functions, as well as, similar predicted growth parameters (Table 2.5 and 2.6). Model diagnostic plots showed similar residual patterns for each variance structure: normally distributed residuals, reasonable distribution of residuals by age, and probability plots showed divergence (see Figure 9, Lombardi-Carlson 2014). The LHW recommends the growth model using the same variance structure as observed in red grouper, constant CV with age. The SEDAR42 growth model was very similar to those of previous assessments (Table 2.5, Figure 2.6), with slightly smaller asymptotic fork lengths, similar growth coefficients (as update in 2009), and similar sizes at time zero.

Recommendation

The LHW recommends using the predicted growth parameters from the growth model using a constant CV at age variance structure as priors in the stock synthesis assessment model, providing growth will be predicted internally in the stock synthesis assessment model.

2.5 MORTALITY

2.5.1 Natural Mortality

There are multiple methods to calculate estimates of natural mortality (M) and these methods use a variety of life history parameters (e.g., von Bertalanffy growth parameters, maximum age, age at 50% maturity, Table 2.7) and environmental parameters (water temperature). A constant natural mortality for the lifetime of a species is unrealistic but an estimate of M is necessary for the calculation of an age-specific vector of natural mortality (Lorenzen 2005).

<u>Point estimates of M</u>

Multiple life history parameters (asymptotic length, growth coefficient, maximum age, age at 50% mature) and water temperature were used to calculate various point estimates of M (Table 2.7 and 2.8). As reported during SEDAR12, the maximum estimated age of red grouper in the Gulf of Mexico is 29 years (Lombardi-Carlson et al. 2006). This red grouper was caught during a fishery independent survey using hook-and-line gear in 1992. During SEDAR12, the Assessment Panel recommended not to use the oldest aged red grouper to calculate natural mortality but to use the next, more frequent age class (age 25, n = 13, Table 2.4); however, this decision was reversed during the Review Panel (SEDAR 2006).

Using the multiple methods to calculate natural mortality, M ranged from 0.10 – 0.82 (Table 2.8). The minimum M was calculated using the Hewitt and Hoenig (2005) method that divides the maximum age by a constant and the maximum M was calculated using Beverton and Holt (1956) that uses both the predicted von Bertalanffy growth coefficient and the age at 50% maturity (Table 2.7 and Table 2.8). The natural mortality methods that utilize the von Bertalanffy growth parameters (Linf and/or k) estimated similar M values (0.19-0.31). Likewise, those natural mortality methods that took in consideration maximum age had similar M values (0.10-0.16).

Recommendation

As was recommended during SEDAR12 and the update assessment in 2009, LHW recommends using the maximum age fish of 29 years to calculate natural mortality by applying Hoenig's regression for teleosts (M = 0.14) as the target M used to calculate an age-specific vector of M.

<u>Age-Specific vector of M</u>

An age-specific vector of M was developed during the red grouper SEDAR12 assessment workshop (SEDAR 2006, following Lorenzen 2005). This vector was re-estimated using the resulting von Bertalanffy growth parameters for SEDAR42 (Table 2.9, Figure 2.7). This vector takes into the consideration the first age at vulnerability into the fishery (age 5), the target M of 0.14 ($Hoenig_{teleost}$, maximum age of 29 years) and the von Bertalanffy growth parameters. The resulting age-specific natural mortality vector was compared to the previous vectors from the update assessment in 2009 and SEDAR12 (SEDAR 2006, SEFSC 2009). The only difference among the age-specific natural mortality vectors were the predicted von Bertalanffy growth parameters used in the estimations.

Recommendation

The LWH recommends applying the age-specific natural mortality vector using Lorenzen 2005 (as was used in previous assessments) adjusted for the newly predicted von Bertalanffy growth parameters.

<u>*Assessment model sensitivities for M*</u>

In previous assessments, model sensitivities for natural mortality have been quite arbitrary (age-specific natural mortality vector increased and decreased by 10%) (SEDAR 2006, SEFSC 2009).

LHW presented 5 different options for model sensitivities for M:

1. Apply the same sensitivities as in the update assessment in 2009 and SEDAR12 (10% increase/decrease in the age-specific natural mortality vector).
2. Apply a range of M (upper: M = 0.20 (corresponds to a maximum age of 21); lower: M = 0.10 (corresponds to a maximum age of 40)).
3. Apply the average ± standard deviation (0.19 ± 0.07) of the point estimates of M (except for the Beverton and Holt outlier) (Table 2.8).

4. Apply the average ± standard deviation (0.13± 0.02) of the point estimates of M (only for those regressions that incorporate maximum age) (Table 2.8).
5. Apply the resulting standard deviation (± 5) for the maximum aged red grouper. Three readers interpreted this otolith (readings: 29, 21, 19; average age 23 yrs, standard deviation 5 yrs).

Recommendation

The LHW recommends applying option 5 as the sensitivities for the age-specific natural mortality vector based on the variation around the maximum aged red grouper (age 29 ± 5 yrs) (Table 2.10, Figure 2.8).

2.5.2 Total Mortality

A catch curve estimated the instantaneous total mortality (Z) using data summarized in Lombardi-Carlson 2014. Age 5 fish were considered fully recruited to the fishery. Combining all cohorts for the 5-18 year age intervals, an overall Z of 0.39 was observed (Figure 2.9a). A catch curve was also developed for all strong cohorts (1989, 1990, 1991, 1996, 1999, 2002, 2006, 2007), an overall Z of 0.49 was observed (Figure 2.9b).

Recommendation

The LHW recommends the use of the catch-curve derived total mortality estimates (Z) as a check on stock synthesis assessment model results.

2.5.3 Discard Mortality

An ad-hoc panel (led by Beverly Sauls, FL FWCC/FWRI, St. Petersburg, FL) convened during the Data Workshop to specifically discuss discard mortality. Participants included data providers, analysts, and professionals from the fishing industry representing both commercial and private recreational sectors. The task for this panel was to review new data and results from studies that have become available since SEDAR12, and formulate recommended mortality percentages to apply to estimated discards. Previous assessments in 1999 and 2002 assumed 10% discard mortality for recreational discards (based on Wilson and Burns 1996) and 33%

discard mortality for commercial discards. For SEDAR12, 10% discard mortality was recommended for both recreational hook-and-line gear and commercial vertical line gear, and 40% discard mortality was recommended for commercial bottom long-line gear. Two new data sources since SEDAR 12 were identified and are summarized here.

Since 2009, Florida FWCC/FWRI (FWC) has worked cooperatively with for-hire vessels that offer recreational fishing trips from the west coast of Florida. FWC biologists are allowed to board vessels and directly observe discarding practices during recreational hook-and-line bottom fishing trips. A detailed description of methods and results is provided in Sauls et al. 2014. For each red grouper not harvested by anglers, fishery observers recorded the length and capture depth, as well as capture and release condition variables. Discards were marked with conventional tags prior to release. Mark-recapture data were used to model the relative survival of fish released in different conditions and estimate overall discard mortality under conditions measured directly in the recreational hook-and-line fishery. Red grouper that re-submerged with assistance from venting (fair condition), and that demonstrated difficulty re-submerging or suffered internal hook injuries or gill injuries (poor condition) survived at lower rates (survival 82.7% and 60.9%, respectively) compared to fish that were re-submerged immediately without the need for venting (good condition). Point estimates for overall discard mortality across all depths fished were 10.4% and 12.9% in the charter fishery (for areas fished adjacent to Tampa Bay and the northwestern panhandle, respectively), and were comparable to the headboat fishery (9.7% to 13.8%, respectively per area). Confidence intervals for all four point estimates overlapped, and a single mean value may be applied across fleets and areas.

Since 2006, National Marine Fisheries Service has placed fishery observers on commercial vessels fishing with vertical line and bottom long-line gears. A detailed description of methods and results are provided in Pulver et al. 2014. Size, capture depth, release condition, and final dispositions were recorded for red grouper discards. Retention rates increased after initiation of the Individual Fishing Quota (IFQ) program in 2010 most likely due to the lowering of the commercial size limit to 18in TL. Immediate discard mortality was estimated by combining fish that were dead on arrival or that were unable to re-submerge following release as a percentage of overall fish discarded (not including discards with unknown conditions; Figure 2.10). In the vertical line fishery, the mean immediate discard mortality rate (weighted based on the number of fishing sets for each depth bin) was 13.8%. Immediate discard mortality was higher in the bottom longline fishery (27.0% and 29.5% of discards observed pre- and post-IFQ, respectively), but these vessels typically fished in deeper depths than the vertical line fishery.

Recommendations

Based on new data available since SEDAR12, the following recommendations were made:

1. For recreational discards, the ad-hoc panel recommended the mean overall depth-integrated estimate of 11.6% (95% C.I. = 5.8% to 14.5%) from the FWC study be applied to live discards in the recreational fishery. This estimate includes all sources of latent discard mortality for fish that were able to re-submerge and those that were alive and floating after release. Dead discards are included in recreational landings estimates, and no immediate mortality should be applied to recreational discards.

2. For vertical line gear used in the commercial sector, the panel recommended an estimate of 19% latent discard mortality as the base value for all discards that re-submerged or floated. This value is based on the recreational hook-and-line gear depth-dependent discard mortality function from the FWC study for live red grouper discarded in fishing depths between 41 meters and 50 meters (Table 2.11, Figure 2.11), where the vertical line fishery primarily operates. This recommendation is based on the assumption that vertical line gear is fished similar to recreational hook-and-line gear (with regards to retrieval and handling time), and commercial observer data were used to select the mean fishing depth range for vertical line gear that is representative of the Gulf-wide fishery. Therefore, this single mortality percentage may be applied to estimated discards across regions in the Gulf. The same method was used to estimate discard mortality for gag in SEDAR33 (SEDAR 2014a). For sensitivity, the panel recommended a range between 10% and 31%. The lower value is based on the previous percentage used in SEDAR12. The upper value assumes that 100% of discards observed to be floating upon release in the vertical line fishery suffer immediate mortality, and the remaining live discards that are able to re-submerge suffer 20% latent discard mortality.

3. For the bottom long-line fishery, the panel agreed that retrieval and handling times for this gear are longer compared to vertical line and recreational gears. Therefore, a more conservative approach was recommended. Commercial observer data also indicated differences

in discarding practices between pre- and post-IFQ years that may influence mortality. The panel recommended base values of 41.5% discard mortality during pre-IFQ years, and 43.6% post-IFQ. These values assume that 100% of floaters suffer immediate mortality, and 20% latent mortality for discards that re-submerge for each 10-m depth bin. The discard mortality rates for each depth bin were combined using the weighted mean average based on the number of fishing sets in each bin. For sensitivity, the panel recommends using the base value of 20% latent mortality plus and minus 10% for fish that re-submerge with these values (Tables 2.12 and 2.13, Figures 2.12 and 2.13).

2.6 REPRODUCTION

There have been several studies on the reproductive biology of red grouper (see references within SEDAR12, including Fitzhugh et al. 2006). The LHW reviewed the size and age-based data in regards to maturity, sexual transition and fecundity. New references pertaining to reproduction include Freitas et al. (2011) and Lowerre-Barbieri et al. (2014).

2.6.1 Maturity

As red grouper have been found to be protogynous hermaphrodites (female first, then male), all transitional and male fish were considered to be mature (see sexual transition below). Comparison of earlier work (e.g. Moe 1969) was conducted during SEDAR12 and records were examined for the period 1991-2005. As in earlier assessments, histological staging techniques were used. New maturity information was provided by NMFS PC and FL FWCC/FWRI for years 2008-2013 for SEDAR42.

Issues regarding assignment of maturity status were discussed during SEDAR12. Similar challenging issues regarding interpretation of some histological traits persisted and were discussed during SEDAR42. Red grouper females exhibit a high degree of parasitism that may result in atresia or in some cases be confused with degenerating follicles. Additionally, a relatively high proportion of females are not developing (vitellogenic) during the spawning season and are of a size or exhibit traits that otherwise suggests they have previously spawned. This indicates some females are either skip spawning or exhibiting asynchronous reproductive seasonality.

Comments on maturity data

As NMFS PC and FL FWCC/FWRI biologists were preparing for SEDAR42, histological images were exchanged during the summer of 2014 for the purposes of discussing these characteristics.

During the SEDAR42 DW, the LHW made the following decisions:

1) To combine maturity results for NMFS PC and FL FWCC/FWRI.

a) NMFS PC reproductive samples were typically obtained from the commercial fleet (via observers or cooperative projects) and thus represented largest and oldest components of the stock.

b) FL FWCC/FWRI sampling filled a gap noted during SEDAR12 wherein small and younger red grouper were under-represented and which previously made it difficult to fit ogives describing the onset of maturity.

2) To retain maturity data only from the reproductive period (March, April, May and June). This was done to minimize uncertainty between resting or regenerating females and immature females.

3) Both NMFS PC and FL FWCC/FWRI further censored females considered to be "uncertain" in histological staging in addition to retaining data for spawning months. NMFS PC retained females exhibiting developing (CA or V) oocytes and spawning females (bearing POFs or maturing oocytes) as "active" mature. FL FWCC/FWRI did the same but took further steps, via consultation with parasitologists, to distinguish regressing mature females from females bearing parasites. Females designated as immature bore no traits that may be associated with prior spawning (Lowerre-Barbieri et al. 2014). Thus similar to the maturity fit recommended for SEDAR12, active mature and clearly regressing mature females are the numerator of a proportion of total active, regressing and immature females (Figure 2.14).

Adequacy of the data for age and size at maturity

The combination of NMFS PC and FL FWCC/FWRI data increased the size and age ranges for maturity analysis and improved resolution of the onset of maturity.

Recommendation for age and size at maturity

The age range of females with spawning markers (postovulatory follicles and hydrated oocytes) overlapped the age range of females deemed "mature" and supports the identification of the age and size range of mature females (Figure 2.14). The logistic fit via Gompertz equation predicts age at 50% maturity to be 2.8 years (Figure 2.15a) and length at 50% maturity at 292 mm FL (Figure 2.15b).

These maturity results are consistent with recent findings and are intermediate between values determined in SEDAR12 and values determined by FL FWCC/FWRI investigation:

SEDAR12: 50% mature at age 2.0 years and 271 mm FL (Fitzhugh et al. 2006; "definitely" mature, original length 280 mm TL)

FL FWCC/FWRI data only: 50% mature at age 2.96 years and 310 mm FL (Lowerre-Barbieri et al. 2014, original length, 258 mm SL).

While the raw data and details of sample sources are not known from Moe (1969), this early classic work indicated that maturity of females occurred between ages 4-6 years with active mature females important after age 6, at much larger sizes (Moe 1969, Table 8, mean sizes > 500 mm SL for mature females) than are observed in recent years. This comparison supports the conclusion that size and age at maturity has declined since the 1960s. Comparisons with the collections made in Brazil also indicate red grouper can obtain larger sizes before becoming mature (L50 = 380 mm SL, Freitas et al. 2011).

2.6.2 Sexual Transition

As with maturity, NMFS PC and FL FWCC/FWRI data regarding histological determination of sex were combined (Figure 2.16). There is broad overlap of the size and age range of males and female red grouper; transition to male occurs as young as age 3. This is somewhat different than observations for gag wherein males, --individuals with "copperbelly" pigmentation, are noted to be large in size and relatively old (SEDAR 2014a). Of greater distinction, the numbers of sampled red grouper that are male (thus sex ratio) are much greater among young age classes than is observed in gag (Figure 2.16). The overall ratio of red grouper male = 28% (Figure 2.16) while ratios for gag are about 2 to 5% male in recent years (SEDAR 2014a).

As reported during the previous red grouper SEDAR (Fitzhugh et al. 2006, Moe 1969, Burgos 2001 and Koenig reported in Schirripa et al. 1999) and more recently by (Lowerre-Barbieri et al. 2014), reduced age at transition for red grouper is observed in the 1990s and 2000s compared to the 1960s. This is similar to the issue for maturity. While sources of Moe's 1960s samples are not well described, Moe's study using data from the eastern Gulf showed an older age at transition (50% by age 15-16). Moe (1969) noted males do not exceed 10% until after age 9. By visual inspection of the age histogram, males now exceed 10% by age 5 (Figure 2.16). The most recent logistical model fits presented to SEDAR42 indicate that red grouper are 50% male at 793 mm FL (681.9 mm SL) and 12.6 years of age for FL FWCC/FWRI data only (Lowerre-Barbieri et al. 2014).

Recommendation age and size at transition

NMFS PC and FL FWCC/FWRI data combined result in a Gompertz logistical fit predicting 50% male at age 11.2 years and size 707 mm FL (Figure 2.17a, 2.17b), similar to findings during SEDAR12.

The LHW noted that at oldest ages and largest sizes of red grouper, females were still evident (red symbols, Figure 2.17a, 2.17b). During SEDAR12 these old females were considered outliers and due to small numbers at age were discounted during the logistical fit. However, female occurrence among low numbers of oldest red grouper may be biologically relevant. The nature of small and broadly distributed harems, perhaps structured by size, may socially mediate the process of sexual transition. While the LHW did not have advice for alternatives to the logistical fit of sexual transition (Figure 2.17a, 2.17b), there is a research recommendation (below) to improve our understanding of the mating system.

Comments on comparison to gag grouper mating behavior

By comparison to red grouper, gag do not show such evidence of change in size or age at sexual transition over time and exhibits overall fewer males except among the largest sizes and ages perhaps because gag typify a lek type of mating system (SEDAR 2014a). As more information is gathered, the difference between these two protogynous groupers and their mating systems is becoming apparent. Because of broadly distributed harems, red grouper may have more in common with protogynous species such as hogfish. Hogfish exhibit differences in size at transition and reproductive potential among inshore smaller sized components- compared to offshore larger sized components of the stock (Collins and McBride 2011, 2014 and SEDAR 2014b). Thus, managers of red grouper may ultimately need to map the haremic pattern and account for regional differences in fishing intensity similar to hogfish.

2.6.3 Fecundity and spawning frequency

As presented in SEDAR12, red grouper exhibit asynchronous oocyte development and an indeterminate fecundity pattern. Previously batch fecundity and spawning frequency data were considered limited thus gonad weight (of ovaries with vitellogenic and maturing oocytes) were used as the form of reproductive potential. An examination of ovary weight suggests reproductive potential of older and larger females greater than would be predicted by a proportional increase in average weight at age (spawning stock biomass or SSB females) (Figure 2.18).

However, the variation in gonad weight, even when classified by stage of development is quite large due to the temporal changes in oocyte size affecting gonad weight (Figure 2.18).

Recommendation for fecundity

As the LHW noted that more batch fecundity data were available (Figure 2.19), the recommendation is to use the power function fit of the batch data as the form of female reproductive potential.

Other assessments of protogynous hermaphrodites, particularly those conducted in the South Atlantic have used male and female combined SSB when data are limited (Shepherd et al. 2013). This is thought to confer some conservation advantage (e.g., result in a more conservative benchmark) by inclusion of males, assuming males are larger and older yet comprise a small amount of stock biomass (Brooks et al. 2008). However, the LHW discussed that while this approach may hold true for gag, the situation for red grouper may be very different due to greater biomass of males, particularly among younger ages.

Recommendation for model sensitivities for fecundity

Thus, the recommendation is to conduct sensitivity model runs using female SSB and male and female combined SSB. A further recommendation to the Assessment Panel is to define the per capita fecundity as the product of proportion female, batch fecundity, and maturity by age directly and secondarily by size (transformed to age within age-based model), if constrained by inputs to the stock synthesis model.

The LHW noted that more information regarding spawning fraction (which can be used to derive spawning frequency and number of batches) is available compared to earlier assessments (Figure 2.20). The increased data indicates that spawning fraction is greater among larger females supporting the assertion that larger/older females spawn more batches. This could further amplify the non-proportional reproductive contribution of older females than would be expected based on body mass. New approaches for modeling egg production of indeterminate species are being developed but they need to incorporate temporal variation in reproductive traits—and may incorporate spatial variation as well (see Porch 2004, Collins and McBride 2014).

2.7 MERISTIC CONVERSIONS

Meristic relationships were calculated for red grouper in the northeastern Gulf of Mexico for length types (total, fork, and standard) and body weights (whole and gutted) (Table 2.14). Data were combined from all data sources, both fishery independent and dependent and all years (1978-2013).

Recommendation

The LWH recommends applying the meristic conversions provided for SEDAR42.

2.8 COMMENTS ON ADEQUACY OF DATA FOR ASSESSMENT ANALYSES

For stock assessments to provide meaningful results to inform management policies, these stock assessments must use the best available data and the assessment scientists should be knowledgeable on data limitations. The life history data provided for SEDAR42 used the combined efforts of fishery dependent and fishery independent sources (Table 2.1).

Fishery dependent data can be advantageous in that it is more generally available for more species (all that have a management plan), inexpensive, and often routinely collected covering a broad geographic area (Begg 2005). There are several caveats to fishery dependent data. One caveat of fishery dependent data is the size-selective nature of fisheries. A fishery can be size-selective due to a variety of fishery regulations of minimum size limit, an upper slot limit, gear restriction (e.g., hook size, bait type), area and seasonal closures, or depth restrictions. Another caveat of fishery dependent data is how port agents collect biological samples from the landed catch. Most port agents' guidelines for biological sampling are to attempt to purposely sample landings of multiple species from one or many fishing vessels at one time, which has lead to some species being under sampled while other more economically important species are oversampled. A third caveat of fishery dependent data is the behavior of commercial fishers. A fishers behavior can be affected by the current economics (i.e., cost per pound, fuel price, boat slip price), as well as technological advances (i.e., vessel electronics, changes in gear), which can alter the species being fished and the location of fishing.

Fishery independent surveys provide an opportunity to collect data without the influences of the dynamics of a fishery (see caveats above). Red grouper were collected by several fishery independent surveys both at the state and federal level, as well as, special projects such as Cooperative Research Projects, Expanded Annual Stock Assessment Survey. Since the last full red grouper assessment in 2006, these surveys have increased their sampling frequency and provided an enormous amount of biological samples (otoliths, n = 6748; gonads, n = 3034) from standardized methodologies (Table 2.2).

The LHW agrees there were periods of low sampling effort from all data sources (pre-2000, fishery dependent; pre-2007, fishery independent) but with the increase in sampling in all sectors, there is an increase in the resolution of the analysis from such data.

2.9 RESEARCH RECOMMENDATIONS

2.9.1 Stock Structure

<u>*Population genetics*</u> - LHW recommends a study using next-generation sequencing of single nucleotide polymorphisms to generate a genetic map that may elucidate sub-populations and refine the stock structure of red grouper.

<u>*Larval transport and connectivity*</u> - Implement a survey to identify red grouper Age 0's locations for an index of recruitment and identify nearshore habitats that provide recruitment to offshore areas.

<u>*Habitat Requirements*</u> - Given the expected high site fidelity of red grouper, an acoustic array around a harem may provide essential information about mating movements, spawning frequency and duration during the spawning season. Anecdotal information about cohort and feeding movements following spawning may guide more targeted tagging studies.

<u>*Tagging, movements, and migrations*</u> - Gulf wide tag-recapture programs using multiple techniques (dart tags, PIT tags, telemetry, gene tagging) to improve estimates for release mortality and movements among and across regions. Some emphasis concentrated on areas of little known information, the northern and western Gulf of Mexico, as well as the Florida Keys, and should include the time of year as a factor.

2.9.2 Age and Growth

<u>*Sources of Age data*</u>

- Conduct further review of current sampling methodologies by sector, including detailed comparison of length data from otolith samples and from more expansive port-based length sampling (via TIP, MRFSS/MRIP, SRHS; see Chih 2014a, 2014b).
- Bring increased attention to the need for strategies improving port sampling (representation of fishery sectors and random sampling)
- It is recommended that an increase in the number of trips intercepted by year by both the MRFSS/MRIP and SRHS occurs in the future and for a higher percentage of the intercepts include collecting biological samples (length, weight, and hard parts).

<u>*Reader Age Precision*</u>

- Continue exchanges of calibration otolith sets and age workshops among state and federal agencies and universities to continue improvements of data comparability and quality control.
- Continue use and development of a reference collection as a means to monitor precision between/among readers.
- Expand the current reference collections to include older age classes (> age 12).

Year Class Progressions

- Continue age structure sampling from all fishing sectors on an annual basis.

Age and Length Data

- Investigate methods to better collect age structure samples randomly and systematically from all fishing sectors.
- The recreational sector is still under sampling for biological samples (e.g., hard parts, n<100/year, all years). It is recommended that there is an increase in the number of trips intercepted by year by both the MRFSS/MRIP and SRHS and that a higher percentages of the intercepts include collecting biological samples (length, weight, and hard parts). In the past 4 years, only 166 trips (on average, 2010-2013; Table 4.8.11) intercepted included collecting biological samples (e.g., length, hard parts) by MRFSS/MRIP port agents and there was an estimated 22 million recreational trips made by recreational anglers in the more recent years (2010-2013; Table 4.8.17). Biological data collected at such a low percentage (< 0.0001%), provide very minimal information regarding age and growth of red grouper. An increase in the number of fish intercepted for biological samples will increase our knowledge of the size and age structure being intercepted by recreational anglers.

Modeling Growth

- Explore growth model alternatives that includes both the non-random sampling due to minimum size restrictions (Diaz et al. 2004) and non-random sampling due to biases in over/under sampling specific length bins (Chih 2014a, 2014b).

2.9.3 Mortality

Gulf wide tag-recapture programs using multiple techniques (dart tags, PIT tags, telemetry, gene tagging) to improve estimates for natural, discard, and fishing mortalities.

Natural Mortality

- Continue the collection of otoliths from all fishing sectors, as well as, fishery independent surveys to monitor any changes in longevity.
- Continue to investigate age-varying M models and their appropriateness.
- LHW recommends further research into mortality rates of juvenile red grouper as they migrate from inshore to the offshore environment.

Total Mortality

- Continue the annual collection of otoliths from all fishing sectors, as well as, fishery independent surveys to monitor any changes in annual catch by age.

Discard Mortality

- Direct estimates of latent discard mortality are needed for the commercial sector for both bottom long line and vertical line gears. Apply innovative tag-recapture programs to the observed discards to estimate discard and other types of mortality.

2.9.4 Reproduction

Improve our understanding of the spatio-temporal aspects of the reproductive strategy. An example may be screen for a spatial- or depth dependence in male transition. Conduct surveys for metapopulation structure in demographics and reproduction (example hogfish assessment, SEDAR 2014b).

As in SEDAR12, the LHW recommends continued work to better understand and discriminate between annual asynchrony in spawning (skipped spawning) and seasonal asynchrony in spawning. Results of aquaculture rearing trials, review of histology, and new information or metadata regarding temperature and the development and duration of oocytes and follicles may increase our understanding.

Age and Size at Maturity - Continue to monitor changes in maturation schedules – evidence of earlier maturity since Moe 1969.

Age and Size at Transition - Continue to monitor changes in transition schedules, evidence of earlier transition since Moe 1969.

Mating Systems - Utilize new approaches to characterize the mating system such as measurement of the amount of androgen across species and across size within species (Shepherd et al. 2013).

Develop full egg production model by accounting for temporal changes in batch fecundity and intensity of spawning and incorporate spawning frequency by size and/or age.

2.9.5 Meristic & Conversion factors

Continue to communicate the need to standardize length (natural total length, maximum total length, fork length, and standard length), weight (whole and gutted) measurements and the units (metric –e.g., millimeters, kilograms) used in collecting data among all sampling programs to minimize measurement errors.

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2.11 TABLES

Table 2.1. Summary of the number of red grouper otoliths collected by source (TIP - Trip Interview Program, FWRI - Florida Fish and Wildlife Research Institute, HB – Southeast Recreational Headboat Survey, MRFSS - Marine Recreational Fisheries Statistical Survey, RECFIN - Recreational Fisheries Information Network, MSLAB -NMFS Pascagoula MS; PCLAB - NMFS Panama City, FL; CRP - Cooperative Research Proposals, EASA – Expanded Annual Stock Assessment Survey, NMFS Pascagoula, MS; Obs – NMFS Reef Fish Observer Program, Galveston, TX; NMFS Shark Bottom Long-line Observer Program, Panama City, FL; Other - ALLIANCE – expanded vertical line survey from MSLAB, DISL – Dauphin Island Sea Lab, Fishery Independent Survey; FIN – Gulf States Marine Fisheries Commission, Fisheries Information Network, samples from Alabama only; SEAMAP – Fishery Independent Survey, state of Alabama; US Geological Survey, Unknown).

Year	TIP	FWRI	HB	MRFSS	RECFIN	MSLAB	PCLAB	CRP	EASA	Obs	Other	Total
1978						1						1
1979							75					75
1980			5								3	8
1981			14			80					215	309
1985			1									1
1986			9									9
1987			11									11
1988			10									10
1989			11									11
1991	102		32									134
1992	252		31			5					2	290
1993	479		18									497
1994	490		23			6	7					526
1995	522		34			25						581
1996	436		34									470
1997	165		10			1						176
1998	283	13				7	3					306
1999	850		2	33		11	9					905
2000	697		11	12		1	88					809
2001	1,852			31		83	100	2			1	2,069
2002	2,190	18	1	69	44	30	216	310			6	2,884
2003	3,026	28	29	121		62	48	54			6	3,374
2004	2,982	63	41	68	87	170	186	478			14	4,089

2005	3,623	21	29	18	67	50	127	458			3	4,396
2006	4,282	122	21		33	58	32				5	4,553
2007	3,625	305	22	7	32	51	24			105	2	4,173
2008	2,853	182	9	18	113	42	92			9		3,318
2009	6,047	1,007	9	8	190	96	132	2,235		10	1	9,735
2010	5,583	1,021	18	35	353	197	100			145	25	7,477
2011	10,679	968	35	68	439	147	139		1,014		19	13,508
2012	14,460	644	34	18	199	140	95	162		463	11	16,226
2013	12,595	833	16		274	56	23			613	2	14,412
Total	78,073	5,225	520	506	1,831	1,319	1,496	3,699	1,014	1,345	315	95,343
Percent	81.9	5.5	0.5	0.5	1.9	1.4	1.6	3.9	1.1	1.4	0.3	

Table 2.2. Summary of the number of red grouper otoliths collected by sector (CM - Commercial, CP - Charter Party, HB – Headboat, PR - Private, SS - Scientific Survey, Other Modes – Tournament, Unknown) and gear (LL - Long-Line, HL - Hand-Line, VLL – Vertical Long-line, TR - Trap, TRW – Trawl, Other – kali pole, seine net, spear, unknown and undersized fish from CRP in 2009 and recreational vessels in 2009-2011). The recreational (REC) sector composed of otoliths intercepted from charter boats (CP), head boats (HB), and private vessels (PR) from HL in 1979-1980 and spears in other years.

Year	CM LL	CM HL	CM VLL	CM TR	CM Other	CP HL	HB HL	PR HL	REC Other	SS HL	SS LL	SS TR	SS TRW	SS VLL	SS Other	Other	Total
1978										1							1
1979									75								75
1980		1					5		2								8
1981		215					14			11	4	64			1		309
1985							1										1
1986							9										9
1987							11										11
1988							10										10
1989							11										11
1991	48	46		2		1	37										134
1992	156	44		16		25	33	1		5						10	290
1993	201	94		84		61	21	2				5				29	497
1994	88	242		29		75	29			7		6				50	526
1995	151	202		41		99	61			21		4				2	581
1996	103	152		9	6	151	44			5							470
1997	8	41		17	1	69	30	9		1							176
1998	124	42		33		74	21	4		8							306
1999	662	77		31		104	9	2		20							905

2000	412	213		38	6	59	12			68		1					809
2001	1,238	583		40	3	48	1	2		71	80	3					2,069
2002	1,809	573		89	1	287	50	7	6	9	16	18				19	2,884
2003	2,422	567		65	4	101	30	64	4	25	62	14	9			7	3,374
2004	2,340	1,070		38	1	144	43	39	2	139	168	52	52		1		4,089
2005	3,442	630			4	64	52	1		72	32	88	5		1	5	4,396
2006	3,465	633		174		38	33	6		5	98	55	28		14	4	4,553
2007	2,553	1,139			2	46	29	10	6	74	80	59	107		60	8	4,173
2008	2,065	755			11	64	44	25	17	33	30	154	97		2	21	3,318
2009	2,704	3,840	180		17	89	104	16	14	400	64	490	261			1,556	9,735
2010	2,481	1,776	1,341		149	263	86	31	18	705	93	341	98	80		15	7,477
2011	4,613	5,892	115		24	391	114	15	1	198	1,090	534	76	15		431	13,508
2012	5,898	8,943	188		40	225	40	12	2	181	116	435	116	6		24	16,226
2013	5,607	7,479	32		80	216	45	17	8	295	111	359	65	71	1	26	14,412
Total	42,590	35,249	1,856	706	349	2,694	1,029	263	155	2,354	2,044	2,682	914	172	80	2,207	95,343
Percent	44.7	37.0	1.9	0.7	0.4	2.8	1.1	0.3	0.2	2.5	2.1	2.8	1.0	0.2	0.1	2.3	

Table 2.3. Summary of the number of red grouper otoliths collected, read, and determined unreadable (1978-2001) or sub-sampled to be aged (2002-2013). *These totals also include those otoliths and ages provided by other ageing facilities. The only fish sub-sampled were those collected by Trip Interview Program port agents from the commercial industry (see Lombardi-Carlson 2014, further information on sub-sampling).

Year	Otoliths collected	Otoliths sub-sampled*	Otoliths read	Otoliths not readable	Otoliths not readable (%)
1978	1		1	1	100
1979	75		75	4	5
1980	8		8	0	0
1981	309		309	8	3
1985	1		1	0	0
1986	9		9	1	11
1987	11		11	0	0
1988	10		10	0	0
1989	11		11	0	0
1991	134		134	15	11
1992	290		290	18	6
1993	497		497	3	1
1994	526		526	7	1
1995	581		581	53	9
1996	470		470	39	8
1997	176		176	17	10
1998	306		306	7	2
1999	905		905	20	2
2000	809		809	15	2
2001	2,069		2,069	41	2
2002	2,884	2,150	2,150	9	0
2003	3,374	2,036	2,036	14	1
2004	4,089	2,910	2,910	20	1
2005	4,396	2,424	2,424	20	1
2006	4,553	1,624	1,624	13	1
2007	4,173	1,577	1,577	19	1
2008	3,318	1,499	1,499	6	0
2009	9,735	4,901	4,901	44	1
2010	7,477	3,447	3,447	45	1
2011	13,508	3,989	3,989	38	1
2012	16,226	3,109	3,109	60	2
2013	14,412	2,993	2,993	54	2
Total	95,343	32,659	39,857	591	1

Table 2.4. Annual observed numbers at age for red grouper sampled from the northeastern Gulf of Mexico for 1991-2013. Data combined from fishery dependent (commercial and recreational) and independent sources.

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
0																3	10		1	1		1		16
1													4	4		6	91	94	19	4	7	15	11	255
2			1								7		3	53	4	22	11	132	280	27	31	53	28	652
3	2	1	3	8		1	1	2	3	8	6	24	21	13	51	17	17	3	1257	408	97	48	35	2026
4	7	5	46	79	16	8	9	20	10	142	71	70	208	129	22	69	16	48	242	1044	1002	92	54	3409
5	19	48	52	125	92	86	19	48	86	67	740	198	131	877	231	52	279	87	364	140	1682	701	195	6319
6	17	54	114	71	159	138	42	61	104	139	236	640	268	221	1048	245	153	361	366	251	187	1336	993	7204
7	14	63	120	89	97	97	51	73	130	95	339	307	439	382	178	643	248	148	1081	360	222	183	1022	6381
8	9	43	86	58	65	32	21	42	211	90	164	261	221	408	250	237	411	227	403	550	168	147	164	4268
9	16	20	35	36	40	42	3	25	165	84	81	169	199	218	248	102	124	233	397	248	266	102	111	2964
10	15	16	15	23	23	18	2	10	79	59	134	97	121	180	135	77	60	59	294	211	94	155	92	1969
11	3	7	9	9	11	3	3	8	46	52	92	101	88	103	72	46	55	38	74	82	95	79	105	1181
12	5	8	3	6	8	2	1	5	23	21	50	87	88	70	49	30	26	23	19	14	53	60	31	682
13	3	3	3	7	6	1	3	1	13	13	31	61	68	56	29	20	15	12	17	21	13	46	41	483
14			1	3	4		1	2	6	7	24	33	40	57	24	12	18	7	11	14	8	9	38	319
15	1		1	1		1	1	2	3	6	16	26	37	36	14	9	7	4	9	8	8	14	6	210
16	2		1		2		2		2	3	13	18	21	18	14	8	5	4	5	7	6	1	5	137
17		2				1			1	1	9	10	23	17	7	5	4	4	4	4	1	2	1	96
18		1	2						1	1	3	12	14	18	6	2	3	4	3	3	1		3	77
19	2									2	3	5	10	10	4	1	3	3	2	4	5	3	1	58
20									1	2	4	2	5	9	5	4	2		2		2	2	1	41
21	1			1	2					1	2	7	2	3	7			1	2		1		1	31
22					1								2	2	1	1		1	2		1	1	1	13
23	1				1					1		1	1	2	2					1				10
24	2		1	1		1					2	4	5	1					1		1			19
25			1	1	1							3	3	1	3				1					14
26												2							1					3
27				1							1	2		2										6
28									1			1												2
29		1																						1
Total	119	272	494	519	528	431	159	299	885	794	2028	2141	2022	2890	2404	1611	1558	1493	4857	3402	3951	3050	2939	38846

Table 2.5. Growth curve parameters ± standard deviation (L_∞ - asymptotic length, k – growth coefficient, t0 – size at time zero, sigma – standard deviation, CV – coefficient of variation) for red grouper from the northeastern Gulf of Mexico for fractional ages and observed fork lengths at capture provided for the current (1991-2013) and previous size-modified growth curves (SEDAR12, years:1991-2005, Lombardi-Carlson et al. 2006; update, years:1991-2008, Lombardi-Carlson et al. 2009). *Suggested growth model to use.

Model	n	L_∞	k	t_0	Sigma	CV
Constant CV*	38813	829 ± 5.50 (FL)	$0.1251 \pm 2.0 \times 10^{-3}$	$-1.2022 \pm 3.4 \times 10^{-2}$		$0.1548 \pm 7.7 \times 10^{-4}$
Constant std dev	38813	841 ± 5.37 (FL)	$0.1248 \pm 2.2 \times 10^{-3}$	$-1.0590 \pm 5.3 \times 10^{-2}$	79.59 ± 0.46	
CV increase with age	38813	830 ± 5.83 (FL)	$0.1249 \pm 2.0 \times 10^{-3}$	$-1.2027 \pm 3.5 \times 10^{-2}$		$0.1559 \pm 2.2 \times 10^{-3}$ $0.1510 \pm 6.9 \times 10^{-3}$
update	20143	884 (TL), 845 ([1]FL)	0.13	-1.01	83.37	
SEDAR12	15953	854 (TL), 817 ([1]FL)	0.16	-0.19	82.83	

[1] Fork length predicted from total length, using FL = 5.35 + TL * 0.95

Table 2.6 The resulting model objective functions (negative log likelihood), the change in the objective function, and resulting Akaike Information Criteria for each phase of the model for the minimum-size corrected von Bertalanffy growth model using three types of the variance structure (std dev – standard deviation, CV – coefficient of variation). *Suggested growth model to use.

Variance Structure	Phase	# parameters	Objective Function (nLL)	Change Obj. function	AIC	AICc	Delta AICc
Constant CV*	1	3	$2.07 \times 10^{+05}$		$4.13 \times 10^{+05}$	$4.13 \times 10^{+05}$	
	2	3	$2.07 \times 10^{+05}$		$4.13 \times 10^{+05}$	$4.13 \times 10^{+05}$	-1.92×10^{-09}
	3	4	$2.01 \times 10^{+05}$	$-5.72 \times 10^{+03}$	$4.02 \times 10^{+05}$	$4.02 \times 10^{+05}$	$-1.14 \times 10^{+04}$
Constant std dev	1	3	$1.08 \times 10^{+06}$		$2.15 \times 10^{+06}$	$2.15 \times 10^{+06}$	
	2	3	$1.08 \times 10^{+06}$		$2.15 \times 10^{+06}$	$2.15 \times 10^{+06}$	-2.33×10^{-09}
	3	4	$2.02 \times 10^{+05}$	$-8.73 \times 10^{+05}$	$4.05 \times 10^{+05}$	$4.05 \times 10^{+05}$	$-1.75 \times 10^{+06}$
CV increase with age	1	3	$2.06 \times 10^{+05}$		$4.12 \times 10^{+05}$	$4.12 \times 10^{+05}$	
	2	3	$2.06 \times 10^{+05}$		$4.12 \times 10^{+05}$	$4.12 \times 10^{+05}$	-3.09×10^{-09}
	3	5	$2.01 \times 10^{+05}$	$-2.53 \times 10^{+03}$	$4.02 \times 10^{+05}$	$4.02 \times 10^{+05}$	$-1.01 \times 10^{+04}$

Table 2.7. Multiple methods used to estimate natural mortality (M). Definitions of parameters: Linf = von Bertalanffy asymptotic length (FL, mm), k = von Bertalanffy growth coefficient, Amax = maximum age (yr), A50 = age at 50% mature, Lat = length at age (t), Temp = average water temperature (^{o}C), S = survivorship. Water temperature based on annual mean estimate at bottom from the U.S. Gulf shelf (Johnson et al. 1995, DeVries 2006).

Method	Parameters	Citation	Equation
Alverson & Carney	k, Amax	Quinn & Deriso (1999)	M = 3k/(exp(0.38*Amax*k)-1)
Beverton & Holt	k, A50	Beverton and Holt (1956)	M = 3k/(exp(A50*k)-1)
$\text{Hoenig}_{\text{teleosts}}$	Amax	Hoenig (1983)	M=exp(1.46 - 1.01*ln(Amax))
$\text{Hoenig}_{\text{all taxa}}$	Amax	Hoenig(1983)	M=exp(1.44-0.982*ln(Amax))
Pauly	Linf, k, Temp	Quinn & Deriso (1999)	M = 10^(-0.0066-.279*(log(Linf))+0.6543*log(k)+0.4634*log(Temp))
Pauly Method II (snappers and groupers)	Linf, k, Temp	Pauly and Binohlan (1996)	M=10^(-0.0636-0.279*(log(Linf)+0.6543*log(k)+0.4634*log(Temp))
Ralston	k	Ralston (1987)	M= 0.0189 + 2.06*k
Ralston (geometric mean)	k	Ralston (1987)	M=-0.0666 + 2.52*k
Ralston Method II	k	Pauly and Binohlan (1996)	M=-0.1778 + 3.1687*k
Lorenzen Age-Specific	M, Linf, k	Lorenzen (2005)	Survival = Exp(-M*t1) = Exp(Ln((Lat/(Lat+Linf*(Exp(k* t1)-1)))*(M1/(Linf*K)))
Jensen	k	Jensen (1996)	M = 1.5*k
Alagaraja	Amax, Survivorship to Amax	Alagaraja (1984)	M=-ln[S(Amax)]/Amax; derived from S(Amax)=exp(-M*Amax)
Rule of Thumb	Amax	Hewitt and Hoenig (2005)	M = 2.996/Amax

Table 2.8. List of parameter values used to estimate natural mortality (M) and resulting natural mortalities (M) for each method described in Table 2.7.

Parameter	Value
Data Source	1991-2013
Maximum age (Amax)	29
Number of fish aged	38,813
von Bertalanffy (Linf, FL mm)	829
von Bertalanffy (k)	0.1251
Age at 50% maturity (A50)	3

Method	M
Alverson & Carney	0.1264
Beverton & Holt	0.8240
$\text{Hoenig}_{\text{teleosts}}$	0.1436
$\text{Hoenig}_{\text{all taxa}}$	0.1546
Pauly	0.3088
Pauly Method II	0.2708
Ralston	0.2767
Ralston (geo mean)	0.2488
Ralston Method II	0.2187
Jensen	0.1877
Hewitt & Hoenig	0.1033
Alagaraja, S = 0.01	0.1588
Alagaraja, S = 0.02	0.1209
Alagaraja, S = 0.05	0.1033

Table 2.9 Resulting age-specific natural mortality (M) vectors for SEDAR42, update assessment 2009 and SEDAR12. Each vector was calculated using the same regression (Lorenzen 2005), age 5 as the first age at vulnerability, with a target M of 0.14 ($\mathrm{Hoenig}_{teleost}$, maximum age of 29 years). The only difference among the age-specific natural mortality vectors were the predicted von Bertalanffy growth parameters used in the estimations.

Age	SEDAR42	2009 update	SEDAR12
0	0.5837	0.6309	1.0000
1	0.3952	0.4092	0.4943
2	0.3082	0.3137	0.3391
3	0.2583	0.2606	0.2681
4	0.2261	0.2269	0.2277
5	0.2036	0.2038	0.2018
6	0.1873	0.1871	0.1840
7	0.1749	0.1745	0.1712
8	0.1652	0.1648	0.1616
9	0.1576	0.1571	0.1542
10	0.1514	0.1510	0.1484
11	0.1463	0.1459	0.1438
12	0.1421	0.1418	0.1401
13	0.1386	0.1383	0.1371
14	0.1356	0.1354	0.1347
15	0.1331	0.1330	0.1327
16	0.1310	0.1309	0.1310
17	0.1291	0.1291	0.1296
18	0.1276	0.1276	0.1284
19	0.1262	0.1263	0.1274
20	0.1250	0.1252	0.1266
21	0.1240	0.1242	0.1259
22	0.1231	0.1234	0.1254
23	0.1224	0.1227	0.1249
24	0.1217	0.1220	0.1244
25	0.1211	0.1215	0.1241
26	0.1206	0.1210	0.1238
27	0.1202	0.1206	0.1235
28	0.1198	0.1202	0.1233
29	0.1194	0.1199	0.1231

Table 2.10. LHW recommended model sensitivities for age-specific natural mortality (M). Apply the standard deviation (± 5 yrs) at age for the maximum aged (29 yrs) red grouper to calculate an upper and lower range for natural mortality.

Age	SEDAR42	Lower	Upper
0	0.5837	0.5053	0.7336
1	0.3952	0.3421	0.4967
2	0.3082	0.2669	0.3874
3	0.2583	0.2236	0.3247
4	0.2261	0.1957	0.2841
5	0.2036	0.1763	0.2560
6	0.1873	0.1621	0.2354
7	0.1749	0.1514	0.2198
8	0.1652	0.1431	0.2077
9	0.1576	0.1364	0.1980
10	0.1514	0.1311	0.1903
11	0.1463	0.1267	0.1839
12	0.1421	0.1230	0.1786
13	0.1386	0.1200	0.1742
14	0.1356	0.1174	0.1705
15	0.1331	0.1152	0.1673
16	0.1310	0.1134	0.1646
17	0.1291	0.1118	0.1623
18	0.1276	0.1105	0.1603
19	0.1262	0.1093	0.1586
20	0.1250	0.1083	0.1572
21	0.1240	0.1074	0.1559
22	0.1231	0.1066	0.1548
23	0.1224	0.1060	0.1538
24	0.1217	0.1054	0.1530
25	0.1211	0.1049	0.1522
26	0.1206	0.1044	0.1516
27	0.1202	0.1040	0.1510
28	0.1198	0.1037	0.1505
29	0.1194	0.1034	0.1501

Table 2.11 Depth-dependent discard mortality values for live red grouper discards caught with recreational hook-and-line gear (see Figure 2.11).

Depth Range (m)	Lower 95% CL	Point Estimate	Upper 95% CL
1-10	0.010	0.089	0.166
11-20	0.015	0.096	0.174
21-30	0.020	0.109	0.194
31-40	0.040	0.157	0.260
41-50	0.057	0.190	0.304
51-60	0.054	0.187	0.301
61-70	0.058	0.203	0.325
71-80	0.117	0.266	0.390
81-90	0.132	0.282	0.406

Table 2.12. Pre-IFQ bottom longline discard mortality rates assuming latent mortality of 0%, 10%, 20%, and 30% for fish that re-submerge for each depth bin (see Figure 2.12).

Depth Range (m)	30 - 39.99	40 - 49.99	50 - 59.99	60 - 69.99	70 - 79.99	80 - 89.99	90 - 99.99	100 - 109.99
Number of Fishing Sets	94	356	117	93	55	14	19	5
Discarded Alive	1659	6747	1322	347	226	16	18	0
Discarded Dead	422	1880	387	198	193	20	19	1
Discard Mortality (0%)	20.3%	21.8%	22.6%	36.3%	46.1%	55.6%	51.4%	100.0%
Recommended (20%)	36.2%	37.4%	38.1%	49.1%	56.8%	64.4%	61.1%	100.0%
Low Sensitivity (10%)	28.3%	29.6%	30.4%	42.7%	51.5%	60.0%	56.2%	100.0%
High Sensitivity (30%)	44.2%	45.3%	45.9%	55.4%	62.2%	68.9%	65.9%	100.0%

Table 2.13. Post-IFQ bottom longline discard mortality rates assuming latent mortality of 0%, 10%, 20%, and 30% for fish that re-submerge for each depth bin (see Figure 2.13).

Depth Range (m)	30 - 39.99	40 - 49.99	50 - 59.99	60 - 69.99	70 - 79.99	80 - 89.99	90 - 99.99	100 - 109.99
Number of Fishing Sets	494	1626	806	836	913	267	32	9
Discarded Alive	9088	31450	11936	6015	6490	1763	23	6
Discarded Dead	2651	10060	5107	2957	3733	1027	18	7
Discard Mortality (0%)	22.6%	24.2%	30.0%	33.0%	36.5%	36.8%	43.9%	53.8%
Recommended (20%)	38.1%	39.4%	44.0%	46.4%	49.2%	49.4%	55.1%	63.1%
Low Sensitivity (10%)	30.3%	31.8%	37.0%	39.7%	42.9%	43.1%	49.5%	58.5%
High Sensitivity (30%)	45.8%	47.0%	51.0%	53.1%	55.6%	55.8%	60.7%	67.7%

Table 2.14. Meristic regressions for red grouper (1978-2013) from the Gulf of Mexico. Data combined from all data sources, both fishery independent and dependent. Length Type: Max TL – Maximum Total Length, FL – Fork Length, Nat TL – Natural Total Length, SL – Standard Length. Weight Type: G Wt – Gutted Weight, W Wt – Whole Weight. Units: length (mm) and weight (kg). Linear and non-linear regressions calculated using R (lm and nls functions, respectively).

Regression	Equation	statistic	N	Data Range
Max TL to FL	FL = 5.35 + max_TL *0.95	r^2=0.9963	5818	Max TL: 120 – 954; FL: 116 – 910
Nat TL to FL	FL = 5.71 + nat_TL * 0.95	r^2=0.9909	3901	Nat TL: 151 – 957; FL: 149 – 910
SL to FL	FL = 15.90 + SL * 1.14	r^2=0.9938	985	SL: 130 – 686; FL: 159 – 830
SL to Max TL	Max_TL = 9.19 + SL * 1.21	r^2=0.9944	3399	SL: 130 – 720; Max TL: 161 – 876
SL to Nat TL	Nat_TL= -51.18 + SL * 1.32	r^2=0.9791	7	SL: 404 – 670; Nat TL: 484 – 860
Max TL to G Wt	G WT = 4.33 x 10^{-8} * (max_TL^$^{2.83}$)	RSE = 0.7421	633	Max TL: 458 – 980; G WT: 0.82 – 15.05
Max TL to W Wt	WWT =5.21 x 10^{-09} * (max_TL^$^{3.16}$)	RSE = 0.5152	3725	Max TL: 127 – 954; W WT: 0.03 – 16.96
Nat TL to G Wt	GWT = 5.70 x 10^{-08} * (nat_TL^$^{2.78}$)	RSE = 0.6398	34	Nat TL: 490 – 802; G WT: 1.28 – 7.17
Nat TL to W Wt	WWT = 7.58 x 10^{-09} * (nat_TL^$^{3.10}$)	RSE = 0.3482	3912	Nat TL: 120 – 957; W WT: 0.02 – 14.00
FL to G Wt	GWT= 3.37 10^{-09} * (FL^$^{3.25}$)	RSE = 0.3499	37414	FL: 230 – 935; G WT: 0.26 – 16.96
FL to W Wt	WWT = 5.46 x 10^{-09} * (FL^$^{3.18}$)	RSE = 0.4667	7361	FL: 123 – 965; W WT: 0.05 – 16.96
SL to W Wt	WWT = 2.32 x 10^{-08} * (SL^$^{3.03}$)	RSE = 0.1825	483	SL: 147 – 670; W WT: 0.10 – 9.00

2.12 FIGURES

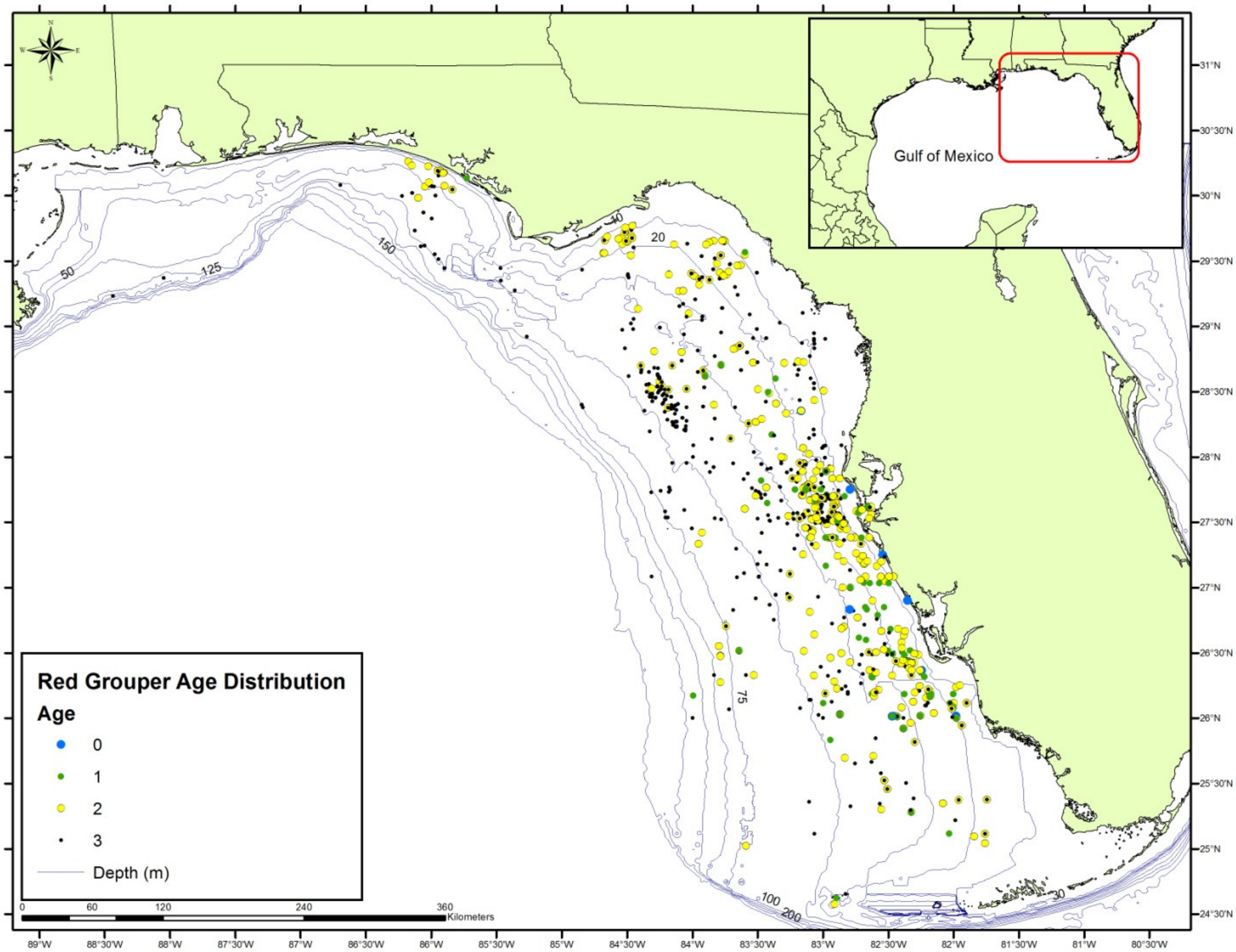


Figure 2.1. Locations of juvenile (age 0 – 3 yr) red grouper collected by state and federal fishery independent surveys along the west Florida shelf.

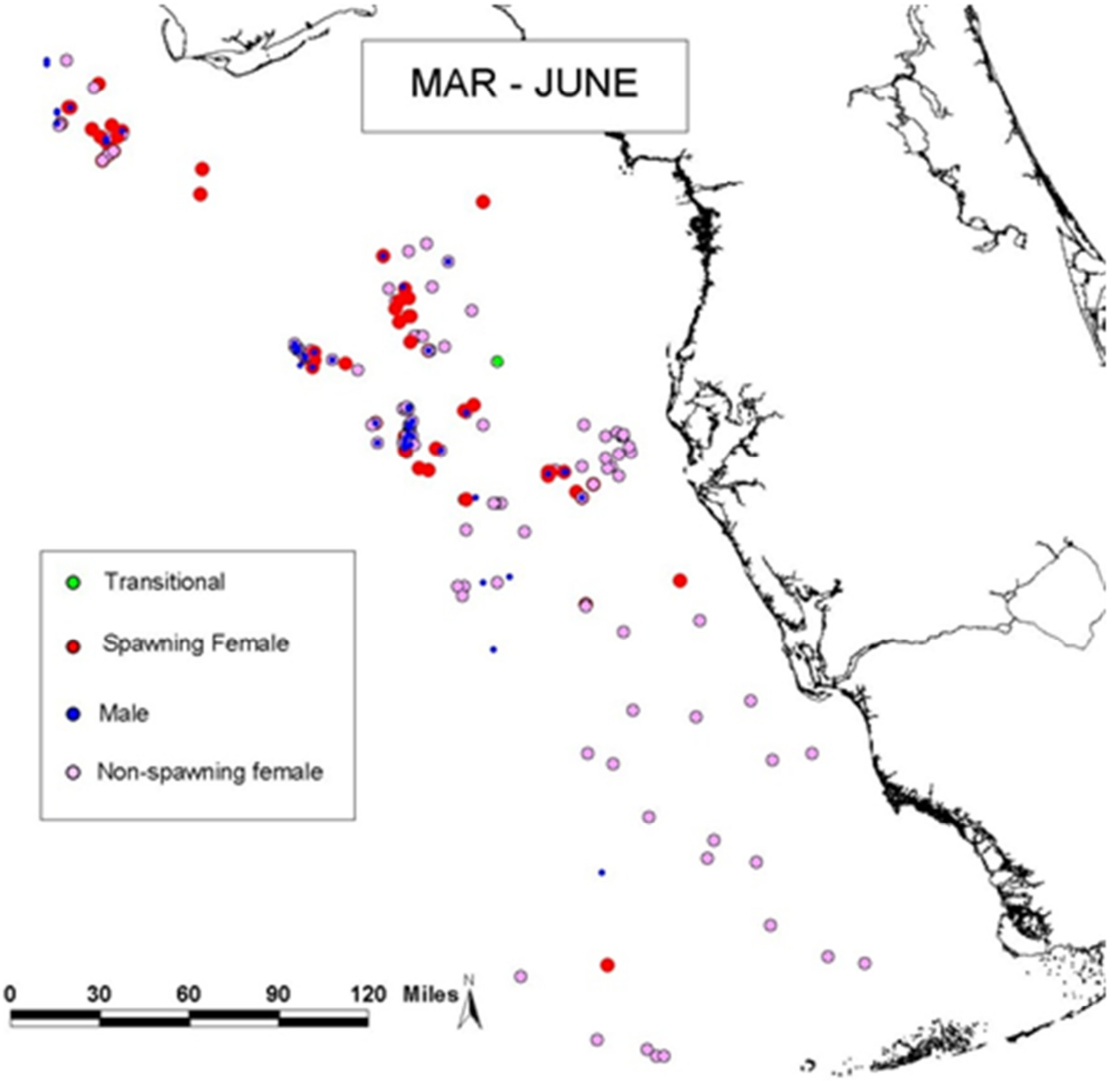


Figure 2.2. Locations of red grouper of various spawning condition (non-spawning female, spawning females, males and transitional fish) collected by FL FWCC/FWRI during red grouper spawning season (March – June 2008-2013) (original figure, Lowerre-Barbieri et al. 2014).

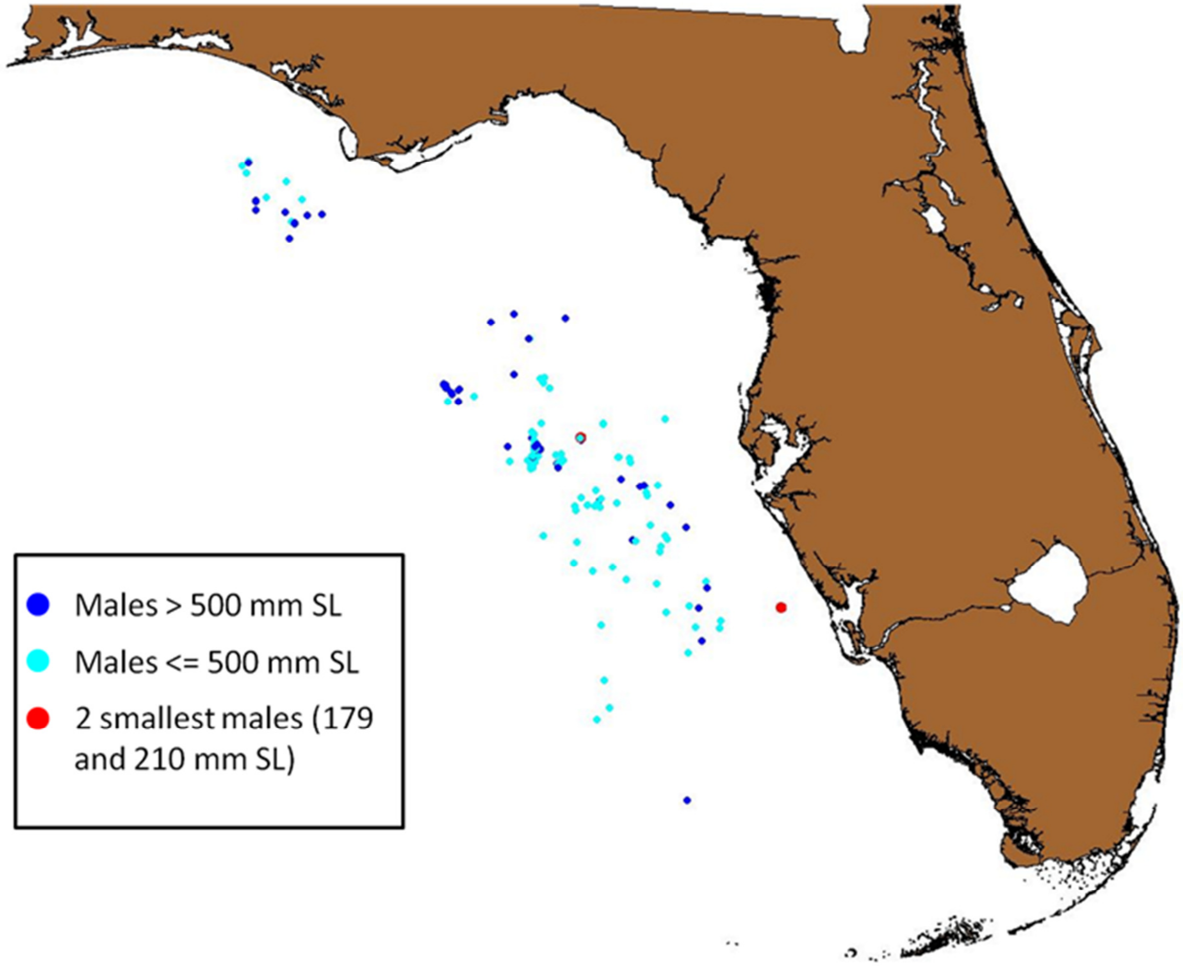


Figure 2.3. Locations of male red grouper by length groups (large ≥ 500 mm SL, small ≤ 500 mm SL), collected by FL FWCC/FWRI during (original figure, Lowerre-Barbieri et al. 2014).

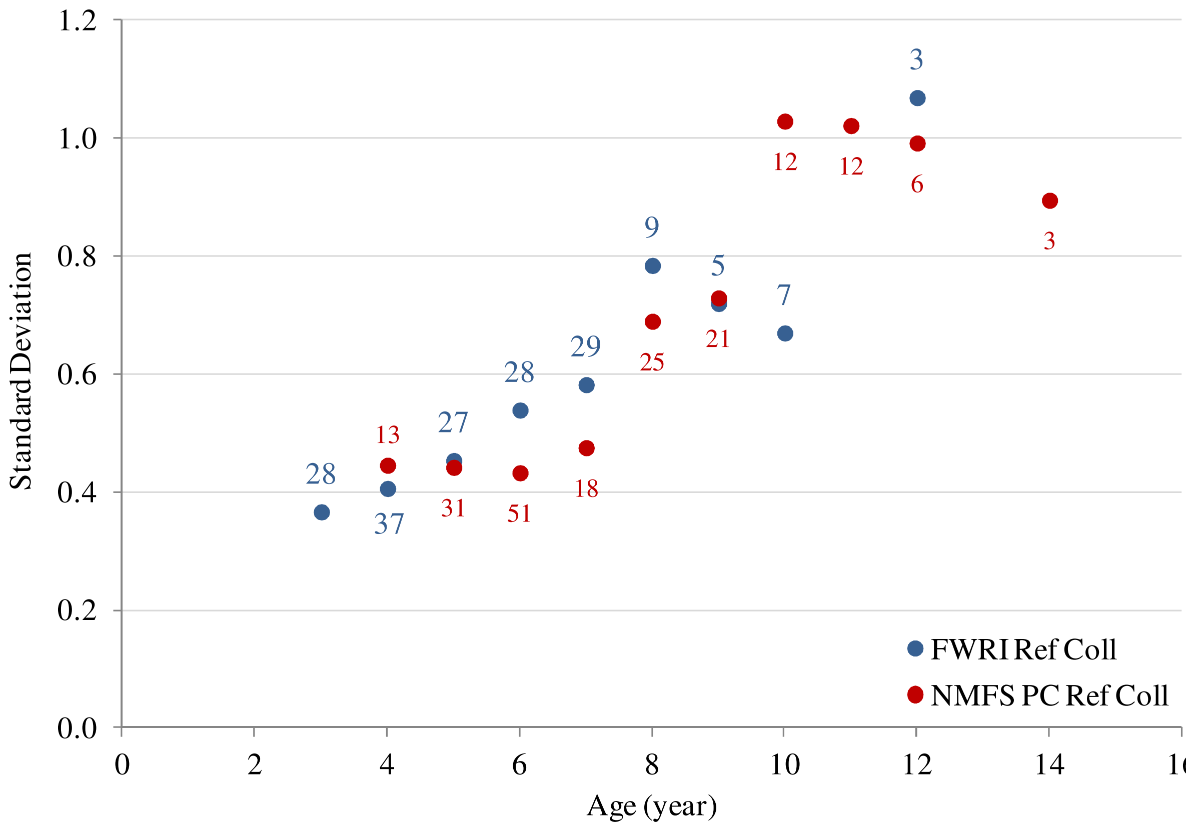


Figure 2.4 Standard deviations at age among readers calculated from the use of two reference collections to determine precision among readers throughout the time series (NMFS Panama City Laboratory and FLFWCC/FWRI). The numbers above and below the data points are the sample size per age per reference collection.

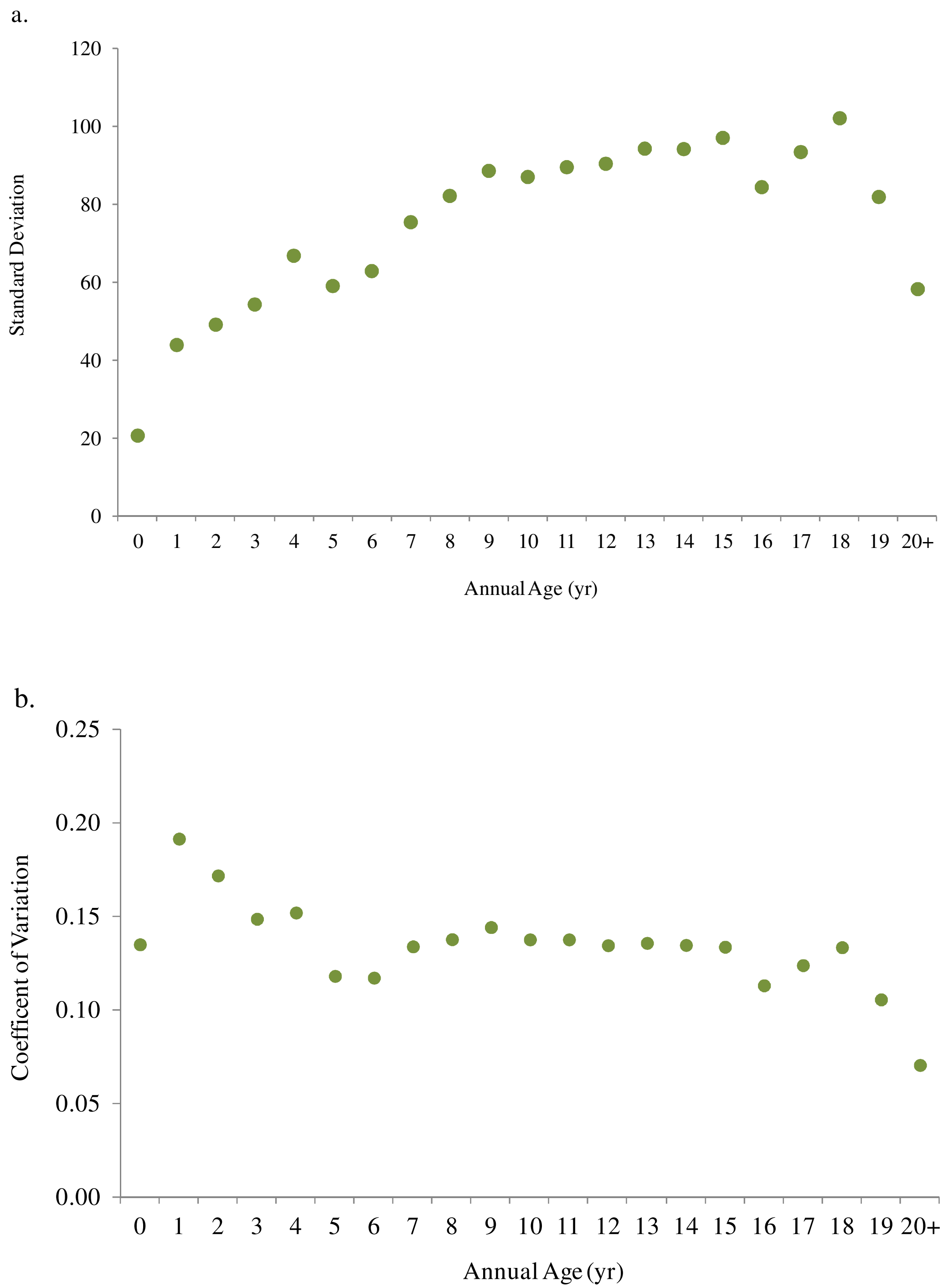


Figure 2.5 Variance structure for observed size-at-age data for red grouper from the northeastern Gulf of Mexico (1991-2013) (a) standard deviation and (b) coefficient of variation at length for each age group.

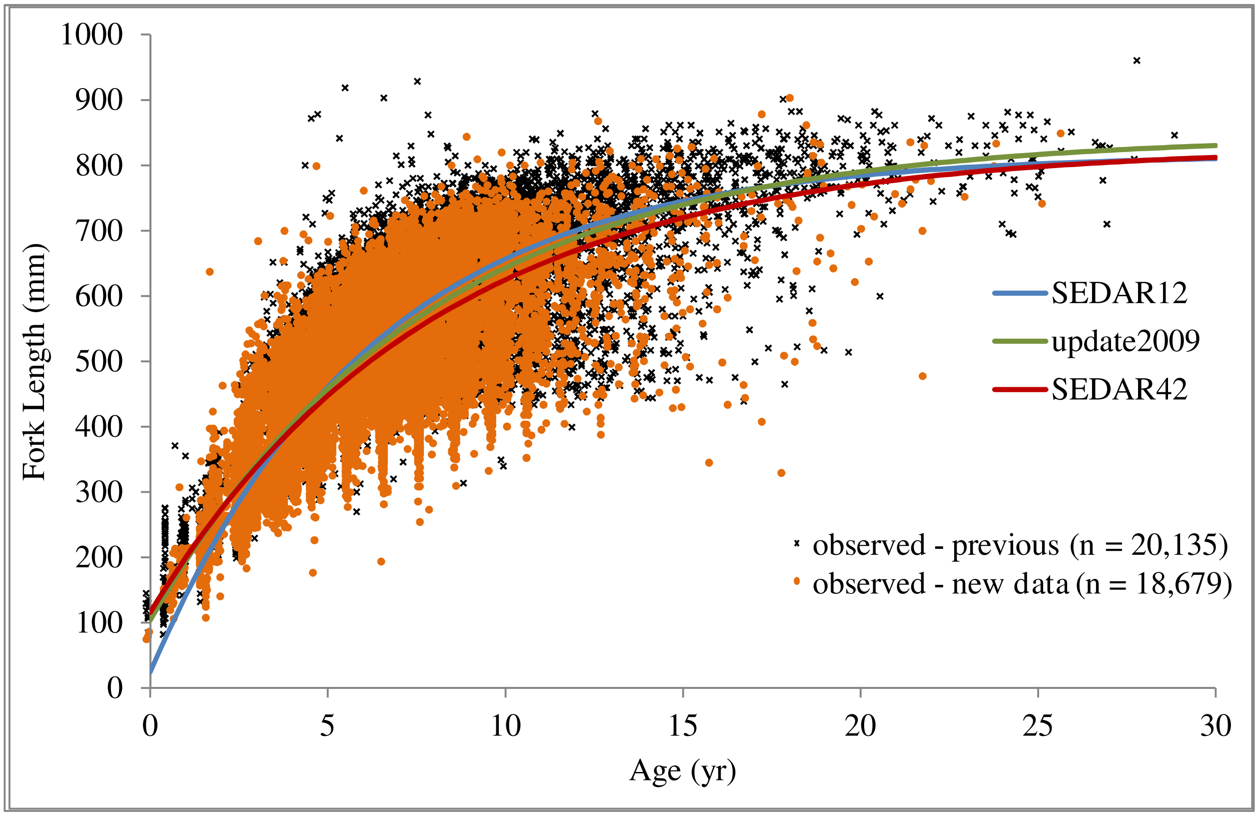


Figure 2.6 Comparison of size-modified von Bertalanffy growth models fit to fractional ages and fork lengths for red grouper from the northeastern Gulf of Mexico for SEDAR42: 1991-2013, n = 38,813; update 2009: 1991-2008, n = 20,143 and SEDAR12: 1991-2005, n = 15,953. SEDAR42 growth model fit the data using a constant coefficient of variation at age variance structure. The update assessment in 2009 and SEDAR12 growth models used a constant standard deviation at age variance structures.

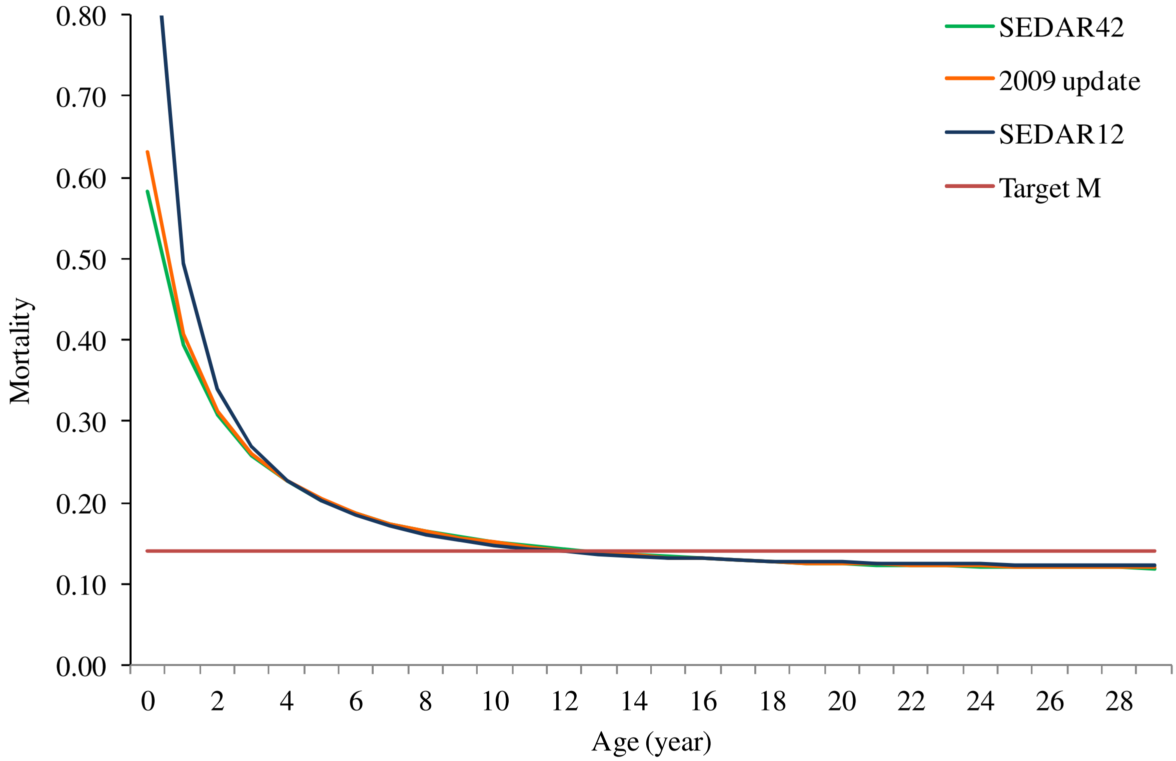


Figure 2.7 Comparison of age-specific natural mortality (M) vectors for red grouper from the northeastern Gulf of Mexico. Each vector was calculated using the same regression (Lorenzen 2005), age 5 as the first age at vulnerability, with a target M of 0.14 ($\text{Hoenig}_{\text{teleost}}$, maximum age of 29 years). The only difference among the age-specific natural mortality vectors were the predicted von Bertalanffy growth parameters used in the estimations.

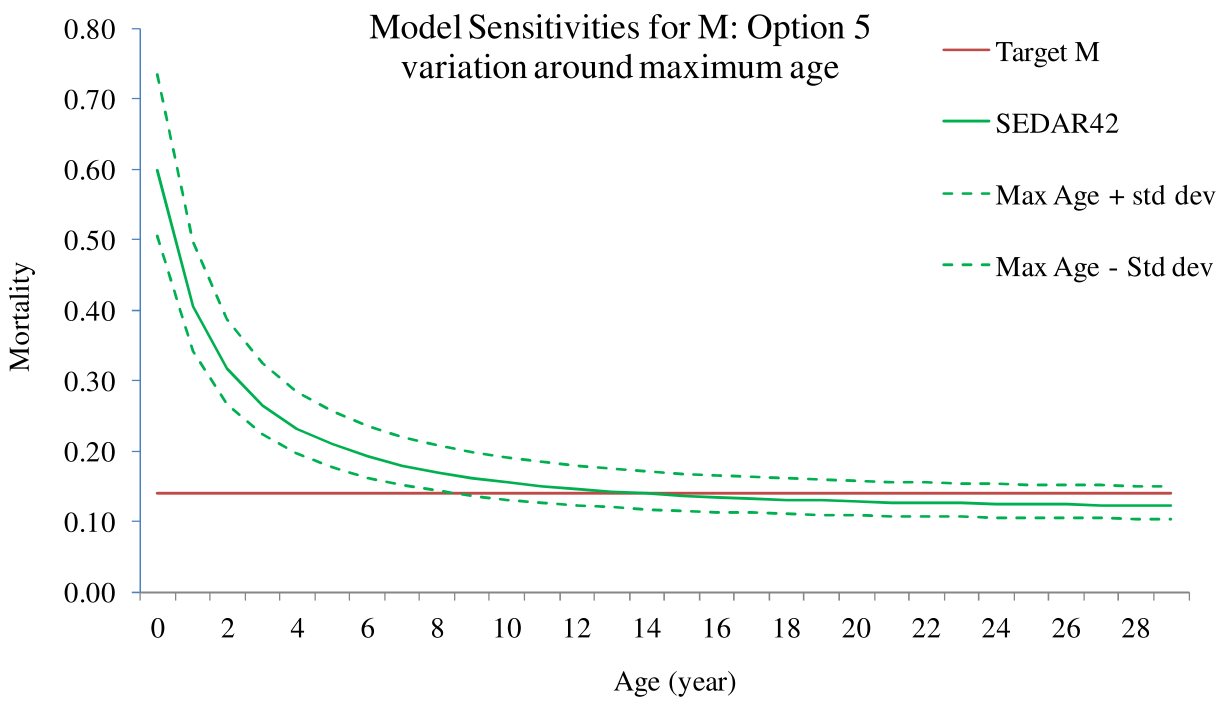


Figure 2.8 Recommended model sensitivities for age-specific natural mortality (M) vector. LWH suggests using the standard deviation at age of the maximum aged red grouper to calculate an upper and lower age-specific mortality vector.

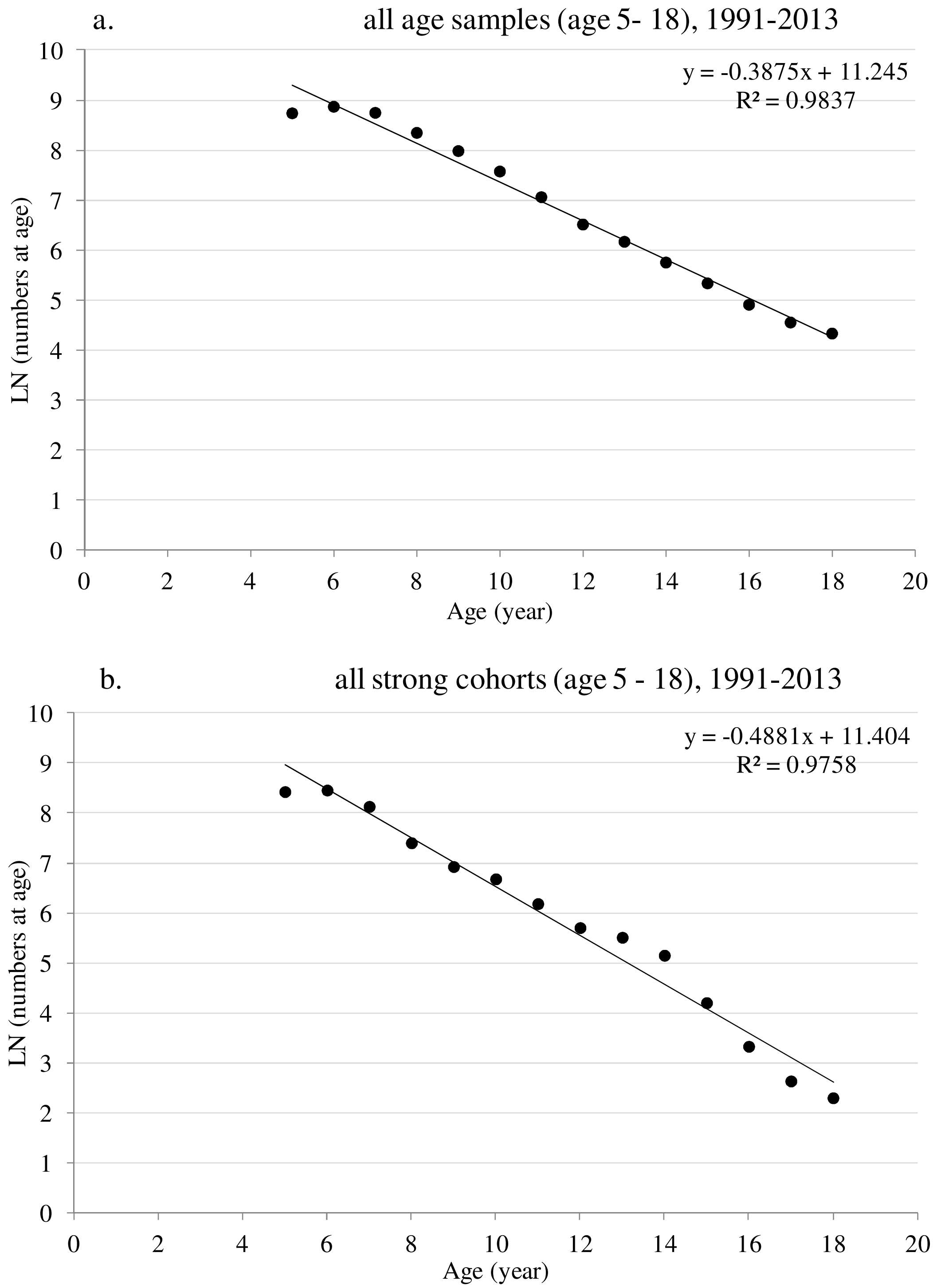


Figure 2.9. Total mortality estimates (Z) using catch curves for (a) all data, 1991-2013, n = 38,813 and (b) all strong cohorts, 1991-2013, n = 22,529 Red grouper were fully vulnerable at age 5 yrs.

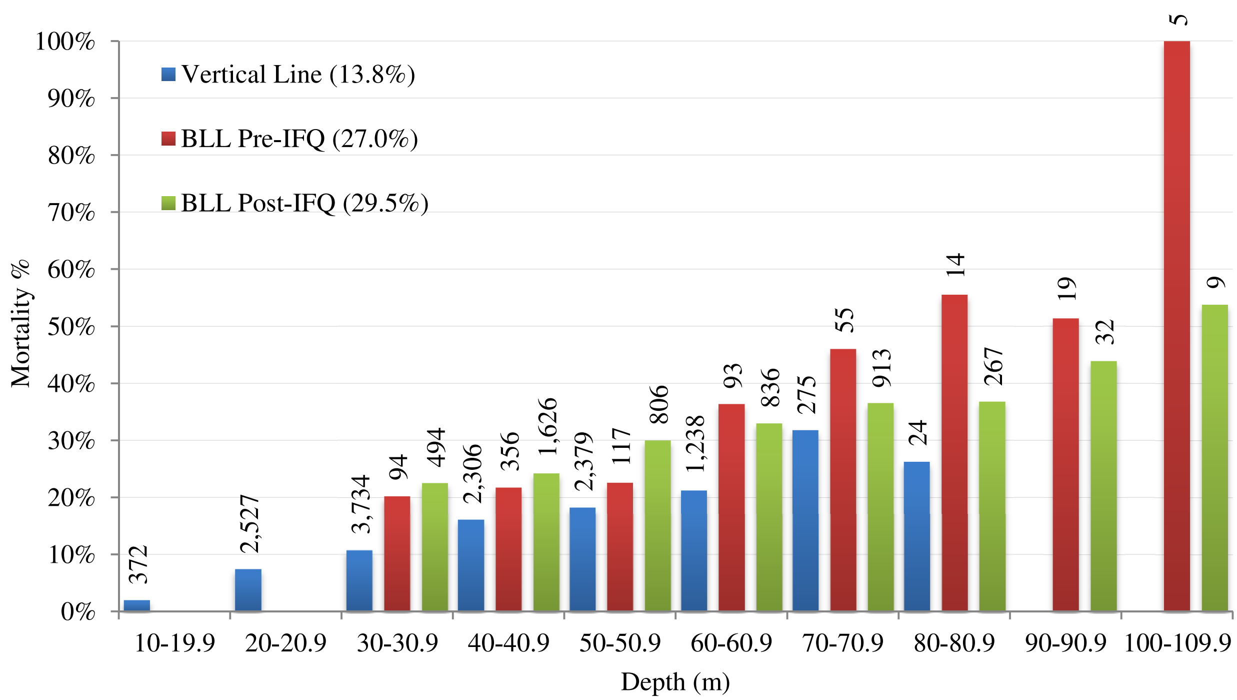


Figure 2.10. Percentage of red grouper discards that were dead on arrival or floating after release observed for each depth bin (n = the number of fishing sets observed per depth bin by gear). The legend values in parenthesis are the weighted mean average discard mortality per gear type and time period for all depths. Red grouper with an unknown discard fate were not used in deriving these percentages. Vertical line – manual or electronic hook and line, BLL – bottom longline, IFQ – Individual Fishing Quota (commenced in 2010 for the shallow-water grouper complex in the Gulf of Mexico).

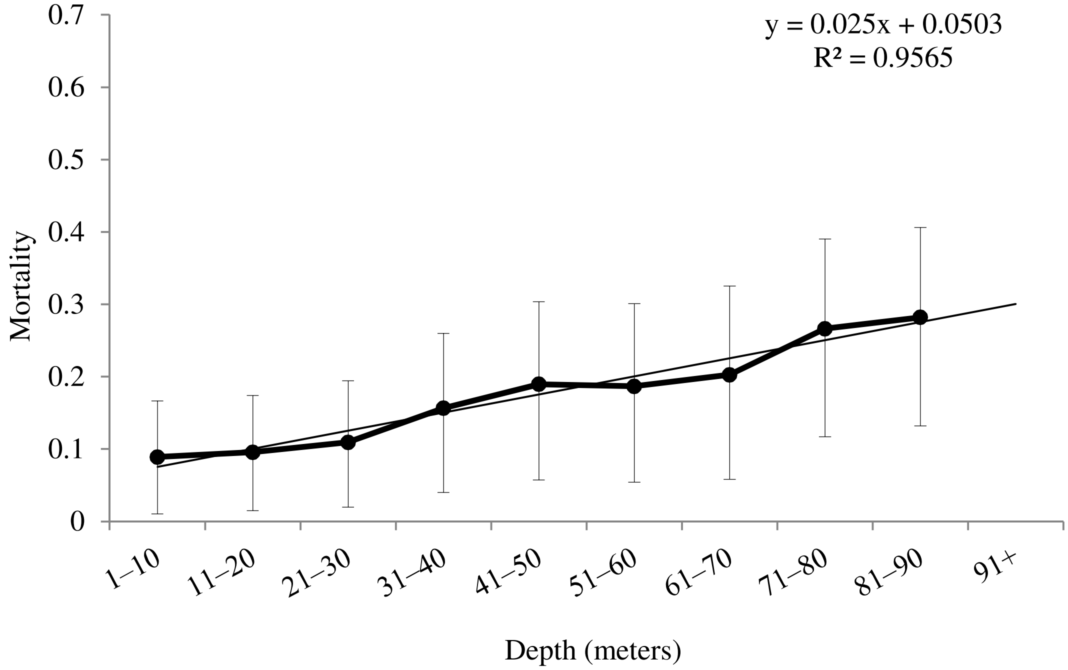


Figure 2.11: Depth-dependent discard mortality estimates with 95% confidence intervals and the fitted regression for live red grouper discards caught with recreational hook-and-line gear (Sauls et al. 2014) (see Table 2.11).

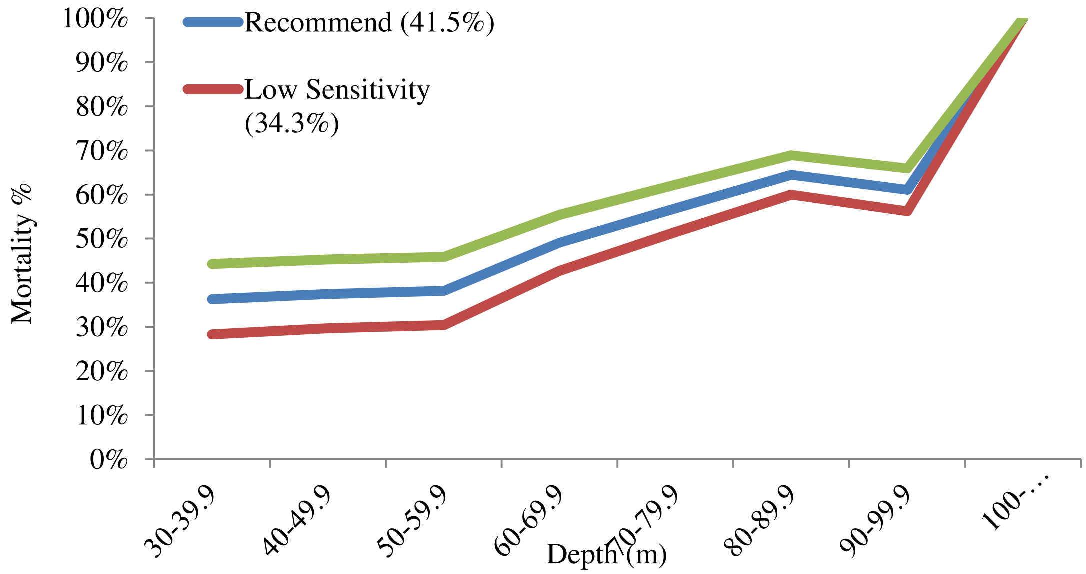


Figure 2.12: Bottom longline recommended discard mortality pre-IFQ based on weighted mean average for each depth bin from 758 fishing sets (see Table 2.12). Discard mortality estimates in the legend in parenthesis represent the base values per latent mortality (recommended = 20%, low sensitivity = 10%, high sensitivity = 30%).

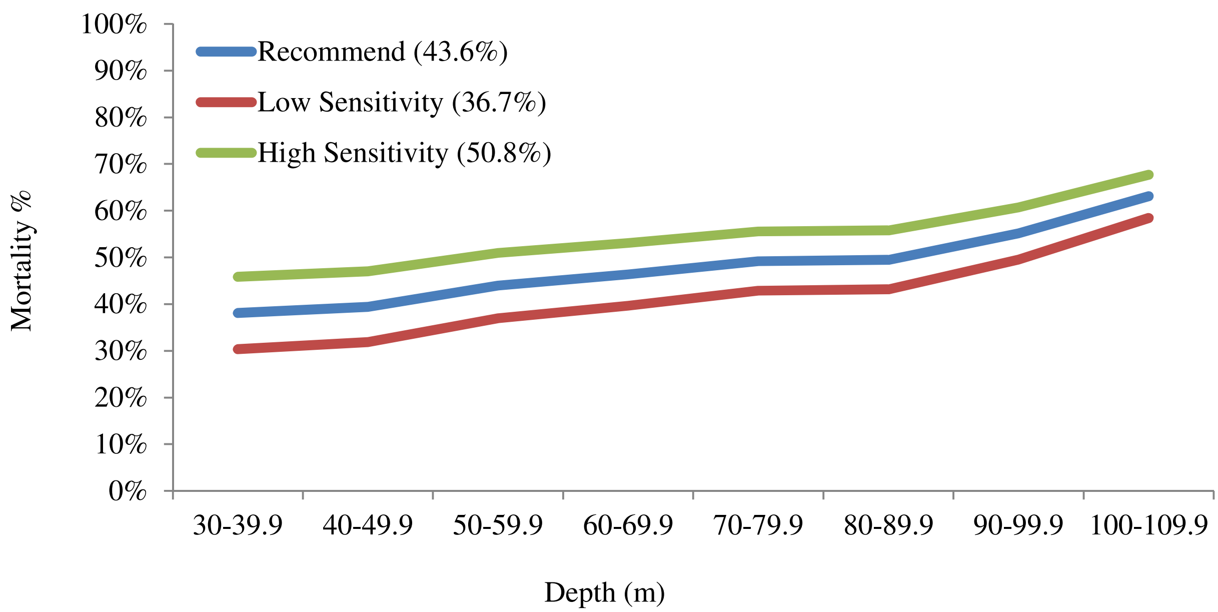


Figure 2.13. Bottom longline recommended discard mortality post-IFQ based on weighted mean average for each depth bin from 4,995 fishing sets (see Table 2.13). Discard mortality estimates in the legend in parenthesis represent the base values per latent mortality (recommended = 20%, low sensitivity = 10%, high sensitivity = 30%).

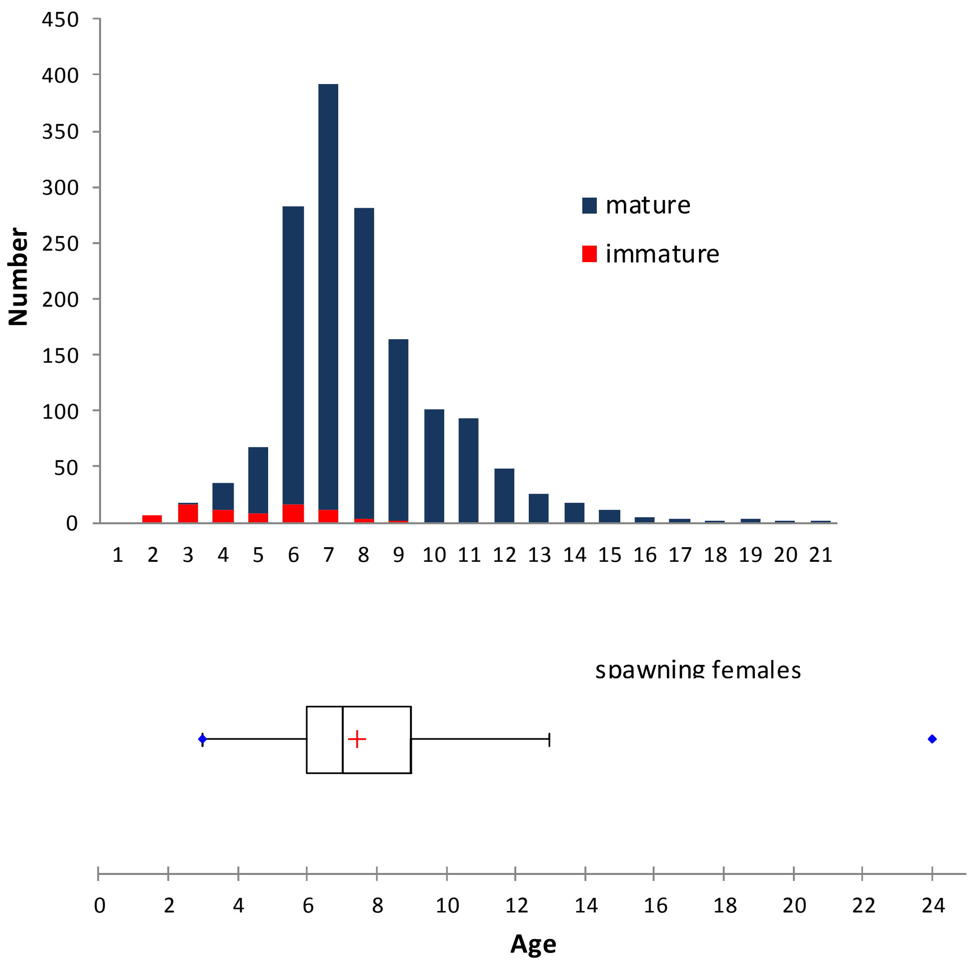


Figure 2.14. Top panel: histogram of mature and immature females by age, n = 1559, NMFS PC and FL FWCC/FWRI data combined. Females are represented from all years (1991-2013) for months March, April, May and June.

Bottom panel: boxplot of age distribution of females with spawning markers (postovulatory follicles and hydrated oocytes). The mean (red cross), median, 25%, 75% quantiles and range (blue symbols) are shown.

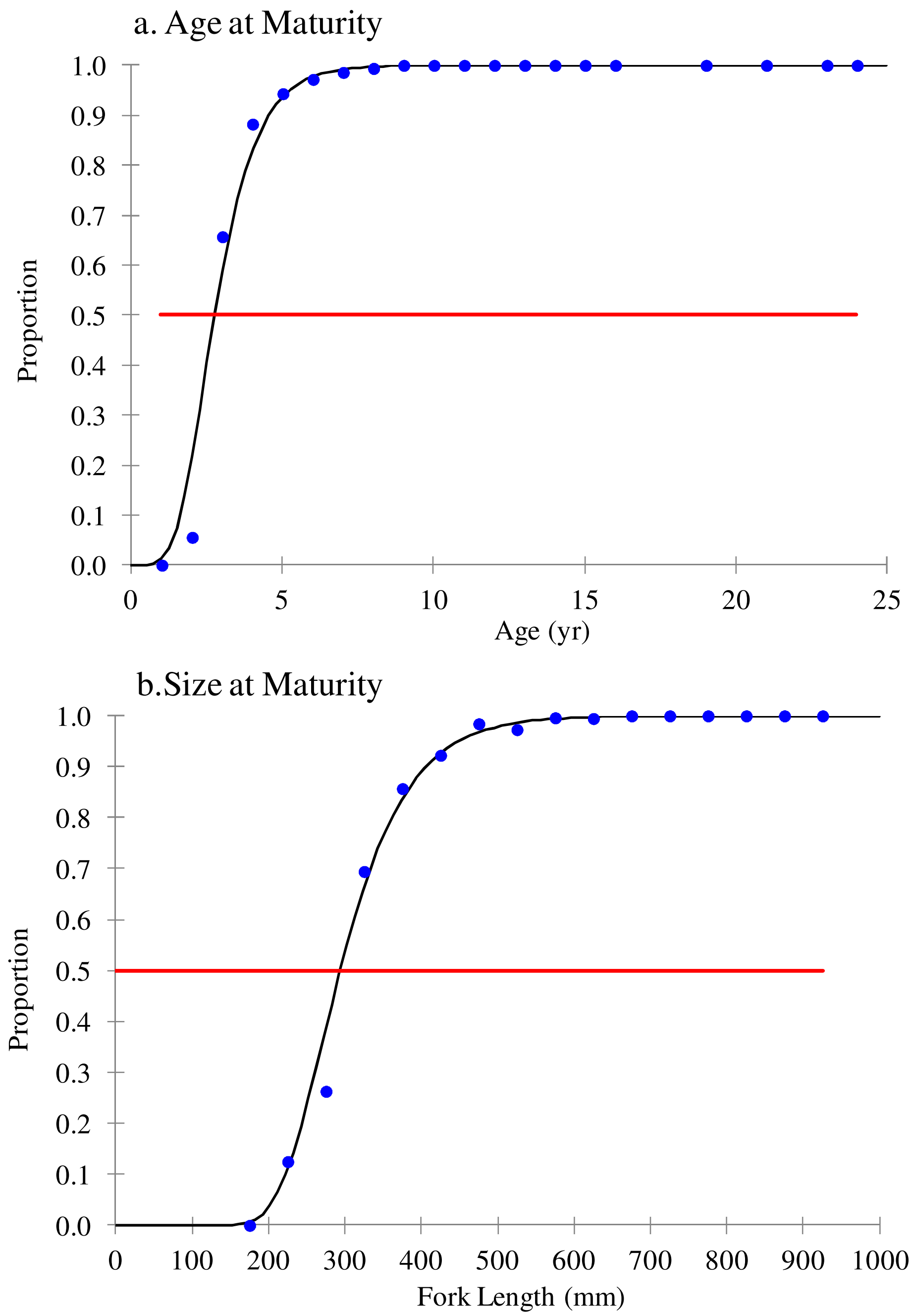


Figure 2.15. Logistic fit of (a) age at maturity (Gompertz model: proportion mature = exp(-exp(-(-2.5493+1.0517*age), r^2 (McFadden) = 0.4, n= 1559, A50 maturity = 2.8 years) and (b) length at maturity (Gompertz model: proportion mature = exp(-exp(-(-4.5622+0.0168*length), r^2 (McFadden) = 0.4, n= 1677, L50 maturity = 292 mm FL). Logistic regression analysis conducted using XLSTAT software v2012.4.03 based upon weighted sums of binary data.

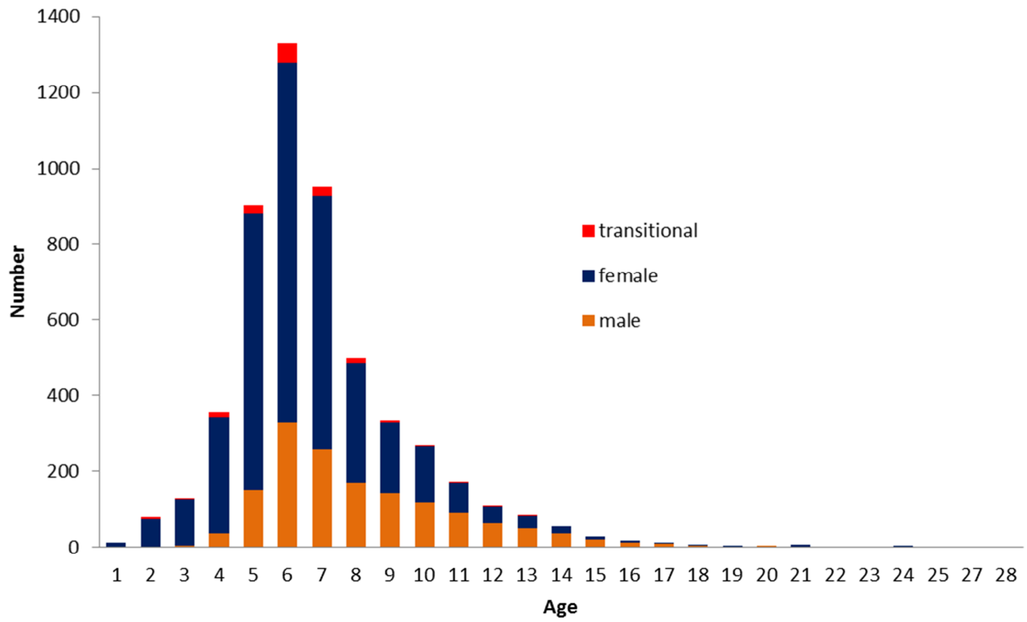


Figure 2.16. Histogram of numbers of red grouper sampled and identified by sex and by age (n = 5381). NMFS PC and FL FWCC/FWRI data combined, years 1991-2013, all months represented.

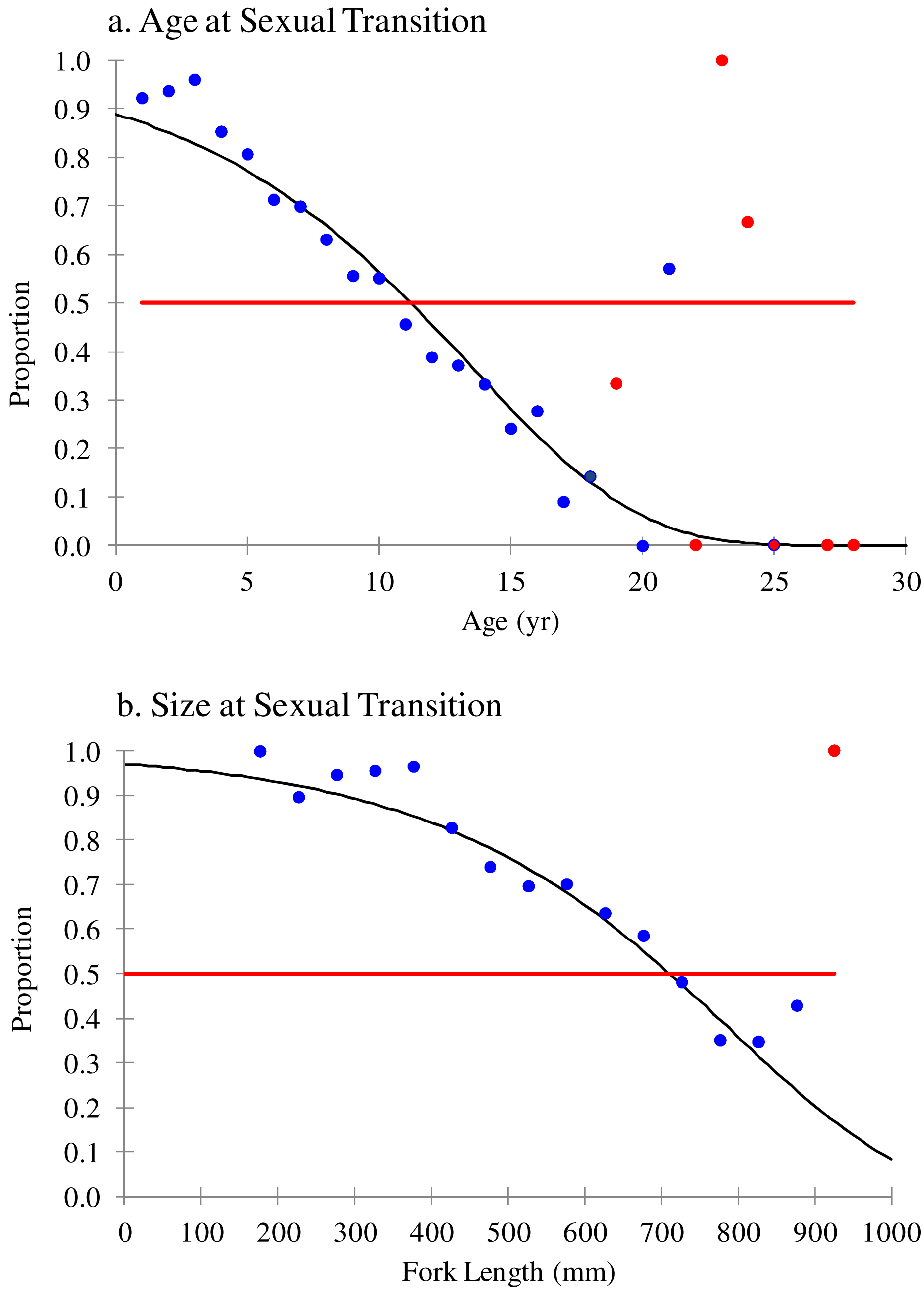


Figure 2.17. Logistic fit of (a) age of sexual transition (Gompertz model: proportion female = exp(-exp(-(-2.142-0.1585*age), r2 (McFaden) = 0.6, n= 5381, A50 transition = 11.2 yr) and (b) length at sexual transition (Gompertz model: proportion female = exp(-exp(-(3.5002-0.0044*length), r2 (McFaden) = 0.06, n=5775, L50 transition = 707 mm FL), NMFS PC and FL FWCC/FWRI data combined. Red symbols indicate ages with n < 4. After age 21, four females and seven males were observed. Logistic regression analysis conducted using XLSTAT software v2012.4.03 based on weighted sums of binary data.

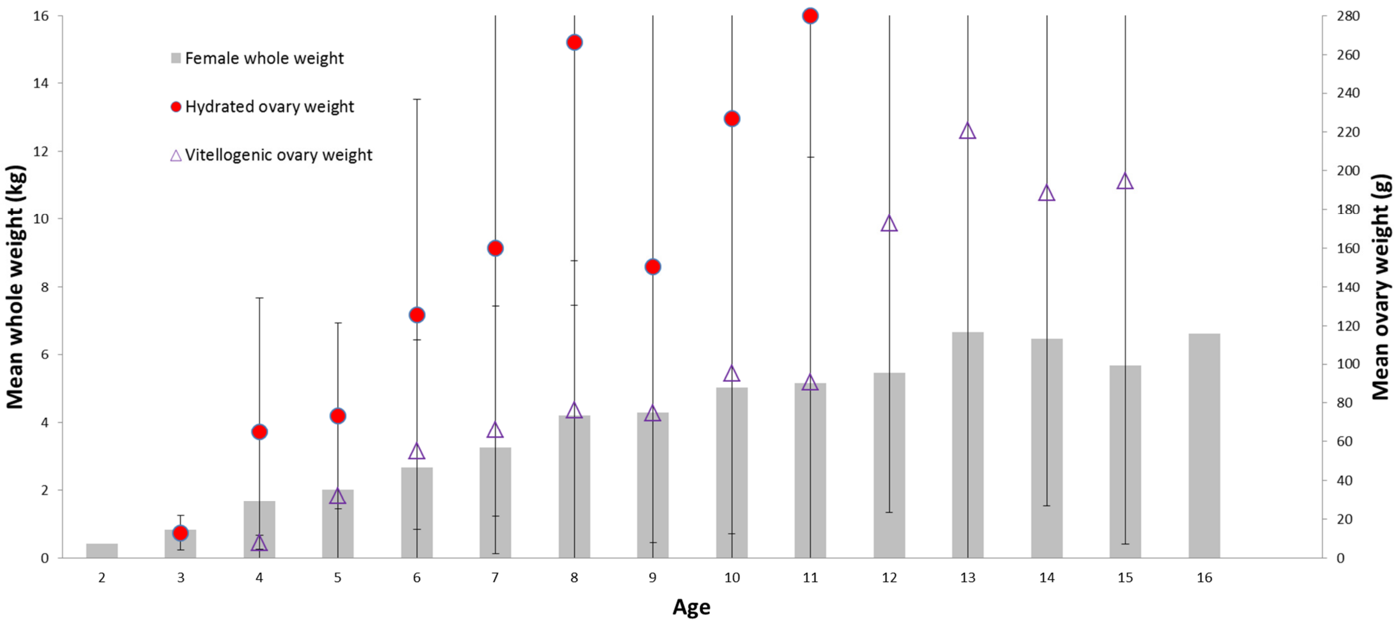
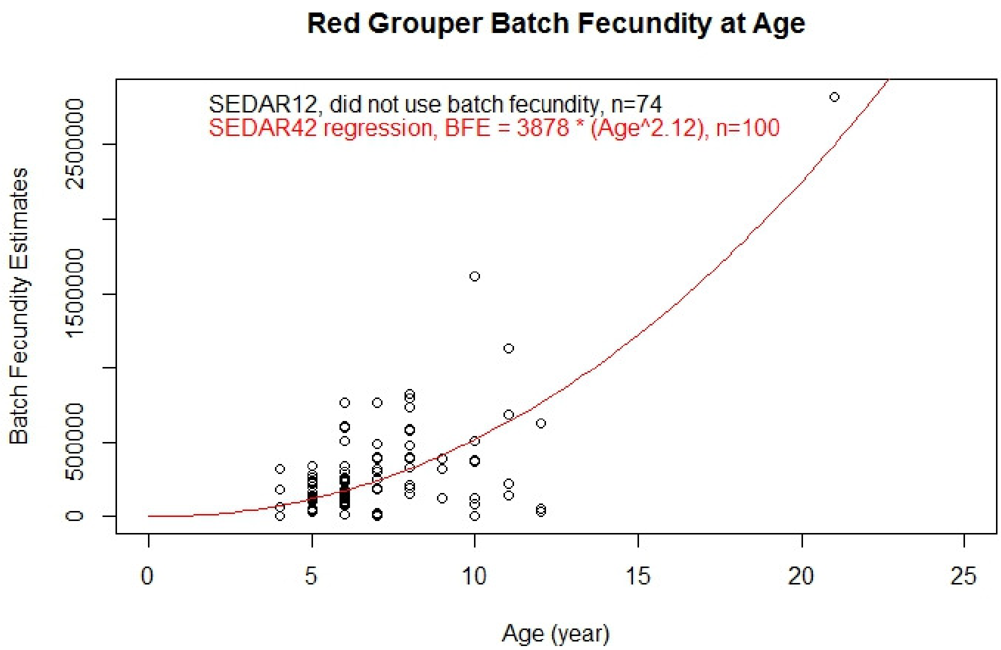
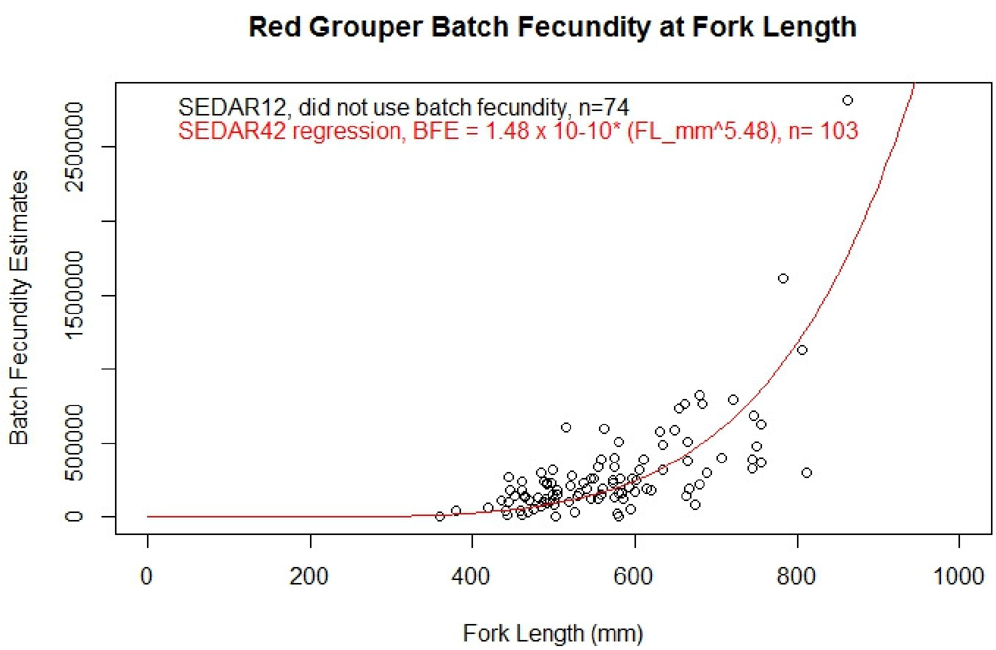


Figure 2.18. Comparison of average female whole weight at age (grey bars, n = 2864) with ovary weights by stage of development. Triangle symbols indicate mean (± 1 SD) weight of ovaries with vitellogenic oocytes (n= 820) and round red symbols indicate mean (± 1 SD) weight of ovaries with hydrated oocytes (n=148). Ovary weight (and thus one aspect of reproductive output) increases with age in a manner that is non-proportional to increase in female body weight.

a.





b.

Figure 2.19. Elements of annual fecundity: a) batch fecundity by age and b) batch fecundity by fork length. Data fit in R (nls).

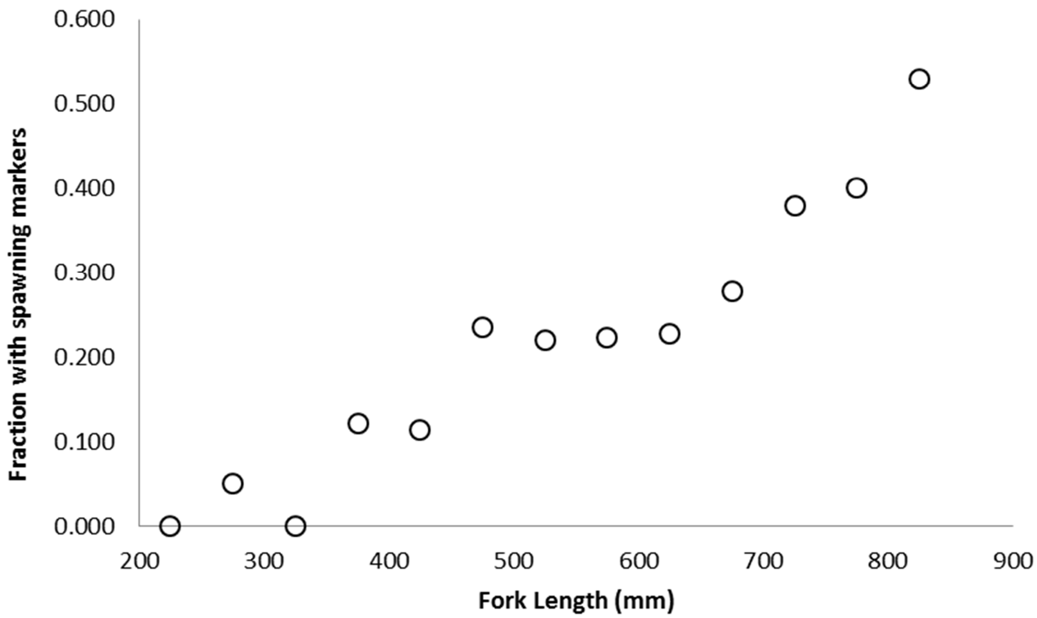


Figure 2.20. Elements of annual fecundity: Fraction of females bearing histological spawning markers (postovulatory follicles and/or hydrated oocytes) out of the total sampled by length during March-June, all years (n=1937).

3 COMMERCIAL FISHERY STATISTICS

3.1 OVERVIEW

Commercial landings of red grouper for the U.S. Gulf of Mexico were constructed primarily using data housed in the NOAA's Southeast Fisheries Science Center's Accumulated Landings System (ALS) from 1963 through 2013. Florida landings from 1986 through 2013 were obtained from the Florida Trip Ticket program and were preferred over ALS due to the data's finer resolution. For historical landings between 1880 and 1962, landings were obtained from Saul (2006). Cuban landings from U.S. waters were also provided from Saul (2006). Overall the methodologies used to produce landings were the same as those used in SEDAR 12. One addition to those methods was the introduction of landings from the Individual Fishing Quota

(IFQ) program for 2011-2013. Final landings were then provided by year and gear (handline, longline, trap, and other).

Discards were calculated for the directed fishery using data from the reef fish observer program. Data were available from 2007 through 2013. Data were stratified to produce discard rates. Some strata had insufficient sample size so mean rates were used. Mean discard rates were used for 1993-2006. All discard rates were applied to total effort from the Coastal Fisheries Logbook Program.

Red grouper length samples were reviewed for the years 1984-2013 using available TIP length data. Commercial landings length frequency distributions will be provided by year, and gear (handline, longline, and trap). Commercial discard lengths from observer data were provided for 2006-2012. Commercial landings ages were weighted by the length frequency distributions and will be provided by year and gear.

3.1.1. Commercial Workgroup Participants

Neil Baertlein	Workgroup leader	NMFS Miami
Ching-Ping Chih*	Data provider	NMFS Miami
Donna Bellais*	Data provider	GulfFIN
Steve Brown	Data provider	FL FWC
Jason Delacruz	Commercial	Florida
Martin Fisher	Commercial	Florida
Kevin McCarthy	Data provider	NMFS Miami
Refik Orhun*	Data provider	NMFS Miami
Jeff Pulver	Data provider	NMFS Galveston
Elizabeth Scott-Denton*	Data provider	NMFS Galveston
Bob Spaeth	Commercial	Florida
Jessica Stephen	Rapporteur/Data provider	NMFS SERO
John Ward		

*Did not attend workshop

3.1.2 Issues Discussed at the Data Workshop

Commercial landings issues the workgroup addressed included historical landings, gears, Florida trip ticket data, and IFQ reported landings. Methodologies from SEDAR 12 were largely used for the production of landings. Incorporation of vessels' allocation for construction discard estimates is ongoing. Length and age samples were also reviewed and weightings of each for the development of length/age frequency distributions were discussed.

3.2 REVIEW OF WORKING PAPERS

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

SEDAR42-DW-01: This document provided a summary of observer data from the reef fish observer program out of NMFS Galveston.

SEDAR42-DW-12: This document provided an analysis of commercial length and age compositions in the Gulf of Mexico. Sample sizes by year, gear, and region were reviewed and found to be sufficient for most strata. Length and age frequency distributions, and age length keys were also discussed.

SEDAR12-DW-11. This document provided historic and Cuban landings of red grouper. These landings were also provided for and used in SEDAR12.

3.3 COMMERCIAL LANDINGS

Accumulated Landings System (ALS)

Most of the commercial landings were compiled from the ALS from 1963-2012. Red grouper landings are provided in Table 3.1 and Figure 3.3 by year and gear (handline, longline, trap, and other). There are several situations where the landings data may not have the desired level of resolution. The following issues were identified:

1. Only annual data are available for 1963 – 1977

2. In 1963, some landings are only reported as water body code 5000 (Gulf of Mexico).

3. For Florida, gear and fishing area are not available for monthly data for 1977 - 1984

4. For Louisiana, gear and fishing area are not available for 1990 - 1999

5. For Texas, gear and fishing area are not available for 1990 - 2011.

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

For the landings on the west coast of Florida during the period 1977 - 1996, data on the allocation of landings gear and fishing area are available from the Florida general canvass data which has annual landings data by gear and water body from 1976 to 1996. Proportions from the annual general canvass were applied to the monthly ALS data to provide the desired resolution for the landings time series. The annual Florida general canvass landings data were used from 1977 – 1985 to allocate gear and statistical area to the landings.

For ALS landings data in Texas, Mississippi, and Alabama, logbook data has been used to assign gear and area information for 1993 forward. The same treatment was applied to the Louisiana landings, but for 1990-1999. The Texas trip ticket program began in 2000.

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

Florida Trip Ticket

Comparisons were made between Florida's commercial trip ticket data (1986-2013) and NMFS logbook data (1992-2013). Both datasets were very similar in landings trends and level of landings reported for matching years. While no direct comparison was made between Florida trip ticket and NMFS general canvass, it was decided to use the total landings from the Florida trip ticket data over the general canvas and logbook since general canvas data are Florida trip ticket data since 1997, and trip ticket data were more complete and are of a longer time series than the logbook data.

One issue arose with regard to red grouper landings from Florida Gulf of Mexico waters: how to apportion red grouper from unclassified grouper. Since red grouper have been coded to species since 1986, it was decided apportion red grouper from unclassified grouper on trips where only unclassified grouper was reported. The rationale was that if grouper were coded to species on trips that also included unclassified grouper, the dealer was probably diligent in reporting major grouper species correctly. To apportion red grouper from unclassified only grouper, Florida trip ticket data were used to calculate the ratio of red grouper to total identified grouper which was then applied to unclassified only grouper landings by year and gear from 1992-2013.

The amount of Gulf red grouper from Florida trip ticket was determined by calculating the proportion of annual Gulf red grouper stratified by area and gear from the logbook data. The decision to use logbook data for proportions was based on the general acceptance that effort and location data are more accurate on fisher reported logbook records than on dealer reported trip tickets. Proportions were calculated by dividing the amount of Gulf red grouper by area and gear into total red grouper for each year from 1992-2013. Since reliable logbook data were not available prior to 1993, gear and area data were retained from the FL general canvass (as described earlier) but were scaled to the Florida trip ticket total.

> **Decision 1:** It was the workgroup's recommendation to use Florida trip ticket data when available (1986-2013).

> **Decision 2:** It was the workgroup's recommendation to use logbook data to apportion annual state landings to gear and area.

3.3.1 Boundaries

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

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

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

> **Decision 3:** The workgroup's recommendation was to maintain the region boundaries as defined by the Gulf of Mexico Council boundaries between statistical grid areas 1 and 21.

3.3.2 Gears

The workgroup investigated reported gears landing red grouper from various data sources (ALS, CFLP, and Florida Trip Ticket) and determined the predominate gears to be handline, longline, and trap. In agreement with SEDAR 12, it was the workgroup's recommendation to then categorize landings into four gear groups: handline, longline, trap, and other. A list of gears included in the handline, longline, and trap categories can be found in Table 3.2.

> **Decision 4:** The workgroup suggested four gear groupings to characterize the red grouper fishery (handlines, longlines, trap, and other). Handlines include hook and line, electric/hydraulic bandit reels, and trolling.

3.3.3 Unclassified Groupers

Prior to 1986 all grouper landings, with the exception of goliath and warsaw, were reported as unclassified grouper. After this time unclassified grouper can still be found to varying degrees depending on the state of reporting. To apportion these landings to red grouper, a proportion of red grouper to the total identified grouper { (red grouper)/(all identified grouper species) } was developed for each year and state. The proportions were then applied to all unclassified grouper landings with the corresponding year and state. Prior to 1986 a mean red grouper proportion was created for each state using data for 1986-1989.

> **Decision 5:** The workgroup recommended using a mean red grouper proportion from 1986 through 1989 for grouper landings prior to 1986. This methodology remains consistent to that used in SEDAR12.

3.3.4 IFQ Landings

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

Individual landings were summed for annual total pounds landed. Additional information concerning the IFQ program can be found in Appendix B.

Landings from IFQ and ALS were compared for 2010 through 2013. Total IFQ landings of red grouper were 98.9% to 100.8% of the calculated ALS landings. 2010 was the only year in which IFQ landings were less than those found in ALS (98.9%). It was discussed that the lower IFQ landings may be attributed to unreported IFQ landings by some fishers as there was likely a period of adjustment to the then new IFQ program. The possibility of unreported IFQ landings in 2010 was corroborated when comparing logbook trip reports to IFQ transactions. It is for this reason the workgroup felt that landings from ALS most accurately reflected landings of red grouper. For 2011- 2013, the workgroup felt the IFQ landings reported were more likely to be accurate as fishers were more aware and accustomed to reporting to the IFQ program and no unclassified grouper can be reported. For the assessment, ALS data are assigned to gear and statistical area (and thereby region) using logbook proportions of the landings (rather than dealer information). To maintain this resolution in ALS data, ALS landings were adjusted across strata using the percent difference between ALS and IFQ landings (Table 3.3). The resulting total ALS landings for 2011 through 2013 would then reflect that of IFQ.

> **Decision 6:** Use total IFQ landings from 2011 through 2013. Apply the differences between ALS and IFQ to ALS data across all strata.

3.3.5 Historical Landings

Historical landings of red grouper were provided from Saul (2006). Landings provided are for 1880 through 1962 and are consistent with those used in SEDAR12. For historical data, all landings of grouper, with the exception of goliath and warsaw groupers, were reported as unclassified grouper. The unclassified grouper data available were by year and state. Of the 83 years of unclassified grouper landings available, only 26 years had data for all states (TX, LA, MS, AL, west FL), 12 years had data for at least one of the states, and 45 years had no data available. To fill in missing years of data, linear interpolations of unclassified grouper landings were made by state. Data were further apportioned to U.S. caught red grouper based on findings from an “exhaustive literature search” (Saul, 2006) and anecdotal evidence. Saul (2006) apportioned 90% of unclassified to red grouper. Landings were further apportioned to U.S.

caught fish based on fleet reports of smaller near shore vessels ("chings"), and larger vessels ("smacks").

The workgroup discussed the possibility of dropping landings during World War II as prior SEDAR discussions mentioned that ports were closed due to the war. Further investigation however, found no substantive evidence that no fishing was occurring (Cortez 2014), (Smith 1948, (Baughman 1943) (Tarbox, National Fisherman 1970 vol 50, no 13) (Carpenter 1965). It is possible that fishing decreased during the war due to labor shortages, but not to the point where no landings were made. While landings levels remain uncertain for the 1940's it was the workgroup's recommendation to keep the calculated values provided by Saul (2006). Historic red grouper landings can be seen in Table 3.4 and Figure 3.4.

Decision 7: Use historic landings as produced by Saul (2006) for SEDAR12.

As with historical US landings of red grouper, Cuban landed red grouper were provided from Saul (2006). These landings represent red grouper landed in Cuba, but were taken from US waters. Landings are from 1937 through 1977. Missing landings in 1959-1962 were likely attributed to the Cuban revolution. The Cuban landings series ends in 1977 due to the expansion of the US EEZ to 200 miles and the expulsion of Cuban vessels. Cuban landings can be found in Table 3.5 and a comparison to US landings in Figure 3.5.

Decision 8: Use Cuban landings as produced by Saul (2006) for SEDAR12.

3.4 DISCARDS AND BYCATCH

Commercial Discards Preliminary Analyses

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

Red grouper discard calculations

Data available for the calculation of red grouper discards from the commercial fishery included vertical line (handline and electric/hydraulic reel) and bottom longline observer data in addition to fisher reported effort data from the coastal logbook program. Complete years of observer data included the years 2007-2013. Coastal logbook data were available for the years 1990-2013; however, during the period 1990-92 only 20% of Florida vessels were selected to report landings and effort data. Beginning in 1993 all vessels with federal fishing permits were required to report to the coastal logbook program. Discards were calculated for the years with full reporting, 1993-2013.

To calculate discard rates of red grouper, observer and coastal logbook effort data were stratified by:

Gear	**Vertical line/bottom longline**
Region	Statistical areas 1-8 (FL Keys to Cape San Blas), 9-21 (west of Cape San Blas to TX/Mexico border)
Size limit	20 inch (1993-2009), 18 inch (2010-2013)
Shallow water grouper season	Open, closed (applies to 1993-2009)
Allocation	0, 1+ pounds (applies to 2010-2013)
Year	Year specific stratification, 2007-2013
Seasonal depth restriction	20 fathoms, 35 fathoms*

*Bottom longline vessels were restricted to fishing in depths 35 fathoms or deeper during June-August beginning in 2010. That restriction did not apply to vertical line vessels.

For the years 1993-2006, mean discard rates within strata across the years 2007-2009 (pre-IFQ, 20 inch minimum size data) were used. Effort data from the coastal logbook program were summed within each stratum.

Yearly discards were calculated for the years 2007-2013 (years with observer data) as:

*Year/stratum-specific discard rate*year/stratum-specific total effort*

For the years 1993-2006 (years with effort data, but no observer data available), discards were calculated as:

*mean stratum-specific discard rate*year/stratum-specific total effort*

Mean discard rates were also used for the years 2007-2013 in cases where a stratum had few (<10) or no observer reports.

Discards were calculated as number of red grouper discarded summed across all strata within a year (Figures 3.6 and 3.7). Discard rates were in number of fish discarded per hook hour fished (vertical line) or per hook fished (bottom longline). High discards from the vertical line fishery in 2011-12 were associated with increased fishing effort and high discard rates in the eastern Gulf of Mexico among vessels with red grouper IFQ allocation. Decreased discards in the bottom longline fishery were likely due to reduced effort in the fishery (Figure 3.8). The fishery was restricted to 50 fathoms or deeper (from the usual 20 fathoms) in May, 2009. Beginning in 2010, depth restrictions were 35 fathoms or deeper during June-August and 20 fathoms or deeper during the remainder of the year. In addition, the bottom longline fishery became a limited entry fishery in 2010. Bottom longline gear was limited to 750 hooks per set, also beginning in 2010. The increase in discards from bottom longline vessels in 2011-12 was due to higher discard rates in the eastern Gulf of Mexico.

Recommendation:

Use calculated discards from both commercial vertical line and bottom longline as data inputs for the Gulf of Mexico red grouper assessment.

3.5 COMMERCIAL EFFORT

The distribution of directed commercial effort in trips by year was compiled from the Coastal Fisheries Logbook Program (CFLP) for 1993-2013 and supplied here for information purposes. These data are presented in Figure 3.9. The distribution of harvest, as reported to the CFLP, is also displayed in Figure 3.10.

3.6 BIOLOGICAL SAMPLING

Biological sample data were obtained from the TIP sample data at NMFS/SEFSC and from the reef fish observer program at SEFSC's Galveston laboratory. Data were filtered to eliminate those records that included a size or effort bias, non-random collection of length data, were not from commercial trips, fish were selected by quota sampling, or the data were not collected shore-side. These data were further limited to those that could be assigned a year, gear, and state. Data that had an unknown sampling year, gear, or sampling state were deleted from the file.

3.6.1 TIP Samples

Commercial length samples are available for handline, longline, and trap gear groups between 1984 and 2013. The number of fish measured appears relatively adequate throughout the time series. The majority of samples are from the longline fishery in the southern Gulf of Mexico (areas 1 through 5), with well over 1,000 samples for most years (except 1988 when there were 0) and over 35,000 in 1999. The number of handline samples was generally above 1,000 for most years in both the north and south categories. Handline samples in the north were below 100 for five years between 1985 and 1990. Aggregation across regions may be necessary for these years. Trap samples were absent in the southern region until 1991. Other years were absent or low so aggregation of northern and southern trap samples may be necessary. The number of measured fish can be found in Table 3.6.

Age samples for handline and longline are available for 1991-2013. Prior to 2000, most years had fewer than 100 handline samples across regions. The number of longline age samples was greater with only four years having fewer than 100 samples prior to 2000. From 2000 forward, both handline and longline appear to have adequate sampling with over 100 ages collected for both gears and regions. A table of age samples can be found in Table 3.7.

There were some concerns about potential differences in size and age between the northern and southern Gulf. As expressed by Chih (2014b) it was recommended that handline and longline samples be weighted by landings and region (north and south Gulf). Length frequency distributions will then be provided by year and gear. There were also concerns about the representativeness of the age samples. It was therefore recommended that, in agreement with

Chih (2014b), ages be weighted by length frequencies for handline and longline by region. Final age frequencies will be provided by year and gear for handline and longline.

> **Decision 9:** Weight length distributions for handline and longline by landings and region. Region is defined as north (areas 6 – 11) and south (areas 1 – 5) Gulf of Mexico.

> **Decision 10:** Weight age distributions for handline and longline by length frequencies and region. Region is defined as north (areas 6 – 11) and south (areas 1 – 5) Gulf of Mexico.

Following these recommendations, length frequency distributions (LFDs) and age frequency distributions (AFDs) were developed for handline and longline, and were presented in Chih (2014a). The methods for estimating LFDs and AFDs for red groupers differ from those used in SEDAR 12 in several ways: (1) LFDs for handline and long line strata were stratified into north and south regions due to apparent differences in LFDs between the two regions (Chih, 2014b), (2) AFDs were reweighted by LFDs due to non-random sampling of some otolith samples, and (3) AFDs for handline and longline strata were also stratified into north and south regions due to apparent differences in ALKs between the two regions (Chih,2014b). All length and age samples collected from trips with Exempted Fishing Permits were also removed. Final sample sizes of lengths and ages can be found in tables 3.8 and 3.9. The resulting LFDs and AFDs can be found in Figures 3.11 – 3.16.

3.6.2 Size frequency data from commercial fisheries observers

Fishery observer data collected on bottom longline and vertical line (handline and electric/hydraulic reels) from the Gulf of Mexico reef fish fishery from July 2006 through December 2013 were used for length frequency distributions. Vessels were randomly selected for observer coverage within gear type, region, and season strata. Strata with the highest effort received greater observer coverage (days at sea) than those strata with lower reported effort. Additionally, increased coverage was directed at either gear type (bottom longline or vertical line) based on enhanced coverage funding levels during various time periods. Data from 2007 and 2008 bottom longline gear were pooled to maintain confidentiality under NOAA Administrative Order 216-100.

Fishery observers record detailed information on both kept and discarded fish for each recorded fishing set; where set was defined as fishing at a specific location. Observers record lengths, weights, barotrauma stress indicators, and dispositions (kept, discarded alive, discarded dead, unknown discard, used for bait, and unknown if kept or discarded) for each fish captured. A total of 314,551 red grouper were recorded as captured by the observer program for bottom longline and vertical line gear types with 98.9% of these measured. For red grouper recorded as kept or discarded, 99.7% of kept and 97.7% of discarded red grouper had length information recorded. The majority (77.5%) of length measurements recorded were on vessels using bottom longline gear. Most (>99%) of the red grouper length measurements were fork length to the nearest mm, but a small amount (1,955) were recorded as stretched total length and converted using Fork Length (mm) = (Total Length (mm) + 5.95) / 1.05.

For length frequency distributions, histograms were produced for longline (Figure 3.17) and handline (Figure 3.18) by year for the proportion of red grouper kept and discarded in 1-cm bins. Further characterization of discarded sizes was explored. To explore the possibility of size selectivity based on available red grouper IFQ allocation, length frequency distributions were developed for longline (Figure 3.19), and handline (Figures 3.20 and 3.21). Sample sizes for each year are provided within each figure.

3.7 COMMENTS ON ADEQUACY OF DATA FOR ASSESSMENT ANALYSES

Overall the workgroup felt the landings were adequate for assessment analyses. The landings time series ran from 1880-2013. There was much uncertainty in the landings provided for 1880-1962 as reported landings of grouper were missing for the majority of years and assumptions on species apportionment and US caught fish remain. Landings post-1962 are felt to be relatively accurate. Landings after 1986 should be considered most accurate as this is when trip tickets went into place and landings were generally reported to species (i.e. reported as red grouper instead of 'unclassified' grouper). Total IFQ landings used for 2011 through 2013 were also agreed upon as being the most accurate.

There was some uncertainty in the discard estimations due to relatively low sample size when dividing observer data into various strata for discard rate calculation. This is most evident when dealing with longline trips. To address low or missing samples size, mean discard rates were used. There is also a greater amount of uncertainty in the discard estimates prior to 2007. Since no observer data were available, a mean discard rate was applied back to 1993. Other than when using mean discards rates, it is felt that discard estimates should be fairly adequate since the observer program is the best source of data available.

The workgroup felt the commercial landings length samples should be adequate for assessment analyses. There appears to be an adequate number of samples for most years for all gears, especially handline and longline. There were fewer age samples, but the workgroup felt those data were adequate and should be weighted by length frequency distributions.

3.8 RESEARCH RECOMMENDATIONS

<u>Landings</u>

-Improve data quality of CFLP Logbook VTR number to state trip ticket for data reconciliation.

<u>IFQ</u>

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

-Explore fishermen behavior in relation to allocation available.

-Add CFLP Logbook VTR number to IFQ landing transaction form for data reconciliation.

-Translate IFQ allocation activity ledger into a useable data set for daily allocation balances.

-Add actual landing date to IFQ reporting form.

-Improved enforcement of IFQ reporting infractions.

-Improve real time seizure reporting from states law enforcements agents. Need vessel, species, pounds, price per pound, dealer, and enforcement agent.

<u>Discard</u>

-Most appropriate method for incorporation of IFQ data into discard estimations.

-Most appropriate method for incorporation of IFQ data into discard size compositions.

-Increased observer funding and coverage.

-More representative observer coverage.

-Assess reliability of effort data in logbook data.

Overall

Meet with fishermen prior to data workshops to provide supplementary information relevant to fishery dependent data.

3.9 LITERATURE CITED

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3.10 TABLES

Table 3.1 Annual red grouper landings in gutted pounds for 1963-2013

Year	Handline	Longline	Trap	Other	Total
1963	3,564,592			2,884	3,567,476
1964	4,140,338		4,628	13,769	4,158,735
1965	4,616,945		5,053		4,621,998
1966	4,433,396		6,553	1,093	4,441,042
1967	3,583,388		7,404	15,447	3,606,239
1968	3,942,688		13,511	3,205	3,959,403
1969	4,587,309		7,804	2,056	4,597,170
1970	4,469,105		12,160		4,481,264
1971	3,812,225		12,149		3,824,374
1972	3,963,622		2,277	10	3,965,908
1973	3,059,028			530	3,059,558
1974	3,568,782			827	3,569,609
1975	4,312,414		12,426	163	4,325,003
1976	3,727,297		11,404		3,738,701
1977	2,977,567		41,873	4,514	3,023,954
1978	2,731,138		88,893	5,628	2,825,658
1979	3,778,962		70,135		3,849,096
1980	3,847,616		44,773	10,672	3,903,060
1981	3,324,172	3	66,685	9,827	3,400,688
1982	3,074,037	815,663	50,020	12,994	3,952,714
1983	2,907,533	3,064,216	1,109	12,650	5,985,509
1984	2,947,579	2,487,094	311,570	3,349	5,749,592
1985	3,647,830	2,073,122	640,413	7,282	6,368,646
1986	3,134,859	2,505,832	721,461	11,217	6,373,369
1987	2,542,122	3,774,849	448,081	11,082	6,776,135
1988	2,049,120	2,192,793	540,228	5,228	4,787,369
1989	3,814,892	3,118,201	592,772	11,051	7,536,916
1990	2,460,952	2,025,693	340,896	5,346	4,832,887
1991	2,093,837	2,583,586	373,747	33,887	5,085,058
1992	1,444,966	2,409,550	602,185	8,636	4,465,337
1993	1,300,324	4,274,356	711,086	43,275	6,329,042
1994	1,241,427	2,699,085	913,825	37,682	4,892,020
1995	1,171,250	2,429,416	1,056,993	16,044	4,673,703
1996	865,153	2,907,190	539,359	10,161	4,321,863
1997	948,379	3,024,185	685,831	6,839	4,665,234
1998	741,613	2,662,645	297,548	5,128	3,706,934
1999	1,212,757	3,815,403	751,819	17,430	5,797,409
2000	1,720,988	2,909,341	1,024,809	30,399	5,685,537

2001	1,555,714	3,399,634	743,289	21,255	5,719,892
2002	1,628,178	3,130,561	980,293	18,484	5,757,516
2003	1,118,263	2,964,737	701,668	12,313	4,796,981
2004	1,376,656	3,383,468	745,209	14,130	5,519,462
2005	1,404,245	3,211,570	612,717	12,402	5,240,934
2006	1,375,688	3,012,663	586,847	8,956	4,984,154
2007	1,561,080	1,984,386	24,476	13,097	3,583,039
2008	1,888,224	2,804,144		24,773	4,717,142
2009	2,445,139	1,124,827		121,721	3,691,687
2010	1,353,711	1,314,422		275,596	2,943,729
2011	1,688,279	3,045,086	15	50,289	4,783,668
2012	2,229,535	2,940,062		49,537	5,219,133
2013	1,540,493	3,017,605		40,902	4,599,001

Table 3.2 ALS gear code grouping.

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

Table 3.3 Annual IFQ correction factors.

Year	IFQ landings	ALS + FTT landings	IFQ correction factor
2011	4,783,668	4,746,990	1.00773
2012	5,219,133	5,203,521	1.00300
2013	4,599,001	4,564,933	1.00746

Table 3.4 Historic red grouper landings from Gulf of Mexico states.

Year	Texas	Louisiana	Mississippi	Alabama	Florida	Total

1880	0	0	0	0	1,514,570	1,514,570
1881	491	0	0	954	1,366,462	1,367,907
1882	981	0	0	1,908	1,218,353	1,221,243
1883	1,472	0	0	2,862	1,070,245	1,074,579
1884	1,963	0	0	3,816	922,136	927,915
1885	2,453	0	0	4,770	774,028	781,251
1886	2,944	0	0	5,724	625,919	634,587
1887	3,434	0	0	6,678	477,811	487,923
1888	6,010	7,727	0	7,632	329,702	351,072
1889	0	15,455	0	8,586	358,895	382,936
1890	0	15,455	0	9,445	342,581	367,481
1891	425	13,247	0	16,559	389,455	419,686
1892	850	11,039	0	23,673	436,329	471,891
1893	1,274	8,831	0	30,787	483,204	524,096
1894	1,699	6,623	0	37,901	530,078	576,301
1895	2,018	4,416	0	42,764	554,849	604,047
1896	2,319	2,208	0	47,438	581,263	633,228
1897	2,557	0	0	50,949	597,236	650,743
1898	7,514	818	1,008	126,714	501,739	637,792
1899	11,996	1,635	2,016	195,295	416,974	627,917
1900	15,756	2,453	3,024	252,593	334,242	608,068
1901	18,885	3,271	4,032	300,172	257,371	583,730
1902	21,728	4,089	5,040	343,483	283,508	657,848
1903	19,402	4,906	6,048	296,220	353,401	679,978
1904	17,180	5,724	7,057	252,406	415,956	698,322
1905	15,061	6,542	8,065	212,040	471,209	712,916
1906	13,350	7,359	9,073	179,196	524,646	733,623
1907	11,428	8,177	10,081	145,382	566,143	741,211
1908	9,610	8,995	11,089	115,018	600,448	745,160
1909	8,169	9,813	12,097	97,623	778,394	906,095
1910	6,548	10,630	13,105	78,133	925,503	1,033,919
1911	6,288	11,448	14,113	74,913	1,120,083	1,226,845
1912	6,029	12,266	15,121	71,693	1,315,282	1,420,391
1913	5,770	13,083	16,129	68,473	1,511,099	1,614,555
1914	5,511	13,901	17,137	65,254	1,707,536	1,809,339
1915	5,251	14,719	18,145	62,034	1,904,591	2,004,741
1916	4,992	15,537	19,153	58,814	2,102,266	2,200,762
1917	4,733	16,354	20,162	55,594	2,300,559	2,397,402
1918	4,473	17,172	21,170	52,375	2,499,471	2,594,660
1919	4,984	15,455	21,424	54,976	2,382,338	2,479,176
1920	5,494	13,738	21,678	57,578	2,264,822	2,363,309
1921	6,004	12,020	21,933	60,179	2,146,923	2,247,059
1922	6,514	10,303	22,187	62,781	2,028,640	2,130,425

1923	7,024	8,586	22,441	65,382	1,909,975	2,013,409
1924	7,267	9,874	25,027	56,774	1,873,771	1,972,714
1925	7,510	11,162	27,613	48,166	1,835,998	1,930,450
1926	7,753	12,450	30,200	39,558	1,796,656	1,886,616
1927	7,996	13,738	32,786	34,785	1,755,744	1,845,048
1928	5,230	429	42,329	83,271	1,761,198	1,892,457
1929	4,857	3,434	21,405	37,814	2,020,038	2,087,548
1930	6,814	3,005	61,040	52,403	1,273,484	1,396,746
1931	11,930	3,580	20,685	25,380	1,174,304	1,235,880
1932	8,372	2,919	13,838	25,281	1,545,659	1,596,069
1933	6,517	9,359	30,531	57,112	1,984,501	2,088,019
1934	2,054	15,798	47,223	28,563	1,918,300	2,011,938
1935	10,694	9,616	88,006	34,234	2,384,720	2,527,271
1936	19,839	3,434	128,790	40,271	2,889,396	3,081,730
1937	11,612	5,237	110,416	46,714	3,165,300	3,339,280
1938	20,067	5,152	135,315	47,375	2,863,585	3,071,494
1939	43,161	8,844	18,288	50,051	4,473,796	4,594,140
1940	53,723	3,434	15,541	52,140	3,133,444	3,258,282
1941	41,755	3,263	13,686	48,354	3,379,013	3,486,070
1942	34,762	3,091	11,832	50,045	3,931,818	4,031,547
1943	24,751	2,919	9,977	40,782	4,122,729	4,201,159
1944	17,686	2,748	8,122	35,481	4,679,268	4,743,304
1945	9,457	2,576	6,268	29,129	4,918,990	4,966,420
1946	27,540	2,948	14,196	51,799	5,300,728	5,397,211
1947	45,397	3,320	22,123	55,834	5,298,183	5,424,857
1948	61,152	3,692	30,051	67,212	5,090,963	5,253,070
1949	81,861	4,465	25,071	45,622	5,205,622	5,362,641
1950	58,769	6,525	12,962	28,910	3,480,371	3,587,538
1951	25,280	15,196	268	70,807	3,929,321	4,040,872
1952	42,499	179	3,710	58,629	2,452,656	2,557,673
1953	26,769	626	7,151	35,225	1,911,275	1,981,046
1954	19,630	1,698	18,593	68,133	1,705,939	1,813,993
1955	27,019	1,788	15,017	49,611	1,576,121	1,669,557
1956	4,756	0	14,839	51,463	2,258,786	2,329,844
1957	18,134	268	15,116	35,817	2,781,496	2,850,830
1958	18,387	0	24,999	55,350	2,822,615	2,921,351
1959	63,903	10,637	45,893	74,465	3,752,333	3,947,231
1960	28,190	21,632	59,727	73,805	4,341,318	4,524,671
1961	33,097	14,124	56,886	69,237	4,270,933	4,444,277
1962	71,270	47,108	81,396	74,274	4,926,802	5,200,851

Table 3.5 Red grouper caught in the U.S. Gulf of Mexico and landed in Cuba.

Year	Cuban Landings
1937	6,486,300
1938	6,486,300
1939	6,486,300
1940	6,486,300
1941	6,486,300
1942	2,640,994
1943	2,029,448
1944	2,999,945
1945	1,668,658
1946	1,791,966
1947	1,891,760
1948	1,968,042
1949	2,020,812
1950	2,050,069
1951	2,055,813
1952	2,038,044
1953	1,996,763
1954	1,931,969
1955	1,843,662
1956	1,949,123
1957	2,773,565
1958	2,130,822
1959	0
1960	0
1961	0
1962	0
1963	1,015,863
1964	2,173,199
1965	4,225,336
1966	5,013,435
1967	5,271,405
1968	5,529,375
1969	5,787,345
1970	5,625,305
1971	3,144,358
1972	3,207,059
1973	6,050,765
1974	4,030,210

1975	4,030,210
1976	4,030,210
1977	4,030,210

Table 3.6 Preliminary number of commercial length samples for red grouper.

	North (of 28N)			South (of 28N)			Total		
Year	Handline	Longline	Trap	Handline	Longline	Trap	Handline	Longline	Trap
1984	161	107	18	1,222	1,014		1,383	1,121	18
1985	39	537	900	2,012	1,178		2,051	1,715	900
1986	10	242	1,244	510	5,519		520	5,761	1,244
1987	7	75	766	1,099	2,483		1,106	2,558	766
1988	1,137	1,229		146			1,283	1,229	
1989	18	176	341	589	1,617		607	1,793	341
1990	89	999	359	856	9,889		945	10,888	359
1991	169	1,351	43	1,681	10,942	367	1,850	12,293	410
1992	447	180	196	1,998	8,218	647	2,445	8,398	843
1993	1,129	1,453	4	1,387	8,232	453	2,516	9,685	457
1994	1,072	1,081	207	2,163	7,136		3,235	8,217	207
1995	1,873	2,511	342	1,425	8,586		3,298	11,097	342
1996	1,251	2,901	415	1,843	6,855	287	3,094	9,756	702
1997	1,377	4,743	1,159	1,040	8,925	363	2,417	13,668	1,522
1998	1,274	4,812	638	2,205	24,121	422	3,479	28,933	1,060
1999	3,263	6,988	1,503	3,489	37,245	380	6,752	44,233	1,883
2000	2,884	5,038	2,185	4,869	25,125	517	7,753	30,163	2,702
2001	3,413	3,665	3,096	3,545	16,342	866	6,958	20,007	3,962
2002	2,706	2,695	1,689	2,758	15,425	489	5,464	18,120	2,178
2003	1,565	1,402	1,209	1,412	12,261	133	2,977	13,663	1,342
2004	1,553	1,150	20	1,299	9,823	364	2,852	10,973	384
2005	1,298	1,839	377	590	5,829	207	1,888	7,668	584
2006	700	1,441	803	173	3,049	186	873	4,490	989
2007	1,340	522		94	2,368		1,434	2,890	
2008	1,178	1,154		305	3,499		1,483	4,653	
2009	2,642	314		1,390	1,652		4,032	1,966	
2010	1,195	372		2,138	2,028		3,333	2,400	
2011	4,759	1,387		1,375	3,283		6,134	4,670	
2012	7,458	2,443		3,270	4,697		10,728	7,140	
2013	6,461	1,436		3,461	5,770		9,922	7,206	

Table 3.7 Preliminary number of commercial age samples for red grouper.

	North		South		Total	
Year	Handline	Longline	Handline	Longline	Handline	Longline
1991	28	35	15	2	43	37
1992	20	1	22	140	42	141
1993	81	10	12	190	93	200
1994	184	24	55	64	239	88
1995	178	14	2	126	180	140
1996	135	96	6		141	96
1997	35		7		42	0
1998	17	37	22	85	39	122
1999	53	96	24	547	77	643
2000	144	137	62	268	206	405
2001	365	872	210	338	575	1,210
2002	155	607	418	460	573	1,067
2003	314	234	247	846	561	1,080
2004	528	200	534	953	1,062	1,153
2005	398	269	228	1,186	626	1,455
2006	299	163	330	375	629	538
2007	436	147	61	452	497	599
2008	377	143	126	366	503	509
2009	801	185	570	1,848	1,371	2,033
2010	482	103	548	547	1,030	650
2011	439	101	190	398	629	499
2012	585	192	434	669	1,019	861
2013	392	275	166	855	558	1,130

Table 3.8 Final number of commercial length samples for red grouper. Exempted Fishing Permit samples removed for final analysis.

Year	Handline	Longline	Trap	Total
1984	1,383	1,121	18	2,522
1985	2,051	1,715	900	4,666
1986	520	5,761	1,244	7,525
1987	1,106	2,558	766	4,430
1988	1,137	1,375		2,512
1989	607	1,793	341	2,741
1990	945	10,888	359	12,192
1991	1,850	12,293	410	14,553
1992	2,445	8,398	843	11,686
1993	2,516	9,685	457	12,658
1994	3,235	8,217	207	11,659
1995	3,298	11,097	342	14,737
1996	3,094	9,756	702	13,552
1997	2,417	13,668	1,522	17,607
1998	3,479	28,933	1,060	33,472
1999	6,752	44,233	1,883	52,868
2000	7,753	30,163	2,702	40,618
2001	6,958	20,007	3,962	30,927
2002	5,464	18,120	2,178	25,762
2003	2,977	13,663	1,342	17,982
2004	2,852	10,973	384	14,209
2005	1,888	7,668	584	10,140
2006	873	4,487	989	6,349
2007	1,434	2,890		4,324
2008	1,483	4,653		6,136
2009	4,032	1,966		5,998
2010	3,324	2,400		5,724
2011	6,134	4,670		10,804
2012	10,728	7,140		17,868
2013	9,922	7,206		17,128

Table 3.9 Final number of commercial age samples for red grouper. Exempted Fishing Permit samples removed for final analysis.

Year	Handline	Longline	Trap	Total
1991	43	37	2	82
1992	42	143	14	199
1993	93	200	84	377
1994	239	88	29	356
1995	180	140	39	359
1996	141	96	8	245
1997	35	7	17	59
1998	39	122	33	194
1999	77	643	31	751
2000	206	405	38	649
2001	575	1,210	39	1,824
2002	573	1,067	89	1,729
2003	561	1,080	65	1,706
2004	1,062	1,153	38	2,253
2005	626	1,455		2,081
2006	629	538	173	1,340
2007	497	599		1,096
2008	503	509		1,012
2009	895	994		1,889
2010	1,030	650		1,680
2011	629	499		1,128
2012	1,019	861		1,880
2013	558	1,130		1,688

3.11 FIGURES

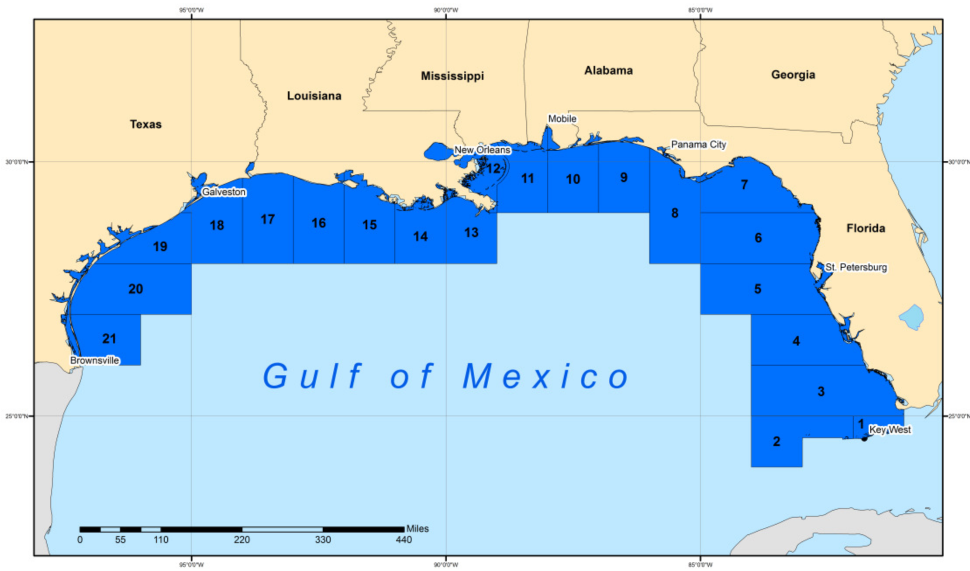

Figure 3.1 Gulf of Mexico region

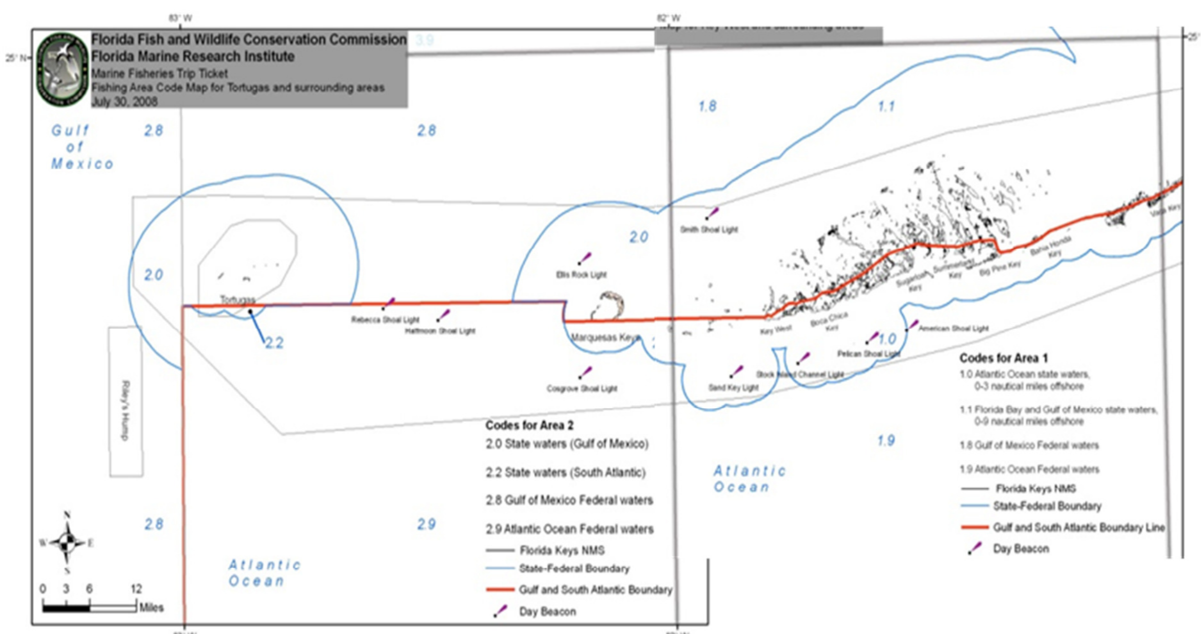

Figure 3.2 Close-up of the southern boundary as defined by the Gulf of Mexico/South Atlantic Council boundary.

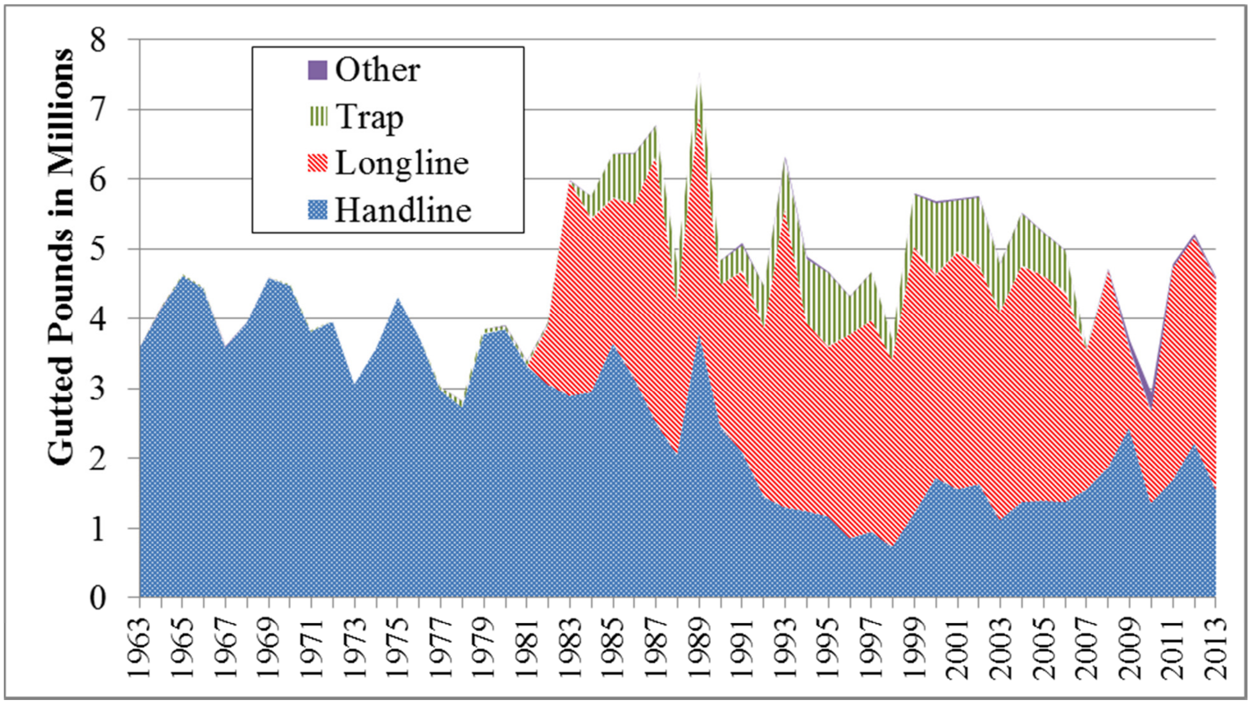

Figure 3.3 Red grouper landings, in gutted weight pounds by gear.

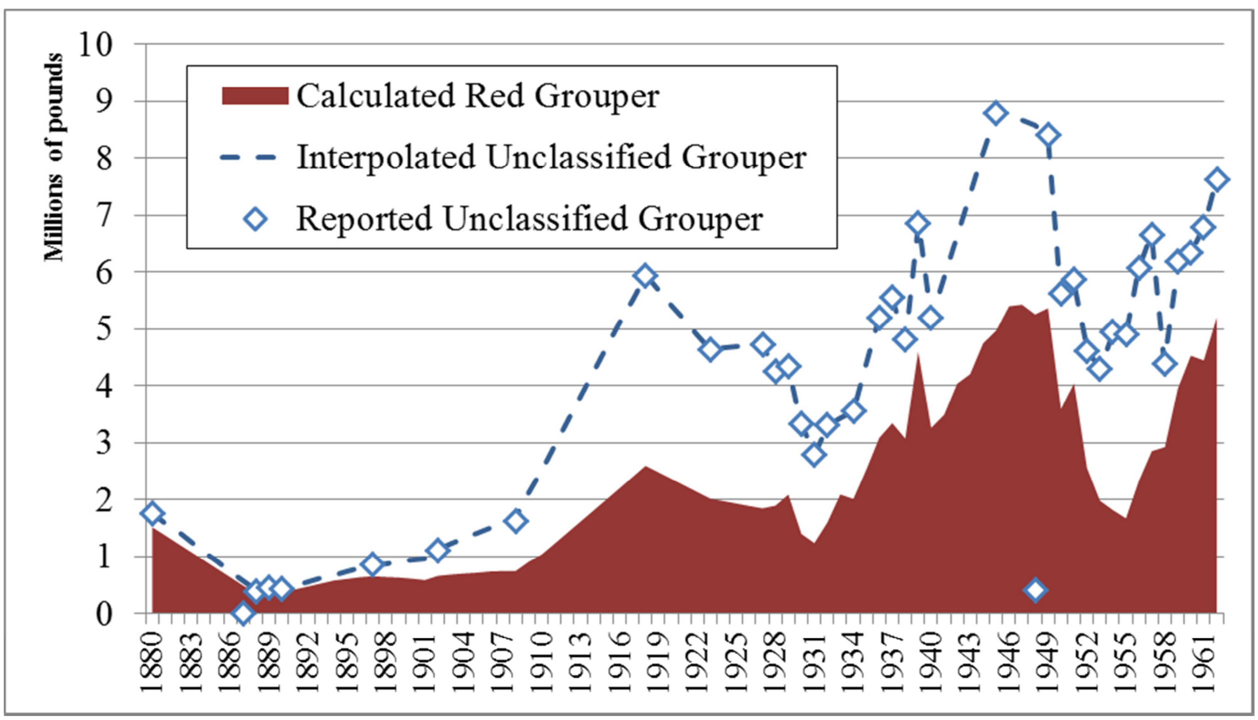

Figure 3.4 Historic red grouper landings as calculated from reported and interpolated unclassified grouper.

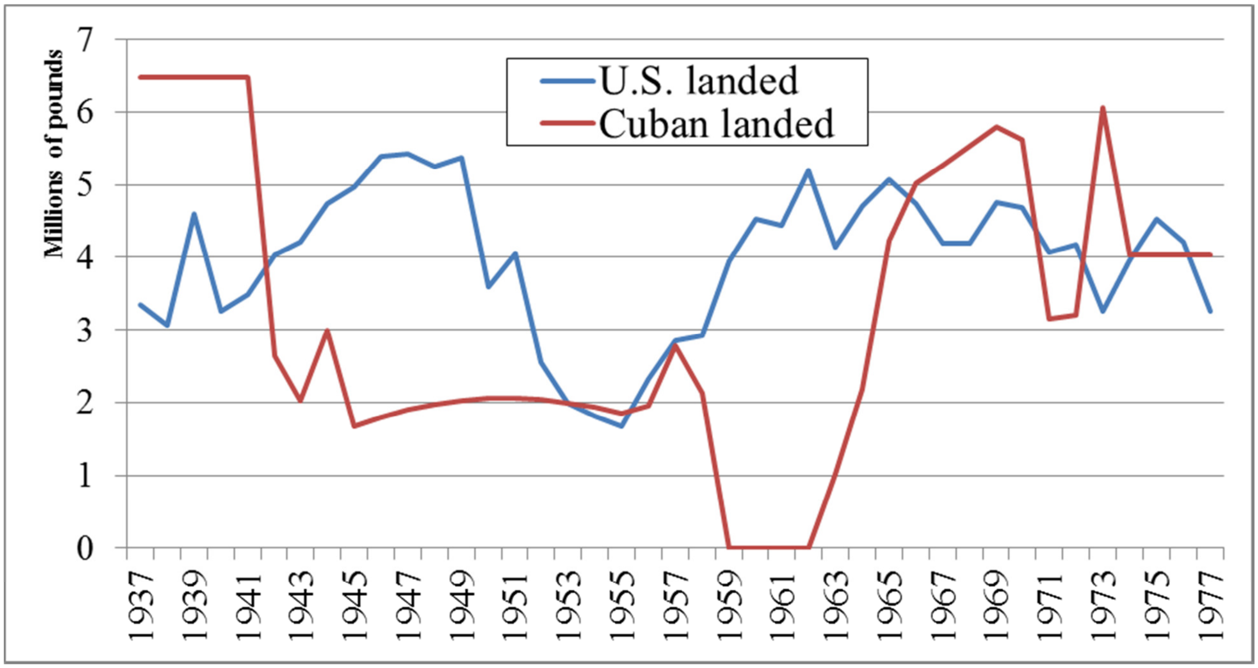

Figure 3.5 A comparison of US and Cuban landed red grouper from the US Gulf of Mexico.

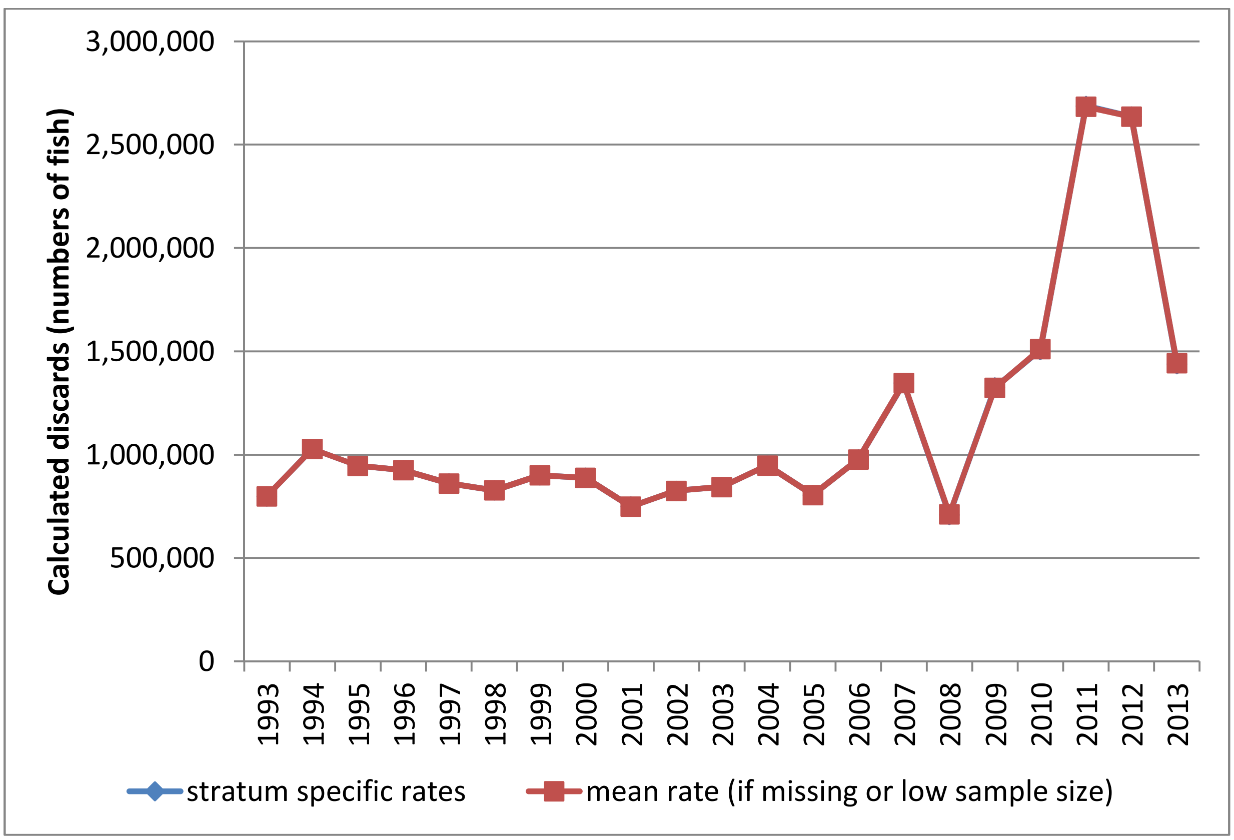

Figure 3.6 Commercial vertical line discards calculated with and without the use of mean discard rates to fill empty or poorly populated (<10 observations) discard rate strata.

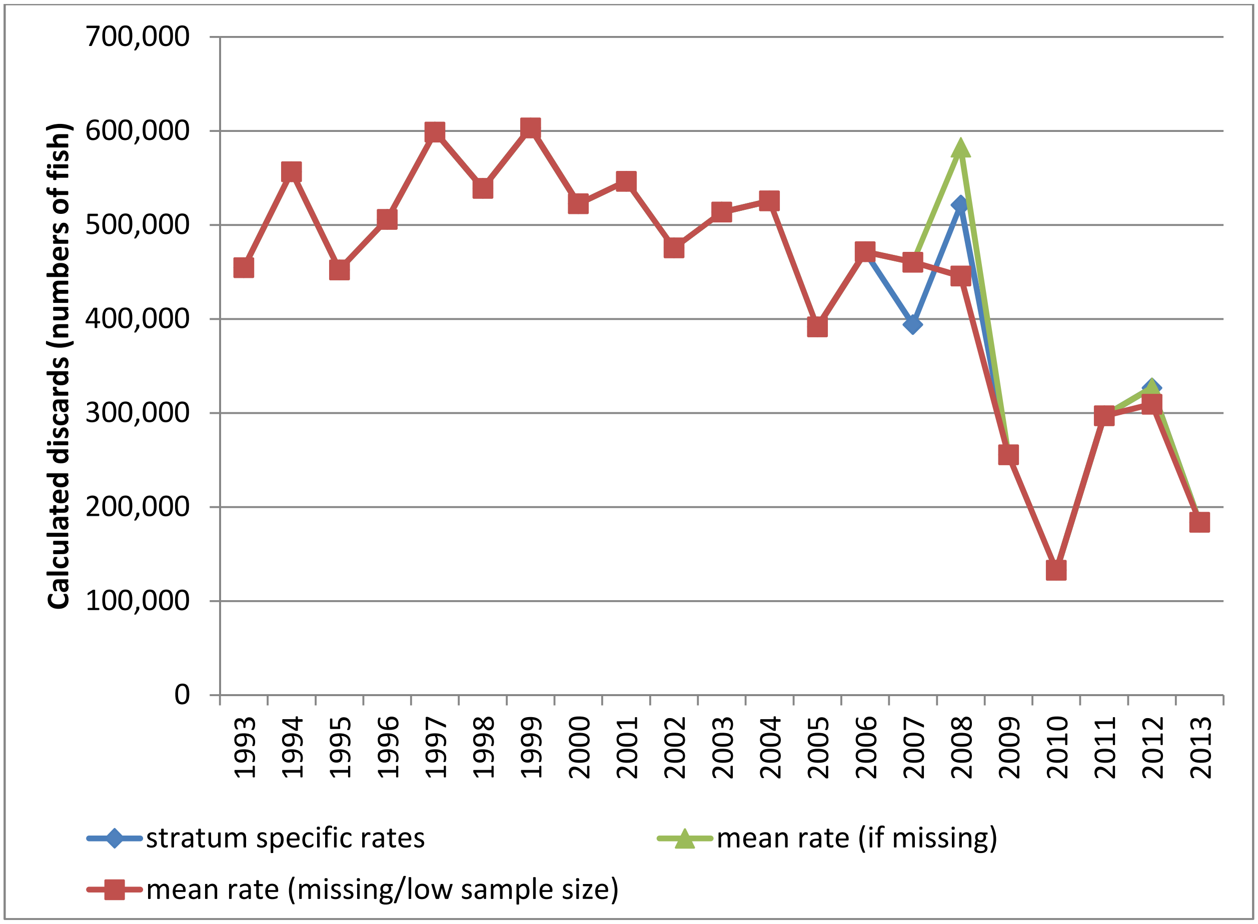

Figure 3.7 Commercial bottom longline discards calculated with and without the use of mean discard rates to fill empty or poorly populated (<10 observations) discard rate strata.

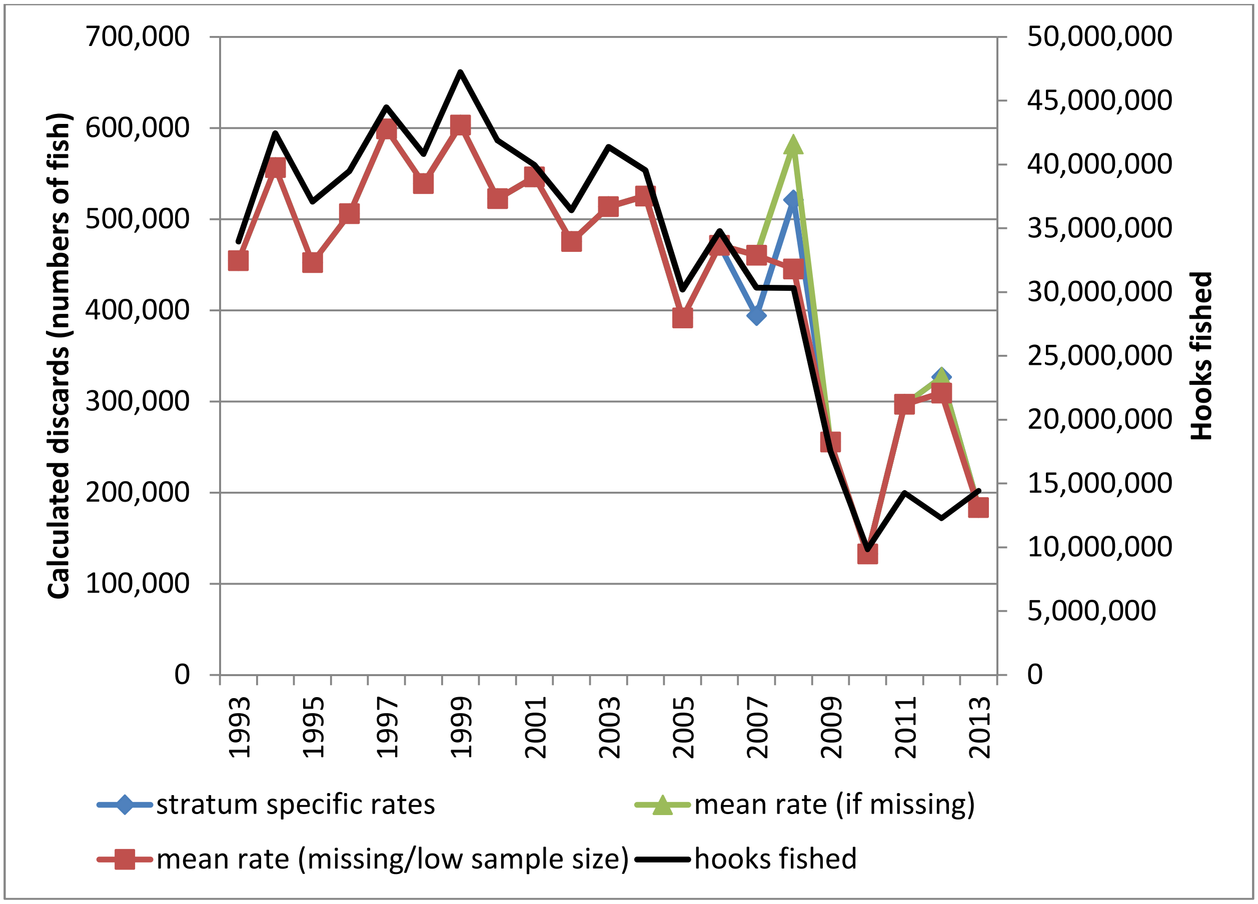

Figure 3.8 Yearly total commercial bottom longline reported effort and red grouper discards calculated with and without the use of mean discard rates to fill empty or poorly populated (<10 observations) discard rate strata.

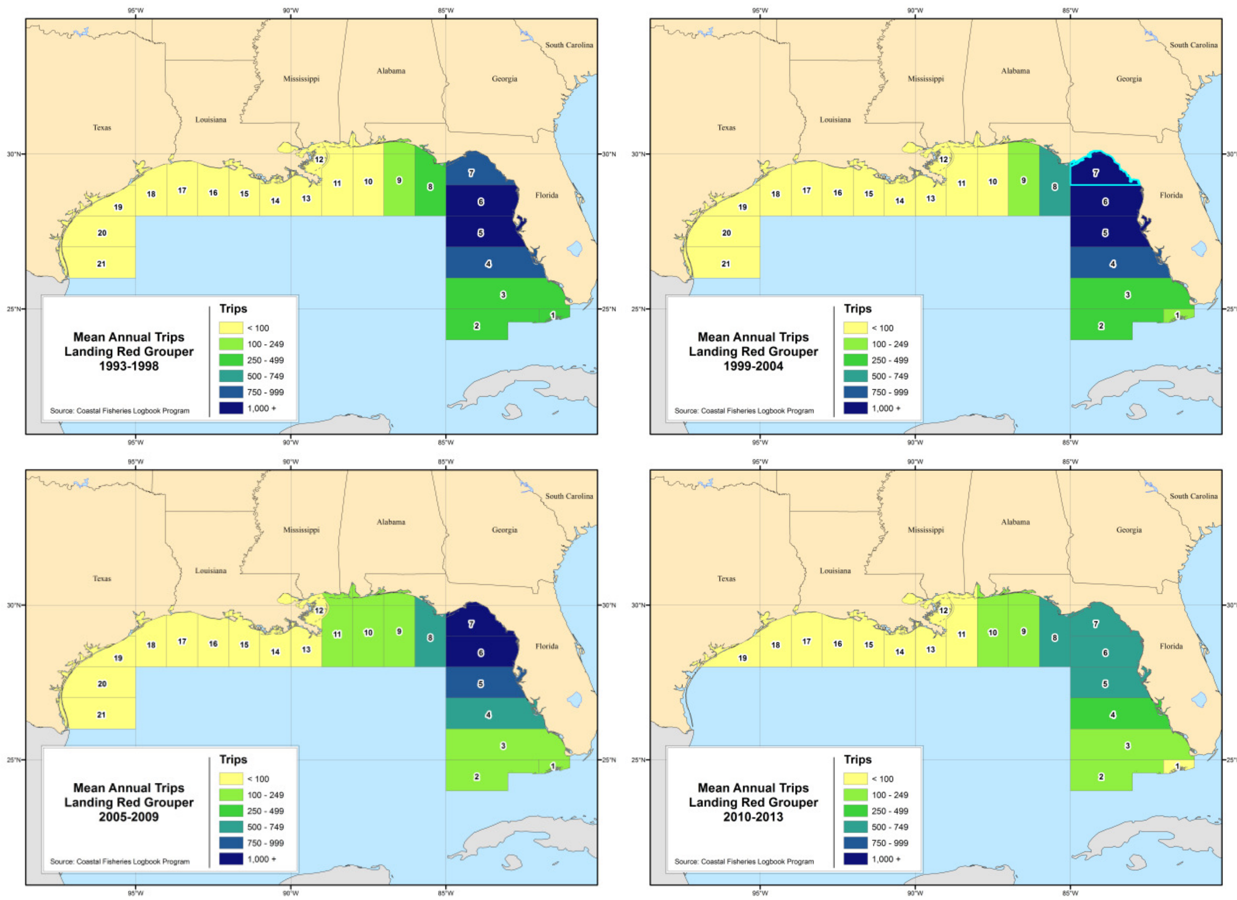

Figure 3.9 Maps of red grouper effort in the Gulf of Mexico as reported to the CFLP

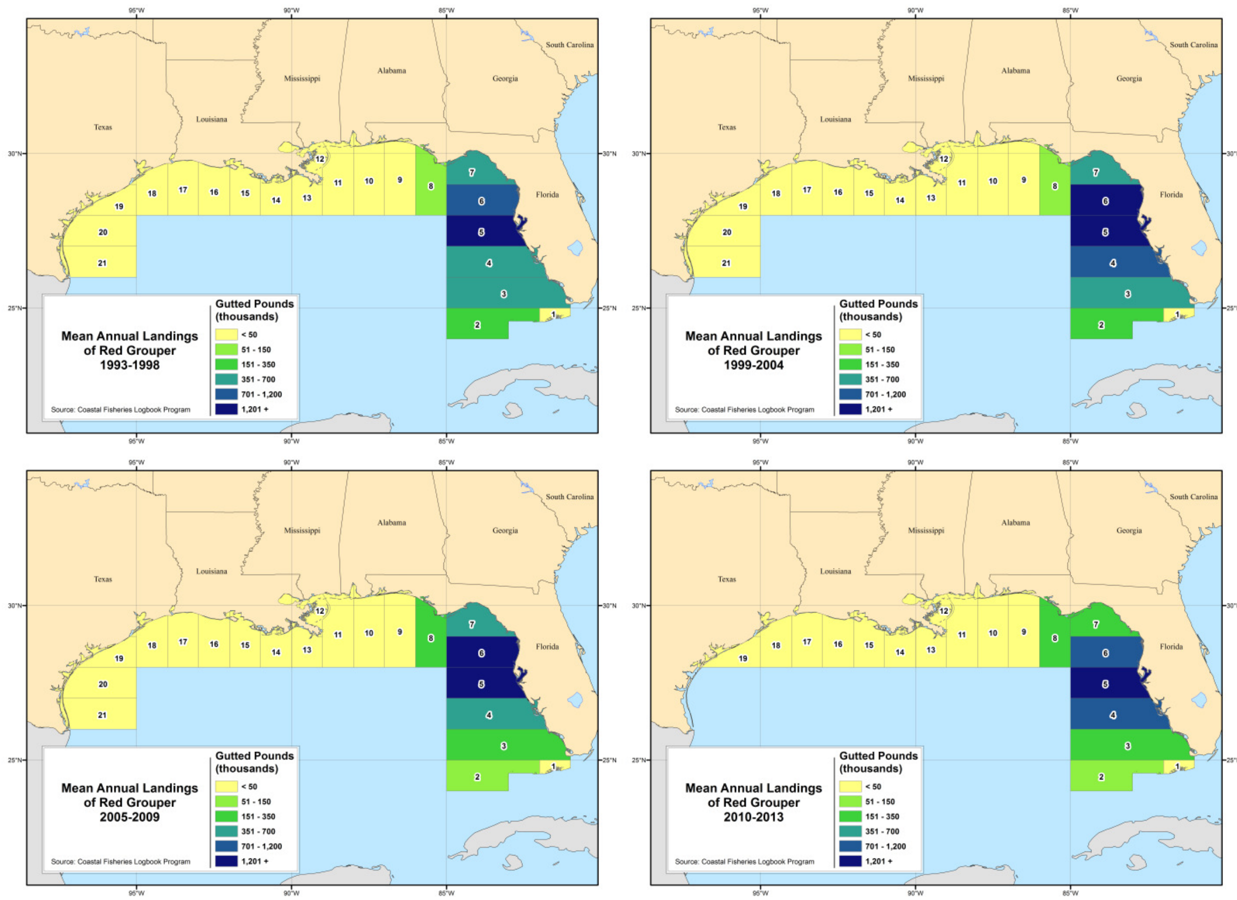

Figure 3.10 Maps of red grouper harvest in the Gulf of Mexico as reported to the CFLP

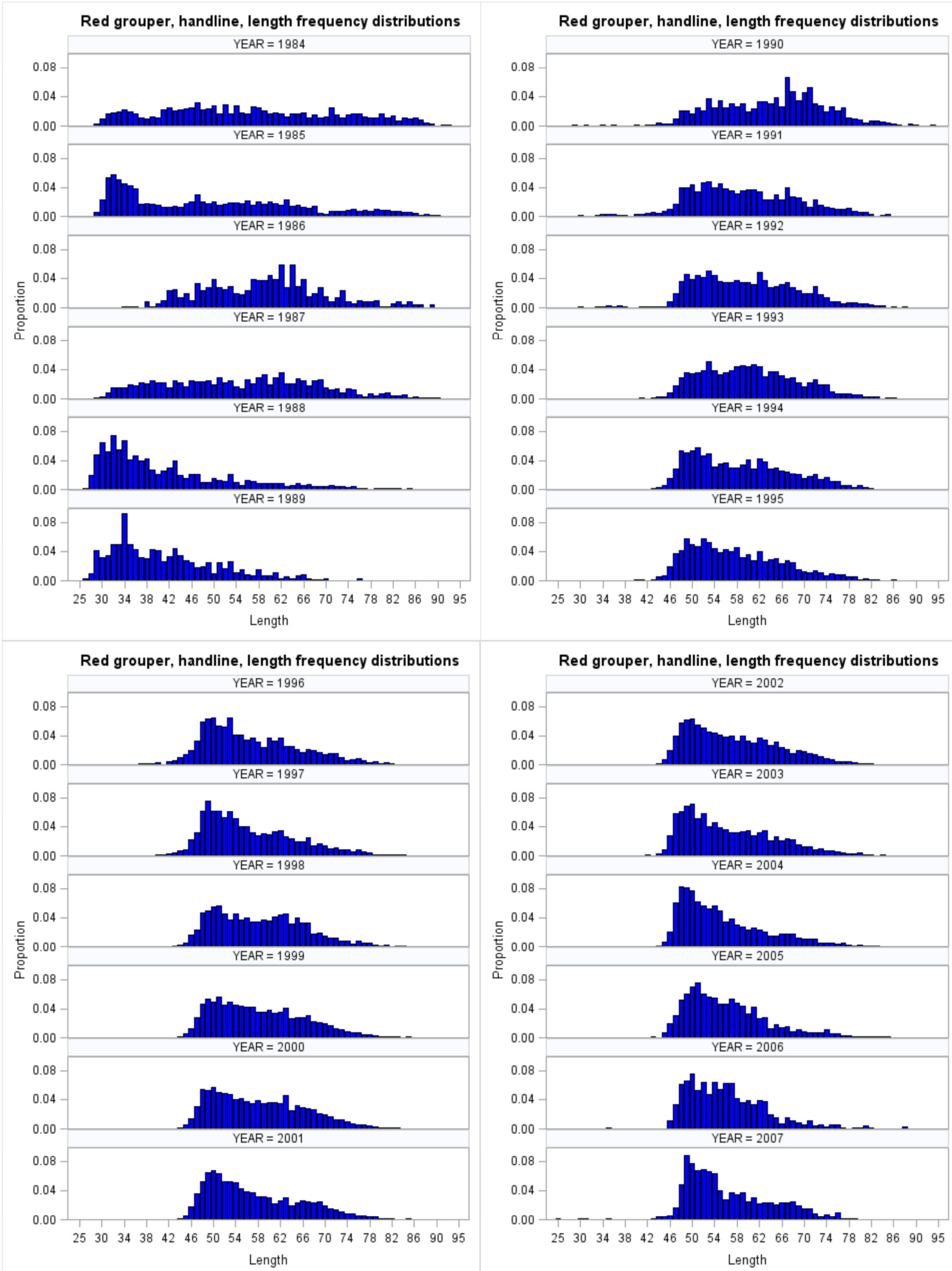

Figure 3.11 (a) Length frequency distributions (LFDs) for red grouper length samples collected between 1984 and 2007 from handline fisheries in the Gulf of Mexico.

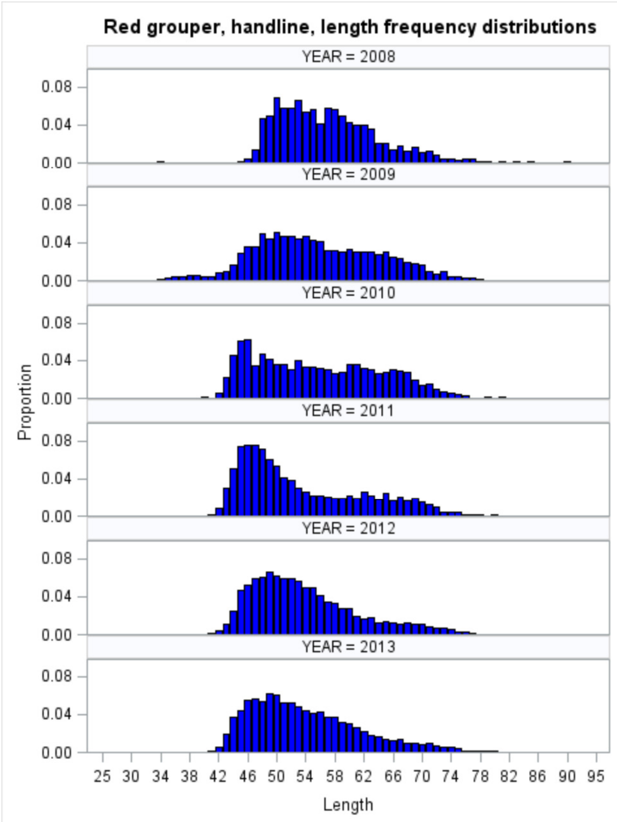

Figure 3.11 (b) Length frequency distributions (LFDs) for red grouper length samples collected between 2008 and 2013 from handline fisheries in the Gulf of Mexico.

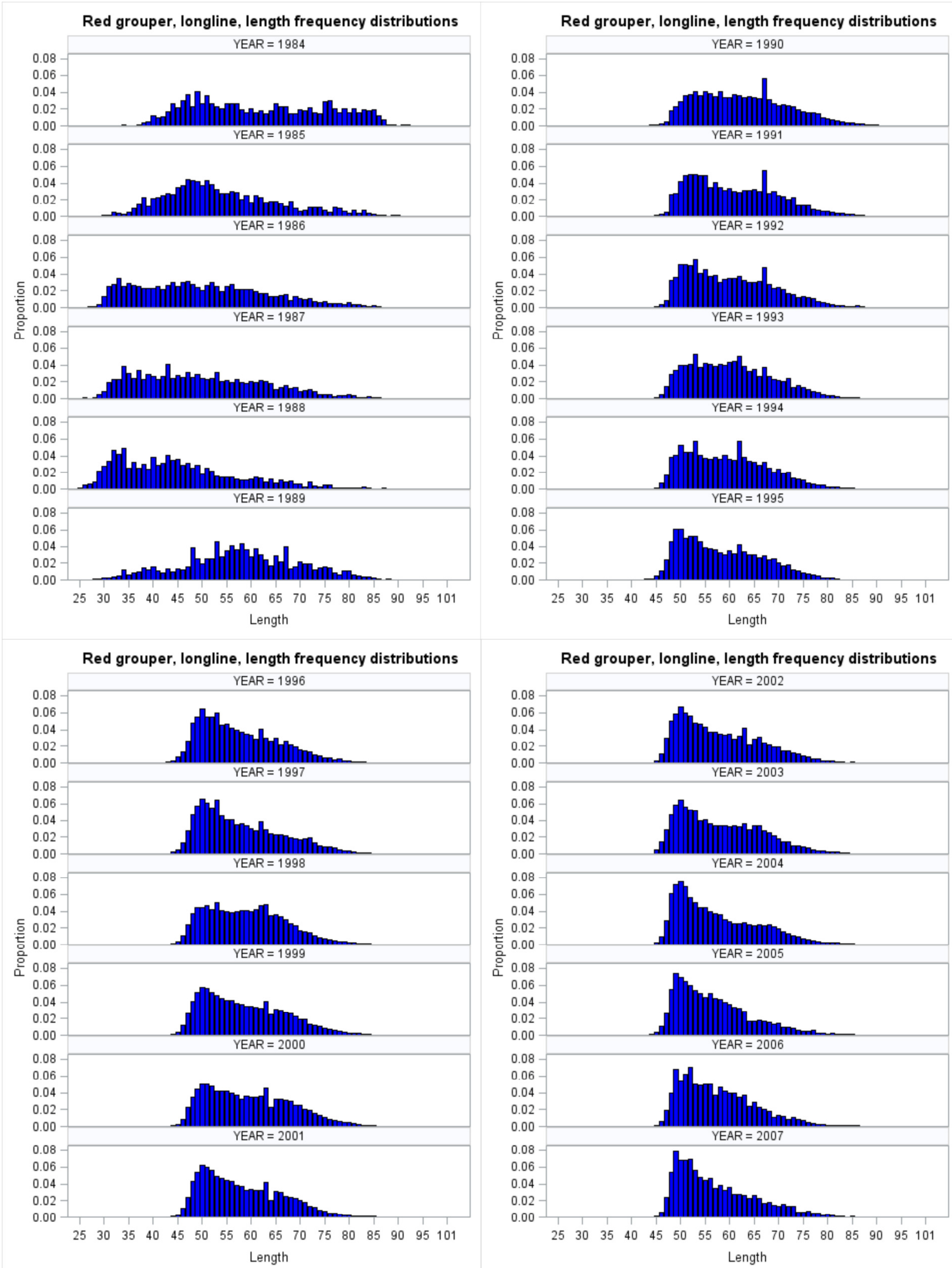

Figure 3.12 (a) Length frequency distributions (LFDs) for red grouper length samples collected between 1984 and 2007 from longline fisheries in the Gulf of Mexico.

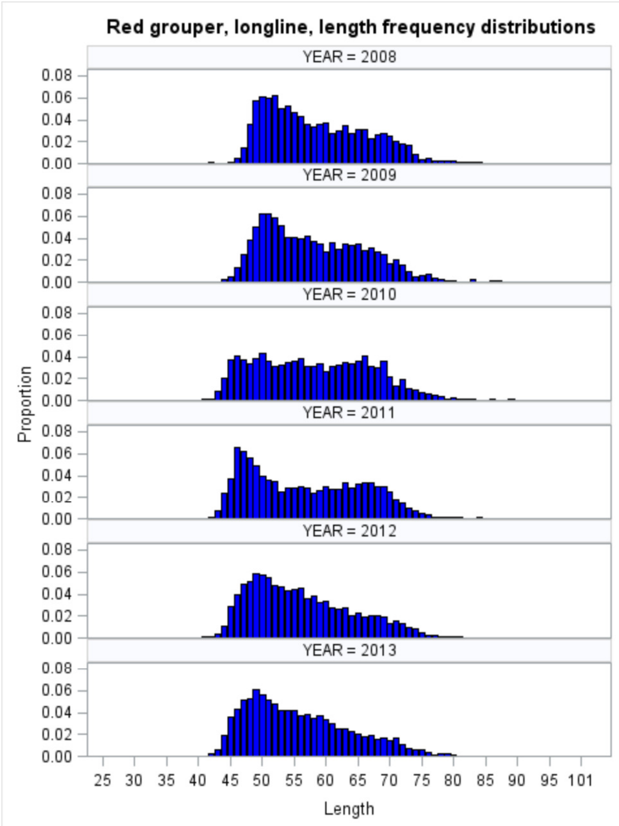

Figure 3.12 (b) Length frequency distributions (LFDs) for red grouper length samples collected between 2008 and 2013 from longline fisheries in the Gulf of Mexico.

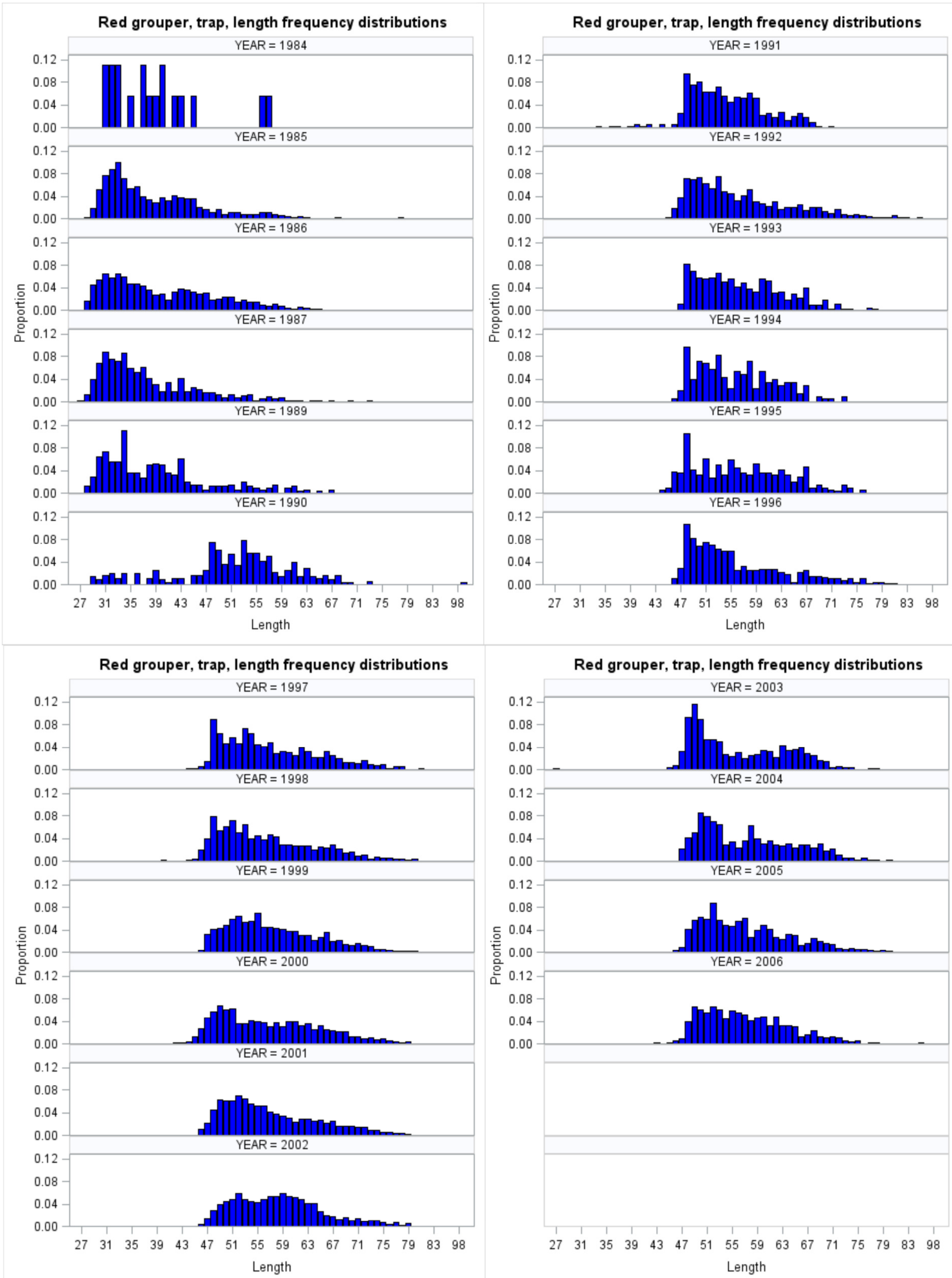

Figure 3.13 Length frequency distributions (LFDs) for red grouper length samples collected between 1984 and 2006 from trap fisheries in the Gulf of Mexico.

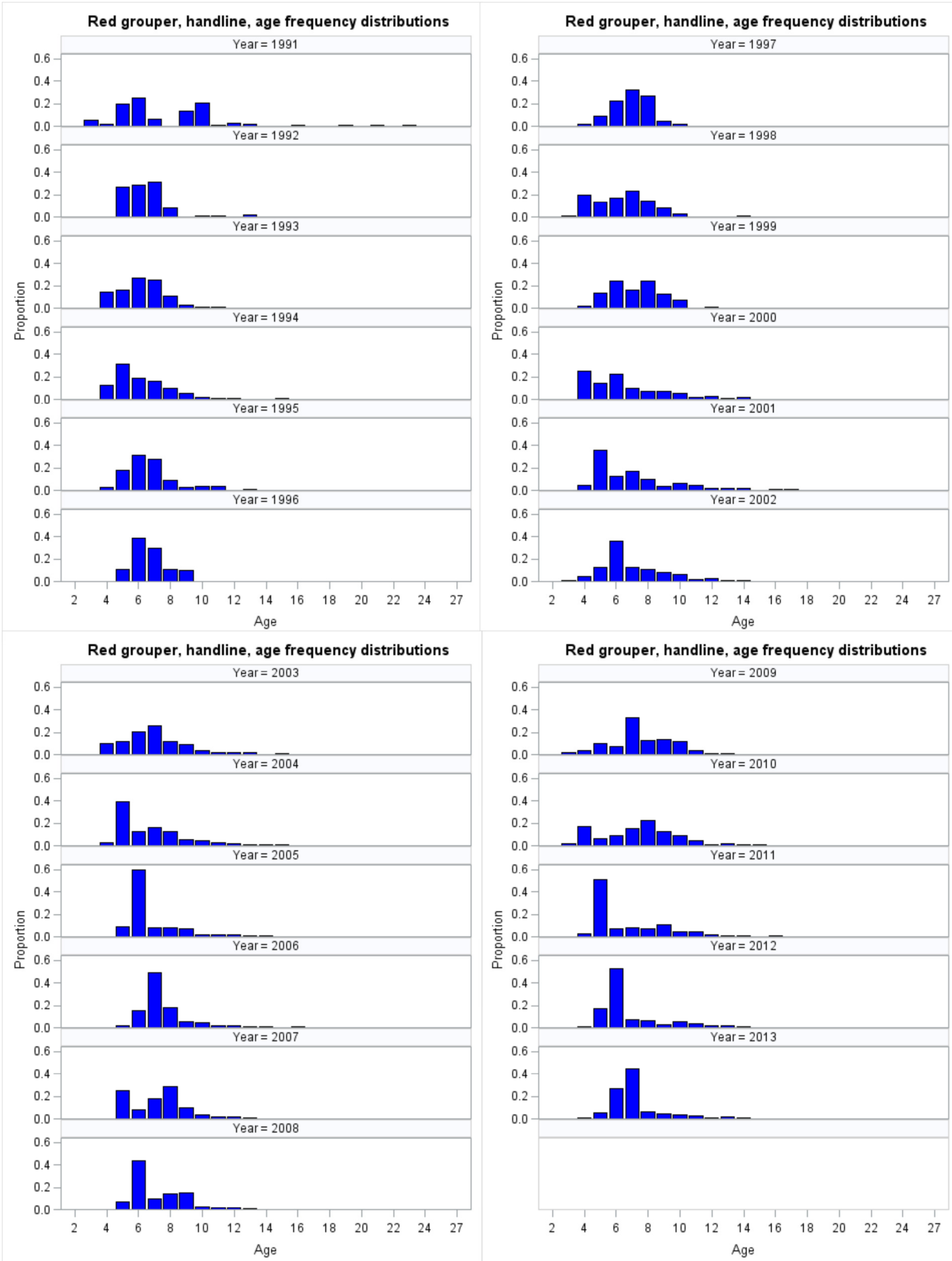

Figure 3.14 Reweighted age frequency distributions (AFDs) for red grouper age samples between 1991 and 2013 collected from handline fisheries in the Gulf of Mexico.

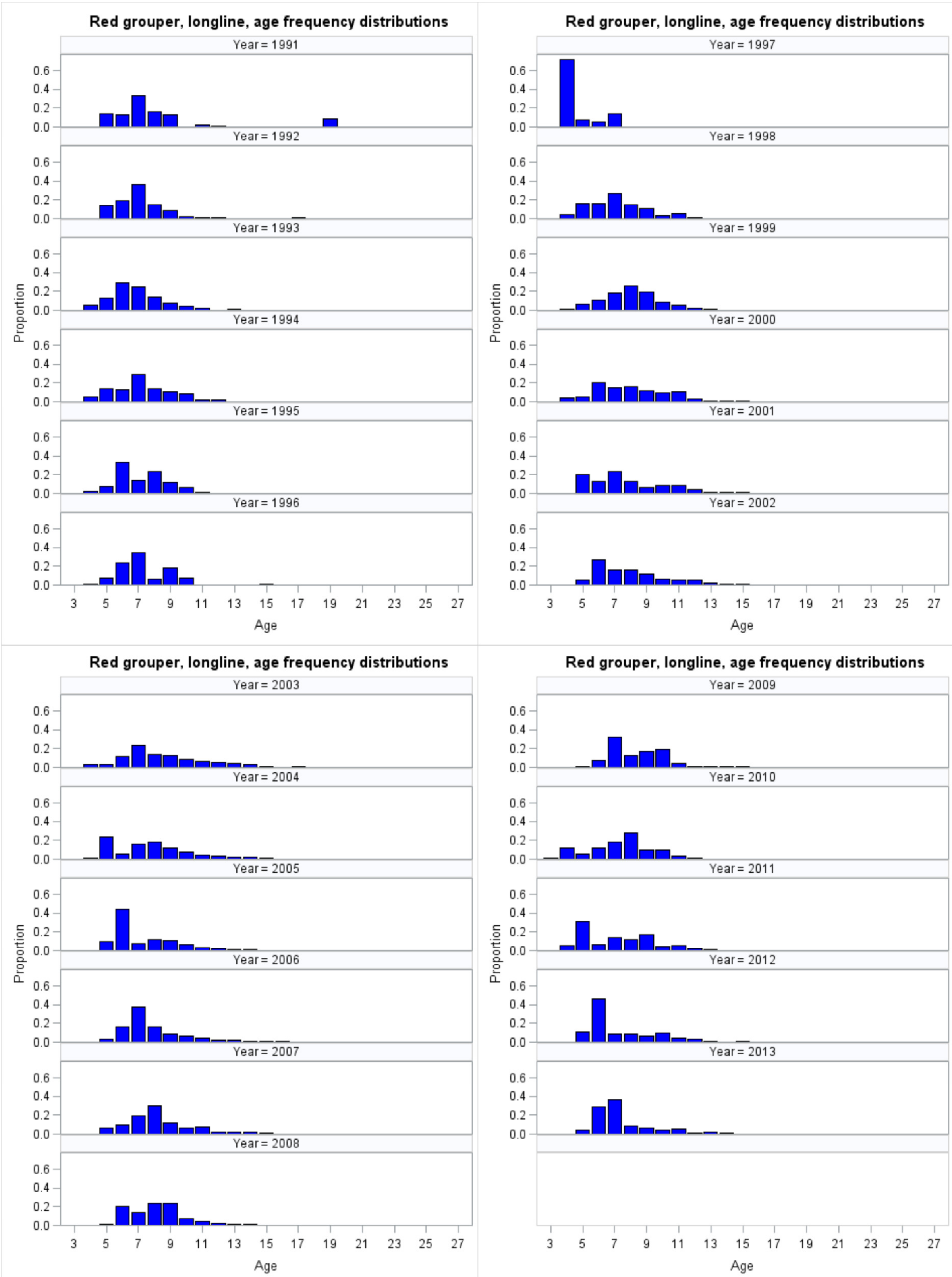

Figure 3.15 Reweighted age frequency distributions (AFDs) for red grouper age samples between 1991 and 2013 collected from longline fisheries in the Gulf of Mexico.

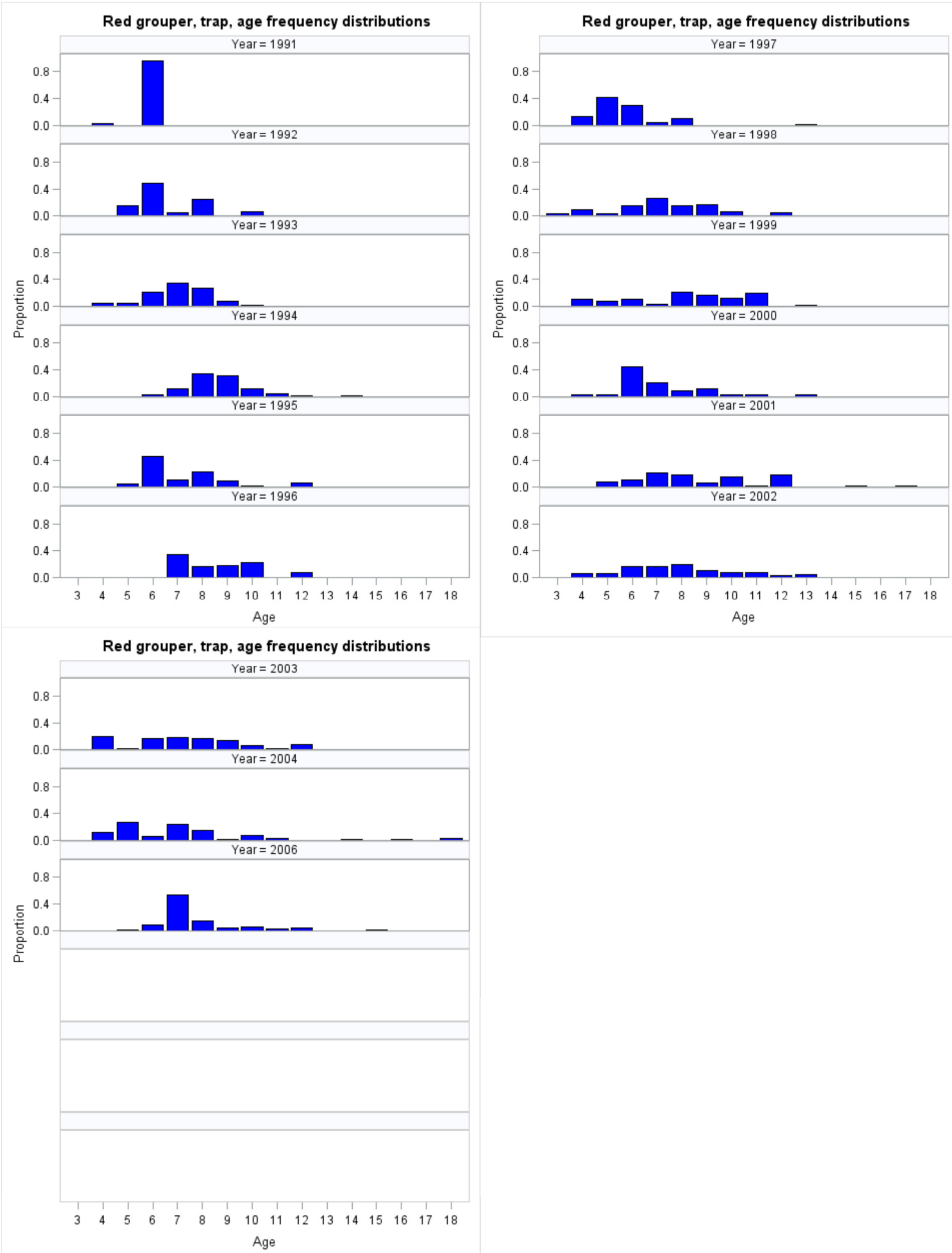

Figure 3.16 Reweighted age frequency distributions (AFDs) for red grouper age samples between 1991 and 2006 collected from trap fisheries in the Gulf of Mexico.

Figure 3.17 Length frequency distribution by year for all red grouper kept and discarded with bottom longline gear based on observer coverage of the U.S. Gulf of Mexico commercial reef fish fishery from August 2006 through December 2013. Data from 2007 and 2008 bottom longline gear were combined to conform to data confidentiality rules.

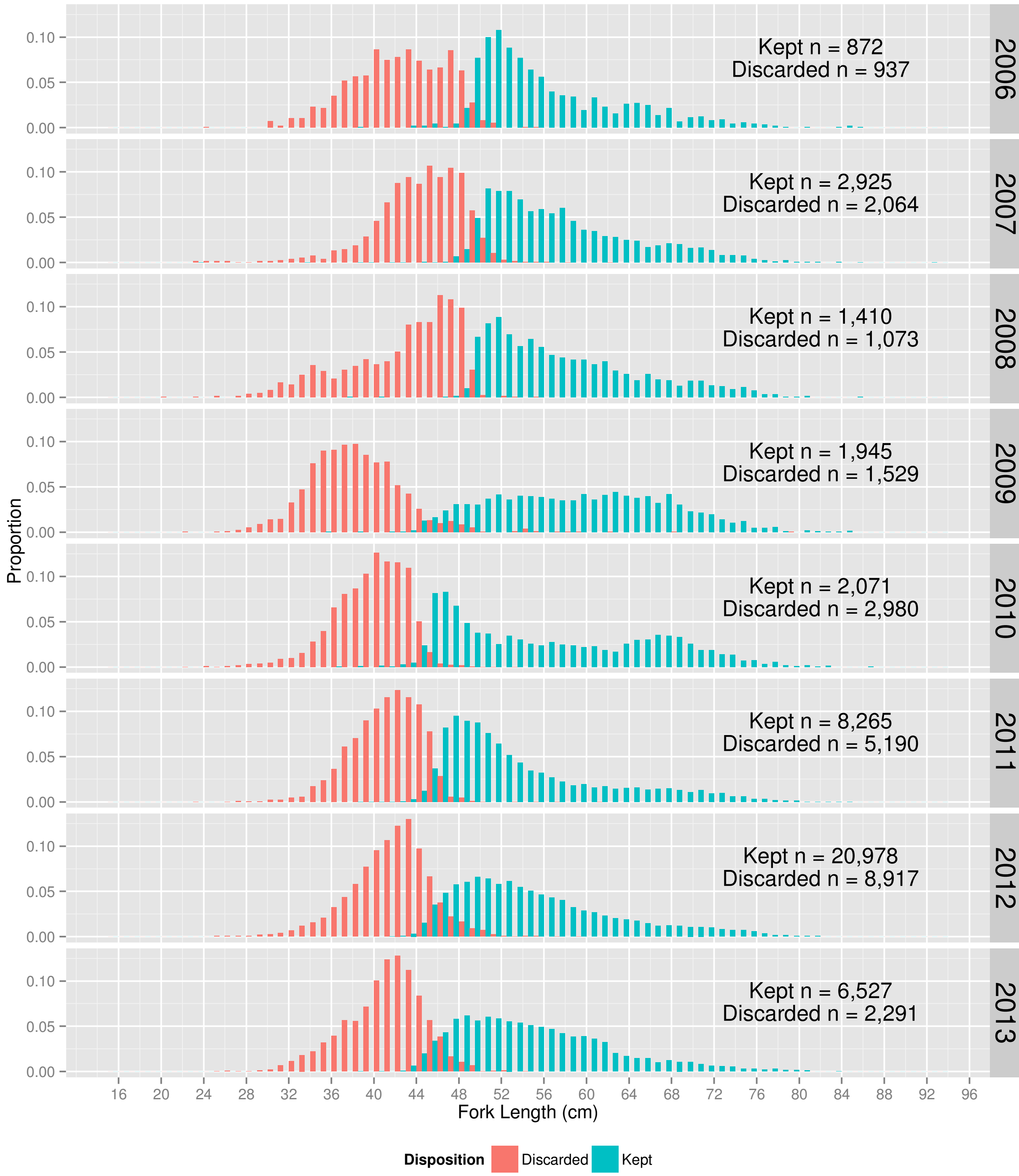

Figure 3.18 Length frequency distribution by year for all red grouper kept and discarded with vertical line gear based on observer coverage of the U.S. Gulf of Mexico commercial reef fish fishery from July 2006 through December 2013.

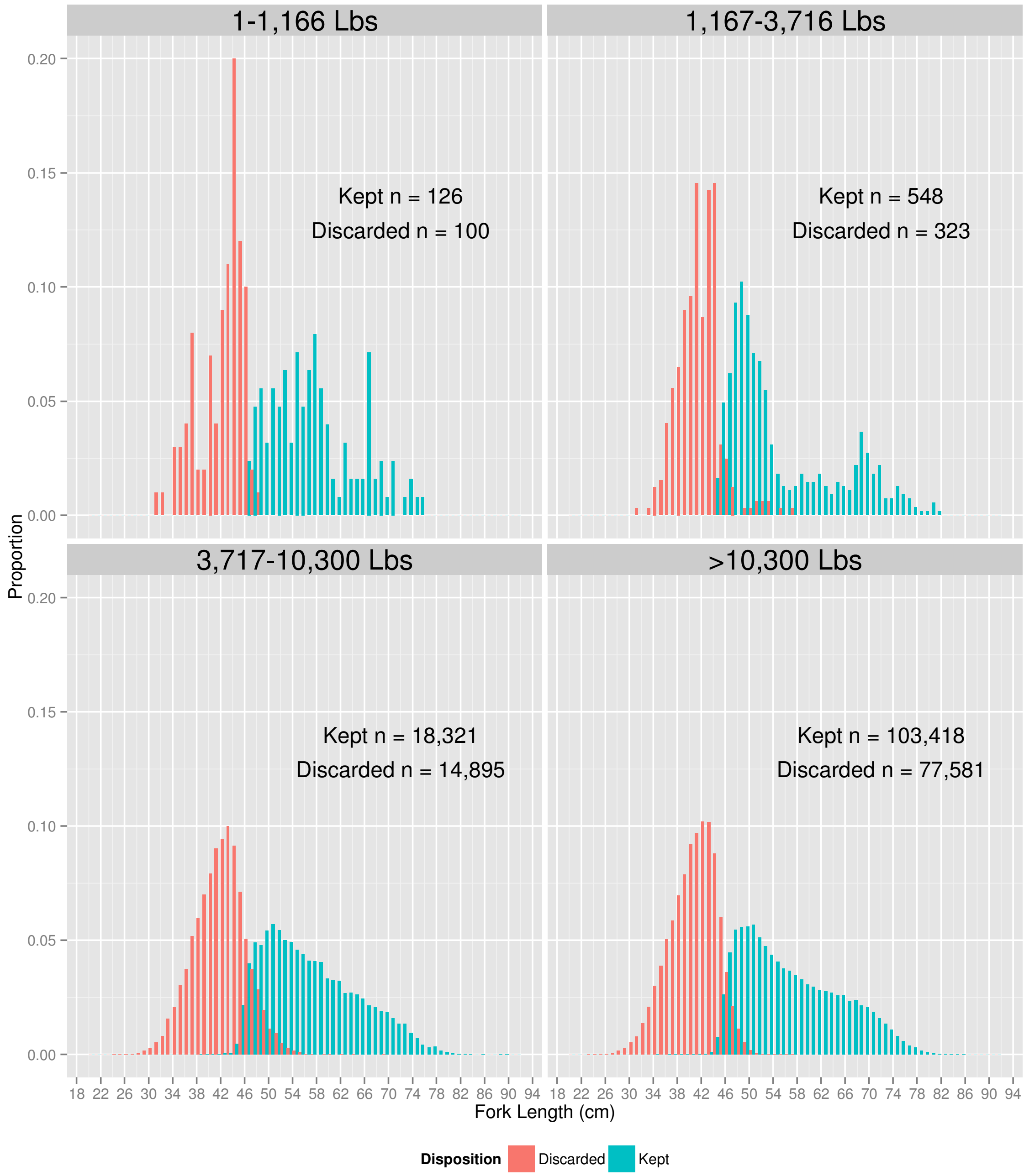

Figure 3.19 Length frequency distribution by IFQ allocation category for all red grouper kept and discarded with bottom longline gear based on observer coverage of the U.S. Gulf of Mexico commercial reef fish fishery from January 2010 through December 2013.

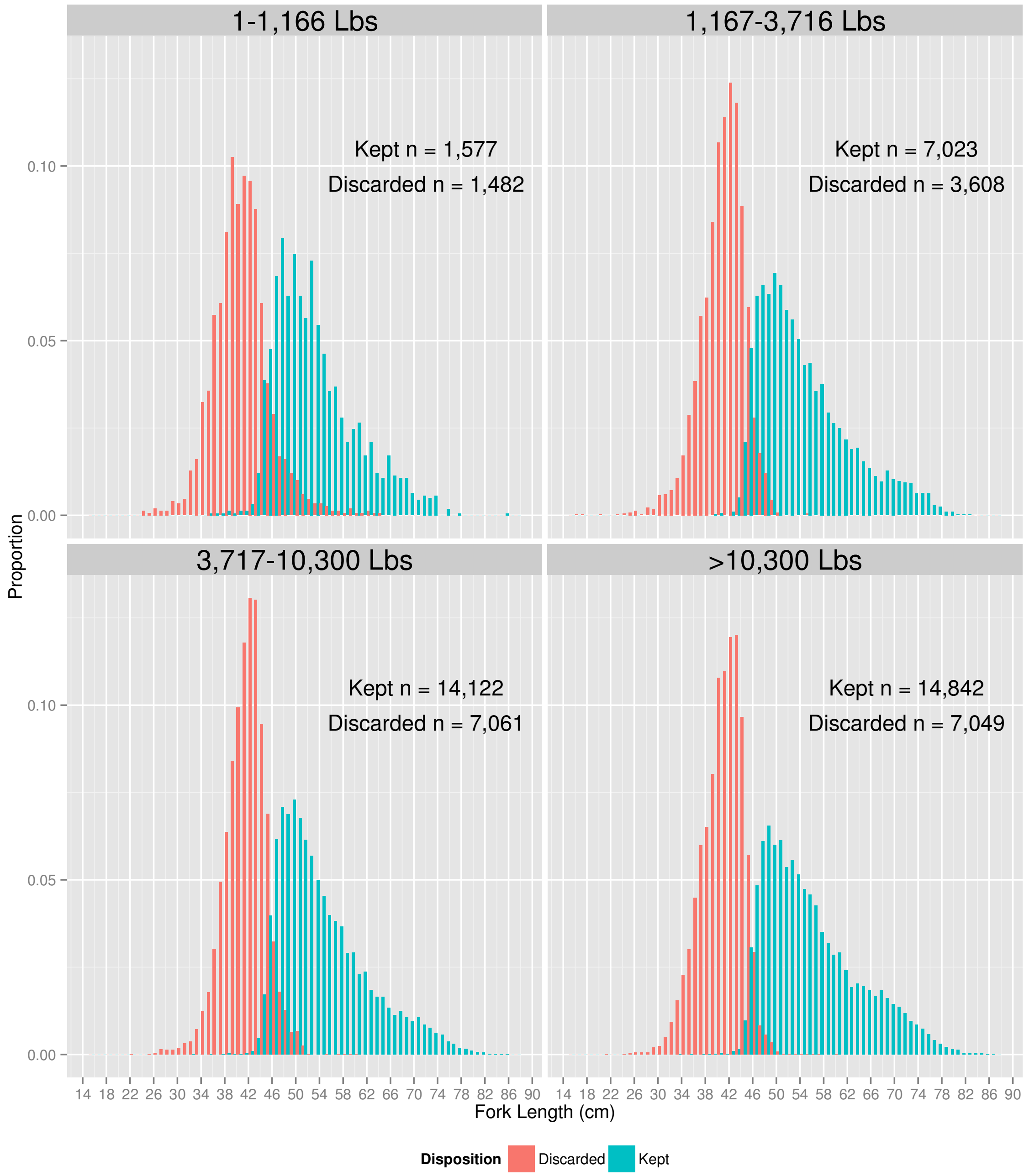

Figure 3.20 Length frequency distribution by IFQ allocation category for all red grouper kept and discarded with vertical line gear based on observer coverage of the U.S. Gulf of Mexico commercial reef fish fishery from January 2010 through December 2013.

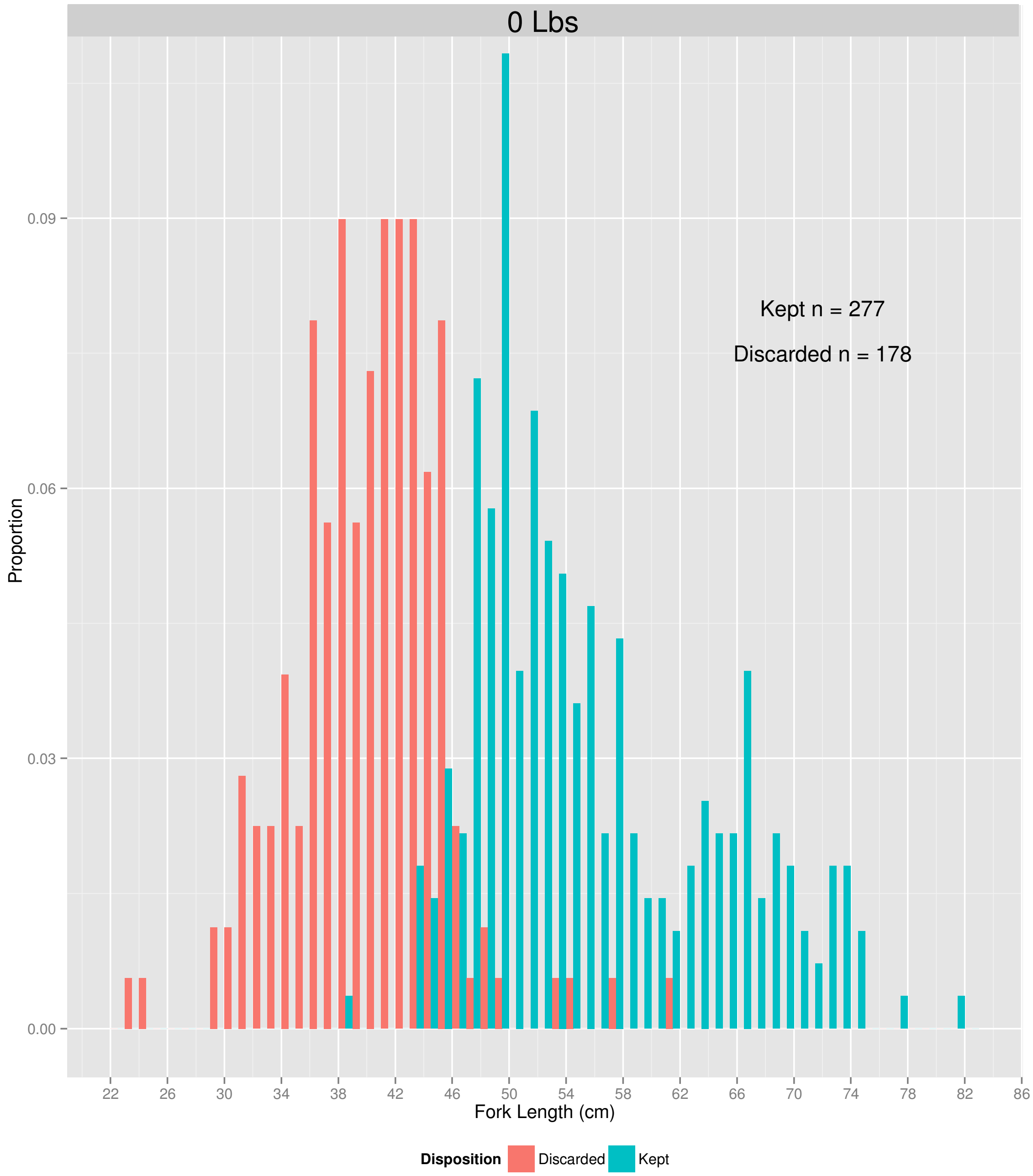

Figure 3.21 Length frequency distribution for red grouper kept and discarded for handline vessels with no IFQ allocation based on observer coverage of the U.S. Gulf of Mexico commercial reef fish fishery from January 2010 through December 2013.

* Note some red grouper recorded as kept may have been from vessels failing to comply with the IFQ program for Gulf reef snapper and groupers.

3.12 APPENDIX A

NMFS SECPR Accumulated Landings System (ALS)

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

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

Commercial landings statistics have been collected and processed by various organizations during the 1962-to-present period that the SECPR data set covers. During the 16 years from 1962 through 1978, these data were collected by port agents employed by the Federal government and stationed at major fishing ports in the southeast. The program was run from the Headquarters Office of the Bureau of Commercial Fisheries in Washington DC until 1970. After 1970 it was run by the newly created National Marine Fisheries Service, which had replaced the Bureau of Commercial Fisheries. Data collection procedures were established by Headquarters and the data were submitted to Washington for processing and computer storage. In 1978, the responsibility for collection and processing was transferred to the SEFSC.

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

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

1960 - Late 1980s
=================

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

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

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

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

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

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

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

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

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

Florida
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Prior to 1986, commercial landings statistics were collected by a combination of monthly mail submissions and port agent visits. These procedures provided quantity and value, but did not provide information on gear, area or distance from shore. Because of the large number of dealers, port agents were not able to provide the gear, area and distance information for monthly

data. This information, however, is provided for annual summaries of the quantity and value and known as the Florida Annual Canvas data (see below).

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

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

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

South Carolina began collecting TIP length frequencies in 1983 as part of the Cooperative Statistics Program. Target species and length quotas were supplied by NMFS and sampling targets were established for monthly commercial trips by gear. Sampling was set to collect those species with associated length frequencies. In 2005, SCDNR began collecting age structures (otoliths and spines) in addition to length frequencies, using ACCSP funding to supplement CSP funding. Typically for every four fish measured a single age structure was collected. This sampling periodicity was changed in 2010 to collect both a length and age structure from every fish intercepted as a recommendation from the SEFSC.

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

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

<u>NMFS SECPR Annual Canvas Data for Florida</u>

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

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

3.13 APPENDIX B

Brief overview on Gulf of Mexico Grouper-Tilefish IFQ programs

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I. Background

The first year of fishing in the Grouper-Tilefish IFQ (GT-IFQ) program began on January 1, 2010. Initial shares were issued based on the amount of grouper-tilefish logbook landings reported under each entity's qualifying permit during 1999 through 2004, with an allowance for dropping one year of data. Initial shares were issued in five different IFQ categories: deep-water grouper, gag, red grouper, other shallow-water grouper, and tilefish (Table 1). For the first five years of the program, shares and allocation can only be sold to and fished by an entity that owns a valid commercial Gulf reef fish permit and has an active GT-IFQ online account. After January 1, 2015, all U.S. citizens and permanent resident aliens will be eligible to purchase GT-IFQ shares and allocation, although a valid Gulf reef fish permit will still be required to harvest, possess, and land any allocation.

The GT-IFQ program is a multi-species program with five share categories: gag, red grouper, other shallow-water groupers, deep-water groupers, and tilefishes. Each share category has distinct shares and associated allocations. Shares are a percentage of the commercial quota, while allocation refers to the poundage that is possessed, landed, or sold during a given calendar year. At the beginning of each year, allocation is distributed based on the annual quota and the share percentages held by a GT-IFQ shareholder account. Allocation can then be used to harvest GT-IFQ species or sold to another valid shareholder account. Adjustments in quota can occur if the status of a stock changes as a result of new assessments or through the reallocation of quota between fishing sectors. Adjustments in quota are distributed proportionately among shareholder accounts based on the percentage of shares each account holds at the time of the adjustment. All transactions (share transfers, allocation transfers, landings, and cost recovery fees) in the GT-IFQ program are completed online.

There are three main account roles in the GT-IFQ system: shareholder, vessel, and dealer accounts. All accounts were assigned to users based on the unique entity (single or combination of individuals and/or business) that held either a Gulf of Mexico (Gulf) dealer or reef fish permit. Shareholder accounts with valid Gulf reef fish permits may transfer GT-IFQ shares and allocation to and from their accounts, as well as land GT-IFQ species at an approved dealer. Shareholder accounts that do not have a valid Gulf reef fish permit can only transfer shares and allocation to other accounts, and may not increase their holdings. A list of all accounts that hold shares is available through the NMFS Southeast Regional Office (SERO) Freedom of Information Act website. Vessel accounts, which belong to shareholder accounts, only hold allocation that is debited from the account through landing transactions. Shareholder accounts may have multiple vessel accounts. Dealer accounts were assigned to a unique entity that has a valid Gulf reef fish dealer permit, and functions are limited to completing landing transactions and paying cost recovery fees.

The GT-IFQ program has several built-in flexibility measures to accommodate the multi-species nature of the fishery and reduce bycatch. Two share categories, gag and red grouper, have a multi-use provision that allows a portion of the red grouper to be harvested under the gag allocation, or vice versa. The three remaining categories (shallow-water grouper, deep-water grouper, and tilefish) are multiple-species categories, designed to capture species complexes that are commonly caught together (Table 1). Three grouper species (scamp, Warsaw grouper, and speckled hind) are found in both shallow and deep water. Flexibility measures in the GT-IFQ program allow for these species to be landed under both share categories. Scamp are designated as a shallow-water grouper species and may be landed using deep-water grouper allocation once all shallow-water grouper allocation in an account has been harvested. Warsaw grouper and speckled hind are designated as deep-water grouper species and may be landed using shallow-water grouper allocation once all deep-water grouper allocation in an account has been harvested. The GT-IFQ program has a built-in flexibility measure to allow a once-per-year allocation overage per share category for any GT-IFQ account that owns shares in that share category. For these accounts, a vessel can land 10% more than their remaining allocation on the vessel. This overage is then deducted from the shareholder's allocation at the start of the following fishing year. Because overages need to be deducted in the following year, GT-IFQ accounts without shares cannot land an excess of their remaining allocation and GT-IFQ accounts with shares are prohibited from selling shares that would reduce the account's shares fewer than the amount needed to repay the overage in the following year.

When harvesting GT-IFQ species, vessels are required to have a GOM reef fish permit, and to hail out before leaving port. While at-sea, vessels are monitored using vessel monitoring systems. When returning to port, vessels landing GT-IFQ species must provide a landing notification indicating the time and location of landing, the intended dealer, and the estimated pounds landed. Landing may occur at any time, but fish may not be offloaded between 6 p.m. and 6 a.m. A landing transaction report is completed by the GT-IFQ dealer and validated by the fisherman. The landing transaction includes the date, time, and location of transaction; weight and actual ex-vessel value of fish landed and sold; and the identity of shareholder account, vessel, and dealer. For current total GT-IFQ landings go to: https://ifq.sero.nmfs.noaa.gov/ and past landings are recorded under 'Additional Documents'. All current landings data are updated in a real-time basis as the landing transaction is processed.

II. Data Description

The GT-IFQ program is a real-time online system, with all transactions recorded immediately upon entry. Data is entered directly by the GT-IFQ participants for all transactions that occur within the system. The GT-IFQ program directly links to the Southeast Regional Office's Permits database in order to validate all vessel and dealer accounts. There are three types of transactions that occur in the GT-IFQ program: share transfer, allocation transfers, and landing transactions. Share transactions contain the following information: transferor, transferee, transaction completion date/time, share category, share percentage transferred, and a confirmation number. Share transfers can only occur between shareholder accounts. Allocation transfers contain similar information as share transfers and include: transferor, transferee, transfer date/time, share category, pounds transferred, and confirmation number. Allocation transfers can occur between a shareholder and his vessel, between two shareholder accounts, or from a shareholder account to another shareholder's vessel account. Landing transactions contain the following information: shareholder account, vessel account, dealer account, landing date/time, landing location, species, pounds, and a landing confirmation number. Additional tables in the GT-IFQ program contain address information for each participant in the GT-IFQ program. The primary contact's address information is used when connecting address information to any transaction.

III. Database Structure

The data is stored in a relational database system that is fishermen-vessel based and accounts are based on unique entities associated with the account, where no account contains the exact same entities as another account. Many vessel accounts may be associated with one shareholder account, if the permit holder is the same on each vessel. This allows the GT-IFQ system to link to the Permits database and establish a validity status for each vessel account. Establishing vessel accounts also allowed IFQ program staff and law enforcement to verify that a vessel has sufficient allocation at the time of a landing notification.

IV. Data Quality

The Vessel Monitoring Systems (VMS) staff provides quality control over GT-IFQ data when vessels are out at sea. Vessels are required to notify VMS staff each time they leave dock (hail out) and complete a landing notification (hail in) prior to landing. While at sea, VMS staff is able to monitor vessel locations hourly to determine if the vessel are fishing in approved areas. GT-IFQ landing notifications can be submitted directly from the GT-IFQ system through VMS units.

The online system has a series of built-in quality assurance measures that reduce the possibility of errors within the system. Pre-designed web-based screens direct the GT-IFQ participants through a detailed process for each transaction. Transactions are not completed until pertinent information has been completed. The system will not allow the completion of any transaction if any of the participating accounts is in a suspended or inactive status. Share transactions are not completed until verified by both the transferor and transferee. Similarly, landing transactions are not completed until the shareholder enters their vessel personal identification number. In 2012, the system was updated to allow for the selection of the associated 3-hour notification for each landing transaction. Dealers can also enter an associated trip ticket number with an IFQ landing transaction, although this is an optional field currently.

IFQ staff provides additional quality control which includes but is not limited to: adjusting landings based on submitted Landing Correction Forms, and auditing landing notifications and transactions. IFQ staff continues to work with system developers to improve data quality and accuracy and ensure that all web-based screen shots capture required information.

4 RECREATIONAL FISHERY STATISTICS

4.1 OVERVIEW

4.1.1 Recreational Workgroup (RWG) Members

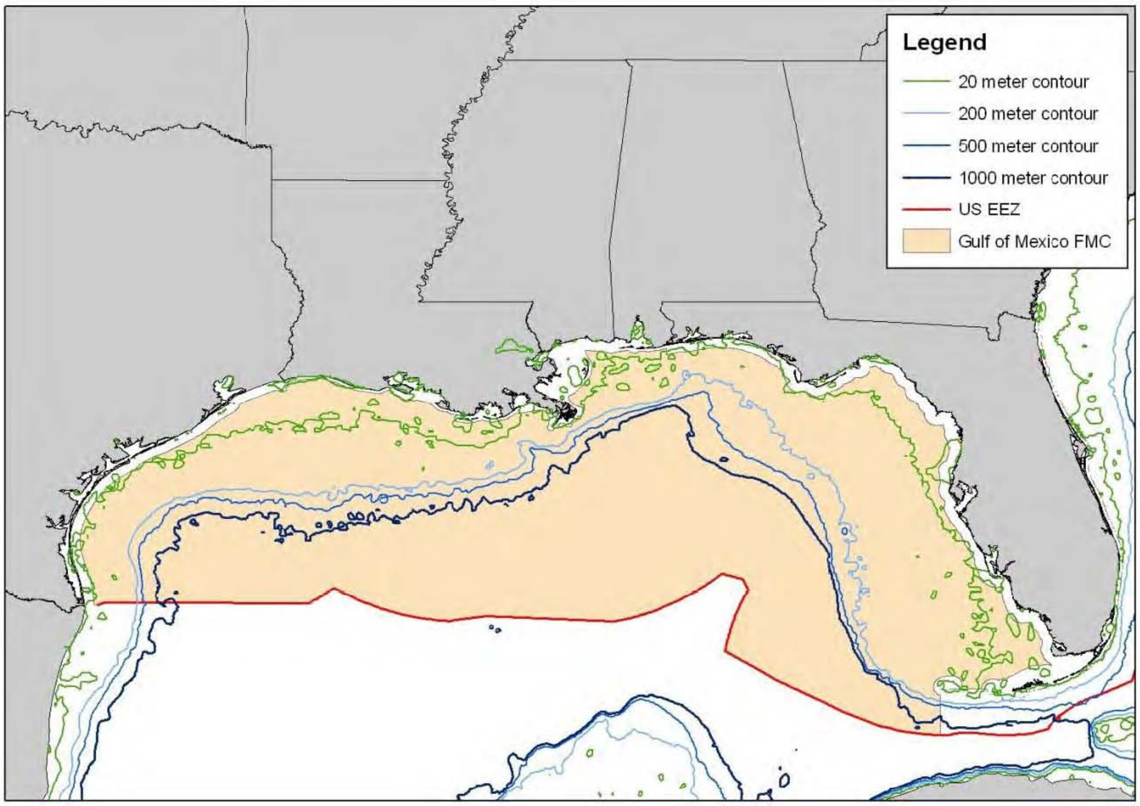
Members- Ken Brennan (NMFS Beaufort, NC), Jim Eliason (SAFMC Panelist, Industry rep FL), *Kelly Fitzpatrick (NMFS Beaufort, NC), Alisha Gray (FWC, FL), Chad Hanson (Pew Trust), *Jeff Isely (NMFS SEFSC), Vivian Matter (Leader, NMFS SEFSC), Adyan Rios (NMFS SEFSC), Beverly Sauls (FWC, FL). *Not present during Data Workshop.

4.1.2 Issues Discussed at the Data Workshop

1) Allocation of Monroe County catches to the Atlantic or the Gulf of Mexico: may vary by data source depending on differing spatial resolutions of the datasets.
2) Headboat discards. Data are available from the SRHS since 2004. Review whether they are reliable for use, and determine if there are other sources of data prior to 2004 that could be used as a proxy to estimate headboat discards.
3) Calibration of Marine Recreational Fisheries Statistics Survey (MRFSS) to Marine Recreational Information Program (MRIP) 1981-2003.
4) Charter boat landings: MRFSS charter survey methods changed in 1998 in the Gulf of Mexico.

5) MRIP APAIS adjustment: change in survey protocols starting in 2013.
6) Usefulness of historical data sources to generate estimates of landings prior to 1981. Review previous methods and other approaches.

4.1.3 Gulf of Mexico Fishery Management Council Jurisdictional Boundaries



4.2 REVIEW OF WORKING PAPERS

SEDAR42-DW-14, *Size Distribution of Red Grouper Observed in For-Hire Recreational Fisheries in the Gulf of Mexico. Alisha Gray and Beverly Sauls 2014.*

Detailed information on the size of discarded fish is not collected in traditional dockside surveys of recreational fisheries. At-sea observer surveys provide valuable information on the size and condition of discarded fish. Such surveys have been conducted on headboat vessels in the eastern Gulf of Mexico since 2005. Coverage was expanded in June of 2009 to include charter vessels on the east coast of Florida, and this coverage continued through 2013. This report provides a summary of available information on the size of red grouper collected from headboats and charter boats from the Gulf coast of Florida.

SEDAR42-DW-16, *Estimates of Historical Private/Charter boat and Headboat Fishery Red Grouper Angler Catch in the Gulf of Mexico 1945-1980. Jeff Isely, Nancie Cummings, and Adyan Rios. 2014.*

Marine recreational catch and effort data in the Gulf of Mexico have been collected and reported by the National Marine Fisheries Service (NMFS) since 1981. Documenting historic (pre-1981) landings in the recreational sector has been problematic because comprehensive surveys were not conducted consistently prior to 1980. Brennan and Fitzpatrick (2012) developed a method of estimating historic catch and effort based on the National Survey of Fishing, Hunting and Wildlife Associated Recreation (FHWAR 2001). This method has been accepted in recent SEDARs and has been applied to several recently assessed species (SEDAR28-spanish mackerel and cobia; SEDAR33-Gulf of Mexico gag and greater amberjack). However, Brennan and Fitzpatrick (2012) did not develop estimates by separate modes. Rios (2013) partitioned recreational catch and effort into private, charter boat and headboat modes. However, the method relied on assumptions related to the development of the historic headboat and charter boat modes that are not well supported. In this paper, we provide data on the development of the headboat mode in the Atlantic, and provide estimates of historical recreational angler catch for the SEDAR42 assessment of Gulf of Mexico red grouper for the private/charter boat and headboat sectors using a modification of the method proposed by Rios (2013) and Brennan and Fitzpatrick (2012).

SEDAR42-DW-17, *Discards of red grouper (Epinephelus morio) for the headboat fishery in the US Gulf of Mexico. Fisheries Ecosystems Branch, Beaufort, NC 2014.*

The Southeast Region Headboat Survey (SRHS) was modified in 2004 to collect self-reported discards for each reported trip. These self-reported data are currently not validated within the SRHS. The SRHS discard rates were compared to the MRFSS/MRIP At-Sea Observer program discard rates for validation purposes and to determine whether the SRHS discard estimates should be used for a full or partial time series (2004-2013). Discard estimates prior to 2004 are calculated using a proxy method. For red grouper, the MRFSS/MRIP CH, MRFSS/MRIP PR, and MRFSS/MRIP CH:SRHS discard ratio methods were evaluated as proxy methods for calculating discards from the headboat fishery.

SEDAR42-DW-18, *Length and age frequency distributions for red groupers collected in the Gulf of Mexico from 1984 to 2013. Ching-Ping Chih. 2014.*

This report documents changes in the length frequency distributions (LFDs) and age frequency distributions (AFDs) of red groupers collected from the Gulf of Mexico from 1981 to 2013. The methods for estimating LFDs and AFDs for red groupers differ from those used in SEDAR 12 in several ways: (1) LFDs for hand line and long line strata were stratified into north and south regions due to apparent differences in LFDs between the two regions (Chih, 2014), (2) AFDs were reweighted by LFDs due to non-random sampling of some otolith samples, and (3) AFDs for handline and longline strata were also stratified into north and south regions due to apparent differences in ALKs between the two regions (Chih, 2014). For trap samples and recreational fisheries samples, AFDs were reweighted by the corresponding LFDs without stratification into north and south regions because of the small sample sizes of age samples.

4.3 RECREATIONAL LANDINGS

Total recreational landings are summarized below by survey. A map and figures summarizing the total recreational red grouper landings are included in Figure 4.9.1. There are no estimates from the Texas Parks and Wildlife Survey for this species.

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

Introduction

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

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

The MRFSS/MRIP design incorporates three complementary survey methods for estimating catch and effort. Catch data are collected through angler interviews during dockside intercept surveys of recreational fishing trips after they have been completed. Effort data are collected using two telephone surveys. The Coastal Household Telephone Survey (CHTS) uses random digit dialing of coastal households to obtain detailed information about the previous two months of recreational fishing trips from the anglers. The weekly For-Hire Survey interviews charter boat operators (captains or owners) to obtain the trip information with only one-week recall period. Effort estimates from the two telephone surveys are aggregated to produce total effort estimates by wave. Catch rates from dockside intercept surveys are combined with estimates of effort from telephone interviews to estimate total landings and discards by wave, mode, and area fished (inland, state, and federal waters).

Catch estimates from early years of the survey are highly variable with high proportional standard errors (PSE's), and sample sizes in the dockside intercept portion have been increased over time to improve precision of catch estimates. Several quality assurance and quality control improvements were implemented for the intercept surveys in 1990. Prior to 1990 the contractor did not have regional representatives hired to supervise the samplers in any given area. All samplers were hired as independent sub-contractors and communicated directly with the contractor's home office staff. It is much more likely that the samplers who worked in the 1980's would have varied more in their interpretation of sampling protocols and their ability to identify at least some of the more difficult-to-recognize species. There were a number of other changes made to enhance consistency in sampling protocols and improve error-checking in the Statement of Work for the 1990-1992 contracts. Improvements have continued over the years, but the biggest changes happened at that time (personal communication, NMFS). Full survey documentation and ongoing efforts to review and improve survey methods are available at: http://www.st.nmfs.gov/st1/recreational.

Survey methods for the for-hire fishing mode have seen the most improvement over time. Increased sample quotas and additional sampling (requested and funded by the states) to the intercept portion of the survey has improved catch rate data. It was also recognized that the random household telephone survey was intercepting relatively few anglers in the for-hire fishing mode and the For-Hire Telephone Survey (FHS) was developed to estimate effort in the for-hire mode. The new method draws a random sample of known for-hire charter and guide vessels each week and vessel operators are called and asked directly to report their fishing activity. The FHS was officially adopted in the Gulf states in 2000, in East Florida in 2003, and in Georgia through Maine in 2005. The FHS was pilot tested in the Gulf of Mexico in 1998 and 1999 and in Georgia through Maine in 2004. The FHS does not consider the estimates during pilot years as official estimates; however, FHS data for these years have been used in past SEDARs (e.g. SEDAR 7 red snapper, SEDAR 16 king mackerel, SEDAR 25 black sea bass, etc). As a result of the Deepwater Horizon oil spill in April 2010, the MRFSS/MRIP For-Hire Survey increased sampling rates of charter boat vessel operators from 10% to 40% from May, 2010 through June 2011.

A further improvement in the FHS method was the pre-stratification of Florida into smaller sub-regions for estimating effort. Pre-stratification defines the sample unit on a sub-state level to produce separate effort estimates by these finer geographical regions. The FHS sub-regions include three distinct regions bordering the Atlantic coast: Monroe County (sub-region 3), SE Florida from Dade through Indian River counties (sub-region 4), and NE Florida from Martin through Nassau counties (sub-region 5). The coastal household telephone survey method for the for-hire fishing mode continues to run concurrently with the newer FHS method.

Calibration of traditional MRFSS charter boat estimates

Conversion factors have been estimated to calibrate the traditional MRFSS charter boat estimates with the FHS for 1986-1997 in the Gulf of Mexico (SEDAR7-AW-03). The relationship between the old charter boat method estimates of angler trips and the FHS estimates of angler trips was used to estimate the conversion factors. Since these factors are based on effort, they can be applied to all species' landings. In the Gulf of Mexico and the South Atlantic, the period of 1981-1985 could not be calibrated with the same ratios developed for 1986+ because in the earlier 1981-1985 time period, MRFSS considered charter boat and headboat as a single combined mode. Thus, in order to properly calibrate the estimates from 1981-1985, headboat data from the Southeast Region Head-boat Survey (SRHS) were included in the analysis. To calibrate the MRFSS combined charter boat and headboat mode effort estimates in 1981-1985, conversion factors were estimated using 1986-1990 effort estimates from both modes, in equivalent effort units, an angler trip (SEDAR28-DW-12). These 1981-1985 calibration factors were updated since the last assessment of Gulf red grouper (SEDAR 12). The calibration factors were applied to the charter boat estimates and are tabulated in Table 4.8.1.

MRIP weighted estimates, APAIS changes, and the calibration of MRFSS estimates

The Marine Recreational Information Program (MRIP) was developed to generate more accurate recreational catch rates by re-designing the MRFSS sampling protocol to address potential biases including port activity and time of day. Revised catch and effort estimates, based on MRIP's improved estimation methodology, were released on January 25, 2012. These estimates are available for the Atlantic and Gulf Coasts starting in 2004.

Starting in 2013, wave 2, the MRIP Access Point Angler Intercept Survey (APAIS) implemented a "revised sampling design that includes an updated sampling frame; eliminates interviewer latitude in selecting interviewing sites; establishes discrete sampling periods of fixed duration, including nighttime sampling; and requires interviewers to collect detailed information about the number of completed boat and angler fishing trips during the sampling period" (MRIP Implementation Plan 2011). Revised catch estimates for red grouper, based on this improved APAIS design, were provided by the Office of Science and Technology for SEDAR 42 (Carmichael 2015). These estimates are provided by state and mode, with all waves and areas combined. Tables 4.8.2 and 4.8.3 show the differences between the Gulf of Mexico red grouper MRIP APAIS landing and discard estimates and the MRFSS estimates for the time period 2004-2012.

As new MRIP APAIS estimates are available for a portion of the recreational time series that the MRFSS covers, conversion factors between the MRFSS estimates and the MRIP APAIS estimates were developed in order to maintain one consistent time series for the recreational catch estimates. Ratio estimators, based on the ratios of the means, were developed for Gulf of Mexico red grouper to hind-cast catch and variance estimates by fishing mode. In order to apply the charter boat ratio estimator back in time to 1981, charter boat landings were isolated from the combined charter boat /headboat mode for 1981-1985. The MRFSS to MRIP APAIS calibration process is the same as the original MRFSS to MRIP adjustment that has been used since 2012, which is detailed in SEDAR31-DW25 and SEDAR32-DW02. Table 4.8.4 shows the ratio estimators used in the calibration. Figure 4.9.2 shows the MRFSS versus MRIP APAIS adjusted estimates for Gulf of Mexico red grouper from 1981 to 2003. The ratio estimator for shore discards is larger than the other modes. However, since shore mode discards are minor compared to the other modes, this does not greatly affect the overall adjusted discard estimates (see Figure 4.9.2).

Monroe County

Monroe County MRFSS landings from 1981 to 2003 can be post-stratified to separate them from the MRFSS West Florida estimates. Post-stratification proportionally distributes the state-wide (FLE and FLW) effort into finer scale sub-regions and then produces effort estimates at this finer geographical scale. This is needed for the private and shore modes (all years) and charter boat mode (prior to FHS). FHS charter boat mode estimates are already pre-stratified, as discussed above.

Originally, during the first MRIP re-estimation, Monroe County landings (2004+) could be estimated separately from the remaining West Florida estimates using domain estimation. The Monroe County domain includes only intercepted trips returning to that county as identified in the intercept survey data. Estimates are then calculated within this domain using standard design-based estimation which incorporates the MRIP design stratification, clustering, and sample weights. However, the new MRIP APAIS calibration does not allow for domain estimation at this time. The recommended approach is to use the annual proportions from the original MRIP domain estimates (panhandle and peninsula over total FLW) and apply those proportions to the new West Florida MRIP APAIS estimates in order to remove Monroe County.

Although Monroe County estimates can be separated using these processes, they cannot be partitioned into those from the Atlantic Ocean and those from the Gulf of Mexico. In the previous Gulf of Mexico assessment, SEDAR 12 (2006), Monroe County was included in the Gulf stock. However, in the last South Atlantic assessment for red grouper, SEDAR 19 (2009), Monroe County was included in the South Atlantic stock. The deviation from SEDAR 12 was noted but new information was available that supported that decision. Beginning in 2005, the MRIP intercept survey began collecting information indicating whether an intercept is capturing fishing occurring on the Atlantic side or the Gulf side of the Keys. Figure 4.9.3 shows the allocation of Monroe County trips which caught red grouper and total catch of red grouper between both regions. The recreational workgroup recommends excluding Monroe County estimates from MRIP from the Gulf of Mexico stock. This decision differs from SEDAR 12 but is consistent with SEDAR 19.

Shore Estimates

Shore landings estimates are sporadic and mostly from the earlier years but shore discard estimates consistently appear throughout the time series. It was noted that it is reasonable for red grouper to be caught from shore mode, especially from bridges in some parts of the coast. Shore mode estimates from MRIP were kept as reported by the survey. This is consistent with SEDAR 12.

Calculating landings estimates in weight

The MRFSS and the MRIP surveys use different methodologies to estimate landings in weight. To apply a consistent methodology over the entire recreational time series, the Southeast Fisheries Science Center (SEFSC) implemented a method for calculating average weights for the MRIP (and MRIP adjusted) landings. This method is detailed in SEDAR32-DW-02. The length-weight equation developed by the Life History Working Group (W=5.46E-9*(L^3.18)) was used to convert red grouper sample lengths into weights, when no weight was recorded. W is whole weight in kilograms and L is fork length in millimeters. Weight estimates were not provided by the recreational workgroup in SEDAR 12 but this method has been consistently used in SEDARs since 2012.

1981, wave 1

MRFSS began in 1981, wave 2. In the Gulf of Mexico, catch for 1981 wave 1 was estimated by determining the proportion of catch in wave 1 to catch in all other waves for 1982-1984 by fishing mode and area. These proportions were then used to estimate wave 1 in 1981 from the estimated catches in other waves of that year. This methodology is consistent with past SEDARs (e.g., SEDAR 28 Spanish mackerel and cobia).

Variances

Variances are provided by MRFSS/MRIP for their recreational catch estimates. Variances are adjusted to take into account the variance of the conversion factor when an adjustment to the estimate has been made (FHS and MRIP conversions). However, the variance estimates of the charter and headboat modes in 1981-1985 are missing. This is due to the MRIP calibration procedure, which requires the combined charter/headboat mode to be split in order to apply the MRIP adjustment to the charter mode back to 1981. In addition, variance estimates are not available for weight estimates generated through the SEFSC method described above.

Variances for MRIP APAIS estimates from 2004+ were calculated for the entire West Florida coast, including the Florida Keys. As discussed above, Monroe County was removed from the new MRIP APAIS estimates using proportions from the original MRIP domain estimates. There is not enough information to adjust the MRIP APAIS variances to account for the removal of Monroe County.

Results

MRIP landings in numbers of fish and in whole weight in pounds are presented in Table 4.8.5. CVs associated with estimated landings in numbers are also shown. Gulf of Mexico red grouper estimates include Louisiana through West Florida, not including Monroe County, FL.

4.3.2 Southeast Region Headboat Survey

Introduction

The Southeast Region Headboat Survey (SRHS) estimates landings and effort for headboats in the South Atlantic and Gulf of Mexico. The SRHS began in the South Atlantic in 1972 and Gulf of Mexico in 1986 and extends from the North Carolina\Virginia border to the Texas\Mexico border. Mississippi headboats were added to the survey in 2010. The South Atlantic and Gulf of Mexico Headboat Surveys generally include 70-80 vessels participating in each region annually.

The SRHS incorporates two components for estimating catch and effort. 1) Biological information: sizes of the fish landed are collected by port samplers during dockside sampling, where fish are measured to the nearest mm and weighed to the nearest 0.01 kg. These data are used to generate length frequency distributions and mean weights for all species by area and month. Port samplers also collect otoliths and spines for ageing studies during dockside sampling events. 2) Information about total catch and effort are collected via a logbook form that is filled out by vessel personnel for individual trips. These logbooks are summarized by vessel to generate estimated landings by species, area, and time strata. Most recently, the SRHS implemented electronic logbook reporting in the South Atlantic and Gulf of Mexico as of Jan 1, 2013. Headboat personnel now have the ability to report trip information via a website or mobile application. Electronic reporting became mandatory in 2014.

The SRHS was inconsistent in LA in 2002-2005. There were no trip reports collected in LA in 2002. Trip reports from 2001 were used (by the HBS) as a substitute to generate estimates of numbers caught (though there are some minor differences between the resulting estimates for the two years). In 2003, there were only a few trip reports but they were still used to generate the estimates. From 2004 to 2005 there were no trip reports or fish sampled, and no substitutes were used, so there are no estimates or samples from 2004 to 2005 due to funding issues and Hurricane Katrina. However, the MRFSS/MRIP For-Hire Survey included the LA headboats in their charter mode estimates for these years, thereby eliminating this hole in the headboat mode estimates.

Variances

Variance estimates are not currently available for the SRHS catch estimates. Further research is required to develop a suitable method to calculate variance. This task has been prioritized and is currently in the planning stage.

Catch Estimates

Final SRHS landings estimates are shown in Table 4.8.6, by year and state in Figure 4.9.4. SRHS areas 18-29 are included in the Gulf of Mexico red grouper stock.

4.3.3 Estimating Historical Recreational Landings

Introduction

Historic recreational landings for the charter boat, headboat, private boat, and shore fishing modes are landings prior to the 1981 start of the current recreational surveys (MRIP and SRHS). The Recreational Working Group was tasked with reviewing all available historical sources of red grouper landings to evaluate potential methods to compile landings prior to the available time series of estimated landings.

The sources of historical landings that were reviewed for potential use are as follows:

- Estimates of Historical Red Grouper Angler Catch in the Gulf of Mexico for the Private/Charter boat and Headboat Recreational Fishing Modes, SEDAR42-DW-16.
- Estimating historical recreational angler effort in the Gulf of Mexico for the private, charter, and headboat fishing modes. Southeast Data, Assessment, and Review (SEDAR) 31-AW-11.
- Historical For-Hire Fishing Vessels: South Atlantic Fishery Management Council, 1930’s to 1985; SEDAR41-DW-25.
- Backcalculation of recreational catch of red grouper from 1945 to 1985. SEDAR 12-DW15.

The Recreational Data Working Group (RWG) reviewed *Estimates of Historical Red Grouper Angler Catch in the Gulf of Mexico for the Private/Charter boat and Headboat Recreational*

Fishing Modes (SEDAR42-DW-16). This paper describes a method that modifies the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (FHWAR) method to include estimates of headboat numbers gleaned from the gray literature and news media accounts of historic headboat fishing. The paper also compares the new method with the previously accepted method. The RWG accepted the methods proposed in SEDAR42-DW-16, but requested a re-analysis of the data to include only the eastern Gulf of Mexico. The RWG concluded that the method used a previously accepted method (FHWAR method; SEDAR41-DW-17) combined with historical archived information that ultimately produced defensible estimates of historical landings.

The RWG reviewed *the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation Survey (FHWAR) census method* (SEDAR41-DW-17). We concluded that the method was sound for the period prior to 1981 for the private/charter sector but the assumption that headboat effort was constant from 1945-1981 was unrealistic.

The RWG reviewed *Historical For-Hire Fishing Vessels: South Atlantic Fishery Management Council, 1930's to 1985* (SEDAR41-DW-25). The RWG concluded that the review was comprehensive for the geographic region surveyed and that the estimates could be used as a proxy for headboat fleet development in the Gulf of Mexico. They also concluded that the charter sector was probably small and indistinguishable from the headboat sector and that charter landings should be combined with the private landings for the purpose of the assessment. This decision is consistent with recent assessments.

The RWG also reviewed *Backcalculation of recreational catch of red grouper from 1945 to 1985* (SEDAR 12-DW15). This paper used the FHWAR method to estimate private landings, point estimates of the numbers of charter boat and catch rates from 1955-1985 for southwest and west central Florida, and from the northwest and panhandle of Florida. The DWG concluded that the methods used to estimate headboat and charter boat effort in the cited studies may not have been similar and that historic effort was likely overestimated.

Issue: Available historical red grouper landings prior to 1981.

Option 1: Use the *Backcalculation of Recreational Catch of Red Grouper from 1945 to 1985 (SEDAR 12-DW15)* method that relies on boat sales as a proxy for effort.

Option 2: Use the *Estimates of Historical Red Grouper Angler Catch in the Gulf of Mexico for the Private/Charter boat and Headboat Recreational Fishing Modes, SEDAR42-DW-16*, which uses the FHWAR census method to estimate red grouper landing 1945-1980 for the combined private/charter modes, and uses the historic headboat fleet size as a proxy for effort for the headboat mode. Use interpolation to complete time series.

Option 3: Use available recreational time series for the MRFSS\MRIP 1981 to 2013 for the charter and private modes, and headboat estimates 1972 – 2013 for the headboat mode.

Decision: *Option 2*.

Option #2: The FHWAR census method with modifications to estimate red grouper landings back in time will provide estimates consistent with recent assessments. The use of historical fleet size information provides a reasonable proxy for historic headboat effort. As red grouper are restricted to the eastern Gulf of Mexico, the group decided that only effort in Louisiana, Mississippi, Alabama and West Florida would be used to calculate historic landings.

Historical Catch Estimates

Final historical landings estimates are shown in Table 4.8.7.

4.4 RECREATIONAL DISCARDS

Total recreational discards are summarized below by survey. A map and figures summarizing the total recreational red grouper discards are included in Figure 4.9.5. There are no estimates from the Texas Parks and Wildlife Survey for this species.

4.4.1 MRFSS/MRIP discards

Discarded live fish are reported by the anglers interviewed by the MRIP/MRFSS. Consequently, neither the identity nor the quantities reported are verified. Lengths and weights of discarded fish are not sampled or estimated by the MRFSS/MRIP.

MRFSS/MRIP estimates of live released fish (B2 fish) were adjusted in the same manner as the landings (i.e., using charter boat calibration factors, MRIP adjustment, substitutions, etc. described above in section 4.3.1).

MRIP discards in numbers of fish and associated CVs are presented in Table 4.8.8. Gulf of Mexico red grouper estimates include Louisiana through West Florida, not including Monroe County, FL.

4.4.2 Headboat Logbook Discards

The Southeast Region Headboat Survey logbook form was modified in 2004 to include a category to collect self-reported discards for each reported trip. This category is described on the form as the number of fish by species released alive and number released dead. Port agents instructed each captain on criteria for determining the condition of discarded fish. A fish is considered "released alive" if it is able to swim away on its own. If the fish floats off or is obviously dead or unable to swim, it is considered "released dead". As of Jan 1, 2013 the SRHS began collecting logbook data electronically. Changes to the trip report were also made at this time, one of which removed the condition category for discards i.e., released alive vs. released dead. The new form now collects only the total number of fish released regardless of condition.

These self-reported data are currently not validated within the Headboat Survey. However, the At-Sea Observer program data are used to validate the Southeast Region Headboat Survey logbook discard data (SEDAR 42-DW-17, 2014). Based on this validation it was determined that the logbook discard data would be used from 2007-2013. The RWG concluded that a proxy should be used to estimate the headboat red grouper discards for years prior to 2007 in FLW. The three proxy method discard estimates are negligible in all other states, as are the SRHS landings estimates. Therefore it is recommended to assume that the SRHS discards are negligible in the rest of the Gulf of Mexico in 1986-2006. The RWG considered the following three possible data sources to be used as a proxy for estimated headboat discards for 1986-2006 (Figure 4.9.6) in FLW.

- MRIP CH discard ratio proxy method 1986-2006.

- MRIP PR discard ratio proxy method 1986-2006.
- MRIP CH:SRHS discard ratio proxy method 1986-2006 (SEDAR 28-Assessment Workshop Report, 2012).

Issue: Discard information not available prior to 2006, need a proxy for estimated headboat discards from 1986-2006.

Option 1: MRIP CH: Apply the yearly MRFSS charter boat discard:landings ratio to estimated headboat landings in order to estimate headboat discards from 1986-2006.

Option 2: MRIP PR: Apply the yearly MRFSS private boat discard:landings ratio to estimated headboat landings in order to estimate headboat discards from 1986-2006.

Option 3: MRIP CH:SRHS Calculate a ratio of the mean ratio of SRHS discard:landings (2007-2013) and MRIP CH discard:landings (2007-2013). Apply this ratio to the yearly MRIP charter boat discard:landings ratio (1986-2006) in order to determine the yearly SRHS discard:landings ratio (1986-2006). This ratio is then applied to the SRHS landings (1986-2006) in order to estimate headboat discards (1986-2006).

Decision: Option 3. The MRFSS/MRIP CH discard ratio is much lower than that of the SRHS in 2007-2013 and therefore is not recommended for consideration. The MRFSS/MRIP PR discard ratio proxy agrees well with the SRHS discard ratio in 2007-2013. The MRFSS/MRIP CH:SRHS discard ratio method is closer to the SRHS discard rate in terms of magnitude. Final discard estimates from the SRHS are shown in Table 4.8.9 by year and state and in Figure 4.9.7.

4.4.3 Headboat At-Sea Observer Survey Discards

Observer surveys of recreational headboats provide detailed information of recreational catch, and in particular of recreational discards. In the Gulf of Mexico, observer surveys were conducted in Alabama from 2004 to 2007, and in West Florida from 2005-2007 and 2009-present. For each survey, headboat vessels were randomly selected throughout each year in each state. Trained biologists then boarded the selected vessels, with permission from a vessel's captain, and observed all fishing activity of a sub-sample of anglers as they fished. The data collected included number and species of landed and discarded fish, size of landed and discarded fish, and the release condition of discarded fish (FL only). Observers also recorded length of the trip, area fished (inland, state, and federal waters) and, in Florida, the minimum and maximum depth fished. As discussed above, the red grouper discard data from the MRFSS At-Sea Observer Headboat program and the Southeast Region Headboat Survey (SRHS) logbook were compared (SEDAR 42-DW-17, 2014). Based on the results of these comparisons, it was determined that the SRHS discard rates were validated by the MRFSS/MRIP At-Sea Observer data starting in 2007.

Total recreational catches (in numbers) from all surveys and all years are presented in Table 4.8.10.

4.5 BIOLOGICAL SAMPLING

Length samples from recreational landings were obtained from the Marine Recreational Fisheries Statistics Survey and the Southeast Region Headboat Survey. Length samples from recreational discards were obtained from the At-sea Observer Program. The recreational sector is under sampled for biological samples (e.g., hard parts, n<100/year, all years). It is recommended that there be an increase in the number of trips intercepted by year and that a higher percentage of the intercepts include collecting biological samples (length, weight, and hard parts).

4.5.1 Sampling Intensity

MRFSS/MRIP Biological Sampling

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

The number of angler trips with measured red grouper in the Gulf of Mexico (LA to FLW, not including the Keys) in the MRFSS/MRIP by year and mode are summarized in Table 4.8.11. Information on the weights collected (number, mean, minimum, and maximum weights) by year and state from the MRFSS/MRIP is tabulated in Table 4.8.12.

Headboat Survey Biological Sampling

Lengths were collected from 1972 to 2013 by headboat dockside samplers. From 1972 to 1975, only North Carolina and South Carolina were sampled whereas Georgia and northeast Florida were sampled beginning in 1976. The Southeast Region Headboat Survey conducted dockside sampling for the entire range of Atlantic waters along the southeast portion of the US from the NC-VA border through the Florida Keys beginning in 1978. The Gulf of Mexico, excluding Mississippi, was added to the dockside sampling program in 1986. Mississippi was added in 2010. Weights are typically collected for the same fish measured during dockside sampling. Also, biological samples (scales, otoliths, spines, stomachs and gonads) are collected routinely and processed for aging, diet studies, and maturity studies.

Annual numbers of red grouper measured for length in the headboat fleet and the number of trips from which red grouper were measured are summarized in Table 4.8.13. Dockside mean weights for the headboat fishery are tabulated for 1972-2013 in Table 4.8.14.

At-sea Observer Program

Observer surveys were conducted aboard charter vessels from 2009-present and aboard recreational headboats from 2005-2007 and 2009-present. Vessels were randomly selected and a subsample of the anglers onboard was observed. All fish harvested and discarded were recorded for species, length, and condition if released. These surveys provided the detailed information of headboat and charter vessel discards with which length distributions of discards could be made (Figure 4.9.8 and Figure 4.9.9). Results presented here provide the discard length distributions for both headboat and charter vessels. Discard lengths are commonly between 20 and 40cm.

4.5.2 Length Distributions

Length and age samples (Table 4.8.15 and Table 4.8.16) for recreational fisheries were obtained from the Marine Recreational Fisheries Statistics Survey (i.e., the Marine Recreational

Information Program, MRIP), the Southeast Region Headboat Survey, the Gulf FIN database, and the TIP database. All recreational samples were combined into one stratum. Length frequency distributions for recreational landings are shown in Figure 4.9.10.

4.5.3 Age Distribution

For the estimation of age frequency distributions, age samples were reweighted by length samples (Chih, SEDAR42-DW-18). Reweighted age frequency distributions for recreational landings are shown in Figure 4.9.11.

4.6 RECREATIONAL EFFORT

Total recreational effort is summarized below by survey. Effort is summarized for all marine fishing by mode, regardless of what was caught. A map and figures summarizing MRFSS/MRIP effort in angler trips are included in Figure 4.9.12. A map and figures summarizing SRHS effort in angler days are included in Figure 4.9.13.

4.6.1 MRFSS/MRIP Effort

Effort estimates for the recreational fishery survey are produced via telephone surveys of both anglers (private/rental boats and shore fishers) and for-hire boat operators (charter boat anglers, and in early years, party or charter anglers). The methods have changed during the full time series (see section 4.3 for descriptions of survey method changes and adjustments to survey estimates for uniform time-series of catch estimates). An angler-trip is defined as a single day of fishing by a single angler in the specified mode, not to exceed 24 hours. MRFSS effort estimates are presented from 1981 to 2003. MRIP effort estimates are presented starting in 2004. Angler trip estimates are tabulated in Table 4.8.17 by year and mode and include all Gulf of Mexico states from Louisiana to West Florida, not including the Keys.

4.6.2 Headboat Effort

Catch and effort data are reported on logbooks provided to all headboats in the survey. These forms are completed by the captain or designated crew member after each trip and represent the total number and weight of all the species kept, along with the total number of fish discarded for each species. Data on effort are provided as number of anglers on a given trip. Numbers of anglers are standardized, depending on the type of trip (length in hours), by converting number of anglers to "angler days" (e.g., 40 anglers on a half-day trip would yield 40 * 0.5 = 20 angler days). Angler days are summed by month for individual vessels. Each month, port agents collect these logbook trip reports and check for accuracy and completeness. Although reporting via the logbooks is mandatory, compliance is not 100% and is variable by location. To account for non-reporting, a correction factor is developed based on sampler observations, angler numbers from office books and all available information. This information is used to provide estimates of total catch (expanded or corrected for non-reporting) by month and area, along with estimates of effort.

Estimated headboat angler days are tabulated for the Gulf of Mexico in Table 4.8.18 and include SRHS areas 18-29.

Estimated headboat angler days have decreased in the South Atlantic and Gulf of Mexico in recent years. The most obvious factor which impacted the headboat fishery in both the South Atlantic and Gulf of Mexico was the high price of fuel. This, coupled with the economic down turn starting in 2008, has resulted in a marked decline in angler days in the South Atlantic and Gulf of Mexico headboat fishery. Reports from industry staff, captains/owners, and port agents indicated fuel prices, the economy and fishing regulations are the factors that most affected the amount of trips, number of passengers, and overall fishing effort. Also important to note, is the decrease in effort in the South Atlantic and Gulf of Mexico in 2010, the year of the Deepwater Horizon oil spill. However, estimated angler days have risen in recent years (2012-2013).

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4.8 TABLES

Table 4.8.1 Gulf of Mexico MRFSS charter boat conversion factors and standard errors (in parentheses).

a) Apply to 1981-1985 charter boat/headboat mode in the South Atlantic and Gulf of Mexico.

	WAVE					
STATE	1	2	3	4	5	6
NC	-	2.151 (0.12)	2.294 (0.12)	1.444 (0.12)	1.763 (0.12)	0.857 (0.12)
SC	-	1.035 (0.04)	1.085 (0.04)	1.437 (0.04)	0.891 (0.04)	0.750 (0.04)
GFE	0.845 (0.02)	0.951 (0.02)	0.985 (0.02)	1.016 (0.02)	0.811 (0.02)	0.696 (0.02)
AFW	0.883 (0.03)	0.883 (0.03)	1.104 (0.05)	1.104 (0.05)	0.883 (0.03)	0.883 (0.03)
MS	1.155 (0.11)	1.155 (0.11)	2.245 (0.11)	2.245 (0.11)	1.155 (0.11)	1.155 (0.11)
LA	0.962 (0.09)	0.962 (0.09)	2.260 (0.13)	2.260 (0.13)	0.962 (0.09)	0.962 (0.09)

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

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

c) Apply to 1986- 1997 charter boat mode in FLW

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

Table 4.8.2. Red grouper MRFSS vs MRIP APAIS estimates of landings (number of fish) for the Gulf of Mexico (sub-region 7, including the Keys) 2004-2012. See accompanying graph below table.

year	MRFSS ab1	MRFSS CV_ab1	MRIP APAIS ab1	MRIP APAIS CV_ab1
2004	495,942	0.08	563,576	0.16
2005	217,464	0.09	184,447	0.15
2006	138,513	0.11	150,111	0.24
2007	147,851	0.10	161,419	0.23
2008	137,920	0.10	138,779	0.16
2009	116,190	0.13	149,896	0.23
2010	107,995	0.12	157,981	0.21
2011	112,871	0.10	118,887	0.16
2012	283,304	0.09	341,232	0.18

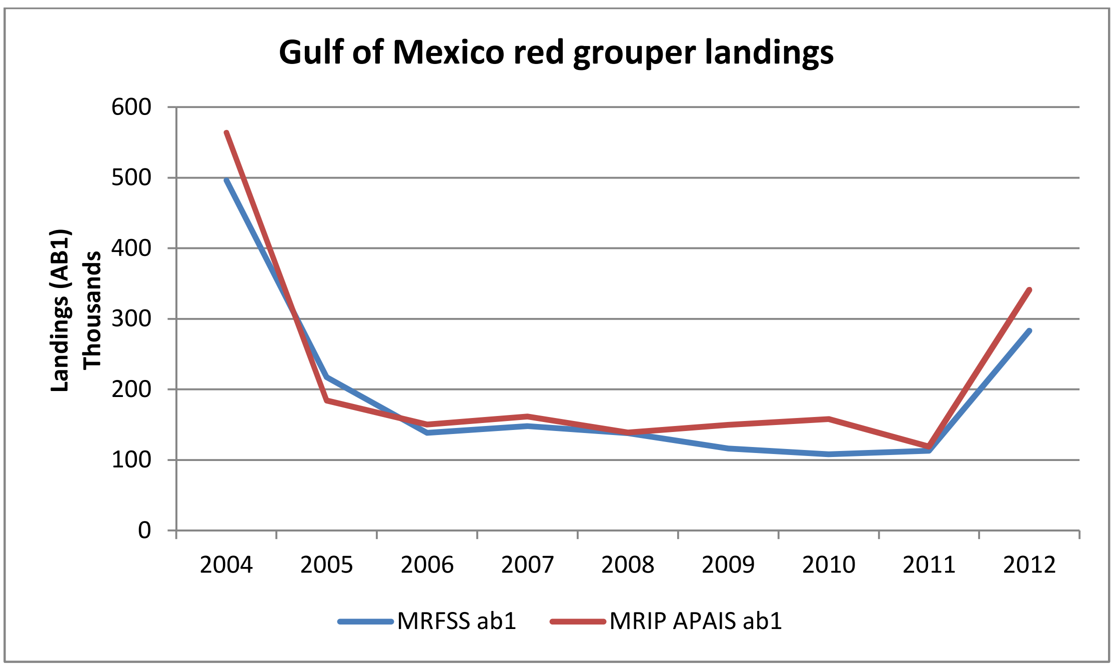


Table 4.8.3. Red grouper MRFSS vs MRIP APAIS estimates of discards (number of fish) for the Gulf of Mexico (sub-region 7, including the Keys) 2004-2012. See accompanying graph below table.

year	MRFSS b2	MRFSS CV_b2	MRIP APAIS b2	MRIP APAIS CV_b2
2004	3,136,801	0.05	3,449,693	0.12
2005	1,644,824	0.07	1,285,731	0.15
2006	874,059	0.09	719,419	0.24
2007	1,050,213	0.10	887,516	0.16
2008	3,174,133	0.06	3,583,099	0.20
2009	3,294,541	0.06	3,357,560	0.13
2010	2,246,179	0.06	2,242,438	0.13
2011	2,156,220	0.07	2,057,735	0.14
2012	1,852,884	0.06	1,807,062	0.11

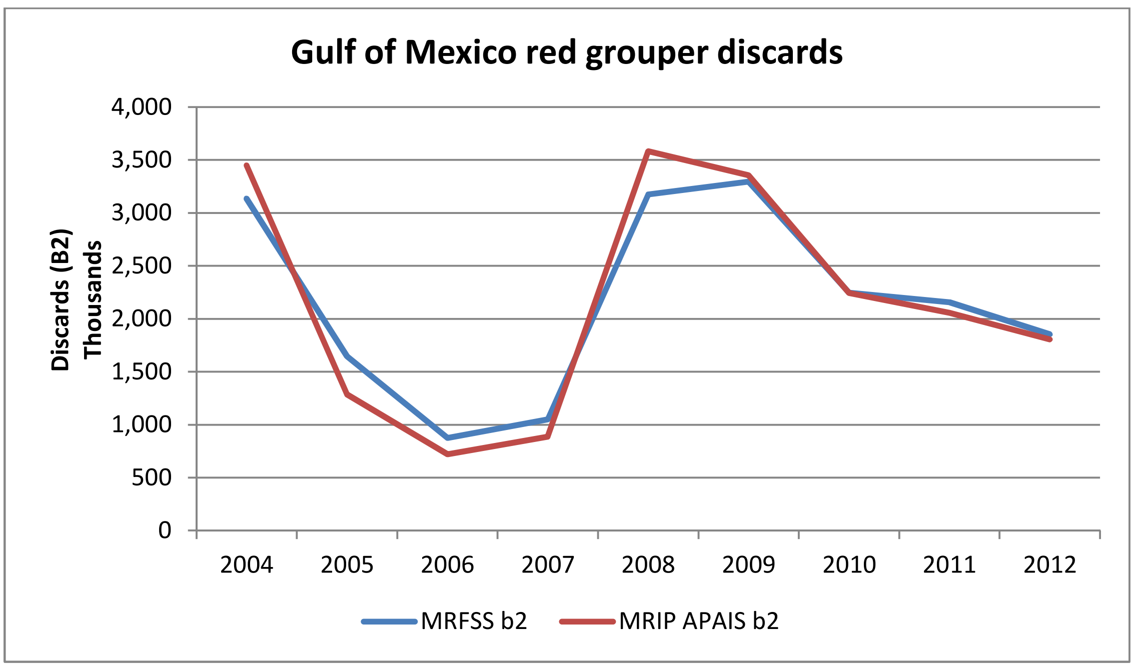


Table 4.8.4. Gulf of Mexico red grouper ratio estimators for adjusting MRFSS numbers and variance estimates (AB1 and B2) to MRIP APAIS numbers and variances for 1981-2003. The variances of the numbers ratio estimators are also shown.

	Numbers Ratio Estimator		Variance Ratio Estimator		Variance of Numbers Ratio Estimator	
MODE	**AB1**	**B2**	**AB1**	**B2**	**AB1**	**B2**
Charter boat	1.123337	1.234725	8.087822	7.746577	0.004217	0.001866
Private	1.116533	0.916223	5.138042	4.226388	0.003068	0.001189
Shore	1.188584	6.167641	1.417673	849.1178		1.331041

Table 4.8.5. Gulf of Mexico (LA-FLW, not including the Keys) red grouper landings (numbers of fish and whole weight in pounds) by year and mode (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004+). MRFSS estimates adjusted to MRIP APAIS estimates prior to 2004. CH mode adjusted for FHS conversion prior to 2004. *CVs for CH and HB mode 1981-1985 are unavailable.

	Estimated CH Landings			Estimated HB Landings			Estimated PR Landings			Estimated SH Landings			ALL MODES Landings		
YEAR	Number	CV*	Pounds	Number	CV*	Pounds	Number	CV	Pounds	Number	CV	Pounds	Number	CV	Pounds
1981	44,565		166,524	24,813		92,715	77,072	0.66	286,584	0	0.00	0	146,450	0.35*	545,822
1982	9,413		44,545	5,241		24,801	163,825	0.41	636,825	0	0.00	0	178,480	0.38*	706,172
1983	27,335		156,106	15,219		120,346	351,074	0.57	1,012,722	0	0.00	0	393,628	0.51*	1,289,175
1984	75,279		581,335	41,913		169,852	118,114	0.54	615,050	28,098	1.01	146,315	263,405	0.27*	1,512,552
1985	107,215		614,026	59,694		396,035	418,989	0.70	2,399,577	0	0.00	0	585,898	0.50*	3,409,638
1986	79,799	0.54	211,420				525,519	0.35	1,482,955	6,969	1.01	19,032	612,286	0.31	1,713,407
1987	38,279	0.82	117,460				298,229	0.33	831,544	0	0.00	0	336,508	0.31	949,003
1988	51,948	0.59	192,055				687,306	0.31	2,359,406	9,160	0.77	32,682	748,415	0.29	2,584,144
1989	38,012	0.77	129,960				713,005	0.29	2,300,517	0	0.00	0	751,017	0.28	2,430,477
1990	50,212	2.06	325,496				130,122	0.40	821,780	16,048	0.92	104,030	196,382	0.59	1,251,306
1991	11,401	1.74	70,274				284,585	0.32	1,816,303	10,155	0.98	62,594	306,142	0.30	1,949,171
1992	52,191	0.50	351,669				419,526	0.19	2,647,074	26,238	0.78	171,988	497,954	0.18	3,170,731
1993	27,501	0.59	162,848				331,594	0.32	2,001,232	18,946	0.79	112,189	378,041	0.28	2,276,269
1994	32,000	0.57	198,505				279,441	0.27	1,869,418	2,750	0.74	17,607	314,190	0.25	2,085,531
1995	59,008	0.68	441,941				226,726	0.27	1,500,034	0	0.00	0	285,734	0.26	1,941,974
1996	22,673	0.78	151,409				87,205	0.31	589,392	0	0.00	0	109,879	0.29	740,801
1997	22,229	0.75	151,836				55,004	0.42	358,425	0	0.00	0	77,233	0.37	510,261
1998	25,665	0.36	164,507				83,245	0.29	584,050	0	0.00	0	108,910	0.24	748,557
1999	34,514	0.41	236,262				160,692	0.22	1,040,547	0	0.00	0	195,205	0.20	1,276,810
2000	126,774	0.49	957,495				240,164	0.23	1,581,860	0	0.00	0	366,937	0.23	2,539,355
2001	63,966	0.51	427,903				173,124	0.23	1,161,066	0	0.00	0	237,090	0.22	1,588,969
2002	49,186	0.25	356,312				218,694	0.31	1,529,477	0	0.00	0	267,880	0.25	1,885,789
2003	53,850	0.22	323,993				164,178	0.21	1,019,413	0	0.00	0	218,029	0.17	1,343,406
2004	91,840	0.10	576,499				438,051	0.20	2,846,732	0	0.00	0	529,891	0.16	3,423,231
2005	86,712	0.11	536,668				96,952	0.27	660,950	0	0.00	0	183,664	0.15	1,197,617
2006	37,001	0.18	250,814				94,509	0.33	667,237	0	0.00	0	131,509	0.24	918,051
2007	26,289	0.16	193,711				128,452	0.27	897,602	0	0.00	0	154,741	0.23	1,091,313
2008	41,527	0.17	291,058				91,601	0.22	605,183	0	0.00	0	133,129	0.16	896,241

2009	28,960	0.16	209,410				95,599	0.30	733,685	1,607	1.00	11,760	126,166	0.23	954,854
2010	55,165	0.36	334,920				100,922	0.25	615,491	0	0.00	0	156,087	0.21	950,411
2011	48,798	0.22	278,039				62,111	0.22	347,762	0	0.00	0	110,909	0.16	625,800
2012	91,304	0.30	512,928				208,979	0.23	1,286,933	0	0.00	0	300,283	0.18	1,799,861
2013	139,184	0.17	799,983				301,203	0.18	1,791,279	0	0.00	0	440,387	0.13	2,591,261

Table 4.8.6. Estimated headboat landings of red grouper in the Gulf of Mexico 1986-2013. Due to headboat area definitions and confidentiality issues, FLW must be combined with AL and MS must be combined with LA.

	Number				Pounds			
Year	FLW/AL	MS/LA	TX	Gulf of Mexico	FLW/AL	MS/LA	TX	Gulf of Mexico
1986	32,902	-	11	32,913	118,249	-	82	118,331
1987	25,698	-	31	25,729	88,139	-	281	88,420
1988	27,946	-	8	27,954	103,794	-	85	103,879
1989	49,774	1	2	49,777	135,003	11	23	135,037
1990	14,578	-	4	14,582	91,471	-	40	91,512
1991	9,504	-	5	9,509	60,659	-	79	60,738
1992	9,047	1	1	9,049	52,632	10	9	52,651
1993	8,787	5	10	8,802	75,944	59	118	76,120
1994	9,616	-	1	9,617	55,345	-	6	55,351
1995	14,498	-	1	14,499	94,203	-	8	94,210
1996	15,594	-	-	15,594	84,369	-	-	84,369
1997	4,674	-	2	4,676	25,093	-	15	25,108
1998	4,368	9	5	4,382	23,240	63	35	23,339
1999	6,913	5	-	6,918	47,960	49	-	48,010
2000	8,860	-	1	8,861	51,048	-	7	51,056
2001	5,557	1	2	5,560	31,613	5	12	31,630
2002	4,399	1	2	4,402	24,617	6	14	24,636
2003	7,514	4	3	7,521	40,297	23	17	40,337
2004	13,808	-	2	13,810	68,263	-	9	68,272
2005	13,965	-	2	13,967	78,599	-	12	78,610
2006	4,629	-	1	4,630	26,697	-	6	26,703
2007	4,235	-	10	4,245	25,803	-	55	25,858
2008	4,998	-	5	5,003	39,368	-	41	39,409
2009	4,659	-	7	4,666	30,956	-	47	31,003
2010	4,949	-	3	4,952	27,291	-	24	27,315
2011	7,387	-	-	7,387	38,459	-	-	38,459
2012	13,543	-	1	13,544	87,316	-	9	87,324
2013	14,085	-	4	14,089	81,230	-	34	81,264

Table 4.8.7. Historic recreational landings of red grouper in the Gulf of Mexico by mode. Private/charter mode uses FHWAR effort estimates referenced to the average of 1981-1985 MRFSS Gulf of Mexico estimates. Headboat mode uses the historic Ponce Inlet headboat fleet size (Hudson 2014) as an effort proxy.

	Recreational Historical Landings (numbers)		
Year	private/charter	headboat	Total
1945	0	0	0
1946	12,022	689	12,711
1947	24,044	1,378	25,422
1948	36,067	2,066	38,133
1949	48,089	2,755	50,844
1950	60,111	3,444	63,555
1951	72,133	4,133	76,266
1952	84,155	4,821	88,977
1953	96,178	5,510	101,688
1954	108,200	6,199	114,399
1955	120,222	6,888	127,110
1956	127,848	9,184	137,032
1957	135,474	11,480	146,953
1958	143,100	13,775	156,875
1959	150,726	16,071	166,797
1960	158,352	18,367	176,719
1961	158,764	20,663	179,428
1962	159,177	22,959	182,136
1963	159,589	25,255	184,844
1964	160,002	27,551	187,553
1965	160,415	29,847	190,261
1966	164,277	32,602	196,879
1967	168,140	35,357	203,497
1968	172,002	38,112	210,114
1969	175,865	40,867	216,732
1970	179,727	43,622	223,349
1971	186,048	43,622	229,670
1972	192,369	45,918	238,287
1973	198,690	48,214	246,904
1974	205,011	48,214	253,225
1975	211,332	66,581	277,914
1976	223,354	64,285	287,639
1977	235,376	59,694	295,069
1978	247,397	57,398	304,795
1979	259,419	64,285	323,704
1980	271,441	64,285	335,726

Table 4.8.8. Gulf of Mexico (LA-FLW, not including the Keys) red grouper discards (numbers of fish) by year and mode (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004+). MRFSS estimates adjusted to MRIP APAIS estimates prior to 2004. CH mode adjusted for FHS conversion prior to 2004. *CVs for CH and HB mode 1981-1985 are unavailable.

	Estimated CH Discards		Estimated HB Discards		Estimated PR Discards		Estimated SH Discards		ALL MODES Discards	
YEAR	Number	CV*	Number	CV*	Number	CV	Number	CV	Number	CV
1981	7,906		4,005		53,292	0.89	11,623	28.63	76,825	4.37
1982	3,078		1,559		35,734	0.68	0	0.00	40,372	0.60
1983	6,516		3,301		42,091	1.26	0	0.00	51,907	1.02
1984	18,893		9,570		27,223	0.96	0	0.00	55,686	0.47
1985	27,212		13,784		35,973	0.92	31,584	17.22	108,552	5.02
1986	75,968	0.83			388,292	0.47	36,162	28.63	500,422	2.10
1987	55,687	0.86			255,963	0.33	0	0.00	311,651	0.31
1988	45,691	0.94			727,407	0.33	71,741	28.63	844,838	2.45
1989	112,586	0.70			1,718,771	0.35	11,065	28.63	1,842,421	0.37
1990	217,875	1.13			1,244,607	0.28	128,784	19.45	1,591,265	1.60
1991	57,281	0.62			2,586,268	0.23	206,175	18.21	2,849,724	1.33
1992	165,448	0.44			2,115,433	0.15	505,104	10.90	2,785,985	1.98
1993	133,344	0.69			1,444,787	0.21	46,668	15.34	1,624,799	0.48
1994	119,009	0.69			1,344,305	0.17	101,182	10.05	1,564,497	0.67
1995	165,497	0.59			1,295,002	0.18	2,252	28.63	1,462,751	0.18
1996	62,371	0.87			705,629	0.20	20,857	16.57	788,857	0.48
1997	108,861	0.51			703,972	0.25	33,507	14.41	846,340	0.61
1998	326,922	0.35			1,139,286	0.15	10,471	17.28	1,476,679	0.18
1999	393,899	0.30			1,572,920	0.13	21,518	14.46	1,988,338	0.20
2000	634,966	0.50			1,524,541	0.17	23,009	22.08	2,182,516	0.30
2001	279,996	0.37			1,289,411	0.14	0	0.00	1,569,407	0.13
2002	273,975	0.27			1,571,390	0.14	0	0.00	1,845,365	0.13
2003	386,452	0.21			1,573,177	0.15	5,635	28.63	1,965,264	0.15
2004	452,240	0.14			2,697,519	0.14	39,812	1.04	3,189,571	0.12
2005	274,709	0.13			999,489	0.19	7,549	1.00	1,281,747	0.15
2006	127,967	0.24			503,284	0.30	0	0.00	631,251	0.24
2007	133,750	0.22			666,434	0.19	19,033	1.04	819,217	0.16
2008	425,320	0.19			2,549,796	0.14	556,633	1.05	3,531,749	0.20
2009	479,498	0.20			2,713,425	0.14	117,783	1.05	3,310,706	0.13
2010	543,936	0.24			1,667,811	0.15	6,583	1.03	2,218,330	0.13
2011	502,370	0.21			1,526,879	0.17	9,170	1.03	2,038,418	0.14
2012	539,422	0.16			1,202,880	0.15	6,982	1.00	1,749,284	0.11
2013	613,660	0.17			2,036,644	0.17	1,281	0.66	2,651,586	0.13

Table 4.8.9. Estimated Gulf of Mexico red grouper discards for SRHS by year and state. Due to headboat area definitions and confidentiality issues, FLW must be combined with AL and MS must be combined with LA. 1986-2006 HB mode uses the MRIP CH:SRHS discard ratio proxy method, 2007-2013 uses the SRHS discard estimates.

Year	FLW/AL	MS/LA	TX	Gulf of Mexico
1986	57,059	0	0	57,059
1987	68,103	0	0	68,103
1988	44,776	0	0	44,776
1989	268,558	0	0	268,558
1990	115,232	0	0	115,232
1991	87,707	0	0	87,707
1992	52,245	0	0	52,245
1993	77,613	0	0	77,613
1994	65,148	0	0	65,148
1995	74,073	0	0	74,073
1996	78,145	0	0	78,145
1997	41,698	0	0	41,698
1998	101,358	0	0	101,358
1999	143,725	0	0	143,725
2000	80,840	0	0	80,840
2001	44,312	0	0	44,312
2002	44,637	0	0	44,637
2003	98,172	0	0	98,172
2004	123,862	0	0	123,862
2005	80,594	0	0	80,594
2006	29,164	0	0	29,164
2007	17,365	0	0	17,365
2008	89,614	0	1	89,615
2009	153,829	0	0	153,829
2010	117,878	0	1	117,879
2011	134,114	0	0	134,114
2012	117,809	0	0	117,809
2013	112,267	0	0	112,267

Table 4.8.10. Total recreational catch (landings and discards) from all sources and years in numbers of fish.

Year	Landings	Year	Landings	Discards	Total Catch
1945	0	1981	146,450	76,825	223,275
1946	12,711	1982	178,480	40,372	218,852
1947	25,422	1983	393,628	51,907	445,535
1948	38,133	1984	263,405	55,686	319,092
1949	50,844	1985	585,898	108,552	694,450
1950	63,555	1986	645,199	557,481	1,202,681
1951	76,266	1987	362,237	379,754	741,991
1952	88,977	1988	776,369	889,614	1,665,983
1953	101,688	1989	800,794	2,110,979	2,911,774
1954	114,399	1990	210,964	1,706,497	1,917,461
1955	127,110	1991	315,651	2,937,431	3,253,082
1956	137,032	1992	507,003	2,838,230	3,345,234
1957	146,953	1993	386,843	1,702,412	2,089,255
1958	156,875	1994	323,807	1,629,644	1,953,452
1959	166,797	1995	300,233	1,536,825	1,837,058
1960	176,719	1996	125,473	867,002	992,475
1961	179,428	1997	81,909	888,039	969,947
1962	182,136	1998	113,292	1,578,038	1,691,330
1963	184,844	1999	202,123	2,132,062	2,334,186
1964	187,553	2000	375,798	2,263,356	2,639,155
1965	190,261	2001	242,650	1,613,718	1,856,368
1966	196,879	2002	272,282	1,890,002	2,162,285
1967	203,497	2003	225,550	2,063,436	2,288,986
1968	210,114	2004	543,701	3,313,433	3,857,134
1969	216,732	2005	197,631	1,362,341	1,559,972
1970	223,349	2006	136,139	660,415	796,554
1971	229,670	2007	158,986	836,582	995,568
1972	238,287	2008	138,132	3,621,364	3,759,495
1973	246,904	2009	130,832	3,464,535	3,595,367
1974	253,225	2010	161,039	2,336,209	2,497,248
1975	277,914	2011	118,296	2,172,532	2,290,828
1976	287,639	2012	313,827	1,867,093	2,180,920
1977	295,069	2013	454,476	2,763,853	3,218,329
1978	304,795				
1979	323,704				
1980	335,726				

Table 4.8.11. Number of angler trips with measured red grouper in the Gulf of Mexico (LA-FLW, not including the Florida Keys) in the MRFSS/MRIP by year and mode.

YEAR	Cbt	Hbt	Priv	Shore	Grand Total
1981	3	11	5	1	20
1982	1	4	21		26
1983	1	31	17		49
1984	8	31	9		48
1985		26	7		33
1986	24		12		36
1987	18		44		62
1988	17		50	2	69
1989	13		39		52
1990	8		24		32
1991	3		37	2	42
1992	26		84	3	113
1993	7		46	1	54
1994	9		47	1	57
1995	11		38		49
1996	6		23		29
1997	17		21		38
1998	63		46		109
1999	99		72		171
2000	125		57		182
2001	112		54		166
2002	164		58		222
2003	248		57		305
2004	406		108		514
2005	334		61		395
2006	153		27		180
2007	103		51		154
2008	82		43		125
2009	52		23	1	76
2010	79		41		120
2011	116		35		151
2012	144		51		195
2013	102		96		198

Table 4.8.12. Number, mean, minimum, and maximum weights of red grouper in the Gulf of Mexico (LA-FLW, not including the Florida Keys) in the MRFSS/MRIP by year and mode.

	CH				HB				PR				SH			
YEAR	N	Mean (lbs)	Min (lbs)	Max (lbs)	N	Mean (lbs)	Min (lbs)	Max (lbs)	N	Mean (lbs)	Min (lbs)	Max (lbs)	N	Mean (lbs)	Min (lbs)	Max (lbs)
1981	12	6.63	1.54	19.18	15	3.12	0.88	8.82	10	5.00	1.10	14.99	8	1.98	1.10	2.87
1982	1	1.98	1.98	1.98	5	11.55	3.09	25.35	71	5.26	0.22	23.81				
1983	10	10.16	3.31	18.74	35	8.48	1.10	23.15	52	4.16	0.66	18.74				
1984	34	5.45	1.54	11.24	46	3.74	1.10	13.89	22	3.22	0.44	7.28				
1985					30	6.77	1.54	22.71	11	2.14	0.22	3.75				
1986	38	2.66	0.88	6.17					21	2.41	0.88	5.95				
1987	24	4.18	1.10	16.75					96	2.83	0.66	13.89				
1988	62	3.67	1.10	13.23					220	3.47	0.88	13.01	4	3.69	0.44	12.79
1989	50	3.36	0.88	9.04					152	2.99	0.66	10.36				
1990	13	6.27	4.41	9.26					37	6.42	2.87	13.89	1	16.53	16.53	16.53
1991	13	4.27	3.31	5.07					90	6.36	3.53	18.74	2	7.05	7.05	7.05
1992	115	6.84	3.53	24.03					222	6.36	1.76	16.31	12	6.32	4.19	10.80
1993	19	5.40	3.75	8.60					119	5.95	1.54	15.43	7	7.18	5.07	9.48
1994	56	6.21	3.75	12.79					86	6.45	3.09	14.55	1	0.77	0.77	0.77
1995	68	7.06	1.54	21.61					96	6.54	2.65	13.23				
1996	29	6.77	3.53	13.89					32	6.72	3.31	14.33				
1997	38	6.62	3.53	14.22					24	6.70	3.97	9.48				
1998	112	6.10	1.54	14.33					77	6.70	2.65	18.74				
1999	239	6.84	1.94	17.64					133	6.59	2.01	15.43				
2000	366	6.81	3.09	24.71					134	6.90	1.94	17.64				
2001	331	6.50	3.13	26.46					110	6.56	3.40	18.65				
2002	465	6.99	2.98	21.10					122	7.29	3.09	19.84				
2003	630	5.94	0.93	22.93					91	6.21	2.73	19.22				
2004	1299	6.27	2.51	23.99					257	6.47	1.63	24.74				
2005	1103	6.17	1.87	17.46					103	6.81	3.62	22.64				
2006	412	6.78	2.43	24.29					42	6.78	3.68	13.89				
2007	232	7.22	1.32	18.83					82	6.94	3.44	14.42				
2008	211	7.01	2.91	21.69					60	6.74	3.53	13.78				
2009	131	7.27	3.13	17.84					45	7.93	3.22	16.23	1	0.62	0.62	0.62
2010	181	6.08	3.17	18.74					95	6.11	3.57	13.12				
2011	301	5.71	2.87	17.99					70	5.60	2.87	14.90				
2012	544	5.62	2.95	19.93					144	6.08	0.66	17.28				
2013	589	5.80	0.71	22.97					207	6.01	2.45	13.05				

Table 4.8.13. Number of red grouper measured and number of trips with measured red grouper in the Gulf of Mexico from the SRHS by year and state 1986-2013. No fish were measured in LA/MS.

	Fish(n)			Trips(n)		
Year	FLW/AL	TX	Gulf of Mexico	FLW/AL	TX	Gulf of Mexico
1986	366	1	367	145	1	146
1987	546		546	206		206
1988	352	1	353	136	1	137
1989	701	1	702	150	1	151
1990	241		241	78		78
1991	103		103	49		49
1992	54		54	31		31
1993	33		33	22		22
1994	37	15	52	29	6	35
1995	57		57	33		33
1996	71		71	34		34
1997	48		48	24		24
1998	40		40	25		25
1999	109		109	39		39
2000	70		70	31		31
2001	52		52	30		30
2002	135		135	72		72
2003	219		219	119		119
2004	173		173	103		103
2005	72		72	44		44
2006	79		79	47		47
2007	94		94	50		50
2008	89		89	47		47
2009	50		50	31		31
2010	54		54	38		38
2011	93		93	52		52
2012	151		151	75		75
2013	156		156	78		78

Table 4.8.14. Mean weight (kg) of red grouper measured in the Gulf of Mexico from the SRHS by year and state, 1986-2013. No fish were measured in MS/LA.

	FLW/AL				TX				Gulf of Mexico			
Year	N	Mean (kg)	Min (kg)	Max (kg)	N	Mean (kg)	Min (kg)	Max (kg)	N	Mean (kg)	Min (kg)	Max (kg)
1986	369	1.73	0.20	16.00	1	0.21	0.21	0.21	370	1.93	0.41	16.21
1987	546	1.64	0.34	11.75					546	1.64	0.34	11.75
1988	352	1.92	0.47	16.92	1	0.35	0.35	0.35	353	2.27	0.82	17.27
1989	700	1.44	0.10	12.45	1				701	1.44	0.10	12.45
1990	241	3.06	0.44	12.11					241	3.06	0.44	12.11
1991	103	3.68	1.63	12.24					103	3.68	1.63	12.24
1992	54	3.15	1.58	10.67					54	3.15	1.58	10.67
1993	33	4.12	0.33	13.56					33	4.12	0.33	13.56
1994	37	2.83	0.66	10.82	15	2.64	1.94	5.00	52	5.47	2.60	15.82
1995	57	3.09	1.69	9.04					57	3.09	1.69	9.04
1996	71	2.73	0.75	8.49					71	2.73	0.75	8.49
1997	48	2.78	1.40	7.14					48	2.78	1.40	7.14
1998	40	2.36	1.48	5.84					40	2.36	1.48	5.84
1999	109	2.95	0.69	12.50					109	2.95	0.69	12.50
2000	69	2.67	1.47	8.04					69	2.67	1.47	8.04
2001	52	2.72	1.50	6.57					52	2.72	1.50	6.57
2002	135	2.39	0.85	4.72					135	2.39	0.85	4.72
2003	219	2.41	1.51	7.27					219	2.41	1.51	7.27
2004	173	2.29	1.49	6.00					173	2.29	1.49	6.00
2005	72	2.65	1.59	4.19					72	2.65	1.59	4.19
2006	79	2.60	1.54	5.34					79	2.60	1.54	5.34
2007	94	2.71	1.52	9.27					94	2.71	1.52	9.27
2008	89	3.14	1.61	8.20					89	3.14	1.61	8.20
2009	50	2.55	1.16	6.14					50	2.55	1.16	6.14
2010	54	2.70	1.18	6.77					54	2.70	1.18	6.77
2011	93	2.41	1.40	6.05					93	2.41	1.40	6.05
2012	151	2.66	1.39	8.81					151	2.66	1.39	8.81
2013	156	2.35	1.48	7.31					156	2.35	1.48	7.31

Table 4.8.15. Sample sizes for length samples collected between 1981 and 2013 from recreational fisheries in the Gulf of Mexico.

Year	Charter boat	Private boat	Headboat	Total
1981	12	10	20	42
1982	1	74	5	80
1983	10	50	35	95
1984	65	22	47	134
1985		11	31	42
1986	39	21	367	427
1987	26	93	546	665
1988	49	182	353	584
1989	48	150	699	897
1990	13	43	240	296
1991	53	91	109	253
1992	142	217	56	415
1993	78	120	36	234
1994	135	103	56	294
1995	73	100	57	230
1996	123	34	79	236
1997	109	32	69	210
1998	189	83	49	321
1999	261	136	112	509
2000	373	143	69	585
2001	369	121	55	545
2002	535	130	144	809
2003	668	102	219	989
2004	1418	279	175	1872
2005	1178	108	77	1363
2006	447	48	87	582
2007	289	90	136	515
2008	280	89	124	493
2009	222	79	145	446
2010	421	135	120	676
2011	631	84	168	883
2012	721	166	157	1044
2013	831	244	183	1258

Table 4.8.16. Sample sizes for age samples collected between 1991 and 2013 from recreational fisheries in the Gulf of Mexico.

Year	Charter boat	Private boat	Headboat	Total
1991	1		36	37
1992	24	1	33	58
1993	61	1	21	83
1994	72		29	101
1995	91		53	144
1996	134		41	175
1997	61	9	28	98
1998	72	4	21	97
1999	104	2	8	114
2000	59		12	71
2001	45	2	1	48
2002	292	7	50	349
2003	101	68	30	199
2004	144	41	43	228
2005	64	1	52	117
2006	38	6	33	77
2007	52	10	28	90
2008	73	32	44	149
2009	90	27	102	219
2010	263	47	85	395
2011	391	13	114	518
2012	223	14	39	276
2013	216	25	45	286

Table 4.8.17. Gulf of Mexico (LA-FLW, not including the Florida Keys) estimated number of angler trips by mode (MRFSS, NMFS, 1981-2003; MRIP, NMFS, 2004+). CH mode adjusted for FHS conversion prior to 2004. *CVs for CH and HB mode 1981-1985 are unavailable.

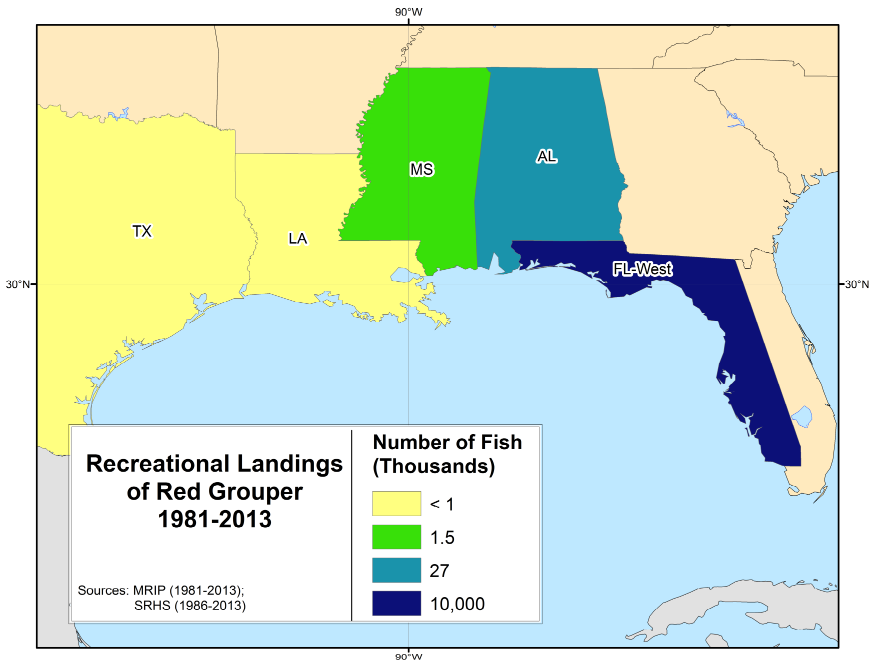
	Estimated CH Angler Trips		Estimated HB Angler Trips		Estimated PR Angler Trips		Estimated SH Angler Trips		ALL Modes	
YEAR	Trips	CV*	Trips	CV*	Trips	CV	Trips	CV	Trips	CV
1981	197,619		54,341		4,443,552	0.10	4,470,098	0.09	9,165,610	0.07*
1982	539,088		184,315		4,885,774	0.06	6,713,660	0.08	12,322,837	0.05*
1983	422,371		143,712		6,086,649	0.06	10,710,328	0.11	17,363,060	0.07*
1984	334,652		107,449		6,315,593	0.06	9,689,765	0.09	16,447,459	0.06*
1985	455,274		177,691		6,383,235	0.07	7,528,397	0.10	14,544,597	0.06*
1986	431,334	0.11			7,844,565	0.04	10,152,934	0.06	18,428,834	0.04
1987	489,262	0.13			7,618,189	0.03	5,861,397	0.07	13,968,848	0.03
1988	500,105	0.10			10,352,803	0.02	8,074,692	0.04	18,927,600	0.02
1989	455,029	0.11			8,220,154	0.03	5,956,223	0.05	14,631,406	0.03
1990	334,713	0.14			6,648,049	0.03	5,180,294	0.05	12,163,056	0.03
1991	294,003	0.14			8,012,939	0.03	7,441,416	0.04	15,748,358	0.03
1992	305,658	0.10			8,549,108	0.02	7,457,773	0.03	16,312,539	0.02
1993	515,454	0.09			8,140,262	0.02	6,724,100	0.02	15,379,816	0.01
1994	621,221	0.08			8,593,115	0.02	6,646,637	0.02	15,860,973	0.01
1995	691,788	0.08			8,896,938	0.02	6,268,982	0.02	15,857,708	0.01
1996	736,610	0.07			8,576,163	0.02	5,959,794	0.03	15,272,567	0.01
1997	775,624	0.09			9,347,283	0.02	6,739,975	0.03	16,862,882	0.02
1998	605,005	0.03			8,530,035	0.02	6,389,504	0.03	15,524,545	0.02
1999	557,003	0.03			8,782,785	0.02	5,671,528	0.03	15,011,316	0.01
2000	666,993	0.03			11,356,651	0.02	8,312,746	0.03	20,336,390	0.02
2001	594,585	0.03			12,068,175	0.02	9,394,401	0.02	22,057,161	0.01
2002	592,349	0.03			11,455,273	0.02	7,103,284	0.03	19,150,906	0.01
2003	552,771	0.03			13,720,239	0.02	7,927,996	0.03	22,201,006	0.01
2004	661,243	0.03			14,901,192	0.03	9,673,558	0.05	25,235,993	0.02
2005	577,958	0.04			13,283,476	0.03	8,780,857	0.05	22,642,292	0.03
2006	716,229	0.05			13,225,412	0.03	8,767,049	0.06	22,708,691	0.03
2007	721,891	0.05			14,275,542	0.03	8,256,792	0.06	23,254,225	0.03
2008	695,218	0.05			14,347,128	0.03	8,425,076	0.05	23,467,421	0.03
2009	692,843	0.06			13,075,467	0.03	8,202,557	0.06	21,970,867	0.03
2010	472,209	0.06			12,286,916	0.03	7,735,905	0.05	20,495,030	0.03
2011	617,454	0.04			12,678,122	0.03	8,790,961	0.05	22,086,537	0.02
2012	731,413	0.04			12,299,016	0.02	9,329,538	0.05	22,359,966	0.02
2013	742,631	0.06			12,712,097	0.03	10,401,416	0.04	23,856,144	0.02

Table 4.8.18. Gulf of Mexico headboat estimated angler days by year and state, 1986-2013.

Year	FLW/AL	MS/LA	TX	Gulf of Mexico
1986	240,077	5,891	56,568	302,536
1987	217,049	6,362	63,363	286,774
1988	195,948	7,691	70,396	274,035
1989	208,325	2,867	63,389	274,581
1990	213,906	6,898	58,144	278,948
1991	174,312	6,373	59,969	240,654
1992	184,802	9,911	76,218	270,931
1993	207,898	11,256	80,904	300,058
1994	204,562	12,651	100,778	317,991
1995	182,410	10,498	90,464	283,372
1996	154,913	10,988	91,852	257,753
1997	149,442	9,008	82,207	240,657
1998	185,331	7,854	77,650	270,835
1999	176,117	8,026	58,235	242,378
2000	159,331	4,952	58,395	222,678
2001	157,243	6,222	55,361	218,826
2002	141,831	6,222	66,951	215,004
2003	144,211	6,636	74,432	225,279
2004	158,430		64,990	223,420
2005	130,233		59,857	190,090
2006	124,049	5,005	70,789	199,843
2007	136,880	2,522	63,764	203,166
2008	130,176	2,945	41,188	174,309
2009	142,438	3,268	50,737	196,443
2010	111,018	715	47,154	158,887
2011	157,025	3,657	47,284	207,966
2012	161,975	3,680	51,776	217,431
2013	174,800	3,406	55,749	233,955

4.9 FIGURES

a) Red Grouper Landings by State 1981-2013



b) Red Grouper Landings by State and Year 1981-2013

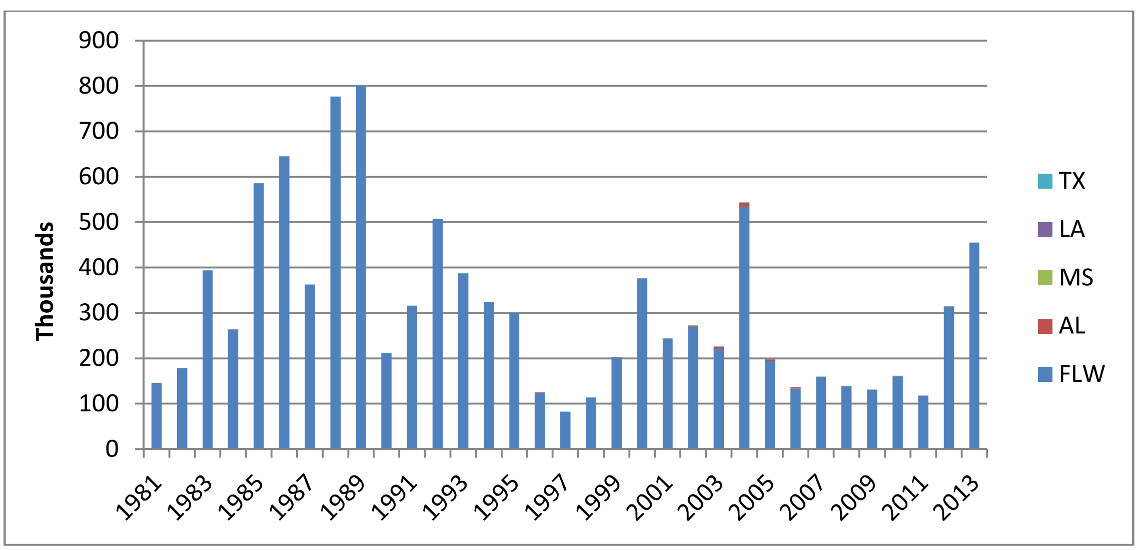
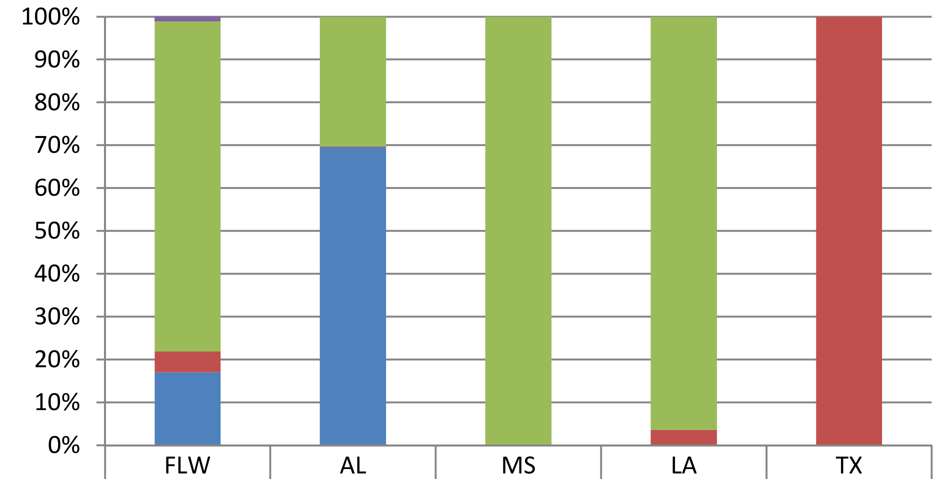


Figure 4.9.1. Estimated number of Gulf of Mexico red grouper landings from MRIP (1981-2013) and SRHS (1986-2013) by state (a), by state and year (b), and by state and mode (c). Due to confidentiality issues, SRHS FLW and AL estimates are combined and shown in FLW and MS and LA are combined and shown in LA.

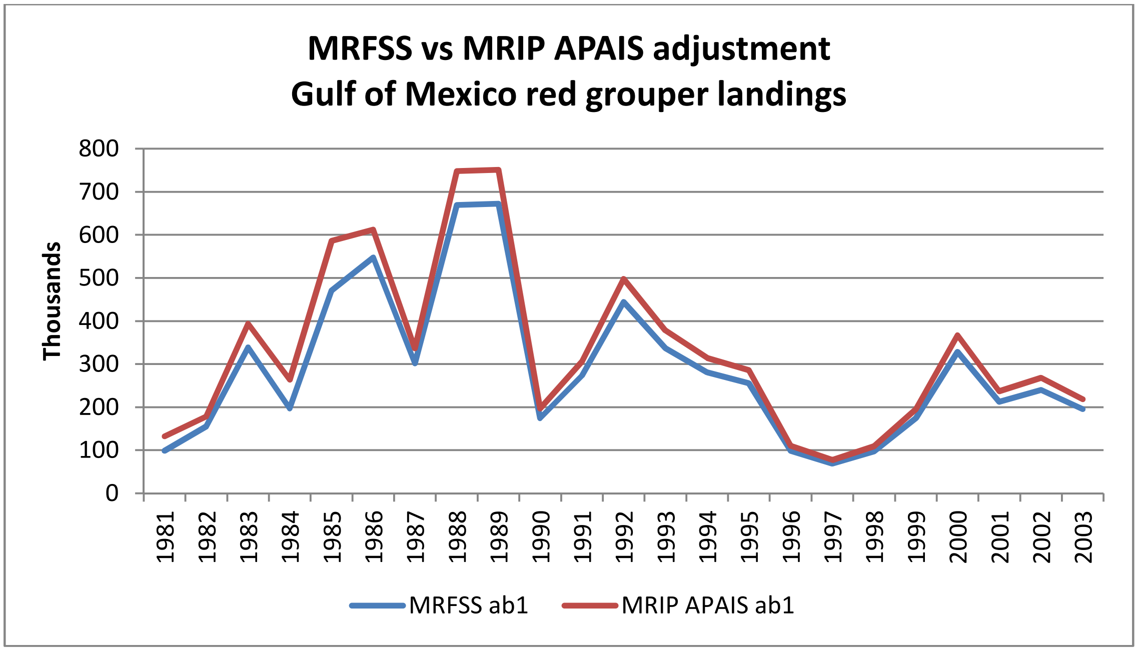
c) Red Grouper Landings by State and Mode 1981-2013



	FLW	AL	MS	LA	TX
Shore	119,971	0	0	0	0
Priv	7,815,464	8,211	1,410	727	0
Hbt	493,322	45	0	27	124
Cbt	1,730,802	18,901	0	0	0

Figure 4.9.1 (continued). Estimated number of Gulf of Mexico red grouper landings from MRIP (1981-2013) and SRHS (1986-2013) by state (a), by state and year (b), and by state and mode (c). Due to confidentiality issues, SRHS FLW and AL estimates are combined and shown in FLW and MS and LA are combined and shown in LA.

a) AB1 (number of fish) landed



b) B2 (number of fish) discarded alive

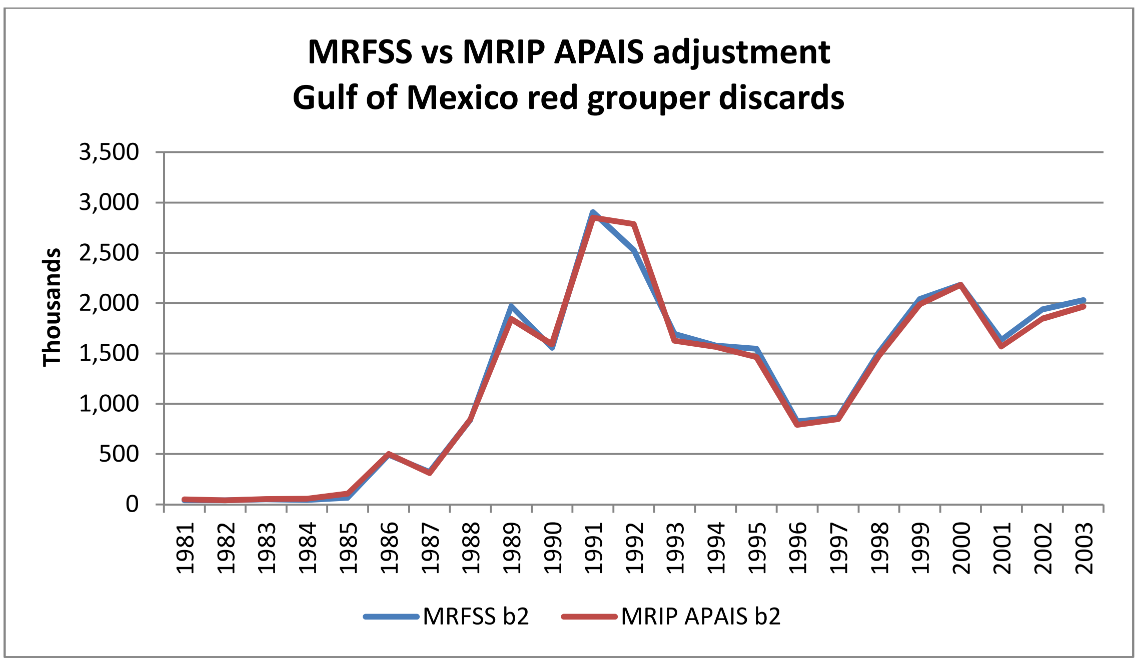
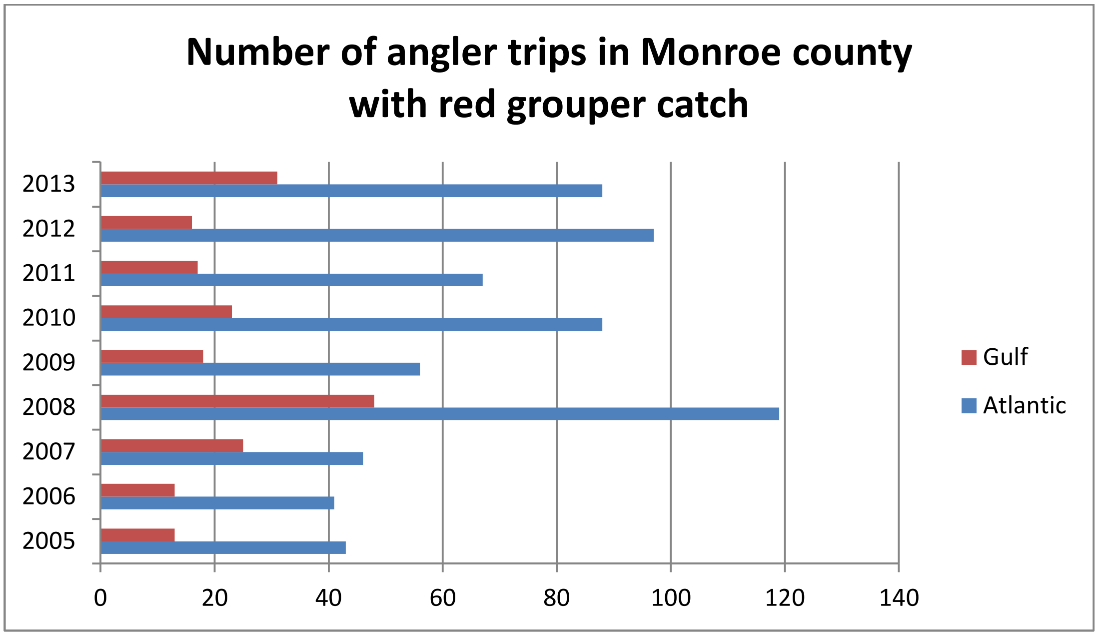


Figure 4.9.2. MRFSS estimates versus MRIP adjusted estimates for Gulf of Mexico red grouper 1981-2003.

a) Angler trips



b) Total catch

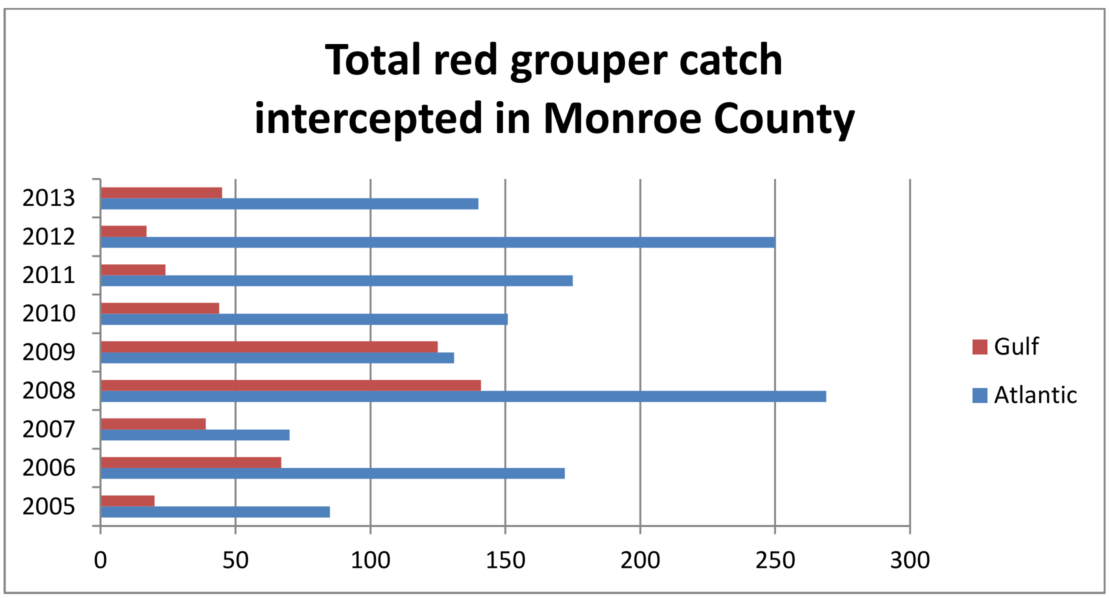


Figure 4.9.3. MRFSS intercept data indicating Gulf or Atlantic fishing (2005-2013).

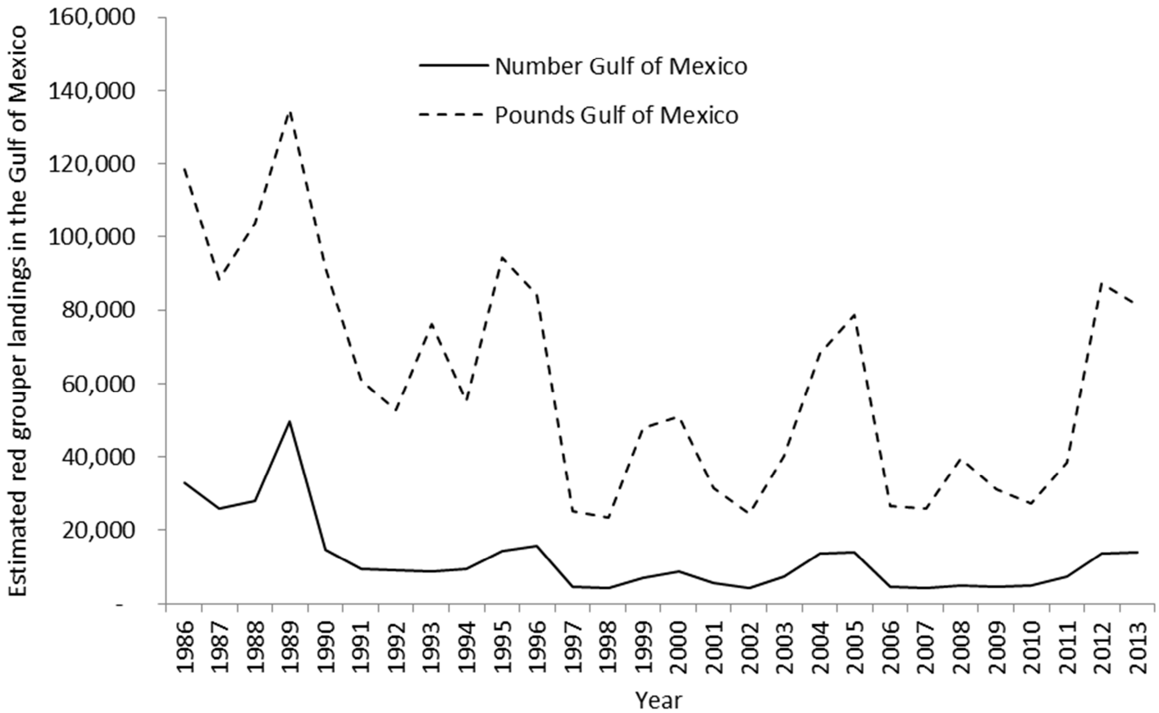
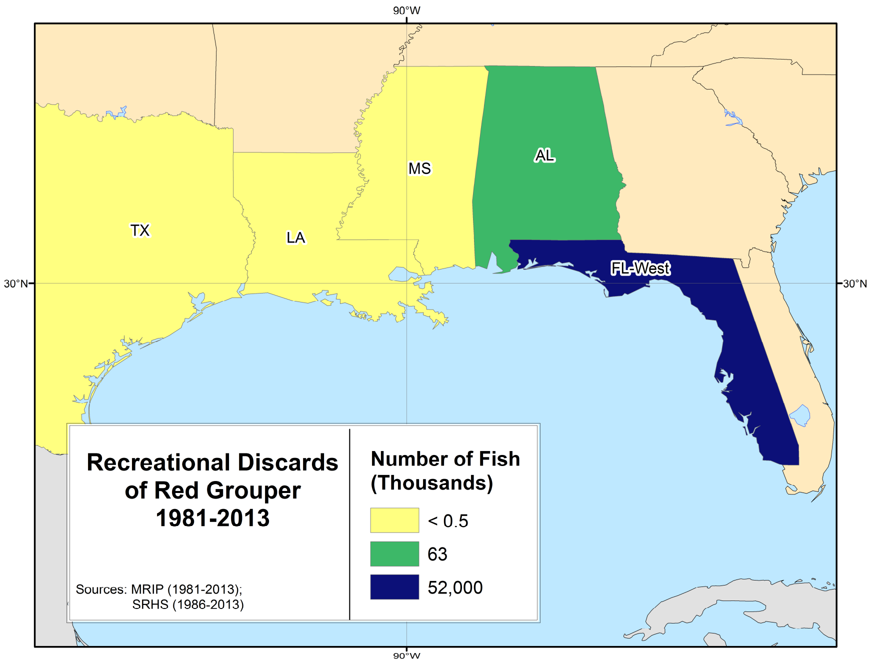


Figure 4.9.4. Gulf of Mexico estimated red grouper landings (number and pounds) for the headboat fishery, 1986-2013.

a) Red Grouper Discards by State 1981-2013



b) Red Grouper Discards by State and Year 1981-2013

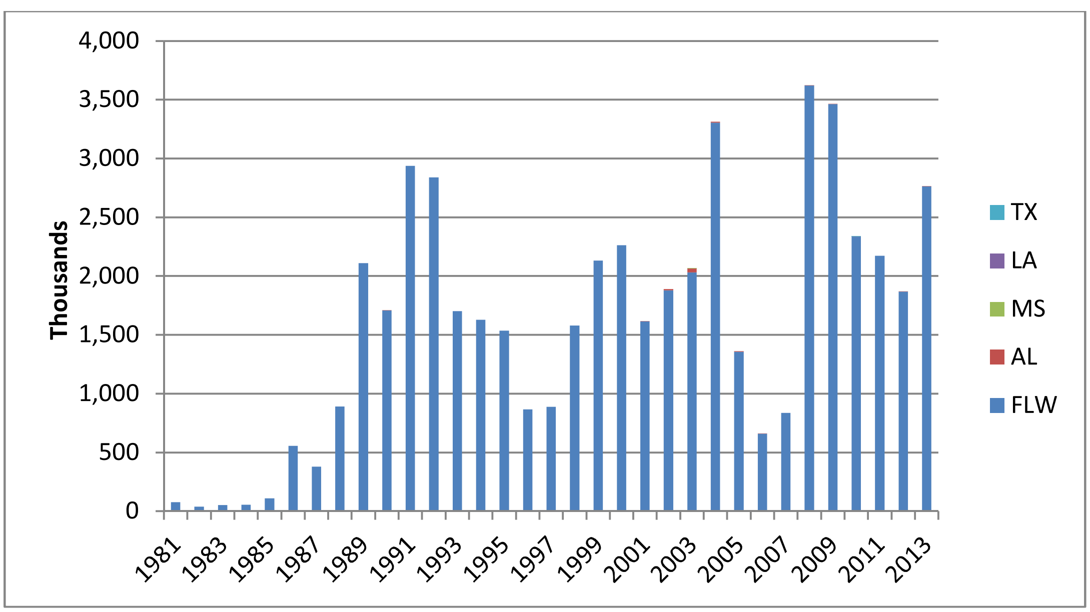
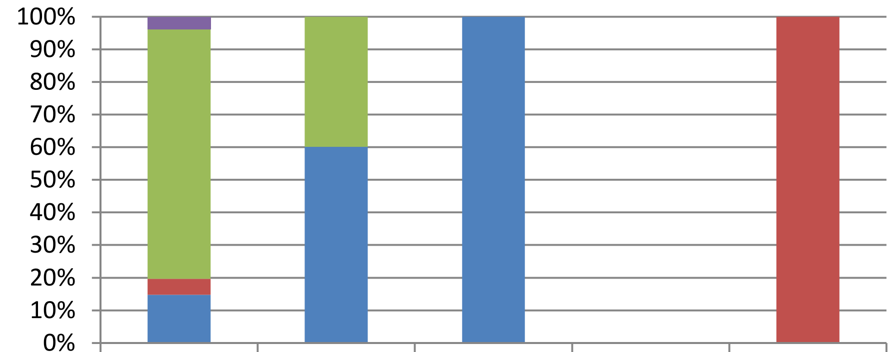


Figure 4.9.5. Estimated number of Gulf of Mexico red grouper discards from MRIP (1981-2013) and SRHS (1986-2013) by state (a), by state and year (b), and by state and mode (c). Due to confidentiality issues, SRHS FLW and AL estimates are combined and shown in FLW and MS and LA are combined and shown in LA.

c) Red Grouper Discards by State and Mode 1981-2013



	FLW	AL	MS	LA	TX
Shore	2,032,161	0	0	0	0
Priv	39,934,538	25,097	0	0	0
Hbt	2,552,116	0	0	0	2
Cbt	7,734,305	37,765	236	0	0

Figure 4.9.5 (continued). Estimated number of Gulf of Mexico red grouper discards from MRIP (1981-2013) and SRHS (1986-2013) by state (a), by state and year (b), and by state and mode (c). Due to confidentiality issues, SRHS FLW and AL estimates are combined and shown in FLW and MS and LA are combined and shown in LA.

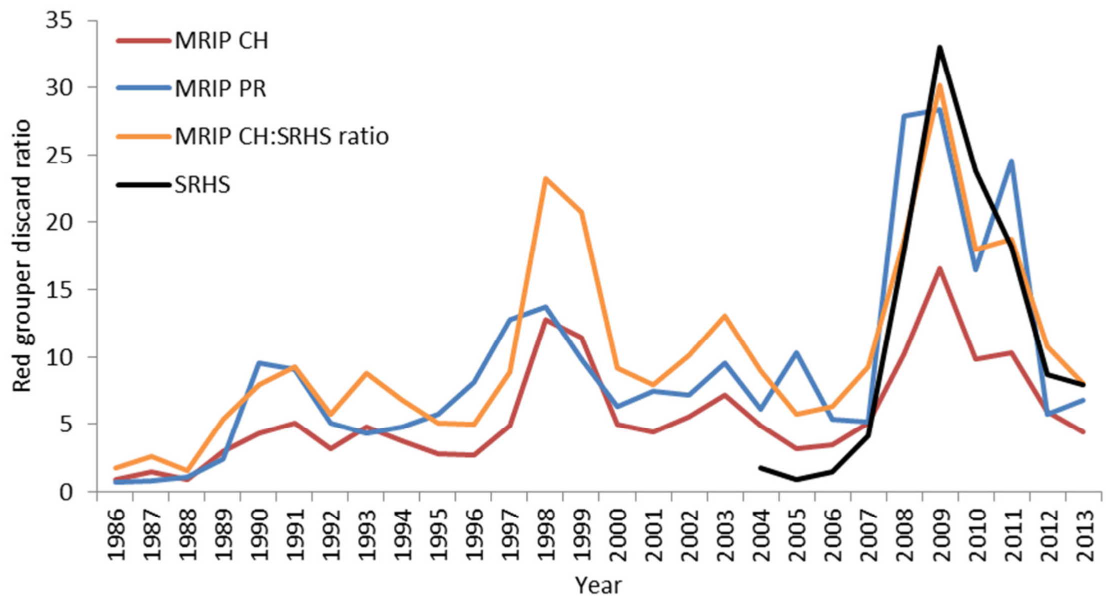


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Figure 4.9.6. MRIP CH (1986-2013), MRIP PR (1986-2013), MRIP CH:SRHS discard ratio methods (1986-2013), and SRHS discard ratios (2004-2013).

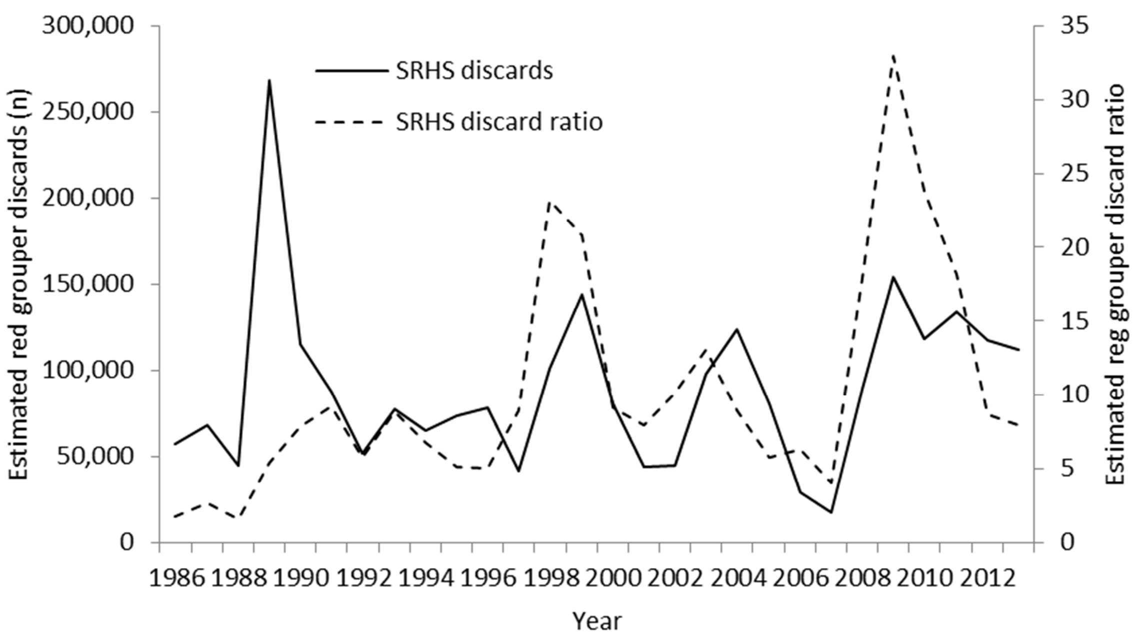


Figure 4.9.7. Gulf of Mexico estimated red grouper discards and discard ratio for headboats (MRIP CH:SRHS proxy method 1986-2006; SRHS 2007-2013).

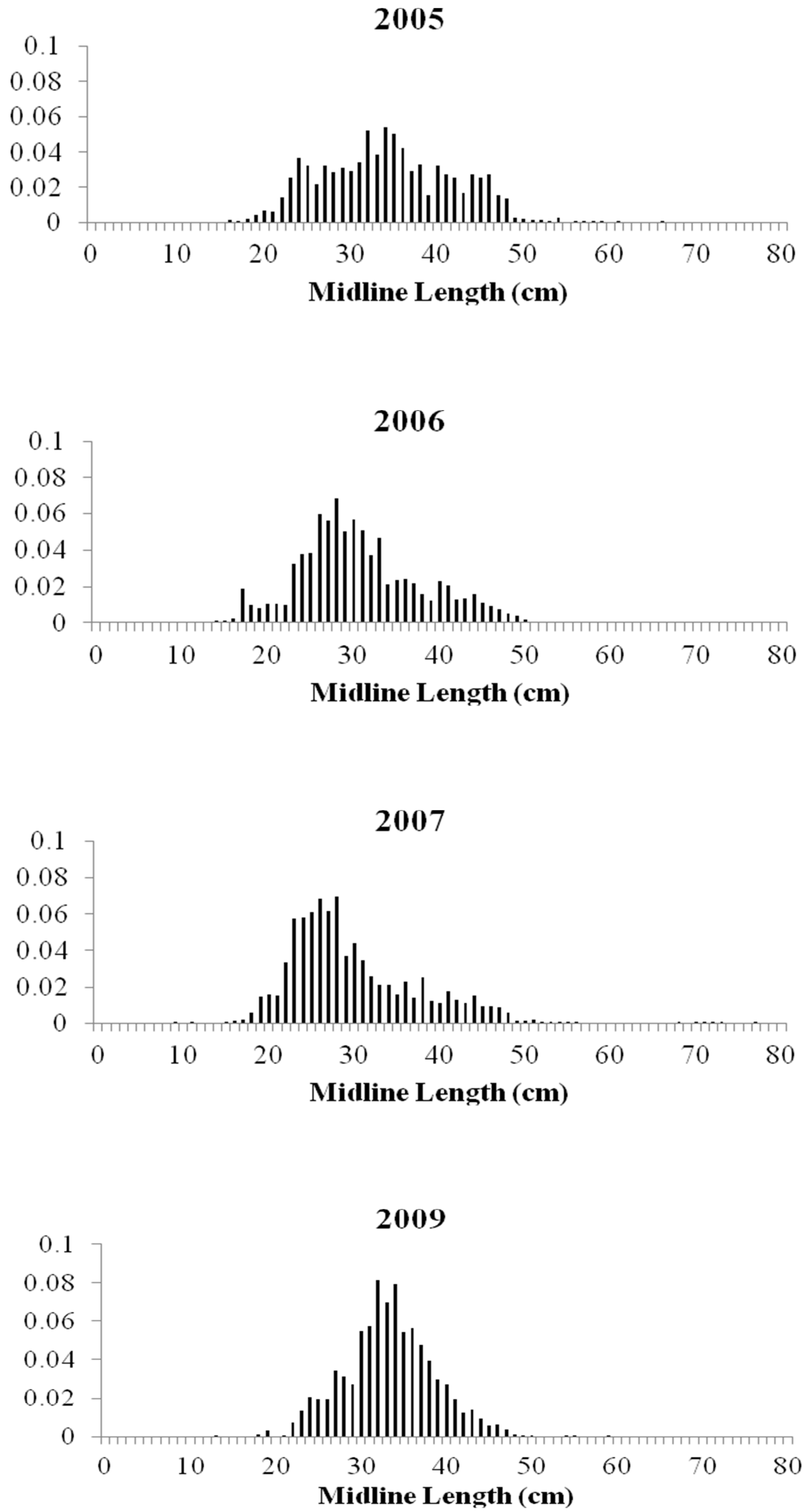


Figure 4.9.8. Weighted length frequencies (expressed as proportions) of red grouper discards for headboat vessels. The minimum size limit for harvest is 20” total length (50.8 cm TL).

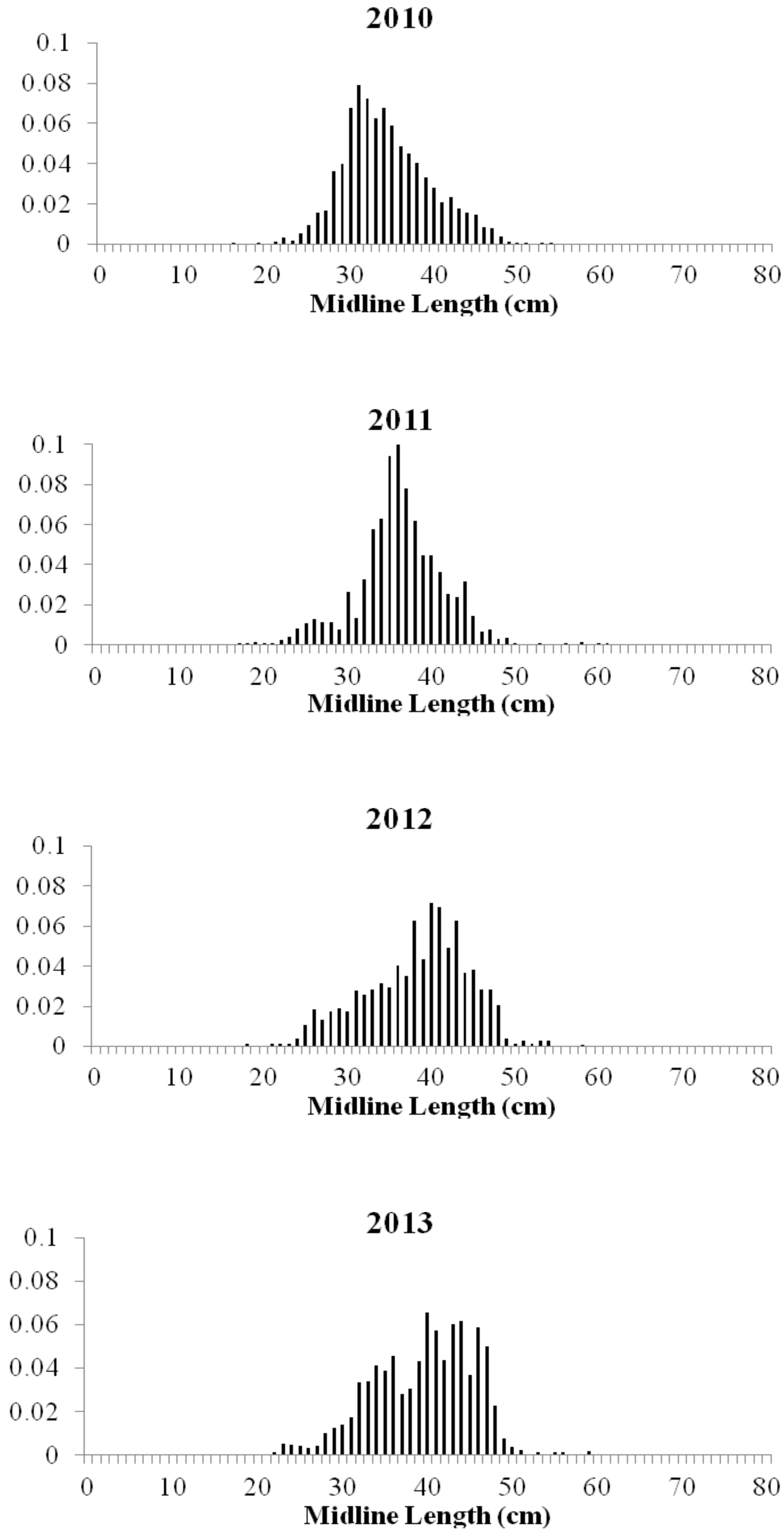


Figure 4.9.8 (continued). Weighted length frequencies (expressed as proportions) of red grouper discards for headboat vessels. The minimum size limit for harvest is 20" total length (50.8 cm TL).

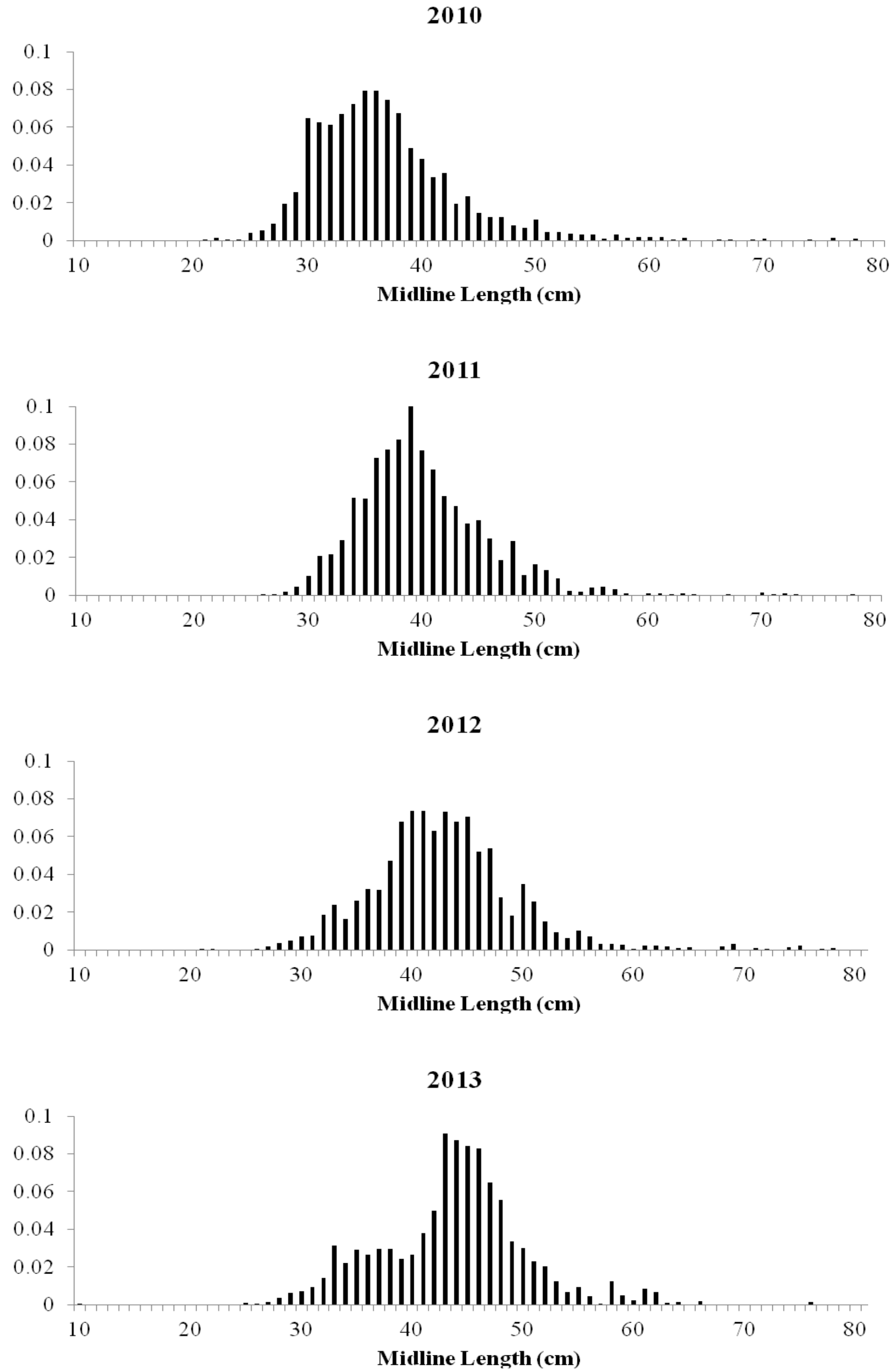


Figure 4.9.9. Weighted length frequencies (expressed as proportions) of red grouper discards for charter vessels. The minimum size limit for harvest is 20” total length (50.8 cm TL).

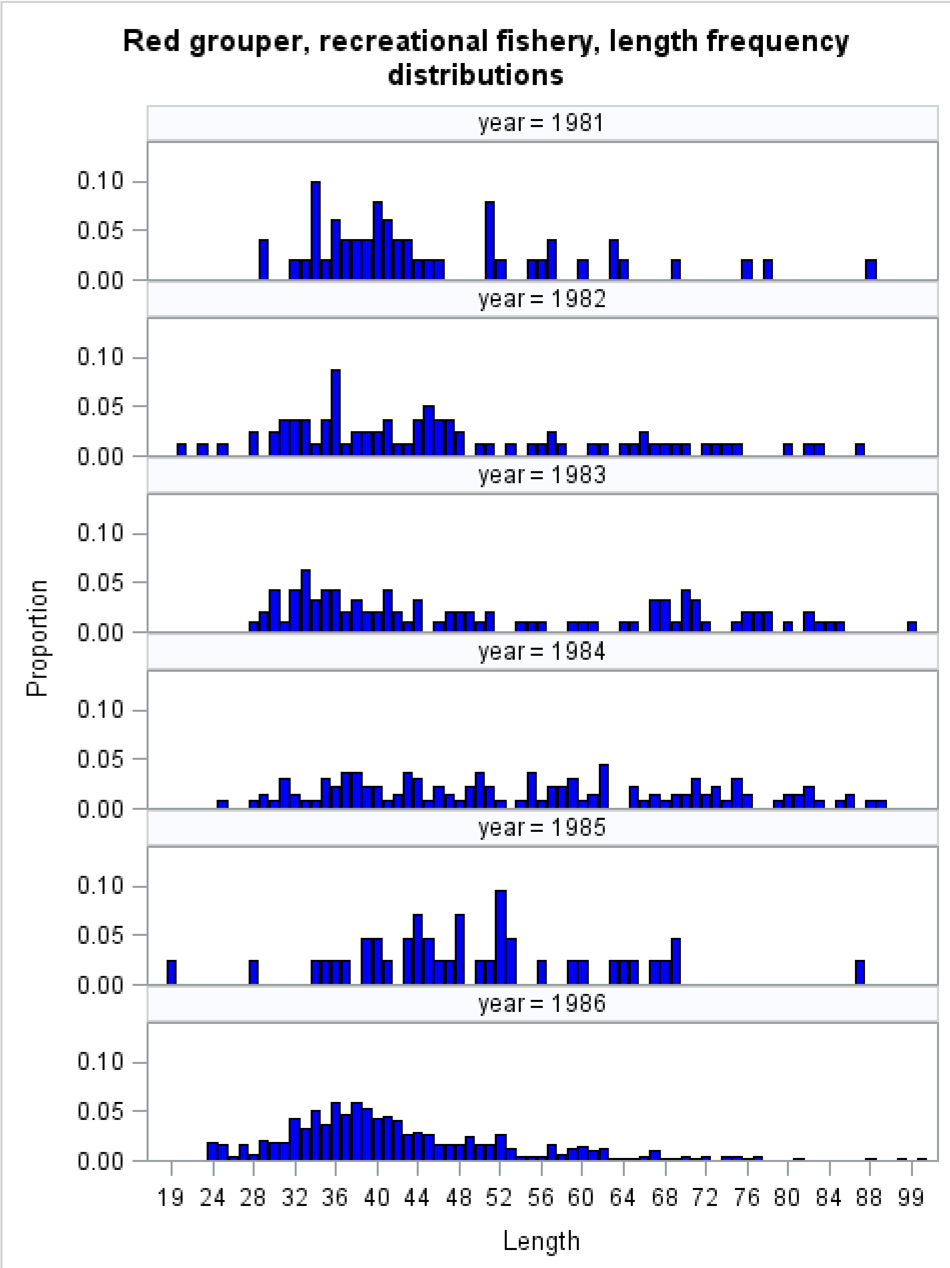


Figure 4.9.10. Length frequency distributions (LFDs) for red grouper length samples collected between 1981 and 1986 from recreational fisheries in the Gulf of Mexico.

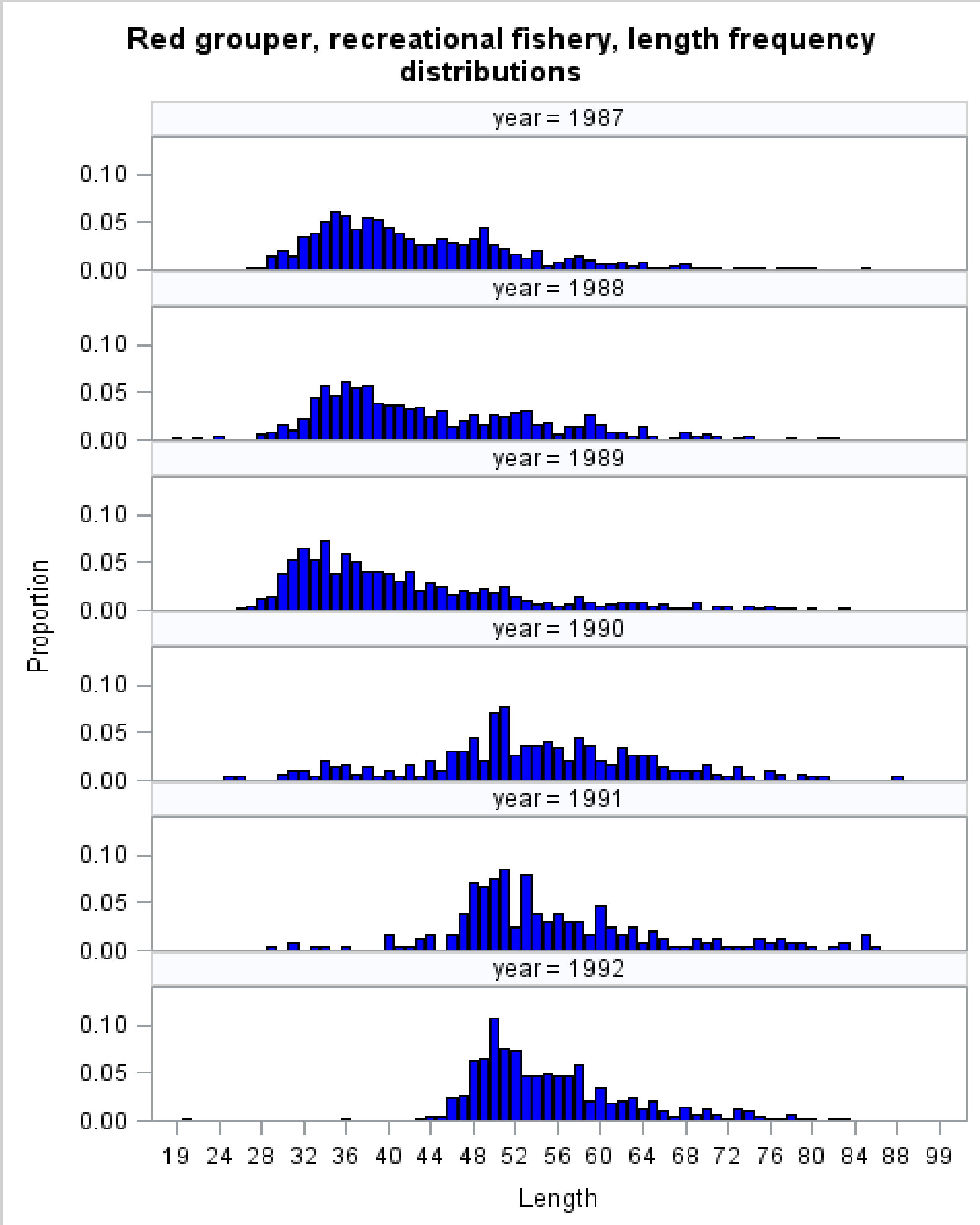


Figure 4.9.10 (continued). Length frequency distributions (LFDs) for red grouper length samples collected between 1987 and 1992 from recreational fisheries in the Gulf of Mexico.

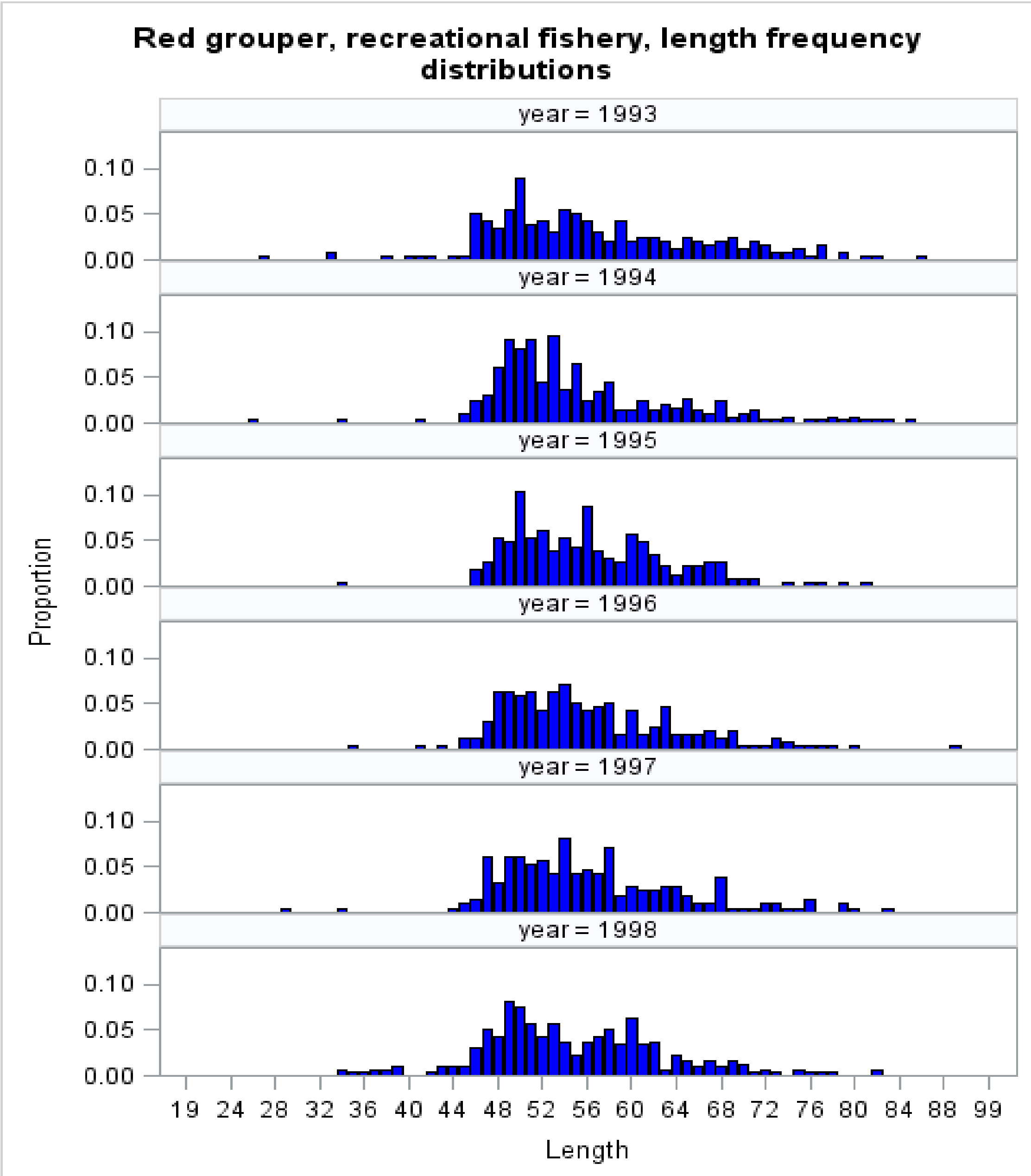


Figure 4.9.10 (continued). Length frequency distributions (LFDs) for red grouper length samples collected between 1993 and 1998 from recreational fisheries in the Gulf of Mexico.

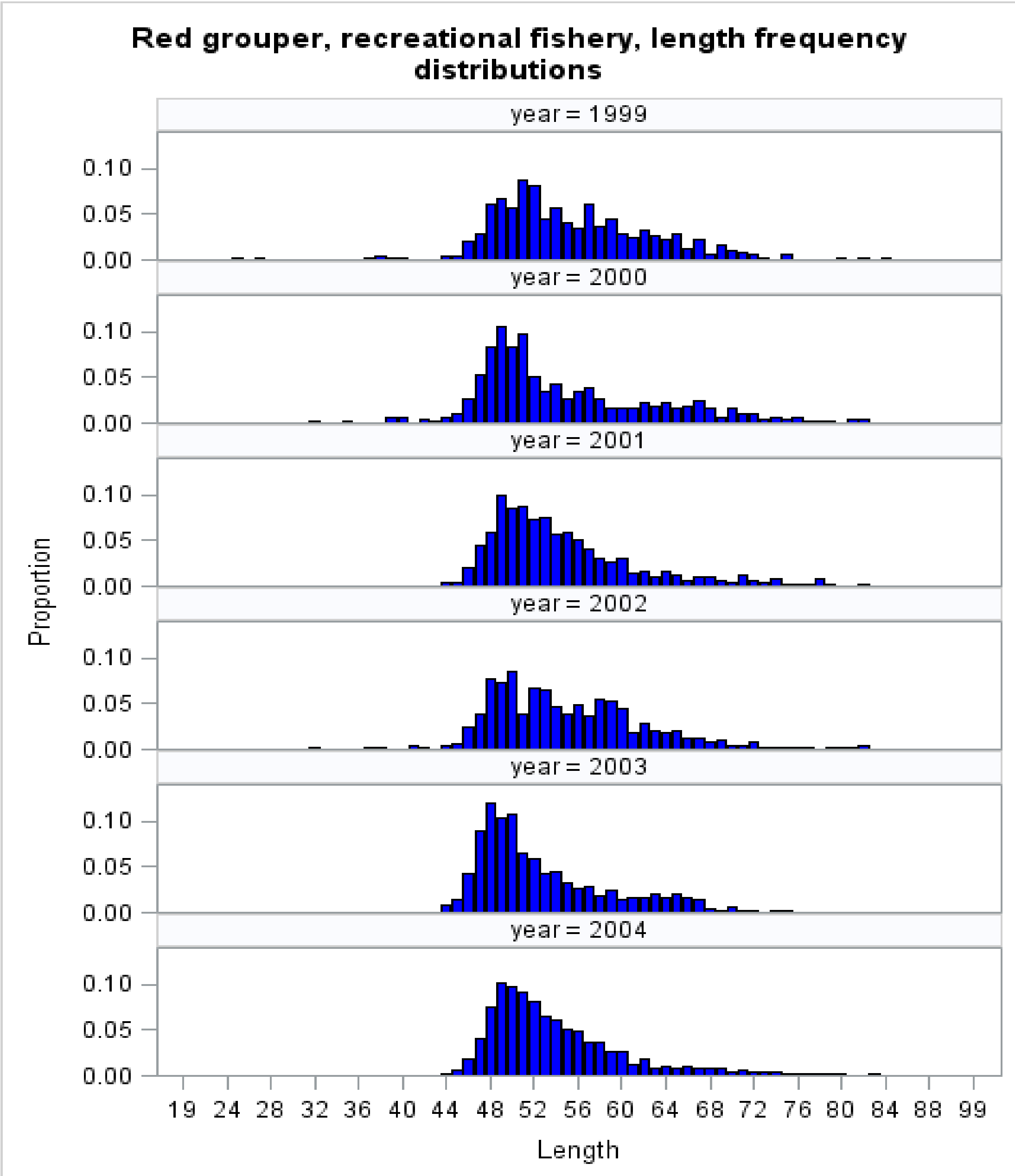


Figure 4.9.10 (continued). Length frequency distributions (LFDs) for red grouper length samples collected between 1999 and 2004 from recreational fisheries in the Gulf of Mexico.

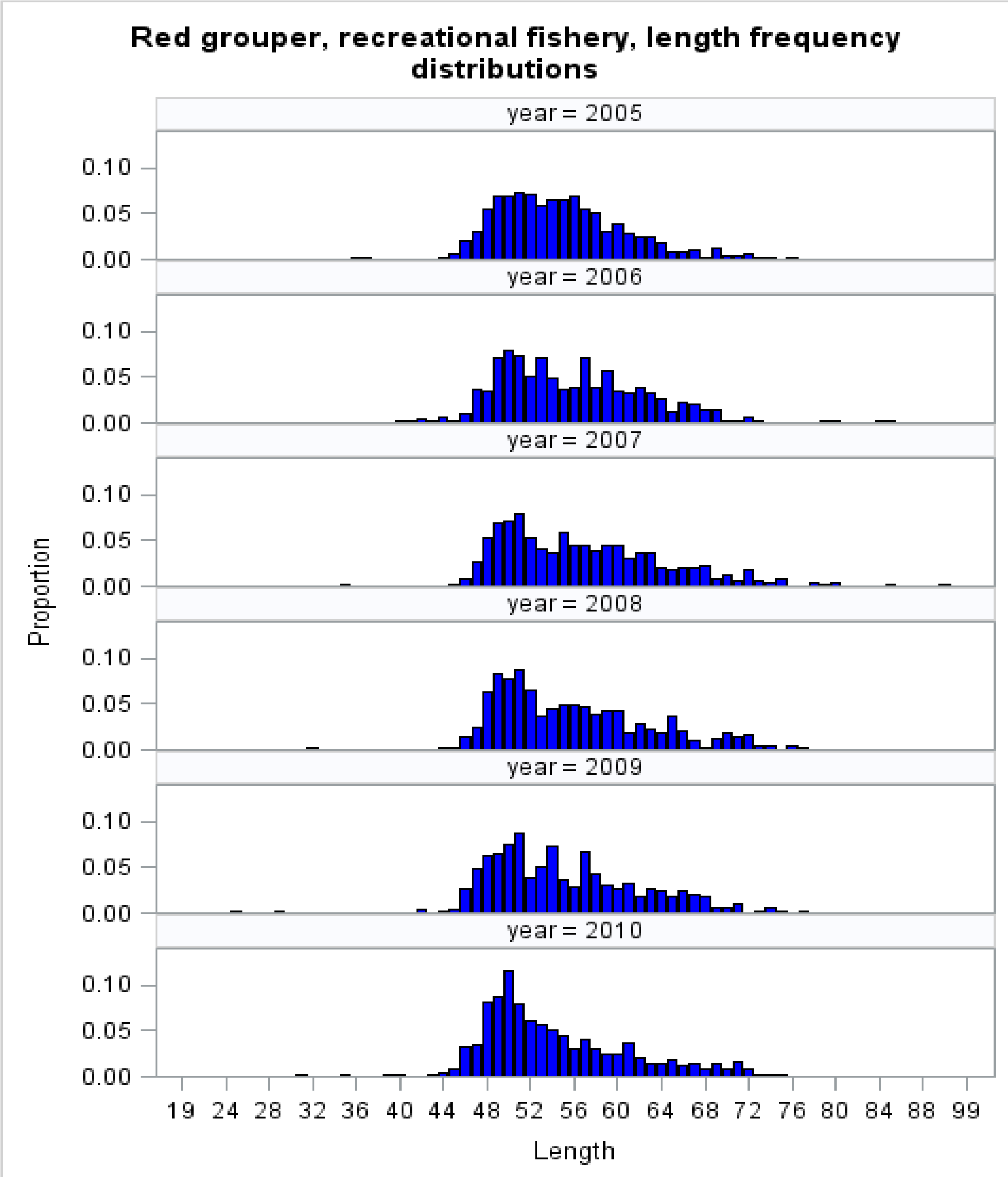


Figure 4.9.10 (continued). Length frequency distributions (LFDs) for red grouper length samples collected between 2005 and 2010 from recreational fisheries in the Gulf of Mexico.

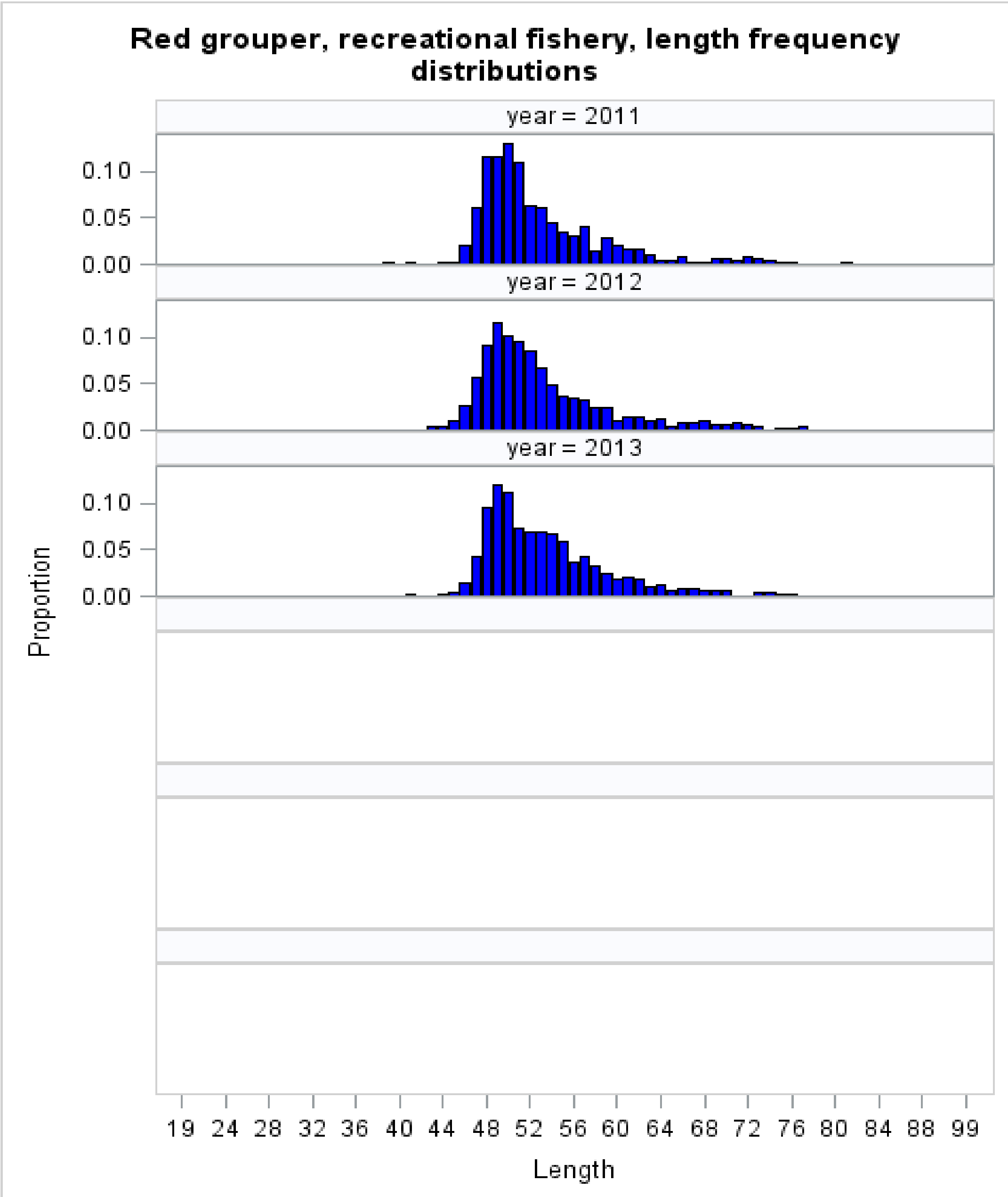


Figure 4.9.10 (continued). Length frequency distributions (LFDs) for red grouper length samples collected between 2011 and 2013 from recreational fisheries in the Gulf of Mexico.

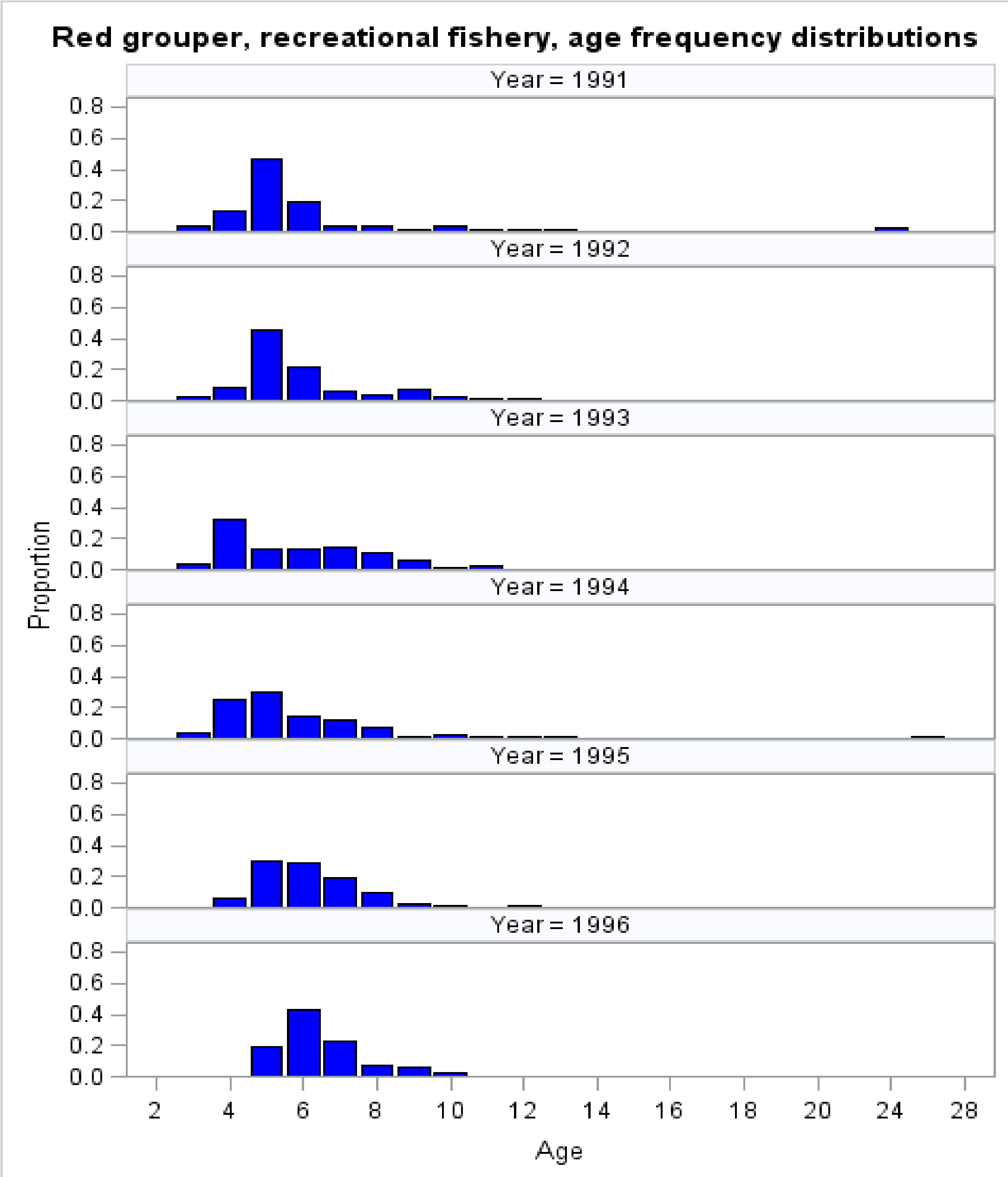


Figure 4.9.11. Reweighted age frequency distributions (AFDs) for red grouper age samples collected between 1991 and 1996 from recreational fisheries in the Gulf of Mexico.

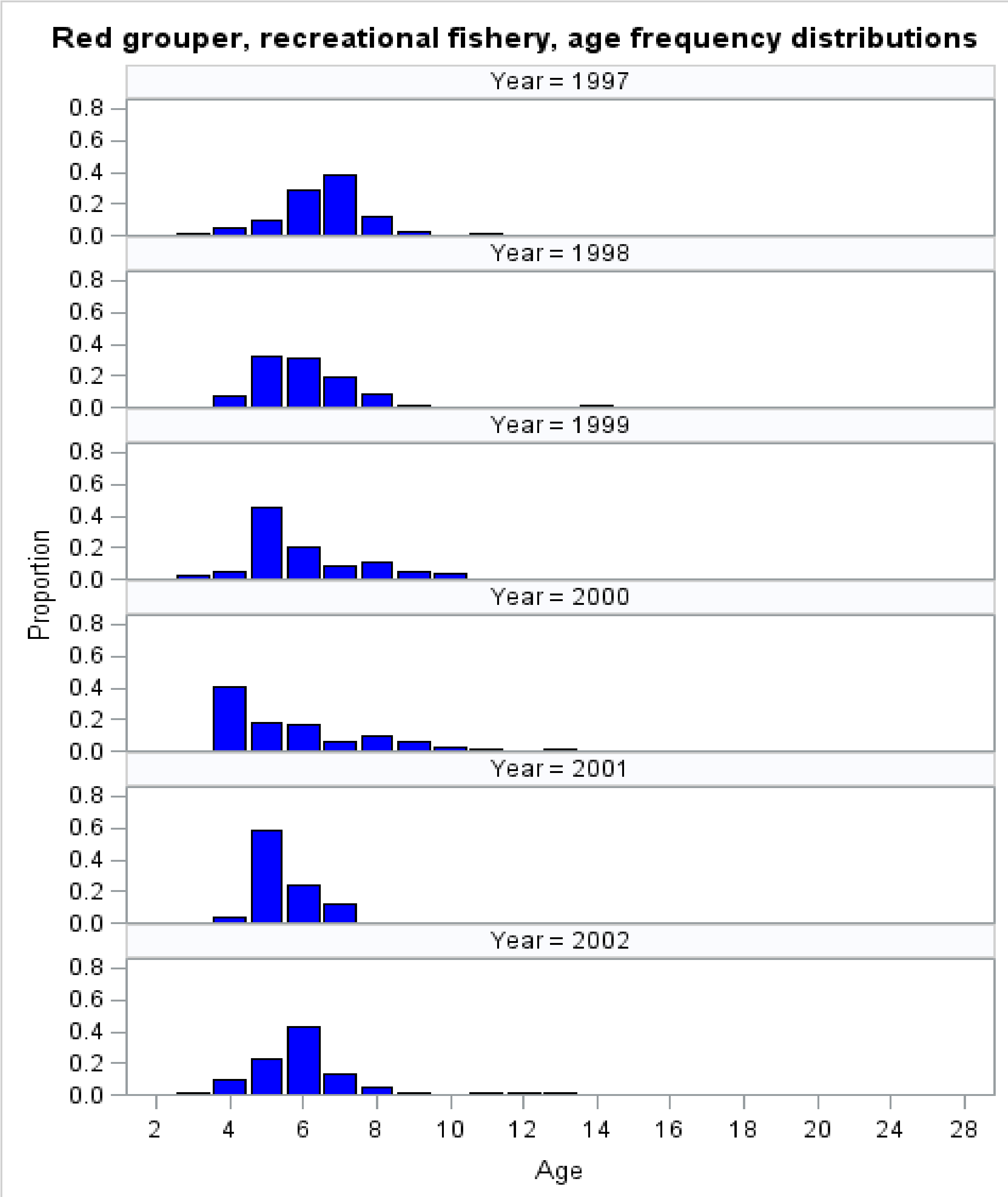


Figure 4.9.11 (continued). Reweighted age frequency distributions (AFDs) for red grouper age samples collected between 1997 and 2002 from recreational fisheries in the Gulf of Mexico.

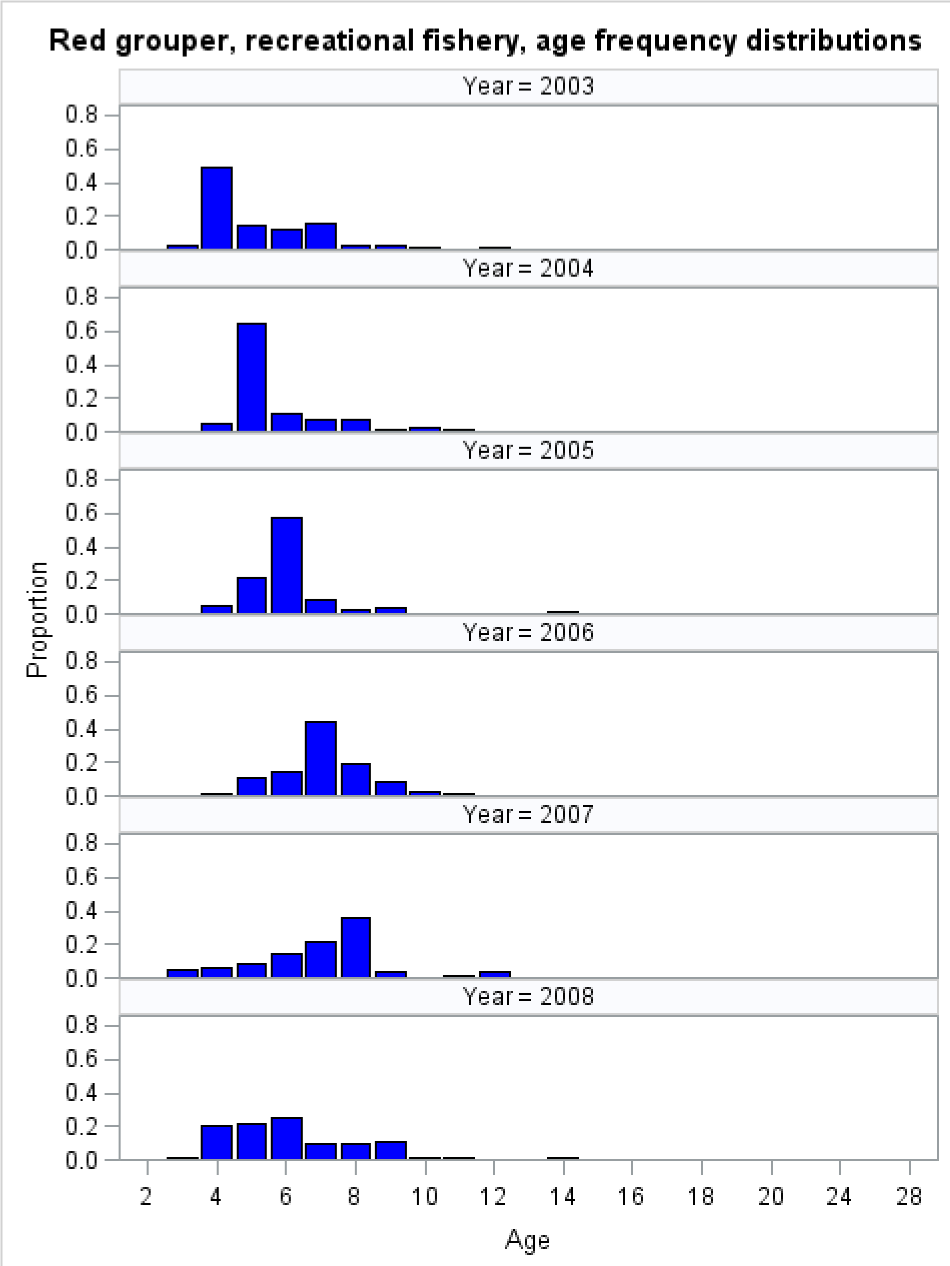


Figure 4.9.11 (continued). Reweighted age frequency distributions (AFDs) for red grouper age samples collected between 2003 and 2008 from recreational fisheries in the Gulf of Mexico.

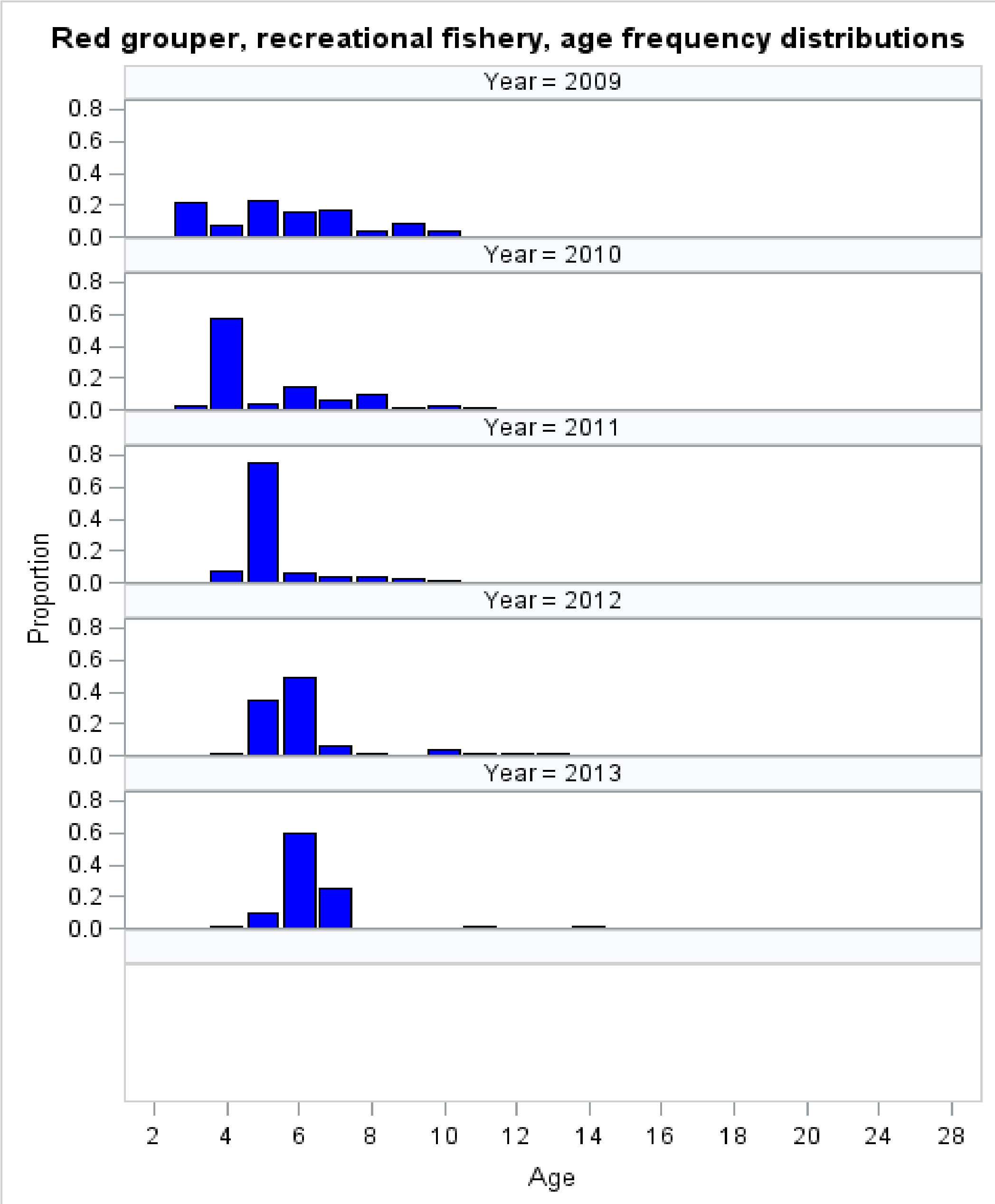
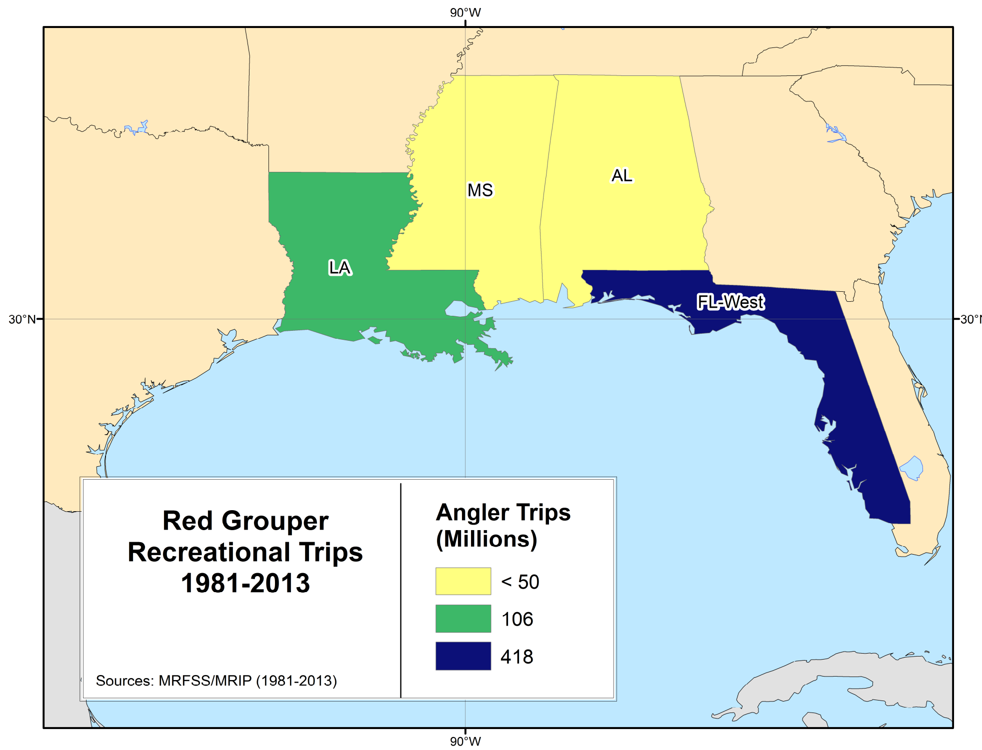


Figure 4.9.11 (continued). Reweighted age frequency distributions (AFDs) for red grouper age samples collected between 2009 and 2013 from recreational fisheries in the Gulf of Mexico.

a) **Angler Trips by State 1981-2013**



b) **Angler Trips by State and Year 1981-2013**

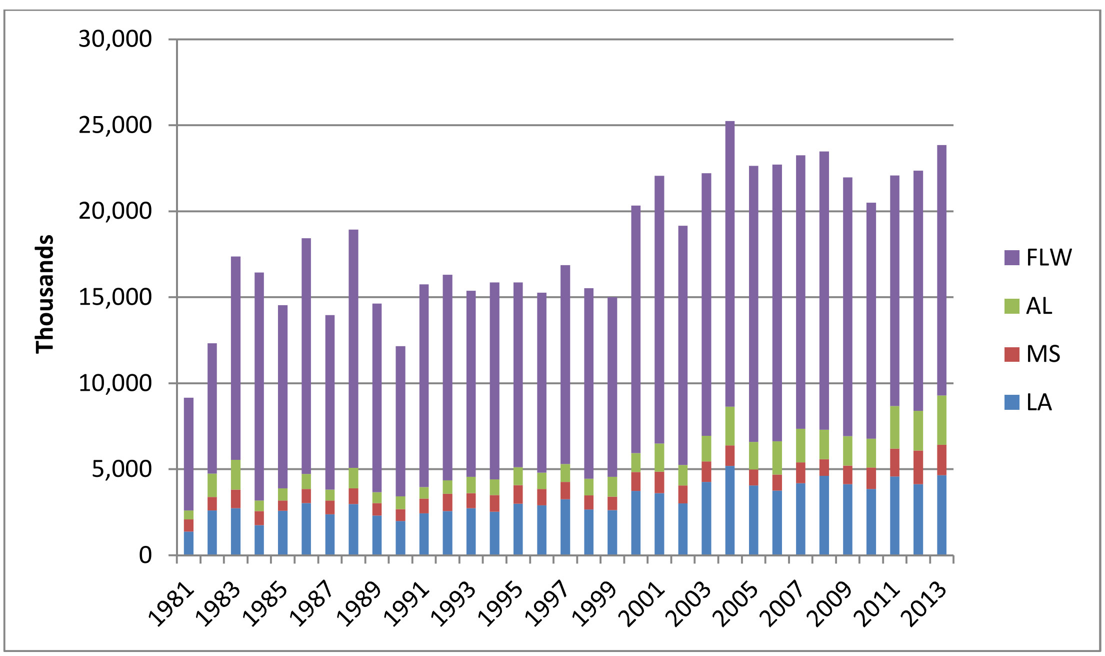
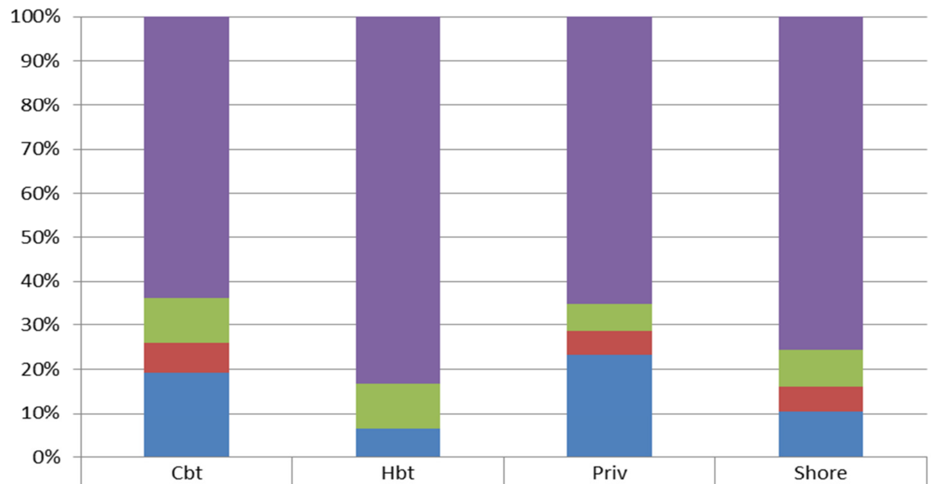


Figure 4.9.12. Gulf of Mexico estimated number of angler trips from MRFSS/MRIP (1981-2013) by state (a), by state and year (b), and by state and mode (c). MRFSS/MRIP data from LA to FLW, not including the Keys. Hbt angler trips from 1981 to 1985 only.

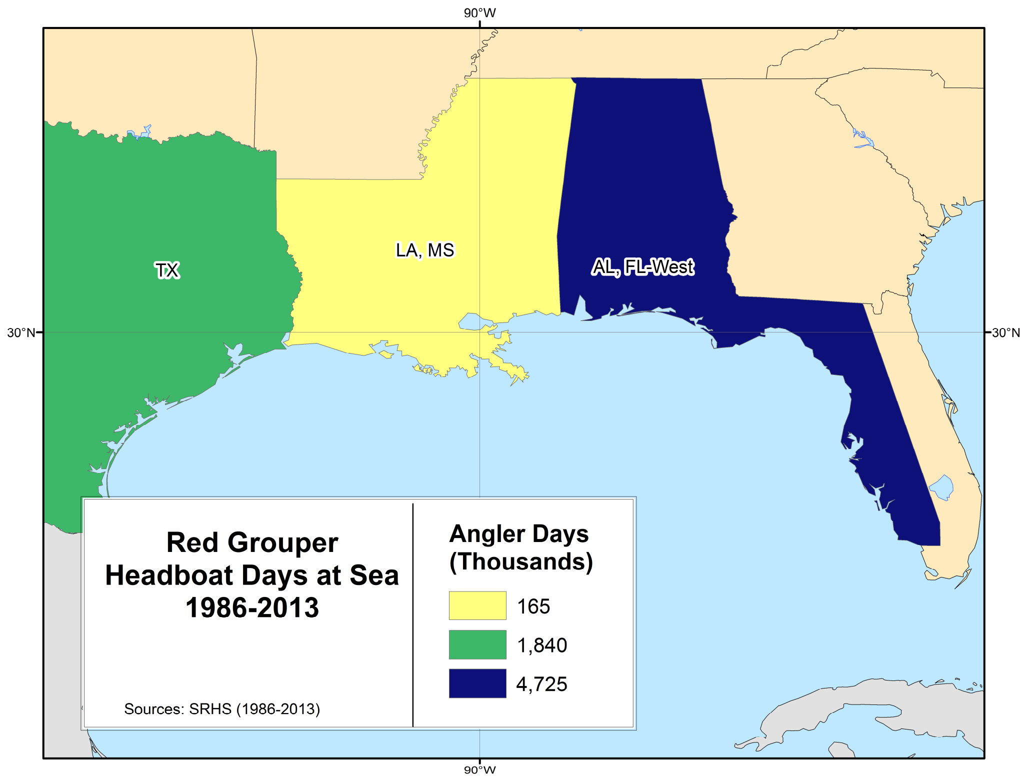
c) **Angler Trips by State and Mode 1981-2013**



	Cbt	Hbt	Priv	Shore
FLW	11,647,657	555,174	213,442,040	192,541,453
AL	1,913,368	69,072	20,315,879	21,097,958
MS	1,214,591	0	18,187,768	14,291,651
LA	3,521,985	43,262	75,966,212	26,808,570

Figure 4.9.12. (continued). Gulf of Mexico estimated number of angler trips from MRFSS/MRIP (1981-2013) by state (a), by state and year (b), and by state and mode (c). MRFSS/MRIP data from LA to FLW, not including the Keys. Hbt angler trips from 1981 to 1985 only.

a) **Angler Days by State 1986-2013**



b) **Angler Days by State and Year 1986-2013**

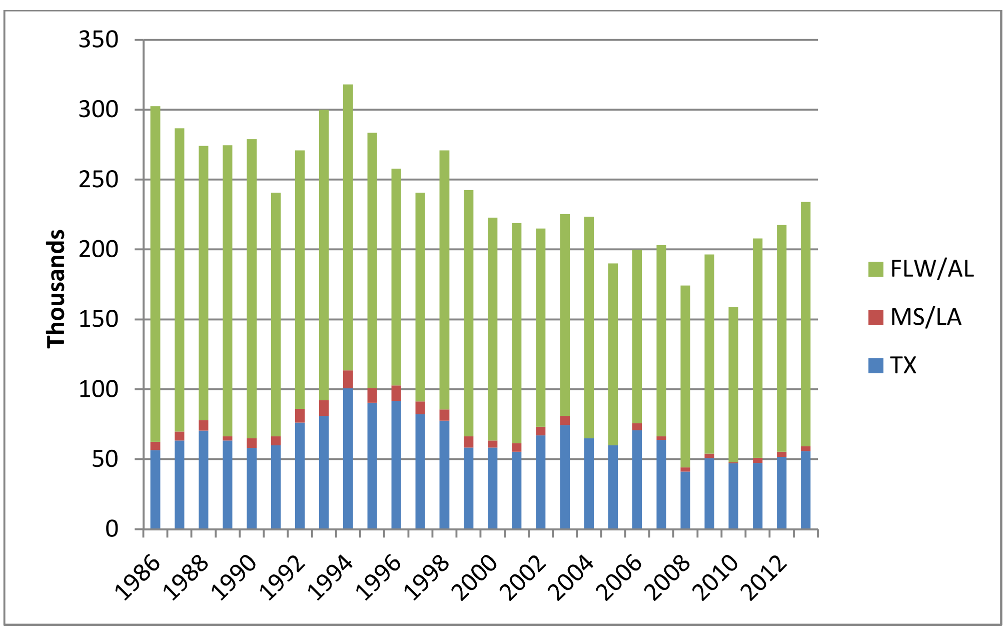


Figure 4.9.13. Gulf of Mexico estimated number of headboat angler days from SRHS (1986-2013) by state (a) and by state and year (b). Due to confidentiality issues, SRHS FLW and AL estimates are combined and shown in FLW and MS and LA are combined and shown in LA.

5 MEASURES OF POPULATION ABUNDANCE

5.1 OVERVIEW

Indices and accompanying analyses from 15 fishery-dependent and fishery-independent datasets were presented to the Index Working Group (IWG). The working papers containing full descriptions of the data sets and analytical methods are listed in Section 5.2, and spatial coverage of each is included in Figure 5.9.1. Rationalizations for the recommendation/exclusion of an index are given herein in the 'Comments on Adequacy for Assessment' section for each individual index. Diagnostic plots for each index can be found in the individual working papers. Three fishery-independent and four fishery-dependent indices of abundance are recommended for use in the assessment by the IWG and include:

Fishery Independent	Fishery Dependent
• SEAMAP Summer Groundfish	Headboat Survey
• NMFS Bottom Longline	MRFSS
• Combined Video	Commercial Longline
(SEAMAP/Panama City/FWRI)	Commercial Vertical Line

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

Fishery Independent	Fishery Dependent
• SEAMAP Video	Commercial Trap
• Panama City Video	Everglades National Park Creel Survey
• Panama City Trap	Headboat Observer Discard
• FWRI Video	
• FWRI Trap	
• Dry Tortugas Visual Census	

5.1.1 Group Membership

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

5.2 REVIEW OF WORKING PAPERS

The IWG reviewed the following working papers:

Document #	Title	Authors
SEDAR42-DW-05	Red Grouper Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico	Adam G. Pollack and G. Walter Ingram, Jr.
SEDAR42-DW-06	Red Grouper Abundance Indices from NMFS Bottom Longline Surveys in the Northern Gulf of Mexico	Adam G. Pollack and G. Walter Ingram, Jr.
SEDAR42-DW-08	Indices of abundance for Red Grouper (*Epinephelus morio*) from the Florida Fish and Wildlife Research Institute (FWRI) video survey on the West Florida Shelf	Cameron B. Guenther, Theodore S. Switzer, Sean F. Keenan, and Robert H. McMichael, Jr.
SEDAR42-DW-09	Indices of abundance for Red Grouper (*Epinephelus morio*) from the Florida Fish and Wildlife Research Institute (FWRI) chevron trap survey on the West Florida Shelf	Cameron B. Guenther, Theodore S. Switzer, Sean F. Keenan, and Robert H. McMichael, Jr.
SEDAR42-DW-11	SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Red Grouper	Matthew D. Campbell, Kevin R. Rademacher, Michael Hendon, Paul Felts, Brandi Noble, Michael Felts, Joseph Salisbury, and John Moser
SEDAR42-DW-14	Size Distribution of Red Grouper Observed in For-Hire Recreational Fisheries in the Gulf of Mexico	Alisha Gray and Beverly Sauls
SEDAR42-DW-15	Red Grouper *Epinephelus morio* Findings from the NMFS Panama City Laboratory Trap & Camera Fishery-Independent Survey – 2004-2014	D.A. DeVries, C.L. Gardner, P. Raley, and W. Ingram
SEDAR42-DW-19	Index report cards	Indices Working Group

5.3 FISHERY INDEPENDENT SURVEYS

5.3.1 SEAMAP Summer Groundfish

The Southeast Fisheries Science Center Mississippi Laboratories and state partners have conducted standardized groundfish surveys under the Southeast Area Monitoring and Assessment Program (SEAMAP) in the Gulf of Mexico (GOM) since 1987. Prior to 1987, the summer survey was conducted under SEAMAP protocols; however, the fall survey operated independent of SEAMAP and dates back to 1972. SEAMAP is a collaborative effort between federal, state and university programs, designed to collect, manage and distribute fishery independent data throughout the region. The primary objective of this trawl survey is to collect data on the abundance and distribution of demersal organisms in the northern GOM. This survey, which is conducted semi-annually (summer and fall), provides an important source of fisheries independent information on many commercially and recreationally important species throughout the GOM.

5.3.1.1 Methods of Estimation

Data Filtering Techniques

The data included in the analysis met the following criteria:

1. No problems with tow (i.e. net torn, doors crossed, etc.).
2. Depths between 5 and 60 fathoms.
3. Within shrimp statistical zones 2 – 8 (east of 86° W) (no catch of red grouper outside of these zones).
4. Sampled with a 40 ft shrimp trawl (Texas uses a 20 ft shrimp trawl and data are not used).
5. Sampled during the summer survey, between 2009 and 2013 (sampling by Florida, which comprises a large percentage of sampling effort in the eastern Gulf of Mexico, has been intermittent in the fall). Earlier years were not included because little or no sampling was done off Florida, the only area where red grouper are normally caught, before 2009.

Standardization

The delta-lognormal index of relative abundance (I_y) (Lo *et al*. 1992) was estimated as:

$$I_y = c_y p_y,$$

where c_y is the estimate of mean CPUE for positive catches only for year y, and p_y is the estimate of mean probability of occurrence during year y. Both c_y and p_y were estimated using generalized linear models. Data used to estimate abundance for positive catches (c) and probability of occurrence (p) were assumed to have a lognormal distribution and a binomial distribution, respectively, and modeled using the following equations:

$$\ln(c) = X\beta + \varepsilon$$

and

$$p = \frac{e^{\mathbf{X\beta+\varepsilon}}}{1+e^{\mathbf{X\beta+\varepsilon}}},$$

respectively, where c is a vector of the positive catch data, p is a vector of the presence/absence data, X is the design matrix for main effects, β is the parameter vector for main effects, and ε is a vector of independent normally distributed errors with expectation zero and variance σ^2. Therefore, c_y and p_y were estimated as least-squares means for each year along with their corresponding standard errors, SE (c_y) and SE (p_y), respectively. From these estimates, I_y was calculated, as in equation (1), and its variance calculated using the delta method approximation

$$V(I_y) \approx V(c_y)p_y^2 + c_y^2 V(p_y).$$

A covariance term is not included in the variance estimator since there is no correlation between the estimator of the proportion positive and the mean CPUE given presence. The two estimators are derived independently and have been shown to not covary for a given year (Christman, unpublished).

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

<u>*Submodel Variables*</u>

Year: 2009 – 2013

Depth: 5-60 fathoms (continuous)

Shrimp Statistical Zone: Zones 2 - 8

Time of Day: Day, Night

<u>Annual Abundance Index</u>

Year, depth and shrimp statistical zone were retained in both the binomial submodel and the lognormal submodel.

5.3.1.2 Sampling Intensity and Time Series

There were a total of 676 stations sampled from the Florida Keys, FL to Panama City, FL (between longitudes 81°W and 86°W), during June and July from 2009 – 2013 (Table 5.8.1)

5.3.1.3 Size/Age Data

The average size of red grouper represented in this index was 302 mm (fork length), with the majority of fish being between 2 and 3 years old. Length and age data are presented in Figure 5.9.2.

5.3.1.4 Catch Rates

Standardized catch rates are presented in Table 5.8.1 and Figure 5.9.3.

5.3.1.5 Uncertainty and Measures of Precision

Annual CVs of catch rates are presented in Table 5.8.1.

5.3.1.6 Comments on Adequacy for Assessment

The SEAMAP Summer Groundfish Survey index was recommended for use in the stock assessment. This fishery independent survey has good spatial coverage of the eastern GOM, although the time series is short (5 years). This survey also covers a much greater portion of younger members of the population (1-2 year olds) than covered by other fishery independent indices.

5.3.2 NMFS Bottom Longline

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

In 2011, the Congressional Supplemental Sampling Program (CSSP) enabled high levels of survey effort to be maintained from April through October. This program used the same gear and a similar survey design as the annual bottom longline survey, differing only in the maximum depths sampled – CSSP to 400 m vs annual survey to 366 m.

Methods of Estimation

Data Filtering Techniques

We used the time series of data between 2001 and 2013 to develop red grouper abundance indices. Data from 1995 – 2000 were not used due to the use of J hooks during those years, resulting in very few red grouper (n=53) being captured, with the change to circle-hooks in 2001, red grouper catch increased by an order of magnitude. Survey year 2002 was dropped from analysis because of the limited spatial coverage in the eastern GOM. Data was limited spatially to an area east of 87°W, since no red grouper had been captured west of this point. Data was also limited to stations less than 119 m, since there were no records of red grouper being caught any deeper. In 2005, additional sampling was done in October and November (43 stations) since most of the survey was canceled due to Hurricane Katrina. However, there was little temporal overlap in other years (17 stations in 2004), so all stations done outside of August and September were removed.

Standardization

A delta –lognormal index of relative abundance (as described in Section 5.3.1.1) was estimated for red grouper (Lo *et al*. 1992).

Submodel Variables

Year: 2001, 2003 – 2013

Depth: 9 – 118 meters (continuous)

Area: Northern (north of 29°N), Central (between 27°N - 29°N), Southern (south of 27°N)

Time of Day: Day, Night

Annual Abundance Indices

Year, area and depth were retained in the binomial submodel, while year and area were retained in the lognormal submodel.

5.3.2.1 Sampling Intensity and Time Series

There were a total of 837 stations sampled from the Florida Keys, FL to Panama City, FL (between longitudes 81°W and 86°W), during August and September from 2001, 2003 – 2013 (Table 5.8.2)

5.3.2.2 Size/Age Data

The average size of red grouper represented in this index was 508 mm (fork length). Length and age data are presented in Figure 5.9.4.

5.3.2.3 Catch Rates

Standardized catch rates are presented in Table 5.8.2 and Figure 5.9.5.

5.3.2.4 Uncertainty and Measures of Precision

Annual CVs of catch rates are presented in Table 5.8.2.

5.3.2.5 Comments on Adequacy for Assessment

The IWG recommended that the NMFS Bottom Longline Index be used in the base run of the model. The pros of this index are that it is a fishery independent survey with good spatial and temporal coverage which also samples the entire depth range of red grouper.

5.3.3 SEAMAP Video

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

The survey has been executed from 1992-1997, 2001-2002, and 2004-2013 and historically takes place May – August. The 2001 survey was abbreviated due to ship scheduling, so that the only sites completed were those located in the western Gulf of Mexico. Types of data collected on the survey include diversity, abundance (minimum count), fish length, habitat type, habitat coverage, and bottom topography. The size of fish sampled with the video gear is species specific, however red grouper sampled over the history of the survey ranged from 190 to 971 mm FL, with annual means from 471 to 516 mm FL. Age and reproductive data cannot be collected with the camera gear but beginning in 2012, a vertical line component was added to the video drops to collect hard parts, fin clips, and gonads.

<u>*Sampling design*</u>

Total reef area available to select survey sites from is approximately 1771 km², of which 1244 km² is in the eastern GOM and 527 km² in the western GOM. The large size of the survey area necessitates a two-stage sampling design to minimize travel times between stations. The first-stage uses stratified random sampling to select blocks 10 minutes of latitude by 10 minutes of longitude. The block strata were defined by geographic region (4 regions: South Florida, Northeast Gulf, Louisiana-Texas Shelf, and South Texas), and by total reef habitat area contained in the block (≤ 20 km², > 20 km²). There are a total of 7 strata. A 0.1 by 0.1 nm grid is then overlaid onto the reef area contained within a given block and the ultimate sampling sites (second stage units) are randomly selected from that grid.

<u>*Gear and deployment*</u>

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

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

Video tape viewing

One video tape from each station is randomly selected for viewing out of all viewable videos. Videos that have issues with visibility, obstructions or camera malfunction are excluded from randomly selection and are not viewed. Selected videos are viewed for 20 min starting from the time when the view clears from suspended sediment. Viewers identify and enumerate all species to the lowest taxonomic level during the 20 min viewable segment. From 1993-2007 the time when each fish entered and left the field of view was recorded – a procedure referred to as time in - time out (TITO) – and from these data a minimum count was calculated. The minimum count is the maximum number of individuals of a selected taxon in the field of view at one instance. Each video is evaluated to determine the highest minimum count observed during the 20 min analyzed. From 2008 to the present, the digital video allows the viewer to record a frame number or time stamp of the image when the maximum number of individuals of a species occurred, along with the number of taxon identified in the image, but the TITO method is not used. Both the TITO and current viewing procedure result in the minimum count estimation of abundance (i.e. - mincount). Minimum count methodology is preferred because it prevents counting the same fish multiple times (e.g. if a fish were swimming in circles around the camera).

Fish length measurement

Beginning in 1995 fish lengths were measured from video using lasers attached on the camera system with known geometry. However, the frequency of hitting targets with the laser is low and precluded estimating size frequency distributions. Additionally, the same fish can be measured more than once at a given station. So, the lengths measured provide the range of sizes observed. The stereo cameras used since 2008 allow size estimation from fish images using Vision Measurement System (Geometrics Inc.) software. Fish measurement is only performed at the point in the video corresponding to the mincount.

5.3.3.1 Methods of Estimation

The IWG recommended that a combined index from the three video surveys (NMFS, Panama City and FWRI) be used rather than having individual indices from each group.

5.3.3.2 Sampling Intensity and Time Series

There were a total of 3025 stations sampled from the Florida Keys, FL to Mobile Bay, AL (between longitudes 81°W and 88°W), from 1993 – 2013 (Table 5.8.3).

5.3.3.3 Size/Age Data

The average size of red grouper represented in this index was 478 mm FL, (Figure 5.9.6).

5.3.3.4 Comments on Adequacy for Assessment

The IWG initially advised that the abundance index from the eastern Gulf of Mexico was appropriate to index adult red grouper. However, evaluation of the positive catch QQ residual plots indicated that fit was poor and it was suggested to explore and evaluate the feasibility of producing indices using other distributions. Code developed by Mary Christman from MCC Statistical Consulting LLC was used to model the indices using Poisson and negative binomial distributions. Both of these models showed improved fit over the delta-lognormal models historically used to model video survey data and future indices should use these alternative models rather than the delta-lognormal method developed by Lo et al. (1992). Evaluation of the spatial distribution of sampling sites showed spatial gaps in coverage for inshore areas less than 25 m and over all depths in the central portion of the west Florida shelf as well.

Following presentations of video survey indices from the NMFS Panama City and FWRI laboratories, it was shown that coverage could be improved by combining the three indices. Additionally, all three groups have participated in the annual west Florida shelf coordination meetings to discuss methods and ensure that survey methods are standardized (e.g. randomized site selection, camera deployment time, video read procedures, and abundance metrics). Because of the significant amount of effort to standardize these three surveys, it was decided to combine the data sets and develop Poisson and Negative-Binomial indices. The IWG evaluated those models and recommended that the combined Poisson index be used rather than the individual surveys indices by themselves. This combined approach improved spatial coverage without a loss in the temporal length of the longest data series (SEAMAP reef fish video). Those results are presented in Section 5.3.8.

5.3.4 Panama City Video

The Panama City NMFS lab reef fish video survey began in 2005 as an expansion of a trap survey begun in 2004 to provide annual relative abundance estimates on exploited species, including gag, scamp, and red grouper; red, vermilion, gray, and lane snapper; gray triggerfish, red porgy, white grunt, black seabass, and hogfish. Other objectives included examining regional catch, recruitment, demographic, and distribution patterns of these and other common reef fishes, as well as insight on trap selectivity, and more complete information on community structure. Video sampling in 2005 was only done in Apalachee Bay off the Big Bend region of north Florida, but in 2006 was expanded to the area off Panama City. These two regions are separated by Cape San Blas - an established hydrographic and likely zoogeographic boundary (Zieman and Zieman 1989), and include shrimp grids 9 (eastern half), 8, 7, and the northern edge of 6. The survey area is bounded by 86°30’ W on the west and 28° 45’ N on the southeast.

Through 2009 the survey design was systematic because of a very limited sampling universe. In 2010 the design was changed to 2-stage random after side scan sonar surveys that year yielded an order of magnitude increase in that universe. In the first stage, five by five minute blocks known to contain reef sites, and proportionally allocated by region, sub-region, and depth (10-20, 20-30, 30+ m) to ensure uniform geographic and bathymetric coverage, were randomly chosen. In the second stage, 2 known reef sites a minimum of 300 m apart within each selected block were randomly selected. Individual sites were weighted using a mean value of individual ratings based on measurements of area, relief, rugosity, and proximity to other reefs derived from side scan sonar data. Reefs with higher weighting factors had a higher probability of being selected. The few sites which have not been side scanned were assigned the average rating for the all side scanned sites in the block in which they are located. Alternates were also selected for use when another boat was found to be fishing the site or no hard bottom could be found with sonar at that site.

Depth coverage was ~8-30 m during 2004-07, and then was steadily expanded to deeper depths. Since 2011 it has remained at about 8 to 50 m. All sampling occurred between May and October (with the exception of four sites in November, 2013), but primarily during June through August. A CTD cast was made at each site to collect temperature, salinity, oxygen, and turbidity profiles.

Sampling was conducted only during daytime from 1 hr after sunrise until 1 hr before sunset.

Visual data were collected using a stationary camera array composed of four Hi-8 video cameras (2005 only) or four high definition (HDEF), digital video cameras (2006-08) mounted orthogonally 30 cm above the bottom of an aluminum frame. From 2007 to 2009, parallel lasers (100 mm spacing) mounted above and below each camera were used to estimate the sizes of fish which crossed the field of view perpendicular to the camera. In 2009 and 2010, one of the HDEF cameras was replaced with a stereo imaging system (SIS) consisting of two high resolution black and white still cameras mounted 8 cm apart, one digital video (mpeg) color camera, and a computer to automatically control these cameras as well as store the data. The SIS provides images from which fish measurements can be obtained with the Vision Measurement System (VMS) software. Beginning in 2011, a second SIS facing 180º from the other was added, reducing the number of HDEFs to two; and both SIS's were also upgraded with HDEF, color mpeg cameras. In 2012 the two HDEFs were replaced with high definition GoPro cameras. The camera array was unbaited 2005-2008, but since 2009 has been freshly baited on each drop with one previously frozen Atlantic mackerel placed in a mesh bag near the center. The switch was made to baiting cameras to standardize methods with the Pascagoula video survey, which had a much longer time series.

Before stereo camera systems were used (prior to 2009), soak time for the array was 30 min to allow sediment stirred up during camera deployment to dissipate and ensure tapes with an unclouded view of at least 20 min duration (Gledhill and David 2003). With the addition of stereo cameras in 2009, soak time was increased to 45 min to allow sufficient time for the SIS to settle on the bottom before starting its hard drive, and to insure the hard drive had time to shut down before retrieval. In 2014, stereo cameras were upgraded with solid state hard drives, enabling soak time to be reduced back to 30 min. Prior to 2009, tapes of the 4 HDEF cameras were scanned, with the one with the best view of the habitat analyzed in detail. If none was obviously better, one was randomly chosen. In 2009 only the 3 HDEF video cameras were scanned and the one with the best view of the reef was analyzed. Starting in 2010, all 4 cameras – the HDEFs and the SIS MPEGs, which have virtually the same fields of view (64 vs 65º) – were scanned, and again, the one with the best view of the habitat was analyzed. Beginning in 2012, when a video from a GoPro camera was selected to be read, because they have a much larger field of view than the SIS MPEGs (122 vs 65º), predetermined, equal portions of each edge of the video monitor were covered so that only the central 65° of the field of view was visible. Twenty min of the tape were viewed, beginning when the cloud of sediment disturbed by the landing of the array had dissipated. All fish captured on videotape were identified to the lowest discernable taxon. Data on habitat type and reef morphometrics were also recorded. If the quality of the mpeg video derived from the SIS was less than desirable (a common problem), fish identifications were confirmed on the much higher quality and concurrent stereo still frames. The estimator of abundance was the maximum number of a given species in the field of view at any time during the 20 min analyzed (= min count; Gledhill and Ingram 2004, or MaxN; Ellis and DeMartini 1995), and VMS measurements were only taken from a still frame showing the min count of a given species to eliminate the possibility of measuring the same fish more than once. Even for deployments where the SIS did not provide a good view of the reef habitat, the files were examined to obtain fish measurements using VMS, and again, those measurements were only taken from a still frame showing the min count of a given species.

To ensure consistency and identify issues in species id, min counts, and habitat classification within the Panama City lab survey, the first 10 tapes analyzed from a given year are read by both readers. Similarly, to ensure consistency among the 3 labs involved in the West Florida shelf cooperative reef fish video survey (NMFS Panama City, NMFS Pascagoula, FWRI), readers from each lab read a sample of 10 tapes from the other 2 labs. Results from these reader/lab comparisons are presented and discussed at an annual Cooperative Survey workshop.

5.3.4.1 Methods of Estimation

The IWG recommended that a combined index from the three video surveys (NMFS, Panama City and FWRI) be used rather than having individual indices from each group.

5.3.4.2 Sampling Intensity and Time Series

There were a total of 993 stations sampled from the Big Bend Area, FL to Panama City, FL (between longitudes 82°W and 86°30'W and north of 28° 45' N), from 2005 – 2013 (Table 5.8.3)

5.3.4.3 Size/Age Data

Red grouper observed with stereo cameras, 2009-2014, ranged from 274 to 885 mm FL with a modal size of roughly 400-450 mm FL and a mean of 503 mm (Figure 5.9.7). Not surprisingly, a comparison of size data from trap catches with that from stereo images from the same years (2009-13) indicated that the traps do select against most red grouper >750 mm FL, although fish that large were much less common in the survey area based on the few stereo measurements obtained (Figure 5.9.7). The stereo camera gear is also selective, but it tends to select against small (<325 mm FL) red grouper, which tend to be much more cryptic than larger individuals and less likely to be visible to camera gear. Age data were not available from this survey.

5.3.4.4 Comments on Adequacy for Assessment

After determining that the NMFS Pascagoula, NMFS Panama City, and Florida FWRI video surveys: 1) sampled very similar sizes and ages of red grouper, 2) used very similar gear and video processing methods , 3) have had concurrent sampling since 2008, and 4) together covered a large proportion of the West Florida Shelf, which in turn includes most of the known range and certainly the center of abundance of red grouper in the U.S. Gulf of Mexico, the indices group agreed that combining all three indices into one would provide the best, most comprehensive information on population trends in the NE Gulf. Those results are presented in Section 5.3.8.

For that reason, the group recommended not including a stand-alone Panama City video index in the assessment.

5.3.5 Panama City Trap Survey

In 2002 the Panama City NMFS lab began development of a fishery-independent trap survey (PC survey) of natural reefs on the inner shelf of the eastern Gulf of Mexico off Panama City, FL, with the primary objective of establishing an age-based annual index of abundance for young (age 0-3), pre-recruit gag, scamp, and red grouper. Secondary objectives included examining regional catch, recruitment, demographic, and distribution patterns of other exploited reef fish species. The chevron trap is efficient at capturing a broad size range of several species of reef fish (Nelson et. al.1982, Collins 1990), and has been used by the South Atlantic MARMAP program for over 20 yr (McGovern et. al. 1998). Initially the PC survey used the same trap configuration and soak time used by MARMAP (McGovern et. al. 1998), but an in-house study indicated that traps with a throat entrance area 50% smaller than that in the MARMAP traps were much more effective at meeting our objective of capturing sufficient numbers of all three species of grouper. Video data from our study and consultations with fishermen suggested that the presence of larger red grouper in a trap tended to deter other species from entering. Beginning in 2004, the 50% trap throat size became the standard. That same year the survey was expanded east of Panama City to Apalachee Bay off the Big Bend region of Florida, an area separated from the shelf off Panama City by Cape San Blas - an established hydrographic and likely zoogeographic boundary (Zieman and Zieman 1989). The survey area is bounded by 86°30’ W on the west and 28° 45’ N on the southeast, and includes shrimp grids 8 and the eastern half of 9 on the west side of the Cape and grids 7, 8, and the northern edge of 6 on the east side.

In 2005 the target species list was expanded to include other exploited reef fishes common in the survey area , i.e., red, vermilion, gray, and lane snapper; gray triggerfish, red porgy, white grunt, black seabass, and hogfish. From 2005 through 2008 each site was sampled first with a stationary video camera array followed immediately by a single trap. Beginning in 2009 trap effort was reduced ~50%, so that more effort could be devoted to the concurrent video survey. At each site, a CTD cast was made to collect temperature, salinity, oxygen, and turbidity profiles.

Through 2009 the survey design was systematic because of a very limited sampling universe. In 2010 the design was changed to 2-stage random after side scan sonar surveys that year yielded an order of magnitude increase in that universe. In the first stage, five by five minute blocks known to contain reef sites, and proportionally allocated by region, sub-region, and depth (10-20, 20-30, 30+ m) to ensure uniform geographic and bathymetric coverage, were randomly chosen. In the second stage, two known reef sites a minimum of 300 m apart within each selected block were randomly selected. Individual sites were weighted using a mean value of individual ratings based on measurements of area, relief, rugosity, and proximity to other reefs derived from side scan sonar data. Reefs with higher weighting factors had a higher probability of being selected. The few sites which have not been side scanned were assigned the average rating for the all side scanned sites in the block in which they are located. Alternates were also selected for use when another boat was found to be fishing the site or no hard bottom could be found with sonar at that site on the day it was to be sampled.

Depth coverage was ~8-30 m during 2004-07, and then was steadily expanded to deeper depths. Since 2011 it has remained at about 8 to 50 m. Sampling effort also increased during the first few years. All sampling has occurred between May and October (with the exception of four sites in November, 2013), but primarily during June through August.

Methods

Sampling is conducted only during daytime from 1 hr after sunrise until 1 hr before sunset. Traps are baited each set with 3 previously frozen Atlantic mackerel *Scomber scombrus*, and soaked for 1.5 hr. Traps are fished as close as possible to the exact location sampled by the camera array. All trap-caught fish are identified, counted and measured to maximum total and fork length (FL only for gray triggerfish and TL only for black seabass). Both sagittal otoliths are collected from 4-5 randomly subsampled specimens of all snappers (gray, lane, red, and vermilion), groupers (gag, red, and scamp), black seabass, red porgy, hogfish, white grunt, and gray triggerfish (first dorsal spine for the latter).

5.3.5.1 Methods of Estimation

Data Filtering Techniques

The only data excluded from index calculations were 9 samples in 2004 and 23 in 2005 from sites which had already been sampled in those years, and 8 samples in 2014 from sites located in an ongoing red tide bloom. As a result of this screening, 33 samples from east of Cape San Blas and 7 from the west were excluded.

Standardization

The index group recommended not including the Panama City trap index in the assessment (see justification in Section 5.3.5.6).

Annual Abundance Indices

The index group recommended not including the Panama City trap index in the assessment (see justification in Section 5.3.5.6).

5.3.5.2 Sampling Intensity and Time Series

Total sample size for 2004-2014 was 791 trap sets — 506 east of and 285 west of Cape San Blas. Annual overall and regional sample sizes, % positive catches, and nominal catch per trap hr with standard errors are shown in Table 5.8.4. Sampling east of Cape San Blas in 2013 was limited (down ~66%) and done later than normal (Oct. and Nov.) because of late receipt of funding, ship mechanical issues, and weather problems.

5.3.5.3 Size/Age Data

Red grouper taken in chevron traps in the Panama City lab survey, 2004-2014, ranged from 211 to 798 mm FL, with a modal size of ~375-400 mm FL and a mean of 448 mm. The survey strongly targets pre-recruit individuals, especially east of Cape San Blas, where mean size was 416 mm FL and 81% were below the minimum legal size limit of 487 mm FL, compared to a mean size of 509 mm and 44% < 487 mm west of the Cape (Figure 5.9.8). East of the Cape, 20% of the fish were <350 mm and only 4% were >600 mm, while in the west only 6% were <350 mm but 21% were >600 mm. This pattern can also be clearly seen in the annual length composition data from 2005-2009 (Figure 5.9.9), the years when the distribution of depths sampled was quite different east and west of Cape San Blas. Despite small sample sizes in some years, annual size structure data revealed at least two obvious and one probable mode which tracked for a few to several years and steadily shifted to increasingly larger sizes (Figure 5.9.9). The first mode observed, at around 325-350 mm FL, was present in 2004 when the trap survey began, and was clearly identifiable through 2006 when about 400-450 mm. The most persistent modal group appeared in 2007 at ~250 mm FL and was readily identifiable every year through 2014. These patterns suggest different, strong cohorts were moving through the population during those periods.

Not surprisingly, given the regional differences observed in size structure, red grouper were also younger east of the Cape (1- 8 yr, mode 3-4 yr) than west (1-19 yr, mode 5 yr) (Figure 5.9.10). Annual age structure data revealed that the obvious size modes represented the 1999, 2002, 2006, and 2007 cohorts. No new strong year classes have been detected since the 2007 cohort.

5.3.5.4 Catch Rates

The index group recommended not including the Panama City trap index in the assessment (see justification in Section 5.3.5.6).

5.3.5.5 Uncertainty and Measures of Precision

The index group recommended not including the Panama City trap index in the assessment (see justification in Section 5.3.5.6).

5.3.5.6 Comments on Adequacy for Assessment

The Panama City trap survey was carefully considered by the index working group. Though it showed very similar trends in proportions of positive samples and CPUE with the concurrent Panama City video survey, the index group decided not to recommend it for inclusion in the assessment because 1) it covered the same area and time period as the latter and less area and a shorter time period than the combined SEAMAP, Panama City, and FWRI video index, 2) the trap data were more variable than the video data, and 3) traps were more selective than video gear.

5.3.6 FWRI Video

The FWRI reef fish video survey includes a portion of the West Florida Shelf (WFS) bounded by 26^o and 28^o N latitude and depths from 10 – 110 m. The boundaries of the WFS sampling universe were chosen to compliment ongoing NMFS – Pascagoula and NMFS – Panama City reef-fish surveys. To assure adequate spatial sampling coverage, the WFS survey area was subdivided into four sampling zones comprised of two NMFS statistical zones (Tampa Bay: NMFS statistical zone 5; Charlotte Harbor: NMFS statistical zone 4) and two depth zones (Nearshore: 10 – 37 m; Offshore: 37 – 110 m). Prior to conducting exploratory sampling in 2008, the WFS survey area was subdivided into 1 km x 1 km sampling units. Results from 2008 indicated that the 1 km x 1 km spatial scale was too large in relation to the small-scale habitat features characteristic of the WFS; accordingly, from 2009 onward the WFS survey area was subdivided into 0.1 nm x 0.3 nm sampling units (E/W by N/S). Overall sampling effort (annual goal of 200 sampling units) was proportionally allocated among the four sampling zones (TBN: Tampa Bay Nearshore; TBO: Tampa Bay Offshore; CHN: Charlotte Harbor Nearshore; CHO: Charlotte Harbor Offshore) based on habitat availability, and specific sampling units were selected randomly within each sampling zone.

For the 2008 reef fish survey, the identification of sampling units with an increased probability of containing reef habitat (and inclusion in the sampling frame for the reef-fish survey) was based on bottom rugosity calculated from 100-m-resolution interpolated bathymetry data. An examination of results from the 2008 survey indicated that a high proportion of sampling effort occurred at sites with no reef habitat (i.e., unconsolidated sediment). Accordingly, the sampling universe was updated in 2009 to include habitat information provided by commercial fishermen as well as published literature. Further, we implemented an adaptive strategy where a three-pass acoustic survey was conducted covering an area of 1 nm to the east and west of the pre-selected sampling unit prior to sampling. In 2009 and part of 2010, the acoustic survey was conducted using the research vessel echo sounder, whereas for part of 2010 and 2011 onward the acoustic survey was conducted using an L3- Klein 3900 side scan sonar. If these acoustic surveys produced evidence of reef habitat in a nearby sampling unit, but not in the pre-selected sampling unit, sampling effort was randomly relocated to the nearby sampling unit.

At each sampling station, 1 – 2 stationary underwater camera arrays (SUCAs) were deployed based on the quantity and distribution of identified reef habitat. All individual gear deployments were spaced a minimum of 100 m apart. In addition to data on the relative abundance of Red Grouper, geographic coordinates, depth, physiochemical conditions (e.g., temperature, salinity, dissolved oxygen, pH), and time of day were recorded at each sampling site. SUCA deployments and collection and processing of field data were identical to those of the NMFS – Pascagoula and NMFS – Panama City surveys. Each SUCA consisted of a pair of stereo imaging system (SIS) units positioned at an angle of 180º from one another to maximize the total field of view. Each SIS unit consisted of an underwater housing containing a digital camcorder to record video and a pair of stereo cameras to capture still images at a rate of one per second. Each SUCA was baited (generally Atlantic Mackerel) and deployed for thirty minutes to assure that twenty minutes of continuous video and stereo images were recorded. Video data from one SIS per SUCA deployment were processed to quantify the relative abundance of Red Grouper (MaxN, or the maximum number of Red Grouper observed on a single video frame). When video conditions allowed, individual Red Grouper were measured to the nearest mm fork length (FL) using stereo still images and Vision Measurement System software (VMS).

5.3.6.1 Methods of Estimation

The IWG recommended that a combined index from the three video surveys (NMFS, Panama City and FWRI) be used rather than having individual indices from each group.

5.3.6.2 Sampling Intensity and Time Series

There were a total of 1078 stations sampled on the west Florida shelf (between latitudes 26°N and 28°N), from 2008 – 2013 (Table 5.8.3).

5.3.6.3 Size/Age Data

Length frequency data are presented in Figure 5.9.11. Length data were aggregated over years because too few length measurements were available per year. Age data are not available.

5.3.6.4 Comments on Adequacy for Assessment

The IWG expressed some concerns with the low proportion positives due to difficulties in identifying reef habitat during the early years of the survey (2008 and 2009). However, the high proportion positives in the later years of the survey, combined with the fact that the spatial footprint was within the heart of Red Grouper distribution, indicated that the index warranted further consideration. After further discussions, the group did not recommend the FWRI video index as a stand-alone index, primarily because it was complementary to other video surveys (NMFS – Pascagoula and NMFS – Panama City), indexing similar portions of the population. Instead, the index working group recommended the development of combined shallow-water (< 50 m) and deep-water (≥ 50 m) indices using data from all three surveys (NMFS – Pascagoula, NMFS – Panama City, and FWRI). Those results are presented in Section 5.3.8.

5.3.7 FWRI Trap Survey

The FWRI reef fish trap survey includes a portion of the West Florida Shelf (WFS) bounded by 26° and 28° N latitude and depths from 10 – 110 m. The boundaries of the WFS sampling universe were chosen to compliment ongoing NMFS – Pascagoula and NMFS – Panama City reef-fish surveys. To assure adequate spatial sampling coverage, the WFS survey area was subdivided into four sampling zones comprised of two NMFS statistical zones (Tampa Bay: NMFS statistical zone 5; Charlotte Harbor: NMFS statistical zone 4) and two depth zones (Nearshore: 10 – 37 m; Offshore: 37 – 110 m). Prior to conducting exploratory sampling in 2008, the WFS survey area was subdivided into 1 km x 1 km sampling units. Results from 2008 indicated that the 1 km x 1 km spatial scale was too large in relation to the small-scale habitat features characteristic of the WFS; accordingly, from 2009 onward the WFS survey area was subdivided into 0.1 nm x 0.3 nm sampling units (E/W by N/S). Overall sampling effort (annual goal of 200 sampling units) was proportionally allocated among the four sampling zones (TBN: Tampa Bay Nearshore; TBO: Tampa Bay Offshore; CHN: Charlotte Harbor Nearshore; CHO: Charlotte Harbor Offshore) based on habitat availability, and specific sampling units were selected randomly within each sampling zone. For the 2008 reef fish survey, the identification of sampling units with an increased probability of containing reef habitat (and inclusion in the sampling frame for the reef-fish survey) was based on bottom rugosity calculated from 100-m-resolution interpolated bathymetry data. An examination of results from the 2008 survey indicated that a high proportion of sampling effort occurred at sites with no reef habitat (i.e., unconsolidated sediment). Accordingly, the sampling universe was updated in 2009 to include habitat information provided by commercial fishermen as well as published literature. Further, we implemented an adaptive strategy where a three-pass acoustic survey was conducted covering an area of 1 nm to the east and west of the pre-selected sampling unit prior to sampling. In 2009 and part of 2010, the acoustic survey was conducted using the research vessel echo sounder, whereas for part of 2010 and 2011 onward the acoustic survey was conducted using an L3- Klein 3900 side scan sonar. If these acoustic surveys produced evidence of reef habitat in a nearby sampling unit, but not in the pre-selected sampling unit, sampling effort was randomly relocated to the nearby sampling unit.

At each sampling station, 1 – 4 chevron traps were deployed based on the quantity and distribution of identified reef habitat. Each chevron trap (1.76m x 1.52m x 0.61m; 28cm throat diameter; 3.81cm vinyl-clad mesh) was baited with fresh Atlantic Mackerel prior to deployment, and allowed to soak for a target of 90 minutes prior to retrieval. All Red Grouper captured were counted and measured to the nearest mm standard length (SL) and total length (TL); results are summarized by SL. In addition to the total number of Red Grouper captured, geographic coordinates, depth, physiochemical conditions (e.g., temperature, salinity, dissolved oxygen, pH), and time of day were generally recorded at each sampling site. All sampling was conducted from June to October, and although overnight trap sets were conducted during the first two years of the survey, our analyses only included those sets conducted during daylight hours.

5.3.7.1 Methods of Estimation

Data Filtering Techniques

Prior to conducting statistical analyses, data from overnight trap sets were removed, as were any trap set exceeding four hours in duration. In total, this excluded 281 traps from subsequent analyses. Overall, 2,186 chevron trap survey deployments were evaluated for developing indices of relative abundance for Red Grouper during the six year sampling period (2008-2013). We excluded any data points where variables of interest were not recorded or standardized sampling methods were not followed. Of the 2,186 trap samples considered for inclusion in the modeling analysis, only four were removed based on the data subsetting approach described, leaving 2,184 samples available for Red Grouper trap analyses from 2008-2013.

Standardization

Trap surveys produce count data that do not conform to assumptions of normality. As such distributions of count data are often modeled using Poisson or negative binomial error distributions. Further, there is evidence that our trap data may have a disproportionate number of zero counts that may differ from the standard error distributions used for count data. These data distributions are referred to as "zero-inflated" and are fairly common in ecologically based count data. Zero-inflation is considered a special case of over dispersion that cannot be easily addressed using traditional transformation procedures (Hall 2000). Due to the count nature of the data, and the possibility of inflation of the zero counts, we used four different error distribution models to construct preliminary evaluation models (i.e., Poisson, Negative Binomial, Zero-inflated Poisson and Zero-inflated Negative Binomial). The zero inflated approaches model the zero counts using two different processes, a binomial and a count process (Zuur et al. 2009).

Initially, four null models were considered utilizing both a Poisson (P) and Negative binomial (NB) error distribution (1), and both Zero-inflated Poisson (ZIP) and zero inflated Negative Binomial (ZINB) formulations (2).

Total RG = Y + M + D + Lat + Eff + Df

and

Total RG = Y + M + D + Lat + Eff + Df | Y + M + D + Lat + Eff + Df

We compared the variance structure of each model formulation using likelihood ratio tests (Zuur et al. 2009) and Akaike's information theoretic criterion (AIC; Zuur et al. 2009) to determine the most appropriate model formulation for the development of a video index for Red Grouper in the Eastern Gulf of Mexico.

A backwards step-wise model selection procedure was used to exclude unnecessary parameters from the null model (2) formulation. The optimum Red Grouper model formulation (3) was determined using a combination of AIC and likelihood ratio tests (Zuur et al. 2009). All data manipulation and analysis was conducted using R version 3.0.2 (R Core Team 2014). Modeling was conducted using the zeroinfl function of the pscl package (Jackman 2008), available from the Comprehensive R Archive Network (CRAN).

Submodel Variables

Year: 2008 – 2013

Month: June – October

Depth: 10 – 110 m, converted to a quartile factor

Latitude: 26° - 28° N, converted to a quartile factor

Soak Time: 1 – 4 hours, in decimal hours

Number of Sand Perch: 0 – 22, included as a habitat proxy (more Sand Perch on sand)

Annual Abundance Indices

Annual abundance indices of the FWRI trap survey are presented in Table 5.8.5.

5.3.7.2 Sampling Intensity and Time Series

From 2008 – 2013, a total of 2,182 sites were sampled. Annually, the number of sites has varied between 291 and 506.

5.3.7.3 Size/Age Data

Length frequency data are presented in Figure 5.9.12. Length data were aggregated over years. Age data were not presented here, but instead were provided to the life history working group.

5.3.7.4 Catch Rates

Nominal and standardized catch rates are presented in Table 5.8.5.

5.3.7.5 Uncertainty and Measures of Precision

Annual CVs of catch rates are presented in Table 5.8.5 and Figure 5.9.13. Model diagnostics showed no discernible patterns of association between Pearson residuals and fitted values or the fitted values and the original data. An examination of residuals for the spatial and environmental model parameters showed no clear patterns of association, indicating correspondence to underlying model assumptions (Zuur et al. 2009). Lastly, a comparison of predicted values against original data distribution indicates a good fit between the model and original data. For diagnostic plots, refer to SEDAR 42- DW-09.

5.3.7.6 Comments on Adequacy for Assessment

The index working group expressed some concerns with the low proportion positives due to difficulties in identifying reef habitat during the early years, especially 2008. However, the high proportion positives in the later years of the survey, combined with the fact that the spatial footprint was within the heart of Red Grouper distribution, indicated that the index warranted further consideration. However, because the working group felt that the proportion of the population covered in this survey was also covered by other video surveys, and that traps were more selective than video gear, this index was not recommended for inclusion in the assessment.

5.3.8 Combined Video

The IWG decided to combine all video surveys from the eastern Gulf of Mexico. Summaries for each survey are provided in Sections 5.3.3, 5.3.4, and 5.3.6.

5.3.8.1 Methods of Estimation

Data Filtering Techniques

All data filtering is described in each surveys respective section.

Standardization

Initially, a delta-Poisson model was developed. However, there were no significant variables to be included in the Poisson submodel. Therefore, a null Poisson submodel, containing only the intercept was used for the nonzero data (Table 5.8.6). The variables used for the binomial submodel include year, two depth strata (>25m and <25m depth zones), and three area strata (north, central and south) (see Figure 5.9.14).

5.3.8.2 Sampling Intensity and Time Series

Figure 5.9.14 illustrates the density of samples along the west Florida shelf. The time series data from each source were of different lengths: NMFS-SEAMAP: 1993-1997, 2002 and 2004-2014; PCVideo: 2005-2013; and FWRI: 2008-2013. The terminal year in the combined model was 2013.

5.3.8.3 Size/Age Data

Size data from each survey is presented in Figure 5.9.6 (SEAMAP Video), Figure 5.9.7 (Panama City Video) and Figure 5.9.11 (FWRI Video).

5.3.8.4 Catch Rates

Table 5.8.7 provides the standardized index.

5.3.8.5 Uncertainty and Measures of Precision

Table 5.8.7 provides the list of CVs and confidence limits on the standardized index.

5.3.8.6 Comments on Adequacy for Assessment

The IWG thought it most appropriate to combine all the video survey data from the three mentioned sources, due to the identical sampling methodologies. This index of abundance shows similar trends from other indices in the later years; and being the longest fishery-independent index, the IWG recommends its use in the base model.

5.3.9 Dry Tortugas RVC

5.3.9.1 Methods of Estimation

This visual census employs a two stage stratified random sample design. The sampling frame includes all mapped hardbottom habitats that are at depths less than 30m. The sampling frame is divided into primary sample units (PSU), which are 200 m x 200 m grid cells. Two single stage units (SSU) are sampled within each PSU. A SSU is comprised of a diver buddy pair, where each diver conducts a separate 15m diameter Bohnsack point count. All fish within the survey cylinder are sized and counted. Red grouper individual lengths are reported to the centimeter.

Density and length mean estimates are first made by averaging diver pairs to get SSU abundance and length composition. The two SSUs are then averaged for a PSU estimate with a variance. Strata estimates are made by averaging all PSUs in a stratum. Strata are defined by habitat types and spatial management type (i.e., inside or outside MPAs). A domain wide estimate is made for inside and outside MPAs where the strata are weighted by total area.

While, the RVC program has been collecting data in the Dry Tortugas since 1999, sampling has not been conducted in all years. Figure 5.9.15 shows the spatial distribution of all sampled sites since 1999.

Annual Abundance Indices

The red grouper mean density estimates, overall and separated into pre-exploited red grouper (i.e., length < 50cm) and exploited red grouper (i.e., length >= 50cm) from the Dry Tortugas RVC data are shown in Figure 5.9.16. The trend in the overall mean density declined between 1999 and 2010. In 2012, overall mean density was as high as the mean density observed in 1999 (Table 5.8.8 and Figure 5.9.16a). The trend in the overall mean density is driven by the mean density of the pre-exploited size class (Figure 5.9.16b). The mean density of legal sized red grouper varied from year to year, but increased between 1999 and 2004, declined between 2004 and 2006, and then exhibited a generally increasing trend between 2006 and 2012 (Figure 5.9.16b).

5.3.9.2 Sampling Intensity and Time Series

Sampling intensity and the time-series are summarized in Table 5.8.8.

5.3.9.3 Size/Age Data

Size data are available for pre-exploited and exploited length classes. The mean length of exploited length classes (i.e., greater than 50 cm) are summarized in Table 5.8.9 and Figure 5.9.17. Mean length of legal sized red grouper increased between 1999 and 2004 and has generally declined since 2004.

5.3.9.4 Catch Rates

Catch rates are not available from this survey, however, mean density estimates are available and summarized in Table 5.8.8 and Figure 5.9.16.

5.3.9.5 Uncertainty and Measures of Precision

Estimates of standard error are summarized in Table 5.8.8 and Figure 5.9.16.

5.3.9.6 Comments on Adequacy for Assessment

The index working group did not recommend this index for inclusion in the stock assessment.

5.4 FISHERY-DEPENDENT MEASURES

5.4.1 Headboat Survey

Rod and reel catch and effort from party (head) boats in the Gulf of Mexico have been monitored by the NMFS Southeast Region Headboat Survey (conducted by the NMFS Beaufort Laboratory) since 1986. The Headboat Survey collects data on the catch and effort for a vessel trip. Reported information includes landing date and location, vessel identification, the number of anglers, fishing location, trip duration and/or type (half/three-quarter/full/multi-day, day/night, morning/afternoon), and catch by species in number and weight. These data were used to construct an index of red grouper catch rates in the Gulf of Mexico. The index was constructed using Generalized Linear Mixed Models, and a delta-lognormal approach.

Effort and catch were estimated by vessel trip. CPUE for each trip was defined as the reported number of red grouper landed per angler hour, where the number of angler hours was calculated using the number of reported contributors times the hours fished. To estimate hours fished, the following assumptions were necessary:

½ day trip = 5 hours fished

¾ day trip = 7 hours fished

Full day trip = 10 hours fished

5.4.1.1 Methods of Estimation

Data Filtering Techniques

Data were limited to trips in southwest Florida, northwest Florida, and Alabama. Data were also limited to include only half-day, three-quarter-day and full-day fishing trips that took place during open season for red grouper. Furthermore, trips that were flagged due to possible errors in effort information or catch amount were excluded.

The Stephens and MacCall (2004) approach was used to restrict the dataset to trips that targeted red grouper. This approach uses the species composition of each trip in a logistic regression of species presence/absence to infer if effort on a given trip occurred in habitat similar to that preferred by red grouper.

Standardization

A delta-lognormal approach (Lo et al., 1992) was used to develop standardized catch rate indices. This method combines separate generalized linear modeling (GLM) analyses of the proportion of trips that observed red grouper and the catch rates on positive trips to construct a single standardized index of abundance. A forward stepwise approach was used during the construction of each GLM. The factors in the table below were examined as possible influences on the proportion of positive trips, and the catch rates on positive trips.

Submodel Variables

Factor	DF	Details
Year	28	1986-2013
Area	2	NW FL & AL, SW FL
Season	4	Dec-Feb, Mar-May, Jun-Aug, Sep-Nov
Anglers*	5	1-10, 11-20, 21-30, 41-50, 51-60
Trip Type*	3	Full day, Half day, Three quarter day

*Trip type and number of anglers were only explored as factors for modeling the proportion of positive trips.

Once a set of fixed factors was identified, interactions were examined. YEAR*FACTOR interaction terms were included in the model as random effects. The final delta-lognormal model was fit using the SAS macro GLIMMIX and the SAS procedure PROC MIXED (SAS Institute Inc. 1997) following the procedures by Lo et al. (1992).

The variation in catch rates by vessel was examined using a "repeated measures" approach (Littell et al., 1998). The term 'repeated measures' refers to multiple measurements taken over time on the same experimental unit (i.e. vessel). Specifying the repeated measure "VESSEL" and the subject "VESSEL(YEAR)" allows PROC MIXED to model the covariance structure of the data. This is particularly important because catch rates may vary by vessel and because catch rates by a given vessel that are close in time can be more highly correlated than those far apart in time (Littell et al., 1998)

<u>Annual Abundance Indices</u>

The final models for the binomial and lognormal components were:

Proportion Positive = YEAR + TRIP TYPE + AREA + YEAR*AREA

LN(CPUE) = YEAR + AREA + SEASON + YEAR*AREA + YEAR*SEASON

5.4.1.2 Sampling Intensity and Time Series

Table 5.8.10 shows the annual number of trips and the number of positive trips that were included in this analysis.

5.4.1.3 Size/Age Data

Recreational size limits for red grouper have been in place since the beginning of the available headboat time series. The size limit in Florida was 18 inches total length (TL) until 1990, when the federal size limit of 20 inches TL was imposed. It is assumed that the size range of red grouper targeted by headboats is comprised of legal sized fish.

5.4.1.4 Catch Rates

Standardized catch rates are presented in Table 5.8.10 and Figure 5.9.18.

5.4.1.5 Uncertainty and Measures of Precision

Annual CVs of catch rates are presented in Table 5.8.10.

5.4.1.6 Comments on Adequacy for Assessment

The headboat index was deemed adequate for use in the assessment by the index working group. This decision was based on the long time series and large spatial coverage associated with the Headboat Survey. The group noted that the Headboat index is associated with high variability and recommended that future investigations should address how to most appropriately model interactions among factors and how to most appropriately calculate the variance associated with the index.

5.4.2 MRFSS

NOAA Fisheries initiated the Marine Recreational Fisheries Statistics Survey (MRFSS) in 1979 in order to obtain standardized estimates of participation, effort and catch by recreational fishermen in U.S. marine waters. Data from the MRFSS dockside interviews were used to construct an index of red grouper catch rates in the Gulf of Mexico. The index was constructed using Generalized Linear Mixed Models, and a delta-lognormal approach.

Effort and catch were estimated by interview. Total numbers of red grouper caught was equal to A + B1 + B2 fish, where A = fish observed, B1 = dead fish not observed, and B2 = fish released alive. Numbers of B1 and B2 fish were corrected for non-interviewed fishermen. CPUE for each interview was defined as the total red grouper caught per angler hour, where the number of angler hours was calculated using the number of reported contributors times the number of reported hours fished.

5.4.2.1 Methods of Estimation

Data Filtering Techniques

Data were limited to interviews that took place in west Florida (excluding Monroe County) from 1986-2013 and that reported at least 30 minutes of fishing time. Data were further filtered to remove the headboat and shore fishing modes, the inshore fishing area, and interviews that occurred before noon or after 6:59pm. Furthermore, interviews that were flagged due to possible errors in group information or catch amount were excluded.

The Stephens and MacCall (2004) approach was used to restrict the dataset to interviews that targeted red grouper. This approach uses the species composition of each interview in a logistic regression of species presence/absence to infer if effort associated with a given interview occurred in similar habitat to red grouper.

Standardization

A delta-lognormal approach (Lo et al., 1992) was used to develop standardized catch rate indices. This method combines separate generalized linear modeling (GLM) analyses of the proportion of trips that observed red grouper and the catch rates on positive trips to construct a single standardized index of abundance. A forward stepwise approach was used during the construction of each GLM. The factors in the table below were examined as possible influences on the proportion of positive trips, and the catch rates on positive trips.

Submodel Variables

Factor	DF	Details
Year	28	1986-2013
Time of Interview	5	12pm-1pm, 2pm, 3pm, 4pm, 5pm-6pm
Season	4	Dec-Feb, Mar-May ,Jun-Aug, Sep-Nov
Reg. Season	2	Open, Closed
Region	3	SWFL, CWFL, NWFL
Area	2	<10 miles offshore, > 10 miles offshore
Mode	2	Private, Charterboat
Hours Fished*	4	1-2, 3-4, 5-6, 7+
Anglers*	7	1, 2, 3, 4, 5, 6, 7+

*Number of hours fished and number of anglers were only explored as factors modeling success

Once a set of fixed factors was identified, interactions were examined. YEAR*FACTOR interaction terms were included in the model as random effects. The final delta-lognormal model was fit using the SAS macro GLIMMIX and the SAS procedure PROC MIXED (SAS Institute Inc. 1997) following the procedures by Lo et al. (1992).

Annual Abundance Indices

The final models for the binomial and lognormal components were:

Proportion Positive = YEAR + AREA + REGION + ANGLERS + YEAR*REGION

LN(CPUE) = YEAR + REGION + MODE + REGION*MODE + YEAR*REGION

5.4.2.2 Sampling Intensity and Time Series

Table 5.8.11 shows the annual number of trips and the number of positive trips that were included in this analysis.

5.4.2.3 Size/Age Data

No size/age data is available.

5.4.2.4 Catch Rates

Standardized catch rates are presented in Table 5.8.11 and Figure 5.9.19.

5.4.2.5 Uncertainty and Measures of Precision

Annual CVs of catch rates are presented in Table 5.8.11.

5.4.2.6 Comments on Adequacy for Assessment

The index was deemed adequate for use in the assessment by the index working group. This decision was based on the long time series and large spatial coverage associated with the MRFSS angler intercept data. The group noted that the MRFSS index is associated with high variability and recommended that future investigations should address how to most appropriately model interactions among factors and how to most appropriately calculate the variance associated with the index. An additional research recommendation related to the MRFSS dataset is to explore an index where catch and effort data are summarized for individual trips, as individual trips can be associated with multiple interviews.

5.4.3 Commercial Longline

Longline catch and fishing effort of commercial vessels operating in the United States Gulf of Mexico (GOM) have been monitored by the National Marine Fisheries Service (NMFS) through the coastal logbook program. The coastal logbook program in the GOM is conducted by the NMFS Southeast Fisheries Science Center. The program collects catch and effort data by trip from permitted vessels for a number of fisheries managed by the Gulf of Mexico Fisheries Management Council. The GOM coastal logbook program began in 1990 with the objective of a complete census of reef fish fishery permitted vessel activity. Florida was the exception, where a 20% sample of vessels was targeted. Beginning in 1993, the sampling in Florida was increased to require reports from all vessels permitted in the reef fish fishery.

An index of abundance was developed for the commercial longline fleet. The data available for the analysis started in 1990 and ended in 2013, the terminal year of the assessment. Two indices were developed using these data. One index was developed from the 1990-2009 logbook data. This index represent the time-period prior to implementing the individual fishing quota (IFQ) program ("pre-IFQ"). The second index was developed from the "IFQ years", 2010 – 2013, data.

5.4.3.1 Methods of Estimation

Data Filtering Techniques

The data exclusions made for the analysis were as follows:

1. Multiple areas fished may be recorded for a single fishing trip. In such cases, assigning catch and effort to specific locations was not possible; therefore, only trips in which one area fished was reported were included in these analyses.
2. Multiple fishing gears may be recorded for a single fishing trip. In such cases assigning catch and effort to a particular gear type was not possible. Trips fishing multiple gears were excluded in these analyses.
3. Logbook reports submitted 45 days or more after the trip completion data were excluded from these analyses due to the lengthy gap in reporting time.
4. Trips that fell outside the 99th percentile were considered to represent misreported data or data entry errors and were excluded from this analysis. The following were excluded from the longline analysis:
   a) The number of hooks fished per line < 16 and the number of hooks per line > 3000,
   b) The number of lines fished 96,
   c) The number of days at sea > 20, and
   d) The number of crew members > 5.

5. Seasonal closures and regulatory closures have been employed to manage the commercial red grouper fishery. Closures were implemented on the following dates: November 8, 1990 - December 31, 1990; February 15 – March 15, 1999-2008; November 15, 2004 – December 31, 2004; and October 10, 2005 – December 31, 2005. The dataset was restricted to time periods for which fishing on red grouper was allowed.
6. Approximately 99% of the red grouper commercial landings were from shrimp grids 1-10. All other shrimp grids were excluded from the analysis.
7. These indices are essentially Florida indices. Between 1990 and 1992 only 20% of vessels were required to report in Florida; therefore, the years 1990, 1991, and 1992 were excluded from the analysis.
8. Trips fishing more the 24 longline sets per day were excluded from this analysis.

Targeted red grouper trips were identified using the Stephens and MacCall (2004) approach, where trips are subset based upon the reported species composition of the landings. This method is intended to identify trips that fished in locations containing red grouper habitat and, therefore, had the potential of catching red grouper. *This was done for the pre-IFQ index.* Prior to using Stephens-MacCall, the percentage of trips catching red grouper was ~74% on average. After implementing Stephens-MacCall, the percentage of trips catching red grouper was ~94% on average.

Stephens-MacCall was not applied to the IFQ-index. The percentage of trips capturing red grouper ranged between 77% and 87%.

Catch rate calculation

Longline catch rates were calculated on a per trip basis. For each trip, catch per unit effort was calculated as:

CPUE = pounds of red grouper/(number of longline sets*number of hooks per set)

The number of hours fished is an unreliable metric of effort for the longline fleet due to misreporting. Therefore, calculating CPUE by hook-hour could not be done for the longline data, as was done for the commercial handline index.

Standardization

Given the high proportion of positive trips, a GLM assuming a binomial error distribution was inappropriate. A GLM assuming a lognormal error distribution was used to examine the above factors for effects on red grouper CPUE. Factors that significantly affected CPUE were then identified using the GLM assuming lognormal error distribution. The index was fit using the Proc Mixed procedure in SAS. All factors were modeled as fixed effects except two-way interaction terms containing YEAR that were modeled as random effects.

The pre-IFQ index model is as follows:
LN(CPUE) = INTERCEPT + AREA + YEAR.

The IFQ-index model is as follows:
LN(CPUE) = INTERCEPT + AREA + YEAR + DEPTH_CLOSURE.

Submodel Variables

The factors that were explored for model development were as follows:

Pre-IFQ index

Factor	Levels	Value
Year	17	1993 - 2009
Area	10	Shrimp grids: 1 - 10
Month	12	Month of year

IFQ-index

Factor	Levels	Value
Year	4	2010 - 2013
Area	10	Shrimp grids: 1 - 10
Depth closure	2	Open (all months except June, July, and August), Closure (June, July, and August). This corresponds with the management rule that excludes longline fishing at depths less than 35 fathoms during June, July, and August.
Allocation category	3	Low (1-7237 lbs), mid (7238 – 26302 lbs), and high (26303 – 206249 lbs) allocation

Annual Abundance Indices

Pre-IFQ index

The pre-IFQ standardized index is summarized in Table 5.8.12 and shown in Figure 5.9.20. After an initial decline between 1993 and 1994, the standardized index had an increasing trend until 2005. The standardized index declined in 2006 and 2007, followed by an increase in 2008. Index values in 2008 and 2009 were similar.

IFQ index

The IFQ standardized index is summarized in Table 5.8.13 and shown in Figure 5.9.21. The lowest catch rate was in 2010 followed by an increase in 2011 and 2012 and a decline in 2013.

5.4.3.2 Sampling Intensity and Time Series

Commercial longline logbook data are available from 1990-2013 for this assessment. As stated in Section 5.4.3.1, only the years 1993-2013 are used in this analysis.

5.4.3.3 Size/Age Data

Size and age data associated with the commercial longline data are available and are summarized in a separate section of this report.

5.4.3.4 Catch Rates

The normalized catch rates for the pre-IFQ and IFQ-indices are summarized in Tables 5.8.12 and 5.8.13 and shown in Figures 5.9.20 and 5.9.21.

5.4.3.5 Uncertainty and Measures of Precision

Estimates of the coefficient of variation associated with each annual CPUE estimate are summarized in Tables 5.8.12 and 5.8.13.

5.4.3.6 Comments on Adequacy for Assessment

The Index Work Group recommended the pre-IFQ index for use in the stock assessment. The IFQ-index was not recommended for use in the stock assessment given that the influence of the IFQ program on fisher behavior is not well understood.

5.4.4 Commercial Vertical Line

Data from the National Marine Fisheries Service (NMFS) coastal logbook program were used to construct abundance indices of red grouper for the eastern Gulf of Mexico (statistical areas 1-11; i.e., Dry Tortugas to Mississippi). Those indices included the years 1993-2009 prior to the implementation of Individual Fishing Quotas (IFQs) for red grouper (the pre-IFQ index) and the years 2010-2013 (IFQ index). Two indices were constructed because the implementation of the IFQ system is believed to have changed fishing behavior and catchability compared to earlier years. Such a change prevents the direct comparison of CPUE during 2010-2013 with CPUE of earlier years.

5.4.4.1 Methods of Estimation

Data Filtering Techniques

Coastal logbook data were filtered to remove clearly erroneous data (e.g., fishing more than 24 hours per day), outliers (effort data beyond the 99.5 percentile of the population), and data reported more than 45 days following the completion of the fishing trip. That last filter was used because of low confidence in the accuracy of such late reported data. In addition, data from red grouper closed seasons were also excluded from the analysis. Data from the years 1990-1992 were excluded from the analysis due to partial reporting from Florida during those first three years of the coastal logbook program. Finally, coastal logbook data were subset using the Stephens and MacCall (2004) method for identifying trips with effort in presumptive red grouper habitat.

Standardization

The delta lognormal model approach (Lo *et al.* 1992) was used to construct the standardized indices of abundance. Parameterization of each model was accomplished using a GLM analysis (GENMOD; Version 8.02 of the SAS System for Windows © 2000. SAS Institute Inc., Cary, NC, USA). For each GLM analysis of proportion positive trips, a type-3 model was fit, a binomial error distribution was assumed, and the logit link was selected. The response variable was proportion successful trips. During the analysis of catch rates on successful trips, a type-3 model assuming lognormal error distribution was examined. The linking function selected was "normal", and the response variable was log(CPUE) where log(CPUE)=ln(pounds of red grouper/hook hours fished). All 2-way interactions among significant main effects were examined. Higher order interaction terms were not examined.

A forward stepwise regression procedure was used to determine the set of fixed factors and interaction terms that explained a significant portion of the observed variability. Each potential factor was added to the null model sequentially and the resulting reduction in deviance per degree of freedom was examined. The factor that caused the greatest reduction in deviance per degree of freedom was added to the base model if the factor was significant based upon a Chi-Square test ($p<0.05$), and the reduction in deviance per degree of freedom was ≥1%. This model then became the base model, and the process was repeated, adding factors and interactions individually until no factor or interaction met the criteria for incorporation into the final model.

Once a set of fixed factors was identified, the influence of the YEAR*FACTOR interactions were examined. YEAR*FACTOR interaction terms were included in the model as random effects. Selection of the final mixed model was based on the Akaike's Information Criterion (AIC), Schwarz's Bayesian Criterion (BIC), and a chi-square test of the difference between the –2 log likelihood statistics between successive model formulations (Littell et al. 1996).

The final delta-lognormal models were fit using the SAS GLIMMIX macro (Russ Wolfinger, SAS Institute). To facilitate visual comparison, relative indices and relative nominal CPUE series were calculated by dividing each value in the series by the mean cpue of the series.

Submodel Variables

For the pre-IFQ index construction, five factors were considered as possible influences on the proportion of trips that landed red grouper and on the catch rate of red grouper. An additional factor, number of hook hours fished, was examined for its effect on the proportion of positive trips. In order to develop a well-balanced sample design it was necessary to define categories within some of the factors examined:

Factor	Levels	Value
YEAR	17	1993-2009
AREA	4	Gulf of Mexico statistical areas 1-5, 6, 7, and 8-11
DAYS	3	1 day at sea, 2-3 days at sea, 5 or more days at sea
MONTH	12	Month of the year

CREW	3	1, 2, 3 or more crew members
Hook hours fished*	4	<33, 33-96, 97-294, and 295 or more hook hours fished

*Hook hours tested for inclusion in the proportion positive (binominal) model

An additional factor, allocation, was examined when constructing the IFQ index. Total red grouper IFQ allocation was assumed to be the sum of red grouper, red grouper multi, and gag grouper multi allocation available to a vessel on a fishing trip. In cases where vessel owners/IFQ shareholders had multiple IFQ accounts, the sum of all red grouper allocation, as defined above, was assigned to trips reported by vessels owned by that IFQ shareholder. Allocation categories were:

- No allocation
- 1-1,166 pounds of allocation
- 1,167-3,716 pounds of allocation
- 3,717-10,300 pounds of allocation
- 10,301 pounds or more of allocation

Annual Abundance Indices

Nominal and standardized abundance indices are provided in Tables 5.8.14 and 5.8.15 and Figures 5.9.22 and 5.9.23.

5.4.4.2 Sampling Intensity and Time Series

Data were available from fisher-reported commercial logbooks for the years 1993-2013. Reporting to the coastal logbook program is mandatory for commercial fishers with federal fishing permits and, therefore, is presumed to be a census of commercial red grouper fishing. Numbers of reported trips per year are provided in Tables 5.8.14 and 5.8.15.

5.4.4.3 Size/Age Data

No size information is directly available in the commercial coastal logbook data set (reports were in pounds landed); however, size composition presumably matches that provided in Trip Interview Program data for commercial vertical line landings.

5.4.4.4 Catch Rates

Nominal and standardized CPUE (pounds landed per hook hour fished) are provided in Tables 5.8.14 and 5.8.15.

5.4.4.5 Uncertainty and Measures of Precision

Coefficients of variation per year for the constructed index are provided in Tables 5.8.14 and 5.8.15.

5.4.4.6 Comments on Adequacy for Assessment

Pre-IFQ index

The working group found that the index was properly constructed and recommended its use in the assessment model(s). The group also recommended that alternate methods for calculating variance, modeling of 'success' rather than 'proportion positive', and use of 'proc glimmix' rather than the 'glimmix macro' be explored. That work has begun, but could not be adequately explored and evaluated prior to the data deadline. Those tasks/recommendations require more discussion as to the appropriateness of their adoption as standard methods in constructing indices of abundance.

IFQ index

This index was not recommended for use in the assessment because the distribution of the logs of calculated CPUEs were not normally distributed, violating an assumption of the analysis (Figure 5.9.24). The distribution of the logs of trip specific CPUEs varied by the amount of IFQ allocation available to vessels. The distribution of log CPUE from trips by vessels with low amounts of allocation was bimodal (Figure 5.9.25A), but approached a normal distribution for those trips with the highest amounts of red grouper allocation (Figure 5.9.25D). The distribution of log CPUE among vessels with intermediate amounts of allocation was bimodal, but with a secondary peak much lower than the mode (Figure 5.9.25B and C). There was insufficient time prior to the data deadline to investigate alternative data transformations or analyses.

5.4.5 Headboat Observer Discard

5.4.5.1 Methods of Estimation

Harvested red grouper were excluded from this index to avoid overlap with other fisheries-dependent indices that measure abundance of legal-sized harvested fish and provide a longer time series. Only single day headboat trips sampled from the two regions with the most consistent observer coverage throughout the time series were included in this index. Other regions in Florida and Alabama that have had inconsistent observer coverage are not included in this index. Multi-day trips from the Tampa Bay region were also excluded since the majority of red grouper caught during these trips are legal sized.

In the Tampa Bay region, red grouper were present on 89% of trips; therefore, all trips in this region are considered potential red grouper trips. In the Panhandle, no red grouper were observed from the majority of trips sampled, and clustering methods were explored to determine the subset of trips from this region to include in an index. The Stephens and McCall method was explored; however, due to the frequency of false negatives (positive trips with a low estimated probability for red grouper presence), this was not a reliable method for identifying red grouper trips in the region. Hierarchical cluster analysis revealed close association between red grouper and numerous reef associated fishes that are abundant in the panhandle (including vermilion snapper, red snapper, and porgies). The species composition for clustering was sensitive to Morisita and Horn-Morisita aggregation indices, and both methods included the most frequently caught species in the panhandle region (red snapper, vermilion, gray triggerfish, red porgy). So in both cases, no trips were dropped from consideration for a red grouper index. Therefore, all single-day headboat trips sampled from the Tampa Bay and panhandle regions were included in this index, regardless of red grouper presence.

Standardization

Separate GLMs were constructed for the binomial presence/absence of red grouper discards and CPUE for positive trips (expressed as the log of discards per observed angler hour). The GLMs were constructed using the GLIMMIX procedure in SAS. A total of 33 unique headboat vessels were sampled repeatedly throughout the time series, and CPUE is likely correlated with the region where individual vessels operate from, patterns in the types of trips offered, locations vessel operators choose to fish, and other potential factors. Correlation within repeated observations on the same vessels was accounted for with a generalized estimating equation (GEE) using the random statement in GLIMMIX (Stokes et al. 2000). To ensure that similar types of trips were clustered together, clusters were defined by vessel and trip type, with trip types defined as half-day (<6 hours), three-quarter-day (6 to <9 hours), or full day (9 hours or longer). Year and region were included as covariates in the model. One other covariate, depth fished, improved the model fit but was not included due to missing values for a large portion of trips in one year (2007) that impacted sample size.

Annual Abundance Indices

Results for the standardized index of abundance are provided in Table 5.8.16.

5.4.5.2 Sampling Intensity and Time Series

This index includes headboat trips sampled in northwest Florida and the central west coast of Florida adjacent to Tampa Bay (Figure 5.9.26) from 2005 through 2007 and June 2009 through 2013.

5.4.5.3 Size/Age Data

The majority of red grouper caught from single-day headboat trips are below the legal size limit of 20” TL. Red grouper of harvestable size are more frequently encountered on multi-day trips that take place farther offshore. Only red grouper discards are included in this index to avoid overlap with other fishery-dependent indices.

5.4.5.4 Catch Rates

Nominal (measured as catch per observed angler-hour) and standardized CPUE are present in Table 5.8.16 and Figure 5.9.27.

5.4.5.5 Uncertainty and Measures of Precision

Annual CVs of catch rates are presented in Table 5.8.16.

5.4.5.6 Comments on Adequacy for Assessment

The workgroup felt this was a viable index for pre-harvest recruits but did not recommend it for use in the assessment. The size ranges of fish observed in this survey overlap with the combined

NMFS and FWC video index, and the geographic range and length of the time series is shorter for this index. If only one fishery-dependent index may be used in the assessment model to represent the headboat fleet, the workgroup favored use of the headboat logbook index (Southeast Headboat Survey) over this index. It should be noted that this index only measures CPUE for sub-legal sized fish and does not overlap with the headboat logbook index, which only measures CPUE for harvested red grouper.

5.5 CONSENSUS RECOMMENDATIONS AND SURVEY EVALUATIONS

After thoroughly reviewing the datasets listed above and their respective indices of abundance, the IWG recommended that the following indices be used in the assessment: SEAMAP Summer Groundfish, NMFS Bottom Longline, Combined Video, MRFSS, Headboat, Commercial Longline and Commercial Vertical Line. Table 5.8.17 contains the index values and CVs for all surveys/datasets recommended for use. Figure 5.9.28 has the indices arranged by portion of the population they represent, overlaid with one another.

Of those datasets/indices not recommended for use, three (SEAMAP Video, Panama City Video, and FWRI Video) were combined into the single Combined Video index. Both the Panama City Trap and FWRI Trap were not recommended because they covered the same portion of the population as the Combined Video Index and the IWG felt the Combined Video was a better index because of the longer time series and more complete spatial coverage.

The Commercial Trap and Everglades National Park Creel Survey were reviewed, however because of the low number of red grouper present in the data and the lack of use in the previous stock assessment these indices were not recommended for use.

Report cards for all the indices can be found in SEDAR42-DW-19.

5.6 RESEARCH RECOMMENDATIONS

- The IWG made note that the delta-lognormal index may not be the most appropriate distribution with some of the data presented and that alternative distributions should be considered. In addition, there is some variation in the SAS code used by the various labs to produce the indices. The recommendation is that a best practices workshop be convened to fully investigate different statistical models and produce a standard version of the appropriate programming code. Further, the use of R in place of SAS should be explored if the workshop warrants such consideration.

- As part of the proposed workshop, the approach to modeling 'success' in binomial portion of the delta models needs investigation. Currently, some labs model the 'proportion positive' rather than ‘success’ which can be an issue when used improperly.
- A calibration study is needed between the FWRI/NMFS video survey. The standardized reef systems are well suited for rigorous calibration studies, which could also include other sampling methods. In addition, exploration is needed for incorporating standardized video habitat covariates in the models.
- An exploration of the effects of IFQ’s on the fishery dependent indices, especially the commercial handline and longline is needed. During the workshop, fishermen indicated that since the implementation of IFQ’s, there has been a drastic change in fisheries behavior. There is also the possibility that dealers can directly influence this behavior. There is a need to incorporate these years into the overall time series in the most appropriate manner and to determine the means for doing so.
- The MRFSS data are clustered in the sense that some records represent individuals on the same boat (a cluster). An issue arose where the proper identifier for those clusters was not obvious in the data set. Hence, further investigation into ‘party id’ and what it represents in the MRFSS data in needed to accurately estimate the variability associated with the indices.
- Expansion of video surveys into Florida Bay
- Development of a YOY survey
- For reef-associated fisheries, the fishery-independent monitoring is based on known distribution of habitat. As side-scan sonar and similar activities increase the list of known habitat, there is a need to ensure that the sampling strategies for the FIM adjust appropriately and are optimized as habitat information becomes available.

5.7 LITERATURE CITED

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5.8 TABLES

Table 5.8.1. Indices of red grouper abundance developed for SEAMAP Summer Groundfish Survey from 2009-2013. The nominal frequency of occurrence, the number of samples (N), the delta-lognormal (DL) index (number per trawl-hour), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

Survey Year	Nominal Frequency	N	DL Index	Scaled Lo Index	CV	LCL	UCL
2009	0.34711	121	1.18369	1.47025	0.26932	0.86605	2.49597
2010	0.31746	126	0.76371	0.94861	0.27511	0.55268	1.62818
2011	0.24390	123	0.75150	0.93343	0.29512	0.52369	1.66375
2012	0.28090	178	0.76632	0.95184	0.25543	0.57570	1.57374
2013	0.25000	128	0.56024	0.69587	0.28890	0.39500	1.22589

Table 5.8.2. Indices of red grouper abundance developed for NMFS Bottom Longline Survey 2001-2013. The nominal frequency of occurrence, the number of samples (N), the delta-lognormal (DL) Index (number per trawl-hour), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
2001	0.21505	93	0.73588	0.64446	0.29285	0.36312	1.14380
2002							
2003	0.34188	117	1.01705	0.89070	0.20235	0.59667	1.32962
2004	0.41837	98	1.65489	1.44930	0.19234	0.98994	2.12181
2005	0.25000	40	0.62097	0.54383	0.40445	0.24968	1.18452
2006	0.28205	39	0.56797	0.49741	0.39043	0.23418	1.05653
2007	0.19048	42	0.87920	0.76998	0.46373	0.31852	1.86132
2008	0.26667	60	0.60496	0.52980	0.32099	0.28321	0.99110
2009	0.34921	63	0.93405	0.81801	0.26314	0.48754	1.37249
2010	0.32836	67	1.25711	1.10094	0.26413	0.65494	1.85067
2011	0.40164	122	2.30746	2.02080	0.18133	1.41025	2.89570
2012	0.46939	49	2.14000	1.87415	0.25422	1.13615	3.09152
2013	0.34043	47	0.98270	0.86062	0.30477	0.47418	1.56199

Table 5.8.3. Survey effort for the three video surveys and the combined video totals.

Year	SEAMAP V	PC V	FWRI V	Total
1993	114			114
1994	75			75
1995	54			54
1996	125			125
1997	153			153
1998				
1999				
2000				
2001				
2002	151			151
2003				
2004	148			148
2005	261	41		302
2006	273	109		382
2007	298	73		371
2008	190	89	109	391
2009	249	111	180	541
2010	204	148	151	504
2011	322	159	221	702
2012	261	159	236	657
2013	147	104	181	432
Total	*3025*	*993*	*1078*	*5102*

Table 5.8.4. Annual trap survey sample sizes, % positive catches, mean catch per trap hour, and standard errors of red grouper east and west of Cape San Blas, 2004-2014, in the Panama City trap survey.

	Total sites sampled			% Positive catches			Mean nominal catch/trap hr			Standard error		
Year	East	West	Total	East	West	Total	East	West	Total	East	West	Total
2004	16	18	34	50.0	33.3	41.2	0.415	0.313	0.361	0.135	0.134	0.094
2005	44	18	62	36.4	50.0	40.3	0.371	0.600	0.437	0.086	0.171	0.079
2006	68	23	91	13.2	30.4	17.6	0.175	0.433	0.240	0.057	0.146	0.057
2007	44	20	64	13.6	5.0	10.9	0.214	0.016	0.152	0.082	0.016	0.058
2008	50	31	81	40.0	51.6	44.4	0.433	0.502	0.459	0.088	0.114	0.069
2009	53	29	82	54.7	31.0	46.3	0.470	0.248	0.391	0.080	0.090	0.062
2010	52	17	69	57.7	23.5	49.3	0.428	0.265	0.388	0.072	0.145	0.065
2011	50	30	80	62.0	50.0	57.5	0.458	0.411	0.441	0.079	0.101	0.062
2012	59	30	89	28.8	23.3	27.0	0.339	0.198	0.292	0.081	0.078	0.060
2013	14	37	51	14.3	8.1	9.8	0.214	0.077	0.115	0.146	0.047	0.052
2014	47	33	80	23.4	21.2	22.5	0.315	0.273	0.298	0.089	0.097	0.066

Table 5.8.5. Model selection results for Zero-Inflated Negative Binomial model of Red Grouper observed during FWRI trap surveys on the West Florida Shelf, 2008-2013.

Year	Relative Nominal CPUE	N	Proportion positive	Standardized Index	CV
2008	0.138	291	0.044	0.083	0.786
2009	0.492	432	0.197	0.774	0.149
2010	0.667	303	0.228	0.561	0.192
2011	2.600	315	0.627	2.539	0.077
2012	0.993	335	0.423	0.953	0.101
2013	1.111	506	0.447	1.089	0.098

Table 5.8.6. Submodel development of the delta-Poisson for the combined video index.

Type III Tests of Fixed Effects for the Binomial Submodel				
Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
year	15	5083	6.11	<.0001
area	2	5083	8.89	0.0001
depthzone	1	5083	10.04	0.0015

Parameter Estimates for Poisson Submodel					
Effect	*Estimate*	*Standard Error*	*DF*	*t Value*	*Pr > |t|*
Intercept	0.2848	0.02134	1650	13.34	<.0001

Table 5.8.7. Indices of red grouper abundance developed for the Combined Video Survey from 2001-2013. The nominal frequency of occurrence, the number of samples (N), the DL Index (number per trawl-hour), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

Survey Year	Nominal Frequency	N	Index (mincount units)	Scaled Index	CV	LCL	UCL
1993	0.25439	114	0.32903	0.76603	0.16446	0.55253	1.06205
1994	0.33333	75	0.43464	1.01191	0.16713	0.72605	1.41030
1995	0.35185	54	0.44861	1.04444	0.19073	0.71564	1.52431
1996	0.30400	125	0.41926	0.97610	0.13605	0.74450	1.27975
1997	0.38562	153	0.50992	1.18718	0.10449	0.96384	1.46228
1998							
1999							
2000							
2001							
2002	0.36424	151	0.49702	1.15713	0.10847	0.93205	1.43657
2003							
2004	0.41216	148	0.56506	1.31555	0.09810	1.08168	1.59998
2005	0.34437	302	0.46718	1.08767	0.08104	0.92517	1.27871
2006	0.29843	382	0.39413	0.91759	0.08129	0.78012	1.07929
2007	0.17520	371	0.24277	0.56520	0.11356	0.45070	0.70880
2008	0.23274	391	0.29837	0.69465	0.09641	0.57308	0.84201
2009	0.28835	541	0.37553	0.87430	0.07249	0.75645	1.01051
2010	0.36111	504	0.47646	1.10928	0.06322	0.97765	1.25863
2011	0.40883	702	0.53536	1.24641	0.05063	1.12646	1.37913
2012	0.34094	657	0.44047	1.02549	0.06003	0.90957	1.15618
2013	0.32870	432	0.43857	1.02106	0.07425	0.88034	1.18428

Table 5.8.8. The number of PSUs, red grouper mean density (overall, pre-exploited, and exploited), and the associated standard error from the Dry Tortugas RVC.

		Overall		Pre-exploited (length < 50cm)		Exploited (length >= 50cm)	
Year	n	Mean Density	SE (Density)	Mean Density	SE (Density)	Mean Density	SE (Density)
1999	169	0.74556	0.05537	0.60297	0.05388	0.14724	0.02465
2000	205	0.65806	0.03739	0.48907	0.03918	0.18179	0.02166
2001	-	-	-				
2002	-	-	-				
2003	-	-	-				
2004	310	0.58172	0.07462	0.35482	0.03861	0.22689	0.04471
2005	-	-	-				
2006	260	0.41299	0.04334	0.28938	0.03645	0.12361	0.01937
2007	-	-	-				
2008	338	0.41000	0.06286	0.24437	0.03566	0.16563	0.03204
2009	-	-	-				
2010	364	0.33129	0.02719	0.19581	0.01967	0.13548	0.01756
2011	-	-	-				
2012	416	0.75750	0.04758	0.51676	0.04830	0.24074	0.02117

Table 5.8.9. Mean length (Lbar) and standard error of red grouper with lengths greater than or equal to 500mm from the Dry Tortugas RVC.

			Exploited (Len >=500 mm)	
Year	n	mm	Lbar_mm	SE_Lmm
1999	169	305	556.43	6.69
2000	205	359	603.58	11.94
2001	-	-	-	-
2002	-	-	-	-
2003	-	-	-	-
2004	310	576	602.81	23.11
2005	-	-	-	-
2006	260	497	596.15	12.01
2007	-	-	-	-
2008	338	653	587.21	15.89
2009	-	-	-	-
2010	364	703	570.98	6.27
2011	-	-	-	-
2012	416	813	575.64	6.54

Table 5.8.10. Relative nominal CPUE, number of positive trips, proportion positive trips (PPT) and abundance index statistics for the NMFS SE Region headboat survey index.

YEAR	TRIPS	POSITIVE TRIPS	PPT	RELATIVE NOMINAL CPUE	RELATIVE INDEX	LOWER 95% CI	UPPER 95% CI	CV
1986	1242	809	0.651	1.8953	1.0334	0.2845	3.7544	0.7183
1987	1055	788	0.747	3.1274	1.6494	0.5133	5.3000	0.6371
1988	998	772	0.774	3.5868	1.6056	0.5101	5.0544	0.6239
1989	1272	930	0.731	3.2024	1.5487	0.4727	5.0744	0.6497
1990	2131	1206	0.566	1.1943	0.6990	0.1831	2.6687	0.7525
1991	2209	1160	0.525	0.7867	0.4941	0.1198	2.0386	0.8076
1992	2058	1045	0.508	0.7488	0.4723	0.1147	1.9451	0.8063
1993	1962	916	0.467	0.5862	0.6343	0.1724	2.3336	0.7269
1994	1871	881	0.471	0.6115	0.5523	0.1442	2.1152	0.7546
1995	1455	717	0.493	2.4753	0.8352	0.2364	2.9504	0.6993
1996	1483	461	0.311	0.4419	0.4933	0.1252	1.9436	0.7746
1997	1117	361	0.323	0.8408	0.4750	0.1199	1.8820	0.7786
1998	1187	482	0.406	0.4631	0.5671	0.1467	2.1927	0.7614
1999	1165	446	0.383	0.2368	0.4741	0.1206	1.8641	0.7731
2000	1439	689	0.479	0.4683	0.5944	0.1540	2.2946	0.7603
2001	1036	467	0.451	0.3499	0.8726	0.2511	3.0328	0.6885
2002	923	412	0.446	0.3568	0.8929	0.2644	3.0162	0.6696
2003	1218	717	0.589	0.4879	1.4145	0.4900	4.0837	0.5696
2004	1473	955	0.648	0.8441	2.1247	0.7860	5.7434	0.5296
2005	1536	975	0.635	0.9737	2.3719	0.8876	6.3388	0.5227
2006	780	287	0.368	0.2924	0.8687	0.2482	3.0405	0.6932
2007	927	397	0.428	0.3731	0.9534	0.2870	3.1670	0.6586
2008	1558	692	0.444	0.5589	0.8800	0.2612	2.9648	0.6679
2009	1876	715	0.381	0.3773	0.6800	0.1950	2.3709	0.6906
2010	1646	874	0.531	0.6013	1.1157	0.3638	3.4216	0.6073
2011	1140	632	0.554	0.4965	1.0953	0.3755	3.1950	0.5760
2012	1648	1018	0.618	0.6944	1.4104	0.5122	3.8832	0.5407
2013	1596	1071	0.671	0.9282	1.1915	0.3983	3.5645	0.5917

Table 5.8.11. Relative nominal CPUE, number of positive trips, proportion positive trips (PPT) and abundance index statistics for the MRFSS index.

YEAR	TRIPS	POSITIVE TRIPS	PPT	RELATIVE NOMINAL CPUE	RELATIVE INDEX	LOWER 95% CI	UPPER 95% CI	CV
1986	138	108	0.783	1.0882	1.0925	0.6301	1.8945	0.2805
1987	144	92	0.639	0.6915	0.8681	0.4525	1.6653	0.3346
1988	138	86	0.623	1.5953	1.1339	0.5436	2.3650	0.3803
1989	119	87	0.731	1.7331	1.3293	0.7039	2.5102	0.3261
1990	108	81	0.750	1.7736	1.5569	0.8833	2.7441	0.2892
1991	112	62	0.554	1.5245	1.4756	0.7198	3.0253	0.3708
1992	329	229	0.696	1.3717	1.2438	0.6673	2.3182	0.3190
1993	305	162	0.531	0.9688	0.7682	0.3693	1.5979	0.3788
1994	336	172	0.512	0.8745	0.8707	0.4369	1.7351	0.3553
1995	344	184	0.535	1.0808	0.8627	0.4374	1.7015	0.3496
1996	356	141	0.396	0.6581	0.5555	0.2497	1.2359	0.4163
1997	357	123	0.345	0.6648	0.5467	0.2425	1.2326	0.4238
1998	720	340	0.472	0.6965	0.6533	0.3191	1.3374	0.3701
1999	973	514	0.528	0.9575	0.7350	0.3740	1.4446	0.3477
2000	729	365	0.501	0.7011	0.8305	0.4296	1.6054	0.3387
2001	791	388	0.491	0.5426	0.6524	0.3332	1.2776	0.3457
2002	865	468	0.541	0.6371	0.7901	0.4099	1.5228	0.3371
2003	1072	604	0.563	0.7479	0.9794	0.5225	1.8358	0.3221
2004	1492	1007	0.675	0.8426	1.2459	0.7184	2.1607	0.2806
2005	1077	651	0.604	0.4660	0.8296	0.4463	1.5423	0.3176
2006	532	224	0.421	0.2531	0.4391	0.2005	0.9617	0.4075
2007	540	257	0.476	0.4802	0.6953	0.3576	1.3519	0.3419
2008	764	462	0.605	0.9736	1.1731	0.6716	2.0489	0.2843
2009	604	401	0.664	1.3996	1.5401	0.9003	2.6346	0.2734
2010	505	334	0.661	1.2237	1.1744	0.6764	2.0389	0.2812
2011	536	341	0.636	1.2586	1.3397	0.7743	2.3180	0.2794
2012	497	332	0.668	1.0868	1.1216	0.6479	1.9416	0.2797
2013	355	242	0.682	1.7081	1.4966	0.8204	2.7299	0.3075

Table 5.8.12. The standardized annual commercial longline index and CV for red grouper captured in shrimp grids 1-10 in the Gulf of Mexico from 1993 - 2009. The annual nominal and standardized index (Index) values were normalized to an average value of one.

Year	Nominal	Index	CV
1993	0.8361	0.9785	0.0535
1994	0.7738	0.7235	0.0474
1995	0.9213	0.7742	0.0491
1996	0.8176	1.0397	0.0513
1997	0.8575	0.9069	0.0428
1998	1.0451	0.9552	0.0441
1999	0.9176	0.9968	0.0438
2000	1.0476	0.8980	0.0465
2001	0.9860	1.0563	0.0447
2002	1.5153	1.0600	0.0471
2003	1.0506	0.9284	0.0453
2004	1.1543	1.1124	0.0440
2005	1.3755	1.4437	0.0455
2006	0.9931	1.0927	0.0435
2007	0.7466	0.7796	0.0502
2008	1.0455	1.1811	0.0496
2009	0.9165	1.0731	0.0731

Table 5.8.13. The standardized annual commercial longline index and CV for red grouper captured in shrimp grids 1-10 in the Gulf of Mexico from 2010 - 2013. The annual nominal and standardized index (Index) values were normalized to an average value of one.

Year	Nominal	Index	CV
2010	0.7335	0.6282	0.0866
2011	1.1028	1.0556	0.0784
2012	1.1362	1.2680	0.0823
2013	1.0275	1.0481	0.0820

Table 5.8.14. Pre-IFQ index relative nominal CPUE, number of trips, proportion positive trips, and standardized abundance index for red grouper constructed using commercial vertical line data.

Year	Normalized Nominal CPUE	Trips	Proportion Successful Trips	Standardized Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1993	0.756179	1,670	0.792	0.731148	0.397892	1.343525	0.311394
1994	0.699744	2,239	0.771	0.716001	0.392517	1.306077	0.307467
1995	0.780493	2,281	0.747	0.788638	0.429262	1.448881	0.311289
1996	0.481552	2,256	0.701	0.490723	0.262637	0.916886	0.320343
1997	0.513838	3,318	0.681	0.564737	0.301849	1.056582	0.321058
1998	0.467955	3,874	0.65	0.518547	0.277908	0.967557	0.319611
1999	0.746172	4,244	0.691	0.739924	0.401314	1.364237	0.3132
2000	0.928729	4,210	0.738	0.991072	0.54536	1.801058	0.305457
2001	1.003921	4,120	0.817	1.347042	0.753577	2.40788	0.29665
2002	1.149352	4,192	0.825	1.387094	0.776572	2.477593	0.296246
2003	0.888259	4,068	0.841	0.947107	0.534658	1.67773	0.291835
2004	1.295183	3,732	0.882	1.273959	0.726246	2.234741	0.286637
2005	1.175149	3,064	0.893	1.416903	0.804867	2.494341	0.288524
2006	1.266166	2,768	0.874	1.143482	0.645103	2.026886	0.292174
2007	1.550833	2,595	0.901	1.206628	0.684535	2.126917	0.28921
2008	1.732271	2,701	0.897	1.530894	0.871158	2.690253	0.287586
2009	1.564206	2,606	0.898	1.206101	0.686788	2.118091	0.287235

Table 5.8.15. IFQ index relative nominal CPUE, number of trips, proportion positive trips, and standardized abundance index for red grouper constructed using commercial vertical line data.

Year	Normalized Nominal CPUE	Trips	Proportion Successful Trips	Standardized Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
2010	0.875777	2,066	0.863	0.672998	0.619842	0.730713	0.041156
2011	1.077042	1,898	0.903	1.24799	1.149515	1.354903	0.041115
2012	1.115281	2,110	0.873	1.233445	1.140231	1.334279	0.039305
2013	0.9319	1,773	0.897	0.845566	0.777091	0.920076	0.042244

Table 5.8.16. Indices of red grouper abundance developed for Headboat Observer Discards from 2005-2013. The nominal frequency of occurrence, the number of samples (N), the DL Index, the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
2005	0.68889	90	0.11637	0.71381	0.17102	0.50829	1.00244
2006	0.54369	103	0.03857	0.23661	0.23070	0.15005	0.37310
2007	0.56075	107	0.02143	0.13145	0.23177	0.08319	0.20770
2009	0.69355	62	0.34522	2.11753	0.17554	1.49456	3.00016
2010	0.62821	78	0.27766	1.70310	0.20465	1.13581	2.55373
2011	0.57282	103	0.22606	1.38662	0.15510	1.01869	1.88744
2012	0.51087	92	0.13684	0.83936	0.17765	0.58998	1.19414
2013	0.54545	88	0.14208	0.87152	0.18340	0.60575	1.25389

Table 5.8.17. Indices recommended for use for red grouper. SEAMAP GF – SEAMAP Summer Groundfish Survey, NMFS BLL – NMFS Bottom Longline Survey, VIDEO – Combined Video Survey, CLL – Commercial Longline, CVL – Commercial Vertical, HEAD – Headboat and MRFSS.

	SEAMAP GF		NMFS BLL		VIDEO		CLL		CVL		HEADBOAT		MRFSS	
Year	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV
1986											1.0334	0.7183	1.0925	0.2805
1987											1.6494	0.6371	0.8681	0.3346
1988											1.6056	0.6239	1.1339	0.3803
1989											1.5487	0.6497	1.3293	0.3261
1990											0.699	0.7525	1.5569	0.2892
1991											0.4941	0.8076	1.4756	0.3708
1992											0.4723	0.8063	1.2438	0.319
1993					0.76603	0.16446	0.9785	0.0535	0.731148	0.311394	0.6343	0.7269	0.7682	0.3788
1994					1.01191	0.16713	0.7235	0.0474	0.716001	0.307467	0.5523	0.7546	0.8707	0.3553
1995					1.04444	0.19073	0.7742	0.0491	0.788638	0.311289	0.8352	0.6993	0.8627	0.3496
1996					0.9761	0.13605	1.0397	0.0513	0.490723	0.320343	0.4933	0.7746	0.5555	0.4163
1997					1.18718	0.10449	0.9069	0.0428	0.564737	0.321058	0.475	0.7786	0.5467	0.4238
1998							0.9552	0.0441	0.518547	0.319611	0.5671	0.7614	0.6533	0.3701
1999							0.9968	0.0438	0.739924	0.3132	0.4741	0.7731	0.735	0.3477
2000							0.8980	0.0465	0.991072	0.305457	0.5944	0.7603	0.8305	0.3387
2001			0.64446	0.29285			1.0563	0.0447	1.347042	0.29665	0.8726	0.6885	0.6524	0.3457
2002					1.15713	0.10847	1.0600	0.0471	1.387094	0.296246	0.8929	0.6696	0.7901	0.3371
2003			0.8907	0.20235			0.9284	0.0453	0.947107	0.291835	1.4145	0.5696	0.9794	0.3221
2004			1.4493	0.19234	1.31555	0.0981	1.1124	0.0440	1.273959	0.286637	2.1247	0.5296	1.2459	0.2806
2005			0.54383	0.40445	1.08767	0.08104	1.4437	0.0455	1.416903	0.288524	2.3719	0.5227	0.8296	0.3176
2006			0.49741	0.39043	0.91759	0.08129	1.0927	0.0435	1.143482	0.292174	0.8687	0.6932	0.4391	0.4075
2007			0.76998	0.46373	0.5652	0.11356	0.7796	0.0502	1.206628	0.28921	0.9534	0.6586	0.6953	0.3419
2008			0.5298	0.32099	0.69465	0.09641	1.1811	0.0496	1.530894	0.287586	0.88	0.6679	1.1731	0.2843
2009	1.47025	0.26932	0.81801	0.26314	0.8743	0.07249	1.0731	0.0731	1.206101	0.287235	0.68	0.6906	1.5401	0.2734
2010	0.94861	0.27511	1.10094	0.26413	1.10928	0.06322					1.1157	0.6073	1.1744	0.2812
2011	0.93343	0.29512	2.0208	0.18133	1.24641	0.05063					1.0953	0.576	1.3397	0.2794
2012	0.95184	0.25543	1.87415	0.25422	1.02549	0.06003					1.4104	0.5407	1.1216	0.2797
2013	0.69587	0.2889	0.86062	0.30477	1.02106	0.07425					1.1915	0.5917	1.4966	0.3075

5.9 FIGURES

Figure 5.9.1. Spatial coverage of fishery-independent (blue text) and fishery-dependent (black text) indices for red grouper recommended for use. Note that all surveys covered roughly the same area, thus only one line is needed to show coverage area.

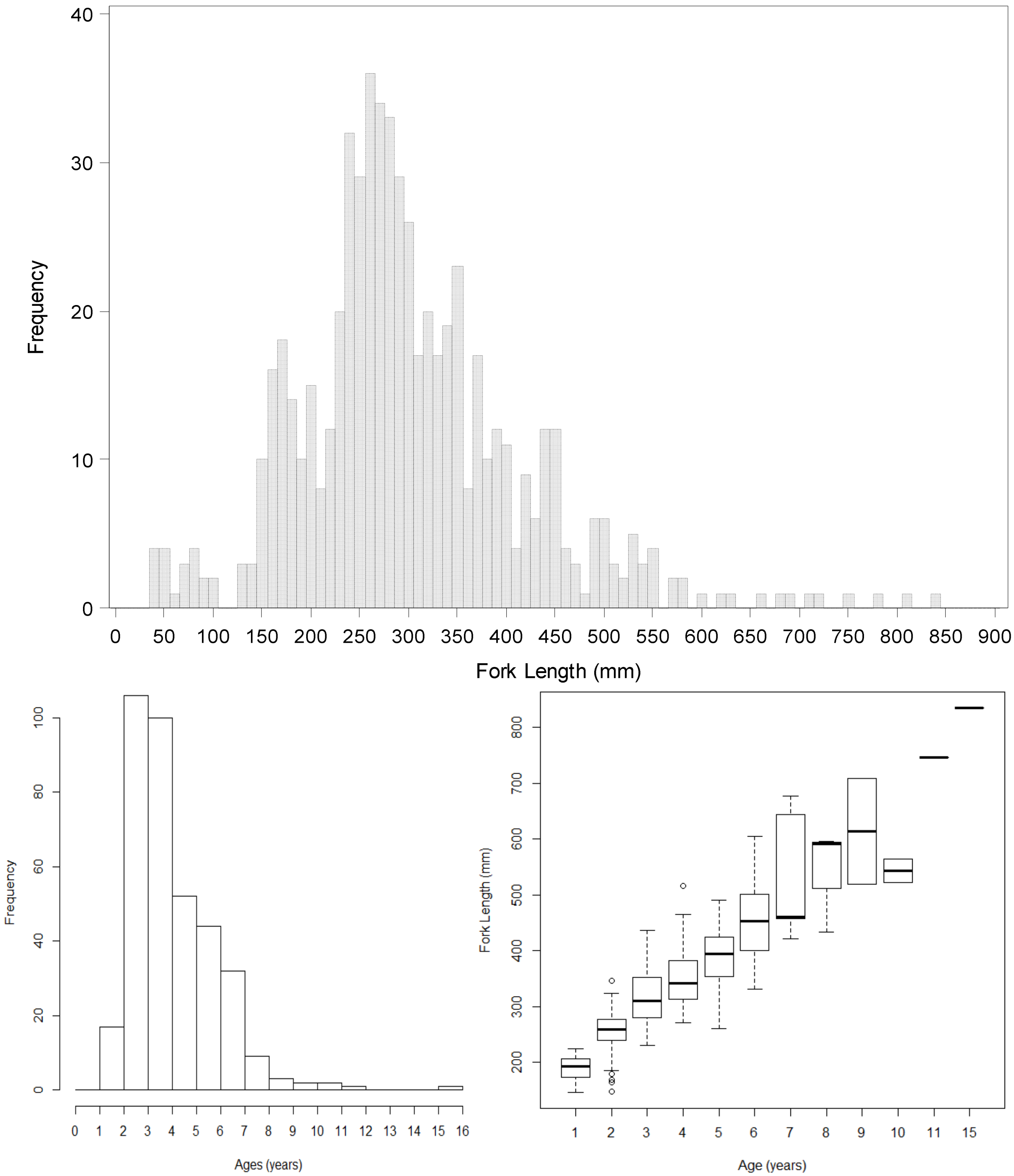


Figure 5.9.2. Length (top) and age (bottom) distribution of red grouper from SEAMAP Summer Groundfish Survey.

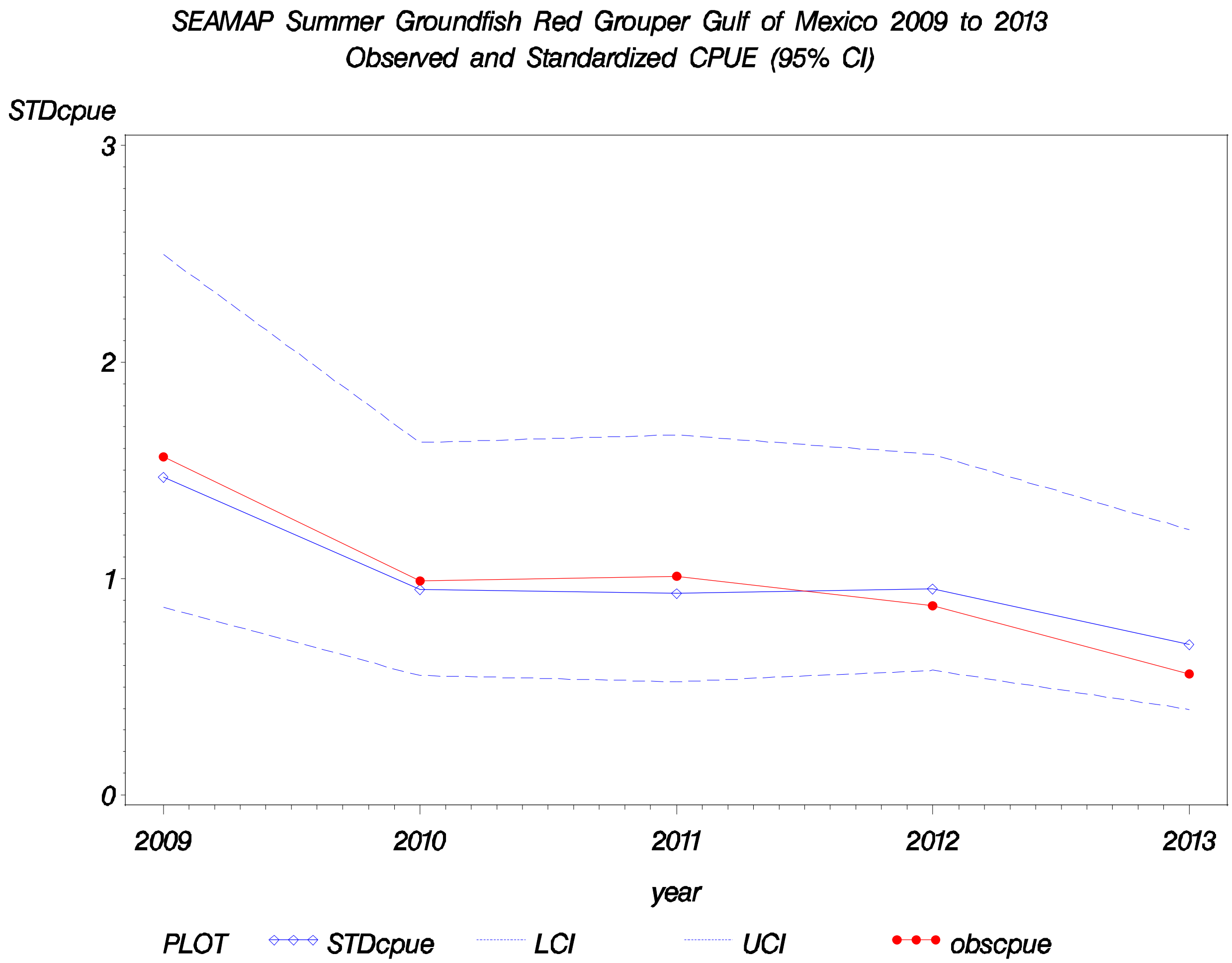


Figure 5.9.3. Annual index of abundance for red grouper from the SEAMAP Summer Groundfish Survey from 2009 – 2013.

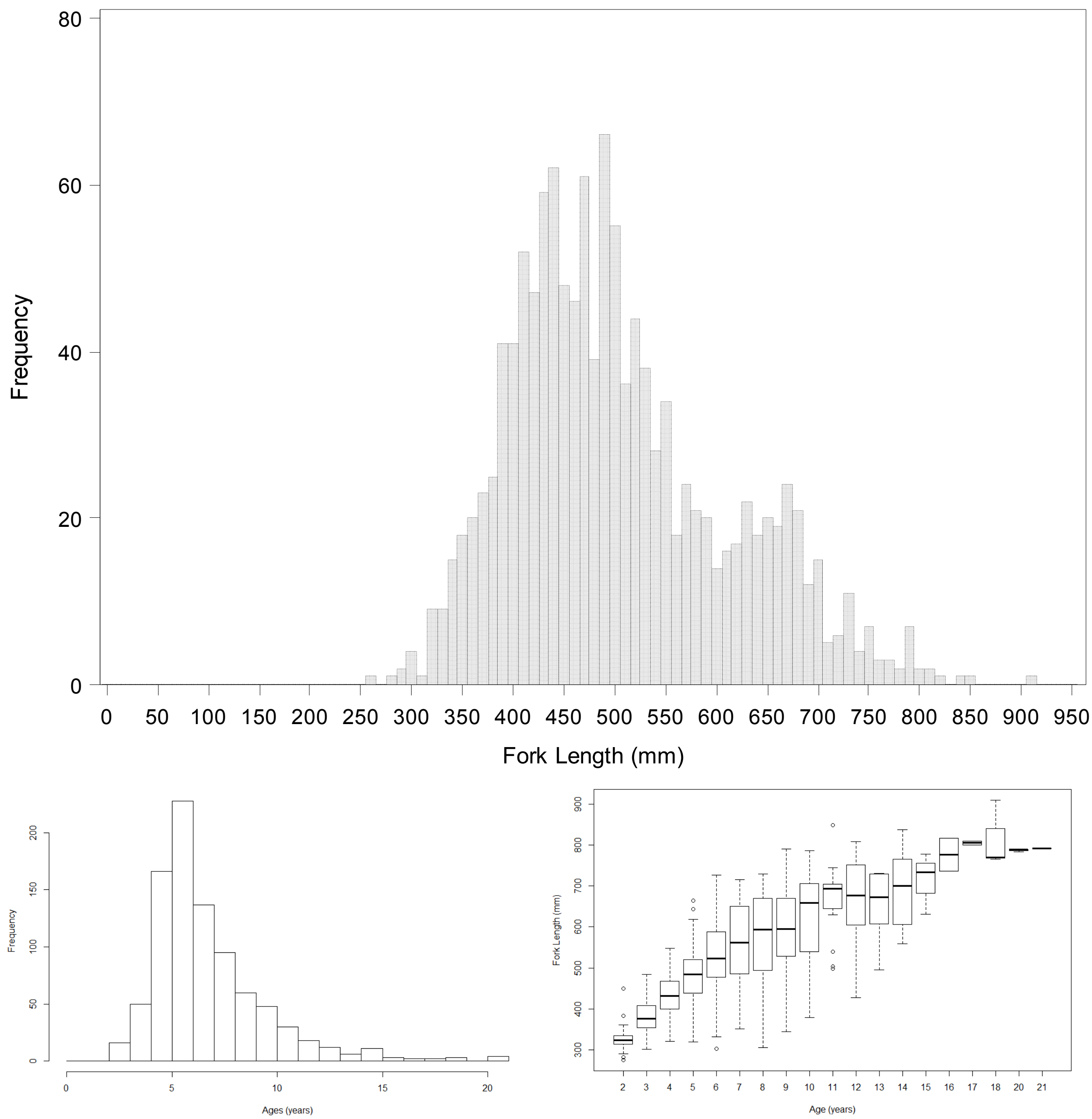


Figure 5.9.4. Length (top) and age (bottom) distribution of red grouper from NMFS Bottom Longline Survey.

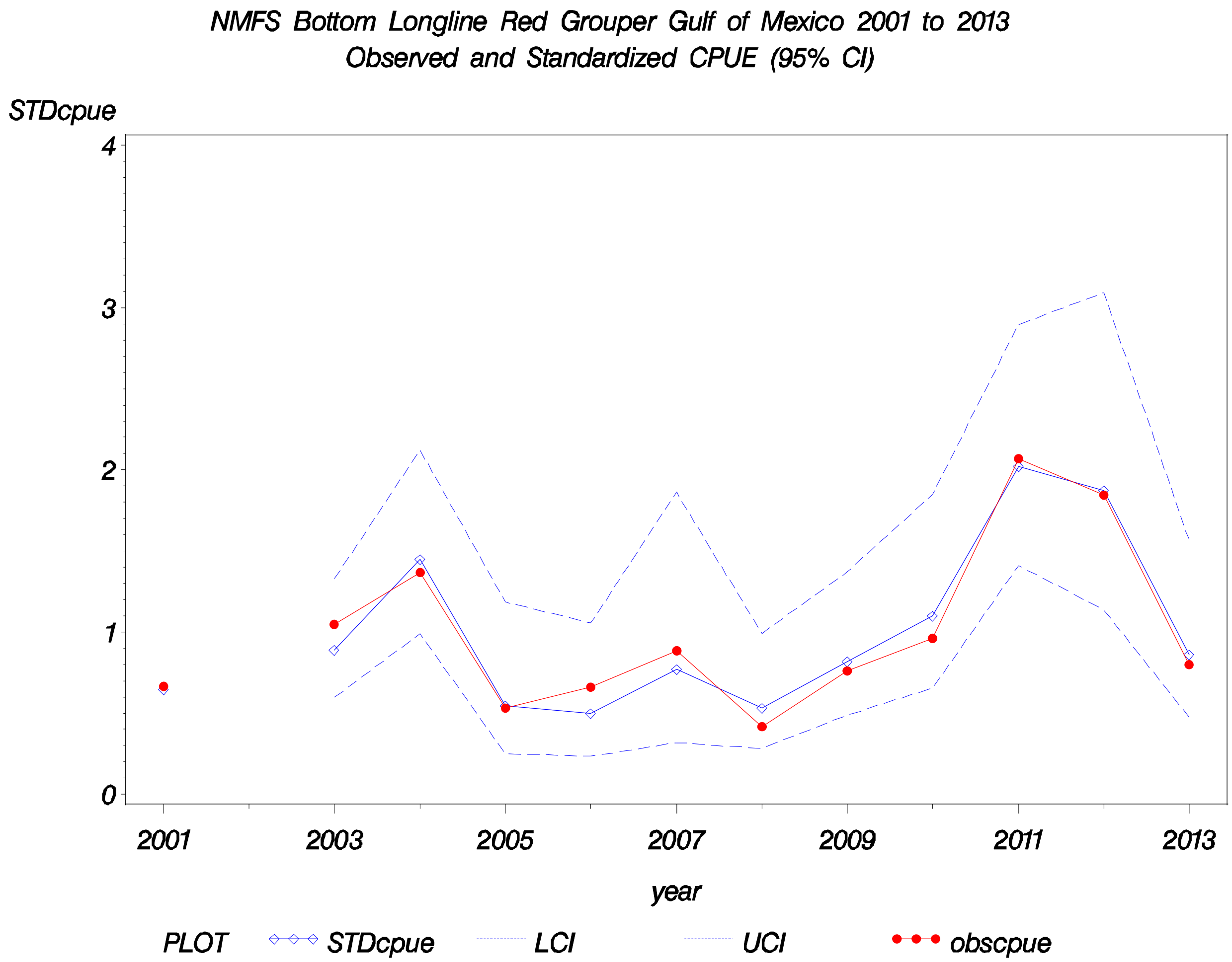


Figure 5.9.5. Annual index of abundance for red grouper from the NMFS Bottom Longline Survey from 2001 – 2013.

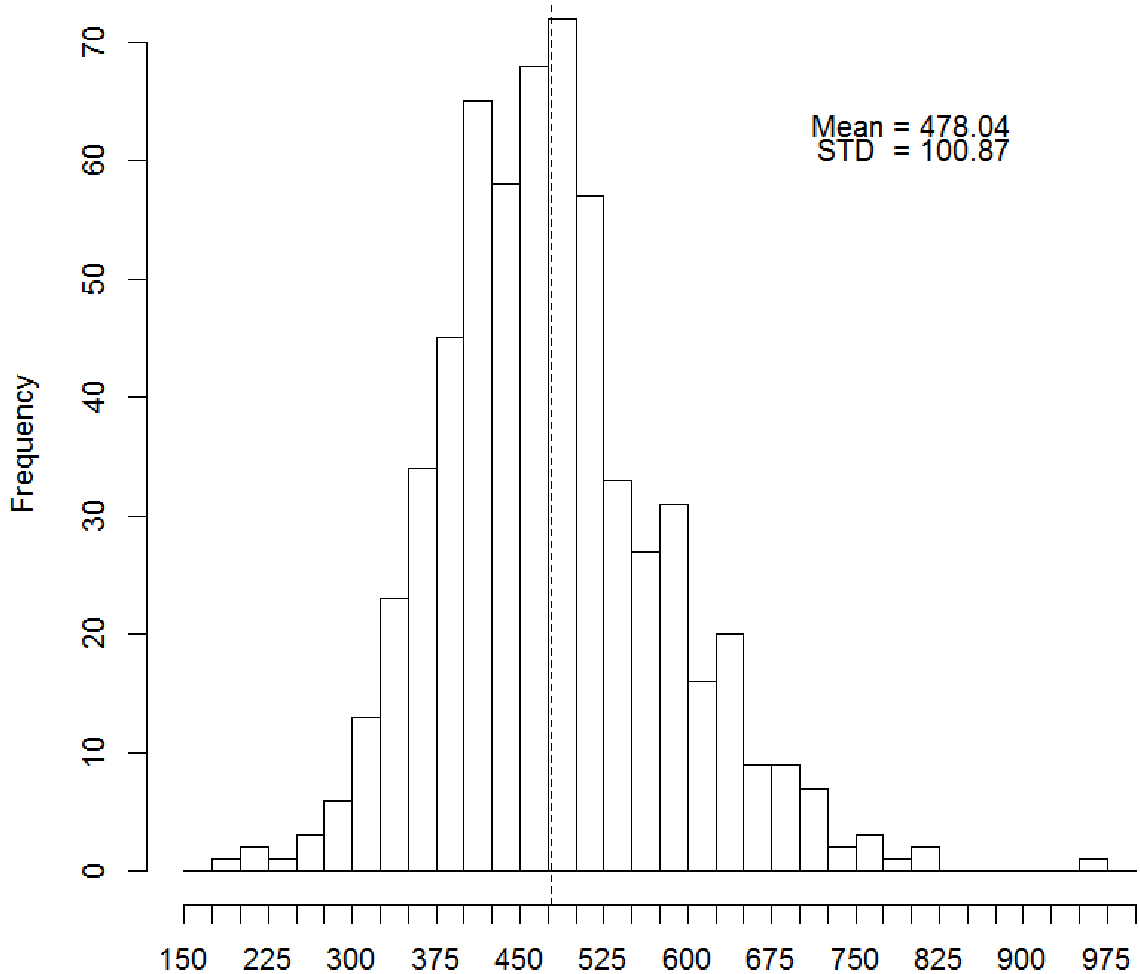


Figure 5.9.6. Red grouper length-frequency histograms (fork length - 25 mm bins) measured using parallel lasers from 1993-2009 and stereo-cameras from 2008-2013 (combined data set, N=609) from the Panama City reef fish survey.

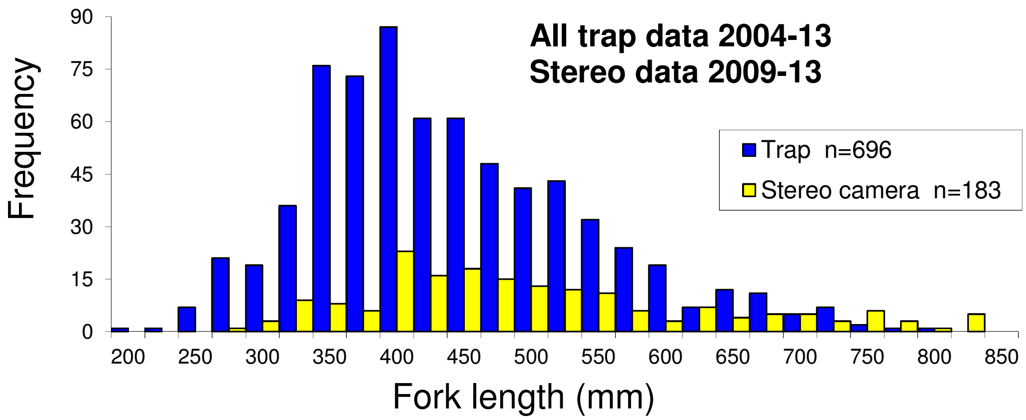


Figure 5.9.7. Overall size distributions of red grouper measured from stereo camera images, 2009-2013 and captured in chevron traps, 2004-2013, in the Panama City reef fish survey.

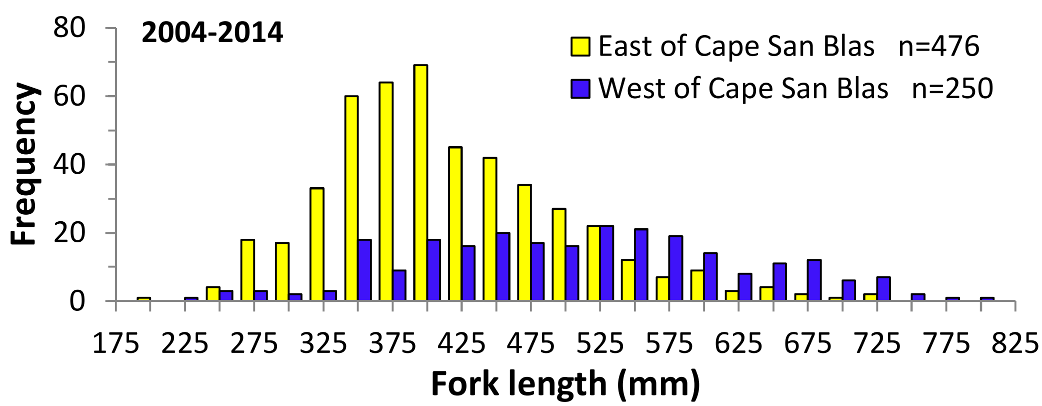


Figure 5.9.8. Overall size distributions of trap-caught red grouper by region, 2004-2014, from the Panama City reef fish survey.

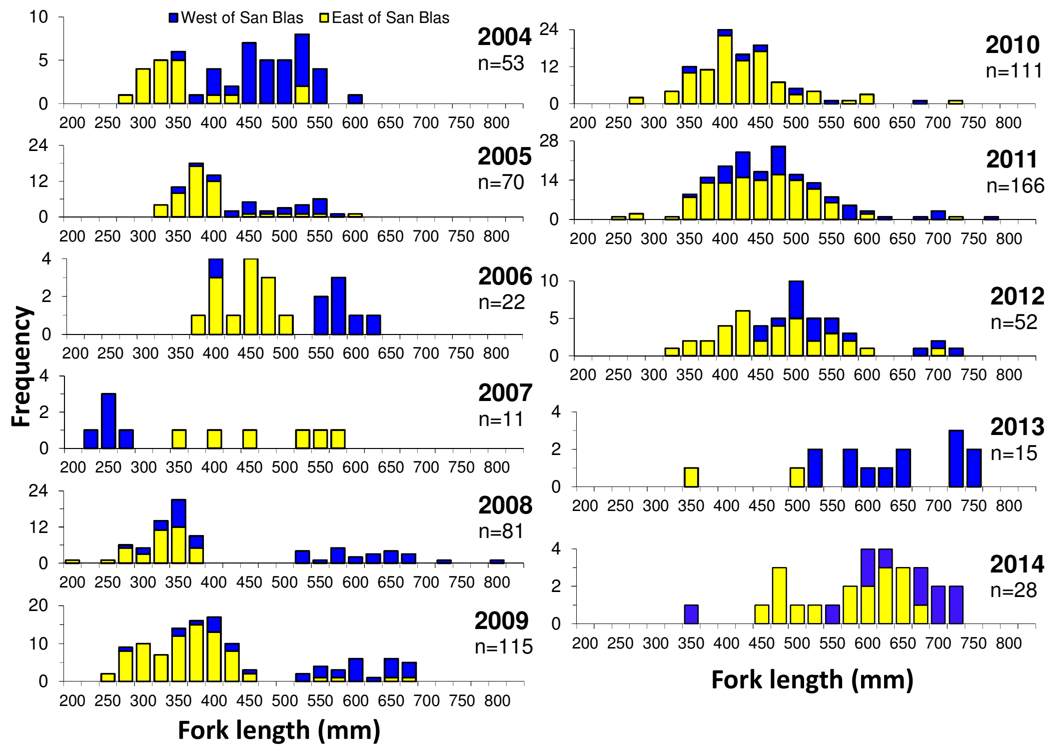


Figure 5.9.9. Annual size distributions of red grouper collected in chevron traps, 2004-2014, east and west of Cape San Blas from the Panama City reef fish survey.

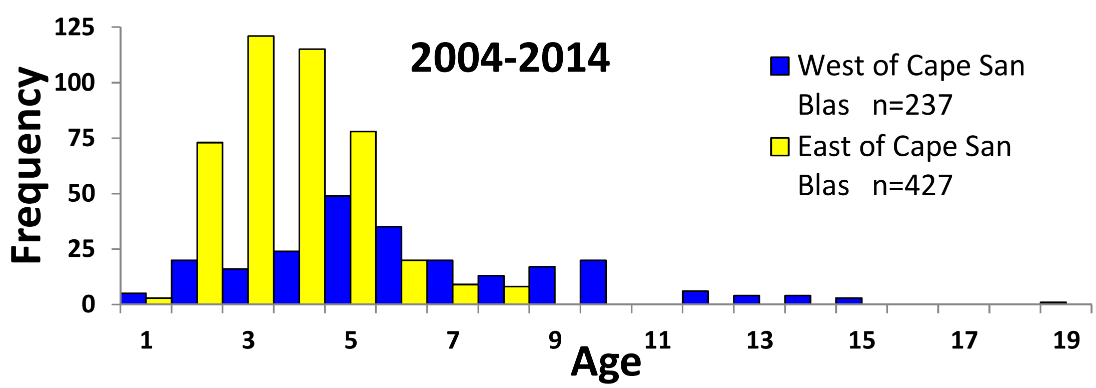


Figure 5.9.10. Overall age structure of trap-caught red grouper, 2004-2014, east and west of Cape San Blas from the Panama City reef fish survey.

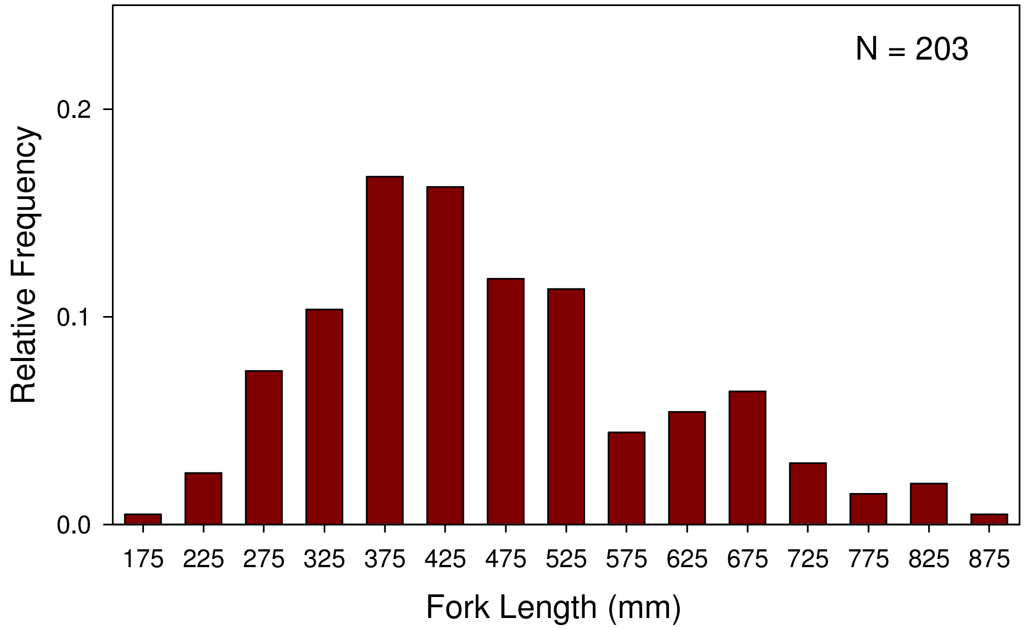


Figure 5.9.11. Length frequency distribution of red grouper observed in the FWRI video survey on stationary underwater camera arrays and measured using Vision Measurement System software.

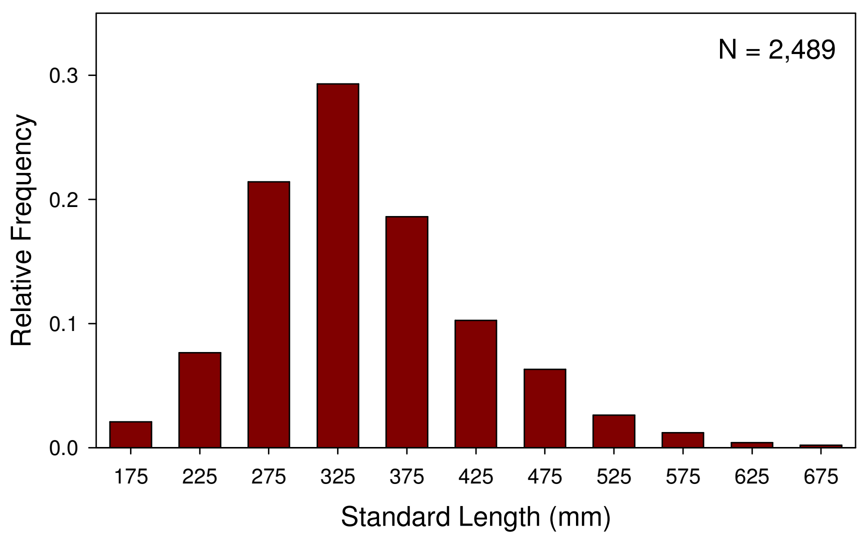


Figure 5.9.12. Length frequency distribution of red grouper captured in chevron traps in the FWRI trap survey.

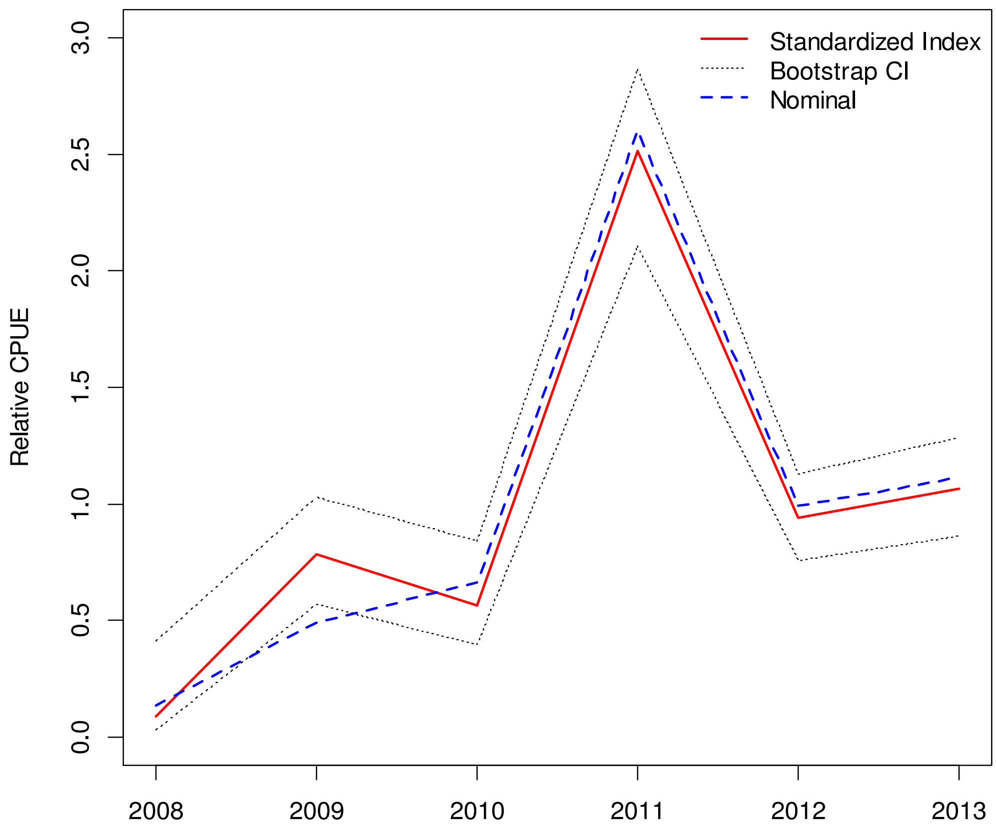


Figure 5.9.13. Relative standardized index (solid red line) with 2.5% and 97.5% confidence intervals (black dotted lines) and the relative nominal index (blue hashed line) for red grouper CPUE in the FWRI West Florida Shelf trap survey.

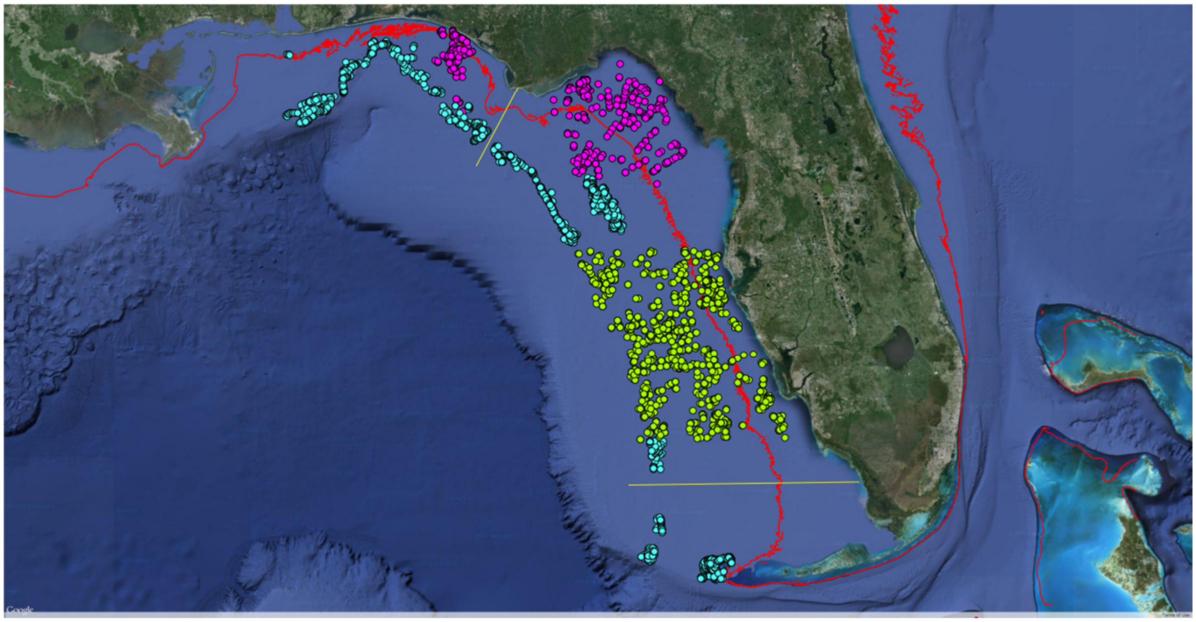


Figure 5.9.14. Video survey effort for NMFS-SEAMAP (light blue circles), PCVideo (pink circles), and FWRI (green circles) video surveys, and division of that effort into two depth strata (red 25 m isobath) and three geographic strata (straight tan lines).

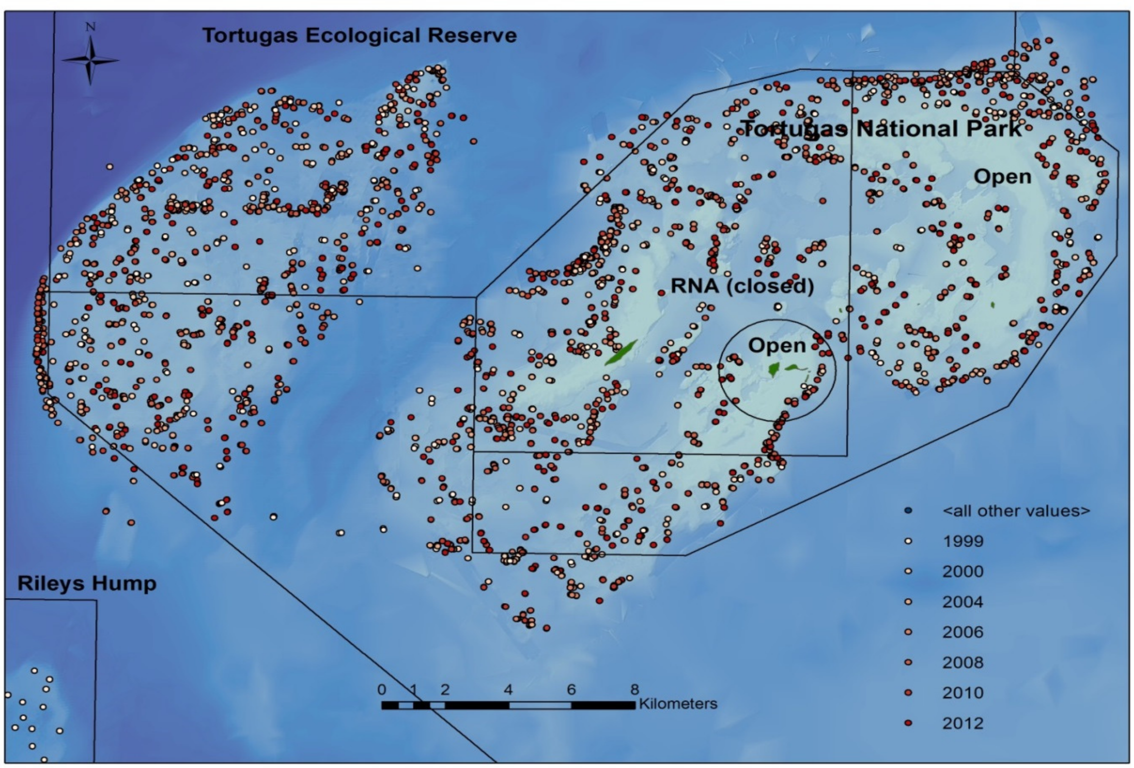
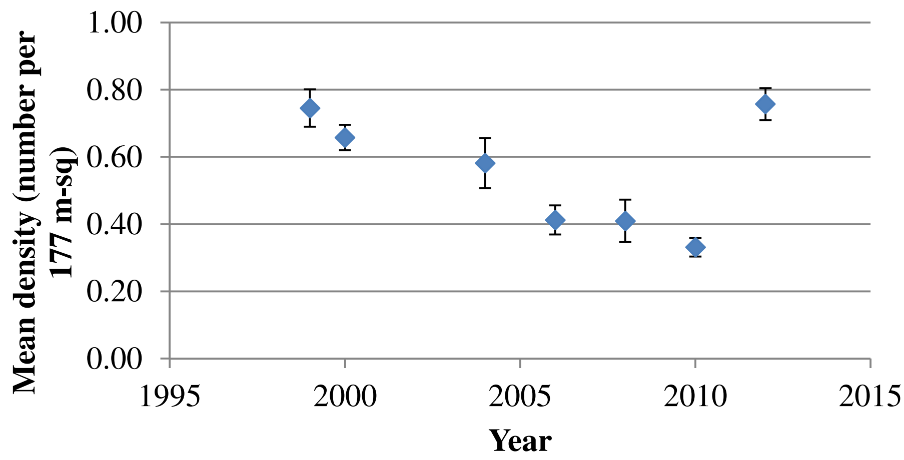


Figure 5.9.15. Map of the RVC sampling sites in the Dry Tortugas.

a)



b)

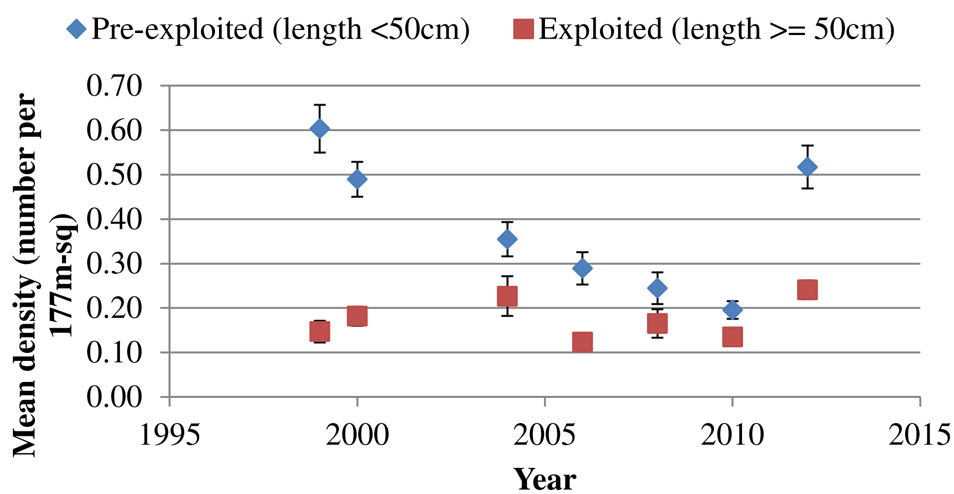


Figure 5.9.16. a) Red grouper overall mean density from the Dry Tortugas RVC project, b) the mean density of pre-exploited red grouper (i.e., length < 50cm) and the mean density of exploited red grouper (i.e., length > = 50cm). The points represent the mean density and the bars represent the standard error.

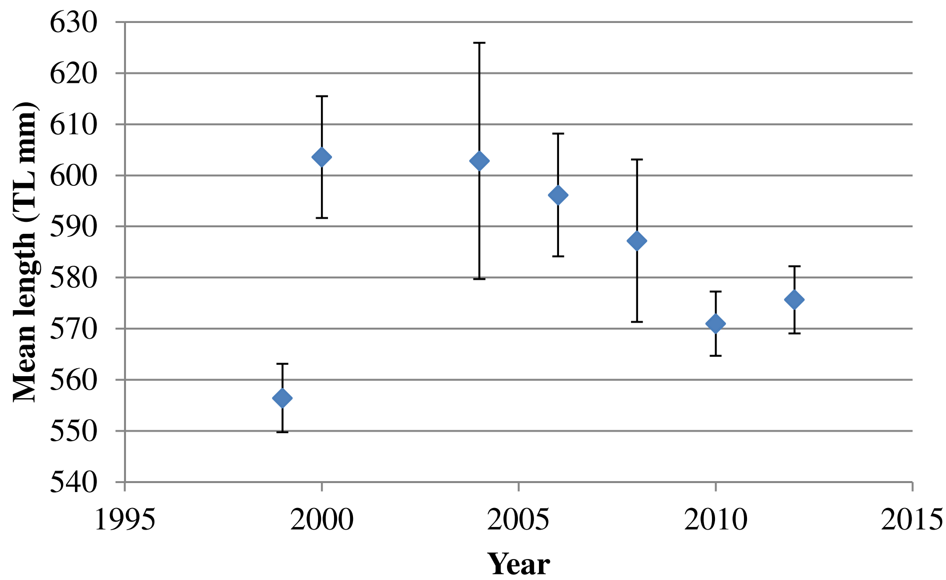


Figure 5.9.17. Mean length (TL mm) of legal red grouper (length > = 50cm TL), from the Dry Tortugas RVC project, 1999 - 2012.

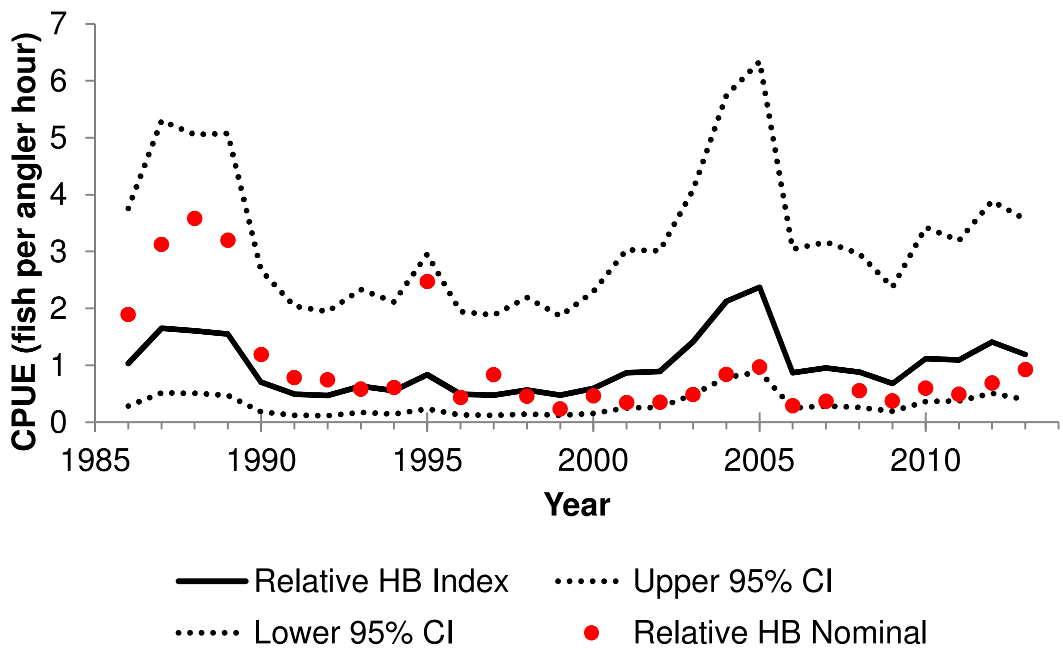


Figure 5.9.18. Standardized indices with 95% confidence intervals and nominal CPUE for the headboat index.

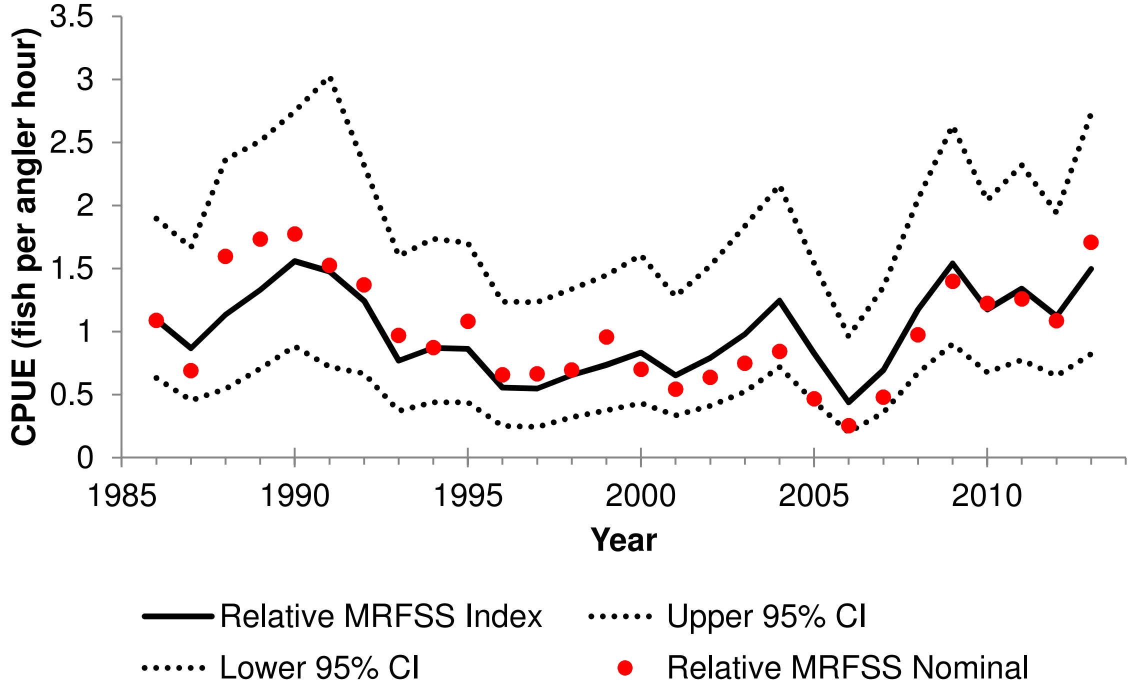


Figure 5.9.19. Standardized indices with 95% confidence intervals and nominal CPUE for the MRFSS index.

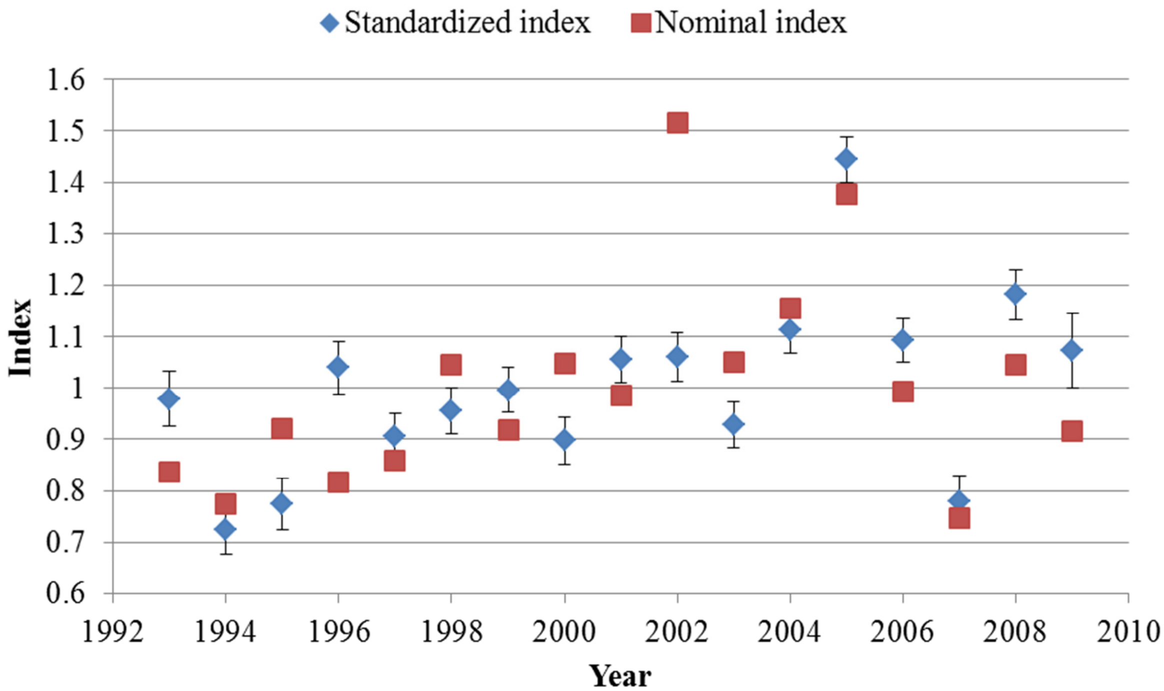


Figure 5.9.20. The standardized red grouper commercial longline index for shrimp grids 1-10 in the Gulf of Mexico from 1993 until 2009 (years before the implementation of IFQ). The points represent the catch rates normalized to an average of one. The bars represent the CV. See Table 5.8.12 for values.

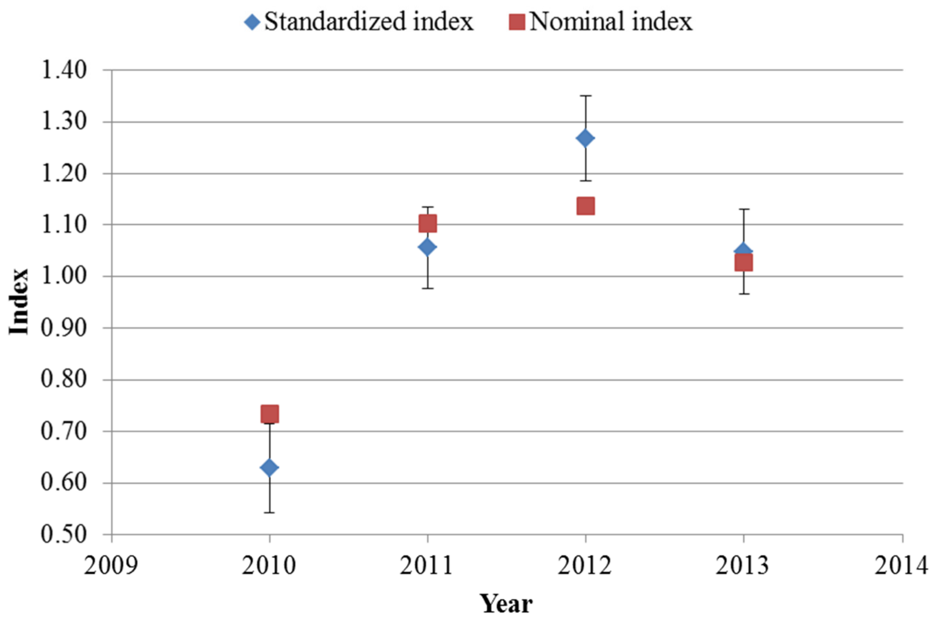


Figure 5.9.21. The standardized red grouper commercial longline index for shrimp grids 1-10 in the Gulf of Mexico from 2010 until 2013 (years of IFQ program). The points represent the catch rates normalized to an average of one. The bars represent the CV. See Table 5.8.13 for values.

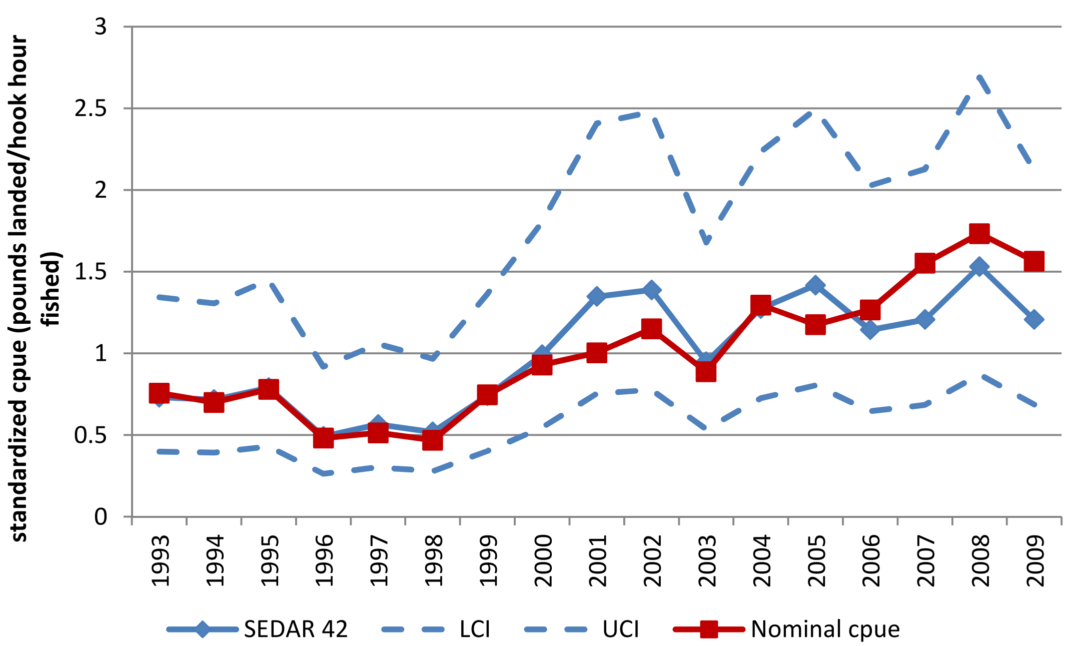


Figure 5.9.22. Pre-IFQ commercial vertical line standardized index of abundance (pounds landed/hook hour fished) of red grouper with 95% confidence intervals.

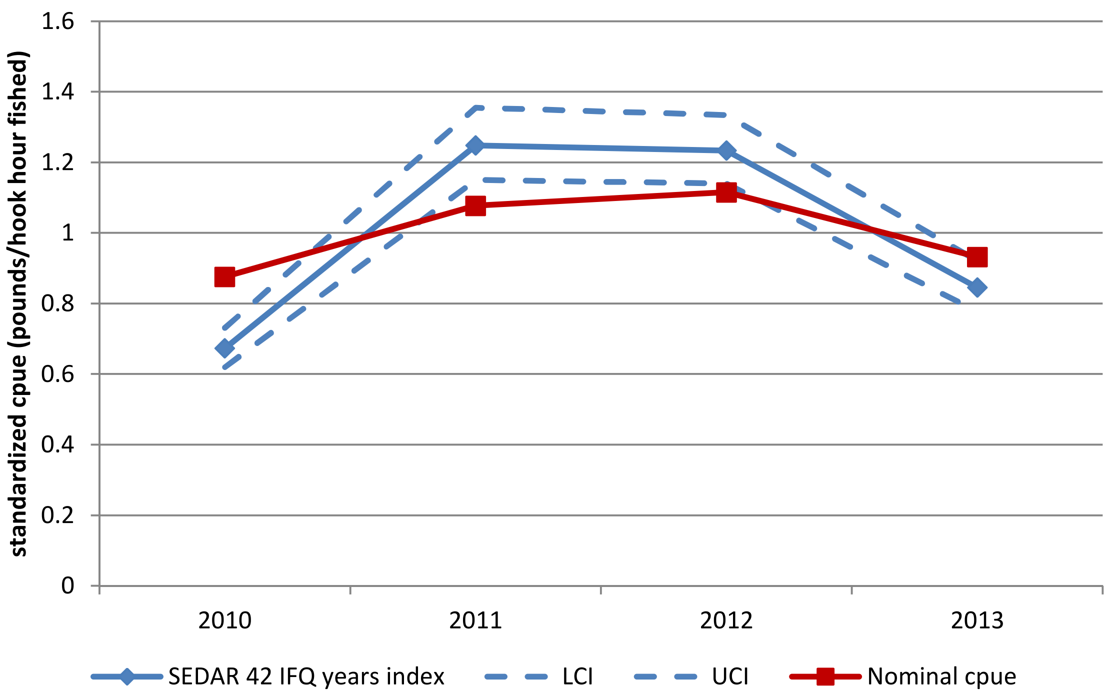


Figure 5.9.23. IFQ commercial vertical line standardized index of abundance (pounds landed/hook hour fished) of red grouper with 95% confidence intervals.

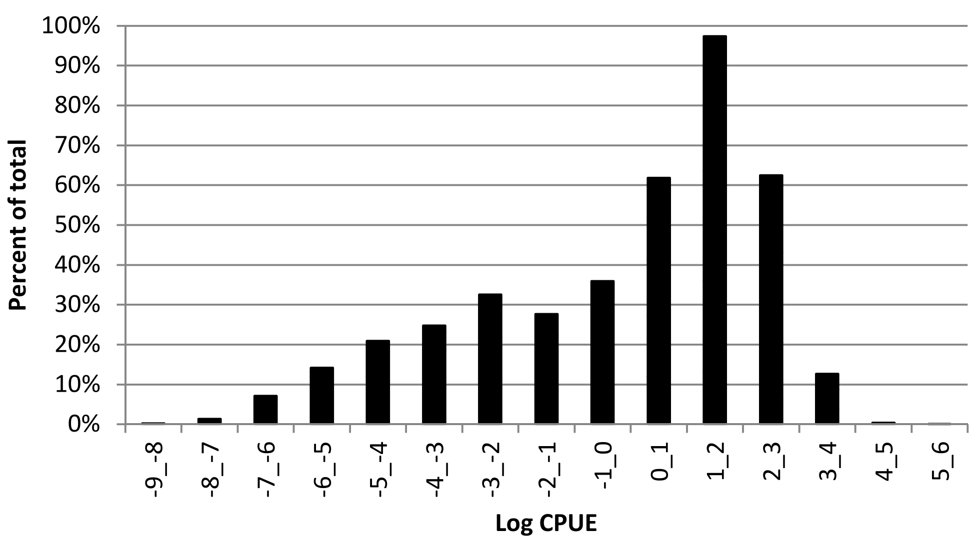


Figure 5.9.24. Commercial vertical line percent frequency of the log of red grouper CPUE, all 2010-2013 positive trips included. Log CPUE bins are: -9 to -8, -8 to -7, etc.

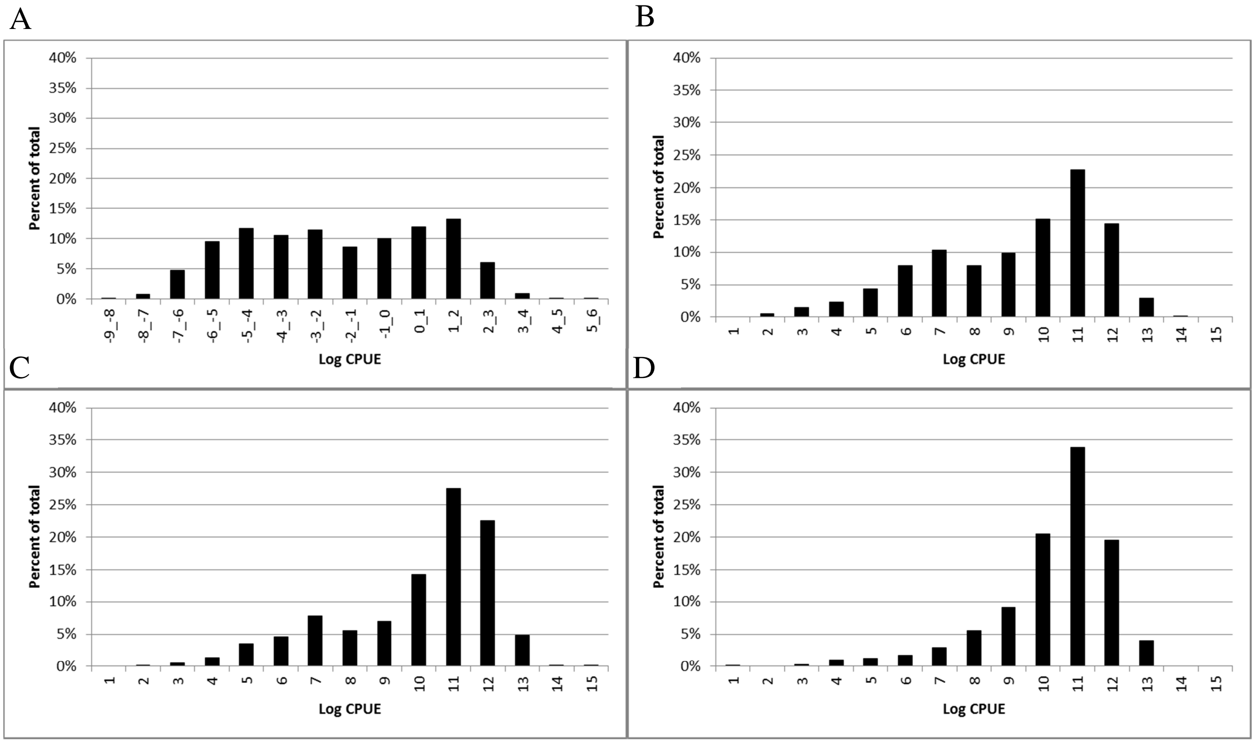


Figure 5.9.25. Commercial vertical line percent frequency of the log of red grouper CPUE by amount of red grouper allocation A. 1-1,166 pounds. B. 1,167-3,716 pounds. C. 3,717-10,300 pounds. D. 10,300 or more pounds.

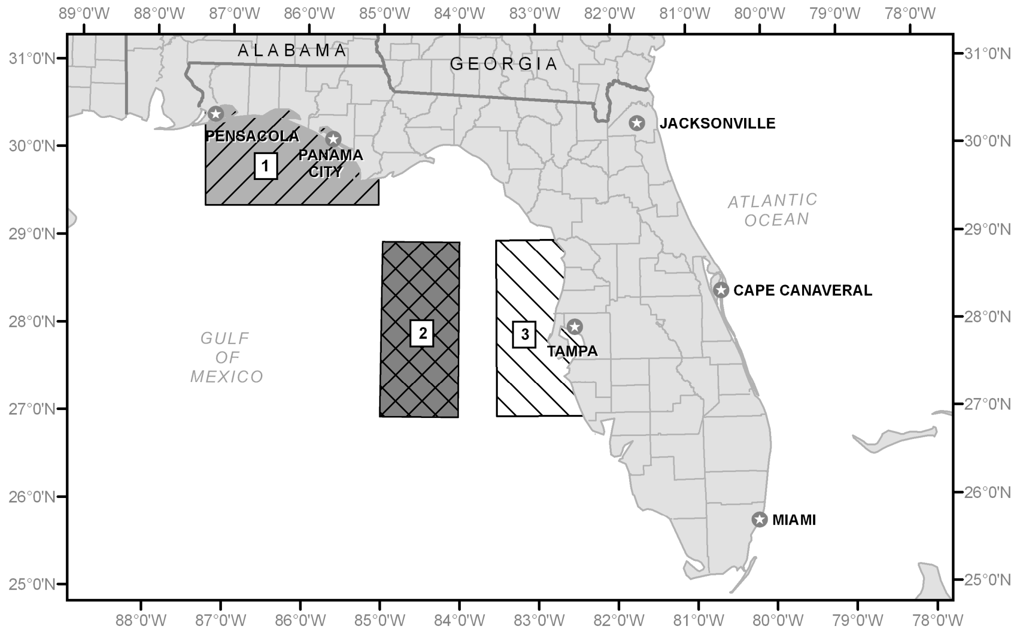


Figure 5.9.26. Areas 1 and 3 represent the two regions where fishing trips included in the headboat observer discard index took place. Multi-day trips in region 2 were excluded from this index since the majority of red grouper caught offshore are legal to harvest.

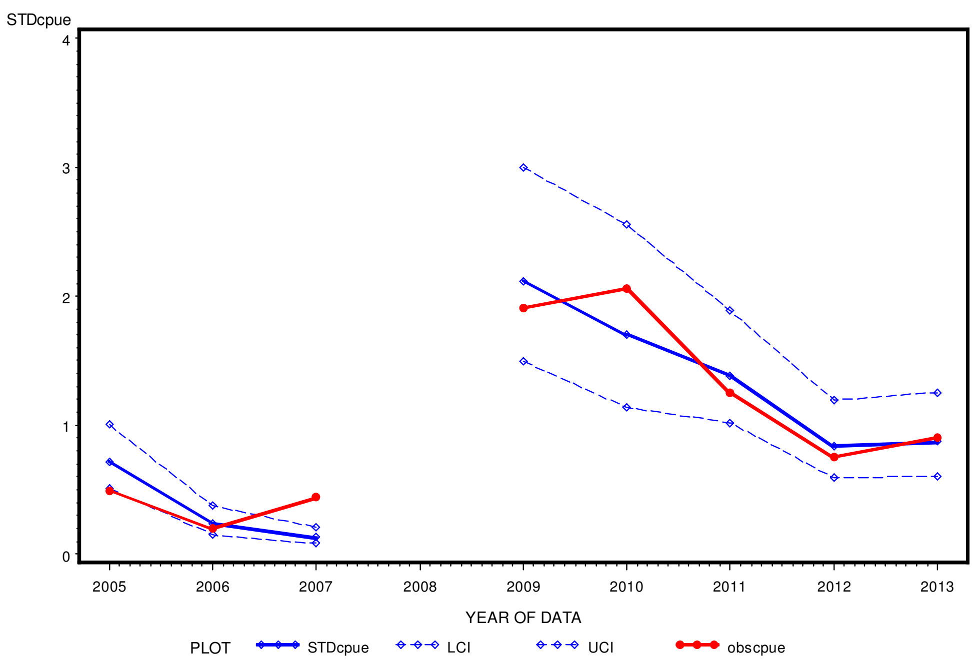


Figure 5.9.27. Annual index of abundance for red grouper from the Headboat Observer Discards from 2005 – 2013.

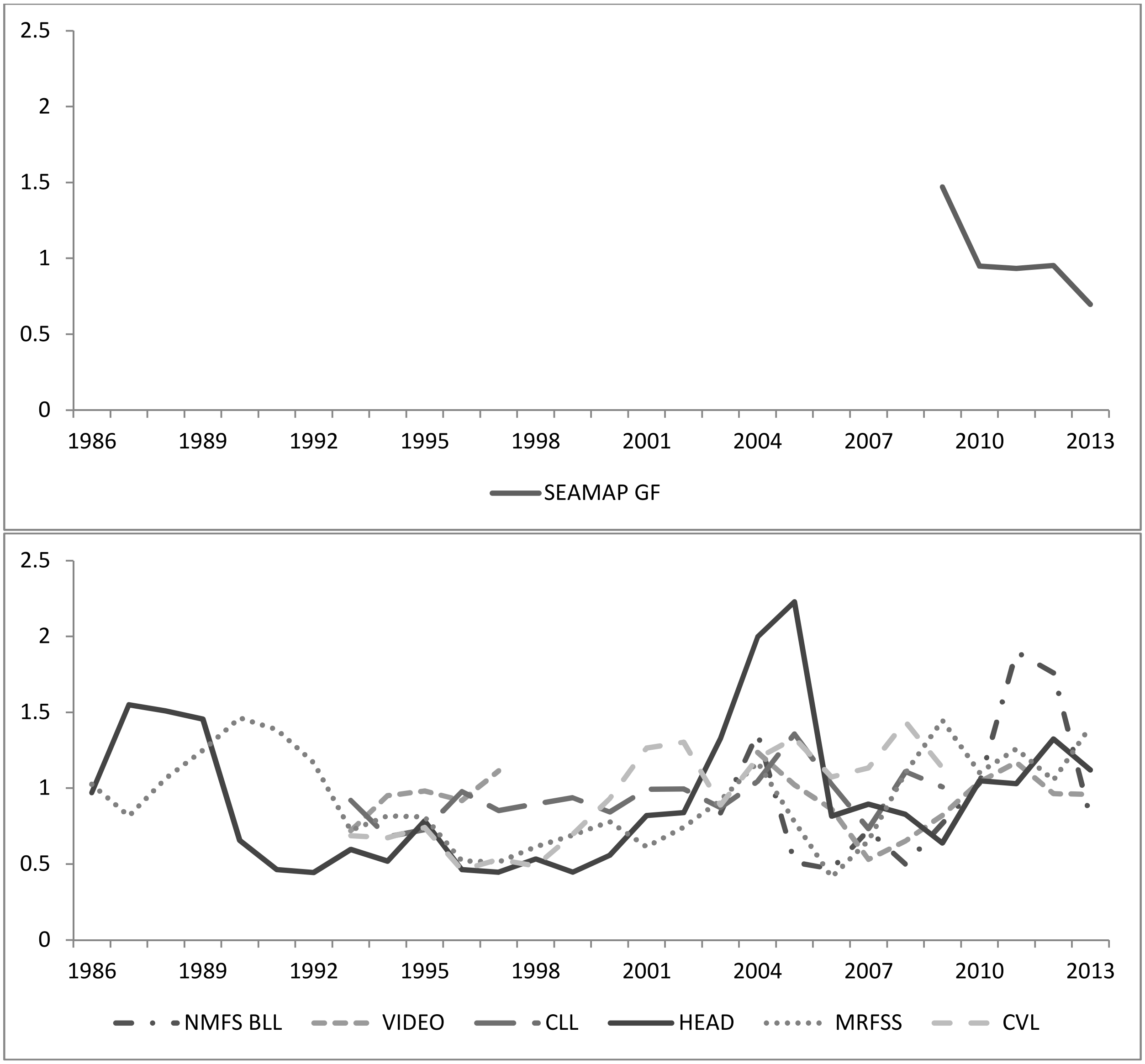


Figure 5.9.28. Plot of all recommended indices (normalized to the common years), grouped by sampled portion of the population (top – juveniles, bottom – adults). SEAMAP GF – SEAMAP Summer Groundfish Survey, NMFS BLL – NMFS Bottom Longline Survey, VIDEO – Combined Video Survey, CLL – Commercial Longline, CVL – Commercial Vertical Line, HEAD – Headboat and MRFSS.

6 INTEGRATED ECOSYSTEM ASSESSMENT AD-HOC WORKING GROUP

6.1 OVERVIEW

The Integrated Ecosystem Assessment (IEA) group sought to develop three products for SEDAR 42. The first product provides quantitative insight into how red tide events are distributed in relation to red grouper, so as to highlight the importance of considering natural mortality due to red tide events in the stock assessment model of red grouper. The other products delivered by the IEA group are intended for integration into the red grouper Stock Synthesis assessment model: (1) estimates of age-specific natural mortality due to predation and other causes (e.g., red tide events); and (2) estimates of recruitment anomalies due to oceanographic factors that are independent of spawning stock biomass. The integration of these two ecosystem products developed by the IEA group will allow the linkage of natural mortality and recruitment to ecosystem processes including predation, red tide events, and oceanographic conditions.

The effects of environmental forces on red grouper and other commercial stocks have been well-established. One of the primary concerns for red grouper in the northern Gulf of Mexico is the presence of sporadic red tide events, which are thought to cause increased mortality in some years. This issue in particular was noted because of a well-observed severe red tide event in 2005, and an associated large decline in multiple abundance indices for red grouper and other species thought to be susceptible to mortality from red tide events. It is unknown whether mortality occurs via absorption of toxins across gill membranes (Abbott et al. 1975, Baden 1988), ingestion of toxic biota (Landsberg 2002), or from some indirect effect of red tide such as hypoxia (Walter et al. 2013). A statistical study conducted within the Gulf of Mexico IEA program evaluated the impacts of including time-varying red tide mortality in the Gulf of Mexico gag grouper (*Mycteroperca microlepis*) Stock Synthesis assessment model configured for SEDAR 33 (Sagarese et al. 2014b). Consideration of red tide mortality in the Stock Synthesis assessment model improved model fit, and was incorporated into the base stock assessment. The inclusion of red tide mortality within the base assessment model better explained historical trends in abundance and accounted for interannual variation resulting from environmental influence otherwise viewed by the model as random deviates.

Other environmental perturbations in addition to red tide events have the potential to affect populations of demersal fishes. The passage of hurricanes, for example, appears to affect movement and site-fidelity of red snapper (Patterson et al. 2001). The presence of red grouper west of the Florida-Alabama line has been suggested to relate to displacement of individuals by hurricanes (Franks 2005). Periodic upwelling events and associated reductions in temperature and increases in nutrients have been documented to contribute to mass mortality of fishes and macroinvertebrates, potentially in association with the development of near-anoxic conditions (Collard & Lugo-Fernández 1999, Collard et al. 2000). Within the Florida Fish and Wildlife Research Institute's (FWRI) fish kill database (http://research.myfwc.com/fishkill/), red grouper fish kills have been documented due to cold weather events. During SEDAR 33 in 2013, a member of the life history group noted that physical conditions in the northeastern Gulf of Mexico were displaying similar patterns to those observed in the spring and summer of 1998, when an extended period of stratification led to hypoxia in this region. Incorporation of this and other sporadic events should be a focus of IEA efforts in future assessments.

It is well-known that factors besides spawning stock biomass can affect recruitment strength. Typically, such factors are not included in assessment models, and therefore manifest themselves as anomalies from the stock-recruitment relationship. The accuracy and/or precision of the assessment can be improved by explaining some of this variation with a suitable index, representing external environmental forces hypothesized as drivers of recruitment. Typically, this is done by looking for correlations between recruitment deviations, and environmental variables such as climate indices (e.g., Atlantic Multidecadal Oscillation), sea surface temperature, or wind strength. Rather than relying on correlational models, which produce relationships which may or may not hold true in future years, the IEA working group has taken a more mechanistic approach to describing anomalies in the stock recruitment relationship. This is done via a hydrodynamic model, the Connectivity Modeling System (CMS) (Paris et al. 2013), which simulates the transport of larvae, and allows us to calculate expected recruitment anomalies based on the oceanographic conditions observed for each year. Estimates of annual recruitment deviations produced using the CMS (Karnauskas et al. 2013) were incorporated in the SEDAR 33 gag grouper Stock Synthesis assessment model as a sensitivity run. These estimates explained about one-third of the variation in the stock-recruitment deviates from the gag grouper assessment model, and their consideration in the Stock Synthesis assessment model informed the recent years of the assessment where cohort strength is poorly estimated. The IEA group estimated annual recruitment anomalies of red grouper due to oceanographic factors over the period 2003–2013, and plans to devise scenarios based on methods for inclusion of the recruitment anomaly index in the red grouper Stock Synthesis assessment model.

6.1.1 IEA Working Group Participants

Michael Schirripa*	NMFS SEFSC Miami
Mandy Karnauskas*	NMFS SEFSC Miami
Meaghan Bryan	NMFS SEFSC Miami
Arnaud Grüss	RSMAS
Skyler Sagarese	RSMAS
William Harford	RSMAS
Walter Ingram	NMFS Pascagoula

*Not present at data workshop.

6.2 CONTRIBUTED MODELING ENVIRONMENTS

The contributed modeling environments for SEDAR 42 include:

1. Spatiotemporal overlap of juvenile and adult red grouper distribution with red tide events in the northeastern Gulf of Mexico
2. An individual-based, multi-species OSMOSE model for the West Florida Shelf
3. The Connectivity Modeling System, a Lagrangian particle-tracking model (Paris et al. 2013)

Each of the modeling efforts is briefly presented below.

6.2.1 Spatiotemporal overlap of red grouper distribution with red tide events

<u>*Methods*</u>

Generalized linear models were developed to quantify ontogenetic spatial distributions of red grouper and to enable an assessment of the spatiotemporal overlap between juvenile and adult red groupers and red tide events. The aggregation of fishery-independent (SEAMAP trawl survey, 2011 expanded annual stock assessment survey, NMFS bottom longline survey) and fishery-dependent data (Shark bottom longline observer program, Observer longline, Observer vertical line) was necessary to provide sufficient data and resolution for rigorous model evaluation. Using the parameters estimated by the optimal binomial GLM, the expected probability of occurrence of each life-history stage was predicted across space. The resulting spatial distribution maps for juvenile and adult red groupers were used to investigate overlap with red tide events.

The predicted presence of red tide throughout the West Florida Shelf was available from 1998 through 2010 and was based on statistical models developed during SEDAR 33 (Walter et al. 2013). Generalized additive models predicted the probability of a red tide bloom using a suite of satellite derived remote sensing products from Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and the FWRI's harmful algal bloom cell counts (Walter et al. 2013). Monthly estimates of the predicted probability of red tide occurrence were averaged to obtain annual estimates of predicted probability of red tide throughout the WFS. Annual estimates of spatiotemporal overlap between red grouper distribution and red tide distribution served as a proxy of the exposure of each life-history stage to red tide events. Further details on methods used for this study are outlined in Sagarese et al. (2014a).

Assessment Contributions

Spatial overlap analyses reinforced the importance of considering the influence of red tide events on red grouper dynamics. Peak overlap between predicted red grouper distribution and red tide occurred in 2005 for both juvenile (ages 1-3) and adult (ages 3+) red groupers.

6.2.2 OSMOSE

Methods

An ecosystem simulation model, OSMOSE-WFS, was developed to describe the trophic structure of the West Florida Shelf (WFS) ecosystem in the 2000s. This model was used to produce estimates of natural mortality rates for different life stages of gag grouper (younger juveniles, older juveniles and adults) for SEDAR 33. OSMOSE-WFS is an individual-based, multi-species model, which explicitly represents major processes in the life cycle of a number of high trophic level groups of species. OSMOSE-WFS builds on WFS Reef fish Ecopath, an Ecopath model for the WFS. However, OSMOSE-WFS and WFS Reef fish Ecopath differ greatly in both their structure and assumptions. In particular, predation mortality and diet compositions emerge from model simulations in OSMOSE-WFS, whereas they are determined *a priori* in WFS Reef fish Ecopath. The use of OSMOSE-WFS, WFS Reef fish Ecopath and other ecosystem models developed within the Gulf of Mexico IEA program through a multi-model approach allows us to have different perspectives on the same research questions, while being able to identify from where discrepancies between the different ecosystem models may originate. Further details on the construction, parameterization, calibration and validation can be found in Grüss et al. (2014b).

In OSMOSE-WFS, we recently switched from the 'iterative mortality algorithm' used in Grüss et al. (2014b) to the better-performing 'stochastic mortality algorithm', which assumes that all types of mortalities are continuous processes that compete with each other, and that there is competition and stochasticity in the predation process (http://www.osmose-model.org/). This update of OSMOSE-WFS entailed a recalibration of the model, which is described in detail in Grüss et al. (2014b).

Assessment Contributions

Once OSMOSE-WFS was recalibrated, the model was used to produce estimates of natural mortality for different stanzas (younger juveniles, older juveniles and adults) and age classes (0-1 year old, 1-2 years old, …, 8-9 years old and 9+ years old individuals) of red grouper. Estimates of natural mortality rates for age classes of red grouper could be used in the Stock Synthesis assessment model employed for SEDAR 42. Several methods have been proposed for incorporating estimates of instantaneous natural mortality into a single-species stock assessment model, each with advantages and disadvantages. The best method depends on the specifics of the assessment model being used, and which is most appropriate for Gulf of Mexico red grouper needs to be evaluated and discussed. Note that the definition of age classes of red grouper presented in SEDAR42-DW-02 can be altered if necessary.

6.2.3 CMS

Methods

The Connectivity Modeling System (CMS) is a biophysical modeling system based on a Lagrangian framework, and was developed to study complex larval migrations (Paris et al. 2013). The CMS uses outputs from hydrodynamic models and tracks the three-dimensional movements of advected particles through time, given a specified set of release points and particle behaviors. Optional modules are provided to allow for complex behaviors and movements, simulating observed biological phenomena such as egg buoyancy and ontogenetic vertical migration. The specific model set up used for SEDAR 42 is outlined in detail in Grüss at al. (2014a).

Assessment Contributions

The CMS modeling effort produced an index of recruitment anomalies due to oceanographic factors for red grouper by year, for the years 2003 – 2013. This index represents the expected recruitment strength due to oceanographic conditions alone, without the influence of spawning stock biomass. The recruitment anomalies index produced with the CMS can be directly input as an environmental covariate into the Stock Synthesis assessment model used for SEDAR 42.

6.3 INTEGRATION OF ECOSYSTEM PRODUCTS INTO STOCK SYNTHESIS

The IEA working group agreed that both estimates of natural mortality and recruitment anomalies would be worthy of consideration for inclusion in the stock assessment process. Schirripa et al. (2013) provided a detailed outline of various methods for incorporating estimates of natural mortality and recruitment anomalies into Stock Synthesis. IEA products could either be incorporated directly into the base model if justified or tested as sensitivities.

Two studies provided estimates of natural mortality. First, the statistical model of the probability of red tide severity (Walter et al. 2013) could be directly input into the stock assessment model as a regulator of natural mortality for red grouper. Although this study was first presented for gag grouper, the results also apply to red grouper since it focused on critical habitat for both grouper species. Secondly, Grüss et al. (2014b) presented a vector of natural mortality estimates for age classes obtained from their OSMOSE model.

Within Stock Synthesis, various methods exist for linking ecosystem products to processes including natural mortality and recruitment. Natural mortality can deviate as a time-varying function of an environmental index, such as red tide severity Walter et al. (2013). Scenarios based on combinations of potential red tide indices and methods for inclusion can be devised to test whether the plausibility of the stock assessment model increases with environmental consideration. The first method termed the '*model method*' requires estimation of an additional parameter which relates the environmental time-series to deviations in natural mortality (Maunder & Watters 2003). This approach also works for recruitment and allows indices of natural mortality and/or recruitment anomalies to be incorporated as an index with a variance, which the stock assessment model then attempts to fit. For recruitment anomalies, the '*data method*' treats environmental data as a survey of annual recruitment deviations (i.e., age-0 survey) with an associated variance. For natural mortality, the '*modified data method*' can be used to link natural mortality to a block design where environmental index values are used as Bayesian priors (with standard deviation) within the Stock Synthesis assessment model. This method is encouraged for situations where episodic events (such as red tides) drive natural mortality (Schirripa & Methot 2013) and allows for annual observation error (Schirripa et al. 2009).

Another avenue for incorporating red tide into natural mortality is through the creation of a discard-only red tide fishing fleet to drive natural mortality. In this pseudo-fishery, all fish encountered are discarded with 100% mortality. Selectivity of the red tide fishing fleet can either be assumed constant at age if data on size-specific red tide mortality is lacking or can be specified based on field collections of individuals in red tide fish kills.

Only one estimate of recruitment anomalies was put forward by the IEA working group (based on the Connectivity Modeling System), and it was agreed that this index would be put forth for recommended inclusion in the assessment. This index could be incorporated via the 'model method' or via the 'data method' discussed above.

6.4 RESEARCH RECOMMENDATIONS

Recommendation 1: Time varying natural mortality

Research is required to incorporate interannual variation in red grouper natural mortality within the assessment process. In particular, elevated mortality rates in fishes, including members of the shallow-water grouper complex, can be caused by severe red tide events (Flaherty & Landsberg 2011). A red tide severity index (Walter et al. 2013) was previously included in the base stock assessment model for Gulf of Mexico gag grouper, which improved model fits to indices of abundance (Sagarese et al. 2014b). In the Gulf of Mexico gag grouper assessment (SEDAR 33), fluctuations in red tide mortality varied more than 10-fold through time, and were estimated to be commensurate with fishing mortality rates in several "severe" years (Sagarese et al. 2014b). Like the gag grouper SEDAR assessment, red tide severity should be considered as a source of mortality for red grouper. This recommendation requires at least four research steps.

First, length/age composition data are needed to determining lengths/ages susceptibility to red tide severity.

Collections of fish during red tide events would allow for the size/age selectivity of mortality to be determined, and might also allow for some minimum estimates of total mortality. Preliminary data were distributed by the NMFS Panama City lab containing red grouper lengths and estimated ages for 16 individuals collected from the Big Bend region during August 1st and 3rd of 2014. During plenary, various participants noted that collection of samples during the NMFS bottom longline survey was complicated by the decomposed nature of many fish encountered, which also prevented length estimates. In addition, otoliths were often difficult to recover from some specimens because they were missing anterior portions of their body.

Second, existing indices of red tide severity should be updated.

The IEA group recommends research to produce candidate indices of red tide severity and to devise scenarios based on red tide indices and methods for inclusion in the red grouper Stock Synthesis assessment model. Updating red tide indices is difficult because the original red tide indices (Walter et al. 2013) were created using SeaWiFS (operational 1998 – December 2010) satellite sensors. More recently, MODIS (Moderate Resolution Imaging Spectrometer) satellite sensors (July 2002 – present) have been used to detect and track harmful algal blooms (Stumpf et al. 2003, Hu et al. 2005). Thus, steps need to be taken to (i) calibrate SeaWiFS and MODIS satellite data during overlap periods; (ii) extend the red tide index through the present period (2014); and (iii) automate compilation of satellite data, and calculation and reporting of index values.

Third, procedures for incorporating red tide indices into Stock Synthesis should be critically evaluated.

Simulations should be conducted to evaluate the consequences of assuming constant or size specific natural mortality, when mortality actually fluctuates according to episodic temporal events. Further, approaches to incorporating environmental indices in stock assessment tuning procedures should be compared through simulated datasets to evaluate the effects of assessment model misspecification.

Fourth, the statistical properties of red tide indices should be characterized for use in simulations and assessment projections.

Evaluate whether all levels of red tide severity are equally likely in near-term future events, or whether information is contained in red tide indices that can be used to generate 'forecast distributions'. Time series decomposition can be used to statistically characterize red tide indices (Stumpf et al. 2003). By quantifying periodicity, trends, and stochasticity, 'forecast distributions' may enable plausible future scenarios to be considered in assessment projections.

Recommendation 2: Index of red tide mortality derived from Ecopath with Ecosim

The IEA working group agreed that additional efforts deriving natural mortality values from the WFS Red tide Ecopath with Ecosim model would be helpful as presented for gag grouper during SEDAR 33 (Gray et al. 2013). These modeling efforts would allow red tide events to affect multiple components of the West Florida Shelf ecosystem and to assess the overall effect of red tide and predator/prey dynamics on the mortality rates of Gulf of Mexico red grouper.

Recommendation 3: Elucidating the response of red grouper to red tide events

Future modeling efforts should aim to address whether groupers move in response to red tide events or if they experience elevated natural mortality during these episodic events.

Recommendation 4: Modifications to the CMS modeling framework

Additional fisheries-independent data (e.g., PCLAB data) will be incorporated in the datasets used for habitat modeling of red grouper. This will allow us to improve the predictions made by the binomial GLMs described in SEDAR42-DW-04. Thus, we will be able to better predict the probability of presence of adult red grouper on the West Florida Shelf and, therefore, to better simulate the production of red grouper eggs over space in the CMS.

The life history working group brought up concerns regarding the aggregated use of all adult red groupers in determining the number of eggs released at red grouper spawning sites. There is evidence in red grouper that the fecundity of large adult females is considerably higher than that of small adult females. To account for this, the IEA group will use data compiled by the life history group to calculate mean age at depth for red grouper. This information will be useful to estimate the number of eggs released at each red grouper spawning site based on (1) the probability of presence of adult red grouper at that site; and (2) the relative fecundity at that site. The relative fecundity at each spawning site will be determined from: (1) the depth at that site; (2) the mean age at depth profile; and (3) the fecundity-at-age (number of eggs released during a spawning event at age) profile.

The CMS index should be extended to cover 2014 to provide insight into potential recruitment for the first year of projections.

Recommendation 5: Enhance fish kill reporting, particularly in offshore regions

Current understanding of fish killed by red tide events largely originates from the Florida Fish and Wildlife Conservation Commission and Fish and Wildlife Research Institute fish kill database, which is informed by a statewide fish kill hotline (http://research.myfwc.com/fishkill/). Many of the observations are based on fish that washed ashore following red tide events. Enhanced reporting of red tides, in addition to observations from offshore waters by recreational and commercial fishermen, could increase understanding of how red tide events impact offshore species. This could be achieved through the creation of a national program or increased citizen science through outreach educating fishermen and other Gulf patrons on their ability to improve fish kill reporting.

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SEDAR

Southeast Data, Assessment, and Review

SEDAR 42

Gulf of Mexico Red Grouper

SECTION III: Assessment Process Report

June 2015

SEDAR
4055 Faber Place Drive, Suite 201
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NOTE: Modifications to the model results reported in this report were made during the Review Workshop held 14-16 July 2015. For complete results reflecting those changes, please see the Addendum of this Stock Assessment Report (Section VI).

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1 Workshop Proceedings

1.1 Introduction

1.1.1. Workshop Time and Place

The SEDAR 42 Assessment Process for Gulf of Mexico red grouper was conducted via a series of webinars held between February and June 2015.

1.1.2. Terms of Reference

1. Review any changes in data following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.
2. Develop population assessment models that are compatible with available data and document input data, model assumptions and configuration, and equations for each model considered.
3. Incorporate known applicable environmental covariates into the selected model, and provide justification for why any of those covariates cannot be included at the time of the assessment

4. Provide estimates of stock population parameters, including:
   - Fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, red grouper being a protogynous hermaphrodite, and other parameters as necessary to describe the population.
   - Appropriate measures of precision for parameter estimates.
5. Characterize uncertainty in the assessment and estimated values.
   - Consider uncertainty in input data, modeling approach, and model configuration.
   - Provide a continuity model consistent with the prior assessment configuration, if one exists, updated to include the most recent observations. Alternative approaches to a strict continuity run that distinguish between model, population, and input data influences on findings, may be considered.
   - Consider and include other sources as appropriate for this assessment.
   - Provide appropriate measures of model performance, reliability, and 'goodness of fit'.
   - Provide measures of uncertainty for estimated parameters.
6. Provide estimates of yield and productivity.
   - Include yield-per-recruit, spawner-per-recruit, and stock-recruitment models.
7. Provide estimates of population benchmarks or management criteria consistent with available data, applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards.
   - Examine the effect of being a protogynous hermaphrodite on stock status criteria and other management benchmarks.
   - Evaluate existing or proposed management criteria as specified in the management summary.
   - Recommend proxy values when necessary.
8. Provide declarations of stock status relative to management benchmarks or alternative data poor approaches if necessary.
9. Provide uncertainty distributions of proposed reference points and stock status metrics that provides the values indicated in the management specifications. Include probability density functions for biological reference point estimates and population metrics (e.g., biomass and exploitation) used to evaluate stock status.
10. Project future stock conditions (biomass, abundance, and exploitation; including probability density functions) and develop rebuilding schedules if warranted; include estimated generation time. Develop stock projections for the following circumstances, in accordance with the guidance on management needs provided in the management history:

    A) If stock is overfished:

    $F=0$, $F_{Current}$, $F=F_{MSY}$, F_{Target}

    $F=F_{Rebuild}$ (max exploitation that rebuild in greatest allowed time)

    Fixed landings equal to the ABC

    B) If stock is overfishing

    $F=F_{Current}$, $F=F_{MSY}$, $F= F_{Target,}$ Fixed landings equal to the ABC

    C) If stock is neither overfished nor overfishing

$F=F_{Current}$, $F=F_{MSY}$, $F=F_{Target}$, Fixed landings equal to the ABC

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

11. Provide recommendations for future research and data collection.
    - Be as specific as practicable in describing sampling design and sampling intensity.
    - Emphasize items which will improve future assessment capabilities and reliability.
    - Consider data, monitoring, and assessment needs.
12. Complete the Assessment Workshop Report in accordance with project schedule deadlines (Section III of the SEDAR Stock Assessment Report).

1.1.3. List of Participants

Workshop Panel

Meaghan Bryan, Lead Analyst........NMFS Miami
Bob Gill........SSC
Patrick Lynch........NMFS Silver Spring
Sean Powers........SSC
Adyan Rios........NMFS Miami
Skyler Sagarese........UM
Jim Tolan........SSC
John Walter........NMFS Miami

Appointed Observers

Jim Clements........
Paul Giordano........

Staff

Julie Neer........SEDAR
Ryan Rindone........GMFMC

Additional Participants via Webinar

Neil Baertlein........NMFS Miami
Shannon Cass-Calay........NMFS Miami
Nancie Cummings........NMFS Miami
Michael Drexler........Ocean Conservancy
Michael Larkin........NMFS/SERO
Linda Lombardi........NMFS Panama City
Rich Malinowski........NMFS/SERO
Vivian Matter........NMFS Miami
Adam Pollack........NMFS Pascagoula
Jessica Stephen........NMFS/SERO
Elbert Whorton........SSC

1.1.4. List of Assessment Workshop Working Papers

Documents Prepared for the Assessment Process			
SEDAR42-AW-01	Red tide mortality on red grouper (*Epinephelus morio*) between 1980 and 2009 on the West Florida Shelf	Skyler R. Sagarese, Alisha M. Gray, Cameron H. Ainsworth, David D. Chagaris, Behzad Mahmoudi	5 Feb 2015
SEDAR42-AW-02	Standardized catch rates for red grouper from the Unites States Gulf of Mexico vertical line and longline fisheries	Meaghan D. Bryan and Kevin McCarthy	10 March 2015
SEDAR42-AW-03	Standardized Catch Rates of Red Grouper (*Epinephelus morio*) from the U.S. Headboat Fishery in the Gulf of Mexico, 1986-2013	Adyan Rios	13 March 2015
SEDAR42-AW-04	Standardized Catch Rates of Red Grouper (*Epinephelus morio*) from the Gulf of Mexico Recreational Charterboat and Private Boat Fisheries (MRFSS) 1986-2013	Adyan Rios	13 March 2015
SEDAR 42-AW-05	Estimating age- and size-specific natural mortality rates for Gulf of Mexico red grouper (*Epinephelus morio*) using the ecosystem model OSMOSE-WFS	A. Grüss, M. J. Schirripa, D. Chagaris, P. Verley, Y.-J. Shin, L. Velez, C. H. Ainsworth, S. R. Sagarese, and L. Lombardi-Carlson	11 March 2015

1.2 Panel Recommendations and Comment on Terms of Reference

Term of Reference 1: *Review any changes in data following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.*

All changes to the data following the data workshop are reviewed in Section **Error! Reference source not found.**.

Term of Reference 2: *Develop population assessment models that are compatible with available data and document input data, model assumptions and configuration, and equations for each model considered.*

A fully integrated age and length based statistical-catch-at-age model configured using Stock Synthesis was used for the assessment. The model configuration and data inputs are described in Section **Error! Reference source not found.**. See section **Error! Reference source not found.** for a complete description of all data inputs. Appendix A includes the data file to run the Stock Synthesis model.

Term of Reference 3: *Incorporate known applicable environmental covariates into the selected model, and provide justification for why any of those covariates cannot be included at the time of the assessment.*

The Assessment Panel recommended that mortality associated with the 2005 red tide event be incorporated into the assessment model. Two alternative approaches to incorporating red tide were explored (see section **Error! Reference source not found.**).

Term of Reference 4: *Provide estimates of stock population parameters, including:*
• Fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, red grouper being a protogynous hermaphrodite, and other parameters as necessary to describe the population. • Appropriate measures of precision for parameter estimates.

Estimates of assessment model parameters and their associated standard errors are reported in Section 3.1.4 and Table 3.1.1. Estimates of stock biomass, spawning stock biomass, recruitment, and fishing mortality are presented in Table 3.2.2 and Table 3.2 3.

Term of Reference 5: *Characterize uncertainty in the assessment and estimated values.*
• Consider uncertainty in input data, modeling approach, and model configuration.
• Provide a continuity model consistent with the prior assessment configuration, if one exists, updated to include the most recent observations. Alternative approaches to a strict continuity run that distinguish between model, population, and input data influences on findings, may be considered.
• Consider and include other sources as appropriate for this assessment.
• Provide appropriate measures of model performance, reliability, and 'goodness of fit'.
• Provide measures of uncertainty for estimated parameters.

Uncertainty in the assessment and estimated values was characterized using sensitivity analyses. Results of the sensitivity analyses are characterized in Section 3.1.7, Table 3.2.4 - Table 3.2. **6**, and Figure 3.2.67 - Figure 3.2.76. Model convergence was tested by varying starting parameters and refitting the model (Table 3.1.3). Uncertainty in the assessment parameters and estimated values is characterized in Section 3.2.2 and Table 3.2.1.

Term of Reference 6: *Provide estimates of yield and productivity.*
• Include yield-per-recruit, spawner-per-recruit, and stock-recruitment models.

Estimates of yield per recruit and spawner per recruit are summarized in Figure 3.2.84.

Term of Reference 7: *Provide estimates of population benchmarks or management criteria consistent with available data, applicable FMPs, proposed FMPs and Amendments, other ongoing or proposed management programs, and National Standards.*
• Examine the effect of being a protogynous hermaphrodite on stock status criteria and other management benchmarks.

• Evaluate existing or proposed management criteria as specified in the management summary.
• Recommend proxy values when necessary.
Reference points were calculated for a SSB-female model, where SSB was derived as a function of the proportion of mature females and batch fecundity. Stock synthesis can calculate reference points in terms of yield-per recruit, spawner biomass per-recruit and equilibrium yield as a function of fishing mortality. Reference points were calculated in terms of equilibrium yield. See section 3.1.9 and 3.2.9.

Term of Reference 8: *Provide declarations of stock status relative to management benchmarks or alternative data poor approaches if necessary.*

Stock status was evaluated with respect to the minimum stock size threshold (MSST= (1-M)*SSBmsy) and Fmsy. This terms of reference is addressed in section 3.2.9.

Term of Reference 9: *Provide uncertainty distributions of proposed reference points and stock status metrics that provides the values indicated in the management specifications. Include probability density functions for biological reference point estimates and population metrics (e.g., biomass and exploitation) used to evaluate stock status.*

Estimates of uncertainty in the proposed reference points and stock status will be provided at the review workshop.

Term of Reference 10: *Project future stock conditions (biomass, abundance, and exploitation; including probability density functions) and develop rebuilding schedules if warranted; include estimated generation time. Develop stock projections for the following circumstances, in accordance with the guidance on management needs provided in the management history:*
A) If stock is overfished: F=0, $F_{Current}$, $F=F_{MSY}$, F_{Target} $F=F_{Rebuild}$ *(max exploitation that rebuild in greatest allowed time) Fixed landings equal to the ABC*
B) If stock is overfishing $F=F_{Current}$, $F=F_{MSY}$, $F= F_{Target}$, *Fixed landings equal to the ABC*
C) If stock is neither overfished nor overfishing $F=F_{Current}$, *F=FMSY,* $F=F_{Target}$, *Fixed landings equal to the ABC*
D) If data limitations preclude classic projections (i.e. A, B, C above), explore alternate models to provide management advice.

Projections were carried out for three fishing mortality scenarios F = Fmsy, F= Foy, and F=Fcurrent. The projection methods are described in Section 3.1.10 and the results are summarized in Section 3.2.10, Figure 3.2.83, and Table 3.2.7.

Term of Reference 11: *Provide recommendations for future research and data collection.*
• Be as specific as practicable in describing sampling design and sampling intensity.
• Emphasize items which will improve future assessment capabilities and reliability.
• Consider data, monitoring, and assessment needs.

Recommendations are provided in Section 3.3.2.

Term of Reference 12: *Complete the Assessment Workshop Report in accordance with project schedule deadlines (Section III of the SEDAR Stock Assessment Report).*

This report satisfies this Term of Reference.

2 Data Review and Update

The following list summarizes the main data inputs used in the assessment model:

- Life history
  - Age and growth
  - Natural mortality
  - Maturity
  - Sex transition
  - Fecundity
- Landings
  - Commercial vertical line: 1880-2013
  - Commercial longline: 1981-2013
  - Commercial trap: 1964-2006
  - Recreational charterboat and private: 1946-2013
  - Recreational headboat: 1946-2013
  - Commercial Cuban landings in present day US waters: 1937-1977
- Discards
  - Commercial vertical line: 1993-2013
  - Commercial longline: 1993-2013
  - Commercial trap: 1990-2006
  - Recreational charterboat and private: 1981-2013
  - Recreational headboat: 1981-2013
- Age composition of landings
  - Commercial vertical line: 1991-2013
  - Commercial longline: 1991-2013
  - Commercial trap: 1992-2006
  - Recreational charterboat and private: 1991-2013
  - Recreational headboat: 1991-2013
- Length composition of discards
  - Commercial vertical line: 2006-2013
  - Commercial longline: 2006-2013
  - Recreational charterboat: 2010-2013
  - Recreational headboat: 2005-2007 & 2009-2013
- Abundance indices
  - Fishery-independent
    - SEAMAP groundfish: 2009-2013
    - NMFS bottom longline: 2001 & 2003-2013
    - Combined video: 1993-1997, 2002 & 2004-2013
  - Fishery-dependent
    - Commercial vertical line: 1993-2009
    - Commercial longline: 1993-2009
    - Recreational charterboat and private: 1986-2013
    - Recreational headboat: 1986-2013
- Length composition data from fishery-independent survey
    - Combined video: 2002 & 2004-2013

SEAMAP groundfish: 2008-2013
NMFS bottom longline: 2000-2013

Discard mortality
- Commercial vertical line
- Commercial longline pre-IFQ
- Commercial longline post-IFQ
- Commercial trap
- Recreational fleets

A brief summary of each input will be provided in the following sections.

2.1 Life history

2.1.1 Age and growth

A single von Bertalanffy equation was used to model growth of Red Grouper for both sexes (Figure 2.1.1). The von Bertalanffy parameters; L_{inf}, the asymptotic length, k, the von Bertalanffy growth coefficient, and t_0, the theoretical age at length zero, were fixed within the SS model.

The von Bertalanffy parameter values recommended from the Data Workshop and described in SEDAR42-DW10 were:

L_{inf} (cm FL) = 82.89
K (year^{-1}) = 0.1251
t_0 (year) = -1.20

The recommendation from the Data Workshop (DW) was to model the distribution of length at age using a constant CV at age (CV = 0.15). More recently, the distribution of length at age was modeled with a CV that increased linearly (CV_{young} = 0.1435 and CV_{old} = 0.1647). Furthermore, t_0 was adjusted to account for peak spawning on May 15th. The von Bertalanffy parameter values used in the SS model were:

L_{inf} (cm FL) = 82.72
K (year^{-1}) = 0.1243
t_0 (year) = -0.89

Meristic relationships were provided at the Data Workshop. The parameters describing these relationships are summarized in Table 2.1.1.

2.1.2 Natural mortality

The recommendation from the Data Workshop was to estimate natural mortality using the Lorenzen (2005) estimator with a target M determined using Hoenig (1983) and a maximum age of 29 years. The natural mortality vector was fixed within the assessment model. The natural mortality vector along with the lower and upper ranges are included in table 2.1.2 and plotted in Figure 2.1.2.

2.1.3 Maturity

A logistic relationship was recommended by the DW to model maturity. The logistic fit via the Gompertz equation predicts age at 50% maturity to be 2.8 years (Figure 2.1.3).

Proportion mature at age = exp(-exp(-(-2.55+1.05*age))).

2.1.4 Sex transition

A logistic relationship was recommended by the Data Workshop to model transition of females to males. The logistic fit via the Gompertz equation predicts 50% male at age 11.2 years (Figure 2.1.4).

Proportion female at age = exp(-exp(-(2.14-0.16*age)))

2.1.5 Fecundity

The Data Workshop recommendation of a power function fit to batch fecundity data was used to model female reproductive potential (Figure 2.1.5).

Batch fecundity (in thousands) = 3.878 * age ^2.12

In the combined single sex SS model, males and females were treated identically. To account for a decrease in fecundity as females transition and become males, the equation characterizing total fecundity at age was modeled as the proportion female * proportion mature * batch fecundity (Figure 2.1.6). The fecundity at age vector was fixed within the SS model.

2.2 Landings

2.2.1 Commercial landings

The commercial landings reviewed at the Data Workshop and described in SEDAR42-RD-02 are presented in Table 2.2.1 and in Figure 2.2.1 (units converted to metric tons). The commercial landings are available by gear including vertical line, longline, trap, and ‘other’. Prior to 1982, almost all of the commercial landings were from the vertical line fishery. In 1983, annual landings by the longline fishery were similar to the landings by the vertical line fishery. In all years after 1990, except 2009 and 2010, landings by the longline fishery made up more than 50% of annual commercial landings. Landings by the trap fishery were largest between 1984 and 2006 and ranged from 5-23% of annual commercial landings.

Landings by vertical line, longline and trap fleets were used in the assessment model. Landings reported under ‘other’ were excluded as they made up less than 1% of overall commercial landings.

2.2.2 Recreational landings

The recreational landings reviewed at the Data Workshop are presented in Table 2.2.2 and Figure 2.2.2 (units in thousands of fish). The recreational landings are available by mode and include headboat, charterboat, private boat, and shore. Prior to 1981 the private and charterboat landings are only available as a single combined mode. Between 1946 and 1980, the combined private and charterboat mode made up 76-95% of annual recreational landings. Between 1981 and 2013 the private mode made up 45-92%, the charterboat mode made up 4-44%, and the headboat mode made up 2-17% of annual recreational landings.

Landings by the headboat, charterboat, and private modes were used in the assessment model. Landings for the charterboat and private modes were aggregated into a combined mode. Landings reported for the shore mode were excluded since they made up only 1% of overall recreational landings.

2.2.3 Commercial Cuban landings in present day US waters

The numbers of Red Grouper caught in the U.S. Gulf of Mexico and landed in Cuba that were reviewed at the Data Workshop and are presented in Table 2.2.1 and in Figure 2.2.1 (units converted to metric tons, the native units of the Stock Synthesis model). Landings are from 1937 through 1977. During these years, Cuban landings made up 0-68% of annual commercial landings. Missing landings in 1959-1962 were likely attributed to the Cuban revolution. The Cuban landings series ends in 1977 due to the expansion of the US Exclusive Economic Zone (EEZ) to 200 nautical miles and the expulsion of Cuban vessels.

Landings in US waters by the Cuban vertical line fleet were used in explorations of the assessment model where the start year was set to 1880. However, these landings were not included in model runs that started in 1986.

2.3 Discards

2.3.1 Commercial discards

The commercial discards are available by gear for vertical line, longline and trap. They are summarized in Table 2.3.1 and Figure 2.3.1 (units in thousands of fish). Numbers of discards for the commercial trap fishery were retained from the SEDAR12 2006 benchmark and 2009 update assessments (fish traps were banned in the Gulf of Mexico beginning in 2006). The vertical line and longline commercial discards that were reviewed at the Data Workshop were re-estimated after evaluating the reliability of the logbook effort data used in the discard calculation. Following a Data Workshop research recommendation to investigate appropriate methods for calculating discards using observer reported discard rates and coastal logbook reported fishing effort, effort data were investigated by calculating total landings as kept rate*logbook effort and comparing the results to the estimates of landings compiled from trip ticket data. The calculated landings differed from the trip ticket landings, particularly in the vertical line fishery (Figure 2.3.2 A and B), and an additional investigation of discard calculation using observer reported discard rates and fisher reported total effort is needed. An alternative method was recommended for the current Red Grouper assessment. That alternative method of estimating discards was:

$$\left(\frac{observer\ reported\ Red\ Grouper\ discard\ rate}{observer\ reported\ Red\ Grouper\ kept\ rate}\right) \times Red\ Grouper\ landings$$

For 2007 and 2008, discards were calculated for each year/subregion/season, whereas for 2009-2013, discards were calculated for each year/subregion/season/IFQ allocation category. Calculated discards across strata within each year were summed to obtain yearly total discards.

Strata were:

Year (2007-2013)
Subregion (east = statistical zones 1-8, west = 9-21)
Season (shallow water grouper season – open or closed)
IFQ allocation available to a vessel during a trip (none or 1+ pounds, applicable to 2009-2013)
Fishery (shark or reef fish, used for bottom longline discard calculations only – shark fishery discards were calculated using shark fishery observer data, reef fish discards were calculated using reef fish fishery observer data)

For years 1993-2006, discard and kept rates were calculated over the years 2007-2009 for each subregion/season/fishery. Calculated discards across strata within each year were summed to obtain yearly total discards. Prior to 1993, only 20% of Florida vessels were required to report the coastal logbook program, therefore proportion of landings by strata could not be accurately calculated.

2.3.2 Recreational discards

The recreational discards reviewed at the Data Workshop are presented in Table 2.3.2 and Figure 2.3.3 (units in thousands of fish). The recreational landings are available by mode for headboat, charterboat, private boat, and shore. The majority of annual discards, 75% on average, are from the private recreational fleet. The discards from the charterboat, headboat and shore fleets make-up 15%, 6% and 4% on average of annual discards.

Discards by the headboat, charterboat, and private modes were used in the assessment model. The discards from the recreational shore mode were excluded since landings from this fleet were excluded from the model (shore mode made up 1% of overall recreational landings).

2.4 Age composition of landings

2.4.1 Commercial age composition of landings

The age composition data for Red Grouper landed by the commercial fleet are summarized in Figures 2.4.1, 2.4.2 and 2.4.3. Age composition data were available by gear for vertical line, longline, and trap (SEDAR 42-DW-12). The number of aged fish by gear was quite small in some years, particularly for the trap fishery (Table 2.4.1).

Cohorts are apparent in the vertical line data in years 1994-1996, 2000-2003, 2004-2006, 2007-2009, and 2011-2013, corresponding to year classes from 1988, 1995, 1998, 2001 and 2005, respectively (Figure 2.4.1). Although less apparent, the 1998, 2001, and 2005 cohorts were also present in the longline data (Figure 2.4.2). Cohorts were not particularly apparent in the trap data (Figure 2.4.3).

2.4.2 Recreational age composition of landings

The age composition data for Red Grouper landed by the recreational fleet are summarized in Figures 2.4.4 and 2.4.5. Age composition data were available by mode for headboat, charterboat, and private boat. The number of aged fish was quite small in some years, particularly for the private fishery (Table 2.4.1). Data for the charterboat and private modes were aggregated into a combined mode.

Previous SEDAR assessments for Red Grouper modeled the recreational fishery using a single combined fleet. In the current assessment, the recreational fishery was separated into two fleets. The assessment panel agreed to have a separate headboat fleet since mode-specific total landings, total discards, age composition of landings, length composition of discards, and a headboat index of abundance wereavailable. The private and charterboat modes were modeled as a single, combined fleet for the following reasons. First, private and charterboat landings between 1946 and 1980 were only available in a single combined mode (Section 2.2). Further, private and charterboat catch rates from 1986 to 2013 were modeled into a single index of abundance (Section 2.6). Lastly, there were few annual age samples (Section 2.4) and no discard lengths associated with the private recreational fishery (Section 2.5).

Cohorts are apparent in the combined charterboat and private mode data in years 1995-1997, 2000-2002, 2003-2007 and 2009-2012, corresponding to year classes from 1989, 1995, 1998 and 2005, respectively (Figure 2.4.4). The 1989, 1998 and 2005 cohorts are also apparent in the headboat data (Figure 2.4.5). In general, the recreational sector captured younger Red Grouper than the commercial sector.

2.5 Length composition of discards

2.5.1 Commercial length composition of discards

In July 2006, a mandatory observer program was implemented to characterize the commercial reef fish fishery operating in the U.S. Gulf of Mexico (SEDAR42-DW-01). The observer program provides detailed information for each trip and each fish captured, including the size and disposition of Red Grouper caught. Length composition data of discarded fish from the commercial fishery were only available and included in the model for the vertical line and longline fleets for 2006-2013. These data are shown in Figures 2.5.1 and 2.5.2.

A 20 inch (50.8 cm) total length commercial size limit was implemented between 1990 and 2008. This size limit was reduced to 18 inches (45.7 cm) in 2009. The majority of the observed length distribution of discards from the vertical line and longline fisheries have been below the size limits with some observations of larger discarded fish in 2009 (Figures 2.5.1 and 2.5.2).

2.5.2 Recreational length composition of discards

A fisheries observer program on recreational for-hire vessels, including headboats and charter vessels, was implemented in 2005 in the U.S. Gulf of Mexico (SEDAR42-DW14). The observer program provides detailed information for each trip and each fish captured, including the size and disposition of all Red Grouper caught. Length composition data of discarded fish from the recreational fleets were only available and included in the model for the headboat and charterboat fleets. These data are shown in Figures 2.5.3 and 2.5.4.

The recreational fishery has been managed using size limits and bag limits. A 20 inch (50.8 cm) total length recreational size limit was implemented in 1990. Also in 1990, a 5 fish bag limit for Red Grouper was implemented. The recreational bag limit was changed to 2 fish in 2004, and was then further reduced to 1 fish in 2005. The bag limit was increased to 4 fish in 2011. The majority of discards from the recreational charterboat and headboat fisheries have been below the size limits (Figures 2.5.3 and 2.5.4). Discards of fish above the size limit were observed in both fleets and particularly in the charterboat fleet. Generally, the Red Grouper discarded by the recreational sector show a larger range in size than Red Grouper discarded by the commercial sector.

2.6 Measures of population abundance

Fifteen indices of abundance were presented and considered during the Data Workshop, seven of which were recommended for use. The indices of abundance that were recommended for use in the assessment include:

Fishery-independent indices	
SEAMAP groundfish	2009-2013
NMFS bottom longline	2001 & 2003-2013
Combined video	1993-1997, 2002 & 2004-2013
Fishery-dependent indices	
Commercial vertical line	1993-2009
Commercial longline	1993-2009
Recreational charterboat and private	1986-2013
Recreational headboat	1986-2013

Three of the seven recommended indices were from fishery-independent data sources: the SEAMAP summer groundfish survey, the NMFS bottom longline survey, and the combined SEAMAP, Panama City and FWRI video survey (Table 2.6.1 and Figures 2.6.1 – 2.6.3). The SEAMAP groundfish index was derived as the number of Red Grouper caught per trawl hour. The NMFS bottom longline index was derived as the number of Red Grouper caught per 100 hook hours. The combined video survey was derived as the minimum count of Red Grouper (maximum number of individuals in the field of view at one instance) per 20 minute recording.

There were four recommended fishery-dependent indices: the Marine Recreational Fishery Statistic Survey (MRFSS) index, the Southeast Regional Headboat Survey index (SERHS), the commercial vertical line index, and the commercial longline index (Table 2.6.2 and Figures 2.6.4 – 2.6.7). The SERHS index was derived using numbers of Red Grouper landed per angler hour and the MRFSS index, which represents the charterboat and private modes, was derived using the numbers of Red Grouper landed or discarded per angler hour. The commercial vertical line index was derived as pounds of Red Grouper landed per hook hour. The commercial longline index was derived as pounds of Red Grouper landed per number of hooks fished. The recommended terminal year for both commercial indices was 2009, prior to the implementation of commercial individual fishing quotas in 2010. This terminal year was chosen because the influence of individual fishing quotas is not well understood.

The standardized indices of relative abundance and associated CVs used in the assessment are presented in Tables 2.6.1 and 2.6.2. For input into the Stock Synthesis assessment model, the coefficients of variation (CV) associated with the standardized indices were converted to log-scale standard errors by:

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

A brief summary of the limitations of the 8 rejected indices will be provided here but the reader is referred to the SEDAR 42 Data Workshop Report for a more comprehensive explanation.

Of the datasets/indices not recommended for use, three (SEAMAP VIDEO, Panama City Video, and FWRI Video) were combined into the Combined Video index. Two trap indices, the Panama City Trap and the FWRI Trap indices, which covered the same portion of the population as the Combined Video index, were not recommended because they had lower spatial coverage and a shorter time series than the Combined Video index. The Commercial Trap and Everglades National Park Creel indices were not recommended because of low numbers of Red Grouper present in the data. Finally, the Headboat Observer Discard index, which covers sub-legal sized fish, was not recommended for two reasons. The first reason is that the observed discards covered similar sizes of fish but had lower spatial coverage and a shorter time series when compared to the Combined Video index. The second reason is that only one fishery-dependent index can represent a single fleet in the assessment model and the Southeast Region Headboat index was favored over the Headboat Observer Discard index to represent the headboat fleet.

2.7 Length composition data from fishery-independent surveys

The length composition data for the fishery-independent surveys are plotted in Figures 2.7.1 – 2.7.3. Cohorts were not particularly apparent in the length composition data for the surveys. Generally, smaller Red Grouper were observed in the SEAMAP groundfish survey than in the combined video and bottom longline surveys.

2.8 Discard Mortality

The Data Workshop included a working group that focused on discard mortality. Based on new data available since the previous assessment (see the SEDAR 42 Data Workshop Report), the following discard mortality rates were used in the assessment model for SEDAR42:

1. An estimate of 11.6% for the recreational fishery (sensitivity range 5.8% to 14.5%).
2. An estimate of 19.0% for the commercial vertical line fishery (sensitivity range 10.0% to 31.0%).
3. An estimate of 41.4% for the commercial bottom longline fishery pre-IFQ (sensitivity range 34.3% to 48.7%).
4. An estimate of 43.6% for the commercial bottom longline fishery post-IFQ (sensitivity range 36.7% to 50.8%).

5. An estimate of 10% for the commercial trap fishery. No new data on discard mortality rates were available for the commercial trap fishery. This estimate was retained from the SEDAR12 2006 benchmark and 2009 update assessments.

2.9 Tables

Table 2.1.1 Meristic regressions for Red Grouper (1978-2013) from the Gulf of Mexico. Data combined from all data sources, both fishery-independent and dependent. Length Type: Max TL – Maximum Total Length, FL – Fork Length, Nat TL – Natural Total Length, SL – Standard Length. Weight Type: G Wt – Gutted Weight, W Wt – Whole Weight. Units: length (mm) and weight (kg). Linear and non-linear regressions calculated using R (lm and nls functions, respectively).

Regression	Equation	Statistic	N	Data Range
Max TL to FL	FL = 5.35 + max_TL *0.95	r^2 = 0.9963	5818	Max TL: 120 – 954; FL: 116 – 910
Nat TL to FL	FL = 5.71 + nat_TL * 0.95	r^2 = 0.9909	3901	Nat TL: 151 – 957; FL: 149 – 910
SL to FL	FL = 15.90 + SL * 1.14	r^2 = 0.9938	985	SL: 130 – 686; FL: 159 – 830
SL to Max TL	Max_TL = 9.19 + SL * 1.21	r^2 = 0.9944	3399	SL: 130 – 720; Max TL: 161 – 876
SL to Nat TL	Nat_TL = -51.18 + SL * 1.32	r^2 = 0.9791	7	SL: 404 – 670; Nat TL: 484 – 860
Max TL to G Wt	GWT = 4.33 x 10^{-8}* (max_TL^$^{2.83}$)	RSE = 0.7421	633	Max TL: 458 – 980; G WT: 0.82 – 15.05
Max TL to W Wt	WWT = 5.21 x 10^{-09}* (max_TL^$^{3.16}$)	RSE = 0.5152	3725	Max TL: 127 – 954; W WT: 0.03 – 16.96
Nat TL to G Wt	GWT = 5.70 x 10^{-08}* (nat_TL^$^{2.78}$)	RSE = 0.6398	34	Nat TL: 490 – 802; G WT: 1.28 – 7.17
Nat TL to W Wt	WWT = 7.58 x 10^{-09}* (nat_TL^$^{3.10}$)	RSE = 0.3482	3912	Nat TL: 120 – 957; W WT: 0.02 – 14.00
FL to G Wt	GWT = 3.37 10^{-09}* (FL^$^{3.25}$)	RSE = 0.3499	37414	FL: 230 – 935; G WT: 0.26 – 16.96
FL to W Wt	WWT = 5.46 x 10^{-09}* (FL^$^{3.18}$)	RSE = 0.4667	7361	FL: 123 – 965; W WT: 0.05 – 16.96
SL to W Wt	WWT = 2.32 x 10^{-08}* (SL^$^{3.03}$)	RSE = 0.1825	483	SL: 147 – 670; W WT: 0.10 – 9.00

Table 2.1.2 Recommended values for age-specific natural mortality for Red Grouper in the Gulf of Mexico. The standard deviation (± 5 yrs) at age for the maximum age (29 yrs) was used to calculate the upper and lower range for natural mortality.

Age	Age-specific natural mortality	Lower	Upper
0	0.5837	0.5053	0.7336
1	0.3952	0.3421	0.4967
2	0.3082	0.2669	0.3874
3	0.2583	0.2236	0.3247
4	0.2261	0.1957	0.2841
5	0.2036	0.1763	0.256
6	0.1873	0.1621	0.2354
7	0.1749	0.1514	0.2198
8	0.1652	0.1431	0.2077
9	0.1576	0.1364	0.198
10	0.1514	0.1311	0.1903
11	0.1463	0.1267	0.1839
12	0.1421	0.123	0.1786
13	0.1386	0.12	0.1742
14	0.1356	0.1174	0.1705
15	0.1331	0.1152	0.1673
16	0.131	0.1134	0.1646
17	0.1291	0.1118	0.1623
18	0.1276	0.1105	0.1603
19	0.1262	0.1093	0.1586
20	0.125	0.1083	0.1572
21	0.124	0.1074	0.1559
22	0.1231	0.1066	0.1548
23	0.1224	0.106	0.1538
24	0.1217	0.1054	0.153
25	0.1211	0.1049	0.1522
26	0.1206	0.1044	0.1516
27	0.1202	0.104	0.151
28	0.1198	0.1037	0.1505
29	0.1194	0.1034	0.1501

Table 2.2.1 Annual Red Grouper commercial landings from the U.S. Gulf of Mexico in metric tons gutted weight from 1880-2013.

Commercial Landings in Metric Tons						
Year	Vertical Line	Longline	Trap	Other	Cuban Vertical Line	Total Commercial
1880	686.997	0.000	0.000	0.000	0.000	686.997
1881	620.472	0.000	0.000	0.000	0.000	620.472
1882	553.947	0.000	0.000	0.000	0.000	553.947
1883	487.421	0.000	0.000	0.000	0.000	487.421
1884	420.895	0.000	0.000	0.000	0.000	420.895
1885	354.369	0.000	0.000	0.000	0.000	354.369
1886	287.844	0.000	0.000	0.000	0.000	287.844
1887	221.318	0.000	0.000	0.000	0.000	221.318
1888	159.244	0.000	0.000	0.000	0.000	159.244
1889	173.697	0.000	0.000	0.000	0.000	173.697
1890	166.687	0.000	0.000	0.000	0.000	166.687
1891	190.366	0.000	0.000	0.000	0.000	190.366
1892	214.046	0.000	0.000	0.000	0.000	214.046
1893	237.726	0.000	0.000	0.000	0.000	237.726
1894	261.406	0.000	0.000	0.000	0.000	261.406
1895	273.991	0.000	0.000	0.000	0.000	273.991
1896	287.227	0.000	0.000	0.000	0.000	287.227
1897	295.172	0.000	0.000	0.000	0.000	295.172
1898	289.298	0.000	0.000	0.000	0.000	289.298
1899	284.818	0.000	0.000	0.000	0.000	284.818
1900	275.815	0.000	0.000	0.000	0.000	275.815
1901	264.775	0.000	0.000	0.000	0.000	264.775
1902	298.395	0.000	0.000	0.000	0.000	298.395
1903	308.433	0.000	0.000	0.000	0.000	308.433
1904	316.754	0.000	0.000	0.000	0.000	316.754
1905	323.373	0.000	0.000	0.000	0.000	323.373
1906	332.766	0.000	0.000	0.000	0.000	332.766
1907	336.208	0.000	0.000	0.000	0.000	336.208
1908	337.999	0.000	0.000	0.000	0.000	337.999
1909	410.998	0.000	0.000	0.000	0.000	410.998
1910	468.978	0.000	0.000	0.000	0.000	468.978
1911	556.488	0.000	0.000	0.000	0.000	556.488
1912	644.279	0.000	0.000	0.000	0.000	644.279
1913	732.350	0.000	0.000	0.000	0.000	732.350
1914	820.702	0.000	0.000	0.000	0.000	820.702
1915	909.335	0.000	0.000	0.000	0.000	909.335

Table 2.2.1 (Continued) Annual Red Grouper commercial landings from the U.S. Gulf of Mexico in metric tons gutted weight from 1880-2013.

Commercial Landings in Metric Tons						
Year	Vertical Line	Longline	Trap	Other	Cuban Vertical Line	Total Commercial
1916	998.249	0.000	0.000	0.000	0.000	998.249
1917	1087.443	0.000	0.000	0.000	0.000	1087.443
1918	1176.918	0.000	0.000	0.000	0.000	1176.918
1919	1124.535	0.000	0.000	0.000	0.000	1124.535
1920	1071.979	0.000	0.000	0.000	0.000	1071.979
1921	1019.249	0.000	0.000	0.000	0.000	1019.249
1922	966.345	0.000	0.000	0.000	0.000	966.345
1923	913.267	0.000	0.000	0.000	0.000	913.267
1924	894.808	0.000	0.000	0.000	0.000	894.808
1925	875.637	0.000	0.000	0.000	0.000	875.637
1926	855.755	0.000	0.000	0.000	0.000	855.755
1927	836.900	0.000	0.000	0.000	0.000	836.900
1928	858.404	0.000	0.000	0.000	0.000	858.404
1929	946.896	0.000	0.000	0.000	0.000	946.896
1930	633.553	0.000	0.000	0.000	0.000	633.553
1931	560.586	0.000	0.000	0.000	0.000	560.586
1932	723.965	0.000	0.000	0.000	0.000	723.965
1933	947.109	0.000	0.000	0.000	0.000	947.109
1934	912.600	0.000	0.000	0.000	0.000	912.600
1935	1146.351	0.000	0.000	0.000	0.000	1146.351
1936	1397.849	0.000	0.000	0.000	0.000	1397.849
1937	1514.672	0.000	0.000	0.000	2942.136	4456.808
1938	1393.206	0.000	0.000	0.000	2942.136	4335.342
1939	2083.867	0.000	0.000	0.000	2942.136	5026.003
1940	1477.932	0.000	0.000	0.000	2942.136	4420.068
1941	1581.255	0.000	0.000	0.000	2942.136	4523.391
1942	1828.679	0.000	0.000	0.000	1197.935	3026.614
1943	1905.614	0.000	0.000	0.000	920.542	2826.156
1944	2151.527	0.000	0.000	0.000	1360.752	3512.279
1945	2252.730	0.000	0.000	0.000	756.891	3009.621
1946	2448.134	0.000	0.000	0.000	812.822	3260.956
1947	2460.674	0.000	0.000	0.000	858.088	3318.762
1948	2382.752	0.000	0.000	0.000	892.689	3275.441
1949	2432.453	0.000	0.000	0.000	916.625	3349.078
1950	1627.280	0.000	0.000	0.000	929.896	2557.176
1951	1832.909	0.000	0.000	0.000	932.501	2765.410

Table 2.2.1 (Continued) Annual Red Grouper commercial landings from the U.S. Gulf of Mexico in metric tons gutted weight from 1880-2013.

Commercial Landings in Metric Tons						
Year	Vertical Line	Longline	Trap	Other	Cuban Vertical Line	Total Commercial
1952	1160.141	0.000	0.000	0.000	924.441	2084.582
1953	898.587	0.000	0.000	0.000	905.716	1804.304
1954	822.813	0.000	0.000	0.000	876.326	1699.140
1955	757.298	0.000	0.000	0.000	836.271	1593.569
1956	1056.799	0.000	0.000	0.000	884.107	1940.907
1957	1293.115	0.000	0.000	0.000	1258.068	2551.183
1958	1325.103	0.000	0.000	0.000	966.525	2291.627
1959	1790.434	0.000	0.000	0.000	0.000	1790.434
1960	2052.356	0.000	0.000	0.000	0.000	2052.356
1961	2015.890	0.000	0.000	0.000	0.000	2015.890
1962	2359.066	0.000	0.000	0.000	0.000	2359.066
1963	1616.872	0.000	0.000	1.308	460.788	2078.968
1964	1878.026	0.000	2.099	6.246	985.746	2872.117
1965	2094.211	0.000	2.292	0.000	1916.580	4013.083
1966	2010.955	0.000	2.972	0.496	2274.056	4288.479
1967	1625.397	0.000	3.358	7.007	2391.069	4026.832
1968	1788.373	0.000	6.128	1.454	2508.082	4304.038
1969	2080.768	0.000	3.540	0.933	2625.096	4710.336
1970	2027.152	0.000	5.516	0.000	2551.595	4584.263
1971	1729.196	0.000	5.511	0.000	1426.257	3160.964
1972	1797.869	0.000	1.033	0.005	1454.697	3253.604
1973	1387.552	0.000	0.000	0.240	2744.581	4132.373
1974	1618.772	0.000	0.000	0.375	1828.073	3447.220
1975	1956.078	0.000	5.636	0.074	1828.073	3789.861
1976	1690.673	0.000	5.173	0.000	1828.073	3523.919
1977	1350.602	0.000	18.993	2.048	1828.073	3199.715
1978	1238.823	0.000	40.321	2.553	0.000	1281.697
1979	1714.108	0.000	31.813	0.000	0.000	1745.921
1980	1745.249	0.000	20.309	4.841	0.000	1770.399
1981	1507.819	0.001	30.248	4.457	0.000	1542.526
1982	1394.360	369.979	22.689	5.894	0.000	1792.921
1983	1318.835	1389.905	0.503	5.738	0.000	2714.981
1984	1336.999	1128.127	141.326	1.519	0.000	2607.971
1985	1654.628	940.352	290.486	3.303	0.000	2888.770
1986	1421.948	1136.626	327.249	5.088	0.000	2890.912
1987	1153.087	1712.243	203.246	5.027	0.000	3073.603

Table 2.2.1 (Continued) Annual Red Grouper commercial landings from the U.S. Gulf of Mexico in metric tons gutted weight from 1880-2013.

Commercial Landings in Metric Tons						
Year	Vertical Line	Longline	Trap	Other	Cuban Vertical Line	Total Commercial
1988	929.465	994.634	245.043	2.371	0.000	2171.514
1989	1730.406	1414.392	268.877	5.013	0.000	3418.688
1990	1116.269	918.839	154.628	2.425	0.000	2192.161
1991	949.748	1171.895	169.529	15.371	0.000	2306.543
1992	655.426	1092.953	273.147	3.917	0.000	2025.443
1993	589.817	1938.815	322.543	19.629	0.000	2870.805
1994	563.102	1224.284	414.504	17.092	0.000	2218.982
1995	531.270	1101.965	479.444	7.277	0.000	2119.956
1996	392.427	1318.679	244.649	4.609	0.000	1960.364
1997	430.177	1371.747	311.088	3.102	0.000	2116.115
1998	336.390	1207.755	134.966	2.326	0.000	1681.437
1999	550.097	1730.638	341.019	7.906	0.000	2629.660
2000	780.627	1319.655	464.846	13.789	0.000	2578.916
2001	705.660	1542.048	337.150	9.641	0.000	2594.499
2002	738.529	1419.999	444.653	8.384	0.000	2611.565
2003	507.236	1344.782	318.271	5.585	0.000	2175.874
2004	624.441	1534.715	338.021	6.409	0.000	2503.586
2005	636.955	1456.744	277.924	5.625	0.000	2377.248
2006	624.002	1366.521	266.189	4.062	0.000	2260.774
2007	708.094	900.102	0.000	5.941	0.000	1625.239
2008	856.484	1271.938	0.000	11.237	0.000	2139.659
2009	1109.096	510.213	0.000	55.212	0.000	1674.521
2010	614.033	596.212	0.000	125.008	0.000	1335.253
2011	765.790	1381.228	0.000	22.811	0.000	2169.836
2012	1011.300	1333.590	0.000	22.470	0.000	2367.359
2013	698.756	1368.763	0.000	18.553	0.000	2086.071

Table 2.2.2. Annual Red Grouper recreational landings from the U.S. Gulf of Mexico in thousands of fish from 1946-2013.

Recreational Landings in Thousands of Fish						
Year	Charterboat	Private	Combined Charterboat Private	Headboat	Shore	Total Recreational
1946	-	-	12.022	0.689	0.000	12.711
1947	-	-	24.044	1.378	0.000	25.422
1948	-	-	36.067	2.066	0.000	38.133
1949	-	-	48.089	2.755	0.000	50.844
1950	-	-	60.111	3.444	0.000	63.555
1951	-	-	72.133	4.133	0.000	76.266
1952	-	-	84.155	4.821	0.000	88.977
1953	-	-	96.178	5.510	0.000	101.688
1954	-	-	108.200	6.199	0.000	114.399
1955	-	-	120.222	6.888	0.000	127.110
1956	-	-	127.848	9.184	0.000	137.032
1957	-	-	135.474	11.480	0.000	146.953
1958	-	-	143.100	13.775	0.000	156.875
1959	-	-	150.726	16.071	0.000	166.797
1960	-	-	158.352	18.367	0.000	176.719
1961	-	-	158.764	20.663	0.000	179.428
1962	-	-	159.177	22.959	0.000	182.136
1963	-	-	159.589	25.255	0.000	184.844
1964	-	-	160.002	27.551	0.000	187.553
1965	-	-	160.415	29.847	0.000	190.261
1966	-	-	164.277	32.602	0.000	196.879
1967	-	-	168.140	35.357	0.000	203.497
1968	-	-	172.002	38.112	0.000	210.114
1969	-	-	175.865	40.867	0.000	216.732
1970	-	-	179.727	43.622	0.000	223.349
1971	-	-	186.048	43.622	0.000	229.670
1972	-	-	192.369	45.918	0.000	238.287
1973	-	-	198.690	48.214	0.000	246.904
1974	-	-	205.011	48.214	0.000	253.225
1975	-	-	211.332	66.581	0.000	277.914
1976	-	-	223.354	64.285	0.000	287.639
1977	-	-	235.376	59.694	0.000	295.069
1978	-	-	247.397	57.398	0.000	304.795
1979	-	-	259.419	64.285	0.000	323.704
1980	-	-	271.441	64.285	0.000	335.726
1981	44.565	77.072	121.637	24.813	0.000	146.450

Table 2.2.2 (Continued) Annual Red Grouper recreational landings from the U.S. Gulf of Mexico in thousands of fish from 1946-2013.

Recreational Landings in Thousands of Fish						
Year	Charterboat	Private	Combined Charterboat Private	Headboat	Shore	Total Rec.
1982	9.413	163.825	173.238	5.241	0.000	178.479
1983	27.335	351.074	378.409	15.219	0.000	393.628
1984	75.279	118.114	193.393	41.913	28.098	263.404
1985	107.215	418.989	526.204	59.694	0.000	585.898
1986	79.799	525.519	605.318	32.913	6.969	645.200
1987	38.279	298.229	336.508	25.729	0.000	362.237
1988	51.948	687.306	739.254	27.954	9.160	776.368
1989	38.012	713.005	751.017	49.777	0.000	800.794
1990	50.212	130.122	180.334	14.582	16.048	210.964
1991	11.401	284.585	295.986	9.509	10.155	315.650
1992	52.191	419.526	471.717	9.049	26.238	507.004
1993	27.501	331.594	359.095	8.802	18.946	386.843
1994	32	279.441	311.441	9.617	2.750	323.808
1995	59.008	226.726	285.734	14.499	0.000	300.233
1996	22.673	87.205	109.878	15.594	0.000	125.472
1997	22.229	55.004	77.233	4.676	0.000	81.909
1998	25.665	83.245	108.910	4.382	0.000	113.292
1999	34.514	160.692	195.206	6.918	0.000	202.124
2000	126.774	240.164	366.938	8.861	0.000	375.799
2001	63.966	173.124	237.090	5.560	0.000	242.650
2002	49.186	218.694	267.880	4.402	0.000	272.282
2003	53.85	164.178	218.028	7.521	0.000	225.549
2004	91.84	438.051	529.891	13.810	0.000	543.701
2005	86.712	96.952	183.664	13.967	0.000	197.631
2006	37.001	94.509	131.510	4.630	0.000	136.140
2007	26.289	128.452	154.741	4.245	0.000	158.986
2008	41.527	91.601	133.128	5.003	0.000	138.131
2009	28.96	95.599	124.559	4.666	1.607	130.832
2010	55.165	100.922	156.087	4.952	0.000	161.039
2011	48.798	62.111	110.909	7.387	0.000	118.296
2012	91.304	208.979	300.283	13.544	0.000	313.827
2013	139.184	301.203	440.387	14.089	0.000	454.476

Table 2.3.1 Annual Red Grouper commercial discards from the U.S. Gulf of Mexico in thousands of fish from 1990-2013.

Commercial Discards in Thousands of Fish				
Year	Vertical Line	Longline	Trap	Total Commercial
1990			69.050	69.050
1991			131.400	131.400
1992			87.500	87.500
1993	510.274	3188.763	169.870	3868.907
1994	487.564	2024.416	53.900	2565.880
1995	459.256	1885.655	124.730	2469.641
1996	338.619	2308.812	732.740	3380.171
1997	370.695	2336.638	598.570	3305.903
1998	290.808	2053.713	50.190	2394.710
1999	474.742	2926.611	106.190	3507.543
2000	674.094	2186.000	234.980	3095.074
2001	728.260	2479.017	167.620	3374.898
2002	853.126	2296.999	146.060	3296.185
2003	549.732	2194.268	134.700	2878.700
2004	709.340	2497.772	81.900	3289.012
2005	829.348	2359.919	122.090	3311.357
2006	612.745	2216.679	139.270	2968.695
2007	553.145	1511.243		2064.388
2008	975.072	1275.026		2250.098
2009	1289.459	793.207		2082.665
2010	994.088	616.223		1610.311
2011	593.650	1408.009		2001.659
2012	599.240	1133.235		1732.476
2013	405.278	840.290		1245.567

Table 2.3.2 Annual Red Grouper recreational discards from the U.S. Gulf of Mexico in thousands of fish from 1981-2013.

Recreational Discards in Thousands of Fish						
Year	Charterboat	Private	Combined Charterboat Private	Headboat	Shore	Total Recreational
1981	7.906	53.292	61.198	4.005	11.623	76.826
1982	3.078	35.734	38.812	1.559	0.000	40.371
1983	6.516	42.091	48.607	3.301	0.000	51.908
1984	18.893	27.223	46.116	9.570	0.000	55.686
1985	27.212	35.973	63.185	13.784	31.584	108.553
1986	75.968	388.292	464.260	57.059	36.162	557.481
1987	55.687	255.963	311.650	68.103	0.000	379.753
1988	45.691	727.407	773.098	44.776	71.741	889.615
1989	112.586	1718.771	1831.357	268.558	11.065	2110.980
1990	217.875	1244.607	1462.482	115.232	128.784	1706.498
1991	57.281	2586.268	2643.549	87.707	206.175	2937.431
1992	165.448	2115.433	2280.881	52.245	505.104	2838.230
1993	133.344	1444.787	1578.131	77.613	46.668	1702.412
1994	119.009	1344.305	1463.314	65.148	101.182	1629.644
1995	165.497	1295.002	1460.499	74.073	2.252	1536.824
1996	62.371	705.629	768.000	78.145	20.857	867.002
1997	108.861	703.972	812.833	41.698	33.507	888.038
1998	326.922	1139.286	1466.208	101.358	10.471	1578.037
1999	393.899	1572.920	1966.819	143.725	21.518	2132.062
2000	634.966	1524.541	2159.507	80.840	23.009	2263.356
2001	279.996	1289.411	1569.407	44.312	0.000	1613.719
2002	273.975	1571.390	1845.365	44.637	0.000	1890.002
2003	386.452	1573.177	1959.629	98.172	5.635	2063.436
2004	452.240	2697.519	3149.759	123.862	39.812	3313.433
2005	274.709	999.489	1274.198	80.594	7.549	1362.341
2006	127.967	503.284	631.251	29.164	0.000	660.415
2007	133.750	666.434	800.184	17.365	19.033	836.582
2008	425.320	2549.796	2975.116	89.615	556.633	3621.364
2009	479.498	2713.425	3192.923	153.829	117.783	3464.535
2010	543.936	1667.811	2211.747	117.879	6.583	2336.209
2011	502.370	1526.879	2029.249	134.114	9.170	2172.533
2012	539.422	1202.880	1742.302	117.809	6.982	1867.093
2013	613.660	2036.644	2650.304	112.267	1.281	2763.852

Table 2.4.1 Number of Red Grouper aged in the Gulf of Mexico by year and fleet.

Number of Aged Fish									
	Commercial				Recreational				
Year	Vertical Line	Longline	Trap	Total	Charterboat	Private	Combined CBT/PRI	Headboat	Total
1980								5	5
1981								13	13
1985								1	1
1986								8	8
1987								11	11
1988								10	10
1989								11	11
1991	43	37	2	80	1	0	1	36	37
1992	42	143	14	185	24	1	25	33	58
1993	93	200	84	293	61	1	62	21	83
1994	239	88	29	327	72	0	72	29	101
1995	180	140	39	320	91	0	91	53	144
1996	141	96	8	237	134	0	134	41	175
1997	35	7	17	42	61	9	70	28	98
1998	39	122	33	161	72	4	76	21	97
1999	77	643	31	720	104	2	106	8	114
2000	206	405	38	611	59	0	59	12	71
2001	575	1210	39	1785	45	2	47	1	48
2002	573	1067	89	1640	292	7	299	50	349
2003	561	1080	65	1641	101	68	169	30	199
2004	1062	1153	38	2215	144	41	185	43	228
2005	626	1455	173	2081	64	1	65	52	117
2006	629	538		1167	38	6	44	33	77
2007	497	599		1096	52	10	62	28	90
2008	503	509		1012	73	32	105	44	149
2009	895	994		1889	90	27	117	102	219
2010	1030	650		1680	263	47	310	85	395
2011	629	499		1128	391	13	404	114	518
2012	1019	861		1880	223	14	237	39	276
2013	558	1130		1688	216	25	241	45	286

Table 2.5.1 Number of discarded Red Grouper lengths measured in the Gulf of Mexico by year and fleet.

Number of Discard Length Measurements						
	Commercial			Recreational		
Year	Vertical Line	Longline	Total	Charterboat	Headboat	Total
2005					1126	1126
2006	937	3926	4863		1058	1058
2007	2064	2931	4995		1633	1633
2008	1073	920	1993			
2009	1529	6496	8025		1734	1734
2010	2980	18735	21715	2313	1592	3905
2011	5190	40572	45762	1834	1056	2890
2012	8917	12028	20945	1324	635	1959
2013	2291	22261	24552	1195	772	1967

Table 2.6.1 Fishery-independent standardized indices of abundance and associated log-scale standard errors for the Gulf of Mexico Red Grouper. The indices are scaled to a mean of one over each respective time series.

	Fishery-Independent Indices					
Year	Combined Video		NMFS Bottom Longline		SEAMAP Groundfish	
	Index	SE	Index	SE	Index	SE
1993	0.7660	0.1634				
1994	1.0119	0.1660				
1995	1.0444	0.1890				
1996	0.9761	0.1354				
1997	1.1872	0.1042				
1998						
1999						
2000						
2001			0.6445	0.2868		
2002	1.1571	0.1082				
2003			0.8907	0.2003		
2004	1.3156	0.0979	1.4493	0.1906		
2005	1.0877	0.0809	0.5438	0.3892		
2006	0.9176	0.0812	0.4974	0.3767		
2007	0.5652	0.1132	0.7700	0.4413		
2008	0.6947	0.0962	0.5298	0.3132		
2009	0.8743	0.0724	0.8180	0.2587	1.4703	0.2646
2010	1.1093	0.0632	1.1009	0.2597	0.9486	0.2701
2011	1.2464	0.0506	2.0208	0.1799	0.9334	0.2890
2012	1.0255	0.0600	1.8742	0.2503	0.9518	0.2514
2013	1.0211	0.0741	0.8606	0.2980	0.6959	0.2831

Table 2.6.2. Fishery-dependent standardized indices of abundance and associated log-scale standard errors for Gulf of Mexico Red Grouper. The indices are scaled to a mean of one over each respective time series.

Fishery-Dependent Indices								
Year	Commercial Vertical Line		Commercial Longline		Recreational MRFSS		Recreational Headboat	
	Index	SE	Index	SE	Index	SE	Index	SE
1986					1.0925	0.2752	1.0334	0.6450
1987					0.8681	0.3258	1.6494	0.5837
1988					1.1339	0.3675	1.6056	0.5734
1989					1.3293	0.3179	1.5487	0.5934
1990					1.5569	0.2834	0.6990	0.6698
1991					1.4756	0.3589	0.4941	0.7086
1992					1.2438	0.3113	0.4723	0.7077
1993	0.7311	0.3042	0.9785	0.0535	0.7682	0.3662	0.6343	0.6513
1994	0.7160	0.3006	0.7235	0.0474	0.8707	0.3448	0.5523	0.6713
1995	0.7886	0.3041	0.7742	0.0491	0.8627	0.3396	0.8352	0.6310
1996	0.4907	0.3126	1.0397	0.0513	0.5555	0.3998	0.4933	0.6856
1997	0.5647	0.3132	0.9069	0.0428	0.5467	0.4064	0.4750	0.6884
1998	0.5185	0.3119	0.9552	0.0441	0.6533	0.3583	0.5671	0.6762
1999	0.7399	0.3059	0.9968	0.0438	0.7350	0.3378	0.4741	0.6845
2000	0.9911	0.2987	0.8980	0.0465	0.8305	0.3295	0.5944	0.6754
2001	1.3470	0.2904	1.0563	0.0447	0.6524	0.3360	0.8726	0.6229
2002	1.3871	0.2900	1.0600	0.0471	0.7901	0.3281	0.8929	0.6086
2003	0.9471	0.2859	0.9284	0.0453	0.9794	0.3142	1.4145	0.5301
2004	1.2740	0.2810	1.1124	0.0440	1.2459	0.2753	2.1247	0.4972
2005	1.4169	0.2828	1.4437	0.0455	0.8296	0.3100	2.3719	0.4915
2006	1.1435	0.2862	1.0927	0.0435	0.4391	0.3920	0.8687	0.6264
2007	1.2066	0.2834	0.7796	0.0502	0.6953	0.3325	0.9534	0.6002
2008	1.5309	0.2819	1.1811	0.0496	1.1731	0.2788	0.8800	0.6073
2009	1.2061	0.2816	1.0731	0.0730	1.5401	0.2685	0.6800	0.6245
2010					1.1744	0.2759	1.1157	0.5603
2011					1.3397	0.2742	1.0953	0.5353
2012					1.1216	0.2744	1.4104	0.5064
2013					1.4966	0.3006	1.1915	0.5479

Table 2.7.1 Number of Red Grouper lengths measured in the Gulf of Mexico by year and survey.

	Number of Measured Lengths			
Year	Combined Video	SEAMAP Groundfish	NMFS Bottom Longline	Total Fishery-Ind.
1996			10	10
1997			6	6
1998			7	7
1999			1	1
2000			26	26
2001			79	79
2002			16	16
2003			162	162
2004			170	170
2005			32	32
2006			32	32
2007			51	51
2008	32	33	31	96
2009	99	298	64	461
2010	48	187	81	316
2011	116	114	312	542
2012	105	151	111	367
2013	39	72	47	158
2014			24	24

2.10 Figures

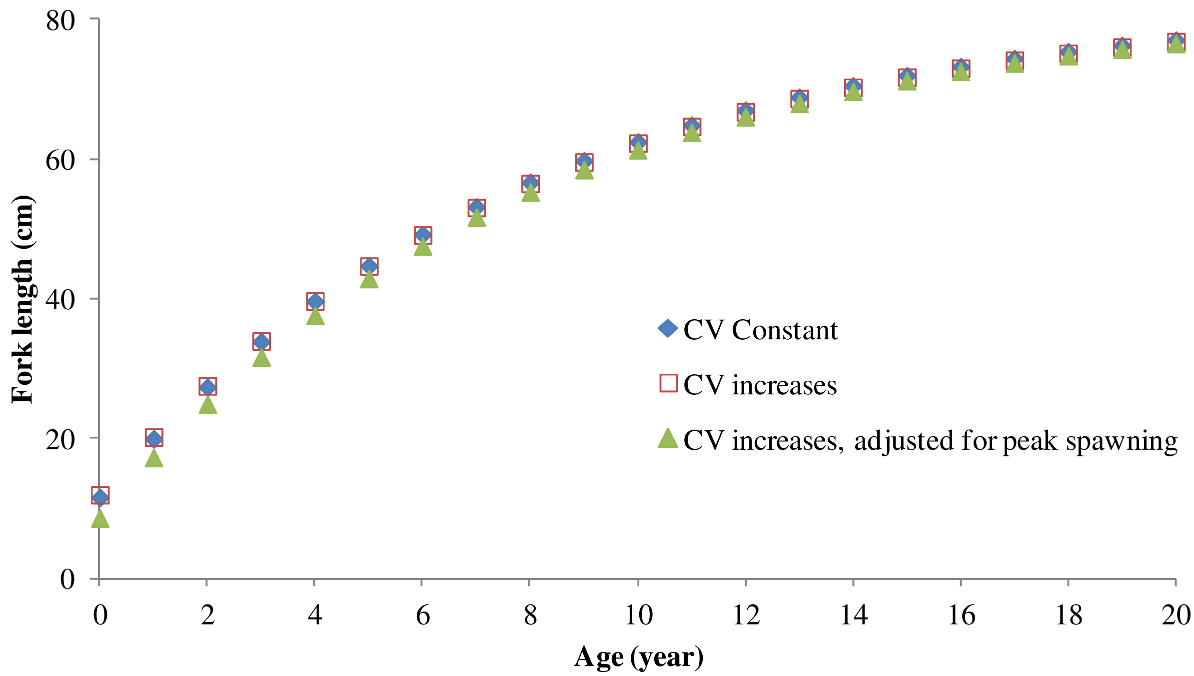


Figure 2.1.1 Von Bertalanffy growth relationship recommended by the Data Workshop (blue diamond) compared to the relationship used in the SS model (green triangle). The von Bertalanffy parameters using constant CV were: L_{inf} = 82.89 cm, K = 0.125, and t_0 = -1.20. The parameters using increasing CV with age were: L_{inf} = 82.72 cm, K = 0.124, and t_0 = -1.26. After adjusting to account for peak spawning on May 15th the parameters were, L_{inf} = 82.72 cm, K = 0.124, and t_0 = -0.89.

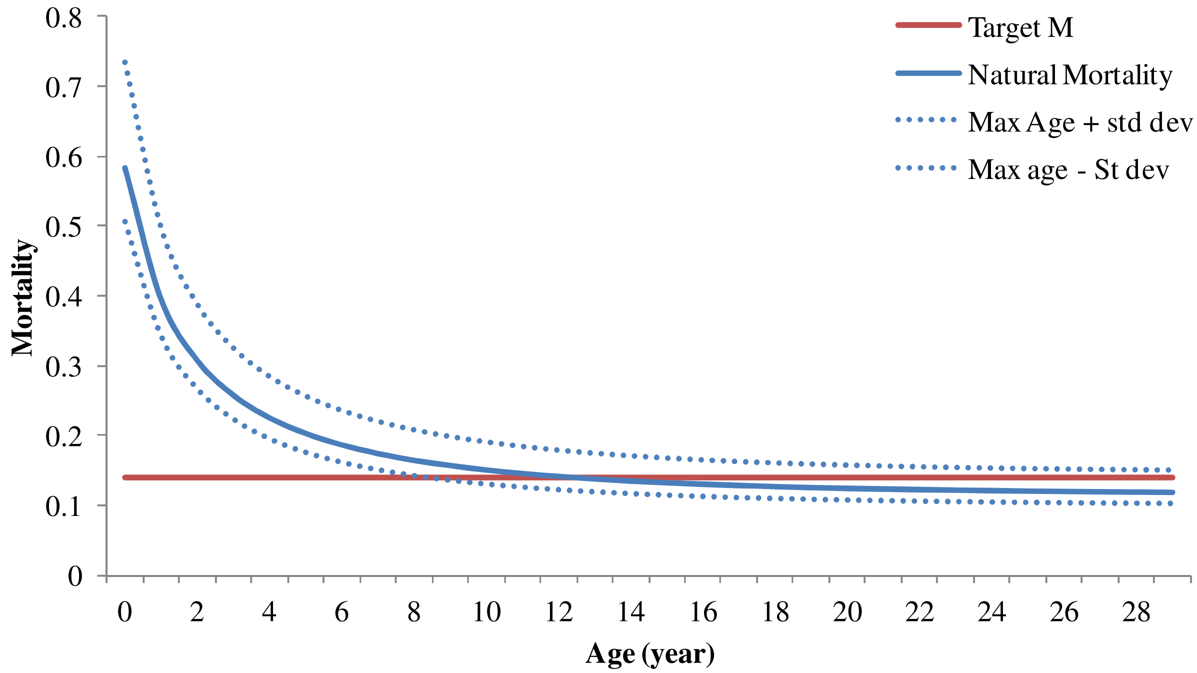


Figure 2.1.2 Recommended age-specific natural mortality vector and upper and lower range recommended by the Data Workshop. The standard deviation (±5 years) at age for the maximum age (29 years) was used to calculate the upper and lower range for natural mortality. The target mortality was 0.14.

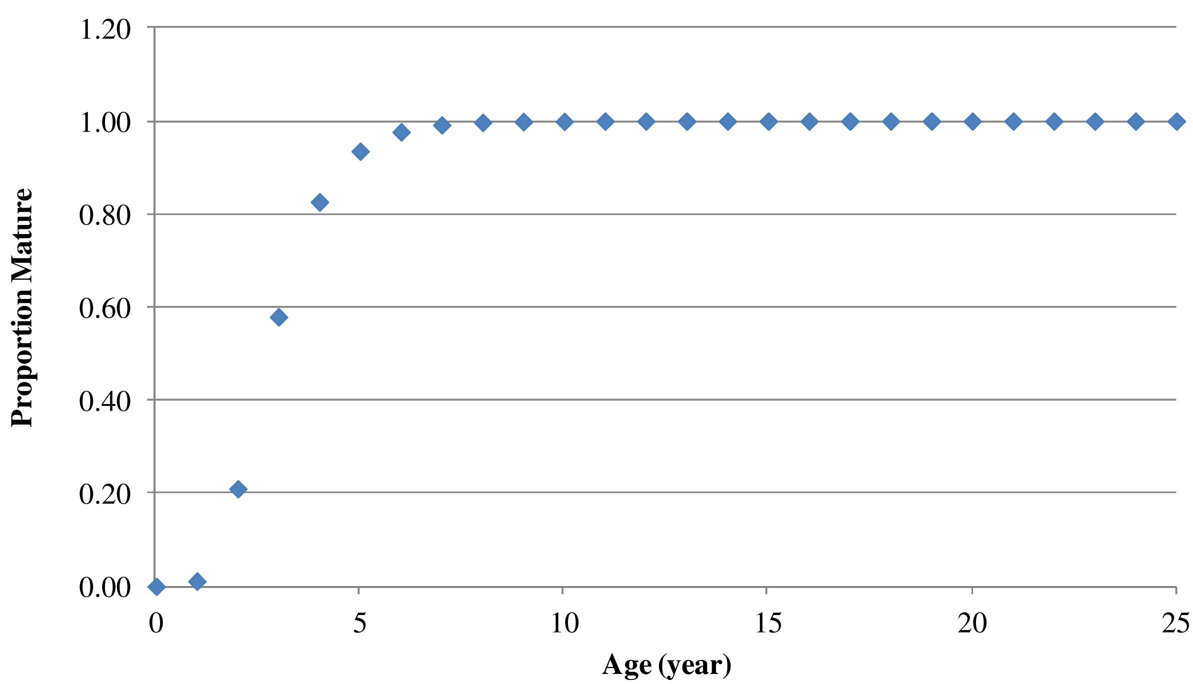


Figure 2.1.3 Proportion mature at age.

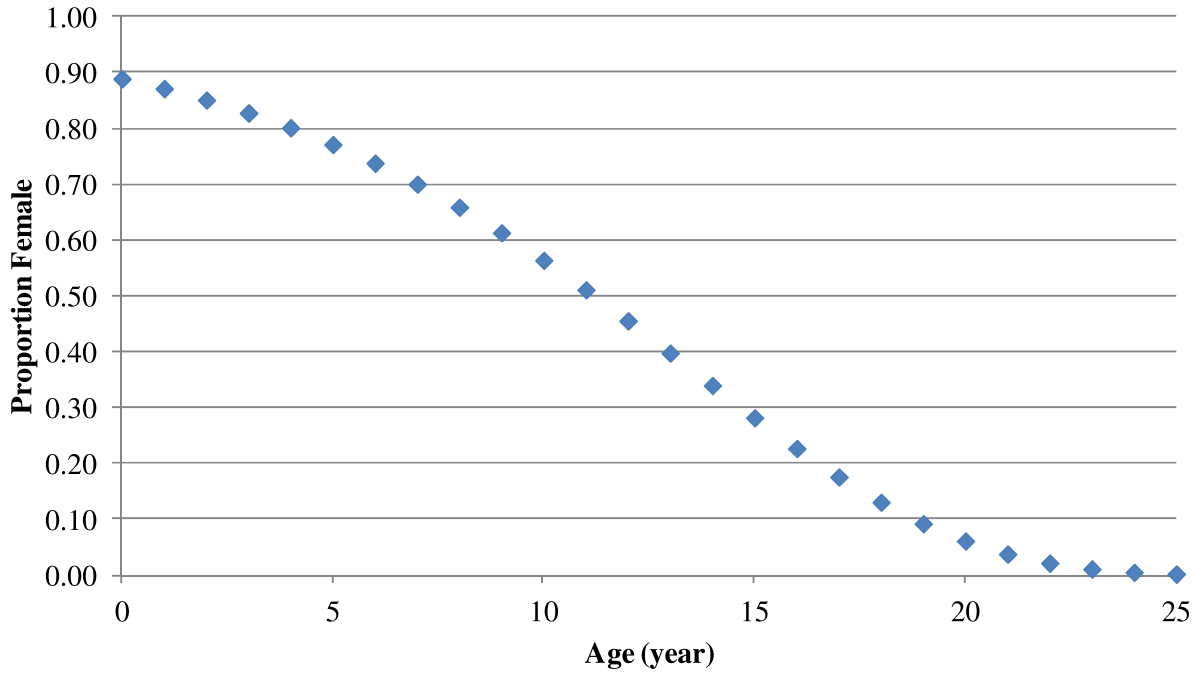


Figure 2.1.4 Proportion female at age.

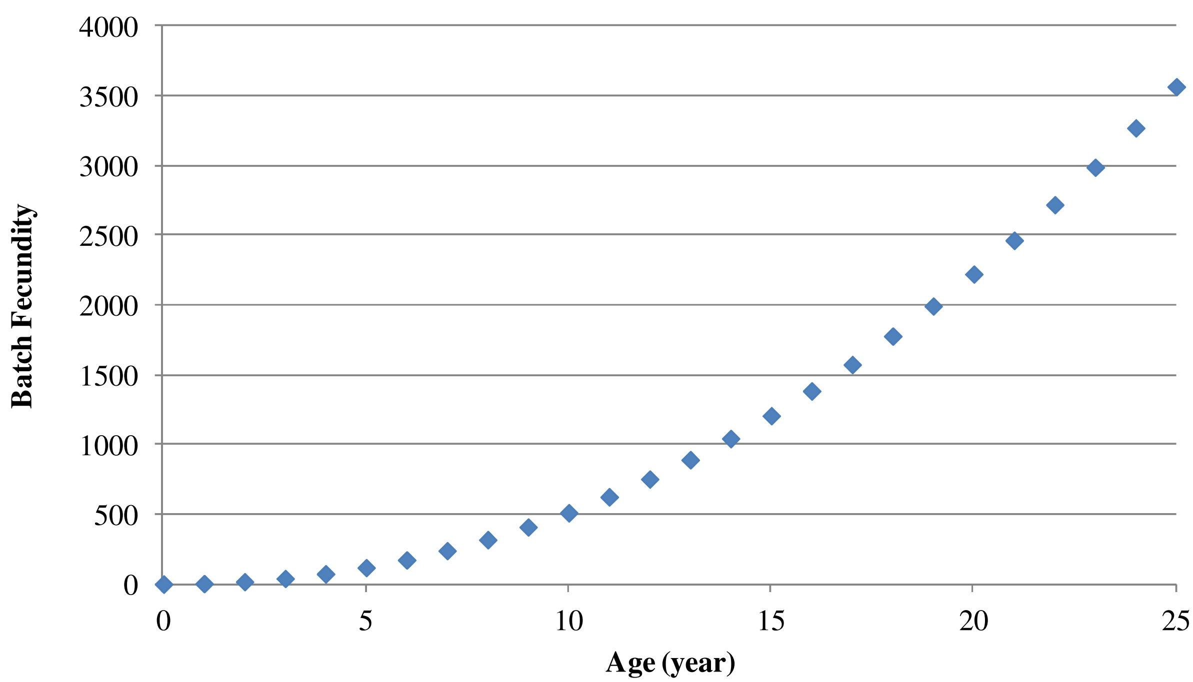


Figure 2.1.5 Batch fecundity at age.

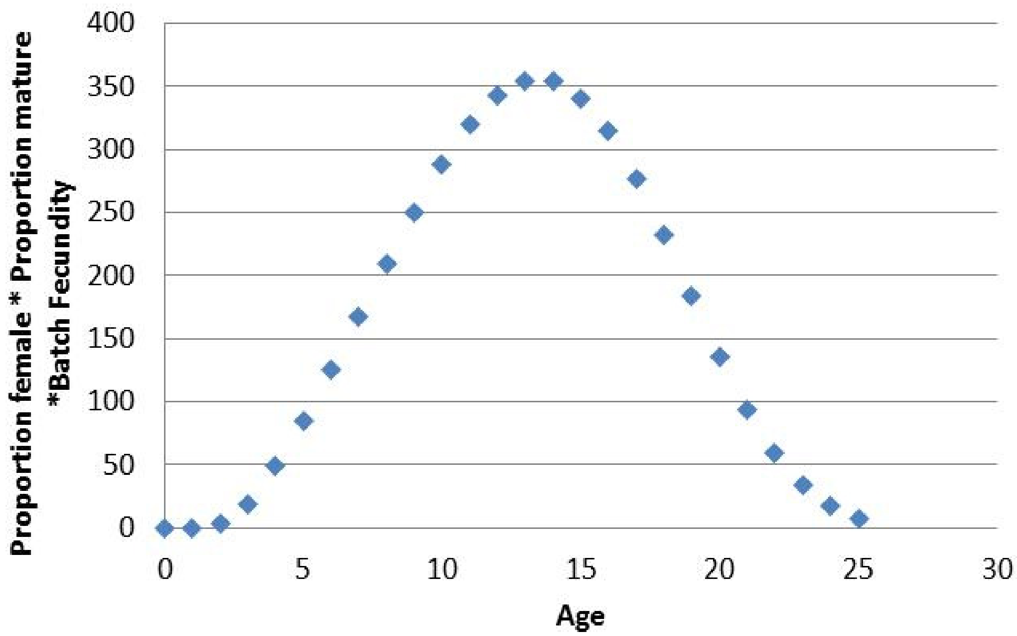


Figure 2.1.6. Fecundity at age equal to proportion mature * proportion female * batch fecundity.

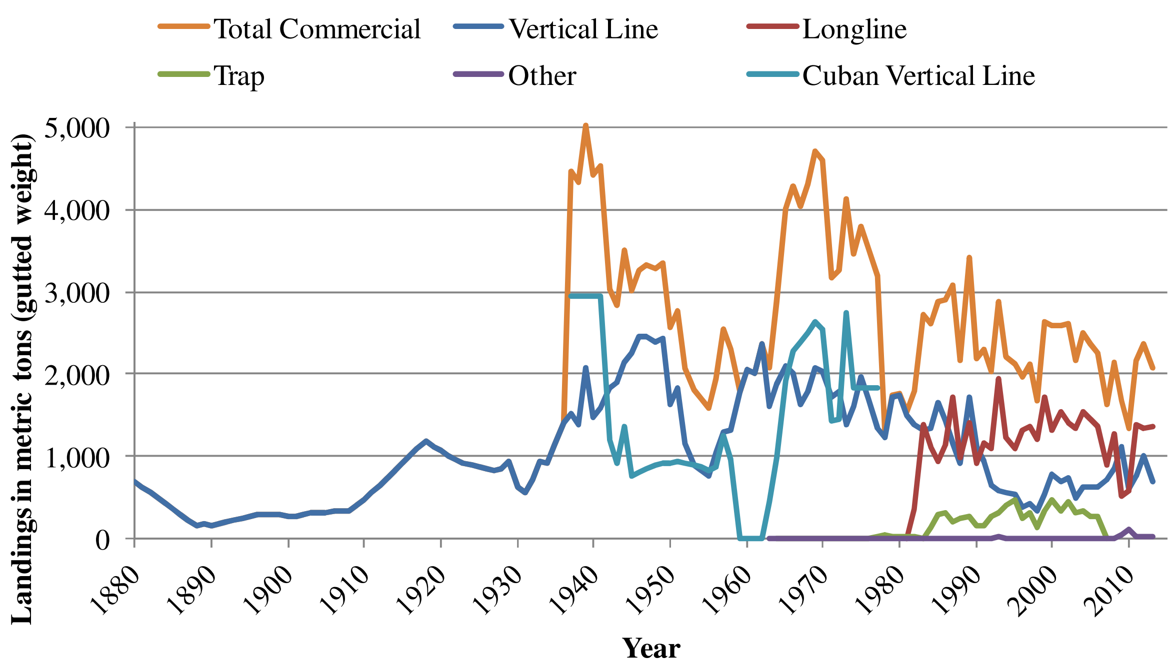


Figure 2.2.1 Red Grouper commercial landings from the U.S. Gulf of Mexico in metric tons gutted weight from 1880-2013.

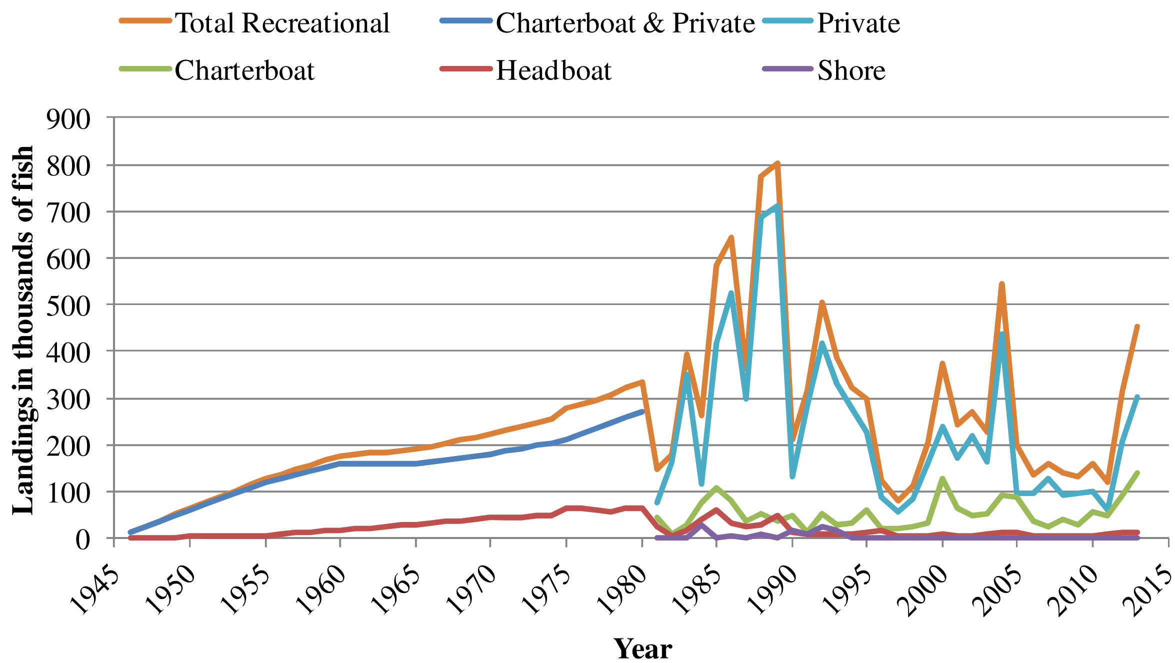


Figure 2.2.2 Red Grouper recreational landings from the U.S. Gulf of Mexico in thousands of fish from 1945-2013.

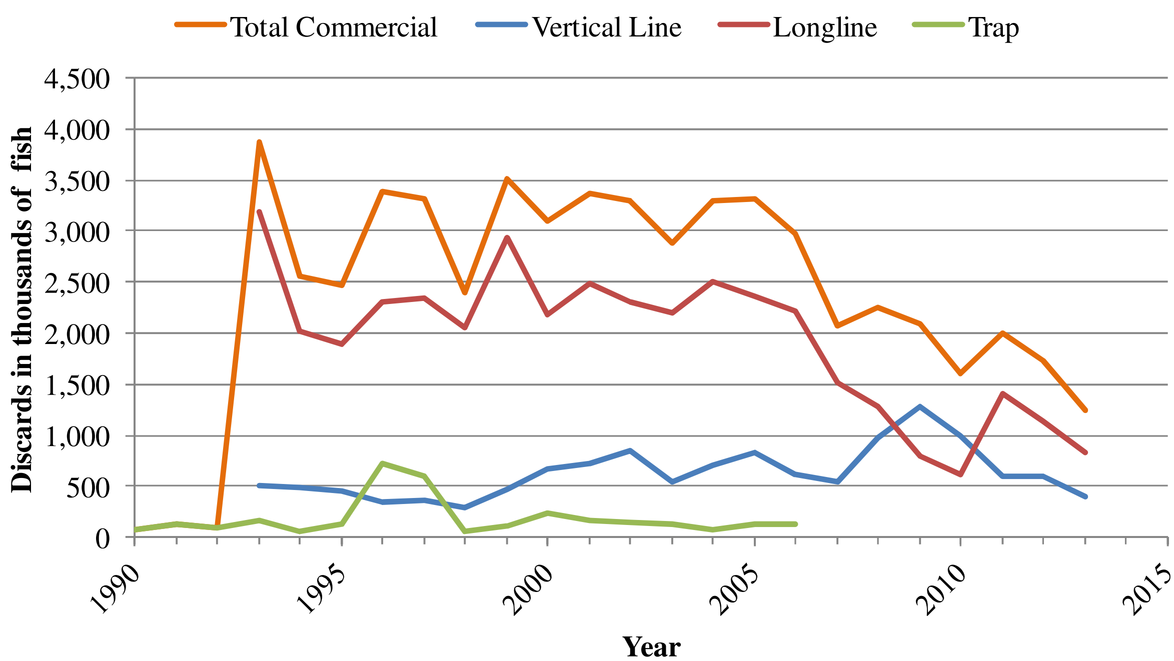
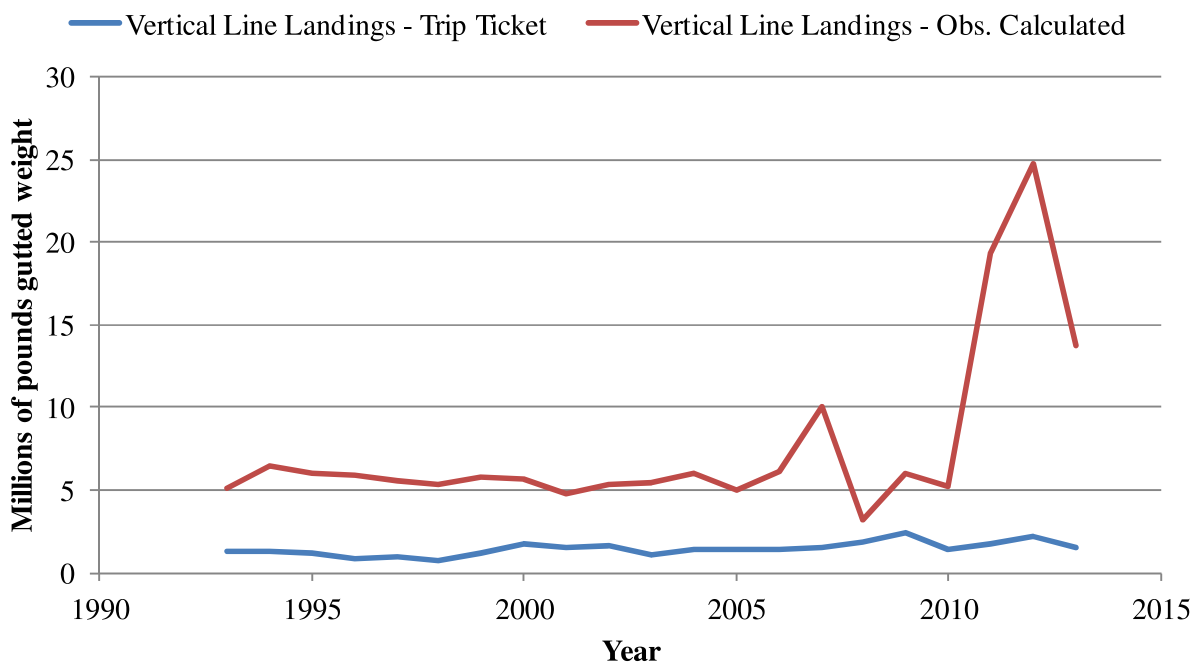


Figure 2.3.1 Red Grouper commercial discards from the U.S. Gulf of Mexico in thousands of fish from 1990-2013.

A.



B.

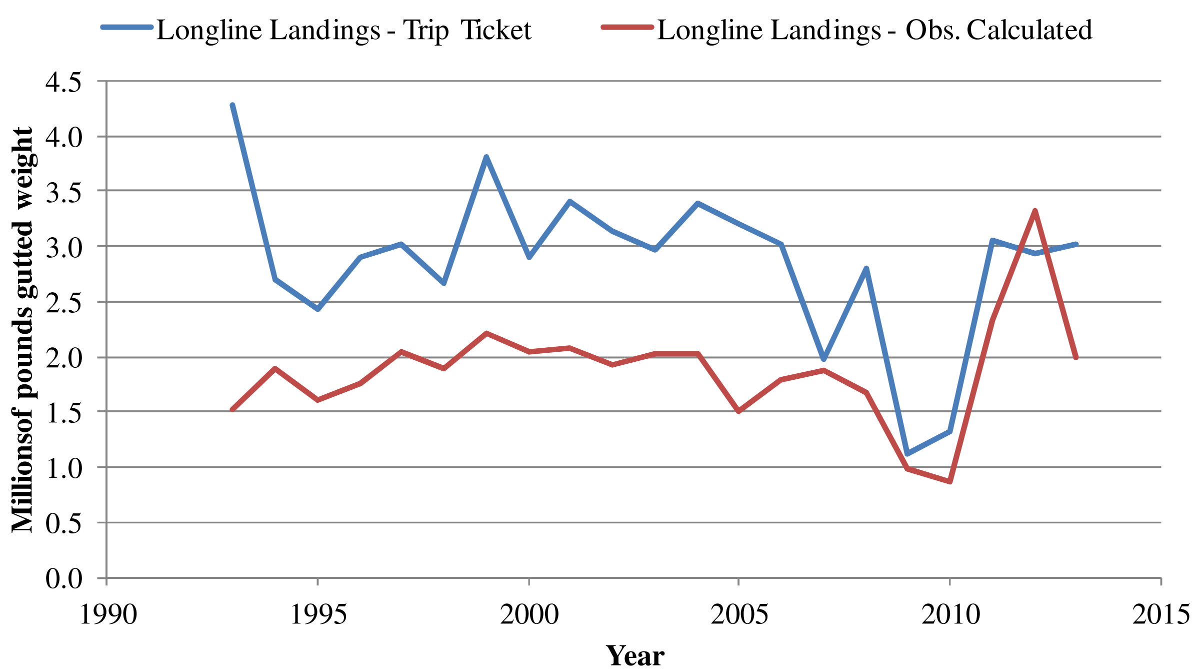


Figure 2.3.2. Comparison of Red Grouper landings compiled for SEDAR 42 and landings calculated as: observer reported Red Grouper kept rate*effort reported in coastal logbook. A. Vertical line landings compared. B. Bottom longline landings compared. Landings from trip ticket data are in blue. Calculated landings are in red.

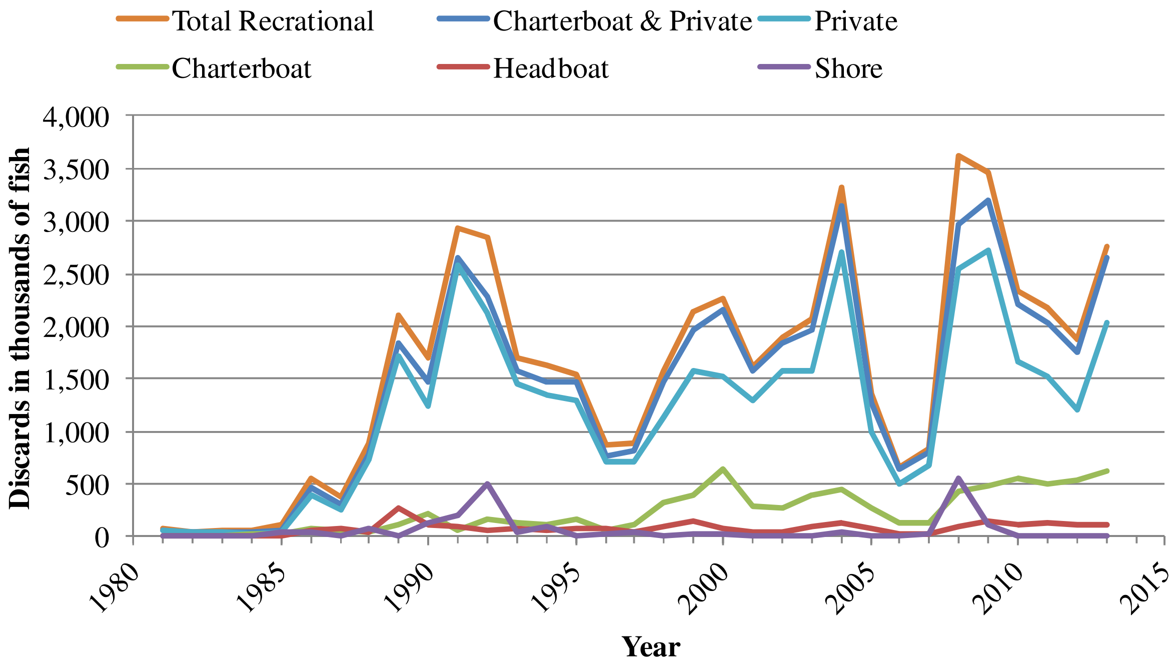


Figure 2.3.3 Red Grouper recreational discards from the U.S. Gulf of Mexico in thousands of fish from 1981-2013.

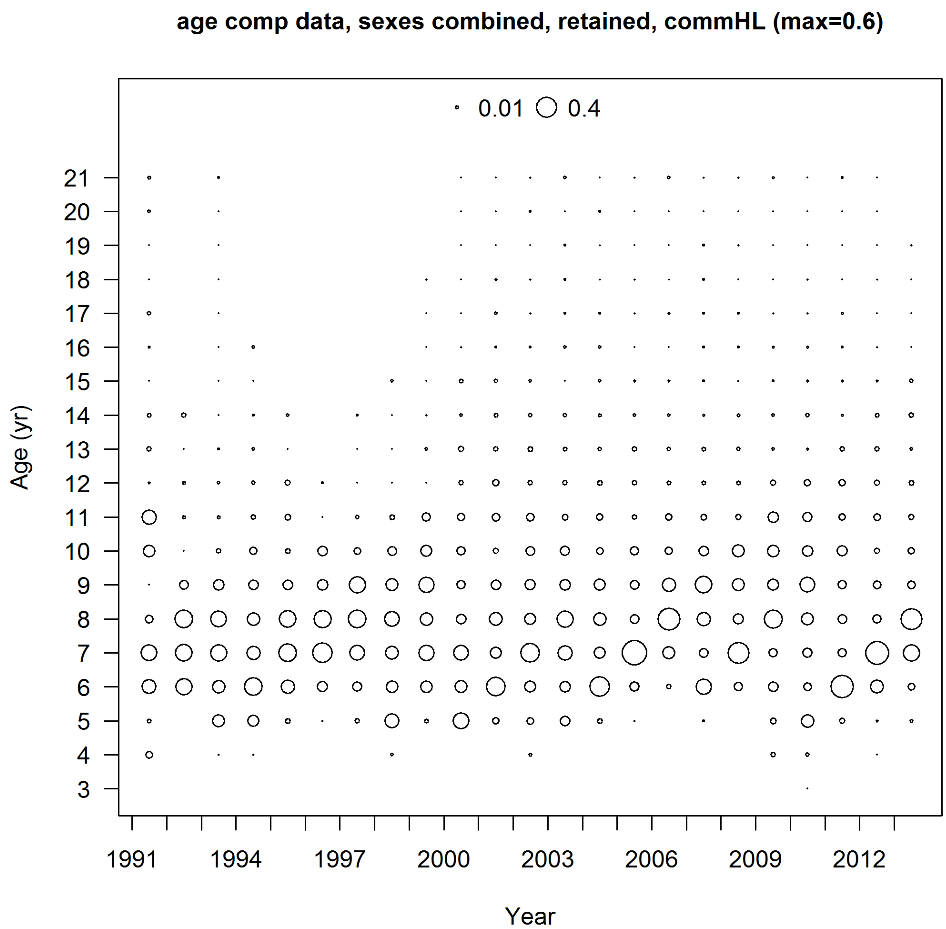


Figure 2.4.1 Annual age composition data of Red Grouper landed by the commercial vertical line fishery.

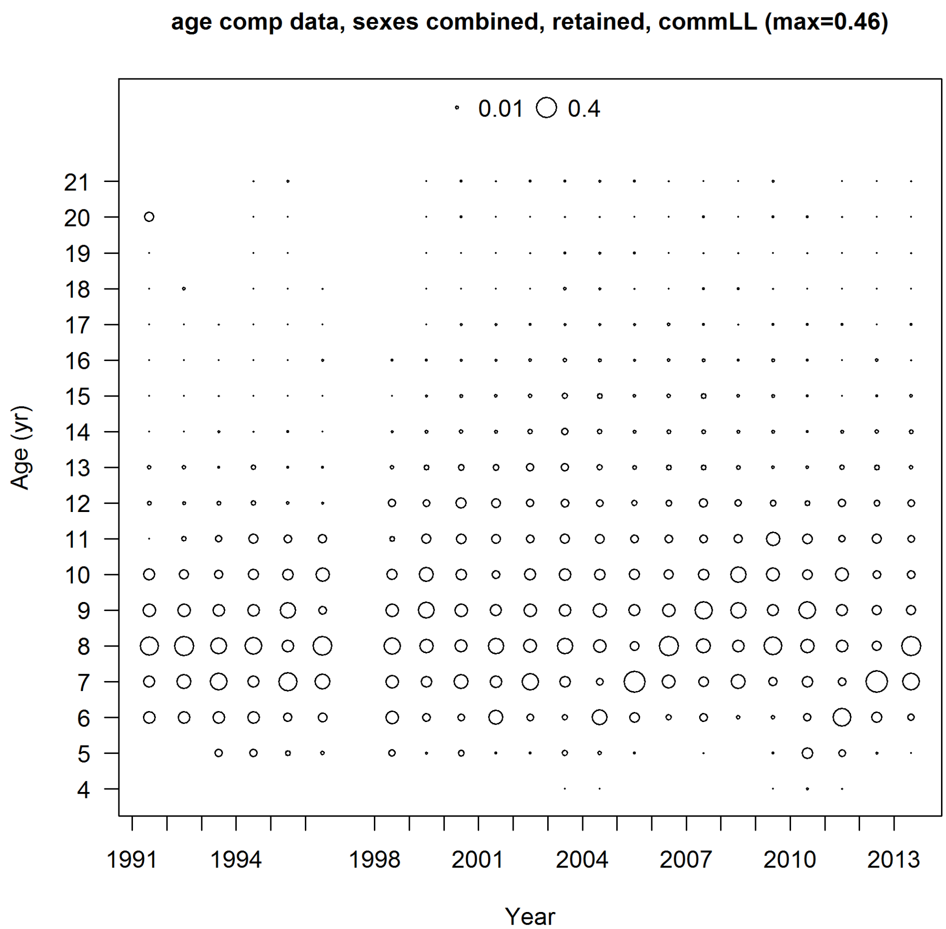


Figure 2.4.2 Annual age composition data of Red Grouper landed by the commercial longline fishery.

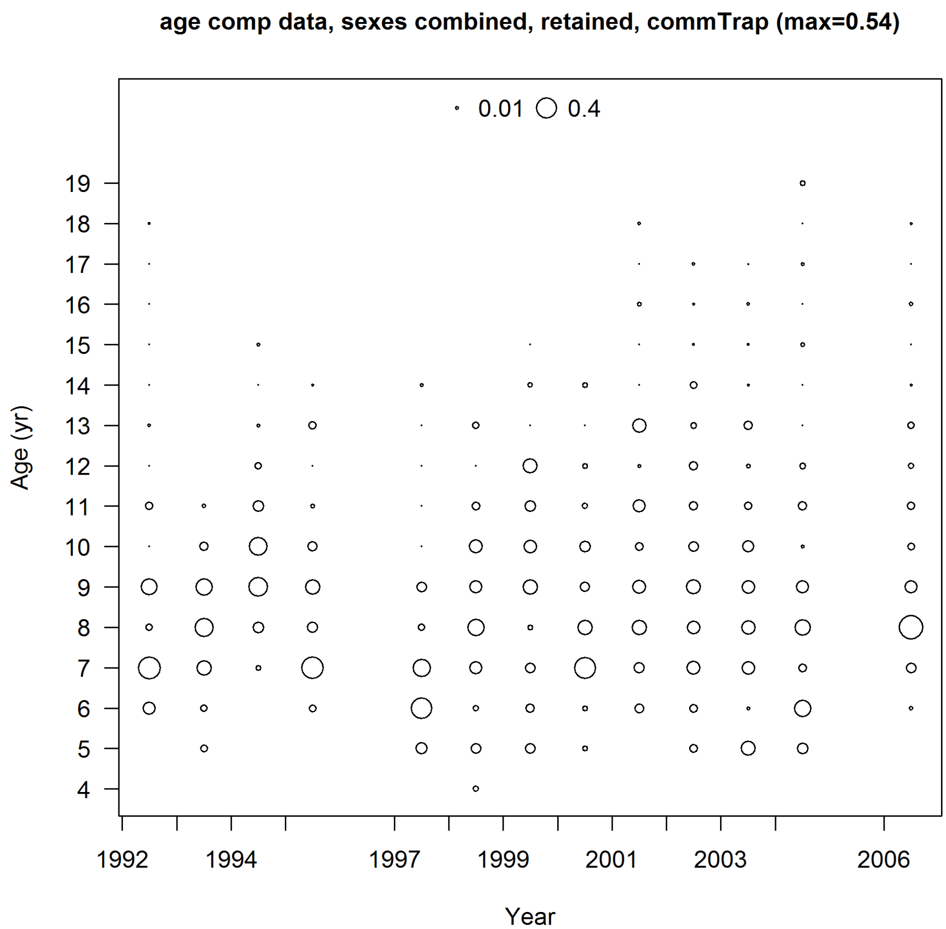


Figure 2.4.3 Annual age composition data of Red Grouper landed by the commercial trap fishery.

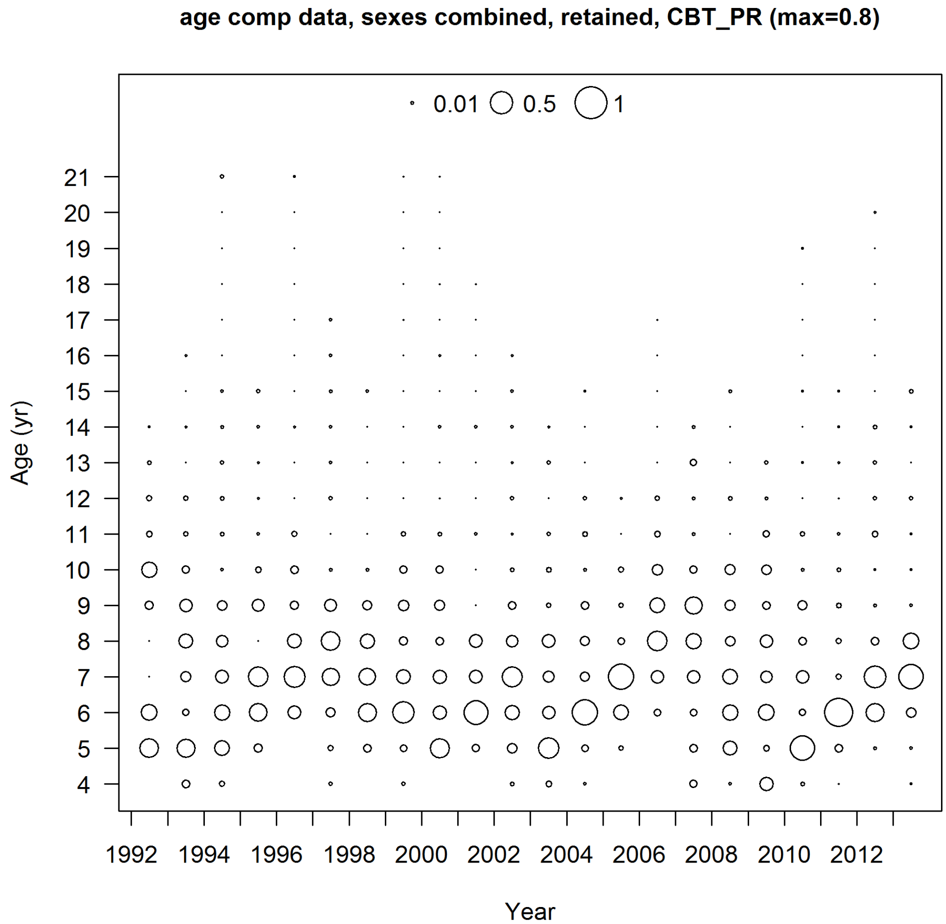


Figure 2.4.4 Annual age composition data of Red Grouper landed by the recreational combined charterboat and private fishery.

Figure 2.4.5 Annual age composition data of Red Grouper landed by the recreational headboat fishery.

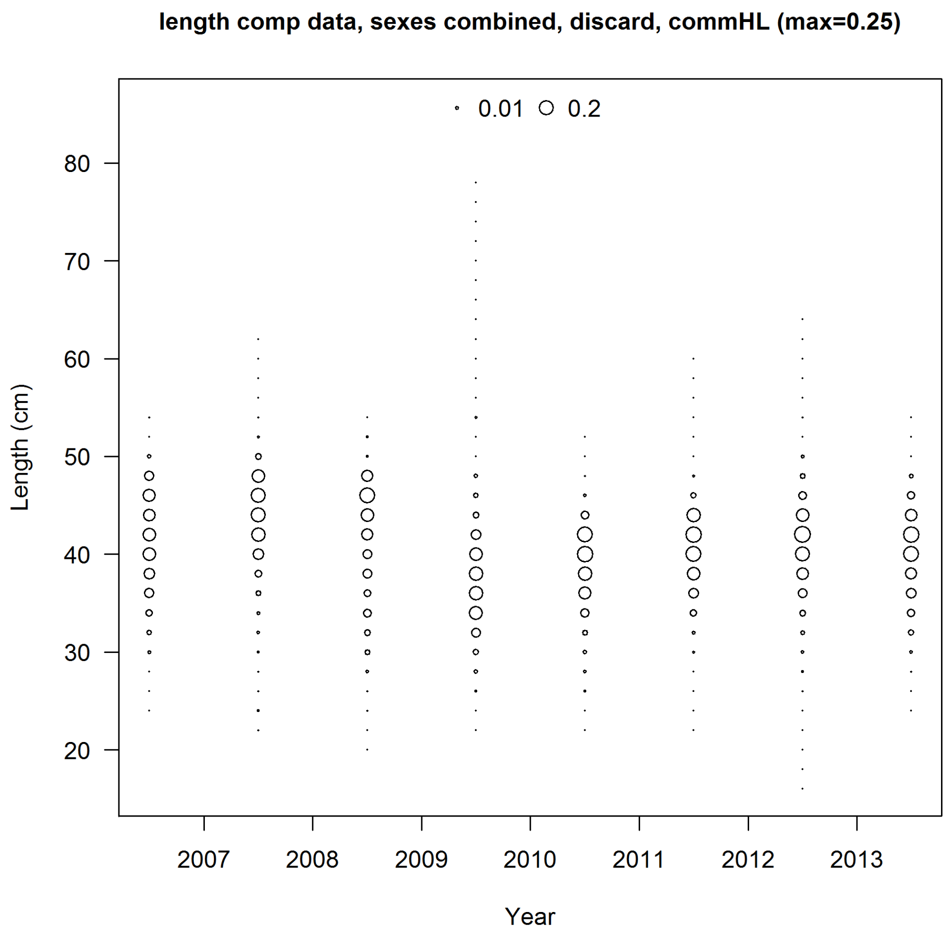


Figure 2.5.1 Annual length composition data of Red Grouper discarded by the commercial vertical line fishery. The y-axis represents fork length of Red Grouper in centimeters.

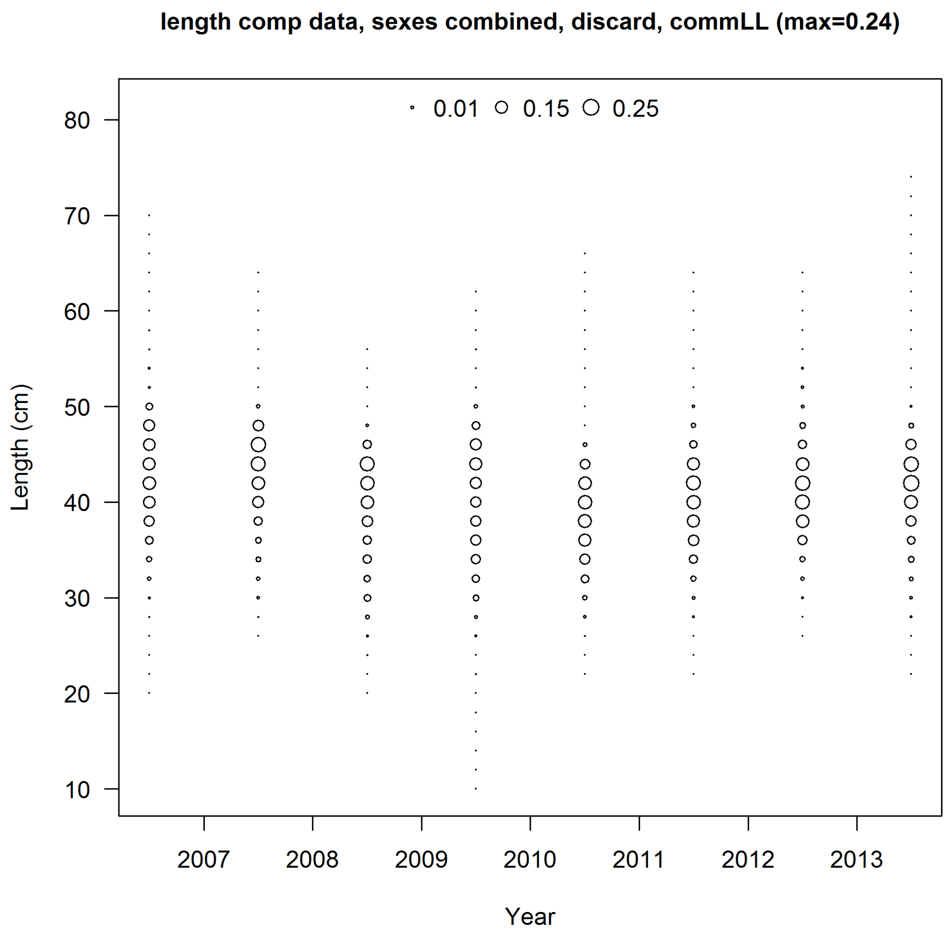


Figure 2.5.2 Annual length composition data of Red Grouper discarded by the commercial longline fishery. The y-axis represents fork length of Red Grouper in centimeters.

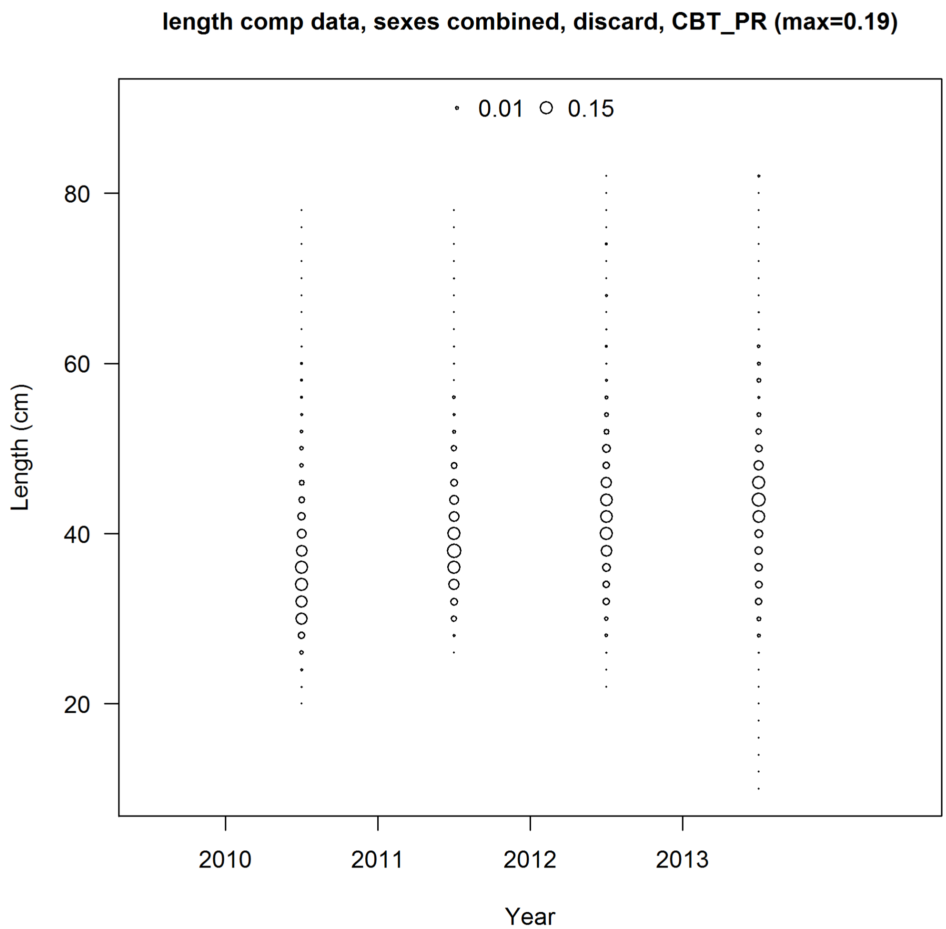


Figure 2.5.3 Annual length composition data of Red Grouper discarded by the recreational combined charterboat and private fishery. The y-axis represents fork length of Red Grouper in centimeters.

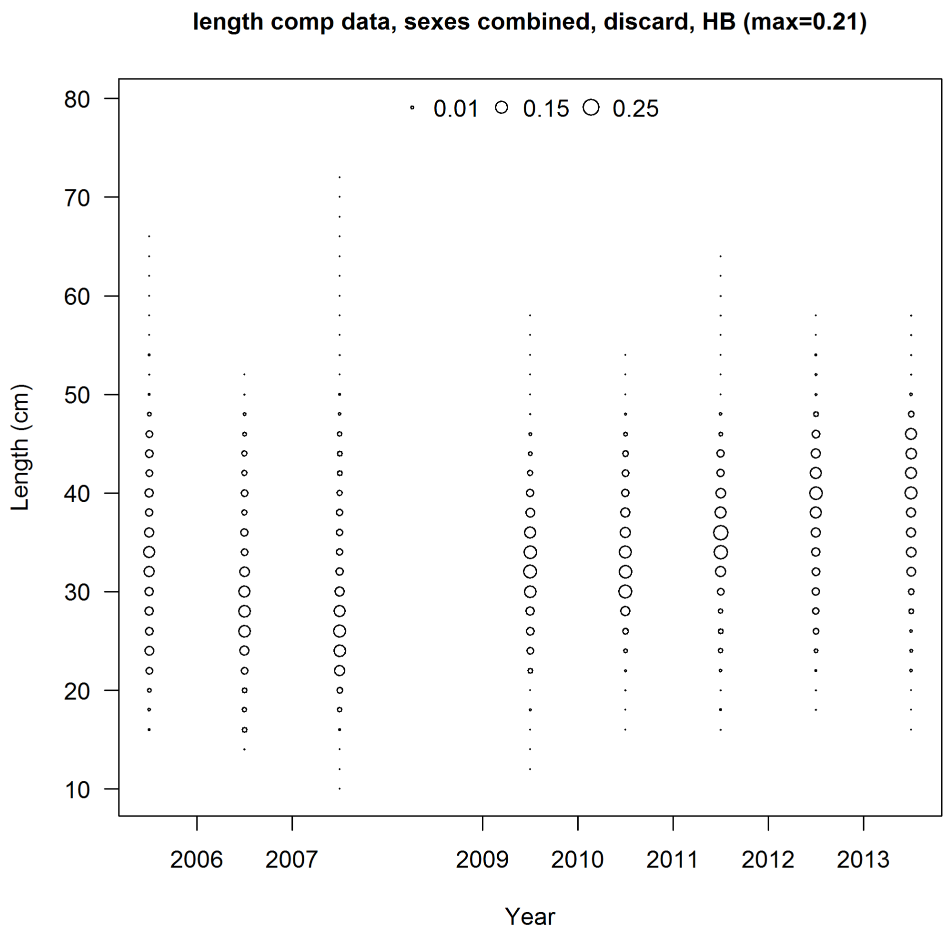


Figure 2.5.4 Annual length composition data of Red Grouper discarded by the recreational headboat fishery. The y-axis represents fork length of Red Grouper in centimeters.

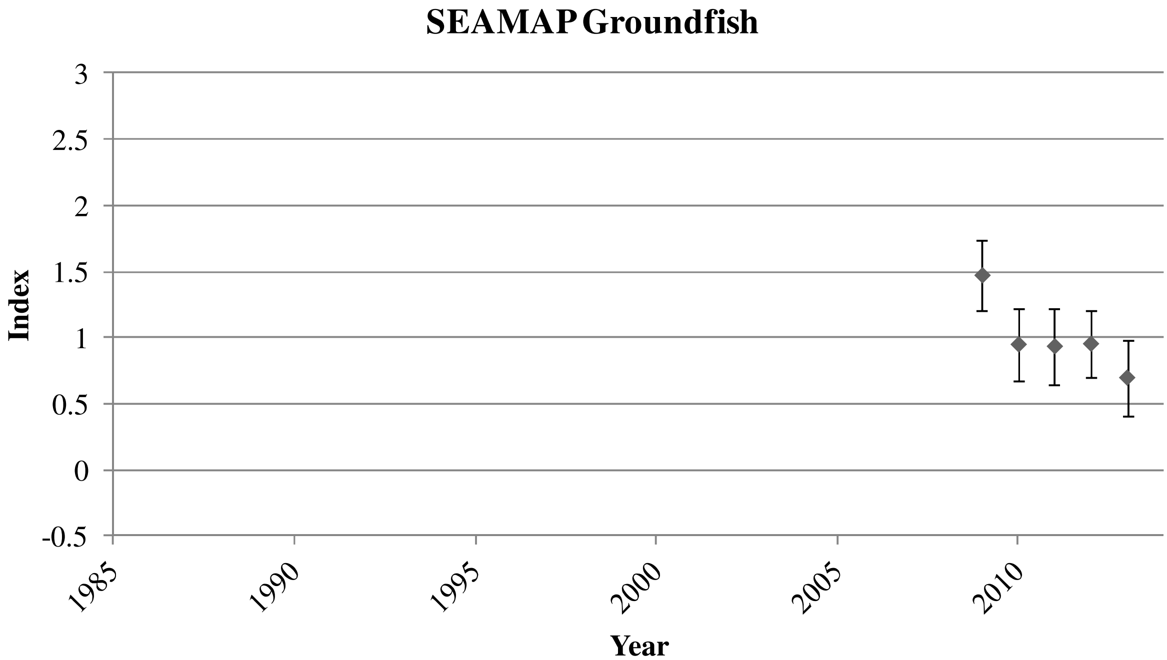


Figure 2.6.1 Standardized indices of abundance and the associated log-scale standard errors from the Gulf of Mexico SEAMAP groundfish survey. The index is scaled to a mean of one over the time series and was derived using the number of Red Grouper per trawl hour.

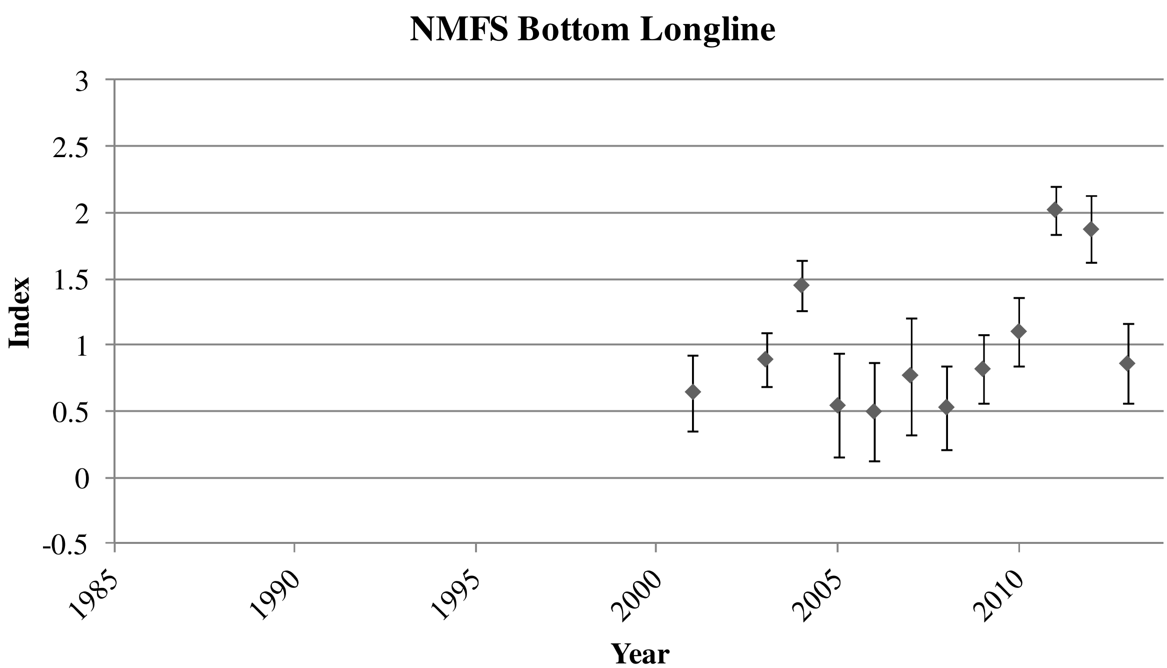


Figure 2.6.2 Standardized indices of abundance and the associated log-scale standard errors from the Gulf of Mexico NMFS bottom longline survey. The index is scaled to a mean of one over the time series and was derived using the number of Red Grouper per 100 hook hours.

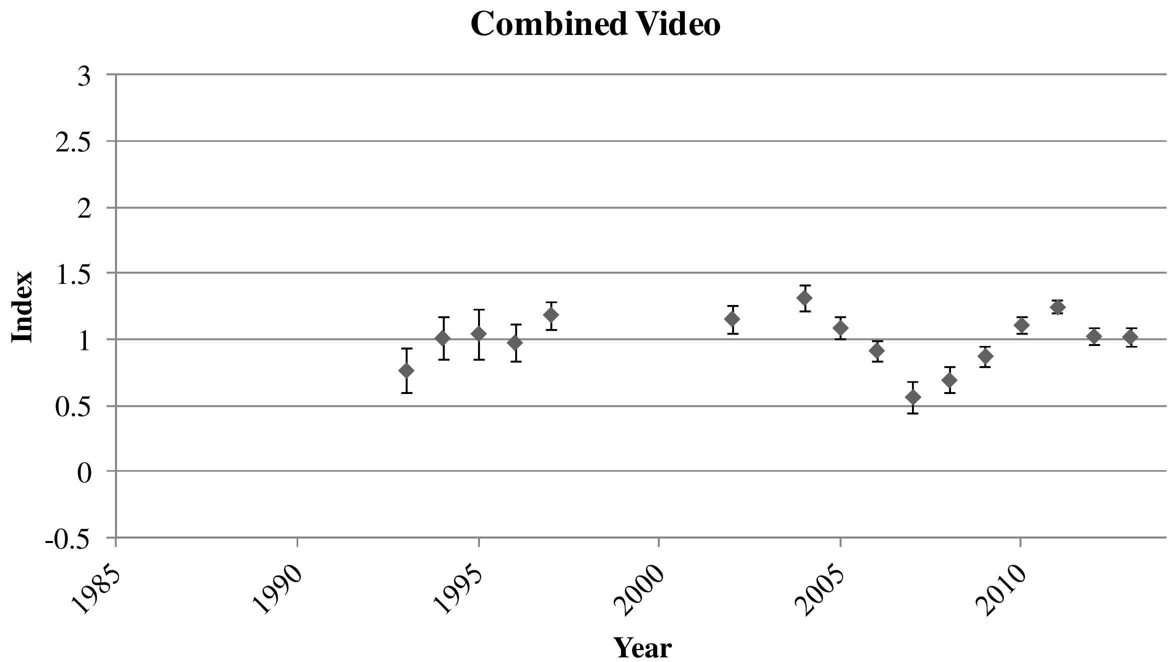


Figure 2.6.3 Standardized indices of abundance and the associated log-scale standard errors from the combined the Gulf of Mexico combined SEAMAP, Panama City and FWRI video survey. The index is scaled to a mean of one over the time series and was derived using the minimum count (maximum number of individuals in the field of view at one instance) of Red Grouper per 20 minute recording.

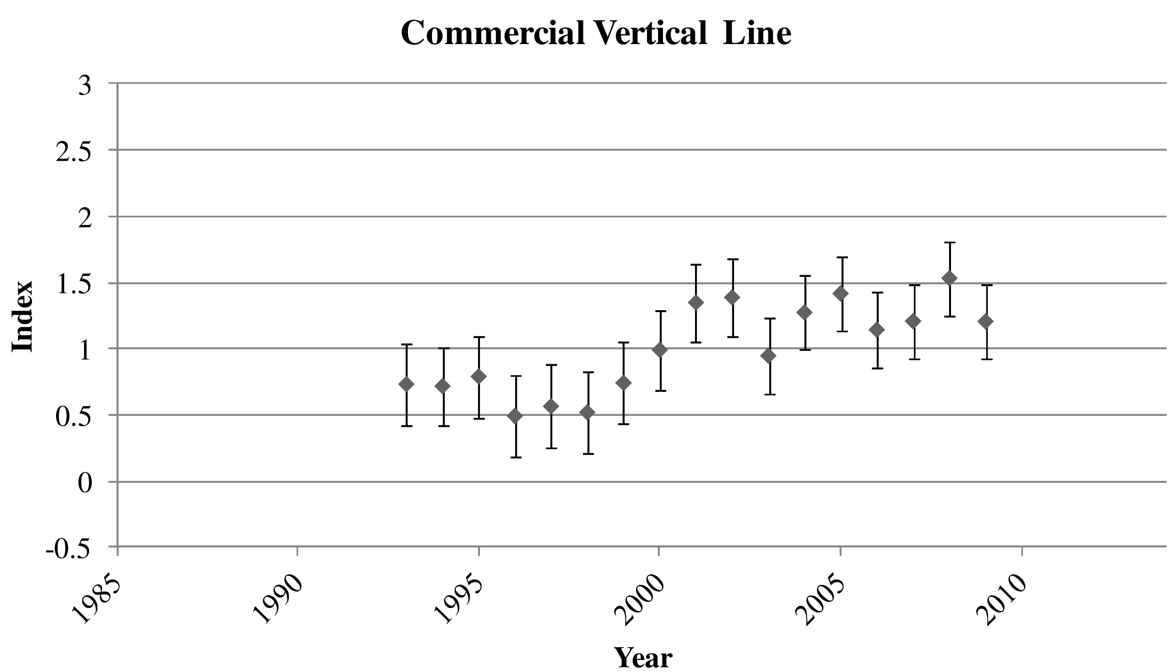


Figure 2.6.4 Standardized indices of abundance and the associated log-scale standard errors from the Gulf of Mexico vertical line commercial fishery. The index is scaled to a mean of one over the time series and was derived using the pounds of Red Grouper per number of hook hours.

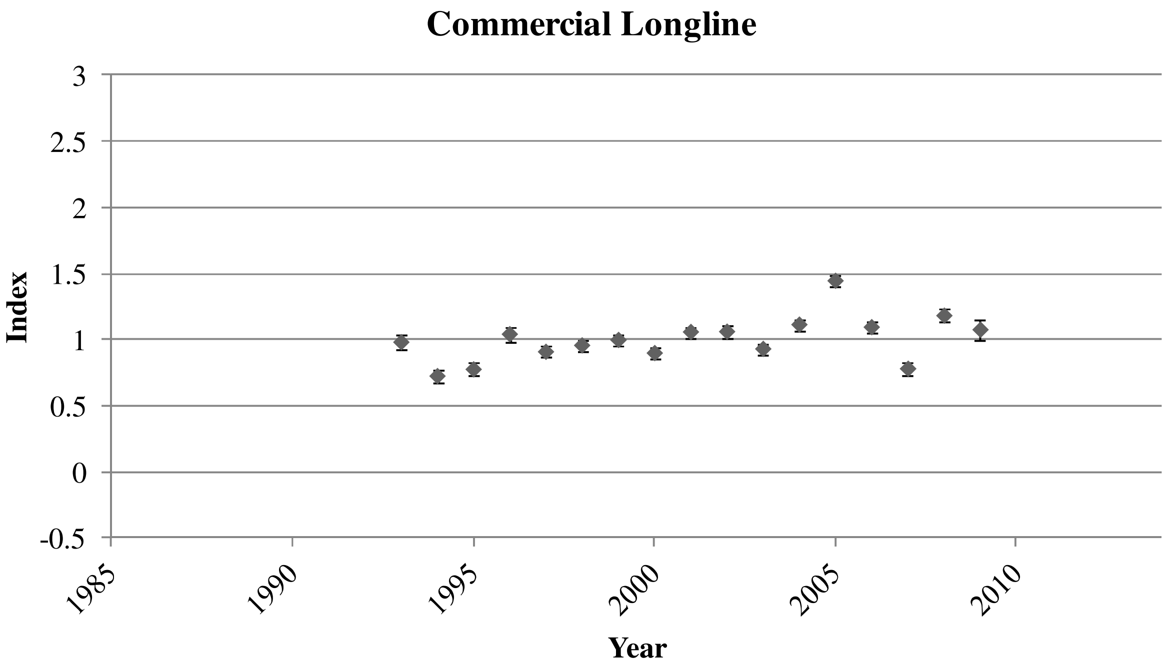


Figure 2.6.5 Standardized indices of abundance and the associated log-scale standard errors from the Gulf of Mexico longline commercial fishery. The index is scaled to a mean of one over the time series and was derived using the pounds of Red Grouper per number of hooks fished.

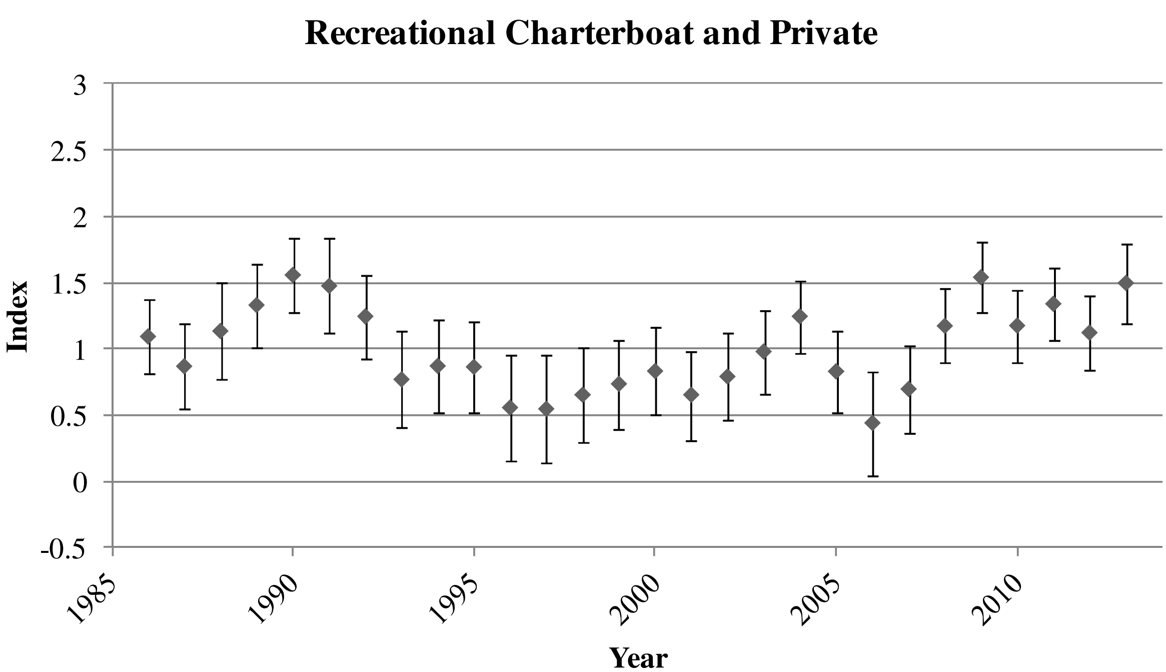


Figure 2.6.6 Standardized indices of abundance and the associated log-scale standard errors from the Gulf of Mexico charterboat and private boat recreational fishery. The index is scaled to a mean of one over the time series and was derived using the number of Red Grouper per angler hour.

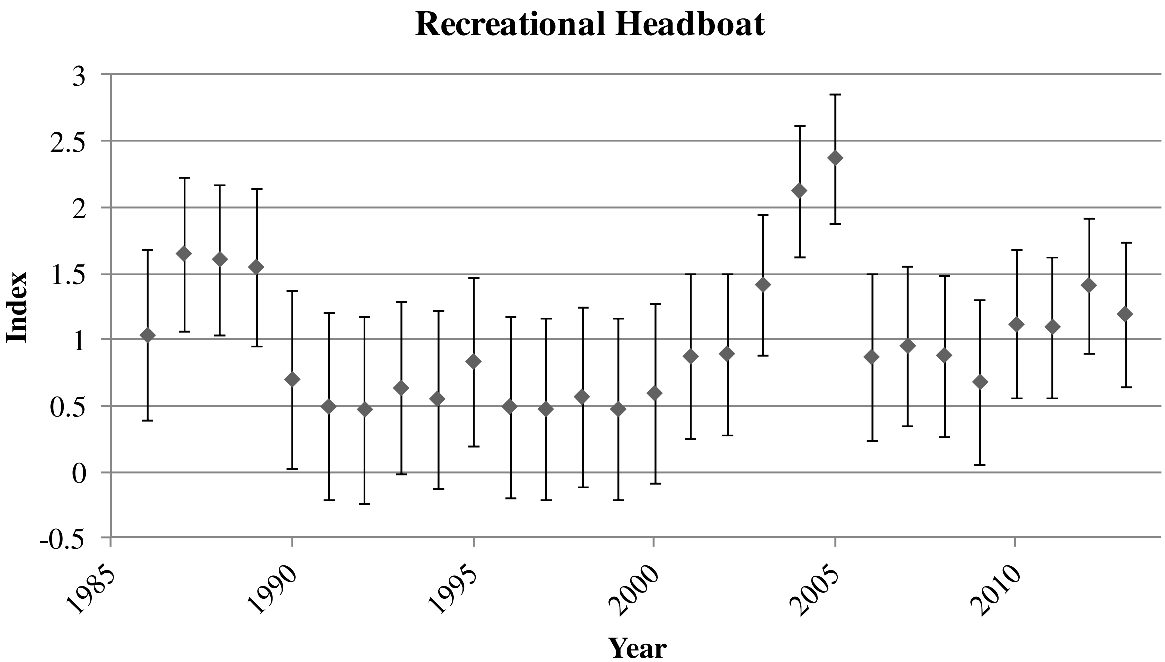


Figure 2.6.7 Standardized indices of abundance and the associated log-scale standard errors from the Gulf of Mexico headboat recreational fishery. The index is scaled to a mean of one over the time series and was derived using the number of Red Grouper per angler hour.

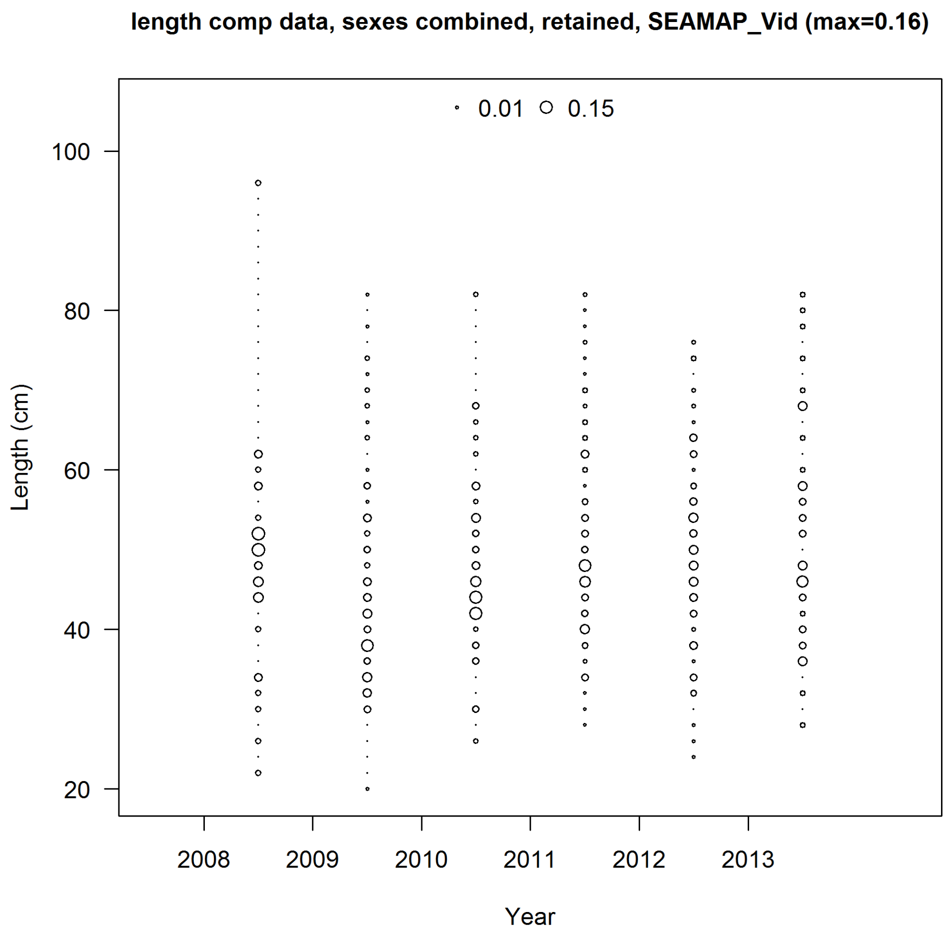


Figure 2.7.1 Annual length composition data of Red Grouper observed in the Combined Video survey.

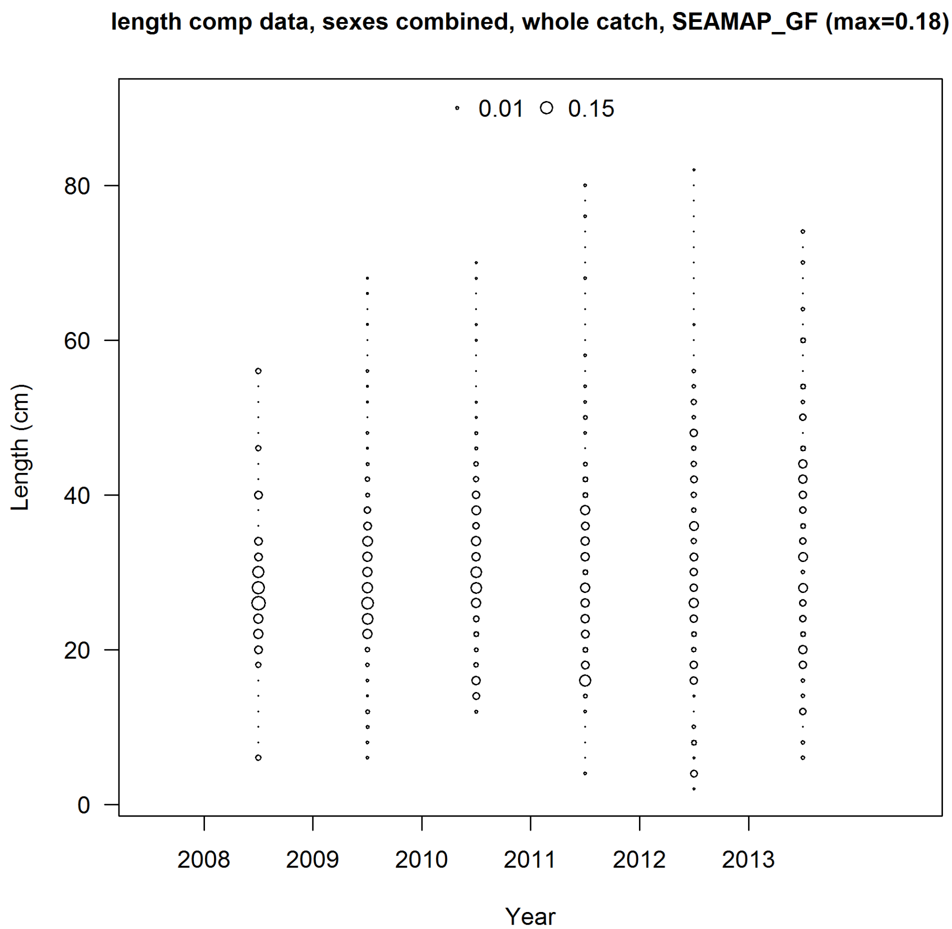


Figure 2.7.2 Annual length composition data of Red Grouper observed in the SEAMAP groundfish survey.

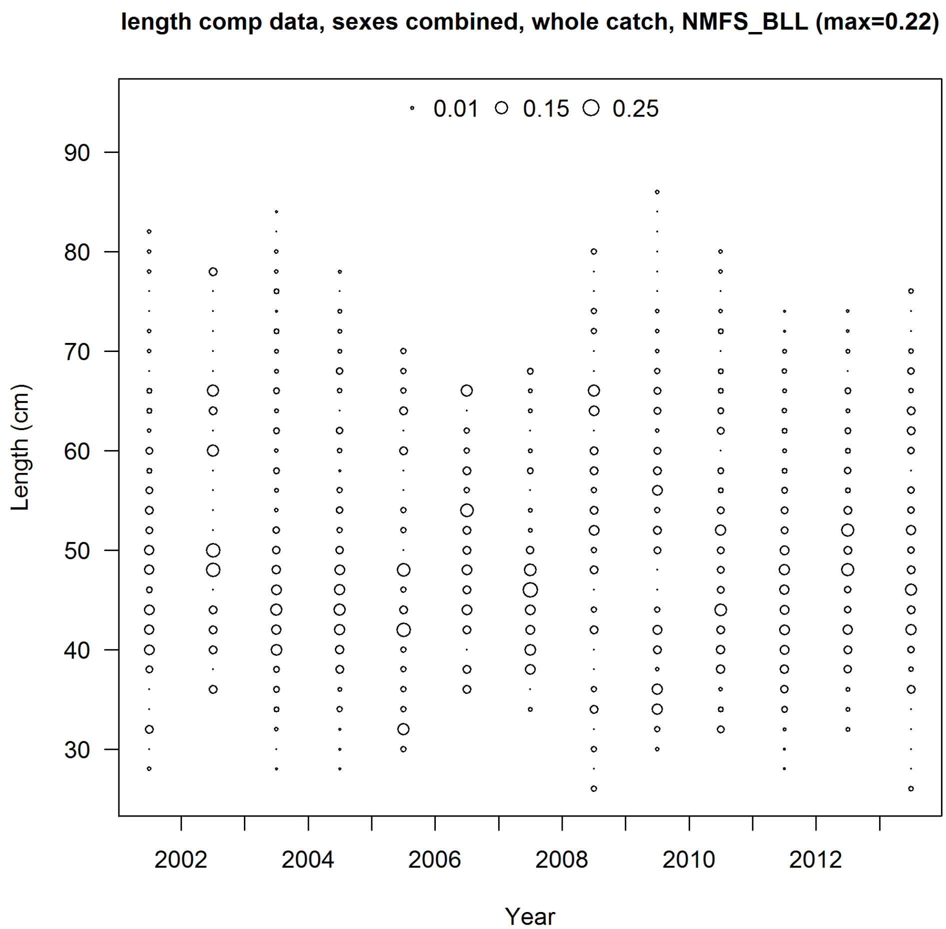


Figure 2.7.3 Annual length composition data of Red Grouper observed in the NMFS bottom longline survey.

3 Stock assessment models and results

3.1 Stock Synthesis

3.1.1 Overview

The primary assessment model selected for the Gulf of Mexico Red Grouper assessment was Stock Synthesis (Methot 2013) version 3.24P. Stock Synthesis (SS) has been widely used and tested for assessment evaluations, particularly in the US west coast NMFS centers (Methot 2013). Descriptions of SS algorithms and options are available in the SS user's manual (Methot 2013; http://nft.nefsc.noaa.gov/Stock_Synthesis_3.htm) and Methot and Wetzel (2013).

Stock Synthesis is an integrated statistical catch-at-age model which is widely used for stock assessments in the United States and throughout the world (Methot and Wetzel 2013). SS takes relatively unprocessed input data and incorporates many important processes (mortality, selectivity, growth, etc.) that operate in conjunction to produce observed catch, size and age composition and CPUE indices. Because many of these inputs are correlated, the concept behind SS is that they should be modeled together, which helps to ensure that uncertainties in the input data are properly accounted for in the assessment. SS is comprised of three sub-models: 1) a population sub-models that recreates an estimate of the numbers/biomass at age using estimates of natural mortality, growth, fecundity, etc.; 2) an observational sub-model that consists of observed (measured) quantities such as CPUE or proportion at length/age; and 3) a statistical sub-model that uses likelihoods to quantify the fit of the observations to the recreated population.

3.1.2 Data sources

The data sources used in the assessment model are described in Section 2. Figure 3.1.1 illustrates the data sources and their corresponding temporal scale. The Stock Synthesis data file is included in Appendix A.

3.1.3 Model configuration and equations

Life history

Growth rates were estimated externally from the model and a single growth curve was estimated for both sexes. The growth curve was modeled using the von Bertalanffy equation. The parameterization of von Bertalanffy included two additional parameters used to describe the variability in size-at-age. These parameters represent the CV in size-at-age at the minimum (age 1) and maximum (age 20) ages. Models testing the variance structure were compared; they assumed either constant standard deviation at age, constant CV at age, linear increase in CV with age, or linear increase in CV with length. AIC results indicated that assuming a linear increase in CV with length best described the data. The growth parameter estimates were used as fixed inputs in the SS3 model.

Growth within SS was modeled with a three parameter von Bertalanffy equation (Lmin, Lmax, and K). In SS, when fish recruit at the real age of 0.0 they have a body size equal to the lower limit of the first population bin (Lbin; fixed at 2 cm FL). Fish then grow linearly until they reach a real age equal to the input value of Amin (growth age for Lmin) and have a size equal to the Lmin. As they age further, they grow according to the von Bertalanffy growth equation. Lmax was specified as equivalent to L_{inf}. Two additional parameters are used to describe the variability in size-at-age; these parameters represent the CV in length-at-age at Amin (age 1) and Amax (age 20). For intermediate ages a linear interpolation of the CV on mean size-at-age is used. The three parameters of the von Bertalanffy equation (Lmin, Lmax, and K) were fixed in the SS model (Table 3.1.1). The CVs for length-at-age were input as fixed parameters at 0.144 and 0.165 for age-1 and age-20 fish, respectively (Table 3.1.1). A fixed length-weight relationship was used to convert body length (cm) to body weight (kg) (Table 3.1.1).

The natural mortality rate (M) was assumed constant over time, but decreasing with age. The form of M as a function of age was based on Lorenzen (2005). The Data Workshop life history working group recommended using a base M = 0.144 y-1, which was developed using the relationship between maximum age (29) and M (Hoenig 1983). The age-specific natural mortality vector developed at the Data Workshop was input into SS as a fixed vector (Table 2.1.1). The Data Workshop life history working group recommended sensitivity runs where the natural mortality vector was adjusted by the base M, where base M was adjusted by the standard deviation in the maximum age (29 $\pm$ 5). Figure 2.1.2 illustrates the base natural mortality values and the sensitivities.

Red Grouper are protogynous hermaphrodites (female at birth, then a portion of the population transitions to male). Hermaphroditism was accounted for implicitly in the fecundity vector in the model. Fecundity was modeled as the product of batch fecundity, the proportion of mature Red Grouper, and the proportion of female Red Grouper (Figure 2.1.6). Immature females transitioned to mature females based on a logistic function of age (Figure 2.1.4). Mature females transitioned to mature males based on a fixed logistic function of age (Figure 2.1.3). In previous Gulf of Mexico assessments of Red Grouper, the form of reproductive potential used in the assessment model was spawning stock biomass of females (SSB-female), based upon a female maturity function, a sex-transition function, and average gonad weight-at-age. The SEDAR 42 life history working group indicated that batch fecundity was a better proxy for fecundity than gonad weight because "the variation in gonad weight, even when classified by stage of development is quite large due to the temporal changes in oocyte size affecting gonad weight". As such, batch fecundity was used in this assessment.

Stock-recruitment model

The Beverton-Holt stock-recruitment model was used in this assessment. Three parameters of the stock recruitment relationship were estimated in the model; the log of unexploited equilibrium recruitment (Ln(R0)), an offset parameter for initial equilibrium recruitment relative to virgin recruitment log(R1) and the steepness (h) parameter. The steepness parameter describes the fraction of the unexploited recruits produced at 20% of the equilibrium spawning biomass level. A fourth parameter representing the standard deviation in recruitment (σ_R) was also estimated.

Annual deviations from the stock-recruit function were estimated for an early period (prior to 1986) and a later data-rich period (1986-2012). Stock Synthesis follows cohorts through time so it was assumed that the age composition data provided some indication of early recruitment. Early recruitment was estimated as far back as 1969. The central tendency that penalizes the log (recruitment) deviations for deviating from zero was assumed to sum to zero over each of the two estimated periods. Stock Synthesis assumes a lognormal error structure for recruitment. Therefore, expected recruitments were bias adjusted. Methot and Taylor (2011) recommend that the full bias adjustment only be applied to data-rich years in the assessment. This is done so Stock Synthesis will apply the full bias-correction only to those recruitment deviations that have enough data to inform the model about the full range of recruitment variability (Methot 2011). Full bias adjustment was used from 1986 to 2012. Bias adjustment was phased in from no bias adjustment to full bias adjustment in 1986 linearly. Bias adjustment was phased out over the last year, decreasing from full bias adjustment to no bias adjustment.

Starting conditions

The starting year of the assessment model is 1986. Removals of Red Grouper are known to have occurred in the Gulf of Mexico prior to 1986, so the stock was not assumed to be at equilibrium at the start of the model. Estimates of Red Grouper removals prior to 1986 were provided at the Data Workshop. Estimates were reconstructed back to 1880. An initial step in transitioning the read grouper assessment to SS3 was to develop a model with the same start year as the previous assessment and ensure its stability. Model runs starting in 1880 were shown to the Assessment Workshop panel; however, this was not done for the resulting base model. Anomalous recruitment events were predicted by the preliminary model runs; thus, the panel recommended starting the model in 1986.

Starting the assessment model in 1986 requires the estimation of initial conditions. These initial conditions include estimates of equilibrium catch and fishing mortality. Equilibrium catch is the catch taken from a stock for which removals and natural mortality are balanced by stable recruitment and growth. This equilibrium catch can be used to estimate the initial fishing mortality rates in the assessment model. Not fitting to the equilibrium catch is equivalent to estimating the catch and therefore the initial fishing mortality rates (Fs) that best correspond to the data during the dynamic period. Equilibrium catches and fishing mortalities for all fleets were estimated in this assessment. In addition, early recruitment deviations were estimated prior to the data-rich period to allow the initial population to better match composition information available at the start of the dynamic period of the model.

<u>Fleet structure and indices of abundance</u>

The assessment model includes five fishing fleets. The fleets represent the commercial handline, commercial longline, commercial trap, the recreational headboat, and the combined recreational charterboat and private fisheries. The previous assessment used the same fleet structure except the recreational fleets were aggregated and modeled as a single recreational fleet.

The assessment model includes seven indices of abundance. The four fishery-dependent indices include the commercial handline (commHL), the commercial longline (commLL), the headboat (HB), and the charter-private mode (CBT_PR) indices (Figures 2.6.4 – 2.6.7). These indices were modeled as landings indices with the exception of the charter-private index. The charter-private index of abundance included discards and as such was treated as a total catch index. The three fishery-independent indices include the combined SEAMAP/PC Lab/FWRI video survey (video), the SEAMAP summer groundfish survey (SEAMAP-GF), and the NMFS bottom-longline survey (NMFS-BLL) (Figures 2.6.1 – 2.6.3). The SEAMAP-GF and NMFS-BLL indices were not used in the previous assessment.

<u>Selectivity and retention distributions</u>

Age-based selectivity functions were specified for the commercial and recreational fleets, whereas length-based selectivity functions were specified for the fishery-independent surveys. Selectivity patterns represent the probability of capture for a given gear and are used to model not only gear function but fishery availability (spatial patterns of fish and fishers) by spatially stratified fisheries.

The age-based selectivities were modeled using the random walk function in SS3. This function models the selectivity of each age as a random walk of the previous age. The first two ages (age-0 and age-1) were fixed parameters; the parameters associated with all other ages were estimated. A normal prior was used to penalize the random walk between ages. The assumed distribution of the penalty for age-2 through age-11 was ~ N(0.25) and for age-12 through age-20 was ~ N(0, 0.1).

The functional form of the double normal curve was used in this assessment to approximate selectivity patterns for the fishery-independent surveys. The double normal selectivity pattern is described by two adjacent normal distributions. Each has its own variance term and the two are joined by a horizontal line. This selectivity pattern is described by six parameters, all of which were estimated.

Selectivity patterns were assumed to be constant over time for each fishery and survey. The Red Grouper fishery has experienced changes in management regulation over time, which were assumed to influence the discard patterns more so than selectivity. As such, these changes were accounted for in the model using time-varying retention patterns and modeling discards explicitly.

Changes in the management regulations for the commercial fleets includes the implementation of a 20 inch total length (50.8 cm TL, 48.80 cm FL) size limit from 1990 until 2008. The commercial size limit was reduced to 18 inches TL (45.7 cm TL, 43.97 cm FL) in 2009. The reduction in the commercial size limit was followed by the implementation of the individual fishing quota (IFQ) program in 2010. The retention patterns were assumed to change with the changes in the size limit. Retention is modeled as a logistic function with size in SS3. Four parameters describe this function; the inflection point, the slope, the asymptote, and the male offset inflection, which is not applicable to this model and assumed to be zero.

The retention pattern associated with the 1990-2008 time block and 20 inch TL commercial size limit was assumed to be knife-edge at the size limit where 100% of individuals were retained above the size limit (Figure 3.1 2 - Figure 3.1 **4**). This was the assumed relationship for the commercial trap fleet since its discard observations only pertain to this time block. The parameters describing the retention pattern for the commercial handline and longline fleets associated with the 2009-2013 time block and 18 inch TL commercial size limit were freely estimated given that the majority of discard length composition data corresponded to this time block (Figure 3.1 2 - Figure 3.1 **3**).

The recreational fishery has also experienced changes in management regulations. An 18 inch TL size limit (43.97 cm FL) was implemented in Florida state waters prior to 1990. Similar to the commercial fishery, a 20 inch TL size limit (50.8 cm FL) was implemented in federal waters starting in 1990 until present. The retention pattern for the 1986-1989 time block and 18 inch TL size limit in FL state waters was assumed to be knife-edge at the size limit where 100% of individuals were retained above the size limit (Figure 3.1 5Figure 3.1 6). The parameters describing the retention pattern associated with the 1990-2013 time block and 20 inch TL recreational size limit in Federal waters were freely estimated (Figure 3.1 5Figure 3.1 6).

__Accounting for mortality due to red tide__

The Assessment Panel recommended the continued consideration of a mortality event associated with the 2005 red tide on the West Florida Shelf in the assessment model. The model configuration used to make management recommendations in the previous assessment (SEDAR 2006) and update (SEDAR

2009) included the 2005 red tide event by estimating an extra mortality term, M_{rt}, in 2005. By including red tide mortality, the model was better able to explain the sudden declines in abundance indices between 2005 and 2006. The point estimate for M_{rt} was applied to all ages in the model in 2005 and was assumed constant with age. Two alternative approaches for incorporating red tide mortality were evaluated using the SS model built to mimic the previous assessment model. The objective was to incorporate red tide mortality into SS such that it would provide similar model predictions as the ASAP model.

The first approach used to incorporate red tide mortality involved adding a constant M deviate to all 21 age classes. This approach is similar to the approach used in ASAP; however, SS does not have the capability of estimating a constant deviate to be added to all ages. Instead, natural mortality was modeled as a vector of age-specific natural mortality and then a fixed deviate was added to each age-specific M solely in 2005. Two fixed deviates were considered within the SS model: (1) the point estimate of extra mortality from the ASAP assessment model (M_{rt} = 0.2548) (SEDAR 2009) and (2) the point estimate that was best supported by the data and was determined using likelihood profiling in SS.

The second approach evaluated for incorporating red tide mortality used a red tide fishing fleet to model removals of Red Grouper from red tide. For this pseudo-fishery, all fish encountered were discarded with 100% mortality and therefore no catches were required as input. An index of fishing effort for the red tide fleet was based on the Walter Threshold Index (Walter et al. 2013), a binary index where red tide events were depicted as present (= 1, solely in 2005) or absent (= 0) between 1998 and 2010 based on the predicted probability of a severe red tide bloom. This threshold index was extended to include 2011 through 2013 (= 0) based on evidence of no severe red tides during these years from both field observations and modeling approaches. This index assumed that negative effects, i.e., red tide mortality, only occurred under severe red tide events. Baseline levels of red tide are likely already accounted for within estimates of natural mortality derived from empirical data. A catchability parameter (Q) was estimated to scale the fishing mortality rate. No discards were input into the model; instead the model used information from data sources already in the model to scale red tide removals. Selectivity of the red tide fishing fleet was set to 1 for age-0 through age-20 and was assumed constant at age due to the lack of available data on size-specific red tide mortality.

The Assessment Panel decided to use this approach (red tide fishing fleet) as the central approach for incorporating red tide mortality. This approach gave similar results as the approach that used a fixed constant M_{rt} applied to all ages (Table 3.1.2, Figure 3.1.7). However, the red tide fishing fleet allows for the level of mortality to be estimated by the assessment model rather than input as a fixed parameter. This configuration should lead to a better representation of model uncertainty to the 2005 red tide mortality event.

3.1.4 Estimated parameters

A total of 331 parameters were estimated for the base case model (Table 3.1.1). Of the 331 parameters, 151 were fleet specific fishing mortality rates. The remaining 180 estimated parameters include 125 used to estimate selectivity and retention curves, 28 annual recruitment deviations, 1 catchability parameter used to scale the red tide mortality index, and 5 initial fishing mortality rates.

Table 3.2.1 includes predicted parameter values and their associated standard errors from SS, initial parameter values, and minimum and maximum values a parameter could take. Parameters designated as fixed were held at their initial values. Steepness was estimated in the base model using a symmetrical beta prior; the mean and standard deviation associated with this parameter was taken from the SEDAR update assessment and is in line with the recommendation of 0.84 by Shertzer et al. (2012). Normal priors were used to penalize the random walk. Parameter bounds were selected to be sufficiently wide to avoid truncating the searching procedure during maximum likelihood estimation. The soft bounds option in SS was utilized when fitting the assessment model. This option creates a weak symmetric beta penalty on selectivity parameters to move parameters away from the bounds (Methot 2011).

3.1.5 Model Convergence

Model convergence was evaluated using jitter analysis. The jitter analysis perturbs the initial values so that a broad range of parameter values along the likelihood surface are used as starting values. This ensures that the model converged to a global solution rather than a local minima. Starting values of all estimated parameters were randomly perturbed by 10% and 50 trials were run. A total of 28 runs converged on a solution that was within 2 likelihood units of the base case (Table 3.1.3). A total of 42 out of 50 runs converged on a solution which provided similar levels (within 5%) of ending depletion and spawning biomass. While this test cannot prove convergence of the model, it did not provide any evidence to the contrary.

3.1.6 Uncertainty and Measures of Precision

Uncertainty in parameter estimates and derived quantities was evaluated using multiple approaches. First, uncertainty in parameter estimates was quantified by computing asymptotic standard errors for each parameter (Table 3.1.1). Asymptotic standard errors are calculated by inverting the Hessian matrix (i.e., the matrix of second derivatives of the likelihood with respect to the parameters) after the model fitting process. Asymptotic standard errors are based upon the model's analytical estimate of the variance near the converged solution.

Likelihood profiles were completed for five model parameters: steepness of the stock-recruit relationship (h), the log of unexploited equilibrium recruitment (R0), the standard deviation in recruitment (σ_R), the offset parameter for initial equilibrium recruitment relative to virgin recruitment log(R1), and the last parameter describing the double normal distribution for the selectivity of the NMFS bottom longline survey. Likelihood profiles are commonly used to elucidate conflicting information among various data sources, to determine how asymmetric the likelihood surfaces surrounding point estimates may be, and to provide an additional evaluation of how precisely parameters are being estimated.

3.1.7 Sensitivity analysis

Uncertainty in data inputs and model configuration was examined through sensitivity analyses. The models reported in this section are by no means a comprehensive evaluation of all possible aspects of model uncertainty, nor do they reflect the full range of models considered in developing the base case. These scenarios are intended to provide more information about sensitivity to key model parameters and potential conflict in signal among data sources. The order in which they are presented is not intended to reflect their importance; each run included here provided important information for developing or evaluating the base case model and alternate states of nature.

Steepness

Steepness is generally a one of the most uncertain but critical parameters estimated in a stock assessment model. In this assessment model, a symmetric beta prior centered at 0.83 and with a standard deviation of 1 on steepness was used. This was an informative prior, as the model tended to estimate steepness at 0.99 when the prior was removed. Given the information provided by the prior about steepness and the model's tendency to estimate steepness at 0.99 two fixed values of steepness were evaluated: a lower value of 0.65 (Run 1) and an upper value of 0.98 (Run 2).

Natural mortality

Model sensitivity to the specification of the natural mortality rate was evaluated. The natural mortality rate (M) was assumed constant over time, but decreasing with age. The form of M as a function of age was based on Lorenzen (2005). The central model uses a base M = 0.144 y-1 .The Data Workshop life history working group recommended two sensitivity runs where the natural mortality vector was adjusted by the base M. More specifically, they recommended that the base M be adjusted assuming higher or lower maximum age where the maximum age was varied by the standard deviation around the maximum age of 29 (+/- 5 or 24-34) and the Hoenig (1983) estimator of M used for the base M in the scaled Lorenzen functions (Figure 2.1.2).

Discards

The absolute magnitude of the commercial discards from 1993 to 2005 is a source of uncertainty in this assessment model. As such, fairly large CVs were put on the total commercial discards. The model's sensitivity to discard weighting was evaluated in two ways. The first was to upweight all discards (Run 5). The second was to remove the discards from 1993-2005, allow them to be estimated given the retention patterns and upweight the 2006-2013 discards (Run 6).

Selectivity pattern of the NMFS bottom longline survey

During the assessment webinars the assessment panel discussed the shape of the NMFS bottom longline selectivity pattern. More specifically, it was suggested that the selectivity of this survey be fixed as asymptotic. The assessment panel was not in total agreement about this and it was decided to allow the model to freely estimate the NMFS bottom longline selectivity parameters for the base case. As such, a sensitivity fixing the NMFS bottom longline selectivity as asymptotic was evaluated as a sensitivity run (Run 7).

Jack-knife analysis

The final set of sensitivity runs was used to evaluate the model sensitivity to each of the indices of abundance. A jack-knife approach was used where each index of abundance was removed from the model and then the model was refit to the remaining data.

3.1.8 Retrospective analysis

Retrospective analysis was conducted to assess the consistency of stock assessment results by sequentially eliminating a year of data from the terminal year while using the same model configuration. The results of this analysis were useful in assessing potential biases and uncertainty in terminal year estimates.

3.1.9 Benchmarks/reference points

Various stock status benchmarks and reference points are calculated in SS. The user can select reference points based on maximum sustainable yield (MSY), equilibrium spawning biomass per recruit (SPR), and spawning stock biomass (SSB). Stock Synthesis calculates SPR as the ratio of the equilibrium reproductive output per recruit that would occur with the current year's F intensities and biology, to the equilibrium reproductive output per recruit that would occur with the current year's biology and no fishing. For SPR-based reference points, SS searches for an F that will produce the specified level of spawning biomass per recruit relative to the unfished value. For spawning biomass-based reference points, SS searches for an F that produces the specified level of spawning biomass relative to the unfished value. Both MSY and spawning biomass-based reference points are dependent on the stock-recruit relationship. YPR and SPR fishing mortality reference points can be calculated independent of the stock-recruit relationship.

The Assessment Workshop panel for SEDAR 42 recommended using MSY-based reference points (i.e., Fmsy) to determine stock status, which is similar to the recommendation from the previous Red Grouper Assessment (SEDAR 2006). MSY-based reference points were recommended because an informative prior on steepness was used, which informed the stock-recruit relationship. The panel also discussed the appropriate units of SSB. The frame of reference for this discussion was Brooks et al. (2008). Brooks et al. (2008) conducted a simulation study evaluating various SSB approaches and stock assessment performance given uncertainties regarding loss of males and reduced fertility. They concluded that the SSB-female approach best estimates biological reference points if the potential for decreased fertilization is weak. Brooks et al. (2008) determined SSB-combined is best when the potential for decreased fertility is moderate or unknown. The Assessment Workshop panel recommended that SSB-female to be used when calculating SSB, where the unit of SSB was the number of eggs. This recommendation was made given that the sex ratio of Red grouper, ~28% male, was relatively high reducing concerns about reduced fertilization. The Assessment Workshop panel also recommended that this decision be revisted by the Review Workshop Panel and the Science and Statistical Committee (SSC).

3.1.10 Projections

Projections were run to evaluate stock status and associated yields for a range of fishing mortality rate scenarios. Projections were run from 2014 to 2030 for the base model configuration . The projections assumed current (2013) yields into the future for 2014. Projections were run assuming that selectivity, discarding, and retention were the same as the most recent five years (2009-2013). This timeframe corresponds to the most recent time block on retention. The catch allocation among fleets used for the projections reflects those used for management, 76% for commercial fleet and 24% for the recreational fleet.

Deterministic projections were run for three fishing mortality rate scenarios:

F = Fmsy,

F=Foy, where Foy is 75% of Fmsy, and

F = Fcurrent.

3.2 Model Results

3.2.1 Measures of model fit

Landings

The predicted landings fit the observed landings perfectly since SS3 effectively treats the landings as known without error. Figure 3.2.1- Figure 3.2.5 show the precise fit of the predicted landings to the observed landings.

Discards

The model was fit to the discards of five fleets including commercial handline, commercial longline, commercial trap, charterboat-private, and headboat. Figure 3.2.6 - Figure 3.2.10 illustrate the model fit to the discards. The observed discards from the commercial handline fleet have an increasing trend between 1993 and 2009 and then decline. The model underestimated the commercial handline discards in all years (Figure 3.2.6). The observed discards from the commercial longline fleet are relatively stable between 1993 and 2006 and then decline. The model underestimated these discards in all years (Figure 3.2.7). The observed commercial trap discards increase between 1990 and 1996 and then generally decline until 2006 (the last year of the fishery). The discards from this fleet are fewer than either the commercial handline or longline discards. The model underestimated the commercial trap discards in all years (Figure 3.2.8).

The observed charterboat-private mode discards varied over time with peaks in 1990, 2005, and 2009. The fits to these discards were generally good, with a systematic underestimation between 2008 and 2013 (Figure 3.2.9). The observed headboat discards were also variable over time with peaks every ten years in 1989, 1999, and 2009. The fits to the headboat discards were generally good with systematic underestimation between 2009 and 2013 (Figure 3.2.10).

Indices of abundance

The model was fit to four fishery-dependent indices, the red tide index, and three fishery-independent indices. Figure 3.2.11 - Figure 3.2.18 show the model fit to the standardized indices.

The model fit to the commercial handline standardized index (RMSE = 0.3097) predicted an increase in the index between 1993 and 2005 (Figure 3.2.11). The standardized index demonstrates a general increase during this time period, however; the main increase was between 1996 and 2005. The model fit dampens this increase. The predicted fit follows the decline between 2005 and 2006 and predicts a stable index between 2006 and 2009 when the observed index increases. The model fit to the commercial longline index (RMSE= 0.1572) predicts an increase in the index between 1993 and 2005 (Figure 3.2.12). The standardized index peaked in 2005 and the model fit underestimates this peak. The model fit also underestimates the decline in the commercial longline index between 2005 and 2007 and instead predicts that the index between 2006 and 2009 is generally flat.

The model fit to the standardized charterboat-private (RMSE = 0.316) and headboat indices (RSME = 0.3067) are shown in Figure 3.2.13 - Figure 3.2.14. The charterboat-private standardized index increased between 1986 and 1990, declined between 1990 and 1995, and then increased between 1986 and 2004 (Figure 3.2.13). The model fit between 1986 and 1996 is rather flat and misses the changes in the index between 1986 and 1996. The model fit predicts the increase between 1996 and 2004, predicting the peak in 2004 exactly. The model fit predicts the decline between 2005 and 2007 fairly well and the following increase between 2006 and 2009. The standardized index is variable between 2010 and 2013 with an increase between 2012 and 2013. The model fit predicts a peak in 2010 followed by a decline. The model fit to the standardized headboat index generally predicts the trends throughout time (Figure 3.2.14). The model predicts the initial increase between 1986 and 1987, albeit an underestimate, followed by a moderate decline between 1987 and 1989, The standardized index exhibits a steep decline between 1989 and 1990, which is predicted by the model fit. The decline is followed by a moderately stable period between 1990 and 2000, which is predicted by the model, although the model overestimates the index during this time period. The standardized headboat index increases between 2000 and 2005 when the index peaks and then steeply declines between 2005 and 2006. The model predicts an increase, but predicts the peak in 2004 followed by a predicted decline between 2004 and 2006. The standardized index was stable between 2006 and 2010 before it exhibits an increase to 2012 and then a decline to 2013. The model fit generally predicts this trend.

The fit to the red tide index was perfect (Figure 3.2.15).

The model fits to the standardized fishery-independent indices are shown in Figure 3.2.16 - Figure 3.2.18. The standardized video survey has a slight increasing trend between 1993 and 2004, which is underestimated by the model fit (Figure 3.2.16). The standardized video index declines between 2004 and 2007. This decline in predicted, but the model predicts an increase after 2006 missing the lowest point of the index in 2007. The increase in the video index between 2008 and 2010 is predicted as is the following decline. The standardized SEAMAP groundfish summer survey (SEAMAP-GF) declines between 2009 and 2013. The model over-predicts this decline (Figure 3.2.17). The standardized NMFS bottom longline index increased between 2001 and 2004, declined between 2004 and 2006, generally increased between 2006 and 2010, and then declined (Figure 3.2.18). The model fit predicts a stable index between 2001 and 2004 that declines between 2004 and 2006. It then predicts an increase between 2007 and 2010 followed by a decline. The model fit misses the peaks in 2011 and 2012 underestimating the final decline in the index.

Length composition

The model fits to the length composition data associated with the discard series and fishery-independent surveys and the Pearson residuals for each fleet and data type are presented in Figure 3.2.19 - Figure 3.2.32. The quality of the fit varied among the fleets and surveys.

The fit to the commercial handline and longline discard length composition was similar (Figure 3.2.19 - Figure 3.2.22). In general, the model fit the discard length composition data relatively well. The peaks of the distributions were underestimated between 2009 and 2011 for commercial handline and between 2010 and 2012 for commercial longline (Figure 3.2.19 - Figure 3.2.22). The Pearson residuals indicate that there is a bit of noise in the model fit to the data for these fleets. This noise is mainly concentrated in the upper tails of the distributions between 2007 and 2009 for the commercial handline fleet and between 2006 and 2009 for the commercial longline fleet. These large residuals are likely due to the underestimation of few individuals.

The model fit to the recreational discard length composition is marginal for both charterboat-private and headboat (Figure 3.2.23 - Figure 3.2.26). The expected distributions are skewed to larger sized fish and the peaks are generally underestimated in all years, except in 2007 for the headboat fishery. The Pearson residuals for the recreational fleets show that there is some evidence of cohorts that are not being accurately predicted by the model.

The model was fit to the length composition data from the three fishery independent surveys (Figure 3.2.27 - Figure 3.2.32). The model fit to these data was relatively good with Pearson residuals that did not exhibit any systematic patterns.

Age composition

The model fits to the age data associated with the landings series and the Pearson residuals for each fleet are presented in Figure 3.2.33 - Figure 3.2.42. The quality of the fit varies among the fleets.

The model fit to the commercial landings age composition is relatively good for the commercial handline and slightly better for the commercial longline (Figure 3.2.33 - Figure 3.2.35). For the handline there are years where the peaks are underestimated (e.g., 2011-2013) and years where the bimodal distribution of the observed data is not accurately captured in the model predictions (e.g., 1991, 1998-2000, 2010). Patterns in the Pearson residuals for the handline provide evidence that the cohorts tracked in the observed data are not being accurately predicted (Figure 3.2.34). More specifically they seem to be underestimated to some degree. The fit to the age composition data for longline is quite good in most years. Similar to the handline fleet but to a lesser extent, the fit to the longline age data shows years with underestimated peaks (e.g., 1999, 2012) and years with lack of fit to observed binomial distributions (e.g., 1995-1996, 2001). While there are patterns in the Pearson residuals for both the handline and longline fleets, the observable patterns for the longline fleet are less pronounced than for the handline fleet (Figure 3.2.34 - Figure 3.2.36). The fit to the age data from the trap fishery is marginal, and in most years the age data for the trap fishery has relatively low sample sizes (Figure 3.2.37). There are fewer systematic patterns in the Pearson residuals fit to the trap data than in the residuals associated with the handline and longline data (Figure 3.2.38).

The fits to the recreational discard length composition for the charterboat-private and headboat fisheries are marginal (Figure 3.2.39 - Figure 3.2.41). In general, the recreational age composition has relatively low samples sizes and the distributions of ages each year are irregular and jagged. The Pearson residuals for the recreational fleets show that there is some evidence of cohorts that are not being accurately predicted by the model, particularly for the 1998 and 2005 cohorts.

3.2.2 Parameter estimates and associated uncertainty

Table 3.1.1 summarizes the parameter estimates and the asymptotic standard errors from SS3. The majority of parameters have relatively low standard errors. Table 3.2.1 summarizes the parameters and their associated coefficients of variation (CVs). The parameters with larger CVs are mainly the size and age selectivity parameters, the initial age parameters, the inflection and slope parameters describing the charterboat-private and headboat retention patterns, and some of the main recruitment deviations (

Table 3.2.1). The size selectivity parameters had the highest uncertainty indicating that they were not well estimated.

Likelihood profiles were generated for several key parameters in this assessment. They include steepness (h), recruitment at an unexploited state (Ln(R0)), variation in recruitment (σ_R), the offset in recruitment from unexploited equilibrium (Ln(R1_offset)), and the parameter describing selectivity of the final population length bin for the NMFS bottom longline survey. This was done to evaluate how well estimated these parameters are and to identify conflicts in the data.

The likelihood profile of the steepness parameter shows that there are conflicts between data sources (Figure 3.2.43). The obvious conflict is between the length composition data and the recruitment, discard, and index information. Less obvious is the conflict between the age data and the recruitment, discard, and index information. The length and age data components favor a smaller steepness value, whereas the recruitment, discard and catch components favor a higher steepness value.

The total likelihood component from the Ln(R0) likelihood profile indicates that the global solution for this parameter is approximately 9.5 (Figure 3.2.44). The recruitment likelihood component is the largest component of the total dictating this outcome. The data conflicts are seemingly minimal, but the length and prior components are in conflict with the other components, favoring a lower Ln(R0) estimate.

The likelihood profile on the variation in recruitment parameter, σ_R, indicates that all likelihood components favor an estimate of larger than 0.5, which is considerably larger than the previous assessment (Figure 3.2.45). The previous assessment estimated σ_R to be ~ 0.3.

The likelihood profile on the parameter accounting for the offset in recruitment from unexploited equilibrium (Ln (R1_offset)) shows that the dominating influence on the likelihood is the recruitment likelihood component (Figure 3.2.46). This likelihood component is in conflict with the other likelihood components favoring a higher offset between the initial recruitment and recruitment at the unexploited equilibrium. This profile also indicates that this parameter is difficult to estimate.

The likelihood profile of the parameter describing the selectivity of the final length bin of the NMFS bottom longline selectivity pattern, indicates that this parameter cannot be well estimated (Figure 3.2.47).

3.2.3 Selectivity and retention

The estimated age-based selectivity patterns for the fishing fleets are shown in Figure 3.2.48 - Figure 3.2.53. Selectivity was assumed to be constant over time in the assessment model. All age-based selectivity patterns were modeled as a random walk and were estimated to have a dome-shape. The estimated selectivity patterns illustrate that the headboat and charterboat-private fleets select smaller Red Grouper than the commercial fleets. Additionally, the age at full selection for headboat is age-3, whereas age-7, age-8, age-9, and age-10 are fully selected for by the charterboat-private, the commercial handline, the commercial trap, and the commercial longline fleets, respectively.

Time blocks were used to describe the retention process in response to changes in size limits over time. Separate time blocks were used for the commercial and recreational fleets due to different management regulations. The first time block used for the commercial fleets corresponds to the 20 in TL (50.8 cm TL and 48.79 cm FL) size limit. The parameters describing this retention function were fixed given that there were few years of discard length composition data for this time period. The retention function for the first time block was assumed to be knife-edged at the size limit with 100% retention of individuals above the size limit (Figure 3.1 2 - Figure 3.1 **4**). The second time block corresponded to the reduction in the commercial size limit to 18 in TL (43.97 cm FL) and the parameters were freely estimated. The estimated inflection points were 45.46 cm FL and 46.38 cm FL, slightly higher than the size limit, for the commercial handline and longline fleets, respectively. Both the slope and asymptote estimates were approximately one for both fleets. Figure 3.1 2 and Figure 3.1 3 show the estimated retention patterns for the commercial handline and longline fleets. These figures show that the majority of retained fish are above the limit.

The retention pattern for the pre-1990 time block for the recreational fleets was a fixed, knife-edge relationship at the 18 inch TL size limit. It was assumed that 100% of fish above the size limit were retained. The charterboat-private and headboat retention patterns were estimated for the 1990-2013 time block. The inflection parameters were estimated to be 53.704 cm FL and 50.304 cm FL for the charterboat-private and headboat fleets, respectively (Table 3.1.1). The slope parameter was estimated at 0.545 for the charterboat-private fleet and 0.319 for the headboat fleet. The asymptote parameter was estimated at 0.833 for the charterboat-private fleet and 0.972 for the headboat fleet. The charterboat-private inflection point is slightly larger than the 20 in TL (50.8 cm FL) size limit. The retention patterns allow for the discarding of legal size Red Grouper due to the combination of the slope and asymptote parameters (Figure 3.1 5 - Figure 3.1 6).

The fishery-independent surveys selectivity patterns were length-based and estimated using the double normal function. Figure 3.2.54 shows the estimated selectivity patterns for the three fishery-independent surveys. The video survey selectivity pattern was estimated to be essentially asymptotic, where Red Grouper are fully selected above 50 cm (Figure 3.2.55). The SEAMAP-GF selectivity pattern was estimated to be dome-shaped, where the pattern increases to full selection sharply between 15 cm FL and 18 cm FL and are fully selected between 18 cm FL and 30 cm FL (Figure 3.2.56). The NMFS_BLL longline survey selectivity pattern was estimated to be dome-shaped, but was essentially asymptotic over the range of observed sizes in the length composition data (Figure 3.2.57).

The Assessment Workshop panel discussed whether the selectivity pattern for the NMFS bottom longline should be fixed as an asymptotic relationship. Support for fixing this relationship to asymptotic was that the fishing gear captures a wide range of sizes and covers a wide distribution of the West Florida shelf where Red Grouper of all sizes should be available for capture. Additionally, as seen in the profiles explained in Section 3.2.2, the parameter that was fixed to ensure asymptotic selectivity was not well estimated from the data. Nonetheless, the Assessment Workshop panel decided to allow the selectivity parameters to be freely estimated because the assessment outcomes were similar between the model where the NMFS bottom longline selectivity pattern was freely estimated and the model that assumed asymptotic selectivity. The reason for the relatively minor differences between these two states was that there were very few fish in the population above the 100 cm where the selectivity was estimated to decline and these differences in estimation of the bottom longline selectivity had relatively minor effects upon the estimation of the selectivities of the other fleets.

3.2.4 Recruitment

The three leading parameters for defining the stock-recruitment relationship were steepness (*h*), virgin recruitment (*R0*), and an offset parameter for initial equilibrium recruitment relative to virgin recruitment Ln (*R1*). Steepness was estimated with a symmetric beta prior centered at 0.83 and the other parameters were estimated without priors (Table 3.1.1). Steepness was estimated at 0.802 for the base model. The log of virgin recruitment was estimated at 9.67 (15,835,350 age-0 recruits). The R1 offset parameter was estimated at -0.048, which suggests the stock was at 95% of virgin recruitment (R1=R0*exp(-Ln(R1_offset)) when the model starts in 1986.

The plot of the stock-recruitment relationship shows high recruitment associated with years 1995, 1998, 2001, and 2005 (Figure 3.2.58). This agrees with the cohort structure seen in the age composition data associated with landings for fishing fleets (Figure 3.2.33, Figure 3.2.35, Figure 3.2.39, Figure 3.2.41).Both high and low levels of recruitment are predicted across the range of spawning biomass values, resulting in a relatively flat stock-recruit relationship.

The likelihood profile for steepness shows that the most likely solution is near 0.8 (Figure 3.2.43). This profile is driven by reductions in the likelihood components for recruitment, discards, and indices. The likelihood profile of equilibrium recruitment shows that this parameter is well estimated (Figure 3.2.44). The recruitment component of the likelihood seems to be the most influential dataset for informing unfished recruitment. The likelihood profile for the offset parameter for initial equilibrium recruitment relative to virgin recruitment log(*R1*) shows that this parameter is not well estimated (Figure 3.2.46).

Predicted age-0 recruits are presented in Figure 3.2.59 and Table 3.2.2. Average recruitment is variable over time. The higher average recruitments are generally preceded and followed by relatively low average recruitments. The RMSE for recruitment deviations was 1.03. The age composition data provides evidence of strong year classes moving through the different fisheries. Recruitment in 2005 is predicted to be the highest recruitment over the time series. Age-0 recruitments in the six most recent years are predicted to be relatively low.

3.2.5 Stock biomass

Predicted total biomass and spawning output in eggs are summarized in Table 3.2.2 and Figure 3.2.60 - Figure 3.2.61 for the base model configuration. Total biomass generally increased from 1986 until 2005, declined in 2006, and increased from 2006 to 2013 (Figure 3.2.60). The decline in 2006 is associated with the red tide event in 2005. The trend seen in total biomass is also evident in the predicted spawning output time-series (Figure 3.2.61).

The predicted numbers-at-age and mean age is presented in Figure 3.2.62. The predicted numbers-at-age indicate that two strong recruitment events were predicted in 1998 and 2005. Mean age varied between two and three between 1986 and 1996. The mean age declined from three to one in 1997 and then varied between one and three between 1998 and 2003. Mean age increased to four in 2003 and then declined to one in 2005 when there was a strong recruitment event (Figure 3.2.59). Predicted mean age steadily increased to five between 2004 and 2013 (Figure 3.2.62).

The trend in the numbers-at-length and mean length is obviously similar to the predicted numbers-at-age and mean age (Figure 3.2.63). Mean length varied between 20 cm FL and approximately 35 cm FL between 1986 and 2004. Mean length declined in 2005 and then steadily increased to approximately 40 cm FL.

3.2.6 Fishing mortality

The overall fishing mortality rate was expressed as exploitation rate in biomass. Fleet specific fishing mortalities are presented as instantaneous rates. The predicted fishing mortalities overall and by fleet are presented in Table 3.2 3 and Figure 3.2.64- Figure 3.2.65. Predicted total fishing mortality declined, on average, between 1986 and 2004. The highest predicted fishing mortality rate was in 2005, which is the year of the red tide event in the eastern Gulf of Mexico (Figure 3.2.64). This red tide event was modeled as a fishing fleet that removed Red Grouper. Its effect was not seen in the landings history, but rather, it was seen as a discard fishery and caused a substantial increase in total catch in 2005 (Figure 3.2.66). The estimated mortality rate from the red tide event was 0.44. Fishing mortality declined in 2006 and continued to do so until 2010, the lowest point of the time series. This decline was followed by an increase in total fishing mortality.

Early in the time series the main sources of fishing mortality were the commercial longline and handlines fleets and the charterboat-private fleet (Figure 3.2.65). The commercial handline fishing mortality declined after 1989 until 1999, remained relatively low and lower than that of the charterboat and private and longline fleets until 2005, increased until 2009 and then declined (Figure 3.2.65). The fishing morality rate of the charterboat-private declined after 1993 until 1997, increased after 1997 until 2000, and then generally declined over the rest of the time period, with a final increase between 2011 and 2013 (Figure 3.2.65). The fishing mortality trends for the commercial handline and charterboat-private fleets are similar to the trends in observed landings. The fishing mortality from the commercial longline fleet has generally declined since 1993 (Figure 3.2.65). Unlike the commercial handline and charterboat-private fleets, this trend in fishing mortality cannot be explained by the trend in landings, which has remained relatively stable over time. Rather this decline in fishing mortality may be better explained by the decline in commercial longline discards (Figure 3.2.7).

The fishing mortalities associated with the commercial trap fleet and headboat fleet were relatively low over time compared to the other fleets (Figure 3.2.65). This corresponds to relatively low landings and discards over time (Figure 3.2.66).

3.2.7 Sensitivity analysis

The results of the sensitivity analyses are summarized in Table 3.2.5 and Figure 3.2.67 - Figure 3.2.73.

Steepness

The absolute magnitude of SSB, recruitment and fishing mortality rate seemed insensitive to the assumed values of steepness (Figure 3.2.71). Nonetheless, stock status estimates will likely be affected by different fixed values of steepness.

Natural mortality

The assessment results seemed most sensitive to the assumed natural mortality vector (

Figure 3.2.70). Estimates of SSB and age-0 recruits were higher than the base when natural mortality was larger and lower when natural mortality was smaller. Fishing mortality was lower than the base when natural mortality was larger and was higher when natural mortality was small than base.

Total discards

The assessment results were relatively insensitive to the data weighting of the total discards (Figure 3.2.72)

Selectivity of NMFS bottom longline survey

The assessment results seemed insensitive to the assumption of asymptotic selectivity for the NMFS bottom longline survey (Figure 3.2.73).

Jack-knife of indices

The results of the jack-knife analysis are summarized in Table 3.2. 6 and Figure 3.2.74 - Figure 3.2.76.

The jack knife analysis of the abundance indices revealed that the model was sensitive to the charterboat-private index and the headboat index. This sensitivity is most obvious when comparing the SSB estimates. Removal of the charterboat-private index exaggerated the increase in SSB in 2005, whereas the removal of the headboat index reduced the absolute estimate of SSB in 2005. This was also true for the fishing mortality estimates. The fits to these indices were similar when comparing the RMSEs, 0.316 and 0.3067 for the charterboat-private fleet and headboat fleet, respectively.

The estimate of the age-0 recruits, especially in the last 4-5 years of the model seemed sensitive to the SEAMAP groundfish index. This makes intuitive sense since this index can be considered as a recruitment index and only covers the last five years of the model.

3.2.8 Retrospective results

The results from the retrospective analysis are summarized in Figure 3.2.77 - Figure 3.2.80. There were no major patterns or systematic bias in the spawning stock biomass, the fishing mortality, or the ratio of SSB and SSB achieved at MSY. The retrospective pattern in the recruits was highly variable for the years prior to the SEAMAP survey, but largely indicative of random fluctuations in the estimates of recruitment in years prior to having a recruitment index. This variability in recruitment does not translate to substantial retrospective bias in SSB (Figure 3.2.79).

3.2.9 Benchmark and reference points

Stock status relative to the minimum stock size threshold (MSST) and maximum fishing mortality threshold (MFMT) are presented in Table 3.2.2 and Figures 3.2.81 – 3.2.82. The comparison of SSB and MSST indicates that Red Grouper were overfished between 1986 and 1996 since spawning stock biomass was below MSST (Figure 3.2.81). Spawning stock biomass has been above the MSST since 1997. The comparison of fishing mortality and MFMT indicates that Red Grouper experienced overfishing between 1986 and 1995 and did not experience overfishing between 1996 and 2013, except for 2000 and 2005 (Figure 3.2.82).

Estimates of yield per recruit and spawner per recruit are summarized in Figure 3.2.84.

3.2.10 Projections

Three projection scenarios were run where fishing mortality was equal to either Fmsy, Foy (i.e., 75% of Fmsy), or Fcurrent. Figure 3.2.83 summarizes the results with respect to the ratio between SSB and the minimum stock size threshold (MSST), age-0 recruits, the ratio between fishing mortality and Fmsy, and retained yield. The ratio between SSB and MSST is projected to decline between 2014 and 2018 and then increase and equilibrate between 2019 and 2030. The ratio between SSB and MSST is projected to drop below 1 (i.e., the stock is expected to be overfished) between 2018 and 2019 when fishing mortality was set equal to Fmsy and be above 1 in all other years. The ratio between fishing mortality and the maximum fishing mortality threshold (MFMT) was projected to increase between 2014 and 2017 and be greater than 1 (i.e., the stock is projected to experience overfishing), decline below 1 after 2017, and equilibrate at sustainable levels between 2024 and 2030. The projections have similar trends under the Foy and Fcurrent fishing mortality scenarios as the Fmsy scenario, but the stock is not expected to be overfished over experience overfishing during the projection period. Retained yield was projected to equilibrate between 2025 and 2030 at ~3700 mt, ~3500 mt, and ~3300 mt for the Fmsy, Foy, and Fcurrent fishing mortality scenarios (Table 3.2.7).

3.3 Discussion and recommendations

3.3.1 Discussion

The assessment model predicts that total biomass and the spawning potential (egg production) increased from 2006 to 2012 and declined slightly between 2012 and 2013 (Figure 3.2.60, Figure 3.2.61). The predicted biomass in 2006 was at a record low due to the red tide event in 2005 and has increased since. In 2005, a large recruitment event was predicted, which may help explain the predicted increase in total biomass and spawning output (Figure 3.2.59). This large recruitment event was supported by the age composition data, which does not suggest subsequent strong year classes (Figure 2.4.1 – Figure 2.4.5).

Overall, total biomass increased between 1986 and 2005. This corresponded to a period of decline in predicted fishing mortality. The fishing mortality rate since 2005 has remained low suggesting that biomass has had the opportunity to accumulate between 2006 and 2012. Biomass is 2013 is similar to biomass in 2012.

3.3.2 Recommendations

1. Evaluate existing methods for deriving historical discard numbers and discard rates and improve methods as appropriate.

2. Develop/evaluate methods to maintain continuity of fishery-dependent indices in light of management regulations and ITQs.

3. Considering red tide is an unpredictable event, but can be a significant source of mortality, a response protocol should be developed for data collection and incorporation of the information into updated assessments.

4. The start year of this assessment is 1986. Future assessments should investigate extending the assessment model further back in time.

5. Develop protocol for reliable estimation of fishery discards.

3.4 Acknowledgements

Many people from state and federal agencies worked diligently to assemble the data included in this stock assessment and the Data Workshop Panel was incredibly helpful with addressing the issues and nuances of the data. The Assessment Panel, as well as scientists from the Sustainable Fisheries Division at the Southeast Fisheries Science Center were instrumental in guiding the stock assessment model configuration.

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3.6 Tables

Table 3.1.1 List of SS parameters for Gulf of Mexico Red Grouper. The list includes predicted parameter values and their associated standard errors from the base model run, initial parameter values, lower and upper bounds of the parameters, and the prior densities assigned to the parameters. Parameters designated as fixed were held at their initial values.

			Predicted			Prior		
Label	Lower bound	Upper bound	Value	SD	Type	Value	SD	Status
L_at_Amin_Fem_GP_1	1	40	17.29	_	No_prior			Fixed
L_at_Amax_Fem_GP_1	60	100	82.72	_	No_prior			Fixed
VonBert_K_Fem_GP_1	0.05	0.3	0.124	_	No_prior			Fixed
CV_young_Fem_GP_1	1.00E-06	0.2	0.144	_	No_prior			Fixed
CV_old_Fem_GP_1	1.00E-06	0.2	0.165	_	No_prior			Fixed
Wtlen_1_Fem	-3	3	0.000	_	No_prior			Fixed
Wtlen_2_Fem	-3	4	3.250	_	No_prior			Fixed
Mat50%_Fem	1	10	2.8	_	No_prior			Fixed
Mat_slope_Fem	-30	3	-1.15	_	No_prior			Fixed
Eggs_scalar_Fem	-3	3	4.47E-08	_	No_prior			Fixed
Eggs_exp_len_Fem	-3	3	5.48	_	No_prior			Fixed
RecrDist_GP_1	-4	4	0	_	No_prior			Fixed
RecrDist_Area_1	-4	4	0	_	No_prior			Fixed
RecrDist_Seas_1	-4	4	0	_	No_prior			Fixed
CohortGrowDev	0.5	1.5	1	_	No_prior			Fixed
SR_LN(R0)	1	40	9.670	0.126	No_prior			Estimated
SR_BH_steep	0.2	0.99	0.802	0.132	Sym_Beta	0.83	1	Estimated
SR_sigmaR	0	2	0.965	0.117	No_prior			Estimated
SR_envlink	-5	5	0.000	_	No_prior			-
SR_R1_offset	-5	5	-0.048	0.123	No_prior			Estimated
SR_autocorr	0	0	0.000	_	No_prior			-
Early_InitAge_17	_	_	0.185	1.052				Estimated
Early_InitAge_16	_	_	0.249	1.081				Estimated
Early_InitAge_15	_	_	0.331	1.116				Estimated
Early_InitAge_14	_	_	-0.037	0.957				Estimated
Early_InitAge_13	_	_	-0.266	0.869				Estimated
Early_InitAge_12	_	_	-0.431	0.813				Estimated
Early_InitAge_11	_	_	-0.633	0.765				Estimated
Early_InitAge_10	_	_	-0.761	0.730				Estimated
Early_InitAge_9	_	_	-0.727	0.712				Estimated
Early_InitAge_8	_	_	-0.567	0.709				Estimated
Early_InitAge_7	_	_	-0.254	0.731				Estimated
Early_InitAge_6	_	_	0.133	0.739				Estimated
Early_InitAge_5	_	_	0.717	0.457				Estimated

Table 3.1.1. Continued

Label	Lower bound	Upper bound	Predicted Value	SD	Prior Value	SD	Status	Value
Early_InitAge_4	_	_	0.063	0.603				Estimated
Early_InitAge_3	_	_	-0.176	0.485				Estimated
Early_InitAge_2	_	_	0.670	0.187				Estimated
Early_InitAge_1	_	_	0.309	0.193				Estimated
Main_RecrDev_1986	_	_	0.706	0.132				Estimated
Main_RecrDev_1987	_	_	-0.495	0.285				Estimated
Main_RecrDev_1988	_	_	0.947	0.108				Estimated
Main_RecrDev_1989	_	_	0.704	0.118				Estimated
Main_RecrDev_1990	_	_	0.160	0.170				Estimated
Main_RecrDev_1991	_	_	0.017	0.180				Estimated
Main_RecrDev_1992	_	_	-0.188	0.182				Estimated
Main_RecrDev_1993	_	_	0.666	0.108				Estimated
Main_RecrDev_1994	_	_	-1.118	0.380				Estimated
Main_RecrDev_1995	_	_	1.190	0.083				Estimated
Main_RecrDev_1996	_	_	-0.353	0.189				Estimated
Main_RecrDev_1997	_	_	-1.383	0.404				Estimated
Main_RecrDev_1998	_	_	1.867	0.071				Estimated
Main_RecrDev_1999	_	_	-0.333	0.278				Estimated
Main_RecrDev_2000	_	_	-0.759	0.355				Estimated
Main_RecrDev_2001	_	_	1.252	0.099				Estimated
Main_RecrDev_2002	_	_	-0.841	0.307				Estimated
Main_RecrDev_2003	_	_	0.430	0.118				Estimated
Main_RecrDev_2004	_	_	-2.499	0.521				Estimated
Main_RecrDev_2005	_	_	2.206	0.100				Estimated
Main_RecrDev_2006	_	_	0.897	0.113				Estimated
Main_RecrDev_2007	_	_	0.804	0.124				Estimated
Main_RecrDev_2008	_	_	0.016	0.166				Estimated
Main_RecrDev_2009	_	_	-0.282	0.150				Estimated
Main_RecrDev_2010	_	_	-0.619	0.170				Estimated
Main_RecrDev_2011	_	_	-1.418	0.234				Estimated
Main_RecrDev_2012	_	_	-0.893	0.237				Estimated
Main_RecrDev_2013	_	_	-0.682	0.450				Estimated
InitF_1commHL	0	1	0.097	0.018	No_prior			Estimated
InitF_2commLL	0	1	0.142	0.030	No_prior			Estimated
InitF_3commTrap	0	1	0.025	0.006	No_prior			Estimated
InitF_4CBT_PR	0	1	0.104	0.011	No_prior			Estimated
InitF_5HB	0	1	0.012	0.001	No_prior			Estimated
InitF_6RedTide	0	1	0.000	_	Normal	0.01	0.1	-
F_fleet_1_YR_1986_s_1	0	8	0.198	0.026				Estimated

Table 3.1.1. Continued

Label	Lower bound	Upper bound	Predicted Value	Predicted SD	Prior Value	Prior SD	Status	Value
F_fleet_1_YR_1987_s_1	0	8	0.154	0.018				Estimated
F_fleet_1_YR_1988_s_1	0	8	0.116	0.012				Estimated
F_fleet_1_YR_1989_s_1	0	8	0.241	0.020				Estimated
F_fleet_1_YR_1990_s_1	0	8	0.194	0.017				Estimated
F_fleet_1_YR_1991_s_1	0	8	0.146	0.013				Estimated
F_fleet_1_YR_1992_s_1	0	8	0.094	0.008				Estimated
F_fleet_1_YR_1993_s_1	0	8	0.086	0.008				Estimated
F_fleet_1_YR_1994_s_1	0	8	0.082	0.007				Estimated
F_fleet_1_YR_1995_s_1	0	8	0.065	0.006				Estimated
F_fleet_1_YR_1996_s_1	0	8	0.043	0.004				Estimated
F_fleet_1_YR_1997_s_1	0	8	0.046	0.004				Estimated
F_fleet_1_YR_1998_s_1	0	8	0.035	0.003				Estimated
F_fleet_1_YR_1999_s_1	0	8	0.058	0.005				Estimated
F_fleet_1_YR_2000_s_1	0	8	0.083	0.008				Estimated
F_fleet_1_YR_2001_s_1	0	8	0.076	0.007				Estimated
F_fleet_1_YR_2002_s_1	0	8	0.073	0.008				Estimated
F_fleet_1_YR_2003_s_1	0	8	0.049	0.005				Estimated
F_fleet_1_YR_2004_s_1	0	8	0.052	0.006				Estimated
F_fleet_1_YR_2005_s_1	0	8	0.050	0.006				Estimated
F_fleet_1_YR_2006_s_1	0	8	0.062	0.005				Estimated
F_fleet_1_YR_2007_s_1	0	8	0.074	0.008				Estimated
F_fleet_1_YR_2008_s_1	0	8	0.087	0.010				Estimated
F_fleet_1_YR_2009_s_1	0	8	0.117	0.012				Estimated
F_fleet_1_YR_2010_s_1	0	8	0.061	0.007				Estimated
F_fleet_1_YR_2011_s_1	0	8	0.059	0.007				Estimated
F_fleet_1_YR_2012_s_1	0	8	0.053	0.007				Estimated
F_fleet_1_YR_2013_s_1	0	8	0.032	0.004				Estimated
F_fleet_2_YR_1986_s_1	0	8	0.230	0.035				Estimated
F_fleet_2_YR_1987_s_1	0	8	0.363	0.051				Estimated
F_fleet_2_YR_1988_s_1	0	8	0.194	0.023				Estimated
F_fleet_2_YR_1989_s_1	0	8	0.284	0.031				Estimated
F_fleet_2_YR_1990_s_1	0	8	0.229	0.025				Estimated
F_fleet_2_YR_1991_s_1	0	8	0.271	0.027				Estimated
F_fleet_2_YR_1992_s_1	0	8	0.233	0.024				Estimated
F_fleet_2_YR_1993_s_1	0	8	0.409	0.043				Estimated
F_fleet_2_YR_1994_s_1	0	8	0.258	0.027				Estimated
F_fleet_2_YR_1995_s_1	0	8	0.208	0.023				Estimated
F_fleet_2_YR_1996_s_1	0	8	0.204	0.021				Estimated
F_fleet_2_YR_1997_s_1	0	8	0.191	0.021				Estimated

Table 3.1.1 Continued

			Predicted		Prior			
Label	Lower bound	Upper bound	Value	SD	Value	SD	Status	Value
F_fleet_2_YR_1998_s_1	0	8	0.154	0.016				Estimated
F_fleet_2_YR_1999_s_1	0	8	0.223	0.022				Estimated
F_fleet_2_YR_2000_s_1	0	8	0.178	0.019				Estimated
F_fleet_2_YR_2001_s_1	0	8	0.215	0.024				Estimated
F_fleet_2_YR_2002_s_1	0	8	0.192	0.023				Estimated
F_fleet_2_YR_2003_s_1	0	8	0.165	0.020				Estimated
F_fleet_2_YR_2004_s_1	0	8	0.188	0.027				Estimated
F_fleet_2_YR_2005_s_1	0	8	0.169	0.020				Estimated
F_fleet_2_YR_2006_s_1	0	8	0.173	0.022				Estimated
F_fleet_2_YR_2007_s_1	0	8	0.120	0.017				Estimated
F_fleet_2_YR_2008_s_1	0	8	0.156	0.017				Estimated
F_fleet_2_YR_2009_s_1	0	8	0.064	0.009				Estimated
F_fleet_2_YR_2010_s_1	0	8	0.075	0.010				Estimated
F_fleet_2_YR_2011_s_1	0	8	0.155	0.020				Estimated
F_fleet_2_YR_2012_s_1	0	8	0.114	0.016				Estimated
F_fleet_2_YR_2013_s_1	0	8	0.087	0.013				Estimated
F_fleet_3_YR_1986_s_1	0	8	0.053	0.009				Estimated
F_fleet_3_YR_1987_s_1	0	8	0.035	0.006				Estimated
F_fleet_3_YR_1988_s_1	0	8	0.040	0.006				Estimated
F_fleet_3_YR_1989_s_1	0	8	0.044	0.006				Estimated
F_fleet_3_YR_1990_s_1	0	8	0.034	0.004				Estimated
F_fleet_3_YR_1991_s_1	0	8	0.036	0.005				Estimated
F_fleet_3_YR_1992_s_1	0	8	0.053	0.007				Estimated
F_fleet_3_YR_1993_s_1	0	8	0.061	0.008				Estimated
F_fleet_3_YR_1994_s_1	0	8	0.077	0.010				Estimated
F_fleet_3_YR_1995_s_1	0	8	0.084	0.010				Estimated
F_fleet_3_YR_1996_s_1	0	8	0.035	0.005				Estimated
F_fleet_3_YR_1997_s_1	0	8	0.039	0.005				Estimated
F_fleet_3_YR_1998_s_1	0	8	0.016	0.002				Estimated
F_fleet_3_YR_1999_s_1	0	8	0.042	0.006				Estimated
F_fleet_3_YR_2000_s_1	0	8	0.060	0.008				Estimated
F_fleet_3_YR_2001_s_1	0	8	0.044	0.006				Estimated
F_fleet_3_YR_2002_s_1	0	8	0.056	0.008				Estimated
F_fleet_3_YR_2003_s_1	0	8	0.034	0.006				Estimated
F_fleet_3_YR_2004_s_1	0	8	0.036	0.005				Estimated
F_fleet_3_YR_2005_s_1	0	8	0.032	0.005				Estimated
F_fleet_3_YR_2006_s_1	0	8	0.030	0.005				Estimated
F_fleet_3_YR_2007_s_1	0	8	0.001	0.000				Estimated
F_fleet_3_YR_2008_s_1	_	_	0.000	_				-

Table 3.1.1 Continued

			Predicted			Prior		
Label	Lower bound	Upper bound	Value	SD	Type	Value	SD	Status
F_fleet_3_YR_2009_s_1	_	_	0.000	_				-
F_fleet_3_YR_2010_s_1	_	_	0.000	_				-
F_fleet_3_YR_2011_s_1	0	8	0.000	0.000				Estimated
F_fleet_3_YR_2012_s_1	_	_	0.000	_				-
F_fleet_3_YR_2013_s_1	_	_	0.000	_				-
F_fleet_4_YR_1986_s_1	0	8	0.151	0.016				Estimated
F_fleet_4_YR_1987_s_1	0	8	0.087	0.008				Estimated
F_fleet_4_YR_1988_s_1	0	8	0.193	0.018				Estimated
F_fleet_4_YR_1989_s_1	0	8	0.208	0.019				Estimated
F_fleet_4_YR_1990_s_1	0	8	0.180	0.020				Estimated
F_fleet_4_YR_1991_s_1	0	8	0.253	0.029				Estimated
F_fleet_4_YR_1992_s_1	0	8	0.408	0.044				Estimated
F_fleet_4_YR_1993_s_1	0	8	0.312	0.038				Estimated
F_fleet_4_YR_1994_s_1	0	8	0.252	0.027				Estimated
F_fleet_4_YR_1995_s_1	0	8	0.201	0.023				Estimated
F_fleet_4_YR_1996_s_1	0	8	0.083	0.010				Estimated
F_fleet_4_YR_1997_s_1	0	8	0.064	0.008				Estimated
F_fleet_4_YR_1998_s_1	0	8	0.091	0.011				Estimated
F_fleet_4_YR_1999_s_1	0	8	0.160	0.018				Estimated
F_fleet_4_YR_2000_s_1	0	8	0.272	0.035				Estimated
F_fleet_4_YR_2001_s_1	0	8	0.173	0.020				Estimated
F_fleet_4_YR_2002_s_1	0	8	0.183	0.025				Estimated
F_fleet_4_YR_2003_s_1	0	8	0.138	0.020				Estimated
F_fleet_4_YR_2004_s_1	0	8	0.242	0.032				Estimated
F_fleet_4_YR_2005_s_1	0	8	0.094	0.014				Estimated
F_fleet_4_YR_2006_s_1	0	8	0.113	0.015				Estimated
F_fleet_4_YR_2007_s_1	0	8	0.125	0.015				Estimated
F_fleet_4_YR_2008_s_1	0	8	0.113	0.016				Estimated
F_fleet_4_YR_2009_s_1	0	8	0.128	0.017				Estimated
F_fleet_4_YR_2010_s_1	0	8	0.104	0.015				Estimated
F_fleet_4_YR_2011_s_1	0	8	0.048	0.006				Estimated
F_fleet_4_YR_2012_s_1	0	8	0.096	0.014				Estimated
F_fleet_4_YR_2013_s_1	0	8	0.168	0.025				Estimated
F_fleet_5_YR_1986_s_1	0	8	0.024	0.003				Estimated
F_fleet_5_YR_1987_s_1	0	8	0.017	0.002				Estimated
F_fleet_5_YR_1988_s_1	0	8	0.019	0.002				Estimated
F_fleet_5_YR_1989_s_1	0	8	0.037	0.004				Estimated
F_fleet_5_YR_1990_s_1	0	8	0.022	0.003				Estimated
F_fleet_5_YR_1991_s_1	0	8	0.013	0.002				Estimated

Table 3.1.1 Continued

Label	Lower bound	Upper bound	Predicted Value	Predicted SD	Prior Type	Prior Value	Prior SD	Status
F_fleet_5_YR_1992_s_1	0	8	0.012	0.002				Estimated
F_fleet_5_YR_1993_s_1	0	8	0.012	0.002				Estimated
F_fleet_5_YR_1994_s_1	0	8	0.012	0.002				Estimated
F_fleet_5_YR_1995_s_1	0	8	0.016	0.002				Estimated
F_fleet_5_YR_1996_s_1	0	8	0.019	0.003				Estimated
F_fleet_5_YR_1997_s_1	0	8	0.006	0.001				Estimated
F_fleet_5_YR_1998_s_1	0	8	0.006	0.001				Estimated
F_fleet_5_YR_1999_s_1	0	8	0.009	0.001				Estimated
F_fleet_5_YR_2000_s_1	0	8	0.011	0.002				Estimated
F_fleet_5_YR_2001_s_1	0	8	0.006	0.001				Estimated
F_fleet_5_YR_2002_s_1	0	8	0.005	0.001				Estimated
F_fleet_5_YR_2003_s_1	0	8	0.007	0.001				Estimated
F_fleet_5_YR_2004_s_1	0	8	0.010	0.002				Estimated
F_fleet_5_YR_2005_s_1	0	8	0.012	0.002				Estimated
F_fleet_5_YR_2006_s_1	0	8	0.006	0.001				Estimated
F_fleet_5_YR_2007_s_1	0	8	0.006	0.001				Estimated
F_fleet_5_YR_2008_s_1	0	8	0.007	0.001				Estimated
F_fleet_5_YR_2009_s_1	0	8	0.007	0.001				Estimated
F_fleet_5_YR_2010_s_1	0	8	0.005	0.001				Estimated
F_fleet_5_YR_2011_s_1	0	8	0.005	0.001				Estimated
F_fleet_5_YR_2012_s_1	0	8	0.007	0.001				Estimated
F_fleet_5_YR_2013_s_1	0	8	0.009	0.002				Estimated
F_fleet_6_YR_1986_s_1	_	_	0.000	_				-
F_fleet_6_YR_1987_s_1	_	_	0.000	_				-
F_fleet_6_YR_1988_s_1	_	_	0.000	_				-
F_fleet_6_YR_1989_s_1	_	_	0.000	_				-
F_fleet_6_YR_1990_s_1	_	_	0.000	_				-
F_fleet_6_YR_1991_s_1	_	_	0.000	_				-
F_fleet_6_YR_1992_s_1	_	_	0.000	_				-
F_fleet_6_YR_1993_s_1	_	_	0.000	_				-
F_fleet_6_YR_1994_s_1	_	_	0.000	_				-
F_fleet_6_YR_1995_s_1	_	_	0.000	_				-
F_fleet_6_YR_1996_s_1	_	_	0.000	_				-
F_fleet_6_YR_1997_s_1	_	_	0.000	_				-
F_fleet_6_YR_1998_s_1	0	8	0.000	0.000				Estimated
F_fleet_6_YR_1999_s_1	0	8	0.000	0.000				Estimated
F_fleet_6_YR_2000_s_1	0	8	0.000	0.000				Estimated
F_fleet_6_YR_2001_s_1	0	8	0.000	0.000				Estimated
F_fleet_6_YR_2002_s_1	0	8	0.000	0.000				Estimated

Table 3.1.1 Continued

Label	Lower bound	Upper bound	Predicted Value	SD	Prior Value	SD	Status	Value
F_fleet_6_YR_2003_s_1	0	8	0.000	0.000				Estimated
F_fleet_6_YR_2004_s_1	0	8	0.000	0.000				Estimated
F_fleet_6_YR_2005_s_1	0	8	0.442	0.096				Estimated
F_fleet_6_YR_2006_s_1	0	8	0.000	0.000				Estimated
F_fleet_6_YR_2007_s_1	0	8	0.000	0.000				Estimated
F_fleet_6_YR_2008_s_1	0	8	0.000	0.000				Estimated
F_fleet_6_YR_2009_s_1	0	8	0.000	0.000				Estimated
F_fleet_6_YR_2010_s_1	0	8	0.000	0.000				Estimated
F_fleet_6_YR_2011_s_1	0	8	0.000	0.000				Estimated
F_fleet_6_YR_2012_s_1	0	8	0.000	0.000				Estimated
F_fleet_6_YR_2013_s_1	0	8	0.000	0.000				Estimated
LnQ_base_6_RedTide	-15	15	0.816	0.217	No_prior			Estimated
Retain_1P_1_commHL	0	85	0.000	_	No_prior			-
Retain_1P_2_commHL	0	20	0.250	_	No_prior			-
Retain_1P_3_commHL	0	1	1.000	_	No_prior			-
Retain_1P_4_commHL	-1	2	0.000	_	No_prior			-
DiscMort_1P_1_commHL	-20	20	-15.000	_	No_prior			-
DiscMort_1P_2_commHL	-2	2	1.000	_	No_prior			-
DiscMort_1P_3_commHL	-1	2	0.190	_	No_prior			-
DiscMort_1P_4_commHL	-1	2	0.000	_	No_prior			-
Retain_2P_1_commLL	0	85	0.000	_	No_prior			-
Retain_2P_2_commLL	0	20	0.250	_	No_prior			-
Retain_2P_3_commLL	0	1	1.000	_	No_prior			-
Retain_2P_4_commLL	-1	10	0.000	_	No_prior			-
DiscMort_2P_1_commLL	-20	20	-15.000	_	No_prior			-
DiscMort_2P_2_commLL	-2	2	1.000	_	No_prior			-
DiscMort_2P_3_commLL	-1	2	0.415	_	No_prior			-
DiscMort_2P_4_commLL	-1	2	0.000	_	No_prior			-
Retain_3P_1_commTrap	0	85	0.000	_	No_prior			-
Retain_3P_2_commTrap	0	20	0.250	_	No_prior			-
Retain_3P_3_commTrap	0	1	1.000	_	No_prior			-
Retain_3P_4_commTrap	-1	2	0.000	_	No_prior			-
DiscMort_3P_1_commTrap	-20	20	-15.000	_	No_prior			-
DiscMort_3P_2_commTrap	-2	2	1.000	_	No_prior			-
DiscMort_3P_3_commTrap	-1	2	0.100	_	No_prior			-
DiscMort_3P_4_commTrap	-1	2	0.000	_	No_prior			-
Retain_4P_1_CBT_PR	20	85	43.969	_	No_prior			-
Retain_4P_2_CBT_PR	0	20	0.500	_	No_prior			-
Retain_4P_3_CBT_PR	0	1	1.000	_	No_prior			-

Table 3.1.1 Continued

Label	Lower bound	Upper bound	Predicted Value	SD	Prior Value	SD	Status	Value
Retain_4P_4_CBT_PR	-1	2	0.000	_	No_prior			-
DiscMort_4P_1_CBT_PR	-20	20	-15.000	_	No_prior			-
DiscMort_4P_2_CBT_PR	-2	2	1.000	_	No_prior			-
DiscMort_4P_3_CBT_PR	-1	2	0.116	_	No_prior			-
DiscMort_4P_4_CBT_PR	-1	2	0.000	_	No_prior			-
Retain_5P_1_HB	20	85	43.969	_	No_prior			-
Retain_5P_2_HB	0	20	0.500	_	No_prior			-
Retain_5P_3_HB	0	1	1.000	_	No_prior			-
Retain_5P_4_HB	-1	2	0.000	_	No_prior			-
DiscMort_5P_1_HB	-20	20	-15.000	_	No_prior			-
DiscMort_5P_2_HB	-2	2	1.000	_	No_prior			-
DiscMort_5P_3_HB	-1	2	0.116	_	No_prior			-
DiscMort_5P_4_HB	-1	2	0.000	_	No_prior			-
SizeSel_7P_1_SEAMAP_Vid	10	60	55.290	3.457	No_prior			Estimated
SizeSel_7P_2_SEAMAP_Vid	-15	15	3.145	75.845	No_prior			Estimated
SizeSel_7P_3_SEAMAP_Vid	-15	15	5.721	0.313	No_prior			Estimated
SizeSel_7P_4_SEAMAP_Vid	-15	15	0.243	400.230	No_prior			Estimated
SizeSel_7P_5_SEAMAP_Vid	-15	15	-4.830	1.409	No_prior			Estimated
SizeSel_7P_6_SEAMAP_Vid	-15	15	2.504	196.010	No_prior			Estimated
SizeSel_8P_1_SEAMAP_GF	10	60	13.350	6.561	No_prior			Estimated
SizeSel_8P_2_SEAMAP_GF	-15	15	-2.147	0.574	No_prior			Estimated
SizeSel_8P_3_SEAMAP_GF	-15	15	-1.068	37.904	No_prior			Estimated
SizeSel_8P_4_SEAMAP_GF	-15	15	4.941	0.279	No_prior			Estimated
SizeSel_8P_5_SEAMAP_GF	-15	15	-2.103	0.251	No_prior			Estimated
SizeSel_8P_6_SEAMAP_GF	-15	15	-2.055	0.231	No_prior			Estimated
SizeSel_9P_1_NMFS_BLL	0.5	129	45.565	0.966	No_prior			Estimated
SizeSel_9P_2_NMFS_BLL	-15	15	0.516	6.058	No_prior			Estimated
SizeSel_9P_3_NMFS_BLL	-15	15	4.284	0.182	No_prior			Estimated
SizeSel_9P_4_NMFS_BLL	-15	15	-0.089	294.529	No_prior			Estimated
SizeSel_9P_5_NMFS_BLL	-15	15	-5.759	0.680	No_prior			Estimated
SizeSel_9P_6_NMFS_BLL	-15	15	0.808	45.495	No_prior			Estimated
AgeSel_1P_1_commHL	-1010	1	-1000	_	No_prior			-
AgeSel_1P_2_commHL	-5	5	0.000	_	Normal	0	0.25	-
AgeSel_1P_3_commHL	-5	5	1.210	0.231	Normal	1	0.25	Estimated
AgeSel_1P_4_commHL	-5	5	1.511	0.217	Normal	1	0.25	Estimated
AgeSel_1P_5_commHL	-5	5	1.516	0.211	Normal	1	0.25	Estimated
AgeSel_1P_6_commHL	-5	5	1.316	0.173	Normal	1	0.25	Estimated
AgeSel_1P_7_commHL	-5	5	0.966	0.103	Normal	0	0.25	Estimated
AgeSel_1P_8_commHL	-5	5	0.674	0.085	Normal	0	0.25	Estimated

Table 3.1.1 Continued

			Predicted			Prior		
Label	Lower bound	Upper bound	Value	SD	Value	SD	Status	Value
AgeSel_1P_9_commHL	-5	5	0.096	0.091	Normal	0	0.25	Estimated
AgeSel_1P_10_commHL	-5	5	-0.056	0.106	Normal	0	0.25	Estimated
AgeSel_1P_11_commHL	-5	5	-0.101	0.124	Normal	0	0.25	Estimated
AgeSel_1P_12_commHL	-5	5	-0.161	0.138	Normal	0	0.25	Estimated
AgeSel_1P_13_commHL	-5	5	-0.130	0.089	Normal	0	0.1	Estimated
AgeSel_1P_14_commHL	-5	5	-0.100	0.089	Normal	0	0.1	Estimated
AgeSel_1P_15_commHL	-5	5	-0.077	0.091	Normal	0	0.1	Estimated
AgeSel_1P_16_commHL	-5	5	-0.062	0.093	Normal	0	0.1	Estimated
AgeSel_1P_17_commHL	-5	5	-0.051	0.095	Normal	0	0.1	Estimated
AgeSel_1P_18_commHL	-5	5	-0.038	0.096	Normal	0	0.1	Estimated
AgeSel_1P_19_commHL	-5	5	-0.024	0.097	Normal	0	0.1	Estimated
AgeSel_1P_20_commHL	-5	5	-0.011	0.097	Normal	0	0.1	Estimated
AgeSel_1P_21_commHL	-5	5	-0.004	0.098	Normal	0	0.1	Estimated
AgeSel_2P_1_commLL	-1010	1	-1000	_	No_prior			-
AgeSel_2P_2_commLL	-5	5	0.000	_	Normal	0	0.25	-
AgeSel_2P_3_commLL	-5	5	1.241	0.229	Normal	1	0.25	Estimated
AgeSel_2P_4_commLL	-5	5	1.581	0.219	Normal	1	0.25	Estimated
AgeSel_2P_5_commLL	-5	5	1.156	0.219	Normal	1	0.25	Estimated
AgeSel_2P_6_commLL	-5	5	1.070	0.201	Normal	1	0.25	Estimated
AgeSel_2P_7_commLL	-5	5	0.807	0.124	Normal	0	0.25	Estimated
AgeSel_2P_8_commLL	-5	5	1.082	0.097	Normal	0	0.25	Estimated
AgeSel_2P_9_commLL	-5	5	0.537	0.091	Normal	0	0.25	Estimated
AgeSel_2P_10_commLL	-5	5	0.119	0.105	Normal	0	0.25	Estimated
AgeSel_2P_11_commLL	-5	5	0.140	0.117	Normal	0	0.25	Estimated
AgeSel_2P_12_commLL	-5	5	-0.181	0.118	Normal	0	0.25	Estimated
AgeSel_2P_13_commLL	-5	5	-0.171	0.086	Normal	0	0.1	Estimated
AgeSel_2P_14_commLL	-5	5	-0.139	0.087	Normal	0	0.1	Estimated
AgeSel_2P_15_commLL	-5	5	-0.098	0.089	Normal	0	0.1	Estimated
AgeSel_2P_16_commLL	-5	5	-0.106	0.092	Normal	0	0.1	Estimated
AgeSel_2P_17_commLL	-5	5	-0.089	0.094	Normal	0	0.1	Estimated
AgeSel_2P_18_commLL	-5	5	-0.075	0.095	Normal	0	0.1	Estimated
AgeSel_2P_19_commLL	-5	5	-0.053	0.096	Normal	0	0.1	Estimated
AgeSel_2P_20_commLL	-5	5	-0.033	0.097	Normal	0	0.1	Estimated
AgeSel_2P_21_commLL	-5	5	-0.024	0.098	Normal	0	0.1	Estimated
AgeSel_3P_1_commTrap	-1010	1	-1000	_	No_prior			-
AgeSel_3P_2_commTrap	-5	5	0.000	_	Normal	0	0.25	-
AgeSel_3P_3_commTrap	-5	5	0.920	0.259	Normal	1	0.25	Estimated
AgeSel_3P_4_commTrap	-5	5	0.799	0.270	Normal	1	0.25	Estimated
AgeSel_3P_5_commTrap	-5	5	0.615	0.270	Normal	1	0.25	Estimated

Table 3.1.1 Continued

			Predicted			Prior		
Label	Lower bound	Upper bound	Value	SD	Value	SD	Status	Value
AgeSel_3P_6_commTrap	-5	5	0.429	0.232	Normal	1	0.25	Estimated
AgeSel_3P_7_commTrap	-5	5	0.255	0.174	Normal	0	0.25	Estimated
AgeSel_3P_8_commTrap	-5	5	0.798	0.169	Normal	0	0.25	Estimated
AgeSel_3P_9_commTrap	-5	5	0.688	0.159	Normal	0	0.25	Estimated
AgeSel_3P_10_commTrap	-5	5	0.146	0.164	Normal	0	0.25	Estimated
AgeSel_3P_11_commTrap	-5	5	-0.036	0.186	Normal	0	0.25	Estimated
AgeSel_3P_12_commTrap	-5	5	-0.238	0.186	Normal	0	0.25	Estimated
AgeSel_3P_13_commTrap	-5	5	-0.048	0.095	Normal	0	0.1	Estimated
AgeSel_3P_14_commTrap	-5	5	-0.036	0.096	Normal	0	0.1	Estimated
AgeSel_3P_15_commTrap	-5	5	-0.077	0.096	Normal	0	0.1	Estimated
AgeSel_3P_16_commTrap	-5	5	-0.070	0.096	Normal	0	0.1	Estimated
AgeSel_3P_17_commTrap	-5	5	-0.053	0.097	Normal	0	0.1	Estimated
AgeSel_3P_18_commTrap	-5	5	-0.043	0.098	Normal	0	0.1	Estimated
AgeSel_3P_19_commTrap	-5	5	-0.033	0.098	Normal	0	0.1	Estimated
AgeSel_3P_20_commTrap	-5	5	-0.025	0.099	Normal	0	0.1	Estimated
AgeSel_3P_21_commTrap	-5	5	-0.020	0.099	Normal	0	0.1	Estimated
AgeSel_4P_1_CBT_PR	-1010	1	-1000	_	No_prior			-
AgeSel_4P_2_CBT_PR	-5	5	0.000	_	Normal	0	0.25	-
AgeSel_4P_3_CBT_PR	-5	5	1.225	0.228	Normal	1	0.25	Estimated
AgeSel_4P_4_CBT_PR	-5	5	1.343	0.216	Normal	1	0.25	Estimated
AgeSel_4P_5_CBT_PR	-5	5	0.411	0.211	Normal	1	0.25	Estimated
AgeSel_4P_6_CBT_PR	-5	5	0.107	0.129	Normal	1	0.25	Estimated
AgeSel_4P_7_CBT_PR	-5	5	0.019	0.104	Normal	0	0.25	Estimated
AgeSel_4P_8_CBT_PR	-5	5	-0.029	0.102	Normal	0	0.25	Estimated
AgeSel_4P_9_CBT_PR	-5	5	-0.625	0.119	Normal	0	0.25	Estimated
AgeSel_4P_10_CBT_PR	-5	5	-0.192	0.139	Normal	0	0.25	Estimated
AgeSel_4P_11_CBT_PR	-5	5	-0.535	0.161	Normal	0	0.25	Estimated
AgeSel_4P_12_CBT_PR	-5	5	-0.264	0.172	Normal	0	0.25	Estimated
AgeSel_4P_13_CBT_PR	-5	5	-0.105	0.094	Normal	0	0.1	Estimated
AgeSel_4P_14_CBT_PR	-5	5	-0.041	0.094	Normal	0	0.1	Estimated
AgeSel_4P_15_CBT_PR	-5	5	-0.013	0.095	Normal	0	0.1	Estimated
AgeSel_4P_16_CBT_PR	-5	5	-0.033	0.096	Normal	0	0.1	Estimated
AgeSel_4P_17_CBT_PR	-5	5	-0.017	0.097	Normal	0	0.1	Estimated
AgeSel_4P_18_CBT_PR	-5	5	-0.008	0.098	Normal	0	0.1	Estimated
AgeSel_4P_19_CBT_PR	-5	5	0.003	0.099	Normal	0	0.1	Estimated
AgeSel_4P_20_CBT_PR	-5	5	0.008	0.099	Normal	0	0.1	Estimated
AgeSel_4P_21_CBT_PR	-5	5	0.010	0.099	Normal	0	0.1	Estimated
AgeSel_5P_1_HB	-1010	1	-1000	_	No_prior			-
AgeSel_5P_2_HB	-5	5	0.000	_	Normal	0	0.25	-

Table 3.1.1. Continued

			Predicted		Prior			
Label	Lower bound	Upper bound	Value	SD	Value	SD	Status	Value
AgeSel_5P_3_HB	-5	5	1.615	0.181	Normal	1	0.25	Estimated
AgeSel_5P_4_HB	-5	5	1.371	0.162	Normal	1	0.25	Estimated
AgeSel_5P_5_HB	-5	5	-1.066	0.159	Normal	1	0.25	Estimated
AgeSel_5P_6_HB	-5	5	-0.215	0.141	Normal	1	0.25	Estimated
AgeSel_5P_7_HB	-5	5	0.231	0.123	Normal	0	0.25	Estimated
AgeSel_5P_8_HB	-5	5	-0.005	0.123	Normal	0	0.25	Estimated
AgeSel_5P_9_HB	-5	5	-0.515	0.143	Normal	0	0.25	Estimated
AgeSel_5P_10_HB	-5	5	-0.200	0.166	Normal	0	0.25	Estimated
AgeSel_5P_11_HB	-5	5	-0.380	0.186	Normal	0	0.25	Estimated
AgeSel_5P_12_HB	-5	5	-0.387	0.197	Normal	0	0.25	Estimated
AgeSel_5P_13_HB	-5	5	-0.038	0.097	Normal	0	0.1	Estimated
AgeSel_5P_14_HB	-5	5	-0.031	0.097	Normal	0	0.1	Estimated
AgeSel_5P_15_HB	-5	5	-0.017	0.098	Normal	0	0.1	Estimated
AgeSel_5P_16_HB	-5	5	-0.006	0.098	Normal	0	0.1	Estimated
AgeSel_5P_17_HB	-5	5	0.006	0.099	Normal	0	0.1	Estimated
AgeSel_5P_18_HB	-5	5	0.013	0.099	Normal	0	0.1	Estimated
AgeSel_5P_19_HB	-5	5	0.016	0.099	Normal	0	0.1	Estimated
AgeSel_5P_20_HB	-5	5	0.018	0.100	Normal	0	0.1	Estimated
AgeSel_5P_21_HB	-5	5	0.018	0.100	Normal	0	0.1	Estimated
AgeSel_6P_1_RedTide	0.1	21	0.100	_	No_prior			-
AgeSel_6P_2_RedTide	21	21	21.000	_	No_prior			-
Retain_1P_1_commHL_BLK2repl_1990	20	85	48.795	_	No_prior			-
Retain_1P_1_commHL_BLK2repl_2009	20	85	45.462	0.254	No_prior			Estimated
Retain_1P_2_commHL_BLK2repl_1990	0	20	0.100	_	No_prior			-
Retain_1P_2_commHL_BLK2repl_2009	0	20	0.986	0.111	No_prior			Estimated
Retain_1P_3_commHL_BLK2repl_1990	0	1	1.000	_	No_prior			-
Retain_1P_3_commHL_BLK2repl_2009	0	1	0.998	0.001	No_prior			Estimated
Retain_2P_1_commLL_BLK2repl_1990	20	85	48.795	_	No_prior			-
Retain_2P_1_commLL_BLK2repl_2009	20	85	46.383	0.305	No_prior			Estimated
Retain_2P_2_commLL_BLK2repl_1990	0	20	0.100	_	No_prior			-
Retain_2P_2_commLL_BLK2repl_2009	0	20	1.229	0.129	No_prior			Estimated
Retain_2P_3_commLL_BLK2repl_1990	0	1	1.000	_	No_prior			-
Retain_2P_3_commLL_BLK2repl_2009	0	1	1.000	0.001	No_prior			Estimated
Retain_3P_1_commTrap_BLK3repl_1990	20	85	48.975	_	No_prior			-
Retain_3P_2_commTrap_BLK3repl_1990	0	20	0.100	_	No_prior			-
Retain_3P_3_commTrap_BLK3repl_1990	0	1	1.000	_	No_prior			-
Retain_4P_1_CBT_PR_BLK1repl_1990	20	85	53.704	0.611	No_prior			Estimated
Retain_4P_2_CBT_PR_BLK1repl_1990	0	20	0.545	0.265	No_prior			Estimated
Retain_4P_3_CBT_PR_BLK1repl_1990	0	1	0.833	0.047	No_prior			Estimated

Table 3.1.1 Continued

			Predicted		Prior			
Label	Lower bound	Upper bound	Value	SD	Value	SD	Status	Value
Retain_5P_1_HB_BLK1repl_1990	20	85	50.304	1.323	No_prior			Estimated
Retain_5P_2_HB_BLK1repl_1990	0	20	0.319	0.615	No_prior			Estimated
Retain_5P_3_HB_BLK1repl_1990	0	1	0.972	0.014	No_prior			Estimated

Table 3.1.2 Model performance comparison: NoRT = no red tide model, EpiM0.25 = model adding an additional mortality due to red tide of 0.2541 to the natural mortality vector in 2005, EpiM0.48 = model adding an additional mortality due to red tide of 0.48 to the natural mortality vector, and FLEET = model accounting for red tide as a fleet.

	NoRT	EpiM0.25	EpiM0.48	FLEET
Performance				
Gradient	0.005	0.047	0.021	0.300
K	179	179	179	331
N	305	305	305	321
AICc	6723	6708	6703	-13645
BIC	6873	6858	6853	7584
Likelihood				
Total	2925	2917	2915	2837
Discard	320	318	316	311
Length composition	1079	1083	1086	1086
Age composition	1454	1453	1452	1451
Recruitment	18	17	17	17
Survey	-80	-88	-90	-164
commHL	-10	-11	-12	-12
commLL	-17	-18	-18	-18
commTrap	0	0	0	0
CBT_PR	0	0	0	0
HB	-11	-15	-18	-18
RedTide	-	-	-	-74
CBT_PRSurv	-22	-20	-18	-18
SEAMAP_Vid	-13	-14	-15	-15
SEAMAP_GF	-4	-4	-4	-4
NMFS_BLL	-3	-5	-5	-5
Red tide				
Ln(Q)	-	-	-	0.83
F_2005	-	-	-	0.48

	NoRT	EpiM0.25	EpiM0.48	FLEET
Performance				
Gradient	0.005	0.047	0.021	0.300
K	179	179	179	331

Table 3.1.3 Model total likelihood, predicted unfished spawning biomass (eggs), predicted 2013 spawning biomass, spawning biomass achieved at MSY (eggs), and unexploited recruitment from 50 model runs from the jitter analysis. * indicates that a positive definite hessian was not obtained.

Run	Total likelihood	SSB_Virgin	SSB_2013	SSB_MSY	R0
1	2838.47	4056110	2215550	1414710	15985
2	2838.34	4057960	2227670	1412140	15992
3*	2954.07	8.28e-317	0	0	8.28e-317
4	2838.47	4056180	2216090	1414580	15985
5	2838.48	4057230	2216910	1415080	15990
6	2888.39	3585530	1936580	1352220	14131
7	2838.48	4057410	2217900	1414890	15990
8	2838.48	4057430	2217910	1414890	15990
9	2838.47	4056190	2216100	1414590	15985
10	2838.47	4055890	2216050	1414490	15984
11	4904.46	2728690	1256910	1051720	10754
12	2888.99	3982000	2303260	1363420	15693
13*	3318.05	8.76e-317	0	0	8.76e-317
14	2866.57	4058480	2198010	1444760	15995
15	2838.47	4056190	2216100	1414590	15985
16	2839.91	4054760	2212850	1414480	15980
17	2839.91	4054960	2213830	1414290	15981
18	2838.35	4059220	2229520	1412450	15997
19	2838.47	4056190	2216090	1414590	15985
20	22225.2	2389670	953613	934868	9418
21	2838.47	4056190	2216100	1414590	15985
22	2861.18	4018010	2164290	1402800	15835
23	2838.35	4059240	2229530	1412450	15997
24	3265.59	3655900	2169240	1188870	14408
25	3072.25	4066880	2218050	1411330	16028
26	2838.35	4059230	2229520	1412450	15997
27	2838.34	4057960	2227670	1412140	15992
28*	2838.58	6.89e-317	0	0	6.89e-317
29	2861.31	4016170	2152180	1405410	15828
30	2862.29	4326920	2075190	1547260	17052
31	2843.67	4049140	2219390	1422530	15958
32	3337.03	4092410	2190690	1418020	16128
33	2892.66	4008420	2289150	1397400	15797
34	2838.48	4057310	2216830	1415140	15990
35	2838.47	4056180	2216090	1414590	15985
36	2838.48	4057420	2217900	1414890	15990
37	2838.47	4056060	2215030	1414840	15985
38	2838.65	4055950	2216760	1416430	15985
39	2866.57	4058540	2198470	1444650	15995
40	2863.54	4055000	2222970	1414200	15981
41	2838.47	4056180	2216090	1414590	15985
42	2838.34	4057960	2227660	1412140	15992
43	2838.47	4055990	2215110	1414780	15985
44	2838.48	4057440	2217900	1414900	15990
45	2838.47	4056170	2216090	1414580	15985
46	7380.78	1449990	3432890	718108	5714
47	2838.47	4056190	2216090	1414590	15985
48	2864.09	4021490	2190740	1405090	15849
49	5618.6	10987900	1099610	3979560	43303
50	2838.51	4056400	2226500	1413620	15986

Table 3.2.1 Parameter estimates with coefficient of variation (CV).

Parameter Label	Value	CV	Parameter description
SizeSel_7P_4_SEAMAP_Vid	0.24	1647.04	Descending width of double normal for video survey
SizeSel_7P_6_SEAMAP_Vid	2.50	78.28	Selectivity of last length bin in double normal for video survey
SizeSel_9P_6_NMFS_BLL	0.81	56.31	Selectivity of last length bin in double normal for NMFS bottom longline
AgeSel_4P_19_CBT_PR	0.00	33.00	Age-18 penalty for charterboat-private fleet
SizeSel_7P_2_SEAMAP_Vid	3.15	24.12	Width of double normal plateau for video survey
AgeSel_5P_17_HB	0.01	16.50	Age-16 penalty for headboat fleet
AgeSel_4P_20_CBT_PR	0.01	12.38	Age-19 penalty for charterboat-private fleet
SizeSel_9P_2_NMFS_BLL	0.52	11.74	Width of double normal plateau for NMFS bottom longline
Main_RecrDev_1991	0.02	10.59	Recruitment deviation in 1991
Main_RecrDev_2008	0.02	10.38	Recruitment deviation in 2008
AgeSel_4P_21_CBT_PR	0.01	9.90	Age-20 penalty for charterboat-private fleet
Early_InitAge_4	0.06	9.57	
AgeSel_5P_18_HB	0.01	7.62	Age-17 penalty for headboat fleet
AgeSel_5P_19_HB	0.02	6.19	Age-18 penalty for headboat fleet
Early_InitAge_17	0.19	5.69	
Early_InitAge_6	0.13	5.56	
AgeSel_5P_20_HB	0.02	5.56	Age-19 penalty for headboat fleet
AgeSel_5P_21_HB	0.02	5.56	Age-20 penalty for headboat fleet
AgeSel_4P_7_CBT_PR	0.02	5.47	Age-6 penalty for charterboat-private fleet
Early_InitAge_16	0.25	4.34	
Early_InitAge_15	0.33	3.37	
Retain_5P_2_HB_BLK1repl_1990	0.32	1.93	Retention slope for headboat fleet 1990-2008
AgeSel_4P_6_CBT_PR	0.11	1.21	Age-6 penalty for charterboat-private fleet
AgeSel_3P_10_commTrap	0.15	1.12	Age-9 penalty for commercial trap fleet
Main_RecrDev_1990	0.16	1.06	Recruitment deviation in 1990
AgeSel_1P_9_commHL	0.10	0.95	Age-8 penalty for commercial handline fleet
AgeSel_2P_10_commLL	0.12	0.88	Age-9 penalty for commercial longline fleet
AgeSel_2P_11_commLL	0.14	0.84	Age-10 penality for commercial longline fleet
AgeSel_3P_7_commTrap	0.26	0.68	Age-6 penalty for commercial trap fleet
Early_InitAge_5	0.72	0.64	
Early_InitAge_1	0.31	0.62	
AgeSel_3P_6_commTrap	0.43	0.54	Age-5 penalty for commercial trap fleet
AgeSel_5P_7_HB	0.23	0.53	Age-6 penalty for headboat fleet
AgeSel_4P_5_CBT_PR	0.41	0.51	Age-4 penalty for charterboat-private fleet
SizeSel_8P_1_SEAMAP_GF	13.35	0.49	Beginning size bin for double normal plateau for SEAMAP groundfish
Retain_4P_2_CBT_PR_BLK1repl_1990	0.55	0.49	Retention slope for charterboat-private fleet 1990-2008
AgeSel_3P_5_commTrap	0.62	0.44	Age-4 penalty for commercial trap fleet
AgeSel_3P_4_commTrap	0.80	0.34	Age-3 penalty for commercial trap fleet
AgeSel_3P_3_commTrap	0.92	0.28	Age-2 penalty for commercial trap fleet
Early_InitAge_2	0.67	0.28	
Main_RecrDev_2003	0.43	0.27	Main recruitment deviation in 2003
LnQ_base_6_RedTide	0.82	0.27	Natural log of the Red Tide fleet's catchability

Table. 3.2.1 continued

Parameter Label	Value	CV	Parameter description
InitF_3commTrap	0.03	0.24	Initial fishing mortality for commercial trap fleet
AgeSel_3P_9_commTrap	0.69	0.23	Penalty on age-8 for commercial trap fleet
F_fleet_5_YR_2013_s_1	0.01	0.22	2013 instantaneous F for headboat fleet
F_fleet_6_YR_2005_s_1	0.44	0.22	2005 instantaneous F for Red Tide fleet
AgeSel_3P_8_commTrap	0.80	0.21	Penalty on age-7 for commercial trap fleet
InitF_2commLL	0.14	0.21	Initial fishing mortality for commercial longline fleet
F_fleet_5_YR_2002_s_1	0.01	0.20	2002 instantaneous F for headboat fleet
F_fleet_5_YR_2004_s_1	0.01	0.20	2004 instantaneous F for headboat fleet
F_fleet_5_YR_2010_s_1	0.01	0.20	2010 instantaneous F for headboat fleet
F_fleet_5_YR_2011_s_1	0.01	0.20	2011 instantaneous F for headboat fleet
AgeSel_1P_3_commHL	1.21	0.19	Penalty on age-2 for commercial handline fleet
AgeSel_2P_5_commLL	1.16	0.19	Penalty on age-4 for commercial longline fleet
AgeSel_2P_6_commLL	1.07	0.19	Penalty on age-5 for commercial longline fleet
Main_RecrDev_1986	0.71	0.19	Main recruitment deviation for 1986
AgeSel_4P_3_CBT_PR	1.23	0.19	Penalty on age-2 for charterboat-private fleet
InitF_1commHL	0.10	0.19	Initial fishing mortality for commercial handline fleet
AgeSel_2P_3_commLL	1.24	0.18	Penalty on age-2 for commercial longline fleet
F_fleet_5_YR_2000_s_1	0.01	0.18	2000 instantaneous F for headboat fleet
F_fleet_3_YR_2003_s_1	0.03	0.18	2003 instantaneous F for commercial trap fleet
F_fleet_3_YR_1987_s_1	0.04	0.17	1987 instantaneous F for commercial trap fleet
F_fleet_3_YR_1986_s_1	0.05	0.17	1986 instantaneous F for commercial trap fleet
AgeSel_2P_9_commLL	0.54	0.17	Penalty on age-8 for commercial longline fleet
Main_RecrDev_1989	0.70	0.17	Main recruitment deviation for 1989
F_fleet_3_YR_2006_s_1	0.03	0.17	2006 instantaneous F for commercial trap fleet
F_fleet_5_YR_1992_s_1	0.01	0.17	1992 instantaneous F for headboat fleet
F_fleet_5_YR_1993_s_1	0.01	0.17	1993 instantaneous F for headboat fleet
F_fleet_5_YR_1994_s_1	0.01	0.17	1994 instantaneous F for headboat fleet
F_fleet_5_YR_1997_s_1	0.01	0.17	1997 instantaneous F for headboat fleet
F_fleet_5_YR_1998_s_1	0.01	0.17	1998 instantaneous F for headboat fleet
F_fleet_5_YR_2001_s_1	0.01	0.17	2001 instantaneous F for headboat fleet
F_fleet_5_YR_2005_s_1	0.01	0.17	2005 instantaneous F for headboat fleet
F_fleet_5_YR_2006_s_1	0.01	0.17	2006 instantaneous F for headboat fleet
F_fleet_5_YR_2007_s_1	0.01	0.17	2007 instantaneous F for headboat fleet
SR_BH_steep	0.80	0.16	Steepness
Main_RecrDev_1993	0.67	0.16	Main recruitment deviation for 1993
AgeSel_4P_4_CBT_PR	1.34	0.16	Penalty on age-3 for charterboat-private fleet
F_fleet_5_YR_1996_s_1	0.02	0.16	1996 instantaneous F for headboat fleet
F_fleet_3_YR_2005_s_1	0.03	0.16	2005 instantaneous F for commercial trap fleet
Main_RecrDev_2007	0.80	0.15	Main recruitment deviation for 2007
F_fleet_5_YR_1991_s_1	0.01	0.15	1991 instantaneous F for headboat fleet
AgeSel_2P_7_commLL	0.81	0.15	Penalty on age-6 for commercial longline fleet
F_fleet_2_YR_1986_s_1	0.23	0.15	1986 instantaneous F for commercial longline fleet
F_fleet_3_YR_1988_s_1	0.04	0.15	1988 instantaneous F for commercial trap fleet
F_fleet_2_YR_2013_s_1	0.09	0.15	2013 instantaneous F for commercial longline fleet
F_fleet_4_YR_2005_s_1	0.09	0.15	2005 instantaneous F for charterboat-private fleet

Table. 3.2.1 continued

Parameter Label	Value	CV	Parameter description
F_fleet_3_YR_1988_s_1	0.04	0.15	1988 instantaneous F for commercial trap fleet
F_fleet_2_YR_2013_s_1	0.09	0.15	2013 instantaneous F for commercial longline fleet
F_fleet_4_YR_2005_s_1	0.09	0.15	2005 instantaneous F for charterboat-private fleet
F_fleet_4_YR_2013_s_1	0.17	0.15	2013 instantaneous F for charterboat-private fleet
F_fleet_4_YR_2012_s_1	0.10	0.15	2012 instantaneous F for charterboat-private fleet

Table 3.2.2 Predicted total biomass (mt), mature biomass (SSB, eggs), and age-0 recruits (thousand fish), minimum stock size threshold (MSST), the ratio between SSB and MSST, fishing mortality (F), maximum fishing mortality threshold (MFMT), which is equal to F_{MSY}, and the ratio between F and MFMT for Gulf of Mexico Red Grouper from the base model run.

Year	Total biomass	SSB	Age-0 recruits	MSST	SSB/MSST	F	MFMT	F/MFMT
1986	21144.7	1156630	17910	1416320	0.95	0.21	0.16	1.32
1987	20727.8	1129980	5363.6		0.93	0.19		1.21
1988	20410.8	1139280	22718.3		0.94	0.20		1.28
1989	20365.1	1144990	17843		0.94	0.27		1.68
1990	19183.6	1050940	10184.5		0.87	0.17		1.04
1991	20302.1	1132070	8957.31		0.93	0.19		1.17
1992	20786.9	1203400	7380.53		0.99	0.21		1.31
1993	20505.6	1228180	17397.2		1.01	0.23		1.44
1994	19794.5	1187210	2905.62		0.98	0.19		1.18
1995	19569.5	1180980	29175		0.97	0.18		1.13
1996	20067.1	1182310	6233.87		0.98	0.13		0.82
1997	21133.3	1228460	2241.56		1.01	0.12		0.77
1998	21897.9	1310930	58466.6		1.08	0.10		0.65
1999	24611.1	1408770	6552.14		1.16	0.15		0.93
2000	26173.7	1430260	4292.6		1.18	0.17		1.04
2001	27042.1	1532670	32396.7		1.26	0.14		0.88
2002	28860.9	1685460	4050.1		1.39	0.14		0.88
2003	29976.9	1775000	14539.2		1.46	0.11		0.70
2004	31571.5	1909760	784.179		1.58	0.16		0.99
2005	31065.4	1925010	86737.4		1.59	0.48		2.97
2006	21545.3	1239230	21962.3		1.02	0.14		0.87
2007	23495.3	1231680	19982.6		1.02	0.10		0.65
2008	26626.1	1399270	9284.35		1.15	0.11		0.69
2009	29283.4	1633450	7049.86		1.35	0.08		0.52
2010	32017.7	1902920	5133.91		1.57	0.07		0.41
2011	34456.5	2140040	2340.96		1.77	0.08		0.51
2012	35330.1	2252710	3978.58		1.86	0.11		0.67
2013	34516.6	2222750	5271.35		1.83	0.12		0.76

Table 3.2 3 Annual fishing mortality, overall and by fleet.

		Fleet					
Year	Overall	commHL	commLL	commTrap	CBT_PR	HB	Red Tide
1986	0.21	0.20	0.23	0.05	0.15	0.02	0.00
1987	0.19	0.15	0.36	0.04	0.09	0.02	0.00
1988	0.20	0.12	0.19	0.04	0.19	0.02	0.00
1989	0.27	0.24	0.28	0.04	0.21	0.04	0.00
1990	0.17	0.19	0.23	0.03	0.18	0.02	0.00
1991	0.19	0.15	0.27	0.04	0.25	0.01	0.00
1992	0.21	0.09	0.23	0.05	0.41	0.01	0.00
1993	0.23	0.09	0.41	0.06	0.31	0.01	0.00
1994	0.19	0.08	0.26	0.08	0.25	0.01	0.00
1995	0.18	0.07	0.21	0.08	0.20	0.02	0.00
1996	0.13	0.04	0.20	0.04	0.08	0.02	0.00
1997	0.12	0.05	0.19	0.04	0.06	0.01	0.00
1998	0.10	0.04	0.15	0.02	0.09	0.01	0.00
1999	0.15	0.06	0.22	0.04	0.16	0.01	0.00
2000	0.17	0.08	0.18	0.06	0.27	0.01	0.00
2001	0.14	0.08	0.22	0.04	0.17	0.01	0.00
2002	0.14	0.07	0.19	0.06	0.18	0.00	0.00
2003	0.11	0.05	0.17	0.03	0.14	0.01	0.00
2004	0.16	0.05	0.19	0.04	0.24	0.01	0.00
2005	0.48	0.05	0.17	0.03	0.09	0.01	0.44
2006	0.14	0.06	0.17	0.03	0.11	0.01	0.00
2007	0.10	0.07	0.12	0.00	0.12	0.01	0.00
2008	0.11	0.09	0.16	0.00	0.11	0.01	0.00
2009	0.08	0.12	0.06	0.00	0.13	0.01	0.00
2010	0.07	0.06	0.07	0.00	0.10	0.01	0.00
2011	0.08	0.06	0.15	0.00	0.05	0.00	0.00
2012	0.11	0.05	0.11	0.00	0.10	0.01	0.00
2013	0.12	0.03	0.09	0.00	0.17	0.01	0.00

Table 3.2.4 Likelihood values for the data components for each sensitivity run.

Run	Model	Data component	Total	commHL	comm LL	comm Trap	CBT_ PR	HB	Red Tide	Video	SEAMAP-GF	NMFS BLL	CBT_ PRSurv
0	Base	Age_like:	1451.0	352.0	283.6	143.6	459.4	212.4	0	0	0	0	0
1	low M	Age_like:	1449.4	351.6	283.2	143.5	459.0	212.2	0	0	0	0	0
2	high M	Age_like:	1452.2	352.3	284.4	143.7	459.3	212.4	0	0	0	0	0
3	low steepness	Age_like:	1451.0	351.9	283.8	143.5	459.4	212.4	0	0	0	0	0
4	high steepness	Age_like:	1450.9	352.0	283.5	143.6	459.4	212.5	0	0	0	0	0
5	Upweight discards	Age_like:	1709.4	433.9	433.8	147.9	476.2	217.6	0	0	0	0	0
6	Upweight recent discards	Age_like:	1523.1	380.6	314.5	145.0	467.9	215.1	0	0	0	0	0
7	Asymptotic selectivity NFMS_BLL	Age_like:	1452.3	351.9	284.7	143.6	459.4	212.7	0	0	0	0	0
0	Base	Catch_like:	3.7	1.0	2.1	0.1	0.1	0.3	0	0	0	0	0
1	low M	Catch_like:	3.8	1.1	2.2	0.1	0.1	0.3	0	0	0	0	0
2	high M	Catch_like:	3.4	1.0	1.9	0.1	0.1	0.3	0	0	0	0	0
3	low steepness	Catch_like:	3.7	1.0	2.1	0.1	0.1	0.3	0	0	0	0	0
4	high steepness	Catch_like:	3.7	1.0	2.1	0.1	0.1	0.3	0	0	0	0	0
5	Upweight discards	Catch_like:	22.5	8.4	9.0	1.9	1.0	2.1	0	0	0	0	0
6	Upweight recent discards	Catch_like:	20.0	6.6	10.2	0.5	0.9	1.9	0	0	0	0	0
7	Asymptotic selectivity NFMS_BLL	Catch_like:	3.7	1.0	2.1	0.1	0.1	0.3	0	0	0	0	0
0	Base	Disc_like:	310.7	108.8	187.1	14.3	-7.0	7.5	0	0	0	0	0
1	low M	Disc_like:	311.5	108.9	187.3	14.9	-7.2	7.6	0	0	0	0	0
2	high M	Disc_like:	307.4	108.4	186.4	13.2	-7.1	6.5	0	0	0	0	0
3	low steepness	Disc_like:	311.3	108.8	187.1	14.3	-6.8	7.8	0	0	0	0	0
4	high steepness	Disc_like:	310.4	108.8	187.0	14.3	-7.1	7.4	0	0	0	0	0
5	Upweight discards	Disc_like:	481.3	207.8	223.4	30.9	-5.2	24.3	0	0	0	0	0
6	Upweight recent discards	Disc_like:	436.8	172.3	246.0	9.8	-9.5	18.0	0	0	0	0	0
7	Asymptotic selectivity NFMS_BLL	Disc_like:	310.8	108.8	187.1	14.3	-6.9	7.6	0	0	0	0	0
0	Base	Length_like:	1085.8	161.4	170.6	0.0	83.3	105.4	0	110.6	201.8	252.7	0
1	low M	Length_like:	1082.9	161.0	170.2	0.0	83.6	105.3	0	110.4	200.9	251.5	0
2	high M	Length_like:	1121.2	162.4	171.8	0.0	83.4	105.2	0	110.5	234.0	253.9	0
3	low steepness	Length_like:	1085.3	161.3	170.6	0.0	83.2	105.2	0	110.6	201.6	252.7	0
4	high steepness	Length_like:	1085.9	161.4	170.7	0.0	83.3	105.4	0	110.5	201.9	252.7	0
5	Upweight discards	Length_like:	1433.5	281.9	400.9	0.0	80.4	111.3	0	108.1	205.2	245.8	0

6	Upweight recent discards	Length_like:	1173.6	193.0	214.2	0.0	80.2	112.8	0	112.7	208.5	252.1	0
7	Asymptotic selectivity NFMS_BLL	Length_like:	1085.4	161.4	170.6	0.0	83.2	105.3	0	110.5	201.7	252.6	0
0	Base	Surv_like:	-164.0	-11.9	-18.4	0.0	0.0	-17.6	-73.7	-14.7	-4.2	-5.0	-18.5
1	low M	Surv_like:	-164.8	-11.8	-18.5	0.0	0.0	-17.3	-73.7	-14.7	-4.4	-5.4	-19.1
2	high M	Surv_like:	-162.3	-12.0	-18.3	0.0	0.0	-18.0	-73.7	-14.7	-4.1	-4.2	-17.3
3	low steepness	Surv_like:	-163.8	-11.8	-18.4	0.0	0.0	-17.3	-73.7	-14.9	-4.1	-4.8	-18.8
4	high steepness	Surv_like:	-164.0	-12.0	-18.4	0.0	0.0	-17.7	-73.7	-14.7	-4.2	-5.0	-18.3
5	Upweight discards	Surv_like:	-166.5	-12.7	-18.6	0.0	0.0	-19.2	-73.7	-16.0	-4.6	-4.7	-16.9
6	Upweight recent discards	Surv_like:	-162.3	-9.6	-18.6	0.0	0.0	-14.6	-73.7	-14.0	-5.0	-6.5	-20.4
7	Asymptotic selectivity NFMS_BLL	Surv_like:	-163.9	-11.9	-18.4	0.0	0.0	-17.6	-73.7	-14.8	-4.2	-4.9	-18.5

Table 3.2.5 Summary of sensitivity runs. The results include estimated virgin recruitment (thousand fish; R0), virgin total biomass (mt; B0), total biomass in final year (mt; B2013), virgin spawning biomass (eggs; SSB0), spawning biomass in final year (eggs; SSB-2013), spawning biomass achieved at MSY (SSB_MSY), fishing mortality in 2013 (F2013), fishing mortality achieved at MSY (F_MSY), the ratio of F2013 and F_MSY, minimum spawning stock threshold (MSST), and the ratio of SSB and MSST.

Run	Model	R0	B0	B2013	SSB0	SSB2013	SSB_MSY	F2013	F_MSY	F/F_MSY	MSST	SSB/MSST
0	Base	15833.9	88350.3	34516.6	4.02E+06	2.22E+06	1.42E+06	0.13	0.160043	0.817643	1.22E+06	1.82E+00
1	low M	11303	99234.8	31910	4.22E+06	2.06E+06	1.50E+06	0.130858	0.152182	0.859878	1.29E+06	1.60E+00
2	high M	30846.1	78346.5	40991.6	3.89E+06	2.62E+06	1.36E+06	0.101834	0.171161	0.59496	1.17E+06	2.24E+00
3	low steepness	17218.7	96077.1	33643.5	4.37E+06	2.17E+06	1.68E+06	0.12389	0.126604	0.978563	1.44E+06	1.50E+00
4	high steepness	14846.4	82840.3	35008.2	3.77E+06	2.25E+06	1.19E+06	0.119219	0.20051	0.594579	1.02E+06	2.21E+00
5	Upweight discards	17300	96530.8	32592.6	4.39E+06	2.09E+06	1.51E+06	0.134786	0.163063	0.826588	1.30E+06	1.60E+00
6	Upweight recent discards	16613.3	92699.1	34800.1	4.22E+06	2.24E+06	1.48E+06	0.125734	0.166162	0.756695	1.27E+06	1.77E+00
7	Asymptotic selectivity NFMS_BLL	15985	89193.5	34407.9	4.06E+06	2.22E+06	1.41E+06	0.121216	0.163763	0.740192	1.22E+06	1.82E+00

Table 3.2. 6 Estimates of key population parameters from the jack-knife analysis of indices of abundance.

Parameter	Base	No_commHL	No_commLL	No_HB	No_CBT_PRSurv	No_Video	No_SEAMAP_GF	No_NMFS_BLL
SR_LN(R0)	9.69197	9.71233	9.72768	9.69684	9.73454	9.68229	9.71466	9.6794
SR_BH_steep	0.811118	0.826445	0.83691	0.815204	0.839927	0.811591	0.819052	0.799961
SR_sigmaR	1.01222	0.899639	0.893099	0.906837	0.951769	0.972815	1.03534	1.01334
SR_R1_offset	-0.0681964	-0.0841788	-0.101037	-0.0705069	-0.109375	-0.0561492	-0.0854636	-0.0467304
SPB_Virgin	4.11E+06	4.19E+06	4.26E+06	4.13E+06	4.29E+06	4.07E+06	4.20E+06	4.06E+06
SPB_Initial	1.52E+06	1.58E+06	1.57E+06	1.57E+06	1.54E+06	1.57E+06	1.58E+06	1.63E+06
Recr_Virgin	16187.1	16520	16775.6	16266.1	16891.1	16031.1	16558.6	15984.8
Recr_Initial	15120	15186.3	15163.5	15158.7	15141.1	15155.8	15202.2	15255
TotBio_Unfished	90321.1	92178.7	93604.6	90761.7	94249.3	89450.6	92393.7	89192.3
SSB_MSY	1.44E+06	1.48E+06	1.49E+06	1.45E+06	1.49E+06	1.44E+06	1.47E+06	1.47E+06
TotYield_MSY	4000.59	4156.9	4241.07	4126.63	4154.14	3995.33	4135.86	3913.51
RetYield_MSY	3430.84	3527.96	3584.44	3581.05	3392.11	3416.72	3517.51	3304.11

Table 3.2.7. Preliminary results from projections.

Criteria	Definition	Value
Base M		0.144
Steepness		0.801
Virgin Recruitment		15833.9
SSB unfished		4017750
	Mortality rate criteria	
Fmsy or proxy	Fmsy	0.1600
MFMT	Fmsy	0.1600
Foy	75% of Fmsy	0.1200
Fcurrent	F2013	0.1209
Fcurrent/MFMT	F2013	0.7554
	Biomass criteria	
SSBmsy	SSB at Fmsy	1416320
MSST	(1-M)*SSBmsy	1212370
SSBcurrent	SSB2013	2222750
SSBcurrent/MSST	SSB2013	1.83
Equilibrium MSY	Equilibrium yield at Fmsy	3329.33
Equilibrium OY	Equilibrium yield at Foy	2497.00
OFL	**Annual yield at MFMT**	
	OFL 2014	3946.13
	OFL 2015	6263.09
	OFL 2016	4835.98
	OFL 2017	3700.32
	OFL 2018	2885.36
	OFL 2019	2499.72
	OFL 2020	2503.59
Annual OY	**Annual yield at Foy**	
	OY2014	3946.13
	OY2015	4839.32
	OY2016	3962.91
	OY2017	3194.04
	OY2018	2596.36
	OY2019	2295.19
	OY2020	2286.2
Annual Yield	**Annual yield at Fcurrent**	
	Y 2014	3946.13
	Y 2015	3961.65
	Y 2016	3358.72
	Y 2017	2792.16
	Y 2018	2327.98
	Y 2019	2086.98
	Y 2020	2078.44

3.7 Figures

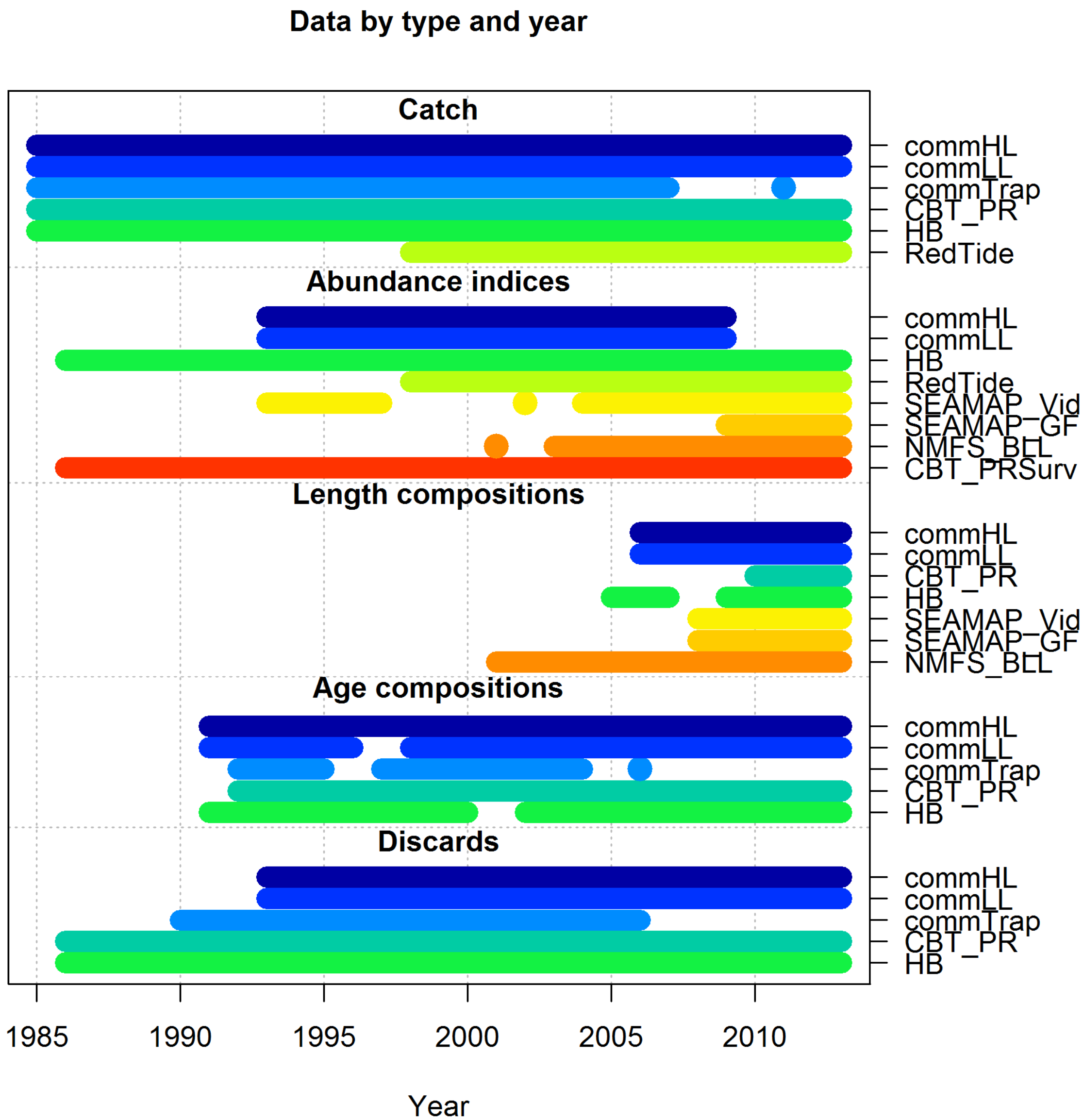


Figure 3.1.1 Data inputs for SEDAR 42 base model.

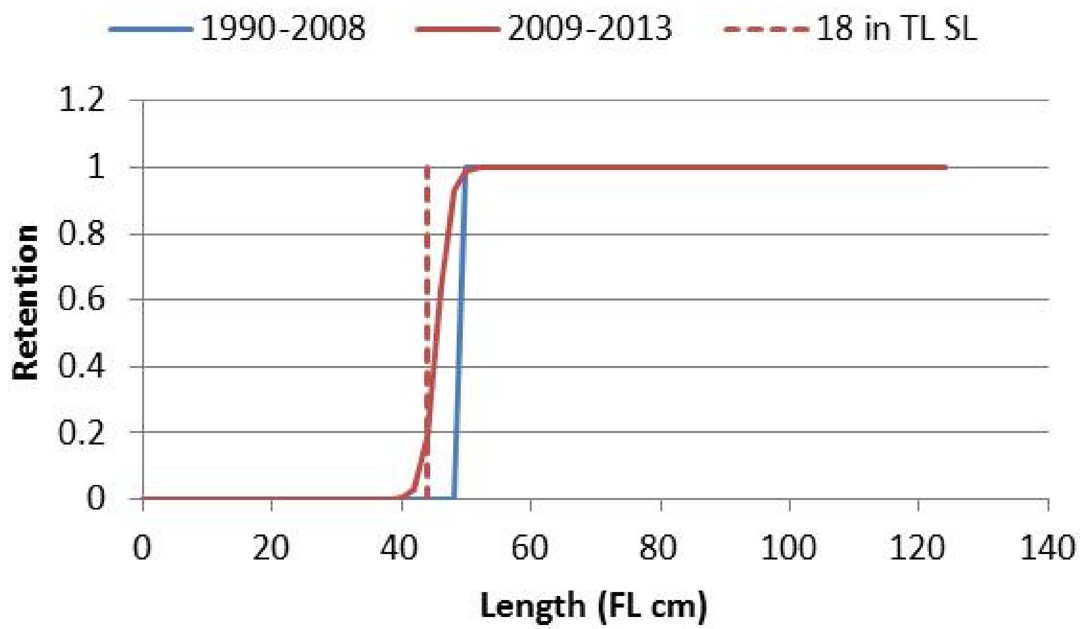


Figure 3.1 2 The commercial handline retention patterns. The 1990-2008 retention pattern was fixed, whereas the 2009-2013 retention pattern was estimated.

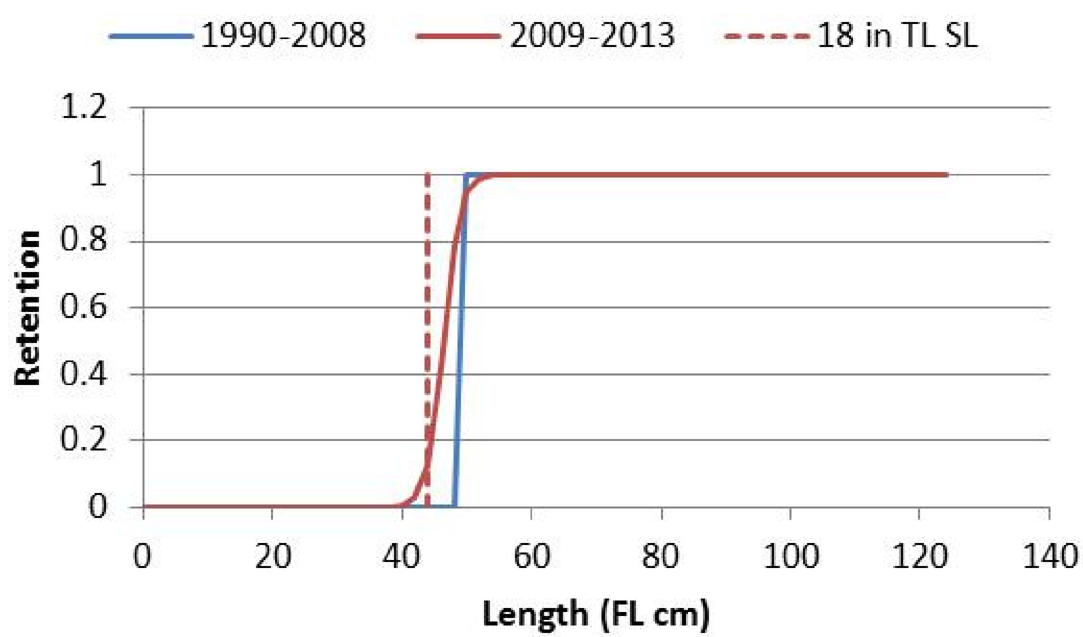


Figure 3.1 3 The commercial longline retention patterns. The 1990-2008 retention pattern was fixed, whereas the 2009-2013 retention pattern was estimated.

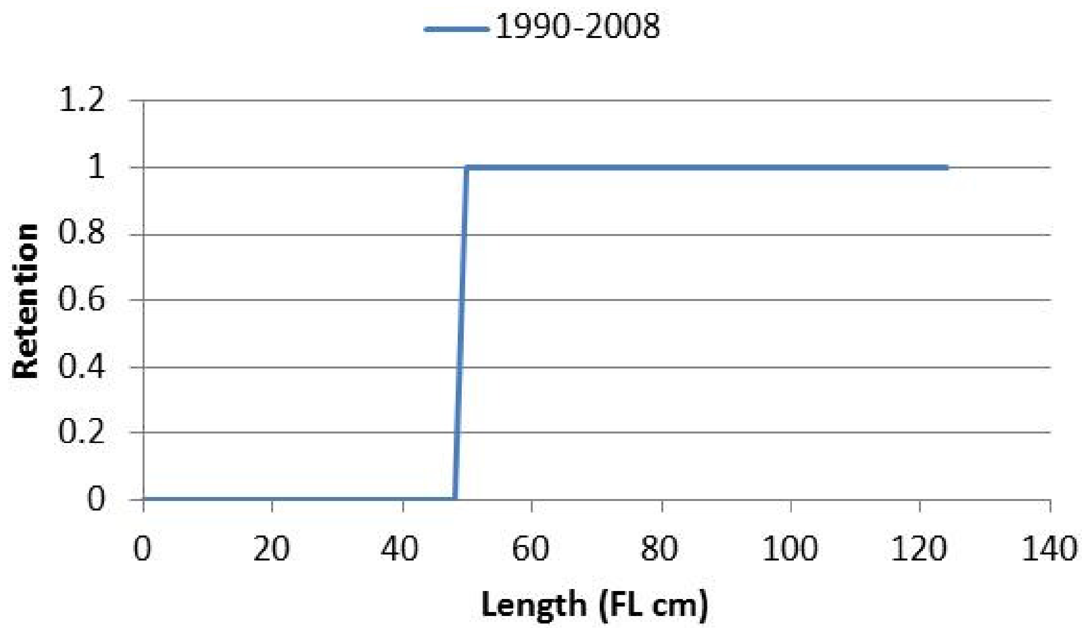


Figure 3.1 4 The commercial trap retention pattern. This pattern was fixed.

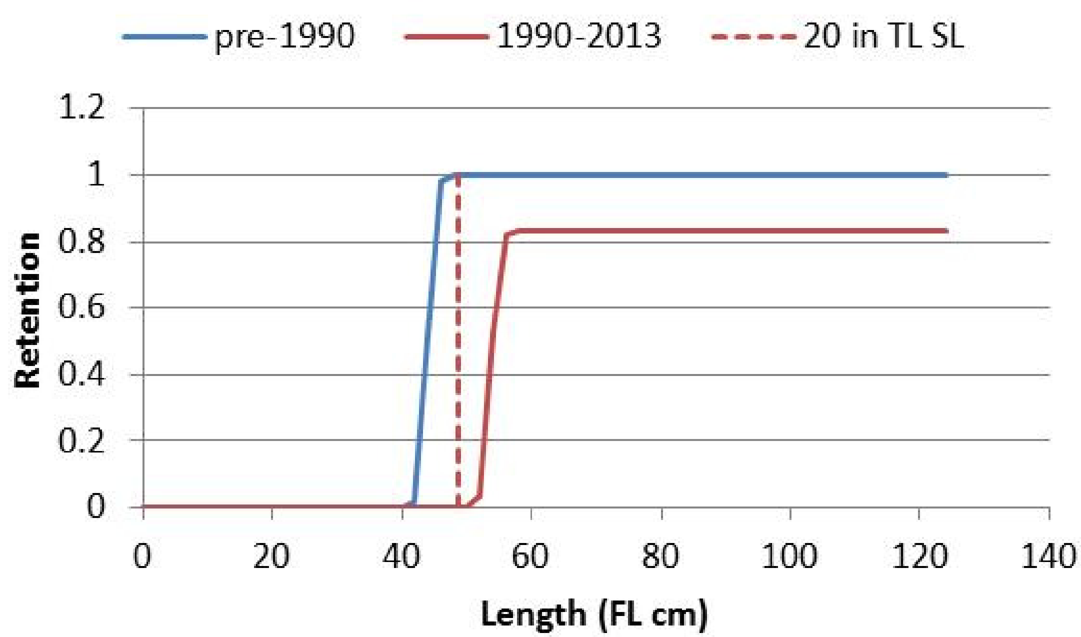


Figure 3.1 5 The recreational charterboat-private mode retention pattern. The pre-1990 retention pattern was fixed, whereas the 1990-2013 retention pattern was estimated.

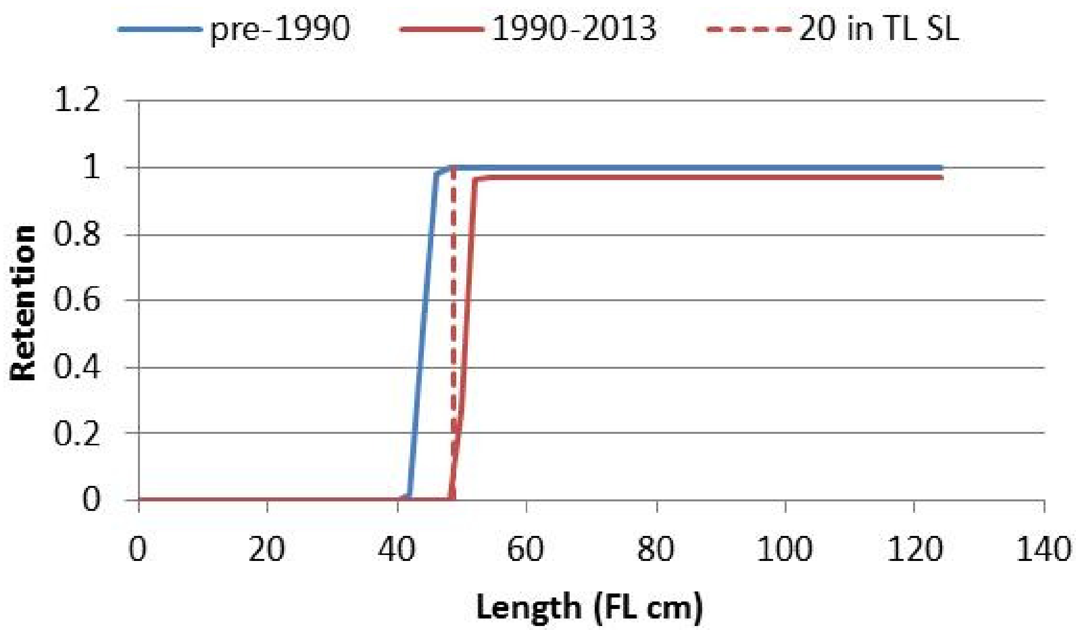


Figure 3.1 6 The recreational headboat retention pattern. The pre-1990 retention pattern was fixed, whereas the 1990-2013 retention pattern was estimated.

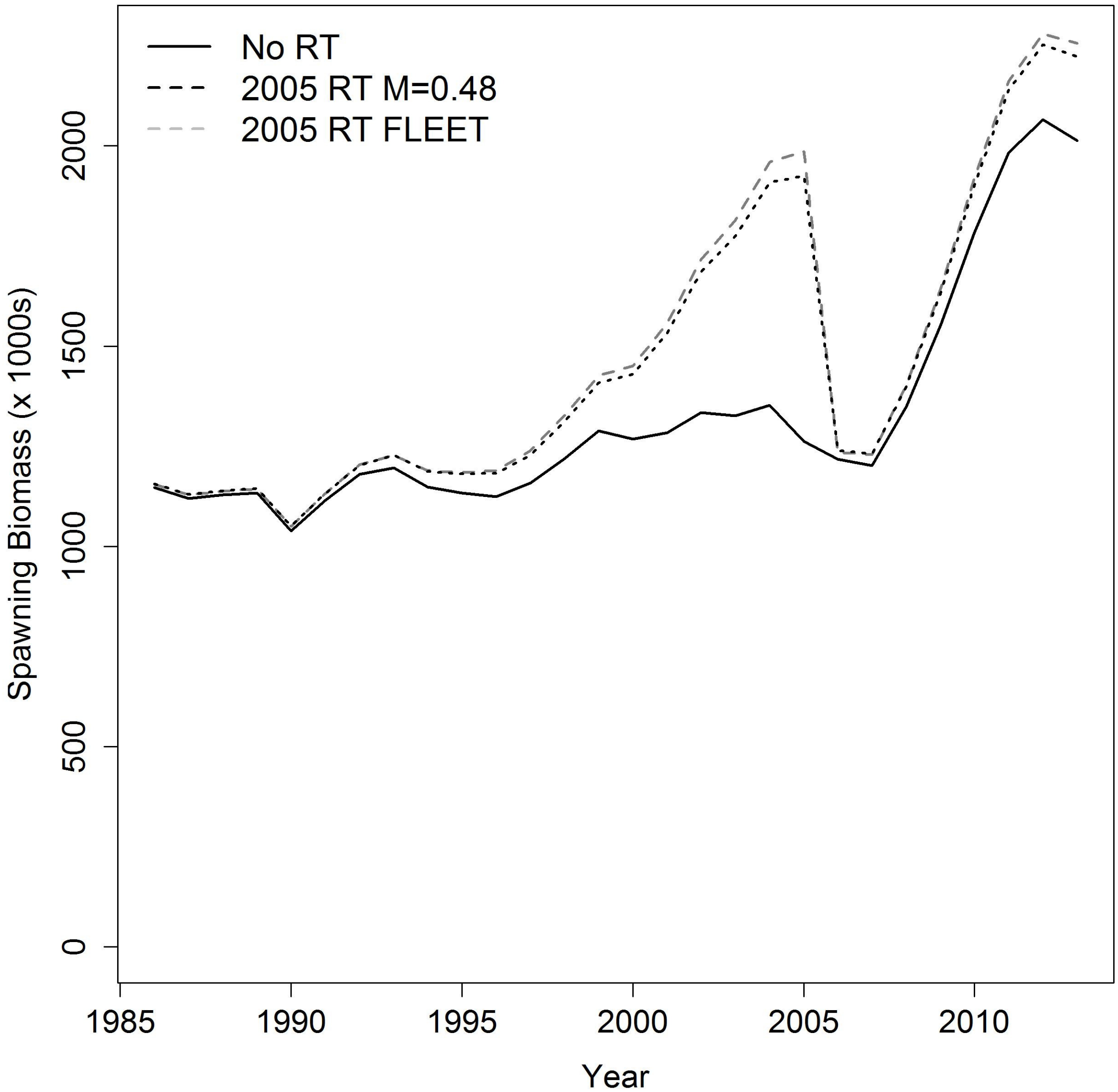


Figure 3.1.7 Comparison of annual estimates of spawning stock biomass (SSB in 1000s of eggs) for Gulf of Mexico Red Grouper derived from a model with no red tide (No RT), a model with an episodic red tide mortality estimate of 0.48 in 2005 (2005 RT M=0.48), and a model with red tide treated as a fishing fleet (2005 RT FLEET).

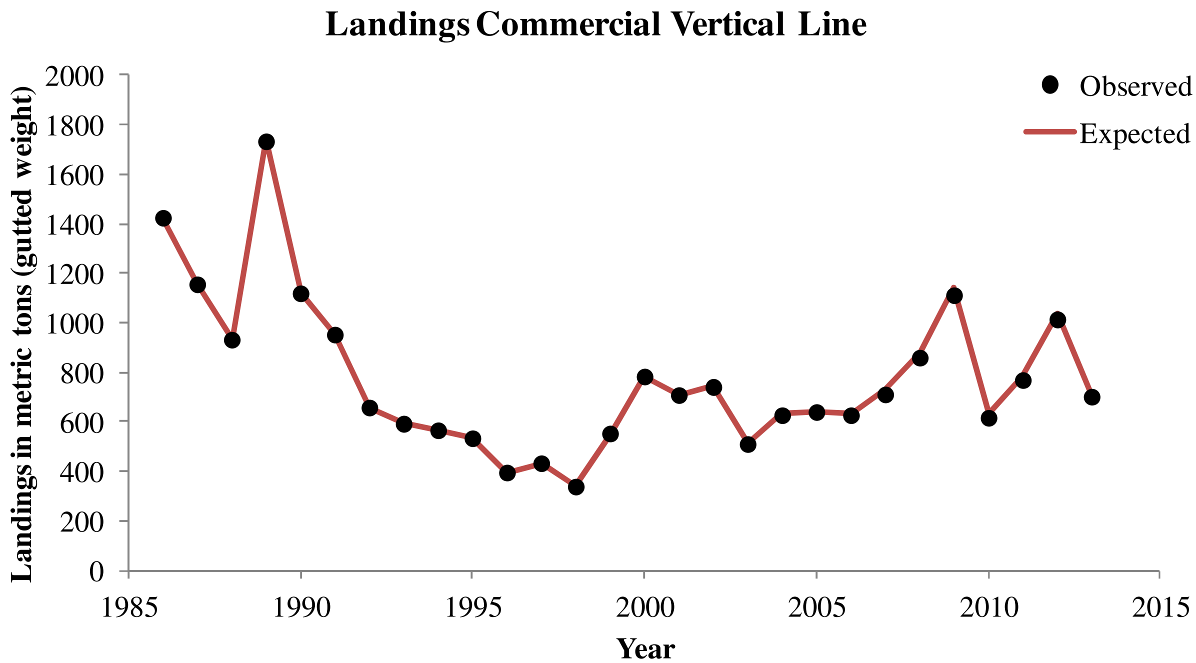


Figure 3.2.1 Observed (black dots) and predicted landings (red line) (mt) of Gulf of Mexico Red Grouper from the commercial vertical line fishing fleet, 1986-2013.

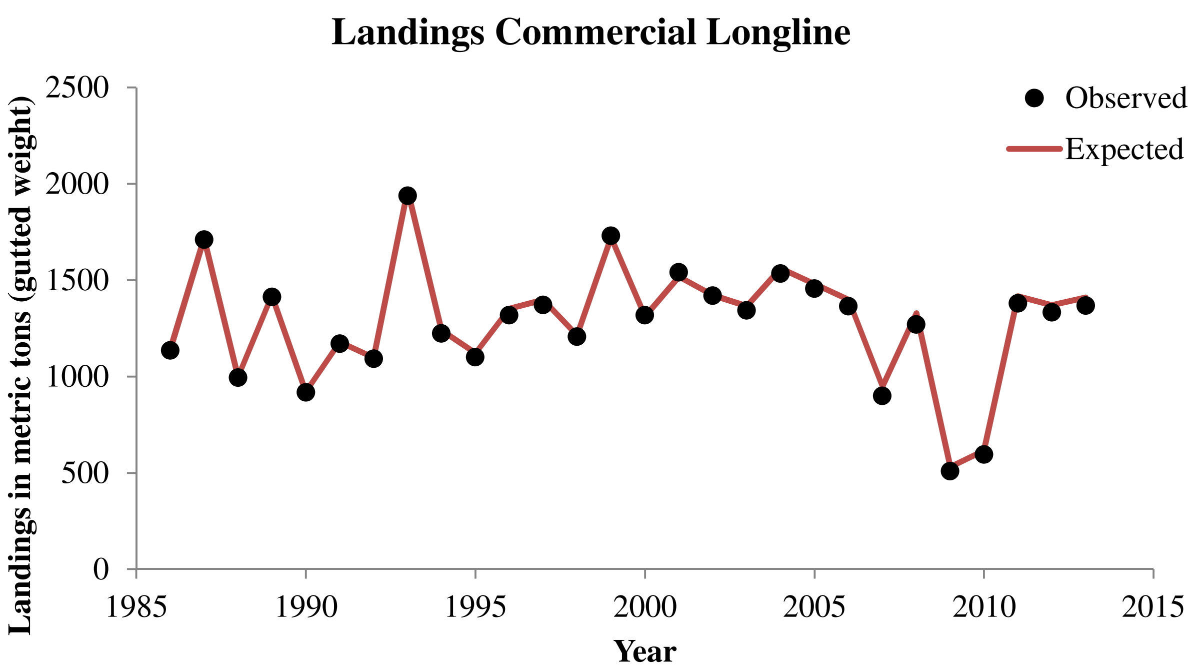


Figure 3.2.2 Observed (black dots) and predicted landings (red line) (mt) of Gulf of Mexico Red Grouper from the commercial longline fishing fleet, 1986-2013.

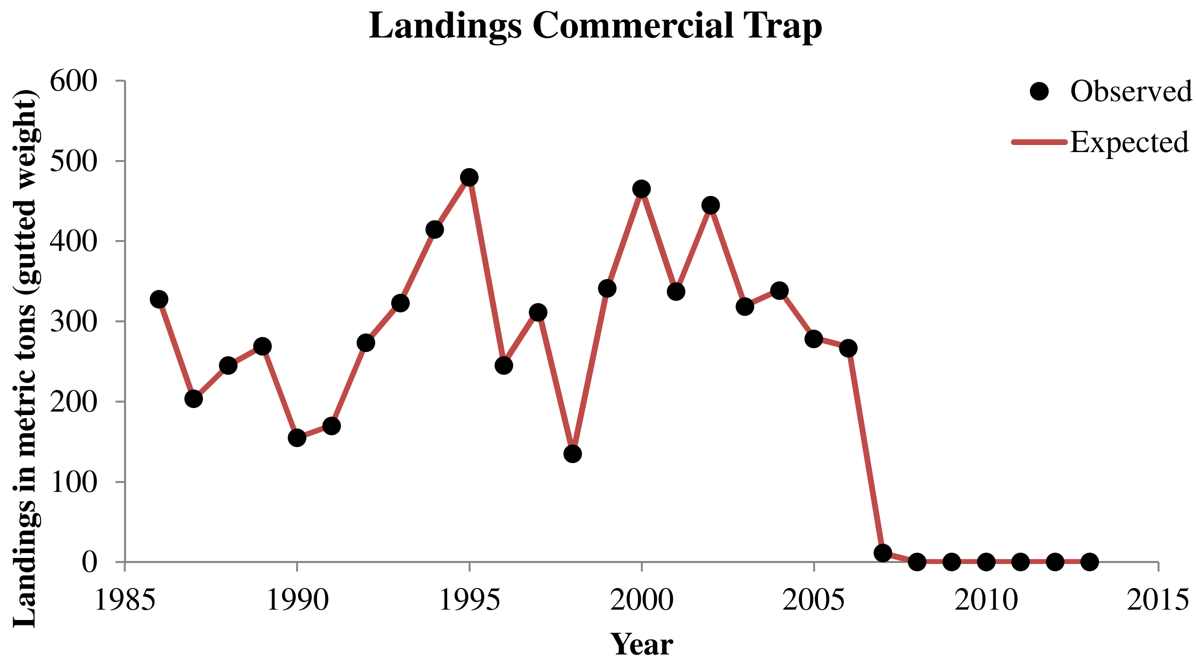


Figure 3.2.3 Observed (black dots) and predicted landings (red line) (mt) of Gulf of Mexico Red Grouper from the commercial trap fishing fleet, 1986-2013.

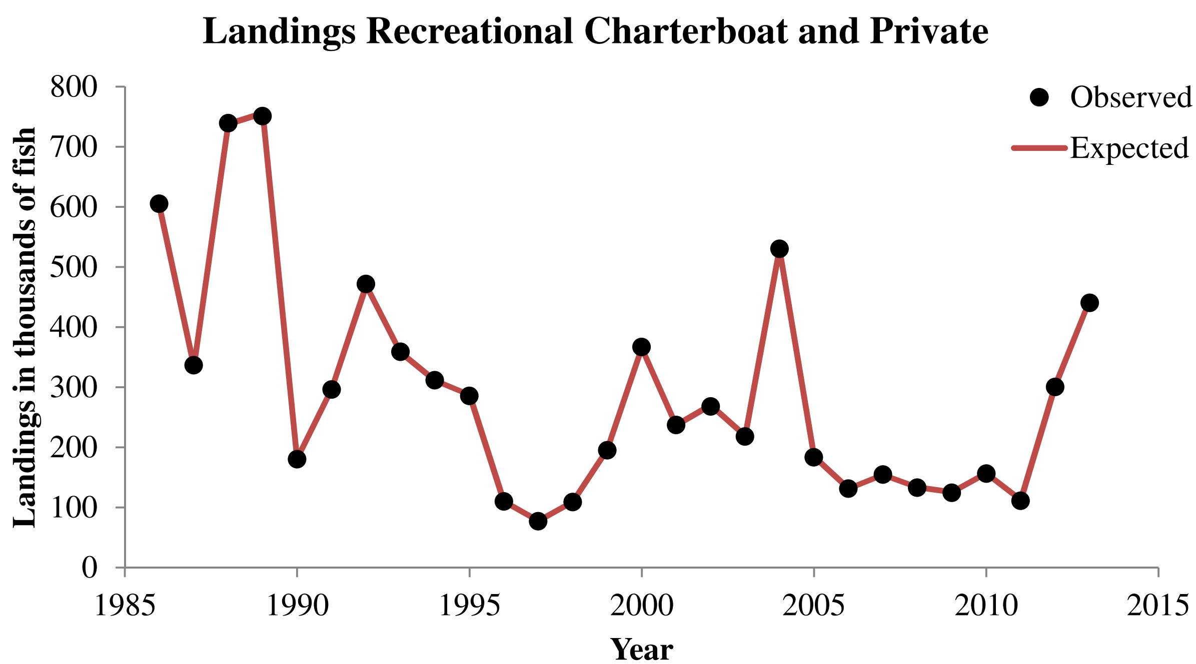


Figure 3.2.4 Observed (black dots) and predicted landings (red line) (thousands of fish) of Gulf of Mexico Red Grouper from the combined recreational charterboat and private fishing fleet, 1986-2013.

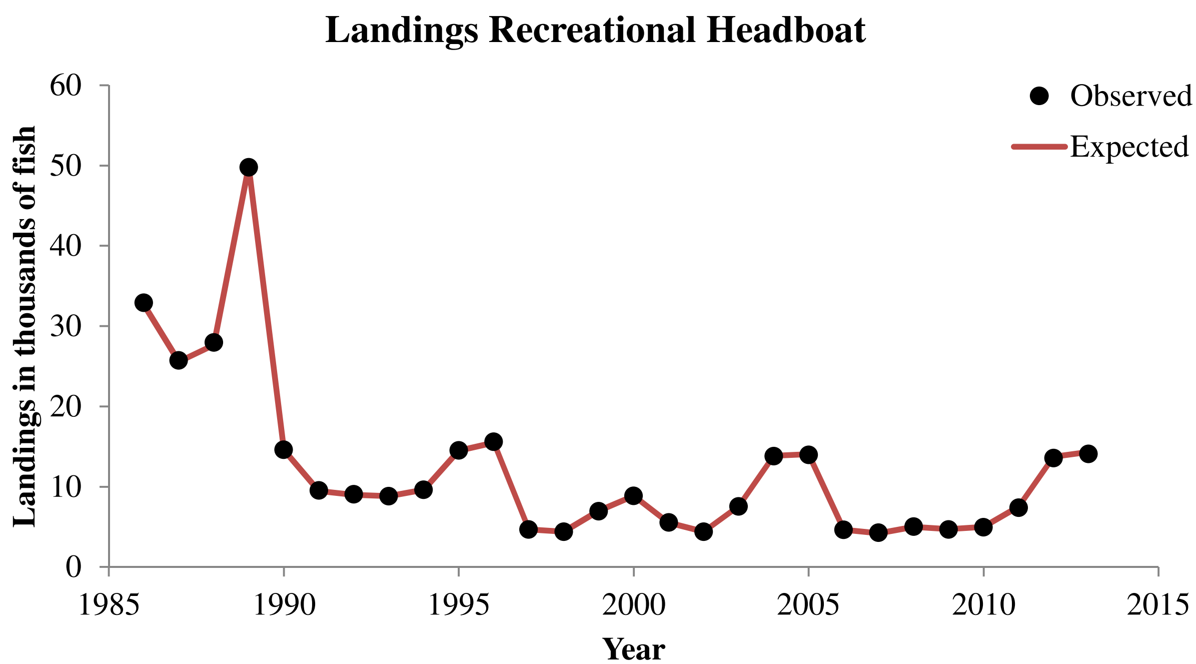


Figure 3.2.5 Observed (black dots) and predicted landings (red line) (thousands of fish) of Gulf of Mexico Red Grouper from the recreational headboat fishing fleet, 1986-2013.

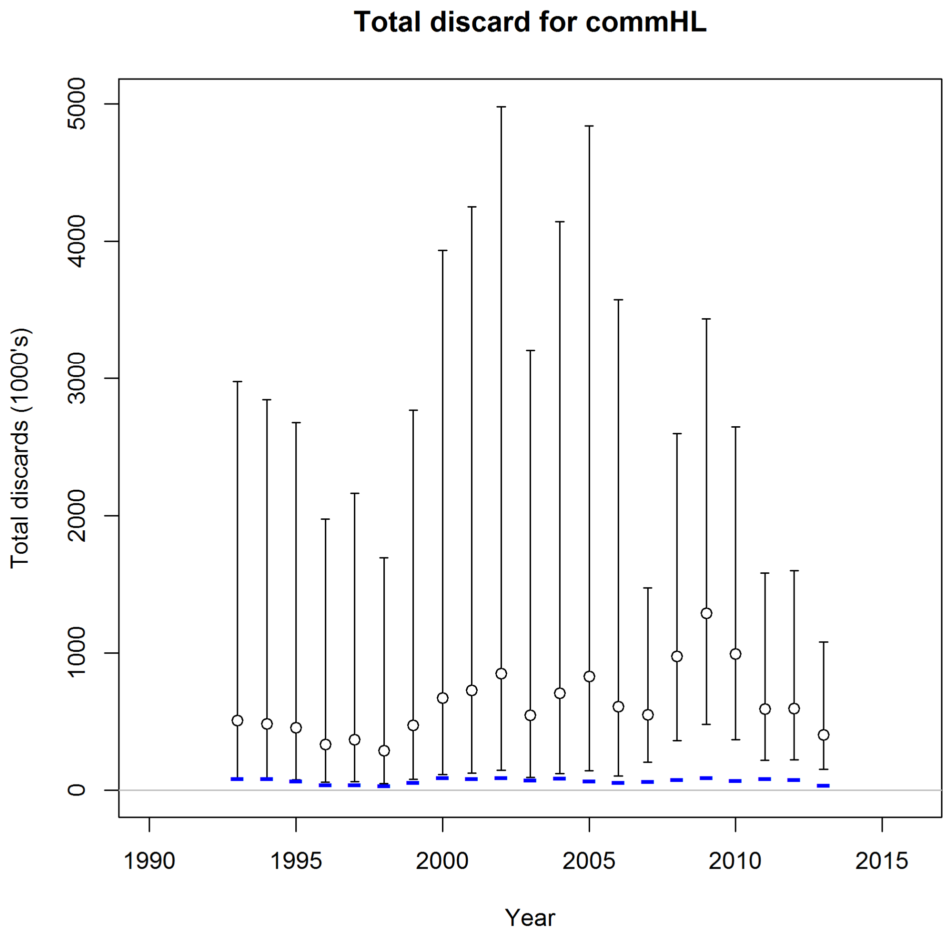


Figure 3.2.6 Observed (open circles) and predicted discards (blue dashes) (thousands of fish) of Gulf of Mexico Red Grouper from the commercial vertical line fishing fleet, 1993-2013.

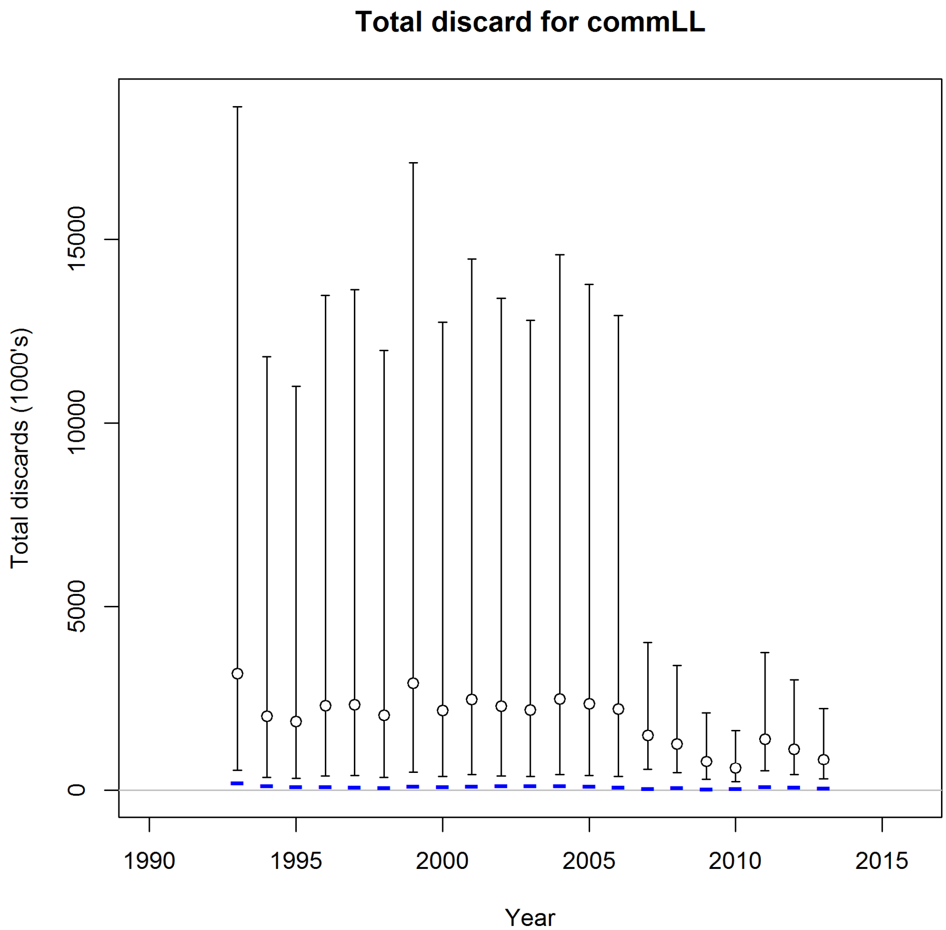


Figure 3.2.7 Observed (open circles) and predicted discards (blue dashes) (thousands of fish) of Gulf of Mexico Red Grouper from the commercial longline fishing fleet, 1993-2013.

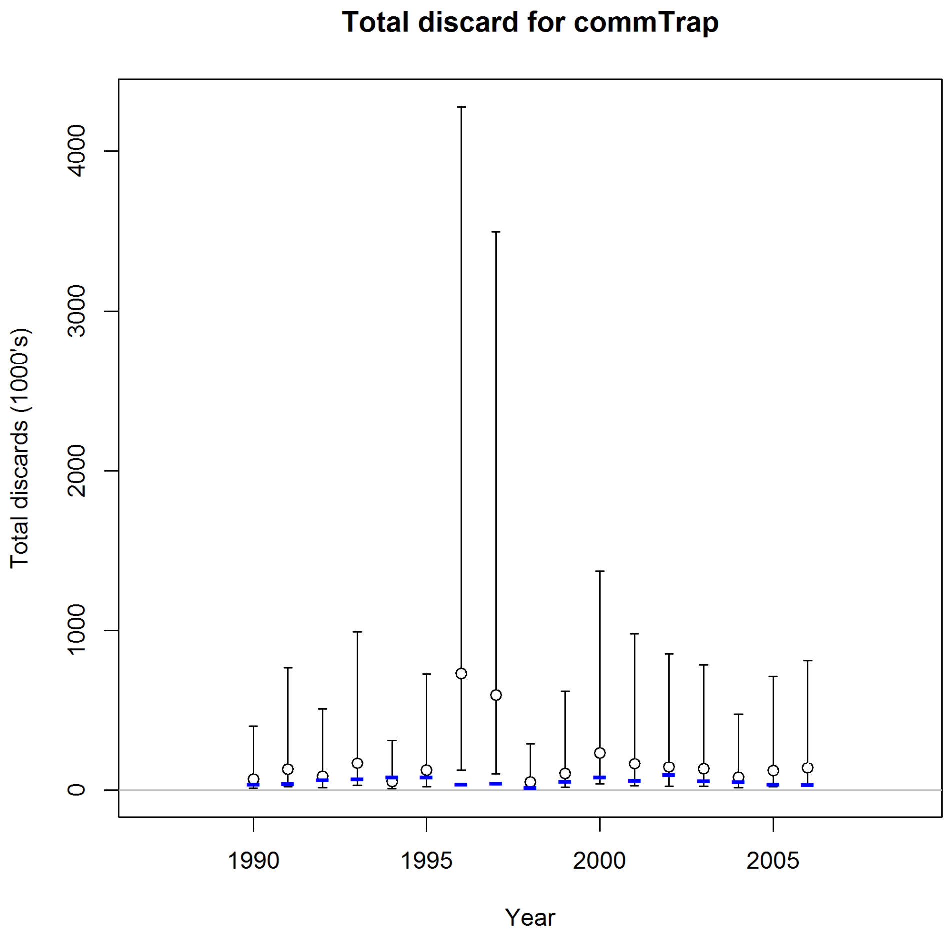


Figure 3.2.8 Observed (open circles) and predicted discards (blue dashes) (thousands of fish) of Gulf of Mexico Red Grouper from the commercial trap fishing fleet, 1990-2006.

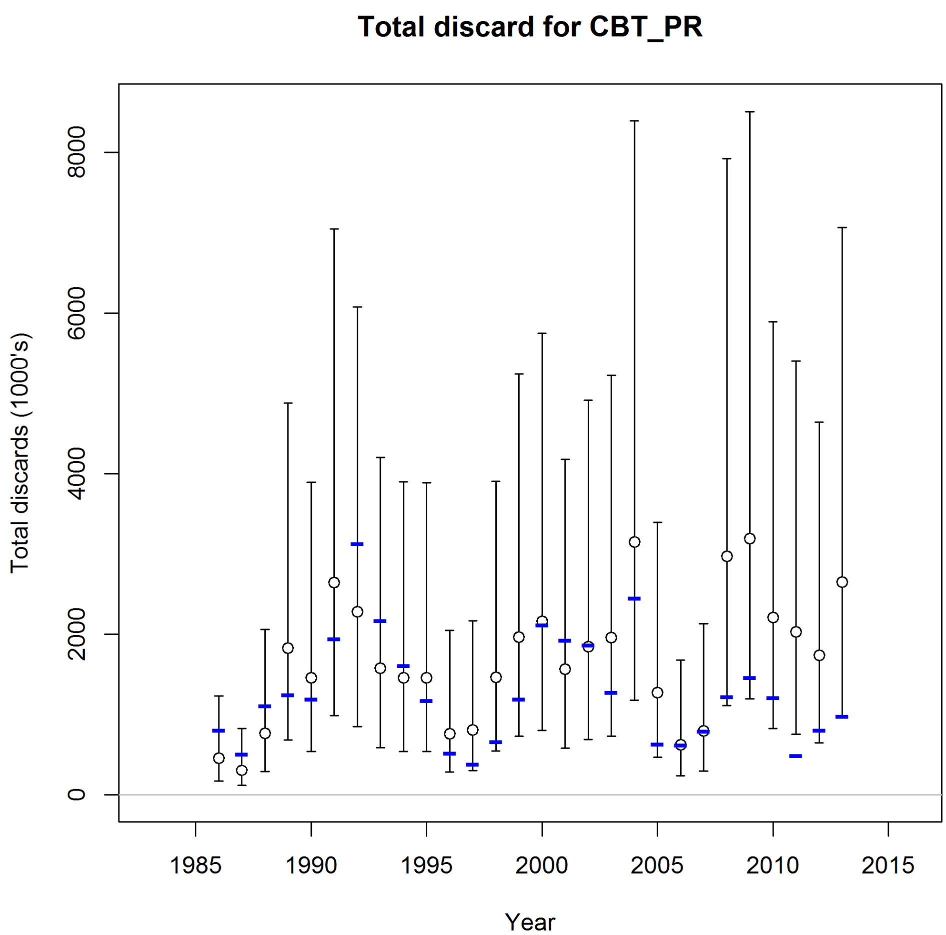


Figure 3.2.9 Observed (open circles) and predicted discards (blue dashes) (thousands of fish) of Gulf of Mexico Red Grouper from the combined recreational charterboat and private fishing fleet, 1986-2013.

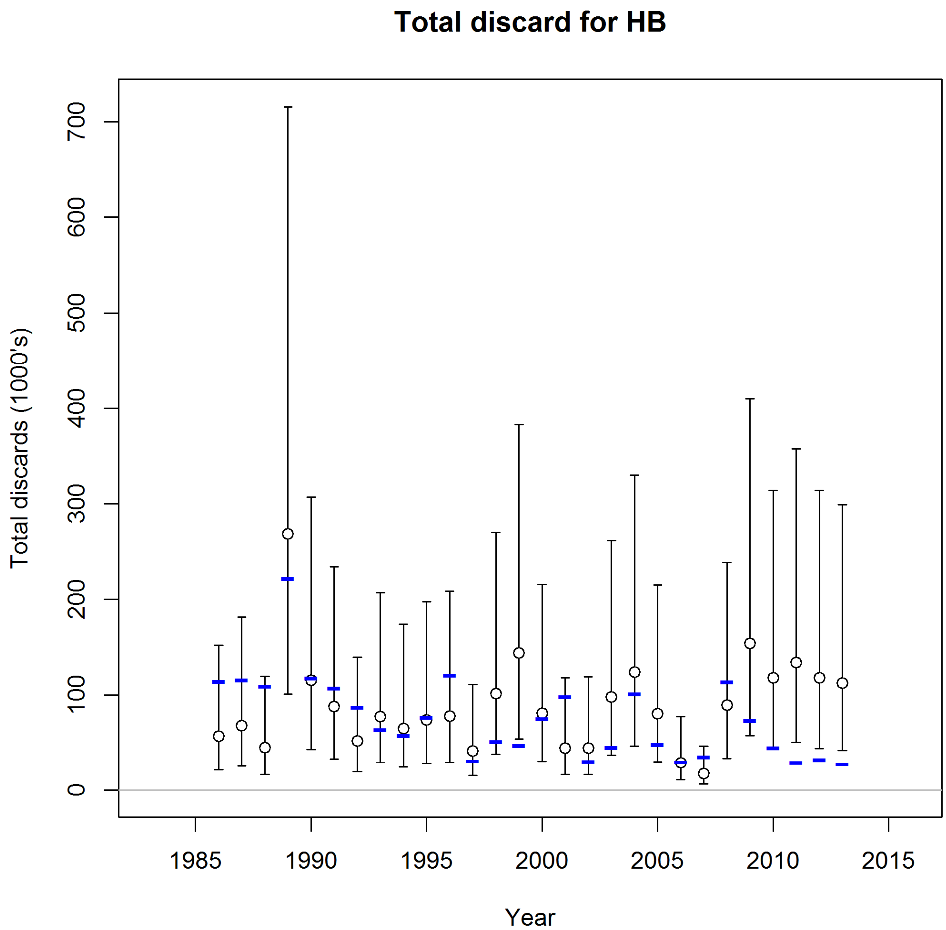


Figure 3.2.10 Observed (open circles) and predicted discards (blue dashes) (thousands of fish) of Gulf of Mexico Red Grouper from the recreational headboat fishing fleet, 1986-2013.

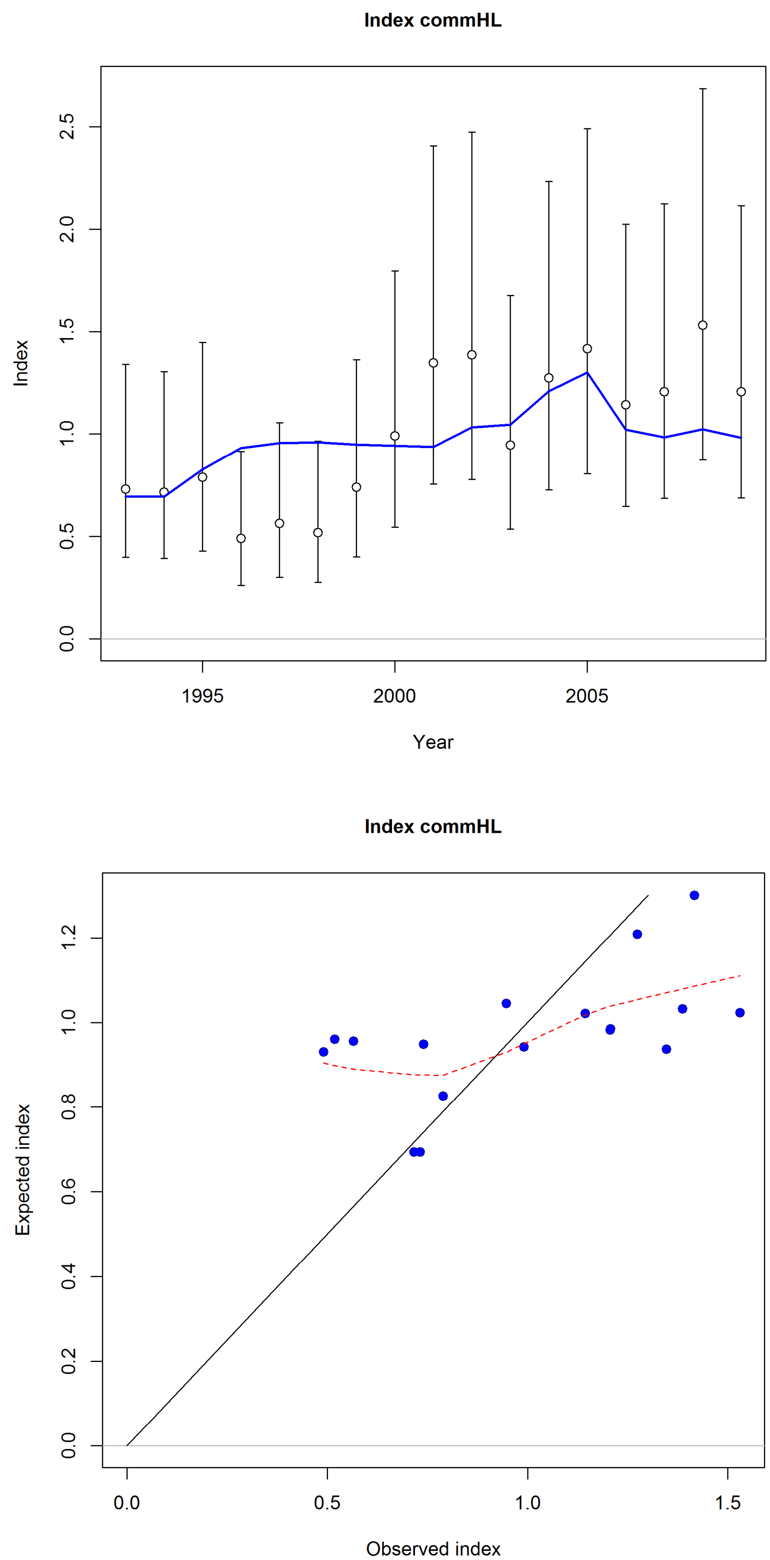


Figure 3.2.11 Model fit (blue line) to the standardized commercial vertical line CPUE index (open circles), 1993-2009 (top panel). The bottom panel also shows a comparison of the observed and predicted indices, where the black line is the 1:1 line.

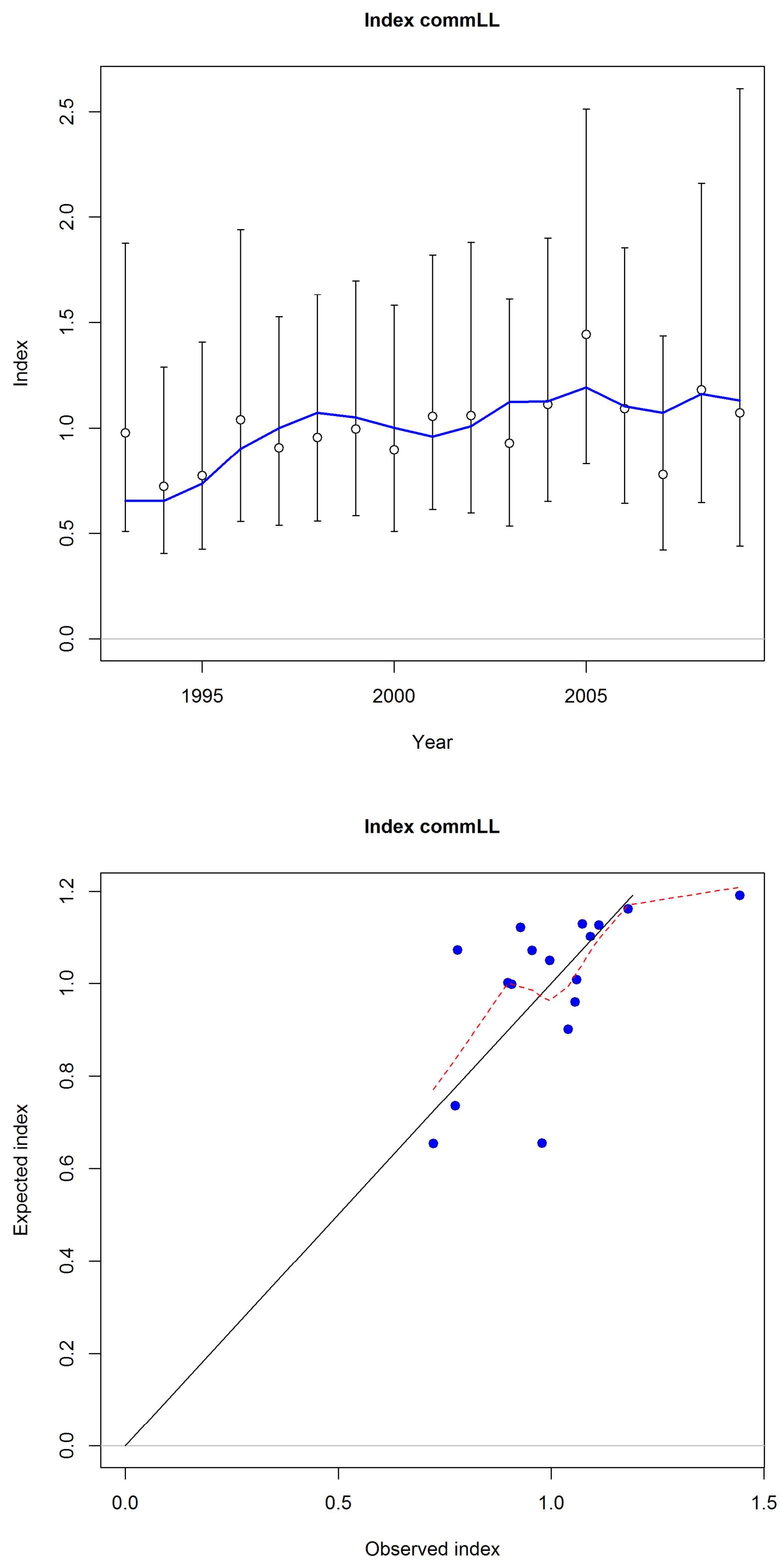


Figure 3.2.12 Model fit (blue line) to the standardized commercial longline CPUE index (open circles), 1993-2009 (top panel). The bottom panel also shows a comparison of the observed and predicted indices, where the black line is the 1:1 line.

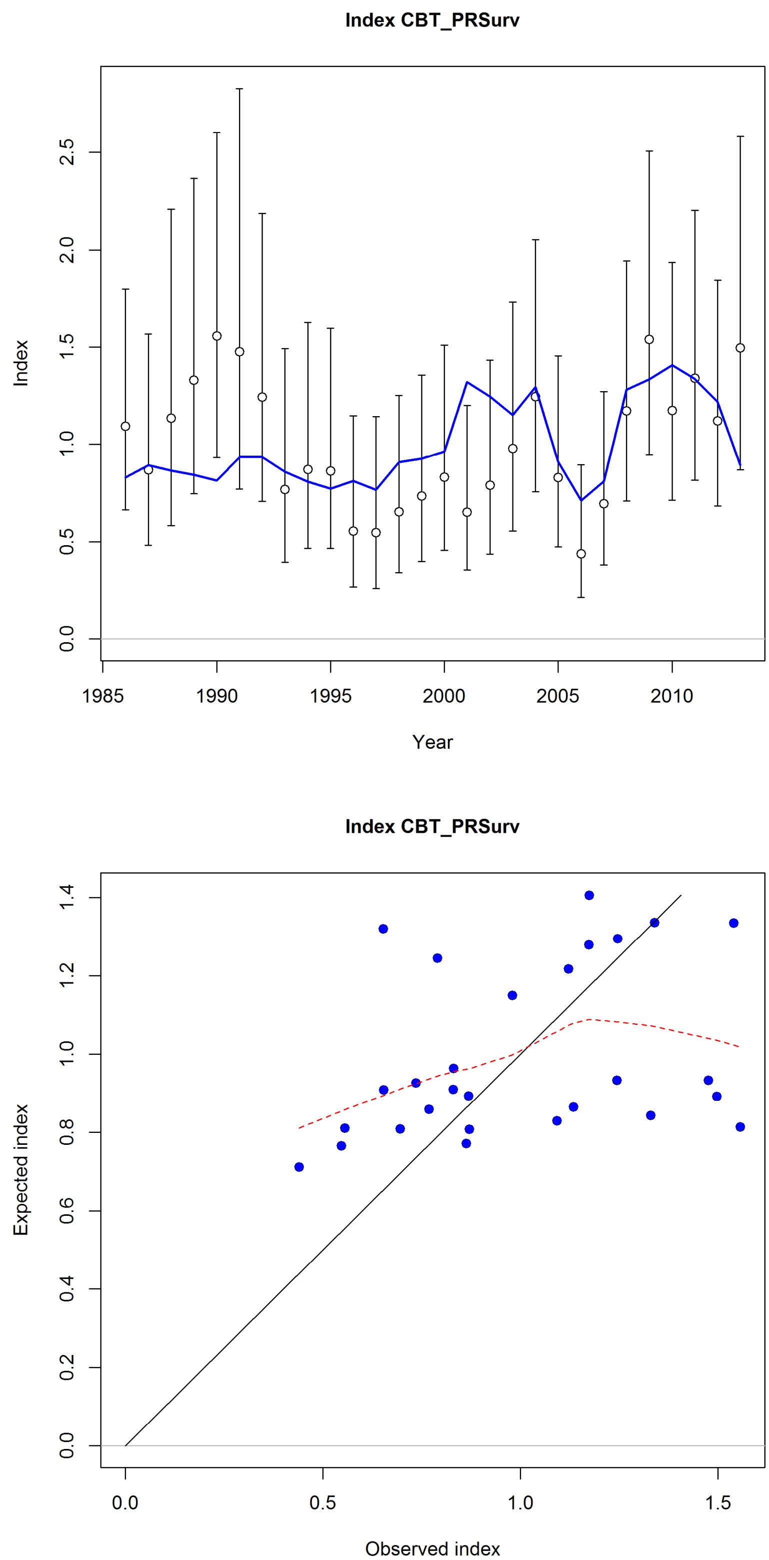


Figure 3.2.13 Model fit (blue line) to the standardized combined recreational charterboat and private CPUE index (open circles), 1986-2013 (top panel). The bottom panel also shows a comparison of the observed and predicted indices, where the black line is the 1:1 line.

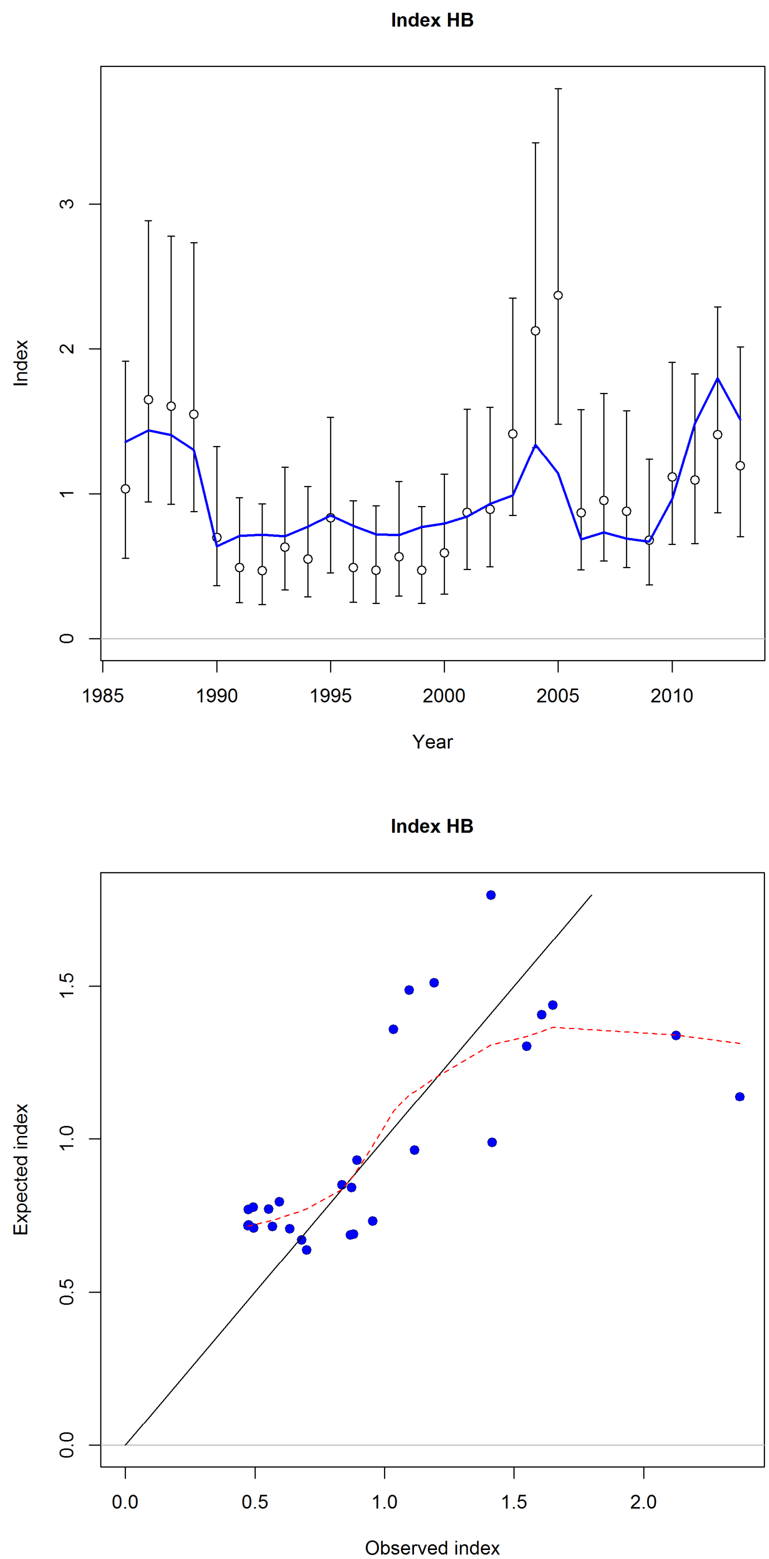


Figure 3.2.14 Model fit (blue line) to the standardized recreational headboat CPUE index (open circles), 1986-2013 (top panel). The bottom panel also shows a comparison of the observed and predicted indices, where the black line is the 1:1 line.

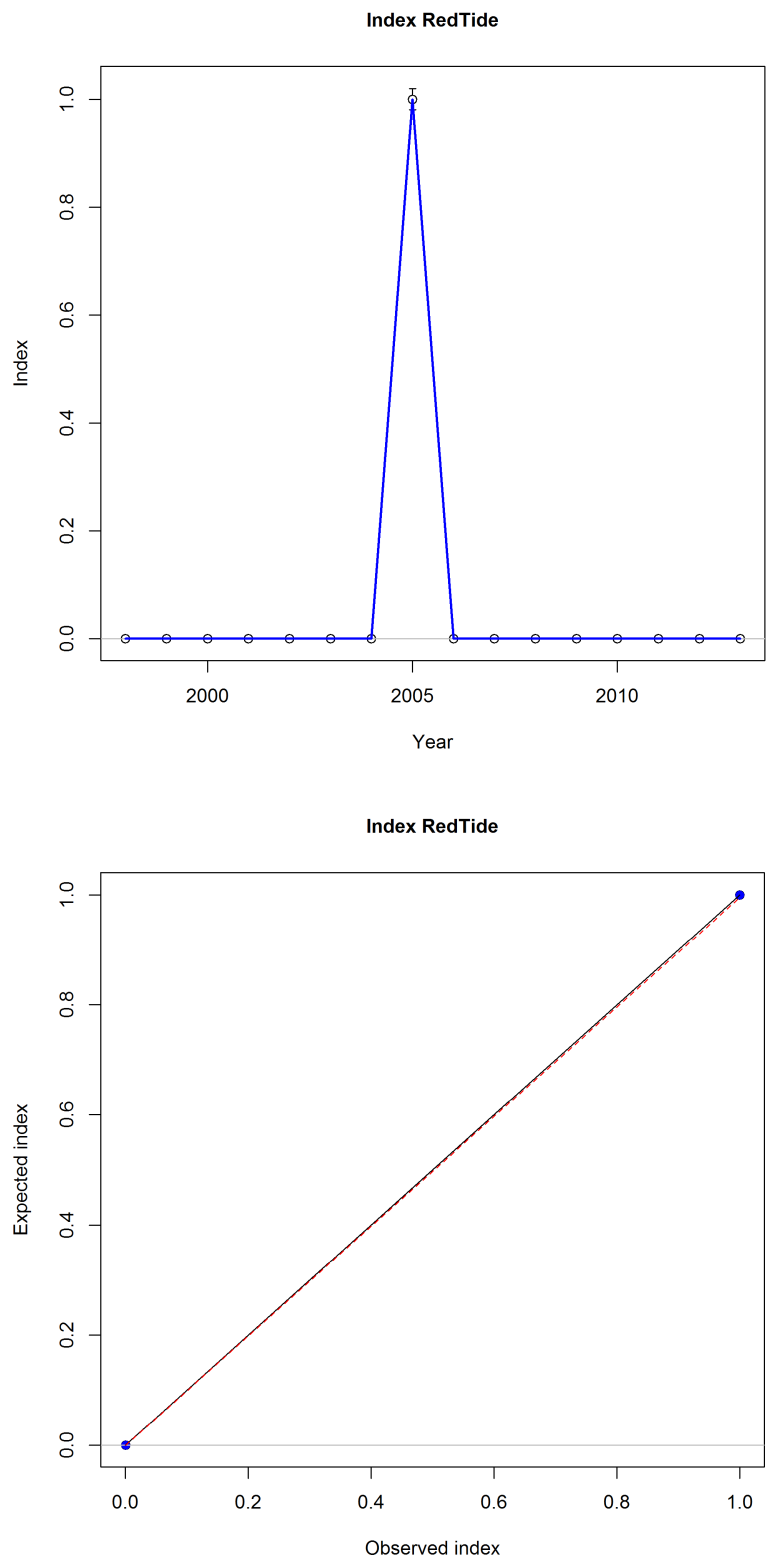


Figure 3.2.15 Model fit (blue line) to the red tide index (open circles), 1998-2013 (top panel). The bottom panel also shows a comparison of the observed and predicted indices, where the black line is the 1:1 line.

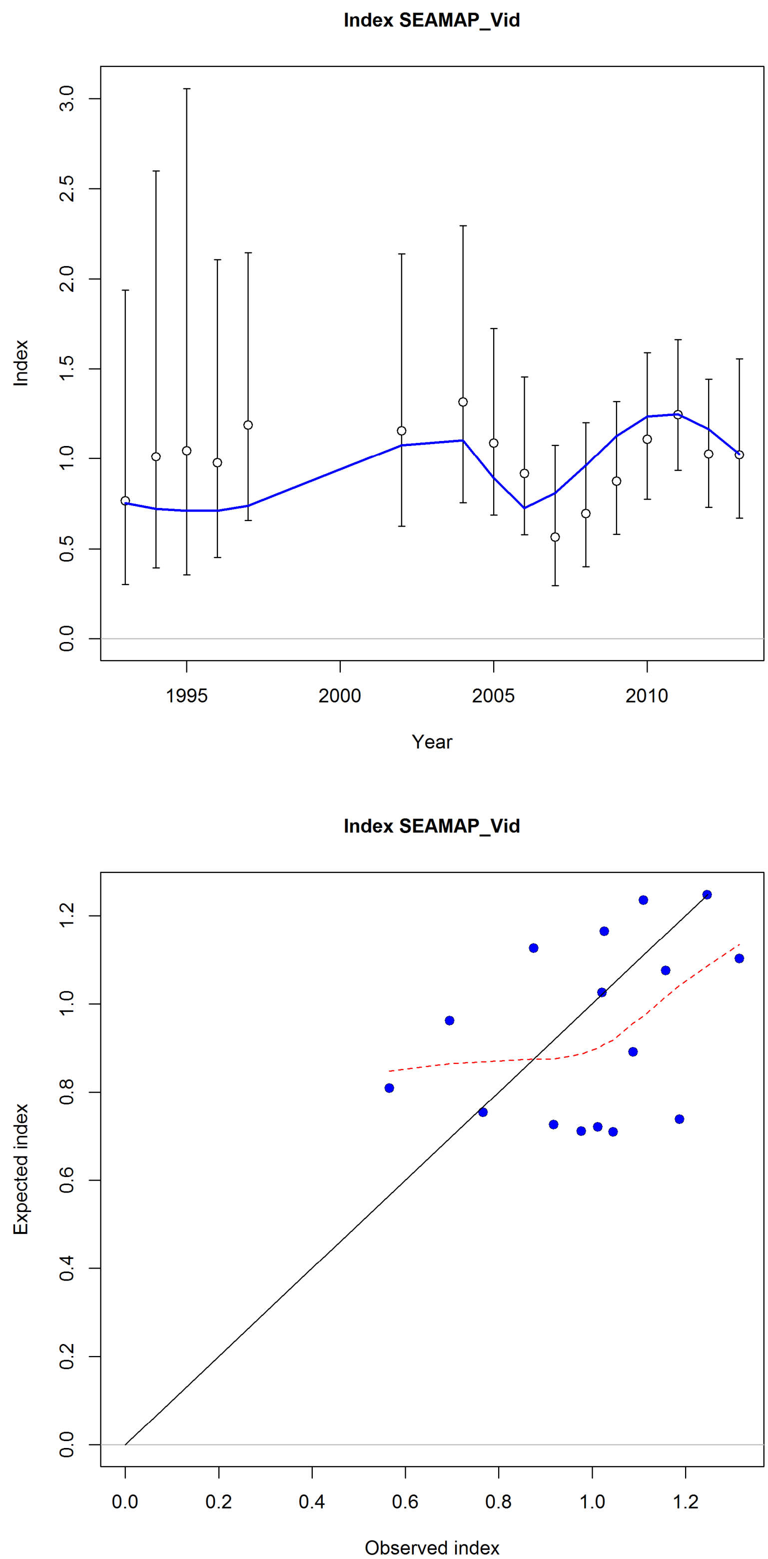


Figure 3.2.16 Model fit (blue line) to the standardized combined video survey index (open circles), 1993-1997, 2002, and 2004-2013 (top panel). The bottom panel also shows a comparison of the observed and predicted indices, where the black line is the 1:1 line.

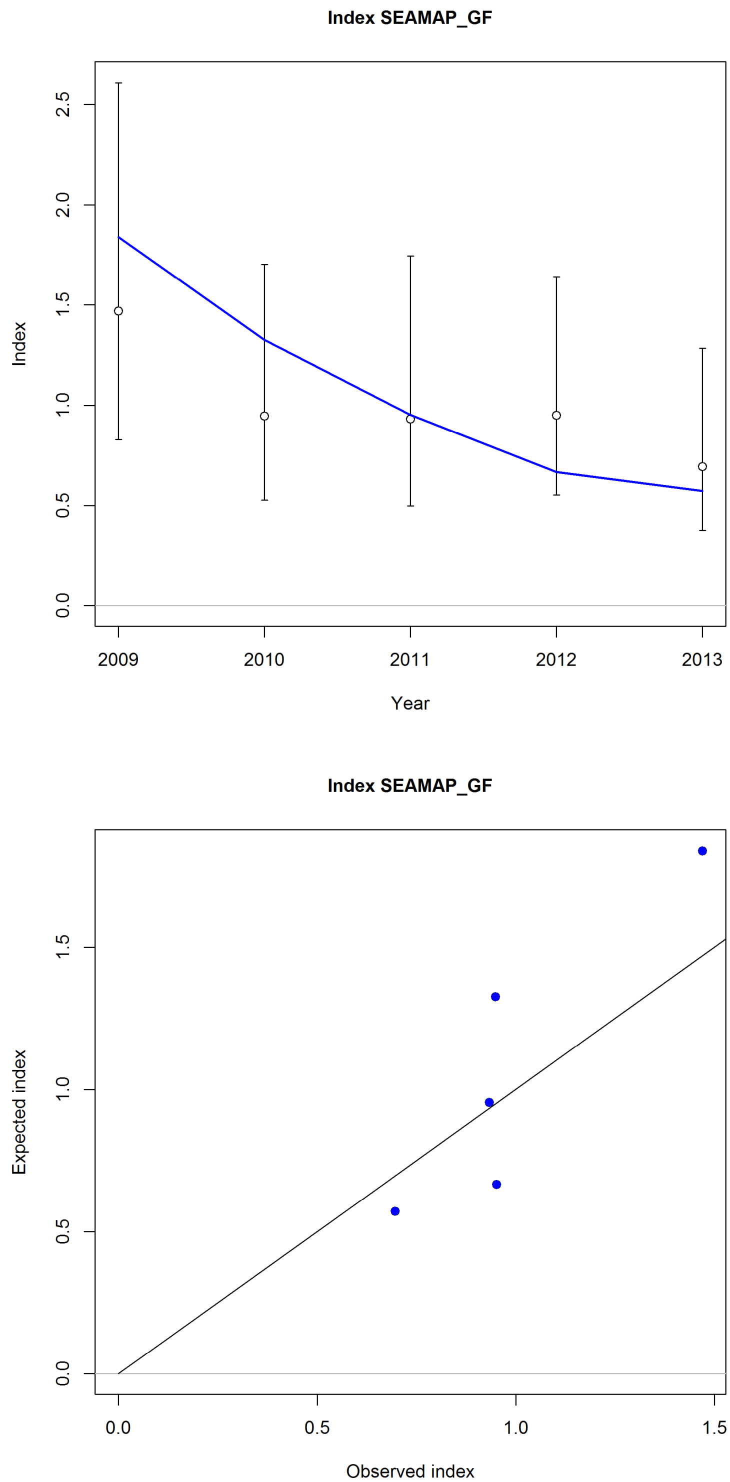
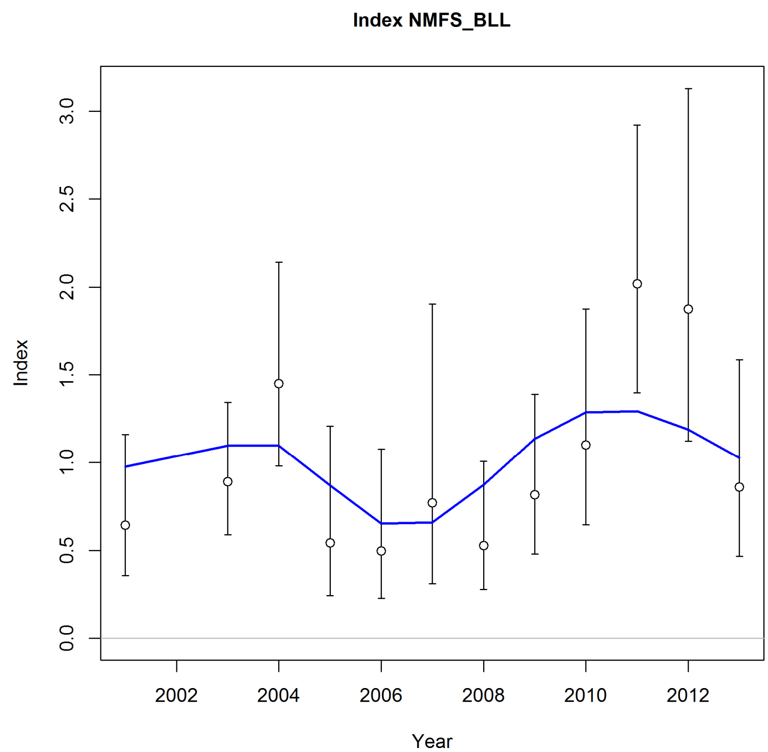


Figure 3.2.17 Model fit (blue line) to the standardized SEAMAP groundfish survey index (open circles), 2009-2013 (top panel). The bottom panel also shows a comparison of the observed and predicted indices, where the black line is the 1:1 line.



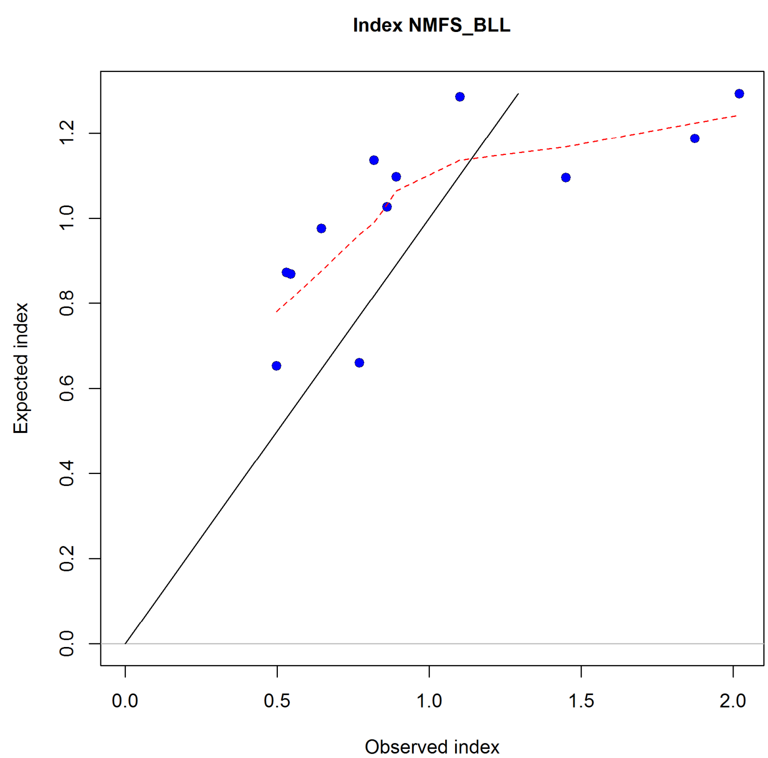


Figure 3.2.18 Model fit (blue line) to the standardized NMFS bottom longline survey index (open circles), 2001, 2003-2013 (top panel). The bottom panel also shows a comparison of the observed and predicted indices, where the black line is the 1:1 line.

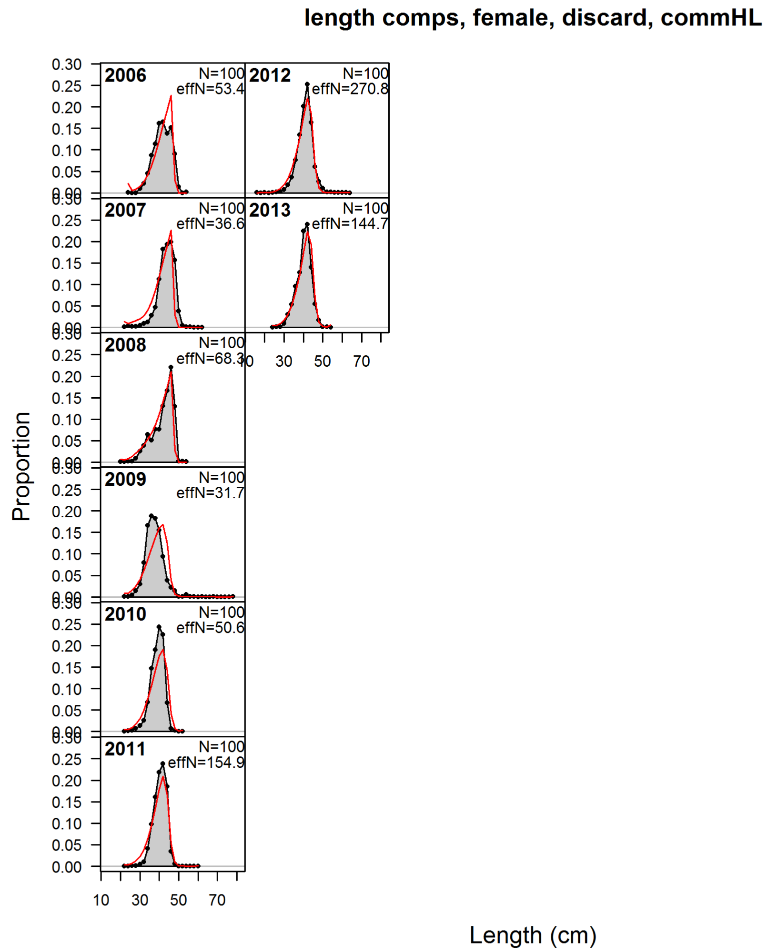


Figure 3.2.19 Observed and predicted length compositions of discards of Red Grouper in the commercial vertical line fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

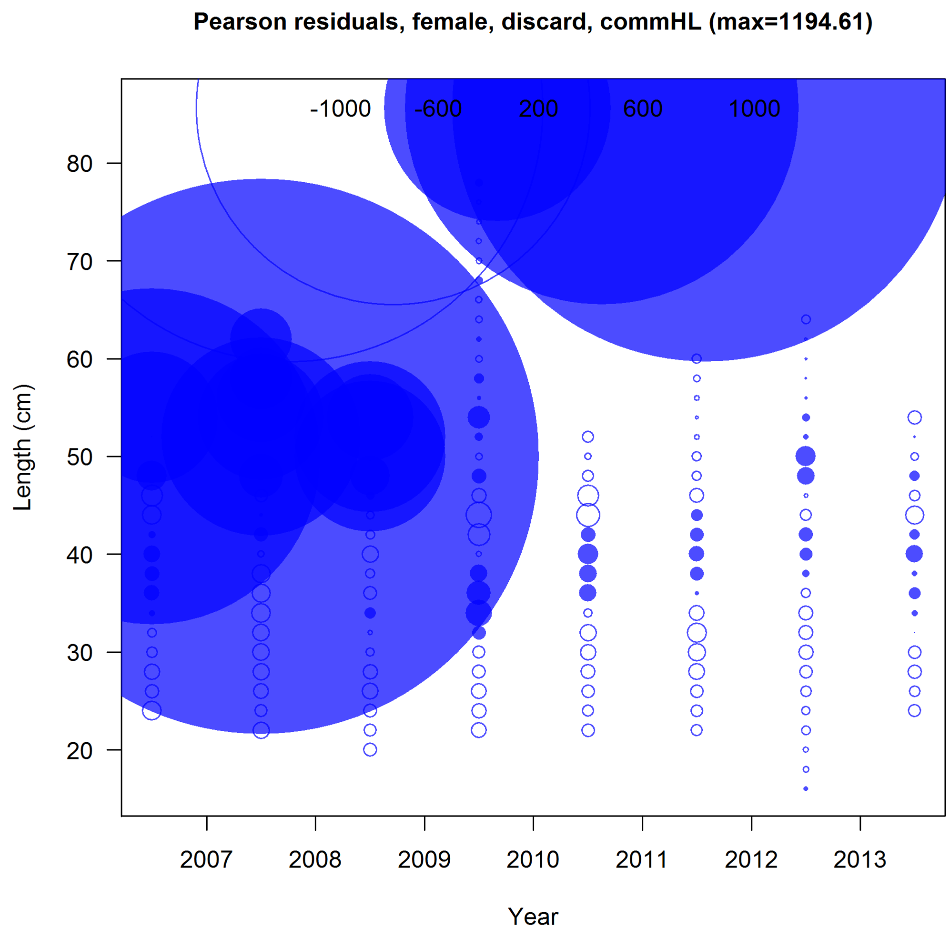


Figure 3.2.20 Pearson residuals for the length composition fit to commercial vertical line discards. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

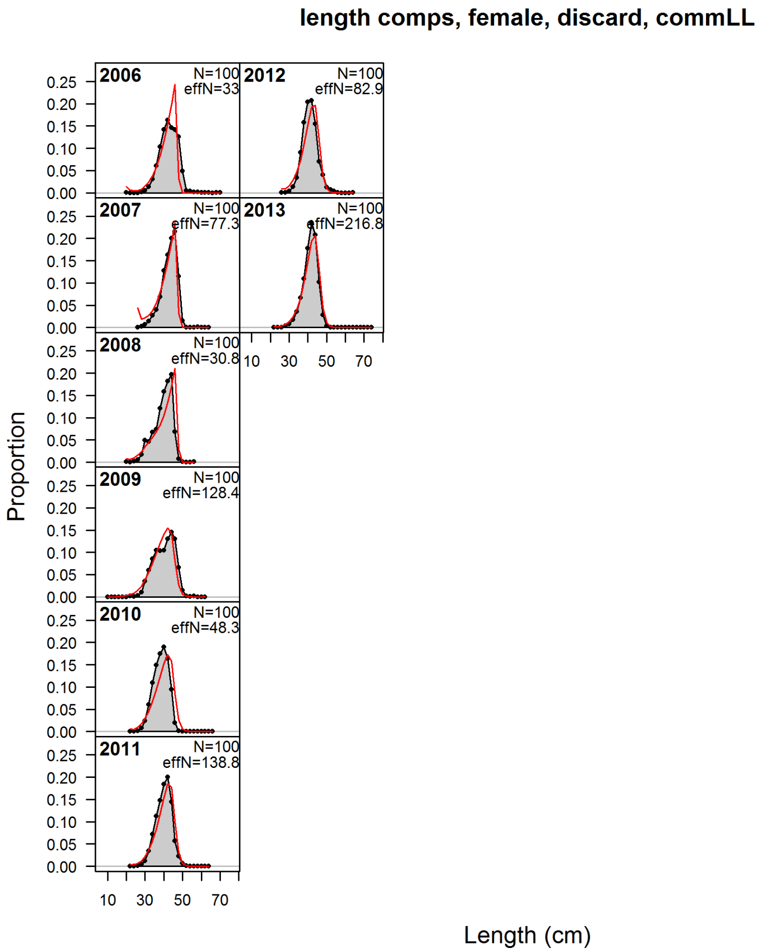


Figure 3.2.21 Observed and predicted length compositions of discards of Red Grouper in the commercial longline fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

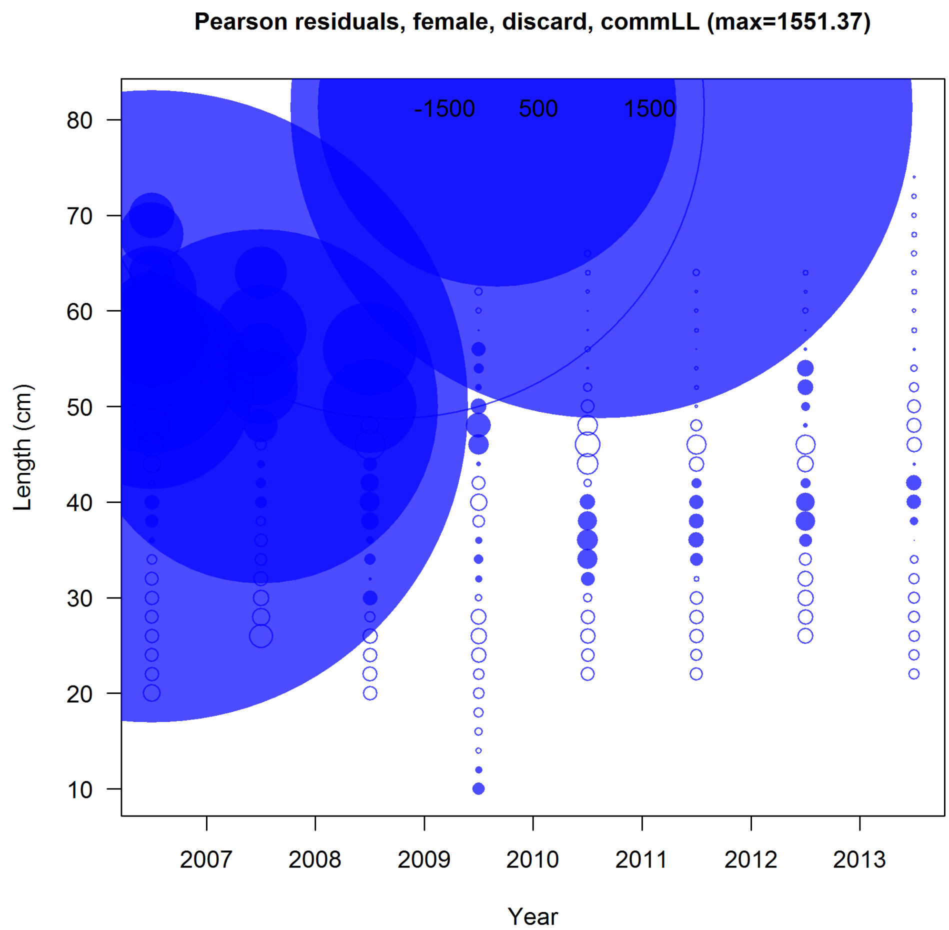


Figure 3.2.22 Pearson residuals for the length composition fit to commercial longline discards. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

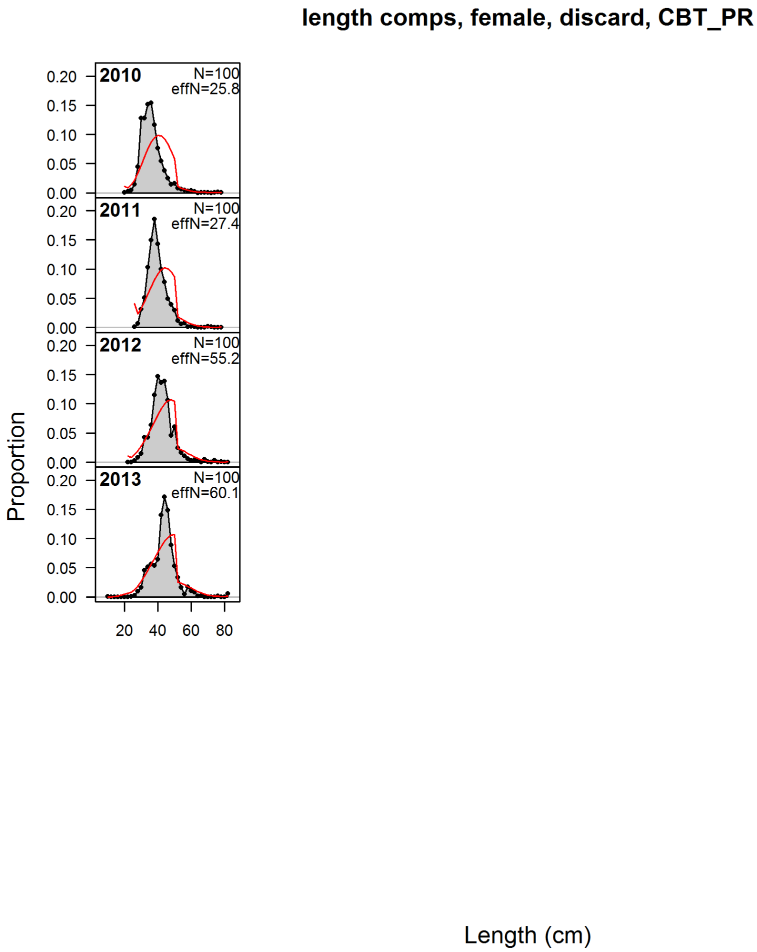


Figure 3.2.23 Observed and predicted length compositions of discards of Red Grouper in the combined recreational charterboat and private fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

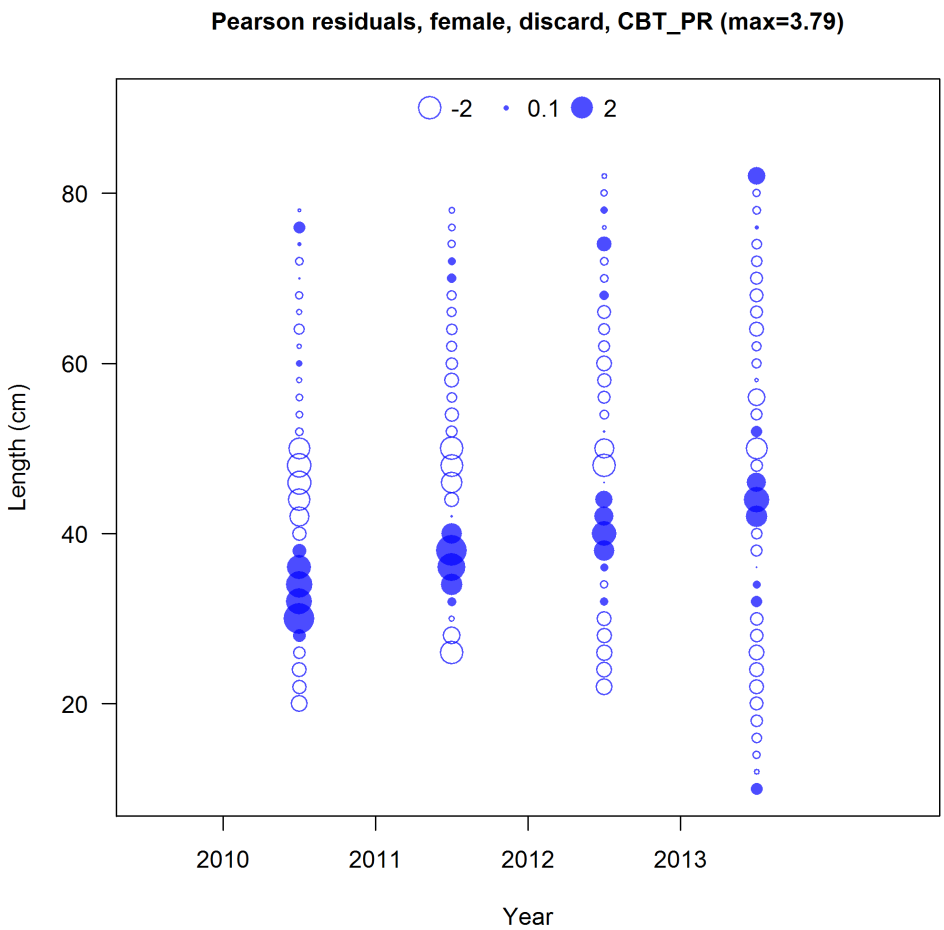


Figure 3.2.24 Pearson residuals for the length composition fit to the combined recreational charterboat and private discards. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

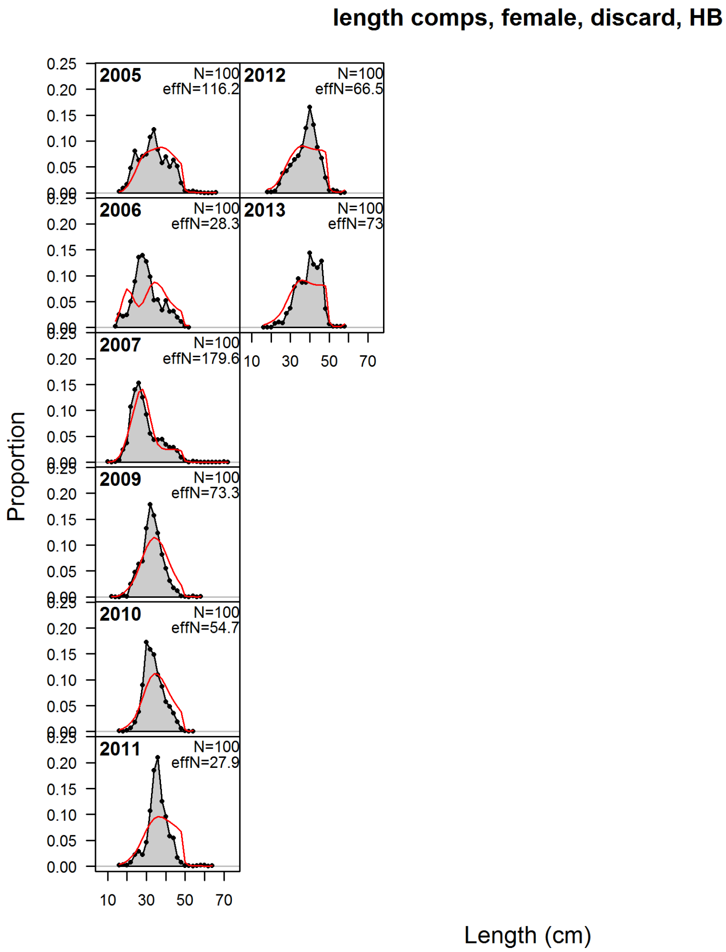


Figure 3.2.25 Observed and predicted length compositions of discards of Red Grouper in the recreational headboat fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

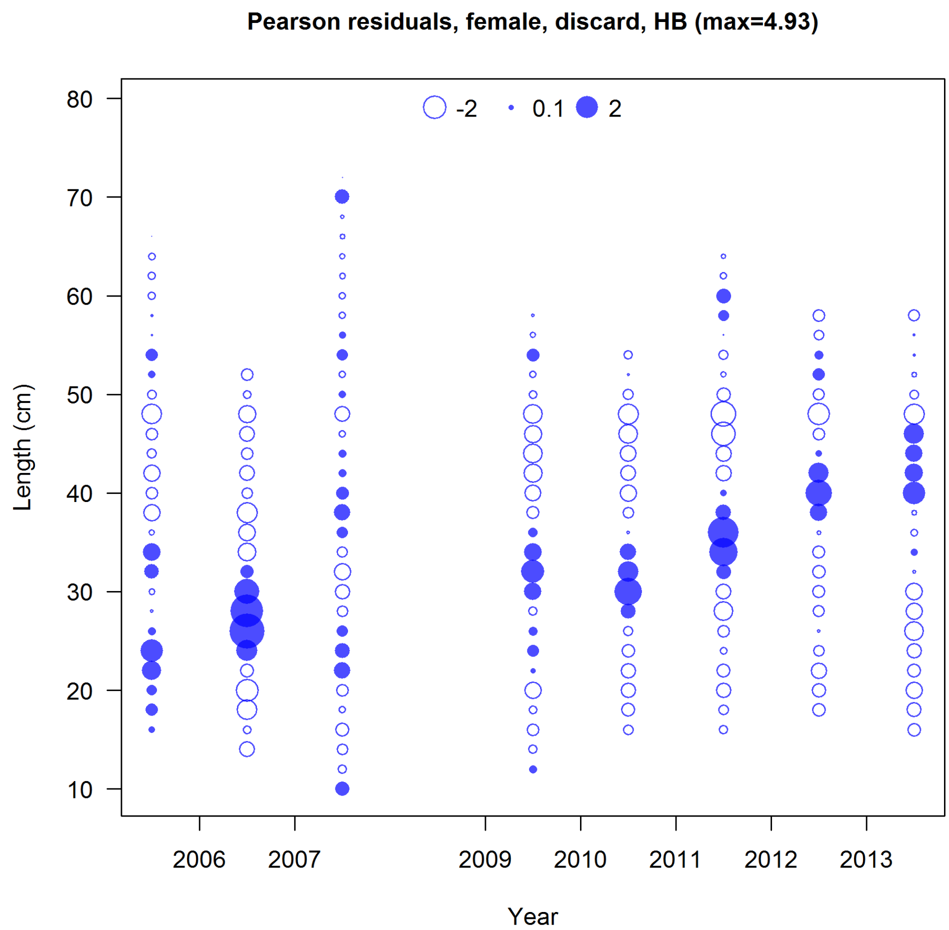


Figure 3.2.26 Pearson residuals for the length composition fit to recreational headboat discards. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

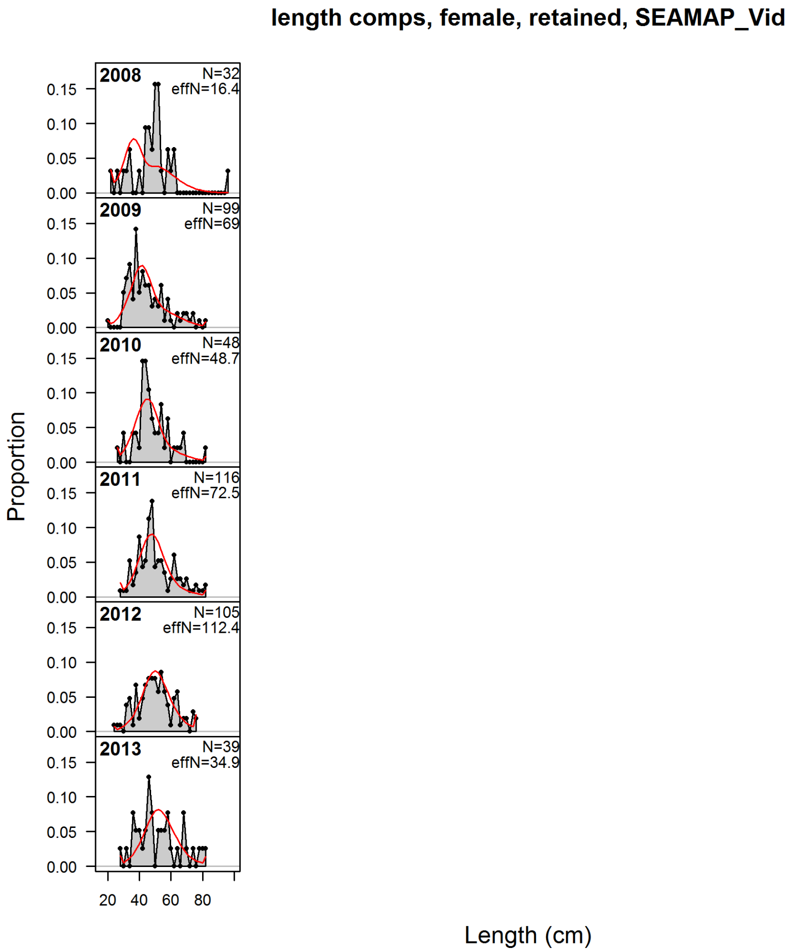


Figure 3.2.27 Observed and predicted length compositions of landings from the combined video survey. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported.

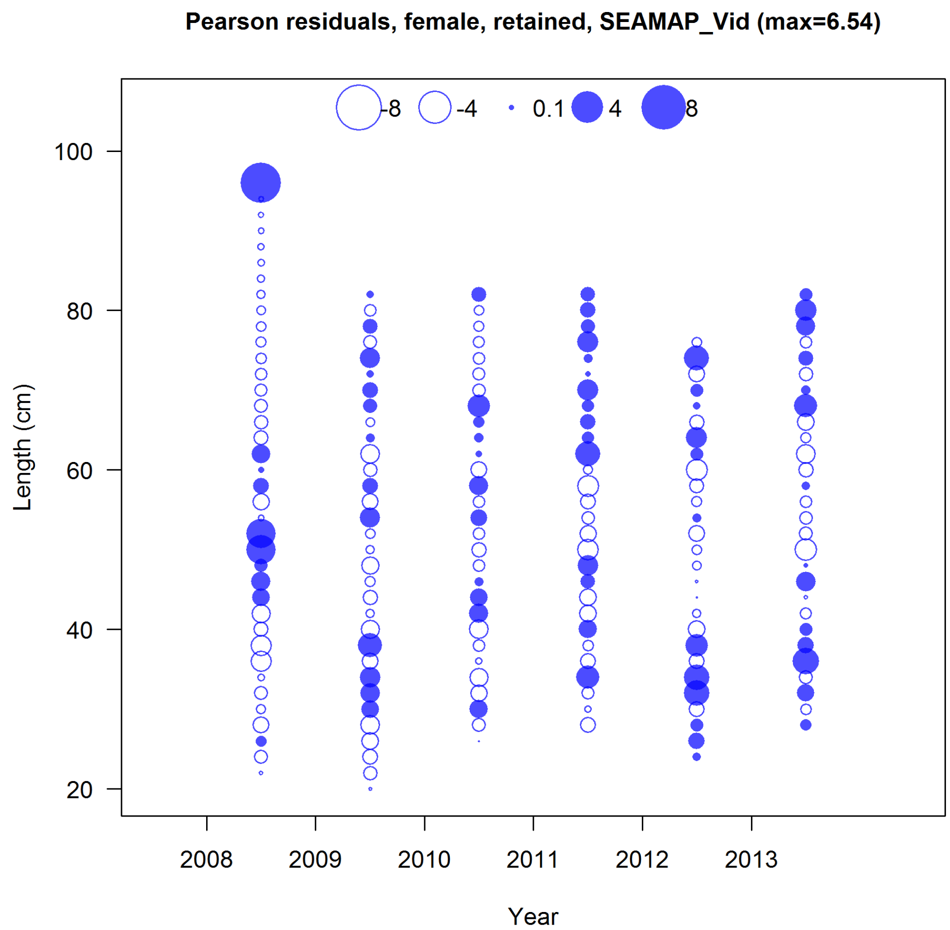


Figure 3.2.28 Pearson residuals for the length composition fit to the combined video survey length observations. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

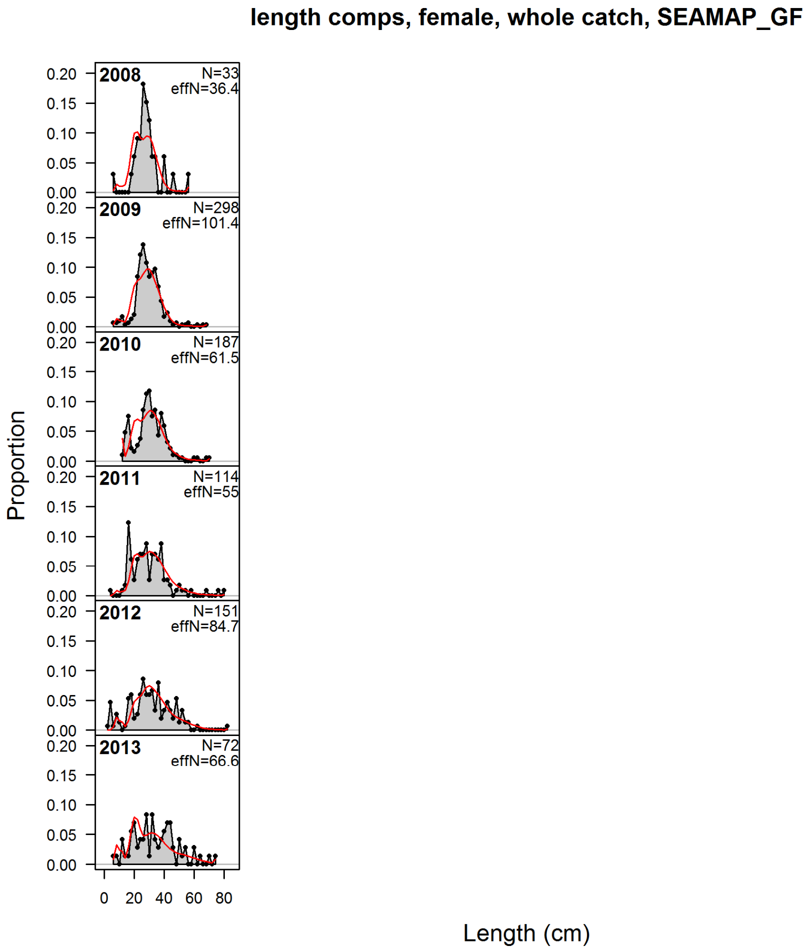


Figure 3.2.29 Observed and predicted length compositions of landings from the SEAMAP groundfish survey. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported.

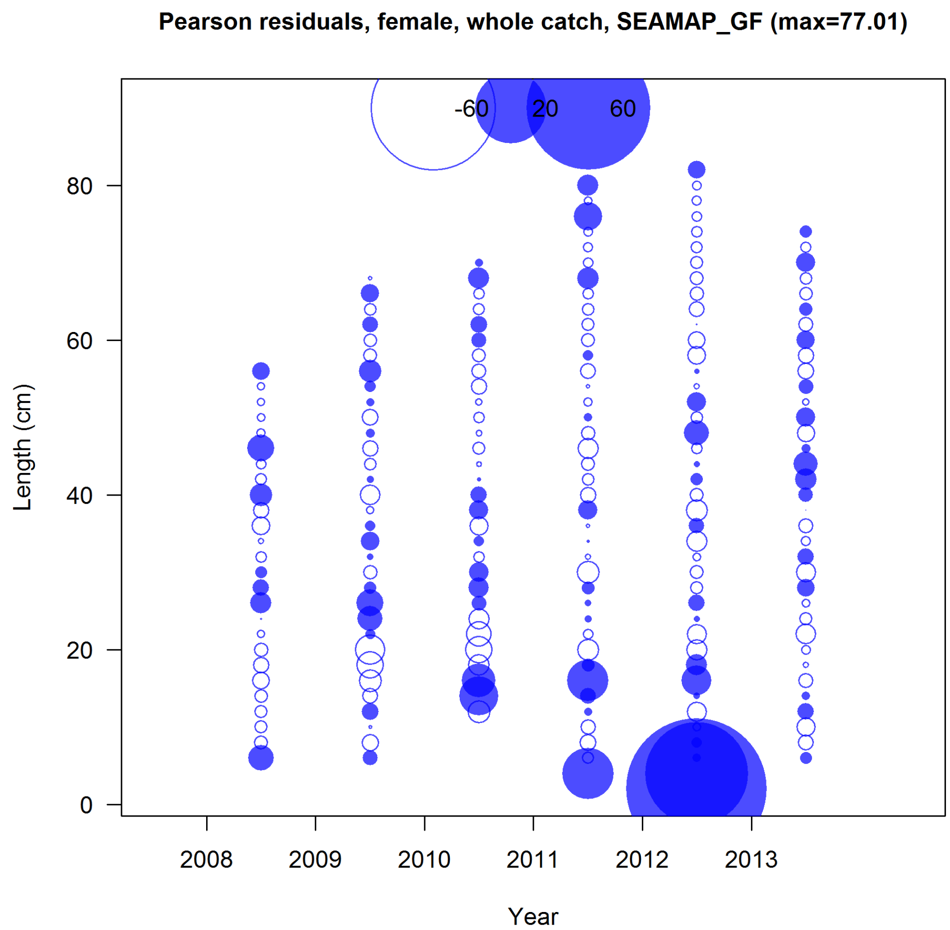


Figure 3.2.30 Pearson residuals for the length composition fit to the SEAMAP groundfish survey length observations. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

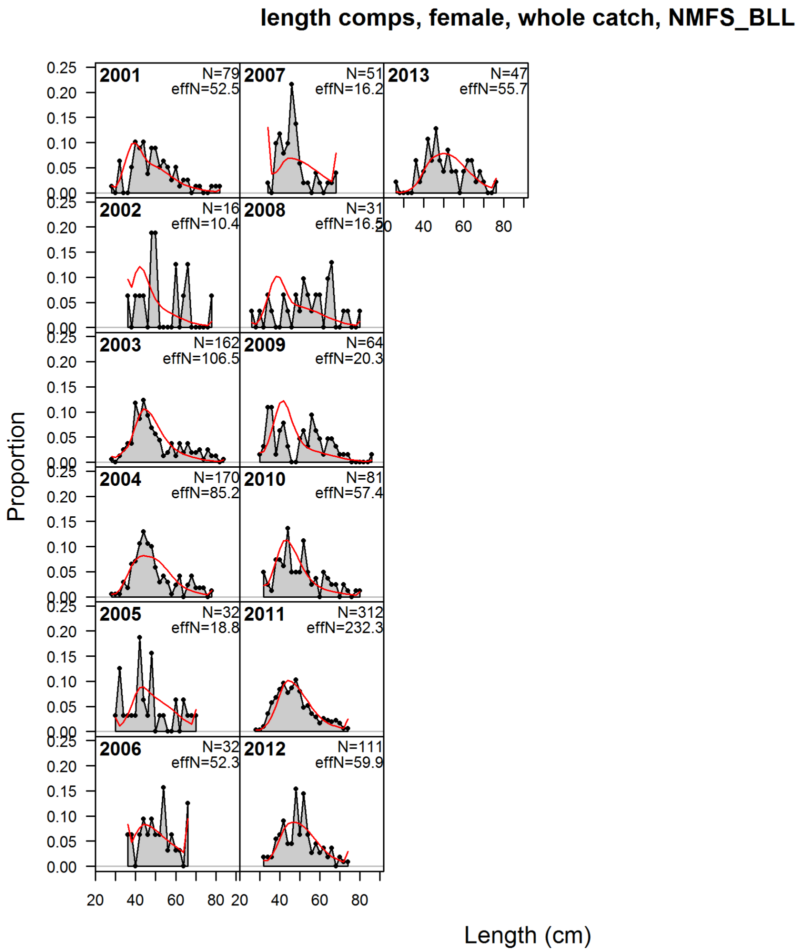


Figure 3.2.31 Observed and predicted length compositions of landings from the NMFS bottom longline survey. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported.

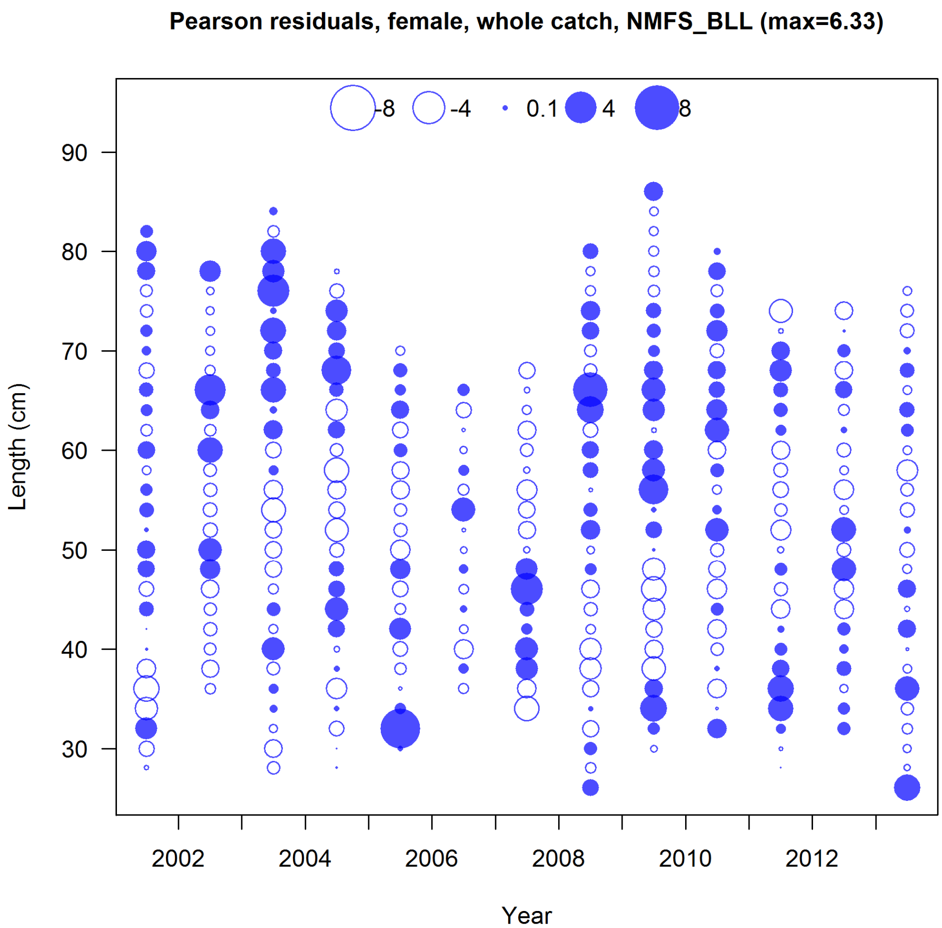


Figure 3.2.32 Pearson residuals for the length composition fit to the NMFS bottom longline survey length observations. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

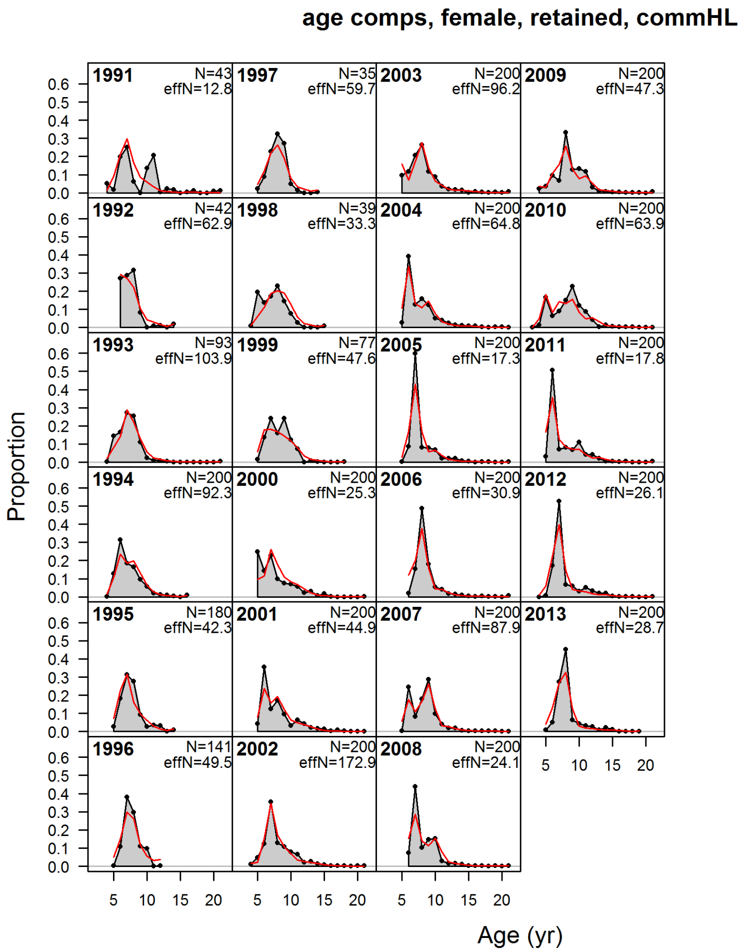


Figure 3.2.33 Observed and predicted age compositions of landings of Red Grouper in the commercial vertical line fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

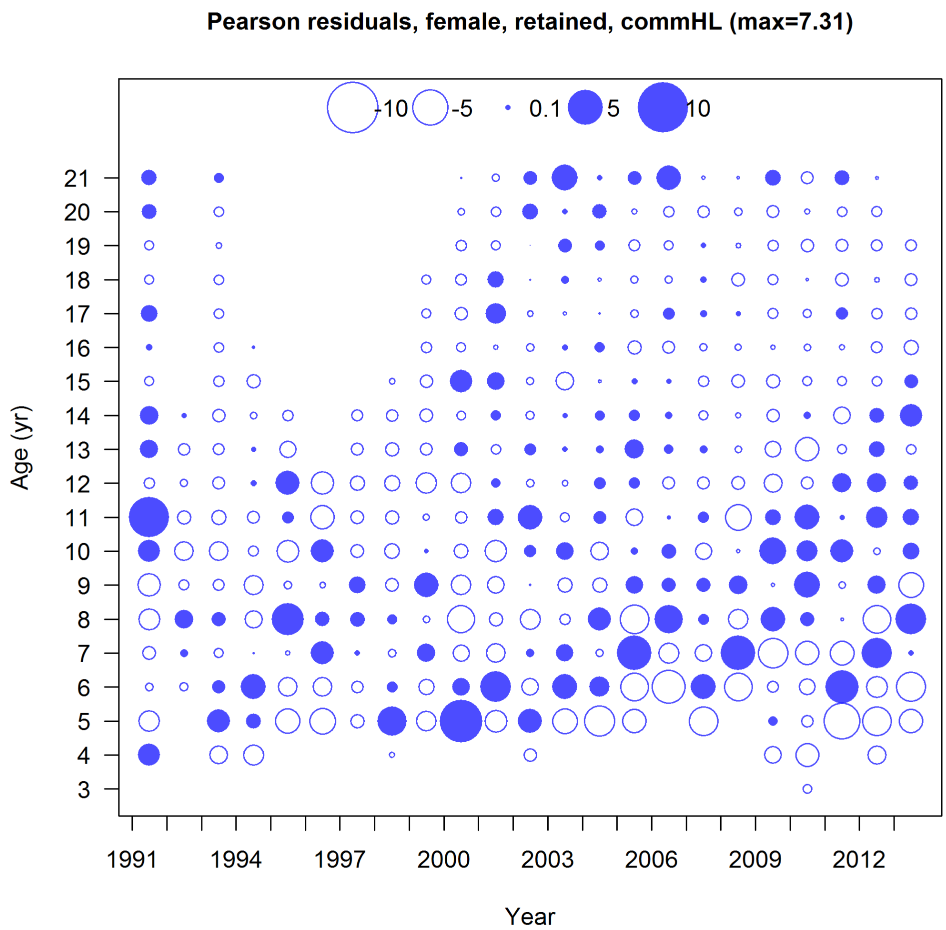


Figure 3.2.34 Pearson residuals for the age composition fit to commercial vertical line landings. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

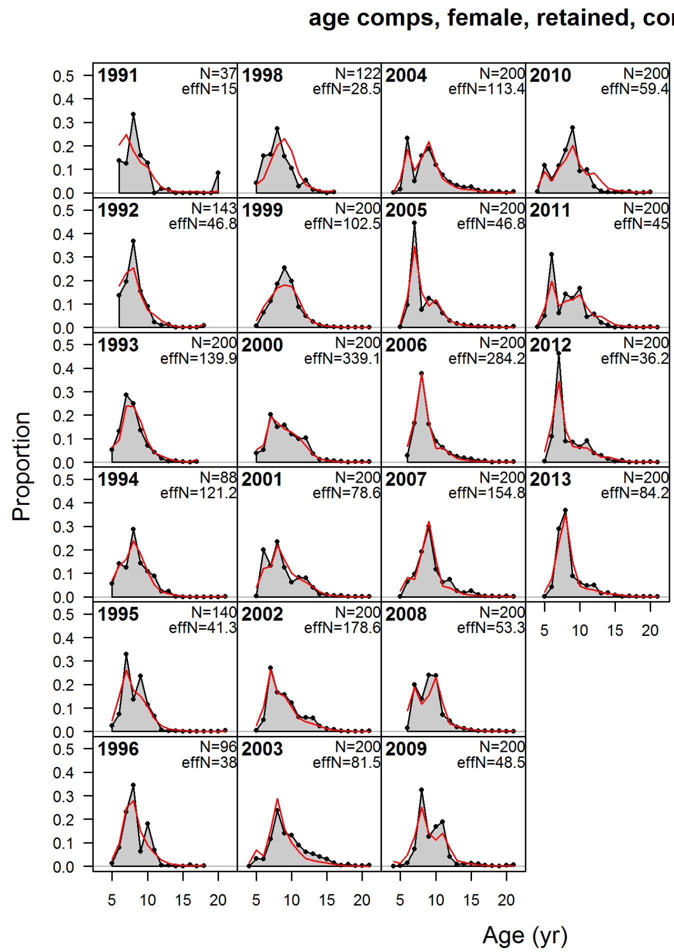


Figure 3.2.35 Observed and predicted age compositions of landings of Red Grouper in the commercial longline fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

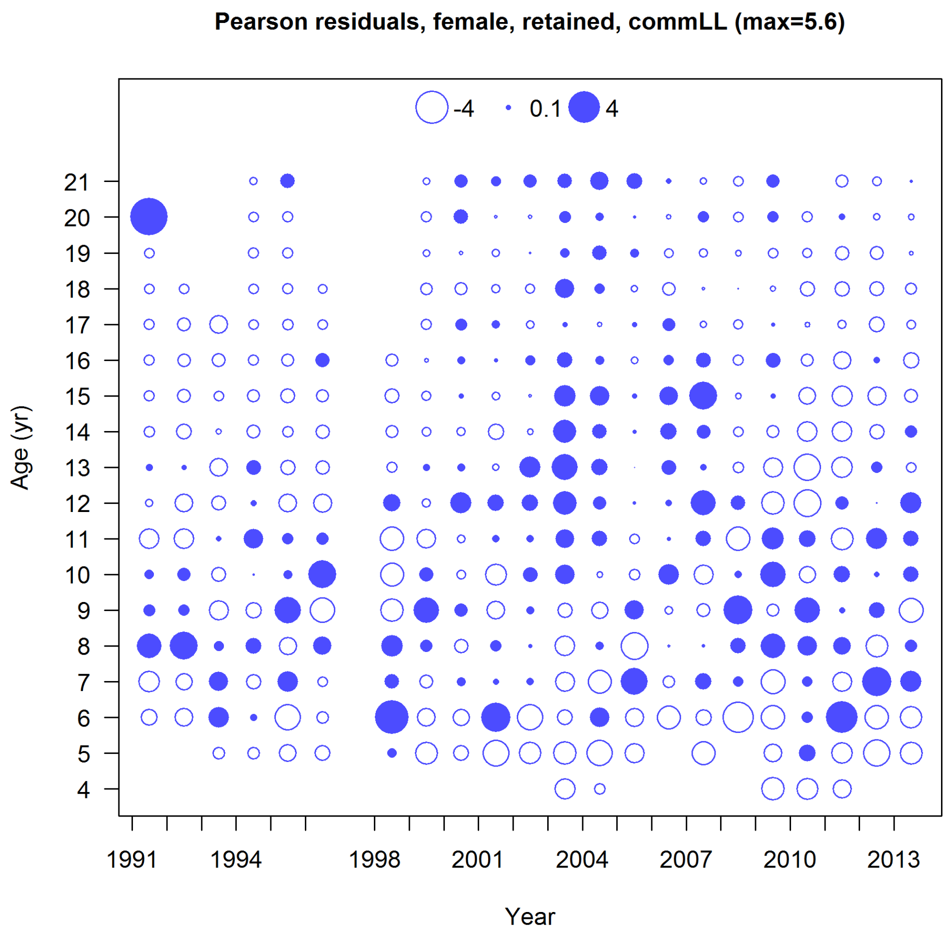


Figure 3.2.36 Pearson residuals for the age composition fit to commercial longline landings. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

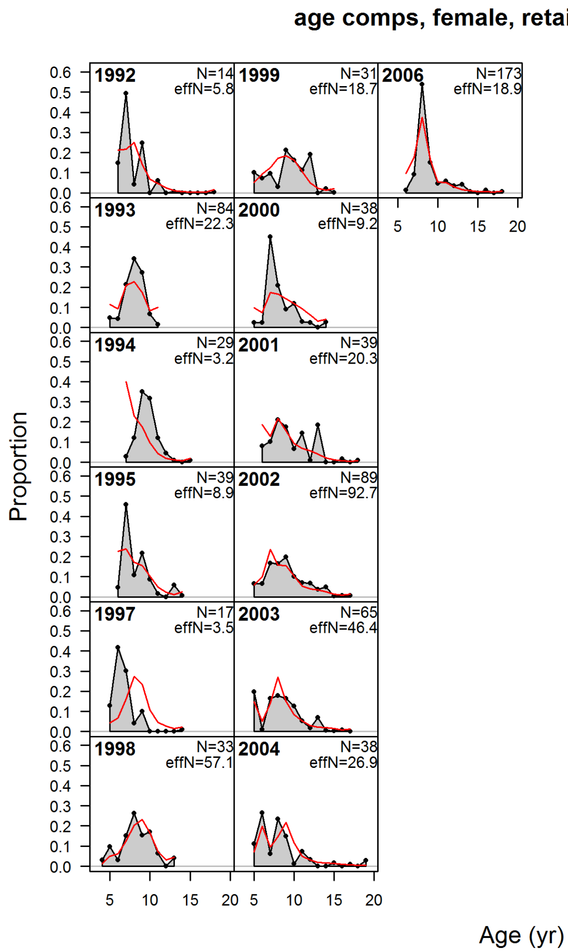


Figure 3.2.37 Observed and predicted age compositions of landings of Red Grouper in the commercial trap fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

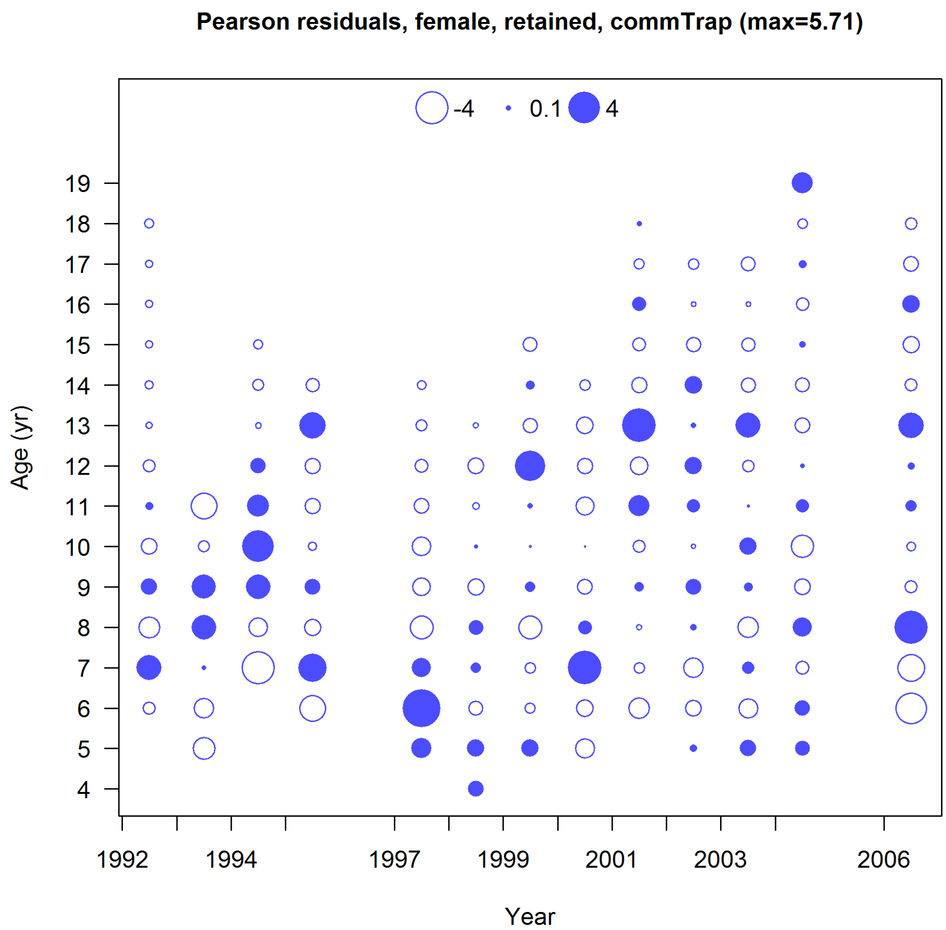


Figure 3.2.38 Pearson residuals for the age composition fit to commercial trap landings. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

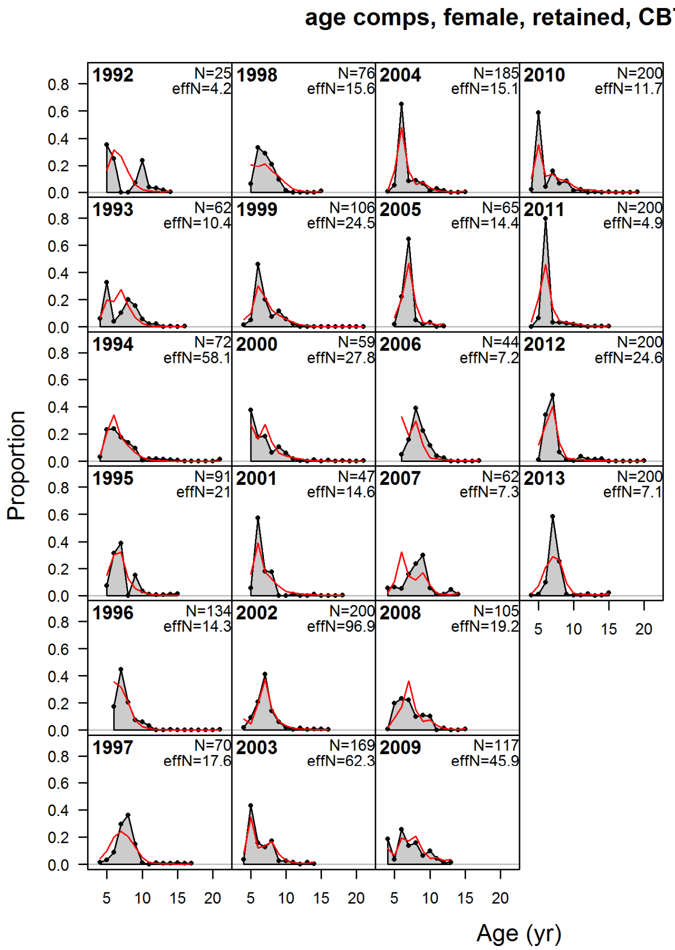


Figure 3.2.39 Observed and predicted age compositions of landings of Red Grouper in the combined recreational charterboat and private fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

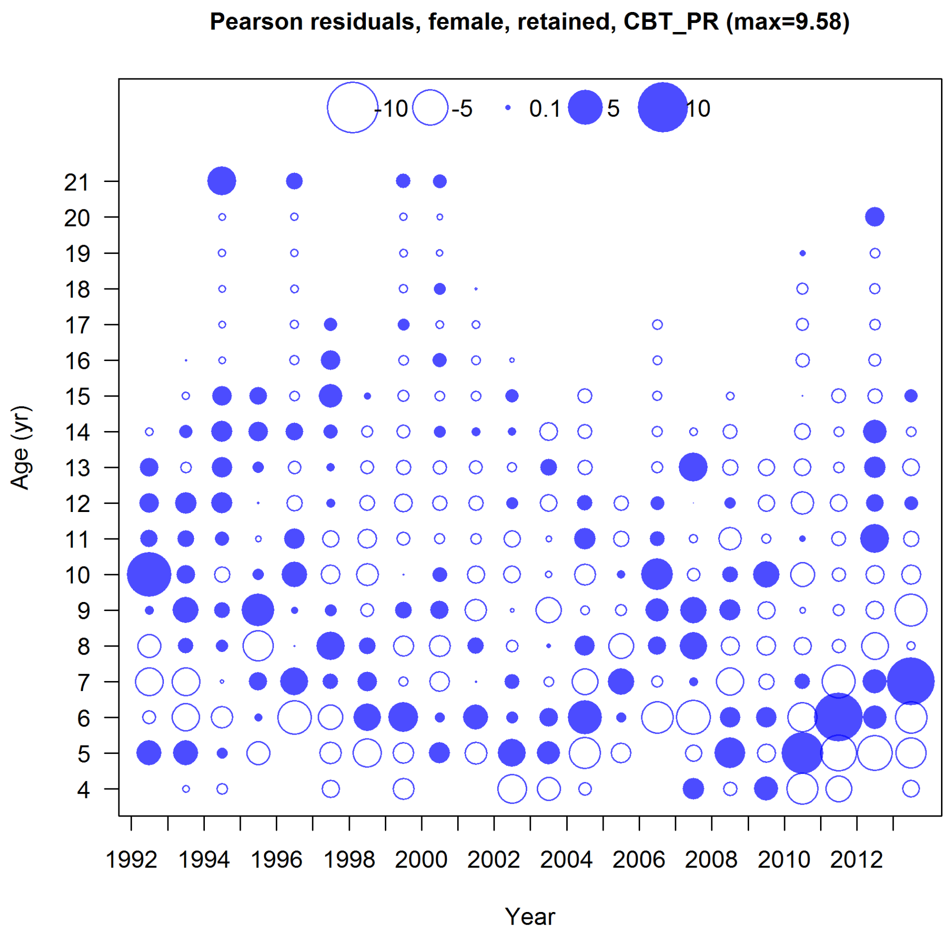


Figure 3.2.40 Pearson residuals for the age composition fit to the combined recreational charterboat and private landings. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

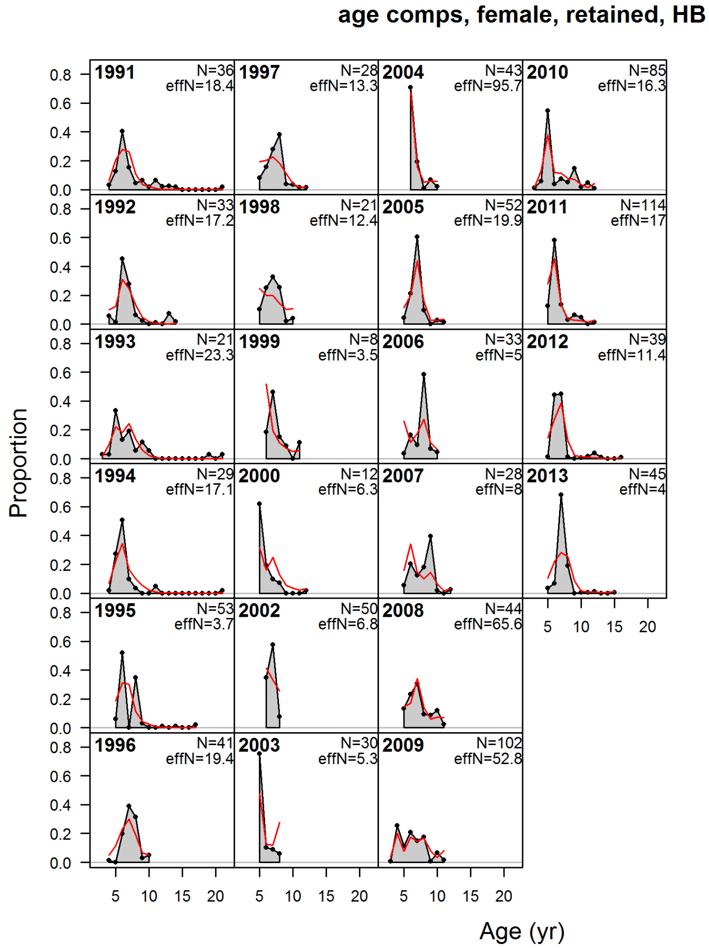


Figure 3.2.41 Observed and predicted age compositions of landings of Red Grouper in the recreational headboat fleet. Observed (N) sample sizes and effective sample sizes (effN) estimated by SS are also reported. Observed sample sizes were capped at a maximum of 200 fish.

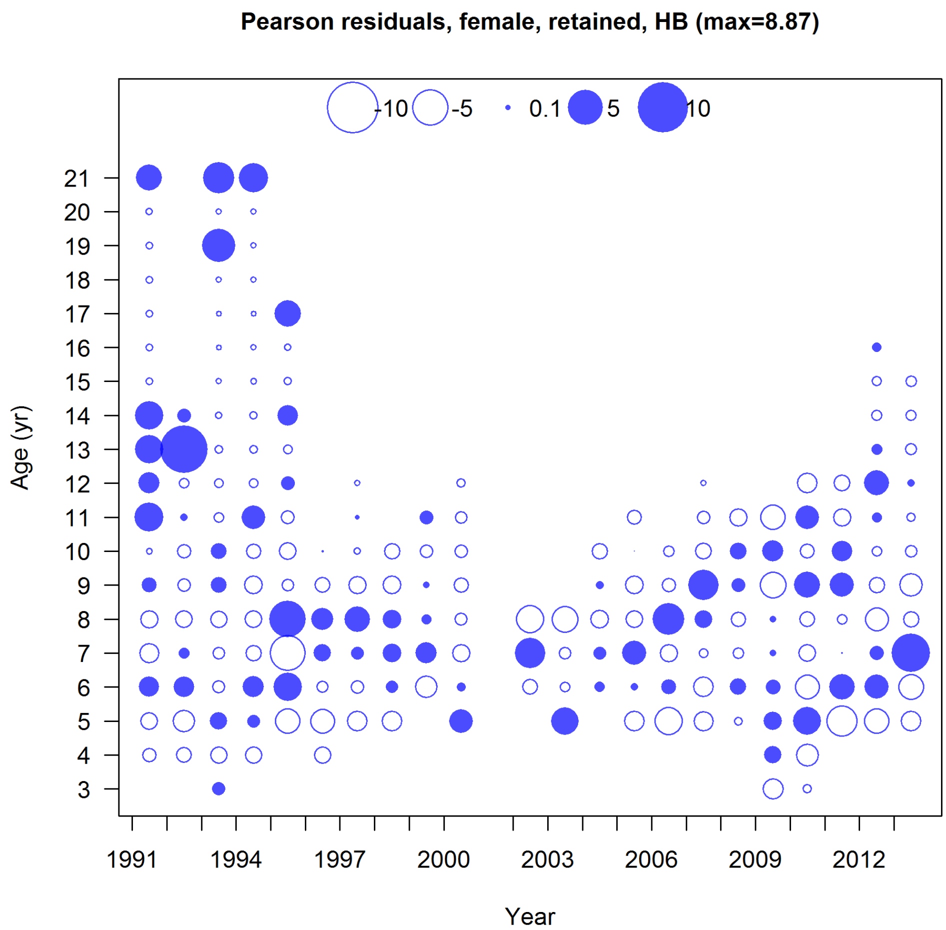


Figure 3.2.42 Pearson residuals for the age composition fit to recreational headboat landings. Solid circles are positive residuals (i.e., observed greater than predicted) and open circles are negative residuals (i.e., predicted greater than observed).

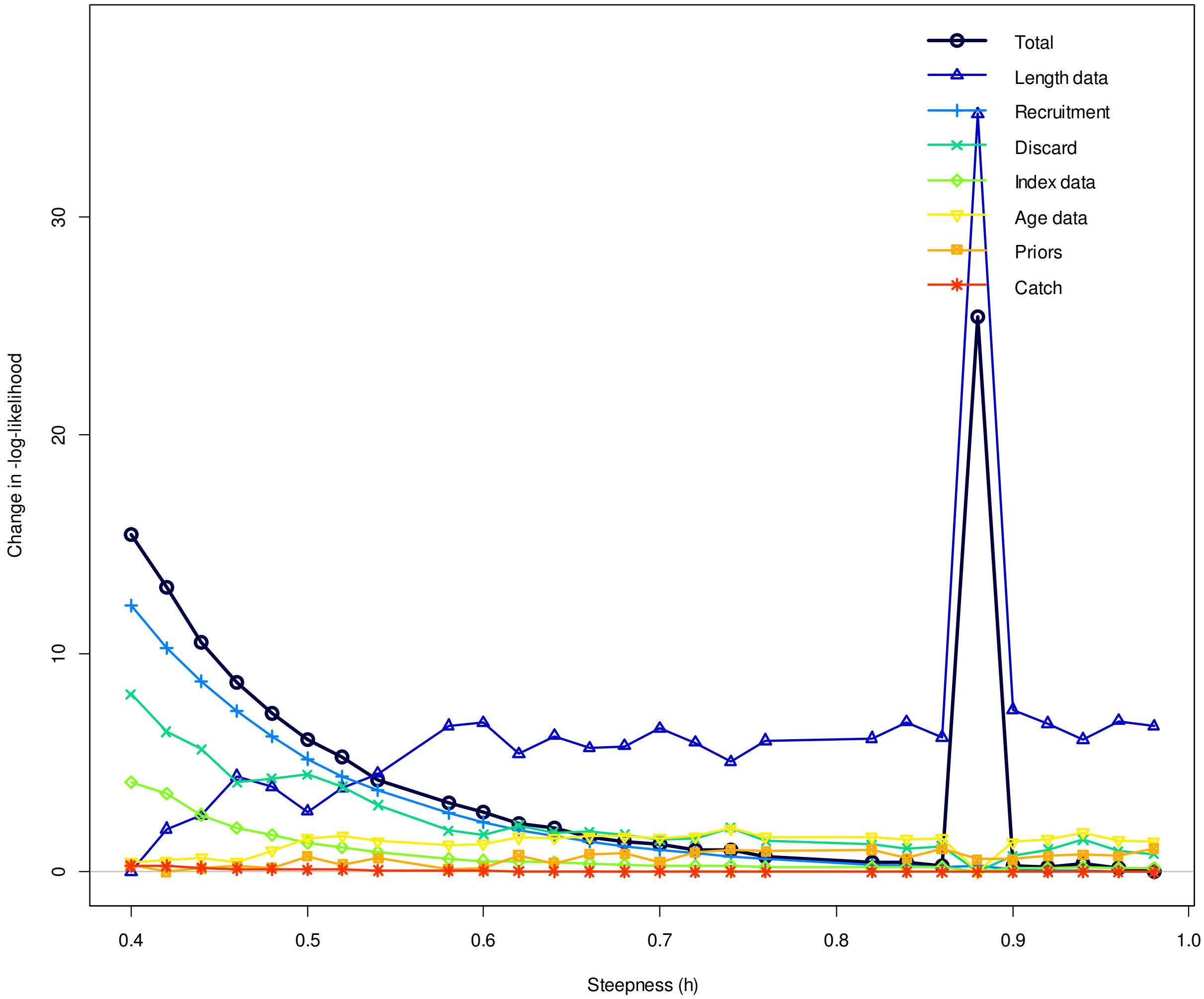


Figure 3.2.43 Likelihood profile on steepness at intervals of 0.02.

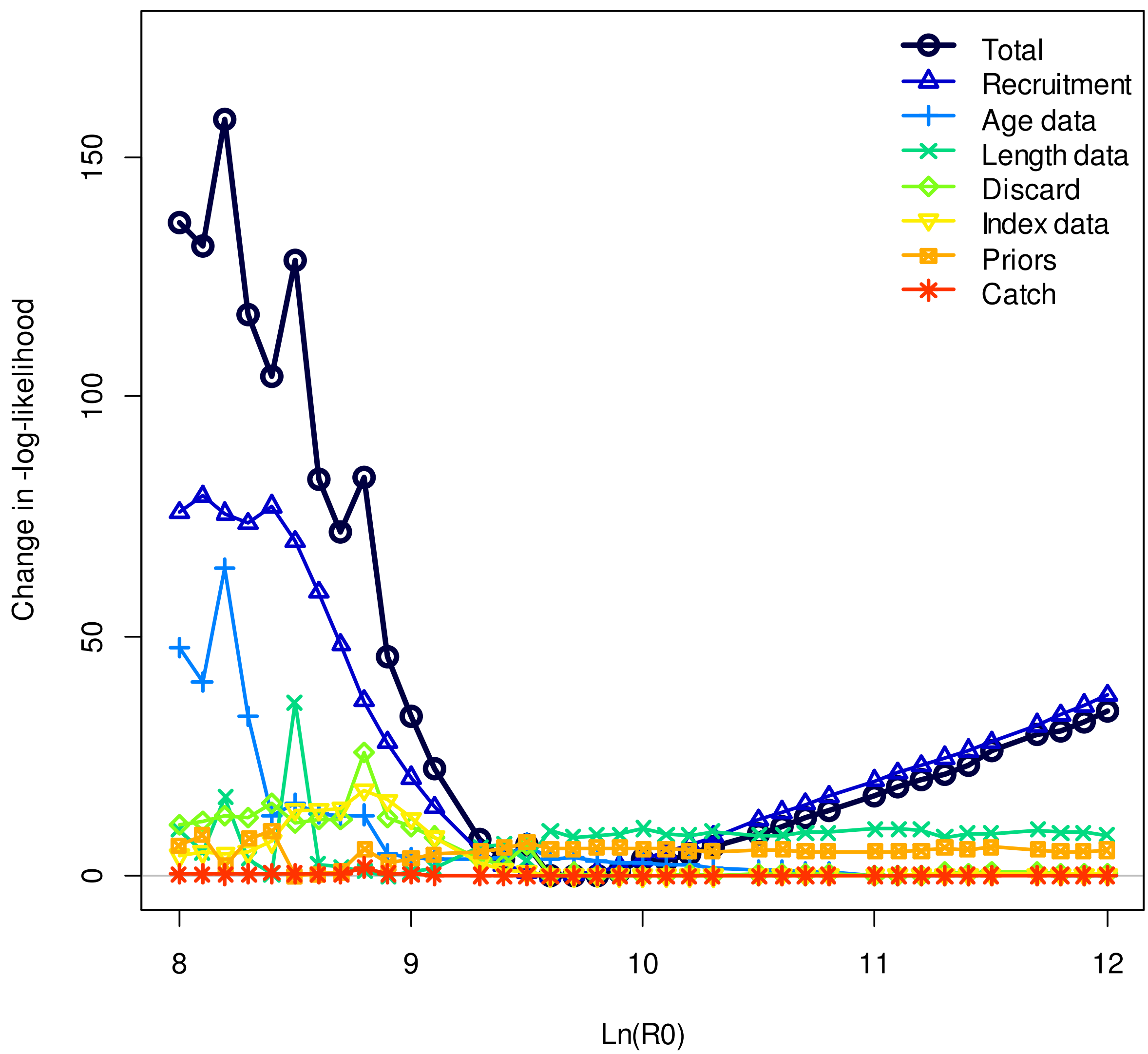


Figure 3.2.44 Likelihood profile on Ln (R0) at intervals of 0.1.

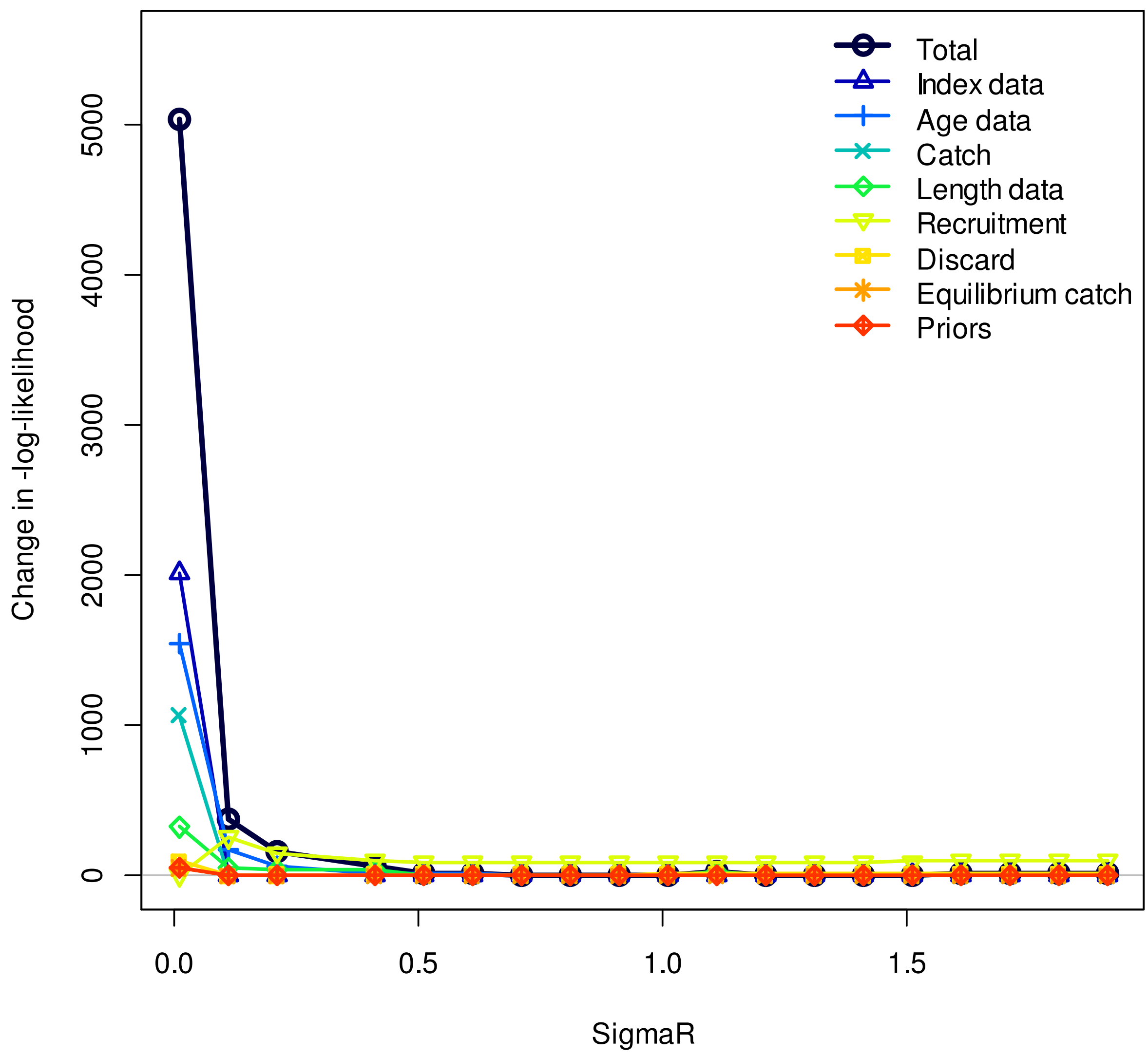


Figure 3.2.45 Likelihood profile on σ_R at intervals of 0.1.

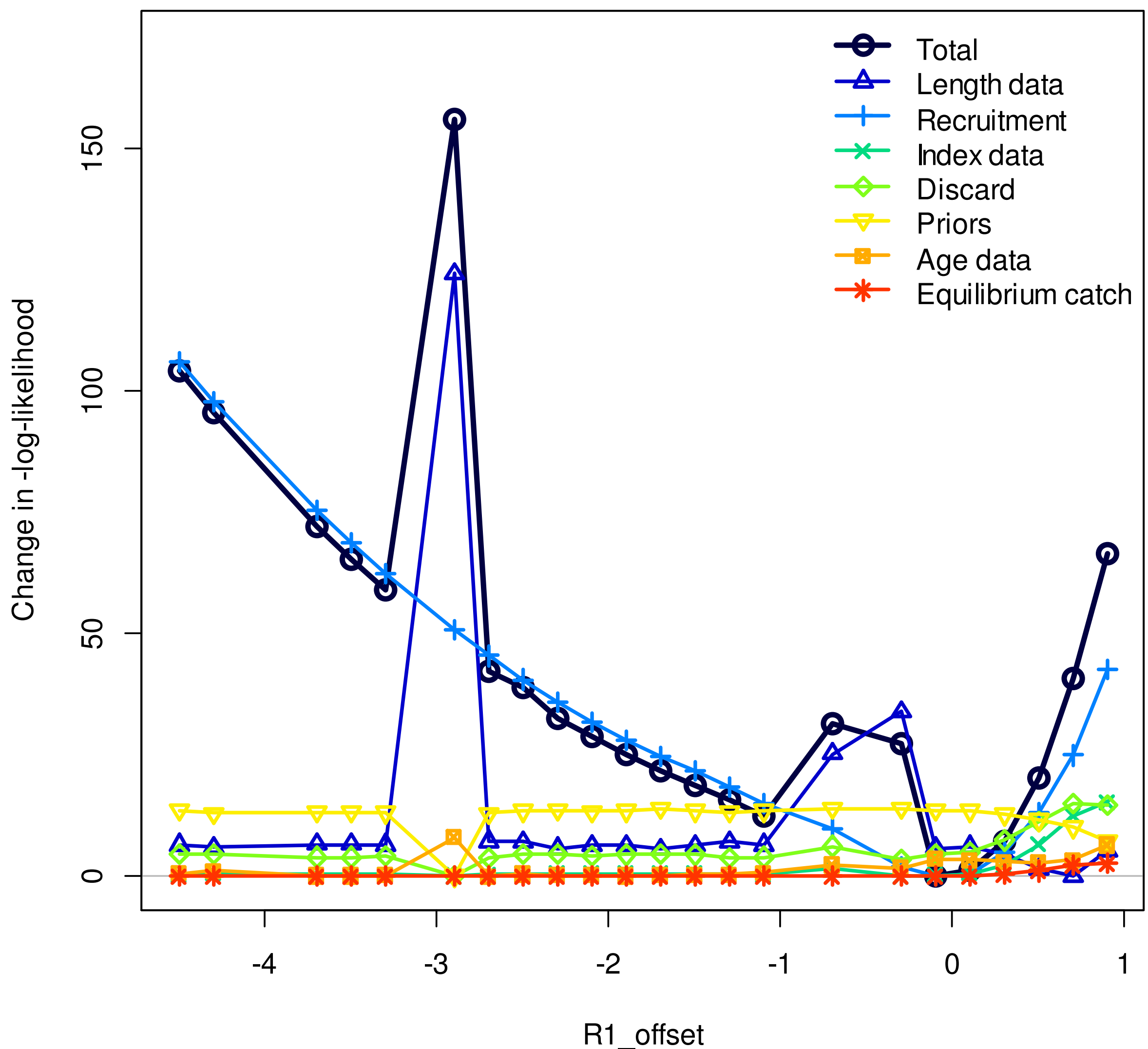


Figure 3.2.46 Likelihood profile on Ln(R1_offset) at intervals of 0.2.

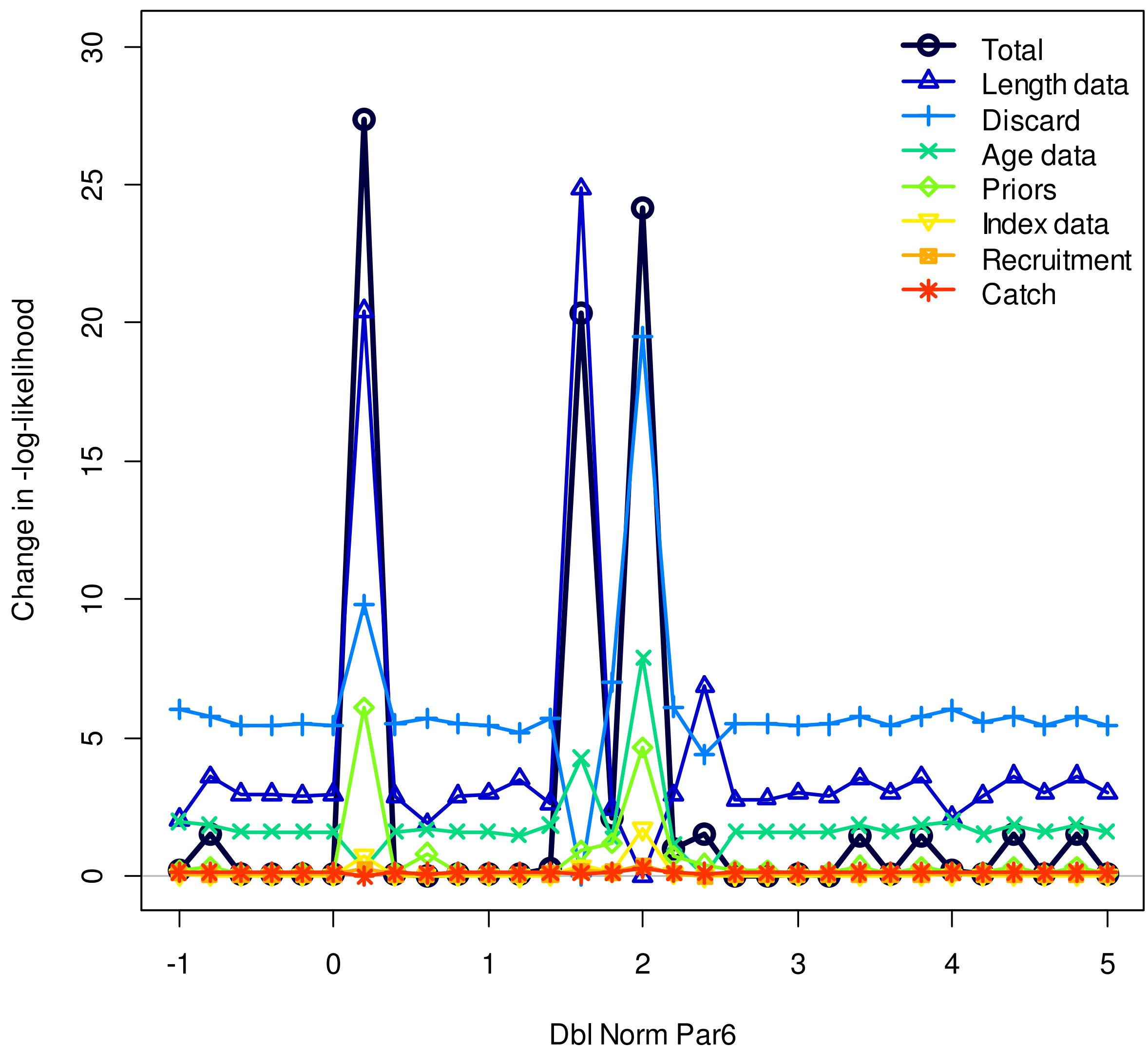


Figure 3.2.47 Likelihood profile on the selectivity of the last length bin for the NMFS bottom longline survey at intervals of 0.2.

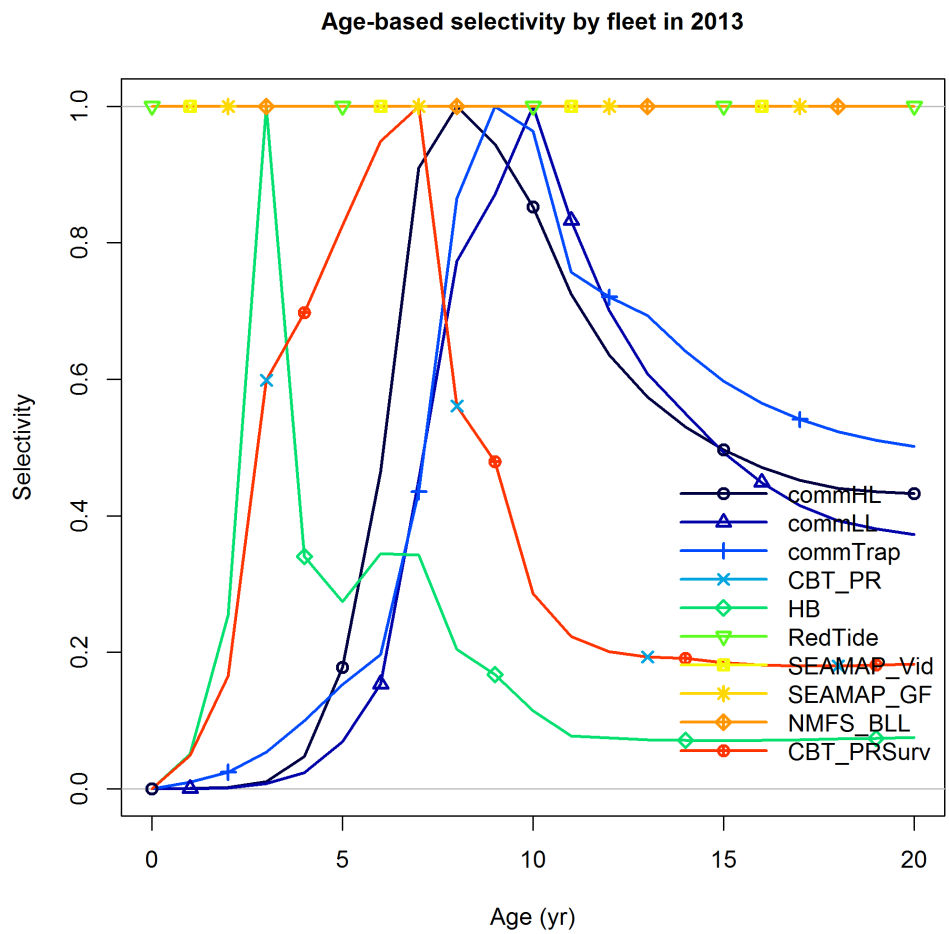


Figure 3.2.48 The estimated age-based selectivity patterns for the five fishing fleets.

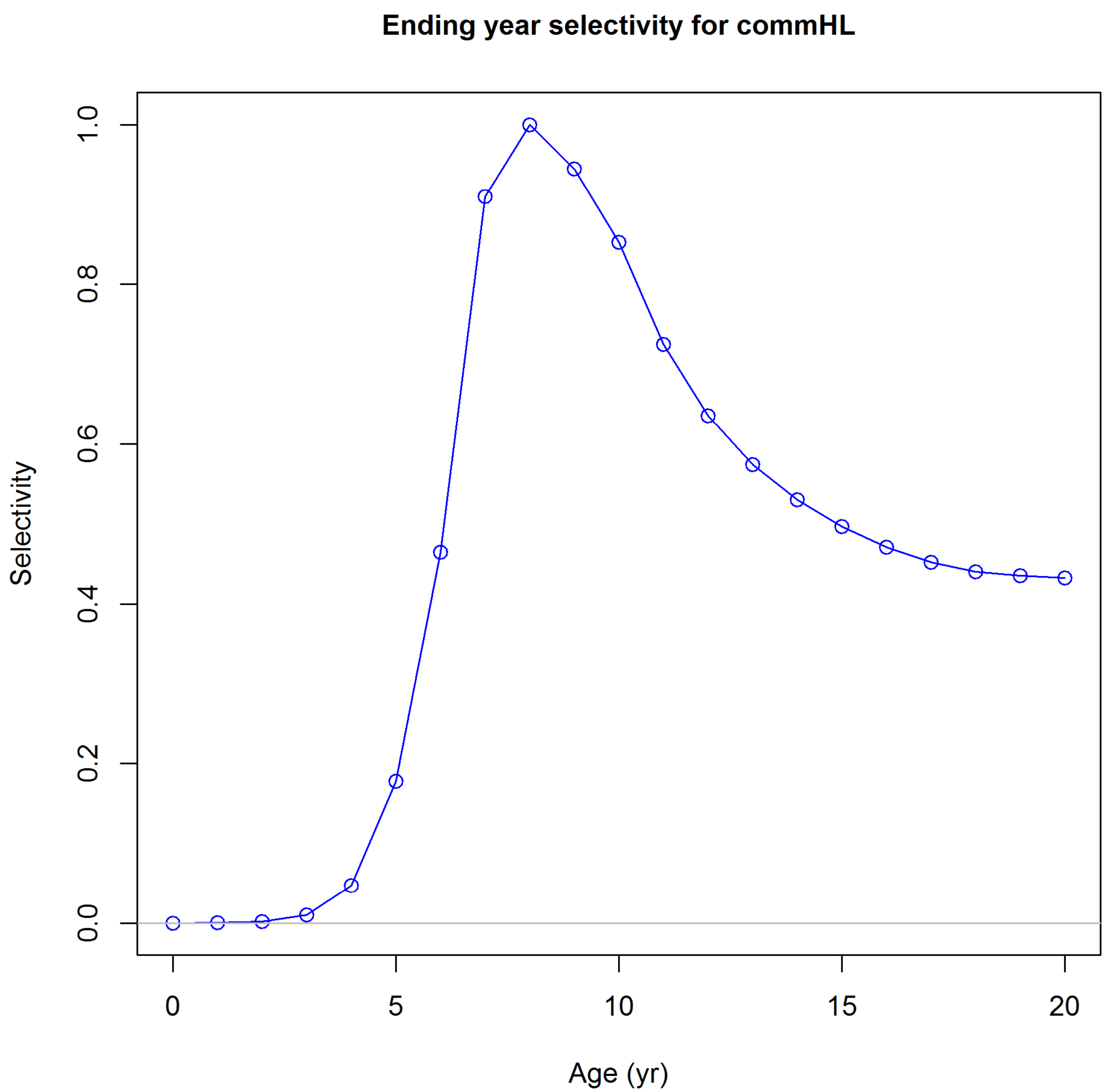


Figure 3.2.49 The estimated, commercial handline selectivity pattern using a random walk.

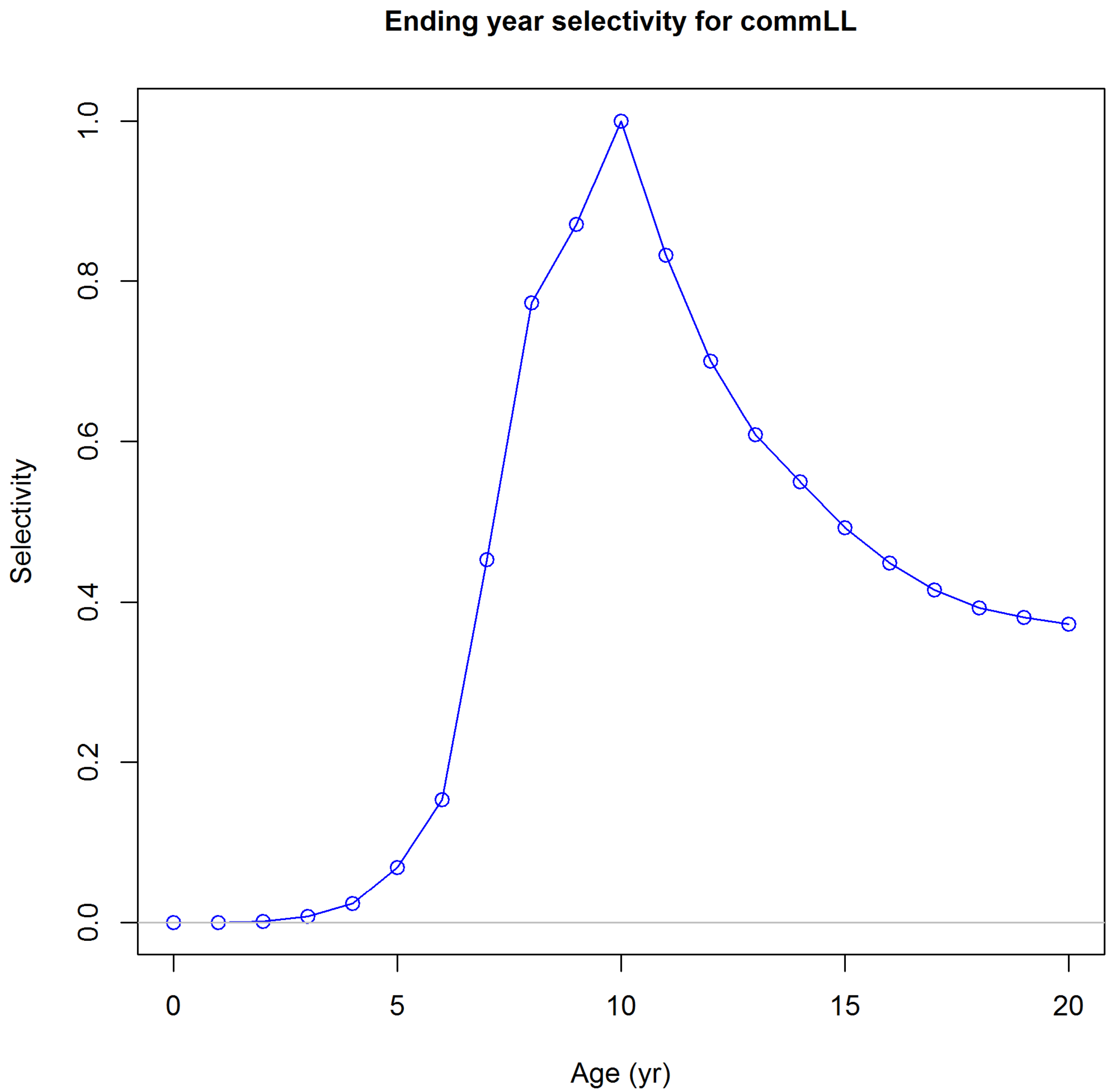


Figure 3.2.50 The estimated, commercial longline selectivity pattern using a random walk.

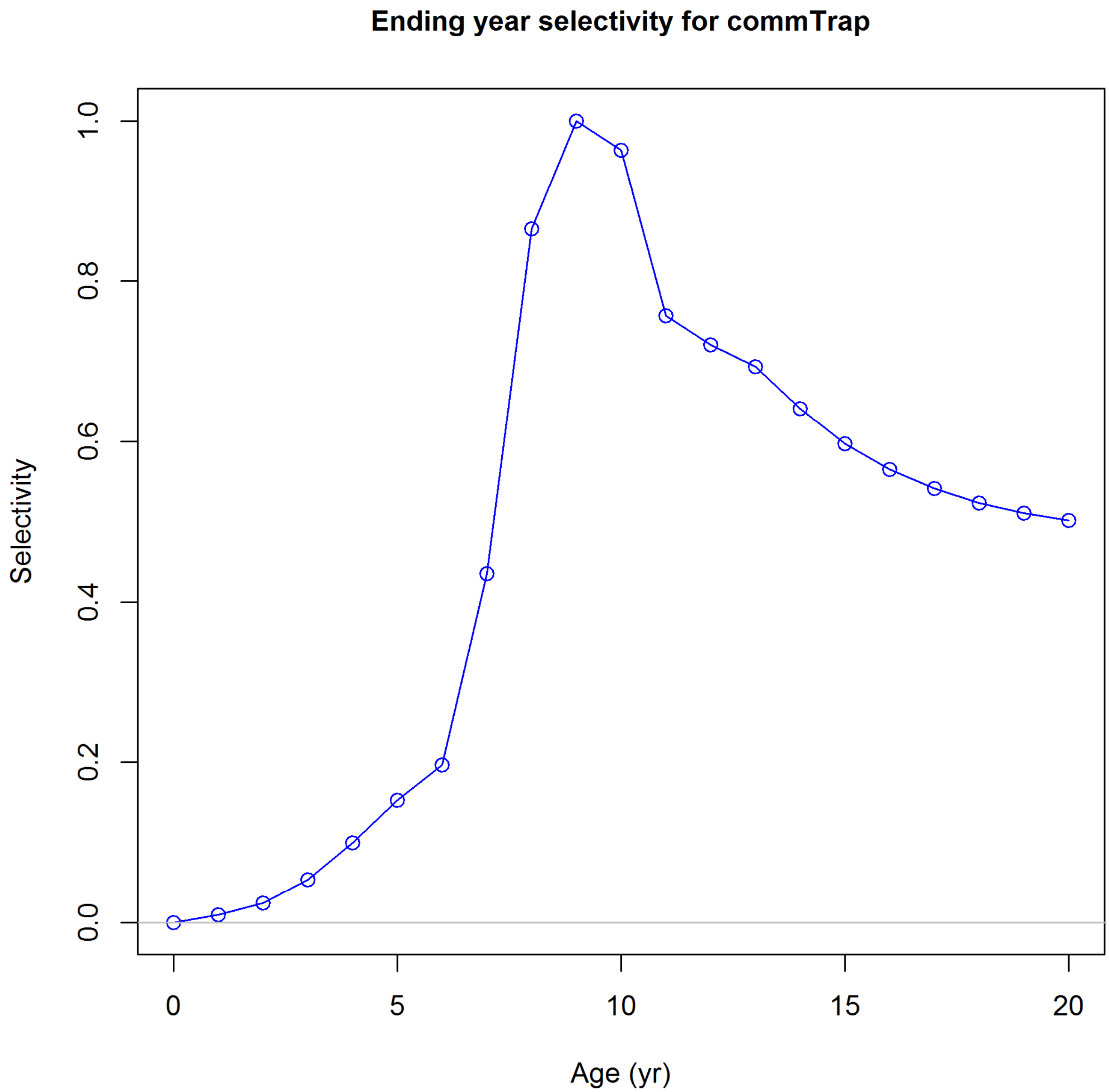


Figure 3.2.51 The estimated commercial trap selectivity pattern using a random walk.

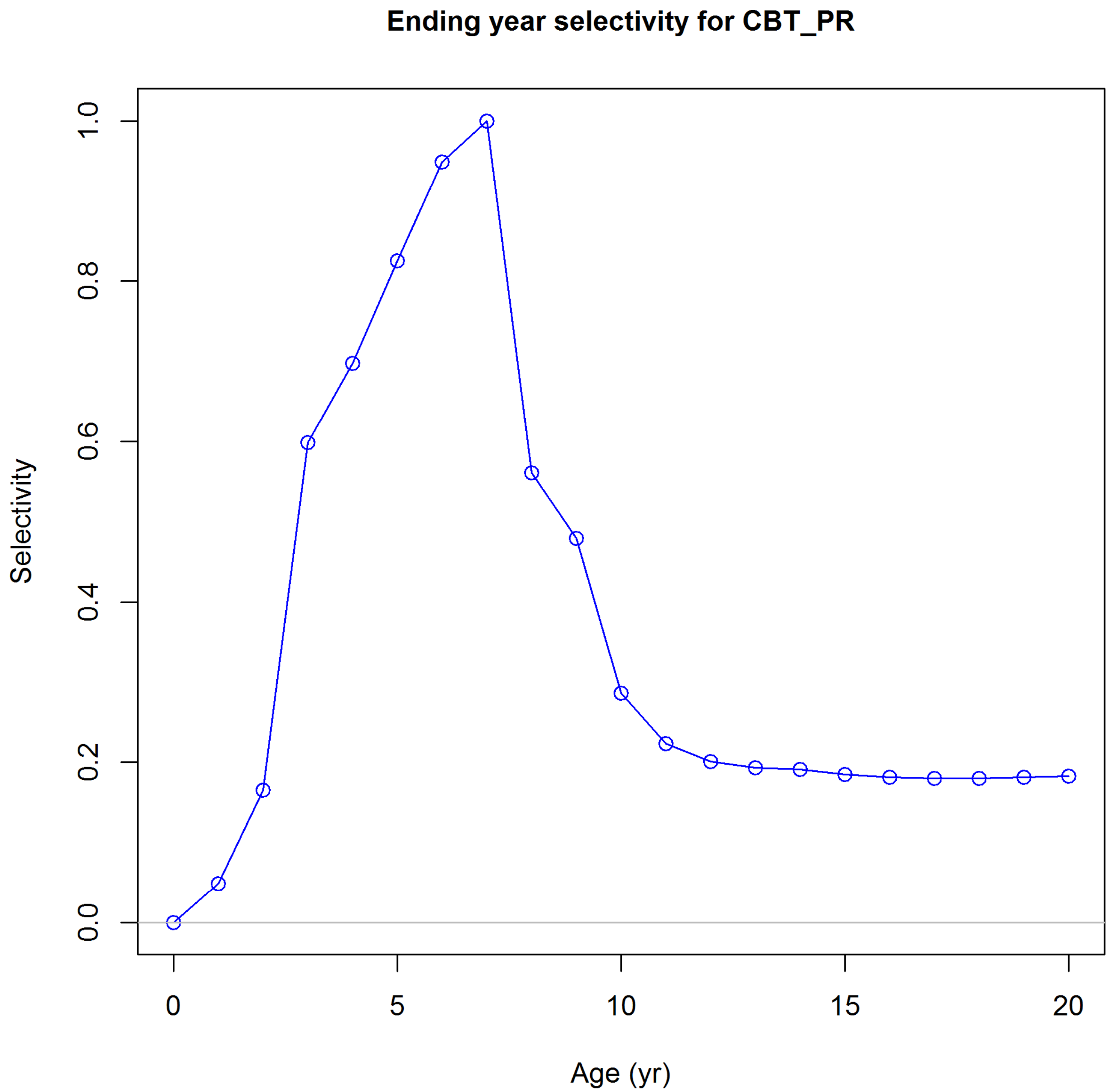


Figure 3.2.52 The estimated charterboat-private mode selectivity pattern using a random walk.

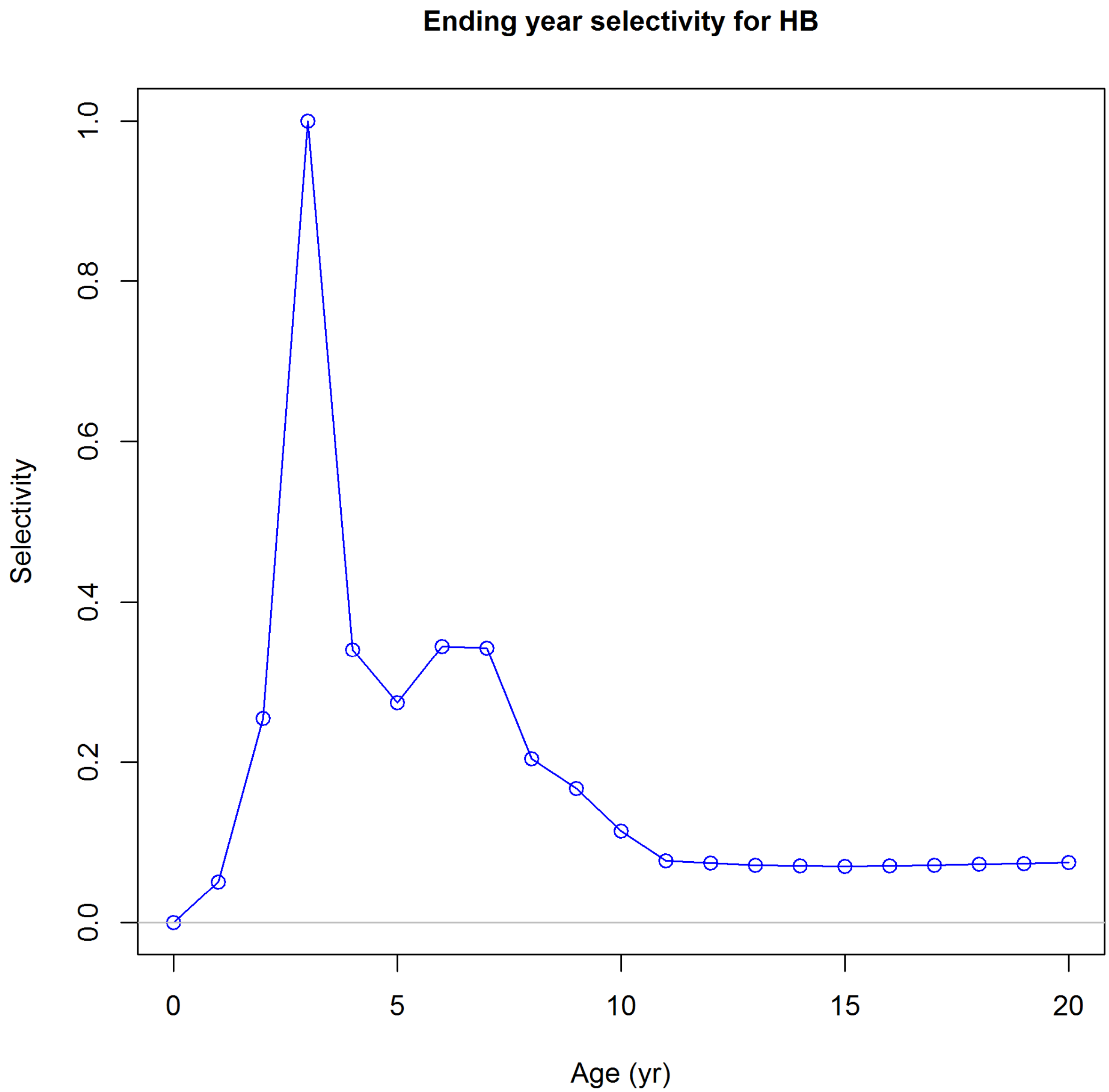


Figure 3.2.53 The estimated headboat mode selectivity pattern using a random walk.

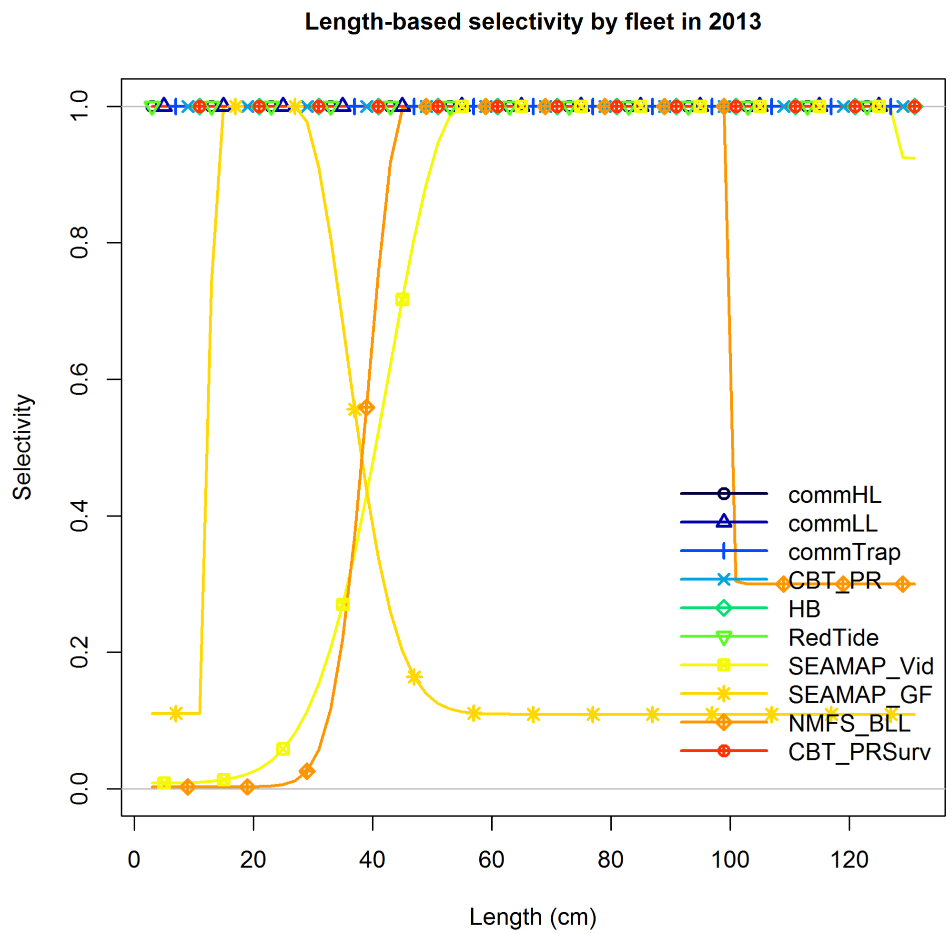


Figure 3.2.54 The estimated length-based selectivity patterns for the three fishery-independent surveys.

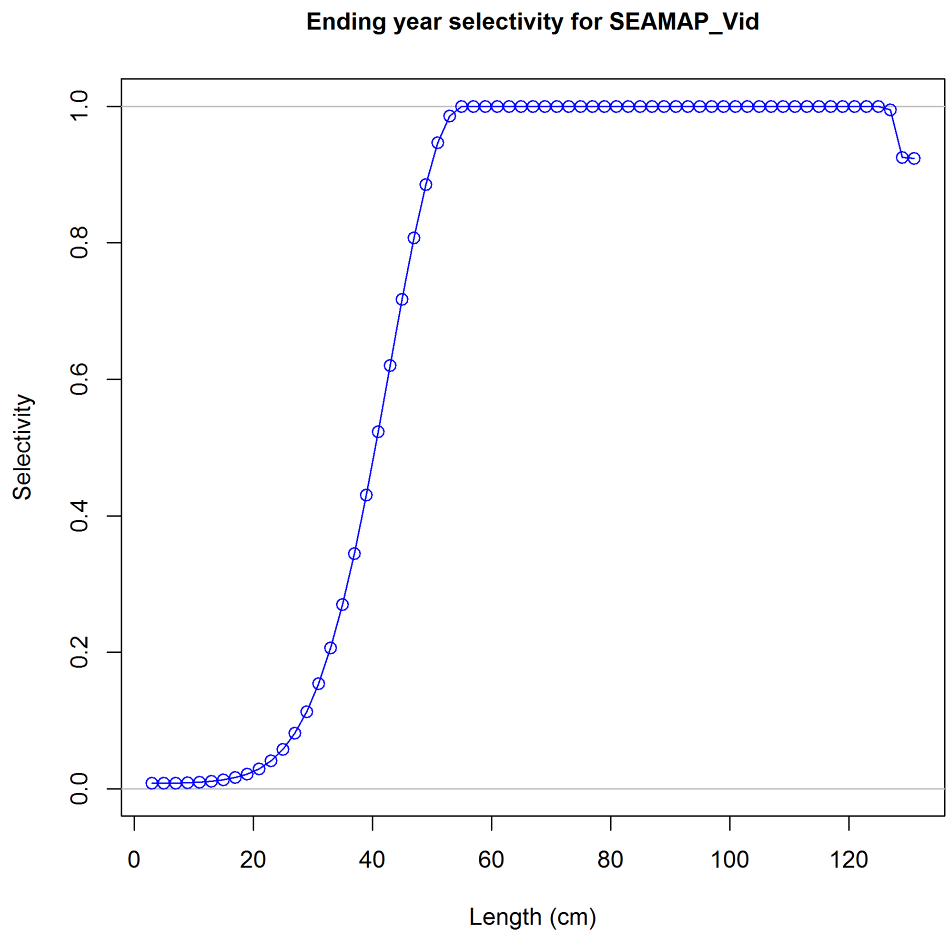


Figure 3.2.55 Length-based selectivity for the fishery-independent combined video survey.

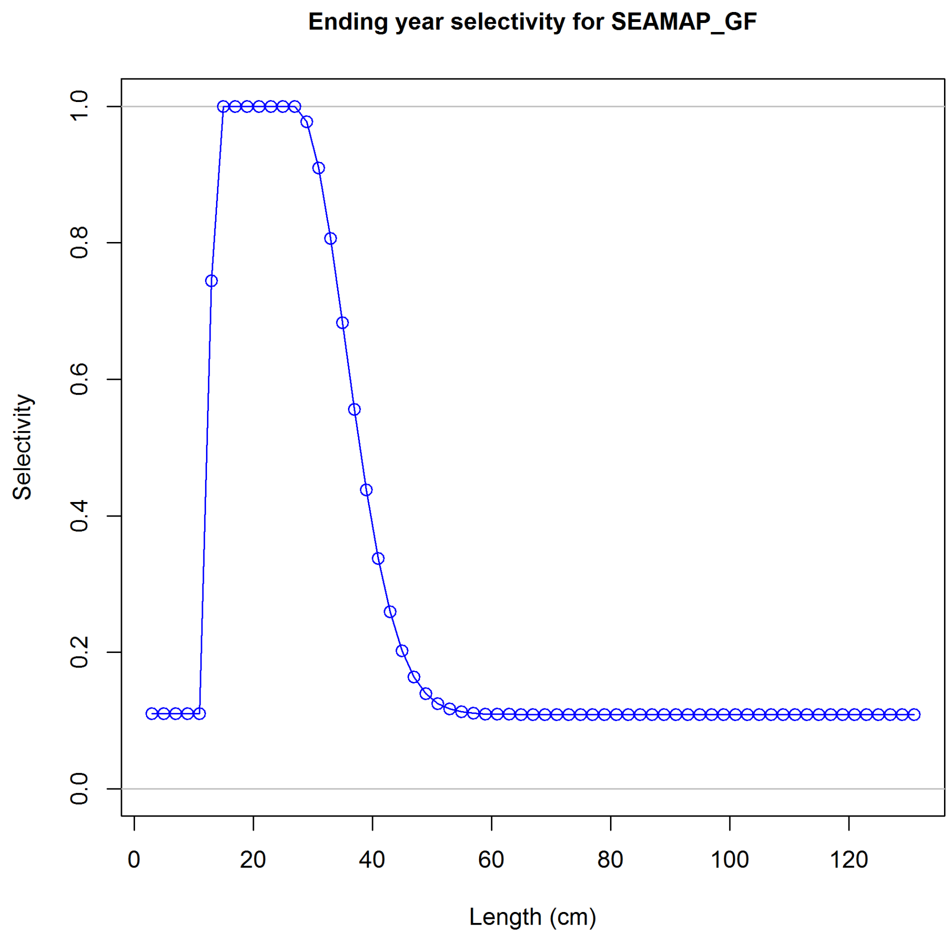


Figure 3.2.56 Length-based selectivity for the fishery-independent SEAMAP groundfish survey.

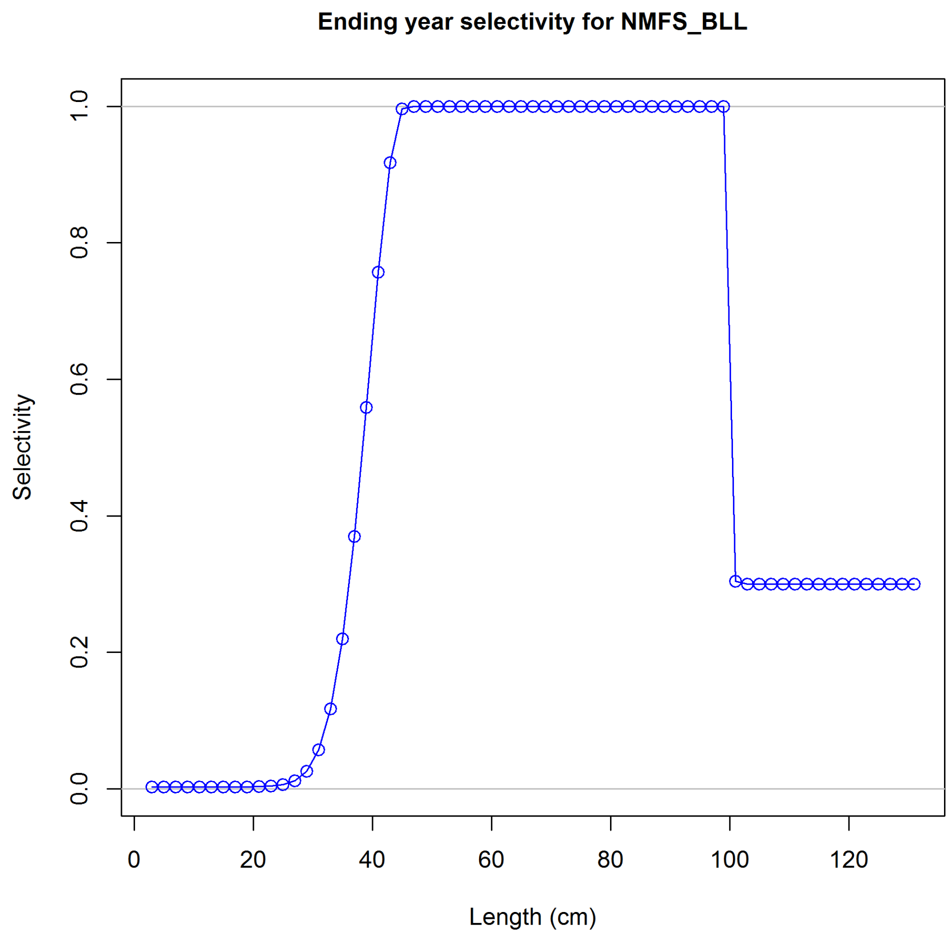


Figure 3.2.57 Length-based selectivity for the fishery-independent NMFS bottom longline survey.

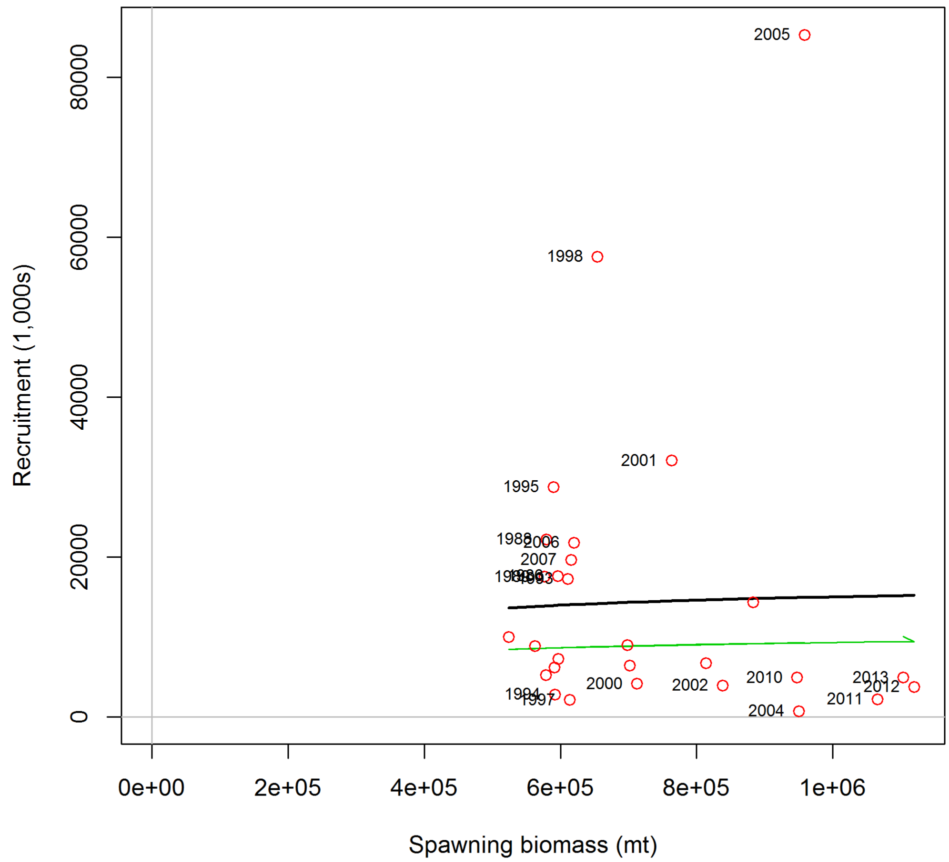


Figure 3.2.58 Predicted stock-recruitment relationship for Gulf of Mexico Red Grouper. Plotted are predicted annual recruitments from SS (circles), expected recruitment from the stock-recruit relationship (black line), and bias adjusted recruitment from the stock-recruit relationship (green line).

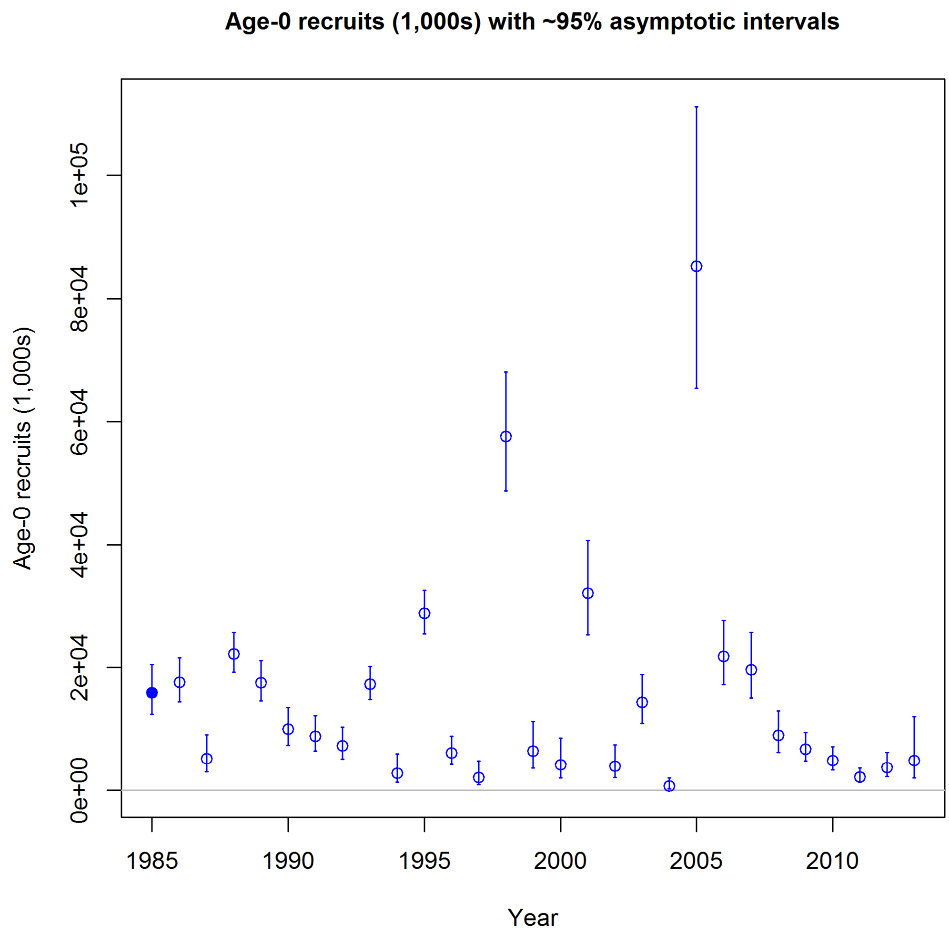


Figure 3.2.59 Predicted age-0 recruits with associated 95% asymptotic intervals.

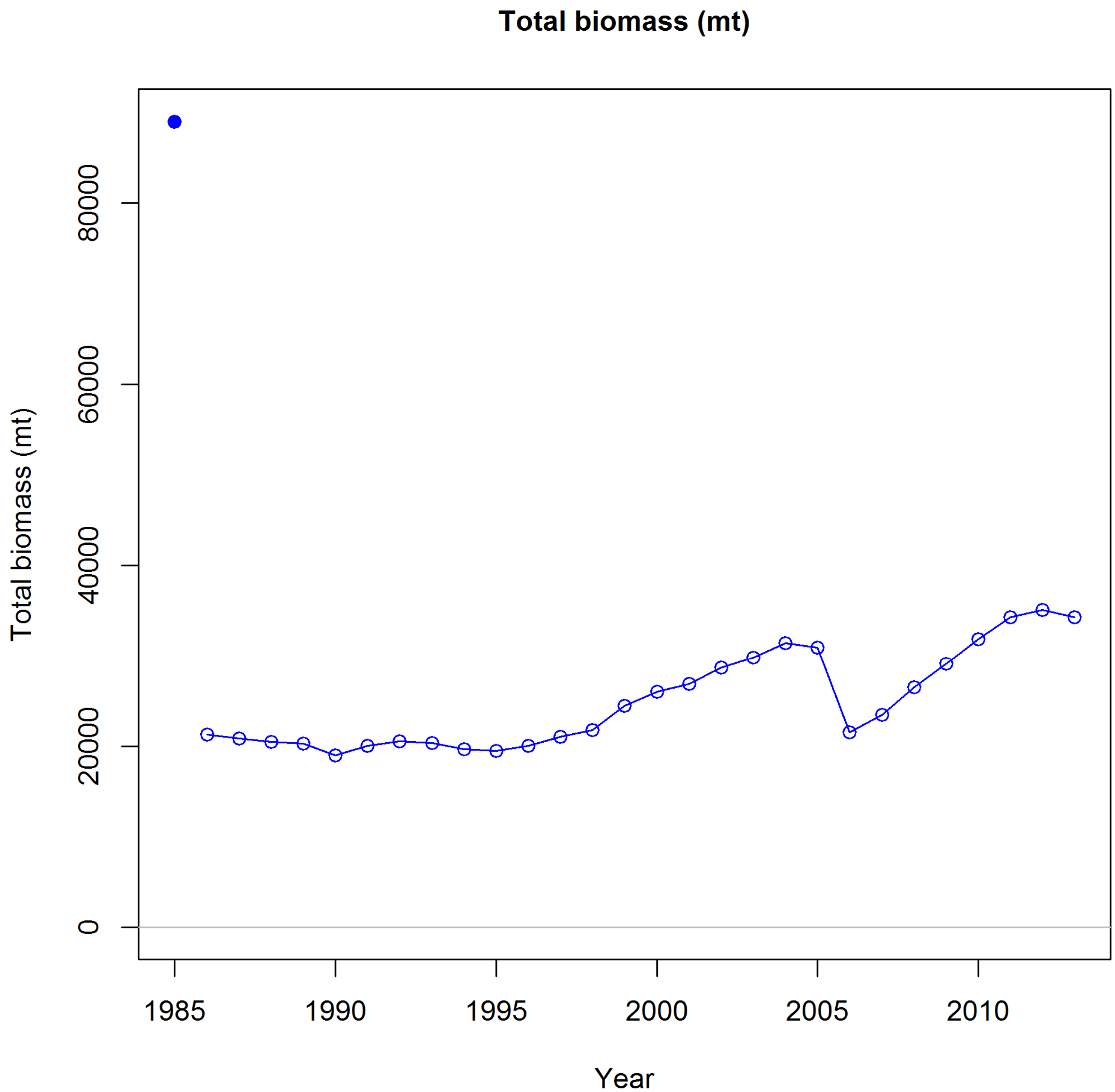


Figure 3.2.60 Predicted total biomass (mt) of Gulf of Mexico Red Grouper from 1986 to 2013

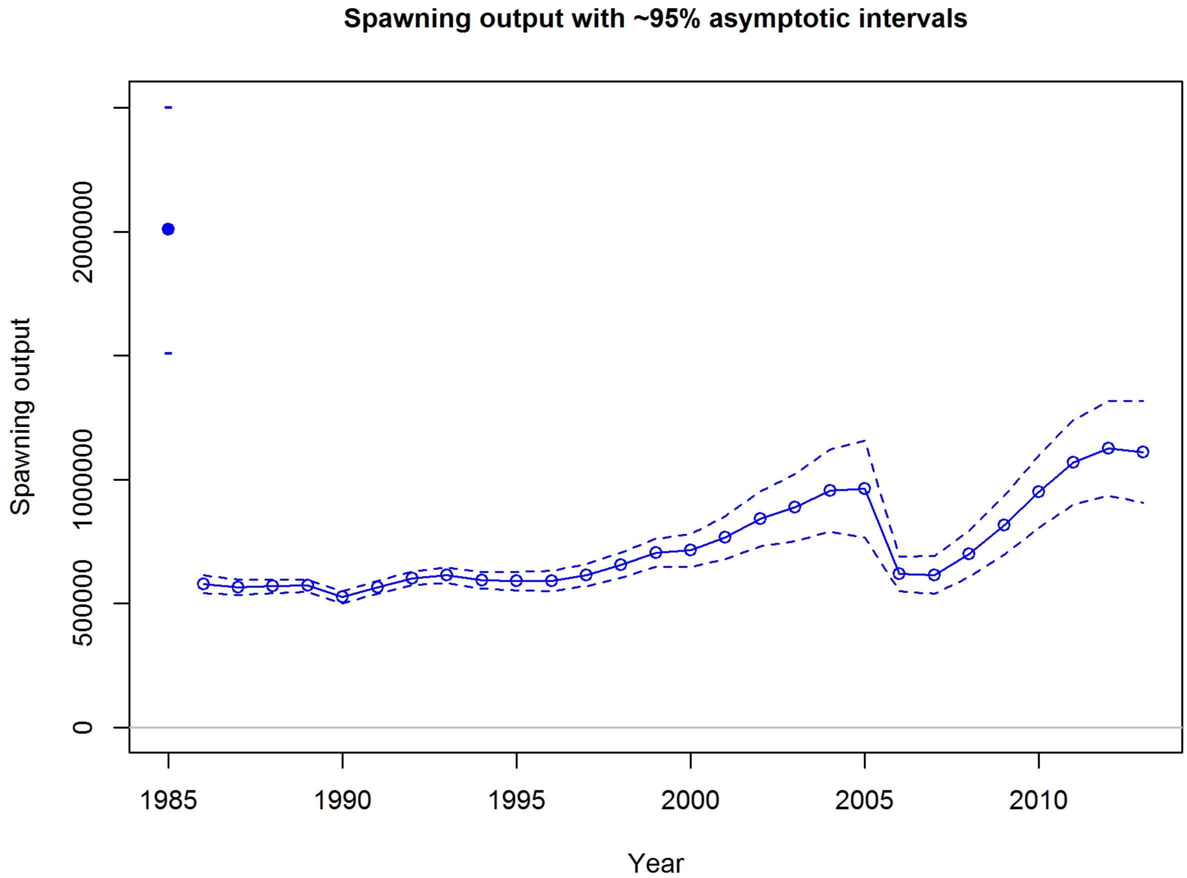


Figure 3.2.61 Predicted spawning output (eggs) with associated 95% asymptotic intervals.

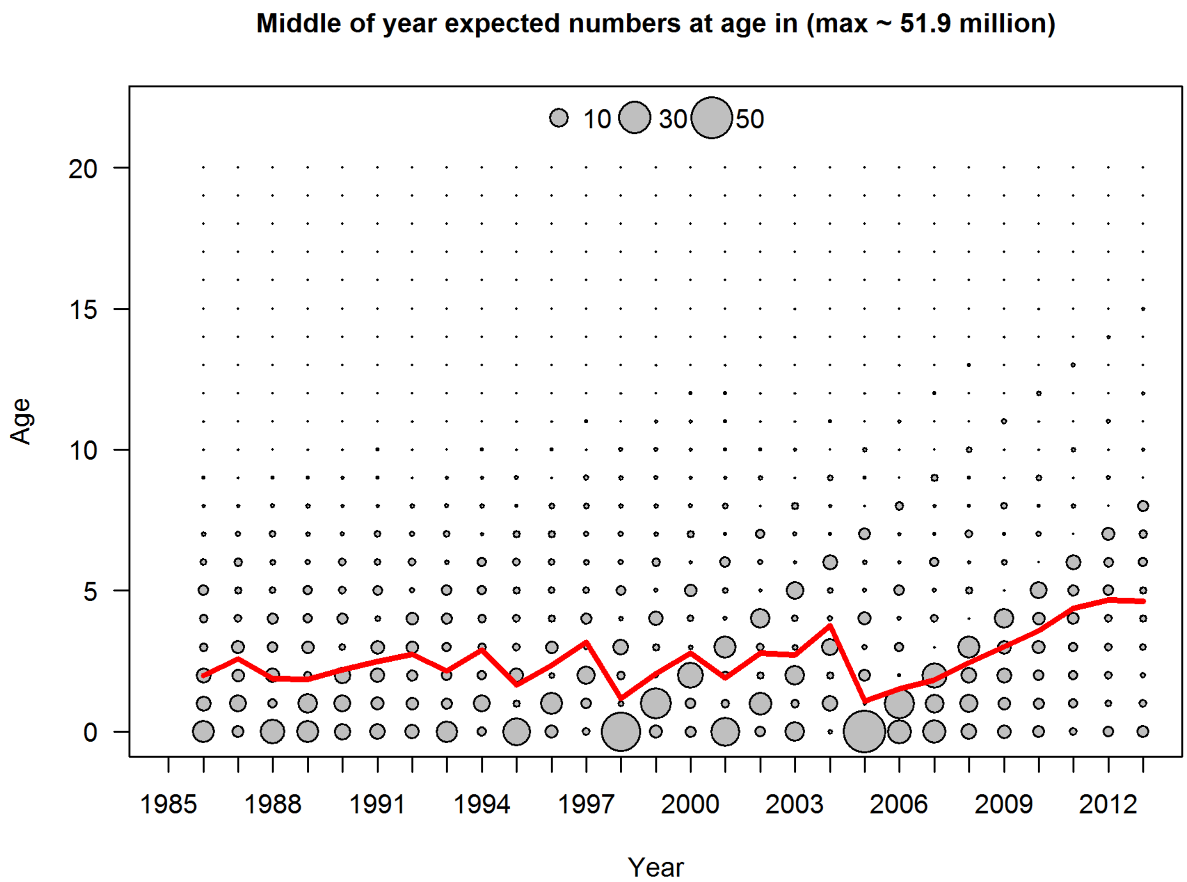


Figure 3.2.62 Predicted numbers-at-age (bubbles) and mean age of Gulf of Mexico Red Grouper.

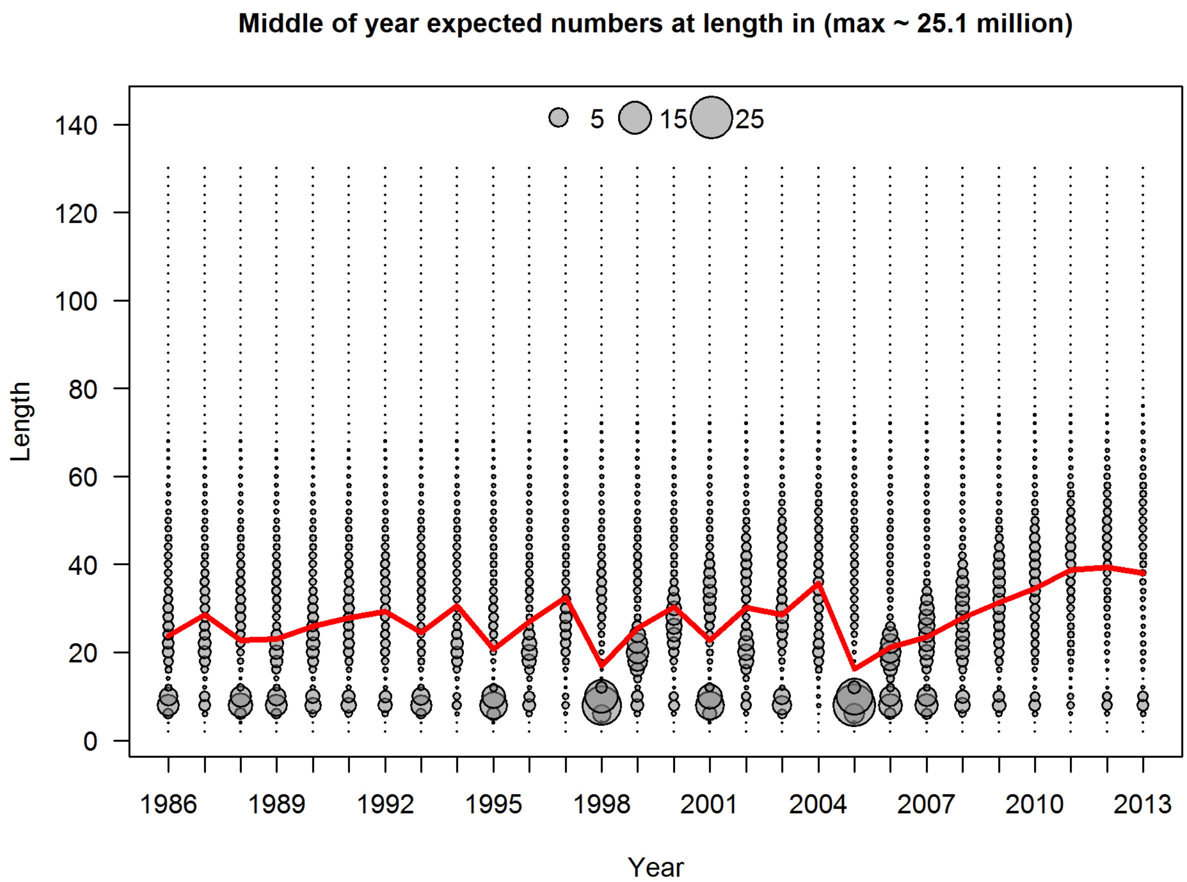


Figure 3.2.63 Predicted numbers-at-length (bubbles) and mean length of Gulf of Mexico Red Grouper.

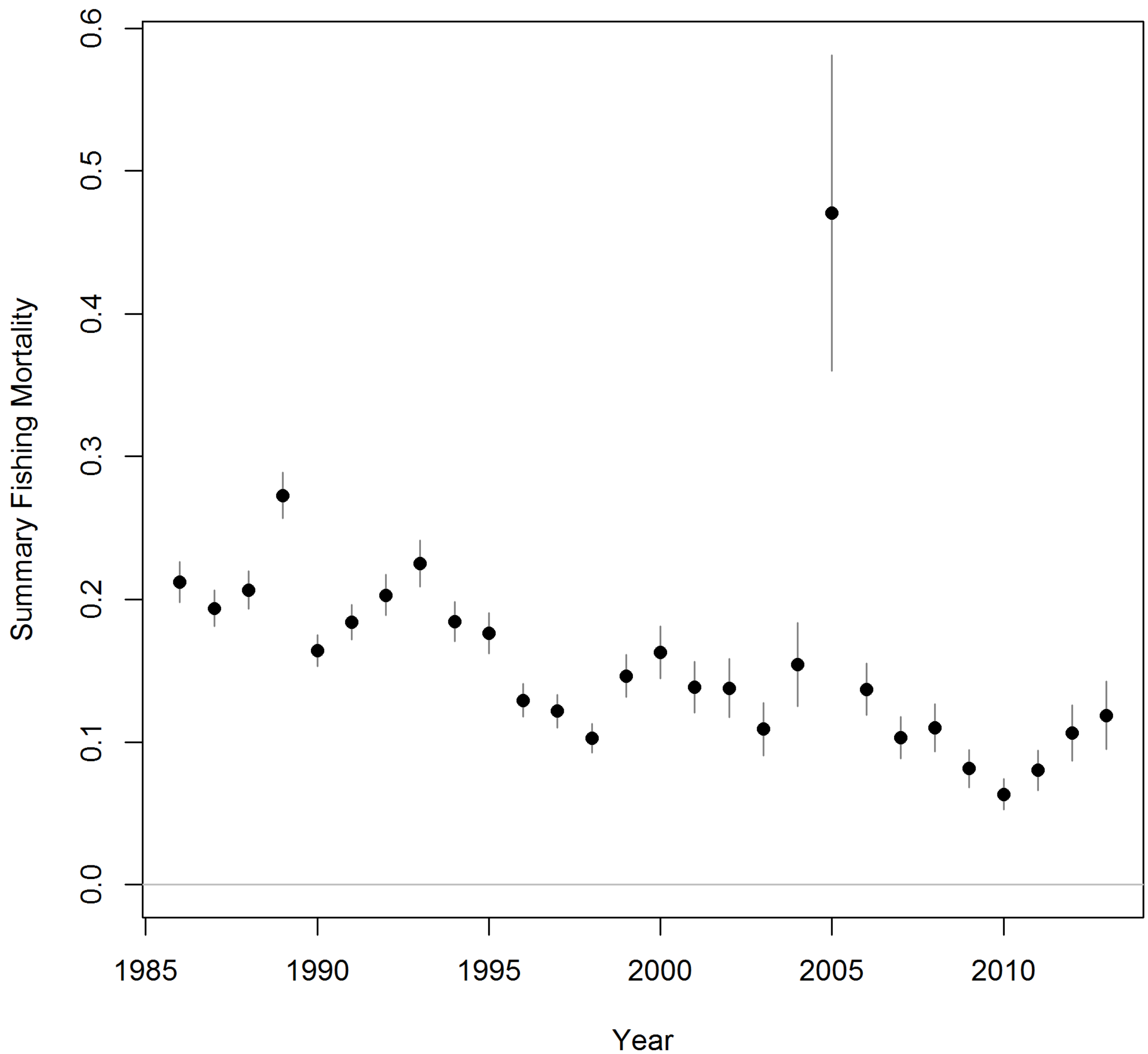


Figure 3.2.64 Predicted annual exploitation rate calculated as the ratio of total annual catch in weight to total biomass in weight. The exceptionally high estimate of exploitation in 2005 is due to the estimation of a red tide mortality term.

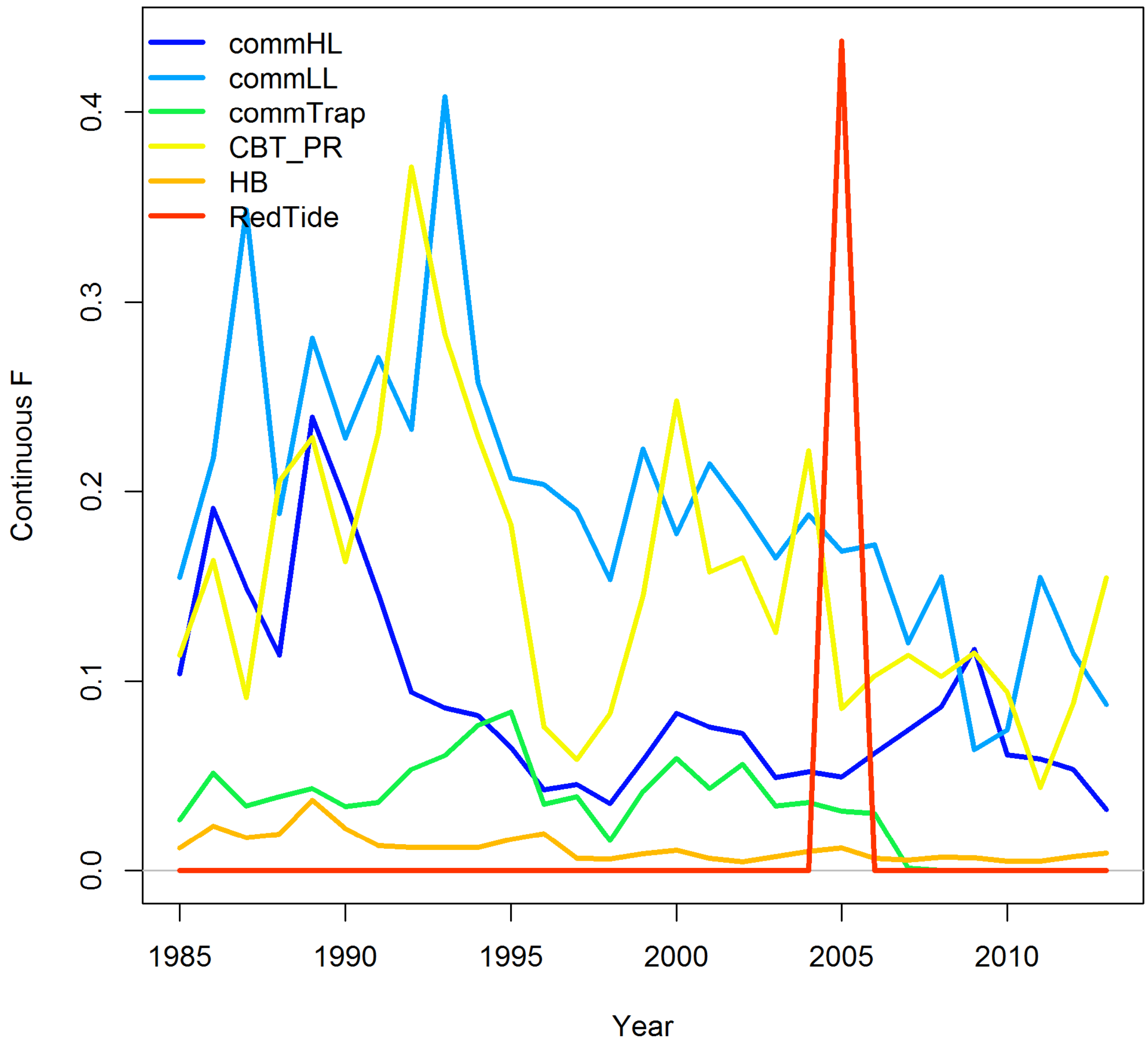


Figure 3.2.65 Predicted fleet specific fishing mortality.

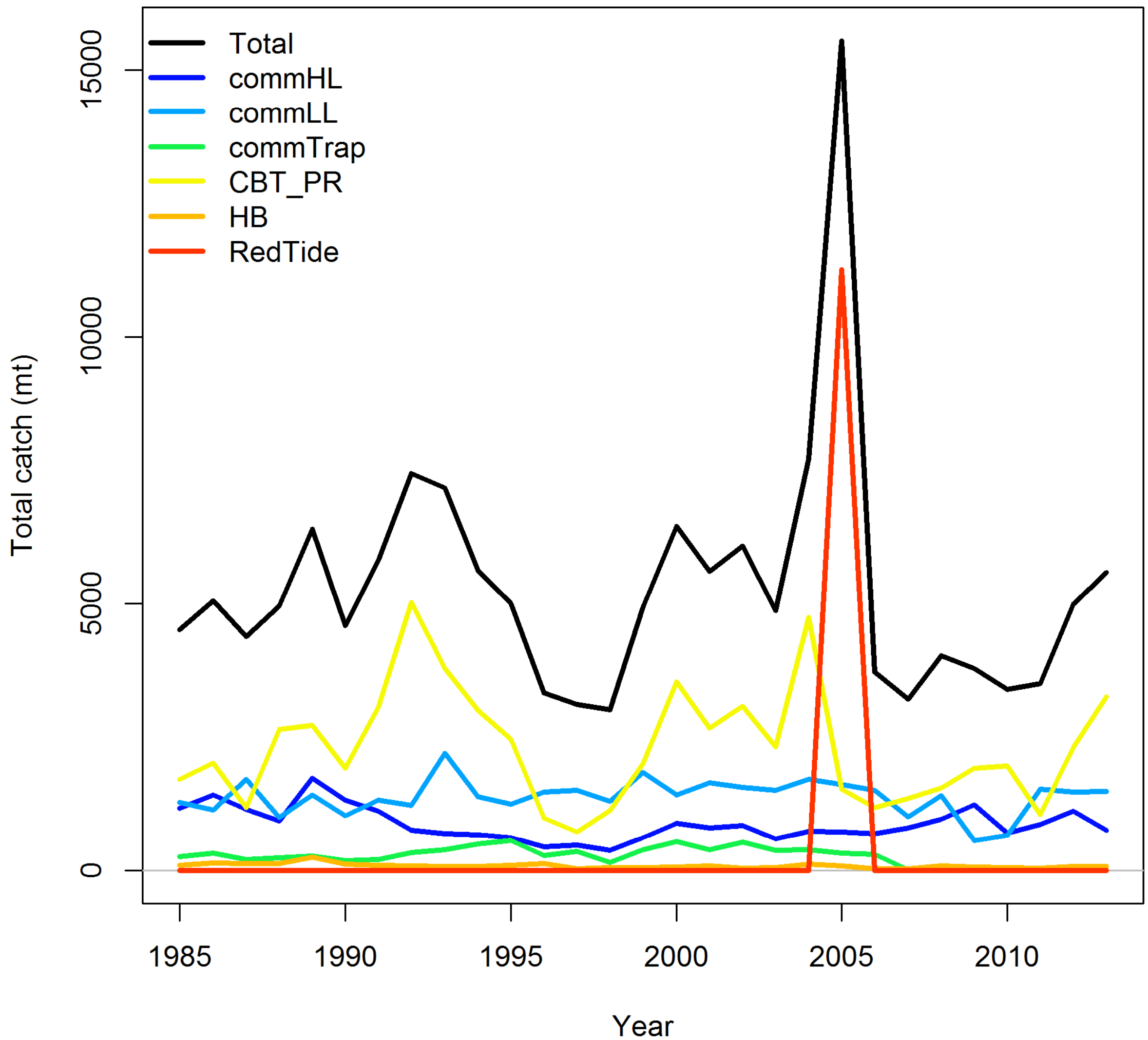


Figure 3.2.66 Fleet specific total catch (landings + discards).

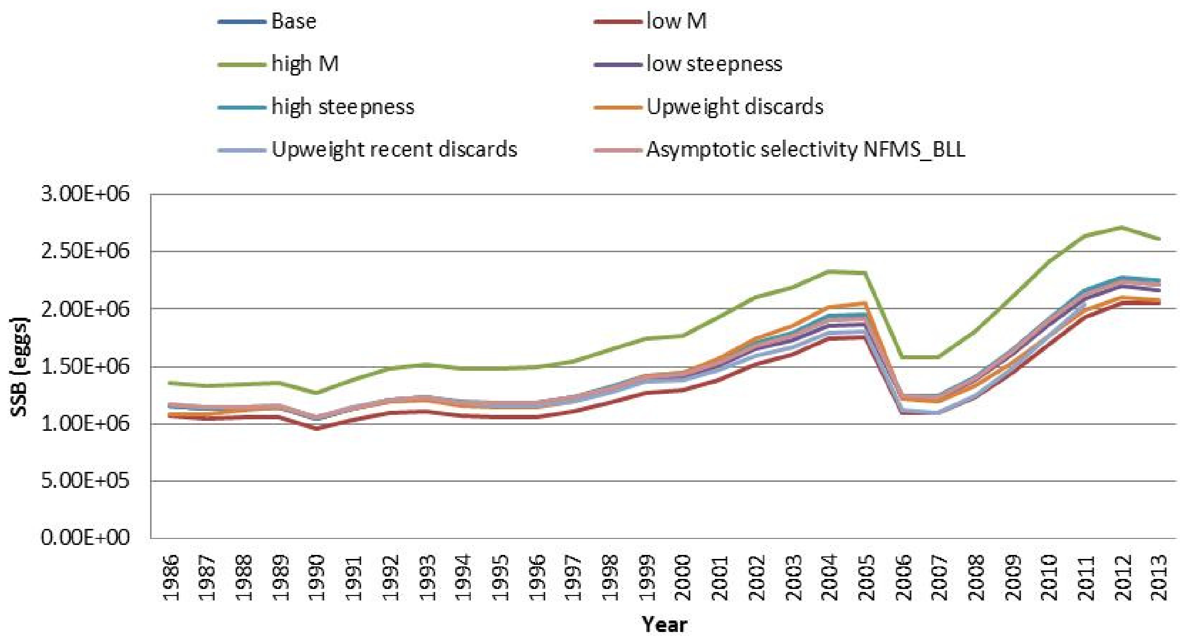


Figure 3.2.67 Estimates of spawning stock biomass (SSB) in eggs from all sensitivity runs.

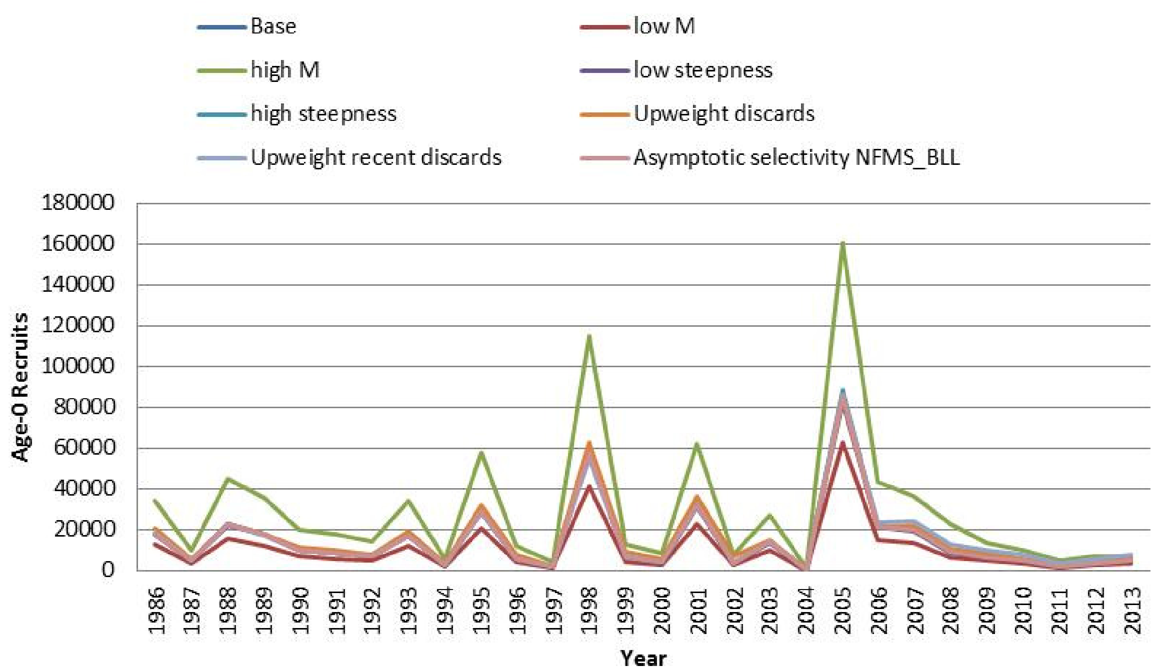


Figure 3.2.68 Estimates of age-0 recruits from all sensitivity runs.

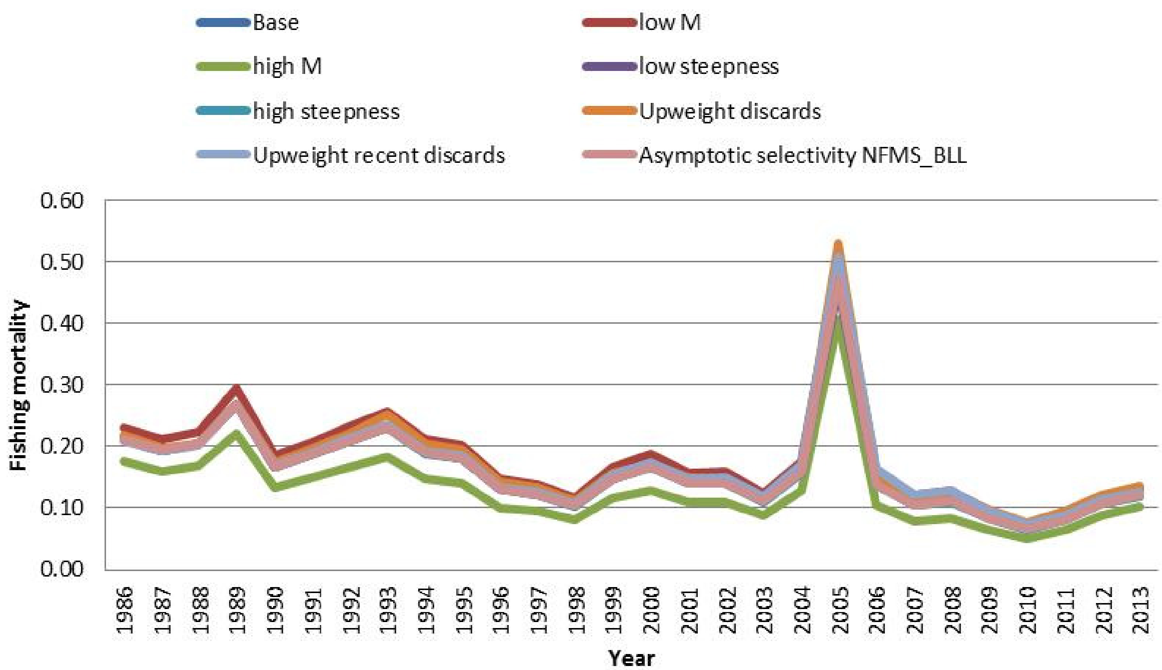


Figure 3.2.69 Estimates of fishing mortality from all sensitivity runs.

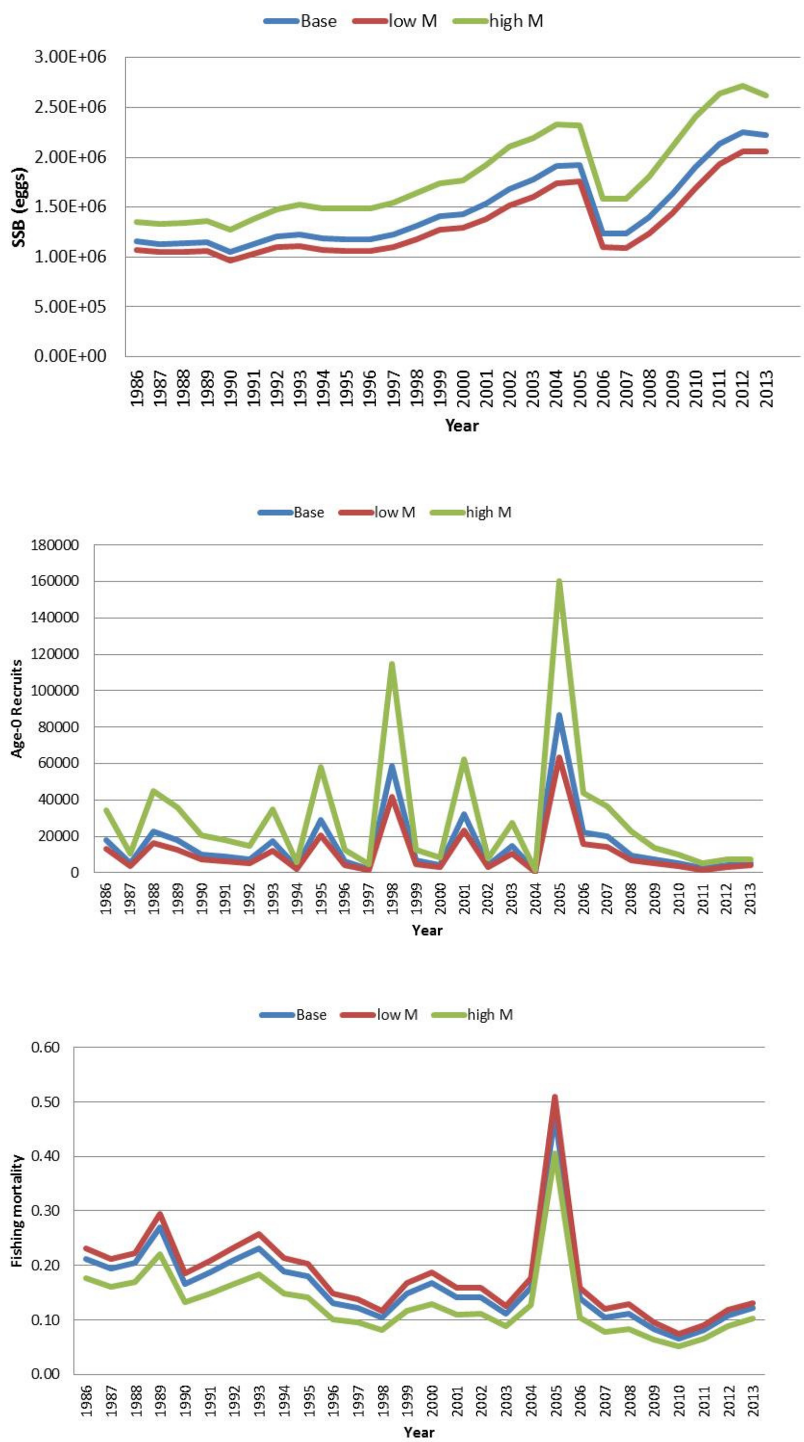


Figure 3.2.70 Estimates of SSB, age-0 recruits, and fishing mortality for the natural mortality sensitivity runs.

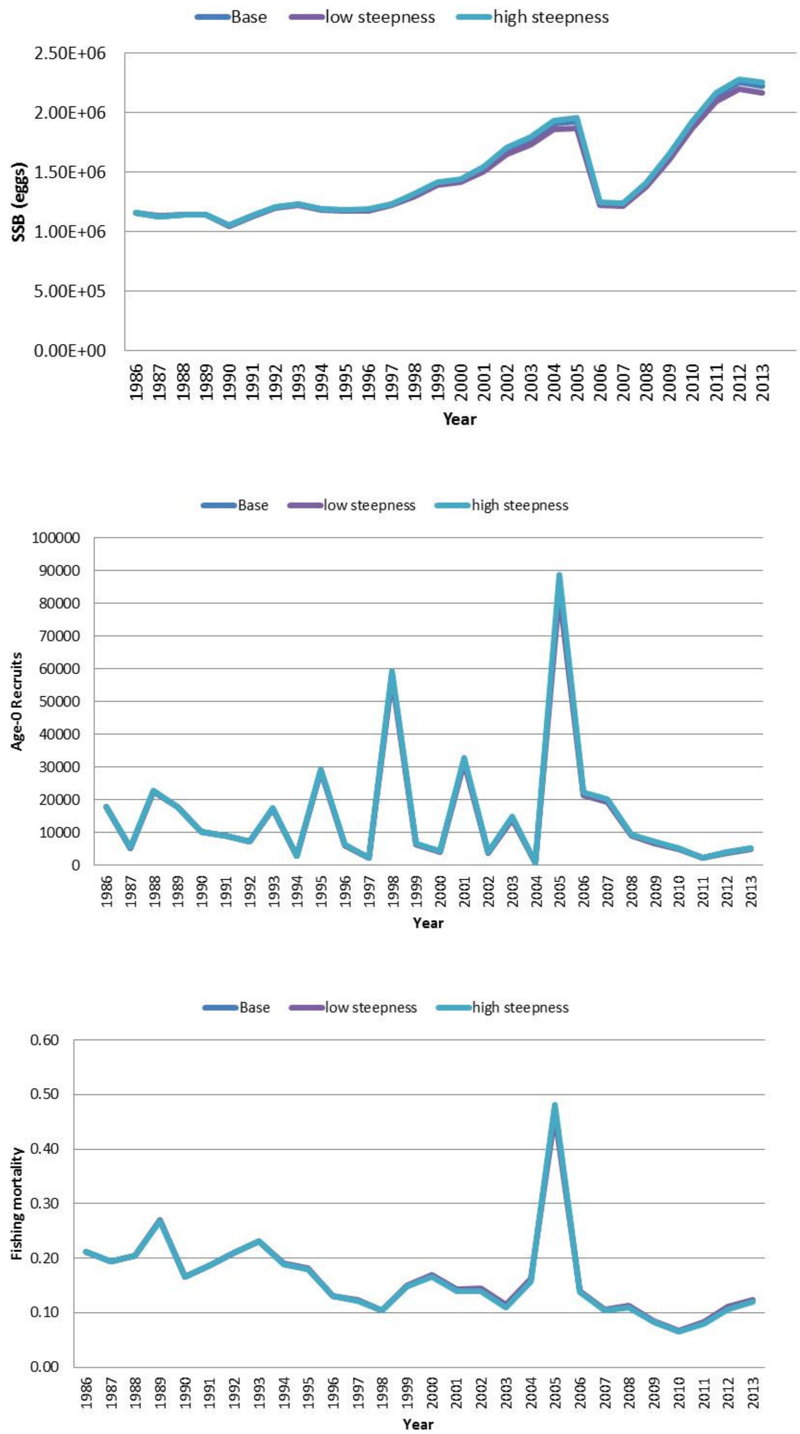
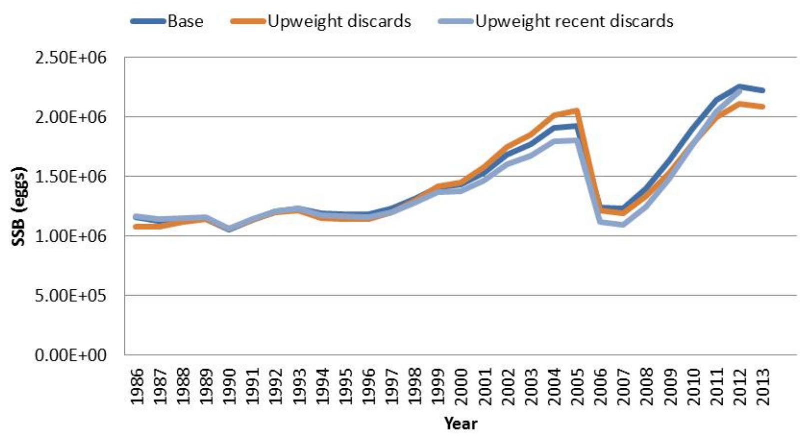
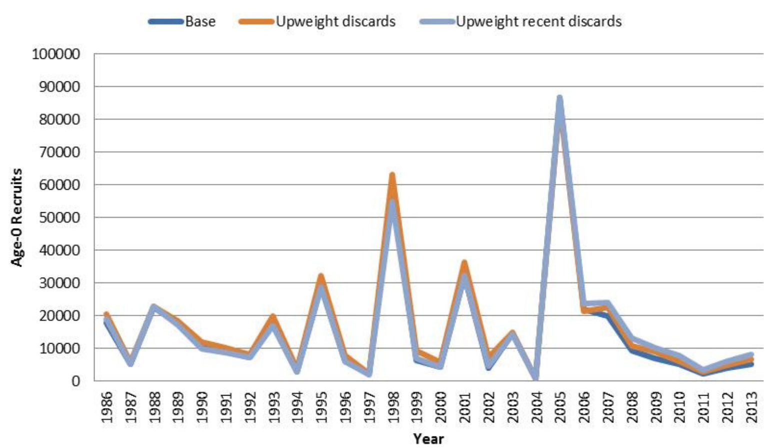


Figure 3.2.71 Estimates of SSB, age-0 recruits, and fishing mortality for the steepness sensitivity runs.





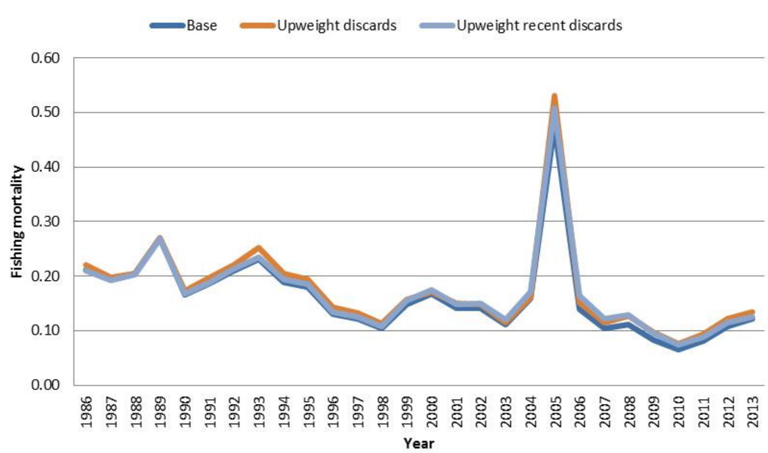
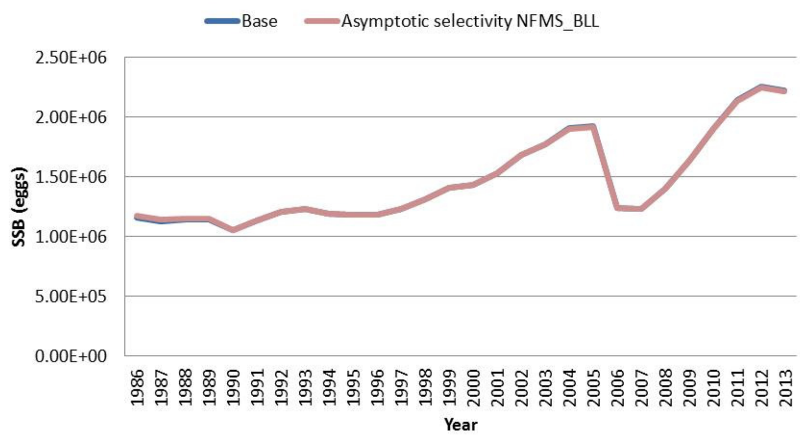
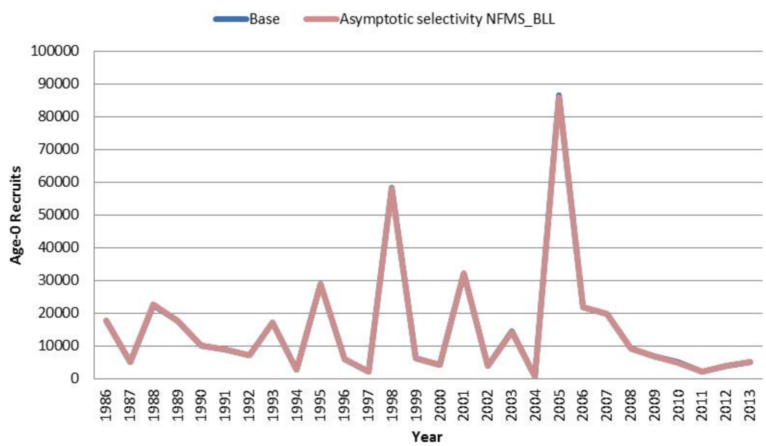


Figure 3.2.72 Estimates of SSB, age-0 recruits, and fishing mortality for the total discard sensitivity runs.





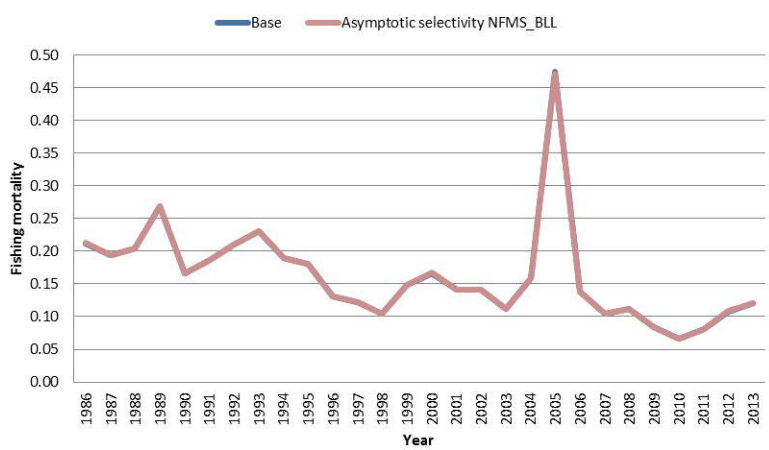


Figure 3.2.73 Estimates of SSB, age-0 recruits, and fishing mortality for the NMFS bottom longline selectivity pattern sensitivity run.

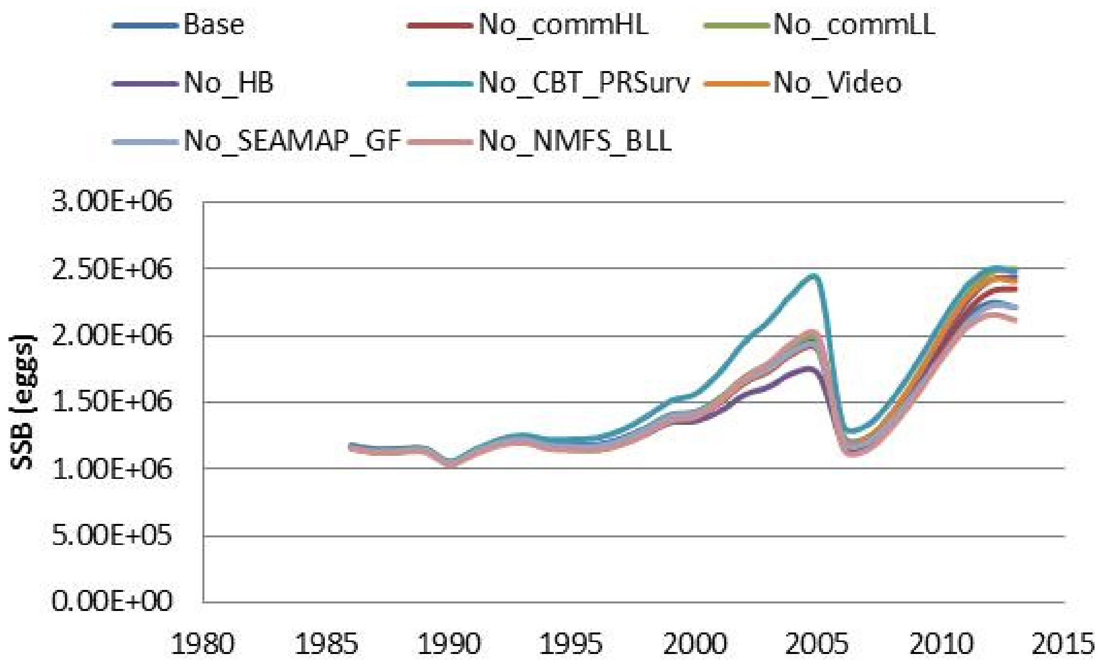


Figure 3.2.74 Estimates of spawning stock biomass (SSB, eggs) from the jack-knife analysis.

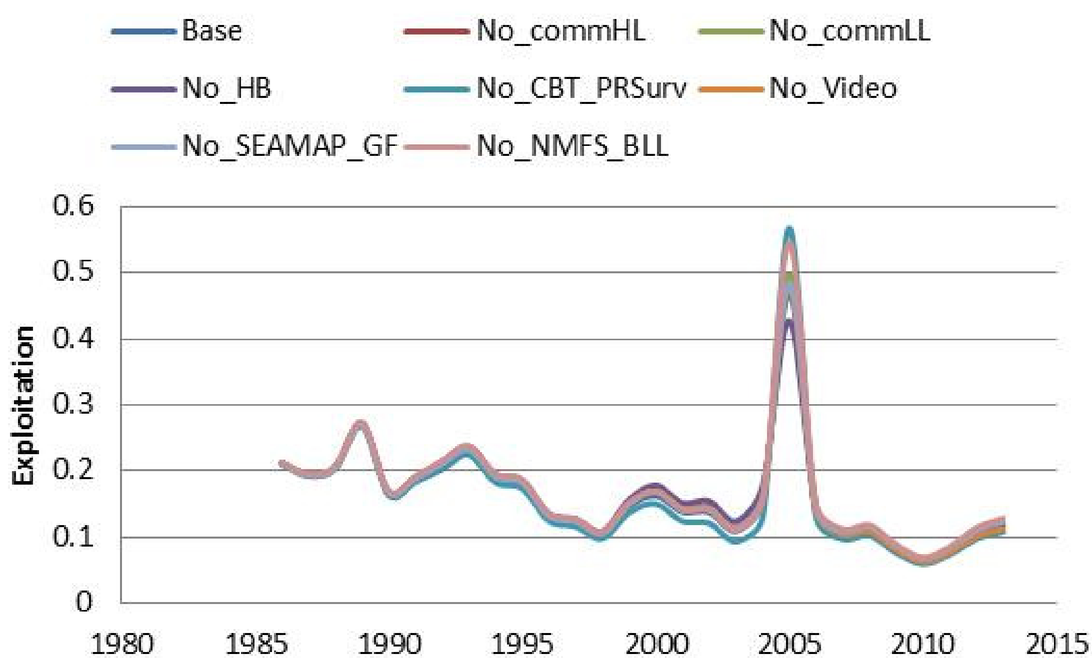


Figure 3.2.75 Estimates of fishing mortality from the jack-knife analysis.

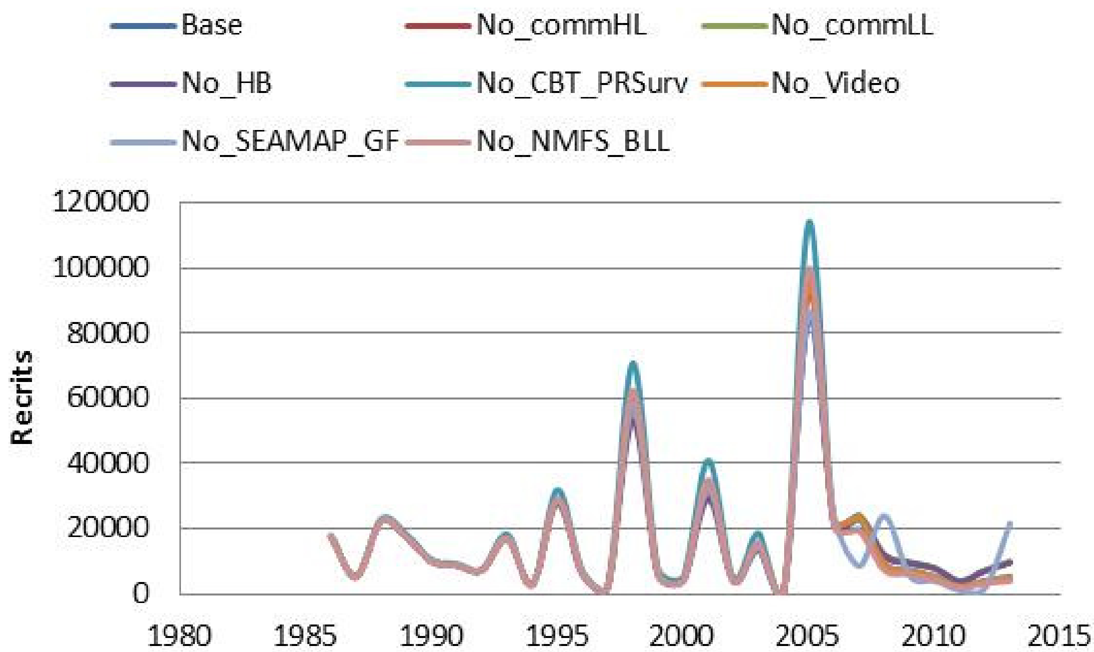


Figure 3.2.76 Estimates of age-0 recruits from the jack-knife analysis.

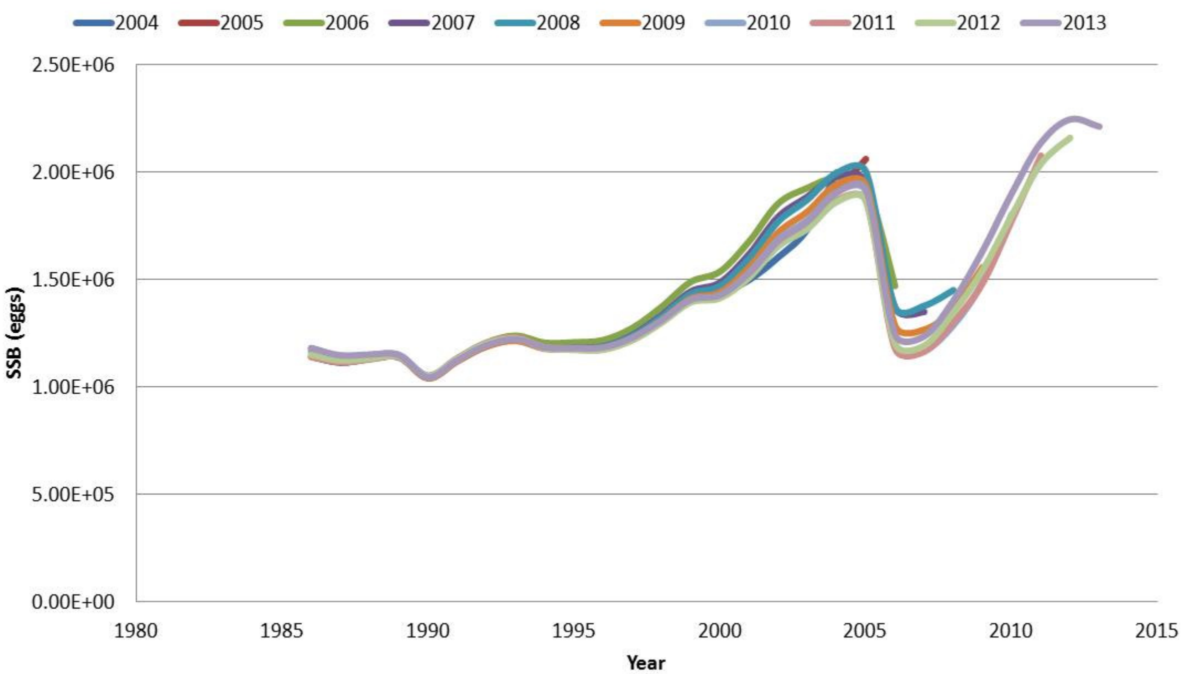


Figure 3.2.77 Estimates of spawning stock biomass (SSB, eggs) from the retrospective analysis.

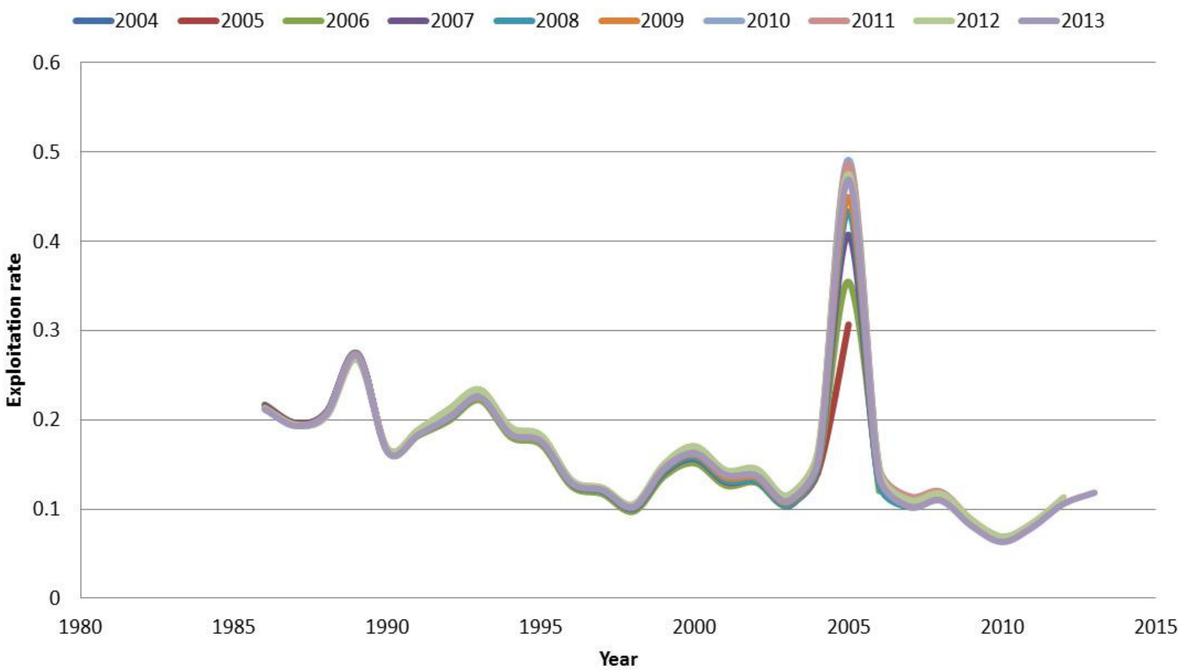


Figure 3.2.78 Estimates of fishing mortality from the retrospective analysis.

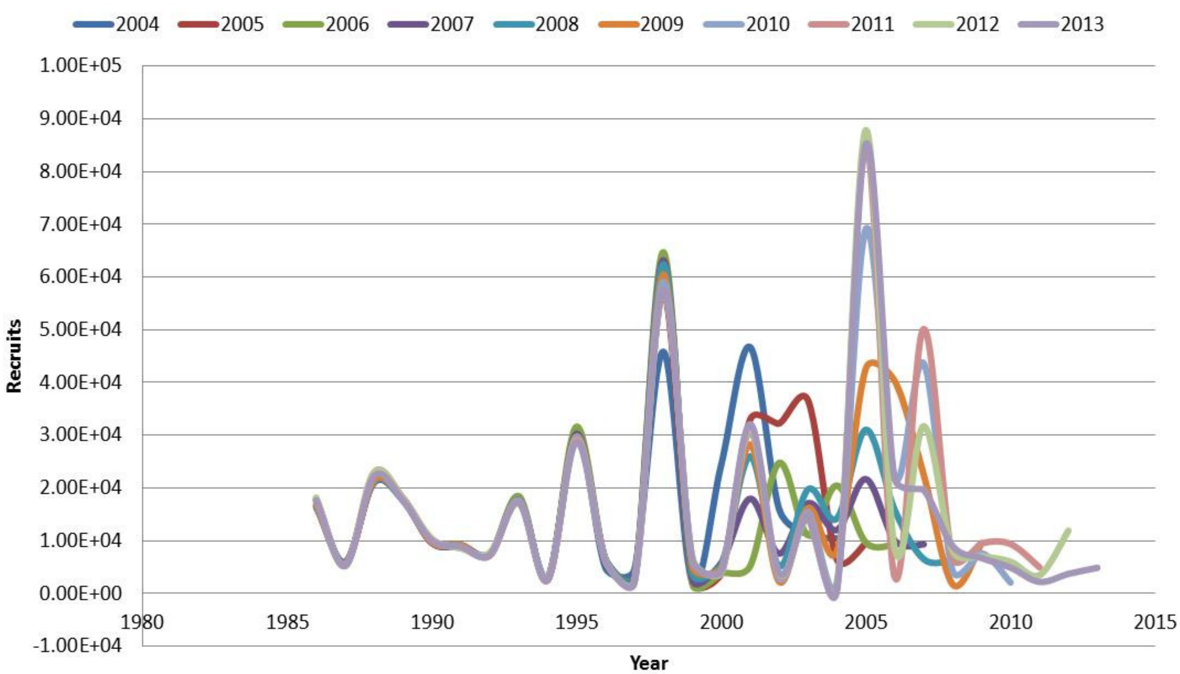


Figure 3.2.79 Estimates of age-0 recruits from the retrospective analysis.

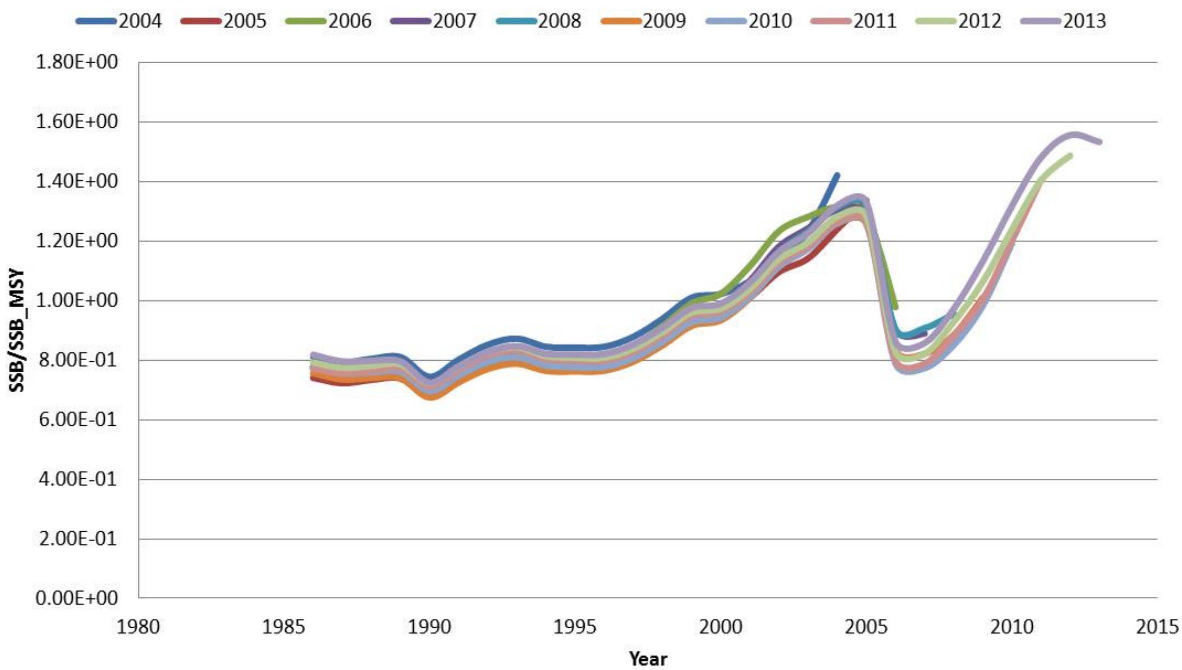


Figure 3.2.80 Estimates of the ratio between spawning stock biomass (SSB) and SSB achieved at MSY (SSB_MSY) from the retrospective analysis.

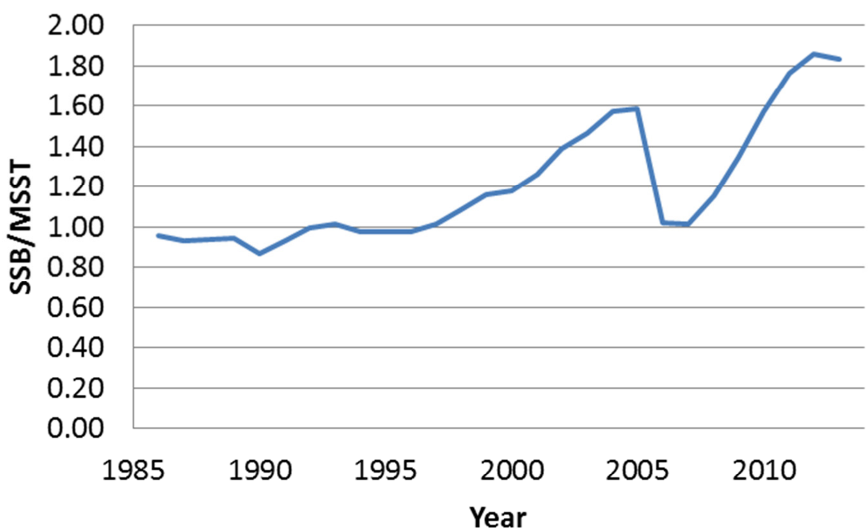


Figure 3.2.81 Stock status with respect to the spawning stock biomass, where the ratio of SSB and the minimum stock stize threshold (MSST) is used to determine whether a population is overfished.

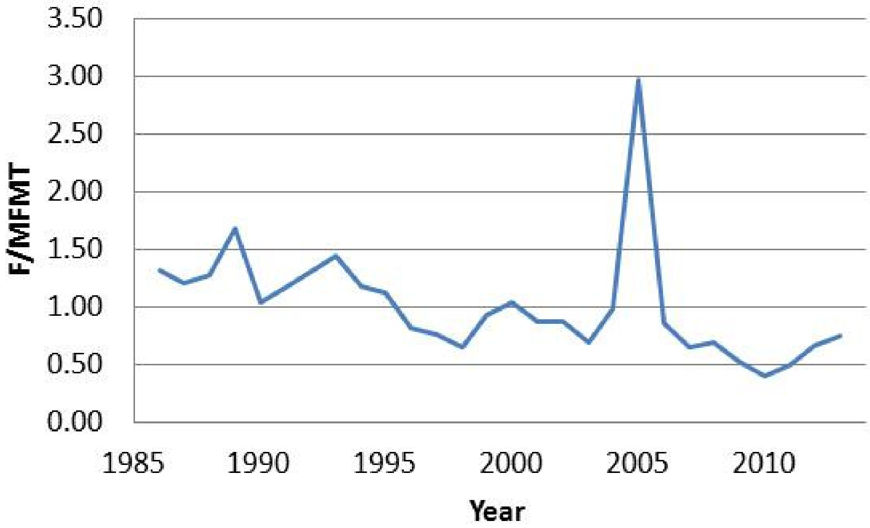


Figure 3.2.82 Stock status with respect to fishing mortality, where the ratio between fishing mortality (F) and the maximum fishing mortlaity threshold (MFMT) is used to determine whether a population is experiencing overfishing.

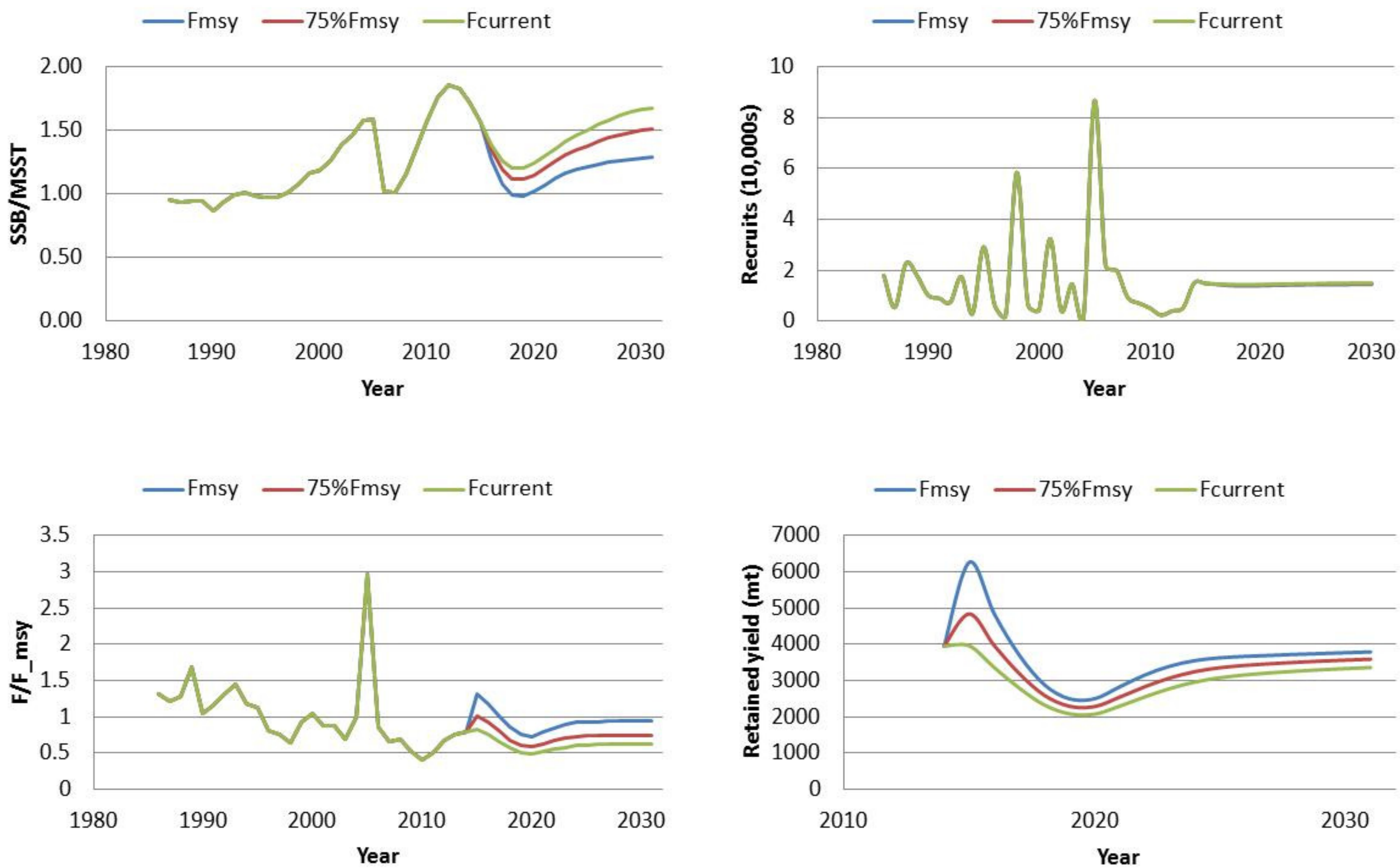


Figure 3.2.83 Projection results, the ratio between reproductive potentional in eggs (SSB) and minimum stock size threshold (MSST, upper left panel), age-0 recruits (upper right panel), the ratio between fishing mortality (F) and Fmsy (lower left panel), and retained yield (lower right panel), for three fishing mortality scenarios: F = Fmsy, F = Foy (75% Fmsy), and F = Fcurrent.

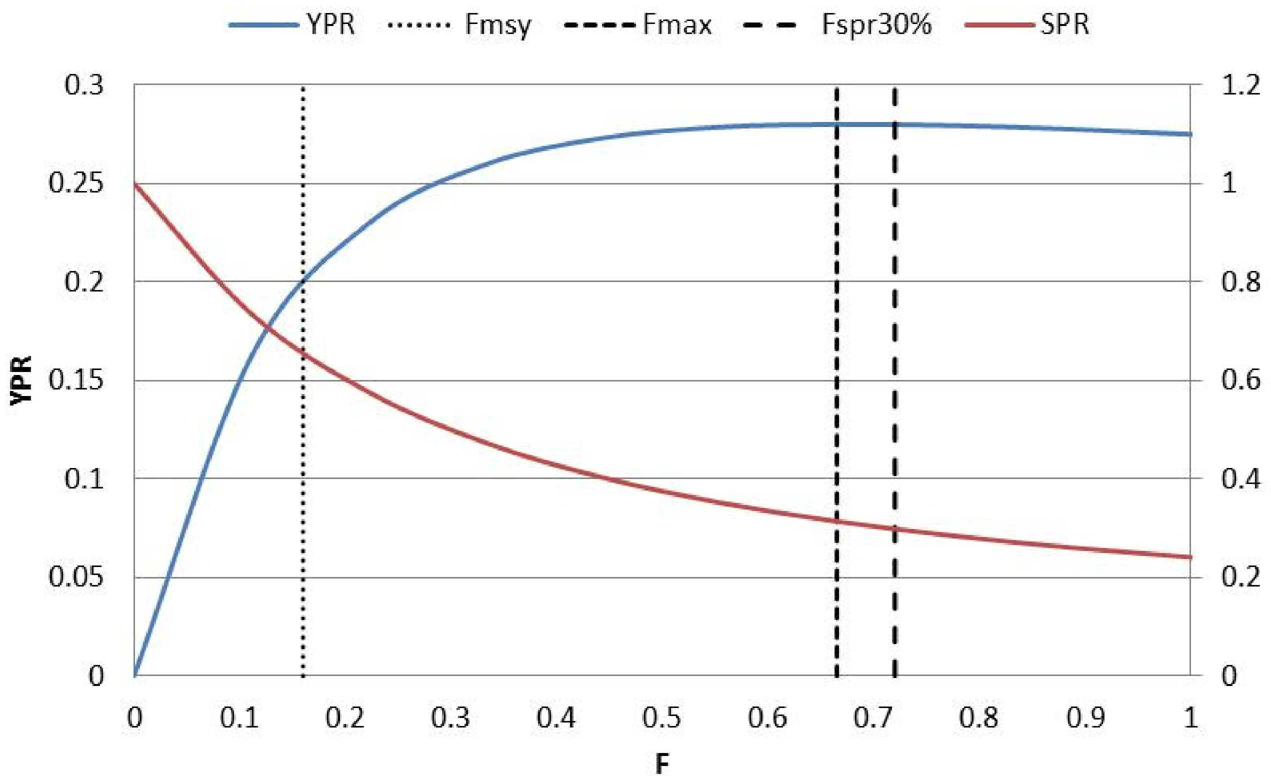


Figure 3.2.84 Yield per recruit (YPR, blue line) and spawner per recruit (SPR, red line) as a function of fishing mortality for SSB-female. Vertical lines represent Fmsy (F = 0.16), Fmax (F = 0.66), and Fspr30% (F = 0.72).

3.8 Appendix

Appendix A. Data file used for the Red Grouper Stock Synthesis model.

#V3.20f

#C this comment will be stored because it starts with #C. It will be written to output files

1986 #_styr

2013 #_endyr

1 #_nseas

12 #_months/season

1 #_spawn_seas

6 #_Nfleet

4 #_Nsurveys

1 #_N_areas

below are the fishery and survey names, separated by a % delimiter; later the data from first survey will have index number 2 and survey 2 will have index number3

commHL%commLL%commTrap%CBT_PR%HB%RedTide%SEAMAP_Vid%SEAMAP_GF%NMFS_BLL%CBT_PRSur

-1 -1 -1 -1 -1 -1 0.5 0.5 0.5 0.5 #_surveytiming_in_season; but use -1 for a fishery so that the expected value will be same as the whole season catch-at-age, rather than a midseason sample

1 1 1 1 1 1 1 1 1 1 #_area_assignments_for_each_fishery_and_survey; so in a multi-area setup, each fleet and survey only occurs in one area

1 1 1 2 2 2 #_units_of_Catch_for_each_Fleet:_1=biomass;_2=numbers; It is OK to have some fleets with catch in biomass and some in numbers

0.05 0.05 0.05 0.05 0.05 -1 #_se_of_log(catch) for each fleet. This is used for init_eq_catch_and_for_Fmethod_2_and_3;_do_not_make_this_overly_small. Year specific values can be input in the control file if needed.

1 #_Ngenders: if 2 gendersare used, femaleswill be gender=1 and their data will be enteredfirst

20 #_Nages: this accumulator age should be large enough so that little growth occurs after reaching this age

1168.167 1281.168 258.513 560.36 28.865 0 #_init_equil_catch_for_each_fishery

134 #_N_lines_of_catch_to_read

#_catch_biomass(mtons):_columns_are_fisheries,year,season

Commercial landings are in gutted metric tons

Rec landings are in numbers

1421.948 1136.626 327.249 605.318 32.913 0 1986 1

1153.087 1712.243 203.246 336.508 25.729 0 1987 1

929.465 994.634 245.043 739.254 27.954 0 1988 1

1730.406 1414.392 268.877 751.017 49.777 0 1989 1

1116.269 918.839 154.628 180.334 14.582 0 1990 1

949.749 1171.895 169.529 295.986 9.509 0 1991 1

655.426 1092.953 273.147 471.717 9.049 0 1992 1

589.817 1938.815 322.543 359.095 8.802 0 1993 1

563.102 1224.284 414.504 311.441 9.617 0 1994 1

531.27 1101.965 479.444 285.734 14.499 0 1995 1

392.427 1318.679 244.649 109.879 15.594 0 1996 1

430.178 1371.747 311.088 77.233 4.676 0 1997 1

336.39 1207.755 134.966 108.91 4.382 0.001 1998 1

550.097 1730.638 341.019 195.205 6.918 0.001 1999 1

780.627 1319.655 464.846 366.937 8.861 0.001 2000 1

705.66	1542.048	337.15	237.09	5.56	0.001	2001	1
738.529	1419.999	444.653	267.88	4.402	0.001	2002	1
507.236	1344.782	318.271	218.029	7.521	0.001	2003	1
624.44	1534.715	338.021	529.891	13.81	0.001	2004	1
636.955	1456.744	277.924	183.664	13.967	0.001	2005	1
624.002	1366.521	266.189	131.509	4.63	0.001	2006	1
708.094	900.102	11.102	154.741	4.245	0.001	2007	1
856.484	1271.938	0	133.129	5.003	0.001	2008	1
1109.097	510.213	0	124.559	4.666	0.001	2009	1
614.033	596.212	0	156.087	4.952	0.001	2010	1
765.79	1381.228	0.007	110.909	7.387	0.001	2011	1
1011.3	1333.59	0	300.283	13.544	0.001	2012	1
698.756	1368.763	0	440.387	14.089	0.001	2013	1

139 #_N_cpue_and_surveyabundance_observations

#_Units: 0=numbers; 1=biomass;

#_Errtype: -1=normal; 0=lognormal;

#_Fleet	Units	Errtype		
1	1	0	#	commHL_1
2	1	0	#	commLL_2
3	1	0	#	commTRAP_3
4	0	0	#	CBT_PR_4
5	0	0	#	HB_5
6	2	0	#	RedTide
7	0	0	#	SEAMAP_Vid_7
8	0	0	#	SEAMAP_GF_8

9	0	0	#	NMFS_BLL_9				
10	0	0	#	CBT_PRSurv				
#_year	seas	index	obs	err	#	Label	#	
1993	1	1	0.7311	0.30939		#	commHL_1	#
1994	1	1	0.716	0.30573		#	commHL_1	#
1995	1	1	0.7886	0.30929		#	commHL_1	#
1996	1	1	0.4907	0.31794		#	commHL_1	#
1997	1	1	0.5647	0.31855		#	commHL_1	#
1998	1	1	0.5185	0.31722		#	commHL_1	#
1999	1	1	0.7399	0.31112		#	commHL_1	#
2000	1	1	0.9911	0.3038	#	commHL_1	#	
2001	1	1	1.347	0.29536		#	commHL_1	#
2002	1	1	1.3871	0.29495		#	commHL_1	#
2003	1	1	0.9471	0.29078		#	commHL_1	#
2004	1	1	1.274	0.2858	#	commHL_1	#	
2005	1	1	1.4169	0.28763		#	commHL_1	#
2006	1	1	1.1435	0.29109		#	commHL_1	#
2007	1	1	1.2066	0.28824		#	commHL_1	#
2008	1	1	1.5309	0.28671		#	commHL_1	#
2009	1	1	1.2061	0.28641		#	commHL_1	#
1993	1	2	0.9785	0.33218		#	commLL_2	#
1994	1	2	0.7235	0.2943	#	commLL_2	#	
1995	1	2	0.7742	0.30486		#	commLL_2	#
1996	1	2	1.0397	0.31852		#	commLL_2	#
1997	1	2	0.9069	0.26574		#	commLL_2	#

1998	1	2	0.9552	0.27381	#	commLL_2	#
1999	1	2	0.9968	0.27195	#	commLL_2	#
2000	1	2	0.898	0.28871	#	commLL_2	#
2001	1	2	1.0563	0.27754	#	commLL_2	#
2002	1	2	1.06	0.29244	#	commLL_2	#
2003	1	2	0.9284	0.28126	#	commLL_2	#
2004	1	2	1.1124	0.27319	#	commLL_2	#
2005	1	2	1.4437	0.28251	#	commLL_2	#
2006	1	2	1.0927	0.27009	#	commLL_2	#
2007	1	2	0.7796	0.31169	#	commLL_2	#
2008	1	2	1.1811	0.30796	#	commLL_2	#
2009	1	2	1.0731	0.45325	#	commLL_2	#
1986	1	5	1.0334	0.31493	#	HB_5	#
1987	1	5	1.6494	0.285	#	HB_5	#
1988	1	5	1.6056	0.27997	#	HB_5	#
1989	1	5	1.5487	0.28973	#	HB_5	#
1990	1	5	0.699	0.32704	#	HB_5	#
1991	1	5	0.4941	0.34598	#	HB_5	#
1992	1	5	0.4723	0.34554	#	HB_5	#
1993	1	5	0.6343	0.318	#	HB_5	#
1994	1	5	0.5523	0.32777	#	HB_5	#
1995	1	5	0.8352	0.30809	#	HB_5	#
1996	1	5	0.4933	0.33475	#	HB_5	#
1997	1	5	0.475	0.33612	#	HB_5	#
1998	1	5	0.5671	0.33016	#	HB_5	#

1999	1	5	0.4741	0.33421	#	HB_5	#
2000	1	5	0.5944	0.32977	#	HB_5	#
2001	1	5	0.8726	0.30414	#	HB_5	#
2002	1	5	0.8929	0.29716	#	HB_5	#
2003	1	5	1.4145	0.25883	#	HB_5	#
2004	1	5	2.1247	0.24276	#	HB_5	#
2005	1	5	2.3719	0.23998	#	HB_5	#
2006	1	5	0.8687	0.30585	#	HB_5	#
2007	1	5	0.9534	0.29305	#	HB_5	#
2008	1	5	0.88	0.29652	#	HB_5	#
2009	1	5	0.68	0.30492	#	HB_5	#
2010	1	5	1.1157	0.27357	#	HB_5	#
2011	1	5	1.0953	0.26137	#	HB_5	#
2012	1	5	1.4104	0.24726	#	HB_5	#
2013	1	5	1.1915	0.26752	#	HB_5	#
1998	1	6	0.0001	0.01	#	REDTIDE	
1999	1	6	0.0001	0.01	#	REDTIDE	
2000	1	6	0.0001	0.01	#	REDTIDE	
2001	1	6	0.0001	0.01	#	REDTIDE	
2002	1	6	0.0001	0.01	#	REDTIDE	
2003	1	6	0.0001	0.01	#	REDTIDE	
2004	1	6	0.0001	0.01	#	REDTIDE	
2005	1	6	1	0.01	#	REDTIDE	
2006	1	6	0.0001	0.01	#	REDTIDE	
2007	1	6	0.0001	0.01	#	REDTIDE	

2008	1	6	0.0001	0.01	#	REDTIDE	
2009	1	6	0.0001	0.01	#	REDTIDE	
2010	1	6	0.0001	0.01	#	REDTIDE	
2011	1	6	0.0001	0.01	#	REDTIDE	
2012	1	6	0.0001	0.01	#	REDTIDE	
2013	1	6	0.0001	0.01	#	REDTIDE	
1993	1	7	0.766	0.47365	#	SEAMAP_Vid_7	#
1994	1	7	1.0119	0.48119	#	SEAMAP_Vid_7	#
1995	1	7	1.0444	0.54786	#	SEAMAP_Vid_7	#
1996	1	7	0.9761	0.39249	#	SEAMAP_Vid_7	#
1997	1	7	1.1872	0.30205	#	SEAMAP_Vid_7	#
2002	1	7	1.1571	0.31364	#	SEAMAP_Vid_7	#
2004	1	7	1.3156	0.28379	#	SEAMAP_Vid_7	#
2005	1	7	1.0877	0.23451	#	SEAMAP_Vid_7	#
2006	1	7	0.9176	0.23538	#	SEAMAP_Vid_7	#
2007	1	7	0.5652	0.32814	#	SEAMAP_Vid_7	#
2008	1	7	0.6947	0.27886	#	SEAMAP_Vid_7	#
2009	1	7	0.8743	0.20987	#	SEAMAP_Vid_7	#
2010	1	7	1.1093	0.1832	#	SEAMAP_Vid_7	#
2011	1	7	1.2464	0.14668	#	SEAMAP_Vid_7	#
2012	1	7	1.0255	0.17392	#	SEAMAP_Vid_7	#
2013	1	7	1.0211	0.2148	#	SEAMAP_Vid_7	#
2009	1	8	1.4703	0.29223	#	SEAMAP_GF_8	#
2010	1	8	0.9486	0.2983	#	SEAMAP_GF_8	#
2011	1	8	0.9334	0.31917	#	SEAMAP_GF_8	#

2012	1	8	0.9518	0.27765	#	SEAMAP_GF_8	#
2013	1	8	0.6959	0.31266	#	SEAMAP_GF_8	#
2001	1	9	0.6445	0.29973	#	NMFS_BLL_9	#
2003	1	9	0.8907	0.20933	#	NMFS_BLL_9	#
2004	1	9	1.4493	0.19919	#	NMFS_BLL_9	#
2005	1	9	0.5438	0.40675	#	NMFS_BLL_9	#
2006	1	9	0.4974	0.39368	#	NMFS_BLL_9	#
2007	1	9	0.77	0.4612	#	NMFS_BLL_9	#
2008	1	9	0.5298	0.32732	#	NMFS_BLL_9	#
2009	1	9	0.818	0.27036	#	NMFS_BLL_9	#
2010	1	9	1.1009	0.27141	#	NMFS_BLL_9	#
2011	1	9	2.0208	0.18801	#	NMFS_BLL_9	#
2012	1	9	1.8742	0.26158	#	NMFS_BLL_9	#
2013	1	9	0.8606	0.31143	#	NMFS_BLL_9	#
1986	1	10	1.0925	0.25451	#	CBT_PRSurv_10	#
1987	1	10	0.8681	0.3013	#	CBT_PRSurv_10	#
1988	1	10	1.1339	0.33987	#	CBT_PRSurv_10	#
1989	1	10	1.3293	0.294	#	CBT_PRSurv_10	#
1990	1	10	1.5569	0.26209	#	CBT_PRSurv_10	#
1991	1	10	1.4756	0.33192	#	CBT_PRSurv_10	#
1992	1	10	1.2438	0.28789	#	CBT_PRSurv_10	#
1993	1	10	0.7682	0.33867	#	CBT_PRSurv_10	#
1994	1	10	0.8707	0.31888	#	CBT_PRSurv_10	#
1995	1	10	0.8627	0.31407	#	CBT_PRSurv_10	#
1996	1	10	0.5555	0.36974	#	CBT_PRSurv_10	#

1997 1 10 0.5467 0.37584 # CBT_PRSurv_10 #

1998 1 10 0.6533 0.33136 # CBT_PRSurv_10 #

1999 1 10 0.735 0.3124 # CBT_PRSurv_10 #

2000 1 10 0.8305 0.30473 # CBT_PRSurv_10 #

2001 1 10 0.6524 0.31074 # CBT_PRSurv_10 #

2002 1 10 0.7901 0.30343 # CBT_PRSurv_10 #

2003 1 10 0.9794 0.29058 # CBT_PRSurv_10 #

2004 1 10 1.2459 0.2546 # CBT_PRSurv_10 #

2005 1 10 0.8296 0.28669 # CBT_PRSurv_10 #

2006 1 10 0.4391 0.36253 # CBT_PRSurv_10 #

2007 1 10 0.6953 0.3075 # CBT_PRSurv_10 #

2008 1 10 1.1731 0.25784 # CBT_PRSurv_10 #

2009 1 10 1.5401 0.24831 # CBT_PRSurv_10 #

2010 1 10 1.1744 0.25516 # CBT_PRSurv_10 #

2011 1 10 1.3397 0.25358 # CBT_PRSurv_10 #

2012 1 10 1.1216 0.25377 # CBT_PRSurv_10 #

2013 1 10 1.4966 0.278 # CBT_PRSurv_10 #

#_discard_units (1=same_as_catchunits(bio/num); 2=fraction; 3=numbers)

#_discard_errtype: >0 for DF of T-dist(read CV below); normal with CV; -1 for normal with se; -2 for lognormal

#_Fleet units errtype

1 3 -2 # commHL_1

2 3 -2 # commLL_2

3 3 -2 # commTRAP_3

4 3 -2 # CBT_PR_4

5 3 -2 # HB_5

6 1 -2 # RedTide_6

125 #_N_discard_obs

#_year	seas	fleet	obs	err		
1993	1	1	510.27	0.9	#	commHL_1
1994	1	1	487.56	0.9	#	commHL_1
1995	1	1	459.26	0.9	#	commHL_1
1996	1	1	338.62	0.9	#	commHL_1
1997	1	1	370.7	0.9	#	commHL_1
1998	1	1	290.81	0.9	#	commHL_1
2000	1	1	674.09	0.9	#	commHL_1
2001	1	1	728.26	0.9	#	commHL_1
2002	1	1	853.13	0.9	#	commHL_1
2003	1	1	549.73	0.9	#	commHL_1
2004	1	1	709.34	0.9	#	commHL_1
2005	1	1	829.35	0.9	#	commHL_1
2006	1	1	612.75	0.9	#	commHL_1
2007	1	1	553.15	0.5	#	commHL_1
2008	1	1	975.07	0.5	#	commHL_1
2009	1	1	1289.46	0.5	#	commHL_1
2010	1	1	994.09	0.5	#	commHL_1
2011	1	1	593.65	0.5	#	commHL_1
2012	1	1	599.24	0.5	#	commHL_1
2013	1	1	405.28	0.5	#	commHL_1
1993	1	2	3188.76	0.9	#	commLL_2
1994	1	2	2024.42	0.9	#	commLL_2
1995	1	2	1885.66	0.9	#	commLL_2

1996	1	2	2308.81	0.9	#	commLL_2
1997	1	2	2336.64	0.9	#	commLL_2
1998	1	2	2053.71	0.9	#	commLL_2
1999	1	2	2926.61	0.9	#	commLL_2
2000	1	2	2186	0.9	#	commLL_2
2001	1	2	2479.02	0.9	#	commLL_2
2002	1	2	2297	0.9	#	commLL_2
2003	1	2	2194.27	0.9	#	commLL_2
2004	1	2	2497.77	0.9	#	commLL_2
2005	1	2	2359.92	0.9	#	commLL_2
2006	1	2	2216.68	0.9	#	commLL_2
2007	1	2	1511.24	0.5	#	commLL_2
2008	1	2	1275.03	0.5	#	commLL_2
2009	1	2	793.21	0.5	#	commLL_2
2010	1	2	616.22	0.5	#	commLL_2
2011	1	2	1408.01	0.5	#	commLL_2
2012	1	2	1133.24	0.5	#	commLL_2
2013	1	2	840.29	0.5	#	commLL_2
1990	1	3	69.05	0.9	#	commTRAP_3
1991	1	3	131.4	0.9	#	commTRAP_3
1992	1	3	87.5	0.9	#	commTRAP_3
1993	1	3	169.87	0.9	#	commTRAP_3
1994	1	3	53.9	0.9	#	commTRAP_3
1995	1	3	124.73	0.9	#	commTRAP_3
1996	1	3	732.74	0.9	#	commTRAP_3
1997	1	3	598.57	0.9	#	commTRAP_3
1998	1	3	50.19	0.9	#	commTRAP_3

1999	1	3	106.19	0.9	#	commTRAP_3
2000	1	3	234.98	0.9	#	commTRAP_3
2001	1	3	167.62	0.9	#	commTRAP_3
2002	1	3	146.06	0.9	#	commTRAP_3
2003	1	3	134.7	0.9	#	commTRAP_3
2004	1	3	81.9	0.9	#	commTRAP_3
2005	1	3	122.09	0.9	#	commTRAP_3
2006	1	3	139.27	0.9	#	commTRAP_3
1981	1	4	61.2	0.5	#	MRFSS_4
1982	1	4	38.81	0.5	#	MRFSS_4
1983	1	4	48.61	0.5	#	MRFSS_4
1984	1	4	46.12	0.5	#	MRFSS_4
1985	1	4	63.19	0.5	#	MRFSS_4
1986	1	4	464.26	0.5	#	MRFSS_4
1987	1	4	311.65	0.5	#	MRFSS_4
1988	1	4	773.1	0.5	#	MRFSS_4
1989	1	4	1831.36	0.5	#	MRFSS_4
1990	1	4	1462.48	0.5	#	MRFSS_4
1991	1	4	2643.55	0.5	#	MRFSS_4
1992	1	4	2280.88	0.5	#	MRFSS_4
1993	1	4	1578.13	0.5	#	MRFSS_4
1994	1	4	1463.31	0.5	#	MRFSS_4
1995	1	4	1460.5	0.5	#	MRFSS_4
1996	1	4	768	0.5	#	MRFSS_4
1997	1	4	812.83	0.5	#	MRFSS_4
1998	1	4	1466.21	0.5	#	MRFSS_4
1999	1	4	1966.82	0.5	#	MRFSS_4

2000	1	4	2159.51	0.5	#	MRFSS_4
2001	1	4	1569.41	0.5	#	MRFSS_4
2002	1	4	1845.37	0.5	#	MRFSS_4
2003	1	4	1959.63	0.5	#	MRFSS_4
2004	1	4	3149.76	0.5	#	MRFSS_4
2005	1	4	1274.2	0.5	#	MRFSS_4
2006	1	4	631.25	0.5	#	MRFSS_4
2007	1	4	800.18	0.5	#	MRFSS_4
2008	1	4	2975.12	0.5	#	MRFSS_4
2009	1	4	3192.92	0.5	#	MRFSS_4
2010	1	4	2211.75	0.5	#	MRFSS_4
2011	1	4	2029.25	0.5	#	MRFSS_4
2012	1	4	1742.3	0.5	#	MRFSS_4
2013	1	4	2650.3	0.5	#	MRFSS_4
1981	1	5	4.01	0.5	#	HBT_5
1982	1	5	1.56	0.5	#	HBT_5
1983	1	5	3.3	0.5	#	HBT_5
1984	1	5	9.57	0.5	#	HBT_5
1985	1	5	13.78	0.5	#	HBT_5
1986	1	5	57.06	0.5	#	HBT_5
1987	1	5	68.1	0.5	#	HBT_5
1988	1	5	44.78	0.5	#	HBT_5
1989	1	5	268.56	0.5	#	HBT_5
1990	1	5	115.23	0.5	#	HBT_5
1991	1	5	87.71	0.5	#	HBT_5
1992	1	5	52.25	0.5	#	HBT_5
1993	1	5	77.61	0.5	#	HBT_5

1994	1	5	65.15	0.5	#	HBT_5
1995	1	5	74.07	0.5	#	HBT_5
1996	1	5	78.15	0.5	#	HBT_5
1997	1	5	41.7	0.5	#	HBT_5
1998	1	5	101.36	0.5	#	HBT_5
1999	1	5	143.73	0.5	#	HBT_5
2000	1	5	80.84	0.5	#	HBT_5
2001	1	5	44.31	0.5	#	HBT_5
2002	1	5	44.64	0.5	#	HBT_5
2003	1	5	98.17	0.5	#	HBT_5
2004	1	5	123.86	0.5	#	HBT_5
2005	1	5	80.59	0.5	#	HBT_5
2006	1	5	29.16	0.5	#	HBT_5
2007	1	5	17.37	0.5	#	HBT_5
2008	1	5	89.62	0.5	#	HBT_5
2009	1	5	153.83	0.5	#	HBT_5
2010	1	5	117.88	0.5	#	HBT_5
2011	1	5	134.11	0.5	#	HBT_5
2012	1	5	117.81	0.5	#	HBT_5
2013	1	5	112.27	0.5	#	HBT_5

0 #_N_meanbodywt_obs

30 #_DF_for_meanbodywt_T-distribution_like

2 # length bin method: 1=use databins(read below); 2=generate from binwidth,min,max below; 3=read vector

2 # binwidth for population size comp

2 # minimum size in the population (lower edge of first bin and size at age 0.00)

130 # maximum size in the population (lower edge of last bin)

#_following two entries are used for all length and age composition processing

0.0001 #_comp_tail_compression

1.00E-07#_add_to_comp

0 #_combine males into females at or below this bin number (useful if hard to sex small fish)

48 #_N_LengthBins

2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
	72	74	76	78	80	82	84	86	88	90	92	94	96				
#year	seas	flt/svy	gender	part	Nsamp	2	4	6	8	10	12	14	16	18	20	22	24
	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58
	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92
	94	96	#	937													
2006	1	1	1	1	100	0	0	0	0	0	0	0	0	0	0	0	0.00107
	0	0	0.00961	0.02134	0.04482	0.08751	0.11419	0.16115	0.16435	0.13767	0.15155	0.09072	0.01387	0	0.00213	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	#	2064	#	937											
2007	1	1	1	1	100	0	0	0	0	0	0	0	0	0	0	0.00145	0.00339
	0.00242	0.00242	0.00436	0.00921	0.01211	0.02762	0.04748	0.1124	0.18169	0.19331	0.19913	0.15649	0.03779	0.00484	0.00194	0.00097	0.00048
	0	0.00048	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	#	1073	#	2064											
2008	1	1	1	1	100	0	0	0	0	0	0	0	0	0	0.00093	0.00093	0.00186
	0.00186	0.00839	0.02516	0.03914	0.06431	0.05126	0.07642	0.07642	0.13048	0.16589	0.22088	0.12954	0.0028	0.0028	0.00093	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	#	1529	#	1073											
2009	1	1	1	1	100	0	0	0	0	0	0	0	0	0	0	0.00065	0.00065
	0.00392	0.01439	0.02943	0.07979	0.16612	0.1877	0.18247	0.155	0.09418	0.03859	0.02224	0.01373	0.00065	0.00131	0.00523	0.00065	0.00131
	0	0.00065	0	0	0.00065	0	0	0	0	0.00065	0	0	0	0	0	0	0
	0	0	#	2980	#	1529											
2010	1	1	1	1	100	0	0	0	0	0	0	0	0	0	0	0.00034	0.00134
	0.00302	0.00705	0.01409	0.0255	0.06779	0.14631	0.18993	0.24262	0.22483	0.06678	0.00671	0.00268	0.00067	0.00034	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	#	5190	#	2980											

2011	1	1	1	1	100	0	0	0	0	0	0	0	0	0	0	0.00019	0
	0.00116	0.00116	0.00482	0.0106	0.04104	0.0975	0.16031	0.21811	0.23873	0.18536	0.0341	0.00559	0.00019	0.00039	0.00039	0.00019	0
	0.00019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	#	8917	#	5190											
2012	1	1	1	1	100	0	0	0	0	0	0	0	0.00022	0	0.00022	0.00011	0.00101
	0.00168	0.00348	0.00707	0.01884	0.03645	0.07648	0.13514	0.20175	0.25221	0.16384	0.06011	0.02568	0.01054	0.00135	0.00146	0.00079	0.00067
	0.00045	0.00034	0.00011	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	#	2291	#	8917											
2013	1	1	1	1	100	0	0	0	0	0	0	0	0	0	0	0	0.00044
	0.00131	0.00175	0.00873	0.03012	0.05412	0.09603	0.12746	0.22392	0.24007	0.14055	0.055	0.01746	0.00131	0.00131	0.00044	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	#	3912	#	2291											
2006	1	2	1	1	100	0	0	0	0	0	0	0	0	0	0.00026	0	0
	0	0.00204	0.00537	0.0138	0.03093	0.06084	0.10302	0.14238	0.16385	0.14647	0.14162	0.12551	0.04908	0.00511	0.00358	0.00179	0.00153
	0.00077	0.00102	0.00026	0	0.00051	0.00026	0	0	0	0	0	0	0	0	0	0	0
	0	0	#	2921	#	3912											
2007	1	2	1	1	100	0	0	0	0	0	0	0	0	0	0	0	0
	0.00068	0.0024	0.00719	0.01404	0.02705	0.03971	0.06915	0.12735	0.16296	0.20096	0.21499	0.11503	0.01541	0.00068	0.00068	0.00034	0.00103
	0	0	0.00034	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	#	917	#	2921											
2008	1	2	1	1	100	0	0	0	0	0	0	0	0	0	0.00109	0	0.00218
	0.00545	0.01745	0.04907	0.0458	0.06761	0.07415	0.12105	0.15812	0.18212	0.19738	0.0687	0.00763	0.00109	0	0	0.00109	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	#	6447	#	917											
2009	1	2	1	1	100	0	0	0	0	0.00016	0.00016	0	0	0	0.00016	0.00155	0.00062
	0.00295	0.01039	0.03459	0.05972	0.08516	0.10408	0.10346	0.1047	0.13029	0.14518	0.13045	0.06654	0.01474	0.00217	0.00124	0.0014	0.00016
	0	0.00016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	#	18635	#	6447											

2010	1	2	1	1	100	0	0	0	0	0	0	0	0	0	0.00005	0.00021	0.00059
	0.0015	0.00762	0.02399	0.06075	0.10942	0.14929	0.17526	0.18975	0.16453	0.0945	0.0198	0.00129	0.00043	0.00027	0.00032	0	0.00016
	0.00011	0.00005	0	0.00005	0	0	0.00005	0	0	0	0	0	0	0	0	0	0
	0	0	#	40239	#	18635											
2011	1	2	1	1	100	0	0	0	0	0	0	0	0	0	0	0.00015	0.00052
	0.0008	0.00422	0.01228	0.03402	0.0718	0.11238	0.14759	0.18363	0.20028	0.14414	0.05713	0.02219	0.00678	0.00127	0.0003	0.0002	0.00005
	0.00005	0.00007	0.00005	0.00005	0.00002	0	0	0	0.00002	0	0	0	0	0	0	0	0
	0	0	#	11969	#	40239											
2012	1	2	1	1	100	0	0	0	0	0	0	0	0	0	0	0	0
	0.00042	0.00117	0.00384	0.01345	0.03367	0.09007	0.15766	0.20361	0.20754	0.15507	0.07035	0.03994	0.01211	0.00685	0.00343	0.00033	0.00017
	0	0.00008	0.00017	0	0.00008	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	#	22056	#	11969											
2013	1	2	1	1	100	0	0	0	0	0	0	0	0	0	0.00009	0.00009	0.00005
	0.00086	0.00317	0.00775	0.01759	0.03595	0.06633	0.10954	0.17791	0.23526	0.20842	0.10251	0.02861	0.0039	0.00077	0.00027	0.00045	0.00009
	0.00014	0.00005	0.00005	0	0	0	0	0.00005	0.00005	0.00005	0	0	0	0	0	0	0
	0	0	#	#	22056												
2010	1	4	1	1	100	0	0	0	0	0	0	0	0	0	0.00021	0.00182	0.00459
	0.01406	0.04494	0.1277	0.12816	0.15155	0.15372	0.11611	0.07649	0.05478	0.03796	0.0247	0.01481	0.01571	0.00822	0.00629	0.00439	0.0034
	0.004	0.00187	0	0.00082	0.00028	0.00082	0	0.00059	0.00128	0.00072	0	0	0	0	0	0	0
	0	0	#	#	2313												
2011	1	4	1	1	100	0	0	0	0	0	0	0	0	0	0	0	0
	0.00112	0.00647	0.03107	0.05086	0.10275	0.1499	0.18568	0.14313	0.09952	0.07783	0.04891	0.0391	0.02981	0.01137	0.00562	0.00758	0.00113
	0.00193	0.0015	0.00047	0.00044	0	0.00197	0.00131	0	0	0.00052	0	0	0	0	0	0	0
	0	0	#	#	1834												
2012	1	4	1	1	100	0	0	0	0	0	0	0	0	0	0.0001	0.00011	0
	0.00215	0.00841	0.01495	0.04218	0.0424	0.06393	0.11507	0.14696	0.13591	0.13842	0.10579	0.04571	0.0604	0.02433	0.01664	0.0103	0.00603
	0.00244	0.00401	0.00227	0	0.00503	0.00088	0.00036	0.00364	0.00038	0.00081	0	0.0004	0	0	0	0	0
	0	0	#	#	1324												

2013	1	4	1	1	100	0	0	0	0	0.00026	0	0	0	0	0	0	0.00096
	0.00212	0.00968	0.01631	0.04516	0.05115	0.05577	0.05394	0.06403	0.14031	0.17147	0.14791	0.08885	0.05259	0.03283	0.01593	0.00494	0.01712
	0.01041	0.00793	0.00151	0.00199	0	0	0	0	0.0013	0	0	0.00552	0	0	0	0	0
	0	0	#	1195													
2005	1	5	1	1	100	0	0	0	0	0	0	0	0.00239	0.00723	0.01353	0.04022	0.06889
	0.0541	0.0599	0.0633	0.09093	0.10375	0.07107	0.04886	0.05949	0.04263	0.05341	0.04335	0.01649	0.00334	0.00181	0.00275	0.00094	0.00087
	0.00007	0	0	0.0008	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	#	1126													
2006	1	5	1	1	100	0	0	0	0	0	0	0.00206	0.02105	0.01799	0.0207	0.04287	0.07574
	0.11561	0.11846	0.10795	0.08351	0.04475	0.04589	0.02836	0.0438	0.02643	0.02695	0.01669	0.0093	0.00181	0.00021	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	#	1058													
2007	1	5	1	1	100	0	0	0	0.00003	0.00082	0	0.0007	0.00349	0.02041	0.03143	0.09084	0.1188
	0.12969	0.10632	0.07839	0.04718	0.03707	0.03696	0.03753	0.02913	0.02441	0.02463	0.01842	0.00751	0.00331	0.00013	0.00137	0.00067	0
	0	0	0	0	0.00003	0.0007	0.00013	0	0.00003	0	0	0	0	0	0	0	0
	0	0	#	1633													
2009	1	5	1	1	100	0	0	0	0	0	0.00053	0	0	0.00403	0.0007	0.02064	0.04008
	0.05362	0.05867	0.11222	0.15123	0.13377	0.10421	0.06921	0.04634	0.02634	0.01492	0.00972	0.0016	0.0007	0	0.00106	0	0.00053
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	#	1734													
2010	1	5	1	1	100	0	0	0	0	0	0	0	0.00101	0.0005	0.00151	0.00554	0.01519
	0.03203	0.07606	0.1466	0.13503	0.12659	0.09329	0.07347	0.04869	0.04108	0.03006	0.01614	0.00533	0.00101	0.0005	0.0005	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	#	1592													
2011	1	5	1	1	100	0	0	0	0	0	0	0	0.0016	0.00242	0.00161	0.00632	0.01906
	0.02435	0.01874	0.03954	0.09063	0.15742	0.17804	0.10608	0.08124	0.04937	0.04659	0.01436	0.00632	0.00081	0.00081	0	0.00081	0.0016
	0.00195	0	0.00046	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	#	1056													

2012 1 5 1 1 100 0 0 0 0 0 0 0 0 0.00136 0.00133 0.0027 0.01471
0.03204 0.03607 0.04515 0.05426 0.06052 0.07549 0.10616 0.1409 0.11164 0.07456 0.05706 0.02459 0.00406 0.00406 0.0027 0 0.00077
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 # 635

2013 1 5 1 1 100 0 0 0 0 0 0 0 0.00042 0.00052 0 0.00665 0.00867
0.00763 0.02278 0.03187 0.0671 0.08033 0.07345 0.07364 0.12248 0.10366 0.09838 0.10886 0.03057 0.00612 0.0015 0.00192 0.0015 0.00202
0.00005 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 # 772

2008 1 7 1 2 32 0 0 0 0 0 0 0 0 0 0 0.03125 0
0.03125 0 0.03125 0.03125 0.0625 0 0 0.03125 0 0.09375 0.09375 0.0625 0.15625 0.15625 0.03125 0 0.0625
0.03125 0.0625 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0.03125

2009 1 7 1 2 99 0 0 0 0 0 0 0 0 0 0.010101 0
0 0 0 0.050505 0.070707 0.090909 0.040404 0.141414 0.050505 0.080808
0.060606 0.060606 0.030303 0.040404 0.030303 0.060606 0.010101 0.040404
0.010101 0 0.020202 0.010101 0.020202 0.020202 0.010101 0.020202 0
0.010101 0 0.010101 0 0 0 0 0 0 0

2010 1 7 1 2 48 0 0 0 0 0 0 0 0 0 0 0 0
0.020833 0 0.041667 0 0 0.041667 0.041667 0.020833 0.145833 0.145833
0.104167 0.0625 0.041667 0.041667 0.083333 0.020833 0.0625 0 0.020833 0.020833
0.020833 0.041667 0 0 0 0 0 0 0.020833 0 0 0 0 0
0 0

2011 1 7 1 2 116 0 0 0 0 0 0 0 0 0 0 0 0
0 0.008621 0.008621 0.008621 0.051724 0.017241 0.034483 0.086207 0.043103
0.051724 0.112069 0.137931 0.043103 0.051724 0.051724 0.034483 0.008621
0.025862 0.060345 0.025862 0.025862 0.017241 0.025862 0.008621 0.008621
0.017241 0.008621 0.008621 0.017241 0 0 0 0 0 0 0

2012 1 7 1 2 105 0 0 0 0 0 0 0 0 0 0 0
0.009524 0.009524 0.009524 0 0.038095 0.047619 0.009524 0.066667 0.019048
0.047619 0.066667 0.07619 0.07619 0.07619 0.057143 0.085714 0.057143 0.038095 0.009524
0.047619 0.057143 0.009524 0.019048 0.019048 0 0.028571 0.019048 0 0
0 0 0 0 0 0 0 0

2013 1 7 1 2 39 0 0 0 0 0 0 0 0 0 0 0 0
0 0.025641 0 0.025641 0 0.076923 0.051282 0.051282 0.025641 0.051282
0.128205 0.076923 0 0.051282 0.051282 0.051282 0.076923 0.025641 0
0.025641 0 0.076923 0.025641 0 0.025641 0 0.025641 0.025641 0.025641
0 0 0 0 0 0 0

2008 1 8 1 0 33 0 0 0.0303 0 0 0 0 0 0.030303 0.060606
0.090909 0.090909 0.181818 0.151515 0.121212 0.060606 0.060606 0 0
0.060606 0 0 0.030303 0 0 0 0 0.030303 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

2009 1 8 1 0 298 0 0 0.00671 0.00671 0.01007 0.01678 0.00336 0.00671 0.013423 0.020134
0.083893 0.120805 0.137584 0.107383 0.083893 0.090604 0.097315 0.067114
0.043624 0.016779 0.02349 0.010067 0.003356 0.006711 0 0.003356 0.003356
0.006711 0 0 0.003356 0 0.003356 0.003356 0 0 0 0 0 0
0 0 0 0 0 0 0 0

2010 1 8 1 0 187 0 0 0 0 0 0.0107 0.04813 0.07487 0.02139 0.016043
0.026738 0.037433 0.085561 0.112299 0.117647 0.074866 0.085561 0.042781
0.080214 0.058824 0.032086 0.02139 0.010695 0.010695 0.005348 0.005348 0 0
0 0.005348 0.005348 0 0 0.005348 0.005348 0 0 0 0 0 0
0 0 0 0 0 0 0

2011 1 8 1 0 114 0 0.00877 0 0 0 0.00877 0.01754 0.12281 0.061404 0.026316
0.061404 0.070175 0.070175 0.087719 0.026316 0.070175 0.070175 0.061404
0.087719 0.026316 0.026316 0.017544 0 0.008772 0.017544 0.008772 0.008772

0 0.008772 0 0 0 0 0.008772 0 0 0 0.008772 0 0.008772
0 0 0 0 0 0 0 0

2012 1 8 1 0 151 0.00662 0.04636 0.00662 0.02649 0.01325 0 0.00662 0.05298 0.059603 0.019868
0.02649 0.059603 0.086093 0.059603 0.059603 0.066225 0.033113 0.07947 0.019868
0.033113 0.046358 0.033113 0.019868 0.05298 0.013245 0.033113 0.013245 0.013245
0 0 0.006623 0 0 0 0 0 0 0 0 0 0.006623 0 0
0 0 0 0 0

2013 1 8 1 0 72 0 0 0.01389 0.01389 0 0.04167 0.01389 0.01389 0.055556 0.069444
0.027778 0.041667 0.041667 0.083333 0.013889 0.083333 0.041667 0.027778
0.041667 0.055556 0.069444 0.069444 0.027778 0 0.041667 0.013889 0.027778
0 0 0.027778 0 0.013889 0 0 0.013889 0 0.013889 0 0 0
0 0 0 0 0 0 0 0

-1995 1 9 1 0 10 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0.1 0.1 0 0 0 0 0.1 0 0.1 0 0 0.1
0.1 0 0.1 0.2 0.1 0 0 0 0 0 0 0 0 0 0 0 0
0 0

-1996 1 9 1 0 6 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0.33333 0.16667 0.16667 0
0.16667 0 0 0 0 0.16667 0 0 0 0 0 0 0 0 0 0 0
0 0

-1997 1 9 1 0 7 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0.14286 0.14286 0.14286
0.14286 0 0 0.28571 0 0 0 0.14286 0 0 0 0 0 0 0 0 0
0 0

-1999 1 9 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0

-2000	1	9	1	0	26	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0.03846	0.03846	0.11538	0.19231	0	0.11538	0.11538	0.15385	0.07692	0.03846	0	0
	0.07692	0	0.03846	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0															
2001	1	9	1	0	79	0	0	0	0	0	0	0	0	0	0	0	0
	0	0.01266	0	0.06329	0	0	0.05063	0.10127	0.08861	0.10127	0.03797	0.08861	0.08861	0.05063	0.06329	0.05063	0.02532
	0.05063	0.01266	0.02532	0.02532	0	0.01266	0.01266	0	0	0.01266	0.01266	0.01266	0	0	0	0	0
	0	0															
2002	1	9	1	0	16	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0.0625	0	0.0625	0.0625	0.0625	0	0.1875	0.1875	0	0	0	0
	0.125	0	0.0625	0.125	0	0	0	0	0	0.0625	0	0	0	0	0	0	0
	0	0															
2003	1	9	1	0	162	0	0	0	0	0	0	0	0	0	0	0	0
	0	0.00617	0	0.01235	0.02469	0.03704	0.03704	0.11728	0.08642	0.12346	0.09259	0.0679	0.05556	0.04321	0.01235	0.01852	0.03704
	0.01235	0.03704	0.01852	0.03704	0.01852	0.01852	0.02469	0.00617	0.02469	0.01235	0.01235	0	0.00617	0	0	0	0
	0	0															
2004	1	9	1	0	170	0	0	0	0	0	0	0	0	0	0	0	0
	0	0.00588	0.00588	0.00588	0.02941	0.01765	0.06471	0.07059	0.10588	0.12941	0.10588	0.1	0.05882	0.02941	0.04118	0.02941	0.00588
	0.02353	0.04118	0	0.02353	0.04118	0.01765	0.01765	0.01765	0	0.01176	0	0	0	0	0	0	0
	0	0															
2005	1	9	1	0	32	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0.03125	0.125	0.03125	0.03125	0.03125	0.03125	0.1875	0.0625	0.03125	0.15625	0	0.03125	0.03125	0	0
	0.0625	0	0.0625	0.03125	0.03125	0.03125	0	0	0	0	0	0	0	0	0	0	0
	0	0															
2006	1	9	1	0	32	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0.0625	0.0625	0	0.0625	0.09375	0.0625	0.09375	0.0625	0.0625	0.15625	0.03125	0.0625
	0.03125	0.03125	0	0.125	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0															

2007	1	9	1	0	51	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0.01961	0	0.09804	0.11765	0.07843	0.09804	0.21569	0.13725	0.05882	0.01961	0.01961	0	0.03922
	0.01961	0	0.01961	0.01961	0.03922	0	0	0	0	0	0	0	0	0	0	0	0
	0	0															
2008	1	9	1	0	31	0	0	0	0	0	0	0	0	0	0	0	0
	0.03226	0	0.03226	0	0.06452	0.03226	0	0	0.06452	0.03226	0	0.06452	0.03226	0.09677	0.06452	0.03226	0.06452
	0.06452	0	0.09677	0.12903	0	0	0.03226	0.03226	0	0	0.03226	0	0	0	0	0	0
	0	0															
2009	1	9	1	0	64	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0.01563	0.03125	0.10938	0.10938	0.01563	0.0625	0.07813	0.03125	0	0	0.04688	0.0625	0.03125	0.09375	0.0625
	0.04688	0.01563	0.04688	0.04688	0.03125	0.01563	0.01563	0.01563	0	0	0	0	0	0.01563	0	0	0
	0	0															
2010	1	9	1	0	81	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0.04938	0.02469	0.01235	0.07407	0.07407	0.06173	0.1358	0.04938	0.04938	0.04938	0.11111	0.04938	0.02469	0.03704
	0	0.04938	0.03704	0.02469	0.02469	0	0.02469	0.01235	0	0.01235	0.01235	0	0	0	0	0	0
	0	0															
2011	1	9	1	0	312	0	0	0	0	0	0	0	0	0	0	0	0
	0	0.00321	0.00321	0.00962	0.03526	0.05769	0.06731	0.08333	0.09615	0.07692	0.08654	0.10256	0.08013	0.04808	0.05128	0.03526	0.02885
	0.01603	0.02564	0.02244	0.01923	0.02244	0.01603	0.00641	0.00641	0	0	0	0	0	0	0	0	0
	0	0															
2012	1	9	1	0	111	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0.01802	0.01802	0.01802	0.05405	0.06306	0.09009	0.04505	0.04505	0.15315	0.06306	0.14414	0.06306	0.02703	0.04505
	0.02703	0.03604	0.01802	0.03604	0	0.01802	0.00901	0.00901	0	0	0	0	0	0	0	0	0
	0	0															
2013	1	9	1	0	47	0	0	0	0	0	0	0	0	0	0	0	0
	0.02128	0	0	0	0	0.06383	0.02128	0.04255	0.10638	0.06383	0.12766	0.06383	0.04255	0.08511	0.04255	0.04255	0
	0.04255	0.06383	0.06383	0.02128	0.04255	0.02128	0	0	0.02128	0	0	0	0	0	0	0	0
	0	0															

-2014	1	9	1	0	24	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0.08333	0.08333	0.08333	0	0.08333	0.08333	0.04167	0.08333	0	0.04167	0	0
	0.08333	0.04167	0.08333	0.16667	0	0	0	0	0.04167	0	0	0	0	0	0	0	0
	0	0		21	#_N_age_bins												
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	19	20	21														
1	#_N_ageerror_definitions																
0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5
	18.5	19.5	20.5														
0.06	0.064	0.272	0.34	0.407	0.474	0.541	0.608	0.676	0.743	0.81	0.877	0.944	1.012	1.079	1.146	1.213	1.28
	1.348	1.415	1.784														
107	#_N_Agecomp_obs																
1	#_Lbin_method:		1=poplenbins;		2=datalenbins;		3=lengths										
1	#_combine		males	into	females	at	or	below	this	bin	number						
#Yr	Seas	Flt/Svy	Gender	Part	Ageerr	Lbin_lo	Lbin_hi	Nsamp	AGE0	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6	AGE7	AGE8
	AGE9	AGE10	AGE11	AGE12	AGE13	AGE14	AGE15	AGE16	AGE17	AGE18	AGE19	AGE20	#				
1991	1	1	1	2	1	-1	-1	43	0	0	0	0.0511	0.0169	0.1973	0.2499	0.0614	0
	0.1345	0.2063	0.0049	0.0227	0.0173	0	0.0045	0.0132	0	0	0.0087	0.0112	#	43			
1992	1	1	1	2	1	-1	-1	42	0	0	0	0	0	0.2716	0.2877	0.3157	0.083
	0	0.01	0.0114	0	0.0205	0	0	0	0	0	0	0	#	42			
1993	1	1	1	2	1	-1	-1	93	0	0	0	0.0019	0.1444	0.1654	0.2725	0.2541	0.1112
	0.0232	0.01	0.0077	0.0041	0	0	0	0	0	0.0012	0	0.0041	#	93			
1994	1	1	1	2	1	-1	-1	200	0	0	0	0.0015	0.1284	0.3128	0.1857	0.1642	0.0951
	0.057	0.0209	0.0133	0.0085	0.0039	0	0.0088	0	0	0	0	0	#	239			

1995	1	1	1	2	1	-1	-1	180	0	0	0	0	0.0276	0.1832	0.3136	0.2767	0.0934
	0.0271	0.036	0.0332	0	0.0092	0	0	0	0	0	0	0	#	180			
1996	1	1	1	2	1	-1	-1	141	0	0	0	0	0.0015	0.1087	0.3815	0.2967	0.1113
	0.0969	0	0.0035	0	0	0	0	0	0	0	0	0	#	141			
1997	1	1	1	2	1	-1	-1	35	0	0	0	0	0.0218	0.0894	0.2267	0.3242	0.2708
	0.0492	0.0136	0	0	0.0043	0	0	0	0	0	0	0	#	35			
1998	1	1	1	2	1	-1	-1	39	0	0	0	0.0081	0.1959	0.1362	0.1715	0.2284	0.1454
	0.0781	0.0278	0	0	0	0.0087	0	0	0	0	0	0	#	39			
1999	1	1	1	2	1	-1	-1	77	0	0	0	0	0.0166	0.1364	0.2409	0.1591	0.2413
	0.1224	0.0728	0	0.0074	0.0015	0	0	0	0.0015	0	0	0	#	77			
2000	1	1	1	2	1	-1	-1	200	0	0	0	0	0.2492	0.1433	0.2277	0.0985	0.0747
	0.0689	0.0562	0.0221	0.0299	0.0081	0.0178	0.0021	0	0	0	0.0004	0.001	#	206			
2001	1	1	1	2	1	-1	-1	200	0	0	0	0	0.0421	0.354	0.124	0.1722	0.0955
	0.0324	0.0643	0.0426	0.0219	0.0175	0.0148	0.0038	0.0092	0.0049	0.0003	0	0.0005	#	575			
2002	1	1	1	2	1	-1	-1	200	0	0	0	0.0111	0.0465	0.1236	0.3553	0.1277	0.1087
	0.0783	0.0665	0.0224	0.0266	0.0126	0.007	0.0032	0.0022	0.0018	0.0012	0.0029	0.0024	#	573			
2003	1	1	1	2	1	-1	-1	200	0	0	0	0	0.0953	0.1162	0.2068	0.2638	0.1162
	0.089	0.0354	0.0199	0.0173	0.0146	0.001	0.0068	0.0031	0.003	0.0034	0.0012	0.0071	#	561			
2004	1	1	1	2	1	-1	-1	200	0	0	0	0	0.0283	0.3927	0.1258	0.1575	0.1248
	0.0515	0.0406	0.0256	0.0136	0.0116	0.0075	0.0081	0.0038	0.002	0.0024	0.0029	0.0013	#	1062			
2005	1	1	1	2	1	-1	-1	200	0	0	0	0	0.0015	0.0879	0.5971	0.0806	0.0793
	0.0695	0.0211	0.0205	0.0207	0.0088	0.0055	0.0008	0.0022	0.0014	0	0.0006	0.0025	#	626			
2006	1	1	1	2	1	-1	-1	200	0	0	0	0	0	0.02	0.1539	0.4878	0.18
	0.0551	0.0411	0.0175	0.0142	0.0085	0.0052	0.0012	0.0056	0.0019	0.0008	0	0.0072	#	629			

2007	1	1	1	2	1	-1	-1	200	0	0	0	0	0.0036	0.2463	0.0834	0.18	0.2865
	0.0984	0.0392	0.0196	0.0193	0.0063	0.003	0.0028	0.0039	0.0035	0.0028	0	0.0014	#	497			
2008	1	1	1	2	1	-1	-1	200	0	0	0	0	0	0.0735	0.4394	0.1023	0.146
	0.1536	0.0298	0.0161	0.015	0.0105	0.0024	0.0032	0.0033	0	0.0019	0.001	0.002	#	503			
2009	1	1	1	2	1	-1	-1	200	0	0	0	0.0221	0.035	0.0965	0.068	0.3336	0.1288
	0.134	0.1169	0.0319	0.0085	0.007	0.0035	0.0045	0.0016	0.0011	0.0007	0	0.0063	#	895			
2010	1	1	1	2	1	-1	-1	200	0	0	0.0011	0.0152	0.1659	0.0629	0.089	0.1508	0.2265
	0.1212	0.0878	0.044	0.0047	0.0141	0.0056	0.0047	0.0024	0.0025	0	0.0013	0.0003	#	1030			
2011	1	1	1	2	1	-1	-1	200	0	0	0	0	0.031	0.5065	0.0717	0.0819	0.0677
	0.1098	0.043	0.0419	0.0217	0.0061	0.0049	0.0037	0.0056	0	0	0.0003	0.0044	#	629			
2012	1	1	1	2	1	-1	-1	200	0	0	0	0.0004	0.0061	0.1718	0.5278	0.0681	0.0607
	0.0301	0.052	0.0335	0.0201	0.0191	0.0055	0.0015	0.0007	0.0015	0	0	0.0011	#	1019			
2013	1	1	1	2	1	-1	-1	200	0	0	0	0	0.0101	0.0521	0.2727	0.4514	0.0653
	0.0431	0.0321	0.026	0.0092	0.0218	0.0127	0.0011	0.0009	0	0.0016	0	0	#	558			
1991	1	2	1	2	1	-1	-1	37	0	0	0	0	0	0.1367	0.1258	0.3341	0.1593
	0.1272	0	0.0183	0.014	0	0	0	0	0	0	0.0846	0	#	37			
1992	1	2	1	2	1	-1	-1	143	0	0	0	0	0	0.1371	0.1949	0.3669	0.1553
	0.0892	0.0232	0.0114	0.0134	0	0	0	0	0.0086	0	0	0	#	143			
1993	1	2	1	2	1	-1	-1	200	0	0	0	0	0.0531	0.1321	0.2866	0.2497	0.135
	0.0709	0.0417	0.0166	0.0039	0.0062	0.0018	0	0.0024	0	0	0	0	#	200			
1994	1	2	1	2	1	-1	-1	88	0	0	0	0	0.056	0.1404	0.1253	0.2879	0.1426
	0.1084	0.0892	0.0236	0.0234	0.0017	0	0	0	0	0	0	0.0014	#	88			
1995	1	2	1	2	1	-1	-1	140	0	0	0	0	0.0251	0.0744	0.3285	0.1364	0.237
	0.1137	0.0647	0.0076	0.0037	0.0037	0	0	0	0	0	0	0.0054	#	140			

1996	1	2	1	2	1	-1	-1	96	0	0	0	0	0.0132	0.0789	0.2309	0.3444	0.0634
	0.1812	0.07	0.0052	0.0041	0	0	0.0064	0	0.0023	0	0	0	#	96			
-1997	1	2	1	2	1	-1	-1	7	0	0	0	0	0.7193	0.0801	0.0583	0.1384	0
	0	0	0	0	0	0	0	0.0039	0	0	0	0	#	7			
1998	1	2	1	2	1	-1	-1	122	0	0	0	0	0.0413	0.1572	0.1643	0.2724	0.1548
	0.1054	0.028	0.0542	0.014	0.0047	0	0.0037	0	0	0	0	0	#	122			
1999	1	2	1	2	1	-1	-1	200	0	0	0	0	0.0061	0.0628	0.1123	0.1849	0.2541
	0.1967	0.0876	0.0492	0.025	0.0105	0.0052	0.0035	0.0007	0	0.0007	0	0.0006	#	643			
2000	1	2	1	2	1	-1	-1	200	0	0	0	0	0.0388	0.0523	0.202	0.1499	0.1586
	0.1197	0.0997	0.1026	0.0363	0.0127	0.0095	0.0063	0.0049	0	0.0011	0.0029	0.0028	#	405			
2001	1	2	1	2	1	-1	-1	200	0	0	0	0	0.0036	0.2011	0.1327	0.2345	0.125
	0.0626	0.0833	0.0809	0.0393	0.012	0.0086	0.0064	0.0049	0.0012	0.0008	0.0009	0.0022	#	1210			
2002	1	2	1	2	1	-1	-1	200	0	0	0	0	0.0042	0.0486	0.2703	0.1661	0.1567
	0.1224	0.0621	0.0588	0.0572	0.0223	0.0129	0.0089	0.0028	0.0013	0.0017	0.0009	0.0028	#	1067			
2003	1	2	1	2	1	-1	-1	200	0	0	0	0.0009	0.0335	0.03	0.1156	0.2377	0.1394
	0.1324	0.0892	0.0611	0.0528	0.041	0.0303	0.0144	0.0048	0.0083	0.0028	0.0024	0.0033	#	1080			
2004	1	2	1	2	1	-1	-1	200	0	0	0	0.0013	0.0146	0.2316	0.0507	0.1566	0.1877
	0.1189	0.0773	0.0463	0.0322	0.0233	0.0255	0.0115	0.0053	0.005	0.005	0.0021	0.0052	#	1153			
2005	1	2	1	2	1	-1	-1	200	0	0	0	0	0.0035	0.0966	0.4442	0.0759	0.1234
	0.1084	0.061	0.0294	0.0172	0.0107	0.0083	0.0053	0.0055	0.0025	0.0029	0.0013	0.004	#	1455			
2006	1	2	1	2	1	-1	-1	200	0	0	0	0	0	0.0293	0.1663	0.3771	0.1627
	0.0898	0.0619	0.0383	0.0242	0.0177	0.0143	0.0069	0.0069	0.0006	0.0011	0.0011	0.0017	#	538			
2007	1	2	1	2	1	-1	-1	200	0	0	0	0	0.002	0.0637	0.0963	0.1927	0.2992
	0.1171	0.0613	0.0743	0.0266	0.0182	0.0265	0.0095	0.0031	0.0033	0.0017	0.0034	0.0013	#	599			

2008	1	2	1	2	1	-1	-1	200	0	0	0	0	0	0.0155	0.2005	0.1393	0.2402
	0.2387	0.0709	0.0457	0.0183	0.012	0.0072	0.003	0.002	0.0029	0.002	0.0008	0.001	#	509			
2009	1	2	1	2	1	-1	-1	200	0	0	0	0.0003	0.003	0.0153	0.0736	0.3252	0.1257
	0.1688	0.1887	0.0399	0.0091	0.0108	0.0119	0.0109	0.0043	0.0025	0.0011	0.0036	0.0054	#	994			
2010	1	2	1	2	1	-1	-1	200	0	0	0	0.0061	0.1163	0.0578	0.1151	0.1808	0.277
	0.093	0.0983	0.0286	0.0073	0.0037	0.0028	0.0043	0.0044	0	0.0014	0.0029	0	#	650			
2011	1	2	1	2	1	-1	-1	200	0	0	0	0.0025	0.0498	0.3107	0.062	0.1427	0.1234
	0.1675	0.0449	0.0571	0.0214	0.0113	0	0.0001	0.0038	0	0	0.0025	0.0004	#	499			
2012	1	2	1	2	1	-1	-1	200	0	0	0	0	0.0047	0.1093	0.4614	0.09	0.0851
	0.0644	0.0917	0.0378	0.0287	0.0134	0.0035	0.0078	0	0	0	0.0011	0.0009	#	861			
2013	1	2	1	2	1	-1	-1	200	0	0	0	0	0.001	0.0422	0.2897	0.3692	0.0887
	0.0602	0.0479	0.0511	0.0158	0.0174	0.0068	0.002	0.0028	0.0008	0.0017	0.001	0.0018	#	1130			
-1991	1	3	1	2	1	-1	-1	2	0	0	0	0	0.0328	0	0.9672	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	#	2			
1992	1	3	1	2	1	-1	-1	14	0	0	0	0	0	0.1471	0.4923	0.0422	0.2481
	0	0.0597	0	0.0068	0	0	0	0	0.0038	0	0	0	#	14			
1993	1	3	1	2	1	-1	-1	84	0	0	0	0	0.047	0.0435	0.2138	0.3409	0.2725
	0.0679	0.0143	0	0	0	0	0	0	0	0	0	0	#	84			
1994	1	3	1	2	1	-1	-1	29	0	0	0	0	0	0	0.0283	0.1208	0.3499
	0.3176	0.12	0.0439	0.0098	0	0.0098	0	0	0	0	0	0	#	29			
1995	1	3	1	2	1	-1	-1	39	0	0	0	0	0	0.0476	0.4586	0.1074	0.2173
	0.0879	0.0166	0	0.0579	0.0066	0	0	0	0	0	0	0	#	39			
-1996	1	3	1	2	1	-1	-1	8	0	0	0	0	0	0	0	0.3504	0.1709
	0.1823	0.2279	0	0.0684	0	0	0	0	0	0	0	0	#	8			

1997	1	3	1	2	1	-1	-1	17	0	0	0	0	0.1291	0.4163	0.3007	0.0421	0.1013
	0	0	0	0	0.0105	0	0	0	0	0	0	0	#	17			
1998	1	3	1	2	1	-1	-1	33	0	0	0	0.03	0.0965	0.03	0.1509	0.2616	0.1537
	0.1716	0.0649	0	0.041	0	0	0	0	0	0	0	0	#	33			
1999	1	3	1	2	1	-1	-1	31	0	0	0	0	0.1012	0.0732	0.0973	0.0288	0.2114
	0.1615	0.1135	0.1914	0	0.021	0.0006	0	0	0	0	0	0	#	31			
2000	1	3	1	2	1	-1	-1	38	0	0	0	0	0.0246	0.0246	0.4501	0.21	0.0902
	0.1193	0.0301	0.0247	0	0.0265	0	0	0	0	0	0	0	#	38			
2001	1	3	1	2	1	-1	-1	39	0	0	0	0	0	0.0807	0.1026	0.2107	0.1754
	0.0658	0.1454	0.0096	0.1843	0	0	0.0171	0	0.0084	0	0	0	#	39			
2002	1	3	1	2	1	-1	-1	89	0	0	0	0	0.0646	0.0649	0.1662	0.1652	0.1977
	0.1002	0.0702	0.0676	0.0374	0.0486	0.0038	0.0066	0.0071	0	0	0	0	#	89			
2003	1	3	1	2	1	-1	-1	65	0	0	0	0	0.1979	0.0102	0.1652	0.1786	0.1629
	0.1271	0.0539	0.0169	0.0696	0.0049	0.0037	0.0073	0.0016	0	0	0	0	#	65			
2004	1	3	1	2	1	-1	-1	38	0	0	0	0	0.1122	0.2652	0.0625	0.2343	0.1503
	0.012	0.0742	0.0343	0	0	0.0167	0	0.0096	0	0.0287	0	0	#	38			
2006	1	3	1	2	1	-1	-1	173	0	0	0	0	0	0.0135	0.0923	0.5382	0.1501
	0.047	0.0595	0.0337	0.0413	0.0058	0	0.013	0	0.0056	0	0	0	#	173			
-1991	1	4	1	2	1	-1	-1	1	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	1	#	1			
1992	1	4	1	2	1	-1	-1	25	0	0	0	0	0.3522	0.2525	0	0	0.0701
	0.2372	0.0359	0.0305	0.018	0.0036	0	0	0	0	0	0	0	#	25			
1993	1	4	1	2	1	-1	-1	62	0	0	0	0.0598	0.3283	0.04	0.1018	0.2007	0.1565
	0.0568	0.0231	0.0228	0	0.0051	0	0.0051	0	0	0	0	0	#	62			

1994	1	4	1	2	1	-1	-1	72	0	0	0	0.0324	0.2312	0.2394	0.1745	0.1369	0.0949
	0.0084	0.0193	0.0182	0.014	0.0111	0.0071	0	0	0	0	0	0.0127	#	72			
1995	1	4	1	2	1	-1	-1	91	0	0	0	0	0.0723	0.3154	0.3879	0	0.1495
	0.0357	0.0089	0.0047	0.0047	0.0082	0.0127	0	0	0	0	0	0	#	91			
1996	1	4	1	2	1	-1	-1	134	0	0	0	0	0	0.1728	0.446	0.203	0.0749
	0.0624	0.0313	0	0	0.0065	0	0	0	0	0	0	0.0032	#	134			
1997	1	4	1	2	1	-1	-1	70	0	0	0	0.0135	0.0322	0.0873	0.2939	0.3596	0.1488
	0.0118	0	0.0124	0.0071	0.0071	0.0118	0.0071	0.0071	0	0	0	0	#	70			
1998	1	4	1	2	1	-1	-1	76	0	0	0	0	0.0606	0.3308	0.2881	0.2088	0.0922
	0.0117	0	0	0	0	0.0078	0	0	0	0	0	0	#	76			
1999	1	4	1	2	1	-1	-1	106	0	0	0	0.0153	0.0499	0.4618	0.1999	0.0744	0.1164
	0.0566	0.0208	0	0	0	0	0	0.0025	0	0	0	0.0025	#	106			
2000	1	4	1	2	1	-1	-1	59	0	0	0	0	0.3738	0.1787	0.1815	0.0618	0.106
	0.0587	0.0167	0.0026	0	0.0092	0	0.0059	0	0.0026	0	0	0.0026	#	59			
2001	1	4	1	2	1	-1	-1	47	0	0	0	0	0.0546	0.5729	0.1771	0.1751	0
	0	0.0092	0	0	0.0092	0	0	0	0.0021	0	0	0	#	47			
2002	1	4	1	2	1	-1	-1	200	0	0	0	0.0179	0.0934	0.2095	0.4108	0.1415	0.0616
	0.0194	0.0051	0.014	0.0063	0.0082	0.0068	0.0054	0	0	0	0	0	#	299			
2003	1	4	1	2	1	-1	-1	169	0	0	0	0.0349	0.4303	0.1575	0.1255	0.1724	0.0233
	0.0244	0.0136	0	0.0136	0.0045	0	0	0	0	0	0	0	#	169			
2004	1	4	1	2	1	-1	-1	185	0	0	0	0.0071	0.0521	0.6512	0.0844	0.0873	0.0648
	0.0108	0.0264	0.0124	0	0	0.0036	0	0	0	0	0	0	#	185			
2005	1	4	1	2	1	-1	-1	65	0	0	0	0	0.0202	0.2226	0.6468	0.0504	0.0201
	0.0337	0	0.0062	0	0	0	0	0	0	0	0	0	#	65			

2006	1	4	1	2	1	-1	-1	44	0	0	0	0	0	0.0509	0.1585	0.3874	0.2226
	0.1163	0.039	0.0231	0	0	0	0	0.002	0	0	0	0	#	44			
2007	1	4	1	2	1	-1	-1	62	0	0	0	0.0554	0.0633	0.0517	0.1577	0.2386	0.3016
	0.0546	0.0112	0.0112	0.0439	0.0112	0	0	0	0	0	0	0	#	62			
2008	1	4	1	2	1	-1	-1	105	0	0	0	0.0085	0.1966	0.2339	0.2222	0.1012	0.1084
	0.1031	0	0.0164	0	0	0.0098	0	0	0	0	0	0	#	105			
2009	1	4	1	2	1	-1	-1	117	0	0	0	0.1854	0.0352	0.2569	0.1365	0.1566	0.0638
	0.098	0.0411	0.0107	0.0157	0	0	0	0	0	0	0	0	#	117			
2010	1	4	1	2	1	-1	-1	200	0	0	0	0.0195	0.5864	0.0413	0.1583	0.0671	0.084
	0.0113	0.0213	0	0.0035	0	0.0036	0	0	0	0.0038	0	0	#	310			
2011	1	4	1	2	1	-1	-1	200	0	0	0	0.0021	0.0646	0.7976	0.0336	0.034	0.0261
	0.0176	0.0082	0.0014	0.0064	0.0042	0.0042	0	0	0	0	0	0	#	404			
2012	1	4	1	2	1	-1	-1	200	0	0	0	0	0.01	0.3389	0.4836	0.0658	0.0101
	0.0037	0.036	0.015	0.0147	0.0171	0	0	0	0	0	0.0051	0	#	237			
2013	1	4	1	2	1	-1	-1	200	0	0	0	0.0039	0.0079	0.0968	0.586	0.255	0.0081
	0.0029	0.0034	0.0139	0	0.0029	0.0193	0	0	0	0	0	0	#	241			
1991	1	5	1	2	1	-1	-1	36	0	0	0	0.0321	0.1284	0.4058	0.1554	0.0451	0.066
	0.0176	0.065	0.0229	0.0245	0.0196	0	0	0	0	0	0	0.0176	#	36			
1992	1	5	1	2	1	-1	-1	33	0	0	0	0.0556	0.0159	0.4546	0.2791	0.0653	0.0247
	0	0.0123	0	0.0741	0.0185	0	0	0	0	0	0	0	#	33			
1993	1	5	1	2	1	-1	-1	21	0	0	0.0286	0.0286	0.3341	0.1315	0.1914	0.0571	0.1143
	0.0571	0	0	0	0	0	0	0	0	0.0286	0	0.0286	#	21			
1994	1	5	1	2	1	-1	-1	29	0	0	0	0.0191	0.2728	0.5085	0.0976	0.0354	0
	0	0.0476	0	0	0	0	0	0	0	0	0	0.0191	#	29			

1995	1	5	1	2	1	-1	-1	53	0	0	0	0	0.0601	0.5195	0	0.3492	0.03
	0	0	0.0103	0	0.0103	0	0	0.0206	0	0	0	0	#	53			
1996	1	5	1	2	1	-1	-1	41	0	0	0	0.0128	0	0.1987	0.391	0.3147	0.0314
	0.0513	0	0	0	0	0	0	0	0	0	0	0	#	41			
1997	1	5	1	2	1	-1	-1	28	0	0	0	0	0.0807	0.1557	0.2781	0.38	0.0391
	0.0351	0.0156	0.0156	0	0	0	0	0	0	0	0	0	#	28			
1998	1	5	1	2	1	-1	-1	21	0	0	0	0	0.102	0.2517	0.3283	0.2568	0.0204
	0.0408	0	0	0	0	0	0	0	0	0	0	0	#	21			
1999	1	5	1	2	1	-1	-1	8	0	0	0	0	0	0.1862	0.4607	0.152	0.0883
	0	0.1128	0	0	0	0	0	0	0	0	0	0	#	8			
2000	1	5	1	2	1	-1	-1	12	0	0	0	0	0.62	0.1938	0.0969	0.0715	0
	0	0	0.0178	0	0	0	0	0	0	0	0	0	#	12			
-2001	1	5	1	2	1	-1	-1	1	0	0	0	0	0	1	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	#	1			
2002	1	5	1	2	1	-1	-1	50	0	0	0	0	0	0.3492	0.5748	0.076	0
	0	0	0	0	0	0	0	0	0	0	0	0	#	50			
2003	1	5	1	2	1	-1	-1	30	0	0	0	0	0.7509	0.1012	0.0886	0.0593	0
	0	0	0	0	0	0	0	0	0	0	0	0	#	30			
2004	1	5	1	2	1	-1	-1	43	0	0	0	0	0	0.7074	0.1921	0.0086	0.0686
	0.0233	0	0	0	0	0	0	0	0	0	0	0	#	43			
2005	1	5	1	2	1	-1	-1	52	0	0	0	0	0.045	0.2121	0.605	0.0978	0
	0.0268	0.0134	0	0	0	0	0	0	0	0	0	0	#	52			
2006	1	5	1	2	1	-1	-1	33	0	0	0	0	0.0373	0.165	0.0964	0.5854	0.0689
	0.047	0	0	0	0	0	0	0	0	0	0	0	#	33			

2007	1	5	1	2	1	-1	-1	28	0	0	0	0	0.0564	0.2025	0.1231	0.1792	0.3941
	0.0184	0	0.0263	0	0	0	0	0	0	0	0	0	#	28			
2008	1	5	1	2	1	-1	-1	44	0	0	0	0	0.1344	0.2317	0.3072	0.0941	0.0873
	0.1198	0.0256	0	0	0	0	0	0	0	0	0	0	#	44			
2009	1	5	1	2	1	-1	-1	102	0	0	0.0069	0.2528	0.1136	0.2083	0.1496	0.1765	0.0083
	0.0666	0.0175	0	0	0	0	0	0	0	0	0	0	#	102			
2010	1	5	1	2	1	-1	-1	85	0	0	0.0105	0.0591	0.5454	0.0373	0.0745	0.0517	0.1462
	0.0202	0.0468	0.0084	0	0	0	0	0	0	0	0	0	#	85			
2011	1	5	1	2	1	-1	-1	114	0	0	0	0	0.1276	0.5803	0.135	0.0315	0.0648
	0.0481	0	0.0128	0	0	0	0	0	0	0	0	0	#	114			
2012	1	5	1	2	1	-1	-1	39	0	0	0	0	0.014	0.4437	0.4486	0.014	0
	0.0064	0.0159	0.0382	0.0096	0	0	0.0096	0	0	0	0	0	#	39			
2013	1	5	1	2	1	-1	-1	45	0	0	0	0	0.0339	0.0679	0.6803	0.1903	0
	0.0055	0.0055	0.011	0	0	0.0055	0	0	0	0	0	0	#	45			
0	#_N_MeanSize-at-Age_obs																
0	#_N_environ_variables																
0	#_N_environ_obs																
0	#	N	sizefreq	methods		to	read										
0	#	no	tag	data													
0	#	no	morph	composition		data											
999	#	end	of	file	marker												

SEDAR

Southeast Data, Assessment, and Review

SEDAR 42

Gulf of Mexico Red Grouper

SECTION IV: Research Recommendations

SEDAR
4055 Faber Place Drive, Suite 201
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1. DATA WORKSHOP RESEARCH RECOMMENDATIONS

1.1 Life History Working Group Recommendations

Stock Structure

Population genetics - LHW recommends a study using next-generation sequencing of single nucleotide polymorphisms to generate a genetic map that may elucidate sub-populations and refine the stock structure of red grouper.

Larval transport and connectivity - Implement a survey to identify red grouper Age 0's locations for an index of recruitment and identify nearshore habitats that provide recruitment to offshore areas.

Habitat Requirements - Given the expected high site fidelity of red grouper, an acoustic array around a harem may provide essential information about mating movements, spawning frequency and duration during the spawning season. Anecdotal information about cohort and feeding movements following spawning may guide more targeted tagging studies.

Tagging, movements, and migrations - Gulf wide tag-recapture programs using multiple techniques (dart tags, PIT tags, telemetry, gene tagging) to improve estimates for release mortality and movements among and across regions. Some emphasis concentrated on areas of little known information, the northern and western Gulf of Mexico, as well as the Florida Keys, and should include the time of year as a factor.

Age and Growth

Sources of Age data

- Conduct further review of current sampling methodologies by sector, including detailed comparison of length data from otolith samples and from more expansive port-based length sampling (via TIP, MRFSS/MRIP, SRHS; see Chih 2014a, 2014b).
- Bring increased attention to the need for strategies improving port sampling (representation of fishery sectors and random sampling)

- It is recommended that an increase in the number of trips intercepted by year by both the MRFSS/MRIP and SRHS occurs in the future and for a higher percentage of the intercepts include collecting biological samples (length, weight, and hard parts).

Reader Age Precision

- Continue exchanges of calibration otolith sets and age workshops among state and federal agencies and universities to continue improvements of data comparability and quality control.
- Continue use and development of a reference collection as a means to monitor precision between/among readers.
- Expand the current reference collections to include older age classes (> age 12).

Year Class Progressions

- Continue age structure sampling from all fishing sectors on an annual basis.

Age and Length Data

- Investigate methods to better collect age structure samples randomly and systematically from all fishing sectors.
- The recreational sector is still under sampling for biological samples (e.g., hard parts, n<100/year, all years). It is recommended that there is an increase in the number of trips intercepted by year by both the MRFSS/MRIP and SRHS and that a higher percentages of the intercepts include collecting biological samples (length, weight, and hard parts). In the past 4 years, only 166 trips (on average, 2010-2013; Table 4.8.11) intercepted included collecting biological samples (e.g., length, hard parts) by MRFSS/MRIP port agents and there was an estimated 22 million recreational trips made by recreational anglers in the more recent years (2010-2013; Table 4.8.17). Biological data collected at such a low percentage (< 0.0001%), provide very minimal information regarding age and growth of red grouper. An increase in the number of fish intercepted for biological samples will increase our knowledge of the size and age structure being intercepted by recreational anglers.

Modeling Growth

- Explore growth model alternatives that includes both the non-random sampling due to minimum size restrictions (Diaz et al. 2004) and non-random sampling due to biases in over/under sampling specific length bins (Chih 2014a, 2014b).

Mortality

Gulf wide tag-recapture programs using multiple techniques (dart tags, PIT tags, telemetry, gene tagging) to improve estimates for natural, discard, and fishing mortalities.

Natural Mortality

- Continue the collection of otoliths from all fishing sectors, as well as, fishery independent surveys to monitor any changes in longevity.
- Continue to investigate age-varying M models and their appropriateness.
- LHW recommends further research into mortality rates of juvenile red grouper as they migrate from inshore to the offshore environment.

Total Mortality

- Continue the annual collection of otoliths from all fishing sectors, as well as, fishery independent surveys to monitor any changes in annual catch by age.

Discard Mortality

- Direct estimates of latent discard mortality are needed for the commercial sector for both bottom long line and vertical line gears. Apply innovative tag-recapture programs to the observed discards to estimate discard and other types of mortality.

Reproduction

Improve our understanding of the spatio-temporal aspects of the reproductive strategy. An example may be screen for a spatial- or depth dependence in male transition. Conduct surveys for metapopulation structure in demographics and reproduction (example hogfish assessment, SEDAR 2014b).

As in SEDAR12, the LHW recommends continued work to better understand and discriminate between annual asynchrony in spawning (skipped spawning) and seasonal asynchrony in spawning. Results of aquaculture rearing trials, review of histology, and new information or metadata regarding temperature and the development and duration of oocytes and follicles may increase our understanding.

Age and Size at Maturity - Continue to monitor changes in maturation schedules – evidence of earlier maturity since Moe 1969.

Age and Size at Transition - Continue to monitor changes in transition schedules, evidence of earlier transition since Moe 1969.

Mating Systems - Utilize new approaches to characterize the mating system such as measurement of the amount of androgen across species and across size within species (Shepherd et al. 2013).

Develop full egg production model by accounting for temporal changes in batch fecundity and intensity of spawning and incorporate spawning frequency by size and/or age.

Meristic & Conversion factors

Continue to communicate the need to standardize length (natural total length, maximum total length, fork length, and standard length), weight (whole and gutted) measurements and the units (metric –e.g., millimeters, kilograms) used in collecting data among all sampling programs to minimize measurement errors.

1.2 Commercial Fisheries Working Group Recommendations

Landings

-Improve data quality of CFLP Logbook VTR number to state trip ticket for data reconciliation.

IFQ

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

-Explore fishermen behavior in relation to allocation available.

-Add CFLP Logbook VTR number to IFQ landing transaction form for data reconciliation.

-Translate IFQ allocation activity ledger into a useable data set for daily allocation balances.

-Add actual landing date to IFQ reporting form.

-Improved enforcement of IFQ reporting infractions.

-Improve real time seizure reporting from states law enforcements agents. Need vessel, species, pounds, price per pound, dealer, and enforcement agent.

Discard

-Most appropriate method for incorporation of IFQ data into discard estimations.

-Most appropriate method for incorporation of IFQ data into discard size compositions.

-Increased observer funding and coverage.

-More representative observer coverage.

-Assess reliability of effort data in logbook data.

Overall

Meet with fishermen prior to data workshops to provide supplementary information relevant to fishery dependent data.

1.3 Recreational Fisheries Working Group Recommendations

No research recommendations were provided, though the group supported the recommendation made the Life History group:

> *The recreational sector is still under sampling for biological samples (e.g., hard parts, n<100/year, all years). It is recommended that there is an increase in the number of trips intercepted by year by both the MRFSS/MRIP and SRHS and that a higher percentages of the*

intercepts include collecting biological samples (length, weight, and hard parts). In the past 4 years, only 166 trips (on average, 2010-2013; Table 4.8.11) intercepted included collecting biological samples (e.g., length, hard parts) by MRFSS/MRIP port agents and there was an estimated 22 million recreational trips made by recreational anglers in the more recent years (2010-2013; Table 4.8.17). Biological data collected at such a low percentage (< 0.0001%), provide very minimal information regarding age and growth of red grouper. An increase in the number of fish intercepted for biological samples will increase our knowledge of the size and age structure being intercepted by recreational anglers.

1.4 Indices of Relative Abundance Working Group Recommendation

- The IWG made note that the delta-lognormal index may not be the most appropriate distribution with some of the data presented and that alternative distributions should be considered. In addition, there is some variation in the SAS code used by the various labs to produce the indices. The recommendation is that a best practices workshop be convened to fully investigate different statistical models and produce a standard version of the appropriate programming code. Further, the use of R in place of SAS should be explored if the workshop warrants such consideration.
- As part of the proposed workshop, the approach to modeling 'success' in binomial portion of the delta models needs investigation. Currently, some labs model the 'proportion positive' rather than ‘success’ which can be an issue when used improperly.
- A calibration study is needed between the FWRI/NMFS video survey. The standardized reef systems are well suited for rigorous calibration studies, which could also include other sampling methods. In addition, exploration is needed for incorporating standardized video habitat covariates in the models.
- An exploration of the effects of IFQ’s on the fishery dependent indices, especially the commercial handline and longline is needed. During the workshop, fishermen indicated that since the implementation of IFQ’s, there has been a drastic change in fisheries behavior. There is also the possibility that dealers can directly influence this behavior. There is a need to incorporate these years into the overall time series in the most appropriate manner and to determine the means for doing so.

- The MRFSS data are clustered in the sense that some records represent individuals on the same boat (a cluster). An issue arose where the proper identifier for those clusters was not obvious in the data set. Hence, further investigation into 'party id' and what it represents in the MRFSS data in needed to accurately estimate the variability associated with the indices.
- Expansion of video surveys into Florida Bay
- Development of a YOY survey
- For reef-associated fisheries, the fishery-independent monitoring is based on known distribution of habitat. As side-scan sonar and similar activities increase the list of known habitat, there is a need to ensure that the sampling strategies for the FIM adjust appropriately and are optimized as habitat information becomes available.

1.5 Integrated Ecosystem Assessment Working Group Recommendations

Recommendation 1: Time varying natural mortality

Research is required to incorporate interannual variation in red grouper natural mortality within the assessment process. In particular, elevated mortality rates in fishes, including members of the shallow-water grouper complex, can be caused by severe red tide events (Flaherty & Landsberg 2011). A red tide severity index (Walter et al. 2013) was previously included in the base stock assessment model for Gulf of Mexico gag grouper, which improved model fits to indices of abundance (Sagarese et al. 2014b). In the Gulf of Mexico gag grouper assessment (SEDAR 33), fluctuations in red tide mortality varied more than 10-fold through time, and were estimated to be commensurate with fishing mortality rates in several "severe" years (Sagarese et al. 2014b). Like the gag grouper SEDAR assessment, red tide severity should be considered as a source of mortality for red grouper. This recommendation requires at least four research steps.

First, length/age composition data are needed to determining lengths/ages susceptibility to red tide severity.

Collections of fish during red tide events would allow for the size/age selectivity of mortality to be determined, and might also allow for some minimum estimates of total mortality. Preliminary data were distributed by the NMFS Panama City lab containing red grouper lengths and estimated ages for 16 individuals collected from the Big Bend region during August 1st and 3rd of 2014. During plenary, various participants noted that collection of samples during the NMFS bottom longline survey was complicated by the decomposed nature of many fish encountered, which also prevented length estimates. In addition, otoliths were often difficult to recover from some specimens because they were missing anterior portions of their body.

Second, existing indices of red tide severity should be updated.

The IEA group recommends research to produce candidate indices of red tide severity and to devise scenarios based on red tide indices and methods for inclusion in the red grouper Stock Synthesis assessment model. Updating red tide indices is difficult because the original red tide indices (Walter et al. 2013) were created using SeaWiFS (operational 1998 – December 2010) satellite sensors. More recently, MODIS (Moderate Resolution Imaging Spectrometer) satellite sensors (July 2002 – present) have been used to detect and track harmful algal blooms (Stumpf et al. 2003, Hu et al. 2005). Thus, steps need to be taken to (i) calibrate SeaWiFS and MODIS satellite data during overlap periods; (ii) extend the red tide index through the present period (2014); and (iii) automate compilation of satellite data, and calculation and reporting of index values.

Third, procedures for incorporating red tide indices into Stock Synthesis should be critically evaluated.

Simulations should be conducted to evaluate the consequences of assuming constant or size specific natural mortality, when mortality actually fluctuates according to episodic temporal events. Further, approaches to incorporating environmental indices in stock assessment tuning procedures should be compared through simulated datasets to evaluate the effects of assessment model misspecification.

Fourth, the statistical properties of red tide indices should be characterized for use in simulations and assessment projections.

Evaluate whether all levels of red tide severity are equally likely in near-term future events, or whether information is contained in red tide indices that can be used to generate ‘forecast distributions'. Time series decomposition can be used to statistically characterize red tide indices (Stumpf et al. 2003). By quantifying periodicity, trends, and stochasticity, 'forecast distributions' may enable plausible future scenarios to be considered in assessment projections.

Recommendation 2: Index of red tide mortality derived from Ecopath with Ecosim

The IEA working group agreed that additional efforts deriving natural mortality values from the WFS Red tide Ecopath with Ecosim model would be helpful as presented for gag grouper during SEDAR 33 (Gray et al. 2013). These modeling efforts would allow red tide events to affect multiple components of the West Florida Shelf ecosystem and to assess the overall effect of red tide and predator/prey dynamics on the mortality rates of Gulf of Mexico red grouper.

Recommendation 3: Elucidating the response of red grouper to red tide events

Future modeling efforts should aim to address whether groupers move in response to red tide events or if they experience elevated natural mortality during these episodic events.

Recommendation 4: Modifications to the CMS modeling framework

Additional fisheries-independent data (e.g., PCLAB data) will be incorporated in the datasets used for habitat modeling of red grouper. This will allow us to improve the predictions made by the binomial GLMs described in SEDAR42-DW-04. Thus, we will be able to better predict the probability of presence of adult red grouper on the West Florida Shelf and, therefore, to better simulate the production of red grouper eggs over space in the CMS.

The life history working group brought up concerns regarding the aggregated use of all adult red groupers in determining the number of eggs released at red grouper spawning sites. There is evidence in red grouper that the fecundity of large adult females is considerably higher than that of small adult females. To account for this, the IEA group will use data compiled by the life history group to calculate mean age at depth for red grouper. This information will be useful to estimate the number of eggs released at each red grouper spawning site based on (1) the probability of presence of adult red grouper at that site; and (2) the relative fecundity at that site. The relative fecundity at each spawning site will be determined from: (1) the depth at that site;

(2) the mean age at depth profile; and (3) the fecundity-at-age (number of eggs released during a spawning event at age) profile.

The CMS index should be extended to cover 2014 to provide insight into potential recruitment for the first year of projections.

Recommendation 5: Enhance fish kill reporting, particularly in offshore regions

Current understanding of fish killed by red tide events largely originates from the Florida Fish and Wildlife Conservation Commission and Fish and Wildlife Research Institute fish kill database, which is informed by a statewide fish kill hotline (http://research.myfwc.com/fishkill/). Many of the observations are based on fish that washed ashore following red tide events. Enhanced reporting of red tides, in addition to observations from offshore waters by recreational and commercial fishermen, could increase understanding of how red tide events impact offshore species. This could be achieved through the creation of a national program or increased citizen science through outreach educating fishermen and other Gulf patrons on their ability to improve fish kill reporting.

2. ASSESSMENT WORKSHOP RESEARCH RECOMMENDATIONS

1. Evaluate existing methods for deriving historical discard numbers and discard rates and improve methods as appropriate.

2. Develop/evaluate methods to maintain continuity of fishery-dependent indices in light of management regulations and ITQs.

3. Considering red tide is an unpredictable event, but can be a significant source of mortality, a response protocol should be developed for data collection and incorporation of the information into updated assessments.

4. The start year of this assessment is 1986. Future assessments should investigate extending the assessment model further back in time.

3. REVIEW PANEL RESEARCH RECOMMENDATIONS (numbered in order of priority)

1) Questions were raised in workshop discussions about changes in reproductive success with age and with population concentration. Although it is known that reproductive success is mitigated by social factors, the degree and extent of mitigation is not well understood. More data are needed to better address the topic, including addressing time-varying changes within age categories. How much variation exists in size at age? Insufficient information leads to greater uncertainty and can have impacts on reference points.

2) The review panel raised questions throughout the evaluation of the assessment reports about the basis or bases of decisions to use the variables actually used. The recommendation is for analysts to provide a justification or rationale for the selection criteria. Review panel evaluations could be more accurately motivated if the selection criteria were better reported. Selection criteria would thereby be carried forward in the evaluations.

3) Paralleling the AW Report, discussions in the Review Workshop focused on initial conditions of the red grouper stock, including assessment of the stock from 1986 to 1993. Composition data was more complete from 1993, raising questions about methods to approach composition prior to that data, in effect, how to decide on what methods and procedures to use and how to establish preferences. The sense of the Review Workshop members was that procedures of ramping up were needed.

4) The core problem in the red grouper assessment was the data on discards. Procedures for reporting discards were not consistent across the fleets, and the fit to indices were poor, leading to major sources of uncertainty. Numerous sensitivity runs helped to reduce the lack of fit, especially up-weighting the commercial fishery dependent data, but problems remain. Discards were missing from the shark longline fishery, raising questions about the amount of resultant uncertainty. Research to address best practices in the reporting of discards is needed in regard to the red grouper stock. Especially useful, also, would be to increase the number of observers and observations among the commercial fleets.

5) Develop a standard protocol for ensuring that appropriate uncertainty in recruitment is applied when developing projections. Using a long-term average recruitment, as the median was used in this assessment, may lead to very different projections, and thus different management advice, compared to a lower or higher average recruitment based on a more recent time-period that may be more likely to reflect the biological/environmental realty of the stock.

6) Research is needed to help address questions about how fecundity can best be measured. Fecundity is a preferred measure for stock biomass and is a function of the number of eggs produced, but it has to be measured indirectly. Gonad weight can be used as a proxy, but obtaining reliable weights can be problematic, dependent in part on methods and timing of data acquisition. Research to address more accurate measurement of gonad weight and to develop protocols would be helpful.

7) Actual measures of individual growth are needed within age categories, as opposed to relying on common assumptions about growth rates and outcomes. Differential growth rates may occur in stock sub-structure within localized species, due to characteristics of the stock and ecosystem variables, or both. They may also affect schedules for hermaphroditic changes, impacting sex-age class composition.

8) Sensitivity runs to assess the impact of the 2005 red tide event on red grouper landings did not show any significant differences from the base model, including fit to discards. Documentation of the red tide mortality, however, presents methodological difficulties. Although analyses of data suggest that red tide primarily affected ages 0+, composition of the red tide kills are difficult to measure, given problems of access to the red tide zones and incomplete records of age, size, and sex in the kills. In addition, red tide events may be best considered in reference to ecosystem considerations (SEDAR42-5W-01). As environmental indices become incorporated into single stock species, criteria for inclusion have to be tested and measured, toward a goal of balanced biological and mechanistic explanation, statistical significance, and predictive performance. More research for red tide impacts on red grouper stock status is especially appropriate, given that the majority of landings are on Florida's West Continental Shelf, where high concentrations of red tide tend to be located.

9) Red grouper are found throughout the Gulf of Mexico and in the Atlantic from Brazil to the southeastern US. Catch levels and age composition data from Cuba, the Caribbean, and especially Mexico would allow for more complete stock assessment. Data could be obtained from the Mexican organization MEXAS.

10) The average age and thus size of females changing to males are known, but a more complete understanding of the conditions under which the changes occur would be helpful for assessing stock size. The number of males in relation to minimum stock size would be a useful metric for stock assessments.

a) Clearly denote research and monitoring that could improve the reliability of, and information provided by future assessments with particular emphasis on the Deepwater Horizon Oil Spill.

SEDAR 42 did not directly address the impacts of Deepwater Horizon on red grouper stock status. Earlier SEDAR Workshops, for example, SEDAR 31 (red snapper), contained discussions and research recommendations. SEDAR 42 contains analyses and recommendations relevant for events such as oil spills, however, in the attention given to the 2005 and 2014 red tide events. Oil spills can be measured as environmental events in a variety of ways, including the event as equivalent to a fleet source for fishing mortality. Ecosystem considerations (see 9 above) can also be utilized to assess impacts on stock status.

b) Provide recommendations on possible ways to improve the SEDAR process.

A topic of discussion throughout the Review Workshop was the need for more attention to commonly used assumptions in categories of data and analyses. The rationale was to make assumptions more explicit and for consideration to be given to criteria for selection of options. The selection criteria would therefore become a part of the record as analyses move forward, and they would be subject to considerations of clarity, efficiency, and parsimony.

The three days of Review Workshop proved insufficient to enable the pre-prepared assessment to be presented and address areas of concern through developing additional work. For the workshop component of the review to be effective (i.e. developing alternatives or options where issues are identified), some additional time would need to be made available to the Assessment Team during the Workshop.

SEDAR
Southeast Data, Assessment, and Review

SEDAR 42

Gulf of Mexico Red Grouper

SECTION V: Review Workshop Report

September 2015

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

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1. INTRODUCTION

1.1 WORKSHOP TIME AND PLACE

The SEDAR 42 Review Workshop was held July 14-16, 2015 in Miami, Florida.

1.2 TERMS OF REFERENCE

1. Evaluate the data used in the assessment, including discussion of the strengths and weaknesses of data sources and decisions, and consider the following:
   a) Are data decisions made by the DW and AW sound and robust?
   b) Are data uncertainties acknowledged, reported, and within normal or expected levels?
   c) Are data applied properly within the assessment model?
   d) Are input data series reliable and sufficient to support the assessment approach and findings?
2. Evaluate and discuss the strengths and weaknesses of the methods used to assess the stock, taking into account the available data, and considering the following:
   a) Are methods scientifically sound and robust?
   b) Are assessment models configured properly and used consistent with standard practices?
   c) Are the methods appropriate for the available data?
3. Evaluate the assessment findings and consider the following:
   a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
   b) Is the stock overfished? What information helps you reach this conclusion?

c) Is the stock undergoing overfishing? What information helps you reach this conclusion?

d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

4. Evaluate the stock projections, including discussing strengths and weaknesses, and consider the following:

   a) Are the methods consistent with accepted practices and available data?

   b) Are the methods appropriate for the assessment model and outputs?

   c) Are the results informative and robust, and useful to support inferences of probable future conditions?

   d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?

5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

   - Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods.
   - Ensure that the implications of uncertainty in technical conclusions are clearly stated.

6. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted.

   - Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments with particular emphasis on the Deepwater Horizon Oil Spill
   - Provide recommendations on possible ways to improve the SEDAR process.

7. Consider whether the stock assessment constitutes the best scientific information available using the following criteria as appropriate: relevance, inclusiveness, objectivity, transparency, timeliness, verification, validation, and peer review of fishery management information.

8. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.

9. Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference.

1.3 LIST OF PARTICIPANTS

Workshop Panel

Luiz Barbieri, Chair .... Chair, SSC
Ben Blount .... SSC
Matt Cieri .... CIE Reviewer
Kai Lorenzen .... SSC
Henrik Sparholt .... CIE Reviewer
Geoff Tingley .... CIE Reviewer

Analytic Representation
Meaghan Bryan .... SEFSC, Miami
Adyan Rios .... SEFSC, Miami

Appointed Observers
Bo Gorham .... Recreational Fisherman
Ed Walker .... Industry Rep

Observers
Shannon Cass-Calay .... SEFSC, Miami
Nancie Cummings .... SEFSC, Miami
Michael Drexler .... Ocean Conservancy
Chad Hanson .... Pew
Bill Harford .... RSMAS/SEFSC
Michael Larkin .... SERO
Patrick Lynch .... NMFS/ST
Clay Porch .... SEFSC, Miami
Skyler Sagarese .... SEFSC/UM

Staff
Julie Neer .... SEDAR
John Froeschke .... GMFMC Staff
Ryan Rindone .... GMFMC Staff
Charlotte Schiaffo .... GMFMC Staff

1.4 LIST OF REVIEW WORKSHOP WORKING PAPERS AND DOCUMENTS

Documents Prepared for the Review Workshop			
SEDAR42-RW-01	Incorporating ecosystem considerations within the Stock Synthesis integrated assessment model for Gulf of Mexico Red Grouper (*Epinephelus morio*)	Skyler R. Sagarese, Meaghan D. Bryan, John F. Walter, Michael Schirripa,	29 June 2015

		Arnaud Grüss, Mandy Karnauskas	
SEDAR42-RW-02	Assessing the impact of the 2014 red tide event on red grouper (*Epinephelus morio*) in the Northeastern Gulf of Mexico	John F. Walter III, Skyler R. Sagarese, William J. Harford, Arnaud Grüss, Richard P. Stumpf, Mary C. Christman	14 July 2015 Updated: 20 July 2015

2. REVIEW PANEL REPORT

1. SEDAR 42 Review Panel Summary Report

The Review Panel was presented outputs and results of the SEDAR 42 Gulf of Mexico red grouper stock assessment. The assessment model framework used was Stock Synthesis 3 (SS3), a highly flexible, integrated analysis, statistical catch-at-age model framework. However, there were significant areas of uncertainty identified in both the data and in components to the model. The Panel had concerns with the lack of more detailed information on red grouper's reproductive biology (especially regarding social and population factors associated with sexual transition), as well as with the landings and discard data series. Of these, the issues associated with the discard data series were considered to be of the greatest importance. However, despite these concerns, the Review Panel concluded that the data used in the assessment were generally sound and robust. Likewise, data generally were applied properly and uncertainty in data inputs was appropriately acknowledged. Numerous sensitivity analyses and exploration of alternative scenarios were presented and discussed during the Review Workshop all of which broadly agreed with the base model run conclusions of stock status. Outputs and diagnostics of a new base model configuration recommended by the Review Panel (RW1) could not be completed and reviewed during the in-person Review Workshop. Therefore, more complete assessment documentation was reviewed and approved *a posteriori* by e-mail. Notwithstanding these problems, the Review Panel was very impressed with the performance of the assessment team. It was clear the analytical team had put considerable thought into the development of the assessment model, which by necessity is very complex. The stock was estimated to be not overfished and not undergoing overfishing. Since the stock-recruitment relationship could not be estimated the Panel recommended the use of proxy reference points (SPR30%). Current level of spawning potential biomass (SPB_{2013}, expressed in number of eggs) is estimated to be above MSST ($SPB_{2013}/MSST = 1.38$), and the estimated current level of fishing mortality ($F_{2010\text{-}2013}$) is about half of $F_{30\%SPR}$ ($F_{2010\text{-}2013}/F_{30\%SPR} = 0.52$), although these observations have an associated moderate to high level of uncertainty.

2. Terms of Reference:

1. Evaluate the data used in the assessment, including discussion of the strengths and weaknesses of data sources and decisions, and consider the following:

General Comments:

Overall the Panel observed that key descriptions on the data elements were not in the final report prepared for the review, despite their importance in how the base model was set up. While many of these can be found in the data workshop report, it was thought that inclusion of these in the review report would be clearer. Further, there was little discussion or justification in the review report as to why the assessment working group chose the current model, fleet structure, start year, and other key elements. This information needs to be included in the review report so that the train of logic can be followed from data workshop, though assessment workshop, to review workshop.

A wide array of input data were used in this assessment. These included:

Life History

- Age and growth

- Fecundity
- Natural mortality
- Maturity
- Sex transition

Landings
- Handline: 1986-2013
- Longline: 1986-2013
- Trap: 1986-2006
- Charter /Private: 1986-2013
- Headboat 1986-2013

Discards
- Handline: 2007-2013 (observer program)
- Longline: 2007-2013 (observer program)
- Trap: Charter/Headboat/Private: 1986-2013

Length composition of discards by fleet
- Handline: 2006-2013 (observer program)
- Longline: 2006-2013 (observer program)
- Charter: 2010-2013 (observer program)
- Headboat: 2005-2007, 2009-2013 (observer program)

Age composition of retained catch
- Handline: 1991-2013
- Longline: 1991-2013
- Charter/Headboat/Private: 1991-2013

Abundance indices
- Handline: 1993-2009
- Longline: 1993-2009
- Charter/Private: 1986-2013
- Headboat: 1986-2013
- Combined video survey: 1993-1997, 2002, 2004-2013
- SEAMAP summer groundfish survey: 2009-2013
- NMFS bottom longline survey: 2001, 2003-2013

The Review Panel examined the available information on life history. They noted that the maturity schedule, the transition from females to males, fecundity, and growth/size at age were all static across years. While there is little data to support alternatives, it is likely that life history traits change based on environmental factors and/or may be subject to density-dependent variation. In particular, the ratio of males to females, the transition from females to males, and the fecundity could have large impacts on reference points and advice on sustainable harvest levels.

The Review Panel had a number of concerns with the landings and discard data series as well as the fishery dependent sampling. While commercial landings were well known, recreational landings were not as precise given the change from MRFSS to MRIP. More importantly, the level of removals as dead discards, both commercial (Comm DD) and recreational (rec DD) in

this fishery is high (Figure 1.1). Similarly, the Panel had concerns with the length and age information because of limited sampling for the discarded and landed fractions of removals, particularly when parsed by fleets. Given the limited sampling at-sea, the Panel recommended down-weighting the discard length compositions by increasing the CV. However, to get the model to perform, it was required to increase the weight of total discards.
The Review Panel also examined the available fishery-dependent and independent abundance indices. The Panel noted that these were restricted geographically to the central part of the stock, and as such, would not be as sensitive to changing stock levels if density remained constant, but the range expanded or contracted in response to stock growth or decline. They also noted that fishery-dependent estimates (as CPUE) were prone to hyper-stability, as well as large uncertainties in standardization given changing management measures.

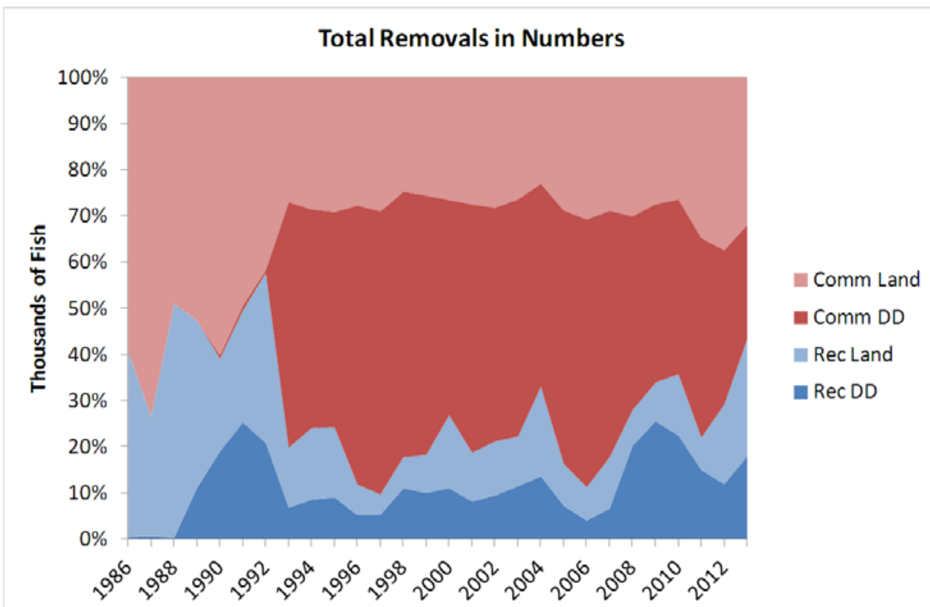

Figure 1.1 – Total removals by fleet and disposition as a percentage of total removals. Note: Dead discards (Comm DD and Rec DD) account for a large fraction of total stock removals.

a) *Are data decisions made by the DW and AW sound and robust?*

Despite the above concerns the Review Panel concluded that both DW and AW decisions were sound and robust given the lack of sampling and other uncertainties. However, the Review Panel suggested a number of alternatives and sensitivity runs to the base model to explore how sensitive the model outputs were to input data uncertainties (*See below*). Because of model fit issues the Panel decided to go with a different configuration as the original base model run.

b) *Are data uncertainties acknowledged, reported, and within normal or expected levels?*

Overall, the Panel concluded that the data uncertainties were acknowledged, reported, and within expected levels given low fishery-dependent sampling.

c) ***Are data applied properly within the assessment model?***

Overall the Panel found that the application of the data within the model was properly done. However the Panel did recommend changes to the model structure as well as sensitivity analyses to examine model behavior in light of data variability and uncertainty (*See below*).

d) ***Are input data series reliable and sufficient to support the assessment approach and findings?***

The Panel noted the lack of fishery dependent sampling, the restricted geographic range of the surveys, the high discard and low levels of at-sea sampling, and the lack of information or data on the socio-biology of the species spawning and recommended a number of model runs to test the sensitivity of the model results, and to examine model behavior. These runs included: (a) Modeling the recreational fleet as one fleet, as was done in the previous benchmark, (b) Starting the model in 1993 to better encapsulate the start of both the fishery-dependent and independent sampling, (c) Relaxing the fit to the landings in light of the transition from MRFSS to MRIP, (d) Removing the fishery-dependent abundance indices given issues with hyper-stability, (e) increasing and decreasing the fit to the discards and the length distributions of discards given low sampling. For these runs resulting residuals and selectivity's were examined to observe model behavior.

2. ***Evaluate and discuss the strengths and weaknesses of the methods used to assess the stock, taking into account the available data, and considering the following:***

a) ***Are methods scientifically sound and robust?***

The stock was assessed with a model developed using the Stock Synthesis 3 (SS3) software. This is a modern and up to date assessment tool which is very flexible and designed to handle assessment like this. It is scientifically sound and robust if configured appropriately. There is a small issue around its documentation. The software is developed constantly and the user guide is often lacking behind. Proper tests of each new version could also be an issue as the best test is often the test of time. SS3 demand a very high level of experience by the user and often the person behind the tool (Rick Methot) has to be called for assistance. Given that SS3 works correctly and that the user is experienced, it is probably one of the best assessment software available for assessments like the present one.

b) ***Are assessment models configured properly and used consistent with standard practices?***

A major problem was apparent in the configuration of the base model initially presented to the Panel. Discard data from the commercial fleets were not fitted by the model. This is illustrated for the long-line fleet (Figure 2.1).

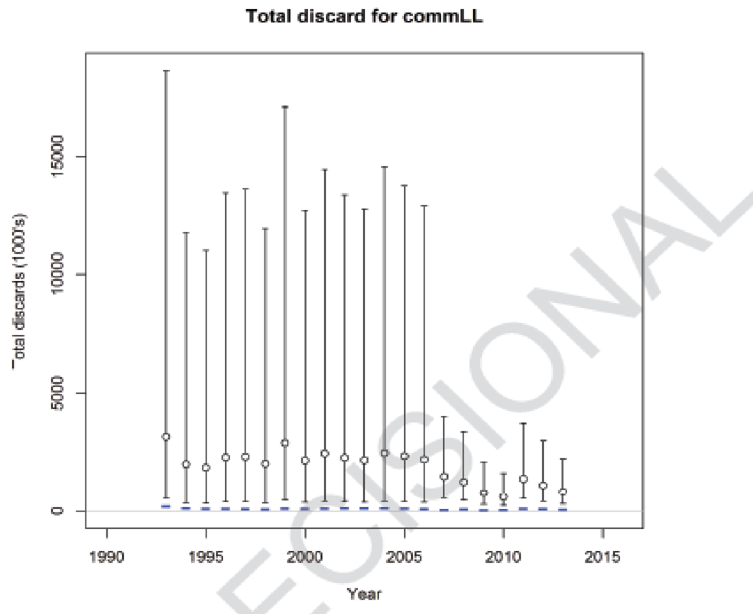

Figure 2.1 – Observed (open circles) and predicted discards (blue dashes) in 1000's of fish of Gulf of Mexico red grouper from the commercial longline fleet, 1993-2013.

It can be seen that in reality the model squeezed out the discard data from the analysis by estimating discards to be very close to zero. The Panel was informed by the assessment team that they had to down-weight the discard data in order for the model to work properly on the rest of the data. After several sensitivity runs and long discussions and reflections it was revealed that the reason for the bad fit was that the selectivity for the commercial fleets was only considering the retained data (i.e. landings data) and not, as would have been correct, both the retained and the discard data. This means that the initial base model struggled to find enough young fish (those that normally are discarded) in the stock to fit the observed discard data and therefore estimated the discards to be very low.

To correct this problem the Panel suggested inclusion of the discard data as a separate fleet (or fleets) or alternatively to convert the discard data from number-at-length to numbers-at-age by age-length keys outside the model. However, both options are time consuming (estimated to take 3-5 work-days) and couldn't be completed during the Review Workshop.

In order to see how much all this affected the outcome of the assessment in terms of stock status and fishing pressure the Panel requested several sensitivity runs: (a) Reducing the CV of the commercial discard data (in total numbers), (b) Increasing it on the discard length distribution, and (c) Letting the model estimate retention curves that would make it possible to fit the discards in numbers. The time span of the data was shortened to start in 1993 instead of 1986 in order to have a more consistent situation for discards (and for the video survey). However, all this was at a cost of a poor fit to the discard length distribution (the model as expected estimated more large fish discards than observed) and the retention curve estimated was very steep indicating that almost 100% of catch of below 52-53 cm were discarded while those above were all retained (which seems peculiar that fishers should discard legal sized fish - a few cm larger than the legal size - almost 100%). Also the selection pattern by fleet deteriorated as they became bimodal. Clearly, indications of a situation, where the model with these moderations was not fitting the data well, re-emphasising that the Panel's recommendation of redoing the model with discard data included in a way that they are used in the estimation of the selectivity of the commercial fleets, is important. Various other moderations to the model like fixing the steepness of the S-R to close to 1, merging the Headboat recreational fleet with the two other recreational ones, and putting more weight at the surveys were also ran.

The overall impression was that it did not change the trend and level of the spawning stock size and nor the fishing mortality very much. The Panel did not have much time to analyse what it meant for reference points, like F_{MSY} and F30%SPR, but it is likely that the effect of the discard problem would be greater here. However, the stock biomass was in the cases tested well above reference levels and the F well below, so the basic question of whether the stock is overfished or is experiencing overfishing can still be answered with a "No" for both, but with moderate to high level of uncertainty.

Selection pattern is always difficult to estimate in stock assessments. The question is how dome shaped is it or maybe even flat. Usually, there are not data or knowledge to estimate this. The type of data needed would be reliable observations of absolute numbers of the older component of the stock, which are almost never available. In the current assessment, a random walks approach was used, with no trend assumed. This seems to work quite well and put a flat selection on the long line survey data, which seems reasonable, as this survey covers the total distribution area of the stock, and one would not expect much hook size selection in the upper fish size range. This gave a dome shaped selection for the other fleets. For the commercial fleets the selection on older fish decreased to about half the one on the main age selected for, which seems reasonable as the fishers probably do not fish so much in very deep water where the older fish are more abundant than in shallower water where the main age groups of the stock are found. The shrimp trawl survey had a very low selection on older fish and given that the survey covers the entire distribution area (shallow to deep water) of all age groups, the reason could be that the gear simply is hauled too slowly or the net opening is too narrow for catching the older fish.

The stock recruitment relationship was not very informative. There was almost no correlation between R and S. The Panel found that a steepness (*h*) of 0.8 was a bit low compared to other comparable fish stocks (around 0.9 would be more in line with other similar stocks) and concluded that it was better to fix it to almost one (here 0.99). Fixing h = 0.99 should not be interpreted as a measure of very high stock productivity of the stock at very low stock sizes, but is merely a method for implementing a forecast going forward with random recruitment.

The Panel did not have much time to discuss the reference points due to the need to spend much time on the discard problem mentioned above. However, the immediate opinion of the Panel was that to compensate for the uncertainty in the productivity of the stock, the review group suggests using SPR reference points as reference points rather than the development of MSY reference points.

A minor point was that the S-R model was estimated with 4 parameters, steepness, R_0 and R_1, and a variance parameter, while only 3 parameters seems to be needed, as two of the three parameters: steepness, R_0 and R_1, would suffice to determine the shape of the B&H S-R curve.

Another minor issue was that the selection patterns used for the commercial CPUE indices were identical to that for the total fishery by the given fleet. This was questioned, because the indices were calculated based on GLM models which take care of part of the selectivity of the commercial fleets, by e.g. stratifying by depth. However, it seems that the SS3 cannot easily accomplish that sophistication.

Red tide mortality was taken care of by creating an artificial fleet with only catch (all discards) in 2005. The Panel was informed that this worked well for the gag grouper assessment made recently. The Panel fund this approach sensible. Some ramping could be tried and it was also mentioned that if the red tide is a usual phenomenon then it is implicitly included in Hoenig's formula (because it will influence the observed maximum age) in which case the approach was a kind of double counting for that mortality. The data presented and the knowledge about the red tide events made the Panel comfortable with the approach chosen by the assessment group.

After examination of model results and diagnostics the Panel decided to recommend changes to the base model. These included (RW_run1): (1) Starting the model in 1993 as opposed to 1986, (2) Combining private, charter, and headboat sectors as just one recreational fleet, (3) Setting steepness to 0.99 and using median recruitment in projections, (4) Relaxing the fit to the landings, (5) increasing the fit on the survey indices, (6) increasing the CV on the discards, and (7) Using batch fecundity as the metric of egg production. An alternate run (RW_run2) was also proposed with the same configuration as the above run, but with only the fishery-independent indices used. Outputs and diagnostics of a new base model configuration recommended by the Review Panel (RW1) could not be completed and reviewed during the in-person Review Workshop. Therefore, more complete assessment documentation was reviewed and approved *a posteriori* by e-mail.

c) Are the methods appropriate for the available data?

Even though the SS3 model framework cannot handle landings and discard data from a given fleet given in different units (by age or by length), the model can still be used and is still appropriate, if the discard data in this case are transformed outside the model from length to age based using appropriate age-length keys, or alternatively, the discard data are inserted as a separate fleet (or fleets). There might also be other ways to circumvent the problem.

3. Evaluate the assessment findings and consider the following:

a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?

As stated above the Panel would much prefer to see a revised assessment with discard data included in the selection pattern estimates for the commercial fleets. However, some deductions can be made of the current assessment. This is mainly because the stock is well clear of the reference points that a revised assessment is unlikely to change this. The run where discards are not underestimated should in that case be the one to use for setting catch limits and reference points. The base run in the assessment report should probably not be used because it ignored almost completely the commercial discard data and will therefore bias the F reference points upwards, and biomass reference points downwards.

In the AW report several different units of fishing mortality were used and it was not always clear which unit was used. Ideally, only one unit should be used in order to easy comparison.

b) Is the stock overfished? What information helps you reach this conclusion?

The various runs all supported the notion that the stock has increased in recent years and is not overfished.

c) Is the stock undergoing overfishing? What information helps you reach this conclusion?

The various runs all supported the notion that fishing mortality has decreased in recent years and that the stock is not undergoing overfished.

d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

The stock recruitment relationship is not informative as the relationship observed is almost flat, i.e. no correlation between R and S. The unknown feature is how quickly recruitment gets impaired (e.g. though socio-biological means) if the stock declines to sizes lower than hitherto observed. As long as the stock is maintained above the lowest observed level, recruitment should not be impaired.

e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

The review panel concluded that the MSY benchmarks provided by the AW were not reliable because of the uncertainty about the stock-recruitment relationship. Therefore, the Panel recommended the use of 30% SPR proxy reference points (based on past practice for this stock). However, this might change if a new assessment shows that the stock recruitment relationship is more informative and properly estimated.

The uncertainty of 30% SPR reference points with respect to the relevant estimated productivity processes (i.e. growth, maturities, and selectivities) was not evaluated. Further, care should be taken to avoid stock declines to below the lowest observed stock size because the productivity at such lower stock sizes is not well established.

Female egg production (fecundity) was used at the stock biomass reference points. This seems appropriate. Gonad weight was judged problematic as red grouper is a batch spawner and thus gonad weight fluctuates over the spawning season. Female mature biomass might be a robust alternative, but will miss changes in fecundity due to poor growth, density dependence and the like. It is suggested to also consider including male mature biomass for this stock as a reference point, because apparently the percentage of males can get very low for species like this, which are first females and at a later stage become males (protogynous hermaphroditism).

On a longer term basis, it was considered useful to analyse and reflect on including density-dependence in growth, sex change, maturity, and cannibalism mortality in the reference point determination, in order to get these as realistic and unbiased as possible.

4. ***Evaluate the stock projections, including discussing strengths and weaknesses, and consider the following:***

   a) ***Are the methods consistent with accepted practices and available data?***

   b) ***Are the methods appropriate for the assessment model and outputs?***

   c) ***Are the results informative and robust, and useful to support inferences of probable future conditions?***

   d) ***Are key uncertainties acknowledged, discussed, and reflected in the projection results?***

The Review Panel agreed on a number of serious concerns over the presented assessment. Principal of these was the virtual lack of fit of all model runs and sensitivities to the discard data, although other concerns were also made, for example, about the quality of the retained abundance index data and the choice of start date for the model. Given these concerns the Panel decided not to use the limited time available for the review in collectively considering the prepared projections as planned. This decision was made as there was insufficient time available to both review the projections and explore alternative model runs to address the concerns expressed above. The Panel, therefore, focused on working with the Assessment Team to develop alternative models that better captured, in particular, the issue of lack of fit to the discard data.

The review of projections was conducted by correspondence following the RW. In preparing the comments about projections below, the Panel has tried to take in to account the drawbacks of this approach to developing review comments, and reflect the additional uncertainty in their comments.

a) Are the methods consistent with accepted practices and available data?

The approaches used to develop the projections for all models, including RW1 and RW2, and sensitivities look to be appropriate for the stock, available data and consistent with accepted practice.

b) Are the methods appropriate for the assessment model and outputs?

The methods are appropriate to the assessment presented and the model runs developed during the RW.

c) Are the results informative and robust, and useful to support inferences of probable future conditions?

Due to the concerns about the underlying models rather than the projection methodology, the results presented are unlikely to be robust or to support inferences about future conditions. However, the approach, if repeated on an accepted base model, would be expected to be both robust and to provide a basis for inferring probable future conditions for the stock.

d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?

Most of the key uncertainties are clearly acknowledged (discards, steepness) but other are not recognized (index retention, model start date). Discussion of uncertainties within the projection sections of the AW Report was overly brief.

Inclusion of projection sensitivities to some of the key variables is strongly recommended for this fishery. These should specifically include, steepness and recruitment. Steepness because this parameter is poorly understood in this stock and where assumptions about the value used in the assessment appears too low and would have underestimated productivity; and recruitment as the assumed pattern of recruitment will likely play an important role in determining future stock status. Specifically, assuming average recruitment (i.e. all years) as done in the projections presented, will likely have very different outcomes compared to using recent average recruitment (e.g. last eight years), as recent recruitment has been below average over this period. This is particularly important given the relatively long projection time-scales typically used.

Note that, had time permitted, most of the issues with the projections identified above would have been fully discussed and addressed during the RW.

5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

- ***Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods.***
- ***Ensure that the implications of uncertainty in technical conclusions are clearly stated.***

A variety of methods were used to evaluate the uncertainty about the model structure, key parameters, stock status, projections, and reference points. These aspects of uncertainty are discussed sequentially below, as indicated by the '5-number' subheadings below. Overall, the uncertainty analysis successfully addressed the main sources of uncertainty.

5.1. Model structure

The SEDAR 42 benchmark assessment involved a transition from the previously used ASAP (Age Structured Assessment Program) model to the Stock Synthesis III model. A 'continuity run' was conducted by applying the Stock Synthesis model to the data used in the 2009/10 update assessment (the last assessment conducted with ASAP) to check that the two models produced similar results on the same data. Two versions of the continuity run were conducted, one with natural mortality, growth, fecundity, selectivity, retention and stock-recruitment parameters fixed at the ASAP values and one in which selectivity parameters and R_0 (unexploited equilibrium recruitment) were estimated. Both continuity runs produced results and management advice that were similar to those obtained previously from the

ASAP model. The Stock Synthesis model was therefore adopted and used for all analyses in SEDAR 42.

Different configurations of the model in terms of model start year and weighting of different data components were explored. Primarily these variations on the model were explored in an attempt to find a configuration that would provide good fits to indices as well as discard numbers and length distributions, which proved difficult to achieve. A jack-knife (‘leave one out at a time’) analysis of the abundance indices was also conducted to determine which index or indices were most influential on abundance estimates, recruitment, and exploitation. However, even extreme configurations which effectively excluded either the discard data or the indices did not provide substantially different results with respect to stock status or management advice. The panel therefore felt that this uncertainty should not preclude use of the assessment (e.g. RW_1 or RW_2) for management advice. It was noted, however, that a better representation of discards and discard mortality in the modeling is a low hanging fruit that, with only a very moderate work effort (say a week’s work) by the assessment experts, would make the whole assessment and the deductions of management advice, much more certain

5.2. Key parameters

Uncertainty about the natural mortality rate M was addressed using sensitivity runs with scenarios based on lower and higher M vectors than the base AW model. The effect of increasing the assumed M was that the estimated stock increased. The range of M values used in the sensitivity runs was narrower than the range implied by use of a wide variety of comparative estimators, and no clear motivation was provided for the choice of the Hoenig estimator to scale the Lorenzen mortality curve for the base run. However, the choices are consistent with previous practice and were deemed appropriate by the panel.

Growth was modelled using a time-invariant von Bertalanffy growth model. Uncertainty in the relationship between variance and age was explored using different error model configurations and found to have a minimal influence on estimated man growth parameters. The possibilities that growth may vary in a density-dependent or environmentally driven manner were discussed but not analysed.

Female egg production (fecundity) was used for the stock biomass reference points. This is considered biologically appropriate because gonad weight fluctuates over the spawning season. The relationship between batch fecundity and length at length was investigated upon request from the panel and found to be satisfactory.

Uncertainty in the stock recruitment relationship was analyzed using profile likelihood. The analysis indicated that steepness was most likely in the range of 0.8-0.85, but poorly defined. The Panel considered a steepness (h) of 0.8 was low compared to other similar stocks (around 0.9). Given this uncertainty, the panel recommended not to develop MSY-based references points but to use 30% SPR proxy reference points. This is consistent with past practice for this stock.

Uncertainties in selectivity patterns were explored in a comparison of three model runs provided after the review workshop. A random walk approach was used to describe age-based selectivity patterns, i.e. no prior assumptions on the shape of the selectivity curve were made.

5.3. Stock status, projections, and reference points

The uncertainty of 30% SPR reference points with respect to the relevant estimated productivity processes (i.e. growth, maturities, and selectivities) was not evaluated during the RW.

6. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted.

- **Data Workshop Recommendations:**

Recommendation 1: Time-varying natural mortality

Research is required to incorporate inter-annual variation in red grouper natural mortality within the assessment process. In particular, elevated mortality rates in fishes, including members of the shallow-water grouper complex, can be caused by severe red tide events (Flaherty & Landsberg 2011). A red tide severity index (Walter et al. 2013) was previously included in the base stock assessment model for Gulf of Mexico gag grouper, which improved model fits to indices of abundance (Sagarese et al. 2014b). In the Gulf of Mexico gag grouper assessment (SEDAR 33), fluctuations in red tide mortality varied more than 10-fold through time, and were estimated to be commensurate with fishing mortality rates in several "severe" years (Sagarese et al. 2014b). Like the gag grouper SEDAR assessment, red tide severity should be considered as a source of mortality for red grouper. This recommendation requires at least four research steps:

1) *length/age composition data are needed to determining lengths/ages susceptibility to red tide severity.*

Collections of fish during red tide events would allow for the size/age selectivity of mortality to be determined, and might also allow for some minimum estimates of total mortality. Preliminary data were distributed by the NMFS Panama City Laboratory containing red grouper lengths and estimated ages for 16 individuals collected from the Big Bend region during August 1st and 3rd of 2014. During plenary, various participants noted that collection of samples during the NMFS bottom longline survey was complicated by the decomposed nature of many fish encountered, which also prevented length estimates. In addition, otoliths were often difficult to recover from some specimens because they were missing anterior portions of their body.

2) *existing indices of red tide severity should be updated.*

The IEA Group recommends research to produce candidate indices of red tide severity and to devise scenarios based on red tide indices and methods for inclusion in the red grouper Stock Synthesis assessment model. Updating red tide indices is difficult because the original red tide indices (Walter et al. 2013) were created using SeaWiFS (operational 1998 – December 2010) satellite sensors. More recently, MODIS (Moderate Resolution Imaging Spectrometer) satellite sensors (July 2002 – present) have been used to detect and track harmful algal blooms (Stumpf et al. 2003, Hu et al. 2005). Thus, steps need to be taken to (i) calibrate SeaWiFS and MODIS satellite data during overlap periods; (ii) extend the red tide index through the present period (2014); and (iii) automate compilation of satellite data, and calculation and reporting of index values.

3) *procedures for incorporating red tide indices into Stock Synthesis should be critically evaluated.*

Simulations should be conducted to evaluate the consequences of assuming constant or size specific natural mortality, when mortality actually fluctuates according to episodic temporal events. Further, approaches to incorporating environmental indices in stock assessment tuning procedures should be compared through simulated datasets to evaluate the effects of assessment model misspecification.

4) *the statistical properties of red tide indices should be characterized for use in simulations and assessment projections.*

Evaluate whether all levels of red tide severity are equally likely in near-term future events, or whether information is contained in red tide indices that can be used to generate ‘forecast distributions’. Time series decomposition can be used to statistically characterize red tide indices (Stumpf et al. 2003). By quantifying periodicity, trends, and stochasticity, ‘forecast distributions’ may enable plausible future scenarios to be considered in assessment projections.

Recommendation 2: Index of red tide mortality derived from Ecopath with Ecosim

The IEA working group agreed that additional efforts deriving natural mortality values from the WFS Red tide Ecopath with Ecosim model would be helpful as presented for gag grouper during SEDAR 33 (Gray et al. 2013). These modeling efforts would allow red tide events to affect multiple components of the West Florida Shelf ecosystem and to assess the overall effect of red tide and predator/prey dynamics on the mortality rates of Gulf of Mexico red grouper.

Recommendation 3: Elucidating the response of red grouper to red tide events

Future modeling efforts should aim to address whether groupers move in response to red tide events or if they experience elevated natural mortality during these episodic events.

Recommendation 4: Modifications to the CMS modeling framework

Additional fisheries-independent data (e.g., PCLAB data) will be incorporated in the datasets used for habitat modeling of red grouper. This will allow us to improve the predictions made by the binomial GLMs described in SEDAR42-DW-04. Thus, we will be able to better predict the probability of presence of adult red grouper on the West Florida Shelf and, therefore, to better simulate the production of red grouper eggs over space in the CMS. The life history working group brought up concerns regarding the aggregated use of all adult red groupers in determining the number of eggs released at red grouper spawning sites. There is evidence in red grouper that the fecundity of large adult females is considerably higher than that of small adult females. To account for this, the IEA group will use data compiled by the life history group to calculate mean age at depth for red grouper. This information will be useful to estimate the number of eggs released at each red grouper spawning site based on (1) the probability of presence of adult red grouper at that site; and (2) the relative fecundity at that site. The relative fecundity at each spawning site will be determined from: (1) the depth at that site; (2) the mean age at depth profile; and (3) the fecundity-at-age (number of eggs released during a spawning event at age) profile. Also, the CMS index should be extended to cover 2014 to provide insight into potential recruitment for the first year of projections.

Recommendation 5: Enhance fish kill reporting, particularly in offshore regions

Current understanding of fish killed by red tide events largely originates from the Florida Fish and Wildlife Conservation Commission and Fish and Wildlife Research Institute fish kill database, which is informed by a statewide fish kill hotline (http://research.myfwc.com/fishkill/). Many of the observations are based on fish that washed ashore following red tide events. Enhanced reporting of red tides, in addition to observations from offshore waters by recreational and commercial fishermen, could increase understanding of how red tide events impact offshore species. This could be achieved through the creation of a national program or increased citizen science through outreach educating fishermen and other Gulf patrons on their ability to improve fish kill reporting.

- **Assessment Workshop Recommendations:**

The AW Report included a Recommendation Section, but the individual recommendations were for methodological improvements and not specifically for future research to produce new data. Nonetheless, the recommendations address problems or issues for improvements in the quality of SEDAR workshop reports, and testing of hypotheses may be necessary to further develop the methods recommended. The recommendations, as stated in the AW Report, are:

1) Evaluate existing methods for deriving historical discard numbers and discard rates and improve methods as appropriate.
2) Develop/evaluate methods to maintain continuity of fishery-dependent indices in light of management regulations and IFQs.
3) Considering red tide as an unpredictable event, but can be a significant source of mortality, a response protocol should be developed for data collection and incorporation of the information into updated assessments.
4) The start of this assessment in 1986. Future assessments should investigate extending the assessment model further back in time.
5) Develop protocol for reliable estimation of fishery discards.

- **Review Workshop Recommendations (numbered in order of priority)**

1) Questions were raised in workshop discussions about changes in reproductive success with age and with population concentration. Although it is known that reproductive success is mitigated by social factors, the degree and extent of mitigation is not well understood. More data are needed to better address the topic, including addressing time-varying changes within age categories. How much variation exists in size at age?

Insufficient information leads to greater uncertainty and can have impacts on reference points.

2) The review panel raised questions throughout the evaluation of the assessment reports about the basis or bases of decisions to use the variables actually used. The recommendation is for analysts to provide a justification or rationale for the selection criteria. Review panel evaluations could be more accurately motivated if the selection criteria were better reported. Selection criteria would thereby be carried forward in the evaluations.

3) Paralleling the AW Report, discussions in the Review Workshop focused on initial conditions of the red grouper stock, including assessment of the stock from 1986 to 1993. Composition data was more complete from 1993, raising questions about methods to approach composition prior to that data, in effect, how to decide on what methods and procedures to use and how to establish preferences. The sense of the Review Workshop members was that procedures of ramping up were needed.

4) The core problem in the red grouper assessment was the data on discards. Procedures for reporting discards were not consistent across the fleets, and the fit to indices were poor, leading to major sources of uncertainty. Numerous sensitivity runs helped to reduce the lack of fit, especially up-weighting the commercial fishery dependent data, but problems remain. Discards were missing from the shark longline fishery, raising questions about the amount of resultant uncertainty. Research to address best practices in the reporting of discards is needed in regard to the red grouper stock. Especially useful, also, would be to increase the number of observers and observations among the commercial fleets.

5) Develop a standard protocol for ensuring that appropriate uncertainty in recruitment is applied when developing projections. Using a long-term average recruitment, as the median was used in this assessment, may lead to very different projections, and thus different management advice, compared to a lower or higher average recruitment based on a more recent time-period that may be more likely to reflect the biological/environmental realty of the stock.

6) Research is needed to help address questions about how fecundity can best be measured. Fecundity is a preferred measure for stock biomass and is a function of the number of eggs produced, but it has to be measured indirectly. Gonad weight can be used as a proxy, but obtaining reliable weights can be problematic, dependent in part on methods and timing of data acquisition. Research to address more accurate measurement of gonad weight and to develop protocols would be helpful.

7) Actual measures of individual growth are needed within age categories, as opposed to relying on common assumptions about growth rates and outcomes. Differential growth rates may occur in stock sub-structure within localized species, due to characteristics of the stock and ecosystem variables, or both. They may also affect schedules for hermaphroditic changes, impacting sex-age class composition.

8) Sensitivity runs to assess the impact of the 2005 red tide event on red grouper landings did not show any significant differences from the base model, including fit to discards. Documentation of the red tide mortality, however, presents methodological difficulties. Although analyses of data suggest that red tide primarily affected ages 0+, composition of

the red tide kills are difficult to measure, given problems of access to the red tide zones and incomplete records of age, size, and sex in the kills. In addition, red tide events may be best considered in reference to ecosystem considerations (SEDAR42-5W-01). As environmental indices become incorporated into single stock species, criteria for inclusion have to be tested and measured, toward a goal of balanced biological and mechanistic explanation, statistical significance, and predictive performance. More research for red tide impacts on red grouper stock status is especially appropriate, given that the majority of landings are on Florida's West Continental Shelf, where high concentrations of red tide tend to be located.

9) Red grouper are found throughout the Gulf of Mexico and in the Atlantic from Brazil to the southeastern US. Catch levels and age composition data from Cuba, the Caribbean, and especially Mexico would allow for more complete stock assessment. Data could be obtained from the Mexican organization MEXAS.

10) The average age and thus size of females changing to males are known, but a more complete understanding of the conditions under which the changes occur would be helpful for assessing stock size. The number of males in relation to minimum stock size would be a useful metric for stock assessments.

a) *Clearly denote research and monitoring that could improve the reliability of, and information provided by future assessments with particular emphasis on the Deepwater Horizon Oil Spill.*

SEDAR 42 did not directly address the impacts of Deepwater Horizon on red grouper stock status. Earlier SEDAR Workshops, for example, SEDAR 31 (red snapper), contained discussions and research recommendations. SEDAR 42 contains analyses and recommendations relevant for events such as oil spills, however, in the attention given to the 2005 and 2014 red tide events. Oil spills can be measured as environmental events in a variety of ways, including the event as equivalent to a fleet source for fishing mortality. Ecosystem considerations (see 9 above) can also be utilized to assess impacts on stock status.

b) *Provide recommendations on possible ways to improve the SEDAR process.*

A topic of discussion throughout the Review Workshop was the need for more attention to commonly used assumptions in categories of data and analyses. The rationale was to make assumptions more explicit and for consideration to be given to criteria for selection of options. The selection criteria would therefore become a part of the record as analyses move forward, and they would be subject to considerations of clarity, efficiency, and parsimony.

The three days of Review Workshop proved insufficient to enable the pre-prepared assessment to be presented and address areas of concern through developing additional work. For the workshop component of the review to be effective (i.e. developing alternatives or options where issues are identified), some additional time would need to be made available to the Assessment Team during the Workshop.

7. *Consider whether the stock assessment constitutes the best scientific information available using the following criteria as appropriate: relevance, inclusiveness, objectivity,*

transparency, timeliness, verification, validation, and peer review of fishery management information.

Despite the many concerns, suggestions, and recommendations outlined above the Review Panel concluded that the SEDAR 42 Gulf of Mexico red grouper stock assessment constitutes the best scientific information available. The data used in the assessment were generally sound and robust. Likewise, data generally were applied properly and uncertainty in data inputs was appropriately acknowledged. Further, the Review Panel was very impressed with the performance of the assessment team. It was clear the analytical team had put considerable thought into the development of the assessment model, which by necessity is very complex.

8. *Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.*

The assessment report provides useful recommendations for further research, covering research on red grouper biology and improved monitoring data. Research on life history and growth has provided a good basis for the stock assessment modeling. However, the Panel had concerns with the lack of more detailed information on red grouper's reproductive biology (especially regarding social and population factors associated with sexual transition), as well as with the landings and discard data series. Further recommendations consist of improvements in biological sampling for lengths and age across all fisheries, development of a fishery independent recruitment index, and improved recreational catch data reporting. The proportional standard errors are very high for all estimated landings and it seems unlikely that catches will vary so significantly year by year as currently estimated. Some of these problems are historical, and recent years' catches appear more accurate. Dealing with past errors is an issue of improved robust estimation only, whereas ongoing improved sampling and estimation procedures could reduce errors in future.

9. *Prepare a Peer Review Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference.*

This report constitutes the Review Panel's summary evaluation of the stock assessment and discussion of the Terms of Reference. The Review Panel will complete edits to its report and submit a final document to the SEDAR program for inclusion in the full set of documents associated with SEDAR 42.

SEDAR

Southeast Data, Assessment, and Review

SEDAR 42

Gulf of Mexico Red Grouper

SECTION IV: Addendum and Post-Review Workshop Updates

August 2015

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Addendum

The S42 review workshop was held on July 14 – July 16, 2015 in Miami, Florida. It was a very productive three-day workshop. A portion of the discussion focused on clarifying terms and providing more detailed justifications for the decisions made during the data workshop and assessment webinar series. Several of these clarifications are outlined in the first section of this addendum. Additionally, the review panel requested a number of sensitivity runs and two alternative model structures that are summarized in this addendum.

Clarifications

How was SSB defined in the assessment model?

There was some discussion about the units of spawning stock biomass (SSB or SPB in Stock Synthesis). Fecundity in this model was derived as a function of the proportion of mature females and the batch fecundity estimates (in number of eggs) provided by the life history working group at the S42 Data Workshop. SSB was expressed as number of eggs. The review panel also questioned the whether batch fecundity was a better metric of fecundity than gonad weight, which was used in SEDAR 12 and the 2009 update. The life history working group recommended using batch fecundity rather than gonad weight due to the high variability in the gonad weight measurements.

What do the commercial discard inputs represent?

The review panel questioned whether the discard inputs were observations or estimates. The commercial discard inputs represent estimates based on observed discard and kept rates from the NMFS observer program database. The commercial discard estimates for 1993-2006 were derived from the discard and kept rates observed between 2007 and 2009, prior to the implementation of the Individual Fishing Quota (IFQ) program. This assumes that discarding practices between 1993 and 2006 were similar to 2007-2009. The methods used to estimate the commercial discards are described in Section 2.3.1 of the Red Grouper stock assessment report.

Why was the headboat fleet separated from charter/private rather than having a single recreational fleet?

The reviewers noted that the headboat fleet represents a very small percentage of the overall Red Grouper landings and questioned why it was separated from the Charterboat/Private modes rather than aggregating the recreational modes into a single recreational fleet. The decision to separate headboat from Charterboat/Private was partially done in an effort to strive for consistency between treatments in other GOM assessment (e.g., Gag Grouper). The other reason for separation was that the discard length composition data suggested differences in discarding and potentially selectivity.

Why were fishery-dependent indices used? Why was the SEAMAP summer groundfish survey index recommended for use?

Often times fishery-dependent indices are not used when fishery-independent indices are available. Fishery-dependent indices were recommended for use in the Red Grouper assessment because they represent a longer time-series than the available fishery-independent indices and cover the main habitat in the GOM where Red Grouper are found. The SEAMAP summer groundfish survey, a fishery-independent survey, was recommended for use in the Red Grouper assessment for the first time. This survey has been run since 1987. Prior to expanding to the eastern Gulf of Mexico this survey had never captured Red Grouper. In 2009, this survey was expanded into the eastern Gulf of Mexico, which is the primary Red Grouper habitat, and Red Grouper observations were collected. Additionally, this survey captures a wide range of Red grouper size classes including small Red Grouper not observed by other surveys or the fishery.

Summary of sensitivity runs

Six sensitivity runs were requested by the review panel during the review workshop. Table A.1.1 lists and describes the sensitivity runs that were considered and the justification for each. They include: 1) increasing the uncertainty in the retained catch by fleet (commercial CV = 0.15 and recreational CV = 0.3, RetCatch0.150.3), 2) excluding the fishery-dependent indices (FI_Indices_Only), 3) excluding the fishery-independent indices (FD_Indices_Only), 4) 1993 start year as opposed to 1986, 5) reducing the uncertainty in the discard inputs (CV=0.3) and estimating the parameters of the retention patterns, and 6) down-weighting the age composition data where lambda was set equal to 0.1 (AgeCompLambda0.1). The goal of the sensitivity analysis was to better evaluate the trade-offs in the assessment model results due to data inputs and assumptions.

Figure A.1.1- Figure A.1.11 summarize and compare the stock assessment results from Base_orig and the six sensitivity runs. Trends in SSB were similar among the sensitivity runs (Figure A.1.1). The biggest departure from the estimate of SSB (eggs) from Base_orig was the estimate from the sensitivity model starting in 1993 (Syr_1993) (Figure A.1.1b). Syr_1993 predicted higher SSB between 1995 and 2013 than Base_orig.

Trends in exploitation rate were similar among the sensitivity runs (Figure A.1.2). The biggest difference in exploitation rate was between Base_orig and DiscCV0.3_RetEst (Figure A.1.2c). Reducing the discard CV and estimating retention allowed the model to better estimate the discards, which required the model to increase the fishing mortality.

The estimated trends in age-0 recruits were similar among models for the majority of years. Removing the fishery-independent indices (FD_Indices_only) and down-weighting the age composition data (AgeCompLambda0.1) led to the biggest differences when compared to the Base_orig (Figure A.1.3a and b). When removing the fishery-independent indices from the model the corresponding age-composition data were also removed. The SEAMAP summer groundfish survey captures the smallest Red Grouper compared to any other fleet or survey and can effectively be considered a recruitment index. Removing this index resulted in more variable recruitment between 2005 and 2013, where Base_orig predicted consistently suppressed recruitment for that time period (Figure A.1.3a). Down-weighting the age composition data also resulted in more variable recruitment between 2005 and 2008 because any strong recruitment signals from the age composition data was reduced (Figure A.1.3b).

The predicted fits to the indices are shown in Figure A.1.4 - Figure A.1.10. The fits to the commercial handline index were similar among models, except for DiscCV0.3_RetEst. The fit predicted by DiscCV0.3_RetEst indicates that the handline index increased between 2012 and 2013, when the predicted fit by all other sensitivity runs and Base_orig were flat (Figure A.1.4). The same is true for the fit to the commercial longline index (Figure A.1.5). The fits to the charterboat/private index were similar; however the fit by model Syr_1993 fits the 1993 point almost exactly and lowered the fit to the index as compared to the others (Figure A.1.6). The fits to the headboat survey and the fits to the combined video survey were similar among the models (Figure A.1.7Figure A.1.8). The fits to the SEAMAP summer groundfish survey were similar among models; however, the first index point in 2009 was best fit by model DiscCV0.3_RetEst (Figure A.1.9). Fits to the NMFS bottom longline survey were similar among the sensitivity models (Figure A.1.10).

Two sensitivity models assumed uncertainty in the catch estimates, RetCatch0.150.3 and AgeCompLambda0.1, to allow for the estimates of fishing mortality to be less dependent on the retained catch inputs alone. Figure A.1.11 shows the fits to the observed retained catch by RetCatch0.150.3 and AgeCompLambda0.1. Although there is some deviation from the observed retained catch the fits are similar among the models.

Alternative model structures and comparison to the proposed base model from the assessment webinar series

Based, in part, on the sensitivity results, the review panel requested to see two models with alternative model structure to Base_orig. The alternative models, RW1 and RW2, are described in Table A.1.2. Each of the RW models start in 1993. The main justification for this was that the majority of informative data, the composition data and indices, start in the early 1990s. Steepness was fixed in these models at 0.99. This was recommended by the review panel in light of the flat stock-recruit relationship predicted by the model. The RW models assume uncertainty in the retained catch inputs to allow for the estimates of fishing mortality to be less dependent on the retained catch inputs alone. Also, it was thought by the panel that it is rare to know retained catch perfectly. The assumed uncertainty in the discards was reduced in the RW models as compared to Base_orig. Additionally, the retention patterns for both time blocks (1990-2008 and 2009-2013) were estimated. The inflection, slope, and asymptotic parameters of the logistic relationship were estimated for all fleets, except commercial trap. Retention of commercial trap was not estimated because discard length composition was never collected for this sector. The main justification behind reducing the discard CV and estimating retention was to allow the model to better estimate the discard inputs, mainly for the commercial fleets which were systematically underestimated by Base_orig. The abundance indices were upweighted in the RW models. Additionally, RW1 included all of the recommended indices and RW2 only included the fishery-independent indices.

Figure A.1.12- Figure A.1.27 show the comparisons of the assessment results and model diagnostics between the Base_orig presented at the review workshop and the RW1 and RW2 model runs. The fits to the indices are shown in Figure A.1.12 and the root mean square error (rmse) estimates are shown in Table A.1.3. The fit to the commercial handline index was better (i.e., lower rmse) for RW1 than Base_orig and the reverse was true for the commercial longline index. The fits to the headboat and charter/private indices were improved in RW1 as compared to Base_orig. The fit to the combined video survey index was similar between Base_orig and RW2 and both were provided an improved fit as compared to RW1. The model with the best fit to the SEAMAP summer groundfish survey index and the NMFS bottom longline index was RW1 followed by Base_orig and then RW2.

Fits to the discards are shown in Figure A.1.13 and the root mean square error (rmse) estimates are shown in Table A.1.3. Root mean square error was used to determine improvement in model fit. Model RW1 had the best fit to the commercial handline followed by RW2 and Base_orig (Table A.1.3); however, all three models systematically underestimate the input discards (Figure A.1.13, top panel). Model RW2 had the best fit to the commercial longline discards followed by RW1 and Base_orig (Table A.1.3). Base_orig systematically underestimated the longline discards, whereas RW1 and RW2 did not exhibit any strong directional bias (Figure A.1.13, middle panel). Model RW1 had the best fit to the commercial trap discards followed by RW2 and Base_orig (Table A.1.3). Similar to the longline fit, Base_orig systematically underestimated the trap discards, whereas RW1 and RW2 did not exhibit any strong directional bias (Figure A.1.13, bottom panel). RW1 fit the combined recreational discards better than RW2 (Table A.1.3).

Fits to the fleet-specific age composition data and the resulting Pearson residuals are shown in Figure A.1.14 - Figure A.1.21. Qualitatively the fits to the fleet-specific age composition data among the models are similar. The commercial handline Pearson residuals for RW1 and RW2 were less than Base_orig, indicating an improvement in fit (Figure A.1.18). The same was true for commercial longline (Figure A.1.19). The fits to the commercial trap and the recreational modes and aggregate recreational age composition data were similar among the models (Figure A.1.20 - Figure A.1.21).

The improvement in the fits to the handline and longline age composition data by RW1 and RW2 may have been, in part, due to relaxing the assumptions about retention in these models. The retention pattern for the 1990-2008 time-block for the commercial fleets was fixed as a knife-edge relationship at the size limit in Base_orig. This resulted in good fits to the commercial handline and longline discard length composition data (Figure A.1.22a and Figure A.1.23a). Discard length composition data was never collected for the commercial trap fleet; therefore, the fixed retention pattern in Base_orig was assumed for the commercial trap fleet in models RW1 and RW2. The retention pattern for the 1990-2008 time-block was estimated by RW1 and RW2. Estimating the retention parameters degraded the fit to the discard length composition from these fleets, where a higher proportion of older (larger) Red grouper were expected to be discarded (Figure A.1.22b, c and Figure A.1.23b, c). This in turn allowed the model to better fit and match the magnitude of the input discards, especially for the commercial longline fleet. The fits to the length composition data associated with the fishery-independent surveys were similar among the models (Figure A.1.25 - Figure A.1.27).

Selectivity was estimated using a random-walk, age-based pattern for all fleets. The estimated patterns are shown in Figure A.1.28. All models estimated fleet-specific selectivity to be dome-shaped.

The selectivity of the commercial fleets were similar and estimated to select for larger Red Grouper than the recreational fleets (Figure A.1.28a). The same is true for RW2 (Figure A.1.28c). The estimated selectivity pattern for the longline fleet was a bit wider for RW1 than the other models (Figure A.1.28b).

The trends in estimated SSB were similar for all three models (Figure A.1.29). The SSB estimates were highest from RW1 compared to RW2 and Base_orig, which were more similar. The RW2 estimates were higher than Base_orig between 1993 and 2002, similar between 2003 and 2006, and then less than Base_orig between 2007 and 2013. SSB estimates from Base_orig were associated with greater uncertainty than RW1 or RW2 (Figure A.1.29, Figure A.1.30). The trends in estimated age-0 recruits were similar among the models, where the estimates were highest from RW1 followed by RW2 and Base_orig (Figure A.1.31, Figure A.1.32). The trends in the overall exploitation rate were also similar among the models (Figure A.1.33, Figure A.1.34). The estimates of fishing mortality were generally greater than Base_orig (Figure A.1.33).

Jitter analysis

Model convergence of each model was evaluated using jitter analysis. The jitter analysis perturbs the initial values so that a broad range of parameter values along the likelihood surface are used as starting values. This ensures that the model converged to a global solution rather than a local minimum. Starting values of all estimated parameters were randomly perturbed by 10% and 50 trials were run. The results are shown in Figure A.1.35- Figure A.1.37 and indicate each of the models were relatively stable.

Over 50-percent of all jitter runs were within 5 likelihood units of the minimum likelihood:

Model	Number of runs within 5 likelihood units of minimum likelihood (50 total runs)
Base_orig	30 (60%)
RW1	26 (52%)
RW2	33 (66%)

Retrospective analysis

Retrospective analyses were conducted for Base_orig, RW1, and RW2. The results of these analyses are shown in Figure A.1.38-Figure A.1.40. Retrospective patterns in SSB and exploitation rate from Base_orig were not evident (Figure A.1.38). Models RW1 and RW2 did exhibit retrospective patterns in SSB; however, the bias was not directional (Figure A.1.39 and Figure A.1.40). Retrospective patterns in exploitation rate from RW1 and RW2 were not apparent. All three models exhibited patterns in recruitment.

Stock status and benchmarks

The review panel requested that stock status estimates be provided for each model. The review panel recommended using spawning potential ratio (SPR) benchmarks to determine stock status rather than MSY-based benchmarks, which was recommended by the assessment panel. SPR benchmarks were recommended by the review panel given the relatively flat relationship between stock size and recruitment.

Stock status was determined with respect to minimum stock size threshold (MSST), where MSST = (1-M)*Bmsy or (1-M)*Bmsy_proxy and maximum fishing mortality threshold (MFMT), where MFMT = Fmsy or MFMT= Fmsy_proxy. In the case of Red Grouper, the review panel recommended using SPR30% as the reference point. Therefore, MSST = (1-M)*SPR30% and MFMT= FSPR30%. Estimates of SPR30% and FSPR30% are provided in Table A.1.4.

The stock status results are shown in Table A.1.5 - Table A.1.6 and Figure A.1.41- Figure A.1.43. The models were in agreement about the starting and ending stock status, the stock started in an overfished state and were experiencing overfishing and in 2013 (the terminal year of the model) the model predicted that the stock not overfished nor experiencing overfishing. There were some obvious differences among the models. Base_orig generally predicted that Red Grouper were not overfished or experiencing overfishing over the time series (Figure A.1.41). The RW1 results indicated that the population was overfished and experienced overfishing over approximately half of the time-series (Figure A.1.42). The RW2 results indicated that population was overfished and experienced overfishing over the majority of the time-series (Figure A.1.43).

There could be a number of possible reasons for the differences in stock status given the changes that were made from Base_orig to the RW variations. The unfished recruit (Ro) estimates from the RW models are approximately two times greater than the Base_orig model (the same is true for $SSB_{SPR30\%}$, measured in eggs) (Table A.1.3, Table A.1.4). This is counter-intuitive given that the RW models have steepness fixed at 0.99, whereas the estimated steepness from Base_orig was ~0.8. The expectation was that the estimate of Ro from the RW models would have been less than the Ro estimate from Base_orig given that these parameters are generally negatively correlated. A big difference between Base_orig and the RW models is the fit to the discard inputs. More specifically, the RW models have a better fit to the discards at the expense of fitting the discard length composition data, whereas Base_orig grossly underestimated the commercial discards while providing a good fit to the discard length composition data. Given the magnitude of the input discards, the RW model runs would need to start the population at large population size in addition to the increased productivity to obtain the improved fits to the discard input data. Given the relatively similar estimates of SSB (measured in eggs) and large difference in the estimates of $SSB_{SPR30\%}$ among Base_orig and the RW model, this leads to the difference in interpretation of stock status. The scale of the difference is somewhat surprising and highlights the need to get a better understanding of discarding.

Tables

Table A.1.1 A list of Base_orig sensitivity runs and the justification behind this runs requested by the review panel at the S42 review workshop.

Model label	Description	Justification
RetCatch0.150.3	Uncertainty in retained catch, commercial CV = 0.15, recreational CV = 0.3	This was done to accept uncertainty in retained catch. Base_orig essentially assumed the retained catch were known perfectly. Relaxing this assumption should allow for the estimates of fishing mortality to be less dependent on the retained catch inputs alone.
FI_Indices_Only	Fishery-independent indices included in model, fishery-dependent indices were excluded	This was done to determine how informative these data were on the assessment outcomes
FD_Indices_Only	Fishery-dependent indices included in model, fishery-independent indices were excluded	This was done to determine how informative these data were on the assessment outcomes
SYR_1993	Start year 1993	The majority of composition data starts in the early 1990s
DiscCV0.3_RetEst	Discard CV for all fleets was equal to 0.3 and retention was estimated for all time blocks	This was done to reduce the assumed uncertainty in the discard inputs and provide better fit to the discards
AgeCompLambda0.1	The age composition lambda was reduced to 0.1 (down-weighting age composition data). This model also assumed uncertainty in retained catch, commercial CV = 0.15, recreational CV = 0.3	This was done to evaluate how informative this data were on the assessment outcomes and to improve the fit to the indices

Table A.1.2 Model labels and definitions used at the S42 review workshop.

Model label	Start year	Fleets	Steepness (h)	Retained catch CV	Included indices	Index lambda	Commercial discard CV	Retention	NMFS bottom longline survey selectivity
Base_orig	1986	Commercial handline, longline, and trap, Charter/Private, and Headboat	Estimated symmetric beta prior (0.83, 1)	0.05 (all fleets)	commHL, commLL, commTrap, CBT_PR, Headboat, Combined video, SEAMAP-summer groundfish, NMFS bottom longline	1	0.9 ('93-'06), 0.5('07 –'13)	Fixed ('90-'08) Estimated ('09-'13)	Estimated, double normal selectivity pattern
RW1	1993	Commercial handline, longline, and trap, and Recreational	Fixed, h = 0.99	0.15 (comm), 0.3 (rec)	commHL, commLL, commTrap, CBT_PR, Headboat, Combined video, SEAMAP-summer groundfish, NMFS bottom longline	5	0.3 (all years and fleets)	Estimated	Fixed asymptotic
RW2	1993	Commercial handline, longline, and trap,and Recreational	Fixed, h = 0.99	0.15 (comm), 0.3 (rec)	Combined video, SEAMAP-summer groundfish, NMFS bottom longline	5	0.3 (all years and fleets)	Estimated	Fixed asymptotic

Table A.1.3 Leading and derived parameter estimates and root mean square error estimates for indices and discards for each model.

PARAMETERS	Base_orig		RW1		RW2	
Stock-Recruitment						
SR_LN(R0)	9.67		10.388		10.355	
SR_BH_steep	0.802		0.990		0.990	
SR_sigmaR	0.965		1.238		1.411	
LN(R1_offset) & R1_offset	-0.048	0.95	0.287	1.33	0.320	1.37
Derived quantities						
SSB_Unfished (eggs)	4110000.00		8236070.00		7970620.00	
TotBio_Unfished (MT)	90321.10		181111.00		175274.00	
Recr_Unfished (age-0)	16187.10		32458.30		31412.20	
Recr_Initial (age-0)	15120.00		43243.80		43257.10	
SSB_MSY (eggs)	1440000.00		2226270.00		2128280.00	
Fstd_MSY	4000.59		9420.84		9260.51	
RetYield_MSY	3430.84		7080.93		7846.08	
INDEX	**q**	**rmse**	**q**	**rmse**	**q**	**rmse**
commHL	0.0001	0.310	0.0001	0.247	-	-
commLL	0.0001	0.157	0.0002	0.206	-	-
commTrap	-	-	-	-	-	-
HB	0.0010	0.307	-	-	-	-
Rec	-	-	0.0004	0.261	-	-
RedTide	2.2608	7.91E-06	1.8112	0.000	1.997	0.000
Video	0.0001	0.257	0.0001	0.291	0.000	0.257
SEAMAP_GF	0.0001	0.248	0.0000	0.164	0.000	0.252
NMFS_BLL	0.0001	0.344	0.0001	0.339	0.000	0.360
CBT_PR	0.0001	0.317	0.0001	0.283	-	-
DISCARDS	**rmse**		**rmse**		**rmse**	
commHL	607.70		390.437		391.670	
commLL	1945.25		646.977		586.537	
commTrap	226.92		192.962		194.744	
CBT_PR	766.44		-		-	
HB	51.15		-		-	
Rec	-		596.814		678.286	

Table A.1.4 SPR30% and FSPR30% estimates for Base_orig, RW1 and RW2.

Model	SPR30%	FSPR30%
Base_orig	1203500.00	0.204
RW1	2444260.00	0.212
RW2	2265390.00	0.214

Table A.1.5 Annual spawning biomass estimates (eggs) and spawning potential ratios (SPR-ratios) for each model (SPR-ratio = SPB (eggs)/MSST).

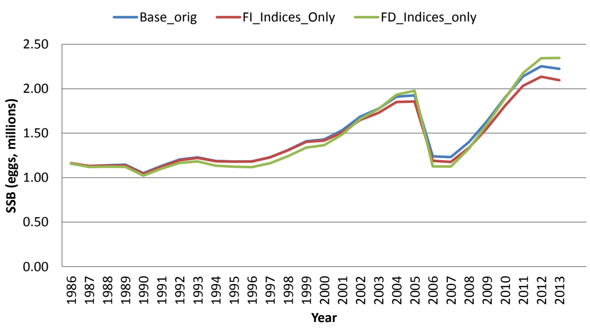
	Base_orig		RW1		RW2	
Year	SPB (eggs)	SPB/((1-M)*SPR30%)	SPB (eggs)	SPB/((1-M)*SPR30%)	SPB (eggs)	SPB/((1-M)*SPR30%)
1986	1156630.00	1.118	-	-	-	-
1987	1129980.00	1.092	-	-	-	-
1988	1139280.00	1.101	-	-	-	-
1989	1144990.00	1.106	-	-	-	-
1990	1050940.00	1.015	-	-	-	-
1991	1132070.00	1.094	-	-	-	-
1992	1203400.00	1.163	-	-	-	-
1993	1228180.00	1.187	1459240.00	0.694	1413700.00	0.726
1994	1187210.00	1.147	1373710.00	0.654	1322870.00	0.679
1995	1180980.00	1.141	1356640.00	0.645	1318340.00	0.677
1996	1182310.00	1.142	1336360.00	0.636	1314870.00	0.675
1997	1228460.00	1.187	1357340.00	0.646	1340240.00	0.688
1998	1310930.00	1.267	1442690.00	0.686	1407550.00	0.722
1999	1408770.00	1.361	1583830.00	0.753	1523090.00	0.782
2000	1430260.00	1.382	1629480.00	0.775	1503840.00	0.772
2001	1532670.00	1.481	1860050.00	0.885	1622580.00	0.833
2002	1685460.00	1.628	2156010.00	1.026	1807290.00	0.928
2003	1775000.00	1.715	2310830.00	1.099	1845960.00	0.948
2004	1909760.00	1.845	2526790.00	1.202	1932610.00	0.992
2005	1925010.00	1.860	2648630.00	1.260	1921490.00	0.986
2006	1239230.00	1.197	1520120.00	0.723	1198310.00	0.615
2007	1231680.00	1.190	1499700.00	0.713	1149600.00	0.590
2008	1399270.00	1.352	1714050.00	0.815	1297620.00	0.666
2009	1633450.00	1.578	2014400.00	0.958	1521280.00	0.781
2010	1902920.00	1.839	2357580.00	1.122	1778980.00	0.913
2011	2140040.00	2.068	2680820.00	1.275	2005990.00	1.030
2012	2252710.00	2.177	2858980.00	1.360	2086230.00	1.071
2013	2222750.00	2.148	2905630.00	1.382	2042940.00	1.049

Table A.1.6 Annual exploitation rate estimates and the fishing mortality ratios (Fratios) for each model (F-ratio = F/MFMT).

	Base_orig		RW1		RW2	
Year	F	F/FSPR30%	F	F/FSPR30%	F	F/FSPR30%
1986	0.212	1.036				
1987	0.194	0.948				
1988	0.204	1.000				
1989	0.269	1.316				
1990	0.166	0.814				
1991	0.187	0.916				
1992	0.210	1.026				
1993	0.231	1.130	0.276	1.303	0.287	1.336
1994	0.189	0.926	0.214	1.011	0.209	0.976
1995	0.180	0.882	0.219	1.033	0.209	0.976
1996	0.131	0.639	0.182	0.861	0.179	0.832
1997	0.122	0.599	0.167	0.788	0.174	0.813
1998	0.104	0.509	0.125	0.592	0.135	0.630
1999	0.149	0.727	0.171	0.807	0.201	0.935
2000	0.167	0.816	0.154	0.728	0.190	0.885
2001	0.141	0.688	0.128	0.606	0.156	0.727
2002	0.141	0.690	0.147	0.694	0.187	0.874
2003	0.112	0.546	0.117	0.552	0.156	0.726
2004	0.158	0.775	0.140	0.659	0.192	0.896
2005	0.475	2.325	0.560	2.644	0.517	2.409
2006	0.139	0.678	0.163	0.769	0.195	0.908
2007	0.105	0.512	0.114	0.538	0.141	0.657
2008	0.111	0.544	0.125	0.591	0.149	0.692
2009	0.084	0.409	0.095	0.449	0.115	0.535
2010	0.066	0.321	0.075	0.352	0.092	0.430
2011	0.081	0.396	0.101	0.479	0.130	0.605
2012	0.108	0.528	0.116	0.550	0.155	0.724
2013	0.121	0.591	0.126	0.593	0.183	0.851

Figures

a)



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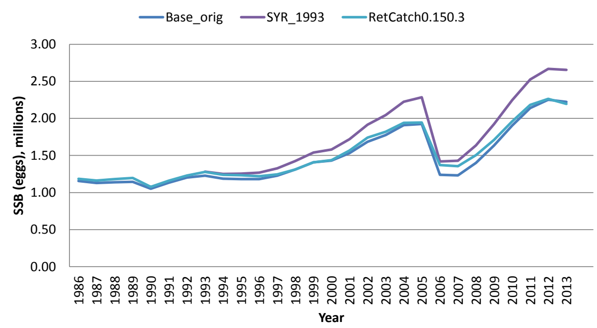

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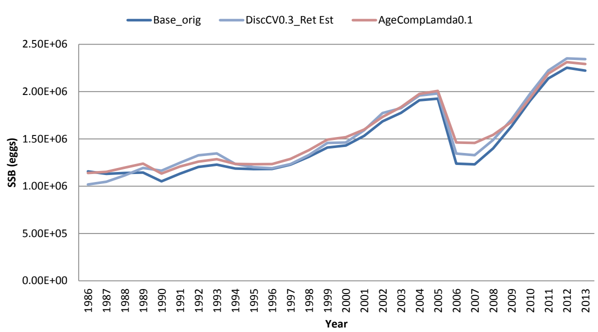
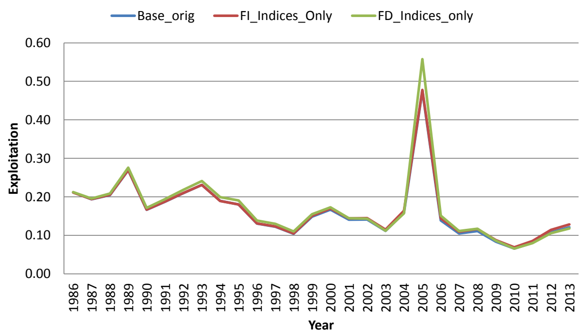


Figure A.1.1 Comparison of SSB (eggs in millions) from the sensitivity runs to the SSB estimates from the preliminary base model from the assessment webinar series, a) comparison to FI_Indices_Only and FD_Indices_Only , b) SYR_1993 and RetCatch0.10.3, and c) DiscCV0.3_RetEst and AgeCompLambda0.1.

a)



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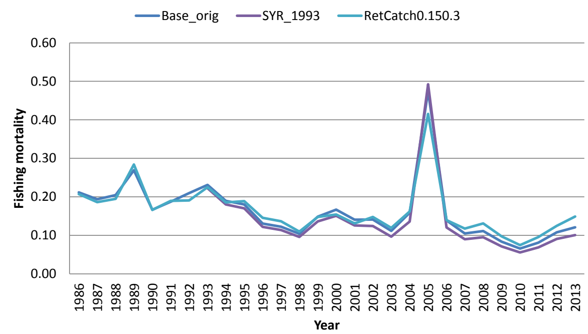

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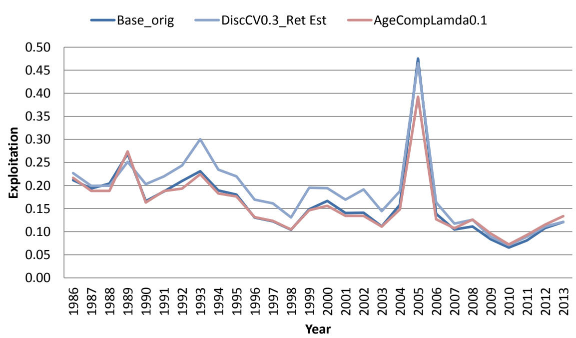
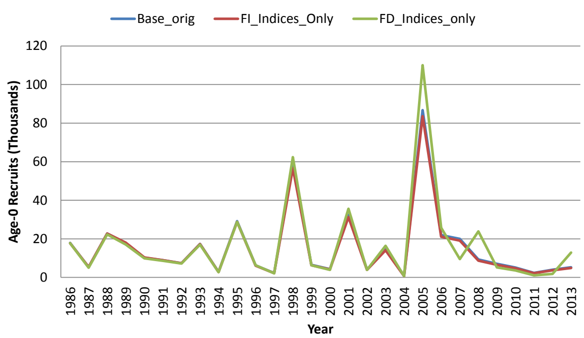


Figure A.1.2 Comparison of exploitation rates from the sensitivity runs to the exploitation estimates from the preliminary base model from the assessment webinar series, a) comparison to FI_Indices_Only and FD_Indices_Only , b) SYR_1993 and RetCatch0.10.3, and c) DiscCV0.3_RetEst and AgeCompLambda0.1.

a)



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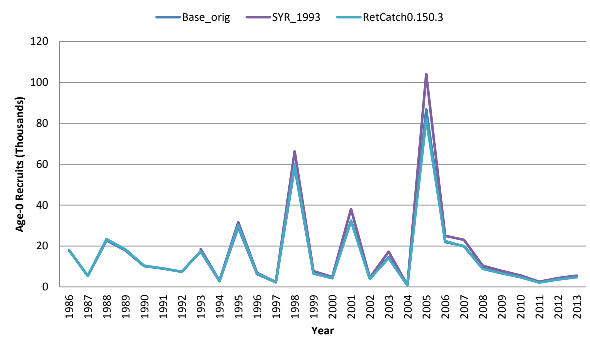

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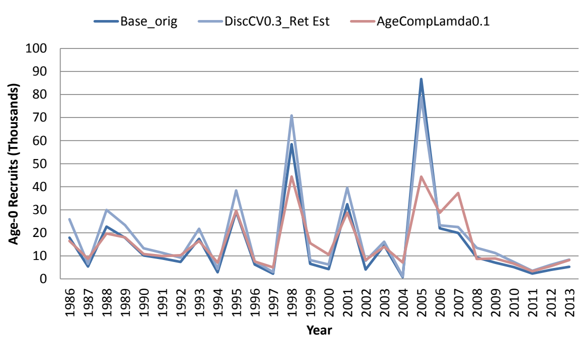
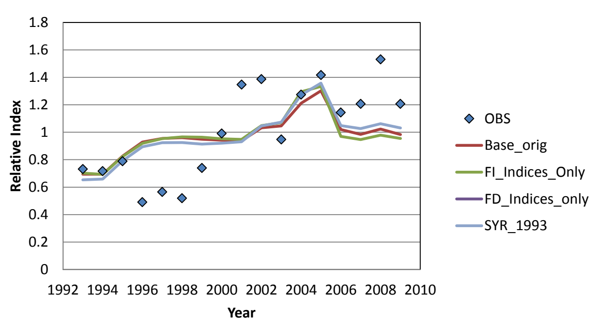


Figure A.1.3 Comparison of age-0 recruits (in thousands) from the sensitivity runs to the age-0 recruits estimates from the preliminary base model from the assessment webinar series. a) comparison to FI_Indices_Only and FD_Indices_Only , b) SYR_1993 and RetCatch0.10.3, and c) DiscCV0.3_RetEst and AgeCompLambda0.1.

a)



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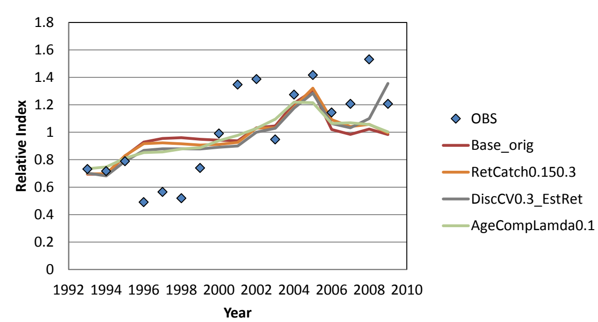


Figure A.1.4 Comparison of the commercial handline index fit from the sensitivity runs to the fit from the preliminary base model from the assessment webinar series, a) comparison to FI_Indices_Only, FD_Indices_Only , and syr_1993 and b) RetCatch0.10.3, DiscCV0.3_RetEst and AgeCompLambda0.1.

a) b)

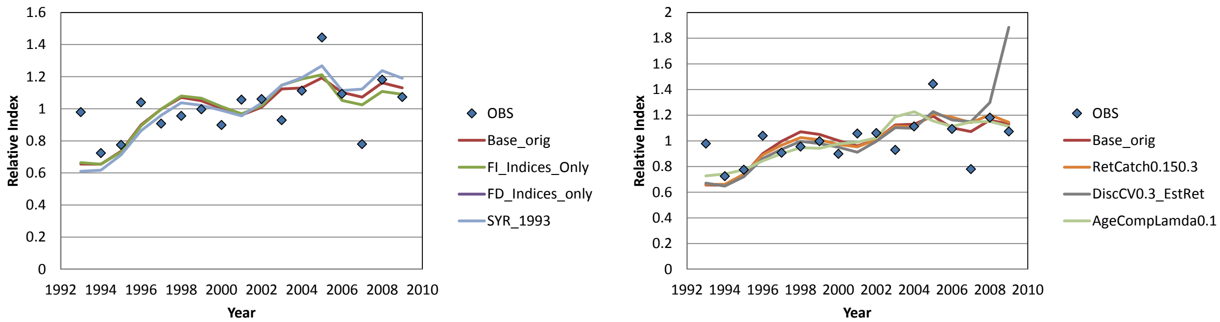


Figure A.1.5 Comparison of the commercial longline index fit from the sensitivity runs to the fit from the preliminary base model from the assessment webinar series, a) comparison to FI_Indices_Only, FD_Indices_Only , and syr_1993 and b) RetCatch0.10.3, DiscCV0.3_RetEst and AgeCompLambda0.1.

a) b)

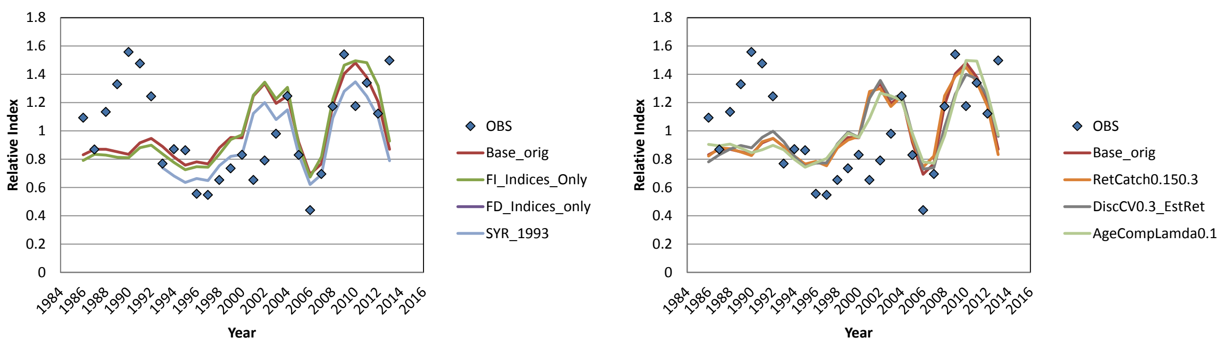


Figure A.1.6 Comparison of the charterboat/private index fit from the sensitivity runs to the fit from the preliminary base model from the assessment webinar series, a) comparison to FI_Indices_Only, FD_Indices_Only , and syr_1993 and b) RetCatch0.10.3, DiscCV0.3_RetEst and AgeCompLambda0.1.

a) b)

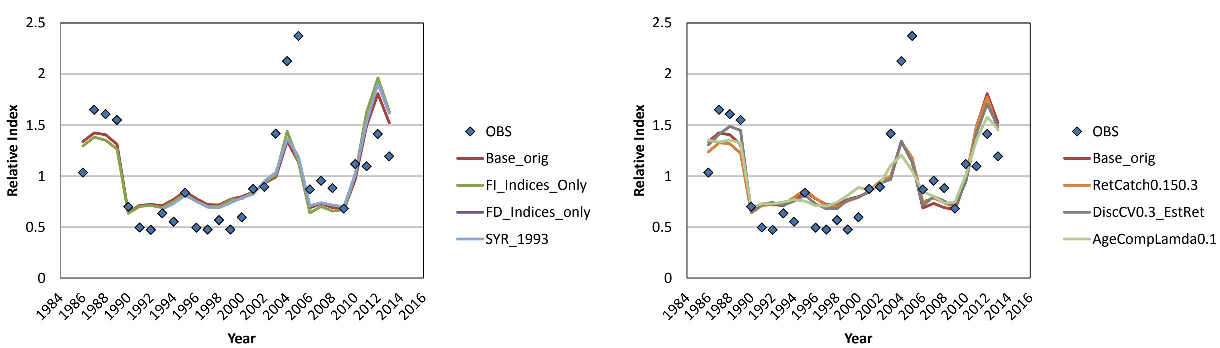
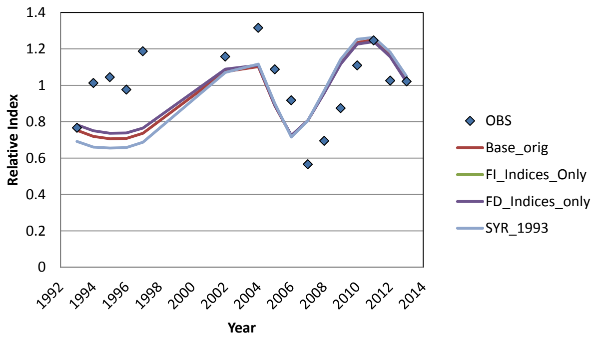


Figure A.1.7 Comparison of the headboat index fit from the sensitivity runs to the fit from the preliminary base model from the assessment webinar series, a) comparison to FI_Indices_Only, FD_Indices_Only , and syr_1993 and b) RetCatch0.10.3, DiscCV0.3_RetEst and AgeCompLambda0.1.

a)



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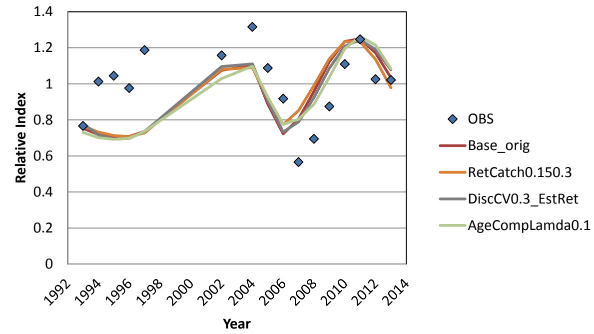
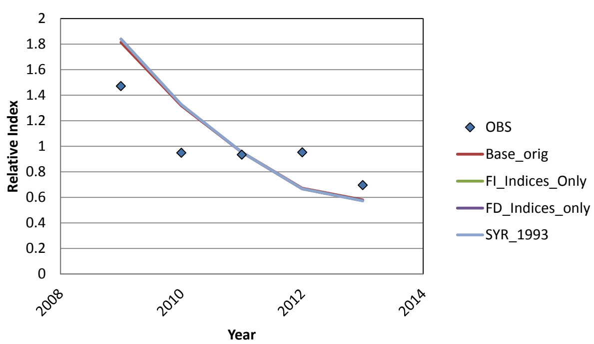


Figure A.1.8 Comparison of the combined video index fit from the sensitivity runs to the fit from the preliminary base model from the assessment webinar series, a) comparison to FI_Indices_Only, FD_Indices_Only , and syr_1993 and b) RetCatch0.10.3, DiscCV0.3_RetEst and AgeCompLambda0.1.

a)



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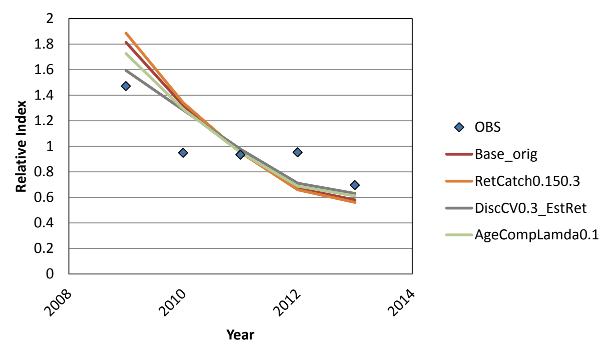
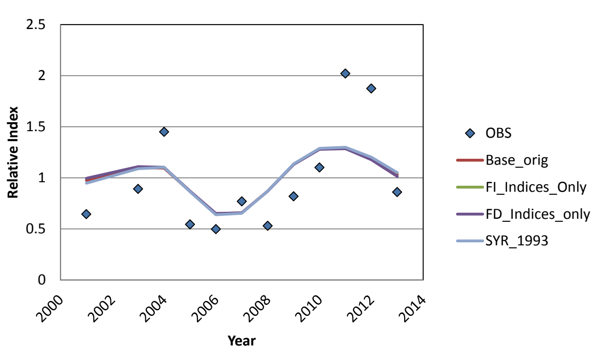


Figure A.1.9 Comparison of the SEAMAP summer groundfish survey index fit from the sensitivity runs to the fit from the preliminary base model from the assessment webinar series, a) comparison to FI_Indices_Only, FD_Indices_Only , and syr_1993 and b) RetCatch0.10.3, DiscCV0.3_RetEst and AgeCompLambda0.1.

a)



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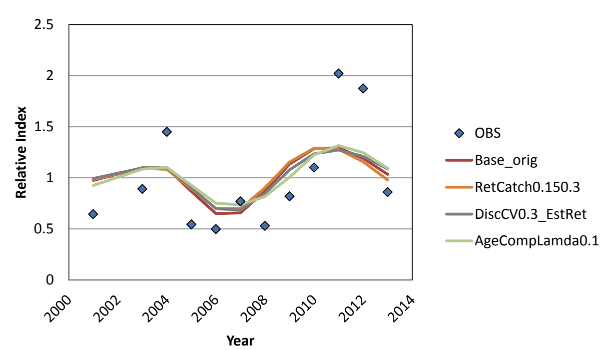


Figure A.1.10 Comparison of the NMFS bottom longline survey index fit from the sensitivity runs to the fit from the preliminary base model from the assessment webinar series, a) comparison to FI_Indices_Only, FD_Indices_Only , and syr_1993 and b) RetCatch0.10.3, DiscCV0.3_RetEst and AgeCompLambda0.1.

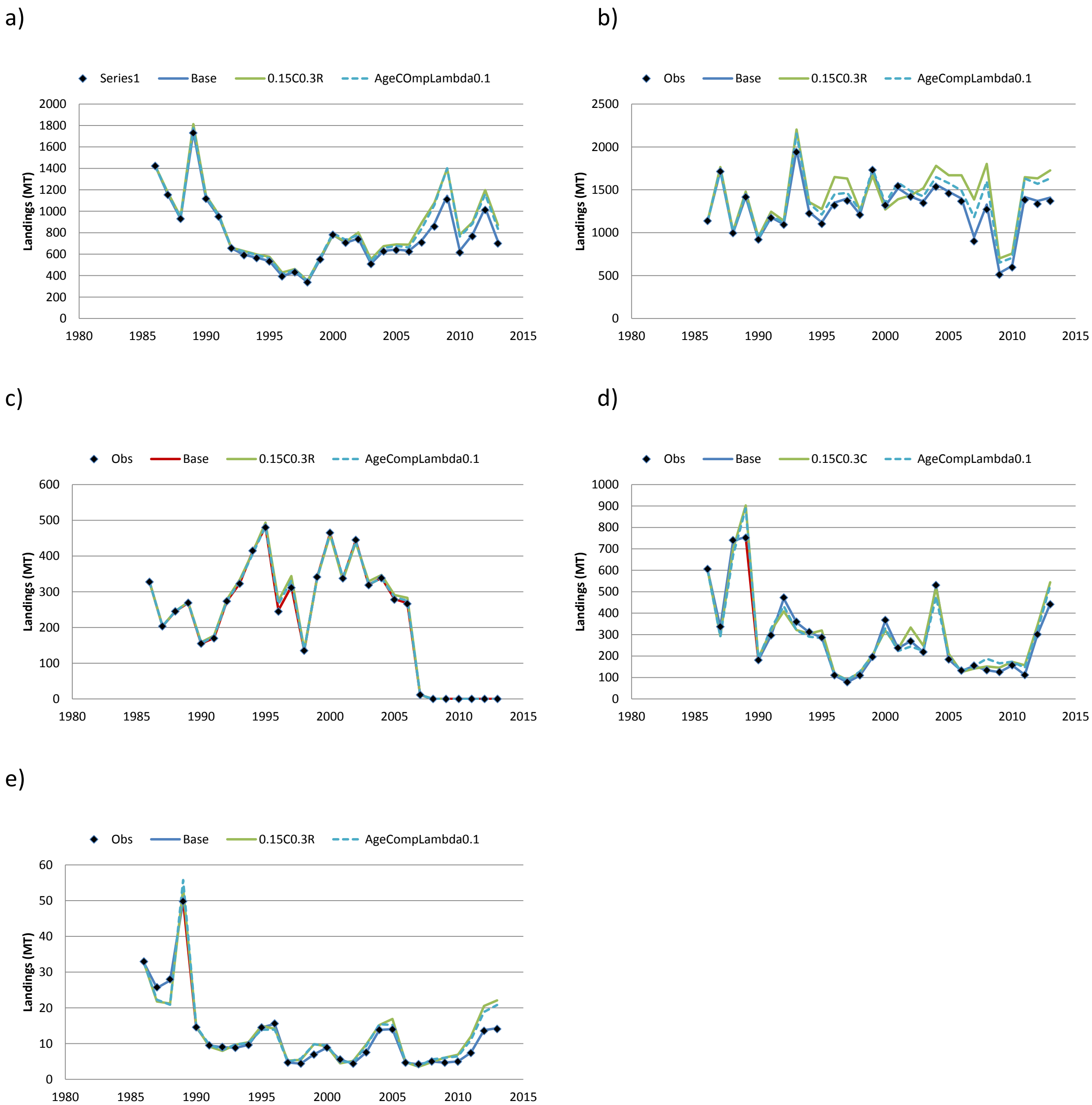


Figure A.1.11 Fits to the observed retained catch by Base_orig, DiscCV0.3_RetEst, and AgeCompLambda0.1, a) Commercial handline, b) Commercial longline, c) Commercial trap, d)Charter/Private, and e) Headboat.

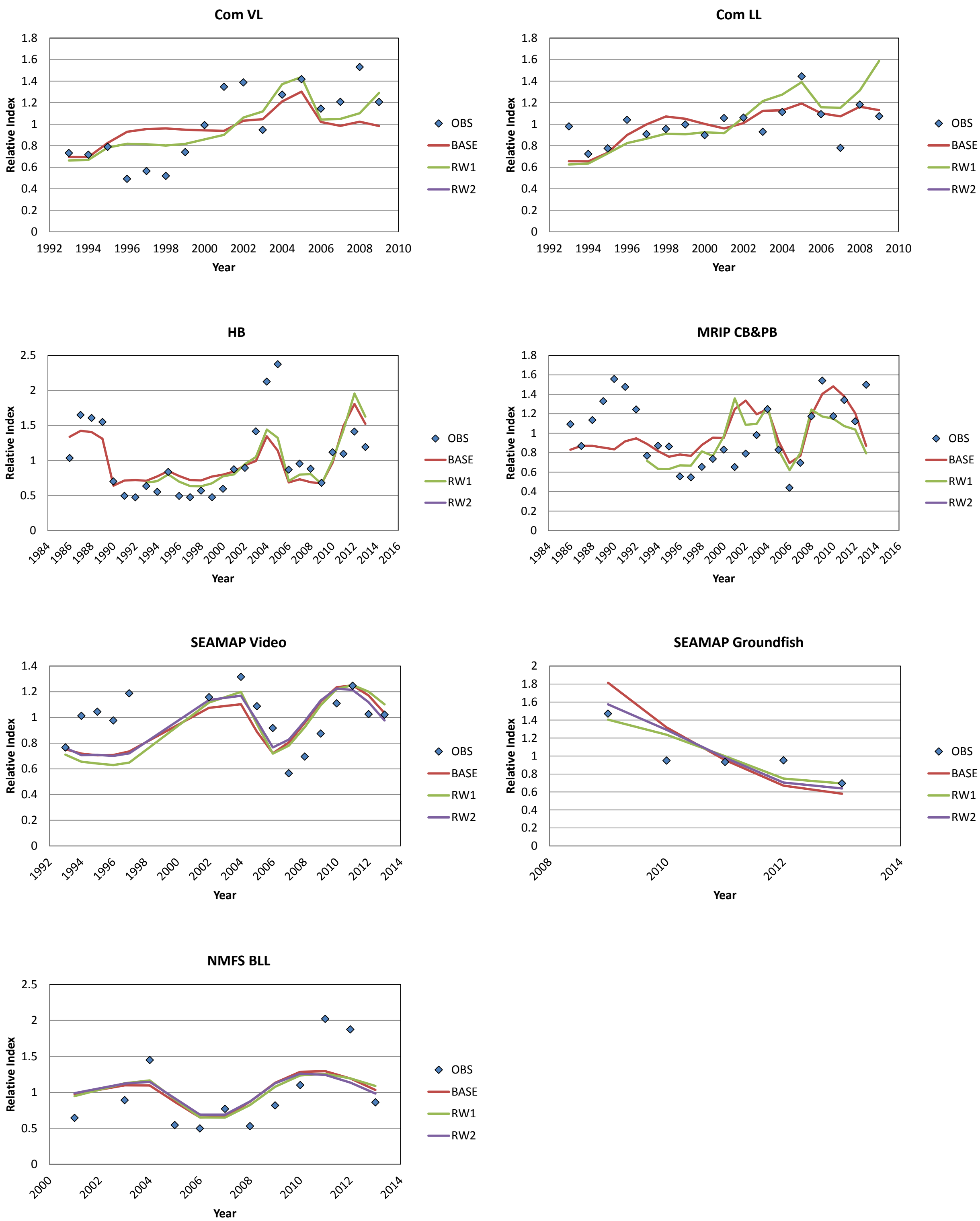
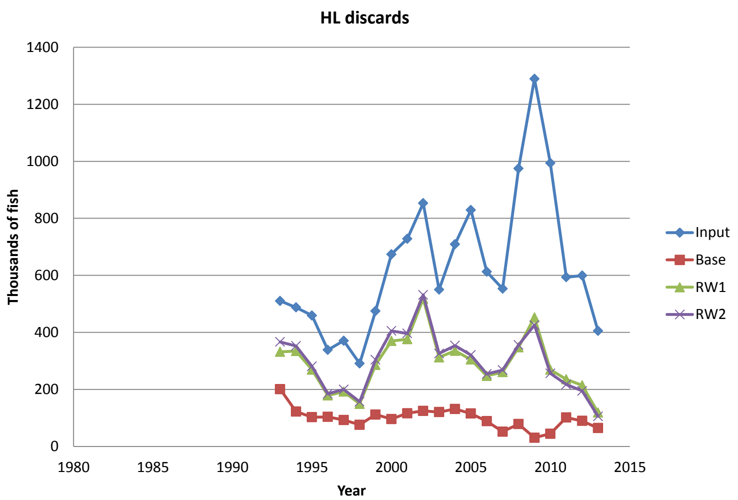
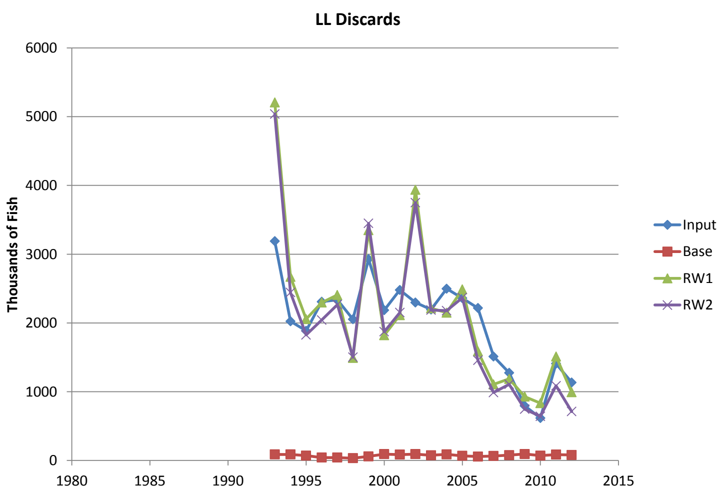


Figure A.1.12 Standard relative indices of abundance and predicted fit to the indices for all fleets and surveys.





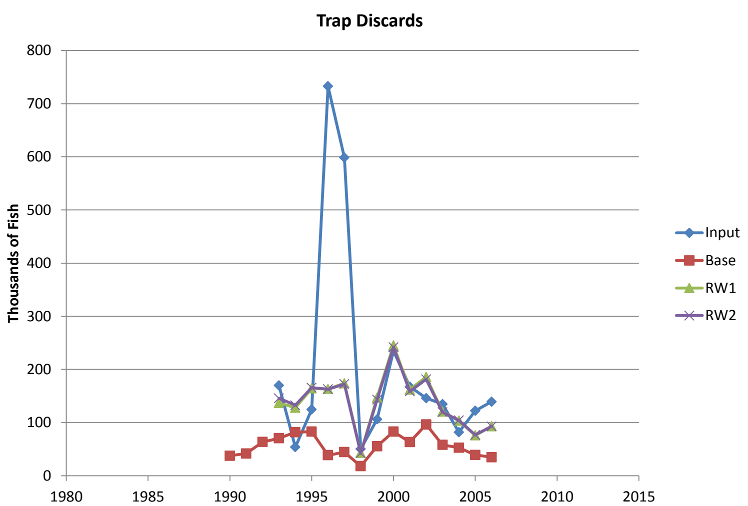
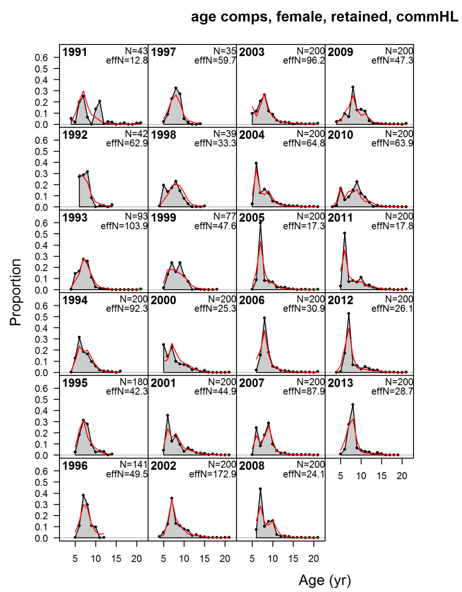


Figure A.1.13 Estimated discards as compared to the discard input values.

a)



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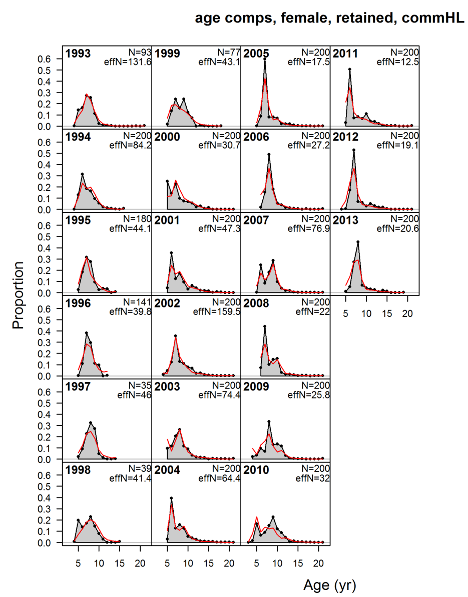


c)

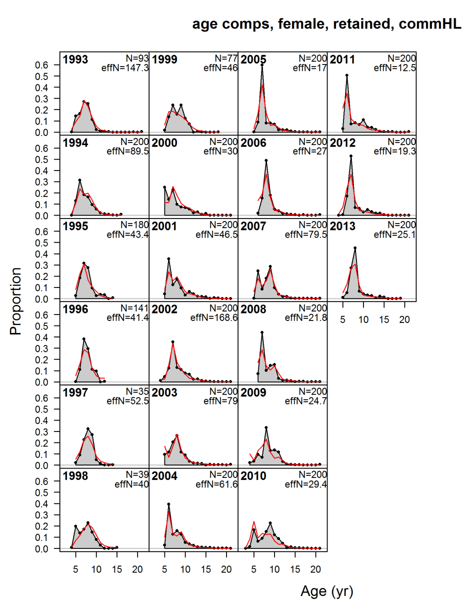
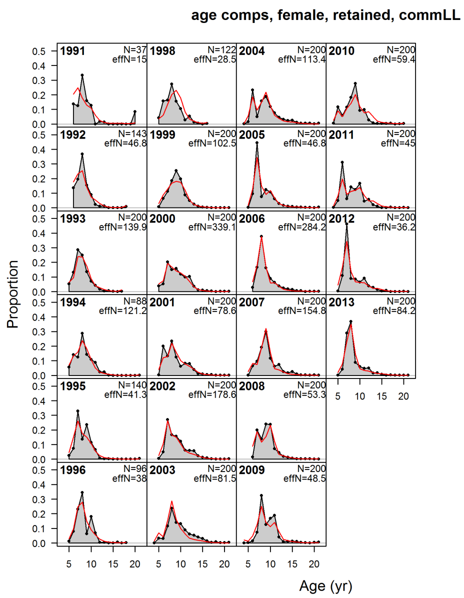
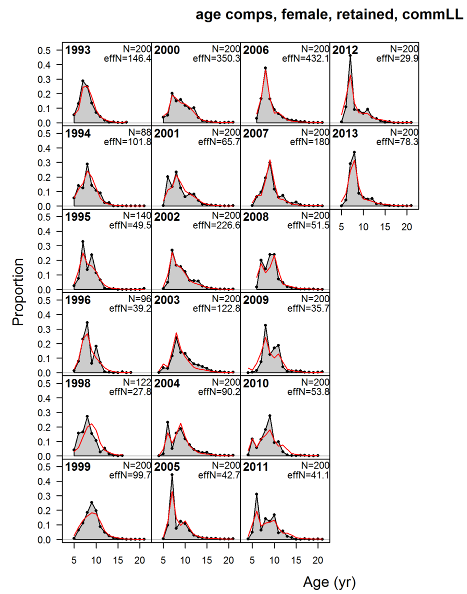


Figure A.1.14 Fits to the commercial handline age composition data, a) Base_orig, b) RW1, and c) RW2.

a)



b)



c)

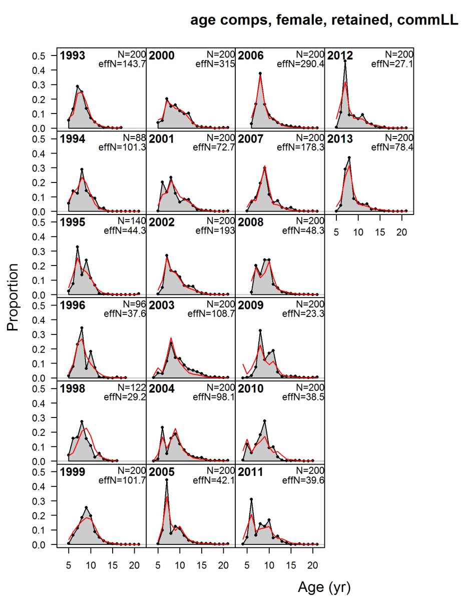
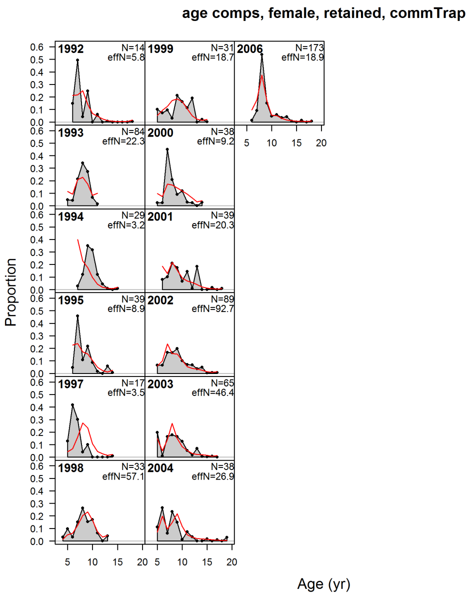
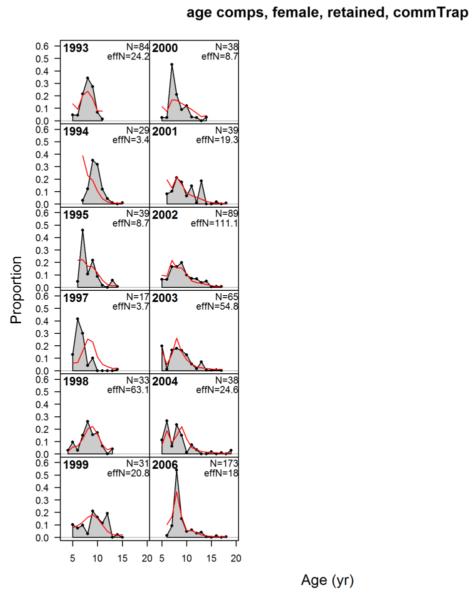


Figure A.1.15 Fits to the commercial longline age composition data, a) Base_orig , b) RW1, and c) RW2.

a)



b)



c)

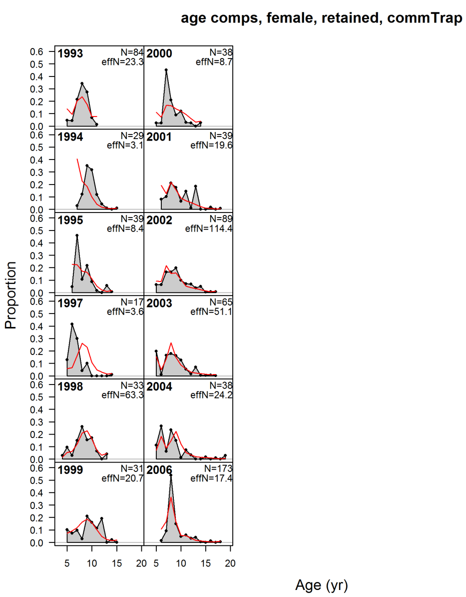
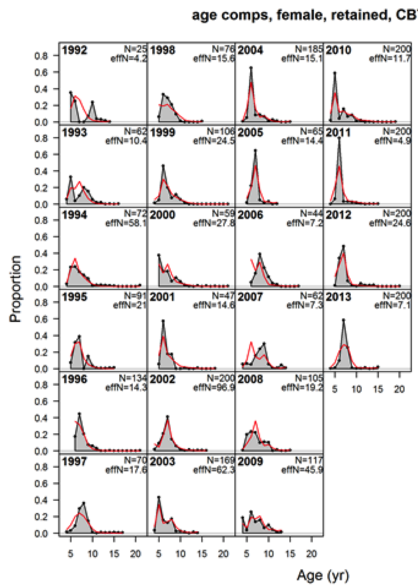
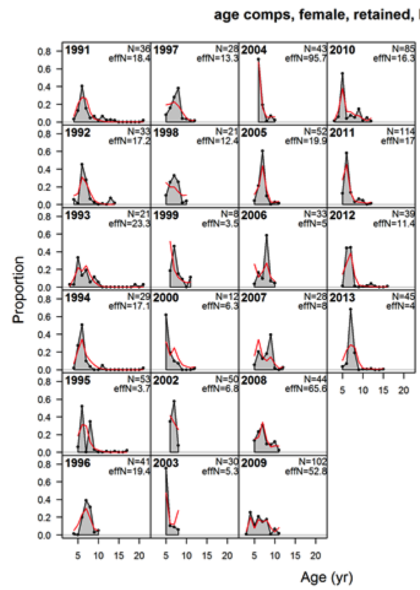


Figure A.1.16 Fits to the commercial trap age composition data, a) Base_orig, b) RW1, and c) RW2.

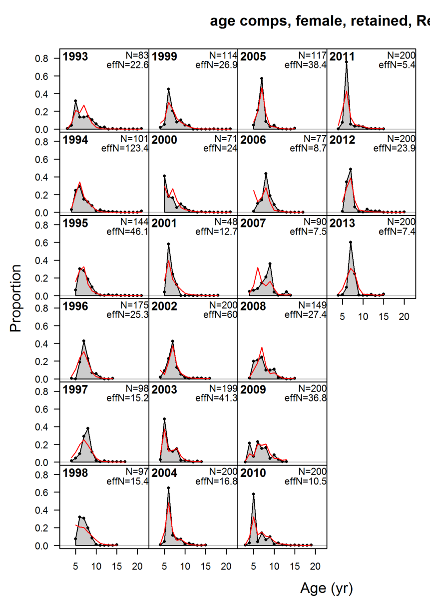
a)



b)



c)



d)

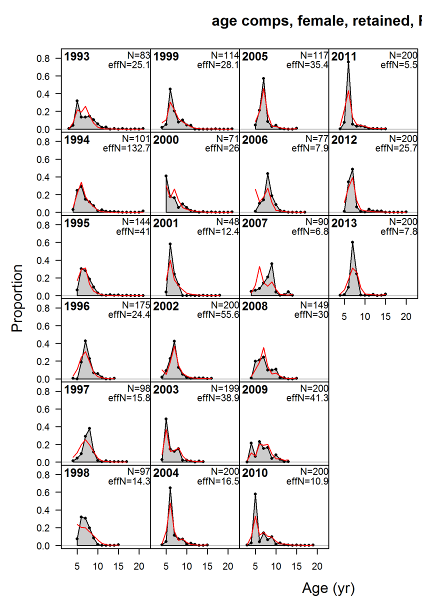
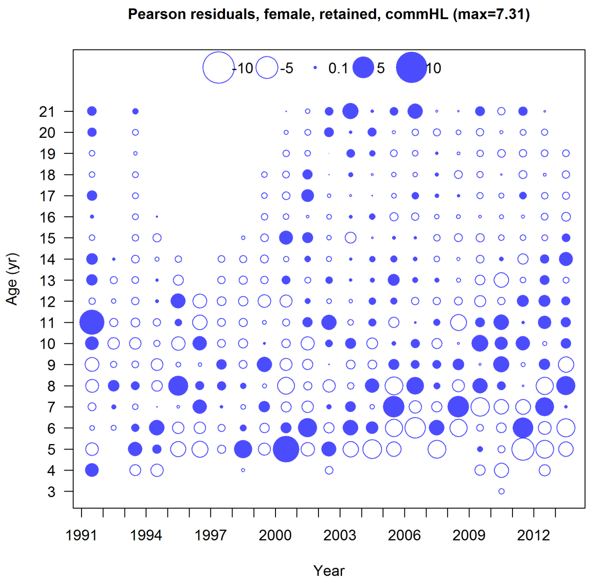
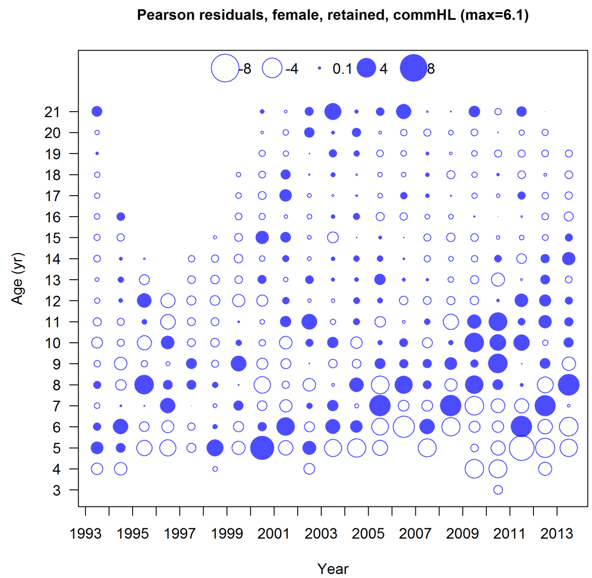


Figure A.1.17 Fits to the recreational age composition data, a) Base_orig charter/private, b) Base_orig headboat, c) RW1, and d) RW2.

a)



b)



c)

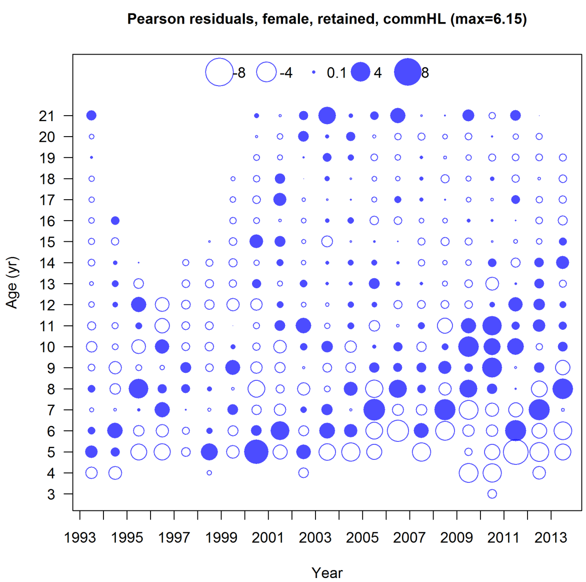
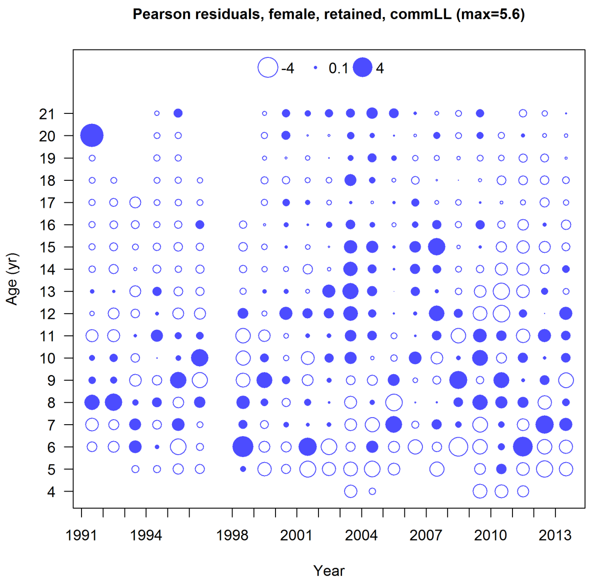
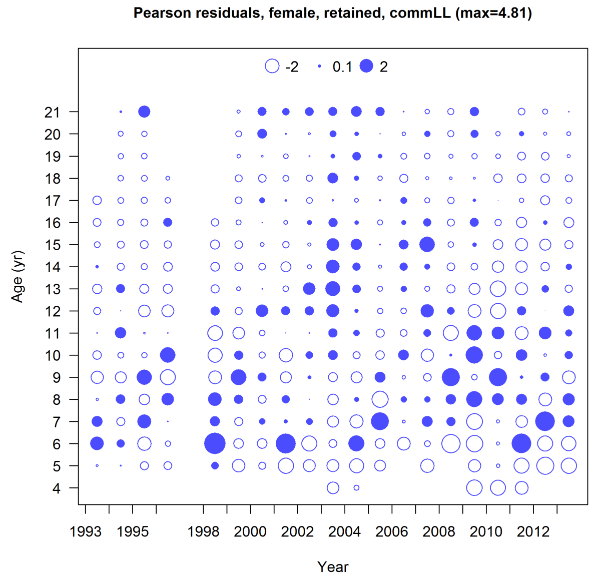


Figure A.1.18 Residuals from the fits to the commercial handline age composition data, a) Base_orig, b) RW1, and c) RW2.

a)



b)



c)

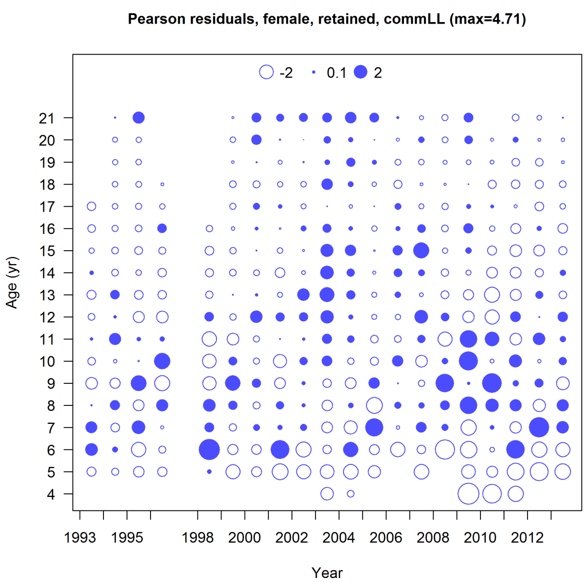
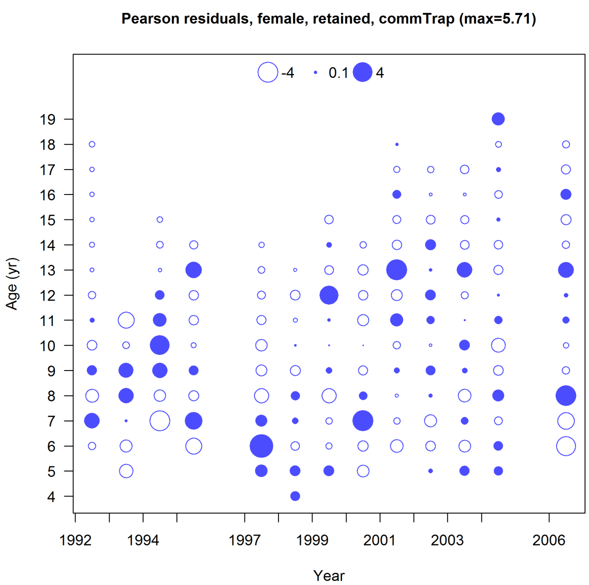
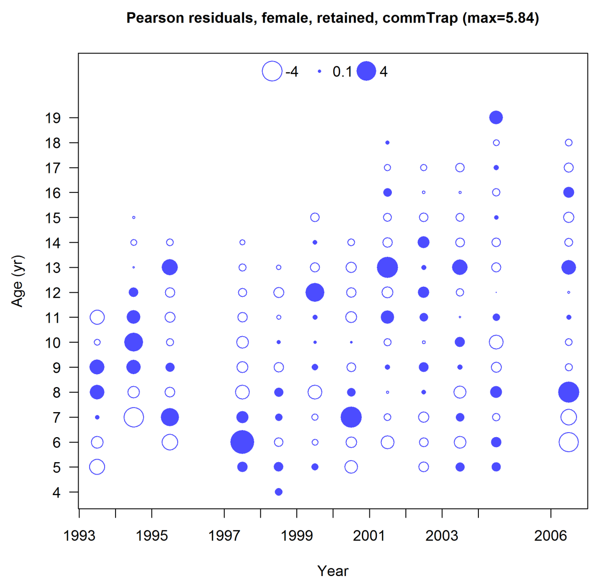


Figure A.1.19 Residuals from the fits to the commercial longline age composition data, a)Base_orig, b) RW1, and c) RW2.

a)



b)



c)

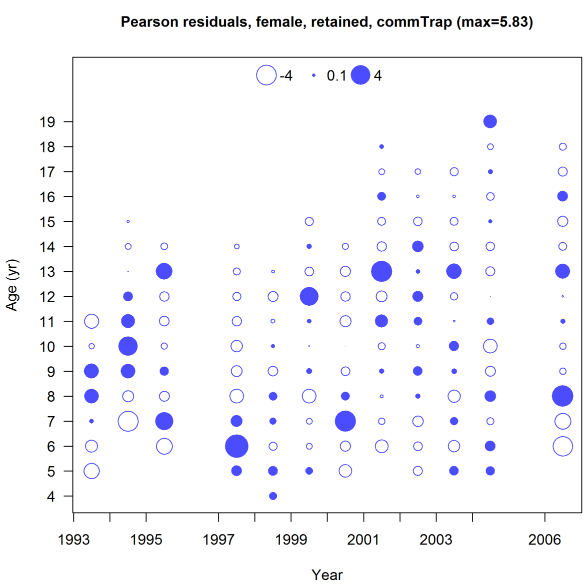


Figure A.1.20 Residuals from the fits to the commercial trap age composition data, a) Base_orig, b) RW1, and c) RW2.

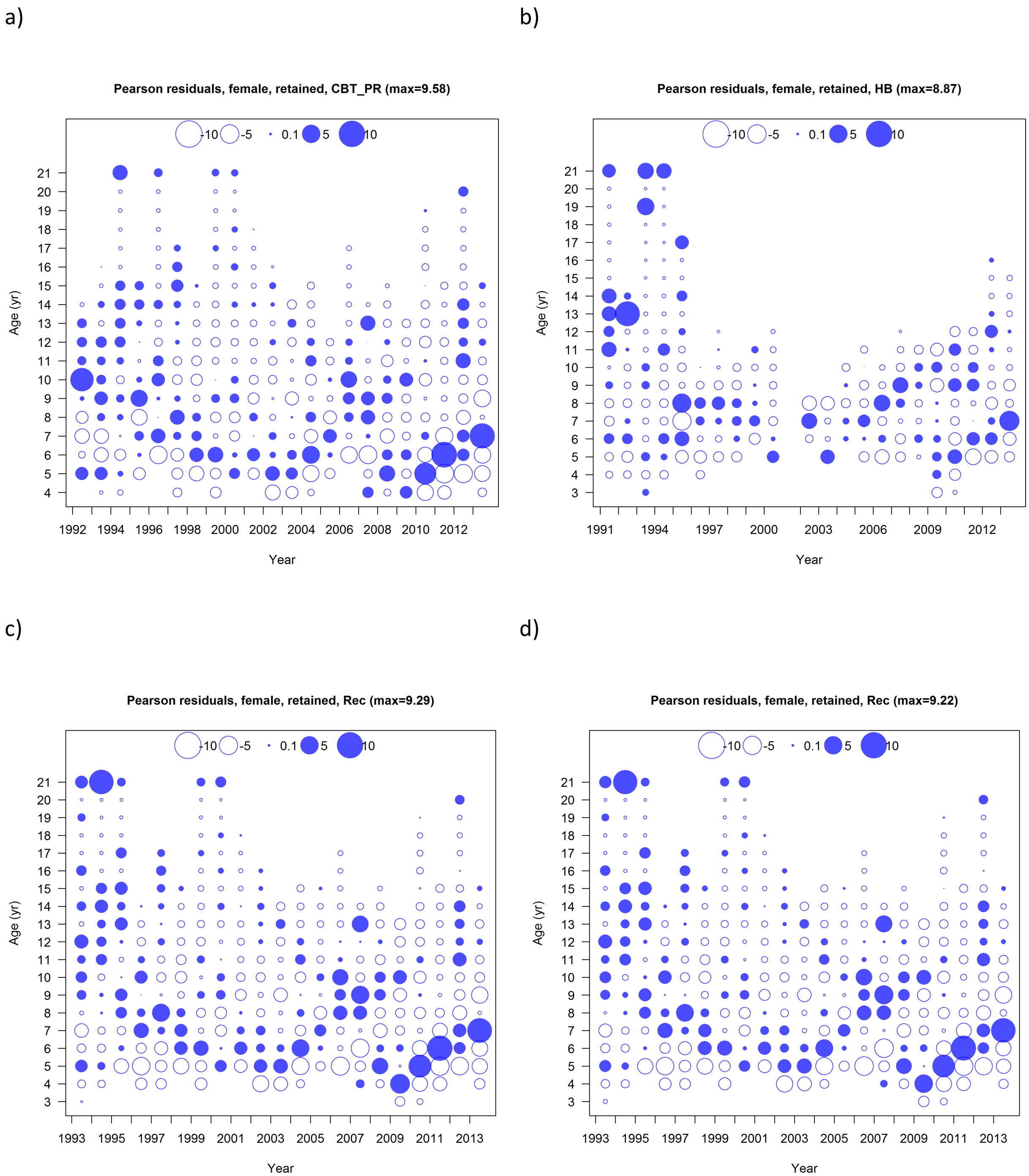
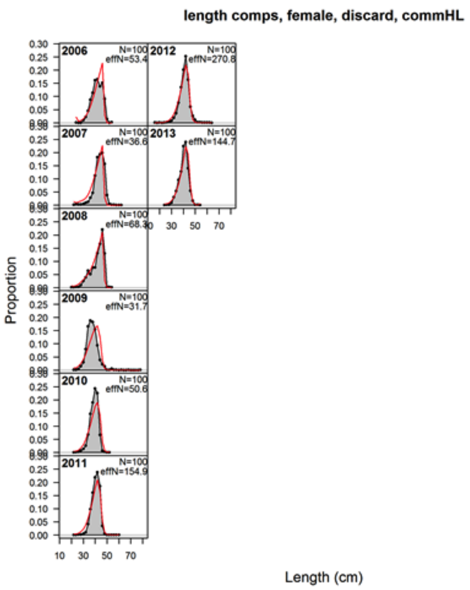
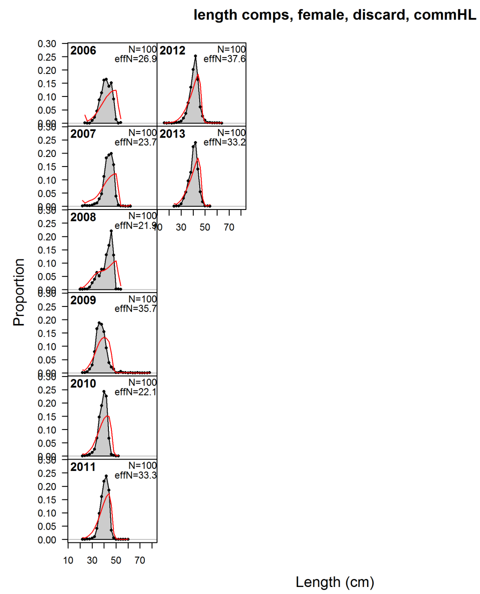


Figure A.1.21 Residuals from the fits to the recreational age composition data, a) Base_orig charter/private, b) Base_orig headboat, c) RW1 recreational, and d) RW2 recreational.

a)



b)



c)

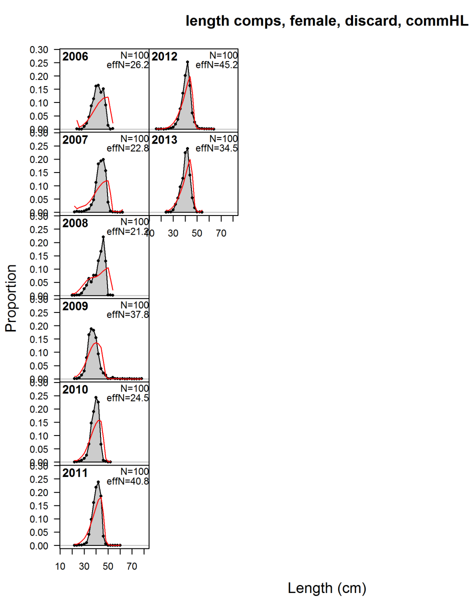
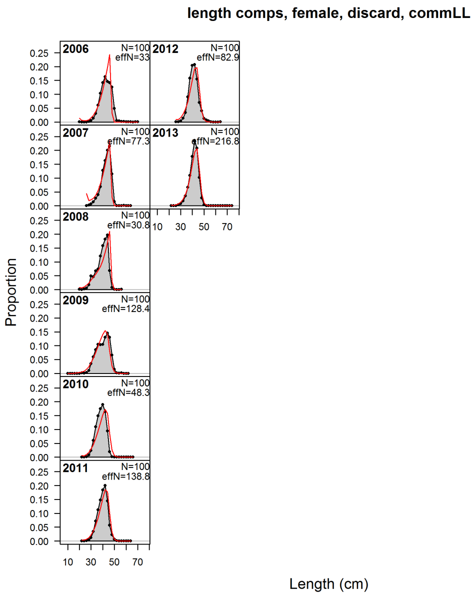
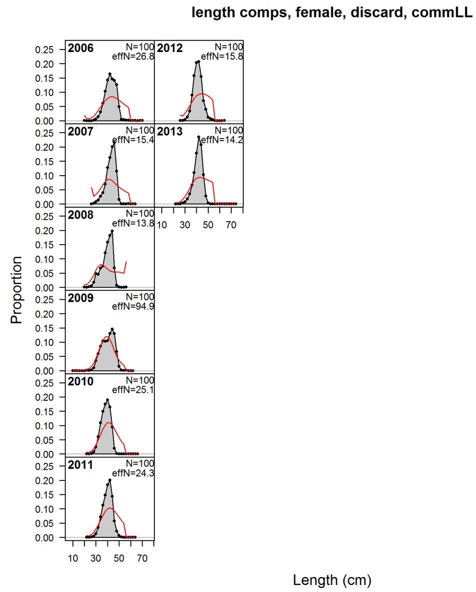


Figure A.1.22 Fits to the commercial handline discard length composition data, a) Base_orig, b) RW1, and c) RW2.

a)



b)



c)

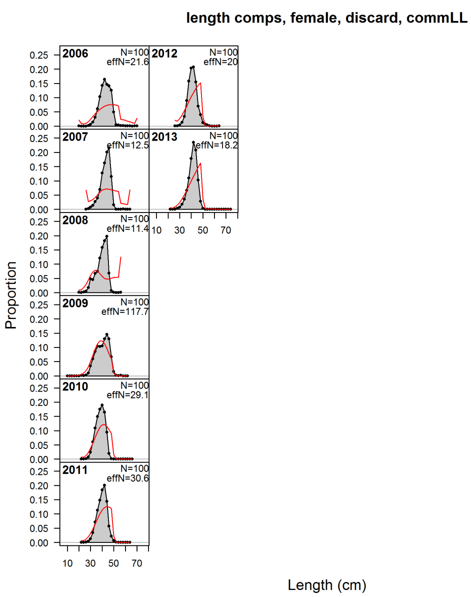
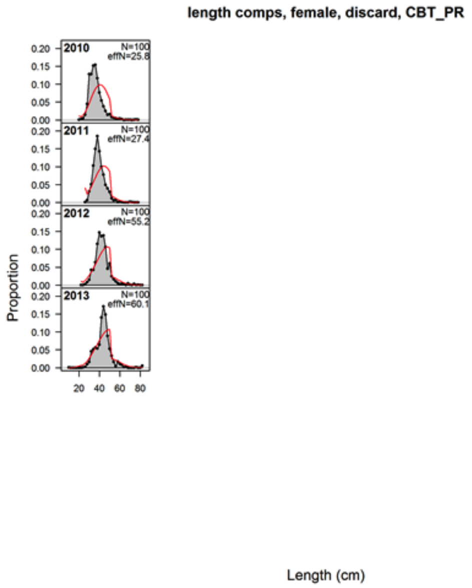
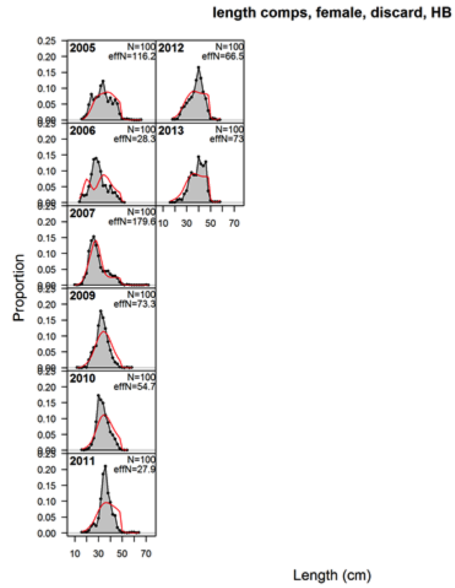


Figure A.1.23 Fits to the commercial longline discard length composition data, a) Base_orig, b) RW1, and c) RW2.

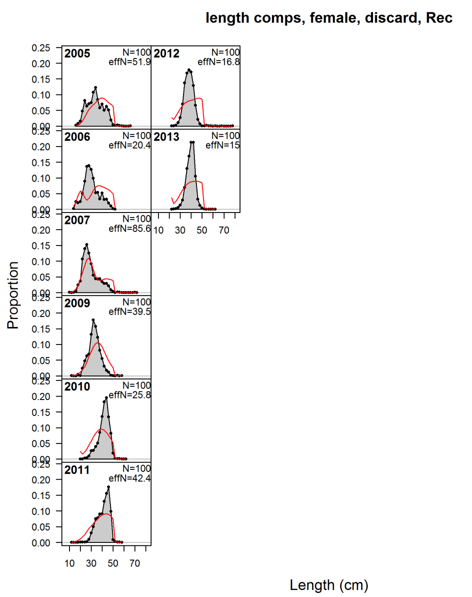
a)



b)



a)



b)

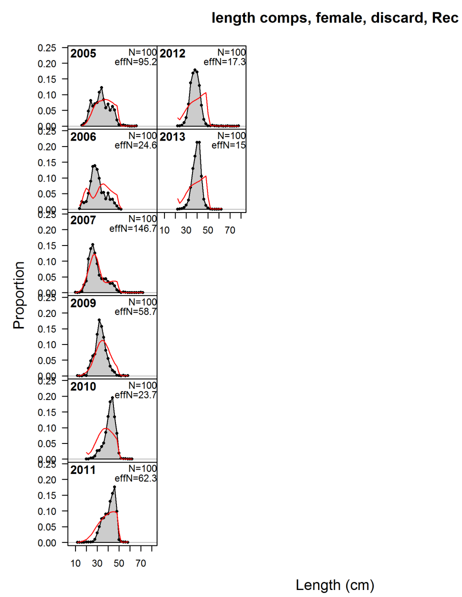
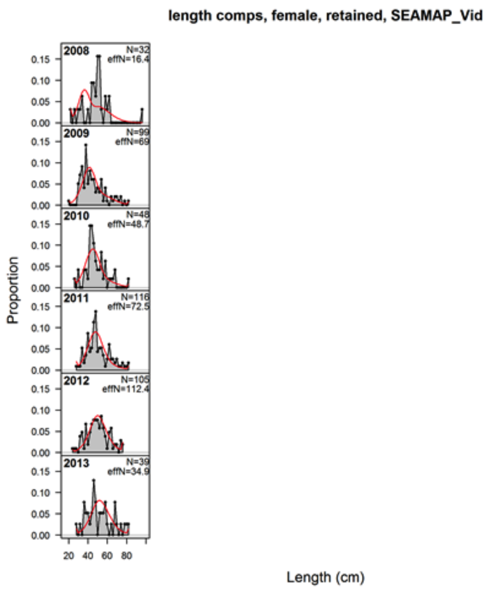
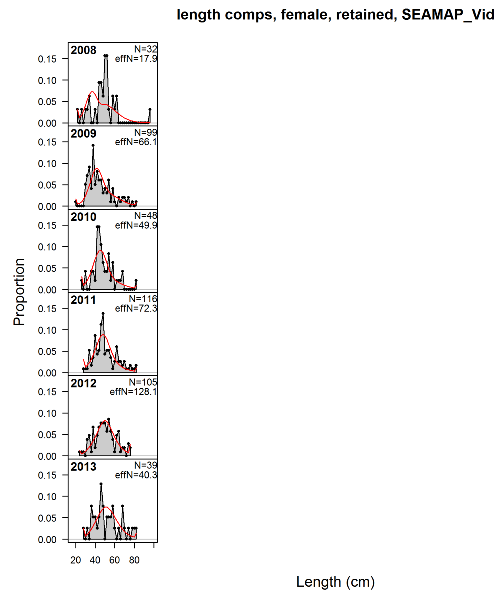


Figure A.1.24 Fits to the recreational discard length composition data, a) Base_orig charter/private, b) Base_orig headboat, c) RW1 recreational, and d) RW2 recreational.

a)



b)



c)

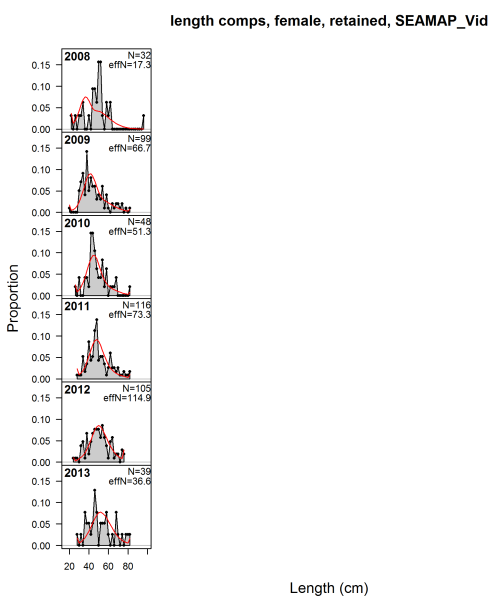
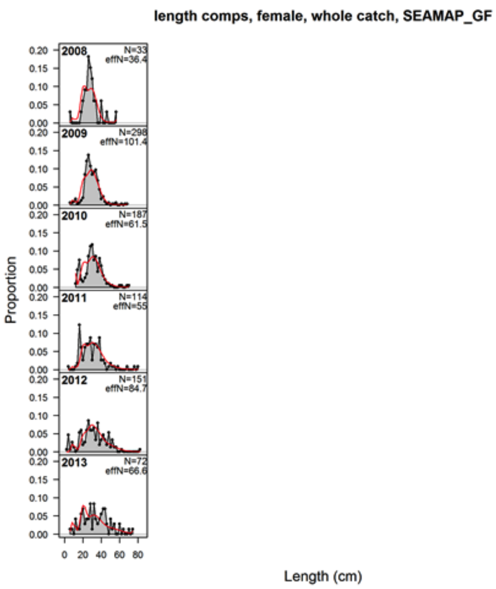
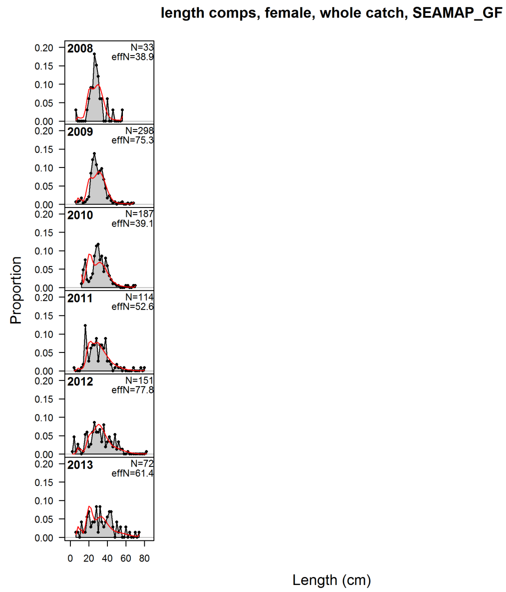


Figure A.1.25 Fits to the video length composition data, a) Base_orig, b) RW1, and c) RW2.

a)



b)



c)

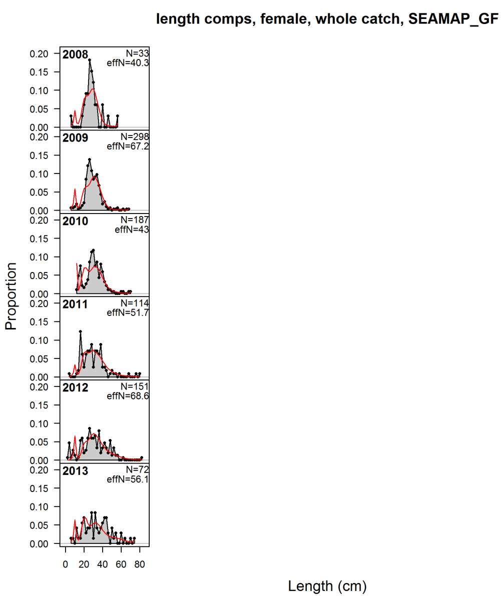
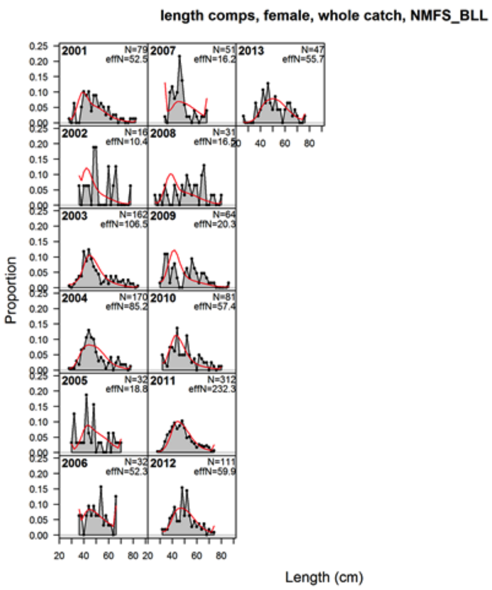
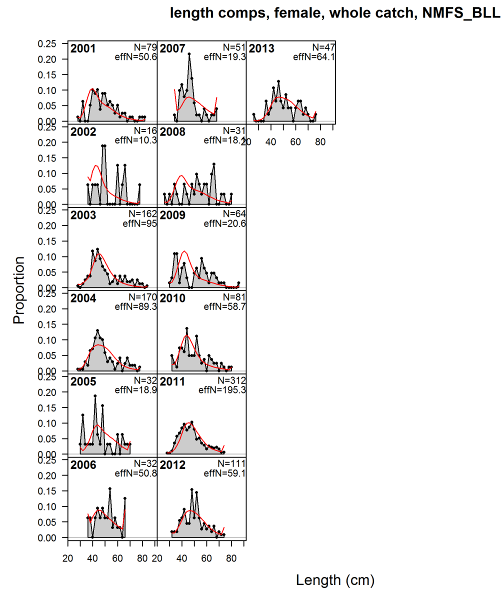


Figure A.1.26 Fits to the SEAMAP summer groundfish length composition data, a) Base_orig, b) RW1, and c) RW2.

a)



b)



c)

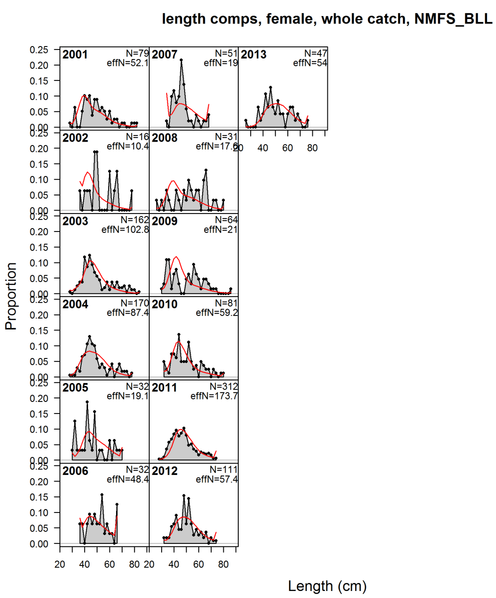
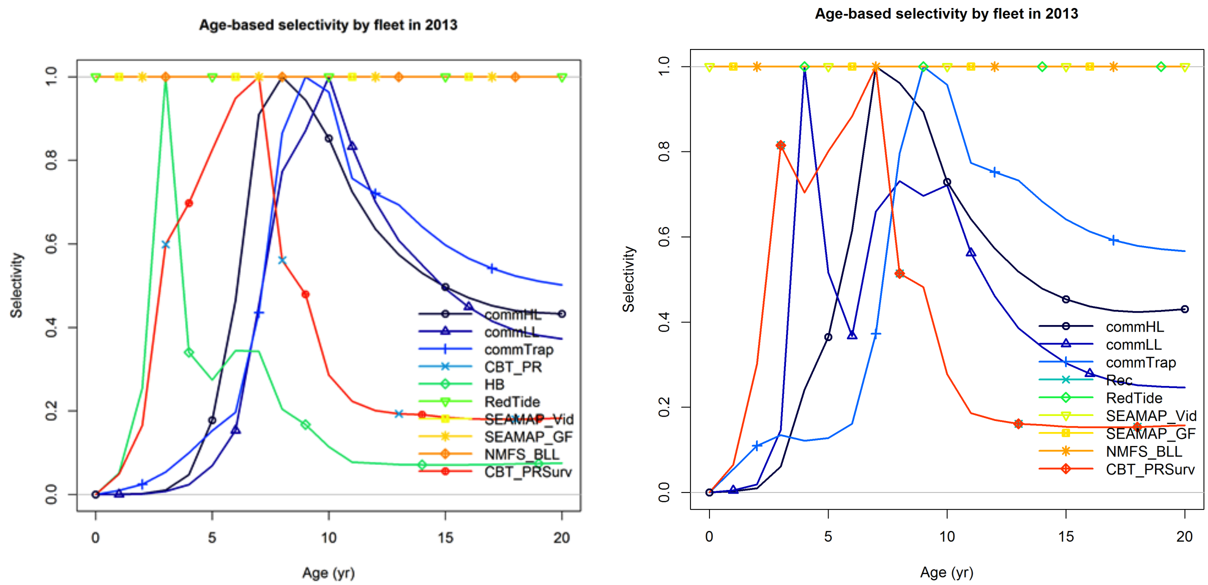


Figure A.1.27 Fits to the NMFS bottom longline composition data, a) Base_orig, b) RW1, and c) RW2.



c)

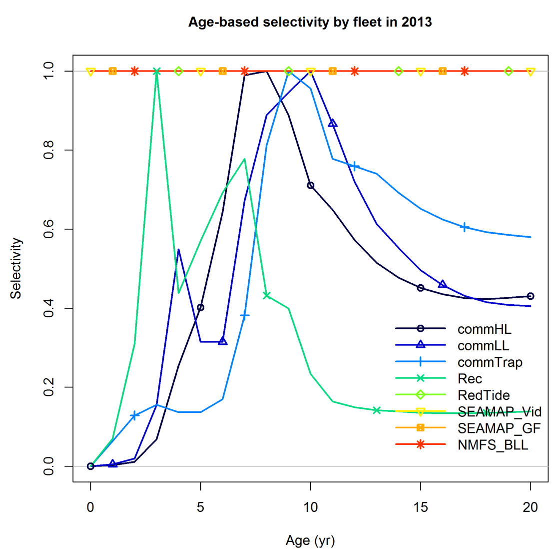


Figure A.1.28 Estimated selectivity patterns, a) Base_orig, b) RW1, and c) RW2.

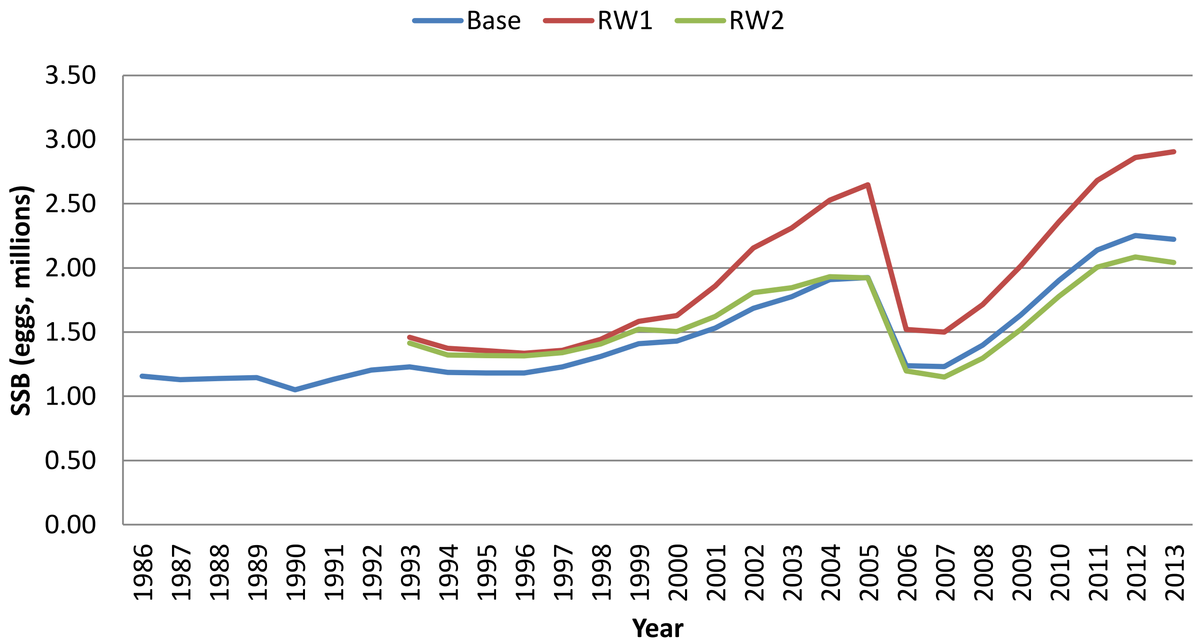
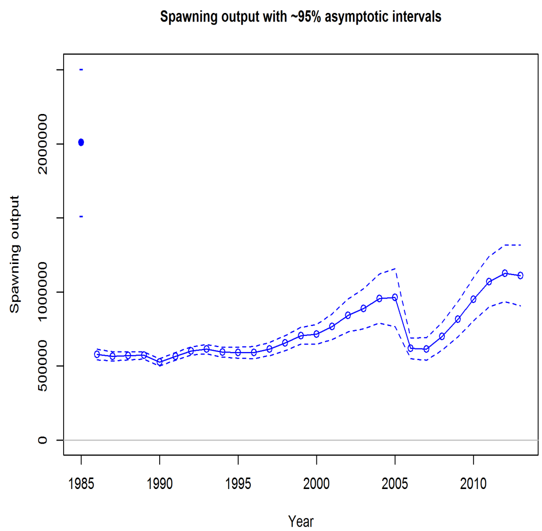
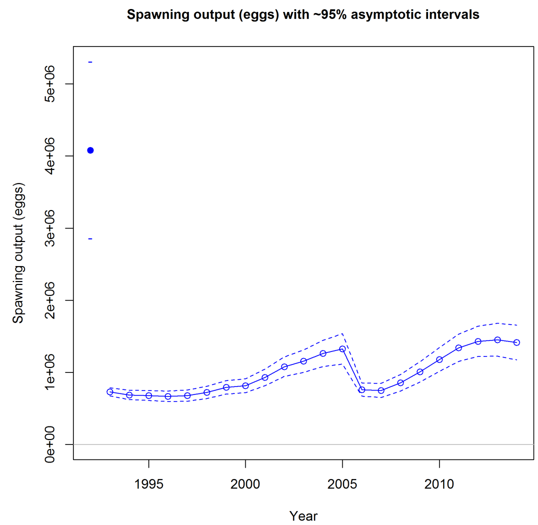


Figure A.1.29 Comparison of SSB estimates (eggs in millions), where the number of eggs is the proxy for SSB.

a)



b)



c)

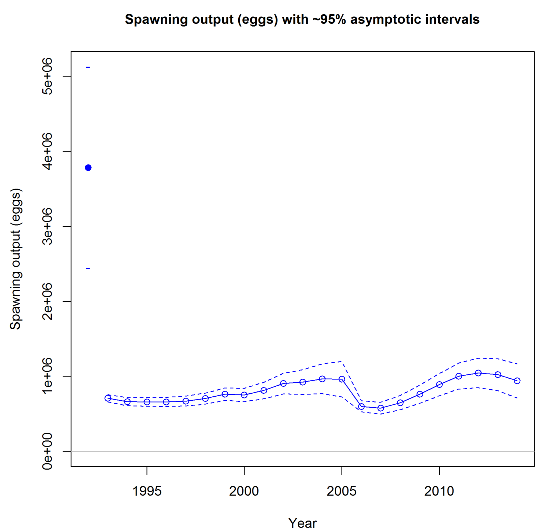


Figure A.1.30 Spawning output and 95% asymptotic intervals: a) Base_orig, b) RW1, and c) RW2. The blue circle represents virgin conditions.

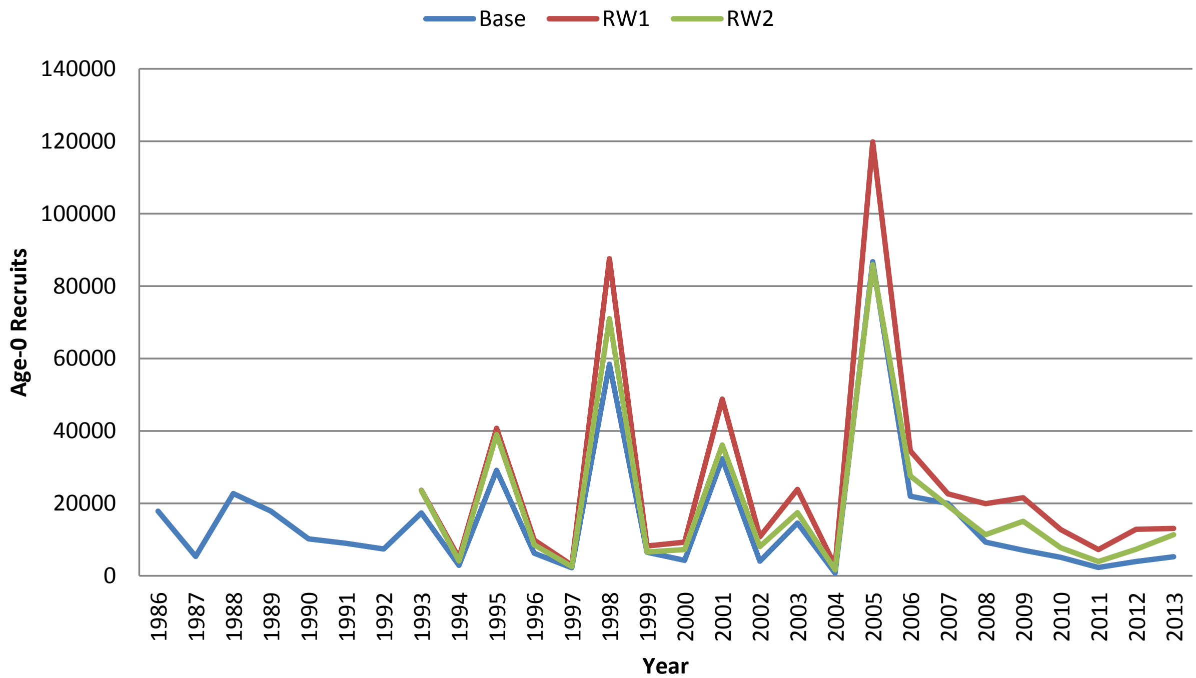
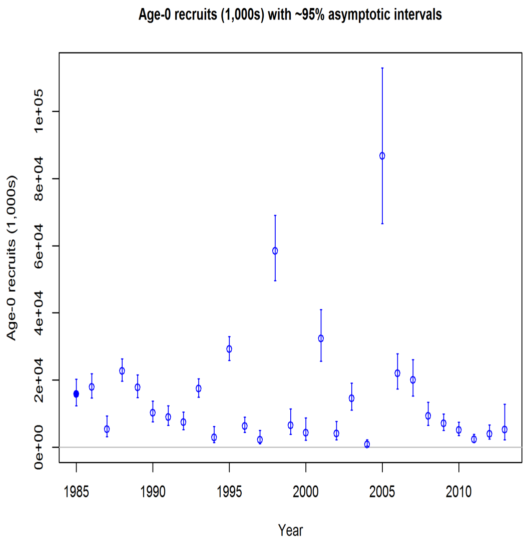
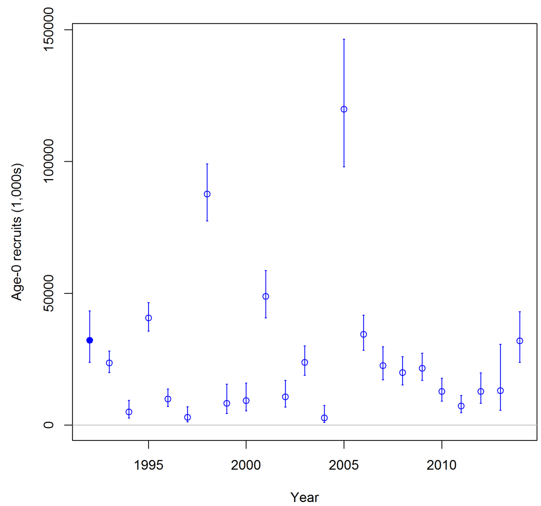


Figure A.1.31 Comparison of age-0 recruit estimates.

a)



b)



c)

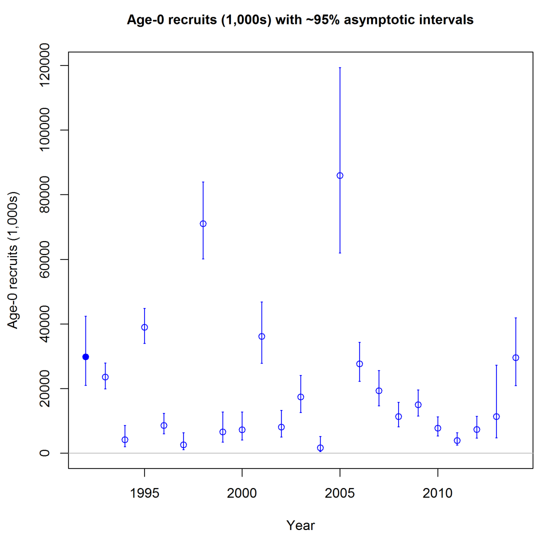


Figure A.1.32 Age-0 recruits: a) Base_orig, b) RW1, and c) RW2. The blue circle represents virgin conditions.

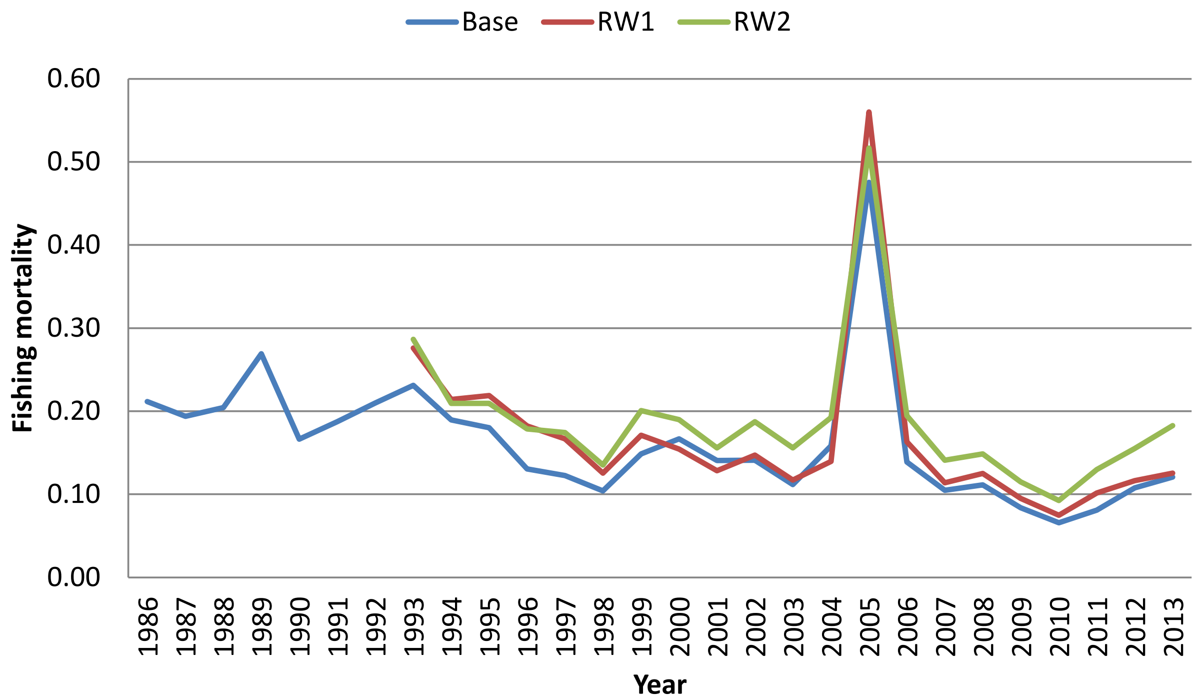
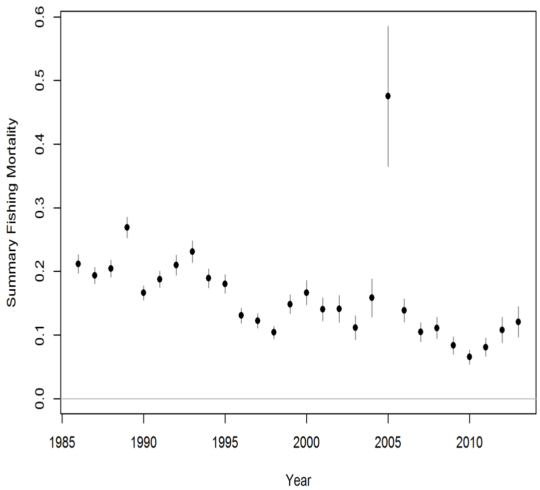
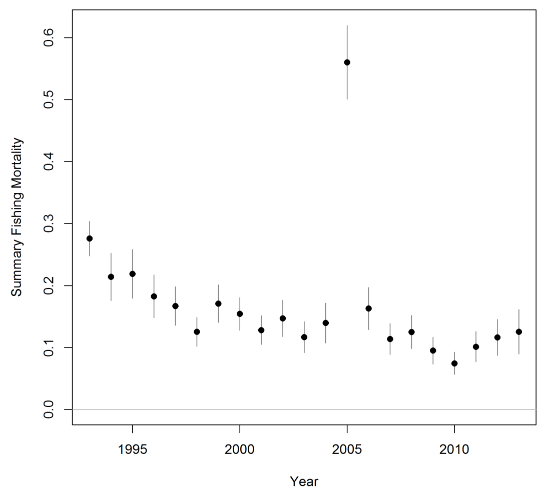


Figure A.1.33 Comparison of exploitation rate estimates.

a)



b)



c)

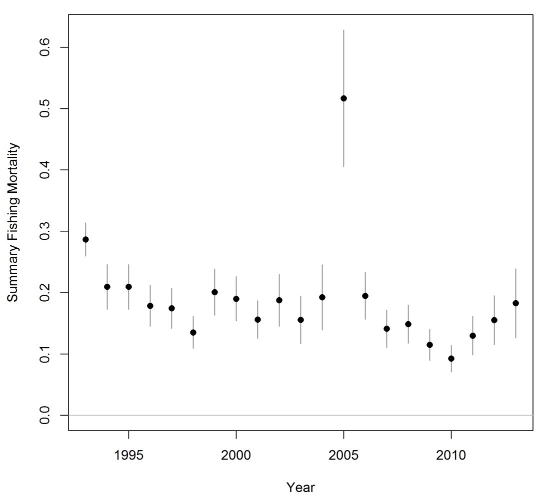


Figure A.1.34 Exploitation rates: a) Base_orig, b) RW1, and c) RW2.

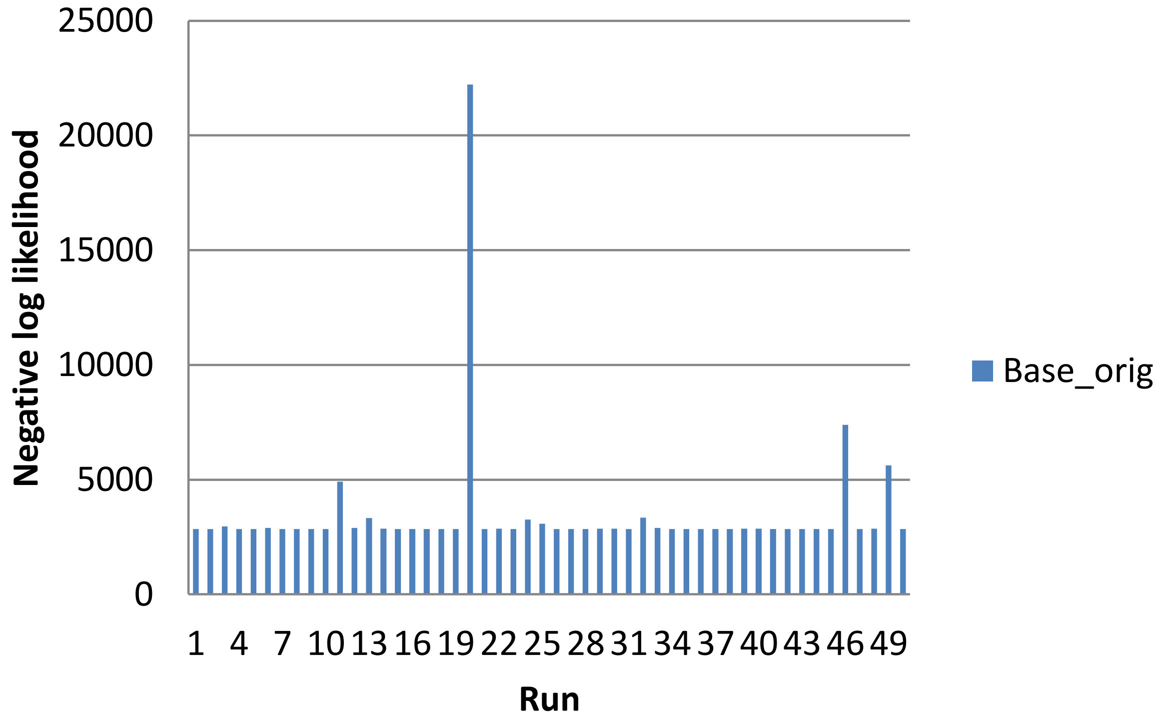


Figure A.1.35 Negative log likelihoods from jitter analysis of model Base_orig.

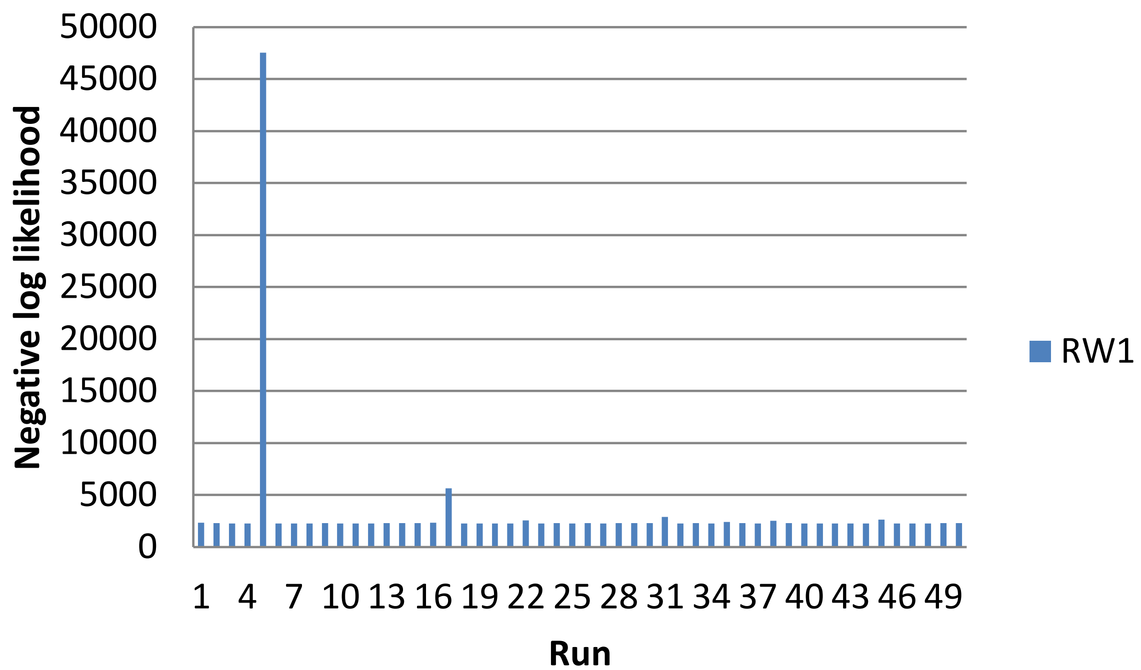


Figure A.1.36 Negative log likelihoods from jitter analysis of model RW1.

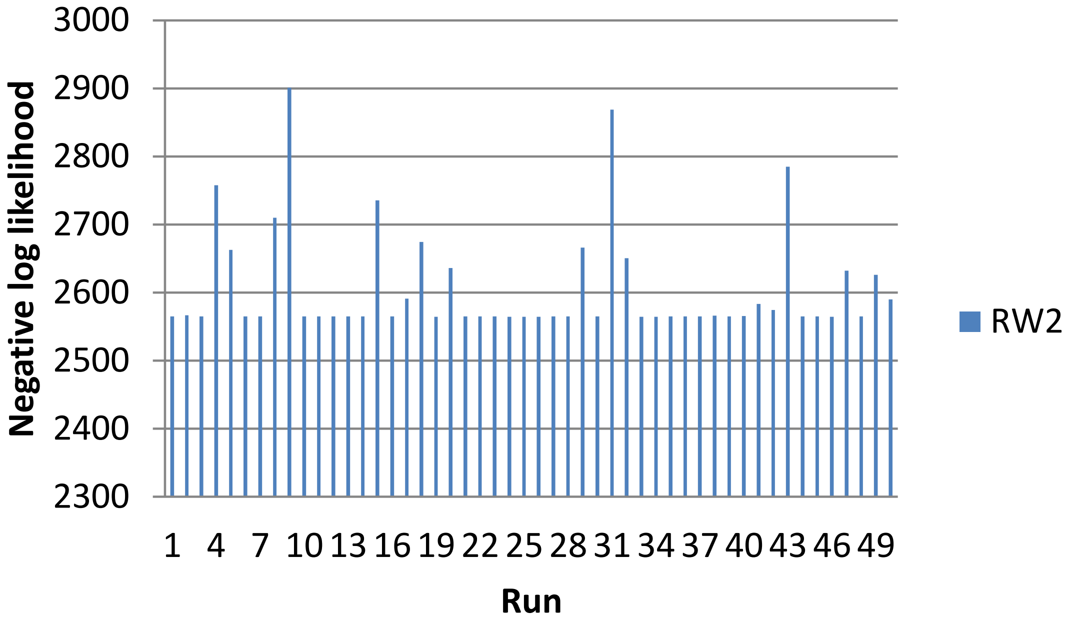


Figure A.1.37 Negative log likelihoods from jitter analysis of model RW2.

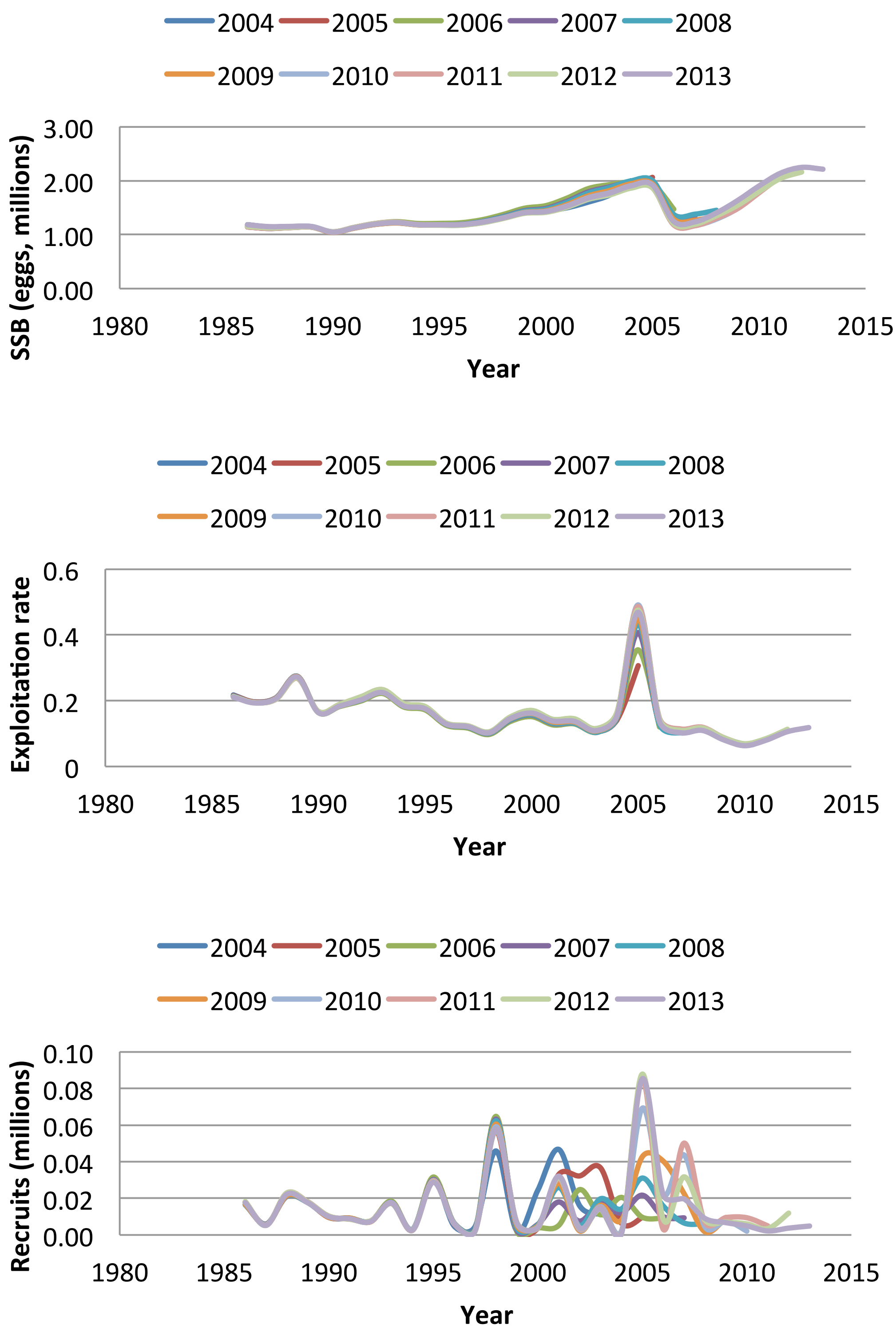


Figure A.1.38 Retrospectives results for model Base_orig. The proxy for SSB is eggs (as shown in the top panel), exploitation rate represents that total catch over total biomass (middle panel), and age-0 recruits (bottom panel).

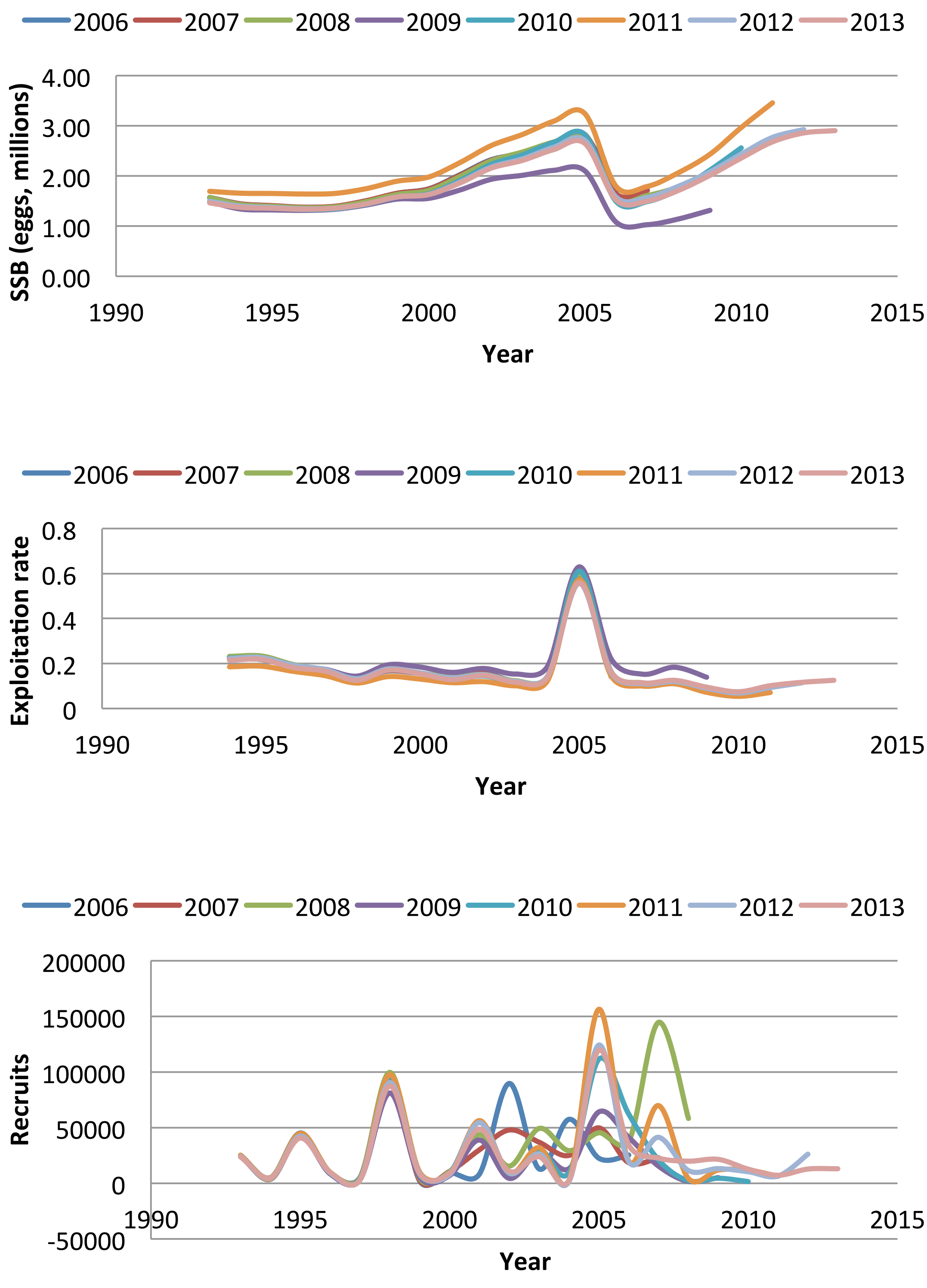


Figure A.1.39 Retrospectives results for model RW1. The proxy for SSB is eggs (as shown in the top panel), exploitation rate represents that total catch over total biomass (middle panel), and age-0 recruits (bottom panel).

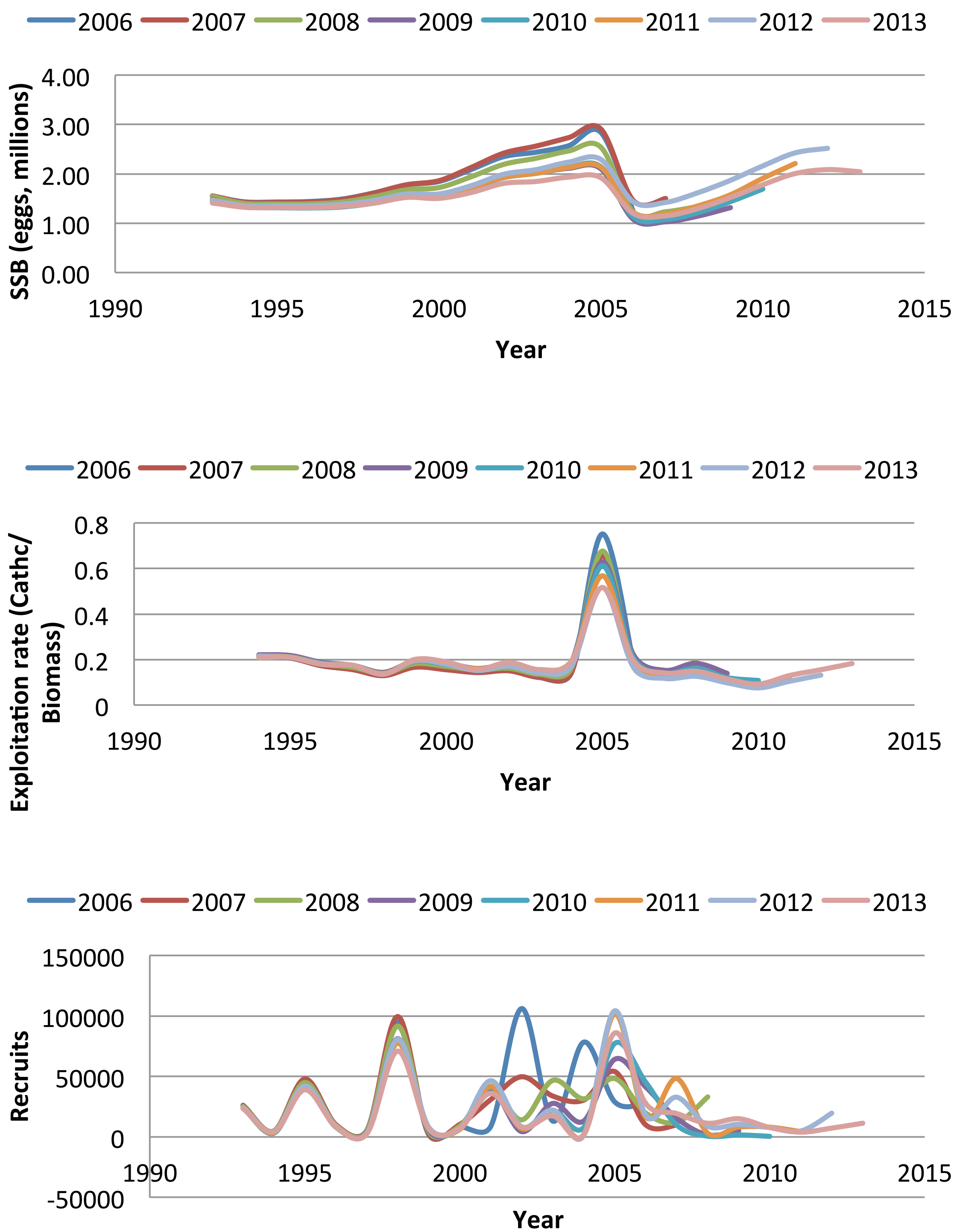


Figure A.1.40 Retrospectives results for model RW2. The proxy for SSB is eggs (as shown in the top panel), exploitation rate represents that total catch over total biomass (middle panel), and age-0 recruits (bottom panel).

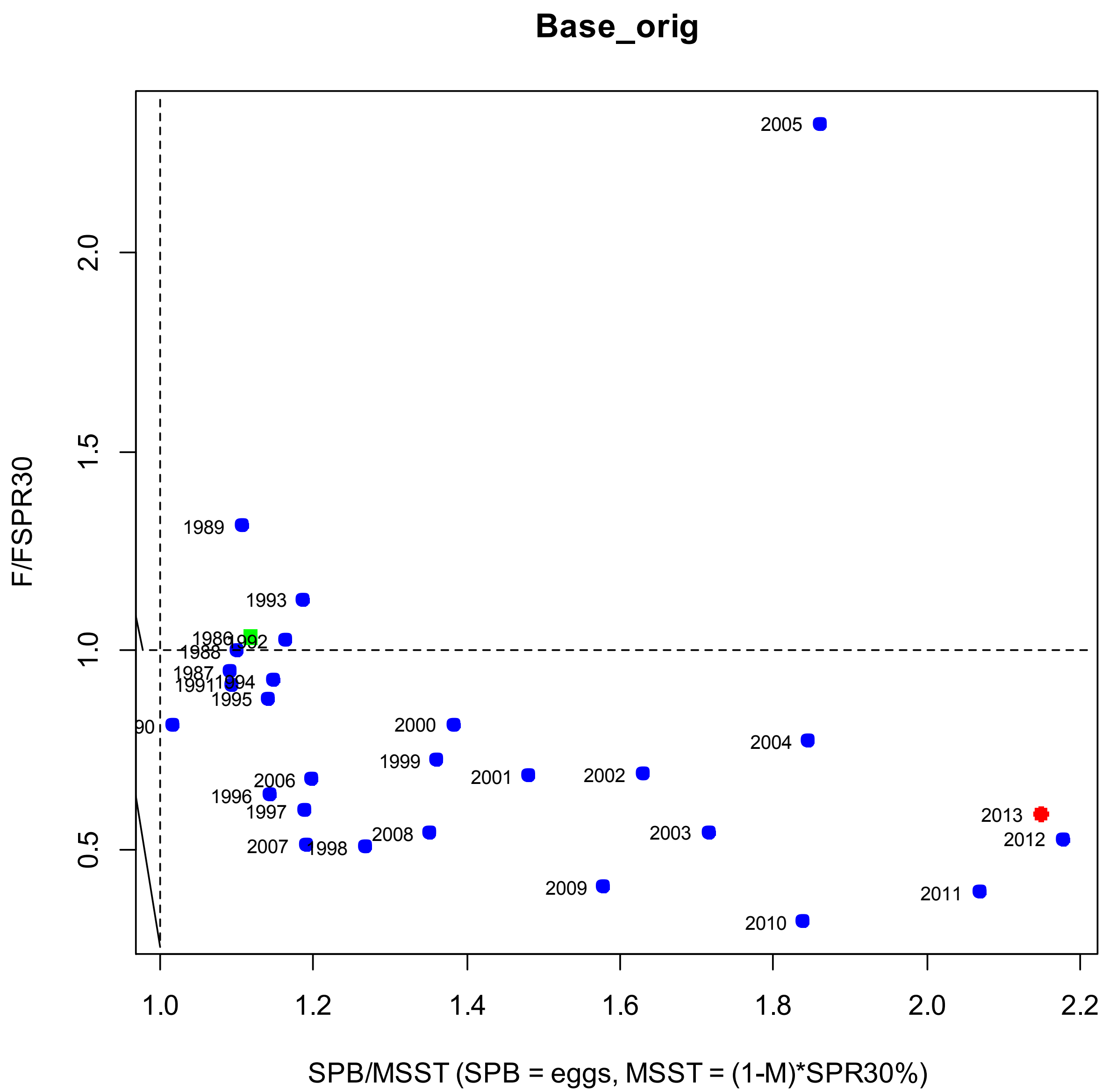


Figure A.1.41 Kobe plot showing stock status for Base_orig using SPR benchmarks, SPR30% and FSPR30%.

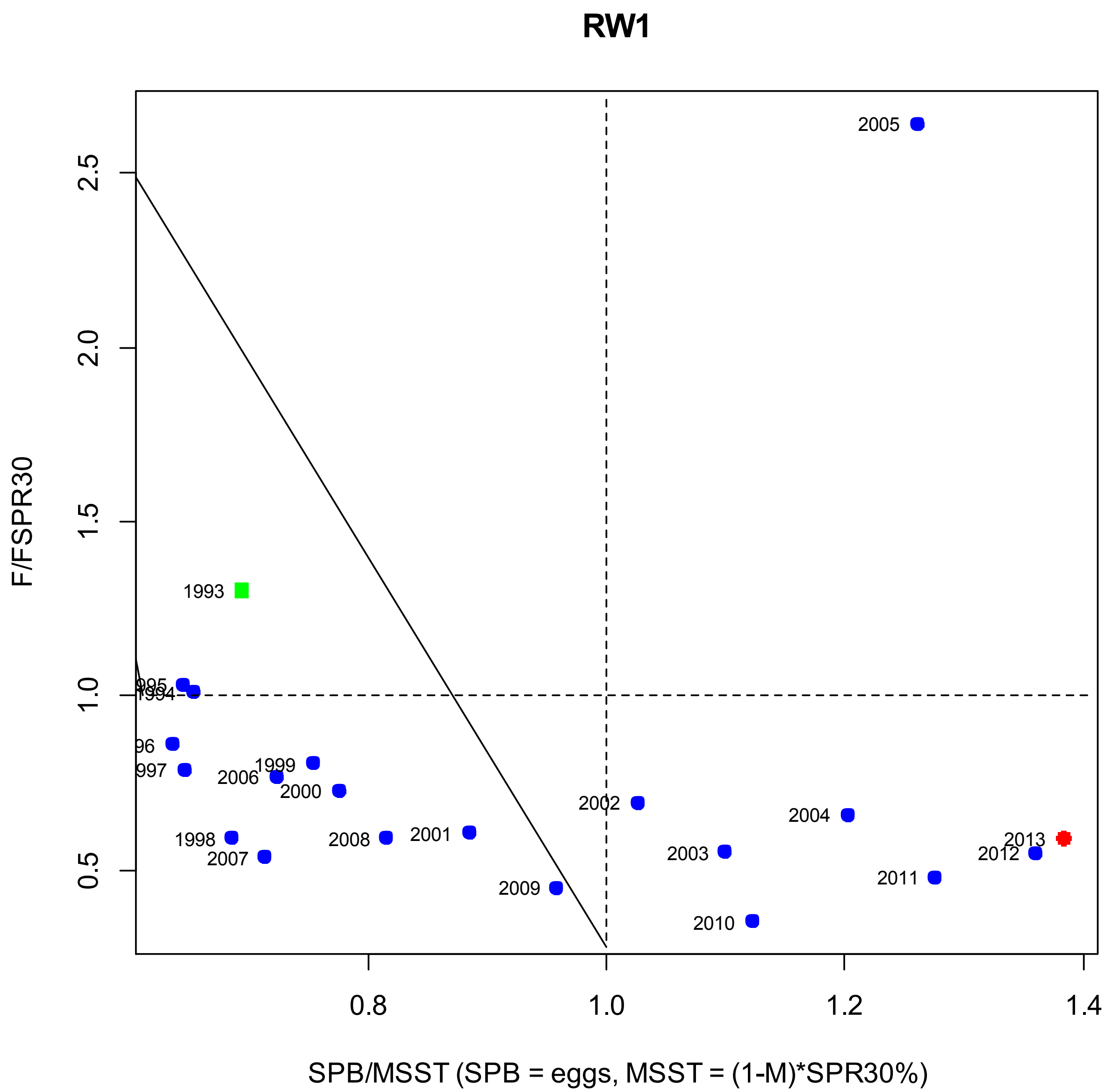


Figure A.1.42 Kobe plot showing stock status for RW1 using SPR benchmarks, SPR30% and FSPR30%.

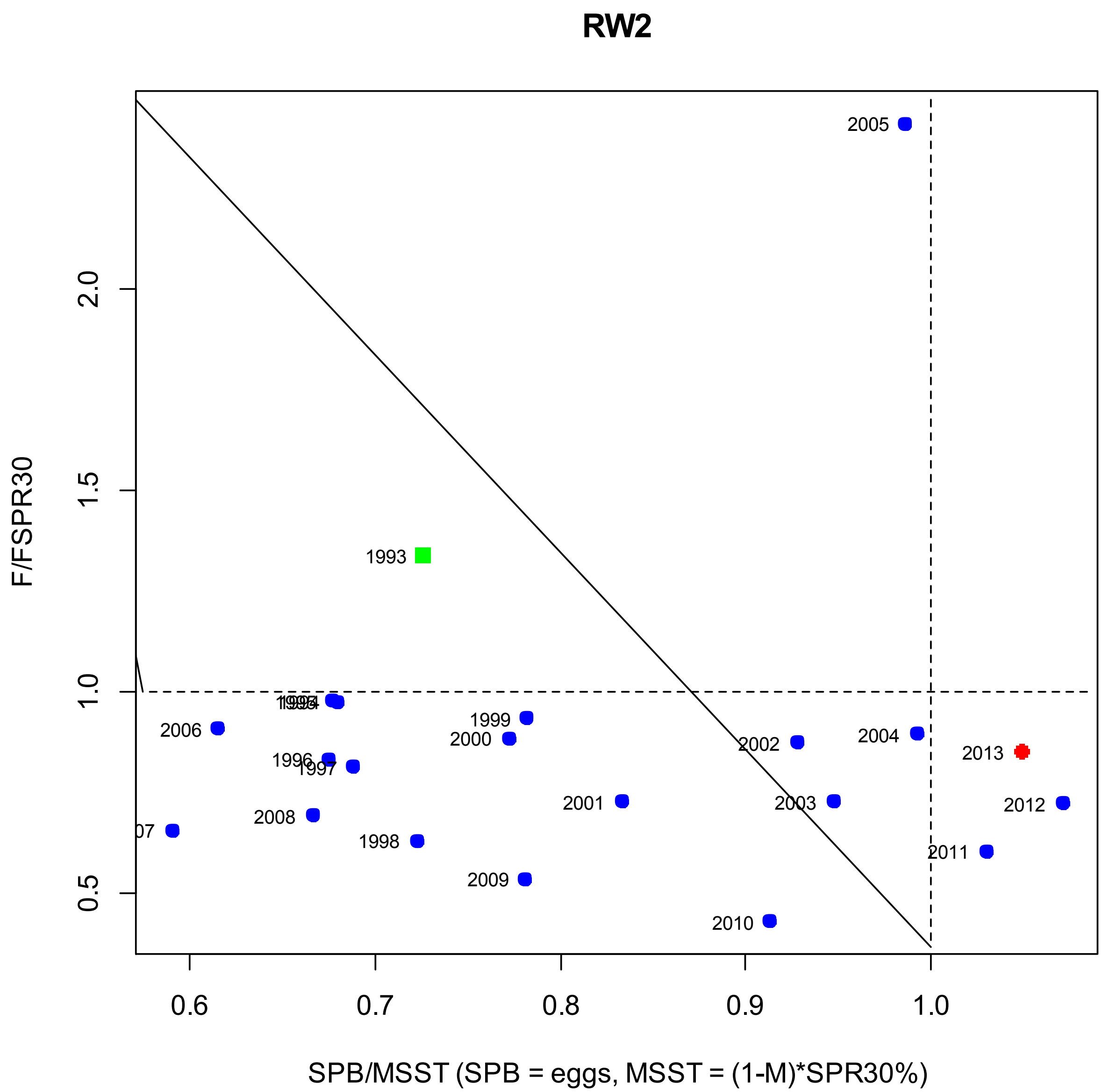


Figure A.1.43 Kobe plot showing stock status for RW2 using SPR benchmarks, SPR30% and FSPR30%.