SEDAR

Southeast Data, Assessment, and Review

SEDAR 10
Stock Assessment Report

Gulf of Mexico Gag Grouper

SEDAR 10
Stock Assessment Report 2

2006

SEDAR
One Southpark Circle #306
Charleston, SC 29414
(843) 571-4366

Table of Contents

SEDAR 10

Stock Assessment Report 2

Gulf of Mexico Gag Grouper

SECTION I. Introduction

SEDAR
1 Southpark Circle # 306
Charleston, SC 29414

1. SEDAR Overview

SEDAR (Southeast Data, Assessment and Review) was initially developed by the Southeast Fisheries Science Center and the South Atlantic Fishery Management Council to improve the quality and reliability of stock assessments and to ensure a robust and independent peer review of stock assessment products. SEDAR was expanded in 2003 to address the assessment needs of all three Fishery Management Council in the Southeast Region (South Atlantic, Gulf of Mexico, and Caribbean) and to provide a platform for reviewing assessments developed through the Atlantic and Gulf States Marine Fisheries Commissions and state agencies within the southeast.

SEDAR strives to improve the quality of assessment advice provided for managing fisheries resources in the Southeast US by increasing and expanding participation in the assessment process, ensuring the assessment process is transparent and open, and providing a robust and independent review of assessment products. SEDAR is overseen by a Steering Committee composed of NOAA Fisheries representatives: Southeast Fisheries Science Center Director and the Southeast Regional Administrator; Regional Council representatives: the Executive Directors and Chairs of the South Atlantic, Gulf of Mexico, and Caribbean Fishery Management Councils; and Interstate Commissions: the Executive Directors of the Atlantic States and Gulf States Marine Fisheries Commissions.

SEDAR is organized around three workshops. First is the Data Workshop, during which fisheries, monitoring, and life history data are reviewed and compiled. Second is the Assessment workshop, during which assessment models are developed and population parameters are estimated using the information provided from the Data Workshop. Third and final is the Review Workshop, during which independent experts review the input data, assessment methods, and assessment products.

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

SEDAR Review Workshop Panels consist of a chair and 3 reviewers appointed by the Center for Independent Experts (CIE), an independent organization that provides independent, expert reviews of stock assessments and related work. The Review Workshop Chair is appointed by the SEFSC director and is usually selected from a NOAA Fisheries regional science center. Participating councils may appoint representatives of their SSC, Advisory, and other panels as observers to the review workshop.

SEDAR 10 was charged with assessing gag grouper (*Mycteroperca microlepis*) in the U.S. waters of the South Atlantic and Gulf of Mexico. A separate stock assessment will be prepared for each management unit. For assessment purposes, the two units will be divided at the Council boundaries.

2. Management Overview

NOAA Fisheries Service and the Gulf of Mexico Fishery Management Council (Council), under provisions of the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), are responsible for management of species within the Gulf of Mexico exclusive economic zone (EEZ). To manage a given species (or group of species), the Council must first develop a fishery management plan (FMP) and submit it to the Secretary of Commerce (Secretary) for approval.

The Reef Fish FMP was one of the first FMPs developed by the Council. It was submitted in August 1981, approved by the Secretary in June 1983, and implemented in November 1984. The goal identified in the FMP was "to manage the reef fish fishery of the United States waters of the Gulf of Mexico to attain the greatest overall benefits to the Nation with particular reference to food production and recreational opportunities on the basis of maximum sustainable yield (MSY) as modified by relevant economic, social, or ecological factors." Pursuant to this goal, one of the primary management objectives set forth in the FMP was to rebuild declining reef fish stocks wherever they occur in the fishery.

2.1 Management Unit

This assessment report addresses gag grouper in the Gulf of Mexico. The management unit includes gag grouper in all waters within Gulf of Mexico Fishery Management Council boundaries.

2.2 Gag Regulatory History

The following history of management pertains only to actions that resulted in regulations directly affecting the gag fishery. These regulations and effective dates are summarized in Table 1.

Gag were included in the Reef Fish Fishery Management Unit (FMU), which was established in the Reef Fish FMP. Species initially included in the FMU were snappers, groupers, and sea basses. The FMP established a collective MSY of 51 million pounds (MP) and an optimum yield (OY) of 45 MP for snappers and groupers of the FMU.

Amendment 1 to the Reef Fish FMP, implemented in 1990, set a minimum size of 20-inches total length (TL) for gag and a five grouper recreational bag limit. Charter vessels and headboats on trips extending beyond 24 hours were allowed a two-day possession limit for reef fish, provided the vessel had two licensed operators aboard as required by the U. S. Coast Guard, and each passenger could provide a receipt to verify the length of the trip. Additionally, an 11.0 MP, whole weight (WW) commercial quota for grouper was established. The quota was divided into a 9.2 MP, WW, shallow-water grouper quota and a 1.8 MP, WW, deep-water grouper quota. The fishing year was defined as January 1 through December 31. The shallow-water grouper complex was defined as black grouper, gag, red grouper, Nassau grouper, yellowfin grouper, yellowmouth grouper, rock hind, red hind, speckled hind, and scamp. The deep-water grouper complex was defined as misty grouper, snowy grouper, yellowedge grouper, and warsaw grouper. Scamp would be included in the deep-water grouper quota should the shallow-water grouper quota be filled; goliath grouper (jewfish) were not included in the quotas. Also, a commercial reef fish vessel permit and a fish trap permit, with a maximum 100 trap per permit limit, were established. A longline and buoy gear boundary at approximately the 50-fathom depth contour west of Cape San Blas, Florida, and the 20-fathom contour east of Cape San Blas, Florida was established. Vessels fishing with longlines and buoy lines were prohibited from fishing inshore of the 20- and 50-fathom contours. Trawl vessels (other than vessels operating in the unsorted groundfish fishery) were limited to the recreational size and daily bag limits of reef fish. Entangling nets were also prohibited from directly harvesting reef fish and were limited to the recreational bag limit for reef fish caught in entangling nets for other fisheries. Finally, a framework procedure for specification of total allowable catch (TAC) was established to allow for annual management changes. Collectively, these regulations were intended to increase the survival rate of grouper into the stock of spawning age fish to achieve at least 20 percent spawning stock biomass per recruit (SSBR), relative to the SSBR that would occur with no fishing, by January 1, 2000.

A July 1991 regulatory amendment, 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. This quota increase was intended to provide the commercial fishery an opportunity to harvest 0.7 MP that went unharvested in 1990. A November 1991 regulatory amendment, which was implemented June 22, 1992, increased the shallow-water grouper commercial quota to 9.8 MP WW. A 1993 regulatory amendment, implemented January 1, 1994, established an allowable biological catch (ABC) of 15.1 MP WW for grouper harvest and maintained the commercial size limit of 20 inches TL.

The first stock assessment for Gulf of Mexico gag was conducted in 1994 (Schirripa and Goodyear, 1994). The Reef Fish Stock Assessment Panel (RFSAP) reviewed the assessment and concluded the stock was not overfished because the spawning potential ratio (SPR) was estimated at 30 percent, which was above the Council's management objective of 20 percent SPR (RFSAP, 1994).

In August 1998, the RFSAP reviewed the 1997 gag stock assessment (Schirripa and Legault, 1997), and did not consider gag to be overfished based upon the management goals of the time (transitional SPR 20 percent), but overfishing may have been occurring based upon the static SPR values (RFSAP, 1998). The RFSAP recommended the Council consider spatial and/or temporal closures designed to protect spawning aggregations. This recommendation was based on research indicating fishing on spawning aggregations can disrupt spawning (Shapiro, 1987; Coleman et al., 1996), result in a reduction in size of spawning fish (Koenig et al., 1996; Coleman et al., 1996), and even result in the loss of an entire aggregation (Gilmore and Jones, 1992; Eklund, 1994).

In response, a regulatory amendment, implemented June 19, 2000, increased the commercial size limit for gag from 20 to 24 inches TL, increased the recreational size limit for gag from 20 to 22 inches TL, prohibited commercial harvest and sale of gag, black, and red grouper each year from February 15 to March 15 (during the peak gag spawning season), and established two marine reserves (Steamboat Lumps and Madison-Swanson) closed year-round to fishing for all species under the Council's jurisdiction. The marine reserves were designed to protect gag spawning aggregations and provide locations to assess the efficacy of marine reserves to protect aggregations.

In October 2001, the RFSAP reviewed the 2001 stock assessment (Turner et al., 2001), and found gag not to be overfished or under going overfishing. The RFSAP recommended the

ABC be no higher than the average yield of the last three years of data (1997-1999), which is about 5 MP.

Secretarial Amendment 1, implemented July 15, 2004, established a ten-year red grouper rebuilding plan, structured in three-year intervals, which would end overfishing and rebuild the stock to MSY. The rebuilding plan sought to achieve a 9.4-percent reduction in the recreational and commercial harvest of red grouper, relative to the average landings for 1999-2001, during the first three years of the ten-year rebuilding plan. Measures in the final rule to accomplish this reduction equitably for the commercial and recreational sectors of the fishery established a 6.56 MP, gutted weight (GW) ABC for red grouper for the period 2003-2006, including a commercial quota of 5.31 MP, GW, and a 1.25 MP, GW, recreational target catch level. Measures in the final rule also reduced the commercial quota for shallow-water grouper from 9.35 to 8.80 MP GW, and reduced the deep-water grouper commercial quota from 1.35 to 1.02 MP GW. Secretarial Amendment 1 requires closure of the entire shallow-water grouper fishery when either the red grouper or shallow-water quota is reached.

At its November 7-12, 2004 meeting, the Council considered a request from the Southern Offshore Fishing Association (SOFA) and Gulf Fishermen's Association (GFA) for an interim or emergency rule to establish commercial trip limits for shallow-water and deep-water grouper. SOFA and GFA maintained the closure of both the deep-water grouper and shallow-water grouper fisheries, combined with the damaging effects of four hurricanes, severely impacted the Florida economy, especially the west coast and Panhandle. Trip limits were requested to potentially extend the 2005 fishing season and delay an end-of-year closure, thus reducing potential adverse economic consequences for all sectors of the commercial grouper fishery, including those fishing communities dependent upon it. After considerable discussion, the Council voted (14-1) to have NOAA Fisheries Service develop an emergency rule establishing these trip limits for the commercial grouper fishery in the Gulf of Mexico for the 2005 fishing year.

The industry-proposed trip limits were structured as follows: 1) On January 1, all vessels would be limited to a 10,000-pound, GW, trip limit for both deep-water grouper and shallow-water grouper combined; 2) if on or before August 1, the fishery is estimated to have landed more than 50 percent of either the shallow-water grouper or the red grouper quota, then a 7,500-pound, GW, trip limit would take effect; and 3) if on or before October 1, the fishery is estimated to have landed more than 75 percent of either the shallow-water grouper or the red grouper quota, then a 5,500-pound, GW, trip limit would take effect.

On February 17, 2005, NOAA Fisheries Service published in the *Federal Register* (70 FR 8037), the emergency rule establishing trip limits for the commercial shallow-water grouper and deep-water grouper fishery in the EEZ (effective March 3, 2005). This emergency rule was extended for an additional 180 days, through February 12, 2006. A regulatory amendment changing the commercial trip limit to 6,000 pounds GW for the entire fishing year is currently under review.

During 2003 and 2004, recreational red grouper landings exceeded the 1.25 MP, GW, target catch level. While landings in 2003 were only slightly greater than the target, 2004 landings were nearly 2.5 times greater and totaled 3.1 MP, GW. At its March 2005 meeting, the Council requested NOAA Fisheries Service implement an interim rule to reduce the 2005 recreational red grouper harvest to target catch levels established in Secretarial Amendment 1.

Without additional regulations, the Council expected recreational red grouper landings in 2005 to continue exceeding the 1.25 MP, GW, target.

The interim rule, implemented August 9, 2005, reduced the red grouper bag limit from two fish per person per day to one fish per person per day and established a closure of the recreational fishery, from November through December of 2005, for all grouper species. The combined effect of these measures was expected to reduce red grouper recreational harvest by 21.5 percent and was expected to reduce recreational harvest of other grouper by 17.8 percent. Because red grouper are part of a multispecies fishery, prohibiting harvest of all groupers during the seasonal closure would have reduced bycatch of red grouper and subsequent discard mortality. Applying the closure to all groupers would also protect other grouper species from a potential shift of fishing effort from red grouper to other groupers. The interim rule also reduced the aggregate bag limit to three grouper, combined, per person per day. The effect of this reduction in the aggregate bag limit was a 5.2-percent reduction in recreational harvest of groupers other than red grouper. The reduction in the aggregate bag limit would have provided protection of other grouper species from redirected red grouper fishing effort and would have reduced bycatch mortality of red grouper, assuming anglers ceased fishing when the aggregate limit was reached. The intended effects were to reduce overfishing of red grouper in the Gulf of Mexico and to minimize potential adverse impacts on other grouper stocks that could have resulted from a shift in fishing effort from red grouper to other grouper species.

The Coastal Conservation Association and Fishing Rights Alliance sued NOAA Fisheries Service shortly after implementation of the temporary rule, and on October 31, 2005, a court decision concluded interim measures could only be applied to grouper species undergoing overfishing. Therefore the interim regulations were modified as follows: 1) The aggregate grouper bag limit was increased from three to five fish per person per day; and 2) only red grouper were prohibited from being harvested during November-December 2005. The red grouper bag limit will remain one per person per day after the closure expires.

Amendment 21, implemented on June 3, 2004, 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 and to provide protection to a portion of the gag spawning aggregations.

2.3 Other Management Measures Affecting Gag

The following management measures may have had an indirect effect on gag either by altering fishing practices or causing fishing effort to shift. On November 7, 1989, NOAA Fisheries Service announced anyone entering the commercial reef fish fishery in the Gulf of Mexico and South Atlantic after a control date of November 1, 1989, may not be assured of future access to the reef fish fishery if a management regime is developed and implemented that limits the number of participants in the fishery.

Amendment 2, implemented in 1990, prohibited the harvest of goliath grouper to provide complete protection for this species in federal waters in response to declines in abundance throughout its range. In July 1991, **Amendment 3** was implemented, which provided additional flexibility in the annual framework procedure for specifying TAC by allowing the target date for rebuilding an overfished stock to be changed depending on changes in scientific evidence, except the rebuilding plan can not exceed 1.5 times the generation time of the species under consideration. It revised the FMP's primary objective, definitions of OY and overfishing, and framework procedure for TAC by replacing the 20 percent SSBR target with 20 percent spawning potential ratio (SPR). **Amendment 3** also transferred speckled hind from the shallow-water grouper complex to the deep-water grouper complex.

In May 1992, **Amendment 4** to the reef fish FMP was implemented, establishing a moratorium on the issuance of new commercial reef fish permits for a maximum period of three years. It also changed the time of year when TAC is specified from April to August and included additional species in the reef fish management unit. **Amendment 5**, implemented in February 1994, established restrictions on the use of fish traps in the Gulf of Mexico EEZ, implemented a three-year moratorium on the use of fish traps by creating a fish trap endorsement and issuing the endorsement only to fishermen who submitted logbook records of reef fish landings from fish traps between January 1, 1991, and November 19, 1992, created a special management zone (SMZ) with gear restrictions off the Alabama coast, created a framework procedure for establishing future SMZs, required all finfish except for oceanic migratory species be landed with head and fins attached, and closed the region of Riley's Hump (near Dry Tortugas, Florida) to all fishing during May and June to protect mutton snapper spawning aggregations.

Amendment 7, implemented in February 1994, established reef fish dealer permitting and record keeping requirements, allowed transfer of fish trap permits and endorsements between immediate family members during the fish trap permit moratorium, and allowed transfer of other reef fish permits or endorsements in the event of the death or disability of the person who was the qualifier for the permit or endorsement.

Amendment 9, implemented in July 1994, extended the commercial reef fish permit moratorium through December 31, 1995. In January 1996, the approved provisions of **Amendment 11** were implemented, which: (1) Required persons possessing Gulf of Mexico commercial reef fish permits to sell to permitted reef fish dealers; (2) required permitted reef fish dealers purchase reef fish caught in Gulf of Mexico federal waters only from permitted vessels; (3) allowed the transfer of reef fish permits and fish trap endorsements in the event of death or disability; (4) implemented a new commercial reef fish permit moratorium for no more than five years or until December 31, 2000, while the Council considered limited access for the reef fish fishery; (5) allowed permit transfers to other persons with vessels by vessel owners (not operators) who qualified for their reef fish permit; and (6) allowed a one time transfer of existing fish trap endorsements to permitted reef fish vessels whose owners have landed reef fish from traps in federal waters, as reported in logbooks received by the Science and Research Director of NOAA Fisheries Service from November 20, 1992, through February 6, 1994.

A ten-year phase out of the fish trap fishery was implemented in March and April 1997 through **Amendment 14**. It allowed transfer of fish trap endorsements for the first two years, and thereafter only upon death or disability of the endorsement holder to another vessel owned by the same entity, or to any of the 56 individuals who were fishing traps after November 19, 1992, and were excluded by the moratorium. The amendment also prohibited the use of fish traps west of Cape San Blas, Florida, provided the Regional Administrator of NOAA Fisheries Service with authority to reopen a fishery prematurely closed before the allocation was reached, and modified the provisions for transfer of commercial reef fish vessel permits. Additionally, the amendment prohibited the harvest or possession of Nassau grouper in the Gulf of Mexico EEZ, consistent with similar prohibitions in Florida state waters, the South Atlantic EEZ, and the Caribbean EEZ.

Amendment 15, implemented in January 1998, prohibited harvest of reef fish from traps other than permitted reef fish traps, stone crab traps, or spiny lobster traps.

Amendment 16A was partially approved and implemented on January 10, 2000. The approved measures provided: (1) The possession of reef fish exhibiting the condition of trap rash on board any vessel with a reef fish permit fishing for spiny lobster or stone crab is prima facie evidence of illegal trap use and is prohibited except for vessels possessing a valid fish trap endorsement; and (2) fish trap vessels submit trip initiation and trip termination reports. **Amendment 16B**, implemented in January 1999, set a recreational bag limit of one speckled hind and one warsaw grouper per vessel per day, with the prohibition on the sale of these species when caught under the bag limit.

The commercial reef fish permit moratorium was extended another five years to December 31, 2005, with the implementation of **Amendment 17** in September 1999. **Amendment 19** was implemented on August 19, 2002, which affected all FMPs for Gulf of Mexico fisheries, by establishing two marine reserve areas off the Dry Tortugas. Fishing for any species or anchoring by fishing vessels inside the two marine reserves was prohibited.

Amendment 20, also known as the Charter/Headboat Moratorium Amendment, affects the Reef Fish (Amendment 20) and Coastal Migratory Pelagic (Amendment 14) FMPs, and was implemented on July 29, 2002, except some provisions which became effective on December 26, 2002. It established a three-year moratorium on the issuance of charter and headboat vessel permits in the recreational for-hire reef fish and coastal migratory pelagic fisheries in the Gulf of Mexico EEZ. Soon after implementation of the permit moratorium, it was determined the amendments implementing regulations contained an error relating to eligibility criteria. NOAA Fisheries Service published an emergency rule in the *Federal Register* (67 FR 77193, December 17, 2002) until the error could be corrected through normal rulemaking. A final rule was published by NOAA Fisheries Service in the *Federal Register* (68 FR 26230, May 15, 2003) implementing corrected Amendments 14 and 20. Measures in the final rule: 1) Corrected the eligibility criterion; 2) reopened the application process for maintaining a moratorium permit; 3) extended the applicable deadlines for applying for and obtaining a moratorium permit; and 4) extended the expiration date of the moratorium.

Amendment 22, implemented on July 5, 2005, specified bycatch reporting methodologies for the reef fish fishery. **Amendment 24** replaced the commercial reef fish permit moratorium with a permanent limited access system. This amendment was implemented on August 17, 2005.

2.4 Future Actions

Amendment 18A, if implemented, would: 1) Prohibit vessels from retaining reef fish caught under the recreational size and possession limits when commercial catches of reef fish are onboard the vessel; 2) adjust the number of crew members allowed onboard when a dually permitted vessel is taking a commercial reef fish trip; 3) prohibit reef fish species, except sand perch and dwarf sand perch, from being used as bait by any gear type in the commercial and recreational fisheries; 4) require vessel monitoring systems onboard all commercially permitted reef fish vessels, including charter vessels with commercial reef fish permits operating in the Gulf of Mexico; 5) adopt rewording changes to the framework procedure and incorporate the Southeast Data, Assessment, and Review process into the TAC framework procedure; and 6) require vessels with commercial or for-hire reef fish vessel permits to comply with sea turtle and smalltooth sawfish release protocols, possess a specific set of release gear, and adopt guidelines for the proper care for incidentally caught sawfish.

Regulatory amendments affecting the commercial and recreational grouper fishery were approved by the Council in October and November 2005, respectively. If implemented, the commercial amendment will establish a 6,000-pound GW grouper trip limit. The recreational amendment will reduce the red grouper bag limit from two to one fish per person per day, establish a closed season from February 15 to March 15 for gag, red grouper, and black grouper, and prohibit captain and crew from retaining bag limits of grouper while under charter.

Generic Amendment 3 for addressing Essential Fish Habitat (EFH) is currently near implementation. EFH Generic Amendment 3 describes and identifies EFH for each fishery; identifies other actions to encourage the conservation and enhancement of such EFH; and identifies measures to minimize to the extent practicable any adverse effects of fishing on such EFH. Measures to protect EFH from adverse fishing effects include: Prohibit bottom anchoring over coral reefs in habitat areas of particular concern; prohibit use of trawling gear, bottom longlines, buoy gear, and all traps/pots on live coral reefs throughout the Gulf of Mexico EEZ; require a weak link in the tickler chain of bottom trawls on all habitats throughout the Gulf of Mexico EEZ; and establish an educational program on the protection of coral reefs for commercial and recreational fishermen.

2.5 Literature Cited

Coleman, F. C., C. C. Koenig, and L. A. Collins. 1996. Reproductive styles of shallow water groupers (Pisces: Serranidae) in the eastern Gulf of Mexico and the consequences of fishing spawning aggregations. Environmental Biology of Fishes 47:129-141.

Eklund, A. M.. 1994. Status of the stocks of Nassau grouper, *Epinephelus striatus*, and jewfish, *Epinephelus itajara* - final report. NOAA FISHERIES SERVICE/SEFSC Miami Laboratory Contribution No. MIA – 94/95 – 15.

Gilmore, R. G. and R. J. Jones. 1992. Color variation and associated behavior in the epinepheline groupers, *Mycteroperca microlepis* (Goode and Bean) and *M. phenax* (Jordan and Swain). Bull. Mar. Sci. 51 (1): 83-103.

Koenig, C. C., F. C. Coleman, L. A. Collins, Y. Sadovy, and P. L. Colin. 1996. Reproduction in gag, Mycteroperca microlepis, in the eastern Gulf of Mexico and the consequences of fishing spawning aggregations. In F. Arreguin-Sanchez, J. L. Monro, M. C. Balgos and D. Pauly (eds.) Biology, Fisheries and culture of tropical groupers and snappers. ICLARM Conf. Proc. 48, 449 p.

RFSAP. 2001. October 2001 Report of the Reef Fish Stock Assessment Panel. Gulf of Mexico Fishery management Council. Tampa, FL. 36 p.

RFSAP. 1998. August 1998. Report of the Reef Fish Stock Assessment Panel. Gulf of Mexico Fishery management Council. Tampa, FL. 19 p.

RFSAP. 1994. 1994 Report of the Reef Fish Stock Assessment Panel. Gulf of Mexico Fishery Management Council. Tampa, FL. 15 p.

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

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

Shapiro, M. J. 1987. Reproduction in groupers. Pp. 295 – 327 in: J. J. Polovina and S. Ralstin (ed.). Tropical Snappers and Groupers: Biology and Fisheries Management. Westview Press, Boulder, Co.

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

Table 1. Timeline and effective dates of various regulations for the Gulf of Mexico gag fishery

Effective Date	Action
February 21, 1990	Establish minimum size of 20 inches TL and 5 grouper recreational bag limit; 9.2 MP, WW, shallow-water quota.
1990	Selected vessel logbook reporting. (SEE NOTE)
November 12, 1991	Increase in shallow-water quota from 9.2 to 9.9 MP, WW.
June 22, 1992	Commercial shallow-water grouper quota set at 9.8 MP WW(NOTE: The change in quota was due to a change in the gutted to whole weight conversion factor and did not represent any change in the actual amount of fish that could be landed.)
May 1992	Commercial Reef Fish Permit Moratorium
1994.	100% logbook Reporting. (SEE NOTE)
January 1, 1994	Established a 15.1 MP ABC, and maintained the 20 inch TL commercial size limit.
February 1994	Fish trap moratorium. Dealer permit and record-keeping requirements.
February 1997	10-yr phase-out of fish traps initiated.
June 19, 2000	Increased the commercial size limit for gag from 20 to 24 inches TL, increased the recreational size limit for gag from 20 to 22 inches TL, prohibited commercial harvest and sale of gag, black, and red grouper each year from February 15 to March 15, and established two marine reserves (Steamboat Lumps and Madison-Swanson) closed year-round to fishing for all species under the Council's jurisdiction..
June 2003	Charterboat/Headboat moratorium
June 3, 2004	Steamboat Lumps and Madison-Swanson marine reserves were continued for an additional six years.
July 15, 2004	Shallow-water aggregate quota reduced to 8.8 MP, GW; Red grouper quota of 6.56 MP, GW, 5.31 MP, GW commercial quota, and 1.25 MP, GW recreational allocation. Deepwater grouper commercial quota closure.
November 15, 2004	Shallow Water Grouper commercial quota closure
February 17, 2005	Commercial trip limits implemented; 10,000-pound limit to start, 7,500-pound limit when 50 percent of the quota is reached (6/9/2005), and 5,500-pound limit when 75 percent of the quota is reached (8/4/2005).
June 23, 2005	Deepwater Grouper quota closure.
August 9, 2005	Aggregate bag limit reduced from 5 to 3 fish per person per day, and closed season for all recreational grouper harvest for November-December 2005. Red grouper recreational bag limit reduced from 2 to 1 fish per person per day.
October 10, 2005	Shallow Water Grouper quota closure
October 31, 2005	Aggregate bag limit for recreational grouper increased from 3 to 5 fish per person per day, and only a red grouper closure for November-December 2005.
November 1, 2005	Red grouper recreational harvest closed Nov. 1, 2005 to Dec. 31 2005. Other groupers remain open
January 1, 2006	6,000 pound commercial trip limit for all SWG and DWG, combined

Under review	1 red grouper (out of 5 aggregate grouper bag limit), zero bag limit of grouper for captain and crew of recreational for hire vessels, and Feb. 15 to March 15 recreational closure for gag, black and red grouper

NOTE on 100% reporting requirement: Reef fish vessel logbook reporting was initiated in April 1990 with a subsample of the permittees required to submit logs of their catch and effort by gear, area and species caught on each trip. In the first year of the program, the selection of the permittees that would be required to report was based on an intent to census trap fishermen and to obtain a 20 percent sample of the fishermen using other gears. In 1991 and 1992 the intent was to census all trap fishermen and all permittees residing outside of Florida and maintain a 20% sample of the vessels owned by Florida residents. In June 1992, the Council requested that NMFS initiate 100 percent coverage for all vessels. Full coverage was phased in by providing logbooks to the vessel owners with the permit renewals. Consequently, 1993 was a transition year, and 100 percent coverage was in place by 1994.

Table 2. Specific Management Criteria for Gulf of Mexico Gag Grouper

Criteria	Current		Proposed	
	Definition	Value	Definition	Value
MSST	20% SPR[1]	UNK	$(1-M)B_{MSY}$[2]	SEDAR10
F_{MSY}	$F_{30\%SPR}$[3]	0.448[4]	F_{MAX}[4]	SEDAR10
MFMT	$F_{30\%SPR}$	0.448[4]	F_{MSY}	SEDAR10
MSY	undefined[5]	[6]	Yield at F_{MSY}[4]	SEDAR10
OY	Yield at 20% SPR[5]	[6]	Yield at 75% of F_{MSY}[2,7]	SEDAR10
F_{OY}	undefined	[6]	$0.75(F_{MSY})$[2,7]	SEDAR10
M	2001 assessment	0.15	SEDAR 10	SEDAR10
Probability value for evaluating status		undefined		50%

1. Source: Reef Fish Amendment 1

2. Following SEDAR 10, the Council may want to consider alternative definitions for MSST, OY, and F_{OY}.

3. Source: Generic Sustainable Fisheries Act Amendment, 1999 (note: fishing mortality thresholds/targets in this amendment based on SPR were accepted by NMFS, but biomass thresholds/targets based on SPR were rejected.)

4. Source: October 2001 RFSAP report; F_{MAX} was used as a proxy for F_{MSY} after consideration of $F_{30\% SPR}$ and $F_{0.1}$ alternate proxies.

5. Proposed biomass definitions of MSY at 30% static SPR, and OY at 40% static SPR, were rejected by NMFS on the basis that SPR was not an appropriate proxy for biomass.

[6.] Values for MSY, OY, and F_{OY} were calculated for the 2001 gag stock assessment. These values are based on different definitions then those currently approved by the Council. MSY = yield at F_{MSY} = 5.58; OY = yield at F_{OY} = 6.09, and $F_{OY} = F_{40\%SPR}$ = 0.327

[7.] Proposed definitions for OY and F_{OY} are based on those adopted by the Council for red grouper.

Table 3. Stock projection information.

First Year of Management:	2008
Projections for interim years should be based on:	If available, actual landings for 2005 should be used for projections. Projections and criteria values for interim years should take into consideration grouper regulatory changes in 2004 and 2005: shallow-water grouper reduced, red grouper bag limit reduced, aggregate grouper bag limit temporarily reduced (See Table 1 for specific management details)
Projection criteria values for interim years should be determined from:	

Table 5. Quota Calculation Details

Note that the quota applies to a species complex.

Current Quota Value	8.80 mp gutted weight[1]
Next Scheduled Quota Change	After red grouper SEDAR (~2008)
Annual or averaged quota ?	Annual
Does the quota include bycatch/discard ?	No

[1.] Quota applies to all shallow-water grouper (gag, red grouper, black grouper, scamp, yellowmouth grouper, yellowfin grouper, red hind, and rock hind)

3. Assessment History

Gulf of Mexico gag grouper were last assessed in 2001 (Turner et. al, 2001). Previous assessments include Schirripa and Goodyear (1994) and Schirripa and Legault (1997).

The 2001 assessment used VPA methods incorporating information on landings and discards from 1986 primarily through 1999, size composition, size at age and catch rate information from multiple recreational and commercial fisheries. Improvements over previous assessments included an additional catch-at-age derived from observed age composition, a revised growth curve, and additional emphasis on development of indices of abundance. The assessment produced a wide range of values for current fishing mortality and stock status criteria, and determined that stock status was uncertain. Due to uncertainty in the stock-recruitment relationship, reference points were based on SPR proxies. Because gag grouper is a protogynous hermaphrodite, the status of both male and female portions of the stock was evaluated.

References

Turner, S. C., C. E. Porch, D. Heinemann, G. P. Scott, and M. Ortiz. 2001. Status of Gag in the Gulf of Mexico: Assessment 3.0. NMFS, Southeast Fisheries Science Center, Miami Laboratory, Miami CRD-01/02-134

Schirripa, M.J. and C.P. Goodyear. 1994. Status of the gag stocks of the Gulf of Mexico: Assessment 1.0. NMFS, Southeast Fisheries Center, Miami Laboratory, Miami CRD-93/94-61. 156 pp

Schirripa, M.J. and C. M. Legault. 1997. Status of the gag stocks of the Gulf of Mexico: Assessment 2.0. NMFS Miami Laboratory MIA-96/97-19. 135pp

SEDAR 10 Review Workshop

Assessment Advisory Report
Gulf of Mexico Gag Grouper

July 27, 2006
revised: September 20, 2006

Stock distribution and identification

- The management unit for Gulf of Mexico gag grouper extends from the United States – Mexico border in the west through northern Gulf of Mexico waters and west of the Dry Tortugas and the Florida Keys (waters within the Gulf of Mexico Fishery Management Council Boundaries).
- The SEDAR 10 Review Workshop (RW), using several sources of information, examined and accepted the current stock definitions for the South Atlantic and Gulf of Mexico gag grouper.

Assessment methods

- Gulf of Mexico gag grouper were primarily assessed with a statistical forward projection catch-at-age model (CASAL). Additionally, the assessment model used in the 2001 assessment (VPA, virtual population analysis), was run to show the effects of updated data and the effects of adding indices of abundance not available in 2001. With the statistical catch-at-age model, various configurations and sensitivity runs were explored. Details of all models are available in the Stock Assessment Report.
- The Assessment Workshop (AW) developed two base runs: one assuming constant catchability for the fishery- dependent indices and the other assuming a time-varying catchability. Each base run of the catch-at-age model was the basis for estimation of benchmarks and stock status.
- The SEDAR 10 Review Workshop recommended the run with constant catchability as the preferred ‘base run’.
- The RW carefully reviewed the stock recruitment relationships developed from 1983-2004, considering the Beverton- Holt, Ricker and “hockey stick” (Barrowman and Meyers, 2000) models. Although the AW preferred the Beverton-Holt relationship over the Ricker, the RW concluded that both might overestimate virgin recruitment and, thus, MSY and SSB_{MSY}.

Assessment data

- Data sources include abundance indices, recorded landings and catch estimates, and calculated total annual size and age composition from the fisheries.

- Both fishery-dependent and fishery-independent indices of abundance were included in the assessment. Fishery-dependent abundance indices were available from the commercial handline fishery, the commercial longline fishery, the recreational headboat fishery and a combined index from the recreational charter and private boat fisheries (MRFSS) as presented by the SEDAR-10 data workshop. The two fishery-independent abundance indices were developed from the SEAMAP reef fish video survey.
- Catch information (including both landings and dead discards) was available for all recreational and commercial fisheries. This benchmark assessment included data through 2004.
- Complete details are available in the SEDAR 10 Data and Assessment Workshop Reports, and the SEDAR 10 workshop working papers. Additional information and discussion can be found in the companion SEDAR 10 Review Workshop Consensus Summary Report for Gulf of Mexico Gag Grouper.

Catch trends

- Estimated catches (landings and dead discards) in the last 7 years (1998-2004) have exceeded all previous levels and show an increasing trend since 2000. The 2004 estimated catches were about 85% higher than the highest estimated catches before 1998 and about 75% above the latest estimated catches (1999) used in the last assessment. Commercial landings since the late 1990's have increased about 60% compared to the 1980's (Figure 1). Estimated recreational landings have almost doubled since the 1980's while the estimated recreational dead discards have roughly tripled (Figure 2).

Fishing mortality trends

- Estimated annual fishing mortality[1] rates have generally increased over the period of the assessment, ranging from about 0.2 to about 0.5 (Figure 3). In the last four years the annual fishing mortality rate has increased every year and is currently estimated to be 0.49.

Stock abundance and biomass trends

- During the 1980's recruitment was estimated to average about 1.4 million fish (age 1). Since 1990 recruitment has averaged about 3 million fish (Figure 4). The model estimated that there were four strong year classes from 1990 to 2000 which averaged about 4.8 million fish. After 2000, estimated recruitment declined each year and was estimated to be 2.3 million fish in 2004.

- Estimated spawning stock biomass declined during the late 1960's and the 1970's, remained at about 20 million pounds during the 1980's and early 1990's and then increased from 1997 to 2001, perhaps as a result of the higher recruitment. Since 2002 spawning stock biomass has remained at about 41 million pounds (Figure 4). Estimated

[1] Assessment runs with CASAL software output "fishing pressure" rates estimated from a Pope's approximation to fit catches within a specific time and area partition of the model. For comparison fishing pressure values were converted to the equivalent annual fishing mortality rates (F), the common reference benchmark in fisheries.

total biomass followed a similar pattern with lower levels in the 1980's and an increase in the 1990's. Estimated total biomass peaked at about 56 million pounds in 2002 and then declined to an estimated 51 million pounds in 2004.

Status determination criteria

- The SFA and management criteria recommendations and values are estimated from the preferred base model by the RW as follows.

Stock Status	Current Definition	Value from Previous Assessment	Value from Current Assessment
MSST	$SPR_{20\%}$ (pre-SFA)	NA	NA
MFMT	$F_{30\%SPR}$ (F_{MSY} Proxy)	0.45	0.25
MSY	Yield at $F_{30\%SPR}$ (F_{MSY} proxy)	5.5 mp	4.3 mp
OY	Yield at $SPR_{20\%}$	NA	NA
F_{OY}	undefined	NA	NA

Proposed Status Criteria	Constant Catchability	
	Definition	Value
MSST	$(1-M)SSB_{MSY}$ (see Special Comments)	NA
MFMT	F_{MSY}	NA
MSY	Yield at F_{MSY}	NA
OY	Yield at $F_{40\%SPR}$	NA
F_{OY}	$F_{40\%SPR}$	NA
M (Age-varying)	Constant Equivalent	0.14

Constant Catchability, Geometric Mean Recruitment 1984-2004			
Additional Benchmarks	Exploitation Rate	SSB[1]	Yield[1,2]
F_{MAX}	0.23	37.6 mp	8.66 mp
$F_{20\%SPR}$	0.37	23.1 mp	8.24 mp
$F_{30\%SPR}$	0.25	34.6 mp	8.64 mp
$F_{0.1}$	0.13	55.9 mp	8.53 mp

1. Assuming future recruitment is equal to geometric mean recruitment from 1984-2004
2. Yield values reflect both landings and dead discards.

Stock Status

- Estimated recruitment has ranged from 1 to 6 million fish over a moderate range of spawning stock sizes, resulting in a high degree of uncertainty about the stock recruitment relationship and estimates of biomass benchmarks (MSY, SSB_{MSY} and MSST). Because of the uncertainty in the biomass benchmarks, current stock status (SSB_{2004} / SSB_{MSY}) is not reported.
- Because of this, the MSY-based benchmarks in this assessment were not deemed useful for management.
- The current (2004) annual fishing mortality rate on this stock is estimated as 0.49. Relative to the current proxy for F_{MSY} ($F_{SPR30\%}$), estimated as 0.25, overfishing of the Gulf of Mexico gag grouper is occurring.
- For the Gulf of Mexico, a MFMT of 0.25 (current value of $F_{30\%SPR}$) is not consistent with the recent dynamics of gag grouper: fishing mortality has been fluctuating around F = 0.36 for more than twenty years (1985-2004) and the stock biomass is near its historical maximum. The Review Panel could not provide advice on target F and biomass reference points, but noted that the stock has apparently increased as a result of good recruitment under estimated fishing mortality rates that have fluctuated around an average value of F = 0.36 since the early 1980s. The Review Panel advised that it would be prudent to reduce fishing mortality below F = 0.36.
- There is currently not a SFA-compliant definition of stock status relative to abundance. Apparently the Gulf of Mexico Fishery Management Council uses (1-M)*SSB_{MSY} as a working definition. Since the value of that reference point cannot be determined, the status of the stock with respect to biomass is unknown
- The Review Panel notes that available stock recruitment information suggests that recruitment may be impaired below 20 million pounds. Given that the model estimates of the spawning stock biomass benchmarks are uncertain, the Panel recommends that the Council consider 20 million pounds as a temporary operational definition of the lower bound for spawning stock size (i.e. MSST). Relative to the Review Panel's suggestion of an operational MSST of 20 million pounds, the stock is not overfished and is not approaching an overfished state.

Projections

- Projections assumed a constant stock recruitment relationship equal to geometric mean recruitment (1984-2004; 2,124,871 fish). Projections were generated for true yield (landings only) and total removals (landings plus dead discards) assuming 2005 total removals of 12.38 million pounds (5.81 mp landed and 6.57 mp dead discards). Stock projections were done for scenarios of constant catch (fixed quotas) and constant fishing mortality rate (F) but only those assuming constant F are shown here.

- Projections for spawning stock biomass (mature females in mp), annual fishing mortality and total removals and yield at various levels of constant fishing mortality rates starting in 2006 are shown in Table 3 and Figure 8.

Special Comments

- *Constant and time-varying catchability alternative.* The Review Panel discussed the relationship of technology to catchability and the effects of catchability changes on fishery-dependent abundance indices. The Panel recognized that technology improvements over time, particularly better electronics, have likely made fishermen more effective and efficient at catching fish. The Panel, however, did not support an assessment that assumed a simple linear (2% annually) increase. Nevertheless, this is an important issue and the Review Panel recommends further investigations of time-varying catchability.

- *Stock-recruitment relationship.* In both stock areas, the stock and recruitment scatter plot does not suggest that recruitment is strongly linked with SSB. In the South Atlantic, the Beverton-Holt stock-recruitment relationship indicates little change in recruitment for a wide range of SSB's and that B_{MSY} falls in the range of SSB's observed in the past. On the other hand, the Ricker stock-recruitment relationship indicates that maximum recruitment occurs at SSBs lower than those observed over the period of the assessment, which implies that B_{MSY} would also be lower than those observed in the period of the assessment. In the Gulf of Mexico, both the Beverton-Holt and Ricker relationships suggest that considerably higher recruitment would result from larger SSBs and SSB_{MSY} is estimated to be higher than SSB's observed in the past. The Review Panel considers that the stock recruitment relationships in the two stock areas are equally uncertain. The derived benchmarks are considered useful for management in the South Atlantic, because they are within the range of past observed values. In the Gulf of Mexico, more stock and recruitment observations are necessary to confirm that the benchmarks estimated in the current assessment are indeed attainable.

- *Discussion of RW recommended MSST.* MSST, defined as (1-M)*SSB_{MSY}, is very close to SSB_{MSY} because M = 0.14 is used. Given the uncertainties in the assessment, the biomass would be expected to be estimated to fall below MSST with a relatively high frequency even if true biomass were close to B_{MSY}. In the Gulf of Mexico, there are indications that recruitment could become impaired below a SSB of 20 million lbs and the Review Workshop suggested that MSST could be set at this level as a temporary operational definition, to be re-examined at the next assessment.

- *Document Revisions.* This document was revised in September 2006 to clarify language regarding the level of fishing. References to 'exploitation rate' and 'fishing pressure' were removed and replaced with 'fishing mortality'. Table and text values reflecting either exploitation rates or fishing pressure were replaced with *F* values (instantaneous fishing mortality rate) where appropriate.

Table 1. Landings and discards for commercial longline fisheries; longline, handline and others, and for recreational fisheries; private/charter (MRFSS) and headboat in columns 1 to 7. Columns 8 to 11 shows the partition of landed and discards by sector, 1963-2004. All values are in gutted weight pounds.

							Landings		Dead discards		
Year	Headboat	MRFSS	Longline	Handline	Others	Total	Commercial	Recreational	Commercial	Recreational	Total
1963	-	443,710	-	1,288,786	1,445	1,733,941	1,290,231	443,710	-	-	1,733,941
1964	-	479,243	-	1,632,460	9,088	2,120,792	1,641,549	479,243	-	-	2,120,793
1965	-	517,622	-	1,815,588	573	2,333,783	1,816,162	514,193	-	3,429	2,333,784
1966	-	559,075	-	1,456,566	1,227	2,016,868	1,457,793	546,372	-	12,703	2,016,868
1967	-	603,848	-	1,155,546	9,839	1,769,233	1,165,387	580,407	-	23,441	1,769,234
1968	-	652,205	-	1,192,284	4,414	1,848,904	1,196,699	616,389	-	35,816	1,848,905
1969	-	704,436	-	1,376,520	3,205	2,084,161	1,379,725	654,412	-	50,024	2,084,161
1970	-	760,849	-	1,283,654	2,502	2,047,005	1,286,158	694,572	-	66,277	2,047,007
1971	-	869,493	-	1,376,502	2,782	2,248,777	1,379,285	779,756	-	89,737	2,248,778
1972	-	993,651	-	1,460,381	3,980	2,458,012	1,464,362	875,105	-	118,546	2,458,013
1973	-	1,135,538	-	1,081,222	4,899	2,221,659	1,086,122	981,786	-	153,752	2,221,660
1974	-	1,297,685	-	1,184,110	1,355	2,483,150	1,185,465	1,101,090	-	196,595	2,483,150
1975	-	1,482,652	-	1,446,621	4,465	2,933,737	1,451,086	1,234,168	-	248,483	2,933,738
1976	-	1,697,042	-	1,198,438	9,115	2,904,595	1,207,552	1,385,311	-	311,731	2,904,594
1977	-	1,942,432	-	977,267	7,513	2,927,212	984,780	1,554,358	-	388,074	2,927,212
1978	-	2,225,942	-	875,262	10,952	3,112,156	886,213	1,745,396	-	480,546	3,112,155
1979	-	2,551,406	1,383	1,342,247	9,685	3,904,721	1,353,314	1,959,527	-	591,879	3,904,720
1980	-	2,908,996	89,304	1,317,859	11,866	4,328,024	1,419,030	2,187,337	-	721,659	4,328,026
1981	-	2,458,563	467,068	1,498,744	15,608	4,439,984	1,981,421	1,829,502	-	629,061	4,439,984
1982	-	3,508,922	1,009,998	1,334,617	14,163	5,867,699	2,358,780	3,216,983	-	291,939	5,867,702
1983	-	7,459,833	681,064	1,039,425	17,652	9,197,974	1,738,139	6,379,368	-	1,080,465	9,197,972
1984	-	2,134,042	433,159	1,098,289	18,407	3,683,897	1,549,855	1,950,479	-	183,563	3,683,898
1985	-	6,967,353	380,850	1,398,341	27,879	8,774,423	1,807,070	6,570,911	-	396,442	8,774,423
1986	308,430	4,263,230	517,405	1,155,013	29,022	6,273,100	1,701,441	3,597,491	-	974,168	6,273,101
1987	230,540	2,827,000	656,042	852,579	29,544	4,595,705	1,538,166	2,447,832	-	609,708	4,595,706
1988	164,606	4,223,613	402,244	791,073	23,178	5,604,715	1,216,494	3,747,483	-	640,736	5,604,713
1989	337,797	3,264,214	426,018	1,235,438	31,374	5,294,841	1,692,830	2,314,324	-	1,287,686	5,294,840
1990	307,722	1,990,704	624,659	1,129,877	40,817	4,093,779	1,793,090	1,259,887	2,261	1,038,538	4,093,777
1991	111,374	4,842,904	509,707	992,667	63,090	6,519,743	1,565,320	2,748,231	145	2,206,048	6,519,744
1992	156,438	3,950,703	592,824	1,002,725	68,548	5,771,238	1,663,880	2,245,860	217	1,861,282	5,771,239
1993	211,126	5,874,147	482,328	1,280,529	105,760	7,953,890	1,865,116	2,787,852	3,502	3,297,421	7,953,892
1994	316,998	6,457,563	351,815	1,148,121	119,046	8,393,543	1,618,740	1,999,707	243	4,774,854	8,393,544
1995	195,110	7,250,518	393,648	1,157,606	104,670	9,101,551	1,651,664	2,700,221	4,260	4,745,406	9,101,551
1996	176,888	5,310,846	397,024	1,106,573	67,504	7,058,835	1,566,658	2,353,437	4,444	3,134,296	7,058,834
1997	167,797	6,793,551	419,837	1,101,101	82,634	8,564,921	1,597,645	2,573,108	5,928	4,388,240	8,564,922
1998	427,681	8,597,631	608,998	1,848,718	81,579	11,564,607	2,530,686	3,519,315	8,610	5,505,998	11,564,609
1999	315,278	7,251,549	549,813	1,481,357	68,278	9,666,274	2,097,739	3,721,784	1,709	3,845,042	9,666,274
2000	270,612	8,375,360	636,817	1,605,425	81,260	10,969,475	2,283,311	4,972,529	40,192	3,673,445	10,969,477
2001	166,914	8,766,604	1,052,744	2,088,284	100,916	12,175,463	3,128,510	4,031,469	113,436	4,902,049	12,175,463
2002	145,311	10,640,507	1,059,401	1,933,577	61,659	13,840,455	2,983,506	4,435,518	71,132	6,350,300	13,840,455
2003	240,352	12,219,344	1,189,696	1,476,593	67,095	15,193,079	2,626,122	3,773,139	107,262	8,686,558	15,193,081
2004	327,271	13,718,083	1,190,773	1,756,584	72,808	17,065,519	2,901,692	4,913,422	118,472	9,131,932	17,065,519

Table 2. Estimated annual fishing mortality rate (F), spawning stock size (millions of pounds of mature females) and recruitment (number age 1) for Gulf of Mexico gag.

Year	F	SSB Female	Recruits
1963	0.030	49.109	214586
1964	0.037	47.911	214574
1965	0.042	46.334	213181
1966	0.040	43.826	211267
1967	0.040	40.962	208019
1968	0.046	37.971	203970
1969	0.056	34.813	199294
1970	0.063	31.532	193783
1971	0.079	28.430	187283
1972	0.098	25.451	180294
1973	0.111	22.661	172637
1974	0.140	20.337	1393800
1975	0.183	17.988	202205
1976	0.202	15.959	721440
1977	0.215	15.804	1267200
1978	0.235	15.164	1216470
1979	0.280	14.805	1541900
1980	0.300	15.072	1712720
1981	0.279	15.696	2094330
1982	0.352	17.165	1972460
1983	0.559	18.335	1364890
1984	0.216	17.021	1358380
1985	0.485	20.498	1252910
1986	0.365	18.521	1476470
1987	0.262	17.885	1192730
1988	0.321	18.595	1086810
1989	0.305	18.550	793166
1990	0.233	18.350	3761120
1991	0.383	18.842	1602020
1992	0.315	17.584	1916250
1993	0.406	20.902	2119320
1994	0.422	21.509	4814020
1995	0.458	20.972	2712410
1996	0.310	20.987	2033390
1997	0.315	26.900	5741390
1998	0.399	30.734	3062170
1999	0.297	30.963	1833230
2000	0.309	37.195	5007130
2001	0.330	40.578	3467710
2002	0.364	40.494	2789170
2003	0.399	41.768	2452980
2004	0.492	40.951	2344190

Table 3. Projection trends for Gulf of Mexico gag grouper assuming constant recruitment and various constant fishing mortality rates. "All Removals" includes landings and dead discards and "Landed Yield" landings only. SPR% refers to fishing rates that will achieve the indicated percent SPR under equilibrium conditions.

ALL REMOVALS

SSB mature femate wgt million pounds

Year	SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
1995	20.48	20.48	20.48	20.48	20.48	20.48	20.48
1996	20.61	20.61	20.61	20.61	20.61	20.61	20.61
1997	26.81	26.81	26.81	26.81	26.81	26.81	26.81
1998	30.73	30.73	30.73	30.73	30.73	30.73	30.73
1999	31.06	31.06	31.06	31.06	31.06	31.06	31.06
2000	37.67	37.67	37.67	37.67	37.67	37.67	37.67
2001	40.64	40.64	40.64	40.64	40.64	40.64	40.64
2002	40.46	40.46	40.46	40.46	40.46	40.46	40.46
2003	41.78	41.78	41.78	41.78	41.78	41.78	41.78
2004	40.55	40.55	40.55	40.55	40.55	40.55	40.55
2005	33.28	33.28	33.28	33.28	33.28	33.28	33.28
2006	29.16	29.16	29.16	29.16	29.16	29.16	29.16
2007	27.20	30.00	31.81	32.97	30.55	30.55	26.85
2008	25.26	30.26	33.79	36.15	31.32	31.32	24.65
2009	24.49	31.30	36.39	39.93	32.78	32.78	23.72
2010	24.19	32.38	38.90	43.61	34.27	34.27	23.28

F annual mortality rate

Year	SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
1995	0.458	0.458	0.458	0.458	0.458	0.458	0.458
1996	0.310	0.310	0.310	0.310	0.310	0.310	0.310
1997	0.315	0.315	0.315	0.315	0.315	0.315	0.315
1998	0.399	0.399	0.399	0.399	0.399	0.399	0.399
1999	0.297	0.297	0.297	0.297	0.297	0.297	0.297
2000	0.309	0.309	0.309	0.309	0.309	0.309	0.309
2001	0.330	0.330	0.330	0.330	0.330	0.330	0.330
2002	0.364	0.364	0.364	0.364	0.364	0.364	0.364
2003	0.400	0.400	0.400	0.400	0.400	0.400	0.400
2004	0.493	0.493	0.493	0.493	0.493	0.493	0.493
2005	0.422	0.422	0.422	0.422	0.422	0.422	0.422
2006	0.375	0.251	0.177	0.132	0.228	0.228	0.392
2007	0.375	0.251	0.177	0.132	0.228	0.228	0.392
2008	0.375	0.251	0.177	0.132	0.228	0.228	0.392
2009	0.375	0.251	0.177	0.132	0.228	0.228	0.392
2010	0.375	0.251	0.177	0.132	0.228	0.228	0.392

Total removals (landed + dead discards)

Year	SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
1995	9.11	9.11	9.11	9.11	9.11	9.11	9.11
1996	7.06	7.06	7.06	7.06	7.06	7.06	7.06
1997	8.55	8.55	8.55	8.55	8.55	8.55	8.55
1998	11.55	11.55	11.55	11.55	11.55	11.55	11.55
1999	9.64	9.64	9.64	9.64	9.64	9.64	9.64
2000	10.93	10.93	10.93	10.93	10.93	10.93	10.93
2001	12.13	12.13	12.13	12.13	12.13	12.13	12.13
2002	13.80	13.80	13.80	13.80	13.80	13.80	13.80
2003	15.15	15.15	15.15	15.15	15.15	15.15	15.15
2004	17.03	17.03	17.03	17.03	17.03	17.03	17.03
2005	12.38	12.38	12.38	12.38	12.38	12.38	12.38
2006	9.99	7.00	5.08	3.86	6.42	6.42	10.37
2007	9.39	7.18	5.49	4.31	6.69	6.69	9.64
2008	8.99	7.39	5.91	4.76	6.97	6.97	9.15
2009	8.79	7.62	6.31	5.21	7.27	7.27	8.87
2010	8.66	7.82	6.67	5.61	7.53	7.53	8.70

LANDED YIELD

SSB mature femate wgt million pounds

Year	SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
1995	20.48	20.48	20.48	20.48	20.48	20.48	20.48
1996	20.61	20.61	20.61	20.61	20.61	20.61	20.61
1997	26.81	26.81	26.81	26.81	26.81	26.81	26.81
1998	30.73	30.73	30.73	30.73	30.73	30.73	30.73
1999	31.06	31.06	31.06	31.06	31.06	31.06	31.06
2000	37.67	37.67	37.67	37.67	37.67	37.67	37.67
2001	40.64	40.64	40.64	40.64	40.64	40.64	40.64
2002	40.46	40.46	40.46	40.46	40.46	40.46	40.46
2003	41.78	41.78	41.78	41.78	41.78	41.78	41.78
2004	40.55	40.55	40.55	40.55	40.55	40.55	40.55
2005	33.28	33.28	33.28	33.28	33.28	33.28	33.28
2006	30.20	30.20	30.20	30.20	30.20	30.20	30.20
2007	28.06	30.95	32.82	33.57	31.04	31.04	27.69
2008	25.88	31.06	34.67	36.15	31.19	31.19	25.24
2009	24.96	31.92	37.14	39.36	32.11	32.11	24.12
2010	24.49	32.89	39.52	42.44	33.13	33.13	23.55

F annual mortality rate

Year	SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
1995	0.46	0.46	0.46	0.46	0.46	0.46	0.46
1996	0.31	0.31	0.31	0.31	0.31	0.31	0.31
1997	0.32	0.32	0.32	0.32	0.32	0.32	0.32
1998	0.40	0.40	0.40	0.40	0.40	0.40	0.40
1999	0.30	0.30	0.30	0.30	0.30	0.30	0.30
2000	0.31	0.31	0.31	0.31	0.31	0.31	0.31
2001	0.33	0.33	0.33	0.33	0.33	0.33	0.33
2002	0.36	0.36	0.36	0.36	0.36	0.36	0.36
2003	0.40	0.40	0.40	0.40	0.40	0.40	0.40
2004	0.49	0.49	0.49	0.49	0.49	0.49	0.49
2005	0.38	0.38	0.38	0.38	0.38	0.38	0.38
2006	0.37	0.25	0.18	0.15	0.25	0.25	0.39
2007	0.37	0.25	0.18	0.15	0.25	0.25	0.39
2008	0.37	0.25	0.18	0.15	0.25	0.25	0.39
2009	0.37	0.25	0.18	0.15	0.25	0.25	0.39
2010	0.37	0.25	0.18	0.15	0.25	0.25	0.39

Total landed yield million pounds

Year	SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
1995	4.45	4.45	4.45	4.45	4.45	4.45	4.45
1996	3.89	3.89	3.89	3.89	3.89	3.89	3.89
1997	4.53	4.53	4.53	4.53	4.53	4.53	4.53
1998	6.61	6.61	6.61	6.61	6.61	6.61	6.61
1999	5.91	5.91	5.91	5.91	5.91	5.91	5.91
2000	7.96	7.96	7.96	7.96	7.96	7.96	7.96
2001	6.98	6.98	6.98	6.98	6.98	6.98	6.98
2002	8.01	8.01	8.01	8.01	8.01	8.01	8.01
2003	7.21	7.21	7.21	7.21	7.21	7.21	7.21
2004	7.63	7.63	7.63	7.63	7.63	7.63	7.63
2005	5.81	5.81	5.81	5.81	5.81	5.81	5.81
2006	5.24	3.68	2.67	2.27	3.64	3.64	5.44
2007	4.79	3.69	2.83	2.46	3.66	3.66	4.91
2008	4.53	3.77	3.04	2.69	3.75	3.75	4.60
2009	4.41	3.90	3.26	2.93	3.88	3.88	4.44
2010	4.32	3.98	3.43	3.12	3.96	3.96	4.33

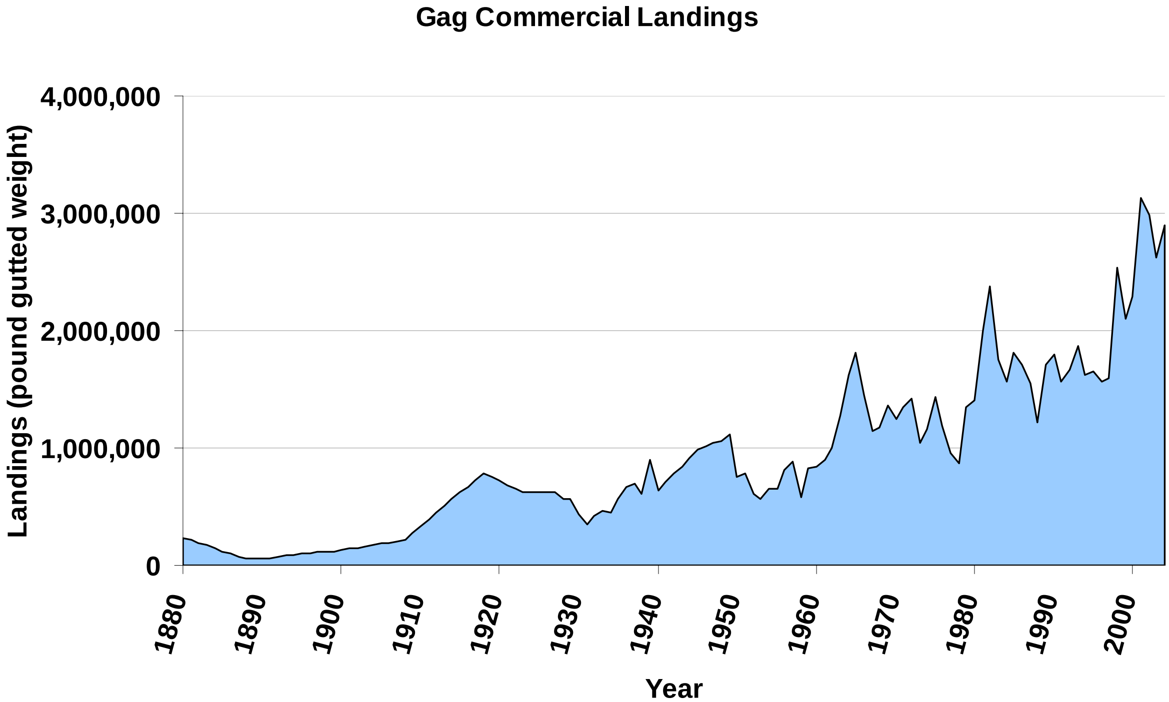


Figure 1. Estimated historical commercial landings of gag from U.S. Gulf of Mexico waters from 1880 to 2004 in pounds gutted weight.

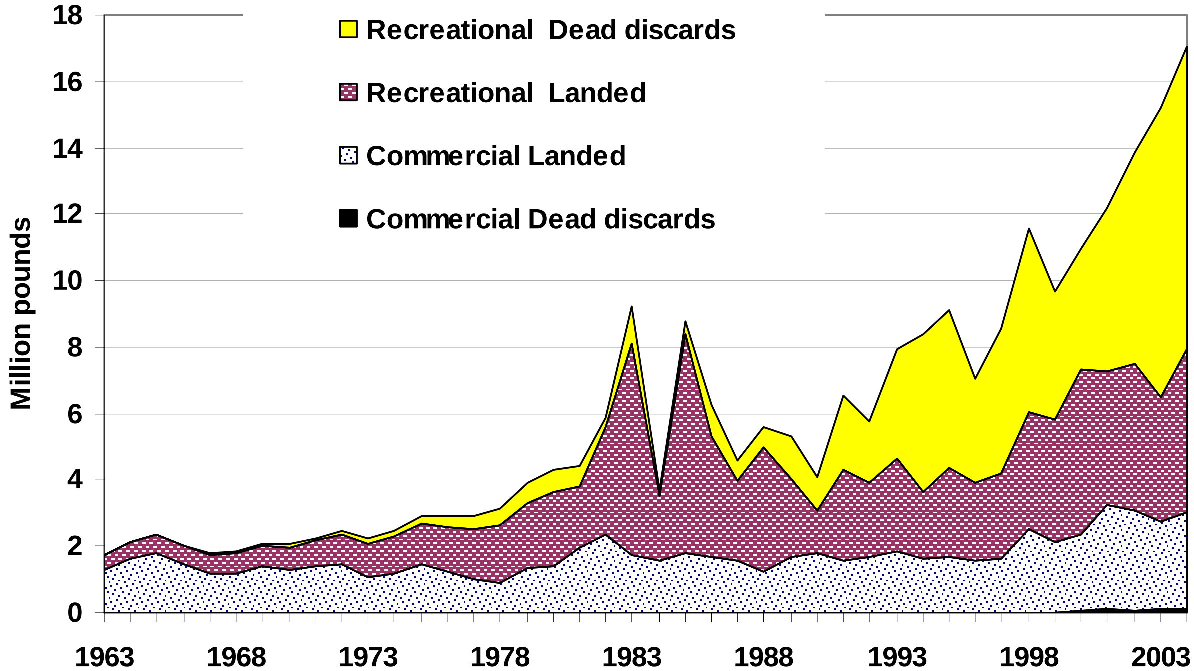


Figure 2. Gulf of Mexico gag landings and dead discards by the commercial and recreational fisheries in pounds gutted weight.

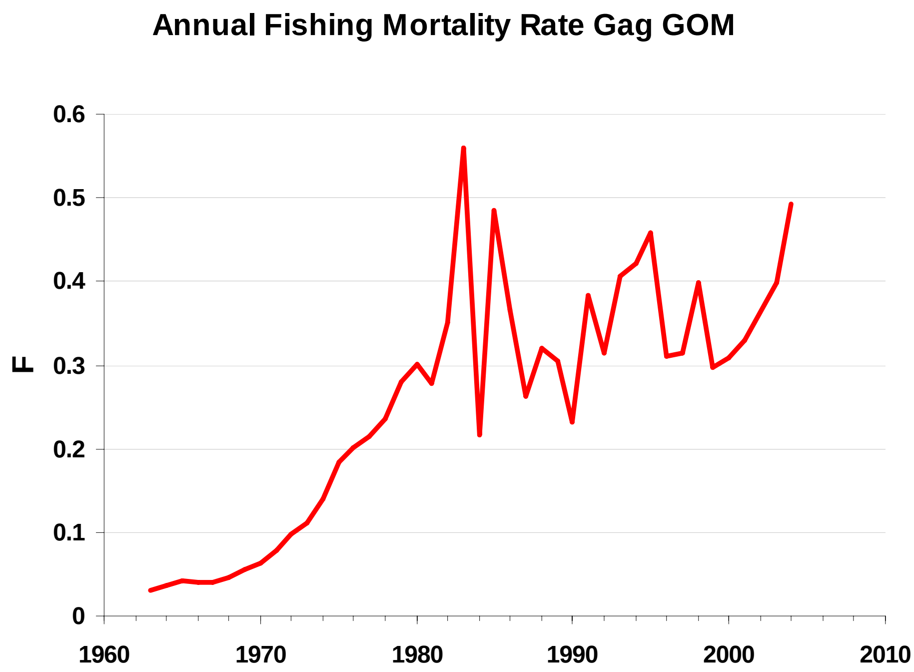


Figure 3. Estimated annual fishing mortality rate on Gulf of Mexico gag.

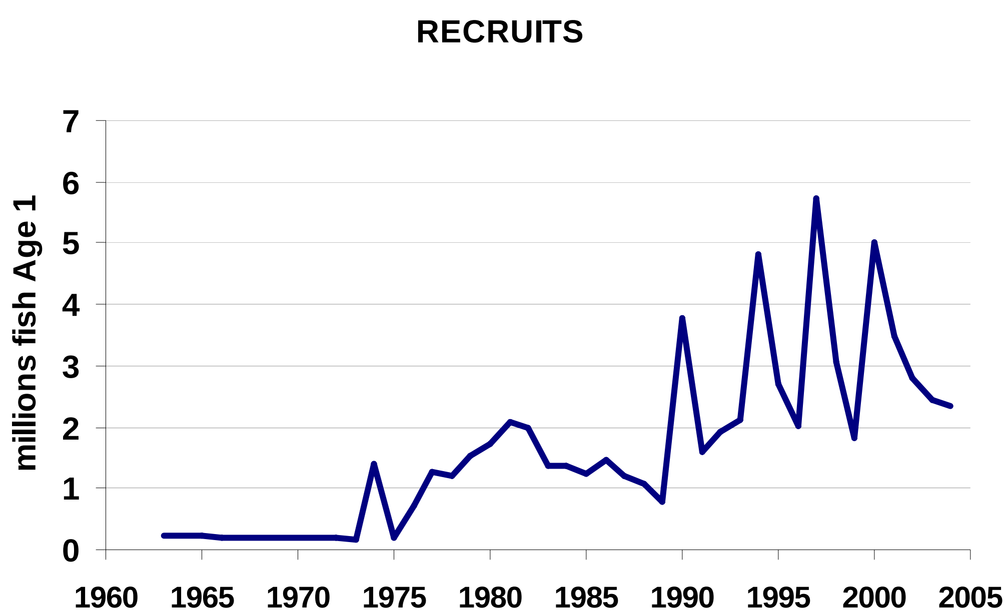


Figure 4. Estimated recruitment of Gulf of Mexico gag. Early recruitment estimates are considered unreliable and are thought to be due in large part to the absence of age composition and indices of abundance before 1981.

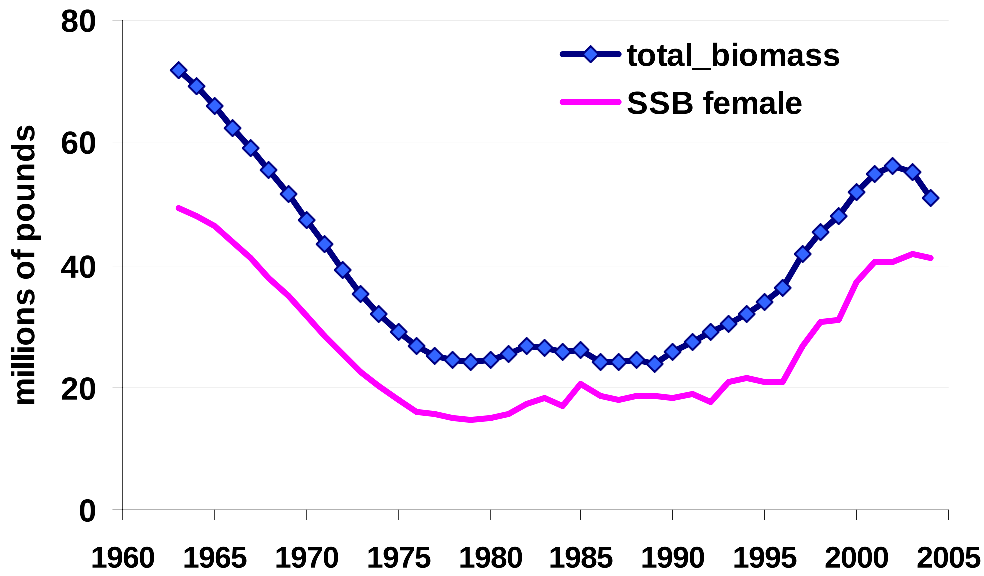


Figure 5. Estimated biomass of Gulf of Mexico showing spawning stock biomass (SSB, mature female) and total biomass in gutted weight.

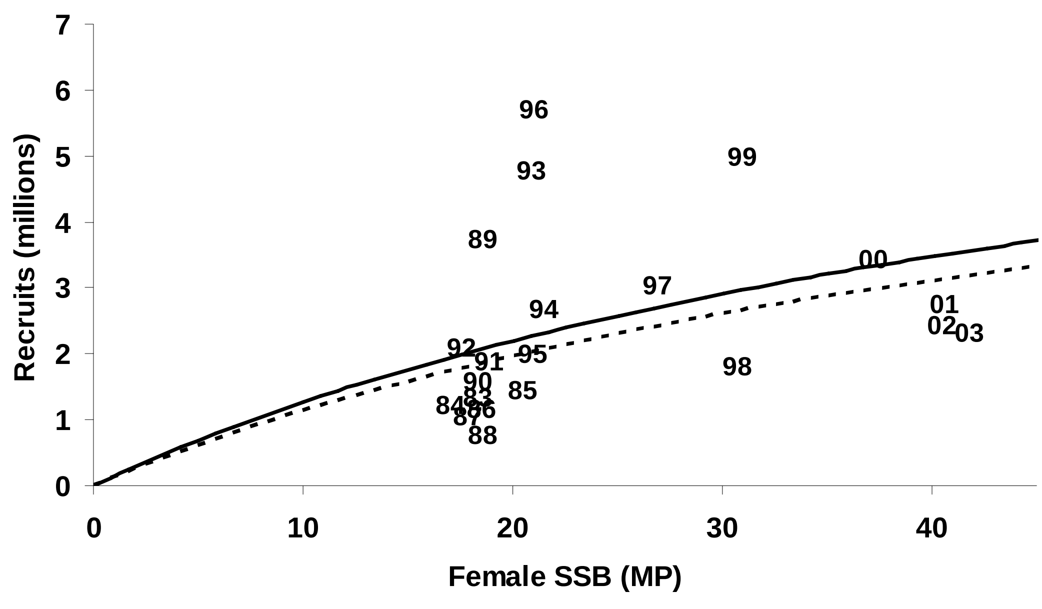


Figure 6. Estimated Beverton-Holt stock-recruitment relationship for Gulf of Mexico gag. Two digit year labels represent estimated recruitment for the 1983-2003 year classes and the associated female spawning stock biomass. The dashed curve is the estimated relationship, and the solid curve is the estimated relationship with lognormal bias correction.

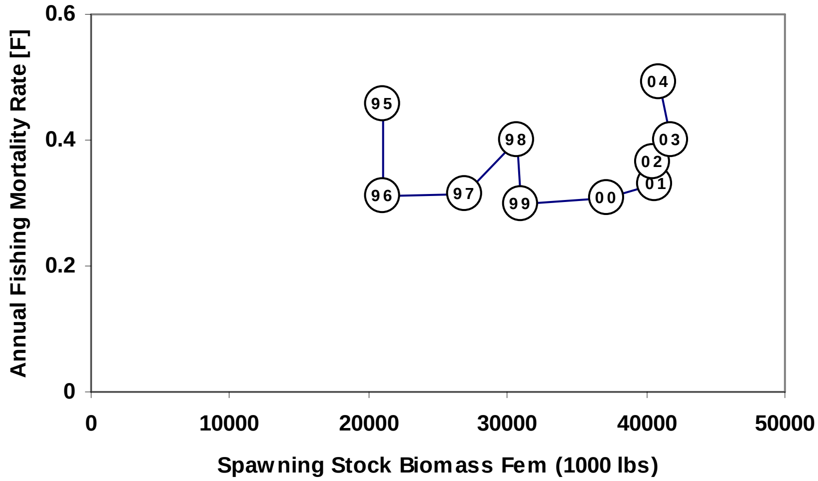


Figure 7. Phase plot of recent estimates of female spawning biomass (thousand pounds, gutted weight) and annual fishing mortality rate for gag GOM stock.

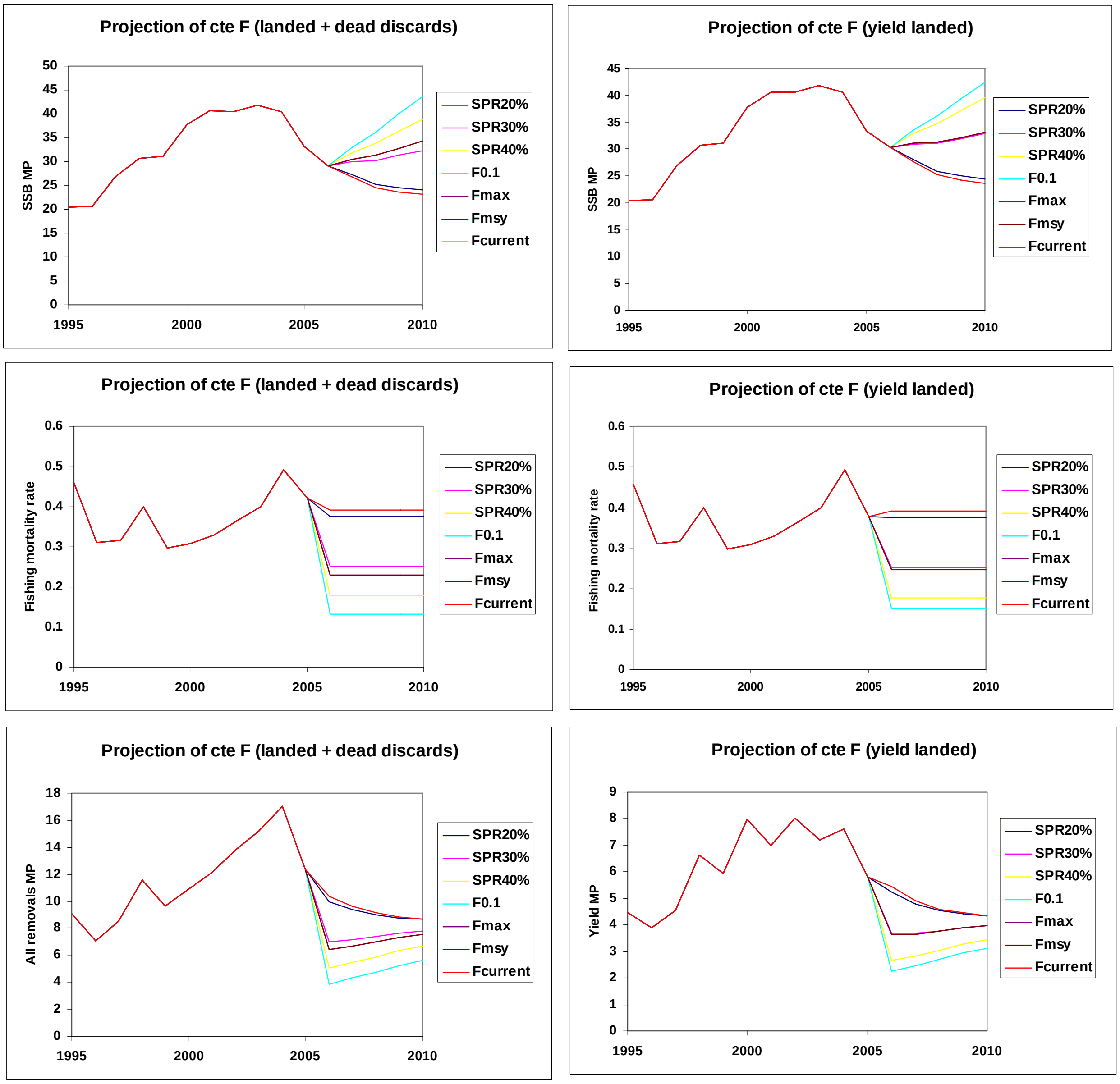


Figure 8. Projection trends from base model run assuming constant future recruitment. Projections of constant F mortality rate scenarios, projections on the left include total removals (landings & dead discards), those shown on the right are landed yield only

SEDAR

SouthEast Data, Assessment, and Review

Gulf of Mexico Gag Grouper
Stock Assessment Report

SECTION 2. Data Workshop

1. Introduction

1.1. Workshop Time and Place

The SEDAR 10 Data Workshop was held January 23 - 27 in Charleston, SC.

1.2. Terms of Reference

1. Characterize stock structure and develop a unit stock definition.
2. Tabulate available life history information (e.g., age, growth, natural mortality, discard mortality, reproductive characteristics); provide appropriate models to describe growth, maturation, and fecundity by age, sex, or length as applicable. Evaluate the adequacy of life-history information for conducting stock assessments and recommend life history information for use in population modeling.
3. Provide measures of population abundance that are appropriate for stock assessment. Document all programs used to develop indices, addressing program objectives, methods, coverage, sampling intensity, and other relevant characteristics. Consider fishery dependent and independent data sources; provide measures of abundance by appropriate strata (e.g., age, size, area, and fishery); provide measures of precision. Provide analyses evaluating the degree to which available indices adequately represent fishery and population conditions.
4. Provide commercial and recreational catch, including both landings and discard removals, in pounds and numbers. Evaluate the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector. Provide length and age distributions if feasible.
5. Evaluate the adequacy of available data for estimating the impacts of past and current management actions.
6. Recommend assessment methods and models that are appropriate given the quality and scope of the data sets reviewed and management requirements.
7. Provide recommendations for future research and monitoring. Include specific guidance on sampling intensity and coverage where possible.
8. Prepare complete documentation of workshop actions and decisions (Section II. of the SEDAR assessment report) and final datasets in a format accessible to all participants. Report and datasets are due no later than March 31, 2006.

1.3. Workshop Participants

Workshop Panel

Pam Baker....................Environmental Defense
Luiz Barbieri....................GMFMC SSC/Fl FWCC
Carolyn Belcher....................SAFMC SSC/Univ. of Georgia
Alan Bianchi....................NCDMF
Craig Brown....................NMFS/SEFSC Miami, FL
Steve Brown....................FL FWCC
Ken Brennan....................NMFS/SEFSC Beaufort, NC
Mike Burton....................NMFS/SEFSC Beaufort, NC
Shannon Calay....................NMFS/SEFSC Miami, FL
Rob Cheshire....................NMFS/SEFSC Beaufort, NC
Brian Cheuvront....................SAFMC SSC/ NCDMF

Ching Ping Chih ....NMFS/SEFSC Miami, FL
William Collier ....NCDMF
Nancie Cummings ....NMFS/SEFSC Miami, FL
Guy Davenport..NMFS/SEFSC Miami, FL
Bob Dixon.. NMFS/SEFSC Beaufort, NC
Karen Edwards..UNC
Mark Fisher..GMFMC FAP/TX PWD
Gary Fitzhugh ....NMFS/SEFSC Panama City, FL
David Gloeckner .... SEFSC/NMFS Beaufort, NC
Patrick Harris..SAFMC SSC/SCDNR
Jack Holland ....NCDMF
Walter Ingram .... NMFS/SEFSC Pascagoula, MS
Nan Jenkins.. SCDNR
Linda Lombardi-Carson...NMFS/SEFSC, Panama City, FL
Gus Loyal...GMFMC Advisory Panel
Vivian Matter..NMFS/SEFSC Miami, FL
Kevin McCarthy ....NMFS/SEFSC Miami, FL
Josh Sladek Nowlis...NMFS/SEFSC Miami, FL
Mauricio Ortiz ....NMFS/SEFSC Miami, FL
Patty Phares ....NMFS/SEFSC Miami, FL
Jennifer Potts .... NMFS/SEFSC Beaufort, NC
Marcel Reichert .... SCDNR
Fritz Rohde ....NCDMF
Jay Rooker ....,..GMFMC FAP/TX A&M
Beverly Sauls ....FL FWCC
Jerry Scott ....NMFS/SEFSC Miami, FL
Kyle Shertzer .... NMFS/SEFSC Beaufort, NC
James Taylor..GMFMC Advisory Panel
Steve Turner...NMFS/SEFSC Miami, FL
Doug Vaughan .... NMFS/SEFSC Beaufort, NC
Robert Wiggers .... SCDNR
Erik Williams.. NMFS/SEFSC Beaufort, NC
David Wyanski .... SCDNR

<u>*Observers*</u>
Roy Williams .... GMFMC Member
David Cupka ....SAFMC Member
Pete Sheridan...NMFS/SEFSC Panama City

Staff
Steven Atran ....GMFMC
John Carmichael ....SEDAR
Rick DeVictor .... SAFMC
Kerry O’Malley .... SAFMC
Cynthia Morant ....SAFMC/SEDAR
Gregg Waugh... SAFMC
Tyree Davis...NMFS/SEFSC Miami, FL

1.4. List of Data Workshop Working Papers

SEDAR10-DW1	Metadata for gag tagging data	McGovern, J., P. Harris
SEDAR10-DW2	Age, Length, and Growth of Gag from the NE Gulf of Mexico 1979-2005	Lombardi-Carlson, L. A., G. R. Fitzhugh, B. A. Fable, M. Ortiz, C. Gardner
SEDAR10-DW3	Update of gag reproductive parameters: Eastern Gulf of Mexico	Fitzhugh, G. R., H. M. Lyon, L. A. Collins, W. T. Walling, L. Lombardi Carlson
SEDAR10-DW4	Standardized Catch Rates of Gag from the United States headboat fishery in the Gulf of Mexico during 1986-2004	Brown, C. A.
SEDAR10-DW5	Description of MARMAP sampling program	Harris, P.
SEDAR10-DW6	Analysis of Preliminary Results for the Release of Satellite-Tracked Drifters over Gag Spawning Sites	Lesher, A. T., G. R. Sedberry
SEDAR10-DW7	Preliminary Notes on FL Gag Data and Trip Ticket Map	Brown, S.
SEDAR10-DW8	Review of Tagging Data for gag grouper from the Southeastern Gulf of Mexico region 1985-2005	Ortiz, M. K. Burns, J. Sprinkel
SEDAR10-DW9	Standardized catch rates for gag grouper from the MRFSS	Ortiz, M.
SEDAR10-DW10	Standardized catch rates for gag grouper from the United States Gulf of Mexico handline fishery during 1993-2004	McCarthy, K. J.
SEDAR10-DW11	Estimates of gag grouper discard by vessels with Federal Permits in the Gulf of Mexico	McCarthy, K. J.
SEDAR10-DW12	NOAA Fisheries Reef Fish Video Surveys: Yearly indices of abundance for Gag	Gledhill, C. T., G. W, Ingram, K. R. Rademacher, P. Felts, B. Trigg.
SEDAR10-DW-13	Report of a gag age workshop	Reichert, M., G. Fitzhugh, J. Potts
SEDAR10-DW-14	QA/QC procedures used for TIP online data	Gloeckner, D.
SEDAR10-DW-15	Analytical report on the age, growth, and reproductive biology of gag from the Southeastern United States	Reichert, M. , D. Wyanski
SEDAR10-DW-16	Gag history of management in the Gulf of Mexico	Rueter, J.
SEDAR10-DW-17	Overview of gag material in Draft SAFMC Snapper-Grouper Amendment 13B	Waugh, G.
SEDAR10-DW-18	Standardized catch rate indices for gag grouper landed by the US Gulf of Mexico longline fishery during 1993-2004	Cass-Calay, S. L.
SEDAR10-DW-19	Standardized catch rates of gag from the commercial handline fishery off the Southeastern United States	Shertzer, K.

SEDAR10-DW-20	Standardized catch rates of gag from the headboat fishery off the Southeastern United States	Cheshire, R., K. Shertzer
SEDAR10-DW-21	Recreational landings and length data summary for South Atlantic gag (DELETED FOLLOWING WORKSHOP DUE TO INCLUSION OF CONFIDENTIAL DATA)	Cheshire, R, and D. Vaughan
SEDAR10-DW-22	Commercial landings and length data summary for South Atlantic gag. (DELEDTED FOLLOWING WORKSHOP DUE TO INCLUSION OF CONFIDENTIAL DATA	Gloeckner, D., D. Vaughan
SEDAR10-DW-23	Effect of some variations in sampling practices on the length frequency distribution of gag groupers caught by commercial fisheries in the Gulf of Mexico	Chih, C-P
SEDAR10-DW-24	Estimation of species misidentification in the commercial landing data of gag groupers and black groupers in the Gulf of Mexico	Chih, C-P., S. Turner
SEDAR10-DW-25	Habitat use by juvenile gag in subtropical Charlotte Harbor, FL.	Casey, J. P., G. R. Poulakis, P. W. Stevens
SEDAR10-DW-26	Recreational survey data for gag and black grouper in the Gulf of Mexico.	Phares, P., V. Matter, S. Turner
SEDAR10-DW-27	Spatial distribution of headboat trips from the Florida Keys	Matter, V. M.
SEDAR10-DW-28	Species ID south Atlantic – ETA 1 week post workshop	Chih
SEDAR10-DW-29	Council Boundaries	anon
SEDAR10-DW-30	Annual indices of abundance for gag from Florida Estuaries	Igram, W., T. Macdonald, L. Barbieri
SEDAR10-DW-31	Age composition information South Atlantic	Potts, J.
Research Documents		
SEDAR10-RD01	Exegeses on Linear Models	Venables, W.N.
SEDAR10-RD02 1977	A reformulation of Linear Models J. Royal Stat. Soc. A 140(1):48-77	Nelder, J. A.
SEDAR10-RD03 1999	Stock identification of gag along the Southeast coast of the United States Mar. Biotechnol. 1, 137-146.	Chapman, R. W., Sedberry, G. R. , C. C. Koenig, B. M. Eleby
SEDAR10-RD04 2005	A tag and recapture study of gag off the Southeastern US Bull Mar Sci 76(1)47-59.	McGovern, J. C.,et al
SEDAR10-RD05 1983	Empirical use of longevity data to estimate mortality rates FishBull 82(1)898-903	Hoenig, J.M.
SEDAR10-RD06 2005	Bycatch, discard composition, and fate in the snapper grouper commercial fishery, North Carolina NCSU/CMAST Proj 04-FEG-08	Rudershaussen, P. J., A. Ng, A. Ng, J. A. Buckel

2. Life History

2.1. Mortality Estimates – Total, Natural, and Release

2.1.1. Juvenile (YOY)

Mortality rates of juvenile gag were examined in shallow seagrass beds located on the northwest coast of Florida using catch curve analysis (regression of CPUE over sampling period). Daily instantaneous mortality (Z) ranged from 0.0027 to 0.0032, suggesting that daily mortality was less than 1% per day at all sampling stations (Koenig and Coleman 1998). Similar to other early life estimates of mortality, early life estimates of Z may be affected by emigration or immigration from juvenile habitats. These juvenile Z values will be taken into account when analyzing data for age-varying M, such as the Lorenzen (1996) model.

2.1.2. Sub-adult/Adult

Maximum age of gag in Gulf of Mexico is 31 years (SEDAR10-DW2) while estimates in the South Atlantic range from 26 (SEDAR10-DW15) to 30 years (SEDAR10-DW31). Using this information, natural mortality (M) of gag was estimated using the regression model reported by Hoenig (1983) for teleosts: $\ln(M) = 1.46-1.01*\ln(t_{max})$. It should be noted that the Data Workshop (DW) did not use the alternative "rule of thumb" approach for estimating M from longevity ($M=2.98/t_{max}$, Quinn and Deriso 1999, Cadima 2003). Recent work by Hewitt and Hoenig (2005) recommend the regression model over the rule-of-thumb approach. Using Hoenig's regression approach, natural mortality of gag was slightly lower in the Gulf (M = 0.13) than the South Atlantic (M = 0.14-0.16). Natural mortality was also estimated using a variety of models based on von Bertalanffy growth or reproductive parameters (e.g., Jensen 1996). Using these alternative models, M ranged from 0.15-0.22 and 0.17-0.33 in the Gulf of Mexico and South Atlantic, respectively. Estimates of natural mortality recommended by the DW are consistent with recently published mortality data (e.g., McGovern et al. 2005) as well as those applied in the previous gag assessment.

Recommendations:

1.) Use a baseline estimate of 0.15 for the initial evaluations for both the Gulf of Mexico and South Atlantic.
2.) For sensitivity analysis, the DW recommended the following ranges of M: Gulf of Mexico (0.10 and 0.20) and South Atlantic (0.10 and 0.25). The upper range of M in the South Atlantic is higher due to estimates of M from models using the von Bertalanffy parameters.
3.) Following the DW, investigate age-varying M models and their appropriateness.

Estimates of total instantaneous mortality (Z) have been reported from recapture data and catch curves. McGovern et al. (2005) reported Z values of 0.38 (recapture data) and 0.40 (catch curves) for gag from the southeastern U.S. Using data in the

SEDAR10-DW2 document, the DW estimated Z values for a range of strong year classes or cohorts (1985 = 0.60, 1989 = 0.53, 1993 = 0.30, and 1996 = 0.52) in the Gulf of Mexico (based on individuals ~ 4-12 years). Catch curve estimates of Z ranged from 0.30-0.62 among individual cohorts. Combining all cohorts for the 4-12 year age interval, an overall Z of 0.52 was observed. A catch curve was also developed for gag 13-25 years, and Z (0.21) was markedly lower than the estimate for individuals in the 4-12 year age interval.

2.1.3. Release Mortality

A previous gag population assessment for the South Atlantic used release mortality rates of 20% and 50%. The first value was from surface observations of released fish on Headboat fishing trips, and the latter value was used because it was expected that mortality would be higher than what was observed at the surface (Robert Dixon, NMFS, Beaufort, NC, *pers. comm.*.; Potts and Manooch 1998). The 2001 Gulf of Mexico gag assessment used discard mortality rates of 20% for the recreational fishery and 30% for the commercial fishery based on different depths fished and an apparent increase in discard mortality rate with increasing depth (Turner et al. 2001). Recent work provides updated information on discard mortality in the South Atlantic and Gulf of Mexico. Discard mortality studies focusing on undersized gag utilized multiple techniques including observational indices (Rudershausen et al. 2005), tag release comparison (Burns et al. 2002; McGovern et al. 2005), and caging observations (Burns et al. 2002; Overton and Zabawski 2003).

A study by Rudershausen et al. (2005) reported pressure related effects, expressed as gastric distension and bleeding, on gag (n = 101) collected off North Carolina from depths ranging from 19-85 m (mean=29 m). Compared to five other species collected in the same study, gag exhibited the second highest rate of gastric distension (37.6%) and the highest occurrence of bleeding (16.8%). Of 29 gag released, all oriented and swam towards the bottom; only 5 were judged to swim in an erratic manner (condition 1 and 2; Patterson et al. 2000). However, gag with gastric distention or bleeding, if released, were expected to experience higher post-release mortality than predicted by the surface observations.

Improved estimates of post-release mortality were obtained through tag release and caging methods (Burns et al. 2002; Overton and Zabawski 2003; McGovern et al. 2005). Using these methods, mean mortality rates were estimated to be 21.2% for depths <35 m (Overton and Zabawski 2003), 23% over a variety of depths (McGovern et al. 2005), and 100% for depths >50 m (Wilson and Burns 1996).

Release mortality rates displayed a positive relationship (logistic regression) with depth, increasing from 14.2% at 15 m to 94.8% at 95 m with a 50% mortality rate at 45.5 m (McGovern et al. 2005). Burns et al. (2002) combined tag release comparison and caging observation methods to estimate discard mortality rate and found 50% mortality at a similar depth (47 m). The depth at 50% swimbladder rupture (47 m) was also similar to that for 50% mortality (Burns et al. 2002).

Vented gag showed increased survivorship compared to non-vented gag based on recapture data with all depths grouped. When recapture rates were stratified by depth, only the shallowest depth (0-12.2 m) had a significant difference between the vented and non-vented gag (Burns et al. 2002).

At depths less than 20 fm (37 m, inner shelf) where survival upon release is likely to be relatively high (about 50% or better survival with proper handling), ages and sizes of gag landed are consistently (in Gulf and SA) more truncated than at deeper depths (Figures 2.1-2.3). At depths greater than 40 fm, (73 m, outer shelf and upper slope) release mortality is likely to be quite high with little to no chance for survival. However, numbers of gag (in the compiled age-structure data) declines in this deepest zone compared to shallower depths; sizes and ages tend to increase compared to shallower depths (thus fewer potential discards, especially for the Gulf, Figure 3) and there appears to be a switch to landings dominated by long-line gear in the Gulf (Figure 2.4). Estimates of release mortality between the depths of 20-40 fm (37- 73 m, mid to outer shelf) are likely to be of *greatest concern* because this is the zone in which evident increases in release mortality (>50%) coincides with increasing depth. Also, compiled data from the Gulf and SA show that high numbers of gag from very broad age and size ranges can be harvested at 20-40 fm (Figures 2.1-2.3); thus undersized gag will be taken and will be at significant risk of mortality upon release. These suppositions are based upon example depth data accompanying biological samples. Conclusions may change when more complete landings data (by depth if available) are reviewed. The DW recognized that functional relationships of depth and release mortality potentially offers improved information over the use of simple point estimates of mortality representing broad depth intervals.

Recommendation:
The DW recommended further investigation into the practicality of applying depth-mortality functions as the assessment proceeds. Since discard mortality functions by depth were very similar between the Gulf of Mexico (Burns et al. 2002) and the South Atlantic (McGovern et al. 2005), a single function may apply to both unit stocks. Workgroup discussions then centered on the issue of whether it may be feasible to use age/length data and depths associated with discards or perhaps depth trends by fishery sector to estimate release mortality using these functions. Analysis is underway and will be made available to the assessment group prior to the Assessment Workshop. If a single function cannot be derived, then the group will further discuss options for release mortality values based on fishery sector.

2.2 Age Data

2.2.1. Age Structure Samples

Three sets of age data were brought to the DW. Contributors included NMFS Panama City with data from the Gulf of Mexico commercial and recreational fisheries, NMFS Beaufort with data from the U.S. South Atlantic commercial and recreational fisheries, and SCDNR/MARMAP with data from the U.S. South Atlantic commercial and recreational fisheries and fishery-independent surveys, combining for a total of about 22,000 gag age estimates. Brief characterization of sampling and related issues follows:

Gulf of Mexico (SEDAR10-DW02)

Issues:
1.) Pre-1998 samples sizes of long-line collected otoliths were low compared to recent years.
2.) Throughout the time series the recreational industry, and in particular the private sector, was not well represented (n<200, 1991-2005). 3.) Fishery independent samples were also not well represented throughout the time series (n<500, 1991-2005).

Recommendations:
1.) 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; see SEDAR10-DW24).
2.) Bring increased attention to the need for strategies to improve port sampling (representation of fishery sectors and random sampling)
3.) Increase the sampling of the recreational sector for biological samples throughout the docks and ports of Florida's west coast.
4.) Continue support of fishery-independent surveys including all gears (hand-line, long-line, and trap) throughout the west Florida shelf.
5.) Recognize that gag landings may be increasing elsewhere in the Gulf and bring increased attention to sampling the northern and western Gulf regions.

South Atlantic (SEDAR10-DW15, SEDAR10-DW31)

Issues:
Data collected by NMFS Beaufort was dominated by samples from the east coast of Florida from two major time periods (1976-1986; 1992-2004). The earlier time period collected mainly from the recreational sector whereas more recent years were from the commercial sector. Data were collected by SC-DNR throughout the region (NC through central FL), with most samples collected off the Carolinas. Most of these samples originated from the commercial sector during an intensive sampling period approximately every 10 years (1977-82, 1994-95, and 2004-05). In 2004-2005, SC-DNR employed commercial fishers under a special permit to collect all sizes of fish (including undersized fish), and collections were made throughout the closed season.

The assignment of an otolith edge type, which allows estimates of annual (calendar) ages and biological (fractional) ages, has changed at SCDNR. Edge type are available for all aged fish collected after 1995, some edge types from samples collected in 1994-95 are available, and all samples collected after 1995 contain edge type information. This restricts the combination of data pre-1996.

Recommendations:
1.) The DW recommended combining the datasets from NMFS Beaufort and SCDNR to increase sample size, improve temporal coverage and growth pattern analysis.
2.) Continue with annual sampling for age structure with increased attention to representative sampling as above.
3.) SCDNR to include additional edge information based on available increment measurements to allow for age advancement, this will result in additional age data for 495 fish collected in 1976-1982, and for 763 fish collected in 1994-95 (this was completed post-DW and made available February16, 2006).
4.) SCDNR may be able to re-examine preparations to add edge information to allow for age advancement however, this will entail additional effort. (Data will be made available by February 17, 2006.)

2.2.2. Age Reader Precision

In September 2005, representatives of these three principal gag aging labs held a workshop to compare otolith interpretation, methods, and readings of gag otoliths for age estimates. Workshop results indicated that all labs use comparable procedures and methods for otolith examination. Furthermore, there was a high level of agreement and precision among readers from all labs and there was no appreciable reader bias evident from reader contrasts (SEDAR10-DW13).

Issue:
Differences in otolith interpretations and methodologies in the past have led, in some instances, to incompatible datasets.

Recommendation:
To continue exchanges of calibration otoliths sets and age workshops among state and federal agencies, and universities to continue improvements of data comparability and quality control.

2.2.3. Age Patterns

Gag year-class trends have been apparent for the Gulf of Mexico and the South Atlantic due to the ease of aging gag and the availability of a continuous series of age structure sampling from 1991 to 2005 from the Gulf, and 1981 to 1986 and 1999 to 2003 from the Atlantic. Strong year classes evident in the Gulf of Mexico were 1985, 1989, 1993, 1996, 1999, and possibly 2000. Strong year classes in the U.S. South Atlantic were 1974, 1978, 1981, 1990, 1994 and 1996. The available overlapping years for the Gulf and South Atlantic revealed similar age progression and a relatively strong 1996 year class in both regions. This further suggests that annual recruitment trends may be similar in both regions. The DW recommends that age structure sampling continue on an annual basis for both regions.

Contributors of the three age data sets found similar age ranges – 1-31 years, 0-30 years and 1-26 years, (NMFS Panama City, NMFS Beaufort, and

SCDNR/MARMAP, respectively) – but did note differences in size-at-age and different maximum size between the Gulf of Mexico and the U.S. South Atlantic (SEDAR10-DW2, SEDAR10-DW15, SEDAR10-DW31).

2.3. Growth

There have been several growth studies on gag in the Gulf of Mexico and South Atlantic (see citations within SEDAR10-DW2, SEDAR10-DW15, and SEDAR10-DW31). The updated data sets provided increased sample sizes for improved temporal coverage and contrasts. Growth models can be influenced by the use of size-biased samples, for example, due to minimum size-limits affecting fishery-dependent sampling. Thus, a modified von Bertalanffy growth model accounting for size limited data was used for the Gulf of Mexico (1991-2005, n=16,147) and South Atlantic (1976-2005, n=5,734; Diaz et al. 2004). Model fits used area, sector and temporal specific size-limits (GOM: 1990-2000 all sectors 20 inches, 2000-2005 recreational 22 inches, 2000-2005 commercial 24 inches; SA 1992-1998 all sectors 20 inches, 1999-2005 all sectors 24 inches).

The model was fit to observed lengths and fractional ages. Gag data from the entire time series were fit to the modified von Bertalanffy growth model (TL mm), separately by area (GOM, SA), to obtain population growth parameters for each area. The modified growth model resulted in an asymptotic length within the range of observed lengths (GOM: L_∞=1310 mm, TL range 245-1384 mm; SA L_∞=1051 mm, TL range 215-1300 mm), growth coefficients (GOM: $k = 0.14\ yr^{-1}$; SA: $k=0.24\ yr^{-1}$) and predicted t_o close to zero (GOM: t_o =-0.37 yr; SA: t_o =-0.48 yr).

Issues:
SCDNR analysis of size-at-age data and von Bertalanffy growth among the three periods (1979-82, 1994-95, and 2004-05) using increment counts and non-weighted data indicated possible temporal patterns in growth (SEDAR10-DW15, SEDAR10-DW31). However, data from NMFS-Beaufort did not show similar patterns.

Recommendations:
Analysis of combined South Atlantic datasets (SCDNR, NMFS Beaufort) for size-at-age and growth with various versions of the von Bertalanffy growth model using unweighted and weighted data will be completed prior to assessment workshop. (Data analysis will be made available by the end of February 2006.)

2.4. Reproduction

There have been several investigations of the reproductive biology of the gag in the U.S. South Atlantic and eastern Gulf of Mexico. Studies have addressed reproductive seasonality, spawning depth, sex ratio, sexual maturity, sexual transition (from female to male), aspects of the mating system, principal spawning habitats and regions, behavior, coloration, reproductive endocrinology, fecundity and spawning frequency (see citations within SEDAR10-DW3 and SEDAR10-DW15). The review below presents a summary of gag reproductive parameters that are most relevant for stock assessment. Topics are discussed jointly for U.S. South Atlantic and eastern Gulf of Mexico.

2.4.1. Spawning Seasonality

Spawning season in the South Atlantic was estimated to extend from mid-January to early May (with a peak in March-April), corresponding to a 114 d spawning duration (SEDAR10-DW15). In the eastern Gulf of Mexico the spawning season was estimated to extend from late January to mid-April (with a peak in March), corresponding to a 91 d spawning duration (SEDAR10-DW3). For both areas, delineation of the spawning season was based on the presence of females in spawning condition (i.e., ovaries containing hydrated oocytes or postovulatory follicles).

2.4.2. Sexual Maturity

Gag are known to be protogynous hermaphrodites (female first, changing to male later in life). Consequently, sexual maturity is reported for females only. Male sexual maturity is being addressed under “Sexual Transition” below.

Although data for the South Atlantic (mostly fishery-dependent) suggested temporal changes in size- and age-at-maturity (Table 2.1.; SEDAR10-DW15), discussion by the Life History Working Group could not resolve the issue of whether these changes were real or a reflection of temporal changes in size limits. Data from the Gulf of Mexico (collected during 1991-2002; SEDAR10-DW3) indicated no temporal changes in size- and age-at-maturity for gag. Size at maturity for Gulf of Mexico gag was 585 mm TL corresponding to an age-at-maturity of 3.7 yrs. These estimates are similar to, or perhaps slightly smaller than, size at maturity reported previously in US waters of the Gulf of Mexico.

Recommendations for South Atlantic:

1.) Provide an estimate of length and age at 50% maturity (L_{50} and A_{50}) for the entire time period (i.e., mean and variance for the data pooled over years). The pooled length and age at 50% maturity estimates are 648 mm TL (3.0 yr). Also, further analysis of data using a modified logistic model that takes into account minimum size regulations will be done following this workshop.

2.) Provide estimates of L_{50} and A_{50} for each of the time periods sampled. Estimates for the 3 separate time periods can be found in SEDAR10-DW15, as well as parameter estimates for each period and periods combined.

2.4.3. Sexual Transition

Similar to what we observed for “Sexual Maturity” data for the South Atlantic showed evidence of temporal change in size and age at sexual transition for gag. Histological examination of 1,128 sexually mature gag collected during 2004-05 revealed that the percentage of males and transitionals increased from 5.5% in 1994-95 (see McGovern et al. 1998, cited in SEDAR10-DW15) to 8.2%. The current percentage of males and transitionals is still much lower than the revised estimate of 19.4% for samples collected during 1977-82; McGovern et al. (1998) reported 21.1% males and transitionals in the 1976-82 samples. However, similar to the approach we took for “Sexual Maturity”, we are providing a single estimate for size and age at transition: 1,025 mm TL for length at 50% transition and 10.5 yr for age at 50% transition. Estimates for the 3 separate time periods can be found in SEDAR10-DW15.

Data for the Gulf of Mexico (collected during 1991-2002, see SEDAR10-DW3) showed no evidence of temporal changes in size and age at transition (compared to Hood & Schlieder’s data from 1977-80, cited in SEDAR10-DW3). Additionally, the histological and visual analyses of female size at transition to male (i.e., visual identification of “copperbellies”) yielded very similar results. Based on histological criteria, size at 50% transition was 1100 mm TL, and based upon visual pigmentation size at 50% transition was 1085 mm TL. In both analyses, transition appeared to begin after 800 mm TL and nearly all gag had undergone transition upon reaching 1300 mm TL. Age at 50% transition was 10.8 years. Transition to “copperbelly” pigmentation began at age 7 and nearly all fish were pigmented after about 15 years of age.

2.4.4. Batch Fecundity

Very consistent parameter estimates were found for Gulf and South Atlantic stocks.

South Atlantic: Batch fecundity as a function of total length did not differ between the three time intervals (Jan-Feb, Mar, and Apr-May), as indicated by the lack of differences in slopes (F=0.05; P=0.956; df=2) and intercepts (F=2.62; P=0.078; df=2). Given the similarity of the equations, data from all time intervals were combined. Linear regression parameters for the relationships between BF and fish size and age can be found in SEDAR10-DW15.

Gulf of Mexico: Batch fecundity (BF) increased with age and length of females, ranging from 60 thousand to 1.7 million ova per batch with a mean of 422 thousand ova (sd = 295 thousand). Variation in batch fecundity was generally high among age and size classes but the variation explained by linear fits of batch fecundity regressed on age and size were similar ($r^2 = 0.30$ and 0.34 respectively). As is common among fishes, the batch fecundity relationship was best predicted by regression with (ovary free) body weight ($r^2 = 0.53$). This is similar to results given in Collins et al. (1998) but expands the sample size of hydrated females. Linear regression parameters for the relationships between BF and fish size and age can be found in SEDAR10-DW3.

2.4.5. Spawning Frequency

South Atlantic: for a spawning season of 114 days the spawning frequency was estimated to be 1 spawn every 2.5 days (corresponding to 38 spawning events per season). See SEDAR10-DW15.
Gulf of Mexico: for a spawning season of 91 days the spawning frequency was estimated to be 1 spawn every 3.7-4.0 days (corresponding to 23-25 spawning events per season). See SEDAR10-DW3.

Recommendation:

Given that there is little evidence in both regions for an age effect on spawning frequency in both regions, annual fecundity at age would merely be the product of the expected number of spawns per female per season multiplied by batch fecundity at age.

2.5. Movements and migrations

The DW reviewed the results of two relatively large gag tagging studies. The objective was to gauge the degree of exchange between Atlantic and Gulf stock units. Approximately 6,500 gag were tagged primarily on the west Florida shelf, resulting in over 600 recaptures exhibiting limited movements (80% within a 9 km radius; SEDAR10-DW8). No movement was detected between the west Florida shelf and Atlantic stock units in this study. Most of these fish were recreational tag and recaptures and predominately showed ontogenetic movements from coastal to deeper waters of the shelf. In contrast, a South Atlantic tagging study (3,876 tags, 435 recaptures) reports a much higher proportion of fish moving a greater distance (23% over 185 km), primarily from the Carolinas towards the south to the Florida east coast (McGovern et al. 2005). There were several fish tagged in the South Atlantic that were recaptured from the Keys to the west Florida shelf.

Depth of tagging and size of fish appears to explain the different results from these two studies. In the Gulf tagging study, the modal size of tagged gag was approximately 400 mm. In the South Atlantic study, fish were tagged primarily from commercial boats across a broad depth range; fish were notably larger, ranging in mean size from 578-832 mm TL across 10-m depth categories. Mean distance moved was significantly greater for gag tagged in the 21-40 m depth range. It has also been reported that events such as hurricanes may cause large scale movements in shallow water groupers including gag. Gag were reported to be more abundant in Mississippi, Alabama and NW Florida after Hurricane Eloise in 1985 (Franks 2005).

In general, information suggests an ontogenetic movement to deeper waters; smaller gag (late juvenile to early adult) exhibit relatively high site fidelity with localized movements on the order of a few km. Gag then make larger along-shelf movements upon reaching depths of the mid to outer shelf (mature adults). There is some evidence that upon reaching older ages and outer shelf depths, associated with spawning habitats, gag again exhibit higher site fidelity (Coleman et al. 1996). Fish tagged and recaptured at the deepest depths (41-80 m) did not exhibit movements as large as those tagged at inner to mid-shelf depths less than 40 m (McGovern et al. 2005). Also, ongoing work suggests copperbelly gag tagged in spawning areas exhibit relatively high site fidelity (Koenig pers.comm.)

Recommendation:
Current data are inconclusive as to whether stock transfer or exchange is taking place between the US South Atlantic and the Gulf of Mexico. Therefore, no rate of migration, stock transfer or exchange should be implemented into the assessment models, and council boundaries should rule as the dividing line of the two stocks.

2.6. Stock definition and recommendations for research

Gag has been managed as separate Atlantic and Gulf stock units, and the SEDAR workshop panel was instructed by the SAFMC and GMFMC to continue with the two US management units in SEDAR 10. However, it was acknowledged that this may change in future assessments. The DW discussed stock identification issues, acknowledging work underway, and made recommendations for further research.

2.6.1 .Otolith Chemistry

Chemical signatures in otoliths have been used recently to discriminate gag from different nursery habitats. Hanson et al. (2004) demonstrated that chemical signatures in otoliths of gag could be used to classify juveniles from four nursery areas along the west coast of Florida (note: classification success ranged 66-100%). Results indicate the approach has promise for determining population structure and the relative contribution of gag from different nurseries. To date, the DW is not aware of reports characterizing chemical signatures in the otoliths of gag from the South Atlantic. If otolith signatures from the Gulf of Mexico and South Atlantic nurseries differ, these natural markers will provide a means of predicting the nursery origin of sub-adult and adult gag (retrospective determination based on quantifying material in the otolith core of sub-adults and adults, which corresponds to the nursery period). In addition, estimates of nursery origin could also be used to characterize population structure and connectivity of the two stocks. The DW recommends continued research on the use of otolith chemistry to evaluate the population structure of gag.

2.6.2. Population genetics

Genetic studies can provide both long-term and short-term estimates of connectivity among regional populations of Gag. Previous studies (Chapman et al 1999) exhibited evidence for population structure among different regions of the Gulf coast and Atlantic coast (a noteworthy result considering the high dispersal potential associated with this species), but significant departures from Hardy-Weinberg equilibrium within these sample groups. These departures from what is considered to be a neutral state assumption could be caused by many different processes such as high variance in reproductive success in individuals from year-to-year or regionally differential reproductive success in a structured population. Research underway addresses these questions and others associated with spatial and temporal population structure and their relationship to dispersal patterns, reproductive success, and effective population size (N. Jue, Florida State University). A recently funded Sea Grant proposal in South Carolina (Erik Sotka – PI, College of Charleston) will compare genetics of spawning gag captured in 2005 by commercial fishermen (sampled by MARMAP at SCDNR) to juveniles collected in North Carolina and South Carolina in subsequent months to determine the source of recruits, especially to North Carolina sounds. The DW recognizes the value of this research and that this type of genetics work can provide key insight into patterns in gag population structure. The DW further highly recommends every opportunity be taken to add Mexican (Campeche) samples to this analysis as these methods can be most informative in divining patterns of gene flow and population connectivity.

2.6.3. Demographic comparisons

Comparing estimates of growth, maturity, and sex-transition between Gulf and Atlantic management units provides inferences for stock connectivity. However, the DW recognized that subtle differences in methods of sampling, laboratory preparation and parameter estimation can obscure biological differences. The DW recognized that there have been recent workshops with productive outcomes on aging and reproductive assessments, targeting gag and similar species, and recommends that such workshops continue to be undertaken to eliminate potential methodological differences. The DW suggests that it may be particularly valuable to convene a workshop to address the potential non-random and non-representative sampling that hampers collection of small numbers of biological samples (relative to numbers of fish landed) which in turn are used for parameter estimates.

2.6.4. Age structure patterns

Gag year-class trends have been apparent for the Gulf of Mexico due to the ease of aging gag and the availability of a continuous series of age structure sampling from 1991 to 2005. The DW recommends that age structure sampling continue on an annual basis in the Gulf. Availability of age data in the South Atlantic is more episodic. The available overlapping years for the Gulf and South Atlantic revealed similar age progression and a relatively strong 1996 year class in both regions. This further suggests that annual recruitment trends are similar between regions. The DW recommends that long-term continuous monitoring of age structure be undertaken in the South Atlantic to test this hypothesis.

2.6.5. Larval transport and connectivity

It has been hypothesized that there are pathways for larval connectivity and transport from the Gulf to the Atlantic (Powles 1977, Fitzhugh et al. 2005). Exploration using a wind-driven 2-d transport model further supported this hypothesis but was unable to account for cross-shelf transport. In addition, there may be larval connectivity between the southern Gulf of Mexico (Campeche) and the west Florida shelf (Fitzhugh et al. 2005). The DW is aware that oceanographic modeling efforts are advancing (3-d models),and recommends that larval transport and modeling efforts associated with development of an Integrated Coastal Ocean Observing System (ICOOS) is further supported.

2.6.6. Tagging

Tagging studies are needed to: 1) clarify the extent of movement between the Gulf and SA regions and within region, and 2) aid further development of age-specific estimates of depth-related mortality in the Gulf region. In the SA region, most of the tagging effort has been off South Carolina. Therefore, we recommend that additional tagging be completed off the east coast of Florida to examine the extent of northerly and southerly movements. In the Gulf region, the bulk of the tagging targeted juveniles and young adults in coastal areas, therefore we recommend that tagging effort be extended to the middle and outer shelf, perhaps with the assistance of cooperating commercial fishers, for the purpose of tagging adult gag. The DW recommends that future tagging studies should be done in a more coordinated manner between researchers in the Gulf and SA regions, particularly with respect to gear, fish size, and depth.

2.7. Meristic Conversions

Gulf of Mexico: Meristic relationships were calculated for gag caught in the Gulf of Mexico for length types (total and fork) and body weights (whole and gutted), (Table 2.2). Coefficients of determination were high for linear (length) and nonlinear (weight) regressions (r^2>0.96).

South Atlantic: Various fishery independent and dependent data sets were used to develop relationships among whole weight (WW), gutted weight (GW), total length (TL), fork length (FL), and standard length (SL). When relating among lengths or among weight no-intercept linear regressions were used (Table 2.3). A linearized regression (ln-ln) was used to relate whole weight to various length measurements (Table 4). Note that when retransforming back to arithmetic space from logarithmic space, a bias correction is necessary based on the mean squared error (MSE) from the regression (Beauchamp and Olson 1973, Sprugel 1983). Estimates for whole weight (WW) at length (L) are obtained from:

$$WW = \exp(\text{Intercept} + MSE/2 + \text{Slope}*\ln(L)).$$

If we let,

$$a = \exp(\text{Intercept} + MSE/2),$$

then

$$WW = a\ L^b.$$

These regressions were originally done by source for the South Atlantic, and ultimately summarized for the region as presented in the tables referenced. Fishery-independent data included whole weight, gutted weight, total length, fork length, and standard length from the SC DNR MARMAP program. These same data (less the gutted weight) were also available from FL FWCC. In recent years, the Headboat program has measured occasional fork lengths along with total lengths. Fishery dependent data for whole weight and lengths were available from headboat (TL), MRFSS (FL), and TIP (TL) for both coasts. All weights shown are in kilograms and all lengths are in millimeters.

2.8. References

Beauchamp, J.J., and J.S. Olson. 1973. Corrections for bias in regression estimates after logarithmic transformation. Ecology 54(6):1403-1407.

Burns, K.M., C.C. Koenig, and F.C. Coleman. 2002. Evaluation of multiple factors involved in the release mortality of undersized red grouper, gag, red snapper, and vermilion snapper. Mote Marine Laboratory Technical Report No. 790.

Cadima, E.L. 2003. Fish Stock Assessment Manual. FAO Fish. Tech. Pap. 393, 161 p. FAO, Rome.

Coleman, F.C., C.C. Koenig, and L.A. Collins. 1996. Reproductive styles of shallow-water grouper (Pisces: Serranidae) in the eastern Gulf of Mexico and the consequences of fishing spawning aggregations. Environ. Biol. Fish. 47:129-141.

Chapman, R.W., G.R. Sedberry, C.C. Koenig, and B.M. Eleby. 1999. Stock identification of gag, Mycteroperca microlepis along the southeast coast of the United States. Mar. Biotechnol. 1:137-146.

Collins, L.A., A.G. Johnson, C.C. Koenig, and M.S. Baker Jr. 1998. Reproductive patterns, sex ratio, and fecundity in gag, *Mycteroperca microlepis* (Serranidae), a protogynous grouper from the northeastern Gulf of Mexico. Fishery Bulletin 96(3):415-427.

Diaz, G.A., C.E. Porch, and M. Ortiz. Growth models for red snapper in US Gulf of Mexico Waters estimated from landings with minimum size limit restrictions. NMFS/SFD Contribution SFD-2004-038. SEDAR7-AW1.

Fitzhugh, G.R., C.C. Koenig, F.C. Coleman, C.B. Grimes and W. Sturges III. 2005. Spatial and temporal patterns in fertilization and settlement of young gag (Mycteroperca microlepis) along the west Florida shelf. Bull. Mar. Sci. 77(3): 377-396.

Franks, J.S. 2005. First record of goliath grouper, Epinephelus itajara, in Mississippi Coastal Waters with comments on the first documented occurrence of red grouper, Epinephelus morio, off Mississippi.

Hanson, P.J., Koenig, C.C., and Zdanowicz, V.S. 2004. Elemental composition of otoliths used to trace estuarine habitats of juvenile gag *Mycteroperca microlepis* along the west coast of Florida. Mar. Ecol. Prog. Ser. 267: 253-265.

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

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

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

Koenig, C.C. and F.C. Coleman. 1998. Absolute abundance and survival of juvenile gag in sea grass beds of the northeastern Gulf of Mexico. Trans. Am. Fish. Soc. 127:44-55.

Lorenzen, K. 1996. the relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystem and aquaculture. Journal of Fish Biology 49:627-647.

McGovern, J.C., G.R. Sedberry, H.S. Meister, T.M. Westendorff, D.M. Wyanski, and P.J. Harris. 2005. A tag and recapture study of gag, *Mycteroperca microlepis*, off the Southeastern U.S. Bulletin of Marine Science, 76(1): 47-59.

Overton, A.S. and J. Zabawski. 2003. Release mortality of undersized fish from the snapper/grouper complex off the North Carolina coast. NC Sea Grant 03-FEG-21.

Patterson, W.F. III, G.W Ingram, Jr., R.L. Shipp, and J.H. Cowan, Jr. 2000. Indirect estimation of red snapper (*Lutjanus campechanus*) and gray triggerfish (*Balistes caprriscus*) release mortality. Proceedings of the 53rd Annual Gulf and Caribbean Fisheries Institute, pp. 526-536.

Potts, J.C. and C.S. Manooch, III. 1998. Population assessment of the gag, *Mycteroperca microlepis*, from the southeastern United States. Report submitted to the South Atlantic Fishery Management Council, Charleston, S.C. 73 p.

Powels, H. 1977. Larval distributions and recruitment hypotheses for snappers and groupers of the South Atlantic Bight. Pages 362, 371 in Proc. Annual Conf. Southeastern Association of Fish and Wildlife Agencies. 31:363-371.

Quinn, T.J., R.B. Deriso. 1999. Quantitative Fish Dynamics, 542 p. Oxford Univ. Press, New York, NY.

Rudershausen, P.J., A. Ng, and J.A. Buckel. 2005. By-catch, discard composition, and fate in the snapper/grouper commercial fishery, North Carolina. NC Sea Grant 04-FEG-08.

SEDAR10-DW2. Lombardi-Carlson. L.A., G.R. Fitzhugh, B.A. Fable, M. Ortiz, C. Gardner. 2006. Age, length and growth of gag from the NE Gulf of Mexico 1979-2005. NMFS Panama City Lab Contribution 06-03.

SEDAR10-DW3. Update of gag reproductive parameters: Eastern Gulf of Mexico. 2006. Fitzhugh, G.R., H.M. Lyon, L.A. Collins, W.T. Walling, L. Lombardi-Carlson. NMFS Panama City Lab Contribution 05-06.

SEDAR10-DW8. Ortiz, M. K. Burns and J. Sprinkel. Review of tagging data for gag grouper from the southeastern Gulf of Mexico region 1985-2005.

SEDAR10-DW13. Reichert, M., G. Fitzhugh, and J. Potts. Report of a gag age workshop.

SEDAR10-DW15. Reichert, M., D. and D. Wyanski. Analytical report on the age, growth, and reproductive biology from the Southeastern United States.

SEDAR10-DW24. Chih, Ching-Ping, 2006. Effect of some variations in sampling practices on the length frequency distribution of gag groupers caught by commercial fisheries in the Gulf of Mexico.

SEDAR10-DW31. Potts, J.C. and D.R. Carr. 2006. Age and growth data of gag from the southeastern United States as collected and analyzed by NMFS Beaufort Laboratory.

Sprugel, D.G. 1983. Correcting for bias in log-transformed allometric equations. Ecology 64(1):209-210

Turner, S.C., C.E. Porch, D. Heinemann, G.P. Scott, and M. Ortiz. 2001. Status of gag in the Gulf of Mexico, Assessment 3.0. NMFS, Southeast Fisheries Science Center, Miami, FL. Sustainable Fisheries Division Contribution: SFD 01/02–134. 32 p + Tables and Figures.

Wilson, R.R. and K.M. Burns. 1996. Potential survival of released grouper caught deeper than 40 m based on shipboard and in-situ observations and tag recapture data. Bulletin of Marine Science 58: 234-257.

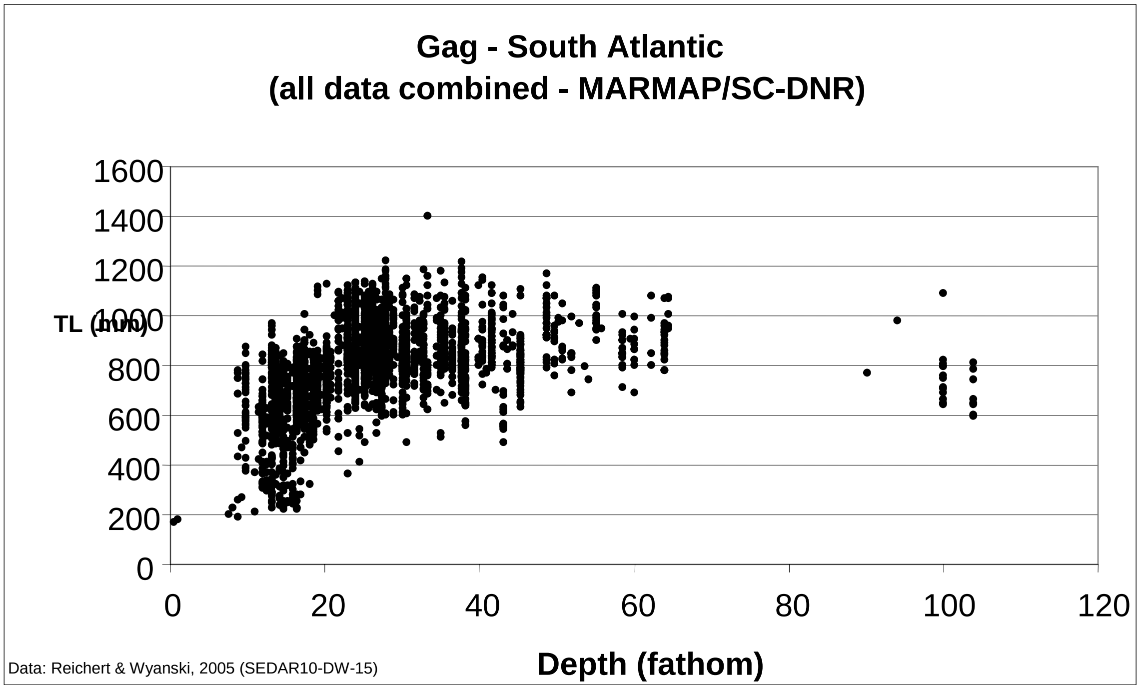


Figure 2.1. Gag total length (mm) plotted with depth (fm) for the South Atlantic. All gears were combined (fishery-independent and dependent) thus accounting for occurrences of undersized fish (below about 500 mm TL).

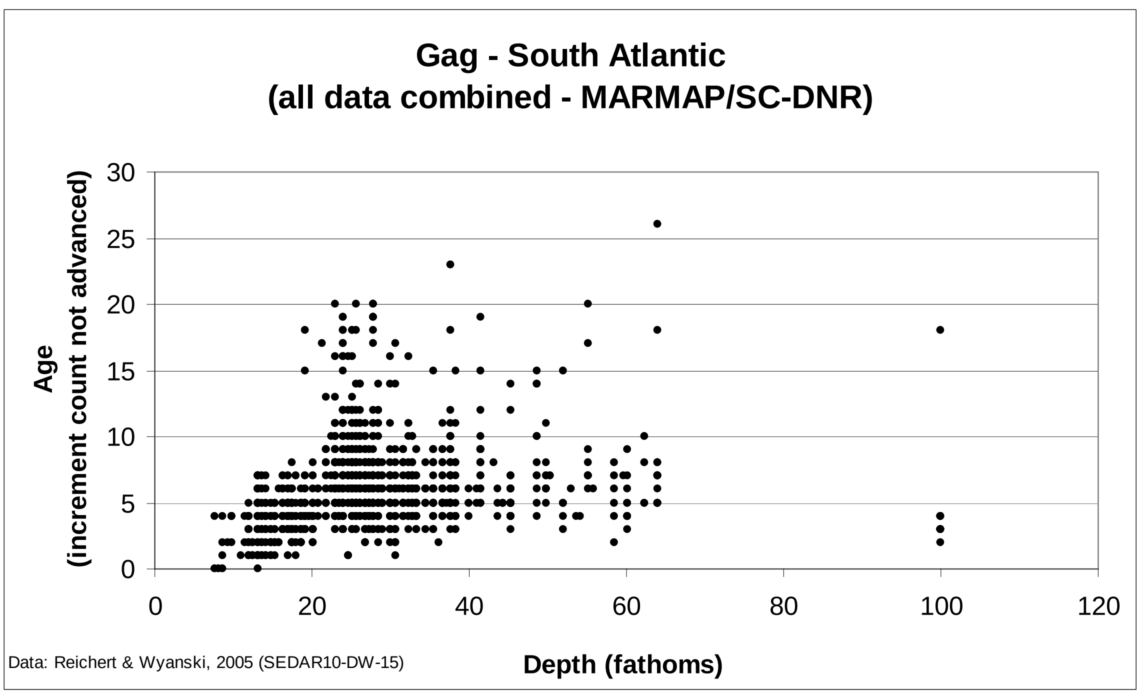


Figure 2.2. Gag age (increment count) plotted with depth (fm) for the South Atlantic. All gears combined (fishery-independent and dependent)

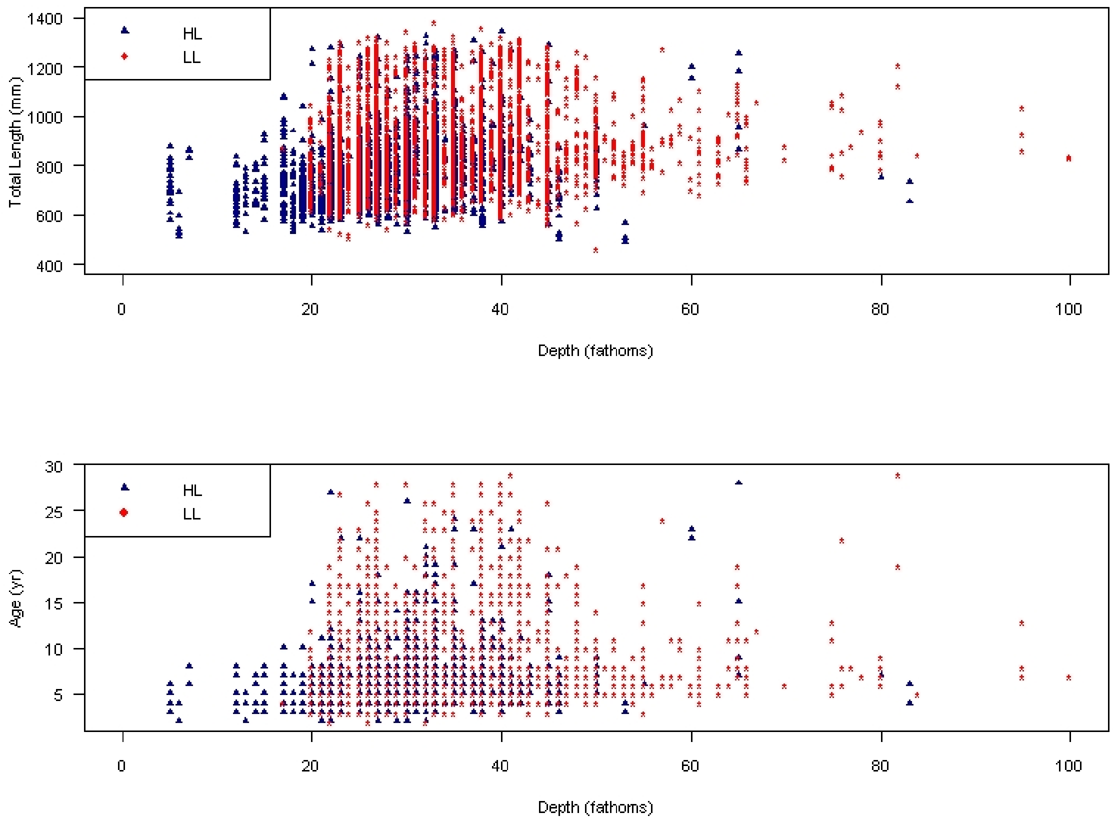


Figure 2.3. Age and length plotted with depth (fm) for the Gulf of Mexico for long-line (LL) and handline (HL) fisheries.

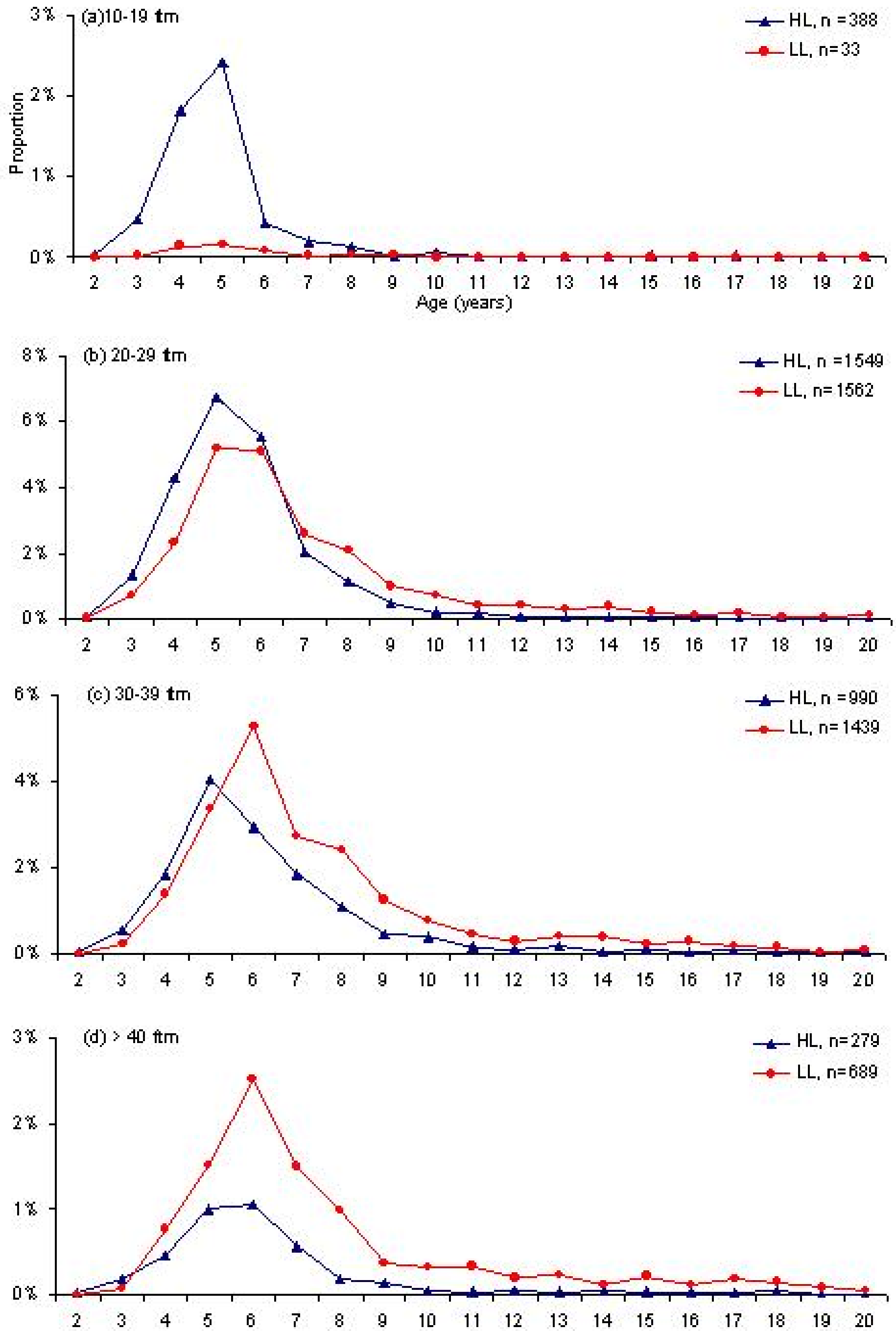


Figure 2.4. Age data proportioned to the depth (fm) fished and commercial gear type. Depth categories in 10-fm bins. Scales on y-axis vary.

Table 2.1. Gag reproductive biology analysis – probit analysis – from the South Atlantic (SCDNR data – SEDAR10-DW15).

Analysis	Period	Cumul. Distrib.	N	Intercept	Standard Error	Independent variable	Standard Error
Age (count) at sex transition	1977-82	Normal	322	-3.37	0.41	0.287	0.047
	1994-95	Normal	1508	-4.26	1.03	0.406	0.129
	2004-05	Normal	1048	-4.60	0.28	0.474	0.036
	all	Normal	2878	-4.16	0.49	0.398	0.061
Total length at sex transition	1977-82	Logistic	501	-22.94	2.17	0.023	0.002
	1994-95	Normal	3836	-13.93	0.89	0.014	0.001
	2004-05	Logistic	1004	-29.45	3.82	0.028	0.004
	all	Logistic	5341	-19.29	0.60	0.018	0.001
Age (count) at maturity	1977-82	Logistic	329	-8.34	1.37	2.239	0.334
	1994-95	Logistic	1439	-6.42	0.77	2.442	0.227
	2004-05	Gompertz	1276	-5.41	0.48	1.594	0.136
	all	Logistic	3044	-7.68	0.81	2.529	0.240
Total length at maturity	1977-82	Gompertz	472	-9.60	1.37	0.015	0.002
	1994-95	Gompertz	3679	-12.68	1.01	0.020	0.002
	2004-05	Logistic	1239	-32.37	2.37	0.048	0.004
	all	Logistic	5390	-24.91	2.19	0.038	0.003

Table 2.2. Meristic regressions for gag from the Gulf of Mexico (1991-2005). Refer to SEDAR-10-DW-2, for details.

Gulf of Mexico

Conversion and Units	Equation	Sample Size	r^2 values	Data Ranges
FL (mm) to TL (mm)	TL = 1.03 * FL – 0.68	4999	0.99	TL (mm): 245 – 1360 FL (mm): 238 – 1321
TL (mm) to W. Wt (kg)	W. Wt = 1 x 10^{-08} * ($TL^{\wedge 3.03}$)	4922	0.97	TL (mm): 245 – 1360 W. Wt (kg): 0.23 – 32.74
FL (mm) to W. Wt (kg)	W. Wt = 1 x 10^{-08} * ($FL^{\wedge 3.02}$)	3809	0.97	FL (mm): 217 – 1321 W. Wt (kg): 0.13 – 32.74
TL (mm) to G. Wt (kg)	G. Wt = 1 x 10^{-08} * ($TL^{\wedge 2.99}$)	527	0.96	TL (mm): 446 – 1295 G. Wt (kg): 0.99 – 27.02
FL (mm) to G. Wt (kg)	G. Wt = 9 x 10^{-9} * ($FL^{\wedge 3.05}$)	2407	0.98	FL (mm): 432 – 1335 G. Wt (kg): 0.99 – 32.21
SL (cm) to TL (cm) *for age-0 gag only*	TL = 1.85 * SL – 0.23	165	0.99	SL (cm): 2.5-10.0 TL (cm): 3.1-12.1

Table 2.3. Length-length and weight-weight regressions (no-intercept) for gag from the South Atlantic.

Sources	Ind. Var.	Dep. Var.	N	Parameter	S.E.	Adj. R^2	Pr > F
Length-Length Regressions:							
FL FWCC (n=176), SC DNR (MARMAP; n=3301), Headboat (n=215)	TL (mm)	FL (mm)	3692	1.0341	0.00020	0.9999	<0.0001
FL FWCC (n=145) & SC DNR (MARMAP; n=3582)	TL (mm)	SL (mm)	3727	1.1908	0.00044	0.9999	<0.0001
Whole Weight (WW)-Gutted Weight (GW):							
SC DNR (MARMAP)	WW (kg)	GW (kg)	136	1.0585	0.0014	0.9998	<0.0001

Note: WW = whole weight; GW = gutted weight
TL = total length; FL = fork length; SL = standard length

Table 2.4. Linearized weight-length regressions for gag from the South Atlantic.

Source	Ind. Var.	Dep. Var.	N	Intercept	S.E. Int	Slope	S.E. Slope	MSE	Adj. R^2	Pr > F
SC DNR (MARMAP; n=4020), Headboat (n=11915), TIP (n=539)	ln(WW)	ln(TL)	16474	-17.843	0.040	2.943	0.006	0.047	0.933	<0.0001
SC DNR (MARMAP; n=2348), MRFSS (n=1334)	ln(WW)	ln(FL)	3682	-15.688	0.113	2.633	0.017	0.100	0.863	<0.0001
SC DNR (MARMAP)	ln(WW)	ln(SL)	2248	-17.332	0.066	2.949	0.010	0.020	0.9735	<0.0001

Note: WW = whole weight; TL = total length; FL = fork length; SL = standard length

3 Commercial Fishery

Participants: Alan Bianchi, Steve Brown, Guy Davenport, Jack Holland, Nan Jenkins, Fritz Rohde, Steve Turner, Doug Vaughan (chair)

Others: Ching-Ping Chih, Kevin McCarthy, Bob Wiggers

3.1 Overview

A series of issues were discussed by the Commercial Working Group concerning stock boundaries between Gulf of Mexico and U.S. South Atlantic, the misidentification of gag as black grouper, and adjusting gag landings to include a portion of unclassified grouper species (primarily historical unclassified grouper landings prior to the mid-1980s). To adjust gag grouper for unclassified groupers, landings of all classified groupers are necessary (see grouper species codes in Table 3.1).

The Data Workshop decided to tabulate landings for 1963-2004. The previous stock assessment of Gulf of Mexico gag used landings starting in 1986 (Turner *et al.* 2001). The stock assessment method was a VPA which relies on having extensive information on age and size composition; 1986 was selected as the earliest year because grouper landings were first identified by species starting in 1986 and because size sampling was initiated only in 1984. The Data Workshop decided to tabulate possible gag landings starting in 1963, because of the possibility that alternative assessment methods which do not require age composition in every year might be investigated. The commercial landings data retained in data bases at the Southeast Fisheries Science Center start in 1962, however the group decided to tabulate U.S. Gulf landings only from 1963, because very little information exists on the areas where fish were caught in 1962 and in subsequent years substantial landings were taken from foreign waters.

Reported commercial landings of gag and other groupers are presented as are calculated (after adjustments for species misidentification and unclassified groupers) commercial gag landings are then presented as a series of tables and figures for the U.S. Gulf of Mexico gag grouper stock. Estimated discards are presented for recent years (2001-2004) subsequent to the last change in minimum size limit for the U.S. Gulf of Mexico. Additionally information is presented on sampling intensity and annual length frequency distributions by gear.

3.2 Commercial Landings

All landings are reported in gutted weight. Landings recorded in whole units in the ALS data base (Texas, Louisiana, Mississippi, and Alabama in all years, Florida 1986 and later) were converted to gutted weight using the standard ALS conversion factor of 1.18.

Statistical Area and Gear

The allocation of landings to one stock or the other was based on statistical areas (water bodies) recorded in the landings data or assigned to the landings from log book data. The specific definitions are provided in the Appendix 1. Capture gears of the landings were aggregated into five types: handline, longline, dive, trap, trawl and other. The gear codes in the landings data and the log book data assigned to each type also are defined in Appendix 1.

Statistical area and gear were recorded by dealers for most states in most years. They were not recorded in the monthly data for Florida in 1977-1996, nor Louisiana from 1990 through 1999 and for Texas gear was not recorded after 1992.. Gear and area were recorded in annual data for Florida, and they were recorded in relatively sparse logbook data starting in 1990 and more extensive logbook data in 1993 and later. The group consensus was data on gear and fishing area reported directly by fishermen through the logbook program was probably more accurate than the data reported by dealers and associated staff to the landings program (Accumulated Landings System, ALS).

The group decided to use the annual data for Florida to assign gear to the monthly data for 1977-1992. They also decided to use the logbook data to assign gear and area rather than the landings data where there were sufficient numbers of observations. There were relatively fewer observations in 1990-1992 for most states and larger numbers of observations for 1993 and later. Despite the relatively lower numbers of observations the log book data were used for Louisiana starting in 1990 because there was no other information available. For the other states the logs were used to assign gear and area for1993 and later.

Misidentification of Gag

Schirripa and Goodyear (1994) reported that historically gag often had been misidentified in the landings as black grouper, They used proportions [gag / (gag + black grouper)] of recreational landings by county in Florida to convert commercial landings of gag and black to gag; for Texas through Alabama it was assumed that all gag and black landings were gag. Turner *et al.* (2001) followed Schirripa and Goodyear's approach. SEDAR10-DW-24 (Chih and Turner, 2006) reviewed the proportions of gag in landings data as well as in biological sampling data collected by port agents at the dock in Gulf of Mexico ports.

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

Unclassified Groupers

Prior to 1986 nearly all groupers except two species, goliath and warsaw which were caught at very large sizes, were landed as 'grouper' in states bordering the Gulf of Mexico (Table 2). Starting in 1986 grouper landings began to be identified by species and the amount of unclassified groupers declined sharply. A proportion of the unclassified grouper landings were then converted to gag and black grouper.

Reported landings of gag and black grouper and all classified groupers combined are shown in Tables 3, 4 and 5. The annual proportions of gag and black grouper in classified groupers were used to calculate the annual amounts of unclassified groupers which were likely to have been each of those species. The proportions of gag and black from 1986-1989 combined were used to calculate the amount of unclassified groupers from 1963-1985 which might have been gag or black grouper. The annual proportions were calculated by year, state, county, gear and statistical area where possible; when there not observations for a stratum, more highly aggregated stratification was used. A similar approach was used for the multi-year proportions.

Calculated landings

The landings for gag and black grouper, both from reported landings and computed from unclassified groupers were combined. The proportion of gag and black which were likely gag (from SEDAR10-DW-24) were applied to those landings to compute 'calculated gag' (Table 6). For calculations involving reported gag and black grouper, if the calculated amount of gag landed was less than the amount of gag reported, then the amount of gag reported was used.

3.3 Commercial Discards

Size limits have been in place for the commercial fishery since February 1990 when a 20" limit was established and that limit was increased to 24" in June 2000. Size limits are thought to have resulted in discarding of undersized fish at sea.

Commercial discards were calculated from the number of handline trips made and the reported number of discards per trip as recorded in discard logs requested from a random sample of permitted fishermen (SEDAR10-DW-11). The final estimates of total discards (live and dead) by the handline fishery for 2001-2004 are given in Table 7. That document reported that about 10% of the discards were reported to be 'all dead', 'mostly dead' or 'kept not sold'; nearly all of the remainder were described as 'all alive' or 'majority alive' .

3.4 Biological Sampling

3.4.1 Sampling Intensity for Length and Age

The number of observations of lengths from the commercial landings by year and gear are shown in Table 8. In that table three gears are shown which are combined into ‘handline’; those are electric reel, rod and reel and handline.

Sampling fractions for size observations were calculated for the number of length observations for the commercial fisheries. The number of landed fish were obtained from the catch at age developed by Ortiz (SEADR10 AW document in preparation) from the landed catch at age in number of fish for Gulf of Mexico gag based on the calculated landings, size samples, age-length keys and the growth equation (Table 9). The overall length sampling fractions increased from 0.2-1% in the 1980’s, to 2-7% in the 1990’ and 3-5% from 2000-2004 (Table 10); length sampling fractions varied by gear with the longline fishery generally being more heavily sampled.

The number of age observations available (aged) for developing age-length keys for the commercial fishery are shown in Table 11; these were developed from the data summarized in SEDAR10-DW-02 (Lombardi *et al.* 2006). The overall age sampling fractions for the commercial fishery generally ranged from 0.1-0.3% for 1991-2000 and then were about 0.6-1% for 2001-2004. The increase in sampling fractions after 2000 occurred in both the handline and longline fisheries, though the increase started earlier in the longline fishery (1999) and was larger.

3.4.2 Length/Age Distribution

The length and age annual distribution of observed size samples by commercial fishery will be presented by Ortiz in a document for the assessment workshop on the development of the catch at age.

3.4.3 Adequacy for characterizing lengths

SEDAR10-DW-18 (Chih, 2006) showed that the length and age distributions of samples from trips on which small numbers of samples were taken differed from the distributions when larger numbers of samples were taken and that weighting the size samples from each trip by the amount of gag landings influenced the annual estimates of size composition. SEDEAR10-DW-18 recommended that age-length keys be used for calculating age composition rather than using the aggregated aged samples to represent the age composition. The group discussed these results extensively and recommended that age-length keys or similar approaches be used and that careful consideration be given to sample size in developing length or age composition estimates.

3.5 Research Recommendations

1. Increase sampling for otoliths for aging.
2. Improve at-sea observation for discards.

3.6 Literature Cited

Chih, C. 2006. Effect of some variations in sampling practices on the length frequency distribution of gag groupers caught by commercial fisheries in the Gulf of Mexico. SEDAR10-DW-18. 36p.

Chih, C. and S.C. Turner. 2006. Estimation of species misidentification in the commercial landing data of gag groupers and black groupers in the Gulf of Mexico. SEDAR10-DW-24. 36p.

Lombardi-Carlson, L.A., G.R. Fitzhugh, W.A. Fable, M. Ortiz, and C. Gardner. 2006. Age, length, and growth of Gag (*Mycteroperca microlepis*) from the northeastern Gulf of Mexico: 1979-2005. SEDAR10-DW-02. 57p.

Schirripa, M.J. and C.P. Goodyear. 1994. Status of the gag stocks of the Gulf of Mexico: assessment 1.0. NMFS, Southeast Fisheries Center, Miami Laboratory, Miami CRD-93/94-61. 156 pp.

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

Table 3.1. Proportions of gag in combined landings of gag and black grouper as estimated from TIP (Trip Interview Program) data. From SEDAR10-DW-24. Proportions are in number of fish.

statistical area	proportion
1	0.167
2	0.485
3	0.717
4	0.945
5	0.976
6	0.987
7	0.995
8	0.995
9	0.995
10	0.995
11	0.995
12	0.995
13	0.995
14	0.995
15	0.995
16	0.995
17	0.995
18	0.995
19	0.995
20	0.995
21	0.995

Table 3.2. Commercial landings of unclassified groupers caught in United States Gulf of Mexico waters in pounds gutted weight. Landings by spear, trap, and trawl were combined with other ensure confidentiality.

	handline	longline	other	total
1963	5,819,408		8,864	5,828,273
1964	6,926,771		30,412	6,957,183
1965	7,679,888		13,042	7,692,931
1966	6,878,768		17,659	6,896,427
1967	5,626,988		51,068	5,678,056
1968	6,097,085		40,268	6,137,353
1969	6,992,276		27,168	7,019,444
1970	6,826,371		33,692	6,860,063
1971	6,295,827		35,880	6,331,707
1972	6,578,807		43,849	6,622,656
1973	5,025,306		33,514	5,058,819
1974	5,635,386		17,084	5,652,469
1975	6,802,028		26,892	6,828,919
1976	5,822,592		39,281	5,861,873
1977	4,683,057		67,137	4,750,193
1978	4,276,249		129,435	4,405,684
1979	5,970,068	45,918	80,568	6,096,554
1980	5,967,652	701,039	92,354	6,761,045
1981	5,993,734	3,628,801	117,451	9,739,986
1982	5,410,300	6,546,482	137,803	12,094,585
1983	4,745,126	4,566,406	40,667	9,352,199
1984	4,996,900	3,824,822	341,682	9,163,404
1985	6,156,690	3,799,440	687,211	10,643,341
1986	226,619	325,331	15,122	567,072
1987	278,281	362,712	11,825	652,819
1988	403,766	298,432	10,502	712,700
1989	299,624	195,144	6,950	501,718
1990	131,892	111,922	9,008	252,821
1991	76,737	106,926	3,248	186,910
1992	95,123	88,428	2,439	185,990
1993	46,058	124,191	10,560	180,809
1994	18,764	45,211	4,299	68,274
1995	14,271	53,247	2,701	70,219
1996	9,570	38,479	427	48,476
1997	12,925	53,599	437	66,961
1998	25,620	75,932	759	102,311
1999	10,588	63,575	1,186	75,349
2000	11,149	35,949	884	47,982
2001	12,469	50,334	442	63,245
2002	8,841	37,650	347	46,837
2003	3,847	23,105	219	27,172
2004	6,766	28,434	602	35,802

Table 3.3. Reported commercial landings of gag from United States Gulf of Mexico waters in pounds gutted weight. Small amounts of landings in 1985 are not shown, and several gear categories (spear, trap, trawl and other) are combined to ensure confidentiality.

	handline	longline	other	total
1986	520,245	216,664	3,278	876,452
1987	416,616	245,672	1,114	827,451
1988	354,196	196,365	1,160	636,038
1989	493,443	218,418	5,359	936,128
1990	517,082	319,804	6,806	1,045,597
1991	644,798	280,308	26,132	1,224,350
1992	784,181	430,472	32,085	1,511,639
1993	994,836	408,382	81,175	1,723,701
1994	893,297	288,941	102,559	1,511,229
1995	903,982	345,144	90,563	1,601,448
1996	880,404	344,934	53,770	1,559,269
1997	969,063	389,066	70,142	1,656,524
1998	1,700,972	579,963	74,955	2,637,463
1999	1,350,454	520,431	62,550	2,151,062
2000	1,462,782	582,604	70,239	2,311,179
2001	1,884,858	951,165	93,627	3,121,477
2002	1,730,090	995,477	56,530	2,927,583
2003	1,308,524	1,039,490	59,566	2,563,867
2004	1,560,443	1,049,723	68,444	2,806,127

Table 3.4. Reported commercial landings of black grouper from United States Gulf of Mexico waters in pounds gutted weight. Small amounts of landings in 1985 are not shown, and several gear categories (spear, trap, trawl and other) are combined to ensure confidentiality.

	handline	longline	other	total
1986	677,365	346,969	42,697	1,067,032
1987	497,399	501,112	45,984	1,044,495
1988	439,843	252,638	34,954	727,436
1989	775,563	274,912	49,603	1,100,079
1990	670,127	389,763	55,070	1,114,959
1991	373,731	268,514	64,181	706,426
1992	263,896	212,377	70,424	546,697
1993	323,354	100,027	44,712	468,093
1994	293,303	83,706	30,067	407,077
1995	287,806	63,239	27,556	378,601
1996	259,518	75,684	23,933	359,135
1997	156,832	55,743	18,930	231,505
1998	177,240	52,542	9,714	239,495
1999	152,923	58,793	10,246	221,963
2000	154,725	66,399	16,184	237,308
2001	194,573	81,823	15,494	291,889
2002	194,132	79,444	12,250	285,826
2003	169,843	135,738	14,198	319,779
2004	189,035	116,281	9,149	314,464

Table 3.5. Reported commercial landings of classified grouper (except goliath and warsaw) from United States Gulf of Mexico waters in pounds gutted weight. Small amounts of landings in 1983 and 1984 are not shown, and several gear categories (spear, trap, trawl and other) are combined to ensure confidentiality.

	handline	longline	other	total
1985	76,618	111,652	-	188,269
1986	4,979,364	4,080,719	767,893	9,827,976
1987	4,013,412	5,188,442	499,287	9,701,142
1988	3,436,591	3,646,921	576,684	7,660,195
1989	5,405,735	4,039,329	644,050	10,089,113
1990	4,024,821	3,480,664	418,948	7,924,433
1991	3,463,845	4,011,621	506,871	7,982,338
1992	2,894,616	4,164,113	728,606	7,787,336
1993	2,895,733	5,616,077	951,446	9,463,256
1994	2,667,899	4,210,230	1,139,854	8,017,982
1995	2,614,166	3,787,627	1,208,853	7,610,647
1996	2,209,351	4,047,513	674,098	6,930,962
1997	2,304,080	4,541,342	825,001	7,670,422
1998	2,805,690	4,235,941	427,384	7,469,015
1999	3,005,234	5,534,881	910,907	9,451,022
2000	3,531,477	4,928,745	1,205,564	9,665,787
2001	3,908,904	5,520,356	953,301	10,382,561
2002	3,929,881	5,198,773	1,067,201	10,195,855
2003	2,896,008	5,606,359	818,574	9,320,941
2004	3,457,456	5,854,879	876,385	10,188,719

Table 3.6. Calculated commercial landings of gag from United States Gulf of Mexico waters by gear and year and by state and year. The other gear category is combined with spear, trap and trawl and longline in 1979) and the other state category includes Texas, Louisiana, Mississippi, Alabama and east Florida to ensure confidentiality.

	handline	longline	other	total
1963	1,288,786		1,446	1,290,231
1964	1,632,461		9,088	1,641,549
1965	1,815,589		573	1,816,162
1966	1,456,567		1,226	1,457,793
1967	1,155,546		9,840	1,165,387
1968	1,192,285		4,414	1,196,699
1969	1,376,519		3,206	1,379,725
1970	1,283,655		2,503	1,286,158
1971	1,376,503		2,782	1,379,285
1972	1,460,382		3,980	1,464,362
1973	1,081,223		4,899	1,086,122
1974	1,184,110		1,355	1,185,465
1975	1,446,622		4,464	1,451,086
1976	1,198,439		9,114	1,207,552
1977	977,267		7,513	984,780
1978	875,262		10,951	886,213
1979	1,342,246		11,068	1,353,314
1980	1,317,860	89,303	11,866	1,419,030
1981	1,498,745	467,068	15,609	1,981,421
1982	1,334,618	1,009,999	14,163	2,358,780
1983	1,039,424	681,064	17,651	1,738,139
1984	1,098,289	433,159	18,408	1,549,855
1985	1,398,342	380,850	27,878	1,807,070
1986	1,155,013	517,406	29,022	1,701,441
1987	852,580	656,042	29,544	1,538,166
1988	791,072	402,244	23,178	1,216,494
1989	1,235,438	426,017	31,375	1,692,830
1990	1,129,790	622,484	40,816	1,793,090
1991	992,523	509,707	63,090	1,565,320
1992	1,002,507	592,824	68,549	1,663,880
1993	1,280,295	479,061	105,760	1,865,116
1994	1,147,880	351,816	119,045	1,618,740
1995	1,157,053	389,941	104,670	1,651,664
1996	1,106,013	393,141	67,503	1,566,658
1997	1,100,767	414,245	82,634	1,597,645
1998	1,847,898	601,209	81,579	2,530,686
1999	1,480,936	548,525	68,277	2,097,739
2000	1,587,117	614,935	81,259	2,283,311
2001	2,040,199	987,396	100,915	3,128,510
2002	1,890,715	1,031,132	61,659	2,983,506
2003	1,445,601	1,113,426	67,095	2,626,122
2004	1,717,249	1,111,637	72,807	2,901,692

	wFL	other	total
1963	1,269,366	20,865	1,290,231
1964	1,623,431	18,118	1,641,549
1965	1,799,778	16,383	1,816,162
1966	1,441,628	16,165	1,457,793
1967	1,147,483	17,904	1,165,387
1968	1,163,785	32,914	1,196,699
1969	1,353,861	25,864	1,379,725
1970	1,248,608	37,550	1,286,158
1971	1,339,665	39,620	1,379,285
1972	1,422,108	42,254	1,464,362
1973	1,040,660	45,462	1,086,122
1974	1,157,593	27,872	1,185,465
1975	1,424,570	26,516	1,451,086
1976	1,180,614	26,939	1,207,552
1977	957,726	27,053	984,780
1978	866,721	19,492	886,213
1979	1,333,948	19,366	1,353,314
1980	1,409,281	9,749	1,419,030
1981	1,964,441	16,980	1,981,421
1982	2,346,331	12,449	2,358,780
1983	1,714,472	23,667	1,738,139
1984	1,495,345	54,510	1,549,855
1985	1,764,596	42,474	1,807,070
1986	1,649,660	51,781	1,701,441
1987	1,479,086	59,079	1,538,166
1988	1,163,544	52,950	1,216,494
1989	1,656,431	36,399	1,692,830
1990	1,759,936	33,154	1,793,090
1991	1,526,374	38,946	1,565,320
1992	1,645,162	18,718	1,663,880
1993	1,842,124	22,993	1,865,116
1994	1,601,099	17,641	1,618,740
1995	1,625,558	26,106	1,651,664
1996	1,541,885	24,773	1,566,658
1997	1,563,166	34,479	1,597,645
1998	2,467,556	63,130	2,530,686
1999	2,033,217	64,521	2,097,739
2000	2,224,179	59,133	2,283,311
2001	3,088,082	40,427	3,128,510
2002	2,939,407	44,098	2,983,506
2003	2,588,772	37,350	2,626,122
2004	2,850,392	51,300	2,901,692

Table 3.7. Estimated number of gag discarded by handline vessels fishing in the Gulf of Mexico. From SEDAR10-DW-11.

	handline trips	total discards
2001	9,876	72,148
2002	9,921	75,084
2003	9,789	106,485
2004	9,159	52,525

Table 3.8. Number of lengths observations of gag caught in the Gulf of Mexico commercial fisheries.

	Handline							
	Electric Reel	Rod & Reel	Handline	Sub Total	Longline	Trap	Other	Total
1984	617	212	-	829	458	-	1	1,288
1985	705	68	2	775	597	-	91	1,463
1986	276	78	4	358	1,133	25	24	1,540
1987	497	51	11	559	685	-	-	1,244
1988	163	12	-	175	276	-	-	451
1989	35	-	7	42	170	21	-	233
1990	679	157	148	984	1,665	1	-	2,650
1991	341	482	182	1,005	940	17	19	1,981
1992	749	321	80	1,150	929	11	49	2,139
1993	633	1,227	28	1,888	789	11	53	2,741
1994	793	2,026	1	2,820	777	23	61	3,681
1995	1,791	643	3	2,437	997	-	26	3,460
1996	2,061	1,084	2	3,147	1,038	23	16	4,224
1997	947	2,156	261	3,364	1,224	38	394	5,020
1998	3,345	2,775	1,879	7,999	5,067	128	94	13,288
1999	3,042	2,569	266	5,877	4,654	181	323	11,035
2000	2,137	1,622	158	3,917	4,168	182	145	8,412
2001	2,734	2,567	132	5,433	4,151	285	11	9,880
2002	1,911	2,157	48	4,116	4,137	285	15	8,553
2003	1,267	914	20	2,201	3,921	85	40	6,247
2004	2,017	818	31	2,866	2,664	-	62	5,592

Table 3.9. Length sampling fractions for Gulf of Mexico commercial fisheries for gag.

	handline	longline	other	total
1984	1.2%	1.5%	0.0%	1.3%
1985	0.9%	2.1%	2.4%	1.2%
1986	0.4%	3.4%	0.7%	1.3%
1987	1.0%	1.8%	0.0%	1.3%
1988	0.4%	1.2%	0.0%	0.6%
1989	0.1%	0.7%	0.0%	0.2%
1990	1.6%	5.5%	0.0%	2.7%
1991	1.6%	3.7%	0.2%	2.0%
1992	1.8%	3.3%	0.6%	2.1%
1993	2.0%	3.3%	0.4%	2.1%
1994	3.0%	3.7%	0.5%	2.9%
1995	2.6%	4.4%	0.2%	2.7%
1996	2.7%	4.4%	0.2%	2.9%
1997	2.7%	5.0%	3.6%	3.2%
1998	4.3%	14.5%	1.0%	5.8%
1999	4.4%	15.7%	3.8%	6.5%
2000	2.8%	13.6%	1.4%	4.6%
2001	3.2%	7.9%	0.1%	4.2%
2002	2.8%	7.6%	0.2%	4.1%
2003	2.0%	6.6%	0.5%	3.5%
2004	2.1%	4.4%	0.6%	2.7%

Table 3.10. Number of gag landed by the Gulf of Mexico commercial fisheries estimated by Ortiz (to be documented in an assessment workshop report).

	Handline	Longline	Others	total
1984	68,710	30,242	2,533	101,485
1985	89,258	28,105	3,733	121,096
1986	80,012	33,700	3,316	117,028
1987	54,293	37,208	3,958	95,459
1988	46,138	22,829	2,981	71,948
1989	67,377	23,532	4,202	95,111
1990	60,773	30,428	5,377	96,578
1991	63,723	25,698	7,647	97,068
1992	65,545	28,360	8,381	102,286
1993	94,266	23,905	12,438	130,609
1994	93,161	21,191	13,525	127,877
1995	92,746	22,544	12,056	127,346
1996	115,163	23,790	8,785	147,738
1997	123,176	24,716	10,828	158,720
1998	185,848	34,943	9,793	230,584
1999	132,454	29,601	8,531	170,586
2000	140,144	30,722	10,154	181,020
2001	169,742	52,447	12,148	234,337
2002	145,258	54,646	7,989	207,893
2003	109,796	59,659	8,791	178,246
2004	137,009	60,589	9,581	207,179

Table 3.11. Age sampling fractions for Gulf of Mexico commercial fisheries for gag.

	Handline	Longline	Other	Total
1991	0.3%	0.0%	0.0%	0.2%
1992	0.1%	0.1%	0.0%	0.1%
1993	0.4%	0.1%	0.0%	0.3%
1994	0.5%	0.0%	0.0%	0.3%
1995	0.3%	0.1%	0.0%	0.2%
1996	0.2%	0.2%	0.0%	0.2%
1997	0.0%	0.0%	0.0%	0.0%
1998	0.1%	0.3%	0.0%	0.1%
1999	0.1%	0.8%	0.0%	0.2%
2000	0.3%	0.6%	0.1%	0.3%
2001	0.4%	1.7%	0.0%	0.7%
2002	0.6%	2.0%	0.2%	0.9%
2003	0.5%	1.9%	0.0%	0.9%
2004	0.7%	2.4%	0.0%	1.1%

Figure 3.1. Most statistical areas for the Gulf of Mexico region.

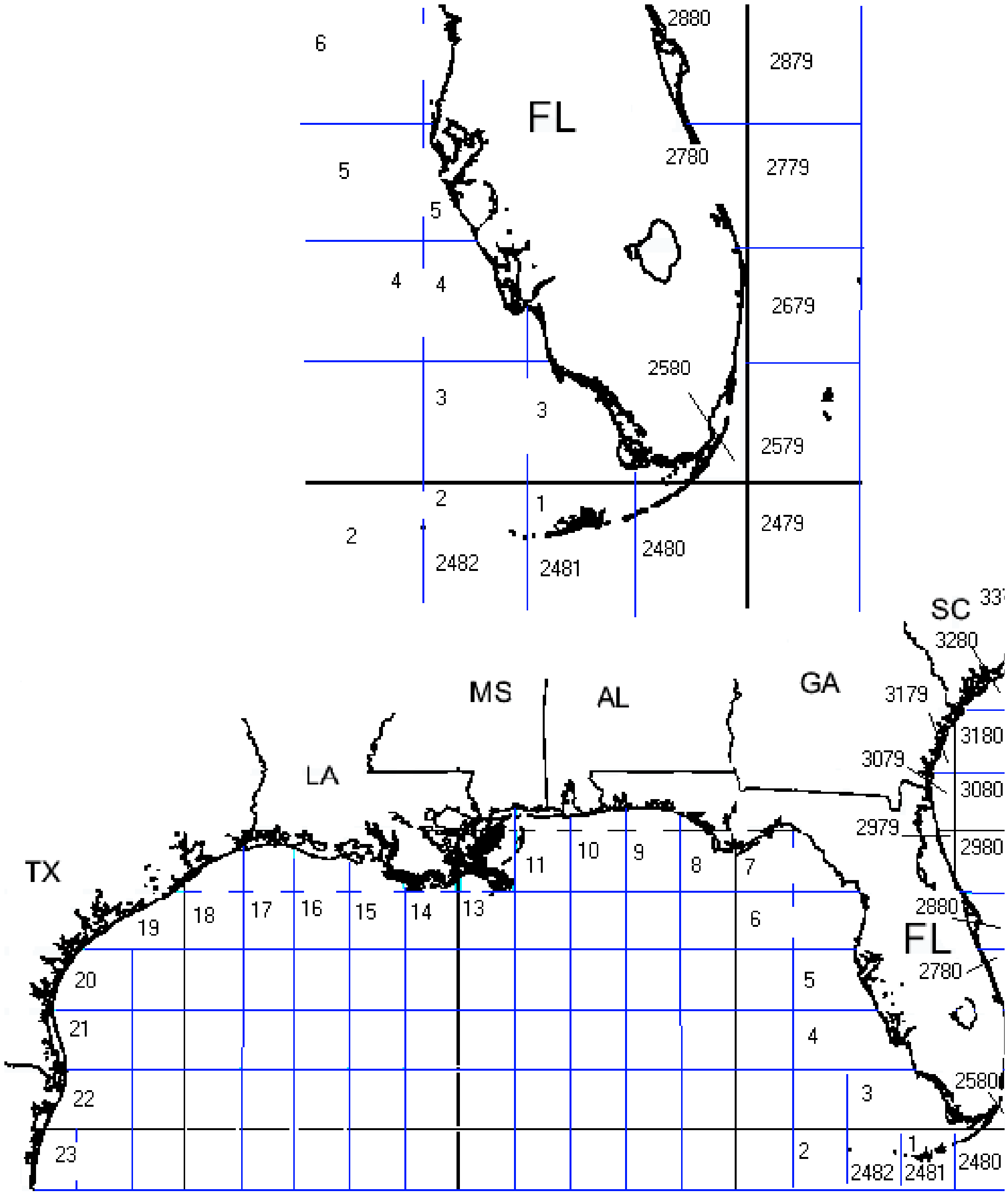
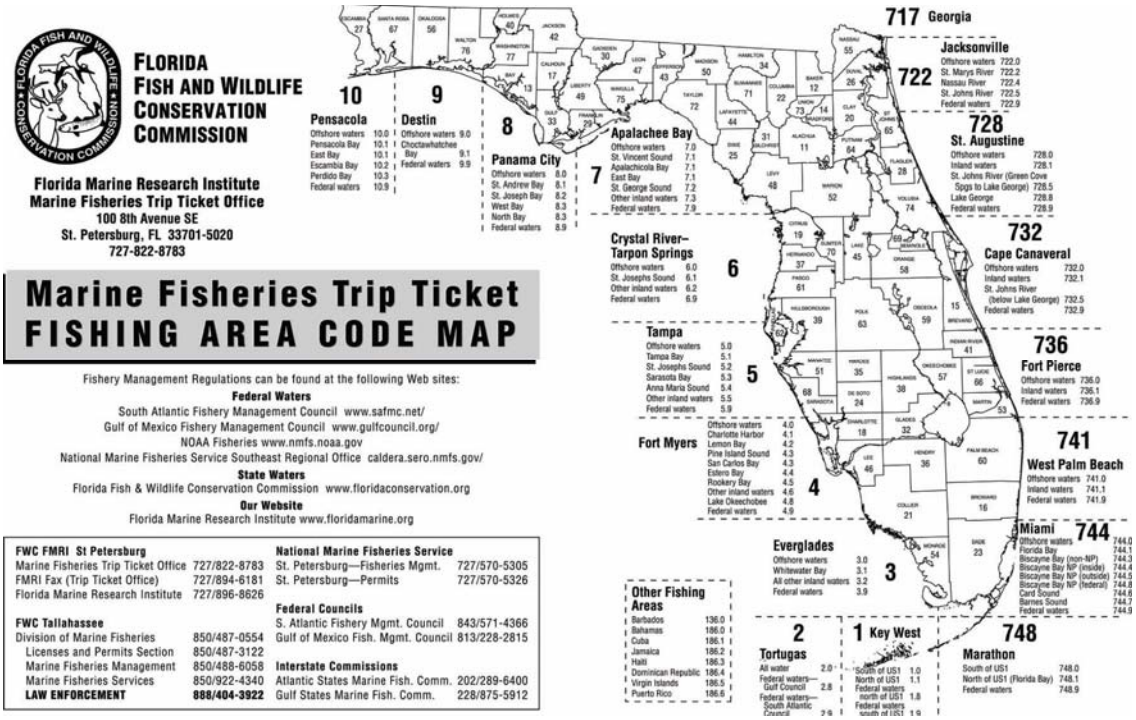


Figure 3.2. Statistical areas for Florida.



Appendix 1. Statistical area and gear code assignments.

Appendix 1. Table 1. Water body codes from the Florida Keys area used to assign grouper landings to the south Atlantic region or the Gulf of Mexico region.

water body	Atlantic	Gulf
0010	x	
0011		x
0018		x
0019	x	
0020		x
0028		x
0029		x
5000		x
7140-7440	x	
7441		x
7442-7480	x	
7481		x
7489	x	
7994-7997	x	

Appendix 1. Table 2. Gear codes from landings data and log book data assigned to gears used for tabulating landings for the assessment.

landings data (ALS)	
gear code	gear
200-299	trawls
345,355	trap
600-660,690	handline
675-677	longline
760, 943	dive
	other

log book data	
gear code	gear
E,H	handline
L	longline
P,S	dive
T	trap
	other

Appendix 2. **Addendum to Commercial Landings (Section 3.2):**

NMFS SEFIN Accumulated Landings(ALS)

Information on the quantity and value of seafood products caught by fishermen in the U.S. has been collected as early as the late1890s. Fairly serious collection activity began in the 1920s. The data set maintained by the Southeast Fisheries Science Center (SEFSC) in the SEFIN database management system is a continuous data set that 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 is not available.

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

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

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

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

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

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

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

There are two problems with the commercial fishery statistics that were collected from seafood dealers. First, dealers do not always record the specific species that are caught and second, fish or shellfish are not always purchased at the same location where they are unloaded, i.e., landed.

Dealers have always recorded fishery products in ways that meet their needs, which sometimes make it ambiguous for scientific uses. Although the port agents can readily identify individual species, they usually were not at the fish house when fish were being unloaded and thus, could not observe and identify the fish.

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

Cooperative Statistics Program

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 reduce duplication of effort and continue to provide the fisheries statistics that are needed for management by both Federal and state agencies. By the mid-1980s, formal cooperative agreements had been signed between the NMFS/SEFSC and each of the eight coastal states in the southeast, Puerto Rico and the US Virgin Islands.

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

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

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

Florida

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

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.

Alabama

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

Mississippi

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

Louisiana

=========

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

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

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

Texas

=====

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

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

NMFS SEFIN Annual Canvas Data for Florida

The Florida Annual Data files from 1976 – 1996 represent annual landings by county(from dealer reports) which are broken out on a percentage estimate by species, gear, area of capture, and distance from shore. These estimates are submitted by Port agents, which were assigned responsibility for the particular county, from interviews and discussions from dealers and fishermen collected through out 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 a commercial landings data base which reports where the marine resource was landed. With the advent of some State trip ticket programs as the data source the definition is more loosely applied (Louisiana Trip tickets for example report landings from the dealer location not necessarily from where it was landed). 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. In order to make that determination you must consider the area of capture.

Florida Annual Canvass 1976-1996 considerations:

1. 1976-1985 Data is as landed weight which was normally landed in a gutted condition. In order to convert to whole weight a factor of 1.18 is universally applied for groupers.
2. State 00 and Grid 0000 in the data set are marine product landed else where and trucked into the State of Florida and are considered to be duplicated else where because they are theoretically reported back to the State of landing and are not included in the Florida totals.
3. State 12 is in the data set represents Florida interior counties which were landed on Florida East Coast and not included in the Gulf catches.

4. Gulf of Mexico Gag Grouper Recreational Statistics Group

21 April 2006

Convened 23-27 January 2006, Charleston, SC

OVERVIEW

Gag grouper (*Mycteroperca microlepis*) represent an important recreational fishery resource in the Gulf of Mexico. Recent recreational landings of gag have topped 500,000 fish annually, with millions more caught and discarded. This report represents the best scientific judgment of the SEDAR 10 Data Workshop, with ideas first vetted in the Recreational Statistics Group but final decisions left to the full working group. A summary of findings are presented here along with discussion of controversies that arose during the workshop.

LANDINGS

General Issues

Monroe County

For management purposes and due to the possibility of distinct stock structure, the Gulf of Mexico and South Atlantic Fishery Management Council (GMFMC and SAFMC) gag grouper stocks were split at the Florida Keys, with a line running down the center of the Keys and then west from Key West to the Dry Tortugas. Unfortunately, this split does not correspond exactly with reporting areas for recreational catches. The Marine Recreational Fisheries Statistics Survey (MRFSS) include all of Monroe County landings in their official estimates for West Florida, yet catches in Monroe County come from both sides of the Keys. Similarly, Headboat Survey reporting areas 12 and 17, which are landings by Atlantic and Keys-based vessels fishing off the Keys and Dry Tortugas, include trips to both sides of the delineation line.

Regarding the MRFSS data, three options were considered. The first was to keep Monroe County catches in the Gulf, which is the default convention for MRFSS data. This alternative was rejected because of the sense that a reef-oriented fish like gag grouper was more likely to come from reef habitats to the south of the Keys (e.g., SAFMC) rather than grass habitats to the north (e.g., GMFMC). We also considered examining intercept data, which would include a landing location, as a way of dividing Monroe County catches. This alternative was also rejected because landing locations do not necessarily indicate on which side of the Keys the fishing activity took place. Instead, it was concluded that the best alternative was to assign Monroe County MRFSS catches to the SAFMC gag grouper stock. This assignment matches the general sense that grouper catches come from the south side of the Keys, and avoids extensive analyses on what is an extremely small fraction of overall catches. This method is also consistent with data treatments in previous assessments (e.g., SEDAR 9-DW-Reports).

Regarding headboat data, two alternatives were considered. The first was to examine effort records reported by captains in logbooks (usually not all trips), which often contain location reported to either 10 minute grids or latitude and longitude rounded to whole numbers. Prior to 1986, the location information was provided for 98% of all trips reported in logbooks. However, from 1986 on, location was only identified 77% of the time (Matter, SEDAR10-DW-27). It is believed that the drop in cooperation was a result of increased concern about the possibility this information would be used in designating marine protected areas. As a result, the location reports may not be random or representative. Also, since location information has not been used to the degree that other aspects of the headboat dataset have, it has not been as carefully error-checked and cleaned. Moreover, there was concern among some members of the group that location reports may have been inaccurate out of concern that favorite fishing spots might be closed. These concerns were supported by the fact that some locations were reported on land or well outside the management area. However, in support of their general accuracy, the distribution of trips that caught gag generally matched the sense of fishing locations (Fig. 1). Therefore, we examined them with the possibility of using their distribution to partition catches.

In area 12, there were a number of trips reported in areas that would unambiguously be considered the SAFMC management area but few that would unambiguously be considered the GMFMC management area (Fig, 1a). A large proportion of trips were reported in grid squares that contained waters on both side of the dividing line. In area 17, the same pattern held but with an even larger proportion of trips reported in grids that fell on the dividing line (Fig. 1b). All things considered, we concluded that the evidence did not warrant diverging from the *status quo* technique of assigning area 12 and 17 to the SAFMC gag grouper stock.

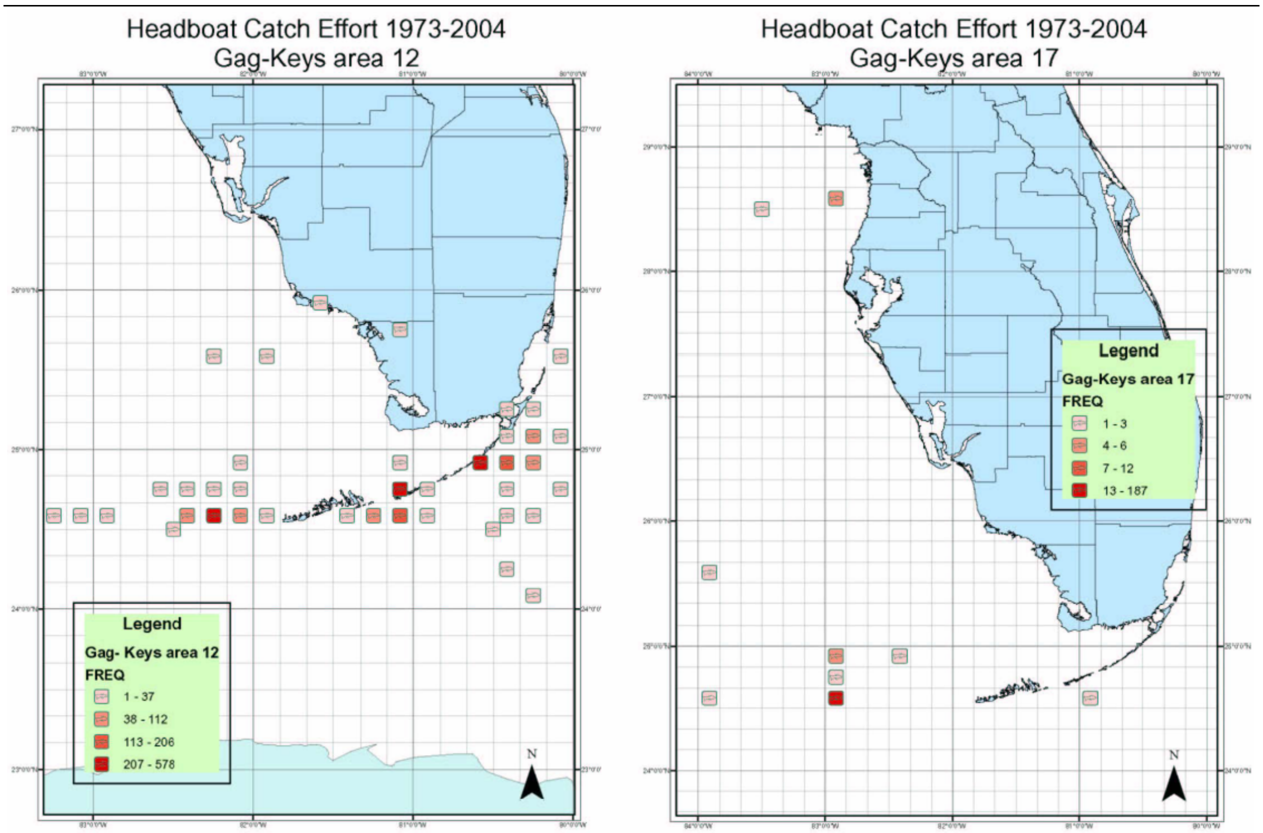


Fig. 1—Geographic distribution of headboat trips in Headboat Survey areas 12 and 17 on which gag grouper were caught, as reported in vessel logbooks (from Matter, SEDAR10-DW-27).

Misreporting of gag as black grouper

Gag grouper (*Mycteroperca microlepis*) and black grouper (*Mycteroperca bonaci*) look similar. This only adds to confusion caused by the fact that, in parts of the Gulf, *Mycteroperca microlepis* has traditionally been called black grouper. The MRFSS data suggest that these challenges resulted in misreporting of many gag landings as black groupers prior to 1990 (Table 1, and Phares et al., SEDAR10-DW-26). The problem was apparently corrected with updated interviewer training, interview supervision, and contractor QA/QC work with many new requirements that were implemented in the 1990 MRFSS contracts. Prior to that year, the numbers of black and gag grouper reported in MRFSS landings were fairly equal, whereas since that time gag landings have swamped black grouper landings in all counties (Table 1) except Monroe County, which has been assigned to the SAFMC stock.

Table 1—Observed gag versus black grouper in MRFSS. Observed gag landings (type A) as a percentage of observed gag + observed black grouper for the Gulf of Mexico MRFSS survey, by year and county.

Area/ Year	LA	MS	AL	FLW Excl Mon	Esc-Wak	Tay	Dix	Lev	Cit	Hern	Pas	Pin	Hil	Man	Sar	Cha	Lee	Col
1981			75	36	35				0			80		24	50		6	0
1982	0	0		53	9	15		0	90		100	85		100	100		10	
1983	0		0	60	42		0		100		86	71		45	100	0	100	
1984	50			61	0				40		33	72		33	9			44
1985	100		0	90	0						7	98		100	0		0	0
1986	38	100	49	55	2						100	82		0	0	0	0	0
1987	20	100	67	53	35	0					88	84		69	100			0
1988	0	74	100	46	29	0					75	75		67	40	100	38	
1989	100	89	100	81	94							74		100	100	27	100	100
1990			100	96	97		100		100		100	97			100	0		
1991	100	100	100	99	100	100		100	100		100	100	100	100	75	100	100	
1992	100	100	100	99	100		100	100	100	100	100	100	100	100	100	100	43	100
1993	100	100	100	100	100		100		100	100	100	100	100	100	100	100		
1994	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	86	100	100
1995	100	100	100	99	100	81		100	100	100	100	99	100	100	100	100	100	
1996	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		100	100
1997	100	100	100	98	99	100	100	100	100	100	100	100	100	100	74	67	100	100
1998	83	100	100	100	99	67	100	100	100	100	100	100	100	100	99	100	100	100
1999	100	100	100	100	100	100	100	97	100	100	100	99	100	98	98	100	100	100
2000	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2001	88	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2002	90	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2003	100	100	100	100	100	100	100	100	100	100	100	100	100	100	96	100	100	100
2004	100		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	96
Mean 90-04	**97.2**	**100**	**100**	**99.4**	99.7	95.7	100	99.8	100	100	100	99.7	100	99.9	96.1	89.5	95.6	99.6

Given this evidence, we chose to correct for the likely misreporting of gag as black grouper prior to 1990. To do so, we examined the data from 1990 onwards and calculated gag as a proportion of all gag and black grouper. This proportion averaged 0.972 for Louisiana, 1 for Mississippi and Alabama, and 0.994 for West Florida, excluding Monroe County. Then, gag catches prior to

1990 were adjusted by applying this proportion to the sum of gag and black grouper for those years.

Headboat data were also examined (Table 2). Outside of the Florida Keys and Dry Tortugas (areas 12, 17, and 18), catches were predominantly gag. Moreover, there seemed to be some consistency in the proportion gag over the time series. The only apparent anomalies were from area 23 in 1986 and 1987. However, absent an external rationale for potential misreporting, the group decided to move forward with these numbers as is.

Table 2—Gag versus black grouper in Headboat Survey. Gag landings as a percentage of observed gag + observed black grouper for the Gulf of Mexico Headboat Survey, by year and area. From Phares et al., SEDAR10-DW-26.

	TX West	TX Mid	TX East	LA	AL/ FLW Panh	FLW Mid gr	FLW SW	FLW Tortu	FLW Tortu	FLW Keys	Total Gulf
Area:	27	26	25	24	23	22	21	18	17	12	Pct
1986	94	100	90	87	62	100	86	98	5	31	80
1987	82	73	98	95	62	100	93		9	28	81
1988	87	76	97	100	99	100	96		8	37	92
1989	89	90	91	96	91	79	94	53	1	40	90
1990	100	75	96	100	91	100	92	67	18	55	92
1991	92	98	93	67	93	90	90	48	0	29	88
1992	100	89	78	68	98	100	87	56	14	24	86
1993	100	100	95	98	96	100	93	73	27	30	91
1994	100	97	93	99	99	94	93	100	21	23	90
1995	100	98	97	97	100	100	69		13	32	73
1996	100	53	99	100	98		83		17	32	86
1997	100	69	98	97	100	95	73		14	40	82
1998	100	99	99	100	99	100	85		31	49	91
1999	100	96	99	51	97	89	99		44	18	95
2000	89	83	96	36	99	97	99		44	32	97
2001	90	90	66	63	98	62	96		15	21	83
2002	99	71	92		99	87	98		10	24	93
2003	99	86	86	100	99	89	98		19	40	95
2004	97	72	56		99	87	99		8	75	95

MRFSS

<u>Shore mode</u>

There was an extensive discussion about catches from MRFSS shore mode. This mode is poorly sampled, with sampling fractions ranging from 0.002 to 0.2%. Therefore large expansion factors are used, which can make rare events appear highly variable. Conventionally, shore mode is excluded entirely or the data are used, presuming that the variability will be swamped by other modes with larger landings or accounted for by considering CVs in the model. Shore mode cannot be entirely ignored for GMFMC gag and the use of CVs is complicated by the fact that this mode is unlikely to be treated as a separate fleet in the model (which would require the estimation of a number of distinct selectivity parameters and F multipliers). One hypothesis was that shore catches might truly be highly variable and indicate recruitment of relatively young fish. This hypothesis was explored by comparing spikes in shore mode catches to periods that would correspond with the appearance of known strong year classes (Fig. 2). This comparison indicated that shore mode catches might show a weak signal for some recruitment events, but also that the noise in shore mode may partially or fully swamp recruitment signals.

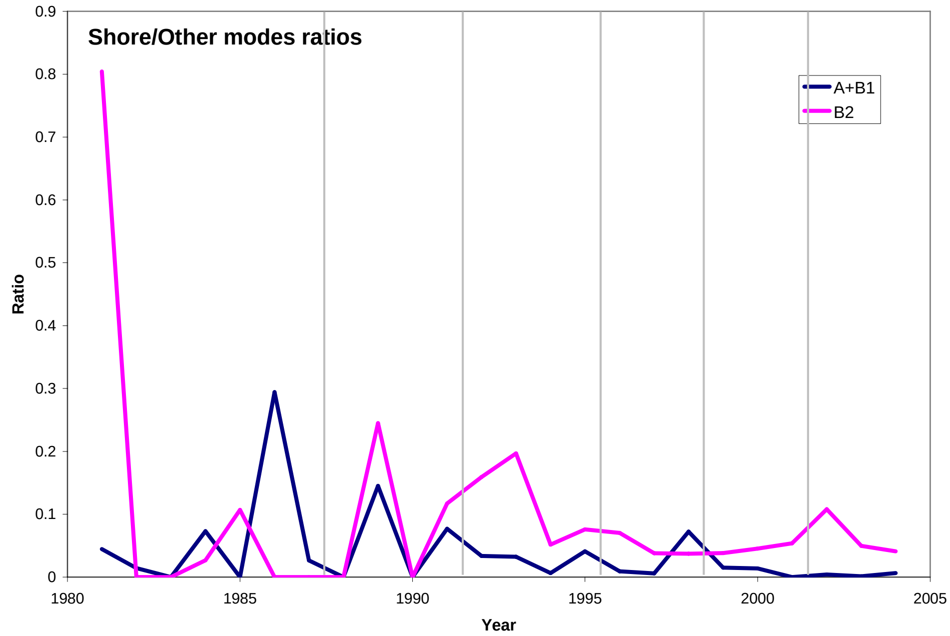


Fig. 2—MRFSS shore mode catches as a fraction of catches from other modes, including raw numbers and various potential substitutions. Raw values with expected years of high recruitment identified with gray vertical lines, assuming recruitment at 2.5 years old.

Therefore, alternatives were explored that would substitute general patterns for the annual estimates conventionally used. The goal was to explore methods for addressing the frequent criticism of large expansion factors in the MRFSS shore mode landings. All of the alternatives relied on replacing estimated shore catches with values generated by examining the ratio between shore and other modes. These alternatives included using a single constant ratio across all years, a ratio that varied as a linear function of time, and a distinct ratio for each period in which a size limits were in place. These alternatives are illustrated in Fig. 3a,b. These alternatives all assumed that the variability in this series is primarily statistical rather than representing true variation. The more general methods tended to reduce high early estimates and increase recent low estimates, although the method that used a constant for each time period for which a size limit was in place merely smoothed out both peaks and troughs.

Ultimately, the working group favored keeping the original data. Preference was given to using the annual estimates in their raw form and accounting for variability in the model itself. However, there was strong support for exploring this issue further in the future.

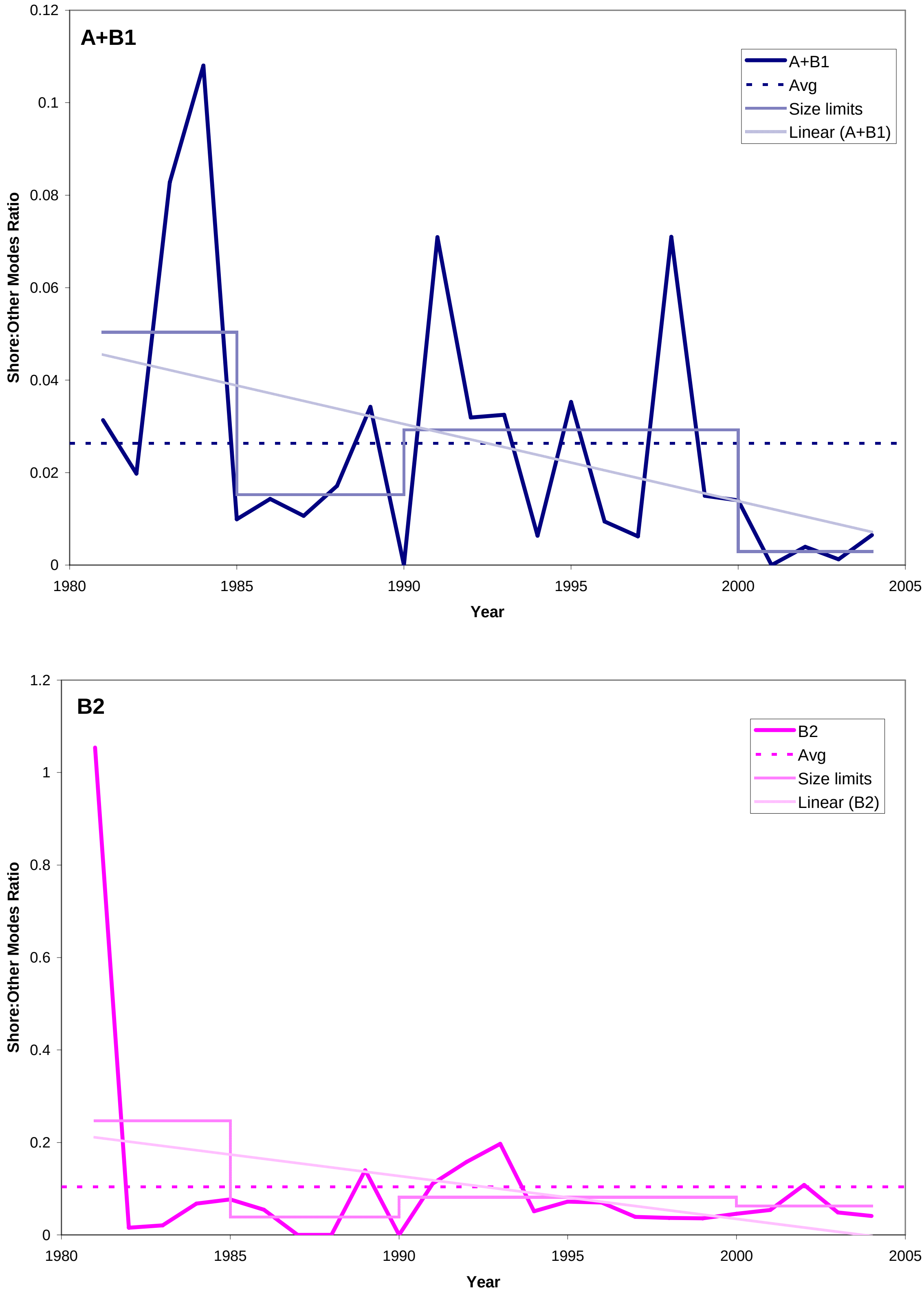


Fig. 3—MRFSS shore mode catches as a fraction of catches from other modes. (a) A+B1; (b) B2.

Charter boat effort

Prior to 1998, charter boat effort was estimated using angler phone surveys. Starting in 1998 interviews of charter boat captains, and the official estimates were based on these interviews starting in 2000. Fortunately, data were collected using both methods for the period 1998 to 2003. Diaz (SEDAR7-AW-03) examined these data using a generalized linear model that standardized across a range of tempo-environmental factors. The GLM analysis provided a correction factor for each stratum, which were then applied to effort records prior to 1998. These corrections were used by relevant strata to adjust the expansion factors for the charter boat mode in MRFSS. The effect of these adjustments was detailed in Phares et al. (SEDAR10-DW-26).

Wave 1, 1981

Data were not available for wave 1 in 1981. This gap was filled by determining the proportion of wave 1 to other waves in years 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.

Results

Catches as estimated from MRFSS are shown by year, mode, and AB1 and B2 (Table 3). Note that these tables do not agree with the preliminary numbers (Phares et al., SEDAR10-DW-26) but reflect analyses as described above.

Table 3—MRFSS estimates by (a) mode, (b) State. Numbers of fish annually.

	Cbt		Cbt/Hbt		Priv		Shore		Total	
Year	ab1	b2	ab1	b2	ab1	b2	ab1	b2	ab1	b2
1981	.	.	77,396	35,814	166,657	85,271	7,646	127,636	251,699	248,721
1982	.	.	100,441	12,423	374,655	101,212	9,390	1,793	484,486	115,428
1983	.	.	171,428	21,201	749,945	397,264	76,261	8,734	997,634	427,199
1984	.	.	85,701	16,051	193,308	51,913	30,147	4,614	309,156	72,578
1985	.	.	514,010	54,167	348,935	91,392	8,560	11,188	871,505	156,747
1986	160,015	51,493	.	.	412,774	300,775	8,199	19,270	580,988	371,538
1987	32,335	17,240	.	.	340,164	206,969	3,956	0	376,455	224,209
1988	62,935	14,717	.	.	491,910	232,432	9,503	0	564,348	247,149
1989	34,803	18,614	.	.	297,381	411,529	11,366	60,108	343,550	490,251
1990	31,751	83,990	.	.	128,072	275,932	.	.	159,823	359,922
1991	12,706	1,838	.	.	228,289	781,550	17,088	86,914	258,083	870,302
1992	44,000	44,692	.	.	183,686	578,904	7,262	98,413	234,948	722,009
1993	100,569	91,818	.	.	220,214	982,654	10,436	211,888	331,219	1,286,360
1994	49,617	148,295	.	.	208,060	1,588,792	1,633	88,547	259,310	1,825,634
1995	107,010	190,853	.	.	283,921	1,530,169	13,792	123,789	404,723	1,844,811
1996	99,369	191,374	.	.	231,473	938,109	3,122	79,197	333,964	1,208,680
1997	94,892	181,141	.	.	278,850	1,460,361	2,315	63,964	376,057	1,705,466
1998	146,440	339,137	.	.	312,828	1,683,159	32,606	74,420	491,874	2,096,716
1999	126,939	209,575	.	.	382,531	1,207,813	7,630	50,876	517,100	1,468,264
2000	156,336	132,716	.	.	527,667	1,231,363	9,577	62,252	693,580	1,426,331
2001	105,071	142,127	.	.	356,723	1,678,443	0	98,240	461,794	1,918,810
2002	91,650	208,723	.	.	412,340	2,033,080	1,996	242,380	505,986	2,484,183
2003	94,330	286,968	.	.	392,208	2,941,048	605	157,079	487,143	3,385,095
2004	123,823	292,511	.	.	500,684	3,119,898	4,060	139,963	628,567	3,552,372

Table 3 (cont.)—MRFSS estimates by (a) mode, (b) State. Numbers of fish annually.

	LA		MS		AL		FL W		Total	
Year	ab1	b2	ab1	b2	ab1	b2	ab1	b2	ab1	b2
1981	.	.	.	.	7,255	0	244,444	248,721	251,699	248,721
1982	3,546	0	4,598	1,797	.	.	476,342	113,631	484,486	115,428
1983	2,912	0	.	.	2,436	0	992,286	427,199	997,634	427,199
1984	172	0	.	.	6	0	308,978	72,578	309,156	72,578
1985	6,319	0	.	.	34,782	0	830,404	156,747	871,505	156,747
1986	2,923	2,839	1,961	0	11,660	2,677	564,444	366,022	580,988	371,538
1987	4,018	0	2,443	0	842	0	369,152	224,209	376,455	224,209
1988	5,875	0	321	0	6	0	558,146	247,149	564,348	247,149
1989	4,277	0	906	235	614	0	337,753	490,016	343,550	490,251
1990	.	.	117	0	1,211	0	158,495	359,922	159,823	359,922
1991	1,983	0	0	0	1,990	471	254,110	869,831	258,083	870,302
1992	2,062	768	612	25	1,338	211	230,936	721,005	234,948	722,009
1993	2,399	2,653	2,159	165	3,040	3,699	323,621	1,279,843	331,219	1,286,360
1994	2,577	1,401	1,447	3,707	5,842	7,187	249,444	1,813,339	259,310	1,825,634
1995	830	186	20	4,851	7,976	9,679	395,897	1,830,095	404,723	1,844,811
1996	10,604	2,572	5,914	2,536	21,133	16,860	296,313	1,186,712	333,964	1,208,680
1997	1,022	2,018	299	1,263	11,751	8,150	362,985	1,694,035	376,057	1,705,466
1998	2,832	607	3,813	310	7,488	36,336	477,741	2,059,463	491,874	2,096,716
1999	17,104	6,647	489	5,602	22,943	77,965	476,564	1,378,050	517,100	1,468,264
2000	3,166	0	2,342	1,566	23,251	21,567	664,821	1,403,198	693,580	1,426,331
2001	4,198	3,054	19	1,888	8,435	11,334	449,142	1,902,534	461,794	1,918,810
2002	1,964	5,635	6,921	8,117	11,002	23,507	486,099	2,446,924	505,986	2,484,183
2003	1,776	5,250	296	81	11,125	31,006	473,946	3,348,758	487,143	3,385,095
2004	14,014	7,342	0	965	6,050	25,287	608,503	3,518,778	628,567	3,552,372

Headboat Survey

The Headboat Survey has been conducted in the Gulf of Mexico since 1986. Total catch by trip is reported in logbooks provided to all headboats in Gulf coast States and corrections for non-reporting are made by the survey. This survey was described more fully in Phares et al. (SEDAR10-DW-26). There were no controversial issues that came up in processing the headboat data for SEDAR10. Results are shown in Table 4.

Texas Parks and Wildlife Survey

Issues

Texas was included in MRFSS in 1981-1985, but only for shore mode in all years and boat modes in 1981 and 1985. However, catches of gag grouper were only encountered by MRFSS in Texas in one year, and those numbers were suspiciously high. The working group agreed that these catches should be considered an anomaly or error and excluded from the analysis. Instead, data were used that spanned 1983-2004 collected by the Texas Parks and Wildlife Department for boat modes together with the few MRFSS estimates. Shore mode in all years is considered 0 (not surveyed by TPWD, all zero in MRFSS 1981-1985, except the anomalous estimated discarded above).

Table 4—Headboat landings. Numbers of fish annually.

Year	TX	LA	AL-FLW	Gulf Total
1986	511	375	41,609	42,495
1987	548	261	31,347	32,156
1988	238	335	25,763	26,336
1989	174	66	34,905	35,145
1990	132	43	18,922	19,097
1991	151	10	11,292	11,453
1992	149	19	13,621	13,789
1993	329	260	18,746	19,335
1994	167	103	20,291	20,561
1995	182	167	17,467	17,816
1996	155	196	15,711	16,062
1997	142	81	15,400	15,623
1998	1,100	604	34,612	36,316
1999	235	484	31,398	32,117
2000	166	75	30,583	30,824
2001	147	50	14,297	14,494
2002	215	101	11,299	11,615
2003	327	147	15,907	16,381
2004	140	100	24,530	24,770

From 1986 to 2004, the TPWD data were considered complete for private and charter boats. However, there were numerous holes prior to 1986. No estimates were available for headboats in 1982-1984, and no boat mode estimates were made by either survey in 1982. MRFSS estimates in 1981 and 1985 for charter were all 0 but were incomplete for wave 4. We assumed charter boat catches were 0 in all years and that 500 fish were caught per year by headboats, equal to an average an approximate average of catches from the earliest years of data available, 1986 and 1987. Results are shown in Table 5.

Extending Recreational Catches Back in Time

Several alternatives were considered for extending estimates of recreational catches back in time. Since commercial catches are available back to at least until the early 1960s, it was desirable to identify a means to make reasonable estimates of recreational catches for the same time period. However, this exercise was made difficult by the fact that at best, we can only find patterns that fit recent years when recreational catches were available and hope those patterns held in earlier years.

We explored three possible relationships to recreational catches: a correlation with commercial catches, a relationship most likely driven by similar technological innovations and potentially by general interest in gag grouper; a correlation with coastal human populations, driven by numbers of potential anglers; and a linear relationship starting at a time when we expect the stock was close to unexploited, such as the end of World War II (i.e., 1945)

Table 5—Landings from Texas. Numbers of fish annually. Numbers prior to 1986 were filled in as indicated above. Note that there were no shore catches indicated in any year except 1984, and that year's data were considered unreliable. Headboat catches are accounted for in the Headboat Survey starting in 1986.

Year	Hb	Cbt	Priv	Total
1981	500	0	0	500
1982	500	0	27	527
1983	500	0	58	558
1984	500	0	19	519
1985	500	0	31	531
1986		313	0	313
1987		0	148	148
1988		0	0	0
1989		0	0	0
1990		50	19	69
1991		0	22	22
1992		0	0	0
1993		0	154	154
1994		90	116	206
1995		0	0	0
1996		134	520	654
1997		0	0	0
1998		431	53	484
1999		24	281	305
2000		92	263	355
2001		0	411	411
2002		0	141	141
2003		0	192	192
2004		313	0	313

Commercial catches were a good predictor of recreational catches over the period 1986 to 2004, based on preliminary results for both series (Figs. 4, 5). The correlation between commercial landings and total recreational catches (including MRFSS A, B1, and B2; headboat and Texas with estimated discards) produced a remarkably good fit ($R^2 = 0.5971$). Interestingly, this fit deteriorated when discards were not included because recreational discards have increased dramatically during this time period while landings stayed about the same. The strength of this relationship suggests that commercial catches prior to 1981 might help to estimate recreational catches during that period. However, it is generally believed that recreational effort has increased more dramatically than commercial effort in recent years.

Coastal human population also provided a good relationship to estimated angler trips, particularly in the private mode (Fig. 6). The group was concerned, though, that this relationship would not account for technological improvements that have intensified effective recreational fishing effort over the past few decades. As an alternative, there was support for a sensitivity analysis using a linear increase in recreational catches, starting at 0 in 1945 and ending at the average of 1981-83 catches in 1981. This relationship is illustrated in Fig. 7.

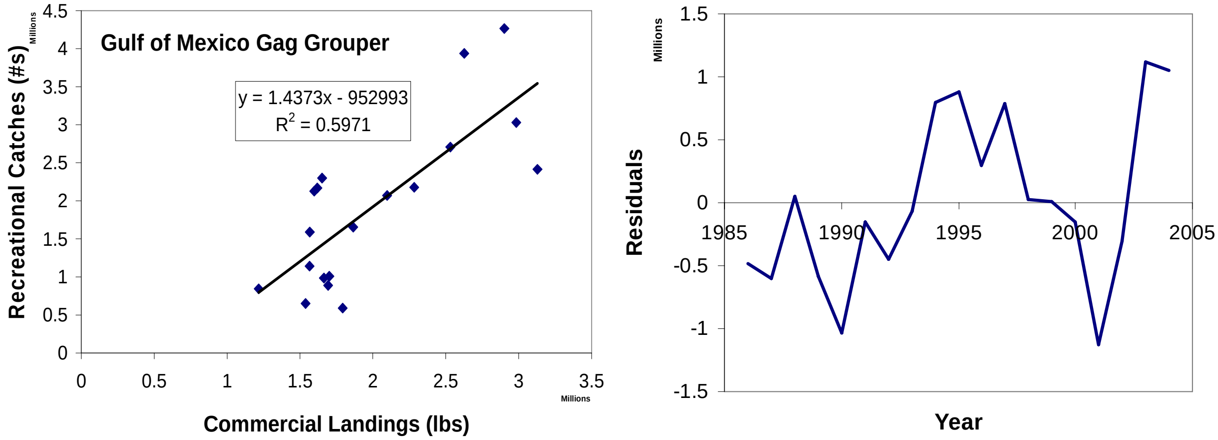


Fig. 4—Goodness of fit between commercial landings and recreational catches, 1986-2004. (a) Regression analysis. (b) Residuals over time.

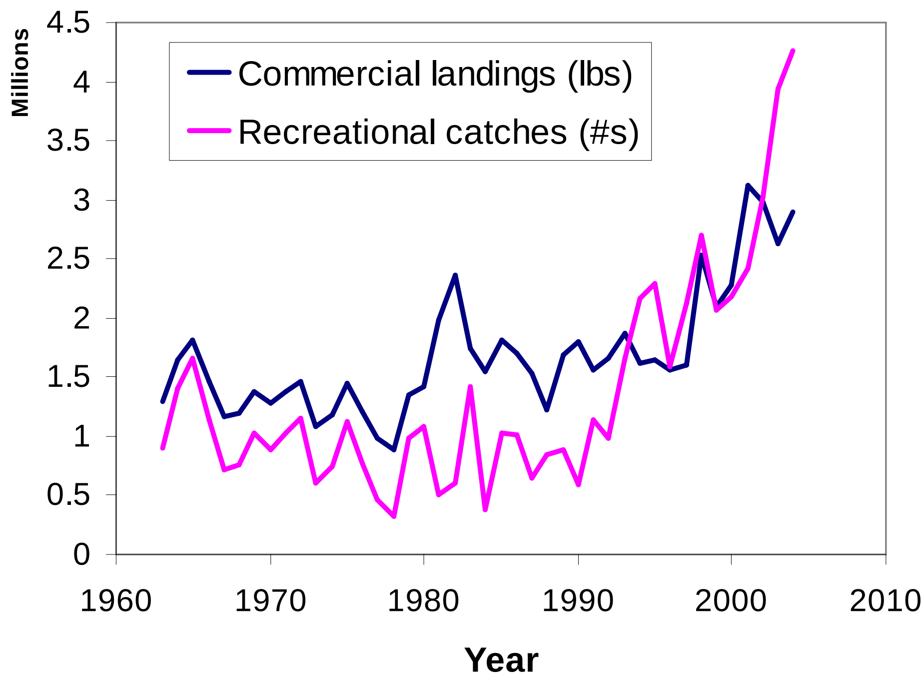


Fig. 5—Temporal pattern of commercial landings and recreational catches (including discards). The recreational catches include backward projection using a correlation to commercial landings.

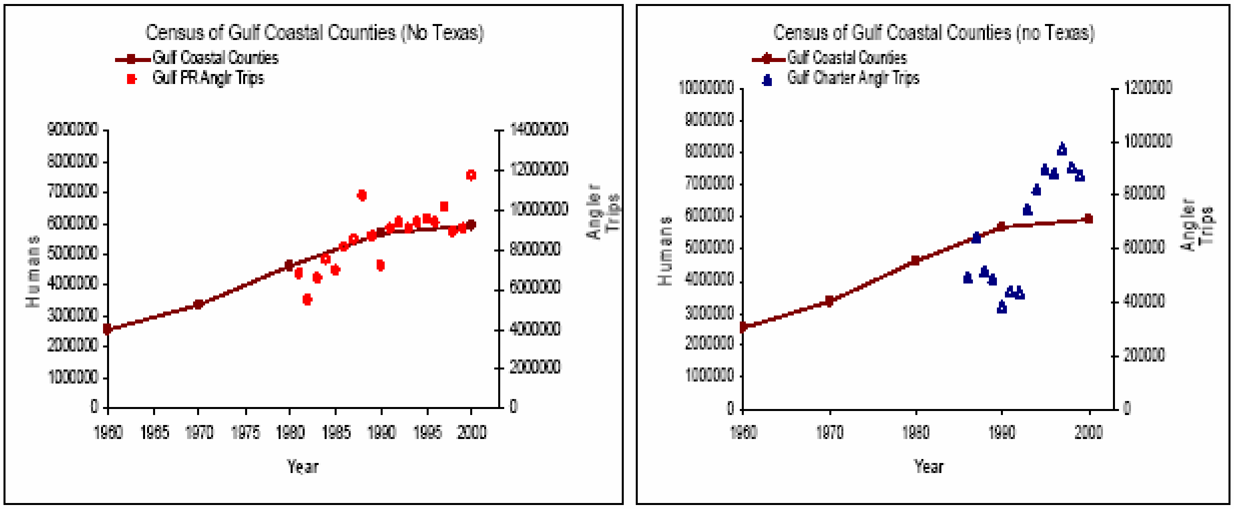


Fig. 6—Relationship between coastal human population and fishing effort (from Scott, SEDAR7-AW-16). (b) Linear increase in catches from 1963 to 1981, when data were available.

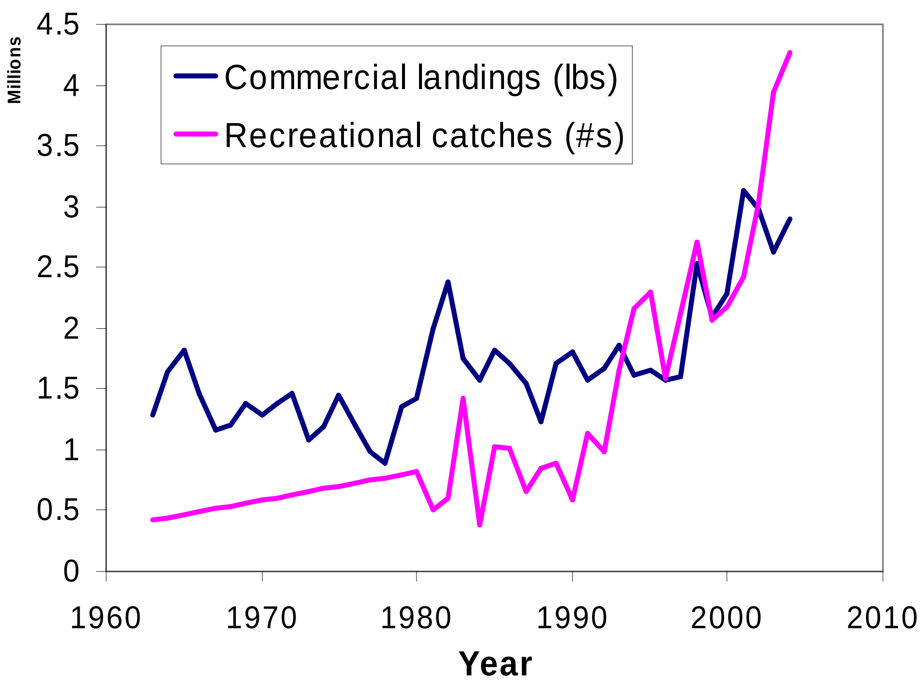


Fig. 7—Alternate temporal pattern of commercial landings and recreational catches (including discards). The recreational catches include backward projection using a linear decrease through time.

DISCARDS

General Issues

Typically, the only information we have to estimate discards in Gulf of Mexico recreational fisheries come from MRFSS. Consequently, the ratios of discards to landings are usually inferred from MRFSS data. Recently, two studies of headboat discards have allowed us to examine the validity of assigning MRFSS charter mode discard rates to headboat data. First, in 2004 the Headboat Survey began to collect information on discards. These data span Florida, Alabama, and Texas. Also, a new observer program collects discard information from Florida and Alabama, and these data were compared to MRFSS estimates as well.

Generally, the headboat and observer discard ratios corresponded well with the MRFSS charter mode discards (Table 6). The only major exception was from the Alabama observer program, which indicated substantially higher discards than the MRFSS survey. This discrepancy could theoretically be because the observer data was from 2005 and MRFSS data from 2004.

Table 6—Ratios of discards to kept gag grouper. Headboat data came from discard and retained fish records as identified in the headboat logbook program in 2004 in Florida, Alabama, and Texas. Observer program data came from headboat observers on vessels in Florida and Alabama in 2005. MRFSS Charter data come from the MRFSS survey using the ratio of B2 to A+B1 fish and include Florida, Alabama, and Louisiana (used as a proxy for Texas). The latter is the typical substitution used for headboats.

State	Headboat	Observer	MRFSS Charter
FL	2.73	3.73	2.42
AL	0.83	2.5	0.92
TX/LA	0.33	NA	0.58

TOTAL RECREATIONAL CATCHES

Based on the decisions outlined above, two series of recreational landings (AB1) and discards (B2) were developed. These are detailed in Table 7.

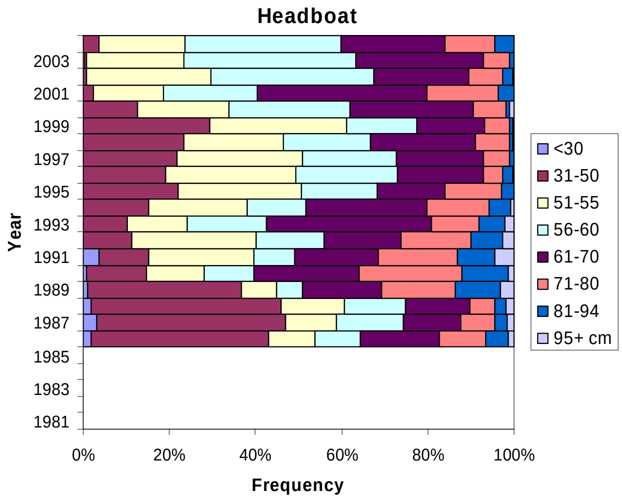
LENGTH FREQUENCY DISTRIBUTIONS

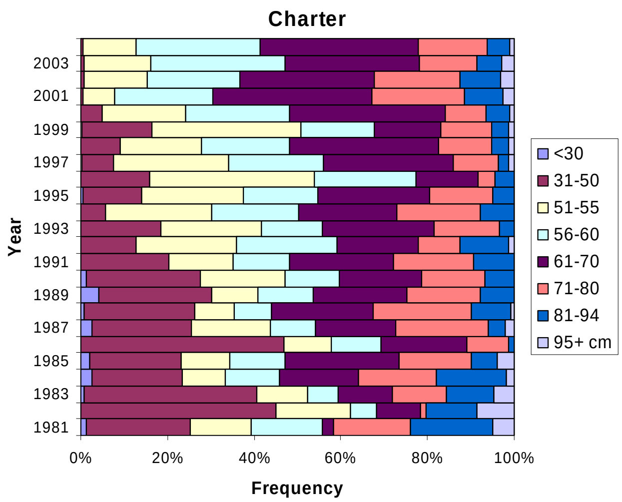
Length data were available from intercepts of recreational fishing activity covering all modes (shore, headboat, charter, and private). These data were processed independently for each mode and year. Because length samples were sparse for some of the MRFSS modes, the modes were combined weighting each by the corresponding landings from each mode in each year. These data were converted to age distributions using the same slicing algorithm as the previous assessment (Turner et al., 2001), and presented elsewhere (SEDAR10-AW-Report).

Results of length frequency analyses are shown by mode in Fig. 8. The aggregated recreational length frequencies, with modes weighted by total landings, are shown in Fig. 9.

Table 7—Total recreational catches and discards for Gulf of Mexico gag grouper. Numbers of fish annually.

	BASE: Commercial Correlation		ALT: Linear Increase from 1945-	
Year	Landed (AB1)	Released (B2)	Landed (AB1)	Released (B2)
1963	897,426	0	421,125	0
1964	1,402,629	0	444,521	0
1965	1,633,054	20,672	462,068	5,849
1966	1,105,826	32,558	477,261	14,052
1967	685,807	32,090	491,701	23,007
1968	716,539	46,386	505,388	32,717
1969	947,211	78,909	518,321	43,179
1970	808,652	82,916	530,501	54,395
1971	913,607	111,881	541,927	66,365
1972	1,004,122	143,708	552,601	79,087
1973	518,580	85,333	562,521	92,563
1974	629,229	117,542	571,687	106,793
1975	932,903	195,836	580,100	121,775
1976	630,922	147,610	587,760	137,511
1977	363,933	94,248	594,666	154,001
1978	246,253	70,186	600,820	171,244
1979	753,062	235,079	606,219	189,240
1980	807,650	274,991	610,866	207,989
1981	252,199	248,721	252,199	248,721
1982	485,013	115,428	485,013	115,428
1983	998,192	427,199	998,192	427,199
1984	309,675	72,578	309,675	72,578
1985	872,036	156,747	872,036	156,747
1986	623,483	385,172	623,483	385,172
1987	408,924	241,070	408,924	241,070
1988	590,684	253,338	590,684	253,338
1989	378,695	509,130	378,695	509,130
1990	179,068	410,624	179,068	410,624
1991	269,605	872,238	269,605	872,238
1992	248,737	735,921	248,737	735,921
1993	350,576	1,303,751	350,576	1,303,751
1994	280,025	1,887,900	280,025	1,887,900
1995	422,539	1,876,261	422,539	1,876,261
1996	350,232	1,239,252	350,232	1,239,252
1997	391,680	1,735,041	391,680	1,735,041
1998	528,844	2,176,986	528,844	2,176,986
1999	549,701	1,520,276	549,701	1,520,276
2000	724,709	1,452,424	724,709	1,452,424
2001	476,643	1,938,186	476,643	1,938,186
2002	518,012	2,510,810	518,012	2,510,810
2003	503,665	3,434,530	503,665	3,434,530
2004	653,528	3,610,622	653,528	3,610,622





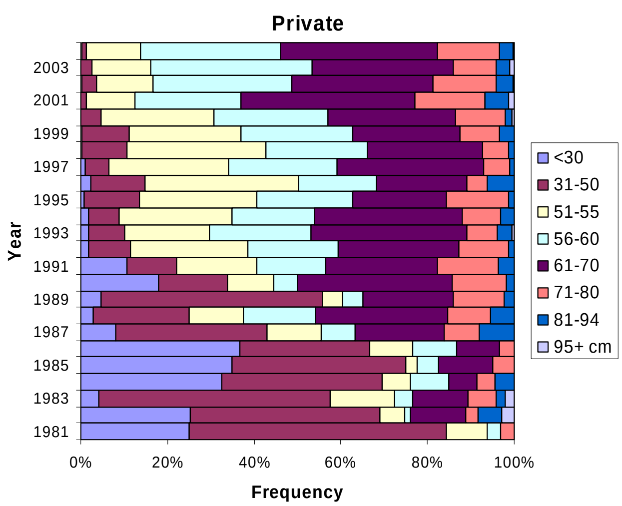


Fig. 8—Length frequencies by year and mode (AB1). Size bins are identical in each figure to facilitate comparisons.

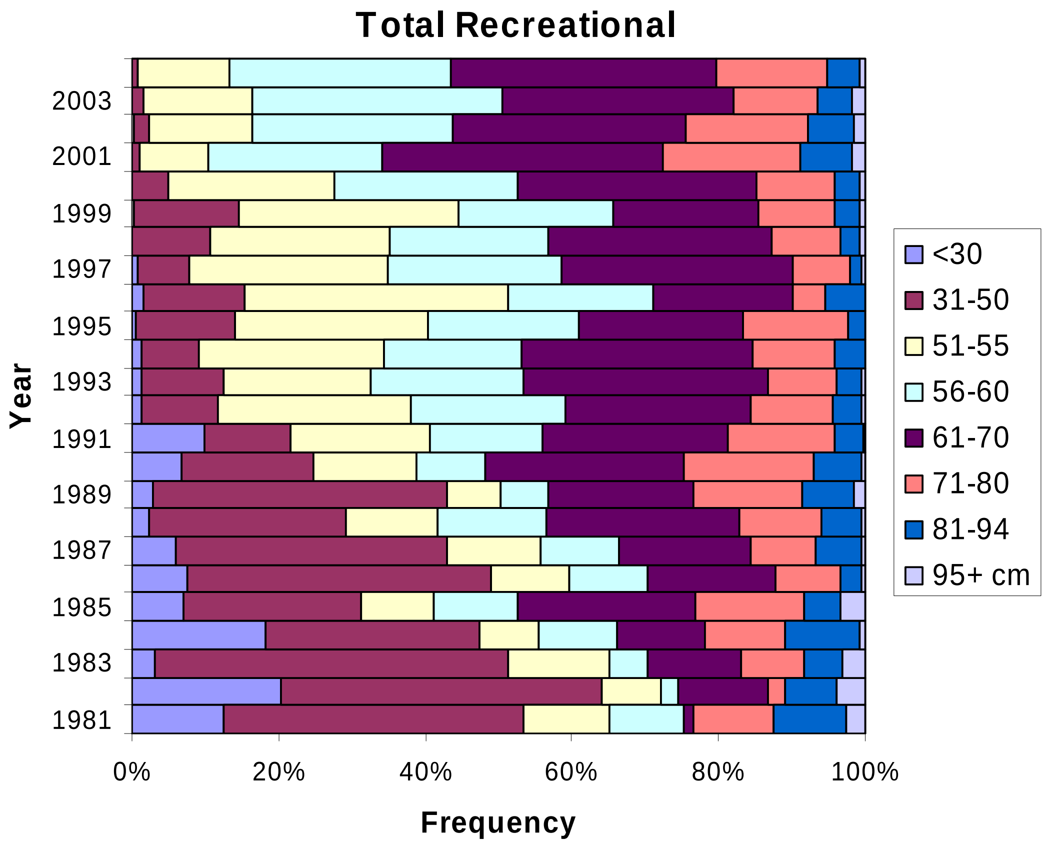


Fig. 9—Length frequency distributions over time from all recreational sources (AB1). Note early loss of the largest length bin and its reemergence in recent years, and drops in smaller size bins with the implementation of size limits in 1985 (18 in. TL), 1990 (20 in TL = 51 cm FL), and 2000 (22 in TL = 56 cm FL).

RESEARCH RECOMMENDATIONS

The group developed three research recommendations. First, we recommended a closer examination of reported headboat fishing locations, with respect to the GMFMC-SAFMC dividing line. Comparing their location reporting pre-1986 when compliance was high to post-1986 when it dropped might shed some light on whether these data are representative. Second, the group suggested that we explore whether there might be good surrogates for recreational fishing effort, for example numbers of recreational boat licenses or numbers of operating headboats. These might be especially valuable for backward projections of catches. Finally, the group recommended that MRFSS shore mode be explored further to elucidate whether it provides a useful annual signal of catches.

REFERENCES

Turner, SC, CE Porch, D Heinemann, GP Scot, M Ortiz. 2001. Status of Gag in the Gulf of Mexico, Assessment 3.0. Sustainable Fisheries Division Contribution: SFD 01/02-134. Department of Commerce, NOAA/NMFS, Southeast Fisheries Science Center, Miami, FL. 156 p.

5. INDICES OF ABUNDANCE

Table 5-1 summarizes the available indices for gag grouper in the U.S. Gulf of Mexico. The recommendations of the SEDAR10 DW index of abundance working group are described in detail below.

Table 5-2 is a summary of the pros and cons associated with each index.

The recommended indices and their associated variances are summarized in Table 5-3 and 5-4.

5.1 FISHERIES DEPENDENT INDICES

In the following discussion, fishing locations are often referenced by shrimp statistical grid. These are illustrated in Figure 5-1.

There is evidence that gag grouper are often misreported as black grouper, particularly in South Florida and the Florida Keys (SEDAR10-DW-24 with the exception of Monroe County (Florida Keys), where gag grouper are seldom misidentified. This issue affects the construction of most fisheries dependent indices, and was addressed in various ways by the index working group. The group decisions are summarized for each index below.

5.1.1 COMMERCIAL HANDLINE

General Description:
The construction of the commercial handline indices is described in the document SEDAR10-DW-10.

The NMFS Gulf of Mexico Reef Fish Logbook Program collects catch and effort data by trip for permitted vessels since 1990. Data include complete census of commercial reef fish trips by vessels permitted in TX, LA, MS, AL and FL. However, between 1990 and 1993 only 20% sample of vessels permitted in FL were required to submit logbooks. The logbook data include unique trip and vessel identifiers, and information regarding trip date, gear class, fishing area (shrimp statistical grids), days at sea, fishing effort, species caught and landed weight.

Methods:
Logbook data were restricted to statistical grids 1-11. Gag grouper handline trips were defined as trips that fished under the following conditions; a) with 10 or fewer hooks per line, b) six or fewer lines fished, c) were at sea for 15 or fewer days, and d) had crews of four or less. Trips that fished during gag or shallow-water grouper closures were excluded from the analysis. Nominal catch rates were estimated as pounds landed per hook-hour fished.

Three indices of abundance for the commercial handline Gulf fishery were presented to the index working group (SEDAR10-DW-10). Indices were constructed for the period 1993-2004, for the period 1993 – June 2000, and for the period July 2000 – 2004, in response to changes in minimum size regulations.

Recommendations/Issues Discussed at Data Workshop:

1. To address the problem of gag grouper misreported as black grouper: the group recommended that areas with high proportion of black grouper (areas 1 and 2) be dropped from the Gulf of Mexico analyses. In areas 3-11, the group decided that all black grouper were likely misreported, and should be assumed to be gag grouper.

2. The group discussed the appropriateness of including coastal logbook data from 1990-1992 in the handline commercial indices. Data from those years were excluded from the initial indices developed in SEDAR 10-DW10 because in Florida only a 20% subsample of the vessels reported during those years. Differences in CPUE by vessels reporting to the logbook program during 1990-1992 and vessels reporting in later years were examined. Little difference was observed in mean yearly CPUE among the two groups of vessels during the years when all the vessels were reporting to the logbook program. The working group found no valid reason to exclude data from 1990-1992.

3. The state of Florida imposed an 18" minimum size limit for GAG in 1985. This limit was raised to 20' on February 21, 1990. After reviewing the data, it appears that there were very few reported trips that occurred before the imposition of the 20" minimum size limit. Therefore, the group recommends that the analysis dataset be restricted to trips occurring after Feb. 21, 1990.

4. The group recommended that gag and shallow-water grouper closures be handled by excluding all trips that occurred during February 15th to March 15th each year (even though the reproductive closure began in 2001), and by excluding trips that occurred during the shallow-water grouper closure from Nov. 15th – Dec.31st, 2004. The group felt that this treatment would improve the statistical quality of the GLM fits to the data.

5. The working group discussed the "gear selection" criteria for defining gag grouper trips. It was suggested to use a multispecies method approach (Stephens and MacCall, 2004) similar to the criteria used for the Atlantic logbook commercial data.

6. The group recommended that year*factor (e.g. year*fishing area) interaction terms be excluded from the GLMs used during index construction. There was concern that these terms, which were modeled as random effects, inflate the variance to such an extent that the trend in catch rates/abundance is essentially nullified.

Results:

Revised indices were constructed based on the recommendations of the SEDAR10-DW index of abundance working group. These are discussed in detail in appendix 1 of the revised document SEDAR10-DW-10.

The recommended commercial handline indices are summarized in Table 5-3 and Figure 5-2. The indices indicate a 3-fold increase in the standardized catch rates of gag grouper during the period 1990 to 2004. This result could be caused by an increase in abundance, or by improvements in gear efficiency or ability to target quality fishing locations (catchability).

Length frequency histograms of gag observed from commercial handline trips by TIP agents are reported in SEDAR10-DW-23. Typically, the commercial handline fishery catches gag larger than the legal minimum size (20" effective Feb 21st 1990; 24" effective June 19th 2000), and smaller than 48 inches, although gag larger than 44 inches are rarely observed. Changes in the mean size of gag are apparent during the time series (SEDAR10-DW-23).

Utility:
The SEDAR10-DW index of abundance working group recommends the use of the commercial handline index, with the following stipulations:

1. The group recommends the use of the indices constructed using the multispecies method to subset observations based on the catch composition (e.g. Stephens and MacCall, 2004).

2. When changes in selectivity can be accounted for in the assessment model using available size or age frequency data, use the 1990-2004 index, without breaking the index at the change in the minimum size limit (June 19th 2000).

3. If changes in selectivity cannot be accounted for in the assessment model (e.g. VPA), consider the use of the broken indices (1990-2000 and 2000-2004). However, the working group has expressed a concern that some information regarding abundance is lost when indices are broken, particularly if abundance is changing at the discontinuity.

4. Potential changes in catchability should be addressed (see research recommendation 4).

These recommendations were presented to, and accepted by the SEDAR10-DW plenary.

5.1.2 COMMERCIAL LONGLINE

General Discussion:
The general discussion regarding the data source can be found in section 5.1.1.

Methods:
Three delta-lognormal indices were presented to the Data Workshop (SEDAR10-DW-18). The first considered the period 1993-2004 without considering the amended size limit (effective date June 19th, 2000). The second was constructed for the period of the 20" size limit (Feb 21st to June 18th 2000), and the third was constructed for the 24" size limit (June 19th, 2000 to Dec. 2004). For each index, the following factors were considered as possible influences on the proportion of trips that observed gag grouper, and the catch rates on positive trips: year, shrimp statistical grid (areas 1&2, 3-8, 9&10), season (Dec-Feb, Mar-May, Jun-Aug and Sep-Nov), and trip length (1-5 days, 6-10 days, >10 days). The proposed indices suggested increasing catch rates during the time series.

Issues Discussed at Data Workshop:

1) Include 1990-1992 during index construction. The proposed indices had been constructed beginning in 1993 due to partial sampling (20%) off Florida during 1990-1992. Beginning in 1993, all permitted reef fish vessels were required to submit logs. The group was advised that the 20% sample was achieved by requesting every fifth

person to receive a permit submit a logbook. The group was satisfied that this procedure was essentially random, although the group recognized that compliance may be non-random.

2) The state of Florida imposed a 18” minimum size limit for GAG in 1985. This limit was raised to 20’ on February 21, 1990. After reviewing the data, it appears that there were very few reported trips that occurred before the imposition of the 20” minimum size limit. Therefore, the group recommends that the analysis dataset be restricted to trips occurring after Feb. 21, 1990.

3) Species-misidentification. To avoid errors in species identification, the group recommended that the analysis dataset be restricted to shrimp statistical grids 3 to 11, and that all black grouper reported within these areas be assumed to be gag. According to Trip Interview Program (TIP) observer data, the proportion of gag+black groupers that are actually gag is 85% in area 3, and greater than 95% in areas 4-10. In addition, areas 3-11 include more than 95% of the landings.

4) The group recommended that gag and shallow-water grouper closures be handled by excluding all trips that occurred during February 15th to March 15th each year (even though the reproductive closure began in 2001), and by excluding trips that occurred during the shallow-water grouper closure from Nov. 15th – Dec.31st, 2004. The group felt that this treatment would improve the statistical quality of the GLM fits to the data.

5) The group recommends that an additional index be constructed that restricts the longline analysis dataset to trips identified by the species composition approach described by Stephens and MacCall (2004).

6) The group recommended that year*factor (e.g. year*fishing area) interaction terms be excluded from the GLMs used during index construction. There was concern that these terms, which were modeled as random effects, inflate the variance to such an extent that the trend in catch rates/abundance is essentially nullified.

Results:

Revised indices were constructed based on the recommendations of the SEDAR10-DW index of abundance working group. These are discussed in detail appendix 1 of the revised document SEDAR10-DW-18.

The recommended commercial longline indices are summarized in Table 5-3 and Figure 5-2. The indices indicate a 2.5-fold increase in the standardized catch rates of gag grouper during the period 1990 to 2004. This result could be caused by an increase in abundance, or by improvements in gear efficiency or ability to target quality fishing locations (catchability).

Length frequency histograms of gag observed from commercial longline trips by TIP agents are reported in SEDAR10-DW-23. Typically, the commercial longline fishery catches gag larger than the legal minimum size (20” effective Feb 21st 1990; 24” effective June 19th 2000), and smaller than 48 inches.

Utility:
The SEDAR10-DW index of abundance working group recommends the use of the commercial longline index, with the following stipulations:

1. The indices constructed using the Stephens and MacCall procedure are not recommended due to the high proportion of positive trips (>83% each year).

2. When changes in selectivity can be accounted for in the assessment model using available size or age frequency data, use the 1990-2004 index, without breaking the index at the change in the minimum size limit (June 19th 2000).

3. If changes in selectivity cannot be accounted for in the assessment model (e.g. VPA), consider the use of the broken indices (1990-2000 and 2000-2004). However, the working group has expressed a concern that some information regarding abundance is lost when indices are broken, particularly if abundance is changing at the discontinuity.

4. Potential changes in catchability should be addressed (see research recommendation 4).

These recommendations were presented to, and accepted by the SEDAR10-DW plenary.

5.1.2 HEADBOAT SURVEY

General Discussion:
Rod and reel catch and effort from party (head) boats in the Gulf of Mexico have been monitored by the NMFS Southeast Zone 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.

Material and Methods:
Abundance indices were developed for Gulf of Mexico gag using data from the NMFS Southeast Zone Headboat Survey. This index spanned from 1986 to 2004, with large sample sizes each year. Based upon the typical geographic distribution of gag, three zones having relatively high catch rates were defined off the Florida and Alabama coasts. The analysis was restricted to data from these three zones in order to reduce variance and to avoid potential difficulties with possible species identification confusion with black grouper, which occur with greater frequency south of the designated areas. Also to reduce variance, the Stephens and MacCall (2004) species association approach was used to identify trips that were likely to catch gag based on the composition of other species landed.

An 18” minimum size limit was imposed by the State of Florida in 1985. Headboat data is available beginning in 1986. Based upon size frequency distributions from the headboat dataset, it appeared likely that the imposition of a 20 inch TL minimum size limit in February

1990 and a later 22 inch TL minimum size limit in June 2000 likely influenced discard rates, which are not recorded in the Headboat Survey data during most of the time period. As a consequence, indices were constructed for three periods corresponding to the various size limits (18”FL: 1986-1989; 20”GOM: 1990-2000 and 24”GOM: 2000-2004) within which discard rates were expected to have remained relatively consistent from year to year. An index for the entire time period (1986-2004) was also constructed.

For each set of data, a model was constructed, assuming a delta-lognormal error distribution, was constructed considering the following factors: year, zone, vessel, month, season (WINTER=Dec.-Feb., SPRING=Mar.-May, etc.), trip category (TRIPCAT: half day/3qtr-full day/multi day), and whether the fishing occurred during the day or night (DAYNIGHT: day/night/unknown). The CPUE unit was number pf gag per angler hour.

Issues discussed at the Data Workshop:

1. To review the effect of misreporting of gag and black groupers, the group examined indices constructed two ways: 1) assuming that no misreporting occurred, 2) assuming that all black grouper were misreported, and were actually gag. The two indices were not notably different. Therefore, the group supported the author’s assumption that black and gag grouper are rarely misidentified or misreported in the headboat data, and no corrections to species identification were required.

2. The group recommended that the South Atlantic and Gulf indices be constructed with similar units of effort (angler*hours, or anglers, unless scientifically inadvisable. The group decided that catch per angler hour was most appropriate for use in the Gulf and South Atlantic.

3. The group recommended that the source data be examined for vessels that fail to report data correctly since the 2004 revision of the survey form (to include discard information).

4. The group recommended that year*factor (e.g. year*fishing area) interaction terms be excluded from the GLMs used during index construction. There was concern that these terms, which were modeled as random effects, inflate the variance to such an extent that the trend in catch rates/abundance is essentially nullified.

Results:

Revised indices were constructed based on the recommendations of the SEDAR10-DW index of abundance working group. These are discussed in detail in document SEDAR10-DW-4.

The recommended headboat indices are summarized in Table 5-3 and Figure 5-2. The indices suggest that, for the headboat fishery, standardized catch rates of gag grouper varied without obvious trend during the period 1986 to 2004. Temporary reductions in catch rates, followed by steadily increasing catch rates may be due to increases in the minimum legal size (to 20” in 1990; 24” in 2000).

Length frequency histograms of gag observed from headboat trips are pending.

Utility:
The SEDAR10-DW index of abundance working group recommends the use of the headboat index, with the following stipulations:

1. When changes in selectivity can be accounted for in the assessment model using available size or age frequency data, use the 1986-2004 index, without breaking the index at the change in the minimum size limit.

2. If changes in selectivity cannot be accounted for in the assessment model (e.g. VPA), consider the use of the broken indices. However, the working group has expressed a concern that some information regarding abundance is lost when indices are broken, particularly if abundance is changing at the discontinuity.

3. Potential changes in catchability should be addressed (see research recommendation 4).

These recommendations were presented to, and accepted by the SEDAR10-DW plenary.

5.1.3 MARINE RECREATIONAL FISHERIES STATISTICAL SURVEY (MRFSS)

General Description:
Data collected and estimated by the Marine Recreational Fisheries Statistical Survey (MRFSS) were used to develop standardized catch per unit effort (CPUE) indices for gag stocks of the Gulf of Mexico. The recreational fisheries survey started in 1979, and its purpose is to establish a reliable database for estimating the impact of marine recreational fishing on marine resources. More detailed information on the methods and protocols of the survey can be found at http://www.st.nmfs.gov/st1/recreational/overview/ overview.html.

Methods:
Catch and effort data from the MRFSS survey was used to generate standardized relative indices of abundance for Gulf of Mexico gag (SEDAR10-DW-9).

Discussion regarding the use of MRFSS catch and effort data for creating indices of abundance for the Atlantic and Gulf of Mexico gag stocks center on two main issues: a) the selection of trip/interview records that have a positive likelihood of capturing gag, and b) the discussion of misreporting gag as black grouper in MRFSS records.

Data included trip/interview records from the Florida west coast to Louisiana. Gag nominal catch rates (number of fish caught AB1B2 per number of angler-hours) were standardized following a delta modeling approach as the proportion of trip/interviews that reported gag catches were low (~ 1%). The model assumed a binomial distribution for the proportion of positive trips and a lognormal distribution for the catch rates of positive gag trips. Factors evaluated in the model were mode (shore, charter, private/rental), area (inshore, ocean < 3 miles, 3 < ocean < 10 miles, ocean > 10 miles), region (Central Gulf; Louisiana, Alabama, Mississippi, and Western Gulf; Florida west coast), season (Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec), and guild (inshore species, reef species, non-reef species, and pelagic species, unclassified). The last factor guild, classifies trips according to the intended target species of the trip, as declared by the angler. If no target was declared, the trip was assigned as unclassified. The standardization model evaluated interactions between factors.

The analyses also investigated two alternative methods to select trip/interview records from the MRFSS data that have higher likelihood or probability of catching gag. These methods were based on analysis of the species typically associated with gag catches. Red grouper and reef snappers show up as the most common species with gag catch. Method one selected trip/interviews records for which the angler reported a target species, and this species belonged to one of the following guilds: reef, non-reef and pelagic. Method two used a multispecies logistic regression approach that predicted a likelihood of catching gag and defined a threshold probability value to accept trip/interview records (Stephens and MacCall 2004). When applied to Gulf of Mexico gag, method two (multispecies logistic regression) converged to a solution but rejected about 98% of the records in the MRFSS database. Trends and estimated 95% confidence bounds were similar for all data subsets.

Issues discussed at the Data Workshop:

1) With regard to species misidentification or misreporting, the Data Working SEDAR10 group recommended adjusting Gulf recreational catches of gag grouper and derived indices. The group recommended that standardized catch rates be adjusted for gag misidentified/misreported as black grouper by excluding from the analysis areas of south west Florida corresponding to the Shrimp-statistical areas 1 and 2, and by assuming the all black grouper in other areas are actually gag grouper that have been misreported.

2) The group does not recommend the use of the Stephens and MacCall (2004) species composition method as applied to the MRFSS index of gag grouper. The Stephens and MacCall method is most appropriately applied to fishing trips that typically land a number of species on a single trip. This is generally not the case in the MRFSS dataset, and this can confound estimation of the threshold required for the procedure.

3) The group recommended that year*factor (e.g. year*fishing area) interaction terms be excluded from the GLMs used during index construction. There was concern that these terms, which were modeled as random effects, inflate the variance to such an extent that the trend in catch rates/abundance is essentially nullified.

Results:

Revised indices were constructed based on the recommendations of the SEDAR10-DW index of abundance working group. These are discussed in detail appendix 1 of the revised document SEDAR10-DW-9.

The recommended MRFSS index is summarized in Table 5-3 and Figure 5-2. The index is quite variable, but indicates a general increase in the standardized catch rates of gag grouper, particularly during the period 1987 to 2004. As the MRFSS dataset contains observations of gag landed, discard dead and released alive, the index is less likely to be influenced by management measures. Therefore, it is not necessary to construct separate indices for the various minimum size limits and bag limits. However, as this index is fisheries dependent, it may still be influenced by changes in catchability.

Utility: The group recommends the use of the MRFSS Recreational Index, with the caveat that potential changes in catchability be addressed (see research recommendation 4).

5.2 FISHERIES INDEPENDENT INDICES

5.2.1 SEAMAP VIDEO SURVEY

The SEAMAP Video Survey is described in SEDAR10-DW-12. Three indices of abundance were constructed, a gulfwide index, an eastern Gulf index and an index of "Copper-belly" gag which are predominately male.

Methods:

- Two-stage sampling design
    - First-stage is made up of blocks 10 minutes of latitude by 10 minutes of longitude, selected by stratified random sampling
    - Second-stage units within a block are selected randomly.
- Random 20-minute sections of videos were reviewed.
- Mincount (i.e., maximum number of fish on the video image at any one time during 20 minute viewing) was recorded for all gag and for those with darkly pigmented ventral surfaces (i.e., copper-belly gag or CBG).
- Delta-lognormal model used to develop abundance index from mincount data.
    - Parameters tested for inclusion in each sub-model were region, year, stratum, and block nested within stratum, station depth.
    - The estimates from each model were weighted using the stratum area, and separate covariance structures were developed for each survey year.

Results:

The recommended index is summarized in Table **5-4** The relative index in compared to other fisheries-independent indices in Figure **5-3.**

- Three models converged.
    - Gag Gulfwide index
        - Parameters retained binomial model: year, region and station depth
        - Parameters retained lognormal model: year
    - Gag East Gulf Index
        - Parameters retained binomial model: year and station depth
        - Parameters retained lognormal model: year
        - Mean annual nonzero mincount estimates not significantly different and all close to one indicating that the binomial portion of the model would provide a useful abundance index.
    - CBG East Gulf Index
        - Parameters retained zero-inflated binomial model: year and station depth
        - Parameters retained lognormal model: year

        - Mean annual nonzero mincount estimates only significantly different for 2002 and all were close to one indicating that the zero-inflated binomial portion of the model may provide a useful abundance index.
        -

- Size of gag observed in videos
    - 50 gag were hit by lasers, indicating sizes ranging from 400 to 1000 mm TL, with the majority of individuals falling between 600 and 775 mm TL.

Issues Discussed at Data Workshop:

1) Gulf-wide index: not appropriate due to extremely low occurrence of gag in the western Gulf. This is an essentially eastern index.

2) Eastern Index: Catch on positive trips is generally very close to one fish, indicating that the binomial portion of the model would provide a useful abundance index. This is essentially a presence/absence index.

3) Copper-Belly Index. Copper-Belly gag is a color morph that is predominately male. Although this index may not be proportional to the entire population of gag grouper, it may be possible to use it to index the abundance of males, or plus group animals, assuming that an age-structured model is used. ***CAUTION:*** Copper-bellies are included in the Eastern SEAMAP Video Survey index. A recalculated index excluding the copper-bellies is pending.

Utility:

The group recommends the use of the eastern video survey index. The group also recognized that the copper-belly index is suitable to index the number of males (or the abundance of the plus group) if an age structured model is used during assessment procedures.

The group ***provisionally*** recommends the use of the "Copper-Belly" index to estimate the abundance of males, or the plus group during sensitivity runs. To use this index, an age structured assessment model is necessary, and the selectivity of the copper-belly index must be parameterized to index the appropriate age classes. Also, the eastern video index must be reconstructed excluding the copper-bellies to allow the simultaneous use of the two indices. The reconstructed video index is pending.

5.2.2 Florida Estuaries Index (FMRI):

General Discussion:

An index of abundance was constructed using gag abundance and habitat data collected throughout Florida estuaries including: Apalachicola Bay, Cedar Key, Tampa Bay, Charlotte Harbor, Southern Indian River Lagoon, Northern Indian River Lagoon, and Northeast Florida (St. Johns, Nassau, and St. Marks Rivers) (SEDAR10-DW-30). The data were collected by the Florida Fish and Wildlife Conservation Commission (FWC), Fish and Wildlife Research Institute's Fisheries-Independent Monitoring program, and are available from 1996 to 2004.

Methods:

Monthly stratified-random sampling was conducted during the day by using three different seines. The estuaries were divided into 1 x 1 nautical-mile cartographic grids (1 nm^2), and grids with appropriate water depths for each seine were selected as the sampling universe. Samples were stratified by depth and habitat type depending on gear. Due to the extremely low occurrence of gag in other gears, only the data from samples collected with the 183-m center-bag haul seine (183 m x 3 m, 37.5-mm stretch mesh) were used for analyses. These sampling stations were stratified based on the presence or absence of overhanging shoreline vegetation (e.g., fringing mangroves). The seine was deployed along shorelines and on offshore flats inside the estuary and retrieved by hand. Only those samples taken in haul seines above sea grass were used in the analyses.
In order to develop standardized indices of annual average CPUE (catch per haul) for gag from Florida estuaries in the Gulf of Mexico, a delta-lognormal model (Lo, 1992) was employed.

Results:
The results, including the standardized index and index variance are summarized in Table **5-4.** The relative index in compared to other fisheries-independent indices in Figure **5-3**

Length frequency histograms of gag collected from Florida estuaries from the Gulf and Atlantic are reported in SEDAR10-DW-30. Gag from Gulf Florida estuaries had a mean standard length (± standard error) of 187 (± 2) mm (N = 1369).

Utility:
The group recommends the use of the FMRI Florida estuaries index, applied to the appropriate age classes.

5.3 RESEARCH RECOMMENDATIONS:

1. Develop a suitable method to correct species misidentification between black and gag grouper on a trip by trip basis. This issue will be of particular concern when assessing black grouper. The catches of gag grouper misidentified as black is likely a substantial proportion of reported black grouper landings.

2. We recognize that many valuable and well designed fisheries-independent sampling programs have been under funded or discontinuously funded, resulting in low sample sizes, variable sampling effort (in time and space), discontinuous series, and poorly stratified designs. The group ***strongly recommends increased funding toward*** developing and maintaining fishery-independent sampling programs, and stresses that quality indices require continuous funding over meaningful time periods (ideally decades).

3. It was proposed that the index working group examine the possibility of including environmental variables in computation of indices. Variable discussed included wave height, sea surface temperature, surface currents and hurricane impact. The group recommended that, when possible, environmental factors should be considered in future standardization procedures. The group also recognized that other model parameters, particularly the spawner-recruit relationship might be directly influenced by environmental variables, and recommended further consideration of this topic.

4. The group recognized the need to quantify changes in catchability over time. Many stock assessments use catch-per-unit-effort (CPUE) data under the assumption that there is a linear relationship between CPUE and abundance. Indeed, much of the work done to 'standardize' catch rates represent adjustments designed to account for nonlinear behavior of catch rates relative to resource abundance. However, there could be features in the data that could not be adjusted for by these standardization procedures due to lack of detail. For instance, an un-quantified systematic increase in efficiency over time could, in a fishery in which there is a declining stock, underestimate the rate of decline, leading to a condition termed hyperstability in the abundance index. On the other hand, there could also be tendencies over time wherein targeting shifts away from the resource leading to a hyperdepletion in the index relative to resource abundance.

   Recommendation: To address these concerns, the SEDAR10 index of abundance working group and the DW plenary recommend the use of an assessment model structure that can accommodate a nonlinear (for example, power-law) relationship between CPUE indices and stock size. Yet we recognize that there is likely to be insufficient information to estimate such a nonlinear relationship since at least one additional parameter must be estimated per abundance index (wherein some non-linearity is hypothesized to occur). Therefore, we recommend that sensitivity analyses that fix the nonlinear parameter(s) at plausible values be conducted to show implications of such assumptions.

Table 5-1. A summary of catch series from the Gulf of Mexico available for the SEDAR10 data workshop.

Fishery Type	Data Source	Area	Years	Units	Standardization Method	Size/Age Range	Problems	Recommended
REC	Headboat	Eastern Gulf	1986-2004	Number per angler-hour	Stephens and MacCall, delta-lognormal	Pending	Address changes in selectivity and catchability	YES
REC	MRFSS	Gulf excluding Texas	1981-2004	Number per 1000 angler hours	Trips are included based on guild composition, delta-lognormal		Address changes in catchability	YES
COM	Longline	Eastern Gulf	1990-2004	Biomass (lbs per hook)	Delta-lognormal	Length distribution from SEDAR10-DW-23	Address changes in selectivity and catchability	YES
COM	Handline	Eastern Gulf	1990-2004	Biomass (lbs per hook-hour)	Stephens and MacCall, Delta-lognormal	Length distribution from SEDAR10-DW-23	Address changes in selectivity and catchability	YES
Fish. Ind.	SEAMAP Video Survey	East Gulf	1993-1997, 2002, 2004	Number (video minimum count)	GLM on binomial model (Presence/Absence Index)	Length distribution from SEDAR10-DW-12.	Gaps in time-series	YES
Fish. Ind.	SEAMAP Video (Copper Belly)	East Gulf	1993-1997, 2002, 2004	Number (video minimum count)	GLM on binomial model (Presence/Absence Index)		Gaps in time-series	Possibly: Could be used to index plus group or males.
Fish. Ind.	NMFS Longline Survey	Gulf	1999-2004?				< 50 gag observed during entire time series	NO
Fish. Ind.	Otter trawl survey	Eastern Gulf	1991-1999				Inconsistent sampling coverage (temporally and spatially).	NO
Fish. Ind.	FMRI Estuarine Sampling	Eastern Gulf (FL coast)	1996-2004		Delta-lognormal	Length distribution from SEDAR10-DW-30.		YES
Fish. Ind.	SEAMAP Trawl Survey	Gulf of Mexico					< 10 gag observed during entire time series	NO

Table 5-2. Pros and Cons for each index as identified by the SEDAR10-DW indices of abundance working group.

Fishery Dependent Indices

Recreational Headboat (*Recommended for use*)

Pros: Relatively long time series (1986-2004)
Consistent
Cover complete area
Large sample size
Large proportion of effort
Non-targeted for gag

Cons: Influenced by regulatory changes
Lacks discard rates until 2004
Variability in fishing practices at vessel level
Catchability may vary over time (Changes in catchability will be estimated in the assessment model)

Issues Addressed:
Possible shift in fisherman preference-addressed using Stephens and MacCall (2004) approach
Change in average trip length over time (accounted for in GLM)

Commercial Indices – Handline and Longline (*Recommended for use*)

Pros: Complete census of fishing trips
Covers broad geographical area
Continuous, 15-year time series (1990-2004)

Cons: Self-reported data
Catchability may vary over time (Changes in catchability will be estimated in the assessment model)
Variability in fishing practices at vessel level

MRFSS (*Recommended for use*)

Pros: Long time series
Complete area coverage
Only FD index that includes discard information (AB1B2)

Cons: Species misreporting issues for black and gag
Should consider changes in catchability.

Table 5-2 (continued). Pros and Cons for each index as identified by the SEDAR10-DW indices of abundance working group.

Fishery Independent

SEAMAP (Trawl Survey)

Gulf of Mexico (Not recommended for use)

Pros: stratified random sample design
Adequate regional coverage
Standardized sampling techniques

Cons: Only captured 4 gag since program inception (1970's)

SEAMAP (Video Survey) (Recommended for use)

Pros: stratified random sample design
Adequate hard bottom coverage
Standardized sampling techniques

Cons: Gaps in time-series. (Includes: 1993-1997, 2002, 2004)

FMRI Estuarine Survey (Recommended for use)

Pros: stratified random sample design
Adequate estuarine coverage
Standardized sampling techniques

Cons: Small number of estuaries sampled. May not represent abundance of entire stock.

NMFS Longline Survey (Not recommended for use)

Pros: stratified random sample design
Adequate regional coverage
Standardized sampling techniques

Cons: Fewer than 30 specimens observed (1981 – 2004). Gear/Survey design does not permit adequately sampling of gag grouper.

Otter Trawl Survey (Not recommended for use)

Pros: Sampled gag

Cons: Opportunistic sampling – not random
Inadequate regional coverage
Some years, sampling occurred at only one location.

Table 5-3. Summary of available fisheries-dependent indices with coefficients of variation.
A) Commercial Indices: CMHL = commercial handline; CMLL = commercial longline

Index Name	**CMHL:1990-2004**		**CMHL:1990-2000**		**CMHL:2000-2004**		**CMLL:1990-2004**		**CMLL:1990-2000**		**CMLL:2000-2004**	
Size Range	>508 mm		>508 mm		>610 mm		>508 mm		>508 mm		>610 mm	
Relative (Scaled to 1)?	YES		YES		YES		YES		YES		YES	
Weight/Numbers	Weight		Weight		Weight		Weight		Weight		Weight	
Units	Lbs/Hook_Hour		Lbs/Hook_Hour		Lbs/Hook_Hour		lbs/hook		lbs/hook		lbs/hook	
YEAR	INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV
1981	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-	-	-	-
1990	0.538	0.117	0.653	0.138	-	-	0.850	0.450	1.264	0.332	-	-
1991	0.380	0.110	0.466	0.134	-	-	0.562	0.463	0.850	0.331	-	-
1992	0.477	0.099	0.576	0.122	-	-	0.452	0.606	0.706	0.417	-	-
1993	0.761	0.062	0.926	0.078	-	-	0.624	0.251	0.976	0.180	-	-
1994	0.595	0.064	0.731	0.084	-	-	0.355	0.326	0.541	0.232	-	-
1995	0.741	0.061	0.891	0.078	-	-	0.499	0.278	0.744	0.202	-	-
1996	0.867	0.053	1.041	0.069	-	-	0.586	0.208	0.878	0.154	-	-
1997	0.927	0.052	1.129	0.067	-	-	0.585	0.210	0.875	0.154	-	-
1998	1.524	0.047	1.831	0.061	-	-	1.029	0.157	1.529	0.120	-	-
1999	1.064	0.048	1.289	0.063	-	-	0.780	0.181	1.184	0.136	-	-
2000	1.130	0.049	1.466	0.070	0.741	0.083	1.014	0.160	1.454	0.170	0.592	0.329
2001	1.543	0.047	-	-	1.088	0.075	1.832	0.110	-	-	1.046	0.154
2002	1.510	0.048	-	-	1.072	0.075	1.752	0.112	-	-	0.994	0.161
2003	1.257	0.048	-	-	0.893	0.076	1.951	0.104	-	-	1.114	0.148
2004	1.686	0.048	-	-	1.206	0.075	2.128	0.097	-	-	1.254	0.134

Table 5-3 (continued).

B) Recreational Indices: HB = headboat; MRFSS = Marine Recreational Fisheries Statistical Survey

Index Name	**MRFSS**		**Headboat:1986-2004**		**Headboat:1986-1989**		**Headboat:1990-2000**		**Headboat:2000-2004**	
Size Range	Pending		Pending		Pending		Pending		Pending	
Relative (Scaled to 1)?	YES		YES		YES		YES		YES	
Weight/Numbers	Numbers		Numbers		Numbers		Numbers		Numbers	
Units	Fish/1000 angler hours		Fish/Angler Hour		Fish/Angler Hour		Fish/Angler Hour		Fish/Angler Hour	
YEAR	INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV
1981	0.987	0.414	-	-	-	-	-	-	-	-
1982	0.435	0.456	-	-	-	-	-	-	-	-
1983	0.835	0.471	-	-	-	-	-	-	-	-
1984	0.303	0.599	-	-	-	-	-	-	-	-
1985	1.182	0.392	-	-	-	-	-	-	-	-
1986	1.062	0.342	1.140	0.156	0.978	0.293	-	-	-	-
1987	0.284	0.376	1.317	0.119	1.205	0.219	-	-	-	-
1988	0.322	0.388	1.057	0.147	0.95	0.284	-	-	-	-
1989	0.439	0.385	0.993	0.157	0.866	0.315	-	-	-	-
1990	0.692	0.397	0.720	0.177	-	-	0.691	0.33	-	-
1991	0.525	0.372	0.597	0.218	-	-	0.606	0.36	-	-
1992	0.466	0.340	0.718	0.214	-	-	0.705	0.354	-	-
1993	1.182	0.324	0.826	0.179	-	-	0.836	0.297	-	-
1994	1.575	0.319	0.836	0.187	-	-	0.868	0.303	-	-
1995	1.504	0.313	0.853	0.2	-	-	0.866	0.307	-	-
1996	1.303	0.322	1.350	0.113	-	-	1.331	0.182	-	-
1997	0.972	0.315	1.327	0.11	-	-	1.339	0.176	-	-
1998	1.966	0.303	1.260	0.121	-	-	1.262	0.197	-	-
1999	1.647	0.301	1.237	0.115	-	-	1.258	0.185	-	-
2000	0.938	0.307	1.048	0.151	-	-	1.239	0.23	0.915	0.386
2001	0.740	0.310	0.778	0.208	-	-	-	-	0.88	0.327
2002	1.457	0.299	0.825	0.209	-	-	-	-	0.94	0.326
2003	1.594	0.299	1.039	0.155	-	-	-	-	1.102	0.273
2004	1.589	0.301	1.078	0.144	-	-	-	-	1.163	0.27

Table 5-4. Summary of available fisheries-independent indices with coefficients of variation.

Index Name	**SeaMAP Reef Fish Video**		**SeaMAP Video (Copper Belly)**		**FMRI Florida Estuaries**	
Size Range	425-975 mm		?		50-400 mm	
Relative (Scaled to 1)?	YES		YES		YES	
Weight/Numbers	***Presence/Absence***		***Presence/Absence***		Numbers	
Units	Proportion Positive		Proportion Positive		Number/Haul	
YEAR	-	-			-	
1981	-	-			-	
1982	-	-			-	
1983	-	-			-	
1984	-	-			-	
1985	-	-			-	
1986	-	-			-	
1987	-	-			-	
1988	-	-			-	
1989	-	-			-	
1990	-	-			-	
1991	-	-			-	
1992	-	-			-	
1993	0.663	0.424	1.244	0.403	-	
1994	0.513	0.528	0.844	0.586	-	
1995	0.446	0.361	0.670	0.497	-	
1996	0.879	0.288	0.758	0.457	1.134	1.134
1997	0.932	0.310	0.544	0.574	0.318	0.318
1998	-	-			0.232	0.232
1999	-	-			0.620	0.620
2000	-	-			0.441	0.441
2001	-	-			0.708	0.708
2002	1.587	0.190	0.964	0.371	3.291	3.291
2003	-	-			1.791	1.791
2004	1.980	0.186	1.977	0.297	0.466	0.466

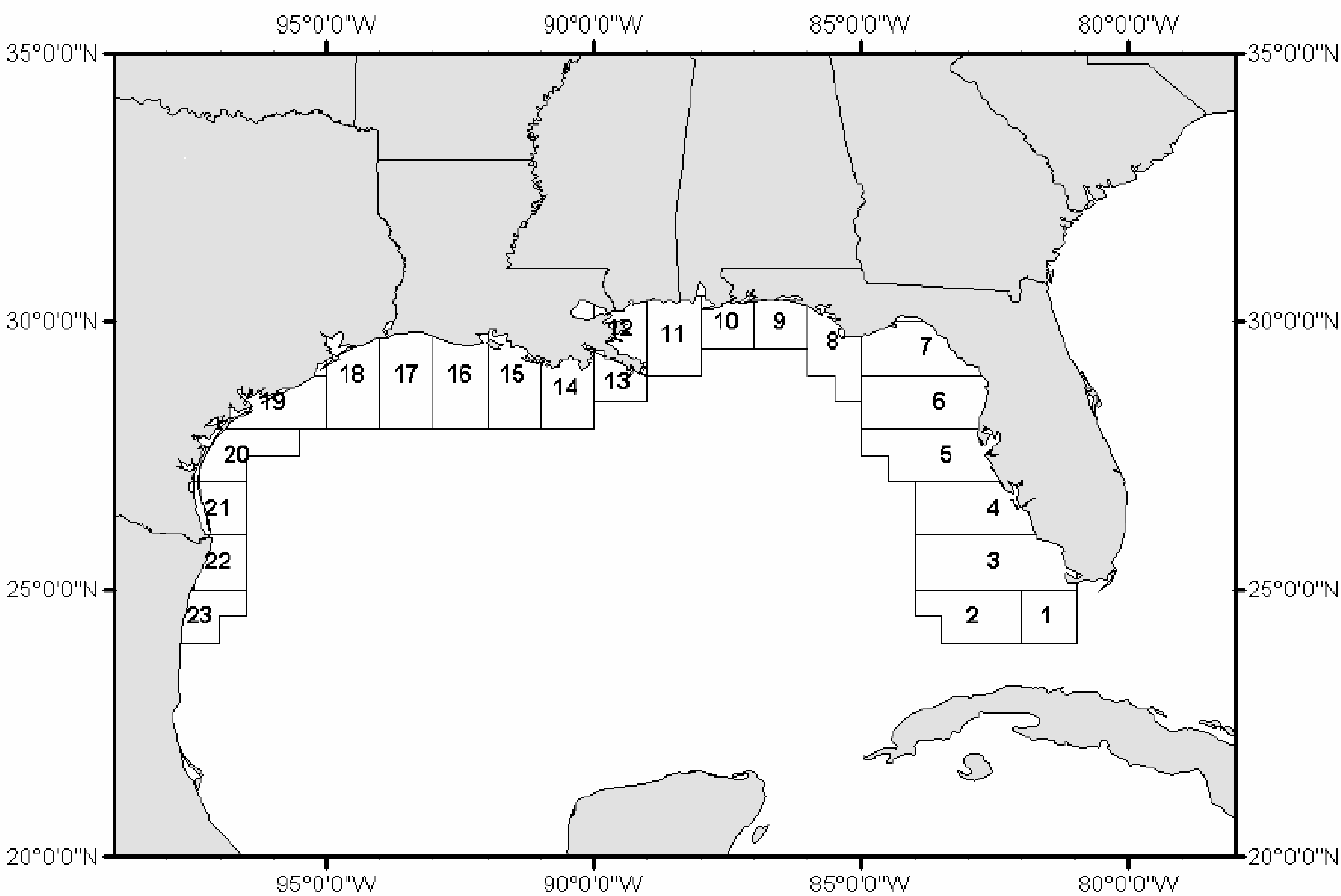


Figure 5-1. Shrimp statistical grids used to identify fishing areas in the U.S. Gulf of Mexico.

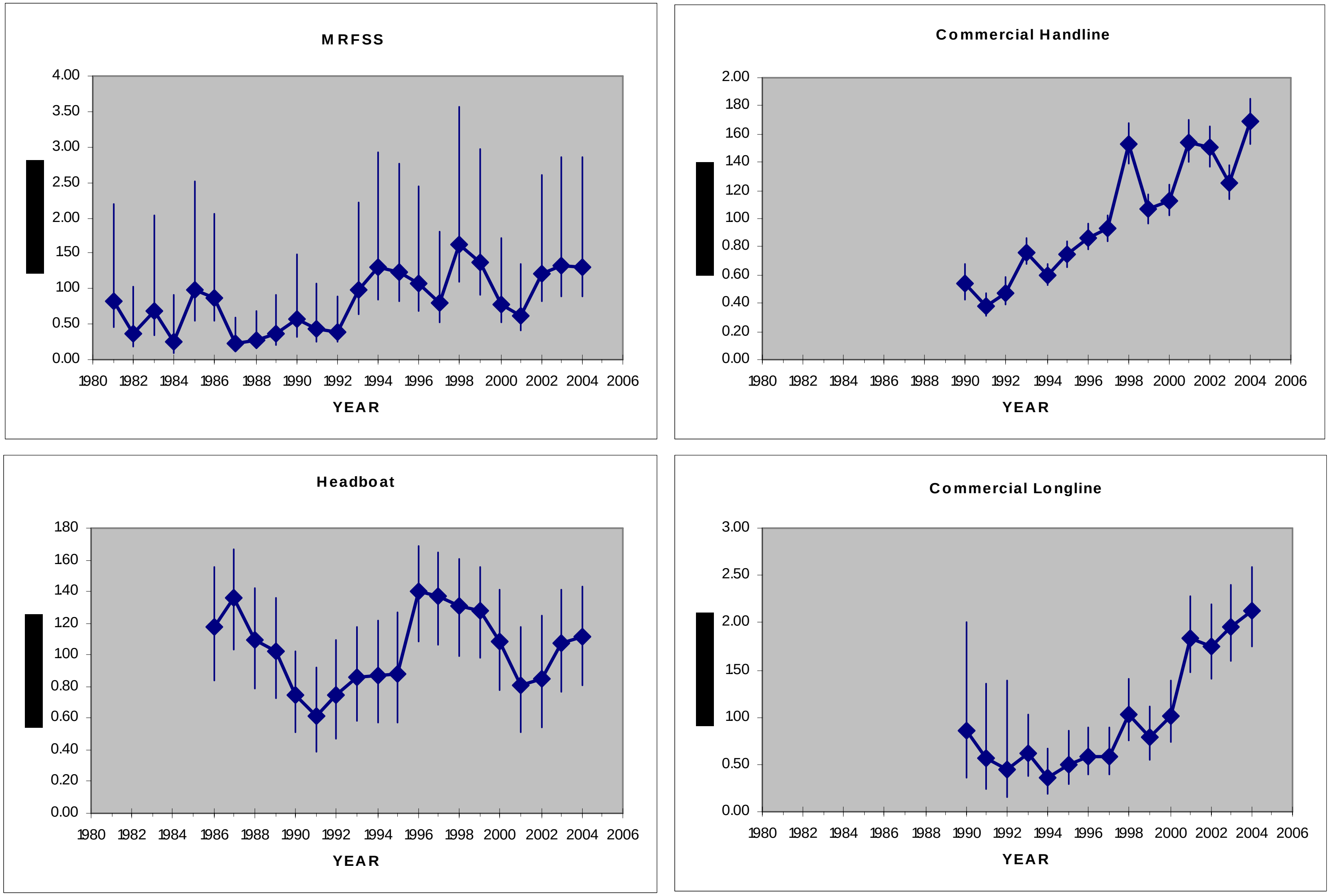


Figure 5-2. Fisheries-dependent indices with 95% confidence intervals.

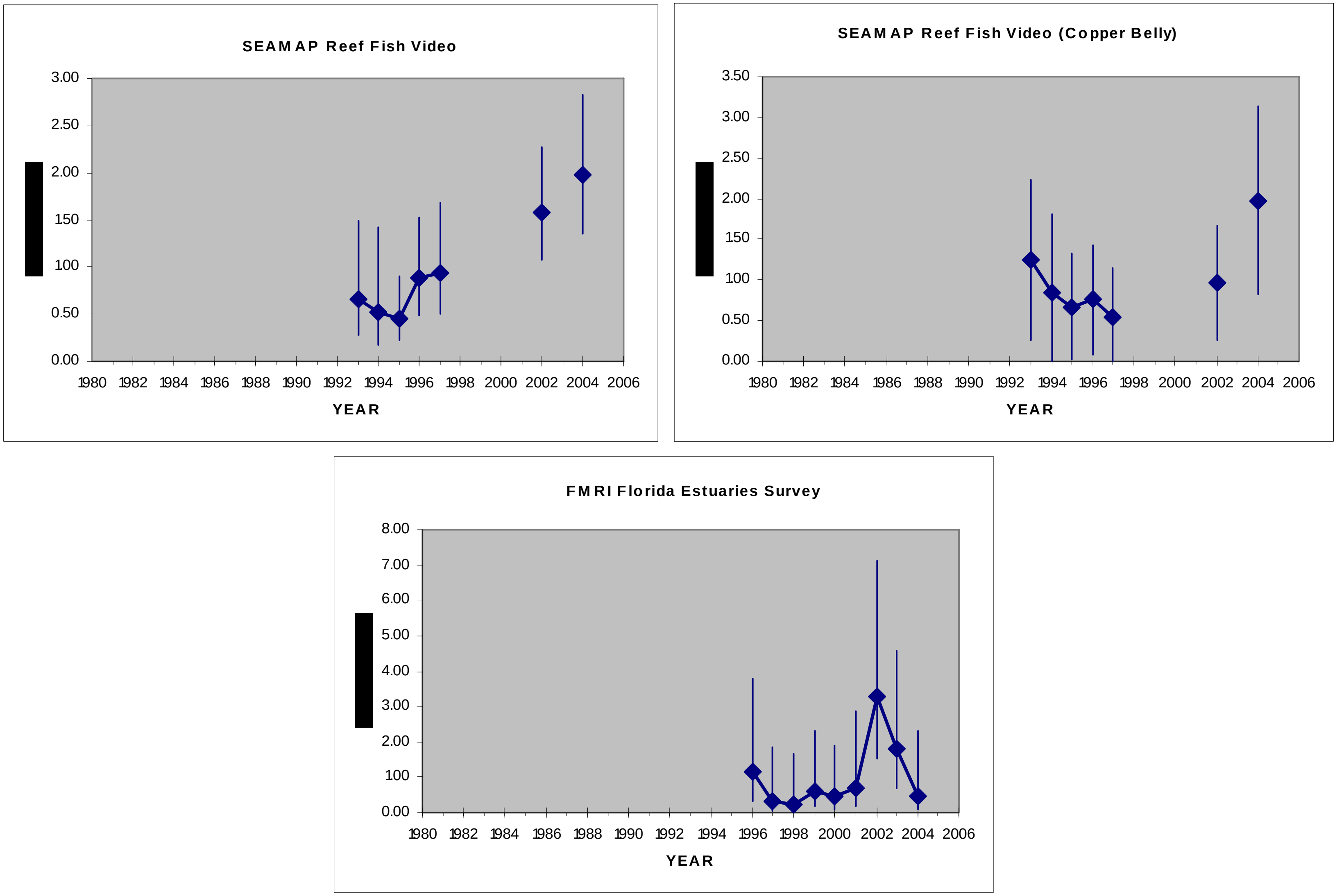


Figure 5-3. Fisheries-independent indices with 95% confidence intervals.

SEDAR

SouthEast Data, Assessment, and Review

SEDAR 10
Stock Assessment Report 2

Gulf of Mexico Gag Grouper

SECTION 3. Assessment Workshop

1. Workshop Proceedings
    1.1. Introduction
        1.1.1. Workshop Time and Place

The SEDAR 10 Assessment Workshop was held May 1 - 5 at the Wyndham Grand Bay, Miami FL.

1.1.2. Assessment Workshop Terms of Reference

1. Select several modeling approaches based on available data sources, parameters and values required to manage the stock, and recommendations of the data workshop. SEE NOTE 1.
2. Provide justification for the chosen data sources and for any deviations from data workshop recommendations.
3. Provide estimates of stock parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, etc); include appropriate and representative measures of precision for parameter estimates and measures of model 'goodness of fit'.
4. Characterize uncertainty in the assessment, considering components such as input data, modeling approach, and model configuration.
5. Provide yield-per-recruit, spawners per recruit, and stock-recruitment analyses.
6. Provide complete SFA criteria. This may include evaluating existing SFA benchmarks or estimating alternative SFA benchmarks (SFA benchmarks include MSY, Fmsy, Bmsy, MSST, and MFMT); recommend proxy values where necessary; provide stock control rules.
7. Provide declarations of stock status relative to SFA benchmarks: MSY, Fmsy, Bmsy, MSST, MFMT.
8. Estimate an Allowable Biological Catch (ABC) range.
9. Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules if warranted; include estimated generation time. Stock projections shall be developed in accordance with the following:
    A) If stock is overfished:
        F=0, F=current, F=Fmsy, Ftarget (OY),
        F=Frebuild (max that rebuild in allowed time)
    B) If stock is overfishing
        F=Fcurrent, F=Fmsy, F= Ftarget (OY)
    C) If stock is neither overfished nor overfishing
        F=Fcurrent, F=Fmsy, F=Ftarget (OY)
10. Evaluate the results of past management actions and probable impacts of current management actions with emphasis on determining progress toward stated management goals.
11. Provide recommendations for future research and data collection (field and assessment); be as specific as practicable in describing sampling design and sampling intensity.

12. Provide the Assessment Workshop Report (Section III of the SEDAR Stock Assessment Report) including tables of estimated values within 4 weeks of workshop conclusion. SEE NOTE 2.

MODEL ACCEPTANCE NOTE 1: The SEDAR Steering Committee requires that models be standard configurations, such as those provided in the NMFS toolbox or other validated sources. Custom programming during the workshops is strongly discouraged. If custom or modified programs are considered, the following must be addressed: 1) complete documentation and code must be provided; 2) an executable version of the program and all necessary input and control files must be provided to workshop participants; 3) the custom code/application used must be validated through application of known parameter datasets and such results must be provided as part of the assessment documentation; 4) justification for use of custom programming in lieu of readily available models must be provided in writing in the assessment documentation.

REPORT COMPLETION NOTE 2: The Assessment Workshop report is due no later than Monday, June 5 2006. If final assessment results are not available for review by workshop panelists during the workshop, the panel shall determine deadlines and methods for distribution and review of the final results and completion of the workshop report.

1.1.3. List of Participants

Workshop Panel

Tom Burgess....................SAFMC AP/Commercial
Shannon Calay....................NMFS/SEFSC Miami, FL
Marianne Cufone.................... GMFMC/Environment Matters
Doug Gregory....................GMFMC SSC/Unvi. Florida Sea Grant
Sherry Larkin....................SAFMC SSC/Univ. of Florida
Behzad Mahmoudi .... GMFMC FAP/FL FWRI
Josh Sladek Nowlis .... NMFS/SEFSC Miami, FL
Mauricio Ortiz.................... NMFS/SEFSC Miami, FL
Clay Porch.................... NMFS/SEFSC Miami, FL
Mike Prager.................... NMFS/SEFSC Beaufort, NC
Robert Spaeth ....GMFMC AP/Commercial
Frank Stephenson ....GMFMC AP/Recreational
Helen Takade....................SAFMC/NCDMF
Steve Turner .... NMFS/SEFSC Miami, FL
Carl Walters....................GMFMC FAP/Mote Marine Lab
Erik Williams .... NMFS/SEFSC Beaufort, NC
Bob Zales, II .... GMFMC AP/Charter

Observers

Roy Williams....................GMFMC Member
Alex Chester.................... NMFS/SEFSC Miami, FL
David Cupka.................... SAFMC Member
Dennis Heinemann .... Ocean Conservancy
Albert Jones....................GMFMC SSC
Russell Nelson.................... CCA
John Walter.................... NMFS/SEFSC Miami FL
Rob Cheshire .... NMFS/SEFSC Beaufort, NC

Staff

Steven Atran..GMFMC
John Carmichael.. SEDAR
Meg Kosick ....GMFMC
Gregg Waugh...SAFMC
Tyree Davis.. NMFS/SEFSC Miami, FL

1.1.4. List of Assessment Workshop Working Papers

SEDAR10-AW1	SEDAR 10 stock assessment model, US South Atlantic gag	Williams, Erik H.
SEDAR10-AW2	Preliminary status of gag grouper in the Gulf of Mexico: continuity run VPA, SEDAR 10	Ortiz, M.
SEDAR10-AW3	Preliminary status of gag grouper in the Gulf of Mexico, SEDAR 10	Ortiz, M.

1.1.5. Research Documents Provided at the Assessment Workshop

SEDAR10-RD07 2007	CASAL users manual version 2.07-2005/08/21 NIWA Tech Rpt.127. ISSN 1174-2631	Bull, B. et al
SEDAR10-RD08 1994	Simulation of the impact of fishing on reproduction of a protogynous grouper, the graysby. NAJFM 14:41-52	Huntsman, G. R. and W. E. Schaaf.
SEDAR10-RD09	Review of effects from fishing mortality on protogynous species and implications for management	SEFSC/MIA SFD Presentation
SEDAR10-RD10 2006	Models to compare management options for a protogynous fish. Ecolog. Apps. 16(1):238-249	Heppell, S. S. et al
SEDAR10-RD11 2004	The effects of size-selective fisheries on the stock dynamics of and sperm limitation in sex changing stocks. Fish Bull 102(1):1-13.	Alonzo, S. H., M. Mangel.
SEDAR10-RD12 2001	Effects of fishing on a protogynous hermaphrodite CJFAS. 58:568-578.	Armsworth, P. R.
SEDAR10-RD13 1996	Production Functions of the Norwegian bottom trawl fisheries of cod in the Barents Sea 84th ICES Statutory Meeting	Skjold, F., A. Eide, O. Flaaten
SEDAR10-RD14 1998	The impact of global positioning systems and plotters on fishing power in the northern prawn fishery, Australia Can. J. Fish. Aquat. Sci. **55**: 1645.1651	Robins, C. M., Y.-G. Wang, D. Die
SEDAR10-RD15 1998	Changes in the sex ratio and size at maturity of gag, *Mycteroperca microlepis*, from the Atlantic Coast of the Southeastern United States, 1976-1995 Fish Bull 96:797-807	McGovern et al.
SEDAR10-RD16	Release mortality of undersized fish from the snapper-grouper complex off the North Carolina Coast. NC SEAGRANT 03-FEG-21	Overton, A. S., J. Zabawski

2. Proceeding of the SEDAR10 Gag Assessment Workshop Gulf of Mexico Gag Grouper Assessment

2.1 Assessment methods considered-

The CASAL (C++ Algorithmic Stock Assessment Laboratory, Bull et al. 2005), which is a statistical age-structured forward reconstruction model, was selected as the primary method by the SEFSC-NMFS scientists for assessment of the Gulf of Mexico gag grouper (see stock assessment report). The CASAL was selected because it provided a great deal of flexibility in specifying the population dynamics, parameter estimation, and model outputs. Previous stock assessments of the Gulf of Mexico gag grouper (Turner et al. 2001) have been based on Virtual Population Analysis (VPA, a backward reconstruction model). VPA differs from CASAL in two important ways. First, VPAs are conditioned on catch-at-age data so data are fit exactly, while indices of abundance and the selectivities of various fleets are estimated within the model. Second, VPAs typically identify stock-recruitment pattern post-analysis; whereas CASAL makes this estimation in the model sometimes with penalties for using recruitments that deviate from the estimated relationship. The SEFSC-NMFS assessment scientists also presented an updated VPA (see NMFS report by Josh Sladek Nowlis) as a ‘continuity case’. The updated VPA was based on same basic formulation as previous assessments, but had an improved age-length key and updated catch and biostatistical data from 2001 through 2004. The new age-length key caused changes in the catch-at-age proportions, maturity vector, the selectivity of various fisheries, and fishing mortality rates. In the updated VPA, selectivities generally shifted so that older age classes were more vulnerable.

In addition to CASAL and VPA models, the assessment workshop participants (AWP) reviewed the Stochastic Stock Reduction Analysis (SRA, Walters et al 2006, appendix 1) using historical (1880-2004) catch time series for the GOM gag. The historical catch time series was assembled at the workshop by NMFS and FWC/FWRI scientists. The stochastic SRA attempts to provide probability distributions for stock size over time under alternative hypotheses about unfished recruitment rates and about variability around assumed stock-recruitment relationships. For the gag SRA assessment, an age structured population model with Beverton-Holt stock-recruitment function was simulated forward in time from the start of the fishery in 1880, with exploitation rates calculated each year from observed catch divided by modeled vulnerable population (sum of vulnerabilities at age times modeled number at age).

2.2 Preferred model and configuration recommendations

The AWP agreed that CASAL should be used as the primary method for the Gulf of Mexico gag assessment, principally because the age structure of the catch was not well known. The AWP recommended to include the updated VPA results and explanations concerning differences between the new VPA and old runs, and between the new VPA and CASAL runs in the assessment report. Some panel members thought there were reasons to believe that vulnerability schedules may have changed due to changes in factors like depth targeting of fishing effort. In principle, VPA is robust to such changes;

CASAL is not, and may give spurious indications of having found information about mortality rates in age-size composition data that are in fact uninformative. However, similarity between CASAL and VPA results appeared sufficient to satisfy the AWP that potential errors associated with confounding of abundance and selectivity changes discussed above were ruled out in this assessment. The AWP further recommended including SRA analysis for modeling the uncertainty.

2.3 Issues Discussed

2.3.1 Catch time series-

To give the best possible long term perspective on stock status, AWP recommended conducting assessments on the longest possible catch data series. Assessments based on short time series, no matter how much detailed composition data are available in recent times, can give very misleading estimates of current stock status relative to unfished stock levels. The AWP recommended running the CASAL model with the catch time series staring in 1880 as alternative to the base runs with the catch time series beginning in 1963. Generally, a model starting in 1880 provide more information on virgin biomass and recruitment levels than a model starting in 1963. But questions were raised concerning the quality of catch statistics prior to 1963. The gag commercial catch time series (1880-2004) was constructed at the meeting (see NMFS report by Steve Turner) based on historical total groupers caught in the eastern Gulf of Mexico.

The historical recreational catch time series developed at the data workshop was rejected by AWP for the Gulf gag assessment. The predicted historical catch level seemed to be unusually high. The AWP suggested an alternative approach using relationship between the MRFSS fishing effort and number of boats built during 1981-2004. The AWP also discussed the recent report of NRC regarding MRFSS estimates and concluded that available estimates of recreational catch and indices of abundance were the best available information. They recommended running alternative runs with MRFSS catch estimates by +/- 25% change.

2.3.2 Discards-

For estimates of commercial discard, data collected in recent years (McCarthy 2006) considered not appropriate except for handlines. The AWP recommended applying same method used in 2001 assessment using size frequency distributions from catch-at-size files for three periods: no size limit (1880-1989), 20” size limit (1990-99), and 24” size limit (2000-04). The AWP agreed with using the B2 portion of MRFSS estimates for the recreational discards.

2.3.3Release Mortality-

The AWP recommended using the size-depth related release mortality estimates (rather than a fixed proportion used in 2001 assessment) developed at the data workshop for the Gulf recreational and commercial gag fisheries.

Catch-at-age proportions for commercial and recreational fisheries- Twelve ages (12+) were used in the assessment, starting at age 1. Catch at size (by fishery and by season) were converted to catch at age using the age-length keys. Age- length keys were developed based on 16,436 otolith samples (11,8K from commercial, 3.8K from recreational, and 0.7K from biological sampling) collected during 1991-2005. These otoliths were also used to update growth parameters, which improved growth curves by including early ages through fishery-independent sampling. Results showed significantly different growth parameters than those estimated for 2001 assessment. New growth models generated different catch at age proportions than those developed in the 2001 assessment.

The AWP made no specific recommendations concerning catch-at-age matrices. Diagnostic generated by CASAL presented no particular inconsistencies.

2.3.4 Selectivity by fishery/index-

Selectivity curves were estimated by CASAL for five fisheries using logistic (longline only) and double logistic (all other gears) functions. Theses patterns seemed reasonable and they generally matched the patterns generated by the VPA analysis.

2.3.5 Catchability rate-

The AWP recommended a 2% annual increase of catchability rate (1984-present) as an equally plausible alternative to constant q to reflect for improvements in gear and fishing electronics that were available to recreational and commercial operations (see NMFS report by Mike Prager). The AW agreed to include the changes in catchability as a constant reduction of the standardized indices (fisheries dependent) by a similar 2% annual change.

2.3.6 Natural mortality estimate-

The AWP recommended using the age-specific estimates of M based on Lorenzen method.

2.3.7 Maturity vector-

Maturity vector at age for females only, estimating spawning biomass as the product of maturity times the average weight at size. The AW recommended
Estimating also the equivalent male spawning biomass component for each run.

2.3.8 Indices of abundance-

Both fishery dependent and fishery independent time series were reviewed. Fishery-dependent indices were partitioned by size limit phases and included commercial handline (1990-1999, 2000-2004, low CV), commercial longline (1990-1999, 2000-2004, low CV), headboat (1986-1989, 1990-1999, 2000-2004, low CV), and MRFSS (1981-

2004, high CV). The fishery-independent indices included videoSEAMAP (1993-2004, high CV), and Copperbelly video index of male only from videoSEAMAP (1993-2004, high CV). In CASAL, the weights assigned to each component of the likelihood function correspond to the inverse of the variance assumed to be associated with that component. In general, all indices exhibited similar trend indicating increase in relative abundance in recent years. There was an extended discussion concerning the reliability of MRFSS-CPUE index, but discussion ultimately tended more toward inclusion than exclusion given low weights assigned to the MRFSS index due to high CV values.

When all relative abundance time series indicate the same stock trend, they simply reinforce one another in driving the assessed stock size while perhaps helping a bit to average out measurement errors. But when they give contradictory signals (one index showing decline, another showing increase), at least one must be wrong, and the overall assessment results are suspect no matter how the different data sources are "weighted" for statistical analysis. Results should be presented showing the full range of uncertainty about stock trend resulting from different weightings of the data, not just a single "best" reconstruction, and assessment scientists should refuse to speculate on which of the alternatives is "correct"; that cannot be decided scientifically except by further experience and possibly analysis of possible causes for one or another index to not be representative of stock trends.

2.3.9 Stock and recruitment relationships-

The AWP was satisfied with the Beverton-Holt spawner/recruit structure assumed in CASAL but had a lengthy discussion on possibility of a Ricker type S/R relationship given the patterns seen with the gag spawning stock and recruitment data.

2.4 Model runs-

AWP made following recommendations for the base and Alternative runs:

1. Base run I.
   Catch 1963 – 2004 with Commercial/Recreational catch 1963-04 assuming a constant catchability.
2. Base run II.
   Catch 1963 – 2004 with Commercial/Recreational catch 1963-04 assuming an increasing catchability 2% annually.
3. Alternative run
   Catch 1880 – 2004 with Commercial catch 1880-04 and recreational catch 1945-04, assuming a constant catchability.
4. Alternative run
   Catch 1880 – 2004 with Commercial catch 1880-04 and recreational catch 1945-04, assuming an annual increase of catchability of 2% since 1984.
5. Alternative run
   Catch1963 – 2004 with 25% increase of total MRFSS catch assuming a constant catchability.

6. Alternative run
   Catch 1963 – 2004 with 25% decrease of total MRFSS catch assuming a constant catchability.
7. Retrospective run
   removing consecutively up to 5 years of recent years of both catch and indices of abundance data

2.5 Stock Condition-

Results generated from the CASAL runs (see assessment report) showed that the spawning biomass in final year 2004 for two base runs were about 19- 21 % of their respective virgin biomass estimates assuming a BH-S/R relationship for all time series. The SSB_{2004}/ SSB_0 for alternative runs ranged from 14 to 35%. The SSB_{2004}/ SSB_0 ranged from 7.7% to 9% assuming a BH-S/R relationship only for 1983-2004 years. Compared to SSB_{MSY} the SSB_{2004} were about 62-70% (assuming S/R for all time series) and 27-28% (assuming S/R for 1983-2004 years). The SSB_{2004}/ SSB_{MSY} for alternative runs ranged from 43% to 155% assuming a BH-S/R relationship for all time series and from 24% to 28% assuming a BH-S/R relationship only for 1983-2004 years. The estimated fishing rates in 2004 were between 0.389 and 0.419 for the base scenarios, and above 0.38 in all the Alternative runs. Overall the F_{2004} was much higher than F_{MAX}, F_{MSY}, or $F_{30\%SPR}$.

The stochasticSRA model results indicated wide uncertainty (plus or minus 50%) on historical (unfished) average biomass and on the extent of depletion since major development of the fishery beginning in the 1940s. The most probable current stock size was estimated to be between 30 and 50% of average unfished biomass. The model attributes recent increases in catch rate to positive recruitment anomalies, and predicts rapid decline in recruitment and exploitable biomass within the next few years if current exploitation rates (averaging around 30% on fully vulnerable ages) continue. It suggests that the decline could be largely prevented by moving to a somewhat lower (20%) exploitation rate target.

The stochasticSRA results were in general agreement with CASAL runs concerning unfished and current stock size, Umsy, and MSY. However, the SRA gave quite a different reconstruction of stock changes from the 1940s through the early 1960s. CASAL fits involved a very large reduction in stock size during that period, so as to make the stock quite low during the 1960s and to continue exhibiting recovery until almost the present day. CASAL accomplishes this reduction through a series of negative recruitment anomalies. In contrast, the SRA model indicated high probabilities that the stock was still relatively large by 1960, and declined more or less steadily as catches grew until a series of positive recruitment anomalies temporarily reversed the decline during the late 1990s and early 2000s.

The SRA model also indicated wide uncertainty about Umsy (90% credibility limits 20% to 40% per year) and somewhat lower uncertainty about MSY (90% credibility limits

7,000,000 to 10,000,000 pounds). As noted above, there is a high probability that the stock will soon decline to levels incapable of producing MSY if current 30% exploitation rates are maintained, and this warning is even stronger if recreational catches and discard mortalities continue to grow at the rates apparent over the last decade. The appendix-4 show the probability distributions for past and future gag grouper stock biomass and probability of stock crashes for two potential TAC (6 and 10 million pounds) scenarios for the GOM gag fishery. For the 6 million pounds TAC, the stochasticSRA estimated a probability of 2% of causing the stock to crash and for the 10 million lb future TAC, the model indicated a 49% probability of causing the stock to crash.

It should be noted that these results were based largely on an instrumental (reconstructed, not raw data) time series of total catches estimated from a variety of sources. There is particularly high uncertainty about recreational catches prior to 1980, and commercial catches (including impact of Cuban fishing) prior to 1970. There was insufficient time during the SEDAR assessment workshop to fully develop the SRA model, and in particular to enter all available relative abundance series for likelihood calculation and all known historical changes in vulnerability schedules due to changes in size limits.

In addition to reviewing the model results and benchmarks, the AWP discussed two key issues concerning the GOM gag stock condition:

First issue was related to high recruitment levels observed in recent years. The AWP focused on biological processes (i.e., Ricker type stock-recruitment relationships with high recruitment as a result of a low stock size) or environmentally driven processes (i.e., regime shift with favorable condition in recent years) as possible reasons for the positive recruitment anomalies in recent years. If recruitment is environmentally driven, the current *F* levels could not be sustainable during unfavorable condition with low recruitment levels and *F* has to be reduced accordingly. If a Ricker type S/R condition existed, *F* could be held high to keep SSB down and recruitment high- a potentially risky approach.

Second issue was related to large catches and potentially high release mortality of young gags in recent years in the recreational sector. Both CASAL and SRA runs generated low F_{MSY}, a clear sign of growth overfishing, primarily due to large catches of young gags. Current estimated *F*s are well above the F_{MSY} and *F* on young fish has to be reduced in order to prevent growth overfishing in this fishery.

2.6 Management benchmark considerations-

The AWP discussed benchmarks estimates from two S/R relationships; one based on recent time series (1983-2004) representing period with positive recruitment anomalies, and second based on historical time series representing the average recruitment condition. Several members of the AWP agreed that the more recent recruitment estimates were better determined as they were based on actual indices and age composition during that period. Others argued that it was uncertain whether the higher recruitment values after the

1980's reflected a true regime shift that will persist into the future, or fortuitous recruitments that will not persist, or simply a modeling artifact (i.e., the apparently lower recruitment estimates for the earlier years may just be poorly estimated). Therefore, AWP agreed that MSST-related reference points, which depend on the S/R relationship, may not be well-determined and that a range of possibilities as a reflection of that uncertainty should be presented. Due to great uncertainty in MSY based benchmarks, the AWP recommended considering YPR and SPR approaches for estimating benchmarks. It should be noted however that while YPR and SPR calculations themselves don't require knowledge of the spawner-recruit relationship, a biomass reference point based on those concepts does.

Appendix-1

STOCK REDUCTION ANALYSIS MODEL

For comparison with the NMFS assessment models, we also ran a stochastic stock reduction analysis (SRA, Walters et al. 2006) on long-term catches (1880-2004). In this approach, an age structured population model with Beverton-Holt stock-recruitment function is simulated forward in time from the start of the fishery, with exploitation rates calculated each year from observed catch divided by modeled vulnerable population (sum of vulnerabilities at age times modeled numbers at age). In Stochastic SRA, recruitment is assumed to have had log-normally distributed annual anomalies, and to account for the effects of these a very large number of simulation runs is made with anomaly sequences chosen from normal prior distributions (with or without autocorrelation). The resulting sample of possible historical stock trajectories is resampled using importance resampling (SIR), or a large sample is taken using MCMC. Summing frequencies of occurrence of different values of leading population parameter values over this sample amounts to solving the full state-space estimation problem for the leading parameters (i.e. find marginal probability distribution for the leading population parameters integrated over the probability distribution of historical state trajectories implied by recruitment process errors).

The stochastic SRA is parameterized by taking Umsy (annual exploitation rate producing MSY at equilibrium) and MSY as leading parameters, then calculating the Beverton-Holt stock-recruit parameters from these and from per-recruit fished and unfished eggs and vulnerable biomasses. Under this parameterization, we effectively assume a uniform Bayes prior for Umsy and MSY, rather than a uniform prior for the stock-recruitment parameters.

The SRA model results indicate wide uncertainty (plus or minus 50%) on historical (unfished) average biomass and on the extent of depletion since major development of the fishery beginning in the 1940s. The most probable current stock size is estimated to be between 30 and 50% of average unfished biomass. The model attributes recent increases in catch rate to positive recruitment anomalies, and predicts rapid decline in recruitment and exploitable biomass within the next few years if current exploitation rates (averaging around 30% on fully vulnerable ages) continue. It suggests that the decline could be largely prevented by moving to a somewhat lower (20%) exploitation rate target.

The SRA results are in general agreement with CASAL runs concerning unfished and current stock size, Umsy, and MSY. However, the SRA gives quite a different reconstruction of stock changes from the 1940s through the early 1960s. CASAL fits involve a very large reduction in stock size during that period, so as to make the stock quite low during the 1960s and to continue exhibiting recovery until almost the present day. CASAL accomplishes this reduction through a series of negative recruitment anomalies. In contrast, the SRA model indicates high probabilities that the stock was still relatively large by 1960, and declined more or less steadily as catches grew until a series of positive recruitment anomalies temporarily reversed the decline during the late 1990s and early 2000s.

The model also indicates wide uncertainty about Umsy (90% credibility limits 20% to 40% per year) and somewhat lower uncertainty about MSY (90% credibility limits 7,000,000 to 10,000,000 pounds). As noted above, there is a high probability that the stock will soon decline to levels incapable of producing MSY if current 30% exploitation rates are maintained, and this warning is even stronger if recreational catches and discard mortalities continue to grow at the rates apparent over the last decade.

We caution that these results are based largely on an instrumental (reconstructed, not raw data) time series of total catches estimated from a variety of sources. There is particularly high uncertainty about recreational catches prior to 1980, and commercial catches (including impact of Cuban fishing) prior to 1970.

There was insufficient time during the SEDAR assessment workshop to fully develop the SRA model, and in particular to enter all available relative abundance series for likelihood calculation and all known historical changes in vulnerability schedules due to changes in size limits.

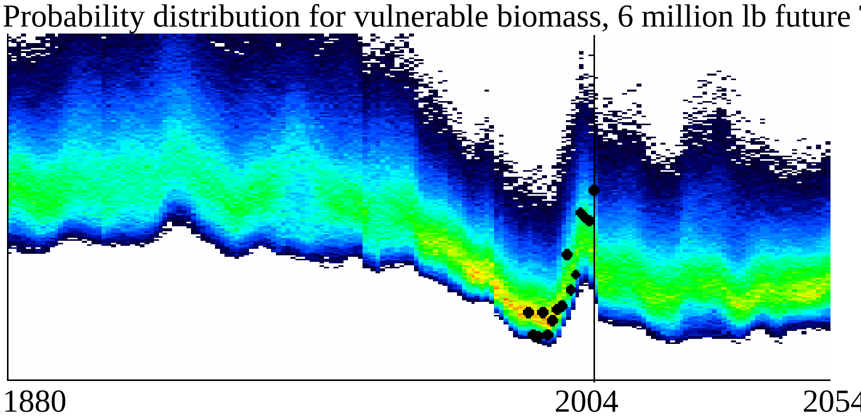
REFERENCE:

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

Appendix-2

Figure 1. Probability distributions for past and future gag grouper stock biomass estimated using stochasticSRA population modeling software. Historical catch data and vulnerability schedules from NMFS estimates using CASAL model. First panel shows predicted future distribution of stock sizes under 6 million lb TAC, for which the model estimates a probability of 2% of causing the stock to crash. Second panel shows 10 million lb future TAC, for which the model indicates a 49% probability of causing the stock to crash. Note that in the second scenario, simulated stock crashes (to biomass less than necessary to obtain TAC) result in policy change to very conservative (Fmsy/3) exploitation rate for years after the crash.

Probability distribution for vulnerable biomass, 6 million lb future TAC



Probability distribution for vulnerable biomass, 10 million lb future TAC

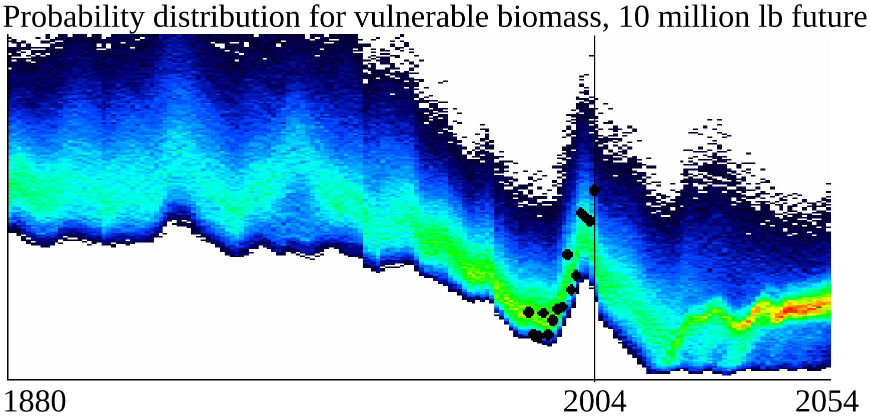
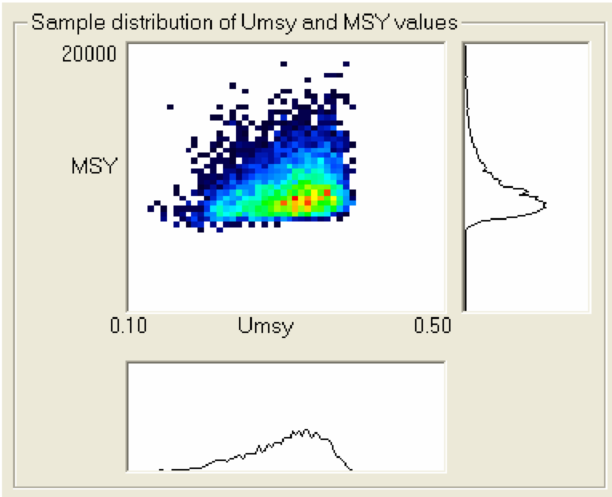


Figure 2. Posterior distribution for MSY (1000lb) and Fmsy estimated using MCMC sampling with the stochasticSRA population model. Historical catch data and age-vulnerability schedules from NMFS estimates using CASAL model. Mode of MSY distribution is around 9 million lb. Modal estimate of Fmsy is around 0.25. Lower modal Fmsy would result from freezing M at best estimate (0.86) rather than assuming any M value between 0.8 and 0.9 to be equally likely as was done for the stochasticSRA run.


Sample distribution of Umsy and MSY values
20000
MSY
0.10
Umsy
0.50

Appendix 3. RECOMMENDATIONS FOR SEDAR ASSESSMENTS

Carl Walters
Fisheries Centre, UBC
c.walters@fisheries.ubc.ca

May 2006

Here are a few recommendations for SEDAR stock assessment scientists; the aims of these recommendations are to uncover possible weaknesses in assessments, and to provide more information for the Council.

1. **Never rely on any one assessment procedure**.
   It is a good idea to run both VPA (backward reconstruction) and SCA (stock synthesis, forward reconstruction) models, especially when vulnerability schedules may have changed in complex ways due to changes in factors like depth targeting of fishing effort. VPA is robust to such changes; SCA is not, and may give spurious indications of having found information about mortality rates in age-size composition data that are in fact uninformative. Further, assessments should present a range of estimates of key reference points (MSY, etc.) for not only age-structured models, but also simple equilibrium and non-equilibrium surplus production models.
2. **Include retrospective analyses showing how estimates change with time**.
   Retrospective analyses (compare estimates for each year from data available as of that year to data available in fullness of time) often reveal serious structural errors in assessment models. They are easy to implement in ADMB, and should be included as a matter of routine in software packages like CASAL. Remember the Canadian cod debacle: retrospective analyses revealed that ADAPT was failing long before the final stock collapse (due to changing vulnerability schedules and increasing commercial catchability as the stock declined), but the warnings were ignored.
3. **Beware of complex size-age and temporally changing vulnerability schedules**.
   Dome-shaped and temporally variable vulnerability schedules “use up” information about mortality and recruitment that would otherwise be present in size-age composition data. When a large number of nuisance parameters need be included in the model to describe such changes, the data then essentially contribute nothing to assessments of overall abundance and rates, except for modest information about relative sizes of adjacent year-classes. The overall assessments then end up being dominated in their basic results by patterns in relative abundance data, which can also be misleading for a variety of obvious reasons.
4. **Beware of confounding between stock-recruitment and recruitment anomaly (environmental) effects**.
   It is not unusual for SCAs to indicate very strong recruitment compensation (steep recruitment curve) while at the same time giving recruitment anomaly trends that are strongly, positively correlated with spawning stock size (which is indicative of

a positive effect of spawn abundance on recruitment). This can happen for both recovering stocks (gag) and declining ones (eg boccacio rockfish in California). Alternative hypotheses about stock-recruitment versus environmental forcing effects cannot be resolved by stock assessment procedures, and demand careful management policy analysis to deal with the deep uncertainty that they represent.

5. **Examine implications of relative abundance time series that give contradictory indications of time trends.**
   When all relative abundance time series indicate the same stock trend, they simply reinforce one another in driving the assessed stock size while perhaps helping a bit to average out measurement errors. But when they give contradictory signals (one index showing decline, another showing increase), at least one must be wrong, and the overall assessment results are suspect no matter how the different data sources are “weighted” for statistical analysis. Results should be presented showing the full range of uncertainty about stock trend resulting from different weightings of the data, not just a single “best” reconstruction, and assessment scientists should refuse to speculate on which of the alternatives is “correct”; that cannot be decided scientifically except by further experience and possibly analysis of possible causes for one or another index to not be representative of stock trends.
6. **Provide time series estimates of fishing mortality rates.**
   Time series estimates of fishing mortality provide a valuable indication of whether protective management measures have been successful, and are much more useful in this regard than catch data. During stock collapses it is quite common for catches to decline more slowly than stock size, due to ineffective regulations and range collapse effects on catchability, so that fishing mortality rate and impact are actually increasing while the catch data indicate the opposite.
7. **Run assessments on the longest possible catch data series, to give the best possible long term perspective on stock status.**
   Assessments based on short time series, no matter how much detailed composition data are available in recent times, can give very misleading estimates of current stock status relative to unfished stock levels. The only way to guard against this problem is to use “stock reduction analysis”, where the assessment model is solved forward in time from the beginning of the fishery, so as to estimate cumulative fishery impacts prior to the advent of detailed sampling programs. Absent such assessments, our methods are very likely to contribute to the “shifting baseline syndrome”.
8. **Carefully examine any available spatial data for evidence of range collapse or expansion**
   Relative abundance time series, including those from spatially consistent surveys that do not fully cover stock ranges, can give grossly misleading patterns for stocks that exhibit range contractions/expansions with changes in overall abundance. In most fisheries there is enough spatial logbook information, along with anecdotal information from experienced fishers, to provide a basic narrative evaluation of historical range changes and how these have likely affected catch and relative abundance time series.

Appendix 4 to Gulf Gag Grouper SEDAR AW Report:
Notes on fishing mortality considerations for a protogynous hermaphrodite species.
The case of gag grouper Gulf of Mexico stock.

Gag grouper are protogynous hermaphrodites. Individuals start life as females and later transform to males. Females mature as early as 3 years of age, by age 4 approximately 70% are mature, and all are mature by 6 years of age (Ortiz 2006). Sex transformation starts in individuals that are 7-8 years old, with 50% transformation occurring by age 13 (Ortiz 2006). Virtually all individuals older than 16 years of age are males (Hood & Schlieder 1992). Transformation in gag appears to be driven primarily by endogenous processes (McGovern et al. 1998; most individuals transform within a fairly narrow size/age range, and all individuals eventually transform), and in part exogenously (some evidence of more rapid transformation when the sex ratio is female biased, references in Huntsmand and Schaaf 1994). Several authors have suggested that selective fishing that results in higher fishing pressure on larger individuals coupled with protogynous hermaphrodism would make protogynous species especially vulnerable to recruitment overfishing (Bannerot et al. 1987, Huntsman and Schaaf 1994, Coleman et al. 1996, Coleman et al. 2000, Armsworth 2001, Fu et al. 2001, Alonzo and Mangel 2004, Heppell et al. 2006). If transformation is driven primarily by endogenous processes then typical size-selective fishing would remove more males than females, and if in the extreme could lead to sperm limitation in the population. If transformation is driven exogenously then facultative transformations could keep the proportion of males sufficiently high, but would result in a decrease in average size of mature females with possible reduction in egg production. Modelling studies have suggested that age/size truncation resulting in changes in sex ratio or female size could result in increased variation in recruitment and increased probability of catastrophic collapse (Armsworth 2001). Estimates of the sex ratio in this population from various time periods have indicated a large decreases in the proportion of males in the Gulf of Mexico and Atlantic (Coleman et al. 1996, McGovern et al 1998).

There are various management implications that derive from this information and the modeling studies that have been conducted (Huntsman and Schaaf 1994, Armsworth 2001, Fu et al. 2001, Alonzo and Mangel 2004, Heppell et al. 2006). First, the selectivity imposed by a fishery is critical. Management options that reduce F on males (larger individuals) will tend to reduce the chance of producing a dangerously low sex ratio. Because large fish are typically targeted in many fisheries and the inherent tendency of many gear types to be size selective this may be difficult to achieve in many fisheries. This has led some authors to argue that the most effective way to protect males would be to establish appropriate MPAs (Coleman et al. 2000). This may work because data indicate that old males are at least partially resident on deep-water reefs (Coleman et al. 1996). Data collected recently from two gag spawning aggregation closures on the west Florida shelf are providing some collaboration for this hypothesis (Coleman and Koening reference in Heppell et al 2006). However, because these large individuals may move considerable differences the size of such closures is critical to their success, and Heppel et al. (2006) have suggested that such closures would have to be coupled with reductions in F outside the closures. Alternatively, controls could be imposed differentially on fisheries based on their selectivity, or F controls could be depth dependent. A modeling study of gag grouper by Heppell et al. (2006) has suggested that simply reducing F substantially (50% in the model) for all age classes could be equally effective. Second, the transition to depensatory dynamics caused by sperm limitation is likely to be abrupt and patchy in space because males may show site fidelity. However, biological knowledge is currently insufficient to estimate a sperm-limitation threshold. Given the uncertainty in the form of the depensatory function and the long lags in population assessment imposed by the management system, it is important from this perspective to set conservative benchmarks for gag.

Figure 7 of SEDAR-10-AW-##(Ortiz Status review of gag grouper in the Gulf of Mexico) shows the estimated trends of spawning biomass for males and females gag grouper GOM stock. By 2004, male proportion was about 7% of mature individuals by weight, and 3% of mature individuals by number. Although, overall spawning biomass for gag GOM has increased in recent years, male biomass component has a much lower rate of increase compared to the female component (Fig 6 SEDAR-10-AW ##).

References

Alonzo, S. H., and M. Mangel. 2004. The effects of size-selective fisheries on the stock dynamics of and sperm limitation in sex-changing fish. Fishery Bulletin 102:1–13.

Armsworth, P. R. 2001. The effects of fishing on a protogynous hermaphrodite. Canadian Journal of Fisheries and Aquatic Sciences 58:568–578.

Bannerot, S. P., W. W. Fox,Jr., and J. E. Powers. 1987. Reproductive strategies and the management of groupers and snappers in the Gulf of Mexico and Caribbean. Pages 561– 606 in J. J. Polovina and S. Ralston, editors. Tropical snappers and groupers: biology and fisheries management. Westview Press, Boulder, Colorado, USA.

Coleman, F. C., C. C. Koenig, and L. A. Collins. 1996. Reproductive styles of shallow-water grouper (Pisces: Serranidae) in the eastern Gulf of Mexico and the consequences of fishing spawning aggregations. Environmental Biology of Fishes 47:129–141.

Coleman, F. C., C. C. Koenig, G. R. Huntsman, J. A. Musick, A. M. Eklund, J. C. McGovern, R. W. Chapman, G. R. Sedberry, and C. B. Grimes. 2000. Long-lived reef fishes: the grouper–snapper complex. Fisheries 25:14–21.

Fu, C., T. J. Quinn, II, and T. C. Shirley. 2001. The role of sex change, growth and mortality in *Pandalus* population dynamics and management. ICES J. Mar. Sci. 58:607−621.

Heppell, S.S., S.A. Heppell, F.C. Coleman and C.C. Koenig. 2006. Models to compare management options for a protogynous fish. Ecological Applications 16: 238-249.

Hood, P.B. and R.A. Schlieder. 1992. Age, growth and reproduction of gag, *Mycteroperca microlepis*, (Pisces: Serranidae) in the eastern Gulf of Mexico. Bulletin of Marine Science 51: 337-352.

Huntsman, G. R., and W. E. Schaaf. 1994. Simulation of the impact of fishing on reproduction of a protogynous grouper, the graysby. North American Journal of Fisheries Management 14:41–52.

McGovern, J. C., D. M. Wyanski, O. Pashuk. C. S. Manooch, II, and G. R. Sedberry. 1998. Changes in the sex ratio and size at maturity of gag, *Mycteroperca microlepis*, from the Atlantic coast of the southeastern United States during 1976–1995. Fishery Bulletin 96:797–807.

SEDAR-10-AW-#. Ortiz, M. 2006. Status Review of gag grouper in the US Gulf of Mexico, SEDAR10.

3.1 Virtual Population Analysis of the Gulf of Mexico Gag Grouper (*Mycteroperca microlepis*) Stock: The Continuity Case

by

Joshua Sladek Nowlis

18 May 2006

NOAA Fisheries
Southeast Fisheries Science Center
75 Virginia Beach Drive
Miami, FL 33149

Sustainable Fisheries Division Contribution No. SFD-2006-022

INTRODUCTION

As part of the collective effort to assess the status of the Gulf of Mexico gag grouper (*Mycteroperca microlepis*) stock, a virtual population analysis (VPA) model was constructed. The mode was constructed using the same basic formulation as in the previous assessment of this stocks (Turner et al. 2001, RFSAP 2001), but used updated data.

VPAs differ from other population models in that they rely predominantly on the age structure of the catch. If this information is available, it can be used to identify strong year classes and back-calculate abundance and fishing mortality rate histories. These exercises are usually aided through the use of life history information and indices of abundance. VPAs differ from statistical age-structured models in two important ways. First, VPAs are conditioned on catch-at-age data so these data are fit exactly, while indices of abundance and the selectivities of various fleets are estimated within the model. Second, VPAs typically identify stock-recruitment patterns post-analysis; whereas statistical age structured models often make this estimation in the model sometimes with penalties for using recruitments that deviate from the estimated relationship.

The principal purpose of these VPA analyses was to explore the influence of new data on our conclusions about the status of Gulf gag grouper. It was expected that the VPA would not be chosen to form the basis of our conclusions about stock status in this round of analysis, principally because the age structure of the catch is not well known. Nevertheless, it is helpful when interpreting a new model to know what the former model would have concluded with the updated data.

METHODS

Data

It was not possible to rely on directly observed catch at age information. Instead, age composition was inferred from size composition using an age-length key (SEDAR10-DW-2, SEDAR10-DW-Report). These data were combined with basic life history information and several indices of abundance. Although a number of indices were developed during the current assessment, this continuity case relied only on the four used in the previous assessment: commercial handline, commercial longline, and recreational headboats (all developed using reported catch and effort), and other recreational (MRFSS, which uses dock intercepts and interviews regarding effort).

Since the last assessment, the data on Gulf gag grouper has changed in two ways. First, the data timeframe was expanded. Five years have passed, which allowed ongoing data collection programs to add five years of data. Additionally, two earlier years (1984 and 1985) were made available in some of the datasets. Second, some data have been revised. Minor changes were made to the four indices of abundance as a result of new and improved standardization procedures (SEDAR10-DW-10, SEDAR10-DW-5, SEDAR10-DW-9, SEDAR10-DW-4; Fig. 1), while major changes were made to the age-length relationship. During the previous assessment, it was noted that limited sample sizes prevented the analysts to resolve ages of younger fish well (Turner et al. 2001). Consequently, an effort was made to sample small fish to provide better resolution. These efforts changed our perspective on the growth of Gulf gag grouper (SEDAR10-DW-2; Fig. 2), which in turn dramatically changed our estimates of catches at age (Fig. 3). Because of the central importance of catch at age data to VPA models, it was expected that the improvement in the age-length relationship could have a substantial influence on our conclusions about stock status.

VPA Construction

Principally, the VPA was constructed using the same conventions as in the previous assessment. Constant selectivities were used for each fishery-dependent index. These were all estimated within the model, with the exception of the longline fishery. As was recommended during the previous assessment (RFSAP 2001), initial estimates were converted into an asymptotic selectivity function for this fleet, which targets large individuals in relatively deep water.

To examine the effects of new years of data from changes in data (principally the age structure), two VPAs were constructed. One used updated data but only from the same timeframe as the original model, 1986-1999. The other VPA used updated data from all available years, 1984-2004.

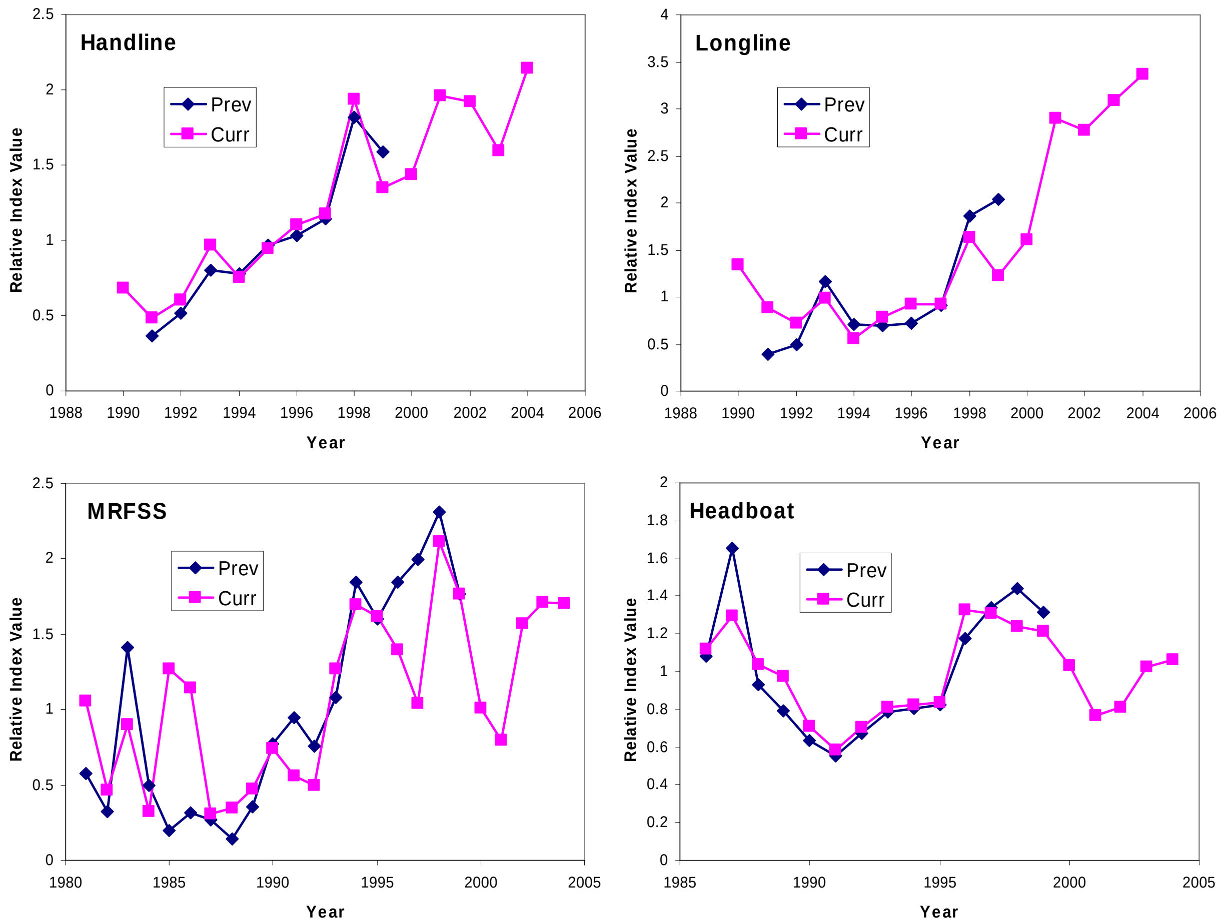


Fig. 1—Indices of Abundance.

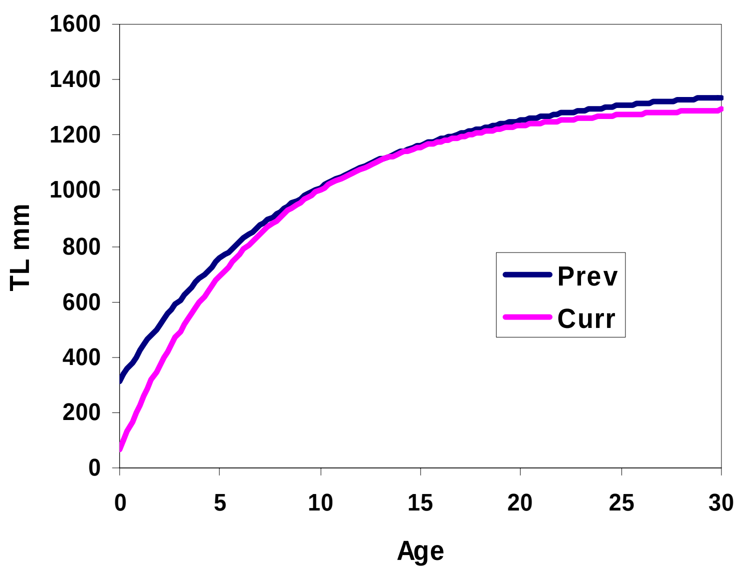
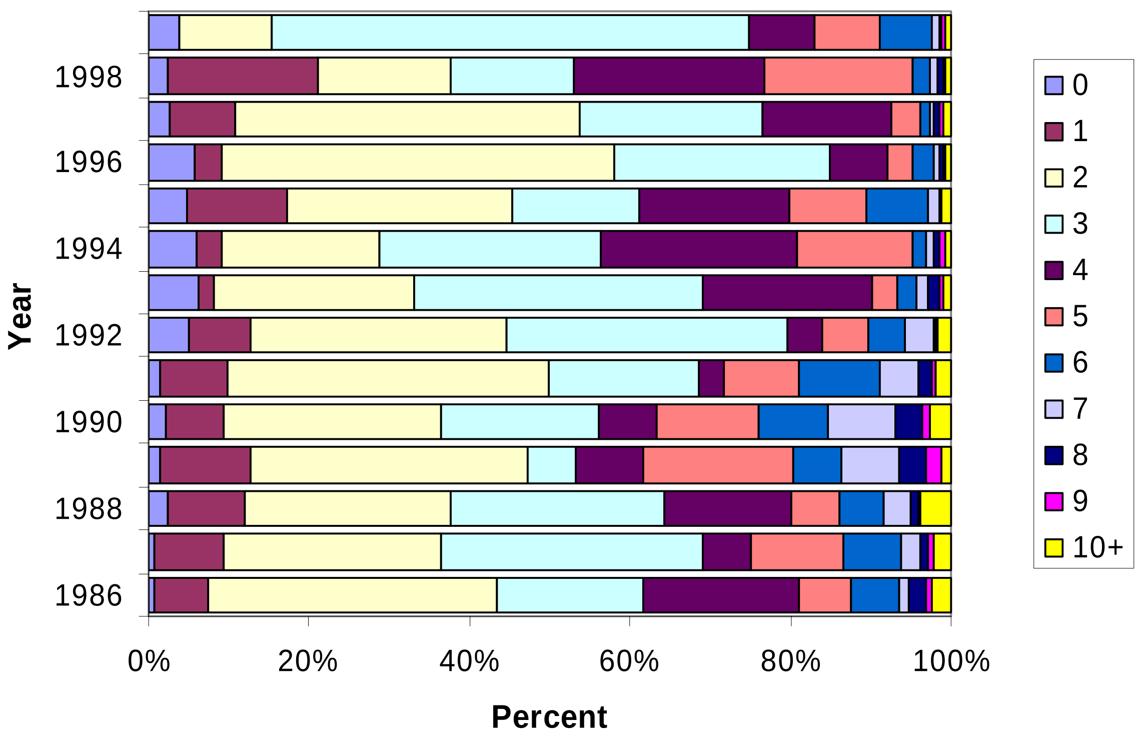


Fig. 2—Age-Length Relationships. Previous assessment: TL (mm) = 1381.5(1-e$^{-0.1061(Age+2.4359)}$); Current assessment: TL (mm) = 1310(1-e$^{-0.14(Age+0.37)}$)

Previous



Current

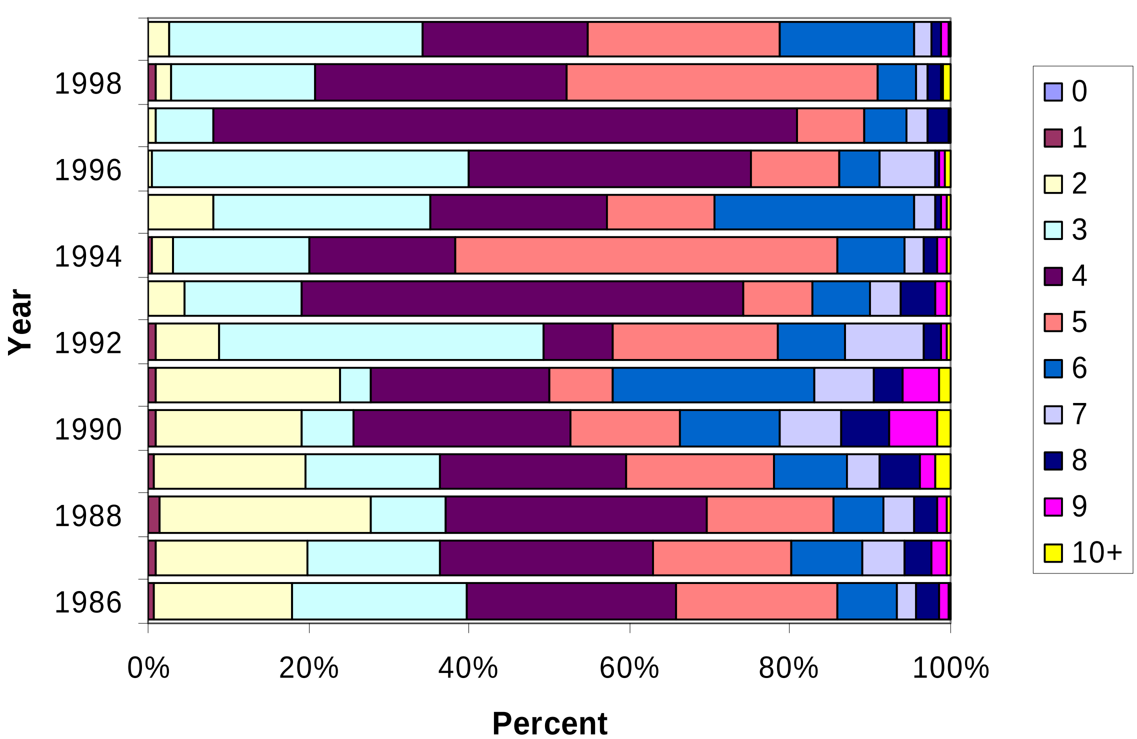


Fig. 3—Catch at Age Estimates.

RESULTS

Parameter Estimates

Estimates of fishing mortality rates at age were surprisingly consistent across runs despite the dramatic changes in inferred age structure (Table 1, Fig. 4). As would be expected, the two new VPAs did not differ in their early year estimates. They only diverged in the late 1990s, where the full timeframe provided additional information on cohorts represented in these years. There were a few spikes in F at age in each of the series. These were not always consistent between the old and new models (e.g., 1994), as a result of the differences in inferred age structure. Interestingly, the results from the new model using the old timeframe were more consistent with the old assessment than with the new assessment using the full timeframe. This observation suggests that the new years of data were more influential than the shift in the age-length key.

Estimates of numbers at age were even more consistent across the old and new models (Table 2, Fig. 5). Some differences included a 1989-born cohort that shows up in the new models but not the old. However, both models suggest a strong year class born in the early 1990s, although the old model suggested a 1993 birthday while the new model indicates 1994. This change was expected because the new age-length key predicted older ages, especially for the youngest fish.

Other Fits and Estimates

Fits to indices changes a bit across the three models tested (Fig. 6). Fits were fairly consistent between the old model and the new one limited to the same time frame. This consistency was not terribly surprising since the change in age-length key affected both the catch at ages and also the selectivities of the different fleets. Note that selectivities generally shifted so that older age classes were more vulnerable (Fig. 7).

CONCLUSIONS

The new assessment for the Gulf of Mexico gag grouper stock included two new or improved sources of information. First, we had an improved age-length key. This change led to an interpretation that fish were caught at older ages than had previously believed. But, it also led to a shift in the reproductive schedule and the selectivity of various fisheries, minimizing the effects of this change on the model as a whole. Second, we had data from recent years, which suggested a growing stock. Despite these changes, the estimates of abundance and fishing mortality rates were mostly quite consistent between the old and new models. When differences did exist, they were primarily in recent years, and apparently influenced more by additional years of data than by the revised age-length key.

REFERENCES

Reef Fish Stock Assessment Panel (RFSAP). 2001. *October 2001 Report of the Reef Fish Stock Assessment Panel, Final Draft—November 26, 2001*. Gulf of Mexico Fishery Management Council, Tampa, FL.

Turner, SC, CE Porch, D Heinemann, GP Scott, and M Ortiz. 2001. *Status of Gag in the Gulf of Mexico, Assessment 3.0*. Sustainable Fisheries Division Contribution SFD 01/02-134. Department of Commerce, National Marine Fisheries Service, Miami, FL.

Table 1—Fishing mortality rates at age by year from the previous assessment and a new VPA run with data from 1986-1999 and with data from 1984-2004.

Previous Assessment

Year	Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9	Age-10+
1986	0.01	0.055	0.34	0.465	0.517	0.261	0.303	0.601	0.411	0.277	0.277
1987	0.005	0.098	0.21	0.357	0.179	0.391	0.324	0.121	0.6	0.193	0.193
1988	0.022	0.1	0.482	0.344	0.305	0.266	0.354	0.264	0.065	0.412	0.412
1989	0.006	0.11	0.498	0.162	0.144	0.571	0.405	0.823	0.365	0.156	0.156
1990	0.005	0.021	0.252	0.343	0.184	0.201	0.339	0.744	0.632	0.119	0.119
1991	0.006	0.036	0.234	0.434	0.128	0.602	0.387	0.504	0.534	0.132	0.132
1992	0.025	0.037	0.165	0.295	0.145	0.316	0.603	0.198	0.027	0.126	0.126
1993	0.014	0.017	0.225	0.404	0.426	0.201	0.291	0.644	0.169	0.114	0.114
1994	0.014	0.009	0.252	0.456	0.581	0.633	0.182	0.187	0.948	0.101	0.101
1995	0.035	0.041	0.119	0.375	0.744	0.538	1.017	0.258	0.117	0.115	0.115
1996	0.014	0.023	0.158	0.113	0.205	0.189	0.192	0.161	0.096	0.067	0.067
1997		0.029	0.556	0.126	0.111	0.182	0.102	0.078	0.268	0.123	0.123
1998			0.093	0.502	0.232	0.223	0.188	0.174	0.14	0.109	0.109
1999				0.402	0.402	0.087	0.087	0.087	0.087	0.087	0.087

New Assessment --> 1999

Year	Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9	Age-10+
1986	0	0.004	0.139	0.299	0.42	0.39	0.36	0.247	0.265	0.208	0.208
1987	0	0.005	0.106	0.117	0.403	0.314	0.18	0.272	0.37	0.174	0.174
1988	0	0.011	0.258	0.086	0.456	0.574	0.221	0.14	0.3	0.231	0.231
1989	0	0.008	0.152	0.193	0.235	0.369	0.549	0.157	0.204	0.265	0.265
1990	0	0.001	0.162	0.04	0.28	0.118	0.246	0.556	0.21	0.211	0.211
1991	0	0.005	0.057	0.064	0.277	0.177	0.493	0.317	0.914	0.372	0.372
1992	0	0.004	0.044	0.118	0.175	0.382	0.247	0.312	0.131	0.321	0.321
1993	0	0.001	0.037	0.165	0.373	0.426	0.351	0.274	0.358	0.182	0.182
1994	0	0.001	0.018	0.193	0.32	0.653	1.051	0.188	0.177	0.152	0.152
1995	0	0	0.019	0.291	0.471	0.487	1.066	1.652	0.085	0.117	0.117
1996	0	0	0.001	0.092	0.526	0.333	0.243	0.708	0.978	0.106	0.106
1997		0	0.007	0.026	0.286	0.261	0.312	0.218	0.818	0.064	0.064
1998			0.017	0.231	0.19	0.315	0.307	0.166	0.297	0.252	0.252
1999				0.346	0.346	0.174	0.174	0.174	0.174	0.174	0.174

Table 1 (cont.)—Fishing mortality rates at age by year from the previous assessment and a new VPA run with data from 1986-1999 and with data from 1984-2004.

New Assessment --> 2004

Year	Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9	Age-10+
1984	0	0.003	0.073	0.046	0.173	0.335	0.164	0.208	0.355	0.158	0.158
1985	0	0.004	0.137	0.195	0.323	0.936	0.381	0.369	0.261	0.349	0.349
1986	0	0.004	0.137	0.299	0.415	0.384	0.356	0.245	0.261	0.206	0.206
1987	0	0.005	0.104	0.115	0.401	0.309	0.177	0.268	0.364	0.171	0.171
1988	0	0.011	0.252	0.084	0.447	0.571	0.216	0.137	0.294	0.226	0.226
1989	0	0.008	0.148	0.188	0.23	0.358	0.544	0.153	0.199	0.259	0.259
1990	0	0.001	0.162	0.039	0.271	0.115	0.236	0.547	0.204	0.204	0.204
1991	0	0.005	0.057	0.064	0.268	0.17	0.477	0.301	0.884	0.357	0.357
1992	0	0.004	0.043	0.118	0.175	0.364	0.234	0.297	0.123	0.303	0.303
1993	0	0.001	0.042	0.16	0.371	0.425	0.327	0.255	0.334	0.169	0.169
1994	0	0.001	0.02	0.226	0.307	0.648	1.045	0.172	0.162	0.139	0.139
1995	0	0	0.027	0.34	0.592	0.458	1.047	1.615	0.077	0.106	0.106
1996	0	0	0.002	0.134	0.67	0.478	0.223	0.679	0.906	0.095	0.095
1997	0	0	0.008	0.048	0.457	0.382	0.536	0.196	0.751	0.057	0.057
1998	0	0.005	0.007	0.286	0.395	0.639	0.531	0.352	0.258	0.219	0.219
1999	0	0	0.014	0.122	0.467	0.463	0.489	0.374	0.468	0.147	0.147
2000	0	0.002	0.127	0.1	0.328	0.197	0.481	0.285	0.35	0.167	0.167
2001	0	0.002	0.003	0.091	0.202	0.501	0.506	0.657	0.299	0.305	0.305
2002		0.004	0.028	0.103	0.186	0.385	0.412	0.422	0.256	0.332	0.332
2003			0.034	0.361	0.186	0.162	0.348	0.346	0.328	0.302	0.302
2004				0.995	0.995	0.236	0.236	0.236	0.236	0.236	0.236

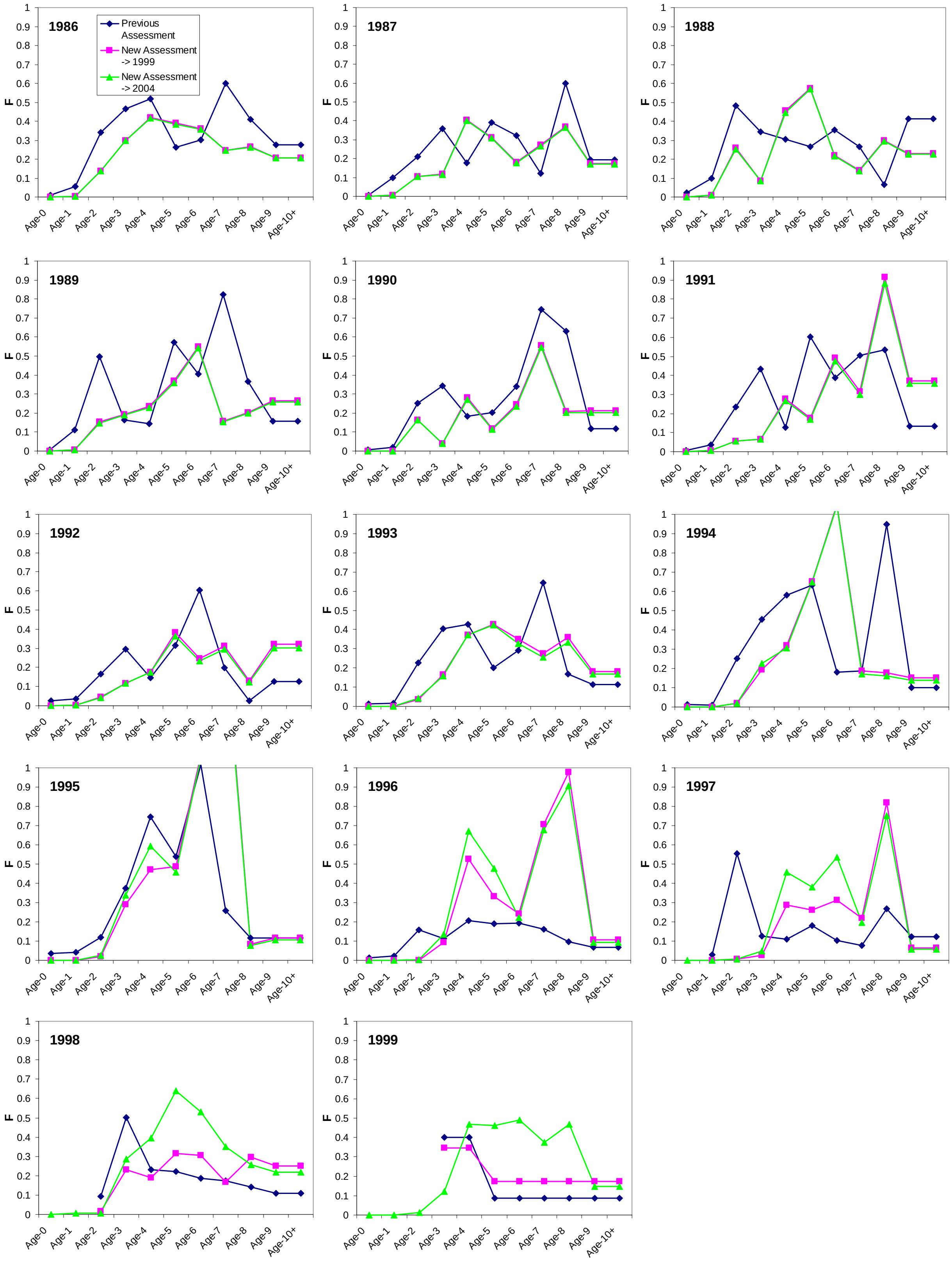


Fig. 4—Fishing mortality rates at age by year from the previous assessment (blue diamonds) and a new VPA run with data from 1986-1999 (pink squares) and with data from 1984-2004 (green triangles).

Table 2—Numbers at age (in millions) by year from the previous assessment and a new VPA run with data from 1986-1999 and with data from 1984-2004.

Previous Assessment

Year	Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9	Age-10+
1986	0.808	1.288	1.303	0.512	0.501	0.294	0.249	0.027	0.065	0.029	0.104
1987	0.939	0.689	1.049	0.798	0.277	0.257	0.195	0.158	0.013	0.037	0.087
1988	0.909	0.804	0.537	0.732	0.481	0.199	0.149	0.121	0.121	0.006	0.088
1989	1.965	0.765	0.626	0.286	0.446	0.305	0.131	0.09	0.08	0.097	0.054
1990	2.096	1.682	0.59	0.328	0.209	0.333	0.148	0.076	0.034	0.048	0.111
1991	1.758	1.795	1.417	0.395	0.2	0.15	0.234	0.091	0.031	0.016	0.121
1992	1.413	1.504	1.491	0.965	0.22	0.152	0.071	0.137	0.047	0.016	0.103
1993	4.609	1.186	1.248	1.088	0.619	0.164	0.095	0.033	0.097	0.04	0.09
1994	4.834	3.912	1.004	0.857	0.626	0.348	0.115	0.061	0.015	0.07	0.1
1995	1.832	4.101	3.337	0.672	0.468	0.301	0.159	0.083	0.044	0.005	0.132
1996	4.316	1.524	3.386	2.551	0.397	0.191	0.151	0.05	0.055	0.033	0.105
1997		3.664	1.281	2.488	1.961	0.279	0.136	0.107	0.036	0.043	0.112
1998			3.062	0.632	1.889	1.51	0.2	0.106	0.086	0.024	0.118
1999				2.402	0.329	1.29	1.04	0.143	0.077	0.064	0.109
2000					1.383	0.19	1.017	0.82	0.112	0.06	0.137

New Assessment --> 1999

Year	Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9	Age-10+
1986	1.167	1.268	1.145	0.724	0.648	0.53	0.21	0.096	0.106	0.058	0.116
1987	1.102	1.004	1.087	0.858	0.462	0.366	0.309	0.126	0.065	0.07	0.122
1988	0.608	0.948	0.86	0.841	0.657	0.266	0.23	0.222	0.083	0.039	0.138
1989	3.014	0.524	0.808	0.572	0.665	0.358	0.129	0.159	0.166	0.053	0.121
1990	1.232	2.594	0.447	0.597	0.406	0.452	0.213	0.064	0.117	0.117	0.115
1991	1.327	1.06	2.23	0.327	0.494	0.264	0.346	0.144	0.032	0.081	0.161
1992	1.681	1.142	0.908	1.813	0.264	0.322	0.19	0.182	0.09	0.011	0.144
1993	5.685	1.447	0.979	0.748	1.386	0.191	0.189	0.128	0.115	0.068	0.097
1994	4.299	4.894	1.244	0.812	0.546	0.821	0.107	0.115	0.084	0.069	0.118
1995	1.752	3.701	4.209	1.052	0.577	0.341	0.368	0.032	0.082	0.06	0.138
1996	1.874	1.508	3.185	3.554	0.677	0.31	0.18	0.109	0.005	0.065	0.152
1997		1.613	1.298	2.739	2.789	0.344	0.191	0.122	0.046	0.002	0.168
1998			1.389	1.11	2.297	1.804	0.228	0.12	0.084	0.018	0.137
1999				1.175	0.758	1.635	1.133	0.144	0.088	0.054	0.103
2000					0.715	0.462	1.182	0.819	0.104	0.063	0.114

New Assessment --> 2004

Year	Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9	Age-10+
1984	1.571	1.126	1.154	1.047	0.868	0.269	0.246	0.126	0.062	0.053	0.16
1985	1.496	1.352	0.966	0.923	0.86	0.628	0.165	0.179	0.088	0.037	0.157
1986	1.19	1.288	1.159	0.726	0.654	0.536	0.212	0.097	0.107	0.058	0.118
1987	1.13	1.024	1.104	0.87	0.463	0.372	0.314	0.128	0.066	0.071	0.123
1988	0.609	0.973	0.877	0.856	0.667	0.267	0.235	0.227	0.084	0.039	0.141
1989	3.024	0.524	0.828	0.587	0.677	0.367	0.13	0.163	0.17	0.054	0.124
1990	1.268	2.603	0.448	0.615	0.419	0.463	0.221	0.065	0.12	0.12	0.118
1991	1.158	1.091	2.237	0.328	0.509	0.275	0.355	0.15	0.032	0.084	0.167
1992	1.478	0.997	0.935	1.819	0.265	0.335	0.2	0.19	0.096	0.011	0.151
1993	4.04	1.272	0.854	0.771	1.391	0.191	0.201	0.136	0.121	0.073	0.104
1994	2.326	3.478	1.094	0.705	0.565	0.826	0.108	0.124	0.091	0.075	0.128
1995	1.453	2.002	2.99	0.923	0.484	0.358	0.372	0.033	0.09	0.066	0.152
1996	4.753	1.251	1.723	2.505	0.565	0.231	0.195	0.112	0.006	0.072	0.169
1997	2.707	4.091	1.077	1.481	1.887	0.249	0.123	0.134	0.049	0.002	0.189
1998	1.908	2.33	3.521	0.919	1.214	1.028	0.146	0.062	0.095	0.02	0.155
1999	7.647	1.643	1.996	3.01	0.594	0.704	0.467	0.074	0.037	0.063	0.121
2000	1.968	6.582	1.414	1.693	2.294	0.321	0.382	0.246	0.044	0.02	0.137
2001	1.009	1.694	5.654	1.072	1.319	1.422	0.227	0.203	0.16	0.027	0.114
2002		0.868	1.455	4.852	0.842	0.928	0.741	0.118	0.091	0.102	0.089
2003			0.744	1.218	3.769	0.602	0.544	0.423	0.066	0.06	0.118
2004				0.619	0.731	2.693	0.441	0.33	0.257	0.041	0.114
2005					0.197	0.233	1.831	0.3	0.225	0.175	0.105

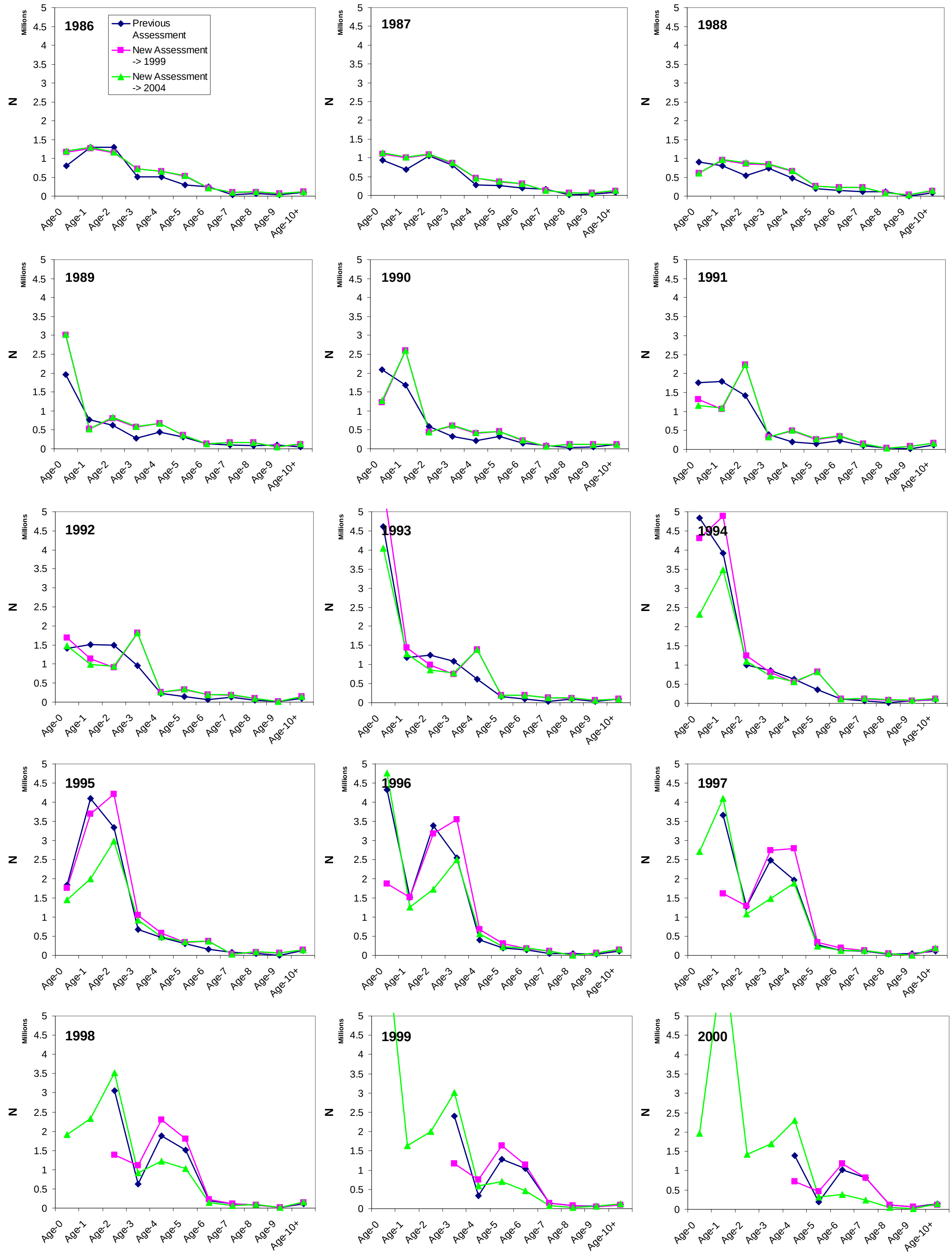


Fig. 5—Numbers at age by year from the previous assessment (blue diamonds) and a new VPA run with data from 1986-1999 (pink squares) and with data from 1984-2004 (green triangles).

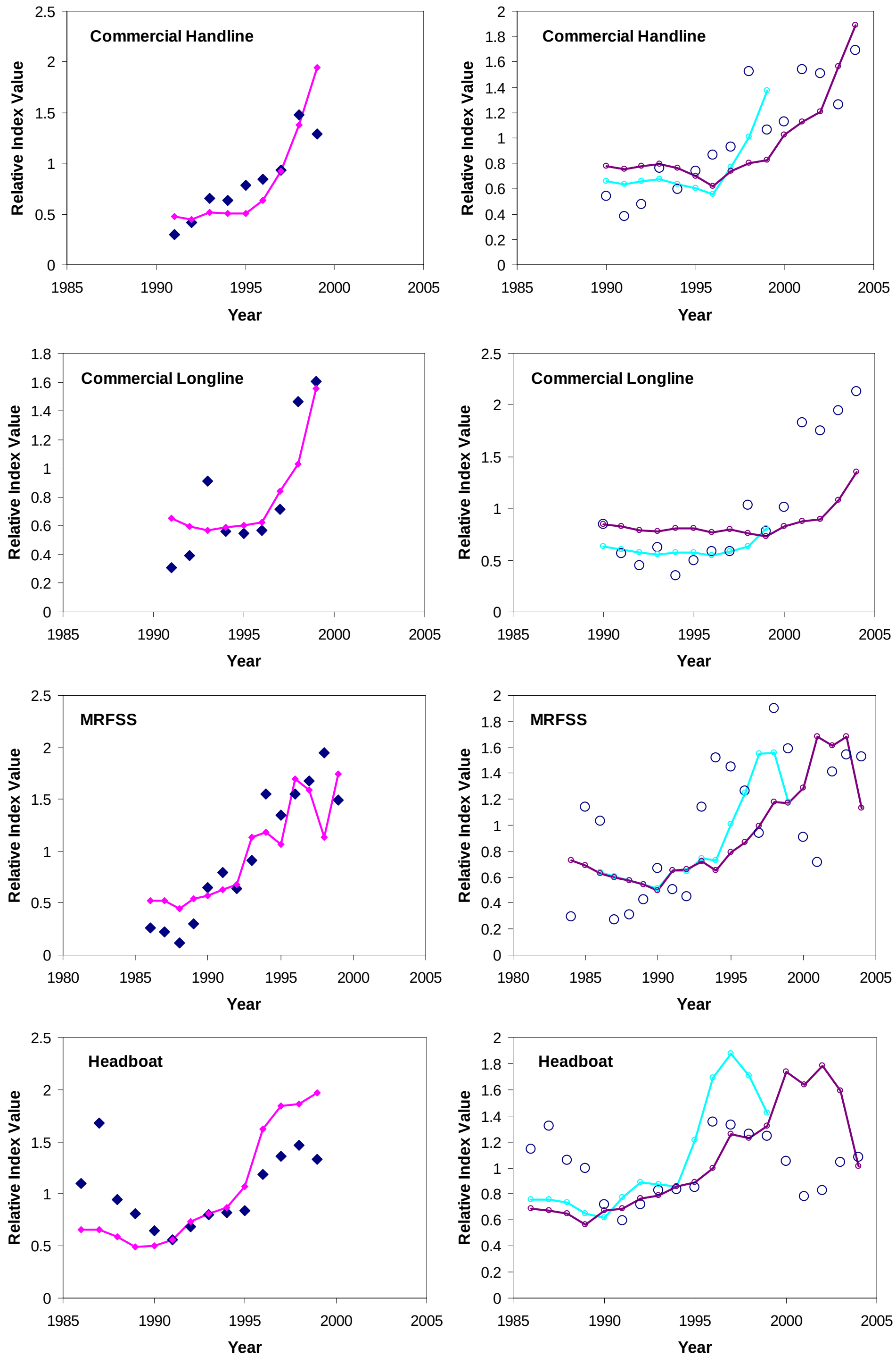


Fig. 6—Fits to indices from the previous assessment (left column) and a new VPA run with data from 1986-1999 (light blue) and with data from 1984-2004 (purple).

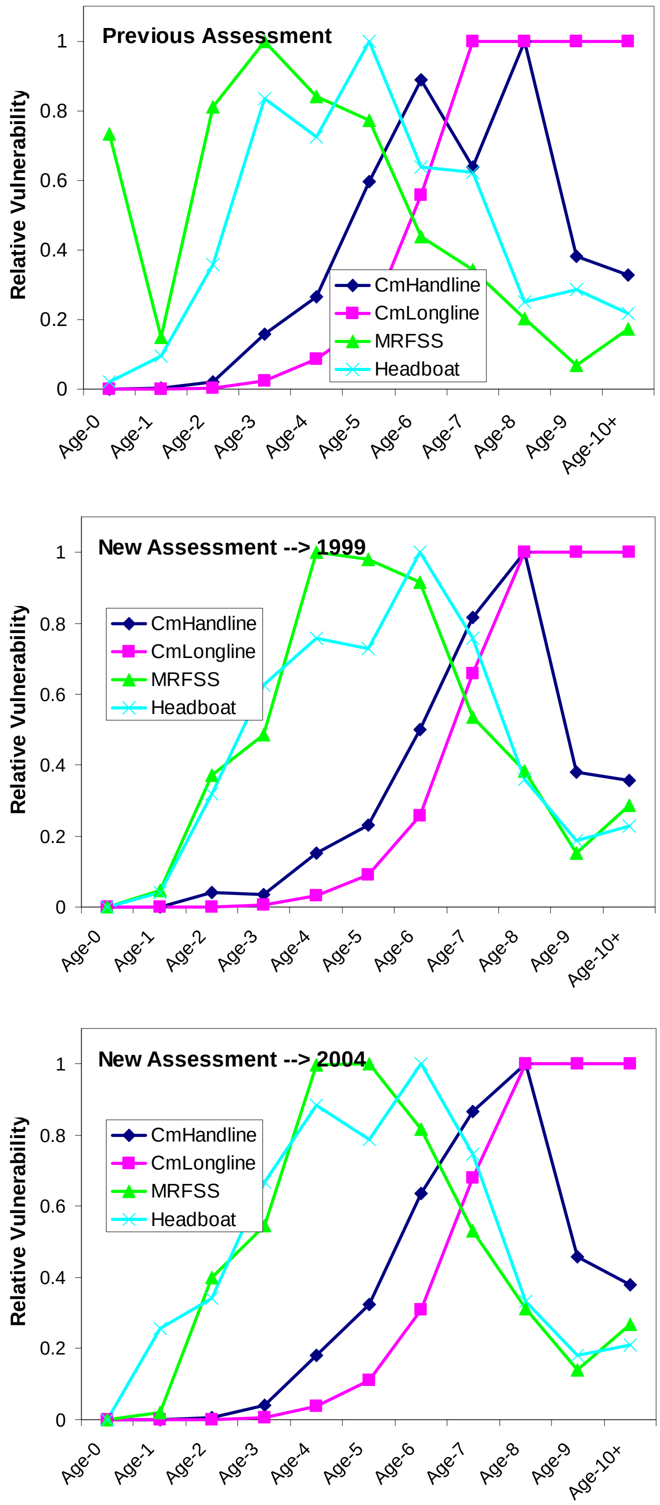


Fig. 7—Selectivity patterns by fleet from the previous assessment (top) and and a new VPA run with data from 1986-1999 (middle) and with data from 1984-2004 (bottom). Note that selectivity in the longline fleet was assumed asymptotic and set by assigning full selectivity to all ages above the estimated age at full selectivity.

3.2 Status review of Gag Grouper
In the U.S. Gulf of Mexico, SEDAR 10

Mauricio Ortiz
Southeast Fisheries Science Center
Sustainable Fisheries Division
75 Virginia Beach Drive
Miami, FL 33149
June 2, 2006

Sustainable Fisheries Division Contribution SFD 2006-0##.

Gag GOM model runs and stock evaluation

Review of catch and effort input data

The assessment workshop (AW) group reviewed the catch and effort input data for gag Gulf of Mexico (GOM) stock and concluded the following:

Historic Recreational Catch

The recreational historic data (1963-1981) estimated by the recreational group of the data workshop was inconsistent with historic trends of other grouper fisheries, and experience of scientist/fisherman present at the meeting. The AW considered that recreational catches in the 1960's were not of the same or higher magnitude compared to the catches in the 1990's (Fig 4 Sedar 10-AW-3). Discussion of the group centered about the number of recreational Headboat vessels during 1960's years, and the perception of limited travel of recreational vessels to offshore areas particularly on the west coast of Florida.

The AW requested estimating recreational historical catch 1960-1980 using regressors that take into account human coastal population, number of vessels and estimated total expend in dollars for recreational fisheries. Figure 1 presents a comparison of the estimated "updated" recreational catch (AW) and the initial (DW) estimates for Gag GOM 1963-2004. Historical estimated of recreational catch were expanded back to 1900 year, but the AW agreed to use 1945 as the initial year for any significant recreational landings of gag grouper in the Gulf of Mexico. Estimates of historical recreational catch were provided in number of fish, as landings and dead discards, conversion to biomass landings and biomass dead discards used the mean weight or recreational catches from 1981-1989. Table 1 and Figures 3 shows the 'final' working estimates of recreational catch for gag GOM 1944-2004.

Historic Commercial Catch

The AW group requested to extend the historic catches of gag grouper as further as possible. Following the protocol for reconstructing commercial catch trends of red snapper, the AW presented gag GOM commercial catch from 1880 to 2004. Figure 2 and Table 1 shows the 'final' working estimates of commercial catch. See text in AW report (section #) for further details in the procedures for estimation of historical commercial catch.

The AW group concluded that release mortality based on depth of capture was a better and more realistic estimate than a fixed proportion as used in 2001 assessment. Therefore dead discards estimated using catch-at-size and depth for both commercial and recreational sectors were selected as part of the total removals component of catch for gag GOM grouper.

The AW also discussed the recent report of NRC regarding MRFSS estimates, and concluded that available estimates of recreational catch and indices of abundance were the best available information. They recommended running sensitivity analyses where MRFSS total estimated catch was increased or decreased by 25% for the whole time series. Figure 4 presents the final catch series for gag GOM including commercial and recreational historic estimates.

Gag GOM CASAL runs

Assessment model assumptions

The AW group adopted the following assumptions for the CASAL assessment model runs of Gag GOM:

- An age structured model, starting with age 1 to age 12+, where age 12 represent the plus group.
- Natural mortality vector age dependent, based on the Lorenzen method.
- Size at age following a von Bertalanffy growth model (2006 DW estimate)
- Beverton-Holt stock recruitment relationship.
- Maturity vector at age for females only, estimating spawning biomass as the product of maturity times the average weight at size. The AW recommended estimating also the equivalent male spawning biomass component for each run.
- Four indices of abundance fisheries dependent Handline, Longline, Headboat, and MRFSS. Handline, Longline and Headboat indices were split at 1989/90 and 1999/00 when management regulations of minimum size were implemented and considered to affect the landings of those fisheries, and thus the CPUE series.
- Two indices of abundance fisheries independent Video SEAMAP survey and the Copper belly video survey.
- Five major fisheries; three commercial Handline, Longline and others (Trap, spear, trawl, others), and two recreational Headboat and MRFSS.
- Five catch at age proportions for Handline, Longline, MRFSS, Headboat and Other fisheries 1984-2004.
- Constant catchability coefficients q's within fishery and associated index time series. Thus Handline, Longline and Headboat fisheries were split similar to their respective indices of abundance.
- Selectivity by fishery/index was assumed to follow a parametric function; double logistic for all; except Longline fishery logistic. Function parameters were estimated by the model.

- Penalties for total catch in each fishery to be realized, and for the average recruitment deviations to be one.

Scenarios

The AW recommended extending the analysis of catch trends as much in time as possible. The AW also recommended including potential changes of catchability in the evaluation, assuming a 2% annual increase of catchability since 1984 to reflect for improvements in gear and fishing electronics that were available to recreational and commercial operations. The AW agreed to include the changes in catchability as a constant reduction of the standardized indices (fisheries dependent) by a similar 2% annual change. With CASAL the following runs were performed;

1. Catch 1963 – 2004 with Commercial/Recreational catch 1963-04 assuming a constant catchability.
2. Catch 1963 – 2004 with Commercial/Recreational catch 1963-04 assuming an increasing catchability 2% annually.
3. Catch 1880 – 2004 with Commercial catch 1880-04 and Recreational catch 1945-04, assuming a constant catchability.
4. Catch 1880 – 2004 with Commercial catch 1880-04 and Recreational catch 1945-04, assuming an annual increase of catchability of 2% since 1984.
5. Catch 1963 – 2004 with 25% increase of total MRFSS catch assuming a constant catchability.
6. Catch 1963 – 2004 with 25% decrease of total MRFSS catch assuming a constant catchability.

All runs were estimated using maximum likelihood estimation (ML), initial guess estimates and bounds for model parameters were consistent through all scenarios. In the case of the extended time runs [1880-04] it was assumed that the stock in 1880 reflected an unexploited stock (virgin stock), therefore no initial biomass parameter was estimated in these runs.

Table 2 presents a summary of the runs performed with CASAL for the gag GOM stock and their corresponding objective function and estimated AIC value. Other stock indicators included virgin stock (SSB_0) or spawning stock biomass unexploited, spawning initial stock (SSB_{initia}l), steepness parameter, mean recruitment of unexploited stock (R_0), terminal year spawning stock biomass (SSB_{2004}), and fishing mortality rates of terminal year (F_{2004}). All references of spawning biomass are of gag GOM female spawning biomass component in metric tons, unless otherwise specified.

Other sensitivity analysis included a retrospective run, where the base case 1 [constant q's] was run removing consecutively up to 5 years of recent data (both catch and indices of abundance).

Results

Base case scenario(s)

The AW group decided to present runs 1 and 2 (see above) as base case scenarios, and the rest as sensitivity runs. Tables 2 and 3 presents a summary of main stock indicators for the fit of run 1 (base 1). Spawning biomass of unexploited stock was estimated at 87,514 MT, while SSB in 1963 was 22,295 MT and SSB in 2004 was 18,592 MT. The stock population indicated an initial stock with few individuals in ages 1 through 11 and a larger plus group (age 12+), this age-structure was continue until 1973/74, when increase recruitments start to move through the stock, by early 1990, recruitment pick up greatly, and larger cohorts enter in the early 1990, with largest recruitments in 1990, 1994, 1997 and 2000 (Fig 5). Figure 5 shows the biomass trends of females and males components, with clear decline in the 1963-1979 period, and stable low values until 1995, and increase trend since 1996. However, male biomass proportion remains low compare to the early period. Fishing mortality show an increasing trend from 1963 through 1983, reaching the highest rate in 1983 (Fig 5). Thereafter F remains high through the 1990's, latest years there is increasing trend since a low in 1999. Figure 5 also shows the estimated selectivity patterns by age for each fishery, the handline fishery shows'logistic' type selectivity similar to the longline fishery although with higher selectivity towards younger age classes. Headboat, MRFSS, and Others fisheries show a dome shape type selectivity.

Tables 2 and 4 show the summary of main stock indicators for the fit of the run 2 (base A) case. There were small differences in the fit, estimates and trend between the two base cases. Assuming an increase of catchability since 1984, the model tends to estimate lower spawning biomass in 1963 and 2004, with higher initial unexploited biomass (SSB_0). Stock age-structure, recruitment pattern, and fishing mortality trends were similar between the two base scenarios (Fig 6). For the base scenarios, steepness was estimated at about 0.75, however the recruitment trend indicated a negative deviate trend of recruitment in the early period (1963-1980) and large positive deviates particularly in the 1990's. Fig A1 shows the fit to indices of abundance from the base run 1. The fit to Headboat index in the last period [2000-04] was poor. The fit of catch-at-age shows larger deviates also for the headboat fishery. Similar plots are presented for the fit of the base run 2 (Fig A2). Figure 7 shows the trend of percent males in relation to the mature population both in numbers of males and biomass of male component. Male spawning component has decreased from a 20-30% in the 1960-70's to a 5-10% in recent years. Although spawning biomass has increased steady since 1996, the rate of increase is much slower for males compare to females.

Sensitivity runs

1880-2004 catch

The fit and results of the runs using the extended historic catch trends are presented in Table 5 and Table 6. Spawning biomass of unexploited stock was estimated at 70,000 MT in both runs (constant catchability, run 3 and increase catchability, run 4). Spawning biomass in 2004 was estimated at 18,548 and 17,220 MT respectively. SSB in 1963 was estimated at 29,320 MT. Steepness parameter were 0.74 and 0.72 respectively, mean recruitment of unexploited stock (R0) was estimated at 2.13 million fish. Fit of indices of abundances and catch-at age proportions by fishery were similar to the base case scenarios. Headboat indices show poor fitting, as well the catch at age proportions. Estimated selectivity patterns by fishery were also similar to the base scenarios, with a logistic type selectivity for the longline and handline fishery of the early period (1980-1989), while dome shape for Headboat, MRFSS and handline fishery of the later periods (1990-04) (Fig 8).

Biomass trends show an increase in the 1900-1950 period, with total mature biomass around 110,000 MT, that decline sharply since the 1960 to a low values in the 1980's, at less than 20,000 MT. Follow by a stable biomass in the 1980'-1990's, and an increase since 1996 to about 23,000 MT in 2004 (Fig 8 and 9). This trend is opposite to the fishing mortality rate trend, with very low exploitation rates in the 1880-1960 period when it start to increase to reach a peak in 1983, and remaining oscillating and high since then. Recruitment show a stable pattern in the 1880-1920 period, follow by a decline, prior to the decline of spawning biomass in early 1950's to a lowest recruitment in the 1960's. Then recruitment increase first in the 1980's, then again in the 1990's with the highest peak in 1997 of about 5.7 million recruits.

Fit and parameter estimates were similar between the runs assuming a constant catchability or an increasing catchability since 1984 (Fig 8 and 9).

MRFSS Catch bias

The AW recommendation for examining possible bias of MRFSS estimates was evaluated with runs 5 and 6. In run 5 total MRFSS catch was increased by 25% of the base scenario run, for all years (1963-04), while in run 6 MRFSS catch was decreased by 25% of the base scenario. Tables 2 and 7 presents a summary of stock indicators when MRFSS catch was increase 25%, fit and parameters estimated did change with respect to the base scenario (case 1 constant q's), the more obvious was the increase in stock recruitment steepness, up to 0.99 compared to 0.75 in the base case. Spawning virgin biomass estimate was lower 64,362 MT and the SSB_{1963}, however final SSB_{2004} was slightly higher 22,213 MT.

Trends of biomass and fishing mortality, as well fit of indices and catch-at-age proportions were similar as in the base scenario (Fig 11). Recreational fisheries are the main component of total removals, particularly in the latest years (Fig 17 Sedar 10-AW-3), with an increase of 25% MRFSS catch the model increase the productivity of the stock with a higher recruitment steepness, increasing the average number of recruits in the 1963-2004 period.

When recreational catch was decreased, MRFSS by 25%, the model decrease the productivity of the stock by lowering the steepness parameter, 0.66 compared to 0.75 in the base case. Virgin biomass was estimated higher (107,757 MT), but SSB_{1963} and SSB_{2004} were lower compared to the base case (19,393 MT and 15,046 MT, respectively). Otherwise, trends of biomass, fishing mortality, and fit indices were similar as in the base case (Fig 10 and 11).

Retrospective Analysis

Table 9 presents main gag GOM indicators of the base case scenario (constant catchability) for the retrospective analysis. In this case data input, catch and indices, proportions at age, etc were removed from 2004 up to 2000 year. The Estimates of virgin biomass (SSB_0) increase as latest years of information were eliminated, from 87,514 MT with all data to 95,476 MT with data up to 2001. Fig 12 shows the trends of total stock population, there was a trend to estimate lower stock size in the latest years, with the removal of information. Similar trend was observed with total biomass estimates (Fig 12). The model also estimated lower steepness parameters as information was removed back in time, from 0.75 in 2004 to 0.67 in 2001.

Spawning biomass estimates also show a trend to lower estimates in the final years as data was removed (Fig 12). In contrary, fishing mortality rates estimates were higher in the latest years, as data was removed from the model (Fig 12).

Gag GOM Stock Status

Table 10 presents the estimated benchmark statistics from the base scenarios and sensitivity runs of CASAL model. These correspond to deterministic estimates from the final runs, projections assumed a Beverton & Holt Stock recruitment relationship for all years in the model. Estimated maximum sustainable yield (MSY) was 3,748 MT (8.25 million lbs) and 3,788 MT (8.34 million lbs) for the base scenarios. Corresponding fishing rates F_{MSY} were 0.132 and 0.131, respectively. $F_{30\%SPR}$ estimates were slight higher than F_{MSY} [0.167] and F at maximum yield per recruit F_{max} was estimated as 0.237 and 0.235, respectively.

All references of spawning biomass in this table correspond to the female component of the stock exclusively, were spawning biomass is defined as the mean weight of females times the maturity vector at age for females. Spawning biomass in final year 2004 was estimated at 18,592 MT and 17,247 MT for the base scenarios, these SSB_{2004} were about 21.2% and 19.3% of their respective virgin biomass estimates. Compared to SSB_{MSY} the SSB2004 were about 69.5% and 62.9%. The estimated fishing rates in 2004 were between 0.389 and 0.419 for the base scenarios, and above 0.38 in all the sensitivity runs. Overall the F_{2004} was much higher than F_{MAX}, F_{MSY}, or $F_{30\%SPR.}$

Figure 13 show the yield per recruit (YPR) and spawner per recruit deterministic trends from the base case 1. Figure 14 shows similar plots for the base case 2 (increasing catchability). Plots of catch (MT) versus fishing rates are shown in Figure 12. These plots also show the percent SSB females versus F in equilibrium conditions and the corresponding estimated F benchmark, $F_{0.1}$, F_{MSY}, $F_{30\%SPR}$, F_{max}, and F_{2004}.

Table 11 presents the estimated benchmark statistics from deterministic estimates assuming a Beverton & Holt stock recruitment relationship for the 1983-2004 years only. Stock recruitment fit for those series (1983-2004) were done externally using ML, estimated steepness and virgin biomass then were projected with CASAL to estimate benchmarks. Figure 13 is a preliminary phase plot showing the status of gag GOM stock, base on SBB_{2004} /SBB_{MSY} ratio and F_{2004} compared to $F_{30\%SPR}$.

Literature Cited

SEDAR 10-AW-3. 2006. Preliminary status of gag grouper in the Gulf of Mexico, SEDAR 10. Ortiz, Mauricio. SFD 2006-019.

Table 1. Final working estimates of catch commercial recreational historic generated at the AW Sedar 10.

Year	Headboat	Handline	Longline	MRFSS	Others	Total MT	Total MLbs
1880		106.3				106.3	0.234
1881		96.2				96.2	0.212
1882		86.0				86.0	0.189
1883		75.9				75.9	0.167
1884		65.8				65.8	0.145
1885		55.6				55.6	0.123
1886		45.5				45.5	0.100
1887		35.0				35.0	0.077
1888		23.6				23.6	0.052
1889		26.9				26.9	0.059
1890		25.8				25.8	0.057
1891		29.1				29.1	0.064
1892		32.9				32.9	0.073
1893		36.6				36.6	0.081
1894		40.3				40.3	0.089
1895		44.0				44.0	0.097
1896		47.7				47.7	0.105
1897		51.4				51.4	0.113
1898		51.9				51.9	0.114
1899		55.7				55.7	0.123
1900		59.5				59.5	0.131
1901		63.3				63.3	0.139
1902		67.0				67.0	0.148
1903		72.2				72.2	0.159
1904		77.4				77.4	0.171
1905		82.5				82.5	0.182
1906		87.6				87.6	0.193
1907		92.8				92.8	0.205
1908		98.0				98.0	0.216
1909		124.0				124.0	0.273
1910		149.9				149.9	0.330
1911		176.0				176.0	0.388
1912		201.9				201.9	0.445
1913		228.0				228.0	0.502
1914		253.9				253.9	0.559
1915		280.0				280.0	0.617
1916		305.9				305.9	0.674
1917		331.9				331.9	0.731
1918		357.9				357.9	0.788
1919		342.2				342.2	0.754
1920		326.6				326.6	0.719
1921		311.0				311.0	0.685
1922		295.4				295.4	0.651
1923		279.7				279.7	0.616
1924		281.0				281.0	0.619
1925		282.3				282.3	0.622
1926		283.5				283.5	0.624
1927		284.8				284.8	0.627
1928		255.7				255.7	0.563
1929		253.8				253.8	0.559
1930		198.5				198.5	0.437
1931		160.7				160.7	0.354
1932		190.8				190.8	0.420
1933		211.2				211.2	0.465
1934		204.1				204.1	0.450
1935		258.0				258.0	0.568
1936		301.8				301.8	0.665
1937		316.9				316.9	0.698
1938		276.5				276.5	0.609
1939		406.4				406.4	0.895
1940		292.6				292.6	0.644
1941		324.5				324.5	0.715
1942		353.5				353.5	0.779
1943		383.9				383.9	0.845
1944		414.2				414.2	0.912
1945		444.5		0.0		444.5	0.979
1946		458.0		9.2		467.2	1.029
1947		471.5		18.5		489.9	1.079
1948		477.7		27.7		505.4	1.113
1949		506.3		37.0		543.2	1.196
1950		339.0		46.2		385.1	0.848
1951		353.4		55.4		408.8	0.901
1952		278.1		64.7		342.8	0.755
1953		258.6		73.9		332.5	0.732
1954		298.1		83.1		381.2	0.840
1955		295.3		92.4		387.7	0.854
1956		365.5		103.1		468.6	1.032
1957		401.6		115.0		516.7	1.138
1958		264.8		128.4		393.2	0.866
1959		372.6		143.3		515.9	1.136
1960		382.3		159.9		542.2	1.194
1961		409.9		172.7		582.6	1.283
1962		453.8		186.5		640.3	1.410
1963		585.1		201.4	0.7	787.2	1.734
1964		741.1		217.6	4.1	962.8	2.121
1965		824.3		235.0	0.3	1059.5	2.334
1966		661.3		253.8	0.6	915.7	2.017
1967		524.6		274.1	4.5	803.2	1.769
1968		541.3		296.1	2.0	839.4	1.849
1969		624.9		319.8	1.5	946.2	2.084
1970		582.8		345.4	1.1	929.3	2.047
1971		624.9		394.7	1.3	1020.9	2.249
1972		663.0		451.1	1.8	1115.9	2.458
1973		490.9		515.5	2.2	1008.6	2.222
1974		537.6		589.1	0.6	1127.4	2.483
1975		656.8		673.1	2.0	1331.9	2.934
1976		544.1		770.5	4.1	1318.7	2.905
1977		443.7		881.9	3.4	1329.0	2.927
1978		397.4		1010.6	5.0	1412.9	3.112
1979		609.4	0.6	1158.3	4.4	1772.7	3.905
1980		598.3	40.5	1320.7	5.4	1964.9	4.328
1981		680.4	212.0	1116.2	7.1	2015.8	4.440
1982		605.9	458.5	1593.1	6.4	2663.9	5.868
1983		471.9	309.2	3386.8	8.0	4175.9	9.198
1984		498.6	196.7	968.9	8.4	1672.5	3.684
1985		634.8	172.9	3163.2	12.7	3983.6	8.774
1986	140.0	524.4	234.9	1935.5	13.2	2848.0	6.273
1987	104.7	387.1	297.8	1283.5	13.4	2086.4	4.596
1988	74.7	359.1	182.6	1917.5	10.5	2544.5	5.605
1989	153.4	560.9	193.4	1482.0	14.2	2403.9	5.295
1990	139.7	513.0	283.6	903.8	18.5	1858.6	4.094
1991	50.6	450.7	231.4	2198.7	28.6	2960.0	6.520
1992	71.0	455.2	269.1	1793.6	31.1	2620.1	5.771
1993	95.9	581.4	219.0	2666.9	48.0	3611.1	7.954
1994	143.9	521.2	159.7	2931.7	54.0	3810.7	8.394
1995	88.6	525.6	178.7	3291.7	47.5	4132.1	9.102
1996	80.3	502.4	180.2	2411.1	30.6	3204.7	7.059
1997	76.2	499.9	190.6	3084.3	37.5	3888.5	8.565
1998	194.2	839.3	276.5	3903.3	37.0	5250.3	11.565
1999	143.1	672.5	249.6	3292.2	31.0	4388.5	9.666
2000	122.9	728.9	289.1	3802.4	36.9	4980.1	10.969
2001	75.8	948.1	477.9	3980.0	45.8	5527.7	12.175
2002	66.0	877.8	481.0	4830.8	28.0	6283.6	13.840
2003	109.1	670.4	540.1	5547.6	30.5	6897.7	15.193
2004	148.6	797.5	540.6	6228.0	33.1	7747.7	17.066

Table 2. Description and summary of scenarios fitted with CASAL to catch and effort data for gag GOM. Stock indicators: unexploited spawning stock biomass (SSB_0), spawning initial stock ($SSB_{initial}$), steepness parameter, mean recruit of unexploited stock (R_0), terminal year spawning stock biomass (SSB2004), and fishing mortality rate of terminal year (F_{2004}). All references of spawning biomass are of gag GOM female component in metric tons.

Scenario	Model Run	Age initial	Age final	M	q's estimation	N Paramet ers	Objective function	AIC	SSB0 (MT)	SSBinitial (MT)	SSB2004 (MT)	steepness	R0	F 2004
Case 1	1963-2004 final MRFSS	1	12+	M(age)	constant	82	7554.78	15273.56	87,514	22,295	18,592	0.751401	2.66E+06	0.3889
Case 2	1963-2004 final MRFSS increase 2% q's	1	12+	M(age)	constant	82	7546.18	15256.36	89,391	22,098	17,247	0.741762	2.72E+06	0.4186
Case 3	1880-2004 final MRFSS 45-04	1	12+	M(age)	constant	164	7555.56	15439.12	70,000	70,000	18,548	0.74292	2.13E+06	0.3894
Case 4	1880-2004 ... increase 2% annual of q's	1	12+	M(age)	constant	164	7546.98	15421.96	70,000	70,000	17,221	0.719875	2.13E+06	0.4189
Case 5	1963-2004 Increse 25% MRFSS	1	12+	M(age)	constant	82	7561.97	15287.94	64,362	20,240	22,214	0.99	1.96E+06	0.3883
Case 6	1963-2004 Decrese 25% MRFSS	1	12+	M(age)	constant	82	7548.03	15260.06	107,757	19,393	15,046	0.66338	3.28E+06	0.3852
Retrospective	Case 1 [1963-2004]	1	12+	M(age)	constant		7554.78		87,514	22,295		0.751401	2.66E+06	
	Case 1 [1963-2003]	1	12+	M(age)	constant		7378.96		87,478	23,088		0.721231	2.66E+06	
	Case 1 [1963-2002]	1	12+	M(age)	constant		7118.50		89,596	22,688		0.715864	2.72E+06	
	Case 1 [1963-2001]	1	12+	M(age)	constant		6819.95		95,477	22,653		0.667183	2.90E+06	
	Case 1 [1963-2000]	1	12+	M(age)	constant		6543.61		92,926	21,978		0.693605	2.83E+06	

Table 3. Base case 1 summary of main stock indicators from CASAL fit for gag GOM.

Estimated Biomass

Year	Biomass MT	SSB fem	SSB mal
1963	32,603	22,295	9,393
1964	31,433	21,751	9,168
1965	29,961	21,036	8,888
1966	28,363	19,897	8,574
1967	26,773	18,597	8,300
1968	25,133	17,239	8,057
1969	23,370	15,805	7,791
1970	21,547	14,315	7,452
1971	19,703	12,907	7,055
1972	17,804	11,555	6,546
1973	15,966	10,288	5,913
1974	14,565	9,233	5,237
1975	13,219	8,167	4,580
1976	12,116	7,245	3,912
1977	11,438	7,175	3,333
1978	11,105	6,884	2,841
1979	11,016	6,721	2,411
1980	11,110	6,843	1,976
1981	11,592	7,126	1,625
1982	12,219	7,793	1,319
1983	11,935	8,324	1,044
1984	11,739	7,728	843
1985	11,863	9,306	810
1986	11,002	8,409	707
1987	10,991	8,120	687
1988	11,137	8,442	732
1989	10,866	8,422	796
1990	11,638	8,331	859
1991	12,503	8,554	936
1992	13,164	7,983	964
1993	13,737	9,490	977
1994	14,513	9,765	931
1995	15,356	9,521	889
1996	16,484	9,528	824
1997	18,910	12,213	827
1998	20,620	13,953	844
1999	21,710	14,057	833
2000	23,555	16,887	905
2001	24,924	18,422	1,079
2002	25,525	18,384	1,200
2003	25,002	18,963	1,339
2004	23,101	18,592	1,509

Stock Recruitment

Year	SSB fem	Recruits
1963	22,295	214,586
1964	21,751	214,574
1965	21,036	213,181
1966	19,897	211,267
1967	18,597	208,019
1968	17,239	203,970
1969	15,805	199,294
1970	14,315	193,783
1971	12,907	187,283
1972	11,555	180,294
1973	10,288	172,637
1974	9,233	1,393,800
1975	8,167	202,205
1976	7,245	721,440
1977	7,175	1,267,200
1978	6,884	1,216,470
1979	6,721	1,541,900
1980	6,843	1,712,720
1981	7,126	2,094,330
1982	7,793	1,972,460
1983	8,324	1,364,890
1984	7,728	1,358,380
1985	9,306	1,252,910
1986	8,409	1,476,470
1987	8,120	1,192,730
1988	8,442	1,086,810
1989	8,422	793,166
1990	8,331	3,761,120
1991	8,554	1,602,020
1992	7,983	1,916,250
1993	9,490	2,119,320
1994	9,765	4,814,020
1995	9,521	2,712,410
1996	9,528	2,033,390
1997	12,213	5,741,390
1998	13,953	3,062,170
1999	14,057	1,833,230
2000	16,887	5,007,130
2001	18,422	3,467,710
2002	18,384	2,789,170
2003	18,963	2,452,980
2004	18,592	2,344,190

Fishing mortality rate

Year	fishing_pressures
1963	0.0295
1964	0.0364
1965	0.0413
1966	0.0393
1967	0.0393
1968	0.0448
1969	0.0544
1970	0.0612
1971	0.0756
1972	0.0935
1973	0.1050
1974	0.1309
1975	0.1675
1976	0.1828
1977	0.1935
1978	0.2098
1979	0.2445
1980	0.2594
1981	0.2432
1982	0.2965
1983	0.4283
1984	0.1944
1985	0.3841
1986	0.3060
1987	0.2308
1988	0.2745
1989	0.2630
1990	0.2076
1991	0.3180
1992	0.2702
1993	0.3339
1994	0.3444
1995	0.3677
1996	0.2667
1997	0.2704
1998	0.3292
1999	0.2572
2000	0.2657
2001	0.2808
2002	0.3053
2003	0.3293
2004	0.3889

Selectivity at age

Age	Headboat 1	Headboat 2	Headboat 3	Handline 1	Handline 3	Longline	MRFSS	Others
1	0.01216	0.00331	0.01034	0.00047	0.00005	0.00011	0.01919	0.00140
2	0.25136	0.15978	0.19853	0.00685	0.00168	0.00129	0.20211	0.01454
3	0.75434	0.70067	0.68720	0.06545	0.03618	0.01143	0.62558	0.13684
4	0.91569	0.91954	0.90252	0.29382	0.27408	0.07015	0.86925	0.67993
5	0.87562	0.93759	0.89440	0.59092	0.62010	0.24597	0.92371	0.89203
6	0.74521	0.90797	0.78887	0.78858	0.82612	0.48694	0.89130	0.75093
7	0.57981	0.83928	0.63622	0.88474	0.88379	0.68858	0.80335	0.58437
8	0.42570	0.73542	0.48329	0.92426	0.84882	0.82215	0.68257	0.41749
9	0.30398	0.61821	0.35589	0.93974	0.77091	0.90103	0.55774	0.27565
10	0.21553	0.50755	0.25941	0.94605	0.67593	0.94448	0.44666	0.17097
11	0.15379	0.41278	0.18969	0.94883	0.58426	0.96772	0.35554	0.10151
12	0.11146	0.33584	0.14038	0.95015	0.50250	0.98027	0.28393	0.05860

Estimated Stock Population

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12+	Total
1963	214,586	524,709	410,346	336,397	283,590	243,507	211,809	185,996	164,513	146,333	130,745	1,257,610	4,110,141
1964	214,574	166,043	409,121	332,980	278,396	237,376	205,719	180,516	159,815	142,367	127,390	1,228,020	3,682,317
1965	213,181	166,028	129,418	331,500	274,584	231,710	199,176	174,067	153,999	137,340	123,102	1,191,150	3,325,255
1966	211,267	164,943	129,348	104,703	272,630	227,644	193,499	167,680	147,749	131,693	118,193	1,149,830	3,019,179
1967	208,019	163,453	128,430	104,484	86,008	226,062	190,350	163,239	142,707	126,745	113,731	1,113,830	2,767,058
1968	203,970	160,929	127,174	103,510	85,599	71,190	188,902	160,623	139,072	122,629	109,705	1,081,510	2,554,813
1969	199,294	157,782	125,088	102,179	84,413	70,469	59,148	158,515	136,146	118,961	105,712	1,045,990	2,363,697
1970	193,783	154,147	122,488	100,083	82,745	68,862	57,959	49,133	133,078	115,430	101,714	1,004,050	2,183,472
1971	187,283	149,863	119,486	97,539	80,502	67,006	56,230	47,831	41,018	112,308	98,325	961,540	2,018,931
1972	180,294	144,804	115,886	94,404	77,500	64,240	53,879	45,724	39,400	34,209	94,672	913,855	1,858,867
1973	172,637	139,360	111,633	90,645	73,840	60,694	50,654	43,002	37,036	32,377	28,466	860,596	1,700,939
1974	1,393,800	133,394	107,026	86,280	69,791	56,968	47,248	40,018	34,579	30,299	26,886	760,322	2,786,612
1975	202,205	1,076,490	101,955	81,423	64,851	52,344	43,066	36,303	31,390	27,684	24,693	663,433	2,405,837
1976	721,440	156,090	818,166	76,084	59,264	46,718	37,902	31,741	27,417	24,299	21,898	565,832	2,586,851
1977	1,267,200	556,712	118,183	602,885	54,352	41,853	33,208	27,495	23,670	21,023	19,088	481,661	3,247,330
1978	1,216,470	977,539	420,023	86,089	424,170	37,819	29,359	23,829	20,338	18,050	16,461	410,268	3,680,416
1979	1,541,900	938,051	734,528	301,798	59,362	288,850	25,995	20,698	17,377	15,340	14,018	348,075	4,305,992
1980	1,712,720	1,188,710	702,920	522,057	203,192	38,946	189,814	17,489	14,426	12,558	11,442	284,653	4,898,927
1981	2,094,330	1,320,160	888,954	496,013	347,140	131,077	25,089	125,086	11,948	10,233	9,207	229,281	5,688,518
1982	1,972,460	1,615,850	997,599	649,230	345,345	232,916	86,528	16,674	84,981	8,336	7,318	178,345	6,195,583
1983	1,364,890	1,520,670	1,210,980	708,578	433,441	219,627	143,938	53,456	10,526	55,282	5,585	131,113	5,858,085
1984	1,358,380	1,048,500	1,095,140	746,160	380,853	218,147	109,215	74,309	29,533	6,252	34,972	95,153	5,196,613
1985	1,252,910	1,048,940	799,705	825,601	546,955	272,169	153,857	77,262	53,341	21,597	4,654	99,861	5,156,851
1986	1,476,470	963,427	763,804	513,099	472,136	295,430	145,815	85,303	45,434	33,374	14,264	75,003	4,883,558
1987	1,192,730	1,137,330	713,650	521,675	325,286	287,581	178,338	89,852	54,647	30,367	23,167	65,665	4,620,288
1988	1,086,810	920,076	856,281	515,900	361,559	219,701	192,421	120,504	62,149	38,845	22,140	67,394	4,463,780
1989	793,166	837,259	683,075	590,195	333,743	227,884	138,648	124,505	81,095	43,584	28,250	68,663	3,950,067
1990	3,761,120	611,511	625,906	481,670	393,012	215,250	146,078	90,485	83,919	56,595	31,373	72,979	6,569,899
1991	1,602,020	2,904,240	465,252	466,239	347,318	276,129	149,247	101,645	63,988	60,588	41,687	79,417	6,557,771
1992	1,916,250	1,233,400	2,142,620	312,782	288,352	206,739	163,813	90,936	64,806	42,824	42,326	89,655	6,594,502
1993	2,119,320	1,477,160	922,295	1,508,810	207,226	184,680	131,233	105,580	60,492	44,680	30,504	98,545	6,890,525
1994	4,814,020	1,631,710	1,089,550	618,368	923,763	121,064	106,998	77,969	65,673	39,543	30,523	93,916	9,613,096
1995	2,712,410	3,704,780	1,196,990	715,944	368,281	526,923	69,034	63,097	48,498	43,184	27,291	91,905	9,568,337
1996	2,033,390	2,086,250	2,702,730	771,876	413,664	202,731	289,788	39,390	38,176	31,183	29,269	86,961	8,725,408
1997	5,741,390	1,567,290	1,558,440	1,897,500	509,974	265,015	129,309	188,449	26,511	26,673	22,529	88,258	12,021,338
1998	3,062,170	4,424,060	1,167,310	1,083,940	1,239,570	323,938	168,187	83,943	126,985	18,590	19,377	84,907	11,802,977
1999	1,833,230	2,357,920	3,266,250	784,859	668,221	730,227	189,004	100,445	52,388	83,157	12,708	75,992	10,154,401
2000	5,007,130	1,413,200	1,763,500	2,302,630	523,039	433,210	471,799	124,443	68,363	36,964	60,605	68,065	12,272,947
2001	3,467,710	3,859,300	1,055,670	1,240,890	1,526,500	335,438	276,682	308,415	84,709	48,637	27,381	100,398	12,331,730
2002	2,789,170	2,672,670	2,882,450	742,229	818,475	966,224	209,830	176,349	204,429	58,716	35,146	98,373	11,654,062
2003	2,452,980	2,148,130	1,980,330	1,972,180	471,080	498,374	583,859	130,033	114,472	139,655	42,025	102,199	10,635,317
2004	2,344,190	1,887,860	1,578,740	1,316,630	1,202,230	275,732	290,730	351,325	82,477	76,835	98,616	109,277	9,614,642

Table 4. Base case 2 summary of main stock indicators from CASAL fit for gag GOM.

Estimated Biomass

Year	Biomass MT	SSB fem	SSB mal
1963	32,314	22,098	9,310
1964	31,152	21,554	9,085
1965	29,695	20,840	8,805
1966	28,116	19,715	8,491
1967	26,548	18,436	8,217
1968	24,935	17,104	7,974
1969	23,200	15,698	7,709
1970	21,406	14,237	7,372
1971	19,590	12,854	6,980
1972	17,718	11,523	6,477
1973	15,905	10,273	5,855
1974	14,526	9,229	5,192
1975	13,195	8,172	4,546
1976	12,102	7,256	3,889
1977	11,431	7,185	3,318
1978	11,102	6,892	2,831
1979	11,015	6,727	2,405
1980	11,110	6,847	1,973
1981	11,593	7,129	1,624
1982	12,221	7,795	1,319
1983	11,937	8,326	1,044
1984	11,741	7,730	843
1985	11,865	9,309	809
1986	11,005	8,412	707
1987	10,993	8,124	687
1988	11,137	8,446	731
1989	10,864	8,424	796
1990	11,629	8,331	859
1991	12,482	8,551	936
1992	13,126	7,973	964
1993	13,677	9,462	976
1994	14,416	9,716	929
1995	15,212	9,447	886
1996	16,284	9,418	818
1997	18,626	12,040	818
1998	20,231	13,711	831
1999	21,199	13,736	815
2000	22,868	16,435	879
2001	24,007	17,824	1,040
2002	24,327	17,624	1,145
2003	23,476	17,940	1,262
2004	21,221	17,247	1,399

Stock Recruitment

Year	SSB fem	Recruits
1963	22,098	221,055
1964	21,554	221,443
1965	20,840	219,668
1966	19,715	217,674
1967	18,436	213,896
1968	17,104	209,381
1969	15,698	204,090
1970	14,237	198,288
1971	12,854	191,196
1972	11,523	183,816
1973	10,273	175,674
1974	9,229	1,391,490
1975	8,172	199,698
1976	7,256	721,216
1977	7,185	1,266,290
1978	6,892	1,216,570
1979	6,727	1,541,410
1980	6,847	1,712,030
1981	7,129	2,094,440
1982	7,795	1,972,970
1983	8,326	1,364,480
1984	7,730	1,358,050
1985	9,309	1,252,630
1986	8,412	1,474,880
1987	8,124	1,191,390
1988	8,446	1,084,290
1989	8,424	790,499
1990	8,331	3,743,460
1991	8,551	1,592,440
1992	7,973	1,902,250
1993	9,462	2,100,870
1994	9,716	4,766,780
1995	9,447	2,682,420
1996	9,418	2,006,970
1997	12,040	5,647,190
1998	13,711	2,996,820
1999	13,736	1,781,490
2000	16,435	4,819,970
2001	17,824	3,298,630
2002	17,624	2,624,170
2003	17,940	2,286,580
2004	17,247	2,210,040

Fishing mortality rate

Year	fishing_pressures
1963	0.0297
1964	0.0368
1965	0.0417
1966	0.0396
1967	0.0396
1968	0.0451
1969	0.0547
1970	0.0614
1971	0.0757
1972	0.0935
1973	0.1049
1974	0.1306
1975	0.1671
1976	0.1823
1977	0.1932
1978	0.2095
1979	0.2444
1980	0.2593
1981	0.2432
1982	0.2965
1983	0.4283
1984	0.1944
1985	0.3840
1986	0.3059
1987	0.2307
1988	0.2744
1989	0.2630
1990	0.2077
1991	0.3182
1992	0.2708
1993	0.3352
1994	0.3464
1995	0.3708
1996	0.2699
1997	0.2743
1998	0.3350
1999	0.2631
2000	0.2730
2001	0.2902
2002	0.3184
2003	0.3479
2004	0.4186

Selectivity at age

Age	Headboat 1	Headboat 2	Headboat 3	Handline 1	Handline 3	Longline	MRFSS	Others
1	0.01225	0.00333	0.01072	0.00047	0.00005	0.00011	0.01936	0.00140
2	0.25113	0.15993	0.19989	0.00683	0.00167	0.00128	0.20213	0.01464
3	0.75358	0.70056	0.68618	0.06538	0.03603	0.01139	0.62455	0.13806
4	0.91540	0.91947	0.90202	0.29377	0.27393	0.06987	0.86857	0.68225
5	0.87509	0.93763	0.89590	0.59095	0.62015	0.24520	0.92361	0.89323
6	0.74407	0.90807	0.79263	0.78864	0.82621	0.48596	0.89150	0.75415
7	0.57830	0.83934	0.64141	0.88479	0.88385	0.68770	0.80379	0.58891
8	0.42416	0.73532	0.48882	0.92430	0.84882	0.82149	0.68313	0.42221
9	0.30260	0.61794	0.36103	0.93976	0.77086	0.90057	0.55834	0.27959
10	0.21437	0.50715	0.26386	0.94606	0.67589	0.94419	0.44724	0.17380
11	0.15284	0.41230	0.19341	0.94883	0.58422	0.96753	0.35608	0.10334
12	0.11071	0.33532	0.14343	0.95015	0.50246	0.98014	0.28442	0.05972

Estimated Stock Population

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12+	Total
1963	221,055	520,066	406,715	333,420	281,080	241,353	209,935	184,351	163,058	145,038	129,588	1,246,490	4,082,149
1964	221,443	171,048	405,491	330,011	275,893	235,225	203,846	178,870	158,359	141,071	126,233	1,216,880	3,664,370
1965	219,668	171,342	133,315	328,533	272,088	229,565	197,307	172,424	152,544	136,045	121,944	1,180,010	3,314,785
1966	217,674	169,961	133,484	107,847	270,137	225,505	191,636	166,041	146,298	130,400	117,036	1,138,690	3,014,709
1967	213,896	168,410	132,333	107,815	88,574	223,929	188,497	161,609	141,262	125,457	112,578	1,102,710	2,767,070
1968	209,381	165,474	131,026	106,647	88,313	73,295	187,062	159,008	137,640	121,352	108,560	1,070,420	2,558,178
1969	204,090	161,967	128,617	105,267	86,958	72,686	60,878	156,922	134,735	117,701	104,581	1,034,980	2,369,382
1970	198,288	157,855	125,734	102,904	85,236	70,922	59,765	50,554	131,698	114,198	100,606	993,177	2,190,936
1971	191,196	153,346	122,360	100,126	82,766	69,012	57,900	49,309	42,193	111,113	97,249	950,881	2,027,451
1972	183,816	147,828	118,581	96,683	79,558	66,042	55,484	47,072	40,608	35,181	93,643	903,514	1,868,009
1973	175,674	142,082	113,968	92,770	75,634	62,309	52,073	44,278	38,122	33,364	29,269	850,702	1,710,244
1974	1,391,490	135,739	109,124	88,112	71,452	58,368	48,514	41,143	35,607	31,187	27,703	752,446	2,790,884
1975	199,698	1,074,690	103,758	83,056	66,263	53,614	44,139	37,285	32,277	28,509	25,417	657,427	2,406,134
1976	721,216	154,153	816,915	77,477	60,500	47,769	38,844	32,546	28,167	24,991	22,552	561,463	2,586,592
1977	1,266,290	556,531	116,731	602,329	55,390	42,755	33,974	28,190	24,278	21,602	19,634	478,613	3,246,318
1978	1,216,570	976,818	419,928	85,078	424,053	38,563	30,006	24,388	20,858	18,517	16,916	408,214	3,679,909
1979	1,541,410	938,109	734,040	301,876	58,697	288,900	26,515	21,159	17,787	15,733	14,381	346,760	4,305,367
1980	1,712,030	1,188,300	702,991	521,914	203,327	38,520	189,882	17,841	14,748	12,855	11,735	283,883	4,898,026
1981	2,094,440	1,319,580	888,665	496,230	347,154	131,187	24,817	125,131	12,188	10,461	9,423	228,887	5,688,163
1982	1,972,970	1,615,890	997,169	649,164	345,566	232,952	86,606	16,493	85,007	8,502	7,480	178,195	6,195,995
1983	1,364,480	1,521,010	1,211,000	708,455	433,495	219,796	143,969	53,501	10,411	55,290	5,695	131,099	5,858,201
1984	1,358,050	1,048,120	1,095,370	746,574	380,955	218,204	109,292	74,306	29,548	6,181	34,966	95,190	5,196,755
1985	1,252,630	1,048,660	799,413	825,900	547,329	272,260	153,900	77,314	53,335	21,606	4,601	99,875	5,156,822
1986	1,474,880	963,158	763,611	513,173	472,523	295,695	145,870	85,317	45,455	33,363	14,266	74,962	4,882,273
1987	1,191,390	1,136,060	713,462	521,733	325,441	287,876	178,519	89,888	54,653	30,379	23,157	65,630	4,618,187
1988	1,084,290	919,017	855,330	515,890	361,681	219,842	192,641	120,632	62,173	38,847	22,147	67,354	4,459,844
1989	790,499	835,281	682,295	589,738	333,835	227,997	138,747	124,645	81,175	43,597	28,249	68,630	3,944,688
1990	3,743,460	609,435	624,426	481,231	392,778	215,328	146,155	90,547	84,008	56,646	31,380	72,948	6,548,341
1991	1,592,440	2,890,540	463,667	465,192	347,033	275,975	149,299	101,692	64,026	60,646	41,721	79,390	6,531,621
1992	1,902,250	1,225,960	2,132,390	311,769	287,704	206,525	163,663	90,927	64,806	42,830	42,350	89,632	6,560,806
1993	2,100,870	1,466,300	916,618	1,501,370	206,465	184,144	130,995	105,396	60,438	44,649	30,491	98,499	6,846,235
1994	4,766,780	1,617,390	1,081,270	614,229	918,133	120,423	106,491	77,685	65,450	39,452	30,465	93,787	9,531,554
1995	2,682,420	3,668,120	1,186,020	709,744	365,050	522,262	68,462	62,616	48,198	42,944	27,179	91,645	9,474,660
1996	2,006,970	2,062,960	2,674,320	763,359	408,631	200,033	285,817	38,882	37,731	30,884	29,025	86,507	8,625,119
1997	5,647,190	1,546,800	1,540,160	1,874,280	502,792	260,753	127,036	185,078	26,068	26,273	22,248	87,523	11,846,201
1998	2,996,820	4,351,030	1,151,220	1,068,820	1,219,620	317,801	164,601	82,041	124,132	18,205	19,020	83,897	11,597,207
1999	1,781,490	2,307,290	3,209,050	771,399	654,912	712,847	183,830	97,479	50,814	80,755	12,375	74,660	9,936,902
2000	4,819,970	1,373,140	1,723,880	2,254,720	511,133	421,508	456,935	120,099	65,876	35,631	58,534	66,496	11,907,922
2001	3,298,630	3,714,490	1,024,470	1,208,120	1,484,360	324,852	266,558	295,856	81,064	46,534	26,236	97,123	11,868,291
2002	2,624,170	2,541,910	2,770,030	716,625	789,809	928,569	200,556	167,718	193,850	55,636	33,347	94,383	11,116,603
2003	2,286,580	2,020,540	1,879,040	1,880,150	448,663	472,595	550,562	122,045	107,146	130,667	39,381	96,981	10,034,351
2004	2,210,040	1,759,140	1,479,670	1,233,650	1,122,100	255,779	268,064	322,630	75,658	70,566	90,845	102,160	8,990,302

Table 5. 1800-2004 Catch sensitivity run stock indicator of model fit.

Estimated Biomass

Year	Biomass MT	SSB fem	SSB mal
1880	103,933	70,000	29,490
1881	103,803	69,930	29,457
1882	103,669	69,864	29,427
1883	103,530	69,768	29,400
1884	103,389	69,652	29,377
1885	103,249	69,527	29,358
1886	103,113	69,401	29,343
1887	102,984	69,280	29,329
1888	102,864	69,170	29,313
1889	102,750	69,077	29,290
1890	102,637	68,997	29,252
1891	102,640	68,936	29,201
1892	102,792	68,880	29,154
1893	103,107	68,889	29,111
1894	103,581	69,220	29,072
1895	104,196	69,805	29,035
1896	104,928	70,546	29,001
1897	105,749	71,380	28,972
1898	106,638	72,254	28,976
1899	107,570	73,119	29,041
1900	108,525	73,921	29,198
1901	109,485	74,619	29,469
1902	110,444	75,188	29,867
1903	111,320	75,712	30,228
1904	112,121	76,195	30,555
1905	112,855	76,640	30,852
1906	113,526	77,048	31,124
1907	114,140	77,422	31,372
1908	114,700	77,763	31,599
1909	115,201	78,075	31,807
1910	115,635	78,343	31,992
1911	116,006	78,572	32,153
1912	116,318	78,763	32,293
1913	116,573	78,918	32,412
1914	116,775	79,041	32,511
1915	116,926	79,133	32,592
1916	117,028	79,194	32,655
1917	117,084	79,227	32,701
1918	117,094	79,232	32,733
1919	117,081	79,208	32,750
1920	117,064	79,185	32,766
1921	117,042	79,159	32,781
1922	117,012	79,129	32,797
1923	116,972	79,091	32,814
1924	116,911	79,043	32,831
1925	116,816	78,970	32,842
1926	116,684	78,871	32,848
1927	116,512	78,743	32,847
1928	116,311	78,585	32,838
1929	116,079	78,413	32,830
1930	115,823	78,205	32,812
1931	115,555	77,995	32,802
1932	115,227	77,763	32,792
1933	114,804	77,461	32,760
1934	114,300	77,092	32,708
1935	113,694	76,671	32,643
1936	112,956	76,155	32,544
1937	112,100	75,549	32,413
1938	111,163	74,869	32,258
1939	110,084	74,147	32,093
1940	108,891	73,267	31,866
1941	107,629	72,386	31,651
1942	106,218	71,400	31,402
1943	104,652	70,307	31,119
1944	102,927	69,101	30,798
1945	101,036	67,779	30,438
1946	98,979	66,338	30,037
1947	96,755	64,778	29,596
1948	94,365	63,099	29,114
1949	91,802	61,302	28,589
1950	89,149	59,374	28,015
1951	86,417	57,444	27,452
1952	83,559	55,392	26,839
1953	80,601	53,284	26,205
1954	77,495	51,088	25,528
1955	74,249	48,783	24,788
1956	70,868	46,410	23,999
1957	67,354	43,943	23,138
1958	63,835	41,427	22,218
1959	60,296	38,989	21,302
1960	56,690	36,493	20,309
1961	53,086	34,023	19,279
1962	49,498	31,591	18,216
1963	45,904	29,204	17,122
1964	42,279	26,829	15,973
1965	38,674	24,471	14,772
1966	35,271	22,203	13,557
1967	32,177	20,174	12,427
1968	29,301	18,351	11,377
1969	26,537	16,641	10,355
1970	23,917	15,001	9,342
1971	21,445	13,498	8,393
1972	19,064	12,059	7,471
1973	16,866	10,676	6,581
1974	15,220	9,456	5,796
1975	13,675	8,260	5,029
1976	12,423	7,248	4,254
1977	11,638	7,137	3,583
1978	11,232	6,836	3,016
1979	11,093	6,682	2,527
1980	11,156	6,819	2,046
1981	11,619	7,116	1,664
1982	12,235	7,792	1,337
1983	11,945	8,329	1,051
1984	11,747	7,735	845
1985	11,869	9,314	811
1986	11,008	8,416	708
1987	10,995	8,126	688
1988	11,139	8,447	732
1989	10,865	8,425	796
1990	11,630	8,332	859
1991	12,481	8,552	937
1992	13,125	7,974	964
1993	13,675	9,461	976
1994	14,411	9,715	929
1995	15,204	9,446	885
1996	16,272	9,414	818
1997	18,607	12,031	817
1998	20,206	13,696	830
1999	21,167	13,714	814
2000	22,832	16,405	877
2001	23,970	17,789	1,037
2002	24,294	17,585	1,141
2003	23,450	17,904	1,257
2004	21,202	17,221	1,392

Stock Recruitment

Year	SSB fem	Recruits
1880	70,000	2,080,490
1881	69,930	2,081,060
1882	69,864	2,081,450
1883	69,768	2,081,860
1884	69,652	2,082,220
1885	69,527	2,082,560
1886	69,401	2,082,930
1887	69,280	2,083,370
1888	69,170	2,083,900
1889	69,077	2,084,510
1890	68,997	2,085,200
1891	68,936	2,454,360
1892	68,880	2,455,190
1893	68,889	2,456,060
1894	69,220	2,457,160
1895	69,805	2,459,330
1896	70,546	2,462,290
1897	71,380	2,465,690
1898	72,254	2,469,280
1899	73,119	2,472,850
1900	73,921	2,476,260
1901	74,619	2,479,320
1902	75,188	2,481,940
1903	75,712	2,484,040
1904	76,195	2,485,850
1905	76,640	2,487,360
1906	77,048	2,488,550
1907	77,422	2,489,410
1908	77,763	2,489,910
1909	78,075	2,490,020
1910	78,343	2,489,710
1911	78,572	2,488,900
1912	78,763	2,487,540
1913	78,918	2,485,580
1914	79,041	2,482,960
1915	79,133	2,479,620
1916	79,194	2,475,490
1917	79,227	2,470,490
1918	79,232	2,464,530
1919	79,208	2,457,510
1920	79,185	2,449,320
1921	79,159	2,439,950
1922	79,129	2,429,270
1923	79,091	2,417,120
1924	79,043	2,403,370
1925	78,970	2,387,880
1926	78,871	2,370,450
1927	78,743	2,350,940
1928	78,585	2,329,190
1929	78,413	2,305,050
1930	78,205	2,278,330
1931	77,995	2,248,760
1932	77,763	2,216,260
1933	77,461	2,180,550
1934	77,092	2,141,220
1935	76,671	2,098,150
1936	76,155	2,051,250
1937	75,549	2,000,190
1938	74,869	1,944,980
1939	74,147	1,885,530
1940	73,267	1,821,700
1941	72,386	1,752,890
1942	71,400	1,679,820
1943	70,307	1,602,070
1944	69,101	1,519,920
1945	67,779	1,433,620
1946	66,338	1,343,880
1947	64,778	1,251,770
1948	63,099	1,157,990
1949	61,302	1,063,560
1950	59,374	969,427
1951	57,444	876,431
1952	55,392	786,369
1953	53,284	700,299
1954	51,088	619,469
1955	48,783	545,192
1956	46,410	477,290
1957	43,943	415,774
1958	41,427	360,678
1959	38,989	312,750
1960	36,493	271,730
1961	34,023	237,815
1962	31,591	211,396
1963	29,204	199,337
1964	26,829	189,250
1965	24,471	168,905
1966	22,203	162,043
1967	20,174	153,620
1968	18,351	148,595
1969	16,641	141,949
1970	15,001	142,378
1971	13,498	134,321
1972	12,059	136,063
1973	10,676	130,923
1974	9,456	1,393,760
1975	8,260	203,892
1976	7,248	729,860
1977	7,137	1,269,520
1978	6,836	1,219,320
1979	6,682	1,541,200
1980	6,819	1,711,720
1981	7,116	2,093,990
1982	7,792	1,972,150
1983	8,329	1,363,300
1984	7,735	1,357,080
1985	9,314	1,251,930
1986	8,416	1,474,850
1987	8,126	1,191,200
1988	8,447	1,084,170
1989	8,425	790,066
1990	8,332	3,742,550
1991	8,552	1,591,890
1992	7,974	1,901,340
1993	9,461	2,099,210
1994	9,715	4,762,360
1995	9,446	2,678,930
1996	9,414	2,004,300
1997	12,031	5,641,670
1998	13,696	2,994,870
1999	13,714	1,781,380
2000	16,405	4,823,110
2001	17,789	3,306,640
2002	17,585	2,633,520
2003	17,904	2,290,620
2004	17,221	2,212,620

Fishing mortality rate

Year	fishing_pressures
1880	0.0011
1881	0.0010
1882	0.0009
1883	0.0008
1884	0.0007
1885	0.0006
1886	0.0005
1887	0.0004
1888	0.0003
1889	0.0003
1890	0.0003
1891	0.0003
1892	0.0004
1893	0.0004
1894	0.0004
1895	0.0005
1896	0.0005
1897	0.0005
1898	0.0005
1899	0.0006
1900	0.0006
1901	0.0006
1902	0.0007
1903	0.0007
1904	0.0008
1905	0.0008
1906	0.0009
1907	0.0009
1908	0.0009
1909	0.0012
1910	0.0014
1911	0.0017
1912	0.0019
1913	0.0022
1914	0.0024
1915	0.0026
1916	0.0029
1917	0.0031
1918	0.0034
1919	0.0032
1920	0.0031
1921	0.0029
1922	0.0028
1923	0.0026
1924	0.0026
1925	0.0027
1926	0.0027
1927	0.0027
1928	0.0024
1929	0.0024
1930	0.0019
1931	0.0015
1932	0.0018
1933	0.0020
1934	0.0020
1935	0.0025
1936	0.0029
1937	0.0031
1938	0.0027
1939	0.0040
1940	0.0029
1941	0.0033
1942	0.0036
1943	0.0040
1944	0.0043
1945	0.0047
1946	0.0051
1947	0.0054
1948	0.0058
1949	0.0064
1950	0.0048
1951	0.0053
1952	0.0048
1953	0.0050
1954	0.0060
1955	0.0065
1956	0.0081
1957	0.0094
1958	0.0084
1959	0.0112
1960	0.0127
1961	0.0147
1962	0.0173
1963	0.0223
1964	0.0290
1965	0.0344
1966	0.0348
1967	0.0371
1968	0.0427
1969	0.0518
1970	0.0587
1971	0.0728
1972	0.0908
1973	0.1037
1974	0.1309
1975	0.1691
1976	0.1856
1977	0.1963
1978	0.2120
1979	0.2456
1980	0.2597
1981	0.2430
1982	0.2963
1983	0.4281
1984	0.1943
1985	0.3839
1986	0.3058
1987	0.2306
1988	0.2743
1989	0.2630
1990	0.2076
1991	0.3181
1992	0.2707
1993	0.3351
1994	0.3464
1995	0.3709
1996	0.2700
1997	0.2745
1998	0.3353
1999	0.2634
2000	0.2735
2001	0.2908
2002	0.3189
2003	0.3484
2004	0.4189

Selectivity at age

Age	Headboat 1	Headboat 2	Headboat 3	Handline 1	Handline 3	Longline	MRFSS	Others
1	0.01236	0.00323	0.01058	0.00047	0.00005	0.00011	0.01939	0.00146
2	0.24768	0.15918	0.19920	0.00688	0.00166	0.00128	0.20228	0.01476
3	0.74870	0.70122	0.68564	0.06559	0.03593	0.01137	0.62465	0.13512
4	0.91398	0.91984	0.90239	0.29393	0.27382	0.06987	0.86857	0.67077
5	0.87298	0.93714	0.89968	0.59086	0.62018	0.24534	0.92370	0.89036
6	0.73961	0.90690	0.80100	0.78846	0.82626	0.48623	0.89188	0.74471
7	0.57248	0.83831	0.65221	0.88463	0.88388	0.68800	0.80459	0.57516
8	0.41829	0.73547	0.49959	0.92419	0.84883	0.82174	0.68423	0.40782
9	0.29738	0.61953	0.37045	0.93970	0.77084	0.90077	0.55958	0.26755
10	0.21003	0.50991	0.27157	0.94603	0.67587	0.94433	0.44848	0.16517
11	0.14935	0.41583	0.19950	0.94881	0.58421	0.96763	0.35724	0.09775
12	0.10794	0.33926	0.14816	0.95014	0.50245	0.98021	0.28547	0.05632

Table 6. 1880-2004 Catch increasing catchability sensitivity run stock indicators of model fit

Estimated Biomass

Year	Biomass M	SSB fem	SSB mal
1880	103,933	70,000	29,490
1881	103,803	69,930	29,457
1882	103,669	69,864	29,427
1883	103,530	69,768	29,400
1884	103,389	69,652	29,377
1885	103,249	69,527	29,358
1886	103,113	69,401	29,343
1887	102,984	69,280	29,329
1888	102,864	69,170	29,313
1889	102,750	69,077	29,290
1890	102,637	68,997	29,252
1891	102,640	68,936	29,201
1892	102,792	68,880	29,154
1893	103,107	68,889	29,111
1894	103,581	69,220	29,072
1895	104,196	69,805	29,035
1896	104,928	70,546	29,001
1897	105,749	71,380	28,972
1898	106,638	72,254	28,976
1899	107,570	73,119	29,041
1900	108,525	73,921	29,198
1901	109,485	74,619	29,469
1902	110,444	75,188	29,867
1903	111,320	75,712	30,228
1904	112,121	76,195	30,555
1905	112,855	76,640	30,852
1906	113,526	77,048	31,124
1907	114,140	77,422	31,372
1908	114,700	77,763	31,599
1909	115,201	78,075	31,807
1910	115,635	78,343	31,992
1911	116,006	78,572	32,153
1912	116,318	78,763	32,293
1913	116,573	78,918	32,412
1914	116,775	79,041	32,511
1915	116,926	79,133	32,592
1916	117,028	79,194	32,655
1917	117,084	79,227	32,701
1918	117,094	79,232	32,733
1919	117,081	79,208	32,750
1920	117,064	79,185	32,766
1921	117,042	79,159	32,781
1922	117,012	79,129	32,797
1923	116,972	79,091	32,814
1924	116,911	79,043	32,831
1925	116,816	78,970	32,842
1926	116,684	78,871	32,848
1927	116,512	78,743	32,847
1928	116,311	78,585	32,838
1929	116,079	78,413	32,830
1930	115,823	78,205	32,812
1931	115,555	77,995	32,802
1932	115,227	77,763	32,792
1933	114,804	77,461	32,760
1934	114,300	77,092	32,708
1935	113,694	76,671	32,643
1936	112,956	76,155	32,544
1937	112,100	75,549	32,413
1938	111,163	74,869	32,258
1939	110,084	74,147	32,093
1940	108,891	73,267	31,866
1941	107,629	72,386	31,651
1942	106,218	71,400	31,402
1943	104,652	70,307	31,119
1944	102,927	69,101	30,798
1945	101,036	67,779	30,438
1946	98,979	66,338	30,037
1947	96,755	64,778	29,596
1948	94,365	63,099	29,114
1949	91,802	61,302	28,589
1950	89,149	59,374	28,015
1951	86,417	57,444	27,452
1952	83,559	55,392	26,839
1953	80,601	53,284	26,205
1954	77,495	51,088	25,528
1955	74,249	48,783	24,788
1956	70,868	46,410	23,999
1957	67,354	43,943	23,138
1958	63,835	41,427	22,218
1959	60,296	38,989	21,302
1960	56,690	36,493	20,309
1961	53,086	34,023	19,279
1962	49,498	31,591	18,216
1963	45,904	29,204	17,122
1964	42,279	26,829	15,973
1965	38,674	24,471	14,772
1966	35,271	22,203	13,557
1967	32,177	20,174	12,427
1968	29,301	18,351	11,377
1969	26,537	16,641	10,355
1970	23,917	15,001	9,342
1971	21,445	13,498	8,393
1972	19,064	12,059	7,471
1973	16,866	10,676	6,581
1974	15,220	9,456	5,796
1975	13,675	8,260	5,029
1976	12,423	7,248	4,254
1977	11,638	7,137	3,583
1978	11,232	6,836	3,016
1979	11,093	6,682	2,527
1980	11,156	6,819	2,046
1981	11,619	7,116	1,664
1982	12,235	7,792	1,337
1983	11,945	8,329	1,051
1984	11,747	7,735	845
1985	11,869	9,314	811
1986	11,008	8,416	708
1987	10,995	8,126	688
1988	11,139	8,447	732
1989	10,865	8,425	796
1990	11,630	8,332	859
1991	12,481	8,552	937
1992	13,125	7,974	964
1993	13,675	9,461	976
1994	14,411	9,715	929
1995	15,204	9,446	885
1996	16,272	9,414	818
1997	18,607	12,031	817
1998	20,206	13,696	830
1999	21,167	13,714	814
2000	22,832	16,405	877
2001	23,970	17,789	1,037
2002	24,294	17,585	1,141
2003	23,450	17,904	1,257
2004	21,202	17,221	1,392

Stock Recruitment

Year	SSB fem	Recruits
1880	70,000	2,080,490
1881	69,930	2,081,060
1882	69,864	2,081,450
1883	69,768	2,081,860
1884	69,652	2,082,220
1885	69,527	2,082,560
1886	69,401	2,082,930
1887	69,280	2,083,370
1888	69,170	2,083,900
1889	69,077	2,084,510
1890	68,997	2,085,200
1891	68,936	2,454,360
1892	68,880	2,455,190
1893	68,889	2,456,060
1894	69,220	2,457,160
1895	69,805	2,459,330
1896	70,546	2,462,290
1897	71,380	2,465,690
1898	72,254	2,469,280
1899	73,119	2,472,850
1900	73,921	2,476,260
1901	74,619	2,479,320
1902	75,188	2,481,940
1903	75,712	2,484,040
1904	76,195	2,485,850
1905	76,640	2,487,360
1906	77,048	2,488,550
1907	77,422	2,489,410
1908	77,763	2,489,910
1909	78,075	2,490,020
1910	78,343	2,489,710
1911	78,572	2,488,900
1912	78,763	2,487,540
1913	78,918	2,485,580
1914	79,041	2,482,960
1915	79,133	2,479,620
1916	79,194	2,475,490
1917	79,227	2,470,490
1918	79,232	2,464,530
1919	79,208	2,457,510
1920	79,185	2,449,320
1921	79,159	2,439,950
1922	79,129	2,429,270
1923	79,091	2,417,120
1924	79,043	2,403,370
1925	78,970	2,387,880
1926	78,871	2,370,450
1927	78,743	2,350,940
1928	78,585	2,329,190
1929	78,413	2,305,050
1930	78,205	2,278,330
1931	77,995	2,248,760
1932	77,763	2,216,260
1933	77,461	2,180,550
1934	77,092	2,141,220
1935	76,671	2,098,150
1936	76,155	2,051,250
1937	75,549	2,000,190
1938	74,869	1,944,980
1939	74,147	1,885,530
1940	73,267	1,821,700
1941	72,386	1,752,890
1942	71,400	1,679,820
1943	70,307	1,602,070
1944	69,101	1,519,920
1945	67,779	1,433,620
1946	66,338	1,343,880
1947	64,778	1,251,770
1948	63,099	1,157,990
1949	61,302	1,063,560
1950	59,374	969,427
1951	57,444	876,431
1952	55,392	786,369
1953	53,284	700,299
1954	51,088	619,469
1955	48,783	545,192
1956	46,410	477,290
1957	43,943	415,774
1958	41,427	360,678
1959	38,989	312,750
1960	36,493	271,730
1961	34,023	237,815
1962	31,591	211,396
1963	29,204	199,337
1964	26,829	189,250
1965	24,471	168,905
1966	22,203	162,043
1967	20,174	153,620
1968	18,351	148,595
1969	16,641	141,949
1970	15,001	142,378
1971	13,498	134,321
1972	12,059	136,063
1973	10,676	130,923
1974	9,456	1,393,760
1975	8,260	203,892
1976	7,248	729,860
1977	7,137	1,269,520
1978	6,836	1,219,320
1979	6,682	1,541,200
1980	6,819	1,711,720
1981	7,116	2,093,990
1982	7,792	1,972,150
1983	8,329	1,363,300
1984	7,735	1,357,080
1985	9,314	1,251,930
1986	8,416	1,474,850
1987	8,126	1,191,200
1988	8,447	1,084,170
1989	8,425	790,066
1990	8,332	3,742,550
1991	8,552	1,591,890
1992	7,974	1,901,340
1993	9,461	2,099,210
1994	9,715	4,762,360
1995	9,446	2,678,930
1996	9,414	2,004,300
1997	12,031	5,641,670
1998	13,696	2,994,870
1999	13,714	1,781,380
2000	16,405	4,823,110
2001	17,789	3,306,640
2002	17,585	2,633,520
2003	17,904	2,290,620
2004	17,221	2,212,620

Fishing mortality rate

Year	fishing_pressures
1880	0.0011
1881	0.0010
1882	0.0009
1883	0.0008
1884	0.0007
1885	0.0006
1886	0.0005
1887	0.0004
1888	0.0003
1889	0.0003
1890	0.0003
1891	0.0003
1892	0.0004
1893	0.0004
1894	0.0004
1895	0.0005
1896	0.0005
1897	0.0005
1898	0.0005
1899	0.0006
1900	0.0006
1901	0.0006
1902	0.0007
1903	0.0007
1904	0.0008
1905	0.0008
1906	0.0009
1907	0.0009
1908	0.0009
1909	0.0012
1910	0.0014
1911	0.0017
1912	0.0019
1913	0.0022
1914	0.0024
1915	0.0026
1916	0.0029
1917	0.0031
1918	0.0034
1919	0.0032
1920	0.0031
1921	0.0029
1922	0.0028
1923	0.0026
1924	0.0026
1925	0.0027
1926	0.0027
1927	0.0027
1928	0.0024
1929	0.0024
1930	0.0019
1931	0.0015
1932	0.0018
1933	0.0020
1934	0.0020
1935	0.0025
1936	0.0029
1937	0.0031
1938	0.0027
1939	0.0040
1940	0.0029
1941	0.0033
1942	0.0036
1943	0.0040
1944	0.0043
1945	0.0047
1946	0.0051
1947	0.0054
1948	0.0058
1949	0.0064
1950	0.0048
1951	0.0053
1952	0.0048
1953	0.0050
1954	0.0060
1955	0.0065
1956	0.0081
1957	0.0094
1958	0.0084
1959	0.0112
1960	0.0127
1961	0.0147
1962	0.0173
1963	0.0223
1964	0.0290
1965	0.0344
1966	0.0348
1967	0.0371
1968	0.0427
1969	0.0518
1970	0.0587
1971	0.0728
1972	0.0908
1973	0.1037
1974	0.1309
1975	0.1691
1976	0.1856
1977	0.1963
1978	0.2120
1979	0.2456
1980	0.2597
1981	0.2430
1982	0.2963
1983	0.4281
1984	0.1943
1985	0.3839
1986	0.3058
1987	0.2306
1988	0.2743
1989	0.2630
1990	0.2076
1991	0.3181
1992	0.2707
1993	0.3351
1994	0.3464
1995	0.3709
1996	0.2700
1997	0.2745
1998	0.3353
1999	0.2634
2000	0.2735
2001	0.2908
2002	0.3189
2003	0.3484
2004	0.4189

Selectivity at age

Age	Headboat 1	Headboat	Headboat	Handline 1	Handline 3	Longline	MRFSS	Others
1	0.01236	0.00323	0.01058	0.00047	0.00005	0.00011	0.01939	0.00146
2	0.24768	0.15918	0.19920	0.00688	0.00166	0.00128	0.20228	0.01476
3	0.74870	0.70122	0.68564	0.06559	0.03593	0.01137	0.62465	0.13512
4	0.91398	0.91984	0.90239	0.29393	0.27382	0.06987	0.86857	0.67077
5	0.87298	0.93714	0.89968	0.59086	0.62018	0.24534	0.92370	0.89036
6	0.73961	0.90690	0.80100	0.78846	0.82626	0.48623	0.89188	0.74471
7	0.57248	0.83831	0.65221	0.88463	0.88388	0.68800	0.80459	0.57516
8	0.41829	0.73547	0.49959	0.92419	0.84883	0.82174	0.68423	0.40782
9	0.29738	0.61953	0.37045	0.93970	0.77084	0.90077	0.55958	0.26755
10	0.21003	0.50991	0.27157	0.94603	0.67587	0.94433	0.44848	0.16517
11	0.14935	0.41583	0.19950	0.94881	0.58421	0.96763	0.35724	0.09775
12	0.10794	0.33926	0.14816	0.95014	0.50245	0.98021	0.28547	0.05632

Table 7. Sensitivity case 5 25% increase of MRFSS catch estimates summary of main stock indicators from CASAL fit for gag GOM.…

Estimated Biomass

Year	Biomass MT	SSB fem
1963	29,554	20,240
1964	28,394	19,658
1965	27,152	18,916
1966	25,900	17,829
1967	24,781	16,742
1968	23,647	16,063
1969	22,383	15,327
1970	21,038	14,470
1971	19,613	13,503
1972	18,079	12,417
1973	16,539	11,313
1974	15,416	10,292
1975	14,270	9,184
1976	13,317	8,176
1977	12,715	8,141
1978	12,451	7,810
1979	12,445	7,623
1980	12,656	7,781
1981	13,340	8,126
1982	14,214	8,987
1983	13,913	9,698
1984	13,658	8,922
1985	13,798	10,834
1986	12,734	9,695
1987	12,739	9,355
1988	12,913	9,765
1989	12,595	9,705
1990	13,598	9,639
1991	14,696	9,997
1992	15,511	9,324
1993	16,230	11,161
1994	17,164	11,500
1995	18,151	11,199
1996	19,474	11,175
1997	22,355	14,375
1998	24,394	16,406
1999	25,726	16,548
2000	27,969	19,951
2001	29,686	21,804
2002	30,512	21,856
2003	29,941	22,631
2004	27,727	22,214

Stock Recruitment

Year	SSB fem	Recruits
1963	20,240	244,975
1964	19,658	244,059
1965	18,916	836,716
1966	17,829	379,478
1967	16,742	434,122
1968	16,063	248,863
1969	15,327	243,496
1970	14,470	318,953
1971	13,503	244,527
1972	12,417	280,608
1973	11,313	244,012
1974	10,292	1,607,510
1975	9,184	242,302
1976	8,176	848,983
1977	8,141	1,501,690
1978	7,810	1,450,390
1979	7,623	1,848,320
1980	7,781	2,054,500
1981	8,126	2,503,670
1982	8,987	2,349,390
1983	9,698	1,621,860
1984	8,922	1,605,600
1985	10,834	1,478,820
1986	9,695	1,743,600
1987	9,355	1,410,170
1988	9,765	1,289,320
1989	9,705	945,864
1990	9,639	4,497,010
1991	9,997	1,918,830
1992	9,324	2,296,390
1993	11,161	2,538,260
1994	11,500	5,760,040
1995	11,199	3,247,000
1996	11,175	2,435,940
1997	14,375	6,887,690
1998	16,406	3,683,750
1999	16,548	2,213,920
2000	19,951	6,061,470
2001	21,804	4,202,720
2002	21,856	3,384,530
2003	22,631	2,992,240
2004	22,214	2,968,710

Fishing mortality rate

Year	fishing_pressures
1963	0.0353
1964	0.0434
1965	0.0494
1966	0.0478
1967	0.0476
1968	0.0524
1969	0.0609
1970	0.0658
1971	0.0788
1972	0.0955
1973	0.1065
1974	0.1322
1975	0.1684
1976	0.1850
1977	0.1979
1978	0.2166
1979	0.2511
1980	0.2662
1981	0.2422
1982	0.2934
1983	0.4394
1984	0.1900
1985	0.3933
1986	0.3095
1987	0.2308
1988	0.2811
1989	0.2630
1990	0.2003
1991	0.3220
1992	0.2694
1993	0.3343
1994	0.3471
1995	0.3728
1996	0.2674
1997	0.2729
1998	0.3297
1999	0.2572
2000	0.2648
2001	0.2775
2002	0.3036
2003	0.3290
2004	0.3883

Selectivity at age

Age	Headboat 1	Headboat 2	Headboat 3	Handline 1	Handline 3	Longline	MRFSS	Others
1	0.01211	0.00320	0.01017	0.00044	0.00004	0.00010	0.01884	0.00139
2	0.24750	0.15866	0.19777	0.00659	0.00162	0.00124	0.19918	0.01436
3	0.74929	0.69979	0.68711	0.06437	0.03563	0.01114	0.62138	0.13463
4	0.91563	0.91914	0.90291	0.29298	0.27342	0.06897	0.86725	0.67303
5	0.88014	0.94223	0.89686	0.59141	0.62009	0.24383	0.92493	0.89350
6	0.75495	0.92140	0.79483	0.78959	0.82645	0.48491	0.89773	0.75287
7	0.59224	0.85895	0.64471	0.88562	0.88428	0.68718	0.81707	0.58651
8	0.43820	0.75221	0.49245	0.92484	0.84932	0.82135	0.70185	0.41949
9	0.31509	0.62712	0.36446	0.94008	0.77126	0.90064	0.57956	0.27723
10	0.22481	0.50829	0.26686	0.94625	0.67611	0.94434	0.46863	0.17207
11	0.16129	0.40688	0.19594	0.94894	0.58423	0.96769	0.37628	0.10221
12	0.11744	0.32533	0.14552	0.95022	0.50228	0.98028	0.30286	0.05903

Table 8. Sensitivity case 5 25% decrease of MRFSS catch estimates summary of main stock indicators from CASAL fit for gag GOM.

Estimated Biomass

Year	Biomass MT	SSB fem
1963	28,343	19,393
1964	27,287	18,889
1965	25,971	18,230
1966	24,568	17,227
1967	23,204	16,122
1968	21,816	14,990
1969	20,321	13,797
1970	18,774	12,546
1971	17,208	11,364
1972	15,591	10,219
1973	14,033	9,134
1974	12,834	8,236
1975	11,658	7,320
1976	10,672	6,502
1977	10,052	6,382
1978	9,728	6,105
1979	9,589	5,945
1980	9,587	5,996
1981	9,879	6,185
1982	10,264	6,635
1983	9,999	6,978
1984	9,862	6,567
1985	9,969	7,814
1986	9,313	7,163
1987	9,285	6,927
1988	9,401	7,161
1989	9,177	7,179
1990	9,715	7,060
1991	10,342	7,145
1992	10,845	6,675
1993	11,269	7,843
1994	11,885	8,051
1995	12,586	7,867
1996	13,521	7,910
1997	15,493	10,080
1998	16,878	11,532
1999	17,731	11,604
2000	19,184	13,864
2001	20,212	15,084
2002	20,597	14,963
2003	20,129	15,358
2004	18,610	15,046

Stock Recruitment

Year	SSB fem	Recruits
1963	19,393	215,311
1964	18,889	215,314
1965	18,230	212,756
1966	17,227	209,324
1967	16,122	203,838
1968	14,990	197,392
1969	13,797	190,317
1970	12,546	182,263
1971	11,364	173,092
1972	10,219	163,644
1973	9,134	153,660
1974	8,236	1,125,250
1975	7,320	160,640
1976	6,502	581,035
1977	6,382	1,016,330
1978	6,105	971,788
1979	5,945	1,228,250
1980	5,996	1,368,650
1981	6,185	1,689,930
1982	6,635	1,595,600
1983	6,978	1,107,410
1984	6,567	1,110,370
1985	7,814	1,025,100
1986	7,163	1,207,070
1987	6,927	973,649
1988	7,161	881,504
1989	7,179	638,639
1990	7,060	3,016,930
1991	7,145	1,282,690
1992	6,675	1,535,330
1993	7,843	1,701,190
1994	8,051	3,867,620
1995	7,867	2,177,930
1996	7,910	1,632,470
1997	10,080	4,596,020
1998	11,532	2,439,450
1999	11,604	1,454,540
2000	13,864	3,960,080
2001	15,084	2,736,560
2002	14,963	2,192,020
2003	15,358	1,914,910
2004	15,046	1,908,600

Fishing mortality rate

Year	fishing_pressures
1963	0.0307
1964	0.0384
1965	0.0436
1966	0.0407
1967	0.0395
1968	0.0445
1969	0.0540
1970	0.0595
1971	0.0727
1972	0.0892
1973	0.0972
1974	0.1204
1975	0.1547
1976	0.1680
1977	0.1773
1978	0.1918
1979	0.2284
1980	0.2445
1981	0.2413
1982	0.2976
1983	0.4077
1984	0.1987
1985	0.3673
1986	0.2978
1987	0.2306
1988	0.2621
1989	0.2601
1990	0.2164
1991	0.3087
1992	0.2681
1993	0.3303
1994	0.3380
1995	0.3571
1996	0.2631
1997	0.2646
1998	0.3264
1999	0.2551
2000	0.2649
2001	0.2836
2002	0.3048
2003	0.3261
2004	0.3852

Selectivity at age

Age	Headboat 1	Headboat 2	Headboat 3	Handline 1	Handline 3	Longline	MRFSS	Others
1	0.01224	0.00340	0.01060	0.00052	0.00005	0.00011	0.01904	0.00145
2	0.25311	0.16061	0.19973	0.00729	0.00180	0.00137	0.21233	0.01495
3	0.75718	0.70041	0.68764	0.06727	0.03722	0.01202	0.64683	0.13943
4	0.91359	0.91919	0.90178	0.29521	0.27519	0.07269	0.87953	0.68734
5	0.86262	0.93619	0.88882	0.59010	0.61975	0.25103	0.92456	0.88663
6	0.71974	0.90268	0.77567	0.78689	0.82553	0.49223	0.88666	0.74006
7	0.54808	0.82702	0.61794	0.88325	0.88337	0.69262	0.79357	0.57020
8	0.39443	0.71624	0.46393	0.92329	0.84881	0.82478	0.66974	0.40337
9	0.27662	0.59491	0.33802	0.93916	0.77118	0.90255	0.54374	0.26412
10	0.19299	0.48288	0.24404	0.94571	0.67617	0.94530	0.43290	0.16283
11	0.13580	0.38859	0.17694	0.94862	0.58446	0.96814	0.34276	0.09628
12	0.09730	0.31311	0.12999	0.95001	0.50267	0.98049	0.27242	0.05545

Table 9. Retrospective analysis results applied to base case 1..

Retrospective Analysis Case 1

	2004	2003	2002	2001	2000
Biomass unexploited	87514.3	87478.2	89596.4	95476.7	92925.7
Biomass 1963	22295.4	23087.6	22687.7	22653.4	21977.5
steepness	0.75140	0.72123	0.71586	0.66718	0.69361

Total Population

Year	2004	2003	2002	2001	2000
1963	3895560	4033980	3964110	3958110	3840010
1964	3467740	3572010	3519860	3517940	3435920
1965	3112070	3189830	3151410	3152650	3099010
1966	2807910	2864170	2836600	2840250	2808810
1967	2559040	2597530	2578710	2584130	2570850
1968	2350840	2374290	2362590	2369000	2370570
1969	2164410	2175010	2169060	2175710	2189710
1970	1989690	1989110	1987910	1993900	2018530
1971	1831650	1821670	1823920	1828980	1862610
1972	1678570	1660320	1665330	1668480	1710120
1973	1528300	1503810	1509940	1511520	1559360
1974	1392810	1363500	1369630	1369460	1422580
1975	2203630	2183600	2192780	2192250	2206500
1976	1865410	1853490	1856980	1856810	1864680
1977	1980130	1973120	1976740	1975270	1976150
1978	2463950	2460030	2464740	2464680	2454820
1979	2764090	2761110	2766880	2767860	2753260
1980	3186200	3183120	3191290	3193830	3174710
1981	3594190	3590860	3599810	3602050	3585490
1982	4223120	4222090	4231350	4233470	4217440
1983	4493190	4489950	4499780	4503450	4480460
1984	3838230	3830090	3837370	3838850	3821420
1985	3903940	3894350	3901500	3904220	3883380
1986	3407090	3393500	3399830	3403190	3380910
1987	3427560	3410690	3416490	3419670	3391480
1988	3376970	3358310	3363580	3367070	3333180
1989	3156900	3135020	3139360	3143030	3104930
1990	2808780	2785370	2788700	2791600	2752660
1991	4955750	4913220	4914130	4914690	4831530
1992	4678250	4627280	4625810	4623430	4540310
1993	4771200	4705590	4701950	4716020	4605100
1994	4799070	4707670	4706630	4743500	4630910
1995	6855920	6708540	6749500	6853580	6657340
1996	6692020	6498290	6530280	6622430	6296720
1997	6279950	6025110	5990650	6043870	5652750
1998	8740810	8162830	7914340	7829800	6740520
1999	8321170	7480980	6892880	6577470	5486330
2000	7265820	6319000	5842730	5741010	6412800
2001	8864030	7111170	6346310	4479640	
2002	8864890	6873610	5447410		
2003	8182330	5420080			
2004	7270450				

Total Biomass

Year	2004	2003	2002	2001	2000
1963	32603	33766	33179	33130	32140
1964	31433	32566	31994	31949	30991
1965	29961	31046	30499	30459	29554
1966	28363	29381	28869	28836	28002
1967	26773	27708	27238	27215	26467
1968	25133	25975	25551	25538	24889
1969	23370	24110	23737	23734	23191
1970	21547	22179	21859	21865	21433
1971	19703	20225	19957	19970	19650
1972	17804	18217	18001	18018	17809
1973	15966	16275	16105	16126	16022
1974	14565	14780	14654	14676	14656
1975	13219	13359	13269	13289	13328
1976	12116	12201	12138	12156	12229
1977	11438	11484	11441	11457	11544
1978	11105	11124	11097	11112	11198
1979	11016	11015	11003	11017	11094
1980	11110	11097	11097	11111	11173
1981	11592	11572	11582	11597	11643
1982	12219	12195	12215	12231	12256
1983	11935	11907	11934	11952	11957
1984	11739	11704	11737	11756	11744
1985	11863	11821	11858	11879	11847
1986	11002	10950	10990	11014	10962
1987	10991	10926	10969	10995	10921
1988	11137	11058	11103	11130	11031
1989	10866	10772	10816	10846	10720
1990	11638	11521	11564	11595	11424
1991	12503	12357	12398	12427	12204
1992	13164	12979	13015	13048	12759
1993	13737	13498	13529	13577	13214
1994	14513	14191	14233	14332	13858
1995	15356	14921	14980	15142	14493
1996	16484	15892	15945	16162	15280
1997	18910	18011	17961	18172	16738
1998	20620	19241	18902	18981	16852
1999	21710	19712	19030	18994	16776
2000	23555	20538	19350	18482	16935
2001	24924	20618	18600	16321	
2002	25525	19470	17333		
2003	25002	17803			
2004	23101				

SSB females

Year	2004	2003	2002	2001	2000
1963	22295.4	23087.6	22687.7	22653.4	21977.5
1964	21751.4	22543.5	22143.5	22109.3	21434.9
1965	21035.5	21820	21423.5	21390.3	20725.9
1966	19896.9	20635.9	20262.6	20235	19620.4
1967	18596.6	19261.2	18926.1	18907.4	18373.2
1968	17238.9	17812.7	17524	17515.9	17078.2
1969	15805	16279.6	16041.2	16044	15710
1970	14315.4	14689.6	14501.5	14514.3	14283.5
1971	12907	13185.3	13044.2	13064.9	12931.2
1972	11554.9	11747.7	11647.3	11672.7	11624.5
1973	10288.3	10410.3	10341.7	10368.3	10390.7
1974	9233.11	9298.81	9253.29	9277.56	9356.44
1975	8166.66	8184.59	8156.43	8176.54	8303.76
1976	7245.28	7227.76	7212.12	7227.27	7384.05
1977	7175.06	7139.79	7133.99	7144.74	7290.4
1978	6884.28	6843.56	6840.44	6849.6	6980.59
1979	6721.32	6682.2	6681.35	6688.45	6801.84
1980	6842.91	6808.3	6810.2	6817.15	6905.35
1981	7125.88	7094.96	7100.87	7109.99	7172.82
1982	7792.77	7764.17	7776	7787.99	7825.12
1983	8324.31	8297.76	8315.97	8330.56	8348.79
1984	7727.71	7702.9	7727.14	7745.18	7753.54
1985	9306.27	9276.14	9304.14	9323.92	9313.1
1986	8408.69	8371.79	8403.89	8425.05	8402.21
1987	8119.61	8073.2	8107.01	8130.12	8093.34
1988	8442.02	8383.99	8418.6	8443.23	8388.12
1989	8421.54	8350.41	8385.28	8411.05	8334.25
1990	8330.85	8245.5	8279.36	8306.43	8205.03
1991	8554.24	8454.15	8485.96	8513.71	8385.51
1992	7983.23	7867.63	7897.89	7927.4	7767.81
1993	9489.7	9336.5	9359.96	9384.37	9159.92
1994	9764.86	9565.37	9581.33	9606.69	9312.36
1995	9521.29	9262.62	9271.77	9319.73	8942.71
1996	9528.3	9184.03	9202.05	9308.97	8837.07
1997	12212.7	11723.1	11780.1	11990.1	11321.9
1998	13953.4	13271.5	13341.3	13630.1	12636.5
1999	14057.1	13076.8	13040.4	13323	11811.7
2000	16886.6	15282.3	14871.9	14962.9	12376.2
2001	18422.4	15974.5	14928.5	14681.1	
2002	18384.3	14923.6	13356.6		
2003	18962.6	13848.9			
2004	18591.6				

Recruits

Year	2004	2003	2002	2001	2000
1963	214586	194653	205512	209727	235244
1964	214574	194815	205527	209680	235483
1965	213181	193529	203801	207775	232399
1966	211267	191805	201668	205339	229539
1967	208019	188549	198021	201031	224552
1968	203970	184502	193519	195692	218839
1969	199294	179591	188332	189294	212345
1970	193783	174421	182265	182609	205231
1971	187283	167677	175170	173917	196744
1972	180294	161762	167587	166175	187994
1973	172637	155057	159364	157209	178505
1974	1393800	1393830	1401890	1401300	1365580
1975	202205	204783	202688	203081	195324
1976	721440	723927	727260	724876	711676
1977	1267200	1269960	1274210	1275680	1253310
1978	1216470	1218610	1223250	1225110	1206330
1979	1541900	1543550	1550400	1553260	1532980
1980	1712720	1714500	1720030	1721300	1708810
1981	2094330	2098810	2103480	2104790	2093610
1982	1972460	1972590	1978090	1981860	1961110
1983	1364890	1363130	1365820	1365320	1356180
1984	1358380	1355960	1358150	1360130	1348660
1985	1252910	1248690	1250870	1252710	1239060
1986	1476470	1471080	1472590	1473540	1456500
1987	1192730	1188100	1189140	1190490	1173690
1988	1086810	1080770	1081330	1082290	1065050
1989	793166	788147	787972	787596	774922
1990	3761120	3732900	3730570	3728550	3660220
1991	1602020	1585850	1584530	1582770	1555540
1992	1916250	1889480	1886980	1906950	1849470
1993	2119320	2075490	2078690	2113220	2080910
1994	4814020	4725740	4781940	4884220	4746930
1995	2712410	2625730	2631890	2653820	2438840
1996	2033390	1916040	1841700	1815600	1653520
1997	5741390	5269920	4981380	4812080	3810980
1998	3062170	2576450	2054020	1714410	1400230
1999	1833230	1482970	1444150	1605500	3611490
2000	5007130	3733970	3227430	900619	2732670
2001	3467710	2702450	1639560	173308	
2002	2789170	1300560	3688920		
2003	2452980	4346640			
2004	2344190				

Fishing mortality rate

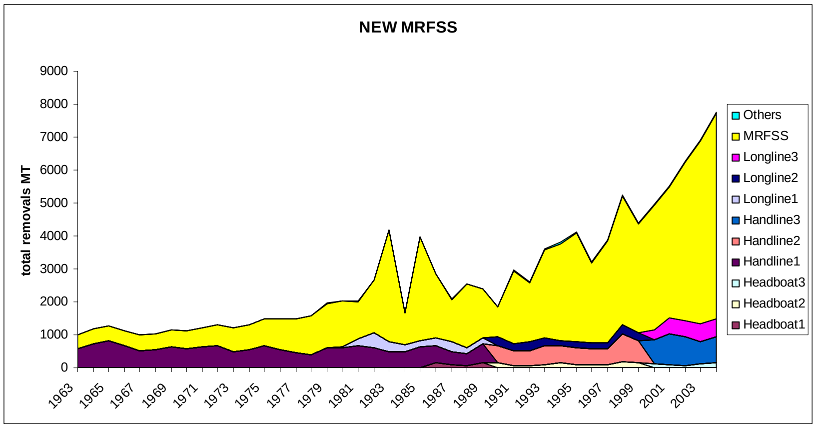
Year	2004	2003	2002	2001	2000
1963	0.0295	0.0285	0.0290	0.0290	0.0296
1964	0.0364	0.0352	0.0358	0.0359	0.0366
1965	0.0413	0.0399	0.0406	0.0407	0.0415
1966	0.0393	0.0380	0.0387	0.0387	0.0394
1967	0.0393	0.0381	0.0389	0.0388	0.0389
1968	0.0448	0.0436	0.0444	0.0443	0.0440
1969	0.0544	0.0532	0.0540	0.0539	0.0532
1970	0.0612	0.0602	0.0610	0.0608	0.0594
1971	0.0756	0.0747	0.0755	0.0752	0.0728
1972	0.0935	0.0929	0.0937	0.0933	0.0897
1973	0.1050	0.1052	0.1058	0.1053	0.0999
1974	0.1309	0.1317	0.1323	0.1318	0.1242
1975	0.1675	0.1691	0.1695	0.1689	0.1589
1976	0.1828	0.1848	0.1849	0.1846	0.1740
1977	0.1935	0.1955	0.1956	0.1954	0.1859
1978	0.2098	0.2116	0.2116	0.2113	0.2029
1979	0.2445	0.2458	0.2457	0.2455	0.2379
1980	0.2594	0.2603	0.2601	0.2599	0.2536
1981	0.2432	0.2436	0.2430	0.2428	0.2403
1982	0.2965	0.2968	0.2958	0.2954	0.2936
1983	0.4283	0.4288	0.4274	0.4270	0.4227
1984	0.1944	0.1947	0.1937	0.1934	0.1931
1985	0.3841	0.3849	0.3835	0.3831	0.3809
1986	0.3060	0.3071	0.3059	0.3053	0.3041
1987	0.2308	0.2319	0.2309	0.2303	0.2307
1988	0.2745	0.2762	0.2751	0.2745	0.2737
1989	0.2630	0.2651	0.2641	0.2634	0.2636
1990	0.2076	0.2095	0.2084	0.2077	0.2101
1991	0.3180	0.3212	0.3201	0.3190	0.3206
1992	0.2702	0.2736	0.2725	0.2718	0.2742
1993	0.3339	0.3388	0.3378	0.3373	0.3421
1994	0.3444	0.3510	0.3503	0.3493	0.3572
1995	0.3677	0.3770	0.3760	0.3732	0.3846
1996	0.2667	0.2755	0.2741	0.2709	0.2819
1997	0.2704	0.2811	0.2795	0.2752	0.2898
1998	0.3292	0.3463	0.3456	0.3397	0.3669
1999	0.2572	0.2772	0.2808	0.2779	0.3155
2000	0.2657	0.2947	0.3058	0.3063	0.3589
2001	0.2808	0.3258	0.3502	0.3623	
2002	0.3053	0.3800	0.4311		
2003	0.3293	0.4533			
2004	0.3889				

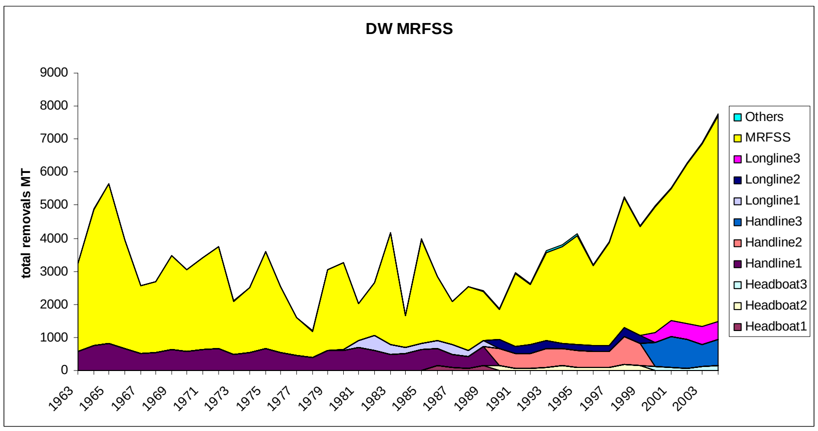
Table 10. Estimated deterministic benchmark statistics from the base scenarios and sensitivity run for gag GOM, assuming a Beverton & Holt Stock recruitment relationship for all time series.

	Base Run	Base A Run	Case 3	Case 4	Case 5	Case 6
Model	**1963-04 final MRFSS**	**1963-04 final MRFSS 2% inc q's**	**1880-04 MRFSS 45-04**	**1880-04 MRFSS 45-04 2% inc q's**	**1963-04 25% Inc MRFSS catch**	**1963-04 25% dec MRFSS catch**
steepness	0.7514	0.7418	0.7429	0.7199	0.9900	0.6634
SSB_0	87,514	89,391	70,000	70,000	64,362	107,757
MSY	3,748	3,788	2,975	2,898	3,492	4,110
SSB_MSY	26,732	27,419	21,533	21,951	14,310	35,276
Fmsy	0.132	0.131	0.131	0.125	0.228	0.110
$F_{30\%SPR}$	0.167	0.167	0.167	0.167	0.168	0.166
F_{max}	0.237	0.235	0.236	0.237	0.255	0.524
$F_{0.1}$	0.126	0.126	0.125	0.125	0.126	0.124
$SSB_{30\%SPR}$						
SSB_{2004}	18,592	17,247	18,548	17,221	22,214	15,046
F_{2004}	0.389	0.419	0.389	0.419	0.388	0.385
F_{2004}/F_{msy}	2.936	3.207	2.983	3.355	1.704	3.490
$F_{2004}/F_{30\%SPR}$	2.332	2.511	2.335	2.512	2.306	2.325
F_{2004}/F_{max}	1.642	1.780	1.650	1.769	1.522	0.735
SSB_{2004}/SSB_0	21.2%	19.3%	26.5%	24.6%	34.5%	14.0%
SSB_{2004}/SSB_{MSY}	69.5%	62.9%	86.1%	78.5%	155.2%	42.7%

Table 11. Estimated deterministic benchmark statistics from the base scenarios and sensitivity run for gag GOM, assuming a Beverton & Holt Stock recruitment relationship for 1983-2004 years.

	Base Run	Base A Run	Case 3	Case 4	Case 5	Case 6
Model	**1963-04 final MRFSS**	**1963-04 final MRFSS 2% inc q's**	**1880-04 MRFSS 45-04**	**1880-04 MRFSS 45-04 2% inc q's**	**1963-04 25% Inc MRFSS catch**	**1963-04 25% dec MRFSS catch**
steepness	0.7032	0.7110	0.7006	0.7098	0.7013	0.6995
SSB_0	219,209	194,744	226,547	197,111	287,040	167,258
MSY	8,877	7,964	9,165	8,065	11,702	6,681
SSB_MSY	69,726	61,578	72,486	62,358	91,918	53,329
Fmsy	0.120	0.122	0.120	0.122	0.120	0.119
$F_{30\%SPR}$	0.167	0.167	0.167	0.167	0.168	0.166
F_{max}	0.236	0.638	0.616	0.633	0.634	0.649
$F_{0.1}$	0.125	0.125	0.125	0.125	0.126	0.124
$SSB_{30\%SPR}$						
SSB_{2004}	18,592	17,247	18,548	17,221	22,214	15,046
F_{2004}	0.389	0.419	0.389	0.419	0.388	0.385
F_{2004}/F_{msy}	3.229	3.422	3.255	3.424	3.224	3.249
$F_{2004}/F_{30\%SPR}$	2.333	2.511	2.335	2.512	2.306	2.325
F_{2004}/F_{max}	1.647	0.656	0.632	0.662	0.613	0.594
SSB_{2004}/SSB_0	8.5%	8.9%	8.2%	8.7%	7.7%	9.0%
SSB_{2004}/SSB_{MSY}	26.7%	28.0%	25.6%	27.6%	24.2%	28.2%





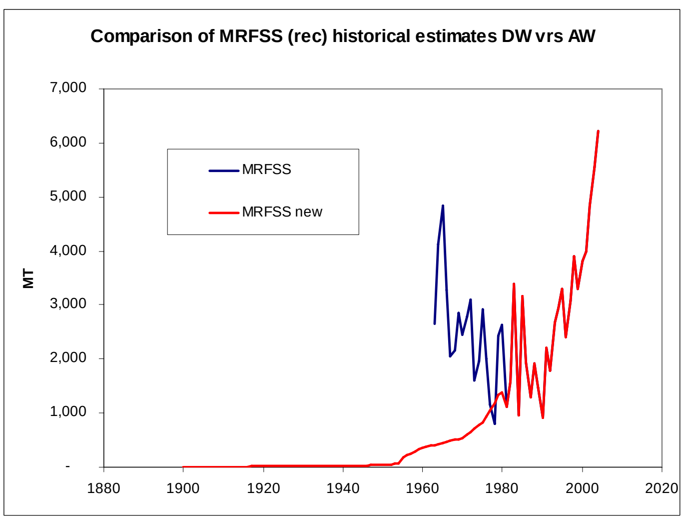


Figure 1. Comparison of recreational historic catch estimated by the recreational group Data Workshop and the Assessment workshop group for gag GOM .

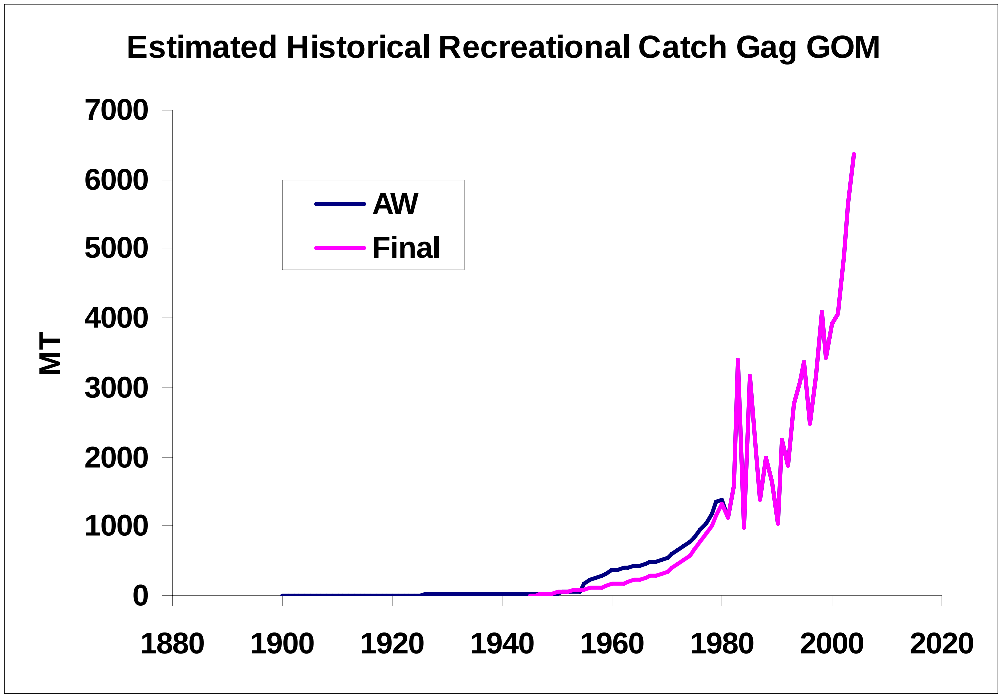


Figure 3. Final estimates of recreational historic catch for gag GOM and initial version during the AW meeting.

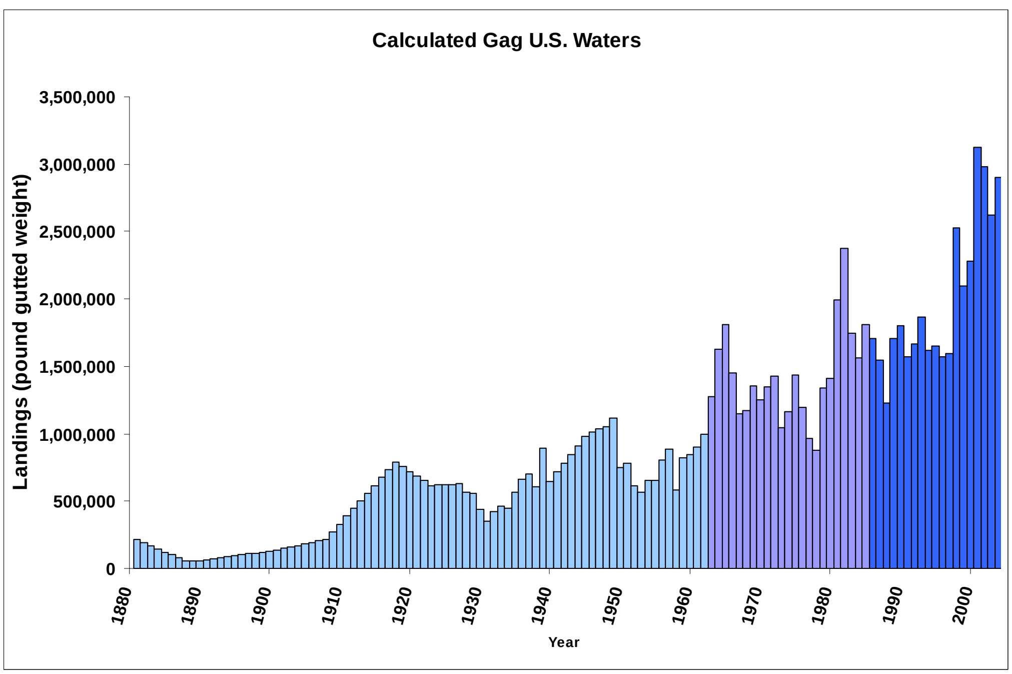
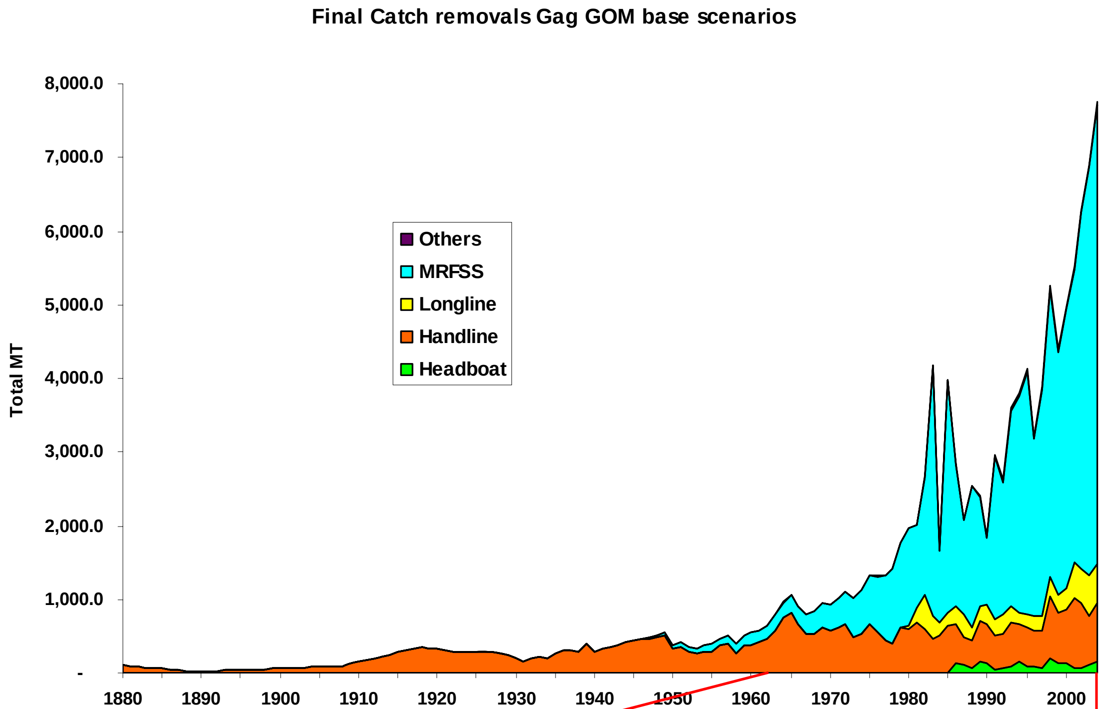


Figure 2. Estimated historic commercial catch for gag GOM from 1880 to 1962.



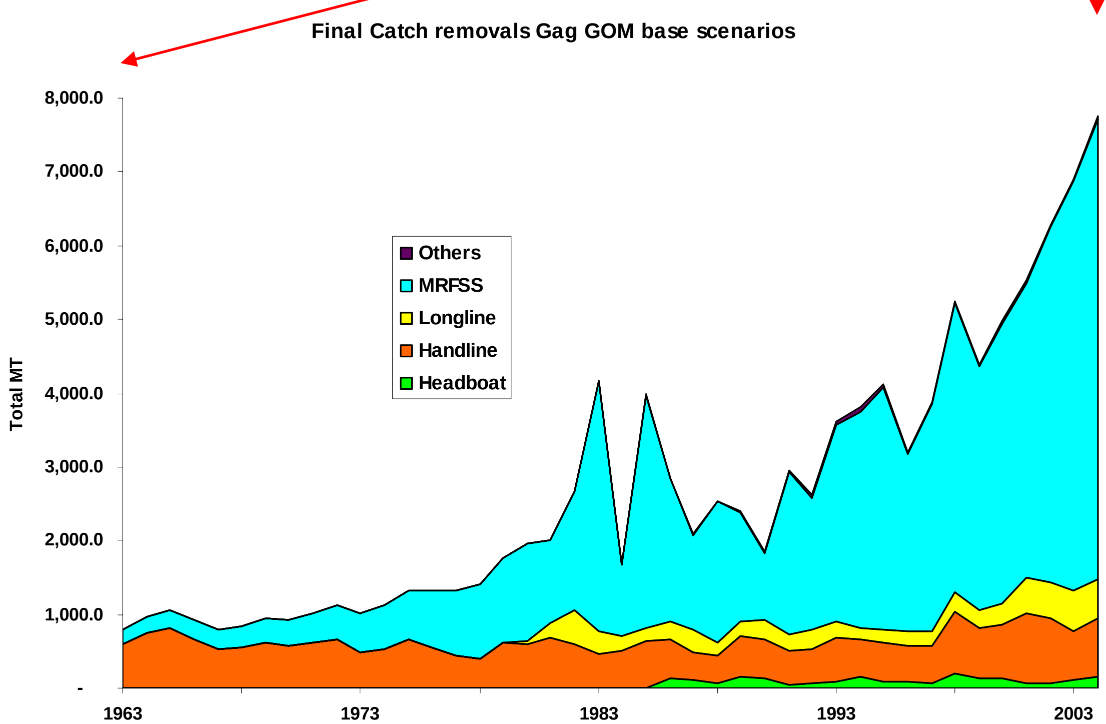


Figure 4. Final catch series for gag GOM including commercial and recreational historic estimates.

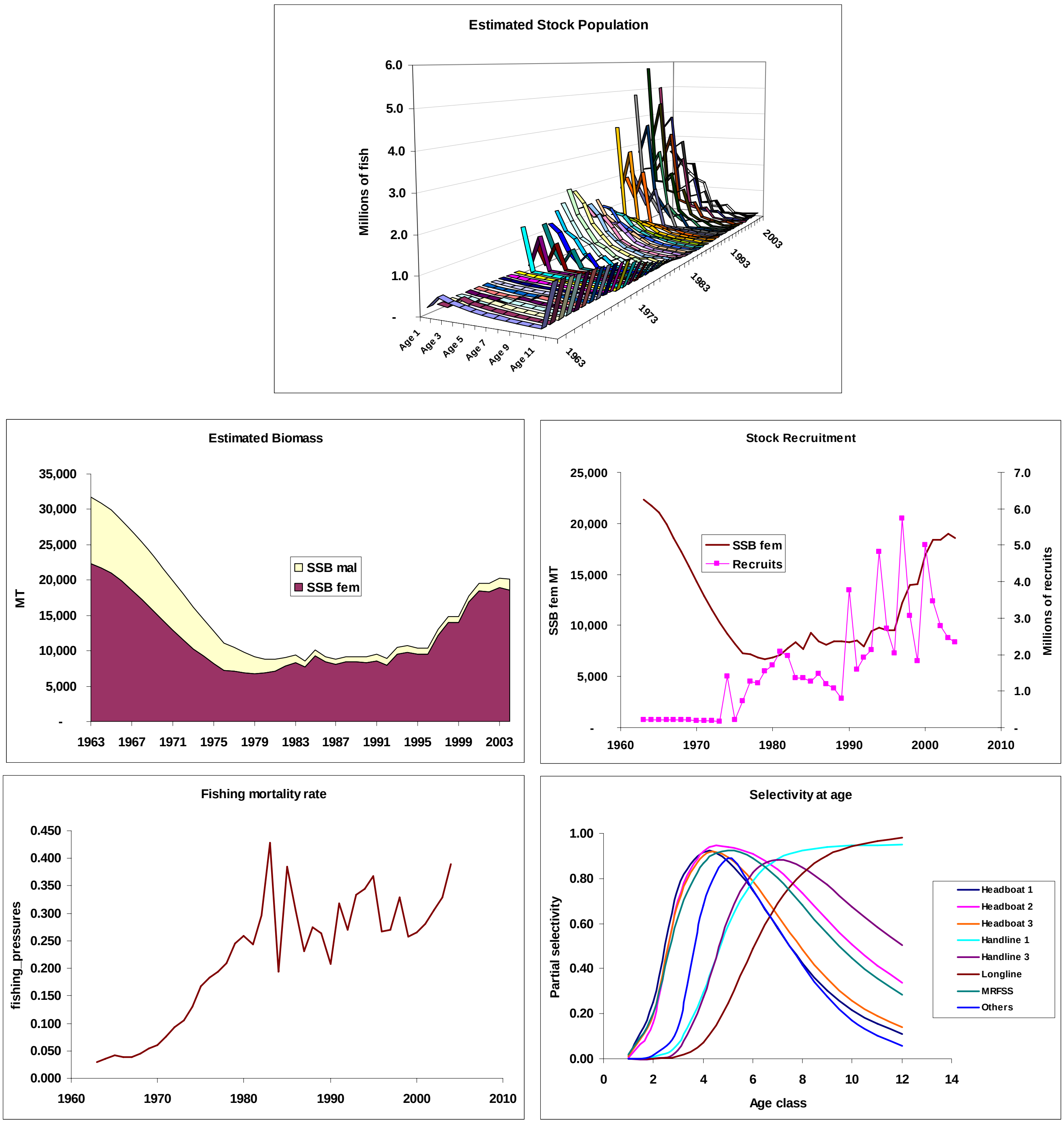


Figure 5. Gag GOM trends of stock size, spawning biomass by sex, recruits, fishing mortality and selectivity at age patterns estimated by the base case 1 scenario.

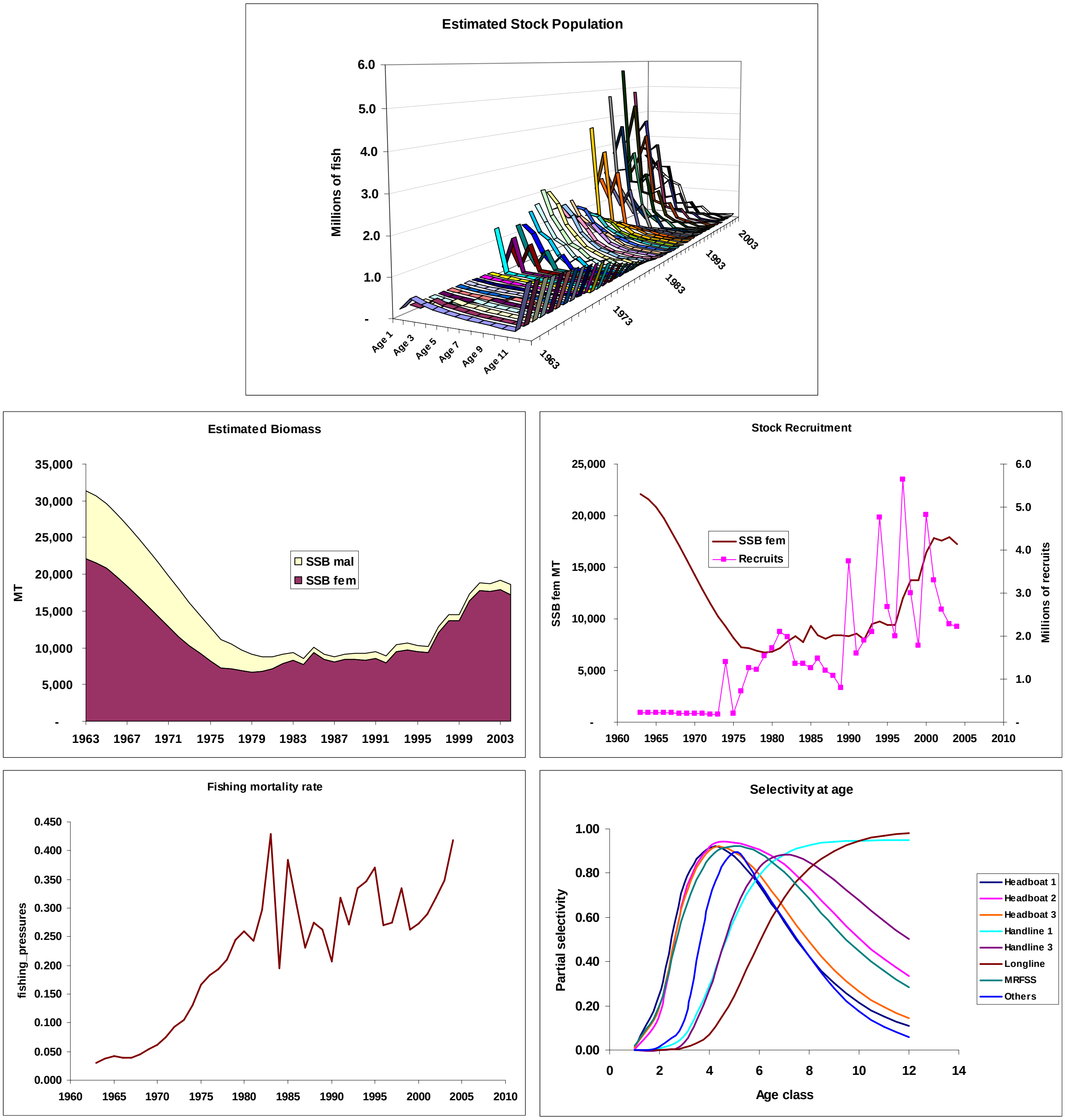
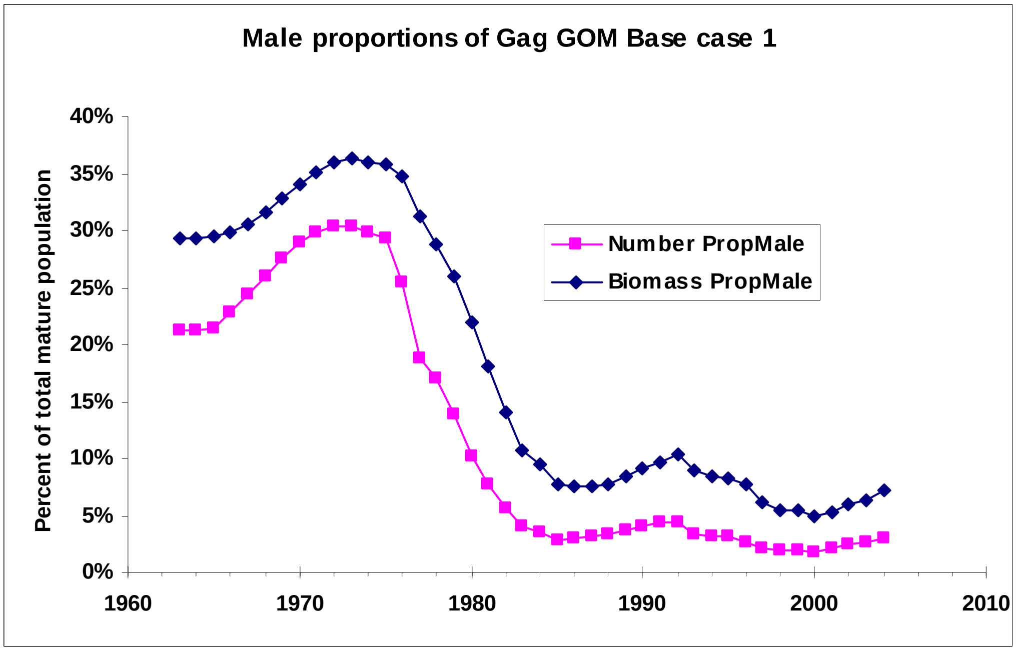


Figure 6. Gag GOM trends of stock size, spawning biomass by sex, recruits, fishing mortality and selectivity at age patterns estimated by the base case 2 scenario.



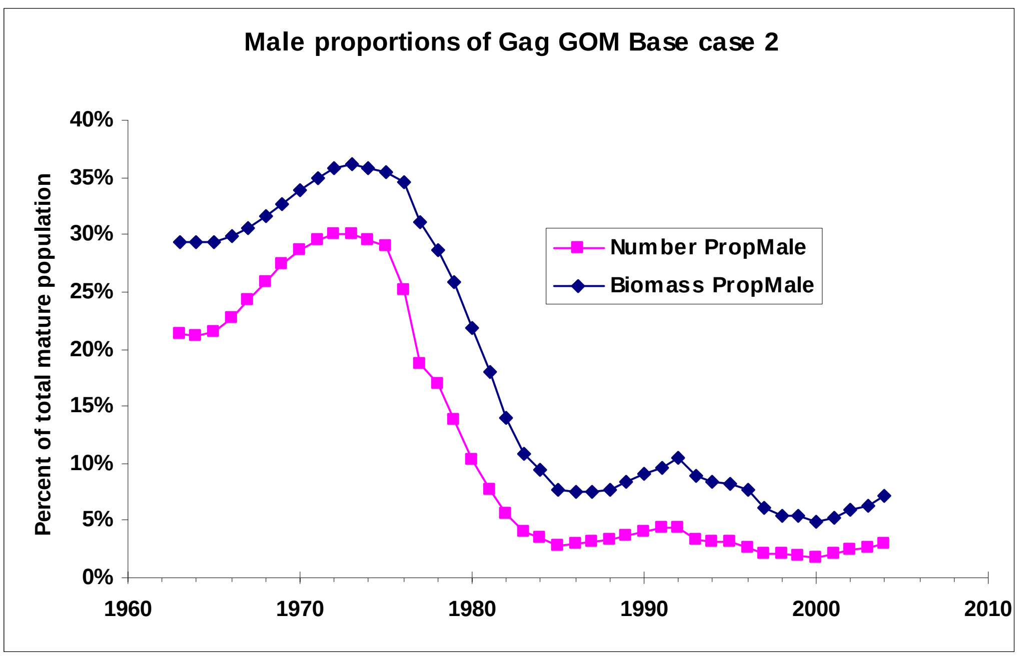


Figure 7. Trends of percent males of mature population in numbers and biomass for gag GOM base case scenarios.

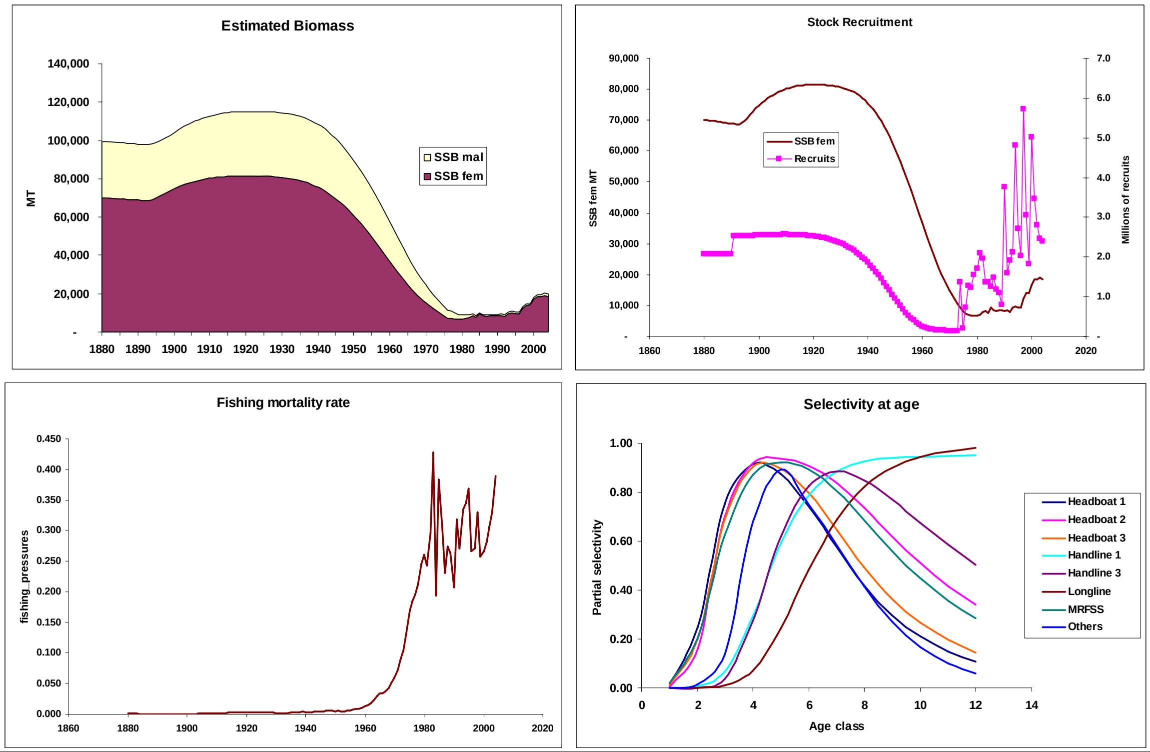


Figure 8. Gag GOM trends of stock size, spawning biomass by sex, recruits, fishing mortality and selectivity at age patterns estimated by the case 3 extended historic catch series 1880-2004.

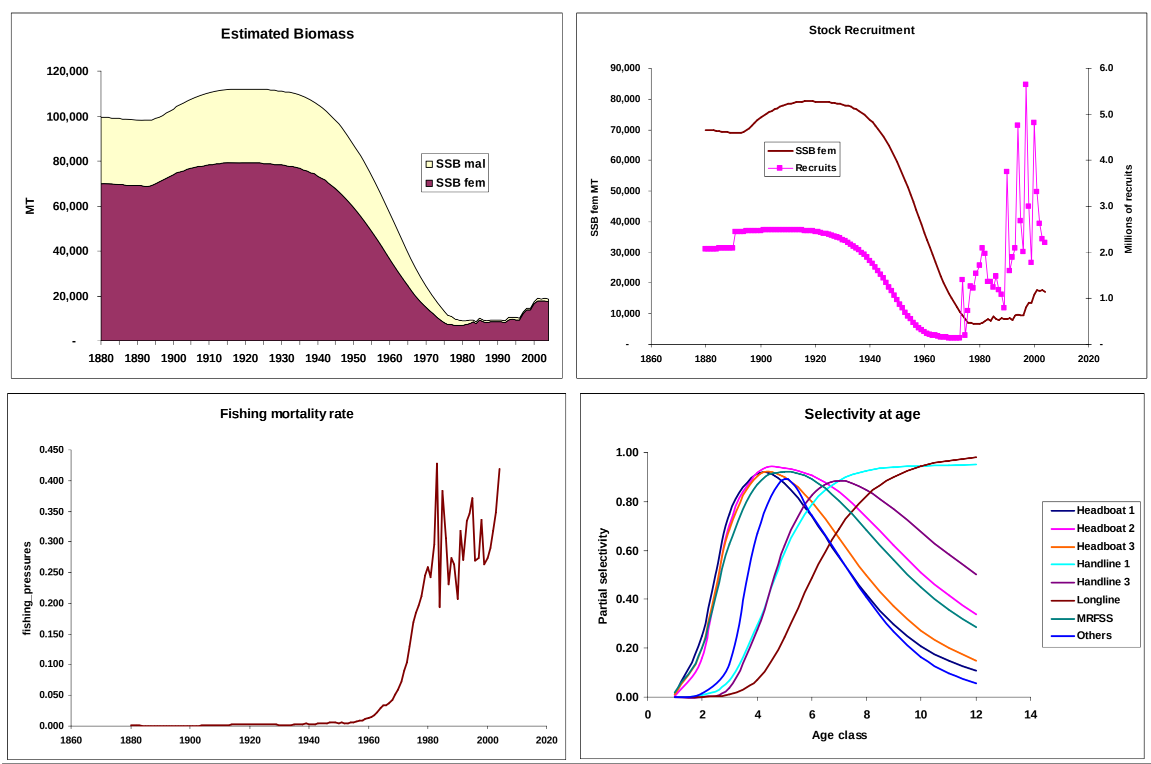


Figure 9. Gag GOM trends of stock size, spawning biomass by sex, recruits, fishing mortality and selectivity at age patterns estimated by the case 4 extended historic catch series 1880-2004 increasing catchability.

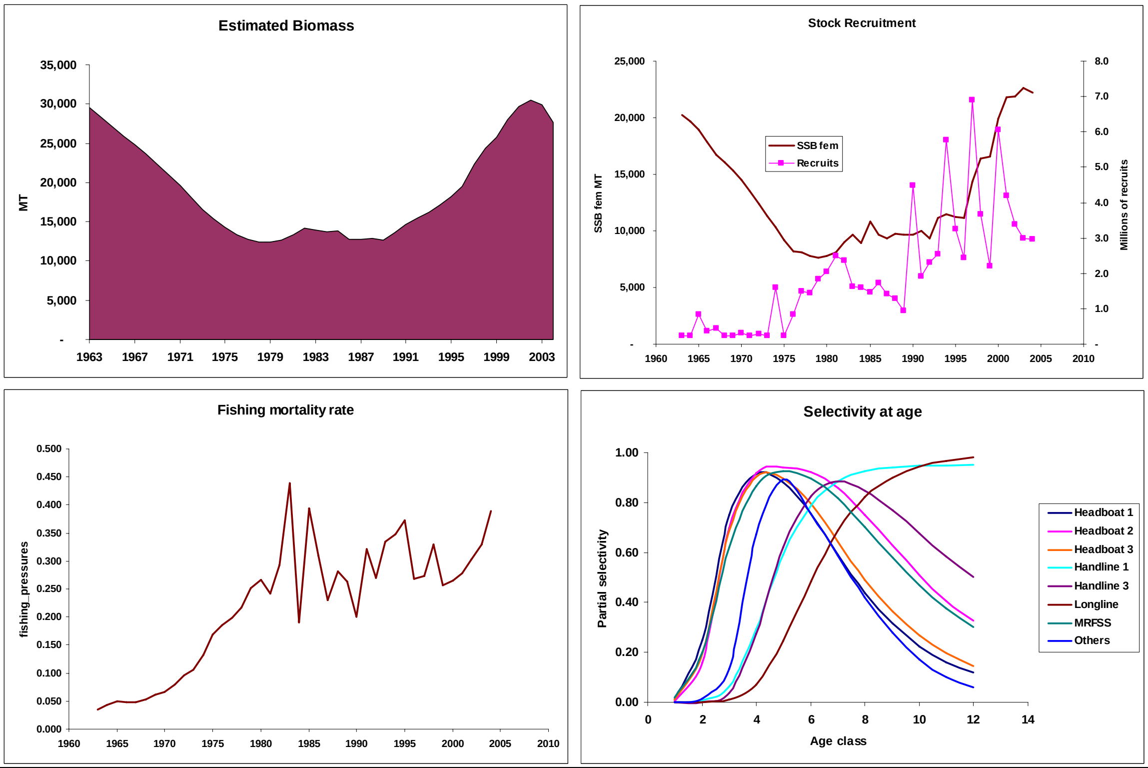


Figure 11. Gag GOM trends of stock size, spawning biomass, recruits, fishing mortality and selectivity at age patterns estimated by the case5 increase MRFSS catch by 25% 1963-2004.

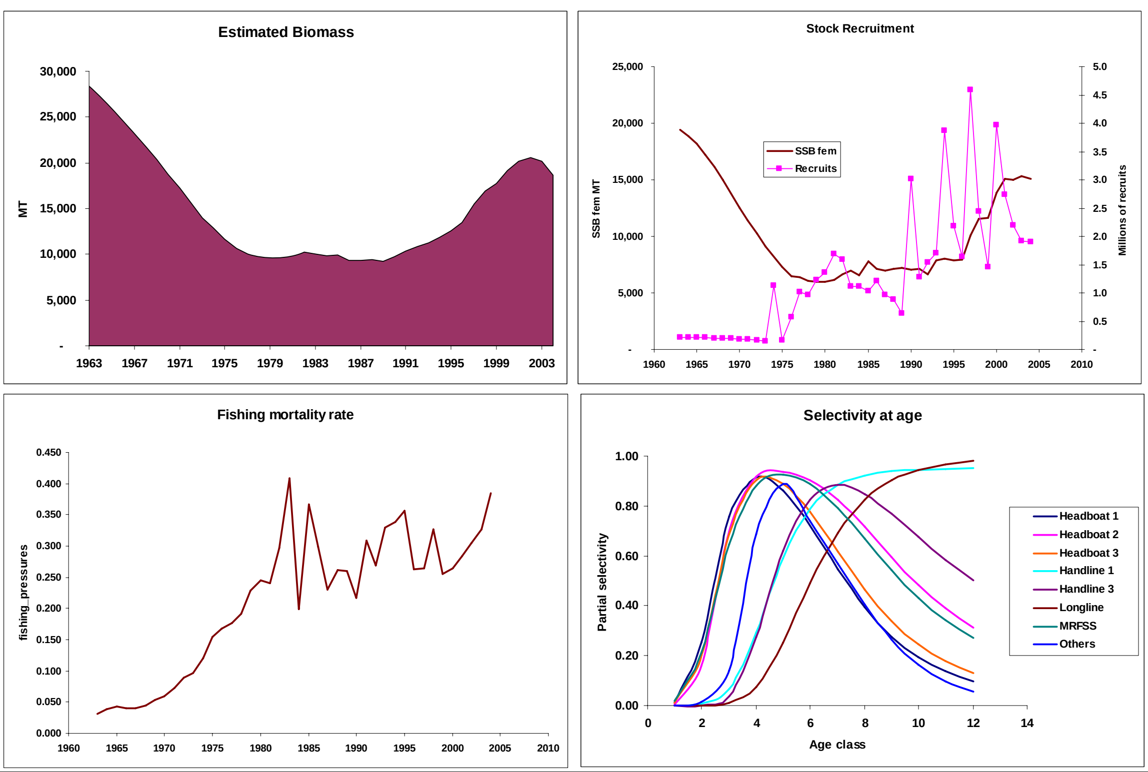


Figure 10. Gag GOM trends of stock size, spawning biomass, recruits, fishing mortality and selectivity at age patterns estimated by the case5 decrease MRFSS catch by 25% 1963-2004.

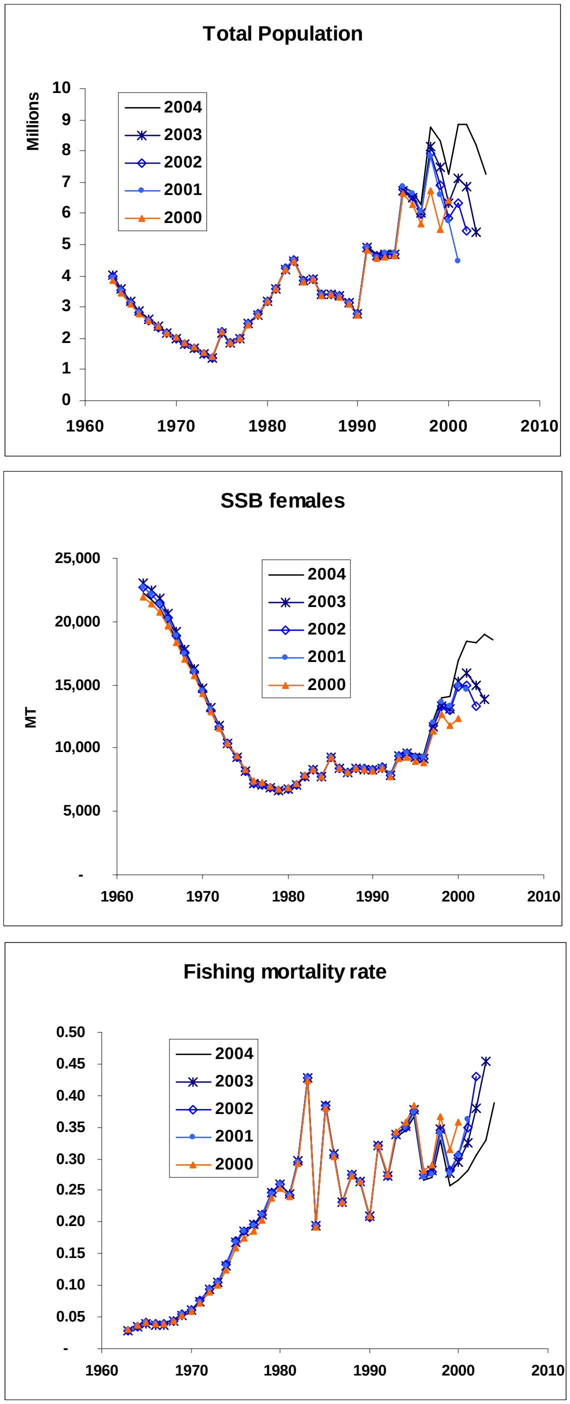


Figure 12. Retrospective analysis plots. Comparison of estimated total population, biomass, spawning biomass, recruits and fishing mortality rates for the base case 1 scenario.

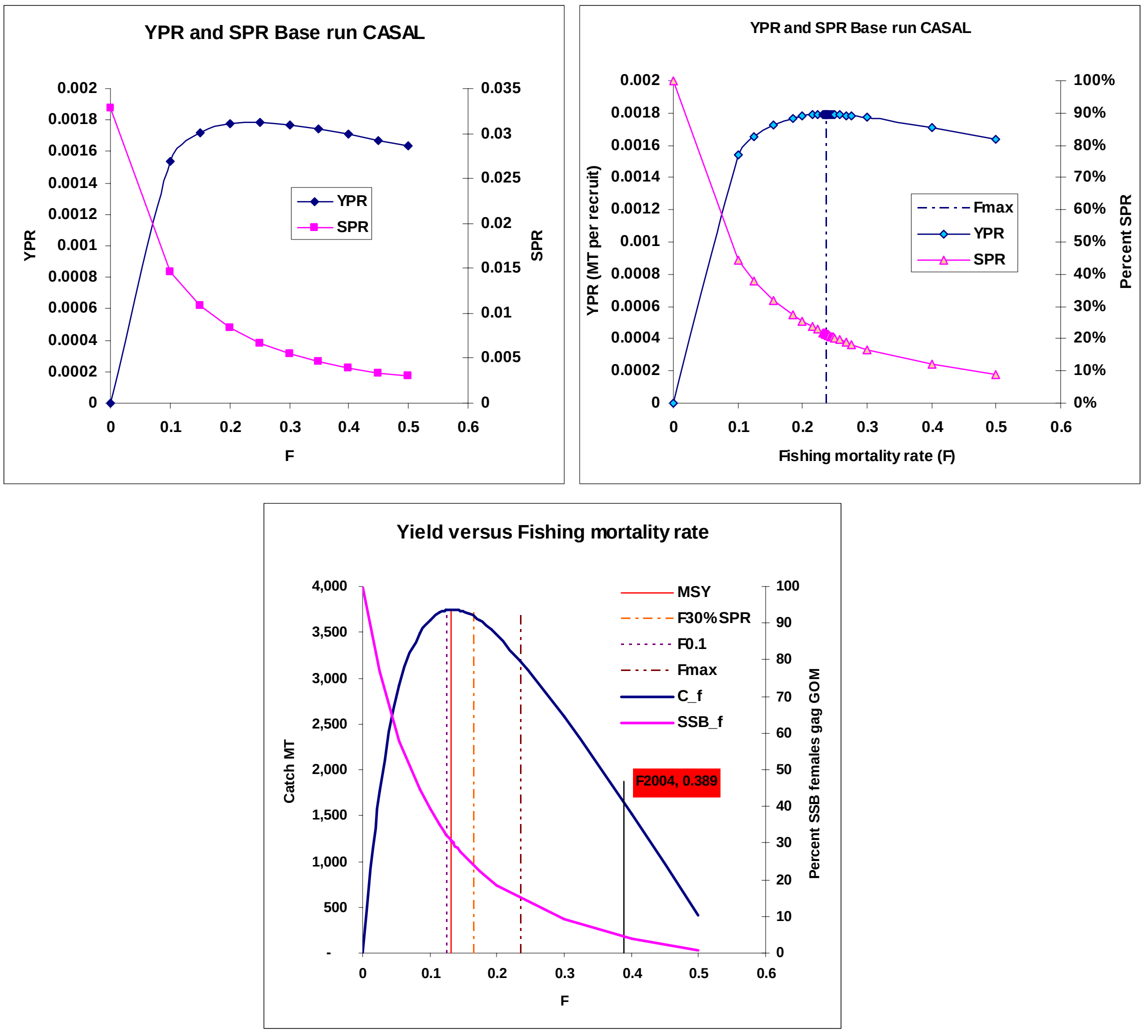


Figure 13. Yield per recruit and spawner per recruit deterministic plots for gag GOM estimated from the base case 1 scenario with projections of Beverton & Holt SR relationship all years. Bottom plot shows the catch and percent spawning biomass versus F with estimated F benchmarks, $F_{0.1}$, F_{MSY}, $F_{30\%SPR}$ and F_{Max}, also plotted is the F_{2004}.

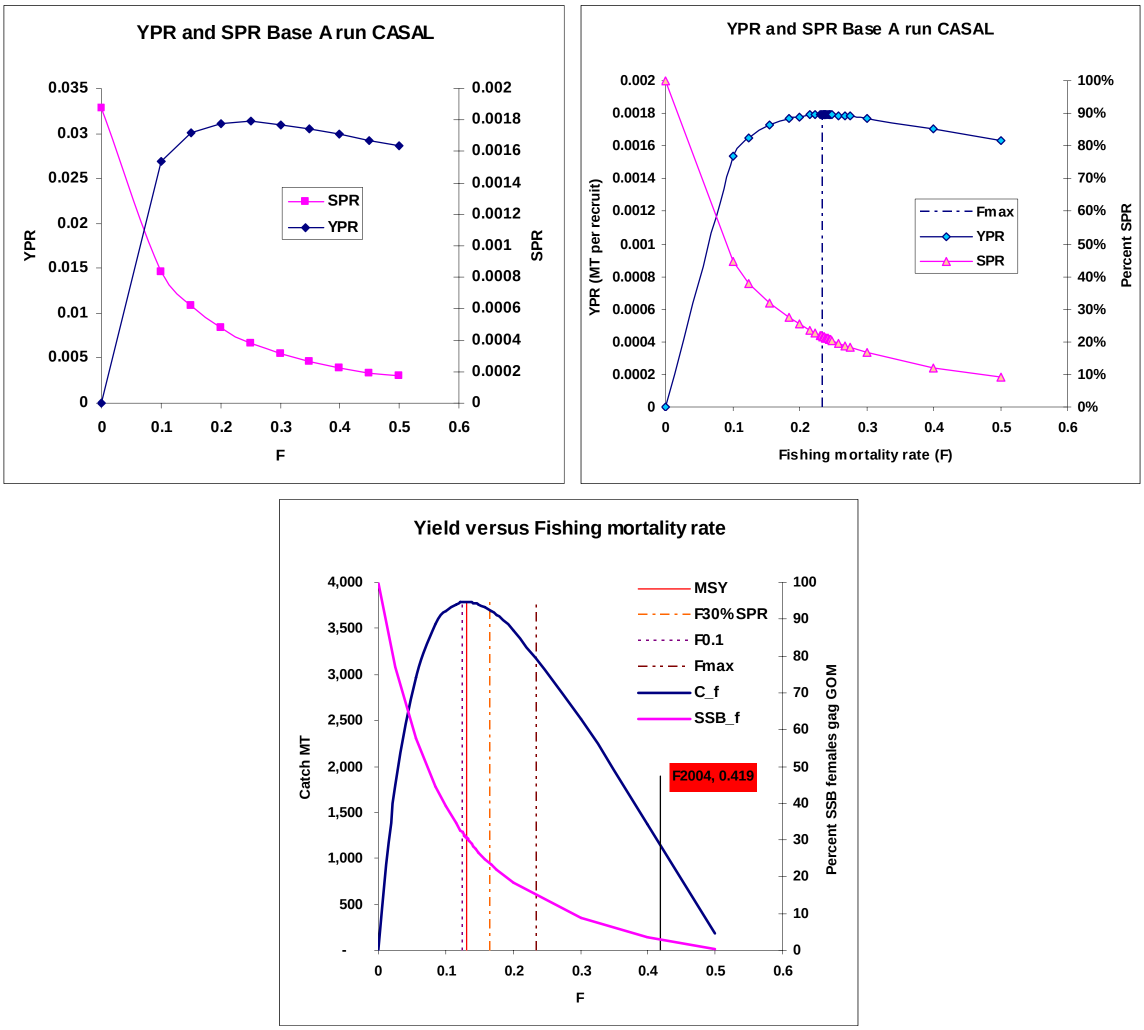


Figure 14. Yield per recruit and spawner per recruit deterministic plots for gag GOM estimated from the base case 2 scenario with projections of Beverton & Holt SR relationship all years. Bottom plot shows the catch and percent spawning biomass versus F with estimated F benchmarks, $F_{0.1}$, F_{MSY}, $F_{30\%SPR}$ and F_{Max}, also plotted is the F_{2004}.

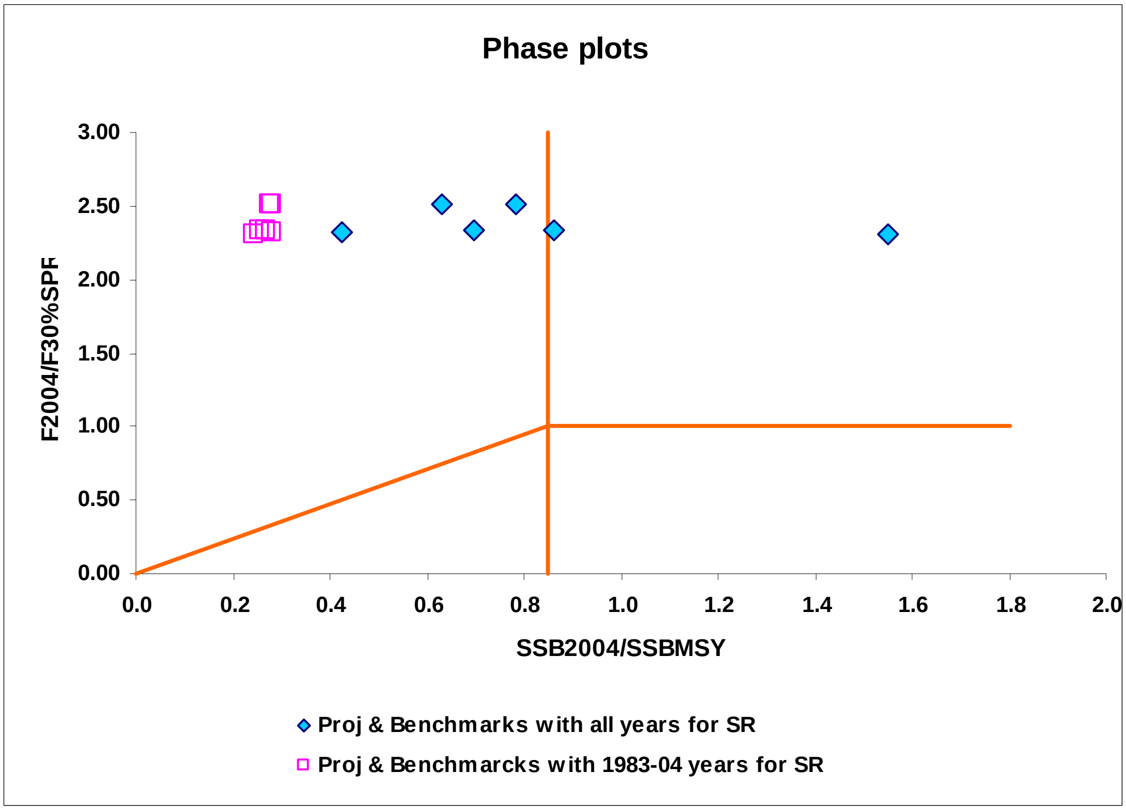
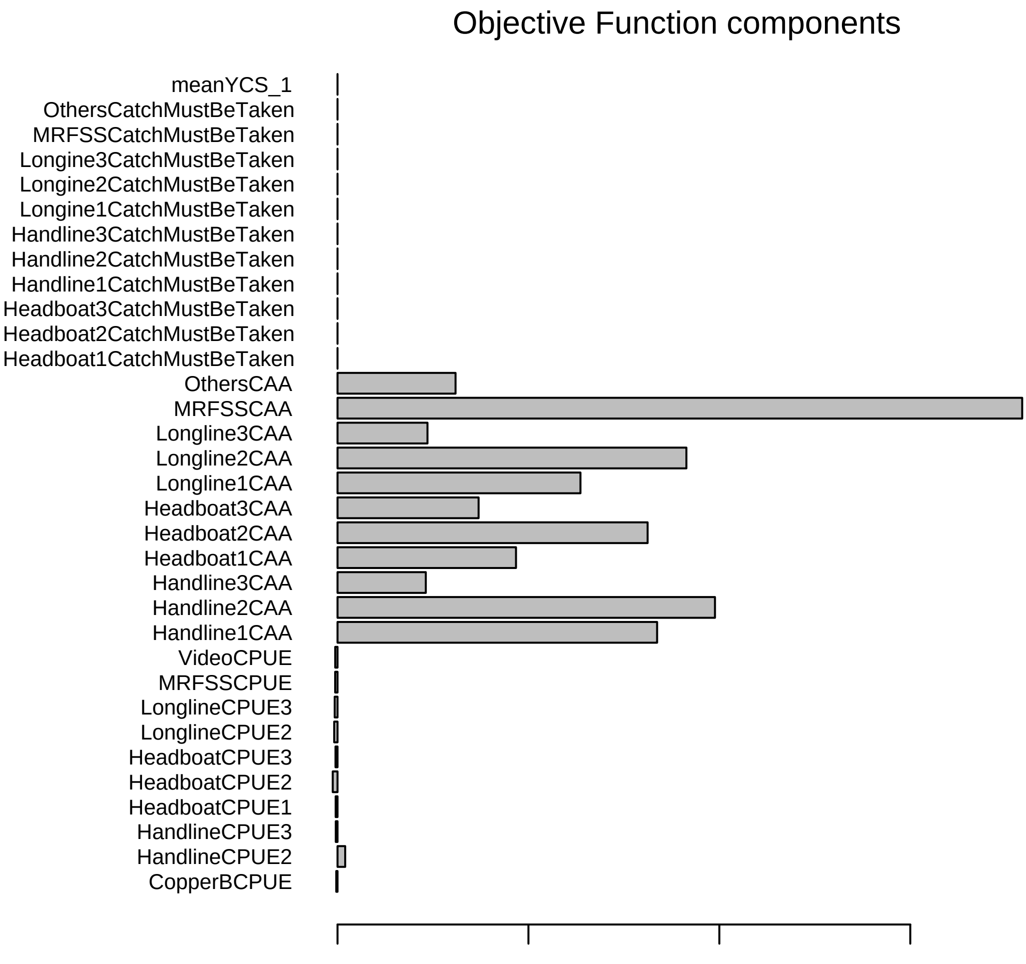
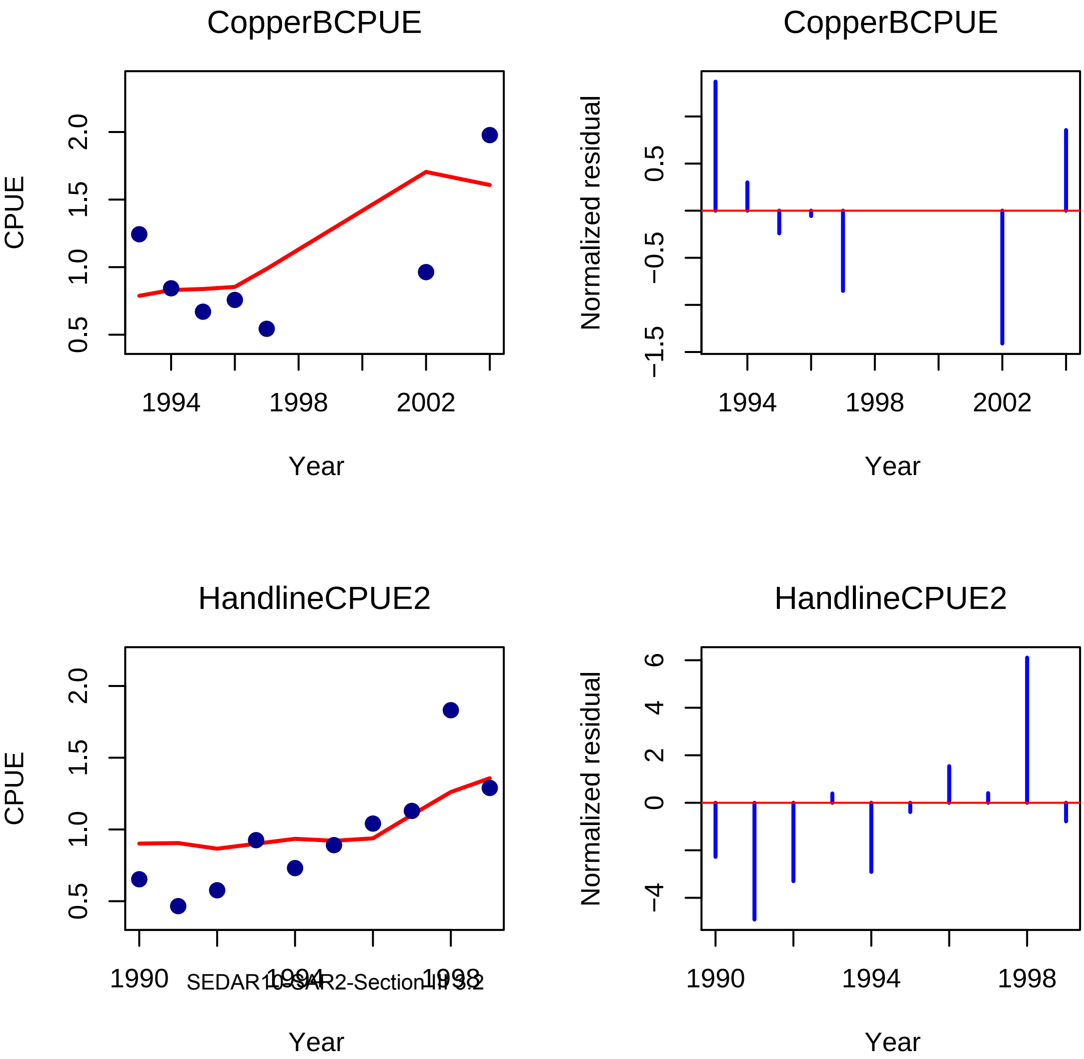
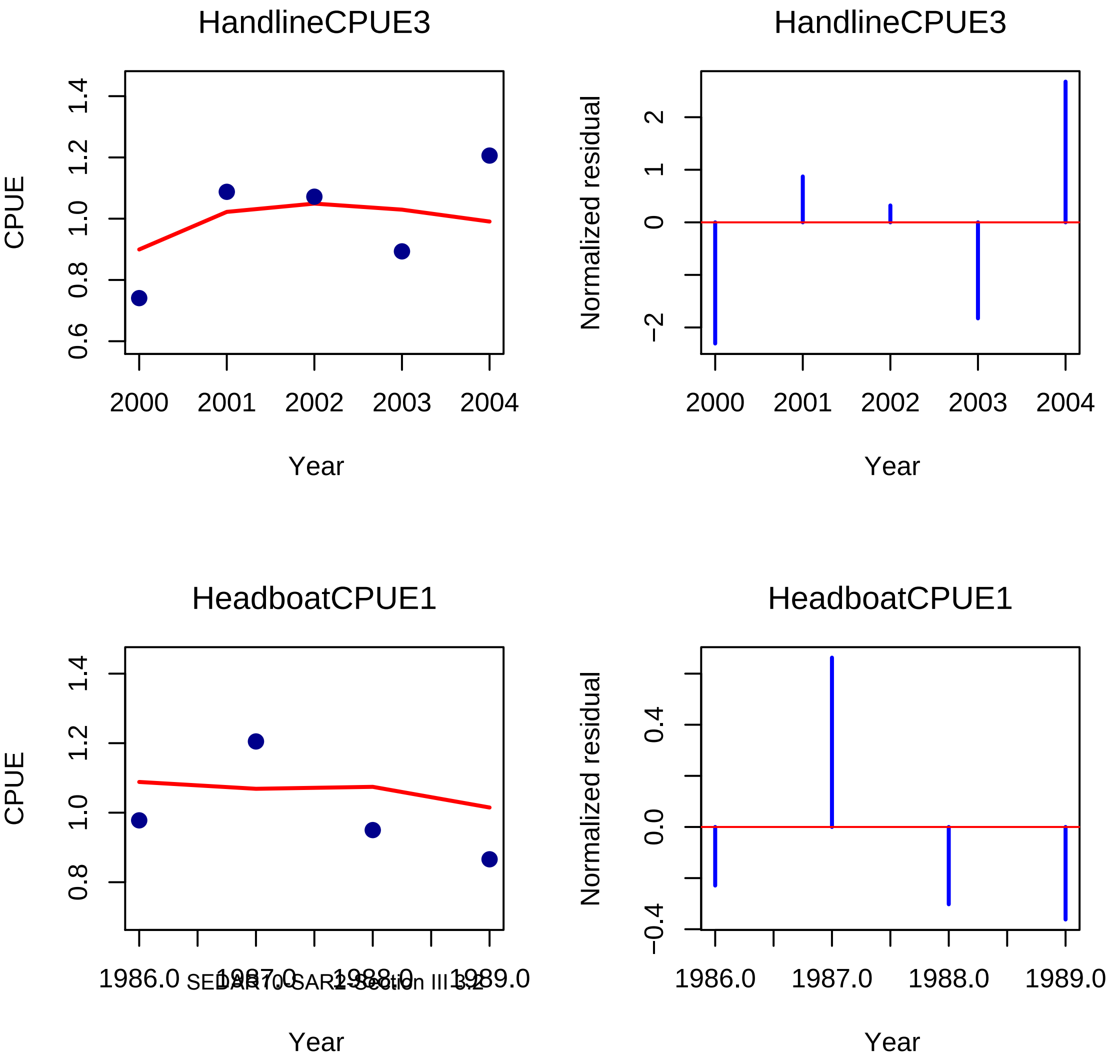
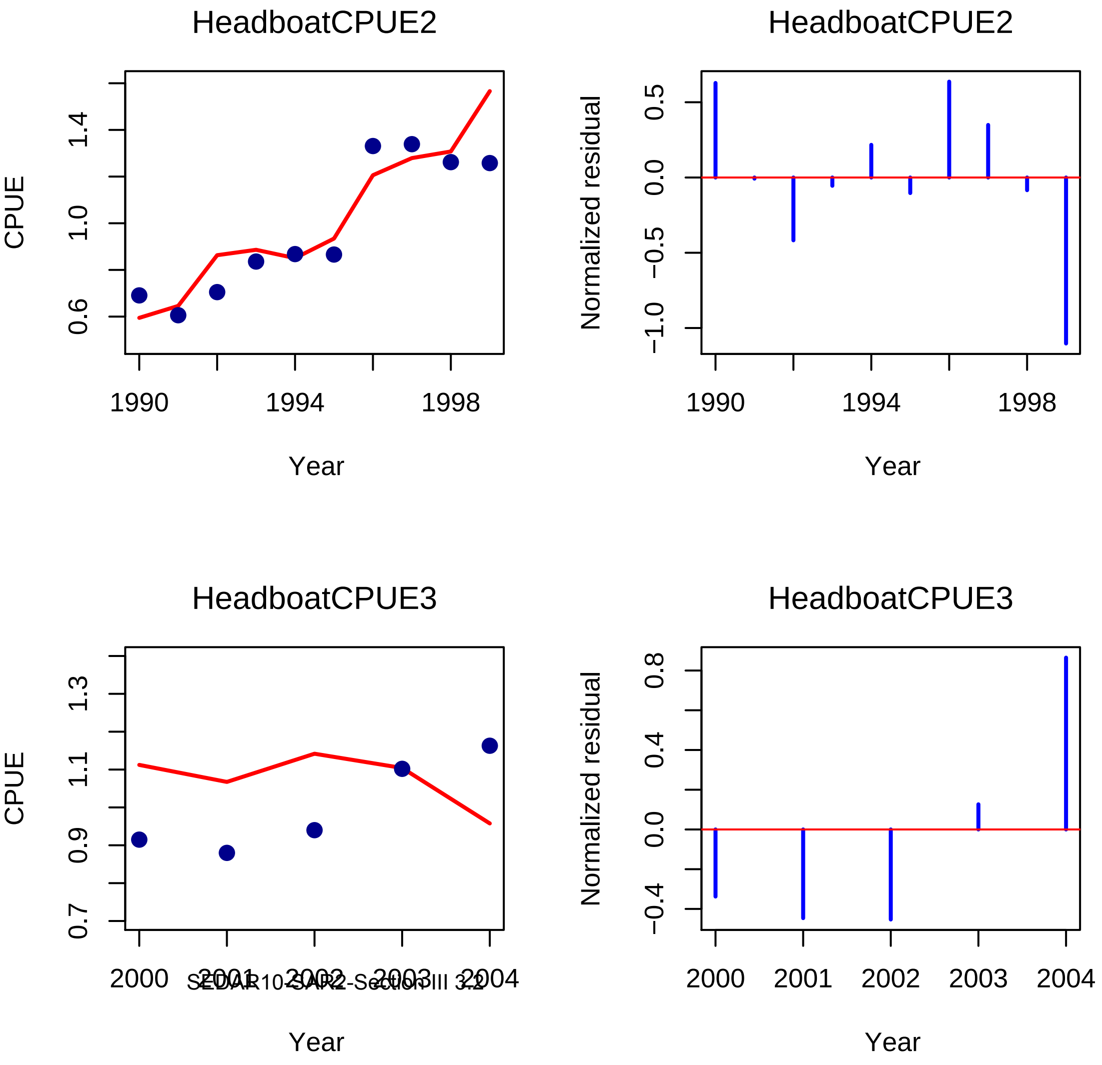


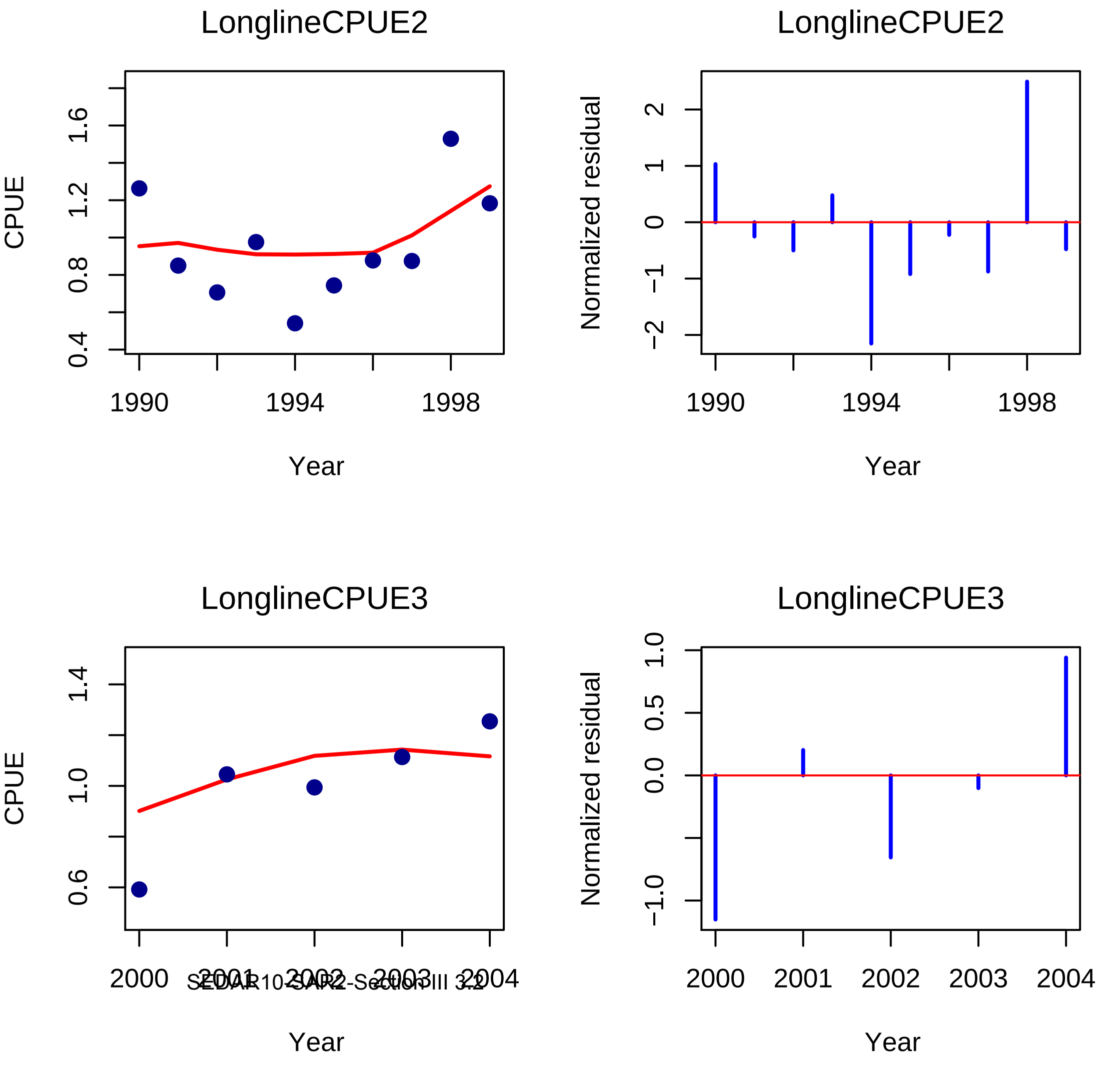
Figure 15. Preliminary phase plot of gag GOM status. Diamonds represent status based on projections and estimation of benchmarks using B&H SR with all years in time series. Squares represent status based on projections and estimation of benchmarks using B&H SR with 1983-2004 years only. Spawning biomass refers to female component.

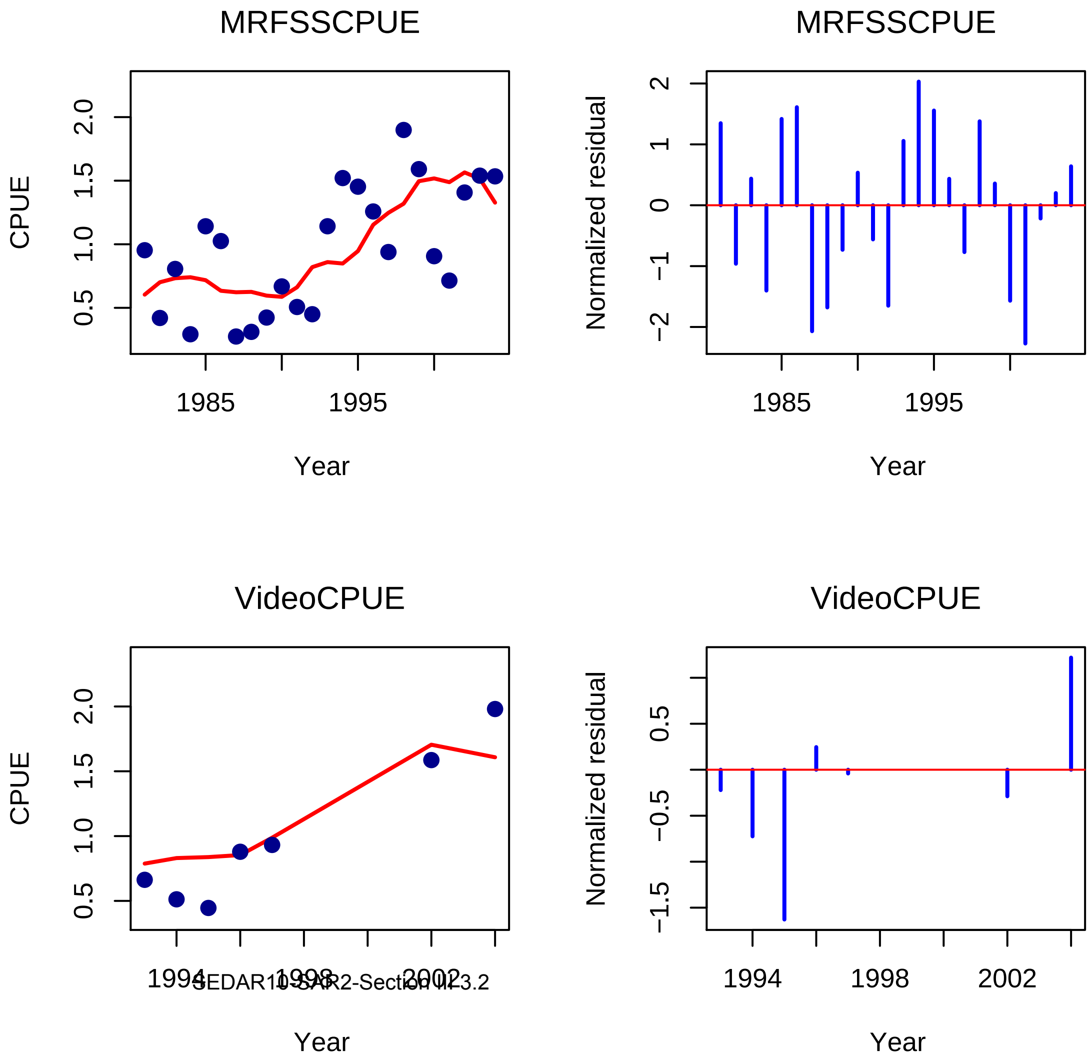

Objective Function components
meanYCS_1
OthersCatchMustBeTaken
MRFSSCatchMustBeTaken
Longine3CatchMustBeTaken
Longine2CatchMustBeTaken
Longine1CatchMustBeTaken
Handline3CatchMustBeTaken
Handline2CatchMustBeTaken
Handline1CatchMustBeTaken
Headboat3CatchMustBeTaken
Headboat2CatchMustBeTaken
Headboat1CatchMustBeTaken
OthersCAA
MRFSSCAA
Longline3CAA
Longline2CAA
Longline1CAA
Headboat3CAA
Headboat2CAA
Headboat1CAA
Handline3CAA
Handline2CAA
Handline1CAA
VideoCPUE
MRFSSCPUE
LonglineCPUE3
LonglineCPUE2
HeadboatCPUE3
HeadboatCPUE2
HeadboatCPUE1
HandlineCPUE3
HandlineCPUE2
CopperBCPUE
0
500
1000
1500

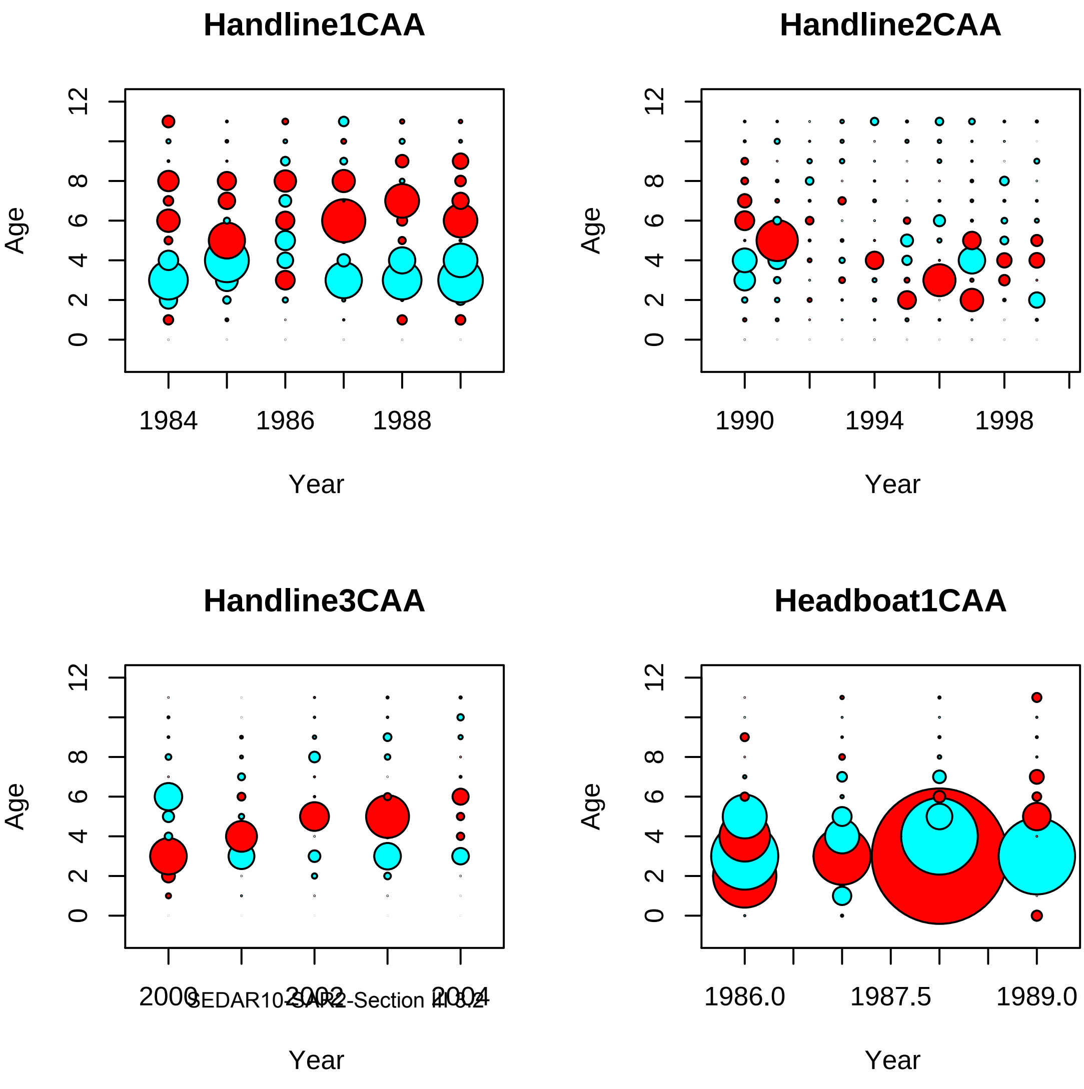

CopperBCPUE
CPUE
0.5
1.0
1.5
2.0
1994
1998
2002
Year
CopperBCPUE
Normalized residual
−1.5
−0.5
0.5
1994
1998
2002
Year
HandlineCPUE2
CPUE
0.5
1.0
1.5
2.0
1990
1994
1998
Year
HandlineCPUE2
Normalized residual
−4
0
2
4
6
1990
1994
1998
Year

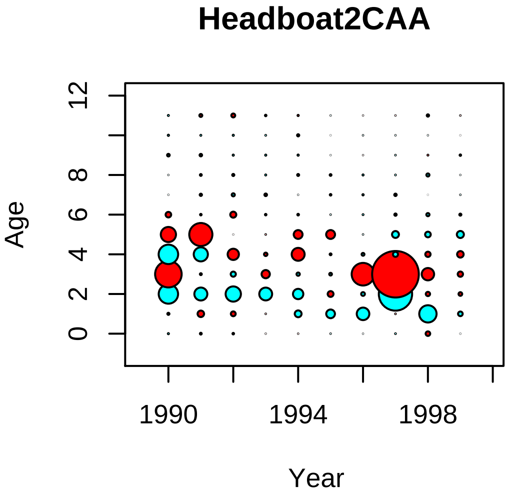

HandlineCPUE3
CPUE
0.6
0.8
1.0
1.2
1.4
2000
2001
2002
2003
2004
Year
HandlineCPUE3
Normalized residual
−2
0
1
2
2000
2001
2002
2003
2004
Year
HeadboatCPUE1
CPUE
0.8
1.0
1.2
1.4
1986.0
1987.0
1988.0
1989.0
Year
HeadboatCPUE1
Normalized residual
−0.4
0.0
0.4
1986.0
1987.0
1988.0
1989.0
Year

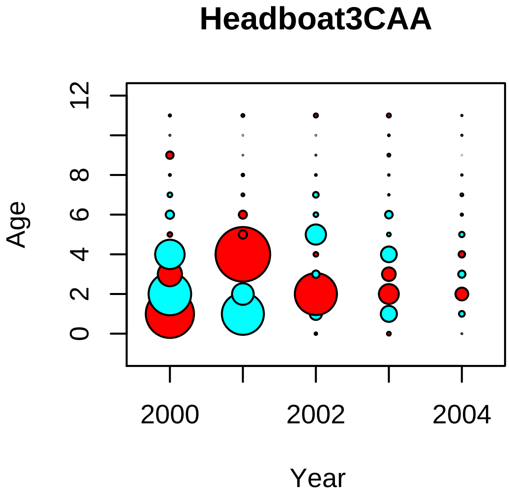

HeadboatCPUE2
CPUE
0.6
1.0
1.4
1990
1994
1998
Year
HeadboatCPUE2
Normalized residual
−1.0
−0.5
0.0
0.5
1990
1994
1998
Year
HeadboatCPUE3
CPUE
0.7
0.9
1.1
1.3
2000
2001
2002
2003
2004
Year
HeadboatCPUE3
Normalized residual
−0.4
0.0
0.4
0.8
2000
2001
2002
2003
2004
Year

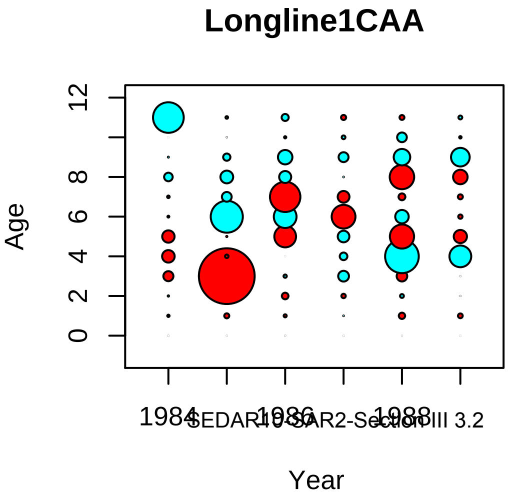

LonglineCPUE2
CPUE
0.4
0.8
1.2
1.6
1990
1994
1998
Year
LonglineCPUE2
Normalized residual
−2
−1
0
1
2
1990
1994
1998
Year
LonglineCPUE3
CPUE
0.6
1.0
1.4
2000
2001
2002
2003
2004
Year
LonglineCPUE3
Normalized residual
−1.0
0.0
0.5
1.0
2000
2001
2002
2003
2004
Year

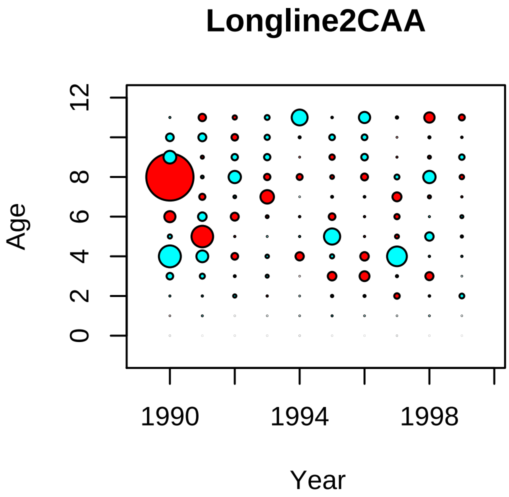

MRFSSCPUE
CPUE
0.5 1.0 1.5 2.0
1985 1995
Year
MRFSSCPUE
Normalized residual
−2 −1 0 1 2
1985 1995
Year
VideoCPUE
CPUE
0.5 1.0 1.5 2.0
1994 1998 2002
Year
VideoCPUE
Normalized residual
−1.5 −0.5 0.5
1994 1998 2002
Year

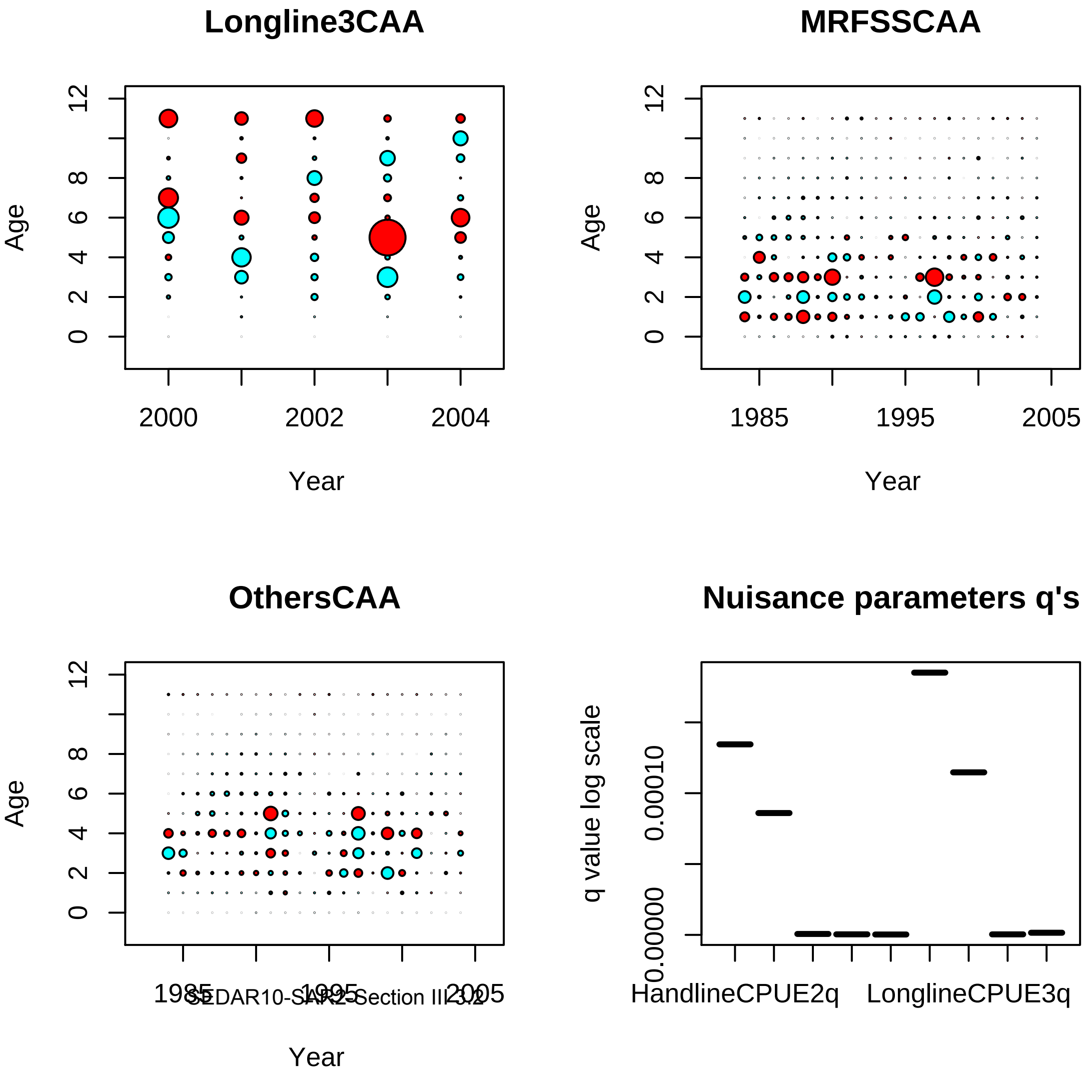

Handline1CAA
Handline2CAA
Handline3CAA
Headboat1CAA
Age
Year
0
2
4
6
8
12
1984
1986
1988
1990
1994
1998
2000
2002
2004
1986.0
1987.5
1989.0

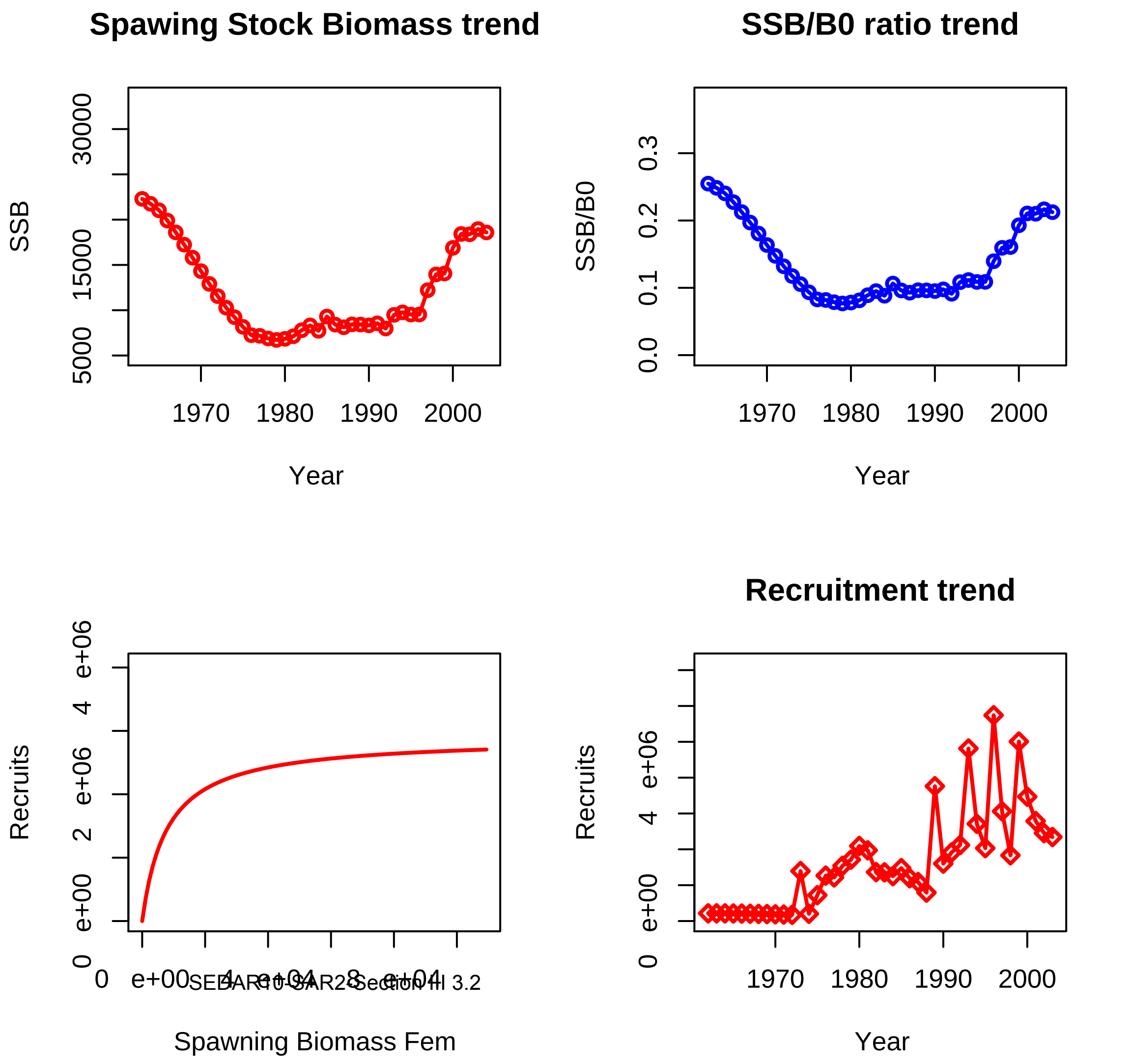

Headboat2CAA
Age
0
2
4
6
8
12
1990
1994
1998
Year

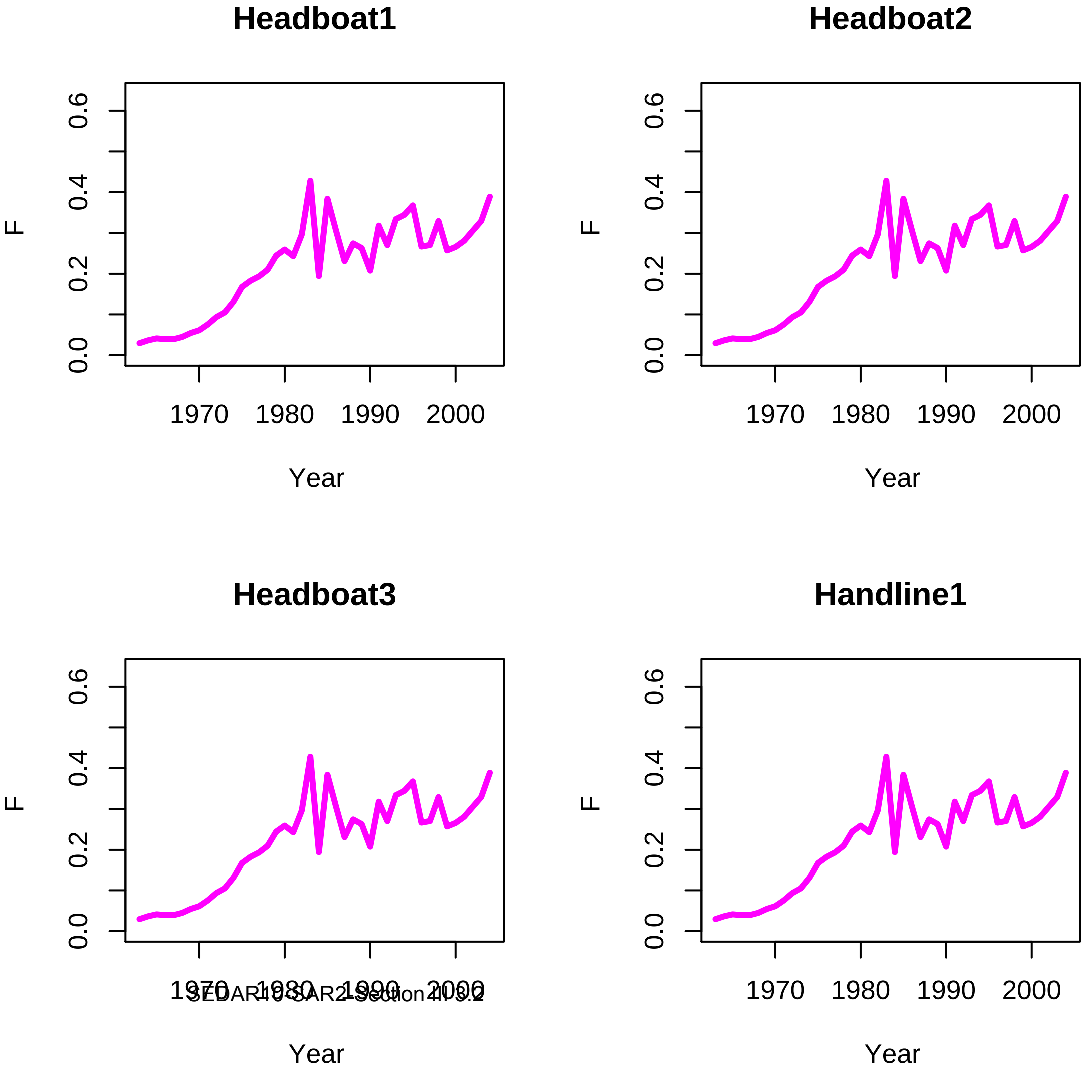

Headboat3CAA
Age
0
2
4
6
8
12
2000
2002
2004
Year

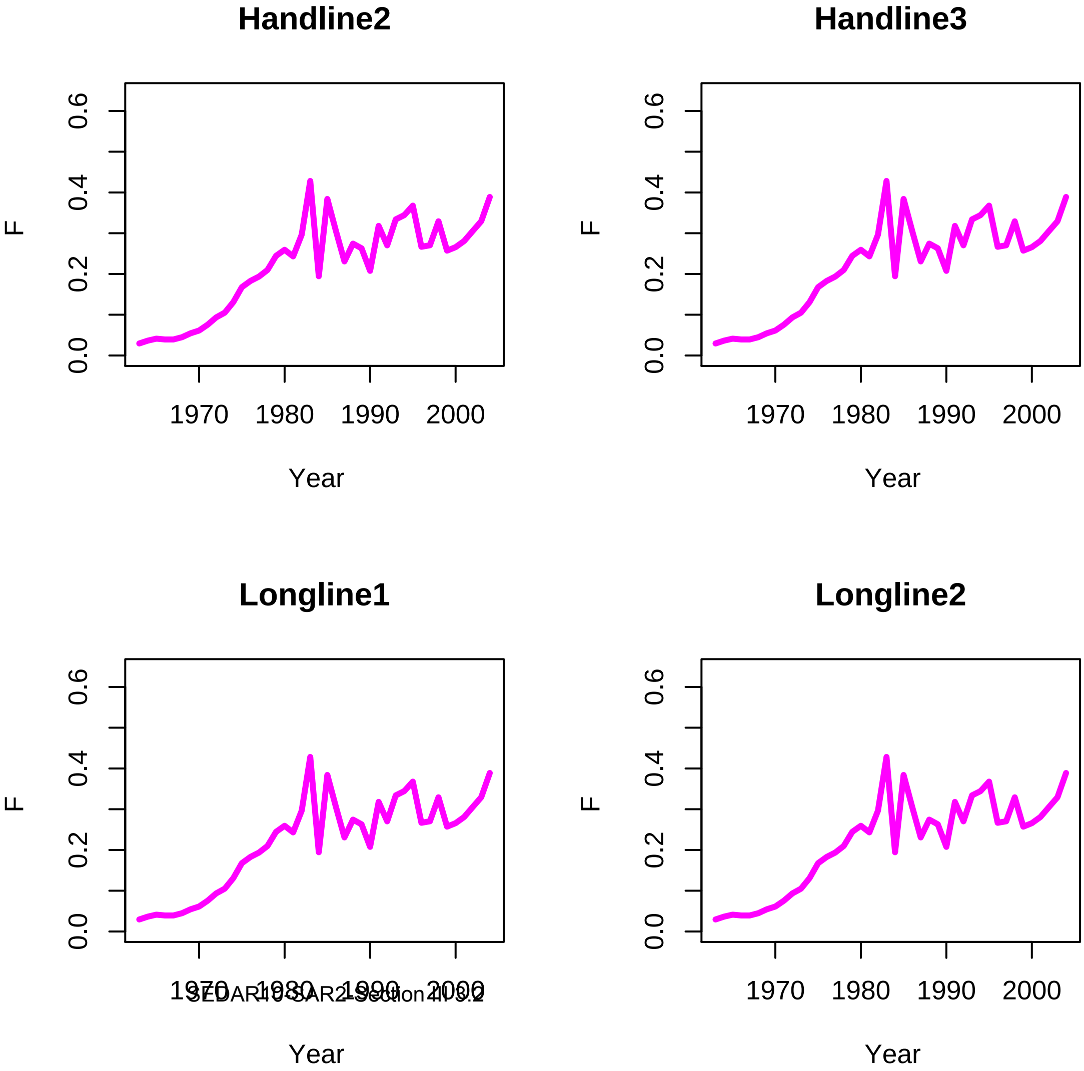

Longline1CAA
Age
0
2
4
6
8
12
1984
1986
1988
Year

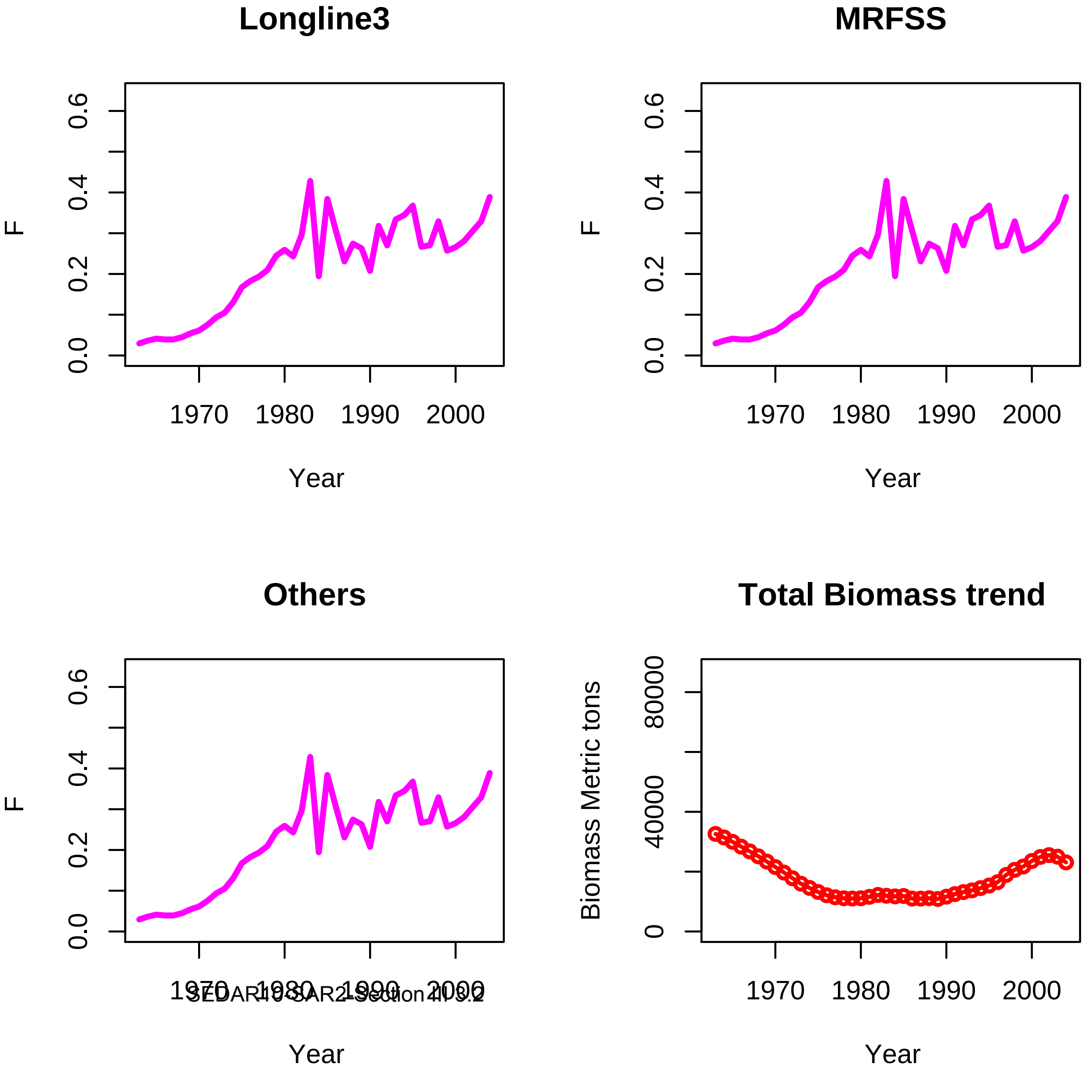

Longline2CAA
Age
0
2
4
6
8
12
1990
1994
1998
Year

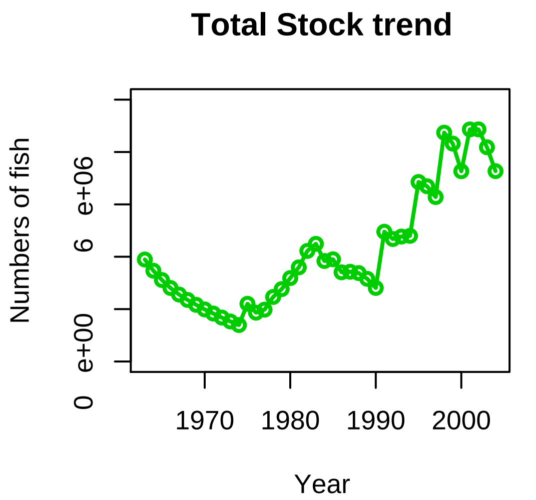

Longline3CAA
MRFSSCAA
OthersCAA
Nuisance parameters q's
Age
Year
0
2
4
6
8
12
2000
2002
2004
1985
1995
2005
q value log scale
0.00000
0.00010
HandlineCPUE2q
LonglineCPUE3q


Spawing Stock Biomass trend
SSB
5000
15000
30000
1970
1980
1990
2000
Year
SSB/B0 ratio trend
SSB/B0
0.0
0.1
0.2
0.3
1970
1980
1990
2000
Year
Recruits
0 e+00
2 e+06
4 e+06
0 e+00
4 e+04
8 e+04
Spawning Biomass Fem
Recruitment trend
Recruits
0 e+00
4 e+06
1970
1980
1990
2000
Year

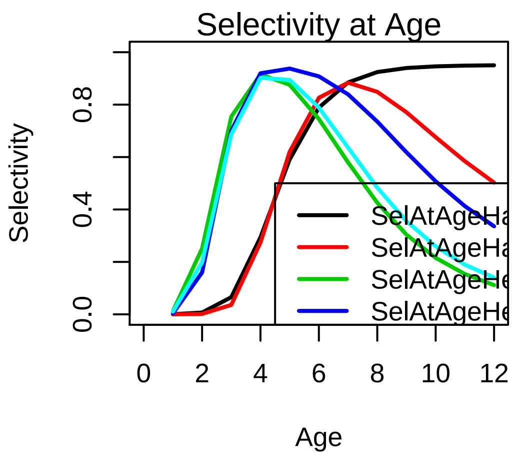

Headboat1
Headboat2
Headboat3
Handline1
F
0.0
0.2
0.4
0.6
1970
1980
1990
2000
Year


Handline2
F
0.0
0.2
0.4
0.6
1970
1980
1990
2000
Year
Handline3
F
0.0
0.2
0.4
0.6
1970
1980
1990
2000
Year
Longline1
F
0.0
0.2
0.4
0.6
1970
1980
1990
2000
Year
Longline2
F
0.0
0.2
0.4
0.6
1970
1980
1990
2000
Year

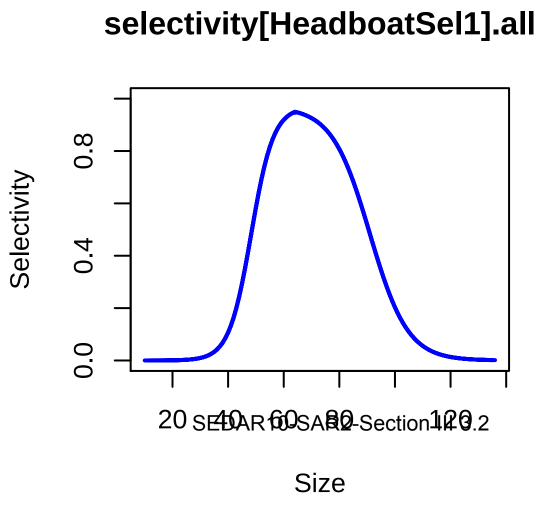

Longline3
MRFSS
Others
Total Biomass trend
F
0.0
0.2
0.4
0.6
1970
1980
1990
2000
Year
Biomass Metric tons
0
40000
80000



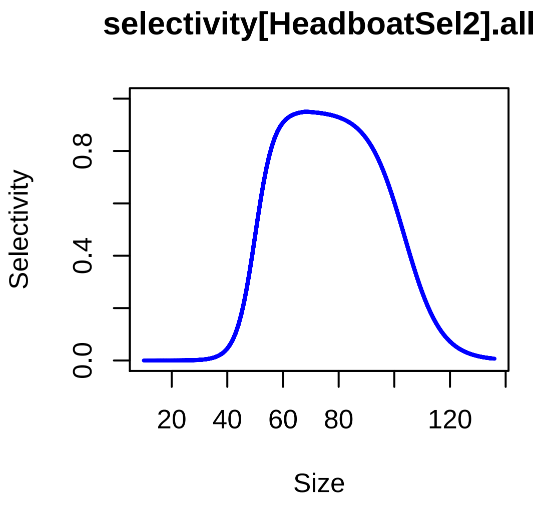
Total Stock trend
Numbers of fish
0 e+00
6 e+06
1970
1980
1990
2000
Year



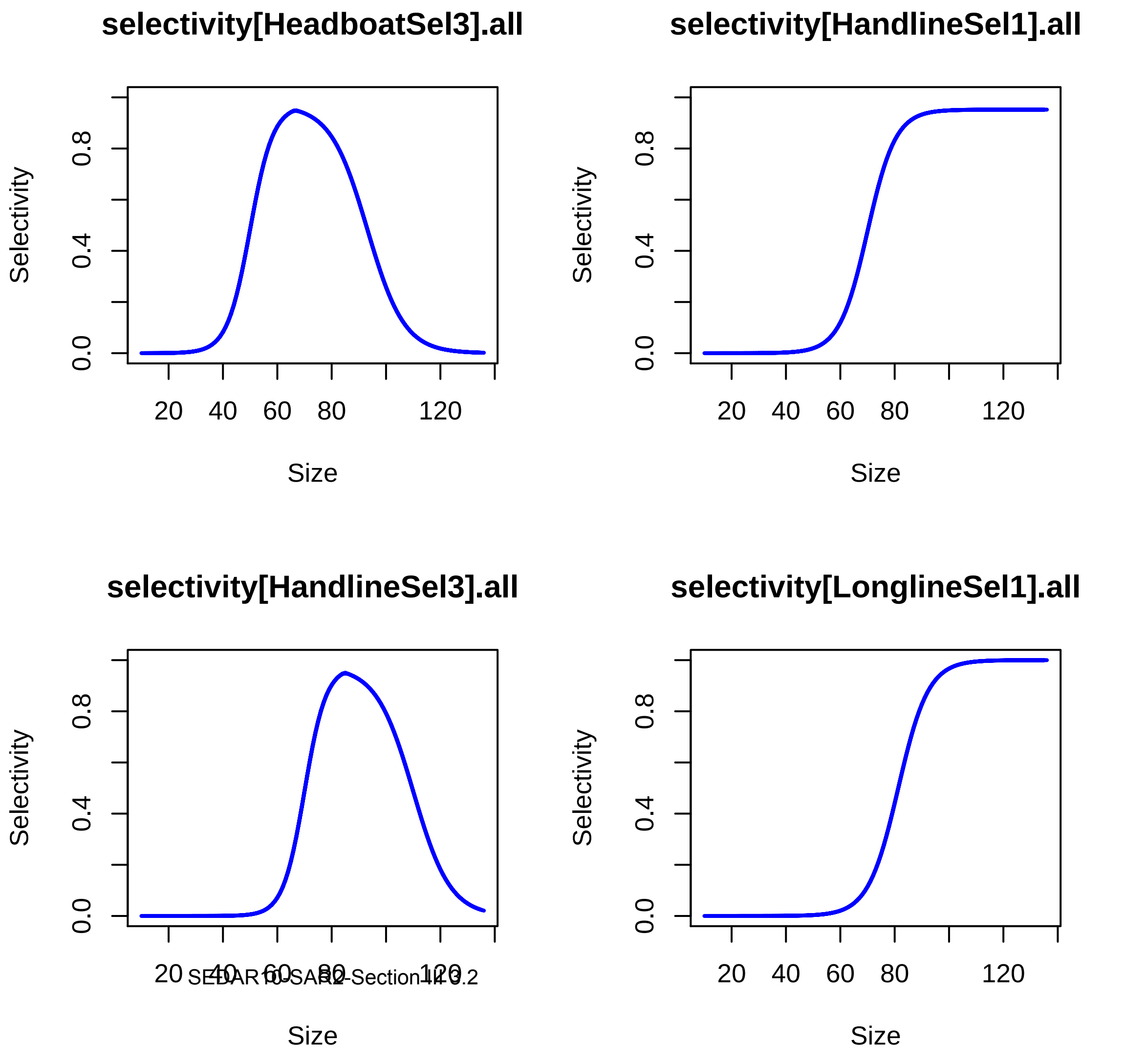
Selectivity at Age
Selectivity
0.0
0.4
0.8
0
2
4
6
8
10
12
Age
SelAtAgeHa
SelAtAgeHa
SelAtAgeHe
SelAtAgeHe

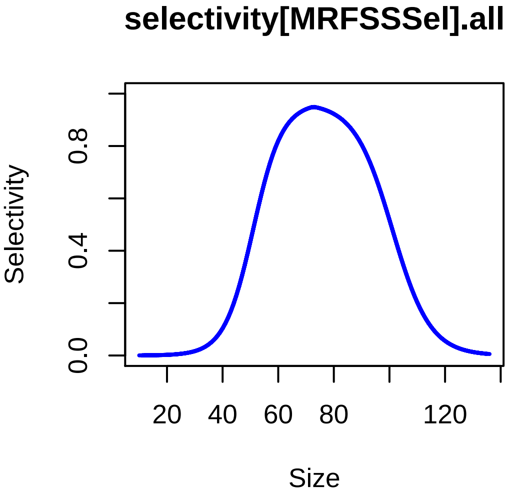


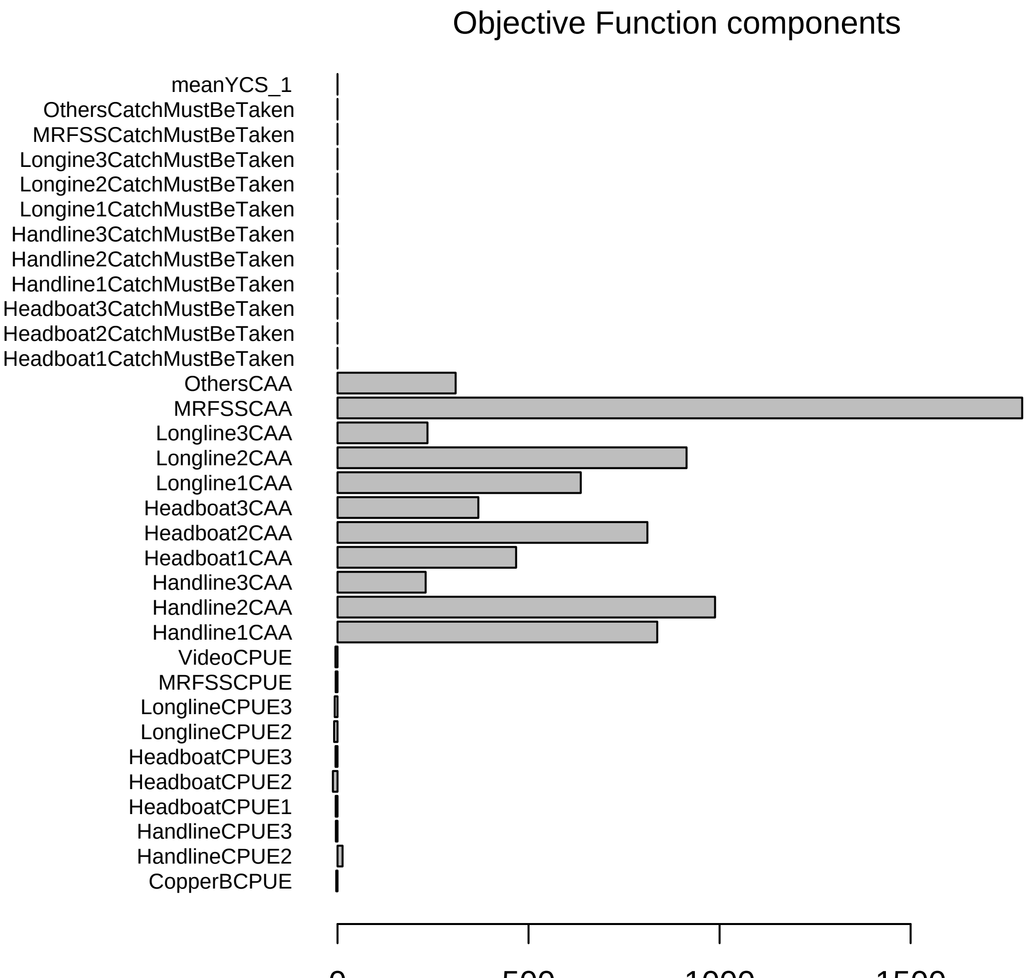
selectivity[HeadboatSel1].all
Selectivity
0.0
0.4
0.8
20
40
60
80
120
Size

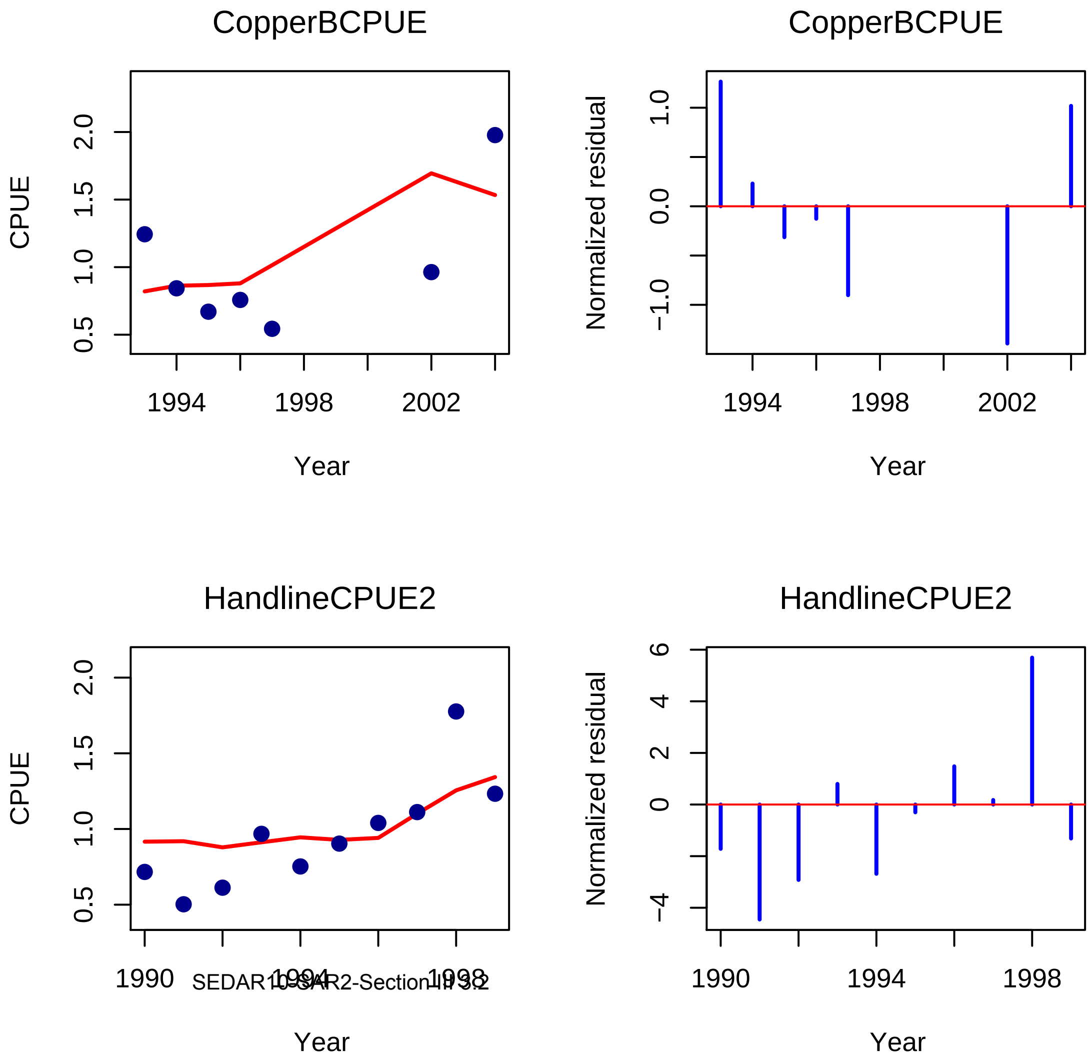


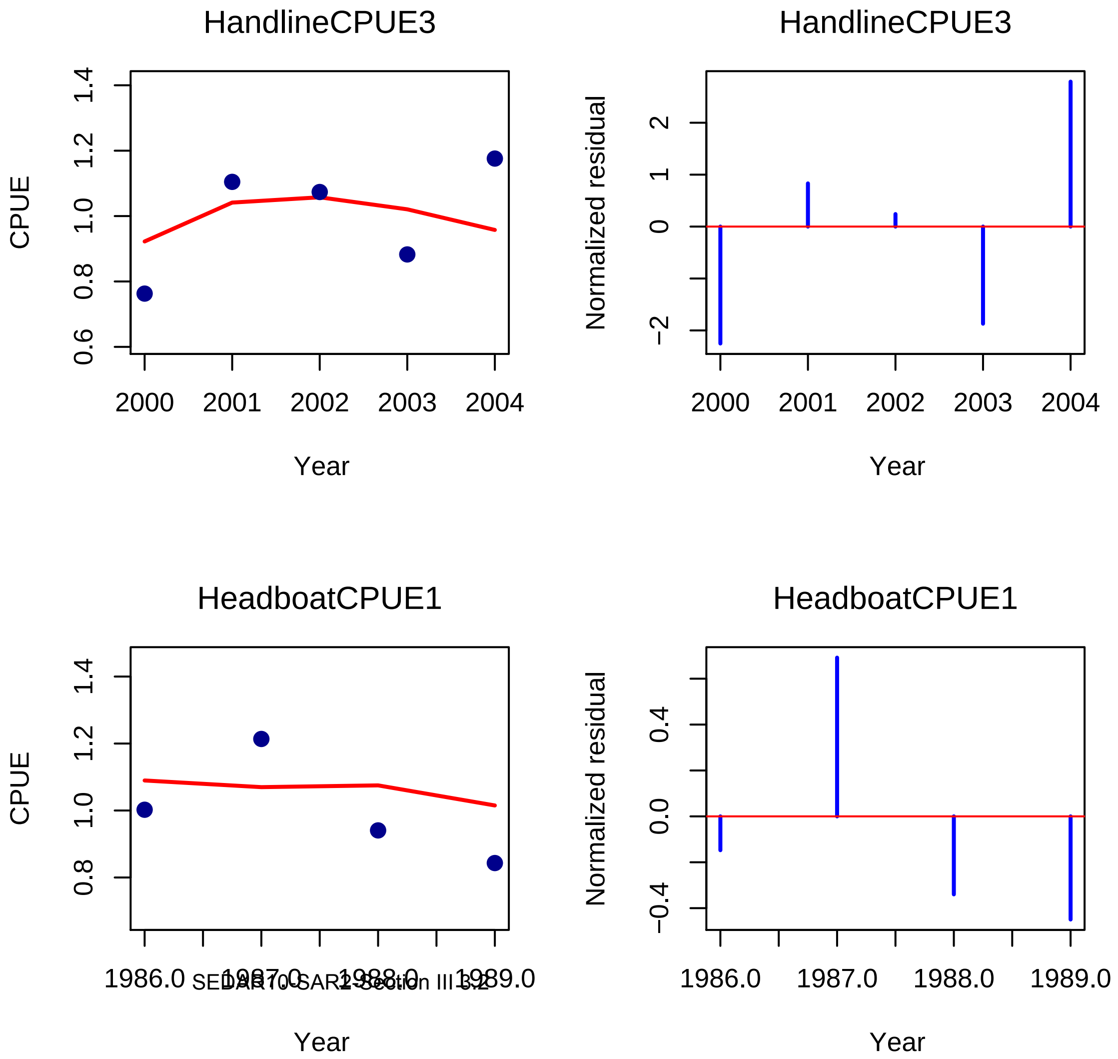
selectivity[HeadboatSel2].all
Selectivity
0.0
0.4
0.8
20
40
60
80
120
Size

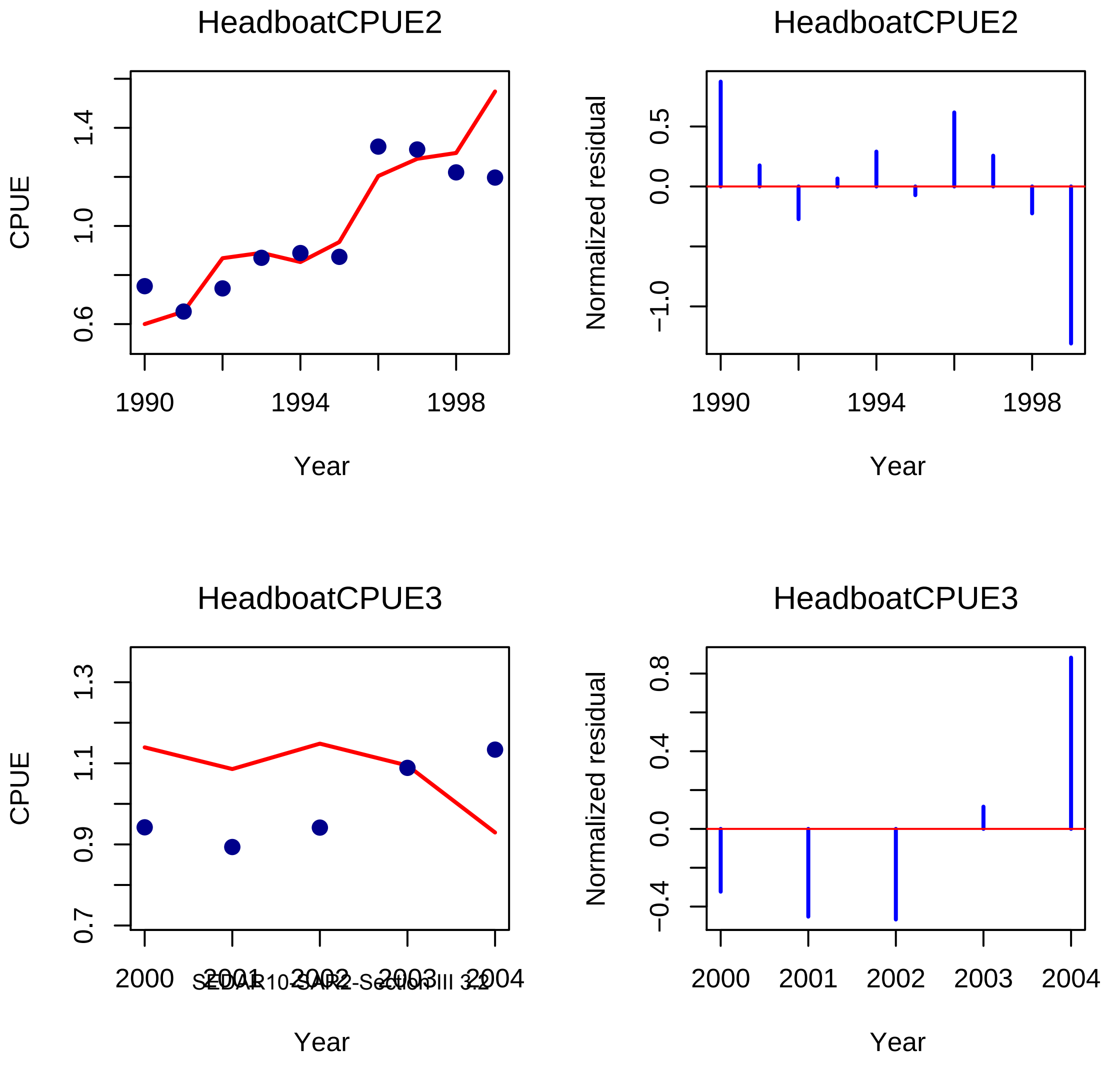

selectivity[HeadboatSel3].all
selectivity[HandlineSel1].all
selectivity[HandlineSel3].all
selectivity[LonglineSel1].all
Selectivity
Size
0.0
0.4
0.8
20
40
60
80
120


selectivity[MRFSSSel].all
Selectivity
0.0
0.4
0.8
20
40
60
80
120
Size

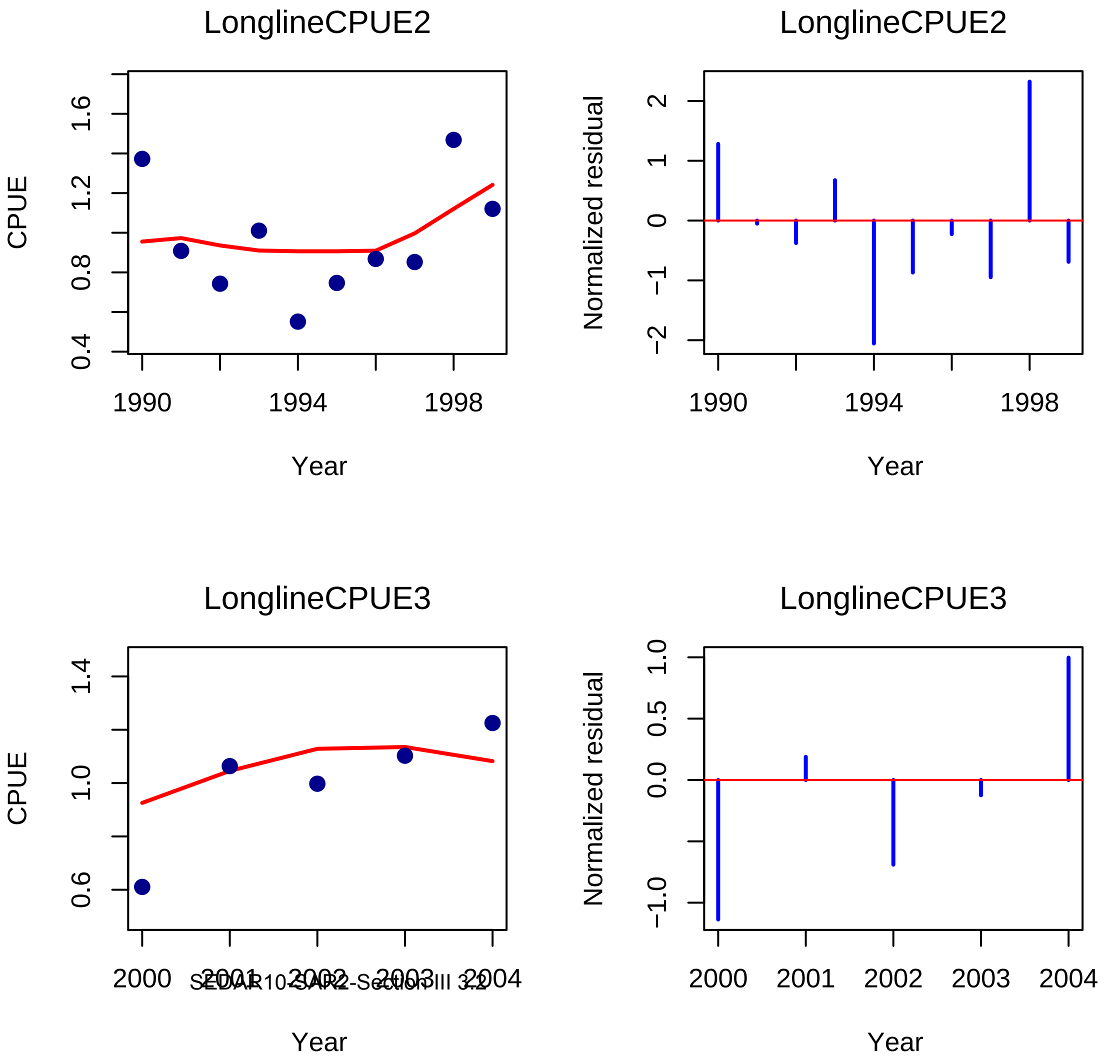

Objective Function components
meanYCS_1
OthersCatchMustBeTaken
MRFSSCatchMustBeTaken
Longine3CatchMustBeTaken
Longine2CatchMustBeTaken
Longine1CatchMustBeTaken
Handline3CatchMustBeTaken
Handline2CatchMustBeTaken
Handline1CatchMustBeTaken
Headboat3CatchMustBeTaken
Headboat2CatchMustBeTaken
Headboat1CatchMustBeTaken
OthersCAA
MRFSSCAA
Longline3CAA
Longline2CAA
Longline1CAA
Headboat3CAA
Headboat2CAA
Headboat1CAA
Handline3CAA
Handline2CAA
Handline1CAA
VideoCPUE
MRFSSCPUE
LonglineCPUE3
LonglineCPUE2
HeadboatCPUE3
HeadboatCPUE2
HeadboatCPUE1
HandlineCPUE3
HandlineCPUE2
CopperBCPUE
0
500
1000
1500

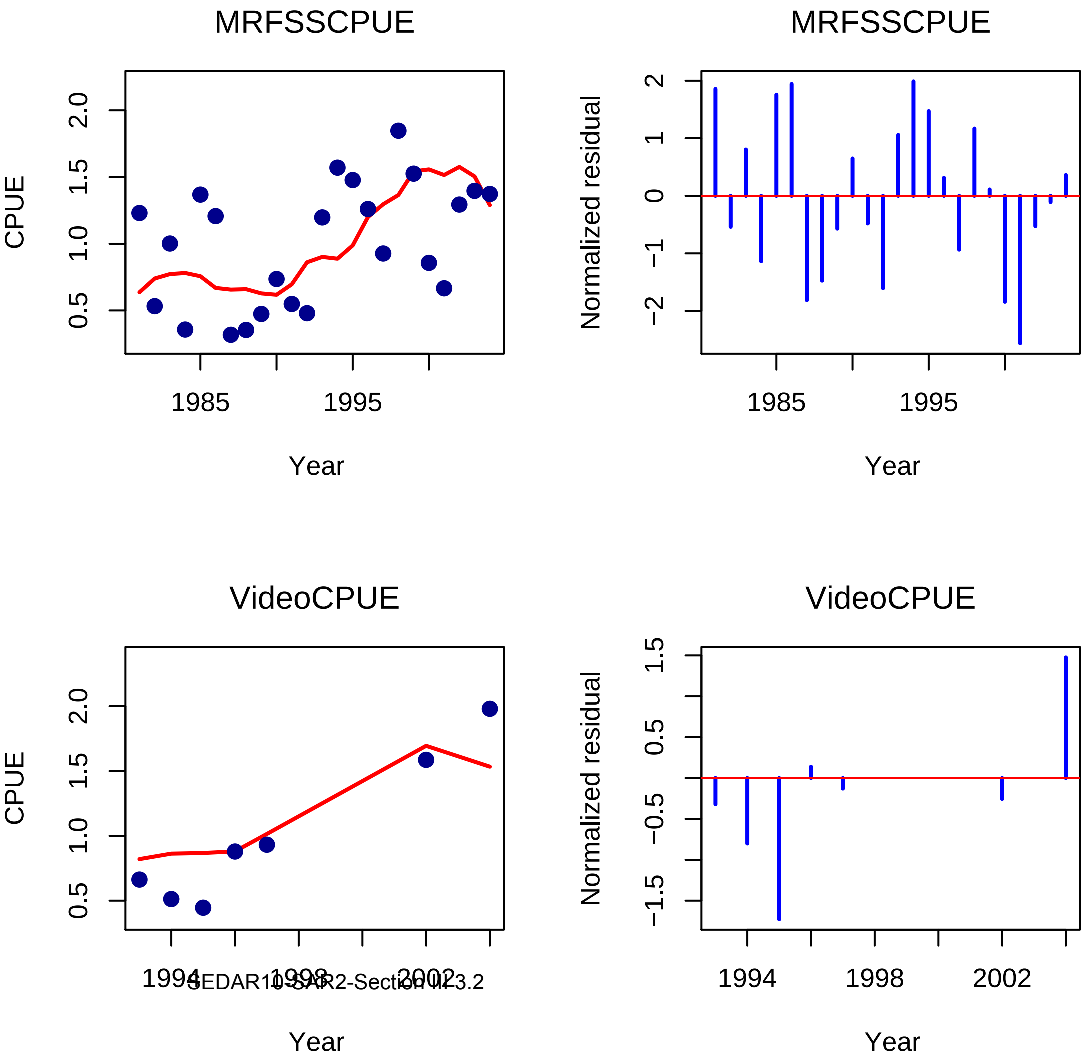

CopperBCPUE
CPUE
0.5
1.0
1.5
2.0
1994
1998
2002
Year
CopperBCPUE
Normalized residual
−1.0
0.0
1.0
1994
1998
2002
Year
HandlineCPUE2
CPUE
0.5
1.0
1.5
2.0
1990
1994
1998
Year
HandlineCPUE2
Normalized residual
−4
0
2
4
6
1990
1994
1998
Year

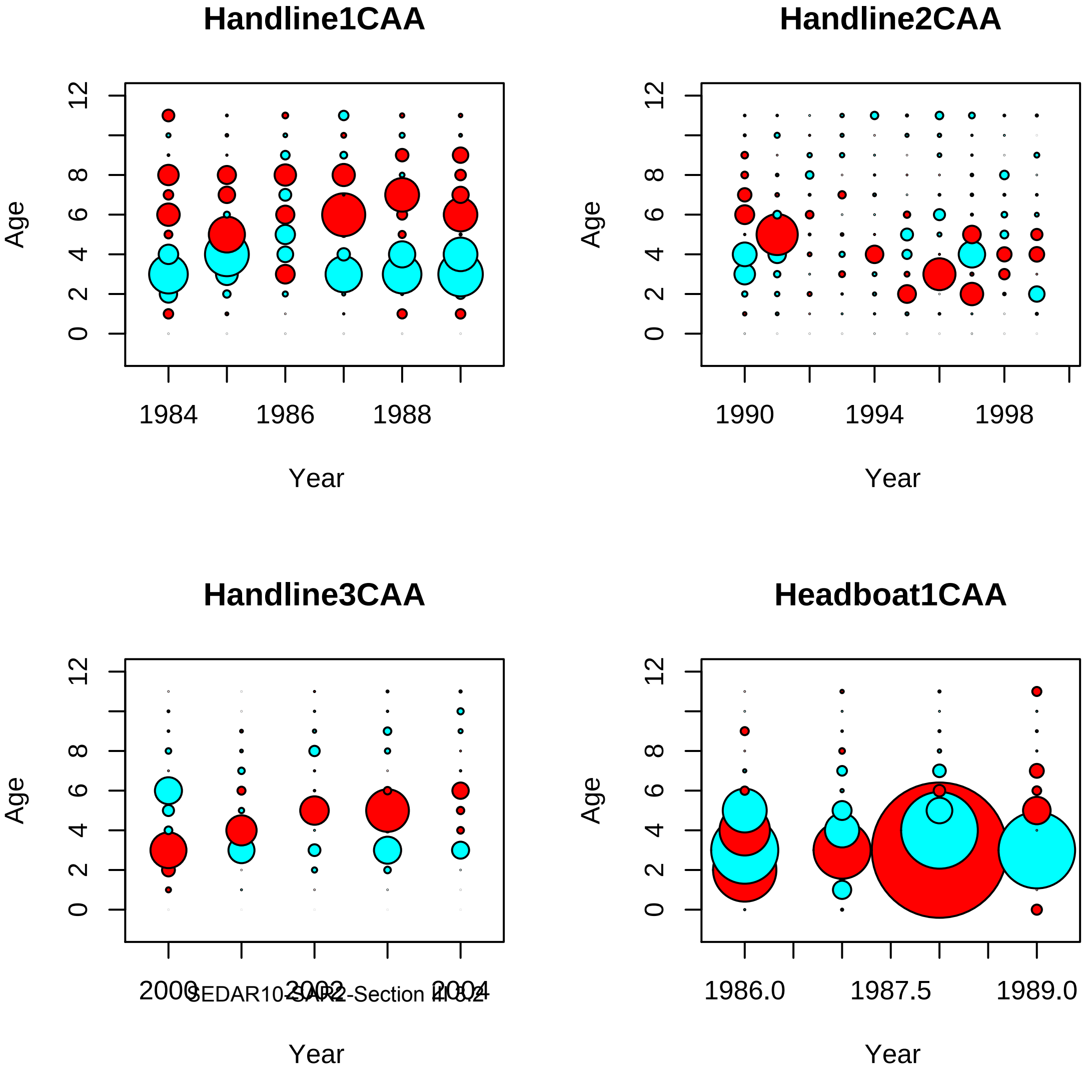

HandlineCPUE3
CPUE
0.6
0.8
1.0
1.2
1.4
2000
2001
2002
2003
2004
Year
HandlineCPUE3
Normalized residual
−2
0
1
2
2000
2001
2002
2003
2004
Year
HeadboatCPUE1
CPUE
0.8
1.0
1.2
1.4
1986.0
1987.0
1988.0
1989.0
Year
HeadboatCPUE1
Normalized residual
−0.4
0.0
0.4
1986.0
1987.0
1988.0
1989.0
Year

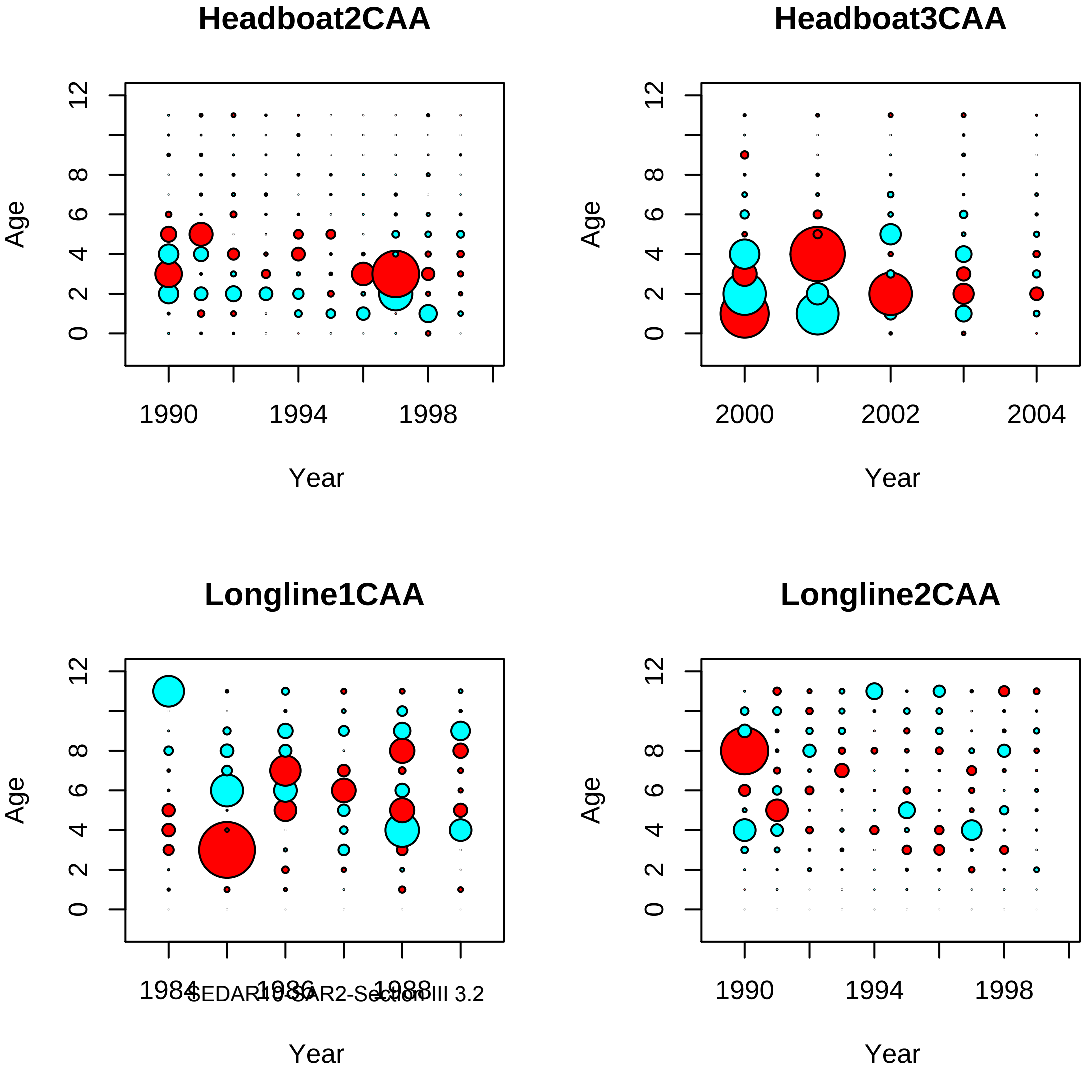


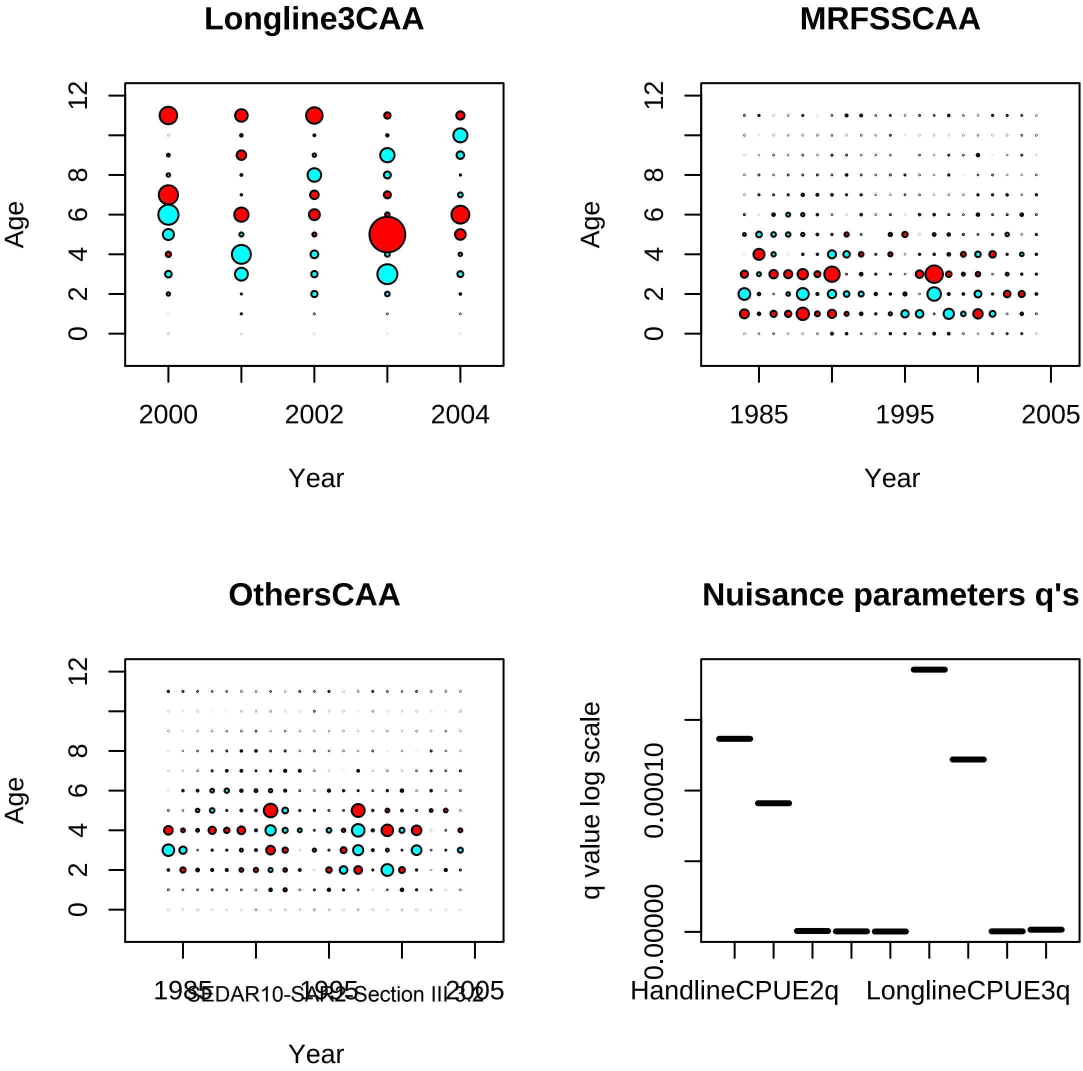
HeadboatCPUE2
CPUE
0.6
1.0
1.4
1990
1994
1998
Year
HeadboatCPUE2
Normalized residual
−1.0
0.0
0.5
1990
1994
1998
Year
HeadboatCPUE3
CPUE
0.7
0.9
1.1
1.3
2000
2001
2002
2003
2004
Year
HeadboatCPUE3
Normalized residual
−0.4
0.0
0.4
0.8
2000
2001
2002
2003
2004
Year

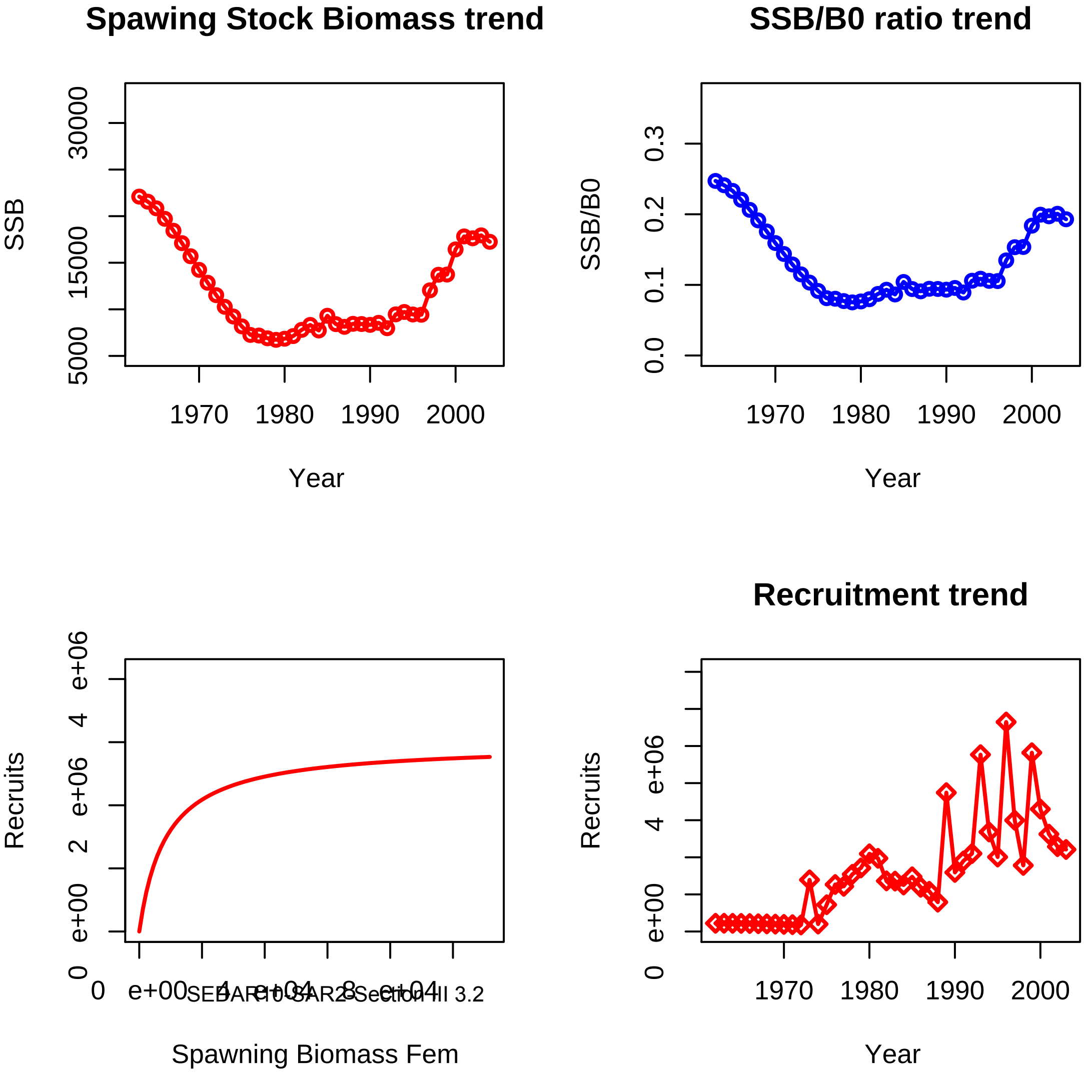

LonglineCPUE2
CPUE
0.4
0.8
1.2
1.6
1990
1994
1998
Year
LonglineCPUE2
Normalized residual
−2
−1
0
1
2
1990
1994
1998
Year
LonglineCPUE3
CPUE
0.6
1.0
1.4
2000
2001
2002
2003
2004
Year
LonglineCPUE3
Normalized residual
−1.0
0.0
0.5
1.0
2000
2001
2002
2003
2004
Year

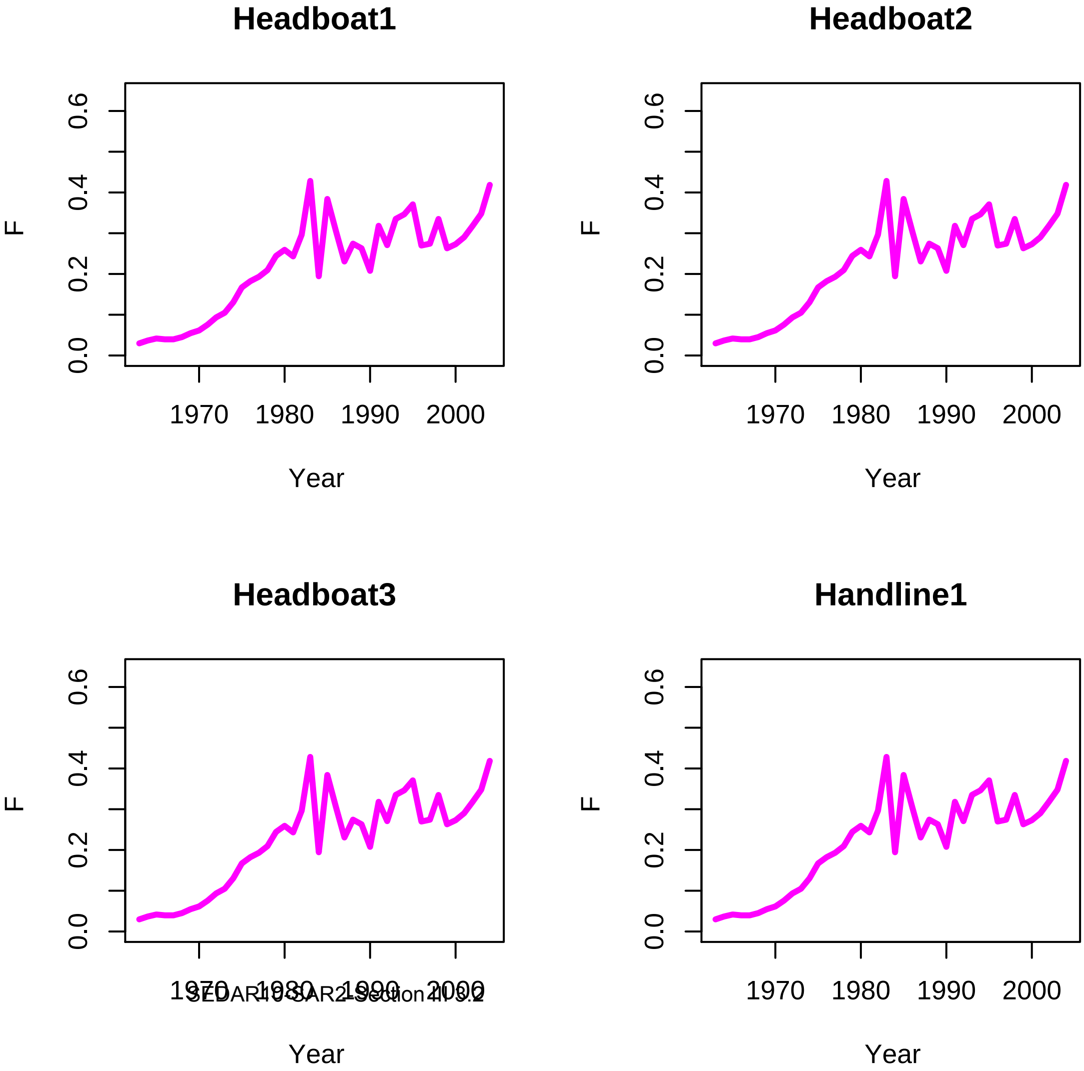

MRFSSCPUE
CPUE
0.5
1.0
1.5
2.0
1985
1995
Year
MRFSSCPUE
Normalized residual
−2
−1
0
1
2
1985
1995
Year
VideoCPUE
CPUE
0.5
1.0
1.5
2.0
1994
1998
2002
Year
VideoCPUE
Normalized residual
−1.5
−0.5
0.5
1.5
1994
1998
2002
Year

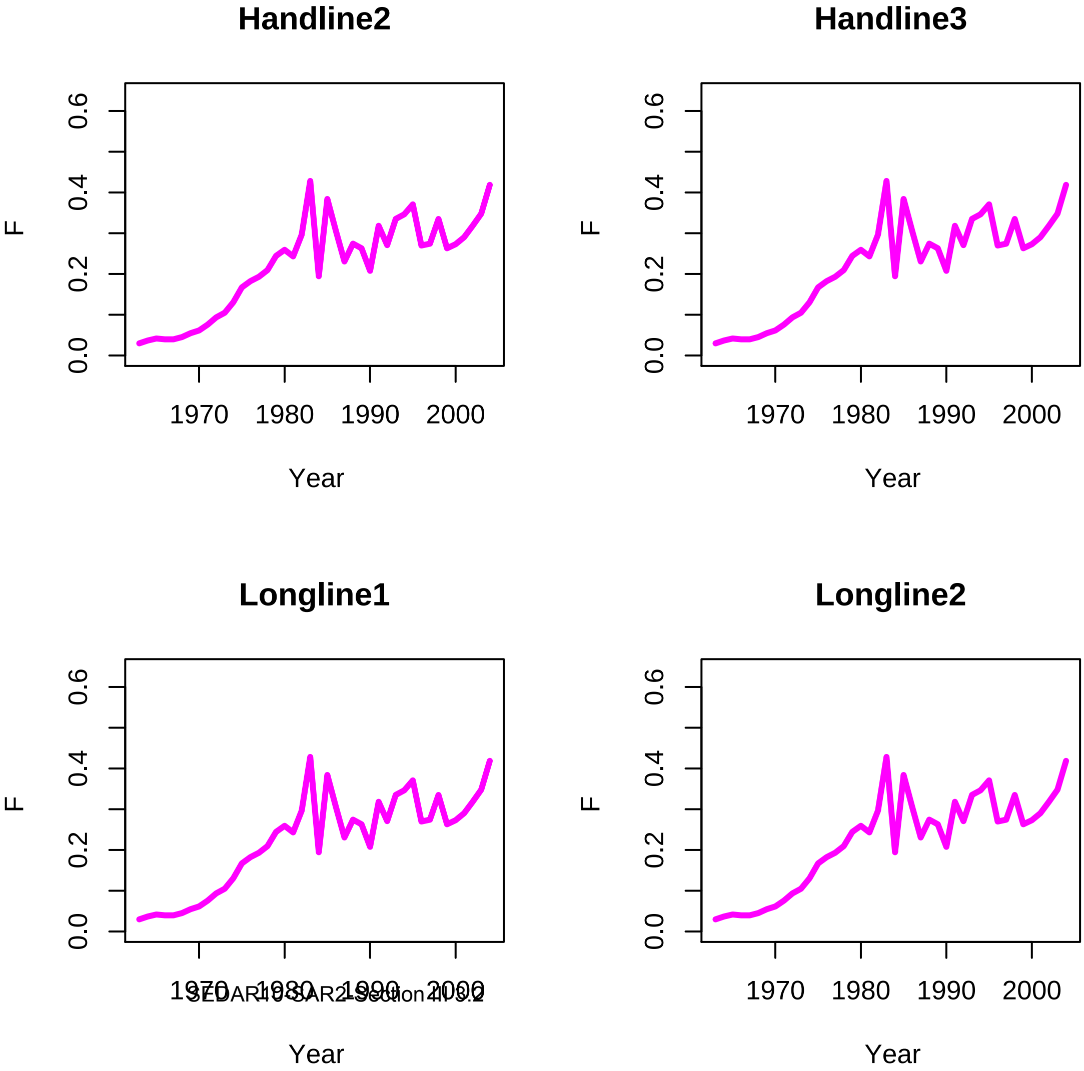

Handline1CAA
Handline2CAA
Handline3CAA
Headboat1CAA
Age
Year
0
2
4
6
8
12
1984
1986
1988
1990
1994
1998
2000
2002
2004
1986.0
1987.5
1989.0

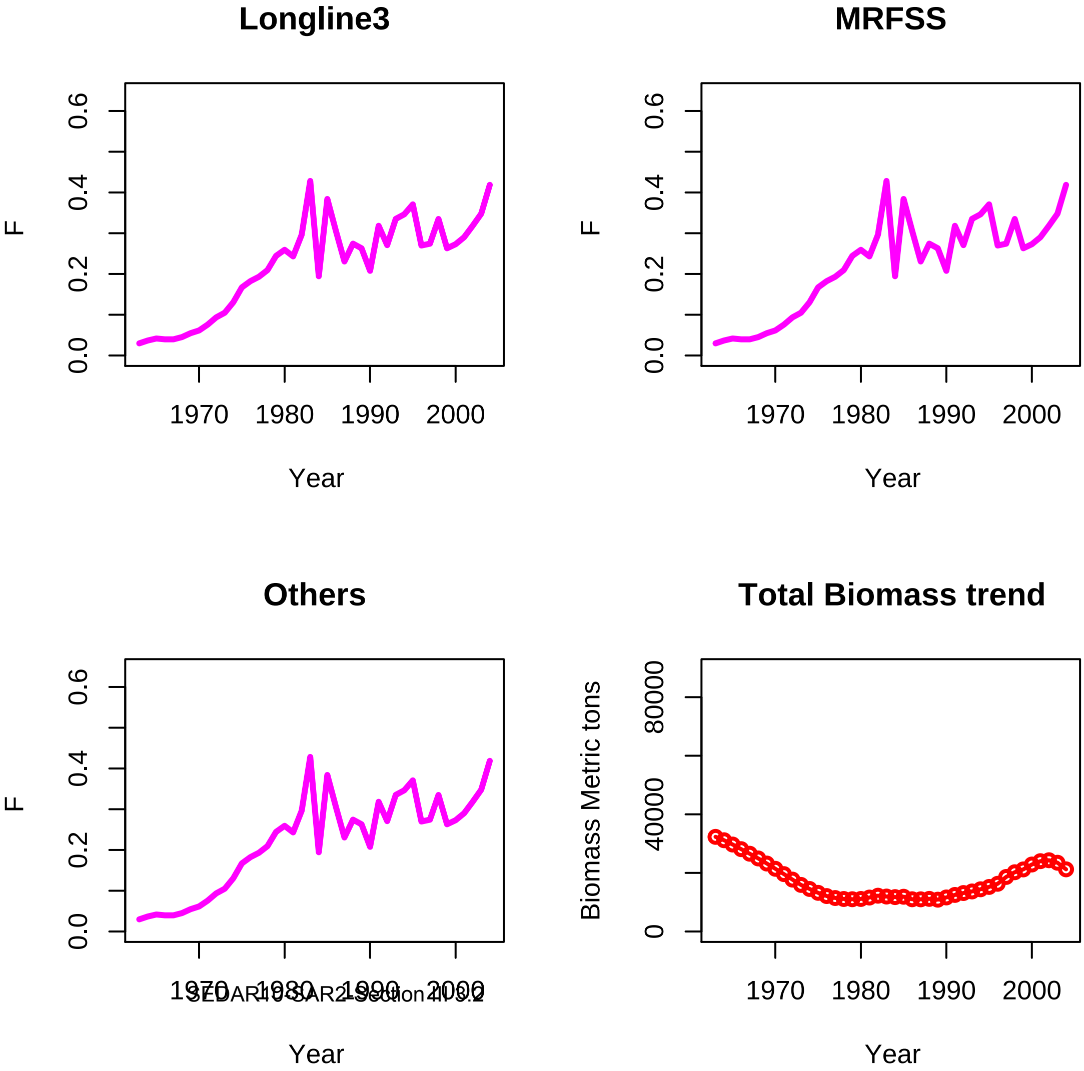

Headboat2CAA
Headboat3CAA
Longline1CAA
Longline2CAA
Age
Year
0
2
4
6
8
12
1990
1994
1998
2000
2002
2004
1984
1986
1988

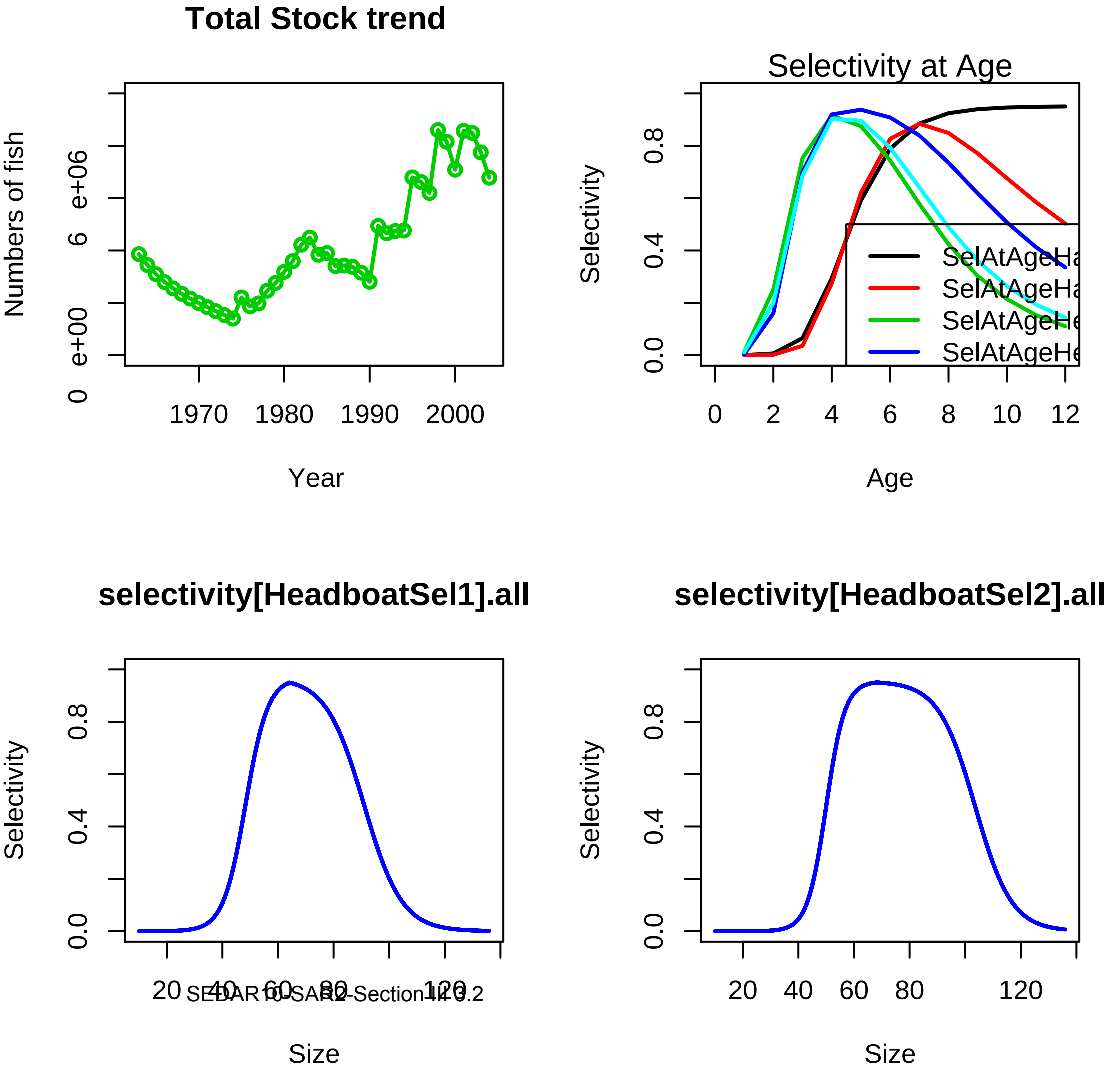

Longline3CAA
MRFSSCAA
OthersCAA
Nuisance parameters q's
Age
Year
0
2
4
6
8
12
2000
2002
2004
1985
1995
2005
q value log scale
0.00000
0.00010
HandlineCPUE2q
LonglineCPUE3q

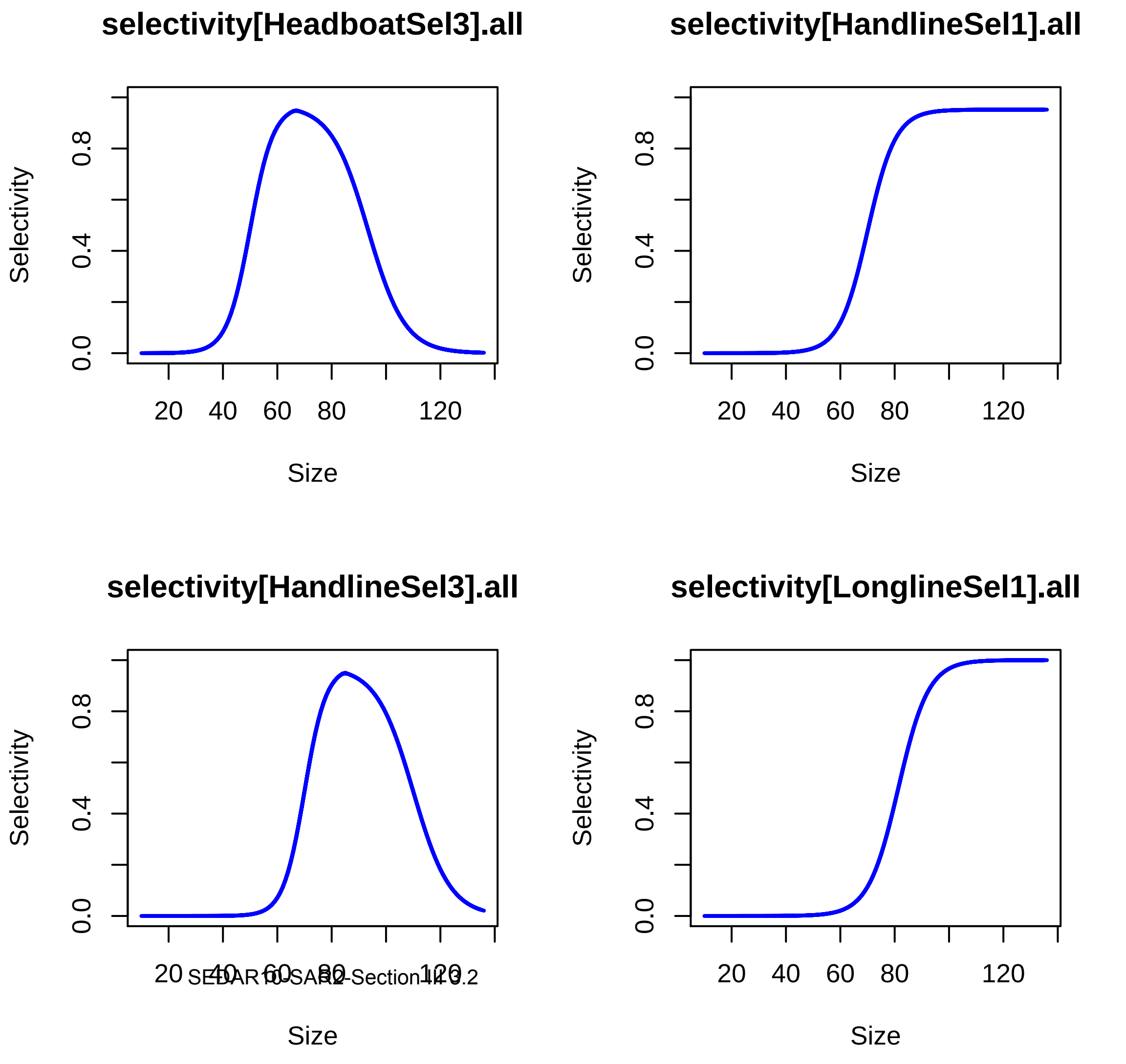

Spawing Stock Biomass trend
SSB
5000
15000
30000
1970
1980
1990
2000
Year
SSB/B0 ratio trend
SSB/B0
0.0
0.1
0.2
0.3
1970
1980
1990
2000
Year
Recruits
0 e+00
2 e+06
4 e+06
0 e+00
4 e+04
8 e+04
Spawning Biomass Fem
Recruitment trend
Recruits
0 e+00
4 e+06
1970
1980
1990
2000
Year

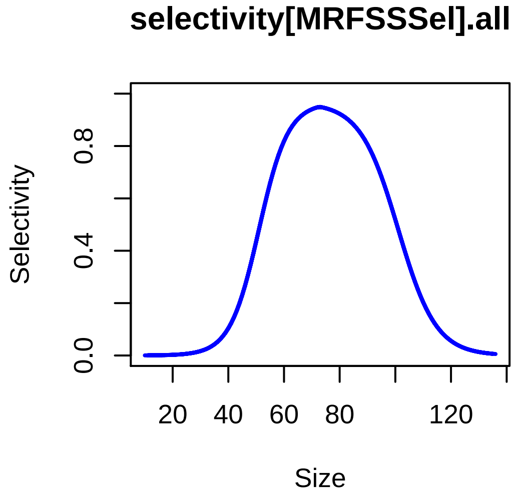

Headboat1
Headboat2
Headboat3
Handline1
F
0.0
0.2
0.4
0.6
1970
1980
1990
2000
Year


Handline2
Handline3
Longline1
Longline2
F
0.0
0.2
0.4
0.6
1970
1980
1990
2000
Year


Longline3
F
0.0
0.2
0.4
0.6
1970
1980
1990
2000
Year
MRFSS
F
0.0
0.2
0.4
0.6
1970
1980
1990
2000
Year
Others
F
0.0
0.2
0.4
0.6
1970
1980
1990
2000
Year
Total Biomass trend
Biomass Metric tons
0
40000
80000
1970
1980
1990
2000
Year


Total Stock trend
Numbers of fish
0 e+00
6 e+06
1970
1980
1990
2000
Year
Selectivity at Age
Selectivity
0.0
0.4
0.8
0
2
4
6
8
10
12
Age
selectivity[HeadboatSel1].all
Selectivity
0.0
0.4
0.8
20
40
60
80
120
Size
selectivity[HeadboatSel2].all
Selectivity
0.0
0.4
0.8
20
40
60
80
120
Size


selectivity[HeadboatSel3].all
selectivity[HandlineSel1].all
selectivity[HandlineSel3].all
selectivity[LonglineSel1].all
Selectivity
0.0
0.4
0.8
20
40
60
80
120
Size


selectivity[MRFSSSel].all
Selectivity
0.0
0.4
0.8
20
40
60
80
120
Size

SEDAR 10

Stock Assessment Report 2

Gulf of Mexico Gag Grouper

SECTION IV. Review Workshop

SEDAR
1 Southpark Circle # 306
Charleston, SC 29414

SEDAR 10 Review Workshop Report

Gulf of Mexico Gag Grouper

Prepared by the SEDAR 10 Review Panel

June 26 - 30, 2006

Atlanta GA

Executive Summary

The SEDAR 10 Review Workshop took place in Atlanta, Georgia, June 26-30, 2006 and reviewed two stock assessments: South Atlantic gag grouper and Gulf of Mexico gag grouper. On Monday, June 26, the Review Workshop Panel received a presentation from the South Atlantic gag grouper assessment team, and on Tuesday, June 27, a similar presentation from the Gulf of Mexico gag grouper assessment team. The balance of the week, through Thursday afternoon, was devoted to additional discussion with the assessment teams to refine and better understand the assessments. Draft versions of the two advisory reports were discussed on Thursday. All parts of the meeting, with the exception of Friday morning, were open to the public. On Friday, the Panel discussed initial drafts of the Consensus Summary documents.

The Review Panel commends the two assessment teams and was especially impressed by the responsiveness of both teams to requests for additional analyses and clarifying information. The Review Panel was also very appreciative of the helpful feedback and suggestions from all SEDAR 10 attendees as we discussed initial drafts of Review Workshop documents.

The Review Panel also appreciates the organization of SEDAR 10 in that two gag grouper stocks were assessed via a common Data Workshop and concurrent and complementary Assessment Workshops. This allowed the Review Panel to not only better understand the individual stock assessments but to offer more consistent advice to the two managing Councils.

From that point of view the Review Panel notes that the development of the stocks has been similar, presumably because the fisheries have followed similar paths.

In both stock areas, recruitment has increased in recent years, although the increase is more pronounced in the Gulf of Mexico than in the South Atlantic. Recruitment is estimated to have been about 5 times higher, on average, in the Gulf of Mexico than in the Atlantic.

For both stocks, relative SSB's were high in the early 1960s, declined more or less regularly until the early 1990s when both started to increase. The 2004 SSB in the Gulf of Mexico is almost 60% above average, close to the maximum observed in the early 1960s, while for the South Atlantic, the 2004 SSB is 20% above average.

Estimated fishing mortality increased at a very similar rate from the early 1960s to the early 1980s. Since then, both have fluctuated without a clear trend around an average of 0.48 in the South Atlantic and about 0.30 in the Gulf of Mexico.

An important result of the Review Workshop is determination of current stock status relative to biological reference points established in the respective FMPs.

In both stock areas, the stock and recruitment data do not suggest that recruitment is strongly linked with SSB. In the South Atlantic, the Beverton-Holt stock-recruitment relationship indicates little change in recruitment for a wide range of SSB's and that B_{MSY} falls in the range of SSB's observed in the past. On the other hand, the Ricker stock-recruitment relationship indicates that maximum recruitment occurs at SSB's lower than those observed over the period of the assessment, which implies that B_{MSY} would also be

lower than those observed in the period of the assessment. In the Gulf of Mexico both the Beverton-Holt and Ricker relationships suggest that considerably higher recruitment would result from larger SSB's and SSB_{MSY} is estimated to be higher than SSB's observed in the past. The Review Panel considers that the stock recruitment relationships in the two stock areas are equally uncertain. The derived benchmarks are considered useful for management in the South Atlantic, because they are within the range of past observed values. In the Gulf of Mexico, more stock and recruitment observations are necessary to confirm that the benchmarks estimated in the current assessment are indeed attainable.

The Minimum Stock Size Threshold (MSST) for the Gulf of Mexico gag grouper stock, $(1\text{-}M)*SSB_{MSY}$, is very close to SSB_{MSY} because age-averaged natural mortality rate, M, is estimated as 0.14. Given the uncertainties in the assessment, the biomass would be expected to fall below MSST with a relatively high frequency even if true biomass were close to SSB_{MSY}. In the Gulf of Mexico, there are indications that recruitment could become impaired below a SSB of 20 million lbs and the Review Workshop suggested that MSST could be set at this level as a temporary operational definition, to be re-examined at the next assessment.

The current (2004) fishing mortality rate on this stock is estimated as 0.39. Relative to the current proxy for F_{MSY} ($F_{SPR30\%}$), estimated as 0.17, overfishing of the Gulf of Mexico gag grouper is occurring. For the Gulf of Mexico, a MFMT of 0.17 is not consistent with the recent dynamics of gag grouper: fishing mortality has been fluctuating around F = 0.30 for more than twenty years and the stock biomass is near its historical maximum. The Review Panel could not provide advice on target F and biomass reference points, but noted that the stock has apparently increased as a result of good recruitment under estimated fishing mortality rates that have fluctuated around an average value of F = 0.30 since the early 1980s. The Review Panel advised that it would be prudent to reduce fishing mortality below F = 0.30.

1. Introduction

1.1. Workshop Time and Place

The SEDAR 10 Review Workshop met at the Doubletree Atlanta Buckhead in Atlanta, Georgia from June 26 - 30, 2006.

1.2. Terms of Reference

1. Evaluate the adequacy, appropriateness, and application of data used in the assessment.
2. Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.
3. Recommend appropriate estimates of stock abundance, biomass, and exploitation.
4. Evaluate the methods used to estimate population benchmarks and management parameters (*e.g., MSY, Fmsy, Bmsy, MSST, MFMT, or their proxies*); provide values for management benchmarks, range of ABC, and declarations of stock status.
5. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; recommend appropriate estimates of future stock condition.
6. Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations.
7. Evaluate the performance of the Data and Assessment Workshops with regard to their respective Terms of Reference; state whether or not the Terms of Reference for those previous workshops were met and are adequately addressed in the Stock Assessment Report.
8. Review research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted.
9. Prepare a Peer Review Consensus Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Prepare an Advisory Report summarizing key assessment results. (Reports to be drafted by the Panel during the review workshop with a final report due two weeks after the workshop ends.)

1.3. List of Participants

Review Panel

Terry Smith, Chair ....NOAA Fisheries/Sea Grant
Din Chen .... CIE
Jean-Jacques Maguire .... CIE
John Wheeler .... CIE

Presenters

Mauricio Ortiz...SEFSC
Clay Porch...SEFSC
Steve Turner..SEFSC

Doug Vaughan ....SEFSC
Erik Williams ....SEFSC

Appointed Observers

Brian Cheuvront...SAFMC SSC
Phil Conklin ....SAFMC AP
Marianne Cufone .... GMFMC NGO Representative
George Geiger ....SAFMC
Will Patterson..GMFMC SSC
Roy Williams ....GMFMC
Bob Zales II...GMFMC AP

Observers

Roy Crabtree .... SERO
Elizabeth Fetherstone.. Ocean Conservancy
Dennis O'Hern ....GMFMC AP
Andy Strelchek.. SERO

Staff

Steven Atran...GMFMC
John Carmichael... SEDAR
Tyree Davis..SEFSC
Rick DeVictor ....SAFMC

1.4. List of Review Workshop Working Papers & Documents

The Review Panel was provided all SEDAR Working Papers and associated research documents considered at the SEDAR 10 Data and Assessment Workshops. Additional resources provided for the Review Workshop are listed below.

SEDAR Working Papers		
SEDAR10-RW01	Virtual population analysis of the Gulf of Mexico gag grouper stock: the continuity case.	Sladek-Nowlis, J.
SEDAR10-RW02	Status review of gag grouper in the US Gulf of Mexico, SEDAR 10.	Ortiz, M
SEDAR DRAFT ASSESSMENT REPORTS		
SEDAR10-SAR1 *Review Draft*	South Atlantic Gag Grouper SEDAR Assessment Report	
SEDASR10-SAR2 *Review Draft*	Gulf of Mexico Gag Grouper SEDAR Assessment Report	

2. Consensus Summary

2.1 Terms of Reference

1. Evaluate the adequacy, appropriateness, and application of data used in the assessment.

The Review Panel concluded that the Data and Assessment Workshops explored a full range of available data sources and selected those that were most appropriate and scientifically sound for the assessment. The data were considered to be adequate, although the Review Panel did concur with the observations of the Data and Assessment Workshops regarding the limited availability of biological sampling data (lengths and ages) prior to the 1980's. The Review Panel concluded that the data selected by the Assessment Workshop were applied appropriately in the assessment.

The Data Workshop categorized available information under four headings: 1) life history, 2) commercial fishery, 3) recreational fishery, and 4) abundance indices. Life history information included: estimates of total, natural and release mortality, age data, growth, reproduction, movements and migration, stock definition, and meristic conversions. Commercial fishery information included: landings, discards, and biological sampling. Recreational fishery information included: landings, discards, total catches, and length frequency distributions. There were six abundance indices; four of which were fishery dependent and two that were fishery independent.

The Data Workshop reviewed several recent studies on estimates of release mortalities and recommended further investigation into the practicality of applying depth-mortality functions. The Assessment Workshop concurred and recommended using size-depth release mortality estimates rather than a fixed proportion, as used in the previous assessment. The Review Panel noted that although data were limited, information was consistent between the South Atlantic and Gulf of Mexico.

Several new growth studies were available for review by the Data Workshop. These updated datasets provided increased sample sizes for improved temporal coverage and contrast. As growth models can be influenced by size-biased samples due, for example, to minimum size limits, the Data Workshop calculated a modified von Bertalanffy growth model accounting for size limited data. Model fits used area, sector and temporal specific size limits. The new von Bertalanffy model, in combination with new age-length keys, resulted in a substantial change in catch in age between the current and previous assessment. There were fewer fish aged 1 to 3 and more fish aged 4 and older. This resulted in an overall lower number of fish caught in the current assessment relative to estimates for the same time period in the previous assessment. The Review Panel noted that, in the recreational fishery since 1990, discards far exceeded landings, suggesting that management measures regarding minimum sizes may not have had as large an effect as anticipated. Catch at age, which includes mostly discards, has increased substantially with the implementation of these measures in the 1990s.

The Data Workshop examined several aspects relating to aging of fish, including age structure samples, age reader precision, and age patterns. With regard to age structure samples, they noted that pre-1998 sample sizes of otoliths collected from the longline fishery were low compared to recent years and that samples from the recreational fishery and fishery independent samples were not well represented throughout the time series. Results from an age reading workshop in 2005 indicated that all labs used comparable procedures and that there was very good agreement and precision among readers. The Review Panel noted the importance of this initiative and recommended that exchange of otoliths between labs continue in the future. In the South Atlantic, the age range tabulated in the analyses extend to age 20 while in the Gulf of Mexico it extends to age 12. In the GOM, the age range used in the assessment could be extended to age 20, as in the assessment for the South Atlantic.

The Data Workshop examined the results of two relatively large tagging studies designed to estimate the degree of exchange between Atlantic and Gulf stock units. In general, the results suggested an ontogenetic movement to deeper waters with smaller gag exhibiting relatively high site fidelity. The Data and Assessment Working Groups concluded that recoveries from the tagging data were inconclusive and that council boundaries should continue to be used as the dividing line for the two stocks. The Review Panel noted that some movement occurred from the South Atlantic to the Gulf. The Florida Keys also represented an area of overlap. Further information was provided to the Panel regarding the results of an ultrasonic tagging study off the west coast of Florida. Tag recoveries indicated extensive migrations by at least two fish, one that was recaptured off Texas and one off Vera Cruz Mexico. The management unit for Gulf of Mexico gag grouper, as defined by the Data Workshop, and endorsed by the Assessment Workshop, extends from the United States – Mexico border in the west through northern Gulf of Mexico waters and west of the Dry Tortugas and the Florida Keys (waters within the Gulf of Mexico Fishery Management Council Boundaries). The Review Panel accepted the current stock definition but recommended a further examination of stock structure before the next assessment. This should include a detailed analysis of existing tagging data and the initiation of new tagging experiments (see SEDAR 10 Consensus Summary Report for South Atlantic gag grouper).

In anticipation that a statistical age-structured model would be used in this assessment, the Data Workshop tabulated commercial landings for 1963 to 2004. The previous stock assessment used landings from 1986. This assessment also examined issues concerning stock boundaries, the misidentification of gag as black grouper, and the adjustment of gag landings to include a portion of unclassified grouper species, primarily prior to the mid-1980s. The proportions of gag and black grouper from 1986 to 1989 were used to calculate the amount of unclassified groupers from 1963 to 1985. This time period was used as size limits had not yet been imposed and it was thought that these proportions would best reflect the historical time period. The Review Panel accepted this method, noting, however, that it introduced a further source of uncertainty in historical commercial landings.

Size limits, which have been in effect since 1990, are thought to have resulted in discarding of undersized fish in the commercial fishery. The Data Workshop examined estimates of total discards by the handline fishery from 2001 to 2004. The Assessment Workshop accepted the handline discard estimates but also used size frequency distributions from catch-at-size files for three periods, prior to 1990 when no size limits existed, 1990 to 1999 when the size limit was 20”, and 2000 to 2004 when the size limit was increased to 24”.

The Data Workshop examined several issues regarding recreational catches, including assignment of catches in the Florida Keys, the misreporting of gag as black grouper, catches from MRFSS shore mode, and extending recreational catches back through time. In back-calculating catches, they examined three possible relationships: a correlation with commercial catches, a correlation with coastal human populations, and a linear relationship starting at a time when the stock was considered to be close to unexploited. Two series of recreational catches and discards from 1963 to 2004 were generated, one based upon a correlation with commercial catches and one based upon a linear increase from 1945. The Assessment Workshop rejected the historical recreational time series and recommended an alternative approach using a relationship between the MRFSS fishing effort and the number of boats built between 1981 and 2004. The issue of extending recreational (and commercial) catches back through time generated considerable debate among the Review Panel. Concerns were expressed regarding the accuracy of such catches and the impact they may have within the assessment model. However, it was concluded that although back-calculated historical catches may not be accurate, they do provide valuable information and should be included in the assessment.

Six abundance indices were considered by the Data Workshop to be appropriate measures of abundance. These included four fishery dependent indices, commercial handline, commercial longline, headboat survey, and the marine recreational fisheries statistical survey (MRFSS). Two independent indices were also available, the SEAMAP video survey, and the Florida Estuaries Index. The Data Workshop described each of these indices in detail, along with concerns and advantages of each index. The Assessment Workshop accepted this set of indices for inclusion in the assessment model. There was a limited discussion by the Review Panel regarding the abundance indices. A question was raised regarding the spatial coverage of the fishery independent indices. The Review Panel concurred with the inclusion of the six indices in the assessment model.

2. *Evaluate the adequacy, appropriateness, and application of methods used to assess the stock.*

The Review Panel generally endorsed the method used in the assessment and considered it to be scientifically sound. The Panel did, however, have concerns regarding the choice of a Beverton-Holt stock recruit function and recommended that a Ricker function be used to examine the sensitivity of the model to assumptions about the form of the stock recruitment function. The Panel was impressed with the number of alternative runs provided by the Assessment Workshop and the thorough presentation regarding model inputs and results presented by the assessment team at the Review Workshop.

The Assessment Workshop selected a statistical age-structured forward reconstruction model (CASAL) as the primary method for the assessment. CASAL was chosen as it provides flexibility in specifying population dynamics, parameter estimation, and model outputs. Most importantly, unlike Virtual Population Analysis (VPA), CASAL does not assume that the catch at age is known exactly, an important feature in the case of Gulf of Mexico gag grouper where catch at age is not well estimated.

Additionally, the assessment model used in the 2001 assessment (VPA) was run to show the effects of updated data and the effects of adding indices of abundance not available in 2001. In addition to CASAL and VPA models, the Assessment Workshop provided a stochastic stock reduction analysis (SRA) using a long term historical (1880 to 2004) catch time series.

The Assessment Workshop considered six scenarios for CASAL model runs. It recommended using the longest possible catch series. Two time series were considered, one with commercial and recreational catches from 1963 to 2004, and a second with commercial catches from 1880 to 2004 and recreational catches from 1945 to 2004. The Assessment Workshop also recommended including potential changes in catchability. Two groups of model runs were made, one assuming constant catchability and a second assuming a 2% annual increase since 1984 to reflect improvements in gear and electronics available to both the commercial and recreational fisheries. The Assessment Workshop also discussed the recent report of NRC regarding MRFSS estimates and concluded that available estimates of recreational catch and indices of abundance were the best available information. However, to estimate the sensitivity of the model to these data, two runs were made, one where the MRFSS total estimated catch was increased by 25% for the entire time series, and a second where it was decreased by 25%.

The Assessment Workshop presented two model runs to the Review Panel as base case scenarios, one with commercial and recreational catches from 1963 to 2004, assuming constant catchability, and the second with the same catch series, assuming 2% annual increase in catchability. Each base run was provided as the basis for estimation of benchmarks and stock status. After considerable discussion, the Review Panel concluded that catchability has changed over time. However, the Panel does not believe that a constant 2% increase per year adequately describes the change in catchability that is likely to have occurred. Step changes with the introduction of new equipment or management measures are more likely than monotonic changes. Learning and technological changes in navigation, fish detection, and fishing gear have no doubt increased the efficiency of nominal fishing effort. However, management measures (increases in minimum size, time and area closures, bag limits) and changes in fishing behaviour (moving on when enough fish have been caught) would likely result in decreased catchability. The Review Panel believes that, overall, catchability is likely to have increased and recommends that a special workshop be convened to estimate and quantify changes in catchability over the last 25 to 30 years.

The base case CASAL model run included commercial and recreational catches from 1963 to 2004. As indicated earlier, the Review Panel expressed concerns regarding the back-calculation of catch data and asked the assessment team to provide a CASAL run with actual catch data only (1986 to 2004). The assessment team was also asked to provide the results of two VPA runs for comparison with the CASAL model. The results indicated similar trends in stock size and fishing mortality estimates with higher biomass and lower fishing mortalities for the shorter time series.

The Assessment Workshop assumed a Beverton-Holt stock recruitment relationship in all CASAL model runs. Examination of stock-recruit scatter plots indicated that recruitment is not strongly linked to SSB. Given the variability in the stock recruit data, the Review Panel requested further evaluation using Ricker and ‘hockey stick’ (Barrowman and Myers 2000) stock recruitment relationships. The assessment team provided these comparisons during the Review Workshop; the Beverton-Holt and Ricker curves were virtually identical through the range of data. However, both the

Beverton-Holt and Ricker relationships suggest that considerably higher recruitment would result from larger SSBs, and B_{MSY} is estimated to be higher than SSBs observed in the past. It was noted that the Assessment Workshop preferred the Beverton-Holt relationship over the Ricker. However, the Review Workshop concluded that both might over estimate virgin recruitment and thus MSY and SSB_{MSY}. More stock and recruitment observations are necessary to confirm that the benchmarks estimated in the current assessment are indeed attainable.

3. *Recommend appropriate estimates of stock abundance, biomass, and exploitation.*

The Review Panel evaluated the various assessment runs provided by the Assessment Workshop. It agreed upon a base run as reported above (terms of reference #2); the base run is described in the addendum to the assessment report. The accepted estimates of stock abundance, biomass, and exploitation are provided in the SEDAR 10 Gulf of Mexico Gag Grouper Advisory Report.

4. *Evaluate the methods used to estimate population benchmarks and management parameters (e.g., MSY, Fmsy, Bmsy, MSST, MFMT, or their proxies); provide values for management benchmarks, range of ABC, and declarations of stock status.*

In both stock areas, the stock and recruitment scatter plots do not suggest that recruitment is strongly linked with SSB. In the South Atlantic, the Beverton-Holt relationship indicates little change in recruitment for a wide range of SSBs and that B_{MSY} falls in the range of SSBs observed in the past. The Ricker relationship indicates that maximum recruitment occurs at SSBs lower than those observed over the period of the assessment, which implies that B_{MSY} would also be lower than those observed in the period of the assessment. In the Gulf of Mexico, both the Beverton-Holt and Ricker relationships suggest that considerably higher recruitment would result from larger SSBs and SSB_{MSY} is estimated to be higher than SSBs observed in the past. The Review Workshop considered that the stock recruitment relationships in both stock areas are equally uncertain. The derived benchmarks are considered useful for management in the South Atlantic, because they are within the range of past observed values. In the Gulf of Mexico, more stock and recruitment observations are necessary to confirm that the benchmarks estimated in the current assessment are indeed attainable.

MSST, defined as (1-M)* SSB_{MSY}, would be very close to SSB_{MSY} because an M = 0.14 is used. Given the uncertainties in the assessment, the biomass would be expected to be estimated to fall below MSST with a relatively high frequency even if in true biomass were close to SSB_{MSY}. In the Gulf of Mexico, there are indications that recruitment could become impaired below 20 million lbs and the Review Workshop suggested that MSST could be set at 20 million lbs as an operational definition, also to be re-examined at the next assessment.

For the Gulf of Mexico, a MFMT of 0.17 (current value of $F_{30\%SPR}$) is not consistent with the recent dynamics of gag grouper: fishing mortality has been fluctuating around F = 0.30 for more than twenty years and the stock biomass is near its historical maximum. The Review Panel could not provide advice on target F and biomass reference points, but noted that the stock has apparently increased as a result of good recruitment under estimated fishing mortality rates that have fluctuated around an average value of F = 0.30 since the early 1980s. The Review Panel advised that it would be prudent to reduce fishing mortality below F = 0.30.

5. *Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; recommend appropriate estimates of future stock condition.*

The Review Panel requested stock projections assuming constant catchability and geometric mean recruitment from 1984 through 2004. These projections were not available during the Review Workshop as they could not be completed using CASAL. They were subsequently provided by the assessment team using an alternative age-structure projection software (PRO-2BOX).

The following output data from CASAL were used as input for PRO-2BOX:

a) Stock size at age (NAA) from 1963 to 2004 ages 1-12+,

b) Fishing mortality rate at age (FAA) from 1963 to 2004,

c) Catch-at-age 1963-2004 all fisheries,

d) Weight at age 1963-2004 for spawning component and mean WAA for fisheries

e) Natural mortality at age 1963-2004.

Because of differences between the software programs, particularly regarding the estimation of mean weight at age and age composition for the plus group, estimates of biomass between CASAL and PRO2BOX differed prior to 1984, when age composition data were not available. However, the SSB and overall stock biomass estimates were similar for the latest years, which are the important components for the projection of current stock status.

As PRO2BOX can distinguish between landed and discarded (dead) numbers at age, the discard proportions were estimated (from CASAL) by age for 1984 - 2004, when age composition data were available; discards by age prior to 1984 were assumed to be the same as in 1984. With this information, estimates and benchmarks were then generated for total yield (landings only) versus total removals (landings plus dead discards).

Stock projections were completed for 2006 to 2010 and included scenarios of constant catch, constant fishing mortality, total yield, and total removals.

Estimates of fishing mortality rates were similar between total yield and total removals. However, estimated retained yields were much lower (~ 50%), due to the large proportion of dead discards in the recreational fishery. Landed yield per recruit (YPR) also dropped by 50% compared to total removals.

Projections indicated that total removals over 6,614 MT or landed catches over 3,268 MT in 2006 and in following years are not sustainable, and would generate a fishing mortality rate at or above 2 (upper limit of fishing mortality rate).

This assessment implies that spawning stock biomass has declined from a 2003 peak. Projections indicate that stock spawning biomass, and also catch (removals or landed yield) would continue to decline at current (2004) fishing mortality rates. The decline would continue if fishing occurred at a rate equivalent to $F_{20\%SPR}$. Fishing rates of $F_{30\%SPR}$, $F_{40\%SPR}$, $F_{0.1}$, F_{MAX} and F_{MSY} would reverse the declining trend

The Review Panel endorsed the inclusion of dead discards with landings to provide an estimate of total removals and recommended that these estimates be used in the Advisory Report.

6. *Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations*.

Initial stock assessment results were clearly and accurately presented in the report of the Assessment Workshop (SEDAR10-SAR2-Section III). Additional analyses requested by the Review Panel will be incorporated as an addendum to the stock assessment report.

7. *Evaluate the performance of the Data and Assessment Workshops with regard to their respective Terms of Reference; state whether or not the Terms of Reference for those previous workshops were met and are adequately addressed in the Stock Assessment Report.*

The Review Panel agreed that the terms of reference of the Data and Assessment Workshops were met and were adequately addressed in the Stock Assessment Report.

8. *Review research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted*.

The Review Panel reviewed research recommendations offered by the Data and Assessment Workshops (see respective reports). The Panel also developed the three additional recommendations listed below.

Age determination: The Review Panel noted the importance of age reading comparisons and recommended that exchange of otoliths between labs continue in the future.

Stock structure: The Review Panel recommended a further examination of stock structure before the next assessment, including a detailed analysis of existing tagging data and the initiation of new tagging experiments.

Time-varying catchability: The Panel is of the opinion that catchability has changed over time, however, it does not believe that a constant 2% increase per year adequately describes the changes in catchability that are likely to have occurred. Step changes with the introduction of new equipment or management measures are more likely than monotonic changes. Learning and technological changes in navigation, fish detection and catching equipment have no doubt increased the efficiency of nominal fishing effort. However, management measures (increases in minimum size, time and area closures, bag limits) and changes in fishing behavior (moving on when “enough” fish have been caught) would be expected to result in decreased catchability. The Panel believes that, overall, catchability is likely to have increased. The Panel recommends that a special workshop be convened to estimate and quantify changes in catchability over the last 25 to 30 years.

9. *Prepare a Peer Review Consensus Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Prepare an Advisory Report summarizing key assessment results. (Reports to be drafted by the Panel during the review workshop with a final report due two weeks after the workshop ends.)*

First drafts of the Consensus Summary and Advisory Report were completed during the Review Workshop. All Review Panel members contributed to the Consensus Report. The assessment team completed the first draft of the Advisory Report which was then reviewed by the Review Panel. The Consensus Report and Advisory Report were completed by email subsequent to the Review Workshop.

2.2 Additional Comments

Participants in the Data and Assessment Workshops are to be highly commended for their detailed compilation and analysis of diverse data sets. Information was summarized well in their respective reports. During the Review Workshop, the assessment team provided a clear presentation of the assessment model and results and was highly capable and willing to accede to requests for further analyses from the Review Panel.

2.3. General recommendations to SEDAR

There was large volume of documentation associated with this RW. The Review Panel recommends a clear executive summary for all substantive Data and Assessment Documents.

It could be more informative to distribute a succinct table of model equations and parameters (estimated and observed) to be provided for each assessment along with, if appropriate, a table of management options (e.g. a decision table) and the risks associated with them.

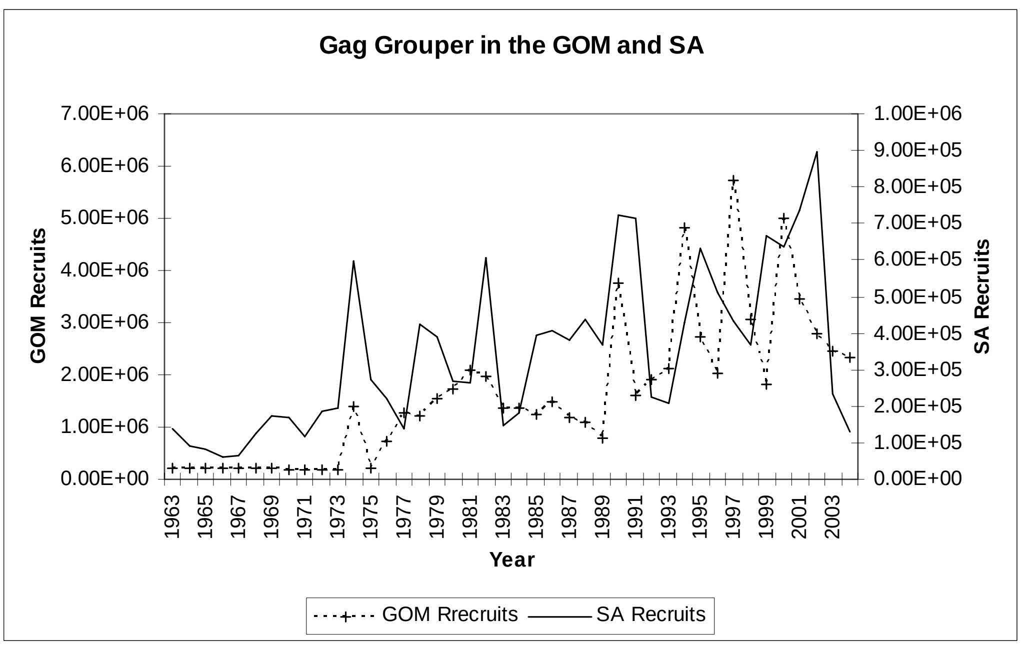
2.4 Special Comments

Comparing and Contrasting the Two Gag Grouper Assessments

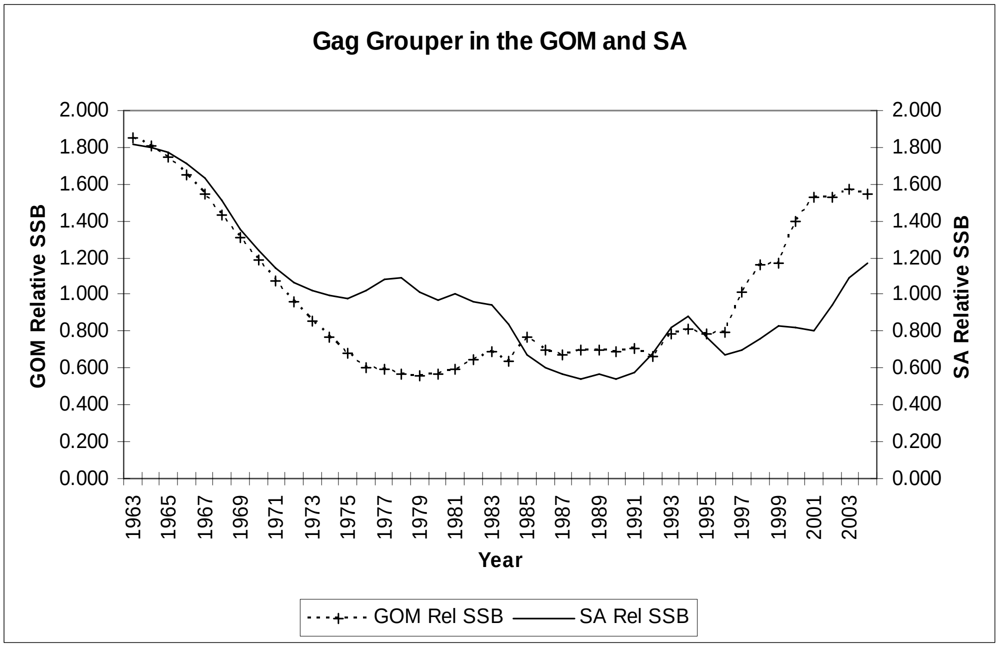
The main assessment model for both stock areas is a statistical catch at age model, but the implementations differ. For the South Atlantic a customized model has been developed using ADMB while for the Gulf of Mexico, an existing software (CASAL (C++ algorithmic stock assessment laboratory) can be downloaded from ftp://ftp.niwa.co.nz/software/casal) was used. CASAL was one of several integrated assessment software recently evaluated by the IATTC; the report can be downloaded at http://www.iattc.org/PDFFiles2/Assessment-methods-WS-Nov05-ReportENG.pdf . For the South Atlantic, a production model (ASPIC) was also run and for the Gulf of Mexico two VPA's were run: one was a strict continuity run and the other one was parameterized to mimic the CASAL run. VPA was not used in the South Atlantic because of insufficient complete catch at age information. The RW Panel considers that the statistical catch at age approach has better statistical foundations and more flexibility in the type of information that can be used than VPA or general production models. The RW Panel recommends that alternate assessment approaches (ASPIC for the South Atlantic and VPA for the Gulf of Mexico) continue to be used in parallel and that the results be presented in the report of the Assessment Workshops. Standard inputs (catch at age, length at age, weights at age, indices of stock size (by age and length if appropriate) and outputs (population numbers at age, population biomass at age, spawning biomass, fishing mortality at age) should be provided in a format easily readable by spreadsheet programs. Neither of the assessments considers gender explicitly.

Although the approach has been used in the assessment of other species, it is not clear that the ADMB statistical catch at age implementation conforms to the Model Acceptance Note 1 in the ToRs of the AW. The assessment team is encouraged to provide the required documentation and work towards including the assessment in the NFT packages. Presumably, the evaluation performed by the IATTC implies that the CASAL does conform to the Model Acceptance Note 1.

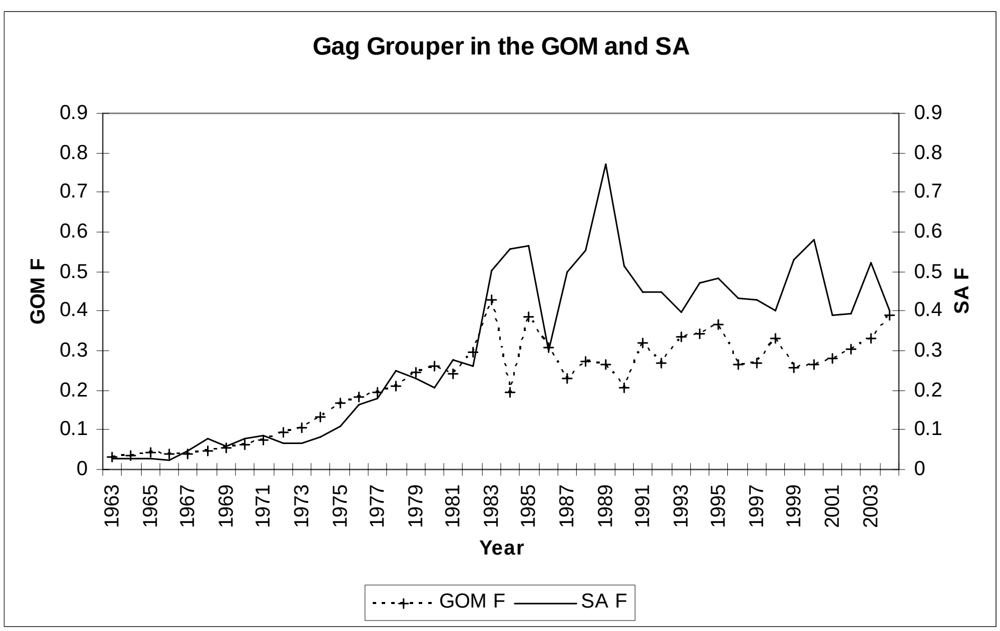
In both stock areas, recruitment has increased in recent years, although the increase is more pronounced in the Gulf of Mexico than in the South Atlantic. Recruitment is estimated to have been about 5 times higher, on average, in the Gulf of Mexico than in the Atlantic.



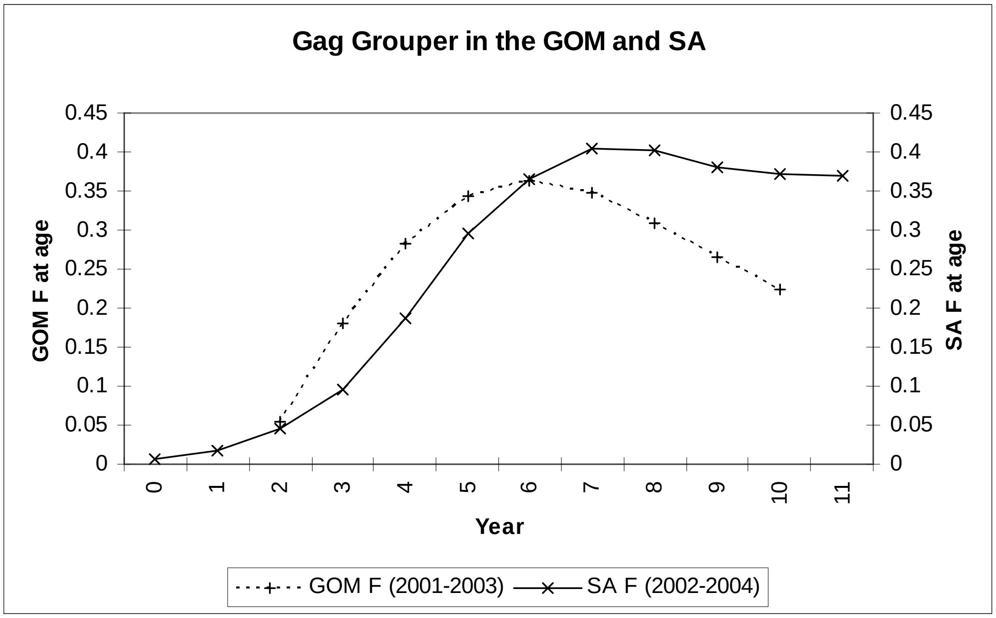
For both stocks, relative SSB's were high in the early 1960s, declined more or less regularly until the early 1990s when both started to increase. The 2004 SSB in the Gulf of Mexico is almost 60% above average, close to the maximum observed in the early 1960s, while for the South Atlantic, the 2004 SSB is 20% above average.



Estimated fishing mortality increased at a very similar rate from the early 1960s to the early 1980s. Since then, both have fluctuated without a clear trend around an average of 0.48 in the South Atlantic and about 0.30 in the Gulf of Mexico.



Average fishing mortality at age (2001-2003 for the GOM, 2002-2004 for the SA) show different patterns. F's are higher at age 3-5 in the Gulf of Mexico than in the South Atlantic but at older ages it is the opposite. The F at age pattern is clearly dome shaped in the Gulf of Mexico and nearly flat topped in the South Atlantic.



References

Barrowman, N.J. and R.A. Myers. 2000. Still more spawner-recruitment curves: The hockey stick and its generalizations. *Can. J. Fish. Aquat. Sci.* 57:665-676.

SEDAR 10

Stock Assessment Report 2

Gulf of Mexico Gag Grouper

SECTION V. Addenda

SEDAR
1 Southpark Circle # 306
Charleston, SC 29414

Report on Gag GOM projections

The review assessment panel requested stock projections of Gag GOM from the base case with constant catchability assuming the stock recruitment defined as the geometric mean of recruits from 1984 through 2004. These projections were not possible to carry out with the assessment package CASAL, therefore they were done using an alternative age-structure projection software PRO-2BOX package (ref).

The following output data was gathered from CASAL base model run and use as input for PRO-2BOX:

a) Stock size at age (NAA) from 1963 to 2004 ages 1-12+,
b) Fishing mortality rate at age (FAA) from 1963 to 2004,
c) Catch-at-age 1963-2004 all fisheries,
d) Weight at age 1963-2004 for spawning component and mean WAA for fisheries, and
e) Natural mortality at age 1963-2004.

CASAL base run used Pope's approximation for estimating fishing pressure by each fishery, thus fishing rates were estimated externally from the changes in stock size by age within a year (number at age decline by year). These annual rates were equivalent to CASAL cumulative natural and fishing mortality declines (Fig 1).

Because of differences between software programs, particularly regarding the estimation of mean weight at age and age composition for the plus group, estimates of biomass between CASAL and PRO2BOX differ prior to 1984, when age composition data is not available (Fig 2). However the SSB and overall stock biomass estimates were similar for the latest years, which are the important components for the projection of current stock status.

The projections of gag GOM assumed a stock recruitment relationship constant for upcoming years. The future recruitment was set at a value of the geometric mean of recruits age 1 from 1984 to 2004 (2,124,871). PRO2BOX can distinguish between landed and discarded (dead discards) numbers at age, it requires a discard proportion by age. With this information, estimates and benchmarks can be generated for true yield (landings only) versus total removals (landings plus dead discards). Discard proportion by age were estimated from CASAL by age for 1984 to 2004, when age composition data were available, prior to 1984 (1963-1983) discards by age were assumed to be the same as in 1984.

Projections of the base model were done from 2006 to 2010, for 2005 it was estimated at the AW a preliminary total Gag GOM removals of 12.38 million pounds (MP) (5,622 MT) , where 5.81 MP (2,637 MT) were landed and 6.57 MP (2,985 MT) were dead discarded. Stock projections were done for scenarios of constant catch (fixed quotas) and constant fishing mortality rate (F) starting in 2006. For the constant catch and constant F rate the following scenarios were run either considering total removals (A) or total Yield landed (B):

Constant Catch	A total removals MP	B Yield landed MP
Scenario 1	0	0
Scenario 2	3.30	1.10
Scenario 3	6.61	3.30
Scenario 4	11.01	4.41
Scenario 5	17.62	5.51
Scenario 6	24.23	6.61
Scenario 7	14.57	7.20

Constant F rate		
Scenario 8	20% SPR	20% SPR
Scenario 9	30% SPR	30% SPR
Scenario 10	40% SPR	40% SPR
Scenario 11	$F_{0.1}$	$F_{0.1}$
Scenario 12	F_{MAX}	F_{MAX}
Scenario 13	F_{MSY}	F_{MSY}
Scenario 14	$F_{current\ (2004)}$	$F_{current\ (2004)}$

Table 1 presents the estimated benchmarks for Gag GOM assuming constant recruitment. The first column shows estimates for all removals (landed plus dead discards), the second column shows estimates for only the landed component. Estimates of fishing mortality rates are similar between total removals or yield landed. On the other hand, estimated retained Yields are much lower, about 50%. This is of course due to the large proportion of dead discards of gag GOM particularly in the recreational component. Landed yield per recruit (YPR) drops also by 50% compare to total removals. For MSY estimated of total removal is 8.66 MP (3,932 MT), while landed MSY is 4.27 MP (1,939 MT). Fishing mortality rate at MSY was estimated at 0.23 (all removals) or 0.25 (landed yield), differences between mortality rates are due to age proportions of dead discards. The spawning biomass equivalent to a 30% SPR is 34.6 MP (15,700 MT) approximately, in 2004 Fishing rates were 0.49 (as annual mortality rate), while SSB was estimated at 40.55 MP (18,410 MT).

Table 2 and Figure 3 show the projected values of the stock for Spawning biomass (SSB), fishing mortality rates (F annual rate), and biomass removals (total removals or yield landed), for the scenarios of constant catch. Total removals over 14.57 MP in 2006 and following years are not sustainable, and the corresponding fishing mortality rate is at or above 2 (upper limit of fishing mortality rate). In terms of landed yield, catches over 7.20 MP are not sustainable either. Furthermore, catches of 11.01 MP (all removals) or 4.41 MP (yield landed) or above will reduce the spawning stock biomass.

Gag GOM Spawning biomass shows a decreasing trend from a peak in 2003, by 2006 only projections of catch of 6.61 MP (total removals) or lower [3.30 MP (yield landed) or lower] will reverse the decreasing trend. Fishing mortality rates also continue to increase if catch is above the 6.61 MP (total removals) or 3.30 MP (yield landed).

Table 3 and Figure 4 show the projected values of the stock for SSB, F and biomass removals (total removals or yield landed) for the scenarios of constant F mortality rates. Projections indicated that harvest at the current (2004) fishing rate will continue declining the stock spawning biomass, and also catch (removals or landed yield). Fishing at rate equivalent to F 20%SPR, will also continue the declining trends of biomass. Fishing rates of 30%SPR, 40%SPR, $F_{0.1}$, F_{MAX} and F_{MSY} will reverse the declining trend. F_{MAX} and F_{MSY} are identical because of the constant recruitment assumption. In all cases, landed yield is expected to decline compare to 2004, or 2005 yields. This is in part due to the past of the large recent cohorts of 2000 and 1997 year-age1 class.

Table 1. Estimated benchmarks for Gag GOM stock base run projections assuming a constant recruitment. All removals refers to landed plus dead discard fish, Yield landed fish reflects benchmarks for only retained fish.

Benchmark	Cte Rec Geomean 1984-04 All removals	Cte Rec Geomean 1984-04 Landed Yield
F at MSY	0.228	0.248
MSY million lbs	8.66	4.27
Y/R at MSY lbs per recruit	4.08	2.01
S/R at MSY	8.04	7.48
SPR AT MSY	32.81%	30.54%
SSB AT MSY million lbs	37.62	35.02
F at max. Y/R	0.228	0.248
Y/R maximum lbs per recruit	4.08	2.01
S/R at Fmax	8.04	7.48
SPR at Fmax	32.81%	30.54%
SSB at Fmax million lbs	37.62	35.02
F 0.1	0.132	0.149
Y/R at F0.1 lbs per recruit	3.80	1.88
S/R at F0.1	11.95	11.10
SPR at F0.1	48.76%	45.32%
SSB at F0.1 million lbs	55.92	51.97
F 20% SPR	0.375	0.375
Y/R at F20 lbs per recruit	3.88	1.92
S/R at F20	4.93	4.94
SSB at F20 million lbs	23.07	23.12
F 30% SPR	0.251	0.251
Y/R at F30 lbs per recruit	4.07	2.01
S/R at F30	7.39	7.40
SSB at F30 million lbs	34.57	34.64
F 40% SPR	0.177	0.177
Y/R at F40 lbs per recruit	4.02	1.95
S/R at F40	9.83	9.85
SSB at F40 million lbs	46.00	46.11
F 90% max Y/R	0.116	0.130
Y 90% max Y/R million lbs	7.79	3.84
Y/R 90% max Y/R lbs per recruit	3.67	1.81
S/R 90% max Y/R	12.87	12.09
SSB 90% max Y/R million lbs	60.23	56.59
F 75% of Fmax	0.171	0.186
Y 75% of Fmax million lbs	8.50	4.18
Y/R at 75% Fmax lbs per recruit	4.00	1.97
S/R at 75% Fmax	10.08	9.49
SSB at 75% Fmax million lbs	47.18	44.43
Y 20% SPR million lbs	8.24	4.09
Y 30% SPR million lbs	8.64	4.27
Y 40% SPR million lbs	8.53	4.14

Table 2. Projection trends of base model gag GOM constant recruitment for scenarios of constant catch. All removals (landings & dead discards) and landed yield.

ALL REMOVALS

SSB mature femate wgt million pounds

Year	0 MP	3.3 MP	6.61 MP	11.01 MP	17.62 MP	24.23 MP	14.57 MP
1995	20.48	20.48	20.48	20.48	20.48	20.48	20.48
1996	20.61	20.61	20.61	20.61	20.61	20.61	20.61
1997	26.81	26.81	26.81	26.81	26.81	26.81	26.81
1998	30.73	30.73	30.73	30.73	30.73	30.73	30.73
1999	31.06	31.06	31.06	31.06	31.06	31.06	31.06
2000	37.67	37.67	37.67	37.67	37.67	37.67	37.67
2001	40.64	40.64	40.64	40.64	40.64	40.64	40.64
2002	40.46	40.46	40.46	40.46	40.46	40.46	40.46
2003	41.78	41.78	41.78	41.78	41.78	41.78	41.78
2004	40.55	40.55	40.55	40.55	40.55	40.55	40.55
2005	33.28	33.28	33.28	33.28	33.28	33.28	33.28
2006	29.16	29.16	29.16	29.16	29.16	29.16	29.16
2007	36.65	33.50	30.37	26.26	20.20	26.85	22.97
2008	44.16	37.64	31.21	22.78	10.74	11.98	16.18
2009	52.89	42.91	33.00	20.01	4.31	4.52	9.93
2010	61.81	48.50	35.13	17.33	2.77	2.81	4.21

F annual mortality rate

Year	0 MP	3.3 MP	6.61 MP	11.01 MP	17.62 MP	24.23 MP	14.57 MP
1995	0.458	0.458	0.458	0.458	0.458	0.458	0.458
1996	0.310	0.310	0.310	0.310	0.310	0.310	0.310
1997	0.315	0.315	0.315	0.315	0.315	0.315	0.315
1998	0.399	0.399	0.399	0.399	0.399	0.399	0.399
1999	0.297	0.297	0.297	0.297	0.297	0.297	0.297
2000	0.309	0.309	0.309	0.309	0.309	0.309	0.309
2001	0.330	0.330	0.330	0.330	0.330	0.330	0.330
2002	0.364	0.364	0.364	0.364	0.364	0.364	0.364
2003	0.400	0.400	0.400	0.400	0.400	0.400	0.400
2004	0.493	0.493	0.493	0.493	0.493	0.493	0.493
2005	0.422	0.422	0.422	0.422	0.422	0.422	0.422
2006	0.000	0.113	0.236	0.421	0.758	0.392	0.591
2007	0.000	0.099	0.227	0.470	1.198	1.349	0.776
2008	0.000	0.087	0.216	0.531	2.000	2.000	1.138
2009	0.000	0.077	0.204	0.606	2.000	2.000	2.000
2010	0.000	0.069	0.193	0.711	2.000	2.000	2.000

Total removals (landed + dead discards)

Year	0 MP	3.3 MP	6.61 MP	11.01 MP	17.62 MP	24.23 MP	14.57 MP
1995	9.11	9.11	9.11	9.11	9.11	9.11	9.11
1996	7.06	7.06	7.06	7.06	7.06	7.06	7.06
1997	8.55	8.55	8.55	8.55	8.55	8.55	8.55
1998	11.55	11.55	11.55	11.55	11.55	11.55	11.55
1999	9.64	9.64	9.64	9.64	9.64	9.64	9.64
2000	10.93	10.93	10.93	10.93	10.93	10.93	10.93
2001	12.13	12.13	12.13	12.13	12.13	12.13	12.13
2002	13.80	13.80	13.80	13.80	13.80	13.80	13.80
2003	15.15	15.15	15.15	15.15	15.15	15.15	15.15
2004	17.03	17.03	17.03	17.03	17.03	17.03	17.03
2005	12.38	12.38	12.38	12.38	12.38	12.38	12.38
2006	0.00	3.30	6.61	11.01	17.62	10.37	14.57
2007	0.00	3.30	6.61	11.01	17.62	24.23	14.57
2008	0.00	3.30	6.61	11.01	14.62	15.81	14.57
2009	0.00	3.30	6.61	11.01	7.70	7.96	13.85
2010	0.00	3.30	6.61	11.01	5.88	5.96	7.52

LANDED YIELD

SSB mature femate wgt million pounds

Year	0 MP	1.1 MP	3.3 MP	4.41 MP	5.51 MP	6.61 MP	7.2 MP
1995	20.48	20.48	20.48	20.48	20.48	20.48	20.48
1996	20.61	20.61	20.61	20.61	20.61	20.61	20.61
1997	26.81	26.81	26.81	26.81	26.81	26.81	26.81
1998	30.73	30.73	30.73	30.73	30.73	30.73	30.73
1999	31.06	31.06	31.06	31.06	31.06	31.06	31.06
2000	37.67	37.67	37.67	37.67	37.67	37.67	37.67
2001	40.64	40.64	40.64	40.64	40.64	40.64	40.64
2002	40.46	40.46	40.46	40.46	40.46	40.46	40.46
2003	41.78	41.78	41.78	41.78	41.78	41.78	41.78
2004	40.55	40.55	40.55	40.55	40.55	40.55	40.55
2005	33.28	33.28	33.28	33.28	33.28	33.28	33.28
2006	30.20	30.20	30.20	30.20	30.20	30.20	30.20
2007	37.82	35.75	31.65	29.60	27.56	27.69	24.45
2008	45.31	41.04	32.51	28.26	24.03	22.16	17.57
2009	54.01	47.47	34.34	27.73	21.09	16.96	10.83
2010	62.84	54.19	36.54	27.49	18.19	11.46	4.41

F annual mortality rate

Year	0 MP	1.1 MP	3.3 MP	4.41 MP	5.51 MP	6.61 MP	7.2 MP
1995	0.458	0.458	0.458	0.458	0.458	0.458	0.458
1996	0.310	0.310	0.310	0.310	0.310	0.310	0.310
1997	0.315	0.315	0.315	0.315	0.315	0.315	0.315
1998	0.399	0.399	0.399	0.399	0.399	0.399	0.399
1999	0.297	0.297	0.297	0.297	0.297	0.297	0.297
2000	0.309	0.309	0.309	0.309	0.309	0.309	0.309
2001	0.330	0.330	0.330	0.330	0.330	0.330	0.330
2002	0.364	0.364	0.364	0.364	0.364	0.364	0.364
2003	0.400	0.400	0.400	0.400	0.400	0.400	0.400
2004	0.493	0.493	0.493	0.493	0.493	0.493	0.493
2005	0.378	0.378	0.378	0.378	0.378	0.378	0.378
2006	0.000	0.070	0.223	0.307	0.397	0.392	0.550
2007	0.000	0.060	0.217	0.321	0.451	0.561	0.730
2008	0.000	0.052	0.207	0.330	0.514	0.715	1.095
2009	0.000	0.045	0.194	0.334	0.593	1.000	2.000
2010	0.000	0.040	0.184	0.340	0.712	1.840	2.000

Total landed yield million pounds

Year	0 MP	1.1 MP	3.3 MP	4.41 MP	5.51 MP	6.61 MP	7.2 MP
1995	4.45	4.45	4.45	4.45	4.45	4.45	4.45
1996	3.89	3.89	3.89	3.89	3.89	3.89	3.89
1997	4.53	4.53	4.53	4.53	4.53	4.53	4.53
1998	6.61	6.61	6.61	6.61	6.61	6.61	6.61
1999	5.91	5.91	5.91	5.91	5.91	5.91	5.91
2000	7.96	7.96	7.96	7.96	7.96	7.96	7.96
2001	6.98	6.98	6.98	6.98	6.98	6.98	6.98
2002	8.01	8.01	8.01	8.01	8.01	8.01	8.01
2003	7.21	7.21	7.21	7.21	7.21	7.21	7.21
2004	7.63	7.63	7.63	7.63	7.63	7.63	7.63
2005	5.81	5.81	5.81	5.81	5.81	5.81	5.81
2006	0.00	1.10	3.30	4.41	5.51	5.44	7.20
2007	0.00	1.10	3.30	4.41	5.51	6.61	7.20
2008	0.00	1.10	3.30	4.41	5.51	6.61	7.20
2009	0.00	1.10	3.30	4.41	5.51	6.61	6.57
2010	0.00	1.10	3.30	4.41	5.51	6.61	3.05

Table 3. Projection trends of base model gag GOM constant recruitment for scenarios of constant Fishing mortality rates. All removals (landings & dead discards) and landed yield. SPR% refers to fishing rates that will achieve the indicated percent SPR in equilibrium conditions.

ALL REMOVALS

SSB mature femate wgt million pounds

Year	SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
1995	20.48	20.48	20.48	20.48	20.48	20.48	20.48
1996	20.61	20.61	20.61	20.61	20.61	20.61	20.61
1997	26.81	26.81	26.81	26.81	26.81	26.81	26.81
1998	30.73	30.73	30.73	30.73	30.73	30.73	30.73
1999	31.06	31.06	31.06	31.06	31.06	31.06	31.06
2000	37.67	37.67	37.67	37.67	37.67	37.67	37.67
2001	40.64	40.64	40.64	40.64	40.64	40.64	40.64
2002	40.46	40.46	40.46	40.46	40.46	40.46	40.46
2003	41.78	41.78	41.78	41.78	41.78	41.78	41.78
2004	40.55	40.55	40.55	40.55	40.55	40.55	40.55
2005	33.28	33.28	33.28	33.28	33.28	33.28	33.28
2006	29.16	29.16	29.16	29.16	29.16	29.16	29.16
2007	27.20	30.00	31.81	32.97	30.55	30.55	26.85
2008	25.26	30.26	33.79	36.15	31.32	31.32	24.65
2009	24.49	31.30	36.39	39.93	32.78	32.78	23.72
2010	24.19	32.38	38.90	43.61	34.27	34.27	23.28

F annual mortality rate

Year	SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
1995	0.458	0.458	0.458	0.458	0.458	0.458	0.458
1996	0.310	0.310	0.310	0.310	0.310	0.310	0.310
1997	0.315	0.315	0.315	0.315	0.315	0.315	0.315
1998	0.399	0.399	0.399	0.399	0.399	0.399	0.399
1999	0.297	0.297	0.297	0.297	0.297	0.297	0.297
2000	0.309	0.309	0.309	0.309	0.309	0.309	0.309
2001	0.330	0.330	0.330	0.330	0.330	0.330	0.330
2002	0.364	0.364	0.364	0.364	0.364	0.364	0.364
2003	0.400	0.400	0.400	0.400	0.400	0.400	0.400
2004	0.493	0.493	0.493	0.493	0.493	0.493	0.493
2005	0.422	0.422	0.422	0.422	0.422	0.422	0.422
2006	0.375	0.251	0.177	0.132	0.228	0.228	0.392
2007	0.375	0.251	0.177	0.132	0.228	0.228	0.392
2008	0.375	0.251	0.177	0.132	0.228	0.228	0.392
2009	0.375	0.251	0.177	0.132	0.228	0.228	0.392
2010	0.375	0.251	0.177	0.132	0.228	0.228	0.392

Total removals (landed + dead discards)

Year	SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
1995	9.11	9.11	9.11	9.11	9.11	9.11	9.11
1996	7.06	7.06	7.06	7.06	7.06	7.06	7.06
1997	8.55	8.55	8.55	8.55	8.55	8.55	8.55
1998	11.55	11.55	11.55	11.55	11.55	11.55	11.55
1999	9.64	9.64	9.64	9.64	9.64	9.64	9.64
2000	10.93	10.93	10.93	10.93	10.93	10.93	10.93
2001	12.13	12.13	12.13	12.13	12.13	12.13	12.13
2002	13.80	13.80	13.80	13.80	13.80	13.80	13.80
2003	15.15	15.15	15.15	15.15	15.15	15.15	15.15
2004	17.03	17.03	17.03	17.03	17.03	17.03	17.03
2005	12.38	12.38	12.38	12.38	12.38	12.38	12.38
2006	9.99	7.00	5.08	3.86	6.42	6.42	10.37
2007	9.39	7.18	5.49	4.31	6.69	6.69	9.64
2008	8.99	7.39	5.91	4.76	6.97	6.97	9.15
2009	8.79	7.62	6.31	5.21	7.27	7.27	8.87
2010	8.66	7.82	6.67	5.61	7.53	7.53	8.70

LANDED YIELD

SSB mature femate wgt million pounds

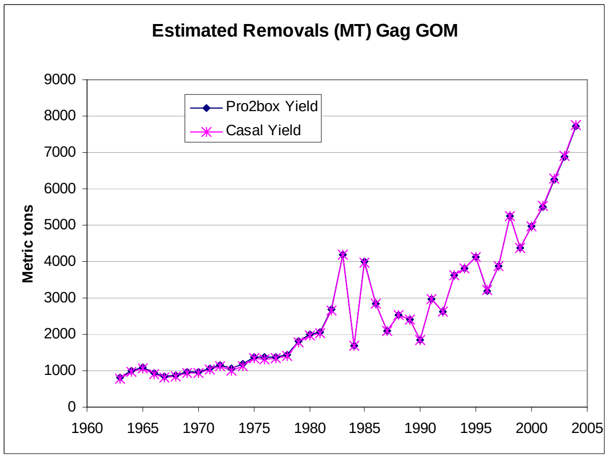
Year	SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
1995	20.48	20.48	20.48	20.48	20.48	20.48	20.48
1996	20.61	20.61	20.61	20.61	20.61	20.61	20.61
1997	26.81	26.81	26.81	26.81	26.81	26.81	26.81
1998	30.73	30.73	30.73	30.73	30.73	30.73	30.73
1999	31.06	31.06	31.06	31.06	31.06	31.06	31.06
2000	37.67	37.67	37.67	37.67	37.67	37.67	37.67
2001	40.64	40.64	40.64	40.64	40.64	40.64	40.64
2002	40.46	40.46	40.46	40.46	40.46	40.46	40.46
2003	41.78	41.78	41.78	41.78	41.78	41.78	41.78
2004	40.55	40.55	40.55	40.55	40.55	40.55	40.55
2005	33.28	33.28	33.28	33.28	33.28	33.28	33.28
2006	30.20	30.20	30.20	30.20	30.20	30.20	30.20
2007	28.06	30.95	32.82	33.57	31.04	31.04	27.69
2008	25.88	31.06	34.67	36.15	31.19	31.19	25.24
2009	24.96	31.92	37.14	39.36	32.11	32.11	24.12
2010	24.49	32.89	39.52	42.44	33.13	33.13	23.55

F annual mortality rate

Year	SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
1995	0.46	0.46	0.46	0.46	0.46	0.46	0.46
1996	0.31	0.31	0.31	0.31	0.31	0.31	0.31
1997	0.32	0.32	0.32	0.32	0.32	0.32	0.32
1998	0.40	0.40	0.40	0.40	0.40	0.40	0.40
1999	0.30	0.30	0.30	0.30	0.30	0.30	0.30
2000	0.31	0.31	0.31	0.31	0.31	0.31	0.31
2001	0.33	0.33	0.33	0.33	0.33	0.33	0.33
2002	0.36	0.36	0.36	0.36	0.36	0.36	0.36
2003	0.40	0.40	0.40	0.40	0.40	0.40	0.40
2004	0.49	0.49	0.49	0.49	0.49	0.49	0.49
2005	0.38	0.38	0.38	0.38	0.38	0.38	0.38
2006	0.37	0.25	0.18	0.15	0.25	0.25	0.39
2007	0.37	0.25	0.18	0.15	0.25	0.25	0.39
2008	0.37	0.25	0.18	0.15	0.25	0.25	0.39
2009	0.37	0.25	0.18	0.15	0.25	0.25	0.39
2010	0.37	0.25	0.18	0.15	0.25	0.25	0.39

Total landed yield million pounds

Year	SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
1995	4.45	4.45	4.45	4.45	4.45	4.45	4.45
1996	3.89	3.89	3.89	3.89	3.89	3.89	3.89
1997	4.53	4.53	4.53	4.53	4.53	4.53	4.53
1998	6.61	6.61	6.61	6.61	6.61	6.61	6.61
1999	5.91	5.91	5.91	5.91	5.91	5.91	5.91
2000	7.96	7.96	7.96	7.96	7.96	7.96	7.96
2001	6.98	6.98	6.98	6.98	6.98	6.98	6.98
2002	8.01	8.01	8.01	8.01	8.01	8.01	8.01
2003	7.21	7.21	7.21	7.21	7.21	7.21	7.21
2004	7.63	7.63	7.63	7.63	7.63	7.63	7.63
2005	5.81	5.81	5.81	5.81	5.81	5.81	5.81
2006	5.24	3.68	2.67	2.27	3.64	3.64	5.44
2007	4.79	3.69	2.83	2.46	3.66	3.66	4.91
2008	4.53	3.77	3.04	2.69	3.75	3.75	4.60
2009	4.41	3.90	3.26	2.93	3.88	3.88	4.44
2010	4.32	3.98	3.43	3.12	3.96	3.96	4.33



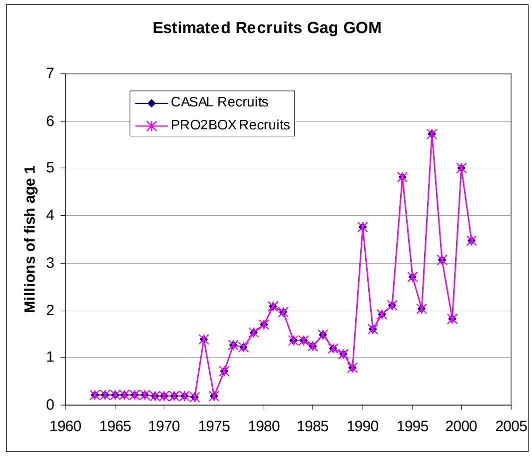


Figure 1. Comparison of estimate removals (landed and dead discards) and recruits for 1963-2004, from the CASAL base model run and the projection software PRO2BOX.

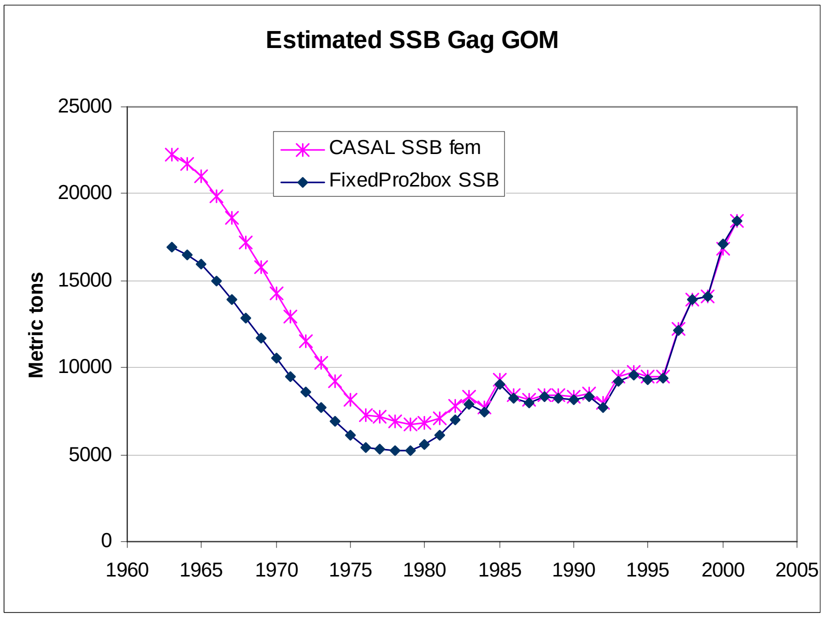


Figure 2. Comparison of estimate spawning stock biomass 1963 – 2004 from the CASAL base run and the projection software PRO2BOX.

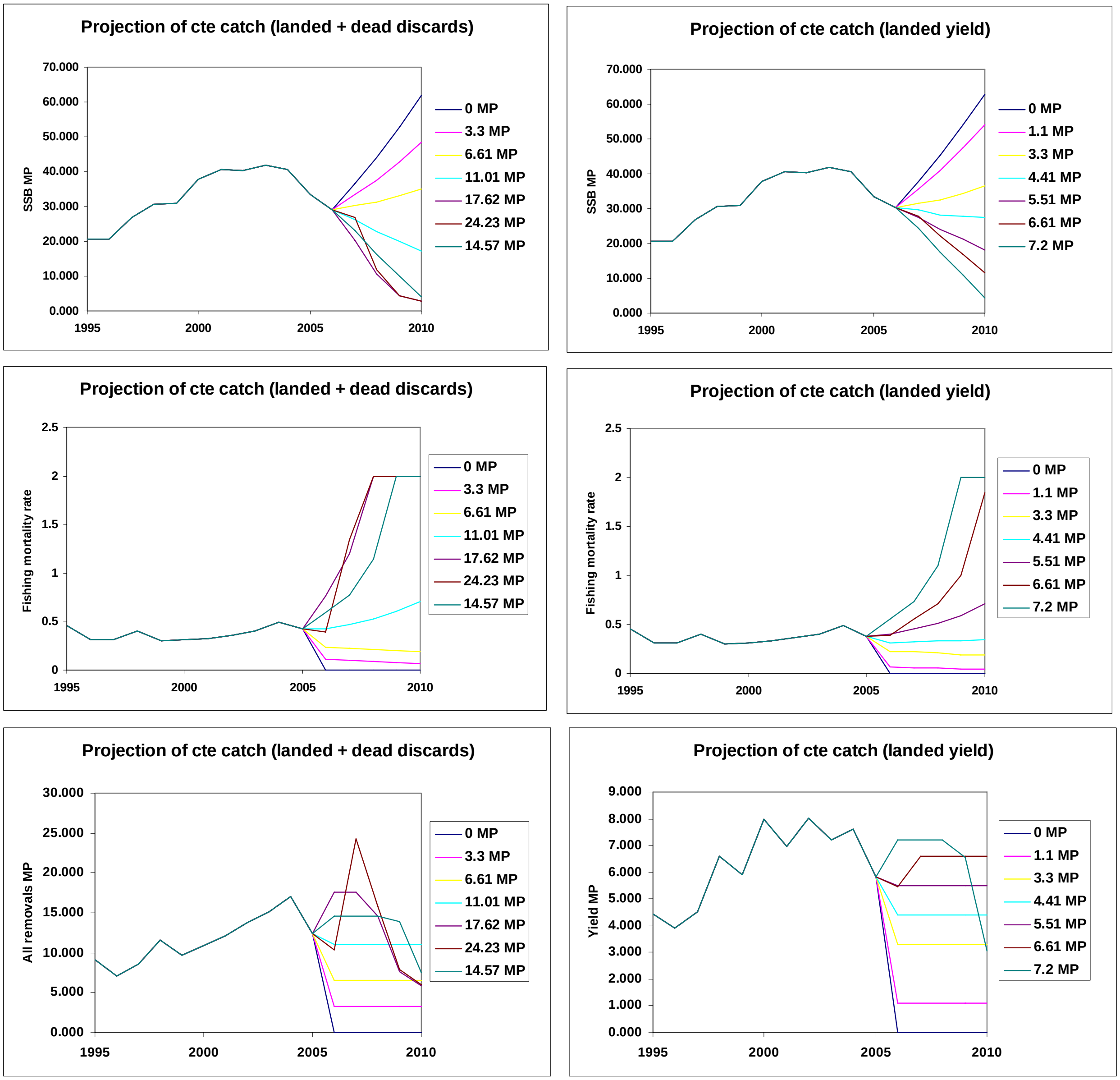


Figure 3. Projection trends from base model run Gag GOM assuming constant recruitment. Projections of constant catch scenarios, left column refers to total removals (landings & dead discards), right column only landed yield.

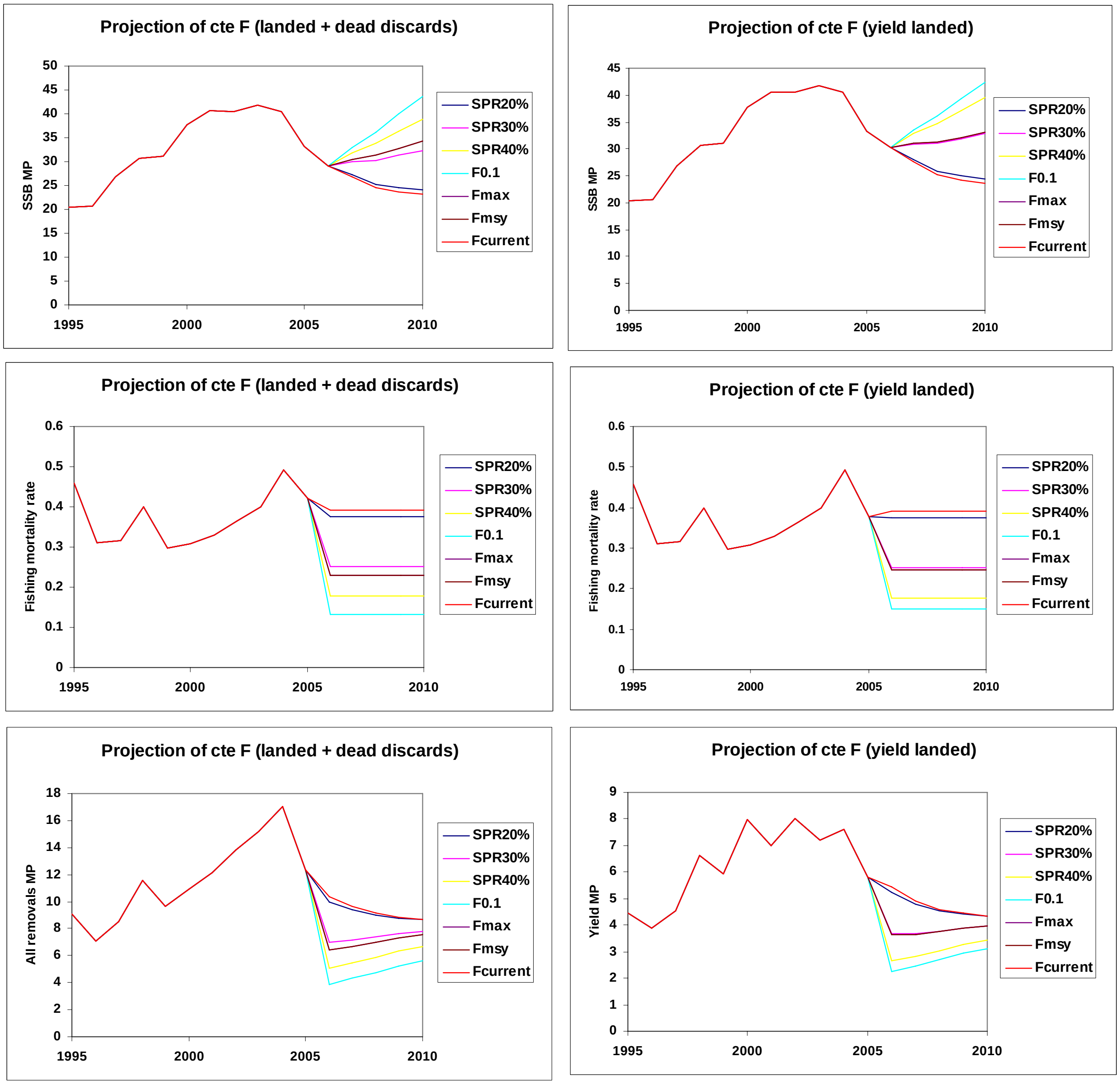


Figure 4. Projection trends from base model run Gag GOM assuming constant recruitment. Projections of constant F mortality rate scenarios, left column refers to total removals (landings & dead discards), right column only landed yield.